Responses to NMED Comments and Cross-Reference to Revised Plume-Front Project Plan

NMED Comments 1 and 2 (respectively):
NASA has submitted the Facility-wide document WSTF SAP in Appendix I. NMED will not comment on the document at this time. Approval of this document is not necessary prior to approval of the Plume-Front Project Plan (PFPP). The WSTF SAP (facility-wide) will be incorporated in the renewed RCRA Permit Application. For the purposes of the PFPP, NASA must prepare a Sampling and Analysis Plan specific to the project.

NASA has submitted the Facility-wide document WSTF QAPP in Appendix I. NMED will not comment on the document at this time. Approval of this document is not necessary prior to approval of the Plume-Front Project Plan. NASA must submit a Facility-wide QAPP separately from the PFPP for review and approval by NMED. For the purposes of the PFPP, NASA must describe the Quality Procedures specific to the project.

NMED submitted the required outline format for use in the Plume-Front Treatment System Project Plan to Jennifer Van Tol in an email dated June, 11, 2003. This outline format incorporated NMED's requirements stated in their letter to NASA dated April 2, 2003. NASA submitted the Project Plan in the NMED required outline format on March 3, 2004. Sections 3.2 and 3.3 of the Plume-Front Treatment System Project Plan provide the project specific sampling and analytical information that NASA intends to utilize during the operation of the plume-front treatment system. Section 4.0 provides the project-specific quality assurance procedures the NASA intends to utilize during the operation of the plume-front treatment system. If NMED requires changes to their outline format utilized by NASA for this Project Plan, NASA requests an alternative outline format and reasoning for the change in scope be submitted in writing to NASA. NASA cautions NMED that a significant change in the outline format of the Plume-Front Project Plan will cause a significant delay in starting the plume-front treatment system. NMED should carefully consider whether there is any added value in changing the format of the Plume-Front Project Plan. In order to eliminate duplication of overall general information, ease updating documents in the future, and to prevent circular references, larger facility-wide documents have been referenced.

NMED Comment 3:
NASA submitted the document "Plume-Front Health Risk Assessment". NMED will not comment on the document at this time. Approval of this document is not necessary prior to approval of the Plume-Front Project Plan.

No response is requested from NASA regarding this comment. However, NASA would like to point out that health risk is an important driver of the design of the plume-front system, and was a significant discussion topic during the NASA/NMED meeting of June

30, 2004. It is imperative that NASA and NMED understand, and agree upon, the methodology used to assess the health risk associated with plume-front remediation activity.

NMED Comment 4:
In section 1.2 of the Plan, NASA provided an Organization Chart of the entire Environmental Compliance Program. In addition, NASA must provide an organizational chart for the Plume-Front Treatment Project. Both charts must contain the names of responsible parties with clear indications of the assigned responsibilities.

Section 1.2 contains the revised Department organizational chart with names provided for each category. Responsibilities were previously outlined in the numbered sections 1 through 5 following the chart and have been updated with a description for the Information Management Group. Section 1.2 contains the new project organizational chart. A Communication, Responsibility, and Decision flow chart was previously provided in Appendix J and has been updated with names for the responsible groups.

NMED Comment 5:
NASA must explain whether the control system would monitor the injection pressure and the pressure on the annulus between the injection tubing and the casing in each injection well (this is a part of the general requirements for injection wells pursuant to 40 CFR 146.13(b)(2).

NASA is proposing to monitor pressure below the static water level in each of the injection wells. Details with respect to the plume front injection well design are provided by sections 2.5.4 and 3.1.1 of the Plume-Front Treatment System Project Plan. Due to the anticipated static water mounding and relatively high transmissivity of the aquifer, pressurizing the well annulus to force water out of the injection wells and into the aquifer will not be required. Real-time monitoring of the pressure in each of the four injection wells will be accomplished by a pressure transducer that measures total head in the well casing and aquifer. This transducer arrangement is appropriate when water is injected to an unconfined or semi-confined drinking water aquifer, as in this case, under a discharge plan or RCRA 3020(b) (42 U.S.C. sec. 6939b) exemption.

The distinction between the NASA proposal and those addressed by EPA under 40 CFR 146.13 (b)(2) is that the regulation cited is intended to ensure well casing and seal integrity for Class I non-hazardous injection wells. For Class I non-hazardous injection wells, fluid must be injected below the lowermost drinking water aquifer, which requires pressures greater than the head pressure. NASA does not propose to subject the plume-front treatment system injection wells to casing pressures that approach those typically encountered in Class I injection wells. NASA will monitor fluid pressure and water level within each well casing, to confirm injection into the aquifer, rather than monitoring casing or seal integrity as would be necessary with a Class I injection well subject to 40 CFR 146.13(b)(2).

Note that the NMED Groundwater Quality Bureau, in Discharge Permit 1255, has classified the plume-front injection wells as Class V injection wells, which are regulated under 40 CFR 144 Subpart G, 40 CFR 146 Subparts A & F, and the applicable sections of WQCC regulation 3107.

NMED Comment 6:
NASA must develop and implement a Community Relations Plan before the pump-and-treat facility becomes operational. NASA may use as guidance the EPA guidance "RCRA Public Participation Manual" (1995 to 2003) provided in the electronic enclosure to this letter. NASA's Community Relation Plan, at a minimum, must include the preparation of newsletters, factsheets, or summaries (describing the pump-and-treat facility with its purpose, and annual updates of the treatment progress) and dissemination of this information to all citizens living within a 5-mile distance from the edge of the plume, in addition to the publicizing of the information in the local newspaper and to the local radio stations. Public meetings (initial and annual) should be planned and held in connection with the publicizing of the newsletters (factsheets or summaries), where NASA and NMED representatives would answer questions from stakeholders. In addition, NASA must include in its Community Relation Plan, the creation and maintenance of public information repositories in the local (Las Cruces) public library where all Work Plans and/or Permits approved by NMED, quarterly and annual reports, and any other relevant information will be available to the public. This repository must be made available in a format accessible to all citizens.

The public was notified in advance and given the opportunity to comment at a public meeting conducted on May 6, 1999 for the plume-front stabilization system as outlined in the Plume-Front Treatment System Project Plan, Appendix C. Additionally, as directed by Mr. James Bearzi of NMED during a June 30, 2004 NASA-NMED meeting, NASA is preparing a fact sheet and scheduling a public meeting. Additionally, NASA is evaluating requirements for the establishment of a public repository at either the City of Las Cruces Branigan Library, or the New Mexico State University library. Additional information relative to the public notification will be provided to NMED as it becomes available.

NMED Comment 7:
NASA must provide the MSDS for the polyphosphate scale inhibitor, which is proposed to be injected in the influent.

MSDS sheets for both scale inhibitors being considered have been added to Appendix D. NASA will not use any scale inhibitor product during the upcoming validation tests.

NMED Comment 8:
In Section 2.1.5, NASA lists the WIWPS numbers of the wastes generated by the treatment facility. According to the description of WIWPS 10-20-17, the disposal method of incineration for the mercury lamps is not appropriate pursuant to 20.4.1.800 NMAC, incorporating 40 CFR 268.3(c) and 268.40. NASA should review the manufacturer's information and revise the disposal method as appropriate.

The description of the waste with WIWPS number 10-20-13 indicates uncertainty about the specific amount of the compounds contained in the waste. Therefore, NASA must establish the VO concentration by direct measurement (alternatively TOC) for the evaluation of the air emissions under Subpart CC. In addition, NASA must provide the MSDS of the product used as scale cleaning solution.

WIWPS 10-20-17 has been updated and provided in Appendix D. The mercury lamps used in the treatment system will be shipped for recycling.

NASA has revised the WIWPS's for routine operation of the Plume-Front Remediation Facility to provide additional detail with respect to the aqueous waste streams and has provided the updated document in Appendix D. WIWPS # 10-20-13, "GW Remediation Aqueous Waste", has been revised to limit the waste to groundwater containing WSTF groundwater contaminants. Compliance with the subpart CC regulations will be based on "knowledge of the waste" (analytical results of the treatment facility influent by methods other than EPA Method 25D).

WIWPS # 10-20-21, "Spent Citric Acid Descaler", has been added to cover routine descaling of the Plume-Front Remediation Facility air strippers per WJI ENV-0065, "Plume Front Stabilization Treatment System Operation and Maintenance Manual". Up to a 10 % citric acid solution will be used during the descaling process. Compliance with the subpart CC regulations will be based on "Direct Measurement" (sampling and analysis by EPA Method 25D). A copy of WIWPS #'s 10-20-21 is also provided in Appendix D.

NMED Comment 9:
In Section 3.1.1.4a, NASA states that groundwater potentiometric surface elevations will be collected quarterly from the monitoring wells. NASA must modify its plan to indicate collection of water levels every time the monitoring wells are sampled (or more frequently). Also, the pressure readings from Westbay wells must be converted to potentiometric elevations and utilized in the potentiometric surface map contouring. In addition, NASA must implement the practice that in the event that the treatment system functions at 50% capacity for more than three days, water levels will be measured within 48 hours in the monitoring wells influenced by pumping.

Per historical and current standard operating procedures for groundwater sample collection, depth to groundwater measurements are taken during every sampling event for conventional wells, and pressure profiles are conducted during every sampling event for

multiport wells. Since sampling events are conducted on varying schedules over several days, these measurements are recorded in field logbooks only and are not used for groundwater elevation contouring. The following paragraph describes NASA's procedure for measurements used in groundwater elevation contouring.

Currently, all conventional wells have depth to groundwater measurements taken on the same day on a monthly schedule. Key multiport wells that are in areas where conventional wells are not located (examples are WW-2 and BLM-37) have pressure profiles taken within several days of each other on a monthly schedule. Pressure readings taken from these key multiport wells on the monthly schedule are converted to potentiometric water levels. NASA considers measurements taken from conventional wells to be more representative of actual static water levels than converted multiport well pressure readings. These measurements will be used to generate overall groundwater elevation contours with actual measurements plotted on a monthly basis.

NASA requests clarification on the following statement, "In addition, NASA must implement the practice that in the event that the treatment system functions at 50% capacity for more than three days, water levels will be measured within 48 hours in the monitoring wells influenced by pumping." Please provide a list of monitor wells NMED considers to be influenced by pumping. In addition, please explain how NMED determined the "50% capacity for more than three day" and "measured within 48 hours" criteria.

NMED Comment 10:

According to section 3.1.1.4B, time concentration plots for monitoring wells located outside of the current limits of the ground water plume will be used to evaluate plume stabilization. NASA's ground water plume is comprised of great number of organic solvents and inorganic contaminants. The current and historical analytical data indicates that all monitoring wells (as visualized outside of the groundwater plume by NASA) show the presence (high and low concentrations) of may organic solvents and inorganic contaminants, such as acetone, benzene, chloroethane, chloromethane, chromium, 1,2-dichloroethane, decane, ethylbenzene, Freon-11, Freon-113, 2-hexane, methylene chloride, napthhalene, propane, PCE, TCE, toluene, styrene, tetrahydrofuran, and vinyl chloride. These constituents has been detected in the plume front wells PL-7, PL-8, PL-9, PL-10, BLM-37, BLM-10, JP-1, JP-2, JP-3, WW-w, WW-2, WW-3, WW-4, and WW-5. Although the detections of TCE in these wells are not consistent, NMED considers these wells to be contaminated by the groundwater plume.

At the present, NASA does not have monitoring wells that have not been contaminated by the groundwater plume. NASA must proposed locations for installation of "sentry" monitoring wells, located downgradient from, and beyond the limits of the plume, and a schedule with approximate dates for their installation. These wells must intercept the entire length of the aquifer in the front of the plume.

Per the June 30, 2004 NASA-NMED meeting, a detailed discussion of this issue was postponed pending further evaluation from NMED. This comment is not addressed in this submittal.

NMED Comment 11:
Table 6 of Section 3.1.3.1 lists COCs at the plume-front. This table contains constituents that the pump-and-treat system is not designed to treat/remove in the groundwater. NASA must explain the relevance of this table to the plume-front monitoring.

As stated in the text of Section 3.1.3.1., the list of COCs for monitoring is generated following the process established in the EPA Risk Assessment Guidance for Superfund (RAGS), presented as Appendix G of the Plume-Front Project Plan. This list of compounds and metals, as NASA interprets RAGS, then forms the basis for the monitoring analyte list, which guides the facility in tracking analyte concentrations over time. The monitoring is critical to determining whether COC concentrations increase significantly in the future. EPA's intent for generating the list of COCs appears obvious; to monitor for a list of compounds and metals that could require treatment if the concentrations were observed increasing in the future.

NMED Comment 12:
NASA must correct the following typographic errors: in section 3.1.2, last paragraph, replace "Attachment L" with "section 9 and 10 of Attachment G"; and in section 3.1.3.5 replace "Additionally, Section" with "Additionally, Section 3.3".

These corrections have been made in Sections 3.1.2 and 3.1.3.5. Additionally, NASA has corrected µg/L in Table 4 for NDMA and DMN to ng/L. In Appendix H, the TCE Concentrations in Groundwater at NASA-WSTF & Vicinity plume map has been corrected by removing the incorrect 200 ppb contour.

NMED Comment 13:
In section 3.3.3.2, NASA did not provide the laboratory manual for the off-site laboratory "Severn Trent" in Denver.

NASA included information for analytical laboratories currently under contract at the time of the Project Plan submittal. However, information for Severn Trent Laboratories has been included in Appendix I.

NMED Comment 14:
NASA must implement the following corrective actions associated with the analytical data with failed data quality samples and contaminated blanks contamination of blank samples at the analytical laboratory must be followed by re-analysis or re-run of the

corresponding samples by the laboratory. Blanks contaminated during the field sampling (field blanks, equipment blanks, etc) will be followed by re-sampling within 30 days of the sampling event of the corresponding wells/effluent. If NASA chooses not to re-analyze or re-sample, then the detected value will be considered valid for the purposes of the PFPP monitoring.

Wells suspected to contribute to the contamination of the ground water through deteriorated screens or other means should be scheduled for replacement of the sampling procedures revised to avoid concerns with well artifacts during sampling.

Per the June 30, 2004 NASA-NMED meeting, a detailed discussion of this issue was postponed pending further evaluation from NMED. This comment is not addressed in this submittal.

Comment 15:
NASA must revise Table 7-14 to indicate the correct level of concern. When an EPA MCL is not available for a contaminant, then the lowest value from the following sources must be considered: Region VI Tap Water Screening level (risk based value), any other EPA screening levels, EPA Drinking Water standard, EPA Health Advisory levels, or NMWQCC levels.

EPA Region 6, EPA Region 3, and EPA Region 9 tap water screening levels have been added to Tables 7 through 14, for those contaminants that do not have a promulgated MCL or NMWQCC standard.

Comment 16:
NASA expects to discharge groundwater with NDMA and DMN levels of below 10 ppt (with 30% extraction efficiency) as determined by EPA Method 607 Mod. As indicated by the revised Plume-Front Stabilization Work Plan (dated May 2002, table 4.6), the actual concentrations of these constituents may only be below 33 ppt to based on the extraction efficiency which is higher than the expected treatment standard of 10 ppt. NASA must explain how this problem will be resolved during the operation of the treatment system. If NASA intends to use an alternate method for these constituents, NASA must provide all necessary information for the approval of the method before the treatment system becomes operational.

NASA submitted a "Request by NASA WSTF to Utilize Alternative Analytical Approaches for Analysis of Nitrosamines" to NMED on September 23, 2003. NMED sent an approval letter "Approval of Proposal to Utilize Alternative Analytical Approaches for Analysis of Nitrosamines" to NASA on November 15, 2003. As instructed by David Cobrain of NMED during a May 6, 2004 conference call, once an analytical laboratory has successfully bid on the contract for nitrosamines analysis for the Plume-Front Treatment System, NASA will submit documentation that the analytical lab did obtain acceptance from the State of California and a copy of the laboratories

analytical method to NMED. NASA intends to solicit bids from the labs that are currently accepted by the State of California for low-level NDMA analysis. NMED may review the list of California-accepted laboratories at http://www.dhs.ca.gov/ps/ddwem/chemicals/NDMA/NDMAlabs.htm.

NASA's approach to the design of the plume-front remediation system, with respect to NDMA treatment, is described in the "Plume-Front Stabilization Workplan" and section 2.1 of the "Plume-Front Treatment System Project Plan".

NASA White Sands Test Facility

Plume-Front Treatment System Project Plan

August 2004

1.0 Project Management 1

1.1 Project Description 1
1.2 Project Organization and Responsibilities 2
1.2.1 Training 4
1.2.2 Records and Documentation 4
1.3 Community Relations 4

2.0 Interim Measure Stabilization Treatment System: Final Construction Plans and Specifications 5

2.1 Treatment System Design 5
2.1.1 Air Stripper Information 7
2.1.2 UV Reactor Information 9
2.1.3 Instrumentation and Control System 10
2.1.4 Alarms 12
2.1.5 Waste Management Practices 13
2.1.6 Maximum Contaminant Levels for TCE and PCE 13
2.1.7 Air Emissions Issues 14
2.2 Plume-Front Stabilization Treatment System Operation and Maintenance Manual 14
2.3 Construction Quality Assurance Plan 15
2.4 Health and Safety Plan 16
2.4.1 Site Description 16
2.4.2 Key Personnel 16
2.4.3 Hazards Assessment 16
2.4.4 Site Control 16
2.4.5 Protection 16
2.4.6 Emergency Procedures 16
2.4.7 Spill Containment 17
2.5 Design of Extraction/Injection Wells and Groundwater Monitoring System 17
2.5.1 Groundwater Contaminants of Concern 17
2.5.2 Groundwater Contaminant Plume and Groundwater Distribution Maps 18
2.5.3 Treatment System Well Placement 19
2.5.4 Treatment System Well Design 19
2.5.5 Groundwater Monitoring System 19

3.0 System Evaluation 20

3.1 System Performance 20
3.1.1 Evaluation of Contaminant Plume Capture and Aquifer Response 20
3.1.1.1 Plume-Front Treatment and Stabilization 20
3.1.1.2 Definition of Capture Zone 20
3.1.1.3 Current Status of Plume-Front Capture 20
3.1.1.4 Plume Capture Evaluation Methodologies 21
3.1.1.5 Plume Capture Evaluation 22
3.1.1.6 Potential Plume-Front Capture Modifications 22
3.1.2 Treatment Process Monitoring 22
3.1.3 Groundwater Monitoring 23
3.1.3.1 Contaminants of Concern 23

3.1.3.2 Plume-Front Treatment Groundwater Monitoring Wells 24
3.1.3.3 Analytical Methods 24
3.1.3.4 Groundwater Monitoring Well Summary 24
3.1.3.5 Evaluation of Analytical Data 24
3.1.4 Treatment System Well Performance 24
3.1.4.1 Volumetric Flow Rates, Groundwater Elevation, and Specific Capacity 25
3.1.4.2 Well Monitoring, Maintenance, and Rehabilitation 25
3.1.4.3 Monitoring Contaminants of Concern 25
3.2 Sampling Procedures 25
3.2.1 Sample Type, Location and Frequency 25
3.2.2 Sampling Activities 25
3.2.3 Corrective Actions 26
3.3 Analytical Procedures 26
3.3.1 Contaminants of Concern 26
3.3.2 Analytical Equipment and Procedures 26
3.3.3 Laboratory Operations 26
3.3.3.1 Sample Management 26
3.3.3.2 Laboratory Manual 26
3.3.3.3 Analytical Methods 26
3.3.3.4 QA/QC Requirements 38
3.3.3.5 Corrective Actions 38
3.3.3.6 Reporting 38
3.3.3.7 Data Validation 38
3.4 Assessment 38
4.0 Quality Assurance and Quality Control Procedures 42
4.1 Internal Quality Control Checks and Frequency 42
4.1.1 Quality Control Samples 42
4.1.2 Corrective Actions for Control Limit Exceedance 42
4.1.3 Quality Control Calculations 42
4.1.4 QA/QC Requirements 42
4.1.5 Field Records 42
4.1.6 Reporting 42
4.1.7 Corrective Actions 43
4.2 Calibration Procedures and Frequency 43
4.2.1 Groundwater Monitoring Equipment 43
4.2.2 Laboratory Equipment 43
4.2.3 Treatment System Equipment 43
4.3 Data Reduction, Validation, and Reporting 43
4.3.1 Data Qualification 43
4.3.2 Data Verification 43
4.3.3 Non-Direct Data Sources 44
4.3.4 Resources and Support 44
4.3.5 Data Management 44
4.4 Data Limitations 44
5.0 Quarterly Report Format 44
5.1 Executive Summary 44

5.2 Regulatory Criteria 45
5.3 Groundwater Monitoring Results 45
5.4 Groundwater Analysis Results 45
5.5 Treatment System Monitoring 45
5.6 Discussion, Conclusions, and Recommendations 45
5.7 Appendices 45
5.7.1 Field Methods 45
5.7.2 Chemical Analytical Program 46
5.7.3 Chemical Analytical Reports 46
5.7.4 Well Construction Summary 46
6.0 References 46

Table 1 Extraction and Injection Well Flow Rates 6
Table 2 Air Stripper Performance Specifications 7
Table 3 NEEP Modeling Data for the Air Strippers 9
Table 4 UV System Performance Specifications 9
Table 5 Construction Status 15
Table 6 WSTF COCs (Extracted from Plume-Front Project Plan Health Risk Assessment) 23
Table 7 WSTF EPA Method 8260B Analyte List 27
Table 8 WSTF EPA Method 524.2 Analyte List 29
Table 9 WSTF Modified EPA Method 607 Analyte List 31
Table 10 WSTF EPA Method 8270C Analyte List 32
Table 11 WSTF EPA Method 6010B/6020 and 7000 Series Metals List 36
Table 12 WSTF General Inorganic Analytes 37
Table 13 WSTF EPA Method 314 Analytes 37
Table 14 WSTF Hydrazine Method (WSTF-Developed HPLC) Analytes 38
Table 15 Performance Metrics 40

Appendix A - Plume Front Stabilization Work Plan (1999 and 2002) and Plume-Front Remediation System Operation and Maintenance Plan 47
Appendix B - Plume-Front Stabilization Treatment System Operation and Maintenance Manual (WJI ENV-0065) 48
Appendix C - Public Notice Information 49
Appendix D - Specific Engineering Information 50
Appendix E - Construction Surveillance Plan 51
Appendix F - WSTF Emergency Preparedness Plan 52
Appendix G - Plume-Front Health Risk Assessment 53
Appendix H - Specific Geologic Information 54
Appendix I - Specific Data Collection Information 55
Appendix J - Decision, Responsibility, and Communication Flow Charts 56

1,1-DCE	1,1-Dichloroethene
3DSWB	Three-Dimensional Site-Wide Bedrock
amsl	above mean sea level
AQB	Air Quality Bureau
BART	Biological Activity Reaction Test
bgs	below ground surface
CAS	Chemical Abstract Service
CCC	Calgon Carbon Corporation
cfm	cubic feet per minute
CFR	Code of Federal Regulations
COCs	Contaminants of Concern
DMN	n-Nitrodimethlyamine
DP	Discharge Plan
DQO	Data Quality Objectives
EPA	Environmental Protection Agency
EPP	Emergency Preparedness Plan
FAR	Federal Acquisition Regulations
Freon 11	Trichlorofluoromethane
Freon 113	1,1,2-Trichloro-1,2,2-trifluoroethane
Freon 123	2,2-Dichloro-1,1,1-trifluoroethane
Freon 123A	1,2-Dichloro-1,1,2-trifluoroethane
Freon 21	Dichlorofluoromethane
gpm	gallons per minute
GWQB	Ground Water Quality Bureau
HA	Health Advisory
HAZMAT	Hazardous Materials
HDPE	High Density Polyethylene
HMI	Human Machine Interface
HWB	Hazardous Waste Bureau
I&C	Instrumentation and Control
IRIS	Integrated Risk Information System
ISO	International Organization for Standardization
JHA	Job Hazard Analysis
JDMB	Jornada del Muerto Basin
kW	kilowatt
LDC	Leak Detection Cable
MCL	Maximum Contaminant Level

mg/L	milligrams per Liter
NASA	National Aeronautics and Space Administration
ND	Not Detected
NDMA	n-Nitrosodimethylamine
NEEP	North East Environmental Products, Inc.
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NOI	Notice of Intent
OSHA	Occupational Safety and Hazard Administration
PCE	Tetrachloroethylene
PFE	Plume-Front Extraction
PFI	Plume-Front Injection
PFSWP	Plume-Front Stabilization Work Plan
PLCs	Programmable Logic Controllers
ppb	parts per billion
PPE	Personal Protective Equipment
ppt	parts per trillion
psig	pounds per square inch, gauge
PTE	Potential to emit
PVC	Polyvinyl chloride
QA/QC	Quality Assurance and Quality Control
QAPP	Quality Assurance Project Plan
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RFI	Draft RCRA Facility Investigation Report
RSI	Request for Supplemental Information
SAP	Sampling and Analysis Plan
SCADA	Supervisory Control and Data Acquisition
SOP	Standard Operating Procedure
SSL	Soil Screening Level
T-C	Time-Concentration
TCE	Trichloroethylene
ug/L	micrograms per Liter
UV	Ultraviolet
VOCs	Volatile Organic Compounds

WBFZ	Western Boundary Fault Zone
WIWPS	WSTF Individual Waste Profile Sheets
WJI	WSTF Job Instruction
WSTF	White Sands Test Facility

1.0 Project Management

This Plume-Front Project Plan is intended to update and augment the National Aeronautics and Space Administration (NASA) White Sands Test Facility (WSTF) Plume-Front Stabilization Work Plan (PFSWP) which was approved by the New Mexico Environment Department (NMED) Hazardous Waste Bureau (HWB) on March 15, 2000. The NMED HWB has indicated that the approved PFSWP is a "living" document and through time, attachments will serve to keep the Work Plan current. This Project Plan is intended to present discussions of technical issues raised in the NMED Request for Supplemental Information (RSI) dated April 4, 2003.

1.1 Project Description

The Plume-Front Stabilization Project is a presumptive remedy interim corrective action. The overall objective (long-term and short-term) of this interim measure is to control threats to human health and the environment through stabilization and mass removal of low-concentration groundwater contamination encountered at the leading (westernmost) edge of the WSTF groundwater contaminant plume. The groundwater is contaminated as a result of historic activities at the site. The groundwater contaminant plume-front area covers an area of approximately 4,000 feet by 8,000 feet and has an average depth of 700 feet. The main contaminants of concern (COCs) at the plume-front include n-nitrosodimethylamine (NDMA), n-nitrodimethylamine (DMN), trichloroethene (TCE), and several other halogenated volatile organic compounds (VOCs).

An ex-situ pump and treat system has been approved to address plume-front stabilization and contaminant mass treatment activities. The plume-front stabilization utilizes six plume-front extraction (PFE) and four plume-front injection (PFI) wells. The WSTF three-dimensional site-wide bedrock (3DSWB) groundwater model was utilized to simulate contaminant plumes for NDMA, TCE, and tetrachloroethene (PCE). Parameters generated from the 3DSWB model wells were used for the plume-front stabilization well designs. The six extraction wells are within or on the eastern boundary of the Western Boundary Fault Zone (WBFZ). Extraction wells PFE-1, PFE-2, PFE-3, PFE-4A, and PFE-7 will specifically address the TCE contaminant plume which extends furthest west. These wells also effectively contain the PCE plume. The five extraction wells will generate an estimated combined flow rate of 1,050 gallons per minute (gpm).

Extraction well PFE-5, with an estimated flow rate of 26 gpm, primarily serves to ensure NDMA/DMN plume containment. In the plume-front vicinity, the DMN plume has a similar extent to the NDMA plume, but generally lower concentrations. To ensure stabilization of the NDMA/DMN plume-front, which does not extend as far west as the TCE plume, well PFE-5 is positioned to stabilize the NDMA/DMN plume-front concentrations east of the TCE target wells. The estimated total system flow rate will be 1,076 gpm.

The groundwater from the extraction well system will be treated by an air stripping (for the VOCs), and UV oxidation (for NDMA and DMN). Contaminant treatment standards for the injected water were developed following standards and guidelines from multiple Federal and State regulatory sources.

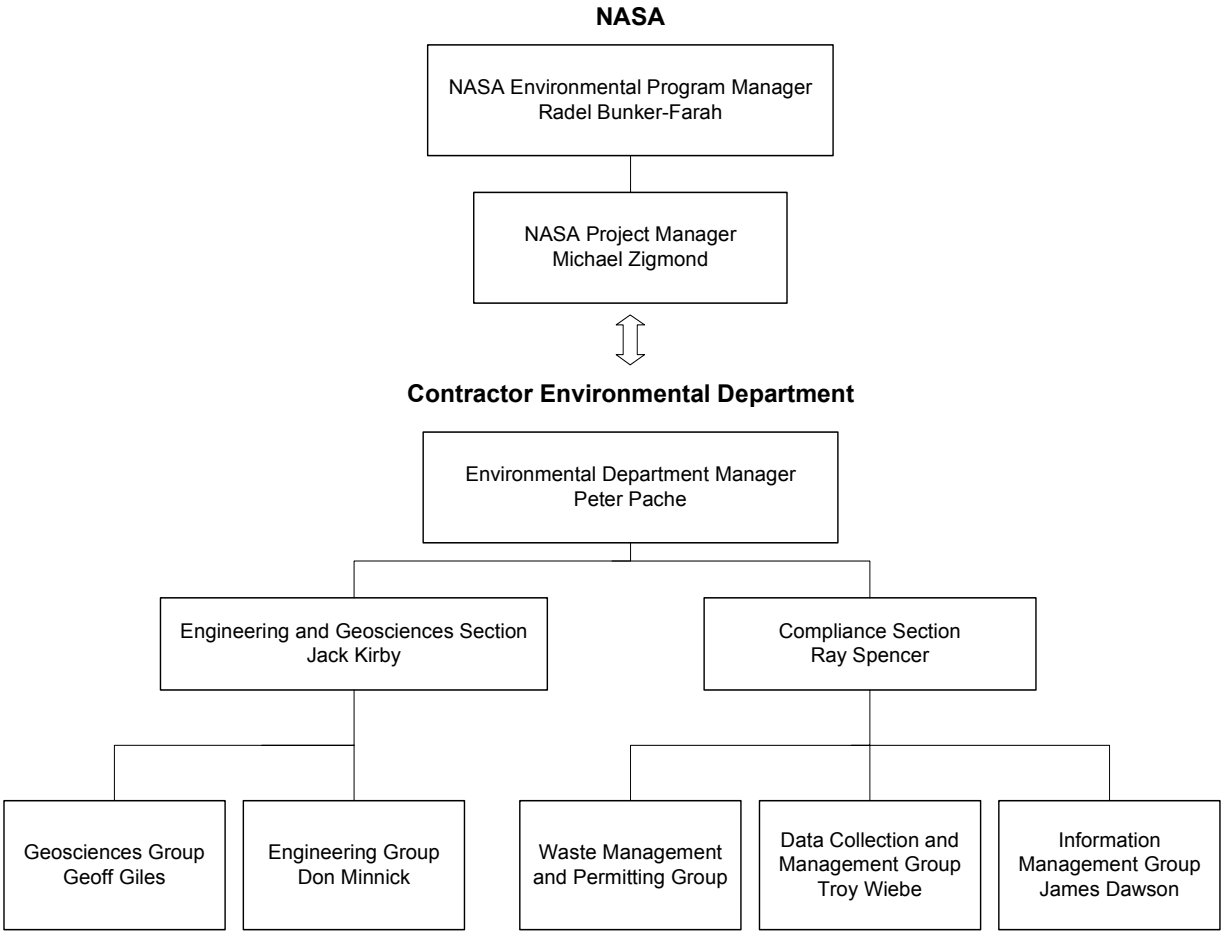
Remediated groundwater injection will be accomplished using four injection wells (PFI-1 through PFI-4) located to the west and south of the contaminant plume. The injection well locations are designed to mitigate future southern migration of the plume by creating a localized groundwater mound.

For additional information including the site conceptual model, the PFSWP submitted in May of 2002 and the Plume-Front Remediation System Operation & Maintenance Plan submitted in June of 2002 are provided for reference in Appendix A. A copy of the Discharge Plan DP-1255 is also included in Appendix A. Information presented in this Plan is intended to update the approved PFSWP. The Table of Contents provides a location for plume maps, geologic information, COCs, and other information requested by NMED. Additional regulatory background and permit requirement information is provided in Section 15.0 of Appendix B.

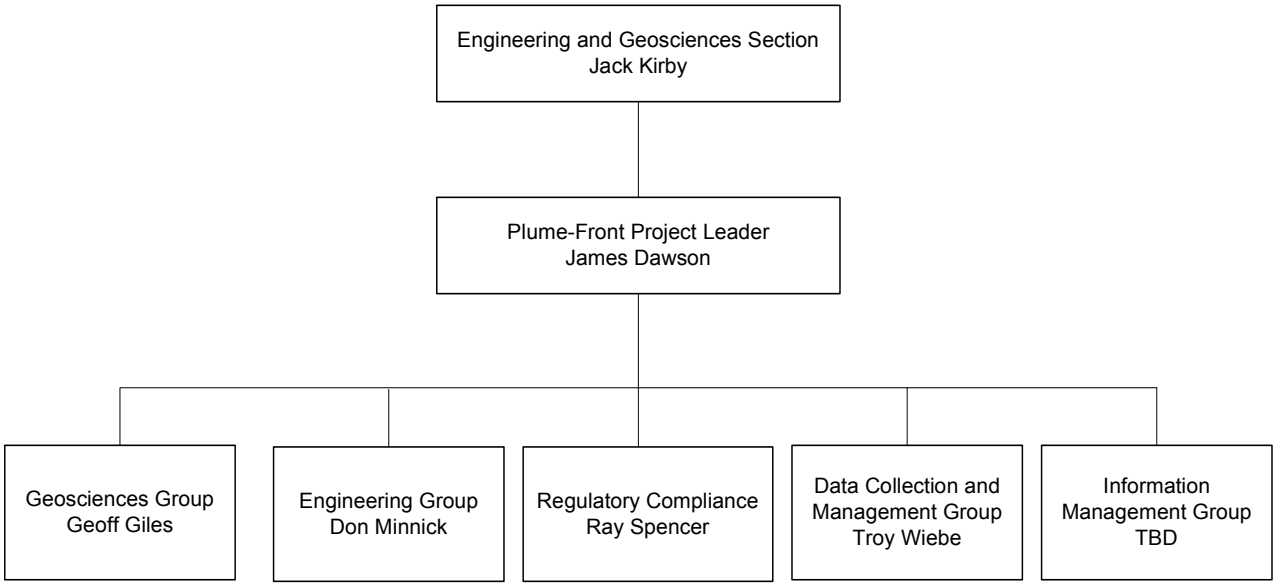
1.2 Project Organization and Responsibilities

The NASA Environmental Program Manager is responsible for and directs all activities associated with WSTF environmental compliance and the plume-front treatment project. The site contractor Environmental Department, under the direction of the NASA Environmental Program Manager, performs and/or coordinates all activities associated with the project. An organizational chart showing the NASA and site contractor Environmental Department is shown below.

NASA White Sands Test Facility Environmental Compliance Organizational Chart



NASA White Sands Test Facility Plume-Front Treatment System Project Organizational Chart



Specific responsibilities of key groups and individuals are as follows:

1. NASA Environmental Program Manager - overall responsibility for WSTF environmental compliance. Responsible for external communication with regulators, interested parties, and the public.
2. NASA Project Manager - authority and responsibility delegated by the NASA Environmental Program Manager for direct treatment system oversight.
3. Environmental Department Manager (Contractor) - responsible for management of the contractor Environmental Department.
4. Engineering and Geoscience and Compliance Section Supervisors (Contractor) - responsible to assign and direct resources and personnel to complete work required by approved permits and work plans.
5. The following groups responsibilies include:
    - Geosciences Group - responsible for administering the installation and development of wells; analyzing and interpreting geologic and hydraulic data; developing conceptual and computer groundwater models; and coordinating and supervising hydrogeologic, geophysical, and drilling contractors.
    - Engineering Group - responsible for conducting engineering functions in connection with remedial actions; designing treatment systems to clean up contaminants in conformance with Quality Assurance (QA) objectives; and operating the Plume-Front treatment system.
    - Data Collection and Management Group - responsible for preparing sampling plans, coordinating sampling activities, preventive maintenance of field equipment and instruments, reporting of well and system information. The QA/Quality Control (QC) coordinator reviews and qualifies project data, monitors laboratory performance, and interacts with the analytical laboratories.
    - Information Management Group - responsible for accessing, archiving, storage, reporting, visualizing and overall management of environmental records and data and managing computing resources.

- Plume-Front Project Leader - responsible for the overal coordination of treatment system activities, scheduling and budget activities.

1.2.1 Training

Relevant personnel qualifications and training are provided in Section 12.0 of the Plume-Front Stabilization Treatment System Operations and Maintenance Manual (WJI ENV-0065) provided in Appendix B.

1.2.2 Records and Documentation

WSTF Job Instructions (WJIs) provide detailed instructions for start-up and operation of the treatment system, identify the system configuration and operating parameters, and identify task-specific safety requirements. Checklists that accompany the WJIs provide a record of activities and are maintained by the contractor Environmental Department as part of the facility operating record. WJIs and other WSTF documentation are managed in accordance with International Organization for Standardization (ISO) 9000 and 14001 standards.

Regulatory correspondence for the Plume-Front is maintained in the contractor Environmental Department Record Management system in Adobe pdf format with searchable database.

1.3 Community Relations

There is no formal community relation plan associated with this project. However, on February 10, 1999, the NMED HWB issued a letter to NASA (NASA Public Notice for Implementation of a Presumptive Remedy) requesting completion of public notice requirements in accordance with Environmental Protection Agency (EPA) guidance "Presumptive Remedies: Policy and Procedures". This letter specifically requested the following:

1. The submittal of a notice of the presumptive remedy to all persons on the facility mailing list maintained by NMED (as enclosed) and to the appropriate units of state and local government;
2. The publication of this notice in a major local newspaper of general circulation; and
3. The notice must include:
   - announcement of a 60-day comment period and a name and address of a facility contact to whom comments must be sent;
   - announcement of a date, time, and place for a public meeting on the presumptive remedy;
   - name and telephone number of the permittee's contact person; and
   - location where copies of the presumptive remedy and any supporting documents can be viewed and copied.

NASA completed the requirements and did not receive any public comments. NASA mailed the public notice to NMED and its mailing list on April 6, 1999. The public notice was published in the Las Cruces Sun-News on Sunday, March 28, 1999 when the 60-day comment period commenced. The public meeting was conducted at the Branigan Memorial Library on May 6, 1999 at 7pm. The text of the public notice is provided below.

> "NASA White Sands Test Facility (WSTF) hereby announces its intent to implement a pump and treat groundwater remediation system to prevent further migration of contaminated groundwater caused by historic site operations. This remedy will pump groundwater from six extraction wells, treat the water using ultraviolet/oxidation and air stripping technologies, and reintroduce the treated groundwater into the aquifer through a network of four injection wells.
>
> System construction is expected to commence in the summer of 1999 and is anticipated to operate 24 hours a day following an initial start-up phase. Approximately 1,000 gpm will be treated and injected during the operational life of the system. WSTF expects the system to be operational in the year 2000.

The owner and operator of the system is NASA White Sands Test Facility, P.O. Box 20, Las Cruces, New Mexico 88004. WSTF is located approximately 16 miles northeast of Las Cruces, New Mexico.

This notice initiates a 60-day comment period to address public comments and questions regarding this interim groundwater treatment remedy. Inquiries regarding this activity should be directed to:

David A. Amidei
NASA Environmental Manager
White Sands Test Facility
P.O. Box 20
Las Cruces, New Mexico 88004
(505) 524-5517

A public meeting has been scheduled for Thursday May 6, 1999 from 5pm to 7pm in the Dresp B Room of the Thomas Branigan Memorial Library to encourage public participation in the presumptive remedy process. WSTF personnel will be available to address any questions or comments. Copies of the proposed Work Plan and supporting documentation (including a pilot-scale ultraviolet/oxidation testing schedule) can be viewed at the Thomas Branigan Memorial Library."

Additionally on May 10, 1999, the NMED Ground Water Quality Bureau submitted a letter to NASA including the public notice being published by NMED for the discharge permit for the injection wells. The text of NMED's notice is as follows:

"DP-1255, NASA White Sands Test Facility (WSTF), Joseph Fries, NASA WSTF Site Manager, proposed to discharge up to 1,872,000 gallons of treated contaminated ground water per day from the NASA WSTF ground water remediation system. The NASA WSTF ground water remediation system is located approximately 18 miles northeast of Las Cruces, NM in Section 5, T21S, R3E. Up to 1,872,000 gallons per day of ground water contaminated with organic compounds will be extracted using several plume front extraction wells. Contaminated ground water will then be treated using UV oxidation/hydrogen peroxide and air stripping. Treated ground water will be reinjected via injection wells located southwest of the plume front to create a ground water mound to prevent further migration of the contaminated plume. Ground water below the site is at a depth of approximately 420 feet and has a total dissolved solids concentration ranging 490 to 1,230 milligrams per liter."

All reference documents are provided in Appendix C.

2.0 Interim Measure Stabilization Treatment System: Final Construction Plans and Specifications

2.1 Treatment System Design

The plume-front treatment system is designed to pump and treat approximately 1,076 gpm of volatile organic and NDMA impacted groundwater. Drawings 652-M-01, 02 and 03 (provided in Appendix B) depict the flow schematics for the entire treatment system. Design flow rates for each extraction and injection well are provided in Table 1.

Table 1 Extraction and Injection Well Flow Rates

Well	Approximate Flowrate (gpm)
PFE-1	288
PFE-2	224
PFE-3	213
PFE-4A	200
PFE-5	26
PFE-7	125
PFI-1	269
PFI-2	269
PFI-3	344
PFI-4	194

Each extraction well is housed in a pre-cast concrete vault and each well vault is equipped with a sampling port and a flow meter. All wells, with the exception of PFE-5, have a flow control valve. In addition, numerous other valves have been installed: check valves to prevent back flow; manual gate valves to allow various components to be isolated for maintenance purposes; and air and vacuum valves to ensure smooth filling and draining of the pipeline and prevent any air pockets from residing in the system.

Untreated water will be conveyed to the treatment system via a dual containment high density polyethylene (HDPE) pipeline with leak detection cable. The diameter of the inner pipe (the carrier pipe) and the diameter of the outer pipe (the leak containment pipe) is denoted on drawing 652-M-01 (Appendix B). Various components such as check valves, air and vacuum valves, and butterfly valves have been installed throughout the pipeline for operation and maintenance purposes.

A Raychem TraceTek leak detection cable (LDC) has been installed in the annular space between the inner and outer pipe, to provide for operator notification and system shut-down, in case of a leak from the inner piping system. The LDC has two insulated wires and two conductive polymer coated electrodes. A small direct current (DC) voltage (five-nine volts) is applied to the sensing cable, and the internal resistors limit the current flow through the sensor cable loop to approximately 75 microamps. Measuring the voltage drop across an internal reference resistor monitors the actual amount of current flowing. If a leak occurs, additional current will seek the path of least resistance and flow across the leak. This results in increased current flow through the reference resistor. The resultant increased voltage drop across the reference resistor causes the leak detection control panel to alarm. By measuring the voltage drop along the sensing cable between the leak and the leak detection control panel, the location of the leak can be determined. The voltage drop is linear and proportional to the distance from the control panel to the leak. The leak dection control panel logs the data, time, and location of any leak. The leak detection control panel can store up to 512 leak or fault events in non-volatile memory.

As depicted in drawing 652-M-02 (Appendix B), the ten-inch HDPE carrier pipe transitions to an eight-inch carbon steel pipe in Building 650. A sampling port is located upstream of the treatment equipment. A polyphosphate scale inhibitor will be injected to prevent scale precipitation in the air stripper(s) and the UV treatment reactor. The solution is stored in a 165 gallon aboveground polyethylene tank and injected via a metering pump. The water will split into two six-inch carbon steel pipes, each equipped with a flow meter, prior to entering the two air strippers (parallel configuration). A scale cleaning system

consisting of a 600 gallon above-ground tank of citric acid and pump is connected to each air stripper. The spent citric acid solution will be discharged into an above-grade 2,500 gallon polyethylene tank located immediately south (outside) of the treatment building. The tank is located on a concrete pad with a two-foot containment wall, providing 3,300 gallons of spill containment. The frequency and duration of scale cleaning system use will be determined as site knowledge is gained during actual system operation.

Building 650 is designed with a dropped floor and containment sump to contain significant leakage (approximately 9,000 gallons) from the piping, piping components or treatment hardware. Should a catastrophic failure occur, a float switch installed in the sump will trigger a full-system shut-down and operator notification. To prevent system over-pressurization downstream of the air strippers, a 100 psi rupture disc is installed. If this disc ruptures, the water will be discharged directly to the sump and trigger system shut-down/operator notification.

Treated water is pumped from each air stripper sump and is discharged into six-inch carbon steel headers. The six-inch headers discharge into a single eight-inch carbon steel header, which conveys the water to the UV reator. An electromagnetic flow meter, installed in the eight-inch header, measures the combined flowrate out of the air stippers and into the UV reactor. Multiple sampling ports are provided to monitor the effluent from the air strippers and the UV reactor. Following treatment by UV oxidation, the treated effluent is conveyed to Building 651 via a ten-inch HDPE pipe. At Building 651, the flow will be split four ways, metered and injected into the four PFI wells located down gradient of the plume (Drawing 652-M-03, Appendix B) at the rates provided in Table 1.

The pipeline for the plume-front treatment system was hydraulically modeled using AFT Fathom. This modeling software was utilized to evaluate flow rates, pressures and velocities throughout the system and determine the appropriate diameter pipe for each segment. These data are shown in Appendix D.

No plume-front components are cathodically protected; it was deemed unnecessary for the polyvinyl chloride (PVC) extraction well casings and associated components. PVC Certa-Lok drop pipe was utilized in the injection wells, negating the need for cathodic protection. Extraction well PFE-3 has been retrofitted with a 6.05” (inside diameter) PVC well casing, negating the need to install cathodic protection.

2.1.1 Air Stripper Information

The system currently contains two ShallowTray low profile air strippers (Model No. 61231) from North East Environmental Products, Inc. (NEEP). A cut-sheet drawing showing the front and side views for one air stripper is provided in Appendix D. The air stripping system is designed to treat, in parallel, WSTF’s VOCs of concern. Each air stripper can accommodate a maximum hydraulic flow rate of 625 gpm, is comprised of three aeration trays, and is sized for an air flow rate of 3,600 cfm.

Design parameters include hydraulic flowrate, air temperature, water temperature, expected influent concentration, and effluent standards (Table 2). To ensure NEEP’s product satisfies NASA’s performance goals, NEEP modeled the performance of the air strippers uaing the design criteria in Table 2. The predicted effluent concentration of each VOC of concern is shown in Table 3. The NEEP air stripper modeling simulations demonstrated that the low-profile air strippers fulfilled the performance goals. NEEP also performed a bench-scale study. Results verified stripping of the VOCs as predicted by the model. Results of this study are shown in Appendix D.

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Table 2 Air Stripper Performance Specifications

Criteria	Specification
Total Hydraulic Flow Rate	1,250 gpm

Table 2 Air Stripper Performance Specifications

Criteria	Specification	
Hydraulic Flow Rate per Air Stripper	625 gpm	
Maximum Run Time	24 hours per day	
	365 days per year	
Design Life	Not less than 15 years	
Air Temperature	Minimum	-13 ºC
	Annual Average	17 ºC
	Maximum	44 ºC
Influent Water Temperature	15 to 20 ºC	
Site Elevation	4,500 feet above mean sea levels (amsl)	
Expected Influent Concentrations*	TCE	130 µg/L
	PCE	4.2 µg/L
	Freon 11	860 µg/L
	Freon 21	60 µg/L
	Freon 113	2,000 µg/L
Effluent Standards (Discharge Plan DP-1255)	TCE	5 µg/L
	PCE	5 µg/L
	Freon 11	100 µg/L
	Freon 21	20 µg/L
	Freon 113	1,200 µg/L
Treatment Goals	TCE	2.5 µg/L
	PCE	2.5 µg/L
	Freon 11	50 µg/L
	Freon 21	10 µg/L
	Freon 113	600 µg/L

*NOTE: Based on numerical modeling of groundwater flow.

NEEP's modeling program indicates that each stripper will treat 625 gpm at a concentration of 130 parts per billion (ppb) TCE to less than 5 ppb. Upstream to the air strippers, a polyphosphate pretreatment scaling solution will be added to address hardness values in the plume-front groundwater. The scaling solution is added to prevent scale build up in the air stripper(s) and the UV treatment reactor.

The air stripper sumps and trays are fabricated of 304L stainless steel. The materials of construction are deemed sufficient protection against corrosion. No supplemental corrosion protection equipment (i.e. cathodic protection) has been installed in the air strippers.

Stripping by-products include VOCs, in addition to mineral deposits in the air stripping units. Emission controls, air monitoring issues, and additional information is provided in Appendix D.

Table 3 NEEP Modeling Data for the Air Strippers

		Volatile Organic Compounds (ppb)				
		TCE	**PCE**	**F11**	**F21**	**F113**
Q = 625 gpm, Water Temp = 15° C						
Air	Min -13°	3.74	0.08	1.55	0.53	0.96
Temp	Avg 17°	3.63	0.08	1.50	0.51	0.93
(° C)	Max 44°	3.53	0.08	1.45	0.50	0.90
Q = 625 gpm, Water Temp = 20° C						
Air	Min -13°	2.53	0.05	0.99	0.34	0.61
Temp	Avg 17°	2.46	0.05	0.96	0.33	0.59
(° C)	Max 44°	2.39	0.05	0.93	0.32	0.58

2.1.2 UV Reactor Information

A 12-lamp Rayox ® reactor manufactured by Calgon Carbon Corporation (CCC). This reactor, the final stage of the treatment process, utilizes ultraviolet photolysis to destroy the semivolatile organics (NDMA and DMN) in the plume-front groundwater. During UV treatment, NDMA is oxidized to nitric oxide radicals (NO●) and dimethylamino radicals ($(CH_3)_2N$●). Destruction of the NDMA and DMN molecules generates water, carbon dioxide and mineral salts as by-products (see Simplified AOP Mechanisms for NDMA in Appendix D). In addition, there are no air emissions. Design parameters include hydraulic flowrate, expected influent concentration, and effluent standards (see Table 4).

Table 4 UV System Performance Specifications

Criteria	Specification	
Total Hydraulic Flow Rate	1,100 gpm	
Minimum Flow Rate	200 gpm	
Design life	Greater than 15 years	
Influent Water Temperature	15º to 20 ºC	
Maximum System Pressure	100 pounds per square inch, gauge (psig)	
Maximum Pressure Drop	10 psig	
Expected Influent Concentrations*	NDMA	2,000 µg/L
	DMN	450 µg/L

Table 4 UV System Performance Specifications

Criteria	Specification	
Effluent Standards (Discharge Plan DP-1255)	NDMA	10 ng/L
	DMN	10 ng/L
Treatment Goals	NDMA	<2 ng/L
	DMN	<2 ng/L

*NOTE: Based on numerical modeling of groundwater flow.

The UV reactor is a cylindrical, stainless steel vessel, approximately four feet in diameter, and eight feet tall. The reactor is capable of accommodating hydraulic flow rates ranging from 200 gpm to 3,000 gpm and is equipped with twelve 30 kW (27 kW nominal) UV lamps. The UV lamps are oriented horizontally in an alternating, perpendicular fashion. The contaminated groundwater enters at the bottom of the vessel, flows upward and exits at the top. CCC performed bench-scale and pilot-scale tests on plume-front groundwater. The bench and pilot scale tests concluded that both NDMA and DMN could be treated to an effluent of less than two ppt with the use of the 12-lamp UV reactor.

The UV reactor is equipped with a brush cleaner that periodically scrubs the quartz sleeves which house the UV lamps. Numerous operational safeguards are incorporated in the UV treatment system control software: alarms will be activated if the influent flowrate is out of range; if the reactor senses high water temperature; if there is lamp failure; or if the quartz cleaner fails to operate, or is low on air pressure. Automatic shutdown occurs if the influent flowrate is out of range, if there is a leak detected, if the reactor experiences high water temperatures, or if there is lamp failure.

2.1.3 Instrumentation and Control System

The treatment system will be operated and monitored using a Supervisory Control and Data Acquisition (SCADA) system. The human-machine interface (HMI) consists of a Rockwell RSView32 software program running on a Windows workstation. The system will display equipment and system operation information, allow operator manipulation of operation setpoints and configuration (with proper administrative privileges), provide alarm notifications, enable data logging, and reporting. The HMI will monitor and control all Programmable Logic Controllers (PLCs) listed below, and the leak detection system using a combination fiber optic (for remote PLCs) and a copper wire (for local PLCs) network. Each of the PLCs is programmed in relay ladder logic to control independent operations of a particular skid or subset of the treatment system. Conventional hand controls are located on equipment skids, at extraction well vaults, and in the injection manifold building (for emergency and maintenance purposes). The control system also includes electrical power monitoring and metering capabilities.

The control system will monitor the conditions listed below.

- Flowrates from each of the PFE wells;
- Water levels in each of the PFE wells:
- The air stripper PLCs will monitor various operational parameters. Alarm conditions and interlocks designed and installed by the air stripper equipment manufacturer include:
    a. High/low water level in each air stripper sump;
    b. High pressure drop across each air stripper;
    c. Pressure drop across each inlet air filter;
    d. High/low air flow into each air stripper;
    e. Run/stop status of each blower motor;
    f. Run/stop status of each injection pump; and
    g. Operation mode – strip, clean, or dump.

- The UV system PLC will monitor various operational parameters. Alarm conditions and interlocks designed and installed by the UV equipment manufacturer include:
    a. UV lamp startup status;
    b. High temperature in lamp drive enclosure;
    c. Low flowrate;
    d. High temperature in the UV reactor;
    e. Leak from the UV reactor;
    f. UV lamp failure;
    g. High voltage cabinet door open;
    h. Reactor access cover(s) open;
    i. Quartz tube wiper failure; and
    j. Flowrate out of UV reactor.
- Leaks in double-wall extraction pipeline;
- Flowrate of water treatment chemicals, to be injected by chemical metering pump(s);
- Flowrate into each of the PFI wells;
- Water level in each of the PFI wells;
- Electrical power quality parameters and usage;
- Storage tank levels; and
- Communication with devices on the network.

The control system has the ability to take the actions listed below.

- Start the entire treatment system;
- Operate the system at 50% or 100% of the design flowrate;
- Take either air stripper off-line for routine cleaning, maintenance, or repair, with an appropriate reduction in flow through the system;
- Compare total flowrates through the extraction wells, treatment equipment, and injection wells, and adjust flow rate via variable speed pumps and flow control valves to prevent injection well flooding, and high/low water levels in the air stripper sumps;
- Shut down an injection well if the water level in the well rises to unacceptable levels;
- Shut down the entire system if more than two of the injection wells shut down;
- Shut down an extraction well if water level in the well draws down to unacceptable levels;
- Shut down the entire system if more than two of the extraction wells shut down;
- Sound an audible alarm in the treatment building and initiate auto-dialer alarm notification, if any of the alarm conditions listed above occur that causes system shutdown. Alarms and changes in system status will also be printed out with time/date stamp;
- Log system alarms and data to hard disc drive at predetermined rates for troubleshooting, historical trending, and preventive maintenance analysis;
- Allow operator shutdown via control system override switch; and
- Shut down the entire treatment system.

The following components are installed as part of the I&C system:

A. Extraction Well Vaults

- An electromagnetic flow meter is installed at each extraction well. Flow control valves and valve controllers are installed at each well, except PFE-5.

- Water levels are monitored via the water-level pressure transducers installed in each extraction wells.
- A programmable logic controller (PLC-PFEx) panel with complete wiring and communication connections is installed at each extraction well.
- One power monitor is installed in each extraction well motor control center (MCC), with complete wiring and communication connections.
- Fiber optic cable are installed in underground conduit between the extraction well vaults and Building 650.

B. Building 650 - Treatment Facility

- An electromagnetic flow meter upstream of the UV reactor and air strippers.
- The scale cleaning system controller (CP-400) and scale control system controller (CP-300) is electronically connected to the Building 650 controller.
- The Building 650 (PLC-Main) control panel.
- The dual-wall pipeline Leak Detection Control Panel.
- A float level switch in the Building 650 floor sump.
- The Building 650 power monitor.
- The control station personal computer, the alarm printer, report printer, and telephone autodialer.
- The wiring and communication lines between the control system PLCs, treatment equipment PLCs, leak detection control panel, control station PC, UV system modem, WSTF telephone system, and telephone auto-dialer.

C. Building 651 - Injection Manifold Building

- The Building 651 control (PLC-PFI) panel.
- Flow control valves and electromagnetic flow meters (one for each injection well).
- All electrical connection between the water-level pressure transducers, flow control valves, flow meters, and the Building 651 control (PLC-PFI) panel.
- The fiber optic cable between Building 650 and Building 651.

2.1.4 Alarms

Depending on the severity of the situation, the system may go into red alarm mode and shut down, or go into amber alarm mode where the treatment system will continue functioning with notifications made to the operator. Amber alarms may transition into red alarms based on the duration and/or the severity of the situation. The following delineates conditions which will activate the amber of red alarms.

The amber alarm mode will be activated when operating parameters are out of the normal range for:

- High flow in an extraction well;
- Low flow in an extraction well;
- Low water level in an extraction well;
- High flow alarm for each injection well
- Low flow alarm for each injection well;
- High water level in an injection well;
- High air pressure alarm for an air stripper;
- Filter pressure high for an air stripper;
- High flow alarm for an air stripper;

- Low water flow for an air stripper;
- Low level in anti-scale solution tank;
- Spent cleaning solution tank high;
- Low air compressor pressure;
- Limited communication failure with remote PLCs;
- Low UV inlet flow; or
- UV system alarm (includes all UV reactor "warning" alarms).

The red alarm mode will be activated for:

- Low-low water level alarm for each extraction well;
- Failure to start pump for an extraction well;
- Failure to stop pump for an extraction well;
- Water elevel high-high for an injection well;
- Low air flow into the air strippers;
- High air flow alarm for air strippers;
- High-high water level alarm for air strippers;
- Low water level alarm for air strippers;
- UV system shutdown (includes all UV reactor "emergency" alarms);
- System discharge block valve fails to open;
- System discharge blow valve fails to close;
- System recycle block valve fails to open;
- System recycle block valve fails to close;
- High level alarm for building 650 floor sump;
- Pipeline leak detection system alarm;
- Main emergency shut down button activated; or
- Major communication failure with remote PLCs.

2.1.5 Waste Management Practices

NASA is anticipating three sources of solid waste from the plume-front treatment system: 1) spent scale cleaning solution and contaminated groundwater; 2) spent UV lamps; and 3) gloves and wipes contaminated with spent scale cleaning solution. WSTF Individual Waste Profile Sheets (WIWPS) 10-20-13, 10-20-17, and 10-20-18 (respectively) address how these wastes will be handled. These documents are provided in Appendix D.

2.1.6 Maximum Contaminant Levels for TCE and PCE

On February 5, 2003, a notice in the Federal Register announced that the EPA Integrated Risk Information System (IRIS) Program is in the process of assessing various chemical constituents. Two of WSTF's COCs are included in this notice: TCE and PCE. The evaluations for these substances are scheduled to enter the IRIS database in fiscal year 2003 or fiscal year 2004 (Federal Register, Vol. 68, No. 24, Feb. 25, 2003, Notices). The HWB has identified this notice to NASA and indicated that the system may need to be configured to meet future lower standards.

The current regulatory effluent standards for TCE and PCE are 5 ppb. Future revisions to these regulated levels will involve factors that neither NASA, nor any other entity, have the ability to predict. NASA will maintain the existing levels specified

by the approved PFSWP and DP-1255. NASA will optimize the treatment system to maintain the lowest effluent levels possible for TCE and PCE, but no modifications to the system will be made at this time. NASA will continue to monitor EPA's regulatory actions concerning any of WSTF's COCs and will take appropriate action if EPA changes any applicable standards.

2.1.7 Air Emissions Issues

Early in the design process, NASA evaluated potential air emissions from the air strippers. Using a number of worst-case assumptions, the design flow rate, and the predicted influent of VOC concentrations, NASA calculated the total plume-front potential to emit (PTE).

Based on the results of the original PTE calculations, NASA determined that an air emission permit was not required and air emissions controls and monitoring were not required. Upon completion of the revised PTE calculations, NASA submitted a Notice of Intent (NOI) to the NMED Air Quality Bureau (AQB). The NOI included a description of the plume-front treatment system and air strippers, the PTE calculations, and a description of the supporting data and assumptions. NASA requested the AQB to make a determination whether an air emissions permit would be required for the plume-front treatment system. The AQB responded that an air emission permit would not be required. The NOI and the AQB's determination are provided in Appendix D.

NASA is not required to obtain an air emission permit for the plume-front treatment system, or to install any air emission controls, and does not plan to perform air emissions monitoring. NASA will monitor plume-front treatment flow rates and VOC concentrations in the groundwater as described in Section 3.0. NASA will periodically re-evaluate the plume-front system's PTE. If the PTE approaches the level which triggers the requirement for an air emissions permit, NASA will take appropriate action to maintain compliance with AQB regulations.

2.2 Plume-Front Stabilization Treatment System Operation and Maintenance Manual

Plume-Front Stabilization Treatment System Operation and Maintenance Manual (WJI ENV-0065 provided in Appendix B) has been established to provide detailed operating procedures for the operation and maintenance of the plume-front treatment system. The WJI contains instructions for routine start-up, operation, inspection, and maintenance of the facility, as well as emergency shutdown and contingency procedures. The WJI will be utilized during system verification testing and post-verification routine system operation.

Attachment G of the WJI, "Facility Maintenance Plan" outlines routine maintenance of all treatment system components including injection and extraction wells, air strippers, UV reactor, treatment and injection buildings, and associated ancillary equipment. Attachment M, "Facility Inspection Plan" provides instructions for periodic inspection of major system components. Checklists provide a record of activities performed and are part of the facility operating record. Critical parts are listed in Attachment F, "Spares Inventory."

Attachment L, "Treatment Facility and Extraction Well Sampling" provides sampling procedures and instructions for the calibration, maintenance and use of field instruments associated with treatment facility and groundwater sampling activities.

The WJI ENV-0065 specifies that any anomalous conditions found during inspection and maintenance activities are recorded and the Groundwater Treatment Facility Project Leader be notified for corrective action. Corrective actions taken may include generating work orders, initiating a Discrepancy Record, and/or initiating a contractor Environmental Department Task Memo to correct the problem. All anomalies are recorded as part of the facility operating record.

Contingency and emergency procedures are included in Attachment N, "Spill Response Procedures for Incidental Releases." This Attachment contains the instructions for dealing with spills and other emergency conditions. If a spill or emergency goes beyond the scope of treatment system personnel resources or training, then WSTF Emergency Services are called for assistance and the WSTF Emergency Preparedness Plan (EPP) is executed.

2.3 Construction Quality Assurance Plan

Construction of the plume-front treatment system is divided into several different subprojects or phases. Table 5 outlines the each subproject and its current status.

Table 5 Construction Status

Description	Status
Installation of Extraction, Injection and Monitoring Wells	Complete
Treatment Building	Complete
Subgrade Piping System	Complete
Installation of Submersible Pumps, Discharge Piping and Injection Piping	Complete
Supply and Installation of Process Piping, Control System, and Related Components	Under construction, anticipated complete by January 2004
System Verification and Optimization	Pending, anticipated to be complete by May 2004

All off-site contractors are required to submit their qualifications to perform the work. Construction activities that could result in contact with the groundwater requires workers to have the Occupational Safety and Health Administration (OSHA) 40-Hour Hazardous Waste Operations Certification.

All construction activities are inspected daily by a NASA or contractor Environmental Department representative. The inspector is responsible for monitoring all construction activities to ensure that the scope of work, plans and specifications are followed. The inspectors complete daily reports, monitor all testing activities, and photo-document activities, as needed. Additional activities include addressing, documenting, or notifying the responsible party of issues such as: change orders, field changes, processing pay applications, and reviewing submittals.

All scopes of work or plans and specifications included quality assurance testing requirements to ensure the quality of the contractors' work. All testing results thus far have met or exceeded manufacturers' requirements.

Prior to acceptance and final payment, each construction project has a final walk-through, attended by all parties involved, to ensure all technical, administrative, and quality requirements have been fulfilled per the contractual requirements. The results of these walk-throughs are documented and maintained as a part of the project record. Remaining construction items are compiled into a punch list and the inspector is responsible for ensuring that punch list is completed prior to close-out of the project.

2.4 Health and Safety Plan

2.4.1 Site Description

Operations to be performed and personnel responsible for operation and maintenance of the treatment system can be found Appendix B. A list of engineering drawings are provided in Attachment B of Appendix B and include water supply, electricity, and other services.

2.4.2 Key Personnel

Key personnel are listed in the organizational chart provided in Section 1.2 and in Appendix J. Emergency personnel are identified in the WSTF EPP provided in Appendix F.

2.4.3 Hazards Assessment

WSTF Job Hazard Assessments (JHAs) are required for each type of task being performed. These JHAs include a description of the known hazards and evaluations of the risks associated with the activity conducted, including exposure to contaminants. JHAs include the identification of an operation of job to be assessed, a breakdown of each task associated with the job, identification of the hazards associated with each task, and a determination of the necessary controls or personal protective equipment for the identified hazard. The hazard assessment for the plume-front treatment system operation and maintenance is provided as Attachment C, "Hazard Assessment and Job Hazard Analyses" in Appendix B.

2.4.4 Site Control

Access to all areas of the plume-front treatment system are controlled by the site security force. Only authorized personnel are granted access to these areas. Section 9.0 of Appendix B provides additional information regarding site control.

2.4.5 Protection

Protection of personnel involved with the plume-front treatment system is accomplished by development of procedures to minimize employee exposure to potential safety hazards. Training personnel in the use of these procedures and the use of JHAs make employees aware of the hazards and also designate personal protective equipment. Specific information is provided in Attachment C, "Hazard Assessment and Job Hazard Analyses" of Appendix B.

2.4.6 Emergency Procedures

Building 650 is equipped with a fire alarm, fire extinguishers, first aid kit, shower, and eyewash. The on-site contractor Fire Department provides emergency response service on a 24-hour per day, 365 day per year basis.

The WSTF EPP is provided in Appendix F. This Plan provides direction to mitigate the effects of hazards, preserving life, and minimizing damage. This Plan directs response during emergencies, and establishes a recovery system in order to return the facility to normal operations after a major incident, such as a natural disaster or a technological accident. In all emergencies, the response precedence shall be:

- Protection of life;
- Prevention and treatment of injuries; and
- Protection of property and the environment.

This Plan includes the following sections:

- Warning;
- Communications;

- Shelter and Mass Care, and Accountability;
- Radiological Protection;
- Evacuation;
- Fire Prevention and Control;
- Security;
- Medical and Occupational Health;
- Emergency Public Information;
- Damage Assessment;
- Plant Engineering and Utilities;
- Resource Management;
- Emergency Operation Center (EOC)/Direction and Control;
- Human Resources;
- Hazard Mitigation;
- HAZMAT/ Hazardous Material/Waste Spill Response;
- Rescue;
- Transportation;
- Training; and
- Legal Services.

Attachment I, "Emergency Shutdown Procedures" of Appendix B, provides emergency shutdown information for the plume-front treatment system.

2.4.7 Spill Containment

Attachment N of Appendix B provides documentation for spill containment and contingency. Procedures for larger releases are outlined in the "HAZMAT/Hazardous Materials/Waste Spill Response" section of the EPP provided in Appendix F. Additionally, Building 650 has a 9,000 gallon containment system for spills that may occur within the building. The extraction pipeline is constructed of dual-wall HDPE pipe to prevent releases of contaminated groundwater in the event of a pipeline line.

2.5 Design of Extraction/Injection Wells and Groundwater Monitoring System

2.5.1 Groundwater Contaminants of Concern

The health-risk assessment to evaluate the list of groundwater COCs at the plume-front is provided in Appendix G. Plume-front treatment evaluations were originally based on the horizontal and vertical distribution of six COCs identified from a baseline health-risk assessment (Volume Six of the RCRA Facility Investigation (RFI; NASA, 1996a)). The original COCs list was comprised of the carcinogens NDMA, TCE, and PCE, and non-carcinogens trichlorofluoromethane (Freon 11), dichlorofluoromethane (Freon 21), and 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113).

A total of 18 contaminants are currently under consideration as part of an updated health risk assessment. The 12 additional COCs are the carcinogens n-nitrodimethylamine (DMN), tetrahydrofuran, chloroform, acrylonitrile, arsenic, and lead, and the non-carcinogens 1,2-dichloro-1,1,2-trifluoroethane (Freon 123A), nickel, cadmium, chromium, nitrate/nitrite, and bromacil. Appendix G provides a detailed discussion of the process utilized to identify the 18 COCs.

2.5.2 Groundwater Contaminant Plume and Groundwater Distribution Maps

Nine groundwater plume maps and two contaminant distribution maps were completed for the COCs (see Appendix H). No distribution map was provided for arsenic, cadmium, lead, nickel, nitrate-nitrite nitrogen, acrylonitrile, and chloroform due to the infrequency of sampling or the absence of results above the detection limit. Plume isoconcentration maps were manually plotted using the maximum concentrations observed from the period July 1, 2002 through August 1, 2003. If results were not available for a specific well during this time period, the most recent result was used. These exceptions are noted on the plume maps with the sample year listed in parentheses next to the analytical result. For multi-port wells, the maximum contaminant concentration was used regardless of depth. The depth (in feet) of the sampling port with the highest concentration was listed in parentheses next to the well and analytical result.

Consideration was taken into account for analytical values with data qualifier flags. All results with data qualifiers were reviewed with historical groundwater analytical data. Results with data qualifiers are included on the maps if the result was determined to be consistent with historical groundwater analytical results. For NDMA and DMN plume maps, analytical results were corrected for analytical extraction efficiency. All results for NDMA, DMN, and bromacil were analyzed using EPA Method 607. EPA Methods 8260 and 8021 were used for TCE, PCE, Freon 11, Freon 113, Freon 21, and Freon 123A. For the tetrahydrofuran and chromium distribution maps, EPA Methods 8260 and 6010 were used, respectively. Lead was analyzed using EPA Methods 7421 and 239.2.

The casing within monitoring well BLM-23-431 leaks, and the last analytical samples for this well were collected in January 1999. This value was used as a guideline for contouring plume isoconcentration lines for the maps. For monitoring wells WW-4 (for DMN) and BLM-37 (for NDMA), the maximum analytical results were inconsistent with historical sampling results and are considered to be outliers at this time. These wells were resampled, and all other results (prior to and after) were all not detected (ND), supporting the use of ND for the isoconcentration maps. A very low detection for NDMA was obtained at WB-5; this result is attributed to sample interference and historical results for the well are ND.

For the Freon 113 isoconcentration map, low Freon 113 detections were obtained for monitoring wells 700-F-455 and ST-5. These results were determined to be unusable due to approximately the same detection level obtained for the field blank and the equipment blank, respectively.

Due to the less frequent historical sampling schedule for bromacil, the plume isoconcentration map was completed using the maximum analytical result for each well from the period January 1, 2001 to August 1, 2003. There were numerous data qualifiers for bromacil analytical data. These analytical data were compared with historical values and the specific data qualifier was reviewed to determine the usability of the result. Results that were not used for the plume isoconcentration map were usually the result of analytical carryover from a sample analyzed in the same batch with a concentration 50 to 2,000 times greater than the reporting limit. These unused sample detections were not consistent with historical groundwater analytical results for each well.

Two additional distribution maps are also provided: chromium and tetrahydrofuran. These two constituents are part of the COC list because of their toxicity and frequency of detection; however, they are not groundwater plume contaminants at WSTF caused by historical testing/waste management activities. These two constituents are believed to be a result of degradation of well casings. A statistical analysis performed in 1997 comparing chromium concentration with the well casing type (stainless steel verses PVC) is provided with the plume maps in Appendix H. The report concluded that a statistically significant difference in chromium levels exists between the two casing types, with the higher chromium levels associated with the stainless steel well casing. There is a strong correlation between PVC well casing and tetrahydrofuran detections.

Several results for tetrahydrofuran were not utilized for the distribution map. The results were considered inaccurate as the detections within the method blanks exceeded the levels detected in the samples. The one exception was for monitoring well ST-6, where tetrahydrofuran was detected in the equipment blank at the same level that was detected within the sample. In all cases, the sample detections were not consistent with historical groundwater analytical results for each well.

Acrylonitrile, chloroform, nitrate-nitrite nitrogen, arsenic, cadmium, lead, and nickel were also determined to be COCs during the health-risk screening process; however, plume maps were not completed for these constituents. Acrylonitrile and chloroform maps were not prepared due to the absence or small number of analytical results above the detection limit for the past year. There were no acrylonitrile results above the detection limit of 1.79 to 3.3 ppb, and there were only three results just above the 0.5 ppb detection limit in the past year for chloroform (at monitoring wells ST-1-486, ST-3-541, and ST-3-630). Acrylonitrile is not believed to be associated with historical WSTF testing/waste management activities, but it is believed to be a result of well casing degradation. Arsenic, cadmium, lead, nickel, and nitrate-nitrite nitrogen plume maps were not prepared due to the infrequency of sampling for these constituents at WSTF based on a NMED-approved sampling plan. In addition, elevated soil and groundwater concentrations of metals are naturally occurring in the WSTF vicinity and the regional Jornada del Muerto Basin (JDMB) aquifer (as described in the WSTF RFI).

2.5.3 Treatment System Well Placement

The PFSWP submitted in 1999 described several groundwater modeling scenarios used to evaluate treatment system well placement. The revised PFSWP submitted in 2002 presented the final modeling scenario utilized for optimum plume-front capture design. This scenario was used to locate plume-front extraction and injection wells in the field. A summary of the justification for treatment system well placement using COC particle tracking analysis is presented in Section 3.1.1.

2.5.4 Treatment System Well Design

The plume-front treatment system utilizes six extraction wells and four injection wells; these wells are shown on the plume and contaminant distribution maps in Appendix H. Five of the extraction wells (PFE-1, PFE-2, PFE-3, PFE-4A, and PFE-5) are located within an area of the plume-front where the vertical extent of the alluvial aquifer is confined by bedrock. Extraction well PFE-7 is located further to the west and does not intersect bedrock. The treatment system well placement relative to the local hydrogeology and contaminant plume distribution is presented in greater detail in Section 3.1.1.

All treatment system well information is provided in Appendix H. This information includes extraction and injection well lithologic logs, completion diagrams, core descriptions for selected intervals at well PFE-3 (formerly the NASA PT well), preliminary analytical data, well design data, and well performance data. Aquifer tests for the plume-front area were performed at well PFE-3 (NASA PT well) and WSTF water supply Well J. Details of these aquifer tests are also provided in Appendix H.

The majority of the preliminary groundwater analytical data for the treatment system wells were collected during development of the plume-front treatment system wells. Groundwater samples collected for the preliminary extraction and injection well analyses were collected at irregular depths within the extensive screened zones and do not represent discrete sampling zones. A regular sampling schedule for the treatment system wells following plume-front system startup is provided in Attachment K, of Appendix B.

2.5.5 Groundwater Monitoring System

Groundwater monitoring wells will be utilized for monitoring the effectiveness of the plume-front treatment system. A list of these wells and their sampling schedule is provided in Attachment K of Appendix B. Monitoring well details are provided in Appendix H. These details include well lithologic logs, completion diagrams, available core descriptions, recent static water levels and equivalent piezometric depths (for multi-port Westbay® wells), and flowrates for all monitoring wells where aquifer testing was performed on site.

3.0 System Evaluation

3.1 System Performance

3.1.1 Evaluation of Contaminant Plume Capture and Aquifer Response

3.1.1.1 Plume-Front Treatment and Stabilization

The plume-front treatment system utilizes six extraction wells located within the vicinity of the WBFZ and four injection wells located further to the southeast within the alluvial aquifer of the JDMB (Figure 1 in Appendix H). Four extraction wells (PFE-1, PFE-2, PFE-3, and PFE-4A) are located within the WBFZ, where the vertical extent of the alluvial aquifer is confined by bedrock, and the plume can be contained without relocating in the deep alluvium of the JDMB. Extraction well PFE-7 is located just to the west of the WBFZ, within an area where the vertical distribution of contaminants is relatively well defined. The five extraction wells PFE-1, PFE-2, PFE-3, PFE-4A, and PFE-7 specifically address containment of the TCE plume and prevent westward migration. Extraction well PFE-5 is located east of the WBFZ within a mixed bedrock/alluvial aquifer and supports effective NDMA/DMN plume containment. Well PFE-5 helps to minimize NDMA/DMN plume-migration toward the outer tier of extraction wells. The total estimated extraction flow rate for the system is 1,076 gpm.

The injection of remediated groundwater through four injection wells (PFI-1 through PFI-4) occurs to the west and south of the plume-front within the JDMB. The injection well locations are designed to assist with containment of the southern edge of the plume by creating a localized groundwater mound. This mound is designed to offset future JDMB drawdown effects and locally reverse groundwater flow directions. The total injection volume for the PFI wells is assumed to be equal to the total extraction flow rate for the PFE wells at 1,076 gpm.

3.1.1.2 Definition of Capture Zone

The three-dimensional target capture zone for the COCs that drive the plume-front health-risk assessment is primarily defined by the location of the TCE plume, which is the most extensive plume-front contaminant. The target capture zone utilized for the development of the plume-front treatment system is defined by the five ppb TCE isoconcentration line. This line represents the TCE drinking water standard for the New Mexico Administrative Code (NMAC, 1998), and was utilized for plume-front capture in the PFSWP (NASA, 1999) and in the revised PFSWP (NASA, 2002). The target capture zone was modified slightly between the two plans temporal TCE migration. This resulted in a modified extraction well configuration for the revised PFSWP. Particle tracking results for TCE and NDMA were performed using the PATH3D program to optimize the placement of additional extraction wells PFE-4A and PFE-7.

The revised PFSWP, modeled capture at the plume-front utilized the May 2001 five ppb TCE isoconcentration line. Extraction well pumping took place from model layers nine to 12 (approximately 330 to 800 feet below ground surface (bgs)). Particles were tracked within model layers nine through 14 (330 to 1,200 feet bgs). TCE and NDMA plume capture was achieved using the proposed treatment system well configuration at the prescribed flow rates provided in the revised PFSWP (Figure 2 in Appendix H).

The plume-front capture zone represents the three-dimensional zone for which all groundwater flow paths converge to the plume-front extraction points. For conservative purposes, the actual modeled capture zone was based on the one ppb TCE isoconcentration line from the May 2001 TCE map. Particle tracking simulations were used to evaluated the one ppb TCE line to supplement the five ppb TCE simulation within the PFSWP (NASA, 2002). The one ppb isoconcentration line also indicated capture by the plume-front extraction well system.

3.1.1.3 Current Status of Plume-Front Capture

A comparison of the May 2001 TCE plume utilized for the design of the plume-front treatment system (NASA, 2002) and the current August 2003 TCE plume indicates that TCE groundwater concentrations have increased in the majority of plume-front

wells, as the plume has continued to move slowly to the west. The most significant plume movement has occurred in the vicinity of well PL-4-464 on the west side of the plume-front and well BLM-6-488 on the south side of the plume-front. Current horizontal plume capture can be verified by comparing the conservative one ppb TCE isoconcentration line from the May 2001 TCE map to the five ppb isoconcentration line from the August 2003 TCE map. The May 2001 one ppb TCE isoconcentration line is either coincident with or located beyond the August 2003 five ppb TCE isoconcentration line.

For the revised PFSWP, plume capture was obtained releasing particles and pumping from model layers nine-12 (approximately 330 feet to 800 feet bgs). No plume-front monitoring well currently exceeds the five ppb TCE treatment standard below 800 feet. In multiport monitoring well PL-5, TCE is present within all sampling zones (595, 715, 795, 895 and 985 feet); however, the TCE within the lowermost two ports at 895 feet and 985 feet are currently less than five ppb.

3.1.1.4 Plume Capture Evaluation Methodologies

NASA will apply three methods to evaluate and verify the hydraulic capture of the WSTF groundwater plume. If any of these methods indicate potential problems associated with plume-front capture, NASA will evaluate potential solutions and corrective actions. The appropriate NMED Bureau(s) will be notified if a modification requires regulatory concurrence or approval.

A. Potentiometric Surface Maps

Potentiometric water level data will be collected from the plume-front treatment system extraction and injection wells on a daily basis. Potentiometric data from plume-front monitoring wells listed in Attachment K of Appendix B will be collected on a quarterly basis.

Potentiometric data will be interpreted and utilized to develop a potentiometric surface map and flow lines. Water level elevation data from treatment system wells will be compared to historical values and simulated response to evaluate potential well productivity, drawdown, and mounding based on groundwater modeling.

The treatment system well elevation data will be treated separately from the monitoring well piezometric data, which are more representative of static aquifer conditions. Monitoring well data will be used for a potentiometric representation of the entire plume-front area to evaluate the effect of regional pumpage within the JDMB on the boundary conditions of the WSTF groundwater model.

B. Time - Concentration Plots

Analytical results from groundwater sampling will be used to prepare time-concentration (T-C) plots for all treatment system wells and monitoring wells presented in Attachment K of Appendix B. Currently, 24 conventional and 14 multiport monitoring wells are included in the plume-front monitoring network. These wells are located within and surrounding the outer boundary of the groundwater plume (Figure 1 of Appendix H). T-C plots for individual wells will be constructed within 30 days following the receipt of analytical results based on the sampling event schedule outlined in Attachment K of Appendix B. The piezometric level collected on the date of the sampling event will be used for the T-C plot evaluation. T-C plots will include all historical data and clearly identify plume-front treatment system startup.

T-C plots for wells within the plume will provide concentration trends for the suite of COCs at each location. Concentrations will be generated on a quarterly basis and used to support evaluations of plume migration. T-C plots for monitoring wells located outside the current limits of the groundwater plume will be used to evaluate plume stabilization. Detections of contamination within these wells will activate resampling and an evaluation of the performance and effectiveness of the plume-front extraction wells.

NASA will immediately evaluate any monitoring wells that develop unforeseen operational problems that inhibit the ability to collect representative groundwater samples. These wells may be rehabilitated, removed and/or replaced as necessary.

Monitoring wells will be added or removed from the list in Attachment L of Appendix B only following the approval of the appropriate NMED Bureaus.

C. Particle Tracking Using Groundwater Modeling Simulations

Stabilization of the groundwater plume will be evaluated on a quarterly basis through WSTF groundwater model TCE particle tracking simulations utilizing PATH3D or equivalent software. Because TCE represents the most extensively distributed plume-front COC, particle tracking simulations will primarily focus on the latest position of the TCE isoconcentration lines. Additional particle tracking simulations will be performed for the NDMA, DMN, PCE, and Freon 113 plumes, which will also be simulated within the groundwater model. Particle tracking evaluations for the remaining plume-front COCs will be performed annually or more frequently as necessary.

Groundwater modeling simulations will also be used to support the evaluation of anticipated trends of the water table as a result of extraction well drawdown and injection well mounding. Modeled water elevations will be compared to the automated treatment system well levels collected through the treatment system. The treatment system water depths will be used to support calibration of the modeled depths as necessary.

3.1.1.5 Plume Capture Evaluation

Following activation of the treatment system, plume capture will be evaluated using the wells defined in Attachment K of Appendix B. These evaluations will utilize all available hydrogeologic and analytical data from 24 conventional monitor wells and 14 multiport monitoring wells, the treatment system wells, and groundwater modeling particle tracking simulations. Analytes and collection methods to be utilized are also defined in Attachment K of Appendix B. A summary of the individual data collection schedules for plume-front capture verification is summarized in Section 3.4 of this Plan.

3.1.1.6 Potential Plume-Front Capture Modifications

Corrective actions may have to be applied to the treatment system to optimize plume-front containment. These actions may include the rehabilitation or replacement of treatment equipment, extraction and/or injection rate adjustments, or potential modifications to the treatment system operating parameters or hardware. NASA will maintain records of all corrective actions and the appropriate NMED Bureau(s) will be notified if a modification requires regulatory concurrence or approval.

3.1.2 Treatment Process Monitoring

NASA has established a sampling schedule for both the influent and effluent of the treatment system to ensure that the applicable discharge standards are achieved. This schedule is located in Attachment K of Appendix B and in Discharge Plan DP-1255 (shown in Appendix A). All analytical results will be evaluated to ensure compliance with the discharge plan. All exceedances will be reported to NMED in writing within 24 hours of receiving the analytical data. Mitigative measures such as performing a mass balance on the influent and effluent analytical data, inspection of the treatment system to ensure system integrity, and/or resampling shall be performed as outlined in the Discharge Plan. Each exceedance will be individually evaluated to determine what mitigative measures shall be implemented to ensure compliance with the Discharge Plan. These measures include, but are not limited to, resampling the treatment system components off-line, scale cleaning of the air strippers, or increasing the number of UV lamps utilized in the UV reactor.

Design to actual parameters for the treatment system will be compared on a regular basis. Details of what shall be analyzed and at what frequency can be found in Section 9 and 10 of Attachment G of Appendix B in the following three sections: 1) Performance Monitoring; 2) Monthly Treatment Facility Performance Review; and 3) Quarterly Treatment Facility Performance Review. The initial design parameters for the plume-front treatment system can be found in Section 2.1 of this document.

3.1.3 Groundwater Monitoring

Throughout the implementation of this interim measure, groundwater monitoring activities will be directed by the WSTF Groundwater Sampling and Analysis Plan (SAP) and the treatment system-specific procedures provided in Attachment K of Appendix B. The WSTF SAP (the facility-wide procedural document included in Appendix I) is a valuable resource for personnel involved in groundwater monitoring activities associated with the plume-front treatment system. The facility-wide SAP:

- identifies all WSTF groundwater monitoring wells;
- discusses the installation of new monitoring wells;
- identifies pre-sampling activities for groundwater monitoring wells;
- identifies the field measurements required as part of groundwater monitoring;
- identifies the required equipment and related supplies for groundwater sample collection activities;
- identifies sampling procedures; and
- establishes the minimum groundwater monitoring requirements and sample collection frequencies at existing WSTF monitoring wells.

This section of the Plan discusses project-specific groundwater monitoring requirements that are beyond the scope of the facility-wide SAP. This section of the Plan will be utilized in conjunction with the facility-wide SAP to direct groundwater monitoring activities specific or unique to the plume-front treatment effort. This document will be used with the facility-wide SAP and the site-specific procedural documentation related to groundwater monitoring.

3.1.3.1 Contaminants of Concern

Utilizing the guidance established in the EPA Risk Assessment Guidance for Superfund (RAGS), NASA performed an evaluation of plume-front analytical data to determine the COCs at the plume-front. The evaluation is provided in Appendix G and the COCs are provided in Table 6.

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Table 6 WSTF COCs (Extracted from Plume-Front Project Plan Health Risk Assessment)

CAS Number	COC
62-75-9	n-Nitrosodimethylamine (NDMA)
4164-28-7	n-Nitrodimethylamine (DMN)
79-01-6	Trichloroethene (TCE)
127-18-4	Tetrachloroethene (PCE)
67-66-3	Trichloromethane (Chloroform)
75-69-4	Trichlorofluoromethane (Freon 11)
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
354-23-4	1,2-Dichloro-1,1,2-trifluoroethane (Freon 123A)
75-43-4	Dichlorofluoromethane (Freon 21)
314-40-9	Bromacil

Table 6 WSTF COCs (Extracted from Plume-Front Project Plan Health Risk Assessment)

CAS Number	COC
107-13-1	Acrylonitrile
109-99-9	Tetrahydrofuran (THF)
7440-38-2	Arsenic
7440-43-9	Cadmium
7440-47-3	Chromium
7440-02-0	Nickel
NA	Nitrate/Nitrite as Nitrogen
7439-92-1	Lead

3.1.3.2 Plume-Front Treatment Groundwater Monitoring Wells

Attachment K of Appendix B identifies the currently installed and operational WSTF groundwater monitoring wells and their respective sampling schedule.

3.1.3.3 Analytical Methods

Groundwater samples collected in association with the plume-front treatment activities will be analyzed by the analytical methods specified in Attachment K of Appendix B.

3.1.3.4 Groundwater Monitoring Well Summary

The construction and installation details of each groundwater monitoring well utilized for assessment at the plume-front are provided in Section 2.5 of this document.

3.1.3.5 Evaluation of Analytical Data

Analytical data will be evaluated in accordance with the WSTF SAP and Quality Assurance Project Plan (QAPP), provided in Appendix I, and the project-specific requirements provided in later sections of this document. Section 3.3 provides information related to the analytical procedures to be utilized for plume-front groundwater monitoring well and treatment system influent/effluent samples. Additionally, Section 3.3 provides specific information related to the collection and evaluation of quality control samples and the performance of quality assurance activities. Finally, Section 3.4 provides a comprehensive description of the evaluation procedures used to determine the efficiency and overall effectiveness of the plume-front treatment effort.

3.1.4 Treatment System Well Performance

Attachments L and G of Appendix B address extraction and injection well maintenance activities, including methodology for determining parameter baselines, maintenance schedules, and mitigation triggers and actions. As described in Section 2.1.3 of this Plan, the I&C system for the plume-front treatment system will continually monitor and intermittently log pertinent operational parameters related to the performance of the extraction and injection wells. These parameters include extraction and injection volumetric flow rates, extraction pump power-related parameters (including current and voltage), extraction well drawdown, and groundwater mounding in each injection well. In addition, periodic sampling and analysis of inorganic water chemistry, biological activity, and visual observation (via downhole video logging) will be performed.

3.1.4.1 Volumetric Flow Rates, Groundwater Elevation, and Specific Capacity

Water elevations and volumetric flow rates will be logged by the I&C system. Water elevations and flow rates will be logged at least every 24 hours for each extraction and injection well. Based on these measures, the I&C system will calculate and plot the specific capacity for each extraction and injection well. At least once per month, the long-range trending of the specific capacity will be evaluated.

3.1.4.2 Well Monitoring, Maintenance, and Rehabilitation

As described in Attachments L and G of Appendix B, extraction and injection well performance and condition will be monitored by five primary methods:

- Flow rate versus drawdown measurements;
- High resolution downhole video logging;
- The collection of physicochemical parameters identified in the O&M WJI to predict scaling and corrosive conditions, and plot environmental change;
- Power parameters related to the operation of pumps (current, voltage); and
- Biological Activity Reaction Test (BART) and other biological testing used to determine the agressivity and composition of microorganisms associated with biofouling. Biological testing is used to provide an early warning method of predicting the biological effects and a means of monitoring biological activity over time.

The frequency (e.g., at start-up and quarterly) for performing monitoring is outlined in Attachment K of Appendix B.

3.1.4.3 Monitoring Contaminants of Concern

The frequency of monitoring COC trends in extraction wells is presented in Section 3.1.3.

3.2 Sampling Procedures

3.2.1 Sample Type, Location and Frequency

Attachment K of Appendix B provides the specific sample types, analytical methods, sample collection locations, and sampling frequencies for plume-front monitoring activities.

3.2.2 Sampling Activities

The WSTF SAP in Appendix I, in conjunction with referenced site-specific procedural documentation, provides instructions related to the sampling activities to be performed at plume-front monitoring wells. In addition to procedural guidance, the SAP identifies the equipment required for groundwater monitoring, water level determinations, sample handling and custody, determination of well integrity, monitoring well security, and numerous other sampling-related activities.

Appendix B provides specific groundwater monitoring procedures and related activities associated with sampling at the plume-front treatment system. Included in Appendix B are detailed instructions for sampling treatment system influent and effluent, as well as other project-specific sampling.

The WSTF SAP and Appendix B provide site-specific procedural documentation for all activities related to plume-front treatment system groundwater monitoring. The procedures presented include: groundwater sample collection; influent/effluent sample collection; decontamination of sampling-related equipment; required sampling equipment and supplies; groundwater depth determinations; pre-sampling activities; in-situ and field measurements; sample handling; custody requirements; and monitoring well integrity and security issues.

3.2.3 Corrective Actions

Sampling operations can and do require corrective actions to resolve problems associated with equipment failure and/or inability to properly function. The WSTF SAP, provided in Appendix I, explains the corrective actions that may be initiated in the event of equipment and sampling problems.

3.3 Analytical Procedures

This section provides information related to the analytical procedures, laboratories, test methods, QA/QC activities, reporting requirements, and data validation. Specific details related to most of these activities are provided in the WSTF SAP and the WSTF QAPP, provided in Appendix I.

3.3.1 Contaminants of Concern

Utilizing the guidance established in the EPA Risk Assessment Guidance for Superfund (RAGS), NASA performed an evaluation of plume-front analytical data to determine the COCs at the plume-front. The evaluation is provided in Appendix G and the COCs are provided in Table 6.

3.3.2 Analytical Equipment and Procedures

Plume-front treatment system groundwater samples will be analyzed by off-site analytical laboratories. Specific sample types, analytical methods, sample collection locations, and sampling frequencies for plume-front monitoring activities are provided in Attachment K of Appendix B. In addition, the Standard Operation Procedures (SOPs) and Quality Plans for each analytical laboratory currently utilized by WSTF are provided in Appendix I. In accordance with Federal Acquisition Regulations (FAR), NASA must periodically solicit competitive bids for analytical services. If NASA selects a new laboratory as the result of a procurement action, NASA will provide the laboratory SOPs and quality documentation for each laboratory selected using the competitive selection process. Analysis of hydrazines will be conducted by the WSTF Laboratory.

3.3.3 Laboratory Operations

This section describes the laboratory operations and QA/QC procedures to be utilized for groundwater monitoring and treatment system sampling activities specified by this Plan.

3.3.3.1 Sample Management

Groundwater and treatment system samples collected under the auspices of this document are managed in accordance with the guidelines established in the WSTF SAP (included in Appendix I) and Attachment K of Appendix B. Chain of custody requirements are provided in the WSTF SAP. Specific sample handling requirements, such as holding times, sample preservation, and sample storage, are provided in Attachment K of Appendix B.

3.3.3.2 Laboratory Manual

As indicated in Section 3.3.2, the specific laboratory manuals for each off-site analytical laboratory employed by WSTF are provided in Appendix I.

3.3.3.3 Analytical Methods

Table 7 through Table 14 provides the current list of chemical constituents analyzed for as part of the plume-front treatment system. These tables include the analytical methods currently utilized by WSTF. Table 7 through Table 14 also included the estimated detection limits and NASA's required quantitation limits for each constituent. The estimated detection limits are provided in each EPA-recommended analytical method. The required quantitation limits are established by NASA to minimize the potential impact of the variability between available analytical laboratories. Because NASA's analytical

contracts are subject to periodic re-competition, minimum required quantitation limits have been established to ensure the continuity of NASA's analytical data.

Table 7 WSTF EPA Method 8260B Analyte List

Chemical Abstract Service (CAS) Number	Analyte	Level of Concern (µg/L)	Source	Estimated Detection Limit (µg/L)	Required Quantitation Limit (µg/L)
100-41-4	Ethylbenzene	700	EPA-1	0.3	1
100-42-5	Styrene	100	EPA-1	0.3	1
10061-01-5	cis-1,3-Dichloropropene	10	HA	0.3	1
10061-02-6	trans-1,3-Dichloropropene	10	HA	0.3	1
106-93-4	1,2-Dibromoethane (EDB)	0.05	EPA-1	0.3	1
107-02-8	Acrolein	0.042	HHMSSL	3	10
107-05-1	Allyl chloride	1800	HHMSSL	0.6	2
107-06-2	1,2-Dichloroethane	5	EPA-1	0.3	1
107-12-0	Propionitrile	NONE	NONE	1.5	5
107-13-1	Acrylonitrile	6	HA	1.2	4
108-05-4	Vinyl acetate	410	HHMSSL	1.5	5
108-10-1	4-Methyl-2-pentanone (MIBK)	1600	PRG	1.5	5
108-87-2	Methylcyclohexane	5200	HHMSSL	3	10
108-88-3	Toluene	750	NMED	0.3	1
108-90-7	Chlorobenzene	100	EPA-1	0.3	1
109-99-9	Tetrahydrofuran	1.6	PRG	0.6	2
110-57-6	trans-1,4-Dichloro-2-butene	0.0012	HHMSSL	0.3	1
110-82-7	Cyclohexane	35000	PRG	3	10
123-91-1	1,4-Dioxane	300	HA	3	100
124-48-1	Dibromochloromethane	80	HA	0.3	1
126-98-7	Methacrylonitrile	1.0	HHMSSL	1.5	5
126-99-8	2-Chloro-1,3-butadiene (chloroprene)	14	HHMSSL	0.3	1
127-18-4	Tetrachloroethene	5	EPA-1	0.3	1
1330-20-7	m+p-Xylene	620[1]	NMED	0.3	1
156-59-2	cis-1,2-Dichloroethene	70	EPA-1	0.3	1
156-60-5	trans-1,2-Dichloroethene	100	EPA-1	0.3	1
1634-04-4	Methyl tert-butyl ether (MTBE)	100	NMED	3	10

Table 7 WSTF EPA Method 8260B Analyte List

Chemical Abstract Service (CAS) Number	Analyte	Level of Concern (µg/L)	Source	Estimated Detection Limit (µg/L)	Required Quantitation Limit (µg/L)
306-83-2	2,2-Dichloro-1,1,1-trifluoroethane	NONE	NONE	0.3	1
354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	NONE	NONE	0.3	1
56-23-5	Tetrachloromethane (carbon tetrachloride)	5	EPA-1	0.3	1
591-78-6	2-Hexanone	NONE	NONE	1.5	5
630-20-6	1,1,1,2-Tetrachloroethane	70	HA	0.3	1
67-63-0	2-Propanol	NONE	NONE	6	50
67-64-1	Acetone	610	PRG	3	10
67-66-3	Chloroform	80	EPA-3	0.3	1
71-43-2	Benzene	5	EPA-1	0.3	1
71-55-6	1,1,1-Trichloroethane	60	NMED	0.3	1
74-83-9	Bromomethane	10	HA	0.6	2
74-87-3	Chloromethane	3	HA	0.6	2
74-88-4	Iodomethane	NONE	NONE		5
74-95-3	Dibromomethane	61	HHMSSL	0.3	1
75-00-3	Chloroethane	3.9	HHMSSL	0.6	2
75-01-4	Vinyl chloride	1	NMED	0.3	1
75-05-8	Acetonitrile	NONE	NONE	6	20
75-09-2	Dichloromethane (methylene chloride)	5	EPA-1	0.3	1
75-15-0	Carbon disulfide	1000	HHMSSL	0.3	1
75-25-2	Bromoform	80	EPA-3	0.3	1
75-27-4	Bromodichloromethane	80	EPA-3	0.3	1
75-34-3	1,1-Dichloroethane	25	NMED	0.3	1
75-35-4	1,1-Dichloroethene	5	NMED	0.3	1
75-43-4	Dichlorofluoromethane	20	DP-1255	0.3	1
75-69-4	Trichlorofluoromethane	2000	HA	0.3	1
75-71-8	Dichlorodifluoromethane	1000	HA	0.3	1
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	59000	HHMSSL	0.3	1
78-83-1	Isobutyl alcohol	1800	HHMSSL	15	50
78-87-5	1,2-Dichloropropane	5	EPA-1	0.3	1
78-93-3	2-Butanone (MEK)	100	HA	1.5	5

Table 7 WSTF EPA Method 8260B Analyte List

Chemical Abstract Service (CAS) Number	Analyte	Level of Concern (µg/L)	Source	Estimated Detection Limit (µg/L)	Required Quantitation Limit (µg/L)
79-00-5	1,1,2-Trichloroethane	5	EPA-1	0.3	1
79-01-6	Trichloroethene	5	EPA-1	0.3	1
79-34-5	1,1,2,2-Tetrachloroethane	10	NMED	0.3	1
80-62-6	Methyl methacrylate	1400	HHMSSL	0.3	1
95-47-6	o-Xylene	620[1]	NMED	0.3	1
96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0.2	EPA-1	0.6	2
96-18-4	1,2,3-Trichloropropane	40	HA	0.3	1
97-63-2	Ethyl methacrylate	550	HHMSSL	0.3	1

[1] Xylene standard is 620 ug/L for m-xylene, p-xylene, and o-xylene combined.

NMED – Table of New Mexico and the U.S. EPA's Groundwater Standards (20.6.2 NMAC) at www.nmenv.state.nm.us/gwb/gwstds.html.

HA – 2002 Edition of the Drinking Water Standards and Health Advisories, EPA 822-R-02-038, (Summer 2002).

EPA-1 – National Primary Drinking Water Regulations Maximum Contaminant Levels, 40 CFR §§141.61 and 141.62.

EPA-3 – National Primary Drinking Water Regulations Maximum Contaminant Levels for Disinfection By-Products, 40 CFR §141.64. The trihalomethane (THMs) standard applies to the sum of chloroform, dichlorobromomethane, dibromochloromethane, and bromoform

HHMSSL - EPA Region 6 Human Health Medium-Specific Screening Levels, 1/13/2004.

PRG - EPA Region 9 Preliminary Remediation Goals, 10/01/02.

RBC - EPA Region 3 Risk Based Concentrations, 4/14/2004.

DP-1255 - Discharge Plan DP-1255 treatment standard.

Table 8 WSTF EPA Method 524.2 Analyte List

CAS Number	Analyte	Level of Concern (µg/L)	Source	Estimated Detection Limit (µg/L)	Required Quantitation Limit (µg/L)
100-41-4	Ethylbenzene	700	EPA-1	0.06	0.5
100-42-5S	Styrene	100	EPA-1	0.04	0.5
10061-01-5	cis-1,3-Dichloropropene	10	HA	0.05	0.5
10061-02-6	trans-1,3-Dichloropropene	10	HA	0.07	0.5
106-93-4	1,2-Dibromoethane (EDB)	0.05	EPA-1	0.05	0.5
107-05-1	Allyl chloride	1800	HHMSSL	0.2	0.5
107-06-2	1,2-Dichloroethane	5	EPA-1	0.03	0.5

Table 8 WSTF EPA Method 524.2 Analyte List

CAS Number	Analyte	Level of Concern (µg/L)	Source	Estimated Detection Limit (µg/L)	Required Quantitation Limit (µg/L)
107-12-0	Propionitrile	NONE	NONE	2	5
107-13-1	Acrylonitrile	6	HA	0.5	1
108-10-1	4-Methyl-2-pentanone (MIBK)	1600	PRG	2	5
108-88-3	Toluene	750	NMED	0.06	0.5
108-90-7	Chlorobenzene	100	EPA-1	0.05	0.5
109-99-9	Tetrahydrofuran	1.6	PRG	0.5	2
110-57-6	trans-1,4-Dichloro-2-butene	0.0012	HHMSSL	0.5	1
124-48-1	Dibromochloromethane	80	HA	0.08	0.5
126-98-7	Methacrylonitrile	1.0	HHMSSL	0.5	1
127-18-4	Tetrachloroethene	5	EPA-1	0.05	0.5
1330-20-7	m+p-Xylene	620[1]	NMED	0.05	0.5
156-59-2	cis-1,2-Dichloroethene	70	EPA-1	0.01	0.5
156-60-5	trans-1,2-Dichloroethene	100	EPA-1	0.05	0.5
1634-04-4	Methyl tert-butyl ether (MTBE)	100	NMED	2	5
306-83-2	2,2-Dichloro-1,1,1-trifluoroethane	NONE	NONE	NA	1
354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	NONE	NONE	NA	1
56-23-5	Tetrachloromethane (carbon tetrachloride)	5	EPA-1	0.3	0.5
591-78-6	2-Hexanone	NONE	NONE	2	5
630-20-6	1,1,1,2-Tetrachloroethane	70	HA	0.07	0.5
67-64-1	Acetone	610	PRG	1	5
67-66-3	Chloroform	80	EPA-3	0.05	0.5
71-43-2	Benzene	5	EPA-1	0.05	0.5
71-55-6	1,1,1-Trichloroethane	60	NMED	0.05	0.5
74-83-9	Bromomethane	10	HA	0.09	0.5
74-87-3	Chloromethane	3	HA	0.2	0.5
74-95-3	Dibromomethane	61	HHMSSL	0.07	0.5
75-00-3	Chloroethane	3.9	HHMSSL	0.06	0.5
75-01-4	Vinyl chloride	1	NMED	0.09	0.5
75-09-2	Dichloromethane (methylene chloride)	5	EPA-1	0.09	0.5
75-15-0	Carbon disulfide	1000	HHMSSL	0.2	0.5
75-25-2	Bromoform	80	EPA-3	0.1	0.5

Table 8 WSTF EPA Method 524.2 Analyte List

CAS Number	Analyte	Level of Concern (µg/L)	Source	Estimated Detection Limit (µg/L)	Required Quantitation Limit (µg/L)
75-27-4	Bromodichloromethane	80	EPA-3	0.06	0.5
75-34-3	1,1-Dichloroethane	25	NMED	0.05	0.5
75-35-4	1,1-Dichloroethene	5	NMED	0.04	0.5
75-43-4	Dichlorofluoromethane	20	DP-1255	NA	0.5
75-69-4	Trichlorofluoromethane	2000	HA	0.05	0.5
75-71-8	Dichlorodifluoromethane	1000	HA	0.05	0.5
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	59000	HHMSSL	NA	0.5
78-87-5	1,2-Dichloropropane	5	EPA-1	0.06	0.5
78-93-3	2-Butanone (MEK)	100	HA	2	5
79-00-5	1,1,2-Trichloroethane	5	EPA-1	0.12	0.5
79-01-6	Trichloroethene	5	EPA-1	0.05	0.5
79-34-5	1,1,2,2-Tetrachloroethane	10	NMED	0.08	0.5
80-62-6	Methyl methacrylate	1400	HHMSSL	0.5	1
95-47-6	o-Xylene	620[1]	NMED	0.04	0.5
96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0.2	EPA-1	0.31	0.5
96-18-4	1,2,3-Trichloropropane	40	HA	0.09	0.5
97-63-2	Ethyl methacrylate	550	HHMSSL	0.1	0.5

Note: The following compounds are on the WSTF EPA Method 8260B target list but not on the target list for EPA Method 524.2: 2,2-Dichloro-1,1,1-trifluoroethane (Freon 123), 1,2-dichloro-1,1,2-trifluoroethane (Freon 123A), dichlorofluoromethane (Freon 21), 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113), acrolein, vinyl acetate, methylcyclohexane, cyclohexane, 1,4-dioxane, 2-chloro-1,3-butadiene (chloroprene), 2-propanol, iodomethane, acetonitrile, and isobutyl alcohol.

Table 9 WSTF Modified EPA Method 607 Analyte List

CAS Number	Analyte	Level of Concern (µg/L)	Source	Estimated Detection Limit (µg/L)	Required Quantitation Limit (µg/L)
62-75-9	n-Nitrosodimethylamine (NDMA)	0.01	DP-1255	0.005	0.01
4164-28-7	n-Nitrodimethylamine (DMN)	0.01	DP-1255	0.005	0.01
314-40-9	Bromacil	90	HA	0.03	0.1

Table 10 WSTF EPA Method 8270C Analyte List

CAS Number	Analyte	Level of Concern (µg/L)	Source	Estimated Detection Limit (µg/L)	Required Quantitation Limit (µg/L)
100-01-6	4-Nitroaniline	NONE	NONE	10	50
100-02-7	Nitrophenol	290	HHMSSL	10	50
100-51-6	Benzyl alcohol	11000	HHMSSL	2	10
100-75-4	n-Nitrosopiperidine	NONE	NONE	2	10
101-55-3	4-Bromophenyl phenyl ether	NONE	NONE	2	10
105-67-9	2,4-Dimethylphenol	730	HHMSSL	2	10
10595-95-6	n-Nitrosomethylethylamine	0.01	DP-1255	2	10
106-46-7	1,4-Dichlorobenzene	75	EPA-1	2	10
106-47-8	p-Chloroaniline	150	HHMSSL	10	50
106-50-3	p-Phenylenediamine	6900	HHMSSL	10	50
108-60-1	2,2'-oxybis(1-Chloropropane)	300	HA	2	10
108-95-2	Phenol	0.004	HA	2	10
109-06-8	2-Picoline	NONE	NONE	2	10
110-86-1	Pyridine	36	PRG	10	50
111-44-4	bis(2-Chloroethyl)ether	0.0096	RBC	2	10
111-91-1	bis(2-Chloroethoxy)methane	NONE	NONE	2	10
117-81-7	bis(2-Ethylhexyl)phthalate	6	EPA-1	2	6 *
117-84-0	Di-n-octyl phthalate	1500	HHMSSL	2	10
118-74-1	Hexachlorobenzene	1	EPA-1	1	1 *
119-93-7	3,3'-Dimethylbenzidine	0.029	HHMSSL	2	10
120-12-7	Anthracene	1800	HHMSSL	2	10
120-58-1	Isosafrole	NONE	NONE	2	10
120-82-1	1,2,4-Trichlorobenzene	70	EPA-1	2	10
120-83-2	2,4-Dichlorophenol	20	HA	2	10
121-14-2	2,4-Dinitrotoluene	73	HHMSSL	2	10
122-09-8	a,a-Dimethylphenethylamine	36	PRG	10	50
122-39-4	Diphenylamine	910	HHMSSL	2	10
122-66-7	1,2-Diphenylhydrazine	0.084	HHMSSL	2	10
126-68-1	o,o,o-Triethyl phosphorothioate	NONE	NONE	2	10
129-00-0	Pyrene	180	HHMSSL	2	10

Table 10 WSTF EPA Method 8270C Analyte List

CAS Number	Analyte	Level of Concern (µg/L)	Source	Estimated Detection Limit (µg/L)	Required Quantitation Limit (µg/L)
130-15-4	1,4-Naphthoquinone	NONE	NONE	10	50
131-11-3	Dimethyl phthalate	360000	PRG	2	10
1319-77-3	3+4-Methylphenol (m+p-Cresol)	180	HHMSSL	2	10
132-64-9	Dibenzofuran	12	HHMSSL	2	10
134-32-7	1-Naphthylamine	NONE	NONE	2	10
140-57-8	Aramite	NONE	NONE	10	50
1888-71-7	Hexachloropropene	NONE	NONE	2	10
191-24-2	Benzo(g,h,i)perylene	NONE	NONE	2	10
193-39-5	Indeno(1,2,3-cd)pyrene	0.4***	NMED	0.05	0.1 SIM
205-99-2	Benzo(b)fluoranthene	0.2***	NMED	0.06	0.1 SIM
206-44-0	Fluoranthene	1500	HHMSSL	2	10
207-08-9	Benzo(k)fluoranthene	0.2***	NMED	0.04	0.1 SIM
208-96-8	Acenaphthylene	NONE	NONE	2	10
218-01-9	Chrysene	0.2***	HHMSSL	0.06	0.1 SIM
2303-16-4	Diallate	1.1	PRG	2	10
23950-58-5	Pronamide	50	HA	2	10
297-97-2	Thionazin	NONE	NONE	2	10
298-00-0	Methyl parathion	2	HA	2	10
298-02-2	Phorate	7.3	PRG	2	10
298-04-4	Disulfoton	0.3	HA	2	10
3689-24-5	Sulfotepp	NONE	NONE	2	10
465-73-6	Isodrin	NONE	NONE	2	10
50-32-8	Benzo(a)pyrene	0.2	EPA-1	0.06	0.1 SIM
510-15-6	Chlorobenzilate	0.25	HHMSSL	2	10
51-28-5	2,4-Dinitrophenol	73	HHMSSL	10	50
534-52-1	4,6-Dinitro-2-Methylphenol	3.7	RBC	10	50
53-70-3	Dibenz(a,h)anthracene	0.3***	NMED	0.03	0.1 SIM
53-96-3	2-Acetylaminofluorene	NONE	NONE	2	10
541-73-1	1,3-Dichlorobenzene	5.5	PRG	2	10
55-18-5	n-Nitrosodiethylamine	0.00045	HHMSSL	2	10
56-38-2	Ethyl parathion	NONE	NONE	2	10

Table 10 WSTF EPA Method 8270C Analyte List

CAS Number	Analyte	Level of Concern (µg/L)	Source	Estimated Detection Limit (µg/L)	Required Quantitation Limit (µg/L)
56-49-5	3-Methylcholanthrene	NONE	NONE	2	10
56-55-3	Benzo(a)anthracene	0.1***	NMED	0.04	0.1 SIM
56-57-5	4-Nitroquinoline-1-oxide	NONE	NONE	10	50
57-97-6	7,12-Dimethylbenz(a)anthracene	NONE	NONE	2	10
58-90-2	2,3,4,6-Tetrachlorophenol	1100	HHMSSL	2	10
59-50-7	4-Chloro-3-methylphenol	NONE	NONE	2	10
59-89-2	n-Nitrosomorpholine	NONE	NONE	2	10
60-11-7	p-(Dimethylamino)azobenzene	NONE	NONE	2	10
60-51-5	Dimethoate	7.3	PRG	10	50
606-20-2	2,6-Dinitrotoluene	36	PRG	2	10
608-93-5	Pentachlorobenzene	29	HHMSSL	2	10
621-64-7	n-Nitroso-n-dipropylamine	0.0096	HHMSSL	2	10
62-44-2	Phenacetin	NONE	NONE	2	10
62-50-0	Ethyl methanesulfonate	NONE	NONE	2	10
62-53-3	Aniline	12	HHMSSL	2	10
62-75-9	n-Nitrosodimethylamine (NDMA)	0.01	DP-1255	2	10
66-27-3	Methyl methanesulfonate	NONE	NONE	2	10
67-72-1	Hexachloroethane	4.8	HHMSSL	2	10
7005-72-3	4-Chlorophenyl phenyl ether	NONE	NONE	2	10
70-30-4	Hexachlorophene	11	HHMSSL	10	50
76-01-7	Pentachloroethane	NONE	NONE	2	10
77-47-4	Hexachlorocyclopentadiene	50	EPA-1	2	10
78-59-1	Isophorone	100	HA	2	10
82-68-8	Pentachloronitrobenzene	0.26	HHMSSL	2	10
83-32-9	Acenaphthene	370	HHMSSL	2	10
84-66-2	Diethyl phthalate	29000	HHMSSL	2	10
84-74-2	Di-n-butyl phthalate	3600	PRG	2	10
85-01-8	Phenanthrene	NONE	NONE	2	10
85-68-7	Butyl benzyl phthalate	7300	HHMSSL	2	10
86-30-6	n-Nitrosodiphenylamine	14	HHMSSL	2	10
86-73-7	Fluorene	240	HHMSSL	2	10

Table 10 WSTF EPA Method 8270C Analyte List

CAS Number	Analyte	Level of Concern (µg/L)	Source	Estimated Detection Limit (µg/L)	Required Quantitation Limit (µg/L)
87-65-0	2,6-Dichlorophenol	NONE	NONE	2	10
87-68-3	Hexachlorobutadiene	1	HA	2	10
88-06-2	2,4,6-Trichlorophenol	3.6	PRG	2	10
88-74-4	2-Nitroaniline	1.0	PRG	10	50
88-75-5	2-Nitrophenol	NONE	NONE	2	10
90-12-0	1-Methylnaphthalene	30**	NMED	2	10
91-20-3	Naphthalene	30**	NMED	2	10
91-57-6	2-Methylnaphthalene	30**	NMED	2	10
91-58-7	2-Chloronaphthalene	490	HHMSSL	2	10
91-59-8	2-Naphthylamine	NONE	NONE	2	10
91-80-5	Methapyrilene	NONE	NONE	10	50
91-94-1	3,3'-Dichlorobenzidine	0.15	HHMSSL	2	10
92-67-1	4-Aminobiphenyl	NONE	NONE	10	50
92-87-5	Benzidine	0.00029	HHMSSL	20	100
930-55-2	n-Nitrosopyrrolidine	0.032	HHMSSL	2	10
94-59-7	Safrole	NONE	NONE	2	10
95-48-7	2-Methylphenol	1800	HHMSSL	2	10
95-50-1	1,2-Dichlorobenzene	600	EPA-1	2	10
95-53-4	o-Toluidine	0.28	HHMSSL	2	10
95-57-8	2-Chlorophenol	40	HA	2	10
95-94-3	1,2,4,5-Tetrachlorobenzene	11	HHMSSL	2	10
95-95-4	2,4,5-Trichlorophenol	3600	PRG	2	10
98-86-2	Acetophenone	610	RBC	2	10
98-95-3	Nitrobenzene	3.4	HHMSSL	2	10
99-09-2	3-Nitroaniline	3.3	RBC	10	50
99-35-4	1,3,5-Trinitrobenzene	1100	HHMSSL	2	10
99-55-8	5-Nitro-o-toluidine	NONE	NONE	2	10
99-65-0	1,3-Dinitrobenzene	3.6	PRG	2	10

* - Selective ion monitoring technique, method modification or alternate method may be required to achieve quantitation limit goals.

** - This standard applies to the sum of napthalene and monomethylnapthalene isomers.

*** - Listed under EPA MCL column in NMED table with (p) designation.

SIM – Selective ion monitoring techniques must be used to achieve quantitation limit goals for the PAHs indicated.

Table 11 WSTF EPA Method 6010B/6020 and 7000 Series Metals List

Method(s)	CAS Number	Analyte	Level of Concern (mg/L)	Source	Estimated Detection Limit (mg/L)	Required Quantitation Limit (mg/L)
6010B/6020	7429-90-5	Aluminum	0.2	EPA-2	0.05	0.1
6010B/6020	7440-36-0	Antimony	0.006	EPA-1	0.003	0.006
6010B/6020/7060A	7440-38-2	Arsenic	0.05	EPA-1	0.002	0.005
6010B/6020	7440-39-3	Barium	1.0	NMED	0.005	0.01
6010B/6020	7440-41-7	Beryllium	0.004	EPA-1	0.001	0.005
6010B	7440-42-8	Boron	0.75	NMED	0.1	0.2
6010B/6020	7440-43-9	Cadmium	0.005	EPA-1	0.001	0.005
6010B	7440-70-2	Calcium	NONE	NONE	0.1	0.5
6010B/6020	7440-47-3	Chromium	0.05	NMED	0.003	0.01
6010B/6020	7440-48-4	Cobalt	0.05	NMED	0.01	0.05
6010B/6020	7440-50-8	Copper	1.3	EPA-4	0.005	0.02
6010B	7439-89-6	Iron	0.3	EPA-2	0.03	0.1
6010B/6020/7421	7439-92-1	Lead	0.015	EPA-4	0.001	0.005
6010B	7439-95-4	Magnesium	NONE	NONE	0.05	0.5
6010B/6020	7439-96-5	Manganese	0.05	EPA-2	0.005	0.01
7470A	7439-97-6	Mercury	0.002	NMED	0.00005	0.0002
6010B	7439-98-7	Molybdenum	1	NMED	0.010	0.025
6010B/6020	7440-02-0	Nickel	0.1	HA	0.01	0.04
6010B	7440-09-7	Potassium	NONE	NONE	0.8	2.0
6010B/7740	7782-49-2	Selenium	0.05	NMED	0.002	0.005
6010B/6020	7440-22-4	Silver	0.05	NMED	0.002	0.01
6010B	7440-23-5	Sodium	20	HA	0.2	0.5
6010B	7440-24-6	Strontium	17	HA	0.005	0.01
6010B/6020/7841	7440-28-0	Thallium	0.002	EPA-1	0.001	0.002
6010B	7440-31-5	Tin	22000	HHMSSL	0.1	0.5
6010B	7440-62-2	Vanadium	0.02	HA	0.01	0.05
6010B/6020	7440-66-6	Zinc	5	EPA-2	0.005	0.02

Table 12 WSTF General Inorganic Analytes

Method	CAS Number	Analyte	Level of Concern (mg/L)	Source	Estimated Detection Limit (mg/L)	Required Quantitation Limit (mg/L)
6010B	7440-70-2	Calcium	NONE	NONE	0.1	0.5
6010B	7439-95-4	Magnesium	NONE	NONE	0.05	0.5
6010B	7440-23-5	Sodium	20	HA	0.2	0.5
6010B	7440-09-7	Potassium	NONE	NONE	0.8	2.0
6010B	7439-89-6	Iron	0.3	EPA-2	0.03	0.1
310.1	NA	Total Alkalinity	NONE	NONE	0.5	2.0
300.0	16887-00-6	Chloride	250	NMED	0.1	0.2
300.0	16984-48-8	Fluoride	1.6	NMED	0.1	0.1
300.0	NA	Sulfate	250	EPA-2	0.1	0.2
353.2	NA	Nitrate/Nitrite	10	NMED	0.002	0.05
160.1	NA	Total Dissolved Solids	500	EPA-2	NA	10
350.1	7664-41-7	Ammonia	30	HA	0.01	0.05

EPA-2 – National Secondary Drinking Water Regulations Maximum Contaminant Levels, 40 CFR §143.3.
EPA-4 – National Primary Drinking Water Regulations Lead and Copper Rule, 40 CFR §141.80.

Table 13 WSTF EPA Method 314 Analytes

CAS Number	Analyte	Level of Concern (µg/L)	Source	Estimated Detection Limit (µg/L)	Required Quantitation Limit (µg/L)
14797-73-0	Perchlorate	4	(40CFR§141.40)	0.5	1.0

Table 14 WSTF Hydrazine Method (WSTF-Developed HPLC) Analytes

CAS Number	Analyte	Level of Concern (µg/L)	Source	Estimated Detection Limit (µg/L)	Required Quantitation Limit (µg/L)
302-01-2	Hydrazine	0.022	HHMSSL	NA	0.10
60-34-4	Monomethylhydrazine	0.022	HHMSSL	NA	0.10
57-14-7	Unsymmetrical dimethylhydrazine	0.022	HHMSSL	NA	0.10

WJI CHEMLAB-0268, "Determination of Propellant Hydrazines in Aqueous Solution Using Hewlett-Packard HPLC 1100 Series with Amperometric Detection (provided in Appendix I).

3.3.3.4 QA/QC Requirements

Quality control samples for plume-front groundwater and treatment system influent/effluent monitoring are collected in accordance with the requirements established in the WSTF QAPP, included with the SAP in Appendix I. The QAPP provides quality control acceptability criteria for the analytical methods utilized at WSTF and the quality control samples collected for each of these analytical methods. More information regarding field and analytical quality control samples, and their collection frequencies, are provided in Section 4.1 of this document.

3.3.3.5 Corrective Actions

Laboratory corrective actions are identified and implemented by the individual contracted analytical laboratories. Specific details related to the corrective actions proposed by the analytical laboratories are provided by these laboratories prior to the initiation of a contract with NASA. Laboratory procedures, as they are provided to NASA, are included with the laboratory manuals and other laboratory information in Appendix I. If not currently present in laboratory reports, any corrective actions implemented by the laboratory to resolve deficiencies will be documented and reported to NASA with the analytical data reports.

3.3.3.6 Reporting

The format and content of the reported results and data are provided in Section 5.0.

3.3.3.7 Data Validation

Section 3 of the WSTF QAPP, included in Appendix I, provides information related to data validation. The QAPP describes the processes used to monitor and estimate the magnitude of the more important potential measurement error sources. Quality planning simultaneously establishes data quality criteria appropriate for the project and data use and defines the required data quality indicators (DQIs). DQIs are qualitative and quantitative measures of principal quality attributes, including precision, bias, representativeness, comparability, completeness, and sensitivity.

3.4 Assessment

The objective of the plume-front treatment system is stabilization of contaminant plume migration and COC mass reduction. Plume-front predictive numerical aquifer flow/transport modeling extrapolated over 30 years has shown that additional migration can be arrested. Due to the anticipated duration of this corrective action, NASA has not formulated a specific exit

strategy, nor is a description included here. Future progress will assist in the formulation of an effective strategy based on contemporary operational data.

In order for NASA to proactively progress with groundwater treatment and meet plume containment goals, operational and maintenance procedures will be adhered to and performance criteria monitored, measured, and evaluated. These performance metrics are summarized in Table 15, with a reference to pertinent sections of this Plan. In addition, Appendix J presents a decision, responsibility, and communication flow chart for the plume-front treatment system.

The trending of pertinent metrics will be performed and evaluated for the life of the treatment system. In order to allow facility operators to anticipate and effectively plan significant system adjustments and modifications, including adding/discontinuing use of system components, NASA will perform an annual review of:

- plume-front aquifer response, groundwater modeling, and modeled plume containment;
- predictive groundwater simulations;
- this Plume-Front Project Plan;
- COC list;
- risk assessment;
- staffing/training requirements;
- regulatory requirements;
- treatment technologies; and
- internal guidance documents (WJIs).

NASA will modify the system appropriately to maintain the system objective. Significant changes/modifications will be proposed to and approved by NMED prior to implementation.

Table 15 Performance Metrics

General Performance Criteria	Measureable Performance Criteria	Data Collection Frequency	Data Evaluation Frequency	Evaluation Responsibility	Related Assessment Parameters and Comments
System Status	Power data	Continually	Continually (by the I&C system)	Engineering Group	As described in Attachment M of Appendix B and Section 3.1.2 of this Plan, numerous operational conditions are continually monitored by on-board programmable logic controllers (PLCs) at each air stripper and the UV reactor. Out of range parameters will result in a variety of actions ranging from operator notification to full system shutdown.
Volumetric Flow Rate	Extraction (each wellhead)	Daily During System Operation	Monthly	Engineering Group	Volumetric flow rates, in conjunction with potentiometric elevations, will be used to calculate specific capacities (per Attachment M of Appendix B). Volumetric flow rates will be used in flow balance calculations to evaluate flow meter performance, evaporative losses, and total volume extracted/injected. Volumetric flow rates will be utilized to calculate mass removal rates.
	Injection (each wellhead)				
	System influent				
	System effluent				
Potentiometric Elevation	Extraction wells	Daily During System Operation	Quarterly	Engineering Group	Measured treatment system well elevations will be used for piezometric monitoring relative to potential well productivity or fouling issues and to assess extraction well drawdown and injection well mounding. This will support system calibration and extraction/injection rate modifications to achieve optimal contaminant removal. Piezometric and modeled treatment system well elevations will also be compared and used to support calibration of the model as necessary.
	Injection wells				
	Monitoring wells	Quarterly		Geosciences/Data Collection and Management Groups	Elevations for all wells will be taken during a single event on a quarterly basis for potentiometric surface evaluation. Elevations for individual wells will be collected prior to each sampling event to support quarterly T-C plot evaluations. Groundwater elevations at monitoring wells will be used to evaluate model boundary effects, plume geometry, and the potential impact of regional JDMB pumpage.

Table 15 Performance Metrics

General Performance Criteria	Measureable Performance Criteria	Data Collection Frequency	Data Evaluation Frequency	Evaluation Responsibility	Related Assessment Parameters and Comments
Contaminant of Concern (COC) Concentrations	System influent	Varies from twice weekly during startup to quarterly; thereafter to monitor ongoing treatment efforts. Specific details in Attachment K of Appendix B.	Within 24 hours of receipt from analytical laboratory.	Data Collection and Management Group	Effluent COC concentrations are monitored to determine compliance with the Discharge Plan. Exceedence of standards requires the implementation of corrective actions, as described in Appendix B. COC concentrations, in conjunction with volumetric flow rate data, will be used to calculate cumulative COC mass removed and to determine system efficiency.
	System effluent				
	Extraction (each wellhead)	Varies from weekly during startup to quarterly; thereafter to monitor ongoing treatment efforts. Specific details in Attachment K of Appendix B.	Quarterly		COC concentrations will be used to develop T-C plots for each of the wells. COC concentrations will be utilized to develop three dimensional plume representations. Isoconcentration lines for selected COCs will be used for groundwater model particle tracking and containment simulations.
	Monitoring wells	Quarterly	Quarterly		
Groundwater Modeling	Plume capture through particle-tracking	Quarterly	Quarterly	Geosciences Group	Quarterly for TCE and annually for other selected COCs.
Reporting	Prior to April 30, July 31, October 30, and January 30	As stated above	Quarterly	Permit Compliance Officer	Quarterly reports shall be submitted to NMED HWB, Ground Water Quality Bureau and the State Land Commission
	Prior to the last day of every month		Monthly	Permit Compliance Officer	Monthly reports shall be submitted to the New Mexico State Engineer Office

4.0 Quality Assurance and Quality Control Procedures

4.1 Internal Quality Control Checks and Frequency

4.1.1 Quality Control Samples

Quality control samples for the plume-front groundwater and influent/effluent monitoring at the plume-front treatment system are collected in accordance with the requirements established in the WSTF QAPP (included in Appendix I). Field quality control samples include duplicate samples, field blanks, equipment blanks (for non-dedicated sampling equipment), trip blanks, and blind quality control samples. Analytical quality control samples include method blanks, laboratory control samples, matrix spikes, matrix spike duplicates, and surrogate spike samples. Descriptions of the field and analytical quality control samples are provided in Tables 3.1 through 3.4 of the WSTF QAPP.

4.1.2 Corrective Actions for Control Limit Exceedance

Corrective action for control limit exceedances exist in individual methods, laboratory standard operating procedures and quality assurance manuals, provided in Appendix I, and in the WSTF QAPP, included in Appendix I. In general, the corrective actions include an effort to correct the analytical conditions affecting the exceedance prior to reanalyzing the affected samples. Failing that, the data must be qualified such that documentation of the exceedance remains with the affected results throughout verification, validation, reporting, and storage procedures.

4.1.3 Quality Control Calculations

The procedures for quality control calculations are provided in the WSTF QAPP, included as part of the WSTF SAP in Appendix I.

4.1.4 QA/QC Requirements

Numerous measurements are collected during the plume-front groundwater sampling activities. The WSTF SAP and QAPP, included at Appendix I, and their referenced site-specific procedural documentation provide the procedures that are followed to ensure the collection of high quality, representative field data. Additional quality control and quality assurance requirements will be developed as the implementation of the treatment system progresses. Specific field measurements and their acceptability criteria are provided in Appendix B and in the project-related procedural documentation.

4.1.5 Field Records

All groundwater monitoring and treatment system influent/effluent sampling activities are recorded in field logbooks. Serially numbered field logbooks (or sequentially numbered database entries in an electronic logbook) are used to record all activities, observations, and measurements that take place during field events. Any problems encountered during monitoring activities are recorded, as are the corrective actions implemented in the field or proposed for future sampling events. A detailed description of the field logbook, including all required entries and information, is provided in the WSTF SAP (Appendix I).

Records of the field activities should be sufficient to allow an individual, not associated with the sampling event, to recreate the events by reading the logbook. These documents serve as legal records of all field activities. All logbooks and/or databases are maintained on-site for immediate availability.

4.1.6 Reporting

The groundwater monitoring results, groundwater chemical data, and treatment system monitoring results are reported in accordance with Section 5.0 of this document, which details the reporting requirements and format for plume-front treatment activities.

4.1.7 Corrective Actions

As indicated previously in Section 3.2.3, potential corrective actions used for problems encountered in the field are identified in the WSTF SAP, provided in Appendix I. Section 6 of the SAP specifically includes corrective actions for sampling and measurement equipment failure.

4.2 Calibration Procedures and Frequency

4.2.1 Groundwater Monitoring Equipment

The collection of groundwater and treatment system samples requires the use of a variety of equipment. The calibration and maintenance of this equipment will be performed in accordance with the equipment manufacturer's recommendations and site-specific calibration requirements. The WSTF SAP, in conjunction with the referenced site-specific procedural documentation and operation and maintenance manuals, provides the procedures and frequencies for performing calibration of the equipment required for groundwater monitoring.

4.2.2 Laboratory Equipment

WSTF utilizes off-site analytical laboratories for groundwater and influent/effluent sample analysis. The calibration procedures and schedules of specific equipment and/or instruments at these laboratories vary depending on lab-specific requirements. The laboratory manuals provided in Appendix I include information related to calibration and maintenance at each laboratory currently utilized by WSTF.

4.2.3 Treatment System Equipment

Calibration and maintenance procedures and frequencies for plume-front treatment system equipment will be established in accordance with WSTF ISO procedures and equipment manufacturer’s guidelines. Calibration intervals for the various components will be initially selected based on manufacturer’s recommendation, then may be adjusted based on the respective component reliability under operating conditions. Calibration and maintenance of the equipment and instrumentation used in the plume-front treatment system will be performed in-place where possible. The in-place calibration is valid only for the equipment configuration specified in a user-generated calibration procedure (if a component is removed from the system, it is no longer considered calibrated). A decal indicating the latest calibration date and the future due date will be placed on each component upon its calibration. Calibration standards that are used will have a known valid relationship to nationally recognized standards. The calibrating organization will be responsible for maintaining calibration and traceability of all standards that are used. Component calibration records will be maintained in a database that includes each component’s unique identification number, initial calibration data, documentation of any nonconformance found during calibration, identification and source of standards used, and final calibration data.

4.3 Data Reduction, Validation, and Reporting

4.3.1 Data Qualification

Analytical data quality criteria for groundwater monitoring are established in the WSTF QAPP, provided with the SAP in Appendix I. Data acceptance, rejection, and qualification requirements are provided in the QAPP.

4.3.2 Data Verification

The procedures for verification of analytical data are described in Section 3.3.3.7.

4.3.3 Non-Direct Data Sources

WSTF utilizes several non-direct data sources including, but not limited to: plume and contaminant concentration models; hydraulic closed pipe flow model; comprehensive analytical databases; vendor and manufacturer-supplied data packages and informational surveys; and qualitative software package evaluations.

4.3.4 Resources and Support

NASA's primary resource or support group is the contractor Environmental Department that is currently responsible for the management of the groundwater assessment and remediation projects. The contractor Environmental Department is staffed with environmental engineers, scientists, geologists, technicians, and management personnel. Other WSTF organizations, such as the contractor Laboratory and Engineering Departments, offer support functions to the contractor Environmental Department.

In addition to the on-site contractor Environmental Department and support groups, several off-site facilities are required for operation of the plume-front treatment system. The primary off-site support facilities are the contracted laboratories that perform analytical services and report to NASA the required chemical analyses from groundwater and treatment system samples. In addition, numerous sub-contractors were utilized in the construction of the plume-front treatment system. These firms have been, and remain, valuable resources in the construction, operation and maintenance of NASA plume-front stabilization efforts.

4.3.5 Data Management

NASA has established site-specific procedural documentation that details the management, record keeping, and data archival requirements for all the analytical data generated from groundwater monitoring operations. Provided in Appendix I is the site-specific procedural document for the WSTF groundwater database operations and quality assurance procedures. This document is reviewed and revised periodically to reflect the evolution of the WSTF groundwater database and quality assurance procedures.

4.4 Data Limitations

The quality assurance procedures outlined in the site-specific procedural document (Appendix I) for the WSTF groundwater database operations and quality assurance address the requirements for data verification and validation. Initially, the laboratory data package is reviewed for completeness, correctness and compliance with project requirements. Any out of control analytical conditions or data anomalies recognized at the laboratory are noted and data are qualified and narratives added as specified in the WSTF QAPP. Next, a review of field QC sample results is performed. Any out of control conditions or data anomalies are noted and data are qualified and narratives added as specified in the WSTF QAPP. Finally, all data qualifiers and narratives remain with the data as they are transferred into the groundwater database. All reports generated from the groundwater database retain data qualification in a format appropriate for the reporting requirement. The end user of the qualified data is responsible for determining the applicability and potential limitations of the analytical data to the project in question.

5.0 Quarterly Report Format

5.1 Executive Summary

This section will provide a summary of all activities performed during the groundwater monitoring event(s) including surveying, field data collection, chemical testing, treatment system monitoring, etc.

5.2 Regulatory Criteria

Information regarding applicable groundwater cleanup standards, risk-based screening levels and/or risk-based cleanup goals will be provided.

5.3 Groundwater Monitoring Results

This section will provide a summary of the results of groundwater monitoring conducted at the site including, but not limited to, the dates that groundwater monitoring was conducted, the measured depths to groundwater, direction(s) of groundwater flow, field water quality measurements, and a comparison to previous groundwater monitoring results. It will also provide field observations or conditions that may influence the results of groundwater monitoring. Problems experienced in the field will be summarized and the corrective action(s) implemented will be identified. Groundwater elevation/depth to groundwater measurements, and field water quality measurements will be summarized in table and/or graphical format.

5.4 Groundwater Analysis Results

This section will include data from groundwater sampling and provide a comparison of the data to the cleanup standards for the site. The rationale for altering or modifying the groundwater sampling program, and analysis of the data in the form of trends, figures, and diagrams will be provided. Measurements of the depth to groundwater will be presented in the form of potentiometric surface maps that indicate the direction of groundwater flow. Plume contour maps on a regular basis will also be included.

5.5 Treatment System Monitoring

This section will summarize the treatment system capabilities, performance, monitoring data, treatment system discharge sampling requirements, system influent and effluent analytical results, and performance of the extraction and injection wells. The dates of operation, system failures and modifications made to the treatment system during the reporting period will also be included.

5.6 Discussion, Conclusions, and Recommendations

A discussion and conclusions with regard to the results of groundwater monitoring conducted at the site, and explanations with regard to data gaps will be provided. This section will discuss the treatment system performance, monitoring results, modifications, if applicable, and compliance with discharge requirements. Recommendations and explanations regarding future monitoring, corrective actions or site closure will be included.

5.7 Appendices

This section includes the following appendices. Additional appendices may be attached to present data or documentation not listed below.

5.7.1 Field Methods

The methods used to acquire field measurements of groundwater elevations, water quality data and groundwater samples will be included in this section. Methods will include, but are not limited to, the methods and types of instruments used to measure depths to water, air or headspace parameters, and water quality parameters. In addition, decontamination, well purging and well sampling techniques, and sample handling procedures will be provided. Methods of measuring and sampling treatment systems will be reported in this section, if applicable.

5.7.2 Chemical Analytical Program

This section will provide the chemical analytical methods, a summary of data quality objectives and data quality review procedures. The data quality exceptions and their effect on the acceptability of the chemical analytical data with regard to the monitoring event along with references to case narratives provided in the laboratory reports will be summarized.

5.7.3 Chemical Analytical Reports

All laboratory chemical analytical data generated for the reporting period, chain-of-custody records, and QA/QC results provided by the laboratory will be provided in this section.

5.7.4 Well Construction Summary

The construction summary of all wells in the monitoring program will be provided.

6.0 References

References for this document are those outlined in the PFSWP and Attachment A of Appendix B.

Appendix A - Plume Front Stabilization Work Plan (1999 and 2002) and Plume-Front Remediation System Operation and Maintenance Plan

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
White Sands Test Facility
P.O. Box 20
Las Cruces, NM 88004-0020

May 16, 2002

Reply to Attn of: RA-02-058

New Mexico Environment Department
Attn: Mr. Phillip Solano
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

Subject: Modification of the NASA White Sands Test Facility (WSTF) Plume-Front Stabilization Work Plan

The enclosed CD-ROM contains the WSTF Plume-Front Stabilization Work Plan modification package. The original Plan was approved March 15, 2000. NASA proposes to modify the Plan with completed well information, updated groundwater modeling simulations, modified extraction well locations, proposed engineering modifications, and revised project timelines. The CD-ROM contains a table presenting an index for the proposed modifications with supporting justifications, a copy of the original Plan submitted in January 1999, a redline/strikeout version, and a revised clean copy of the Plan.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

To the extent that information has been submitted electronically, I acknowledge that the New Mexico Environment Department will rely solely on the electronic information as accurate and complete information and that it is this data that will be used for compliance and enforcement purposes pursuant to the provisions set forth in the NASA WSTF Final Project Agreement. If you have any questions or comments concerning this submittal, please call Michael Zigmond at 505–524–5484.

/S/ Michael Zigmond

for Joseph Fries
Manager

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HTSI Team/P. H. Pache

RA/MZigmond:ljg:5/15/02:5484

#4 zip LTRS\Env-02-1\PF Work Plan Modification

CONCUR						
	CODE →	RA				
	SIGNATURE→	M. Zigmond				
	DATE →	5/16/02				

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Section 1
Proposed Modifications with Justifications for the Plume-Front Stabilization Work Plan

Proposed Modifications with Justifications - Plume-Front Stabilization Work Plan

Location of Modification(s)	Modification(s)	Justification(s)
Cover Page	• Provided the date of revision	• Update
Table of Contents	• Provided correct page numbers for Sections, Tables, and Figures where appropriate	• The redline and revised copies of the Plan changed the document length
List of Tables	• Table 5.4 was added and the page numbers adjusted	• Table 5.4 was inadvertently left out of the List of Tables in the original Plan
List of Acronyms and Abbreviations used in Report	• Acronyms changed or added where necessary • Acronyms deleted where necessary	• Revised acronyms required due to changes in text and tables • Only one occurrence of acronyms in the text
Section 1.0 Executive Summary	• Additional monitoring wells (PL-9, WW-3, WW-4, and WW-5) were completed and added to the Plan • Extraction wells PFE-4A and PFE-7 were added to the Plan and extraction wells PFE-4 and PFE-6 were removed • System plans and pumping totals were updated	• Well PL-9 was requested by New Mexico Environment Department • Wells WW-3, WW-4, and WW-5 provide monitoring points outside the contaminant plume • Contaminant levels within extraction well PFE-4 are insufficient for remediation purposes • Well PFE-6 was only capable of producing five gallons per minute. This well provides negligible remediation benefit • PFE-4A was installed to replace PFE-4 • PFE-7 was installed to address recently identified TCE contamination in the vicinity of monitoring well ST-6 • Update
Section 2.2 Regulatory Background	• Citation relative to the submittal of the modified Plan • Minor re-wording	• Update • Update
Figure 2.2 Groundwater Plume Hydrogeological Features	• The Trichloroethene (TCE) groundwater plume was updated using more recent analytical data (May 2001) and the well configuration modified • TCE isoconcentration line was changed from 0.5 ppb to 1 ppb • Removed abandoned wells and piezometers	• The revised TCE plume illustrates the higher concentrations near ST-6 that justify adding extraction well PFE-7 to the plume-front containment system • 1 ppb TCE provides a more accurate representation of plume remediation (the system will treat TCE to 3.8 ppb) and remains conservative • Unnecessary information
Section 3.2.1 Aquifer Description	• Updated the Flow Banded Rhyolite (FBR) description describing recently reported volatile organic compound contamination • Deleted references	• Recent analytical results within the FBR indicate it does not completely restrict groundwater flow • References are out dated. Mid-Plume Constriction Area evaluations are on-going and a report is in preparation

Location of Modification(s)	Modification(s)	Justification(s)
Section 3.2.2 Groundwater Movement	• Corrected the location of the pediment region from west to east of the Western Boundary Fault Zone (WBFZ)	• Correction
Section 3.2.3 Groundwater Recharge/Discharge	• Modified the current groundwater discharge for White Sands Test Facility and the Jornada del Muerto Basin, recharge to the basin, and percentage utilized by users	• Updates
Section 3.2.4 Groundwater Quality	• Acronym was deleted	• Only one occurrence of acronym in the text
Section 3.3.1 Groundwater Contamination	• Updated the maximum contaminant concentrations using analytical data through May 2001 and updated the text regarding N-nitrodimethylamine (DMN) concentrations	• Updates
Section 3.4 Groundwater Model Setup and Calibration	• Added a recent reference (Daniel B. Stephens and Associates (DBS&A) communication) and updated text	• Update
Section 3.4.1 Description of Groundwater Model and Programs	• Indicated the regional groundwater model will be reviewed and compared to a recent model presented by Shomaker • Corrected Plan to indicate groundwater modeling is performed with MODFLOW-SURFACT program	• Groundwater modeling is in the process of being updated/upgraded • Update
Figure 3.1 NASA-White Sands Test Facility (WSTF) Modeling Plume-Front Containment-Simulated N-nitrosodimethylamine (NDMA) Plume for 1992	• The WSTF site boundary was modified to reflect recent co-use area changes • TCE isoconcentration line was changed from 0.5 ppb to 1 ppb	• Updated to accommodate the co-use area agreement between the Jornada Experimental Range (JER), the Department of Defense (DOD), and NASA • 1 ppb TCE provides a more accurate representation of plume remediation (the system will treat TCE to 3.8 ppb) and remains conservative
Figure 3.2 NASA-WSTF Modeling Plume-Front Containment-Simulated TCE Plume for 1992	• Modified WSTF site boundary to reflect recent co-use area changes	• Updated to accommodate the co-use area agreement between the JER, the DOD, and NASA
Figure 3.3 NASA-WSTF Modeling Plume-Front Containment-Simulated Tetrachloroethene (PCE) Plume for 1992	• Modified WSTF site boundary to reflect recent co-use area changes	• Updated to accommodate the co-use area agreement between the JER, the DOD, and NASA

Location of Modification(s)	Modification(s)	Justification(s)
Figure 3.4 WSTF Land Ownership & Location of 1 part per billion (ppb) TCE Plume	• Updated figure with most recent TCE plume (using analytical data through May 2001) • Modified the WSTF site boundary and land ownership to reflect recent changes	• Update • Updated to accommodate the co-use area agreement between the JER, the DOD, and NASA
Section 3.5.3 Risk Characterization	• Revised the text and health risk calculations with updated analytical data	• Update
Section 3.5.3.1 Carcinogenic Risk Estimates	• Updated the cancer risk estimates • Acronyms changed/added where needed • Modified cumulative cancer risk calculation text	• Cancer risk calculated using more conservative Environmental Protection Agency (EPA) age-adjusted equations • New acronyms were used for revised cancer risk calculations • Clarification
Table 3.3 Chronic Daily Intake (CDI) Assumptions Adult Ingestion of Contaminated Groundwater	• Format change to parameter and exposure assumption columns • Updated the CDI assumptions • Acronyms changed/added	• Clarification • Revision of risk data based on update in section 3.5.3.1 • New acronyms were used for revised cancer risk calculations
Table 3.4 Carcinogenic Risk Estimates for Plume-Front Monitoring Wells	• Updated the carcinogenic risk estimates for plume-front wells	• Revised the risk estimates based on the revised calculations from section 3.5.3.1
Figure 3.5 Contour Map of Cumulative Cancer Risk (NDMA-DMN-TCE-PCE)	• Modified the cancer risk plume • Modified WSTF site boundary to reflect recent changes	• Revised the plume to conform with updated cancer risk calculations • Updated to accommodate the co-use area agreement between the JER, the DOD, and NASA
Section 3.6 Data Sufficiency	• Corrected the Plan relative to the number of sampling events, sampling results, number of wells, and plans for testing the extraction wells	• Correction and updates
Section 4.1 Evaluation of Three Dimensional Site-Wide Bedrock (3DSWB) Model Predictive Remedial Scenarios	• Added recent DBS&A references • Added current groundwater modeling software • Added an additional groundwater modeling scenario (Scenario 11) and updated text • Described Scenario 11 modifications	• Reference update • Software update • Scenario 11 was performed after submittal of original Plan. The scenario excludes wells PFE-4 and PFE-6 and includes wells PFE-4A and PFE-7 to achieve plume stabilization • Provided Scenario 11extraction well modifications required to achieve plume stabilization
Table 4.1 Summary of 3DSWB Model Interim Measures Remedial Scenarios	• Added Scenario 11 to the table	• Scenario 11 was performed to address the problem with clean water at well PFE-4, low water production at well PFE-6, and the need for additional wells PFE-4A and PFE-7 to achieve effective plume stabilization

Location of Modification(s)	Modification(s)	Justification(s)
Section 4.2 Description of Plume-Front Stabilization Scenario	• Updated Section with appropriate information relative to Scenario 11 modeling	• The previous scenario in the original Plan (Scenario 10) is no longer valid with the absence of contamination at PFE-4, low production at PFE-6, and contamination encountered at monitoring well ST-6. Scenario 11 was established to address these issues
Figure 4.1 NASA-WSTF Modeling Plume Front Containment Well Locations	• Remediation well configuration modified • Position of WBFZ adjusted to incorporate the latest bedrock information and coincide with other figures • Modified WSTF site boundary to reflect recent changes	• Scenario 11 update • Additional bedrock information from recently installed wells • Updated to accommodate the co-use area agreement between the JER, the DOD, and NASA
Section 4.2.1 Remediation Well Characteristics	• Identify remediation well modifications in Table 4.2 • Summarize concept of discharge variations within a single well	• Update • Simplification of potentially confusing statement
Table 4.2 Plume-Front Containment Well Locations, Pumping Rates and Design Parameters	• Updated pumping rates, casing specifications and depth specifications • Replaced offline extraction wells with new extraction wells	• Additional information available from remediation well field installations • Scenario 11 update
Section 4.3.1 PATH3D Plume-Front Stabilization Diagrams	• TCE particle tracking results updated to conform with latest groundwater plume (through May 1, 2001) and remediation well configuration	• TCE particle tracking modified to test capture effectiveness of latest remediation system (Scenario 11)
Section 4.3.2 Predictive Isoconcentration Maps	• Statement that the isoconcentration maps for the original Plan are applicable for the revised Plan • Re-evaluation of plume capture using Scenario 11	• Well positions and total pumpage are very similar resulting in negligible change on the map • Addresses small zone of apparent plume migration seen in previous scenarios
Figure 4.2 NASA-WSTF Modeling Simulated Contaminant Pathlines for NDMA Plume Front Containment	• Modified WSTF site boundary to reflect recent changes	• Updated to accommodate the co-use area agreement between the JER, the DOD, and NASA
Figure 4.3 Simulated Contaminant Pathlines for TCE Plume-Front Containment	• Five ppb TCE containment utilized for particle tracking with revised TCE plume and well configuration • Modified WSTF site boundary to reflect recent changes	• Five ppb TCE containment is a realistic evaluation due to treatment standards – remediation well capture conservatively captures TCE concentrations as low as one ppb • Updated to accommodate the co-use area agreement between the JER, the DOD, and NASA
Figure 4.4 NASA-WSTF Modeling Plume Front Containment Simulated NDMA Plume for 2026	• Modified WSTF site boundary to reflect recent changes	• Updated to accommodate the co-use area agreement between the JER, the DOD, and NASA

Location of Modification(s)	Modification(s)	Justification(s)
Figure 4.5 NASA-WSTF Modeling Plume Front Containment Simulated TCE Plume for 2026	• Removed 0.1 ppb isoconcentration line • Modified WSTF site boundary to reflect recent changes	• Remaining 1 ppb isoconcentration line is conservative and a more realistic capture concentration • Updated to accommodate the co-use area agreement between the JER, the DOD, and NASA
Figure 4.6 NASA-WSTF Modeling Plume Front Containment Simulated PCE Plume for 2026	• Removed 0.1 ppb isoconcentration line • Modified WSTF site boundary to reflect recent changes	• Remaining 1 ppb isoconcentration line is conservative and a more realistic capture concentration • Updated to accommodate the co-use area agreement between the JER, the DOD, and NASA
Section 4.3.3 Mass Extraction Calculations	• Statement made that mass extraction plots are based on the original Plan configuration and will not be modified significantly due to the new well configuration	• Scenario 11 has a negligible effect on mass extraction plots derived from predictive modeling simulations. These would be time consuming to regenerate
Section 4.3.4 Other Modeling Considerations	• Text modifications to incorporate new remediation well flowrates, configuration, and installation status	• Scenario 11 updates
Section 4.4.1 Groundwater Treatment Standards	• Minor re-wording • Low level NDMA sampling statement • Modified the cumulative cancer risk value to cumulative age-adjusted cancer risk value	• Update • Update • Conservative modification of health risk number
Table 4.4 Predicted Influent Contaminant Concentrations to the Plume-Front System	• Updated the residential cancer risk	• Update using the more conservative EPA age-adjusted exposure factors
Section 4.5 Presumptive Remedy Remedial System Conceptual Design	• Updated list of monitoring wells • Text modifications to incorporate new remediation well configuration and flowrates • Adjustment made to indicate the pretreatment of water and that air stripping will now precede ultraviolet (UV) oxidation in the treatment process • Modified description of UV oxidation process • Identified well PFE-3 as the only non-PVC remediation well • Permitting status and well installation modifications • Added acronym	• Added new wells • Scenario 11 updates • Remediation system design modifications • Clarification • Clarification • Updates • Update
Table 4.5 Treatment Standards for Plume-Front Contaminants	• Recalculated residential cancer risk using age-adjusted exposure	• Conservative adjustment

Location of Modification(s)	Modification(s)	Justification(s)
Table 4.6 Individual and Cumulative Risk Assuming 30% Analytical Extraction Efficiency for NDMA and DMN	• Recalculated residential cancer risk using age-adjusted exposure	• Conservative adjustment
Figure 4.10 Remedial System Well Locations and Conceptual Design	• Added monitoring wells WW-3, WW-4, and WW-5 and planned monitoring wells JER-1 and JER-2 • Modified WSTF site boundary to reflect recent changes • Removed abandoned wells and piezometers	• Update • Updated to accommodate the co-use area agreement between the JER, the DOD, and NASA • Unnecessary information
Table 4.7 Anticipated Plume-Front Remediation System Performance	• Corrected the remediation system flow rates	• Updates
Figure 4.11 Remedial System Process Flow Diagram	• Air stripping unit adjusted to precede UV oxidation unit in process flow and water flow direction added	• Air stripping volatiles prior to UV oxidation provides a more cost effective treatment process and does not compromise remediation goals
Section 4.6 Site Safety and Security	• Text updated to reflect completed tasks	• Updates
Section 4.7 System Start-Up	• Text updated to reflect current status of procurement • System startup period adjusted from three months to six months	• Updates • Startup period made consistent between text, Table 5.4 and Figure 6.2 timeline
Section 4.8.1 Operation and Maintenance	• Minor re-wording	• Updates
Section 5.1 Introduction, Objectives and Scope	• Text modifications relative to new plume-front monitoring wells and minor re-wording • Acronyms deleted	• Updates • Only one occurrence of acronym in the text
Section 5.2.1 Groundwater Monitoring	• Minor text changes to indicate wells have been installed	• Update
Table 5.2 Plume-Front Sampling Frequencies for Conventional Wells/Zones	• Changed sampling frequencies for conventional wells/zones • Minor footnote edit	• Changes correspond to new sampling frequencies proposed in a pending modification to the WSTF Sampling and Analysis Plan • Clarification
Table 5.3 Plume-Front Sampling Frequencies for Westbay® Multi-Port Wells/Zones	• Added data for wells/zones completed following original Plan submittal • Changed sampling frequencies where applicable • Minor footnote edit	• Updates • Changes correspond to new sampling frequencies proposed in a pending modification to the WSTF Sampling and Analysis Plan • Clarification

Location of Modification(s)	Modification(s)	Justification(s)
Section 5.2.3 Treatability Testing	• Minor text updates regarding the UV oxidation system	• Update
Section 5.3.1 Sample Collection	• Minor text edit	• Correction
Section 5.3.2 Sampling Frequencies	• Changed the frequencies of inorganic water quality parameters from quarterly to semi-annual	• Change corresponds to new sampling frequencies proposed in a pending modification to the WSTF Sampling and Analysis Plan
Table 5.4 Influent/Effluent Sampling Schedule	• Changed the initial startup sampling period to six months • Changed frequency of influent/effluent sampling	• System startup period increased to six months • Change corresponds to new sampling frequencies proposed in a pending modification to the WSTF Sampling and Analysis Plan
Section 5.4.4 Data Quality Objectives	• Acronym deleted	• Only one occurrence of acronym in the text
Section 5.4.4.1 Quality Assurance/Quality Control Samples	• Acronym added to text • Reference added	• The acronym was not listed at the first occurrence in the text • Supplemental information referenced
Table 5.9 Method Specific Data Acceptability Requirements	• Adjusted table format and ordering of footnotes	• Clarification
Figure 6.1 Organizational Chart for NASA WSTF Environmental Activities	• Corrected for personnel adjustments	• Updates
Section 6.4.1 Work Plans, Operations and Maintenance Plans and System Specifications	• Updated permitting completed since the original submittal, and identified pending activities • Added pipeline construction to list of activities	• Updates • Activity previously omitted
Figure 6.2 NASA WSTF Plume-Front Stabilization Timeline	• Timeline modified to incorporate the latest Plume-Front Stabilization well installation activities • Modified Work Plan Modifications, System Plans and Specifications and Operation and Maintenance Plan sections	• Updates • Updates
Section 6.4.2 Technical Feasibility Study	• Added Section 6.4.2 heading • Updated text to reflect the completion of pilot scale testing of the UV oxidation system • Indicated that no public comment was received	• The heading was inadvertently omitted from the original Plan. • Update • Update
Section 6.4.3 Groundwater Discharge Plan	• Added information regarding the approved Discharge Plan to text	• Update

Location of Modification(s)	Modification(s)	Justification(s)
Section 6.4.6 National Environmental Policy Act	• Acronym deleted • Indicated completion of Environmental Assessment and public comment period	• Only one occurrence of acronym in the text • Update
Section 7.0 References	• Added four references cited in the updated/redline text and deleted one outdated reference	• Updates

RA

JAN 20 1999

New Mexico Environment Department
Attn: Mr. B. J. Garcia, Chief
Hazardous and Radioactive Materials Bureau
2044 Galisteo Street
Santa Fe, NM 87505

Subject: Plume-Front Stabilization Work Plan for NASA White Sands Test Facility (WSTF)

NASA hosted a meeting with Environmental Protection Agency (EPA) Region 6 and New Mexico Environment Department (NMED) personnel on September 16, 1998, with plume-front contamination and containment the primary topics of discussion. NASA presented a general approach to accomplish containment of plume-front contamination, and EPA and NMED representatives encouraged NASA to pursue this approach and requested a work plan detailing the effort.

Enclosure 1 provides the Plume-Front Stabilization Work Plan for WSTF. This Plan is based upon our comprehensive discussions with NMED Hazardous and Radioactive Materials Bureau personnel. Enclosure 2 gives a timeline of major compliance activities at WSTF, which illustrates that several RFI projects will be delayed to accommodate plume-front stabilization activities. A new WSTF support contract will become effective May 1, 1999. This contract has not yet been awarded, but may present procurement, subcontracting, and funding delays that may affect the timelines. Any modifications to these timelines will be submitted as soon as they become apparent.

If you have any questions or comments concerning this submittal, please call David Amidei at (505) 524-5517.

ORIGINAL SIGNED BY
JOSEPH FRIES

Joseph Fries
Manager

2 Enclosures BINDER NO. 16

cc:
See List

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RCRA Enforcement Branch
Hazardous Waste Management Division
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New Mexico Environment Department
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Ground Water Protection and Remediation Bureau
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Santa Fe, NM 87502

bc:
ATSC Team/P. H. Pache (w/o encls.)

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ENCLOSURE ONE

PLUME-FRONT STABILIZATION WORK PLAN

NASA-JSC WHITE SANDS TEST FACILITY

January 1999

TABLE OF CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS USED IN REPORT vi

1.0 EXECUTIVE SUMMARY 1

2.0 INTRODUCTION 2
2.1 SITE LOCATION AND DESCRIPTION OF PROJECT AREA 2

2.2 REGULATORY BACKGROUND 2

3.0 CURRENT CONDITIONS 5
3.1 SITE GEOLOGY 5
3.1.1 Stratigraphy 5
3.1.2 Structure 6

3.2 SITE HYDROGEOLOGY 6
3.2.1 Aquifer Description 6
3.2.2 Groundwater Movement 7
3.2.3 Groundwater Recharge/Discharge 7
3.2.4 Groundwater Quality 8
3.2.5 Background Metals' Concentrations 8

3.3 CONTAMINATION 9
3.3.1 Groundwater Contamination 9

3.4 GROUNDWATER MODEL SETUP AND CALIBRATION 9
3.4.1 Description of Groundwater Model and Programs 14
3.4.2 Construction of the WSTF 3DSWB Conceptual Model 15
3.4.3 3DSWB Model Calibration for Contaminant Migration 15

3.5 HEALTH RISK ASSESSMENT 16
3.5.1 Chemicals of Concern 16
3.5.1.1 Carcinogens 17
3.5.1.2 Non-Carcinogens 17
3.5.2 Potential Receptors and Exposure Pathways 18
3.5.3 Risk Characterization 21
3.5.3.1 Carcinogenic Risk Estimates 21
3.5.3.2 Non-Carcinogenic Hazard Quotients and Indices 24
3.5.4 Uncertainties 24
3.5.4.1 Carcinogenicity Evidence Under Review 24
3.5.4.2 Lack of Toxicity Data 24
3.5.4.3 Chemical Concentrations 26

3.6 DATA SUFFICIENCY 26

4.0 PRESUMPTIVE REMEDY FOR PLUME-FRONT STABILIZATION 26
4.1 EVALUATION OF 3DSWB MODEL PREDICTIVE REMEDIAL SCENARIOS 26

4.2 DESCRIPTION OF PLUME-FRONT STABILIZATION SCENARIO 29
4.2.1 Remediation Well Characteristics 31

4.3 PLUME-FRONT STABILIZATION SCENARIO SIMULATIONS 31
4.3.1 PATH3D Plume-Front Stabilization Diagrams 31
4.3.2 Predictive Plume-Front Isoconcentration Maps 35
4.3.3 Mass Extraction Calculations 35
4.3.4 Other Modeling Considerations 42

4.4 TREATMENT STANDARDS 42
4.4.1 Groundwater Treatment Standards 43

4.5 PRESUMPTIVE REMEDY REMEDIAL SYSTEM CONCEPTUAL DESIGN 46

4.6 SITE SAFETY AND SECURITY 54

4.7 SYSTEM START-UP 54

4.8 REMEDIAL SYSTEM OPERATION AND MAINTENANCE AND CONTINGENCY PLANNING 55
4.8.1 Operation and Maintenance 55
4.8.2 Contingency Plan 55
4.8.3 Waste Management 56

5.0 SAMPLING AND ANALYSIS 56
5.1 INTRODUCTION, OBJECTIVES AND SCOPE 56

5.2 SAMPLING ACTIVITIES AND FIELD METHODS 57
5.2.1 Groundwater Monitoring 57
5.2.2 Treatment System Monitoring 61
5.2.3 Treatability Testing 61
5.2.4 Treatment System Start-Up 61

5.3 SAMPLE COLLECTION, SCHEDULING, AND ANALYSIS 62
5.3.1 Sample Collection 62
5.3.2 Sampling Frequencies 62
5.3.3 Analytical Methods 62

5.4 QUALITY ASSURANCE PROJECT PLAN 62
5.4.1 Purpose 62
5.4.2 Project Organization 63
5.4.3 Off-Site Laboratories 63
5.4.4 Data Quality Objectives 63
5.4.4.1 QA/QC Samples 64
5.4.4.2 QA/QC Sample Requirements 64
5.4.4.3 Data Quality Requirements 64
5.4.5 Sample Containers, Preservation and Holding Times 64

6.0 PROJECT MANAGEMENT 71
6.1 ORGANIZATION 71

6.2 SCHEDULE 71

6.3 REPORTING REQUIREMENTS 71

6.4 PERMITTING ISSUES 74
6.4.1 Work Plans, Operations and Maintenance Plans and System Specifications 74
6.4.2 Technical Feasibility Study 74
6.4.3 Groundwater Discharge Plan 74
6.4.4 Hazardous Waste Permits 75
6.4.5 Air Quality 75
6.4.5.1 Subpart AA 75
6.4.5.2 Subpart BB 76
6.4.5.3 Subpart CC 76
6.4.6 National Environmental Policy Act 76
6.4.7 Well Permits 76

7.0 REFERENCES 77

LIST OF FIGURES

Figure 2.1: WSTF Location Map 3
Figure 2.2: Groundwater Plume Hydrogeological Features 4
Figure 3.1: Plume-Front Containment Simulated NDMA Plume for 1992 11
Figure 3.2: Plume-Front Containment Simulated TCE Plume for 1992 12
Figure 3.3: Plume-Front Containment Simulated PCE Plume for 1992 13
Figure 3.4: WSTF Vicinity Well Location Map 20
Figure 3.5: Contour Map of Cumulative Cancer Risk 23
Figure 4.1: Plume-Front Containment Well Locations 30
Figure 4.2: Simulated Contaminant Pathlines for NDMA Plume-Front Containment 33
Figure 4.3: Simulated Contaminant Pathlines for TCE Plume-Front Containment 34
Figure 4.4: Plume-Front Containment Simulated NDMA Plume for 2026 36
Figure 4.5: Plume-Front Containment Simulated TCE Plume for 2026 37
Figure 4.6: Plume-Front Containment Simulated PCE Plume for 2026 38
Figure 4.7: Simulated NDMA Concentration and Cumulative Mass Removed for All Extraction Wells 39
Figure 4.8: Simulated TCE Concentration and Cumulative Mass Removed for All Extraction Wells 40
Figure 4.9: Simulated PCE Concentration and Cumulative Mass Removed for All Extraction Wells 41
Figure 4.10: Remedial System Well Locations and Conceptual Design 50
Figure 4.11: Preliminary Remedial System Process Flow Diagram 53
Figure 6.1: Organizational Chart for NASA WSTF Environmental Activities 72
Figure 6.2: Plume-Front Stabilization Schedule 73

LIST OF TABLES

Table 3.1:	Physical and Chemical Properties of Plume-Front Constituents of Concern	10
Table 3.2:	Toxicity Information for Plume-Front Chemicals	19
Table 3.3:	Chronic Daily Intake (CDI) Assumptions	22
Table 3.4:	Carcinogenic Risk Estimates for Plume-Front Monitoring Wells	22
Table 3.5:	Hazard Quotients and Indices for Plume-Front Wells	25
Table 4.1:	Summary of 3DSWB Model Interim Measures Remedial Scenarios	28
Table 4.2:	Plume-Front Containment Well Locations, Pumping Rates and Design Parameters	32
Table 4.3:	Summary of Regulatory Standards and Remediation Goals	44
Table 4.4:	Expected Influent Contaminant Concentrations to the Plume-Front Remediation System	45
Table 4.5:	Presumptive Remedy Goals for Plume-Front Contaminants	47
Table 4.6:	Individual and Cumulative Risk Assuming 30% Analytical Extraction Efficiency for NDMA and DMN	48
Table 4.7:	Anticipated Plume-Front Remediation System Performance	51
Table 5.1:	Sample Collection and Analysis Requirements	58
Table 5.2:	Plume-Front Sampling Frequencies for Conventional Wells/Zones	59
Table 5.3:	Plume-Front Sampling Frequencies for Westbay® Multi-Port Wells/Zones	60
Table 5.4:	Description of Field Quality Control Samples	65
Table 5.5:	Description of Analytical Quality Control Samples	66
Table 5.6:	Field QA/QC Control Sample Frequencies	67
Table 5.7:	Analytical QA/QC Control Sample Frequencies	68
Table 5.8:	Method Specific Data Acceptability Requirements	69
Table 5.9:	Description of Data Quality Assurance Flags	70

LIST OF APPENDICES

APPENDIX A:	CONTINGENCY PLAN FOR THE WSTF HAZARDOUS WASTE OPERATING PERMIT
APPENDIX B:	WSTF GROUNDWATER SAMPLING AND ANALYSIS PLAN
APPENDIX C:	WSTF QUALITY ASSURANCE PROJECT PLAN
APPENDIX D:	LABORATORY QUALITY ASSURANCE/QUALITY CONTROL

LIST OF ACRONYMS AND ABBREVIATIONS USED IN REPORT

3DSWB	Three Dimensional Site-Wide Bedrock (Groundwater Model)
amsl	Above mean sea level
ASTM	American Society for Testing and Materials
AT	Averaging-Time
bgs	Below ground surface
BW	Body Weight
CCV	Continuous Calibration Verification
CDI	Chronic Daily Intake
CFR	Code of Federal Regulations
CMS	Corrective Measures Study
COCs	Contaminants of Concern
CW	Concentration in Water
DBS&A	Daniel B. Stephens and Associates Inc.
DMN	N-nitrodimethylamine
DQO	Data Quality Objective
EA	Environmental Assessment
ED	Exposure Duration
EF	Exposure Frequency
EPA	U.S. Environmental Protection Agency
F-11	Trichlorofluoromethane (Freon 11)
F-21	Dichlorofluoromethane (Freon 21)
F-113	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
FAR	Federal Acquisition Regulation
FBR	Flow-Banded Rhyolite
FC-21	Dichlorofluoromethane (Freon 21)
GCL	Geoscience Consultants, Ltd.
GC/MS	Gas Chromatography/Mass Spectroscopy
gpm	Gallons per minute
GWQB	Ground Water Quality Bureau
HDPE	High-Density Polyethylene
HI	Hazard Index
HQ	Hazard Quotient
HRMB	Hazardous and Radioactive Materials Bureau
HWMU	Hazardous Waste Management Unit
IR	Ingestion Rate
IRIS	Integrated Risk Information System
JDMB	Jornada del Muerto Basin
K	Hydraulic Conductivity
LCS	Laboratory Calibration Standard
MCL	Maximum Contaminant Level
MOSDAX	Modular Subsurface Data Acquisition System
MPCA	Mid-Plume Constriction Area
N/A	Not Applicable

NARA	National Archives and Records Administration
NASA	National Aeronautics and Space Administration
NCEA	National Center for Environmental Assessment
NDMA	N-nitrosodimethylamine
NEPA	National Environmental Policy Act
NIOSH	National Institute for Occupational Safety and Health
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
O&M	Operation and Maintenance
PARCC	Precision, Accuracy, Reproducibility, Completeness, and Comparability
PCE	Tetrachloroethene (perchloroethene)
PFE	Plume-Front Extraction (well)
PFI	Plume-Front Injection (well)
Plan	Plume-Front Stabilization Work Plan
ppb	Parts per billion
ppm	Parts per million
ppmw	Parts per million by weight
ppt	Parts per trillion
PRG	Preliminary Remediation Goal
PT	Pump Test
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RAGS	Risk Assessment Guidance for Superfund
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RFI	RCRA Facility Investigation
SAP	Sampling and Analysis Plan
SAP-PFRS	Sampling and Analysis Plan for the Plume-Front Remediation System
SEO	New Mexico State Engineer Office
SF	Slope Factor
SW	Site-Wide
T	Transmissivity
TCE	Trichloroethene
TDS	Total Dissolved Solids
TLV	Threshold Limit Value
UF/MF	Uncertainty Factor/Modifying Factor
UV	Ultraviolet
VOC	Volatile Organic Compound
WBFZ	Western Boundary Fault Zone
WSTF	White Sands Test Facility

1.0 EXECUTIVE SUMMARY

This Plume-Front Stabilization Work Plan (Plan) describes a presumptive remedy corrective action for the National Aeronautics and Space Administration (NASA) White Sands Test Facility (WSTF). This presumptive remedy is intended to control threats to human health and/or the environment at the westernmost extent of a groundwater contaminant plume within the aquifer below WSTF. The groundwater is contaminated as a result of historic activities at the site. The groundwater contaminant plume-front area covers an area of approximately 4,000 feet by 8,000 feet and has a depth of 700 feet. The contaminants of concern (COCs) at the plume-front include N-nitrosodimethylamine (NDMA), N-nitrodimethylamine (DMN) and several halogenated volatile organic compounds (VOCs).

An ex-situ pump and treat remediation system is proposed to address plume-front stabilization and contaminant mass treatment activities. This system will include the installation of five Westbay® multi-port groundwater monitoring wells (WW-2, ST-7, JP-3, PL-8 and BLM-37). These wells will assist with plume-front extraction/injection well design, enhance plume-front monitoring capabilities and monitor the effectiveness of the stabilization system.

The plume-front stabilization will utilize six plume-front extraction (PFE) and four plume-front injection (PFI) wells. The WSTF three-dimensional site-wide bedrock (3DSWB) groundwater model was utilized to simulate contaminant plumes for NDMA, trichloroethene (TCE), and tetrachloroethene (PCE). Parameters generated from the 3DSWB model wells were used for the plume-front stabilization well designs. Extraction wells PFE-1 through PFE-6 will remain within or on the eastern boundary of the Western Boundary Fault Zone (WBFZ). Three high-volume extraction wells (PFE-1 through PFE-3) and one lower volume extraction well (PFE-4) will specifically address the TCE contaminant plume which extends furthest west. These wells also effectively contain the PCE plume. Extraction wells PFE-1 through PFE-4 will utilize an estimated combined flow rate of 810 gallons per minute (gpm).

Extraction wells PFE-5 and PFE-6, with an estimated combined flow rate of 200 gpm, specifically address NDMA/DMN plume containment. In the plume-front vicinity, the DMN plume has a similar extent to the NDMA plume but significantly lower concentrations. To ensure stabilization of the NDMA/DMN plume-front, which does not extend as far west as the TCE plume, wells PFE-5 and PFE-6 will be positioned to stabilize the NDMA/DMN plume-front concentrations east of the TCE target wells. The estimated total system flow rate will be 1,010 gpm.

Groundwater contaminant destruction will be performed using a groundwater treatment system. The groundwater from the extraction well system will be pretreated as necessary, treated by an ultraviolet (UV) oxidation unit (primarily for NDMA and DMN), and an air-stripper unit (for the VOCs). Contaminant treatment standards for the injected water have been developed following standards and guidelines from multiple Federal and State regulatory sources.

Remediated groundwater injection will be accomplished by four injection wells (PFI-1 through PFI-4) located to the west and south of the contaminant plume. The injection well locations are designed to contain the southern migration of the plume by creating a localized groundwater mound.

2.0 INTRODUCTION

This Plan addresses the stabilization and mass removal of low-concentration groundwater contamination encountered at the leading (westernmost) edge of the WSTF groundwater contaminant plume (referred to as the plume-front). This Plan presents a pump and treat presumptive remedy. Descriptions of presumptive remedies policies and procedures are provided in U.S. Environmental Protection Agency (EPA) Presumptive Remedies Policy and Procedures Directive (EPA, 1993; EPA, 1996).

2.1 SITE LOCATION AND DESCRIPTION OF PROJECT AREA

WSTF is located on the western flank of the southern San Andres Mountains approximately 18 miles northeast of Las Cruces, New Mexico and 65 miles north of El Paso, Texas (Figure 2.1). Access to the site from Las Cruces is provided by a paved road, which intersects U.S. Highway 70 one mile west of Organ, New Mexico.

The WSTF plume is approximately 20,000 feet in length, up to 8,000 feet in width (at the plume-front) and 700 feet in depth. The plume consists of three general areas: the source areas; the mid-plume constriction area (MPCA); and the plume-front area. The WSTF plume-front area illustrated by Figure 2.2 is hosted within a transitional hydrogeological zone between the western San Andres Mountains fractured bedrock pediment slope and the alluvial filled Jornada del Muerto Basin (JDMB). This transitional zone is referred to as the WBFZ (Figure 2.2), and comprises an area of pronounced half-graben bedrock faulting related to Tertiary Basin and Range extension. Groundwater at the plume-front occurs at a depth of 420 feet below ground surface (bgs), with low-concentration groundwater contamination confined to the upper 600 feet of the aquifer.

2.2 REGULATORY BACKGROUND

This Plan has been prepared in response to discussions on September 16, 1998 between representatives from the EPA Region 6, New Mexico Environment Department (NMED) Hazardous and Radioactive Materials Bureau (HRMB), NMED Ground Water Quality Bureau (GWQB), and NASA. EPA and NMED representatives requested this Plan to identify and describe the plume-front stabilization and treatment activities proposed by NASA.

The format of this Plan was developed in accordance with Chapter II and Appendix E of the Resource Conservation and Recovery Act (RCRA) Corrective Action Plan Final (EPA, 1994), Presumptive Remedies: Policy and Procedures Directive (EPA, 1993), and Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites (EPA, 1996). NASA, during the September 16, 1998 meeting, voluntarily proposed a corrective action for the WSTF plume-front area. Both the

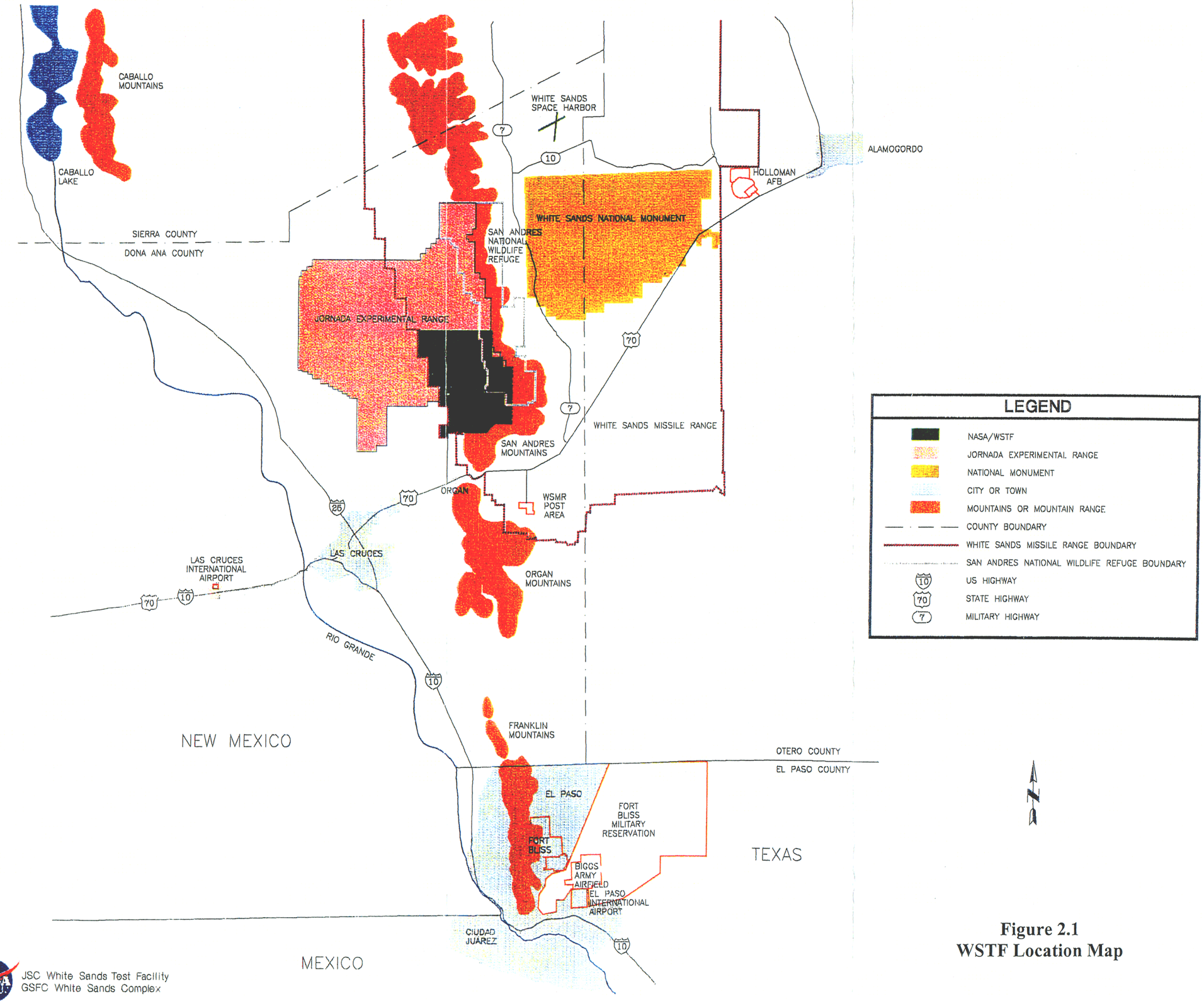
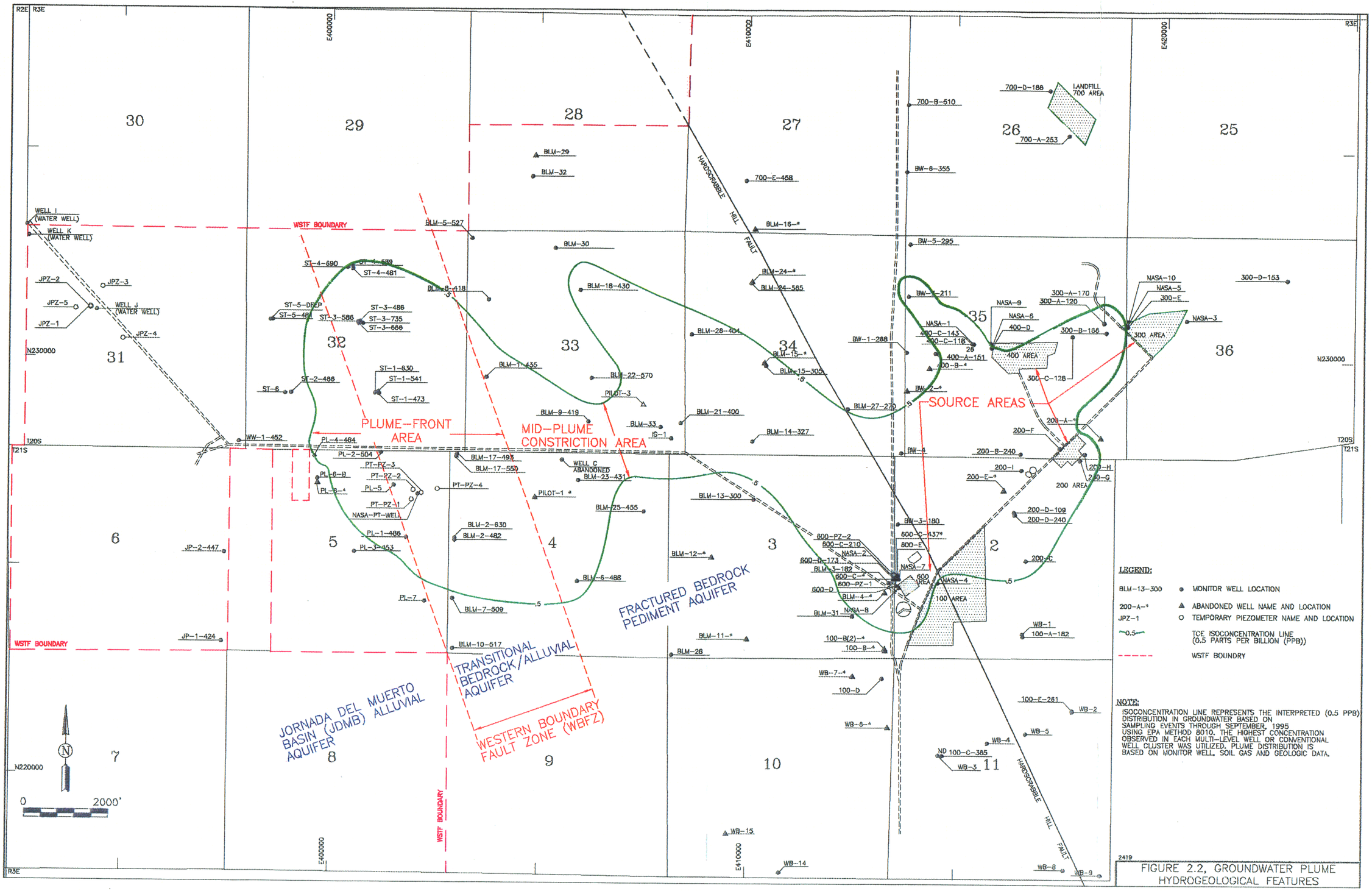


Figure 2.1
WSTF Location Map



LEGEND:

BLM-13-300	MONITOR WELL LOCATION
200-A-*	ABANDONED WELL NAME AND LOCATION
JPZ-1	TEMPORARY PIEZOMETER NAME AND LOCATION
0.5	TCE ISOCONCENTRATION LINE (0.5 PARTS PER BILLION (PPB))
	WSTF BOUNDRY

NOTE:

ISOCONCENTRATION LINE REPRESENTS THE INTERPRETED (0.5 PPB) DISTRIBUTION IN GROUNDWATER BASED ON SAMPLING EVENTS THROUGH SEPTEMBER, 1995 USING EPA METHOD 8010. THE HIGHEST CONCENTRATION OBSERVED IN EACH MULTI-LEVEL WELL OR CONVENTIONAL WELL CLUSTER WAS UTILIZED. PLUME DISTRIBUTION IS BASED ON MONITOR WELL, SOIL GAS AND GEOLOGIC DATA.

2419

FIGURE 2.2, GROUNDWATER PLUME HYDROGEOLOGICAL FEATURES

EPA and NMED verbally concurred with this proposal and encouraged NASA to give high prioity to implementation of the plume-front stabilization activities.

Technical information relative to the nature of the WSTF groundwater contaminants, their environmental setting and modes of transport in the subsurface have been collected at WSTF and evaluated from the mid-1980s to present. Pursuant to a 3008(h) Consent Order between EPA Region 6 and NASA, technical results and evaluations were provided in the Draft RCRA Facility Investigation (RFI) and Corrective Measures Study (CMS) Reports (NASA, 1996a; NASA, 1996b).

The primary groundwater contaminants observed within the plume-front area are NDMA, DMN and halogenated VOCs. Chapter Three of the Draft CMS Report (NASA, 1996b) identified and evaluated treatment technologies available to remediate these groundwater contaminants. Unfortunately, NDMA and DMN are particularly recalcitrant to in-situ treatment and require ex-situ pump and treat methodologies.

3.0 CURRENT CONDITIONS

This section provides an overview of the current conditions which influence the nature, distribution and migration of plume-front groundwater contamination. Comprehensive discussions of current conditions are provided in Volumes Two through Four of the Draft RFI Report (NASA, 1996a). Historical, current and predicted geological, hydrogeological and contaminant conditions have been input into a conceptual WSTF groundwater model which is described in detail later in this Plan. The groundwater model is used as a tool to simulate predictive contaminant trends and examine the effectiveness of different plume-front stabilization alternatives.

3.1 SITE GEOLOGY

3.1.1 Stratigraphy

Bedrock locally outcrops adjacent and east of the WSTF test areas, the primary sources for groundwater contamination. Bedrock stratigraphic units include Pennsylvanian to Permian-age limestone, sandstone, siltstone, and shales to the east within the WSTF test areas, and Tertiary volcanic rocks to the west. The two bedrock lithologies are juxtaposed in the subsurface along the regional northwest-trending Hardscrabble Hill Fault (Figure 2.2). Bedrock is covered with a veneer of alluvium, which increases in thickness to the west from a few feet in the vicinity of the test areas to over 400 feet near the WBFZ. This alluvium consists of Quaternary alluvial fan deposits of the Santa Fe Group derived from the San Andres Mountains to the east.

The Santa Fe Group alluvium is a consolidated to unconsolidated, poorly sorted gravel with a matrix of sand, silt, and clay. Surface geology in the plume-front area consists of Quaternary mid to distal alluvial fan Santa Fe Group deposits made up of limestone, siltstone, shale, rhyolite, andesite, and granite clasts. The thickness of alluvial deposits in the plume-front

vicinity increase from approximately 400 feet on the bedrock pediment to in excess of 2,500 feet within the JDMB (Draft RFI Report, Volume Two, Chapter Four, NASA, 1996a).

Tertiary volcanic bedrock units within the plume-front area consist of variable acidic volcanic rocks. Rhyolitic tuffs predominate and consist of crystal-vitric-lithic ash-flow tuffs. Correlative lithologies have been reported in association with the Organ Mountains Intrusive Complex (Seager, 1981). The flow-banded rhyolite (FBR) volcanic unit represents the most texturally distinct lithology of the west pediment area. The FBR forms a distinct hydrostratigraphic unit that is fundamental in creating a hydrogeological feature referred to as the MPCA.

3.1.2 Structure

Two types of geologic deformation are recognized within WSTF. The oldest and least prevalent deformation consists of west to northwest-trending folding and faulting associated with the Late Cretaceous to Early Tertiary Laramide Orogeny. This compressional deformation type is confined to the western San Andres Mountains, and is exposed within the Bear Peak Fold and Thrust Zone (Seager, 1981).

The second deformation type consists of Late Tertiary Basin and Range normal faulting and is significant relative to the plume-front stabilization activities. East-west extensional forces resulted in the formation of north-trending structural depressions and adjacent fault-bound mountains from the Oligocene period to present. Numerous subsurface Basin and Range-related normal faults have been inferred from seismic and well log data throughout the site, including the Hardscrabble Hill Fault (Draft RFI Report, Volume Two, Chapter Four, NASA, 1996a). The most significant expression of normal faulting at WSTF is the WBFZ, which is coincident with the plume-front area. The WBFZ is a north-northwest trending, regional-scale series of normal half-graben faults that offset the top of the bedrock by greater than 2,000 feet over a width of 2,000 feet. Each normal fault within the series dips steeply to the west.

3.2 SITE HYDROGEOLOGY

3.2.1 Aquifer Description

Groundwater below the WSTF test areas and west to the WBFZ is hosted within a fractured bedrock aquifer at depths which increase from approximately 100 feet to 400 feet bgs. Within and west of the WBFZ, groundwater is located within the JDMB alluvial aquifer at a depth of approximately 420 feet bgs (Figure 2.2). The alluvial aquifer has a thickness in excess of 2,500 feet toward the center of the JDMB (Maciejewski, 1996) where it yields relatively large quantities of potable water. Within the WBFZ area, the plume-front is hosted within a transitional alluvium/bedrock aquifer, with the thickness of saturated alluvium increasing to the west.

Two hydrogeologic groundwater flow barriers have been identified on the WSTF pediment slope within the mid-plume, semi-confined, fractured bedrock aquifer. Secondary porosity

consisting of fractures with dips ranging from 45 to 65 degrees with minor separation predominates within the aquifer. These barriers combine to form the narrow MPCA. To the north, the northwest-southeast trending FBR unit with low permeability and transmissivity (T) restricts groundwater flow. Groundwater sample analyses within this area indicate no detectable contaminant concentrations. To the south, a second flow barrier is created by andesite that has been altered to impermeable clay, promoting low hydraulic conductivities and no detectable contaminant concentrations. These barriers result in a natural confining area to contaminant flow both to the north and south. In the MPCA, groundwater occurs at a depth of 300 feet bgs and is coincident with bedrock. An MPCA measure evaluation is currently in progress within this area to determine if mid-plume interception and treatment of the groundwater contamination is feasible (NASA, 1998a; Giles and Pearson, 1998).

Aquifer conditions in the vicinity of the plume-front vary from unconfined to leaky confined. Leaky confined conditions are generally prevalent within and to the west of the WBFZ. Discontinuous confining layers are interpreted to comprise clay or cemented alluvial horizons. Hydraulic conductivity (K) and T values for the alluvial aquifer are typically several orders of magnitude greater than for the fractured bedrock aquifer.

3.2.2 Groundwater Movement

East to west groundwater flow within the fractured bedrock aquifer below WSTF is generated as a result of San Andres Mountain-front recharge and subsequent infiltration downgradient into the JDMB. Horizontal hydraulic gradients at WSTF are relatively steep within the pediment area at 0.05 (250 feet/mile) and decrease west of the WBFZ within the alluvial aquifer to 0.0002 (1.1 feet/mile). Localized bedrock variations and alluvial lithologies influence the groundwater flow direction. Within the Tertiary volcanic pediment region of the bedrock aquifer (within and west of the WBFZ), small-scale, interconnected fractures are interpreted to promote localized irregular downgradient groundwater movement. The fracture matrix density is generally high enough to approximate a porous flow environment.

3.2.3 Groundwater Recharge/Discharge

The San Andres Mountains provide recharge to the bedrock and alluvial aquifers through the infiltration of precipitation into exposed bedrock fractures and faults. Mountain-front recharge is estimated to be 50 to 200 acre-feet per mile of mountain front annually (Wilson et. al., 1981; Geoscience Consultants, Ltd. (GCL), 1995; NASA, 1997a).

Direct recharge by infiltration into the JDMB is low as a result of high evaporation, low precipitation, significant depths to groundwater, and the presence of thick lacustrine clays, which inhibit percolation. Minor point recharge areas are present on the pediment slope where WSTF has discharged excess water relatively continuously over the last 30 years. Approximately 90 percent of the groundwater utilized by WSTF is used for testing in the 300 and 400 Areas. The spent test water is then discharged to grade and percolates into the adjacent arroyo to recharge the groundwater. A total of 90 acre-feet annually is estimated to recharge the aquifer over a distance of 7,000 feet downgradient of the 300 Area.

The current total groundwater discharge/pumpage of the JDMB aquifer is approximately 2,000 acre-feet per annum (1,200 gpm). Approximately 55 percent of the withdrawn water is used by small independent users, 33 percent by local water companies, nine percent by WSTF, and three percent by the City of Las Cruces. Conservative over-estimates predict future JDMB water usage/pumpage to total 32,000 acre-feet per annum by the year 2026, of which 55 percent will be used by the City of Las Cruces, 28 percent by local water companies, 17 percent by small independent users, and two percent by WSTF. The JDMB aquifer is not currently significantly stressed; however, the future population growth and expanded JDMB groundwater usage are anticipated to result in significant groundwater drawdown (Draft RFI Report, Volume Four, Chapter Two, NASA, 1996a).

3.2.4 Groundwater Quality

WSTF groundwater is classified as fresh to slightly saline and is characterized by elevated levels of sodium, sulfate, and bicarbonate (Wilson et. al., 1981; Draft RFI Report, Volume Two, Chapter Four, NASA, 1996a). Total dissolved solids (TDS) concentrations range from 490 to 1,230 parts per million (ppm). Fluoride, iron and manganese levels are generally low. Water hardness ranges from 24 to 320 ppm, and water pH values are slightly alkaline with values ranging from 7.2 to 8.3. Sulfate is the most abundant anion, with concentrations ranging from 185 to 600 ppm. Chloride and bicarbonate concentrations range from 15 to 126 ppm and 89 to 376 ppm, respectively. Nitrate levels are generally below 10 ppm, although concentrations up to 40 ppm have been detected. Concentrations of fluoride are usually less than two ppm. Dominant cations comprise the metals calcium, iron, magnesium, potassium, and sodium. Calcium concentrations range from 22 to 179 ppm. Magnesium and sodium concentrations range from 12.6 to 84 ppm and 28 to 500 ppm, respectively. Iron and potassium occur in trace amounts to 0.8 ppm and 9 ppm, respectively. Concentrations of sodium range from 30 to 157 ppm.

3.2.5 Background Metals' Concentrations

Volume Four, Chapter Two of the Draft RFI Report (NASA, 1996a) provides discussions concerning observed concentrations of RCRA regulated metals in groundwater samples. This chapter includes discussions of observed metals' concentrations such as barium, lead and selenium, which are indicative of naturally occurring levels in the JDMB. In addition, chromium detections are discussed and attributed to either naturally occurring levels or to published leaching problems associated with stainless steel casing. EPA and NMED comments to the Draft RFI Report (EPA, 1997) requested additional data presentations and evaluations concerning these metals.

The EPA/NMED comments have resulted in additional data evaluations by WSTF personnel; these evaluations have thus far supported the Draft RFI Report statements. Final evaluations and statistical analyses will be presented within the revised Draft RFI Report. Data collected from the plume-front wells do not indicate that metals' concentrations are associated with groundwater contamination. No corrective action evaluations are required for these constituents at the plume-front.

3.3 CONTAMINATION

Groundwater contamination within the plume-front area originated from historical site waste management activities. The primary sources of contamination were the closed 200, 300, 400, and 600 hazardous waste management units (HWMUs). NASA submitted closure reports and a Certificate of Closure was issued for the 200 through 600 Areas in May and August 1989. NMED approved the Certificates of Closure for the 200, 300, 400 and 600 Areas in November 1989. The individual contributions of the closed HWMUs to the plume-front contamination cannot be determined. Detailed discussions of the historical source area activities and contributions to the groundwater contamination are provided in Volume Three and Volume Four, Chapter Two of the Draft RFI Report (NASA, 1996a).

3.3.1 Groundwater Contamination

The following COCs have been observed within the plume-front area: NDMA; DMN; TCE; PCE; trichlorofluoromethane (Freon 11); dichlorofluoromethane (Freon 21); and 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113). The maximum reported concentrations from groundwater samples within the plume-front area taken from the WSTF contaminant analytical database through September 1, 1998 are: NDMA - 3,400 parts per trillion (ppt), DMN - 1,700 ppt, TCE - 380 parts per billion (ppb), PCE - 19 ppb, Freon 11 - 860 ppb, Freon 21 - 60 ppb, and Freon 113 - 2,000 ppb. NDMA and DMN are highly soluble in water. TCE, PCE, and the Freon compounds are halogenated volatile organic, dense, non-aqueous phase liquids. Table 3.1 presents a summary of the physical and chemical characteristics for the plume-front contaminants. Detailed discussions of these contaminants, excluding DMN, are provided in Volume Four, Chapter Two of the Draft RFI Report (NASA, 1996a). DMN contamination was discovered at WSTF following the submission of the Draft RFI Report.

The groundwater contamination plume has migrated downgradient with the flow of groundwater from the WSTF test areas, west through the MPCA, and into the WBFZ at the eastern margin of the JDMB. The contaminants with the most extensive plumes (Freon 113, Freon 11, TCE, NDMA, and DMN) are characterized by plume boundaries of similar shape and extent. Because DMN contamination was discovered after the Draft RFI/CMS Reports were submitted, the DMN plume was not simulated by the WSTF groundwater model. Stabilizing the NDMA plume will also contain the DMN plume because the plumes for DMN and NDMA are extremely similar and the concentrations of DMN are lower than NDMA. Therefore, the data generated for NDMA will be utilized for DMN. The conceptualized plumes for NDMA, TCE and PCE generated by the WSTF groundwater model are presented by Figures 3.1, 3.2 and 3.3, respectively. The contaminant plumes can be divided into three sections with distinct characteristics, comprising the industrial source areas, MPCA and the plume-front area (Figure 2.2).

3.4 GROUNDWATER MODEL SETUP AND CALIBRATION

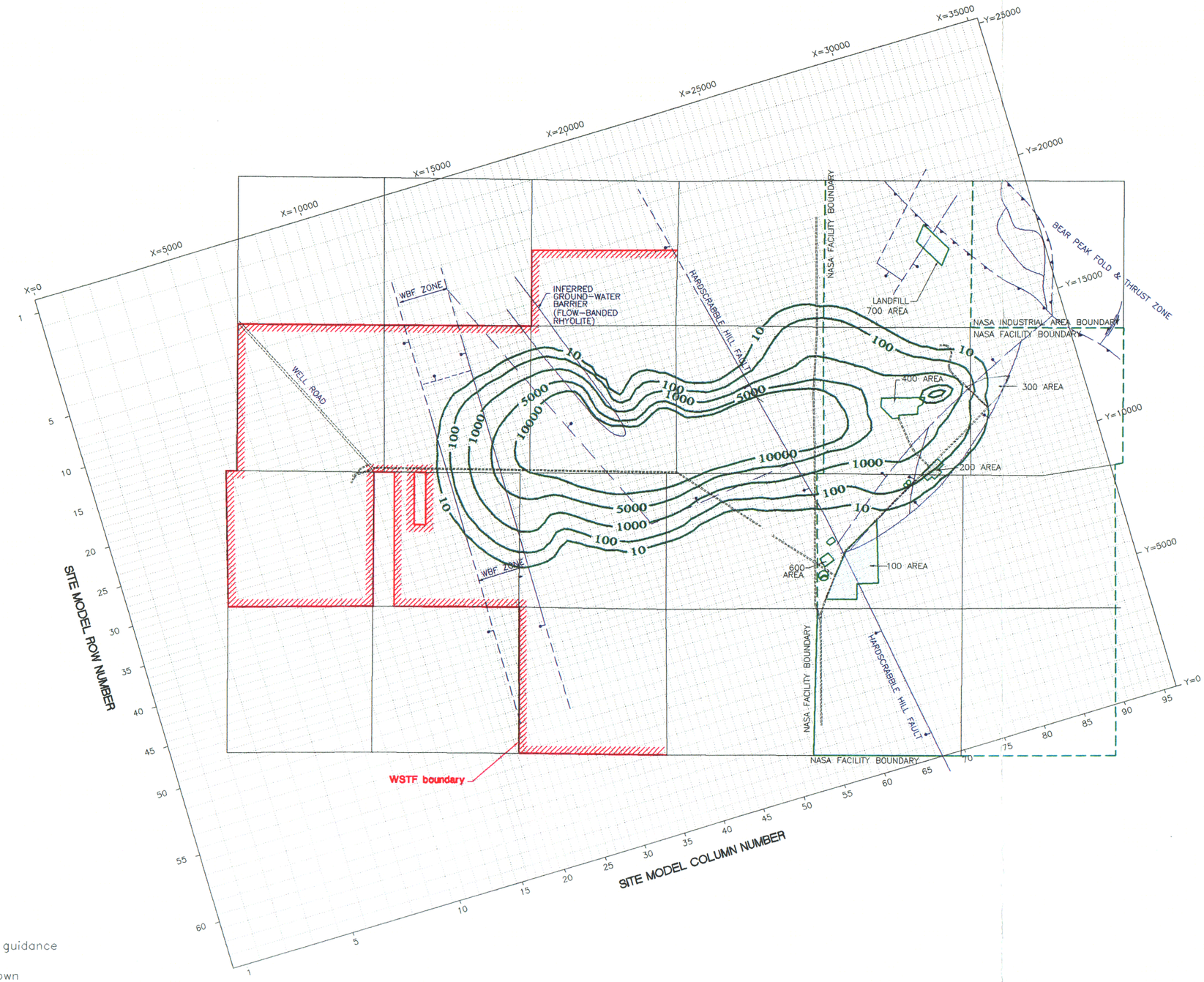
Groundwater modeling activities at WSTF were initiated in 1989. Development procedures for the groundwater model through 1994 are documented by GCL (1995).

TABLE 3.1: PHYSICAL AND CHEMICAL PROPERTIES OF PLUME-FRONT CONSTITUENTS OF CONCERN

COMPOUND	MOLECULAR WEIGHT (g/mol)	SPECIFIC GRAVITY	SOLUBILITY (mg/l)	BOILING POINT (°C)	VAPOR PRESSURE (mm Hg)	HENRY'S LAW CONSTANT ($atmm^3/mol$)	LOG K_{ow}
NDMA	74.08[a]	1.0059[a] $_{20/4°C}$	Miscible[a]	154[a]	8[a] $_{25°C}$	1.43E-1[a] $_{25°C}$	-0.47[a]
PCE	165.83[a]	1.6227[a] $_{20/4°C}$	150[a] $_{25°C}$	121[a]	19[a] $_{25°C}$	2.685E-2[a] $_{25°C}$	2.53[a]
TCE	131.39[a]	1.4642[a] $_{20/4°C}$	1,100[a] $_{25°C}$	87[a]	77[a] $_{25°C}$	1.17E-2[a] $_{25°C}$	2.53[a]
Freon 113	187.38[b]	1.5635[b] $_{20/4°C}$	170[b] $_{25°C}$	47.7[b]	362.5[c] $_{25°C}$	5.26E-1[c] $_{25°C}$	3.16[c]
Freon 11	137.38[a]	1.494[a] $_{17.2/4°C}$	1,100[a] $_{25°C}$	23.7[a]	687[a] $_{20°C}$	5.83E-2[a] $_{25°C}$	2.53[a]
Freon 21	102.92[b]	1.405[a] $_{9°C}$	9,500[b] $_{25°C}$	9[b]	1,199[e]	1.04E-2[e]	1.29[d]
DMN	90.08[h]	---	Miscible[h]	---	1.7[h] $_{20°C}$	---	---

[a] Handbook of RCRA Ground-Water Monitoring Constituents Chemical and Physical Properties, September 1992.
[b] CRC Handbook of Chemistry and Physics, 71st Edition, 1990.
[c] Handbook of Environmental Fate and Exposure Data for Organic Chemicals, 1990.
[d] EPA Treatability Manual, 1981.
[e] *Journal of Physical Chemistry Reference Data*, Vol. 10, No. 4, 1981.
[f] Henne, L., *Journal of American Chemical Society*, 1936.
[g] Bitner et. al., U.S. Dep. Comm. Off. Tech. Serv. Rep., 1958.
[h] New Jersey Department of Health and Senior Services, Hazardous Substance Fact Sheet, 1998.

K_{ow} Octanol-water Partition coefficient



N

0 4000 ft

Explanation

- 10 — Maximum simulated NDMA concentration (ppt) for 1992
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side (dashed where inferred)

T:\VDR\8010\801014F.DWG

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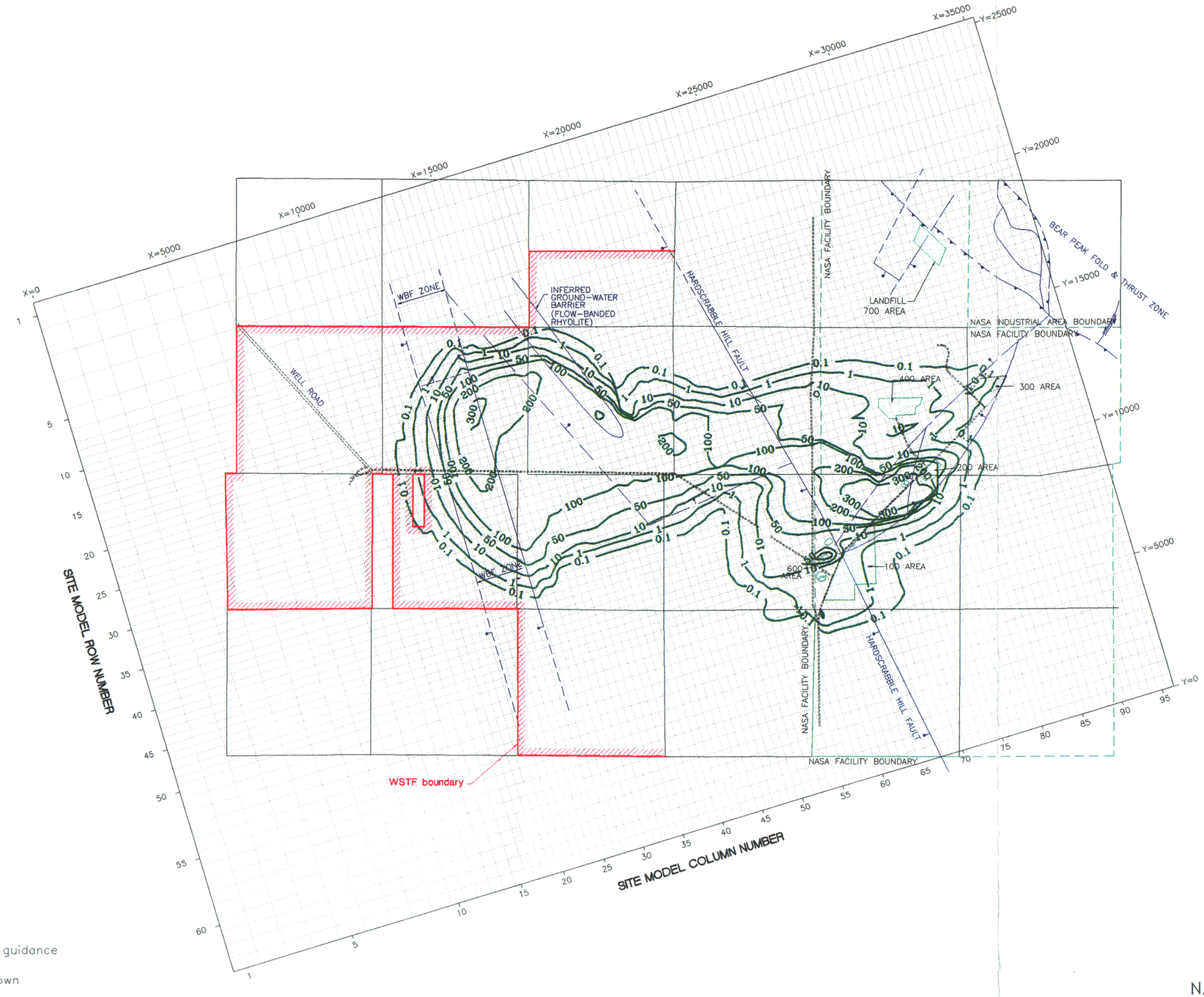
11-5-98 JN 8010

NASA–WSTF MODELING

Plume Front Containment
Simulated NDMA Plume for 1992

Figure 3.1



N

0 4000 ft

Explanation

- 0.1 — Maximum simulated TCE concentration (ppb) for 1992
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side (dashed where inferred)

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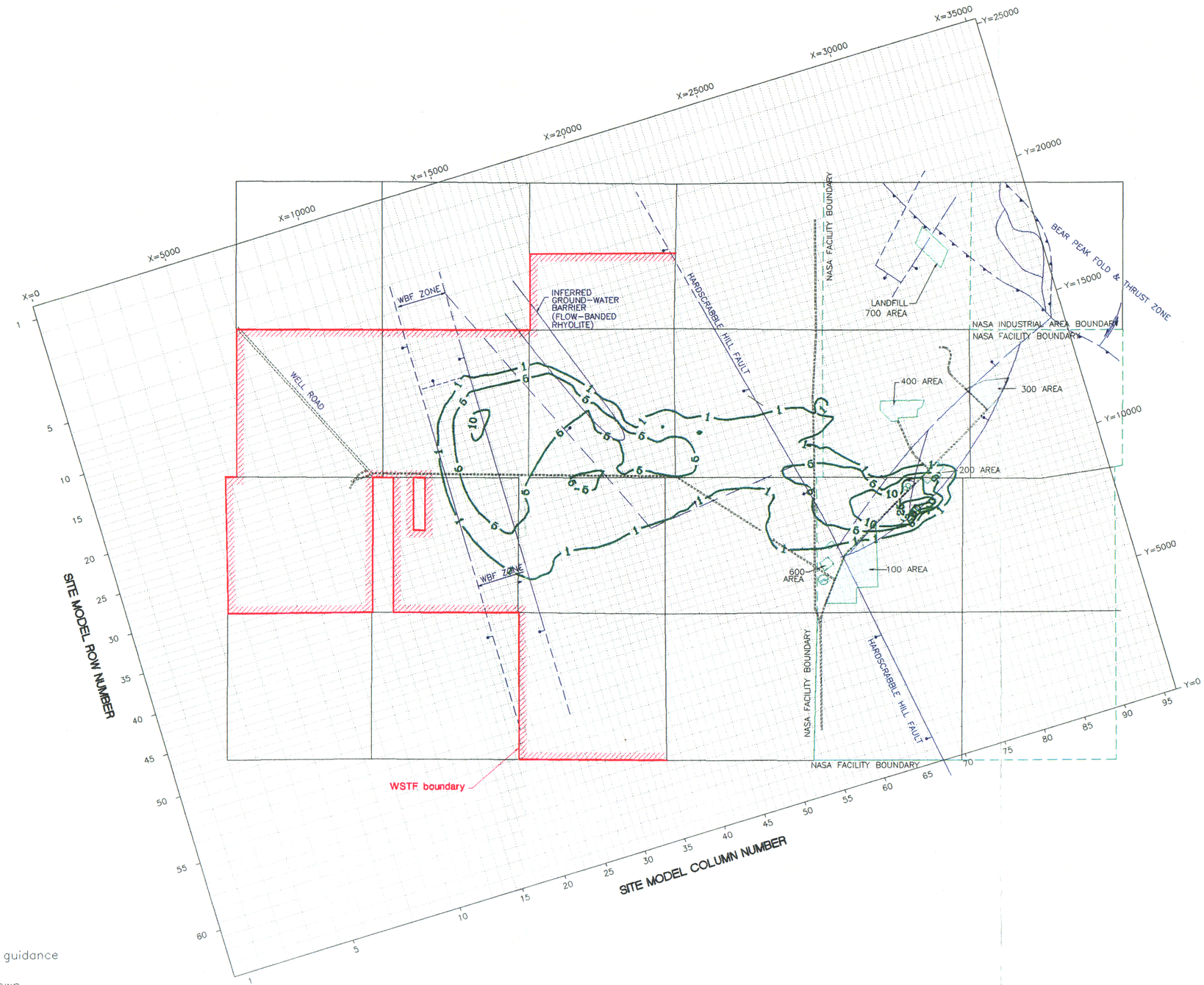
NASA–WSTF MODELING

Plume Front Containment
Simulated TCE Plume for 1992

Figure 3.2



N

0 4000 ft

Explanation

- Maximum simulated PCE concentration (ppb) for 1992
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side (dashed where inferred)

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NASA-WSTF MODELING

Plume Front Containment
Simulated PCE Plume for 1992

Figure 3.3

Daniel B. Stephens & Associates, Inc. (DBS&A) have performed subsequent model calibration activities and the processing of predictive simulations. Results of these modeling activities are documented in three reports (DBS&A, 1995a; DBS&A 1995b and DBS&A, 1998). All groundwater modeling activities and reports through 1996 are included within the Draft RFI and CMS Reports (NASA, 1996a; NASA, 1996b).

3.4.1 Description of Groundwater Model and Programs

Two separate groundwater models have been constructed to simulate WSTF groundwater flow and contaminant solute transport conditions. The first model comprises a two-dimensional basin-scale representation of the southern JDMB. This model provides a regional-scale simulation capable of addressing the impacts that future JDMB pumpage may have on site model boundary water levels. The regional model is calibrated to regional groundwater levels recorded in the JDMB between 1963 and 1992, and is used to predict site model boundary conditions for the period 1992 to 2026.

The second model is utilized for predictive groundwater flow and solute transport simulations, and is referred to as the 3DSWB model. This local-scale model has dimensions of 26,000 feet by 36,000 feet and is elongate to the east-northeast parallel to the axis of the contaminant plume. Grid spacing is sufficiently dense to account for site-specific features. Three computer programs are applied as part of the 3DSWB model. The United States Geological Survey's three-dimensional finite difference program, MODFLOW (McDonald and Harbaugh, 1988), is used to simulate groundwater flow. Once the groundwater flow field is determined for a remedial scenario using MODFLOW, the appropriate output files are used as input to two additional programs, PATH3D (Zheng, 1989) and MT3D (Zheng, 1992), to evaluate contaminant transport.

PATH3D is a three-dimensional particle tracking program in which imaginary particles are introduced into the groundwater flow field to trace groundwater flow pathlines. The program is used in conjunction with MODFLOW to simulate flow pathlines for groundwater recovery scenarios. This tool is used to identify the number of wells required and determine their respective optimal pumping rates to contain the contaminant plumes. PATH3D runs have been performed for two of the four primary health risk contaminants (NDMA and TCE). PATH3D is utilized to predict optimum groundwater recovery well locations by tracking flow pathlines from the boundary of the NDMA plume (maximum concern relative to health risk) and the TCE plume (greatest dimensions of the significant health risk contaminants) to ensure recovery well capture.

The PATH3D program assumes that contaminant transport is due to advection only. The three-dimensional numerical transport program MT3D accounts for the physical processes of advection, dispersion, retardation, and chemical decay, and is applied to simulate changes in contaminant concentrations over time.

The 3DSWB flow and solute transport model is utilized as a tool to:

- understand the complex site hydraulics;

- predict contaminant fate and transport;
- integrate site data;
- assist in monitor/remediation well placements;
- prioritize data collection efforts;
- predict future health and environmental risks;
- assess the performance of potential corrective actions; and
- serve as a facility management tool to address water supply considerations.

3.4.2 Construction of the WSTF 3DSWB Conceptual Model

The complex WSTF hydrogeological and groundwater contaminant conditions simulated by the 3DSWB model are addressed in Sections 3.1 through 3.4 of this Plan. Detailed physical parameter analyses for each of the contaminants, excluding DMN, and potential migration patterns are provided in Volume Four, Chapter Two of the Draft RFI Report (NASA, 1996a). The model contains calibrated groundwater flow conditions for the period January 1963 to December 1992, and a calibrated contaminant transport model for the contaminants NDMA, TCE and PCE for the same period. The calibration of the groundwater flow model relies largely on the reproduction of observed groundwater heads within water wells across WSTF and into the JDMB. Contaminant transport models for NDMA, PCE and TCE were calibrated to simulate current observed concentrations primarily by adjusting the contaminant source area parameters. While the hydrologic properties of the model can be created using detailed information from groundwater monitoring wells, the simulation of volume and timing of the source area releases is an iterative process and cannot be accurately defined. The simulation results for 1993 were used as the starting concentrations for the predictive simulations.

The model plume simulations are conservative and are constructed to approximate hand-contoured plumes for maximum observed WSTF contaminant concentrations. Hand-contoured plumes presented in Volume Four, Chapter Two of the Draft RFI Report (NASA, 1996a) represent the maximum contaminant concentration measured at any depth at a particular well location. Simulated plumes provide the maximum concentration within any model layer at a particular Cartesian coordinate. Near the eastern edge of the model domain, the maximum contaminant concentrations will most often be found in fractured bedrock corresponding to model layers two through seven, while in the western portion of the model domain, the maximum contaminant concentration generally occurs within alluvium in layers 10, 11 or 12.

3.4.3 3DSWB Model Calibration for Contaminant Migration

The simulated NDMA, TCE and PCE contaminant plumes, calibrated to historical analytical results for 1992, are presented in Figures 3.1 through 3.3. The simulations differ slightly from the observed (measured) plumes in the respect that the simulated plumes are more dispersed, particularly within the plume-front area specific to this Plan. These differences allow an aggressive approach to plume-front containment due to the greater dimensions of contamination for the simulated plume. Conversely, the high concentration zones east of the plume-front area are slightly underestimated by the simulation results. Because plume-front

capture is achieved and remedial system design for the influent groundwater is based on observed concentrations as well as the simulations, the simulated plumes are considered to be conservative.

Simulation of the NDMA plume is critical relative to health risk evaluations. The NDMA plume (Figure 3.1) has two distinct concentration areas: relatively higher concentrations to the east, and lower concentrations downgradient between the 400 Area and the plume-front. Because the NDMA plume-front distribution has a similar generalized configuration and extent as the TCE and PCE plumes, the NDMA releases are assessed to have roughly the same timing as the TCE and PCE releases. High concentrations toward the eastern source areas are likely to have been formed as a result of later releases after the early 1960s. The source contaminants used for the final NDMA calibration run utilized a starting date of January 1973. Details of the methods used in matching simulated to observed plumes for NDMA, TCE and PCE are provided in DBS&A (1995a).

Retardation factors of 1.0 (no retardation) were used for TCE and PCE. The NDMA plume utilized a retardation factor of 1.2, indicating that the contaminant moves at a rate less than the average groundwater flow. The NDMA retardation value factor is justifiable due to the location of the main NDMA source areas. The observed dimensions of the NDMA plume were effectively simulated, particularly in the plume-front area, although the distribution of mass was not easy to simulate within the high-concentration NDMA zones to the east. The simulations yield higher than expected NDMA concentrations within the plume-front area. The NDMA plume-front modeling conservatively stabilizes the relatively higher NDMA concentrations generated by the modeling simulations.

3.5 HEALTH RISK ASSESSMENT

This section discusses the COCs at the plume-front, evaluates health risk and toxicity values, identifies potential receptors, summarizes exposure pathways, and presents the most current contour map of cumulative cancer risk values for the WSTF contaminant plume. Volume Six, Chapter One of the Draft RFI Report (NASA, 1996a) contains a detailed baseline human health risk assessment of the contaminant plume, excluding DMN.

Carcinogenic risk calculations were made using the Risk Assessment Guidance for Superfund (RAGS) (EPA, 1989), the most recent toxicity values obtained from the EPA Integrated Risk Information System (IRIS) (EPA, 1998a), and/or EPA Region 3 Risk-Based Concentration (RBC) Tables (EPA, 1998b), unless otherwise indicated.

3.5.1 Chemicals of Concern

The chemicals of primary health risk concern at the plume-front are NDMA, DMN, TCE, and PCE. Volume Six, Chapter One of the Draft RFI Report (NASA, 1996a) details the method of determining which chemicals become a concern to human health and/or the environment. Additional chemicals of concern, but of lesser health threat, are Freon 11, Freon 21 and Freon 113. Detailed release and toxicological data for each of these chemicals

is located in Appendices B-E, Volume Six of the Draft RFI Report (NASA, 1996a), excluding DMN.

3.5.1.1 Carcinogens

NDMA and DMN groundwater contamination originates from the historical management of hydrazine rocket fuels at WSTF. Due to the obscurity of DMN, there are limited toxicological or carcinogenic data available. NDMA and DMN have extremely similar chemical structures, and the most conservative approach for the health risk assessment of DMN is to apply NDMA health and cancer risk calculations to DMN. NDMA is considered a probable human carcinogen classified in Group B2 by the EPA. The primary target organs are the liver and lungs. Liver toxicity is the main effect from both acute and chronic exposure to NDMA. IRIS reports an oral slope factor (SF) of 51 $(mg/kg/day)^{-1}$.

TCE was used as a cleaning solvent for various test article components processed at WSTF. In the past, the EPA had classified TCE as a Group B2 carcinogen with cardiovascular and central nervous system effects and the liver as the target organ. However, chronic exposure effects in humans are uncertain at this point. A carcinogen assessment summary for TCE is currently under review by the EPA, and the toxicity information used for this assessment was taken from the EPA-National Center for Environmental Assessment (NCEA) provisional values. For purposes of the WSTF health risk assessment, a conservative approach was chosen. Therefore, TCE will be maintained as a carcinogen pending publication of a new carcinogen summary. The RBC Table lists an oral SF for TCE of 0.011 $(mg/kg/day)^{-1}$, the value drawn from IRIS, and a Reference Dose (RfD) of 0.01 mg/kg/day.

There is no carcinogen assessment summary of PCE available at this time from the EPA. Since chronic exposure effects in humans are uncertain at this point, the SF of 0.011 $(mg/kg/day)^{-1}$ used for this assessment is an EPA-NCEA provisional value. IRIS has published a RfD 0.01 mg/kg/day with liver damage noted in animal studies.

3.5.1.2 Non-Carcinogens

Halogenated VOCs were used historically as cleaning solvents and referee propellants at WSTF. Human exposure to high vapor concentrations could result in respiratory, central nervous system and/or cardiac effects, unconsciousness, and, in some cases, death by asphyxiation. Freon 11 is considered more toxic than Freon 113. IRIS assigns an RfD of 0.3 mg/kg/day to Freon 11 and 30 mg/kg/day to Freon 113.

Limited toxicological data exists for Freon 21. The National Institute for Occupational Safety and Health (NIOSH, 1990) lists a threshold limit value (TLV) of 10 ppm, two orders of magnitude less than the TLVs for Freon 11 and Freon 113 (both 1,000 ppm). From the Hazardous Substances Data Base:

> "Although toxicity due to acute inhalation is low, FC-21 is appreciably more toxic than related difluorinated methanes such as dichlorodifluoromethane or

chlorodifluoromethane. The chronic toxicity of FC-21 is markedly different from these compounds, and appears to be more similar to chloroform."

For purposes of the WSTF health risk assessment, the RfD for chloroform was used to calculate hazard quotients for Freon 21 concentrations detected in the groundwater plume. IRIS assigns a RfD to chloroform of 0.01 mg/kg/day. Toxicity information for plume-front chemicals is summarized in Table 3.2.

3.5.2 Potential Receptors and Exposure Pathways

Volume Five of the Draft RFI Report (NASA, 1996a) provides a detailed evaluation of potential receptors. There are no current human or ecological receptors of contamination within the plume-front area. The Draft RFI Report projects that contamination will not impact potential receptors for at least the next 30 years. The Draft RFI Report also contains a detailed discussion of population characteristics and current and future land use at and around WSTF. Exposure via groundwater is the pathway of potential concern for the plume-front area. Therefore, the focus of potential receptors and exposure pathways are groundwater wells located hydraulically downgradient from the plume-front.

The potential exposure pathway of concern to NASA is potential future contamination of the WSTF water supply wells. WSTF maintains three supply wells, Wells I, J and K, located in Section 31 of Township 20 South, Range 3 East (Figure 2.2). The proximity of these wells to the plume-front is presented in Figure 3.4. Currently, Well I is inactive and Wells J and K are used alternately to supply water to WSTF through a one million gallon reservoir in the 300 Area. If contamination of the water supply wells occurred, WSTF employees could be exposed to plume-front contaminants through ingestion or dermal contact with contaminated water. The possibility of exposure is low because WSTF is not open to the public and there are no permanent residents at the site. Only employees (all adults) are allowed on site, and therefore, employee exposures would be solely industrial in nature (40 hours/week).

Potential receptors include the privately owned domestic and irrigation wells located west of the NASA facility boundary. The five domestic wells shown in Figure 3.4 serve household and non-commercial yard and domestic animal uses. If the groundwater contamination plume reached these wells, residents could be exposed to plume-front contaminants through ingestion, dermal contact with, or possible consumption of garden crops or domestic animals exposed to contaminated water.

Two irrigation wells are located downgradient from the plume-front in Section 35, Township 20 South, Range 2 East (Figure 3.4). The eastern irrigation well is used to irrigate a 100-tree pecan orchard. The western irrigation well has been unused for many years. If the plume-front ever intercepted the pecan orchard well, human exposure could occur through bioaccumulation in the pecans and eventual human consumption. Human exposure resulting from use of the western irrigation well is uncertain at this time. The exposure scenario depends upon how the water would be used, whether for domestic animals or commercial crops.

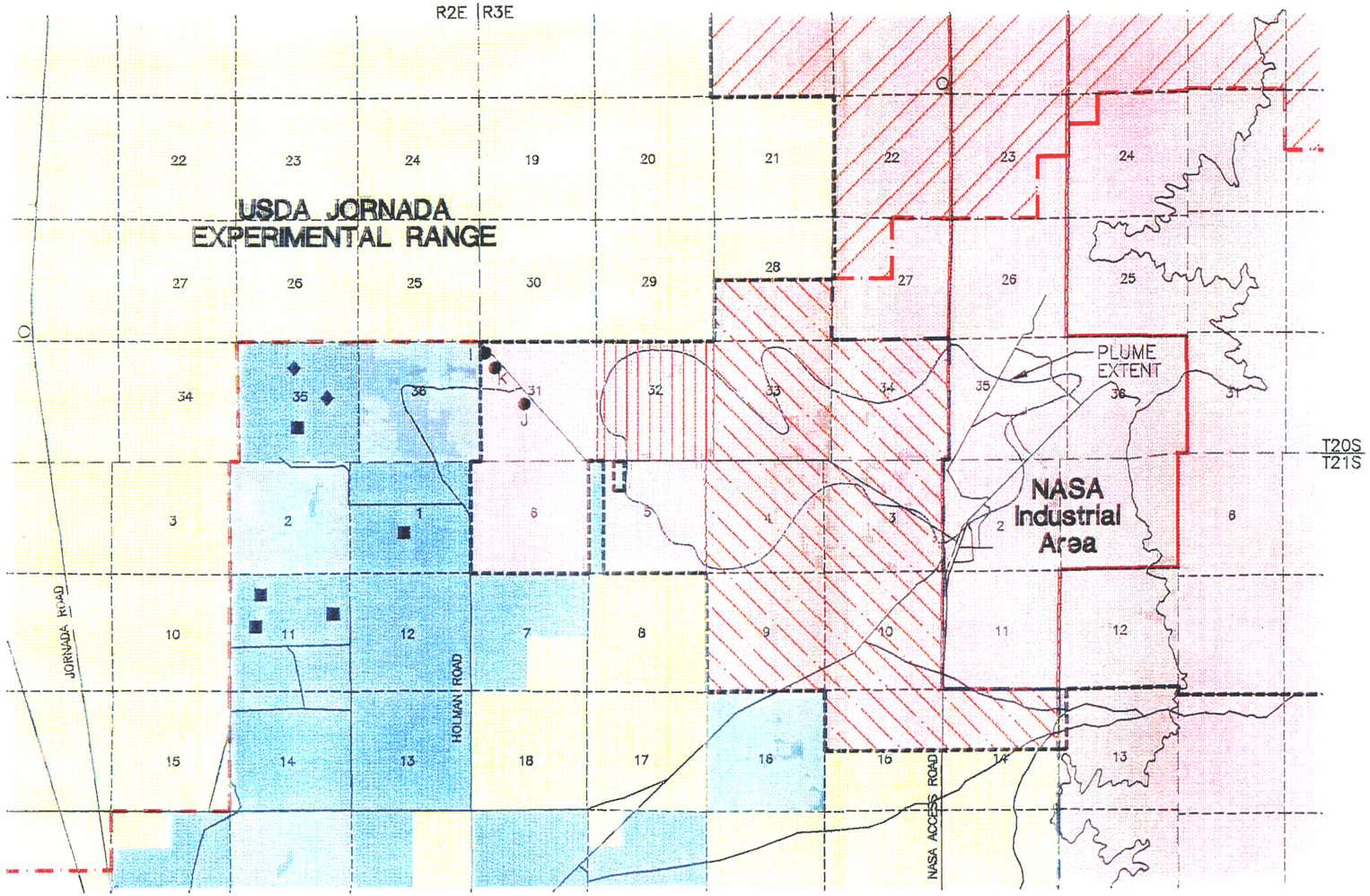
TABLE 3.2: TOXICITY INFORMATION FOR PLUME-FRONT CHEMICALS

Carcinogen	Oral Slope Factor (SF) $(mg/kg/day)^{-1}$	EPA Weight of Evidence Classification	Target Organ(s)	SF Source
NDMA	51	B2	Liver	IRIS
DMN	51[1]	B2[1]	Liver[1]	IRIS[1]
TCE	0.011	Under EPA review	Under EPA review	EPA-NCEA provisional value
PCE	0.052	Under EPA review	Under EPA review	EPA-NCEA provisional value
Non-Carcinogen	**Oral Reference Dose (RfD) (mg/kg/day)**	**Confidence Level & UF/MF**	**Health Effect**	**RfD Source**
Freon 11	0.3	Medium 1000/1	Psychomotor impairment	IRIS
Freon 113	30	Low 10/1	Psychomotor impairment	IRIS
Freon 21	0.01*	Medium* 1000/1	Psychomotor impairment	IRIS*
TCE**	0.006	No data	No data	EPA-NCEA provisional value
PCE**	0.01	Medium 1000/1	Liver	IRIS

*Chloroform RfD (see text in Section 3.5.2, Non-carcinogens)
**Carcinogens with RfD data available are included in the evaluation of non-carcinogenic effects.

MF- Modifying Factor
UF- Uncertainty Factor

[1] NDMA values are applied to DMN



6000 2000 0 12000

4000 6000

SCALE: 1" = 6000'

FIGURE 3.4

WSTF VICINITY WELL LOCATION MAP

CLIENT: NASA–WSTF

DATE: 8/2/95

DRAWN BY: A SILVA REVISED BY: R. CARPENTER

CHECKED BY: M. RUSSELL

DWG. NO. 2139

- STATE LAND
- FEDERAL LAND
- BLM LAND
- PRIVATE LAND
- INTER–AGENCY (STATE LAND COMMISSION–NASA Joint Use Agreement)
- INTER–AGENCY (USDA–DOD Joint Use Agreement)
- INTER–AGENCY (BLM–NASA Joint Use Agreement)
- NASA INDUSTRIAL AREA BOUNDARY
- JORNADA EXPERIMENTAL BOUNDARY
- WHITE SANDS MISSILE RANGE BOUNDARY
- NASA FACILITY BOUNDARY
- WSTF SUPPLY WELL
- IRRIGATION WELL
- DOMESTIC WELL
- LIVESTOCK WELL

Community water supply systems could also be potential receptors of contaminated groundwater. The Moongate Water Company, the City of Las Cruces, the Mountain View Water Company, and various smaller water companies have multiple wells to the south and west of WSTF. The City of Las Cruces has also proposed 14 new wells in the vicinity of Moongate to acquire an additional 14,000 acre-feet of water per year from the JDMB. Water usage has been conservatively estimated for the two-dimensional regional groundwater model within the JDMB through the year 2026.

3.5.3 Risk Characterization

The approaches used to determine cancer risk and hazard indices are based on the assumption that there are no synergistic or antagonistic interactions among the compounds involved, and that all compounds have the same toxic end points and mechanisms of action. The effects of exposure to each of the contaminants have been considered separately, then totaled for a straight-line additive effect, for both carcinogens and non-carcinogens.

NASA opted to take the most conservative approach in calculating cancer risk values and hazard indices. Maximum contaminant concentrations detected in RFI monitoring wells from the time period January 1, 1997 through September 1, 1998 were used. In wells where individual contaminants were not detected, cancer risk and hazard indices were calculated based on the lowest analytical detection limit. Intake assumptions associated with residential exposure via ingestion of contaminated groundwater were used, although no exposure pathways are complete, and industrial exposure to WSTF employees is the primary concern at this time.

3.5.3.1 Carcinogenic Risk Estimates

Carcinogenic SFs obtained from IRIS or EPA Region 3 RCB Tables were used to estimate the potential excess cancer risks associated with maximum levels of contamination detected at the WSTF groundwater monitoring wells. The chronic daily intake (CDI) was calculated using:

$$CDI = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$

where the variables for the equation are defined in Table 3.3.

The potential cancer risk was calculated by multiplying the CDI values by the chemical-specific SF (Risk = CDI x SF) and then by summing the carcinogenic chemicals of concern at each monitoring well. Table 3.4 lists the individual chemical and cumulative carcinogenic risk estimates for the plume-front monitoring wells. Values listed in bold italics reflect those calculated using the lowest analytical detection limit when a contaminant was not detected. The cumulative cancer risk values for all RFI groundwater monitoring wells have been contoured and the resultant map is shown as Figure 3.5.

TABLE 3.3: CHRONIC DAILY INTAKE (CDI) ASSUMPTIONS

Adult Ingestion of Contaminated Groundwater

PARAMETER	EXPOSURE ASSUMPTION
CW (Exposure Point Concentration in Groundwater)	Maximum concentration detected in monitoring wells.
IR (Ingestion Rate)	2 liters/day
EF (Exposure Frequency)	350 days/year
ED (Exposure Duration)	30 years at a residence
BW (Body Weight)	70 kg Adult
AT (Averaging Time)	70 years x 365 days/year-Carcinogens 30 years x 365 days/year-Non-carcinogens

TABLE 3.4: CARCINOGENIC RISK ESTIMATES FOR PLUME-FRONT MONITORING WELLS

Well(s)	NDMA	DMN	TCE	PCE	Cumulative
BLM-2 Group	$1.07x10^{-3}$	$4.59x10^{-4}$	$3.35x10^{-5}$	$6.69x10^{-6}$	$1.57x10^{-3}$
BLM-7-509	***<2.98x10^{-5}***	***<2.27x10^{-5}***	***<6.44x10^{-8}***	***<3.04x10^{-7}***	***<5.29x10^{-5}***
BLM-17 Group	$3.70x10^{-3}$	$1.97x10^{-3}$	$2.45x10^{-5}$	$6.08x10^{-6}$	$5.70x10^{-3}$
PL-1-486	***<2.98x10^{-5}***	***<2.27x10^{-5}***	$1.03x10^{-5}$	$1.22x10^{-6}$	***<6.40x10^{-5}***
PL-2-504	***<2.98x10^{-5}***	$1.25x10^{-5}$	$1.67x10^{-5}$	$4.26x10^{-7}$	***<5.95x10^{-5}***
PL-3-453	$2.46x10^{-6}$	***<5.97x10^{-6}***	***<6.44x10^{-8}***	***<3.04x10^{-7}***	***<8.79x10^{-6}***
PL-4-464	***<5.97x10^{-6}***	***<5.97x10^{-6}***	$1.93x10^{-7}$	***<3.04x10^{-7}***	***<1.24x10^{-5}***
PL-5	$8.59x10^{-4}$	$3.22x10^{-4}$	$4.50x10^{-5}$	$9.73x10^{-6}$	$1.24x10^{-3}$
PL-6	$6.98x10^{-7}$	$5.37x10^{-6}$	$4.89x10^{-7}$	***<3.04x10^{-7}***	***<6.86x10^{-6}***
PL-7	***<5.97x10^{-6}***	***<5.97x10^{-6}***	***<6.44x10^{-8}***	***<3.04x10^{-7}***	***<1.23x10^{-5}***
ST-1 Group	$1.11x10^{-3}$	$4.71x10^{-4}$	$4.89x10^{-5}$	$1.16x10^{-5}$	$1.64x10^{-3}$
ST-2	$2.51x10^{-7}$	***<5.97x10^{-6}***	$1.24x10^{-7}$	***<3.04x10^{-7}***	***<6.65x10^{-6}***
ST-3 Group	$1.07x10^{-3}$	$3.88x10^{-4}$	$3.73x10^{-5}$	$7.91x10^{-6}$	$1.51x10^{-3}$
ST-4 Group	$1.29x10^{-6}$	***<5.97x10^{-6}***	$1.42x10^{-6}$	$4.50x10^{-7}$	***<9.12x10^{-6}***
ST-5 Group	$5.97x10^{-6}$	***<2.27x10^{-5}***	$2.57x10^{-6}$	***<3.04x10^{-7}***	***<3.15x10^{-5}***
ST-6	***<2.98x10^{-5}***	***<2.98x10^{-5}***	***<6.44x10^{-8}***	***<3.04x10^{-7}***	***<6.00x10^{-5}***

This table presents the individual cancer risks associated with maximum contaminant concentrations observed for each well. Values listed in bold italics reflect those calculated using the lowest analytical detection limit when a contaminant was not detected.

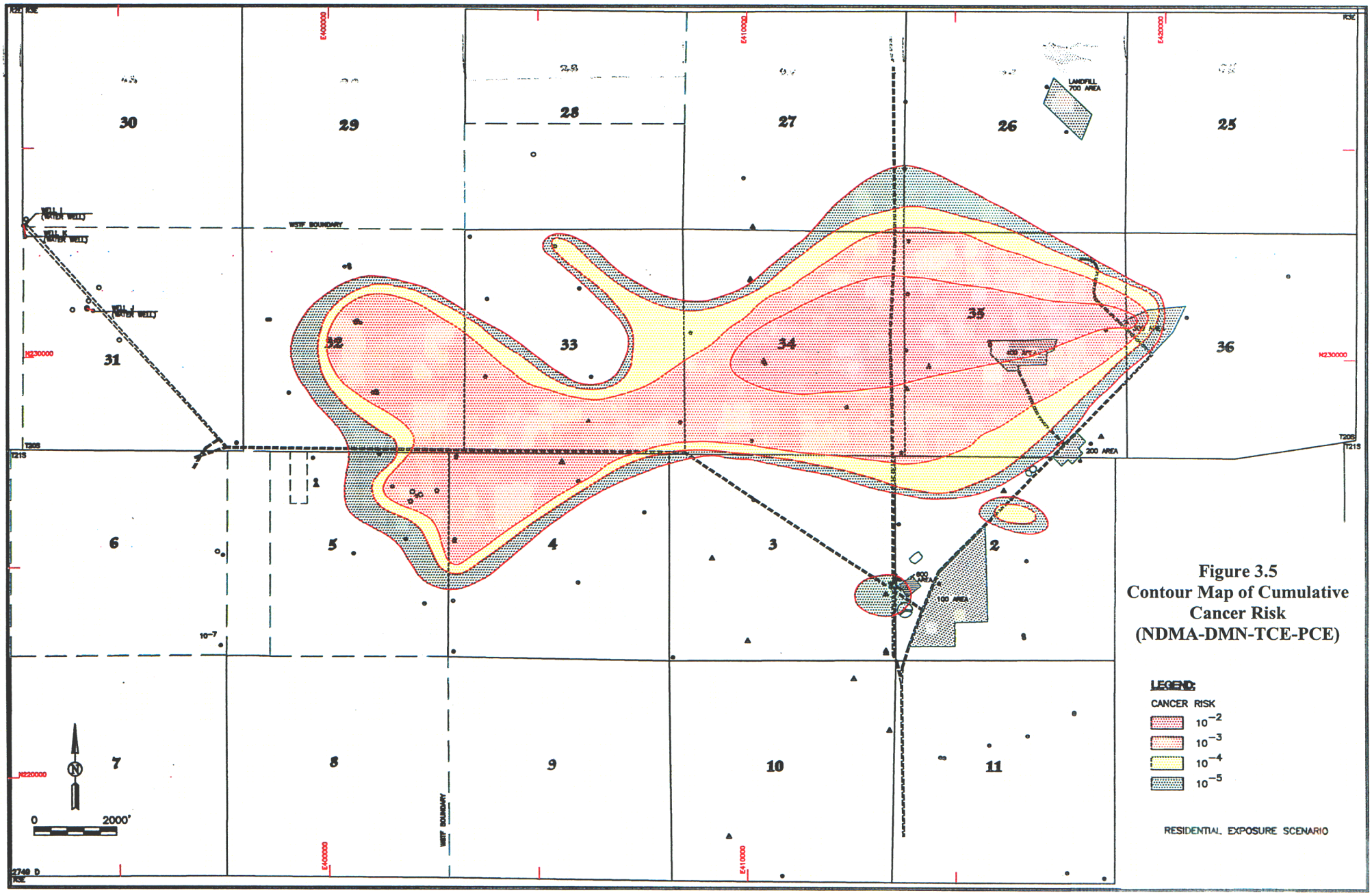


Figure 3.5
Contour Map of Cumulative Cancer Risk (NDMA-DMN-TCE-PCE)

3.5.3.2 Non-Carcinogenic Hazard Quotients and Indices

RfDs obtained from IRIS or the RCB Tables were used to compute hazard quotients (HQs) for maximum concentrations of TCE, PCE, Freon 11, Freon 21, and Freon 113 detected at monitoring wells. NDMA and DMN were not included because applicable RfDs are not available. HQs were computed by dividing the CDI by the chemical-specific RfD (HQ = CDI/RfD) and then by summing each non-carcinogenic chemical to determine the Hazard Index (HI) at each plume-front monitoring well. Table 3.5 lists the HQs and HIs estimated for the plume-front wells. HQs and HIs calculated on the lowest analytical detection limits are listed in bold italics. Table 3.5 shows that the highest HQs are associated with TCE and its presence in a monitoring well constitutes the greatest contribution to the well's HI. The contribution to the HI from all the Freon compounds totaled is small in comparison to TCE, and is generally less than 0.1. TCE is the primary chemical of concern that causes the HIs to exceed 1.0.

3.5.4 Uncertainties

The assumptions and inputs used to assess potential human health risks posed by the WSTF contaminant plume are subject to several uncertainties that have effects of either overestimation or underestimation of risk. These are discussed in detail in Volume Six, Chapter One of the Draft RFI Report (NASA, 1996a). The primary uncertainty factors are discussed below.

3.5.4.1 Carcinogenicity Evidence Under Review

Currently, the evidence for the carcinogenicity of TCE and PCE is under review. The SFs used in risk calculations are the EPA provisional values. Until EPA finalizes the determinations for these chemicals, NASA will consider TCE and PCE carcinogenic and estimate potential excess risk associated with their presence in groundwater in its health risk assessment. If new carcinogen summaries determine these chemicals are not carcinogenic, then the cumulative cancer risk values in this report become overestimates.

3.5.4.2 Lack of Toxicity Data

Toxicity data are not available for DMN or Freon 21. The RAGS suggests grouping chemicals by class in such situations and applying a known toxicity value from a chemical in that class to characterize risk. Due to their extremely similar chemical structures, DMN was grouped with NDMA, and the NDMA SF was applied to estimate the cancer risk for DMN. This introduces uncertainty in the risk calculations for DMN and the cumulative cancer risk values.

The RfD for chloroform was applied to Freon 21 (see discussion of non-carcinogens in Section 3.5.1.2 indicating similar toxicities). This is a conservative approach to the risk posed by Freon 21 given the limited data available. Using the RfD of chloroform for Freon 21 introduces uncertainty into the HQ calculations for Freon 21 and also the HIs calculated for each monitoring well.

TABLE 3.5: HAZARD QUOTIENTS AND INDICES FOR PLUME-FRONT WELLS

Well	TCE	PCE	Freon 11	Freon 21	Freon 113	Hazard Index
BLM-2 Group	1.19	0.03	0.02	***<0.001***	***<0.001***	***<1.242***
BLM-7-509	***<0.002***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.006***
BLM-17 Group	0.87	0.02	0.03	***<0.001***	***<0.001***	***<0.922***
PL-1-486	0.37	0.01	0.01	***<0.001***	***<0.001***	***<0.392***
PL-2-504	0.59	***<0.001***	0.02	***<0.001***	***<0.001***	***<0.613***
PL-3-453	***<0.002***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.006***
PL-4-464	0.01	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.014***
PL-5	1.60	0.04	0.03	0.16	***<0.001***	***<1.831***
PL-6	0.02	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.024***
PL-7	0.01	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.014***
ST-1 Group	1.74	0.05	0.04	***<0.001***	***<0.001***	***<1.832***
ST-2	***<0.002***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.006***
ST-3 Group	1.32	0.04	0.02	***<0.001***	***<0.001***	***<1.382***
ST-4 Group	0.05	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.054***
ST-5 Group	0.09	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.094***
ST-6	0.03	***<0.001***	***<0.001***	0.02	***<0.001***	***<0.053***

Table lists the hazard quotients and hazard indices estimated for the plume-front wells.

The bold italics values represent hazard quotients and hazard indices calculated on the lowest analytical detection limits.

3.5.4.3 Chemical Concentrations

Health risk estimates from ingestion of contaminated groundwater were made using a hypothetical residential exposure scenario and the maximum concentration of a chemical of concern detected at each RFI monitoring well over a specified time period. Using maximum concentrations rather than the 95% Upper Confidence Limit of the mean, as suggested in RAGS, results in overestimation of risk.

3.6 DATA SUFFICIENCY

The WSTF groundwater plume has been extensively monitored since 1987 and more than 220,000 sampling events have occurred to date. The plume monitoring network currently includes 77 conventional and 26 Westbay Multi-Port® monitoring wells. Data collected from existing plume-front wells have been used to design the presumptive remedy for this Plan.

Previous experience with monitoring wells along the plume-front has shown that geologic formation characteristics can vary significantly. Therefore, prior to completing the extraction and injection wells, recovery tests will be conducted in the open boreholes of those wells. After completion of the extraction wells, step tests will be performed on each of the wells to confirm the pumping capacity for each well. The T and specific yield of the formation, derived from the step test results, will be compared to existing values within the 3DSWB groundwater model, and additional simulations performed to confirm plume stabilization will be accomplished with the system presented in this Plan.

4.0 PRESUMPTIVE REMEDY FOR PLUME-FRONT STABILIZATION

This Plan presents a plume-front stabilization presumptive remedy that incorporates plume-front monitoring wells, plume-front extraction wells, ex-situ treatment to reduce contaminants to prescribed concentrations, and reinjection of the remediated groundwater into the JDMB using injection wells. The system is designed to mitigate further plume-front migration and serves to actively remove contaminant mass from the groundwater.

4.1 EVALUATION OF 3DSWB MODEL PREDICTIVE REMEDIAL SCENARIOS

The 3DSWB model has been used as a tool to simulate future contaminant migrations over a wide range of predictive remedial scenarios. The model has served to simulate "no-action" groundwater conditions over a 30 year period and also to determine optimum extraction/injection well locations for a variety of remedial system designs (GCL, 1995; DBS&A, 1995a; DBS&A, 1995b).

The most important feature of the predictive simulation groundwater flow field performed by the MODFLOW program is that the flow direction within the JDMB is anticipated to change from west-southwest to south over the next 30 years. Conservatively overestimated pumping rates for the JDMB indicate that the average hydraulic gradient may increase by an order of magnitude. This condition results from significant increases in predicted groundwater withdrawals south of WSTF in the vicinity of U.S. Highway 70 by the City of Las Cruces

and other water suppliers. The major implication to the JDMB groundwater model is that under a "no-action" scenario the contaminants that currently exist in the WBFZ migrate in a more southerly direction, and at an increased velocity.

The three computer programs described in Section 3.4.1 were applied to obtain the predictive remedial scenario results. When locating or withdrawing an extraction well, the MODFLOW program was rerun to obtain the revised groundwater flow field throughout the predictive simulation period. The PATH3D program was then used to evaluate the effectiveness of the various plume capture schemes. MT3D was run for each final predictive simulation to simulate contaminant concentrations that may occur in response to the various groundwater remediation scenarios.

Ten predictive remedial simulation scenarios were performed to assess the potential NDMA, TCE and PCE migration from January 1993 to December 2026 as part of the Draft RFI and CMS Reports (NASA, 1996a; NASA, 1996b). These scenarios are summarized in Table 4.1. The first scenario was "no-action", and the remaining scenarios addressed the assessment of different pump and treat remedial alternatives. Each scenario used initial hydraulic heads and initial contaminant concentrations from the December 1992 time step of the site model calibration run for each of the three COCs modeled (Figures 3.1 through 3.3). A description of the predictive simulation scenarios, including well descriptions and flow rates, are provided in Volume One, Chapter Four of the Draft CMS Report (NASA, 1996b).

The first six predictive simulations run are presented in DBS&A (1995a). Scenario One indicates that if no action is taken, the contaminant plumes can be expected to migrate west and south of their present location up to one mile west of the WBFZ by the year 2026. Scenarios Two, Three and Four indicate containment of the plume with between 12 to 41 extraction wells placed within or near the WBFZ, and at upgradient locations within the fractured bedrock pediment. The injection of treated groundwater for all treatment scenarios is to the southwest of the contaminant plume.

The results of Scenario Four indicate that even if numerous extraction wells are placed throughout the plume and favorable extraction rates are maintained for each well, the overall extent of the plume would not be reduced significantly, although a reduction in maximum concentrations would occur. The predictive simulation results should be regarded as conservative relative to the plume-front for two reasons. First, the simulated plumes are greater in horizontal extent than the observed plumes. Second, the physical process of retardation was neglected for TCE and PCE, where conservative retardation estimates for TCE in basin alluvium environments are typically 1.5 and for PCE are 3.0 (DBS&A, 1995a). This promotes an increased rate of migration for the predictive scenarios.

The potential for eliminating or reducing mass flux to the plume-front using interception techniques in the MPCA was examined using Scenarios Five and Six. The potential is limited due to low predicted groundwater withdrawal rates. Assessment work continues in this hydrogeologically significant area due to the potential of intercepting the high source area NDMA and DMN concentrations; for example, a series of wells along the MPCA could

TABLE 4.1: SUMMARY OF 3DSWB MODEL INTERIM MEASURES REMEDIAL SCENARIOS

Scenario #	Description	Remedial Wells	Estimated Remediation System Flow Rates	Advantages	Disadvantages
1 No-action	Monitored natural attenuation of plume	---	---	Low cost.	Contaminant plume mass undergoes advective-dispersive transport.
2&3 Plume-front containment and NDMA hot spot remediation	Extraction wells located across plume-front in WBFZ and bedrock pediment. Injection wells southwest of the plume. Discharge increased for high-capacity WBFZ wells in Scenario 3.	15 extraction 2 injection	Total discharge 1,170 gpm, with 800 gpm from 3 high-capacity WBFZ wells. Discharge increased to 1,420 gpm for Scenario 3.	Effective containment of the plume. Reduction of contaminant concentrations. Injection restricts plume movement to the south. Increased cone of depression for Scenario 3 ensures effective plume-front containment.	Predicted plume-front concentrations remain above maximum contaminant level for TCE (5 ppb) and anticipated contaminant level for NDMA (10 ppt) inside captured plume. Bedrock flow rates may be difficult to reproduce. Increased volumes of extracted groundwater have limited effectiveness.
4 Aggressive plume remediation	As for Scenario 2&3 plus 29 additional extraction wells. Injection wells southwest of the plume.	41 extraction 2 injection	Total discharge is 1,420 gpm.	Reductions in peak concentration areas within the plume. Injection restricts plume movement to the south.	Limited additional reduction in plume boundary. Withdrawal rates from the majority of wells are small due to bedrock locations. Concentrations remain above treatment standards inside captured plume.
5 Plume-front containment with mid-plume interception	Utilizes the three high-capacity WBFZ extraction wells from Scenario 2&3 plus 3 mid-plume extraction wells. Injection wells southwest of the plume.	11 extraction 2 injection	Total discharge is 880 gpm including additional 70 gpm prescribed for mid-plume wells.	Plume-front containment. Partial reduction of the mass accessing the plume-front from source areas via the mid-plume. Injection restricts plume movement to the south.	Narrow mid-plume pumping does not effectively intercept contaminants or reduce mass flux. Plume-front concentrations above Scenario 2 because seven of the plume-front area wells were not simulated. Concentrations remain above treatment standards inside captured plume.
6 Mid-plume interception	No-action at plume-front and remediation of the mid-plume.	3 extraction	Total discharge is 70 gpm.	Supply of contaminants from source areas to plume-front reduced.	Plume-front appears similar to Scenario One (no-action). Concentrations remain above treatment standards inside captured plume.
7 Basic plume-front containment	Containment of the plume-front within the WBFZ. Injection wells southwest of the plume.	4 extraction 4 injection	Total discharge is 810 gpm.	Plume-front containment and mass removal. Uses wells predominantly screened within alluvium of WBFZ.	Potential for pump and treat within the MPCZ will be addressed independently. Concentrations remain above treatment standards inside captured plume.
8&9 Scenario 7 with mid-plume interception and hot spots	As for Scenario 7, with additional wells in the mid-plume the zone of high NDMA west of the 400 Area.	Between 4 and 10 extraction 4 injection	Total discharges are 880 gpm (Scenario 8) and 900 gpm (Scenario 9).	Increased mass concentration removal.	Results similar to Scenario 7, despite the considerable increase in extraction wells. Larger reductions in concentrations limited due to the potential capacity of the additional wells. Concentrations remain above treatment standards inside captured plume.
10 Scenario 7 with additional plume-front area NDMA target wells	As for Scenario 7, with two additional plume-front extraction wells on the east WBFZ boundary. System independently targets TCE and NDMA mass removal.	6 extraction 4 injection	Total discharge is 1,010 gpm.	As for Scenario 7. Well configuration independently addresses TCE and NDMA contaminant fronts resulting in increased mass removal.	Potential for pump and treat within the MPCZ will be addressed independently. Concentrations remain above treatment standards inside captured plume.

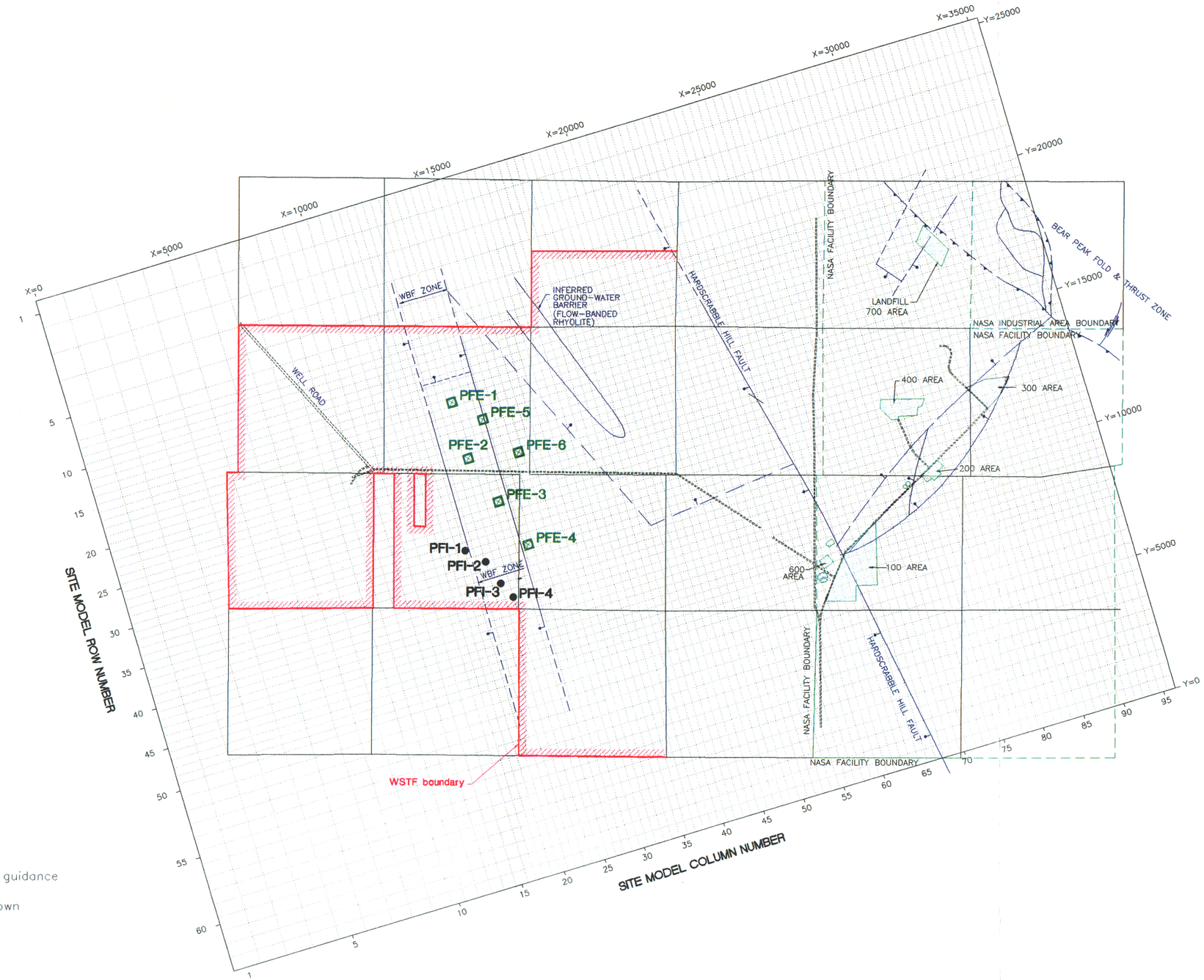
potentially be pumped dry and pumping be allowed to resume after some period of water level recovery. This approach would form an effective barrier to contaminant transport and is in the process of being simulated using MODFLOW SURFACT (HydroGeoLogic, 1997), a modified version of the MODFLOW program.

Predictive simulations for Scenario Seven through Scenario Nine are presented in DBS&A (1995b). Scenario Seven is a basic and effective plume-front containment scenario, while Scenarios Eight and Nine consider the containment plus additional extraction wells in strategic areas. Scenario Seven indicates that plume containment can be achieved using four extraction wells, and four injection wells located southwest of the plume. The existing NASA-Pump Test (PT) well, which was utilized for a previously performed pump test (NASA, 1990), is suitable for service as one of the high-volume WBFZ extraction wells. Three of the four extraction wells are within the WBFZ and the remaining extraction well is in the bedrock within the southern lobe of the contaminant plume. The injection wells are positioned to the south and southwest of the plumes within or near the WBFZ. The results of the three simulations are very similar. The additional withdrawal wells in Scenarios Eight and Nine cause localized reductions in contaminant concentrations, but do not significantly affect the plume-front contaminant concentrations. Larger reductions are not observed because the pumping capacities of the additional wells are limited.

Scenario Ten presented in DBS&A (1998) is regarded as the most efficient plume-front stabilization scenario. The remedial system utilizes the four WBFZ plume-front extraction wells and four injection wells simulated by Scenario Seven, and adds two additional extraction wells located to the east, which specifically address the low-level NDMA/DMN plume-front contamination. This scenario was devised because, although the TCE plume-front is similar to the NDMA/DMN plume-front, the optimum positions for extraction wells to address mass removal for each contaminant are different. Table 4.1 summarizes the advantages of this scenario.

4.2 DESCRIPTION OF PLUME-FRONT STABILIZATION SCENARIO

The Scenario Ten stabilization option from Table 4.1 has been selected as the preferred plume-front containment remedial option. Figure 4.1 presents the well configuration for this plume-front system. The current position of the contaminant plume is significant relative to the placement of six PFE and four PFI wells. The six extraction wells (PFE-1 through PFE-6) remain within or on the eastern boundary of the WBFZ, where the vertical extent of the alluvial aquifer is confined by bedrock, and the plume can be contained without relocating in the deep alluvium of the JDMB. Wells PFE-1 through PFE-4 specifically address containment of the TCE plume utilizing an estimated combined flow rate of 810 gpm. Containing TCE will also prevent PCE from migrating further west. However, these four TCE extraction wells do not fully prevent western movement of the NDMA/DMN plumes which are not as extensive to the west. Wells PFE-5 and PFE-6 have been added to the scenario to ensure effective NDMA/DMN plume containment. These wells are located in high NDMA concentration zones and have an estimated combined flow rate of 200 gpm. Containing NDMA will also contain DMN because the two plumes are extremely similar and the DMN concentrations are much lower than the NDMA plume. The injection of



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0 4000 ft

Explanation

- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side (dashed where inferred)
- Extraction well
- Injection well

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Plume Front Containment Well Locations

Figure 4.1

remediated groundwater through four injection wells (PFI-1 through PFI-4) occurs to the west and south of the contaminant plumes. The injection well locations are designed to assist with containment of the southern edge of the plume by creating a localized groundwater mound. This mounding offsets future drawdown effects, and locally reverses the groundwater flow directions.

The optimum positioning of the proposed remedial well locations provided through the MODFLOW SURFACT program reduces the volume of groundwater required for the groundwater treatment process. Plume-front extraction wells PFE-1 through PFE-6 are simulated to have an estimated total withdrawal rate of 1,010 gpm.

Modeling work relative to the plume-front containment scenario has involved contouring NDMA data to more sensitive ppt isoconcentrations. This represents advancements in groundwater analytical technologies and addresses NDMA concentrations of health risk concern. Plume-front NDMA analytical data, with a lowered reporting limit of 10 ppt, were utilized for these modeling activities (DBS&A, 1998). Previous modeling activities performed for the Draft CMS Report (NASA, 1996b) addressed capture of the simulated plume to the 0.1 ppb (100 ppt) isoconcentration line.

4.2.1 Remediation Well Characteristics

Remediation well locations, pumping and injection rates and design parameters are provided in Table 4.2. The design parameters listed include well casing and annular materials specifications, well design strategies and well depth specifications. The pumping rates, injection rates and design parameters generated from the 3DSWB model wells were used to establish the preliminary well designs proposed for the groundwater pump and treat system. The total injection volume for the PFI wells was set equal to the total extraction volume for the PFE wells at 1,010 gpm.

When the remediation wells were simulated for predictive scenarios, the well discharge for each layer the well penetrated was prescribed based on hydrogeological conditions input to the 3DSWB model. Ultimately, well discharge was apportioned among model layers based on hydraulic conductivity values. As an example, well PFE-2 (Table 4.2) shows extractions of 100 gpm from layers 10 and 11, 30 gpm from layer 12, and 16 gpm from layer 13. Approximately 500 feet to the north at WSTF monitoring well ST-1-630, the depth to bedrock is 645 feet at an elevation of 3,856 feet above mean sea level (amsl). The junction of layer 11 (3,950 to 3,850 feet) and 12 (3,850 to 3,750 feet) at 3,850 feet amsl corresponds to a change in hydraulic parameters within the model which represents the bedrock surface. Bedrock parameters allow only limited well PFE-2 pumpage from layers 12 and 13.

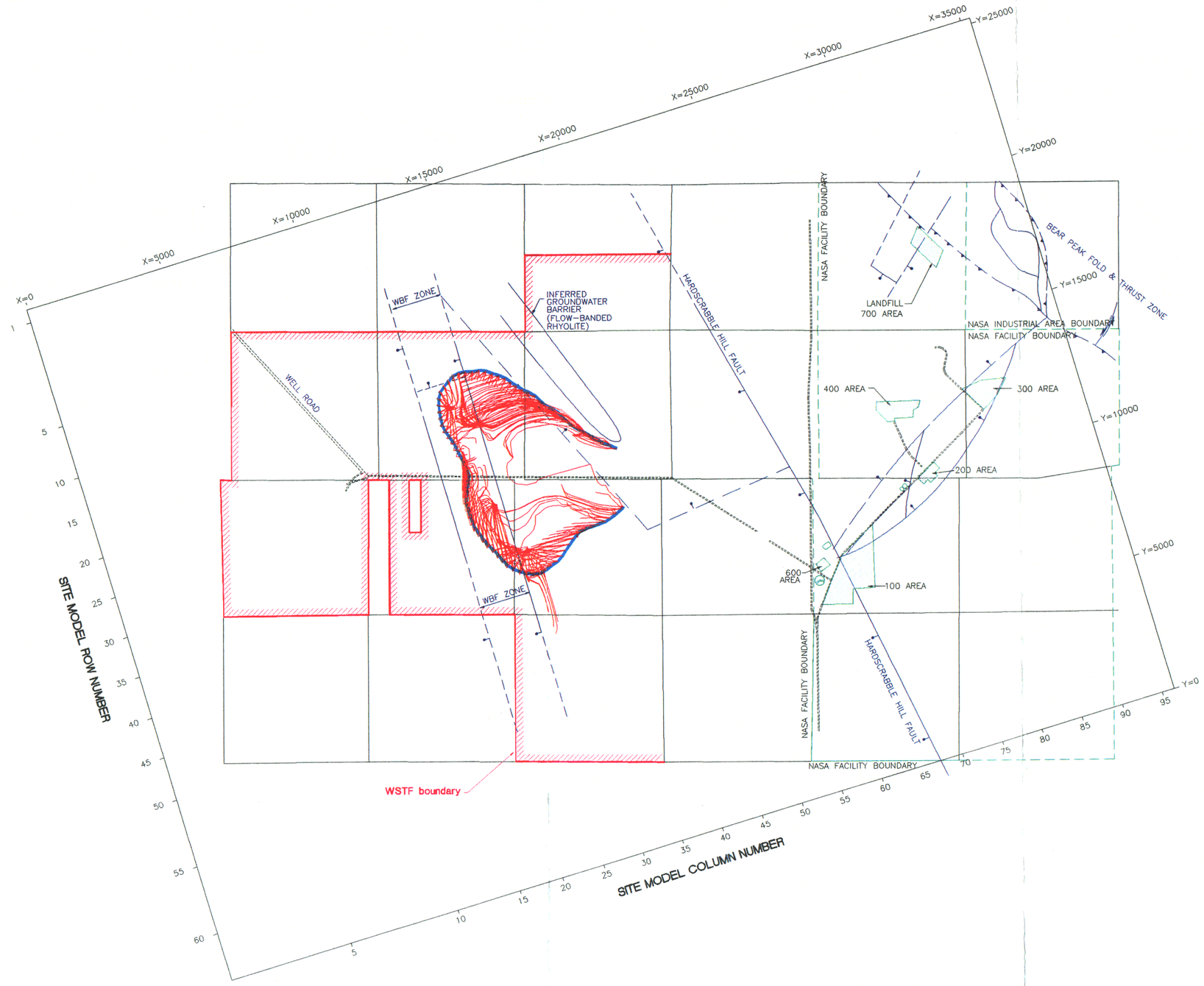
4.3 PLUME-FRONT STABILIZATION SCENARIO SIMULATIONS

4.3.1 PATH3D Plume-Front Stabilization Diagrams

Particle tracking results for NDMA (Figure 4.2) and TCE (Figure 4.3) were obtained using the PATH3D program. A series of points along the 10 ppt NDMA and 0.5 ppb TCE

TABLE 4.2: PLUME-FRONT CONTAINMENT WELL LOCATIONS, PUMPING RATES AND DESIGN PARAMETERS

Remedial Well	Well Coordinates relative to Model Grid	Layer	Anticipated Pumping/ Injection Rates (gpm)	Well Casing Specifications	Well Design Strategy & Depth Specifications
PFE-1	Row 15 Column 23	10 11 12 13	104 104 104 26	8-inch diameter, 60-Slot Screen	Depth to groundwater = 430 ft Anticipated pumping drawdown = <25 Screened interval (to total depth) = 425-900 ft Anticipated top of sand pack = 410 ft
PFE-2	Row 22 Column 23	10 11 12 13	104 104 26 16	8-inch diameter, 60-Slot Screen	Depth to groundwater = 435 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 430-900 ft Anticipated top of sand pack = 415 ft
PFE-3 (Existing NASA-PT Well)	Row 28 Column 25	10 11 12 13	104 104 5 0	10-inch diameter, 80-Slot Screen	Depth to groundwater = 453 ft Anticipated pumping drawdown = <15 ft Screened interval (to total depth) = 507-828 ft Actual top of sand pack = 443 ft
PFE-4	Row 34 Column 27	10 11 12 13	3 1 3 3	6-inch diameter, 60-Slot Screen	Depth to groundwater = 469 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 465-900 ft Anticipated top of sand pack = 450 ft
PFE-5	Row 18 Column 26	10 11 12 13	48 48 3 3	8-inch diameter, 60-Slot Screen	Depth to groundwater = 432 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 430-900 ft Anticipated top of sand pack = 412 ft
PFE-6	Row 23 Column 29	10 11 12 13	48 48 3 2	8-inch diameter, 60-Slot Screen	Depth to groundwater = 460 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 455-900 ft Anticipated top of sand pack = 440 ft
PFI-1	Row 32-33 Column 19-20	10 11 12 13	73 73 57 57	8-inch diameter, 80-Slot Screen	Depth to groundwater = 450 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 460-1,000 ft Anticipated top of sand pack = 430 ft
PFI-2	Row 34-35 Column 21-22	10 11 12 13	105 105 20 20	8-inch diameter, 80-Slot Screen	Depth to groundwater = 450 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 460-1,000 ft Anticipated top of sand pack = 430 ft
PFI-3	Row 37-38 Column 22-23	10 11 12 13	147 147 16 15	8-inch diameter, 80-Slot Screen	Depth to groundwater = 450 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 460-1,000 ft Anticipated top of sand pack = 430 ft
PFI-4	Row 39-40 Column 23-24	10 11 12 13	83 83 7 6	8-inch diameter, 80-Slot Screen	Depth to groundwater = 450 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 460-1,000 ft Anticipated top of sand pack = 430 ft



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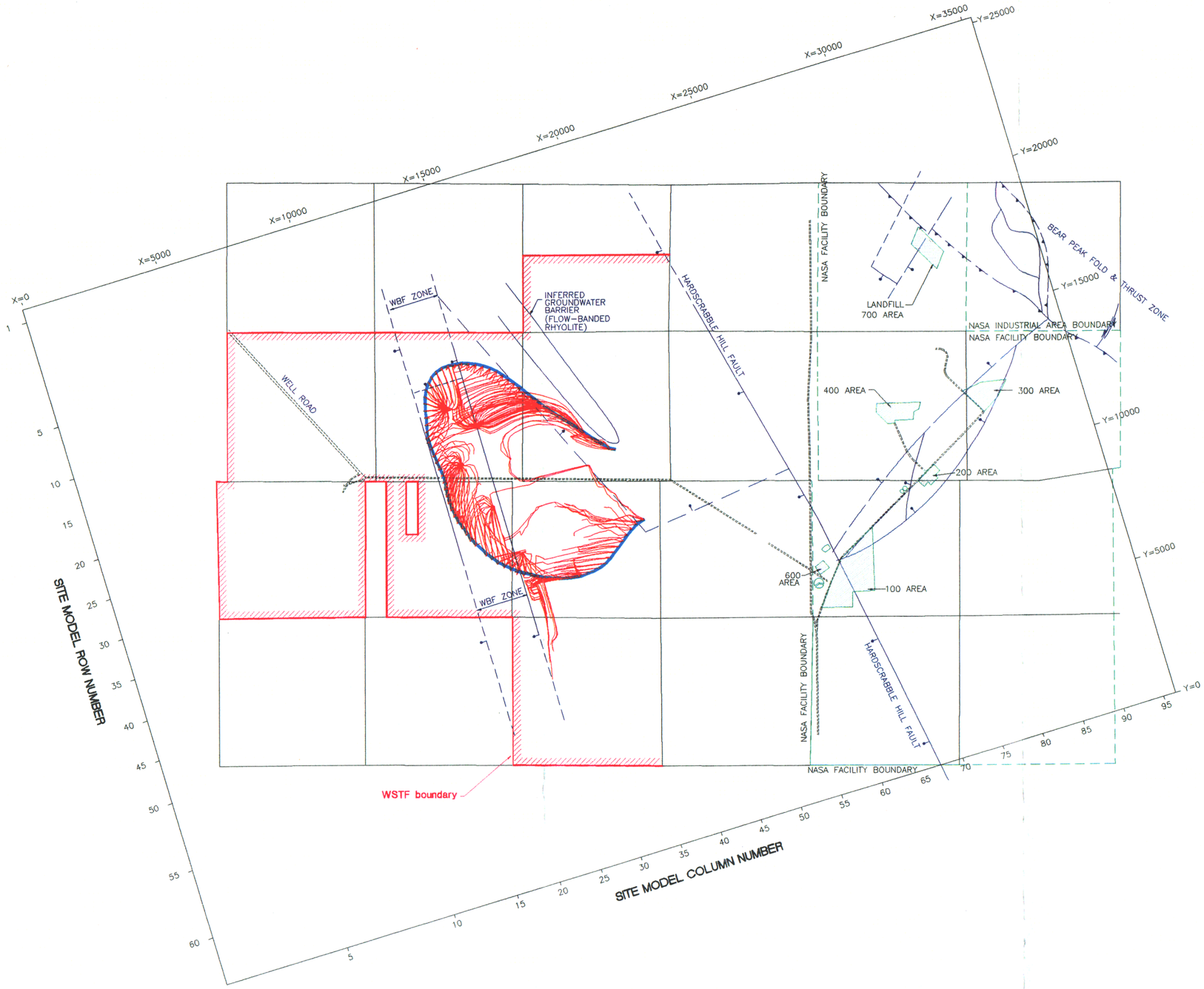
Simulated Contaminant Pathlines for NDMA Plume Front Containment

Figure 4.2



N

0 4,000 ft

Explanation

- Simulated contaminant pathlines
- 0.5 part per billion TCE contour
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side, dashed where inferred

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Simulated Contaminant Pathlines for TCE Plume Front Containment

Figure 4.3

plume-fronts, defined based on recent analytical data, were used as release points. Particles were tracked in model layers 3 through 14. Effective capture of the current 10 ppt NDMA and 0.5 ppb TCE contours were achieved. In order to evaluate this capture, DBS&A (1998) converted the plume-front stabilization scenario to run under the MODFLOW SURFACT program which allowed variable saturation of the model cells. This provides a more exact solution of the flow equations, especially in the vicinity of the extraction and injection wells where the water levels can be anticipated to be more variable. MODFLOW SURFACT program results and the original simulation results were found to be compatible.

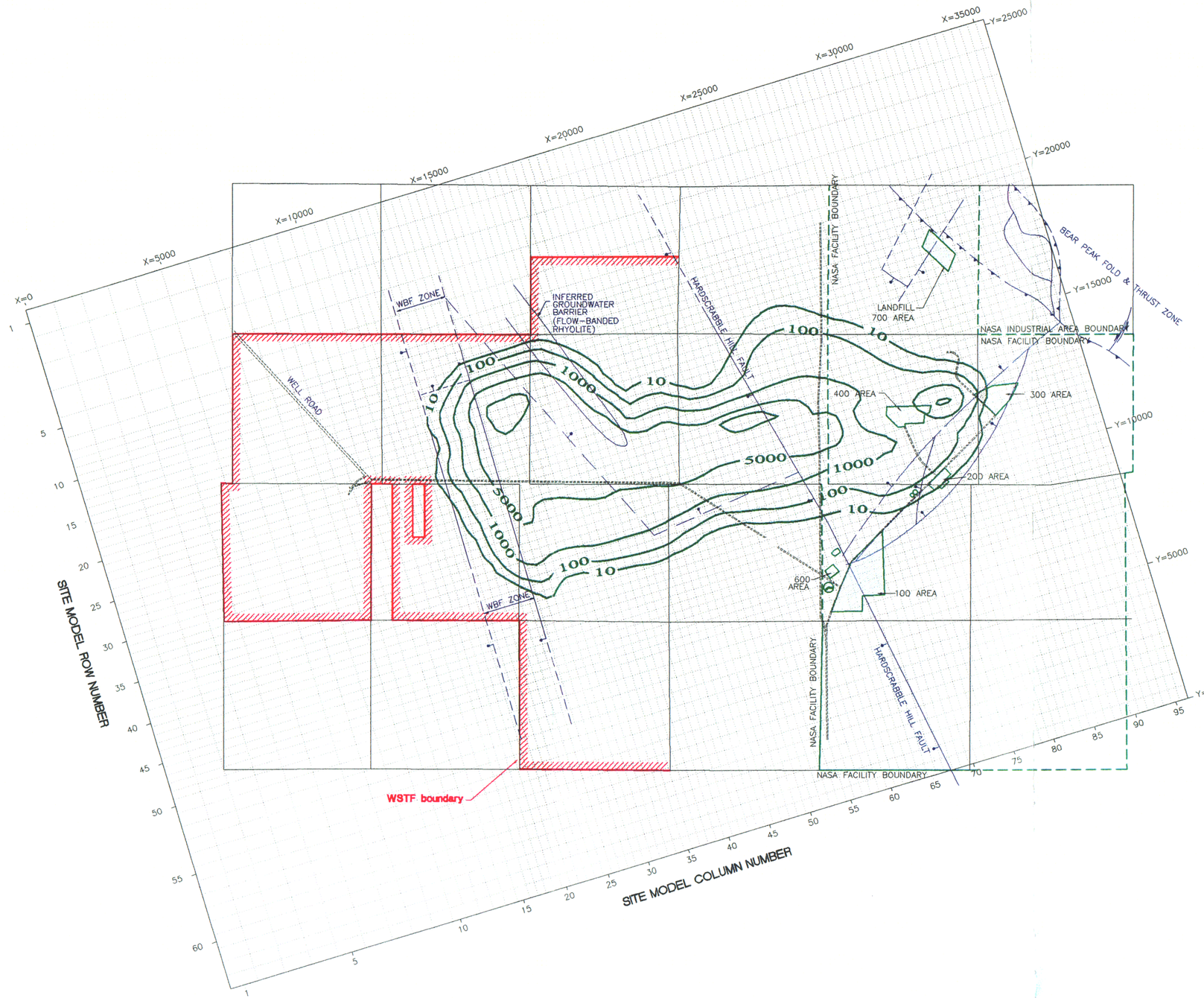
4.3.2 Predictive Plume-Front Isoconcentration Maps

Predictive plume isoconcentration maps for NDMA (to 10 ppt), TCE (to 0.1 ppb) and PCE (to 0.1 ppb) for the year 2026 are provided in Figures 4.4, 4.5 and 4.6, respectively. These figures can be compared to the current simulated plume isoconcentration maps discussed in Section 3.0 (Figures 3.1 through 3.3) to evaluate plume-front capture and mass removal. These figures illustrate that NDMA, TCE and PCE plume-front capture is achieved. Concentration reductions can be seen for each of the contaminants within the plume-front area. The leading edge of the westernmost plume, represented by the TCE plume, is retracted (a distance of approximately 2,000 feet) for the predictive simulation. The NDMA plume maps indicate stabilization of the 10 ppt contour. Differences in the retraction of the two contaminant plumes relate to the positioning of the three high volume extraction wells PFE-1 through PFE-3 designed for TCE capture, and the retardation factor input for NDMA. A significant reduction in mass over the period of the simulation occurs for NDMA, TCE and PCE (Figures 4.7, 4.8 and 4.9 respectively).

Each of the predictive simulations indicates a small zone of contaminant migration to the south in the vicinity of the eastern edge of the WBFZ. This appears unlikely, due to the fact that contaminant particles that escape are released at greater depths in the model than current contamination observed in the field. This migration will be re-evaluated once the system is in place and the withdrawal capacity of extraction well PFE-4 (currently projected to be relatively low at 10 gpm) can be assessed.

4.3.3 Mass Extraction Calculations

Influent concentration and cumulative mass removal plots for the plume-front containment scenario for NDMA, TCE and PCE over 30 years are provided in Figures 4.7, 4.8 and 4.9, respectively. The figures provide simulated contaminant concentrations for all extraction wells and the cumulative mass of contaminants removed. These well concentrations are indicative of concentrations that may be expected for treatment plant influent and were utilized for treatment system design. The simulated initial well concentration (or influent) for NDMA is 1,200 ppt, which gradually increases to 2,000 ppt, and is then reduced to 1,200 ppt over the period of the predictive simulation through the year 2026. Initial TCE concentrations of 130 ppb decrease relatively rapidly to less than 20 ppb during the predictive simulation, and initial PCE concentrations also show a steady decline from 4.2 ppb to less than 0.5 ppb by the end of the simulation period.



N

0 4,000 ft

Explanation

- 10 — Maximum simulated NDMA concentration (ppt) for 2026
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side, dashed where inferred

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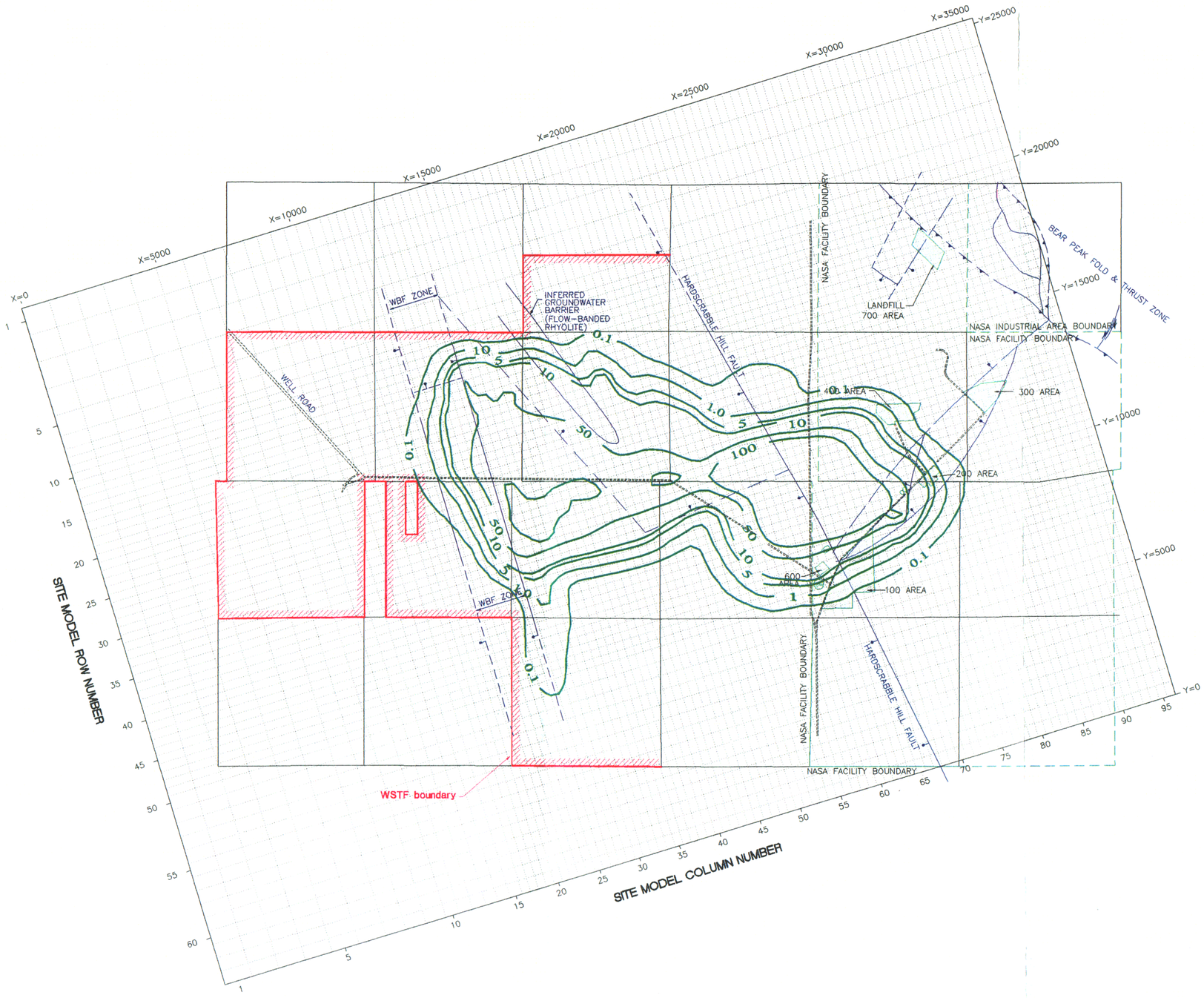
Plume Front Containment
Simulated NDMA Plume for 2026

Figure 4.4



N

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Explanation

- 0.1 — Maximum simulated TCE concentration (ppb) for 2026
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side, dashed where inferred

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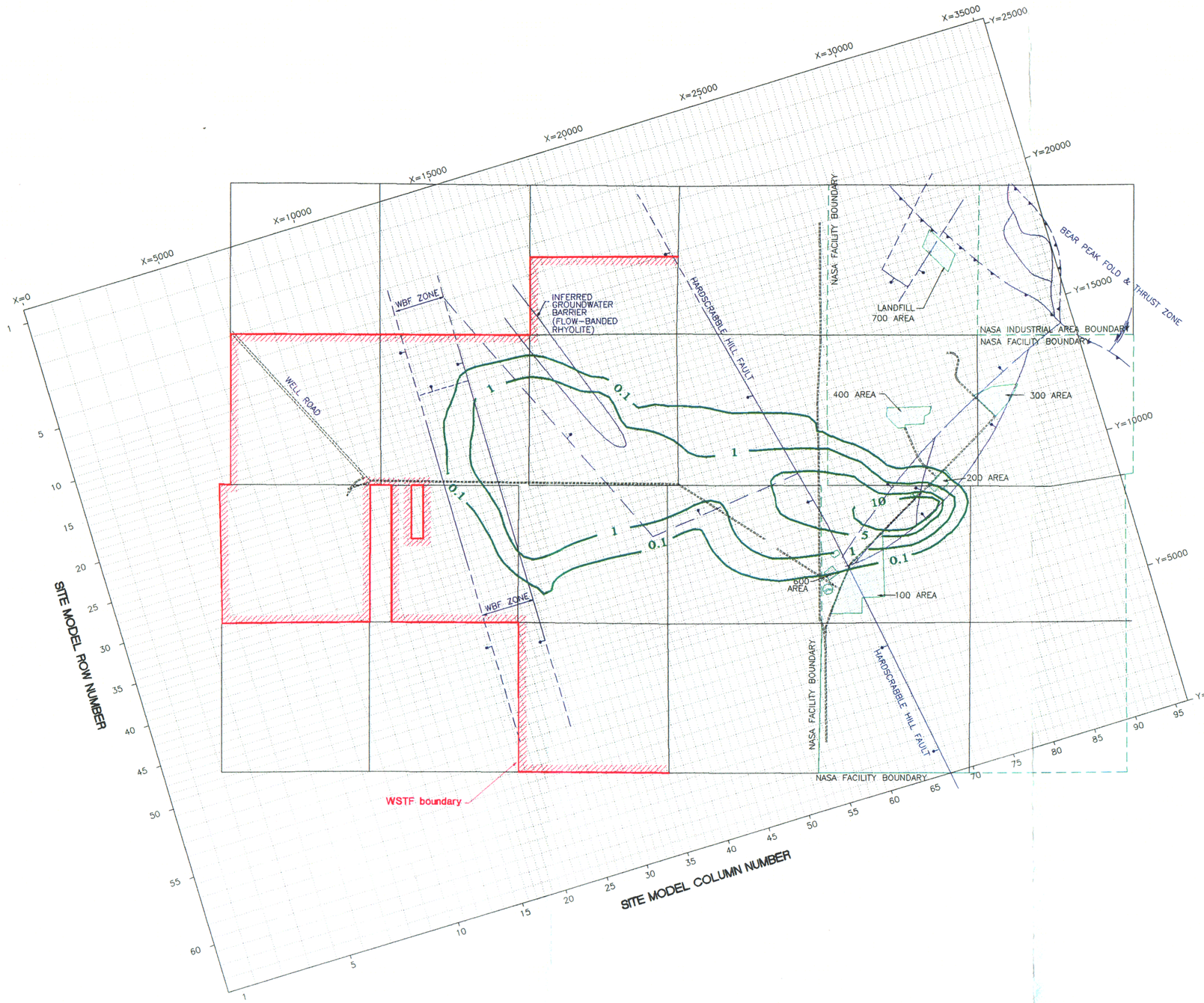
Plume Front Containment Simulated TCE Plume for 2026

Figure 4.5



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0 4,000 ft

Explanation

- 0.1 — Maximum simulated PCE concentration (ppb) for 2026
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side, dashed where inferred

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Plume Front Containment
Simulated PCE Plume for 2026

Figure 4.6

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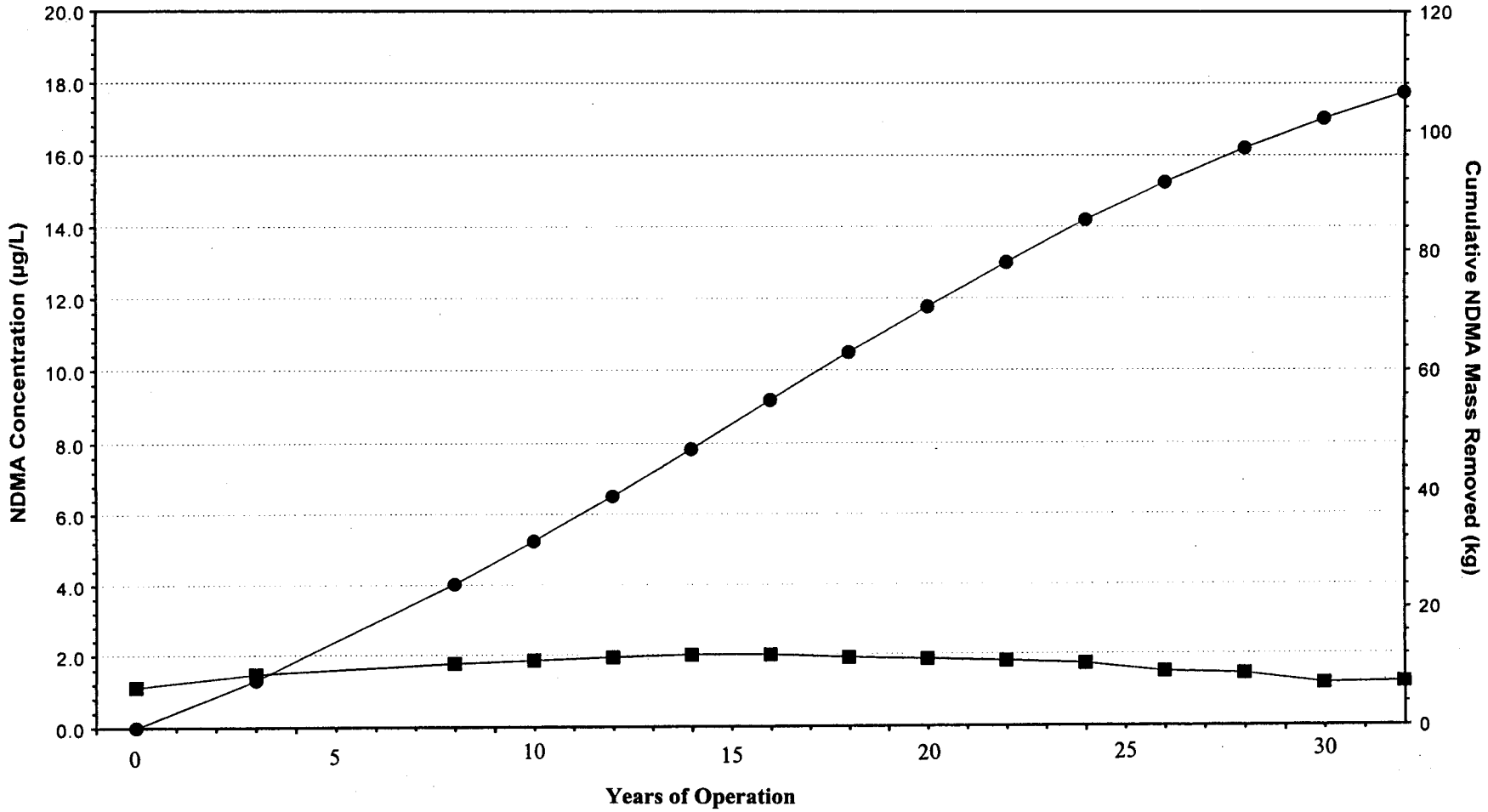

Explanation

Well Concentration

Cumulative Mass Removed

Figure 4.7

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Simulated NDMA Concentration and Cumulative Mass Removed for All Extraction Wells

Figure 4.7

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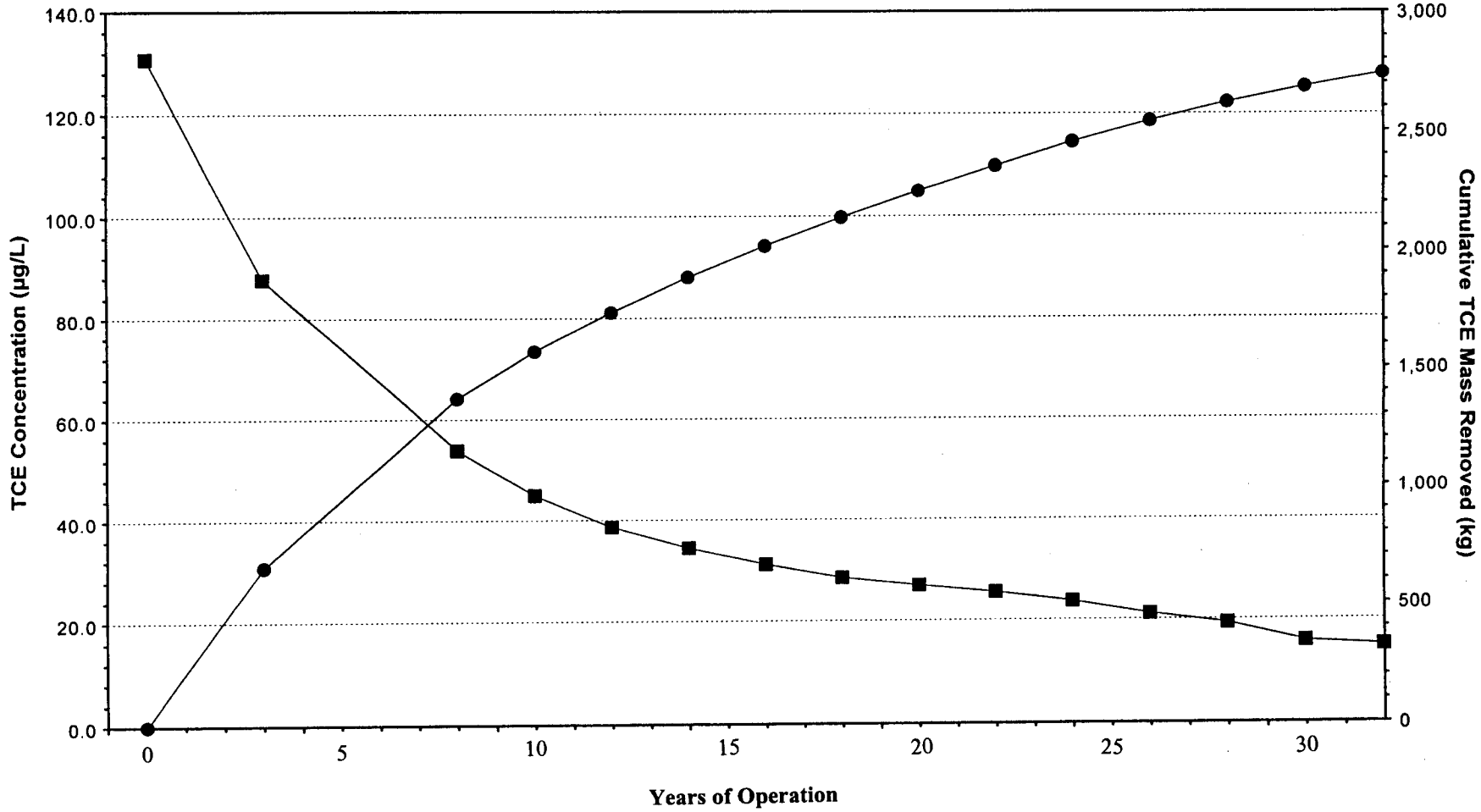

Explanation

Well Concentration

Cumulative Mass Removed

Figure 4.8

NASA-WSTF MODELING

Simulated TCE Concentration and Cumulative Mass Removed for All Extraction Wells

Figure 4.8

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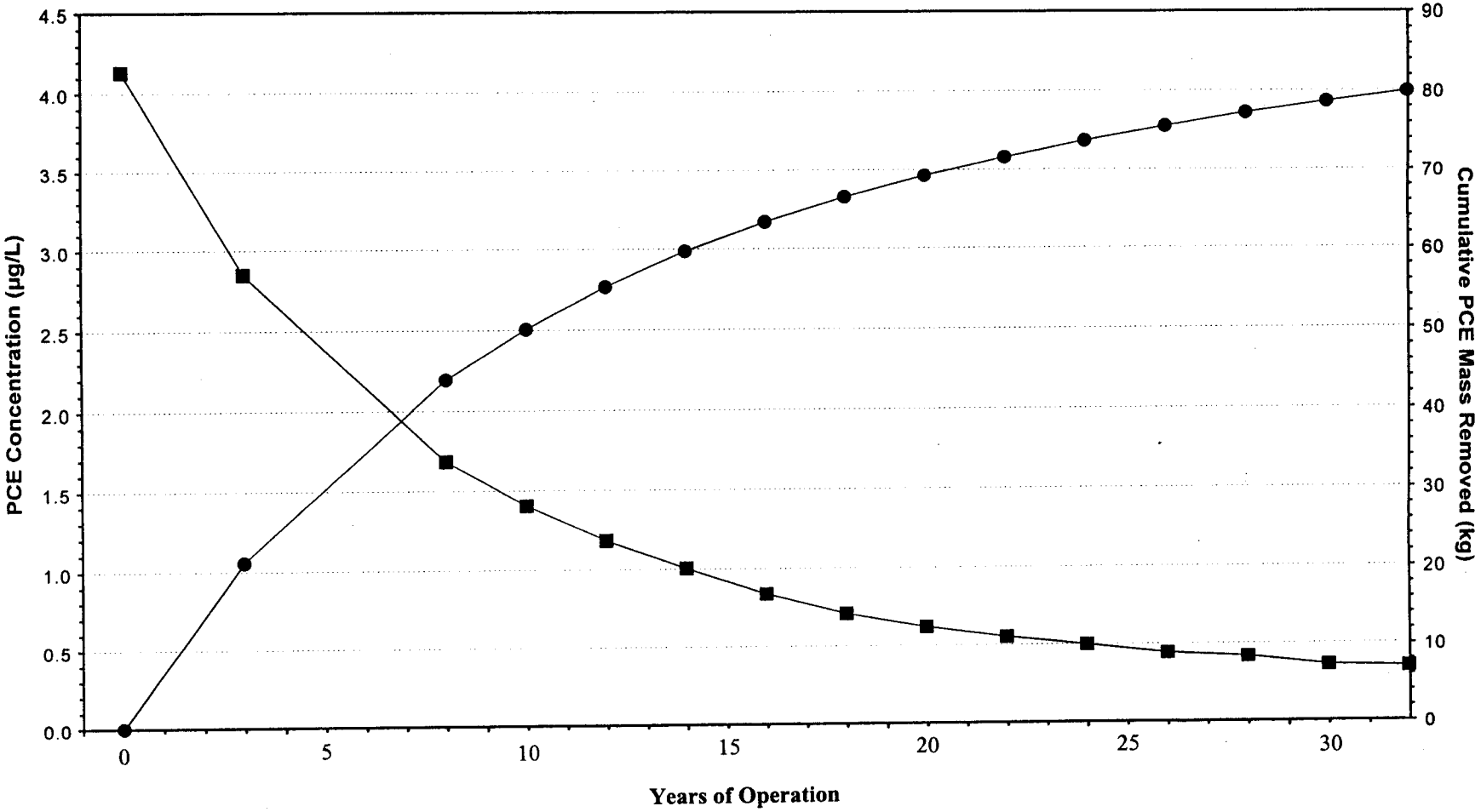

Explanation

- Well Concentration
- Cumulative Mass Removed

Figure 4.9

NASA-WSTF MODELING

Simulated PCE Concentration and Cumulative Mass Removed for All Extraction Wells

Figure 4.9

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4.3.4 Other Modeling Considerations

The 3DSWB model predictive simulation results indicate that plume-front containment can be achieved using six extraction wells (Figure 4.1) pumping at an estimated cumulative rate of 1,010 gpm. The TCE plume primarily drives the optimum placement of the three high-volume extraction wells PFE-1 through PFE-3 and one lower volume extraction well (PFE-4). Well PFE-4 is a reduced volume extraction well as it is located more proximal to the pediment area within fractured bedrock. This restricts the volume of water that can be extracted. Because the TCE plume extends further west than the NDMA plume, the wells will be located further west than the optimum location of wells for the NDMA plume.

Extraction wells PFE-5 and PFE-6 were added to the plume-front containment scenario to specifically address containment of the NDMA/DMN plume-front. The wells will be positioned adjacent to each other within the area of highest NDMA/DMN plume-front concentrations. These well locations will be east of the TCE target wells adjacent to the boundary between the eastern WBFZ and the pediment slope. The placement of PFE-5 and PFE-6 to the east of wells PFE-1 through PFE-4 will ensure stabilization of the NDMA/DMN plume over the simulated period. Additional movement of the wells to the east was restricted by the fractured-bedrock pediment aquifer, where potential extraction rates decrease by an order of magnitude.

As remediation wells are installed, they will be evaluated to determine if predicted water production rates are accurate and to determine contaminated groundwater concentrations. Assessments of extraction or injection wells will be provided in monthly reports submitted by NASA (see section 6.3) to NMED and EPA. If unanticipated conditions are encountered which will significantly affect water extraction or injection rates for individual wells or require movement or the addition or elimination of specified wells, the appropriate regulatory authorities will be notified in writing of the conditions and required approvals will be requested. Modeling simulations will be performed using the collected data to determine optimum pumpage rates and to determine if future injection wells are located in a manner to provide for an effective plume containment system.

4.4 TREATMENT STANDARDS

Treatment standards for this Plan have been developed following standards and guidelines from multiple Federal and State regulatory sources. Regulations and guidance documents used in the development of treatment standards include:

- the New Mexico Ground and Surface Water Protection Regulations (New Mexico Administrative Code (NMAC), 1998a);
- the New Mexico Drinking Water Regulations (NMAC, 1998b);
- concentration limits from 40 CFR 264.94 (National Archives and Records Administration (NARA), 1998a);
- Risk Assessment Guidance for Superfund (EPA, 1989);
- EPA Region 9 Preliminary Remediation Goals (EPA, 1998c); and
- other health and toxicological risk resources.

If technically achievable, the most conservative of the issued standards were selected as treatment standards. Table 4.3 provides a summary of regulatory standards and treatment goals for plume-front contaminants. EPA Region 9 has compiled a list of risk-based preliminary remediation goals (PRGs) which are used as decision-making tools for evaluating and remediating contaminated sites (EPA, 1998c). EPA indicates that PRGs are not intended as a stand-alone decision-making tool. Chemical concentrations above a PRG indicate that further evaluation of the risks posed by site contaminants is appropriate.

4.4.1 Groundwater Treatment Standards

Treatment standards for the contaminants identified at the plume-front are a combination of concentration-based and health-risk-based standards, and are summarized in Table 4.3. In selecting standards for the plume-front remediation system, three issues were addressed: the analytical reporting limits and cancer risk levels for NDMA and DMN; the concentration-based standards for TCE and PCE; and the absence of standards for the Freon compounds. The standards selected were designed to comply, as technically achievable, with state of New Mexico standards for cumulative cancer risk ($< 1 \times 10^{-5}$) and conform to a cumulative hazard index of less than 1.0.

Table 4.4 summarizes the projected influent contaminant concentrations to the plume-front remediation system, and their associated risks. The predicted influent concentrations of NDMA, TCE and PCE are taken from their respective mass extraction plots (Figures 4.7 through 4.9). The influent concentrations of DMN, Freon 11, Freon 21, and Freon 113 were assumed to be the highest historical concentrations of those compounds observed in any plume-front monitoring well. Using modeled and assumed concentrations, the cumulative cancer risk of remediation system influent is 2.23×10^{-3}, and the cumulative hazard index is 0.850. The cancer risk of the influent exceeds EPA and NMED standards, but the hazard index does not. The hazard quotients of the Freon compounds are very low, even though worst-case assumptions were made about their influent concentrations.

The proposed groundwater treatment system will utilize UV oxidation and air stripping. The UV oxidation is primarily used for NDMA/DMN treatment. However, the system will lower volatile organic concentrations. TCE, PCE and the Freon compounds will be lowered to levels below treatment standards by air stripping. The removal efficiency for each compound depends primarily on their Henry's Law constants, and solubilities. Table 3.1 summarizes those properties for each contaminant. The Henry's Law constants of TCE and PCE are 0.0117 and 0.02685 atm·m³/mole, while the Henry's Law constants of the Freon compounds range from 0.0104 to 0.526 atm·m³/mole. Similarly, the solubilities of TCE and PCE are 1,100 and 150 mg/L, while the solubilities of the Freon compounds range from 170 to 9,500 mg/L. Using the predicted influent concentration and drinking water standard for TCE, its removal efficiency must be at least $\frac{100 \times (130\ \text{ppb} - 5\ \text{ppb})}{130\ \text{ppb}} = 96.2\%$. A pilot test of a cascade air stripper was conducted by NASA in 1995. The pilot test demonstrated that VOC removal efficiencies of up to 99% could be achieved (NASA, 1996b).

TABLE 4.3: SUMMARY OF REGULATORY STANDARDS AND REMEDIATION GOALS

Contaminant	Drinking Water Standard[1]	Groundwater Standard[2]	PRG[3]
NDMA	N/A	$<1.0 \times 10^{-5}$ Risk	1.3 ppt
DMN	N/A	$<1.0 \times 10^{-5}$ Risk	1.3 ppt[4]
TCE	5 ppb	100 ppb	1.6 ppb
PCE	5 ppb	20 ppb	1.1 ppb
Freon 11	N/A	N/A	1,288 ppb
Freon 21	N/A	N/A	N/A
Freon 113	1,200 ppb[5]	N/A	59,180 ppb
Cumulative	N/A	$<1.0 \times 10^{-5}$ Risk	N/A

1 20 NMAC 7.1-Drinking Water
2 20 NMAC 6.2-Ground and Surface Water Protection
3 EPA Region 9 Preliminary Remediation Goals (PRGs)
4 Values presented for DMN are extrapolated from published NDMA data.
5 State of California Drinking Water Standard

N/A Not Applicable

TABLE 4.4: PREDICTED INFLUENT CONTAMINANT CONCENTRATIONS TO THE PLUME-FRONT REMEDIATION SYSTEM

Contaminant	Expected Influent Concentration	Residential Cancer Risk	Residential Hazard Quotient
NDMA	2,000 ppt [1]	1.19×10^{-3}	N/A
DMN	1,700 ppt [2]	1.01×10^{-3}	N/A
TCE	130 ppb [3]	1.67×10^{-5}	0.594
PCE	4.2 ppb [4]	2.51×10^{-6}	0.012
Freon 11	860 ppb [2]	N/A	0.079
Freon 21	60 ppb [2]	N/A	0.164
Freon 113	2,000 ppb [2]	N/A	0.002
Cumulative	---	2.23×10^{-3}	0.850

[1] Maximum concentration from Figure 4.7, Page 39.
[2] Highest historical concentration from any plume-front monitoring well.
[3] Maximum concentration from Figure 4.8, Page 40.
[4] Maximum concentration from Figure 4.9, Page 41.

N/A Not Applicable

Recent enhancements by a commercial analytical laboratory have resulted in the ability to achieve a 10 ppt reporting limit for NDMA and DMN using EPA Method 607. This reporting limit is lower than reporting limits established for other U. S. sites with NDMA contaminated groundwater. The current NDMA treatment standards for the Rocky Mountain Arsenal in Colorado and the GenCorp Aerojet Facility in Sacramento, California are 33 ppt (Swanick, 1998) and 100 ppt (Edson, 1998), respectively.

NASA is currently working with a commercial analytical laboratory to develop a reliable analytical method with a reporting limit more sensitive than the current 10 ppt level for NDMA and DMN. At such time that the analytical method is developed to the satisfaction of both NASA and the appropriate regulatory authorities, it will be proposed as a revision to this Plan.

Table 4.5 presents the individual and cumulative risk for the proposed plume-front contaminant presumptive remedy goals. The cumulative cancer risk for the treatment standards is 1.56×10^{-5}, and the cumulative hazard quotient is 0.102. The projected cumulative cancer risk is slightly higher than the Ground and Surface Water Protection Regulations cancer risk level (1×10^{-5}) provided in the concentration-based standards of Table 4.3. NDMA and DMN concentrations of less than 5 ppt would achieve this cancer risk level. This level cannot currently be measured by any EPA-recommended analytical method.

The NDMA and DMN standards presented in Table 4.5 are reporting limit concentrations as received from the analytical laboratory. The EPA Method 607 allowable limits for extraction efficiency range from 13% to 109%. Per the analytical method, the laboratory cannot adjust analytical data for the observed extraction efficiencies. Typically, the off-site laboratory used by WSTF achieves an NDMA extraction efficiency of 30% to 40%. Assuming a typical extraction efficiency of 30%, a reported NDMA/DMN concentration of 10 ppt corresponds to an estimated actual concentration of 33 ppt. The residential cancer risk associated with reported NDMA and DMN concentrations of 10 ppt and an extraction efficiency of 30% are shown in Table 4.6.

In summary, the anticipated development, implementation and approval of a more sensitive analytical method for NDMA and DMN will result in lowered reporting limits for these contaminants and allow NASA to measure and verify lowered treatment levels for NDMA and DMN. Recent data received for a potential alternative method are promising, but no definitive time frame can be provided for completion.

4.5 PRESUMPTIVE REMEDY REMEDIAL SYSTEM CONCEPTUAL DESIGN

The plume-front remediation system will consist of: five additional groundwater monitoring wells (WW-2, ST-7, JP-3, PL-8, and BLM-37); six groundwater extraction wells (PFE-1 through PFE-6); groundwater transport pipelines from the extraction wells to the treatment facility; pre-treatment and treatment systems; pipelines from the treatment facility to the injection wells; and four groundwater injection wells (PFI-1 through PFI-4).

TABLE 4.5: TREATMENT STANDARDS FOR PLUME-FRONT CONTAMINANTS

Contaminant	Treatment Standards	Residential Cancer Risk	Residential Hazard Quotient	Basis
NDMA	10 ppt	5.97×10^{-6}	N/A	Method 607 Reporting Limit
DMN	10 ppt	5.97×10^{-6}	N/A	Method 607 Reporting Limit
TCE	5 ppb	6.44×10^{-7}	0.023	20 NMAC 7.1
PCE	5 ppb	2.98×10^{-6}	0.014	20 NMAC 7.1
Freon 11	100 ppb	N/A	0.009	Conservative Health Risk Value
Freon 21	20 ppb	N/A	0.055	Conservative Health Risk Value
Freon 113	1,200 ppb	N/A	0.0011	California Drinking Water Standard
Cumulative	---	1.56×10^{-5}	0.102	---

N/A Not Applicable

TABLE 4.6: INDIVIDUAL AND CUMULATIVE RISK ASSUMING 30% ANALYTICAL EXTRACTION EFFICIENCY FOR NDMA AND DMN

Contaminant	Treatment Standard (Estimated Actual Concentration)	Residential Cancer Risk	Residential Hazard Quotient
NDMA	10 ppt (33 ppt actual)	1.99×10^{-5}	N/A
DMN	10 ppt (33 ppt actual)	1.99×10^{-5}	N/A
TCE	5 ppb	6.44×10^{-7}	0.023
PCE	5 ppb	2.98×10^{-6}	0.014
Freon 11	100 ppb	N/A	0.009
Freon 21	20 ppb	N/A	0.055
Freon 113	1,200 ppb	N/A	0.0011
TOTAL	---	4.34×10^{-5}	0.102

N/A Not Applicable

The additional plume-front monitoring wells will be installed to enhance vertical delineation of the plume-front, aid in the design and location of extraction and injection wells, enhance plume-front monitoring capabilities, and support monitoring of the effectiveness of the containment system. The plume-front remediation system will be designed to remove contaminant mass at the plume-front and create a hydraulic barrier to prevent further westward migration of the plume. The projected locations of the monitoring wells, extraction wells, injection wells, and the treatment system are illustrated by Figure 4.10.

Treatment alternatives for NDMA, described in Volume One, Chapter Three of the Draft CMS Report (NASA, 1996b), indicate that the contaminant is recalcitrant to treatment. UV oxidation is the only practicable technology available for both NDMA and DMN. The UV oxidation treatment will not independently remediate the halogenated VOCs to acceptable levels, therefore air stripping will be subsequently used to complement the UV oxidation system.

The anticipated performance of the full-scale plume-front treatment system is summarized in Table 4.7. The influent NDMA, PCE and TCE concentrations are the maximum values expected during the lifetime of the presumptive remedy, based on hydrogeological modeling. The projected maximum influent concentrations of NDMA, PCE and TCE are taken from their respective mass removal plots derived from the plume-front containment modeling simulations (Figures 4.7, 4.8, and 4.9). Concentrations of DMN and the other halogenated VOCs listed in Table 4.7 are equal to the highest concentration of each contaminant measured in any of the plume-front wells. The effluent concentrations of NDMA and DMN will be below the current 10 ppt reporting limit of EPA Method 607.

Extraction wells PFE-1 through PFE-6 will be installed along the plume-front. The projected locations of the extraction wells are shown in Figure 4.10. The locations of the extraction wells were selected based on the results of hydrogeological modeling (Figure 4.1). The depths and diameters of the extraction wells will be designed based on the plume-front containment modeling simulation (Table 4.2), and the results of a pump test previously performed on the existing NASA PT well (NASA, 1990), which is plume-front extraction well PFE-3. Depending on the hydrological conditions encountered, the depths and diameters of the extractions wells may change. Hydrogeological modeling provides an extraction flow rate of 1,010 gpm for the most efficient plume-front containment scenario (Sections 4.2 and 4.3 of this Plan). NASA anticipates that additional extraction wells may be installed in the future, for either possible MPCA remedial actions or to supplement plume-front wells identified by this Plan. Therefore, the UV oxidation and VOC treatment equipment will be designed to accommodate a maximum flow rate of 1,300 gpm.

The pipeline from the extraction wells to the treatment facility will be constructed of double-walled high-density polyethylene (HDPE) pipe. In the event of a leak in the inner pipe, the annular space between the inner and outer pipes will serve as secondary containment. Leak detection sensors will be installed in the annular space allowing for the detection, localization and repair of any leaks. The extraction pipeline will be installed underground to protect against external damage, exposure to solar UV radiation, thermal expansion/contraction, and freezing.

R2E R3E

E400000

E410000

E420000

R3E

30 29 28 27 26 25

31 32 33 34 35 36

6 5 4 3 2 1

7 8 9 10 11

T20S

T21S

N230000

N220000

WELL I (WATER WELL)

WELL K (WATER WELL)

WELL J (WATER WELL)

WSTF BOUNDARY

JPZ-1 JPZ-2 JPZ-3 JPZ-4 JPZ-5

WW-2

ST-4-589 ST-4-690 ST-4-481

ST-5-DEEP ST-5-481 ND ST-3-586 ST-3-735 ST-3-686 ST-3-486

PFE-1 PFE-5 PFE-2 PFE-6

ST-1-630 ST-1-541 ST-1-473

ST-8 ST-2-466 ST-7

WW-1-452 PL-4-464

TREATMENT FACILITY

WELL C ABANDONED

PL-2-504 PT-PZ-3 PT-PZ-2 PL-6-B PL-6-A PL-5 PT-PZ-1 NASA-PT-WELL PFE-3 PT-PZ-4

JP-3

PL-1-486 PL-3-453 BLM-2-630 BLM-2-482 PFE-4

PFI-1 PFI-2 PFI-3 PFI-4 PL-7

PL-8

BLM-7-509

CONTROL/MANIFOLD BUILDING

BLM-10-517

JP-2-447

JP-1-424

BLM-37

BLM-5-527 BLM-30 BLM-18-430 BLM-8-418 BLM-1-435 BLM-22-570 BLM-9-419 BLM-17-493 BLM-17-550 BLM-23-431 BLM-25-455 BLM-6-488

BLM-29

BLM-28-404 BLM-15-* BLM-15-305 BLM-21-400 BLM-27-270 BLM-14-327 BLM-13-300 BLM-12-* BLM-11-* BLM-26

BLM-24-* BLM-24-565

700-E-458

BLM-16-*

700-B-510

BW-8-355

BW-5-295

BW-7-211

BW-1-268

BW-2-*

BW-4

BW-3-180

700-D-186 LANDFILL 700 AREA 700-A-253

600-PZ-2 600-C-210 NASA-2 600-C-173 BLM-3-182 600-C-* 600-PZ-1 BLM-4-* 600-D NASA-8 BLM-31

NASA-7 600 AREA NASA-4 100 AREA

600-C-437

NASA-1 400-C-143 400-C-118 400-A-151 400-B-* NASA-9 NASA-6 400-D 400 AREA

300-A-170 300-A-120 300-B-156 300-C-128 NASA-10 NASA-5 300-E 300 AREA NASA-3 300-D-153

200-A-* 200-F 200-B-240 200 AREA 200-G 200-H 200-E-* 200-D-109 200-D-240 200-C

100-B(2)-* 100-B-*

WB-1 100-A-182

WB-7-* WB-8-* 100-E-261 WB-2 WB-5 WB-4 ND 100-C-385 WB-3 WB-15 WB-14 ND WB-6 WB-9

0 2000'

2036 R3E

2782

LEGEND:

EXISTING MONITORING WELLS:

- GROUNDWATER MONITORING WELLS
- ABANDONED WELL
- PIEZOMETER

REMEDIATION:

- PLUME-FRONT EXTRACTION WELL
- PLUME-FRONT INJECTION WELL
- ADDITIONAL PLUME-FRONT MULTI-PORT MONITORING WELL
- TREATMENT INFLUENT
- TREATMENT EFFLUENT

FIGURE 4.10
REMEDIAL SYSTEM WELL LOCATIONS AND CONCEPTUAL DESIGN

TABLE 4.7: ANTICIPATED PLUME-FRONT REMEDIATION SYSTEM PERFORMANCE

Criteria	Value	
Estimated Average Flow Rate	1,010 gallons per minute	
Estimated Maximum Flow Rate	1,300 gallons per minute	
Predicted Influent Concentrations	NDMA DMN PCE TCE Freon 11 Freon 21 Freon 113	2,000 ppt[1] 1700 ppt[2] 4.2 ppb[3] 130 ppb[4] 860 ppb[2] 60 ppb[2] 2,000 ppb[2]
Predicted Effluent Concentrations	NDMA DMN PCE TCE Freon 11 Freon 21 Freon 113	< 10 ppt < 10 ppt 0.06 ppb [5] 3.8 ppb [5] 43 ppb [6] 3 ppb [6] 100 ppb [6]
Effluent Cancer Risk	---	$<1.25 \times 10^{-5}$ [7]

1 Maximum concentration from Figure 4.7, Page 39.
2 Highest historical concentration from any plume-front monitoring well.
3 Maximum concentration from Figure 4.8, Page 40.
4 Maxumum concentration from Figure 4.9, Page 41.
5 Based on packed-tower aeration model calculations.
6 Represents a conservative 95% reduction in influent concentrations.
7 Based on 100% NDMA/DMN analytical extraction efficiency.

Groundwater pre-treatment may be required to remove turbidity, suspended solids and hardness from the water. Turbidity and suspended solids may interfere with the transmission of UV radiation into the untreated water and cause plugging of the injection formation. Hardness values observed in plume-front monitoring wells have ranged from 173 to 613 mg/l (as $CaCO_3$). These hardness values represent a significant potential for scaling in the treatment system, pipelines, wells, and/or the injection formation. Pretreatment recommendations of the manufacturers of the UV oxidation and air stripper treatment units selected through the federal procurement process will be included in the detailed project design.

The treatment system will be designed to remove NDMA and DMN and the halogenated VOCs. UV oxidation will be utilized to oxidize NDMA and DMN; the final oxidation products are bicarbonate and nitrate ions. In the oxidation process, UV radiation generates hydroxyl radicals ($OH^{\bullet}$) by photolysis of ozone and/or hydrogen peroxide:

$$O_3 + H_2O + UV \Rightarrow 2OH^{\bullet} + O_2$$
$$H_2O_2 + UV \Rightarrow 2OH^{\bullet}$$

The hydroxyl radicals in-turn will oxidize the NDMA and DMN molecules to bicarbonate and nitrate.

NDMA Oxidation: $(CH_3)_2\text{-}N\text{-}N{=}O + OH^{\bullet} + UV \Rightarrow 2HCO_3^- + 2NO_3^-$

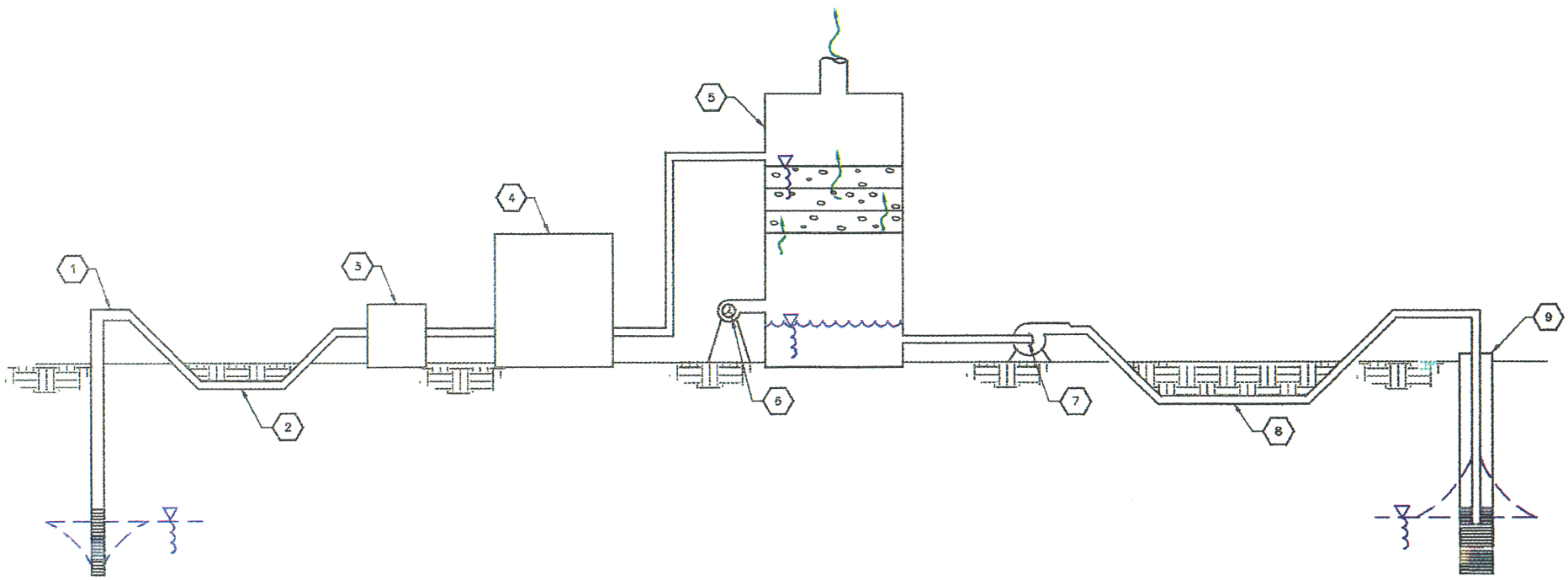
DMN Oxidation: $(CH_3)_2\text{-}N\text{-}N\text{-}O_2 + OH^{\bullet} + UV \Rightarrow 2HCO_3^- + 2NO_3^-$

The oxidation reaction should produce two moles of nitrate for each mole of NDMA or DMN oxidized. Assuming an initial concentration of 2,000 ppt NDMA, and 1,700 ppt DMN, the concentration of NO_3^- in the treated groundwater should be 5.7 ppb.

NASA has previously performed bench-scale testing of a UV oxidation system and the results were reported in Volume Two, Chapter Two the Draft CMS Report (NASA, 1996b). NASA is required by the Federal Acquisition Regulations (FARs) to competitively bid major procurements, such as the UV oxidation system. Prior to the purchase of UV oxidation treatment equipment, pilot-scale testing of the equipment of the potential bidders will be performed to ensure satisfactory system performance and allow development of an engineering design basis. This testing will be performed as a part of the UV oxidation system Technical Feasibility Study (discussed in Section 6.4.2).

Following UV oxidation, the treatment system will utilize an air stripping unit to remove VOCs from contaminated groundwater. A process flow diagram illustrating the conceptual arrangement of the treatment system is presented in Figure 4.11.

The pipeline to the injection wells will consist of single-wall HDPE pipe. The pipeline will be installed underground, to protect against external damage, exposure to the solar UV radiation, thermal expansion/contraction, and freezing.



1. GROUNDWATER EXTRACTION WELLS
2. EXTRACTION PIPELINE (DUAL-WALL) POLYETHYLENE
3. PRETREATMENT SYSTEM FOR HARDNESS AND TURBIDITY REMOVAL
4. UV / PEROXIDE OXIDATION SYSTEM FOR NDMA TREATMENT
5. LOW PROFILE SIEVE TRAY AIR STRIPPER FOR VOC TREATMENT
6. AIR BLOWER
7. INJECTION PUMP
8. INJECTION PIPELINE (SINGLE WALL)
9. GROUNDWATER INJECTION WELLS

AIR FLOW

2758

FIGURE 4.11
PRELIMINARY REMEDIAL SYSTEM
PROCESS FLOW DIAGRAM

Injection wells PFI-1 through PFI-4 will be installed southwest of the plume-front, as shown in Figure 4.10. The locations of the injection wells were selected based on the results of hydrogeological modeling presented in Section 4.2. The well casing and annular materials specifications, design strategy and depth specifications are provided in Table 4.2. Tubing installed in the casing will allow the injection of the treated groundwater below the pre-injection static water level. Cathodic protection will be installed on any extraction/injection wells that utilize carbon or stainless steel components. Flow rates and water levels will be monitored throughout the operation of the injection wells.

Installation of the monitoring wells, extraction wells, injection wells, and treatment equipment will be a staged process. This process is discussed in Section 6.2 of this Plan. Following Plan submission, NASA will submit a Discharge Plan application for the injection wells to the NMED GWQB. Any necessary well drilling permits will be coordinated through the State Engineer's Office (SEO). Upon receipt of the required regulatory approvals, NASA will initiate drilling and installation of two extraction and two injection wells. During the drilling and installation of these wells, it is anticipated that the treatment system will be designed, procured, constructed, and readied for use.

4.6 SITE SAFETY AND SECURITY

Access to the WSTF site is controlled by a security force that is on duty on a 24-hour, 365 day per year basis. Security guards control access to the industrial complex and also patrol the plume-front area at least every 8 hours during non-working hours.

Due to the nature of their design, the extraction and injection wellheads will be sealed to prevent the loss of untreated or treated groundwater. This design will also prevent the accidental or intentional introduction of foreign materials into the remediation wells. The water treatment equipment will be located inside a building. The treatment facility building will be locked, and access restricted to authorized WSTF employees. In addition, access to the treatment facility building will be restricted by the use of fencing and a locked gate.

The treatment building will be equipped with a fire alarm, fire extinguishers, first aid kit, and eyewash. The on-site Fire Department at WSTF provides emergency response service on a 24-hour, 365 day per year basis.

4.7 SYSTEM START-UP

Following evaluation of potential vendor's equipment, final procurement specifications will be generated and procurement of the treatment system and the ancillary equipment will be accomplished in compliance with the FAR. Upon award of the contracts, NASA will be able to complete final design packages and basic operating procedures for the remediation system.

Following installation, the full-scale treatment system will undergo a start-up period of approximately three months. During the start-up period, the system will be intermittently operated to determine the most effective conditions for contaminant treatment, identify any potential design refinements and ensure system integrity. Treated effluent collected during

the start-up pumping periods will be stored in a series of holding tanks pending receipt of laboratory analyses. If the water in the holding tank does not meet treatment standards, it will be recycled through the treatment system or transferred to the permitted WSTF 200 Area Hazardous Waste Evaporation Tanks. If the effluent does meet treatment standards, the treated groundwater will be injected.

4.8 REMEDIAL SYSTEM OPERATION AND MAINTENANCE AND CONTINGENCY PLANNING

4.8.1 Operation and Maintenance

The WSTF plume-front stabilization and groundwater treatment system will require normal, periodic maintenance of various components to ensure optimum operating efficiencies and to minimize potential impacts to human health or the environment. Detailed operational and maintenance (O&M) procedures will be provided with the design packages. A description of water sampling activities is presented in Section 5.0 of this Plan.

4.8.2 Contingency Plan

Appendix A provides the most recent Contingency Plan for the NMED-approved Hazardous Waste Operating Permit for WSTF. This Contingency Plan will be incorporated into this Plan. If the NMED approves future modifications to the Contingency Plan contained within the Hazardous Waste Operating Permit, NASA will provide the modified plan for inclusion as Appendix A of this document.

The plume-front stabilization and groundwater treatment system design will incorporate several interlocks that will halt system operation when specific conditions arise. These conditions include:

- leakage within the dual-wall extraction piping;
- near-surface water levels within injection well(s);
- catastrophic failure of any major component (i.e., air stripper blower motor, injection pump, extraction pumps, UV system); and
- significant leakage from any piping or component within the treatment building facility.

In the event of a significant component failure that results in a system shut-down of more than 24 hours, NASA will notify the NMED verbally within 24 hours and in writing within 72 hours of the event. The written notification will summarize system status, cause of shut-down, response taken and/or planned, expected duration of the shut-down, and any potential impacts on human health and the environment.

4.8.3 Waste Management

Wastes generated from the construction, operation or maintenance of the system will be handled and disposed of per the WSTF Standard Instruction, Waste Management (NASA, 1998b) and the NMED-issued Hazardous Waste Operating Permit for NASA.

Rainwater accumulation and run-off are not anticipated to be a concern; the treatment building that houses the treatment equipment will be located away from existing surface drainage features. The building site will be graded to route roof drainage and precipitation run-on away from the proposed treatment facility.

5.0 SAMPLING AND ANALYSIS

5.1 INTRODUCTION, OBJECTIVES AND SCOPE

As described in previous sections of this document, NASA has determined that plume-front containment and groundwater treatment is required to prevent further migration of the contaminated groundwater at the plume-front. Five additional plume-front monitoring wells will be installed to ensure the effectiveness of the plume-front containment system and to supplement existing monitoring wells. Figure 4.10 provides locations for these additional groundwater monitoring wells. These additional wells are anticipated to be completed as Westbay multi-port® wells with targeted depths of 1,000 feet.

Current WSTF documentation provides detailed instructions for groundwater contamination assessment and monitoring activities. This section compliments the existing documentation with the requirements for the plume-front remediation system.

The purpose of this section is to provide WSTF with a Sampling and Analysis Plan for the plume-front remediation system (SAP-PFRS). This plan provides personnel with project-specific procedures for the collection and analysis of samples associated with plume-front containment activities. These will be used in conjunction with the most recently approved WSTF Groundwater Sampling and Analysis Plan (SAP) (NASA, 1997b) and the WSTF Quality Assurance Project Plan (QAPP) (NASA, 1997c). The most recently approved SAP and QAPP are provided as Appendix B and C, respectively, of this Plan. If future modifications to these Plans are approved, NASA will submit the modified versions to replace the current appendices of this Plan.

These Plans list procedures which address the following:

- collection and preservation of groundwater samples;
- quality assurance and quality control (QA/QC);
- data quality objectives (DQOs);
- chain of custody documentation;
- sample shipment; and
- sample analysis.

The protocols specified in this section assure that samples are collected in a consistent manner, representative of actual environmental conditions, shipped and tracked in an acceptable manner, and analyzed using appropriate EPA-recommended analytical methods. The QA/QC portion of this Plan, used in conjunction with the WSTF QAPP, provides the quality assurance steps necessary to substantiate data collected for this project.

5.2 SAMPLING ACTIVITIES AND FIELD METHODS

WSTF personnel are responsible for conducting all sampling activities associated with the plume-front remediation project. Current WSTF sample collection and quality control procedures will be followed during all phases of the project. Samples will be collected at designated groundwater monitoring wells and sampling points within the remediation system.

All plume-front containment and remediation sampling events will be performed using the same sample collection protocols utilized for 3008(h) Consent Order groundwater assessment sampling events. All necessary safety issues will be addressed and procedures followed as directed in the relevant documentation. This includes, but is not limited to, the following:

- use of appropriate safety equipment (boots, gloves, goggles, etc.) during sampling activities;
- field logbook annotation with all relevant information as outlined in the WSTF QAPP;
- use of proper decontamination procedures;
- use of appropriate sample containers and preservation techniques as outlined in Table 5.1;
- strict adherence to QA/QC procedures; and
- strict adherence to WSTF sample documentation and chain of custody requirements as outlined in the WSTF QAPP.

5.2.1 Groundwater Monitoring

Tables 5.2 and 5.3 designate monitoring wells that will be sampled specifically for this Plan. These wells include existing conventional and Westbay multi-port® wells utilized for RFI/CMS sampling, as well as the additional Westbay monitoring wells to be installed as a part of this Plan.

Conventional groundwater monitoring wells will typically use non-dedicated pumps to evacuate the necessary volume of purge water and dedicated Teflon bailers to collect samples. Typically, an air driven piston pump is used to purge the well and collect indicator parameters. When the required volume of water has been purged and groundwater parameters have stabilized, the pump is withdrawn and the well is sampled using the dedicated bailer. Samples are collected in the appropriate sample containers, labeled, sealed, and prepared for shipment to the appropriate analytical laboratory. Specific instructions for purging and sampling conventional monitoring wells using this process are provided in the WSTF SAP.

TABLE 5.1: SAMPLE COLLECTION AND ANALYSIS REQUIREMENTS

TREATMENT FACILITY/GROUNDWATER ANALYTES				
Analysis	**EPA Method**	**Sample Container[1]**	**Sample Preservative[1]**	**Holding Time[1]**
Halogenated Volatile Organics	EPA Method 8021 or EPA approved/recommended equivalent	40 mL amber glass	Cool to 4°C	14 days
Volatile Organics	EPA Method 8260 or EPA approved/recommended equivalent	40 mL amber glass	Cool to 4°C	14 days
NDMA/DMN	EPA Methods 607, 8070 or EPA approved/recommended equivalent	1 L amber glass	Cool to 4°C	7 days until extraction 40 days after extraction
TREATMENT FACILITY ANALYTES FOR ENGINEERING PURPOSES				
Analysis	**Method**	**Sample Container**	**Sample Preservative**	**Holding Time**
Cations	EPA Method 6010B or EPA approved/recommended equivalent	1 L polyethylene	4°C, 0.45 um filtration, HNO_3 to pH<2	6 months
<u>Anions</u> Total Alkalinity	EPA Method 310.1 or EPA approved/recommended equivalent	1 L polyethylene	Cool to 4°C	14 days
Chloride, Sulfate	EPA Method 300.0 or EPA approved/recommended equivalent			28 days
Fluoride	ASTM SM 4500 F C or EPA approved/recommended or equivalent			14 days
Nitrate/Nitrites	EPA Method 353.2 or EPA approved/recommended equivalent	500 mL polyethylene	4°C, H_2SO_4 to pH<2	28 days
Total Dissolved Solids	EPA Method 160.1 or EPA approved/recommended equivalent	500 mL polyethylene	Cool to 4°C	7 days
Ammonia	EPA Method 350.1 or EPA approved/recommended equivalent	500 mL polyethylene	4°C, H_2SO_4 to pH<2	28 days

[1] Sample containers, preservations and holding times will remain consistent with current regulatory and SW-846 guidance.

TABLE 5.2: PLUME-FRONT SAMPLING FREQUENCIES FOR CONVENTIONAL WELLS/ZONES

Well/Zone ID	Sampling Frequency
BLM-2-482	Quarterly[1]
BLM-2-630	Quarterly[1]
BLM-7-509	Quarterly[1]
BLM-10-517	Quarterly
BLM-17-493	Quarterly[1]
BLM-17-550	Quarterly[1]
JP-1-424	Quarterly
JP-2-447	Quarterly
PL-1-486	Quarterly
PL-2-504	Quarterly
PL-3-453	Quarterly[1]
PL-4-464	Quarterly[1]
ST-1-473	Quarterly[1]
ST-1-541	Quarterly[1]
ST-1-630	Quarterly[1]
ST-2-466	Annually
ST-3-486	Quarterly[1]
ST-3-586	Quarterly[1]
ST-3-666	Quarterly[1]
ST-3-735	Quarterly[1]
ST-4-481	Quarterly
ST-4-589	Quarterly
ST-4-690	Quarterly
WW-1-452	Quarterly

[1] Indicates after active extraction/remediation/reinjection activities have been initiated, the well will be monitored monthly for four months, bi-monthly for eight months and quarterly thereafter.

TABLE 5.3: PLUME-FRONT SAMPLING FREQUENCIES FOR WESTBAY® MULTI-PORT WELLS/ZONES

WELL/ZONE ID	SAMPLING FREQUENCY
BLM-37[1]	Quarterly
JP-3[1]	Quarterly
PL-5-495	Quarterly[2]
PL-5-595	Quarterly[2]
PL-5-715	Quarterly[2]
PL-5-795	Quarterly[2]
PL-5-895	Quarterly[2]
PL-5-985	Quarterly[2]
PL-6-545	Quarterly
PL-6-725	Quarterly
PL-6-915	Quarterly
PL-6-1035	Quarterly
PL-6-1195	Quarterly
PL-6-1335	Quarterly
PL-6-1485	Quarterly
PL-6-1645	Quarterly
PL-6-1815	Quarterly
PL-7-480	Quarterly[2]
PL-7-560	Quarterly[2]
PL-7-630	Quarterly[2]
PL-8[1]	Quarterly[2]
ST-5-485	Annually
ST-5-655	Quarterly[2]
ST-5-815	Quarterly[2]
ST-5-985	Quarterly[2]
ST-5-1175	Quarterly[2]
ST-6-535	Quarterly
ST-6-575	Quarterly
ST-6-685	Quarterly
ST-6-830	Quarterly
ST-6-975	Quarterly
ST-7[1]	Quarterly[2]
WW-2[1]	Quarterly

[1] Anticipated multi-port monitoring well.

[2] Indicates after active extraction/remediation/reinjection activities have been initiated, the well/zone will be monitored monthly for four months, bi-monthly for eight months and quarterly thereafter.

Samples are also collected from Westbay multi-port® wells. Westbay wells are sampled with specialized equipment that collects groundwater directly from the formation through sampling ports in the Westbay casing. A MOSDAX® sampler probe, with attached sample collection bottles and electronic surface controls, can sample groundwater in-situ for uncompromised sample quality. The probe and bottles are inserted into the well, lowered to the desired sampling port and sample collection is initiated. When the sample bottles are filled, they are raised to the surface where the groundwater is dispensed into the appropriate sample container. Refer to Table 5.1 for sample container, preservation and analytical requirements. Westbay sampling procedures are provided in the WSTF SAP.

5.2.2 Treatment System Monitoring

Treatment facility efficiency will be monitored by sampling/analyzing the untreated and treated groundwater at multiple locations. Sample taps will be installed at each of the extraction wells and on the treatment facility influent and effluent piping. These sampling locations will allow monitoring of the influent and effluent contaminant concentrations and allow verification/adjustment of modeling simulations during the operational life of the treatment facility. The O&M Plan for this system will provide specific sampling instructions for influent, effluent and system monitoring port sampling. Table 5.4 provides the influent/effluent sample schedule.

5.2.3 Treatability Testing

NASA has previously performed bench-scale testing of a UV oxidation system and the results were reported in Volume Two, Chapter Two the Draft CMS Report (NASA, 1996b). NASA is required, through the FARs, to competitively bid major procurements such as the UV oxidation system. Potential bidder's systems must be capable of meeting previously tested capabilities. As a result, selected potential bidders will provide pilot-scale verification testing to ensure that previously obtained treatment efficiencies are maintained and that final procurement specification design criteria can be developed for the procurement process.

5.2.4 Treatment System Start-Up

The analyses for the treatment system operation cannot be performed on a real-time basis. Samples are analyzed by off-site laboratories and analytical data for specific sampling events will not be available until weeks after sample collection. Therefore, a high level of confidence is required to ensure that all phases of the treatment system operate effectively and consistently.

Following installation of the remediation system, high intensity start-up sampling of the treatment system will be performed. During this testing, all treated water will be contained in tanks and verified to meet the treatment standards of this Plan prior to injection. Specifics concerning this start-up testing will be provided in the forthcoming Operations and Maintenance Plan.

TABLE 5.4: INFLUENT/EFFLUENT SAMPLING SCHEDULE

Time Period	Sampling Location	Sampling Frequency	Analytes
0-3 Months (initial start-up and testing period)	Treatment Facility Influent and Effluent Piping	Twice per week (during operational periods)	NDMA, DMN, halogenated volatiles, and general inorganics
0-3 Months (initial start-up and testing period)	Each Extraction Well	Once per week (during operational periods)	NDMA, DMN, halogenated volatiles, and general inorganics
3-12 Months	Treatment Facility Influent and Effluent Piping	Once per month	NDMA, DMN, halogenated volatiles, and general inorganics
3-12 Months	Each Extraction Well	Quarterly	NDMA, DMN, halogenated volatiles, and general inorganics
After 12 Months	Treatment Facility Influent and Effluent Piping	Quarterly	NDMA, DMN, halogenated volatiles, and general inorganics

5.3 SAMPLE COLLECTION, SCHEDULING, AND ANALYSIS

5.3.1 Sample Collection

Groundwater samples will be collected from specified wells prior to the installation and also during operation of the treatment facility. These samples will be collected from the plume-front monitoring and extraction wells prior to system operation. These data will provide background information to evaluate the long-term effectiveness of the plume-front containment system.

5.3.2 Sampling Frequencies

Tables 5.2 and 5.3 provide sampling frequencies for all plume-front monitoring wells for volatile, halogenated volatile and nitrosamine analyses. All inorganic water quality parameters will be collected on at least a quarterly basis.

5.3.3 Analytical Methods

Based on historical groundwater assessment data, WSTF has identified specific contaminants in the plume-front groundwater. The specific contaminants targeted for containment and remediation include halogenated volatile organics, NDMA and DMN. WSTF has incorporated the use of the most sensitive analyte-specific EPA-recommended analytical methods for the identification and quantitation of these compounds. As discussed previously, NASA is working with an off-site analytical laboratory to reliably lower the reporting limits for NDMA and DMN using a method not currently approved by EPA. If this method is approved for use by both NASA and the appropriate regulatory authorities, it will be included for use in this Plan.

5.4 QUALITY ASSURANCE PROJECT PLAN

5.4.1 Purpose

This QAPP establishes guidelines for ensuring that the monitoring data for this Plan are scientifically valid, of known quality and legally defensible. To achieve these goals, the following specific QAPP requirements are addressed:

- a consistent and acceptable framework for the collection and generation of physical and chemical data;
- data quality objectives that measure the precision, accuracy, comparability and completeness of generated data;
- acceptance criteria for the data measurements to ensure that data collection and analytical systems provide data of sufficient quality for the program;
- the early detection of deficiencies that may affect data quality and provide corrective actions;
- sufficient document control to verify data completeness; and

- a fundamental framework for the storage and management of plume-front stabilization data.

All data-generation steps, including sample collection, analyses, document control, and data review are performed using established procedures to ensure reported data quality, accuracy and completeness. This document, and adherence to guidelines outlined in specific EPA analytical methods, the WSTF SAP, the WSTF QAPP and site-specific procedural documentation, ensures that data meet the project-specific requirements for this Plan.

5.4.2 Project Organization

The contractor Environmental Department organizational structure is discussed in Section 6.1 of this Plan. All sample collection, analysis and data management activities are performed by or coordinated through the contractor Environmental Department. All personnel who collect environmental data will have access to, and a clear understanding of, this document, the WSTF SAP, the WSTF QAPP, and applicable site-specific procedural documentation.

5.4.3 Off-Site Laboratories

NASA contracts off-site laboratories to analyze groundwater samples in support of RFI/CMS activities, Post-Closure Care monitoring and other regulatory driven activities. Prior to awarding any analytical support contracts, each off-site laboratory must submit their laboratory QAPP to the contractor Environmental Department for review and approval. Appendix C contains the QAPP for laboratories currently performing analytical work for this Plan. Since contracts for analytical services are recompeted and renewed on at least an annual basis, new laboratories may be contracted. Contract laboratories may also revise their QAPPs. If either change occurs, NASA will submit to EPA and NMED the appropriate QAPP for inclusion in Appendix C.

5.4.4 Data Quality Objectives

Quantitative measurements used to estimate true physical and chemical conditions involve some level of uncertainty. Uncertainty can be attributed to natural variability, sampling handling operations and conditions, spatial and temporal patterns, and analytical variability. It is critical that levels of uncertainty are measured and acceptable limits of uncertainty established.

Several parameters are measured to estimate the level of uncertainty of generated data. Data quality is characterized by the precision, accuracy, reproducibility, completeness, and comparability (PARCC) parameters.

Detailed definitions and discussions of the parameters that characterize data quality are contained in Section 3.0 of the most current approved WSTF QAPP (Appendix C). The guidance contained in the WSTF QAPP will be used for this Plan.

5.4.4.1 QA/QC Samples

Several types of QA/QC samples are required to evaluate data uncertainty. A list of field and analytical QA/QC samples and a brief description of each is provided in Tables 5.5 and 5.6. Frequencies for these samples are provided in Tables 5.7 and 5.8. Frequencies represent a summary of guidance from specific EPA analytical methods and site-wide document SW-846. EPA methods provide specific details of the verification required for each analytical process.

5.4.4.2 QA/QC Sample Requirements

It is essential that all QA/QC samples are of the highest possible quality. Reference standards will be certified prior to use. Reagent water used for field and laboratory blanks will be continuously monitored for non-interference with the analyses. Blind quality control standards will represent the types and concentrations of constituents normally found in the WSTF groundwater.

In order to alleviate bias generated by the analytical laboratories, all environmental and audit samples are submitted "blind." Samples are disguised in a manner where laboratory personnel do not recognize the sample source or composition. Identities of all samples, including QA/QC samples, are recorded in the field logbook. Documentation provided to laboratory personnel (i.e., chain of custody forms, sample labels and sample seals) does not contain any information concerning sample identities.

5.4.4.3 Data Quality Requirements

The acceptability requirements for data produced in support of this Plan are provided in Table 5.9. This table provides data quality objectives for detectability, precision, accuracy, and completeness for groundwater matrices. Table 5.10 describes the data qualifiers used to identify data that does not meet the objectives outlined in Table 5.9.

5.4.5 Sample Containers, Preservation and Holding Times

Table 5.1 specifies sample containers, preservation and holding time requirements for samples associated with this Plan. In general, samples not analyzed within the specified holding times are not acceptable for reporting purposes. If the data are crucial, samples are retaken to provide the required information. However, if resampling of the environmental source is impractical, samples that have exceeded their holding times are analyzed and reported with the appropriate data qualifier.

Blind quality control samples and analytical check standards are subject to the same holding time requirements as environmental samples. When blind quality control samples are prepared, the corresponding container is annotated with the preparation date. Blind quality control samples for volatile organics analysis are prepared immediately prior to shipment to the analytical lab.

TABLE 5.5: DESCRIPTION OF FIELD QUALITY CONTROL SAMPLES

Sample Type	Description
Equipment Blank	ASTM Type II water is transported to the sampling site, opened, poured over and/or through the sampling device, and collected in sample containers. This type of blank indicates the effectiveness of decontamination procedures and also indicates contamination in the field which may affect analytical results.
Field Blank	ASTM Type II water is transported to the sampling site, opened and poured directly into sample containers. This type of sample provides a check on reagent quality and contamination derived in the field.
Trip Blank	ASTM Type II water is poured into sampling containers in a contaminant free environment, placed in coolers, transported to the field, back to the laboratory, and analyzed. This type of sample serves as a check on sample contamination originating from sample handling, transport, shipping, and site conditions. This sample may also be used to estimate the system detection limit.
Blind QC Sample	A check standard is prepared from a source other than the calibration standard, which is provided blind to the analytical lab. This type of sample serves as an independent check of analytical techniques, handling and standards.
Field Duplicate	A second sample is taken immediately after an original sample at the same sampling location. This sample provides an estimate of the overall system precision.

TABLE 5.6: DESCRIPTION OF ANALYTICAL QUALITY CONTROL SAMPLES

Sample Type	Description
Reagent Blank	ASTM Type II water is processed through the entire analytical process which, at the time of analysis, contains the same reagent concentrations as samples that have been processed. This type of sample indicates contamination resulting from the preparation or processing of a sample. This sample can be used to establish the analytical detection limit.
Sample Matrix Spike	A predetermined amount of stock solution, containing an analyte of interest, is added to the sample matrix prior to sample extraction/digestion and analysis. This sample indicates the effects of the sample matrix on analysis and also is a measure of the accuracy of the measurement system.
QC Check Standard	A standard is obtained from a source other than the calibration standard. This sample indicates the accuracy and consistency of calibration.
Surrogate Spike	Introduction of a compound similar to the analytes of interest, but not normally found in environmental samples, blanks and standards. This type of sample provides a continuous monitor of the performance of the analytical system and the effectiveness of the method in dealing with sample matrices.
Matrix Duplicate	An intralaboratory split sample which is used to document the precision of a method in a given sample matrix.
Matrix Spike Duplicate	Intralaboratory split samples spiked with identical concentrations of target analyte(s). The spiking occurs prior to sample preparation and analysis. These samples are used to document the precision and bias of a method in a given sample matrix.

TABLE 5.7: FIELD QA/QC CONTROL SAMPLE FREQUENCIES

Control	Halogenated Volatile Organics Method	Volatile Organics Method	Nitrosamines Method
Equipment Blank	100% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	100% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	5% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.
Field Blank	Not required if equipment blanks are taken, otherwise 100% of all halogenated volatile organics sampling days.	Not required if equipment blanks are taken, otherwise 100% of all volatile organics sampling days.	Not required if equipment blanks are taken, otherwise 5% of all nitrosamine sampling days or at least once per month, whichever is the most frequent.
Duplicate Sample	10% of all halogenated volatile organics sampling events or at least once per month, whichever is the most frequent.	10% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	10% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.
Blind QC Sample	5% of all halogenated volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.
Trip Blank	5% of all halogenated volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.

TABLE 5.8: ANALYTICAL QA/QC CONTROL SAMPLE FREQUENCIES

Type Of Control	Halogenated Volatile Organics	Volatile Organics	Nitrosamines
Reagent Blank	At least daily.	At least daily.	One for each set of samples processed.
Sample Matrix Spike	10% of samples analyzed.	5% of samples analyzed.	10% of samples analyzed.
QC Check Standard	10% or less frequently if spike recoveries meet all specified QC criteria.	5% or less frequently if spike recoveries meet all specified QC criteria.	10% or less frequently if spike recoveries meet all specified QC criteria.
Surrogate Spike	100% of all blanks, samples and standards.	100% of all blanks, samples and standards.	100% of all blanks, samples and standards.
Replicate Sample	Aliquoting is not appropriate; therefore, duplicate samples must be analyzed for 5% of the samples analyzed.	Aliquoting is not appropriate; therefore, duplicate samples must be analyzed for 5% of samples analyzed.	5% of samples analyzed.

TABLE 5.9: METHOD SPECIFIC DATA ACCEPTIBILITY REQUIREMENTS

Analysis	Measurement Units	RL	Precision 3	Accuracy 4	Completeness 5
Halogenated Volatile Organics	µg/L	1	1	1	80
Volatile Organics	µg/L	2	2	2	80
NDMA	µg/L	0.010	25	13-109	80
DMN	µg/L	0.010	25	13-109	80

RL - Reporting Limit.

1 Specific criteria are provided in the halogenated volatile organics method.
2 Specific criteria are provided in the volatile organics method.
3 As relative percent difference for field duplicates.
4 As percent recovery of matrix spikes.
5 Percentage of measurements which meet expressed data quality criteria for precision, accuracy and detectability.

TABLE 5.10: DESCRIPTION OF DATA QUALITY ASSURANCE FLAGS

Data Qualifier	Description
*	User defined flag.
A	Indicates that the result of an analyte for a check standard (LCS or CCV) was outside standard limits.
AD	Indicates that the precision for analyst duplicates was outside standard limits.
EB	Indicates that the analyte was detected in the equipment blank at or above the reporting limit.
FB	Indicates that the analyte was detected in the field blank at or above the reporting limit.
G	Indicates that the result is an estimated value greater than the calibration limit.
J	Indicates that the result is an estimated value less than the reporting limit, but greater than or equal to the detection limit.
NA	Indicates that the value/result was either not analyzed or not applicable.
ND	Indicates that the analyte was not detected at or above the detection limit.
Q	Indicates that the result for a blind control was outside standard limits.
QD	Indicates that the precision for a field duplicate was outside standard limits.
RB	Indicates that the analyte was detected in the reagent blank at or above the reporting limit.
S	Indicates that the result was determined by the method of standard addition.
SP	Indicates that either the spike recovery or the relative percent difference for spike duplicates was outside standard limits.
T	Indicates that the analyte was analyzed outside the specified holding time.
TB	Indicates that the analyte was detected in the trip blank at or above the reporting limit.
TIC	Indicates that the analyte was tentatively identified by a GC/MS library search and the amount reported is an estimated value.

CCV Continuous Calibration Verification
GC/MS Gas Chromatography/Mass Spectroscopy
LCS Laboratory Calibration Standard

6.0 PROJECT MANAGEMENT

6.1 ORGANIZATION

The NASA Environmental Program Manager directs all activities associated with WSTF environmental compliance and the plume-front remediation project. The site contractor Environmental Department, under the direction of the NASA Environmental Program Manager, performs and/or coordinates all activities associated with the project. Figure 6.1 provides an organizational chart for NASA WSTF environmental activities.

Design, implementation, operation, and maintenance of the plume-front containment project will be supported by a contractor Environmental Department staff of over 30 engineers, hydrogeologists, scientists, and technicians experienced in multiple facets of environmental compliance.

In addition, support from the existing WSTF infrastructure is available. This includes heavy equipment, engineering, drafting, and administrative support. For activities in which WSTF infrastructure is not available (well drilling services, groundwater modeling expertise, downhole geophysical logging, etc.), off-site contractors will be used.

6.2 SCHEDULE

The anticipated time-line for design and implementation of the plume-front containment project is presented as Figure 6.2. A phased approach will be employed, allowing a portion of the system to be brought online and operational as soon as feasible. Additional extraction and injection wells and remediation system capacity will be added as the work progresses. Although every effort will be made to adhere to this schedule, there are multiple factors beyond the control of NASA, which may impact it. These factors include:

- the timeframe required for the electrical utility company to provide the electrical power distribution system to the project area;
- the regulatory review/approval timeframes associated with submitted reports and plans;
- the ability to schedule subcontractor support; and
- the availability of vendor-supplied equipment and materials.

If the projected time-line elements cannot be completed in compliance with the schedule, NASA shall, as early as possible, notify the appropriate regulatory agencies with identification of the delay, contributing factors for the delay, and revised time-line projections.

6.3 REPORTING REQUIREMENTS

Progress and subsequent data reporting will be accomplished through use of the monthly RFI/CMS reports to EPA/NMED. The format of the current reports will be modified to accommodate reporting of activities and data directly applicable to plume-front containment. These reports will at a minimum provide: significant project accomplishments; activity

NASA White Sands Test Facility
Environmental Compliance

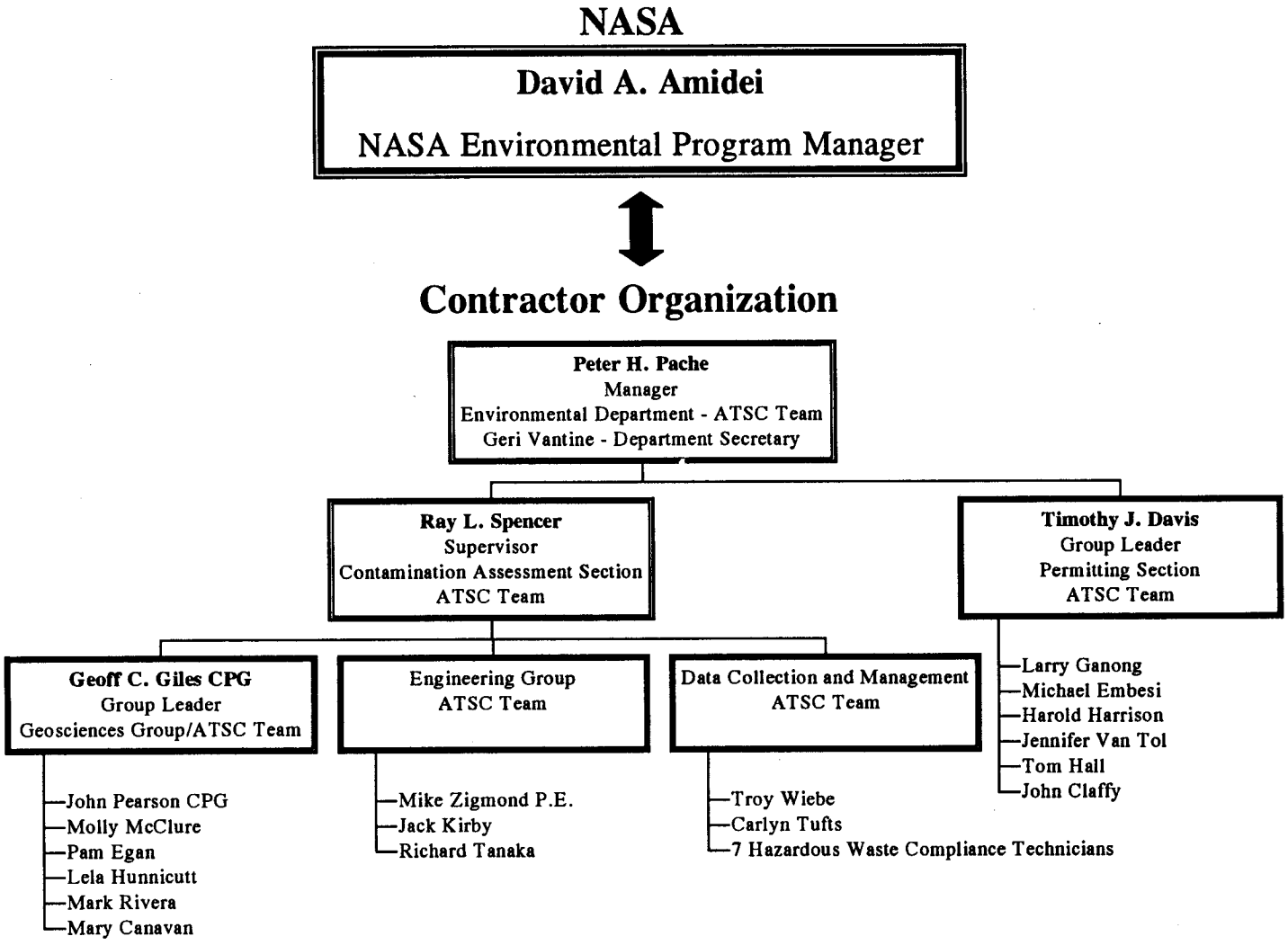


Figure 6.1
Organizational Chart for NASA WSTF Environmental Activities

NASA-WSTF

Plume-Front Stabilization Schedule

ID	Task Name	Start	Finish
1	**Permitting and Reporting**	1/19/1999	11/5/1999
2	Submission of Plume-Front Stabilization Plan (anticipated)	1/19/1999	
3	EPA/NMED Review/Approval (anticipated)	1/19/1999	3/19/1999
4	Technical Feasability Demonstration/Pilot-Scale Testing (anticipated)	2/15/1999	4/30/1999
5	Submission of Discharge Plan Application	2/10/1999	
6	NMED Review of Discharge Plan Application (including public comment)	2/19/1999	8/10/1999
7	NMED Approval of Discharge Plan Application (anticipated)	8/10/1999	
8	Remediation System Specifications and Operation & Maintenance Plan submittal/approval (anticipated)	9/13/1999	11/5/1999
9	**Plume-Front Treatment System (design, construction, and implementation)**	10/5/1998	11/16/2001
10	Design of Interim Measure System	10/5/1998	9/3/1999
11	Procurement of Remediation System Equipment/Contractor Services	5/3/1999	8/30/1999
12	Drilling of Plume-Front Wells (monitoring, extraction and injection)	1/18/1999	11/16/2001
13	Design/Installation of Electrical Power Distribution System (anticipated)	12/1/1998	9/10/1999
14	Construction of Remediation System	9/6/1999	11/16/2001
15	Phase 1 Remediation System Start-Up	6/16/2000	
16	Phase 2 Full Scale Remediation System Operational	11/16/2001	
17	**Related Tasks**	12/16/1998	6/1/1999
18	Conduct Environmental Assessment	12/16/1998	3/30/1999
19	NASA Headquarters Comments	3/31/1999	4/30/1999
20	Public Comment	5/3/1999	6/1/1999

Figure 6.2

updates; monitoring data; and significant problems and corrective actions taken. NASA will initiate use of these reports as soon as plume-front activities are initiated. If revisions to the format are required, revisions to the format can be implemented which are amenable to EPA, NMED and NASA.

6.4 PERMITTING ISSUES

Several permitting actions are required for implementation of the plume-front remediation system. The following outlines permitting actions required for this project.

6.4.1 Work Plans, Operations and Maintenance Plans and System Specifications

Submittal of this Plan initiates the regulatory review and approval process for the plume-front stabilization project. Procurement of drilling services has been initiated, with drilling and installation of groundwater monitoring wells anticipated to begin by January 1999. Activities such as the drilling of injection and extraction wells, procurement of treatment equipment, and installation of electrical power to the plume-front area are pending EPA/NMED review/approval of this plan.

Future submittals to EPA/NMED will be the O&M Plan and specifications and drawings for the plume-front system. This submittal will be dependent upon regulatory comments/approval of this Plan, completion of the competitive bid process for the UV oxidation treatment equipment, and completion of the design package and O&M Plan.

6.4.2 Technical Feasibility Study

Using HRMB recommendations, NASA will perform pilot-scale testing of selected UV oxidation systems as a Technical Feasibility Study. This study will allow public involvement with regards to the pilot-scale testing. The process will provide the public with information regarding UV oxidation systems, provide general information regarding the plume-front stabilization effort, incorporate a public meeting to discus any relevant issues, and allow the public to submit written comments concerning the project.

NASA anticipates detailed written guidance from HRMB delineating the public notification process. NASA will adhere to this guidance when received.

6.4.3 Groundwater Discharge Plan

A Discharge Plan is required by the NMED GWQB to accommodate the injection of treated water. This Plan will be prepared and submitted in accordance with Ground and Surface Water Protection Regulations (NMAC, 1998a). This Discharge Plan will incorporate all the requirements of the regulations and follow guidelines received from NMED, including a public comment period.

6.4.4 Hazardous Waste Permits

Discussions with the NMED HRMB indicate that hazardous waste permitting actions will not be required for this plume-front containment project. The current WSTF Hazardous Waste Operating Permit has been reviewed and there were no issues identified that will require permit modifications. The current permitted active units on-site are appropriate to manage hazardous wastes generated from the project. Waste generation is anticipated to be minimal and will include grease/oil, air stripper scale, UV mercury vapor lamps, and other minor waste streams. These waste streams can be managed using existing permit guidelines and the site operating procedures. Satellite accumulation areas and the permitted Container Storage Unit will be utilized to accumulate and store any generated wastes. Existing manifesting and shipping procedures will be utilized for wastes shipped off-site for disposal.

The current Post-Closure Care Permit was also reviewed for possible regulatory impacts. The Permit requires the annual reporting of information from closure units. This information includes water levels, contaminant concentrations, hydrostratigraphic units, flow rates, statistical evaluations, and other associated information. The Permit requires the eventual implementation of corrective measures as specified by the submitted and approved RFI and CMS. The plume-front remediation is considered a presumptive remedy which may be utilized in the preparation, or as a part of, the final corrective measures selection. Therefore, NASA believes that this remediation does not impact the specific reporting requirements of the Post-Closure Care Permit (Module IV, Section IV H.2).

6.4.5 Air Quality

The NMED Air Quality Bureau does not regulate emissions from stripping operations during remediation activities. These emissions are considered RCRA-related emissions that could be regulated under Subpart AA, BB and CC of 40 CFR §264 (NARA, 1998b, 1998c, and 1998d). According to the NMED Air Quality Bureau, this issue should be addressed by HRMB. The following discussion addresses each of the three subparts mentioned above.

6.4.5.1 Subpart AA

EPA has established air emissions standards which apply to owners and operators of facilities that treat, store or dispose of hazardous waste (40 CFR §264.1030; NARA, 1998b). These standards apply to process vents associated with various treatment processes, including air stripping, that manage hazardous waste with organic concentrations of at least 10 parts per million by weight (ppmw). Subpart AA standards apply to operations that are conducted in units subject to the permitting requirements of 40 CFR §270, or in hazardous waste recycling units that are located at RCRA-permitted facilities. The plume-front remediation system will not manage groundwater with 10 ppmw concentrations of regulated contaminants. An initial waste stream determination will be performed to ensure that concentrations are below 10 ppmw. This determination will be performed using process knowledge and documented in the Operating Record.

6.4.5.2 Subpart BB

EPA has established air emissions standards which apply to owners and operators of facilities that treat, store or dispose of hazardous waste (40 CFR §264.1050; NARA, 1998c). These standards apply to equipment leaks from equipment that contain or contact hazardous waste with organic concentrations of at least 10 percent by weight. Subpart BB standards apply to operations that are conducted in units subject to the permitting requirements of 40 CFR §270, or in hazardous waste recycling units that are located at RCRA-permitted facilities. The remediation system will not manage groundwater with this concentration of organics. A process knowledge waste stream determination will be performed and documented as previously stated in section 6.4.2.1.

6.4.5.3 Subpart CC

The air emissions standards for units that treat groundwater with tanks, surface impoundments, or containers does not apply. Section §264.1080 of the Post-Closure Care Permit states that a waste management unit that is used solely for on site treatment or storage of hazardous waste that is generated as the result of implementing remedial activities is exempt from Subpart CC requirements (40 CFR §264.1080; NARA, 1998d).

6.4.6 National Environmental Policy Act

NASA will ensure the requirements of the National Environmental Policy Act (NEPA) will be incorporated into the plume-front containment project. This will require the preparation of an Environmental Assessment (EA) for this project. The EA will provide a public comment period to ensure the public has an opportunity for direct involvement.

6.4.7 Well Permits

NASA will comply with all New Mexico SEO well permitting requirements (SEO, 1995). Permits will be obtained for all wells within the following three SEO categories:

1. test, exploratory or observation wells;
2. monitoring and injection wells; and
3. plume control and recovery.

Specific components of each SEO permit application will be met.

7.0 REFERENCES

Daniel B. Stephens & Associates, 1995a, "Preliminary Simulation Of Remedial Design Alternatives", White Sands Test Facility, Las Cruces, NM, September, 1995.

Daniel B. Stephens & Associates, 1995b, "Remedial Design Alternatives Letter Report," White Sands Test Facility, Las Cruces, NM, report prepared for AlliedSignal Technical Services Corporation, December, 1995.

Daniel B. Stephens & Associates, 1998, "Remedial Design Alternatives Letter Report", White Sands Test Facility, Las Cruces, NM, report prepared for AlliedSignal Technical Services Corporation, DBS&A Inc., September, 1998.

Edson, J., 1998, Personal Communication, Colorado Department of Health, Hazardous Waste Division, Federal Facilities Section, August 25, 1998.

Environmental Protection Agency, 1986, RCRA Ground Water Monitoring Technical Enforcement Guidance Document, OSWER Directive 9950.1, Office of Solid Waste and Emergency Response (OSWER), Washington D.C., September 1986.

Environmental Protection Agency, 1989, Risk Assessment Guidance for Superfund (RAGS): Volume 1, Human Health Evaluation Manual, Part A, Interim Final, EPA/540/1-89/002, Office of Solid Waste and Emergency Response, Washington D.C., December 1989.

Environmental Protection Agency, 1993, Presumptive Remedies: Policy and Procedures, Directive 9355.0-47FS, EPA/540-F-93-047, Office of Solid Waste and Emergency Response, Washington, D.C., September, 1993.

Environmental Protection Agency, 1994, RCRA Corrective Action Plan (Final), OSWER Directive 9902.3-2A, EPA/520/R-94/004, Office of Solid Waste and Emergency Response, Washington, D.C., May, 1994.

Environmental Protection Agency, 1996, Presumptive Response Strategy and Ex-Situ Technologies for Contaminated Ground Water at CERCLA Sites, Directive 9283.1-12, EPA 540/R-96/023, Office of Solid Waste and Emergency Response, Washington, D.C., October 1996.

Environmental Protection Agency, 1997, Comments on the NASA WSTF RCRA Facility Investigation and Corrective Measures Study Reports, February 27, 1997.

Environmental Protection Agency, 1998a, "Integrated Risk Information System," Up-to-date chemical-specific cancer slope factors, reference doses and toxicity information available on the Internet at http://www.epa.gov/iris.

Environmental Protection Agency, 1998b, Risk-Based Concentration Tables, EPA Region 3, October 1998 Update, Internet at http://www.epa.gov/reg3hwmd/risk.

Environmental Protection Agency, 1998c, Preliminary Remediation Goals, EPA Region 9, updated May 1998, Internet at http://www.epa.gov/region09/waste/sfund/prg.

Geoscience Consultants, Ltd., 1995, "NASA-WSTF Groundwater Modeling Report to EPA Region 6," Consultant report prepared for NASA Environmental Program Manager, NASA White Sands Test Facility, Las Cruces, NM, January, 1995.

Giles, G. C., and Pearson, J.W., 1998, "Characterization of Hydrostratigraphy and Groundwater Flow on the Southern San Andres Mountains Pediment, NASA-JSC White Sands Test Facility", New Mexico Geological Society Guidebook, 49th Field Conference, Las Cruces Country II, 1998.

HydroGeoLogic Inc., 1997, MODFLOW-SURFACT, "First Fully Integrated MODFLOW-Based Flow and Transport Simulator", HydroGeoLogic Inc., Herndon, Virginia, 1997.

Maciejewski, T.J., 1996, "Integrated Geophysical Interpretation of Bedrock Geology, San Andres Mountains, New Mexico", Unpublished Masters Thesis – University of Texas at El Paso, 123 p, 1996.

McDonald, M.G., and Harbaugh, A.W., 1988, "A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model", Techniques of Water-Resources Investigations 06-A, United States Geological Survey, 1988.

National Aeronautics and Space Administration, 1990, "Aquifer Pumping Test Report NASA PT Well", NASA White Sands Test Facility, Las Cruces, NM, December 5, 1990.

National Aeronautics and Space Administration, 1996a, Draft RCRA Facility Investigation Report, NASA WSTF, Las Cruces, NM, March 1996.

National Aeronautics and Space Administration, 1996b, Draft Corrective Measures Study Report, NASA WSTF, Las Cruces, NM, March 1996.

National Aeronautics and Space Administration, 1997a, "Jornada del Muerto Pumpage and Mountain Recharge Rates", Letter to the U.S. EPA, Region 6, Dallas, TX, June 17, 1997.

National Aeronautics and Space Administration, 1997b, "Groundwater Sampling and Analysis Plan," WSTF, Las Cruces, NM, July 1997.

National Aeronautics and Space Administration, 1997c, "Quality Assurance Project Plan", NASA WSTF, Las Cruces, NM, July 1997.

National Aeronautics and Space Administration, 1998a, RFI/CMS Interim Measures Evaluation Report, NASA WSTF, Las Cruces, NM, March 1998.

National Aeronautics and Space Administration, 1998b, "White Sands Test Facility Standard Instruction, Waste Management", (WSI 22-W-005.A), Las Cruces, NM, June 5, 1998.

National Archives and Records Administration, Office of the Federal Register, 1998, Code of Federal Regulations (CFR), Protection of Environment, Title 40, Part 264, Washington D.C., July, 1998.

National Institute for Occupational Safety and Health (NIOSH), Pocket Guide to Chemical Hazards, NIOSH, June 1990.

New Mexico Administrative Code, 1998a, New Mexico Environment Department, Ground and Surface Water Protection, Title 20, Chapter 6, Part 2, Internet at http://www.nmenv.state.nm.us.

New Mexico Administrative Code, 1998b, New Mexico Environment Department, Drinking Water Regulations, Title 20, Chapter 7, Part 1, Internet at http://www.nmenv.state.nm.us.

Seager, W.R., 1981, Geology of the Organ Mountains and Southern San Andres Mountains, New Mexico, New Mexico Bureau of Mines and Mineral Resources, Memoir 36, Albuquerque, NM, May, 1981.

State Engineer Office (SEO), 1995, Rules and Regulations Governing Drilling of Wells and Appropriation and Use of Ground Water in New Mexico, State Engineer Office, Santa Fe, New Mexico, 1995.

Swanick, J., Personal Communication, GenCorp Aerojet, September 1, 1998.

Wilson, C.A., White, R.R., Orr, B.R., and Roybal, R.G., 1981, Water Resources of the Rincon and Mesilla Valleys and Adjacent Areas, New Mexico, New Mexico State Engineer Technical Report 43, 1981.

Zheng, C., 1989, PATH3D, Version 3.2, "A Ground-Water Path and Travel-Time Simulator", S.S. Papadopulos & Associates, Inc., Rockville, Maryland, 1989.

Zheng, C., 1992, MT3D, Version 1.5, "A Modular Three-Dimensional Transport Model for Simulation of Advection, Dispersion and Chemical Reactions of Contaminants in Groundwater Systems", S.S. Papadopulos & Associates, Inc., Rockville, Maryland, 1992.

APPENDIX A

CONTINGENCY PLAN FOR THE WSTF HAZARDOUS WASTE OPERATING PERMIT

PERMIT ATTACHMENT II - 6

CONTINGENCY PLAN

Table of Contents

for the
Contingency Plan

Contents Page

Introduction.....2
Purpose.....2
Definitions.....2
Responsibilities 3
Organization and Duties 5
Coordinated Emergency Services.....5
Training.....5
Contingency Plan Distribution.....5
Amendment of Plan 6
Preparedness and Prevention.....7
Internal Communications and Alarm Equipment.....7
External Communications and Alarm Equipment.....7
Fire Control Equipment and Procedures.....7
Spill Control and Equipment.....8
Decontamination of Equipment.....10
Water Supply..... 11
Arrangements with Local Authorities.....11
Emergency Procedures.....12
General.....12
Releases From Permitted Hazardous Waste Units.....14
Soil Assessment and Clean-Up Procedures.....17
Fires and Explosions.....18
Containment Activities.....20
Decontamination Procedures.....20
Evacuation Plan 21
Record Keeping and Incident Reports.....22
Operating Record 22
Incident Reports.....22
Compliance.....23
Corrective Action.....23

Appendix 1 Floor Plan of Buildings Nearest Permitted Units Showing Locations of Fire Alarms, Electric Supply Pull Boxes and Fire Extinguishers

Appendix 2 Chemical Hazard Information

Introduction

Purpose

The purpose of this plan is to establish procedures, delineate responsibilities and provide planning guidance for the following:

a. the prevention and control of discharges of hazardous waste or hazardous waste constituents to air, soil or surface water;

b. identification of resources to be used to clean-up discharges at WSTF (e.g. chemical absorbants, personal protective equipment);

c. the response activities to be conducted in the event of an emergency;

d. the protection of human health, property and the environment; and,

e. reporting spills as required.

This plan will be implemented immediately in the event of a fire, explosion, or release of hazardous waste or hazardous waste constituents which could threaten human health or the environment.

Definitions

Emergency - A fire, explosion, or release of hazardous waste or hazardous waste constituents, which could threaten health, environment or property.

Emergency Response Team - A team made up of on site personnel who have been trained in emergency response.

Environment - All surface waters, ground water, drinking water supply, land surfaces, below ground surfaces (geology) and ambient air.

First Responder - The first certified emergency response team member to arrive on site at an emergency.

Reporting Spill - Any release (other than those acceptable to regulatory agencies) into the environment of a listed hazardous substance in quantities greater than or equal to the listed quantities found in 40 CFR 302 (refers to the National Emergency Response Center, the NM State Police and the NMED), any release of hazardous waste which could threaten human health or the environment, or any release of hazardous waste from a permitted

environment, or any release of hazardous waste from a permitted unit.

Release - Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment.

Spill Response Team

Responsibilities

All persons appearing on the list of emergency coordinators (Table II-6-1) are persons with a minimum of one year experience in the areas for which they are involved. They have the authority to commit necessary resources in the event of an emergency. Their responsibilities are described below.

Emergency Coordinator (**EC**) - The official predesignated by the NASA WSTF Manager to act as an emergency response commander. The specific response actions to be taken in the event of an emergency will be determined by the EC, utilizing environmental information provided to him by the EPM and the AeNC. He will coordinate and direct the actual emergency activities. He is typically head of the Quality Assurance, Reliability and Safety Office because of familiarity with availability of resources and his first hand knowledge of emergency response. In the chain of command, the EC is directly responsible to the WSTF Manager.

Environmental Program Manager (**EPM**) - The official predesignated by the NASA WSTF Manager who will act as an advisor on environmental matters to the EC. This person is the contact to the regulatory community and other outside agencies. The EPM will also be responsible for fulfilling the notification requirement referred to in this plan. In the chain of command, the EPM is directly responsible to the WSTF Manager.

Area Environmental Coordinator (**AeNC**) - The official predesignated by the NASA Manager for his familiarity with specific wastes streams in the affected Area of the facility and his ability to provide specific chemical information to the EC. After the Emergency Response Team has completed their work, the AeNC will coordinate activities of the Spill Response Team in completing the task of waste clean-up. In the chain of command the AeNC is responsible both to the EC and the EPM.

The NMED will be notified within 90 days of any personnel changes which effect the Emergency Coordinator List

Table II-6-1 Emergency Coordinators List

Emergency Coordinator (EC)

	NAME	WORK NO.	HOME NO.	PAGER NO.
Primary Don Hall	J. Nelson	524-5282	524-0663	None
Alternate Pratt	T. Hogge	524-5230	522-5314	5230

Environmental Program Manager (EPM)

	NAME	WORK NO.	HOME NO.	PAGER NO.
Primary	D. Amidei	524-5517	523-4495	None
Alternate	P. Pache	524-5462	382-8643	5462
Second Alternate	C. Wolf	524-5152	526-3833	5152

Area Environmental Coordinator (AeNC)

100, 300, 400, 500, and 700 Areas	NAME	WORK NO.	HOME NO.	PAGER NO.
Primary Wolf	I.D. Smith	524-5524	522-3449	5524
Alternate Schwartz	J.Mulholland	524-5516	527-4611	5516
Second Alternate J. Griffin	D. Gorham	524-5141	523-9005	5141

200 and 800 Areas	NAME	WORK NO.	HOME NO.	PAGER NO.
Primary	H. Johnson	524-5725	522-8137	5725
Alternate	D. Baker	524-5605	526-5480	5605
Second Alternate	H. Beeson	524-5542	521-0960	5542

Organization and Duties

The Emergency Coordinator will establish a command post for specific response to a spill and receive input from all WSTF responsible groups and make decisions on clean-up methods and resource allocations.

The on site contractor will provide an Emergency Response Team trained in the cleanup of spills of hazardous substances.

Coordinated Emergency Services

All emergency response activities will be directed by the NASA EC. In the event outside support is required, the EC will maintain authority over response activities.

Training

All personnel involved in spill response have received specialized training as outlined in the Training Plan, Permit Attachment II-4, Training Plan.

Contingency Plan Distribution

The Contingency Plan will be distributed as follows. Any changes to the original will be followed up with a change notice or revised copy to all Contingency Plan holders.

Distribution and locations of the Contingency Plan is as follows:

WSTF Site Copies:

Original Copy - NASA WSTF Manager's Office
WSTF Environmental Emergency Coordinator
On site Contractor's Environmental Section
Fire Department
200 Area Office Chief
300 Area Blockhouse
400 Area Blockhouse

800 Area Control Room

Off-site Copies:

White Sands Missile Range, White Sands, NM
Memorial General Hospital, Las Cruces, NM
Dona Ana Sheriff's Department, Las Cruces, NM
New Mexico State Police, Hazardous Material Emergency Response Division, Santa Fe

In the Part B RCRA Application and RCRA Permit:

New Mexico Environment Department, Hazardous and Radioactive Materials Bureau, Santa Fe, NM
United States Environmental Protection Agency, Region VI, Dallas

Amendment of Plan

It is the responsibility of the EC to review the Contingency Plan and amend, if necessary, whenever:

a) the facility permit is modified;

b) the plan fails during a test run or in an emergency;

c) the facility design, construction, operation, maintenance or other circumstances change to increase the potential for fires, explosions, or release of hazardous waste or hazardous waste constituents or changes in the response necessary in an emergency;

d) the list of emergency coordinators changes; or

e) the list of emergency equipment changes.

A request for a permit modification must be sent to NMED and EPA concurrently with the change. Whenever the plan is changed, all parties identified on the Contingency Plan distribution listed above will also receive copies of the changes.
II-6-1

Preparedness and Prevention

Internal Communications and Alarm Equipment (264.32(a))

All inhabited buildings at WSTF are equipped with telephone communication and fire alarm systems. Pull box alarms are available and accessible in buildings near the hazardous waste management units (Figures II-6-1 and II-6-2). Pull box alarm locations, for those buildings located nearest the hazardous waste units, are indicated in Appendix 1. In the case of an emergency, facility personnel will be notified through public address system announcements, siren wails or fire bells.

External Communications and Alarm Equipment (264.32(b))

Any site telephone may be used to summon emergency assistance from WSTF security, fire and emergency response teams. The Emergency Center, in addition to telephones, maintains a radio system which is capable to summoning assistance.

When a pull box alarm is used, an alarm signal is sent to the Emergency Center in Building 112. If the emergency involves a fire or potential fire, and off-site assistance is required, it can then be summoned by telephone.

Telephone communication is provided by U.S. West. Telephones are located at the 100 Area Container Storage Unit, at the 200 Area Evaporation Tank Unit (evaporation tanks), at the 500 Area Waste Fuel Treatment Unit, in every occupied building, and in marked boxes along the access road. The Emergency Center is immediately alerted by either lifting the receiver or by dialing 5111, depending on the type of phone.

Additional communications are provided by the use of hand-held and mobile two-way radios. In addition to the extensive telephone network available for internal and external communications, WSTF maintains 4 dedicated radio frequencies. The security personnel, the Emergency Services Center, Fire Department and personnel operation at the 700 Area Open Detonation Unit are all equipped with hand-held or mobile radios which can be utilized in the event of an emergency.

Fire Control Equipment and Procedures (264.32(c))

WSTF fire protection is provided by the use of fire hydrants, fire extinguishers, hose racks, and an on site Fire Department. Fire hydrants and water supply risers are located 700 feet south of the Container Storage Unit; there is another one ajacent to the Evaporation Tanks Unit (evaporation tanks); and one at the Waste Fuel Treatment Unit. The Container Storage Unit is located one half mile north of the WSTF Fire Department and is equipped

with fire extinguishers and a communication system that can be used to notify the appropriate personnel in the case of an emergency. All fire hydrants and fire protection water risers are inspected semiannually by the WSTF Fire Department for static pressure, flow pressure and water flow.

The WSTF Fire Department can respond with three fire trucks/pumpers in the event of an emergency. Each pumper truck carries 500 gallons of water and has an operating pressure of 150 psi. Two of the trucks pump at a rate of 750 gallons per minute and are capable of operating two 2 1/2-inch fire hoses. The other truck delivers 1,000 gallons per minute and can operate five 2 1/2-inch fire hoses. Each vehicle's operational status is checked daily and preventive maintenance is conducted on a weekly basis. Additionally, each pumper is back-flushed semi-monthly.

Portable fire extinguishers are present throughout WSTF. Fire extinguisher locations and types, for buildings near the hazardous waste units, are found in Appendix 1.

Fire control vehicles have an unobstructed path to all hazardous waste management areas and emergency procedures restrict access to authorized vehicles and personnel.

Spill Control and Equipment (264.32(c))

The WSTF contingency plan employs a spill response team, which is provided by the Environmental Section, that responds immediately to emergencies. The team is made up of professionals with experience in supervision, heavy equipment operations, fire fighting, safety engineering, contamination control, and environmental protection. This team is equipped with a portable source of self-contained breathing air, protective suits, commercial adsorbents, neutralization solutions, and assorted hand tools and containers. In the event of a spill or release at WSTF, the containment activities outlined the section on "Containment Activities" will be implemented.

A wide variety of the WSTF heavy equipment can be utilized for containment and clean-up in the event of a hazardous waste spill. In the event of a large spill, a bulldozer, backhoe and front-end loader are available for spill control.

Temporary storage tanks, portable pumps and hoses can be used to transfer and provide temporary storage for spill materials.

Absorbents and temporary construction materials, such as soil, sand and gravel, are readily available at WSTF. Other materials such as emulsifiers, specialty adsorbents, and containers can be obtained immediately from a central on site spill response stockpile. WSTF also maintains numerous hand tools, such as shovels and rakes, which can be utilized in the event of an

emergency. There is also a wide variety of protective clothing with breathing apparatus for personnel who may become engaged in spill control and clean-up operations. See Table II-6-2 for a complete list of spill control equipment.

Table II-6-2 Emergency Response Materials

Equipment	WSTF Location	Capabilities
3 Fire Truck/Pumpers	Building 112	500 gallons
Rescue Vehicle	Building 112	
2 ea Ambulance	Building 112	
Bulldozer	Landfill	
Cranes, Mobile (10-ton, 30-ton)	150 Yard	10 ton, 30 ton
Backhoe	Building 113	
2 ea Dump-Truck	150 Yard	
Diesel Semi-Truck	150 Yard	20 tons
Low-boy Trailer	150 Yard	6000 gallons
Tanker Trailer	150 Yard	
Forklift	All Areas	
4" Pump - Portable Wheel-mounted, Hitch-equipped	100 Area Sewage Lagoon	100 GPM
3 ea Heat Resistant FireKing Fire Suits	Building 112	
Sand	Site	
Livestock Storage Tanks	150 Yard	1000 Gallons
Hoses	Building 112	6000 feet
Polyurethane Foam	Building 112	
a. AFFF Alcohol Type		
b. Protein base		

Personnel Protection Equipment:	Safety Crib Building 120	
- Hard Hats		
- Goggles		
- Safety Glasses		
- Face Shields		
- Splash Suits		
- Totally Encapsulates Suits		
- SCBA's		
- Chemical Cartridges		
- Respirators		
- Escape Masks		
- Assorted Gloves		
Spill Pillows	Warehouse	
Shovels	Facilities	
Rakes	Facilities	
Rope and Line	Warehouse	
Drums	150 Yard	
Salvage Drums	150 Yard	
Drum Hoist	Facilities	
Bung Wrench	Container Storage Unit	
Hand Pumps	Warehouse	

Decontamination of Equipment

If a spill should occur, all contaminated equipment will be decontaminated as a latter part of the response process. WSTF is equipped with a cleaning unit for decontamination. Post-

emergency equipment will be serviced in the "clean room" or on the "clean pad" by the on site cleaning personnel. Decontamination will be accomplished with the use of biodegradable soap, hot water and steam. The resulting waste is expected to be of such a dilute nature that no incompatible reactions will occur. Typically these wastes will be transported and added to the evaporation tanks. Determination for the completeness of decontamination will be based on physical and chemical analysis of the particular contaminants.

Water Supply

Site water is provided by two drinking water wells. The water is pumped to fill a 1,000,000-gallon gravity storage tank by two 100 horsepower electric motors. The pumps lift the water 1,038 feet, from the water table to the tank, a distance of over 7 miles. The storage tank, located northeast of the main facility development, is monitored remotely by electronic gauges from the Emergency Center. Physically inspections are conducted at tank by security personnel a minimum of six times a day. Adequate volume and pressure will be maintained to efficiently operate all water supplied fire fighting equipment.

Arrangements with Local Authorities

WSTF has agreements with several outside agencies for support in the event of an emergency. In all cases, the support activities involve materials, personnel and equipment which will be released to the WSTF Emergency Coordinator for use at his discretion. These groups have been provided with a copy of this plan in order to familiarize them with the layout and possible hazards at WSTF. Details of these agreements can be found in the Permit Application, Part B.

AGREEMENTS

Dona Ana County Sheriff - Has been provided with a copy of this plan in order to familiarize them with the layout, and possible hazards at WSTF.

U.S. Army White Sands Missile Range - WSTF is on WSMR and therefore is addressed in the WSMR contingency plan. WSMR is capable of providing fire fighting, spill clean-up, and evacuation support. NASA also has an agreement with McAffee Medical Center on WSMR to provide medical assistance.

Memorial General Hospital - Has been made aware of the types of medical emergencies which could result at this site.

State of New Mexico - The State does not enter into agreements with individual facilities, but does have a mandated duty to assist when notified. The State has been provided with a copy of

this plan in order to familiarize them with the layout and possible hazards at WSTF.

Emergency Procedures

General

WSTF emergencies will be reported to the Emergency Center switchboard which is manned 24 hours a day. The initial notification may be automatic, such as fire alarms or manual by telephone (Emergency Center, dial 5111) or radio. Site tours by firemen every 90 minutes during off-duty hours assists in notification. In the event of an emergency situation during working hours there are personnel in all areas who are trained and authorized to act as first responders. The Emergency Center will still be notified and the rest of the chain of events followed even if a first responder is on scene at the time of the emergency.

The switchboard operator at the Emergency Center will concurrently: dispatch the Fire Department; notify the area specific EC for the area in which the emergency is located; and notify the EEC.

The Fire Department will act as the first responder when they arrive on scene.

The First Responder will obtain technical information about hazards (Appendix 2: Contains information on the chemical hazards of the most widely used chemicals on site), perform search and rescue as required, identify vapor clouds, establish the command post, set up road blocks, and evaluate and implement initial Containment Activities procedures and the Evacuation Plan procedures as needed.

The Emergency Center will relay the information on the type of emergency to the EC and the EPM. The EC will proceed to the scene of the emergency and evaluate the situation. The EC will determine actions to be taken in response to the emergency. The EC will maintain contact with the EPM during all stages of the emergency.

EMERGENCY PHONE NUMBERS

White Sands Missile Range	(505) 678-4187
Memorial General Hospital	(505) 522-8641
NMED Emergency Response	(505) 827-9329

NOTIFICATION

National Response Center (Spills and Releases)	(800) 424-8802
State of New Mexico	(505) 827-9329

CHEMICAL INFORMATION

Chemtrec (Chemical Manufacturer's Association - Washington, D.C.)	(800) 424-9300

The EC will immediately identify the character, amounts, source, and areal extent of any released material. This initial assessment will be based on documentation of materials routinely managed in each area and existing physical and chemical analyses (Permit Attachment II-1, Waste Analysis Plan). The EC will advise the AeNC of his findings.

The EC, as assisted and/or advised by the EPM and the AeNC, will also assess any direct or indirect hazards to human health and the environment which may result from any release due to the emergency situation. The assessment will consider such pertinent factors as Threshold Limit Values (TLV's) of chemical constituents, potential combustion by-products, potential incompatibilities and adverse reactions, and the necessity for providing adequate run-off control for both released materials and agents used in fire control, containment or decontamination efforts.

Based on this evaluation, the EC will activate internal alarms as needed and request assistance as outlined in the coordinated emergency response (Permit Attachment II-4, Training Plan). The EPM will notify authorities as outlined in the section on Record Keeping and Incident Report procedures if the incident involves a reportable release. The EC, as assisted and advised by the EPM and the AeNC, will assess the situation and decide on the materials and manpower required to respond to immediate threats to human health and the environment. The EC will then notify the members of the Emergency Response Team and designate a command post from which the operations will be coordinated.

The EC will take whatever actions necessary to protect human health and the environment during the emergency. This may include shutdown of operations and commitment of resources and manpower. If operation systems are shut down, the EC is responsible to see that monitoring for leaks, pressure buildup, gas generation, or rupture in valves, pipes or other equipment, wherever appropriate, is accomplished.

As soon as the immediate threat to health has been brought under

control, the EC will relinquish control of the clean-up effort to the AeNC who will oversee the clean up of the on site contractor.

Releases From Permitted Hazardous Waste Units

This section outlines some specific considerations for the units which handle hazardous waste.

Evaporation Tanks (264.56(e), 264.194(c))

The 200 Area hazardous waste evaporation tanks at WSTF provide for leak detection and secondary containment. In the event of a double failure or handling accident, the EC will make an initial assessment of fire, explosive, toxicity hazards, and potential threat to human health and the environment as previously described. The Contingency Plan will then be implemented as necessary and as outlined in the first part of the Emergency Procedures section. In the event a release from a tank is suspected or documented, the EC will be immediately notified and insure that the process flow to the tank is shut-off and the waste diverted to the stand-by tank. Because both tanks have independent leak detection systems, a leak in one tank will not preclude the use of the other independent tank. Notifications will be made as outlined in the section of this plan on Record Keeping and Incident Reports.

After the initial assessment has been made, any free-standing liquid will be contained with berms to prevent any further migration and to contain any additional releases which may occur until the tank is repaired and the remaining waste is removed. Any free-standing liquid and any hazardous waste residue which remains in the tank will then be removed and placed in another tank or container and transported off-site to a permitted disposal facility. A soil assessment and clean up-will be performed as outlined in the Soil Assessment and Clean-Up Procedures portion of the plan.

During the decontamination operation, the tanks will be inspected to determine the cause of the hazardous waste leak. If the leak cannot be repaired or the tank's integrity is so impaired that it is no longer usable, the tank will be decontaminated using appropriate decontamination solutions, removed from service and the Closure Plan implemented. If the leak is repaired, the tank will be leak tested prior to returning to service.

If the tank cannot be successfully decontaminated it will be removed from its location and transported off-site for disposal at a permitted disposal facility.

Hazardous Waste Drain Lines and Drain Line Sump (264.15(c), 264.56(e))

Releases of hazardous waste would be identified during routine inspections of the drain line, drain line sump and the associated secondary containment systems. Other areas indicative of potential leaks may be where there is subsidence, damp earth surrounding equipment, or noticeable surface spills. The EC will be notified immediately and the drain line flow will be shut down. This will be accomplished with the use of an announcement over the public address system saying that the hazardous waste drain is closed to additions and the placement of signs on all drains directing personnel that the drains are closed. During the time the drain lines are closed, the waste will be held in the individual shops until the system is reopened. Notifications will be made as outlined in the Report Keeping and Incident Report section described in the latter part of this plan.

The EC will then make an initial assessment of fire, explosive, toxicity hazards and potential threat to human health and the environment. The Contingency Plan will then be implemented as needed. Upon completion of the initial assessment, any liquid or wastes remaining in the drain line or drain line sump will be drained into tanks or containers, or taken to the evaporation tanks.

If it is suspected that a release has resulted in soil contamination, measures will be implemented as outlined in the Soil Assessment and Clean-Up Procedure portion of the plan.

The drain lines and the drainline sump will be inspected to determine the cause of the hazardous waste leak. If the leak cannot be repaired or the equipment integrity is so impaired that it is no longer usable, the equipment will be decontaminated by triple rinsing. The rinsate produced in the decontamination procedure will be handled as hazardous waste and disposed of accordingly. In the event the leak is repaired, the line will be leak tested prior to being put back in service.

If the drain line(s) and the drain line sump cannot be successfully decontaminated, defective components will be removed from their location and disposed of off-site at a permitted disposal location.

Container Storage Unit (264.15(c), 264.56(e), 264.171)

Noticeable spills or free-standing liquids inside the Container Unit may be indicative of release of hazardous waste. If a release is suspected or documented, the Emergency Center will be notified immediately. The Center sill in turn notify the EC. Notifications will be made as outlined in the plan section, Record Keeping and Incident Reports.

Initial assessment of the fire, explosive, toxicity hazards, and the potential threat to human health or the environment will be made by the EC as described in the General portion of the plan. Subsequent to the initial assessment, any spills will be cleaned up and packaged for disposal at an permitted off-site RCRA facility.

Subsequent assessment will be made to determine if any contamination has escaped from the containment system. If contamination is confirmed, the soils will be excavated to remove all contamination by measures outlined in the plan section, Soil Assessment and Clean-Up Procedures. Contaminated soils will be disposed of at an off-site permitted disposal location.

Drums in the storage area will be inspected for deterioration, leakage or improperly secured closure devices. Any drums that are deteriorated or that cannot be sealed will have the contents removed and repackaged in serviceable drums. Unserviceable drums will be removed from service, cleaned in accordance with the Decontamination Procedures or disposed of off-site at a permitted disposal location if they cannot be decontaminated.

Open Detonation Unit (264.56(e), 264.171)

Any release of hazardous waste from the Open Detonation Unit (OD) would be indicated by elevated explosive residual organics and total metals in the soil as a result of inefficient treatment (refer to the Permit Attachment II-1, Waste Analysis). If elevated hazardous wastes are detected in the soil, a soil assessment and clean-up will be performed as noted in the Soil Assessment and Clean-Up Procedures portion of the plan.

In the event of a fire involving explosives, all personnel and equipment will be evacuated to a position no closer than the entrance to the Sanitary Landfill (refer to Figure II-6-2). The fire will be observed from this position until it burns out or undergoes a transition from deflagration to detonation. A waiting period of 24 hours will be observed before explosive personnel can approach the OD Unit and assess the situation. Soils around the OD Unit, which show indications of contamination from the burning of explosives, will be managed in accordance with Soil Assessment and Clean-Up Procedures. The soil will then be analyzed for explosive residual organics and total metals as discussed in Permit Attachment II-1, Waste Analysis. Any soils exhibiting concentrations in excess of the established background will be disposed in accordance with HWMR-6.

In the event there are other emergency situation not involving fire, all unnecessary personnel will be evacuated from the OD Unit. Only the qualified personnel needed to handle the emergency and take corrective measures will remain at the site.

Waste Fuel Treatment Unit (264.56(e), 264.171)

A release of hazardous waste from the waste fuel treatment unit would be identified during routine inspections of the unit's tanks, piping and secondary containment. In the event a release from the treatment facility is suspected or documented, the EC will be notified immediately and all process equipment turned off.

The EC will then make an initial assessment of fire, explosive, toxicity hazards, and potential threat to human health and the environment as previously described. The necessary measures will then be implemented as outlined in the Emergency Procedures portion of the plan. Upon completion of the initial assessment, the waste fuel in the treatment and holding tanks will be secured by closing the tank outlet valves and if required, by transferring the waste to a tanker trailer. Any waste remaining in ancillary equipment will be drained to tanks or containers.

A subsequent assessment will be made to determine if any contamination has escaped from the containment system. If contamination is confirmed, the soils will be excavated until all contamination is removed. The extent of contamination will be assessed as outlined the Soil Assessment and Clean-Up Procedures of the plan, and to background or risk assessment levels.

The tanks and ancillary equipment will be inspected to determine the cause of the leak. If the leak cannot be repaired or the equipment integrity is so impaired that is no longer usable, the equipment will be decontaminated by triple rinsing. The rinsate produced in the decontamination procedure will be handled as a hazardous waste and disposed of accordingly. In the event the leak is repaired, the tanks or ancillary equipment will be leak tested prior to being put back in service. All waste fuel removed from the tanks and ancillary equipment will be treated and disposed of in accordance with HWMR-6.

Tanks or equipment that can not be successfully decontaminated will be removed from their location and disposed of off-site at a permitted disposal location.

Soil Assessment and Clean-Up Procedures

After a spill has been contained and all free liquid has been removed, the AeNC will conduct an assessment of the contaminated soils. This assessment will include the identity of the waste streams associated with the Unit that released the contamination. This will allow the AeNC to determine the safety precautions that will be utilized by clean-up personnel and determine what analytical methods are appropriate for determining the extent of contamination.

Using portable monitoring instrumentation and visual observations, the soils that appear to be contaminated will be excavated. All excavated soils will be properly containerized, characterized and disposed of in compliance with HWMR-6.

After all soils that appear to be contaminated are removed from the area, a sampling grid will be developed based on the size and quantity of the spill to determine the extent of horizontal and vertical contamination. Core samples will be taken and analyzed from different locations and depths within and adjacent to the spill area. Analytical parameters will be based on the knowledge of the waste stream.

Based on the analytical results, and background or risk assessment levels, the AeNC will determine if the initial clean-up removed all contaminated soils or if more excavating, sampling, and analyses are required. All equipment used for the clean-up will be washed after completing the response, in accordance with the Decontamination Procedures. Equipment that cannot be successfully decontaminated will be characterized and disposed of in accordance with HWMR-6.

Fires and Explosions (264.56(e))

In the event of a potential or actual fire or explosion at WSTF, the Emergency Center or the Fire Department will be notified through either emergency fire alarms, telephone or radio contact. The Emergency Center or Fire Department will then notify the EC and the appropriate AeNC of the Area in which the emergency exists. The EC will activate the Contingency Plan. The WSTF Fire Department will have the duty to take the necessary actions to contain and alleviate the emergency under the direction of the Fire Department Chief and the command of the EC.

If flammable materials are involved in an incident and are on fire, the EC will immediately:

1) have all non-essential personnel evacuated from the affected area;

2) ensure that the appropriate fire control measures are taken (e.g., removal of ignition sources, availability of suitable fire control agents, activation of fire suppression systems);

3) direct containment activities (e.g., dikes, berms) to control the spread of flammable materials and potentially contaminated run-off; and

4) ensure that all process control systems are shut off and monitored for any leaks or pressure build-up.

If flammable materials are involved and are not on fire, the EC will take all steps necessary to prevent ignition or recurrence of any fire.

The primary concerns during a potential or actual fire situation, whether it involves flammable or non-flammable materials, are the spread of fire to adjacent areas, exposure of personnel to toxic gases or vapors, and the potential of contaminated water run-off due to fire control activities.

The spread, or recurrence of fire, can occur through direct impingement on neighboring structures or from movement of flammable vapors to points of ignition. The EC will evaluate data on known chemical constituents in effected areas and will include such factors as flammability, vapor density, lower and upper explosive limits, wind direction and velocity, surrounding topography and possible sources of ignition when formulating emergency response activities. Possible alternatives in any fire control situation may include: water deluge on neighboring structures to prevent ignition; water mist to knock down and dissipate explosive or flammable vapors; evacuation of low lying areas where vapors may collect; and the removal of all ignition sources in potentially affected areas.

If the EC determines that evacuation of surrounding areas is necessary, he shall follow the Evacuation Plan procedures included in the greater plan. The initial evacuation will be at least ½ mile downwind from the effected area.

As part of the initial assessment, the EC will also determine the type and level of personnel protection equipment that will be necessary for emergency response activities. Both flammable and non-flammable materials which are involved in a fire can potentially emit highly toxic decomposition products when subjected to hear or flame. As part of any emergency assessment, a thorough evaluation will be made of the potential for human exposure and the levels of personnel protection that may be required for emergency response activities. Based on known toxicities and potential combustion by-products, specified equipment may include: bunker gear; splash suits; chemical cartridge respirators; self-contained breathing apparatus (SCBA's), or; SCAPE suite (self-contained atmospheric protective ensemble).

To prevent run-off of contaminated water which may be used in fire control activities, the EC will evaluate the existing topography in the effected area to determine potential flow paths. If substantial amounts of water are to be used, dikes and berms will be constructed to provide containment for any run-off. After emergency response activities are completed, the contained run-off will be analyzed to determine if it is a hazardous waste and, if required, will be managed in accordance

with all applicable regulations.

Containment Activities

In the event of a spill or release of a hazardous substance, one of the duties of the first responder is the containment of any free liquids. This is to be done with spill control booms, spill pillows, earth, or any materials available, as needed. the objective of containment activities is to first control the spread and runoff of the material, and then to absorb the contained materials to minimize infiltration into the ground.

Decontamination Procedures (264.56(h)(2))

Post clean-up decontamination of personnel will take place in a decon stations designed to prevent the spread of contamination. The clean-up personnel will wear disposable outer garments or totally encapsulated suits. Decontamination will include: the physical removal of loose contaminants using rinse water and antistatic solutions; the scraping, brushing, wiping or absorption of adhering contaminants; and the rinsing or evaporation of volatile liquids. Disposable garments will be containerized for disposal in compliance with HWMR-6 and the totally encapsulated suits will be cleaned and inspected by the WSTF contamination control facility (clean room).

WSTF is equipped with a cleaning facility for the decontamination of a wide variety of materials that are tested on site. Post-emergency equipment for decontamination can be serviced in the "clean room" or on the "clean pad" by the on site cleaning facility. The location for cleaning will depend upon the size of equipment contaminated. Decontamination will be accomplished with the use of biodegradable soap, hot water, and steam. The resulting waste will be of such a dilute nature that no incompatibilities will result. Decontamination will be determined by visual inspection or by analysis of the rinsate. The determination of decontamination will be based on the chemical and physical nature of the contaminant.

Decontaminated equipment will be inspected by the facilities maintenance group. Diaphragms, gaskets, seals, and other soft goods that require replacement will be disposed in compliance with HWMR-6. Protective breathing equipment is inspected and maintained by the WSTF Quality Assurance, Reliability Safety Office. Materials that require disposal will be restocked from with the WSTF warehouse or reordered by the WSTF Environmental Section.

Any hazardous waste generated by the decontamination process at the cleaning facility will be collected by the 200 area evaporation tanks, which services the clean room and clean pad. Any emergency response equipment or materials which cannot be

decontaminated at the WSTF cleaning facility will be shipped off-site for disposal at a permitted disposal facility.

Evacuation Plan (264.56(d))

Once the decision has been made to activate evacuation procedures, facility personnel will be notified by the following:

1. Fire

   a. 200 and 800 Areas - Local fire bell rings continuously
   b. 300 and 400 Areas - Evacuation horn is sounded

2. Liquid Spill or Release

   a. 200 Area - Public address announcement
   b. 300 and 400 Areas - Public Address Anouncement

Evacuation Routes

100 Area (Container Storage)

If it becomes necessary to evacuate the 100 Area and adjoining structures, personnel will be directed south along the main NASA WSTF access road to State Highway 70.

200 and 800 Areas (Evaporation Tank Unit)

During any emergency situation, personnel in the 200 and 800 Areas will be restricted from any affected areas and will remain inside the 200 and 800 Area Buildings. All air handling systems may be turned off to prevent any gasses from entering the building. If it becomes necessary to evacuate personnel from the buildings, personnel will be directed to leave any exits located up wind at points further from the effect area and at locations on opposite sides of the building. Depending on the location of the area affected, personnel will then be directed south on Apollo Boulevard to the 100 Area or north on Complex Road B to the 400 Area.

500 and 700 Areas (Waste Fuel Treatment Unit and Open Detonation respectively)

There is no planned evacuation plan for the 500 and 700 Areas since there are no adjacent buildings that house WSTF personnel and since personnel are not usually stationed at these hazardous waste units.

Record Keeping and Incident Reports (264.56(j))

Operating Record (264.56(j))

After any incident occurs which requires implementation of the Contingency Plan, the same information required in Incident Reports section, regarding that incident will also be entered into the NASA operating record.

Incident Reports (264.56(j))

If it is determined that the emergency situation poses a threat to human health or the environment, or that the spill is a reportable spill, the EPM will make the following notifications:

1. Immediate notification to the National Response Center (800) 424-8802;

2. Within 24 hours after any spill or release of hazardous waste, WSTF will notify the NMED Secretary or their designee. The report will include:

   a. name and telephone number of reporter;

   b. name address of facility;

   c. time and type of incident (e.g., spill, fire);

   d. name and quantity of materials involved, to the extent known;

   e. the extent of injuries, if any; and,

   f. the possible hazards to human health or the environment.

3. Within 15 days after any incident occurs, NASA will submit to the NMED Secretary a written report on the incident. The report will include:

   a. name, address, and telephone number of the owner or operator;

   b. name, address, and telephone number of the facility;

   c. date, time, and type of incident (e.g., fire, explosion);

   d. name and quantity of material(s) involved;

   e. the extent of injuries, if any;

   f. an assessment of actual or potential hazards to human health or the environment, where this is applicable; and

g. estimated quantity and disposition of recovered material that resulted from the incident.

Compliance (264.54(j))

Operation will resume only after the EPM notifies the NMED Secretary that no wastes which are incompatible with the released material have been stored, treated or disposed of in the affected Area before clean-up has been completed and that all emergency equipment used in any emergency response activity has been decontaminated and is fit for its intended use.

Corrective Action (270.14(b)(7))

After a response to a release requiring implementation of the Emergency Procedures, the EPM will initiate a review process and develop a corrective action plan to prevent spill recurrence. The corrective action plan will be reviewed and approved by management and then incorporated into operating procedures.

APPENDIX 1

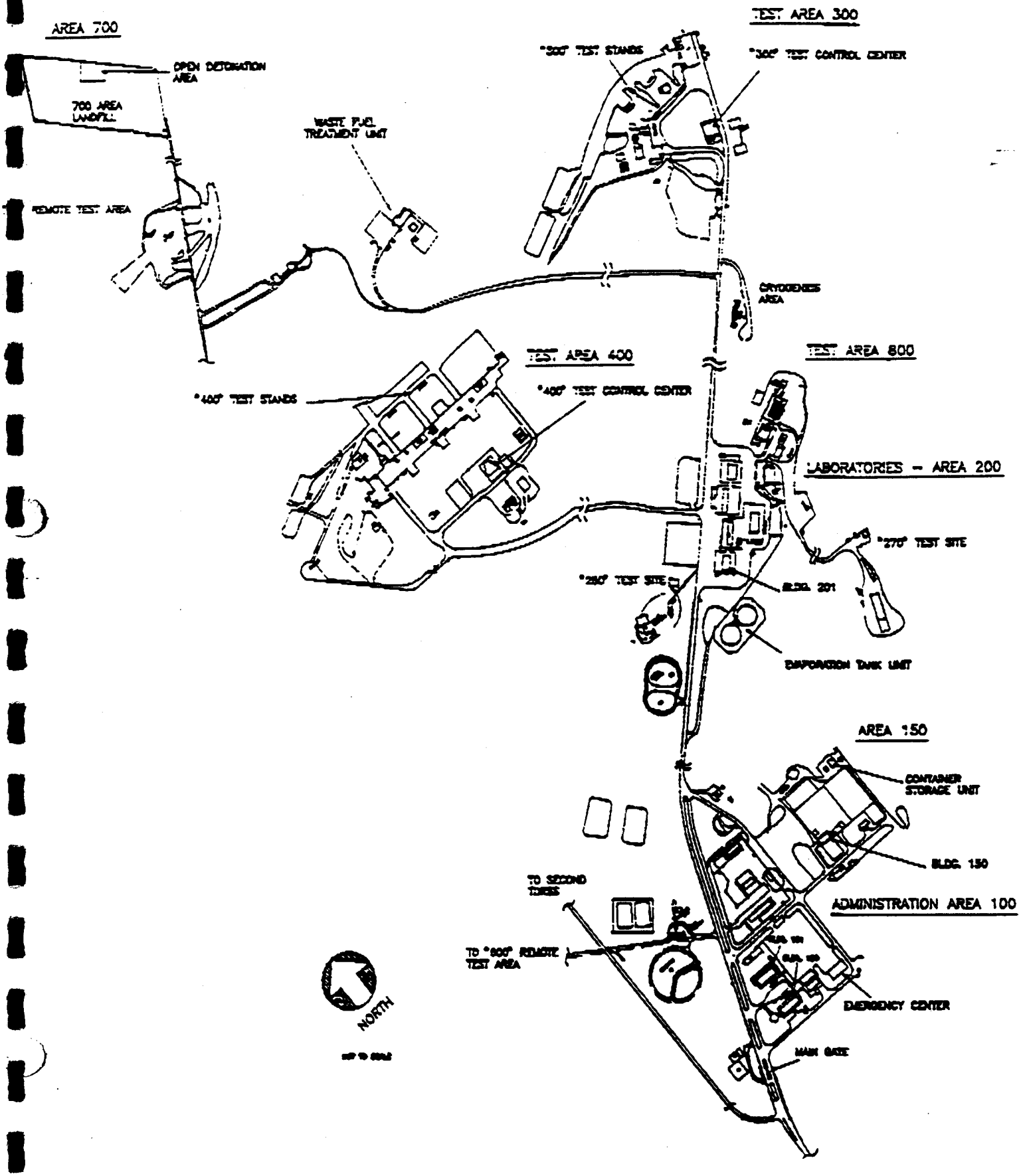
(PERMIT ATTACHMENT II-6)

FLOOR PLANS OF BUILDINGS NEAREST PERMITTED UNITS

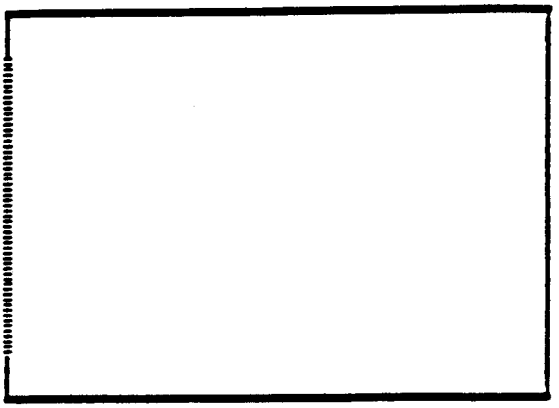
SHOWING LOCATIONS OF

FIRE ALARMS, ELECTRIC SUPPLY PULL BOXES AND FIRE EXTINGUISHERS

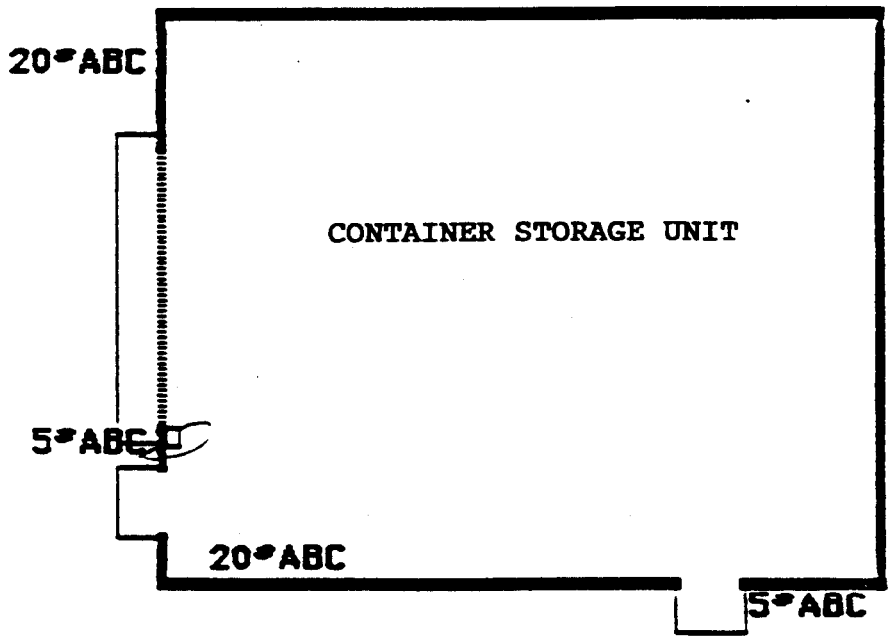
WHITE SANDS TEST FACILITY



EMERGENCY RESPONSE BUILDING

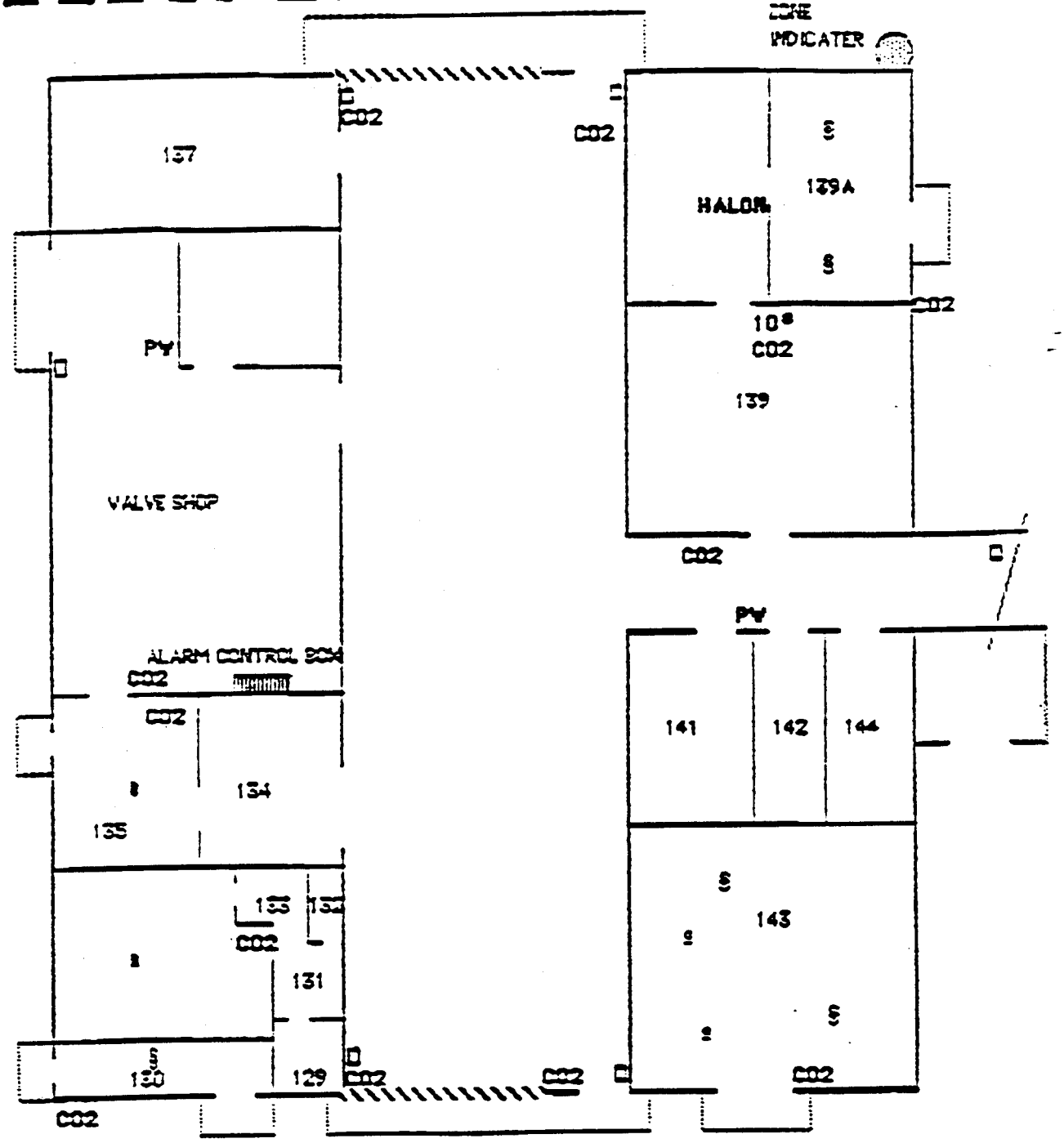


BLDG. 161



2- ABC-20# DRY POWDER FIRE EXTINGUISHERS
2- ABC- 5# DRY POWDER FIRE EXTINGUISHERS
1- □ -FIRE ALARM PULL BOX

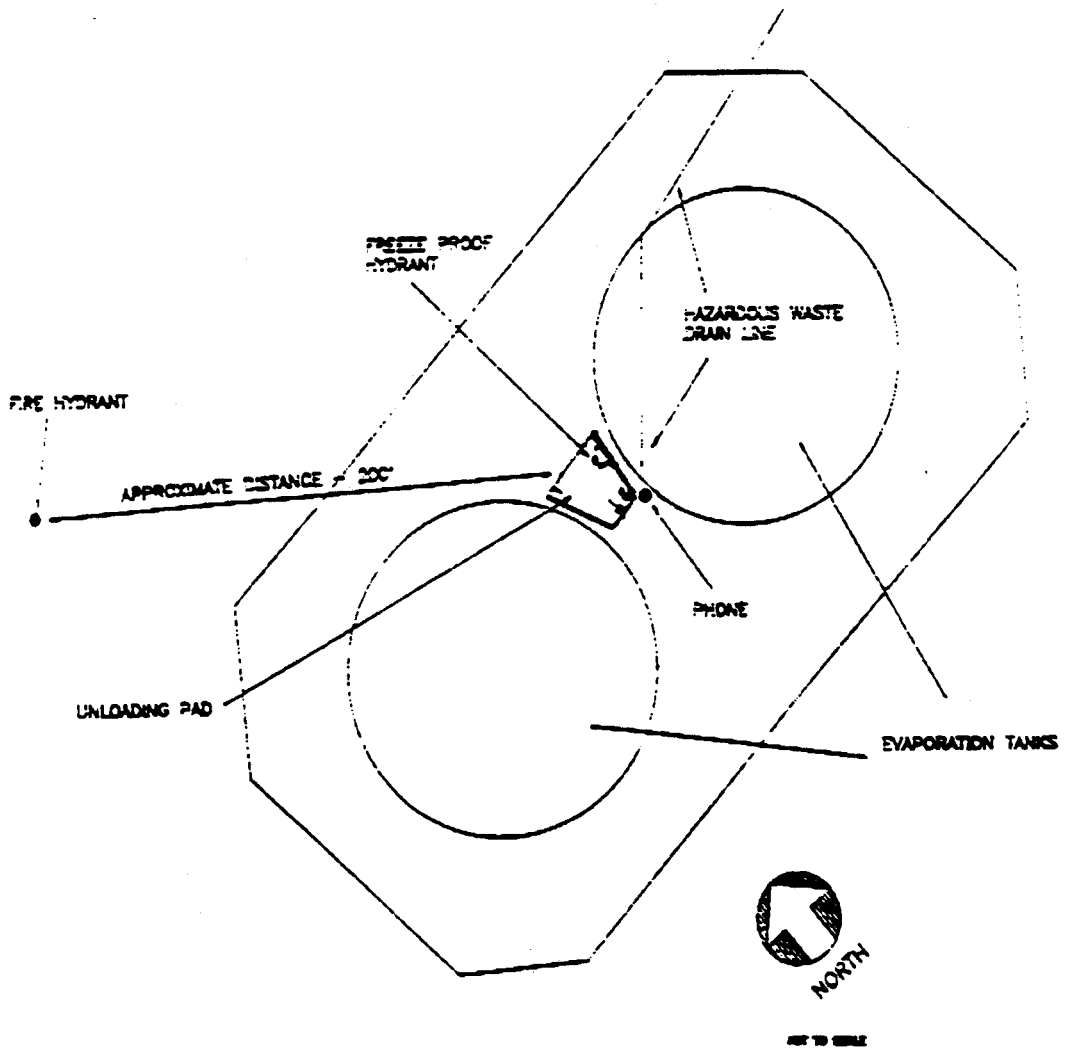
REVISED 2/9.



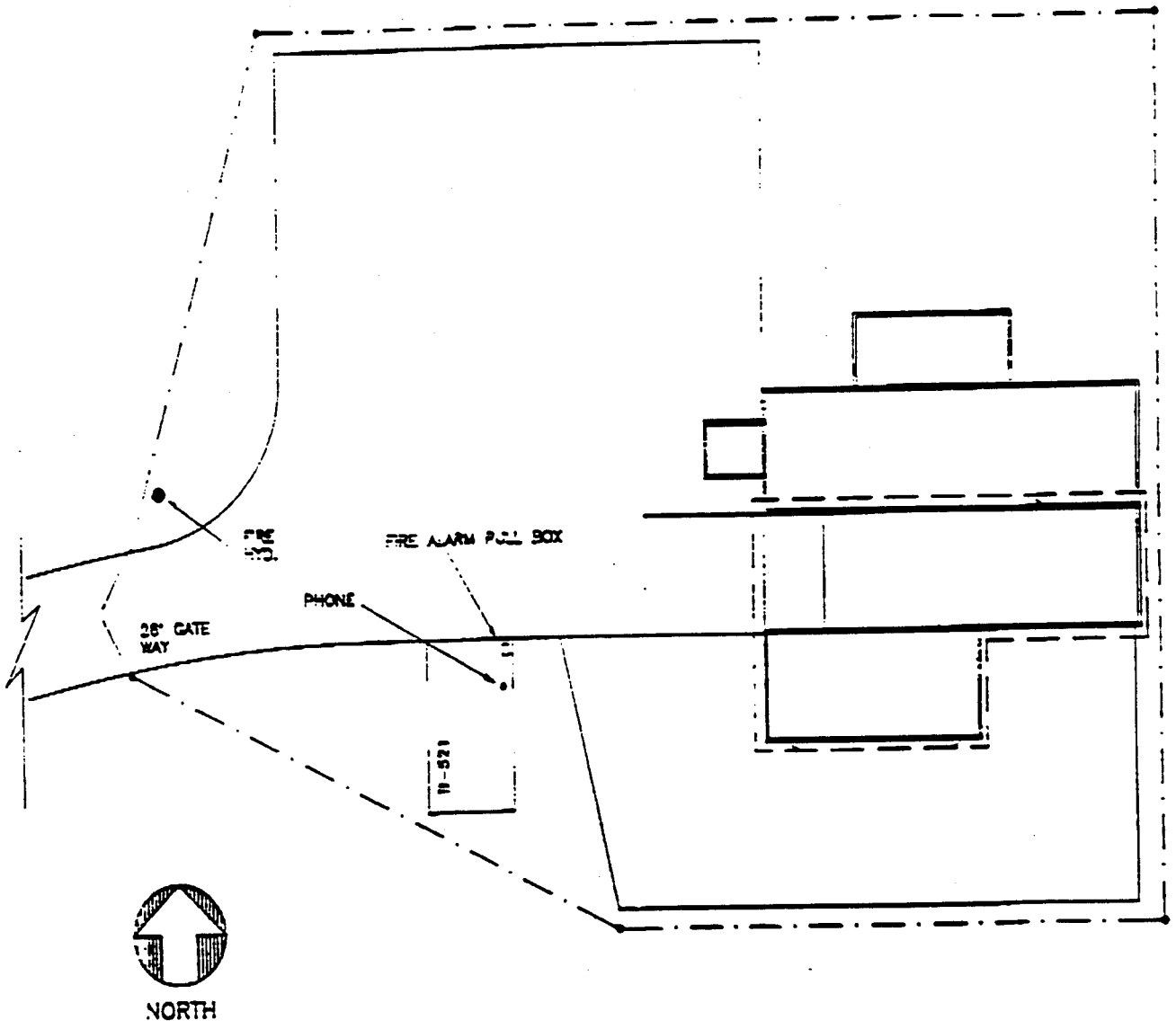
2-PW-PRESSURIZED WATER EXTING.
11-CO2-CARBON DIOXIDE EXTING.
6-□-PULL BOXES
5-S-SMOKE AND HEAT DETECTORS
4-S-HEAT DETECTORS
1- -ALARM CONTROL BOX
1- -ZONE INDICATOR

REVISED 10/91

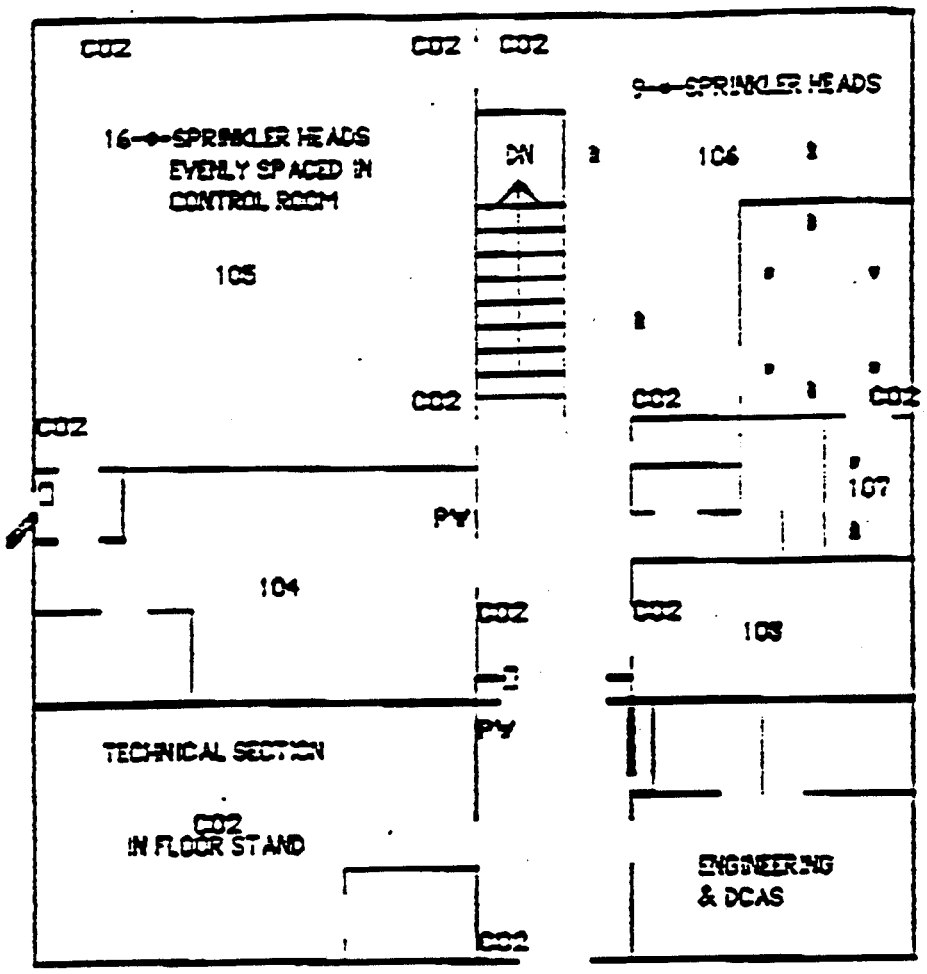
EVAPORATION TANK UNIT



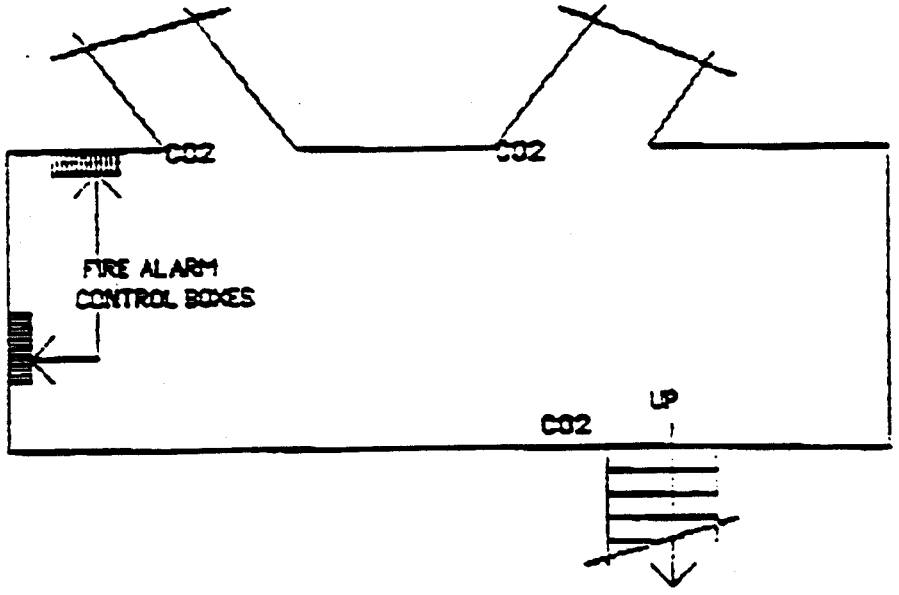
WASTE FUEL TREATMENT UNIT

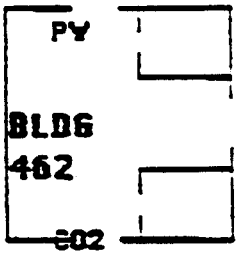


462 BLOCK HOUSE



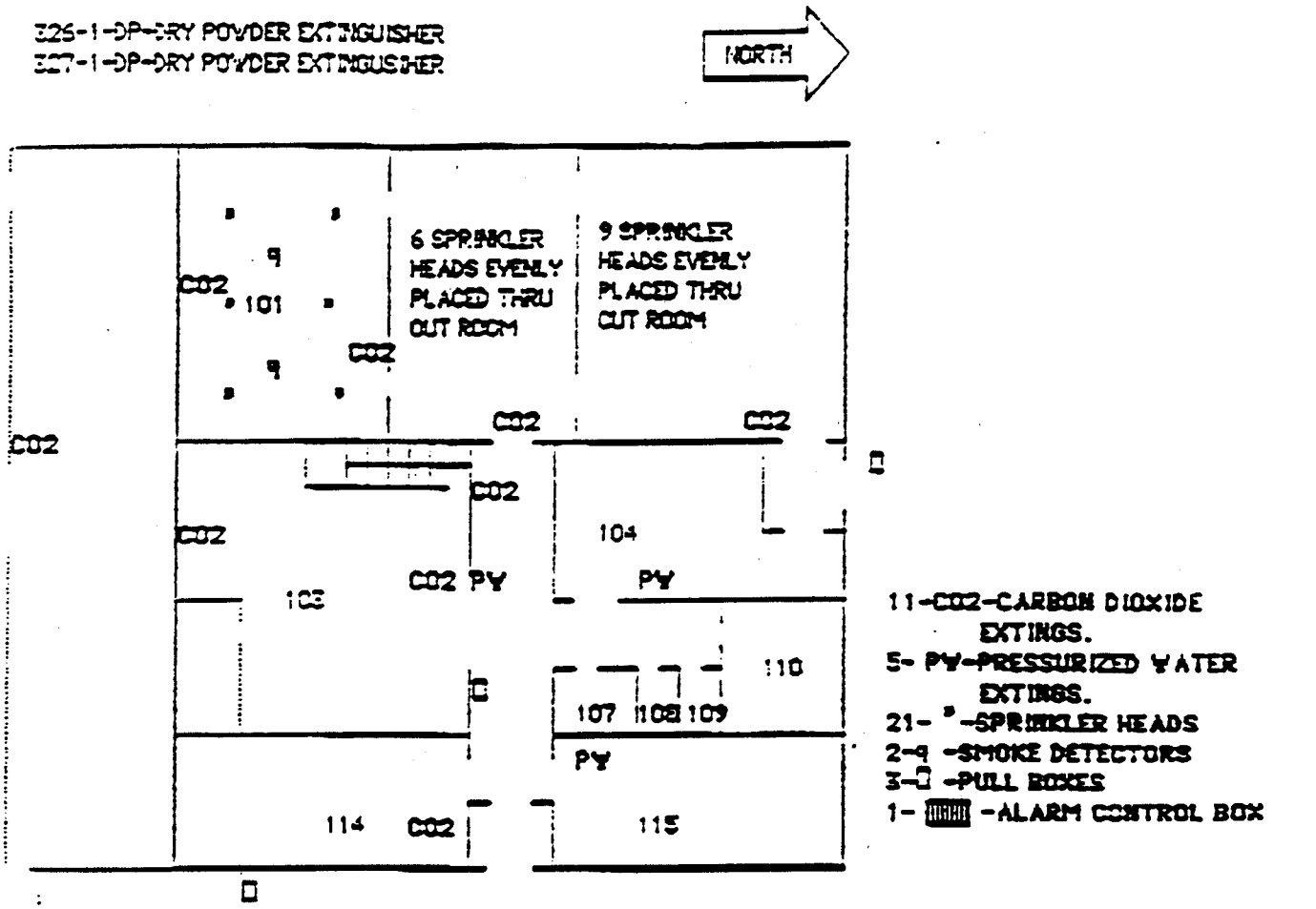
14-CO2-CARBON DIOXIDE EXTINGUISHERS
3-PW-PRESSURIZED WATER EXTINGUISHERS
30- 9"-SPRINKLER HEADS
6- 2-HEAT DETECTORS
2-3-PULL BOXES

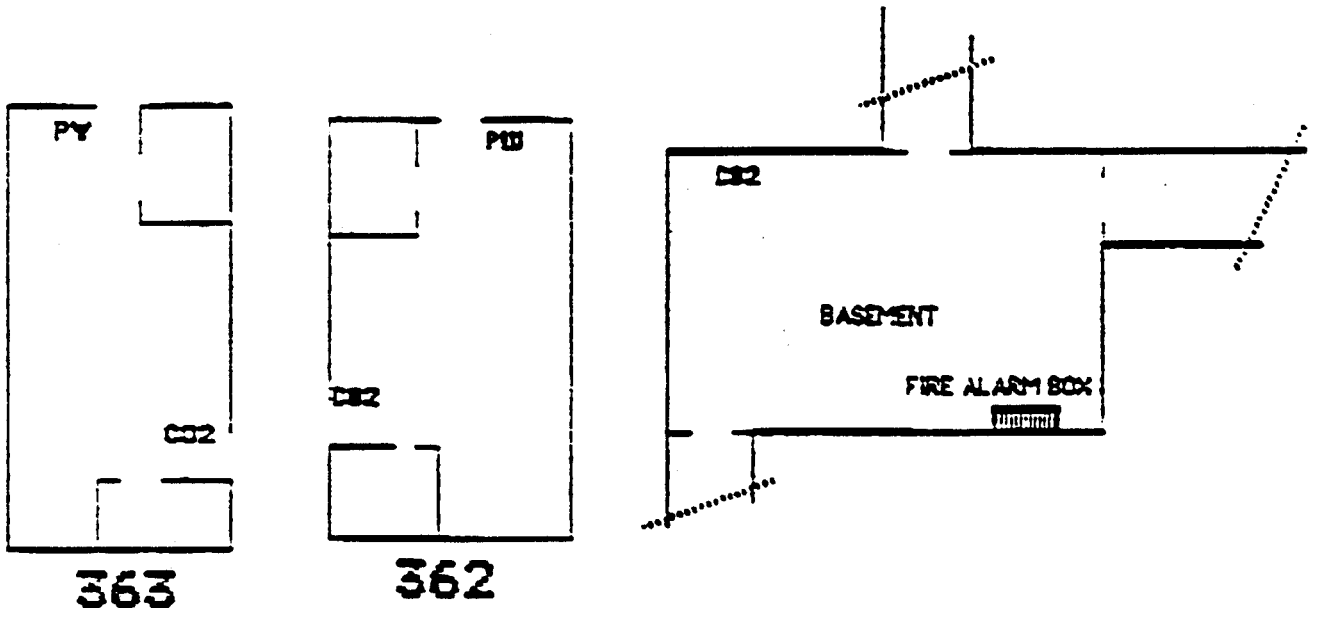




REVISED 10-90

326-1-DP-DRY POWDER EXTINGUISHER
327-1-DP-DRY POWDER EXTINGUISHER





300 BLOCK HOUSE

REVISED 10-90

APPENDIX 2

(PERMIT ATTACHMENT II-6)

CHEMICAL HAZARD INFORMATION

TABLE OF CONTENTS

CHEMICAL HAZARD INFORMATION

Chromic acid

Freon 113

Isopropyl alcohol

Methyl ethyl ketone

Phosphoric acid

Sodium hydroxide

Toluene

1,1,1-Trichloroethane

Xylene

Hydrazine

Monomethyl hydrazine

Unsymmetrical dimethyl hydrazine

Nitrogen tetroxide

Tetrafluorohydrazine

1. Chromic acid

Toxicity:

PEL 0.1mg Cr O_3/m^3 (ceiling). Very high via inhalation route. Corrosive to all tissues. Respiratory and dermal protection required.

Fire Hazard:

Non-flammable, but a powerful oxidizing agent which can react violently with reducing agents and organic matter.

Explosion Hazard:

Can cause violent explosions upon contact with powerful reducing agents.

Potential Incompatibilities:

Alcohols - Heat generation

Caustics - Heat generation

Halogenated organics - Heat and toxic gas generation

Ketones - Heat generation

Toxic metals - Solubilization

2. Freon 113

Toxicity:

TLV = 1000 ppm

Fire Hazard:

Non-flammable.

When heated to decomposition may emit highly toxic fumes of phosgene and/or fluorides.

Dangerous when exposed to heat or flame.

Explosion Hazard:

Not applicable.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat and toxic gas generation.

Caustics - Heat and flammable gas generation.

3. Isopropyl alcohol

Toxicity:

TLV = 400 ppm

Moderate toxicity. An eye irritant.

Fire Hazard:

Flash point = 53° F

Vapor density = 2.07

LEL = 2.0%

UEL = 12%

Dangerous when exposed to heat, flame, or oxidizers.

Explosion Hazard:

Moderate when exposed to heat or flame.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat generation.

Organic acids - Heat generation. violent polymerization.

4. Methyl ethyl ketone

Toxicity:

TLV = 200 ppm

Moderate via oral route. A strong irritant.

Fire Hazard:

Flash point = 35° F

Vapor density = 2.42

LEL = 1.8%

UEL = 10%

Dangerous when exposed to heat or flame.

Explosion Hazard:

Moderate when exposed to flame.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat generation.

Caustics - Heat generation.

5. Phosphoric acid

Toxicity:

Corrosive via dermal and inhalation routes. Suitable respiratory and dermal protection required.

Fire Hazard:

Non-flammable.

When heated to decomposition emits toxic fumes of PO_x.

Explosion Hazard:

Not applicable.

Potential Incompatibilities:

Alcohols - Heat generation.

Caustics - Heat generation.

Halogenated organics - Heat and toxic gas generation.

Ketones - Heat generation.

Toxic metals - Solubilization.

6. Sodium hydroxide

Toxicity:

Extremely corrosive via inhalation and dermal exposures. Suitable respiratory and dermal protection may be required.

Fire Hazard:

Non-flammable.

Will react with water or steam to produce heat.

Explosion Hazard:

Not applicable.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat generation.

Organic acids - Heat generation.

Halogenated organics - Heat and flammable gas generation.

Ketones - Heat generation.

Toxic metals - Solubilization.

7. Toluene

Toxicity:

TLV(skin) = 100 ppm

Moderate via inhalation.

Fire Hazard:

Flash point = 40° F(CC)

Vapor density = 3.14

LEL = 1.27%

UEL = 7%

Slight when exposed to heat, flame, or oxidizers. Can emit toxic fumes when heated to decomposition.

Explosion Hazard:

Moderate when exposed to flame.

Potential Incompatibilities:

Oxidizers - Heat and flammable gas generation.

8. 1,1,1-Trichloroethane

Toxicity:

TLV = 350 ppm

Moderate via oral route.

Fire Hazard:

Non-flammable.

When heated to decomposition can emit highly toxic fumes of phosgene.

Explosion Hazard:

Not applicable.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat and toxic gas generation.

Caustics - Heat and flammable gas generation.

9. Xylenes

Estimated quantity:

< 0.5 liters per week

Toxicity:

TLV(skin) = 100 ppm

Moderate via innalation route.

Fire Hazard:

Flasn point = 29° F

Vapor density = 3.66

LEL = 1.0%

UEL = 7.0%

Dangerous when exposed to heat or flame. Can react with oxidizing agents.

Explosion Hazard:

Moderate in the form of vapor when exposed to heat or flame.

Potential Incompatibilities:

Oxidizers - Heat and flammable gas generation.

10. Hydrazine

Toxicity:

TLV(skin) = 1 ppm

Dermal protection and SCBA required.

Fire Hazard:

Flash Point = 126° F(CC)

Vapor density - 1.1

LEL = 4.7%

UEL = 100%

Dangerous when exposed to heat, flame or oxidizing agents. When heated to decomposition emits highly toxic fumes.

Explosion Hazard:

Severe when exposed to heat or flame or by chemical reaction.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat, innocuous and non-flammable gas generation.

Organic acids - Heat, and innocuous and non-flammable gas generation.

Alcohols - Heat, and innocuous and non-flammable gas generation.

Aldehydes - Heat generation.

11. Monomethyl hydrazine

Toxicity:

TLV(skin) = 0.2 ppm

High via inhalation and dermal route. SCBA's and dermal protection required.

Fire Hazard:

Flash point = 80° F

Vapor density = 1.6

LEL = 2.5%

UEL = 97%

Dangerous when exposed to heat, flame or oxidizers.

Explosion Hazard:

Severe when exposed to heat or flame or by chemical reaction.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat, innocuous and non-flammable gas generation.

Organic acids - Heat, and innocuous and non-flammable gas generation.

Alcohols - Heat, and innocuous and non-flammable gas generation.

Aldehydes - Heat generation.

12. Unsymmetrical dimethyl hydrazine

Toxicity:

TLV(skin) = 0.5 ppm

Highly corrosive and irritating to skin, eyes and mucous membranes.

SCBA's and dermal protection required.

Fire Hazard:

Flash point = 5° F

Vapor density = 1.94

LEL = 2%

UEL = 95%

Dangerous when exposed to heat, flame or oxidizers.

Explosion Hazard:

Severe when exposed to heat or flame or by chemical reaction.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat, innocuous and non-flammable gas generation.

Organic acids - Heat, and innocuous and non-flammable gas generation.

Alcohols - Heat, and innocuous and non-flammable gas generation.

Aldehydes - Heat generation.

13. Nitrogen tetroxide

Toxicity:

High via inhalation.

TLV 3 ppm in air as NO_2.

Fire Hazard:

Noncombustible but supports combustion.

Explosion Hazard:

Powerful oxidizing agent. can explode when in contact with reducing agents.

Potential Incompatibilities:

Reducing agents - Heat, explosions.

Bases - Heat generation.

14. Tetrafluorohydrazine

Toxicity:

Irritant

Fire Hazard:

Explosion Hazard:

Powerful oxidizing agent. can explode when in contact with reducing agents.

Potential Incompatibilities:

Alkalines - Heat generation.

Reducing agent - Heat explosion.

APPENDIX B

WSTF GROUNDWATER SAMPLING AND ANALYSIS PLAN

GROUNDWATER SAMPLING AND ANALYSIS PLAN

NASA
WHITE SANDS TEST FACILITY

LAS CRUCES, NEW MEXICO

Revised July 7, 1997

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY 1

2.0 PURPOSE, SCOPE AND HISTORICAL BACKGROUND

2.1 Purpose 1
2.2 Scope 1
2.3 Historical Background 2

3.0 DESIGN AND MAINTENANCE OF CONVENTIONAL RCRA MONITOR WELLS 3

3.1 Design of Conventional RCRA Monitor Wells 3
3.2 Well Development 3
3.3 Well Security 3

4.0 CONVENTIONAL WELL SAMPLING EQUIPMENT 10

4.1 Dedicated Well Sampling Systems 10

4.1.1 Bladder Pump Systems 10
4.1.2 Inflatable Packer/Bladder Pump Systems 10
4.1.3 Purge Pump/Bladder Pump System 10
4.1.4 Inflatable Packer/Purge Pump/Bladder Pump Systems 12
4.1.5 Bailers 12

4.2 Non-dedicated Sampling Equipment

4.2.1 Pneumatically Operated Pumps 12
4.2.2 Miscellaneous Non-dedicated Sampling Equipment 12

4.3 Field Analytical Equipment 13
4.4 Sample Containers 13
4.5 Other Equipment and Supplies 13

5.0 CONVENTIONAL WELL SAMPLING PROCEDURES 13

5.1 Static Water Level Measurement 13
5.2 Well Purging 13

6.0 WESTBAY MULTI-PORT WELL MONITORING SYSTEMS 14

6.1 Design of Westbay Wells 14
6.2 Development of Westbay Wells 15
6.3 Well Security 15
6.4 Monitoring Equipment

6.4.1 MOSDAX Sampler Probe 15
6.4.2 In Situ Datalogger 15

6.5 Collection of Hydrogeological Data

6.5.1 Pressure Profiles 16
6.5.2 Hydraulic Conductivity Determinations 16

6.6 Collection of Groundwater Samples 17
6.7 Decontamination of Westbay Sampling Equipment 17

7.0 MONITOR WELL SAMPLING FREQUENCIES/ANALYTICAL PARAMETERS 18

7.1 Groundwater Assessment Sampling Schedule 18
7.2 Analytical Parameters 18

7.2.1 Initial Sampling Events 20
7.2.2 Standard Plan A Sampling Events 20
7.2.3 Standard Plan B Sampling Events 20
7.2.4 Additional Analyses 20
7.2.5 Appendix IX Sampling 27

7.3 Sample Collection

7.3.1 Sample Identification 27
7.3.2 Sample Collection 27

7.4 Field Analyses 32
7.5 Sample Preservation and Storage 32
7.6 Equipment Decontamination and Verification 32

8.0 ANALYTICAL METHODS 32

8.1 Modifications to the Referenced EPA Methods 34

9.0 QUALITY ASSURANCE PROCEDURES 34

9.1 Field Quality Control Samples 34
9.2 Documentation 34

9.2.1 Field Logbook 34
9.2.2 Sample Seals and Labels 38
9.2.3 Chain of Custody Forms 39

9.3 Sample Delivery 39

9.3.1 Shipment of Off-Site Samples 39

9.4 Analytical Quality Assurance 39

10.0 ANALYTICAL REPORTS AND DATA MANAGEMENT 39

11.0 REFERENCES 40

TABLES

TABLE 3.1	Summary of WSTF Groundwater Wells	4
TABLE 3.2	Well Designations Cross Reference	9
TABLE 4.1	Dedicated Well Sampling Equipment	11
TABLE 7.1	Sampling Frequency for WSTF Groundwater Assessment Wells/Zones	19
TABLE 7.2	Parameter Collection Frequencies	21
TABLE 7.3	Groundwater Assessment Wells and Their Corresponding Parameter Collection Plans	26
TABLE 7.4	Groundwater Assessment Containers, Preservation Methods and Holding Times	28
TABLE 7.5	Containers, Preservatives and Holding Times	29
TABLE 8.1	Analytical Methods Currently Used at WSTF	33
TABLE 8.2	Halogenated Volatile Organic Compounds	35
TABLE 9.1	Descriptions of Field Quality Control Samples	36
TABLE 9.2	Field QA/QC Controls	37

1.0 EXECUTIVE SUMMARY

Under the provisions of the Resource Conservation and Recovery Act (RCRA), specific requirements are outlined to establish groundwater sampling and analysis programs. Included in these regulations are requirements for a written Sampling and Analysis Plan. This document is written to provide the NASA White Sands Test Facility (WSTF) with a Sampling and Analysis Plan which satisfies the regulatory requirements and provides personnel involved in the groundwater assessment project with site-specific procedures for the collection and analysis of groundwater samples.

Specified by this Sampling and Analysis Plan and additional site-specific procedural documentation are written procedures concerning the following:

- collection and preservation of groundwater samples;
- chain of custody documentation;
- sample shipment; and
- analytical procedures.

The on-site environmental contractor organization is involved in the collection and processing of groundwater samples at WSTF. This document is designed to be used in conjunction with site-specific procedural documentation to ensure the consistency of all work involved in the collection and processing of groundwater samples. The current site-specific procedures include White Sands Test Facility Job Instructions (WJIs), Test Preparation Sheets (TPSs), and specific equipment Operations and Maintenance Manuals. All procedures are written to comply with requirements and guidelines found in the Technical Enforcement Guidance Document (TEGD), Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846), RCRA Ground Water Monitoring: Draft Technical Guidance, and other applicable technical guidance sources.

This Sampling and Analysis Plan is reviewed annually, and revised as necessary, to ensure that the procedures reflect the future needs of the groundwater assessment program, comply with future regulatory requirements, and are responsive to advances in scientific knowledge and technologies. Copies of all revisions of this document are retained at WSTF to provide historical documentation of methodologies used throughout the groundwater sample collection period.

2.0 PURPOSE, SCOPE AND HISTORICAL BACKGROUND

2.1 PURPOSE

This document serves as a procedural guide for personnel engaged in groundwater sampling and analysis at WSTF. It is used in conjunction with site-specific procedures and specific equipment Operations and Maintenance Manuals. Procedures outlined are consistent with those specified for use at sites subject to the requirements of RCRA, and have been adapted to meet the specific requirements of the WSTF groundwater assessment program.

2.2 SCOPE

This document is intended for use as an aid for training technical staff and as a procedural guide for trained personnel involved in the collection of WSTF groundwater samples. Adherence to the protocols presented in this document assures that samples are collected in a consistent manner, representative of actual groundwater conditions, shipped and tracked in an acceptable manner, and analyzed by appropriate EPA-recommended analytical methods.

In addition to this document, the WSTF Quality Assurance Project Plan provides the quality assurance steps necessary to substantiate collected groundwater data. The WSTF Quality Assurance Project Plan, used in conjunction with the WSTF Sampling and Analysis Plan, provides protocols for the collection and analysis of groundwater samples.

2.3 HISTORICAL BACKGROUND

During the course of operations at WSTF from the early 1960s to the early 1980s, hazardous constituents were released to the environment and eventually migrated to the groundwater. As mandated by RCRA, NASA established a detection monitoring program to investigate the presence of hazardous constituents in the groundwater. Groundwater monitoring wells were installed up gradient and down gradient of hazardous waste management units. Sampling and analysis of these wells was performed and hazardous waste contamination of the groundwater was detected.

Based on the original information obtained from these wells, a groundwater assessment program was initiated to characterize the nature and extent of contamination. Using soil gas data, seismic reflection data, soil borings, and the installation and sampling of groundwater assessment wells, sufficient information was gathered to form a conceptual visualization of the contamination problem.

Based on the analytical data collected, groundwater contamination extends as far as two miles west of the WSTF facility boundary. The types of hazardous constituents found in the groundwater include several halogenated volatile organic compounds, N-nitrosodimethylamine (NDMA), and chromium.

NASA, with the support of EPA Region 6, has incorporated the use of Westbay Multi-Port (MP) well systems to complement existing conventional groundwater assessment wells. These wells are incorporated to vertically profile specified areas where a three-dimensional understanding of the contamination plume is essential. The Westbay MP system is discussed in detail in Section 6 of this document.

Currently, more than one hundred wells and monitoring zones are sampled by WSTF personnel on a regular basis. Several additional wells are scheduled to be drilled and installed in the near future.

The present goal of the groundwater assessment program is to collect groundwater data to:

- determine the distribution and migration of hazardous constituents;
- determine potential threats to the environment and human health; and
- if required, aid in the design and location of remedial systems to mitigate the environmental contamination.

The on-site environmental contractor organization is tasked with the groundwater assessment project. This organization is staffed with both hydrogeological and groundwater personnel. Hydrogeological personnel are primarily involved in the installation of groundwater assessment wells and hydrogeologic interpretation. Groundwater personnel are primarily involved in the collection and analysis of groundwater samples. An explanation of the functions of on-site environmental contractor personnel is provided in the WSTF Quality Assurance Project Plan.

3.0 DESIGN AND MAINTENANCE OF CONVENTIONAL RCRA MONITOR WELLS

A summary of groundwater monitoring wells, piezometers, and related wells is provided in Table 3.1. Well designations presented in this Table supersede all previous designations. Groundwater wells are identified by an alphanumeric code stenciled on the protective outer casing. Well identifications, for wells installed after March 1987, are determined by location of the well-site, an alphanumeric identification digit, and the depth to the top of the screen from ground level. Wells that were installed as part of the original RCRA groundwater detection program are designated as NASA 3 through 10.

Wells completed since January 1987 have a brass cap permanently cemented in the well pad. Each brass cap contains information regarding well coordinates, casing elevations, and well identification. From January 1987 to March 1987 these wells were originally identified according to site location and relative depth to other wells in the area (e.g., 600-C (Shallow)). These wells were renamed to reflect the identification system referenced above. However, the brass caps originally installed in the well pads reflect the original designations. A cross-reference detailing original and new well designations is provided in Table 3.2.

Well installation and construction details are described in the WSTF Groundwater Monitoring Network Installation Plan (February 17, 1989).

3.1 DESIGN OF CONVENTIONAL RCRA MONITOR WELLS

The original eight detection wells installed at WSTF were two inches (5.08 cm) in diameter and constructed of PVC and stainless steel. All subsequent conventional wells are four inches (10.16 cm) in diameter and are constructed of PVC and/or stainless steel. The wells are screened at an interval which is either at, or below, the water table with 0.020-inch (0.051 cm) slotted stainless steel screen.

3.2 WELL DEVELOPMENT

Monitor wells are developed immediately following completion by bailing and/or overpumping. These processes are designed to clean the screen, the filter-pack, and the surrounding aquifer to allow representative water samples to be collected. Wells are considered fully developed when stable values for pH, temperature and specific conductance are observed. Additionally, turbidity values are monitored to ensure the turbidity is stable and less than five nephelometric turbidity units (NTUs).

Due to the possible infiltration of fine-grained sediments into the well and filter pack, occasional redevelopment may be necessary. Well recovery times and turbidity values are used to monitor the well to determine if redevelopment is required.

3.3 WELL SECURITY

Monitor wells are equipped with locking caps which are secured at all times, except for sampling and analysis procedures conducted in accordance with this document. Keys are issued only to personnel directly involved in the collection of groundwater samples or well maintenance.

TABLE 3.1
Summary of WSTF Groundwater Wells

Well I.D.	Elevation Brass Cap (feet amsl)	Screen Interval (feet)	Date Completed
100-A-182	4842.36	182.00-192.40	05/30/89
100-B(2)	4756.61	N/A	N/A
100-B	4756.79	364.59-385.32	07/12/89
100-C-365	4816.82	365.00-385.80	09/18/89
100-D-176	N/A	176.00-196.00	05/14/97
100-E-261	4900.99	260.90-271.30	07/07/89
200-A	4891.27	N/A	N/A
200-B-240	4837.77	239.80-250.10	01/11/89
200-C	4810.68	Three Screened Zones	01/21/93
200-D-109	4785.79	108.80-129.50	03/12/87
200-D-240	4785.25	239.60-250.00	07/20/88
200-E	4818.36	N/A	N/A
200-F	4879.19	Four Screened Zones	10/11/94
200-G	4875.36	Five Screened Zones	11/14/94
200-H	4882.13	Four Screened Zones	09/21/94
300-A-120	4911.67	120.00-146.00	02/03/87
300-A-170	4911.28	170.00-175.50	03/26/87
300-B-166	4931.92	165.50-175.90	10/09/87
300-C-128	4877.27	128.20-154.30	03/09/87
300-D-153	5108.71	153.10-173.80	04/04/88
300-E	4926.31	Two Screened Zones	02/12/95
400-A-151	4795.09	150.50-275.60	02/09/87
400-B	No Brass Cap	N/A	N/A
400-C-118	4808.74	118.00-143.00	02/17/87
400-C-143	4808.55	143.00-153.40	02/20/87
400-D	4824.17	Three Screened Zones	03/27/95
600-C	4743.13	N/A	N/A
600-C-173	4744.01	172.50-193.20	02/25/87
600-C-210	4744.31	210.00-220.30	02/20/87

TABLE 3.1
Summary of WSTF Groundwater Wells

Well I.D.	Elevation Brass Cap (feet amsl)	Screen Interval (feet)	Date Completed
600-C-437	4745.04	436.90-447.20	02/08/88
600-D	4747.51	Four Screened Zones	06/15/95
600-PZ-1	N/A	265.00-270.00	04/21/89
600-PZ-2	N/A	429.65-434.65	04/27/89
700-A-253	4908.14	253.00-263.40	11/09/89
700-B-510	4805.89	510.00-530.84	08/14/90
700-D-186	4885.28	186.00-196.30	12/21/89
700-E-458	4717.77	458.10-478.90	03/12/90
700-F-455	4763.62	455.00-475.03	01/31/91
BLM-1-435	4551.67	435.30-445.70	11/13/87
BLM-2-482	4535.48	482.40-492.80	10/25/87
BLM-2-630	4535.35	629.50-639.80	06/13/88
BLM-3-182	4743.93	182.30-203.00	02/10/87
BLM-4	4743.81	N/A	N/A
BLM-5-527	4551.80	527.30-537.70	04/04/88
BLM-6-488	4588.36	487.70-498.20	04/18/90
BLM-7-509	4529.80	509.30-519.70	05/17/88
BLM-8-416	4556.33	418.00-428.40	06/28/88
BLM-9-419	4692.24	419.30-440.00	11/09/88
BLM-10-517	4533.71	516.60-526.90	03/03/88
BLM-11	4677.05	N/A	N/A
BLM-12	4647.61	N/A	N/A
BLM-13-300	4665.98	300.40-310.80	09/02/88
BLM-14-327	4675.54	320.00-327.42	09/27/90
BLM-15	4702.60	N/A	N/A
BLM-15-305	4703.69	305.00-315.30	04/14/89
BLM-16	4716.07	N/A	N/A
BLM-17-493	4538.13	492.80-513.50	02/17/89
BLM-17-550	4638.24	550.44-560.86	09/10/90

TABLE 3.1
Summary of WSTF Groundwater Wells

Well I.D.	Elevation Brass Cap (feet amsl)	Screen Interval (feet)	Date Completed
BLM-18-430	4609.84	430.00-450.80	09/19/89
BLM-21-400	4648.73	400.00-410.01	07/02/91
BLM-22-570	4606.84	570.21-591.69	08/24/90
BLM-23-431	4588.06	430.82-441.25	06/25/90
BLM-24-565	4713.84	564.85-584.88	01/08/91
BLM-25-455	4619.42	454.95-464.95	10/23/91
BLM-26-404	4664.97	404.0-414.0	11/05/91
BLM-27-270	4729.75	270.01-280.27	08/08/91
BLM-28	4639.30	Three Screened Zones	05/10/94
BLM-29	No Brass Cap	N/A	N/A
BLM-30	4595.79	One Screened Zone	05/15/95
BLM-31	4726.98	Three Screened Zones	03/17/95
BW-1-268	4772.15	268.10-288.80	12/07/88
BW-2	4778.18	N/A	N/A
BW-3-180	4734.03	179.60-200.30	08/24/88
BW-4	4750.75	Three Screened Zones	02/23/93
BW-5-295	4814.52	294.90-305.20	02/04/89
BW-6-355	4815.23	355.0-375.53	01/31/92
BW-7-211	4798.64	211.30-221.60	01/12/88
J-PZ-1	N/A	416.60-421.60	02/15/89
J-PZ-2	N/A	568.00-573.00	02/12/89
J-PZ-3	N/A	416.50-421.40	02/23/89
J-PZ-4	N/A	387.60-392.61	02/17/89
J-PZ-5	N/A	416.30-421.10	02/22/89
JP-1-424	4444.09	424.00-434.30	12/05/87
JP-2-447	4446.17	446.50-456.90	08/15/88
NASA 1	4808.99	100.00-260.00	08/08/83
NASA 2	4743.85	90.00-390.00	07/13/84
NASA 3	5010.42	118.75-138.75	02/27/85

TABLE 3.1
Summary of WSTF Groundwater Wells

Well I.D.	Elevation Brass Cap (feet amsl)	Screen Interval (feet)	Date Completed
NASA 4	4770.74	146.20-166.20	03/04/85
NASA 5	4925.53	119.25-130.25	03/06/85
NASA 6	4821.03	127.60-147.60	03/07/85
NASA 7	4747.23	177.20-197.20	03/26/85
NASA 8	4751.35	172.00-192.00	04/01/85
NASA 9	4822.23	129.56-149.56	04/03/85
NASA 10	4835.48	110.00-130.00	04/12/85
NASA-PT	4522.79	507.72-828.44	03/29/90
PL-1-486	4518.14	486.00-496.40	10/08/88
PL-2-504	4508.04	504.00-514.40	11/28/88
PL-3-453	4496.89	453.40-463.80	11/09/88
PL-4-464	4480.88	463.96-474.36	01/23/90
PL-5	4512.60	Six Screened Zones	11/10/90
PL-6	4482.15	N/A	N/A
PL-6-B	4481.69	Nine Screened Zones	01/15/91
PL-7	4519.12	Three Screened Zones	12/17/92
PT-PZ-1	No Brass Cap	485.00-490.00	10/13/89
PT-PZ-2	No Brass Cap	503.85-508.85	01/18/90
PT-PZ-3	No Brass Cap	515.44-520.44	01/22/90
PT-PZ-4	No Brass Cap	508.81-513.91	01/25/90
ST-1-473	4503.64	472.70-483.10	05/30/89
ST-1-541	4502.39	541.21-551.22	11/19/91
ST-1-630	4501.61	630.38-640.38	07/21/92
ST-2-466	4467.22	465.70-476.20	08/18/89
ST-3-486	4495.98	486.00-496.42	08/08/91
ST-3-586	4494.59	585.77-595.79	04/10/92
ST-3-666	4494.36	665.88-675.84	06/12/92
ST-3-735	4496.62	735.32-755.22	08/21/92
ST-4-481	4493.16	480.78-490.78	04/23/92

TABLE 3.1
Summary of WSTF Groundwater Wells

Well I.D.	Elevation Brass Cap (feet amsl)	Screen Interval (feet)	Date Completed
ST-4-589	4493.13	588.75-598.75	05/20/92
ST-4-690	4491.16	490.42-710.42	10/05/92
ST-5-481	4459.24	480.75-490.78	05/06/92
ST-5	4458.74	Five Screened Zones	06/29/93
WB-1	4840.94	Three Screened Zones	04/12/90
WB-2	4901.00	Three Screened Zones	04/13/90
WB-3	4812.16	Four Screened Zones	04/09/90
WB-4	4844.78	Four Screened Zones	04/06/90
WB-5	4872.41	Four Screened Zones	06/14/90
WB-6	4775.34	N/A	N/A
WB-7	4745.53	N/A	N/A
WB-8	4961.68	Three Screened Zones	03/10/93
WB-9	5001.61	Three Screened Zones	02/26/92
WB-14	4731.68	One Screened Zone	03/23/92
WW-1-452	4455.09	451.90-462.20	01/21/88

N/A - Not Applicable

TABLE 3.2
Well Designations Cross Reference

Brass Cap Designation	Revised Designation
200-D (S)	200-D-109
300-A (S)	300-A-120
300-A (M)	300-A-170
300-B (S)	300-B-166
300-C (S)	300-C-128
400-A (S)	400-A-151
400-C (S)	400-C-118
400-C (M)	400-C-143
600-C (S)	600-C-173
600-C (M)	600-C-210
600-C (D)	600-C-437

4.0 CONVENTIONAL WELL SAMPLING EQUIPMENT

Equipment used for the collection of groundwater samples is designed to minimally alter sample integrity during the sample collection process. The following sections provide a brief discussion of the basic sampling equipment. Detailed procedures are provided in the site-specific procedural documentation.

4.1 DEDICATED WELL SAMPLING SYSTEMS

Several types of dedicated well sampling systems are used at WSTF due to the variability of sampling conditions encountered. Factors that influence the type of system selected for each well are depth to water, volume of water to be purged, water recovery rate, frequency of sampling, and the cost of system installation. The following sections provide an overview of the WSTF systems.

Table 4.1 provides a summary of the specific dedicated sampling systems that are installed in each of the groundwater assessment wells. Detailed instructions for the use of these systems are provided in the site-specific procedural documentation.

4.1.1 Bladder Pump Systems

Sixteen wells are equipped with dedicated positive displacement bladder pump systems. In this design, the pumps are used for both purging and sampling the wells. The pumps are constructed of stainless steel and Teflon. Teflon-lined discharge tubing is used to minimize the sorptive effects of the tubing on sample quality. The pressure required to operate the pumps is supplied by compressed nitrogen cylinders and/or dewars. This system type is used in wells where the static water levels are relatively shallow and required purge volumes are small.

4.1.2 Inflatable Packer/Bladder Pump Systems

Three wells are equipped with dedicated inflatable packer/bladder pump systems. In this system, an inflatable packer is used to isolate a zone in the well extending from just above the screened interval to the bottom of the well. This significantly reduces the amount of purge water required prior to sample collection. Water is purged and sampled from this zone using a dedicated bladder pump. The bladder pump is stainless steel/Teflon construction and Teflon-lined discharge tubing is used to ensure sample quality. This system type is used in relatively shallow wells where a large amount of purging would be required if the packer was not used.

4.1.3 Purge Pump/Bladder Pump System

One well is equipped with a purge pump/bladder pump system. An air displacement pump is installed above the bladder pump to purge the water prior to sample collection. A bladder pump is then used to sample the well. This system type minimizes the time required to sample wells where moderate purge volumes are required prior to sample collection.

TABLE 4.1
Dedicated Well Sampling Equipment

DEDICATED BLADDER PUMP SYSTEM	DEDICATED BAILERS		INFLATABLE PACKER/ BLADDER PUMP SYSTEM	PURGE PUMP/ BLADDER PUMP SYSTEM	PURGE PUMP/ INFLATABLE PACKER/ BLADDER PUMP SYSTEM
NASA 3	100-C-365	BLM-23-431	100-E-261	200-D-240	600-C-437
NASA 4	100-D-176	BLM-24-565	200-B-240		
NASA 5	200-D-109	BLM-25-455	BW-5-295		
NASA 6	300-A-170	BLM-26-404			
NASA 7	300-B-166	BLM-27-270			
NASA 8	700-A-253	BW-1-268			
NASA 9	700-B-510	BW-3-180			
NASA 10	700-D-186	BW-7-211			
100-A-182	700-E-458	JP-1-424			
300-A-120	700-F-455	JP-2-447			
300-C-128	BLM-1-435	PL-1-486			
300-D-153	BLM-2-482	PL-2-504			
400-A-151	BLM-2-630	PL-3-453			
400-C-118	BLM-3-182	PL-4-464			
400-C-143	BLM-5-527	ST-1-473			
600-C-173	BLM-6-488	ST-1-541			
	BLM-7-509	ST-1-630			
	BLM-8-418	ST-2-466			
	BLM-9-419	ST-3-486			
	BLM-10-517	ST-3-586			
	BLM-13-300	ST-3-666			
	BLM-14-327	ST-3-735			
	BLM-15-305	ST-4-481			
	BLM-17-493	ST-4-589			
	BLM-17-550	ST-4-690			
	BLM-18-430	ST-5-481			
	BLM-21-400	WW-1-452			
	BLM-22-570				

NOTE: Wells which are equipped with dedicated pump systems may periodically experience problems due to equipment malfunctions/static water level fluctuations. These problems may require WSTF to utilize the pneumatically driven pump/dedicated bailer technique for sampling until they can be corrected. If this alternate procedure is used, all corresponding documentation will reference the use of the alternate technique.

4.1.4 Inflatable Packer/Purge Pump/Bladder Pump Systems

An inflatable packer/purge pump/bladder pump system is installed in one well. The inflatable packer is used to isolate a zone from immediately above the screened interval to the bottom of the well. Due to the completion depth, a purge pump is used to purge three volumes of water from the isolated zone. After purging has been performed, a bladder pump is used to collect groundwater samples. This system type is used in wells where large purge volumes are required if the packer was not used and also at depths where the purge rate of the bladder pump would be insufficient to remove three volumes of water from the isolated zone.

4.1.5 Bailers

In wells without dedicated pump systems, dedicated Teflon bailers are used to collect samples. A non-dedicated purge pump is used to evacuate the required volume of water prior to sampling with the bailer. The bailers are constructed of Teflon and are equipped with bottom-filling check valves. Bailers are lowered into the well with non-dedicated stainless steel cable.

A bailer is dedicated to each well. Each bailer is attached to the well cap, using a length of stainless steel cable, and suspended in the well until sampling is performed. This precludes the need to decontaminate the bailer prior to each use. Dedicated bailers are installed in groundwater wells where it is neither technically nor economically feasible to install dedicated pump systems.

4.2 NON-DEDICATED SAMPLING EQUIPMENT

4.2.1 Pneumatically Operated Pumps

Wells not equipped with dedicated purging equipment are purged using a pneumatically driven pump. This pump, if required, can be used to collect samples for inorganic analytes. Due to possible effects on sample integrity, this pump is not used to collect samples with volatilization potential.

To preclude cross-contamination between wells, the pneumatic pump is decontaminated prior to each use. If the pump is used to collect inorganic samples, then equipment blanks are required for the corresponding inorganic analyses.

4.2.2 Miscellaneous Non-Dedicated Sampling Equipment

All miscellaneous non-dedicated sampling equipment is decontaminated prior to each use.

4.3 FIELD ANALYTICAL EQUIPMENT

Specific equipment necessary for the field determination of indicator parameters includes a specific conductance meter, pH/temperature meter and turbidity meter. Standard solutions are included for field calibrations and all instruments are functionally checked and calibrated according to the manufacturer's specifications and EPA-recommended protocols.

4.4 SAMPLE CONTAINERS

Sample containers are obtained from an independent supplier. The supplier provides containers which are cleaned using EPA-recommended analyte-specific cleaning procedures. A cleanliness verification is provided by the supplier before use. If unforeseen circumstances require WSTF to clean containers, the analyte-specific cleaning methods referenced in SW-846 are used.

All sample containers are rinsed with sample water prior to sample collection. The sizes and types of sample containers used for each analysis comply with the guidance provided in SW-846, the TEGD and RCRA Groundwater Monitoring: Draft Technical Guidance.

4.5 OTHER EQUIPMENT AND SUPPLIES

Lists of all equipment and supplies used for sample collection are provided in the site-specific procedural documentation.

5.0 CONVENTIONAL WELL SAMPLING PROCEDURES

Sampling procedures include: field determinations of static water level, temperature, specific conductance, pH, and turbidity; well purging; sample collection; sample preservation; sample transport and storage; and documentation of field activities. These procedures are briefly described in the following sections. Detailed procedures are provided in the site-specific procedural documentation.

5.1 STATIC WATER LEVEL MEASUREMENT

Static water level measurements are performed on at least a quarterly basis and prior to each sampling event. The static water level is measured to the nearest 0.01 meters and recorded in the field logbook. Measurements are made from the top of each well's inner casing. Detailed procedures for the measurements are described in the site-specific procedural documentation. Water level elevations are determined by subtracting the depth to water from the surveyed elevation of the measuring point.

Total well depth measurements are performed on at least an annual basis in wells without dedicated pump systems. Historical data indicate that more frequent determinations are not necessary due to observed slow rates of change over time. Wells with dedicated pump systems are measured for total depths once every five years.

5.2 WELL PURGING

All conventional groundwater assessment wells are purged prior to sample collection. Wells are purged using dedicated positive displacement bladder pumps, dedicated purge pumps or the non-dedicated pneumatically driven pump.

Evacuation rates are maintained at slow speeds to prevent the rapid withdrawal of water and the subsequent cascading of water down the sides of the well screen. Wells are pumped until a minimum of three casing volumes have been purged. The pH, temperature and specific conductance are monitored to ensure that these parameters stabilize. Turbidity values are monitored to ensure values are less than five NTUs and stable. If these criteria are not achieved after three casing volumes, the purging process continues until the values stabilize and the turbidity is less than five NTUs.

Field personnel utilize all measures possible to lower the turbidity to a value of five or less NTUs prior to sampling. If the turbidity values remain above five NTUs, and samples are collected, all data reported for the sampling event are referenced to reflect the elevated turbidity value.

Some wells have slow recovery rates which require purging to dryness. In these cases, the wells are evacuated to dryness and the volume of water purged is recorded. Wells with a recharge rate of greater than three meters/hour are allowed to recharge for at least one hour, purged to dryness, allowed to recover to a level adequate for sample collection, then sampled. Wells with a recharge rate of less than three meters/hour are allowed to recharge to an adequate level and sampled. For each case, the length of time required for the well to recover, recharge rates, pumping volumes, water levels, and corresponding times are recorded in the field logbook.

Detailed procedures for the determination of the required purge volumes are provided in the site-specific procedural documentation. For wells where inflatable packers are utilized, a casing volume is calculated as the volume of water isolated between the packer and the bottom of the well casing.

All water purged from groundwater wells is considered hazardous until analysis or characterization is performed. Water purged during sampling activities is contained in stock tanks located at each well site.

All potential interferences observed by field personnel are eliminated/minimized prior to sample collection. Actions taken to minimize interferences can include: redevelopment of wells; postponement of sampling activities due to nearby heavy equipment operations or inclement weather; or more stringent decontamination procedures.

6.0 WESTBAY MULTI-PORT WELL MONITORING SYSTEMS

As a result of the 3008(h) Consent Order agreement between EPA Region 6 and NASA, WSTF has incorporated the use of Westbay Multi-Port (MP) well systems in the groundwater assessment program. The Westbay MP systems are designed to monitor multiple water-bearing zones within a single drillhole. The systems are currently in use at WSTF to collect groundwater samples, obtain piezometric water pressures, and perform hydraulic conductivity determinations. Data obtained from these wells are used to formulate a three-dimensional conceptualization of the groundwater contamination plume in critical areas.

6.1 DESIGN OF WESTBAY WELLS

The Westbay MP system is a multiple-level groundwater monitoring system which employs a single, closed access, 1 1/2" (3.8 cm) diameter PVC casing with valved ports to perform well monitoring activities. The valved ports are used to provide controlled access to a multiple number of monitoring zones within a single drillhole.

Prior to the installation of the Westbay MP systems, the drillhole is bailed and\or pumped to remove a majority of the remaining drilling fluids. The Westbay system is then installed in the drillhole or in a multi-screened stainless steel monitoring well. Inflatable packers are integrated into the Westbay casing design and are individually inflated against the walls of the drillhole or the stainless steel casing. These packers isolate specific monitoring zones.

The Westbay wells are designed to provide direct access to formation water. This allows the collection of in situ groundwater samples and hydrogeological data. As a result of this design, the requirement to purge each zone prior to sample collection is eliminated. Specialized downhole instruments are used to access the valved ports within the well. Design specifics of the Westbay wells and the associated downhole equipment are provided in the site-specific procedural documentation and Westbay Operation and Maintenance Manuals.

6.2 DEVELOPMENT OF WESTBAY WELLS

A pumping port is installed in each Westbay sampling zone. Individual pumping ports are opened using the Westbay open/close tool and zone development is accomplished by overpumping and/or bailing the Westbay standpipe until indicator parameters (pH, temperature, conductivity, and turbidity) are constant. Additionally, the turbidity must be lowered to a value less than five NTUs. Upon development completion, the pumping port is closed using the open/close tool. Detailed instructions for the development of Westbay wells are provided in the site-specific procedural documentation. If elevated turbidity values are observed during subsequent sampling activities, redevelopment is performed.

6.3 WELL SECURITY

All Westbay wells are equipped with locking caps which are secured at all times except for sampling and analysis procedures conducted in accordance with this document. Keys are issued only to personnel directly involved in sample collection or well maintenance activities.

6.4 MONITORING EQUIPMENT

6.4.1 MOSDAX Sampler Probe

The MOSDAX sampler probe is used to measure downhole fluid pressures and obtain in situ groundwater samples from Westbay MP well systems. The system is operated by a handheld controller. The controller displays pressure readings and controls downhole fluid measurement and sample collection functions. The probe contains an electric strain-gauge pressure transducer for measuring fluid pressures through the measurement port couplings located in each monitoring zone.

The MOSDAX sampler probe is utilized to collect in situ groundwater samples. Stainless steel sample bottles are connected to the probe to transport the collected formation water from the sampling port to ground surface. The sampling functions are also operated by the handheld controller. Specific sampling zones are located by magnetic location collars which are installed as part of the Westbay MP casing system.

6.4.2 In Situ Datalogger

An in situ datalogger can be used in lieu of the electric pressure probe to perform hydraulic conductivity determinations. The datalogger is used with a downhole transducer in wells with relatively high hydraulic conductivities.

6.5 COLLECTION OF HYDROGEOLOGICAL DATA

6.5.1 Pressure Profiles

Pressure profiles of Westbay wells are performed after the monitoring zones of the well have been developed. Piezometric water pressures are collected using the MOSDAX sampler probe. Piezometric pressure profiles of each Westbay well are performed at least quarterly and prior to each sampling event.

To perform this operation, the MOSDAX sampler probe is lowered into the well and the desired zone is located. After the zone is located, the probe's location arm is activated and the probe is positioned into a helical landing ring located in the monitor port coupling. A backing shoe is then activated which presses the probe transducer against the measurement valve. This process isolates the probe from the fluid inside the standpipe and hydraulically connects it with the formation zone outside of the measurement valve. The corresponding pressure reading is displayed on the handheld controller and recorded.

Pressure readings can be converted to piezometric water levels using the calculations provided in the Westbay site-specific procedural documentation and Operation and Maintenance Manuals. Using the piezometric water pressures from the entire multi-port well, a piezometric pressure profile can be developed.

6.5.2 Hydraulic Conductivity Determinations

Hydraulic conductivity determinations (K-testing) of Westbay wells are performed at least one month after well development completion and after the initial groundwater samples have been collected from the zone. K-tests are performed by monitoring the rising head of water in the standpipe after the pumping port has been opened, resulting in hydraulic communication of the standpipe with the formation. The rising head is monitored with respect to time using the Westbay pressure probe, or the in situ datalogger with a downhole transducer.

For each K-test, the water level in the standpipe is lowered below the piezometric water level of the zone being measured, the open/close tool and the transducer or the pressure probe are positioned in the well, and the sliding pumping port coupling is opened with the open/close tool. The rising head of water in the standpipe is measured and recorded with respect to time. Upon completion of a hydraulic conductivity test, the pumping port is closed and the system is allowed to return to equilibrium. Instructions for performing this test are provided in the site-specific procedural documentation and Operations and Maintenance Manuals for the K-testing equipment. After completion of each test, the data are provided to a hydrogeologist who calculates the corresponding hydraulic conductivities using the Bouwer and Rice Method and the Papadopulos (et.al.) Method.

6.6 COLLECTION OF GROUNDWATER SAMPLES

Groundwater samples are collected using the MOSDAX sampler probe with the handheld controller. Up to four 250 ml stainless steel sample containers are attached to the sampling probe to transport formation water to the surface. The sample containers are evacuated at the surface to permit the collection of formation samples. The sampling apparatus is lowered into the well and the sampling zone is located using the magnetic collar system installed in the well casing. The location arm is then activated and the probe is positioned into the helical landing ring located in the monitor port coupling. The backing shoe is activated and the sampling port is positioned against the measurement port valve. This process isolates the sampling port from the standpipe fluids and hydraulically connects the sampling probe to the formation water. The sampling probe valve is then activated allowing formation water to collect in the evacuated sampling system. After sufficient time is allowed for filling, the sampling probe valve is deactivated, the backing shoe is retracted, and the sampling apparatus is raised to ground surface.

The first sample from each zone is used to rinse the sampling probe and stainless steel sample bottles and to measure indicator parameters (pH, temperature, conductivity, and turbidity). All excess fluid is discarded and the sample collection process is repeated to collect groundwater samples. Samples are collected in the order of their volatilization potential. After all samples are collected, final indicator parameters are measured to indicate changes in groundwater quality over time.

6.7 DECONTAMINATION OF WESTBAY SAMPLING EQUIPMENT

Upon receipt of new Westbay sampling equipment, or equipment that has been shipped off-site for servicing or repair, a steam-cleaning/deionized water rinse is performed prior to use. To ensure the absence of volatile contaminants prior to sampling, deionized water is poured into the assembled sampling probe and bottles, allowed to reside for one hour, and sampled as an equipment blank for halogenated volatile organics. If the results indicate the absence of contamination, the unit is ready for use.

Decontamination of Westbay downhole sampling equipment is performed prior to use in each well. Decontamination procedures include steam-cleaning of all metal components and a rinse of all components with deionized water. Prior to sampling a well, deionized water is poured into the assembled sampling probe and bottles and allowed to reside for at least thirty minutes. The deionized water is then sampled as an equipment blank for the analytical parameters specified by the WSTF Quality Assurance Project Plan.

Immediately prior to sampling a specific zone, the sampling probe and bottles are decontaminated by rinsing with deionized water. To obtain equipment blanks, deionized water is poured into the assembled sampling system, allowed to reside for thirty minutes, and sampled for halogenated volatile organics. In order to minimize potential cross-contamination between zones, each Westbay well is originally sampled from the lower-most sampling zone up. The results of the original sampling event are reviewed and subsequent sampling will collect samples from zones in the reverse order of their relative contaminant concentrations.

7.0 MONITOR WELL SAMPLING FREQUENCIES/ANALYTICAL PARAMETERS

Groundwater monitoring wells are installed to fulfill three basic requirements:

- provide post-closure care monitoring networks for each of the hazardous waste management units;
- permit horizontal and vertical plume definition; and
- provide chemical and physical data to predict future plume migration.

The following sections identify the sampling frequencies and analytical parameters used to fulfill these requirements.

7.1 GROUNDWATER ASSESSMENT SAMPLING SCHEDULE

Table 7.1 provides the current schedule for sampling groundwater assessment wells/zones. Sampling frequencies given in this Table are determined by well locations in relation to the hazardous waste management units, conceptualized location in the contaminant plume, spatial location in relationship to other groundwater assessment wells, and the relative chemical significance of the data.

All assessment wells are sampled quarterly for one year after installation. After this initial period, the analytical data are reviewed and a sampling frequency for each well is determined. The sampling schedule is reviewed annually to ensure that adequate information is generated to support the assessment program. If modifications to the schedule are necessary, they are included in updated versions of this document.

Due to the possible effects of drilling and well construction, at least four weeks are allowed between final well development and the initial collection of samples from a completed well. This allows the groundwater system to return to chemical equilibrium after drilling and installation.

On an annual basis, ten monitoring wells are sampled for Appendix IX parameters. This is a requirement of Post-Closure Care Permit No. NM8800019434-2 issued by NMED. As specified by the Permit, point of compliance monitoring wells in the 200, 300, 400, and 600 Areas require annual Appendix IX sampling for all parameters with the exception of dioxins and furans. Dioxins and furans are sampled every three years due to their historical non-use at the WSTF facility. Information gathered from this activity ensures that WSTF continues to direct its monitoring activities to the detection and evaluation of all hazardous constituents contained in the groundwater.

7.2 ANALYTICAL PARAMETERS

Historical analytical data from the WSTF groundwater monitoring wells indicate the presence of groundwater contamination from halogenated volatile organics, N-nitrosodimethylamine (NDMA), and chromium. On January 12, 1994 EPA Region 6 approved modifications to the January 10, 1992 WSTF Groundwater Sampling and Analysis Plan. These modifications were made to facilitate more area-specific groundwater monitoring.

TABLE 7.1
Sampling Frequencies for WSTF Groundwater Assessment Wells/Zones

QUARTERLY	SEMI-ANNUALLY	SEMI-ANNUALLY	ANNUALLY	BIENNIALLY
100-D-176	200-B-240	BLM-28-425	300-B-166	100-A-182
600-D-230	200-C-170	BLM-28-470	300-C-128	100-C-365
600-D-365	200-C-225	BLM-28-525	700-E-458	100-E-261
600-D-635	200-C-270	BLM-30-585	700-F-455	
600-D-845	200-D-109	BLM-31-350	BLM-3-182	
BLM-6-488	200-D-240	BLM-31-485	BLM-5-527	
BLM-18-430	200-F-225	BW-4-270	BLM-22-570	
PL-3-453	200-F-370	BW-4-355	BW-1-268	
PL-4-464	200-F-420	BW-4-455	BW-3-180	
PL-5-495	200-G-175	BW-7-211	BW-5-295	
PL-6-545	200-G-220	NASA 3	BW-6-355	
PL-6-725	200-G-340	NASA 5	JP-1-424	
PL-6-915	200-G-420	NASA 6	JP-2-447	
PL-6-1195	200-G-495	NASA 7	NASA 4	
PL-6-1335	200-H-150	NASA 8	WB-3-330	
PL-6-1485	200-H-225	NASA 9	WB-3-355	
PL-6-1645	200-H-331	NASA 10	WB-3-425	
PL-6-1815	200-H-433	PL-1-486	WB-3-450	
PL-7-480	300-A-120	PL-2-504	WB-8-275	
PL-7-560	300-A-170	PL-5-595	WB-8-320	
PL-7-630	300-D-153	PL-5-715	WB-8-410	
ST-1-473	300-E-138	PL-5-795	WB-9-310	
ST-1-541	300-E-183	PL-5-895	WB-9-335	
ST-1-630	400-A-151	PL-5-985	WB-9-360	
ST-2-466	400-C-118	WB-1-200	WB-14-520	
ST-3-486	400-C-143	WB-1-255	WW-1-452	
ST-3-586	400-D-195	WB-1-330		
ST-3-666	400-D-275	WB-2-245		
ST-3-735	400-D-355	WB-2-270		
ST-4-481	600-C-173	WB-2-365		
ST-4-589	600-C-473	WB-5-250		
ST-4-690	700-A-253	WB-5-280		
ST-5-481	700-B-510	WB-5-345		
ST-5-485	700-D-186			
ST-5-655	BLM-1-435			
ST-5-815	BLM-2-482			
ST-5-985	BLM-2-630			
ST-5-1175	BLM-7-509			
	BLM-8-418			
	BLM-9-419			
	BLM-10-517			
	BLM-13-300			
	BLM-14-327			
	BLM-15-305			
	BLM-17-493			
	BLM-17-550			
	BLM-21-400			
	BLM-23-431			
	BLM-24-565			
	BLM-25-455			
	BLM-26-404			
	BLM-27-270			

The parameter collection schedule is presented in Table 7.2. Wells and zones completed after issuance of this Plan will initially have samples collected for halogenated volatile organics, volatile organics, NDMA, and total metals. Based on the results of these analyses, including a statistical analysis of the first year's total metals' results, a collection schedule will be designated for each new well. NASA will notify EPA Region 6 in the monthly status reports of the collection schedule selected for each new well/zone.

Table 7.2 provides a summary of all current assessment wells/zones and their corresponding sample collection plans. All wells completed subsequent to the issuance of this Sampling and Analysis Plan will be identified in the site-specific procedural documentation, then the appropriate sampling plan will be assigned based on the location of the well in relation to the conceptualized sources of the contamination plume. If results of the initial sampling indicate the appropriate plan was not selected, the data will be reviewed and the collection plan modified as necessary.

7.2.1 Initial Sampling Events

After a well is completed and developed, initial samples are collected. Samples are analyzed for halogenated volatile organics, volatile organics, NDMA, and total RCRA metals.

7.2.2 Standard Plan A Sampling Events

After initial sample collection, wells designated as Plan A wells are sampled for halogenated volatile organics and NDMA. Total metals will be collected quarterly for the first year of sampling activities. These first year metals' results are then statistically analyzed to determine the appropriate sampling plan. Additionally, on at least an annual basis, samples are collected for volatile organics and total chromium.

7.2.3 Standard Plan B Sampling Events

After initial sample collection, wells designated as Plan B wells are sampled for halogenated volatile organics. Total metals will be collected quarterly for the first year of sampling activities. These first year metals' results are then statistically analyzed to determine the appropriate sampling plan. Additionally, on at least an annual basis, samples are collected for volatile organics and total chromium.

7.2.4 Additional Analyses

Due to elevated chromium concentrations detected in the immediate vicinity of the 600 Area, additional sampling for total chromium is performed. Table 7.3 indicates the wells for which chromium samples are collected.

In order to confirm the absence of NDMA in 100 and 600 Area wells, at least one well from each area will be sampled annually for NDMA. The well(s) selected from each area will represent the well(s) most susceptible to NDMA contamination.

TABLE 7.2

Parameter Collection Frequencies

Well I.D.	Method 8010	Method 8240	Method 607	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury
100-A-182	X	X					X				
100-C-365	X	X					X				
100-D-176	X	X	X	X	X	X	X	X	X	X	X
100-E-261	X	X					X				
200-B-240	X	X	X	X	X	X	X	X	X	X	X
200-C-170	X	Y	X	X			Y				
200-C-225	X	Y	X				Y				
200-C-270	X	Y	X				Y				
200-D-109	X	X	X	X	X	X	X	X	X	X	X
200-D-240	X	X	X	X	X	X	X	X	X	X	X
200-F-225	X	X	X	X	X	X	X	X	X	X	X
200-F-370	X	X	X	X	X	X	X	X	X	X	X
200-F-420	X	X	X	X	X	X	X	X	X	X	X
200-G-175	X	X	X	X	X	X	X	X	X	X	X
200-G-220	X	X	X	X	X	X	X	X	X	X	X
200-G-340	X	X	X	X	X	X	X	X	X	X	X
200-G-420	X	X	X	X	X	X	X	X	X	X	X
200-G-495	X	X	X	X	X	X	X	X	X	X	X
200-H-150	X	X	X	X	X	X	X	X	X	X	X
200-H-225	X	X	X	X	X	X	X	X	X	X	X
200-H-331	X	X	X	X	X	X	X	X	X	X	X
200-H-433	X	X	X	X	X	X	X	X	X	X	X
300-A-120	X	X	X	X	X	X	X	X	X	X	X
300-A-170	X	X	X	X	X	X	X	X	X	X	X
300-B-166	X	Y	X		X		Y	X			
300-C-128	X	Y	X		X		Y				
300-D-153	X	X	X	X	X	X	X	X	X	X	X
300-E-138	X	X	X	X	X	X	X	X	X	X	X
300-E-183	X	X	X	X	X	X	X	X	X	X	X
400-A-151	X	X	X				Y				
400-C-118	X	X	X	X	X	X	X	X	X	X	X
400-C-143	X	X	X	X	X	X	X	X	X	X	X
400-D-195	X	X	X	X	X	X	X	X	X	X	X
400-D-275	X	X	X	X	X	X	X	X	X	X	X
400-D-355	X	X	X	X	X	X	X	X	X	X	X
600-C-173	X	X	X	X	X	X	X	X	X	X	X

X - Indicates that samples are collected for this parameter at each scheduled sampling event.
Y - Indicates that samples are collected annually for this parameter.

TABLE 7.2

Parameter Collection Frequencies

Well I.D.	Method 8010	Method 8240	Method 607	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury
600-C-437	X	X	X	X	X	X	X	X	X	X	X
600-D-230	X	X	X	X	X	X	X	X	X	X	X
600-D-365	X	X	X	X	X	X	X	X	X	X	X
600-D-635	X	X	X	X	X	X	X	X	X	X	X
600-D-845	X	X	X	X	X	X	X	X	X	X	X
700-A-253	X	Y	X				Y				
700-B-510	X	Y	X				Y				
700-D-186	X	Y	X				Y				
700-E-458	X	Y	X				Y				
700-F-455	X	Y	X				X				
BLM-1-435	X	X	X				X				
BLM-2-482	X	X	X				X				
BLM-2-630	X	X	X				X	X			
BLM-3-182	X	Y	X		X		X				
BLM-5-527	X	Y	X				X				
BLM-6-488	X	X	X		X		X				
BLM-7-509	X	Y	X				X				
BLM-8-418	X	Y	X		X		Y				
BLM-9-419	X	X	X				Y				
BLM-10-517	X	Y	X				Y				
BLM-13-300	X	X	X				Y				
BLM-14-327	X	X	X				Y				
BLM-15-305	X	X	X		X		Y				
BLM-17-493	X	X	X				X				
BLM-17-550	X	X	X				X				
BLM-18-430	X	X	X				Y				
BLM-21-400	X	X	X				Y				
BLM-22-570	X	Y	X				Y				
BLM-23-431	X	X	X		X		X				
BLM-24-565	X	Y	X				Y				
BLM-25-455	X	Y	X				Y				
BLM-26-404	X	Y	X				Y				
BLM-27-270	X	Y	X		X		X				
BLM-28-425	X	Y	X				X		X		
BLM-28-470	X	Y	X				X				
BLM-28-525	X	Y	X				Y				

X - Indicates that samples are collected for this parameter at each scheduled sampling event.
Y - Indicates that samples are collected annually for this parameter.

TABLE 7.2

Parameter Collection Frequencies

Well I.D.	Method 8010	Method 8240	Method 607	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury
BLM-30-585	X	Y	X				Y				
BLM-31-350	X	Y	X				Y				
BLM-31-485	X	Y	X				Y				
BW-1-268	X	Y	X		X		Y				
BW-3-180	X	X					X				
BW-4-270	X	Y	X		X		Y				
BW-4-355	X	Y	X				Y				
BW-4-455	X	Y	X				Y				
BW-5-295	X	Y	X				Y				
BW-6-355	X	Y	X				Y				
BW-7-211	X	Y	X		X		Y				
JP-1-424	X	Y	X				X				
JP-2-447	X	Y	X				Y				
NASA 3	X	Y	X				Y				
NASA 4	X	Y	X		X		X				
NASA 5	X	X	X	X	X	X	X	X	X	X	X
NASA 6	X	X	X	X	X	X	X	X	X	X	X
NASA 7	X	X	X	X	X	X	X	X	X	X	X
NASA 8	X	X	X	X	X	X	X	X	X	X	X
NASA 9	X	X	X	X	X	X	X	X	X	X	X
NASA 10	X	X	X	X	X	X	X	X	X	X	X
PL-1-486	X	Y	X				X				
PL-2-504	X	X	X				X				
PL-3-453	X	Y	X				Y				
PL-4-464	X	Y	X				Y				
PL-5-495	X	X	X				Y				
PL-5-595	X	Y	X				Y				
PL-5-715	X	Y	X				Y				
PL-5-795	X	Y	X				Y				
PL-5-895	X	Y	X	X			Y				
PL-5-985	X	Y	X		X		Y				
PL-6-545	X	Y	X				Y				
PL-6-725	X	Y	X				Y				
PL-6-915	X	Y	X	X			Y				
PL-6-1195	X	Y	X				Y				
PL-6-1335	X	Y	X				Y				

X - Indicates that samples are collected for this parameter at each scheduled sampling event.
Y - Indicates that samples are collected annually for this parameter.

TABLE 7.2

Parameter Collection Frequencies

Well I.D.	Method 8010	Method 8240	Method 607	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury
PL-6-1485	X	Y	X				Y				
PL-6-1645	X	Y	X	X			Y				
PL-6-1815	X	Y	X		X		Y				
PL-7-480	X	Y	X		X		Y				
PL-7-560	X	Y	X				Y				
PL-7-630	X	Y	X				Y				
ST-1-473	X	Y	X				Y				
ST-1-541	X	X	X				Y				
ST-1-630	X	Y	X		X		Y				
ST-2-466	X	Y	X				Y				
ST-3-486	X	Y	X				X				
ST-3-586	X	Y	X		X		X				
ST-3-666	X	Y	X		X		Y				
ST-3-735	X	Y	X		X		Y				
ST-4-481	X	Y	X				Y				
ST-4-589	X	Y	X		X		Y				
ST-4-690	X	Y	X		X		X	X			
ST-5-481	X	Y	X				X				
ST-5-485	X	Y	X				Y				
ST-5-655	X	Y	X				Y				
ST-5-815	X	Y	X				Y				
ST-5-985	X	Y	X				Y				
ST-5-1175	X	Y	X	X	X		Y				
WB-1-200	X	Y	Y				Y				
WB-1-255	X	Y					Y				
WB-1-330	X	Y					Y				
WB-2-245	X	Y					Y				
WB-2-270	X	Y					Y				
WB-2-365	X	Y					Y				
WB-3-330	X	Y					Y				
WB-3-355	X	Y					Y				
WB-3-425	X	Y					Y				
WB-3-450	X	Y					Y				
WB-5-250	X	Y					Y				
WB-5-280	X	Y					Y				
WB-5-345	X	Y					Y				

X - Indicates that samples are collected for this parameter at each scheduled sampling event.
Y - Indicates that samples are collected annually for this parameter.

TABLE 7.2

Parameter Collection Frequencies

Well I.D.	Method 8010	Method 8240	Method 607	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury
WB-8-275	X	Y					Y				
WB-8-320	X	Y					Y				
WB-8-410	X	Y				X	Y				
WB-9-310	X	Y					Y				
WB-9-335	X	Y					Y				
WB-9-360	X	Y					Y				
WB-14-520	X	Y					Y				
WW-1-452	X	Y					Y				

X - Indicates that samples are collected for this parameter at each scheduled sampling event.
Y - Indicates that samples are collected annually for this parameter.

TABLE 7.3

Groundwater Assessment Wells and Their Corresponding Parameter Collection Plans

WELL I.D.	PLAN	WELL I.D.	PLAN	WELL I.D.	PLAN
100-A-182	B	BLM-17-550	A	PL-6-1195	A
100-C-365	B	BLM-18-430	A	PL-6-1335	A
100-D-176	A	BLM-21-400	A	PL-6-1485	A
100-E-261	B	BLM-22-570	A	PL-6-1645	A
200-B-240	A	BLM-23-431	A[1]	PL-6-1815	A
200-C-170	A	BLM-24-565	A	PL-7-480	A
200-C-225	A	BLM-25-455	A	PL-7-560	A
200-C-270	A	BLM-26-404	A	PL-7-630	A
200-D-109	A	BLM-27-270	A	ST-1-473	A
200-D-240	A	BLM-28-425	A	ST-1-541	A
200-F-225	A	BLM-28-470	A	ST-1-630	A
200-F-370	A	BLM-28-525	A	ST-2-466	A
200-F-420	A	BLM-30-585	A	ST-3-486	A
200-F-570	A	BLM-31-350	A	ST-3-586	A
200-G-175	A	BLM-31-485	A	ST-3-666	A
200-G-220	A	BLM-31-770	A	ST-3-735	A
200-G-340	A	BW-1-268	A	ST-4-481	A
200-G-420	A	BW-3-180	B	ST-4-589	A
200-G-495	A	BW-4-270	A	ST-4-690	A
200-H-150	A	BW-4-355	A	ST-5-481	A
200-H-225	A	BW-4-455	A	WB-1-200	B[2]
200-H-331	A	BW-5-295	A	WB-1-255	B
200-H-433	A	BW-6-355	A	WB-1-330	B
300-A-120	A	BW-7-211	A	WB-2-245	B
300-A-170	A	JP-1-424	A	WB-2-270	B
300-B-166	A	JP-2-447	A	WB-2-365	B
300-C-128	A	NASA 3	A	WB-3-330	B
300-D-153	A	NASA 4	B[2]	WB-3-355	B
300-E-138	A	NASA 5	A	WB-3-425	B
300-E-183	A	NASA 6	A	WB-3-450	B
400-A-151	A	NASA 7	B[1]	WB-5-250	B
400-C-118	A	NASA 8	B	WB-5-280	B
400-C-143	A	NASA 9	A	WB-5-345	B
400-D-195	A	NASA 10	A	WB-5-380	B
400-D-275	A	PL-1-486	A	WB-8-275	B
400-D-355	A	PL-2-504	A	WB-8-320	B
600-C-173	B	PL-3-453	A	WB-8-410	B
600-C-437	B[1]	PL-4-464	A	WB-9-310	B
600-D-230	B[1]	PL-5-495	A	WB-9-335	B
600-D-365	B[1]	PL-5-595	A	WB-9-360	B
600-D-635	B[1]	PL-5-715	A	WB-14-520	B
600-D-845	B[1]	PL-5-795	A	WW-1-452	A
700-A-253	A	PL-5-895	A		
700-B-510	A	PL-5-985	A		
700-D-186	A	PL-6-545	A		
700-E-458	A	PL-6-725	A		
700-F-455	A	PL-6-915	A		
BLM-1-435	A				
BLM-2-482	A				
BLM-2-630	A				
BLM-3-182	A				
BLM-5-527	A				
BLM-6-488	A[1]				
BLM-7-509	A				
BLM-8-418	A				
BLM-9-419	A				
BLM-10-517	A				
BLM-13-300	A[1]				
BLM-14-327	A				
BLM-15-305	A				
BLM-17-493	A				

Collection Plan A - Indicates the well is sampled for halogenated volatile organics and NDMA each time the well is scheduled for sampling. Additionally, on at least an annual basis, samples are collected for volatile organics and total chromium.

Collection Plan B - Indicates the well is sampled for halogenated volatile organics each time the well is scheduled for sampling. Additionally, on at least an annual basis, samples are collected for volatile organics and total chromium.

1 Indicates that due to the proximity on this well to the 600 Area, total chromium samples are collected each time the well is scheduled for sampling.

2 Indicates that on at least an annual basis samples are collected for NDMA.

7.2.5 Appendix IX Sampling

As required by the NMED-issued Post-Closure Care Permit No. NM8800019434-2, ten on-site monitoring wells are sampled annually for Appendix IX parameters. These point of compliance monitoring wells are located in each of the closure areas and were selected based on their proximity to known hazardous waste releases, observed concentrations of hazardous constituents, and/or anomalous concentrations of hazardous constituents in comparison to other wells in the immediate area.

Appendix IX analyses include halogenated volatile organics, volatile organics, semi-volatile organics, nitrosamines, herbicides, pesticides/PCBs, total cyanide, total sulfide, and total Appendix IX metals. Analyses for dioxins and furans are performed every three years due to their non-applicability to the site.

7.3 SAMPLE COLLECTION

7.3.1 Sample Identification

Sample numbers are assigned at the time of collection with an unique ten digit number. An example of a sample number is: 9701021030. In this example, 97 refers to the year, 0102 indicates the sample was collected on January 2nd, and 1030 indicates the sample was taken at 1030 hours. This sample identification format is used for all samples, field blanks, and quality assurance samples.

7.3.2 Sample Collection

To minimize volatilization of constituents, samples are collected in the order of their respective sensitivities to volatilization. When using dedicated bladder pumps, pumping rates during collection of volatile, semi-volatile and pH samples are adjusted to 100 ml/min or less. Care is exercised to ensure the pumping proceeds in a slow and continuous manner to minimize the aeration of samples. After samples sensitive to volatilization are collected, a higher pumping rate is used.

When bailers are used to collect samples sensitive to volatilization, aeration of the samples is minimized by slowly lowering the bailer into the water. When the bailer is brought to the surface, samples are dispensed to the appropriate containers using a bottom-emptying stop-cock device.

Sample volumes, types of containers, and preservation methods conform to the recommendations of SW-846 and the TEGD. Table 7.4 provides a summary of the information required to select the proper containers and preservatives for each required analyses. Table 7.5 provides a summary of the proper sample containers and preservatives used to collect groundwater samples.

TABLE 7.4
Standard Groundwater Assessment Containers, Preservation Methods and Holding Times

Analysis	Containers	Preservation	Maximum Holding Time
Halogenated Volatile Organics	40 ml glass vials	Zero headspace and cool to 4°C	14 days
Volatile Organics	40 ml glass vials	Zero headspace and cool to 4°C	14 days
Nitrosamines	1 liter glass bottle	Cool to 4°C	7 days until extraction 40 days after extraction
Metals	500 ml poly bottle	HNO_3 to pH <2 and cool to 4°C	6 months*

* Except for mercury which has a holding time of 28 days.

TABLE 7.5
Containers, Preservatives and Holding Times

NAME	CONTAINER[1]	PRESERVATION	MAXIMUM HOLDING TIME
Bacterial Tests:			
Coliform, fecal and total	P, G	Cool, 4°C, 0.008% $Na_2S_2O_3$	6 hours
Fecal streptococci	P, G	Cool, 4°C, 0.008% $Na_2S_2O_3$	6 hours
Inorganic Tests:			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Biochemical oxygen demand	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Biochemical oxygen demand, carbonaceous	P, G	Cool, 4°C	48 hours
Chemical oxygen demand	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Chloride	P, G	None required	28 days
Chlorine, total residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, total and amenable to chlorination	P, G	Cool, 4°C, NaOH to pH>12, 0.6g ascorbic acid	14 days
Fluoride	P	None required	28 days
Hardness	P, G	HNO_3 or H_2SO_4 to pH<2	6 months
Hydrogen ion (pH)	P, G	None required	Analyze immediately
Kjeldahl and organic nitrogen	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Residue, total	P, G	Cool, 4°C	7 days
Residue, filterable	P, G	Cool, 4°C	7 days
Residue, nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, settleable	P, G	Cool, 4°C	48 hours
Residue, volatile	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days
Sulfide	P, G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH>9	7 days

TABLE 7.5
Containers, Preservatives and Holding Times

Sulfite	P, G	None required	Analyze immediately
Surfactants	P, G	Cool, 4°C	48 hours
Temperature	P, G	None required	Analyze
Turbidity	P, G	Cool, 4°C	48 hours
Metals:			
Chromium VI	P, G	Cool, 4°C	24 hours
Mercury	P, G	HNO_3 to pH<2	28 days
Metals, except chromium VI and mercury	P, G	HNO_3 to pH<2	6 months
Nitrate	P, G	Cool, 4°C	48 hours
Nitrate-nitrite	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrite	P, G	Cool, 4°C	48 hours
Oil and grease	G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic carbon	P, G	Cool, 4°C, HCl or H_2SO_4 to pH<2	28 days
Orthophosphate	P, G	Filter immediately, cool, 4°C	48 hours
Oxygen, dissolved probe	G bottle and top	None required	Analyze immediately
Winkler DO		Fix on site and store in dark	8 hours
Phenols	G only	Cool, 4°C, H_2SO_4 to pH<2	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 hours
Phosphorus, total	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Tests:			
Purgeable halocarbons	G, Teflon-lined septum	Cool, 4°C	14 days
Purgeable aromatic hydrocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$, HCl to pH2	14 days
Acrolein and acrylonitrile	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$, Adjust pH to 4-5	14 days
Phenols	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$	7 days until extraction, 40 days after extraction
Benzidines	G, Teflon-lined	Cool, 4°C, 0.008% $Na_2S_2O_3$	7 days until extraction
Phthalate esters	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitrosamines	G, Teflon-lined cap	Cool, 4°C, store in dark,	40 days after extraction

TABLE 7.5
Containers, Preservatives and Holding Times

PCBs, acrylonitrile	G, Teflon-lined cap	Cool, 4°C	40 days after extraction
Nitroaromatics and	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$,	40 days after extraction
Polynuclear aromatic hydrocarbons	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$, store in dark	40 days after extraction
Haloethers	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$	40 days after extraction
Chlorinated hydrocarbons	G, Teflon-lined cap	Cool, 4°C	40 days after extraction
TCDD	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$	40 days after extraction
Total organic halogens	G, Teflon-lined cap	Cool, 4°C, H_2SO_4 to pH<2	7 days
Pesticides Tests:			
Pesticides	G, Teflon-lined cap	Cool, 4°C, pH 5-9	40 days after extraction
Radiological Tests:			
Alpha, Beta and radium	P, G	HNO_3 to pH<2	6 months

[1]Polyethylene (P) or Glass (G)

From SW-846

Nytek gloves are worn during sampling events to prevent contamination of samples and sampling equipment. The gloves also protect sampling personnel from direct contact with potentially hazardous constituents. Tyvek or equivalent protective clothing is required when sampling wells with hazardous constituents present in levels above recognized safe limits of exposure or if information concerning the contamination is unknown prior to sampling. Gloves are discarded after each sampling event. A detailed discussion of standard sampling procedures is provided in the site-specific procedural documentation.

7.4 Field Analyses

The first and last samples collected at each well are reserved for the field determinations of temperature, specific conductance, turbidity, and pH. Detailed procedures for field determinations are described in the site-specific procedural documentation and specific equipment Operations and Maintenance Manuals. The results of field analyses are recorded in the field logbook.

7.5 Sample Preservation and Storage

Samples are preserved in accordance with the methods detailed in Table 7.5. Each sample container is preserved (as necessary), labeled, sealed, and promptly placed on ice.

To prevent alteration of samples during collection, sample containers are cooled on ice prior to sample collection. Additionally, all collected volatile samples are stored with the septum facing down. This procedure minimizes possible volatilization through the septum.

7.6 Equipment Decontamination and Verification

After use at each sampling site, non-dedicated sampling equipment is decontaminated. Step-by-step decontamination procedures are included in the site-specific procedural documentation. Equipment blanks are taken at each well where non-dedicated sampling equipment is used. Equipment blanks are obtained by flushing distilled water over and/or through the steam cleaned equipment in the field immediately before sampling. The rinse water is collected in sample bottles corresponding to the analytes being sampled. Equipment blanks are labeled, assigned sample numbers, and handled in the same manner as groundwater samples. The sample number is recorded as an equipment blank in the field notebook, but is submitted "blind" to the analytical laboratories. This process allows identification of irregularities that might occur due to improper decontamination of equipment or field introduction of contaminants.

8.0 ANALYTICAL METHODS

Based on the groundwater assessment data collected to this point, WSTF has identified specific hazardous constituents in the groundwater. These hazardous constituents include halogenated volatile organics, N-nitrosodimethylamine and chromium. WSTF has incorporated the use of the most sensitive analyte-specific EPA-recommended analytical methods for identification and quantification of these compounds. Table 8.1 summarizes the analytical methods currently utilized at WSTF. The WSTF Quality Assurance Project Plan provides a detailed description of the analytical methods currently utilized in the WSTF groundwater assessment project.

TABLE 8.1
Analytical Methods Currently Used at WSTF

EPA Method Number	Analysis
Method 8021 or EPA equivalent	Halogenated Volatile Organics
Method 8260 or EPA equivalent	Volatile Organics
Method 607, 8070 or EPA equivalent	Nitrosamines
Method 6060 or EPA equivalent	Chromium
Method 8081 or EPA equivalent	Pesticides and PCBs
Method 8270 or EPA equivalent	Semi-volatile Organics
Method 8150 or EPA equivalent	Herbicides
Method 9066 or EPA equivalent	Phenolics
Method 9012 or EPA equivalent	Cyanide
Method 9030 or EPA equivalent	Sulfide
Several EPA approved Methods	Total RCRA Metals

8.1 Modifications to the Referenced EPA Methods

WSTF has identified several halogenated volatile organic compounds as hazardous constituents in the groundwater. Table 8.2 provides a list of the hazardous constituents that have been targeted for halogenated volatile organic analysis. Three of these compounds, 1,2-dichloro-1,1,2-trifluoroethane, 1,1,2-trichloro-1,2,2-trifluoroethane, and dichlorofluoromethane are not listed as standard compounds for quantification by the halogenated volatile organics method. However, calibrations for each of these compounds are made and they are quantified in the same manner as other listed compounds. The volatile organics method, which is currently used to provide mass spectral confirmation of compounds identified by the halogenated volatile organics method, has also been modified to accommodate the quantification of these additional compounds.

9.0 QUALITY ASSURANCE PROCEDURES

The WSTF Quality Assurance Project Plan provides a complete discussion of the quality assurance procedures required in the field and the laboratory. This section provides a summary of the quality assurance measures required for sample collection and processing. The WSTF Quality Assurance Project Plan provides specific details concerning these procedures.

9.1 FIELD QUALITY CONTROL SAMPLES

Table 9.1 provides a summary and description of quality control samples used in the field. These samples are required to ensure that data are collected to adequately define the accuracy, precision, representativeness, completeness, and comparability of groundwater samples. Table 9.2 provides the frequency of use for each of these controls.

9.2 DOCUMENTATION

Documentation of all procedures used in sample collection, transport, and analysis is critical to ensure that data generated in support of the groundwater assessment program are legally defensible. Documentation includes field logbooks, sample seals, sample labels, and chain of custody forms.

The WSTF Quality Assurance Project Plan provides a comprehensive description, detailed instructions, and examples of the documentation required for the groundwater assessment program.

9.2.1 Field Logbook

A serially numbered field logbook is used to record all activities, observations, and measurements that take place in the field during sampling events. Records of the field activities should be sufficient to allow an individual, not associated with the sampling event, to recreate the events by reading the logbook. These documents are a legal record of all field activities. All logbooks are kept on-site for immediate availability.

TABLE 8.2
Halogenated Volatile Organic Compounds

IUPAC Nomenclature	CAS #	Other Common Designations
Dichlorofluoromethane	75-43-4	Freon 21
Dichloromethane	75-09-2	Methylene Chloride
Trichlorofluoromethane	75-69-4	Freon 11, MF Freon
1,2-Dichloro-1,1,2-trifluoroethane	354-23-4	Freon 123A
Trichloromethane	67-66-3	Chloroform
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	Freon 113, TF Freon
1,1,1-Trichloroethane	71-55-6	1,1,1-TCA
Trichloroethene	79-01-6	Trichloroethylene, TCE
Tetrachloroethene	127-18-4	Perchloroethene, PCE

TABLE 9.1
Descriptions of Field Quality Control Samples

Sample Type	Description
Equipment Blank	ASTM Type II water is transported to the sampling site, opened, poured over and/or through the sampling device, and collected in sample containers. This type of blank indicates the effectiveness of decontamination procedures and also indicates contamination in the field which may affect analytical results.
Field Blank	ASTM Type II water is transported to the sampling site, opened, and poured directly into sample containers. This type of sample provides a check on reagent quality and contamination derived in the field.
Trip Blank	ASTM Type II water is poured into sampling containers in a contaminant free environment, placed in coolers, transported to the field, back to the laboratory, and analyzed. This type of sample serves as a check on sample contamination originating from sample handling, transport, shipping, and site conditions. This sample may also be used to estimate the system detection limit.
Blind Quality Control Sample	A check standard is prepared from a source other than the calibration standard, which is provided blind to the analytical lab. This type of sample serves as an independent check of analytical techniques, handling, and standards.
Duplicate Sample	A second sample is taken immediately after an original sample at the same sampling location. This sample provides an estimate of the overall system precision.

TABLE 9.2
Field QA/QC Controls

TYPE OF CONTROL	HALOGENATED VOLATILE ORGANICS	VOLATILE ORGANICS	NITROSAMINES	RCRA METALS
Equipment Blank	100% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	100% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	5% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	5% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.
Field Blank	Not required if equipment blanks are taken, otherwise 100% of all sampling days.	Not required if equipment blanks are taken, otherwise 100% of all sampling days.	Not required if equipment blanks are taken, otherwise 5% of all sampling days or at least once per month, whichever is the most frequent.	Not required if equipment blanks are taken, otherwise 5% of all metals' sampling days or at least once per month, whichever is the most frequent.
Duplicate Sample	10% of all sampling events or at least once per month, whichever is the most frequent.	10% of all sampling events or at least once per month, whichever is the most frequent.	10% of all sampling events or at least once per month, whichever is the most frequent.	10% of all metals' sampling events or at least once per month, whichever is the most frequent.
Blind Quality Control Sample	5% of all sampling events or at least once per month, whichever is the most frequent.	5% of all sampling events or at least once per month, whichever is the most frequent.	5% of all sampling events or at least once per month, whichever is the most frequent.	5% of all metals' sampling events or at least once per month, whichever is the most frequent.
Trip Blank	5% of all sampling events or at least once per month, whichever is the most frequent.	5% of all sampling events or at least once per month, whichever is the most frequent.	5% of all sampling events or at least once per month, whichever is the most frequent.	5% of all metals' sampling events or at least once per month, whichever is the most frequent.

Information that is recorded in the field logbook each time sampling is conducted includes:

- identification of the well;
- date;
- members of the sampling party;
- climatic conditions;
- static water level;
- calculated purge volume;
- purge rate, purge duration, purge time, and volume of water purged;
- well evacuation method and equipment;
- sample collection method and equipment;
- sample collection sequence;
- types of sample containers used and sample identification numbers;
- preservative(s) used;
- analytical parameters;
- indicator parameter determinations;
- laboratory(ies) performing the analyses; and
- any other relevant field observations.

9.2.2 Sample Seals and Labels

All samples collected in support of the groundwater assessment program are labeled and have sample seals affixed immediately after sample collection. Sample labels are necessary to ensure that samples are correctly identified and the laboratory performs the required analyses. Sample seals ensure that samples are not opened and/or chemically altered until analytical procedures are initiated.

Information which is required on sample labels includes:

- sample identification number;
- collector's name;
- date and time of collection;
- sample collection location;
- analytical method required; and
- preservation method.

Information which is required on sample seals includes:

- sample collection location;
- sample identification number; and
- collector's name.

9.2.3 Chain of Custody Forms

Chain of custody forms are used to track possession of groundwater samples from the time of collection through sample analysis. These forms provide legal documentation of possession throughout the entire sampling and analysis process. Information provided on these forms includes:

- sample number(s);
- sample matrix (groundwater);
- sample location;
- requested analysis(es);
- signature(s), date(s), and time(s) of all personnel involved in sample custody;
- container description(s); and
- preservative(s) used.

9.3 SAMPLE DELIVERY

Specific procedures are required to ensure that groundwater assessment samples are transported to the respective analytical laboratories in an acceptable manner. The following sections provide a basic overview of procedures used in transporting samples to the analytical laboratory. Specific details of the sample delivery process are provided in the WSTF Quality Assurance Project Plan.

9.3.1 Shipment of Off-Site Samples

Samples sent to independent off-site laboratories require processing prior to shipment. Samples are inspected prior to packaging for correctness and completeness. Containers are then packaged as necessary to prevent breakage, transferred to an ice chest, and packed with ice. The ice chest is then secured and shipped via next-day delivery to the analytical laboratory. The off-site laboratory custodian inspects the samples upon delivery, notifies WSTF if any irregularities are encountered, and signs and returns the chain of custody form to WSTF.

9.4 ANALYTICAL QUALITY ASSURANCE

Specific quality control procedures are provided in each of the referenced EPA analytical methods. In addition, the WSTF Quality Assurance Project Plan provides supplementary quality assurance guidance.

10.0 ANALYTICAL REPORTS AND DATA MANAGEMENT

The WSTF Quality Assurance Project Plan provides a detailed discussion of data management and analytical report generation procedures.

11.0 REFERENCES

American Society for Testing and Materials, Ground-Water Contamination: Field Methods, STP 963, Baltimore, MD, July 1988.

Barcelona, M., J. Gibb, J. Helfrich, and E. Garske, Practical Guide for Ground-Water Sampling, Illinois State Water Survey, Champaign, IL, November 1985.

Black, W., H. Smith, F. Patton, "Multiple-Level Groundwater Monitoring with the MP System", Proceedings of the Surface and Borehole Geophysical Methods and Ground Water Instrumentation Conference and Exposition, National Water Well Association, Denver, CO, October 1986.

Bouwer, H. and R. Rice, "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells", Water Resources Research, Volume 12, Number 3, Phoenix AZ, June 1976.

Driscoll, F., Groundwater and Wells, Second Edition, Johnson Division, St. Paul MN, 1986.

Ford, P., P. Turina, and D. Seely, Characterization of Hazardous Waste Sites - A Methods Manual: Volume II Available Sampling Methods, Second Edition, EPA 600/4-84-076, U.S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring Systems Laboratory, Las Vegas, NV, December 1984.

National Archives and Records Administration, Office of the Federal Register, Code of Federal Regulations, Protection of Environment, Title 40, Parts 100 to 149, Washington, D.C., July 1, 1991.

National Archives and Records Administration, Office of the Federal Register, Code of Federal Regulations, Protection of Environment, Title 40, Parts 260 to 299, Washington, D.C., July 1, 1991.

Nielson, D., Practical Handbook of Ground-Water Monitoring, Lewis Publishers Inc., Chelsea, MI, 1991.

Papadopulos, S., J. Bredehoeft, and H. Cooper, "On the Analysis of 'Slug Test Data'", Water Resources Research, Volume 9, Number 4, 1973.

Scalf, M., J. McNabb, W. Dunlap, R. Cosby, and J. Fryberger, Manual of Ground-Water Sampling Procedures, U. S. Environmental Protection Agency, Office of Research and Development, Robert S. Kerr Environmental Research Laboratory, Ada, OK, 1981.

U.S. Environmental Protection Agency, Hazardous Waste Ground Water Task Force, Protocol for Ground-Water Evaluations, OSWER 9080.0-1, September 1986.

U.S. Environmental Protection Agency, Office of Research and Development, Center for Environmental Research Information, Handbook: Ground Water Volume I: Ground Water and Contamination, EPA/625/6-90/016a, Cincinnati, OH, September 1990.

U.S. Environmental Protection Agency, Office of Research and Development, Center for Environmental Research Information, Handbook: Ground Water Volume II: Methodology and Contamination, EPA/625/6-90/016b, Cincinnati, OH, July 1991.

U.S. Environmental Protection Agency, Office of Solid Waste, RCRA Ground-Water Monitoring: Draft Technical Guidance, EPA/530-R-93-001, Washington D.C., November 1992.

U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response and Office of Waste Programs Enforcement, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, OSWER-9950-1, Washington, DC, September 1986.

U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Test Methods for Evaluating Solid Waste, Third Edition, SW-846, Washington, DC, 1986.

U.S. Environmental Protection Agency, Waste Management Division, Office of Solid Waste, Interim Final RCRA Facility Investigation Guidance Volumes I-IV, EPA 530/SW-89-031, Washington, DC, May 1989.

APPENDIX C

WSTF QUALITY ASSURANCE PROJECT PLAN

QUALITY ASSURANCE PROJECT PLAN

NASA WHITE SANDS TEST FACILITY

October 28, 1997

Table of Contents

1.0 INTRODUCTION

1.1 Project Description 1
1.2 Purpose 1
1.3 Scheduled Plan Reviews 2

2.0 PROJECT ORGANIZATION

2.1 Introduction 2
2.2 Environmental Program Manager 3
2.3 Environmental Department 3
2.4 Environmental Department Personnel 3

2.4.1 Groundwater Sampling Coordinator 3
2.4.2 Hazardous Waste Compliance Technicians 3
2.4.3 QA/QC Coordinator 4

2.5 Off-Site Laboratories 4

3.0 DATA QUALITY OBJECTIVES

3.1 Introduction 4
3.2 QA/QC Samples 5

3.2.1 QA/QC Sample Requirements 5

3.3 Precision 5

3.3.1 Relative Percent Difference 10
3.3.2 Relative Standard Deviation 10

3.4 Accuracy 10
3.5 Representativeness 11
3.6 Comparability 11
3.7 Completeness 11
3.8 Detectability 12
3.9 Data Quality Requirements 12

4.0 SAMPLE COLLECTION AND MANAGEMENT

4.1 Introduction 12
4.2 Sampling and Analysis Plan 12
4.3 Sample Collection 12

4.3.1 Groundwater Samples 16
4.3.2 Soil and Sediment Samples 16

4.4 Sample Preservation and Holding Times

4.4.1 Sample Preservation 16
4.4.2 Sample Holding Times 16

4.5 Documentation 20

4.5.1 Site-Specific Procedural Documentation 20
4.5.2 Field Logbook 20
4.5.3 Sample Labels and Seals 21
4.5.4 Chain of Custody Record 21
4.5.5 Authorizing Documentation for Sample Analysis 21

4.6 Sample Delivery 24

5.0 ANALYTICAL PROCEDURES

5.1 Introduction 24
5.2 WSTF Analytical Methods 24

5.2.1 Halogenated Volatile Organics Analytical Method 24
5.2.2 Volatile Organics Analytical Method 27
5.2.3 Nitrosamines Analytical Method 27

5.3 Documentation 27

6.0 SYSTEMS AUDITS AND QUALITY ASSURANCE REPORTS

6.1 Introduction 28
6.2 Systems Audit 28

7.0 CORRECTIVE ACTIONS AND REPORTS TO MANAGEMENT

7.1 Corrective Actions 28
7.2 Quality Assurance Report 29

8.0 DATA MANAGEMENT

8.1 Introduction 29
8.2 Data Management Module 29

8.2.1 Cover Page 30
8.2.2 Field Logbook Copies 30
8.2.3 Analytical Results 30
8.2.4 Quality Assurance Appendix 30
8.2.5 Signature Blocks 30

8.3 Environmental Database Module 30

8.3.1 Summary Report Reviews 31
8.3.2 Database Management 31
8.3.3 End-Users of Data 31

9.0 REFERENCES 32

Table of Tables

TABLE 3.1 Descriptions of Field Quality Control Samples 6
TABLE 3.2 Descriptions of Analytical Quality Control Samples 7
TABLE 3.3 Field QA/QC Controls 8
TABLE 3.4 Analytical QA/QC Controls 9
TABLE 3.5 Method Specific Data Quality Objectives 13
TABLE 3.6 Description of Data Quality Flags 15
TABLE 4.1 Containers, Preservations and Holding Times 17
TABLE 5.1 Analytical Methods Currently Used at WSTF 25
TABLE 5.2 Target Compounds 26

Table of Figures

FIGURE 4.1 WSTF Sample Label and Seal 22
FIGURE 4.2 WSTF Chain of Custody Record 23

1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

During the course of historical operations at the NASA White Sands Test Facility (WSTF), hazardous constituents were released to the environment and subsequently migrated to the groundwater. As mandated by 40 CFR Part 264 Subpart F - Releases From Solid Waste Management Units, NASA has established a Compliance Monitoring Program. The purpose of this program is to collect data required to: determine the distribution and migration of hazardous constituents; determine potential threats to the environment and public health; and, if required, to aid in the design and implementation of remediation systems.

The WSTF contamination is divided into three contaminant categories:

- The most prevalent contaminants are halogenated volatile organics. These compounds have been used throughout the site's active life for hardware precision cleaning.

- The second most widespread contaminant affecting the WSTF groundwater is N-nitrosodimethylamine (NDMA). This compound is suspected to originate as an oxidation product from the handling of rocket fuels.

- The third type of groundwater contamination is chromium. This compound is suspected to originate and be localized to the 600 Area impoundments.

1.2 PURPOSE

This Quality Assurance Project Plan (QAPP) establishes guidelines for ensuring that the NASA compliance monitoring data are scientifically valid, of known quality and legally defensible. To achieve these goals, the following specific QAPP requirements are addressed:

- A consistent and acceptable framework for the collection and generation of physical and chemical data;

- Data quality objectives that measure the precision, accuracy, representativeness, comparability, and completeness of generated data;

- Acceptance criteria for the data measurements to ensure that data collection and analytical systems provide data of sufficient quality for the program;

- The early detection of deficiencies that may affect data quality and provide corrective actions;

- Sufficient document control to verify data completeness; and

- A fundamental framework for the storage and management of environmental data.

All data generating steps, including sample collection, analyses, document control, and data reviews are performed using established procedures to ensure reported data quality, accuracy and completeness. This document, coupled with adherence to guidelines outlined in specific EPA analytical methods, the WSTF Sampling and Analysis Plan and site-specific procedural documentation, ensures that data meet the project-specific requirements of the Groundwater Assessment and Post-Closure Care Monitoring Programs.

1.3 SCHEDULED PLAN REVIEWS

This Plan is reviewed annually to ensure that it provides the level of effort necessary to support the Groundwater Assessment and Post-Closure Care Monitoring Programs. If modifications to the Plan are necessary, NASA will submit the revisions to the EPA for concurrence and approval. If elements of the modifications affect NASA compliance with the Post-Closure Care Permit, the appropriate actions will also be taken through NMED. All historical documents are archived for future reference.

2.0 PROJECT ORGANIZATION

2.1 INTRODUCTION

Groundwater assessment projects are performed by, or in conjunction with, the on-site contractor Environmental Department. This Department is staffed with scientists, engineers and hydrogeologists. The primary objectives of the Department are the installation of the groundwater monitoring network, the hydrogeologic interpretation of collected data, generation of technical reports, collection of groundwater samples for analyses, technical review of project requirements, management and review of generated environmental data, and regulatory compliance.

All personnel assigned to these projects are required to have the training and expertise necessary to perform their assigned duties. Furthermore, all personnel who collect environmental data must have access to, and a clear understanding of, the Sampling and Analysis Plan, Quality Assurance Project Plan, Post-Closure Care Permit, and applicable site-specific procedural documentation.

2.2 ENVIRONMENTAL PROGRAM MANAGER

The NASA Environmental Program Manager administers all WSTF environmental programs. The Program Manager provides environmental compliance work directives to the on-site contractor Environmental Department.

2.3 ENVIRONMENTAL DEPARTMENT

The on-site contractor Environmental Department is responsible for work authorizing document generation, monitoring well installation, hydrogeologic interpretation, establishing sampling and analytical methodologies, collecting groundwater samples, prioritizing work, and ensuring that groundwater assessment and post-closure care work is conducted within regulatory and site-specific guidelines. This Department is also responsible for interpreting, evaluating and accepting data generated in support of the Groundwater Assessment and Post-Closure Care Programs.

2.4 ENVIRONMENTAL DEPARTMENT PERSONNEL

Environmental Department personnel are the primary participants in the collection, analysis and management of environmental data. The following describes the individuals involved in the data collection and generation processes. The contractor Environmental Department is responsible for maintaining a list of qualifications for all personnel involved in the Groundwater Assessment and Post-Closure Care Programs.

2.4.1 Groundwater Sampling Coordinator

The Sampling Coordinator directs and participates with Hazardous Waste Compliance Technicians in sample collection using procedures delineated in the WSTF Sampling and Analysis Plan and site-specific procedural documentation. The Coordinator schedules all sampling events and ensures that samples are collected, preserved, documented, and shipped off-site for analysis using proper procedures.

2.4.2 Hazardous Waste Compliance Technicians

Hazardous Waste Compliance Technicians perform field sampling activities. These technicians follow procedures delineated in the WSTF Sampling and Analysis Plan and site-specific procedural documentation to obtain representative samples. In addition, these technicians perform hydrogeological data collection in support of the Groundwater Assessment and Post-Closure Care Monitoring Programs.

2.4.3 QA/QC Coordinator

The Environmental Department QA/QC Coordinator has the ultimate responsibility for ensuring the correctness, accuracy, precision, and completeness of reported data. By using field and analytical QA/QC samples, the Coordinator assesses the quality of the reported data, sets data quality flags and generates a Quality Assurance Narrative for each Summary Report.

The QA/QC Coordinator collects raw data from the contracted analytical laboratories and manipulates/formats it to create a Draft Summary Report. Prior to issuance of a Final Summary Report, it is reviewed and approved by the appropriate Environmental Department personnel.

The QA/QC Coordinator can also perform periodic audits of the data collection and generation systems. Audit results are reported to the Environmental Department Supervisor. In addition, the QA/QC Coordinator prepares a monthly summary report of quality assurance activities.

2.5 OFF-SITE LABORATORIES

NASA contracts off-site laboratories to analyze groundwater samples in support of the Groundwater Assessment and Post-Closure Care Monitoring Programs. Prior to awarding any analytical support contracts, each off-site laboratory must submit their laboratory Quality Assurance Project Plan to the contractor Environmental Department for review and approval. In addition, contractor Environmental Department personnel will supply the laboratory with a Statement of Work delineating the specific requirements for WSTF sample analyses. These documents ensure that off-site laboratories meet the data quality criteria required for the WSTF Groundwater Assessment and Post-Closure Care Programs.

3.0 DATA QUALITY OBJECTIVES

3.1 INTRODUCTION

Quantitative measurements used to estimate true physical and chemical conditions always involve some level of uncertainty. Uncertainty can be attributed to natural variability, sampling handling operations and conditions, spatial and temporal patterns, and analytical variability. It is critical that levels of uncertainty are measured and acceptable limits of uncertainty established.

Several parameters are measured to estimate the uncertainty of generated data. Data quality are characterized by the PARCC parameters (precision, accuracy, reproducibility,

completeness, and comparability). The following sections define and discuss these parameters.

3.2 QA/QC SAMPLES

Several types of QA/QC samples are required to evaluate data uncertainty. A list of field and analytical QA/QC samples and a brief description of each is provided in Tables 3.1 and 3.2. The frequencies for these samples are provided in Tables 3.3 and 3.4. The frequencies represent a summary of guidance from specific EPA analytical methods and SW-846. The EPA methods provide specific details of the verification required for each analytical process.

3.2.1 QA/QC Sample Requirements

It is essential that all QA/QC samples are of the highest possible quality. Reference standards must be certified prior to use. The reagent water used for field and laboratory blanks must be continuously monitored for non-interference with the analyses. Blind quality control standards must represent the types and concentrations of constituents normally found in the WSTF groundwater.

In order to alleviate bias generated by the analytical laboratories, all environmental and audit samples are submitted "blind". Samples are disguised in a manner where laboratory personnel do not recognize the sample source or composition. The identities of all samples, including QA/QC samples, are recorded in the field logbook. The information provided to laboratory personnel (i.e., chain of custody forms, sample labels and sample seals) does not contain any information concerning sample identities.

3.3 PRECISION

Precision is the measurement of the mutual agreement among individual measurements of the same property. Precision examines the spread of reported values about their mean. For the purposes of the Groundwater Assessment and Post-Closure Care Programs, precision is expressed as either relative percent difference, or as relative standard deviation.

The overall precision of measurement data is a mixture of sampling and analytical factors. Overall precision is determined by collecting and analyzing duplicate field samples. Analytical precision is measured by creating laboratory replicates from collected field samples. Sampling precision is estimated by subtracting the analytical precision from the overall precision.

TABLE 3.1

DESCRIPTIONS OF FIELD QUALITY CONTROL SAMPLES

Sample Type	Description
Equipment Blank	ASTM Type II water is transported to the sampling site, opened, poured over and/or through the sampling device, and collected in sample containers. This type of blank indicates the effectiveness of decontamination procedures and also indicates contamination in the field which may affect analytical results.
Field Blank	ASTM Type II water is transported to the sampling site, opened and poured directly into sample containers. This type of sample provides a check on reagent quality and contamination derived in the field.
Trip Blank	ASTM Type II water is poured into sampling containers in a contaminant free environment, placed in coolers, transported to the field, back to the laboratory, and analyzed. This type of sample serves as a check on sample contamination originating from sample handling, transport, shipping, and site conditions. This sample may also be used to estimate the system detection limit.
Blind Quality Control Sample	A check standard is prepared from a source other than the calibration standard, which is provided blind to the analytical lab. This type of sample serves as an independent check of analytical techniques, handling and standards.
Field Duplicate	A second sample is taken immediately after an original sample at the same sampling location. This sample provides an estimate of the overall system precision.

TABLE 3.2

DESCRIPTION OF ANALYTICAL QUALITY CONTROL SAMPLES

Sample Type	Description
Reagent Blank	ASTM Type II water is processed through the entire analytical process which, at the time of analysis, contains the same reagent concentrations as samples that have been processed. This type of sample indicates contamination resulting from the preparation or processing of a sample. This sample can be used to establish the analytical detection limit.
Sample Matrix Spike	A predetermined amount of stock solution, containing an analyte of interest, is added to the sample matrix prior to sample extraction/digestion and analysis. This sample indicates the effects of the sample matrix on analysis and also is a measure of the accuracy of the measurement system.
QC Check Standard	A standard is obtained from a source other than the calibration standard. This sample indicates the accuracy and consistency of calibration.
Surrogate Spike	Introduction of a compound similar to the analytes of interest, but not normally found in environmental samples, blanks and standards. This type of sample provides a continuous monitor of the performance of the analytical system and the effectiveness of the method in dealing with sample matrices.
Matrix Duplicate	An intralaboratory split sample which is used to document the precision of a method in a given sample matrix.
Matrix Spike Duplicate	Intralaboratory split samples spiked with identical concentrations of target analyte(s). The spiking occurs prior to sample preparation and analysis. These samples are used to document the precision and bias of a method in a given sample matrix.

***Note**: The Quality Assurance Project Plan of off-site contracted laboratories may contain additional, or more stringent, lab-specific requirements.*

TABLE 3.3

FIELD QA/QC CONTROLS

CONTROL	HALOGENATED VOLATILE ORGANICS METHOD	VOLATILE ORGANICS METHOD	NITROSAMINES METHOD	TOTAL CHROMIUM METHOD
Equipment Blank	100% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	100% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	5% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	5% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.
Field Blank	Not required if equipment blanks are taken, otherwise 100% of all halogenated volatile organics sampling days.	Not required if equipment blanks are taken, otherwise 100% of all volatile organics sampling days.	Not required if equipment blanks are taken, otherwise 5% of all nitrosamine sampling days or at least once per month, whichever is the most frequent.	Not required if equipment blanks are taken, otherwise 5% of all total chromium sampling days or at least once per month, whichever is the most frequent.
Duplicate Sample	10% of all halogenated volatile organics sampling events or at least once per month, whichever is the most frequent.	10% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	10% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.	10% of all total chromium sampling events or at least once per month, whichever is the most frequent.
Blind Quality Control Sample	5% of all halogenated volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.	5% of all total chromium sampling events or at least once per month, whichever is the most frequent.
Trip Blank	5% of all halogenated volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.	5% of all total chromium sampling events or at least once per month, whichever is the most frequent.

TABLE 3.4

ANALYTICAL QA/QC CONTROLS

TYPE OF CONTROL	HALOGENATED VOLATILE ORGANICS	VOLATILE ORGANICS	NITROSAMINES	TOTAL CHROMIUM
Reagent Blank	At least daily.	At least daily.	One for each set of samples processed.	One for each analytical batch.
Sample Matrix Spike	10% of samples analyzed.	5% of samples analyzed.	10% of samples analyzed.	5% of samples analyzed.
QC Check Standard	10% or less frequently if spike recoveries meet all specified QC criteria.	5% or less frequently if spike recoveries meet all specified QC criteria.	10% or less frequently if spike recoveries meet all specified QC criteria.	5% of samples analyzed.
Surrogate Spike	100% of all blanks, samples and standards.	100% of all blanks, samples and standards.	100% of all blanks, samples and standards.	Not applicable.
Replicate Sample	Aliquoting is not appropriate; therefore, duplicate samples must be analyzed for 5% of the samples analyzed.	Aliquoting is not appropriate; therefore, duplicate samples must be analyzed for 5% of samples analyzed.	5% of samples analyzed.	5% of samples analyzed.

Note: *The Quality Assurance Project Plan of off-site contracted laboratories may contain additional, or more stringent, lab-specific requirements.*

3.3.1 Relative Percent Difference

Precision is determined on the basis of duplicate sample analytical results. When two values are used, precision is expressed in terms of relative percent difference (**RPD**). RPD is calculated as follows:

$$\mathbf{RPD} = [\,|x_1 - x_2|\,/\,((x_1 + x_2)/2)]\,(100)$$

Where:
x_1 and x_2 are the reported concentrations for each duplicate sample.

3.3.2 Relative Standard Deviation

When more than two values are used to determine precision, it is calculated as the relative standard deviation (**RSD**). The RSD is calculated as follows:

$$\mathbf{RSD} = (s/\bar{x})\,(100)$$

Where:
s is the standard deviation of a series of measurements, and
$\bar{x}$ is the mean of the series of individual measurements.

The standard deviation (s) for a set of measurements is determined as follows:

$$s = [\Sigma(x_i - \bar{x})^2 / (n - 1)]^{1/2}$$

Where:
x_i represents each of the individual measurements, and
n is the number of measurements.

The mean ($\bar{x}$) of a set of individual measurements is calculated by summing the values for the individual measurements ($x_1 \ldots x_n$), then dividing by the number of measurements (n). This calculation is as follows:

$$\bar{x} = (x_1 + x_2 + x_3 + \ldots + x_n) / n$$

3.4 ACCURACY

Accuracy is the degree of agreement between a measurement and its true value, or between the average of a number of measurements and the true or expected value. For the purposes of the groundwater assessment programs, accuracy is expressed as percent recovery. Percent recovery (**%R**) is calculated as follows:

$$\%R = (R / S)\,(100)$$

Where:
R is the reported concentration, and
S is the spiked concentration.

Sources of error are the sampling process, field contamination, preservation, handling, sample matrix, and analysis techniques.

Sampling accuracy is assessed by evaluating the results of field/trip blanks. Analytical accuracy is assessed through the use of known and blind quality control samples and matrix spikes.

3.5 REPRESENTATIVENESS

Representativeness expresses the degree to which sample data accurately and precisely represent a population characteristic. The representativeness criteria is satisfied by ensuring that samples are collected using standard techniques. Standard techniques include procedures outlined in SW-846, the WSTF Sampling and Analysis Plan, site-specific procedural documentation, and specific equipment Operations and Maintenance Manuals.

3.6 COMPARABILITY

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Sample data should be comparable with other measurement data for similar samples and sample conditions. This goal is achieved using standard collection and analytical techniques and reporting analytical data in appropriate units.

3.7 COMPLETENESS

Completeness expresses the percentage of all measurements which are judged to be valid. Completeness (**%C**) is calculated as follows:

$$\%C = 100 \times (V/T)$$

Where:
V is the number of valid measurements, and
T is the total number of measurements taken.

3.8 DETECTABILITY

Detectability refers to the minimum concentration that a constituent can be measured with a stated level of confidence. It is determined by assessing the variability of replicate measurements at zero or near-zero constituent concentrations. For the purposes of this investigation, detection limits refer to the minimum concentration at which constituent calibrations can be established.

3.9 DATA QUALITY REQUIREMENTS

The acceptability requirements for data produced in support of this project are provided in Table 3.5. This Table provides data quality objectives for detectability, precision, accuracy, and completeness for both groundwater and soil matrices. Table 3.6 describes the quality assurance flags utilized to identify data that does not meet the objectives outlined in Table 3.5.

4.0 SAMPLE COLLECTION AND MANAGEMENT

4.1 INTRODUCTION

This section, in conjunction with the WSTF Sampling and Analysis Plan and site-specific procedural documentation, provides guidance for all sampling activities performed as part of the Groundwater Assessment and Post-Closure Care Programs.

4.2 SAMPLING AND ANALYSIS PLAN

The WSTF Sampling and Analysis Plan provides detailed procedures for the collection, handling and transport of environmental samples. This document is used in conjunction with site-specific procedural documentation. The site-specific procedural documentation includes WSTF Job Instructions (WJIs), Test Preparation Sheets (TPSs) and/or specific equipment Operations and Maintenance Manuals.

4.3 SAMPLE COLLECTION

In general, all samples are collected using the most currently available EPA guidelines. Specific procedures utilized for sample collection are provided in the WSTF Sampling and Analysis Plan and site-specific procedural documentation.

TABLE 3.5

METHOD SPECIFIC DATA QUALITY OBJECTIVES
Groundwater Samples

ANALYSIS	MEASUREMENT UNITS	RL*	PRECISION (3)	ACCURACY (4)	COMPLETENESS (5)
Halogenated Volatile Organics	µg/L	(1)	(1)	(1)	80
Volatile Organics	µg/L	(2)	(2)	(2)	80
N-nitrosodimethylamine	µg/L	0.1	25	13-109	80
Arsenic	mg/L	0.0050	25	75-125	80
Barium	mg/L	0.010	25	75-125	80
Cadmium	mg/L	0.0050	25	75-125	80
Chromium	mg/L	0.010	25	75-125	80
Lead	mg/L	0.0050	25	75-125	80
Mercury	mg/L	0.00020	25	75-125	80
Selenium	mg/L	0.010	25	75-125	80
Silver	mg/L	0.010	25	75-125	80

(1) Specific criteria are provided in the halogenated volatile organics method.
(2) Specific criteria are provided in the volatile organics method.
(3) As relative percent difference for field duplicates.
(4) As percent recovery of matrix spikes.
(5) Percentage of measurements which meet expressed data quality criteria for precision, accuracy and detectability.

* - Reporting Limit.

TABLE 3.5 Cont.

METHOD SPECIFIC DATA QUALITY OBJECTIVES
Soil Samples

ANALYSIS	TOTAL MEAS. UNITS	TOTAL RL*	TCLP MEAS. UNITS	TCLP RL*	PRECISION (3)	ACCURACY (4)	COMPLETENESS (5)
Halogenated Volatile Organics	µg/kg	(1)	µg/L	(1)	(1)	(1)	80
Volatile Organics	µg/kg	(2)	µg/L	(2)	(2)	(2)	80
N-nitrosodimethylamine	µg/kg	50	N/A	N/A	25	13-109	80
Arsenic	mg/kg	0.5	mg/L	1.0	30	65-130	80
Barium	mg/kg	5	mg/L	0.10	20	75-125	80
Cadmium	mg/kg	3	mg/L	0.050	20	80-120	80
Chromium	mg/kg	5	mg/L	0.10	30	70-130	80
Lead	mg/kg	30	mg/L	0.50	30	70-120	80
Mercury	mg/kg	0.1	mg/L	0.0020	35	75-120	80
Selenium	mg/kg	10	mg/L	0.05	50	35-125	80
Silver	mg/kg	5	mg/L	0.10	30	55-130	80

(1) Specific criteria are provided in the halogenated volatile organics method.
(2) Specific criteria are provided in the volatile organics method.
(3) As relative percent difference for field duplicates.
(4) As percent recovery of matrix spikes.
(5) Percentage of measurements which meet expressed data quality criteria for precision, accuracy and detectability.

* - Reporting Limit.
N/A - Not applicable.

TABLE 3.6

DESCRIPTION OF DATA QUALITY FLAGS

Data Qualifier	Description
*	User defined flag.
A	Indicates that the result of an analyte for a check standard (LCS or CCV) was outside standard limits.
AD	Indicates that the precision for analyst duplicates was outside standard limits.
EB	Indicates that the analyte was detected in the equipment blank at or above the reporting limit.
FB	Indicates that the analyte was detected in the field blank at or above the reporting limit.
G	Indicates that the result is an estimated value greater than the calibration limit.
J	Indicates that the result is an estimated value less than the reporting limit, but greater than or equal to the detection limit.
NA	Indicates that the value/result was either not analyzed or not applicable.
ND	Indicates that the analyte was not detected at or above the detection limit.
Q	Indicates that the result for a blind control was outside standard limits.
QD	Indicates that the precision for a field duplicate was outside standard limits.
RB	Indicates that the analyte was detected in the reagent blank at or above the reporting limit.
S	Indicates that the result was determined by the method of standard addition.
SP	Indicates that either the spike recovery or the relative percent difference for spike duplicates was outside standard limits.
T	Indicates that the analyte was analyzed outside the specified holding time.
TB	Indicates that the analyte was detected in the trip blank at or above the reporting limit.
TIC	Indicates that the analyte was tentatively identified by a GC/MS library search and the amount reported is an estimated value.

4.3.1 Groundwater Samples

To ensure the representativeness of groundwater samples, samples are not collected until monitoring wells have been fully developed. Due to drilling and well construction effects on the natural groundwater system, at least four weeks are allowed between final development and sampling to allow the hydrogeological system to return to chemical equilibrium.

Representativeness is ensured by purging the wells until at least three casing volumes are evacuated and all indicator parameters (pH, conductivity, turbidity, and temperature) have stabilized. All sampling equipment is constructed of materials that do not influence the quality of collected samples. Specific guidance for groundwater sample collection procedures is provided in the WSTF Sampling and Analysis Plan and the site-specific procedural documentation.

4.3.2 Soil and Sediment Samples

Soil and sediment samples are collected using the most current EPA recommended procedures. Samples are collected in a manner which minimally disrupts sample integrity. Samples for volatile organic constituents are transferred from the collection device into sample containers as quickly as possible to minimize potential losses.

4.4 SAMPLE PRESERVATION AND HOLDING TIMES

4.4.1 Sample Preservation

Sample preservation prevents or retards the chemical or biological degradation of the sample's chemical integrity. Preservation is initiated immediately after sample collection. Preservation and storage requirements are presented in Table 4.1.

4.4.2 Sample Holding Times

Holding time is based on the constituents of interest and is the maximum time allowed between sample collection and analysis/preparation. Table 4.1 provides the maximum acceptable holding times for environmental samples. All samples are, at a minimum, refrigerated at 4°C.

In general, samples not analyzed within the specified holding times generate data that are not acceptable for reporting purposes. If the data are crucial, samples are retaken to provide the required information. However, if resampling of the environmental source is impractible, samples that have exceeded their holding times are analyzed and reported with the appropriate data qualification/flagging.

TABLE 4.1

CONTAINERS, PRESERVATIONS AND HOLDING TIMES

NAME	CONTAINER[1]	PRESERVATION	MAXIMUM HOLDING TIME
Bacterial Tests:			
Coliform, fecal and total	P, G	Cool, 4°C, 0.008% $Na_2S_2O_3$	6 hours
Fecal streptococci	P, G	Cool, 4°C, 0.008% $Na_2S_2O_3$	6 hours
Inorganic Tests:			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Biochemical oxygen demand	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Biochemical oxygen demand, carbonaceous	P, G	Cool, 4°C	48 hours
Chemical oxygen demand	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Chloride	P, G	None required	28 days
Chlorine, total residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, total and amenable to chlorination	P, G	Cool, 4°C, NaOH to pH>12, 0.6g ascorbic acid	14 days
Fluoride	P	None required	28 days
Hardness	P, G	HNO_3 or H_2SO_4 to pH<2	6 months
Hydrogen ion (pH)	P, G	None required	Analyze immediately
Kjeldahl and organic nitrogen	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Residue, total	P, G	Cool, 4°C	7 days
Residue, filterable	P, G	Cool, 4°C	7 days
Residue, nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, settleable	P, G	Cool, 4°C	48 hours
Residue, volatile	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific conductance	P, G	Cool, 4°C	28 days

TABLE 4.1, Cont.

Sulfate	P, G	Cool, 4°C	28 days
Sulfide	P, G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH>9	7 days
Sulfite	P, G	None required	Analyze immediately
Surfactants	P, G	Cool, 4°C	48 hours
Temperature	P, G	None required	Analyze
Turbidity	P, G	Cool, 4°C	48 hours
Metals:			
Chromium VI	P, G	Cool, 4°C	24 hours
Mercury	P, G	HNO_3 to pH<2	28 days
Metals, except chromium VI and mercury	P, G	HNO_3 to pH<2	6 months
Nitrate	P, G	Cool, 4°C	48 hours
Nitrate-nitrite	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrite	P, G	Cool, 4°C	48 hours
Oil and grease	G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic carbon	P, G	Cool, 4°C, HCl or H_2SO_4 to pH<2	28 days
Orthophosphate	P, G	Filter immediately, cool, 4°C	48 hours
Oxygen, dissolved probe	G bottle and top	None required	Analyze immediately
Winkler DO		Fix on site and store in dark	8 hours
Phenols	G only	Cool, 4°C, H_2SO_4 to pH<2	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 hours
Phosphorus, total	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Tests:			
Purgeable halocarbons	G, Teflon-lined septum	Cool, 4°C	14 days
Purgeable aromatic hydrocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$, HCl to <pH2	14 days
Acrolein and acrylonitrile	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$, Adjust pH to 4-5	14 days

Table 4.1, Cont.

Phenols	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$	7 days until extraction, 40 days after extraction
Benzidines	G, Teflon-lined	Cool, 4°C, 0.008% $Na_2S_2O_3$	7 days until extraction
Phthalate esters	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitrosamines	G, Teflon-lined cap	Cool, 4°C, store in dark,	40 days after extraction
PCBs, acrylonitrile	G, Teflon-lined cap	Cool, 4°C	40 days after extraction
Nitroaromatics	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$,	40 days after extraction
Polynuclear aromatic	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$,	40 days after extraction
Haloethers	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$	40 days after extraction
Chlorinated hydrocarbons	G, Teflon-lined cap	Cool, 4°C	40 days after extraction
TCDD	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$	40 days after extraction
Total organic halogens	G, Teflon-lined cap	Cool, 4°C, H_2SO_4 to pH<2	7 days
Pesticides Tests:			
Pesticides	G, Teflon-lined cap	Cool, 4°C, pH 5-9	40 days after extraction
Radiological Tests:			
Alpha, Beta and radium	P, G	HNO_3 to pH<2	6 months

[1]Polyethylene (P) or Glass (G)

Derived From SW-846

Blind quality control samples and analytical check standards are subject to the same holding time requirements as environmental samples. When blind quality control samples are prepared, the corresponding container is annotated with the preparation date. Blind quality control samples for volatile organics analysis are prepared immediately prior to shipment to the analytical lab.

4.5 DOCUMENTATION

An essential element of the sampling process is documentation of data collection steps. NASA requires several procedures to ensure that the collection process is adequately documented. These include: generation of site-specific procedural documentation; annotation of the field logbook with all pertinent collection information; use of sample labels and seals on sample bottles; and tracking of all samples with chain of custody documentation. Off-site laboratories are also required to include chain of custody documentation with their final reports.

4.5.1 Site-Specific Procedural Documentation

For WSTF sampling events, site-specific procedural documentation is required. This documentation currently includes Test Preparation Sheets (TPSs), WSTF Job Instructions (WJIs) and specific equipment Operations and Maintenance Manuals. This documentation is provided by the Environmental Department and is reviewed/signed by the NASA Environmental Program Manager.

4.5.2 Field Logbook

The Sampling Coordinator and Hazardous Waste Compliance Technicians are responsible for recording all pertinent information regarding field operations in a serially numbered field notebook. The quantity and quality of information recorded is considered sufficient for a third party to recreate the sampling event based on the logbook information. The specific information required in the field logbook for each sampling event is delineated in the WSTF Sampling and Analysis Plan.

To ensure that the field notebook provides a clear and complete record of field operations, the Hazardous Waste Compliance Technicians submit the field logbooks to the Sampling Coordinator for review (no less than weekly). The Sampling Coordinator verifies the information recorded is clear and provides a complete account of all field activities. After review, the Sampling Coordinator signs the bottom of each page, indicating an understanding of the information recorded, and that the information is complete and correct.

Field logbooks are an essential legal document to provide validity of collected samples. At all times logbook possession is controlled by the contractor Environmental Department.

4.5.3 Sample Labels and Seals

Sample labels are required to avoid sample misidentification, either in the field or at the laboratory. Sample labels are filled out and affixed to each sample container immediately after sample collection. Figure 4.2 provides an example of the currently used sample label.

Sample seals are required to ensure that samples are not tampered with prior to analysis. Sample seals are filled out and affixed immediately after the samples are preserved and the sample labels are affixed. Figure 4.2 provides an example of the currently used sample seal.

4.5.4 Chain of Custody Record

Sample possession from the time of collection until sample analysis is traced by a chain of custody record. The Sampling Coordinator and Hazardous Waste Compliance Technicians are responsible for generating chain of custody records for samples submitted to the off-site analytical laboratories. These forms are generated prior to sample delivery and/or shipment. Figure 4.3 provides an example of the currently used chain of custody record.

The required information for the chain of custody record is provided in the WSTF Sampling and Analysis Plan. All samples are considered in the possession of the Sampling Coordinator or Hazardous Waste Compliance Technician until the laboratory custodian or warehouse shipping coordinator signs the chain of custody record, indicating acceptance. When analytical results are received from off-site laboratories, copies of the chain of custody record are included to document the sample possession at the laboratory.

4.5.5 Authorizing Documentation for Sample Analysis

Prior to sample delivery to the analytical laboratory, the Sampling Coordinator initiates a laboratory work authorizing document. This document can be in the form of a Statement of Work and/or analytical laboratory services purchase agreements. These documents ensure the site-specific analytical requirements for all samples are achieved.

FIGURE 4.1

WSTF SAMPLE LABEL AND SEAL

WSTF

SAMPLE LABEL

Sample No. _____ Chem. Lab. Log No. _____

Collection Location _____

TPS No. _____ Analysis By: _____

Collected By: _____

Method of Preservation _____

Analysis Required _____

_____

WSTF Sample Label

NASA

JOHNSON SPACE CENTER
WHITE SANDS TEST FACILITY
LAS CRUCES, NEW MEXICO

SAMPLE # _____

COLLECTOR _____

COLLECTION LOCATION _____

DATE SEAL BROKEN _____

INITIALS _____

WSTF Sample Seal

FIGURE

WSTF CHAIN OF CUSTODY RECORD

Date _____

Page ____ of ____

Laboratory / PO #

Return Address for Analyses:

NASA / WSTF / AlliedSignal
P.O. Box 20
Las Cruces, NM 88004
Attn: Tom Hall

Analysis Requirements

Sample No.	Well Id.	# of Containers	Sample Type (Aqueous)	Halogenated Volatile Organics (40 ml VoA) (Incl/No Headspace)	Semi-Volatile Organics (40 ml VoA) (Incl/No Headspace)	Nitrocellulose (1L Glass Bottle)	RCRA Metals (As, Ba, Cd, Cr, Pb, Hg Se, Ag) (no / HNO_3 (300 ml Poly)				

Special Instructions

Please return coolers and contents of coolers as soon as possible.

Return Address:

NASA / WSTF / AlliedSignal
Building 120 / Route 70
Las Cruces, NM 88012
Attn: Michael Embesi

Comments

Relinquished By:	Date/Time:	Accepted By:	Date/Time:

WSTF - 381B (06/97)

4.6 SAMPLE DELIVERY

Samples are delivered and/or shipped to off-site laboratories for analysis. All samples are accompanied by the appropriate chain of custody record and shipping documents.

The Sampling Coordinator and Hazardous Waste Compliance Technicians are responsible for inspecting documentation for accuracy and the samples for proper collection, preservation and labeling prior to shipment/delivery to the laboratory. If discrepancies are observed, they are researched and corrected at this time.

When the shipping coordinator and/or the off-site sample receiving department is satisfied the samples are acceptable, the chain of custody record is signed, accepting sample responsibility. Upon completion of the analyses, the off-site laboratory forwards an analytical results report with copies of the chain of custody included.

5.0 ANALYTICAL PROCEDURES

5.1 INTRODUCTION

EPA approved methods are used, when available, to identify and quantify hazardous constituents in WSTF environmental samples. In cases where EPA methods are not provided for specific hazardous constituents, the best available technology is researched, utilized and referenced. NASA currently analyzes for halogenated volatile organics, volatile organics and nitrosamines. Metals are analyzed by several different EPA-approved methods.

5.2 WSTF ANALYTICAL METHODS

During the course of the Compliance Monitoring Program, NASA has incorporated minor modifications to the referenced EPA methods. The currently utilized EPA Methods are listed in Table 5.1. The following sections outline and explain these modifications.

5.2.1 Halogenated Volatile Organics Analytical Method

NASA currently analyzes for halogenated volatile organics. Several halogenated volatiles are present in the groundwater which are not normally analyzed by the halogenated volatile organics method. However, these additional constituents are suitable for identification and quantification. Calibration standards for these compounds are used to quantify them. The supplemental compounds include dichlorofluoromethane (Freon 21), 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113) and 1,2-dichloro-1,1,2-trifluoroethane (Freon 123A). Table 5.2 provides a list of constituents most likely to be observed in WSTF groundwater samples.

TABLE 5.1

ANALYTICAL METHODS CURRENTLY USED AT WSTF

EPA Method Number	Analysis
Method 8021 or EPA equivalent	Halogenated Volatile Organics
Method 8260 or EPA equivalent	Volatile Organics
Method 607, 8070 or EPA equivalent	Nitrosamines
Method 6060 or EPA equivalent	Chromium
Method 8081 or EPA equivalent	Pesticides and PCBs
Method 8270 or EPA equivalent	Semi-volatile Organics
Method 8150 or EPA equivalent	Herbicides
Method 9066 or EPA equivalent	Phenolics
Method 9012 or EPA equivalent	Cyanide
Method 9030 or EPA equivalent	Sulfide
Method 7060 or EPA equivalent	Arsenic
Method 6010 or EPA equivalent	Barium
Method 6010 or EPA equivalent	Cadmium
Method 6010 or EPA equivalent	Chromium
Method 7421 or EPA equivalent	Lead
Method 7470 or EPA equivalent	Mercury
Method 7740 or EPA equivalent	Selenium
Method 6010 or EPA equivalent	Silver

TABLE 5.2

TARGET COMPOUNDS

IUPAC Nomenclature	CAS #	Other Common Designations
Dichlorofluoromethane	75-43-4	Freon 21
Dichloromethane	75-09-2	Methylene Chloride
Trichlorofluoromethane	75-69-4	Freon 11, MF Freon
1,2-Dichloro-1,1,2-trifluoroethane	354-23-4	Freon 123A
Trichloromethane	67-66-3	Chloroform
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	Freon 113, TF Freon
1,1,1-Trichloroethane	71-55-6	1,1,1-TCA
Trichloroethene	79-01-6	Trichloroethylene, TCE
Tetrachloroethene	127-18-4	Perchloroethene, PCE

5.2.2 Volatile Organics Analytical Method

NASA currently analyzes for volatile organics. Volatile organics analysis is performed at least annually for all WSTF groundwater monitoring wells. This analysis provides mass spectral confirmation of compounds previously identified by the halogenated volatile organics method. As with the halogenated volatile organics method, NASA has included the WSTF-specific halogenated volatile organic compounds which are not specified by the method.

The volatile organics analytical method is used as a confirmational check, therefore all parameters referenced in the method, plus the WSTF supplemental constituents, are reported.

5.2.3 Nitrosamines Analytical Method

NASA currently analyzes for N-nitrosodimethylamine (NDMA). If extraneous peaks are observed to occur in the retention windows for nitrosamine method target compounds, they are identified and quantified by using a post-run calibration.

Commencing with nitrosamine samples analyzed since January 1996, one tentatively identified compound (TIC), N-nitrodimethylamine (CAS No. 4164-28-7), has been observed and reported for samples collected from numerous WSTF groundwater monitoring wells. Efforts are underway to determine if this TIC is representative of actual groundwater contamination, is a naturally occuring groundwater constituent or is an artifact of related sampling and analysis operations. A detailed discussion of this compound and incorporation into the WSTF Sampling and Analysis Plan and Quality Assurance Project Plan will be deferred until substantiating information is obtained.

5.3 DOCUMENTATION

Documentation of the analytical effort is outlined in the Quality Assurance Project Plan submitted by the off-site laboratories. The laboratory Quality Assurance Project Plan must be submitted, reviewed, approved, and maintained on file in the site contractor Environmental Department prior to commencing analyses. In addition, site-specific requirements delineated in the Statement of Work must be met. The laboratory's Quality Assurance Project Plan must include, at a minimum, the following:

- Personnel qualifications and training plans;
- Documentation and records management procedures;
- Quality control procedures;

- Work processes, operations procedures and methods; and

- Quality assessment, standardization and response action plans.

When analytical results are received from the off-site laboratory, the QA/QC Coordinator will review the reports for compliance with the laboratory Quality Assurance Project Plan. If descrepancies are present, they are researched and rectified at this time.

6.0 SYSTEMS AUDITS AND QUALITY ASSURANCE REPORTS

6.1 INTRODUCTION

Technical system audits are an essential element in the Quality Assurance Project Plan. These audits are designed to ensure compliance with the Plan and to assess the overall quality of data collected during the measurement process. Audits evaluate sample collection, sample analysis procedures and data management techniques.

6.2 SYSTEMS AUDIT

A technical systems audit is a comprehensive qualitative evaluation of the entire data collection and generation system. This audit examines all phases of the sampling and analysis system: collection of samples; preservation and handling of samples; transport of samples; documentation of field and analytical steps; quality control procedures; data reporting; and data management.

This evaluation is performed on a quarterly basis by the QA/QC Coordinator or an independent individual with the training and expertise to perform the audit. The auditor submits a summary report to the Environmental Department Supervisor. This report presents the results of the inspection and provides recommendations for corrective actions.

7.0 CORRECTIVE ACTIONS AND REPORTS TO MANAGEMENT

7.1 CORRECTIVE ACTIONS

The QA/QC Coordinator initiates corrective actions when data evaluation, preparation of environmental reports and/or technical systems audits indicate dicrepancies. The corrective actions can include procedural changes, resampling, preparation of additional site-specific quality control samples, additional field audits, review of analytical laboratory procedures, and/or any other procedure that will mitigate the discrepancies. Corrective actions, recommendations and specific steps taken to resolve data quality discrepancies are reported in writing to the contractor Environmental Department Supervisor.

7.2 QUALITY ASSURANCE REPORT

The QA/QC Coordinator provides a monthly written Quality Assurance Report to the Environmental Department's Contamination Assessment Supervisor. At a minimum, this report includes a summary of quality assurance procedures utilized, the quantity and type of field quality assurance samples analyzed, a summary of laboratory quality assurance procedures/samples used, a list of all samples analyzed and reported using data qualifiers, an overall assessment of the quality of environmental data, and a chronology of any corrective actions initiated to resolve discrepancies.

8.0 DATA MANAGEMENT

8.1 INTRODUCTION

The amount of data produced by the Groundwater Assessment and Post-Closure Care Programs requires that standard procedures are used to manage, store and process all environmental data. This section delineates procedures used to ensure that environmental data are effectively processed.

The environmental database used by the site contractor Environmental Department is a modular database system. .Modules included in this system are the data management module and the environmental database module. The contractor Environmental Department also maintains hard copies of all final analytical reports and related documentation. After three years, hard copies of Summary Reports are transferred to compact disks for long-term archival.

8.2 DATA MANAGEMENT MODULE

The data management module is used to gather and organize analytical data into a Final Summary Report. Summary reports are generated for each individual sampling event performed at WSTF. The QA/QC Coordinator organizes the raw laboratory data and the corresponding QA discussion, sets data qualifier flags and prepares the Final Summary Report. The report is reviewed, approved and signed by the Environmental Sampling Coordinator and the QA/QC Coordinator prior to release.

The analytical laboratory is required to maintain raw data, chromatographs, logbooks, and all other relevant analytical information. This information is required to ensure the validity of reported data and to rectify any discrepancies that may arise.

There are several elements incorporated into a Summary Report. These elements are: the cover page; field logbook copies; the analytical results; the quality assurance section; a table listing data qualifier flags; and the signature blocks. The following sections provide a brief description of these elements and information which is required for each section.

8.2.1 Cover Page

The cover page provides the pertinent information concerning the identification of the samples. Information required includes: sampling location/Well I.D.; sampling date; report date; analytical methods performed; and a signature block for reviewers/approvers.

8.2.2 Field Logbook Copies

Copies of the field logbook provide the pertinent information concerning sample collection in the field. Information required includes: sampling location; sampling date; field measured indicator parameters; static water level; purge device; purge rate; purge volume; sample collection device; and any other information relevant to the sample's collection.

8.2.3 Analytical Results

Analytical results are reported for each analysis performed. Information required for each report includes: analytical method used; sample ID number(s); sample location; date sampled; date extracted or digested; analytical laboratory name; date received; date analyzed; compounds analyzed for; corresponding CAS numbers; concentrations observed; reporting limits; and quality assurance flags.

8.2.4 Quality Assurance Appendix

The Quality Assurance Appendix provides the QA/QC Coordinator's evaluation of the reported data quality. Minimally, this section includes a summary of quality assurance procedures performed and the results for quality assurance samples which are observed out of specified acceptance limits. The Quality Assurance Appendix also defines flags used to identify data falling outside of WSTF established criteria (Table 3.6).

8.2.5 Signature Blocks

Summary Reports are reviewed and approved prior to release. The Sampling Coordinator and the QA/QC Coordinator sign and date the report indicating the information is complete and correct.

8.3 ENVIRONMENTAL DATABASE MODULE

The WSTF environmental database module is managed by the site contractor Environmental Department. Summary Reports are reviewed, evaluated and approved by the Environmental Department prior to incorporation into the environmental database

module. This module is the final repository for all reviewed and approved data and allows data end-users the ability to manipulate stored data for generating reports, tables, graphs, and other visual presentations.

8.3.1 Summary Report Reviews

Summary Reports are reviewed by the contractor Environmental Department for correctness and completeness. If the quality assurance criteria are not met, the Environmental Department will determine how critical the data point is and, if it is essential to the program, the sample is retaken. In either case, the original data are stored in the database.

8.3.2 Database Management

The site contractor Environmental Department is the only organization which can input or edit data in the environmental database module. All other individuals are granted "read only" access. This precludes data modification by personnel other than in the site contractor's Environmental Department.

Hard copies of all Summary Reports are maintained on file in the site contractor Environmental Department. The environmental database system is backed up on at least a weekly basis. After three years, hard copies of Summary Reports are transferred to compact disks for long-term archival.

8.3.3 End-Users of Data

The primary end-users of environmental data are the contractor Environmental Department and the NASA Environmental Program Manager. The contractor Environmental Department uses the data, in conjuction with collected geophysical data, to interpret and present technical assessments of the hydrogeological system. In addition, the contractor Environmental Department uses the data to prepare regulatory and technical reports. The NASA Environmental Program Manager uses data presentations as guidance for making managerial decisions concerning the Groundwater Assessment and Post-Closure Care Programs.

9.0 REFERENCES

Barcelona, M., J. Gibb, J. Helfrich, and E. Garske, Practical Guide for Ground-Water Sampling, Illinois State Water Survey, Champaign, IL, November 1985.

Evans, R., and E. Koglin, Ground-Water Monitoring Quality Assurance For RCRA, EPA 600/X-87/035, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, NV, January 1987.

Geoscience Consultants, Ltd., Internal Data Management Plan, Albuquerque, NM, July 1988.

Geoscience Consultants, Ltd., Quality Assurance and Quality Control, Environmental Support Contract #NA59-95595, 200, 300, 400, 600 Area Contamination Assessments, for NASA-JSC-White Sands Test Facility, Albuquerque, NM, January 1987.

National Archives and Records Administration, Office of the Federal Register, Code of Federal Regulations, Protection of Environment, Title 40, Parts 100 to 149, Washington, D.C., 1997.

National Archives and Records Administration, Office of the Federal Register, Code of Federal Regulations, Protection of Environment, Title 40, Parts 260 to 299, Washington, D.C., 1997.

Nielson, D., Practical Handbook of Ground-Water Monitoring, Lewis Publishers Inc., Chelsea, MI, 1991.

Stanley, T. and S. Verner, Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, U.S. Environmental Protection Agency, Office of Exploratory Research, Washington, D.C., February 1983.

U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Handbook for Analytical Quality Control in Water and Wastewater Laboratories, EPA-600/4-79-019, Cincinnati, OH, March 1979.

U.S. Environmental Protection Agency, Office of Emergency and Remedial Response and Office of Waste Programs Enforcement, Data Quality Objectives for Remedial Response Activities: Development Process, EPA/540/G-87/003, Washington, D.C., March 1987.

U.S. Environmental Protection Agency, Office of Emergency and Remedial Response and Office of Waste Programs Enforcement, Data Quality Objectives for Remedial Response Activities, Example Scenario: RI/FS Activities at a Site With Contaminated Soils and Ground Water, EPA/540/540/G-87/004, Washington, D.C., March 1987.

U.S. Environmental Protection Agency, Office of Research and Development, Center for Environmental Research Information, Handbook: Ground Water Volume I: Ground Water and Contamination, EPA/625/6-90/016a, Cincinnati, OH, September 1990.

U.S. Environmental Protection Agency, Office of Research and Development, Center for Environmental Research Information, Handbook: Ground Water Volume II: Methodology and Contamination, EPA/625/6-87/016b, Cincinnati, OH, July 1991.

U.S. Environmental Protection Agency, Office of Research and Development, Hazardous Waste Engineering Laboratory, Preparation Aid for HWERL's Category III Quality Assurance Project Plans, PA QAPP-007-GFS, Cincinnati, OH, June 1987.

U.S. Environmental Protection Agency, Office of Solid Waste, RCRA Ground-Water Monitoring Draft Technical Guidance, EPA/530-R-93-001, Washington D.C., November 1992.

U.S. Environmental Protection Agency, Office of Solid Waste, RCRA Facility Investigation (RFI) Guidance Volume 1: Development of an RFI Work Plan and General Considerations for RCRA Facility Investigations, EPA 530/SW-87-001, Washington, D.C., July 1987.

U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Test Methods for Evaluating Solid Waste, Third Edition, SW-846, Washington D.C., 1986.

U.S. Environmental Protection Agency, Office of Waste Programs Enforcement and Office of Solid Waste and Emergency Response, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, OSWER-9950.1, Washington, D.C., September 1986.

APPENDIX D

LABORATORY QUALITY ASSURANCE/QUALITY CONTROL

Quanterra
Environmental
Services

Quality Assurance Management Plan for Environmental Services

Revision 2
June 30, 1997

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Quanterra®

Quality Assurance Management Plan

Approved by:

Mark A. Matthews
Chief Operating Officer

Chris M. Lee
Vice President of Operations Services

Jack R. Hall
Corporate Director of Quality Assurance

Revision 2
June 30, 1997

Controlled Copy Number: _____

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Preface

The purpose of the Quanterra® Quality Assurance Management Plan (QAMP) is to provide internal quality assurance (QA) guidance to Quanterra® operating units. This guidance allows Quanterra® to operate under a standardized, rigorous quality management system (QMS) and ensures that our clients are consistently provided with data that are of known and documented quality and are legally defensible. The QAMP outlines the purpose, policies, organization, responsibilities, and operations related to ensuring high quality performance in all Quanterra® activities. The QAMP also fulfills the requirement of our clients and of government programs to document our QMS.

The QAMP contains many references to other essential Quanterra® quality documents. These quality documents, including the QAMP, Policy Documents, and Standard Operating Procedures (SOPs), both corporate and laboratory-specific, help ensure the quality of our products and intertwine to produce a strong QMS within Quanterra®. This system is the foundation that provides our operations with guidance and ensures consistently-produced quality deliverables. The project-specific requirements delineated in project plans may supersede the general quality requirements described in this manual.

The document is designed to follow the basic outline required for a quality management plan as described by the United States Environmental Protection Agency (EPA). Table 2.3-1 cross-references the narrative sections of the QAMP to the appropriate sections of the EPA document and other nationally recognized quality standards.

There are two basic types of information included in the QAMP. General information is applicable to all Quanterra® operating units. Operation-specific information, provided in the Facility-Specific Appendix, describes the quality control (QC) requirements that apply only to a specific laboratory. The Facility-Specific Appendix includes information such as method detection limits (MDLs), performance evaluation (PE) studies, and laboratory SOPs that cannot be standardized throughout the Quanterra® laboratory network due to client-specific, laboratory-specific, or instrument-specific nature.

Forward

QAMP Revision 2 Implementation:

Quality Assurance Managers are to distribute the document and conduct training on the changes to the QAMP within 45 days of the issuance date. Implementation of the changes to the QAMP shall be completed within 120 days of the issuance date.

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Table of Contents

Page

Table of Contents
Title and Signature Page i
Copyright Statement ii
Preface iii
Forward iiii
Table of Contents v
List of Figures xi
List of Tables xii
List of Appendices xiv
Acronyms and Initialisms xv

1.0 Management Commitment and Organization 1
1.1 Vision Statement 1
1.2 Statement of Management Commitment to Quality 1
1.3 Organizational Structure 2
1.4 Quality Organization 2
1.4.1 President and Chief Executive Officer (CEO) 2
1.4.2 Chief Operating Officer 2
1.4.3 Vice President of Operations Services 4
1.4.4 Corporate Director of Quality Assurance 4
1.4.5 Assistant Quality Assurance Director 4
1.4.6 Quality Assurance (QA) Manager 5
1 4.7 Customer Service Managers (CSMs) 5
1.4.8 Regional General Manager 6
1 4.9 Laboratory Manager 6
1.4.10 Operations Manager 6
1.4.11 Systems Manager 6
1.4.12 Project Manager 7
1.4.13 Group Leader or Team Leader 7
1.4.14 Analyst 7
1.4.15 Sample Custodian 8
1.4.16 Report Production Staff 8
1.5 General Responsibilities 8
1.6 Waste, Fraud, and Abuse 8

2.0 Quality System and Description 9
2.1 Quality Management System 9
2.2 Quality Assurance 9

Table of Contents (continued)

Page

2.0 Quality System and Description (continued)

2.3 Quality Documents 10
2.3.1 Quality Assurance Management Plan for Environmental Services 10
2.3.2 Quality Policy Documents 11
2.3.3 Standard Operating Procedures 11
2.3.4 Quality Assurance Project or Program Plans 11
2.3.4.1 Quality Assurance Summary (QAS) 12
2.3.5 Other Documents 12

3.0 Associate Qualification and Training 13
3.1 Associate Qualifications 13
3.2 Orientation and Training of Laboratory Staff 13
3.2.1 Quality Orientation 14
3.2.2 Quality Training 14
3.2.3 Health and Safety Orientation and Training 15
3.2.4 QA Manager Training 15
3.3 Training Files 15
3.3.1 Associate Resumes 15
3.3.2 Individual Training Records for the Areas of Quality, Health and Safety, and Technical 15
3.3.3 Training Records for Professional Development 16
3.3.4 Training Records for Regulatory/Compliance Information 16

4.0 Procurement of Items and Services 17
4.1 Selection of Vendors 17
4.2 Procurement of Quality-Related Items 18
4.2.1 Role of Quanterra® Purchasing 19
4.2.2 Procurement Procedures 19
4.2.3 Evaluation of QRIs 20
4.2.4 Special Requirements for Standard Reference Materials 21
4.3 Procurement of Subcontract Laboratory Services 21
4.4 Vendor Partnerships 23

5.0 Documentation and Records 23
5.1 Quality Documents and Records 23
5.2 Document Review and Revision 23
5.3 Document Control and Distribution 23

Table of Contents (continued)

Page

5.0 Documentation and Records (continued)
5.4 Records Management 24
5.4.1 Quality Records 24
5.4.2 Project Records 25
5.5 Validation of Records 25
5.6 Retention and Disposal of Records 25
5.7 Data Confidentiality 25

6.0 Computer Hardware and Software 27
6.1 Use of Hardware 27
6.2 Security 27
6.3 Use of Software 27
6.3.1 Industry Standard Software 28
6.3.2 Quanterra® -Developed Software 28
6.3.3 Control of Software Changes 28
6.3.4 Software Revalidation 28
6.4 Documentation 29
6.5 Computer Viruses 29

7.0 Planning 31
7.1 Data Collection Process 31
7.2 Organizational Responsibilities 31
7.3 Determination of Project QC Requirements 33
7.4 Communication of Project-Specific Requirements 33
7.5 Customer Service Teams 34
7.6 Contingency Planning 34

8.0 Work Processes and Operations 39
8.1 Standard Operating Procedures 39
8.2 Analytical Methods 39
8.3 Data Quality Objectives 40
8.3.1 Precision and Accuracy 41
8.3.2 Completeness 41
8.3.3 Representitiveness 41
8.3.4 Comparability 42
8.3.5 Method Detection Limits 42
8.3.6 Instrument Detection Limits 42

Table of Contents (continued)

Page

8.0 Work Processes and Operations (continued)

8.3.7 Reporting Limits 43
8.4 Quality Control Samples 44
8.4.1 Field QC Samples 44
8.4.1.1 Trip Blank 44
8.4.1.2 Rinsate Blank 45
8.4.1.3 Field Blank 45
8.4.1.4 Field Duplicate 45
8.4.1.5 Field Matrix Spike 45
8.4.1.6 Collocated Samples 45
8.4.1.7 Split Sample 46
8.4.2 Laboratory QC Samples 46
8.4.2.1 Quality Control (QC) Batch 47
8.4.2.2 Method Blank 47
8.4.2.3 Instrument Blank 47
8.4.2.4 Laboratory Control Sample 48
8.4.2.5 Matrix Spike 48
8.4.2.6 Matrix Spike Duplicate 48
8.4.2.7 Sample Duplicate 48
8.4.2.8 Surrogates 49
8.4.2.9 Analytical Spike 49
8.4.2.10 Interference Check Sample 49
8.4.2.11 Internal Standards 49
8.4.2.12 Radiological QC Samples 49
8.5 Data Collection Operations 50
8.5.1 Field Collection and Shipment 50
8.5.2 Sample Containers, Shipping Containers, Preservatives, and Holding Times 51
8.5.2.1 Sample Containers 51
8.5.2.2 Shipping Containers 51
8.5.2.3 Sample Preservatives 53
8.5.2.4 Sample Holding Times 53
8.5.3 Sample Handling 54
8.5.3.1 Sample Receipt 54
8.5.3.2 Sample Log-in 55
8.5.3.3 Sample Storage 55
8.5.3.4 Internal Sample Chain-of-Custody and Interlaboratory Transfers 58

Table of Contents (continued)

Page

8.0 Work Processes and Operations (continued)

8.5.3.5 Sample Disposal and Return Chain-of-Custody 59
8.5.4 Calibration Procedures and Criteria 59
8.5.4.1 Physical Reference Standards 60
8.5.4.2 Chemical Reference Standards 60
8.5.4.3 Standard Verification/Independent Standard 60
8.5.4.4 Periodic Calibration 61
8.5.4.5 Operational Calibration 61
8.5.4.6 Calibration Failure 62
8.5.4.7 Calibration Records 62
8.6 Quality Assessment 62
8.6.1 Data Quality Assessment 62
8.6.2 Statistical Evaluation of Data 63
8.7 Data Recording Procedures 63
8.8 Data Reduction and Verification Procedures 64
8.8.1 Data Reduction and Initial Verification 64
8.8.2 Data Verification 66
8.8.3 Completeness Verification 67
8.9 Data Reporting 68
8.9.1 Data Reports 68
8.9.2 Verbal Results 68
8.9.3 Reporting Analytical Results 69
8.10 Data Validation 69
8.11 Preventive Maintenance and Service 70
8.11.1 Analytical Instrumentation and Equipment 70
8.11.2 Facilities 70
8.11.3 Frequency of Maintenance 71
8.12 Other Requirements 71
8.12.1 Water 71
8.12.2 Compressed Air and Gases 71
8.12.3 Glassware Preparation 72
8.12.4 Chemical Storage 72
8.12.5 Waste Disposal 72
8.12.6 Facility Security 72

Table of Contents (continued)

Page

9.0 Quality Assessment and Response 73
9.1 Nonconformance and Corrective Action 73
9.1.1 Nonconformance 73
9.1.2 Corrective Action 73
9.1.3 Responsibilities 73
9.1.4 Nonconformance Memo 73
9.2 Audits 73
9.2.1 Performance Audits 74
9.2.2 Systems Audits 75
9.2.2.1 Internal Systems Audits or Evaluations 75
9.2.2.2 External Systems Audits 76
9.2.3 Data Audits 77
9.2.4 Spot Assessments 77
9.3 Client Inquiries and Complaints 77
9.4 Quality Reports to Management 77
9.5 Management Review of the QMS 78

10.0 Quality Improvement 79
10.1 Standardization of Procedures 79
10.2 Continuous Quality Improvement 79
10.3 Benchmarking 80
10.4 Quality Assessment 80
10.5 Understanding the Clients' Needs 80
10.6 Quality Measures and Standards 80

List of Figures

Figure	Title	Page
1.3-1	Quanterra® Organizational Chart	3
7.1-1	Data Collection Process Flow Diagram	32
7.4-1	Example Quality Assurance Summary	35-36
8.5-1	Example Quanterra® Chain-of-Custody Form	52
8.5-2	Example Condition Upon Receipt Anomaly Report (CUR)	56-57
8.8-1	Data Reduction, Verification, and Reporting	65

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List of Tables

Table No.	Title	Page
2.3-1	Quanterra® Quality Assurance Management Plan Requirements Matrix	5
4.2-1	List of Quanterra® Quality-Related Items that Require Evaluation Prior to Use	9
5.1-1	Quanterra® Quality Documents and Required Approval	10
5.2-1	Quanterra® Quality Document Review Requirements	11
8.2-1	Analytical Methods Routinely Performed by Quanterra®	12
8.4-1	Field Quality Control Samples	24
8.4-2	Laboratory Quality Control Samples	25
8.4-3	Laboratory Performance Quality Control Samples	26
8.4-4	Matrix Specific Quality Control Samples	27
8.4-5	Inorganic Laboratory Quality Control Samples	28
8.4-6	Organic Laboratory Quality Control Samples	77
8.4-7	USEPA Contract Laboratory Program Statement of Work Quality Control Samples	102
8.5-1	Inorganic Sample Containers, Preservatives, and Holding Times	116
8.5-2	Organic Sample Containers, Preservatives, and Holding Times	128
8.5-3	Radiological Sample Containers, Preservatives, and Holding Times	137
8.5-4	Sample Containers, Preservatives, and Holding Times for USEPA Contract Laboratory Program Statement of Work	140
8.5-5	Sample Containers, Preservatives, and Holding Times for TCLP	142
8.5-6	Periodic Equipment Calibrations	143
8.5-7	Summary of Inorganic Method Calibrations	144
8.5-8	Summary of Organic Method Calibrations	160
8.5-9	Summary of USEPA Contract Laboratory Program Statement of Work Method Calibrations	169
8.6-1	Precision and Accuracy Measurements	173
8.11-1	Instrument Maintenance Schedule - Ion Chromatograph	175
8.11-2	Instrument Maintenance Schedule - LACHAT Auto Analyzer	175
8.11-3	Instrument Maintenance Schedule - Total Organic Halide Analyzer	176
8.11-4	Instrument Maintenance Schedule - High Pressure Liquid Chromatograph	176
8.11-5	Instrument Maintenance Schedule - Flame Atomic Absorption Spectroscopy	177
8.11-6	Instrument Maintenance Schedule - Inductively Coupled Argon Plasma/ Mass Spectrometry (ICAP/MS)	177
8.11-7	Instrument Maintenance Schedule - ICP	178
8.11-8	Instrument Maintenance Schedule - Graphite Furnace Atomic Absorption	179
8.11-9	Instrument Maintenance Schedule - Cold Vapor Atomic Absorption (Leeman PS 200)	179

Table of Contents (continued)

Table No.	Title	Page
8.11-10	Instrument Maintenance Schedule - Cold Vapor Atomic Absorption (PE 5000)	179
8.11-11	Instrument Maintenance Schedule - Gas Chromatograph	180
8.11-12	Instrument Maintenance Schedule - Mass Spectrometer	182
8.11-13	Instrument Maintenance Schedule - TRAACS 800 Auto Analyzer	183
8.11-14	Instrument Maintenance Schedule - Sonicator	183
8.11-15	Instrument Maintenance Schedule - Analytical/Top Loading Balances	183
8.11-16	Instrument Maintenance Schedule - Refrigerators/Walk-in Coolers	183
8.11-17	Instrument Maintenance Schedule - Ovens	184
8.11-18	Instrument Maintenance Schedule - Specific Digital Ion Analyzer	184
8.11-19	Instrument Maintenance Schedule - Turbidimeter	184
8.11-20	Instrument Maintenance Schedule - Dissolved Oxygen Meter	184
8.11-21	Instrument Maintenance Schedule - Conductance Meter	185
8.11-22	Instrument Maintenance Schedule - Chemical Oxygen Demand (COD) Reactor	185
8.11-23	Instrument Maintenance Schedule - Spectrophotometer	185
8.11-24	Instrument Maintenance Schedule - pH Meter	185
8.11-25	Instrument Maintenance Schedule - Fourier Transform Infrared Spectrometry	186
8.11-26	Instrument Maintenance Schedule - Radiological Analysis Equipment	186
8.11-27	Instrument Maintenance Schedule - Total Organic Carbon Analyzer (OI 7000)	187

List of Appendices

Appendix A — Corporate Key Personnel List and Quanterra® Operations Organizational Chart

Appendix B — Addresses of Quanterra® Locations

Appendix C — Facility-Specific Appendix: ***This appendix contains facility-specific quality-related information and requirements for*** Quanterra® ***laboratories. These laboratories are located in the following cities:***

- Anchorage, Alaska
- Austin, Texas
- City of Industry, California
- Denver, Colorado
- Knoxville, Tennessee
- North Canton, Ohio
- Pittsburgh, Pennsylvania
- Richland, Washington
- Sacramento, California
- Santa Ana, California
- St. Louis, Missouri
- Tampa, Florida

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Each laboratory section in this appendix contains information specific to that laboratory only and contains the following basic outline:

Section	Contents
0	Table of Contents
1	Organizational Chart
2	Instrument List
3	Standard Operating Procedures List
4	Analytical Methods
5	MDLs, RLs, and CRDLs
6	Performance Evaluation Studies
7	Additional Operation-Specific Information

Acronyms and Initialisms

A2LA	American Associatio for Laboratory Accreditation
AA	Atomic Absorption
ANSI	American National Standards Institute
AR/COC	Analysis Request/Chain-of-Custody
ASQC	American Society for Quality Control
ASTM	American Society for Testing and Materials
BFB	Bromofluorobenzene
BLK	Blank
BOD	Biochemical Oxygen Demand
CCC	Calibration Check Compound
CEO	Chief Executive Officer
CF	Calibration Factor
CFR	Code of Federal Regulations
CHP	Chemical Hygiene Plan
CLP	Contract Laboratory Program
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act (Superfund)
COC	Chain-of-Custody
COD	Chemical Oxygen Demand
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CSM	Customer Service Manager
CSRM	Certified Standard Reference Material
CST	Customer Service Team
CUR	Condition Upon Receipt
CV	Coefficient of Variation
CVAA	Cold Vapor Atomic Absorption (Spectroscopy)
DFTPP	Decafluorotriphenylphosphine
DOC	Dissolved Organic Carbon
DOE	Department of Energy
DOT	Department of Transportation
DQO	Data Quality Objective

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Acronyms and Initialisms (continued)

EH&S	Environmental Health and Safety
EPA	(U. S.) Environmental Protection Agency
FAS	Field Analytical Services
FLAA	Flame Atomic Absorption (Spectroscopy)
FTIR	Fourier Transform Infrared (Spectrometry)
GC	Gas Chromatograph(y)
GC/MS	Gas Chromatography/Mass Spectrometry
GFAA	Graphite Furnace Atomic Absorption (Spectroscopy)
HDPE	High Density Polyethylene
HPLC	High Performance Liquid Chromatography
HRGC	High Resolution Gas Chromatography
HRMS	High Resolution Mass Spectrometry
ICAP	Inductively Coupled Argon Plasma (Spectroscopy)
ICAP/MS	Inductively Coupled Argon Plasma/Mass Spectrometry
ICS	Interference Check Sample
IDL	Instrument Detection Limit
IR	Infrared (Spectroscopy)
IS	Information Systems
IS	Internal Standard
ISO	International Organization for Standardization
IT	Information Technology
KRI	Key Result Indicator
LAN	Local Area Network
LCL	Lower Control Limit
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LIMS	Laboratory Information Management System
LRGC	Low Resolution Gas Chromatography
LRMS	Low Resolution Mass Spectrometry
LWL	Lower Warning Limit
MBAS	Methylene Blue Active Substance

Acronyms and Initialisms (continued)

MDA	Minimum Detectable Amount
MDL	Method Detection Limit
MS	Matrix Spike
MSA	Method of Standard Additions
MSD	Matrix Spike Duplicate
MSDS	Material Safety Data Sheet
NCM	Nonconformance Memo
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards Technology
NMOC	Non-Methane Organic Compounds
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NRM	National Reference Material
PAH	Polynuclear Aromatic Hydrocarbons (or PNA)
PC	Personal Computer
PCB	Polychlorinated Biphenyls
PDS	Post Digestion Spike
PE	Performance Evaluation
PEM	Performance Evaluation Mixture
PM	Project Manager
PQL	Practical Quantitation Limit
PSRL	Project-Specific Reporting Limit
PUF	Polyurethane Foam
QA	Quality Assurance
QAMP	Quality Assurance Management Plan
QAPP	Quality Assurance Project Plan or Quality Assurance Program Plan
QAS	Quality Assurance Summary
QC	Quality Control
QMS	Quality Management System
QuantIMS	Quanterra® Laboratory Information Management System
QRI	Quality-Related Item

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Acronyms and Initialisms (continued)

RCRA	Resource Conservation and Recovery Act
RF	Response Factor
RFP	Request for Proposal
RFQ	Request for Quote
RL	Reporting Limit
RPD	Relative Percent Difference
RRF	Relative Response Factor
RSD	Relative Standard Deviation
RSO	Radiation Safety Officer
SDG	Sample Delivery Group
SOP	Standard Operating Procedure
SOW	Statement of Work
SPCC	System Performance Check Compounds
SPLP	Synthetic Precipitation Leaching Procedure
SRL	Standard Reporting Limit
SRM	Standard Reference Material
TCLP	Toxicity Characteristic Leaching Procedure
TIC	Tentatively Identified Compound
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TOX	Total Organic Halides
UCL	Upper Control Limit
UPS	Uninterruptable Power Supply
USEPA	United States Environmental Protection Agency
UWL	Upper Warning Limit
VOA	Volatile Organic Analysis
VOST	Volatile Organic Sampling Train
WAN	Wide Area Network
WS	Water Supply
WP	Water Pollution

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1.0 Management Commitment and Organization

1.1 Vision Statement

Quanterra®'s vision is to be a world-class, profitable analytical services company providing high-value, compliant, innovative problem solutions and state-of-the-art products wherever they are required.

1.2 Statement of Management Commitment to Quality

Quanterra®'s management is committed to providing quality services that meet the requirements of our clients and satisfy applicable regulatory requirements. Management is dedicated to providing an environment that encourages the achievement of excellence, demands integrity in all aspects of its operations, and requires active participation of all associates and vendors in meeting its quality goals.

A comprehensive Quality Management System (QMS) has been developed to ensure that Quanterra®'s clients receive high-quality analytical and environmental services that are timely, reliable, and meet their intended purpose in a cost-effective manner. The QMS provides the organizational structure that ensures quality in its work processes, products, and services. The Quanterra® QMS is described in this Quanterra® Quality Assurance Management Plan (QAMP) and applies to all technical, business, and administrative functions at Quanterra®. The principles and practices described in this QAMP apply to all Quanterra® associates at every level and are fundamental to the services we provide and to the way we do business.

The Quanterra® QAMP provides the foundation for planning, implementing, and assessing the Quanterra® QMS. It is an overall statement of quality policy as well as a plan used to implement quality programs throughout the company. Each business function of the organization shall put in place plans, policies, and procedures that will meet the requirements of the QAMP. The QAMP provides guidance to Quanterra®'s associates in fulfilling their responsibilities and serves as a statement to clients, agencies, and associates of Quanterra®'s commitment to quality.

Implementation of the QAMP is the responsibility of all Quanterra® associates. Management at every level has the responsibility and authority to lead the development and implementation of a structured management system that supports the quality programs. Management must ensure that the principles and practices of the

quality program are followed and implemented at all levels.

1.3 Organizational Structure

Quanterra® is incorporated in the state of Delaware with corporate headquarters located in Englewood, Colorado. The organizational structure for Quanterra® is presented in Figure 1.3-1. Laboratory locations are given in the List of Appendices in the Table of Contents. A list of key corporate personnel and an organizational chart for Quanterra® operations including Corporate Quality Assurance are given in Appendix A. The organizational structure for each laboratory is presented in the Facility-Specific Appendix C. The responsibilities and authorities of the members of the organization, as they relate to quality management, are outlined in Section 1.4.

At some Quanterra® laboratories, positions identified in this section may not exist due to the laboratory size or other factors. In these cases, the responsibilities and authorities described here are assigned to other positions by the Laboratory Manager or next senior level of management as appropriate.

1.4 Quality Organization

The achievement of quality in all activities is the responsibility of each Quanterra® associate and is led by management. Quality-related responsibilities within the organization provide for the implementation of the QAMP and for completion of quality control (QC) activities. The following sections describe these activities for key Quanterra® positions. The quality-related responsibilities may be reassigned by assigning the activities among different individuals or enhanced by adding activities, but they must not be eliminated. If an operation does not have the titled position outlined below, the responsibilities under that position go to next upward position. The accountability is retained by the person delegating the activity or by the person assigned the activity by the next senior level of management.

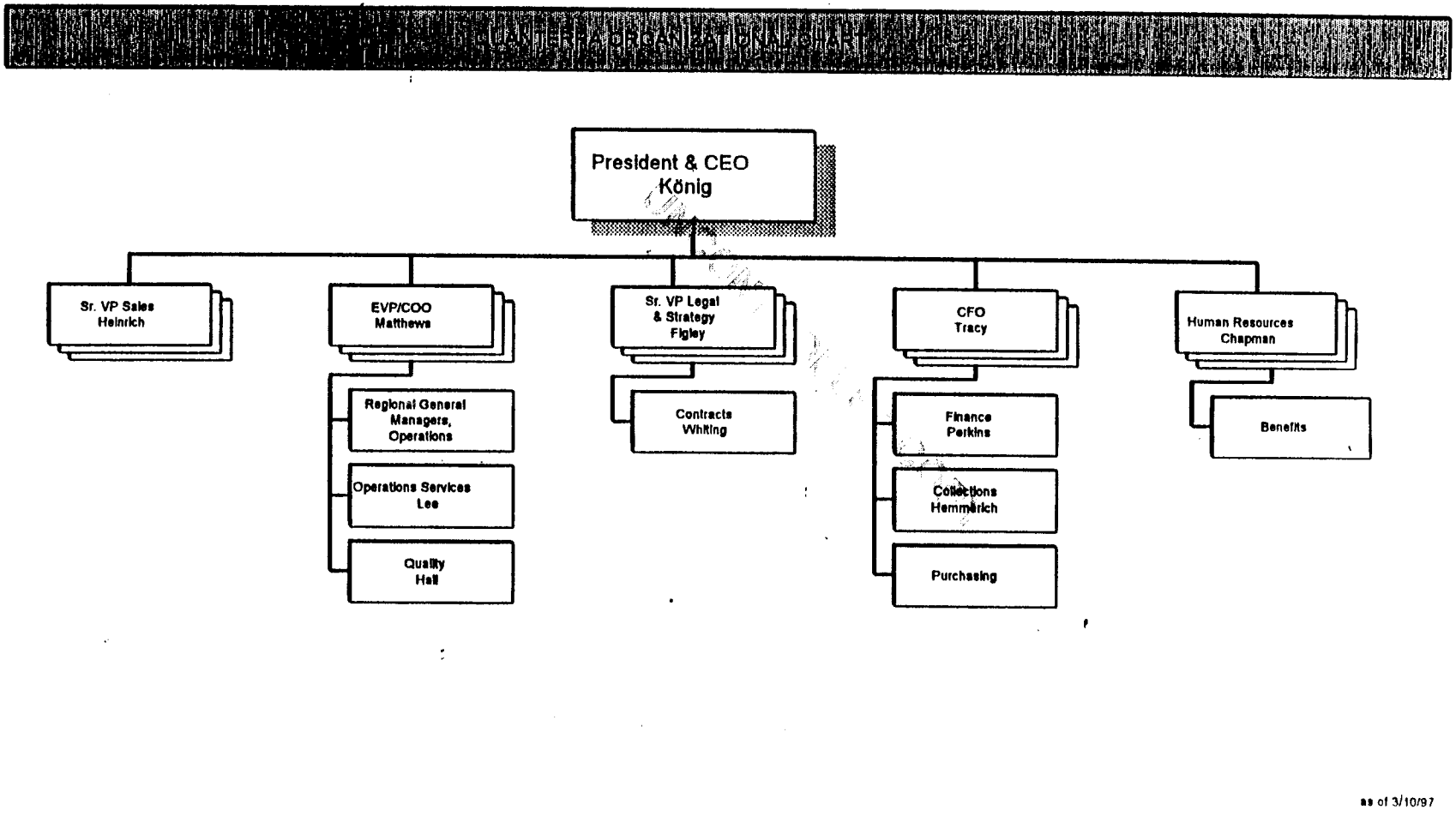
1.4.1 President and Chief Executive Officer (CEO)

- Reports directly to the Board of Directors
- Responsible for overall corporate policy and strategy for quality
- Responsible for maintaining effective quality management
- Provides the resources to implement the Quanterra® QAMP.

1.4.2 Chief Operating Officer

- Reports directly to the President and CEO
- Approves the Quanterra® QAMP

FIGURE 1.3-1


QUANTERRA ORGANIZATIONAL CHART
President & CEO
König
Sr. VP Sales
Heinrich
EVP/COO
Matthews
Regional General Managers, Operations
Operations Services
Lee
Quality
Hall
Sr. VP Legal & Strategy
Figley
Contracts
Whiting
CFO
Tracy
Finance
Perkins
Collections
Hemmerich
Purchasing
Human Resources
Chapman
Benefits
as of 3/10/97

- Responsible for implementation of an effective QMS
- Implements improvements in operations and quality programs
- Provides feedback regarding customer satisfaction.

1.4.3 *Vice President of Operations Services*

- Reports directly to the Chief Operating Officer
- Approves the Quanterra® QAMP and Quality Policy Documents
- Recommends improvements in operations and quality programs
- Oversees evaluation of new technology and required quality control

1.4.4 *Corporate Director of Quality Assurance*

- Reports directly to the Vice President of Operations Services and Chief Operating Officer on all quality issues
- Reviews and approves changes in laboratory quality assurance (QA) staff
- Maintains a strong line of communication to and provides guidance to the QA Managers
- Approves the Quanterra® QAMP, the Facility Appendices to the QAMP, Quality Policy Documents, and Corporate Standard Operating Procedures (SOP)
- Serves as a technical consultant and resource on quality issues to ensure uniform excellence in quality and regulatory analytical compliance at all Quanterra® operations
- Responsible for assessing, maintaining, and improving the Quanterra® QAMP
- Supervises and provides guidance to corporate QA staff
- Suspends processing when significant quality requirements are not met
- Oversees independent audits of Quanterra® laboratories to identify areas where improvement is needed to comply with the QAMP
- Responsible for reporting all matters of quality assurance to the President and senior management.
- Issues Corporate Quality Assurance Directives as required to clarify policy
- Duties completed by Assistant QA Director in absence of the Director

1.4.5 *Assistant Quality Assurance (QA) Director*

- Reports directly to the Corporate Director of Quality Assurance
- Primary duty is to fill in for the Corporate Director of Quality Assurance in their absence
- Completes special projects related to corporate QA issues

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1.4.6 Quality Assurance (QA) Manager

- Reports directly to the Laboratory Manager and indirectly for all QA matters to the Corporate Director of Quality Assurance
- Approves the Facility-Specific Appendix to the Quanterra® QAMP
- Approves operation-specific SOPs
- Responsible for assessing and maintaining the QAMP within the facility operations
- Responsible for ensuring and improving quality within facility operations
- Recommends resolutions for ongoing or recurrent nonconformances within the laboratory
- Supervises and provides guidance and training to laboratory QA staff
- Suspends sample processing when significant quality requirements are not met
- Assists in maintaining regulatory analytical compliance
- Serves as the in-house client representative on all project inquiries involving data quality issues
- Monitors data quality measures via statistical methods to verify that the laboratory routinely meets stated quality goals
- Performs QA assessments
- Tracks and closes external and internal findings of QA audits
- Reviews and approves corrective action plans for nonconformances, trends nonconformances to detect systematic problems, and initiates additional corrective actions as needed.
- Assists in the preparation of and approves Quality Assurance Project Plans (QAPPs)
- Coordinates laboratory certification and accreditation programs
- Maintains controlled quality documents
- Prepares a monthly quality report to management
- Responsible for approving reference data and changes on LIMS.

1.4.7 Customer Service Managers (CSMs)

- Reports directly to the Laboratory Manager
- Defines customer requirements through project definition
- Assesses and assures customer satisfaction
- Provides feedback to management on changing customer needs
- Brings together resources necessary to ensure customer satisfaction.

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1.4.8 Regional General Manager

- Reports directly to the Chief Operating Officer
- Implements the Quanterra® QAMP in their operating units and approves the QAMP Facility-Specific Appendices for those units.
- Assigns specific responsibilities within operational units to resolve quality-related problems within their region
- Maintains a dialogue with the Chief Operating Officer and the Corporate Director of Quality Assurance
- Assesses the effectiveness of the Quanterra® QMS within their region.

1.4.9 Laboratory Manager

- Reports directly to the Regional General Manager
- Responsible for implementing the Quanterra® QAMP and all corporate policies and procedures within the laboratory
- Approves the Facility-Specific Appendix to the Quanterra® QAMP and Facility-Specific SOPs
- Periodically assesses the effectiveness of the QAMP within the operation
- Maintains adequate staffing documented on organization charts.

1.4.10 Operations Manager

- Reports directly to the Laboratory Manager
- Supervises daily activities of the Operational Groups
- Schedules analytical operations
- Supervises QC activities performed as a part of routine analytical operations
- Implements data review procedures
- Supervises the preparation and maintenance of laboratory records
- Supervises maintenance of instruments and scheduling of repairs
- Works with the Systems Manager and Group/Team Leaders to assure the requirements of projects are met in a timely manner
- Responsible for meeting quality requirements.

1.4.11 Systems Manager

- Reports directly to the Laboratory Manager
- Supervises daily activities of the Project Management, Sample Control, Administrative, and Report Production Groups
- Works with the Operations Manager and/or Group/Team Leaders to ensure the requirements of projects are met in a timely manner

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- Responsible for meeting quality requirements.

1.4.12 Project Manager

- Monitors analytical and QA project requirements
- Acts as a liaison between the client and the laboratory staff
- Prepares Quality Assurance Summary (QAS) or equivalent summary form and communicates project-specific requirements to all parties involved
- Assists the laboratory staff with interpretation of work plans, contracts, and QAPP requirements
- Reviews project data packages for completeness and compliance to client needs
- Keeps the laboratory and client informed of project status
- Together with the QA Manager, approves customer requested variances to methods and to standard laboratory protocols
- Monitors, reviews, and evaluates the progress and performance of projects
- Reports client inquiries involving data quality issues or data acceptability to the facility QA Manager and to the operations staff
- Conducts project reviews to assess the laboratory's performance in meeting customer requirements
- Prepares reissue requests for project data
- Responsible for meeting quality requirements.

1.4.13 Group Leader or Team Leader

- Reports directly to either the Systems Manager, or Operations Manager or Laboratory Manager depending on specific laboratory organization.
- Supervises daily activities of analyses within the group
- Supervises QC activities performed as a part of routine analytical operations
- Implements data review procedures
- Supervises the preparation and maintenance of laboratory records
- Evaluates instrument performance and supervises the calibration, preventive maintenance, and scheduling of repairs
- Oversees or performs review and approval of all analytical data
- Reports nonconformances to the appropriate managers
- Responsible for meeting quality requirements.

1.4.14 Analyst

- Performs analytical methods and data recording in accordance with documented procedures

- Performs and documents calibration and preventive maintenance
- Performs data processing and data review procedures
- Reports nonconformances to the Supervisor/Manager and QA Manager
- Ensures sample and data integrity by adhering to internal chain-of-custody procedures
- Responsible for meeting quality requirements.

1.4.15 Sample Custodian

- Ensures implementation of proper sample receipt procedures, including maintenance of chain-of-custody
- Reports anomalies associated with condition-upon-receipt of samples to the Project Manager
- Logs samples into the LIMS
- Ensures that all samples are stored in the proper environment
- Assists Environmental Health and Safety staff with sample disposal
- Responsible for meeting quality requirements.

1.4.16 Report Production Staff

- Accurately generates and compiles analytical reports and associated deliverables for delivery to the client
- Responsible for meeting quality requirements.

1.5 General Responsibilities

It is the responsibility of each Quanterra® associate to perform their job-related duties in compliance with all Quanterra® corporate and operation-specific SOPs and policies applicable to their position.

1.6 Waste, Fraud, and Abuse

Quanterra®, through its ethics policy (Corporate Policy Number LEG-001) and ethics training, and the Quanterra® Compliance Program (Corporate Policy Number LEG-009) requires and encourages all associates to report any activity that may be considered wasteful or fraudulent. Any incidents reported are subject to a complete investigation per Quanterra® Corporate Policy Number LEG-005, "Internal Investigation". Associates involved in such activities are subject to immediate dismissal.

Substance abuse is unacceptable behavior for Quanterra® associates and abuses are subject to Human Resources disciplinary policies. Prior to hiring, all Quanterra® associates undergo drug screening and are subject to random screening on an annual basis. The Quanterra® procedures on substance abuse meet the federal contracting guidelines.

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SECTION 2.0

2.0 Quality System and Description

Quanterra® has defined Quality as meeting the requirements of our clients, both internal and external. The QMS provides the structure to achieve the total quality management goals necessary to obtain world class standards of performance and quality in all areas.

2.1 Quality Management System

The purpose of the QMS is to ensure the quality of products and services. The QMS is a structured management system of principles, objectives, policies, responsibilities, and implementation plans at the organizational and project-specific levels. At the organizational level, the QMS provides the framework within which project-specific planning, implementation, and performance assessment may occur. The QAMP documents the QMS and describes both the organizational and project-specific principles, goals, controls, and tools of the QMS. The QMS is described in detail in this QAMP, Quality Policy Documents, and SOPs.

The QMS steering committee is comprised of the Quanterra® President and CEO and his staff. This committee establishes the Quanterra® Vision and its strategic plan and provides leadership and support for the achievement of all quality goals and objectives. It is the responsibility of all Quanterra® directors and managers to implement the QMS elements by setting goals and objectives which lead to the achievement of the Quanterra® Vision.

2.2 Quality Assurance

Quality Assurance (QA) is defined as a system of activities which ensures a process, product, or service that meets the needs and expectations of the customer. QA is an integral part of Quanterra® 's QMS.

The organizational and project-specific systems of the Quanterra® QMS, discussed in Section 2.1, are used to define QA goals. Controls at the organizational level regulate activities that support common or standardized functions such as associate qualifications and training, document control, and material procurement. Controls at the project level regulate the definition and implementation of customer requirements to produce the desired type and quality of product. Some specific examples of quality controls are:

- Measuring lab and instrument performance on a daily basis to ensure that the measurement systems are in statistical control
- Demonstrating lab capability through data quality assessments which document the

overall qualification of the laboratory to perform environmental analyses

- Utilizing SOPs to ensure uniformity and compliance in the measurement process
- Providing controlled flexibility in routine methodology to meet project-specific sample and data requirements
- Monitoring operational performance of the laboratory on a routine basis and providing corrective action if needed
- Recognizing and promptly correcting any factors which adversely affect quality
- Maintaining complete records of sample receipt, laboratory analysis, data evaluation and reporting, and sample disposal.

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2.3 Quality Documents

The QMS is defined by a series of documents which are described in Sections 2.3.1 through 2.3.5. The review and control of these documents are described in Section 5.0.

Following is a list of documents used to develop Quanterra®'s QAMP. The requirements of several of these documents are cross-referenced with the content of the QAMP in Table 2.3-1.

- Interim Draft EPA Requirements for Quality Management Plans, U.S. Environmental Protection Agency, EPA QA/R-2, July 1993
- EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5
- Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs, American Society for Quality Control, Energy and Environmental Quality Division, Environmental Issues Group, ANSI/ASQC E4-1994 (Formerly EQA-1), January 1994
- Quality Assurance Program Requirements for Nuclear Facilities, The American Society of Mechanical Engineers, ASME NQA-1-1989 edition
- Quality Assurance, Office of Nuclear Energy & Office of Environment, Safety, and Health, United States Department of Energy, DOE ORDER 5700.6C, August 1991
- Performance Criteria for Radiobioassay, ANSI N 13.30, September 1989
- Measurement Quality Assurance for Radioassay Laboratories, ANSI N 42.2, Revised May 21, 1992, Revision 10A
- Quality Management and Quality System Elements for Laboratories - Guidelines, American National Standard, American Society for Quality Control, ANSI/ASQC Q2-1991
- International Standard ISO/IEC Guide 25-1990.

2.3.1 Quality Assurance Management Plan

This Quanterra® Quality Assurance Management Plan (QAMP), along with Quality Policy Documents and SOPs, provides the criteria and specifications for the

generation of environmental analytical data. The QAMP provides QC criteria for standard procedures and facility-specific instrumentation as well as method detection limit (MDL) information.

2.3.2 Quality Policy Documents

Quality Policy Documents provide further detail to the QAMP. They describe the requirements for a specific program on a corporate-wide level. Quality Policy Documents use the concepts and requirements contained in the QAMP and provide sufficient detail so that corporate or facility-specific SOPs can be developed.

2.3.3 Standard Operating Procedures

Standard Operating Procedures (SOPs) describe step-by-step instructions for performing a method or activity. In addition, there are SOPs which relate to other support services performed in the company. In general, SOPs will be corporate or operation specific. Corporate SOPs specify procedures that are standard across Quanterra®. Operation-specific SOPs detail procedures that pertain to a specific facility operation only. SOPs specify procedures, methods, corrective action requirements, documentation, review, and verification requirements. SOP format and document control are described in Quanterra® Policy Number QA-001, "Standard Operating Procedures." SOPs that are performed by each Quanterra® operating unit are listed in Section 3 of the Facility Appendix to this QAMP. SOPs are living documents and may supersede some requirements in this document until the QAMP update every two years.

2.3.4 Quality Assurance Project or Program Plans (QAPPs)

Regulations and contracts may contain QA requirements which are different from Quanterra® 's QAMP. To address unique or project requirements, Quality Assurance Project Plans (QAPP) may be prepared and implemented. The requirements documented in a QAPP take precedence over the Quanterra® QAMP for that project.

Similarly, some regulatory programs such as Florida Department of Environmental Protection (FDEP) and Florida Department of Health (FDH) require QA Plans specific to their program. The FDEP and FDH require that each laboratory certified in the state submit and maintain a Comprehensive QA Plan. Many state certifying agencies have reciprocal certification agreements with Florida. In these situations, the QA Plan submitted for regulatory programs takes precedence over the Quanterra® QAMP.

If requested and approved by the client, project-specific requirements may be less stringent than the Quanterra® quality program.

Typical specifications contained in a QAPP or documentation include:

- New or modified testing methods
- Unique QC logic
- Special requirements for equipment use and maintenance
- Special handling due to safety considerations
- Project-specific detection and reporting limits
- Project-specific accuracy and precision limits or the statistical treatment of data
- Additional or unique documentation or records management requirements.

2.3.4.1 Quality Assurance Summary

Quality Assurance Summaries (QAS) are used to distill client-specific requirements onto a single table or form. The summary describes quality control samples, batching schemes, flagging conventions, deliverables, or other client requests that may differ from routine laboratory operations. The QAS is made available to laboratory operations by the Project Manager to document client needs. The QAS may be used alone or in conjunction with the QAPP.

2.3.5 Other Documents

Other documents which can affect the quality program may include the Chemical Hygiene Plan (CHP), the Quanterra® Compliance Program , memos, guidance documents, work instructions, and periodic reports. These documents may further define or guide the implementation of quality standards at Quanterra® but shall not conflict with the QAMP or diminish the effectiveness of the QMS.

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3.0 Associate Qualification and Training

All activities performed by Quanterra® shall be accomplished by qualified associates. The following definitions are relevant to the discussion of associate qualification and training presented in this section:

- Qualification - The characteristics or abilities gained through education, training, or experience that enable an individual to perform a required task.
- Orientation - The act or process of acquainting individuals with an existing situation, environment, or condition.
- Training - In-depth instruction to develop proficiency in the application of requirements, methods, and procedures. Instruction may be internal or external classroom sessions, courses, or on-the-job training.

Employee orientation and training must be performed in compliance with Quanterra® Corporate SOP Number CORP-QA-0013, "Employee Orientation and Training".

3.1 Associate Qualifications

Each operating unit shall have job descriptions for all positions. These job descriptions must specify the minimum qualifications for education and experience, knowledge, and skills which are necessary to perform at a satisfactory level. An associate's performance shall be compared with the requirements of his/her job description at least annually, in conjunction with the associate's annual performance review.

Quanterra® expects the necessary knowledge, experience, and skills to be demonstrated by formal academic training. Qualifications of professional associates shall be documented by resumes which include academic credentials, employment history, experience, and professional registrations. A copy of the resume will be placed in the associate's training file or may be maintained in electronic format.

3.2 Orientation and Training of Laboratory Staff

Associates receive internal, external, formal, and informal training. Training is performed to maintain and develop proficiency, and to promote improvement. Training is performed by individuals knowledgeable in the subject matter.

Quanterra® associates are qualified based on the experience and training documented in the individual's training file, and are assigned duties within their experience and training.

Each new associate shall receive orientation and training in quality and health and safety. Each new associate shall be supervised in their assigned duties by their supervisor or designee. The authorization to perform independently shall be documented in the training files. In addition, training for associates may include professional, managerial, communication, and interpersonal skills as appropriate. On-going or periodic assessments will be performed to determine training needs and effectiveness of instruction.

3.2.1 *Quality Orientation*

Each newly hired Quanterra® associate receives a Quality orientation. The QA Manager or designee shall conduct this orientation within two weeks of the associate's report-to-work date. This orientation will be documented in the associate's training file. The QA Manager shall review the following topics (at a minimum) with the new associate:

- Quanterra® Quality Policy and applicable documents including the Quanterra® QAMP
- Quanterra® policies on ensuring data integrity, meeting client requirements, and ethics
- Identification and documentation of nonconformance and corrective action procedures
- Proper data recording practices
- Key elements of Quanterra® Quality Control Program Policy (No. QA-003).

The QA orientation or on-going training shall be documented using a written exam, a checklist, or a preprinted form. This documentation is required to demonstrate an understanding of the Quality orientation and to determine if any areas covered require further training.

3.2.2 *Quality Training*

Continued training in the mission and goals of the QAMP shall be provided at least once per year. Formal training sessions are conducted and documented by the QA Manager or designee. The training program shall address relevant regulatory requirements, basic QC practices, responsibilities of the technical and QA staff, and the reporting of nonconformances.

In addition, each Quanterra® associate shall become familiar with the operating unit's quality programs by reading the relevant sections of the Quanterra® QAMP, policies, and SOPs pertinent to his/her position.

3.2.3 Health and Safety Orientation and Training

Each newly hired Quanterra® associate, contract worker, or working visitor is required to go through health and safety orientation and training as per the laboratory Chemical Hygiene Plan (CHP). The orientation must be performed as soon as possible after the associate's report-to-work date and before chemicals are handled. Quanterra® associates and contract workers shall be given comprehensive health and safety training within ninety days of the start-to-work date. Documentation is maintained in the associate's training file.

3.2.4 QA Manager Training

All QA Managers shall receive training so that they are proficient in the requirements of the Quanterra® QAMP. Continued proficiency of QA Managers shall be maintained through active participation in QA audits and the preparation and review of QA documents.

3.3 Training Files

Each Quanterra® associate has an individual training file maintained by the QA Manager or designee. The types of training documents included in the training file are the following:

- Associate's resume
- Quality
- Health and Safety
- Technical
- Professional Development
- Regulatory/Compliance.

Information is filed in the training file as training is received. Not all associates will have training records for all areas depending upon their job function or tenure with the company.

3.3.1 Associate Resumes

A copy of the associate's current resume will be placed in the associate's training file or maintained in electronic format. Quanterra® has developed a standard format for resumes. Qualifications of associates, as documented on resumes, include academic credentials, employment history, experience, and professional memberships and registrations.

3.3.2 Individual Training Records for the Areas of Quality, Health and Safety, and Technical

Training of each associate shall be summarized and documented on training forms. These include documentation of participation in orientation training, one-on-one training, on-the-job training, or

participation in classes and other presentations, and any other formal training sessions, either internal or external. Examples of some of the forms used to document this training are provided in the Corporate SOP, "Employee Orientation and Training", SOP Number CORP-QA-0013. Technical training records shall include documentation of the ability to perform sample preparation or analysis. In addition, if any tests are given as part of the training in each of these areas, the results are filed in the individual's training file.

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3.3.3 *Training Records for Professional Development*

This category includes documentation of all courses taken relating to an individual's professional development. Examples of courses include Conflict Resolution, Time Management, Conducting Effective Meetings, and Interviewing Skills.

3.3.4 *Training Records for Regulatory/Compliance Information*

This category provides for documentation of training on topics required by law (with the exception of safety documented previously). Examples of this category are Sexual Harassment, Drug-Free Workplace, and Quanterra® ethics.

4.0 Procurement of Items and Services

This section defines the Quanterra® requirements for the procurement of items and services. Controlling the quality of items and services procured by Quanterra® will help us meet the needs of our customers. The Quanterra® procurement program requires:

- Assurance that purchased items and services meet Quanterra® -established requirements and perform as expected
- Definitions and descriptions of the documentation levels required for the applicable technical and administrative requirements
- Evaluation and qualification of vendors.

4.1 Selection of Vendors

Prospective vendors are selected based upon criteria appropriate to the materials or services provided. For national vendors and contracts, the vendor is selected through either a competitive proposal/bid process, strategic business alliance or negotiated vendor partnership. Vendors are evaluated on the following criteria as appropriate:

- The vendor's history of providing identical or similar products that perform satisfactorily in actual use
- The vendor's service record and ability to provide a complete product line and commensurate service
- The vendor's ability to administer inventory at Quanterra® facilities through a fully developed inventory management system that will ensure correct stocking levels as well as shelf-life tracking
- Software systems that will integrate with Quanterra® systems
- Objective evaluation of the vendor's current quality records supported by documentation
- Ability of the vendor to provide service agreements for instruments that meet Quanterra® specifications
- Evaluation of the vendor's business strategy and the ability of that strategy to complement Quanterra®'s quality program
- Results of audits by Quanterra® of the vendor's technical and quality capability.

A Quanterra® quality representative shall determine the appropriate level of evaluation criteria for the item or service being purchased. Vendors that provide test and measuring equipment, solvents, standards, instrument-related service contracts, or subcontracted laboratory services shall be subject to more rigorous controls than vendors that provide off-the-shelf items. For the procurement of testing and measuring

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equipment it is recognized that the environment in which the measurement system is placed may have a bearing on its performance. Therefore, in lieu of other supplier qualification activities, the quality representative shall ensure that an acceptance testing plan is in place to ensure that the measurement system is able to meet specifications in the intended operating environment.

4.2 *Procurement of Quality-Related Items*

The quality of instruments, equipment, standards, reagents, solvents, other chemicals, gases, water, and laboratory containers used in analyses must be known so that their effect upon analytical results can be defined. Quality-related items (QRIs) are items that are used in the operational unit that must meet a minimum quality requirement. All QRIs purchased by Quanterra® operating units shall be evaluated to ensure that they meet the requirements and specifications established by Quanterra®. These requirements and specifications include, but are not limited to, client contracts, project-specific QA requirements, data quality objectives (DQOs) and analytical method requirements, and defined technical specifications.

Quality specifications shall be included or referenced in the purchasing documents for the procurement of the applicable items. The quality representatives, in conjunction with the procurement team, shall approve items purchased. This approval shall be maintained by Purchasing as a "Quality Approved" list of items. If items which may affect laboratory quality are requested from non-preapproved vendors, quality approval must be obtained prior to placing the order.

When ordering QRIs, a system shall be put in place to verify the quality of the item received. Each laboratory shall assign individuals responsible for material procurement and control. Duties include:

- Specifying, in purchase orders or requisitions, suitable grades of materials (grade shall be defined by the responsible manager and detailed in SOPs)
- Verifying upon receipt that materials meet requirements (see section 4.2.3) and that, as applicable, material certificates are provided and maintained
- Identifying and storing materials
- Verifying that material storage is properly maintained, and removing materials from use when shelf life has expired.

4.2.1 Role of Quanterra® Purchasing

Quanterra® Purchasing supports the laboratory by:

- Maintaining, issuing, and negotiating contracts
- Identifying potential vendors and subcontractors
- Identifying vendors for unique or scarce materials
- Maintaining a system to facilitate purchases made by each facility
- Maintaining lists of available items through catalogs or contract agreements with approved vendors
- Preparing and communicating corporate policies regarding purchasing and procurement
- Developing and implementing a review of the purchasing program as it pertains to procurement of QRIs.

In order to enhance the quality and consistency of the product within the laboratory network, the Director of Purchasing shall pursue national contracts for laboratory supplies, standards, and instruments of known quality and proven reliability.

4.2.2 Procurement Procedures

The specifications for standards, chemical reagents, solvents, gases, water, and other QRIs shall be documented in SOPs. In addition, each laboratory must have SOPs that cover the following:

- Checking purity of standards, reagents, reagent grade water, and other chemicals as appropriate versus intended use
- Preparation, storage and expiration of standards, reagents, and other chemicals as appropriate
- Requirements for lab containers (e.g., volumetric glassware).

Corporate SOPs will be developed for these processes where appropriate. Operation-specific SOPs shall be in place if a corporate SOP does not exist.

Corrective actions for failure of an item to meet required specifications are as follows:

- Review current supplies and eliminate from use; this must include communication to the Quanterra® laboratory network and corporate purchasing to avoid additional problems in other facilities
- Return to vendor
- Evaluate a new lot or alternate supplier

- Evaluate the impact on product or process.

The Corporate Director of Purchasing or the Corporate Director of Quality Assurance shall be notified promptly of any quality problems with national vendors.

4.2.3 Evaluation of QRIs

Most QRIs will be evaluated as a function of the standard analytical process. This involves the analysis of method blanks, as well as other QC samples as described in Section 8.0. For some QRIs, small variability in the item may significantly affect analytical results. For these QRIs the analysis and evaluation must take place prior to using the item. The Corporate SOP CORP-QA-0001; "Quality Testing of Solvents, Acids, and Reagents (QRI Program)"; documents the testing procedures and acceptance criteria. A list of QRIs that require testing prior to use is listed in Table 4.2-1. If any QRI is determined during routine use to be the source of quality problems, or has demonstrated variability that affects analytical results, the QRI may be added to the list in Table 4.2-1. Facility QA Managers must forward such requests to the Corporate Director of Quality Assurance, the Director of Purchasing, and Corporate Technology.

For items that are used regularly by Quanterra® facilities where no unique requirements or specifications are required, the items may be purchased off-the-shelf. These items are ordered from the supplier on the basis of specifications set forth in the supplier's published product description. Off-the-shelf items include general laboratory supplies such as glassware, filter paper, pipettes, and chromatography columns. These items are evaluated as a function of the standard analytical process. An off-the-shelf item can be added to the list in Table 4-2.1 when it is determined that evaluation prior to use is required. Requests to add items to this list are made to the facility QA Manager.

Evaluation of instruments purchased shall be conducted according to the acceptance testing plan as established in the procurement documents. Acceptance criteria may include instrument reliability, sensitivity, stability, accuracy, and ability to interface with existing computer systems and networks.

4.2.4 Special Requirements for Standard Reference Materials

For all standard reference materials (SRMs), Quanterra® will use materials of known quality for the intended use. Where available, SRMs will be traceable to the National Institute of Standards Technology (NIST), the American Association for Laboratory Accreditation (A2LA), or to an equivalent source. If the traceability is not commercially accessible, the best available standard for the material or isotope shall be used. Certificates for Certified Standard Reference Materials (CSRMs) shall be procured from the supplier. Documentation received with each standard shall include the following information as appropriate:

- Traceability to an approved source (where available) or other certificate of analysis
- Radionuclide identification with activity and error
- Reference Material Certificate
- Certification Report that will include pertinent information such as:
  - Starting material characteristics including purity and traceability
  - Expiration date
  - Lot number
  - Preparation date
  - Methods of measurement and associated uncertainty
  - Actual weights and measurements determined by gravimetric or volumetric measurement
  - Unique identifying number
  - Formula weight
  - Density
  - Half-life of radionuclide(s)
  - Mass and volume of standards
  - Percent of impurities

Receipt, storage, evaluation, use, control, and disposal of all standards as well as documentation of these activities are described in operation-specific SOPs. Additional discussion of standards can be found in section 8.5.4.

4.3 Procurement of Subcontract Laboratory Services

A subcontract laboratory is defined, for the purposes of this QAMP, as a laboratory external to the Quanterra® laboratory network. However, for certain federal programs, a branch location of the Quanterra® laboratory network may also be defined as a subcontractor and require client and agency

approval prior to use on a project. If required, Quanterra® will meet those requirements. A subcontracted laboratory will be used only in the event that any of the Quanterra® laboratories do not have the capability or capacity to perform the requested testing, or as directed by the customer. A subcontracted laboratory shall be used only after approval is obtained from the client and the quality of the laboratory is determined to be acceptable according to Quanterra® Corporate SOP Number CORP-QA-0012, "Selection and Evaluation of Subcontractor Laboratories". Once these conditions are met, the subcontract laboratory will be added to an approved subcontractor list maintained in a database.

Subcontracted laboratories may be removed from approved status on the basis of a failure to perform adequately, as a result of audit findings, nationally recognized or other performance evaluation sample results, or at the request of the Corporate Director of Quality Assurance. The QA staff are responsible for evaluating, approving, and recommending subcontractors. The Project Manager of the primary laboratory is responsible for identifying and initiating prequalification of the subcontract laboratory and managing the subcontractor throughout project implementation.

4.4 Vendor Partnerships

Quanterra® may enter into partnership agreements with vendors under the auspices of the technology organization. The purpose of these vendor partnerships is to standardize instruments, data handling systems, and other products or services which enable or enhance our ability to meet or exceed the requirements of our clients. Vendor partnership agreements must meet the requirements in Section 4.1.

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5.0 Documentation and Records

5.1 Quality Documents and Records

Quality documents are those which define the objectives, policies, and procedures that ensure the quality of items and services provided by Quanterra®. A system has been designed to revise, distribute, and control quality documents. Quanterra® quality documents are listed in Table 5.1-1 along with their approval requirements.

Records are completed documents that provide objective evidence of the performance of an item or process. Records are discussed in Sections 5.4 through 5.6.

5.2 Document Review and Revision

Quality documents have multiple levels of review and approval appropriate for the document. These reviews are demonstrated by the signature of the reviewer on the document. Quality documents are required to be periodically reviewed and, if necessary, revised. The frequency of this review is dependent upon the type of document and upon regulations and client requirements. In addition to periodic review and revision, quality documents must be revised when the activity, policy, or procedure they describe changes in a significant manner. Table 5.2-1 lists the Quanterra® quality documents along with their required frequency of review and the individuals responsible for performing those reviews.

5.3 Document Control and Distribution

Document control is necessary to ensure that associates have access to current policies and procedures at all times. Quality documents that are placed under a controlled distribution include, but are not limited to this QAMP, Quality Policy Documents, and SOPs. Format and control of SOPs are described in Quanterra® Policy Number QA-001, "Standard Operating Procedures." QAPPs are also placed under a controlled distribution when that document is generated by Quanterra®.

Quality documents are controlled by initially distributing them to the associates who need to be aware of or follow the contained information or procedures. All subsequent revisions or updates to the document are also distributed to the associate. A controlled copy distribution list is maintained with the name of each associate who received a copy along with their controlled copy number. Records of controlled distribution are maintained by

Quanterra® and demonstrate that current policies and procedures have been issued to all appropriate personnel.

Controlled documents are marked "Controlled Copy" and are numbered according to the controlled copy distribution list. Copies of documents placed under controlled distribution are sometimes released with the understanding that no further updates or revisions of that document will be issued to that individual document holder. Those copies are marked "Uncontrolled Copy" and are not numbered.

5.4 Records Management

Information for each business function of the organization is stored appropriately according to its type of information. Details of the records management program are contained in the Quanterra® Record Retention Policy No. LEG-004 and supporting documents.

Quanterra® is committed to providing scientifically sound, legally defensible data of known and documentable quality. Legally defensible data are referred to as data which will stand against reasonable adversarial inquiry. Data must be supported by a QAPP, client agreements, or the Quanterra® QAMP. Data must also be documented so that the analytical process can be reconstructed.

Project files must be organized so that the project events can be reconstructed if necessary. Accountability for the completeness and accuracy of information must be specified. Supporting information, including data that demonstrates a facility's ability to perform specific analyses, shall be properly maintained.

Records are divided into two distinct types. Quality and project records are discussed in the following sections. Each laboratory shall have a system in place that provides for appropriate and adequate implementation of these records management requirements.

5.4.1 Quality Records

Quality records demonstrate overall laboratory operation. Examples of quality records are the following:

- Instrument logbooks
- Equipment monitoring records
- Calibration records
- Instrument calibration data
- QC sample data
- Standard preparation logbooks
- Standard certificates
- Internal and external PE sample results
- Laboratory licenses and accreditations
- Quality reports to management

- Internal and external audit reports
- Nonconformance memos.

These records may apply to one or more projects, but in general they are applicable to many projects. Quality records must be properly maintained in the facility files.

5.4.2 Project Records

Project records are documents which are specific to a project or a group of samples within an ongoing project. Examples of project records are the following:

- Chain-of-custody forms
- Raw analytical data
- Final data reports with case narrative and cover letter
- QC and calibration results
- Project-specific nonconformance memos
- Project correspondence.

Project records shall be properly maintained.

5.5 Validation of Records

When records, as contained in files, are transferred to a records storage area or off-site storage area, they shall be placed in suitable containers and an inventory sheet prepared by the person submitting the records. The contents of each container will be compared to the inventory sheet and labeled. If there are any discrepancies, the container and inventory sheet shall be returned to the supervisor or Group/Team Leader submitting the records for resolution.

5.6 Retention and Disposal of Records

Quanterra® shall maintain and dispose of records according to the Quanterra® Policy Number LEG-004, "Record Retention".

5.7 Data Confidentiality

Quanterra® considers the data and associated information for a project to be confidential and the property of the client. In order to preserve client confidentiality, reports and supporting records are only released to third party persons or organizations after consultation with the direct client and laboratory management. If however directed by courts-of-law or other competent authorities, such as regulatory agencies, Quanterra® will provide required records and notify its clients and provide information as to the identification of the requester and the records that will be released.

When confidentiality clauses are contained in contractual documents, no information or records are released without first obtaining written approval from the client.

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6.0 Computer Hardware And Software

The purpose of defining controls for computer hardware and software is to protect the integrity of computer-resident data. SOPs shall be put in place to ensure that computer-resident data and programs are accurate, controlled, and secure. The required SOPs and their scope will be presented in the Quanterra® Software Quality Assurance Plan.

Quanterra®'s commitment to meeting good automated laboratory practices is presented in the Quanterra® Corporate Policy Number CORP-IT-013, Software Quality Assurance.

6.1 Use of Hardware

Computer hardware used in the generation, measurement, or assessment of client data shall be of appropriate design and of adequate capacity to function according to specifications. Computer hardware shall be suitably located for operation, inspection, cleaning, and maintenance. The computer shall be installed in accordance with the manufacturer's recommendations. Any changes to the equipment shall be approved by the laboratory Information Technology (IT) representative.

6.2 Security

Procedures shall be in place to insure the integrity of client data. These may include both physical and logical protection and will ensure that access is limited to authorized persons.

Data files will have backup copies made at regular intervals to protect data against accidental loss through a hardware or software failure.

6.3 Use of Software

If computer software is used to acquire, process, or report client data, that software will be tested to ensure that it correctly performs its intended function. Software may be validated or verified, depending upon its complexity, size, and whether it was purchased or developed by Quanterra®. The following definitions are used by Quanterra®:

- Validation - the process of establishing documented evidence which provides a high degree of assurance that a specific process will consistently produce a product meeting predetermined specifications and quality attributes. This process

demonstrates and documents that the software performs correctly and meets all specified requirements.

- Verification - the process of checking the accuracy of automatically (electronically) calculated information.

6.3.1 Industry Standard Software

Industry standard software programs are defined as those which are purchased and widely used without modification to the program itself. The program is initially verified for use by using test problems with known solutions to demonstrate that the program is operational for the desired application.

All purchased software must be used in accordance with the terms of its software license. Any use of software contrary to its license terms is expressly prohibited by Quanterra®.

6.3.2 Quanterra®-Developed Software

For programs used to process client data and developed within Quanterra®, and externally prepared programs which are modified by Quanterra®, validation or verification must be performed. The process used is dependent upon the function of the software as follows:

- Large complex systems consisting of several programs operating in unison to produce an intended result must be validated.

- For smaller software which only performs numerical manipulation, sample sets of numbers for which results are known should be processed and the results verified. In this case, known results are usually generated by performing hand calculations using the same equations and procedures as the software to verify that the software produces identical results.

- Software which performs as part of instrument operation should be verified as previously described and by processing reference materials through the instrument system. Processed instrument response should be evaluated against expected instrument response and performance.

6.3.3 Control of Software Changes

Changes to software used for processing client data shall be controlled and documented according to the procedures presented in the Quanterra® Corporate Policy Number CORP-IT-013, Software Quality Assurance.

6.3.4 Software Revalidation

Whenever a program is changed, the change will be evaluated to determine if revalidation is necessary. If the software has had features added, previous test problems should be rerun to demonstrate that their function has not been affected. New test problems should be

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processed, as previously discussed, to verify added performance. If software revision changes the basic operation of the program, complete revalidation of the program may be required.

Spreadsheets and unprotected software used to acquire, process, or report client data must be documented and reverified when changes are made. The test problems used to provide initial verification shall be reprocessed and the results compared to demonstrate that performance of the software is unchanged.

Laboratory operations is responsible for the generation of the validation and verification data for instrument level software. QA will maintain the necessary documentation. Corporate Information Technology is responsible for generation and maintenance of documentation relating to verification and validation of LIMS system. This is described in the Quanterra® Corporate Policy Number CORP-IT-013, Software Quality Assurance.

6.4 Documentation

Documentation shall be established for system development, change control, validation, verification, and security. Documentation will be retained according to the Quanterra® Records Retention Policy No. LEG-004.

6.5 Computer Viruses

Quanterra® shall employ the use of anti-virus software to detect and remove viruses from software.

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SECTION 7.0

7.0 Planning

The generation of environmental analytical data is an intricate process. Success is dependent upon the timely execution of interrelated steps, many of which may be project-specific. Quanterra® has an organizational system in place to ensure that all projects are properly planned prior to project initiation, and are monitored for conformance to project requirements during the course of the project. This system ensures that Quanterra®'s clients receive quality deliverables, as well as quality service.

Quanterra® communicates with its clients to identify the client's needs. Project Managers (PMs) work together with Customer Service Managers (CSMs), or designee, to assess and coordinate Quanterra®'s resources. Each client is assigned a single point of contact, usually a PM, to ensure that there is a strong line of communication between the client and Quanterra®. Projects receive technical and QA support at the laboratory or corporate level as needed to ensure that project DQOs are achievable.

7.1 Data Collection Process

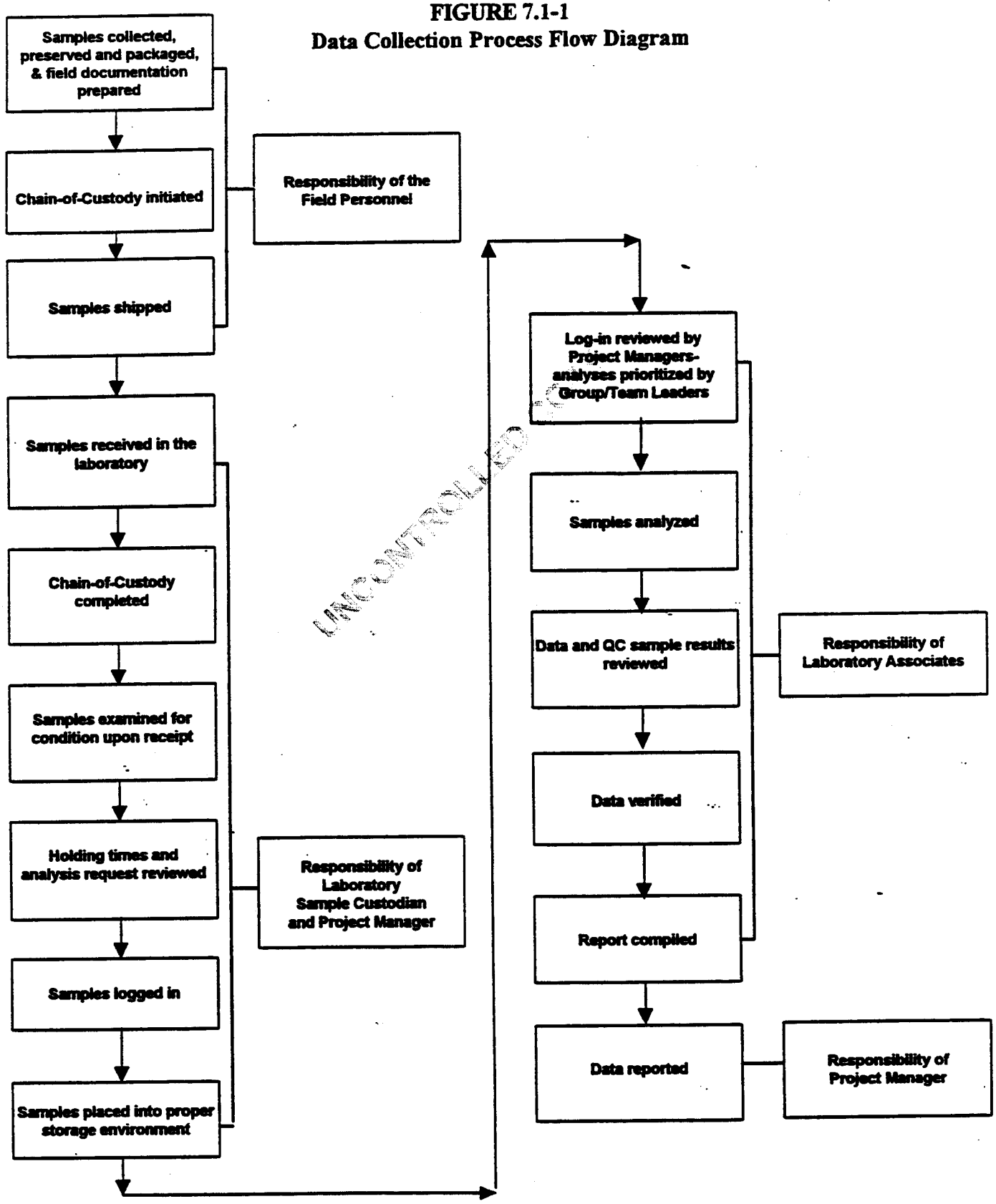
The sample collection and data generation processes are designed to produce analytical data that accurately reflect the nature of the site or sampling point. Figure 7.1-1 shows the sample collection and data collection processes. To ensure our services meet client and project requirements, communication and planning with the client are emphasized. The organization described in Section 7.2 is in place to ensure that these goals are achieved.

7.2 Organizational Responsibilities

Project planning is normally performed within Quanterra® by the operational units. Each operating unit also has the responsibility for customer service within their operating unit. CSMs or designee, Account Managers (AMs), PMs, Operations Managers, and Laboratory Managers play an integral part that will collectively ensure that all projects are thoroughly planned and communicated to all appropriate personnel.

Successful project planning and communication of project requirements ensures that samples will be handled appropriately and that analytical data will be reported in compliance with project requirements. CSMs or designee, AMs, PMs, Lab Managers, and Operations Managers work together to ensure that the following will occur prior to receipt of samples at the laboratory:

FIGURE 7.1-1
Data Collection Process Flow Diagram



- Samples are scheduled for arrival at the laboratory
- All unique project requirements have been identified and communicated to all appropriate personnel
- Standardized client, state, federal, or Quanterra® programs are appropriately selected
- Fully-qualified subcontract laboratories have been selected if needed
- A review has been performed on all pre-project documents such as proposals, contracts, and/or QAPPs to identify unique project-specific requirements
- All appropriate and required preparations have been made at the laboratory to accommodate or meet project requirements as described in proposals, contracts, and/or QAPPs
- It has been determined that the laboratory has the capability and the capacity to analyze the samples
- The laboratory has been determined to be able to meet the required sample holding times and is able to report the resulting data within the time line specified by the client
- All safety hazards associated with the samples have been communicated to all appropriate personnel.

7.3 Determination of Project QC Requirements

A system must be in place to review project documents (e.g., Request for Proposals (RFP), Request for Quote (RFQ), QAPPs, technical Statements of Work (SOW), and other contractual materials) before a project begins. For larger projects this can involve an inter-laboratory Customer Service Team (CST) (see Section 7.5). Within the laboratory it generally involves the CSM or designee working in conjunction with staff from laboratory operations, QA, IT, and management. The goal of the evaluation process is to ensure that client needs and expectations are properly understood, and that the laboratory can meet those requirements. Internal and external communications should be in writing to avoid misunderstandings. The CSM or designee, with support of others in the laboratory, will work with our client to ensure that project requirements are properly aligned with laboratory capabilities.

When QC requirements are not specified by a client, Quanterra® will follow the requirements given in Corporate Policy Number QA-003, "Quanterra® Quality Control Program".

7.4 Communication of Project-Specific Requirements

Each operating unit shall use a Quality Assurance Summary (QAS) (example shown in Figure 7.4-1) or an equivalent summary form to document all project-specific requirements. This document is prepared by the PM for all projects prior to sample receipt

FIGURE 7.4-1 (Page 1 of 2)
Example Quanterra® Quality Assurance Summary

Client: _____
Project Code: _____
Contract Name: _____
Site: _____
Project Mgr: _____
Analysis Type: ____ Chemical ____ Radiochemical

RAD SCREEN by:
_____ Code
_____ Client-Specific
_____ Screens not needed

SAMPLE DISPOSAL:
_____ Disposal by Lab
_____ Return to Client
_____ Archive

QAS No.: _____
Date Initiated: _____
Revision No.: _____
Date Revised: _____

ANY SPECIAL QC DOCUMENTS? ____ Yes ____ No

REPORTING

Report to Client:
_____ Lab PQL
_____ MDL/IDL/MDA
_____ < Client DLs
_____ Other: _____

QC Samples to be Reported:
_____ BLK _____ MS
_____ LCS _____ MSD
_____ DUP
_____ Other: _____

Report Type:
_____ Certificate of Analysis
_____ CLP
_____ Other: _____

Report Grouping:
_____ SDG
_____ Chain-of-Custody
_____ Analytical Batch
_____ Other: _____

Report Deliverables:
____ No. of Hard Copies to: _____
____ Electronic Data Deliverable to: (Diskette Type: _____)
Client: _____
Address: _____
_____
ATTN: _____

Report Deliverables:
____ No. of Hard Copies to:
____ Electronic Data Deliverable to: (Diskette Type: _____)
Client: _____
Address: _____
_____
ATTN: _____

INVOICING

Invoice to:
Client: _____
Address: _____
_____
_____
_____
ATTN: _____

Supporting Documentation:
_____ Certificate of Analysis
_____ RFA/COC
_____ Screening Records
_____ Other (list): _____
_____

No. of Invoices: _____
Special Instructions:
_____
_____
_____
_____

ADDITIONAL COMMENTS OR INSTRUCTIONS:
_____
_____

Project Manager's Approval: _____ Date: _____

FIGURE 7.4-1 (Page 2 of 2)
Example Quanterra® Quality Assurance Summary

Client: _____
Project Code: _____
QAS No.: _____ **Revision No.:** _____

Number of Samples Expected by Matrix:
_____ Air (A) _____ Water (W)
_____ Soil (S) _____ Other (O): _____

Analysis/Product Code	Matrix (circle)	Method Prep/Analysis	QC Samples		Required Reporting Limit/Units/ Report as*	Holding Time (Days)	TAT** (Days)	Radiochemical-Specific	
			Type (circle)	Frequency				Count Time	Sample Size
	A W S O		B LCS DUP MS MSD	per					
	A W S O		B LCS DUP MS MSD	per					
	A W S O		B LCS DUP MS MSD	per					
	A W S O		B LCS DUP MS MSD	per					
	A W S O		B LCS DUP MS MSD	per					
	A W S O		B LCS DUP MS MSD	per					
	A W S O		B LCS DUP MS MSD	per					

* A = "As Is" or D = Dry Weight Basis

**TAT = Turn Around Time

SAFETY HAZARDS: Chemical? _____ No _____ Yes: Define: _____
Radioactive? ____ No ____ Yes:
Isotopes Expected: _____ RSO Approval (sign/date): _____

Special Instructions: _____

Comments: _____

even if an approved QAPP is on file at the laboratory.

Each laboratory shall put into place a system that will ensure that the project-specific requirements are disseminated to all appropriate laboratory personnel prior to project initiation.

To further ensure that project-specific requirements regarding analytical methods, QC, and data reporting are thoroughly understood by the laboratory staff, the PMs may conduct project initiation meetings. For large projects that continue over time, the PMs may hold project refresher meetings to ensure that project requirements are continually being met. The PM takes the lead role in implementation of project requirements at the laboratory including changes in project requirements during the course of a project.

7.5 Customer Service Teams

Each operating unit shall establish and maintain long term and substantive relationships with our clients, identify customer needs, and seek to attain value for our customers according to our customers' definitions. An operating unit may create, at any time, client-specific Customer Service Teams (CST). A CST may be created before any discrete projects exist, during on-going projects, or even after the completion of a project. A CST generally contains a CSM, an AM, a PM, a QA representative, and an IT representative. The team may also contain associates from the operations, technical, contracts, and/or accounting organizations.

7.6 Contingency Planning

An effective QA Program must emphasize contingency planning, actions to prevent problems from reoccurring, and to ensure timely and effective completion of a measurement effort. The following are considered relative to contingency planning:

- Staffing - A primary objective is to ensure that qualified staff are always available to perform the necessary analytical work, regardless of employee turnover, vacation (personal time off), illness, or other absence. Sources of qualified staffing may include temporary agencies specializing in providing technically trained personnel and other Quanterra® facilities. Employee qualification requirements are described in Section 3.0.

- Redundant Instrumentation or Equivalent Methods - At most locations, duplicate instrumentation may be available to ensure uninterrupted work flow. A laboratory may also choose to lease equipment when there is a sufficient time window prior to arrival of samples. However, in circumstances where a catastrophic instrument failure occurs, alternative but equivalent methods may be recommended to the client for approval and implementation.

- Preventive Maintenance - Quanterra®'s preventive maintenance program is designed to minimize analytical instrument malfunctions, permit simple adjustments, and to ensure fewer and shorter breakdowns of critical analytical equipment. (See Section 8.11, "Preventive Maintenance and Service".)

- Network Laboratories & Subcontractor Laboratories - To support the laboratory during peak periods or in the event of a critical instrument malfunction, Quanterra® has the capability to arrange the use of other network laboratories or qualified analytical laboratories as subcontractors for short-term backup analytical support. Through an extensive process, QA personnel evaluate, identify, and select qualified analytical laboratories before an analytical contract is awarded. In order to qualify, a subcontractor laboratory must pass this evaluation. Furthermore, any use of a subcontractor laboratory is approved by the client prior to award of a contract or sample shipment for existing contracts.

- Uninterruptable Power Supply - An Uninterruptable Power Supply (UPS) system which provides line conditioning and backup power to the LIMS computer system/server. This contingency plan allows sufficient time for the main computer system to be shut down and for data archival. All electronically generated data that are stored on the main computer system and on the individual personal computer (PC) hard drives are backed up at regular intervals. In the event that the main laboratory computer system fails, the analytical data can be retrieved from the PC hard drives.

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8.0 Work Processes and Operations

Much of the environmental project activity is planned and designed externally to the laboratory or field operation and presented in the form of a contract, work plan, or QAPP. Laboratory and field activities are in turn planned, implemented, and assessed to meet client requirements according to approved procedures and methodologies. The QAMP provides the systems to document and implement these activities. The execution and assessment of the implemented operational systems are detailed in Quanterra® corporate or operation-specific SOPs. The entire process is assessed on a regular basis for conformance to prescribed requirements.

Standard practices for Quanterra® operations are detailed in this section. Specific project or program requirements which differ from those described here can be met. These must exist in approved contracts, work plans, or QAPPs.

8.1 Standard Operating Procedures

SOPs are required in all Quanterra® operating units for analytical and administrative activities from the receipt of samples in the laboratory through analysis, reporting, and subsequent sample disposition. Training, health and safety procedures, QC, method procedures, and instrument and equipment calibrations are included in SOPs. Preprinted forms, either standardized across Quanterra® through a Corporate SOP requirement, or shown as an example form when not standardized, are included in SOPs as appropriate. Standard SOP formats for all activities related to the generation and reporting of data are discussed in the Quanterra® Quality Policy Document No. QA-001, "Standard Operating Procedures". SOPs shall be reviewed by technically-qualified associates. SOPs are controlled documents and are distributed and maintained as described in this policy. SOP requirements for approval and frequency of review are given in Tables 5.1-1 and 5.2-1.

8.2 Analytical Methods

Whenever possible, Quanterra® operations use industry- and regulatory agency-recognized analytical methods from source documents published by agencies such as the Environmental Protection Agency (EPA), Department of Energy (DOE), the American Society for Testing and Materials (ASTM), and the National Institute for Occupational Safety and Health (NIOSH) as described in Quanterra®'s SOPs. The analytical methods

performed by Quanterra® are given in Section 4 of the Facility Appendix for each laboratory. A list of methods routinely performed by Quanterra® is given in Table 8.2-1.

Method performance data (i.e., detection limits, precision and accuracy data) are developed by the laboratory operations staff. The operations staff and the QA staff will evaluate and must approve the performance data before a methodology is performed routinely. The method must also be described and documented with an SOP. In the event that the laboratory staff is required to modify a procedure to meet a unique project requirement, the client will be notified to obtain written approval prior to implementing the change.

All SOPs contain Quanterra®'s interpretation of the published methods. Significant modifications to the published method are described in the SOP. Operations are performed as described in these SOPs. Changes in procedure which may occur due to sample matrix or other events shall be documented in the project-specific case narratives or in QAPPs.

8.3 *Data Quality Objectives*

Data quality objectives (DQOs) are qualitative and quantitative statements used to ensure the generation of the type, quantity, and quality of environmental data that will be appropriate for the intended application (EPA 1994)[1]. Typically, DQOs are identified during project scope and the development of sampling and analysis plans. In this QAMP, however, we refer to only the analytical DQOs because laboratories generally do not have any authority over sample collection, shipment, or other field-related activities that may affect the data quality of the environmental sample before the sample is received in the laboratory. The EPA has established six primary analytical DQOs for environmental studies. These DQOs are precision, accuracy, representativeness, completeness, comparability, and detectability.

The components of analytical variability (uncertainty) can be estimated when QA and QC samples of the right types and quantities are incorporated into measurement procedures at the analytical laboratory. Quanterra® incorporates numerous QA and QC samples to obtain data for comparison with the analytical DQOs and to ensure that the measurement system is functioning properly. The QA/QC samples and their applications, described in Section 8.4, are selected on the basis of method- or client-specific requirements. Field

[1] "Guidance for the Data Quality Objectives Process", EPA 600/R-96/005, September 1994.

blanks, field duplicates, and performance evaluation (PE) samples are received from the client as unknown samples. Analytical laboratory QC samples for inorganic, organic, and radionuclide analyses may include calibration or instrument blanks, method blanks, background, duplicates, replicates, laboratory control samples (LCSs), calibration standards, matrix spikes (MSs), matrix spike duplicates (MSDs), surrogate spikes, and yield monitors.

8.3.1 Precision And Accuracy

Precision is an estimate of variability, that is, it is an estimate of agreement among individual measurements of the same physical or chemical property, under prescribed similar conditions. The precision of a measurement system is affected by random errors. Precision is expressed either as relative standard deviation (RSD) for replicate measurements greater than two or as relative percent difference (RPD) for duplicate measurements. Table 8.6-1 illustrates the formulae used to calculate units of precision (i.e., RSD and RPD).

Accuracy is the degree of agreement between a measurement and the true or expected value, or between the average of a number of measurements and the true or expected value. Systematic errors affect accuracy. For chemical properties, accuracy is expressed either as a percent recovery (R) or as a percent bias (R - 100).

The precision and accuracy DQOs that are to be used in evaluating inorganic, organic, and radionuclide constituents at Quanterra® are provided in Tables 8.4-5, 8.4-6, and 8.4-7, method-specific SOPs, and in the documentation for the analytical method of interest.

Precision and accuracy are determined, in part, by analyzing data from matrix spike and matrix spike duplicates, unspiked duplicates, LCSs, and single blind audit samples. For radiochemical determinations, counting statistics can also provide an estimate of uncertainty. A description of these QC samples is provided in Section 8.4.

8.3.2 Completeness

Completeness is a measure of the percentage of measurements that are judged to be valid measurements. At a minimum, the objective for completeness of data is 90% for each constituent analyzed.

8.3.3 Representativeness

Representativeness is the degree to which data accurately and precisely represent a

characteristic of a population, a variation in a physical or chemical property at a sampling point, or an environmental condition. Data representativeness is primarily a function of sampling strategy; therefore, the sampling scheme must be designed to maximize representativeness. Representativeness also relates to ensuring that, through sample homogeneity, the sample analysis result (concentration) is representative of the constituent concentration in the sample matrix. At each Quanterra® laboratory, every effort must be made to analyze an aliquot that is representative of the original sample, and to ensure the homogeneity of the sample before subsampling.

8.3.4 Comparability

Comparability is a measure of the confidence with which one data set can be compared to another. To ensure comparability, all laboratory analysts are required to use uniform procedures (i.e., SOPs) and a uniform set of units and calculations for analyzing and reporting environmental data.

8.3.5 Method Detection Limits

It is Quanterra® policy to strictly follow the specification in the U.S. EPA 40 CFR Part 136 Appendix B in determining MDLs for chemical tests. The Quanterra® requirement for this procedure is further detailed in Quanterra® Policy Number QA-005 entitled "Determination of Method Detection Limits for Chemical Tests." This policy requires that the MDLs be determined for each analyte of interest representing the aqueous and solid matrices within the capability of the primary analytical methods. Following the EPA's guidelines, Quanterra® does not provide MDLs for each instrument representing a group of constituents using the same analytical techniques. This policy is based on the statement in the scope and application of the CFR procedure which states that "The MDL procedure was designed for applicability to a broad variety of physical and chemical methods. To accomplish this the procedure was made device- or instrument-independent." Exceptions to this approach are described in Quanterra® Corporate Policy Number CORP-QA-005, "Determination of Method Detection Limits for Chemical Tests". MDLs determined by each laboratory are listed in Section 5 of the Facility Appendix to this QAMP.

8.3.6 Instrument Detection Limits

Instrument Detection Limits (IDLs) are required to be performed quarterly for metals constituents when analyses are performed in support of Comprehensive Environmental Response, Compensation and Liability Act

(CERCLA) activities or when the USEPA CLP SOW protocol is required. The requirement for this procedure is described in the Quanterra® Policy Number QA-014, "Determination of Instrument Detection Limits."

IDL samples are introduced at a later stage of the analytical process so that the IDL is a more direct indication of instrument sensitivity. The primary distinction is that the IDL estimates the detection limit of the instrument under ideal conditions, whereas the MDL estimates the detection limit in more-practical terms by subjecting a known concentration matrix to the total method process. IDLs are not required by the SW-846 methods, except for method 6020 where the IDLs are a requirement.

When required, IDLs will be performed in accordance with the procedures defined in the applicable USEPA SOW, ILMO3.0 or subsequent versions, and Quanterra® Policy Number QA-014, Determination of Instrument Detection Limits.

Prior to acceptance and use for reporting purposes, all data from detection limit studies and reporting limits must undergo technical review and approval by the laboratory management and QA staff.

8.3.7 Reporting Limits

Two reporting limit conventions are used within Quanterra®: the Reporting Limit (RL) and the Project-Specific Reporting Limit (PSRL). The RL is a uniform, Quanterra®-wide, reporting limit based on an evaluation of the Practical Quantitation Limits (PQLs) at Quanterra® laboratories and the expected method performance in routine water and soil matrices. The PQL is the lowest concentration a method can reliably achieve within limits of precision and accuracy and is derived from empirical, matrix-free method performance studies. The Quanterra® RLs and PSRLs are maintained in the LIMS.

Reporting limits are established and modified within Quanterra® according to the Corporate SOP Number QA-009, "Reporting Limits."

PSRLs are used when project data quality objectives (DQO) require a reporting limit other than the RL. PSRLs tailor Quanterra®'s product to meet customer requirements.

For radiochemistry, whether the net result is negative, zero, or positive, the actual calculated result is reported with its associated propagated uncertainty. The minimum detectable amount (MDA) is affected by many factors, such as the length of count, chemical yield, half-life, background of the instrument,

counting efficiency, and the matrix interference. The MDA for radiochemical analyses is defined as the smallest concentration of material that yields a net count above background with a 95 percent probability (a true signal is reported 95 percent of the time) and no greater than a 5 percent probability of calling a blank a true signal. MDAs are determined according to Quanterra® Policy Number QA-007, "Determination of Minimum Detectable Amount for Radiochemical Tests."

8.4 Quality Control Samples

Two types of Quality Control (QC) samples are field QC samples and laboratory QC samples. Field QC samples are collected during the sampling event and are useful in determining sampling precision and accuracy and monitoring for contamination that may occur during collection, transport or storage of environmental samples. Laboratory QC samples are routinely added at the laboratory to the normal sample stream. Successful analysis of these samples demonstrates that the laboratory is operating within prescribed requirements for accuracy and precision. In addition, utilizing matrix-specific laboratory QC samples, information regarding the effect of the matrix or field conditions on the analytical results can be obtained. The following sections describe common field and laboratory QC samples.

8.4.1 Field QC Samples

When field QC sample collection and analysis are required for a project, it is the responsibility of the project sampling supervisor to ensure that this sampling is performed correctly and at the project-required frequencies. Field QC samples may or may not be identified as such to the laboratory and are considered by the laboratory as field samples for the purpose of QC batching, sample preparation and analysis. Field QC sample results are reported in the same manner as actual field samples, unless a specific deliverable is requested by the client. No correction of the analytical data is done in the laboratory based on the analysis of field QC samples.

Field QC sample types, applicability to organic and inorganic analyses, precision and accuracy applications and by whom they are introduced are summarized in Table 8.4-1. The following sections provide descriptions of field QC samples.

8.4.1.1 Trip Blank

Volatile organic samples are susceptible to contamination by diffusion of organic

contaminants through the septum of the sample vial. Trip blanks, also referred to as travel blanks, are analyzed to monitor for possible sample contamination during shipment for volatile organics only. Trip blanks are prepared by filling preserved VOA vials (with no headspace) with organic-free water. Trip blanks accompany the sample bottles during collection and shipment to the laboratory and are stored with the samples.

8.4.1.2 Rinsate Blank

A rinsate blank or equipment blank is a volume of rinse solution (deionized, distilled water or organic solvent) used to rinse a sampling tool. The rinse solution is collected after the sampling equipment has been cleaned in order to demonstrate that there is no residual contamination remaining on the tool that would carry over into the next sample.

8.4.1.3 Field Blank

A field blank is a contaminant-free volume of water or soil that is provided by the sample collector to demonstrate the absence of contamination introduced during sampling. Deionized, distilled water or previously-prepared solid material (e.g., Ottawa sand) is placed into sample containers by the sample collection crew, packaged, and shipped with the other field samples.

8.4.1.4 Field Duplicate

A field duplicate sample is a replicate taken from the same sampling event for that location. The field duplicate sample is submitted to the laboratory as a separate sample by the sample collection personnel. Results of field duplicate samples can provide a measure of sampling precision.

8.4.1.5 Field Matrix Spike

A field matrix spike sample is created by spiking target analytes into a sample in the field at the point of sample acquisition. These sample results provide information on the target analyte stability after collection and during transport and storage.

8.4.1.6 Collocated Samples

Collocated samples are independent samples collected in such a manner that they are equally representative of the variable(s) of interest at a given point in space and time. Examples of collocated samples include: samples from two air quality analyzers, sampling from a common sample manifold, or two water samples collected at the same time and from the same point in a lake.

Collocated samples processed and analyzed by the same organization provide intralaboratory precision information for the entire measurement system including sample acquisition, handling, shipping, storage, preparation, and analysis. Both samples can be carried through the steps in the measurement process together to provide an estimate of short-term precision for the entire measurement system. Likewise, the two samples, if separated and processed at different times or by different people, and/or analyzed using different instruments, provide an estimate of long-term precision of the entire measurement system. Collocated samples processed and analyzed by different organizations provide interlaboratory precision information for the entire measurement system.

8.4.1.7 Split Sample

A split sample is a sample divided into two portions at the sampling site. One portion is sent to a different organization or laboratory and subjected to the same environmental conditions and steps in the measurement process as the other portion sent to another laboratory.

A split sample can be divided into portions at different points in the sampling and analysis process to obtain precision information on the various components of the measurement system. For example, a field split sample provides precision information about all steps after sample acquisition including the effects of storage, shipment, analysis, and data processing. Field split sample results may also reflect the degree of sample homogeneity.

8.4.2 Laboratory QC Samples

Laboratory performance QC is required to ensure the laboratory systems (instrumentation, sample preparation, analysis, data reduction, etc.) are operating within acceptable QC guidelines during data generation as required to meet the client's objectives. Laboratory QC samples consist of method blanks (MB), instrument blanks, laboratory control samples (LCS) and calibration verification samples. In addition to laboratory performance QC, matrix-specific QC is utilized to determine the effect of the sample matrix on the data being generated. Typically, this includes matrix spikes (MS), matrix spike duplicates (MSD), sample duplicates, and the use of surrogate compounds.

Laboratory and matrix-spike QC sample types are summarized in Tables 8.4-2, 8.4-3 and 8.4-4. In addition, Tables 8.4-5, 8.4-6 and 8.4-7 list laboratory QC samples, acceptance criteria and corrective actions by

reference method for inorganic methods, organic methods, and the USEPA CLP Statements of Work respectively. The following sections provide descriptions of laboratory QC samples and their frequency of use. Quanterra® Policy Number QA-003, "Quanterra® Quality Control Program", describes in detail the QC data evaluation process.

8.4.2.1 Quality Control (QC) Batch

The QC batch consists of a set of up to 20 field samples that behave similarly (i.e., same matrix) and are processed using the same procedures, reagents, and standards within the same time period. This definition of a QC batch is utilized by Quanterra® unless there is clear regulatory guidance, contract specifications, or differing client requirements that are explicitly documented. Further details and requirements for the application of the definition of QC batch are described in QA Policy Number QA-003.

8.4.2.2 Method Blank

The method blank (MB) is a QC sample that consists of all reagents specific to the method and is carried through every aspect of the procedure, including preparation, cleanup, and analysis. The method blank is used to identify any interferences or contamination of the analytical system that may lead to the reporting of elevated analyte concentrations or false positive data. Potential sources of contamination include solvent, reagents, glassware, other sample processing hardware, or the laboratory environment. In general, the method blank is a volume of deionized laboratory water for water samples, or a purified solid matrix for soil/sediment samples, that is processed as a sample. In the event that no appropriate solid matrix exists, deionized water may be used. The volume or weight of the method blank must be approximately equal to the sample volume or sample weight processed. A method blank shall be prepared with each group of samples processed.

8.4.2.3 Instrument Blank

The instrument blank is an unprocessed aliquot of reagent used to monitor the contamination of the analytical system at the instrument. System contamination may lead to the reporting of elevated analyte concentrations or false positive data. The instrument blank does not undergo the entire analytical process and generally consists of an aliquot of the same reagent(s) used for a sample dilution. Instrument blanks are also referred to as continuing calibration blanks.

8.4.2.4 Laboratory Control Sample

A laboratory control sample (LCS) is a laboratory-generated clean matrix sample that is fortified with target analytes. Review of the LCS recovery data is used to monitor the performance of the analytical methods. Day to day performance is characterized by the measure of the accuracy of the results. On-going monitoring of the LCS results provides evidence that the laboratory is performing the method within both acceptable accuracy and precision guidelines. The results of the LCS, used in conjunction with the MS samples can provide evidence of whether the laboratory performed the method correctly or the sample matrix affected the results. When a laboratory control sample duplicate (LCSD) is required, a percent recovery may be calculated, as well as a relative percent difference (RPD) between the LCS and the LCSD.

8.4.2.5 Matrix Spike

A matrix spike (MS) is an environmental sample to which known concentrations of target analytes have been added. MS samples are analyzed to evaluate the effect of the sample matrix on the analytical methodology. MS samples are generated by taking a separate aliquot of an actual client sample and spiking it with the selected target analyte(s) prior to sample extraction. The MS sample then undergoes the same extraction and analytical procedures as the unfortified client sample. Due to the potential variability of the matrix of each sample, these results may have immediate bearing only on the specific sample spiked and not on all samples in the QC batch.

8.4.2.6 Matrix Spike Duplicate

A matrix spike duplicate (MSD) is a second aliquot of a sample that is spiked with the selected target analyte(s) and analyzed with the associated sample and MS sample. The results of the MS and MSD are used together to determine the effect of a matrix on the accuracy and precision of the analytical process. Due to the potential variability of the matrix of each sample, the MS/MSD results may have immediate bearing only on the specific sample spiked and not all samples in the QC batch.

8.4.2.7 Sample Duplicate

A sample duplicate is a second aliquot of an environmental sample taken from the same sample container that is processed identically with the first aliquot of that sample. That is, sample duplicates are processed as independent samples within the same QC batch. The results are compared

to determine the sample homogeneity and the precision of the analytical process.

8.4.2.8 Surrogates

Surrogates are organic compounds that are similar in chemical composition and behavior to the target analytes but that are not normally found in environmental samples. Surrogates are added to all appropriate samples and QC samples being tested for organic analytes to monitor the effect of the sample matrix and the procedure on the accuracy of the process.

8.4.2.9 Analytical Spike

An analytical spike is created by spiking target analytes into a prepared portion (i.e., post digestion) of a sample just prior to analysis. It provides information on matrix effects encountered during analysis such as suppression or enhancement of instrument signal levels. It is most often used in elemental analysis involving various forms of atomic emission or atomic absorption spectroscopy. A single analytical spike serves as a single point application of the "method of standard additions" or MSA.

8.4.2.10 Interference Check Sample

An interference check sample (ICS) is a solution containing known concentrations of both interfering and analyte elements. Analysis of this sample can be used to verify background and interelement correction factors.

8.4.2.11 Internal Standards

An internal standard (IS) is a compound or element with similar chemical characteristics and behavior in the analysis process to the target analytes, but is not normally found in environmental samples. The internal standard is usually added after sample preparation. The primary function of the internal standard is quantitation, however, it also provides a short-term indication of instrument performance. For isotope dilution methods, internal standards are added during sample preparation and are used for quantitation.

8.4.2.12 Radiological QC Samples

The primary QC sample type used for radiological testing to monitor recovery is the yield monitor. The two types of yield monitors are tracers and carriers. A tracer is a radioisotope, usually of the same element and having the same mode of decay as the analyte. A carrier is a non-radioactive solution added to assist in isolating the specific isotope of an element. When

standardized, the carrier can also provide recovery information gravimetrically.

Radiological QC samples and their required frequencies are listed in Section 7 of the Facility-Specific Appendix when applicable.

8.5 Data Collection Operations

Laboratory analyses are designed to produce data that are representative of existing conditions present at the time the sample was obtained. The data collection design includes field sampling events, sample handling and custody, analytical operations, data recording procedures, data assessments, data verification, and data reporting requirements and techniques to assess limitations of data use. These operations are discussed in Sections 8.5 through 8.10.

8.5.1 Field Collection and Shipment

In order to provide a sample that most accurately represents the test matrix, field sample collection personnel must abide by the sample collection guidelines and procedures established by involved regulatory agencies. A significant part of the efforts of regulatory agencies include the use of "approved" sample containers, chemical and physical preservation techniques, and observance of specified holding times. It is imperative that all samples be collected and preserved according to the appropriate analytical method specified in the QAPP (if one exists). Although the sampling may be performed by non-Quanterra® personnel, the importance of sampling and transportation of the sample to the laboratory is understood and must be considered during data validation.

Sampling requirements must be communicated to the sampling team prior to field collection.

Field personnel are responsible for labeling each individual sample collected with the following information:

- Project number
- Unique sample number
- Sample location (including as appropriate: borehole and depth or grid coordinates)
- Sampling date and time
- Sample preservation
- Analysis required.

An overriding consideration for the resulting analytical data is the ability to demonstrate that the samples have been obtained from the locations stated and that they have reached the laboratory without alteration. Evidence of collection, shipment, laboratory receipt,

laboratory custody, and disposal must be documented to accomplish this. Figure 8.5-1 shows an example Chain-of-Custody (COC) form that is used by the Quanterra® laboratory network to document this evidence. Field personnel are responsible for initiating the COC form.

The prompt shipment of samples to the laboratory is necessary to ensure that required holding times are met. Samples should be shipped by an overnight carrier, be hand-delivered, or transported in a manner that assures prompt delivery to the laboratory.

Some sites require an extensive radioactive screening process before a sample may be shipped. In these cases, it is imperative for the Project Manager to maintain good communications with the client to assure proper staffing of the laboratory in response to a decreased holding time.

Radioactive samples that are shipped to Quanterra® radiochemistry operations must be screened upon receipt and found not to contain radioactivity that exceeds the level stated in the laboratory's operation license. Samples received by a Quanterra® facility containing radioactivity exceeding their license limit will immediately be returned to the project site.

8.5.2 Sample Containers, Shipping Containers, Preservatives, and Holding Times

8.5.2.1 Sample Containers

A sample container is defined as the sealed enclosure, usually made of plastic or borosilicate glass that the sample is collected in and stored in until analysis. All sample containers provided by Quanterra® operations for environmental sampling are new, with the exception of some air sampling canisters, which must be recertified before reuse, and demonstrated to be clean for their appropriate use. All documentation certifying sample container cleanliness must be maintained by the laboratory or the vendor and can be provided to the client upon request. The sample containers to be supplied are listed in Tables 8.5-1 through 8.5-5. Sample containers provided to the client by Quanterra® are transmitted under custody.

8.5.2.2 Shipping Containers

Shipping containers are defined as the sealed enclosure in which the sample containers are stored during shipment from the sample collection site to the analytical laboratory. Shipping containers must be of sufficient number and size to accommodate the samples in an upright condition. Shipping containers must also meet all requirements for the

Quanterra®

FIGURE 8.5-1
Example Quanterra® Chain-of-Custody Form

Reference Document No. _____
Page 1 of _____

Project Name/No.: _____
Sample Team Members: _____
Profit Center No.: _____
Project Manager: _____
Purchase Order No.: _____
Required Report Date: _____

Sample Shipment Date: _____
Lab Destination: _____
Lab Contact: _____
Project Contact/Phone: _____
Carrier/Waybill No.: _____

Bill To: _____

Report To: _____

ONE CONTAINER PER LINE

Sample Number	Sample Description/Type	Date/Time Collected	Container Type	Sample Volume	Preservative	Requested Testing Program	Condition on Receipt	Disposal Record No.

Special Instructions:

Possible Hazard Identification:
Non-hazard ❑ Flammable ❑ Skin Irritant ❑ Poison B ❑ Unknown ❑

Sample Disposal:
Return to Client ❑ Disposal by Lab ❑ Archive _____ (mos.)

Turnaround Time Required:
Normal ❑ Rush ❑

QC Level:

1. Relinquished by: *(Signature/Affiliation)*	Date: / Time:	1. Received by: *(Signature/Affiliation)*	Date: / Time:
2. Relinquished by: *(Signature/Affiliation)*	Date: / Time:	2. Received by: *(Signature/Affiliation)*	Date: / Time:
3. Relinquished by: *(Signature/Affiliation)*	Date: / Time:	3. Received by: *(Signature/Affiliation)*	Date: / Time:

Comments:

shipment of environmental and/or radioactive samples.

Packaged samples must be shipped to the analytical laboratory in a safe manner that preserves the integrity of the samples. The most common method of sample shipment employs coolers or ice chests that are sealed with custody tape and shipping tape. These coolers must be durable and resistant to crushing during shipment. All coolers must be well maintained and cleaned to prevent cross-contamination of the samples. It is the ultimate responsibility of the person collecting and packaging the sample for shipment to ensure that the shipping containers are clean and functional.

To help prevent sample breakage during shipment, additional consideration must be given to providing shock absorbency to all samples packaged inside the shipping container. Use of bubble-wrap around each sample container is the best way to provide this protection. Foam packing materials and vermiculite are also successfully used.

8.5.2.3 Sample Preservatives

Most analytes have a finite holding time in a given sample matrix. Sample preservation is the chemical or physical means by which samples are treated during and/or following sample collection to aid in the stability of the analytes of interest in that matrix. Sample holding times are also adversely affected when samples are improperly preserved, or shipped unpreserved. The preservation of samples at the time of sample collection will follow the requirements of the analytical methods used. This preservation includes the addition of reagents to deter chemical and biochemical degradation and the maintenance of refrigeration during transit and ultimate storage in the laboratory. The required preservatives for the analysis to be performed on each matrix are included in Tables 8.5-1 through 8.5-5.

8.5.2.4 Sample Holding Times

Holding time is defined as the maximum allowable time a sample can be stored after sample collection and preservation (or laboratory receipt for CLP) until appropriate processing occurs (preparation or analysis). The holding time may vary according to method or client requirements. Tests designated with holding times as "analyze immediately or ASAP" are considered parameters that should be tested by field personnel or on-site. Each operation has a system in place to ensure that holding times are monitored by each group within the operating unit. It is the responsibility of each Quanterra® associate processing the sample to

assure that holding times are met. Quanterra® laboratories are responsible for meeting all holding times for properly preserved samples received within 48 hours of collection or if less than half the holding time has passed at the time of sample receipt if the sample is received after 48 hours of collection. If these conditions are not met, Quanterra® will attempt to expedite sample analysis as soon as possible.

Sample holding times are listed in Tables 8.5-1 through 8.5-5.

8.5.3 Sample Handling

Each Quanterra® laboratory has a SOP describing sample receipt and log-in in detail. The following sections describe the general program followed by all Quanterra® laboratories.

8.5.3.1 Sample Receipt

Samples shall be received and logged in at Quanterra® operations by a designated sample custodian or other properly trained associate. Upon sample receipt, the sample custodian shall, as appropriate:

- Wear appropriate personal protective equipment. At a minimum, this consists of gloves, a lab coat, safety glasses, and in some cases a respirator
- Examine the shipping containers to verify that the custody tape is intact
- Examine all sample containers for damage
- Open shipping containers in adequately ventilated areas to assure worker safety
- Determine if the temperature required by the requested testing program has been maintained during shipment. Document the shipping container temperature on the COC
- Compare samples received against those listed on the COC
- Verify that sample holding times have not been exceeded
- Examine all sample records for accuracy and completeness
- Determine sample pH (if required for the scheduled analysis) and record on the COC
- Sign and date the COC immediately (only after shipment is accepted) and attach the waybill
- Note any problems associated with the samples on the COC, immediately initiate a Condition Upon Receipt Report, and notify the PM who in turn notifies the client
- Attach appropriate laboratory sample container labels with laboratory identification number and test
- Place the samples in proper laboratory

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storage.

A CUR is generated by sample control during the sample log-in process to document anomalies identified upon the receipt of samples in the laboratory. These anomalies are outside of laboratory control and do not require corrective actions to be taken within the laboratory. The affected client shall be notified by the PM or designee of all CURs generated for their samples. The PM is responsible for resolving with the client how to proceed with the samples. CURs must be resolved prior to sample preparation and analysis. The completed CUR form shall be stored the project file. An example CUR is shown in Figure 8.5-2.

8.5.3.2 Sample Log-in

Sample log-in activities at Quanterra® operating units are fully documented in operation-specific SOPs. The following is a general description of the log-in process:

- Enter the samples in the laboratory sample log-in book, and/or the LIMS which contains the following information at a minimum:
  - Project identification number
  - Sample numbers (both client and laboratory)
  - Type of samples
  - Required tests
  - Date received at the laboratory
- Assess sample holding times
- Notify the PM and appropriate Group/Team Leader(s) of sample arrival
- Place the completed COCs, waybills, and any additional documentation in the project file.

8.5.3.3 Sample Storage

The primary considerations for sample storage are:

- Maintenance at the prescribed temperature, if required
- Maintenance of sample integrity through adequate protection from contamination from outside sources or from cross-contamination of samples. Low-level and high-level samples, when known, must be stored separately. Samples and standards must be stored in separate refrigerators or freezers. Storage areas for volatile organic test requests should be monitored twice per month by the analysis of a holding blank (an aliquot of contaminant-free water stored in a VOA vial)
- Security of samples within the laboratory.

The requirements listed in Tables 8.5-1 through 8.5-5 for temperatures and holding times shall be used. Placing of

FIGURE 8.5-2

Example Quanterra® Condition Upon Receipt Anomaly Report (CUR)

Page 1 of 2

CUR No.: _____
Lot: _____

Client: _____
Project Name: _____

Date Received: _____
Initiated By: _____
RFA/COC Nos.: _____

Condition/Anomaly/Variance (select from legend on back):

Client Sample ID	Analysis Requested	Condition (see legend)	Comments/Actions

Corrective Action:

- ☐ Client informed verbally on: _____ By: _____ In writing on: _____ By: _____
- ☐ Sample(s) processed "as is"
- ☐ Sample(s) ON HOLD until further notice
- ☐ Other action required (see above comments)
- ☐ No action required.

Sample Control Reviewer: _____ Project Manager: _____

SIGNED ORIGINAL MUST BE RETAINED IN THE PROJECT FILE

FIGURE 8.5-2
Example Quanterra® Condition Upon Receipt Anomaly Report (CUR)
Page 2 of 2

Legend:

Cooler:
1a Not received, COC available
1b Leaking
1c Other: _____

Temperature:
2a Temp. Blank: _____
2b Cooler Temp: _____
(cooler temp should only be used if there is no Temp. Blank)

Containers:
3a Leaking
3b Broken
3c Extra
3d No labels
3e Headspace (VOA only)
3f Other: _____

Samples:
4a Samples received but not on COC
4b Samples not received but on COC
4c Holding Time Expired
4d Sample Preservative: _____
4e Other: _____

Custody Seals:
5a None
5b Not intact
5c Other: _____

Chain of Custody (COC):
6a Not relinquished by client
6b Incomplete information
6c Other: _____

Container Labels:
7a Doesn't match COC
7b Incomplete information
7c Marking smeared
7d Label torn
7e Other: _____

Other (8): _____
_____
_____

SIGNED ORIGINAL MUST BE RETAINED IN THE PROJECT FILE

samples in the proper storage environment is the responsibility of sample control personnel. Quanterra® operations will assign individuals the responsibility of notifying the Operations Manager and Group/Team Leaders if there are any samples which must be analyzed immediately because of holding time requirements.

8.5.3.4 *Internal Sample Chain-of-Custody and Interlaboratory Transfers*

Sample custody within Quanterra® laboratories is described in operation-specific SOPs. The sample custody documentation shall include the following minimum requirements:

- Name of associate taking custody of the sample from the sample storage area for preparation or analysis
- Dates sample removed from and returned to the sample storage area
- Identification of tests to be performed on the sample aliquot(s) selected by the associate
- Sample matrix
- Laboratory sample numbers
- Sample storage location.

Additional custody records can be provided by a facility at the specific request of the client. Access to all Quanterra® facilities is restricted to prevent any unauthorized contact with samples, extracts, or documentation.

Samples transferred to a different laboratory than the original receiving facility are transferred under chain-of-custody (COC). The COC is maintained whether the laboratory is another Quanterra® facility or a subcontracted laboratory. If the entire sample volume is transmitted, the original copy of the client's COC form will be used to document the relinquishing of the sample and will accompany the sample to its destination. A copy of the completed COC form shall be retained in the laboratory project file. In the case where an aliquot of a sample is shipped from the laboratory, a new COC will be generated by the laboratory and shipped with the sample aliquot. The original COC will be retained in the project file at the site holding the original sample container.

Samples are not transferred to other Quanterra® facilities or to subcontractor laboratories without prior approval of the client.

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8.5.3.5 Sample Disposal and Return Chain-of-Custody

After the requested analyses on the samples have been completed, any remaining portions of the samples will be maintained by the sample custodian until the samples are disposed of or returned to the client. The disposal of each sample is recorded on the client's COC form or referenced in the project file. Sample disposal procedures and documentation are described in operation-specific SOPs. Quanterra®'s routine sample retention period is at least thirty days after the analytical report is issued to the client, unless otherwise specified by the client.

For Nuclear Regulatory Commission (NRC) or state licensed laboratories, a real-time inventory of all radioactive isotopes contained in the laboratory (including radioactive samples), as required by the NRC or state, is maintained by the Radiation Safety Officer (RSO). If the quantities of radioactive materials in-house approach the limits stipulated by the laboratory NRC or state license, appropriate action must be taken to ensure the licensed level is not exceeded. This may involve returning samples to clients immediately.

If samples are returned to the client rather than disposed of by the laboratory, the original COC is used to document custody transfer back to the client from the laboratory. A copy of the completed COC is retained in the laboratory project file.

8.5.4 Calibration Procedures and Criteria

All equipment and instruments used at Quanterra® operations for quantitative measurements are controlled by a formal calibration program. Calibrations may be periodic or operational. These are described in operation-specific and corporate SOPs. At a minimum, these procedures shall include:

- Instrument to be calibrated
- Reference standards used for calibration
- Calibration technique (e.g., linear, quadratic)
- Acceptable performance tolerances and corrective actions required if specifications are not met
- Frequency of calibration
- Calibration documentation requirements.

Whenever possible, recognized procedures such as those published by ASTM or the USEPA or procedures provided by manufacturers shall be adopted. If established procedures are not available, a procedure shall be developed considering

the type of equipment, stability characteristics of the equipment, required accuracy, and the effect of operation error on the quantities measured.

8.5.4.1 Physical Reference Standards

Physical reference standards associated with periodic calibrations include weights for calibrating balances and certified thermometers for calibrating working thermometers. Whenever possible, physical reference standards shall have known relationships to nationally recognized standards. If national standards are not available, the basis for the reference standard shall be documented.

Physical reference standards shall be used only for calibration procedures and shall be stored separately from equipment used for analysis.

8.5.4.2 Chemical Reference Standards and Reagents

Chemical reference standards are generally associated with operational calibration. These standards include reference materials provided by recognized standards suppliers. This may include vendor-certified materials traceable to NIST or A2LA.

All chemical reference standards maintained in the laboratory for use in calibrations (or as QC spiking solutions) shall be labeled or referenced to appropriate documentation with the following information at a minimum:

- A unique identification including concentration (solutions containing several analytes can be identified such that the solution constituents and concentrations can be referenced to a logbook)
- Medium prepared in
- Preparation date
- Expiration date
- Initials of preparer.

Vials containing standard solutions that are not large enough to accommodate labels listing the above information may be referenced to a laboratory logbook or notebook entry. The expiration date of the working standard must not exceed the expiration date of the original material.

8.5.4.3 Standard Verification

When possible, reference standards are purchased from a single approved vendor. Standards are verified before use by Quanterra® or the vendor where applicable.

Prior to use, the laboratories must confirm that the lot they received from the vendor was approved. Special standards that are obtained from another source must be independently verified at the lab.

Stock and working standards are checked regularly for signs of deterioration, such as discoloration, formation of precipitates, or change in concentration. Care is exercised in the proper storage and handling of standard solutions. Standards are always stored separately from samples.

An independent standard is used to verify initial calibrations. An independent standard is defined as a standard composed of the same target constituents as, but from a different source than those used in the standards for the initial calibration. An independent standard may be a laboratory-prepared or a certified independent standard solution(s). Independence of reference material can be achieved by: (1) purchasing reference materials from two separate vendors, (2) using a different lot, or (3) having two separate individuals prepare the calibration and verification standard solutions if independent sources are not available for neat standards.

Records for all purchased standards and reagents shall include the date of receipt, the date opened, and, where applicable, the expiration date.

8.5.4.4 Periodic Calibration

Periodic calibration is performed at prescribed intervals. In general, equipment which can be calibrated periodically is a distinct, singular purpose unit and is relatively stable in performance. These include balances, micropipettors, counters, thermometers, refrigerators, freezers, and ovens. Equipment employed at Quanterra® operations requiring periodic calibration are listed along with their respective calibration requirements in Table 8.5-6. Each Quanterra® operating unit has SOPs in place for the calibration of this equipment if in use at their location.

8.5.4.5 Operational Calibration

Operational calibration is routinely performed as part of instrument usage, such as the development of a standard calibration curve. Initial calibrations must be verified and documented for each constituent by the analysis of laboratory-prepared certified independent standard solutions. Detailed requirements for operational calibration are contained in method-specific SOPs. A summary of the various operational calibrations performed at Quanterra®

operations is shown in Tables 8.5-7 through 8.5-9.

8.5.4.6 Calibration Failure

Equipment or instruments that fail calibration or become inoperable during use shall be tagged to indicate they are out of calibration. Such instruments or equipment shall be repaired and successfully recalibrated before reuse. The procedure for tagging out such instruments or equipment is described in the Corporate SOP Number CORP-QA-0010, "Nonconformance and Corrective Action."

Recalibration may occur more frequently than scheduled. At any time, if equipment calibration becomes suspect, it shall undergo a calibration check to determine whether the current calibration is still acceptable or if recalibration is required.

8.5.4.7 Calibration Records

Calibration shall be documented for each piece of equipment subject to calibration. All calibration records (periodic and operational) directly affect data and may not be limited to one project. These records shall be stored in either the quality records or the associated project files. Project files that include sample data shall either include the calibration records or include reference to them.

8.6 Quality Assessment

The effectiveness of the QA practices at a laboratory is measured by the quality of data generated by the laboratory. Each Quanterra® operating unit shall establish, implement and document procedures to detect, prevent, and correct quality problems and to ensure quality improvement. Items and processes that do not meet established requirements must be investigated to determine their cause. Improvements must be implemented in the operations which will prevent a recurrence of these quality problems and provide overall quality performance. All phases of laboratory work should be designed with the objective of preventing problems and improving quality on a continuous basis.

8.6.1 Data Quality Assessment

Data quality is judged in terms of precision, accuracy, representativeness, completeness and comparability. The areas of representativeness, comparability, and completeness for an overall project, inclusive of sampling issues, may be beyond the control of the laboratory. The elements over which the laboratory has direct control

are precision, accuracy, and completeness (relative to analytical testing results).

Precision and accuracy assessments are made as part of the evaluation of laboratory QC data generated during sample preparation and analysis. The QC samples employed at Quanterra® as part of routine sample analysis are summarized in Section 8.4 of this document. Table 8.6-1 shows the precision and accuracy measurements employed by Quanterra®. Analytical method SOPs and Quanterra® Policy Number QA-003, "Quanterra® Quality Control Program", include information on requirements for the type of QC samples, frequencies, and acceptance criteria. Additionally, the SOPs and Policy describe the appropriate actions to be taken when a QC sample result does not meet acceptance criteria.

8.6.2 *Statistical Evaluation of Data*

In-house limits for all QC data must be evaluated at least annually and compared to the limits published in the methods for applicable matrices. Method limits will be employed until sufficient QC data are acquired. A minimum of 20 to 30 data points are recommended to establish the limits. QC limits are normally in-house limits unless they exceed method limits, which are then adopted. Calculated results of these QC samples are evaluated by comparing against control limits or creating control charts to spot trends. Facility-wide data are accumulated for evaluation and limit determination.

Program-specific data analysis requirements for control charts are followed as required for data generated under those programs. These additional requirements shall be documented in a QAPP or QAS. It is the responsibility of each analyst to update any client-required control charts or control tables as a part of routine data reduction.

Precision and accuracy measurements employed by Quanterra® are shown in Table 8.6-1. Calculated results of these QC samples are evaluated using control tables or control charts. Facility-wide data are accumulated in the laboratory LIMS and are accessed from the database for further evaluation and limit determination.

8.7 *Data Recording Procedures*

To ensure data integrity, all documentation of data and records generated or used during the process of data generation must be performed in compliance with Quanterra® Corporate SOP Number QA-008, "Data Recording Requirements".

8.8 Data Reduction and Verification Procedures

Data review procedures, defined as a set of computerized and manual checks applied at appropriate levels of the measurement process, will be clearly defined for all measurement systems in SOPs. Data review begins with the reduction or processing of data and continues through verification of the data and the reporting of analytical results. Calculations are checked from the raw data to the final value prior to reporting results for each group of samples. Data reduction can be performed by the analyst who obtained the data or by another analyst. Data verification starts with the analyst who performs a 100 percent review of the data to ensure the work was done correctly the first time. Data verification continues with review by a second reviewer who verifies that data reduction has been correctly performed and that the analytical results correspond to the data acquired and processed. This procedure is outlined in Figure 8.8-1.

8.8.1 Data Reduction and Initial Verification

Data reduction and initial verification may be performed by more than one analyst depending upon the analytical method employed. The preparation and analytical data may be reviewed independently by different analysts. In these instances, each item may not be applicable to the subset of the data verified or an item may be applicable in both instances. It is the responsibility of the analyst to ensure that the verification of data in his or her area is complete. The data reduction and initial verification process must ensure that:

- Sample preparation information is correct and complete including documentation of standard identification, solvent lot numbers, sample amounts, etc.
- Analysis information is correct and complete including proper identification of analysis output (charts, chromatograms, mass spectra, etc.)
- Analytical results are correct and complete including calculation or verification of instrument calibration, QC results, and qualitative and quantitative sample results with appropriate qualifiers
- The appropriate SOPs have been followed and are identified in the project records
- Proper documentation procedures have been followed
- All nonconformances have been documented
- Special sample preparation and analytical requirements have been met

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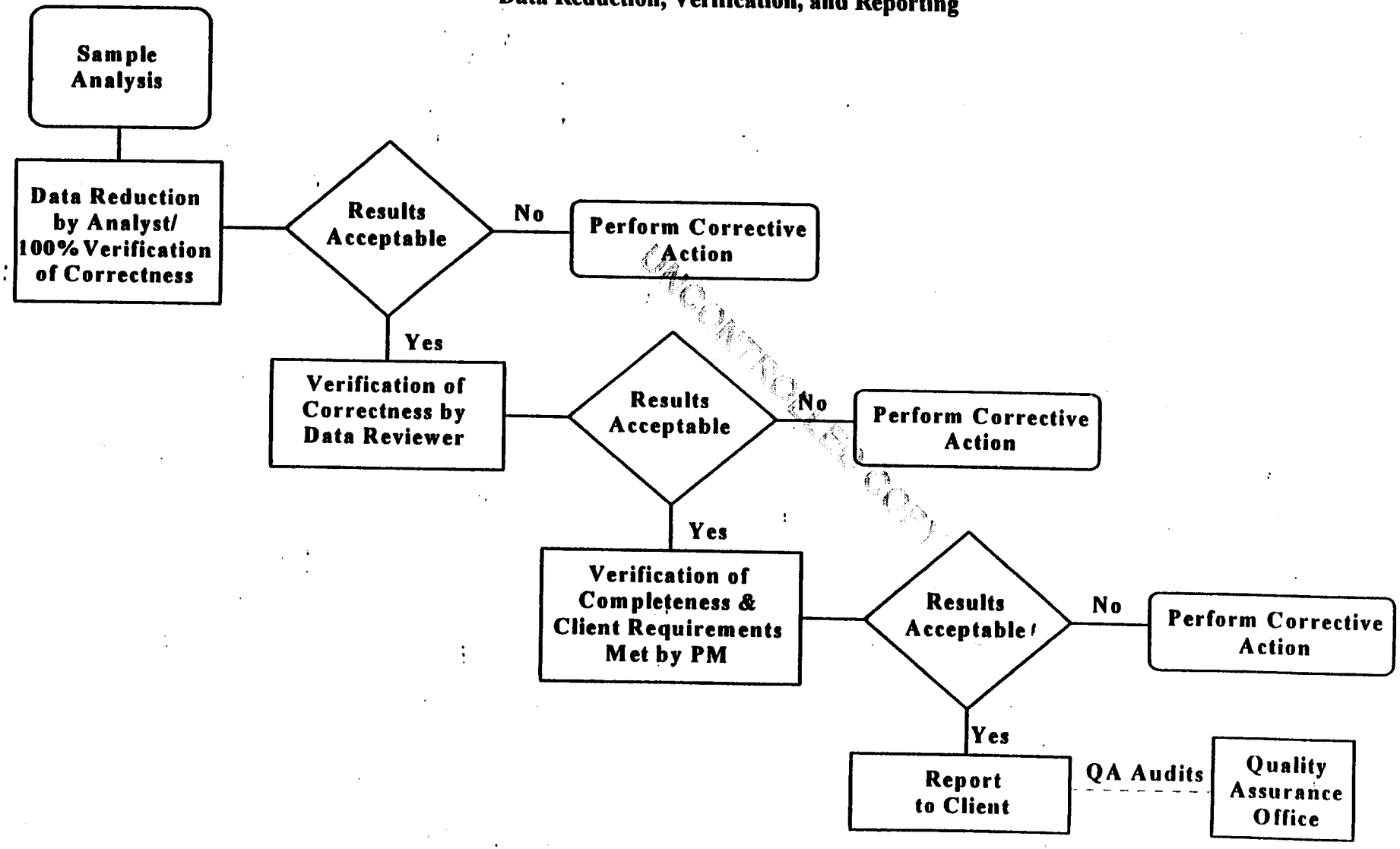
FIGURE 8.8-1
Data Reduction, Verification, and Reporting



- The data generated have been reported with the appropriate number of significant figures as defined by the analytical method in the LIMS or otherwise specified by the client.

In general, data will be processed by an analyst in one of the following ways:

- Manual computation of results directly on the data sheet or on calculation pages attached to the data sheets
- Input of raw data for computer processing
- Direct acquisition and processing of raw data by a computer.

If data are manually processed by an analyst, all steps in the computation shall be provided including equations used and the source of input parameters such as response factors (RFs), dilution factors, and calibration constants. If calculations are not performed directly on the data sheet, they may be attached to the data sheets.

For data that are input by an analyst and processed using a computer, a copy of the input shall be kept and uniquely identified with the project number and other information as needed. The samples analyzed must be clearly identified.

If data are directly acquired from instrumentation and processed, the analyst must verify that the following are correct:

- Project and sample numbers
- Calibration constants and RFs
- Units
- Numerical values used for reporting limits.

Analysis-specific calculations for methods are provided in SOPs. In cases where computers perform the calculations, software must be validated or verified, as described in Section 6.0 of this document, before it is used to process data.

The data reduction is documented, signed and dated by the analyst completing the process. Initial verification of the data reduction by the same analyst is documented on a data review checklist, signed and dated by the analyst.

8.8.2 Data Verification

Following the completion of the initial verification by the analyst performing the data reduction, a systematic second-level verification of the data is performed by an experienced peer, supervisor, or designee. The second level reviewer examines the data

signed by the analyst. This review includes an evaluation of all items required in the raw data package. Any exceptions noted by the analyst must be reviewed. Included in this review is an assessment of the acceptability of the data with respect to:

- Adherence of the procedure used to the requested analytical method SOP
- Correct interpretation of chromatograms, mass spectra, etc.
- Correctness of numerical input when computer programs are used (checked randomly)
- Correct identification and quantitation of constituents with appropriate qualifiers
- Numerical correctness of calculations and formulas (checked randomly)
- Acceptability of QC data
- Documentation that instruments were operating according to method specifications (calibrations, performance checks, etc.)
- Documentation of dilution factors, standard concentrations, etc.
- Sample holding time assessment.

This review also serves as verification that the process the analyst has followed is correct in regard to the following:

- The analytical procedure follows the methods and specific instructions given on the project QAS or equivalent summary form
- Nonconforming events have been addressed by corrective action as defined on a nonconformance memo
- Valid interpretations have been made during the examination of the data and the review comments of the initial reviewer are correct
- The package contains all of the necessary documentation for data review and report production and results are reported in a manner consistent with the method used for preparation of data reports.

The specific items covered in the second stage of data verification may vary according to the analytical method, but this review of the data must be documented by signing the same checklist.

8.8.3 Completeness Verification

A third-level review is performed by the PM. This review is required before results are submitted to clients. This review serves to verify the completeness of the data report and to ensure that project requirements are met for the analyses performed. The items to be reviewed are:

- Analysis results are present for every sample in the analytical batch, reporting

group, or sample delivery group (SDG)

- Every parameter or target compound requested is reported with either a value or reporting limit
- The correct units and correct number of significant figures are utilized
- All nonconformances, including holding time violations, and data evaluation statements that impact the data quality are accompanied by clearly expressed comments from the laboratory
- The final report is legible, contains all the supporting documentation required by the project, and is in either the standard Quanterra® format or in the client-required format.

A case narrative to accompany the final report will be finalized by the PM. This narrative will include relevant comments collected during the earlier reviews.

8.9 Data Reporting

8.9.1 Data Reports

Quanterra® is capable of developing a variety of data deliverable reports. In general, Quanterra® reports contain:

- Cover Letter/Case Narrative - Information on sample types, tests performed, any problems encountered, and general comments are provided.
- Analytical Data - Data are reported by sample or by test with the appropriate significant figures and reporting limits, and have been adjusted for dilution, if appropriate. Pertinent information including dates sampled, received, prepared, extracted, and analyzed are provided.
- Laboratory Performance QC Information - The results of LCSs analyzed with the project are listed. Also, the analytical results for associated method blanks are given. Any data or QC anomalies are discussed.
- Matrix-Specific QC Information - Results of any sample duplicates and MS/MSDs analyzed with the samples as batch QC are reported. Other project-specific QC requested by the client are also reported. The results include supporting information such as amount spiked, percent recovery, or percent difference/RPD.
- Methodology - Reference for analytical methodology used is cited.
- Other Deliverables - Other deliverables available include disk deliverables, electronic data transfer, sample raw data packages, complete deliverable packages, and custom report formats.

8.9.2 Verbal Results

Quanterra®, as a policy, discourages the release of data verbally or without full data review. If however, the client requests analytical results to be communicated verbally or by facsimile prior to final review, they must

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be clearly identified as "Preliminary" results. The client must understand that the data have not undergone the required levels of review and may change.

8.9.3 *Reporting Analytical Results*

Sample results are reported according to analytical method SOPs or client specifications. Normally, the laboratory uses the Quanterra® Reporting Limit (RL) at which any analyte of interest detected at or above that level is reported as a positive value and any analyte of interest not detectable or detected below that level is reported as "not detected" at the RL. The laboratory will normally report results within the calibration, however, any reported results outside of the calibration range will be documented in the final report.

In some cases a contract, QAPP, or documented client request may require the laboratory to report sample results in a specified manner. Some examples are given below:

- The laboratory may be requested to report all analytes of interest that are less than the laboratory's RL but are greater than the MDL. This data will be flagged with an appropriate qualifier.
- The laboratory may be requested to report any tentatively identified compounds (TICs). This data will be flagged with an appropriate qualifier.
- The laboratory may be requested to report sample results using a RL that is higher than their normal level. In this case, only the analytes of interest found at or above that level would be reported as positive values. In this case, the laboratory will state the PSRL rather than the RL. All analytes of interest not detected or detectable below that level would be reported as "not detected" at the PSRL.

In these types of cases, the laboratory must include documentation in the project file that supports the reporting procedure employed.

It is the responsibility of the laboratory to provide for a reporting system that assures that any problems associated with an analysis are properly documented on a nonconformance memo, communicated to the appropriate Quanterra® associates, and addressed appropriately in the data report. If, after issuance of a report, Quanterra® observes any mistake that affects the results reported or the QC interpretation of those results, the client will be notified.

8.10 *Data Validation*

Data validation for Quanterra® refers to data reviews conducted in accordance with the USEPA CLP "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses" and "Laboratory Data Validation

Functional Guidelines for Evaluating Inorganic Analyses", or modifications thereof, for non-CLP type analyses.

This form of data validation provides an impartial evaluation of the laboratory's results. It is usually performed by a third party, one which was not involved with the sample analysis. Qualifiers are assigned to data, when required, according to the requirements of the data validation protocol being used.

8.11 Preventive Maintenance and Service

Facilities, instruments, equipment, and parts are subject to wear, deterioration, or change in operational characteristics. Within Quanterra®, preventive maintenance, coupled with vendor service agreements, is an organized program of actions taken to maintain facilities and equipment.

8.11.1 Analytical Instrumentation and Equipment

The primary purpose of the maintenance program is to prevent instrument and equipment failure and to minimize down time. A properly implemented maintenance program increases the reliability of a measurement system.

At each laboratory each instrument or piece of equipment shall be uniquely identified. Each operating unit shall maintain the following:

- Instrument/equipment inventory list
- Instrument/equipment major spare parts list or inventory
- External service-agreement documents (if applicable)
- Instrument-specific preventive maintenance logbook or file for each functional unit.

The record of maintenance shall include at a minimum:

- Actions taken, including parts replaced
- Analyst initials and the date maintenance was performed whether by the analyst or a contracted service representative.

Quanterra® documents and describes in detail instrument and equipment preventive maintenance procedures and requirements in operation-specific SOPs.

8.11.2 Facilities

Another important aspect of the laboratory operation is the existence and maintenance of adequate, safe, and clean facilities including appropriate engineering controls such as proper ventilation, lighting, dust control, hoods, air flow, protection from extreme

temperatures, waste disposal, and a source of stable power.

The maintenance and use of these facilities and proper operations are described in the Quanterra® Chemical Hygiene Plan (CHP). The Laboratory Manager, through a facilities maintenance staff, has responsibility for ensuring a properly maintained facility. The Laboratory Manager also has the responsibility for ensuring that samples are stored properly without contamination, work areas are equipped with adequate bench, hood and operational space, and the areas are free from chemical and radiological contamination that may affect analytical results.

8.11.3 Frequency of Maintenance

The frequency of maintenance must consider manufacturer's recommendations and previous experience. Schedules of preventive maintenance along with the recommended frequency are given in Tables 8.11-1 through 8.11-27 for analytical instrumentation and equipment. Frequency of maintenance for the facility systems is documented in the Quanterra® CHP.

8.12 Other Requirements

8.12.1 Water

High purity water (i.e., ASTM reagent grade or equivalent water) will be used in all metals, radiological, wet chemistry, and organic analyses. Proof of contaminant-free water is shown through the use of the reagent waters as method blanks which are analyzed on a daily basis for the analyte of interest. This water is obtained by the use of either a commercial ion-exchange deionizing, distillation, or reverse osmosis unit plus an appropriate polishing unit. The resulting water has a maximum conductivity of 1.0 umho-cm at 25°C or a minimum resistivity of 1.0 Mohm at 25°C. Conductivity and/or resistivity will be monitored and documented daily or on each day that water is dispensed for analytical use.

For volatile analyses the water may be further purified by purging with an inert gas before use to remove potential traces of organic solvents.

Water monitoring procedures used by Quanterra® operating units are detailed in operation-specific SOPs.

8.12.2 Compressed Air and Gases

Ultra high-purity compressed gases from preapproved vendors or in-house gas generators will be used when required for instrumentation. These air and gases must meet the requirements and specifications of the analytical methods performed. In-line filters

will be used when appropriate to minimize contamination and moisture from the gases.

8.12.3 Glassware Preparation

Glassware preparation procedures implemented at Quanterra® operating units are designed to ensure that contaminants are not introduced during sample analysis. Procedures describing glassware preparation are detailed in operation-specific SOPs.

8.12.4 Chemical Storage

Storage of chemicals shall be conducted in a manner to minimize the potential for fire or release of hazardous material resulting from an unplanned chemical reaction. Refrigerators used for storing flammable liquids must have spark-free interior construction. Flammable solvents shall be stored in appropriate cabinets meeting all necessary codes. All chemicals are stored according to chemical compatibility. Further details regarding chemical storage are provided in the Quanterra® CHP.

8.12.5 Waste Disposal

Laboratory wastes shall be disposed of safely and in a manner consistent with applicable regulations. The Laboratory Manager or designee is responsible for the development, implementation, and maintenance of site-specific procedures that will document all aspects of the disposal program. These procedures and the training requirements are described in the Quanterra® CHP.

8.12.6 Facility Security

Each Quanterra® laboratory is a limited access, secure facility. To ensure that only authorized personnel are able to enter the building from an entrance that is not monitored, entry into each building is limited in one or more of the following ways at a minimum:

- The use of key pads or electronic locks activated by swipe or magnetic cards which are issued only to authorized personnel
- Locking doors and issuing keys only to authorized personnel
- Alarm systems to detect unauthorized entrance
- During business hours, entry is possible only through the main entrance. This entrance is monitored at all times, usually by a receptionist. All guests are required to sign in by using a visitor logbook.

9.0 Quality Assessment and Response

9.1 Nonconformance and Corrective Action

9.1.1 Nonconformance

A nonconformance is an unplanned deviation from an established protocol or plan. The deviation may be the result of Quanterra's® actions, then termed a deficiency, or the result of events beyond the control of Quanterra®, then termed an anomaly.

9.1.2 Corrective Action

Corrective actions are measures taken to rectify conditions adverse to quality and, where possible, to prevent their reoccurrence. Corrective actions should be timely, determine the root cause, and evaluate any propagation of the error or problem. Whenever a systematic error is discovered that affects the accuracy or defensibility of results reported to Quanterra®'s clients, client notification will be part of the corrective action. Corrective actions should be implemented with an understanding of the technology and work activities associated with the quality element, with appropriate training of Quanterra® associates and vendors, and should be monitored for progress and success.

9.1.3 Responsibilities

The responsibilities associated with nonconformance and corrective action, as well as the procedures to be followed, are described in the Quanterra® Corporate SOP Number CORP-QA-0010, "Nonconformance and Corrective Action."

9.1.4 Nonconformance Memo

As defined in the SOP, deficiencies and anomalies for all activities other than sample log-in or matrix related incidents shall be documented on a nonconformance memo. A log or computerized data base will be maintained for all nonconformances determined to be deficiencies. Deficiencies will be examined for trends periodically, and this evaluation will be documented and reported to management. The original or copy of the nonconformance memo will be kept in the project files along with the data it refers to. The original form or a copy shall also be kept in the quality files.

9.2 Audits

Audits of Quanterra® laboratories are performed to assess the degree of adherence to policies, procedures, and standards. These assessments are conducted internally by Quanterra® personnel, who are independent of the area being evaluated, and externally by clients and regulatory agencies. Audits can

identify areas for improvement with regard to compliance with policies, procedures, and standards. Audits also provide a means for correction prior to system failure. The following types of audits and assessments are performed at Quanterra® laboratories:

- Performance Audits
- Systems Audits or Internal Systems Evaluations
- Data Audits
- Spot Assessments.

Internal systems audits or evaluations are generally conducted by QA staff, although periodic self-audits may be conducted by the operational units. Audits and assessments are generally conducted through the use of checklists and appropriate reference documents. Internal systems audits or evaluations are conducted with an opening meeting in which representatives from management, key operational staff, and QA staff participate. The opening meeting provides a review of the objectives of the audit and the schedule required to conduct the audit. At the completion of the audit, a debriefing is held to outline the findings, including identification of positive performance, to discuss requirements in areas of deficiencies, and to answer questions. Spot assessments are generally more informal than systems audits, and may be conducted without prior scheduling.

Internal systems audits or evaluations are conducted at a minimum yearly by QA staff external to the lab. Spot assessments are conducted per schedule by the laboratory QA group.

The findings of all audits and assessments are documented as is the laboratory response and any corrective actions. Follow-up checks are performed and the status of implementation of corrective actions is documented for all categories of audits and assessments. This cycle continues until all issues are closed.

9.2.1 *Performance Audits*

Performance audits or performance evaluations (PEs) are conducted to verify the ability of the laboratory to correctly identify and quantitate compounds in PE samples. These PE samples may be supplied internally or externally as single-blind or double-blind samples. The results of internal performance audits may be used to document the proficiency of the analyst performing the work or to assess the overall performance of the facility. Double-blind performance audits are conducted by Quanterra® Corporate QA to assess the effectiveness of all aspects of laboratory performance from project initiation through analysis and reporting. In addition,

any problems detected regarding quotes, bids, and invoicing are brought to the attention of the PM and to the finance/accounting department, as appropriate.

The results of each performance audit shall be reported to laboratory management. All performance audit results which are identified as unacceptable must be investigated. The findings of the investigation and corrective action taken must be documented.

9.2.2 *Systems Audits*

A systems audit assesses fulfillment of the QAMP and the state of the QMS. Each laboratory undergoes numerous systems audits performed by external parties, including certifying agencies and clients.

9.2.2.1 *Internal Systems Audits or Evaluations*

An annual systems evaluation will be performed under the direction of the Corporate Director of Quality Assurance and according to Corporate SOP Number, CORP-QA-0014. This evaluation is performed to assess each laboratory's adherence to the requirements of the QAMP, SOPs, internal policies, and to assess the status of corrective actions from other audits at that facility.

The Corporate Director of Quality Assurance shall appoint a lead auditor to conduct the systems evaluation. A corporate audit outline shall be used. The lead auditor has the authority to lengthen the evaluation, revise the scope of the evaluation, stop work, or specify an accelerated schedule for re-evaluation. The lead auditor shall be responsible for preparing a report detailing the results of the evaluation. The report shall be submitted to the audited Laboratory Manager, Regional General Manager, and Laboratory QA Manager within five weeks of the audit. A copy of the report shall be distributed to the Corporate QA Director. The audit report shall provide a summary of the audit results with the auditor's comments and the findings that were determined by the lead auditor.

The evaluated laboratory must respond in writing within four weeks of receiving the evaluation report. The QA Manager is responsible for coordinating the response to the evaluation report. The Laboratory Manager must approve all responses to internal evaluation reports prior to submittal to the auditor.

The evaluation may result in findings, areas needing improvement, and notable practices. Each term will be defined as such:

- Findings - are defined as those noncompliant practices or policies which have significant adverse impact on data quality, technical defensibility, or

regulatory acceptance of data. Findings require immediate attention by the laboratory management and must be resolved to comply with Quanterra®'s quality documents and laboratory-established procedures.

- Areas Needing Improvement - represent isolated instances of noncompliance or issues that are judged to have a less immediate impact on data quality. Laboratory management must correct the situation or otherwise ensure that the condition does not recur. This term will replace the previous term used "Observations."

- Notable Practices - should also be pointed out during the audit. These are defined as laboratory practices that increase effectiveness and quality and represent improvements with respect to conventional laboratory operations.

It is the responsibility of the QA Manager at each facility to verify implementation of the corrective actions and close all internal evaluation findings. This process shall be documented and provided to the recipients of the original audit report. This process is described in the Quanterra® Corporate SOP Number CORP-QA-0014, "Laboratory Internal Systems Evaluation".

Internal evaluation reports shall be maintained according to the Quanterra® Record Retention Policy (LEG-004) as confidential documents and shall not be released for use outside the laboratory. External auditors may view internal audit reports as part of their on-site audit.

9.2.2.2 *External Systems Audits*

Audits of Quanterra® laboratories are performed by external agencies and clients. All scheduled audits shall be placed on the facility's calendar with the knowledge of the Laboratory Manager and the Laboratory QA Manager to assure no scheduling conflicts occur and that appropriate staff will be available to meet the agencies' or clients' objectives.

All deficiencies reported to the laboratory must be responded to within the time line specified by the client. A plan of action to correct the deficiencies, as well as corrective actions taken, must be documented. It is the responsibility of the QA Manager to coordinate the response to the audit report. The development and implementation of the corrective actions is the responsibility of the Operations management as related to their respective areas. All responses must be approved by the Laboratory Manager prior to submittal to the auditor. A copy of the audit report and the laboratory's response must be provided to the Laboratory Manager and Corporate QA. It is the responsibility of the QA Manager to verify implementation of the corrective actions and inform the responsible

manager of the closure of all deficiencies from the audit.

9.2.3 Data Audits

Data audits are routinely performed and documented to ensure that project records meet project requirements as described in method SOPs, project plans, or other documented requirements. The data audit is used to identify any lab errors that may have occurred. The laboratory QA Manager or designee is responsible for performing data audits as specified in Quanterra® SOP Number CORP-QA-0004, "QA Data Review".

9.2.4 Spot Assessments

Spot assessments are conducted to monitor or observe a process or activity in order to verify conformance to the SOP requirements for that activity. The frequency, normally monthly, for performing these assessments is determined by the facility QA Manager. The scope of the assessment is also determined by the QA Manager and may be directed based on information obtained from client inquiries, trends in recorded nonconformances, performance audits, or other sources. A spot assessment may be used to assess a procedure performance relative to the documented SOP. This assessment identifies deviations from requirements that may not be detected in a detailed review of the data package alone. Such an assessment is conducted by observation of the associates performing the task compared with the documented SOP. In some cases, the assessment may be conducted through interviews with the associate when observation of a task is not possible. Review of relevant documentation for the completed procedure is included in such an assessment. A checklist may be used in conducting the assessment. The results of the assessment are documented, as are the corrective actions. All deficiencies noted as a result of a spot assessment must be corrected by the responsible staff in a timely manner.

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9.3 Client Inquiries and Complaints

Client inquiries are generally received through the PM or a member of the CST. Typically, the PM communicates with the client to determine the details of the inquiries, including technical data problems, deliverable issues, turn-around-time problems, etc. Technical and deliverable issues are coordinated by the PM and usually involve input from operations, QA, and management staff. A formal written response to the client is coordinated by the PM, but may on occasion be delivered by the CSM or the Account Manager.

9.4 Quality Reports to Management

The QA Manager and Corporate Director of

Quality Assurance shall prepare and maintain copies of reports to management on a monthly basis indicating the effectiveness of the QMS. The operations monthly reports to management shall, at a minimum, include discussion of the following activities that occurred during the month:

- Internal audit findings
- Certification changes
- PE sample results
- Summary of client inquiries for which QA was asked to assist the laboratory in developing a response
- General comments or concerns.

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The corporate reports serve as executive summaries to members of senior management of the detailed information provided by the QA Managers.

9.5 Management Review of the QMS

Based upon laboratory audits or input from clients or the QA group, management may elect to assess any of the operations or processes therein. These reviews and corrective actions would be documented and followed up by management. The purpose of these assessments would be to correct systematic issues or processes before they impact data quality.

10.0 Quality Improvement

Quality improvement at Quanterra® is a critical element of our quality strategy as well as our business strategy. Quanterra® will become a world class organization through a commitment to continuous quality improvement. Every Quanterra® associate must understand that continuous improvement is a guiding principle pertinent to all aspects of our business.

The key elements of quality improvement are:

- Standardization of procedures
- Continuous quality improvement
- Benchmarking
- Quality assessment
- Understanding the clients' needs
- Quality measures and standards.

10.1 Standardization of Procedures

Due to the vast number of methods that have been introduced into the environmental analytical field, as well as revisions and proposed updates to currently promulgated methods, many methodologies contain conflicting requirements. It is through the generation and use of standard operating procedures, which contain Quanterra®'s best technical interpretation of published methods, that Quanterra® succeeds in providing quality standardized analytical testing to our clients. This standardization is achieved through the implementation of standardized or corporate SOPs and policies. Quanterra® will generate and implement new SOPs and policies as the need arises, and will train associates in their importance and use.

The standardization of procedures, as they are implemented throughout Quanterra®, result in improved quality of our services and deliverables provided to our clients at some level at all operations.

10.2 Continuous Quality Improvement

The continuous improvement of processes throughout Quanterra® is the responsibility of each Quanterra® associate. Processes are followed in every operating unit, group, and by each individual, and each of these processes is applicable to this discussion. All associates are empowered and encouraged to bring suggestions for process improvement changes to the attention of laboratory management, as well as the

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Technology and QA groups. Management is responsible for assessing the recommendation for improvement and following through with an implementation plan when appropriate.

10.3 Benchmarking

Benchmarking is a step-by-step method of improving performance by identifying and studying best practices and comparing them to industry practices. Benchmarking is performed within Quanterra®, as well as on the industry. Changes to processes resulting from benchmarking may be tested in a single laboratory under senior technical and QA management. If successful, the process change may be implemented throughout Quanterra®.

10.4 Quality Assessment

Quality improvement is also achieved through the practice of quality assessment and subsequent correction of detected quality-related problems when they occur. Quality assessment and response are described in Section 9.0.

10.5 Understanding the Client's Needs

Client satisfaction must be a goal of all Quanterra® associates. Periodic client satisfaction surveys are performed by Quanterra® customer service staff to determine if we are meeting their needs. While quality is defined as meeting the requirements of our clients, both internal and external, we must also strive to exceed our client's expectations. Every Quanterra® associate is either directly or indirectly involved in meeting our client's needs, therefore effective communication of these needs to all associates as described in this QAMP is essential.

Any inquires or complaints from clients to any associate must be addressed in a timely manner and any issue concerning data quality must be documented. (See Section 9.3).

10.6 Quality Measures and Standards

Measures and standards used by Quanterra® are fundamental to assessing and achieving our commitment to continuous improvement. With most business processes, performance is generally measured at the end. Quanterra® managers must provide continuous feedback to all associates regarding performance measures and standards.

Key Result Indicators (KRIs) provide one of Quanterra®'s measures. Additional measures and standards shall be added to track

programs, processes, or projects, as appropriate.

KRIs measure performance in areas considered critical to achieving world class Quality in customer satisfaction and business performance. KRIs focus quality measures on the customer as well as the processes that our customers value. KRIs are intended to demonstrate continuous improvement and focus on the "vital few" issues for the business. Quanterra® KRIs include:

- On-time delivery
- Holding time violations
- Reissued reports
- Turn-around-time
- Safety.

Measurements of performance include internal and external audits, performance evaluations, and double-blind evaluations which are further described in Section 9.0. Improved results from these measurements show successfulness of process improvements.

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TABLES

Tables

Quanterra®
Quality Assurance Management Plan

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Table Section

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Table of Contents

Table No.	Title	Page
2.3-1	Quanterra® Quality Assurance Management Plan Requirements Matrix	5
4.2-1	List of Quanterra® Quality-Related Items that Require Evaluation Prior to Use	9
5.1-1	Quanterra® Quality Documents and Required Approval	10
5.2-1	Quanterra® Quality Document Review Requirements	11
8.2-1	Analytical Methods Routinely Performed by Quanterra®	12
8.4-1	Field Quality Control Samples	24
8.4-2	Laboratory Quality Control Samples	25
8.4-3	Laboratory Performance Quality Control Samples	26
8.4-4	Matrix Specific Quality Control Samples	27
8.4-5	Inorganic Laboratory Quality Control Samples	28
8.4-6	Organic Laboratory Quality Control Samples	77
8.4-7	USEPA Contract Laboratory Program Statement of Work Quality Control Samples	102
8.5-1	Inorganic Sample Containers, Preservatives, and Holding Times	116
8.5-2	Organic Sample Containers, Preservatives, and Holding Times	128
8.5-3	Radiological Sample Containers, Preservatives, and Holding Times	137
8.5-4	Sample Containers, Preservatives, and Holding Times for USEPA Contract Laboratory Program Statement of Work	140
8.5-5	Sample Containers, Preservatives, and Holding Times for TCLP	142
8.5-6	Periodic Equipment Calibrations	143
8.5-7	Summary of Inorganic Method Calibrations	144
8.5-8	Summary of Organic Method Calibrations	160
8.5-9	Summary of USEPA Contract Laboratory Program Statement of Work Method Calibrations	169
8.6-1	Precision and Accuracy Measurements	173
8.11-1	Instrument Maintenance Schedule - Ion Chromatograph	175
8.11-2	Instrument Maintenance Schedule - LACHAT Auto Analyzer	175
8.11-3	Instrument Maintenance Schedule - Total Organic Halide Analyzer	176
8.11-4	Instrument Maintenance Schedule - High Pressure Liquid Chromatograph	176
8.11-5	Instrument Maintenance Schedule - Flame Atomic Absorption Spectroscopy	177
8.11-6	Instrument Maintenance Schedule - Inductively Coupled Argon Plasma/ Mass Spectrometry (ICAP/MS)	177
8.11-7	Instrument Maintenance Schedule - ICP	178
8.11-8	Instrument Maintenance Schedule - Graphite Furnace Atomic Absorption	179
8.11-9	Instrument Maintenance Schedule - Cold Vapor Atomic Absorption (Leeman PS 200)	179

Table of Contents (continued)

Table No.	Title	Page
8.11-10	Instrument Maintenance Schedule - Cold Vapor Atomic Absorption (PE 5000)	179
8.11-11	Instrument Maintenance Schedule - Gas Chromatograph	180
8.11-12	Instrument Maintenance Schedule - Mass Spectrometer	182
8.11-13	Instrument Maintenance Schedule - TRAACS 800 Auto Analyzer	183
8.11-14	Instrument Maintenance Schedule - Sonicator	183
8.11-15	Instrument Maintenance Schedule - Analytical/Top Loading Balances	183
8.11-16	Instrument Maintenance Schedule - Refrigerators/Walk-in Coolers	183
8.11-17	Instrument Maintenance Schedule - Ovens	184
8.11-18	Instrument Maintenance Schedule - Specific Digital Ion Analyzer	184
8.11-19	Instrument Maintenance Schedule - Turbidimeter	184
8.11-20	Instrument Maintenance Schedule - Dissolved Oxygen Meter	184
8.11-21	Instrument Maintenance Schedule - Conductance Meter	185
8.11-22	Instrument Maintenance Schedule - Chemical Oxygen Demand (COD) Reactor	185
8.11-23	Instrument Maintenance Schedule - Spectrophotometer	185
8.11-24	Instrument Maintenance Schedule - pH Meter	185
8.11-25	Instrument Maintenance Schedule - Fourier Transform Infrared Spectrometry	186
8.11-26	Instrument Maintenance Schedule - Radiological Analysis Equipment	186
8.11-27	Instrument Maintenance Schedule - Total Organic Carbon Analyzer (OI 7000)	187

TABLE 2.3-1

Quanterra® Quality Assurance Management Plan Requirements Matrix

EPA QA/R-2	Quanterra QAMP (Rev 2)	ANSI/ASQC E4-1994	NQA-1[1]	5700.6C[2]	ANSI N 13.30	ANSI/ASQC Q2-1991[3]
1 Management and Organization	1.0 Management Commitment and Organization	2.1 Management and Organization	1 Organization	9.a. General	1.1 Introduction 1.2 Purpose 1.3 Scope	5.0 Management Responsibility
2 Quality System and Description	2.0 Quality System and Description	2.2 Quality System and Description	2 Quality Assurance Program	1 Program	2.1 Special Word Usage 2.2 Specific Terms 5.1 Quality Assurance 5.2 Quality Control	5.2 Quality System
3 Personnel Qualification and Training	3.0 Associate Qualification and Training	2.3 Personnel Training and Qualification	2 Quality Assurance Program	2 Personnel Training and Qualification	3.2 Personnel Preparation	14.0 Personnel
4 Procurement of Items and Services	4.0 Procurement of Items and Services	2.4 Procurement of Items and Services	4 Procurement Document Control 7 Control of Purchased Items and Services	7 Procurement	N/A	7.0 Quality in Procurement 13.0 Subcontracting
5 Documentation and Records	5.0 Documentation and Records	2.5 Documents and Records	6 Document Control 17 Quality Assurance Records	4 Documents and Records	3.6 Direct Bioassay-Record Retention 4.5 Indirect Bioassay-Record Retention	8.4 Quality Documentation and Records
6 Computer Hardware and Software	6.0 Computer Hardware and Software	2.6 Computer Hardware and Software	3 Design Control 11 Test Control	N/A	N/A	ISO 9000-3[4]

TABLE 2.3-1
Quanterra® Quality Assurance Management Plan Requirements Matrix
(Continued)

EPA QA/R-2	Quanterra QAMP (Rev 2)	ANSI/ASQC E4-1994	NQA-1[1]	5700.6C[2]	ANSI N 13.30	ANSI/ASQC Q2-1991[3]
7 Planning	7.0 Planning	2.7 Planning 3.1 Planning and Scoping 3.3 Implementation of Planned Operations	2 Quality Assurance Program 3 Design Control 5 Instructions, Procedures, and Drawings 8 Identification and Control of Items 9 Control of Processes 11 Test Control 13 Handling, Storage, and Shipping	1 Program 6 Design N/A	3.1 Facility Criteria 3.4 Direct Bioassay-Performance Criteria for Service Laboratories 3.5 Direct Bioassay-Reporting Results 4.1 Indirect Bioassay-Responsibilities of the Service Laboratory Customer 4.2 Indirect Bioassay-Analytical Methodology 4.3 Indirect Bioassay-Performance Criteria for Service Laboratories 5.2 Quality Control	6.3.3 Quality Plans
8 Implementation of Work Processes	8.0 Work Processes and Operations	2.8 Implementation of Work Processes	1 Organization 5 Instructions, Procedures, and Drawings	5 Work Processes 6 Design	3.1 Facility Criteria	8.0 Laboratory Operations Quality Assurance 9.0 Control of Measuring and Test Equipment 10.0 Data Validation 15.0 Use of Statistical Methods

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TABLE 2.3-1
Quanterra® Quality Assurance Management Plan Requirements Matrix
(Continued)

EPA QA/R-2	Quanterra QAMP (Rev 2)	ANSI/ASQC E4-1994	NQA-1[1]	5700.6C[2]	ANSI N 13.30	ANSI/ASQC Q2-1991[3]
8 Implementation of Work Processes (Continued)		3.2 Design of Data Collection Operations	10 Inspection 12 Control of Measuring and Test Equipment 14 Inspection, Test, and Operating Status	8 Inspection and Acceptance Testing		
9 Assessment and Response[5]	9.0 Quality Assessment and Response	2.9 Assessment and Response 3.4 Assessment and Response 3.5 Assessment and Verification of Data Usability	2 Quality Assurance Program 13 Handling, Storage, and Shipping 15 Control of Non-conforming Items 16 Corrective Action 18 Audits	9 Management Assessment 10 Independent Assessment	3.3 Direct Bioassay-Interpretation of Measurements 3.5 Direct Bioassay-Reporting Results 4.4 Indirect Bioassay-Reporting Results 6.1 Direct Bioassay Measurements 6.2 Indirect Bioassay Measurements	16.0 Nonconformity 17.0 Corrective Action 18.0 Auditing the Quality System
9 Quality Improvement[5]	10.0 Quality Improvement	2.10 Quality Improvement	N/A	3 Quality Improvement	N/A	N/A

TABLE 2.3-1
Quanterra® Quality Assurance Management Plan Requirements Matrix
(Continued)

Footnotes

(1) Section II, "Basic Requirements."
(2) Criterion from Section 9, "Requirements."
(3) Technically equivalent to ISO 9001.
(4) Quality Management and Quality Assurance Standards, ISO 9000, Part 3, "Guidelines for the Application of ISO 9001 to the Development, Supply and Maintenance of Software."
(5) This document has two sections numbered "9."

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TABLE 4.2-1
List of Quanterra® Quality-Related Items that Require Evaluation Prior to Use

Quality-Related Item	Standard Operating Procedure for Quality Testing
Acetone	CORP-QA-0001
Dichloromethane	CORP-QA-0001
Hexane	CORP-QA-0001
Hydrochloric acid	CORP-QA-0001
Freon	CORP-QA-0001
Methanol	CORP-QA-0001
Nitric acid	CORP-QA-0001
Sulfuric acid	CORP-QA-0001
Toluene	CORP-QA-0001

TABLE 5.1-1
Quanterra® Quality Documents and Required Approval

Quality Document	Required Approvals
Quality Assurance Management Plan (QAMP)	• Corporate Director of Quality Assurance • Vice President of Operations Services • Chief Operating Officer
Quality Assurance Management Plan (QAMP) Facility Appendix	• Quality Assurance Manager • Laboratory Manager • Regional General Manager • Corporate Director of Quality Assurance
Corporate Standard Operating Procedures (SOPs)	• Corporate Director of Quality Assurance • Corporate Director of Environmental Health and Safety[1] • Management (generally a Vice President) • Technical Specialist
Operation-Specific Standard Operating Procedures (SOPs)	• Quality Assurance Manager • Laboratory Health and Safety Coordinator[1] • Laboratory Manager • Technical Specialist
Quality Policy Documents	• Corporate Director of Quality Assurance • Vice President of Operations Services

(1) Required only if procedure encompasses more than standard office safety requirements.

TABLE 5.2-1
Quanterra® Quality Document Review Requirements

Document Type	Frequency of Review	Responsible Party
Quality Assurance Management Plan (QAMP)	Every Two Years	Corporate Director of Quality Assurance
Quality Assurance Management Plan (QAMP) Facility Appendix	Annual	Quality Assurance Manager
Corporate Standard Operating Procedures (SOP)	Every Two Years	Corporate Technology/QA
Operation-Specific Standard Operating Procedures (SOP)	Every Two Years	Laboratory Staff
Quality Policy Documents	Every Two Years	Corporate Director of Quality Assurance

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TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
Chapter 7	RCRA	2	September 1994	SW-846	"Section 7.3.3, "Interim Guidance for Reactive Cyanide" and Section 7.3.4, "Interim Guidance for Reactive Sulfide"
D1943-90	ASTM	N/A	1990	ASTM	"Standard Test Method for Alpha Particle Radioactivity of Water"
D3454-86	ASTM	N/A	1986	ASTM	"Test Method for Radium-226 in Water"
D3649-85	ASTM	N/A	1985	ASTM	"Practice for Gamma Ray Spectrometry"
DFLM01.1	USEPA	N/A	1991	USEPA CLP (DFLM01.1)	"Statement of Work for Analysis of Polychlorinated Dibenzo-p-Dioxins (PCDD) and Polychlorinated Dibenzofurans (PCDF)"
ILM03.0	USEPA	N/A	1992	USEPA CLP (ILM03.0)	"Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration"
OLM01.8	USEPA	N/A	1991	USEPA CLP (OLM01.8)	"Statement of Work for Organic Analysis, Multi-Media, Multi-Concentration"
TO-1	USEPA	1.0	April 1984	EPA-600/4-84-041	"Method for the Determination of Volatile Organic Compounds in Ambient Air Using Tenax® Adsorption and Gas Chromatography/Mass Spectrometry (GC/MS)"
TO-2	USEPA	1.0	April 1984	EPA-600/4-84-041	"Method for the Determination of Volatile Organic Compounds in Ambient Air by Carbon Molecular Sieve Adsorption and Gas Chromatography/Mass Spectrometry (GC/MS)"
TO-3	USEPA	1.0	April 1984	EPA-600/4-84-041	"Method for the Determination of Volatile Organic Compounds in Ambient Air Using Cryogenic Preconcentration Techniques and Gas Chromatography with Flame Ionization and Electron Capture Detection"
110.2	NPDES	N/A	1971	MCAWW	"Color" (Colorimetric-Platinum-Cobalt)
120.1	NPDES	N/A	1982	MCAWW	"Conductance" (Specific conductance, µmhos at 25°C)
130.2	NPDES	N/A	1982	MCAWW	"Hardness, Total" (mg/L as $CaCO_3$), (Titrimetric, EDTA)
140.1	NPDES	N/A	1971	MCAWW	"Odor" (Threshold Odor, Consistent Series)
150.1	NPDES	N/A	1982	MCAWW	"pH" (Electrometric)
160.1	NPDES	N/A	1971	MCAWW	"Residue, Filterable" (Gravimetric, Dried at 180°C)
160.2	NPDES	N/A	1971	MCAWW	"Residue, Non-Filterable" (Gravimetric, Dried at 103-105°C)
160.3	NPDES	N/A	1971	MCAWW	"Residue, Total" (Gravimetric, Dried at 103-105°C)
160.4	NPDES	N/A	1971	MCAWW	"Residue, Volatile" (Gravimetric, Ignition at 550°C)
160.5	NPDES	N/A	1971	MCAWW	"Residue, Settleable"
170.1	NPDES	N/A	1971	MCAWW	"Temperature" (Thermometric)
180.1	NPDES	N/A	1978	MCAWW	"Turbidity" (Nephelometric)

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
200.7	NPDES	N/A	December 1982	MCAWW	"Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes"
200.8	USEPA	4.4	May 1994	EPA/600/R-94/111	"Determination of Trace Metals in Waters and Wastes by Inductively Coupled Plasma-Mass Spectrometry"
202.1	NPDES	N/A	1978	MCAWW	"Aluminum" (Atomic Absorption, direct aspiration)
202.2	NPDES	N/A	1978	MCAWW	"Aluminum" (Atomic Absorption, furnace technique)
204.1	NPDES	N/A	1978	MCAWW	"Antimony" (Atomic Absorption, direct aspiration)
204.2	NPDES	N/A	1978	MCAWW	"Antimony" (Atomic Absorption furnace technique)
206.2	NPDES	N/A	1978	MCAWW	"Arsenic" (Atomic Absorption furnace technique)
206.3	NPDES	N/A	1974	MCAWW	"Arsenic" (Atomic Absorption-gaseous hydride)
206.4	NPDES	N/A	1974	MCAWW	"Arsenic" (Spectrophotometric-SDDC)
206.5	NPDES	N/A	1978	MCAWW	"Arsenic" (Sample Digestion Prior to Total Arsenic Analysis by Silver Diethyldithiocarbamate or Hydride Procedures)
208.1	NPDES	N/A	1974	MCAWW	"Barium" (Atomic Absorption, direct aspiration)
208.2	NPDES	N/A	1978	MCAWW	"Barium" (Atomic Absorption furnace technique)
210.1	NPDES	N/A	1974	MCAWW	"Beryllium" (Atomic Absorption, direct aspiration)
210.2	NPDES	N/A	1978	MCAWW	"Beryllium" (Atomic Absorption furnace technique)
212.3	NPDES	N/A	1974	MCAWW	"Boron" (Colorimetric, Curcumin)
213.1	NPDES	N/A	1974	MCAWW	"Cadmium" (Atomic Absorption, direct aspiration)
213.2	NPDES	N/A	1978	MCAWW	"Cadmium" (Atomic Absorption furnace technique)
215.1	NPDES	N/A	1971	MCAWW	"Calcium" (Atomic Absorption, direct aspiration)
215.2	NPDES	N/A	1978	MCAWW	"Calcium" (Titrimetric, EDTA)
218.1	NPDES	N/A	1978	MCAWW	"Chromium" (Atomic Absorption, direct aspiration)
218.2	NPDES	N/A	1978	MCAWW	"Chromium" (Atomic Absorption, direct aspiration)
218.3	NPDES	N/A	1978	MCAWW	"Chromium" (Atomic Absorption, chelation-extraction)
218.4	NPDES	N/A	1978	MCAWW	"Chromium, Hexavalent" (Atomic Absorption, chelation-extraction)
218.5	NPDES	N/A	December 1982	MCAWW	"Chromium, Dissolved Hexavalent" (Atomic Absorption, Furnace Technique
219.1	NPDES	N/A	1978	MCAWW	"Cobalt" (Atomic Absorption, direct aspiration)
219.2	NPDES	N/A	1978	MCAWW	"Cobalt" (Atomic Absorption furnace technique)
220.1	NPDES	N/A	1978	MCAWW	"Copper" (Atomic Absorption, direct aspiration)
220.2	NPDES	N/A	1978	MCAWW	"Copper" (Atomic Absorption furnace technique)

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
231.1	NPDES	N/A	1978	MCAWW	"Gold" (Atomic Absorption, direct aspiration)
231.2	NPDES	N/A	1978	MCAWW	"Gold" (Atomic Absorption furnace technique)
235.1	NPDES	N/A	1978	MCAWW	"Iridium" (Atomic Absorption, direct aspiration)
235.2	NPDES	N/A	1978	MCAWW	"Iridium" (Atomic Absorption furnace technique)
236.1	NPDES	N/A	1978	MCAWW	"Iron" (Atomic Absorption, direct aspiration)
236.2	NPDES	N/A	1978	MCAWW	"Iron" (Atomic Absorption furnace technique)
239.1	NPDES	N/A	1978	MCAWW	"Lead" (Atomic Absorption, direct aspiration)
239.2	NPDES	N/A	1978	MCAWW	"Lead" (Atomic Absorption furnace technique)
242.1	NPDES	N/A	1978	MCAWW	"Magnesium" (Atomic Absorption, direct aspiration)
243.1	NPDES	N/A	1978	MCAWW	"Manganese" (Atomic Absorption, direct aspiration)
243.2	NPDES	N/A	1978	MCAWW	"Manganese" (Atomic Absorption furnace technique)
245.1	NPDES	N/A	1974	MCAWW	"Mercury" (Manual Cold Vapor Technique)
245.2	NPDES	N/A	1974	MCAWW	"Mercury" (Automated Cold Vapor Technique)
245.5	NPDES	N/A	1974	MCAWW	"Mercury in Sediment" (Manual Cold Vapor Technique)
246.1	NPDES	N/A	1978	MCAWW	"Molybdenum" (Atomic Absorption, direct aspiration)
246.2	NPDES	N/A	1978	MCAWW	"Molybdenum" (Atomic Absorption furnace technique)
249.1	NPDES	N/A	1978	MCAWW	"Nickel" (Atomic Absorption, direct aspiration)
249.2	NPDES	N/A	1978	MCAWW	"Nickel" (Atomic Absorption furnace technique)
252.1	NPDES	N/A	1978	MCAWW	"Osmium" (Atomic Absorption, direct aspiration)
252.2	NPDES	N/A	1978	MCAWW	"Osmium" (Atomic Absorption furnace technique)
253.1	NPDES	N/A	1978	MCAWW	"Palladium" (Atomic Absorption, direct aspiration)
253.2	NPDES	N/A	1978	MCAWW	"Palladium" (Atomic Absorption furnace technique)
255.1	NPDES	N/A	1978	MCAWW	"Platinum" (Atomic Absorption, direct aspiration)
255.2	NPDES	N/A	1978	MCAWW	"Platinum" (Atomic Absorption furnace technique)
258.1	NPDES	N/A	1974	MCAWW	"Potassium" (Atomic Absorption, direct aspiration)
264.1	NPDES	N/A	1978	MCAWW	"Rhenium" (Atomic Absorption, direct aspiration)
264.2	NPDES	N/A	1978	MCAWW	"Rhenium" (Atomic Absorption furnace technique)
265.1	NPDES	N/A	1978	MCAWW	"Rhodium" (Atomic Absorption, direct aspiration)
265.2	NPDES	N/A	1978	MCAWW	"Rhodium" (Atomic Absorption furnace technique)
267.1	NPDES	N/A	1978	MCAWW	"Ruthenium" (Atomic Absorption, direct aspiration)
267.2	NPDES	N/A	1978	MCAWW	"Ruthenium" (Atomic Absorption furnace technique)

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
270.2	NPDES	N/A	1978	MCAWW	"Selenium" (Atomic Absorption furnace technique)
270.3	NPDES	N/A	1974	MCAWW	"Selenium" (Atomic Absorption, gaseous hydride)
272.1	NPDES	N/A	1978	MCAWW	"Silver" (Atomic Absorption, direct aspiration)
272.2	NPDES	N/A	1978	MCAWW	"Silver" (Atomic Absorption furnace technique)
273.1	NPDES	N/A	1974	MCAWW	"Sodium" (Atomic Absorption, direct aspiration)
273.2	NPDES	N/A	December 1982	MCAWW	"Sodium" (Atomic Absorption, furnace technique)
279.1	NPDES	N/A	1978	MCAWW	"Thallium" (Atomic Absorption, direct aspiration)
279.2	NPDES	N/A	1978	MCAWW	"Thallium" (Atomic Absorption, furnace technique)
282.1	NPDES	N/A	1978	MCAWW	"Tin" (Atomic Absorption, direct aspiration)
282.2	NPDES	N/A	1978	MCAWW	"Tin" (Atomic Absorption, furnace technique)
283.1	NPDES	N/A	1974	MCAWW	"Titanium" (Atomic Absorption, direct aspiration)
283.2	NPDES	N/A	1978	MCAWW	"Titanium" (Atomic Absorption, furnace technique)
286.1	NPDES	N/A	1974	MCAWW	"Vanadium" (Atomic Absorption, direct aspiration)
286.2	NPDES	N/A	1978	MCAWW	"Vanadium" (Atomic Absorption, furnace technique)
289.1	NPDES	N/A	1974	MCAWW	"Zinc" (Atomic Absorption, direct aspiration)
289.2	NPDES	N/A	1978	MCAWW	"Zinc" (Atomic Absorption, furnace technique)
300.0	NPDES	2.1	August 1993	EPA-600/R-93/100	"Determination of Inorganic Anions by Ion Chromatography"
305.1	NPDES	N/A	1974	MCAWW	"Acidity"
310.1	NPDES	N/A	1978	MCAWW	"Alkalinity" (Titrimetric, pH 4.5)
320.1	NPDES	N/A	1974	MCAWW	"Bromide" (Titrimetric)
325.1	NPDES	N/A	1971	MCAWW	"Chloride" (Colorimetric, Automated Ferricyanide AAI)
325.2	NPDES	N/A	1978	MCAWW	"Chloride" (Colorimetric, Automated Ferricyanide AAII)
325.3	NPDES	N/A	1982	MCAWW	"Chloride" (Titrimetric, Mercuric Nitrate)
330.1	NPDES	N/A	1978	MCAWW	"Chlorine, Total Residual" (Titrimetric, Amperometric)
330.3	NPDES	N/A	1978	MCAWW	"Chlorine, Total Residual" (Titrimetric, Iodometric)
335.1	NPDES	1.0	August 1993	EPA-600/R-93/100	"Determination of Total Cyanide by Semi-Automated Colorimetry"
335.2	NPDES	N/A	1980	MCAWW	"Cyanide, Total" (Titrimetric; Spectrophotometric)
335.3	NPDES	N/A	1978	MCAWW	"Cyanide, Total" (Colorimetric, Automated UV)
340.2	NPDES	N/A	1974	MCAWW	"Fluoride" (Potentiometric, Ion Selective Electrode)
345.1	NPDES	N/A	1974	MCAWW	"Iodide" (Titrimetric)
350.1	NPDES	2.0	August 1993	EPA-600/R-93/100	"Determination of Ammonia Nitrogen by Semi-Automated Colorimetry"

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
351.2	NPDES	2.0	August 1993	EPA-600/R-93/100	"Determination of Total Kjeldahl Nitrogen by Semi-Automated Colorimetry"
351.3	NPDES	N/A	1978	MCAWW	"Nitrogen, Kjeldahl, Total" (Colorimetric; Titrimetric; Potentiometric)"
352.1	NPDES	N/A	1971	MCAWW	"Nitrogen, Nitrate" (Colorimetric, Brucine)
353.1	NPDES	N/A	1978	MCAWW	"Nitrogen, Nitrate-Nitrite" (Colorimetric, Automated, Hydrazine Reduction)
353.2	NPDES	2.0	August 1993	EPA-600/R-93/100	"Determination of Nitrate-Nitrite Nitrogen by Automated Colorimetry"
353.3	NPDES	N/A	1974	MCAWW	"Nitrogen, Nitrate-Nitrite" (Spectrophotometric, Cadmium Reduction)
354.1	NPDES	N/A	1971	MCAWW	"Nitrogen, Nitrite" (Spectrophotometric)
365.1	NPDES	2.0	August 1993	EPA-600/R-93/100	"Determination of Phosphorus by Semi-Automated Colorimetry"
365.2	NPDES	N/A	1971	MCAWW	"Phosphorus, All Forms" (Colorimetric, Ascorbic Acid, Single Reagent)
365.3	NPDES	N/A	1978	MCAWW	"Phosphorus, All Forms" (Colorimetric, Ascorbic Acid, Two Reagent)
365.4	NPDES	N/A	1974	MCAWW	"Phosphorus, Total" (Colorimetric, Automated, Block Digester AA II)
370.1	NPDES	N/A	1978	MCAWW	"Silica, Dissolved" (Colorimetric)
375.1	NPDES	N/A	1971	MCAWW	"Sulfate" (Colorimetric, Automated, Chloranilate)
375.4	NPDES	N/A	1978	MCAWW	"Sulfate" (Turbidimetric)
376.1	NPDES	N/A	1978	MCAWW	"Sulfide" (Titrimetric, Iodine)
376.2	NPDES	N/A	1978	MCAWW	"Sulfide" (Colorimetric, Methylene Blue)
377.1	NPDES	N/A	1978	MCAWW	"Sulfite" (Titrimetric)
405.1	NPDES	N/A	1974	MCAWW	"Biochemical Oxygen Demand" (5 Days, 20°C)
410.1	NPDES	N/A	1978	MCAWW	"Chemical Oxygen Demand" (Titrimetric, Mid-Level)
410.2	NPDES	N/A	1978	MCAWW	"Chemical Oxygen Demand" (Titrimetric, Low Level)
410.4	NPDES	2.0	August 1993	EPA-600/R-93/100	"Determination of Chemical Oxygen Demand by Semi-Automated Colorimetry"
413.1	NPDES	N/A	1978	MCAWW	"Oil and Grease, Total, Recoverable" (Gravimetric, Separatory Funnel Extraction)
413.2	NPDES	N/A	1978	MCAWW	"Oil and Grease, Total Recoverable" (Spectrophotometric, Infrared)
415.1	NPDES	N/A	1974	MCAWW	"Organic Carbon, Total" (Combustion or Oxidation)
410.2	NPDES	N/A	1978	MCAWW	"Chemical Oxygen Demand" (Titrimetric, Low Level)
410.4	NPDES	2.0	August 1993	EPA-600/R-93/100	"Determination of Chemical Oxygen Demand by Semi-Automated Colorimetry"

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
413.1	NPDES	N/A	1978	MCAWW	"Oil and Grease, Total, Recoverable" (Gravimetric, Separatory Funnel Extraction)
413.2	NPDES	N/A	1978	MCAWW	"Oil and Grease, Total Recoverable" (Spectrophotometric, Infrared)
415.1	NPDES	N/A	1974	MCAWW	"Organic Carbon, Total" (Combustion or Oxidation)
418.1	NPDES	N/A	1978	MCAWW	"Petroleum Hydrocarbons, Total Recoverable" (Spectrophotometric, Infrared)
420.1	NPDES	N/A	1978	MCAWW	"Phenolics, Total Recoverable" (Spectrophotometric, Manual 4-AAP with Distillation)
420.2	NPDES	N/A	1974	MCAWW	"Phenolics, Total Recoverable (Colorimetric, Automated 4-AAP with Distillation)
425.1	NPDES	N/A	1971	MCAWW	"Methylene Blue Active Substances (MBAS)", (Colorimetric)
450.1	N/A	N/A	November 1980	EPA 600/4-81-056	"Total Organic Halide"
601	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Purgeable Halocarbons"
602	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Purgeable Aromatics"
603	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Acrolein and Acrylonitrile"
608	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Organochlorine Pesticides and PCBs"
610	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Polynuclear Aromatic Hydrocarbons"
613	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"2,3,7,8-Tetrachlorodibenzo-p-Dioxin"
615	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Chlorinated Herbicides"
624	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Purgeables"
625	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Base/Neutrals and Acids"
900.0	USEPA	N/A	August 1980	EPA/600/4-80-032	"Gross Alpha and Gross Beta Radioactivity in Drinking Water"
901.1	USEPA	N/A	August 1980	EPA/600/4-80-032	"Gamma Emitting Radionuclides in Drinking Water"
903.0	USEPA	N/A	August 1980	EPA/600/4-80-032	"Alpha-Emitting Radium Isotopes in Drinking Water"
903.1	USEPA	N/A	August 1980	EPA/600/4-80-032	"Radium in Drinking Water - Radium Emanation Technique"
904.0	USEPA	N/A	August 1980	EPA/600/4-80-032	"Radium-228 in Drinking Water"
905.0	USEPA	N/A	August 1980	EPA/600/4-80-032	"Radioactive Strontium in Drinking Water"
906.0	USEPA	N/A	August 1980	EPA/600/4-80-032	"Tritium in Drinking Water"
1010	RCRA	0	September 1986	SW-846	"Pensky-Martens Closed-Cup Method for Determining Ignitability"
1020A	RCRA	1	July 1992	SW-846	"Setaflash Closed-Cup Method for Determining Ignitability"
1311	RCRA	0	July 1992	SW-846	"Toxicity Characteristic Leaching Procedure"
1312	RCRA	0	September 1994	SW-846	"Synthetic Precipitation Leaching Procedure"

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
1664[4]	USEPA	N/A	April 1995	EPA-821-B-94-004b	"N-Hexane Extractable Material (HEM) and Silica Gel Treated N-Hexane Extractable Material (SGT-HEM) by Extraction and Gravimetry (Oil and Grease Total Petroleum Hydrocarbons)"
3060A	RCRA	1	January 1995	SW-846	"Alkaline Digestion for Hexavalent Chromium"
2320B	NPDES	N/A	1992	Standard Methods	"Alkalinity, Titration Method"
2340B	NPDES	N/A	1992	Standard Methods	"Hardness by Calculation"
3005A	RCRA	1	July 1992	SW-846	"Acid Digestion of Waters for Total Recoverable or Dissolved Metals for Analysis by FLAA or ICP Spectroscopy"
3010A	RCRA	1	July 1992	SW-846	"Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by FLAA or ICP Spectroscopy"
3020A	RCRA	1	July 1992	SW-846	"Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by GFAA Spectroscopy"
3050A	RCRA	1	July 1992	SW-846	"Acid Digestion of Sediments, Sludges, and Soils"
3500-Cr D	APHA, AWWA, and WEF	N/A	1992	Standard Methods	"Colorimetric Method" (Hexavalent Chromium - Cr^{+6}), Part 3000: "Metals"
3500-Fe D	NPDES	N/A	1992	Standard Methods	"Iron, Phenanthroline Method"
3500A	RCRA	1	July 1992	SW-846	"Organic Extraction and Sample Preparation"
3510B	RCRA	2	September 1994	SW-846	"Separatory Funnel Liquid-Liquid Extraction"
3520B	RCRA	2	September 1994	SW-846	"Continuous Liquid-Liquid Extraction"
3540B	RCRA	2	September 1994	SW-846	"Soxhlet Extraction"
3550A	RCRA	1	September 1994	SW-846	"Ultrasonic Extraction"
3580A	RCRA	1	July 1992	SW-846	"Waste Dilution"
3600B	RCRA	2	September 1994	SW-846	"Cleanup"
3610A	RCRA	1	July 1992	SW-846	"Alumina Column Cleanup"
3620A	RCRA	1	July 1992	SW-846	"Florisil Column Cleanup"
3630B	RCRA	2	September 1994	SW-846	"Silica Gel Cleanup"
3640A	RCRA	1	September 1994	SW-846	"Gel-Permeation Cleanup"
3650A	RCRA	1	July 1992	SW-846	"Acid-Base Partition Cleanup"
3660A	RCRA	1	July 1992	SW-846	"Sulfur Cleanup"
4500-H^+ B	NPDES	N/A	1992	Standard Methods	"pH Value, Electrometric Method"
4500-Cl E	NPDES	N/A	1992	Standard Methods	"Chloride, Automated Ferricyanide Method"

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
4500-CN E	NPDES	N/A	1992	Standard Methods	"Cyanide, Colorimetric Method"
5030A	RCRA	1	July 1992	SW-846	"Purge-and-Trap"
5320B	APHA, AWWA, and WEF	N/A	1988	Standard Methods	"Dissolved Organic Halogen, Adsorption-Pyrolysis-Titrimetric Method"
6010A	RCRA	1	July 1992	SW-846	"Inductively Coupled Plasma-Atomic Emission Spectroscopy"
6020	RCRA	0	September 1994	SW-846	"Inductively Coupled Plasma"
7020	RCRA	0	September 1986	SW-846	"Aluminum (Atomic Absorption, Direct Aspiration)"
7040	RCRA	0	September 1986	SW-846	"Antimony (Atomic Absorption, Direct Aspiration)"
7041	RCRA	0	September 1986	SW-846	"Antimony (Atomic Absorption, Furnace Technique)"
7060A	RCRA	1	September 1994	SW-846	"Arsenic (Atomic Absorption, Furnace Technique)"
7061A	RCRA	1	July 1992	SW-846	"Arsenic (Atomic Absorption, Gaseous Hydride)"
7062	RCRA	1	September 1994	SW-846	"Antimony and Arsenic (Atomic Absorption, Borohydride Reduction)"
7080A	RCRA	1	September 1994	SW-846	"Barium (Atomic Absorption, Direct Aspiration)"
7090	RCRA	0	September 1986	SW-846	"Beryllium (Atomic Absorption, Direct Aspiration)"
7091	RCRA	0	September 1986	SW-846	"Beryllium (Atomic Absorption, Furnace Technique)"
7110	APHA, AWWA, and WEF	N/A	1991	Standard Methods	"Gross Alpha and Gross Beta Radioactivity (Total, Suspended, and Dissolved)"
7130	RCRA	0	September 1986	SW-846	"Cadmium (Atomic Absorption, Direct Aspiration)"
7131A	RCRA	1	September 1994	SW-846	"Cadmium (Atomic Absorption, Furnace Technique)"
7140	RCRA	0	September 1986	SW-846	"Calcium (Atomic Absorption, Direct Aspiration)"
7190	RCRA	0	September 1986	SW-846	"Chromium (Atomic Absorption, Direct Aspiration)"
7191	RCRA	0	September 1986	SW-846	"Chromium (Atomic Absorption, Furnace Technique)"
7195	RCRA	0	September 1986	SW-846	"Chromium, Hexavalent (Coprecipitation)"
7196A	RCRA	1	July 1992	SW-846	"Chromium, Hexavalent (Colorimetric)"
7197	RCRA	0	September 1986	SW-846	"Chromium, Hexavalent (Chelation/Extraction)"
7198	RCRA	0	September 1986	SW-846	"Chromium, Hexavalent (Differential Pulse Polarography)"
7200	RCRA	0	September 1986	SW-846	"Cobalt (Atomic Absorption, Direct Aspiration)"
7201	RCRA	0	September 1986	SW-846	"Cobalt (Atomic Absorption, Furnace Technique)"
7210	RCRA	0	September 1986	SW-846	"Copper (Atomic Absorption, Direct Aspiration)"
7211	RCRA	0	July 1992	SW-846	"Copper (Atomic Absorption, Furnace Technique)"

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
7380	RCRA	0	September 1986	SW-846	"Iron (Atomic Absorption, Direct Aspiration)"
7381	RCRA	0	July 1992	SW-846	"Iron (Atomic Absorption, Furnace Technique)"
7420	RCRA	0	September 1986	SW-846	"Lead (Atomic Absorption, Direct Aspiration)"
7421	RCRA	0	September 1986	SW-846	"Lead (Atomic Absorption, Furnace Technique)"
7430	RCRA	0	July 1992	SW-846	"Lithium (Atomic Absorption, Direct Aspiration)"
7450	RCRA	0	September 1986	SW-846	"Magnesium (Atomic Absorption, Direct Aspiration)"
7460	RCRA	0	September 1986	SW-846	"Manganese (Atomic Absorption, Direct Aspiration)"
7461	RCRA	0	July 1992	SW-846	"Manganese (Atomic Absorption, Furnace Technique)"
7470A	RCRA	1	September 1994	SW-846	"Mercury in Liquid Waste (Manual Cold-Vapor Technique)"
7471A	RCRA	1	September 1994	SW-846	"Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique)"
7480	RCRA	0	September 1986	SW-846	"Molybdenum (Atomic Absorption, Direct Aspiration)"
7481	RCRA	0	September 1986	SW-846	"Molybdenum (Atomic Absorption, Furnace Technique)"
7500-^{3}H	APHA, AWWA, and WEF	N/A	1988	Standard Methods	"Tritium"
7520	RCRA	0	September 1986	SW-846	"Nickel (Atomic Absorption, Direct Aspiration)"
7550	RCRA	0	September 1986	SW-846	"Osmium (Atomic Absorption, Direct Aspiration)"
7610	RCRA	0	September 1986	SW-846	"Potassium (Atomic Absorption, Direct Aspiration)"
7740	RCRA	0	September 1986	SW-846	"Selenium (Atomic Absorption, Furnace Technique)"
7741A	RCRA	1	September 1994	SW-846	"Selenium (Atomic Absorption, Gaseous Hydride)"
7742	RCRA	0	September 1994	SW-846	"Selenium (Atomic Absorption, Borohydride Reduction)"
7760A	RCRA	1	July 1992	SW-846	"Silver (Atomic Absorption, Direct Aspiration)"
7761	RCRA	0	July 1992	SW-846	"Silver (Atomic Absorption, Furnace Technique)"
7770	RCRA	0	September 1986	SW-846	"Sodium (Atomic Absorption, Direct Aspiration)"
7780	RCRA	0	July 1992	SW-846	"Strontium (Atomic Absorption, Direct Aspiration)"
7840	RCRA	0	September 1986	SW-846	"Thallium (Atomic Absorption, Direct Aspiration)"
7841	RCRA	0	September 1986	SW-846	"Thallium (Atomic Absorption, Furnace Technique)"
7870	RCRA	0	September 1986	SW-846	"Tin (Atomic Absorption, Direct Aspiration)"
7910	RCRA	0	September 1986	SW-846	"Vanadium (Atomic Absorption, Direct Aspiration)"
7911	RCRA	0	September 1986	SW-846	"Vanadium (Atomic Absorption, Furnace Technique)"
7950	RCRA	0	September 1986	SW-846	"Zinc (Atomic Absorption, Direct Aspiration)"

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
7951	RCRA	0	July 1992	SW-846	"Zinc (Atomic Absorption, Furnace Technique)"
8010B	RCRA	2	September 1994	SW-846	"Halogenated Volatile Organics by Gas Chromatography"
8020A	RCRA	1	September 1994	SW-846	"Aromatic Volatile Organics by Gas Chromatography"
8021A	RCRA	1	September 1994	SW-846	"Halogenated Volatiles by Gas Chromatography Using Photoionization and Electrolytic Conductivity Detectors in Series: Capillary Column Technique"
8030A	RCRA	1	July 1992	SW-846	"Acrolein and Acrylonitrile by Gas Chromatography"
8080A	RCRA	1	September 1994	SW-846	"Organochlorine Pesticides and Polychlorinated Biphenyls by Gas Chromatography"
8100	RCRA	0	September 1986	SW-846	"Polynuclear Aromatic Hydrocarbons"
8140	RCRA	0	September 1986	SW-846	"Organophosphorus Pesticides"
8141A	RCRA	1	September 1994	SW-846	"Organophosphorus Compounds by Gas Chromatography: Capillary Column Technique"
8150B	RCRA	2	September 1994	SW-846	"Chlorinated Herbicides by Gas Chromatography"
8240B	RCRA	2	September 1994	SW-846	"Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)"
8260A	RCRA	1	September 1994	SW-846	"Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique"
8270B	RCRA	2	September 1994	SW-846	"Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique"
8280	RCRA	0	September 1986	SW-846	"The Analysis of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans"
8290	RCRA	0	September 1994	SW-846	"Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (HRGC/HRMS)"
8310	RCRA	0	September 1986	SW-846	"Polynuclear Aromatic Hydrocarbons"
8330	RCRA	0	September 1994	SW-846	"Nitroaromatics and Nitramines by High Performance Liquid Chromatography (HPLC)"
9010A	RCRA	1	July 1992	SW-846	"Total and Amenable Cyanide"
9012	RCRA	0	September 1986	SW-846	"Total and Amenable Cyanide (Colorimetric, Automated UV)"
9020B	RCRA	2	September 1994	SW-846	"Total Organic Halides (TOX)"
9030A	RCRA	1	July 1992	SW-846	"Acid-Soluble and Acid-Insoluble Sulfides"

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
9038	RCRA	0	September 1986	SW-846	"Sulfate (Turbidimetric)"
9040B	RCRA	2	January 1995	SW-846	"pH Electrometric Measurement"
9045C	RCRA	3	January 1995	SW-846	"Solid and Waste pH"
9050	RCRA	0	September 1986	SW-846	"Specific Conductance"
9056	RCRA	0	September 1994	SW-846	"Determination of Inorganic Anions by Ion Chromatography"
9060	RCRA	0	September 1986	SW-846	"Total Organic Carbon"
9065	RCRA	0	September 1986	SW-846	"Phenolics (Spectrophotometric, Manual 4-AAP with Distillation)"
9066	RCRA	0	September 1986	SW-846	"Phenolics (Colorimetric, Automated 4-AAP with Distillation)"
9070	RCRA	0	September 1986	SW-846	"Total Recoverable Oil and Grease (Gravimetric, Separatory Funnel Extraction)"
9071A	RCRA	1	September 1994	SW-846	"Oil and Grease Extraction Method for Sludge and Sediment Samples"
9200	RCRA	0	September 1986	SW-846	"Nitrate"
9251	RCRA	0	September 1986	SW-846	"Chloride (Colorimetric, Automated Ferricyanide AAI)"
9252A	RCRA	1	September 1994	SW-846	"Chloride (Titrimetric, Mercuric Nitrate)"
9310	RCRA	0	September 1986	SW-846	"Gross Alpha and Gross Beta"
9315	RCRA	0	September 1986	SW-846	"Alpha-Emitting Radium Isotopes"
9320	RCRA	0	September 1986	SW-846	"Radium-228"

[1] NPDES - National Pollutant Discharge Elimination System
RCRA - Resource Conservation and Recovery Act
USEPA - United States Environmental Protection Agency
ASTM - American Society for Testing and Materials
GAC - Goodyear Atomic Corporation
APHA - American Public Health Association
AWWA - American Water Works Association
WEF - Water Environment Federation
The co-publishers for Standard Methods for the Examination of Water and Wastewater are APHA, AWWA, and WEF.

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

[2] For the NPDES methods, the date listed is the date the method was issued if no revisions were made. If a technical or editorial revision was made, the latest of those dates is listed here.

[3] The following table provides full source references:

Source	Source Reference
40CFR Part 136 - Appendix A	40CFR Part 136 - "Guidelines Establishing Test Procedures for the Analysis of Pollutants , Appendix A: "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", Code of Federal Regulations, Revised July 1, 1995.
ASTM	1993 Annual Book of ASTM Standards, Section 11, Water and Environmental Technology, Volume 11.02, Water (II).
EPA-600/4-84-041	"Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air", Document No.: EPA-600/4-84-041, Environmental Monitoring System Laboratory, Office of Research and Development, United States Environmental Protection Agency, Research Triangle Park, North Carolina 27711, April 1984.
EPA-821-B-94-004b	Proposed Method 1664: "N-Hexane Extractable Material (HEM) and Silica Gel Treated N-Hexane Extractable Material (SGT-HEM) by Extraction and Gravimetry (Oil and Grease Total Petroleum Hydrocarbons)", Document No.: EPA-821-B-94-004b, Office of Water, Engineering and Analysis Division, Washington, D.C., 20460, April 1995. (This method has not been promulgated by the EPA).
EPA/600/4-80-032	"Prescribed Procedures for Measurement of Radioactivity in Drinking Water", Document No.: EPA/600/4-80-032, EMSL, Cincinnati, OH 45268, August 1980.
EPA/600/R-93/100	"Methods for the Determination of Inorganic Substances in Environmental Samples", Document Number EPA/600/R-93/100. Office of Research and Development, Washington, D.C. 20460, August 1993.
EPA/600/R-94/111	"Methods for the Determination of Metals in Environmental Samples", Supplement I, EMSL-CI, May 1994.
MCAWW	Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983, United States Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio 45268.
Standard Methods	Standard Methods for the Examination of Water and Wastewater, 18th Edition, 1992. Prepared and published jointly by: APHA, AWWA, and WEF.
SW-846	Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), and Final Update IIB (January 1995). United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC 20460.
USEPA CLP (DFLM01.1)	United States Environmental Protection Agency, Statement of Work for Analysis of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans (PCDF).
USEPA CLP (ILM01.8)	United States Environmental Protection Agency, Statement of Work for Organics Analysis, Multi-Media, Multi-Concentration, Document Number OLM01.0 (including revisions OLM01.1 (December 1990), OLM01.2 (January 1991), OLM01.3 (February 1991), OLM01.4 (March 1991), OLM01.5 (April 1991), OLM01.6 (June 1991), OLM01.7 (July 1991), and OLM01.8 (August 1991).
USEPA CLP (ILM03.0)	United States Environmental Protection Agency, Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, Document Number ILM03.0.
USEPA CLP (OLM03.0)	United States Environmental Protection Agency, Statement of Work for Organics Analysis, Document Number OLM03.0.

[4] This is an SW-846 Proposed Update III method and has not been promulgated. Proposed Update III was released for public comment January 1995.

TABLE 8.4-1
Field Quality Control Samples

Type	Applicability		Accuracy and Precision Application	Introduced By
	Inorganic	Organic		
Trip Blank (volatiles)	No	Yes	Accuracy	Supplier of Containers
Field Blank	Yes	Yes	Accuracy	Field Sampler
Rinsate Blank	Yes	Yes	Accuracy	Field Sampler
Collocated Sample	Yes	Yes	Precision	Field Sampler
Split Sample	Yes	Yes	Precision	Field Sampler
Field Duplicate	Yes	Yes	Precision	Field Sampler
Field Matrix Spike	Yes	Yes	Accuracy	Field Sampler

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TABLE 8.4-2
Laboratory Quality Control Samples

Type	Frequency	Applicability		Accuracy and Precision Application	Introduced By
		Inorganic/ Radiochemical	Organic		
Analytical Spike	As specified in methods, or as needed	Yes	No	Accuracy	Analyst/ Prep
Duplicate	1 out of 20 or at least 1/month/run	Yes	Yes	Precision	Analyst/ Prep
Instrument Blank	As specified methods, or as needed	Yes	Yes	Accuracy	Analyst
Interference Check Sample	As specified in methods	Yes	No	Accuracy	Analyst
Internal Standard	Each sample and standard	Yes	Yes	Both	Analyst/ Prep
Laboratory Control Sample	1 per each group of samples processed up to 20 samples.	Yes	Yes	Accuracy	Analyst/ Prep
Matrix Spike	1 per each group of samples processed up to 20 samples.	Yes	Yes	Accuracy	Analyst/ Prep
Matrix Spike Duplicate	1 per each group of samples processed up to 20 samples.	Yes	Yes	Both	Analyst/ Prep
Method Blank	1 per each group of samples processed up to 20 samples.	Yes	Yes	Accuracy	Analyst/ Prep
Surrogate	All standards, method blanks, LCS, and samples.	No	Yes Method Dependent	Accuracy	Analyst/ Prep
Yield Monitor	Operation-specific	Yes	No	Accuracy	Prep

TABLE 8.4-3
Laboratory Performance Quality Control Samples

Sample/Measurement	Purpose
Method Blanks	Demonstrates that the laboratory systems (*e.g.*, glassware cleaning procedures) and laboratory reagents used for the preparation and analysis of samples have not contributed to a false positive or negative measurement.
Instrument Blank	Demonstrates that the analytical system has not contributed to a false positive or negative measurement.
Laboratory Control Sample	Demonstrates the laboratory's ability to perform an analysis within the performance requirements of the method.

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TABLE 8.4-4
Matrix Specific Quality Control Samples

Quality Control Sample	Purpose
Duplicate Samples	Estimates the ability of the laboratory to obtain precise measurements on a sample. This measure is dependent on the homogeneity of the sample being duplicated. Solid samples often portray poor sample homogeneity and therefore often have poor duplication with regards to the sample result.
Matrix Spike Sample	Estimates the ability of the laboratory to obtain accurate measurements on a sample. The measure is dependent on the bias a sample matrix may cause regarding a given analyte.
Matrix Spike Duplicate Sample	In addition to verifying the accuracy of the matrix spike sample, the matrix spike duplicate can be used with the matrix spike sample as a measure of precision by calculating the relative percent difference (RPD).

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Acidity	Method Blank	305.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	305.1	Not Applicable	—	Not Applicable
	Matrix Spike	305.1	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	305.1	Not Applicable	—	Not Applicable
	Duplicate	305.1	Frequency: 1 per batch of 10 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Alkalinity	Method Blank	310.1 2320B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	310.1 2320B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	310.1 2320B	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	310.1 2320B	Not Applicable	—	Not Applicable
	Duplicate	310.1 2320B	Frequency: 1 per batch of 10 samples Criteria 310.1: ≤ 20 % RPD[3] Criteria 2320B: ≤ 25 % RPD[3] Corrective Action: Flag data outside of limit.	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Ammonia	Method Blank	350.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	350.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	350.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	350.1	Not Applicable	—	Not Applicable
	Duplicate	350.1	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
Ammonia (TKN)	Method Blank	351.2 351.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	351.2 351.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	351.2 351.3	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	351.2 351.3	Not Applicable	—	Not Applicable
	Duplicate	351.2 351.3	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
BOD	Method Blank	405.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	405.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	405.1	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	405.1	Not Applicable	—	Not Applicable
	Duplicate	405.1	Not Applicable	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Bromide	Method Blank	300.0[6] 320.1 D1246	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	300.0[6] 320.1 D1246	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within control limits, rerun all associated samples	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within control limits, rerun all associated samples
	Matrix Spike	300.0[6] 320.1 D1246	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data associated with MS outside of limit
	Matrix Spike Duplicate	300.0[6] 320.1 D1246	Not Applicable	9056	Not Applicable
	Duplicate	300.0[6] 320.1 D1246	Methods 300.0, 320.1: Not Applicable Frequency: Method D1246: 1 with each batch of samples processed not to exceed 20 samples	9056	Frequency: 1 with each batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data associated with duplicates outside of laboratory RPD[3] limits

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Chemical Oxygen Demand (COD)	Method Blank	410.1 410.2 410.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	410.1 410.2 410.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	410.1 410.2 410.4	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	410.1 410.2 410.4	Not Applicable	—	Not Applicable
	Duplicate	410.1 410.2 410.4	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Chloride	Method Blank	300.0[6] 325.1 325.2 325.3 4500-Cl E	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9056 9251 9252A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	300.0[6] 325.1 325.2 325.3 4500-Cl E	Frequency: 1 with each batch of samples processed not to exceed 20 samples. Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within control limits, rerun all associated samples	9056 9251 9252A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	300.0[6] 325.1 325.2 325.3 4500-Cl E	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9056 9251 9252A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Methods 9251/9252 Corrective Action: If not within laboratory control limits, rerun all associated samples Method 9056 Corrective Action: Flag data associated with MS outside of limits

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Chloride (continued)	Matrix Spike Duplicate	300.0[6] 325.1 325.2 325.3 4500-Cl E	Not Applicable	9056 9251 9252A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits/< 20 % RPD[3] Corrective Action: Flag data outside of limit Method 9056: MSD is not applicable
	Duplicate	300.0[6] 325.1 325.2 325.3 4500-Cl E	Methods 300.0, 325.1, 325.2, 325.3: Not Applicable Method 4500-Cl E: Frequency: 1 with each batch of samples processed not to exceed 20 samples	9056 9251 9252A	Method 9056 only: Frequency: 1 with each batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data associated with duplicates outside of laboratory RPD[3] limits
Chlorine, Residual	Method Blank	330.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Chlorine, Residual (continued)	Laboratory Control Sample	330.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	330.1 330.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	330.1 330.3	Not Applicable	—	Not Applicable
	Duplicate	330.1 330.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	—	Water

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Chromium (Cr^{+6})	Method Blank	218.4 3500 Cr-D	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	3060A [5] 7196A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	218.4 3500 Cr-D	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	3060A [5] 7196A	Frequency: 1 with each batch of samples processed not to exceed 20 samples prepped Criteria: percent recovery for water must be within ± 15 % and for solids must be within ± 20% Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	218.4 3500 Cr-D	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag data outside of limit	3060A [5] 7196A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Advisory limits are 75% - 125% recovery Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	218.4 3500 Cr-D	Not Applicable	3060A [5] 7196A	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Chromium (Cr^{+6}) (continued)	Duplicate	218.4 3500 Cr-D	Not Applicable	3060A[5] 7196A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] limit Corrective Action: Flag data outside of limit.
Color	Method Blank	110.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	110.2	Not Applicable	—	Not Applicable
	Matrix Spike	110.2	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	110.2	Not Applicable	—	Not Applicable
	Duplicate	110.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	—	Not Applicable
Conductivity	Method Blank	120.1	Not Applicable	9050	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Conductivity (continued)	Laboratory Control Sample	120.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9050	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	120.1	Not Applicable	9050	Not Applicable
	Matrix Spike Duplicate	120.1	Not Applicable	9050	Not Applicable
	Duplicate	120.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	9050	Frequency: 1 with each batch of samples processed not to exceed 10 samples
Cyanide (Amenable)	Method Blank	335.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Cyanide (Amenable) (continued)	Laboratory Control Sample	335.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	335.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Advisory limits are 75% - 125% recovery Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	335.1	Not Applicable	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Advisory limits are 75% - 125% recovery Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	335.1	Not Applicable	9010A 9012	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Cyanide (Total)	Method Blank	335.2 335.3 4500-CN E	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	335.2 335.3 4500-CN E	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	335.2 335.3 4500-CN E	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Advisory limit is 75% - 125% recovery Corrective Action: Flag data associated with unacceptable Matrix Spike

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Cyanide (Total) (continued)	Matrix Spike Duplicate	335.2 335.3 4500-CN E	Not Applicable	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Limit is 75% - 125% recovery Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	335.2 335.3	Methods 335.2, 335.3: Not Applicable Method 4500-CN E: Frequecny: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	9010A 9012	Not Applicable
Flashpoint	Method Blank	—	Not Applicable	1010 1020A	Not Applicable
	Laboratory Control Sample	—	Not Applicable	1010 1020A	Not Applicable
	Matrix Spike	—	Not Applicable	1010 1020A	Not Applicable
	Matrix Spike Duplicate	—	Not Applicable	1010 1020A	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Flashpoint (continued)	Duplicate	—	Not Applicable	1010 1020A	Frequency: 1 per batch of ≤20 samples Criteria: RPD[3] must be ≤ 20% Corrective Action: Flag data associated with unacceptable Duplicate
Fluoride	Method Blank	300.0[6] 340.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable
	Laboratory Control Sample	300.0[6] 340.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within control limits, rerun all associated samples

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Fluoride (continued)	Matrix Spike	300.0[6] 340.2	Frequency: 1 per 10 samples by IC Criteria: Must be within laboratory QC limits Corrective Action: Flag data outside of limit	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data associated with outside of limit
	Matrix Spike Duplicate	300.0[6] 340.2	Not Applicable	9056	Not Applicable
	Duplicate	300.0[6] 340.2	Not Applicable	9056	Frequency: 1 with each batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data associated with duplicates outside of laboratory RPD[3] limits
Hardness	Method Blank	130.2 2340B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Hardness (continued)	Laboratory Control Sample	130.2 2340B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	130.2 2340B	Method 130.2, Not Applicable Method 2340B: Frequency, Criteria, and Corrective Action: See ICP Metals Method 200.7 Requirements	—	Not Applicable
	Matrix Spike Duplicate	130.2 2340B	Method 130.2, Not Applicable Method 2340B: Frequency, Criteria, and Corrective Action: See ICP Metals Method 200.7 Requirements	—	Not Applicable
	Duplicate	130.2 2340B	Frequency: 1 per 20 samples, minimum of one per batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Iodide	Method Blank	345.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	345.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	345.1	Frequency: 1 per batch of 20 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag associated data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	345.1	Not Applicable	—	Not Applicable
	Duplicate	345.1	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
Iron	Method Blank	3500-Fe D	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	3500-Fe D	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	3500-Fe D	Frequency: 1 every 10 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag associated data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	3500-Fe D	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Iron (continued)	Duplicate	3500-Fe D	Frequency: 1 per batch of 20 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag associated data outside of limit	—	Not Applicable
Methylene Blue Active Substances (MBAS)	Method Blank	425.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	425.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Methylene Blue Active Substances (MBAS) (continued)	Matrix Spike	425.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	425.1	Not Applicable	—	Not Applicable
	Duplicate	425.1	Not Applicable	—	Not Applicable
Nitrate	Method Blank	300.0[6] 352.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9056 9200	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	300.0[6] 352.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9056 9200	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitrate (continued)	Matrix Spike	300.0[6] 352.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Must be within laboratory control limits Corrective Action: Flag data outside of limit	9056 9200	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, flag all associated samples
	Matrix Spike Duplicate	300.0[6] 352.1	Not Applicable	9056 9200	Method 9056: Not applicable Method 9200: Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery and RPD[3] must be within laboratory control limits Corrective Action: If not within laboratory control limits, flag all associated samples
	Duplicate	300.0[6] 352.1	Not Applicable	9056 9200	Method 9056: Frequency: 1 per 10 samples Criteria: RPD[3] must be within laboratory control limits Corrective Action: If not within laboratory control limits, flag all associated samples Method 9200: Not applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitrite	Method Blank	300.0[6] 354.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	300.0[6] 354.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	300.0[6] 354.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Must be within laboratory control limits Corrective Action: Flag data outside of limit	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, flag all associated samples
	Matrix Spike Duplicate	300.0[6] 354.1	Not Applicable	9056	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitrite (continued)	Duplicate	300.0[6] 354.1	Not Applicable	9056	Frequency: 1 per 10 samples Criteria: RPD[3] must be within laboratory control limits Corrective Action: If not within laboratory control limits, flag all associated samples
Nitrate-Nitrite	Method Blank	353.1 353.2 353.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	353.1 353.2 353.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitrate-Nitrite (continued)	Matrix Spike	353.1 353.2 353.3	Frequency: 1 per 20 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	353.1 353.2 353.3	Not Applicable	—	Not Applicable
	Duplicate	353.1 353.2 353.3	Not Applicable	—	Not Applicable
Odor	Method Blank	140.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	140.1	Not Applicable	—	Not Applicable
	Matrix Spike	140.1	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	140.1	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
Odor (continued)	Duplicate	140.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	—	Not Applicable
pH	Method Blank	150.1 4500-H^+ B	Not Applicable	9040B 9045C	Not Applicable
	Laboratory Control Sample	150.1 4500-H^+ B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Sample provided by external source, must be within ± 0.05 pH units Corrective Action: If not within laboratory control limits, rerun all associated samples	9040B 9045C	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Sample provided by external source, must be within ± 0.05 pH units Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	150.1 4500-H^+ B	Not Applicable	9040B 9045C	Not Applicable
	Matrix Spike Duplicate	150.1 4500-H^+ B	Not Applicable	9040B 9045C	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
pH (continued)	Duplicate	150.1 4500-H^+ B	Method 150.1 Frequency: 1 with each batch of samples processed not to exceed 20 samples Method 4500-H^+B Frequency: 1 with each batch of 10 samples Method 150.1 Criteria: ≤20 % RPD[3] limit Method 4500-H^+B Criteria: ≤ 25 % RPD[3] limit Corrective Action: Flag data outside of limit.	9040B 9045C	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Advisory limits are ≤ 20% RPD[3] Corrective Action: Flag data associated with unacceptable Duplicate
Phenolics	Method Blank	420.1 420.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9065 9066	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	420.1 420.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9065 9066	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Phenolics (continued)	Matrix Spike	420.1 420.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data associated with unacceptable Matrix Spike	9065 9066	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data
	Matrix Spike Duplicate	420.1 420.2	Not Applicable	9065 9066	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data
	Duplicate	420.1 420.2	Not Applicable	9065 9066	Not Applicable
Phosphate	Method Blank	—	Not Applicable	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	—	Not Applicable	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Phosphate (continued)	Matrix Spike	—	Not Applicable	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data associated with MS outside of limits
	Matrix Spike Duplicate	—	Not Applicable	9056	Not Applicable
	Duplicate	—	Not Applicable	9056	Frequency: 1 with each batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data associated with duplicates outside of laboratory RPD[3] limits
Phosphorus (Total and Ortho-phosphate)	Method Blank	300.0[4,6] 365.1 365.2 365.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicabine

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Phosphorus (Total and Ortho-phosphate) (continued)	Laboratory Control Sample	300.0[4,6] 365.1 365.2 365.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	300.0[4,6] 365.1 365.2 365.3	Frequency: 1 per 10 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	300.0[4,6] 365.1 365.2 365.3	Not Applicable	—	Not Applicable
	Duplicate	300.0[4,6] 365.1 365.2 365.3	Not Applicable	—	Not Applicable
Reactivity (Cyanide and Sulfide)	Method Blank	—	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Reactivity (Cyanide and Sulfide) (continued)	Laboratory Control Sample	—	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	—	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	Follow QC sample requirements of determinative method
	Matrix Spike Duplicate	—	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	Follow QC sample requirements of determinative method
	Duplicate	—	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	Not Applicable
Silica, Dissolved	Method Blank	370.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Silica, Dissolved (continued)	Laboratory Control Sample	370.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	370.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	370.1	Not Applicable	—	Not Applicable
	Duplicate	370.1	Not Applicable	—	Not Applicable
Solids	Method Blank	160.1 160.2 160.3 160.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Solids (continued)	Laboratory Control Sample	160.1 160.2 160.3 160.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	160.1 160.2 160.3 160.4	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	160.1 160.2 160.3 160.4	Not Applicable	—	Not Applicable
	Duplicate	160.1 160.2 160.3 160.4 160.5	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag data outside of limit	—	Not Applicable
Specific Conductance	Method Blank	120.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9050	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Specific Conductance (continued)	Laboratory Control Sample	120.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9050	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	120.1	Not Applicable	9050	Not Applicable
	Matrix Spike Duplicate	120.1	Not Applicable	9050	Not Applicable
	Duplicate	120.1	Frequency: 1 with each batch of 20 samples processed Criteria: RPD[3] must be within laboratory QC limits Corrective Action: Flag associated data if outside of limits	9038 9050	Frequency: 1 with each batch of 20 samples processed Criteria: RPD[3] must be within laboratory QC limits Corrective Action: Flag associated data if outside of limits
Sulfate	Method Blank	300.0[6] 375.1 375.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9038 9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Sulfate (continued)	Laboratory Control Sample	300.0[6] 375.1 375.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9038 9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Method 9038 Criteria: Percent recovery must be within ± 15 % Method 9056 Criteria: Percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS (ICV)
	Matrix Spike	300.0[6] 375.1 375.4	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9038 9056	Frequency: 1 with each batch of samples processed not to exceed 10 samples (Method 9038) or 20 samples (Method 9056) Method 9038 Criteria: Limits are 75% - 125% recovery Method 9056 Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	300.0[6] 375.1 375.4	Not Applicable	9038 9056	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Sulfate (continued)	Duplicate	300.0[6] 375.1 375.4	Not Applicable	9038 9056	Frequency: 1 with each batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data associated with duplicates outside of laboratory RPD[3] limits
Sulfide	Method Blank	376.1 376.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	376.1 376.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Sulfide (continued)	Matrix Spike	376.1 376.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data
	Matrix Spike Duplicate	376.1 376.2	Not Applicable	9030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data
	Duplicate	376.1 376.2	Not Applicable	9030A	Not Applicable
Sulfite	Method Blank	377.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Sulfite (continued)	Laboratory Control Sample	377.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	377.1	Frequency: 1 per 20 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	377.1	Not Applicable	—	Not Applicable
	Duplicate	377.1	Not Applicable	—	Not Applicable
Temperature	Method Blank	170.1	Not Applicable	—	Not Applicable
	Laboratory Control Sample	170.1	Not Applicable	—	Not Applicable
	Matrix Spike	170.1	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	170.1	Not Applicable	—	Not Applicable
	Duplicate	170.1	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Total Organic Carbon (TOC)	Method Blank	415.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9060	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	415.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9060	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	415.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9060	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Reanalyze if sample remaining. If not, flag data associated with unacceptable Matrix Spike

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Total Organic Carbon (TOC) (continued)	Matrix Spike Duplicate	415.1	Not Applicable	9060	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Reanalyze if sample remaining. If not, flag data associated with unacceptable Matrix Spike Duplicate
	Duplicate	415.1	Not Applicable	9060	Not Applicable
Total Organic Halides (TOX)	Method Blank	SM 5320B[6] 450.1[6]	Frequency: 1 with each set of 8 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9020B	Frequency: Run in duplicate between each group of 8 analytical determinations Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	SM 5320B[6] 450.1[6]	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery of analyte must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS (ICV)	9020B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery of analyte must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS (ICV)

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Total Organic Halides (TOX) (continued)	Matrix Spike	SM 5320B [6] 450.1 [6]	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Must be within laboratory control limits Corrective Action: Reanalyze if sample remaining. If not, flag data with unacceptable Matrix Spike	9020B	Frequency: 1 per batch of 10 samples Criteria: Must be within laboratory control limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	SM 5320B [6] 450.1 [6]	Not Applicable	9020B	Not Applicable
	Duplicate	SM 5320B [6] 450.1 [6]	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] limit Corrective Action: Flag data outside of limit.	9020B	Frequency: All samples will be analyzed in duplicate Criteria: ≤ 20 % RPD[3] limit Corrective Action: Flag data outside of limit.
Turbidity	Method Blank	180.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Turbidity (continued)	Laboratory Control Sample	180.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	180.1	Not applicable	—	Not Applicable
	Matrix Spike Duplicate	180.1	Not Applicable	—	Not Applicable
	Duplicate	180.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag data outside of limit Not Applicable.	—	Not Applicable
Water Content	Method Blank	—	Not Applicable	—	Not Applicable
	Laboratory Control Sample	—	Not Applicable	—	Not Applicable
	Matrix Spike	—	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Water Content (continued)	Matrix Spike Duplicate	—	Not Applicable	—	Not Applicable
	Duplicate	—	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	—	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] limit Corrective Action: Reanalyze if sample remaining. If not, flag data outside of limit.
GFAA and Flame AA Metals, Mercury by CVAA	Method Blank	200 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	7000 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	200 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery of analyte must be within ± 20 % Corrective Action: Rerun all samples associated with unacceptable LCS	7000 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery of analyte must be within ± 20 % Corrective Action: Rerun all samples associated with unacceptable LCS

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
GFAA and Flame AA Metals, Mercury by CVAA (continued)	Matrix Spike	200 series	Frequency: with each batch of samples processed not to exceed 20 samples Criteria: Recovery must be within 80-120 % Corrective Action: Flag data associated with unacceptable MS. (See SOP for detailed corrective action procedure and for other QC procedures.)	7000 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery must be within 80-120 % Corrective Action: Flag data associated with unacceptable MS. (See SOP for detailed corrective action procedure and for other QC procedures.)
	Matrix Spike Duplicate	200 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery must be within 80-120 %, RPD[3] must be within 20 % Corrective Action: Flag data associated with unacceptable MSD	7000 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery must be within 80-120 %, RPD[3] must be within 20 % Corrective Action: Flag data associated with unacceptable MSD
	Duplicate	200 series	Not Applicable	7000 series	Not Applicable
	Post Digestion Spikes	200 series	Post Digestion Spike is conducted on all samples	7000 series	Post Digestion Spike is conducted on all samples
ICP Metals	Method Blank	200.7	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	6010A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
ICP Metals (continued)	Laboratory Control Sample	200.7	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery of analyte must be ± 20 % Corrective Action: Rerun all samples associated with unacceptable LCS	6010A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery of analyte must be ± 20 % Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	200.7	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Limits for percent recovery are 80-120% Corrective Action: Flag data associated with unacceptable Matrix Spike	6010A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Limits for percent recovery are 80-120% Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	200.7	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Limits for percent recovery are 80-120%, RPD[3] must be within 20 % Corrective Action: Flag data associated with unacceptable Matrix Spike	6010A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Limits for percent recovery are 80-120%, RPD[3] must be within 20 % Corrective Action: Flag data associated with unacceptable Matrix Spike

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
ICP Metals (continued)	Duplicate	200.7	Not Applicable	6010A	Not Applicable
	Serial Dilutions	200.7	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: 10 % Difference Corrective Action: Flag data associated with unacceptable Serial Dilution	6010A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: 10 % Difference Corrective Action: Flag data associated with unacceptable Serial Dilution
ICP/MS Metals	Method Blank	200.8	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	6020	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	200.8	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS	6020	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable blank
	Matrix Spike	200.8	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Recovery within laboratory control limits Corrective Action: Qualify data "suspect/matrix"	6020	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
ICP/MS Metals (continued)	Matrix Spike Duplicate	200.8	Not Applicable	6020	Not Applicable
	Duplicate	200.8	Not Applicable	6020	Frequency: 1 per 20 samples, minimum of one per batch of samples processed Criteria: 20% RPD[3] Corrective Action: Re-analyze samples associated with unacceptable duplicate
	Post Duplicate Spike	200.8	Not Applicable	6020	Frequency: 1 per 20 samples Criteria: 75-125% Corrective Action: Dilute and reanalyze
	Serial 5x Dilution	200.8	Not Applicable	6020	Frequency: 1 per 20 samples Criteria: ± 10% D Corrective Action: Use alternate isotope or quality data "suspect/matrix"

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Footnotes

(1) National Pollutant Discharge Elimination System
(2) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), and Final Update IIB (January 1995).
(3) RPD-Relative Percent Difference
(4) Orthophosphate only
(5) This is an SW-846 Proposed Update III Method
(6) Method not listed in 40 CFR Part 136.

TABLE 8.4-6
Organic Laboratory Quality Control Samples

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
Aromatic Volatiles by GC	Method Blank	602	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8020A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	602	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8020A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	602	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8020A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
Aromatic Volatiles by GC (continued)	Matrix Spike Duplicate	602	Not Applicable	8020A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	602	Not Applicable	8020A	Not Applicable
	Surrogates	602	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria	8020A	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	602	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.	8020A	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Acrolein & Acrylonitrile by GC	Method Blank	603	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	603	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	603	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Acrolein & Acrylonitrile by GC (continued)	Matrix Spike Duplicate	603	Not Applicable	8030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	603	Not Applicable	8030A	Not Applicable
	Surrogates	603	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria	8030A	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	603	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.	8030A	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Dioxins/ Dibenzo-furans	Method Blank	613	Frequency: 1 per batch of ≤ 20 samples extracted Criteria: Concentration less than reporting limit Corrective Action: Rerun all positive samples associated with unacceptable blank	8280 8290	Frequency: 1 per batch of ≤ 20 samples extracted Criteria: Concentration less than reporting limit Corrective Action: Rerun all positive samples associated with unacceptable blank
	Laboratory Control Sample	613	Frequency: 1 per batch of ≤ 20 samples extracted Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8280 8290	Frequency: 1 per batch of ≤ 20 samples extracted Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	613	Frequency: 1 per analytical batch of ≤ 20 samples Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8280 8290	Frequency: 1 per analytical batch of ≤ 20 samples Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	613	Frequency: 1 per analytical batch of ≤ 20 samples Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable matrix spike Duplicate	8280 8290	Frequency: 1 per analytical batch of ≤ 20 samples Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable matrix spike duplicate

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Dioxins/ Dibenzo-furans (continued)	Duplicate	613	Not Applicable	8280 8290	Not Applicable
	Surrogates	613	Not Applicable	8280 8290	Not Applicable
	Internal Standards	613	Internal standards are added to all samples (QC samples included). Internal standard recovery should be between 40 % to 120 %.	8280 8290	Internal standards are added to all samples (QC samples included). Internal standard recovery should be between 40 % - 120 % for Method 8280 and between 40 % - 135 % for Method 8290. Use limits in laboratory SOP.
Halogenated Volatiles by GC	Method Blank	--	Not Applicable	8021A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	--	Not Applicable	8021A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
Halogenated Volatiles by GC (continued)	Matrix Spike	--	Not Applicable	8021A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	--	Not Applicable	8021A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	--	Not Applicable	8021A	Not Applicable
	Surrogates	--	Not Applicable	8021A	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria.

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Halogenated Volatiles by GC (continued)	Internal Standards	--	Not Applicable	8021A	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.
Herbicides	Method Blank	615 [3]	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Re-extract all samples associated with unacceptable blank	8150B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Re-extract all samples associated with unacceptable blank
	Laboratory Control Sample	615 [3]	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Re-extract all samples associated with unacceptable LCS	8150B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte must be within historical acceptance limits Corrective Action: Re-extract all samples associated with unacceptable LCS
	Matrix Spike	615 [3]	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8150B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Herbicides (continued)	Matrix Spike Duplicate	615 [3]	Not Applicable	8150B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within control limits Corrective Action: Flag data associated with unacceptable matrix spike sample
	Duplicate	615 [3]	Not Applicable	8150B	Not Applicable
	Surrogates	615 [3]	Not Applicable	8150B	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must fall within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	615 [3]	Not Applicable	8150B	Optional
Nitro-aromatics by HPLC	Method Blank	--	Not Applicable	8330	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitro-aromatics by HPLC (continued)	Laboratory Control Sample	–	Not Applicable	8330	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	–	Not Applicable	8330	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	–	Not Applicable	8330	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	–	Not Applicable	8330	Not Applicable
	Surrogates	–	Not Applicable	8330	Not Applicable
	Internal Standards	–	Not Applicable	8330	Not Applicable

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
Organo-phosphorus Pesticides	Method Blank	–	Not Applicable	8140 8141A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	–	Not Applicable	8140 8141A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	–	Not Applicable	8140 8141A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable MS
	Matrix Spike Duplicate	–	Not Applicable	8140 8141A	Not Applicable
	Duplicate	–	Not Applicable	8140 8141A	Not Applicable

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
Organo-phosphorus Pesticides (continued)	Surrogates	--	Not Applicable	8140 8141A	Method 8140: Not Applicable Method 8141A: Surrogates spiked into method blank and all samples (QC included) Method Blank and LCS Criteria: Results must fall within laboratory-established control limits Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
PAHs by GC and HPLC	Method Blank	610	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8100 8310	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	610	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8100 8310	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
PAHs by GC and HPLC (continued)	Matrix Spike	610	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8100 8310	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	610	Not Applicable	8100 8310	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	610	Not Applicable	8100 8310	Not Applicable
	Surrogates	610	Not specified in method	8100 8310	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: Results must fall within laboratory established control limits Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	610	Optional	8100 8310	Optional

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
Pesticides/ PCBs	Method Blank	608	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8080A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	608	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8080A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	608	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8080A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Pesticides/ PCBs (continued)	Matrix Spike Duplicate	608	Not Applicable	8080A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	608	Not Applicable	8080A	Not Applicable
	Surrogates	608	Not specified in method	8080A	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: Results must fall within laboratory established control limits Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	608	Optional	8080A	Optional
Petroleum Hydro-carbons/Oil and Grease	Method Blank	413.1 413.2 418.1	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank Method 413.1: Not Applicable	9070 9071A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank Method 413.1: Not Applicable

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Petroleum Hydro-carbons/Oil and Grease (continued)	Laboratory Control Sample	413.1 413.2 418.1	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples Method 413.1: Not Applicable	9070 9071A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within ± 20% Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	413.1 413.2 418.1	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data Method 413.1: Not Applicable	9070 9071A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data
	Matrix Spike Duplicate	413.1 413.2 418.1	Not Applicable	9070 9071A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated Method 9071: Not Applicable

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Petroleum Hydro-carbons/Oil and Grease (continued)	Duplicate	413.1 413.2 418.1	Not Applicable	9070 9071A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated Method 9070: Not Applicable
	Surrogates	413.1 413.2 418.1	Not Applicable	9070 9071A	Not Applicable
	Internal Standards	413.1 413.2 418.1	Not Applicable	9070 9071A	Not Applicable
Petroleum Hydro-carbons	Method Blank	1664[4]	Frequency: 1 with each preparation batch Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	—

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Petroleum Hydro-carbons (continued)	Laboratory Control Sample	1664[4]	Frequency: 1 with each analytical batch Criteria: Waters - See limits in Table 2 of SOP No.: CORP-WC-0003 Soils - Percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS	—	—
	Matrix Spike	1664[4]	Frequency: 1 with every 10 samples per site Criteria: See percent recovery limits in Table 2 of SOP No. CORP-WC-0003 Corrective Action: See Section 9.6.1 of SOP No. CORP-WC-0003	—	—
	Matrix Spike Duplicate	1664[4]	Frequency: 1 with every 10 samples per site Criteria: See percent recovery and RPD limits in Table 2 of SOP No. CORP-WC-0003 Corrective Action: See Section 9.6.1 of SOP No. CORP-WC-0003	—	—
	Duplicate	1664[4]	Not Applicable	—	—

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Purgeable Halocarbons by GC	Method Blank	601	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8010B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	601	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8010B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	601	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8010B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Purgeable Halocarbons by GC (continued)	Matrix Spike Duplicate	601	Not Applicable	8010B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	601	Not Applicable	8010B	Not Applicable
	Surrogates	601	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria	8010B	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	601	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.	8010B	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Semivolatiles	Method Blank	625	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8270B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	625	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8270B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	625	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8270B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Semivolatiles (continued)	Matrix Spike Duplicate	625	Not Applicable	8270B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	625	Not Applicable	8270B	Not Applicable
	Surrogates	625	Surrogates spiked into method blank and all samples (QC included) Method Blank and LCS Criteria: All surrogates must be in control before sample analysis may proceed Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria	8270B	Surrogates spiked into method blank and all samples (QC included) Method Blank and LCS Criteria: All surrogates must be in control before sample analysis may proceed Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	625	Frequency: Internal standards spiked into method blank and all samples (QC included) Criteria: All internal standard recoveries must be within laboratory control limits Corrective Action: Flag sample data not meeting internal standard recovery requirements	8270B	Internal Standards are added to all samples (QC samples included). Internal standard area of daily standard must be within -50% to +100% from the last daily calibration check standard.

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Volatiles by GC/MS	Method Blank	624	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8240B 8260A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	624	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8240B 8260A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	624	Frequency: 1 per ≤ 20 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8240B 8260A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Volatiles by GC/MS (continued)	Matrix Spike Duplicate	624	Not Applicable	8240B 8260A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	624	Not Applicable	8240B 8260A	Not Applicable
	Surrogates	624	Surrogates spiked into Method Blank and all samples (QC included) Method Blank Criteria: All surrogates must be in control before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria	8240B 8260A	Surrogates spiked into Method Blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be in control before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	624	Frequency: Internal standards spiked into method blank and all samples (QC included) Criteria: All internal standard recoveries must be within laboratory control limits Corrective Action: Flag sample data not meeting internal standard recovery requirements	8240B 8260A	Internal Standards are added to all samples (QC samples included). Internal standard area of daily standard must be within -50 % to +100 % from the last daily calibration check standard.

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Footnotes

(1) National Pollutant Discharge Elimination System

(2) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), and Final Update IIB (January 1995).

(3) Method not listed in 40 CFR Part 136.

(4) Method 1664 is a proposed method only, and has not been promulgated by the EPA. These requirements are from Quanterra® SOP Number CORP-WC-0003, "HEM/SGT-HEM by Method 1664".

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples

Analysis	QC Sample	Method	Requirement
Cyanide, Total	Method Blank	ILM03.0	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than CRDL or less than 10x sample concentration Corrective Action: Reprep all samples associated with unacceptable blank
	Laboratory Control Sample	ILM03.0	Frequency: 1 with each batch of samples processed or for each SDG, whichever is more frequent Criteria: Water - 80-120% Solid - Meet control limits established for solid reference material Corrective Action: Reprep all samples associated with unacceptable LCS
	Matrix Spike	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG, whichever is more frequent Criteria: 75-125% unless sample result > 4x spike amount Corrective Action: Flag data associated with unacceptable Matrix Spike, perform post distillation spike at 2 x CRDL or 2x sample concentration whichever is greater
	Matrix Spike Duplicate	ILM03.0	Not Applicable
	Duplicate	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG whichever is more frequent Criteria: RPD ≤ 20% or ± CRDL if sample or duplicate value < 5x CRDL Corrective Action: Flag all associated data associated if duplicate results outside control limits
	Surrogates	ILM03.0	Not Applicable
	Internal Standards	ILM03.0	Not Applicable

TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
ICAP (excludes mercury)	Method Blank	ILM03.0	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than CRDL or less than 10x sample concentration. Corrective Action: Reprep all samples associated with unacceptable blank
	Laboratory Control Sample	ILM03.0	Frequency: 1 with each batch of samples processed or for each SDG, whichever is more frequent Criteria: Water - 80-120% except silver and antimony Solid - Meet control limits established for solid reference material Corrective Action: Reprep all samples associated with unacceptable LCS
	Matrix Spike	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG whichever is more frequent Criteria: 75-125% unless sample result > 4x spike amount Corrective Action: Flag data associated with unacceptable Matrix perform post digestion spike at 2xCRDL or 2x sample concentration whichever is greater
	Matrix Spike Duplicate	ILM03.0	Not Applicable
	Duplicate	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG whichever is more frequent Criteria: RPD ≤ 20% or ± CRDL if sample or duplicate value < 5x CRDL Corrective Action: Flag all data associated with duplicate results outside control limits

TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
ICAP (excludes mercury) (continued)	Serial Dilution	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG whichever is more frequent Criteria: <10% D when sample concentration > 50x IDL Corrective Action: Flag all data associated with results outside control limits
	Surrogates	ILM03.0	Not Applicable
	Internal Standards	ILM03.0	Not Applicable.
GFAA (excludes mercury)	Method Blank	ILM03.0	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than CRDL or less than 10x sample concentration Corrective Action: Reprep all samples associated with unacceptable blank
	Laboratory Control Sample	ILM03.0	Frequency: 1 with each batch of samples processed or for each SDG, whichever is more frequent Criteria: Water - 80-120% except silver and antimony Solid - Meet control limits established for solid reference material Corrective Action: Reprep all samples associated with unacceptable LCS
	Matrix Spike	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG whichever is more frequent Criteria: 75-125% unless sample result > 4x spike amount Corrective Action: Flag data associated with unacceptable Matrix
	Matrix Spike Duplicate	ILM03.0	Not Applicable

TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
GFAA (excludes mercury) (continued)	Duplicate	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG whichever is more frequent Criteria: RPD ≤ 20% or ± CRDL if sample or duplicate value < 5x CRDL Corrective Action: Flag all associated data associated if duplicate results outside control limits
	Analytical Spike	ILM03.0	Frequency: 1 with each sample except matrix spike Criteria: Evaluate per method requirements Corrective action: Perform per method requirements
	Surrogates	ILM03.0	Not Applicable
	Internal Standards	ILM03.0	Not Applicable.
Mercury (CVAA)	Method Blank	ILM03.0	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than CRDL Corrective Action: Reprep all samples associated with unacceptable blank
	Laboratory Control Sample	ILM03.0	Frequency: 1 with each batch of samples processed or for each SDG, whichever is more frequent Criteria: Water - 80-120% Solid - Meet control limits established for solid reference material Corrective Action: Reprep all samples associated with unacceptable LCS
	Matrix Spike	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG Criteria: 75-125% unless sample result > 4x spike amount Corrective Action: Flag data associated with unacceptable Matrix Spike

TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Mercury (CVAA) (continued)	Matrix Spike Duplicate	ILM03.0	Not Applicable
	Duplicate	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG whichever is more frequent Criteria: RPD ≤ 20% or ± CRDL if sample or duplicate value < 5x CRDL Corrective Action: Flag all associated data associated if duplicate results outside control limits
	Surrogates	ILM03.0	Not Applicable
	Internal Standards	ILM03.0	Not Applicable.
PCDD, PCDF	Method Blank	DFLM01.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Chemical interference or electronic noise must be less than 5% of the appropriate internal standard ion A peak that meets identification criteria must be less than 2% of the signal of the appropriate internal standard ion Corrective Action: Reprep all samples with positive results or those not meeting all identification criteria associated with unacceptable blank
	Laboratory Control Sample	DFLM01.1	Not Applicable
	Matrix Spike	DFLM01.1	Frequency: 1 for each matrix analyzed for each SDG Criteria: 50-150% Corrective Action: Verify all calculations and spiking; no further action required
	Matrix Spike Duplicate	DFLM01.1	Not Applicable

TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
PCDD, PCDF (continued)	Duplicate	DFLM01.1	Frequency: 1 for each matrix analyzed for each SDG Criteria: RPD ≤ 50% Corrective Action: Verify all calculations and spiking; no further action required
	Surrogates	DFLM01.1	Not Applicable
	Internal Standards	DFLM01.1	Frequency: Internal standards are spiked into all samples and QC samples Criteria: 25 - 150% Corrective Action: Re-extract and reanalyze all samples with unacceptable surrogate recoveries
Pesticides/PCBs	Method Blank	OLM03.1	Frequency: 1 with each case of samples received (up to 20 samples), for each extraction procedure within each SDG, whichever is most frequent or whenever samples are extracted Criteria: Concentration < CRQL Corrective Action: Re-extract and reanalyze all samples associated with unacceptable blank
	Laboratory Control Sample	OLM03.1	Not Applicable.
	Matrix Spike	OLM03.1	Frequency: 1 with each case of samples received (up to 20 samples), for each extraction procedure or for each SDG, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike recoveries outside of advisory limits

TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Pesticides/PCBs (continued)	Matrix Spike Duplicate	OLM03.1	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each SDG, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method RPD between MS/MSD should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike recoveries or RPD outside of advisory limits
	Duplicate	OLM03.1	Not Applicable
	Surrogates	OLM03.1	Frequency: Surrogates spiked onto all samples and QC samples Criteria: Percent recovery for each surrogate in samples should be within 30-150% Percent recovery for each surrogate in the method blank must be 30-150% Corrective Action: Flag unacceptable surrogate recoveries in samples Re-extract all samples associated with unacceptable surrogate recoveries in the method blank
	Internal Standards	OLM03.1	Not Applicable.
	Method Blank	OLM01.8	Frequency: 1 with each case of samples received (up to 20 samples and including matrix spikes and reanalyses) that are of similar matrix (water or soil) or similar concentration (soil), or 1 with each 14 calendar day period (7 calendar day for 14-day data turnaround contracts) during which samples in a case are received), or 1 whenever samples are extracted by the same procedure (continuous liquid - liquid extraction or sonication) Criteria: Concentration < CRQL Corrective Action: Re-extract and re-analyze all samples associated with unacceptable blank

TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Pesticides/PCBs (continued)	Laboratory Control Sample	OLM01.8	Not Applicable
	Matrix Spike	OLM01.8	Frequency: 1 with every 20 samples of each matrix Criteria: Percent recovery should be within advisory limits given in method Corrective Action: Flag data associated with matrix spike recoveries outside of advisory limits
	Matrix Spike Duplicate	OLM01.8	Frequency: 1 with every 20 samples of each matrix Criteria: Percent recovery and RPD should be within advisory limits given in method Corrective Action: Flag data associated with percent recovery or RPD outside of advisory limits
	Duplicate	OLM01.8	Not Applicable
	Surrogates	OLM01.8	Frequency: Spiked onto all samples and QC samples Criteria: Advisory limits are 60% - 150% Corrective Action: Flag surrogate recoveries outside of advisory limits
	Internal Standards	OLM01.8	Not Applicable
Semivolatiles by GC/MS	Method Blank	OLM03.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than CRQL except phthalates which must be ≤ 5x CRQL Corrective Action: Re-extract and re-analyze all samples associated with unacceptable blank
	Laboratory Control Sample	OLM03.1	Not Applicable.

TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Semivolatiles by GC/MS (continued)	Matrix Spike	OLM03.1	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each SDG, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike outside of advisory limits
	Matrix Spike Duplicate	OLM03.1	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each SDG, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method RPD between MS/MSD should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike recoveries or RPD outside of advisory limits
	Duplicate	OLM03.1	Not Applicable
	Surrogates	OLM03.1	Frequency: Surrogates spiked onto all samples and QC samples Criteria: Percent recovery for each surrogate must be within limits given in method (one base/neutral and/or one acid surrogate may be outside of limits but not below 10%) Corrective Action: Flag data associated with unacceptable recoveries or reanalyze all samples with unacceptable surrogate recoveries as required in method
	Internal Standards	OLM03.1	Frequency: Internal Standards are spiked onto all samples and QC samples Criteria: Internal Standard areas must be within -50% to + 100% from the last daily calibration check standard Corrective Action: Reanalyze all samples with unacceptable areas

TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Semivolatiles by GC/MS (continued)	Method Blank	OLM01.8	Frequency: 1 with each case of samples received (up to 20 samples) and including matrix spikes and reanalyses) that are of similar matrix (water or soil) or similar concentration (soil), or 1 with each 14 calendar day period (7 calendar day for 14-day data turnaround contracts) during which samples in a case are received, or 1 whenever samples are extracted by the same procedure (continuous liquid-liquid extraction or sonication) Criteria: Concentration ≤ CRQL except phthalates which must be < 5 x CRQL Corrective Action: Re-extract and re-analyze all samples associated with unacceptable blank
	Laboratory Control Sample	OLM01.8	Not Applicable
	Matrix Spike	OLM01.8	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each 14 day calendar period (7 calendar day period for 14 day data turnaround contracts) during which field samples in a case were received, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike recoveries outside of advisory limits
	Matrix Spike Duplicate	OLM01.8	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each 14 day calendar period (7 calendar day period for 14 day data turnaround contracts) during which field samples in a case were received, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method. RPD between MS/MSD should be within advisory limits given in method. Corrective Action: Flag data associated with Matrix Spike recoveries or RPD outside of advisory limits

TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Semivolatiles by GC/MS (continued)	Duplicate	OLM01.8	Not Applicable
	Surrogates	OLM01.8	Frequency: Surrogates spiked onto all samples and QC samples Criteria: Percent recovery for each surrogate must be within limits given in method (one base/neutral and/or one acid surrogate may be outside of limits, but not below 10%) Corrective Action: Flag data associated with unacceptable recoveries or reanalyze all samples with unacceptable surrogate recoveries as required in method
	Internal Standards	OLM01.8	Frequency: Internal Standards are spiked onto all samples and QC samples Criteria: Internal Standard areas must be within -50% to + 100% from the last daily calibration check standard Corrective Action: Reanalyze all samples with unacceptable areas
Volatiles by GC/MS	Method Blank	OLM03.1	Frequency: 1 per 12 hours Criteria: Concentration less than CRQL except methylene chloride, acetone, 2-butanone must be ≤ 5x CRQL Corrective Action: Reanalyze all samples associated with unacceptable blank
	Laboratory Control Sample	OLM03.1	Not Applicable
	Matrix Spike	OLM03.1	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each SDG, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike outside of advisory limits

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Volatiles by GC/MS (continued)	Matrix Spike Duplicate	OLM03.1	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each SDG, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method RPD between MS/MSD should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike recoveries or RPD outside of advisory limits
	Duplicate	OLM03.1	Not Applicable
	Surrogates	OLM03.1	Frequency: Surrogates spiked onto all samples and QC samples Criteria: Percent recovery for each surrogate must be within limits given in method Corrective Action: Reanalyze all samples with unacceptable surrogate recoveries
	Internal Standards	OLM03.1	Frequency: Internal Standards are spiked onto all samples and QC samples Criteria: Internal Standard areas must be within -50% to + 100% from the last daily calibration check standard Corrective Action: Reanalyze all samples with unacceptable Internal Standard areas
	Storage Blank	OLM03.1	Frequency: 1 per SDG Criteria: Concentration less than CRQL except methylene chloride, acetone, 2-butanone must be ≤ 5x CRQL Corrective Action: Narrate with corrective action plan

TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Volatiles by GC/MS (continued)	Method Blank	OLM01.8	Frequency: 1 per 12 hours Criteria: Concentration less than CRQL except methylene chloride, acetone, and 2-butanone must be ≤ 5x CRQL Corrective Action: Re-purge and re-analyze all associated samples
	Laboratory Control Sample	OLM01.8	Not Applicable
	Matrix Spike	OLM01.8	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each 14 day calendar period (7 calendar day period for 14 day data turnaround contracts) during which field samples in a case were received, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike recoveries outside of advisory limits
	Matrix Spike Duplicate	OLM01.8	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each 14 day calendar period (7 calendar day period for 14 day data turnaround contracts) during which field samples in a case were received, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method. RPD between MS/MSD should be within advisory limits given in method. Corrective Action: Flag data associated with Matrix Spike recoveries or RPD outside of advisory limits
	Duplicate	OLM01.8	Not Applicable
	Surrogates	OLM01.8	Frequency: Surrogates spiked onto all samples and QC samples Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Re-analyze all samples with unacceptable surrogate recoveries

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Volatiles by GC/MS (continued)	Internal Standards	OLM01.8	Frequency: Internal Standards are spiked onto all samples and QC samples Criteria: Internal Standard areas must be within -50% to + 100% from the last daily calibration check standard. Corrective Action: Re-analyze all samples with unacceptable Internal Standard areas
	Storage Blank	OLM01.8	Not Applicable

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Notes:

SDG = Sample Delivery Group

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Acidity	Water	100 mL	305.1	250 mL plastic or glass, Cool, 4°C, 14 days	—	Not Applicable
	Solid[5]	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Alkalinity	Water	100 mL	310.1 2320B	250 mL plastic or glass, Cool, 4°C, 14 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Ammonia	Water	400 mL	350.1	500 mL plastic or glass, Cool, 4°C H_2SO_4 to pH < 2, 28 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Biochemical Oxygen Demand (BOD)	Water	200 mL	405.1	1000 mL plastic or glass, Cool, 4°C 48 hours	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Bromide	Water	100 mL	300.0[7] 320.1 ASTM D1246-88	250 mL plastic or glass, No preservative required, 28 days	9056	Cool, 4°C, analyze ASAP after collection
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Chemical Oxygen Demand (COD)	Water	100 mL	410.1 410.2 410.4	250 mL glass or plastic, Cool, 4°C, H_2SO_4 to pH < 2, 28 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Chloride	Water	50 mL	300.0[7] 325.1 325.2 325.3 4500 Cl E	250 mL plastic or glass, No preservative required, 28 days	9056 9251 9252A	Method 9056: Cool, 4°C, analyze ASAP after collection. Method 9251/9252A: 250ml plastic or glass, no preservative required, 28 days
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Chlorine, Residual	Water	100 mL	330.1 330.3	250 mL glass or plastic, Cool, 4°C, analyze immediately	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Chromium (Cr^{+6})	Water	100 mL	218.4 3500 Cr-D	Method 218.4: 200 mL plastic or glass, Cool, 4°C, 24 hours Method 3500 Cr-D: 200 mL quartz, TFE, or polypropylene HNO_3 to pH <2 Cool, 4°C Analyze ASAP after collection	7196A	200 mL plastic or glass, Cool, 4°C, 24 hours
	Solid	Not Applicable	—	Not Applicable	3060A/ 7196A	30 days to digestion, 96 hours after digestion
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [5], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Color	Water	100 mL	110.2	250 mL plastic or glass, Cool, 4°C, 48 hours	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Conductivity	Water	100 mL	120.1	200 mL glass or plastic, Cool, 4°C, 28 days	9050	200 mL glass or plastic, Cool, 4°C, 24 hours
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Cyanide (Amenable)	Water	IL	335.1	1 liter plastic or glass, NaOH to pH >12 0.6g ascorbic acid[6] Cool, 4°C, 14 days unless sulfide is present. Then maximum holding time is 24 hours	9010A 9012	1 liter plastic or glass, NaOH to pH >12 0.6g ascorbic acid[6] Cool, 4°C, 14 days
	Solid	50g	—	Not Applicable	9010A, 9012	Not Specified
	Waste	50g	—	Not Applicable	9010A, 9012	Not Specified
Cyanide (Total)	Water	IL	335.1 335.2 335.3 4500 CN D	1 liter plastic or glass, NaOH to pH >12 0.6g ascorbic acid[6] Cool, 4°C, 14 days unless sulfide is present. Then maximum holding time is 24 hours	9010A 9012	1 liter plastic or glass, NaOH to pH >12 0.6g ascorbic acid[6] Cool, 4°C, 14 days
	Solid	50g	–	Not Applicable	9010A 9012	8 or 16 oz glass Teflon-lined lids, Cool, 4°C, 14 days

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TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Cyanide (Total) (continued)	Waste	50g	—	Not Applicable	9010A, 9012	8 or 16 oz glass Teflon-lined lids, Cool, 4°C
Flashpoint (Ignitability)	Liquid	Not Applicable	—	Not Applicable	1010	No requirements, 250 mL amber glass, Cool, 4°C is recommended
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Fluoride	Water	300 mL	300.0[7] 340.2	500 mL plastic, No preservation required, 28 days	9056	Cool, 4°C, analyze ASAP after collection
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Hardness (Total)	Water	50 mL	130.2 2340B	250 mL glass or plastic, Cool, 4°C, HNO_3 to pH < 2, 6 months	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Iodide	Water	100 mL	345.1 Dionex	100 mL plastic or glass, Cool, 4°C, 24 hours		Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Iron (Ferrous)	Water	100 mL	3500-Fe D	1 liter glass or polyethylene container, 6 months **This test should be performed in the field.**	-	Not Applicable
	Solid	Not Applicable	-	Not Applicable	-	Not Applicable
	Waste	Not Applicable	-	Not Applicable	-	Not Applicable

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Methylene Blue Active Substances (MBAS) (Surfactant)	Water	100 mL	425.1	250 mL plastic or glass, Cool, 4°C, 48 hours	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Nitrate	Water	100 mL	300.0[7] 352.1	Method 300.0: 250 mL plastic or glass, Cool, 4°C, 48 hours. Method 352.1: 250 mL plastic or glass, Cool, 4°C, 48 hours. For samples from non-chlorinated drinking water supplies concentrated H_2SO_4 should be added to lower sample pH to less than 2. The sample should be analyzed before 14 days.	9056 9200	Method 9056: Cool, 4°C, analyze ASAP after collection Method 9200: Cool, 4°C if analyzed within 24 hours. If > 24 hours, cool, 4°C, and 2 mL/L conc. H_2SO_4
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	9200	Not Specified
Nitrite	Water	50 mL	300.0[7] 354.1	250 mL plastic or glass Cool, 4°C, 48 hours	9056	Cool, 4°C, analyze ASAP after collection
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable

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TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Ortho-phosphate	Water	50 mL	300.0[7] 365.1 365.2 365.3 365.4	100 mL plastic or glass, Filter on site Cool, 4°C, 48 hours	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
pH	Water	50 mL	150.1 4500-H^+ B	100 mL plastic or glass. Analyze immediately. **This test should be performed in the field.**	9040B	100 mL plastic or glass. Analyze immediately. **This test should be performed in the field.**
	Solid	Not Applicable	—	Not Applicable	9045C	4 oz glass or plastic, Cool, 4°C, Analyze as soon as possible.
	Waste	Not Applicable	—	Not Applicable	9045C	4 oz glass or plastic, Cool, 4°C, Analyze as soon as possible.
Phenolics	Water	100 mL	420.1 420.2	500 mL glass, Cool, 4°C, H_2SO_4 to pH < 2, 28 days	9065 9066	1 liter glass recommended, Cool, 4°C, H_2SO_4 to pH < 2, 28 days
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	9065	Not Specified
Phosphate	Water	50 mL	—	Not Applicable	9056	Cool, 4°C, analyze ASAP collection
	Solid	Not Applicable	—	Not Applicable	9056	Not Applicable
	Waste	Not Applicable	—	Not Applicable	9056	Not Applicable
Phosphorus (Total)	Water	50 mL	365.1 365.2 365.3 365.4	100 mL plastic or glass, H_2SO_4 to pH < 2, 28 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Nitrate-Nitrite	Water	100 mL	353.1 353.2 353.3	250 mL plastic or glass, Cool, 4°C, H_2SO_4 to pH < 2, 28 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Odor	Water	IL	140.1	200 mL glass only, Cool, 4°C, 24 hours		Not Applicable
	Solid	Not Applicable	–	Not Applicable	—	Not Applicable
	Waste	Not Applicable	–	Not Applicable	—	Not Applicable
Reactivity (Cyanide and Sulfide)	Liquid	10 g	—	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	10 oz amber glass, Cool, 4°C, no headspace, analyze as soon as possible.
	Solid	10 g	—	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	10 oz amber glass, Cool, 4°C, no headspace, analyze as soon as possible.
	Waste	10 g	—	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	10 oz amber glass, Cool, 4°C, no headspace, analyze as soon as possible.
Settleable Solids	Water	1000 mL	160.5	1000 mL plastic or glass, Cool, 4°C, 48 hours	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Silica, Dissolved	Water	50 mL	370.1	Plastic only, 100 mL, Cool, 4°C, 28 days	—	Not Applicable
	Solid Waste	Not Applicable Not Applicable	— —	Not Applicable Not Applicable	— —	Not Applicable Not Applicable

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Specific Conductance	Water	50 mL	120.1	250 mL plastic or glass, Cool, 4°C, 28 days	9050	250 mL plastic or glass, Cool, 4°C, 24 hours
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Sulfate (SO_4)	Water	100 mL	300.0[7] 375.1 375.4	100 mL plastic or glass, Cool, 4°C, 28 days	9056 9038	Method 9056: Cool, 4°C, analyze ASAP collection Method 9038: 200 mL plastic or glass, Cool, 4°C, 28 days
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	100 mL	—	Not Applicable	9038	200 mL plastic or glass, Cool, 4°C, 28 days
Sulfide	Water	100 mL	376.1 376.2	500 mL plastic or glass, Cool, 4°C, Add 2 mL zinc acetate plus NaOH to pH > 9, 7 days	9030A	500 mL plastic, no headspace, Cool, 4°C, Add 2 mL zinc acetate plus NaOH to pH > 9, 7 days
	Solid	50 g	—	Not Applicable	9030A	Cool, 4°C, store headspace-free
	Waste	50 g	—	Not Applicable	9030A	Cool, 4°C, store headspace-free

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Sulfite (SO_3)	Water	100 mL	377.1	100 mL plastic or glass, No preservative required, analyze immediately **This test should be performed in the field.**	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Temperature	Water	200 mL	170.1	1 liter plastic or glass, analyze immediately in the field	—	Not Applicable
	Solid	Not Applicable	–	Not Applicable	–	Not Applicable
	Waste	Not Applicable	–	Not Applicable	–	Not Applicable
Total Dissolved Solids (Filterable)	Water	100 mL	160.1	250 mL plastic or glass, Cool, 4°C, 7 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Total Kjeldahl Nitrogen (TKN)	Water	500 mL	351.2 351.3	500 mL plastic or glass, Cool, 4°C, H_2SO_4 to pH < 2, 28 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Total Organic Carbon (TOC)	Water	100 mL	415.1	100 mL plastic or glass, Cool, 4°C, H_2SO_4 to pH < 2, 28 days	9060	100 mL plastic or glass, Cool, 4°C, H_2SO_4 or HCl to pH < 2, 28 days
	Solid	Not Applicable	—	Not Applicable	9060	Not Specified
	Waste	Not Applicable	—	Not Applicable	9060	Not Specified

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Total Organic Halides (TOX)	Water	100 mL	5320B[7] 450.1[7]	Method 5320B: 500 mL amber glass, Teflon®-lined lid, Cool, 4°C, HNO_3 to pH <2, no headspace, 14 days Method 450.1: 500 mL amber glass, Teflon®-lined lid, Cool, 4°C, HNO_3 to pH <2, no headspace, 28 days	9020B	500 mL amber glass, Teflon®-lined lid, Cool, 4°C, H_2SO_4 to pH < 2, no headspace, 28 days
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Total Solids	Water	100 mL	160.3	250 mL plastic or glass, Cool, 4°C, 7 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Total Suspended Solids (Nonfilterable)	Water	100 mL	160.2	250 mL plastic or glass, Cool, 4°C, 7 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Turbidity	Water	50 mL	180.1	250 mL plastic or glass, Cool, 4°C, 48 hours	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Volatile Solids	Water	100 mL	160.4	250 mL plastic or glass, Cool, 4°C, 7 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Water Content	Water	Not Applicable	—	Not Applicable	—	Not Applicable
	Solid	10 g	—	Refer to specific method used	—	Refer to specific method used
	Waste	10 g	—	Refer to specific method used	—	Refer to specific method used
Metals (excludes Hg)	Water	100 mL	200 series	1 liter glass or polyethylene container, HNO_3 to pH ≤ 2, 6 months	6010A, 6020, 7000 series	1 liter glass or polyethylene container, HNO_3 to pH ≤ 2, 6 months
	Solid	200 g	200 series	8 or 16 oz glass or polyethylene container storage at °C	6010A, 6020, 7000 series	8 or 16 oz glass or polyethylene container, storage at 4°C, 6 months
	Waste	200 g	200 series	Not Applicable	6010A, 6020, 7000 series	8 or 16 oz glass or polyethylene container, storage at 4°C, 6 months
Mercury (CVAA)	Water	100 mL	245.1	1 liter glass or polyethylene container, Cool, 4°C HNO_3 to pH ≤ 2, 28 days	7470A	1 liter glass or polyethylene container, HNO_3 to pH ≤ 2, 28 days
	Solid	200 g	245.5	8 or 16 oz glass or polyethylene container, Cool, 4°C, 28 days	7471A	8 or 16 oz glass or polyethylene container, Cool, 4°C, Holding Time Not Specified
	Waste	200 g	–	Not Applicable	7471A	8 or 16 oz glass or polyethylene container, Cool, 4°C, Holding Time Not Specified

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times (Continued)

Footnotes

(1) Minimum sample size indicates sample amount needed for a single analysis. Matrix spikes or duplicates will require an additional sample amount of at least this amount for each additional QC sample aliquot required.
(2) National Pollutant Discharge Elimination System - MCAWW, March 1983.
(3) Holding times are calculated from date of collection.
(4) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA, (August 1993), Final Update II (September 1994), and Final Update IIB (January 1995)
(5) Solid matrix type includes soil, sediment, sludge and other solid materials not classified as waste.
(6) Samples to be analyzed for cyanide should be field-tested for residual chlorine. If residual chlorine is detected, ascorbic acid should be added.
(7) Method not listed in 40 CFR Part 136.

TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2],[3]		RCRA (SW846)[3],[4]	
			Method	Requirements	Method[6]	Requirements
Aromatic Volatiles	Water	40 mL	602	40 mL glass, VOA vial (in triplicate) with Teflon®-lined septa without headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine, 7 days with pH > 2, 14 days with pH < 2	8020A	40 mL glass, VOA vial (in triplicate) with Teflon®-lined septa without headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine, HCl or H_2SO_4 or solid $NaHSO_4$ to pH ≤ 2, 14 days with pH ≤ 2
	Solid[5]	10 g	--	Not Applicable	8020A	4 or 8 oz glass with Teflon®-lined lid, Cool, 4°C, 14 days
	Waste	10 g	--	Not Applicable	8020A	4 or 8 oz glass with Teflon®-lined lid, Cool, 4°C, 14 days
Acrolein & Acrylonitrile by GC	Water	40 mL	603	Glass with Teflon®-lined septum, Cool, 4 °C (± 2°C), 0.008% $Na_2S_2O_3$[11], Adjust pH 4-5[8] 14 days	8030A	Glass with Teflon®-lined septum, Cool, 4 °C (± 2°C), 0.008% $Na_2S_2O_3$[11], Adjust pH 4-5[8] 14 days
	Solid	-	-	Not Applicble	-	Not Applicable
	Waste	-	-	Not Applicble	-	Not Applicable
Dioxins/ Dibenzo-furans	Water	1L	613	1 liter amber glass with Teflon®-lined lid, Cool, 4°C, Extraction, 7 days Analysis, 40 days	8280	1 liter glass amber with Teflon®-lined lid, Cool, 4°C, Extraction, 30 days Analysis, 45 days from date of collection
	Solid	10 g	--	Not Applicable	8280	8 or 16 oz glass amber wide mouth with Teflon®-lined lid, Cool, 4°C, Extraction, 30 days Analysis, 45 days from date of collection

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TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
Dioxins/ Dibenzo-furans (continued)	Waste	10 g	–	Not Applicable	8280	8 or 16 oz glass amber wide mouth with Teflon®-lined lid, Cool, 4°C, Extraction, 30 days Analysis, 45 days from date of collection
	Water	1L	613	1 liter amber glass with Teflon®-lined lid, Cool, 4°C, Extraction, 7 days Analysis, 40 days	8290	1 liter glass amber with Teflon®-lined lid, Cool, 4°C, Extraction, 30 days Analysis, 45 days from date of extraction
	Solid	10 g	–	Not Applicable	8290	8 or 16 oz glass amber wide mouth with Teflon®-lined lid, Cool, 4°C, Extraction, 30 days Analysis, 45 days from date of extraction
	Waste	10 g	–	Not Applicable	8290	8 or 16 oz glass amber wide mouth with Teflon®-lined lid, Cool, 4°C, Extraction, 30 days Analysis, 45 days from date of extraction
Halogenated Volatiles	Water	40 mL	–	Not Applicable	8021A	40 mL glass, VOA vial (in triplicate) with Teflon®-lined septa without headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine, HCl or H_2SO_4 or solid $NaHSO_4$ to pH ≤ 2, 14 days with pH ≤ 2
	Solid[5]	10 g	–	Not Applicable	8021A	4 or 8 oz glass with Teflon®-lined lid, Cool, 4°C, 14 days

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TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
Halogenated Volatiles (continued)	Waste	10 g	—	Not Applicable	8021A	4 or 8 oz glass with Teflon®-lined lid, Cool, 4°C, 14 days
Herbicides	Water	1L	615 [10]	1 liter amber glass with Teflon®-lined lid, Sodium thiosulfate or ascorbic acid if residual chlorine present, Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction	8150B	1 liter amber glass with Teflon®-lined lid. If residual chlorine present, add 3 mL sodium thiosulfate per gallon. Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction
	Solid	50 g	—	Not Applicable	8150B	4 or 8 oz glass widemouth with Teflon®-lined lid, no preservative required, Extraction, 14 days Analysis, 40 days after extraction
	Waste	50 g	—	Not Applicable	8150B	4 or 8 oz glass widemouth with Teflon®-lined lid. No preservative required. Extraction, 14 days Analysis, 40 days after extraction
Nitroaromatics	Water	1L	—	Not Applicable	8330	1 liter amber glass with Teflon®-lined lid. If residual chlorine present, add 3 mL sodium thiosulfate per gallon. Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction
	Solid	50 g	—	Not Applicable	8330	4 or 8 oz glass widemouth with Teflon®-lined lid Cool, 4°C

TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2],[3]		RCRA (SW846)[3],[4]	
			Method	Requirements	Method[6]	Requirements
Nitroaromatics (continued)	Waste	50 g	—	Not Applicable	8330	4 or 8 oz glass widemouth with Teflon®-lined lid no preservative required
Organo-phosphorus Pesticides	Water	1L	—	Not Applicable	8140 8141A	1 liter amber glass with Teflon®-lined lid. If residual chlorine present, add 3 mL sodium thiosulfate per gallon. Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction
	Solid	50 g	—	Not Applicable	8140 8141A	4 or 8 oz glass widemouth with Teflon®-lined lid Cool, 4°C
	Waste	50 g	—	Not Applicable	8140 8141A	4 or 8 oz glass widemouth with Teflon®-lined lid no preservative required
PAHs by GC and HPLC	Water	1L	610	1 liter amber glass with Teflon®-lined lid, Adjust pH to 5-9 if extraction not to be done within 72 hours of sampling. Add sodium thiosulfate if residual chlorine present. Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction	8100 8310	1 liter amber glass with Teflon®-lined lid, If residual chlorine present, add 3 mL sodium thiosulfate per gallon, Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction

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TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
PAHs by GC and HPLC (continued)	Solid	50 g	—	Not Applicable	8100 8310	4 or 8 oz glass widemouth with Teflon®-lined lid, Cool, 4°C, Extraction, 14 days Analysis, 40 days after extraction
	Waste	50 g	—	Not Applicable	8100 8310	4 or 8 oz glass widemouth with Teflon®-lined lid, no preservative required, Extraction, 14 days Analysis, 40 days after extraction
Pesticides/ PCBs	Water	1L	608	1 liter amber glass with Teflon®-lined lid, Adjust pH to 5-9 if extraction not to be done within 72 hours of sampling. Add sodium thiosulfate if residual chlorine present and aldrin is being determined. Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction	8080A	1 liter amber glass with Teflon®-lined lid, If residual chlorine present, add 3 mL 10% sodium thiosulfate per gallon, Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction
	Solid	50 g	—	Not Applicable	8080A	4 or 8 oz glass widemouth with Teflon®-lined lid, Cool, 4°C, Extraction, 14 days Analysis, 40 days after extraction
	Waste	50 g	—	Not Applicable	8080A	4 or 8 oz glass widemouth with Teflon®-lined lid, no preservative required, Extraction, 14 days Analysis, 40 days after extraction

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TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
Petroleum Hydrocarbons /Oil and Grease	Water	1L	413.1 413.2 418.1	1 liter glass, Cool, 4°C, HCl to pH <2, 28 days	9070	1 liter glass with Cool, 4°C, HCl to pH <2, 28 days
	Solid	—	—	Not Applicable	9071A	8 oz. glass with Teflon®-lined lid, Holding Time not specified
	Waste	—	—	Not Applicable	9071A	8 oz. glass with Teflon®-lined lid, Holding Time not specified
	Water	1 L	1664[7]	1 liter glass, Cool, 0-4°C HCl or H_2SO_4 to pH <2 28 days	—	—
	Solid	30 g	1664[7]	8 or 16 oz. wide mouth glass jar, Cool, 0-4°C, 28 days	—	—
	Waste	—	—	Not Applicable	—	—
Purgeable Halocarbons	Water	40 mL	601	40 mL glass VOA vial (in triplicate) with Teflon®-lined septa with no headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine present, 14 days	8010B	40 mL glass VOA vial (in triplicate) with Teflon®-lined septa with no headspace, Cool, 4°C, HCl or H_2SO_4 or solid $NaHSO_4$ to pH ≤ 2, sodium thiosulfate if residual chlorine present, 14 days
	Solid	10 g	—	Not Applicable	8010B	4 or 8 oz glass container with Teflon®-lined lid, Cool, 4°C, 14 days

TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
Purgeable Halocarbons (continued)	Waste	10 g	—	Not Applicable	8010B	4 or 8 oz glass container Teflon®-lined lid, no preservative required, 14 days
Semivolatiles	Water	1L	625	1 liter amber glass with Teflon®-lined lid, Cool, 4°C, Extraction, 7 days Analysis, 40 days	8270B	1 liter amber glass with Teflon®-lined lid, If residual chlorine present, add 3 mL sodium thiosulfate per gallon, Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction
	Solid	50 g	—	Not Applicable	8270B	8 or 16 oz glass wide mouth with Teflon-lined lid, Cool, 4°C, Extraction, 14 days Analysis, 40 days after extraction
	Waste	50 g	—	Not Applicable	8270B	8 or 16 oz glass wide mouth with Teflon®-lined lid, Cool, 4°C, Extraction, 14 days Analysis, 40 days after extraction

TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2],[3]		RCRA (SW846)[3],[4]	
			Method	Requirements	Method[6]	Requirements
Volatile Organics	Water	40 mL	624	40 mL glass, VOA vial (in triplicate) with Teflon®-lined septa without headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine, 7 days with pH > 2, 14 days with pH ≤ 2[8]	8240B, 8260A	40 mL glass, VOA vial (in triplicate) with Teflon®-lined septa without headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine, HCl or H_2SO_4 or solid $NaHSO_4$ to pH ≤ 2, 14 days with pH ≤ 2[9]
	Solid[5]	10 g	–	Not Applicable	8240B, 8260A	4 or 8 oz glass with Teflon®-lined lid, Cool, 4°C, 14 days
	Waste	10 g	–	Not Applicable	8240B, 8260A	4 or 8 oz glass with Teflon®-lined lid, Cool, 4°C, 14 days

TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Footnotes

(1) Minimum sample size indicates sample amount needed for a single analysis. Matrix spikes or duplicates will require an additional sample amount of at least this amount for each additional QC sample aliquot required.
(2) National Pollutant Discharge Elimination System - 40 CFR Part 136, Appendix A.
(3) Holding times are calculated from the date of collection.
(4) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), and Final Update IIB (January 1995).
(5) Solid matrix type includes soil, sediment, sludge or other solids not classified as waste.
(6) Only one determination method is listed when separate methods are required for preparation and analysis.
(7) Method 1664 is a proposed only method and has not been promulgated by the EPA.
(8) For acrolein and acrylonitrile the pH should be adjusted to 4-5. This pH adjustment is not required if acrolein is not being measured. Samples requiring analysis of acrolein that received no pH adjustment must be analyzed within three days of sampling.
(9) For acrolein and acrylonitrile the pH should be adjusted to 4-5.
(10) Method not listed in 40 CFR Part 136.
(11) Should only be used in the presence of residual chlorine.

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TABLE 8.5-3
Radiological Sample Containers, Preservatives, and Holding Times

Analytical Parameters	Matrix	Recommended Containers[1]	Preservative	Maximum Holding Time	Minimum Volume Required for Analysis[2]
Gross Alpha/Beta	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	500 mls
	Soil	P, G	None		50[4] gms
Americium-241	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Carbon-14	Water	P, G	Field adjusted to pH > 9 with NaOH[3]	180 days after collection	100 mls
	Soil	P, G	None		50[4] gms
Calcium-45	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	100 mls
Curium-242	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Gamma Emitters Actinides, as applicable, Co-60, Cs-137, K-40, Mn-54, and other fission/activation products	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		650[7] gms
Iron-55	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	50 mls
Lead-210	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	500 mls
	Soil	P, G	None		50[4] gms
Neptunium-237	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Promethium-147	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	250 mls

TABLE 8.5-3
Radiological Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Recommended Containers[1]	Preservative	Maximum Holding Time	Minimum Volume Required for Analysis[2]
Plutonium-238, 239/240	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Radium-226	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Radium-228	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Strontium-89, 90 and Total Strontium	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Technetium-99	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	100 mls
	Soil	P, G	None		50[4] gms
Thorium-227, 228, 230, 232	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Total Uranium	Water	P,G	Field acidified to pH < 2 with HNO_3	180 days after collection	50 mls
	Soil	P, G	None		50[4] gms
Tritium	Water	P, G[6]	None	180 days after collection	100 mls
	Soil	P, G[6]	None		100 gms
Uranium-233/234, 235/236	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Uranium-238	Soil	P, G	None	180 days after collection	50[4] gms

TABLE 8.5-3
Radiological Sample Containers, Preservatives, and Holding Times (Continued)

Footnotes

(1) Plastic (polyethylene), Glass

(2) Assumes that quality control samples have been assigned in the field. If duplicates, matrix spikes and/or matrix spike duplicates are to be assigned by the laboratory, additional multiple sample volumes are required. Volumes listed are for standard aliquot size. Detection limit requirements may necessitate larger volumes.

(3) Assumes that carbon is in the form of CO_3^{--}.

(4) May be aliquoted or sequentially determined from the same volume.

(5) May be aliquoted or sequentially determined from the same volume.

(6) Tritium is very volatile. Sample containers must be air tight to eliminate tritium loss.

(7) Dry weight.

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TABLE 8.5-4
Sample Containers, Preservatives, and Holding Times for USEPA Contract Laboratory Program Statement of Work

Analytical Parameters	Matrix	Minimum Sample Size	Requirements[1]
Cyanide, Total and Amenable to Chlorination	Water	500 mL	500 mL, glass or polyethylene container, 0.6 g ascorbic acid (only in presence of residual chlorine) NaOH to pH > 12, Cool, 4°C, 12 days
	Soil/Sediment	25 g	8 or 16 oz glass with Teflon-lined lids, Cool, 4°C, 12 days
ICAP and GFAA (excludes mercury)	Water	100 mL	1 liter glass or polyethylene container, HNO_3 to pH ≤2, 180 days
	Soil/Sediment	25 g	4 or 8 oz glass or polyethylene container, Cool, 4°C, 180 days
Mercury (CVAA)	Water	100 mL	1 liter glass or polyethylene container, HNO_3 to pH ≤2, 26 days
	Soil/Sediment	25 g	8 or 16 oz glass with Teflon®-lined lids, Cool, 4°C, 26 days
Pesticides/PCBs	Water	1 L	1 liter amber glass with Teflon®-lined lid, Cool, 4°C, Extraction within 5 days of sample receipt Analysis within 40 days after start of extraction
	Soil/Sediment	50 g	8 or 16 oz glass widemouth with Teflon®-lined lid, protect from light, Cool, 4°C, Extraction within 10 days of sample receipt Analysis within 40 days after start of extraction
PCDD, PCDF[2]	Water	1 L	1 liter amber glass with Teflon®-lined lid, Cool, 4°C, No holding time requirements specified
	Soil/Sediment/ Fly Ash/ Chemical Waste	25 g	4 or 8 oz glass widemouth with Teflon®-lined lid, protect from light, room temperature, No holding time requirements specified

TABLE 8.5-4
Sample Containers, Preservatives, and Holding Times for USEPA Contract Laboratory Program Statement of Work (Continued)

Analytical Parameters	Matrix	Minimum Sample Size	Requirements[1]
Semivolatiles	Water	1L	1 liter amber glass with Teflon®-lined lid, Cool, 4°C, Extraction within 5 days of sample receipt Analysis within 40 days after start of extraction
	Soil/Sediment	50 g	8 or 16 oz glass widemouth with Teflon®-lined lid, Cool, 4°C, Extraction within 10 days of sample receipt Analysis within 40 days after start of extraction
Volatiles	Water	40 mL	40 mL glass with Teflon®-lined lid, no entrapped air bubbles pH <2[3], Cool, 4°C, 10 days
	Soil/Sediment	25 g	4 or 8 oz glass with Teflon®-lined lids, Cool, 4°C, 10 days

Footnotes

(1) Holding times are calculated from verified time of sample receipt.

(2) PCDD: Polychlorinated Dibenzo-p-dioxins
PCDF: Polychlorinated Dibenzofurans

(3) The OLM03.0 requirement is to acidify the sample to pH<2. The OLM01.8 requirement is to determine and report the pH of the sample to check that the sample was acidified in the field.

TABLE 8.5-5
Sample Containers, Preservatives, and Holding Times for TCLP[1] and SPLP[2]

Analytical Parameters	Matrix	Minimum Sample Size[3]	TCLP Method 1311 and SPLP Method 1312 Requirements	
			From Field Collection to TCLP/SPLP Extraction	From TCLP/SPLP Extraction to Analysis
Mercury	Liquid Solid Waste	1L	1L glass, Cool, 4°C, 28 days	Glass or polyethylene 28 days
Metals (except mercury)	Liquid Solid Waste	1L	1L glass, Cool, 4°C, 180 days	Glass or polyethylene 180 days
Semivolatiles	Liquid Solid Waste	1L	1L glass, Cool 4°C, 14 days	1L glass Extraction of leachate within 7 days of TCLP extraction, Analyze extract within 40 days
Volatiles	Liquid Solid Waste	6 oz	4 oz glass, Cool 4°C, 14 days	40 mL glass, 14 days

Footnotes

(1) TCLP = Toxicity Characteristic Leaching Procedure

(2) SPLP = Synthetic Precipitation Leaching Procedure

(3) Smaller sample size is adequate for solid samples or individual fractions. A combined volume of 32 oz. is recommended for semivolatiles and metals. A separate 4 oz. container should always be used for the volatile fraction. Volatile fractions should be stored with minimal headspace.

TABLE 8.5-6
Periodic Equipment Calibrations

Type of Equipment	Calibration Requirements
Balances	• Must be serviced and calibrated annually by a manufacturer's representative • Calibration must be checked daily or before use by analyst with weight(s) classified as Class "S" (or Class "S" traceable) by NIST per operation-specific SOPs. Acceptance criteria vary according to weight used and accuracy of balance. Acceptance criteria must be documented in log. • All Class "S" weights must be certified by an outside agency every three years.
Thermometers	• Working glass thermometers must be calibrated against a certified NIST thermometer at least annually as described in operation-specific SOPs. • Working non-glass thermometers must be calibrated against a certified NIST thermometer quarterly as described in operation-specific SOPs. • The NIST thermometer must be recertified every three years.
Refrigerators/Freezers	• Thermometers must be immersed in a liquid such as mineral oil or glycol. • Temperature of units used for sample or standard storage must be checked daily as described in operation-specific SOPs. Refrigerator acceptance limits: 4°C ± 2°C Freezer acceptance limits: < - 10°C
Ovens	• Temperature of units must be checked daily or before use. • Acceptance limits vary according to use as described in operation-specific SOPs and must be documented in the temperature log.
Micropipettors	• Calibrations are checked gravimetrically as required by the operation-specific SOP. • Must be calibrated at the frequency (normally quarterly) required by the manufacturer at a minimum.
Syringes, Volumetric Glassware and Graduated Glassware	• All syringes and volumetric glassware are purchased as Class A items. • Class A items are certified by the manufacturer to be within ± 1% of the measured volume, therefore, calibration of these items by Quanterra® laboratories is not required. • All analysts are trained in the proper use and maintenance of measuring devices to ensure the measurement of standards, reagents and sample volumes are within method tolerances.

TABLE 8.5-7
Summary of Inorganic Method Calibrations

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Acidity	Initial	305.1	2 point calibration of pH meter (± 0.05 pH units of true value)	--	Not Applicable
	Continuing	305.1	Not Applicable	--	Not Applicable
	Ending	305.1	Not Applicable	--	Not Applicable
Alkalinity	Initial	310.1 2320B	2 point calibration of pH meter (± 0.05 pH units of true value)	--	Not Applicable
	Continuing	310.1 2320B	Not Applicable	--	Not Applicable
	Ending	310.1 2320B	Not Applicable	--	Not Applicable
Ammonia	Initial	350.1	6 levels including blank, "r"[3] ≥ 0.995	--	Not Applicable
	Continuing	350.1	1 level or LCS every 10 samples ± 10% of true value	--	Not Applicable
	Ending	350.1	1 level or LCS every 10 samples ± 10% of true value	--	Not Applicable
Biochemical Oxygen Demand (BOD)	Initial	405.1	a. Winkler titration: Iodometric with standard thiosulfate b. Membrane electrode: Read in air and in water with zero dissolved oxygen	--	Not Applicable
	Continuing	405.1	Not Applicable	--	Not Applicable
	Ending	405.1	Not Applicable	--	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Bromide	Initial	300.0[4] 320.1 ASTM D1246-88	Method 300.0 & ASTM D1246-88: 5 levels plus a blank, "r"[3] ≥ 0.995 Method 320.1: Not Applicable	9056	Method 300.0: 5 levels plus a blank, "r"[3] ≥ 0.995
	Continuing	300.0[4] 320.1 ASTM D1246-88	Method 300.0 & ASTM D1246-88:1 level every 10 samples ± 10% of true value Method 320.1 Not Applicable	9056	Method 300.0: Not Applicable
	Ending	300.0[4] 320.1 ASTM D1246-88	Not Applicable	9056	Not Applicable
Chemical Oxygen Demand (COD)	Initial	410.4 410.1 410.2	Method 410.4: 5 levels plus a blank"r"[3] ≥ 0.995 Methods 410.1 & 410.2: Standardize titrant.	–	Not Applicable
	Continuing	410.4 410.1 410.2	Method 410.4: 1 level every 10 samples ± 10% of true value Methods 410.1 & 410.2: Not Applicable	–	Not Applicable
	Ending	410.4	Method 410.4: 1 level ± 10% of true value Methods 410.1 & 410.2: Not Applicable	–	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Chloride	Initial	300.0[4] 325.1 325.2 325.3 4500-Cl E	Method 300.0, 325.1, and 325.2, 4500 Cl E: 5 levels plus blank "r"[3] ≥ 0.995 Method 325.3: Standardize titrant	9056 9251 9252A	Method 9056: 3 levels plus a blank Method 9251: 5 levels plus blank "r"[3] ≥ 0.995 Method 9252A: Standardize titrant
	Continuing	300.0[4] 325.1 325.2 325.3 4500-Cl E	Method 300.0, 325.1, and 325.2, 4500-Cl E: 1 level every 10 samples ± 10% of true value Method 325.3: Not Applicable	9056 9251 9252A	Method 9056: 1 per batch of 20 samples, ± 10% of true value Method 9251: 1 level every 10 samples ± 10% of true value Method 9252A: Not Applicable
	Ending	300.0[4] 325.1 325.2 325.3 4500-Cl E	Method 300.0, 325.1, and 325.2, 4500-Cl E: 1 level every 10 samples ± 10% of true value Method 325.3: Not Applicable	9056 9251 9252A	Method 9056 and 9252A: Not Applicable Method 9251: 1 level ± 10% of true value
Chromium Cr^{+6}	Initial	218.4 3500 Cr-D	Method 218.4: 5 levels plus blank "r"[3] ≥ 0.995 Method 3500 Cr-D: 3 levels plus blank	7196A	5 levels plus blank "r"[3] ≥ 0.995
	Continuing	218.4 3500 Cr-D	1 level every 10 samples ± 10% of true value	7196A	1 level every 10 samples ± 15%
	Ending	218.4 3500 Cr-D	1 level ± 10% of true value	7196A	1 level ± 15%

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Chlorine, Residual	Initial	330.1 330.3	Standardize titrant	--	Not Applicable
	Continuing	330.1 330.3	Not Applicable	--	Not Applicable
	Ending	330.1 330.3	Not Applicable	--	Not Applicable
Color	Initial	110.2	3 levels plus blank	--	Not Applicable
	Continuing	110.2	1 level every 10 samples	--	Not Applicable
	Ending	110.2	1 level	--	Not Applicable
Conductivity	Initial	120.1	Standard KCl solution	9050	1 level to determine cell constant
	Continuing	120.1	Not Applicable	9050	Not Applicable
	Ending	120.1	Not Applicable	9050	Not Applicable
Cyanide (Amenable)	Initial	335.1	7 levels plus blank "r"[3] ≥ 0.995	9010A 9012	7 levels plus blank "r"[3] ≥ 0.995
	Continuing	335.1	1 level every 10 samples ± 10% of true	9010A 9012	1 mid-level every 10 samples ± 15% of true value
	Ending	335.1	1 level ± 10 % of true value	9010A 9012	± 15% of true value
Cyanide (Total)	Initial	335.1 335.2 335.3 4500-CN E	7 levels plus blank "r"[3] ≥ 0.995	9010A 9012	7 levels plus blank "r"[3] ≥ 0.995
	Continuing	335.1 335.2 335.3 4500-CN E	1 mid-level every 10 samples ± 10 % of true value	9010A 9012	1 mid-level every 10 samples ± 15% of true value
	Ending	335.1 335.2 335.3 4500-CN E	1 mid-level ± 10 % of true value	9010A 9012	± 15% of true value

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Flashpoint	Initial	–	Not Applicable	1010	p-Xylene reference standard must have flashpoint of 27.2°C ± 1.1°C
	Continuing	–	Not Applicable	1010	Not Applicable
	Ending	–	Not Applicable	1010	Not Applicable
Fluoride	Initial	300.0[4] 340.2	Method 300.0: 5 levels plus a blank, "r"[3] ≥ 0.995 Method 340.2: 6 levels "r"[3] ≥ 0.995	9056	3 levels plus a blank
	Continuing	300.0[4] 340.2	1 mid-level every 10 samples ± 10% of true value	9056	1 per batch of 20 samples ± 10% of true value
	Ending	300.0[4] 340.2	1 mid-level ± 10% of true value	9056	Not Applicable
Hardness	Initial	130.2 2340B	Method 130.2: Standardize titrant Method 2340B: See ICP Metals 200.7	–	Not Applicable
	Continuing	130.2 2340B	Method 130.2: Not Applicable Method 2340B: See ICP Metals 200.7	–	Not Applicable
	Ending	130.2 2340B	Method 130.2: Not Applicable Method 2340B: See ICP Metals 200.7	–	Not Applicable
Iodide	Initial	345.1 Dionex[3]	Method 345.1: Standardize titrant Dionex: 4 levels plus blank "r"[3] ≥ 0.995	–	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Iodide (continued)	Continuing	345.1 Dionex[3]	Method 345.1: Not Applicable Dionex: 1 mid-level every 10 samples ± 10 % of true value	–	Not Applicable
	Ending	345.1 Dionex[3]	Method 345.1: Not Applicable Dionex: 1 mid-level ± 10% of true value	–	Not Applicable
Iron (Ferrous)	Initial	3500-Fe D	3 levels plus a blank, "r"[3] ≥ 0.995	-	Not Applicable
	Continuing	3500-Fe D	1 mid-level every 10 samples ± 10% of true value	-	Not Applicable
	Ending	3500-Fe D	1 mid-level ± 10% of true value	-	Not Applicable
Methylene Blue Active Substances (MBAS)	Initial	425.1	4 levels plus blank "r"[3] ≥ 0.995	–	Not Applicable
	Continuing	425.1	1 level every 10 samples ± 10 % of true value	–	Not Applicable
	Ending	425.1	1 level ± 10 % of true value	–	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Nitrate	Initial	300.0[4] 352.1	5 levels plus a blank $r^{[3]} \geq 0.995$	9056 9200	Method 9056: 3 levels plus a blank Method 9200: 5 levels plus a blank must be analyzed with each batch of 20 samples
	Continuing	300.0[4] 352.1	1 mid-level every 10 samples ± 10% of true value	9056 9200--	Method 9056: 1 per batch of 20 samples, ± 10% of true value Method 9200: Independently - prepared check standard every 15 samples
	Ending	300.0[4] 352.1	1 mid-level ± 10% of true value	9056 9200--	Not Applicable
Nitrite	Initial	300.0[4] 354.1	5 levels plus a blank $r^{[3]} \geq 0.995$	9056	3 levels plus a blank
	Continuing	300.0[4] 354.1	1 mid-level every 10 samples ± 10% of true value	9056	1 per batch of 20 samples, ± 10% of true value
	Ending	300.0[4] 354.1	1 mid-level ± 10% of true value	9056	Not Applicable
Nitrate-Nitrite	Initial	353.1 353.2 353.3	5 levels plus blank $r^{[3]} \geq 0.995$	--	Not Applicable
	Continuing	353.1 353.2 353.3	1 level every 10 samples ± 10% of true value	--	Not Applicable
	Ending	353.1 353.2 353.3	1 mid-level ± 10% of true value	--	Not Applicable

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Odor	Initial	140.1	No calibration	–	Not Applicable
	Continuing	140.1	Not Applicable	–	Not Applicable
	Ending	140.1	Not Applicable	–	Not Applicable
Phosphorus (total and Ortho-phosphate)	Initial	300.0[4] 365.1 365.2 365.3 365.4	Method 300.0/365.3/365.4: 3 levels plus a blank Method 365.2: 8 levels plus a blank	–	Not Applicable
	Continuing	300.0[4] 365.1 365.2 365.3 365.4	Method 300.0/365.3/365.4: 1 level every 10 samples ± 10% of true value Method 365.2: Blank and 2 standards with each series of samples, ± 2% of true value or recalibrate	–	Not Applicable
	Ending	300.0[4] 365.1 365.2 365.3 365.4	Method 300.0/365.3/365.4: ± 10% of true value Method 365.2: Not Applicable	–	Not Applicable
pH	Initial	150.1 4500-H+ B	2 level calibration that bracket the expected pH of the sample (± 0.05 pH units of true value)	9040B 9045C	2 point calibration (± 0.05 pH units of true value)
	Continuing	150.1 4500-H+ B	1 buffer check every 10 samples ± 5% of true value	9040B 9045C	Not Applicable
	Other	150.1 4500-H+ B	Third point check	9040B 9045C	Third point check

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
pH (continued)	Ending	150.1 4500-H^+ B	1 buffer check ± 5% of true value	9040B 9045C	Not Applicable
Phenolics	Initial	420.1 420.2	5 levels plus a blank "r"[3] ≥ 0.995	9065	5 levels plus a blank "r"[3] 0.995
	Continuing	420.1 420.2	1 mid-level every 10 samples ± 10% true value	9065	1 mid-level ± 15% true value
	Ending	420.1 420.2	1 mid-level ± 10% true value	9065	1 mid-level ± 15% true value
Phosphate	Initial	—	Not Applicable	9056	3 levels plus a blank
	Continuing	—	Not Applicable	9056	1 per batch of 20 samples, ± 15% of true value
	Ending	—	Not Applicable	9056	Not Applicable
Reactivity	Initial	—	Not Applicable	Chap 7	See Total Cyanide and Sulfide
	Continuing	—	Not Applicable		
	Ending	—	Not Applicable		
Settleable Solids	Initial	160.5	Not Applicable	—	Not Applicable
	Continuing	160.5		—	Not Applicable
	Ending	160.5		—	Not Applicable
Silica, Dissolved	Initial	370.1	Approximately 6 levels plus blank "r"[3] ≥ 0.995	—	Not Applicable
	Continuing	370.1	1 level ± 15% of true value	—	Not Applicable
	Ending	370.1	1 level ± 15% of true value	—	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Specific Conductance	Initial	120.1	Standardize meter with 0.01 M KCl	9050	Not Applicable
	Continuing	120.1	1 level every 10 samples ± 10% of true value	9050	Not Applicable
	Ending	120.1	1 level ± 10% of true value	9050	Not Applicable
Sulfate	Initial	300.0[4] 375.1 375.4	Method 300.0/375.1: 5 levels plus blank "r"[3] ≥ 0.995 Method 375.4: 3 levels plus blank "r"[3] ≥ 0.995	9038 9056	Method 9038: 3 levels plus a blank for every hour of continuous sample analysis. Method 9056: 3 levels plus a blank
	Continuing	300.0[4] 375.1 375.4	Method 300.0/375.1: 1 mid-level after every 10 samples ± 10% of true value Method 375.4: 1 level every 3 or 4 samples ± 10% of true value	9038 9056	Method 9038: Independent-prepared check standard every 15 samples Method 9056: 1 per batch of 20 samples, ± 10% of true value
	Ending	300.0[4] 375.1 375.4	± 10% of true value	9038 9056	Not Applicable
Sulfide	Initial	376.1 376.2	Method 376.1: This is a titration method. Therefore, calibrations are not applicable. Method 376.2: 5 levels plus a blank "r"[3] ≥ 0.995	9030A	This is a colorimetric titration. Therefore, calibrations are not applicable.

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Sulfide (continued)	Continuing	376.1 376.2	Method 376.1: Not Applicable Method 376.2: 1 level every 10 samples ± 10% of true value	9030A	This is a colorimetric titration. Therefore, calibrations are not applicable.
	Ending	376.1 376.2	Method 376.1: Not Applicable Method 376.2: ± 10% of true value	9030A	This is a colorimetric titration. Therefore, calibrations are not applicable.
Sulfite	Initial	377.1	This is a colorimetric titration. Therefore, calibrations are not applicable.	–	Not Applicable
	Continuing	377.1		–	Not Applicable
	Ending	377.1		–	Not Applicable
Temperature	Initial	170.1	Not Applicable	–	Not Applicable
	Continuing	170.1	Not Applicable	–	Not Applicable
	Ending	170.1	Not Applicable	–	Not Applicable
Total Dissolved Solids	Initial	160.1	This is a gravimetric determination. Calibrate balance prior to analysis	–	Not Applicable
	Continuing	160.1		–	Not Applicable
	Ending	160.1		–	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Total Kjeldahl Nitrogen (TKN)	Initial	351.2 351.3	Method 351.2: 5 levels plus blank "r"[3] ≥ 0.995 Method 351.3: Titrimetric: Standardize titrant Colorimetric: 7 levels plus blank	–	Not Applicable
	Continuing	351.2 351.3	Method 351.2: 1 mid-level every 10 samples ± 10% of true value Method 351.3: Not Applicable	–	Not Applicable
	Ending	351.2 351.3	Method 351.2: ± 10% of true value Method 351.3: Not Applicable	–	Not Applicable
Total Organic Carbon (TOC)	Initial	415.1	3 levels plus blank	9060	3 levels plus blank "r"[3] ≥ 0.995
	Continuing	415.1	1 mid-level every 10 samples ± 15% of true value	9060	1 mid-level every 10 samples ± 15% of true value
	Ending	415.1	± 15% of true value	9060	± 15% of true value

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Total Organic Halides (TOX)	Initial	SM 5320B [4] 450.1 [4]	Method 5320B: 7 levels plus a blank ± 10% of true value Method 450.1: Daily instrument calibration standard and blank in duplicate ± 10% of true value (calibration std.) Verify with independently-prepared check standard	9020B	Daily instrument calibration standard and blank in duplicate ± 10% of true value (calibration std.) Verify with independently-prepared check standard
	Continuing	SM 5320B [4] 450.1 [4]	± 10% of true value	9020B	CCV ± 10% of true value
	Ending	SM 5320B [4] 450.1 [4]	± 10% of true value	9020B	CCV ± 10% of true value
Total Solids	Initial	160.3	This is a gravimetric determination. Calibrate balance before use.	–	Not Applicable
	Continuing	160.3		–	Not Applicable
	Ending	160.3		–	Not Applicable
Total Suspended Solids (Nonfilterable)	Initial	160.2	This is a gravimetric determination. Calibrate balance before use.	–	Not Applicable
	Continuing	160.2		–	Not Applicable
	Ending	160.2		–	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Turbidity	Initial	180.1	Minimum of 1 level in each instrument range Follow manufacturer's instructions	–	Not Applicable
	Continuing	180.1	Not Applicable	–	Not Applicable
	Ending	180.1	Not Applicable	–	Not Applicable
Volatile Solids	Initial	160.4	This is a gravimetric determination. Calibrate balance before use.	–	Not Applicable
	Continuing	160.4		–	Not Applicable
	Ending	160.4		–	Not Applicable
Water Content	Initial	–	Calibrate Balance	–	Calibrate Balance
	Continuing	–	Not Applicable	–	Not Applicable
	Ending	–	Not Applicable	–	Not Applicable
GFAA Metals (excludes Hg)	Initial	200 series	3 levels plus blank ICV ± 10% of true value "r"[3] ≥ 0.995	7000 series	3 levels plus blank ICV ± 10% of true value "r"[3] ≥ 0.995
	Continuing	200 series	Every 10 samples ± 10% of true value	7000 series	Every 10 samples ± 20% of true value
	Ending	200 series	± 10% of true value	7000 series	± 20% of true value
	Other	200 series	Annually - Instrument detection limits	7000	Annually - Instrument detection limits

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
ICAP Metals (excludes Hg)	Initial	200.7	1 level and blank Rerun high calibration standard: verify quantitation at ± 5% of true value	6010A	1 level and blank Rerun high calibration standard: verify quantitation at ± 5% of true value
	Continuing	200.7	Every 10 samples ± 5% of true value	6010A	Mid-level calibration standard Every 10 samples ± 10% of true value
	Ending	200.7	± 5% of true value	6010A	Mid-level calibration standard ± 10% of true value
	Other	200.7	ICSA, ICSAB: Analyze at beginning and end or every 8 hours whichever is more frequent <u>Annually</u>: ICP interelement correction factors Instrument detection limits	6010A	ICSA, ICSAB: Analyze at beginning and end or every 8 hours whichever is more frequent <u>Annually</u>: ICP interelement correction factors Instrument detection limits
ICP/MS Metals	Initial	200.8	1 level and blank, ICV: ± 10% of true	6020	1 level and blank, ICV: ± 10% of true
	Continuing	200.8	Mid-level calibration standard Every 10 samples, ± 10% of true value	6020	Mid-level calibration standard Every 10 samples, ± 10% of true value
	Ending	200.8	Not specified	6020	Mid-level calibration standard, ± 10% of true value
	Other	200.8	Initial tuning standard deviation ≤ 5% for five replicates; Mass calibration ≤ 0.1 amu from true; Resolution ≤ 0.75 amu full width at 5% peak height; Analyze ICSA and ICSAB at the beginning of each run and every 12 hours	6020	Initial tuning standard deviation ≤ 5% for four replicates; Mass calibration ≤ 0.1 amu from true; Resolution ≤ 0.9 amu full width at 10% peak height; Analyze ICSA and ICSAB at the beginning of each run and every 12 hours

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Mercury by CVAA	Initial	245.1 245.5	5 levels plus blank ICV ± 10% of true value "r"[3] ≥ 0.995	7470A 7471A	5 levels plus blank ICV ± 10% of true value "r"[3] ≥ 0.995
	Continuing	245.1 245.5	Daily or every 10 samples, whichever is more frequent ± 20% of true value	7470A 7471A	Every 10 samples ± 20% of true value
	Ending	245.1 245.5	± 20% of true value	7470A 7471A	± 20% of original prepared standard
	Other	245.1 245.5	Annually - Instrument detection limits	7470A 7471A	Annually - Instrument detection limits

Footnotes

(1) National Pollutant Discharge Elimination System

(2) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), and Final Update IIB (January 1995).

(3) "r" = correlation coefficient

(4) Method not listed in 40 CFR Part 136.

TABLE 8.5-8
Summary of Organic Method Calibrations

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Aromatic Volatiles by GC	Initial	602	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8020A	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.
	Continuing	602	Analyze QC check sample and evaluate per method requirements	8020A	Mid-level calibration standard analyzed every 10 samples. Evaluate per method requirements.
	Ending	602	Not Applicable	8020A	Mid-level calibration standard Evaluate per method requirements.
	Other	602	Not Applicable	8020A	Not Applicable
Acrolein & Acrylonitrile by GC	Initial	603	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8030A	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.
	Continuing	603	Analyze QC check sample and evaluate per method requirements	8030A	Mid-level calibration standard analyzed every 10 samples. Evaluate per method requirements.8
	Ending	603	Not Applicable	8030A	Mid-level calibration standard Evaluate per method requirements.
	Other	603	Not Applicable	8030A	Not Applicable
Dioxins/ Dibenzofurans by HRGC/LRMS	Initial	613	3 levels If % RSD <10%, use mean RF. Otherwise calibration curve employed	8280	5 levels in triplicate % RSD ≤ 15%

TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Dioxins/ Dibenzofurans by HRGC/LRMS (continued)	Continuing	613	1 level each working day. % D must be ≤ 15%.	8280	1 level every 12 hours after window performance mix Standard must have RFs with %D ≤ 30% from initial
	Ending	613	Not Applicable	8280	Window performance mix
	Other	613	Establish Single Ion Monitoring conditions described in method	8280	Window mix to set congener windows every 12 hours at beginning of sequence. Isotope ratios in standard must meet criteria in method. Valley between 2,3,7,8-TCDD[3] and 1,2,3,4-TCDD must be ≤ 25% of the 2,3,7,8-TCDD[3] peak height.
Dioxins/ Dibenzofurans by HRGC/HRMS	Initial	–	Not Applicable	8290	5 levels plus window defining solution. %RSD for natives ≤ 20% for RFs; %RSD for labeled compounds ≤ 30% for RFs.
	Continuing	–	Not Applicable	8290	1 level every 12 hours after window defining solution. RFs with %D ≤ 20% for natives; %D ≤ 30% for labeled compounds from initial
	Ending	–	Not Applicable	8290	1 level: RFs with %D ≤ 20% for natives; %D ≤ 30% for labeled compounds from initial

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TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Dioxins/ Dibenzofurans by HRGC/HRMS (continued)	Other	–	Not Applicable	8290	Isotope ratios in standard must meet criteria in method. Valley between 2,3,7,8-TCDD[3] and all other TCDDs must be ≤ 25% of the 2,3,7,8-TCDD height
Herbicides by GC	Initial	615[9]	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8150B	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.
	Continuing	615[9]	1 or more calibration standards analyzed daily %D ± 15% of predicted response	8150B	Mid-level calibration standard analyzed every 10 samples. % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to - 15% for analytes not detected.
	Ending	615[9]	Not Applicable	8150B	Mid-level calibration standard. % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to - 15% for analytes not detected.
	Other	615[9]	Not Applicable	8150B	Not Applicable
Nitroaromatics by HPLC	Initial	–	Not Applicable	8330	Minimum of 5 levels. Curve should be linear with zero intercept.
	Continuing	–	Not Applicable	8330	Midpoint calibration standard at beginning and after the midpoint of sample run. %D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to - 15% for analytes not detected.

TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Nitroaromatics by HPLC (continued)	Ending	–	Not Applicable	8330	Midpoint calibration standard. %D: ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to - 15% for analytes not detected.
	Other	–	Not Applicable	8330	Not Applicable
Polyaromatic Hydrocarbons by GC or HPLC	Initial	610	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8100 8310	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.
	Continuing	610	1 or more calibration standards analyzed daily % D ± 15% of predicted response	8100 8310	Mid-level calibration standard analyzed every 10 samples. % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to - 15% for analytes not detected.
	Ending	610	Not Applicable	8100 8310	Mid-level calibration standard. % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to - 15% for analytes not detected.
	Other	610	Not Applicable	8100 8310	Not Applicable
Pesticides/ PCBs by GC	Initial	608	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8080A	Minimum of 5 levels. If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.
	Continuing	608	1 or more calibration standards analyzed daily % D ± 15% of predicted response	8080A	Mid-level calibration standard analyzed every 10 samples. % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to - 15% for analytes not detected.

TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Pesticides/ PCBs by GC (continued)	Ending	608	Not Applicable	8080A	Mid-level calibration standard. % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.
	Other	608	Not Applicable	8080A	Not Applicable
Petroleum Hydrocarbons/ Oil and Grease	Initial	413.1 413.2 418.1	Method 413.1: This is a gravimetric determination. Calibrate balance before use. Method 413.2/418.1: 3 levels plus a blank "r" ≥ 0.995	9070 9071A	This is a gravimetric determination. Calibrate balance before use
	Continuing	413.1 413.2 418.1	Not Applicable	9070 9071A	Not Applicable
	Ending	413.1 413.2 418.1	Not Applicable	9070 9071A	Not Applicable
	Initial	1664[3]	Calibrate analytical balance at 2 mg and 1000 mg Calibration must be ± 10% at 2 mg and ± 0.5% at 1000 mg or recalibrate balance	–	–
	Continuing	1664[3]	Not Applicable	–	–
	Ending	1664[3]	Not Applicable	–	–
Organophos-phorous Pesticides by GC	Initial	–	Not Applicable	8140 8141A	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.

TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Organophos-phorous Pesticides by GC (continued)	Continuing	--	Not Applicable	8140 8141A	Mid-level calibration standard analyzed every 10 samples. % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.
	Ending	--	Not Applicable	8140 8141A	Mid-level calibration standard % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.
	Other	--	Not Applicable	8140 8141A	Not Applicable
Purgeable Halocarbons by GC	Initial	601	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8010B	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.
	Continuing	601	Analyze QC check sample and evaluate per method requirements	8010B	Mid-level calibration standard analyzed every 10 samples. Evaluate per method requirements.
	Ending	601	Not Applicable	8010B	Mid-level calibration standard Evaluate per method requirements.
	Other	601	Not Applicable	8010B	Not Applicable

TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Halogenated Volatiles by GC	Initial	–	Not Applicable	8021A	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.
	Continuing	–	Not Applicable	8021A	Mid-level calibration standard analyzed every 10 samples. % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.
	Ending	–	Not Applicable	8021A	Mid-level calibration standard % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.
	Other	–	Not Applicable	8021A	Not Applicable
Semivolatiles	Initial	625	Minimum of 3 levels, lowest near but above MDL If % RSD ≤ 35%, use avg RF Otherwise calibration curve employed.	8270B	Minimum of 5 levels, % RSD for RF for CCCs[4] ≤ 30% SPCCs[5]: RF > 0.050
	Continuing	625	1 level every 24 hours Acceptance criteria are found in the method	8270B	Mid-level standard every 12 hours (after tuning) %D for CCCs[4] < 20 % between RF from standard and avg RF from initial SPCCs[5]: RF > 0.050

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TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Semivolatiles (continued)	Ending	625	Not Applicable	8270B	Not Applicable
	Other	625	DFTPP[7] tuning every 24 hours before standard or sample runs.	8270B	DFTPP[7] tuning at the beginning of every 12 hour shift.
Volatiles	Initial	624	Minimum of 3 levels, If % RSD ≤ 35%, can use mean RF Otherwise calibration curve employed	8240B	Minimum of 5 levels, % RSD for RF for CCCs[4] ≤ 30% SPCCs[5]: RF > 0.300 (0.10 for Bromoform)
	Continuing	624	1 level every 24 hours Acceptance criteria are found in the metnod	8240B	Mid-level standard every 12 hours (after tuning) %D for CCCs[4] < 20 % between RF from standard and avg RF from initial SPCCs[5]: RF > 0.300 (0.10 for Bromoform
	Ending	624	Not Applicable	8240B	Not Applicable
	Other	624	BFB[6] tuning every 24 hours before standard or sample runs.	8240B	BFB[6] tuning at the beginning of every 12 hour shift.
	Initial	--	Not Applicable	8260A	Minimum of 5 levels, %RSD for RF for CCCs[4] < 30% SPCCs[5]: RF ≥ 0.30 for Chlorobenzene and 1,1,2,2-tetrachloroethane, RF ≥ 0.10 for Chloromethane and 1,1-dichloroethane, RF > 0.10 for Bromoform

TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Volatiles (continued)	Continuing	--	Not Applicable	8260A	Mid-level standard every 12 hours (after tuning) %D for CCCs[4] < 30% between RF from standard and avg RF from initial SPCCs[5]: RF ≥ 0.30 for Chlorobenzene and 1,1,2,2-tetrachloroethane, RF ≥ 0.10 for Chloromethane and 1,1-dichloroethane, RF > 0.10 for Bromoform
	Ending	--	Not Applicable	8260A	Not Applicable
	Other	--	Not Applicable	8260A	BFB[6] tuning at the beginning of every 12 hour shift.

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Footnotes

(1) National Pollutant Discharge Elimination System
(2) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), and Final Update IIB (January 1995).
(3) TCDD - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
(4) CCC - Continuing Calibration Compounds
(5) SPCC - System Performance Check Compound
(6) BFB - Bromofluorobenzene
(7) DFTPP - Decafluorotriphenylphosphine
(8) Method 1664 is a proposed only method and has not been promulgated by the EPA.
(9) Method not listed in 40 CFR Part 136.

TABLE 8.5-9
Summary of USEPA Contract Laboratory Program Statement of Work Method Calibrations

Analytical Parameter	Calibration	Method	Requirement
Cyanide, Total	Initial	ILM03.0	Minimum 5 levels plus blank "r" ≥ 0.995
	Continuing	ILM03.0	1 mid-level every 10 samples ± 15 % of true value
	Ending	ILM03.0	± 15 % of true value
	Other	ILM03.0	Not Applicable
ICAP (excludes mercury)	Initial	ILM03.0	1 level and blank ICV: ± 10% of true
	Continuing	ILM03.0	Mid-level calibration standard Every 10 samples ± 10% of true value
	Ending	ILM03.0	Mid-level calibration standard ± 10% of true value
	Other	ILM03.0	ICSA, ICSAB: Analyze at beginning and end or every 8 hours whichever is more frequent CRI: Beginning and end of each run, and every 8 hours for all analytes at 2x CRDL or 2x IDL whichever is greater, except for Al, Ba, Ca, Fe, Mg, Na, K Quarterly: Instrument detection limits Linear Range Verification Annually: ICP interelement correction factors

TABLE 8.5-9
Summary of USEPA Contract Laboratory Program Statement of Work
Method Calibrations
(Continued)

Analytical Parameter	Calibration	Method	Requirement
GFAA (excludes Hg)	Initial	ILM03.0	Minimum 3 levels plus blank ICV: ± 10%
	Continuing	ILM03.0	Every 10 samples ± 10% of true value
	Ending	ILM03.0	± 10% of true value
	Other	ILM03.0	CRA: Beginning of every analytical run (no acceptance criteria) Quarterly - Instrument detection limits
Mercury (CVAA)	Initial	ILM03.0	Minimum 3 levels plus blank "r"[4] ≥ 0.995 ICV: ± 20%
	Continuing	ILM03.0	Every 10 samples ± 20% of true value
	Ending	ILM03.0	± 20% of true value
	Other	ILM03.0	Quarterly - Instrument detection limits
Pesticides/PCBs	Initial	OLM03.1	3 levels for single component analytes, 1 level for multicomponent analytes RSD must be ≤ 20% except α-BHC and δ-BHC at 25% (allow up to 2 target analytes to be 20% ≤ 30%)
	Continuing	OLM03.1	Instrument Blank and midpoint calibration or PEM every 12 hours % D: ± 25% of predicted response

TABLE 8.5-9
Summary of USEPA Contract Laboratory Program Statement of Work
Method Calibrations
(Continued)

Analytical Parameter	Calibration	Method	Requirement
Pesticides/PCBs (continued)	Ending	OLM03.1	Instrument Blank and midpoint calibration or PEM
	Other	OLM03.1	Resolution Check Mixture ≥ 60% PEM: ≥ 90% DDT, Endrin breakdown must each be ≤ 20% (≤ 30% combined)
	Initial	OLM01.8	3 levels for single component analytes, 1 level for multicomponent analytes RSD must be ≤20% for each single component target compounds (up to two single components target compounds per column may be > 20.0% but those compounds must have an RSD ≤30.0%.
	Continuing	OLM01.8	Instrument Blank and mid-point calibration standard or PEM every 12 hours Must meet resolution, retention time window, and RPD requirements in method
	Ending	OLM01.8	Instrument Blank and mid-point calibration standard or PEM Must meet resolution retention time window, and RPD requirements in method
PCDD, PCDF	Initial	DFLM01.1	Minimum 5 levels Resolution: 13C12-2378-TCDD and 13C12-1234-TCDD < 25% 123478-HxCDD and 123678-HxCDD ≤ 50% %RSD unlabeled PCDDs/PCDFs and internal standards ≤ 15%
	Continuing	DFLM01.1	Analyze CC3 or CPS solution every 12 hours Must meet ion abundance, S/N, and %D criteria in method
	Ending	DFLM01.1	Analyze CC1 solution at end of 12 hour period Must meet ion abundance and S/N criteria in method
	Other	DFLM01.1	Window Defining Mix: verify switching times

TABLE 8.5-9
Summary of USEPA Contract Laboratory Program Statement of Work
Method Calibrations
(Continued)

Analytical Parameter	Calibration	Method	Requirement
Semivolatiles by GC/MS	Initial	OLM03.1	5 levels RRF and RSD must meet method criteria
	Continuing	OLM03.1	Mid-level every 12 hours after tuning check %D and RRF must meet minimum criteria
	Ending	OLM03.1	Not Applicable
	Other	OLM03.1	DFTPP tuning at the beginning of every 12 hour shift
	Initial	OLM01.8	5 levels RRF and RSD must meet method criteria
	Continuing	OLM01.8	1 level every 12 hours %D and RRF must meet minimum method criteria
	Ending	OLM01.8	Not Applicable
Volatiles by GC/MS	Initial	OLM03.1	5 levels RRF and RSD must meet method criteria
	Continuing	OLM03.1	Mid-level every 12 hours after tuning check %D and RRF must meet minimum criteria
	Ending	OLM03.1	Not Applicable
	Other	OLM03.1	BFB tuning at the beginning of every 12 hour shift
	Initial	OLM01.8	5 levels RRF and RSD must meet method criteria
	Continuing	OLM01.8	1 level every 12 hours %D and RRF must meet minimum method criteria
	Ending	OLM01.8	Not Applicable
	Other	OLM01.8	BFB tuning at the beginning of every 12 hour shift

TABLE 8.6-1
Precision and Accuracy Measurements

Measurement	Definition
Accuracy	The degree of agreement of a measurement with an accepted reference or true value. The only true or known values in the laboratory are spiked samples. Expressed as laboratory control sample (LCS) percent recovery (% R): $$LCS\ \%\ Recovery = \frac{X}{t} x 100$$ where: X = observed concentration t = concentration of spike added Expressed as matrix spike/matrix spike duplicate (MS/MSD) sample percent recovery (% R): $$MS / MSD\ \%\ Recovery = \frac{X_s - X}{t} x\ 100$$ where: X_s = observed concentration in spiked sample X = observed concentration in unspiked sample t = concentration of spike added
Precision	The measure of analytical reproducibility of two values. Expressed as the relative percent difference (RPD) of two values. $$RPD = \left[\frac{|X_1 - X_2|}{\left(\frac{X_1 + X_2}{2}\right)} \right] x\ 100$$ where: X_1 = first observed concentration X_2 = second observed concentration

TABLE 8.6-1
Precision and Accuracy Measurements
(Continued)

Measurement	Definition
Arithmetic mean	The average of a set of values. $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$ where: $\bar{x}$ = the mean x_i = the ith data value n = number of data values
Standard Deviation	A measure of the random (probable) error associated with a single measurement within a data set. $s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$ where: s = sample standard deviation $\bar{x}$ = the mean x_i = the ith data value n = number of data values
Quality Control Chart	A graphical representation of analytical accuracy. Displays the arithmetic mean of a data set, the upper and lower warning limits and the upper and lower control limits.
Upper Control Limit (UCL)	For LCS $UCL = \bar{x} + 3s$ For QC Samples UCL = mean +2s
Upper Warning Limit (UWL)	For LCS $UWL = \bar{x} + 2s$ For QC Samples UWL = mean + 1s
Lower Warning Limit (LWL)	For LCS $LWL = \bar{x} - 2s$ For QC Samples LWL = mean - 1s
Lower Control Limit (LCL)	For LCS $LCL = \bar{x} - 3s$ For QC Samples LCL = mean - 2s

TABLE 8.11-1
Instrument Maintenance Schedule
Ion Chromatograph[1]

As Needed	Daily	Weekly	Monthly	Semi-annually
Clean micromembrane suppressor when decreases in sensitivity are observed.	Check plumbing/leaks.	Check pump heads for leaks.	Check all air and liquid lines for discoloration and crimping, if indicated.	Lubricate left hand piston.
Check fuses when power problems occur.	Check gases.	Check filter (inlet)	Check/change bed supports guard-and analytical columns, if indicated.	Clean conductivity cell.
Reactivate or change column when peak shape and resolution deteriorate or when retention time shortening indicates that exchange sites have become deactivated.	Check pump pressure.			Check conductivity cell for calibration.
De-gas pump head when flow is erratic.	Check conductivity meter.			

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TABLE 8.11-2
Instrument Maintenance Schedule
LACHAT Auto Analyzer[1]

As Needed	Daily	Monthly	Semi-annually	Annually
Prepare fresh reagents.	Clean detector cell and make sure there are no trapped bubbles in detector cell.	Replace tubing.	Lubricate pump roller.	Clean pump rollers with steel wool and lubricate.
	Check tubing.	Clean pump, diluter, and XYZ Sampler.		
	Clean sample probe shaft.			

TABLE 8.11-3
Instrument Maintenance Schedule
Total Organic Halide Analyzer[1]

Daily	As Needed
Check electrodes for damage, polish the electrodes.	Examine and clean or replace pyrolysis tube.
Replace dehydrating fluid and electrolyte fluid.	Clean titration cell.
Clean quartz boat.	Observe gas flow.
Observe check valves during use for backfeed.	Replace reference electrode fluid.
At end of each day of use, wash out absorption module, empty electrolyte and fill cell with DI water. Empty dehydrator tube	Change quartz wool.
Perform cell performance check.	Replace o-rings and seals.

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TABLE 8.11-4
Instrument Maintenance Schedule
High Pressure Liquid Chromatograph[1]

Daily	As Needed
Check level of solution in reservoirs. If adding, verify that solvent is from the same source. If changing, rinse gas and delivery lines to prevent contamination of the new solvent.	Replace columns when peak shape and resolution indicate that chromatographic performance of column is below method requirements.
Check gas supply.	Oil autosampler slides when sample does not advance.
Flush with an appropriate solvent to remove all bubbles.	Rinse flow cell with 1N nitric acid if sensitivity low.
Pre-filter all samples.	Change pump seals when flow becomes inconsistent.
	Repack front end of column Backflush column.

TABLE 8.11-5
Instrument Maintenance Schedule
Flame Atomic Absorption Spectroscopy[1]

Daily	Monthly	As Needed
Verify proper safety precautions are working.	Clean all filters and fans.	Check drain receptacle.
Verify gas box operates properly and safely.	Change capillary tubing	Check background corrector for alignment.
Verify sensitivity using elements in UV/VIS spectrum.	Clean optical windows	Clean burner head.
		Clean nebulizer.
		Clean spray chamber.
		Check sample introduction O-rings.

TABLE 8.11-6
Instrument Maintenance Schedule
Inductively Coupled Argon Plasma/Mass Spectrometry (ICAP/MS)[1]

Daily	Weekly	Monthly	Quarterly	Annually	As Needed
Check sample waste container level.	Check peristaltic pump: proper roller pressure, sample introduction tubing, correct pump rotation, condition of drain tubing.	Clean all filters and fans.	Replace oil in roughing pumps.	Replace oil in turbo-molecular pump.	Check electronic settings for optimum sensitivity: resolution, mass calibration, ion optics, CEM, deflector voltage.
Check quartz torch condition.	Check condition of sampler and skimmer cones.	Check recirculator water level.			
Measure quartz torch for proper alignment.	Check and drain oil mist eliminator on roughing pumps.				
Clean spray chamber and nebulizer.					
Check oil level of roughing pumps.					

TABLE 8.11-7
Instrument Maintenance Schedule
ICP[1]

Daily	As Needed	Semi-annually	Annually
Check that argon tank pressure is 50-60 psi and that a spare tank is available.	Clean plasma torch assembly to remove accumulated deposits.	Change vacuum pump oil.	Notify manufacturer service engineer for scheduled preventive maintenance service.
Check vacuum pump gage. (<10 millitorr)	Clean nebulizer and drain chamber; keep free-flowing to maintain optimum performance.	Replace coolant water filter. (may require more or less frequently depending on the quality of water)	
Check that cooling water supply system is full and drain bottle is not full. Also that drain tubing is clear, tight fitting and has few bends.	Clean filters on back of power unit to remove dust.		
Check that nebulizer is not clogged.	Replace when needed: peristaltic pump tubing sample capillary tubing autosampler sipper probe		
Check that capillary tubing is clean and in good condition.	Check ytrium position.		
Check that peristaltic pump windings are secure.			
Check that high voltage switch is on.			
Check that exhaust screens are clean.			
Check that torch, glassware, aerosol injector tube, bonnet are clean.			

TABLE 8.11-8
Instrument Maintenance Schedule
Graphite Furnace Atomic Absorption[1]

Daily	Monthly	As Needed	Annually
Check gas lines and gas supply.	Check coolant level in cooling unit. Add coolant if error message appears.	Replace contact cylinder.	Notify manufacturer service engineer to clean optics.
Clean optical windows.		Adjust autosampler arm.	
Clean contact cylinders.			
Check tubes and platform; replace if corroded, faking, or if low absorbance results.			
PE4100ZL: clean fume extraction tip, replace fume extraction filter and H_2O trap.			
As needed, trim sampling capillary.			
Check drain lines and waste containers; empty as needed.			
Check acid rinse containers; fill as needed.			

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TABLE 8.11-9
Instrument Maintenance Schedule
Cold Vapor Atomic Absorption (Leeman PS 200)[1]

Daily	As Needed	Annually
Change drying tube	Change pump tubing	Change Hg lamp.
Check pump tubing/drain tubing	Check/change Hg lamp	
Check gas pressure	Clean optical cell	
Check aperture reading	Lubricate pump	

TABLE 8.11-10
Instrument Maintenance Schedule
Cold Vapor Atomic Absorption (PE 5000)[1]

Daily	Monthly
Clean aspirator by flushing with DI water.	Clean cell in aqua regia.
Check tubing and replace if needed.	Clean aspirator in aqua regia.
Clean windows with methanol.	
Change silica gel in drying tube.	
Check argon gas supply.	
Adjust lamp.	

TABLE 8.11-11
Instrument Maintenance Schedule
Gas Chromatograph[1]

Daily	As Needed	Quarterly/Semi-annually/Annually
Check for sufficient supply of carrier and detector gases. Check for correct column flow and/or inlet pressures.	Replace front portion of column packing or break off front portion of capillary columns. Replace column if this fails to restore column performance or when column performance (e.g. peak tailing, poor resolution, high backgrounds, etc.) indicates it is required.	Quarterly ELCD: change roughing resin, clean cell assembly.
Check temperatures of injectors and detectors. Verify temperature programs.	Change glass wool plug in injection port and/or replace injection port liner when front portion of column packing is changed or front portion of capillary column is removed.	Semi-annually ECD: perform wipe test.
Check inlets, septa.	Replace septum (approximately every 100 injections).	Annually ELCD: change finishing resin, clean solvent filter.
Check baseline level.	Perform gas purity check (if high baseline indicates that impure carrier gas may be in use).	
Check reactor temperature of electrolytic conductivity detector.	Replace or repair flow controller if constant gas flow cannot be maintained.	
	Replace fuse.	
	Reactivate external carrier gas dryers.	
	Detectors: clean when baseline indicates contamination or when response is low. FID: clean/replace jet, replace ignitor. NPD: clean/replace collector assembly. PID: clean lamp window, replace seals. ELCD: check solvent flow weekly, change reaction tube, replace solvent, change reaction gas, clean/replace Teflon® transfer line. ECD: follow manufacturers suggested maintenance schedule	
	Reactivate flow controller filter dryers when presence of moisture is suspected.	

TABLE 8.11-11
Maintenance Schedule
Gas Chromatograph[1]
(Continued)

Daily	As Needed	Quarterly/Semi-annually/Annually
GC (continued)	HP 7673 Autosampler: replace syringe, fill wash bottle, dispose of waste bottle contents.	(continued)
	Purge & trap devices: periodic leak checks, replace/condition traps (when poor response or disappearance of reactive or poorly trapped compounds), clean sample lines, valves (if they become contaminated), clean glassware.	
	Purge & trap autosamplers: leak check system, clean sample lines, valves. PTA-30 autosampler also requires cleaning the syringes, frits, valves, and probe needles, adjustment of micro switches, replacement of Teflon® valve, and lubrication of components.	

TABLE 8.11-12
Instrument Maintenance Schedule
Mass Spectrometer[1]

Daily	As Needed[2]	Semi-Annually	Annually
Check for sufficient gas supply. Check for correct column flow and/or inlet pressure.	Check level of oil in mechanical pumps and diffusion pump if vacuum is insufficient. Add oil if needed between service contract maintenance.	Change oil in the mechanical rough pump. Relubricate the turbomolecular pump bearing wick.	Replace the exhaust filters on the mechanical rough pump every 1-2 years.
Check temperatures of injector, detector. Verify temperature programs.	Replace electron multiplier when the tuning voltage approaches the maximum and/or when sensitivity falls below required levels.		
Check inlets, septa.	Clean Source, including all ceramics and lenses - the source cleaning is indicated by a variety of symptoms including inability of the analyst to tune the instrument to specifications, poor response, and high background contamination.		
Check baseline level.	Repair/replace jet separator.		
Check values of lens voltages, electron multiplier, and relative abundance and mass assignments of the calibration compounds.	Replace filaments when both filaments burn out or performance indicates need for replacement.		

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TABLE 8.11-13
Instrument Maintenance Schedule
TRAACS 800 Auto Analyzer [1]

As Needed	Daily	Monthly	Semi-annually	Annually
Replaces air filter when progressive loss of air pressure is observed.	Check air pressure gauge (22 ± 2 psi)	Change all pump tubes (or after 200 hours of pumping time)	(or after 1000 hours of pumping time)	Lightly lubricate the Linear Sample Rails (use semi-fluid lubricant)
Replace air valve tubing when occlusion in tubing is observed	Use recommended washout procedure (at end of analysis operations)	Clean sample probe shaft	Replace pump platens	Replace colorimeter lamp (or after 2500 hours of use)

TABLE 8.11-14
Instrument Maintenance Schedule
Sonicator [1]

Daily	As Needed
Daily when used: Inspect probe tips for inconsistencies (etching/pitting).	Replace probe tip.
	Disassemble and clean sonicator probe tips.
	Tune sonicator assembly.

TABLE 8.11-15
Instrument Maintenance Schedule
Analytical/Top Loading Balances [1]

Daily	Annually
Daily when used: Calibrate with check weights.	Internal weight train serviced. Gears and electronics serviced.

TABLE 8.11-16
Instrument Maintenance Schedule
Refrigerators/Walk-in Coolers [1]

Daily	As Needed
Temperatures checked and logged.	Refrigerant system and electronics serviced.

TABLE 8.11-17
Instrument Maintenance Schedule
Ovens[1]

Daily	As Needed
Temperatures checked and logged.	Electronics serviced.

TABLE 8.11-18
Instrument Maintenance Schedule
Specific Digital Ion Analyzer[1]

Daily	As Needed
Daily when used: Calibrate with check standards.	Electronics serviced.

TABLE 8.11-19
Instrument Maintenance Schedule
Turbidimeter[1]

Daily	As Needed
Daily when used: Calibrate with check standards.	Electronics serviced.

TABLE 8.11-20
Instrument Maintenance Schedule
Dissolved Oxygen Meter[1]

Daily	As Needed
Daily when used: Calibrate with check standards.	Electronics serviced.

TABLE 8.11-21
Instrument Maintenance Schedule
Conductance Meter[1]

Daily	As Needed
Daily when used: Calibrate with check standards.	Electronics serviced.

TABLE 8.11-22
Instrument Maintenance Schedule
Chemical Oxygen Demand (COD) Reactor

Daily	As Needed
Daily when used: Calibrate with check standards.	Electronics serviced.

TABLE 8.11-23
Instrument Maintenance Schedule
Spectrophotometer[1]

As Needed	Daily	Monthly	Annually
Dust the lamp and front of the front lens.	Check the zero %T adjustment.	Perform wavelength calibration at 530 nm.	Oil bearings.

TABLE 8.11-24
Instrument Maintenance Schedule
pH Meter[1]

As Needed	Daily
Clean electrode.	Verify electrodes are properly connected and filled.
Refill reference electrode.	Make sure electrode is stored in buffer.

TABLE 8.11-25
Instrument Maintenance Schedule
Fourier Transform Infrared Spectrometry (FTIR)[1]

Check desiccant every 3 months.
Check KBr window every 3 months.

TABLE 8.11-26
Instrument Maintenance Schedule
Radiological Analysis Equipment[1]

Instrument	Items Checked/Service	Minimum Frequency
Alpha Proportional	Check gas flow	Daily
	Clean sample tray	Weekly
	Check bubbler oil level	Monthly
Beta Proportional	Check gas flow	Daily
	Clean sample holders	Weekly
Liquid Scintillation	Clean sample changer	Weekly
	Check condensate trays	Weekly
	Check air filters	Monthly
Quad aß Proportional	Check gas flow	Daily
	Clean sample holders	Weekly
Gamma Spectroscopy	Check LN_2 level	Bi-weekly
	Replace plastic liner	Weekly
Alpha Spectroscopy	Clean sample holder	As needed
	Change vacuum pump oil	Every six months
LIPA	Clean sample changer	Weekly
	Check laser dye performance	Weekly
Benzene Synthesizer	Check gas tubes	Weekly
	Clean instrument	Monthly
Electrolytic Enrichment	Check electrical leads	Monthly
	Clean system	Monthly
Fluorometer	Clean sample holder	Weekly

TABLE 8.11-27
Instrument Maintenance Schedule
Total Organic Carbon Analyzer (OI 7000)

Daily	Weekly	Monthly	Semi-Annually
Check: Oxygen supply Persulfate supply Acid supply Carrier gas flow rate (~ 150 cc/min) IR millivolts for stability (after 30 min. warm-up)	Check liquid-flow-rate-pump-tubing conditions on autosampler Check injection port septum	Clean digestion vessel Clean condenser column Do the leak test	Change pump tubing

Footnotes to Preventive Maintenance Tables

(1) Refer to manufacturer's instructions for each instrument to perform maintenance operations.
(2) Also see Table 8.11-11 for applicable "As Needed" GC maintenance.

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Glossary

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Glossary (continued)

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Glossary (continued)

acceptance limits

Data quality limits specified for analytical method performance.

accuracy

Accuracy is the degree of agreement between a measurement and the true or expected value, or between the average of a number of measurements and the true or expected value. Systematic errors affect accuracy. For chemical properties, accuracy is expressed either as a percent recovery (R) or as a percent bias (R - 100).

aliquot, aliquant

A measured portion of a sample taken for analysis.

analytical spike

A sample created by spiking target analytes into a prepared portion of a sample just prior to analysis. (Also see matrix spike.)

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anomaly

See nonconformance.

areas needing improvement

Represent isolated instances of noncompliance or issues that are judged to have a less immediate impact on data quality. Laboratory management must correct the situation or otherwise ensure that the condition does not recur. This term replaces the previous term used "Observations."

arithmetic mean

The arithmetic mean ($\bar{x}$) is the average of a set of values. It is equal to the sum of the observed values divided by the number of observations. Also called "average".

where: $\bar{x}$ = the mean

x_i = the ith data value

n = number of data values

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

Glossary (continued)

assessment
The evaluation process used to measure the performance or effectiveness of a system and its elements. Assessment is used as an all-inclusive term to denote any of the following: performance, systems, data and compliance audits, management systems reviews, peer reviews, inspections, or spot assessments.

associate
Employee.

audit
A planned and documented investigative evaluation of an item or process to determine its adequacy and effectiveness as well as compliance with established procedures, instructions, drawings, quality management plans, and other applicable documents.

benchmarking
A step-by-step method of improving performance by identifying and studying best practices and comparing them to industry practices.

bias
A systematic (consistent) error in test results. Bias is expressed as the difference between the population mean and the true or reference value, or as estimated from sample statistics, the difference between the sample average and the reference value.

blind performance evaluation sample
A sample either submitted to the laboratory or prepared in the laboratory whereby the concentrations of parameters of concern are known by the preparer and not by the laboratory.

calibration
Establishment of a relationship between various calibration standards and the measurements of them obtained by a measurement system, or portions thereof. The levels of the calibration standard should bracket the range of levels at which actual measurements are to be made. Calibration is also the act of making a scheduled comparison of instrument performance against national standards for instruments

Glossary (continued)

which measure physical parameters such as mass, time, and temperature. This type of calibration is independent of use in specific analyses and projects.

calibration curve
The graphical relationship between the known values for a series of calibration standards and instrument responses.

calibration factor (CF)
The ratio of the instrument response of an analyte to the amount injected. CFs are used in external standard calibrations.

$$CF = \frac{Total\ Area\ of\ Peak}{Mass\ Injected}$$

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calibration standard
A standard used to quantitate the relationship between the output of a sensor and a property to be measured. Calibration standards should be traceable to standard reference materials (provided by NIST, or other recognized standards agencies) or a primary standard.

Certificate of Analysis
The standard Quanterra® format for reporting analytical results.

certified reference material
A reference material accompanied by a certificate issued by an organization certifying the contents and concentration(s) of the material. (See also standard reference material.)

chain-of-custody (COC)
A system of documentation demonstrating the physical custody and traceability of samples.

Glossary (continued)

check standard analyses
A standard (often a midpoint standard) analyzed at a frequency specified in the method or in an SOP to verify the continuing calibration of the standard curve.

client
Any individual or organization for whom items or services are furnished or work is performed in response to defined requirements and expectations.

client sample
The material or collection media submitted to the laboratory for analysis. Field QC samples are considered client samples but laboratory QC samples are not counted as client samples when counting samples for QC batches.

coefficient of variation (relative standard deviation)
A measure of precision (relative dispersion). It is equal to the standard deviation (s) divided by the mean ($\bar{x}$) and multiplied by 100 to give a percentage value.

$$CV\,(RSD) = \left(\frac{s}{\bar{x}}\right) x\,100$$

collocated samples
Independent samples collected in such a manner that they are equally representative of the variable(s) of interest at a given point in space and time. The results will indicate sampling as well as analytical variability.

comparability
Comparability is a measure of the confidence with which one data set can be compared to another. To ensure comparability, all laboratory analysts are required to use uniform procedures (i.e., SOPs) and a uniform set of units and calculations for analyzing and reporting environmental data.

Glossary (continued)

completeness

Completeness is a measure of the percentage of measurements that are judged to be valid measurements. At a minimum, the objective for completeness of data is 90% for each constituent analyzed. It is usually expressed as a percentage:

$$\%\ Completeness = \frac{V}{n} x\ 100$$

where: V = number of measurements judged valid
n = total number of measurements

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composite

A sample composed of two or more increments.

control chart

A graphical representation of analytical accuracy. Displays the arithmetic mean of a data set, the upper and lower warning limits and the upper and lower control limits.

control table

A tabular presentation of test results with respect to time or sequence of measurement, together with limits within which the results are expected to lie when the analytical process is in a state of control.

controlled document

A document for which the distribution is known. Updates of the document are sent to the original recipients, unless the copy distributed is an uncontrolled copy.

corrective action

A measure taken to rectify conditions adverse to quality and, where necessary, to preclude their recurrence.

Glossary (continued)

correlation coefficient
The correlation coefficient (r) is a determination of how closely data "fits" a straight line. It is a number between -1 and 1 that indicates the degree of linear relationship between two sets of numbers. A correlation coefficient of +1 (usually calculated to three decimal places or 1.000) means the data falls exactly on a straight line with positive slope. A correlation coefficient of -1 (or -1.000) means the data falls exactly on a straight line with negative slope.

customer
See client.

data quality objective (DQO)
Data quality objectives (DQOs) are qualitative and quantitative statements used to ensure the generation of the type, quantity, and quality of environmental data that will be appropriate for the intended application (EPA 1994). Typically, DQOs are identified during project scope and development of sampling and analysis plans. In this QA manual, however, we refer to only the analytical DQOs because laboratories generally do not have any authority over sample collection, shipment, or other field-related activities that may affect the data quality of the environmental sample before the sample is received in the laboratory. EPA has established six primary analytical DQOs for environmental studies: precision, accuracy, representativeness, completeness, comparability, and detectability.

The components of analytical variability (uncertainty) can be estimated when QA and QC samples of the right types and quantities are incorporated into measurement procedures at the analytical laboratory. Quanterra incorporates numerous QA and QC samples to obtain data for comparison with the analytical DQOs and to ensure that the measurement system is functioning properly. The QA and QC samples and their applications, described in Section 8.4 and are selected on the basis of method- or client-specific requirements. Field blanks, field duplicates, and performance evaluation (PE) samples are received from the client as unknown samples. Analytical laboratory QC samples for inorganic, organic, and radionuclide analyses may include calibration or instrument blanks, method blanks, background, duplicates, replicates, laboratory control samples (LCSs), calibration standards, matrix spikes (MSs), matrix spike duplicates (MSDs), surrogate spikes, and yield tracers.

Glossary (continued)

data validation
See validation - data.

data verification
See verification - data.

deficiency
See nonconformance.

degrees of freedom
The number of independent deviations used in calculating an estimate of the standard deviation.

double blind performance evaluation sample
A sample that contains select parameters at defined levels. The levels are unknown to the laboratory. The laboratory is also unaware that the sample is a performance evaluation sample.

duplicate sample analyses
Different aliquots of the same sample are analyzed to evaluate the precision of an analysis.

error
The difference between an observed or measured value and its true value.

field blank
A blank that is prepared and handled in the field and analyzed in the same manner as its corresponding client samples.

field matrix spike
A sample created by spiking target analytes into a sample in the field at the point of sample acquisition.

Glossary (continued)

finding
Noncompliant practices or policies which have significant adverse impact on data quality, technical defensibility, or regulatory acceptance of data. Findings require immediate attention by the laboratory management and must be resolved to comply with Quanterra®'s quality documents and laboratory-established procedures.

geometric mean
The nth root of the product of all values in a set of n values or the antilogarithm of the arithmetic mean of the logarithms of all the values of a set of n values. The geometric mean is generally used when the logarithms of a set of values are nearly normally (Gaussian) distributed, such as is the case of much population data.

initial calibration
Analysis of a series of analytical standards at different specified concentrations; used to define the linearity and dynamic range of the response of an instrument to the target compounds prior to the analysis of samples.

inspection
Examination or measurement of an item or activity to verify conformance to specific requirements.

instrument detection limit (IDL)
The smallest concentration or amount an instrument can reliably detect.

internal standard (IS)
A compound added to every standard, QC sample, client sample, or sample extract at a known concentration prior to analysis for the purpose of quantitation. For example, internal standards are used as the basis for quantitation of the target compounds by GC/MS.

linear regression
A statistical method for finding a straight line that best fits a set of two or more data points, thus providing a relationship between two or more variables.

Glossary (continued)

matrix
The component or substrate which contains the analyte(s) of interest. Examples of matrices are water, soil or sediment, and air. Matrix is not synonymous with phase (liquid or solid).

matrix effect
An interference in the measurement of analyte(s) in a sample that is caused by materials in the sample. Matrix effects may cause elevated reporting limits or may prevent the acquisition of acceptable results.

matrix spike (MS)
An aliquot of a matrix fortified (spiked) with known quantities of specific compounds and subjected to an entire analytical procedure in order to indicate the appropriateness of the method for a particular matrix. The percent recovery for the respective compound(s) is then calculated.

matrix spike duplicate (MSD)
A second aliquot of the same matrix as the matrix spike (above) that is spiked in order to determine the precision of the method.

may
Denotes permission but not a requirement.

mean
See arithmetic mean.

measurement
The process or operation of ascertaining the extent, degree, quantity, dimensions, or capability with respect to a standard.

median
The middle value of a set of data when the data set is ranked in increasing or decreasing order.

Glossary (continued)

method
An assemblage of techniques.

method blank (MB)
An analytical control consisting of all reagents, which may include internal standards and surrogate standards, that is carried through the entire analytical procedure. The method blank is used to define the level of laboratory background contamination. Examples of method blanks are a volume of deionized or distilled laboratory water for water samples, a purified solid matrix for soil/sediment samples, or a generated zero air.

method detection limit (MDL)
The minimum concentration of an analyte that, in a given matrix and with a specific method, can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero. The MDL is operationally defined as:

$$MDL = st_{(n-1,\ \alpha=0.99)}$$

where:

s = the standard deviation of a number of measurements of a blind or sample matrix containing the analyte at a concentration near the lowest standard recommended in the method and

$t_{(n-1,\ \alpha=0.99)}$ = the student's value for a one-sided t-statistic appropriate for the number of samples used to determine (s), at the 99% confidence level and n-1 degrees of freedom.

modified method
A standard or reference method which has been changed to meet project or matrix requirements.

must
Denotes a requirement is mandatory and has to be met.

Glossary (continued)

notable practices

Laboratory practices that increase effectiveness and quality and represent improvements with respect to conventional laboratory operations.

nonconformance

An unplanned deviation from an established protocol or plan. The deviation may be the result of Quanterra's® actions, then termed a deficiency. If the deviation is the result of events beyond the control of Quanterra®, it is termed an anomaly.

operational calibration

Routinely performed as part of instrument usage, such as the development of a standard calibration curve. Operational calibration is generally performed for instrument systems.

outlier

A result excluded from the statistical calculations due to being deemed "suspicious" when applying the "Grubbs Test" (or equivalent).

parameter

A constant or coefficient that describes some characteristic of a population (e.g., standard deviation, mean, regression coefficients). Also, a chemical being measured, i.e., an analyte.

percent difference

When two independent measurements of the same characteristics are available, it is possible to use the percent difference instead of the coefficient of variation to measure precision.

$$\%D = \left| \frac{X_1 - X_2}{X_1} \right| x\ 100\%$$

where: $\%D$ = percent difference
X_1 = first value
X_2 = second value

Glossary (continued)

percent recovery
A measure of accuracy determined from the comparison of a reported spike value to its true spike concentration.

$$\%R = \frac{observed\ conc. - sample\ conc.}{true\ spike\ conc.} \times 100\%$$

performance audit
See performance evaluation.

performance evaluation (PE)
A type of audit in which a known or characterized value is compared to the result obtained through the routine analysis of the sample in the laboratory to evaluate the proficiency of an analyst or laboratory.

periodic calibration
A calibration that is performed at prescribed intervals for equipment such as balances, thermometers, and balance weights. In general, they are performed on equipment that are distinct, singular purpose units, and are relatively stable in performance.

population
A generic term denoting any finite or infinite collection of individual things, objects, or events.

practical quantitation limit (PQL)
The lowest concentration a method can reliably achieve within limits of precision and accuracy and is derived from empirical, matrix-free method performance studies.

precision
Precision is an estimate of variability, that is, it is an estimate of agreement among individual measurements of the same physical or chemical property, under prescribed similar conditions. The precision of a measurement system is affected by random errors. Precision is expressed either as relative standard deviation (RSD) for replicate measurements greater than two or as relative percent

Glossary (continued)

difference (RPD) for duplicate measurements. Table 8.6-1 illustrates the formulae used to calculate units of precision (i.e., RSD and RPD).

preventive maintenance
An organized program within Quanterra® laboratories of actions (such as equipment cleaning, lubricating, reconditioning, adjustment and/or testing) taken to maintain proper instrument and equipment performance and to prevent instruments and equipment from failing during use.

primary standard
A material having a known, stable property that can be accurately measured or derived from established physical or chemical constants. It is readily reproducible and can be accepted (within stated limits) and used to establish the same value of another substance or item.

procedure
Detailed instructions to permit replication of a method. (See standard operating procedure.)

proficiency testing
A series of planned tests which will determine the ability of field technicians or laboratory analysts to perform routine analyses. The results from this testing may be used for comparison against established criteria or for relative comparisons among the data from a group of technicians or analysts.

project-specific reporting limit (PSRL)
See reporting limit.

protocol
Methodology specified in regulatory, authoritative, or contractual situations.

QC batch
The QC batch consists of a set of up to 20 field samples that behave similarly (i.e., same matrix) and are processed using the same procedures, reagents, and standards within the same time period.

Glossary (continued)

QC check sample
A reference matrix containing known concentrations of parameters of interest. If prepared in the laboratory, it is made using stock standard solutions independent of those used for calibration. If the results of these parameters do not meet acceptance criteria, corrective actions are taken.

qualification (personnel)
The characteristics of abilities gained through education, training, or experience, as measured against established requirements, such as standards or tests, that qualify an individual to perform a required function.

quality
The sum of features and properties/characteristics of a process, item, or service that bears on its ability to meet the stated needs of the user. Quanterra® has defined quality as meeting the needs of our clients, both internal and external.

quality assurance (QA)
An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the customer.

Quality Assurance Management Plan (QAMP)
The Quality Assurance Management Plan for Environmental Analyses (QAMP) is a formal document that describes quality systems in terms of organizational structure, functional responsibilities of management, and staff, and lines of authority. The QAMP documents the QMS and describes both the organizational and project-specific principles, goals, controls, and tools of the QMS. The QAMP provides the criteria and specifications for the generation of environmental analytical data.

Quality Assurance Project or Program Plan (QAPP)
A formal document describing in comprehensive detail the necessary QA, QC, and other technical activities that must be implemented to ensure the results of the work performed will satisfy the stated performance criteria.

Glossary (continued)

quality control (QC)
The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that it meets the stated requirements established by the client or by Quanterra®.

quality improvement
The process of improving the quality of operations. This process encourages worker recommendations for improvement of work processes and requires timely management evaluation and feedback or implementation.

quality management
That aspect of the overall management system of the organization that determines and implements the quality policy. Quality management includes strategic planning, allocation of resources, and other systematic activities (e.g., planning, implementation, and assessment) pertaining to the quality management system.

quality management system (QMS)
A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, and implementation plan of an organization for ensuring quality in its work processes, products, and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required QA and QC.

random error
Variations of repeated measurements that are random in nature and individually not predictable.

range
The difference between the largest and smallest numbers in a set of numbers.

Glossary (continued)

raw data
All documentation associated with the original recording of analytical results pertinent to a specific sample or set of samples. This may include laboratory worksheets, calculation forms, instrument-generated output, analyst notes, etc., from sample receipt through final reporting.

reagent water
Water in which an interferant is not observed at or above the minimum quantitation limit of the parameters of interest. The reagent water's purity and acceptability is verified by analysis with each set of samples.

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recovery
See percent recovery.

reference method
A method of known and demonstrated accuracy.

regression coefficients
The quantities describing the slope and intercept of a regression line.

relative error
An error expressed as a percentage of the true value or accepted reference value.

relative percent different (RPD)
Statistic for evaluating the precision of a replicate set. For replicate results x_1 and x_2 :

$$RPD = \left[\frac{|X_1 - X_2|}{\left(\frac{X_1 + X_2}{2} \right)} \right] x\ 100$$

where: X_1 = first observed concentration
X_2 = second observed concentration

Glossary (continued)

relative response factor (RRF)
A measure of the relative mass spectral response of a compound compared to its internal standard. RRFs are determined by analysis of standards and are used in the calculation of concentrations of analytes in samples. Because a RRF is the comparison of two responses, it is a unitless number. RRFs are determined by the following equation:

$$RRF = \frac{A_x}{A_{IS}} x \frac{C_{IS}}{C_x}$$

where: A = area of the characteristic ion measured
C = concentration
IS = internal standard
x = analyte of interest

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relative standard deviation (RSD)
See coefficient of variation.

reporting limit (RL)
One of two types of reporting limit conventions within Quanterra®. The Reporting Limit (RL) is a uniform, Quanterra® -wide reporting limit based on an evaluation of the PQLs at Quanterra® laboratories and the expected method performance in routine water and soil matrices. Project Specific Reporting Limits (PSRLs) are reporting limits that are defined by project requirements.

representative sample
A sample taken to represent a lot or population as accurately and precisely as possible.

representativeness
Representativeness is the degree to which data accurately and precisely represent a characteristic of a population, a variation in a physical or chemical property at a sampling point, or an environmental condition. Data representativeness is primarily a function of sampling strategy; therefore, the sampling scheme must be designed to maximize representativeness. Representativeness also relates to ensuring that, through sample homogeneity, the sample analysis result (concentration) is

Glossary (continued)

representative of the constituent concentration in the sample matrix. At each Quanterra laboratory, every effort must be made to analyze an aliquot that is representative of the original sample, and to ensure the homogeneity of the sample before subsampling.

reproducibility
The precision, usually expressed as a standard deviation, measuring the variability among results of measurements of the same sample at different laboratories.

response factor (RF)
A factor derived from the calibration of a compound that is used in the quantitation calculation of sample analytes. A response factor may be derived from an external standard calibration (then called a Calibration Factor) or from an internal standard calibration (then called a Relative Response Factor).

secondary standard
A material having a property that is calibrated against a primary standard.

self assessment
Assessments of work conducted by individuals, groups, or organizations directly responsible for overseeing or performing the work.

shall
Denotes a requirement that is mandatory and has to be met.

should
Denotes a guideline or recommendation.

standard addition
The procedure of adding known increments of the analyte of interest to a sample to cause increases in detection response to subsequently establish, by extrapolation of the plotted responses, the level of the analyte of interest present in the original sample.

Glossary (continued)

standard deviation

A measure of the dispersion about the mean of the elements in a population. The square root of the variance of a set of values:

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

where: s = standard deviation
Σ = sum of
X = observed values
n = number of observations

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standardization

The establishment of the value of a potential standard with respect to an established or known standard.

standard method

A method of known and demonstrated precision issued by an organization generally recognized as competent to do so.

standard operating procedure (SOP)

A written document that details an operation, analysis, or action, with prescribed techniques and steps, that is officially approved as the method for performing certain routine or repetitive tasks.

standard reference material (SRM)

A material produced in quantity, of which certain properties have been certified by the National Institute of Standards and Technology (NIST), formerly NBS, or other agencies to the extent possible to satisfy its intended use.

standard verification

Standard is checked by Quanterra® versus manufacturer specification. See Section 8.5.4.3.

Glossary (continued)

statistic
A constant or coefficient that describes some characteristic of a sample. Statistics are used to estimate parameters of populations.

stock solution
A concentrated solution of analyte(s) or reagent(s) prepared and verified by prescribed procedure(s), and used for preparing working standards or standard solutions.

subsample
A portion taken from a sample. A laboratory sample may be a subsample of a gross sample; similarly, a test portion may be a subsample of a laboratory sample.

supplier
See vendor.

surrogate (surrogate standard)
Compounds, when required by a method, that are used added to every blank, sample, LCS, matrix spike, matrix spike duplicate, and standard. They are used to evaluate analytical efficiency by measuring recovery. Surrogates include brominated, fluorinated, or isotopically-labeled compounds that are not expected to be detected in environmental media.

systematic error
The condition of a consistent deviation of the results of a measurement process from the reference or known level.

systems audit or evaluation
A systematic on-site qualitative review of facilities, procedures, equipment, training, record keeping, data verification, and reporting aspects of a quality assurance system to arrive at a measure of the capability of the system. Within Quanterra®, system audits or evaluations are performed on a periodic basis under the direction of the Quanterra® Corporate Director of Quality Assurance.

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Glossary (continued)

technique
Physical or chemical principle for characterizing materials of chemical systems.

traceability of data
The entire documented chain of acquired data from the original acquisition effort through to the final tabulation, synthesis, reduction, and storage activities. The documentation will allow complete reconstruction of the data.

traceability of samples
During all environmental monitoring field efforts, acquired samples will be assigned specific and unique identification numbers. These sample numbers shall be accompanied by documentation (chain-of-custody form) which clearly identifies all parameters associated with sample acquisition. All additional sample numbering systems applied to the sample must be clearly cross-referenced to the field sample number to provide for traceability of samples from acquisition to reporting of sample results.

traceability of standards
The ability of an analytical standard material used for calibration purposes to be traced to its source. The standards used by Quanterra® must be traceable via written documentation to sources which produce or sell verified or certified standards, i.e., National Institute for Standards and Technology, or vendors preparing standards from those sources which they have certified.

validation - computer software
The process of establishing documented evidence which provides a high degree of assurance that a specific process will consistently produce a product meeting predetermined specifications and quality attributes. This process demonstrates and documents that the software performs correctly and meets all specified requirements.

validation - data
The process of a second party performing a systematic review of the raw and final data produced by a laboratory using predetermined criteria to ascertain the validity of the data with respect to the criteria (e.g., HAZWRAP data validation).

Glossary (continued)

vendor
Any individual or organization furnishing items or services or performing work according to a procurement document. This is an all-inclusive term used in place of any of the following: supplier, seller, contractor, subcontractor, or consultant.

verification - computer software
The process of checking the accuracy of manually entered or automatically (electronically) calculated information.

verification - data
The process of reviewing data to ensure that data reduction has been correctly performed and that analytical results to be reported correspond to the data acquired and processed.

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INDEX

Index

UNCONTROLLED COPY

Index (continued)

UNCONTROLLED COPY

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Index (continued)

Page/Location

Accuracy (See Precision and Accuracy Measurements)

Anomaly (See Nonconformance)

Assessment (Quality) 62, 80
- Audit (See Audit)
- Data Accuracy (See Precision and Accuracy Measurements)
- Data Completeness 41
- Data Precision (See Precision and Accuracy Measurements)
- Data Quality Objectives 40
- Management Review of the QMS 78
- Quality Reports to Management 77

Audit (Quality Assurance) 73
- Data Audit 77
- Findings 75
- Areas Needing Improvement 76
- Performance Audit 74
- Report 75
- Spot Assessment 77
- Systems Audit (Internal) 75
- Systems Audit (External) 75

Benchmarking 80

Calibration
- Contract Laboratory Program (CLP) Method Calibrations
  - Cyanide, Total ..... Table 8.5-9
  - GFAA ..... Table 8.5-9
  - ICAP ..... Table 8.5-9
  - Mercury (CVAA) ..... Table 8.5-9
  - PCDD/PCDF ..... Table 8.5-9
  - Pesticides/PCBs ..... Table 8.5-9
  - Semivolatiles ..... Table 8.5-9
  - Volatiles ..... Table 8.5-9

Index (continued)

Page/Location

Calibration (Continued)

Criteria ..... 59, Tables 8.5-7, 8.5-8, 8.5-9
Failure 62
Inorganic Method Calibrations
Acidity ..... Table 8.5-7
Alkalinity ..... Table 8.5-7
Ammonia ..... Table 8.5-7
Biochemical Oxygen Demand (BOD) ..... Table 8.5-7
Bromide ..... Table 8.5-7
Chemical Oxygen Demand (COD) ..... Table 8.5-7
Chloride ..... Table 8.5-7
Chlorine, Residual ..... Table 8.5-7
Chromium (Hexavalent) Cr^{+6} ..... Table 8.5-7
Color ..... Table 8.5-7
Conductivity ..... Table 8.5-7
Cyanide (Amenable) ..... Table 8.5-7
Cyanide (Total) ..... Table 8.5-7
Flashpoint ..... Table 8.5-7
Fluoride ..... Table 8.5-7
Hardness ..... Table 8.5-7
Iodide ..... Table 8.5-7
Iron, Phenanthroline Method ..... Table 8.5-7
Methylene Blue Active Substances (MBAS) ..... Table 8.5-7
Metals ..... Table 8.5-7
Graphite Furnace AA ..... Table 8.5-7
ICAP ..... Table 8.5-7
ICP/MS ..... Table 8.5-7
Mercury (CVAA) ..... Table 8.5-7
Nitrate ..... Table 8.5-7
Nitrite ..... Table 8.5-7
Nitrate-Nitrite ..... Table 8.5-7
Odor ..... Table 8.5-7
pH ..... Table 8.5-7
Phenolics ..... Table 8.5-7

Index (continued)

Page/Location

Calibration (Continued)

Phosphate ..... Table 8.5-7
Phosphorous (Total and Orthophosphate) ..... Table 8.5-7
Reactivity ..... Table 8.5-7
Settleable Solids ..... Table 8.5-7
Silica, Dissolved ..... Table 8.5-7
Specific Conductance ..... Table 8.5-7
Sulfate ..... Table 8.5-7
Sulfide ..... Table 8.5-7
Sulfite ..... Table 8.5-7
Temperature ..... Table 8.5-7
Total Dissolved Solids ..... Table 8.5-7
Total Kjeldahl Nitrogen (TKN) ..... Table 8.5-7
Total Organic Carbon (TOC) ..... Table 8.5-7
Total Organic Halides (TOX) ..... Table 8.5-7
Total Solids ..... Table 8.5-7
Total Suspended Solids ..... Table 8.5-7
Total Volatile Solids ..... Table 8.5-7
Turbidity ..... Table 8.5-7
Water Content ..... Table 8.5-7

Organic (Method Calibrations)

Aromatic Volatiles by GC ..... Table 8.5-8
Dioxins/Dibenzofurans by HRGC/HRMS ..... Table 8.5-8
Dioxins/Dibenzofurans by HRGC/LRMS ..... Table 8.5-8
Halogenated Volatiles by GC ..... Table 8.5-8
Herbicides by GC ..... Table 8.5-8
Nitroaromatics by HPLC ..... Table 8.5-8
Organophosphorous Pesticides by GC ..... Table 8.5-8
Polyaromatic Hydrocarbons (PAHs) by GC or HPLC ..... Table 8.5-8
Pesticides/PCBs by GC ..... Table 8.5-8
Petroleum Hydrocarbons/Oil and Grease ..... Table 8.5-8

Organic Method Calibrations (Continued)

Purgeable Halocarbons by GC ..... Table 8.5-8
Acrolein and Acrylonitrile ..... Table 8.5-8
Semivolatiles ..... Table 8.5-8

Index (continued)

Page/Location

Calibration (Continued)
Volatiles ..... Table 8.5-8
Operational 61
Periodic ..... 61, Table 8.5-6
Balance ..... Table 8.5-6
Freezer ..... Table 8.5-6
Graduated Glassware ..... Table 8.5-6
Micropipettor ..... Table 8.5-6
Oven ..... Table 8.5-6
Refrigerator ..... Table 8.5-6
Syringe ..... Table 8.5-6
Thermometer ..... Table 8.5-6
Volumetric Glassware ..... Table 8.5-6
Procedures 59
Records 24

Chain-of-Custody
Chain-of-Custody Form 52
Internal Chain-of-Custody 58
Return Chain-of-Custody 59

Chemical Storage 72

Comparability (Data) 42

Completeness (Data) 41, 62

Computer (See also Software)
Backup 27
Hardware 27
Security 27
Viruses 29

Condition Upon Receipt (See Nonconformance)

UNCONTROLLED COPY

Index (continued)

Page/Location

Control Chart ..... Table 8.6-1

Corrective Action 73

Customer Service Team 34

Data

- Assessment 62
- Collection 31, 62
- Electronic Data Transfer 68
- Qualifiers 64, 69
- Recording Procedures 63
- Reduction 64, 65
- Reporting 68
- Reports 68
- Review 64-68
- Statistical Evaluation of Data 63
- Validation 69
- Verbal Results 68
- Verification 64-68

Data Quality Objective 40

Deficiency (See Nonconformance)

Deliverables 68

Document

- Approval ..... 23, Table 5.1-1
- Control 23
- Controlled 23
- Distribution 23
- Quality ..... 10, 23, Table 5.1-1, Table 5.2-1

Index (continued)

Page/Location

Document (Continued)
Review ..... 23, Table 5.2-1
Revision ..... 23, Table 5.2-1
Confidentiality 25

Ethics 8

Facility Security 72

Gas, compressed (See Internal QC Requirements)

Holding Times (See Sample Containers, Preservatives, and Holding Times)

Instrument Maintenance (See Maintenance)

Internal QC Requirements
Air (Compressed) 71
Gases (Compressed) 71
Glassware 72
Water 70, 71

Key Result Indicators 80-81

Maintenance
Equipment 70
Facility 70
Preventative Maintenance 70
Instrument Maintenance 70
Instrument Maintenance Schedules
Balances (Analytical, Top Loading) ..... Table 8.11-15
Chemical Oxygen Demand (COD) Reactor ..... Table 8.11-22
Cold Vapor Atomic Absorption (CVAA) - Leeman PS 200 ..... Table 8.11-9
Cold Vapor Atomic Absorption (CVAA) - PE 5000 ..... Table 8.11-10
Conductance Meter ..... Table 8.11-21

UNCONTROLLED COPY

Index (continued)

Page/Location

Maintenance (continued)
Dissolved Oxygen Meter ..... Table 8.11-20
Flame Atomic Absorption (Flame AA) ..... Table 8.11-5
Fourier Transform Infrared Spectrometry (FTIR) ..... Table 8.11-25
Gas Chromatograph (GC) ..... Table 8.11-11
Graphite Furnace Atomic Absorption (GFAA) ..... Table 8.11-8
High Pressure Liquid Chromatography (HPLC) ..... Table 8.11-4
ICAP/MS ..... Table 8.11-6
ICP ..... Table 8.11-7
Ion Chromatograph (IC) ..... Table 8.11-1
LACHAT Auto Analyzer ..... Table 8.11-2
Mass Spectrometer (MS) ..... Table 8.11-12
Ovens ..... Table 8.11-17
pH Meter ..... Table 8.11-24
Radiological Analysis Equipment ..... Table 8.11-26
Refrigerator ..... Table 8.11-16
Sonicator ..... Table 8.11-14
Specific Digital Ion Analyzer ..... Table 8.11-18
Spectrophotometer ..... Table 8.11-23
Total Organic Carbon (TOC) Analyzer (OI 7000) ..... Table 8.11-27
Total Organic Halide (TOX) Analyzer ..... Table 8.11-3
TRAACS 800 Auto Analyzer ..... Table 8.11-13
Turbidimeter ..... Table 8.11-19
Walk-in Cooler ..... Table 8.11-16
Service Agreements 70
Method
Analytical ..... 39, Table 8.2-1
Modifications 40

Method Detection Limit (See Reporting Limit)

Method of Standard Additions 49

Index (continued)

Page/Location

Nonconformance 73
- Anomaly 73
- Condition Upon Receipt Report (CUR) ..... 55, Figure 8.5-2
- Corrective Action 73
- Deficiency 73
- Nonconformance Log 73
- Nonconformance Memo 73
- Responsibilities 73

Organization
- Chart (Also see Section 1 of the Facility-Specific Appendix C and Appendix A) ..... Figure 1.3-1
- Structure 2

Orientation (See Training)

Performance Evaluation Samples (Also See Section 6 of the Facility-Specific Appendix C) 74

Practical Quantitation Limit (See Reporting Limit)

Precision and Accuracy Measurements
- Accuracy ..... 41, Table 8.6-1
- Arithmetic Mean ..... Table 8.6-1
- Laboratory QC Measurements ..... Table 8.4-3
- Lower Control Limit (LCL) ..... Table 8.6-1
- Lower Warning Limit (LWL) ..... Table 8.6-1
- Matrix QC Measurements ..... Table 8.4-4
- Precision ..... 41, Table 8.6-1
- Standard Deviation ..... Table 8.6-1
- Upper Warning Limit (UWL) ..... Table 8.6-1
- Upper Control Limit (UCL) ..... Table 8.6-1

Preservatives (See Sample Containers, Preservatives, and Holding Times)

Preventive Maintenance (See Maintenance)

UNCONTROLLED COPY

Index (continued)

Page/Location

Procedures (Standardization of) 79

Procurement (Also see Vendor) 17
- Procedures 19
- Reference Materials (See Standards)
- Role of Quanterra® Purchasing 19
- Selection of Vendors 17
- Subcontract Laboratory Service 21

Project Planning 31

Project-Specific Reporting Limit (See Reporting Limit)

Qualification, Associate (See Training)

Quality Assurance 9

Quality Assurance Management Plan (QAMP) 10

Quality Assurance Program or Project Plan (QAPP) 11

Quality Assurance Summary (QAS) 12

Quality Control Samples 44
- Contract Laboratory Program (CLP) QC Samples
  - Cyanide, Total ..... Table 8.4-7
  - GFAA ..... Table 8.4-7
  - ICAP ..... Table 8.4-7
  - Mercury (CVAA) ..... Table 8.4-7
  - PCDD/PCDF ..... Table 8.4-7
  - Pesticides/PCBs ..... Table 8.4-7
  - Semivolatiles by GC/MS ..... Table 8.4-7
  - Volatiles by GC/MS ..... Table 8.4-7

UNCONTROLLED COPY

Index (continued)

Page/Location

Quality Control Samples (continued)

Field ..... 44, Table 8.4-1
- Collocated Sample ..... 45, Table 8.4-1
- Field Blank ..... 45, Table 8.4-1
- Field Duplicate ..... 45, Table 8.4-1
- Field Matrix Spike ..... 45, Table 8.4-1
- Rinsate Blank ..... 45, Table 8.4-1
- Split Sample ..... 46, Table 8.4-1
- Trip Blank ..... 44, Table 8.4-1

Inorganic (QC Samples)
- Acidity ..... Table 8.4-5
- Alkalinity ..... Table 8.4-5
- Ammonia ..... Table 8.4-5
- Ammonia (TKN) ..... Table 8.4-5
- Biochemical Oxygen Demand (BOD) ..... Table 8.4-5
- Bromide ..... Table 8.4-5
- Chemical Oxygen Demand (COD) ..... Table 8.4-5
- Chloride ..... Table 8.4-5
- Chlorine, Residual ..... Table 8.4-5
- Chromium (Hexavalent) Cr^{+6} ..... Table 8.4-5
- Color ..... Table 8.4-5
- Conductivity ..... Table 8.4-5
- Cyanide (Amenable) ..... Table 8.4-5
- Cyanide (Total) ..... Table 8.4-5
- Flashpoint ..... Table 8.4-5
- Fluoride ..... Table 8.4-5
- Hardness ..... Table 8.4-5
- Iodide ..... Table 8.4-5
- Iron, Phenanthroline Method ..... Table 8.4-5
- Methylene Blue Active Substances (MBAS) ..... Table 8.4-5
- Metals ..... Table 8.4-5

Index (continued)

Page/Location

Quality Control Samples (continued)

Flame AA ..... Table 8.4-5
Graphite Furnace AA ..... Table 8.4-5
ICP ..... Table 8.4-5
ICP/MS ..... Table 8.4-5
Mercury (CVAA) ..... Table 8.4-5
Nitrate ..... Table 8.4-5
Nitrite ..... Table 8.4-5
Nitrate-Nitrite ..... Table 8.4-5
Odor ..... Table 8.4-5
pH ..... Table 8.4-5
Phenolics ..... Table 8.4-5
Phosphate ..... Table 8.4-5
Phosphorous (Total and Orthophosphate) ..... Table 8.4-5
Reactivity (Cyanide and Sulfide) ..... Table 8.4-5
Silica, Dissolved ..... Table 8.4-5
Solids ..... Table 8.4-5
Specific Conductance ..... Table 8.4-5
Sulfate ..... Table 8.4-5
Sulfide ..... Table 8.4-5
Sulfite ..... Table 8.4-5
Temperature ..... Table 8.4-5
Total Organic Carbon (TOC) ..... Table 8.4-5
Total Organic Halides (TOX) ..... Table 8.4-5
Turbidity ..... Table 8.4-5
Water Content ..... Table 8.4-5
Laboratory QC Samples ..... 46, Table 8.4-2, Table 8.4-3
Analytical Spike ..... 49, Table 8.4-2
Duplicate ..... 48, Table 8.4-2, Table 8.4-4
Instrument Blank ..... 47, Table 8.4-2, Table 8.4-3
Interference Check Sample ..... 49, Table 8.4-2
Internal Standard ..... 49, Table 8.4-2
Laboratory Control Sample ..... 48, Table 8.4-2, Table 8.4-3
Laboratory Performance QC Samples ..... Table 8.4-3

Index (continued)

Page/Location

Quality Control Samples (continued)
Matrix Spike ..... 48, Table 8.4-2, Table 8.4-4
Matrix Spike Duplicate ..... 48, Table 8.4-2, Table 8.4-4
Method Blank ..... 47, Table 8.4-2, Table 8.4-3
Method of Standard Additions 52
Post Digestion Spike (See Analytical Spike)
Surrogate ..... 49, Table 8.4-2
Matrix QC Samples ..... Table 8.4-4
Organic QC Samples
Aromatic Volatiles by GC ..... Table 8.4-6
Dioxins/Dibenzofurans by HRGC/HRMS ..... Table 8.4-6
Dioxins/Dibenzofurans by HRGC/LRMS ..... Table 8.4-6
Halogenated Volatiles by GC ..... Table 8.4-6
Herbicides ..... Table 8.4-6
Nitroaromatics by HPLC ..... Table 8.4-6
Organophosphorous Pesticides ..... Table 8.4-6
Polyaromatic Hydrocarbons (PAHs) by HPLC and GC ..... Table 8.4-6
Pesticides/PCBs ..... Table 8.4-6
Petroleum Hydrocarbons ..... Table 8.4-6
Purgeable Halocarbons by GC ..... Table 8.4-6
Acrolein and Acrylonitrile ..... Table 8.4-6
Semivolatiles ..... Table 8.4-6
Volatiles by GC/MS ..... Table 8.4-6
Radiological QC Samples
(Also See Section 7 of the Facility-Specific Appendix C, where applicable) 49
Carrier 49
Tracer 49
Yield Monitors ..... 49, Table 8.4-2

Quality Document (See Document, Quality)

Quality Improvement 79

Quality Management System (QMS) 1

Index (continued)

Page/Location

Quality Organization 2

Quality Policy Document 11

Quality-Related Item (QRI) ..... 18, Table 4.2-1

Quality Report to Management 77

Radioisotope ..... 49, Table 8.5-3

Record
- Attendance (See Training, Attendance Records)
- Disposal 25
- Project 25
- Management 24
- Quality 24
- Retention 25
- Validation 25

Reference Material (See Standards)

Reference Standards (See Standards)

Reporting Limit 43
- Method Detection Limit (MDL) 42
- Minimum Detectable Amount 43
- Practical Quantitation Limit (PQL) 43
- Project-Specific Reporting Limit (PSRL) 43
- Radiochemical 43

Resume (Associate) 15

UNCONTROLLED COPY

Index (continued)

Page/Location

Sample Containers, Preservations, and Holding Times

Contract Laboratory Program (CLP)

Cyanide, Total and Amenable to Chlorination ..... Table 8.5-4
PCDD/PCDF ..... Table 8.5-4
GFAA ..... Table 8.5-4
ICAP ..... Table 8.5-4
Mercury (CVAA) ..... Table 8.5-4
Pesticides/PCBs ..... Table 8.5-4
Semivolatiles ..... Table 8.5-4
Volatiles ..... Table 8.5-4

Inorganic (Sample Containers, Preservations, and Holding Times)

Acidity ..... Table 8.5-1
Alkalinity ..... Table 8.5-1
Ammonia ..... Table 8.5-1
Biochemical Oxygen Demand (BOD) ..... Table 8.5-1
Bromide ..... Table 8.5-1
Chemical Oxygen Demand (COD) ..... Table 8.5-1
Chloride ..... Table 8.5-1
Chlorine, Residual ..... Table 8.5-1
Chromium (Hexavalent) Cr^{+6} ..... Table 8.5-1
Color ..... Table 8.5-1
Conductivity ..... Table 8.5-1
Cyanide (Amenable) ..... Table 8.5-1
Cyanide (Total) ..... Table 8.5-1
Flashpoint (Ignitability) ..... Table 8.5-1
Fluoride ..... Table 8.5-1
Hardness (Total) ..... Table 8.5-1
Iodide ..... Table 8.5-1
Iron, Phenanthroline Method ..... Table 8.5-1
Methylene Blue Active Substances (MBAS) ..... Table 8.5-1
Metals ..... Table 8.5-1
Mercury (CVAA) ..... Table 8.5-1
Nitrate ..... Table 8.5-1
Nitrite ..... Table 8.5-1

Index (continued)

Page/Location

Sample Containers, Preservations, and Holding Times (continued)

Nitrate-Nitrite ..... Table 8.5-1
Odor ..... Table 8.5-1
Orthophosphate ..... Table 8.5-1
pH ..... Table 8.5-1
Phenolics ..... Table 8.5-1
Phosphate ..... Table 8.5-1
Phosphorous (Total) ..... Table 8.5-1
Reactivity (Cyanide and Sulfide) ..... Table 8.5-1
Settleable Solids ..... Table 8.5-1
Silica, Dissolved ..... Table 8.5-1
Specific Conductance ..... Table 8.5-1
Sulfate ..... Table 8.5-1
Sulfide ..... Table 8.5-1
Sulfite ..... Table 8.5-1
Temperature ..... Table 8.5-1
Total Dissolved Solids ..... Table 8.5-1
Total Kjeldahl Nitrogen (TKN) ..... Table 8.5-1
Total Organic Carbon (TOC) ..... Table 8.5-1
Total Organic Halides (TOX) ..... Table 8.5-1
Total Solids ..... Table 8.5-1
Total Suspended Solids ..... Table 8.5-1
Total Volatile Solids ..... Table 8.5-1
Turbidity ..... Table 8.5-1
Water Content ..... Table 8.5-1

Organic

Aromatic Volatiles ..... Table 8.5-2
Dioxins/Dibenzofurans ..... Table 8.5-2
Halogenated Volatiles ..... Table 8.5-2
Herbicides ..... Table 8.5-2
Nitroaromatics ..... Table 8.5-2
Organophosphorous Pesticides ..... Table 8.5-2
Pesticides/PCBs ..... Table 8.5-2
Petroleum Hydrocarbons/Oil and Grease ..... Table 8.5-2

Index (continued)

Page/Location

Sample Containers, Preservations, and Holding Times (continued)

Polyaromatic Hydrocarbons (PAH) by GC and HPLC ..... Table 8.5-2
Purgeable Halocarbons ..... Table 8.5-2
Acrolein and Acrylonitrile ..... Table 8.5-2
Semivolatiles ..... Table 8.5-2
Volatiles ..... Table 8.5-2

Radiological

Alpha/Beta (Gross) ..... Table 8.5-3
Americium-241 ..... Table 8.5-3
Carbon-14 ..... Table 8.5-3
Calcium-45 ..... Table 8.5-3
Curium-242 ..... Table 8.5-3
Gamma Emitters ..... Table 8.5-3
Iron-55 ..... Table 8.5-3
Lead-210 ..... Table 8.5-3
Neptunium-237 ..... Table 8.5-3
Promethium-147 ..... Table 8.5-3
Plutonium-238, 239/240 ..... Table 8.5-3
Radium-226 ..... Table 8.5-3
Radium-228 ..... Table 8.5-3
Strontium-89, 90 and Total Strontium ..... Table 8.5-3
Technetium-99 ..... Table 8.5-3
Thorium-227, 228, 230, 232 ..... Table 8.5-3
Total Uranium ..... Table 8.5-3
Tritium ..... Table 8.5-3
Uranium-233/234, 235/236 ..... Table 8.5-3
Uranium-238 ..... Table 8.5-3

TCLP and SPLP

Mercury ..... Table 8.5-5
Metals (except mercury) ..... Table 8.5-5
Semivolatiles ..... Table 8.5-5
Volatiles ..... Table 8.5-5

Index (continued)

Page/Location

Samples
- Containers (Sample) 51
- Containers (Shipping) 51
- Disposal 59
- Field Collection 50
- Handling 54
- Holding Times (Also see Sample Containers, Preservatives, and Holding Times) 53
- Interlaboratory Transfers 58
- Log-In 55
- Preservatives (Also see Sample Containers, Preservatives, and Holding Times) 53
- Quality Control Samples (See Quality Control Samples)
- Radioactive 51
- Receipt 54
- Storage 55

Software (Also see Computer)
- Changes (Control of) 28
- Documentation 29
- Industry Standard Software 28
- Quanterra® -Developed Software 28
- Revalidation 28
- Security 27
- Use 27
- Validation 27
- Verification 28
- Viruses 29

Standard Operating Procedures 11, 39

Standard Reporting Limit (See Reporting Limit)

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Index (continued)

Page/Location

Standards
- Chemical Reference Standards 60
- Physical Reference Standards 60
- Reference Materials 21, 60
- Standard Verification 60

Statement of Management Position on Quality 1

Subcontractor (See Procurement)

Training
- Associate 13
- Files 15
- Health and Safety 15
- Individual Training Records 15
- Laboratory Staff 15
- Orientation 14
- QA Manager 15
- Qualification, Associate 13
- Quality 14
- Quality Orientation 14
- Records 16

Vision Statement 1

Vendor 17
- Partnerships 23
- Selection of 17

Waste Disposal 72

Water (See Internal QC Requirements)

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Appendix A

Quanterra®
Quality Assurance Management Plan

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Corporate Key Personnel List and Quanterra® Operations Organizational Chart

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Quanterra®
Corporate Key Personnel List

Associate Name	Title	Degree	Years of Experience
Gerhard F. König	President and CEO	MBA	32
Enos Tracey	Chief Financial Officer	BS, Accounting MBA, Accountancy	13
Elizabeth Chapman	Human Resources Manager	MS, Human Resources	8
Mark Matthews	Chief Operating Officer	BA, Accounting	18
Chris M. Lee	Vice President Operations Services	Business/Biology	13
Donnie Heinrich	Senior Vice President of Sales	BS, Chemistry	22
Brad S. Figley	Senior Vice President Legal and Strategy	JD in Law	16
Bill Henning	Director of Information Technology	BA, Sociology MBA, Quantitative Studies	14
Jack Hall	Corporate Director of Quality Assurance	BS, Chemistry	33
Don Dihel	Corporate Director of Environmental Health and Safety	BA, Chemistry	23
Richard Burrows	Technology/Principal Scientist	BS, Chemistry Ph.D., Analytical Chemistry	12

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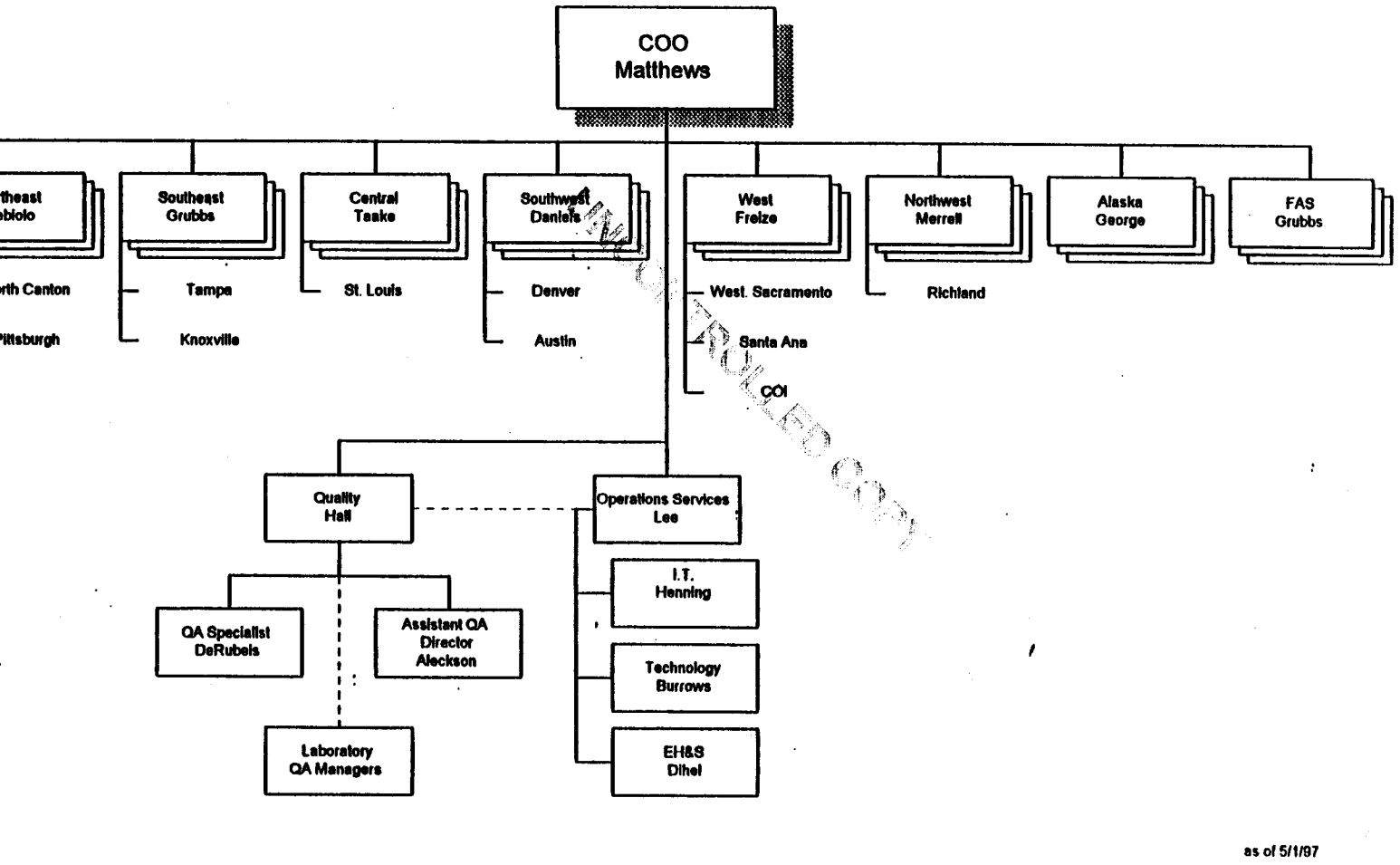
COO
Matthews
Northeast
Nebiolo
North Canton
Pittsburgh
Southeast
Grubbs
Tampa
Knoxville
Central
Taske
St. Louis
Southwest
Daniels
Denver
Austin
West
Freize
West. Sacramento
Santa Ana
COI
Northwest
Merrell
Richland
Alaska
George
FAS
Grubbs
Quality
Hall
QA Specialist
DeRubeis
Assistant QA
Director
Aleckson
Laboratory
QA Managers
Operations Services
Lee
I.T.
Henning
Technology
Burrows
EH&S
Dihel

as of 5/1/97

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APPENDIX B

Appendix B

Quanterra®
Quality Assurance Management Plan

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Addresses of Quanterra® Locations

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APPENDIX B

ADDRESSES OF Quanterra® LOCATIONS

LABORATORIES

Alaska
Quanterra®
5761 Silverado Way
Suite N
Anchorage, Alaska 99518
Voice: (907) 563-4800
Fax: (907) 563-4815

California
Quanterra®
18501 East Gale Avenue
Suite 130
City of Industry, California 91748
Voice: (818) 965-1006
Fax: (818) 965-1003

Quanterra®
1721 South Grand Avenue
Santa Ana, California 92705
Voice: (714) 258-8610
Fax: (714) 258-0921

Quanterra®
880 Riverside Parkway
West Sacramento, California 95605
Voice: (916) 373-5600
Fax: (916) 372-1059

Colorado
Quanterra®
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Arvada, Colorado 80002
Voice: (303) 421-6611
Fax: (303) 431-7171

Florida
Quanterra®
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Tampa, Florida 33610
Voice: (813) 621-0784
Fax: (813) 623-6021

Missouri
Quanterra®
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Earth City, Missouri 63045
Voice: (314) 298-8566
Fax: (314) 298-8757

Ohio
Quanterra®
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North Canton, Ohio 44720
Voice: (216) 497-9396
Fax: (216) 497-0772

Pennsylvania
Quanterra®
450 William Pitt Way, Building 6
Pittsburgh, Pennsylvania 15238
Voice: (412) 826-5477
Fax: (412) 826-5571

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LABORATORIES (Continued)

Tennessee
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Knoxville, Tennessee 37921
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Fax: (423)584-4315

Texas
Quanterra®
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Suite 160
Austin, Texas 78735
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Fax: (512) 892-6652

Washington
Quanterra®
2800 George Washington Way
Richland, Washington 99352
Voice: (509) 375-3131
Fax: (509) 375-5590

CORPORATE HEADQUARTERS

Quanterra®
One DTC
5251 DTC Parkway
Suite 415
Englewood, Colorado 80111
Voice: (303) 796-2222
Fax: (303) 796-2002

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FIELD ANALYTICAL SERVICES

California
Quanterra®
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Fax: (510) 676-0436

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Quanterra®
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Knoxville, Tennessee 37921
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Fax: (423) 693-2348

APPENDIX C

Appendix C

Quanterra®
Quality Assurance Management Plan

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Facility-Specific Appendix

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List of Laboratory Locations

This appendix contains facility-specific, quality-related information and requirements for Quanterra® laboratories. These laboratories are located in the following cities:

- Anchorage, Alaska
- Austin, Texas
- City of Industry, California
- Denver, Colorado
- Knoxville, Tennessee
- North Canton, Ohio
- Pittsburgh, Pennsylvania
- Richland, Washington
- Sacramento, California
- Santa Ana, California
- St. Louis, Missouri
- Tampa, Florida

Each laboratory section in this appendix contains information specific to that laboratory only and contains the following basic outline:

Section	Contents
0	Table of Contents
1	Organizational Chart
2	Instrument List
3	Standard Operating Procedures List
4	Analytical Methods
5	MDLs, RLs, and CRDLs
6	Performance Evaluation Studies
7	Additional Operation-Specific Information

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DENVER

Facility Appendix

Quality Assurance Management Plan
Quanterra Incorporated

Denver Laboratory

Approved by:

4/23/97

Larry Penfold
Quality Assurance Manager
Denver Laboratory

4/28/97

Thomas Daniels
Laboratory Director
Denver Laboratory

4/30/97

Jack R. Hall
Corporate Director
of Quality Assurance

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Facility Appendix

Denver Laboratory

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Section Denver-0

Table of Contents,
Denver Laboratory

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List of Sections

Section No.	Contents	Page
Section Denver-0	Table of Contents, Denver Laboratory	3
Section Denver-1	Organizational Chart	9
Section Denver-2	Instrument List	13
Section Denver-3	Standard Operating Procedures (SOP) List	23
Section Denver-4	Analytical Methods	35
Section Denver-5	MDLs and RLs	65
Section Denver-6	Performance Evaluation Studies	117
Section Denver-7	Additional Operation-Specific Information	121

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List of Figures

Figure No.	Title	Page
Denver-1-1	Organizational Chart	10
Denver-7-1	Floor Plan	122

List of Tables

Table No.	Title	Page
TABLE 1-1	Key Personnel List	12
TABLE 2-1	Instrument List	15
TABLE 3-1	Standard Operating Procedures (SOP) List	25
TABLE 4-1	Wet Chemistry Methods	37
TABLE 4-2	Graphite Furnace Atomic Absorption Methods	46
TABLE 4-3	Inorganic ICAP/Trace ICP Metals Methods	48
TABLE 4-4	Inorganic ICP/MS Metals Methods	55
TABLE 4-5	Metals Sample Preparation Methods	56
TABLE 4-6	Flame Atomic Absorption Inorganic Methods	58
TABLE 4-7	Organic Sample Preparation Methods	59
TABLE 4-8	Organic Methods	62
TABLE 5-1	Wet Chemistry Methods, Method Detection Limits (MDL) and Reporting Limits (RL)	67
TABLE 5-2	GFAA Metals Contract Required Detection Limits (CRDL), Contract Laboratory Program (CLP), Method Detection Limits (MDL) and Reporting Limits	70
TABLE 5-3	ICAP Metals Contract Required Detection Limits (CRDL), Contract Laboratory Program (CLP), Method Detection Limits (MDL) and Reporting Limits	71
TABLE 5-4	Trace ICP Metals Contract Required Detection Limits (CRDL), Method 6010A Method Detection Limits (MDL) and Reporting Limits	73
TABLE 5-5	Method 6020 ICP/MS Metals Method Detection Limits (MDL) and Reporting Limits (RL)	74
TABLE 5-6	Method 601 CWA Halogenated Volatile Organics Method Detection Limits (MDL) and Reporting Limits (RL)	75
TABLE 5-7	Method 8010A Halogenated Volatile Organics Method Detection Limits (MDL) and Reporting Limits	77
TABLE 5-8	Method 8015 (Modified) for Gasoline and Diesel Range Organics Method Detection Limits (MDL) and Reporting Limits (RL)	79
TABLE 5-9	602 CWA Aromatic Volatile Organics Method Detection Limits (MDL) and Reporting Limits (RL)	80
TABLE 5-10	Method 8020 Aromatic Volatile Organics Method Detection Limits (MDL) and Reporting Limits (RL)	81
TABLE 5-11	CLP Pesticides and PCBs Contract Required Quantitation Limits (CRQL)	82
TABLE 5-12	Method 608 CWA Pesticides and PCBs Method Detection Limits (MDL) and Reporting Limits (RL)	83

List of Tables (continued)

Table No.	Title	Page
TABLE 5-13	Method 8080 Target Compound List and Appendix IX Pesticides and PCBs Method Detection Limits (MDL) and Reporting Limits (RL)	84
TABLE 5-14	Methods 8140/8141 and Appendix IX Pesticides Method Detection Limits (MDL) and Reporting Limits (RL)	86
TABLE 5-15	Method 8150A Herbicides Method Detection Limits (MDL) and Reporting Limits (RL)	87
TABLE 5-16	Method 8330 Explosives by HPLC Method Detection Limits (MDL) and Reporting Limits (RL)	88
TABLE 5-17	Method 8310 Polynuclear Aromatic Hydrocarbons Method Detection Limits (MDL) and Reporting Limits (RL)	89
TABLE 5-18	Method 8315 Formaldehyde by HPLC Method Detection Limits (MDL) and Reporting Limits (RL)	90
TABLE 5-19	Method 524.2 Purgeable Organic Compounds in Water by GC/MS Method Detection Limits (MDL) and Reporting Limits (RL)	91
TABLE 5-20	Method 8240A Target Compound List, Appendix IX, and F039 for Volatile Organics Method Detection Limits (MDL) and Reporting Limits (RL)	94
TABLE 5-21	Method 624 CWA Volatile Organics by GC/MS Method Detection Limits (MDL) and Reporting Limits (RL)	97
TABLE 5-22	CLP Volatile Organics by GC/MS Contract Required Quantitation Limits (CRQL)	99
TABLE 5-23	Method 8260 Volatile Organics by GC/MS Method Detection Limits (MDL) and Reporting Limits (RL)	101
TABLE 5-24	CLP Semivolatile Organics by GC/MS with Contract Required Quantitation Limits (CRQL)	105
TABLE 5-25	Method 625 CWA Semivolatile Organics by GC/MS Method Detection Limits (MDL) and Reporting Limits (RL)	108
TABLE 5-26	Method 8270A Target Compound List, Appendix IX, and F039 for Semivolatile Organics by GC/MS Method Detection Limits (MDL) and Reporting Limits (RL)	111
TABLE 6-1	PE Sample Programs	119

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Facility Appendix
Denver Laboratory

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Section Denver-1

Organizational
Chart

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Quanterra Denver

TOM DANIELS
SW Regional General Manager

VERONICA SANDOVAL
Admin. Assistant

JOHN LAFERTY
Systems Manager

PROGRAM MANAGEMENT
280320

JENNIFER ALLENDER
LINDSAY BREYER
PATRICK BROWN
TONY CIACCO
SUE DAVIS
MARK DYMERSKI
DEB FAZIO (GL)
KURT ILL
ANNE LANG
ELLEN LARIVIERE
SUE McCOOL
TAMMY SMITH
MARK STELLA

PROJECT ASSISTANCE
280250

JEREMY DECHANT
MARY HELEN HAND (GL)
DEE KETTULA
JULIA POTTER
RAMONA POWER
KEVIN ZAHLLER

INFORMATION SYSTEMS
280260

GARTH ATKINS (GL)
RON ECKERT
GARY WALTERS

ADMINISTRATION
280280

SHIRLEY TEETS
JULIE MARTINEZ
BETH MILLER

QUALITY ASSURANCE
280200

LARRY PENFOLD
QA Manager

TIM MILLER
THOM SCHUMANN
BILL SULLIVAN

CUSTOMER SERVICE
280280

DIANNE JAZDZYK
SUSAN SECKMAN (PT)

FACILITIES
280200

JOHN JOHNSON
JEFF MERCER (GL)

STAN DUNLAVY
Operations Manager

JEFF CORNELL
Organics Manager

GC (VOA)
280070

DAN APPELHANS*
BLAKE BESSER
MATT GRAVES (GL)

GC (SEMI-VOA)
280080

BRET COLLINS
DIANNE LINK
DON VIEAUX
HOUA VUE

GC/MS (VOA)
280050

STEVE FRANCIS
MIKE HOFFMAN (GL)
SANDRA JONES
AL QUICK
PAUL SMITH

GC/MS (SEMI-VOA)
280060

DAN ALBRITTON
LISA BURGESSER* (PT)
TOM CLAEYS
DEB COYLE (PT)
DENEEN SPENCE (PT)

DATA REVIEW

LYNN CALVIN (PT)(GL)
AUDREY CORNELL
KRISTIN SHADOWLIGHT

ORGANIC PREP
280010

PAUL BEFORT (GL)*
JILL ELLIS
RHONDA JOHNSON (GL)
LES JOY (PT)
RICK LOWE*
ERMA POTTRUFF
MARSHALL TILBURY

QT-PCB
280081

JUSTIN CHAPPELL
DUSTIN HARDING
STEVE McKEE (GL)

LC/MS
280063

DIANNE BUCKHEISTER
PAUL WINKLER

DAVE ROBERTS
Inorganics Manager

WETCHEM
280085

MARK FOSTER
CHERYL JONES
PATTY JUNGK*
JUDY LANGE
SCOTT McPHAIL
KEN SCHROEDER (GL)

METALS
280090

ADAM ALBAN
DOUG GOMER
MATT HALL
KAYE RYMAN
ROBIN TIPTON
JAMIE WICKHAM (GL)
MARK WOOLLEY*

DATA REVIEW

RICK PERSICHITTE
LYLE RYMAN
LINDA SULLIVAN (PT)
ROXANNE SULLIVAN (PT)(GL)

GL = GROUP LEADER
PT = PART TIME
(F) = FURLOUGHED
LOA = LEAVE OF ABSENCE
* = SWING SHIFT

MARCH 26, 1997
E:\ORGCHART\DENVER.VSD

TABLE 1-1
DENVER LABORATORY
Key Personnel List

Position	Name	Degree(s), Institution(s), Year	Years Experience Environmental Lab	Years with Company
Laboratory Director	Thomas F. Daniels	BS Biology Glassboro State College, 1981	14	13
Systems Manager	John M. Laferty, III	BS Chemistry University of Colorado, 1982	16	13
Operations Manager	Stanley L. Dunlavy	BS Forest Biology Colorado State University, 1979	8	8
Inorganics Manager	David B. Roberts, Jr.	B. S. Microbiology Colorado State University, 1977	18	10
Organics Manager	Jeffrey L. Cornell	BS Chemistry Colorado State University, 1983	11	11
Quality Assurance Manager	Larry Penfold	Chemistry California State University, 1979	22	2
Client Service Manager	Susan Seckman	BS Geology Colorado State University, 1983	12	9
Client Service Manager	Dianne Jazdzyk	BS Medical Technology Grand Valley State College, 1979	10	9
Program Manager	Ellen LaRiviere	MS Environmental Health, Colorado State University, 1983 / BS Biology/Chemistry College of Sante Fe, 1980	14	4
Program Manager	Lindsay Breyer	MS Environmental Science & Engineering, Colorado School of Mines, 1993 / BA Chemistry University of Colorado, 1975	20	8
Program Manager	Patrick Brown	BS Natural Resource Management Rutgers University, 1986	6	1
Program Manager	Mark L. Dymerski	BS Biology Metro State College, 1980	15	11
Program Manager (Group Leader)	Deborah J. Fazio	AA Medical Technician State University of New York, 1971	10	9

Facility Appendix
Denver Laboratory

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Section Denver-2

Instrument
List

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TABLE 2-1
DENVER LABORATORY
Instrument List

Instrument Type	Manufacturer	Model	Age (years)	Autosampler
GC Semivolatiles	Hewlett-Packard (B) S/N 2032A01670	5880A Dual ECD	12	Yes
	Hewlett-Packard (E) S/N 1931A90378	5880A Dual ECD	12	Yes
	Hewlett-Packard (T) S/N 2417A06692	5890A Dual ECD	12	Yes
	Hewlett-Packard (V) S/N 2303A04718	5880A Dual FID	12	Yes
	Hewlett-Packard (A) S/N 2750A16891	5890A Dual FID	9	Yes
	Hewlett-Packard (R) S/N 2413A00921	5890A Dual FID	8	Yes
	Hewlett-Packard (G) S/N 2413A01572	5890A Dual ECD	8	Yes
	Hewlett-Packard (I) S/N 2728A14510	5890A Dual ECD	8	Yes
	Hewlett-Packard (K) S/N 2541A06663	5890A Dual ECD	8	Yes
	Hewlett-Packard (M) S/N 2643A09588	5890A Dual ECD	8	Yes
	Hewlett-Packard (N) S/N 6243A19457	5890A Dual ECD	8	Yes
	Hewlett-Packard (U) S/N 2643A11844	5890A Dual ECD	8	Yes
	Hewlett-Packard (U) S/N 2413A06566	5890A Dual ECD	8	Yes
	Hewlett-Packard (S) S/N 3029A29891	5890A Dual FID	8	Yes
	Hewlett-Packard (D) S/N 2728A14239	5890 Dual FPD	8	Yes
	Hewlett-Packard (XT) S/N 2843A20053	5890A Dual FID	8	Yes

TABLE 2-1
DENVER LABORATORY
Instrument List
(Continued)

Instrument Type	Manufacturer	Model	Age (years)	Autosampler
GC Semivolatiles (continued)	Hewlett-Packard (Z2) S/N 2618A08124	5890A Dual FID	8	Yes
	Hewlett-Packard (O) S/N 2518A04808	5890A Dual FID	8	Yes
	Hewlett-Packard (L) S/N 2950A27957	5890A Dual FID	7	Yes
	Hewlett-Packard (W) S/N 3126A36250	5890II Dual ECD	6	Yes
	Hewlett-Packard (W2) S/N 3121A35608	5890II Dual ECD	6	Yes
	Hewlett-Packard (Y) S/N 2921A23314	5890II Dual ECD	6	Yes
	Hewlett-Packard (Z) S/N 3121A35607	5890II Dual ECD	6	Yes
GC Volatiles	Hewlett-Packard (G) S/N 2244A01558	5790A PID/FID	10	Yes
	Hewlett-Packard (Y) S/N 2843A19484	5890A PID/ELCD	8	Yes
	Hewlett-Packard (I2) S/N 2643A11361	5890A Dual FID	8	Yes
	Hewlett-Packard (J) S/N 2607A07269	5890A Dual ELCD	8	Yes
	Hewlett-Packard (H) S/N 2750A16573	5890A PID	8	Yes
	Hewlett-Packard (K) S/N 2843A19497	5890A PID/FID	8	Yes
	Hewlett-Packard (L) S/N 2336A00164	5890A PID/FID	8	Yes
	Hewlett-Packard (P/Q) S/N 2518A05337	5890A PID	6	Yes
	Hewlett-Packard (A/B) S/N 3019A28634	5890II PID/FID	6	Yes

TABLE 2-1
DENVER LABORATORY
Instrument List
(Continued)

Instrument Type	Manufacturer	Model	Age (years)	Autosampler
GC Volatiles (continued)	Hewlett-Packard (F) S/N LR47359C	5890II Dual ELCD	6	Yes
	Varian (V) S/N 5628	3400 PID/ELCD	9	Yes
HPLC	Hewlett-Packard S/N 2304G00374	1090A	12	Yes
	Hewlett-Packard S/N 2733A01573	1090A	10	Yes
	Hewlett-Packard S/N 2304G00117	1090A	8	Yes
GC/MS Semivolatiles	Hewlett-Packard (A) S/N 3018A00334	5989	6	Yes
	Hewlett-Packard (E) S/N 3524A02942	5972	2	Yes
	Hewlett-Packard (V) S/N 3232A00843	5989	3	Yes
	Hewlett-Packard (M) S/N (not available at this time)	5973	0	Yes
	Hewlett-Packard (P) S/N (not available at this time)	5973	0	Yes
	Hewlett-Packard (C) S/N US70820571	5973	0	Yes
	Hewlett-Packard (D) S/N US70820565	5973	0	Yes
	Hewlett-Packard (B) S/N US70820566	5973	0	Yes
GC/MS Volatiles	Hewlett-Packard (W) S/N 2905A12014	5970	8	Yes
	Hewlett-Packard (L) S/N 2905A11729	5970	7	Yes
	Hewlett-Packard (N) S/N 2905A11861	5970	6	Yes

TABLE 2-1
DENVER LABORATORY
Instrument List
(Continued)

Instrument Type	Manufacturer	Model	Age (years)	Autosampler
GC/MS Volatiles (continued)	Hewlett-Packard (S) S/N 5524A03017	5972	2	Yes
	Hewlett-Packard (Z) S/N 3524A02617	5972	2	Yes
	Hewlett-Packard (H) S/N 3524A03013	5972	2	Yes
	Hewlett-Packard (J) S/N 3524A03016	5972	2	Yes
LC/MS	Finnigan S/N TS000451	TSQ 700	6	Yes
ICP	Thermo Jarrell Ash S/N 16281	9000 ICAP	14	Yes
	Thermo Jarrell Ash S/N 89090	61E ICAP	7	Yes
	Thermo Jarrell Ash S/N 200390	61E Trace	4	Yes
ICP/MS	Perkin Elmer SCIEX S/N 113920888	ELAN 5000	4	Yes
GFAA	Perkin Elmer S/N 128892	2380	18	Yes
	Perkin Elmer S/N 125214	5000	11	Yes
	Perkin Elmer S/N 128369	5000	11	Yes
	Perkin Elmer S/N 128624	5000	11	Yes
	Perkin Elmer S/N 130253	5100 PC	8	Yes
	Perkin Elmer S/N 134721	5100 PC	8	Yes
	Perkin Elmer S/N 131178	5100 PC	8	Yes

TABLE 2-1
DENVER LABORATORY
Instrument List
(Continued)

Instrument Type	Manufacturer	Model	Age (years)	Autosampler
GFAA (continued)	Perkin Elmer S/N 132350	5100 PC	8	Yes
Mercury Analyzer	Spectro Products S/N 389/4701	HG-4	13	Yes
	Spectro Products S/N 389/4711	HG-4	13	Yes
	Leeman Labs S/N 3047	PS-200	3	Yes
	Leeman Labs S/N 1054A	PS-200	3	Yes
IC	Dionex S/N 844901	APM-2	8	Yes
	Dionex S/N 874423	GPM-2	8	Yes
TOC	O.I. S/N 1091-7-276	700 (Aqueous)	10	Yes
	LECO S/N 3032	CR-12 (Solid)	8	No
	Shimadzu S/N 30724214	TOC-5000	4	Yes
TOX	Dohrman S/N HE2143	AD-2 (Aqueous)	13	No
	Mitsubishi S/N 43R30338	TOX-10R	9	No
	Mitsubishi S/N 75R01382	TOX-10E	4	No
TKN Digestion System	Tecator System 40 S/N 662	1000-3454	11	No
FTIR	Perkin Elmer S/N 137979	FTIR 1600	7	No
UV/VIS	Milton Roy S/N 3800107006	Spectronic 301	11	No

TABLE 2-1
DENVER LABORATORY
Instrument List
(Continued)

Instrument Type	Manufacturer	Model	Age (years)	Autosampler
UV/VIS (continued)	Bausch & Lomb S/N 1280242N	Spectronic 501	9	No
Wet Chemistry	Technicon (1) S/N (not available at this time)	AAII	13	Yes
	Technicon (2) S/N (not available at this time)	AAII	13	Yes
	Technicon (3) S/N 9310-104	AAII	13	Yes
	Technicon (4) S/N TC00026	TRAACS 800	9	Yes
	Lachat S/N 2000-0526	Quick Chem AE	4	Yes
Ion Analyzer	Orion Research S/N PX94A	EA940	11	No
Digital Ion Analyzer	Orion Research S/N 59861	701A	13	No
	Orion Research S/N 55197	701A	13	No
Autotitrator	Radiometer S/N 77R08N072	TTT85	10	Yes
	Radiometer S/N 77R08N035	TTT85	4	Yes
pH Meter	Corning S/N 5707	140	9	No
	Corning S/N 9578	240	9	No
Dissolved Oxygen Meter	YSI S/N F9003509	50	9	No
	YSI S/N 91C27855	50B	9	No
Turbidimeter	HACH S/N 881019614	2100A	13	No

TABLE 2-1
DENVER LABORATORY
Instrument List
(Continued)

Instrument Type	Manufacturer	Model	Age (years)	Autosampler
Conductance Meter	YSI S/N 403	32	13	No
COD	HACH S/N 881211913	16500-10	13	No
	O.I (1) S/N 0489-1141	2090-01C	13	No
	O.I. (2) S/N 0489-1144	2090-01C	13	No

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Facility Appendix
Denver Laboratory

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Section Denver-3

Standard Operating
Procedures List

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TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List

SOP No.	Rev. No.	Rev. Date	Title
CORP-GC-0001	2.0	1/31/96	Gas Chromatographic Analysis Based on Methods 8000A, 8010B, 8020A, 8080A, and 8150B, SW-846
CORP-IP-0001	0	12/9/95	Acid Digestion of Waters and Soils, CLP SOW ILMO3.0
CORP-IP-0002	0	12/9/95	Acid Digestion of Soils, SW-846 Method 3050A
CORP-IP-0003	0	12/9/95	Acid Digestion of Aqueous Samples by SW-846 and 200 Series Methods
CORP-IP-0004	0	1/12/96	Toxicity Characteristic Leaching Procedure and Synthetic Leaching Procedure
CORP-IS-0001	0	3/28/95	LIMS Change Management
CORP-IS-0004	0	2/28/95	Validation and Generation of Electronic Data Transfer Files
CORP-IS-0007	0	2/17/95	LIMS Acceptance Testing
CORP-MS-0001	1.0	1/31/96	GC/MS Analysis Based on Method 8270B, SW-846
CORP-MS-0001DEN	1.1	10/25/96	GC/MS Analysis Based on Method 8270B, SW-846 - Denver Facility-Specific SOP
CORP-MS-0002	1.0	1/31/96	Determination of Volatile Organics by GC/MS Based on Methods 8240B and 8260A
CORP-MS-0002DEN	1.2	1/4/97	Volatile Organics by GC/MS Based on Methods 8240B and 8260A - Denver Facility-Specific SOP
CORP-MT-0001	1.0	9/18/95	Inductively Coupled Plasma-Atomic Emission Spectroscopy, Spectrophotometric Method for Trace Element Analysis, Method 6010A and Method 200.7
CORP-MT-0001DEN	1.1	7/26/96	(Denver-Specific) Inductively Coupled Plasma-Atomic Emission Spectroscopy, Spectrophotometric Method for Trace Element Analysis, Method 6010A and Method 200.7
CORP-MT-0002	1.0	1/31/96	Inductively Coupled Plasma-Atomic Emission Spectroscopy, Method 200.7 CLP-M, SOW ILMO3.0
CORP-MT-0002DEN	1.1	1/28/97	(Denver-Specific) Inductively Coupled Plasma-Atomic Emission Spectroscopy, Method 200.7 CLP-M, SOW ILMO3.0
CORP-MT-0003	1.0	10/18/95	Graphite Furnace Atomic Absorption Spectroscopy, SW-846 Method 7000A and MCAWW 200 Series Methods
CORP-MT-0003DEN	1.1	1/1/00	(Denver-Specific) Graphite Furnace Atomic Absorption Spectroscopy, SW-846 Method 7000A and MCAWW 200 Series Methods
CORP-MT-0004	1.0	8/22/95	Graphite Furnace Atomic Absorption Spectroscopy, Method 2XX.X CLP-M, SOW ILMO3.0
CORP-MT-0004DEN	1.1	1/28/97	(Denver-Specific) Graphite Furnace Atomic Absorption Spectroscopy, Method 2XX.X CLP-M, SOW ILMO3.0
CORP-MT-0005	1.0	12/19/95	Preparation and Analysis of Mercury in Aqueous Samples by Cold Vapor Atomic Absorption, SW-846 7470A and MCAWW 245.1
CORP-MT-0005DEN	1.1	3/31/97	(Denver-Specific) Preparation and Analysis of Mercury in Aqueous Samples by Cold Vapor Atomic Absorption, SW-846 7470A and MCAWW 245.1
CORP-MT-0005FA	0	5/22/96	Preparation and Analysis of Mercury in Aqueous Samples by Cold Vapor Atomic Absorption, SW-846 7470A and MCAWW 245.1, Denver Facility Attachment
CORP-MT-0006	0	8/1/95	Preparation and Analysis of Mercury in Aqueous Samples by Cold Vapor Atomic Absorption, Method 245.1 CLP-M, SOW ILMO3.0

TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
CORP-MT-0006FA	0	1/29/97	Preparation and Analysis of Mercury in Aqueous Samples by Cold Vapor Atomic Absorption, Method 245.1 CLP-M, SOW ILMO3.0, Denver Facility Attachment
CORP-MT-0007	1.0	12/19/95	Preparation and Analysis of Mercury in Solid Samples by Cold Vapor Atomic Absorption, SW-846 7471A and MCAWW 245.5
CORP-MT-0007DEN	1.1	3/31/97	(Denver-Specific) Preparation and Analysis of Mercury in Solid Samples by Cold Vapor Atomic Absorption, SW-846 7471A and MCAWW 245.5
CORP-MT-0007FA	0	6/19/96	Preparation and Analysis of Mercury in Solid Samples by Cold Vapor Atomic Absorption, SW-846 7471A and MCAWW 245.5, Denver Facility Attachment
CORP-MT-0008	0	8/1/95	Preparation and Analysis of Mercury in Solid Samples by Cold Vapor Atomic Absorption, Method 245.5 CLP-M, SOW ILMO3.0
CORP-OP-0001	2.0	1/31/96	Extraction and Cleanup of Organic Compounds from Waters and Soils, Based on SW-846 3500 Series, 3600 Series, 8150 and 600 Series Methods
CORP-OP-0001DEN	2.1	11/22/96	(Denver-Specific) Extraction and Cleanup of Organic Compounds from Waters and Soils, Based on SW-846 3500 Series, 3600 Series, 8150 and 600 Series Methods
CORP-QA-0001	1.0	5/14/96	Quality Testing of Solvents, Acids, and Reagents (QRI Program)
CORP-QA-0002	0	1/27/95	QuantIMS Reference Data Creation and Maintenance
CORP-QA-0003	0	1/1/00	Valid Component Names for QuantIMS
CORP-QA-0004	0	10/27/95	Independent QA Data Review
CORP-QA-0005	1.0	9/7/95	GC/VOA Data Assessment for 95-1
CORP-QA-0006	0	10/17/95	GC/VOA Data Recalculation or Reprocessing for 95-1
CORP-QA-0007	0	12/1/95	GC/VOA Data Recalculation or Reprocessing for 95-1 Specific to Method 8015/GRO
CORP-QA-0008	0	11/21/95	GC/VOA Data Recalculation or Reprocessing for 95-1 Specific to Method 8010
CORP-QA-0009	0	11/22/95	GC/VOA Data Recalculation or Reprocessing for 95-1 Specific to Method 8020
CORP-QA-0010	0	12/11/95	Nonconformance and Corrective Action
CORP-QA-0011	0	1/1/00	GC/VOA Data Recalculation or Reprocessing for 95-1 Phase II Report--1993 Data
CORP-QA-0012	0	4/29/96	Selection and Evaluation of Subcontractor Laboratories
CORP-QA-0013	0	10/1/96	Employee Orientation and Training
CORP-WC-0001	0	1/1/00	Total Organic Halides in Water by SW-846 Method 9020B
CORP-WC-0002	1.0	1/1/00	Determination of Solids in Waters and Wastes
CORP-WC-0003	0	2/9/96	HEM/SGT-HEM Method 1664 (Formerly Oil and Grease/TPH)
CORP-WC-0004	0	1/1/97	Ignitability of Solids for Waste Characterization, EPA SW-846 Chapter 7, Section 7.1
DEN-CHP-0001	0	9/25/95	Chemical Hygiene Plan, Denver Procedure for Waste Characterization and Categorization

TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
DEN-CHP-0002	0	9/20/95	Chemical Hygiene Plan, Denver Procedure for Waste Collection, Accumulation, and Storage
DEN-CHP-0003	0	9/20/95	Chemical Hygiene Plan, Denver Procedure for Waste Shipping and Manifesting
DEN-CHP-0004	0	2/14/96	Radiation Protection Program
DEN-CHP-0005	0	3/8/96	Screening Coolers for Radioactivity Upon Receipt
DEN-GC-0001	0	5/24/95	Analysis of Organochlorine Pesticides and Polychlorinated Biphenyls by under USEPA CLP, March 1990 SOW
DEN-GC-0002	1.0	11/18/96	Diesel Range Organics
DEN-GC-0003	3.0	3/19/96	Determination of Polychlorinated Biphenyls
DEN-GC-0004	4.0	5/15/96	Determination of Polychlorinated Biphenyls for the State of Kentucky under SW-846 Method 8080 and USEPA Method 505
DEN-GC-0005	0	8/5/96	Preparation And Analysis Of Bis(2-chloroethyl)ether And 1,2-Bis(2-chloroethoxy)ethane In Aqueous And Soil Samples By SW-846 Method 8100
DEN-GC-0006	0	1/22/96	Analysis Of Water Miscible Solvents By GC/FID; Direct Aqueous Injection
DEN-GC-0007	0	1/1/00	Clean Up Procedures for the Analysis of PCBs
DEN-GC-0008	0	1/1/00	Polynuclear Aromatic Hydrocarbons by Methods 610 and 8310
DEN-GC-0010	0	1/1/00	Gas Range Organics by API Methodology
DEN-GC-0011	0	1/1/00	Formaldehyde By High Pressure Liquid Chromatography (HPLC)
DEN-HS-0001	0	3/6/96	Determination of Face Velocities of Fume Hoods
DEN-IP-0001	0	8/7/95	Preparation of Mercury Samples for United States Army Environmental Center Type Work
DEN-IP-0002	1.0	3/13/96	Metals Digestion for Soil Matrices for United States Army Environmental Center Type Work
DEN-IP-0003	1.0	3/12/96	Metals Digestion for Aqueous Matrices for United States Army Environmental Center Type Work
DEN-IP-0005	0	12/13/95	Inorganic Glassware Washing Procedure
DEN-IP-0006	0	1/31/97	Acid Digestion of Aqueous Samples by SW-846 and MCAWW 200 Series Methods
DEN-IS-0002	0	1/1/00	Software Quality Assurance
DEN-LC-0001	0	9/10/95	Aqueous and Soil Analysis of Nitroaromatics and Nitroamines by High Performance Liquid Chromatography under SW-846 Method 8330 (Modified) for United States Army Environmental Center Type Work
DEN-LC-0002	0	9/24/96	Nitroaromatics And Nitroamines By High Performance Liquid Chromatography (HPLC) Method 8330
DEN-LC-0003	0	1/1/00	Analysis of MCBT by 8321
DEN-LC-0004	0	1/1/00	Preparation of MCBT for Analysis by 8321
DEN-LC-0005	0	1/1/00	Analysis of Explosives by 8321
DEN-LC-0006	0	1/1/00	Preparation of Explosives for Analysis by 8321
DEN-MS-0001	0	5/15/96	Case File Assembly for Department of Energy Type Work
DEN-MS-0002	0	5/15/96	Analysis of Polynuclear Aromatic Hydrocarbons by Selective Ion Monitoring

TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
DEN-MS-0003	0	1/1/00	GC/MS Volatile Organics Analysis For Multi-Media, Multi-Concentration Samples For USAEC
DEN-MS-0004	0	1/1/00	GC/MS Volatile Analysis of Water by Method 624
DEN-MS-0005	0	10/11/96	Polynuclear Aromatic Hydrocarbons by SIM for City of St. Louis Park Work
DEN-MS-0006	0	1/27/97	Low Concentration Volatiles by GC/MS, CLP SOW OLCO2.0
DEN-MT-0001	0	1/6/95	Dupont/Delaware Soluble Organic Lead
DEN-MT-0002	1.0	1/30/97	Inductively Coupled Plasma-Mass Spectrometry, EPA Methods 6020 and 200.8
DEN-MT-0004	0	8/7/95	Analysis of Mercury Samples for United States Army Environmental Center Type Work
DEN-MT-0005	0	6/14/95	Inductively Coupled Plasma-Atomic Emission Spectroscopy Method 200.7 CLP-M, SOW ILM03.0 for the United States Army Environmental Center Type Work
DEN-MT-0006	1.0	3/13/96	Inductively Coupled Plasma-Mass Spectrometry, EPA Method 6020 CLP-M Version 9.0 for United States Army Environmental Center Type Work
DEN-MT-0007	1.0	1/19/96	Graphite Furnace Atomic Absorption Spectroscopy, SW-846 Method 7000A, for United Sates Army Environmental Center Type Work
DEN-MT-0008	0	1/1/00	Ignitability
DEN-OP-0004	0	12/13/95	Organic Glassware Washing Procedures
DEN-OP-0006	0	1/1/00	Organic Standard Stock Preparation
DEN-QA-0001	0	5/2/95	Thermometer Calibration Procedure
DEN-QA-0002	0	5/2/95	Analyst Certification Process for Department of Energy Specific Work
DEN-QA-0003	1.0	3/4/96	Sample Receipt and Chain-of-Custody
DEN-QA-0005	0	1/1/00	Document Archiving Procedure
DEN-QA-0006	0	6/1/95	Instrument Maintenance and Nonconformance
DEN-QA-0007	0	6/1/95	Nonconformance and Corrective Action
DEN-QA-0008	0	9/12/95	Calibration Verification of Mechanical Pipettes
DEN-QA-0009	0	1/1/00	Sonicator Tuning
DEN-QA-0010	0	5/3/96	Document Control
DEN-QA-0011	1.0	9/25/96	Calibration Procedure for Laboratory Ovens, Hotplates, and Furnaces
DEN-QA-0012	0	3/22/96	Monitoring Refrigerator Temperature
DEN-QA-0013	0	9/26/96	Holding Blanks
DEN-QA-0014	1.0	1/17/97	Balance Daily Check Procedure
DEN-QA-0015	1.0	3/21/96	Verification and Storage of Calibration Standards
DEN-QA-0016	0	9/30/96	Internal Trip Blanks
DEN-QA-0017	0	1/1/00	Bottle Preparation and Cooler Shipment
DEN-QA-0018	0	12/11/96	Validation and Generation of Electronic Data Deliverables
DEN-RD-0001	0	1/31/96	Screening Samples for the Presence of Radioactive Materials
DEN-RD-0002	0	8/7/96	Analysis of Gross Alpha and Beta Radioactivity in Drinking Water
DEN-RD-0003	0	8/6/96	Analysis of Tritium in Drinking Water

TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
DEN-WC-0001	0	6/11/96	Soil and Waste pH
DEN-WC-0002	0	5/24/96	Total Recoverable Phenolics - City of St. Louis Park (Manual)
DEN-WC-0003	1.0	7/24/96	Cyanide Analysis
DEN-WC-0004	0	1/1/00	Ammonia as Elemental Nitrogen (LACHAT Quikchem Autoanalyzer)
DEN-WC-0005	0	1/1/00	Total Recoverable Petroleum Hydrocarbons for the State of Arizona
DEN-WC-0006	0	11/21/95	Carbon in Water (TOC, TIC, DOC, TC)
DEN-WC-0007	0	10/25/96	Nitrate + Nitrite (LACHAT Autoanalyzer)
DEN-WC-0008	0	7/25/95	Analysis of Oil and Grease and Total Petroleum Hydrocarbons in the Aqueous Phase using MCAWW Methods 413.2 and 418.1 for United States Army Environment Center Type Work
DEN-WC-0009	0	7/25/95	Analysis of Oil and Grease and Total Petroleum Hydrocarbons in Soil and Waste Matrices using MCAWW 413.2 and 418.1 for United States Army Environmental Center Type Work
DEN-WC-0010	0	7/25/95	Analysis of Nitrate + Nitrite (Technicon Autoanalyzer) for United States Army Environmental Center Type Work
DEN-WC-0011	0	4/15/95	Analysis of Cyanide (Automated Colorimetric) for the United States Army Environmental Center Type Work
DEN-WC-0012	0	7/27/95	Preparation of Total Cyanide for the United States Army Environmental Center Type Work
DEN-WC-0013	1.0	5/24/96	Total Recoverable Phenolics
DEN-WC-0014	0	11/15/95	Total Suspended Solids
DEN-WC-0015	0	2/1/96	Hexavalent Chromium, Alkaline Digestion
DEN-WC-0016	0	11/27/95	Total Dissolved Solids
DEN-WC-0017	0	7/16/96	Total Phosphorus By Autoanalyzer
DEN-WC-0018	0	1/1/00	Chemical Oxygen Demand
DEN-WC-0019	0	1/9/96	Biochemical Oxygen Demand
DEN-WC-0020	0	1/1/00	Determination Of Inorganic Anions By Ion Chromatography
DEN-WC-0021	1.0	2/26/96	Hexavalent Chromium By Method 7196A
DEN-WC-0022	0	1/23/96	Turbidimetric Sulfate
DEN-WC-0023	0	1/12/96	Total, Fixed And Volatile Solids; % Water (Soils/Wastes)
DEN-WC-0024	0	9/30/96	Water And Sediment In Crude And Fuel Oils By Centrifuge
DEN-WC-0025	0	8/12/96	pH, Specific Conductance, and Alkalinity (Automatic Titrator)
DEN-WC-0026	0	1/1/00	Total Kjeldahl Nitrogen (TKN)
DEN-WC-0027	0	8/15/96	Oil & Grease/Total Petroleum Hydrocarbon Liquid-Liquid Extraction/IR Analysis (Aqueous)
DEN-WC-0028	0	1/1/00	Fluoride Analysis by SIE
DEN-WC-0029	0	8/21/96	CLP Cyanide Preparation and Analysis
DEN-WC-0030	0	10/29/96	Alkalinity (Manual Titration)
DEN-WC-0031	0	10/30/96	Manual pH
DEN-WC-0032	0	10/1/96	Settleable Solids
DEN-WC-0033	0	9/30/96	Corrosivity Towards Steel (NACE)
DEN-WC-0034	0	11/15/96	Chloride Analysis (Technicon AAII)

TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
DEN-WC-0035	0	9/30/96	Acidity
DEN-WC-0036	0	2/21/97	D.I. Leach
DEN-WC-0041	0	1/1/00	Sulfide Preparation and Analysis of Sulfide (Total, Dissolved Reactive, and Non-Aqueous)
DEN-WC-0042	0	1/1/00	Sulfide Analysis by EPA Method 9030A
ET-CLM-0001	0	4/27/94	Accelerated One-Step: Continuous Liquid/Liquid Extraction for Semivolatile Organics in Water Samples
LE-RMA-0018	0	11/1/88	Use of the Nitrogen Evaporation (N-Evap)
LE-RMA-0019	0	11/1/88	Use of the Kuderna-Danish Evaporative Concentrator (K-D)
LE-RMA-1001	0	12/8/87	Technicon Start-Up Procedure
LE-RMA-1002	0	12/8/87	Technicon TRAACS 800
LE-RMA-1003	0	12/8/87	DX-20 Total Organic Halide Analyzer System
LE-RMA-1004	0	12/8/87	Ion Chromatography System
LE-RMA-2005	0	4/29/88	Tuning the Heat Systems W385 Sonicator
LE-RMA-3002	1.0	4/1/88	Use of Nitrogen Gas Pressurized Column
LE-RMA-3003	0	4/1/89	Exchanging and Filling Liquid Nitrogen Dewars
LE-RMA-3004	0	4/1/89	Removing and Cleaning Sparge Cell
LE-RMA-4012	1.0	7/19/91	Gas Cylinders
LM-RMA-1006	0	4/5/88	Chemical Oxygen Demand: EPA Method 410.4
LM-RMA-1013	2.0	5/1/91	Color
LM-RMA-1022	0	4/27/88	Fluoride Analysis
LM-RMA-1024	2.0	3/5/90	Ion Balance Calculation
LM-RMA-1025	3.0	1/25/93	Anion Analysis by Ion Chromatography
LM-RMA-1025B	1.0	1/21/94	Anion Analysis by Ion Chromatography For USAEC
LM-RMA-1036	1.02	2/26/90	Ignitability: (Pensky-Martens Closed Cup)
LM-RMA-1041	2.0	5/16/91	Nitrate as N
LM-RMA-1042	1.0	9/11/89	Total Kjeldahl Nitrogen (TKN)
LM-RMA-1044	4.1	7/11/91	Oil & Grease; Total Petroleum Hydrocarbons: Sonication Prep/IR Analysis: (Soil, Wastes)
LM-RMA-1044A	4.0	8/28/91	Oil & Grease: Sonication Extraction/Gravimetric Analysis: (Soils, Wastes)
LM-RMA-1045	3.0	7/15/91	Oil & Grease/Total Petroleum Hydrocarbon: Liquid-Liquid Extraction/IR Analysis: (Aqueous)
LM-RMA-1045A	3.0	7/30/91	Oil & Grease: Liquid-Liquid Extraction/Gravimetric Analysis: (Aqueous)
LM-RMA-1049	3.0	10/27/93	Phosphorus, All Forms
LM-RMA-1059	2.0	1/16/89	Sulfite
LM-RMA-1069	1.0	3/17/89	Total Organic Halides (TOX): Dohrmann Analyzer
LM-RMA-1070	2.0	8/4/93	Turbidity
LM-RMA-1071B	1.0	1/21/94	Appendix I pH, Specific Conductance, and Alkalinity for USAEC
LM-RMA-1076	0	8/15/88	TKN TRAACS
LM-RMA-1079	0	5/2/88	Ammonia Nitrate + Nitrate TRAACS

TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
LM-RMA-1080	3.0	8/4/93	Sulfide: Total, Dissolved Reactive: (Analysis)
LM-RMA-1081	0	4/29/88	Fluoride Distillation
LM-RMA-1082	1.0	8/27/92	Reactive Cyanide and Sulfide: Sample Preparation
LM-RMA-1084	2.0	2/28/94	Methylene Blue Active Substances (MBAS)
LM-RMA-1086	1.0	3/24/89	Total Organic Halides (TOX): MCI Analyzer
LM-RMA-1088	0	11/1/88	Formaldehyde
LM-RMA-1089	0	11/1/88	Hardness, Calculation
LM-RMA-1090	0	11/7/88	Hardness, Titration
LM-RMA-1091	0	11/18/88	pH, Manual
LM-RMA-1092	0	3/6/89	Chlorine, Total Residual: (Starch Endpoint)
LM-RMA-1094	1.0	9/27/90	Sulfide, Total: (Prep-Nonaqueous)
LM-RMA-1095	0	11/18/88	Total Solids, Total Volatile Solids (Aqueous Matrix)
LM-RMA-1096	0	3/6/89	Total Organic Halides (TOX): Preparation
LM-RMA-1097	0	11/18/88	Volatile Suspended Solids
LM-RMA-1098	X	1/1/00	Specific Conductance (Manual Method)
LM-RMA-1101	0	5/1/89	Specific Gravity (Hydrometric)
LM-RMA-1102	0	5/15/89	Chloride (Titrimetric)
LM-RMA-1109	0	6/26/89	Potassium or Sodium Absorption Ratio (PAR/SAR)
LM-RMA-1110	1.0	4/2/90	Hydrazine (N_2H_4)
LM-RMA-1113	0	7/2/90	Oil/Water/Solids: Modified Oven Drying Technique: (MODT)
LM-RMA-1114	0	1/23/91	Nitrogen, Ammonia (Technicon AAII)
LM-RMA-1115	1.0	4/16/93	Oil & Grease/Total Petroleum Hydrocarbon: Soxhlet Extraction (Soils, Wastes)
LM-RMA-1116	1.0	6/9/92	Total Organic Carbon in Soils & Sediments
LM-RMA-1117	0	9/9/91	Paint Filter Liquids Test: (Percent Free Liquids)
LM-RMA-1118	0	9/11/91	Chevron Soluble Salts
LM-RMA-1119C	1.0	4/15/94	Anion Analysis by Ion Chromatography: For United States Geological Survey
LM-RMA-1120	0	1/18/93	Nitrate + Nitrite; Nitrate (Technicon AAII)
LM-RMA-1122	0	6/25/94	Acid Volatile Sulfide (AVS): Simultaneously Extracted Metals (SEM)
LM-RMA-2006	1.0	3/3/91	Metals: GFAA Analysis
LM-RMA-2034	1.0	10/23/89	Lead, Organic: Flame AA
LM-RMA-2038	0	2/5/90	Cation-Exchange Capacity: CEC
LM-RMA-3001C	3.0	4/24/90	GC/MS Analysis of Volatile Organics for Hagen Farms
LM-RMA-3013	3.0	1/20/93	GC/MS Analysis of Semivolatile Organics
LM-RMA-3022	1.0	9/1/89	Volatiles Screening Analysis by GC/FID
LM-RMA-3023	1.0	5/28/93	Volatiles Screening Analysis by Headspace GC/FID
LM-RMA-3030	1.0	2/5/91	Preparation of Refinery Wastes, Soils, and Solids for the Analysis of Refinery List Semivolatiles by GC/MS
LM-RMA-3038	1.0	1/3/92	Determination of Volatile Aromatics by GC/MS/SIM
LM-RMA-3040	1.0	2/21/94	Preparation of Water Samples to be Analyzed for Semivolatile Organic Compounds under CLP SOW OLMO1.1.1

TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
LM-RMA-3040B	1.0	1/20/94	Appendix I: Preparation of Water to be Analyzed for Semivolatiles for USAEC
LM-RMA-3041	0	9/27/91	Soil Sample Preparation for Semivolatile Organic Compounds to be Analyzed by GC/MS Under CLP Protocol SOW 3/90
LM-RMA-3041B	1.0	1/21/94	Appendix I Soil Sample Prep for Semi-VOA Organic Compounds for USAEC
LM-RMA-3042	0	9/30/91	GC/MS Analysis of Semivolatile Organics: CLP Methodology 3/90 SOW
LM-RMA-3042a	0	12/1/91	GC/MS Analysis of Semivolatile Organics: CLP Methodology 4/90 SOW
LM-RMA-3045	X	1/1/00	Preparation of Explosive Soils for Semivolatile Analysis by LC/MS
LM-RMA-3046	X	1/1/00	Preparation of Water Samples for Semivolatile Explosives Analysis by LC/MS
LM-RMA-3048	X	1/1/00	GC/MS Analysis of Semivolatile Organics in Water by Method 625
LM-RMA-3049	0	8/17/92	GC/MS Volatile Analysis of Water by Method 624
LM-RMA-3050	0	11/20/92	Determination of Polynuclear Aromatic Hydrocarbons (PAH) in Aerosols
LM-RMA-3051C	0	1/27/94	GC/MS Analysis of Semivolatile Organics for USAEC CLP SOW
LM-RMA-4001	5.1	7/20/93	Aromatic Volatile Organics (Purgable Aromatics): EPA Method 8020
LM-RMA-4003	4.0	2/7/94	Analysis of Organochlorine Pesticides and Poly Chlorinated Biphenyls EPA Method 8080
LM-RMA-4004	0	12/9/87	Polynuclear Aromatic Hydrocarbons (EPA Method 610/8310)
LM-RMA-4006	2.0	3/3/89	Organophosphorous Pesticides (EPA Method 614/8140)
LM-RMA-4007	3.0	12/10/91	Analysis of Environmental Samples for Chlorinated Phenoxyacid Herbicides (Modified EPA Method 615/8150)
LM-RMA-4008	1.0	1/31/89	Halogenated Volatile Organics - Purgable Halocarbons (EPA Method 601/8010)
LM-RMA-4017	4.0	7/9/91	Organochlorine Pesticide/Polychlorinated Biphenyl Screening Analysis by GC/ECD
LM-RMA-4038	5.0	2/7/94	Preparation of Organochlorine Pesticides and PCBs in Industrial Aqueous and Solid Samples
LM-RMA-4041	2.2	4/4/94	Determination of Aroclors in Tissue
LM-RMA-4044	2.0	3/21/91	Preparation of Chlorinated Phenoxyacid Herbicides in Industrial Aqueous and Solid Samples
LM-RMA-4045	2.0	2/1/91	Standard Product Organochlorine Pesticides (OCP) and Polychlorinated Biphenyl (PCB) in Soil and Vegetation
LM-RMA-4046	0	7/3/91	Preparation of Organophosphorus Pesticides in Industrial Aqueous Samples
LM-RMA-4059	0	9/30/91	CLP Preparation of Organochlorine Pesticides and Aroclors in Soil Organic SOW 3/90
LM-RMA-4059B	1.0	4/14/94	Appendix I CLP Prep of OCPs and Aroclors in Soil for USAEC
LM-RMA-4060	0	5/22/91	CLP Preparation of Organochlorine Pesticides in Water Organic SOW 3/90
LM-RMA-4060B	1.0	4/1/94	Appendix I CLP Prep of OCPs and Aroclors in Water

TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
LM-RMA-4070	0	8/17/92	Purgeable Aromatic Volatile Organics (EPA Method 602)
LM-RMA-4071	0	11/16/92	Analysis of Organochlorine Pesticides and Polychlorinated Biphenyls (EPA Method 608)
LM-RMA-4076	0	3/29/94	Sulfuric Acid Cleanup of Polychlorinated Biphenyls
LM-RMA-4077	0	5/9/94	PETN and Nitroglycerin by LC/UV/MS
LM-RMA-5015B	1.0	2/11/94	Analysis of Organochlorine Pesticides and Polychlorinated Biphenyls in Low Concentration Water Samples By CLP for USAEC
LM-RMA-5018	0	6/17/92	GC/MS Volatile Organics Analysis for Multi-Media Multi-Concentration Samples
LM-RMA-5018B	1.0	1/19/94	GC/MS Volatile Organics Analysis for Multi-Media Samples for USAEC
LM-RMA-5019B	1.0	2/9/94	Appendix I CLP Percent Solids Determination (Soil/Sediment) for USAEC
LP-RMA-0001	0	9/28/90	Building Security
LP-RMA-0008	1.0	4/8/88	Final Report Preparation - Industrial Projects
LP-RMA-0010	0	11/1/88	Automatic Pipette Washer
LP-RMA-0011	1.0	12/9/87	Ammonium Persulfate/H_2SO_4 Acid Bath
LP-RMA-0039	0	5/22/89	Quarantine Soils Procedures
LP-RMA-0044	1.0	5/27/93	Laboratory Data review/Industrial Inorganics Preview Report Package
LP-RMA-0051	0	1/1/91	Industrial Raw Data Packages
LP-RMA-0065	0	2/15/90	GC/MS Static Data Validation SOP
LP-RMA-0067	0	7/2/90	Laboratory Data Review Industrial Inorganics Level 2 Metals
LP-RMA-0068	0	7/2/90	Laboratory Data Review - Industrial Inorganics Level 2 Wet Chemistry
LP-RMA-0071	1.0	4/27/93	Sample Archival
LP-RMA-0080	0	8/26/91	Mobile Laboratory Sample Disposition of PCB Samples Analyzed for Texas Eastern
LP-RMA-0081	0	10/1/91	Linear and Quadratic Calibration Curves
LP-RMA-2000	0	7/1/93	ICP-MS Operation and Maintenance
LP-RMA-2001	0	3/4/94	Operation and Maintenance of TJA 61E Trace ICP
LP-RMA-5001	1.0	5/25/92	CLP Sample Receipt and Logging
LP-RMA-5010	1.0	11/15/90	Laboratory Documentation Practices and Form Generation
LP-RMA-5011	1.0	5/28/93	Organics Laboratory Data Review
TEN-GC-0003	0	6/19/96	Polychlorinated Biphenyls Based on SW-846 Method 8080 For Gas Pipeline Projects
TEX-GC-0007	0	3/19/96	Determination of Polychlorinated Biphenyls in Tissue Based on SW-846 For Pipeline Projects
U33.3	6	8/18/93	Method for Determination of Gasoline Range Organics

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Facility Appendix
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Section Denver-4

Analytical
Methods

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TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Acidity	Water	Method 305.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 305.1 (M)	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 305.1 (M)	Not Applicable	Not Applicable	Not Applicable
Alkalinity	Water	Method 310.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Not Applicable	Not Applicable	Not Applicable
	Soil	310.1 (M)	Not Applicable	Not Applicable	Not Applicable
Biochemical Oxygen Demand	Water	Method 405.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Bromide	Water	Method 300.0	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 300.0 (M)	Not Applicable	Not Applicable	ASTM D240
	Soil	Method 300.0 (M)	Not Applicable	Not Applicable	Not Applicable
Chemical Oxygen Demand	Water	Method 410.4	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 410.4	Not Applicable	Not Applicable	Not Applicable

TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Chloride	Water	Method 300.0 Method 325.1 Method 325.2	Method 9251 Method 9252A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 300.0 (M)	Method 9252	Not Applicable	Not Applicable
	Soil	Method 300.0 (M)	Method 9251 (M) Method 9252A	Not Applicable	Not Applicable
Chlorine (Residual)	Water	Method 330.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 330.1 (M)	Not Applicable	Not Applicable	Not Applicable
Chromium, Hexavalent	Water	Method 3500-Cr-D	Method 7196A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 3500-Cr-D (M)	Method 3060A/7196A	Not Applicable	Not Applicable
	Soil	Method 3500-CR-D (M)	Method 3060A/7196A	Not Applicable	Not Applicable
Specific Conductance	Water	Method 120.1	Method 9050	Method 120.1	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 120.1	Method 9050	Not Applicable	Not Applicable
	Soil	Method 120.1 (M)	Method 9050	Method 9050	Not Applicable

TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Cyanide (Amenable)	Water	Method 335.1	Method 9012	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Not Applicable	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 9012	Not Applicable	Not Applicable
Cyanide (Reactive)	Water	Not Applicable	Section 7.3	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Section 7.3	Not Applicable	Not Applicable
	Soil	Not Applicable	Section 7.3	Not Applicable	Not Applicable
Cyanide (Total)	Water	Method 4500 C & E	Method 9012	Method 335.2 CLP - (M)	Not Applicable
	TCLP Leachate	Not Applicable	Method 9012	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Method 9010A Method 9012	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 9010A Method 9012	Method 335.2 CLP-(M)	Not Applicable
Cyanide (Weak and Dissociable)	Water	4500 I	Not Applicable	Not Applicable	ASTM D-2036-81
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Not Applicable	Not Applicable	ASTM D-2036-81 (M)
	Soil	Not Applicable	Not Applicable	Not Applicable	ASTM D-2036-81
Fluoride	Water	Method 300.0 Method 340.2	Not Applicable	Not Applicable	Not Applicable

TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Fluoride (continued)	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 340.2 (M) Method 300.0 (M)	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 340.2 (M) Method 300.0 (M)	Not Applicable	Not Applicable	Not Applicable
Ignitability	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Method 1010	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 1010	Not Applicable	Not Applicable
Hardness	Water	Method 130.2	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Moisture	Soil	Not Applicable	ASTM D2216	ASTM D2216	Not Applicable
Nitrogen, Ammonia	Water	Method 350.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 350.1	Not Applicable	Not Applicable	Not Applicable
Nitrite (NO_2)	Water	Method 300.0 Method 354.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 300.0 (M) Method 354.1	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 354.1 (M)	Not Applicable	Not Applicable	Not Applicable

TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Nitrate (NO_3)	Water	Method 300.0 Method 353.2 Method 354.1	Not Applicable	Method 353.2	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 300.0 (M) Method 353.2	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 300.0 (M) Method 353.2 (M)	Not Applicable	Not Applicable	Not Applicable
Nitrate plus Nitrate	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 353.2 (M)	Not Applicable	Not Applicable	Not Applicable
Total Kjeldahl Nitrogen (TKN)	Water	Method 351.3	Not Applicable	Method 351.3	Not Applicable
	Domestic Waste, Industrial Waste Sludge, Solid, Sediment	Method 351.3	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 351.3	Not Applicable	Not Applicable	Not Applicable
Oil and Grease	Water	Method 413.1 Method 413.2	Not Applicable	Method 413.1	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 413.1 Method 413.2	Method 9071A	Not Applicable	Not Applicable
	Soil	Method 413.1 (M) Method 413.2 (M)	Method 9071A	Not Applicable	Not Applicable
Ortho-phosphate	Water	Method 300.0 Method 365.3	Not Applicable	Not Applicable	Not Applicable

TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Ortho-phosphate (continued)	Soil	Method 300.0 (M) Method 365.3 (M)	Not Applicable	Not Applicable	Not Applicable
pH	Water	Method 150.1	Method 9040A	Method 150.1	Not Applicable
	TCLP Leachate	Not Applicable	Method 1311	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Method 9045B	Method 9045A	Not Applicable
	Soil	Not Applicable	Method 9045B	Method CLP	Method A.2.2.1
Phenolics	Water	Method 420.1 Method 420.2	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Method 9065 Method 9066	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 9065 Method 9066	Not Applicable	Not Applicable
Phosphate	Water	Method 300.0	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 300.0 (M)	Not Applicable	Not Applicable	Not Applicable
Phosphorus (Total)	Water	Method 365.3	Not Applicable	Method 365.3	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 365.3	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 365.3	Not Applicable	Not Applicable	Not Applicable
Sulfate (SO_4)	Water	Method 300.0 Method 375.4	Method 9038	Method 375.4	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 300.0 (M) Method 375.4	Not Applicable	Not Applicable	Not Applicable

TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Sulfate (SO_4) (continued)	Soil	Method 300.0 (M)	Method 9038 (M)	Method 375.4 (M)	Not Applicable
Sulfide	Water	Method 376.2	Not Applicable	Not Applicable	Not Applicable
Sulfide (Reactive)	Water	Not Applicable	Section 7.3	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Section 7.3	Not Applicable	Not Applicable
	Soil	Not Applicable	Section 7.3 Method 9030A	Not Applicable	Not Applicable
Sulfite (SO_3)	Water	Method 377.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 377.1 (M)	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 377.1 (M)	Not Applicable	Not Applicable	Not Applicable
Total Organic Carbon (TOC)	Water	Method 415.1 Method 415.2	Method 9060	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Method 9060	Not Applicable	Not Applicable
	Soil	Method 415.1 (M)	Method 9060 (M)	Not Applicable	Not Applicable
Total Organic Halides (TOX)	Water	Not Applicable	Method 9020B	Not Applicable	Not Applicable

TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Total Organic Halides (TOX) (continued)	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Method 9020B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 9020B	Not Applicable	Not Applicable
Total Petroleum Hydro-carbons	Water	Method 418.1 Method 1664	Not Applicable	Method 418.1	Not Applicable
	TCLP Leachate	Method 418.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 418.1	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 418.1	Method 9071A	Method 418.1	Not Applicable
Total Solids	Water	Method 160.3	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 160.3	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 160.3 (M)	Not Applicable	Not Applicable	Not Applicable
Total Dissolved Solids	Water	Method 160.1	Not Applicable	Not Applicable	Not Applicable
Total Suspended Solids	Water	Method 160.2	Not Applicable	Not Applicable	Not Applicable
Volatile Solids and Volatile Suspended Solids	Water	Method 160.4	Not Applicable	Not Applicable	Not Applicable
Settleable Solids	Water	Method 160.5	Not Applicable	Not Applicable	Method 2540 F

TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Turbidity	Water	Method 180.1	Not Applicable	Not Applicable	Not Applicable

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TABLE 4-2
DENVER LABORATORY
Graphite Furnace Atomic Absorption Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Antimony	Water	Method 204.2 Method 3113B	Method 7041	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 7041	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solid, Sediment	Not Applicable	Method 7041	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7041	Method CLP	Not Applicable
Arsenic	Water	Method 206.2 Method 3113B	Method 7060A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 7060A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 7060A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7060A	Method CLP	Not Applicable
Cadmium	Water	Method 213.2 Method 3113B	Method 7131A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 7131A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 7131A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7131A	Not Applicable	Not Applicable
Chromium	Water	Method 218.2 Method 3113B	Method 7191	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 7191	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7191	Not Applicable	Not Applicable
Copper	Water	Method 220.2 Method 3113B	Method 7211	Not Applicable	Not Applicable

TABLE 4-2
DENVER LABORATORY
Graphite Furnace Atomic Absorption Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Lead	Water	Method 239.2 Method 3113B	Method 7421	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 7421	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 7421	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7421	Method CLP	Not Applicable
Selenium	Water	Method 270.2 Method 3113B	Method 7740	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 7740	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 7740	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7740	Method CLP	Not Applicable
Silver	Water	Method 272.2 Method 3113B	Method 7761	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 7761	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment, Soil	Not Applicable	Method 7761	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7761	Method CLP	Not Applicable
Thallium	Water	Method 279.2	Method 7841	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 7841	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 7841	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7841	Method CLP	Not Applicable

TABLE 4-3
DENVER LABORATORY
Inorganic ICAP/Trace ICP Metals Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Aluminum	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Antimony [1]	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Arsenic [1]	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Barium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Beryllium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable

TABLE 4-3
DENVER LABORATORY
Inorganic ICAP/Trace ICP Metals Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Beryllium (continued)	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Boron	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Calcium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Cadmium [1]	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Cobalt	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable

TABLE 4-3
DENVER LABORATORY
Inorganic ICAP/Trace ICP Metals Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Chromium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Copper	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Iron	Water	Method 200.7	Method 6010A	Method CLP	
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Lead [1]	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Lithium	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable

TABLE 4-3
DENVER LABORATORY
Inorganic ICAP/Trace ICP Metals Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Lithium (continued)	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Magnesium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Manganese	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Molybdenum	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Nickel	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable

TABLE 4-3
DENVER LABORATORY
Inorganic ICAP/Trace ICP Metals Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Phosphorous	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Potassium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Selenium [1]	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Silicon	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Silver	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable

TABLE 4-3
DENVER LABORATORY
Inorganic ICAP/Trace ICP Metals Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Sodium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Strontium	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Tin	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Thallium [1]	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Titanium	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Vanadium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable

TABLE 4-3
DENVER LABORATORY
Inorganic ICAP/Trace ICP Metals Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Vanadium (continued)	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Zinc	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable

Footnotes

[1] These metals can also be analyzed by Trace ICP.

TABLE 4-4
DENVER LABORATORY
Inorganic ICP/MS Metals Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Aluminum* Antimony* Arsenic* Barium* Beryllium* Boron Bromine Cadmium* Calcium Chromium* Cobalt* Copper* Iron Lead* Lithium Magnesium Manganese* Molybdenum* Nickel* Phosphorous Potassium Selenium* Silicon Silver* Sodium Strontium Thallium* Tin Thorium* Titanium Uranium* Vanadium* Zinc*	Water	Not Applicable	Method 6020	Not Applicable	200.8*
Arsenic Barium Cadmium Chromium Lead Selenium Silver Thallium	TCLP Leachate	Not Applicable	Method 6020	Not Applicable	Not Applicable

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TABLE 4-5
DENVER LABORATORY
Metals Sample Preparation Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Toxicity Characteristic Leaching Procedure (TCLP)	Water	Not Applicable	Method 1311	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 1311	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 1311	Not Applicable	Not Applicable
ICAP Metals	Water	Method 200.7	Method 3005A Method 3010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 3010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 3050A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3050A	Method CLP	Not Applicable
CVAA	Water	Method 245.1	Method 7470A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 7470A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 7471A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7471A	Method CLP	
Flame AA Metals	Water	Method 200.0	Method 3020A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 3050A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3050A	Not Applicable	Not Applicable

TABLE 4-5
DENVER LABORATORY
Metals Sample Preparation Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
GFAA Metals	Water	Not Applicable	Arsenic 3050A/7060 Antimony 3005A/7041 Lead 3020A Selenium 3050A/7740 Silver 7761 Thallium 3050A/7841	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 3020A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Arsenic 3050A/7060 Antimony 7041 Lead 3020A Selenium 3050A/7740 Silver 7761 Thallium 3050A/7841	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3050A	Not Applicable	Not Applicable

TABLE 4-6
DENVER LABORATORY
Flame Atomic Absorption Inorganic Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Lead	Water	Not Applicable	Method 7420	Not Applicable	Not Applicable
Organic Lead	Water	Not Applicable	Not Applicable	Not Applicable	CA LUFT Method
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Not Applicable	Not Applicable	CA LUFT Method
	Soil	Not Applicable	Not Applicable	Not Applicable	CA LUFT Method

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TABLE 4-7
DENVER LABORATORY
Organic Sample Preparation Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Volatiles by GC/MS	Water	Method 624	Method 5030A	Method CLP	Method 524.2
	TCLP Leachate	Not Applicable	Method 5030A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 5030A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 5030A	Method CLP	Not Applicable
Halogenated Volatiles by GC	Water	Method 601	Method 5030A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 5030A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 5030A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 5030A	Not Applicable	Not Applicable
Aromatic Volatiles by GC	Water	Method 602	Method 5030A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 5030A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 5030A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 5030A	Not Applicable	Not Applicable
Semivolatiles by GC/MS	Water	Method 625	Method 3510B Method 3520B	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 3550A Method 3580A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3550A	Method CLP	Not Applicable
Pesticides/ PCBs by GC	Water	Method 608	Method 3510B Method 3520B	Method CLP	Not Applicable

TABLE 4-7
DENVER LABORATORY
Organic Sample Preparation Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Pesticides/ PCBs by GC (continued)	TCLP Leachate	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 3550A Method 3580A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3550A	Method CLP	Not Applicable
Pesticides (Organophos-phorus) by GC	Water	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 3540B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3550A	Not Applicable	Not Applicable
PAHs by GC	Water	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3550A	Not Applicable	Not Applicable
PAHs by HPLC	Water	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3550A	Not Applicable	Not Applicable
Herbicides by GC	Water	Method 615	Method 8150B	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 8150B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 8150B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8150B	Not Applicable	Not Applicable
Gasoline Range Organics by GC	Water	Not Applicable	Method 5030A	Not Applicable	Not Applicable

TABLE 4-7
DENVER LABORATORY
Organic Sample Preparation Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Gasoline Range Organics by GC	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 5030A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 5030A	Not Applicable	Not Applicable
Total Petroleum Hydrocarbons (diesel range) by GC	Water	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 3550A Method 3580A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3550A	Not Applicable	Not Applicable

TABLE 4-8
DENVER LABORATORY
Organic Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Volatiles by GC/MS	Water	Method 624	Method 8240B Method 8260A	Method CLP	Method 524.2
	TCLP Leachate	Not Applicable	Method 8240B Method 8260A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 8240B Method 8260A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8240B Method 8260A	Method CLP	Not Applicable
Halogenated Volatiles by GC	Water	Method 601	Method 8010B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 8010B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8010B	Not Applicable	Not Applicable
Aromatic Volatiles by GC	Water	Method 602	Method 8020A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 8020A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 8020A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8020A	Not Applicable	Not Applicable
Semivolatiles by GC/MS	Water	Method 625	Method 8270B	Method CLP	
	TCLP Leachate	Not Applicable	Method 8270B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 8270B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8270B	Method CLP	Not Applicable

TABLE 4-8
DENVER LABORATORY
Organic Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Pesticides/ PCBs by GC	Water	Method 608	Method 8080A	Method CLP	Method 505
	TCLP Leachate	Not Applicable	Method 8080A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 8080A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8080A	Method CLP	Not Applicable
Pesticides (Organophos-phorus) by GC	Water	Not Applicable	Method 8140	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 8140	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8140	Not Applicable	Not Applicable
PAHs by GC	Water	Not Applicable	Method 8100	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8100	Not Applicable	Not Applicable
PAHs by HPLC	Water	Not Applicable	Method 8310	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediments	Not Applicable	Method 8310	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8310	Not Applicable	Not Applicable
Herbicides by GC	Water	Method 615	Method 8150B	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 8150B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 8150B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8150B	Not Applicable	Not Applicable

TABLE 4-8
DENVER LABORATORY
Organic Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Gasoline Range Organics by GC	Water	Not Applicable	Method 8015A (M)	Not Applicable	Method API
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 8015A (M)	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8015A (M)	Not Applicable	Method API
Total Petroleum Hydrocarbons (diesel range) by GC	Water	Not Applicable	Method 8015A (M)	Not Applicable	Method API
	Domestic Waste, Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 8015A (M)	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8015A (M)	Not Applicable	Method API
Explosives by HPLC	Water	Not Applicable	Method 8330	Not Applicable	Method LW-12
	Soil	Not Applicable	Method 8330	Not Applicable	Method LW-12

Facility Appendix

Denver Laboratory

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Section Denver-5

MDLs and RLs

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TABLE 5-1
DENVER LABORATORY
Wet Chemistry Methods[1], Method Detection Limits (MDL) and Reporting Limits (RL)[2]

Parameter	CAS Number	Method	Water MDL Date	Water MDL mg/L	Soil MDL Date	Soil MDL[3] mg/kg	Water RL mg/L	Soil RL[3] mg/Kg
Acidity	76-40-0	EPA 305.1	—	—	—	—	10	50
Alkalinity	477520-60-0	EPA 310.1	4/3/97	0.69	—	N/A	5	25
Biochemical Oxygen Demand	1-00-2	EPA 405.1	1/9/97	0.20	N/A	N/A	2.0	N/A
Bromide	28-20-0	EPA 300.0	6/19/96	0.02	—	—	1.0	1.0
Chemical Oxygen Demand (COD)	1-00-4	410.4 (Hach)	9/9/96	5.63	N/A	N/A	20	N/A
Chloride	1-00-3	EPA 300.0	6/19/96	0.10	—	—	3.0	15
		SW846 9056	6/19/96	0.10	—	—	3.0	15
		SW846 9251	—	—	—	—	3.0	15
		EPA 325.3	3/31/97	0.50	—	—	3.0	15
		SW846 9252A	3/31/97	0.50	—	—	3.0	15
Chlorine (Residual)	97286-40-0	EPA 330.1	1/2/97	0.13	—	—	0.2	—
Chromium, hexavalent	18540-29-9	3500-Cr-D	7/8/96	0.0023			0.01	
		SW846 7196A	7/8/96	0.0023	3/28/69	0.14	0.01	0.40
Conductivity, specific	1-01-1	EPA 120.1	N/A	N/A	N/A	N/A	1 µmhos/cm	1 µmhos/cm
		SW846 9050	N/A	N/A	N/A	N/A		
Cyanide	5955-70-0	4500-C&E	3/13/97	0.0010	—	—	0.01	0.50
		SW846 9012	3/13/97	0.0010	1/17/97	0.18	0.01	0.50
		Section 7.3	—	—	—	—	—	—
		SW846 9010A	3/13/97	0.0010	1/17/97	0.18	0.01	0.50
		ASTM D-2036-81	—	—	—	—	0.01	0.50
Fluoride	66-30-0	EPA 300.0	6/19/96	0.07	—	—	0.5	2.5
		SM4500	3/17/97	0.01	—	—	0.1	0.5
Formaldehyde	50-00-0	NIOSH 3500	6/18/96	0.015	—	—	0.05	1.0
Hardness	35-50-0	EPA 130.2	4/5/96	4.36	—	—	5	—
Hydrazine	302-01-2	ASTM D1385	—	—	—	—	0.05	0.25
Ignitability	1-01-3	SW846 1010	—	—	—	—	—	—
Nitrogen, Ammonia	310-90-0	EPA 350.1	10/3/96	0.017	—	—	0.1	0.5

TABLE 5-1
DENVER LABORATORY
Wet Chemistry Methods[1], Method Detection Limits (MDL) and Reporting Limits (RL)[2]
(Continued)

Parameter	CAS Number	Method	Water MDL Date	Water MDL mg/L	Soil MDL Date	Soil MDL[3] mg/kg	Water RL mg/L	Soil RL[3] mg/Kg
Nitrite as N	15-90-0	EPA 354.1	3/24/97	0.002	—	—	0.01	—
		EPA 300.0	6/19/96	0.05	—	—	0.50	2.5
Nitrate plus Nitrite	1-00-5	EPA 353.2	1/14/96	0.016	—	—	0.1	0.05
Nitrate as N	25-90-0	EPA 300.0	6/19/96	0.04	—	—	0.5	2.5
Nitrogen, Total Kjeldahl	5228003-90-0	EPA 351.2	8/16/96	0.38	—	—	0.5	50
Oil and Grease	1-00-7	EPA 413.1	3/18/97	2.52	11/21/96	65	5.0	100
		SW846 9070	3/18/97	2.52	11/21/96	65	5.0	100
		EPA 413.2	3/31/97	0.14	—	—	1.0	20
		SW846 9071A	—	—	3/19/96	77.9	1.0	200
		EPA 1664 (HEM)	12/14/95	1.07	—	—	5.0	—
Orthophosphate	226750-80-0	EPA 365.3	3/7/97	0.005	—	—	0.05	0.25
		EPA 300.0	6/19/96	0.06	—	—	0.50	2.5
Phosphorus, total	6791520-80-0	EPA 365.3	3/7/97	0.005	—	—	0.05	5
Phenolics, total recoverable	54-30-0	EPA 420.1	4/2/97	0.0028	—	—	0.005	—
		EPA 420.2	1/7/97	0.018	—	—	0.02	—
		SW846 9065	4/2/97	0.0028	—	—	0.005	1.0
		SW846 9066	1/7/97	0.018	—	—	0.02	2.0
Sulfate	3-03-5	EPA 300.0	6/19/96	0.10	—	—	5	25
		EPA 375.4	1/3/97	1.61	—	—	5	—
		SW846 9038	1/3/97	1.61	—	—	5	—
Sulfide	1055-70-0	EPA 376.2 SW846 Section 7.3	10/1/96	0.017	—	—	0.05	—
Sulfite	18-20-0	EPA 377.1	6/12/96	0.84	—	—	2	20
Total Organic Carbon (TOC)	1-01-2	EPA 415.1	11/13/96	0.18	—	—	1.0	
		EPA 415.2	—	—	—	—	1.0	0.20%
		SW846 9060	11/13/96	0.18	2/14/97	549	1.0	2000
Total Organic Halides (TOX)	59473-04-0	SW846 9020B	4/2/97	0.0075	—	—	0.03	0.3

TABLE 5-1
DENVER LABORATORY
Wet Chemistry Methods[1], Method Detection Limits (MDL) and Reporting Limits (RL)[2]
(Continued)

Parameter	CAS Number	Method	Water MDL Date	Water MDL mg/L	Soil MDL Date	Soil MDL[3] mg/kg	Water RL mg/L	Soil RL[3] mg/Kg
Total Recoverable Petroleum Hydrocarbons	5289290-40-0	EPA 418.1	4/7/97	0.10	03/22/96	6.03	1.0	20
		SW846 9071A	—	—	03/22/96	6.03	—	40
		EPA 1664 (SGT-HEM)	12/14/95	1.68	—	—	5.0	—
Total Dissolved Solids	1-01-0	EPA 160.1	2/7/97	7.88	N/A	N/A	10	N/A
Total Suspended Solids	1-00-9	EPA 160.2	11/11/96	1.6	N/A	N/A	2.0	N/A
Total Solids	1-00-8	EPA 160.3	3/12/96	5.44	—	—	10	0.1%
Volatile Suspended Solids	8279840-70-0	EPA 160.4	—	—	N/A	N/A	1	N/A
Settleable Solids	3069938-50-0	Method 209E	—	—	N/A	N/A	1mL/L	N/A
Turbidity	3-01-6	EPA 180.1	3/19/96	0.04 NTU	N/A	N/A	0.1 NTU	N/A

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] Reporting Limits are generally within 1 to 10 times of the MDL.

[3] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-2
DENVER LABORATORY
GFAA Metals[1],[4] Contract Required Detection Limits (CRDL), Contract Laboratory Program (CLP), Method Detection Limits (MDL),[2] and Reporting Limits (RL)[3]

Element	CAS Number	Water CRDL (µg/L)	Soil CRDL[5] (mg/Kg)	Water MDL (µg/L)	Soil MDL[5] (mg/Kg)	Water RL (µg/L)	Soil RL[5] (mg/Kg)
Arsenic	7440-38-2	10	2	1.37	0.21	5	0.5
Lead	7439-92-1	3	0.6	1.24	0.09	5	0.5
Selenium	7782-49-2	5	1	2.66	0.25	5	0.5
Thallium	7440-28-0	10	2	0.50	0.12	5	0.5
Antimony	7440-36-0	60	12	3.40	0.36	10	1
Cadmium	7440-43-9	5	1	0.10	0.011	0.5	0.05
Chromium	7440-47-3	10	2	0.86	0.01	5	0.5
Silver	7440-22-4	10	2	0.074	0.010	0.5	0.05
Mercury[6]	7439-97-6	0.2	0.04	0.11	0.056	0.2	0.1

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit studies for As, Cd, Pb, Se, and Tl were performed 12/04/96 for waters and 11/19/96 for soils, Ag was performed 03/6/97 (water) and 04/24/96 (soil), Sb was performed 06/24/96 (water) and 01/16/97 (soil), Cr was performed 02/10/97 (water), Hg was performed 1/8/97 (water) and 01/17/97 (soil).

[3] Reporting Limits are within 1 to 10 times of the MDL.

[4] Higher detection limits may be utilized under the following circumstances: If the sample concentration exceeds five (5) times the detection limit of the instrument, the values may be reported even though the instrument detection limit may not equal the contract required detection limit.

[5] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

[6] Analyzed by Cold Vapor AA.

TABLE 5-3
DENVER LABORATORY
ICAP Metals[1],[4] Contract Required Detection Limits (CRDL) Contract Laboratory Program, Methods 6010A/200.7 Method Detection Limits (MDL),[2] and Reporting Limits (RL)[3]

Element	CAS Number	Water CRDL (µg/L)	Soil CRDL[5] (mg/Kg)	Water MDL (µg/L)	Soil MDL[5] (mg/Kg)	Water RL (µg/L)	Soil RL[5] (mg/Kg)
Aluminum	7429-90-5	200	40	20	3.7	100	10
Antimony	7440-36-0	60	12	37	1.8	60	6
Arsenic[6]	7440-38-2	10	—	78	3.1	100	10
Barium	7440-39-3	200	40	1.9	0.16	10	1
Beryllium	7440-41-7	5	1	1.3	0.04	2	0.2
Boron	7440-42-8		—	29	1.5	100	10
Cadmium[6]	7440-43-9	5	1	3.3	0.37	5	0.50
Calcium	7440-70-2	5000	1000	110	5.9	200	20
Chromium	7440-47-3	10	2	5.2	0.44	10	1
Cobalt	7440-48-4	50	10	4.2	0.81	10	1
Copper	7440-50-8	25	5	3.3	0.78	20	2
Iron	7439-89-6	100	20	35	2.6	100	10
Lead[6]	7439-92-1	3	—	32	1.6	50	5
Lithium	7439-93-2	—	—	20	0.18	50	5
Magnesium	7439-95-4	5000	1000	38	17	200	20
Manganese	7439-96-5	15	3	1.6	0.54	10	1
Molybdenum	7439-98-7	—	—	12	0.79	20	2
Nickel	7440-02-0	40	8	6.9	1.7	40	4
Phosphorus	7723-14-0	—	—	120	7.3	300	30
Potassium	7440-09-7	5000	1000	660	55	5000	500
Selenium[6]	7782-49-2	5	—	79	9.5	200	20
Silica as SiO_2	7404-20-0	—	—	140	16	500	50
Silver	7440-22-4	10	2	4.1	0.33	10	1
Sodium	7440-23-5	5000	1000	1340	74	5000	500
Strontium	7440-24-6	—	—	12	2.3	50	5
Thallium[6]	7440-28-0	10	—	650	24	2000	200
Tin	7440-31-5	—	—	51	2.2	100	10

TABLE 5-3
DENVER LABORATORY
ICAP Metals[1],[4] Contract Required Detection Limits (CRDL) Contract Laboratory Program, Methods 6010A/200.7 Method Detection Limits (MDL),[2] and Reporting Limits (RL)[3]
(Continued)

Element	CAS Number	Water CRDL (µg/L)	Soil CRDL[5] (mg/Kg)	Water MDL (µg/L)	Soil MDL[5] (mg/Kg)	Water RL (µg/L)	Soil RL[5] (mg/Kg)
Titanium	7440-32-6	—	—	6.2	0.19	15	1.5
Vanadium	7440-62-2	50	10	2.0	0.23	10	1
Zinc	7440-66-6	20	4	8.0	0.43	20	2

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 02/15/96 (water) and 12/14/95 (soil).

[3] Reporting Limits are within 1 to 10 times of the MDL.

[4] Higher detection limits may be utilized under the following circumstances: If the sample concentration exceeds five (5) times the detection limit of the instrument, the values may be reported even though the instrument detection limit may not equal the contract required detection limit.

[5] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

[6] These elements are routinely analyzed by GFAA or Trace ICP.

TABLE 5-4
DENVER LABORATORY
Trace ICP Metals[1], [3] Contract Required Detection Limits (CRDL)
Method 6010A Method Detection Limits (MDL)[2] and Reporting Limits (RL)

Element	CAS Number	Water CRDL (µg/L)	Soil CRDL[5] (mg/Kg)	Water MDL (µg/L)	Soil MDL[5] (mg/Kg)	Water RL (µg/L)	Soil RL[5] (mg/Kg)
Antimony	7440-36-0	60	12	2.62	0.31	10	1
Arsenic	7440-38-2	10	—	3.46	0.44	10	1
Cadmium	7440-43-9	5	1	0.58	0.06	5	0.5
Lead	7439-92-1	3	—	2.72	0.21	3	0.3
Selenium	7782-49-2	5	—	3.12	0.34	5	0.5
Thallium	7440-42-8	1	—	2.11	0.66	10	1

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 2/3/97 for waters and 5/2/96 for soils.

[3] Higher detection limits may be utilized under the following circumstances: If the sample concentration exceeds five (5) times the detection limit of the instrument, the values may be reported even though the instrument detection limit may not equal the contract required detection limit.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-5
DENVER LABORATORY
Method 6020 ICP/MS Metals[1] Method Detection Limits (MDL) and Reporting Limits (RL)

Element	CAS Number	Water MDL (µg/L)	Soil MDL[2] (µg/Kg)	Water RL (µg/L)	Soil RL[2] (mg/Kg)
Aluminum	7429-90-5	2.57	—	15	1.5
Antimony	7440-36-0	0.3	—	0.50	0.050
Arsenic	7440-38-2	0.44	—	5.0	0.50
Barium	7440-39-3	0.34	—	1.0	0.10
Beryllium	7440-41-7	0.32	—	0.50	0.050
Cadmium	7440-43-9	0.055	—	0.30	0.030
Chromium	7440-47-3	0.94	—	1.0	0.10
Cobalt	7440-48-4	0.15	—	0.50	0.050
Copper	7440-50-8	0.19	—	2.0	0.20
Iron	7439-89-6	12	—	50	5.0
Lead	7439-92-1	0.74	—	1.0	0.10
Manganese	7439-96-5	0.054	—	0.20	0.020
Molybdenum	7439-98-7	0.087	—	0.25	0.025
Nickel	7440-02-0	0.050	—	0.20	0.020
Selenium	7782-49-2	0.54	—	5.0	0.50
Silver	7440-22-4	0.30	—	0.50	0.050
Thallium	7440-28-0	0.045	—	0.10	0.010
Tin	7440-31-5	2.70	—	15	1.5
Titanium	7440-32-6	0.70	—	5.0	0.50
Uranium	7440-61-1	0.034	—	0.20	0.020
Vanadium	7440-62-2	0.20	—	0.50	0.050
Zinc	7440-66-6	2.30	—	10	1.0

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

[3] The MDLs were completed on 05/09/95, 12/23/96 and 1/13/97.

TABLE 5-6
DENVER LABORATORY
Method 601 CWA Halogenated Volatile Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Bromodichloromethane	75-27-4	0.065	1.0
Bromoform	75-25-2	0.14	5.0
Bromomethane	74-83-9	0.050	5.0
Carbon Tetrachloride	56-23-5	0.050	0.5
Chlorobenzene	108-90-7	0.31	2.0
Chloroethane	75-00-3	0.091	5.0
2-Chloroethylvinyl ether	110-75-8	0.081	5.0
Chloroform	67-66-3	0.050	0.5
Chloromethane	74-87-3	0.050	5.0
1,2-Dichlorobenzene	95-50-1	0.12	2.0
1,3-Dichlorobenzene	541-73-1	0.10	2.0
1,4-Dichlorobenzene	106-46-7	0.11	2.0
Dichlorodifluoromethane	75-71-8	0.050	5.0
1,1-Dichloroethane	75-34-3	0.050	0.5
1,2-Dichloroethane	107-06-2	0.051	1.0
1,1-Dichloroethene	75-35-4	0.050	0.5
trans-1,2-Dichloroethene	156-60-5	0.050	0.5
cis-1,2-Dichloroethene	156-59-2	0.050	0.5
1,2-Dichloropropane	78-87-5	0.058	1.0
cis-1,3-Dichloropropene	10061-01-5	0.072	2.0
trans-1,3-Dichloropropene	10061-02-6	0.10	1.0
Dibromochloromethane	124-48-1	0.11	1.0
Methylene Chloride	75-09-2	0.050	5.0
1,1,2,2-Tetrachloroethane	79-34-5	0.14	1.0
Tetrachloroethene	127-18-4	0.051	0.5
1,1,1-Trichloroethane	71-55-6	0.050	0.5
1,1,2-Trichloroethane	79-00-5	0.13	1.0

TABLE 5-6
DENVER LABORATORY
Method 601 CWA Halogenated Volatile Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Trichloroethene	79-01-6	0.050	0.5
Trichlorofluoromethane	75-69-4	0.086	5.0
Vinyl Chloride	75-01-4	0.050	1.0

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was completed on 10/21/96 for waters.

[3] Reporting Limits are within 1 to 10 times of the MDL.

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TABLE 5-7
DENVER LABORATORY
Method 8010B Halogenated Volatile Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (µg/Kg)
Bromodichloromethane	75-27-4	0.065	7.0	1.0	100
Bromoform	75-25-2	0.14	17	5.0	500
Bromomethane	74-83-9	0.050	7.2	5.0	500
Carbon Tetrachloride	56-23-5	0.050	7.4	0.5	50
Chlorobenzene	108-90-7	0.31	33	2.0	200
Chloroethane	75-00-3	0.091	11	5.0	500
2-Chloroethyl vinyl ether	110-75-8	0.081	6.9	5.0	500
Chloroform	67-66-3	0.081	5.5	0.5	50
Chloromethane	74-87-3	0.050	11	5.0	500
Dibromochloromethane	124-48-1	0.050	12	1.0	100
1,2-Dibromoethane (EDB)	106-93-4	0.10	11	2.0	100
1,2-Dichlorobenzene	95-50-1	0.12	33	2.0	100
1,3-Dichlorobenzene	541-73-1	0.10	22	2.0	100
1,4-Dichlorobenzene	106-46-7	0.11	25	2.0	100
Dichlorodifluoromethane	75-71-8	0.050	26	5.0	500
1,1-Dichloroethane	75-34-3	0.050	5.7	0.5	50
1,2-Dichloroethane	107-06-2	0.051	11	1.0	100
1,1-Dichloroethene	75-35-4	0.050	5.0	0.5	50
trans-1,2-Dichloroethene	156-60-5	0.050	8.8	0.5	50
cis-1,2-Dichloroethene	156-59-2	0.050	6.6	0.5	50
1,2-Dichloropropane	78-87-5	0.058	7.6	1.0	100
cis-1,3-Dichloropropene	10061-01-5	0.072	7.0	2.0	200
trans-1,3-Dichloropropene	10061-02-6	0.10	11	1.0	100
Methylene Chloride	75-09-2	0.050	16	5.0	500
1,1,2,2-Tetrachloroethane	79-34-5	0.14	23	1.0	100
Tetrachloroethene	127-18-4	0.051	7.5	0.5	50

TABLE 5-7
DENVER LABORATORY
Method 8010A CWA Halogenated Volatile Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (µg/Kg)
1,1,1-Trichloroethane	71-55-6	0.050	7.6	0.5	50
1,1,2-Trichloroethane	79-00-5	0.13	12	1.0	100
Trichloroethene	79-01-6	0.050	6.3	0.5	50
Trichlorofluoromethane	75-69-4	0.086	11	5.0	500
1,1,2-Trichloro-1,2,2-trifluoromethane	76-13-1	0.096	15	5.0	100
Vinyl Chloride	75-01-4	0.050	6.4	1.0	100

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was completed on 10/21/96 for waters and soils.

[3] Reporting Limits are within 1 to 10 times of the MDL.

TABLE 5-8
DENVER LABORATORY
Method 8015(Modified) for Gasoline and Diesel Range Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[4] (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
Gasoline (by purge and trap) API Method	3999176-70-0	4.34	310	10	500
Gasoline (by purge and trap) 8015 Modified	3999176-70-0	3.59	250	25	1250
Diesel (by extraction) API Method	3948788-70-0	58	1040	100	4000
Diesel (by extraction) 8015 Modified	3948788-70-0	54	1040	100	4000

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit studies for gasoline were performed 10/2/96 for both waters and soils. The MDL studies for DRO in water were performed 4/1/97 (API) and 2/27/97 (8015M). For DRO in soil, MDLs were performed 11/17/95 (API) and 11/14/96 (8015M)

[3] Reporting Limits are within 1 to 10 times of the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-9
DENVER LABORATORY
602 CWA Aromatic Volatile Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Benzene	71-43-2	0.079	0.50
Chlorobenzene	108-90-7	0.091	0.50
Ethylbenzene	100-41-4	0.070	0.50
1,2-Dichlorobenzene	95-50-1	0.077	0.50
1,3-Dichlorobenzene	541-73-1	0.13	0.50
1,4-Dichlorobenzene	106-46-7	0.33	0.50
tert-Methyl-butyl ether (MTBE)	1634-04-4	0.27	5.0
Toluene	108-88-3	0.058	0.50
m- & p-Xylene	61-30-0	0.13	0.50
o-Xylene	95-47-6	0.26	0.50
Xylene (total)	1330-20-7	0.35	0.50

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 1/23/97 for waters.

[3] Reporting Limits are within 1 to 10 times of the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-10
DENVER LABORATORY
Method 8020A Aromatic Volatile Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[4] (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
Benzene	71-43-2	0.079	0.50	0.50	5.0
Chlorobenzene	108-90-7	0.091	0.50	0.50	5.0
1,2-Dichlorobenzene	95-50-1	0.077	0.50	0.50	5.0
1,3-Dichlorobenzene	541-73-1	0.13	0.50	0.50	5.0
1,4-Dichlorobenzene	106-46-7	0.33	0.50	0.50	5.0
Ethylbenzene	100-41-4	0.070	0.59	0.50	5.0
tert-Methyl-butyl ether (MTBE)	1634-04-4	0.27	0.79	1.13	5.0
Toluene	108-88-3	0.058	0.90	1.24	5.0
m- & p-Xylene	61-30-0	0.13	1.07	1.0	5.0
o-Xylene	95-47-6	0.26	0.63	0.50	5.0
Xylene (total)	1330-20-7	0.35	1.07	1.5	5.0

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 1/23/97 for waters and 2/28/97 for soils.

[3] Reporting Limits are within 1 to 10 times of the MDL.

[4] Quantitation limits listed for soil are based on a direct purge. The quantitation limits based on dry weight as required, will be higher.

[5] Quantitation limits listed for soil are based on a methanol extraction. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-11
DENVER LABORATORY
CLP Pesticides and PCBs Contract Required Quantitation Limits (CRQL)[1]

Analyte	CAS Number	Water CRQL (µg/L)	Soil CRQL[2] (µg/Kg)
Aldrin	309-00-2	0.05	1.7
a-BHC	319-84-6	0.05	1.7
b-BHC	319-85-7	0.05	1.7
d-BHC	319-86-8	0.05	1.7
g-BHC (Lindane)	58-89-9	0.05	1.7
a-Chlordane	5103-71-9	0.05	1.7
g-Chlordane	5103-74-2	0.05	1.7
4,4'-DDD	72-54-8	0.10	3.3
4,4'-DDE	72-55-9	0.10	3.3
4,4'-DDT	50-29-3	0.10	3.3
Dieldrin	60-57-1	0.10	3.3
Endosulfan I	959-98-8	0.05	1.7
Endosulfan II	33213-65-9	0.10	3.3
Endosulfan sulfate	1031-07-8	0.10	3.3
Endrin	72-20-8	0.10	3.3
Endrin Aldehyde	7421-93-4	0.10	3.3
Endrin Ketone	53494-70-5	0.10	3.3
Heptachlor	76-44-8	0.05	1.7
Heptachlor Epoxide	1024-57-3	0.05	1.7
Methoxychlor	72-43-5	0.50	17.0
Aroclor 1016	12674-11-2	1.0	33.0
Aroclor 1221	11104-28-2	2.0	67.0
Aroclor 1232	11141-16-5	1.0	33.0
Aroclor 1242	53469-21-9	1.0	33.0
Aroclor 1248	12672-29-6	1.0	33.0
Aroclor 1254	11097-69-1	1.0	33.0
Aroclor 1260	11096-82-5	1.0	33.0
Toxaphene	8001-35-2	5.0	170.0

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable

[2] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-12
DENVER LABORATORY
Method 608 CWA Pesticides and PCBs[1]
Method Detection Limit (MDL)[2] and Reporting Limit (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Aldrin	309-00-2	0.023	0.050
a-BHC	319-84-6	0.022	0.050
b-BHC	319-85-7	0.026	0.050
d-BHC	319-86-8	0.022	0.050
g-BHC (Lindane)	58-89-9	0.022	0.050
Chlordane, Technical	57-74-9	0.056	0.50
4,4'-DDD	72-54-8	0.012	0.10
4,4'-DDE	72-55-9	0.021	0.10
4,4'-DDT	50-29-3	0.033	0.10
Dieldrin	60-57-1	0.022	0.10
Endosulfan I	959-98-8	0.025	0.050
Endosulfan II	33213-65-9	0.022	0.10
Endosulfan sulfate	1031-07-8	0.027	0.10
Endrin	72-20-8	0.027	0.10
Endrin Aldehyde	7421-93-4	0.022	0.10
Heptachlor	76-44-8	0.023	0.050
Heptachlor Epoxide	1024-57-3	0.024	0.050
Aroclor 1016	12674-11-2	0.11	1.0
Aroclor 1221	11104-28-2	0.45	2.0
Aroclor 1232	11141-16-5	0.65	1.0
Aroclor 1242	53469-21-9	0.18	1.0
Aroclor 1248	12672-29-6	0.22	1.0
Aroclor 1254	11097-69-1	0.13	1.0
Aroclor 1260	11096-82-5	0.12	1.0
Toxaphene	8001-35-2	0.18	5.0

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on single component pesticides on 1/15/97 for waters. PCBs were performed 2/12/96. Toxaphene was performed on 05/2/96 and technical chlordane was performed on 02/17/96.

[3] Reporting Limits are within 1 to 10 times the MDL.

TABLE 5-13
DENVER LABORATORY
Method 8080 Target Compound List and Appendix IX Pesticides and PCBs[1]
Method Detection Limit (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[4] (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
Aldrin	309-00-2	0.023	0.33	0.050	1.7
a-BHC	319-84-6	0.022	0.41	0.050	1.7
b-BHC	319-85-7	0.026	0.54	0.050	1.7
d-BHC	319-86-8	0.022	0.42	0.050	1.7
g-BHC (Lindane)	58-89-9	0.022	0.43	0.050	1.7
Chlordane (Tech)	57-74-9	0.056	2.5	0.50	17
a-Chlordane	5103-71-9	0.025	0.39	0.050	1.7
g-Chlordane	5103-74-2	0.025	0.36	0.050	1.7
Chlorobenzilate	510-15-6	049	5.87	1.0	33
4,4'-DDD	72-54-8	0.012	0.43	0.10	3.3
4,4'-DDE	72-55-9	0.021	0.47	0.10	3.3
4,4'-DDT	50-29-3	0.033	0.37	0.10	3.3
Diallate	2303-16-4	0.42	5.66	1.0	33
Dieldrin	60-57-1	0.022	0.37	0.10	3.3
Endosulfan I	959-98-8	0.025	0.19	0.050	1.7
Endosulfan II	33213-65-9	0.022	0.24	0.10	3.3
Endosulfan sulfate	1031-07-8	0.027	0.43	0.10	3.3
Endrin	72-20-8	0.027	0.60	0.10	3.3
Endrin Aldehyde	7421-93-4	0.022	0.30	0.10	3.3
Endrin ketone	53494-70-5	0.026	0.22	0.10	3.3
Heptachlor	76-44-8	0.023	0.34	0.050	1.7
Heptachlor Epoxide	1024-57-3	0.024	0.38	0.050	1.7
Isodrin	465-73-6	0.036	0.57	0.10	3.3
Kepone	143-50-0	1.11	17.9	2.5	83
Methoxychlor	72-43-5	0.025	0.51	0.50	17
Aroclor 1016	12674-11-2	0.11	3.4	1.0	33
Aroclor 1221	11104-28-2	0.45	17	1.0	33

TABLE 5-13
DENVER LABORATORY
Method 8080 Target Compound List and Appendix IX Pesticides and PCBs[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[4] (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
Aroclor 1232	11141-16-5	0.65	3.7	1.0	33
Aroclor 1242	53469-21-9	0.18	7.9	1.0	33
Aroclor 1248	12672-29-6	0.22	8.8	1.0	33
Aroclor 1254	11097-69-1	0.13	4.4	1.0	33
Aroclor 1260	11096-82-5	0.12	5.0	1.0	33
Toxaphene	8001-35-2	0.18	29.6	5.0	170

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 1/15/97 for waters, except for Toxaphene performed 05/02/96, PCBs performed 02/12/96, and technical chlordane performed 2/17/96. Appendix IX MDLs for both waters and soils were completed on 3/21/97. Soil MDLs completed 12/14/96 for pesticides, 1/5/96 for toxaphene, 2/28/96 for technical chlordane, and 1/4/96 for PCBs.

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-14
DENVER LABORATORY
Methods 8140/8141A and Appendix IX Pesticides[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[4] (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
Azinphos methyl (Guthion)	86-50-0	0.069	—	2.5	83
Bolstar (Sulprofos)	35400-43-2	0.056	—	0.5	17
Chlorpyrifos (Dursban)	2921-88-2	0.041	—	0.25	8.3
Coumaphos	56-72-4	0.094	—	0.5	17
Demeton, o,s	8065-48-3	0.073	—	0.25	8.3
Diazinon	333-41-5	0.038	—	0.25	8.3
Dichlorvos (Vapona)	62-73-7	0.038	—	0.5	17
Dimethoate	60-51-5	0.063	—	0.5	17
Disulfoton (Disyston)	298-04-4	0.043	—	0.25	8.3
Ethoprop	13194-48-4	0.035	—	0.25	8.3
Ethyl parathion	56-38-2	0.035	—	0.25	8.3
Famphur	52-85-7	0.060	—	1.0	33
Fensulfothion	115-90-2	0.243	—	2.5	83
Fenthion (Baytex)	55-38-9	0.047	—	0.25	8.3
Malathion	121-75-5	0.077	—	1.2	42
Merphos	150-50-5	0.043	—	0.25	8.3
Methyl parathion	298-00-0	0.040	—	0.25	8.3
Mevinphos (Phosdrin)	7786-34-7	0.033	—	6.2	210
Naled (Dibrom)	300-76-5	0.058	—	10	330
o,o,o-Triethylphosphorothioate	126-68-1	0.048	—	0.25	8.3
Phorate (Thimet)	298-02-2	0.059	—	0.25	8.3
Ronnel	299-84-3	0.070	—	0.25	8.3
Sulfotepp	3689-24-5	0.038	—	0.25	8.3
Tetrachlorovinphos (Stirophos)	961-11-5	0.095	—	2.5	83
Thionazin	297-97-2	0.048	—	0.25	8.3
Tokuthion (Prothiophos)	53-10-0	0.050	—	0.25	8.3
Trichloronate	327-98-0	0.040	—	0.25	8.3

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 4/1/96 and 03/6/97 for waters.

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-15
DENVER LABORATORY
Method 8150B Herbicides[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[4] (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
2,4-D	94-75-7	0.53	—	2.0	40
2,4-DB	94-82-6	1.14	—	5.0	100
Dalapon	75-99-0	0.50	—	5.0	100
Dicamba	1918-00-9	0.14	—	0.50	10
Dichloroprop	120-36-5	0.50	—	1.0	20
Dinoseb	88-85-7	0.36	—	1.0	20
MCPA	94-74-6	88	—	250	5000
MCPP	93-65-2	106	—	250	5000
2,4,5-T	93-76-5	0.14	—	0.50	10
2,4,5-TP (Silvex)	93-72-1	0.14	—	0.50	10

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 3/4/97 for waters.

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-16
DENVER LABORATORY
Method 8330 Explosives by HPLC[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[2] (µg/g)	Water RL (µg/L)	Soil RL[2] (µg/g)
2-Amino-4,6-dinitrobenzene	355-72-78-2	0.034	0.037	0.10	0.25
4-Amino-2,6-dinitrotoluene	1946-51-0	0.067	0.045	0.10	0.25
1,3-Dinitrobenzene	99-65-0	0.033	0.033	0.10	0.25
2,4-Dinitrotoluene	121-14-2	0.032	0.058	0.10	0.25
2,6-Dinitrotoluene	606-20-2	0.046	0.077	0.25	0.25
Ethylene glycol dinitrate	628-96-6	0.313	0.53	2.5	5.0
HMX	2691-41-0	0.024	0.050	0.25	0.25
Nitrobenzene	98-95-3	0.025	0.062	0.25	0.25
Nitroglycerin	55-63-0	0.599	0.70	2.5	5.0
2-Nitrotoluene	88-72-2	0.057	0.084	0.25	0.25
3-Nitrotoluene	99-08-1	0.058	0.082	0.25	0.25
4-Nitrotoluene	99-99-0	0.038	0.059	0.25	0.25
RDX	121-82-4	0.042	0.12	0.25	0.25
Tetryl	479-45-8	0.043	0.054	0.50	0.50
1,3,5-Trinitrobenzene	99-35-4	0.021	0.026	0.25	0.25
2,4,6-Trinitrotoluene	118-96-7	0.043	0.054	0.10	0.25

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 12/30/96 for waters and 2/17/97 for soils, except ethylene glycol dinitrate and nitroglycerin.

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-17
DENVER LABORATORY
Method 8310 Polynuclear Aromatic Hydrocarbons[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[2] (µg/Kg)	Water RL (µg/L)	Soil RL[2] (µg/Kg)
Acenaphthene	83-32-9	0.93	57.3	1.0	200
Acenaphthylene	208-96-8	0.040	95.6	1.0	200
Anthracene	120-12-7	0.030	10.4	0.10	20
Benzo(a)anthracene	56-55-3	0.060	4.43	0.10	20
Benzo(a)pyrene	50-32-8	0.065	5.26	0.10	20
Benzo(b)fluoranthene	205-99-2	0.059	3.46	0.10	20
Benzo(g,h,i)perylene	191-24-2	0.071	2.80	0.20	40
Benzo(k)fluoranthene	207-08-9	0.059	4.04	0.10	20
Chrysene	218-01-9	0.073	4.18	0.20	40
Dibenzo(a,h)anthracene	53-70-3	0.076	3.53	0.20	40
Fluoranthene	206-44-0	0.036	7.52	0.20	40
Fluorene	86-73-7	0.035	12.9	0.20	40
Indeno(1,2,3-cd)pyrene	193-39-5	0.055	2.16	0.20	40
1-Methylnaphthalene	90-12-0	0.058	68.7	1.0	200
2-Methylnaphthalene	91-57-6	0.043	55.6	1.0	200
Naphthalene	91-20-3	0.059	132	1.0	200
Phenanthrene	85-01-8	0.030	6.00	0.20	40
Pyrene	129-00-0	0.043	8.07	0.20	40

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 12/30/96 for waters and 04/17/96 for soils

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-18
DENVER LABORATORY
Method 8315 Formaldehyde by HPLC[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[2](µg/Kg)	Water RL (µg/L)	Soil RL[2] (µg/Kg)
Formaldehyde	50-00-0	1.79	—	5.0	40

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 05/01/96 for waters.

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

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TABLE 5-19
DENVER LABORATORY
Method 524.2 Purgeable Organic Compounds in Water by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Benzene	71-43-2	0.22	1.0
Bromobenzene	108-86-1	0.20	1.0
Bromochloromethane	74-97-5	0.28	1.0
Bromodichloromethane	124-48-1	0.27	1.0
Bromoform	75-25-2	0.23	1.0
Bromomethane	74-83-9	0.18	1.0
n-Butylbenzene	104-51-8	0.19	1.0
sec-Butylbenzene	135-98-8	0.20	1.0
tert-Butylbenzene	98-06-6	0.13	1.0
Carbon Tetrachloride	56-23-5	0.24	1.0
Chlorobenzene	108-90-7	0.20	1.0
Chloroethane	75-00-3	0.47	1.0
Chloroform	67-66-3	0.13	1.0
Chloromethane	74-87-3	0.21	1.0
2-Chlorotoluene	95-49-8	0.23	1.0
4-Chlorotoluene	106-43-4	0.29	1.0
Dibromochloromethane	75-27-4	0.26	1.0
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	0.71	2.0
1,2-Dibromoethane (EDB)	106-93-4	0.21	1.0
Dibromomethane	74-95-3	0.25	1.0
1,2-Dichlorobenzene	95-50-1	0.24	1.0
1,3-Dichlorobenzene	541-73-1	0.10	1.0
1,4-Dichlorobenzene	106-46-7	0.17	1.0
Dichlorodifluoromethane	75-71-8	0.33	1.0
1,1-Dichloroethane	75-34-3	0.24	1.0
cis-1,2-Dichloroethene	156-59-2	0.25	1.0
trans-1,2-Dichloroethene	156-60-5	0.24	1.0

TABLE 5-19
DENVER LABORATORY
Method 524.2 Purgeable Organic Compounds in Water by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
1,2-Dichloroethane	107-06-2	0.29	1.0
1,1-Dichloroethene	75-35-4	0.22	1.0
1,2-Dichloropropane	78-87-5	0.15	1.0
1,3-Dichloropropane	142-28-9	0.49	1.0
2,2-Dichloropropane	594-20-7	0.29	1.0
1,1-Dichloropropene	563-58-6	0.21	1.0
cis-1,3-Dichloropropene	10061-01-5	0.20	1.0
trans-1,3-Dichloropropene	10061-02-6	0.43	1.0
Ethylbenzene	100-41-4	0.24	1.0
Hexachlorobutadiene	87-68-3	0.20	1.0
Isopropylbenzene	98-82-8	0.13	1.0
4-Isopropyltoluene	99-87-6	0.16	1.0
Methylene Chloride	75-09-2	0.29	1.0
Naphthalene	91-20-3	0.18	1.0
n-Propylbenzene	103-65-1	0.19	1.0
Styrene	100-42-5	0.10	1.0
1,1,1,2-Tetrachloroethane	630-20-6	0.26	1.0
1,1,2,2-Tetrachloroethane	79-34-5	0.42	1.0
Tetrachloroethene	127-18-4	0.13	1.0
Toluene	108-88-3	0.19	1.0
1,2,3-Trichlorobenzene	87-61-6	0.60	1.0
1,2,4-Trichlorobenzene	120-82-1	0.32	1.0
1,1,1-Trichloroethane	71-55-6	0.21	1.0
1,1,2-Trichloroethane	79-00-5	0.44	1.0
Trichloroethene	79-01-6	0.19	1.0
Trichlorofluoromethane	75-69-4	0.39	1.0
1,2,3-Trichloropropane	96-18-4	0.79	1.0

TABLE 5-19
DENVER LABORATORY
Method 524.2 Purgeable Organic Compounds in Water by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
1,2,4-Trimethylbenzene	95-63-6	0.13	1.0
1,3,5-Trimethylbenzene	108-67-8	0.15	1.0
Vinyl Chloride	75-01-4	0.18	1.0
m&p-Xylenes	61-30-0	0.34	1.0
o-Xylene	95-47-6	0.29	1.0

Footnotes

1 Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

2 The Method Detection Limit study was performed on 11/17/95.

3 Reporting Limits are within 1 to 10 times the MDL.

TABLE 5-20
DENVER LABORATORY
Method 8240B Target Compound List, Appendix IX, and F039 for Volatile Organics[1] Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (µg/Kg)
Acetone	67-64-1	2.15	3.78	20	20
Acetonitrile	75-05-8	12.9	32.7	100	100
Acrolein	107-02-8	9.58	3.54	100	100
Acrylonitrile	107-13-1	7.24	16.7	100	100
Allyl Chloride (3-Chloroprene)	107-05-1	2.33	0.71	10	10
Benzene	71-43-2	1.21	1.10	5.0	5.0
Bromodichloromethane	75-27-4	1.15	1.13	5.0	5.0
Bromoform	75-25-2	1.24	1.28	5.0	5.0
Bromomethane	74-83-9	1.10	2.32	10	10
2-Butanone	78-93-3	2.43	6.03	20	20
Carbon Disulfide	75-15-0	1.35	1.52	5.0	5.0
Carbon Tetrachloride	56-23-5	1.21	1.45	5.0	5.0
Chlorobenzene	108-90-7	1.16	1.24	5.0	5.0
Chloroprene (2-Chloro-1,3-butadiene)	126-99-8	0.57	0.50	5.0	5.0
Chloroethane	75-00-3	2.95	0.52	10	10
2-Chloroethylvinyl ether	110-75-8	3.01	7.68	---	50
Chloroform	67-66-3	1.22	1.10	5.0	5.0
Chloromethane	74-87-3	1.45	0.56	10	10
Cyclohexanone	108-94-1	42.3	25.0	250	250
Dibromochloromethane	124-48-1	1.20	1.11	5.0	5.0
1,2-Dibromoethane (EDB)	106-93-4	3.33	1.16	5.0	5.0
Dibromomethane	74-95-3	1.85	1.13	5.0	5.0
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	7.66	9.87	10	10
1,2-Dichlorobenzene	95-50-1	1.35	1.28	5.0	5.0
1,3-Dichlorobenzene	541-73-1	1.20	1.14	5.0	5.0
1,4-Dichlorobenzene	106-46-7	1.34	1.50	5.0	5.0

TABLE 5-20
DENVER LABORATORY
Method 8240B Target Compound List, Appendix IX, and F039 for Volatile Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (µg/Kg)
trans-1,4-Dichloro-2-butene	110-57-6	1.42	1.95	5.0	5.0
Dichlorodifluoromethane	75-71-8	1.57	0.72	10	10
1,1-Dichloroethane	75-34-3	1.30	1.15	5.0	5.0
1,2-Dichloroethane	107-06-2	1.12	0.92	5.0	5.0
1,1-Dichloroethene	75-35-4	1.37	1.58	5.0	5.0
cis-1,2-Dichloroethene	156-59-2	1.32	1.25	2.5	2.5
trans-1,2-Dichloroethene	156-60-5	1.44	1.37	2.5	2.5
1,2-Dichloroethene (total)	540-59-0	3.03	2.60	5.0	5.0
1,2-Dichloropropane	78-87-5	1.23	1.21	5.0	5.0
cis-1,3-Dichloropropene	10061-01-5	1.30	1.14	5.0	5.0
trans-1,3-Dichloropropene	10061-02-6	1.27	1.10	5.0	5.0
1,4-Dioxane	123-91-1	85.57	90.3	500	500
Ethanol (Ethyl alcohol)	64-17-5	69.1	46.7	500	500
Ethyl Acetate	141-78-6	2.62	3.17	10	10
Ethylbenzene	100-41-4	1.17	1.36	5.0	5.0
Ethyl Ether	60-29-7	1.72	0.50	10	10
Ethyl Methacrylate	97-63-2	2.97	1.46	20	20
Hexane	110-54-3	2.73	1.89	5	5
2-Hexanone	591-78-6	2.16	4.02	20	20
Iodomethane	74-88-4	2.73	1.24	5.0	5.0
Isobutyl Alcohol	78-83-1	34.38	33.7	200	200
Methacrylonitrile	126-98-7	2.06	1.37	5.0	5.0
Methylene Chloride	75-09-2	1.23	1.10	5.0	5.0
Methyl Methacrylate	80-62-6	1.99	1.15	5	5
4-Methyl-2-Pentanone	108-10-1	1.73	1.47	20	20
Methyl-tert-butyl ether	1634-04-4	1.91	1.05	20	20
Propionitrile	107-12-0	18.2	3.74	20	20

TABLE 5-20
DENVER LABORATORY
Method 8240B Target Compound List, Appendix IX, and F039 for Volatile Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (µg/Kg)
Styrene	100-42-5	1.14	1.25	5.0	5.0
1,1,1,2-Tetrachloroethane	630-20-6	1.00	0.50	5.0	5.0
1,1,2,2-Tetrachloroethane	79-34-5	1.18	1.66	5.0	5.0
Tetrachloroethene	127-18-4	1.21	1.44	5.0	5.0
Tetrahydrofuran	109-99-9	2.55	1.88	20	20
Toluene	108-88-3	1.15	1.23	5.0	5.0
1,1,1-Trichloroethane	71-55-6	1.20	1.30	5.0	5.0
1,1,2-Trichloroethane	79-00-5	1.22	1.02	5.0	5.0
Trichloroethene	79-01-6	1.25	1.12	5.0	5.0
Trichlorofluoromethane	75-69-4	1.85	0.96	10	10
1,2,3-Trichloropropane	96-18-4	1.56	1.73	5.0	5.0
1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	1.82	1.58	20	20
Vinyl Acetate	108-05-4	2.01	1.83	10	10
Vinyl Chloride	75-01-4	1.64	0.56	10	10
m&p-Xylenes	61-30-0	2.87	1.37	2.5	2.5
o-Xylene	95-47-6	1.19	0.96	2.5	2.5
Xylenes (total)	1330-20-7	4.21	2.36	5.0	5.0

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 9/8/95 and 3/6/97 for waters and 2/25/97 for soils.

[3] Reporting Limits are within 1 to 10 times the MDL.

TABLE 5-21
DENVER LABORATORY
Method 624 CWA Volatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Acrolein	107-02-8	9.20	100
Acrylonitrile	107-13-1	5.10	100
Benzene	71-43-2	0.54	5.0
Bromodichloromethane	75-27-4	0.51	5.0
Bromoform	75-25-2	0.53	5.0
Bromomethane	74-83-9	4.16	10
Carbon tetrachloride	56-23-5	0.76	5.0
Chlorobenzene	108-90-7	1.87	5.0
Chloroethane	75-00-3	2.61	10
2-Chloroethylvinyl ether	110-75-8	1.03	--
Chloroform	67-66-3	0.51	5.0
Chloromethane	74-87-3	1.31	10
Dibromochloromethane	124-48-1	0.75	5.0
1,2-Dichlorobenzene	95-50-1	0.63	5.0
1,3-Dichlorobenzene	541-73-1	1.60	5.0
1,4-Dichlorobenzene	106-46-7	0.73	5.0
1,1-Dichloroethane	75-34-3	0.91	5.0
1,2-Dichloroethane	107-06-2	0.84	5.0
1,1-Dichloroethene	75-35-4	1.88	5.0
trans-1,2-Dichloroethene	156-60-5	0.50	5.0
1,2-Dichloropropane	78-87-5	0.56	5.0
cis-1,3-Dichloropropene	10061-01-5	0.59	5.0
trans-1,3-Dichloropropene	10061-02-6	0.58	5.0
Ethylbenzene	100-41-4	2.27	5.0
Methylene Chloride	75-09-2	0.72	5.0
1,1,2,2-Tetrachloroethane	79-34-5	0.50	5.0
Tetrachloroethene	127-18-4	0.72	5.0

TABLE 5-21
DENVER LABORATORY
Method 624 CWA Volatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Toluene	108-88-3	1.51	5.0
1,1,1-Trichloroethane	71-55-6	2.08	5.0
1,1,2-Trichloroethane	79-00-5	0.90	5.0
Trichloroethene	79-01-6	0.77	5.0
Trichlorofluoromethane	75-69-4	0.77	10
Vinyl Chloride	75-01-4	0.97	10

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 02/29/96 for waters.

[3] Reporting Limits are within 1 to 10 times the MDL.

TABLE 5-22
DENVER LABORATORY
CLP Volatile Organics by GC/MS[1]
Contract Required Quantitation Limits (CRQL)

Analyte	CAS Number	Water CRQL (µg/L)	Soil CRQL[2] (µg/L)
Acetone	67-64-1	10	10
Benzene	71-43-2	10	10
Bromodichloromethane	75-27-4	10	10
Bromoform	75-25-2	10	10
Bromomethane	74-83-9	10	10
2-Butanone	78-93-3	10	10
Carbon Disulfide	75-15-0	10	10
Carbon Tetrachloride	56-23-5	10	10
Chlorobenzene	108-90-7	10	10
Chloroethane	75-00-3	10	10
Chloroform	67-66-3	10	10
Chloromethane	74-87-3	10	10
Dibromochloromethane	124-48-1	10	10
1,2-Dichloroethene (Total)	540-59-0	10	10
1,1-Dichloroethane	75-34-3	10	10
1,2-Dichloroethane	107-06-2	10	10
1,1-Dichloroethene	75-35-4	10	10
1,2-Dichloropropane	78-87-5	10	10
cis-1,3-Dichloropropene	10061-01-5	10	10
trans-1,3-Dichloropropene	10061-02-6	10	10
Ethylbenzene	100-41-4	10	10
2-Hexanone	591-78-6	10	10
Methylene Chloride	75-09-2	10	10
4-Methyl-2-Pentanone	108-10-1	10	10
Styrene	100-42-5	10	10
1,1,2,2-Tetrachloroethane	79-34-5	10	10
Tetrachloroethene	127-18-4	10	10

TABLE 5-22
DENVER LABORATORY
CLP Volatile Organics by GC/MS[1]
Contract Required Quantitation Limits (CRQL)
(Continued)

Analyte	CAS Number	Water CRQL (µg/L)	Soil CRQL[2] (µg/L)
Toluene	108-88-3	10	10
1,1,1-Trichloroethane	71-55-6	10	10
1,1,2-Trichloroethane	79-00-5	10	10
Trichloroethene	79-01-6	10	10
Vinyl Chloride	75-01-4	10	10
Xylene (total)	1330-20-7	10	10

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-23
DENVER LABORATORY
Method 8260A Volatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
Acetone	67-64-1	3.78	3.78	10	20
Acrylonitrile	107-13-1	7.23	32.7	20	100
Benzene	71-43-2	0.12	1.10	1.0	5.0
Bromobenzene	108-86-1	0.20	1.24	1.0	5.0
Bromochloromethane	74-97-5	0.28	0.75	1.0	5.0
Bromodichloromethane	75-27-4	0.20	1.13	1.0	5.0
Bromoform	75-25-2	0.55	1.28	1.0	5.0
Bromomethane	74-83-9	0.11	2.32	2.0	10
2-Butanone (MEK)	78-93-3	0.70	6.03	5.0	20
n-Butylbenzene	104-51-8	0.19	2.55	1.0	5.0
sec-Butylbenzene	135-98-8	0.20	2.11	1.0	5.0
tert-Butylbenzene	98-06-6	0.13	1.70	1.0	5.0
Carbon disulfide	75-15-0	0.17	1.52	1.0	5.0
Carbon tetrachloride	56-23-5	0.12	1.45	1.0	5.0
Chlorobenzene	108-90-7	0.18	1.24	1.0	5.0
Chlorodibromomethane	124-48-1	0.37	1.11	1.0	5.0
Chloroethane	75-00-3	0.10	0.52	2.0	10
2-Chloroethyl vinyl ether	110-75-8	1.20	7.68	---	50
Chloroform	67-66-3	0.10	1.10	1.0	5.0
Chloromethane	74-87-3	0.10	0.56	2.0	10
2-Chlorotoluene	95-49-8	0.23	1.30	1.0	5.0
4-Chlorotoluene	106-43-4	0.29	0.84	1.0	5.0
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	0.71	9.87	2.0	10
1,2-Dibromoethane (EDB)	106-93-4	0.29	1.16	1.0	5.0
Dibromomethane	74-95-3	0.25	1.13	1.0	5.0
1,2-Dichlorobenzene	95-50-1	0.36	1.28	1.0	5.0

TABLE 5-23
DENVER LABORATORY
Method 8260A Volatile Organics by GC/MS[1]
Method Detection Limit (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
1,3-Dichlorobenzene	541-73-1	0.31	1.14	1.0	5.0
1,4-Dichlorobenzene	106-46-7	0.28	1.50	1.0	5.0
Dichlorodifluoromethane	75-71-8	0.11	0.72	2.0	10
1,1-Dichloroethane	75-34-3	0.11	1.15	1.0	5.0
1,2-Dichloroethane	107-06-2	0.10	0.92	1.0	5.0
1,1-Dichloroethene	75-35-4	0.14	1.58	1.0	5.0
cis-1,2-Dichloroethene	156-59-2	0.10	1.25	0.5	2.5
trans-1,2-Dichloroethene	156-60-5	0.15	1.37	0.5	2.5
1,2-Dichloroethene (total)	540-59-0	0.23	2.60	1.0	5.0
1,2-Dichloropropane	78-87-5	0.20	1.21	1.0	5.0
1,3-Dichloropropane	142-28-9	0.49	1.08	1.0	5.0
2,2-Dichloropropane	594-20-7	0.29	1.16	1.0	5.0
1,1-Dichloropropene	563-58-6	0.21	1.98	1.0	5.0
cis-1,3-Dichloropropene	10061-01-5	0.18	1.14	1.0	5.0
trans-1,3-Dichloropropene	10061-02-6	0.25	1.10	1.0	5.0
Ethylbenzene	100-41-4	0.10	1.36	1.0	5.0
Hexachlorobutadiene	87-68-3	0.20	2.57	1.0	5.0
Hexane	110-54-3	0.19	1.89	1.0	5.0
2-Hexanone	591-78-6	0.63	4.02	5.0	20
Iodomethane	74-88-4	0.12	1.24	1.0	5.0
Isopropylbenzene (Cumene)	98-82-8	0.13	0.50	1.0	5.0
p-Isopropyltoluene	99-87-6	0.16	1.87	1.0	5.0
Methylene Chloride	75-09-2	0.10	1.10	1.0	5.0
4-Methyl-2-Pentanone	108-10-1	0.52	1.47	5.0	20
Methyl-tert-butyl ether (MTBE)	1634-04-4	0.13	1.05	5.0	20
Naphthalene	91-20-3	0.50	2.05	1.0	5.0

TABLE 5-23
DENVER LABORATORY
Method 8260A Volatile Organics by GC/MS[1]
Method Detection Limit (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
n-Propylbenzene	103-65-1	0.19	1.99	1.0	5.0
Styrene	100-42-5	0.21	1.25	1.0	5.0
1,1,1,2-Tetrachloroethane	630-20-6	0.26	0.50	1.0	5.0
1,1,2,2-Tetrachloroethane	79-34-5	0.72	1.66	1.0	5.0
Tetrachloroethene	127-18-4	0.11	1.44	1.0	5.0
Tetrahydrofuran	109-99-9	1.03	1.88	5.0	20
Toluene	108-88-3	0.14	1.23	1.0	5.0
1,2,3-Trichlorobenzene	87-61-6	0.60	1.53	1.0	5.0
1,2,4-Trichlorobenzene	120-82-1	0.32	1.67	1.0	5.0
1,1,1-Trichloroethane	71-55-6	0.13	1.30	1.0	5.0
1,1,2-Trichloroethane	79-00-5	0.37	1.02	1.0	5.0
Trichloroethene	79-01-6	0.10	1.12	1.0	5.0
Trichlorofluoromethane	75-69-4	0.19	0.96	2.0	10
1,2,3-Trichloropropane	96-18-4	0.58	1.73	1.0	5.0
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	0.14	1.58	1.0	5.0
1,2,4-Trimethylbenzene	95-63-6	0.13	1.63	1.0	5.0
1,3,5-Trimethylbenzene	108-67-8	0.15	1.55	1.0	5.0
Vinyl Acetate	108-05-4	0.68	1.83	2.0	10
Vinyl Chloride	75-01-4	0.14	0.56	2.0	10
m- & p-Xylenes	5113-90-0	0.25	1.37	0.50	2.5
o-Xylene	95-47-6	0.18	0.96	0.50	2.5
Xylenes (total)	1330-20-7	0.47	2.36	1.0	5.0

TABLE 5-23
DENVER LABORATORY
Method 8260A Volatile Organics by GC/MS[1]
Method Detection Limit (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit studies for waters were performed on 11/21/96 and 3/11/97. Soil MDLs were performed on 8/30/95 and 2/25/97.

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

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TABLE 5-24
DENVER LABORATORY
CLP Semivolatile Organics by GC/MS[1] with Contract Required Quantitation Limits (CRQL)

Analyte	CAS Number	Water CRQL (µg/L)	Soil CRQL[2] (µg/Kg)
Acenaphthene	83-32-9	10	330
Acenaphthylene	208-96-8	10	330
Anthracene	120-12-7	10	330
Benzo(a)anthracene	56-55-3	10	330
Benzo(b)fluoranthene	205-99-2	10	330
Benzo(k)fluoranthene	207-08-9	10	330
Benzo(g,h,i)perylene	191-24-2	10	330
Benzo(a)pyrene	50-32-8	10	330
4-Bromophenyl-phenylether	101-55-3	10	330
Butyl benzyl phthalate	85-68-7	10	330
Carbazole	86-74-8	10	330
4-Chloroaniline	106-47-8	10	330
bis(2-Chloroethoxy)methane	111-91-1	10	330
bis(2-Chloroethyl)ether	111-44-4	10	330
bis(2-Chloroisopropyl)ether	108-60-1	10	330
4-Chloro-3-methylphenol	59-50-7	10	330
2-Chloronaphthalene	91-58-7	10	330
2-Chlorophenol	95-57-8	10	330
4-Chlorophenyl-phenylether	7005-72-3	10	330
Chrysene	218-01-9	10	330
Dibenzo(a,h)anthracene	53-70-3	10	330
Dibenzofuran	132-64-9	10	330
Di-n-butylphthalate	84-74-2	10	330
1,2-Dichlorobenzene	95-50-1	10	330
1,3-Dichlorobenzene	541-73-1	10	330
1,4-Dichlorobenzene	106-46-7	10	330
3,3'-Dichlorobenzidine	91-94-1	10	330

TABLE 5-24
DENVER LABORATORY
CLP Semivolatile Organics by GC/MS[1] with Contract Required Quantitation Limits (CRQL)
(Continued)

Analyte	CAS Number	Water CRQL (µg/L)	Soil CRQL[2] (µg/Kg)
2,4-Dichlorophenol	120-83-2	10	330
Diethylphthalate	84-66-2	10	330
2,4-Dimethylphenol	105-67-9	10	330
Dimethyl phthalate	131-11-3	10	330
4,6-Dinitro-2-methylphenol	534-52-1	25	800
2,4-Dinitrophenol	51-28-5	25	800
2,4-Dinitrotoluene	121-14-2	10	330
2,6-Dinitrotoluene	606-20-2	10	330
Di-n-octylphthalate	117-84-0	10	330
bis(2-Ethylhexyl) phthalate	117-81-7	10	330
Fluoranthene	206-44-0	10	330
Fluorene	86-73-7	10	330
Hexachlorobenzene	118-74-1	10	330
Hexachlorobutadiene	87-68-3	10	330
Hexachlorocyclopentadiene	77-47-4	10	330
Hexachloroethane	67-72-1	10	330
Indeno(1,2,3-cd)pyrene	193-39-5	10	330
Isophorone	78-59-1	10	330
2-Methylnaphthalene	91-57-6	10	330
2-Methylphenol	95-48-7	10	330
4-Methylphenol	106-44-5	10	330
Naphthalene	91-20-3	10	330
2-Nitroaniline	88-74-4	25	800
3-Nitroaniline	99-09-2	25	800
4-Nitroaniline	100-01-6	25	800
Nitrobenzene	98-95-3	10	330
2-Nitrophenol	88-75-5	10	330

TABLE 5-24
DENVER LABORATORY
CLP Semivolatile Organics by GC/MS[1] with Contract Required Quantitation Limits (CRQL)
(Continued)

Analyte	CAS Number	Water CRQL (µg/L)	Soil CRQL[2] (µg/Kg)
4-Nitrophenol	100-02-7	25	800
N-Nitrosodiphenylamine	86-30-6	10	330
N-Nitroso-di-n-propylamine	621-64-7	10	330
Pentachlorophenol	87-86-5	25	800
Phenanthrene	85-01-8	10	330
Phenol	108-95-2	10	330
Pyrene	129-00-0	10	330
1,2,4-Trichlorobenzene	120-82-1	10	330
2,4,5-Tricholorphenol	95-95-4	25	800
2,4,6-Trichlorophenol	88-06-2	10	330

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-25
DENVER LABORATORY
Method 625 CWA Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Acenaphthene	83-32-9	1.36	10
Acenaphthylene	208-96-8	1.37	10
Anthracene	120-12-7	1.00	10
Benzidene	92-87-5	22.2	100
Benzo(a)anthracene	56-55-3	1.00	10
Benzo(b)fluoranthene	205-99-2	3.44	10
Benzo(k)fluoranthene	207-08-9	2.61	10
Benzo(g,h,i)perylene	191-24-2	1.38	10
Benzo(a)pyrene	50-32-8	1.42	10
4-Bromophenyl-phenylether	101-55-3	1.00	10
Butyl benzyl phthalate	85-68-7	1.00	10
bis(2-Chloroethoxy)methane	111-91-1	2.11	10
bis(2-Chloroethyl) ether	111-44-4	1.30	10
bis(2-Chloroisopropyl) ether	108-60-1	1.00	10
4-Chloro-3-methylphenol	59-50-7	1.00	10
2-Chloronaphthalene	91-58-7	1.47	10
2-Chlorophenol	95-57-8	1.22	10
4-Chlorophenylphenylether	7005-72-3	1.28	10
Chrysene	218-01-9	1.87	10
Dibenzo(a,h)anthracene	53-70-3	1.00	10
Di-n-butylphthalate	84-74-2	1.00	10
1,2-Dichlorobenzene	95-50-1	1.36	10
1,3-Dichlorobenzene	541-73-1	1.11	10
1,4-Dichlorobenzene	106-46-7	1.51	10
3,3'-Dichlorobenzidine	91-94-1	7.51	20
2,4-Dichlorophenol	120-83-2	1.18	10
Diethylphthalate	84-66-2	1.00	10

TABLE 5-25
DENVER LABORATORY
Method 625 CWA Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
2,4-Dimethylphenol	105-67-9	1.52	10
Dimethylphthalate	131-11-3	1.00	10
4,6-Dinitro-2-methylphenol	534-52-1	11.2	50
2,4-Dinitrophenol	51-28-5	18.1	50
2,4-Dinitrotoluene	121-14-2	1.00	10
2,6-Dinitrotoluene	606-20-2	1.00	10
Di-n-octylphthalate	117-84-0	1.41	10
1,2-Diphenylhydrazine	122-66-7	1.00	10
bis(2-Ethylhexyl) phthalate	117-81-7	1.00	10
Fluoranthene	206-44-0	1.75	10
Fluorene	86-73-7	1.16	10
Hexachlorobenzene	118-74-1	1.00	10
Hexachlorobutadiene	87-68-3	1.90	10
Hexachlorocyclopentadiene	77-47-4	5.38	--
Hexachloroethane	67-72-1	1.00	10
Indeno(1,2,3-cd)pyrene	193-39-5	1.27	10
Isophorone	78-59-1	1.67	10
Naphthalene	91-20-3	2.11	10
Nitrobenzene	98-95-3	1.50	10
2-Nitrophenol	88-75-5	1.09	10
4-Nitrophenol	100-02-7	8.91	50
N-Nitrosodimethylamine	62-75-9	1.00	10
N-Nitroso-di-n-propylamine	621-64-7	1.32	10
N-Nitrosodiphenylamine	86-30-6	1.00	10
Pentachlorophenol	87-86-5	11.0	50
Phenanthrene	85-01-8	1.00	10
Phenol	108-95-2	1.00	10

TABLE 5-25
DENVER LABORATORY
Method 625 CWA Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Pyrene	129-00-0	1.00	10
1,2,4-Trichlorobenzene	120-82-1	1.96	10
2,4,6-Trichlorophenol	88-06-2	1.41	10

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 04/08/96.

[3] Reporting Limits are within 1 to 10 times the MDL.

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TABLE 5-26
DENVER LABORATORY
Method 8270B Target Compound List, Appendix IX, and F039 for Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL[4] (µg/kg)
Acenaphthene	83-32-9	1.0	174	10	330
Acenaphthylene	208-96-8	1.2	181	10	330
Acetophenone	98-86-2	1.0	36	10	330
2-Acetylaminofluorene	53-96-3	1.0	41	100	3300
4-Aminobiphenyl	92-67-1	1.0	42	50	1600
Aniline	62-53-3	5.1	60	10	330
Anthracene	120-12-7	1.1	177	10	330
Aramite	140-57-8	1.0	30	20	660
Azobenzene	103-33-3	1.0	178	10	330
Benzenethiol	108-98-5	29	—	100	3300
Benzidine	92-87-5	43	—	100	3300
Benzo(a)anthracene	56-55-3	1.0	165	10	330
Benzo(b)fluoranthene	205-99-2	1.2	127	10	330
Benzo(j)fluoranthene	205-82-3	1.1	—	10	330
Benzo(k)fluoranthene	207-08-9	1.2	222	10	330
Benzoic acid	65-85-0	22	885	50	1600
Benzo(g,h,i)perylene	191-24-2	1.6	144	10	330
Benzo(a)pyrene	50-32-8	1.4	153	10	330
Benzyl alcohol	100-51-6	1.2	150	10	330
4-Bromophenyl-phenylether	101-55-3	1.0	170	10	330
Butyl benzyl phthalate	85-68-7	1.0	151	10	330
2-sec-Butyl 4,6-dinitrophenol Dinoseb	88-85-7	1.0	30	20	660
Carbazole	86-74-8	1.0	158	10	330
4-Chloroaniline	106-47-8	1.9	77	10	330
bis(2-Chloroethoxy)methane	111-91-1	1.1	241	10	330
bis(2-Chloroethyl) ether	111-44-4	1.1	160	10	330

TABLE 5-26
DENVER LABORATORY
Method 8270B Target Compound List, Appendix IX, and F039 for Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL[4] (µg/kg)
bis(2-Chloroisopropyl) ether 2,2'-oxybis(1-Chloropropane)	108-60-1	1.1	210	10	330
Chlorobenzilate	510-15-6	1.0	—	10	330
4-Chloro-3-methylphenol	59-50-7	1.4	157	10	330
1-Chloronaphthalene	90-13-1	1.0	30	50	2500
2-Chloronaphthalene	91-58-7	1.2	170	10	330
2-Chlorophenol	95-57-8	1.1	166	10	330
4-Chlorophenyl-phenylether	7005-72-3	1.6	176	10	330
Chrysene	218-01-9	1.2	173	10	330
Diallate	2303-16-4	2.0	—	20	660
Dibenz(a,j)acridine	224-42-0	1.0	30	20	660
Dibenzo(a,h)anthracene	53-70-3	1.6	128	10	330
Dibenzofuran	132-64-9	1.2	179	10	330
Di-n-butylphthalate	84-74-2	1.0	151	10	330
1,2-Dichlorobenzene	95-50-1	1.3	158	10	330
1,3-Dichlorobenzene	541-73-1	1.3	154	10	330
1,4-Dichlorobenzene	106-46-7	1.5	158	10	330
3,3'-Dichlorobenzidine	91-94-1	1.6	225	50	1600
2,4-Dichlorophenol	120-83-2	1.4	153	10	330
2,6-Dichlorophenol	87-65-0	1.0	34	10	330
Diethylphthalate	84-66-2	1.0	182	10	330
Dimethoate	60-51-5	1.0	30	20	660
4-Dimethylaminoazobenzene	60-11-7	1.1	30	20	660
7,12-Dimethylbenz(a)anthracene	57-97-6	1.0	146	20	660
3,3-Dimethylbenzidine	95-53-4	3.5	103	20	660
a,a-Dimethylphenethylamine	122-09-8	19	30	50	1600

TABLE 5-26
DENVER LABORATORY
Method 8270B Target Compound List, Appendix IX, and F039 for Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL[4] (µg/kg)
2,4-Dimethylphenol	105-67-9	1.6	198	10	330
Dimethyl phthalate	131-11-3	1.0	183	10	330
1,3-Dinitrobenzene	99-65-0	1.0	31	10	330
1,4-Dinitrobenzene	100-25-4	1.0	30	10	330
4,6-Dinitro-2-methylphenol (4,6-Dinitro-o-cresol)	534-52-1	1.0	921	50	1600
2,4-Dinitrophenol	51-28-5	1.3	904	50	1600
2,4-Dinitrotoluene	121-14-2	1.0	131	10	330
2,6-Dinitrotoluene	606-20-2	1.0	154	10	330
Di-n-octylphthalate	117-84-0	1.4	152	10	330
Diphenylamine	122-39-4	1.2	43	10	330
1,2-Diphenylhydrazine	122-66-7	1.0	56	10	330
Disulfoton	298-04-4	1.4	30	50	1600
bis(2-Ethylhexyl) phthalate	117-81-7	1.3	170	10	330
Ethyl methanesulfonate	62-50-0	1.0	39	10	330
Famphur	52-85-7	—	—	—	—
Fluoranthene	206-44-0	1.1	175	10	330
Fluorene	86-73-7	1.6	201	10	330
Hexachlorobenzene	118-74-1	1.0	166	10	330
Hexachlorobutadiene	87-68-3	1.6	158	10	330
Hexachlorocyclopentadiene	77-47-4	2.3	107	50	1600
Hexachloroethane	67-72-1	1.5	147	10	330
Hexachlorophene	70-30-4	—	—	—	—
Hexachloropropene	1888-71-7	1.0	33	100	3300
Indene	95-13-6	—	213	10	330
Indeno(1,2,3-cd)pyrene	193-39-5	1.5	138	10	330
Isodrin	465-73-6	1.0	—	10	330

TABLE 5-26
DENVER LABORATORY
Method 8270B Target Compound List, Appendix IX, and F039 for Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL[4] (µg/kg)
Isophorone	78-59-1	1.1	175	10	330
Isosafrole	120-58-1	2.0	32	20	660
Kepone	143-50-0	—	—	—	—
Methapyrilene	91-80-5	—	30	50	1600
3-Methylcholanthrene	56-49-5	2.7	30	20	660
6-Methylchrysene	1705-85-7	1.0	—	10	330
Methyl methanesulfonate	66-27-3	1.0	42	10	330
1-Methylnapthalene	90-12-0	1.0	173	10	330
2-Methylnaphthalene	91-57-6	1.3	182	10	330
Methyl parathion	298-00-0	1.0	30	50	1600
2-Methylphenol (o-cresol)	95-48-7	1.3	173	10	330
3-Methylphenol (m-cresol)	108-39-4	1.2	182	10	330
4-Methylphenol (p-cresol)	106-44-5	1.2	182	10	330
Naphthalene	91-20-3	1.1	234	10	330
1,4-Napthoquinone	130-15-4	1.3	30	50	1600
1-Naphthylamine	134-32-7	2.0	63	10	330
2-Naphthylamine	91-59-8	1.2	53	10	330
2-Nitroaniline	88-74-4	1.2	169	50	1600
3-Nitroaniline	99-09-2	1.1	244	50	1600
4-Nitroaniline	100-01-6	1.6	369	50	1600
Nitrobenzene	98-95-3	1.4	149	10	330
2-Nitrophenol	88-75-5	1.2	181	10	330
4-Nitrophenol	100-02-7	1.5	418	50	1600
4-Nitroquinoline-1-oxide	56-57-5	10	30	100	3300
N-Nitroso-di-n-butylamine	924-16-3	1.0	30	10	330
N-Nitrosodiethylamine	55-18-5	1.0	45	10	330

TABLE 5-26
DENVER LABORATORY
Method 8270B Target Compound List, Appendix IX, and F039 for Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL[4] (µg/kg)
N-Nitrosodimethylamine	62-75-9	1.0	145	10	330
N-Nitrosodiphenylamine (Diphenylnitrosamine)	86-30-6	1.2	301	10	330
N-Nitroso-di-n-propylamine	621-64-7	1.0	183	10	330
N-Nitrosomethylethlyamine	10595-95-6	1.0	30	10	330
N-Nitrosomorpholine	59-89-2	1.0	52	10	330
N-Nitrosopiperdine	100-75-4	1.0	30	10	330
N-Nitrosopyrolidine	930-55-2	1.0	40	10	330
5-Nitro-o-toluidine	99-55-8	1.2	60	20	660
Parathion	56-38-2	1.0	30	50	1600
Pentachlorobenzene	608-93-5	1.0	30	10	330
Pentachloroethane	76-01-7	1.0	40	50	1600
Pentachloronitrobenzene	82-68-8	1.0	30	50	1600
Pentachlorophenol	87-86-5	1.0	583	50	1600
Phenacetin	62-44-2	1.0	30	20	660
Phenanthrene	85-01-8	1.0	193	10	330
Phenol	108-95-2	1.0	152	10	330
4-Phenylenediamine	106-50-3	10	388	100	3300
Phorate	298-02-2	1.0	30	50	1600
2-Picoline	109-06-8	1.0	30	20	660
Pronamide	23950-58-5	1.0	30	20	660
Pyrene	129-00-0	1.0	184	10	330
Pyridine	110-86-1	1.0	243	20	660
Quinoline	91-22-5	5.5	---	50	330
Safrole	94-59-7	1.0	30	20	660
1,2,4,5-Tetrachlorobenzene	95-94-3	1.0	30	10	330
2,3,4,6-Tetrachlorophenol	58-90-2	1.3	30	50	1600

TABLE 5-26
DENVER LABORATORY
Method 8270B Target Compound List, Appendix IX, and F039 for Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL[4] (µg/kg)
Tetraethyldithiopyrophosphate (Sulfotepp)	3689-24-5	1.0	34	50	1600
Thionazin	297-97-2	1.1	30	50	1600
2-Toluidine	95-53-4	1.0	103	20	660
1,2,4-Trichlorobenzene	120-82-1	1.4	147	10	330
2,4,5-Tricholorphenol	95-95-4	1.4	141	10	330
2,4,6-Trichlorophenol	88-06-2	1.2	141	10	330
O,O,O-Triethylphosphorothioate	126-68-1	1.0	30	50	1600
1,3,5-Trinitrobenzene	99-35-4	1.0	30	50	1600

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 4/1/96 and 11/19/96 for waters. The MDL for soils was completed 4/2/96 and 2/3/97.

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

Comments:

1) N-Nitrosodiphenylamine decomposes in the gas chromatographic inlet and cannot be distinguished from diphenylamine.

2) Hexachlorophene is not amenable to analysis by this method.

3) 3-Methylphenol cannot be separated from 4-methylphenol by the conditions specified in this method.

4) Azobenzene is formed by decomposition of 1,2-diphenylhydrazine. If 1,2-diphenylhydrazine is requested, it will be analyzed as azobenzene.

Facility Appendix
Denver Laboratory

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Section Denver-6

Performance
Evaluation
Studies

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TABLE 6-1
DENVER LABORATORY
PE Sample Programs

PE Sample Program Description	Analysis Performed	Frequency of Participation
US Environmental Protection Agency Water Pollution Laboratory PE Study	Trace Metals, Minerals, Nutrients, Demand, PCBs in Water, PCBs in Transformer Oil, Pesticides (Insecticides), Volatile Halocarbons, Volatile Aromatics, and Miscellaneous (TSS, Cyanide, Oil & Grease, Total Phenolics)	Semi-annually
US Environmental Protection Agency Water Supply Laboratory PE Study	Trace Metals, Nitrate/Nitrite/Fluoride, Pesticides, Herbicides, Trihalomethanes, Volatile Organics, and Miscellaneous (TDS, Hardness, pH, Alkalinity, Sodium, Sulfate, Cyanide, Residual Chlorine, Turbidity, and TOC)	Semi-annually
Analytical Products Group, Inc. (APG) Real World Matrix PE Program	Volatile Organics, Acid Extractables, Base/Neutral Extractables, Purgeable Aromatics (BTEX)	Semi-annually
Army Corp of Engineers	Project Specific Parameter List	As needed per approval period - 18 months
Quanterra Corporate Double Blind	Parameter list not announced in advance.	Annually
Quanterra Environmental Services' Denver Internal PEs	As needed	As a follow-up to unacceptable PEs on other programs.

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Facility Appendix
Denver Laboratory

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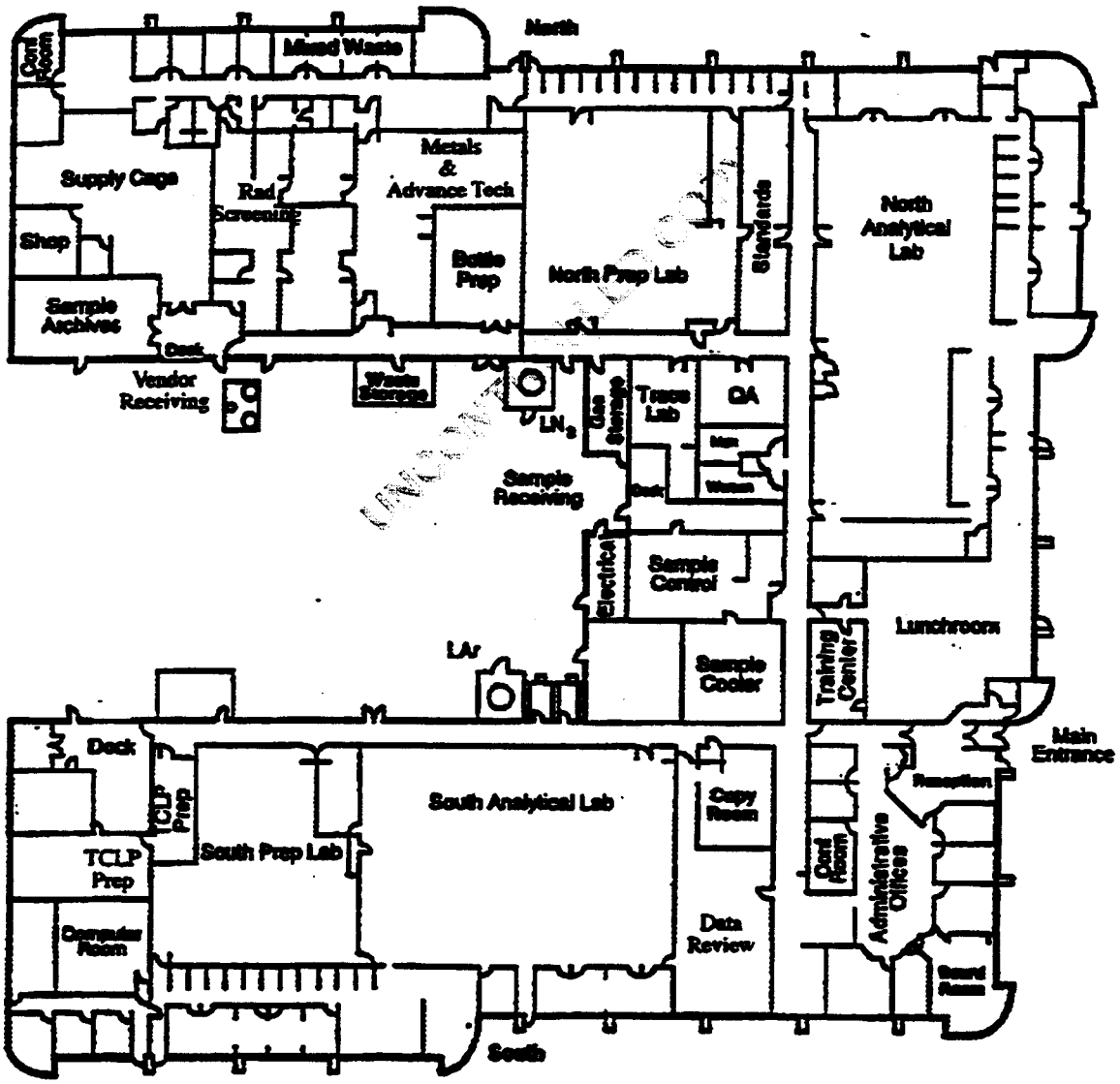
Section Denver-7

Additional
Operation-Specific
Information

FIGURE 7-1

Quanterra Denver Floor Plan



QUALITY ASSURANCE PROGRAM PLAN

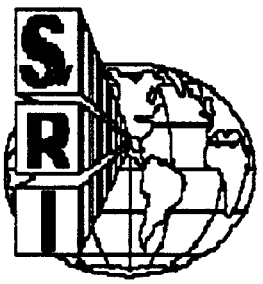
FOR
ENVIRONMENTAL SAMPLING
AND
NON-RADIOACTIVE/RADIOACTIVE ANALYSIS

by

Jo Ann Boyd

Copy No. _____

Chemistry and Chemical Engineering Division
Southwest Research Institute
San Antonio, Texas 78284



September 1996

SOUTHWEST RESEARCH INSTITUTE

TABLE OF CONTENTS

		No. of Pages	Rev	Date
1.	IDENTIFICATION OF SUBMITTAL LABORATORY	1	9	11-93
2.	INTRODUCTION	2	11	6-95
	2.1 Commitment to Quality Assurance			
	2.2 Purpose and Scope of Quality Assurance Program Plan			
	2.3 Quality Operating Plans			
3.	QUALITY ASSURANCE POLICY	1	7	1-93
4.	QUALITY ASSURANCE MANAGEMENT	33	10	5-96
	4.1 SwRI Quality Assurance Management Structure			
	4.2 Assignment of Quality Responsibilities within the Chemistry and Chemical Engineering Division			
	4.3 Communication			
	4.4 Document Control			
	4.5 QA Program Assessment			
	4.6 Tracking			
	4.7 Analytical Procedures			
5.	PERSONNEL QUALIFICATIONS	2	11	5-96
	5.1 Training			
	5.2 Personnel Safety			
6.0	FACILITIES, EQUIPMENT AND SERVICES	14	8	6.95
	6.1 Cleaning of Sample Preparation Containers			
	6.2 Instrument Calibration			
	6.3 Geophysical Testing Calibration			
	6.4 Material Procurement and Control			
	6.5 Maintenance			
	6.6 Balances, Refrigerators and Ovens			

TABLE OF CONTENTS

		No. of Pages	Rev	Date
7.0	DATA GENERATION	20	8	12-95
	7.1 Quality Assurance Project Plan			
	7.2 Quality Control Samples			
	7.3 Method Validation			
	7.4 Documentation and Sample Custody			
	7.5 Sample and Extract Storage			
	7.6 Preventing Sample Contamination			
	7.7 Security for Laboratory and Samples			
	7.8 Traceability of Standards			
	7.9 Maintaining Instrument Records and Logbooks			
	7.10 Analysis Work Order Form			
	7.11 Standard Operating Procedures			
	7.12 Study Planning and Design			
8.	DATA PROCESSING	2	6	2-93
	8.1 Collection			
	8.2 Validation			
	8.3 Data Storage			
	8.4 Data Transfer			
	8.5 Data Reduction			
9.	DATA QUALITY ASSESSMENT	1	6	11-93
10.	CORRECTIVE ACTION	2	9	9-96
11.	BIBLIOGRAPHY	2	6	11-93

Appendix A - Radioactive Material License
Appendix B - "Requirements for Quality Control of Analytical Data for the Environmental Restoration Program"
- Lockheed Martin Energy Systems (LMES)

1. **IDENTIFICATION OF SUBMITTAL LABORATORY**
(Effectivity and Approval)

Document Title: Quality Assurance Project Plan for Environmental Sampling and Nonradioactive/Radioactive Analysis Laboratory in San Antonio

Organization Title: Southwest Research Institute
Chemistry and Chemical Engineering Division
Department of Environmental Chemistry

Address: P.O. Drawer 28510, 6220 Culebra Road
San Antonio, Texas 78284

Responsible Officer: Donald E. Johnson, Phone: 512/522-2176
Title: Vice President, Chemistry and Chemical Engineering Division

Quality Officer: Jo Ann Boyd, Phone: 512/522-2169
Plan Coverage: Division 01
Department of Environmental Chemistry Laboratory in San Antonio

Concurrences

Name Jo Ann Boyd
Title Quality Assurance Officer
Signature Jo Ann Boyd

Name J.P. Hsu, Ph. D
Title Director, Department of Environmental Chemistry
Signature

Approval for Division

Name Donald E. Johnson, Ph.D.
Title Vice President, Chemistry and Chemical Engineering Division
Signature Donald E Johnson

Name Thomas C. Trbovich
Title SwRI Quality Assurance Manager
Signature Thomas C Trbovich

Date: 11/30/93

INTRODUCTION

REV 11

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Approvals:

Division 01 Quality Assurance	JoAnn Boyd	Date: 6/27/95
Division 01 Management	Donald E Johnson	Date: 6/28/95
SwRI QA Management	T.C. Silvoril	Date: 6/27/95

2.0 INTRODUCTION

2.1 Commitment to Quality Assurance (QA)

The Southwest Research Institute (SwRI) Division 01 Environmental Laboratory shall devote the necessary personnel and equipment to fulfill the quality assurance/quality control (QA/QC) requirements of all projects. The SwRI Environmental Laboratory has implemented the QA/QC program described in this document in all laboratories on the main campus in San Antonio to assure generation of monitoring and analytical measurement data of known acceptable quality to meet the requirements of each project's statement of work.

2.2 Purpose and Scope of Quality Assurance Project Plan (QAPP)

The purpose of this QAPP is to convey the philosophy, organizational structure and procedures governing the QA/QC program for environmental sampling and analysis services performed by the Environmental Laboratory in San Antonio. This plan has been prepared in accordance with "Guidelines and Specifications for Preparing Quality Assurance Program Plans, "QAMS-004/80, September 20, 1980", " QAMS-005/80, December 29, 1980; "Quality Assurance", Office of Nuclear Energy, DOE 5700.6C, August 21, 1991; ASME/NQA-1, "Quality Assurance Program Requirements for Nuclear Facilities. The Quality Assurance Department at Southwest Research Institute is an independent organizational element that reports directly to the President of SwRI. The QA support for projects has been tailored to meet the quality requirements imposed by organizations including the Department of Energy (DOE), the Department of Defense (DOD), the Nuclear Regulatory Commission (NRC), the Environmental Protection Agency (EPA), and many industrial firms. These quality programs have been designed to satisfy applicable requirements of quality documents such as MIL-Q-9858A, MIL-I-45208A, MIL-STD-45662A, and DOE Order 5700.6C, Federal Acquisition Regulations (FAR) paragraphs 52.246-1 through 52.246-8, the Food and Drug Administration (FDA) Good Laboratory Practices and Good Manufacturing Practices, and the Environmental Protection Agency (EPA) Good Laboratory Practices, and the requirements specified by the Air Force Center for Environmental Excellence (AFCEE).

SwRI's Nuclear Quality Assurance Program Manual (NQAPM) describes an effective and economical Quality Assurance (QA) Program that complies with the requirements of 10 CFR 50, Appendix B, ASME NQA-1, and DOE 5700.6C. The procedures within this manual establish the basic quality requirements for activities such as Engineering, Design, Fabrication, Inspection, and Testing performed by applicable division personnel.

2.3 Quality Operating Plans

The written quality plan for each contract will be separate from the QAPP but will ensure procedures within this QAPP for documentation and reporting requirements are satisfied. For nuclear requirements, sections of the Institute NQAPM will be invoked and applicable Standard Operating Procedures will be used to conduct the quality activity for the project.

All environmental sampling and analytical services performed within the laboratory in San Antonio, will follow the QAPP to assure compliance to the clients' requirements and validity of the data. If a workplan is required it will be established prior to the initiation of the project, the approvals will be by the Project Manager, Analytical Supervisor, and Division 01 QAU. The client will be notified of any modifications to the QA workplan during the project. Smaller projects requiring minimal QA/QC effort will be established upon initiation of the project and submission in writing from the Project Manager that the client requests to minimize QC samples.

In the event that no QA workplan is specified by the client, all environmental sampling and analytical services preformed within the laboratory at San Antonio shall be conducted in accordance with the provisions of this QAPP.

QUALITY ASSURANCE POLICY

REV 7

Copy No. _____

Approvals:

Division 01 Quality Assurance _____ Date: 11/30/93

Division 01 Management _____ Date: 11/30/93

SwRI QA Management _____ Date: 12/1/93

3.0 QUALITY ASSURANCE POLICY

The following paragraphs are quoted from Southwest Research Institute Operating Policies and Procedures 10.1.1 and present the quality assurance policy of the Institute.

> *It is the policy of Southwest Research Institute (SwRI) to ensure that the equipment and items supplied to, or services performed for, clients shall conform to the specified requirements of the applicable codes, regulations, standards, specifications, and contracts.*
>
> *The responsibility for developing, conducting, and auditing the Quality Assurance (QA) Program to ensure the implementation and enforcement at SwRI of the policy stated above, is assigned to the Quality Assurance Department. In recognition of the importance of this policy, the Director of the Quality Assurance Department will keep the Office of the President of SwRI informed on QA program performance and recommend action as necessary to ensure the required quality assurance.*
>
> *Although quality assurance programs are administered by the QA Department with oversight provided by the Office of the President of SwRI, quality assurance is a responsibility of all SwRI employees performing project activities.*
>
> *Each Division Vice President (DVP) is responsible for (1) ensuring that for each project, the need for a formal QA program is identified and (2) if a QA program is required, ensuring that the Quality Assurance Department is made aware of that requirement. In the case of programs with no formal QA requirements, the DVP or his delegate will determine the extent and application of any QA program and will request QA support as appropriate from the Manager of the QA Department. In either case, the Director of the QA Department will ensure that the QA requirements and documentation necessary to implement those requirements are identified. The Manager of the QA Department is responsible for ensuring that those activities to be performed by QA personnel are documented. The DVP is responsible for ensuring that those activities to be performed by project personnel are documented. QA personnel shall review and approve all procedures governing quality-related activities and will maintain a record copy of each procedure*

It is the policy of the Chemistry and Chemical Engineering Division (C&CED) to implement a quality assurance program in all environmental projects to ensure that all measurement data generated shall be scientifically sound, of known quality, and adequately documented.

QUALITY ASSURANCE MANAGEMENT

REV 9

Copy No. _____

Approvals:

Division 01 Quality Assurance JoAnn Boyd Date: 6/27/95

Division 01 Management Donald E Johnson Date: 6/28/95

SwRI QA Management L.C. Silvernail Date: 6/27/95

4.0 QUALITY ASSURANCE MANAGEMENT

4.1 *SwRI Quality Assurance Management Structure*

The Director of Institute Quality Assurance has been given the responsibility of operating quality assurance programs for the Institute. The President of SwRI has given the Director of QA the authority and organizational freedom to ensure that quality activities shall be accomplished. The organization chart of the Quality Assurance Department is shown in Figure 4.1.

The Institute Quality Assurance Manager is responsible for the activities of the QA personnel and for providing direction to his staff. The QA Manager is responsible for helping to evaluate and assisting in the resolution of deficiencies and quality problems.

The Assistant Manager of Institute Quality Assurance plans, coordinates and directs the efforts of QA Engineers and Technicians to ensure that quality assurance program activities satisfy contractual quality requirements.

The Quality Assurance Engineer (QAE) is responsible for verifying that contract quality activities for projects to which he/she is assigned are be properly implemented or reported as deficiencies. A QAE will be assigned to review the requirements of this QAPP.

The Quality Assurance Technician (QAT) inspects, surveys, monitors, and audits products and services for compliance with contractual requirements. The QAT assigned will perform these functions under the guidance of the responsible QAE.

This plan defines the QA/QC program for all sampling, analytical services, and environmental measurements performed in the San Antonio laboratory (i.e., Environmental Engineering, Environmental Chemistry, Fire Technology, Applied Chemistry, and Chemical Demilitarization sections) within the C&CED Environmental Monitoring and Analysis,. The organization charts of the C&CED and the analysis and sampling group are presented in Figures 4.2, 4.3, and 4.4, respectively.

4.2 *Assignment of Quality Responsibilities within the Chemistry and Chemical Engineering Division*

4.2.1 *Organization Independence of Quality Function*

The manager of SwRI Quality Assurance maintains responsibility to oversee the quality assurance within the C&CED. He then delegates the coordination of quality activities within the division to a quality officer. This designee will supervise all quality control (QC) activities, and submit QA program assessment reports (see Section 4.5) to the manager of Quality Assurance for review. Thus, the Institute Quality Assurance Department will provide independent overview of the QA/QC effort. In addition, as shown in Figure 4.3, the quality officer reports directly to the director(s) of the division on quality matters, giving the quality officer the necessary independence to supervise quality activities within each project. The Institute Quality Assurance Department will conduct system audits and surveillances as necessary to confirm conformance to requirements or to investigate chronic deficiencies in the QA/QC program.

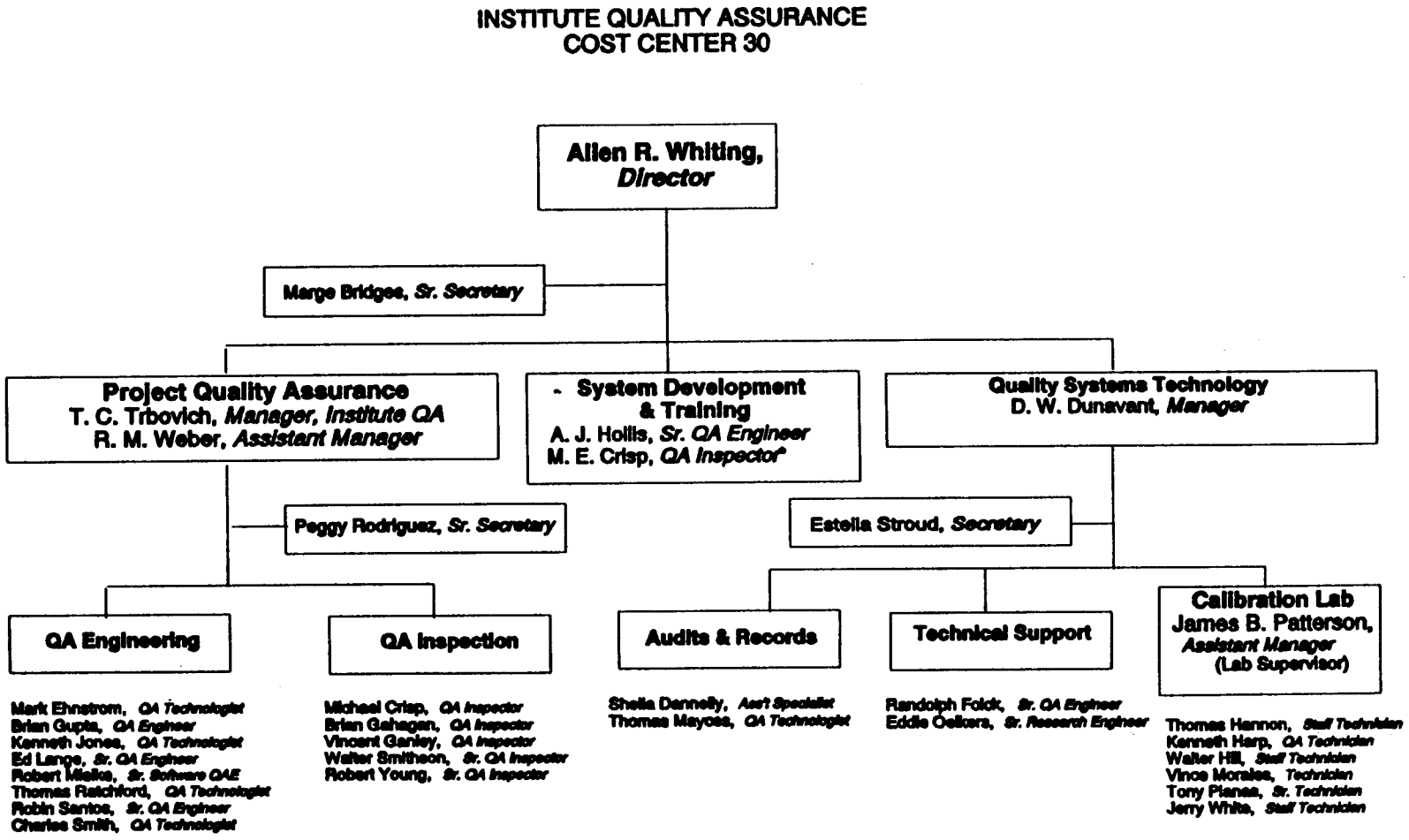
4.2.2 *Responsibilities in Large Projects with a Quality Assurance Project Plan*

4.2.2.1 Typical Positions

Large projects for which a quality assurance project plan is prepared will typically have the following positions:

Project Manager
Study Director
Analytical Supervisor
Analyst
Sampling Coordinator (if applicable)
Quality Assurance/Quality Control Officer (Institute QAE)
Quality Assurance/Quality Control Officer (Division)
Quality Assurance Auditor

Figure 4.1 Department of Quality Assurance and Administration



*As needed, in addition to QA inspection duties.

3/31/95

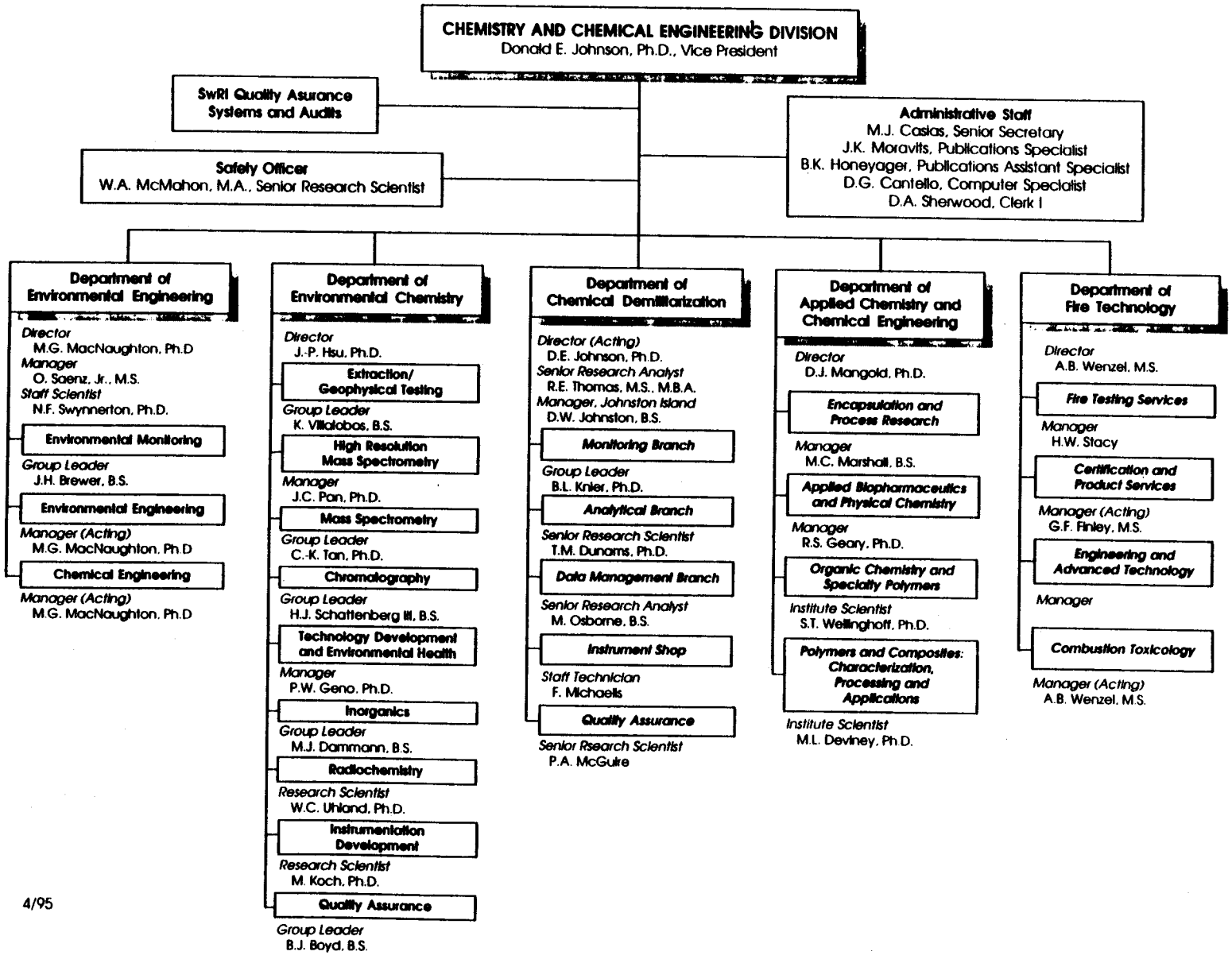


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Figure 4.2 Chemistry and Chemical Engineering Division

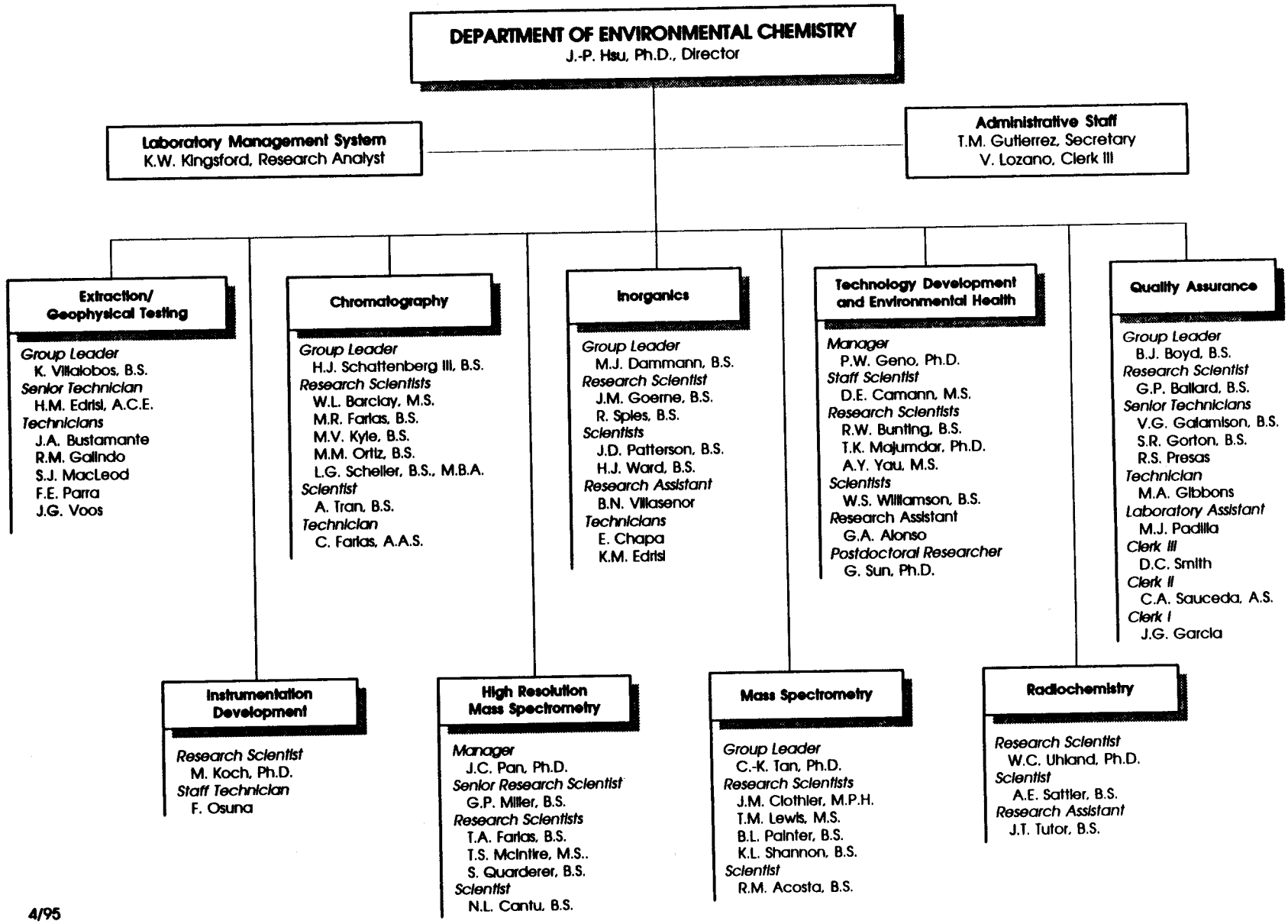
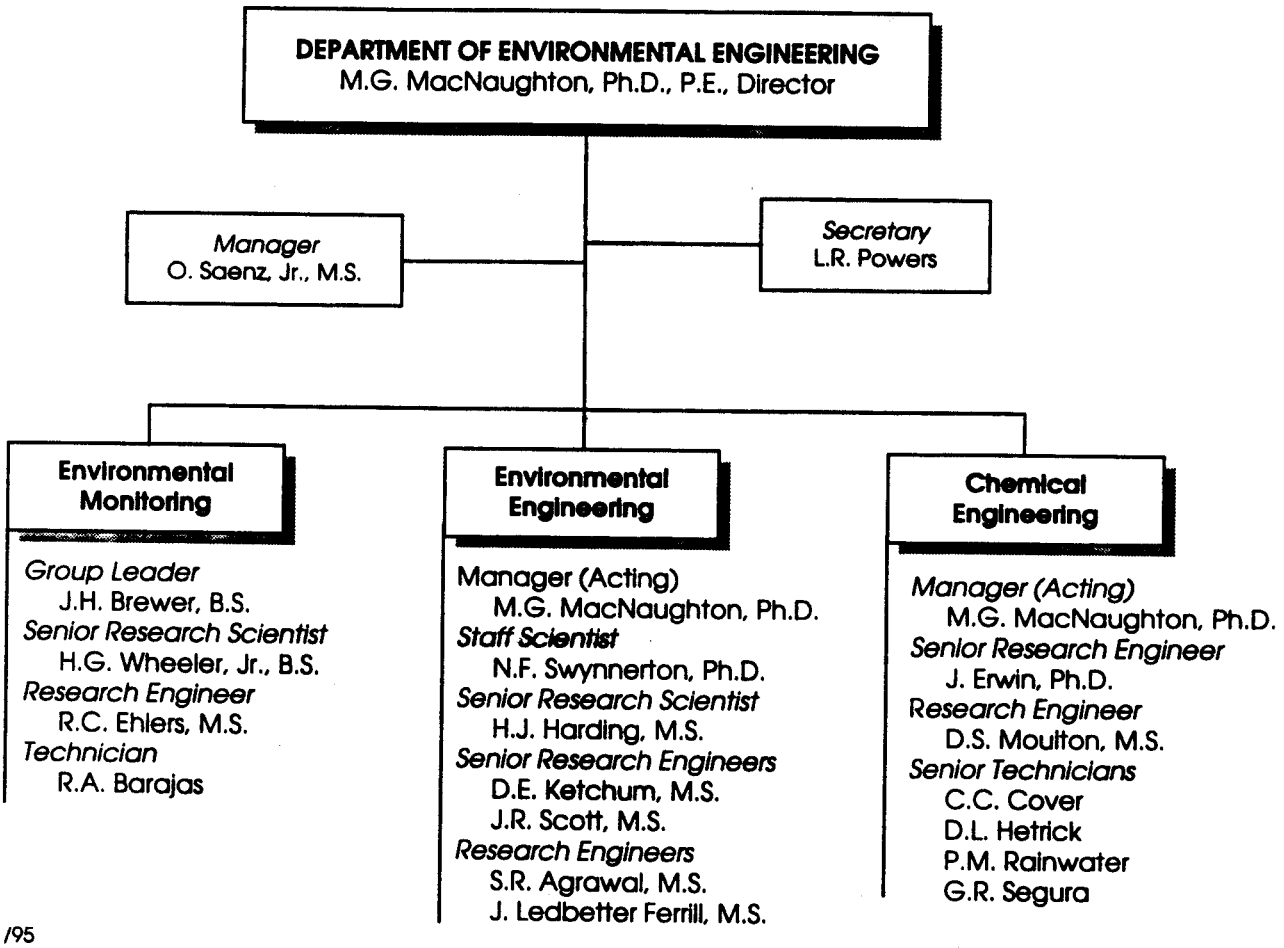


Figure 4.3 Department of Environmental Chemistry

Figure 4.4 Department of Environmental Engineering



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The typical duties of these positions are given below:

Project Manager

- design the work plan/technical proposal
- general technical supervision of project personnel
- financial management
- sponsor communications
- resolve major problems and issues

Study Director

- manages projects requiring GLP regulations
- design the work plan/technical proposal
- general technical supervision of project personnel
- financial management
- sponsor communications
- resolve major problems and issues

Analytical Supervisor

- assist in developing the analytical plan/technical proposal
- assist in preparing the Quality Assurance Project Plan for analytical activities
- develop necessary analytical protocols and analytical standard operating procedures, including control charts
- review analytical results for questionable data and initiate necessary repeat analyses
- report problems to the Project Manager and the QA/QC Officer.

Analyst

- perform analyses
- calculate analytical results
- calculate quality control results
- maintain control charts
- report problems to the Analytical Supervisor for resolution

Sampling Coordinator

- develop necessary sampling protocols, standard operating procedures, and equipment requirements related to sample collection
- prepare the Quality Assurance Project Plan for sampling activities
- train and supervise field sampling personnel
- maintain and calibrate field sampling equipment
- arrange for transport of equipment and supplies to field locations
- determine logistic and custody requirements for sample transport
- document all activities associated with sample collection
- report problems to the Project Manager and the QA/QC Officer

Quality Assurance Officer (Institute QAE)

- monitors project activities and conducts surveillances
- report results of quality activities to project line and quality assurance management
- assist in problem resolution

Quality Assurance/Quality Control Officer (Division)

- assist in preparing the Quality Assurance Project Plan
- schedules internal system audits, blind spiked samples, and performance audits
- report results of quality activities to project line and quality assurance management
- establish and set up procedures for log in, documentation of samples, and data deliverable of analytical results
- coordinate sample shipments from the field to the lab
- establish QC requirement, holding times, and deliverable required by the client and communicate to the analyst through a work order
- report analytical and QC data to the sponsor
- report results of Division QA/QC activities to Institute QA/QC Officer and Division 01 Management

Quality Assurance Auditor (Division)

- periodic review of control charts
- check instrument conditions and calibrations
- report results of quality activities to Division QA/QC Officer
- conducts internal inspections/audits
- check holding times of sample extraction and analysis and track status of analytical results
- spot check QC on analytical results and report any problems to the QA/QC Officer
- provide finished data package to QA/QC Officer and Project Manager for review

All assigned project personnel shall remain diligent to identify, report, and promptly rectify problems affecting data quality as they occur. Unresolved problems must be reported to a member of the quality team.

4.2.2.2 Quality and Project Organizations

A generic organization chart for large projects which have a quality assurance project plan is presented in Figure 4.5. This chart indicates the typical reporting relationships among project management, the quality team, and senior C&CED management.

The quality team consists of the QA/QC Officer, and the QA Auditor. The QC auditor shall perform system audits, prepare the blind spiked samples and summarize their results, and monitor control charts.

4.2.3 *Responsibilities in Other Laboratory Projects*

4.2.3.1 Typical Positions

The functions of the QA/QC Officer and QA Auditor remain as specified in 4.2.2.1. However, the QA/QC scope encompasses all instrumentation and methods employed. Projects that require deviation from the QAPP shall have such deviations documented in memorandum form with the work order.

4.2.3.2 Quality and Lab Organizations

A generic organization chart showing the Chemistry and Chemical Engineering Department labs in San Antonio and their relationship to the quality team is presented in Figure 4.5. The QA/QC Officer shall supervise the quality team. The QA Auditor shall conduct all audit activities as scheduled and submit audit reports to the Division QA/QC Officer. He/she shall then interact with the section managers and report to senior management through the SwRI QA Officer regarding quality issues. The QA Auditor shall coordinate internal system audits, prepare needed blind spiked samples and summarize their results, and monitor control charts. The same QA Auditor will perform this function in Division 01 environmental laboratories in San Antonio.

4.3 Communication

The organization charts presented in Figures 4.5 and 4.6 indicate the internal and external flow of QA information and reports. Figure 4.5 illustrates typical QA information flow for projects with a QA project plan. Figure 4.6 shows the QA information flow for projects lacking a QA project plan. Reporting responsibilities are discussed in Sections 4.2 and 4.4.

4.4 Document Control

The Division QA/QC Officer and QA Auditor will maintain files of QA program assessment reports, other QA reports to management, and other vital information, plans, and directives. The pagination of every section of the QAPP shall include the number and date of all revisions. The QA Auditor will maintain distribution lists of personnel who need to receive QA reports and information.

Figure 4.5 Generic Organization Chart for Large Projects with a QA Project Plan Showing Relationships Among Project Management, Senior Management, and Quality Team

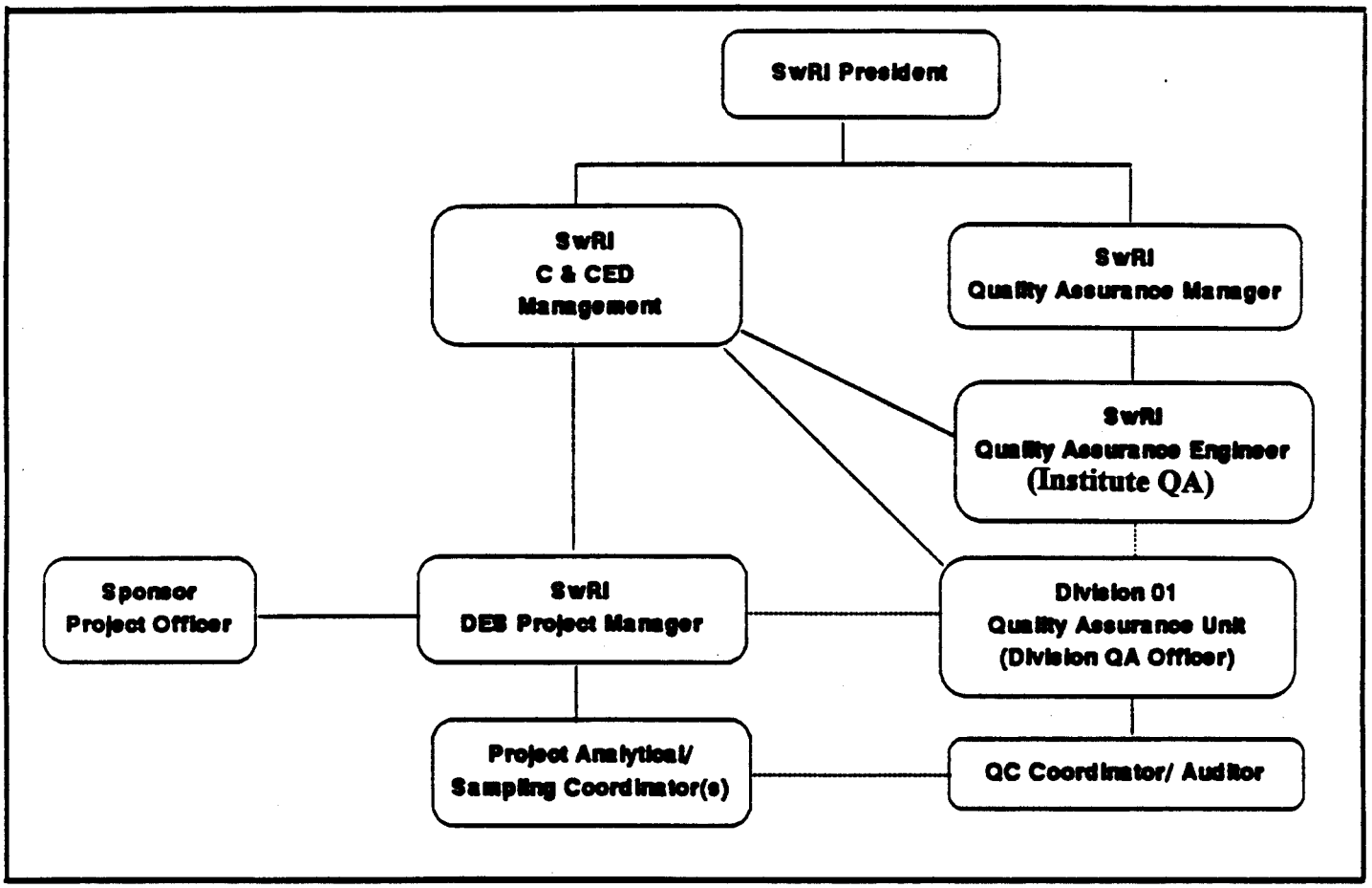
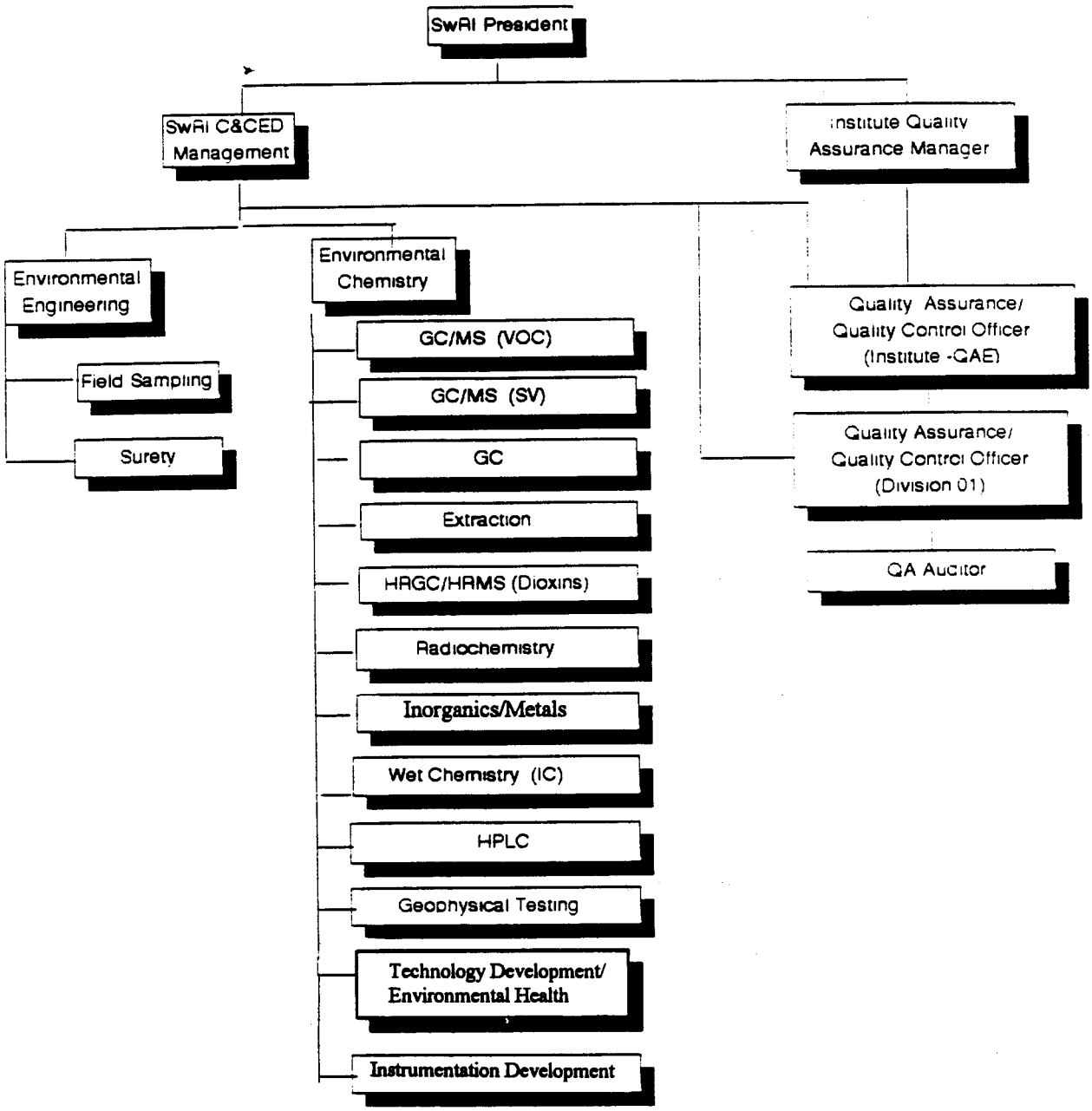


Figure 4.6 Generic Organization Chart for Laboratories in San Antonio Showing Relationships to Laboratory Supervisors, Management and Quality Team



4.5 QA Program Assessment

The QA/QC Officer shall conduct reviews of the total QA/QC program to evaluate its benefits and effectiveness. Based on these assessments, the QA/QC Officer shall prepare a written annual status report of QA activities and progress each year. This annual program assessment report will be submitted to the SwRI quality assurance manager, the directors and the C&CED vice president. This assessment report will include such information as:

1. Status of or changes to the QA/QC Project Plan
2. Significant QA problems, accomplishments, and recommendations
3. Results of Performance Audits
4. Results of Systems Audits
5. Summary of QA Training
6. External Audit Findings and Corrective Actions
7. SwRI Internal QA Audit and Surveillance Activities

The Institute QA will conduct surveillance on nuclear or Department of Defense analytical activities as well as inspection of documentation of files and assure duplicate file archives for all raw data. The QAE will also conduct periodic reviews of GLP projects. Routine project reviews shall be performed at the discretion of the Institute Quality Manager.

4.6 Tracking

Work orders are sent to all analytical areas involved, as well as individual personnel assigned to each section. The work order is reviewed against the contract or solicitation to confirm the quality control requirements. Holding times are adhered to as shown in Figures 4.7, 4.8 and 4.9 unless otherwise stated in the contract.

Tracking Forms as shown in Figure 4.10 are used as follows on every sample:

1. The case/SDG and each sample, by number, will be listed on the form.

2. Actual holding times and deliverables will be listed.

The personnel assigned to the area will use the Tracking Form to check against the logbook each morning. If the samples have not been analyzed (or extracted) within 48 hours prior to holding time, the supervisor of the section will be notified. This will enable priority adjustment, if necessary.

During the tracking the proper methods, sample preparations, equipment calibration, and quality control requirements are checked. If the samples have been analyzed and the case and quality control has met requirements, i.e., surrogates, CRQL, MS/MSD and all reanalyses, a request will be made for data transfer to the Division QA/QC Officer.

The individual assigned to the section will notify quality control of any discrepancies and non-compliance items. A correction action is submitted. Follow-up review will be done to confirm the problem has been corrected and provide narrative response.

The sample control records will remain at the storage area until the appropriate sample disposal. At this time the samples are evaluated for each specific hazard to determine the method of disposal. All samples categorized as Hazardous Waste are disposed of through the Institute's Hazardous Waste Disposal System as described in Division 01 SOP-01-01-09 and in the Institute Safety Manual. Documentation of Hazardous Waste Disposal including Waste Data Sheet (Figures 4.12 and 4.13) and a Sample Disposal Log (Figure 4.11). The Sample Control Record is documented with the Sample Disposal data and is filed. These files are kept for a period of 5 years.

Figure 4.7 Required Containers, Preservation Techniques and Holding Time

Required Containers, Preservation Techniques and Holding Times (40 CFR, Part 136, July 1, 1990)			
Parameter No/Name	Container[1]	Preservation[2,3]	Maximum Holding Time[4]
Table 1A-Bacterial Tests			
1-4. Coliform, fecal and total	P, G	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	6 hours
5. Fecal streptococci	P, G	do	Do
Table 1B-Inorganic Tests			
1. Acidity	P, G	Cool, 4°C	14 days
2. Alkalinity	P, G	do	Do
4. Ammonia	P, G	Cool, 4°C, H_2SO_4 to pH <2	28 days
9. Biochemical oxygen demand	P, G	Cool, 4°C	48 hours
11. Bromide	P, G	None required	28 days
14. Biochemical oxygen demand, carbonaceous	P, G	Cool, 4°C	48 hours
15. Chemical oxygen demand	P, G	Cool, 4°C, H_2SO_4 to pH <2	28 days
16. Chloride	P, G	None required	Do
17. Chlorine, total residual	P, G	do	Analyze immediately
21. Color	P, G	Cool, 4°C	48 hours
23-24. Cyanide, total and amenable to chlorination	P, G	Cool, 4°C, NaOH to pH >12. 0.6 g ascorbic acid[5]	14 days[6]
25. Fluoride	P	None required	28 days
27. Hardness	P, G	HNO_3 to pH <2, H_2SO_4 to pH <2	6 months
28. Hydrogen ion (pH)	P, G	None required	Analyze immediately
31, 43. Kjeldahl and organic nitrogen	P, G	Cool, 4°C, H_2SO_4 to pH <2	6 months
Metals[7]			Analyze immediately
18. Chromium VI	P, G	Cool, 4°C	24 hours
35. Mercury	P, G	HNO_3 to pH <2	28 days
3, 5-8, 10, 12, 13, 19, 20, 22, 26, 29, 30, 32-34, 36, 37, 45, 47, 51, 52, 58-60, 62, 63, 70-72, 74, 75. Metals, except chromium VI and mercury	P, G	do	6 months
38. Nitrate	P, G	Cool, 4°C	48 hours
39. Nitrate-nitrite	P, G	Cool, 4°C, H_2SO_4 to pH <2	28 days
40. Nitrite	P, G	Cool, 4°C	48 hours
41. Oil and grease	G	Cool, 4°C, H_2SO_4 to pH <2	28 days
42. Organic carbon	P, G	Cool, 4°C, HCl or H_2SO_4 to pH <2	Do
44. Orthophosphate	P, G	Filter immediately, Cool, 4°C	48 hours
46. Oxygen, Dissolved Probe	G, Bottle and top	None required	Analyze immediately
47. Winkler	do	Fix on site and store in dark	8 hours
48. Phenols	G only	Cool, 4°C, H_2SO_4 to pH <2	28 days
49. Phosphorus (elemental)	G	Cool, 4°C	48 hours
50. Phosphorus, total	P, G	Cool, 4°C, H_2SO_4 to pH <2	28 days

Required Containers, Preservation Techniques and Holding Times (40 CFR, Part 136, July 1, 1990)			
Parameter No/Name	Container[1]	Preservation[2,3]	Maximum Holding Time[4]
53. Residue, total	P, G	Cool, 4°C	7 days
54. Residue, Filterable	P, G	do	7 days
55. Residue, Nonfilterable (TSS)	P, G	do	7 days
56. Residue, Settleable	P, G	do	48 hours
57. Residue, Volatile	P, G	do	7 days
61. Silica	P	do	28 days
64. Specific conductance	P, G	do	Do
65. Sulfate	P, G	do	Do
66. Sulfide	P, G	Cool, 4°C add zinc acetate plus sodium hydroxide to pH >9	7 days
67. Sulfite	P, G	None required	Analyze immediately
68. Surfactants	P, G	Cool, 4°C	48 hours
69. Temperature	P, G	None required	Analyze
73. Turbidity	P, G	Cool, 4°C	48 hours
Table 1C-Organic Tests[8]			
13, 18-20, 22, 24-28, 34-37, 39-43, 45-47, 56, 66, 88, 89, 92-95, 97. Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2SO_2O_3$[5]	14 days
6, 57, 90. Purgeable aromatic hydrocarbons	do	Cool, 4°C, 0.008% $Na_2S_2O_3$[5], HCl to pH 2[9]	Do
3, 4. Acrolein and acrylonitrile	do	Cool, 4°C, 0.008% $Na_2S_2O_3$[5], adjust pH to 4-5[10]	Do
23, 30, 44, 49, 53, 67, 70, 71, 83, 85, 96. Phenols[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction, 40 days after extraction
7, 38. Benzidines[11]	do	do	7 days until extraction[13]
14, 17, 48, 50-52. Phthalate esters[11]	do	Cool, 4°C	7 days until extraction; 40 days after extraction
72-74. Nitrosamines[11,14]	do	Cool, 4°C, store in dark, 0.008% $Na_2S_2O_3$[5]	Do
76-82. PCBs[11] acrylonitrile	do	Cool, 4°C	Do
54, 55, 65, 69. Nitroaromatics and isophorone[11]	do	Cool, 4°C, 0.008% $Na_2S_2O_3$[5] store in dark	Do
1, 2, 5, 8-12, 32, 33, 58, 59, 64, 68, 84, 86. Polynuclear aromatic hydrocarbons[11]	do	do	Do
15, 16, 21, 31, 75. Haloethers[11]	do	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	Do
29, 35-37, 60-63, 91. Chlorinated hydrocarbons[11]	do	Cool, 4°C	Do
87. TCDD[11]	do	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	Do
Table ID-Pesticides Tests:			
1-70. Pesticides[11]	do	Cool, 4°C, pH 5-9[15]	Do
Table IE-Radiological Tests			

Required Containers, Preservation Techniques and Holding Times (40 CFR, Part 136, July 1, 1990)			
Parameter No/Name	Container[1]	Preservation[2,3]	Maximum Holding Time[4]
1-5. Alpha, beta and radium	P, G	HNO_3 to pH <2	6 months

1. Polyethylene (P) or Glass (G).

2. Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.

3. When any sample is to be shipped by common carrier or sent through the United States Mails, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of this table, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: hydrochloric acid (HCl) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); and sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

4. Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer time, and has received a variance from the Regional Administrator under § 136.3(e). Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show that this is necessary to maintain sample stability. See § 136.3(e) for details.

5. Should only be used in the presence of residual chlorine.

6. Maximum holding time is 24 hours when sulfide is present. Optionally all samples may be tested with lead acetate paper before pH adjustments in order to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

7. Samples should be filtered immediately on site before adding preservative for dissolved metals.

8. Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.

9. Sample receiving no pH adjustment must be analyzed within 7 days of sampling.

10. The pH adjustment is not required if acrolein will not be measured. Samples of acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

11. When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re the requirement for thiosulfate reduction of residual chlorine), and footnotes 12 and 13 (re the analysis of benzidine).

12. If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0 ± 0.2 to prevent rearrangement to benzidine.

13. Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.

14. For the analysis of diphenylnitrosamine, add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.

15. The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

Figure 4.8 Preservative and Holding Times for the Contract Laboratory Protocol

Preservative and Holding Times for the Contract Laboratory Protocol				
			Holding Times	
Parameter	Container	Preservative	Soil	Water
Volatiles by gas chromatography /mass spectroscopy (GC/MS)	Water: 40-mL glass vial with Teflon-lined septa Soil-gas with Teflon-lined septa	Cool, 4°C	10 days	10 days
PCB/Pesticides	G, Teflon-lined lid	Cool, 4°C	Extract within 10 days, analyze 40 days	Extract within 5 days, analyze 40 days
Extractable organics	G, Teflon-lined lid	Cool, 4°C	Extract within 10 days, analyze 40 days	Extract within 5 days, analyze 40 days
Metals	P, G	HNO_3 to pH <2	6 months	6 months
Mercury	P, G	HNO_3 to pH <2	26 days	26 days
Cyanide	P, G	NaOH to pH >12, cool 4°C, add 0.6 g ascorbic acid if residual chlorine present	14 days	14 days
Chromium VI	P, G	HNO_3 to pH <2	24 h	24 h

Figure 4.9 Preservative and Holding Times for the EPA Document - SW-846, 3rd Edition

Preservative and Holding Times for the Contract Laboratory Protocol				
			Holding Times	
Parameter	Container	Preservative	Soil	Water
Volatiles by gas chromatography/ mass spectroscopy (GC/MS) and GC	Water: 40-mL glass vial with Teflon-lined septa Soil-gas with Teflon-lined septa	Cool, 4°C	14 days	14 days
PCB/Pesticides	G, Teflon-lined lid	Cool, 4°C	Extract within 7 days, analyze 40 days	Extract within 7 days, analyze 40 days
Extractable organics	G, Teflon-lined lid	Cool, 4°C	Extract within 7 days, analyze 40 days	Extract within 7 days, analyze 40 days
Metals	P, G	HNO_3 to pH <2	6 months	6 months
Mercury	P, G	HNO_3 to pH <2	28 days	28 days
Cyanide	P, G	NaOH to pH >12, cool 4°C, add 0.6 g ascorbic acid if residual chlorine present	14 days	14 days
Chromium VI	P, G	HNO_3 to pH <2	24 h	24 h

Figure 4.10 Tracking Form

Division One
Environmental Chemistry

Southwest Research Institute
Tracking Sheet

Project No
Case
SDG
Client
Work Order

				DOXORUBICIN		VX-710					
				ANALYSIS FOR DOXORUBICIN		*ANALYSIS FOR VX-710*					
Sample ID	Client Sample ID	CED	VTSR	Required	Actual	Required	Actual	Required	Actual	Required	Actual
52948	AJF0106 SD7 26-28HR	04/18/95	04/20/95	05/18/95		05/18/95	/ /				
52949	AJF0106 SD7 28-32HR	04/18/95	04/20/95	05/18/95		05/18/95	/ /				
52950	AJF0106 SD7/8 32-40	04/18/95	04/20/95	05/18/95		05/18/95	/ /				
52951	AJF0106 SD4/5 72-84	04/13/95	04/20/95	05/18/95		05/18/95	/ /				
52952	AJF0106 SD6 -8-0	04/17/95	04/20/95	05/18/95		05/18/95	/ /				
52953	AJF0106 SD6 0-8	04/17/95	04/20/95	05/18/95		05/18/95	/ /				
52954	AJF0106 SD6/7 8-16	04/17/95	04/20/95	05/18/95		05/18/95	/ /				
52955	AJF0106 SD7 16-24	04/18/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52956	AJF0106 SD5 84-96	04/14/95	04/20/95	05/18/95		05/18/95	/ /				
52957	AJF0106 SD5 96-98	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52958	AJF0106 SD5 98-100	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52959	AJF0106 SD5 100-104	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52960	AJF0106 SD5 104-108	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52961	CEH0104 SD9 72-84	04/13/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52962	CEH0104 SD9 84-96	04/13/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52963	CEH0104 SD9 96-98	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52964	CEH0104 SD9 98-100	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52965	CEH0104 SD9 100-104	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52966	CEH0104 SD9 104-108	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				

END OF REPORT

Comments or Notes:

rev (6/27/94)

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Figure 4.11 Hazardous Waste Log

Southwest Research Institute

HAZARDOUS WASTE LOG				
Date	Compound	Quantity (mL)	Name	Project No.

Figure 4.12 Mixed Waste Data Sheet

WASTE DATA SHEET

Item No.	ID Number	Material Description	Material Quantity	Project No.
01				
02				
03				
04				
05				
06				
07				
08				
09				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

I hereby certify that the above information is complete and accurate.

Printed Name _____ Signature _____ Date _____

Figure 4.13 Bulk Waste Data Sheet

WASTE DATA SHEET

Container ID Number (Assigned at Central Storage) _____

Division Hazardous Waste Representative _____ Ext. _____

General Waste Description _____

_____

Quantity in Container(s) _____ kg, lb, cc, oz.

	Chemical Constituents	Concentration
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____
5.	_____	_____
6.	_____	_____
7.	_____	_____
8.	_____	_____

EPA Characterization Codes (D Nos.) _____ _____ _____

EPA Hazardous Waste Number (F, K, P, U Nos.) _____

OSHA: Contain listed compounds? ☐ Yes ☐ No PHS: Infectious Wastes? ☐ Yes ☐ No

Is the waste reactive with water? ☐ Yes ☐ No with air? ☐ Yes ☐ No

Viscosity ☐ Low ☐ Medium ☐ High

Layers at 70°F ☐ None ☐ Two ☐ Multilayers

Give any additional information on the hazards of the waste: pH _____ Flash pt: _____

BTU: _____ Specific Wt: _____ Color: _____

NOTICE: THIS DATA SHEET WILL NOT BE ACCEPTED WITHOUT SIGNATURE AND DATE.

I hereby certify that the above information is complete and accurate.

_____	_____	_____
Signature	Title	Date

NOTE: PLEASE WRITE YOUR NAME AND BUILDING NUMBER ON EACH DRUM.

4.7 Analytical Procedures

The laboratory currently handles all EPA, ASTM, SW-846, and other methods (see Figure 4.14) used for Routine Analytical Services and Special Analytical Services. These methods shall be readily available to all analysts with detection limits and matrix requirements by method. If variances will be needed the client is contacted in writing regarding these modifications and the purpose for any changes. A notation is made in the analytical report identifying the approval of modification.

Figure 4.14 Laboratory Analytical Methods

CONVENTIONAL PARAMETERS AND BACTERIOLOGICAL ANALYSES ON WATER AND WASTEWATER

Parameter	Methods	
	Std Mtds	EPA
Acidity	402	305.2
Alkalinity	403	310.1
Bicarbonate (only)	403	310.1
Calcium	314B	130.2
Carbonate (only)	403	310.2
Carbon dioxide	410A	
Chloride	407B	325.3
Chlorine demand	409	
Chlorine residual	408F	330.2
Color	204	110.3
Cyanide	412	335.2
Hardness	314B	130.2
Nitrate	418D	352.1
Nitrite	419	354,1
Nitrogen		
Ammonia with distillation	417A	350.2
Ammonia without distillation	417B	350.2
TKN	420B	351.3
Organic (only)		
Oil and Grease		
Separatory funnel technique	503A	413.1
Infrared	503B	413.2
Soxhlet extraction	503C	
Oxygen Demand		
Biochemical	507	405.1
Chemical	508	410.1
Immediate		

CONVENTIONAL PARAMETERS AND BACTERIOLOGICAL ANALYSES ON WATER AND WASTEWATER

Parameter	Methods	
	Std Mtds	EPA
pH Value	423	150.1
Phenol with distillation	410A	420.1
Phenol without distillation	510B	420.1
Phosphorus		
Ortho	424E	365.2
Total	424C	365.2
Residue		
Total	209A	160.3
Total volatile and/or fixed	209F	160.4
Settleable matter	209E	160.5
Total dissolved solids	209B	160.1
Total Suspended solids	209C	160.2
Fixed and volatile solids	209D	160.4
Silica	525	370.1
Specific conductance	205	120.1
Sulfate	426	375.4
Suflide	427	376.1
Sulfite	428	377.1
Surfactants	412B	425.1
Total carbon	505	415.2
Total organic carbon	505A	415.2
Turbidity	214	180.1

QC requirements specified in the methods will be followed

METAL ANALYSES

Metal	AAS/Furnance			AAS/Flame			ICAP/AES		
	SW-846	EPA	CLP-M	SW-846	EPA	CLP-M	SW-846	EP A	CLP-M
Aluminum (Al)		202.2		7020	202.1		6010	200.7	200.7
Antimony(Sb)	7041	204.2	204.2	7040	204.1		6010	200.7	200.7
Arsenic(As)	7060	206.2	206.2	7061	206.1		6010	200.7	200.7
Barium(Ba)		208.2		7080	208.1		6010	200.7	200.7
Beryllium(Be)	7091	210.2	210.2	7090	210.1		6010	200.7	200.7
Boron(B)							6010	200.7	200.7
Cadmium(Cd)	7131	213.2	213.2	7130	213.1		6010	200.7	200.7
Calcium(Ca)				7140	215.1	215.1	6010	200.7	200.7
Chromium(Cr)	7191	218.2	218.2	7190	218.1		6010	200.7	200.7
Cobalt(Co)	7201	219.2		7200	219.1		6010	200.7	200.7
Copper(Cu)		220.2		7210	220.1		6010	200.7	200.7
Gold(Au)		231.2			231.1				
Iron(Fe)		236.2		7380	236.1		6010	200.7	200.7
Lead(Pb)	7421	239.2	239.2	7420	239.1		6010	200.7	200.7
Lithium(Li)									
Magnesium(Mg)	7450				242.1	241.1	6010	200.7	200.7
Manganese(Mn)		243.2		7460	243.1		6010	200.7	200.7
Mercury (Hg)	7470‡ 7471‡	245.1‡ 245.1‡	245.1‡						
Molybdenum(Mo)				7480	2 46.1		6010	200.7	200.7
Nickel(Ni)		249.2		7520	249.1		6010	200.7	200.7
Potassium(K)		258.1		7610		258.1	6010	200.7	200.7
Phosphorus(P)									
Selenium(Se)	7740	270.2	270.2	7741	270.3		6010	200.7	200.7
Silicon(Si)							6010	200.7	200.7
Silver(Ag)		272.2	272.2	7760	272.1		6010	200.7	200.7
Sodium(Na)		273.2		7770	273.1	273.1	6010	200.7	200.7
Thallium(Tl)	7841	279.2	279.2	7840	279.1		6010	200.7	200.7
Tin(Sn)		282.2		7870	282.1				
Titanium(Ti)		283.2			283.1				200.7
Vanadium(V)	7911	286.2		7910	286.1		6010	200.7	200.7
Zinc(Zn)		286.2		7950	289.1		6010	200.7	200.7

* Gaseous hydride
† On request
‡ Manual cold vapor method

ORGANIC ANALYSIS

Parameter	Methods		
	CFR	SW-846	EPA
GAS CHROMATOGRAPHY(GC)			
Halogenated volatile organics	601	8010	502.1
Nonhalogenated volatile organics		8015	
Aromatic volatile organics	602	8029	
Acrolein, acrylonitrile, acetonitrile	603	8030	
Organochlorine pesticides and PCBs	608	8080	505/508
PCBs only	608	8080	508
Chlorinated hydrocarbons	612	8120	
Organophosphorus pesticides	614	8140	507
Chlorinated herbicides	615	8150	515.1
Other analyses not listed			
GAS CHROMATOGRAPHY/MASS SPECTROMETRY(GC/MS)			
Priority pollutants			
Volatile organics (VOAs)	624	8240	524.2
Semivolatile organics using fused silica capillary columns	625	8270	525.1
Up to 10 additional peaks for VOAs and semivolatiles	625	8270	
Polynuclear aromatic hydrocarbons (PAH) using the PAH retention index system	675		
2,3,7,8-Tetrachlorodibenzo-p-dioxin(TCDD) or total TCDD	613		
2,3,7,8-TCDD and 2,3,7,8-TCDF		8280	
Tetra through octa polychlorinated dibenzo-p-dioxins(PCDD) and dibenzofurans (PCDF)		8280	
Tetra through octa PCDD and PCDF		8290	
Special analysis including chemical ionization (pulsed positive ion and negative chemical ionization), PCB isomers, pyrolysis, head space, characterization, etc.			
CONTRACT LABORATORY PROGRAM (CLP) FOR ORGANICS including hazardous substances and additional compounds by GC/MS and GC/EC	Methods listed above		
EPA APPENDIX IX COMPOUNDS (Organics and Inorganics)	Part 261		
FOURIER TRANSFORM INFRARED SPECTROMETER (FTIR) Qualitative and/or quantitative characterization of various organic and inorganic compounds in aqueous and nonaqueous matrices			

ORGANIC ANALYSIS

Parameter	Methods		
	CFR	SW-846	EPA
COMPUTERIZED ULTRAVIOLET-NEAR INFRARED AND ULTRAVIOLET-VISIBLE ARRAY PROCESSOR This array processing system observes the evolution of the UV-visible spectrum at 0.1 second intervals. Data handling is similar to the FTIR (storage, subtraction, etc.). The spectrophotometer has a very large dynamic range and small quantities of chromophoric impurities can be detected.			
NUCLEAR MAGNETIC RESONANCE (NMR) • Structure identification of organic compounds in aqueous or organic solutions • High temperature polymer characterization • Purity analysis of organic materials • Analysis of ^{1}H, ^{13}C, ^{15}N, ^{17}O, ^{31}P and a number of other nuclei in organic molecules.			
HIGH PERFORMANCE LIQUID CHROMATOGRAPHY (HPLC)			
Polynuclear aromatic hydrocarbons (PAH)		8310	525.1
Explosives		8330	
Carbamate pesticides	531		
LIQUID CHROMATOGRAPHY/MASS SPECTROMETRY (LC/MS) Analysis of high molecular weight polar and nonpolar organic compounds in aqueous and nonaqueous liquids			

MISCELLANEOUS ANALYSIS

Parameter	Method(s)
ION CHROMATOGRAPHY	
Major anions (individual)	
Chloride	EPA 300.0
Fluoride	"
Nitrate-N	"
Mitrite-N	"
Ortho phosphate-P	"
Sulfate	"
Major cations (individual)	
Calcium	Dionex (IC)
Magnesium	"
Sodium	"
Potassium	"
Major anions or cations (complete)	"
Other ions Phenols	Dionex (IC)
Formate	"
Acetate	"
Cyanides	"
Sulfides	"
Others not listed	
BIOTREATABILITY - Lab Study	ASTM D2667-82
X-RAY FLUORESCENCE Metal scan of liquids and solids for elements heavier than sodium	NA
COULTER COUNTER (COMPUTERIZED) Particle size distribution of soils, sediments, dust, etc., from 1 μm to 1 mm. Instrument is capable of performing volume and/or weight distributions.	

RCRA ANALYSIS OF GROUND WATER

Parameter	Methods
INDICATORS OF DRINKING WATER SUITABILITY (IDWS)	
Metals by AAS/Furnace	
Arsenic	EPA 206.2
Barium	EPA 208.2
Cadmium	EPA 213.2
Chromium	EPA 218.2
Lead	EPA 239.2
Mercury*	EPA 245.1
Selenium	EPA 270.2
Silver	EPA 272.2
Sample Preparation	
TOTAL METALS	
PESTICIDES BY GC/ECD	
Endrin Lindane Methoxychlor Toxaphene	CFR 608
2,4-D 2,4-TP (Silvex)	CFR 615
TOTAL PESTICIDES	
RADIOACTIVITY	
Radium 226 and 288	STD 707; 708
Gross Alpha	STD 703
Gross Beta	STD 703
Strontium	STD 704
Tritium	STD 708
TOTAL RADIOACTIVITY	
OTHERS	
Nitrate as N	EPA 300.0 (IC)
Fluorides	EPA 300.0 (IC)
Turbidity	EPA 180.1;STD 214
Total coliform bacteria	STD 909
TOTAL OTHERS	
TOTAL IDWS	

RCRA ANALYSIS OF GROUND WATER

Parameter	Methods
INDICATORS OF GROUND WATER QUALITY (IGWQ)	
Chloride	EPA 300.0 (IC)
Sulfate	EPA 300.0 (IC)
Iron	EPA 200.7 (ICP)
Manganese	EPA 200.7 (ICP)
Sodium	EPA 200.7 ICP)
Phenol	EPA 420.1
TOTAL IGWQ QUALITY	
INDICATORS OF GROUND WATER CONTAMINATION (IGWC) (Quadruplicate Analysis)	
pH	EPA 150.1;STD 423
Specific conductance	EPA 120.1;STD 205
Total organic carbon	EPA 415.2; STD 5-05A
Total organic halides	SW-846 9020
TOTAL COST FOR IGWC	
TOTAL FOR COMPLETE RCRA ANALYSIS	

* Mercury is analyzed by the cold vapor method

† These isotopes are analyzed only if the gross alpha exceed 5 pCi/L and gross beta exceeds 8 pCi/L

WASTE EVALUATION BY SW-846 PROCEDURES

Parameter	SW-846 Method
IGNITABILITY Pensky-Martens Closed Cup	1010
CORROSIVITY (toward steel)	1110
REACTIVITY	Gas evolution
EXTRACTION PROCEDURE TOXICITY (EP TOX)	
Leachate preparation	1310
Analysis of Leachate	
Metals*	
Arsenic	7060 (furn)
Barium	7080 (flame)
Cadmium	7130 "
Chromium	7190 "
Lead	7420 "
Mercury	7470 (cold vapor)
Selenium	7740 (furn)
Silver	7760 (flame)
Sample preparation	
Pesticides by GC/EC	
Endrin Lindane Methoxychlor Toxaphene	8080
2,4-D 2,4,5-TP (Silvex)	8150
TOTAL EP TOX	
TOXICITY CHARACTERISTIC LEACHING PROCEDURE (TCLP) includes volatile and semivolatile organics and metals	40 CFR 261.3

* Analysis by method of additions

AIR SAMPLES

Parameter
AMBIENT AIR**
Vost Tube (TO 1) or CMS Tube (TO 2) Analysis
Preparation
PUF (TO 10)
Analysis (GC/ECD)
Preparation
2.2 cm ID x 7.6 cm length
6.5 cm ID x 7.6 cm length
8.9 cm ID x 7.6 cm length
Canister (TO 14) Analysis
Canister cleaning
Canister sampler cleaning
Fixed Gases (O_2, N_2, CO_2) Percent
Trace
Formaldehyde† (NIOSH 3500)
Nitrogen oxides† (NO_2, NO_x) by IC
Sulfur dioxide† (total sulfur by ICAP)
Suspended particulate matter† (TSS)
Carbon monoxide
Hydrogen sulfide† (total sulfide by titration)
Asbestos (bulk identification or fiber count)
Others
INDUSTRIAL HYGIENE (PERSONAL SAMPLES)
Chemical substances in the work environment adopted by ACGIH

* The range of adsorbents used to collect contaminants for these types of analysis is broad and includes polyurethane foam (PUF), XAD resins, florisil, charcoal, Tenax and bag sampling. Preparation includes media clean-up and quality control check by an approved and analytical method. Methodology is also varied. Specific sampling and analytical plans are designed on an individual basis to accomplish the goals of each task. Methods are those sepcified by EPA and ACGIH

** All other TO methods are also performed. Prices upon request.

† From impinger

GEOPHYSICAL TESTING

Parameter	Method
Atterberg Limits	ASTM-4318
Calcium Carbonate	ASTM-4373
Hydrometer	ASTM-D422
Moisture Retention	ASTM-D2325
Moisture Content	ASTM-D2216
Permeability	ASTM-D2434
Procter	ASTM-D69/D1557
Wet Sieve	ASTM-C117/C136
Dry Sieve	ASTM-D422
Specific Gravity	ASTM-C127/C128/C854
Unconfined Compressive Strength	ASTM-C39/C109/D2166
One-Dimensional Consolidation Properties	ASTM-D4186

PERSONNEL QUALIFICATIONS

REV 10

Copy No. _____

Approvals:

Division 01 Quality Assurance _____ Date: 6/27/95

Division 01 Management _____ Date: 6/28/95

SwRI QA Management _____ Date: 6/27/95

5. PERSONNEL QUALIFICATIONS

All professional staff members in the laboratory shall have a complete understanding of the requirements of the quality assurance program. A control copy of each revision of the plan and a briefing on the plan will be provided by the quality officer or his/her designee.

The QA/QC Officer and QA Auditor will review the QA requirements specific to the project with the Analytical Supervisor and Project Manager prior to starting project. The quality assurance plan for the project will be prepared in accordance with the project requirements. Upon project start-up, the remaining project assignments will be made. All personnel assignments to tasks affecting data quality shall be made on the basis of adequate education, training, and experience. Inexperienced personnel will be closely supervised and provided with standard operating procedures located on the Laboratory Information Management System (LIMS). All project personnel will be trained in QA/QC responsibilities upon assignment to the project.

5.1 Training

New laboratory technicians shall be shown location of controlled copies of the QAPP and standard operating procedures. They will be formally trained by the QA Auditor as well as the Analytical Supervisor. Documentation of any training is maintained in a training file for each employee. All revisions to procedures shall be given to staff maintaining controlled copies (in written form). A new employee training session and annual training are offered to all employees by Division Personnel. Prior to any actual work procedures requiring GLP or Nuclear procedures, employees will be trained by the QA/QC Officer for Good Laboratory Practice Procedures and by the Institute QA for Nuclear Training. Training files will be updated to show the latest training and will be re-evaluated annually.

A training seminar will be held for all new analytical personnel and random refresher trainings for all personnel performing project work will be conducted on an annual basis. This training will cover the following information:

- Quality Assurance Program Plan
- Standard Operating Procedures
- Documentation requirements
- Custody procedures
- Special analytical request procedures
- Contact personnel for questions/problems

* A handout may be provided to supplement the training information.

At the end of the initial QA training session, a Certificate of Completion will be given to the employee and a copy will be put in his/her training file. The personnel training manual will be updated annually with new training information.

5.2 Personnel Safety

The purpose of a laboratory safety program is to provide convenient information for hazard recognition and control. Fires, explosions and exposure to chemical, biological agents, and other hazards can usually be anticipated and therefore prevented.

For these reasons, Southwest Research Institute has developed a Safety Manual which is distributed to every employee. In addition to the Safety Manual, every employee is familiarized and instructed with the proper use of safety equipment in his/her laboratory. According to the Federal (OSHA) Hazard Communication standard each laboratory has a continually updated notebook of Material Safety Data Sheets.

FACILITIES, EQUIPMENT AND SERVICES

REV 8

Copy No. _____

Approvals:

Division 01 Quality Assurance	[signature]	Date: 6/27/95
Division 01 Management	[signature]	Date: 6/28/95
SwRI QA Management	[signature]	Date: 6/27/95

6. FACILITIES, EQUIPMENT, AND SERVICES

6.1 Cleaning of Sample Preparation Containers

In analyzing for trace amounts of organic and inorganic substances, it is imperative to ensure that all materials that may come in contact with the sample will be free from contamination. Specific instructions for preparation of material will be incorporated into the project work plan, and the instructions in the laboratory SOP will be followed. All glassware used for inorganic and organic analyses shall be cleaned in accordance with the standard operating procedures. The quality of glassware cleaning procedure is checked through the use of method blank preparations with each sample set. Should the blank preparation show the presence of contamination, then the source of contamination is sought by examination of the various components of sample preparation including glassware, reagents, and sample storage containers.

6.1.1 Organic Analysis

All solvents used will be distilled in glass and glassware will be cleaned as specified in SOP-01-08-01.

6.1.2 Inorganic Analysis

During the sample preparation, contamination from the laboratory can also affect the analytes content of the samples. For this reason, all operations which require the same or some stage of its processing to be exposed to the laboratory atmosphere (i.e., weighing operations, opening digestion bombs, etc.) will be performed on clean benches. To reduce the quantity of contamination in the laboratories, routine cleaning will be scheduled into the work week. This is to consist of house cleaning duties at the end of each day and on the last work day of the week the last few minutes will be utilized in very thorough cleaning of the laboratories and equipment. This ensures a minimum of contaminants in the laboratory atmosphere at any particular time.

6.2 Instrument Calibration

6.2.1 Gas Chromatographs shall be calibrated in accordance with SOP 01-05-01.

The analytical coordinator or the analyst will prepare calibration standards that contain the compound(s) of interest. The standards will normally be prepared at concentrations covering two or more orders of magnitude that completely bracket the working range of the chromatographic system.

The analyst will assemble the chromatographic apparatus delineated in the work plan and establish the proper operating parameters for the compound(s) under study. By injecting calibration standards, the analyst will establish the sensitivity limit of the detector and the linear range of the analytical system for each compound.

Prior to using a cleanup procedure, e.g., Florisil column, the analyst will process a set of calibration standards through the system to validate the elution pattern given in the analytical method and the absence of interferences from the reagents used.

A list of equipment and capabilities is listed in Table 1.

6.2.2 Gas Chromatography/Mass Spectrometry shall be calibrated in accordance with SOP 01-05-01.

Daily calibration checks will be made using perfluorotributylamine (FC-43) as the calibration standard. When the calibration is complete, performance evaluation will be made.

For volatile organic analysis, 4-bromofluorobenzene (BFB) is used to tune the mass spectrometer. The key ion abundance criteria are shown in Table 2.

6.2.3 Dioxin shall be calibrated in accordance with SOP-01-13-01 and SOP-01-13-03.

Minimum calibration shall be performed using Native CDDs and CDFs requirements given in the above-referenced SOPs.

6.2.4 Atomic Absorption Spectrophotometry shall be calibrated in accordance with SOPs 01-07-05 and 01-07-13.

This calibration procedure is patterned after "Monitoring Industrial Wastewater," USEPA Technology Transfer, August 1973, Section 8, Preparation of Standards and Calibration. Stock solutions of the metal(s) under study will be prepared using high purity standards and reagents at concentrations of 1000 mg of the metal per liter of water. These stock solutions will be used to prepare the calibration standards.

Prepare a blank acid and calibration standard using the same type of acid as will be used for sample processing. The calibration standards should cover the range of the samples, where this is known or can be reasonably determined. Aspirate the blank, followed by the standards from highest to lowest concentration. To establish that the calibration has not changed, blanks and standards will be run not less frequently than after every 20 samples, but more frequently if in the judgment of the analyst a system change seems likely. Flameless analysis generally requires more frequent continuous calibration verification (after every 10 to 15 samples).

If the sample matrix is so complex that viscosity, surface tension, and components cannot be accurately matched with standards, the method of standard additions will be used. Standard additions will be made to portions of the sample, and the calibration curve will be prepared from the responses to these aspirations. These standards will be analyzed in the same manner and with the same frequency as the reagent standards discussed above. A complete description of the method of additions technique is given in Section 8.5 of "Monitoring Industrial Wastewater."

6.2.5 Ion Chromatograph(s) shall be calibrated in accordance with SOP-11-02

At the beginning of each work day or upon each alteration to the analysis being performed, the analyst will establish the calibration by running a series of standards at a minimum of three concentration levels: low, medium and high. The medium standard will be run after every ten samples to verify the calibration. If the response differs from the calibration response by more than 10%, the analyst will:

- repeat the standard injection to determine if the previous result was correct,
- if correct, repeat the calibration using the three standards,
- rerun all samples after the last consistent calibration check.

6.2.6 Total Organic Carbon (TOC) Analyzer shall be calibrated in accordance with SOP 01-11-01.

The TOC analyzer is internally calibrated to give a direct readout of micrograms per milliliter (μg/mL) of organic carbon. At the beginning of each work day, the analyst will prepare and inject the standard for the appropriate range:

- 10 ppm for 1 mL
- 400 ppm for 250 μl
- 2000 ppm for 40 μl

A second injection of the standard should be performed. If the two are within 5% of each other, the instrument is calibrated as such. A third injection is performed. The output should read within 5% of the standards true value. It this is so, analysis is started.

If this is not true, then calibration is repeated until the standard is adequate. A CCV (standard of original concentration) will be injected after every six sample "sets" of injections, or after six soil sample combustions. If the response differs from the true value by more than 10%, or per client, the analyst will repeat the injection to determine if previous result was correct. If correct, repeat the calibration and rerun all samples after the last consistent calibration check.

Table 1 ANALYTICAL INSTRUMENTATION

Description	Number	Year(s) Purchased
Gas Chromatographs/High Resolution Mass Spectrometer (GC/HRMS)		
■ Fisons Autospec Ultima with CTC A200S autosampler	1	1993
■ Fisons Autospec with CTC A200S autosampler	1	1991
■ Finnigan 8200	1	1989
Gas Chromatographs/Mass Spectrometers/Mass Spectrometers (GC/MS/MS)		
■ Fisons TRIO-III with Waters 600-MS HPLC connected to a Vestec particle beam interface (Universal Interface, Module B)	1	1989
■ Finnigan TSQ-4600	1	1991
Gas Chromatographs/Mass Spectrometers (GC/MS); Total: 17		
■ Finnigan 4600 with CTC A200S autosampler	2	1986
■ Finnigan 4500 with CTC A200S autosampler	1	1985
■ Finnigan 4500 with Tekmar 2000/Dynatec Precision Sampling PTA-30 autosampler	2	1985
■ Fisons TRIO-1S with Entech ELA Model 2000 canister autosampler	2	1991
■ Fisons TRIO-1000 with Tekmar LSC-2000 purge and trap unit/Dynatec Precision Sampling PTA-30 autosampler	1	1992
■ Fisons MD-800 with CTC A200S autosampler	6	1992-94
■ Fisons TRIO-II with CTC A200S autosampler	2	1989
■ Finnigan with ion trap	1	1990
Gas Chromatographs (GC); Total: 24		
■ Hewlett-Packard 5890 GC with NP/FP detectors/a HP 7673A autosampler	3	1986-91
■ Hewlett-Packard 5890 GC with NP detector/a HP 7673A autosampler	1	1988
■ Hewlett-Packard 5890 Series II GC with ion trap	1	1990
■ Hewlett-Packard 5890 GC with a FP detector/a HP 7673A autosampler	1	1991
■ Hewlett-Packard 5890 GC with dual EC detectors/a HP 7673A autosampler	9	1986-91
■ Hewlett-Packard 5890 GC with single EC detectors/a HP 7673A autosampler	1	1986
■ Hewlett-Packard 5890 Series II GC with TC/FP detectors	1	1991
■ Hewlett-Packard 5890 GC with TC detectors/a HP 7673A autosampler	1	1986
■ Fisons GC 8000 GC with dual EC detectors/a CTC A200S autosampler	3	1992
■ Hewlett-Packard 5890 GC with FI/TC detectors/a HP 7673A autosampler	1	1987
■ Hewlett-Packard 5890 GC with FI detector	1	1987
■ Hewlett-Packard 5890 GC with dual pairs of OI PI/ELC detectors/Tekmar LCS-2000 purge and trap unit/Dynatec Precision Sampling PTA-30 autosampler	1	1989

Description	Number	Year(s) Purchased
High Performance Liquid Chromatographs (HPLC); Total: 9		
■ Waters HPLC with Waters 600E multisolvent delivery system capable of generating gradients using up to four solvents, postcolumn derivatization, Waters 420-AC fluorescence, and Waters 700 Satellite Waters Intelligent Sample Processor (WISP) autosampler	2	1989
■ Waters HPLC with 600E multisolvent delivery system, 990 photodiode array detector capable of continuous spectral monitoring and acquisition from 190 to 800 nm, 410 differential refractometer, 700 Satellite WISP autosampler, and U6K manual injector	1	1988
■ Waters HPLC with 600E multisolvent delivery system, 486 tunable absorbance detector, and 600 satellite WISP autosampler	3	1991
■ Waters HPLC with 486 tunable absorbance detector, 470 scanning fluorescence detector, and 717 autosampler	3	1992
Air Sampling and Analysis (Method TO-14 and PM-10)		
■ Anderson or Scientific Instrumentation Specialist (SIS) canisters (6 liter)	210	1988-1993
■ Entech 16-canister sampling manifold	2	1990
■ SwRI canister cleaning system with 16-port manifold, canister heating unit and two diffusion pumps (capable of reaching 10^{-6} torr with 16 canisters on manifold)	1	1993
■ Wedding & Associates, Inc. critical flow high volume sampler	1	1991
Gel Permeation Chromatographs (GPC); Total: 5		
■ Waters GPC with fraction collector, 501 HPLC pump, 440 absorbance detector, and 712 WISP autosampler	4	1990-91
■ Analytical Bio-Chemistry Laboratories with Autoprep 1002A with a fixed wavelength ISCO UH-5 UV detector	1	1986
Radiochemistry		
■ Beckman LS6000TA liquid scintillation counter	1	1993
■ Canberra 2400F proportional counter	1	1993
■ Canberra CWSLC-D gamma and alpha spectroscopy system	1	1993
■ Jarrell Ash 26-000 fluorometer for uranium detection	1	1983
Ion Chromatograph (IC)		
■ Dionex 2020i two conductivity, two electrochemical, and one UV-Vis detectors and Dionex autosampler	1	1985
■ Dionex 4000i with conductivity detector, degas module, and gradient pump	1	1994

Description	Number	Year(s) Purchased
Atomic Absorption Spectrophotometers (AAS)		
■ Perkin-Elmer 4100 Zeeman with Perkin-Elmer AS-60 autosampler	1	1993
■ Perkin-Elmer 5100 Zeeman with Perkin-Elmer AS-60 autosampler	2	1989 1994
■ Perkin-Elmer Fias 400 flow injection system with hydride attachment	1	1994
Inductively Coupled Argon Plasma Atomic Emission Spectrometer (ICP)		
■ Spectro FME-50 with Spectro ultrasonic nebulizer and a microprocessor controlled random access autosampler	1	1992
■ Perkin-Elmer 6500 including a Perkin-Elmer AS-3 automatic microsampler system	2	1984
Ion Chromatograph/Inductively Coupled Plasma/Mass Spectrometer (IC/ICP/MS)		
■ Dionex 4000i IC with Dionex conducting detector and gradient pump connected to Perkin-Elmer Elan 5000 ICP/MS with graphite furnace, flow injection and chelation sample introduction systems	1	1994
Mercury Analyzers		
■ Perkin-Elmer mercury amalgam system for ultralow level mercury detection	1	1994
■ Leeman Lab PS200 automated mercury analyzer	1	1992
■ Leeman Lab AP200 automated mercury digestor	1	1992
■ Perkin-Elmer AA set up for mercury determinations	1	1978
Supercritical Fluid Chromatograph (SFC)		
■ Lee Scientific 622 with pneumatically operated valve system for split/direct SFC injection, split/splitless GC injection, and two FIDs	1	1988
Supercritical Fluid Extractor (SFE)		
■ Suplex SFE-50	1	1990
Microwave Digestor		
■ GT Instruments Milestone MLS 1200 digestor/drying module with GT Fam 35 fumes absorbing module, Em 5 exhaust module and Acm 100 automated capping module	1	1991
Total Organic Halide Analyzer		
■ Xertex Dohrman	1	1982
Total Organic Carbon Analyzer		
■ Xertex Dohrman	1	1982

Description	Number	Year(s) Purchased
Geophysical Testing		
■ Mechanical soil compactor	1	1992
■ Hydrometer jar bath	1	1992
■ US standard sieves with sieve size from 3.5" to 53 μm	1 each	1989
■ Motorized sieve shaker	1	1989
■ Specific gravity set	1	1986
■ Sand density cone	1	1989
■ Five-bar pressure plate extractor	1	1991
■ Electromagnetic vibrator table	1	1991
■ Liquid limit device with removable cup	1	1991
■ Unconfined compressor apparatus	1	1991
■ Liquid limit device with counter	1	1989
■ 12" and 18" standard compaction hammers	2	1992
■ 4" and 6" standard compaction mold	2	1992
■ Sample ejector	1	1992
■ Mechanical analysis stirrer	1	1992
■ Desiccator	4	1986
■ Hydrometer jars	12	1989
■ AASHTO grooving tool	2	1992
■ Plastic limit set	2	1989
■ Compaction permeameters	4	1991
■ Combination permeameter (constant or falling head)	4	1991
■ Table top consolidation apparatus	1	1993
■ Shrinkage limit set	1	1992
■ Multiframe compression test system	1	1980
Wet Chemistry		
■ Technicon TRAACS 800	1	1991
■ Kjeltec System 1026 distilling unit	1	1991
■ Milton Roy Spectronic 1201	1	1990
■ Perkin-Elmer Junior III spectrophotometer	1	1985
■ YSI dissolved oxygen analyzer	1	1989

Table 2 Ion Abundance Criteria

For volatile organic analysis, 4-bromofluorobenzene (BFB) is used to tune the mass spectrometer. The key ion abundance criteria are as follows:

Mass	Ion Abundance Criteria
50	8.0 - 40 % of mass 95
75	30 - 66.0 % of mass 95
95	Base Peak, 100 % of relative abundance
96	5.0 - 9.0 % of mass 95
173	< 2.0 % of mass 174
174	50.0 - 120.0 % of mass 95
175	4.0 - 9.0 % of mass 174
176	93.0 - 101.0 % of mass 174
177	5.0 - 9.0 % of mass 176

For extractable organic analysis, performance evaluation will be performed using decafluorotriphenylphosphine (DFTPP). The key ion abundance criteria are as follows.

Mass	Ion Abundance Criteria
51	30.0 - 80.0 % of mass 198
68	< 2 % of mass 69
69	Mass 69 relative abundance
70	< 2 % of mass 198
127	25.0 - 75.0 % of mass 198
197	<1 % of mass 198
198	Base peak, 100 % of relative abundance
199	5.0 - 9.0 % of mass 198
275	10.0 - 30.0 % of mass 198
365	> 0.75 % of mass 198
441	Present, but less than mass 443
442	40.0 - 110.0 % of mass 198
443	15.0 - 24.0 % of mass 442

Method blanks shall be run to determine background daily and when changing columns to avoid contamination. For quantitation, inject one or more of the appropriate standards at the initiation of each analytical exercise to ensure that the column is performing properly.

There are 10 GC/MS instruments available. The Finnigan 3000 series is 12 years old; the Finnigan 4000 series is less than 6 years old; and all VG GC/MS are less than 1 year old.

6.2.7 Atomic Emission Spectrometry shall be calibrated in accordance with SOPs 01-07-12 and 01-07-25.

Calibration Standards - This calibration procedure is patterned after Test Methods for Evaluating Solid Waste, Method 6010, Paragraph 7.2, 7.3. Stock solutions of the metal(s) under study will be prepared using high purity standards and reagents at concentrations of 1000 mg/per liter. These stock solutions will be used to prepare the calibration standards.

Daily Calibration - At the beginning of each day the instrument will be profiled and calibrated as per the manufacturer specifications. The sample introductory system is optimized before calibration begins. Prepare a blank and calibration standards using the same type of acid as will be used for sample processing. The calibration standards should cover the range of the samples where this is known or can be reasonably determined. Aspirate the blank followed by the standards from highest to lowest.

Initial Calibration Blank (ICB), Initial Calibration Verification (ICV), Continuing Calibration Blank, (CCB) and Continuing Calibration Verification (CCV) - To establish that the calibration has not changed a blank and a continuing calibration verification standard will be run immediately after calibration, then after every 10 samples, and at the end of the analytical run. The standard material for making up the continuing calibration verification standard shall be from a source different than that used to make up the calibration standards. Preferably the use of NBS Standard material shall be employed for this purpose. If one is not available then a source from a different vendor than the one from which the calibration standards were obtained shall be used.

6.2.8 Mercury Analyzer shall be calibrated in accordance with SOP-01-07-24.

The PS200 Mercury Analyzer uses a program called a MACRO. Depending on the MACRO used this instrument will run a 5 point or 6 point calibration curve.

If the curve falls out (r-value of less than .995), the PS200 will automatically re-run the curve.

The check standard must be within $\pm 20\%$ of the true value or the PS200 will automatically recalibrate and rerun the Initial Calibration Blank (ICB) and Initial Calibration Verification (ICV).

The PS200 runs a Continuing Calibration Blank (CCB) and Continuing Calibration Verification (CCV) every 10 samples. If the CCV is not within 20% of true value the instrument will re-calibrate and rerun the last 10 samples before the last CCV run and continue with the sample run.

6.2.9 Radio Chemistry

6.2.9.1 Liquid Scintillation Counter:

The calibration of the liquid scintillation counter shall be checked each day that it is to be used. This shall be performed in accordance with SOP-01-16-05, which is patterned from the procedure in the counter's manual for checking the system's calibration.

During analysis of samples, backgrounds shall be run at the beginning of a procedure and automatically subtracted from the sample's values, or shall be intermixed with the samples and manually subtracted. One background will be run for every twenty samples, and more frequently if necessary. Standards shall be run as necessary, with a minimum of one per run, and more frequently, if necessary.

6.2.9.2 Proportional Counter:

The calibration of the proportional counter shall be checked each day that it is to be used. This will be performed in accordance with SOPs 01-16-12 and 01-16-13, which is patterned from the procedure in the Los Alamos publication *Health and Environmental Chemistry: Analytical Techniques, Data Management, and Quality Assurance*, in the section referencing proportional counter calibration.

One background shall be run for every twenty samples, and more frequently, if necessary. Standards shall be run as necessary, with a minimum of one per run, and more frequently, if necessary.

6.2.9.3 Gamma Spectroscopy System:

The calibration of each gamma detector shall be checked each day that it is to be used. This shall be performed in accordance with SOP 01-16-25, depending on the type of analysis performed. Both methods are patterned from the procedure in the Los Alamos publication *Health and Environmental Chemistry: Analytical Techniques, Data Management, and Quality Assurance*, from the section referencing gamma ray spectroscopy.

While running samples, backgrounds shall be taken initially, and additional ones shall be taken later, if necessary. Standards shall be measured with the detector in question, as necessary.

6.2.9.4 Alpha Spectroscopy System:

The calibration of each alpha detector shall be checked each day that it is to be used. This shall be performed in accordance with SOP 01-16-32. This method is patterned from the procedure in the Los Alamos publication *Health and Environmental Chemistry: Analytical Techniques, Data Management, and Quality Assurance*, from the section referencing alpha ray spectroscopy.

While running samples, backgrounds shall be taken initially, and additional ones shall be taken later if necessary. Standards shall be measured with the detector in question, as necessary.

6.2.10 Other Instrumentation

Other instrumentation including Fourier transform infrared spectrophotometer, nuclear magnetic resonance analyzer, and UV/VIS spectrophotometers will be calibrated according to manufacturer's specifications. Performance checks will be run to assure that the instruments will be operating properly and that operational checks shall be run to verify proper system performance.

6.3 Geophysical Testing Calibration

6.3.1 Attenberg Limits - Method ASTM-4318:

The calibration will be accomplished in accordance with SOP 01-20-15.

6.3.2 Calcium Carbonate - Method ASTM-4373:

The calibration will be accomplished in accordance with SOP 01-20-16.

6.3.3 Hydrometer - Method ASTM-D422:

The calibration will be accomplished in accordance with SOP 01-20-09.

6.3.4 Moisture Retention - Method ASTM-D2325:

The calibration will be accomplished in accordance with SOP 01-20-13.

6.3.5 Moisture Content - Method ASTM-2216:

The calibration will be accomplished in accordance with SOP 01-20-17.

6.3.6 Permeability - Method ASTM-D2434:

The calibration will be accomplished in accordance with SOP 01-20-18.

6.3.7 Proctor - Method ASTM-D69/D1557

The calibration will be accomplished in accordance with SOP 01-20-11.

6.3.8 Wet Sieve - Method ASTM-C117/C136:

The calibration will be accomplished in accordance with SOP 01-20-03 and SOP 01-20-06.

6.3.9 Dry Seive - Method ASTM-D422:

The calibration will be accomplished in accordance with SOP 01-20-09.

6.3.10 Specific Gravity - Method ASTM-C127/C128/C136:

The calibration will be accomplished in accordance with SOP 01-20-04, SOP 01-20-05 and SOP 01-20-07.

6.3.11 Unconfined Compressive Strength - Method ASTM-C39/C109/D2166:

The calibration will be accomplished in accordance with SOP 01-20-01, SOP 01-20-02 and SOP 01-20-12.

6.3.12 One Dimensional Consolidation Properties - Method ASTM-D4186:

The calibration will be accomplished in accordance with SOP 01-20-14.

6.4 Material Procurement and Control

All standards used for analysis of samples shall be made up from neat standards or solutions traceable to standards. All neat standards shall be kept in a refrigerator specifically assigned to the storage of such standards.

All standards used for each analytical area shall be stored in a refrigerator assigned exclusively to the storage of such standards. Analytical standards shall be prepared under a designated laboratory hood.

The preparation of all standards shall be documented in a laboratory notebook. An example of an entry may be sequentially coded with a seven digit number aaa-bb-cc-(L23-STD1), where:

aaa	=	Lab location
bb	=	Notebook number
cc	=	Page number

The preparation of all standards shall be documented in a notebook reserved for this purpose.

All standards labels shall contain as a minimum the following information:

1. standard identification information (i.e., components, concentration, etc.)
2. date prepared
3. expiration date
3. initials of person preparing standard
4. solvent(s) used in preparation

Solvents shall be ordered in lots and marked with lot and date upon receipt at the laboratory. Solvents for the organic analytical area shall be monitored by the extraction laboratory. Chemicals for trace metals shall be monitored by the metals preparation laboratory. Each time an individual solvent or chemical is used the date opened and lot number shall be marked on the solvent bottle.

6.5 Maintenance

All instruments will be maintained in accordance with manufacturer's recommendations and normal laboratory practice. All maintenance will be documented and maintained in permanent records by the individual responsible for each instrument. This will include both routine, scheduled maintenance and unscheduled maintenance required by operational failures.

Each instrument shall be assigned a specific log book in which the following information is recorded:

1. samples analyzed
2. operating conditions
3. routine maintenance
4. date and signature of person(s) making entry
5. supervisory review

Major maintenance for all HP gas chromatographs shall be recorded in a separate logbook. Likewise, all major maintenance for the GC/MS and other analytical systems shall be recorded in a separate logbook.

All documentation in logbooks and other documents shall be in black water-resistent ink. If an error is made, corrections shall be made by crossing a line through the error and entering the correct information. Changes shall be dated and initialed. Inserts shall be taped on page with initials and date of insert written over both insert and logbook page. No information shall be obliterated or rendered unreadable. A copy of the instrument logbook covering all the samples of a project shall be filed in the project file.

6.6 Balances, Refrigerators, and Ovens

Calibration of all laboratory balances shall be verified and the results documented in a logbook on a weekly basis with a complete set of "S" weights by grams. There are top balances located in several of the laboratories. Calibration of balances located in the laboratories shall be verified upon use by the analyst and documented in a separate bound logbook. Balances shall be checked every six months by the Institute Calibration Group with traceable standards to the NIST. An inspection sticker shall be placed on the balance dated and initialed as well as an inspection report being filed.

The temperatures of all refrigerators, freezers, and drying ovens shall be monitored daily and the results documented in a bound logbook. Logbooks shall contain the required temperature for each refrigerator and oven with tolerance ranges. When the tolerances are exceeded, documentation shall be made and the discrepancy reported and repaired. If the ovens are being used for drying glassware, constituting a deviation from analytical temperature, this will be documented in the log.

DATA GENERATION

REV 8

Copy No. _____

Approvals:

Division 01 Quality Assurance	Jo Ann Boyd	Date: 12/1/95
Division 01 Management	for D. Boyd Jr	Date: 12/1/95
SwRI QA Management	S.C. Silovich	Date: 12/6/95

7. DATA GENERATION

To provide high quality data to the sponsor, certain quality control measures must be incorporated into every scope of work and implemented. The numbers and types of quality control samples will be specified by the sponsor in the statement of work. The Proposal/Project Manager and Analytical/Sampling Coordinator shall review these requirements with the QA/QC Officer and QA Auditor and incorporate them along with any additional requirements felt necessary into the work order, the work plan, or the technical or QA project plans as they shall be developed. The QA/QC Officer will be consulted to ensure consistency with organizational goals.

7.1 Quality Assurance Project Plans

The laboratory participates in the following series of blind spiked performance evaluation samples (shipment at the stated frequency) as the external portion of its performance audit program:

- EPA Water Supply (WS) series-semiannual
- EPA Water Pollution (WP) series-semiannual
- Performance Evaluation Samples for proposals
- U.S. Army Corp of Engineers Missouri River Division - 18 months/Contract
- EPA/EMSL Radiochemistry Intercomparison Study
- AASHTO Physical Testing - Round Robin
- MAPED - DOE Performance Study
- EML - DOE Radiochemistry

The nature and frequency of additional internal blind spiked samples needed to assure the accuracy of the project data shall be specified by the analytical coordination in a specific work plan, as required, after consultation with the project manager and the quality officer.

The depth and frequency of internal system audits should depend on the familiarity of project personnel with the instrumentation, methods, and operating procedures to be employed and the frequency of sampling and analysis. The QA/QC Officer or QA Auditor will schedule the audits on an annual basis with changes made for new contracts. Typically the QA/QC Officer or a designated auditor who is not in a production capacity will conduct an initial evaluation of proposed methods and standard operating protocols. The initial systems audit will be performed by the QA/QC Officer or his designated auditor. Follow-up audits will normally be performed by the QA/QC Officer or QA Auditor.

7.2 Quality Control Samples

In each work order or plan, the numbers and types of blank, duplicate, matrix spike and matrix spike duplicate samples will be specified. The frequency of these analyses must be related to the purpose of the study, but the following serve as general guidelines for the development of the quality control portion of the work plan.

At the initiation of an analytical procedure for trace organics and inorganics, the apparatus and the reagents necessary for analysis of samples will be assembled and a Method Detection Limit (MDL) Study will be performed. These blank determinations will involve all reagent solvents and glassware as required in a standard method of analysis and will determine when background peaks are sufficiently low (or absent) to permit the analysis of the sample to proceed. If satisfactory blanks are not obtained in these initial samples, then additional steps will be taken to determine the cause and eliminate it. Once the initial methodology has been established, then blank determinations will be performed as a routine procedure throughout the program as samples are analyzed. A blank will normally be analyzed to verify non-contamination of the samples.

The following tests will normally be run with each designated batch of samples for analysis, as specified in the method/client solicitation: (Results and raw data will be available to the client upon request.

- one method blank,
- one standard at a median concentration, as a continuing calibration verification
- one matrix spike sample for determination of recovery,
- one matrix spike duplicate sample for determination of recovery for organics
- one duplicate analyses of one sample from the batch for repeatability for inorganics

Other Quality Control sample types and their uses are given in the following table.

Type	Purpose
Field Blank	Evaluate handling and shipping procedures
Field Spike	Evaluate laboratory performance
Laboratory Control Sample	Evaluate the laboratory performance (no matrix interferences)

If appropriate to the purpose of the study, these will be incorporated into the work plan and implemented, as required by the client.

7.3 Method Validation

If a method is to be used for which no accuracy and precision statements are available and with which this laboratory has no familiarity, then a series of samples will typically be run to determine these characteristics. The following suggested program is patterned after *"Analytical Quality Control."* (see Bibliography)

The study will include concentrations at three different levels: near the sensitivity limit, near the upper bound of expected values, and in between the two. Seven replicates of each concentration should be made, with all the normal procedural steps involved. The recommended order of analysis is seven sequences of low, medium, and high concentrations, which allows for the maximum interferences during operation.

Calculations of average percent recovery and associated standard deviations, will be available from the EPA Quality Control Manual or the quality officer.

7.4 Documentation and Sample Custody

The maintenance of records on the samples collected, received, and analyzed is a critical part of the laboratory's performance. The following records are normally kept for a sampling and analysis program:

- Field log
- Custody transfer sheet
- Laboratory log
- Data form

The uses of these forms are specified below.

7.4.1 Field Log for Samples Collected by SwRI

All samples taken in the field should be recorded on chain-of-custody sheets. Entries should include the date and time of sampling, intended analysis, preservation, if required, date of shipment to the analytical laboratory, and sample designation. In many programs conducted in this laboratory, the field sampling crew is provided with preprinted labels for attaching to the sample containers as the samples shall be collected. All pertinent information can be placed on the sample label and a Project Identification Number (PIN) assigned for future identification.

7.4.2 Field Chain-of-Custody Documents

The sampling coordinator will be responsible for documenting the samples collected. Documentation will consist of sample labels, field sampling log books, and chain-of-custody forms. Samples will be collected in prelabeled bottles with the appropriate information in waterproof ink. If the sampling is performed by SwRI, the Field Sampling Crew Chief will collect the samples and record the identifying numbers and other pertinent information in the field sampling log book. If the samples are collected by the client, the custody transfer form will serve as permanent documentation.

The Field Sampling Crew Chief will execute the chain-of-custody documentation utilizing the two-part SwRI custody transfer form (Figure 7.1). The disposition of the copies will be as follows:

White	Placed in shipping containers and sent with samples to laboratory
Yellow	Supplied to responsible individual at sampling site as record of samples collected.

7.4.3 Laboratory Custody Procedures

Upon arrival in the laboratory, the Sample Custodian will note the condition of the samples, verify that all sample labels correspond to the identifying numbers on the custody transfer form, and sign and date the transfer form to acknowledge receipt. The sample custodian will retain the original (yellow) part of the form and place it in the permanent project file. The original (white) form will be returned with the data report.

Unless another log-in procedure is specified in the QA Project Plan, the Sample Custodian will ensure that the samples will be registered in the electronic laboratory log book. The following information is entered into the electronic sample log: SwRI System ID number, client sample ID number, sample source, sample description, matrix type, date of receipt, and SwRI project number. The samples will be assigned a unique sample ID number, as they are received as well as the client sample number. The SwRI system ID is a six-digit number sequentially assigned by the Laboratory Information Management System.

The client ID or SwRI control number will be carried through the analytical procedures and all results will have the control number on them as a means of verifying the origin of the result.

Samples with critical holding time requirements will be transferred to the analytical lab immediately by use of the Custody Transfer Sheet (Figure 7.2).

Samples shall be delivered to the Shipping/Receiving Department at SwRI. The Sample Custodian is responsible for transferring samples to the laboratory and for obtaining the original airbill which is kept in the project file.

In the event of Saturday delivery, the Sample Custodian or his designated representative (only Sample custodian is mentioned hereafter) will pick up the samples from the guardhouse at the front gate of SwRI and transfer them to the laboratory.

At the laboratory sample log-in, the Sample Custodian initiates an **SwRI Sample Log-In Form** (Figure 7.3) for each project, or for each set of concurrently arriving samples.

- The Sample Custodian first examines the shipping container and:
  - Records any evidence of tampering or other damage on the Sample Log-In sheet (called the Sheet herein),
  - Records the presence/absence of custody seal(s) on the shipping container,
  - Records the condition of the custody seal(s) (i.e., intact, broken)
  - Removes the custody seal(s), which will be incorporated into the project file
- He/she opens the shipping container, removes the enclosed sample documents and records the following information on the sheet:
  - Log-in date
  - Presence/absence of the chain-of-custody records
  - Receipt of airbill and record airbill number
  - Project or batch number
- The Sample Custodian removes sample containers and sorts them by client sample number sequence.
- Records the condition of samples (intact, broken, leaking, etc.) presence/absence of sample tags on sheet.
- If sample tags are present, will compare them with chain of custody record(s)
- Documents whether these numbers agree, or if there is a discrepancy between tag numbers received and those listed on the chain-of-custody record.
- If sample tags are not listed on the chain-of-custody record, he/she will record this fact.

Figure 7.1 Custody Transfer Form

SOUTHWEST RESEARCH INSTITUTE

CHAIN OF CUSTODY

Client: ____________________ Sampled by: ____________________ WO No.: ____________________

Address: ____________________ Project No.: ____________________

Requested Turnaround:
- ☐ 1 Week
- ☐ 2 Weeks (Normal)
- ☐ 3 Weeks
- ☐ Other: __________

City ____________ State/Zip ____________ Project Manager: ____________________

Attention ____________ Telephone # ____________

Sample ID	Date Sampled	Time Sampled	Matrix	# of Containers	Preservative	pH	Sample Condition	Analyses Requested

Relinquished by:	Date/Time:	Received by:	Date/Time:	Relinquished by:	Date/Time	Comments:
Received by:	Date/Time:	Relinquished by:	Date/Time:	Received by:	Date/Time	

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Figure 7.2 Custody Transfer Sheet

SwRI Sample Custody Transfer Sheet

CLIENT: _____ PROJECT NUMBER: _____
DATE: _____ VTSR: _____ TIME: _____
SAMPLE ID(s): _____ _____
_____ _____
_____ _____
_____ _____

RELINQUISHED BY: _____ OF _____
DATE: _____ TIME: _____

RECEIVED BY: _____ OF _____
DATE: _____ TIME: _____

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DATE: _____ TIME: _____

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DATE: _____ TIME: _____

RECEIVED BY: _____ OF _____
DATE: _____ TIME: _____

Figure 7.3 SwRI Sample Log-In Sheet

Southwest Research Institute
Traffic Report
Sample Custodian Signature: _____

Date: 11/08/95
Project: 01-5108-30X
CASE #: CLS / SDG: 541-8031007
Airbill: 3591611494
Work Order #: 0000006012

1. Custody Seal — Not Present or Damaged
2. Chain of Custody — Not Present
3. Sample Tags — Not Present
   Sample Tag Numbers — Not on COC
4. SMO Forms — Not Present

Date RecD	Time RecD	COC Record #	SMO Sample #	Corresponding		TFIC RPT, TAGS, COC AGREE Y/N	Cond of Sample
				Sample Tag #	SwRI Lab #		
08/31/94	09:30	NONE	541-8031007	NONE	46454		INTACT
08/31/94	09:30	NONE	542-0852004	NONE	46455		INTACT
08/31/94	09:30	NONE	543-5951009	NONE	46456		INTACT
08/31/94	09:30	NONE	544-9171000	NONE	46459		INTACT
08/31/94	09:30	NONE	545-5351002	NONE	46460		INTACT
08/31/94	09:30	NONE	546-9071002	NONE	46461		INTACT
08/31/94	09:30	NONE	547-1782004	NONE	46462		INTACT
08/31/94	09:30	NONE	548-5131008	NONE	46463		INTACT
08/31/94	09:30	NONE	549-0391003	NONE	46464		INTACT
08/31/94	09:30	NONE	550-9491002	NONE	46465		INTACT

PAGE 001

- Compares the following documents to verify agreement of the information contained in them:
  - Chain-of-custody record(s)
  - Sample tags
  - Packing lists
  - Airbill

- Documents both agreement among the forms and any discrepancies found.
- Completes the custody sheets for each sample:

  - Condition of sample containers (good, broken, leaking, headspace on volatile water samples, etc.)
  - Custodian signature and date received
  - Sample delivery group identification

If all samples recorded on the chain-of-custody record were received by the laboratory and there are no problems observed with the sample shipment, the custodian signs the chain-of-custody record in the "received for laboratory by:" box on the document. If problems are noted, a Log-in Non-conformance detailing the problems is FAXED to the client. The problems and client directions shall be detailed in a telephone conversation record reported to appropriate lab personnel and stored in the project file and described in the narrative.

The information on the date and time of sample receipt, chain-of-custody record number, sample numbers, SwRI laboratory numbers, and sample tag numbers is recorded on the table of the sample log-in sheet and the inter-laboratory work order (Figure 7.4) Samples will be logged into a bound logbook documenting information needed for tracking. (Figure 7.5)

The Sample Custodian then removes sample tags from sample containers and adds them to the project file. A Sample Control Record (Figure 7.6) is filled out for each location at which samples will be stored (Volatiles in the locked refrigerators for volatiles, pesticides/semivolatiles/inorganics in the locked walk-in refrigerator). Samples will be stored in the appropriate location, and the Sample Control Record remains on a notebook by the correct storage location.

The Sample Custodian then generates and prints the Laboratory Work Order (which will be incorporated into the appropriate sample tracking file) with the holding dates, QC requirements, and deliverables deadlines, attaches a copy of the custody sheets and distributes a copy of the entire set to the appropriate personnel.

Finally, the Sample Custodian assembles all paperwork in the project file in the sequence specified in the standard project file inventory. Typically, these documents will include the airbill, chain-of-custody record, UPS records of sample cooler return, the sample tags and cooler seals, and the photocopy and carbon copies of the custody sheets.

Figure 7.4 Laboratory Work Order

Southwest Research Institute

Laboratory Work Order

Serial Number 6012

VTSR: 31 August 94 Time: 09:30

Project: 01-8109-30K
Case #: CLS
SDG : 541-8031007
Client: CHILDHOOD LEUKEMIA STUDY

Manager: CAMANN, DAVID
Logged In by: JMORIN
Creation Date: 04 October 94
Checked by: _____

Notes

SAMPLES RECEIVED AT ROOM TEMP.

EACH WORK ORDER IS A NEW SDG.

TAT IS BASED ON LAST SAMPLE RECEIVED WITHIN A MONTH.

THIS IS A TWO AND ONE HALF YEAR PROJECT, SEE PROJECT MANAGER FOR DETAILS.

System ID	#	QC	Customer ID	CED	Matrix	Required Analyses
48454	1		541-8031007	08/31/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
48455	1		542-0852004	09/01/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
48456	1		543-5651009	09/02/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
48459	1		544-9171000	09/06/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
48460	1		545-5351002	09/07/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
48461	1		546-9071002	09/08/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
48462	1		547-1752004	09/13/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
48463	1		548-5131008	09/14/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
48464	1		549-0391003	09/21/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
48465	1		550-9491002	10/03/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
					Samples:	10

Data must be to QA..... 28 August 95
Absolute Latest Date..... 30 August 95

Samples Received to Date: 010
Turnaround time is 365 Days from VTSR.

Date Printed: 08 November 95 Time Printed: 13:37:47

Work Orders in this SDG:

6012

* - Indicates work group contains an MS/MSD

Thermometer: 1
Temperature: 22

Page Number: 001

ver (08/16/95)

Figure 7.4 Laboratory Work Order (cont.)

Test Code Key

Southwest Research Institute

Serial Number 6012

VTSR: 31 August 94 Time: 09:30

Project: 01-6109-30X
Case #: CLS
SDG: 641-6031007
Client: CHILDHOOD LEUKEMIA STUDY

Manager: CAMANN, DAVID

NOTES

SAMPLES RECEIVED AT ROOM TEMP.

EACH WORK ORDER IS A NEW SDG.

TAT IS BASED ON LAST SAMPLE RECEIVED WITHIN A MONTH.

THIS IS A TWO AND ONE HALF YEAR PROJECT. SEE PROJECT MANAGER FOR DETAILS.

Group	Test	Stat	Method Date	Deadline	Number	Description	Fridge	Shelf
EXT	ECLS	Wat	10/30/94	10/20/94	10	EXTRACTION - DUST/SEE DAVID CAMANN (60 DAYS ADVISORY)	FRZ29	MID
EXT	SWCLS	Wat	09/30/94	09/30/94	10	SIEVE AND WEIGH SAMPLE/SPLIT (30 DAYS ADVISORY)	FRZ29	MID
TDG	CLS-PAH	Wat	02/27/95	02/27/95	10	PAH ANALYSIS - SEE DAMANN (180 DAYS ADVISORY) GC/MS (FISIONS MD800) SEE ATTACHED LIST	FRZ29	MID
TDG	CLS-PEST	Wat	02/27/95	02/27/95	10	PESTICIDE ANALYSIS - SEE CAMANN (180 DAYS ADVISORY) GC/MS (FISIONS MD800) SEE ATTACHED LIST	FRZ29	MID

Date Must be to QA Unit..... 28 August 95

Absolute Latest Date..... 30 August 95

Date Printed: 11/08/95

Time Printed: 13:39:02

Figure 7.4 Laboratory Work Order (cont.)

Distribution List

Serial Number 6012

SwRI
Division 1

BOYD, JOANN
CAMANN, DAVID
CUMMINS, WAYNE
EDRISI, HAMED
GENO, PAUL
LOGIN AREA
MAJUMDAR, TAPAN
VILLALOBOS, KEVIN
YAU, ALICE

Number of Copies: 9

Number of Work Orders: 9

Date Printed: 11/08/95

Figure 7.5 Electronic Sample Log-in

SwRI Login Area
Division 1

Sample Login Book
11/07/95

Work Order: 7960	Project: 01-2867-300	Client:HEB
VTSR Date: 11/07/95	VTSR Time: 07:59	Manager: SCHATTENBERG, HERB

System ID	Customer Sample ID	Matrix	Assay
62420	(CC-A)CUCUMBERS	CUCUMBERS	FC CA, FC OC, FC OP
62421	(GW-A)GRAPES, WHITE	GRAPES, WHIT	FC CA, FC DI, FC OC, FC OP
62422	(TN-A)TANGERINE, FAI	TANGERINE, F	FC CA, FC OC, FC OP
62423	(BR-A)BROCCOLI	BROCCOLI	FC CA, FC OC, FC OP
62424	(CT-A)CARROTS, CELLO	CARROTS, CEL	FC CA, FC OC, FC OP
62425	(RP-A)POTATOES, RUSS	POTATOES, RU	FC CA, FC OC, FC OP
62426	(RD-A)APPLES, RED DE	APPLES, RED	FC CA, FC OC, FC OP
62427	(TN-B)TANGERINE, FAI	TANGERINE, F	FC CA, FC OC, FC OP
62428	(6D-A)(KROPF)RED DEL	(KROPF)RED D	FC CA, FC OC, FC OP
62429	(EW-A)ROMA TOMATOES	ROMA TOMATOE	FC CA, FC OC, FC OP

Work Order: 7966	Project: 01-6746-259	Client:SOUTHERN PETROLEUM
VTSR Date: 11/07/95	VTSR Time: 10:00	Manager: SUN, GANG

System ID	Customer Sample ID	Matrix	Assay
62446	9511056-01A	LIQUID	ICP_MS

Work Order: 7964	Project: 01-7604-001	Client:NOAH TECH
VTSR Date: 11/07/95	VTSR Time: 10:20	Manager: DAMMANN, MIKE

System ID	Customer Sample ID	Matrix	Assay
62441	3069/1.1	LIQUID	AMMONIA, FE, MET, PH, SO4, WETCHEM

Work Order: 7969	Project: 01-7518-024	Client:SAN ANTONIO WATER
VTSR Date: 11/07/95	VTSR Time: 13:40	Manager: DAMMANN, MIKE

System ID	Customer Sample ID	Matrix	Assay
62452	511 SUSANWOOD	WATER	HG

Page Number: 1222

Printed: Tuesday, 11/07/95 at 16:56:40

Rev (9/20/95)

Figure 7.6 Sample Control Record

SWRI Sample Control Record (EXT, TDG) Client: CHILDHOOD LEUKEMIA STUDY

Required Analysis: CLS-PAH, CLS-PEST, ECLS, SWCLS Refrigerator: FRZ28 Shelf: MID

Project: 91-6166-30X
Case: CLS
SDG: 541-8831007
Work Order #: 6612
Logged In: 8/31/94 JMORIN

					DATE									
					TIME									
					BY									
					Analysis									Disposal
System ID	Customer ID	Matrix	#	Cont. Desc	Section	Lab Out		In	Lab Out		In	Lab Out		In	OUT
46454	541-8831007	DUST	1												
46455	542-0852004	DUST	1												
46456	543-8861009	DUST	1												
46459	544-8171000	DUST	1												
46460	545-5351002	DUST	1												
46461	546-8071002	DUST	1												
46462	547-1782004	DUST	1												
46463	548-5131009	DUST	1												
46464	549-0391009	DUST	1												
46465	550-8491002	DUST	1												

For Transfer of Custody....note below on this form the date, from whom, to whom, and reason for the CoC.

Number of Samples: 10 Number of Containers: 10

7.5 Sample and Extract Storage

7.5.1 The following procedures shall be used to control the storage of samples:

1. Immediately after sample receipt and log-in, samples shall be stored in a secure area designated for samples. The samples shall be stored in their original containers unless damaged. The client is contacted regarding any problems. Damaged samples shall be disposed of in an appropriate manner and this disposal is documented.

   The following areas are designated for storage of samples:

   - Volatile soil and water samples shall be stored in a locked refrigerator/freezer located in the volatiles area.
   - Soil and water samples for semivolatiles/pesticide/inorganics analysis shall be kept in locked walk-in coolers, as designated.
   - Dioxin samples are stored in separate refrigerators.
   - Potentially radioactive samples are stored in the Radiochemistry refrigerators.

   Under no circumstances will samples be stored in the same refrigerator/freezer as standards or quality control samples. The storage areas shall be kept secure at all times. The sample custodian shall control access to the storage area through custody documentation. Control of keys is documented by a signature list.

2. Whenever samples are transferred into or out of storage, the transfer shall be documented on a SwRI Sample Control Record sheet. (Ordinarily, samples will only be removed once for the purpose of extraction, digestion, or analysis.)

3. The location of stored samples shall be recorded on the Sample Control Record.

4. Volatile, Dioxin, and Radiochemistry samples shall be stored separately from other samples.

5. The temperatures of the refrigerators and freezers shall be recorded on regular work days.

6. Samples shall be disposed of according to Standard Disposal Procedures. Samples may be disposed of 60 days after data submission of the data package. (See Standard Operating Procedures for sample and extract storage.)

7.5.2 The following procedures shall be used to control the storage of sample extracts:

1. Sample extracts shall be preserved in bottles/vials with Teflon-lined septa and maintained at 4°C. Pesticide and semivolatile extracts will be stored in a locked refrigerator devoted exclusively to the storage of sample extracts. Sample extracts shall not be stored with standards or extracts from industrial clients.

2. Immediately upon generating the sample extract, it is stored in the appropriate location and a Sample Control Record is initiated for the extracts for that project. Each Sample Control Record is used to record only samples from that particular project. Extracts remain in locked sample storage until removed for analysis.

3. Whenever sample extracts are removed from the storage area, this is documented on a Sample Control Record. After an extract has been removed for storage by an analyst, the analyst is responsible for the custody of the sample. Each analyst must return the extracts to the storage area before the end of the working day. In the event that samples or sample extracts shall be transferred from one analyst to another, this fact must be documented on a Sample Control Record documenting change of custody. If the extract is used in entirety, this shall be documented on the Sample Control Record.

4. After final submission of analytical data for the particular project, all sample extracts for the project are boxed (along with the VOA samples), and stored in a locked refrigerator. This fact is also documented on the appropriate Sample Control Records.

5. Within 60 days after data submission, SwRI will dispose of samples and sample extracts.

7.6 Preventing Sample Contamination

Preventing contamination of samples, sample extracts, and standards is a continuous process starting with the log-in and storage and continuing throughout all stages of analysis.

7.6.1 Sample Log-in and Storage

Sample containers shall be checked for damage or leakage upon arrival. Any sample showing signs of damage or contamination is disposed of in an appropriate manner. This is documented, the client is contacted, and the issue is discussed in the project narrative or report.

Soil and water samples shall be stored in a locked walk-in refrigerator devoted exclusively for the storage of these samples.

Standards shall not stored with samples.

7.6.2 Sample Extraction for Organic Analysis

To keep sample contamination to a minimum during all processes, the following laboratory procedures are followed:

1. Extraction glassware used for extraction of low level samples is kept separately from glassware used for extraction of higher level samples.

2. Phthalate contamination is minimized by avoiding the use of plastics in the organic extraction laboratory.

3. All extraction solvents will be pesticide grade or equivalent.

4. Cleaning of laboratory glassware is done according to standard operating procedures.

7.6.3 Storage of Sample Extracts

Pesticide and semivolatile extracts generated from the extraction of samples shall be kept in a locked refrigerator specifically assigned to the storage of these samples. Separate locations shall be assigned to the storage of standards and of extracts from other industrial clients.

*7.7 **Security for Laboratory and Samples***

The National Enforcement Investigations Center (NEIC) of EPA defines custody of evidence in the following ways:

1. It is in your actual possession, or

2. It is in your view, after being in your physical possession, or

3. It was in your possession and then you locked it up or sealed it up to prevent tampering, or

4. It is in a secure area.

To satisfy these custody provisions, the following standard operating procedures are implemented by SwRI Chemistry and Chemical Engineering Division:

1. Samples and extracts shall be stored in a secure area.

2. Access to the laboratory in the main building (Bldg 70) is through a monitored reception area, and all exit doors shall be auto-locking. All other buildings follow the same security procedures. All SwRI employees must wear a picture identification badge. Any person in the lab without an employee badge or a visitor identification badge is escorted to the reception area.

3. All personnel entering or leaving the building outside of regular working hours will be required to sign-in, documenting time of arrival and/or departure.

4. Visitors must sign-in the reception area and be escorted while in the laboratory.

5. Refrigerators, freezers, and other sample storage areas will be kept locked.

6. Only the designated sample custodian and designated personnel have keys to the sample preparation or analysis.

7. Samples and extracts remain in locked sample storage until removed for sample preparation or analysis.

8. All transfers of samples and extracts into and out of storage or from one analyst to another shall be documented on a Sample Control Sheet.

9. These internal custody records will be maintained by the Sample Custodian.

10. After a sample or extract has been removed from storage by the analyst, the analyst is responsible for the custody of the sample. Each analyst must return the samples or extract to the storage area before the end of the working day. If the extract is used in entirety, this shall be documented on the Sample Control Record.

7.8 Traceability of Standards

All standards used for analysis of samples will be made up from neat standards or solutions provided by an outside source traceable to the NIST.

All neat standards shall be kept in a refrigerator specifically assigned to the storage of such standards. Only pesticide grade or equivalent solvents will be used to prepare working standards.

All standards will be stored in designated refrigerators assigned exclusively to the storage of such standards. If indicated, analytical standards shall be prepared within the laboratory hood.

The preparation of all standards shall be documented in a laboratory notebook.

All standards labels must contain as a minimum the following information:

1. Standard identification information (i.e., components, concentration, etc)
2. Date prepared
3. Expiration date
4. Initials of person preparing standard
5. Solvent(s) used in preparation

If standards will be stored in noncalibrated glassware, volumes shall be marked and monitored.

7.9 Maintaining Instrument Records and Logbooks

Each instrument is assigned a specific log book in which the information shall be recorded as shown in section 6.4.

Major maintenance for all instruments is recorded in a separate logbook.

All documentation in logbooks and other documents shall be as shown in Section 6.4.

7.10 Analysis Work Order Form

An analysis work order form (Figure 7.4) will be provided to each analyst which indicates the type of analysis and the specific parameters to be sought. The sample identifier is placed on the form to minimize the risk of the analyst assigning an analytical result to the wrong sample. Other items noted on the work order form will be the date of receipt, collection end date, holding time requirements, deliverables requirements, and the QC required for the project.

7.10.1 Data Reporting Forms

Analytical results shall be reported by the analyst who is assigned responsibility for these specific parameter(s). Included on the data will be sample identification, analytical results for blanks and samples, quality control results including matrix spikes, matrix spike duplicates, date of analysis, and signature of analyst. All supporting material for the analytical results such as strip charts, computer printouts, and copies of laboratory notebooks will be submitted with data for archive requirements.

The analytical coordinator or his/her designee reviews the data reporting form for the quality of the data. The data package then is submitted to the QA/QC officer for required QA/QC validation, narrative construction identifying the problems incurred and construction of the data package. The data is then submitted to the analytical coordinator for final review. After this review, any remaining deficiencies shall be corrected, the project manager is notified for a review of the data to be submitted, and the data is made a part of the permanent project file.

7.10.2 *Maintenance of Records*

All records will be kept on file for the duration of the project in the central files at the San Antonio laboratory. Upon completion of the project, the files shall be transferred to inactive status and maintained for a minimum of two years.

7.10.3 *Data Evaluation*

All data generated by this laboratory will undergo a thorough review and validation prior to their release to the sponsor. The review process will be specified in the work plan and will follow the guidelines delineated in Section 8 of this document.

7.11 Standard Operating Procedures

The standard procedures listed in this document and any procedures supplied by the sponsor will be incorporated into the work plan quality assurance program by reference. Additional standard operating procedures shall be prepared by the analytical coordinator to describe routine tasks which shall be delegated and/or performed frequently.

7.12 Study Planning and Design

If the data are to be useful to the client, then the studies must be designed in a manner that will provide valid defensible results. Considerations in this regard include:

- selection of numbers of samples, locations of samples and acceptable conditions for sample collection,
- sampling methodology and analytical methodology used,
- selection of parameters for study and of data to be measured concurrently,
- inclusion of quality control samples, including field blanks and spikes, samples for analysis by an alternative laboratory, and others as appropriate,
- frequency and depth of performance and systems audits,
- statistical soundness in terms of the ability of the plan to address the questions under study.

All of these factors should be considered in developing the work plan in order to allow the underlying questions to be answered in a timely and efficient manner.

DATA PROCESSING

REV 6

Copy No. _____

Approvals:

Division 01 Quality Assurance _____ Date: 11/30/93

Division 01 Management _____ Date: 11/30/93

SwRI QA Management _____ Date: 12/1/93

8. DATA PROCESSING

Each work plan will describe procedures to collect, validate, store, transfer, and reduce all data generated. General procedures are given below.

8.1 Collection

The Analytical Supervisor will prepare the data for the recording of data generated on each program. Each analyst will provide the analytical data pertinent to the analysis being performed and will execute these upon completion of the analysis. The analyst will be responsible for reviewing the data as it is generated to ensure that the results shall be reasonable and interpretable and that all information required for recalculation of the results is available. The analytical data sheets, chromatograms, absorbance traces, or spectra, and supporting information will be supplied to the analytical coordinator for review.

8.2 Validation

The Analytical Supervisor for each analytical task will perform a review of all data. This review will consist of the following elements: review of analytical program, examination of results, verification of results to insure the QC requested by the client. The data is then validated by the QC validator who is independent of the actual production of the analytical results.

8.2.1 Review of Analytical Program

The Analytical Supervisor will review each set of results to ensure that the required program elements, including method blanks, surrogate spikes, and QC samples, have been accomplished according to the project workplan. The supporting data will be reviewed to ensure that analyses were performed under the correct conditions and that all required procedural steps were performed.

8.2.2 Examination of Results

The Analytical Supervisor will examine the results obtained along with the pertinent chromatograms, spectra, or absorption traces to ensure that the results shall be reasonable and that the analyst has interpreted the results correctly. Any unusual or unexpected results will be reviewed and a resolution will be made as to whether the analysis should be repeated or the result recalculated.

8.2.3 Recalculation of Results

The Analytical Supervisor will selectively recalculate results to ensure that the calculation was performed properly. Emphasis will be placed on those results showing a significant concentration of one or more of the analytes of interest. As a minimum, one set of calculations will be checked for each batch of samples analyzed.

8.3 Data Storage

The QA/QC officer will have the responsibility for the control and protection of archived data. Where the project deals with material of a sensitive or confidential nature, measures will be included in the work plan to ensure that access is limited to those individuals who have agreed to be bound by terms of the confidentiality agreement and who have a need for the information.

8.4 Data Transfer

Following the analyst review, the verified data will be transferred from the analytical data sheets to reporting forms. The analyst will be responsible for ensuring that all required information is provided for validation purposes. All data will be verified against the analytical data sheets, and the completed forms will be reviewed by the Project Manager or his designee prior to submission of the results to the sponsor.

8.5 Data Reduction

Data reduction will be carried out using prescribed documented techniques. Any statistical summaries of the data will be presented in such a manner that the reviewer can easily judge the validity of the procedure and of any conclusions drawn. Assumptions made in performing any statistical analyses will be clearly stated, as will confidence/ significance levels used for any tests of hypotheses. Data summaries will be checked against the raw data for consistency and summary statistics recalculated in the event of doubt.

DATA QUALITY ASSESSMENT

REV 6

Copy No. _____

Approvals:

Division 01 Quality Assurance _____ Date: 11/30/93

Division 01 Management _____ Date: 11/30/93

SwRI QA Management _____ Date: 12/1/93

9. DATA QUALITY ASSESSMENT

The data report shall include the accuracy and precision data designed during the project. Upon request, accuracy and precision will be performed from analysis of spiked samples, replicate samples, or other designated QC requests. If the samples will be collected by SwRI, a statement will be included assessing the degree to which the samples represent the entity being sampled. (e.g. 10% of sampling).

CORRECTIVE ACTION

REV 9

Copy No. _____

Approvals:

Division 01 Quality Assurance	Jo Ann Boyd	Date: 9/10/96
Division 01 Management	Donald E Johnson	Date: 9/10/96
SwRI QA Management	S. C. Silovich	Date: 9/13/96

10. CORRECTIVE ACTION

The ultimate responsibility for maintaining quality of the analyses and sampling lies with the management of the department and division. The routine operation of the quality assurance/quality control program, however, falls upon the analysts, Laboratory Supervisors, Analytical, and Sampling Coordinators, QA Auditor, Project Managers, and the QA/QC Officer. Major responsibilities are discussed in Section 4.2. Evaluation of the QA/QC Program is discussed in Section 4.5. QA/QC reporting is also discussed in Section 4. For further information refer to SwRI SOP 01-12-02 "Internal Inspections".

It is the responsibility of the project personnel to identify perceived problems which may affect data quality and to report these problems both to their project supervisor and to their quality team contact. If the supervisor regards the problem as serious enough to potentially impact data quality, he/she will initiate appropriate corrective action. Corrective action relates to the overall QA management scheme: who is responsible for taking corrective actions; when corrective actions are to be taken; and who follows-up to see that corrective actions have been taken and that they have produced the desired results. Results from the following QA activities may indicate a need for corrective action:

1. Performance audits
2. Systems audits
3. Inter-laboratory comparison studies
4. Failure to adhere to a QA Program or Project Plan or to a Standard Operating Procedure

Non-compliances will be minimized through specification (in the work plan or operating protocols) and implementation of internal controls prior to an adverse project impact. Each measurement system shall have limits to establish when corrective action must be taken. A procedure shall be established for each measurement system to show what corrective action will be followed when established limits for this procedures have been exceeded. The level within the organization that is responsible for taking corrective action shall also be specified.

The process involves corrective actions to the areas involved and management. Responses to corrective actions indicating the cause of the problem and corrective actions to prevent recurrence shall be submitted for inclusion in the final report. A copy of the corrective action form is presented in Figure 10.1

□

Figure 10.1 Corrective Action Form

CAR # _____

Southwest Research Institute
Division 01

CORRECTIVE ACTION REQUEST

(To be filled out by QAU)

Discrepancy:

Initiated by: _____ Date _____

Area Supervisor Responsible _____

Response Due Date : _____

(To be filled out by Area Supervisor/Study Director/Project Manager)

ROOT CAUSE:

- ☐ Equipment Problem
- ☐ Procedural Problems
- ☐ External Phenomena
- ☐ Analyst Error
- ☐ Management Problem
- ☐ Training Deficiency

Corrective Action Taken:

Suggested Corrective Action to Prevent Recurrence:

Date for Completion of Corrective Action: _____

Supervisor : _____ Date: _____

Proposed Corrective Action Approval: _____ Date: _____
(QAU Group Leader)

QAU Verified _____ **Date** _____

cc: **J. Boyd**
D. Johnson
T. Trbovich
Study Director/Area Supervisor

BIBLIOGRAPHY

REV 6

Copy No. _____

Approvals:

Division 01 Quality Assurance _____ Date: 11/30/93

Division 01 Management _____ Date: 11/30/93

SwRI QA Management _____ Date: 12/1/93

11. BIBLIOGRAPHY

Guidelines and Specifications for Preparing Quality Assurance Program Plans, EPA, QAMS-005/80, December 29, 1980

Handbook for Analytical Quality Control in Water and Wastewater Laboratories, EPA-600/4-79-019, March 1979

Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, EPA, QAMS-005-80, December 29, 1980

Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, EPA, QAMS-004-80, December 20, 1980

Manual of Analytical Quality Control for Pesticides and Related Compounds in Human and Environmental Samples, EPA-600/1-79-008, January 1979

Quality Assurance for Environmental Measurements, J. K. Taylor and T. W. Stanley (eds.), ASTM STP867, 1985

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I, "Principles", EPA-600/9-76-005, March 1976

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, "Ambient Air Specific Methods", EPA-600/4-77-027a, May 1977

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, "Stationary Source Specific Methods", EPA-600/4-77-027b, August 1977

Quality Assurance Requirements, DOE 5700.6C, August 21, 1991, Office of Nuclear Energy, Office of Environment, Safety, and Health.

American Society of Mechanical Engineers (ASME)/NQA-1, Quality Assurance Program Requirements for Nuclear Facilities.

American Society of Mechanical Engineers (ASME)/NQA-2, Quality Asurance Requirements for Nuclear Facility Applications

SW-846, Test Methods for Evaluating Solid Wastes, Chapter 1.

Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program, NEESA 20.2-047B, June 1988.

11. BIBLIOGRAPHY

Interim Draft EPA Requirements for Quality Management Plans, EPA QA/R-2, July 1993

EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations, EPA QA/R-5, July 1993

RADIOACTIVE MATERIAL LICENSE

SOUTHWEST RESEARCH INSTITUTE

INTERNAL MEMORANDUM

November 21, 1995

TO: Radiological Health and Safety Committee

FROM: John P. Hageman, Radiation Safety Officer John P. Hageman

SUBJECT: License Renewal And Response to Several Requested License Amendments.

The Bureau of Radiation Control has renewed our Radioactive Material License, which was submitted to the Bureau on November 16, 1993. The Bureau has also approved the four pending License Amendment requests of: (i) June 15, (ii) August 2, (iii) September 18, and (iv) October 10, 1995. The good news is that our renewed license is effective until December 31, 1999 and all requested amendments were approved. A copy of the new Radioactive Material License (Amendment Number 55) is attached.

Congratulations are in order for **Mike MacNaughton**, the Bureau has approved him to be the Institute's Radiological Health and Safety Committee Chairman.

In the transmittal letter, the Bureau has requested that SwRI submit a separate Radioactive Material License request for four items listed on the attached license. These four items are:

1. Item 8P - 100,000 curies of cobalt-60 sealed sources with an authorized use of: "Irradiation of materials and lower animals for research and development. For receipt and storage in the licensee's Radiation Effects Facility and for transfer to authorized recipients."

2. Item 8S - 75,000 curies of cobalt-60 sealed sources with an authorized use of: "Receipt, storage, and transfer to authorized recipients."

3. Item 8W - 60,000 curies of cesium-137 sealed sources with an authorized use of: "For receipt and storage and for transfer to authorized recipients."

4. Item 8AI - 1 curie of nickel-63 with an authorized use of: "Clean, repair or rebuild Electron Capture Detectors (ECD) and redistribution to specifically authorized customers. Also, for redistribution of generally licensed ECDs to persons authorized by TRCR (Texas Regulations for Control of Radiation) 40.61(a)."

If this separate license is not approved by the Bureau before May 1, 1996 the radioactive material listed in these four items can only be stored at SwRI, which excludes receiving, transferring, using, cleaning, etc.

At the December 6, 1995 meeting, the Radiological Health and Safety Committee needs to recommend actions to respond to the Bureau's request. If you have any questions or comments please call me at extension 2633.

c:\doc\rsc1195.mem

Texas Department of Health

David R. Smith, M.D.
Commissioner

1100 West 49th Street
Austin, Texas 78756-3189
(512) 458-7111

Radiation Control
(512) 834-6688

Carol S. Daniels
Deputy Commissioner for Program

Roy L. Hogan
Deputy Commissioner for Administra

November 1, 1995

RECEIVED
NOV - 1995

John P. Hageman
Southwest Research Institute
P.O. Drawer 28510
San Antonio, Texas 78284

Dear Mr. Hageman:

We have enclosed Amendment No. 55 to Radioactive Material License No. L00775 in response to your requests dated November 16, 1993, November 19, 1993, June 15, 1995, August 2, 1995, September 18, 1995 and October 10, 1995. Please note that during our review, we found several authorizations that are contrary to Texas Regulations for Control of Radiation 41.26(f)(3). These items must be authorized on a separate license and we have provided application forms and the appropriate guides to assist you in applying for a new license. You will note that Condition 27 was added as an incentive.

If we may answer any questions or be of any assistance, please do not hesitate to call or write.

Sincerely,

Floyd R. Hamiter

Floyd R. Hamiter, Chief
Industrial Program
Division of Licensing, Registration
and Standards
Bureau of Radiation Control

Enclosure

TRC Form 12-1
7/90

Texas Department of Health
BUREAU OF RADIATION CONTROL

077376

RADIOACTIVE MATERIAL LICENSE

Pursuant to the Texas Radiation Control Act and Texas Health Department regulations on radiation, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess and transfer radioactive material listed below; and to use such radioactive material for the purpose(s) and at the place(s) designated below. This license is subject to all applicable rules, regulations and orders of the Texas Department of Health (Agency) now or hereafter in effect and to any conditions specified below.

LICENSEE	This license is issued pursuant to and in accordance with an application
1. Name: Southwest Research Institute ATTN: John P. Hageman	Dated: November 19, 1993 Signed by: Frank A. Iddings
2. Address: P. O. Drawer 28510 San Antonio, Texas 78284	3. License Number: L00775 / Amendment Number: 55
	PREVIOUS AMENDMENTS ARE VOID
	4. Expiration Date: December 31, 1999

RADIOACTIVE MATERIAL AUTHORIZED

5. Radioisotope	6. Form of Material	7. Maximum Activity*	8. Authorized Use
A. Any radioactive material with Atomic number less than 84	A. Any	A. 500 mCi of any single radioisotope. Total: 25 Ci	A. Research and Development (R&D).
B. H-3	B. Any	B. 50 Ci	B. Wear testing of engine parts.
C. Cr-51	C. Any	C. 500 Ci	C. R&D.
D. Mn-54	D. Any	D. 200 Ci	D. R&D.
E. Fe-55/ Fe-59	E. Any	E. 500 Ci	E. Wear testing of engine parts.
F. Co-58	F. Any	F. 600 Ci	F. R&D.
G. Co-60	G. Any	G. 100 Ci	G. R&D.
H. Ni-63	H. Any	H. 1 Ci	H. R&D.
I. Po-210	I. Sealed sources	I. 500 Ci	I. R&D.
J. Ra-226	J. Sealed sources	J. 100 μCi	J. R&D.
K. Am-241	K. Any	K. 1 Ci	K. R&D.
L. U-238 and its activation products	L. Any	L. 50 mgms	L. R&D.

* Ci-Curie mCi-Millicurie μCi-Microcurie

Texas Department of Health
BUREAU OF RADIATION CONTROL

07734

RADIOACTIVE MATERIAL LICENSE

LICENSE NUMBER	AMENDMENT NUMBER
L00775	55

5. Radioisotope (continued)	6. Form of Material (continued)	7. Maximum Activity (continued)	8. Authorized Use (continued)
M. Np-237	M. Any	M. 50 mgms	M. R&D.
N. U-238	N. Depleted Uranium	N. 500 kgms	N. R&D, shielding and performance testing of sealed sources and devices as part of the "Sealed Source and Device Design Safety Testing" program with the United States Nuclear Regulatory Commission (NRC).
O. Cs-137	O. Sealed source (NC Model 850233)	O. 1 Ci	O. Survey instrument calibration.
P. Co-60	P. Sealed sources	P. 100,000 Ci	P. Irradiation of materials and lower animals for research and development. For receipt and storage in the licensee's Radiation Effects Facility and for transfer to authorized recipients.
Q. Am-241	Q. Sealed source (GI Model VD[HP])	Q. 1 source of 25 mCi	Q. R&D of well logging instrumentation.
R. Cs-137	R. Sealed source (TN Model 57157C)	R. 2 sources of 500 mCi each	R. Density measurement using Texas Nuclear Model 5202 source holder.
S. Co-60	S. Sealed sources	S. 75,000 Ci	S. Receipt, storage and transfer to authorized recipients.
T. Pu-238	T. Sealed source (A/S Mod. PPC2,PPC4, PPC5 or PPC-X)	T. 1 source of 30 mCi	T. X-ray fluorescence analysis in Columbia Scientific Model 700 Minilab analyzer.
U. Cf-252	U. Sealed source (IPL foil)	U. 1 source of 100 μCi	U. R&D of a time-of-flight mass spectrometer.
V. Any radioactive material	V. Any	V. 1 mCi/gm of total activity per sample	V. Possession as a consequence of laboratory analysis of hazardous material samples.

Texas Department of Health
BUREAU OF RADIATION CONTROL

077350

RADIOACTIVE MATERIAL LICENSE

LICENSE NUMBER	AMENDMENT NUMBER
L00775	55

5. Radioisotope (continued)	6. Form of Material (continued)	7. Maximum Activity (continued)	8. Authorized Use (continued)
W. Cs-137	W. Sealed sources	W. 60,000 Ci	W. For receipt and storage and for transfer to authorized recipients.
X. Any radioactive material	X. Any	X. 1 mCi/gm of total activity per sample	X. Alpha and gamma ray spectroscopy of soils.
Y. Any radioactive material	Y. Any	Y. As acquired incident to decontamination	Y. Possession incident to decontamination of sealed sources.
Z. Ir-192	Z. Any	Z. 1000 Ci	Z. Possession incident to failure and metallurgical analysis of sealed sources.
AA. Ra-226	AA. Solid	AA. 100 μCi	AA. R&D using Pylon RN-1025 Radon Generator.
AB. Rn-222	AB. Gas	AB. 100 μCi	AB. R&D using Pylon RN-1025 Radon Generator.
AC. Cs-137	AC. Sealed Source (JLS Model 6810)	AC. 130 Ci	AC. Survey instrument calibration using J.L. Shepherd Model 81-10 Calibrator.
AD. Cs-137	AD. Sealed source (TEL Model A-102112)	AD. 5 sources of 9 mCi each	AD. Possession incident to failure and metallurgical testing of Troxler Electronics Laboratories Model 3400 series moisture/density gauge.
AE. Am-241	AE. Sealed source (TEL Model A-102451)	AE. 5 sources of 44 mCi each	AE. Possession incident to failure and metallurgical testing of Troxler Electronics Laboratories Model 3400 series moisture/density gauge.
AF. Cs-137	AF. Sealed source (A/S Model CDC.711)	AF. 1 source of 300 mCi	AF. R&D in licensee's custom source housing.
AG. Th-230	AG. Sealed sources	AG. No source to exceed 1.1 μCi	AG. Alpha and gamma spectroscopy standards.
AH. H-3	AH. Any	AH. 25 Ci	AH. Testing of self-luminous lights.

Texas Department of Health
BUREAU OF RADIATION CONTROL

RADIOACTIVE MATERIAL LICENSE

LICENSE NUMBER	AMENDMENT NUMBER
L00775	55

5. Radioisotope (continued)	6. Form of Material (continued)	7. Maximum Activity (continued)	8. Authorized Use (continued)
AI. Ni-63	AI. Any	AI. 1 Ci	AI. Clean, repair or rebuild Electron Capture Detectors (ECD) and redistribution to specifically authorized customers. Also, for redistribution of generally licensed ECDs to persons authorized by TRCR 40.61(a).
AJ. Cf-252	AJ. Sealed source (FTC Model 100 ser.)	AJ. 1 source of 53.5 mCi	AJ. R&D of a waste sampling probe.
AK. Any radioactive material with Atomic number less than 84	AK. Any	AK. No single source to exceed 100 Ci Total of any isotope not to exceed 1000 Ci	AK. Performance testing of sources and devices as part of the "Sealed Source and Device Design Safety Testing" program with the NRC.
AL. Am-241	AL. Any	AL. No single source to exceed 50 mCi	AL. Performance testing of sources and devices as part of the "Sealed Source and Device Design Safety Testing" program with the NRC.
AM. Sn-113	AM. Any	AM. 200 Ci	AM. Wear testing of engine parts.
AN. Sb-124/ Sb-125	AN. Any	AN. 400 Ci	AN. Wear testing of engine parts.
AO. Zn-65	AO. Any	AO. 200 Ci	AO. Wear testing of engine parts.
AP. Co-60	AP. Any	AP. 50 Ci	AP. Receipt and interim storage of the licensee's radioactive waste.
AQ. Any radioactive material with atomic number less than 84.	AQ. Any	AQ. Total not to exceed 14.33 Ci	AQ. Receipt and interim storage of the licensee's radioactvie waste.

Texas Department of Health
BUREAU OF RADIATION CONTROL

077352

RADIOACTIVE MATERIAL LICENSE

LICENSE NUMBER	AMENDMENT NUMBER
L00775	55

9. Radioactive material shall be stored and used only at:

Site Number	Location
000	San Antonio - 6220 Culebra Road

10. Each site shall maintain documents and records pertinent to the operations at that site. Copies of all documents and records required by this license shall be maintained for Agency review at Site 000.

11. Radioactive material authorized in Part Q of Conditions 5, 6, 7 and 8 shall also be used at temporary sites throughout Texas.

12. The licensee shall comply with the provisions of Parts 11, 12, 13, 21, 22, 40 and 41 of the Texas Regulations for Control of Radiation (TRCR).

13. Radioactive material shall only be used by, or under the supervision of, individuals designated by the Radiological Health and Safety Committee, **Michael G. MacNaughton**, Ph.D., Chairman.

14. The licensee is hereby exempted from TRCR Part 36, provided that all downhole operations authorized by this license are accomplished in cased wells and at depths of 200 feet or less. However, the licensee shall comply with the provisions of TRCR 36.4 and 36.501.

15. The individual designated to perform the functions of Radiation Safety Officer (RSO) for activities covered by this license is John P. Hageman.

16. Sealed sources containing radioactive material shall be opened only in accordance with procedures listed in Condition 28 below.

17. Sealed sources of radioactive material, Ni-63 foil, and/or plated alpha emitting sources shall be tested for leakage and/or contamination in accordance with the provisions of TRCR 11.7.

18. In accordance with TRCR 11.7, the interval of testing for leakage of the sources described in Part R of Conditions 5, 6, 7 and 8 shall not exceed three years.

19. The licensee is authorized to perform survey instrument calibration in accordance with procedures listed in Condition 28 below.

20. Individuals involved in operations which utilize, during any 24 hour period, more than 50 mCi of I-125 and/or I-131 or unvented laboratory operations involving 10 mCi of I-125 and/or I-131 in a noncontained form shall have bioassays performed within one week. If the use of more than 50 mCi of I-125 and/or I-131 occurs during any calendar week and this level of use persists for a minimum of any two weeks during any four week period, bioassays shall be performed once every two weeks for a period of one calendar quarter. Records of action points listed below shall be observed.

RADIOACTIVE MATERIAL LICENSE

LICENSE NUMBER	AMENDMENT NUMBER
L00775	55

20. A. Whenever the thyroid burden at the time of measurement exceeds 0.12 μCi of I-125 or 0.04 μCi of I-131, the following actions shall be taken:
    1. An investigation of the operations involved, including ventilation surveys shall be carried out to determine the causes of exposure and to evaluate the potential for further exposures.
    2. If the investigation indicates that further work in the area might result in exposure of a worker to concentrations that are excessive, the licensee shall restrict the worker from further exposure until the source of exposure is discovered and corrected.
    3. Corrective actions that will eliminate or lower the potential for further exposures shall be implemented.
    4. A repeat bioassay shall be taken within one week of the previous measurement in order to confirm the effectiveness of the corrective action taken or to verify internal radioiodines present.
    5. Reports or notification shall be provided as required by TRCR Sections 21.1203 and 21.1207.

    B. If the thyroid burden at any time exceeds 0.5 μCi of I-125 or 0.14 μCi of I-131, the following actions shall be taken:
    1. Prevent the individual from any further handling of I-125 or I-131 until the thyroid burden is below the above limits.
    2. Carry out all steps described above.
    3. As soon as possible, refer the case to appropriate medical consultation for recommendations regarding therapeutic procedures that may be carried out to accelerate removal of radioactive iodine from the body. This should be done within two to three hours after exposure when the time of exposure is known so that any prescribed thyroid blocking agent would be effective.
    4. Carry out repeated measurements at approximately one week intervals at least until the thyroid burden is less than 0.12 μCi of I-125 or 0.04 μCi of I-131.

21. The licensee shall not use radioactive material in or on human beings or in any field application where such activity is released except as provided otherwise by specific condition of this license.

22. Each person using radioactive material shall be provided with a copy of the licensee's Radiological Health and Safety Manual. Proposed changes in or additions to the licensee's manual shall be submitted to the Agency for approval before being incorporated into this document.

23. The licensee is authorized to receive and load teletherapy sources into customer's teletherapy source holders.

24. A. Tritium shall not be used in such a manner as to cause any individual to receive a radiation exposure such that urinary excretion rates exceed 28 μCi of tritium per liter when averaged over a calendar quarter.

Texas Department of Health
BUREAU OF RADIATION CONTROL

077354

RADIOACTIVE MATERIAL LICENSE

LICENSE NUMBER	AMENDMENT NUMBER
L00775	55

24. B. Urinalysis shall be performed at weekly intervals on all individuals who work in the restricted areas of facilities in which tritium is used. If the average concentration of tritium in urine for any single individual during a calendar quarter is less than 10 μCi per liter, urinalysis may be performed on that individual at monthly intervals for the following calendar quarter and may continue at monthly intervals so long as the average concentration in the calendar quarter remains below 10 μCi per liter. The urine specimen shall be collected on the same day of the week if possible.
    C. A report of an average concentration in excess of the limit specified in (A) above for any individual shall be filed, in writing, within 30 days of the end of the calendar quarter with the Agency. The report shall contain the results of all urinalyses for the individual during the calendar quarter, the cause of the excessive concentrations, and the corrective steps taken or planned to assure against a recurrence.
    D. Any single urinalysis which discloses a concentration of greater than 50 μCi per liter shall be reported, in writing, within seven days of the licensee's receipt of the results.

25. The licensee is authorized to perform tests for leakage and/or contamination on teletherapy sources for customers and on their own sealed sources. Such tests shall be capable of detecting 0.005 μCi of contamination on the test sample and the results of such tests shall be provided to the customer in terms of μCi.

26. The licensee is authorized to disassemble and clean Ni-63 electron capture detector cells in accordance with procedures listed in Condition 28 below.

27. The authorized use of radioactive material listed in Conditions 8P, 8S 8W and 8AI shall be restricted to storage only after May 1, 1996.

Texas Department of Health
BUREAU OF RADIATION CONTROL

077355

RADIOACTIVE MATERIAL LICENSE

LICENSE NUMBER	AMENDMENT NUMBER
L00775	55

28. Except as specifically provided otherwise by this license, the licensee shall possess and use the radioactive material authorized by this license in accordance with statements, representations, and procedures contained in the following:

appplication dated November 19, 1993,
Radiological Health and Safety Manual received April 15, 1994, and
letters dated November 16, 1993, November 30, 1993, December 17, 1993,
March 22, 1994, April 4, 1994, August 12, 1994,
October 10, 1994, December 9, 1994, December 28, 1994,
April 10, 1995, June 15, 1995, August 2, 1995,
September 18, 1995 and October 20, 1995.

The TRCR shall prevail over statements contained in the above documents unless such statements are more restrictive than the regulations.

FRH:sw

FOR THE TEXAS DEPARTMENT OF HEALTH

Date November 1, 1995

Wesley M. Dunn, C.H.P., Administrator
Licensing Branch

ENCLOSURE TWO

NASA-WSTF
Environmental Department

Preliminary Schedule

ID	Task Name	Start	Finish
1	**Plume-Front Stabilization**		
2	Work Plan Submittal/Approval (anticipated)	1/19/99	3/19/99
3	Discharge Plan Submittal/Approval (anticipated)	2/19/99	8/19/99
4	Operation and Maintenance/Remediation System Specifications Submittal/Approval (anticipated)	9/13/99	11/5/99
5	Technical Feasibility Demonstration (including public comment)	2/15/99	4/30/99
6	Drilling of Plume-Front Wells (monitoring, extraction, injection)	1/18/99	11/16/01
7	Design/Installation of Electrical Distribution System	12/1/98	9/10/99
8	Design/Installation of Remediation System	10/5/98	11/16/01
9	Phase 1 Remediation System Start-Up		6/16/00
10	Phase 2 Start-Up of Remediation System		11/16/01
11	**Mid-Plume Constriction Zone Evaluation**		
12	Drilling and Aquifer Testing of Mid-Plume Wells (monitoring and extraction)	10/1/98	7/30/99
13	Remediation Evaluation/Modeling	10/29/99	1/31/00
14	Remediation	TO BE DETERMINED	
15	**700 Area Landfill**		
16	Monitoring Well Installation Plan/Approval (anticipated)	1/15/99	6/15/99
17	Monitoring Well Installation	7/1/99	12/29/99
18	Data Evaluation/Possible Remediation	TO BE DETERMINED	
19	**Angled Soil Gas Wells**		
20	Installation	1/31/00	6/29/00
21	Data Collection/Evaluation	9/1/00	11/30/01
22	**Draft RFI/CMS Report**		
23	RFI/CMS Report Related Activities	10/1/98	1/30/02
24	Submittal		1/30/02
25	**Well Corrosion Evaluation**		
26	Down-Hole Camera Logging/Evaluations	11/2/98	5/4/99
27	Replacement/Rehabilitation/Abandonment of Wells	TO BE DETERMINED	
28	Cathodic Protection Installation	TO BE DETERMINED	
29	**Permitting**		
30	Hazardous Waste Operating/Post-Closure Care Permit Modifications/Consolidation	TO BE DETERMINED	

PLUME-FRONT STABILIZATION WORK PLAN

NASA-JSC WHITE SANDS TEST FACILITY

Original Submission January 1999

Revised May 2002

TABLE OF CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS USED IN REPORT..... vi

1.0 EXECUTIVE SUMMARY.....1

2.0 INTRODUCTION.....2
2.1 SITE LOCATION AND DESCRIPTION OF PROJECT AREA.....2

2.2 REGULATORY BACKGROUND.....2

3.0 CURRENT CONDITIONS.....5
3.1 SITE GEOLOGY.....5
3.1.1 Stratigraphy.....5
3.1.2 Structure.....6

3.2 SITE HYDROGEOLOGY.....6
3.2.1 Aquifer Description.....6
3.2.2 Groundwater Movement.....7
3.2.3 Groundwater Recharge/Discharge.....7
3.2.4 Groundwater Quality.....8
3.2.5 Background Metals' Concentrations.....8

3.3 CONTAMINATION.....9
3.3.1 Groundwater Contamination.....9

3.4 GROUNDWATER MODEL SETUP AND CALIBRATION.....11
3.4.1 Description of Groundwater Model and Programs.....11
3.4.2 Construction of the WSTF 3DSWB Conceptual Model.....15
3.4.3 3DSWB Model Calibration for Contaminant Migration.....16

3.5 HEALTH RISK ASSESSMENT.....16
3.5.1 Chemicals of Concern.....17
3.5.1.1 Carcinogens.....17
3.5.1.2 Non-Carcinogens.....18
3.5.2 Potential Receptors and Exposure Pathways.....18
3.5.3 Risk Characterization.....21
3.5.3.1 Carcinogenic Risk Estimates.....21
3.5.3.2 Non-Carcinogenic Hazard Quotients and Indices.....22
3.5.4 Uncertainties.....26
3.5.4.1 Carcinogenicity Evidence Under Review.....26
3.5.4.2 Lack of Toxicity Data.....26
3.5.4.3 Chemical Concentrations.....26

3.6 DATA SUFFICIENCY.....26

4.0 PRESUMPTIVE REMEDY FOR PLUME-FRONT STABILIZATION 27
4.1 EVALUATION OF 3DSWB MODEL PREDICTIVE REMEDIAL SCENARIOS 27
4.2 DESCRIPTION OF PLUME-FRONT STABILIZATION SCENARIO 30
4.2.1 Remediation Well Characteristics 32
4.3 PLUME-FRONT STABILIZATION SCENARIO SIMULATIONS 35
4.3.1 PATH3D Plume-Front Stabilization Diagrams 35
4.3.2 Predictive Plume-Front Isoconcentration Maps 35
4.3.3 Mass Extraction Calculations 44
4.3.4 Other Modeling Considerations 44
4.4 TREATMENT STANDARDS 45
4.4.1 Groundwater Treatment Standards 47
4.5 PRESUMPTIVE REMEDY REMEDIAL SYSTEM CONCEPTUAL DESIGN 49
4.6 SITE SAFETY AND SECURITY 58
4.7 SYSTEM START-UP 58
4.8 REMEDIAL SYSTEM OPERATION AND MAINTENANCE AND CONTINGENCY PLANNING 58
4.8.1 Operation and Maintenance 58
4.8.2 Contingency Plan 59
4.8.3 Waste Management 59

5.0 SAMPLING AND ANALYSIS 59
5.1 INTRODUCTION, OBJECTIVES AND SCOPE 59
5.2 SAMPLING ACTIVITIES AND FIELD METHODS 60
5.2.1 Groundwater Monitoring 61
5.2.2 Treatment System Monitoring 61
5.2.3 Treatability Testing 66
5.2.4 Treatment System Start-Up 66
5.3 SAMPLE COLLECTION, SCHEDULING, AND ANALYSIS 66
5.3.1 Sample Collection 66
5.3.2 Sampling Frequencies 66
5.3.3 Analytical Methods 68

5.4 QUALITY ASSURANCE PROJECT PLAN 68
5.4.1 Purpose 68
5.4.2 Project Organization 68
5.4.3 Off-Site Laboratories 69
5.4.4 Data Quality Objectives 69
5.4.4.1 QA/QC Samples 69
5.4.4.2 QA/QC Sample Requirements 69
5.4.4.3 Data Quality Requirements 74
5.4.5 Sample Containers, Preservation and Holding Times 74

6.0 PROJECT MANAGEMENT 74
6.1 ORGANIZATION 74

6.2 SCHEDULE 78

6.3 REPORTING REQUIREMENTS 78

6.4 PERMITTING ISSUES 78
6.4.1 Work Plans, Operations and Maintenance Plans and System Specifications 78
6.4.2 Technical Feasibility Study 81
6.4.3 Groundwater Discharge Plan 81
6.4.4 Hazardous Waste Permits 81
6.4.5 Air Quality 82
6.4.5.1 Subpart AA 82
6.4.5.2 Subpart BB 82
6.4.5.3 Subpart CC 83
6.4.6 National Environmental Policy Act 83
6.4.7 Well Permits 83

7.0 REFERENCES 84

LIST OF FIGURES

Figure 2.1: WSTF Location Map 3
Figure 2.2: Groundwater Plume Hydrogeological Features 4
Figure 3.1: Plume-Front Containment Simulated NDMA Plume for 1992 12
Figure 3.2: Plume-Front Containment Simulated TCE Plume for 1992 13
Figure 3.3: Plume-Front Containment Simulated PCE Plume for 1992 14
Figure 3.4: WSTF Vicinity Well Location Map 20
Figure 3.5: Contour Map of Cumulative Cancer Risk 24
Figure 4.1: Plume-Front Containment Well Locations 31
Figure 4.2: Simulated Contaminant Pathlines for NDMA Plume-Front Containment 36
Figure 4.3: Simulated Contaminant Pathlines for TCE Plume-Front Containment 37
Figure 4.4: Plume-Front Containment Simulated NDMA Plume for 2026 38
Figure 4.5: Plume-Front Containment Simulated TCE Plume for 2026 39
Figure 4.6: Plume-Front Containment Simulated PCE Plume for 2026 40
Figure 4.7: Simulated NDMA Concentration and Cumulative Mass Removed for All Extraction Wells 41
Figure 4.8: Simulated TCE Concentration and Cumulative Mass Removed for All Extraction Wells 42
Figure 4.9: Simulated PCE Concentration and Cumulative Mass Removed for All Extraction Wells 43
Figure 4.10: Remedial System Well Locations and Conceptual Design 53
Figure 4.11: Preliminary Remedial System Process Flow Diagram 56
Figure 6.1: Organizational Chart for NASA WSTF Environmental Activities 77
Figure 6.2: Plume-Front Stabilization Schedule 79

LIST OF TABLES

Table 3.1: Physical and Chemical Properties of Plume-Front Constituents of Concern 10
Table 3.2: Toxicity Information for Plume-Front Chemicals 19
Table 3.3: Chronic Daily Intake (CDI) Assumptions 23
Table 3.4: Carcinogenic Risk Estimates for Plume-Front Monitoring Wells 23
Table 3.5: Hazard Quotients and Indices for Plume-Front Wells 25
Table 4.1: Summary of 3DSWB Model Interim Measures Remedial Scenarios 29
Table 4.2: Plume-Front Containment Well Locations, Pumping Rates and Design Parameters 33
Table 4.3: Summary of Regulatory Standards and Remediation Goals 46
Table 4.4: Expected Influent Contaminant Concentrations to the Plume-Front Remediation System 48
Table 4.5: Presumptive Remedy Goals for Plume-Front Contaminants 50
Table 4.6: Individual and Cumulative Risk Assuming 30% Analytical Extraction Efficiency for NDMA and DMN 51
Table 4.7: Anticipated Plume-Front Remediation System Performance 54
Table 5.1: Sample Collection and Analysis Requirements 62
Table 5.2: Plume-Front Sampling Frequencies for Conventional Wells/Zones 63
Table 5.3: Plume-Front Sampling Frequencies for Westbay® Multi-Port Wells/Zones 64
Table 5.4 Influent/Effluent Sampling Schedule 67
Table 5.~~4~~5: Description of Field Quality Control Samples ..... 70~~65~~
Table 5.~~5~~6: Description of Analytical Quality Control Samples ..... 71~~66~~
Table 5.~~6~~7: Field QA/QC Control Sample Frequencies ..... 72~~67~~
Table 5.~~7~~8: Analytical QA/QC Control Sample Frequencies ..... 73~~68~~
Table 5.~~8~~9: Method Specific Data Acceptability Requirements ..... 75~~69~~
Table 5.~~9~~10: Description of Data Quality Assurance Flags ..... 76~~70~~

LIST OF APPENDICES

APPENDIX A: CONTINGENCY PLAN FOR THE WSTF HAZARDOUS WASTE OPERATING PERMIT
APPENDIX B: WSTF GROUNDWATER SAMPLING AND ANALYSIS PLAN
APPENDIX C: WSTF QUALITY ASSURANCE PROJECT PLAN
APPENDIX D: LABORATORY QUALITY ASSURANCE/QUALITY CONTROL

LIST OF ACRONYMS AND ABBREVIATIONS USED IN REPORT

3DSWB	Three Dimensional Site-Wide Bedrock (Groundwater Model)
~~amsl~~	~~Above mean sea level~~
ASTM	American Society for Testing and Materials
AT	Averaging-Time
bgs	Below ground surface
BWa	Body Weight for an adult
BWc	Body Weight for a child
CCV	Continuous Calibration Verification
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Cfadj	Age-Adjusted Calculation Factor
CFR	Code of Federal Regulations
CMS	Corrective Measures Study
COCs	Contaminants of Concern
CW	Concentration in Water
DBS&A	Daniel B. Stephens and Associates Inc.
DMN	N-nitrodimethylamine
DP	Discharge Plan
~~DQO~~	~~Data Quality Objective~~
EA	Environmental Assessment
EDa	Exposure Duration for an adult
EDc	Exposure Duration for a child
EDtot	Exposure Duration total
EF	Exposure Frequency
EPA	U.S. Environmental Protection Agency
Freon -11	Trichlorofluoromethane ~~(Freon 11)~~
Freon -21	Dichlorofluoromethane ~~(Freon 21)~~
Freon -113	1,1,2-Trichloro-1,2,2-trifluoroethane ~~(Freon 113)~~
~~FAR~~	~~Federal Acquisition Regulation~~
FBR	Flow-Banded Rhyolite
FC-21	Dichlorofluoromethane (Freon 21)
GCL	Geoscience Consultants, Ltd.
GC/MS	Gas Chromatography/Mass Spectroscopy
gpm	Gallons per minute
GWQB	Ground Water Quality Bureau
HDPE	High-Density Polyethylene
HI	Hazard Index
HQ	Hazard Quotient
HRMB	Hazardous and Radioactive Materials Bureau
HWMU	Hazardous Waste Management Unit
ID	Identification
IFWadj	Age-Adjusted Ingestion Factor
IRWa	Ingestion Rate of Water for an adult

IRWc	Ingestion Rate of Water for a child
IRIS	Integrated Risk Information System
JDMB	Jornada del Muerto Basin
K	Hydraulic Conductivity
kW hr	Kilowatt-hour
LCS	Laboratory Calibration Standard
MOSDAX	Modular Subsurface Data Acquisition System
MPCA	Mid-Plume Constriction Area
N/A	Not Applicable
NARA	National Archives and Records Administration
NASA	National Aeronautics and Space Administration
NCEA	National Center for Environmental Assessment
NDMA	N-nitrosodimethylamine
~~NEPA~~	~~National Environmental Policy Act~~
NIOSH	National Institute for Occupational Safety and Health
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
O&M	Operation and Maintenance
~~PARCC~~	~~Precision, Accuracy, Reproducibility, Completeness, and Comparability~~
PCE	Tetrachloroethene (perchloroethene)
PFE	Plume-Front Extraction (well)
PFI	Plume-Front Injection (well)
Plan	Plume-Front Stabilization Work Plan
ppb	Parts per billion
ppm	Parts per million
ppmw	Parts per million by weight
ppt	Parts per trillion
PRG	Preliminary Remediation Goal
PT	Pump Test
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RAGS	Risk Assessment Guidance for Superfund
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RFI	RCRA Facility Investigation
RL	Reporting Limit
SAP	Sampling and Analysis Plan
~~SAP-PFRS~~	~~Sampling and Analysis Plan for the Plume-Front Remediation System~~
SEO	New Mexico State Engineer Office
SF	Slope Factor
SW	Site-Wide
T	Transmissivity
TCE	Trichloroethene
~~TDS~~	~~Total Dissolved Solids~~

TLV	Threshold Limit Value
UF/MF	Uncertainty Factor/Modifying Factor
UV	Ultraviolet
VOC	Volatile Organic Compound
WBFZ	Western Boundary Fault Zone
WSTF	White Sands Test Facility

1.0 EXECUTIVE SUMMARY

This Plume-Front Stabilization Work Plan (Plan) describes a presumptive remedy corrective action for the National Aeronautics and Space Administration (NASA) White Sands Test Facility (WSTF). This presumptive remedy is intended to control threats to human health and/or the environment at the westernmost extent of a groundwater contaminant plume within the aquifer below WSTF. The groundwater is contaminated as a result of historic activities at the site. The groundwater contaminant plume-front area covers an area of approximately 4,000 feet by 8,000 feet and has a depth of 700 feet. The contaminants of concern (COCs) at the plume-front include N-nitrosodimethylamine (NDMA), N-nitrodimethylamine (DMN) and several halogenated volatile organic compounds (VOCs).

An ex-situ pump and treat remediation system is proposed to address plume-front stabilization and contaminant mass treatment activities. This system will include the installation of ~~five~~nine Westbay® multi-port groundwater monitoring wells (WW-2, WW-3, WW-4, WW-5, ST-7, JP-3, PL-8, PL-9 and BLM-37). These wells will assist with plume-front extraction/injection well design, enhance plume-front monitoring capabilities and monitor the effectiveness of the stabilization system.

The plume-front stabilization will utilize six plume-front extraction (PFE) and four plume-front injection (PFI) wells. The WSTF three-dimensional site-wide bedrock (3DSWB) groundwater model was utilized to simulate contaminant plumes for NDMA, trichloroethene (TCE), and tetrachloroethene (PCE). Parameters generated from the 3DSWB model wells were used for the plume-front stabilization well designs. ~~Extraction~~ The six extraction wells ~~PFE-1 through PFE-6 will~~ remain within or on the eastern boundary of the Western Boundary Fault Zone (WBFZ). ~~Three high-volume e~~Extraction wells ~~(PFE-1 through PFE-3)~~ PFE-1, PFE-2, PFE-3, PFE-4A and PFE-7~~and one lower volume extraction well (PFE-4)~~ will specifically address the TCE contaminant plume which extends furthest west. These wells also effectively contain the PCE plume. ~~Extraction~~ The five extraction wells ~~PFE-1 through PFE-4~~ will utilize an estimated combined flow rate of ~~810~~1,050 gallons per minute (gpm).

Extraction well~~s~~ PFE-5 ~~and PFE-6~~, with an estimated ~~combined~~ flow rate of ~~200~~ 26 gpm, specifically addresses the NDMA/DMN plume containment. In the plume-front vicinity, the DMN plume has a similar extent to the NDMA plume but ~~significantly~~ generally lower concentrations. To ensure stabilization of the NDMA/DMN plume-front, which does not extend as far west as the TCE plume, well~~s~~ PFE-5 ~~and PFE-6 will be~~ is positioned to stabilize the NDMA/DMN plume-front concentrations east of the TCE target wells. Any NDMA/DMN contamination not addressed by well PFE-5 or wells anticipated for installation in the mid-plume area will be effectively captured by the high volume extraction wells to the west. The estimated total system flow rate will be 1,0~~10~~76 gpm.

Groundwater contaminant destruction will be performed using a groundwater treatment system. The groundwater from the extraction well system will be pretreated as necessary, treated by an air stripper unit (for the VOCs), and an ultraviolet (UV) oxidation unit (primarily for NDMA and DMN)~~, and an air stripper unit (for the VOCs)~~. Contaminant

treatment standards for the injected water have been developed following standards and guidelines from multiple Federal and State regulatory sources.

Remediated groundwater injection will be accomplished by four injection wells (PFI-1 through PFI-4) located to the west and south of the contaminant plume. The injection well locations are designed to contain the southern migration of the plume by creating a localized groundwater mound.

2.0 INTRODUCTION

This Plan addresses the stabilization and mass removal of low-concentration groundwater contamination encountered at the leading (westernmost) edge of the WSTF groundwater contaminant plume (referred to as the plume-front). This Plan presents a pump and treat presumptive remedy. Descriptions of presumptive remedies policies and procedures are provided in U.S. Environmental Protection Agency (EPA) Presumptive Remedies Policy and Procedures Directive (EPA, 1993; EPA, 1996).

2.1 SITE LOCATION AND DESCRIPTION OF PROJECT AREA

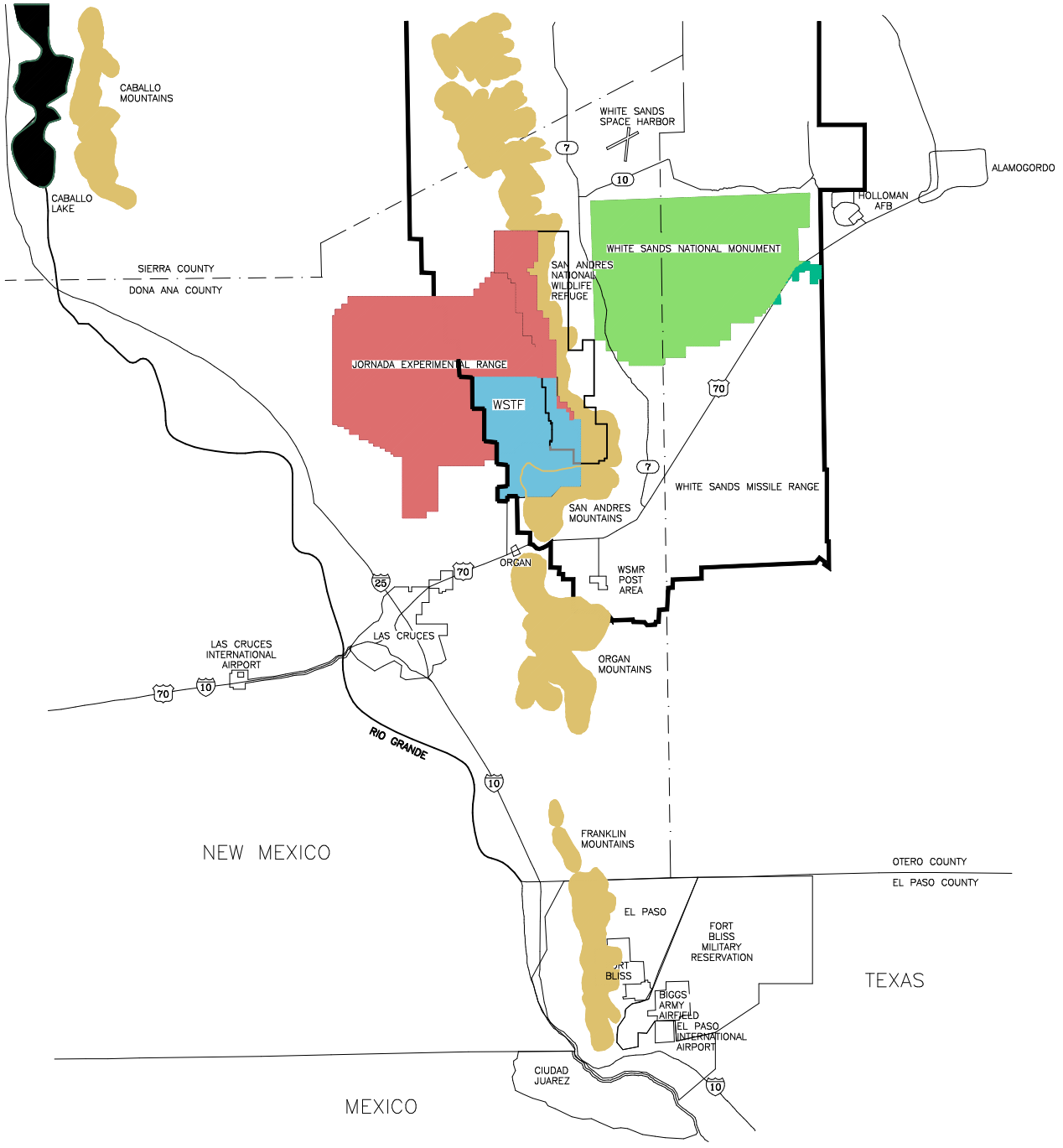
WSTF is located on the western flank of the southern San Andres Mountains approximately 18 miles northeast of Las Cruces, New Mexico and 65 miles north of El Paso, Texas (Figure 2.1). Access to the site from Las Cruces is provided by a paved road, which intersects U.S. Highway 70 one mile west of Organ, New Mexico.

The WSTF plume is approximately 20,000 feet in length, up to 8,000 feet in width (at the plume-front) and 700 feet in depth. The plume consists of three general areas: the source areas; the mid-plume constriction area (MPCA); and the plume-front area. The WSTF plume-front area illustrated by Figure 2.2 is hosted within a transitional hydrogeological zone between the western San Andres Mountains fractured bedrock pediment slope and the alluvial filled Jornada del Muerto Basin (JDMB). This transitional zone is referred to as the WBFZ (Figure 2.2), and comprises an area of pronounced half-graben bedrock faulting related to Tertiary Basin and Range extension. Groundwater at the plume-front occurs at a depth of 420 feet below ground surface (bgs), with low-concentration groundwater contamination confined to the upper 600 feet of the aquifer.

2.2 REGULATORY BACKGROUND

This Plan ~~has been~~ was prepared in response to discussions on September 16, 1998 between representatives from the EPA Region 6, New Mexico Environment Department (NMED) Hazardous and Radioactive Materials Bureau (HRMB), NMED Ground Water Quality Bureau (GWQB), and NASA. EPA and NMED representatives requested this Plan to identify and describe the plume-front stabilization and treatment activities proposed by NASA. This version of the Plan (May 2002) provides modifications to the original Plan submitted in January 1999.

The format of this Plan was developed in accordance with Chapter II and Appendix E of the Resource Conservation and Recovery Act (RCRA) Corrective Action Plan Final (EPA,



LEGEND

- NASA/WSTF
- JORNADA EXPERIMENTAL RANGE
- NATIONAL MONUMENT
- MOUNTAINS OR MOUNTAIN RANGE
- COUNTY BOUNDARY
- WHITE SANDS MISSILE RANGE BOUNDARY
- SAN ANDRES NATIONAL WILDLIFE REFUGE BOUNDARY
- US HIGHWAY (10)
- STATE HIGHWAY (70)
- MILITARY HIGHWAY (7)

N

NOT TO SCALE

FIGURE 2.1
WSTF LOCATION MAP

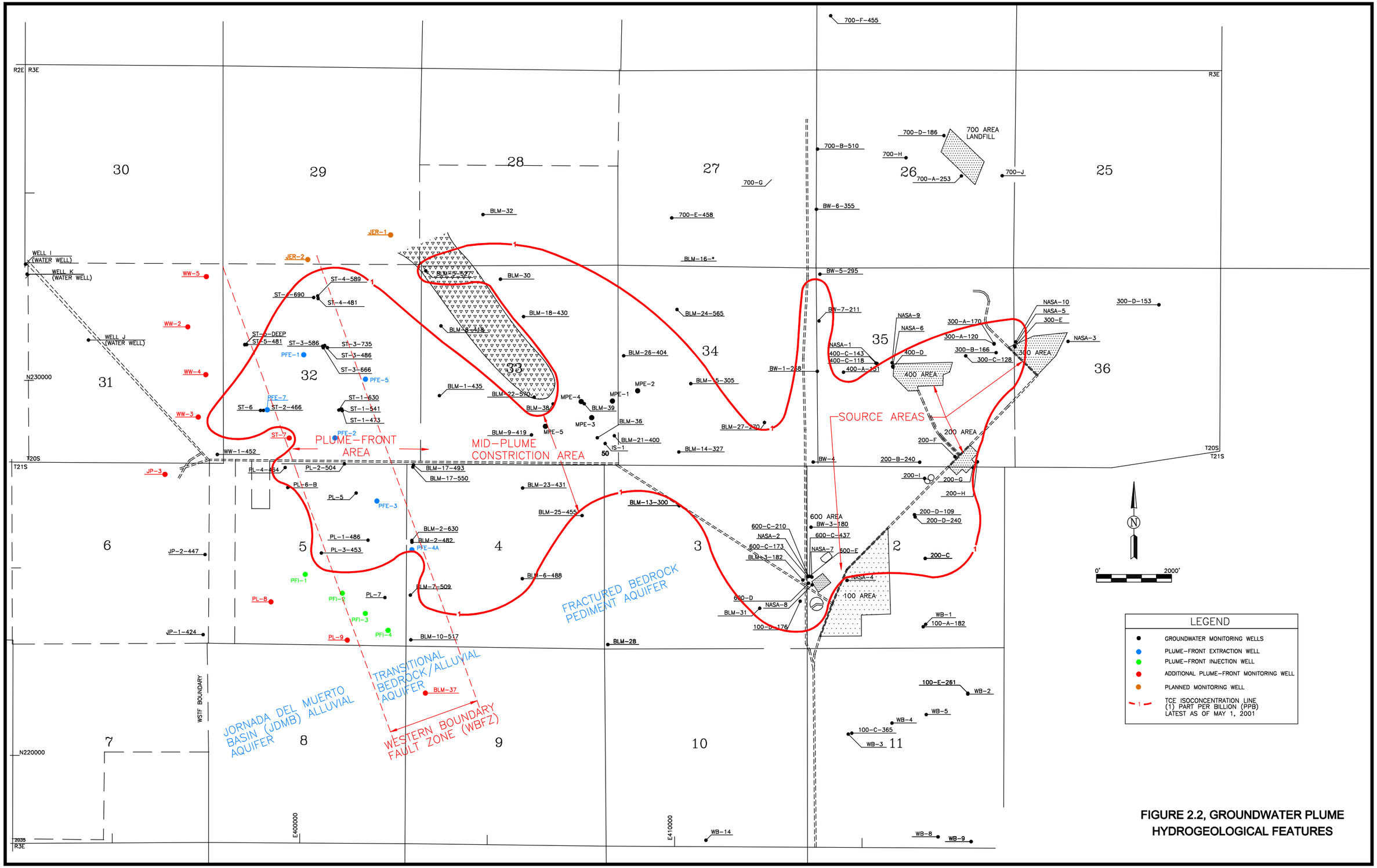


FIGURE 2.2, GROUNDWATER PLUME HYDROGEOLOGICAL FEATURES

1994), Presumptive Remedies: Policy and Procedures Directive (EPA, 1993), and Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites (EPA, 1996). NASA, during the September 16, 1998 meeting, voluntarily proposed a corrective action for the WSTF plume-front area. Both the EPA and NMED verbally concurred with this proposal and encouraged NASA to give high priority to implementation of the plume-front stabilization activities.

Technical information relative to the nature of the WSTF groundwater contaminants, their environmental setting and modes of transport in the subsurface have been collected at WSTF and evaluated from the mid-1980s to present. Pursuant to a 3008(h) Consent Order between EPA Region 6 and NASA, technical results and evaluations were provided in the Draft RCRA Facility Investigation (RFI) and Corrective Measures Study (CMS) Reports (NASA, 1996a; NASA, 1996b).

The primary groundwater contaminants observed within the plume-front area are NDMA, DMN and halogenated VOCs. Chapter Three of the Draft CMS Report (NASA, 1996b) identified and evaluated treatment technologies available to remediate these groundwater contaminants. Unfortunately, NDMA and DMN are particularly recalcitrant to in-situ treatment and require ex-situ pump and treat ~~methodologies~~ technology.

3.0 CURRENT CONDITIONS

This section provides an overview of the current conditions which influence the nature, distribution and migration of plume-front groundwater contamination. Comprehensive discussions of current conditions are provided in Volumes Two through Four of the Draft RFI Report (NASA, 1996a). Historical, current and predicted geological, hydrogeological and contaminant conditions have been input into a conceptual WSTF groundwater model which is described in detail later in this Plan. The groundwater model is used as a tool to simulate predictive contaminant trends and examine the effectiveness of different plume-front stabilization alternatives.

3.1 SITE GEOLOGY

3.1.1 Stratigraphy

Bedrock locally outcrops adjacent and east of the WSTF test areas, the primary sources for groundwater contamination. Bedrock stratigraphic units include Pennsylvanian to Permian-age limestone, sandstone, siltstone, and shales to the east within the WSTF test areas, and Tertiary volcanic rocks to the west. The two bedrock lithologies are juxtaposed in the subsurface along the regional northwest-trending Hardscrabble Hill Fault (Figure 2.2). Bedrock is covered with a veneer of alluvium, which increases in thickness to the west from a few feet in the vicinity of the test areas to over 400 feet near the WBFZ. This alluvium consists of Quaternary alluvial fan deposits of the Santa Fe Group derived from the San Andres Mountains to the east.

The Santa Fe Group alluvium is a consolidated to unconsolidated, poorly sorted gravel with a matrix of sand, silt, and clay. Surface geology in the plume-front area consists of Quaternary mid to distal alluvial fan Santa Fe Group deposits made up of limestone, siltstone, shale, rhyolite, andesite, and granite clasts. The thickness of alluvial deposits in the plume-front vicinity increase from approximately 400 feet on the bedrock pediment to in excess of 2,500 feet within the JDMB (Draft RFI Report, Volume Two, Chapter Four, NASA, 1996a).

Tertiary volcanic bedrock units within the plume-front area consist of variable acidic volcanic rocks. Rhyolitic tuffs predominate and consist of crystal-vitric-lithic ash-flow tuffs. Correlative lithologies have been reported in association with the Organ Mountains Intrusive Complex (Seager, 1981). The flow-banded rhyolite (FBR) volcanic unit represents the most texturally distinct lithology of the west pediment area. The FBR forms a distinct hydrostratigraphic unit that is fundamental in creating a hydrogeological feature referred to as the MPCA.

3.1.2 Structure

Two types of geologic deformation are recognized within WSTF. The oldest and least prevalent deformation consists of west to northwest-trending folding and faulting associated with the Late Cretaceous to Early Tertiary Laramide Orogeny. This compressional deformation type is confined to the western San Andres Mountains, and is exposed within the Bear Peak Fold and Thrust Zone (Seager, 1981).

The second deformation type consists of Late Tertiary Basin and Range normal faulting and is significant relative to the plume-front stabilization activities. East-west extensional forces resulted in the formation of north-trending structural depressions and adjacent fault-bound mountains from the Oligocene period to present. Numerous subsurface Basin and Range-related normal faults have been inferred from seismic and well log data throughout the site, including the Hardscrabble Hill Fault (Draft RFI Report, Volume Two, Chapter Four, NASA, 1996a). The most significant expression of normal faulting at WSTF is the WBFZ, which is coincident with the plume-front area. The WBFZ is a north-northwest trending, regional-scale series of normal half-graben faults that offset the top of the bedrock by greater than 2,000 feet over a width of 2,000 feet. Each normal fault within the series dips steeply to the west.

3.2 SITE HYDROGEOLOGY

3.2.1 Aquifer Description

Groundwater below the WSTF test areas and west to the WBFZ is hosted within a fractured bedrock aquifer at depths which increase from approximately 100 feet to 400 feet bgs. Within and west of the WBFZ, groundwater is located within the JDMB alluvial aquifer at a depth of approximately 420 feet bgs (Figure 2.2). The alluvial aquifer has a thickness in excess of 2,500 feet toward the center of the JDMB (Maciejewski, 1996) where it yields relatively large quantities of potable water. Within the WBFZ area, the plume-front is hosted

within a transitional alluvium/bedrock aquifer, with the thickness of saturated alluvium increasing to the west.

Two hydrogeologic groundwater flow barriers have been identified on the WSTF pediment slope within the mid-plume, semi-confined, fractured bedrock aquifer. Secondary porosity consisting of fractures with dips ranging from 45 to 65 degrees with minor separation predominates within the aquifer. These barriers combine to form the narrow MPCA. To the north, the northwest-southeast trending FBR unit with low permeability and transmissivity (T) restricts groundwater flow. Groundwater sample analyses within this ~~area~~ unit indicated no detectable contaminant concentrations through September 1, 1998. Low levels of VOCs have recently been reported in the northern portions of this unit, and are currently under evaluation. To the south, a second flow barrier is created by andesite that has been altered to impermeable clay, promoting low hydraulic conductivities and no detectable contaminant concentrations. These barriers result in a natural confining area to contaminant flow both to the north and south. In the MPCA, groundwater occurs at a depth of 300 feet bgs and is coincident with bedrock. A MPCA measure evaluation is currently in progress within this area to determine if mid-plume interception and treatment of the groundwater contamination is feasible (MPCA Progress Report (in preparation), NASA, 2002~~NASA, 1998a; Giles and Pearson, 1998~~).

Aquifer conditions in the vicinity of the plume-front vary from unconfined to leaky confined. Leaky confined conditions are generally prevalent within and to the west of the WBFZ. Discontinuous confining layers are interpreted to comprise clay or cemented alluvial horizons. Hydraulic conductivity (K) and T values for the alluvial aquifer are typically several orders of magnitude greater than for the fractured bedrock aquifer.

3.2.2 Groundwater Movement

East to west groundwater flow within the fractured bedrock aquifer below WSTF is generated as a result of San Andres Mountain-front recharge and subsequent infiltration downgradient into the JDMB. Horizontal hydraulic gradients at WSTF are relatively steep within the pediment area at 0.05 (250 feet/mile) and decrease west of the WBFZ within the alluvial aquifer to 0.0002 (1.1 feet/mile). Localized bedrock variations and alluvial lithologies influence the groundwater flow direction. Within the Tertiary volcanic pediment region of the bedrock aquifer (within and ~~west~~ east of the WBFZ), small-scale, interconnected fractures are interpreted to promote localized irregular downgradient groundwater movement. The fracture matrix density is generally high enough to approximate a porous flow environment.

3.2.3 Groundwater Recharge/Discharge

The San Andres Mountains provide recharge to the bedrock and alluvial aquifers through the infiltration of precipitation into exposed bedrock fractures and faults. Mountain-front recharge is estimated to be 50 to 200 acre-feet per mile of mountain front annually (Wilson et. al., 1981; Geoscience Consultants, Ltd. (GCL), 1995; NASA, 1997a).

Direct recharge by infiltration into the JDMB is low as a result of high evaporation, low precipitation, significant depths to groundwater, and the presence of thick lacustrine clays, which inhibit percolation. Minor point recharge areas are present on the pediment slope where WSTF has discharged excess water relatively continuously over the last 30 years. Approximately 90 percent of the groundwater utilized by WSTF is used for testing in the 300 and 400 Areas. The spent test water is then discharged to grade and percolates into the adjacent arroyo to recharge the groundwater. ~~A~~Presently, a total of ~~90~~ 135 acre-feet annually is estimated to recharge the aquifer over a distance of 7,000 feet downgradient of the 300 Area.

The current total groundwater discharge/pumpage of the JDMB aquifer is approximately ~~2,000~~ 6,300 acre-feet per annum (~~1,2~~3,900 gpm). Approximately ~~55~~ 49 percent of the withdrawn water is used by small independent users, ~~33~~ 49 percent by local water companies, ~~nine~~and two percent by WSTF~~, and three percent by the City of Las Cruces~~. Conservative over-estimates predict future JDMB water usage/pumpage to total 32,000 acre-feet per annum (20,000 gpm) by the year 2026, of which 55 percent will be used by the City of Las Cruces, 28 percent by local water companies, 17 percent by small independent users, and two percent by WSTF. The JDMB aquifer is not currently significantly stressed; however, the future population growth and expanded JDMB groundwater usage are anticipated to result in significant groundwater drawdown (Draft RFI Report, Volume Four, Chapter Two, NASA, 1996a).

3.2.4 Groundwater Quality

WSTF groundwater is classified as fresh to slightly saline and is characterized by elevated levels of sodium, sulfate, and bicarbonate (Wilson et. al., 1981; Draft RFI Report, Volume Two, Chapter Four, NASA, 1996a). Total dissolved solids ~~(TDS)~~ concentrations range from 490 to 1,230 parts per million (ppm). Fluoride, iron and manganese levels are generally low. Water hardness ranges from 24 to 320 ppm, and water pH values are slightly alkaline with values ranging from 7.2 to 8.3. Sulfate is the most abundant anion, with concentrations ranging from 185 to 600 ppm. Chloride and bicarbonate concentrations range from 15 to 126 ppm and 89 to 376 ppm, respectively. Nitrate levels are generally below 10 ppm, although concentrations up to 40 ppm have been detected. Concentrations of fluoride are usually less than two ppm. Dominant cations comprise the metals calcium, iron, magnesium, potassium, and sodium. Calcium concentrations range from 22 to 179 ppm. Magnesium and sodium concentrations range from 12.6 to 84 ppm and 28 to 500 ppm, respectively. Iron and potassium occur in trace amounts to 0.8 ppm and 9 ppm, respectively. Concentrations of sodium range from 30 to 157 ppm.

3.2.5 Background Metals' Concentrations

Volume Four, Chapter Two of the Draft RFI Report (NASA, 1996a) provides discussions concerning observed concentrations of RCRA regulated metals in groundwater samples. This chapter includes discussions of observed metals' concentrations such as barium, lead and selenium, which are indicative of naturally occurring levels in the JDMB. In addition, chromium detections are discussed and attributed to either naturally occurring levels or to

published leaching problems associated with stainless steel casing. EPA and NMED comments to the Draft RFI Report (EPA, 1997) requested additional data presentations and evaluations concerning these metals.

The EPA/NMED comments have resulted in additional data evaluations by WSTF personnel; these evaluations have thus far supported the Draft RFI Report statements. Final evaluations and statistical analyses will be presented within the revised Draft RFI Report. Data collected from the plume-front wells do not indicate that metals' concentrations are associated with groundwater contamination. No corrective action evaluations are required for these constituents at the plume-front.

3.3 CONTAMINATION

Groundwater contamination within the plume-front area originated from historical site waste management activities. The primary sources of contamination were the closed 200, 300, 400, and 600 hazardous waste management units (HWMUs). NASA submitted closure reports and a Certificate of Closure was issued for the 200 through 600 Areas in May and August 1989. NMED approved the Certificates of Closure for the 200, 300, 400 and 600 Areas in November 1989. The individual contributions of the closed HWMUs to the plume-front contamination cannot be determined. Detailed discussions of the historical source area activities and contributions to the groundwater contamination are provided in Volume Three and Volume Four, Chapter Two of the Draft RFI Report (NASA, 1996a).

3.3.1 Groundwater Contamination

The following COCs have been observed within the plume-front area: NDMA; DMN; TCE; PCE; trichlorofluoromethane (Freon 11); dichlorofluoromethane (Freon 21); and 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113). The maximum reported concentrations from groundwater samples within the plume-front area taken from the WSTF contaminant analytical database ~~through (~~ between September 1, 1998 and May 1, 2001~~)~~ are: NDMA - ~~3,400~~3,000 parts per trillion (ppt), DMN - ~~1,700~~3,270 ppt, TCE - ~~380~~540 parts per billion (ppb), PCE - ~~19~~20 ppb, Freon 11 - ~~860~~640 ppb, Freon 21 - ~~60~~18 ppb, and Freon 113 - ~~2,000~~1,100 ppb. NDMA and DMN are highly soluble in water. TCE, PCE, and the Freon compounds are halogenated volatile organic, dense, non-aqueous phase liquids. Table 3.1 presents a summary of the physical and chemical characteristics for the plume-front contaminants. Detailed discussions of these contaminants, excluding DMN, are provided in Volume Four, Chapter Two of the Draft RFI Report (NASA, 1996a). DMN contamination was discovered at WSTF following the submission of the Draft RFI Report.

The groundwater contamination plume has migrated downgradient with the flow of groundwater from the WSTF test areas, west through the MPCA, and into the WBFZ at the eastern margin of the JDMB. The contaminants with the most extensive plumes (Freon 113, Freon 11, TCE, NDMA, and DMN) are characterized by plume boundaries of similar shape and extent. Because DMN contamination was discovered after the Draft RFI/CMS Reports were submitted, the DMN plume was not simulated by the WSTF groundwater model. Stabilizing the NDMA plume will also contain the DMN plume because the plumes for

TABLE 3.1: PHYSICAL AND CHEMICAL PROPERTIES OF PLUME-FRONT CONSTITUENTS OF CONCERN

COMPOUND	MOLECULAR WEIGHT (g/mol)	SPECIFIC GRAVITY	SOLUBILITY (mg/l)	BOILING POINT (°C)	VAPOR PRESSURE (mm Hg)	HENRY'S LAW CONSTANT ($atmm^3/mol$)	LOG K_{ow}
NDMA	74.08[a]	1.0059[a] $_{20/4°C}$	Miscible[a]	154[a]	8[a] $_{25°C}$	1.43E-1[a] $_{25°C}$	-0.47[a]
PCE	165.83[a]	1.6227[a] $_{20/4°C}$	150[a] $_{25°C}$	121[a]	19[a] $_{25°C}$	2.685E-2[a] $_{25°C}$	2.53[a]
TCE	131.39[a]	1.4642[a] $_{20/4°C}$	1,100[a] $_{25°C}$	87[a]	77[a] $_{25°C}$	1.17E-2[a] $_{25°C}$	2.53[a]
Freon 113	187.38[b]	1.5635[b] $_{20/4°C}$	170[b] $_{25°C}$	47.7[b]	362.5[c] $_{25°C}$	5.26E-1[c] $_{25°C}$	3.16[c]
Freon 11	137.38[a]	1.494[a] $_{17.2/4°C}$	1,100[a] $_{25°C}$	23.7[a]	687[a] $_{20°C}$	5.83E-2[a] $_{25°C}$	2.53[a]
Freon 21	102.92[b]	1.405[a] $_{9°C}$	9,500[b] $_{25°C}$	9[b]	1,199[e]	1.04E-2[e]	1.29[d]
DMN	90.08[h]	---	Miscible[h]	---	1.7[h] $_{20°C}$	---	---

[a] Handbook of RCRA Ground-Water Monitoring Constituents Chemical and Physical Properties, September 1992.
[b] CRC Handbook of Chemistry and Physics, 71st Edition, 1990.
[c] Handbook of Environmental Fate and Exposure Data for Organic Chemicals, 1990.
[d] EPA Treatability Manual, 1981.
[e] *Journal of Physical Chemistry Reference Data*, Vol. 10, No. 4, 1981.
[f] Henne, L., *Journal of American Chemical Society*, 1936.
[g] Bitner et. al., U.S. Dep. Comm. Off. Tech. Serv. Rep., 1958.
[h] New Jersey Department of Health and Senior Services, Hazardous Substance Fact Sheet, 1998.

K_{ow} Octanol-water Partition coefficient

DMN and NDMA are extremely similar and the concentrations of DMN are generally lower than NDMA. Therefore, the data generated for NDMA will be utilized for DMN. The conceptualized plumes for NDMA, TCE and PCE generated by the WSTF groundwater model are presented by Figures 3.1, 3.2 and 3.3, respectively. The contaminant plumes can be divided into three sections with distinct characteristics, comprising the industrial source areas, MPCA and the plume-front area (Figure 2.2).

3.4 GROUNDWATER MODEL SETUP AND CALIBRATION

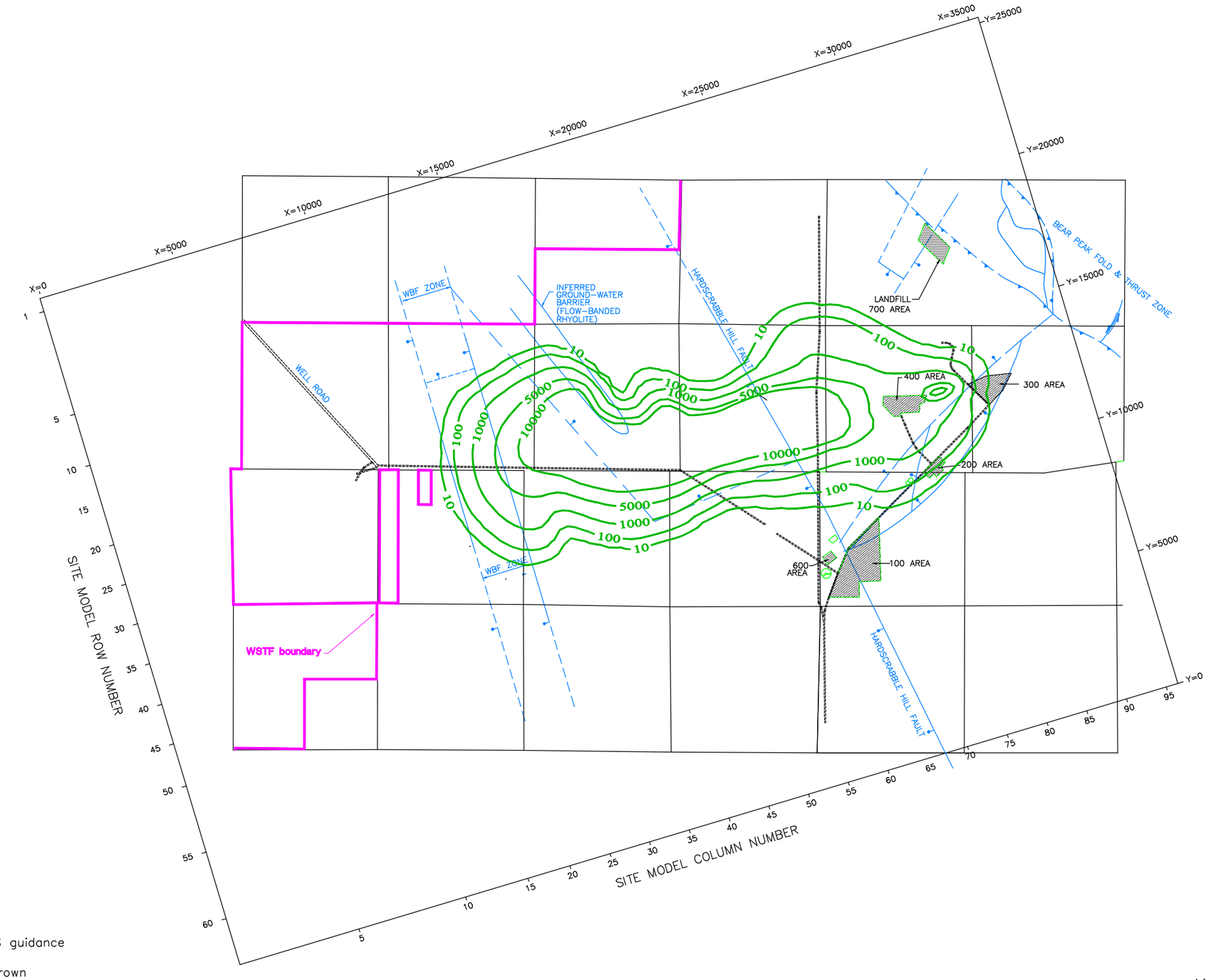
Groundwater modeling activities at WSTF were initiated in 1989. Development procedures for the groundwater model through 1994 are documented by GCL (1995). Daniel B. Stephens & Associates, Inc. (DBS&A) have performed subsequent model calibration activities and the processing of predictive simulations. Results of these modeling activities are documented in three reports (DBS&A, 1995a; DBS&A 1995b and DBS&A, 1998) and within written communications between DBS&A and NASA between 1998 and the present (specifically DBS&A, 2000). All groundwater modeling activities and reports through 1996 are included within the Draft RFI and CMS Reports (NASA, 1996a; NASA, 1996b).

3.4.1 Description of Groundwater Model and Programs

Two separate groundwater models have been constructed to simulate WSTF groundwater flow and contaminant solute transport conditions. The first model comprises a two-dimensional basin-scale representation of the southern JDMB. This model provides a regional-scale simulation capable of addressing the impacts that future JDMB pumpage may have on site model boundary water levels. The regional model is calibrated to regional groundwater levels recorded in the JDMB between 1963 and 1992, and is used to predict site model boundary conditions for the period 1992 to 2026. A regional model review is planned with respect to the predictive groundwater flow model more recently presented by Shomaker (1996).

The second model is utilized for predictive groundwater flow and solute transport simulations, and is referred to as the 3DSWB model. This local-scale model has dimensions of 26,000 feet by 36,000 feet and is elongate to the east-northeast parallel to the axis of the contaminant plume. Grid spacing is sufficiently dense to account for site-specific features. Three computer programs are applied as part of the 3DSWB model. The HydroGeoLogic, Inc. MODFLOW-SURFACT program (Version 2.2) is an integrated MODFLOW (McDonald and Harbaugh, 1988)-based visual modeling system that is ~~The United States Geological Survey's three-dimensional finite-difference program, MODFLOW (McDonald and Harbaugh, 1988), is~~ used to simulate groundwater flow. Once the groundwater flow field is determined for a remedial scenario using MODFLOW-SURFACT, the appropriate output files are used as input to two additional programs, PATH3D (Zheng, 1989) and MT3D (Zheng, 1992), to evaluate contaminant transport.

PATH3D is a three-dimensional particle tracking program in which imaginary particles are introduced into the groundwater flow field to trace groundwater flow pathlines.



N

0 4000 ft

Explanation

- 10 — Maximum simulated NDMA concentration (ppt) for 1992
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side (dashed where inferred)

T:\VDR\8010\801014F.DWG

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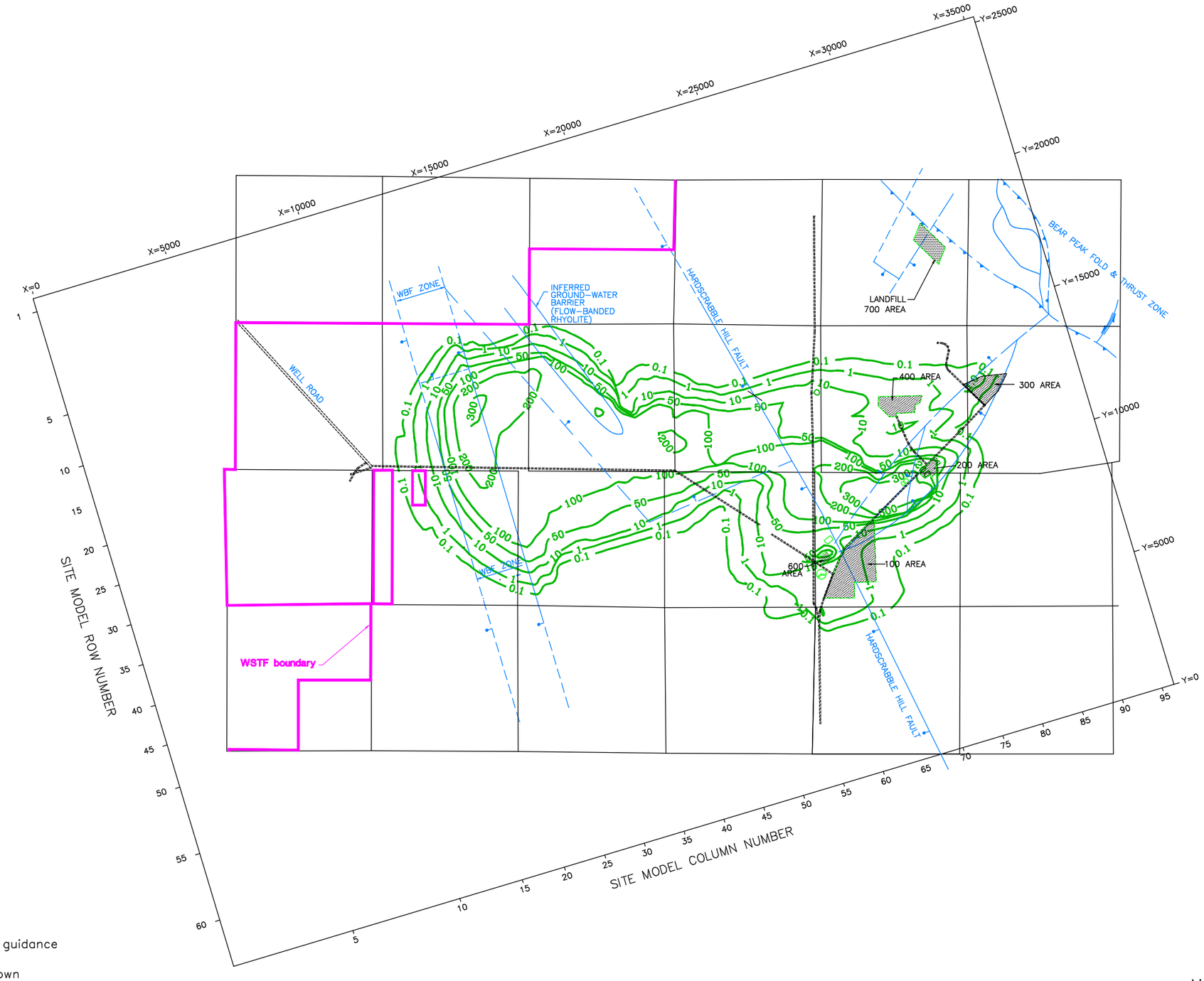
NASA-WSTF MODELING

Plume Front Containment
Simulated NDMA Plume for 1992

Figure 3.1



N

0 4000 ft

Explanation

- 0.1 — Maximum simulated TCE concentration (ppb) for 1992
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side (dashed where inferred)

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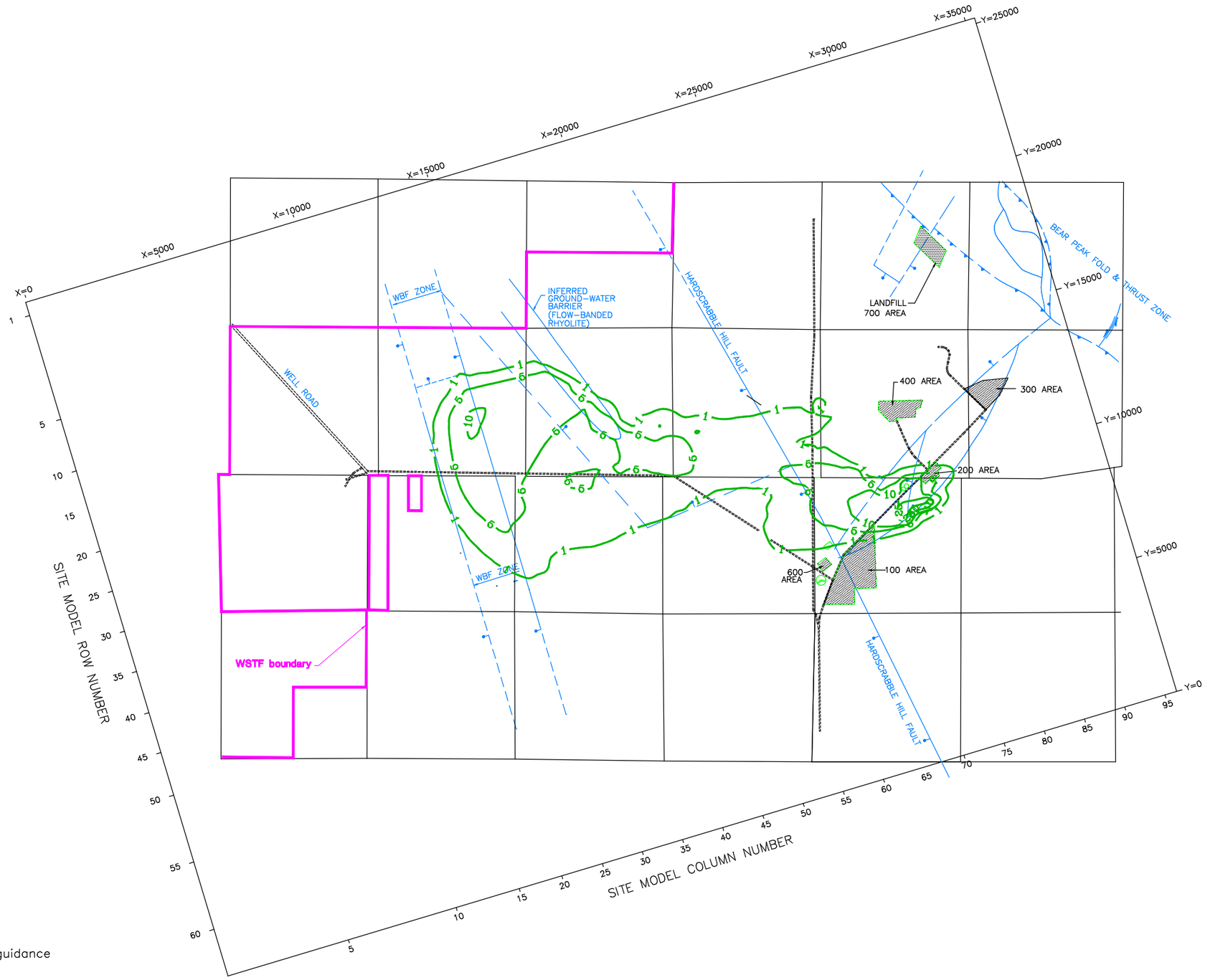
NASA–WSTF MODELING

Plume Front Containment
Simulated TCE Plume for 1992

Figure 3.2



N

0 4000 ft

Explanation

- Maximum simulated PCE concentration (ppb) for 1992
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side (dashed where inferred)

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NASA–WSTF MODELING

Plume Front Containment
Simulated PCE Plume for 1992

Figure 3.3

The program is used in conjunction with MODFLOW-SURFACT to simulate flow pathlines for groundwater recovery scenarios. This tool is used to identify the number of wells required and determine their respective optimal pumping rates to contain the contaminant plumes. PATH3D runs have been performed for two of the four primary health risk contaminants (NDMA and TCE). PATH3D is utilized to predict optimum groundwater recovery well locations by tracking flow pathlines from the boundary of the NDMA plume (maximum concern relative to health risk) and the TCE plume (greatest dimensions of the significant health risk contaminants) to ensure recovery well capture.

The PATH3D program assumes that contaminant transport is due to advection only. The three-dimensional numerical transport program MT3D accounts for the physical processes of advection, dispersion, retardation, and chemical decay, and is applied to simulate changes in contaminant concentrations over time.

The 3DSWB flow and solute transport model is utilized as a tool to:

- understand the complex site hydraulics;
- predict contaminant fate and transport;
- integrate site data;
- assist in monitor/remediation well placements;
- prioritize data collection efforts;
- predict future health and environmental risks;
- assess the performance of potential corrective actions; and
- serve as a facility management tool to address water supply considerations.

3.4.2 Construction of the WSTF 3DSWB Conceptual Model

The complex WSTF hydrogeological and groundwater contaminant conditions simulated by the 3DSWB model are addressed in Sections 3.1 through 3.4 of this Plan. Detailed physical parameter analyses for each of the contaminants, excluding DMN, and potential migration patterns are provided in Volume Four, Chapter Two of the Draft RFI Report (NASA, 1996a). The model contains calibrated groundwater flow conditions for the period January 1963 to December 1992, and a calibrated contaminant transport model for the contaminants NDMA, TCE and PCE for the same period. The calibration of the groundwater flow model relies largely on the reproduction of observed groundwater heads within water wells across WSTF and into the JDMB. Contaminant transport models for NDMA, PCE and TCE were calibrated to simulate current observed concentrations primarily by adjusting the contaminant source area parameters. While the hydrologic properties of the model can be created using detailed information from groundwater monitoring wells, the simulation of volume and timing of the source area releases is an iterative process and cannot be accurately defined. The simulation results for 1993 were used as the starting concentrations for the predictive simulations.

The model plume simulations are conservative and are constructed to approximate hand-contoured plumes for maximum observed WSTF contaminant concentrations. Hand-contoured plumes presented in Volume Four, Chapter Two of the Draft RFI Report (NASA,

1996a) represent the maximum contaminant concentration measured at any depth at a particular well location. Simulated plumes provide the maximum concentration within any model layer at a particular Cartesian coordinate. Near the eastern edge of the model domain, the maximum contaminant concentrations will most often be found in fractured bedrock corresponding to model layers two through seven, while in the western portion of the model domain, the maximum contaminant concentration generally occurs within alluvium in layers 10, 11 or 12.

3.4.3 3DSWB Model Calibration for Contaminant Migration

The simulated NDMA, TCE and PCE contaminant plumes, calibrated to historical analytical results for 1992, are presented in Figures 3.1 through 3.3. The simulations differ slightly from the observed (measured) plumes in the respect that the simulated plumes are more dispersed, particularly within the plume-front area specific to this Plan. These differences allow an aggressive approach to plume-front containment due to the greater dimensions of contamination for the simulated plume. Conversely, the high concentration zones east of the plume-front area are slightly underestimated by the simulation results. Because plume-front capture is achieved and remedial system design for the influent groundwater is based on observed concentrations as well as the simulations, the simulated plumes are considered to be conservative.

Simulation of the NDMA plume is critical relative to health risk evaluations. The NDMA plume (Figure 3.1) has two distinct concentration areas: relatively higher concentrations to the east, and lower concentrations downgradient between the 400 Area and the plume-front. Because the NDMA plume-front distribution has a similar generalized configuration and extent as the TCE and PCE plumes, the NDMA releases are assessed to have roughly the same timing as the TCE and PCE releases. High concentrations toward the eastern source areas are likely to have been formed as a result of later releases after the early 1960s. The source contaminants used for the final NDMA calibration run utilized a starting date of January 1973. Details of the methods used in matching simulated to observed plumes for NDMA, TCE and PCE are provided in DBS&A (1995a).

Retardation factors of 1.0 (no retardation) were used for TCE and PCE. The NDMA plume utilized a retardation factor of 1.2, indicating that the contaminant moves at a rate less than the average groundwater flow. The NDMA retardation value factor is justifiable due to the location of the main NDMA source areas. The observed dimensions of the NDMA plume were effectively simulated, particularly in the plume-front area, although the distribution of mass was not easy to simulate within the high-concentration NDMA zones to the east. The simulations yield higher than expected NDMA concentrations within the plume-front area. The NDMA plume-front modeling conservatively stabilizes the relatively higher NDMA concentrations generated by the modeling simulations.

3.5 HEALTH RISK ASSESSMENT

This section discusses the COCs at the plume-front, evaluates health risk and toxicity values, identifies potential receptors, summarizes exposure pathways, and presents the most current

contour map of cumulative cancer risk values for the WSTF contaminant plume. Volume Six, Chapter One of the Draft RFI Report (NASA, 1996a) contains a detailed baseline human health risk assessment of the contaminant plume, excluding DMN.

Carcinogenic risk calculations were made using the Risk Assessment Guidance for Superfund (RAGS) (EPA, 1989), the most recent toxicity values obtained from the EPA Integrated Risk Information System (IRIS) (EPA, 1998a), and/or EPA Region 3 Risk-Based Concentration (RBC) Tables (EPA, 1998b), unless otherwise indicated.

3.5.1 Chemicals of Concern

The chemicals of primary health risk concern at the plume-front are NDMA, DMN, TCE, and PCE. Volume Six, Chapter One of the Draft RFI Report (NASA, 1996a) details the method of determining which chemicals become a concern to human health and/or the environment. Additional chemicals of concern, but of lesser health threat, are Freon 11, Freon 21 and Freon 113. Detailed release and toxicological data for each of these chemicals is located in Appendices B-E, Volume Six of the Draft RFI Report (NASA, 1996a), excluding DMN.

3.5.1.1 Carcinogens

NDMA and DMN groundwater contamination originates from the historical management of hydrazine rocket fuels at WSTF. Due to the obscurity of DMN, there are limited toxicological or carcinogenic data available. NDMA and DMN have extremely similar chemical structures, and the most conservative approach for the health risk assessment of DMN is to apply NDMA health and cancer risk calculations to DMN. NDMA is considered a probable human carcinogen classified in Group B2 by the EPA. The primary target organs are the liver and lungs. Liver toxicity is the main effect from both acute and chronic exposure to NDMA. IRIS reports an oral slope factor (SF) of 51 $(mg/kg/day)^{-1}$.

TCE was used as a cleaning solvent for various test article components processed at WSTF. In the past, the EPA had classified TCE as a Group B2 carcinogen with cardiovascular and central nervous system effects and the liver as the target organ. However, chronic exposure effects in humans are uncertain at this point. A carcinogen assessment summary for TCE is currently under review by the EPA, and the toxicity information used for this assessment was taken from the EPA-National Center for Environmental Assessment (NCEA) provisional values. For purposes of the WSTF health risk assessment, a conservative approach was chosen. Therefore, TCE will be maintained as a carcinogen pending publication of a new carcinogen summary. The RBC Table lists an oral SF for TCE of 0.011 $(mg/kg/day)^{-1}$, the value drawn from IRIS, and a Reference Dose (RfD) of 0.01 mg/kg/day.

There is no carcinogen assessment summary of PCE available at this time from the EPA. Since chronic exposure effects in humans are uncertain at this point, the SF of 0.011 $(mg/kg/day)^{-1}$ used for this assessment is an EPA-NCEA provisional value. IRIS has published a RfD 0.01 mg/kg/day with liver damage noted in animal studies.

3.5.1.2 Non-Carcinogens

Halogenated VOCs were used historically as cleaning solvents and referee propellants at WSTF. Human exposure to high vapor concentrations could result in respiratory, central nervous system and/or cardiac effects, unconsciousness, and, in some cases, death by asphyxiation. Freon 11 is considered more toxic than Freon 113. IRIS assigns an RfD of 0.3 mg/kg/day to Freon 11 and 30 mg/kg/day to Freon 113.

Limited toxicological data exists for Freon 21. The National Institute for Occupational Safety and Health (NIOSH, 1990) lists a threshold limit value (TLV) of 10 ppm, two orders of magnitude less than the TLVs for Freon 11 and Freon 113 (both 1,000 ppm). From the Hazardous Substances Data Base:

> "Although toxicity due to acute inhalation is low, FC-21 is appreciably more toxic than related difluorinated methanes such as dichlorodifluoromethane or chlorodifluoromethane. The chronic toxicity of FC-21 is markedly different from these compounds, and appears to be more similar to chloroform."

For purposes of the WSTF health risk assessment, the RfD for chloroform was used to calculate hazard quotients for Freon 21 concentrations detected in the groundwater plume. IRIS assigns a RfD to chloroform of 0.01 mg/kg/day. Toxicity information for plume-front chemicals is summarized in Table 3.2.

3.5.2 Potential Receptors and Exposure Pathways

Volume Five of the Draft RFI Report (NASA, 1996a) provides a detailed evaluation of potential receptors. There are no current human or ecological receptors of contamination within the plume-front area. The Draft RFI Report projects that contamination will not impact potential receptors for at least the next 30 years. The Draft RFI Report also contains a detailed discussion of population characteristics and current and future land use at and around WSTF. Exposure via groundwater is the pathway of potential concern for the plume-front area. Therefore, the focus of potential receptors and exposure pathways are groundwater wells located hydraulically downgradient from the plume-front.

The potential exposure pathway of concern to NASA is potential future contamination of the WSTF water supply wells. WSTF maintains three supply wells, Wells I, J and K, located in Section 31 of Township 20 South, Range 3 East (Figure 2.2). The proximity of these wells to the plume-front is presented in Figure 3.4. Currently, Well I is inactive and Wells J and K are used alternately to supply water to WSTF through a one million gallon reservoir in the 300 Area. If contamination of the water supply wells occurred, WSTF employees could be exposed to plume-front contaminants through ingestion or dermal contact with contaminated water. The possibility of exposure is low because WSTF is not open to the public and there are no permanent residents at the site. Only employees (all adults) are allowed on site, and therefore, employee exposures would be solely industrial in nature (40 hours/week).

TABLE 3.2: TOXICITY INFORMATION FOR PLUME-FRONT CHEMICALS

Carcinogen	Oral Slope Factor (SF) $(mg/kg/day)^{-1}$	EPA Weight of Evidence Classification	Target Organ(s)	SF Source
NDMA	51	B2	Liver	IRIS
DMN	51[1]	B2[1]	Liver[1]	IRIS[1]
TCE	0.011	Under EPA review	Under EPA review	EPA-NCEA provisional value
PCE	0.052	Under EPA review	Under EPA review	EPA-NCEA provisional value
Non-Carcinogen	**Oral Reference Dose (RfD) (mg/kg/day)**	**Confidence Level & UF/MF**	**Health Effect**	**RfD Source**
Freon 11	0.3	Medium 1000/1	Psychomotor impairment	IRIS
Freon 113	30	Low 10/1	Psychomotor impairment	IRIS
Freon 21	0.01*	Medium* 1000/1	Psychomotor impairment	IRIS*
TCE**	0.006	No data	No data	EPA-NCEA provisional value
PCE**	0.01	Medium 1000/1	Liver	IRIS

*Chloroform RfD (see text in Section 3.5.2, Non-carcinogens)
**Carcinogens with RfD data available are included in the evaluation of non-carcinogenic effects.

MF- Modifying Factor
UF- Uncertainty Factor

[1] NDMA values are applied to DMN

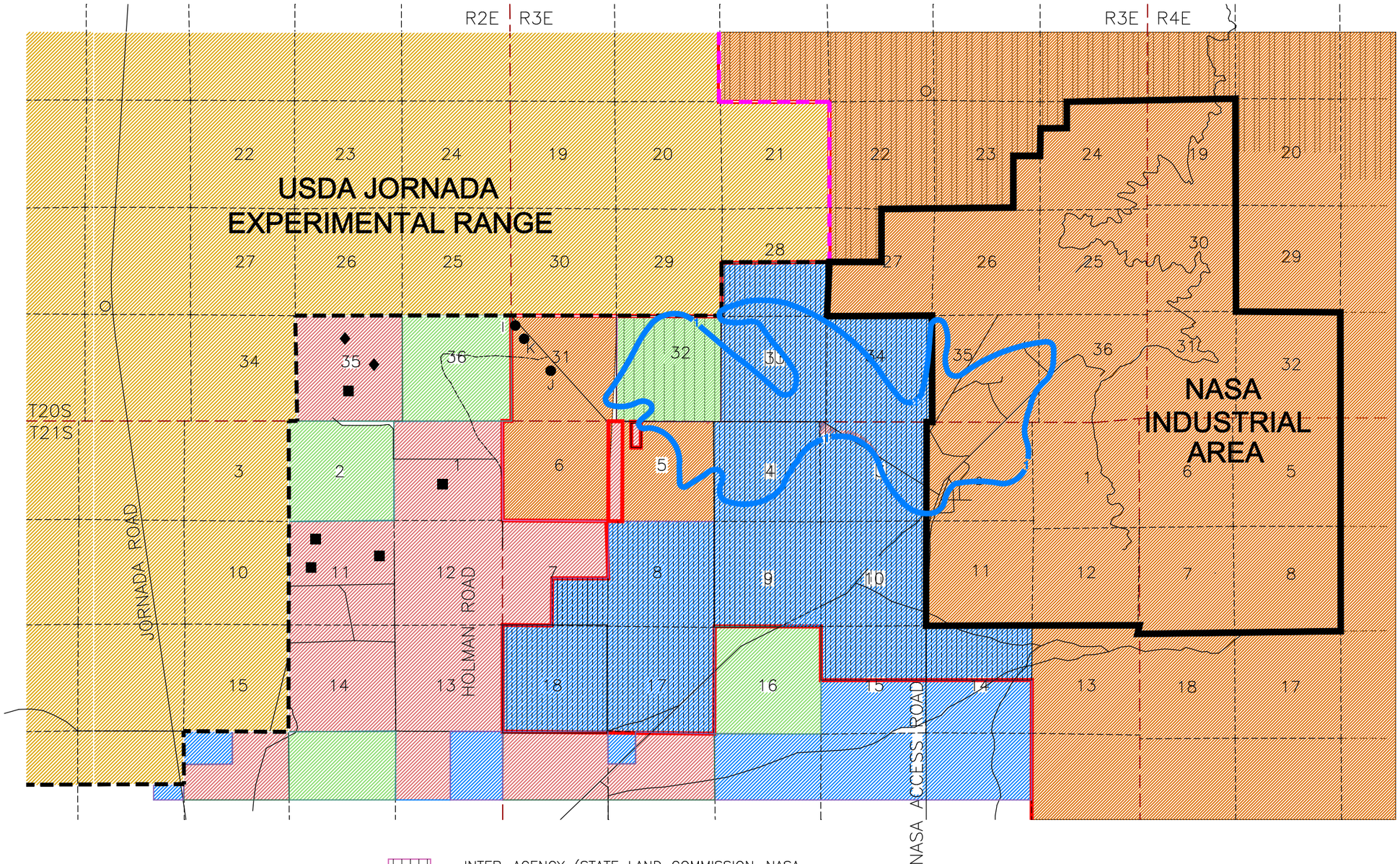


FIGURE 3.4
WSTF LAND OWNERSHIP &
LOCATION OF 1 (PPB) TCE PLUME

Potential receptors include the privately owned domestic and irrigation wells located west of the NASA facility boundary. The five domestic wells shown in Figure 3.4 serve household and non-commercial yard and domestic animal uses. If the groundwater contamination plume reached these wells, residents could be exposed to plume-front contaminants through ingestion, dermal contact with, or possible consumption of garden crops or domestic animals exposed to contaminated water.

Two irrigation wells are located downgradient from the plume-front in Section 35, Township 20 South, Range 2 East (Figure 3.4). The eastern irrigation well is used to irrigate a 100-tree pecan orchard. The western irrigation well has been unused for many years. If the plume-front ever intercepted the pecan orchard well, human exposure could occur through bioaccumulation in the pecans and eventual human consumption. Human exposure resulting from use of the western irrigation well is uncertain at this time. The exposure scenario depends upon how the water would be used, whether for domestic animals or commercial crops. Community water supply systems could also be potential receptors of contaminated groundwater. The Moongate Water Company, the City of Las Cruces, the Mountain View Water Company, and various smaller water companies have multiple wells to the south and west of WSTF. The City of Las Cruces has also proposed 14 new wells in the vicinity of Moongate to acquire an additional 14,000 acre-feet of water per year from the JDMB. Water usage has been conservatively estimated for the two-dimensional regional groundwater model within the JDMB through the year 2026.

3.5.3 Risk Characterization

The approaches used to determine cancer risk and hazard indices are based on the assumption that there are no synergistic or antagonistic interactions among the compounds involved, and that all compounds have the same toxic end points and mechanisms of action. The effects of exposure to each of the contaminants have been considered separately, then totaled for a straight-line additive effect, for both carcinogens and non-carcinogens.

NASA opted to take the most conservative approach in calculating cancer risk values and hazard indices. Maximum contaminant concentrations detected in RFI monitoring wells from the time period April 1, 2000 through May 31, 2001~~January 1, 1997 through September 1, 1998~~ were used. In wells where individual contaminants were not detected, cancer risk and hazard indices were calculated based on the lowest analytical detection limit. Intake assumptions associated with residential exposure via ingestion of contaminated groundwater were used, although no exposure pathways are complete, and industrial exposure to WSTF employees is the primary concern at this time.

3.5.3.1 Carcinogenic Risk Estimates

Carcinogenic slope factors obtained from IRIS or EPA Region 3 RBC Tables were used to estimate the potential excess cancer risks associated with maximum levels of contamination detected at the WSTF groundwater monitoring wells. The chronic daily intake (CDI) was calculated using the EPA age-adjusted calculations (from EPA Region 3 RBC Table: Technical Background Information and RAGS).

~~$$CDI = \frac{CW \times IR \times EF \times ED}{BW \times AT}$$~~

1) To calculate Age-Adjusted Ingestion Factor (IFWadj):

$$IFWadj = \frac{EDc \times IRWc}{BWc} + \frac{(EDtot-EDc) \times IRWa}{BWa}$$

2) Age-Adjusted Calculation Factor:

$$CFadj = \frac{IFWadj \times EF}{AT}$$

3) To calculate Chronic Daily Intake (age adjusted):

$$CDI = (CFadj)(CW)$$

4) To calculate Cancer Risk:

$$Risk = (CDI)(SF)$$

~~where the v~~Variables for the equations are defined in Table 3.3.
~~The potential cancer risk was calculated by multiplying the CDI values by the chemical-specific SF (Risk = CDI x SF) and then by summing the carcinogenic chemicals of concern at each monitoring well.~~ The cumulative cancer risk at each monitoring well was estimated by calculating the cancer risk for each contaminant, then summing those risk values at each well. Table 3.4 lists the individual chemical and cumulative carcinogenic risk estimates for the plume-front monitoring wells. Values listed in bold italics reflect those calculated using the lowest analytical detection limit when a contaminant was not detected. The cumulative cancer risk values for all RFI groundwater monitoring wells have been contoured and the resultant map is shown as Figure 3.5.

3.5.3.2 Non-Carcinogenic Hazard Quotients and Indices

RfDs obtained from IRIS or the RCB Tables were used to compute hazard quotients (HQs) for maximum concentrations of TCE, PCE, Freon 11, Freon 21, and Freon 113 detected at monitoring wells. NDMA and DMN were not included because applicable RfDs are not available. HQs were computed by dividing the CDI by the chemical-specific RfD (HQ = CDI/RfD) and then by summing each non-carcinogenic chemical to determine the Hazard Index (HI) at each plume-front monitoring well. Table 3.5 lists the HQs and HIs estimated for the plume-front wells. HQs and HIs calculated on the lowest analytical detection limits are listed in bold italics. Table 3.5 shows that the highest HQs are associated with TCE and its presence in a monitoring well constitutes the greatest contribution to the well's HI. The contribution to the HI from all the Freon compounds totaled is small in comparison to TCE, and is generally less than 0.1. TCE is the primary chemical of concern that causes the HIs to exceed 1.0.

TABLE 3.3: CHRONIC DAILY INTAKE (CDI) ASSUMPTIONS

Adult Ingestion of Contaminated Groundwater

PARAMETER	EXPOSURE ASSUMPTION
CW (Exposure Point Concentration in Groundwater in mg/l)	Maximum concentration detected in monitoring wells.
IRWa or IRWc (Ingestion Rate)	2 liters/day (adult) or 1 liter per day (child)
EF (Exposure Frequency)	350 days/year
EDa or EDc or EDtot (Exposure Duration)	~~30 years at a residence~~ 24 years adult +6 years child = 30 year total
BWa or BWc (Body Weight)	70 kg adult or 15 kg child
AT (Averaging Time)	70 years x 365 days/year-Carcinogens 30 years x 365 days/year-Non-carcinogens
IFWadj (Age Adjusted Ingestion Factor)	1.09 L-y/kg-d
CDI (Chronic Daily Intake (mg/kg/d)	(CFadj)(CW)
CFadj (Age Adjusted Calculation Factor)	1.49×10^{-2}
SF (Slope Factor)	

TABLE 3.4: CARCINOGENIC RISK ESTIMATES FOR PLUME-FRONT MONITORING WELLS

Well(s)	NDMA	DMN	TCE	PCE	Cumulative
BLM-2 Group	1.307x10^{-3}	~~4.59~~5.85x10^{-4}	~~3.35~~4.26x10^{-5}	8.52~~6.69~~x10^{-6}	~~1.57~~2.00x10^{-3}
BLM-7-509	***<~~2.98~~3.80x10^{-5}***	***<~~2.27~~2.89x10^{-5}***	***<~~6.44~~8.20x10^{-8}***	***<3.~~04~~87x10^{-7}***	***<~~5.29~~6.73x10^{-5}***
BLM-17 Group	~~34~~.701x10^{-3}	~~1.97~~2.51x10^{-3}	~~2.45~~3.11x10^{-5}	~~6.08~~7.75x10^{-6}	~~5.70~~7.26x10^{-3}
PL-1-486	***<~~2.98~~3.80x10^{-5}***	***<2.~~27~~89x10^{-5}***	1.~~03~~31x10^{-5}	1.~~22~~55x10^{-6}	***<~~6.40~~8.15x10^{-5}***
PL-2-504	***<~~2.98~~3.80x10^{-5}***	1.60~~1.25~~x10^{-5}	2.13~~1.67~~x10^{-5}	5.42~~4.26~~x10^{-7}	***<~~7.58~~5.95x10^{-5}***
PL-3-453	3.13~~2.46~~x10^{-6}	***<~~7.60~~5.97x10^{-6}***	***<~~8.20~~6.44x10^{-8}***	***<~~3.87~~3.04x10^{-7}***	***<~~1.12~~8.79x10^{-5}***
PL-4-464	***<~~7.60~~5.97x10^{-6}***	***<~~7.60~~5.97x10^{-6}***	2.46~~1.93~~x10^{-7}	***<3.~~87~~04x10^{-7}***	***<1.~~58~~24x10^{-5}***
PL-5	1.09~~8.59~~x10^{-34}	4.10~~3.22~~x10^{-4}	5.74~~4.50~~x10^{-5}	1.24~~9.73~~x10^{-5}	1.57~~24~~x10^{-3}
PL-6	8.89~~6.98~~x10^{-7}	6.84~~5.37~~x10^{-6}	6.23~~4.89~~x10^{-7}	***<3.~~87~~04x10^{-7}***	***<~~8.74~~6.86x10^{-6}***
PL-7	***<~~7.60~~5.97x10^{-6}***	***<~~7.60~~5.97x10^{-6}***	***<~~8.20~~6.44x10^{-8}***	***<3.~~87~~04x10^{-7}***	***<1.~~57~~23x10^{-5}***
ST-1 Group	1.~~41~~1x10^{-3}	6.00~~4.71~~x10^{-4}	6.23~~4.89~~x10^{-5}	1.47~~1.16~~x10^{-5}	2.09~~1.64~~x10^{-3}
ST-2	3.19~~2.51~~x10^{-7}	***<~~7.60~~5.97x10^{-6}***	1.57~~24~~x10^{-7}	***<3.~~87~~04x10^{-7}***	***<~~8.46~~6.65x10^{-6}***
ST-3 Group	1.307x10^{-3}	4.94~~3.88~~x10^{-4}	4.75~~3.73~~x10^{-5}	1.01~~7.91~~x10^{-5}	1.92~~51~~x10^{-3}
ST-4 Group	1.64~~29~~x10^{-6}	***<~~7.60~~5.97x10^{-6}***	1.80~~42~~x10^{-6}	5.73~~4.50~~x10^{-7}	***<~~1.16~~9.12x10^{-5}***
ST-5 Group	7.60~~5.97~~x10^{-6}	***<2.~~89~~27x10^{-5}***	3.28~~2.57~~x10^{-6}	***<3.~~87~~04x10^{-7}***	***<~~4.01~~3.15x10^{-5}***
ST-6	***<~~3.80~~2.98x10^{-5}***	***<~~3.80~~2.98x10^{-5}***	***<~~8.20~~6.44x10^{-8}***	***<3.~~87~~04x10^{-7}***	***<~~7.65~~6.00x10^{-5}***

This table presents the individual cancer risks associated with maximum contaminant concentrations observed for each well. Values listed in bold italics reflect those calculated using the lowest analytical detection limit when a contaminant was not detected.

R2E R3E

R3E

E400000

E410000

E420000

LANDFILL
700 AREA

30

29

28

27

26

25

WSTF BOUNDARY

32

33

34

35

300 AREA

400 AREA

36

N230000

N230000

31

T20S
T21S

T20S
T21S

200 AREA

6

5

4

3

2

600
AREA

100 AREA

10^{-7}

WSTF BOUNDARY

7

8

9

10

11

N220000

N

0 2000'

E400000

E410000

2749 D
R3E

LEGEND:

CANCER RISK

- 10^{-2}
- 10^{-3}
- 10^{-4}
- 10^{-5}

RESIDENTIAL EXPOSURE SCENARIO

FIGURE 3.5
CONTOUR MAP OF
CUMULATIVE CANCER RISK
(NDMA-DMN-TCE-PCE)

TABLE 3.5: HAZARD QUOTIENTS AND INDICES FOR PLUME-FRONT WELLS

Well	TCE	PCE	Freon 11	Freon 21	Freon 113	Hazard Index
BLM-2 Group	1.19	0.03	0.02	***<0.001***	***<0.001***	***<1.242***
BLM-7-509	***<0.002***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.006***
BLM-17 Group	0.87	0.02	0.03	***<0.001***	***<0.001***	***<0.922***
PL-1-486	0.37	0.01	0.01	***<0.001***	***<0.001***	***<0.392***
PL-2-504	0.59	***<0.001***	0.02	***<0.001***	***<0.001***	***<0.613***
PL-3-453	***<0.002***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.006***
PL-4-464	0.01	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.014***
PL-5	1.60	0.04	0.03	0.16	***<0.001***	***<1.831***
PL-6	0.02	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.024***
PL-7	0.01	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.014***
ST-1 Group	1.74	0.05	0.04	***<0.001***	***<0.001***	***<1.832***
ST-2	***<0.002***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.006***
ST-3 Group	1.32	0.04	0.02	***<0.001***	***<0.001***	***<1.382***
ST-4 Group	0.05	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.054***
ST-5 Group	0.09	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.094***
ST-6	0.03	***<0.001***	***<0.001***	0.02	***<0.001***	***<0.053***

Table lists the hazard quotients and hazard indices estimated for the plume-front wells.

The bold italics values represent hazard quotients and hazard indices calculated on the lowest analytical detection limits.

3.5.4 Uncertainties

The assumptions and inputs used to assess potential human health risks posed by the WSTF contaminant plume are subject to several uncertainties that have effects of either overestimation or underestimation of risk. These are discussed in detail in Volume Six, Chapter One of the Draft RFI Report (NASA, 1996a). The primary uncertainty factors are discussed below.

3.5.4.1 Carcinogenicity Evidence Under Review

Currently, the evidence for the carcinogenicity of TCE and PCE is under review. The SFs used in risk calculations are the EPA provisional values. Until EPA finalizes the determinations for these chemicals, NASA will consider TCE and PCE carcinogenic and estimate potential excess risk associated with their presence in groundwater in its health risk assessment. If new carcinogen summaries determine these chemicals are not carcinogenic, then the cumulative cancer risk values in this report become overestimates.

3.5.4.2 Lack of Toxicity Data

Toxicity data are not available for DMN or Freon 21. The RAGS suggests grouping chemicals by class in such situations and applying a known toxicity value from a chemical in that class to characterize risk. Due to their extremely similar chemical structures, DMN was grouped with NDMA, and the NDMA SF was applied to estimate the cancer risk for DMN. This introduces uncertainty in the risk calculations for DMN and the cumulative cancer risk values.

The RfD for chloroform was applied to Freon 21 (see discussion of non-carcinogens in Section 3.5.1.2 indicating similar toxicities). This is a conservative approach to the risk posed by Freon 21 given the limited data available. Using the RfD of chloroform for Freon 21 introduces uncertainty into the HQ calculations for Freon 21 and also the HIs calculated for each monitoring well.

3.5.4.3 Chemical Concentrations

Health risk estimates from ingestion of contaminated groundwater were made using a hypothetical residential exposure scenario and the maximum concentration of a chemical of concern detected at each RFI monitoring well over a specified time period. Using maximum concentrations rather than the 95% Upper Confidence Limit of the mean, as suggested in RAGS, results in overestimation of risk.

3.6 DATA SUFFICIENCY

The WSTF groundwater plume has been extensively monitored since 1987 and more than ~~220,000~~ 5,000 sampling events and 400,000 sample results have occurred to date. The plume monitoring network currently includes ~~77~~79 conventional and ~~26~~39 Westbay Multi-Port®

monitoring wells. Data collected from existing plume-front wells have been used to design the presumptive remedy for this Plan.

Previous experience with monitoring wells along the plume-front has shown that geologic formation characteristics can vary significantly. ~~Therefore, prior to completing the extraction and injection wells, recovery tests will be conducted in the open boreholes of those wells. After completion of the extraction wells,~~ Therefore, step tests will be performed on each of the wells to confirm the pumping capacity for each well. The T and specific yield of the formation, derived from the step test results, will be compared to existing values within the 3DSWB groundwater model, and additional simulations performed to confirm plume stabilization will be accomplished with the system presented in this Plan.

4.0 PRESUMPTIVE REMEDY FOR PLUME-FRONT STABILIZATION

This Plan presents a plume-front stabilization presumptive remedy that incorporates plume-front monitoring wells, plume-front extraction wells, ex-situ treatment to reduce contaminants to prescribed concentrations, and reinjection of the remediated groundwater into the JDMB using injection wells. The system is designed to mitigate further plume-front migration and serves to actively remove contaminant mass from the groundwater.

4.1 EVALUATION OF 3DSWB MODEL PREDICTIVE REMEDIAL SCENARIOS

The 3DSWB model has been used as a tool to simulate future contaminant migrations over a wide range of predictive remedial scenarios. The model has served to simulate "no-action" groundwater conditions over a 30 year period and also to determine optimum extraction/injection well locations for a variety of remedial system designs (GCL, 1995; DBS&A, 1995a; DBS&A, 1995b, DBS&A, 1998, and DBS&A, 2000).

The most important feature of the predictive simulation groundwater flow field performed by the MODFLOW-SURFACT program is that the flow direction within the JDMB is anticipated to change from west-southwest to south over the next 30 years. Conservatively overestimated pumping rates for the JDMB indicate that the average hydraulic gradient may increase by an order of magnitude. This condition results from significant increases in predicted groundwater withdrawals south of WSTF in the vicinity of U.S. Highway 70 by the City of Las Cruces and other water suppliers. The major implication to the JDMB groundwater model is that under a "no-action" scenario the contaminants that currently exist in the WBFZ migrate in a more southerly direction, and at an increased velocity.

The three computer programs described in Section 3.4.1 were applied to obtain the predictive remedial scenario results. When locating or withdrawing an extraction well, the MODFLOW-SURFACT program was rerun to obtain the revised groundwater flow field throughout the predictive simulation period. The PATH3D program was then used to evaluate the effectiveness of the various plume capture schemes. MT3D was run for each final predictive simulation to simulate contaminant concentrations that may occur in response to the various groundwater remediation scenarios.

Ten predictive remedial simulation scenarios were performed to assess the potential NDMA, TCE and PCE migration from January 1993 to December 2026 as part of the Draft RFI and CMS Reports (NASA, 1996a; NASA, 1996b). One additional scenario (Scenario Eleven) has been added to this version of the Plan to account for remediation well design modifications which have taken place since the original submittal of the Plan in January 1999. These eleven scenarios are summarized in Table 4.1. The first scenario was "no-action", and the remaining scenarios addressed the assessment of different pump and treat remedial alternatives. Each scenario used initial hydraulic heads and initial contaminant concentrations from the December 1992 time step of the site model calibration run for each of the three COCs modeled (Figures 3.1 through 3.3). A description of the predictive simulation scenarios, including well descriptions and flow rates, are provided in Volume One, Chapter Four of the Draft CMS Report (NASA, 1996b).

The first six predictive simulations run are presented in DBS&A (1995a). Scenario One indicates that if no action is taken, the contaminant plumes can be expected to migrate west and south of their present location up to one mile west of the WBFZ by the year 2026. Scenarios Two, Three and Four indicate containment of the plume with between 12 to 41 extraction wells placed within or near the WBFZ, and at upgradient locations within the fractured bedrock pediment. The injection of treated groundwater for all treatment scenarios is to the southwest of the contaminant plume.

The results of Scenario Four indicate that even if numerous extraction wells are placed throughout the plume and favorable extraction rates are maintained for each well, the overall extent of the plume would not be reduced significantly, although a reduction in maximum concentrations would occur. The predictive simulation results should be regarded as conservative relative to the plume-front for two reasons. First, the simulated plumes are greater in horizontal extent than the observed plumes. Second, the physical process of retardation was neglected for TCE and PCE, where conservative retardation estimates for TCE in basin alluvium environments are typically 1.5 and for PCE are 3.0 (DBS&A, 1995a). This promotes an increased rate of migration for the predictive scenarios.

The potential for eliminating or reducing mass flux to the plume-front using interception techniques in the MPCA was examined using Scenarios Five and Six. The potential is limited due to low predicted groundwater withdrawal rates. Assessment work continues in this hydrogeologically significant area due to the potential of intercepting the high source area NDMA and DMN concentrations; for example, a series of wells along the MPCA could potentially be pumped dry and pumping be allowed to resume after some period of water level recovery. This approach would form an effective barrier to contaminant transport and is in the process of being simulated using MODFLOW-SURFACT. (HydroGeoLogic, 1997), a modified version of the MODFLOW program.

Predictive simulations for Scenario Seven through Scenario Nine are presented in DBS&A (1995b). Scenario Seven is a basic and effective plume-front containment scenario, while Scenarios Eight and Nine consider the containment plus additional extraction wells in strategic areas. Scenario Seven indicates that plume containment can be achieved using four extraction wells, and four injection wells located southwest of the plume. The existing

TABLE 4.1: SUMMARY OF 3DSWB MODEL INTERIM MEASURES REMEDIAL SCENARIOS

Scenario #	Description	Remedial Wells	Estimated Remediation System Flow Rates	Advantages	Disadvantages
1 No-action	Monitored natural attenuation of plume	---	---	Low cost.	Contaminant plume mass undergoes advective-dispersive transport.
2&3 Plume-front containment and NDMA hot spot remediation	Extraction wells located across plume-front in WBFZ and bedrock pediment. Injection wells southwest of the plume. Discharge increased for high-capacity WBFZ wells in Scenario 3.	15 extraction 2 injection	Total discharge 1,170 gpm, with 800 gpm from 3 high-capacity WBFZ wells. Discharge increased to 1,420 gpm for Scenario 3.	Effective containment of the plume. Reduction of contaminant concentrations. Injection restricts plume movement to the south. Increased cone of depression for Scenario 3 ensures effective plume-front containment.	Predicted plume-front concentrations remain above maximum contaminant level for TCE (5 ppb) and anticipated contaminant level for NDMA (10 ppt) inside captured plume. Bedrock flow rates may be difficult to reproduce. Increased volumes of extracted groundwater have limited effectiveness.
4 Aggressive plume remediation	As for Scenario 2&3 plus 29 additional extraction wells. Injection wells southwest of the plume.	41 extraction 2 injection	Total discharge is 1,420 gpm.	Reductions in peak concentration areas within the plume. Injection restricts plume movement to the south.	Limited additional reduction in plume boundary. Withdrawal rates from the majority of wells are small due to bedrock locations. Concentrations remain above treatment standards inside captured plume.
5 Plume-front containment with mid-plume interception	Utilizes the three high-capacity WBFZ extraction wells from Scenario 2&3 plus 3 mid-plume extraction wells. Injection wells southwest of the plume.	11 extraction 2 injection	Total discharge is 880 gpm including additional 70 gpm prescribed for mid-plume wells.	Plume-front containment. Partial reduction of the mass accessing the plume-front from source areas via the mid-plume. Injection restricts plume movement to the south.	Narrow mid-plume pumping does not effectively intercept contaminants or reduce mass flux. Plume-front concentrations above Scenario 2 because seven of the plume-front area wells were not simulated. Concentrations remain above treatment standards inside captured plume.
6 Mid-plume interception	No-action at plume-front and remediation of the mid-plume.	3 extraction	Total discharge is 70 gpm.	Supply of contaminants from source areas to plume-front reduced.	Plume-front appears similar to Scenario One (no-action). Concentrations remain above treatment standards inside captured plume.
7 Basic plume-front containment	Containment of the plume-front within the WBFZ. Injection wells southwest of the plume.	4 extraction 4 injection	Total discharge is 810 gpm.	Plume-front containment and mass removal. Uses wells predominantly screened within alluvium of WBFZ.	Potential for pump and treat within the MPCA~~Z~~ will be addressed independently. Concentrations remain above treatment standards inside captured plume.
8&9 Scenario 7 with mid-plume interception and hot spots	As for Scenario 7, with additional wells in the mid-plume the zone of high NDMA west of the 400 Area.	Between 4 and 10 extraction 4 injection	Total discharges are 880 gpm (Scenario 8) and 900 gpm (Scenario 9).	Increased mass concentration removal.	Results similar to Scenario 7, despite the considerable increase in extraction wells. Larger reductions in concentrations limited due to the potential capacity of the additional wells. Concentrations remain above treatment standards inside captured plume.
10 Scenario 7 with additional plume-front area NDMA target wells	As for Scenario 7, with two additional plume-front extraction wells on the east WBFZ boundary. System independently targets TCE and NDMA mass removal. ~~6 extraction~~	6 extraction 4 injection	Total discharge is 1,010 gpm.	As for Scenario 7. Well configuration independently addresses TCE and NDMA contaminant fronts resulting in increased mass removal.	Potential for pump and treat within the MPCA~~Z~~ will be addressed independently. ~~Concentrations remain above treatment standards inside captured plume.~~
11 Scenario 10 with modifications based on recent field data	Scenario 10 with one NDMA well (PFE-6) removed, well PFE-4 location modified (PFE-4A) and TCE well PFE-7 added.	6 extraction 4 injection	Total discharge is 1,076 gpm.	As for Scenarios 7 &10. Well configuration modified to address anomalies detected following Scenario 10 installation.	Potential for pump and treat within the MPCA will be addressed independently.

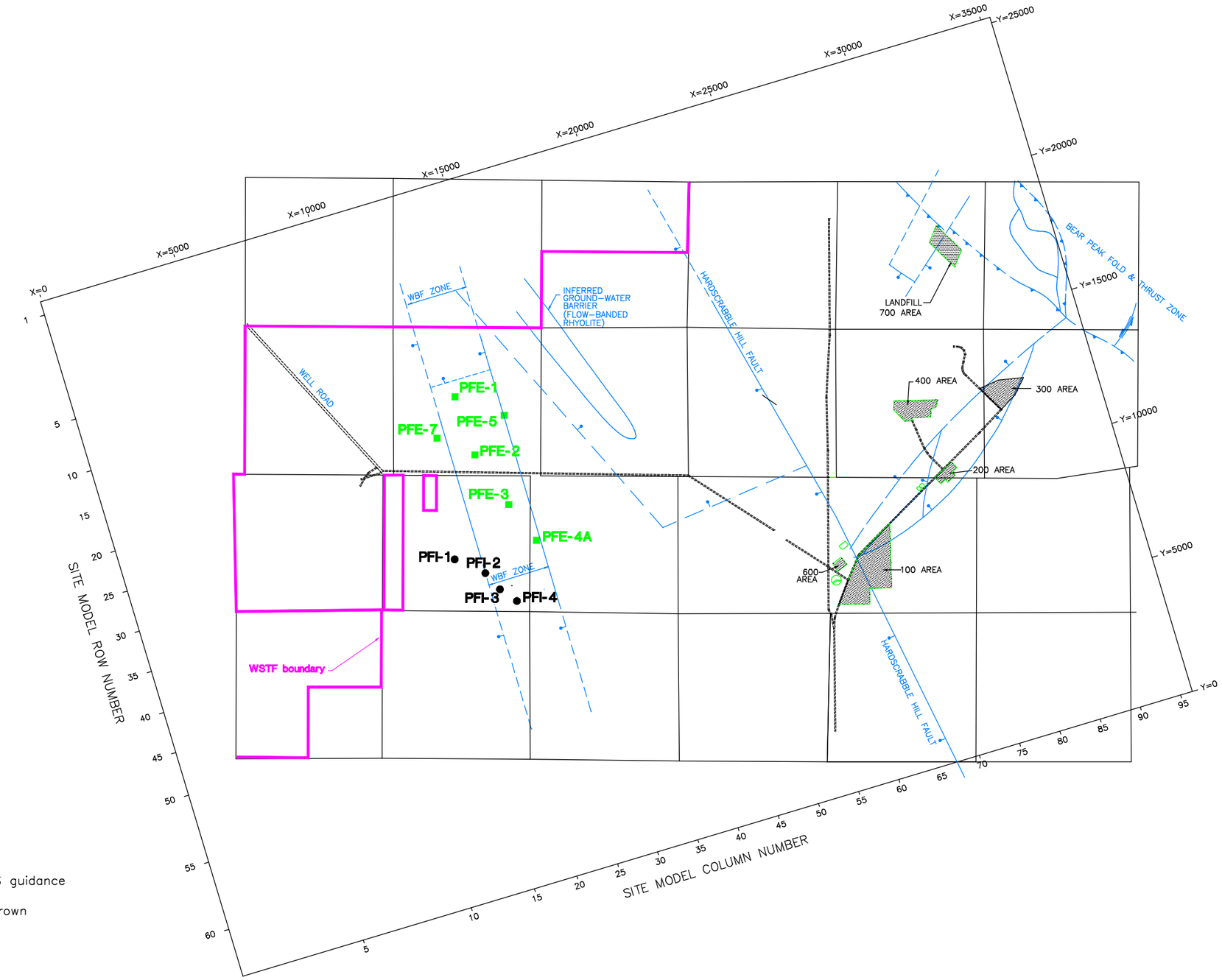
NASA-Pump Test (PT) well, which was utilized for a previously performed pump test (NASA, 1990), is suitable for service as one of the high-volume WBFZ extraction wells. Three of the four extraction wells are within the WBFZ and the remaining extraction well is in the bedrock within the southern lobe of the contaminant plume. The injection wells are positioned to the south and southwest of the plumes within or near the WBFZ. The results of the three simulations are very similar. The additional withdrawal wells in Scenarios Eight and Nine cause localized reductions in contaminant concentrations, but do not significantly affect the plume-front contaminant concentrations. Larger reductions are not observed because the pumping capacities of the additional wells are limited.

Scenario Ten presented in DBS&A (1998) ~~is~~was regarded as the most efficient plume-front stabilization scenario at the time of submittal of the original Plan (January 1999). The remedial system utilizes the four WBFZ plume-front extraction wells and four injection wells simulated by Scenario Seven, and adds two additional extraction wells located to the east, which specifically address the low-level NDMA/DMN plume-front contamination. This scenario was devised because, although the TCE plume-front is similar to the NDMA/DMN plume-front, the optimum positions for extraction wells to address mass removal for each contaminant are different. Table 4.1 summarizes the advantages of this scenario.

Following submittal of the original Plan in 1999, remediation well installations in the field were designed in accordance with Scenario Ten. Results of the field installations indicated that only one of the additional two extraction wells (PFE-5) could sustain a flowrate sufficient to be added to the plume-front stabilization scenario. The Scenario Eleven remediation system removes extraction well PFE-6 from the stabilization scenario due to the low production rate of five gpm (Table 4.1). Scenario Eleven also modifies the location of well PFE-4 to PFE-4A and adds an additional high volume well (PFE-7) to stabilize an anomalous westward protrusion of VOC contamination recently observed in the area adjacent and west of monitoring well ST-6 (Figure 2.2).

4.2 DESCRIPTION OF PLUME-FRONT STABILIZATION SCENARIO

The Scenario ~~Ten~~ Eleven stabilization option from Table 4.1 ~~has been selected~~ succeeds Scenario Ten from the January 1999 Plume-Front Stabilization Plan as the preferred plume-front containment remedial option. Figure 4.1 presents the well configuration for this plume-front system with modifications made to account for the removal of well PFE-6 (low production rate of five gpm), repositioning of well PFE-4 to PFE-4A and the addition of well PFE-7 (modified plume configuration based on the latest analytical results through May 1, 2001). The current position of the contaminant plume is significant relative to the placement of six PFE and four PFI wells. ~~The six~~Five extraction wells (PFE-1, PFE-2, PFE-3, PFE-4A, ~~through~~ and PFE-~~6~~7) ~~remain within or on the eastern boundary~~ are located in the vicinity of the WBFZ, where the vertical extent of the alluvial aquifer is confined by bedrock, and the plume can be contained without relocating in the deep alluvium of the JDMB. Well PFE-7 is located just to the west of the WBFZ, but the vertical distribution of contaminants in this area is relatively well defined. ~~Wells PFE-1 through PFE-4~~ The five wells specifically address containment of the TCE plume utilizing an estimated combined flow rate of ~~810~~ 1,050 gpm.



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Plume Front Containment Well Locations

Figure 4.1

Containing TCE will also prevent PCE from migrating further west. However, these ~~four~~five TCE extraction wells do not fully prevent western movement of the NDMA/DMN plumes which are not as extensive to the west. Well~~s~~ PFE-5 ~~and PFE-6 have been added to the scenario to ensure~~ supports effective NDMA/DMN plume containment. Th~~ese~~ese well~~s~~ ~~are~~is located in high NDMA concentration zones and have an estimated ~~combined~~ flow rate of 2~~6~~00 gpm. Containing NDMA will also contain DMN because the two plumes are extremely similar in distribution~~and the DMN concentrations are much lower than the NDMA plume~~. The injection of remediated groundwater through four injection wells (PFI-1 through PFI-4) occurs to the west and south of the contaminant plumes. The injection well locations are designed to assist with containment of the southern edge of the plume by creating a localized groundwater mound. This mounding offsets future drawdown effects, and locally reverses the groundwater flow directions.

The optimum positioning of the proposed remedial well locations provided through the MODFLOW-SURFACT program reduces the volume of groundwater required for the groundwater treatment process. Plume-front extraction wells PFE-1, ~~through PFE-6~~PFE-2, PFE-3, PFE-4A, PFE-5 and PFE-7 are simulated to have an estimated total withdrawal rate of 1,0~~10~~76 gpm.

Modeling work relative to the plume-front containment scenario has involved contouring NDMA data to more sensitive ppt isoconcentrations. This represents advancements in groundwater analytical technologies and addresses NDMA concentrations of health risk concern. Plume-front NDMA analytical data, with a lowered reporting limit of 10 ppt, were utilized for these modeling activities (DBS&A, 1998, DBS&A, 2000). Previous modeling activities performed for the Draft CMS Report (NASA, 1996b) addressed capture of the simulated plume to the 0.1 ppb (100 ppt) isoconcentration line.

4.2.1 Remediation Well Characteristics

Remediation well locations, pumping and injection rates and design parameters are provided in Table 4.2. The design parameters listed include well casing and annular materials specifications, well design strategies and well depth specifications. The pumping rates, injection rates and design parameters generated from ~~the~~ extraction well field installations were incorporated into the 3DSWB model to provide the best stabilization simulation available ~~3DSWB model wells were used to establish the preliminary well designs proposed for the groundwater pump and treat system~~. The total injection volume for the PFI wells was set equal to the total extraction volume for the PFE wells at 1,0~~10~~76 gpm.

When the remediation wells were simulated for predictive scenarios, the well discharge for each layer the well penetrated was prescribed based on hydrogeological conditions input to the 3DSWB model. Ultimately, well discharge was apportioned among model layers based on hydraulic conductivity values. The most notable discharge variations within a single well occur where the screened zone transects the alluvium/bedrock interface. ~~As an example, well PFE-2 (Table 4.2) shows extractions of 100 gpm from layers 10 and 11, 30 gpm from layer 12, and 16 gpm from layer 13. Approximately 500 feet to the north at WSTF monitoring well ST-1-630, the depth to bedrock is 645 feet at an elevation of 3,856 feet above mean sea~~

TABLE 4.2: PLUME-FRONT CONTAINMENT WELL LOCATIONS, PUMPING RATES AND DESIGN PARAMETERS

Remedial Well	Well Coordinates relative to Model Grid	Layer	Anticipated Pumping/ Injection Rates (gpm)	Well Casing Specifications	Well Design Strategy & Depth Specifications
PFE-1	Row 15 Column 23	10 11 12 13	89104 89104 89104 2126	10.758-inch outside diameter, 8560-Slot Screen	Depth to groundwater = 4230 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 389425-748900 ft Anticipated tTop of sand pack = 368410 ft
PFE-2	Row 22 Column 23	10 11 12 13	93104 93104 246 146	10.758-inch outside diameter, 8560-Slot Screen	Depth to groundwater = 4345 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 398430-876900 ft Anticipated tTop of sand pack = 381415 ft
PFE-3 (Existing NASA-PT Well)	Row 28 Column 25	10 11 12 13	104 104 5 0	10-inch diameter, 80-Slot Screen	Depth to groundwater = 453 ft Anticipated pumping drawdown = <15 ft Screened interval (to total depth) = 507-828 ft Actual tTop of sand pack = 443 ft
PFE-4A	Row 34 Column 27	10 11 12 13	603 201 603 603	10.756-inch outside diameter, 8560-Slot Screen	Depth to groundwater = 370469 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 398465-697900 ft Anticipated tTop of sand pack = 378450 ft
PFE-5	Row 18 Column 26	10 11 12 13	1248 1248 13 13	9.058-inch outside diameter, 8560-Slot Screen	Depth to groundwater = 45132 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 41830-797900 ft Anticipated tTop of sand pack = 400412 ft
PFE-76	Row 1823 Column 1929	10 11 12 13	5948 5948 43 32	10.758-inch outside diameter, 8560-Slot Screen	Depth to groundwater = 413460 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 398455-678900 ft Anticipated tTop of sand pack = 379440 ft
PFI-1	Row 32-33 Column 19-20	10 11 12 13	73 73 57 57	9.058-inch outside diameter, 850-Slot Screen	Depth to groundwater = 41950 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 41860-9771,000 ft Anticipated tTop of sand pack = 399430 ft
PFI-2	Row 34-35 Column 21-22	10 11 12 13	105 105 20 20	9.058-inch outside diameter, 850-Slot Screen	Depth to groundwater = 43750 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 41860-9771,000 ft Anticipated tTop of sand pack = 396430 ft

Remedial Well	Well Coordinates relative to Model Grid	Layer	Anticipated Pumping/ Injection Rates (gpm)	Well Casing Specifications	Well Design Strategy & Depth Specifications
PFI-3	Row 37-38 Column 22-23	10 11 12 13	147 147 16 15	9.08-inch outside diameter, 850-Slot Screen	Depth to groundwater = 44750 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 41860-9971,000 ft Anticipated tTop of sandpack = 398430 ft
PFI-4	Row 39-40 Column 23-24	10 11 12 13	83 83 7 6	9.08-inch outside diamter, 850-Slot Screen	Depth to groundwater = 4580 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 398460-8781,000 ft Anticipated tTop of sandpack = 378430 ft

~~level (amsl). The junction of layer 11 (3,950 to 3,850 feet) and 12 (3,850 to 3,750 feet) at 3,850 feet amsl corresponds to a change in hydraulic parameters within the model which represents the bedrock surface. Bedrock parameters allow only limited well PFE-2 pumpage from layers 12 and 13.~~

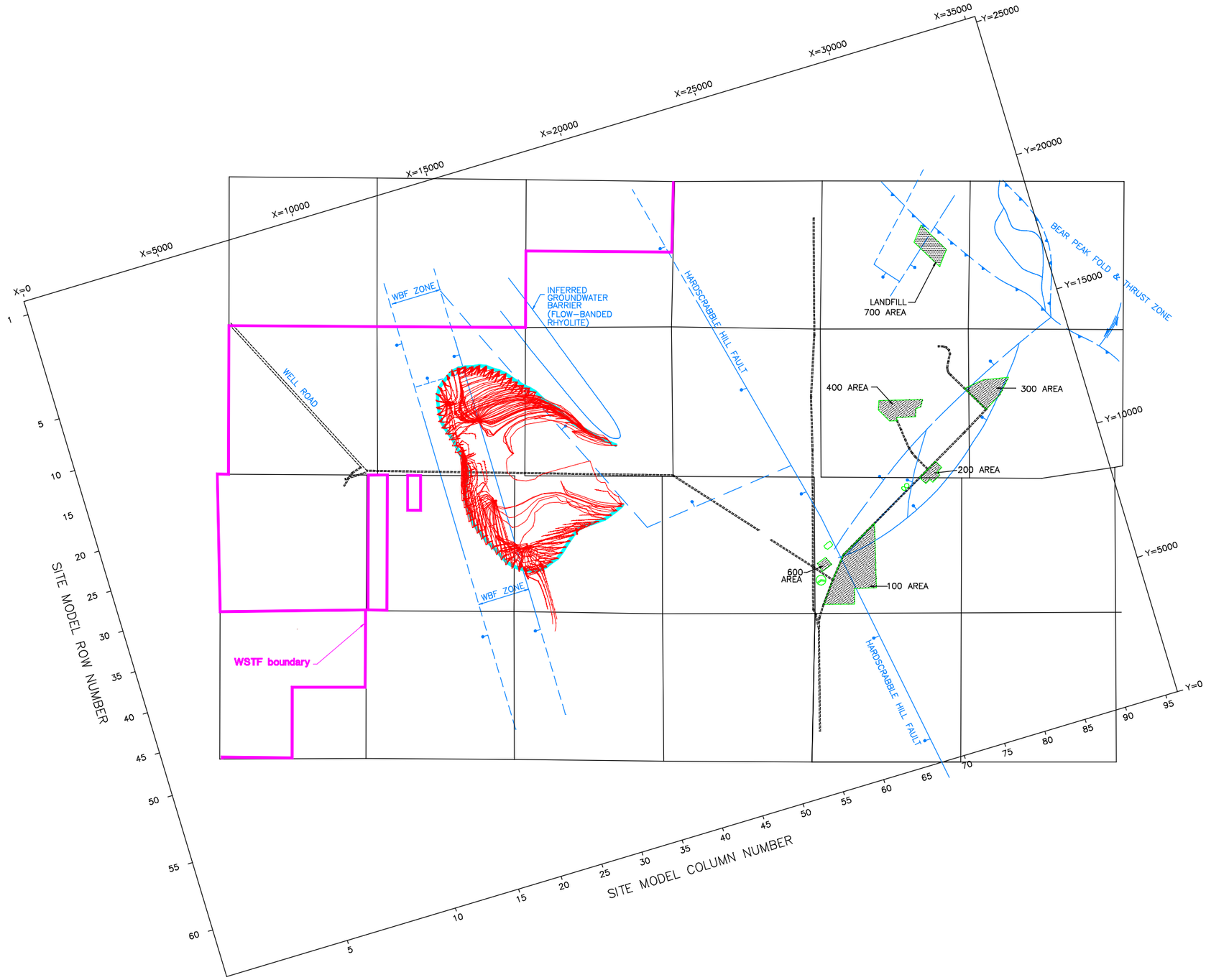
4.3 PLUME-FRONT STABILIZATION SCENARIO SIMULATIONS

4.3.1 PATH3D Plume-Front Stabilization Diagrams

Particle tracking results for NDMA (Figure 4.2) and TCE (Figure 4.3) were obtained using the PATH3D program. The particle tracking results for TCE have been modified from the original Plan to take into consideration the latest TCE groundwater plume (results through May 1, 2001) and the modified remediation well configuration. The capture of TCE at the WSTF plume-front, using the more recent and extensive May 2001 TCE plume, allows a conservative estimate of plume stabilization due to its extensive distribution relative to other contaminants such as NDMA and DMN. A series of points along the 10 ppt NDMA and ~~0.~~5 ppb TCE plume-fronts, defined based on recent analytical data, were used as release points. Particles were tracked in model layers ~~3~~9 through 14. Effective capture of the current 10 ppt NDMA and ~~0.5~~5 ppb TCE contours ~~were~~ was achieved. ~~In order to evaluate this capture, DBS&A (1998) converted~~ Simulation of the plume-front stabilization scenario ~~to run under~~with the MODFLOW-SURFACT program ~~which~~ allow~~sed~~ variable saturation of the model cells. This provides a more exact solution of the flow equations, especially in the vicinity of the extraction and injection wells where the water levels can be anticipated to be more variable. MODFLOW-SURFACT program results and the original MODFLOW simulation results were found to be compatible.

4.3.2 Predictive Plume-Front Isoconcentration Maps

Predictive plume isoconcentration maps for NDMA (to 10 ppt), TCE (to ~~0.1~~ 1 ppb) and PCE (to ~~0.1~~ 1 ppb) for the year 2026 are provided in Figures 4.4, 4.5 and 4.6, respectively. These predictive figures are based on the performance of the remediation system in the original Plan. Due to the similarity in well positions between the original and modified remediation systems and compatible total extraction rates, the configuration of these plumes will remain approximately the same. These figures can be compared to the current simulated plume isoconcentration maps discussed in Section 3.0 (Figures 3.1 through 3.3) to evaluate plume-front capture and mass removal. These figures illustrate that NDMA, TCE and PCE plume-front capture is achieved. Concentration reductions can be seen for each of the contaminants within the plume-front area. The leading edge of the westernmost plume, represented by the TCE plume, is retracted (a distance of approximately 2,000 feet) for the predictive simulation. The NDMA plume maps indicate stabilization of the 10 ppt contour. Differences in the retraction of the two contaminant plumes relate to the positioning of the three high volume extraction wells PFE-1 through PFE-3 designed for TCE capture, and the retardation factor input for NDMA. A significant reduction in mass over the period of the simulation occurs for NDMA, TCE and PCE (Figures 4.7, 4.8 and 4.9 respectively).



N

0 4,000 ft

Explanation

- Simulated contaminant pathlines
- 10 part per trillion NDMA contour
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side, dashed where inferred

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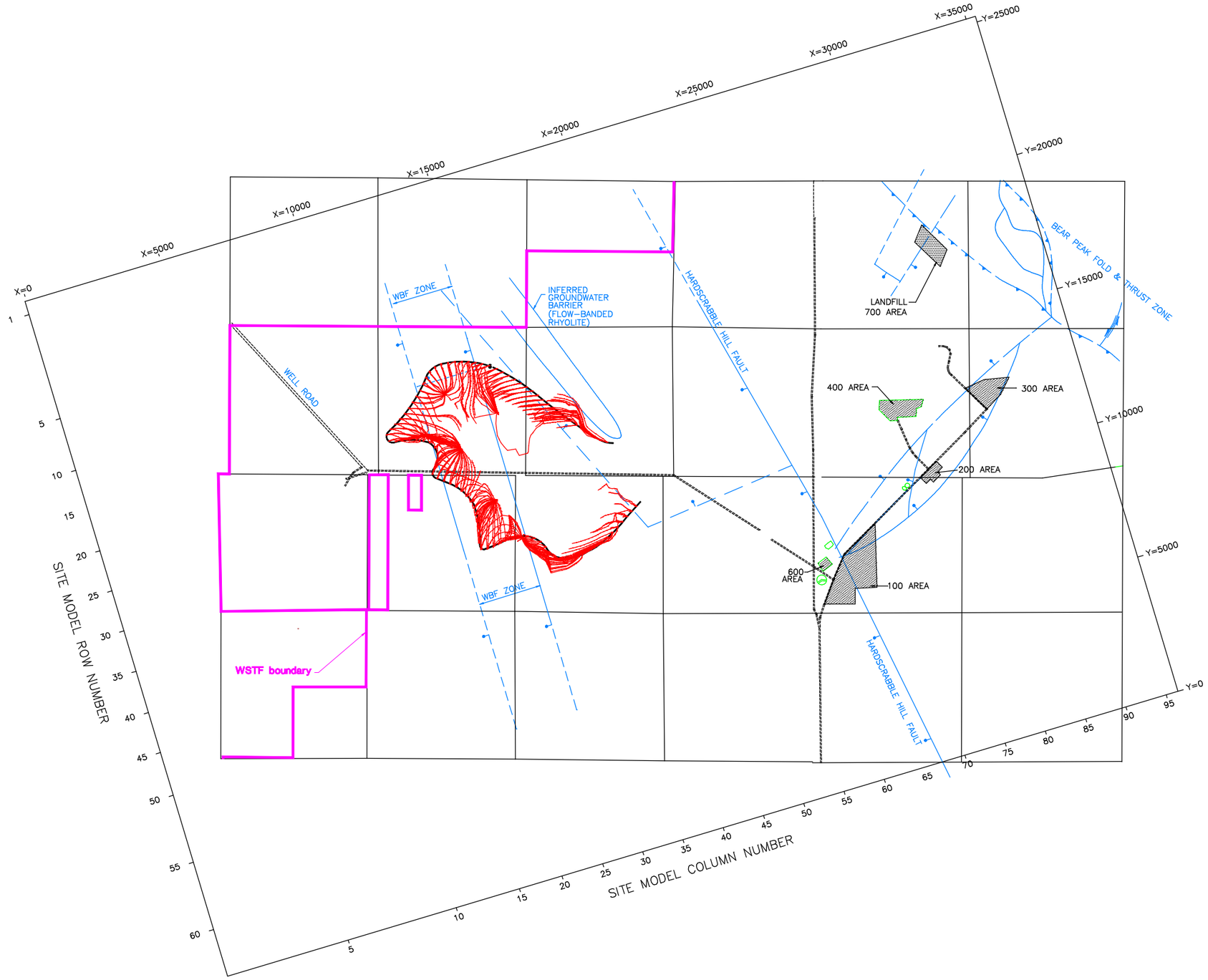
Simulated Contaminant Pathlines for NDMA Plume Front Containment

Figure 4.2



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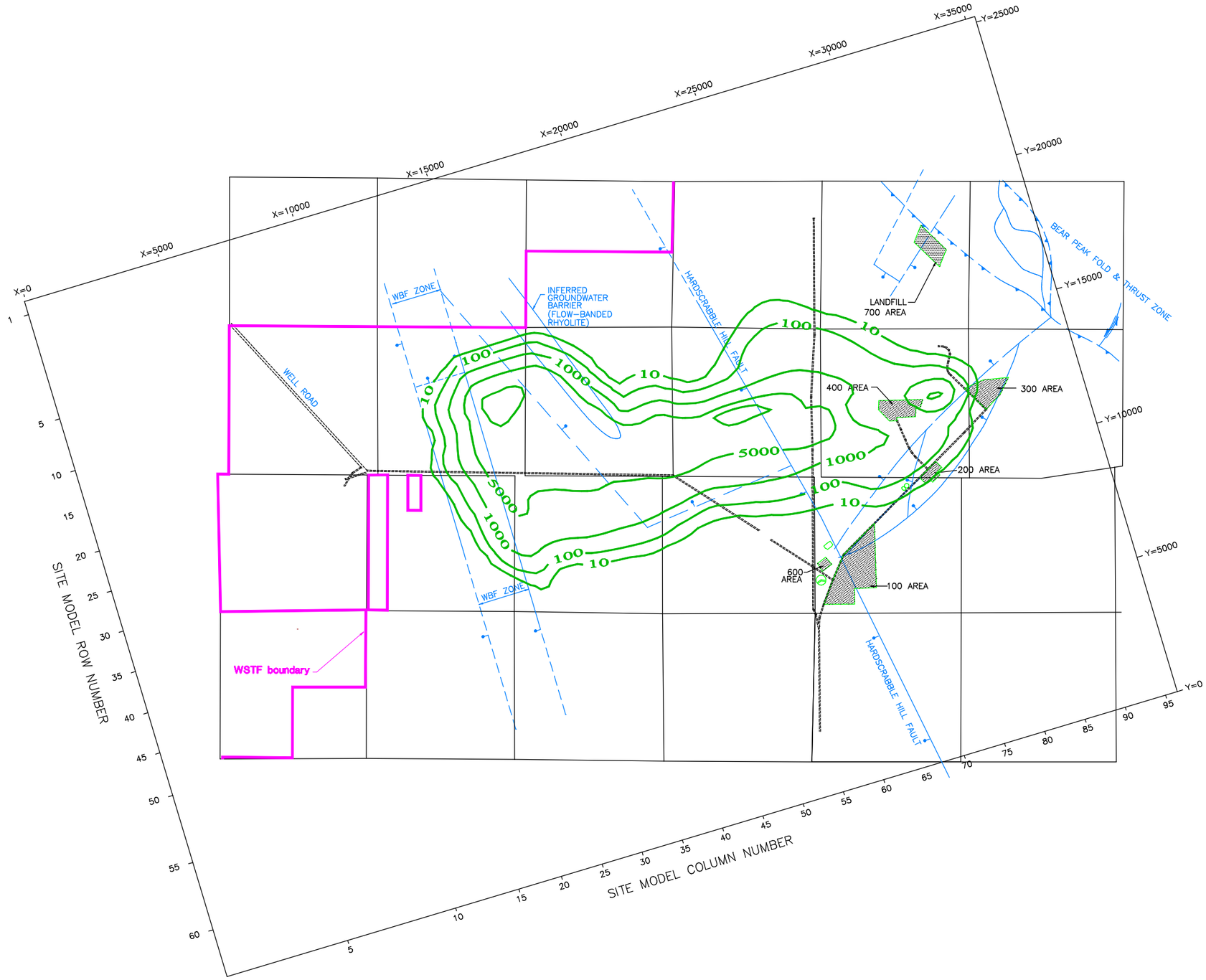
Simulated Contaminant Pathlines for TCE Plume Front Containment

Figure 4.3



N

0 4,000 ft

Explanation

- 10 — Maximum simulated NDMA concentration (ppt) for 2026
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side, dashed where inferred

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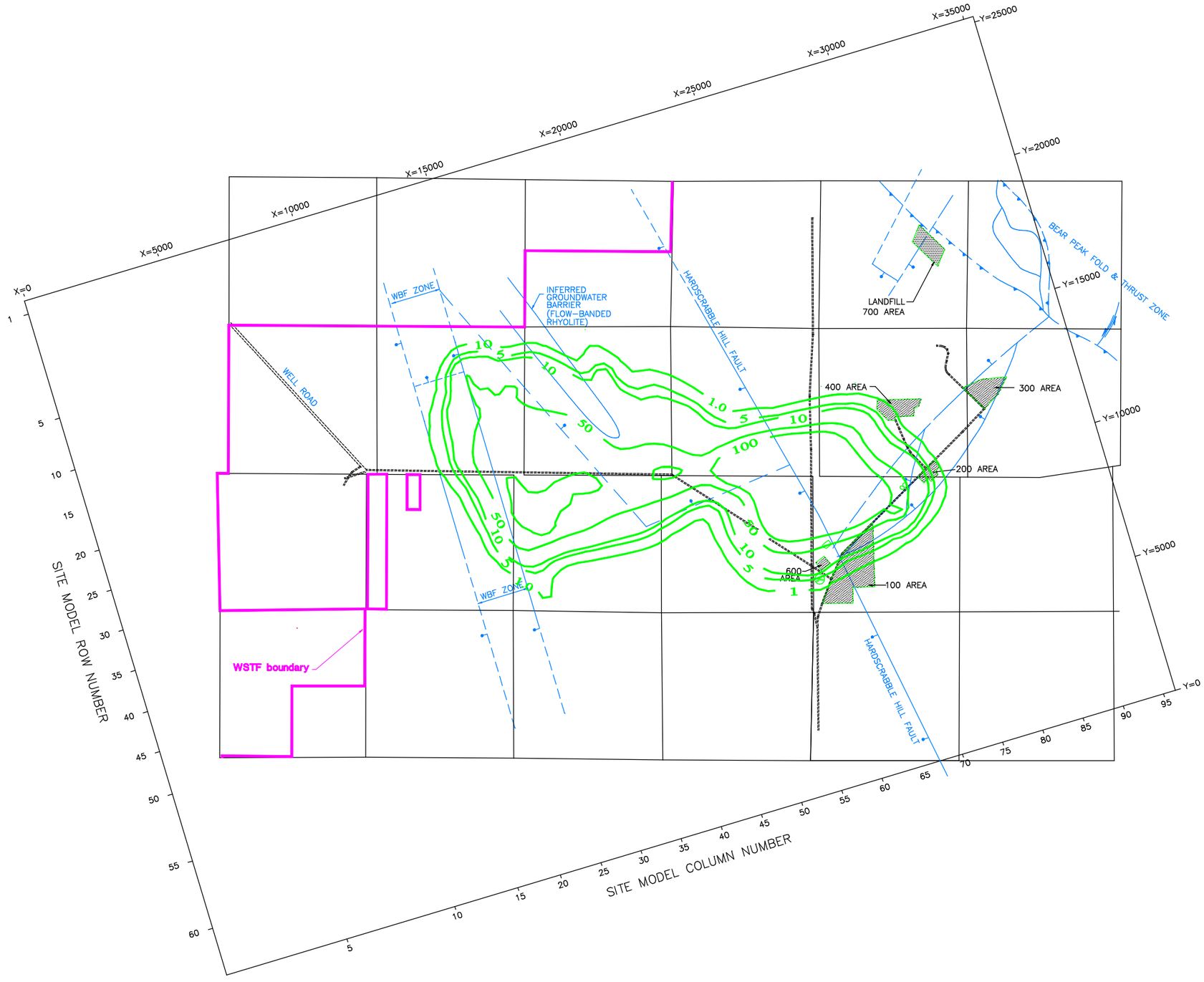
Plume Front Containment
Simulated NDMA Plume for 2026

Figure 4.4



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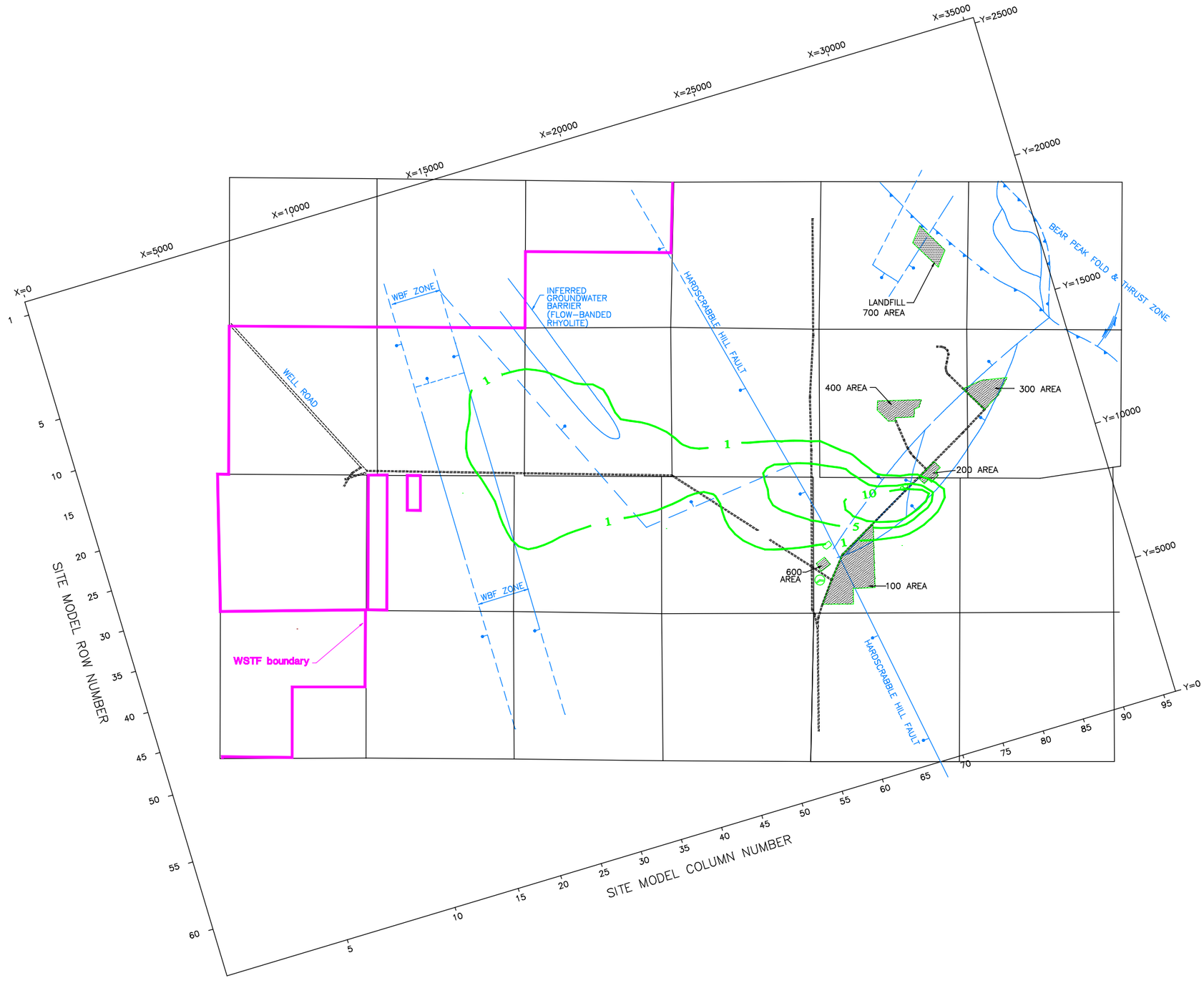
Plume Front Containment
Simulated TCE Plume for 2026

Figure 4.5



N

0 4,000 ft

Explanation

- 0.1 — Maximum simulated PCE concentration (ppb) for 2026
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side, dashed where inferred

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NASA–WSTF MODELING

Plume Front Containment Simulated PCE Plume for 2026

Figure 4.6

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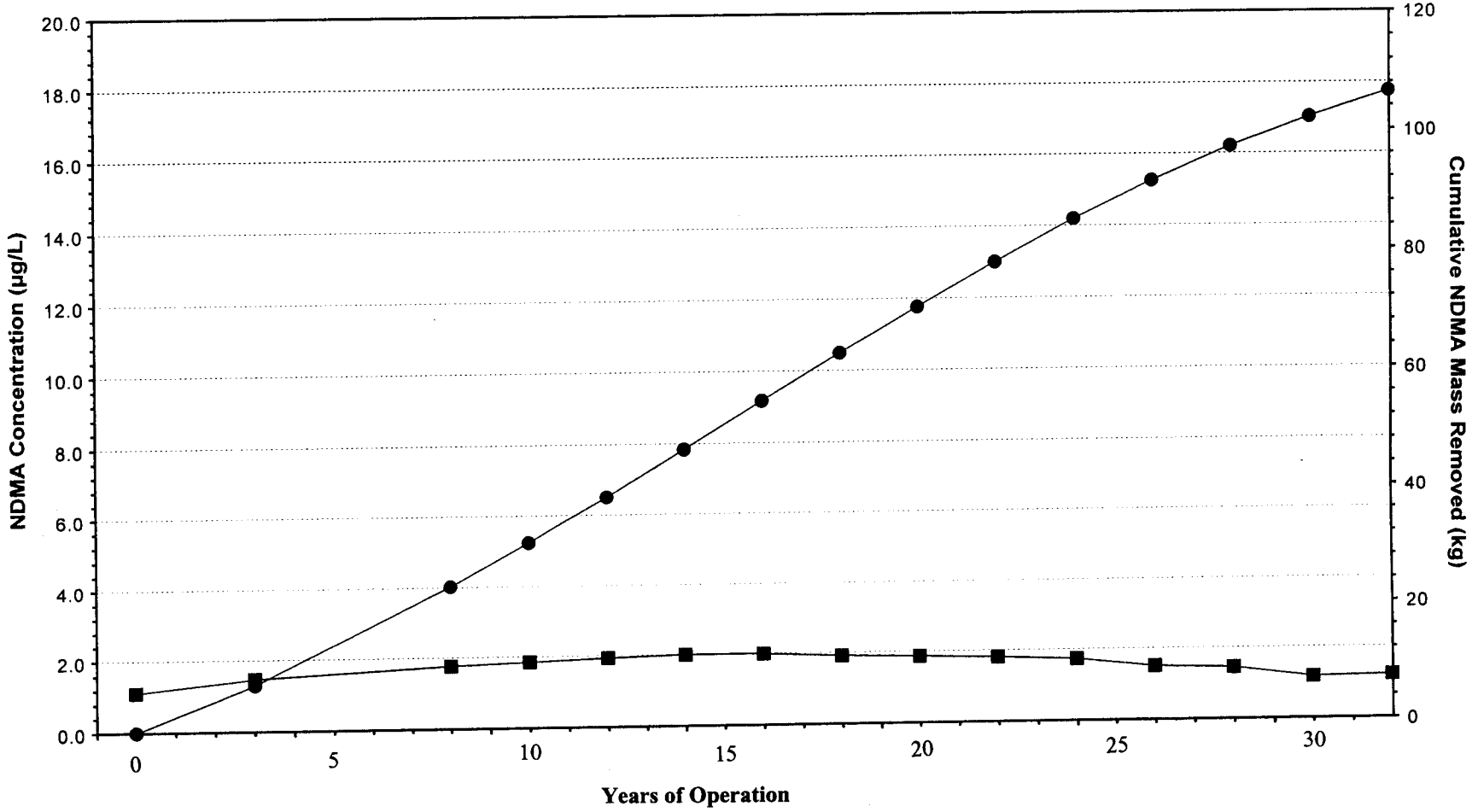

Explanation

- Well Concentration
- Cumulative Mass Removed

Figure 4.7

NASA-WSTF MODELING

Simulated NDMA Concentration and Cumulative Mass Removed for All Extraction Wells

Figure 4.7

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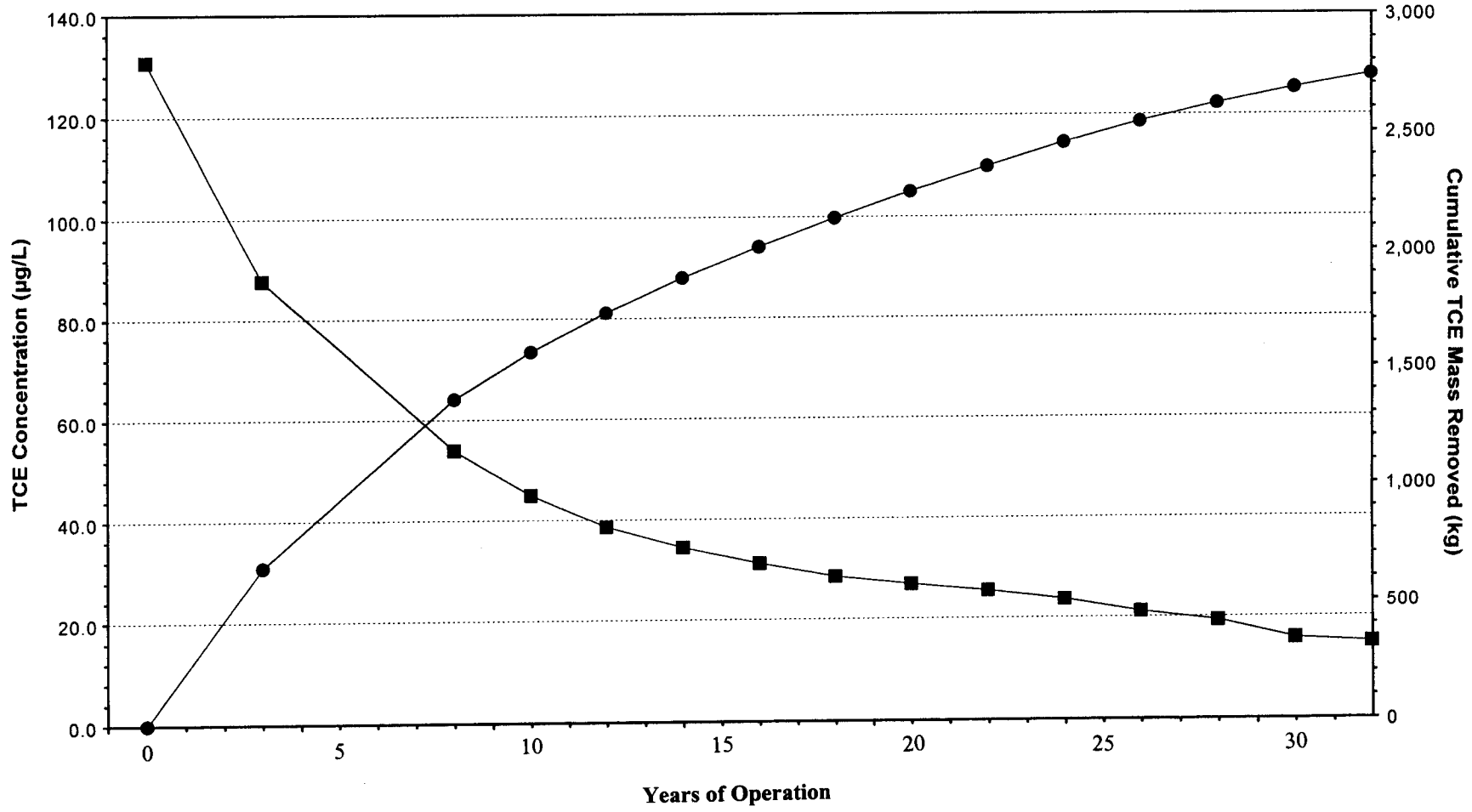

Explanation

- Well Concentration
- Cumulative Mass Removed

Figure 4.8

NASA-WSTF MODELING

Simulated TCE Concentration and Cumulative Mass Removed for All Extraction Wells

Figure 4.8

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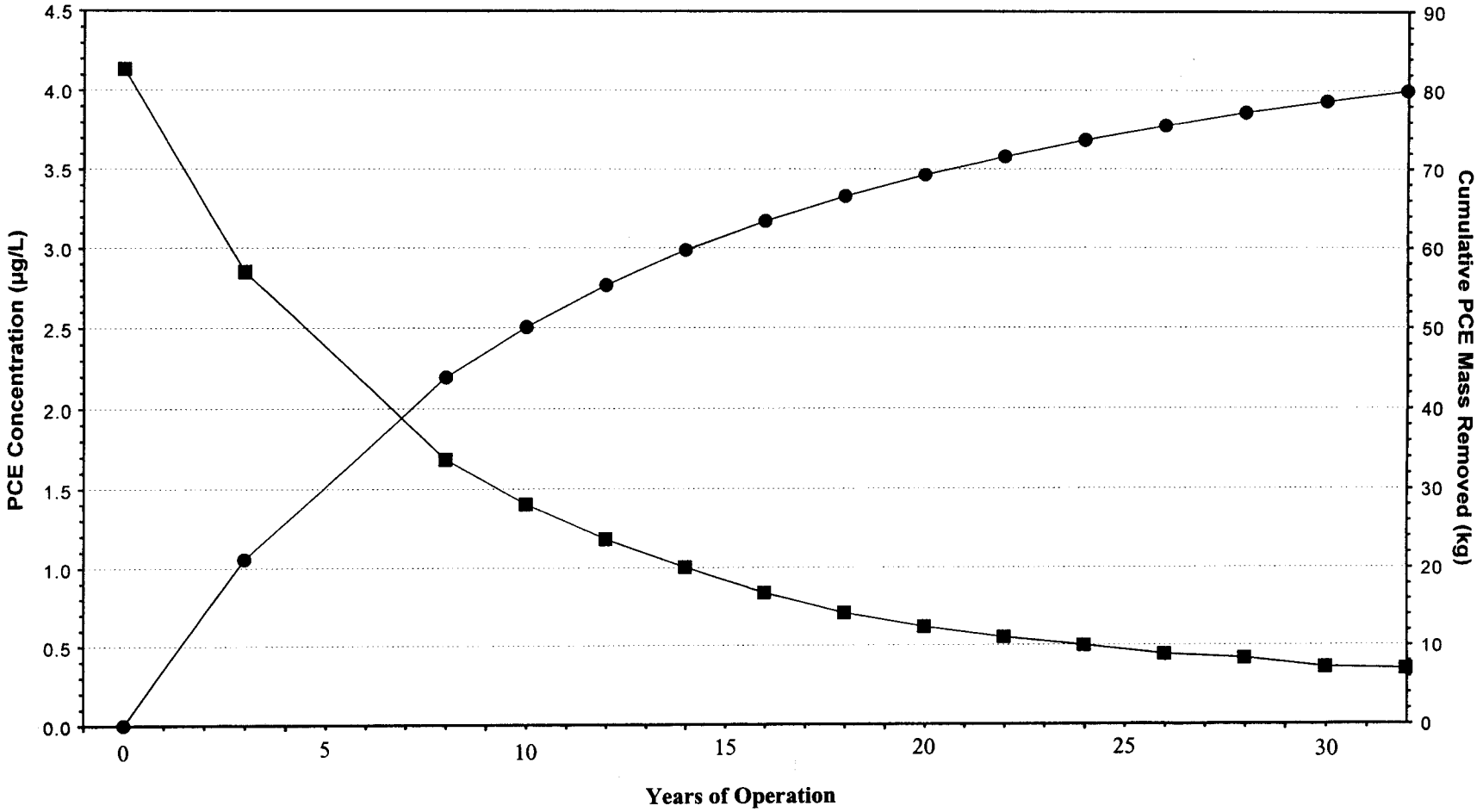

Explanation

- Well Concentration
- Cumulative Mass Removed

Figure 4.9

NASA-WSTF MODELING

Simulated PCE Concentration and Cumulative Mass Removed for All Extraction Wells

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Each of the predictive simulations indicates a small zone of contaminant migration to the south in the vicinity of the eastern edge of the WBFZ. This ~~appears~~ movement is unlikely, due to the fact that contaminant particles that escape are released at greater depths in the model than current contamination observed in the field. This migration ~~will be~~ was re-evaluated ~~once the system is in place and the~~ as part of Scenario 11, using the 200 gpm pumping rate for ~~withdrawal capacity of~~ extraction well PFE-4A. ~~(projected to be relatively low at~~ This rate significantly exceeded the 10 gpm pumping rate used for well PFE-4 in Scenario 10 of the original Plan~~.) can be assessed. Recent field installation data at the PFE-4 well indicate that the production capability at proposed well PFE-4A will increase from 10 to in excess of 200 gpm~~. No problems for plume capture within this area ~~are anticipated~~ were encountered.

4.3.3 Mass Extraction Calculations

Influent concentration and cumulative mass removal plots for the original Plan plume-front containment scenario for NDMA, TCE and PCE over 30 years are provided in Figures 4.7, 4.8 and 4.9, respectively. These plots are based on the simulations used to generate the plume maps in Figures 4.4, 4.5 and 4.6. The mass extraction plots for the original and modified Plans will remain approximately the same due to the similarity in well positions and compatible total extraction rates. The figures provide simulated contaminant concentrations for all extraction wells and the cumulative mass of contaminants removed. These well concentrations are indicative of concentrations that may be expected for treatment plant influent and were utilized for treatment system design. The simulated initial well concentration (or influent) for NDMA is 1,200 ppt, which gradually increases to 2,000 ppt, and is then reduced to 1,200 ppt over the period of the predictive simulation through the year 2026. Initial TCE concentrations of 130 ppb decrease relatively rapidly to less than 20 ppb during the predictive simulation, and initial PCE concentrations also show a steady decline from 4.2 ppb to less than 0.5 ppb by the end of the simulation period.

4.3.4 Other Modeling Considerations

The 3DSWB model predictive simulation results indicate that plume-front containment can be achieved using six extraction wells (Figure 4.1) pumping at an estimated cumulative rate of ~~1,010~~1,076 gpm. The TCE plume primarily drives the optimum placement of the ~~three~~ five high-volume extraction wells PFE-1, PFE-2, PFE-3, PFE-4A, and PFE-7. Well PFE-4A is now considered to be a potential high volume well due to field information collected from well PFE-4. A shallow seismic survey of the area was completed in February 2001; survey results were used to confirm the position of bedrock in the area and assist in placement of the PFE-4A well. ~~through PFE-3 and one lower volume extraction well (PFE-4). Well PFE-4 is a reduced volume extraction well as it is located more proximal to the pediment area within fractured bedrock. This restricts the volume of water that can be extracted.~~ Because the TCE plume extends further west than the NDMA plume, the se five wells will be located further west than the optimum location of the PFE-5 well~~s~~ for the NDMA plume.

Extraction well~~s~~ PFE-5 ~~and PFE-6 were~~ was added to the plume-front containment scenario to specifically address containment of the NDMA/DMN plume-front. The well~~s~~ ~~will be~~ was

positioned ~~adjacent to each other~~ within the area of highest NDMA/DMN plume-front concentrations. ~~These~~ This well location~~s will be~~ is east of the TCE target wells adjacent to the boundary between the eastern WBFZ and the pediment slope. The placement of PFE-5 ~~and PFE-6~~ to the east of the five high-volume wells ~~PFE-1 through PFE-4 will ensure~~ assisted with stabilization of the NDMA/DMN plume over the simulat~~ed~~ion period. Additional movement of the well~~s~~ to the east was restricted by the fractured-bedrock pediment aquifer, where potential extraction rates decrease by an order of magnitude.

~~As remediation wells are installed,~~ Following installation of the remediation wells, they ~~will be~~ were evaluated to ~~determine if~~ confirm that predicted water production rates ~~are~~ were accurate and to determine ~~contaminated~~ groundwater contaminant concentrations. As of May 2002, extraction wells PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, PFE-7 and injection wells PFI-1 through PFI-4 had been tested for production capacity and sampled. All well capacities exceeded the required rates, and contaminant groundwater results were within the anticipated ranges. Assessments of extraction or injection wells ~~will be~~ are provided in monthly reports submitted by NASA (see section 6.3) to NMED~~. and EPA.~~ If any unanticipated conditions are encountered which will significantly affect water extraction or injection rates for individual wells or require movement or the addition or elimination of specified wells, the appropriate regulatory authorities will be notified in writing of the conditions and required approvals will be requested. Modeling simulations will be performed using the collected data to determine optimum pumpage rates and to determine if future injection wells are ~~located in a manner~~ required to provide for an effective plume containment system.

4.4 TREATMENT STANDARDS

Treatment standards for this Plan have been developed following standards and guidelines from multiple Federal and State regulatory sources. Regulations and guidance documents used in the development of treatment standards include:

- the New Mexico Ground and Surface Water Protection Regulations (New Mexico Administrative Code (NMAC), 1998a);
- the New Mexico Drinking Water Regulations (NMAC, 1998b);
- concentration limits from 40 CFR 264.94 (National Archives and Records Administration (NARA), 1998a);
- Risk Assessment Guidance for Superfund (EPA, 1989);
- EPA Region 9 Preliminary Remediation Goals (EPA, 1998c); and
- other health and toxicological risk resources.

If technically achievable, the most conservative of the issued standards were selected as treatment standards. Table 4.3 provides a summary of regulatory standards and treatment goals for plume-front contaminants. EPA Region 9 has compiled a list of risk-based preliminary remediation goals (PRGs) which are used as decision-making tools for evaluating and remediating contaminated sites (EPA, 1998c). EPA indicates that PRGs are not intended as a stand-alone decision-making tool. Chemical concentrations above a PRG indicate that further evaluation of the risks posed by site contaminants is appropriate.

TABLE 4.3: SUMMARY OF REGULATORY STANDARDS AND REMEDIATION GOALS

Contaminant	Drinking Water Standard[1]	Groundwater Standard[2]	PRG[3]
NDMA	N/A	$<1.0 \times 10^{-5}$ Risk	1.3 ppt
DMN	N/A	$<1.0 \times 10^{-5}$ Risk	1.3 ppt[4]
TCE	5 ppb	100 ppb	1.6 ppb
PCE	5 ppb	20 ppb	1.1 ppb
Freon 11	N/A	N/A	1,288 ppb
Freon 21	N/A	N/A	N/A
Freon 113	1,200 ppb[5]	N/A	59,180 ppb
Cumulative	N/A	$<1.0 \times 10^{-5}$ Risk	N/A

1 20 NMAC 7.1-Drinking Water
2 20 NMAC 6.2-Ground and Surface Water Protection
3 EPA Region 9 Preliminary Remediation Goals (PRGs)
4 Values presented for DMN are extrapolated from published NDMA data.
5 State of California Drinking Water Standard

N/A Not Applicable

4.4.1 Groundwater Treatment Standards

Treatment standards for the contaminants identified at the plume-front are a combination of concentration-based and health-risk-based standards, and are summarized in Table 4.3. In selecting standards for the plume-front remediation system, three issues were addressed: the analytical reporting limits and cancer risk levels for NDMA and DMN; the concentration-based standards for TCE and PCE; and the absence of standards for the Freon compounds. The standards selected were designed to comply, as technically achievable, with state of New Mexico standards for cumulative cancer risk ($< 1 \times 10^{-5}$) and conform to a cumulative hazard index of less than 1.0.

Table 4.4 summarizes the projected influent contaminant concentrations to the plume-front remediation system, and their associated risks. The predicted influent concentrations of NDMA, TCE and PCE are taken from their respective mass extraction plots (Figures 4.7 through 4.9). The influent concentrations of DMN, Freon 11, Freon 21, and Freon 113 were assumed to be the highest historical concentrations of those compounds observed in any plume-front monitoring well. Using modeled and assumed concentrations, the cumulative cancer risk of remediation system influent is 2.23×10^{-3}, and the cumulative hazard index is 0.850. The cancer risk of the influent exceeds EPA and NMED standards, but the hazard index does not. The hazard quotients of the Freon compounds are very low, even though worst-case assumptions were made about their influent concentrations.

The proposed groundwater treatment system will utilize UV oxidation and air stripping. The UV oxidation is primarily used for NDMA/DMN treatment. ~~However, the system will lower volatile organic concentrations.~~ TCE, PCE and the Freon compounds will be lowered to levels below treatment standards by air stripping. The removal efficiency for each ~~compound~~ VOC depends primarily on their Henry's Law constants, and solubilities. Table 3.1 summarizes those properties for each contaminant. The Henry's Law constants of TCE and PCE are 0.0117 and 0.02685 atm·m³/mole, while the Henry's Law constants of the Freon compounds range from 0.0104 to 0.526 atm·m³/mole. Similarly, the solubilities of TCE and PCE are 1,100 and 150 mg/L, while the solubilities of the Freon compounds range from 170 to 9,500 mg/L. Using the predicted influent concentration and drinking water standard for TCE, its removal efficiency must be at least $\frac{100 \times (130\ \text{ppb} - 5\ \text{ppb})}{130\ \text{ppb}} = 96.2\%$. A pilot test of a cascade air stripper was conducted by NASA in 1995. The pilot test demonstrated that VOC removal efficiencies of up to 99% could be achieved (NASA, 1996b).

Recent enhancements by a commercial analytical laboratory have resulted in the ability to achieve a 10 ppt reporting limit for NDMA and DMN using EPA Method 607. This reporting limit is lower than reporting limits established for other U. S. sites with NDMA contaminated groundwater. The current NDMA treatment standards for the Rocky Mountain Arsenal in Colorado and the GenCorp Aerojet Facility in Sacramento, California are 33 ppt (Swanick, 1998) and 100 ppt (Edson, 1998), respectively.

NASA is currently working with a commercial analytical laboratory to develop a reliable analytical method with a reporting limit more sensitive than the current 10 ppt level for

TABLE 4.4: PREDICTED INFLUENT CONTAMINANT CONCENTRATIONS TO THE PLUME-FRONT REMEDIATION SYSTEM

Contaminant	Expected Influent Concentration	Residential Cancer Risk*	Residential Hazard Quotient
NDMA	2,000 ppt [1]	1.52~~19~~ X 10^{-3}	N/A
DMN	1,700 ppt[2]	1.29~~01~~ X 10^{-3}	N/A
TCE	130 ppb[3]	2.13~~1.67~~ X 10^{-5}	0.594
PCE	4.2 ppb[4]	3.25~~2.51~~ X 10^{-6}	0.012
Freon 11	860 ppb [2]	N/A	0.079
Freon 21	60 ppb [2]	N/A	0.164
Freon 113	2,000 ppb [2]	N/A	0.002
Cumulative	---	2.84~~23~~ X 10^{-3}	0.850

[1] Maximum concentration from Figure 4.7, Page 39.
[2] Highest historical concentration from any plume-front monitoring well.
[3] Maximum concentration from Figure 4.8, Page 40.
[4] Maximum concentration from Figure 4.9, Page 41.

N/A Not Applicable
* Residential Cancer Risk calculated using EPA age-adjusted exposure factors

NDMA and DMN. The proposal to use this method in conjunction with EPA Method 607 is in draft form and should be submitted to the NMED Hazardous Waste Bureau in the near future. At such time that the analytical method is developed to the satisfaction of both NASA and the appropriate regulatory authorities, it will be proposed as a revision to this Plan.

Table 4.5 presents the individual and cumulative risk for the proposed plume-front contaminant presumptive remedy goals. The cumulative age-adjusted cancer risk for the treatment standards is ~~1.56~~ 1.98 x 10^{-5}, and the cumulative hazard quotient is 0.102. The projected cumulative cancer risk is slightly higher than the Ground and Surface Water Protection Regulations cancer risk level (1 x 10^{-5}) provided in the concentration-based standards of Table 4.3. NDMA and DMN concentrations of less than 5 ppt would achieve this cancer risk level. This level cannot currently be measured by any EPA-recommended analytical method.

The NDMA and DMN standards presented in Table 4.5 are reporting limit concentrations as received from the analytical laboratory. The EPA Method 607 allowable limits for extraction efficiency range from 13% to 109%. Per the analytical method, the laboratory cannot adjust analytical data for the observed extraction efficiencies. Typically, the off-site laboratory used by WSTF achieves an NDMA extraction efficiency of 30% to 40%. Assuming a typical extraction efficiency of 30%, a reported NDMA/DMN concentration of 10 ppt corresponds to an estimated actual concentration of 33 ppt. The residential cancer risk associated with reported NDMA and DMN concentrations of 10 ppt and an extraction efficiency of 30% are shown in Table 4.6.

In summary, the anticipated development, implementation and approval of a more sensitive analytical method for NDMA and DMN will result in lowered reporting limits for these contaminants and allow NASA to measure and verify lowered treatment levels for NDMA and DMN. Recent data received for a potential alternative method are promising, but no definitive time frame can be provided for completion.

4.5 PRESUMPTIVE REMEDY REMEDIAL SYSTEM CONCEPTUAL DESIGN

The plume-front remediation system will consist of: ~~five~~ nine additional groundwater monitoring wells (WW-2, WW-3, WW-4, WW-5, ST-7, JP-3, PL-8, PL-9 and BLM-37); six groundwater extraction wells (PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5 and ~~through~~ PFE-7~~6~~); groundwater transport pipelines from the extraction wells to the treatment facility; ~~pre-treatment and~~ air stripping and UV oxidation treatment systems; pipelines from the treatment facility to the injection wells; and four groundwater injection wells (PFI-1 through PFI-4).

The additional plume-front monitoring wells will be installed to enhance vertical delineation of the plume-front, aid in the design and location of extraction and injection wells, enhance plume-front monitoring capabilities, and support monitoring of the effectiveness of the containment system.

TABLE 4.5: TREATMENT STANDARDS FOR PLUME-FRONT CONTAMINANTS

Contaminant	Treatment Standards	Residential Cancer Risk (Age Adjusted)	Residential Hazard Quotient	Basis
NDMA	10 ppt	7.6 X ~~5.97 X~~ 10^{-6}	N/A	Method 607 Reporting Limit
DMN	10 ppt	7.6 ~~5.97~~ X 10^{-6}	N/A	Method 607 Reporting Limit
TCE	5 ppb	8.2 ~~6.44~~ X 10^{-7}	0.023	20 NMAC 7.1
PCE	5 ppb	3.8 ~~2.98~~ X 10^{-6}	0.014	20 NMAC 7.1
Freon 11	100 ppb	N/A	0.009	Conservative Health Risk Value
Freon 21	20 ppb	N/A	0.055	Conservative Health Risk Value
Freon 113	1,200 ppb	N/A	0.0011	California Drinking Water Standard
Cumulative	---	1.98~~1.56~~ X 10^{-5}	0.102	---

N/A Not Applicable

TABLE 4.6: INDIVIDUAL AND CUMULATIVE RISK ASSUMING 30% ANALYTICAL EXTRACTION EFFICIENCY FOR NDMA AND DMN

Contaminant	Treatment Standard (Estimated Actual Concentration)	Residential Cancer Risk (Age Adjusted)	Residential Hazard Quotient
NDMA	10 ppt (33 ppt actual)	~~1.99 x~~2.5 X-10^{-5}	N/A
DMN	10 ppt (33 ppt actual)	~~1.99 x~~ 2.5 X 10^{-5}	N/A
TCE	5 ppb	~~6.44 x~~8.2 X -10^{-7}	0.023
PCE	5 ppb	~~2.98 x~~3.8 X 10^{-6}	0.014
Freon 11	100 ppb	N/A	0.009
Freon 21	20 ppb	N/A	0.055
Freon 113	1,200 ppb	N/A	0.0011
TOTAL	---	~~4.34 x~~5.4 X 10^{-5}	0.102

N/A Not Applicable

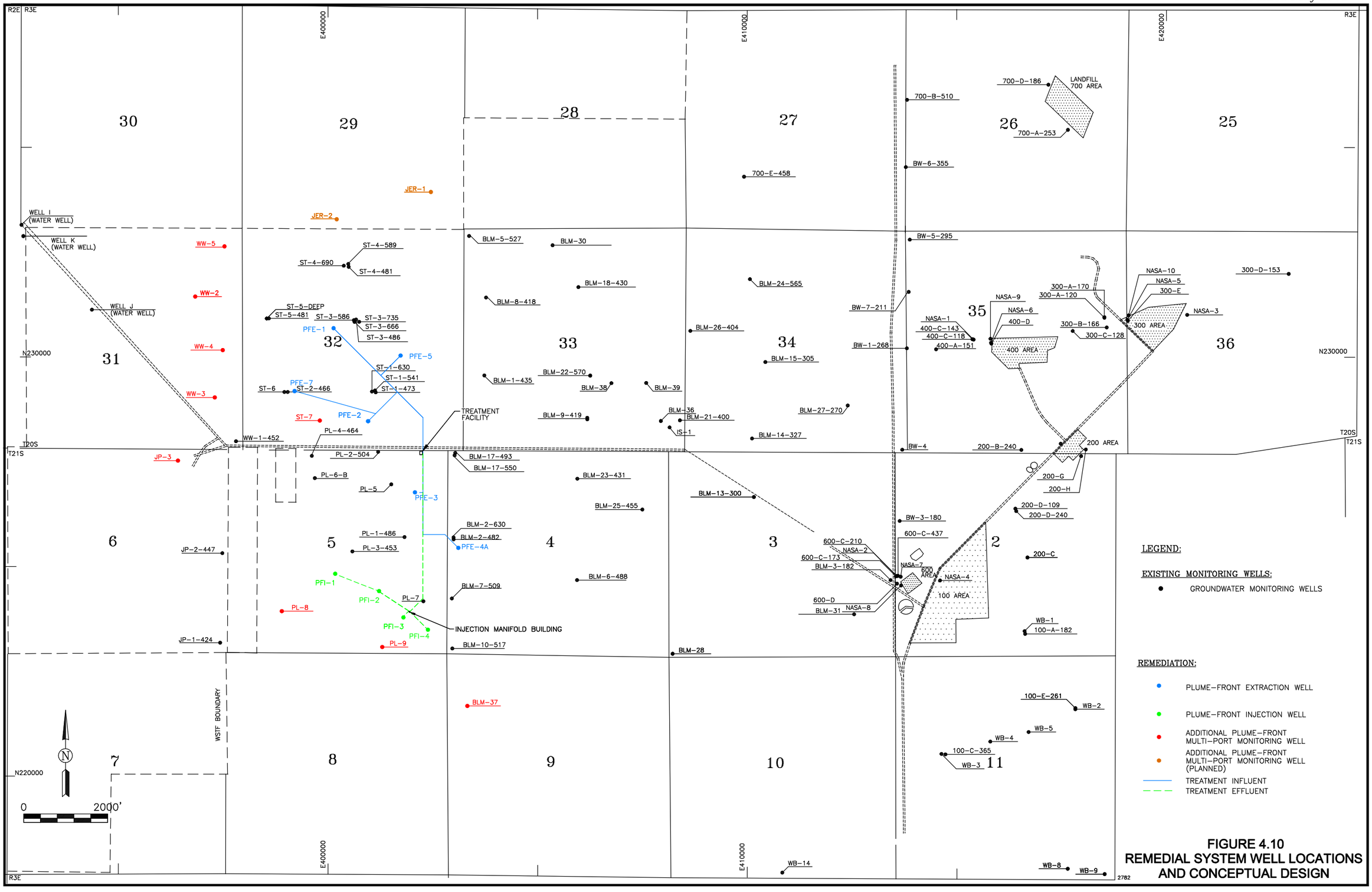
The plume-front remediation system will be designed to remove contaminant mass at the plume-front and create a hydraulic barrier to prevent further westward migration of the plume. The locations of the monitoring wells, extraction wells, injection wells, and the treatment system are illustrated by Figure 4.10.

Treatment alternatives for NDMA, described in Volume One, Chapter Three of the Draft CMS Report (NASA, 1996b), indicate that the contaminant is recalcitrant to treatment. UV oxidation is the only practicable technology available for both NDMA and DMN. The UV oxidation treatment will not independently remediate the halogenated VOCs to acceptable levels, therefore air stripping will be initially used to complement the UV oxidation system.

The anticipated performance of the full-scale plume-front treatment system is summarized in Table 4.7. The influent NDMA, PCE and TCE concentrations are the maximum values expected during the lifetime of the presumptive remedy, based on hydrogeological modeling. The projected maximum influent concentrations of NDMA, PCE and TCE are taken from their respective mass removal plots derived from the plume-front containment modeling simulations (Figures 4.7, 4.8, and 4.9). Concentrations of DMN and the other halogenated VOCs listed in Table 4.7 are equal to the highest concentration of each contaminant measured in any of the plume-front wells. The effluent concentrations of NDMA and DMN will be below the current 10 ppt reporting limit of EPA Method 607.

~~Extraction wells PFE-1 through PFE-6 will be installed along the plume-front. The projected locations of the extraction wells are shown in Figure 4.10.~~ The locations of the extraction wells were selected based on the results of hydrogeological modeling (Figure 4.1). The depths and diameters of the extraction wells were~~will be~~ designed based on the plume-front containment modeling simulation (Table 4.2), and the results of a pump test previously performed on the existing NASA PT well (NASA, 1990), which is plume-front extraction well PFE-3. ~~Depending on the hydrological conditions encountered, the depths and diameters of the extractions wells may change.~~ Hydrogeological modeling provides an extraction flow rate of ~~1,010~~1,076 gpm for the most efficient plume-front containment scenario (Sections 4.2 and 4.3 of this Plan). NASA anticipates that additional extraction wells may be installed in the future, for either possible MPCA remedial actions or to supplement plume-front wells identified by this Plan. Therefore, the UV oxidation and VOC treatment equipment will be designed to accommodate a maximum flow rate of ~~1,300~~1,250 gpm.

The pipeline from the extraction wells to the treatment facility will be constructed of double-walled high-density polyethylene (HDPE) pipe. In the event of a leak in the inner pipe, the annular space between the inner and outer pipes will serve as secondary containment. Leak detection sensors will be installed in the annular space ~~allowing for~~ to aid in the detection~~,~~ and localization ~~and repair~~ of any leaks. The extraction pipeline will be installed underground to protect against external damage, exposure to solar UV radiation, thermal expansion/contraction, and freezing.



LEGEND:

EXISTING MONITORING WELLS:

- GROUNDWATER MONITORING WELLS

REMEDIATION:

- PLUME–FRONT EXTRACTION WELL
- PLUME–FRONT INJECTION WELL
- ADDITIONAL PLUME–FRONT MULTI–PORT MONITORING WELL
- ADDITIONAL PLUME–FRONT MULTI–PORT MONITORING WELL (PLANNED)
- TREATMENT INFLUENT
- TREATMENT EFFLUENT

FIGURE 4.10
REMEDIAL SYSTEM WELL LOCATIONS AND CONCEPTUAL DESIGN

TABLE 4.7: ANTICIPATED PLUME-FRONT REMEDIATION SYSTEM PERFORMANCE

Criteria	Value	
Estimated Nominal~~Average~~ Flow Rate	1,076~~10~~ gallons per minute	
Estimated Maximum Flow Rate	1,250~~300~~ gallons per minute	
Predicted Influent Concentrations	NDMA DMN PCE TCE Freon 11 Freon 21 Freon 113	2,000 ppt[1] 1700 ppt[2] 4.2 ppb[3] 130 ppb[4] 860 ppb[2] 60 ppb[2] 2,000 ppb[2]
Predicted Effluent Concentrations	NDMA DMN PCE TCE Freon 11 Freon 21 Freon 113	< 10 ppt < 10 ppt 0.06 ppb [5] 3.8 ppb [5] 43 ppb [6] 3 ppb [6] 100 ppb [6]
Effluent Cancer Risk	---	$<1.25 \times 10^{-5}$ [7]

1 Maximum concentration from Figure 4.7, Page 39.
2 Highest historical concentration from any plume-front monitoring well.
3 Maximum concentration from Figure 4.8, Page 40.
4 Maxumum concentration from Figure 4.9, Page 41.
5 Based on packed-tower aeration model calculations.
6 Represents a conservative 95% reduction in influent concentrations.
7 Based on 100% NDMA/DMN analytical extraction efficiency.

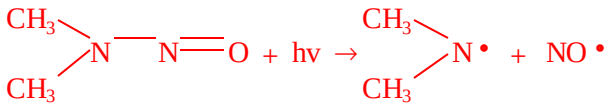
Groundwater pre-treatment may be required to remove turbidity, suspended solids and hardness from the water. Hardness values observed in plume-front monitoring wells have ranged from 173 to 613 mg/l (as $CaCO_3$). These hardness values represent a significant potential for scaling in the treatment system, pipelines, wells, and/or the injection formation. ~~Pretreatment recommendations of the manufacturers of the UV oxidation and air stripper treatment units selected through the federal procurement process will be included in the detailed project design.~~ A polyphosphate scale control chemical (AquaMag or equivalent) will be injected into the process piping, upstream of the airstrippers to prevent the formation of scale in the air strippers and UV reactor.

The treatment system will utilize two sieve-tray air strippers, operating in parallel, to remove VOCs from contaminated groundwater. A process flow diagram illustrating the conceptual arrangement of the treatment system is presented in Figure 4.11.

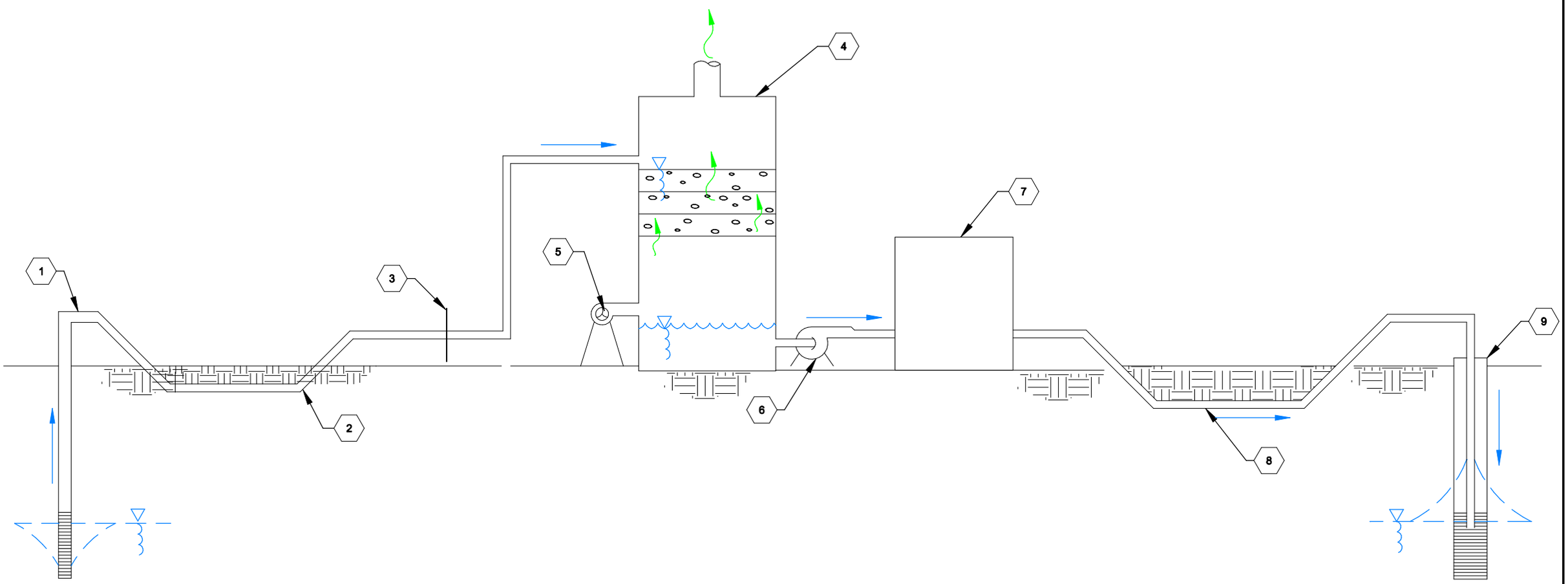
~~The treatment system will be designed to remove NDMA and DMN and the halogenated VOCs. UV oxidation will be utilized to oxidize NDMA and DMN; the final oxidation products are bicarbonate and nitrate ions. In the oxidation process, UV radiation generates hydroxyl radicals ($OH^{\bullet}$) by photolysis of ozone and/or hydrogen peroxide:~~

~~$O_3 + H_2O + UV \Rightarrow 2OH^{\bullet} + O_2$~~
~~$H_2O_2 + UV \Rightarrow 2OH^{\bullet}$~~

~~The hydroxyl radicals in turn will oxidize the NDMA and DMN molecules to bicarbonate and nitrate.~~
Following air stripping, UV/oxidation will be utilized to treat the NDMA and DMN. NDMA absorbs UV radiation most strongly in a band centered around 227 nm. The wavelength of the UV radiation emitted by the lamps is in the range 200-250 nm. Absorption of UV radiation breaks the N-N bond, producing a NO radical and a dimethylamino radical:



Prior to the purchase of the UV oxidation treatment equipment, bench-scale and pilot-scale testing of the equipment was performed to ensure satisfactory system performance and allow development of an engineering design basis. This testing was performed as a part of the UV oxidation system Technical Feasibility Study (discussed in Section 6.4.2). Both the bench- and pilot-scale test results indicated the UV power required would be about 1 kilowatt-hour (kW·hr) per 1000 gallons (3,785 liters) treated per order of magnitude reduction in NDMA concentration. The UV oxidation system contains twelve UV lamps (each rated at 30 kW), with a total power requirement of 360 kW. At the design flow rate of 1,076 gpm (4,073 Lpm), nine lamps will be operated to achieve the NDMA and DMN design discharge concentration of 2 ppt.



1 GROUNDWATER EXTRACTION WELLS
2 EXTRACTION PIPELINE (DUAL–WALL) POLYETHYLENE
3 POLYPHOSPHATE SCALE CONTROL INJECTION
4 LOW PROFILE SIEVE TRAY AIR STRIPPER FOR VOC TREATMENT
5 AIR BLOWER
6 INJECTION PUMP
7 UV OXIDATION SYSTEM FOR NDMA TREATMENT
8 INJECTION PIPELINE (SINGLE WALL)
9 GROUNDWATER INJECTION WELLS

AIR FLOW

WATER FLOW

FIGURE 4.11
REMEDIAL SYSTEM
PROCESS FLOW DIAGRAM

~~The oxidation reaction should produce two moles of nitrate for each mole of NDMA or DMN oxidized. Assuming an initial concentration of 2,000 ppt NDMA, and 1,700 ppt DMN, the concentration of NO_3^- in the treated groundwater should be 5.7 ppb.~~

NASA has previously performed bench-scale testing of a UV oxidation system and the results were reported in Volume Two, Chapter Two the Draft CMS Report (NASA, 1996b). ~~NASA is required by the Federal Acquisition Regulations (FARs) to competitively bid major procurements, such as the UV oxidation system. Prior to the purchase of UV oxidation treatment equipment, pilot-scale testing of the equipment of the potential bidders will be performed to ensure satisfactory system performance and allow development of an engineering design basis . This testing will be performed as a part of the UV oxidation system Technical Feasibility Study (discussed in Section 6.4.2).~~

~~Following UV oxidation, the treatment system will utilize an air stripping unit to remove VOCs from contaminated groundwater. A process flow diagram illustrating the conceptual arrangement of the treatment system is presented in Figure 4.11.~~

The pipeline to the injection wells will consist of single-wall HDPE pipe. The pipeline will be installed underground, to protect against external damage, exposure to the solar UV radiation, thermal expansion/contraction, and freezing.

Injection wells PFI-1 through PFI-4 were~~will be~~ installed southwest of the plume-front, as shown in Figure 4.10. The locations of the injection wells were selected based on the results of hydrogeological modeling presented in Section 4.2. The well casing and annular materials specifications, design strategy and depth specifications are provided in Table 4.2. Tubing installed in the casing will allow the injection of the treated groundwater below the pre-injection static water level. Cathodic protection will be installed on ~~any extraction/injection~~ extraction well PFE-3, ~~wells that~~ which utilizes carbon ~~or stainless~~ steel ~~components~~ casing. Flow rates and water levels will be monitored throughout the operation of the injection wells.

Installation of the monitoring wells, extraction wells, injection wells, and treatment equipment will be a staged process. This process is discussed in Section 6.2 of this Plan. Following original Plan submission in January 1999, NASA ~~will submit~~ submitted a Discharge Plan (DP) application for the injection wells to the NMED GWQB (DP-1255) on February 10, 1999 which was subsequently approved on March 10, 2000.~~.~~ ~~Any~~ All of the necessary ~~well~~ drilling permits ~~will be~~ for plume-front wells have been coordinated through the State Engineer's Office (SEO). ~~Upon receipt of the required regulatory approvals, NASA will initiate drilling and installation of two extraction and two injection wells.~~ As of May 2002, NASA has completed the installation of ten remediation wells (extraction wells PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, and PFE-7 and injection wells PFI-1 through PFI-4). During the drilling~~, and~~ installation, testing, and sampling of these wells, ~~it is anticipated that~~ the treatment system ~~will be~~ design~~ed~~, procure~~d~~ment~~, constructed~~ and construction has been in progress.~~, and readied for use.~~ NASA have also completed the installation of the nine additional Westbay® multi-port wells (WW-2, WW-3, WW-4, WW-5, ST-7, JP-3, PL-8, PL-9 and BLM-37) designed to assist in the monitoring of the remediation system.

4.6 SITE SAFETY AND SECURITY

Access to the WSTF site is controlled by a security force that is on duty on a 24-hour, 365 day per year basis. Security guards control access to the industrial complex and also patrol the plume-front area at least every 8 hours during non-working hours.

Due to the nature of their design, the extraction and injection wellheads are ~~will be~~ sealed to prevent the loss of untreated or treated groundwater. This design ~~will~~ also prevents the accidental or intentional introduction of foreign materials into these ~~remediation~~ wells. The water treatment equipment will be located inside a building. The treatment facility building will be locked, and access restricted to authorized WSTF employees. In addition, access to the treatment facility building will be restricted by the use of fencing and a locked gate.

The treatment building is ~~will be~~ equipped with a fire alarm, fire extinguishers, first aid kit, and eyewash. The on-site Fire Department at WSTF provides emergency response service on a 24-hour, 365 day per year basis.

4.7 SYSTEM START-UP

~~Following evaluation of potential vendor's equipment, f~~Final procurement specifications ~~will~~ are being generated and procurement of the treatment system and the ancillary equipment is in progress ~~will be accomplished in compliance with the FAR~~. Upon award of all ~~the~~ contracts, NASA will be able to complete final design packages and basic operating procedures for the remediation system.

Following installation, the full-scale treatment system will undergo a start-up period of approximately ~~three~~ six months. During the start-up period, the system will be intermittently operated to determine the most effective conditions for contaminant treatment, identify any potential design refinements and ensure system integrity. Treated effluent collected during the start-up pumping periods will be stored in a series of holding tanks pending receipt of laboratory analyses. If the water in the holding tank does not meet treatment standards, it will be recycled through the treatment system or transferred to the permitted WSTF 200 Area Hazardous Waste Evaporation Tanks. If the effluent does meet treatment standards, the treated groundwater will be injected.

4.8 REMEDIAL SYSTEM OPERATION AND MAINTENANCE AND CONTINGENCY PLANNING

4.8.1 Operation and Maintenance

The WSTF plume-front stabilization and groundwater treatment system will require normal, periodic maintenance of various components to ensure optimum operating efficiencies and to minimize potential impacts to human health or the environment. Detailed operational and maintenance (O&M) procedures will be provided ~~with the~~ as well as design packages for the system. A description of water sampling activities is presented in Section 5.0 of this Plan.

4.8.2 Contingency Plan

Appendix A provides the most recent Contingency Plan for the NMED-approved Hazardous Waste Operating Permit for WSTF. This Contingency Plan will be incorporated into this Plan. If the NMED approves future modifications to the Contingency Plan contained within the Hazardous Waste Operating Permit, NASA will provide the modified plan for inclusion as Appendix A of this document.

The plume-front stabilization and groundwater treatment system design will incorporate several interlocks that will halt system operation when specific conditions arise. These conditions include:

- leakage within the dual-wall extraction piping;
- near-surface water levels within injection well(s);
- catastrophic failure of any major component (i.e., air stripper blower motor, injection pump, extraction pumps, UV system); and
- significant leakage from any piping or component within the treatment building facility.

In the event of a significant component failure that results in a system shut-down of more than 24 hours, NASA will notify the NMED verbally within 24 hours and in writing within 72 hours of the event. The written notification will summarize system status, cause of shut-down, response taken and/or planned, expected duration of the shut-down, and any potential impacts on human health and the environment.

4.8.3 Waste Management

Wastes generated from the construction, operation or maintenance of the system will be handled and disposed of per the WSTF Standard Instruction, Waste Management (NASA, 1998b) and the NMED-issued Hazardous Waste Operating Permit for NASA.

Rainwater accumulation and run-off are not anticipated to be a concern; the treatment building that houses the treatment equipment will be located away from existing surface drainage features. The building site will be graded to route roof drainage and precipitation run-on away from the proposed treatment facility.

5.0 SAMPLING AND ANALYSIS

5.1 INTRODUCTION, OBJECTIVES AND SCOPE

As described in previous sections of this document, NASA has determined that plume-front containment and groundwater treatment is required to prevent further migration of the contaminated groundwater at the plume-front. ~~Five~~ Nine additional plume-front monitoring wells ~~will be~~ have been installed to ensure the effectiveness of the plume-front containment system and to supplement existing monitoring wells. Figure 4.10 provides locations for these additional groundwater monitoring wells. These additional wells ~~are anticipated to be~~ were

completed as Westbay multi-port® wells with four sampling zones ~~with targeted~~ and depths of approximately 1,000 feet.

Current WSTF documentation provides detailed instructions for groundwater contamination assessment and monitoring activities. This section compliments the existing documentation with the requirements for the plume-front remediation system.

The purpose of this section is to ~~provide~~ describe the WSTF ~~with a~~ Sampling and Analysis Plan for the plume-front remediation system ~~(SAP-PFRS)~~. This plan provides personnel with project-specific procedures for the collection and analysis of samples associated with plume-front containment activities. These will be used in conjunction with the most recently approved WSTF Groundwater Sampling and Analysis Plan (SAP) (NASA, 1997b) and the WSTF Quality Assurance Project Plan (QAPP) (NASA, 1997c). The most recently approved SAP and QAPP are provided as Appendix B and C, respectively, of this Plan. If future modifications to these Plans are approved, NASA will submit the modified versions to replace the current appendices of this Plan.

These Plans list procedures which address the following:

- collection and preservation of groundwater samples;
- quality assurance and quality control (QA/QC);
- data quality objectives ~~(DQOs)~~;
- chain of custody documentation;
- sample shipment; and
- sample analysis.

The protocols specified in this section assure that samples are collected in a consistent manner, representative of actual environmental conditions, shipped and tracked in an acceptable manner, and analyzed using appropriate EPA-recommended analytical methods. The QA/QC portion of this Plan, used in conjunction with the WSTF QAPP, provides the quality assurance steps necessary to substantiate data collected for this project.

5.2 SAMPLING ACTIVITIES AND FIELD METHODS

WSTF personnel are responsible for conducting all sampling activities associated with the plume-front remediation project. Current WSTF sample collection and quality control procedures will be followed during all phases of the project. Samples will be collected at designated groundwater monitoring wells and sampling points within the remediation system.

All plume-front containment and remediation sampling events will be performed using the same sample collection protocols utilized for 3008(h) Consent Order groundwater assessment sampling events. All necessary safety issues will be addressed and procedures followed as directed in the relevant documentation. This includes, but is not limited to, the following:

- use of appropriate safety equipment (boots, gloves, goggles, etc.) during sampling activities;
- field logbook annotation with all relevant information as outlined in the WSTF QAPP;
- use of proper decontamination procedures;
- use of appropriate sample containers and preservation techniques as outlined in Table 5.1;
- strict adherence to QA/QC procedures; and
- strict adherence to WSTF sample documentation and chain of custody requirements as outlined in the WSTF QAPP.

5.2.1 Groundwater Monitoring

Tables 5.2 and 5.3 designate monitoring wells that will be sampled specifically for this Plan. These wells include existing conventional and Westbay multi-port® wells utilized for RFI/CMS sampling, as well as the additional Westbay monitoring wells ~~to be~~ installed as a part of this Plan.

Conventional groundwater monitoring wells will typically use non-dedicated pumps to evacuate the necessary volume of purge water and dedicated Teflon bailers to collect samples. Typically, an air driven piston pump is used to purge the well and collect indicator parameters. When the required volume of water has been purged and groundwater parameters have stabilized, the pump is withdrawn and the well is sampled using the dedicated bailer. Samples are collected in the appropriate sample containers, labeled, sealed, and prepared for shipment to the appropriate analytical laboratory. Specific instructions for purging and sampling conventional monitoring wells using this process are provided in the WSTF SAP.

Samples are also collected from Westbay multi-port® wells. Westbay wells are sampled with specialized equipment that collects groundwater directly from the formation through sampling ports in the Westbay casing. A MOSDAX® sampler probe, with attached sample collection bottles and electronic surface controls, can sample groundwater in-situ for uncompromised sample quality. The probe and bottles are inserted into the well, lowered to the desired sampling port and sample collection is initiated. When the sample bottles are filled, they are raised to the surface where the groundwater is dispensed into the appropriate sample container. Refer to Table 5.1 for sample container, preservation and analytical requirements. Westbay sampling procedures are provided in the WSTF SAP.

5.2.2 Treatment System Monitoring

Treatment facility efficiency will be monitored by sampling/analyzing the untreated and treated groundwater at multiple locations. Sample taps will be installed at each of the extraction wells and on the treatment facility influent and effluent piping. These sampling locations will allow monitoring of the influent and effluent contaminant concentrations and allow verification/adjustment of modeling simulations during the operational life of the treatment facility.

TABLE 5.1: SAMPLE COLLECTION AND ANALYSIS REQUIREMENTS

TREATMENT FACILITY/GROUNDWATER ANALYTES				
Analysis	**EPA Method**	**Sample Container[1]**	**Sample Preservative[1]**	**Holding Time[1]**
Halogenated Volatile Organics	EPA Method 8021 or EPA approved/recommended equivalent	40 mL amber glass	Cool to $4^{O}C$	14 days
Volatile Organics	EPA Method 8260 or EPA approved/recommended equivalent	40 mL amber glass	Cool to $4^{O}C$	14 days
NDMA/DMN	EPA Methods 607, 8070 or EPA approved/recommended equivalent	1 L amber glass	Cool to $4^{O}C$	7 days until extraction 40 days after extraction
TREATMENT FACILITY ANALYTES FOR ENGINEERING PURPOSES				
Analysis	**Method**	**Sample Container**	**Sample Preservative**	**Holding Time**
Cations	EPA Method 6010B or EPA approved/recommended equivalent	1 L polyethylene	$4^{O}C$, 0.45 um filtration, HNO_3 to pH<2	6 months
<u>Anions</u> Total Alkalinity	EPA Method 310.1 or EPA approved/recommended equivalent	1 L polyethylene	Cool to $4^{O}C$	14 days
Chloride, Sulfate	EPA Method 300.0 or EPA approved/recommended equivalent			28 days
Fluoride	ASTM SM 4500 F C or EPA approved/recommended or equivalent			14 days
Nitrate/Nitrites	EPA Method 353.2 or EPA approved/recommended equivalent	500 mL polyethylene	$4^{O}C$, H_2SO_4 to pH<2	28 days
Total Dissolved Solids	EPA Method 160.1 or EPA approved/recommended equivalent	500 mL polyethylene	Cool to $4^{O}C$	7 days
Ammonia	EPA Method 350.1 or EPA approved/recommended equivalent	500 mL polyethylene	$4^{O}C$, H_2SO_4 to pH<2	28 days

[1] Sample containers, preservations and holding times will remain consistent with current regulatory and SW-846 guidance.

TABLE 5.2: PLUME-FRONT SAMPLING FREQUENCIES FOR CONVENTIONAL WELLS/ZONES

Well/Zone ID	Sampling Frequency
BLM-2-482	~~Quarterly~~Semi-Annually[1]
BLM-2-630	~~Quarterly~~Semi-Annually[1]
BLM-7-509	~~Quarterly~~Semi-Annually[1]
BLM-10-517	~~Quarterly~~Semi-Annually[1]
BLM-17-493	~~Quarterly~~Semi-Annually[1]
BLM-17-550	~~Quarterly~~Semi-Annually[1]
JP-1-424	Quarterly
JP-2-447	Quarterly
PL-1-486	~~Quarterly~~Semi-Annually[1]
PL-2-504	~~Quarterly~~Semi-Annually[1]
PL-3-453	~~Quarterly~~Semi-Annually[1]
PL-4-464	~~Quarterly~~Semi-Annually[1]
ST-1-473	~~Quarterly~~Semi-Annually[1]
ST-1-541	~~Quarterly~~Semi-Annually[1]
ST-1-630	~~Quarterly~~Semi-Annually[1]
ST-2-466	Semi-Annually[1]
ST-3-486	~~Quarterly~~Semi-Annually[1]
ST-3-586	~~Quarterly~~Semi-Annually[1]
ST-3-666	~~Quarterly~~Semi-Annually[1]
ST-3-735	~~Quarterly~~Semi-Annually[1]
ST-4-481	Quarterly
ST-4-589	Quarterly
ST-4-690	Quarterly
WW-1-452	~~Quarterly~~Annually[1]

[1] Indicates after active extraction/remediation/~~re~~injection activities have been initiated, the well will be monitored monthly for four months, bi-monthly for eight months and ~~quarterly~~ revert to the sampling frequency specified in the WSTF Sampling and Analysis Plan thereafter.

TABLE 5.3: PLUME-FRONT SAMPLING FREQUENCIES FOR WESTBAY® MULTI-PORT WELLS/ZONES

WELL/ZONE ID	SAMPLING FREQUENCY
BLM-37-490[1]	Quarterly
BLM-37-640	Quarterly
BLM-37-750	Quarterly
BLM-37-885	Quarterly
JP-3-515[1]	Quarterly
JP-3-695	Quarterly
JP-3-825	Quarterly
JP-3-970	Quarterly
PL-5-495	Quarterly[2]
PL-5-595	Quarterly[2]
PL-5-715	Quarterly[2]
PL-5-795	Quarterly[2]
PL-5-895	Quarterly[2]
PL-5-985	Quarterly[2]
PL-6-545	Quarterly
PL-6-725	Quarterly
PL-6-915	Quarterly
PL-6-1035	Quarterly
PL-6-1195	Quarterly
PL-6-1335	Quarterly
PL-6-1485	Quarterly
PL-6-1645	Quarterly
PL-6-1815	Quarterly
PL-7-480	~~Quarterly~~Semi-Annually[1,2]
PL-7-560	~~Quarterly~~Semi-Annually[1,2]
PL-7-630	~~Quarterly~~Semi-Annually[1,2]
PL-8-455[1]	Quarterly[2]
PL-8-605	Quarterly
PL-8-780	Quarterly
PL-8-965	Quarterly
PL-9-484	Quarterly
PL-9-594	Quarterly
PL-9-814	Quarterly
PL-9-964	Quarterly
ST-5-485	Semi-Annually[1]
ST-5-655	~~Quarterly~~Semi-Annually[1,2]
ST-5-815	~~Quarterly~~Semi-Annually[1,2]
ST-5-985	~~Quarterly~~Semi-Annually[1,2]
ST-5-1175	~~Quarterly~~Semi-Annually[1,2]
ST-6-535	Quarterly
ST-6-575	Quarterly
ST-6-685	Quarterly

TABLE 5.3: PLUME-FRONT SAMPLING FREQUENCIES FOR WESTBAY® MULTI-PORT WELLS/ZONES (continued)

WELL/ZONE ID	SAMPLING FREQUENCY
ST-6-830	Quarterly
ST-6-975	Quarterly
ST-7-450[1]	Quarterly[2]
ST-7-550	Quarterly
ST-7-785	Quarterly
ST-7-975	Quarterly
WW-2-495[1]	Quarterly
WW-2-670	Quarterly
WW-2-845	Quarterly
WW-2-960	Quarterly
WW-3-468	Quarterly
WW-3-569	Quarterly
WW-3-710	Quarterly
WW-3-978	Quarterly
WW-4-423	Quarterly
WW-4-594	Quarterly
WW-4-853	Quarterly
WW-4-953	Quarterly
WW-5-464	Quarterly
WW-5-582	Quarterly
WW-5-814	Quarterly
WW-5-912	Quarterly

~~1~~ ~~Anticipated multi-port monitoring well.~~

12 Indicates after active extraction/remediation/~~re~~injection activities have been initiated, the well/zone will be monitored monthly for four months, bi-monthly for eight months and ~~quarterly~~ revert to the sampling frequency specified in the WSTF Sampling and Analysis Plan thereafter.

The O&M Plan for this system will provide specific sampling instructions for influent, effluent and system monitoring port sampling. Table 5.4 provides the influent/effluent sample schedule.

5.2.3 Treatability Testing

NASA has previously performed bench-scale testing of a UV oxidation system and the results were reported in Volume Two, Chapter Two the Draft CMS Report (NASA, 1996b). ~~NASA is required, through the FARs, to competitively bid major procurements such as the UV oxidation system. Potential bidder's systems must be capable of meeting previously tested capabilities.~~ NASA performed pilot-scale testing of a UV oxidation system between March 25 and April 9, 1999. The results of the testing are discussed in Section 6.4.2. Procedures in the SAP and QAP in effect at that time were utilized during the bench-scale and pilot-scale tests. ~~As a result, the selected bidder has provided pilot-scale verification testing to ensure that previously obtained treatment efficiencies are maintained and that final procurement specification design criteria were achieved.~~

5.2.4 Treatment System Start-Up

The analyses for the treatment system operation cannot be performed on a real-time basis. Samples are analyzed by off-site laboratories and analytical data for specific sampling events will not be available until weeks after sample collection. Therefore, a high level of confidence is required to ensure that all phases of the treatment system operate effectively and consistently.

Following installation of the remediation system, high intensity start-up sampling of the treatment system will be performed. During this testing, all treated water will be contained in tanks and verified to meet the treatment standards of this Plan prior to injection. Specifics concerning this start-up testing will be provided in the forthcoming Operations and Maintenance Plan.

5.3 SAMPLE COLLECTION, SCHEDULING, AND ANALYSIS

5.3.1 Sample Collection

Groundwater samples will be collected from specified wells prior to the installation and ~~also~~ during operation of the treatment facility. These samples will be collected from the plume-front monitoring and extraction wells prior to system operation. These data will provide background information to evaluate the long-term effectiveness of the plume-front containment system.

5.3.2 Sampling Frequencies

Tables 5.2 and 5.3 provide sampling frequencies for all plume-front monitoring wells for volatile, halogenated volatile and nitrosamine analyses. All inorganic water quality parameters will be collected on at least a semi-annual~~quarterly~~ basis.

TABLE 5.4: INFLUENT/EFFLUENT SAMPLING SCHEDULE

Time Period	Sampling Location	Sampling Frequency	Analytes
0-3 Months (initial start-up and testing period)	Treatment Facility Influent and Effluent Piping	Twice per week (during operational periods)	NDMA, DMN, halogenated volatiles, and general inorganics
0-3 Months (initial start-up and testing period)	Each Extraction Well	Once per week (during operational periods)	NDMA, DMN, halogenated volatiles, and general inorganics
After 3 ~~12~~ Months	Treatment Facility Influent and Effluent Piping	Once per month	NDMA, DMN, halogenated volatiles, and general inorganics
After 3 ~~12~~ Months	Each Extraction Well	Quarterly	NDMA, DMN, halogenated volatiles, and general inorganics
~~After 12 Months~~	~~Treatment Facility Influent and Effluent Piping~~	~~Quarterly~~	~~NDMA, DMN, halogenated volatiles, and general inorganics~~

5.3.3 Analytical Methods

Based on historical groundwater assessment data, WSTF has identified specific contaminants in the plume-front groundwater. The specific contaminants targeted for containment and remediation include halogenated volatile organics, NDMA and DMN. WSTF has incorporated the use of the most sensitive analyte-specific EPA-recommended analytical methods for the identification and quantitation of these compounds. As discussed previously, NASA is working with an off-site analytical laboratory to reliably lower the reporting limits for NDMA and DMN using a method not currently approved by EPA. If this method is approved for use by both NASA and the appropriate regulatory authorities, it will be included for use in this Plan.

5.4 QUALITY ASSURANCE PROJECT PLAN

5.4.1 Purpose

This QAPP establishes guidelines for ensuring that the monitoring data for this Plan are scientifically valid, of known quality and legally defensible. To achieve these goals, the following specific QAPP requirements are addressed:

- a consistent and acceptable framework for the collection and generation of physical and chemical data;
- data quality objectives that measure the precision, accuracy, comparability and completeness of generated data;
- acceptance criteria for the data measurements to ensure that data collection and analytical systems provide data of sufficient quality for the program;
- the early detection of deficiencies that may affect data quality and provide corrective actions;
- sufficient document control to verify data completeness; and
- a fundamental framework for the storage and management of plume-front stabilization data.

All data-generation steps, including sample collection, analyses, document control, and data review are performed using established procedures to ensure reported data quality, accuracy and completeness. This document, and adherence to guidelines outlined in specific EPA analytical methods, the WSTF SAP, the WSTF QAPP and site-specific procedural documentation, ensures that data meet the project-specific requirements for this Plan.

5.4.2 Project Organization

The contractor Environmental Department organizational structure is discussed in Section 6.1 of this Plan. All sample collection, analysis and data management activities are performed by or coordinated through the contractor Environmental Department. All personnel who collect environmental data will have access to, and a clear understanding of, this document, the WSTF SAP, the WSTF QAPP, and applicable site-specific procedural documentation.

5.4.3 Off-Site Laboratories

NASA contracts off-site laboratories to analyze groundwater samples in support of RFI/CMS activities, Post-Closure Care monitoring and other regulatory driven activities. Prior to awarding any analytical support contracts, each off-site laboratory must submit their laboratory QAPP to the contractor Environmental Department for review and approval. Appendix C contains the QAPP for laboratories currently performing analytical work for this Plan. Since contracts for analytical services are recompeted and renewed on at least an annual basis, new laboratories may be contracted. Contract laboratories may also revise their QAPPs. If either change occurs, NASA will submit to EPA and NMED the appropriate QAPP for inclusion in Appendix C.

5.4.4 Data Quality Objectives

Quantitative measurements used to estimate true physical and chemical conditions involve some level of uncertainty. Uncertainty can be attributed to natural variability, sampling handling operations and conditions, spatial and temporal patterns, and analytical variability. It is critical that levels of uncertainty are measured and acceptable limits of uncertainty established.

Several parameters are measured to estimate the level of uncertainty of generated data. Data quality is characterized by the precision, accuracy, reproducibility, completeness, and comparability ~~(PARCC)~~ parameters.

Detailed definitions and discussions of the parameters that characterize data quality are contained in Section 3.0 of the most current approved WSTF QAPP (Appendix C). The guidance contained in the WSTF QAPP will be used for this Plan.

5.4.4.1 QA/QC Samples

Several types of QA/QC samples are required to evaluate data uncertainty. A list of field and analytical QA/QC samples and a brief description of each is provided in Tables 5.5 and 5.6. Frequencies for these samples are provided in Tables 5.7 and 5.8. Frequencies represent a summary of guidance from specific EPA analytical methods and site-wide (SW) document SW-846 (EPA, 1997). EPA methods provide specific details of the verification required for each analytical process.

5.4.4.2 QA/QC Sample Requirements

It is essential that all QA/QC samples are of the highest possible quality. Reference standards will be certified prior to use. Reagent water used for field and laboratory blanks will be continuously monitored for non-interference with the analyses. Blind quality control standards will represent the types and concentrations of constituents normally found in the WSTF groundwater.

TABLE 5.5: DESCRIPTION OF FIELD QUALITY CONTROL SAMPLES

Sample Type	Description
Equipment Blank	ASTM Type II water is transported to the sampling site, opened, poured over and/or through the sampling device, and collected in sample containers. This type of blank indicates the effectiveness of decontamination procedures and also indicates contamination in the field which may affect analytical results.
Field Blank	ASTM Type II water is transported to the sampling site, opened and poured directly into sample containers. This type of sample provides a check on reagent quality and contamination derived in the field.
Trip Blank	ASTM Type II water is poured into sampling containers in a contaminant free environment, placed in coolers, transported to the field, back to the laboratory, and analyzed. This type of sample serves as a check on sample contamination originating from sample handling, transport, shipping, and site conditions. This sample may also be used to estimate the system detection limit.
Blind QC Sample	A check standard is prepared from a source other than the calibration standard, which is provided blind to the analytical lab. This type of sample serves as an independent check of analytical techniques, handling and standards.
Field Duplicate	A second sample is taken immediately after an original sample at the same sampling location. This sample provides an estimate of the overall system precision.

TABLE 5.6: DESCRIPTION OF ANALYTICAL QUALITY CONTROL SAMPLES

Sample Type	Description
Reagent Blank	ASTM Type II water is processed through the entire analytical process which, at the time of analysis, contains the same reagent concentrations as samples that have been processed. This type of sample indicates contamination resulting from the preparation or processing of a sample. This sample can be used to establish the analytical detection limit.
Sample Matrix Spike	A predetermined amount of stock solution, containing an analyte of interest, is added to the sample matrix prior to sample extraction/digestion and analysis. This sample indicates the effects of the sample matrix on analysis and also is a measure of the accuracy of the measurement system.
QC Check Standard	A standard is obtained from a source other than the calibration standard. This sample indicates the accuracy and consistency of calibration.
Surrogate Spike	Introduction of a compound similar to the analytes of interest, but not normally found in environmental samples, blanks and standards. This type of sample provides a continuous monitor of the performance of the analytical system and the effectiveness of the method in dealing with sample matrices.
Matrix Duplicate	An intralaboratory split sample which is used to document the precision of a method in a given sample matrix.
Matrix Spike Duplicate	Intralaboratory split samples spiked with identical concentrations of target analyte(s). The spiking occurs prior to sample preparation and analysis. These samples are used to document the precision and bias of a method in a given sample matrix.

TABLE 5.7: FIELD QA/QC CONTROL SAMPLE FREQUENCIES

Control	Halogenated Volatile Organics Method	Volatile Organics Method	Nitrosamines Method
Equipment Blank	100% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	100% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	5% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.
Field Blank	Not required if equipment blanks are taken, otherwise 100% of all halogenated volatile organics sampling days.	Not required if equipment blanks are taken, otherwise 100% of all volatile organics sampling days.	Not required if equipment blanks are taken, otherwise 5% of all nitrosamine sampling days or at least once per month, whichever is the most frequent.
Duplicate Sample	10% of all halogenated volatile organics sampling events or at least once per month, whichever is the most frequent.	10% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	10% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.
Blind QC Sample	5% of all halogenated volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.
Trip Blank	5% of all halogenated volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.

TABLE 5.8: ANALYTICAL QA/QC CONTROL SAMPLE FREQUENCIES

Type Of Control	Halogenated Volatile Organics	Volatile Organics	Nitrosamines
Reagent Blank	At least daily.	At least daily.	One for each set of samples processed.
Sample Matrix Spike	10% of samples analyzed.	5% of samples analyzed.	10% of samples analyzed.
QC Check Standard	10% or less frequently if spike recoveries meet all specified QC criteria.	5% or less frequently if spike recoveries meet all specified QC criteria.	10% or less frequently if spike recoveries meet all specified QC criteria.
Surrogate Spike	100% of all blanks, samples and standards.	100% of all blanks, samples and standards.	100% of all blanks, samples and standards.
Replicate Sample	Aliquoting is not appropriate; therefore, duplicate samples must be analyzed for 5% of the samples analyzed.	Aliquoting is not appropriate; therefore, duplicate samples must be analyzed for 5% of samples analyzed.	5% of samples analyzed.

In order to alleviate bias generated by the analytical laboratories, all environmental and audit samples are submitted "blind." Samples are disguised in a manner where laboratory personnel do not recognize the sample source or composition. Identities of all samples, including QA/QC samples, are recorded in the field logbook. Documentation provided to laboratory personnel (i.e., chain of custody forms, sample labels and sample seals) does not contain any information concerning sample identities.

5.4.4.3 Data Quality Requirements

The acceptability requirements for data produced in support of this Plan are provided in Table 5.9. This table provides data quality objectives for detectability, precision, accuracy, and completeness for groundwater matrices. Table 5.10 describes the data qualifiers used to identify data that does not meet the objectives outlined in Table 5.9.

5.4.5 Sample Containers, Preservation and Holding Times

Table 5.1 specifies sample containers, preservation and holding time requirements for samples associated with this Plan. In general, samples not analyzed within the specified holding times are not acceptable for reporting purposes. If the data are crucial, samples are retaken to provide the required information. However, if resampling of the environmental source is impractical, samples that have exceeded their holding times are analyzed and reported with the appropriate data qualifier.

Blind quality control samples and analytical check standards are subject to the same holding time requirements as environmental samples. When blind quality control samples are prepared, the corresponding container is annotated with the preparation date. Blind quality control samples for volatile organics analysis are prepared immediately prior to shipment to the analytical lab.

6.0 PROJECT MANAGEMENT

6.1 ORGANIZATION

The NASA Environmental Program Manager directs all activities associated with WSTF environmental compliance and the plume-front remediation project. The site contractor Environmental Department, under the direction of the NASA Environmental Program Manager, performs and/or coordinates all activities associated with the project. Figure 6.1 provides an organizational chart for NASA WSTF environmental activities.

Design, implementation, operation, and maintenance of the plume-front containment project will be supported by a contractor Environmental Department staff of over 30 engineers, hydrogeologists, scientists, and technicians experienced in multiple facets of environmental compliance.

In addition, support from the existing WSTF infrastructure is available. This includes heavy equipment, engineering, drafting, and administrative support.

TABLE 5.9: METHOD SPECIFIC DATA ACCEPTIBILITY REQUIREMENTS

Analysis	Measurement Units	RL	Precision[1] ~~3~~	Accuracy[2] ~~4~~	Completeness[3] ~~5~~
Halogenated Volatile Organics	µg/L	~~1~~[4]	~~1~~[4]	~~1~~[4]	80
Volatile Organics	µg/L	~~2~~[5]	~~2~~[5]	~~2~~[5]	80
NDMA	µg/L	0.010	25	13-109	80
DMN	µg/L	0.010	25	13-109	80

RL - Reporting Limit.

~~1 Specific criteria are provided in the halogenated volatile organics method~~ .
~~2 Specific criteria are provided in the volatile organics method.~~
~~3~~[1] As relative percent difference for field duplicates.
~~4~~[2] As percent recovery of matrix spikes.
~~5~~[3] Percentage of measurements which meet expressed data quality criteria for precision, accuracy and detectability.
[4] Specific criteria are provided in the halogenated volatile organics method.
[5] Specific criteria are provided in the volatile organics method.

TABLE 5.10: DESCRIPTION OF DATA QUALITY ASSURANCE FLAGS

Data Qualifier	Description
*	User defined flag.
A	Indicates that the result of an analyte for a check standard (LCS or CCV) was outside standard limits.
AD	Indicates that the precision for analyst duplicates was outside standard limits.
EB	Indicates that the analyte was detected in the equipment blank at or above the reporting limit.
FB	Indicates that the analyte was detected in the field blank at or above the reporting limit.
G	Indicates that the result is an estimated value greater than the calibration limit.
J	Indicates that the result is an estimated value less than the reporting limit, but greater than or equal to the detection limit.
NA	Indicates that the value/result was either not analyzed or not applicable.
ND	Indicates that the analyte was not detected at or above the detection limit.
Q	Indicates that the result for a blind control was outside standard limits.
QD	Indicates that the precision for a field duplicate was outside standard limits.
RB	Indicates that the analyte was detected in the reagent blank at or above the reporting limit.
S	Indicates that the result was determined by the method of standard addition.
SP	Indicates that either the spike recovery or the relative percent difference for spike duplicates was outside standard limits.
T	Indicates that the analyte was analyzed outside the specified holding time.
TB	Indicates that the analyte was detected in the trip blank at or above the reporting limit.
TIC	Indicates that the analyte was tentatively identified by a GC/MS library search and the amount reported is an estimated value.

CCV Continuous Calibration Verification
GC/MS Gas Chromatography/Mass Spectroscopy
LCS Laboratory Calibration Standard

NASA White Sands Test Facility
Environmental Compliance

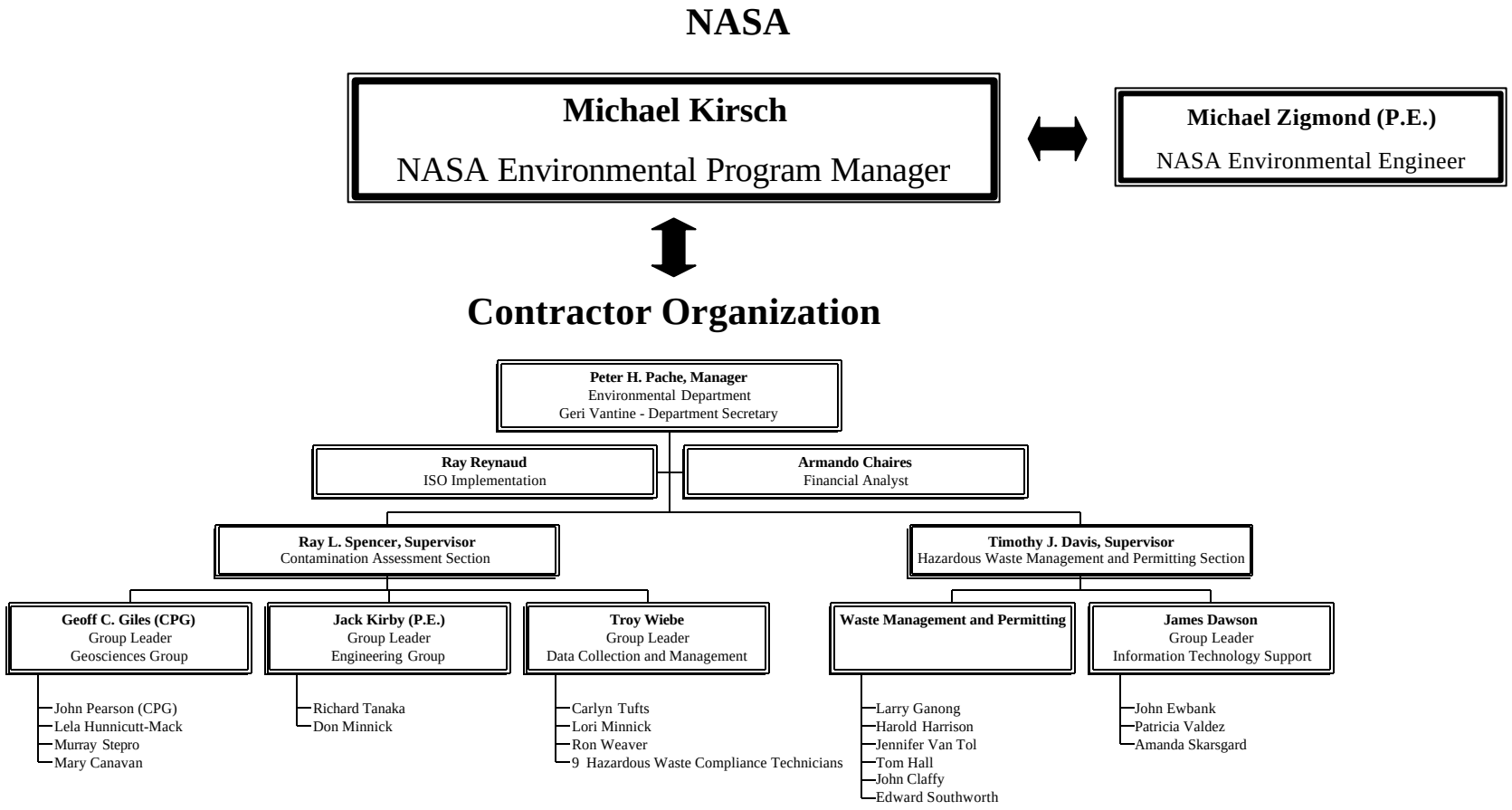


Figure 6.1

Organizational Chart for NASA WSTF Environmental Activities

For activities in which WSTF infrastructure is not available (well drilling services, groundwater modeling expertise, downhole geophysical logging, etc.), off-site contractors will be used.

6.2 SCHEDULE

The anticipated time-line for design and implementation of the plume-front containment project is presented as Figure 6.2. Although every effort will be made to adhere to this schedule, there are multiple factors beyond the control of NASA, which may impact it. These factors include:

- the timeframe required to provide the electrical power distribution system to the project area;
- the regulatory review/approval timeframes associated with submitted reports and plans;
- the ability to schedule subcontractor support; and
- the availability of vendor-supplied equipment and materials.

If the projected time-line elements cannot be completed in compliance with the schedule, NASA shall, as early as possible, notify the appropriate regulatory agencies with identification of the delay, contributing factors for the delay, and revised time-line projections.

6.3 REPORTING REQUIREMENTS

Progress and subsequent data reporting will be accomplished through use of the monthly RFI/CMS reports to EPA/NMED. The format of the current reports will be modified to accommodate reporting of activities and data directly applicable to plume-front containment. These reports will at a minimum provide: significant project accomplishments; activity updates; monitoring data; and significant problems and corrective actions taken. NASA will initiate use of these reports as soon as plume-front activities are initiated. If revisions to the format are required, revisions to the format can be implemented which are amenable to EPA, NMED and NASA.

6.4 PERMITTING ISSUES

Several permitting actions are required for implementation of the plume-front remediation system. The following outlines permitting actions required for this project.

6.4.1 Work Plans, Operations and Maintenance Plans and System Specifications

Submittal of the ~~is~~ original Plan initiate~~s~~d the regulatory review and approval process for the plume-front stabilization project. The Plan was submitted to the NMED HRMB on January 20, 1999 and approved on March 15, 2000. The procurement of drilling services ~~has been initiated, with drilling and installation of groundwater monitoring wells anticipated to begin by Janyary 1999.~~ and installation of groundwater monitoring and remediation wells have been completed. Activities such as the ~~drilling of injection and extraction wells, procurement~~

NASA WSTF Plume-Front Stabilization Timeline
Fri 5/10/02

National Aeronautics and Space Administration/White Sands Test Facility
Plume-Front Stabilization Work Plan
Modified May 2002

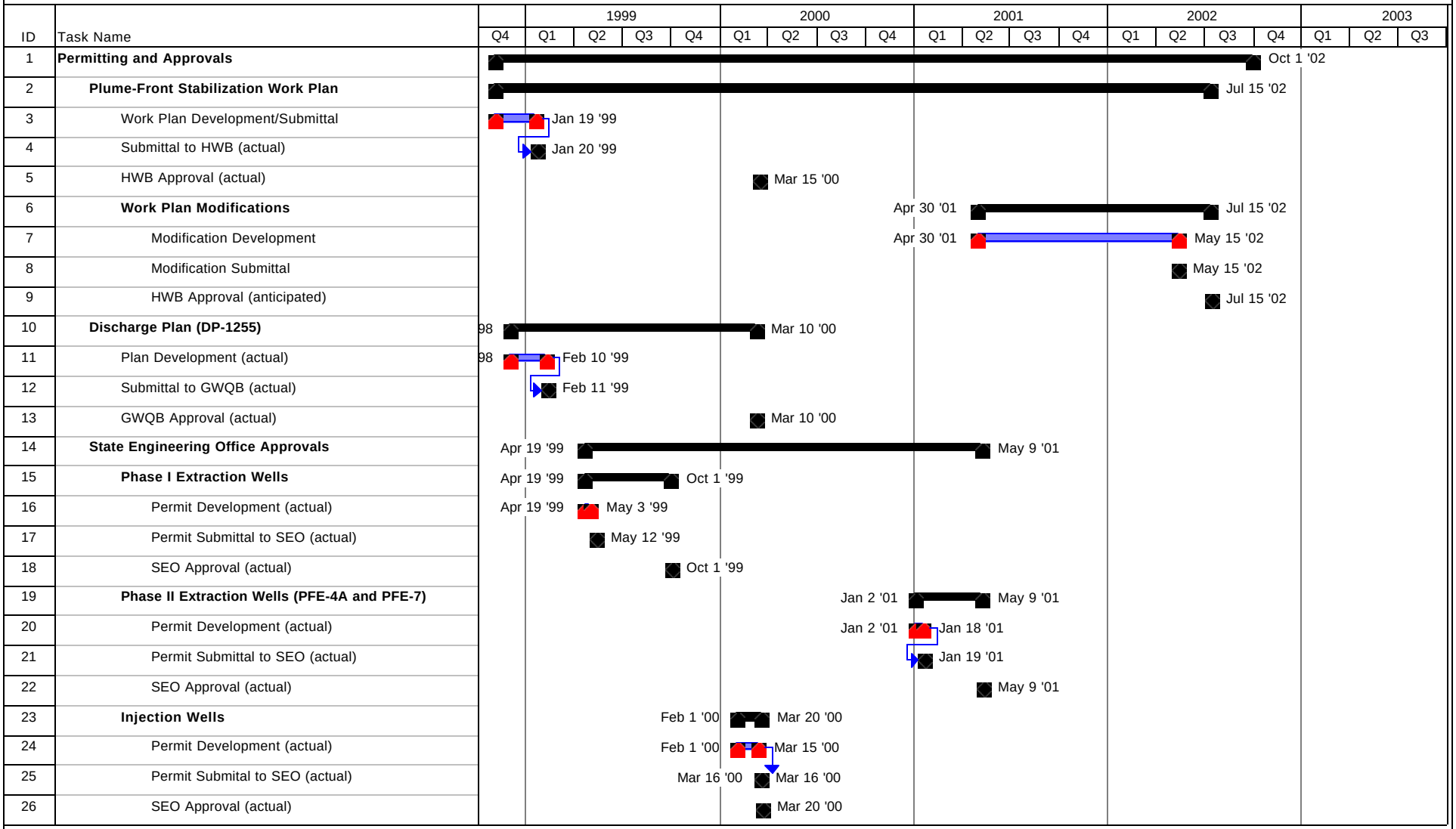
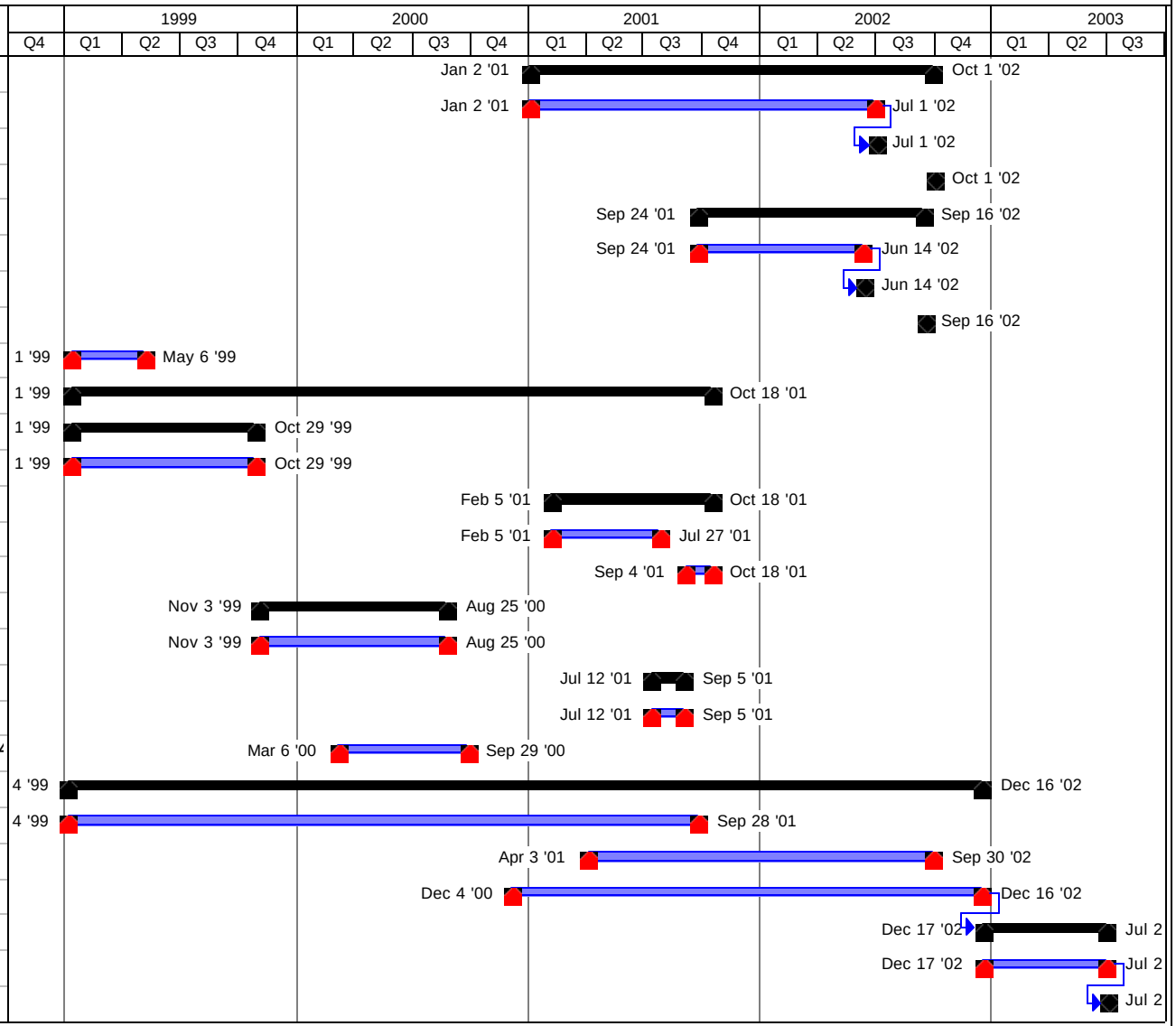


Figure 6.2

ID	Task Name
27	**System Plans and Specifications**
28	Development
29	Submittal to HWB
30	HWB Approval (anticipated)
31	**Operation and Maintenance Plan**
32	Development
33	Submittal to HWB
34	HWB Approval (anticipated)
35	Environmental Assessment (actual)
36	**Well Installation Activities**
37	**Phase I Monitor Well Installations**
38	BLM-37, JP-3, PL--8, ST-7, and WW-2
39	**Phase II Monitor Well Installations**
40	WW-3 and WW-4
41	WW-5
42	**Phase I Extraction Well Installations**
43	PFE-1, PFE-2, PFE-3, PFE-4, and PFE-5
44	**Phase II Extraction Well Installations**
45	PFE-4A and PFE-7
46	**Injection Well Installations (PFI-1, PFI-2, PFI-3, and PFI-4**
47	**Engineering Activities**
48	System Design
49	Procurement of System Hardware/Contractor Services
50	System Installation/Construction
51	**System Completion Activities**
52	System Performance Verification
53	System On-Line and Operational (anticipated)



installation of treatment equipment, construction of the pipelines, and installation of electrical power to the plume-front area are in progress. ~~pending EPA/NMED review/approval of this plan.~~

Future submittals to EPA/NMED will be the O&M Plan and specifications and drawings for the plume-front system. ~~This submittal will be dependent upon regulatory comments/approval of this Plan, completion of the competitive bid process for the UV oxidation treatment equipment, and completion of the design package and O&M Plan.~~

6.4.2 Technical Feasibility Study

~~Using~~ Following HRMB recommendations, NASA ~~will~~ perform~~ed~~ pilot-scale testing of ~~selected~~ a UV oxidation system~~s~~ as a Technical Feasibility Study. This study ~~will~~ allow~~ed~~ the public ~~involvement with regards to the~~ to review and comment concerning pilot-scale testing. The process ~~will~~ provide~~d~~ the public with information regarding UV oxidation systems, ~~provide~~ general information regarding the plume-front stabilization effort, ~~incorporate~~ the opportunity to ~~a public meeting to~~ discuss any relevant issues, and allow~~ed~~ the ~~public~~ option to submit written comments concerning the project. No public comments were received by NASA regarding this project.

~~NASA anticipates detailed written guidance from HRMB delineating the public notification process. NASA will adhere to this guidance when received.~~

6.4.3 Groundwater Discharge Plan

A Discharge Plan ~~is~~ was obtained in accordance with the requirements of ~~required by~~ the NMED GWQB to accommodate the injection of treated water. ~~This~~ The Plan ~~will be~~ was prepared and submitted in accordance with Ground and Surface Water Protection Regulations (NMAC, 1998a). ~~This~~ The Discharge Plan ~~will~~ incorporate~~d~~ all the requirements of the regulations and follow~~ed~~ guidelines received from NMED, including a public comment period. The injection well Discharge Plan (DP-1255) was submitted to the NMED GWQB on February 11, 1999 and approved on March 10, 2000.

6.4.4 Hazardous Waste Permits

Discussions with the NMED HRMB indicate that hazardous waste permitting actions will not be required for this plume-front containment project. The current WSTF Hazardous Waste Operating Permit has been reviewed and there were no issues identified that will require permit modifications. The current permitted active units on-site are appropriate to manage hazardous wastes generated from the project. Waste generation is anticipated to be minimal and will include grease/oil, air stripper scale, UV mercury vapor lamps, and other minor waste streams. These waste streams can be managed using existing permit guidelines and the site operating procedures. Satellite accumulation areas and the permitted Container Storage

Unit will be utilized to accumulate and store any generated wastes. Existing manifesting and shipping procedures will be utilized for wastes shipped off-site for disposal.

The current Post-Closure Care Permit was also reviewed for possible regulatory impacts. The Permit requires the annual reporting of information from closure units. This information includes water levels, contaminant concentrations, hydrostratigraphic units, flow rates, statistical evaluations, and other associated information. The Permit requires the eventual implementation of corrective measures as specified by the submitted and approved RFI and CMS. The plume-front remediation is considered a presumptive remedy which may be utilized in the preparation, or as a part of, the final corrective measures selection. Therefore, NASA believes that this remediation does not impact the specific reporting requirements of the Post-Closure Care Permit (Module IV, Section IV H.2).

6.4.5 Air Quality

The NMED Air Quality Bureau does not regulate emissions from stripping operations during remediation activities. These emissions are considered RCRA-related emissions that could be regulated under Subpart AA, BB and CC of 40 CFR §264 (NARA, 1998b, 1998c, and 1998d). According to the NMED Air Quality Bureau, this issue should be addressed by HRMB. The following discussion addresses each of the three subparts mentioned above.

6.4.5.1 Subpart AA

EPA has established air emissions standards which apply to owners and operators of facilities that treat, store or dispose of hazardous waste (40 CFR §264.1030; NARA, 1998b). These standards apply to process vents associated with various treatment processes, including air stripping, that manage hazardous waste with organic concentrations of at least 10 parts per million by weight (ppmw). Subpart AA standards apply to operations that are conducted in units subject to the permitting requirements of 40 CFR §270, or in hazardous waste recycling units that are located at RCRA-permitted facilities. The plume-front remediation system will not manage groundwater with 10 ppmw concentrations of regulated contaminants. An initial waste stream determination will be performed to ensure that concentrations are below 10 ppmw. This determination will be performed using process knowledge and documented in the Operating Record.

6.4.5.2 Subpart BB

EPA has established air emissions standards which apply to owners and operators of facilities that treat, store or dispose of hazardous waste (40 CFR §264.1050; NARA, 1998c). These standards apply to equipment leaks from equipment that contain or contact hazardous waste with organic concentrations of at least 10 percent by weight. Subpart BB standards apply to operations that are conducted in units subject to the permitting requirements of 40 CFR §270, or in hazardous waste recycling units that are located at RCRA-permitted facilities. The remediation system will not manage groundwater with this concentration of organics. A process knowledge waste stream determination will be performed and documented as previously stated in section 6.4.2.1.

6.4.5.3 Subpart CC

The air emissions standards for units that treat groundwater with tanks, surface impoundments, or containers does not apply. Section §264.1080 of the Post-Closure Care Permit states that a waste management unit that is used solely for on site treatment or storage of hazardous waste that is generated as the result of implementing remedial activities is exempt from Subpart CC requirements (40 CFR §264.1080; NARA, 1998d).

6.4.6 National Environmental Policy Act

NASA will ensure the requirements of the National Environmental Policy Act ~~(NEPA)~~ will be incorporated into the plume-front containment project. ~~This will require the preparation of a~~ An Environmental Assessment (EA) for this project was completed and presented to the public on May 6, 1999. The comment period to ~~. The EA will provide a public comment period to~~ ensure that the public has~~d~~ an opportunity for direct involvement ended on June 11, 1999.

6.4.7 Well Permits

NASA will comply with all New Mexico SEO well permitting requirements (SEO, 1995). Permits will be obtained for all wells within the following three SEO categories:

1. test, exploratory or observation wells;
2. monitoring and injection wells; and
3. plume control and recovery.

Specific components of each SEO permit application will be met.

7.0 REFERENCES

Daniel B. Stephens & Associates, 1995a, "Preliminary Simulation Of Remedial Design Alternatives", White Sands Test Facility, Las Cruces, NM, September, 1995.

Daniel B. Stephens & Associates, 1995b, "Remedial Design Alternatives Letter Report," White Sands Test Facility, Las Cruces, NM, report prepared for AlliedSignal Technical Services Corporation, December, 1995.

Daniel B. Stephens & Associates, 1998, "Remedial Design Alternatives Letter Report", White Sands Test Facility, Las Cruces, NM, report prepared for AlliedSignal Technical Services Corporation, ~~DBS&A Inc.,~~ September, 1998.

Daniel B. Stephens & Associates, 2000, "ST-6 Area Optimization Results", White Sands Test Facility, Las Cruces, NM, email transmittal prepared for Honeywell Technical Services Inc., December 14, 2000.

Edson, J., 1998, Personal Communication, Colorado Department of Health, Hazardous Waste Division, Federal Facilities Section, August 25, 1998.

Environmental Protection Agency, 1986, RCRA Ground Water Monitoring Technical Enforcement Guidance Document, OSWER Directive 9950.1, Office of Solid Waste and Emergency Response (OSWER), Washington D.C., September 1986.

Environmental Protection Agency, 1989, Risk Assessment Guidance for Superfund (RAGS): Volume 1, Human Health Evaluation Manual, Part A, Interim Final, EPA/540/1-89/002, Office of Solid Waste and Emergency Response, Washington D.C., December 1989.

Environmental Protection Agency, 1993, Presumptive Remedies: Policy and Procedures, Directive 9355.0-47FS, EPA/540-F-93-047, Office of Solid Waste and Emergency Response, Washington, D.C., September, 1993.

Environmental Protection Agency, 1994, RCRA Corrective Action Plan (Final), OSWER Directive 9902.3-2A, EPA/520/R-94/004, Office of Solid Waste and Emergency Response, Washington, D.C., May, 1994.

Environmental Protection Agency, 1996, Presumptive Response Strategy and Ex-Situ Technologies for Contaminated Ground Water at CERCLA Sites, Directive 9283.1-12, EPA 540/R-96/023, Office of Solid Waste and Emergency Response, Washington, D.C., October 1996.

Environmental Protection Agency, 1997a, Comments on the NASA WSTF RCRA Facility Investigation and Corrective Measures Study Reports, February 27, 1997.

Environmental Protection Agency, 1997b, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846), Third Edition, Office of Solid Waste and Emergency Response, Washington, D.C., June 1997, Internet at http://www.epa.gov/epaoswer/hazwaste/test/maina.htm

Environmental Protection Agency, 1998a, "Integrated Risk Information System," Up-to-date chemical-specific cancer slope factors, reference doses and toxicity information available on the Internet at http://www.epa.gov/iris.

Environmental Protection Agency, 1998b, Risk-Based Concentration Tables, EPA Region 3, October 1998 Update, Internet at http://www.epa.gov/reg3hwmd/risk.

Environmental Protection Agency, 1998c, Preliminary Remediation Goals, EPA Region 9, updated May 1998, Internet at http://www.epa.gov/region09/waste/sfund/prg.

Geoscience Consultants, Ltd., 1995, "NASA-WSTF Groundwater Modeling Report to EPA Region 6," Consultant report prepared for NASA Environmental Program Manager, NASA White Sands Test Facility, Las Cruces, NM, January, 1995.

~~Giles, G. C., and Pearson, J.W., 1998, "Characterization of Hydrostratigraphy and Groundwater Flow on the Southern San Andres Mountains Pediment, NASA-JSC White Sands Test Facility", New Mexico Geological Society Guidebook, 49th Field Conference, Las Cruces Country II, 1998.~~

HydroGeoLogic Inc., 1997, MODFLOW-SURFACT, "First Fully Integrated MODFLOW-Based Flow and Transport Simulator", HydroGeoLogic Inc., Herndon, Virginia, 1997.

Maciejewski, T.J., 1996, "Integrated Geophysical Interpretation of Bedrock Geology, San Andres Mountains, New Mexico", Unpublished Masters Thesis – University of Texas at El Paso, 123 p, 1996.

McDonald, M.G., and Harbaugh, A.W., 1988, "A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model", Techniques of Water-Resources Investigations 06-A, United States Geological Survey, 1988.

National Aeronautics and Space Administration, 2002, Mid-Plume Constriction Area Progress Report (in preparation).

National Aeronautics and Space Administration, 1990, "Aquifer Pumping Test Report NASA PT Well", NASA White Sands Test Facility, Las Cruces, NM, December 5, 1990.

National Aeronautics and Space Administration, 1996a, Draft RCRA Facility Investigation Report, NASA WSTF, Las Cruces, NM, March 1996.

National Aeronautics and Space Administration, 1996b, Draft Corrective Measures Study Report, NASA WSTF, Las Cruces, NM, March 1996.

National Aeronautics and Space Administration, 1997a, "Jornada del Muerto Pumpage and Mountain Recharge Rates", Letter to the U.S. EPA, Region 6, Dallas, TX, June 17, 1997.

National Aeronautics and Space Administration, 1997b, "Groundwater Sampling and Analysis Plan," WSTF, Las Cruces, NM, July 1997.

National Aeronautics and Space Administration, 1997c, "Quality Assurance Project Plan", NASA WSTF, Las Cruces, NM, July 1997.

National Aeronautics and Space Administration, 1998a, RFI/CMS Interim Measures Evaluation Report, NASA WSTF, Las Cruces, NM, March 1998.

National Aeronautics and Space Administration, 1998b, "White Sands Test Facility Standard Instruction, Waste Management", (WSI 22-W-005.A), Las Cruces, NM, June 5, 1998.

National Archives and Records Administration, Office of the Federal Register, 1998, Code of Federal Regulations (CFR), Protection of Environment, Title 40, Part 264, Washington D.C., July, 1998.

National Institute for Occupational Safety and Health (NIOSH), Pocket Guide to Chemical Hazards, NIOSH, June 1990.

New Mexico Administrative Code, 1998a, New Mexico Environment Department, Ground and Surface Water Protection, Title 20, Chapter 6, Part 2, Internet at http://www.nmenv.state.nm.us.

New Mexico Administrative Code, 1998b, New Mexico Environment Department, Drinking Water Regulations, Title 20, Chapter 7, Part 1, Internet at http://www.nmenv.state.nm.us.

Seager, W.R., 1981, Geology of the Organ Mountains and Southern San Andres Mountains, New Mexico, New Mexico Bureau of Mines and Mineral Resources, Memoir 36, Albuquerque, NM, May, 1981.

Shomaker, John & Associates, 1996, Multilayer Ground-Water Flow Model of Southern Jornada del Muerto Basin, Dona Ana county, New Mexico, and Predicted Affects of Pumping Wells LRG-430-S-29 and –S-30, City of Las Cruces, New Mexico, May 1996.

State Engineer Office (SEO), 1995, Rules and Regulations Governing Drilling of Wells and Appropriation and Use of Ground Water in New Mexico, State Engineer Office, Santa Fe, New Mexico, 1995.

Swanick, J., Personal Communication, GenCorp Aerojet, September 1, 1998.

Wilson, C.A., White, R.R., Orr, B.R., and Roybal, R.G., 1981, Water Resources of the Rincon and Mesilla Valleys and Adjacent Areas, New Mexico, New Mexico State Engineer Technical Report 43, 1981.

Zheng, C., 1989, PATH3D, Version 3.2, "A Ground-Water Path and Travel-Time Simulator", S.S. Papadopulos & Associates, Inc., Rockville, Maryland, 1989.

Zheng, C., 1992, MT3D, Version 1.5, "A Modular Three-Dimensional Transport Model for Simulation of Advection, Dispersion and Chemical Reactions of Contaminants in Groundwater Systems", S.S. Papadopulos & Associates, Inc., Rockville, Maryland, 1992.

PLUME-FRONT STABILIZATION WORK PLAN

NASA-JSC WHITE SANDS TEST FACILITY

Original Submission January 1999

Revised May 2002

TABLE OF CONTENTS

LIST OF ACRONYMS AND ABBREVIATIONS USED IN REPORT vi

1.0 EXECUTIVE SUMMARY 1

2.0 INTRODUCTION 2
2.1 SITE LOCATION AND DESCRIPTION OF PROJECT AREA 2

2.2 REGULATORY BACKGROUND 2

3.0 CURRENT CONDITIONS 5
3.1 SITE GEOLOGY 5
3.1.1 Stratigraphy 5
3.1.2 Structure 6

3.2 SITE HYDROGEOLOGY 6
3.2.1 Aquifer Description 6
3.2.2 Groundwater Movement 7
3.2.3 Groundwater Recharge/Discharge 7
3.2.4 Groundwater Quality 8
3.2.5 Background Metals' Concentrations 8

3.3 CONTAMINATION 9
3.3.1 Groundwater Contamination 9

3.4 GROUNDWATER MODEL SETUP AND CALIBRATION 14
3.4.1 Description of Groundwater Model and Programs 14
3.4.2 Construction of the WSTF 3DSWB Conceptual Model 15
3.4.3 3DSWB Model Calibration for Contaminant Migration 16

3.5 HEALTH RISK ASSESSMENT 16
3.5.1 Chemicals of Concern 17
3.5.1.1 Carcinogens 17
3.5.1.2 Non-Carcinogens 17
3.5.2 Potential Receptors and Exposure Pathways 18
3.5.3 Risk Characterization 21
3.5.3.1 Carcinogenic Risk Estimates 21
3.5.3.2 Non-Carcinogenic Hazard Quotients and Indices 22
3.5.4 Uncertainties 22
3.5.4.1 Carcinogenicity Evidence Under Review 22
3.5.4.2 Lack of Toxicity Data 26
3.5.4.3 Chemical Concentrations 26

3.6 DATA SUFFICIENCY 26

4.0 PRESUMPTIVE REMEDY FOR PLUME-FRONT STABILIZATION 27
4.1 EVALUATION OF 3DSWB MODEL PREDICTIVE REMEDIAL SCENARIOS 27

4.2 DESCRIPTION OF PLUME-FRONT STABILIZATION SCENARIO 30
4.2.1 Remediation Well Characteristics 32

4.3 PLUME-FRONT STABILIZATION SCENARIO SIMULATIONS 32
4.3.1 PATH3D Plume-Front Stabilization Diagrams 32
4.3.2 Predictive Plume-Front Isoconcentration Maps 37
4.3.3 Mass Extraction Calculations 37
4.3.4 Other Modeling Considerations 44

4.4 TREATMENT STANDARDS 44
4.4.1 Groundwater Treatment Standards 45

4.5 PRESUMPTIVE REMEDY REMEDIAL SYSTEM CONCEPTUAL DESIGN 51

4.6 SITE SAFETY AND SECURITY 56

4.7 SYSTEM START-UP 56

4.8 REMEDIAL SYSTEM OPERATION AND MAINTENANCE AND CONTINGENCY PLANNING 57
4.8.1 Operation and Maintenance 57
4.8.2 Contingency Plan 57
4.8.3 Waste Management 58

5.0 SAMPLING AND ANALYSIS 58
5.1 INTRODUCTION, OBJECTIVES AND SCOPE 58

5.2 SAMPLING ACTIVITIES AND FIELD METHODS 59
5.2.1 Groundwater Monitoring 59
5.2.2 Treatment System Monitoring 64
5.2.3 Treatability Testing 64
5.2.4 Treatment System Start-Up 64

5.3 SAMPLE COLLECTION, SCHEDULING, AND ANALYSIS 66
5.3.1 Sample Collection 66
5.3.2 Sampling Frequencies 66
5.3.3 Analytical Methods 66

5.4 QUALITY ASSURANCE PROJECT PLAN 66
5.4.1 Purpose 66
5.4.2 Project Organization 67
5.4.3 Off-Site Laboratories 67
5.4.4 Data Quality Objectives 67
5.4.4.1 QA/QC Samples 68
5.4.4.2 QA/QC Sample Requirements 68
5.4.4.3 Data Quality Requirements 68
5.4.5 Sample Containers, Preservation and Holding Times 68

6.0 PROJECT MANAGEMENT 75
6.1 ORGANIZATION 75

6.2 SCHEDULE 75

6.3 REPORTING REQUIREMENTS 75

6.4 PERMITTING ISSUES 79
6.4.1 Work Plans, Operations and Maintenance Plans and System Specifications 79
6.4.2 Technical Feasibility Study 79
6.4.3 Groundwater Discharge Plan 79
6.4.4 Hazardous Waste Permits 79
6.4.5 Air Quality 80
6.4.5.1 Subpart AA 80
6.4.5.2 Subpart BB 80
6.4.5.3 Subpart CC 81
6.4.6 National Environmental Policy Act 81
6.4.7 Well Permits 81

7.0 REFERENCES 82

LIST OF FIGURES

Figure 2.1: WSTF Location Map 3
Figure 2.2: Groundwater Plume Hydrogeological Features 4
Figure 3.1: Plume-Front Containment Simulated NDMA Plume for 1992 11
Figure 3.2: Plume-Front Containment Simulated TCE Plume for 1992 12
Figure 3.3: Plume-Front Containment Simulated PCE Plume for 1992 13
Figure 3.4: WSTF Vicinity Well Location Map 20
Figure 3.5: Contour Map of Cumulative Cancer Risk 24
Figure 4.1: Plume-Front Containment Well Locations 31
Figure 4.2: Simulated Contaminant Pathlines for NDMA Plume-Front Containment 36
Figure 4.3: Simulated Contaminant Pathlines for TCE Plume-Front Containment 36
Figure 4.4: Plume-Front Containment Simulated NDMA Plume for 2026 38
Figure 4.5: Plume-Front Containment Simulated TCE Plume for 2026 39
Figure 4.6: Plume-Front Containment Simulated PCE Plume for 2026 40
Figure 4.7: Simulated NDMA Concentration and Cumulative Mass Removed for All Extraction Wells 41
Figure 4.8: Simulated TCE Concentration and Cumulative Mass Removed for All Extraction Wells 42
Figure 4.9: Simulated PCE Concentration and Cumulative Mass Removed for All Extraction Wells 43
Figure 4.10: Remedial System Well Locations and Conceptual Design 52
Figure 4.11: Preliminary Remedial System Process Flow Diagram 55
Figure 6.1: Organizational Chart for NASA WSTF Environmental Activities 76
Figure 6.2: Plume-Front Stabilization Schedule 77

LIST OF TABLES

Table 3.1: Physical and Chemical Properties of Plume-Front Constituents of Concern 10
Table 3.2: Toxicity Information for Plume-Front Chemicals 19
Table 3.3: Chronic Daily Intake (CDI) Assumptions 23
Table 3.4: Carcinogenic Risk Estimates for Plume-Front Monitoring Wells 23
Table 3.5: Hazard Quotients and Indices for Plume-Front Wells 25
Table 4.1: Summary of 3DSWB Model Interim Measures Remedial Scenarios 28
Table 4.2: Plume-Front Containment Well Locations, Pumping Rates and Design Parameters 33
Table 4.3: Summary of Regulatory Standards and Remediation Goals 46
Table 4.4: Expected Influent Contaminant Concentrations to the Plume-Front Remediation System 47
Table 4.5: Presumptive Remedy Goals for Plume-Front Contaminants 49
Table 4.6: Individual and Cumulative Risk Assuming 30% Analytical Extraction Efficiency for NDMA and DMN 50
Table 4.7: Anticipated Plume-Front Remediation System Performance 53
Table 5.1: Sample Collection and Analysis Requirements 60
Table 5.2: Plume-Front Sampling Frequencies for Conventional Wells/Zones 61
Table 5.3: Plume-Front Sampling Frequencies for Westbay® Multi-Port Wells/Zones 62
Table 5.4 Influent/Effluent Sampling Schedule 65
Table 5.5: Description of Field Quality Control Samples 69
Table 5.6: Description of Analytical Quality Control Samples 70
Table 5.7: Field QA/QC Control Sample Frequencies 71
Table 5.8: Analytical QA/QC Control Sample Frequencies 72
Table 5.9: Method Specific Data Acceptability Requirements 73
Table 5.10: Description of Data Quality Assurance Flags 74

LIST OF APPENDICES

APPENDIX A: CONTINGENCY PLAN FOR THE WSTF HAZARDOUS WASTE OPERATING PERMIT
APPENDIX B: WSTF GROUNDWATER SAMPLING AND ANALYSIS PLAN
APPENDIX C: WSTF QUALITY ASSURANCE PROJECT PLAN
APPENDIX D: LABORATORY QUALITY ASSURANCE/QUALITY CONTROL

LIST OF ACRONYMS AND ABBREVIATIONS USED IN REPORT

3DSWB	Three Dimensional Site-Wide Bedrock (Groundwater Model)
ASTM	American Society for Testing and Materials
AT	Averaging-Time
bgs	Below ground surface
BWa	Body Weight for an adult
BWc	Body Weight for a child
CCV	Continuous Calibration Verification
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Cfadj	Age-Adjusted Calculation Factor
CFR	Code of Federal Regulations
CMS	Corrective Measures Study
COCs	Contaminants of Concern
CW	Concentration in Water
DBS&A	Daniel B. Stephens and Associates Inc.
DMN	N-nitrodimethylamine
DP	Discharge Plan
EA	Environmental Assessment
EDa	Exposure Duration for an adult
EDc	Exposure Duration for a child
EDtot	Exposure Duration total
EF	Exposure Frequency
EPA	U.S. Environmental Protection Agency
Freon 11	Trichlorofluoromethane
Freon 21	Dichlorofluoromethane
Freon 113	1,1,2-Trichloro-1,2,2-trifluoroethane
FBR	Flow-Banded Rhyolite
FC-21	Dichlorofluoromethane (Freon 21)
GCL	Geoscience Consultants, Ltd.
GC/MS	Gas Chromatography/Mass Spectroscopy
gpm	Gallons per minute
GWQB	Ground Water Quality Bureau
HDPE	High-Density Polyethylene
HI	Hazard Index
HQ	Hazard Quotient
HRMB	Hazardous and Radioactive Materials Bureau
HWMU	Hazardous Waste Management Unit
ID	Identification
IFWadj	Age-Adjusted Ingestion Factor
IRWa	Ingestion Rate of Water for an adult
IRWc	Ingestion Rate of Water for a child
IRIS	Integrated Risk Information System
JDMB	Jornada del Muerto Basin

K	Hydraulic Conductivity
kW hr	Kilowatt-hour
LCS	Laboratory Calibration Standard
MOSDAX	Modular Subsurface Data Acquisition System
MPCA	Mid-Plume Constriction Area
N/A	Not Applicable
NARA	National Archives and Records Administration
NASA	National Aeronautics and Space Administration
NCEA	National Center for Environmental Assessment
NDMA	N-nitrosodimethylamine
NIOSH	National Institute for Occupational Safety and Health
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
O&M	Operation and Maintenance
PCE	Tetrachloroethene (perchloroethene)
PFE	Plume-Front Extraction (well)
PFI	Plume-Front Injection (well)
Plan	Plume-Front Stabilization Work Plan
ppb	Parts per billion
ppm	Parts per million
ppmw	Parts per million by weight
ppt	Parts per trillion
PRG	Preliminary Remediation Goal
PT	Pump Test
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RAGS	Risk Assessment Guidance for Superfund
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RfD	Reference Dose
RFI	RCRA Facility Investigation
RL	Reporting Limit
SAP	Sampling and Analysis Plan
SEO	New Mexico State Engineer Office
SF	Slope Factor
SW	Site-Wide
T	Transmissivity
TCE	Trichloroethene
TLV	Threshold Limit Value
UF/MF	Uncertainty Factor/Modifying Factor
UV	Ultraviolet
VOC	Volatile Organic Compound
WBFZ	Western Boundary Fault Zone
WSTF	White Sands Test Facility

1.0 EXECUTIVE SUMMARY

This Plume-Front Stabilization Work Plan (Plan) describes a presumptive remedy corrective action for the National Aeronautics and Space Administration (NASA) White Sands Test Facility (WSTF). This presumptive remedy is intended to control threats to human health and/or the environment at the westernmost extent of a groundwater contaminant plume within the aquifer below WSTF. The groundwater is contaminated as a result of historic activities at the site. The groundwater contaminant plume-front area covers an area of approximately 4,000 feet by 8,000 feet and has a depth of 700 feet. The contaminants of concern (COCs) at the plume-front include N-nitrosodimethylamine (NDMA), N-nitrodimethylamine (DMN) and several halogenated volatile organic compounds (VOCs).

An ex-situ pump and treat remediation system is proposed to address plume-front stabilization and contaminant mass treatment activities. This system will include the installation of nine Westbay® multi-port groundwater monitoring wells (WW-2, WW-3, WW-4, WW-5, ST-7, JP-3, PL-8, PL-9 and BLM-37). These wells will assist with plume-front extraction/injection well design, enhance plume-front monitoring capabilities and monitor the effectiveness of the stabilization system.

The plume-front stabilization will utilize six plume-front extraction (PFE) and four plume-front injection (PFI) wells. The WSTF three-dimensional site-wide bedrock (3DSWB) groundwater model was utilized to simulate contaminant plumes for NDMA, trichloroethene (TCE), and tetrachloroethene (PCE). Parameters generated from the 3DSWB model wells were used for the plume-front stabilization well designs. The six extraction wells remain within or on the eastern boundary of the Western Boundary Fault Zone (WBFZ). Extraction wells PFE-1, PFE-2, PFE-3, PFE-4A and PFE-7will specifically address the TCE contaminant plume which extends furthest west. These wells also effectively contain the PCE plume. The five extraction wells will utilize an estimated combined flow rate of 1,050 gallons per minute (gpm).

Extraction well PFE-5, with an estimated flow rate of 26 gpm, specifically addresses the NDMA/DMN plume containment. In the plume-front vicinity, the DMN plume has a similar extent to the NDMA plume but generally lower concentrations. To ensure stabilization of the NDMA/DMN plume-front, which does not extend as far west as the TCE plume, well PFE-5 is positioned to stabilize the NDMA/DMN plume-front concentrations east of the TCE target wells. Any NDMA/DMN contamination not addressed by well PFE-5 or wells anticipated for installation in the mid-plume area will be effectively captured by the high volume extraction wells to the west. The estimated total system flow rate will be 1,076 gpm.

Groundwater contaminant destruction will be performed using a groundwater treatment system. The groundwater from the extraction well system will be pretreated as necessary, treated by an air stripper unit (for the VOCs), and an ultraviolet (UV) oxidation unit (primarily for NDMA and DMN). Contaminant treatment standards for the injected water have been developed following standards and guidelines from multiple Federal and State regulatory sources.

Remediated groundwater injection will be accomplished by four injection wells (PFI-1 through PFI-4) located to the west and south of the contaminant plume. The injection well locations are designed to contain the southern migration of the plume by creating a localized groundwater mound.

2.0 INTRODUCTION

This Plan addresses the stabilization and mass removal of low-concentration groundwater contamination encountered at the leading (westernmost) edge of the WSTF groundwater contaminant plume (referred to as the plume-front). This Plan presents a pump and treat presumptive remedy. Descriptions of presumptive remedies policies and procedures are provided in U.S. Environmental Protection Agency (EPA) Presumptive Remedies Policy and Procedures Directive (EPA, 1993; EPA, 1996).

2.1 SITE LOCATION AND DESCRIPTION OF PROJECT AREA

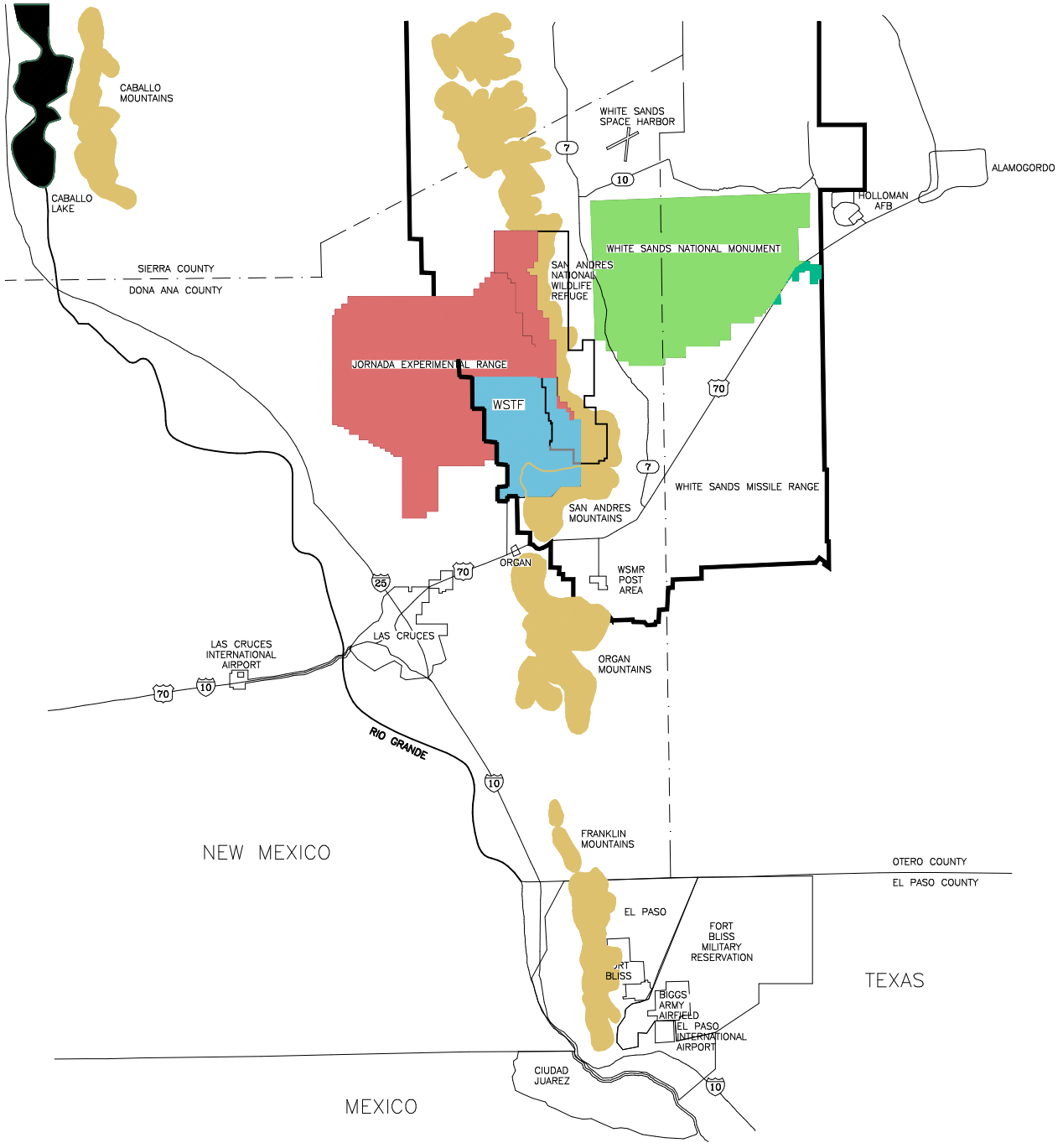
WSTF is located on the western flank of the southern San Andres Mountains approximately 18 miles northeast of Las Cruces, New Mexico and 65 miles north of El Paso, Texas (Figure 2.1). Access to the site from Las Cruces is provided by a paved road, which intersects U.S. Highway 70 one mile west of Organ, New Mexico.

The WSTF plume is approximately 20,000 feet in length, up to 8,000 feet in width (at the plume-front) and 700 feet in depth. The plume consists of three general areas: the source areas; the mid-plume constriction area (MPCA); and the plume-front area. The WSTF plume-front area illustrated by Figure 2.2 is hosted within a transitional hydrogeological zone between the western San Andres Mountains fractured bedrock pediment slope and the alluvial filled Jornada del Muerto Basin (JDMB). This transitional zone is referred to as the WBFZ (Figure 2.2), and comprises an area of pronounced half-graben bedrock faulting related to Tertiary Basin and Range extension. Groundwater at the plume-front occurs at a depth of 420 feet below ground surface (bgs), with low-concentration groundwater contamination confined to the upper 600 feet of the aquifer.

2.2 REGULATORY BACKGROUND

This Plan was prepared in response to discussions on September 16, 1998 between representatives from the EPA Region 6, New Mexico Environment Department (NMED) Hazardous and Radioactive Materials Bureau (HRMB), NMED Ground Water Quality Bureau (GWQB), and NASA. EPA and NMED representatives requested this Plan to identify and describe the plume-front stabilization and treatment activities proposed by NASA. This version of the Plan (May 2002) provides modifications to the original Plan submitted in January 1999.

The format of this Plan was developed in accordance with Chapter II and Appendix E of the Resource Conservation and Recovery Act (RCRA) Corrective Action Plan Final (EPA, 1994), Presumptive Remedies: Policy and Procedures Directive (EPA, 1993), and Presumptive Response Strategy and Ex-Situ Treatment Technologies for Contaminated Ground Water at CERCLA Sites (EPA, 1996). NASA, during the September 16, 1998



LEGEND

- NASA/WSTF
- JORNADA EXPERIMENTAL RANGE
- NATIONAL MONUMENT
- MOUNTAINS OR MOUNTAIN RANGE
- COUNTY BOUNDARY
- WHITE SANDS MISSILE RANGE BOUNDARY
- SAN ANDRES NATIONAL WILDLIFE REFUGE BOUNDARY
- US HIGHWAY (10)
- STATE HIGHWAY (70)
- MILITARY HIGHWAY (7)

N

NOT TO SCALE

FIGURE 2.1
WSTF LOCATION MAP

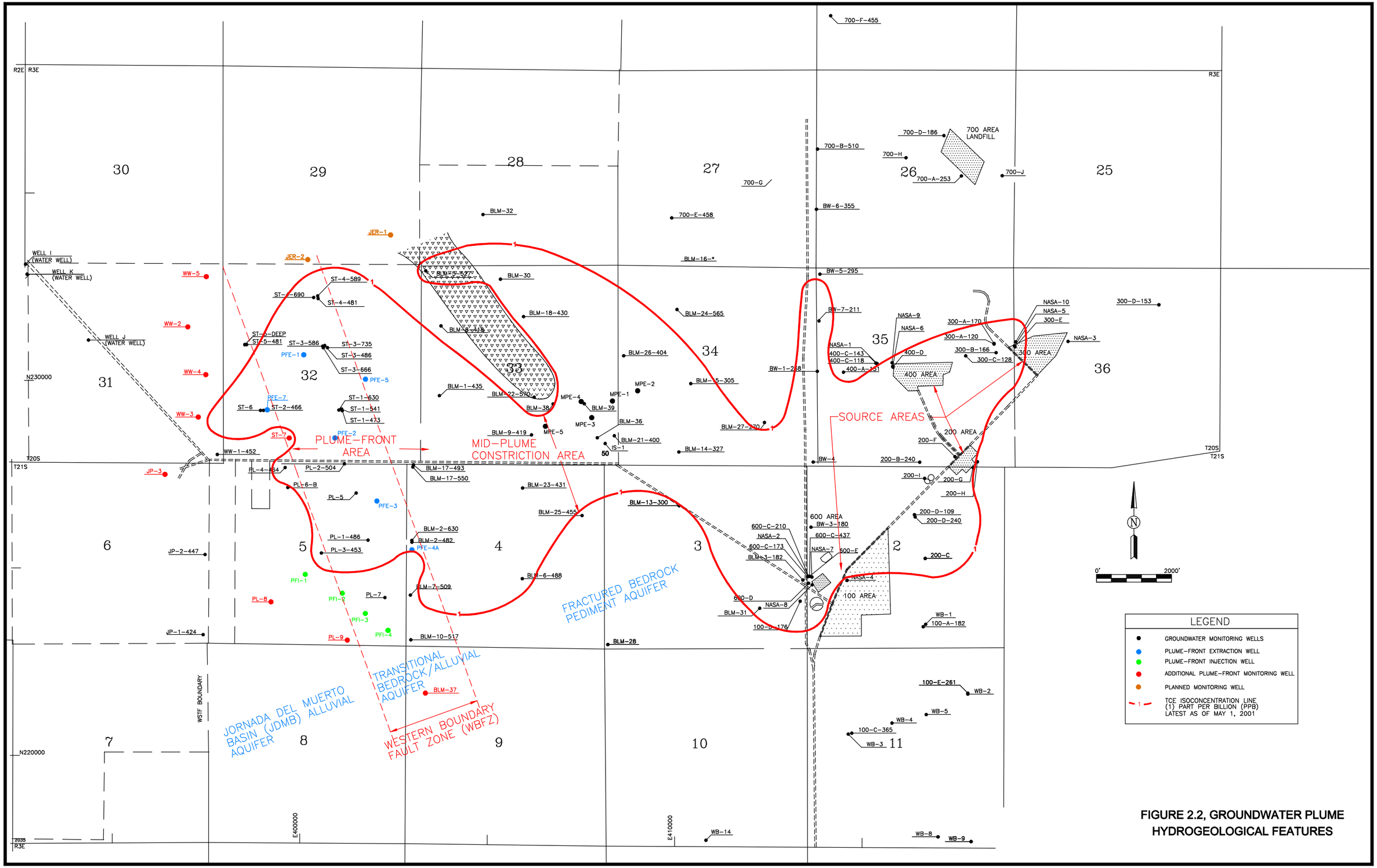


FIGURE 2.2, GROUNDWATER PLUME HYDROGEOLOGICAL FEATURES

meeting, voluntarily proposed a corrective action for the WSTF plume-front area. Both the EPA and NMED verbally concurred with this proposal and encouraged NASA to give high priority to implementation of the plume-front stabilization activities.

Technical information relative to the nature of the WSTF groundwater contaminants, their environmental setting and modes of transport in the subsurface have been collected at WSTF and evaluated from the mid-1980s to present. Pursuant to a 3008(h) Consent Order between EPA Region 6 and NASA, technical results and evaluations were provided in the Draft RCRA Facility Investigation (RFI) and Corrective Measures Study (CMS) Reports (NASA, 1996a; NASA, 1996b).

The primary groundwater contaminants observed within the plume-front area are NDMA, DMN and halogenated VOCs. Chapter Three of the Draft CMS Report (NASA, 1996b) identified and evaluated treatment technologies available to remediate these groundwater contaminants. Unfortunately, NDMA and DMN are particularly recalcitrant to in-situ treatment and require ex-situ pump and treat technology.

3.0 CURRENT CONDITIONS

This section provides an overview of the current conditions which influence the nature, distribution and migration of plume-front groundwater contamination. Comprehensive discussions of current conditions are provided in Volumes Two through Four of the Draft RFI Report (NASA, 1996a). Historical, current and predicted geological, hydrogeological and contaminant conditions have been input into a conceptual WSTF groundwater model which is described in detail later in this Plan. The groundwater model is used as a tool to simulate predictive contaminant trends and examine the effectiveness of different plume-front stabilization alternatives.

3.1 SITE GEOLOGY

3.1.1 Stratigraphy

Bedrock locally outcrops adjacent and east of the WSTF test areas, the primary sources for groundwater contamination. Bedrock stratigraphic units include Pennsylvanian to Permian-age limestone, sandstone, siltstone, and shales to the east within the WSTF test areas, and Tertiary volcanic rocks to the west. The two bedrock lithologies are juxtaposed in the subsurface along the regional northwest-trending Hardscrabble Hill Fault (Figure 2.2). Bedrock is covered with a veneer of alluvium, which increases in thickness to the west from a few feet in the vicinity of the test areas to over 400 feet near the WBFZ. This alluvium consists of Quaternary alluvial fan deposits of the Santa Fe Group derived from the San Andres Mountains to the east.

The Santa Fe Group alluvium is a consolidated to unconsolidated, poorly sorted gravel with a matrix of sand, silt, and clay. Surface geology in the plume-front area consists of Quaternary mid to distal alluvial fan Santa Fe Group deposits made up of limestone, siltstone, shale, rhyolite, andesite, and granite clasts. The thickness of alluvial deposits in the plume-front

vicinity increase from approximately 400 feet on the bedrock pediment to in excess of 2,500 feet within the JDMB (Draft RFI Report, Volume Two, Chapter Four, NASA, 1996a).

Tertiary volcanic bedrock units within the plume-front area consist of variable acidic volcanic rocks. Rhyolitic tuffs predominate and consist of crystal-vitric-lithic ash-flow tuffs. Correlative lithologies have been reported in association with the Organ Mountains Intrusive Complex (Seager, 1981). The flow-banded rhyolite (FBR) volcanic unit represents the most texturally distinct lithology of the west pediment area. The FBR forms a distinct hydrostratigraphic unit that is fundamental in creating a hydrogeological feature referred to as the MPCA.

3.1.2 Structure

Two types of geologic deformation are recognized within WSTF. The oldest and least prevalent deformation consists of west to northwest-trending folding and faulting associated with the Late Cretaceous to Early Tertiary Laramide Orogeny. This compressional deformation type is confined to the western San Andres Mountains, and is exposed within the Bear Peak Fold and Thrust Zone (Seager, 1981).

The second deformation type consists of Late Tertiary Basin and Range normal faulting and is significant relative to the plume-front stabilization activities. East-west extensional forces resulted in the formation of north-trending structural depressions and adjacent fault-bound mountains from the Oligocene period to present. Numerous subsurface Basin and Range-related normal faults have been inferred from seismic and well log data throughout the site, including the Hardscrabble Hill Fault (Draft RFI Report, Volume Two, Chapter Four, NASA, 1996a). The most significant expression of normal faulting at WSTF is the WBFZ, which is coincident with the plume-front area. The WBFZ is a north-northwest trending, regional-scale series of normal half-graben faults that offset the top of the bedrock by greater than 2,000 feet over a width of 2,000 feet. Each normal fault within the series dips steeply to the west.

3.2 SITE HYDROGEOLOGY

3.2.1 Aquifer Description

Groundwater below the WSTF test areas and west to the WBFZ is hosted within a fractured bedrock aquifer at depths which increase from approximately 100 feet to 400 feet bgs. Within and west of the WBFZ, groundwater is located within the JDMB alluvial aquifer at a depth of approximately 420 feet bgs (Figure 2.2). The alluvial aquifer has a thickness in excess of 2,500 feet toward the center of the JDMB (Maciejewski, 1996) where it yields relatively large quantities of potable water. Within the WBFZ area, the plume-front is hosted within a transitional alluvium/bedrock aquifer, with the thickness of saturated alluvium increasing to the west.

Two hydrogeologic groundwater flow barriers have been identified on the WSTF pediment slope within the mid-plume, semi-confined, fractured bedrock aquifer. Secondary porosity

consisting of fractures with dips ranging from 45 to 65 degrees with minor separation predominates within the aquifer. These barriers combine to form the narrow MPCA. To the north, the northwest-southeast trending FBR unit with low permeability and transmissivity (T) restricts groundwater flow. Groundwater sample analyses within this unit indicated no detectable contaminant concentrations through September 1, 1998. Low levels of VOCs have recently been reported in the northern portions of this unit, and are currently under evaluation. To the south, a second flow barrier is created by andesite that has been altered to impermeable clay, promoting low hydraulic conductivities and no detectable contaminant concentrations. These barriers result in a natural confining area to contaminant flow both to the north and south. In the MPCA, groundwater occurs at a depth of 300 feet bgs and is coincident with bedrock. A MPCA measure evaluation is currently in progress within this area to determine if mid-plume interception and treatment of the groundwater contamination is feasible (MPCA Progress Report (in preparation), NASA, 2002).

Aquifer conditions in the vicinity of the plume-front vary from unconfined to leaky confined. Leaky confined conditions are generally prevalent within and to the west of the WBFZ. Discontinuous confining layers are interpreted to comprise clay or cemented alluvial horizons. Hydraulic conductivity (K) and T values for the alluvial aquifer are typically several orders of magnitude greater than for the fractured bedrock aquifer.

3.2.2 Groundwater Movement

East to west groundwater flow within the fractured bedrock aquifer below WSTF is generated as a result of San Andres Mountain-front recharge and subsequent infiltration downgradient into the JDMB. Horizontal hydraulic gradients at WSTF are relatively steep within the pediment area at 0.05 (250 feet/mile) and decrease west of the WBFZ within the alluvial aquifer to 0.0002 (1.1 feet/mile). Localized bedrock variations and alluvial lithologies influence the groundwater flow direction. Within the Tertiary volcanic pediment region of the bedrock aquifer (within and east of the WBFZ), small-scale, interconnected fractures are interpreted to promote localized irregular downgradient groundwater movement. The fracture matrix density is generally high enough to approximate a porous flow environment.

3.2.3 Groundwater Recharge/Discharge

The San Andres Mountains provide recharge to the bedrock and alluvial aquifers through the infiltration of precipitation into exposed bedrock fractures and faults. Mountain-front recharge is estimated to be 50 to 200 acre-feet per mile of mountain front annually (Wilson et. al., 1981; Geoscience Consultants, Ltd. (GCL), 1995; NASA, 1997a).

Direct recharge by infiltration into the JDMB is low as a result of high evaporation, low precipitation, significant depths to groundwater, and the presence of thick lacustrine clays, which inhibit percolation. Minor point recharge areas are present on the pediment slope where WSTF has discharged excess water relatively continuously over the last 30 years. Approximately 90 percent of the groundwater utilized by WSTF is used for testing in the 300 and 400 Areas. The spent test water is then discharged to grade and percolates into the

adjacent arroyo to recharge the groundwater. Presently, a total of 135 acre-feet annually is estimated to recharge the aquifer over a distance of 7,000 feet downgradient of the 300 Area.

The current total groundwater discharge/pumpage of the JDMB aquifer is approximately 6,300 acre-feet per annum (3,900 gpm). Approximately 49 percent of the withdrawn water is used by small independent users, 49 percent by local water companies, and two percent by WSTF. Conservative over-estimates predict future JDMB water usage/pumpage to total 32,000 acre-feet per annum (20,000 gpm) by the year 2026, of which 55 percent will be used by the City of Las Cruces, 28 percent by local water companies, 17 percent by small independent users, and two percent by WSTF. The JDMB aquifer is not currently significantly stressed; however, the future population growth and expanded JDMB groundwater usage are anticipated to result in significant groundwater drawdown (Draft RFI Report, Volume Four, Chapter Two, NASA, 1996a).

3.2.4 Groundwater Quality

WSTF groundwater is classified as fresh to slightly saline and is characterized by elevated levels of sodium, sulfate, and bicarbonate (Wilson et. al., 1981; Draft RFI Report, Volume Two, Chapter Four, NASA, 1996a). Total dissolved solids concentrations range from 490 to 1,230 parts per million (ppm). Fluoride, iron and manganese levels are generally low. Water hardness ranges from 24 to 320 ppm, and water pH values are slightly alkaline with values ranging from 7.2 to 8.3. Sulfate is the most abundant anion, with concentrations ranging from 185 to 600 ppm. Chloride and bicarbonate concentrations range from 15 to 126 ppm and 89 to 376 ppm, respectively. Nitrate levels are generally below 10 ppm, although concentrations up to 40 ppm have been detected. Concentrations of fluoride are usually less than two ppm. Dominant cations comprise the metals calcium, iron, magnesium, potassium, and sodium. Calcium concentrations range from 22 to 179 ppm. Magnesium and sodium concentrations range from 12.6 to 84 ppm and 28 to 500 ppm, respectively. Iron and potassium occur in trace amounts to 0.8 ppm and 9 ppm, respectively. Concentrations of sodium range from 30 to 157 ppm.

3.2.5 Background Metals' Concentrations

Volume Four, Chapter Two of the Draft RFI Report (NASA, 1996a) provides discussions concerning observed concentrations of RCRA regulated metals in groundwater samples. This chapter includes discussions of observed metals' concentrations such as barium, lead and selenium, which are indicative of naturally occurring levels in the JDMB. In addition, chromium detections are discussed and attributed to either naturally occurring levels or to published leaching problems associated with stainless steel casing. EPA and NMED comments to the Draft RFI Report (EPA, 1997) requested additional data presentations and evaluations concerning these metals.

The EPA/NMED comments have resulted in additional data evaluations by WSTF personnel; these evaluations have thus far supported the Draft RFI Report statements. Final evaluations and statistical analyses will be presented within the revised Draft RFI Report. Data collected from the plume-front wells do not indicate that metals' concentrations are associated with

groundwater contamination. No corrective action evaluations are required for these constituents at the plume-front.

3.3 CONTAMINATION

Groundwater contamination within the plume-front area originated from historical site waste management activities. The primary sources of contamination were the closed 200, 300, 400, and 600 hazardous waste management units (HWMUs). NASA submitted closure reports and a Certificate of Closure was issued for the 200 through 600 Areas in May and August 1989. NMED approved the Certificates of Closure for the 200, 300, 400 and 600 Areas in November 1989. The individual contributions of the closed HWMUs to the plume-front contamination cannot be determined. Detailed discussions of the historical source area activities and contributions to the groundwater contamination are provided in Volume Three and Volume Four, Chapter Two of the Draft RFI Report (NASA, 1996a).

3.3.1 Groundwater Contamination

The following COCs have been observed within the plume-front area: NDMA; DMN; TCE; PCE; trichlorofluoromethane (Freon 11); dichlorofluoromethane (Freon 21); and 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113). The maximum reported concentrations from groundwater samples within the plume-front area taken from the WSTF contaminant analytical database between September 1, 1998 and May 1, 2001 are: NDMA - 3,000 parts per trillion (ppt), DMN - 3,270 ppt, TCE - 540 parts per billion (ppb), PCE - 20 ppb, Freon 11 - 640 ppb, Freon 21 - 18 ppb, and Freon 113 - 1,100 ppb. NDMA and DMN are highly soluble in water. TCE, PCE, and the Freon compounds are halogenated volatile organic, dense, non-aqueous phase liquids. Table 3.1 presents a summary of the physical and chemical characteristics for the plume-front contaminants. Detailed discussions of these contaminants, excluding DMN, are provided in Volume Four, Chapter Two of the Draft RFI Report (NASA, 1996a). DMN contamination was discovered at WSTF following the submission of the Draft RFI Report.

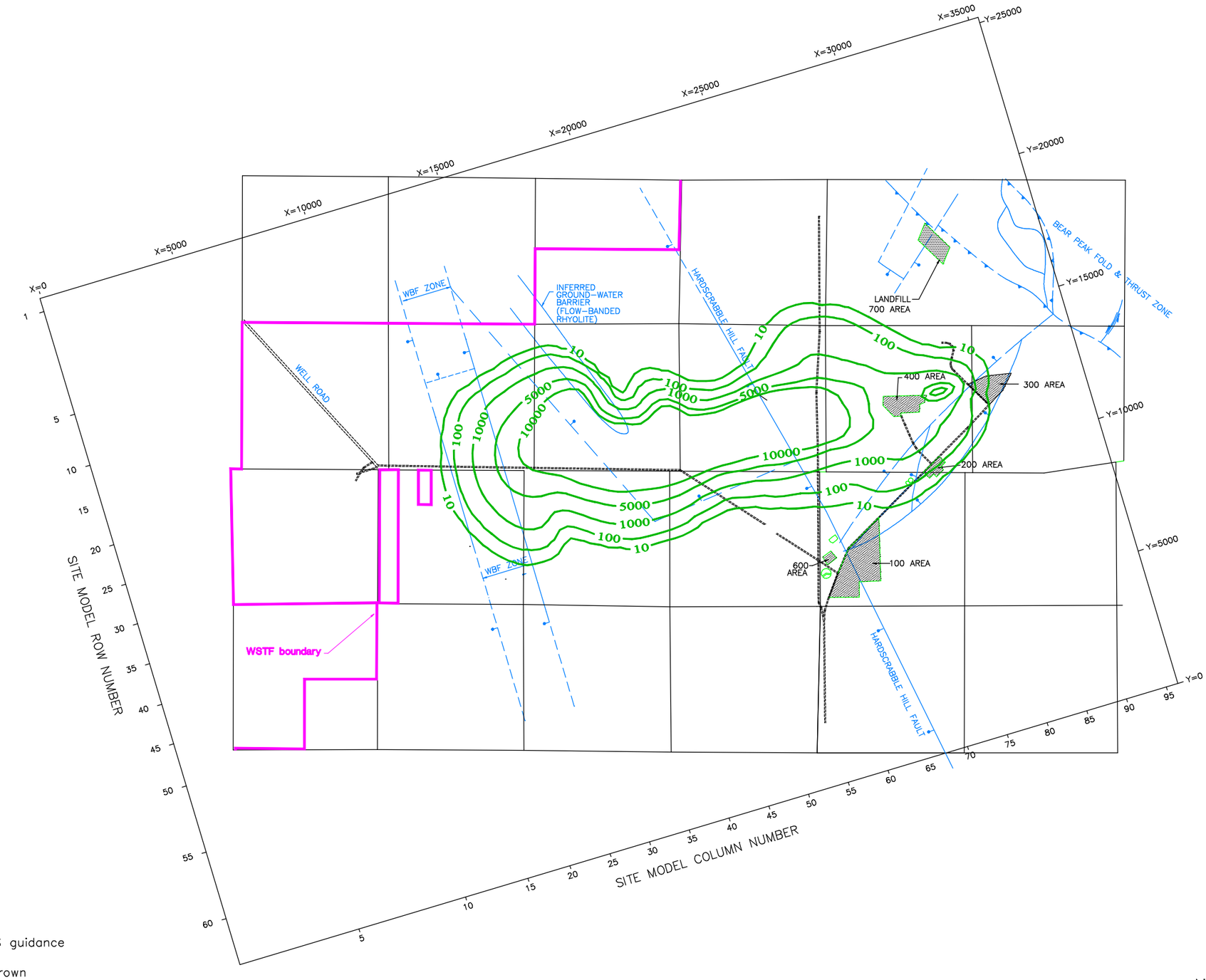
The groundwater contamination plume has migrated downgradient with the flow of groundwater from the WSTF test areas, west through the MPCA, and into the WBFZ at the eastern margin of the JDMB. The contaminants with the most extensive plumes (Freon 113, Freon 11, TCE, NDMA, and DMN) are characterized by plume boundaries of similar shape and extent. Because DMN contamination was discovered after the Draft RFI/CMS Reports were submitted, the DMN plume was not simulated by the WSTF groundwater model. Stabilizing the NDMA plume will also contain the DMN plume because the plumes for DMN and NDMA are extremely similar and the concentrations of DMN are generally lower than NDMA. Therefore, the data generated for NDMA will be utilized for DMN. The conceptualized plumes for NDMA, TCE and PCE generated by the WSTF groundwater model are presented by Figures 3.1, 3.2 and 3.3, respectively. The contaminant plumes can be divided into three sections with distinct characteristics, comprising the industrial source areas, MPCA and the plume-front area (Figure 2.2).

TABLE 3.1: PHYSICAL AND CHEMICAL PROPERTIES OF PLUME-FRONT CONSTITUENTS OF CONCERN

COMPOUND	MOLECULAR WEIGHT (g/mol)	SPECIFIC GRAVITY	SOLUBILITY (mg/l)	BOILING POINT (°C)	VAPOR PRESSURE (mm Hg)	HENRY'S LAW CONSTANT ($atmm^3/mol$)	LOG K_{ow}
NDMA	74.08[a]	1.0059[a] $_{20/4°C}$	Miscible[a]	154[a]	8[a] $_{25°C}$	1.43E-1[a] $_{25°C}$	-0.47[a]
PCE	165.83[a]	1.6227[a] $_{20/4°C}$	150[a] $_{25°C}$	121[a]	19[a] $_{25°C}$	2.685E-2[a] $_{25°C}$	2.53[a]
TCE	131.39[a]	1.4642[a] $_{20/4°C}$	1,100[a] $_{25°C}$	87[a]	77[a] $_{25°C}$	1.17E-2[a] $_{25°C}$	2.53[a]
Freon 113	187.38[b]	1.5635[b] $_{20/4°C}$	170[b] $_{25°C}$	47.7[b]	362.5[c] $_{25°C}$	5.26E-1[c] $_{25°C}$	3.16[c]
Freon 11	137.38[a]	1.494[a] $_{17.2/4°C}$	1,100[a] $_{25°C}$	23.7[a]	687[a] $_{20°C}$	5.83E-2[a] $_{25°C}$	2.53[a]
Freon 21	102.92[b]	1.405[a] $_{9°C}$	9,500[b] $_{25°C}$	9[b]	1,199[e]	1.04E-2[e]	1.29[d]
DMN	90.08[h]	---	Miscible[h]	---	1.7[h] $_{20°C}$	---	---

[a] Handbook of RCRA Ground-Water Monitoring Constituents Chemical and Physical Properties, September 1992.
[b] CRC Handbook of Chemistry and Physics, 71st Edition, 1990.
[c] Handbook of Environmental Fate and Exposure Data for Organic Chemicals, 1990.
[d] EPA Treatability Manual, 1981.
[e] *Journal of Physical Chemistry Reference Data*, Vol. 10, No. 4, 1981.
[f] Henne, L., *Journal of American Chemical Society*, 1936.
[g] Bitner et. al., U.S. Dep. Comm. Off. Tech. Serv. Rep., 1958.
[h] New Jersey Department of Health and Senior Services, Hazardous Substance Fact Sheet, 1998.

K_{ow} Octanol-water Partition coefficient



N

0 4000 ft

Explanation

- 10 — Maximum simulated NDMA concentration (ppt) for 1992
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side (dashed where inferred)

T:\VDR\8010\801014F.DWG

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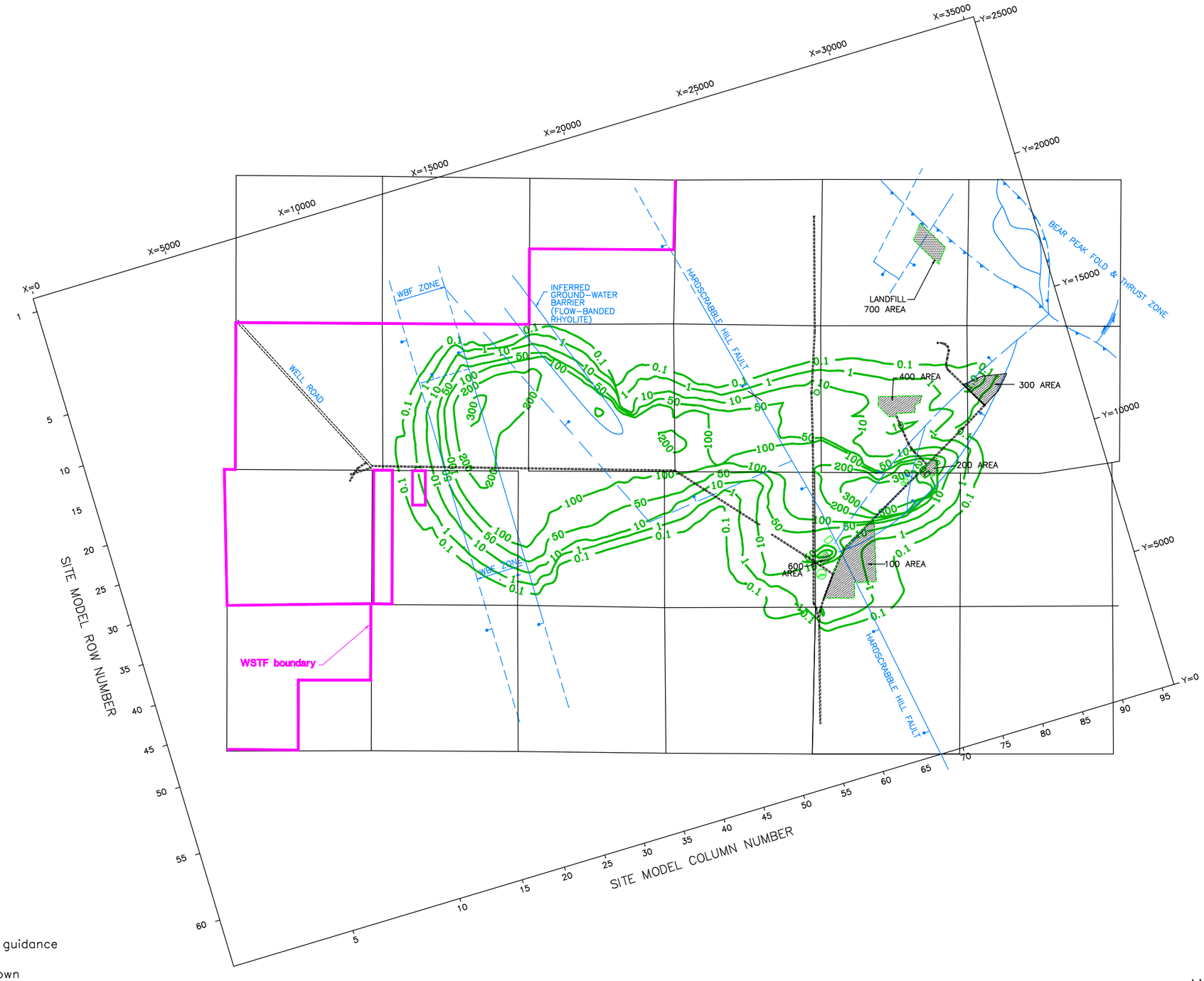
11-5-98 JN 8010

NASA-WSTF MODELING

Plume Front Containment
Simulated NDMA Plume for 1992

Figure 3.1



N

0 4000 ft

Explanation

- 0.1 — Maximum simulated TCE concentration (ppb) for 1992
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side (dashed where inferred)

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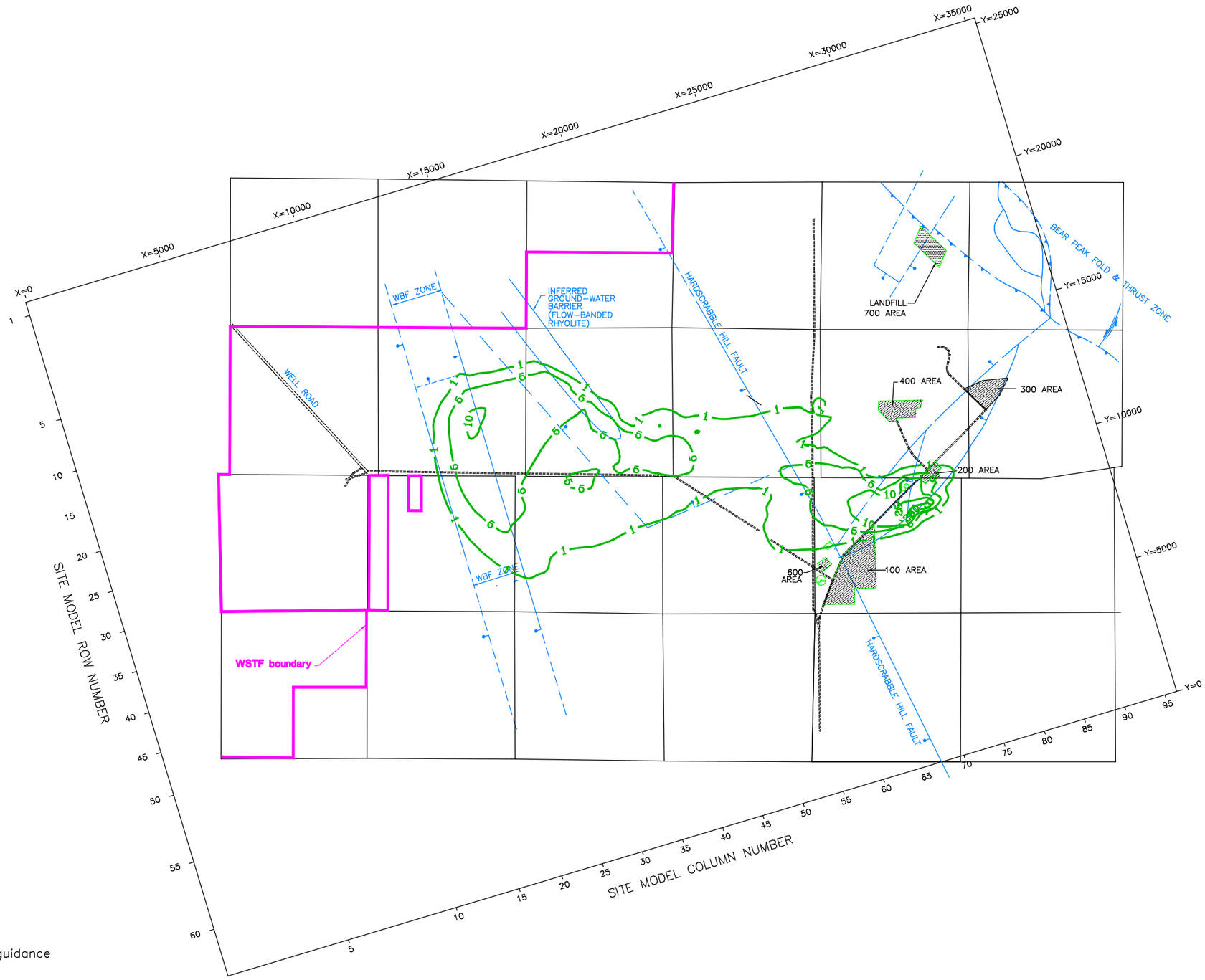
11-3-98 JN 8010

T:\VDR\8010\801012F.DWG

NASA–WSTF MODELING

Plume Front Containment
Simulated TCE Plume for 1992

Figure 3.2



N

0 4000 ft

Explanation

- Maximum simulated PCE concentration (ppb) for 1992
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side (dashed where inferred)

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Daniel B. Stephens & Associates, Inc.
11-3-98 JN 8010

NASA–WSTF MODELING

Plume Front Containment
Simulated PCE Plume for 1992

Figure 3.3

3.4 GROUNDWATER MODEL SETUP AND CALIBRATION

Groundwater modeling activities at WSTF were initiated in 1989. Development procedures for the groundwater model through 1994 are documented by GCL (1995). Daniel B. Stephens & Associates, Inc. (DBS&A) have performed subsequent model calibration activities and the processing of predictive simulations. Results of these modeling activities are documented in three reports (DBS&A, 1995a; DBS&A 1995b and DBS&A, 1998) and within written communications between DBS&A and NASA between 1998 and the present (specifically DBS&A, 2000). All groundwater modeling activities and reports through 1996 are included within the Draft RFI and CMS Reports (NASA, 1996a; NASA, 1996b).

3.4.1 Description of Groundwater Model and Programs

Two separate groundwater models have been constructed to simulate WSTF groundwater flow and contaminant solute transport conditions. The first model comprises a two-dimensional basin-scale representation of the southern JDMB. This model provides a regional-scale simulation capable of addressing the impacts that future JDMB pumpage may have on site model boundary water levels. The regional model is calibrated to regional groundwater levels recorded in the JDMB between 1963 and 1992, and is used to predict site model boundary conditions for the period 1992 to 2026. A regional model review is planned with respect to the predictive groundwater flow model more recently presented by Shomaker (1996).

The second model is utilized for predictive groundwater flow and solute transport simulations, and is referred to as the 3DSWB model. This local-scale model has dimensions of 26,000 feet by 36,000 feet and is elongate to the east-northeast parallel to the axis of the contaminant plume. Grid spacing is sufficiently dense to account for site-specific features. Three computer programs are applied as part of the 3DSWB model. The HydroGeoLogic, Inc. MODFLOW-SURFACT program (Version 2.2) is an integrated MODFLOW (McDonald and Harbaugh, 1988)-based visual modeling system that is used to simulate groundwater flow. Once the groundwater flow field is determined for a remedial scenario using MODFLOW-SURFACT, the appropriate
output files are used as input to two additional programs, PATH3D (Zheng, 1989) and MT3D (Zheng, 1992), to evaluate contaminant transport.

PATH3D is a three-dimensional particle tracking program in which imaginary particles are introduced into the groundwater flow field to trace groundwater flow pathlines. The program is used in conjunction with MODFLOW-SURFACT to simulate flow pathlines for groundwater recovery scenarios. This tool is used to identify the number of wells required and determine their respective optimal pumping rates to contain the contaminant plumes. PATH3D runs have been performed for two of the four primary health risk contaminants (NDMA and TCE). PATH3D is utilized to predict optimum groundwater recovery well locations by tracking flow pathlines from the boundary of the NDMA plume (maximum concern relative to health risk) and the TCE plume (greatest dimensions of the significant health risk contaminants) to ensure recovery well capture.

The PATH3D program assumes that contaminant transport is due to advection only. The three-dimensional numerical transport program MT3D accounts for the physical processes of advection, dispersion, retardation, and chemical decay, and is applied to simulate changes in contaminant concentrations over time.

The 3DSWB flow and solute transport model is utilized as a tool to:

- understand the complex site hydraulics;
- predict contaminant fate and transport;
- integrate site data;
- assist in monitor/remediation well placements;
- prioritize data collection efforts;
- predict future health and environmental risks;
- assess the performance of potential corrective actions; and
- serve as a facility management tool to address water supply considerations.

3.4.2 Construction of the WSTF 3DSWB Conceptual Model

The complex WSTF hydrogeological and groundwater contaminant conditions simulated by the 3DSWB model are addressed in Sections 3.1 through 3.4 of this Plan. Detailed physical parameter analyses for each of the contaminants, excluding DMN, and potential migration patterns are provided in Volume Four, Chapter Two of the Draft RFI Report (NASA, 1996a). The model contains calibrated groundwater flow conditions for the period January 1963 to December 1992, and a calibrated contaminant transport model for the contaminants NDMA, TCE and PCE for the same period. The calibration of the groundwater flow model relies largely on the reproduction of observed groundwater heads within water wells across WSTF and into the JDMB. Contaminant transport models for NDMA, PCE and TCE were calibrated to simulate current observed concentrations primarily by adjusting the contaminant source area parameters. While the hydrologic properties of the model can be created using detailed information from groundwater monitoring wells, the simulation of volume and timing of the source area releases is an iterative process and cannot be accurately defined. The simulation results for 1993 were used as the starting concentrations for the predictive simulations.

The model plume simulations are conservative and are constructed to approximate hand-contoured plumes for maximum observed WSTF contaminant concentrations. Hand-contoured plumes presented in Volume Four, Chapter Two of the Draft RFI Report (NASA, 1996a) represent the maximum contaminant concentration measured at any depth at a particular well location. Simulated plumes provide the maximum concentration within any model layer at a particular Cartesian coordinate. Near the eastern edge of the model domain, the maximum contaminant concentrations will most often be found in fractured bedrock corresponding to model layers two through seven, while in the western portion of the model domain, the maximum contaminant concentration generally occurs within alluvium in layers 10, 11 or 12.

3.4.3 3DSWB Model Calibration for Contaminant Migration

The simulated NDMA, TCE and PCE contaminant plumes, calibrated to historical analytical results for 1992, are presented in Figures 3.1 through 3.3. The simulations differ slightly from the observed (measured) plumes in the respect that the simulated plumes are more dispersed, particularly within the plume-front area specific to this Plan. These differences allow an aggressive approach to plume-front containment due to the greater dimensions of contamination for the simulated plume. Conversely, the high concentration zones east of the plume-front area are slightly underestimated by the simulation results. Because plume-front capture is achieved and remedial system design for the influent groundwater is based on observed concentrations as well as the simulations, the simulated plumes are considered to be conservative.

Simulation of the NDMA plume is critical relative to health risk evaluations. The NDMA plume (Figure 3.1) has two distinct concentration areas: relatively higher concentrations to the east, and lower concentrations downgradient between the 400 Area and the plume-front. Because the NDMA plume-front distribution has a similar generalized configuration and extent as the TCE and PCE plumes, the NDMA releases are assessed to have roughly the same timing as the TCE and PCE releases. High concentrations toward the eastern source areas are likely to have been formed as a result of later releases after the early 1960s. The source contaminants used for the final NDMA calibration run utilized a starting date of January 1973. Details of the methods used in matching simulated to observed plumes for NDMA, TCE and PCE are provided in DBS&A (1995a).

Retardation factors of 1.0 (no retardation) were used for TCE and PCE. The NDMA plume utilized a retardation factor of 1.2, indicating that the contaminant moves at a rate less than the average groundwater flow. The NDMA retardation value factor is justifiable due to the location of the main NDMA source areas. The observed dimensions of the NDMA plume were effectively simulated, particularly in the plume-front area, although the distribution of mass was not easy to simulate within the high-concentration NDMA zones to the east. The simulations yield higher than expected NDMA concentrations within the plume-front area. The NDMA plume-front modeling conservatively stabilizes the relatively higher NDMA concentrations generated by the modeling simulations.

3.5 HEALTH RISK ASSESSMENT

This section discusses the COCs at the plume-front, evaluates health risk and toxicity values, identifies potential receptors, summarizes exposure pathways, and presents the most current contour map of cumulative cancer risk values for the WSTF contaminant plume. Volume Six, Chapter One of the Draft RFI Report (NASA, 1996a) contains a detailed baseline human health risk assessment of the contaminant plume, excluding DMN.

Carcinogenic risk calculations were made using the Risk Assessment Guidance for Superfund (RAGS) (EPA, 1989), the most recent toxicity values obtained from the EPA Integrated Risk Information System (IRIS) (EPA, 1998a), and/or EPA Region 3 Risk-Based Concentration (RBC) Tables (EPA, 1998b), unless otherwise indicated.

3.5.1 Chemicals of Concern

The chemicals of primary health risk concern at the plume-front are NDMA, DMN, TCE, and PCE. Volume Six, Chapter One of the Draft RFI Report (NASA, 1996a) details the method of determining which chemicals become a concern to human health and/or the environment. Additional chemicals of concern, but of lesser health threat, are Freon 11, Freon 21 and Freon 113. Detailed release and toxicological data for each of these chemicals is located in Appendices B-E, Volume Six of the Draft RFI Report (NASA, 1996a), excluding DMN.

3.5.1.1 Carcinogens

NDMA and DMN groundwater contamination originates from the historical management of hydrazine rocket fuels at WSTF. Due to the obscurity of DMN, there are limited toxicological or carcinogenic data available. NDMA and DMN have extremely similar chemical structures, and the most conservative approach for the health risk assessment of DMN is to apply NDMA health and cancer risk calculations to DMN. NDMA is considered a probable human carcinogen classified in Group B2 by the EPA. The primary target organs are the liver and lungs. Liver toxicity is the main effect from both acute and chronic exposure to NDMA. IRIS reports an oral slope factor (SF) of 51 $(mg/kg/day)^{-1}$.

TCE was used as a cleaning solvent for various test article components processed at WSTF. In the past, the EPA had classified TCE as a Group B2 carcinogen with cardiovascular and central nervous system effects and the liver as the target organ. However, chronic exposure effects in humans are uncertain at this point. A carcinogen assessment summary for TCE is currently under review by the EPA, and the toxicity information used for this assessment was taken from the EPA-National Center for Environmental Assessment (NCEA) provisional values. For purposes of the WSTF health risk assessment, a conservative approach was chosen. Therefore, TCE will be maintained as a carcinogen pending publication of a new carcinogen summary. The RBC Table lists an oral SF for TCE of 0.011 $(mg/kg/day)^{-1}$, the value drawn from IRIS, and a Reference Dose (RfD) of 0.01 mg/kg/day.

There is no carcinogen assessment summary of PCE available at this time from the EPA. Since chronic exposure effects in humans are uncertain at this point, the SF of 0.011 $(mg/kg/day)^{-1}$ used for this assessment is an EPA-NCEA provisional value. IRIS has published a RfD 0.01 mg/kg/day with liver damage noted in animal studies.

3.5.1.2 Non-Carcinogens

Halogenated VOCs were used historically as cleaning solvents and referee propellants at WSTF. Human exposure to high vapor concentrations could result in respiratory, central nervous system and/or cardiac effects, unconsciousness, and, in some cases, death by asphyxiation. Freon 11 is considered more toxic than Freon 113. IRIS assigns an RfD of 0.3 mg/kg/day to Freon 11 and 30 mg/kg/day to Freon 113.

Limited toxicological data exists for Freon 21. The National Institute for Occupational Safety and Health (NIOSH, 1990) lists a threshold limit value (TLV) of 10 ppm, two orders of magnitude less than the TLVs for Freon 11 and Freon 113 (both 1,000 ppm). From the Hazardous Substances Data Base:

> "Although toxicity due to acute inhalation is low, FC-21 is appreciably more toxic than related difluorinated methanes such as dichlorodifluoromethane or chlorodifluoromethane. The chronic toxicity of FC-21 is markedly different from these compounds, and appears to be more similar to chloroform."

For purposes of the WSTF health risk assessment, the RfD for chloroform was used to calculate hazard quotients for Freon 21 concentrations detected in the groundwater plume. IRIS assigns a RfD to chloroform of 0.01 mg/kg/day. Toxicity information for plume-front chemicals is summarized in Table 3.2.

3.5.2 Potential Receptors and Exposure Pathways

Volume Five of the Draft RFI Report (NASA, 1996a) provides a detailed evaluation of potential receptors. There are no current human or ecological receptors of contamination within the plume-front area. The Draft RFI Report projects that contamination will not impact potential receptors for at least the next 30 years. The Draft RFI Report also contains a detailed discussion of population characteristics and current and future land use at and around WSTF. Exposure via groundwater is the pathway of potential concern for the plume-front area. Therefore, the focus of potential receptors and exposure pathways are groundwater wells located hydraulically downgradient from the plume-front.

The potential exposure pathway of concern to NASA is potential future contamination of the WSTF water supply wells. WSTF maintains three supply wells, Wells I, J and K, located in Section 31 of Township 20 South, Range 3 East (Figure 2.2). The proximity of these wells to the plume-front is presented in Figure 3.4. Currently, Well I is inactive and Wells J and K are used alternately to supply water to WSTF through a one million gallon reservoir in the 300 Area. If contamination of the water supply wells occurred, WSTF employees could be exposed to plume-front contaminants through ingestion or dermal contact with contaminated water. The possibility of exposure is low because WSTF is not open to the public and there are no permanent residents at the site. Only employees (all adults) are allowed on site, and therefore, employee exposures would be solely industrial in nature (40 hours/week).

Potential receptors include the privately owned domestic and irrigation wells located west of the NASA facility boundary. The five domestic wells shown in Figure 3.4 serve household and non-commercial yard and domestic animal uses. If the groundwater contamination plume reached these wells, residents could be exposed to plume-front contaminants through ingestion, dermal contact with, or possible consumption of garden crops or domestic animals exposed to contaminated water.

Two irrigation wells are located downgradient from the plume-front in Section 35, Township 20 South, Range 2 East (Figure 3.4). The eastern irrigation well is used to irrigate a 100-tree

TABLE 3.2: TOXICITY INFORMATION FOR PLUME-FRONT CHEMICALS

Carcinogen	Oral Slope Factor (SF) $(mg/kg/day)^{-1}$	EPA Weight of Evidence Classification	Target Organ(s)	SF Source
NDMA	51	B2	Liver	IRIS
DMN	51[1]	B2[1]	Liver[1]	IRIS[1]
TCE	0.011	Under EPA review	Under EPA review	EPA-NCEA provisional value
PCE	0.052	Under EPA review	Under EPA review	EPA-NCEA provisional value
Non-Carcinogen	**Oral Reference Dose (RfD) (mg/kg/day)**	**Confidence Level & UF/MF**	**Health Effect**	**RfD Source**
Freon 11	0.3	Medium 1000/1	Psychomotor impairment	IRIS
Freon 113	30	Low 10/1	Psychomotor impairment	IRIS
Freon 21	0.01*	Medium* 1000/1	Psychomotor impairment	IRIS*
TCE**	0.006	No data	No data	EPA-NCEA provisional value
PCE**	0.01	Medium 1000/1	Liver	IRIS

*Chloroform RfD (see text in Section 3.5.2, Non-carcinogens)
**Carcinogens with RfD data available are included in the evaluation of non-carcinogenic effects.

MF- Modifying Factor
UF- Uncertainty Factor

[1] NDMA values are applied to DMN

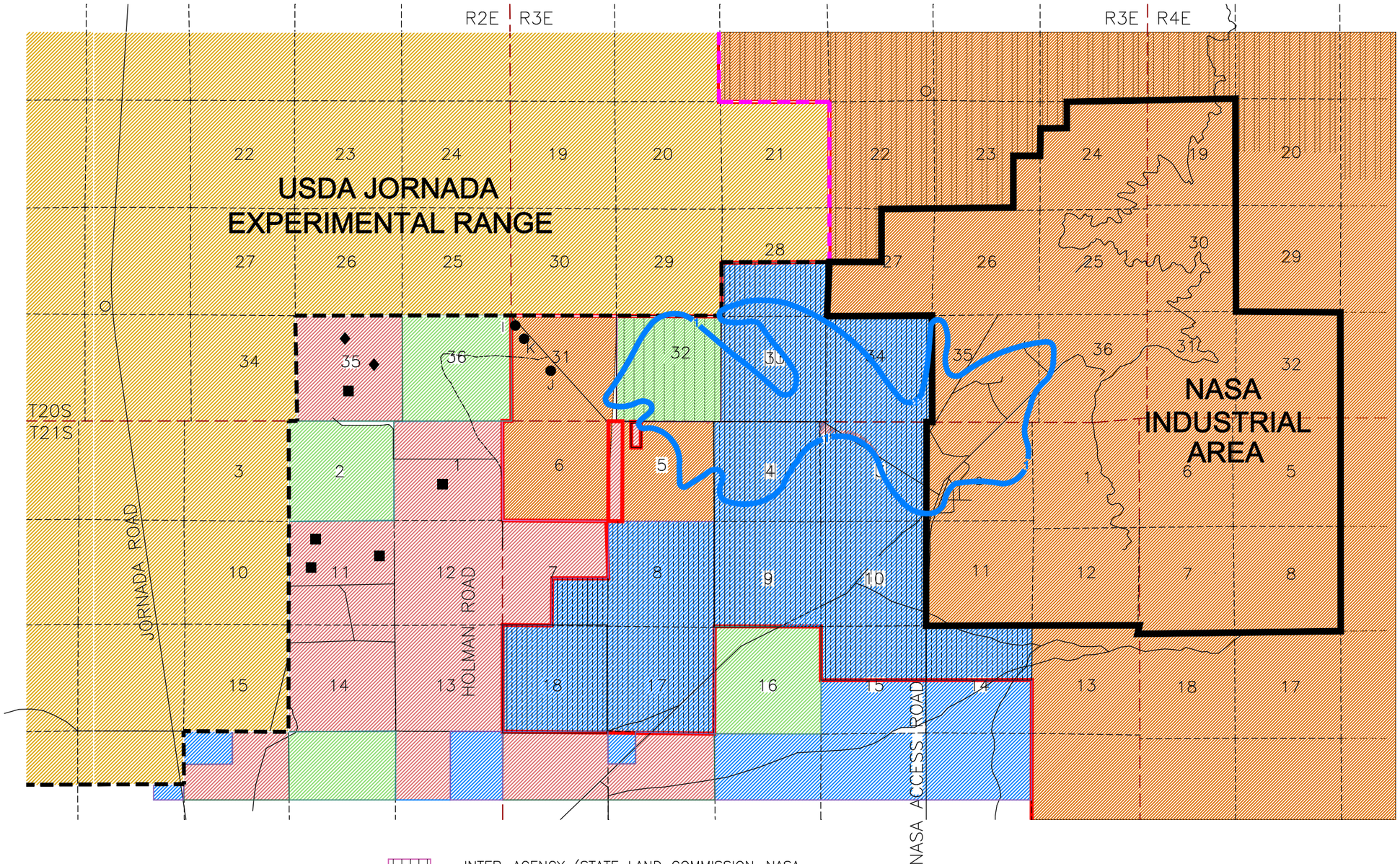


FIGURE 3.4
WSTF LAND OWNERSHIP &
LOCATION OF 1 (PPB) TCE PLUME

pecan orchard. The western irrigation well has been unused for many years. If the plume-front ever intercepted the pecan orchard well, human exposure could occur through bioaccumulation in the pecans and eventual human consumption. Human exposure resulting from use of the western irrigation well is uncertain at this time. The exposure scenario depends upon how the water would be used, whether for domestic animals or commercial crops. Community water supply systems could also be potential receptors of contaminated groundwater. The Moongate Water Company, the City of Las Cruces, the Mountain View Water Company, and various smaller water companies have multiple wells to the south and west of WSTF. The City of Las Cruces has also proposed 14 new wells in the vicinity of Moongate to acquire an additional 14,000 acre-feet of water per year from the JDMB. Water usage has been conservatively estimated for the two-dimensional regional groundwater model within the JDMB through the year 2026.

3.5.3 Risk Characterization

The approaches used to determine cancer risk and hazard indices are based on the assumption that there are no synergistic or antagonistic interactions among the compounds involved, and that all compounds have the same toxic end points and mechanisms of action. The effects of exposure to each of the contaminants have been considered separately, then totaled for a straight-line additive effect, for both carcinogens and non-carcinogens.

NASA opted to take the most conservative approach in calculating cancer risk values and hazard indices. Maximum contaminant concentrations detected in RFI monitoring wells from the time period April 1, 2000 through May 31, 2001 were used. In wells where individual contaminants were not detected, cancer risk and hazard indices were calculated based on the lowest analytical detection limit. Intake assumptions associated with residential exposure via ingestion of contaminated groundwater were used, although no exposure pathways are complete, and industrial exposure to WSTF employees is the primary concern at this time.

3.5.3.1 Carcinogenic Risk Estimates

Carcinogenic slope factors obtained from IRIS or EPA Region 3 RBC Tables were used to estimate the potential excess cancer risks associated with maximum levels of contamination detected at the WSTF groundwater monitoring wells. The chronic daily intake (CDI) was calculated using the EPA age-adjusted calculations (from EPA Region 3 RBC Table: Technical Background Information and RAGS).

1) To calculate Age-Adjusted Ingestion Factor (IFWadj):

$$IFWadj = \frac{EDc \times IRWc}{BWc} + \frac{(EDtot-EDc) \times IRWa}{BWa}$$

2) Age-Adjusted Calculation Factor:

$$CFadj = \frac{IFWadj \times EF}{AT}$$

3) To calculate Chronic Daily Intake (age adjusted):

CDI = (CFadj)(CW)

4) To calculate Cancer Risk:

Risk = (CDI)(SF)

Variables for the equations are defined in Table 3.3. The cumulative cancer risk at each monitoring well was estimated by calculating the cancer risk for each contaminant, then summing those risk values at each well. Table 3.4 lists the individual chemical and cumulative carcinogenic risk estimates for the plume-front monitoring wells. Values listed in bold italics reflect those calculated using the lowest analytical detection limit when a contaminant was not detected. The cumulative cancer risk values for all RFI groundwater monitoring wells have been contoured and the resultant map is shown as Figure 3.5.

3.5.3.2 Non-Carcinogenic Hazard Quotients and Indices

RfDs obtained from IRIS or the RCB Tables were used to compute hazard quotients (HQs) for maximum concentrations of TCE, PCE, Freon 11, Freon 21, and Freon 113 detected at monitoring wells. NDMA and DMN were not included because applicable RfDs are not available. HQs were computed by dividing the CDI by the chemical-specific RfD (HQ = CDI/RfD) and then by summing each non-carcinogenic chemical to determine the Hazard Index (HI) at each plume-front monitoring well. Table 3.5 lists the HQs and HIs estimated for the plume-front wells. HQs and HIs calculated on the lowest analytical detection limits are listed in bold italics. Table 3.5 shows that the highest HQs are associated with TCE and its presence in a monitoring well constitutes the greatest contribution to the well's HI. The contribution to the HI from all the Freon compounds totaled is small in comparison to TCE, and is generally less than 0.1. TCE is the primary chemical of concern that causes the HIs to exceed 1.0.

3.5.4 Uncertainties

The assumptions and inputs used to assess potential human health risks posed by the WSTF contaminant plume are subject to several uncertainties that have effects of either overestimation or underestimation of risk. These are discussed in detail in Volume Six, Chapter One of the Draft RFI Report (NASA, 1996a). The primary uncertainty factors are discussed below.

3.5.4.1 Carcinogenicity Evidence Under Review

Currently, the evidence for the carcinogenicity of TCE and PCE is under review. The SFs used in risk calculations are the EPA provisional values.

TABLE 3.3: CHRONIC DAILY INTAKE (CDI) ASSUMPTIONS

Adult Ingestion of Contaminated Groundwater

PARAMETER	EXPOSURE ASSUMPTION
CW (Exposure Point Concentration in Groundwater in mg/l)	Maximum concentration detected in monitoring wells.
IRWa or IRWc (Ingestion Rate)	2 liters/day (adult) or 1 liter per day (child)
EF (Exposure Frequency)	350 days/year
EDa or EDc or EDtot (Exposure Duration)	24 years adult +6 years child = 30 year total
BWa or BWc (Body Weight)	70 kg adult or 15 kg child
AT (Averaging Time)	70 years x 365 days/year-Carcinogens 30 years x 365 days/year-Non-carcinogens
IFWadj (Age Adjusted Ingestion Factor)	1.09 L-y/kg-d
CDI (Chronic Daily Intake (mg/kg/d)	(CFadj)(CW)
CFadj (Age Adjusted Calculation Factor)	1.49×10^{-2}
SF (Slope Factor)	

TABLE 3.4: CARCINOGENIC RISK ESTIMATES FOR PLUME-FRONT MONITORING WELLS

Well(s)	NDMA	DMN	TCE	PCE	Cumulative
BLM-2 Group	$1.37\text{x}10^{-3}$	$5.85\text{x}10^{-4}$	$4.26\text{x}10^{-5}$	$8.52\text{x}10^{-6}$	$2.00\text{x}10^{-3}$
BLM-7-509	***<3.80x10^{-5}***	***<2.89x10^{-5}***	***<8.20x10^{-8}***	***<3.87x10^{-7}***	***<6.73x10^{-5}***
BLM-17 Group	$4.71\text{x}10^{-3}$	$2.51\text{x}10^{-3}$	$3.11\text{x}10^{-5}$	$7.75\text{x}10^{-6}$	$7.26\text{x}10^{-3}$
PL-1-486	***<3.80x10^{-5}***	***<2.89x10^{-5}***	$1.31\text{x}10^{-5}$	$1.55\text{x}10^{-6}$	***<8.15x10^{-5}***
PL-2-504	***<3.80x10^{-5}***	$1.60\text{x}10^{-5}$	$2.13\text{x}10^{-5}$	$5.42\text{x}10^{-7}$	***<7.58x10^{-5}***
PL-3-453	$3.13\text{x}10^{-6}$	***<7.60x10^{-6}***	***<8.20x10^{-8}***	***<3.87x10^{-7}***	***<1.12x10^{-5}***
PL-4-464	***<7.60x10^{-6}***	***<7.60x10^{-6}***	$2.46\text{x}10^{-7}$	***<3.87x10^{-7}***	***<1.58x10^{-5}***
PL-5	$1.09\text{x}10^{-3}$	$4.10\text{x}10^{-4}$	$5.74\text{x}10^{-5}$	$1.24\text{x}10^{-5}$	$1.57\text{x}10^{-3}$
PL-6	$8.89\text{x}10^{-7}$	$6.84\text{x}10^{-6}$	$6.23\text{x}10^{-7}$	***<3.87x10^{-7}***	***<8.74x10^{-6}***
PL-7	***<7.60x10^{-6}***	***<7.60x10^{-6}***	***<8.20x10^{-8}***	***<3.87x10^{-7}***	***<1.57x10^{-5}***
ST-1 Group	$1.41\text{x}10^{-3}$	$6.00\text{x}10^{-4}$	$6.23\text{x}10^{-5}$	$1.47\text{x}10^{-5}$	$2.09\text{x}10^{-3}$
ST-2	$3.19\text{x}10^{-7}$	***<7.60x10^{-6}***	$1.57\text{x}10^{-7}$	***<3.87x10^{-7}***	***<8.46x10^{-6}***
ST-3 Group	$1.37\text{x}10^{-3}$	$4.94\text{x}10^{-4}$	$4.75\text{x}10^{-5}$	$1.01\text{x}10^{-5}$	$1.92\text{x}10^{-3}$
ST-4 Group	$1.64\text{x}10^{-6}$	***<7.60x10^{-6}***	$1.80\text{x}10^{-6}$	$5.73\text{x}10^{-7}$	***<1.16x10^{-5}***
ST-5 Group	$7.60\text{x}10^{-6}$	***<2.89x10^{-5}***	$3.28\text{x}10^{-6}$	***<3.87x10^{-7}***	***<4.01x10^{-5}***
ST-6	***<3.80x10^{-5}***	***<3.80x10^{-5}***	***<8.20x10^{-8}***	***<3.87x10^{-7}***	***<7.65x10^{-5}***

This table presents the individual cancer risks associated with maximum contaminant concentrations observed for each well. Values listed in bold italics reflect those calculated using the lowest analytical detection limit when a contaminant was not detected.

R2E R3E

R3E

E400000

E410000

E420000

LANDFILL
700 AREA

30

29

28

27

26

25

WSTF BOUNDARY

32

33

34

35

300 AREA

400 AREA

36

N230000

N230000

31

T20S
T21S

T20S
T21S

200 AREA

6

5

4

3

2

600
AREA

100 AREA

10^{-7}

WSTF BOUNDARY

7

8

9

10

11

N220000

N

0 2000'

E400000

E410000

2749 D
R3E

LEGEND:

CANCER RISK

- 10^{-2}
- 10^{-3}
- 10^{-4}
- 10^{-5}

RESIDENTIAL EXPOSURE SCENARIO

FIGURE 3.5
CONTOUR MAP OF
CUMULATIVE CANCER RISK
(NDMA-DMN-TCE-PCE)

TABLE 3.5: HAZARD QUOTIENTS AND INDICES FOR PLUME-FRONT WELLS

Well	TCE	PCE	Freon 11	Freon 21	Freon 113	Hazard Index
BLM-2 Group	1.19	0.03	0.02	***<0.001***	***<0.001***	***<1.242***
BLM-7-509	***<0.002***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.006***
BLM-17 Group	0.87	0.02	0.03	***<0.001***	***<0.001***	***<0.922***
PL-1-486	0.37	0.01	0.01	***<0.001***	***<0.001***	***<0.392***
PL-2-504	0.59	***<0.001***	0.02	***<0.001***	***<0.001***	***<0.613***
PL-3-453	***<0.002***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.006***
PL-4-464	0.01	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.014***
PL-5	1.60	0.04	0.03	0.16	***<0.001***	***<1.831***
PL-6	0.02	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.024***
PL-7	0.01	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.014***
ST-1 Group	1.74	0.05	0.04	***<0.001***	***<0.001***	***<1.832***
ST-2	***<0.002***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.006***
ST-3 Group	1.32	0.04	0.02	***<0.001***	***<0.001***	***<1.382***
ST-4 Group	0.05	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.054***
ST-5 Group	0.09	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.094***
ST-6	0.03	***<0.001***	***<0.001***	0.02	***<0.001***	***<0.053***

Table lists the hazard quotients and hazard indices estimated for the plume-front wells.

The bold italics values represent hazard quotients and hazard indices calculated on the lowest analytical detection limits.

Until EPA finalizes the determinations for these chemicals, NASA will consider TCE and PCE carcinogenic and estimate potential excess risk associated with their presence in groundwater in its health risk assessment. If new carcinogen summaries determine these chemicals are not carcinogenic, then the cumulative cancer risk values in this report become overestimates.

3.5.4.2 Lack of Toxicity Data

Toxicity data are not available for DMN or Freon 21. The RAGS suggests grouping chemicals by class in such situations and applying a known toxicity value from a chemical in that class to characterize risk. Due to their extremely similar chemical structures, DMN was grouped with NDMA, and the NDMA SF was applied to estimate the cancer risk for DMN. This introduces uncertainty in the risk calculations for DMN and the cumulative cancer risk values.

The RfD for chloroform was applied to Freon 21 (see discussion of non-carcinogens in Section 3.5.1.2 indicating similar toxicities). This is a conservative approach to the risk posed by Freon 21 given the limited data available. Using the RfD of chloroform for Freon 21 introduces uncertainty into the HQ calculations for Freon 21 and also the HIs calculated for each monitoring well.

3.5.4.3 Chemical Concentrations

Health risk estimates from ingestion of contaminated groundwater were made using a hypothetical residential exposure scenario and the maximum concentration of a chemical of concern detected at each RFI monitoring well over a specified time period. Using maximum concentrations rather than the 95% Upper Confidence Limit of the mean, as suggested in RAGS, results in overestimation of risk.

3.6 DATA SUFFICIENCY

The WSTF groundwater plume has been extensively monitored since 1987 and more than 5,000 sampling events and 400,000 sample results have occurred to date. The plume monitoring network currently includes 79 conventional and 39 Westbay Multi-Port® monitoring wells. Data collected from existing plume-front wells have been used to design the presumptive remedy for this Plan.

Previous experience with monitoring wells along the plume-front has shown that geologic formation characteristics can vary significantly. Therefore, step tests will be performed on each of the wells to confirm the pumping capacity for each well. The T and specific yield of the formation, derived from the step test results, will be compared to existing values within the 3DSWB groundwater model, and additional simulations performed to confirm plume stabilization will be accomplished with the system presented in this Plan.

4.0 PRESUMPTIVE REMEDY FOR PLUME-FRONT STABILIZATION

This Plan presents a plume-front stabilization presumptive remedy that incorporates plume-front monitoring wells, plume-front extraction wells, ex-situ treatment to reduce contaminants to prescribed concentrations, and reinjection of the remediated groundwater into the JDMB using injection wells. The system is designed to mitigate further plume-front migration and serves to actively remove contaminant mass from the groundwater.

4.1 EVALUATION OF 3DSWB MODEL PREDICTIVE REMEDIAL SCENARIOS

The 3DSWB model has been used as a tool to simulate future contaminant migrations over a wide range of predictive remedial scenarios. The model has served to simulate "no-action" groundwater conditions over a 30 year period and also to determine optimum extraction/injection well locations for a variety of remedial system designs (GCL, 1995; DBS&A, 1995a; DBS&A, 1995b, DBS&A, 1998, and DBS&A, 2000).

The most important feature of the predictive simulation groundwater flow field performed by the MODFLOW-SURFACT program is that the flow direction within the JDMB is anticipated to change from west-southwest to south over the next 30 years. Conservatively overestimated pumping rates for the JDMB indicate that the average hydraulic gradient may increase by an order of magnitude. This condition results from significant increases in predicted groundwater withdrawals south of WSTF in the vicinity of U.S. Highway 70 by the City of Las Cruces and other water suppliers. The major implication to the JDMB groundwater model is that under a "no-action" scenario the contaminants that currently exist in the WBFZ migrate in a more southerly direction, and at an increased velocity.

The three computer programs described in Section 3.4.1 were applied to obtain the predictive remedial scenario results. When locating or withdrawing an extraction well, the MODFLOW-SURFACT program was rerun to obtain the revised groundwater flow field throughout the predictive simulation period. The PATH3D program was then used to evaluate the effectiveness of the various plume capture schemes. MT3D was run for each final predictive simulation to simulate contaminant concentrations that may occur in response to the various groundwater remediation scenarios.

Ten predictive remedial simulation scenarios were performed to assess the potential NDMA, TCE and PCE migration from January 1993 to December 2026 as part of the Draft RFI and CMS Reports (NASA, 1996a; NASA, 1996b). One additional scenario (Scenario Eleven) has been added to this version of the Plan to account for remediation well design modifications which have taken place since the original submittal of the Plan in January 1999. The eleven scenarios are summarized in Table 4.1. The first scenario was "no-action", and the remaining scenarios addressed the assessment of different pump and treat remedial alternatives. Each scenario used initial hydraulic heads and initial contaminant concentrations from the December 1992 time step of the site model calibration run for each of the three COCs modeled (Figures 3.1 through 3.3). A description of the predictive simulation scenarios, including well descriptions and flow rates, are provided in Volume One, Chapter Four of the Draft CMS Report (NASA, 1996b).

TABLE 4.1: SUMMARY OF 3DSWB MODEL INTERIM MEASURES REMEDIAL SCENARIOS

Scenario #	Description	Remedial Wells	Estimated Remediation System Flow Rates	Advantages	Disadvantages
1 No-action	Monitored natural attenuation of plume	---	---	Low cost.	Contaminant plume mass undergoes advective-dispersive transport.
2&3 Plume-front containment and NDMA hot spot remediation	Extraction wells located across plume-front in WBFZ and bedrock pediment. Injection wells southwest of the plume. Discharge increased for high-capacity WBFZ wells in Scenario 3.	15 extraction 2 injection	Total discharge 1,170 gpm, with 800 gpm from 3 high-capacity WBFZ wells. Discharge increased to 1,420 gpm for Scenario 3.	Effective containment of the plume. Reduction of contaminant concentrations. Injection restricts plume movement to the south. Increased cone of depression for Scenario 3 ensures effective plume-front containment.	Predicted plume-front concentrations remain above maximum contaminant level for TCE (5 ppb) and anticipated contaminant level for NDMA (10 ppt) inside captured plume. Bedrock flow rates may be difficult to reproduce. Increased volumes of extracted groundwater have limited effectiveness.
4 Aggressive plume remediation	As for Scenario 2&3 plus 29 additional extraction wells. Injection wells southwest of the plume.	41 extraction 2 injection	Total discharge is 1,420 gpm.	Reductions in peak concentration areas within the plume. Injection restricts plume movement to the south.	Limited additional reduction in plume boundary. Withdrawal rates from the majority of wells are small due to bedrock locations. Concentrations remain above treatment standards inside captured plume.
5 Plume-front containment with mid-plume interception	Utilizes the three high-capacity WBFZ extraction wells from Scenario 2&3 plus 3 mid-plume extraction wells. Injection wells southwest of the plume.	11 extraction 2 injection	Total discharge is 880 gpm including additional 70 gpm prescribed for mid-plume wells.	Plume-front containment. Partial reduction of the mass accessing the plume-front from source areas via the mid-plume. Injection restricts plume movement to the south.	Narrow mid-plume pumping does not effectively intercept contaminants or reduce mass flux. Plume-front concentrations above Scenario 2 because seven of the plume-front area wells were not simulated. Concentrations remain above treatment standards inside captured plume.
6 Mid-plume interception	No-action at plume-front and remediation of the mid-plume.	3 extraction	Total discharge is 70 gpm.	Supply of contaminants from source areas to plume-front reduced.	Plume-front appears similar to Scenario One (no-action). Concentrations remain above treatment standards inside captured plume.
7 Basic plume-front containment	Containment of the plume-front within the WBFZ. Injection wells southwest of the plume.	4 extraction 4 injection	Total discharge is 810 gpm.	Plume-front containment and mass removal. Uses wells predominantly screened within alluvium of WBFZ.	Potential for pump and treat within the MPCA will be addressed independently. Concentrations remain above treatment standards inside captured plume.
8&9 Scenario 7 with mid-plume interception and hot spots	As for Scenario 7, with additional wells in the mid-plume the zone of high NDMA west of the 400 Area.	Between 4 and 10 extraction 4 injection	Total discharges are 880 gpm (Scenario 8) and 900 gpm (Scenario 9).	Increased mass concentration removal.	Results similar to Scenario 7, despite the considerable increase in extraction wells. Larger reductions in concentrations limited due to the potential capacity of the additional wells. Concentrations remain above treatment standards inside captured plume.
10 Scenario 7 with additional plume-front area NDMA target wells	As for Scenario 7, with two additional plume-front extraction wells on the east WBFZ boundary. System independently targets TCE and NDMA mass removal.	6 extraction 4 injection	Total discharge is 1,010 gpm.	As for Scenario 7. Well configuration independently addresses TCE and NDMA contaminant fronts resulting in increased mass removal.	Potential for pump and treat within the MPCA will be addressed independently.
11 Scenario 10 with modifications based on recent field data	Scenario 10 with one NDMA well (PFE-6) removed, well PFE-4 location modified (PFE-4A) and TCE well PFE-7 added.	6 extraction 4 injection	Total discharge is 1,076 gpm.	As for Scenarios 7 &10. Well configuration modified to address anomalies detected following Scenario 10 installation.	Potential for pump and treat within the MPCA will be addressed independently.

The first six predictive simulations run are presented in DBS&A (1995a). Scenario One indicates that if no action is taken, the contaminant plumes can be expected to migrate west and south of their present location up to one mile west of the WBFZ by the year 2026. Scenarios Two, Three and Four indicate containment of the plume with between 12 to 41 extraction wells placed within or near the WBFZ, and at upgradient locations within the fractured bedrock pediment. The injection of treated groundwater for all treatment scenarios is to the southwest of the contaminant plume.

The results of Scenario Four indicate that even if numerous extraction wells are placed throughout the plume and favorable extraction rates are maintained for each well, the overall extent of the plume would not be reduced significantly, although a reduction in maximum concentrations would occur. The predictive simulation results should be regarded as conservative relative to the plume-front for two reasons. First, the simulated plumes are greater in horizontal extent than the observed plumes. Second, the physical process of retardation was neglected for TCE and PCE, where conservative retardation estimates for TCE in basin alluvium environments are typically 1.5 and for PCE are 3.0 (DBS&A, 1995a). This promotes an increased rate of migration for the predictive scenarios.

The potential for eliminating or reducing mass flux to the plume-front using interception techniques in the MPCA was examined using Scenarios Five and Six. The potential is limited due to low predicted groundwater withdrawal rates. Assessment work continues in this hydrogeologically significant area due to the potential of intercepting the high source area NDMA and DMN concentrations; for example, a series of wells along the MPCA could potentially be pumped dry and pumping be allowed to resume after some period of water level recovery. This approach would form an effective barrier to contaminant transport and is in the process of being simulated using MODFLOW-SURFACT.

Predictive simulations for Scenario Seven through Scenario Nine are presented in DBS&A (1995b). Scenario Seven is a basic and effective plume-front containment scenario, while Scenarios Eight and Nine consider the containment plus additional extraction wells in strategic areas. Scenario Seven indicates that plume containment can be achieved using four extraction wells, and four injection wells located southwest of the plume. The existing NASA-Pump Test (PT) well, which was utilized for a previously performed pump test (NASA, 1990), is suitable for service as one of the high-volume WBFZ extraction wells. Three of the four extraction wells are within the WBFZ and the remaining extraction well is in the bedrock within the southern lobe of the contaminant plume. The injection wells are positioned to the south and southwest of the plumes within or near the WBFZ. The results of the three simulations are very similar. The additional withdrawal wells in Scenarios Eight and Nine cause localized reductions in contaminant concentrations, but do not significantly affect the plume-front contaminant concentrations. Larger reductions are not observed because the pumping capacities of the additional wells are limited.

Scenario Ten presented in DBS&A (1998) was regarded as the most efficient plume-front stabilization scenario at the time of submittal of the original Plan (January 1999). The remedial system utilizes the four WBFZ plume-front extraction wells and four injection wells simulated by Scenario Seven, and adds two additional extraction wells located to the east,

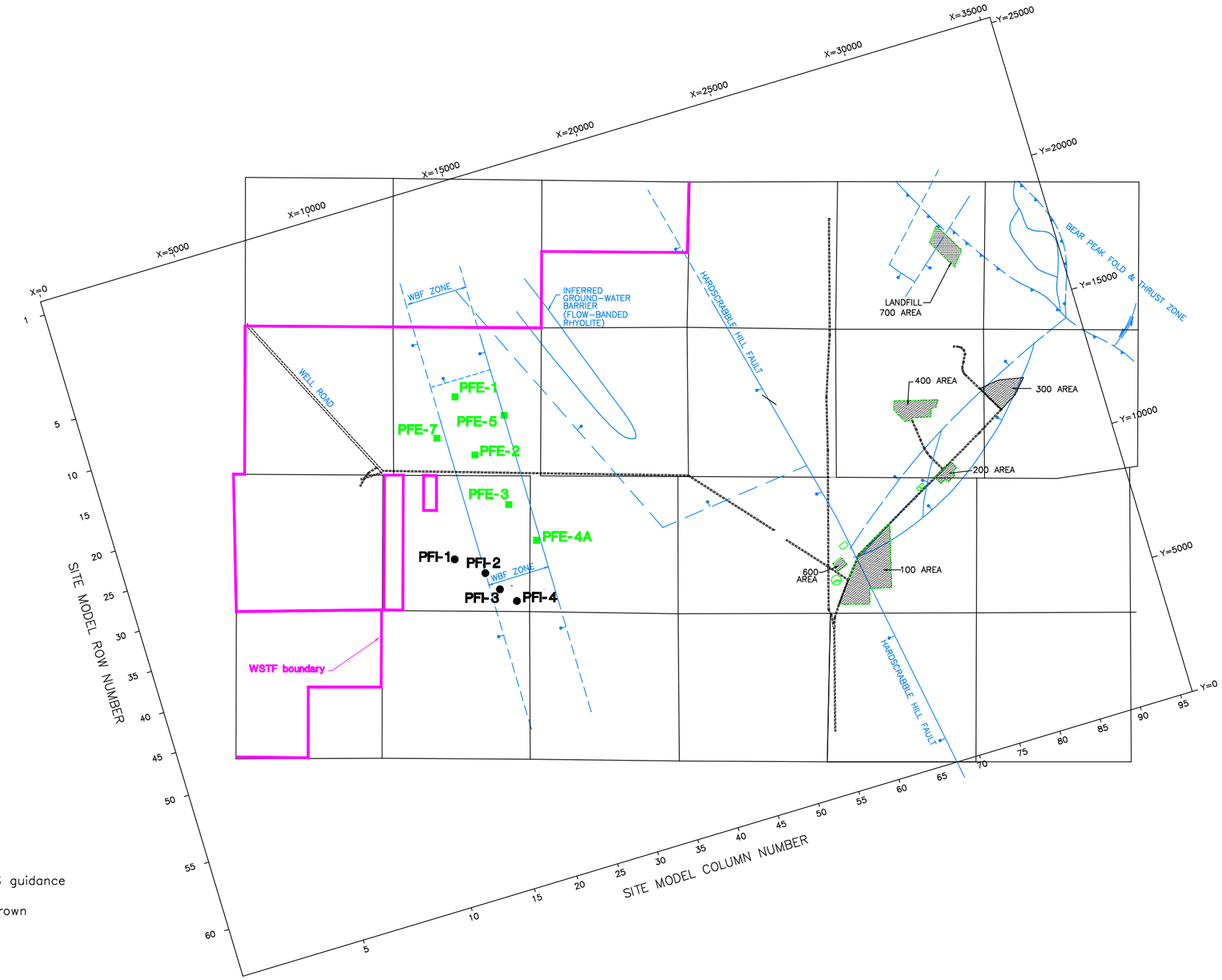
which specifically address the low-level NDMA/DMN plume-front contamination. This scenario was devised because, although the TCE plume-front is similar to the NDMA/DMN plume-front, the optimum positions for extraction wells to address mass removal for each contaminant are different. Table 4.1 summarizes the advantages of this scenario.

Following submittal of the original Plan in 1999, remediation well installations in the field were designed in accordance with Scenario Ten. Results of the field installations indicated that only one of the additional two extraction wells (PFE-5) could sustain a flowrate sufficient to be added to the plume-front stabilization scenario. The Scenario Eleven remediation system removes extraction well PFE-6 from the stabilization scenario due to the low production rate of five gpm (Table 4.1). Scenario Eleven also modifies the location of well PFE-4 to PFE-4A and adds an additional high volume well (PFE-7) to stabilize an anomalous westward protrusion of VOC contamination recently observed in the area adjacent and west of monitoring well ST-6 (Figure 2.2).

4.2 DESCRIPTION OF PLUME-FRONT STABILIZATION SCENARIO

The Scenario Eleven stabilization option from Table 4.1 succeeds Scenario Ten from the January 1999 Plume-Front Stabilization Plan as the preferred plume-front containment remedial option. Figure 4.1 presents the well configuration for this plume-front system with modifications made to account for the removal of well PFE-6 (low production rate of five gpm), repositioning of well PFE-4 to PFE-4A and the addition of well PFE-7 (modified plume configuration based on the latest analytical results through May 1, 2001). The current position of the contaminant plume is significant relative to the placement of six PFE and four PFI wells. Five extraction wells (PFE-1, PFE-2, PFE-3, PFE-4A,and PFE-7) are located in the vicinity of the WBFZ, where the vertical extent of the alluvial aquifer is confined by bedrock, and the plume can be contained without relocating in the deep alluvium of the JDMB. Well PFE-7 is located just to the west of the WBFZ, but the vertical distribution of contaminants in this area is relatively well defined. The five wells specifically address containment of the TCE plume utilizing an estimated combined flow rate of 1,050 gpm. Containing TCE will also prevent PCE from migrating further west. However, these five TCE extraction wells do not fully prevent western movement of the NDMA/DMN plumes which are not as extensive to the west. Well PFE-5 supports effective NDMA/DMN plume containment. This well is located in high NDMA concentration zones and have an estimated flow rate of 26 gpm. Containing NDMA will also contain DMN because the two plumes are extremely similar in distribution. The injection of remediated groundwater through four injection wells (PFI-1 through PFI-4) occurs to the west and south of the contaminant plumes. The injection well locations are designed to assist with containment of the southern edge of the plume by creating a localized groundwater mound. This mounding offsets future drawdown effects, and locally reverses the groundwater flow directions.

The optimum positioning of the proposed remedial well locations provided through the MODFLOW-SURFACT program reduces the volume of groundwater required for the groundwater treatment process. Plume-front extraction wells PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5 and PFE-7 are simulated to have an estimated total withdrawal rate of 1,076 gpm.



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Plume Front Containment Well Locations

Figure 4.1

Modeling work relative to the plume-front containment scenario has involved contouring NDMA data to more sensitive ppt isoconcentrations. This represents advancements in groundwater analytical technologies and addresses NDMA concentrations of health risk concern. Plume-front NDMA analytical data, with a lowered reporting limit of 10 ppt, were utilized for these modeling activities (DBS&A, 1998, DBS&A, 2000). Previous modeling activities performed for the Draft CMS Report (NASA, 1996b) addressed capture of the simulated plume to the 0.1 ppb (100 ppt) isoconcentration line.

4.2.1 Remediation Well Characteristics

Remediation well locations, pumping and injection rates and design parameters are provided in Table 4.2. The design parameters listed include well casing and annular materials specifications, well design strategies and well depth specifications. The pumping rates, injection rates and design parameters generated from extraction well field installations were incorporated into the 3DSWB model to provide the best stabilization simulation available. The total injection volume for the PFI wells was set equal to the total extraction volume for the PFE wells at 1,076 gpm.

When the remediation wells were simulated for predictive scenarios, the well discharge for each layer the well penetrated was prescribed based on hydrogeological conditions input to the 3DSWB model. Ultimately, well discharge was apportioned among model layers based on hydraulic conductivity values. The most notable discharge variations within a single well occur where the screened zone transects the alluvium/bedrock interface.

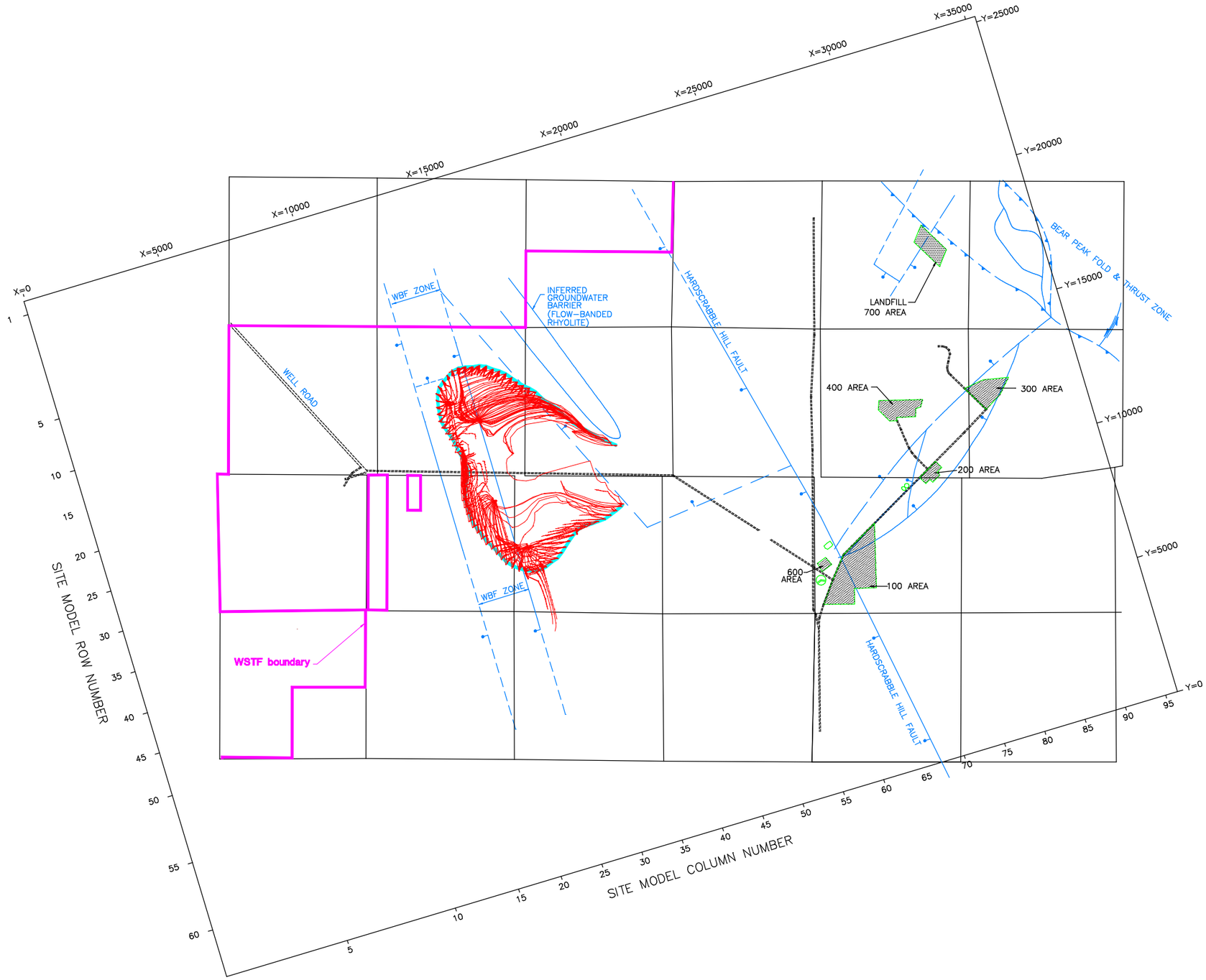
4.3 PLUME-FRONT STABILIZATION SCENARIO SIMULATIONS

4.3.1 PATH3D Plume-Front Stabilization Diagrams

Particle tracking results for NDMA (Figure 4.2) and TCE (Figure 4.3) were obtained using the PATH3D program. The particle tracking results for TCE have been modified from the original Plan to take into consideration the latest TCE groundwater plume (results through May 1, 2001) and the modified remediation well configuration. The capture of TCE at the WSTF plume-front, using the more recent and extensive May 2001 TCE plume, allows a conservative estimate of plume stabilization due to its extensive distribution relative to other contaminants such as NDMA and DMN. A series of points along the 10 ppt NDMA and 5 ppb TCE plume-fronts, defined based on recent analytical data, were used as release points. Particles were tracked in model layers 9 through 14. Effective capture of the current 10 ppt NDMA and 5 ppb TCE contours was achieved. Simulation of the plume-front stabilization scenario with the MODFLOW-SURFACT program allows variable saturation of the model cells. This provides a more exact solution of the flow equations, especially in the vicinity of the extraction and injection wells where the water levels can be anticipated to be more variable. MODFLOW-SURFACT program results and the original MODFLOW simulation results were found to be compatible.

TABLE 4.2: PLUME-FRONT CONTAINMENT WELL LOCATIONS, PUMPING RATES AND DESIGN PARAMETERS

Remedial Well	Well Coordinates relative to Model Grid	Layer	Anticipated Pumping/ Injection Rates (gpm)	Well Casing Specifications	Well Design Strategy & Depth Specifications
PFE-1	Row 15 Column 23	10 11 12 13	89 89 89 21	10.75-inch outside diameter, 85-Slot Screen	Depth to groundwater = 423 ft Anticipated pumping drawdown = <25 Screened interval (to total depth) = 389-748 ft Top of sand pack = 368 ft
PFE-2	Row 22 Column 23	10 11 12 13	93 93 24 14	10.75-inch outside diameter, 85-Slot Screen	Depth to groundwater = 434 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 398-876 ft Top of sand pack = 381 ft
PFE-3 (Existing NASA-PT Well)	Row 28 Column 25	10 11 12 13	104 104 5 0	10-inch diameter, 80-Slot Screen	Depth to groundwater = 453 ft Anticipated pumping drawdown = <15 ft Screened interval (to total depth) = 507-828 ft Actual top of sand pack = 443 ft
PFE-4A	Row 34 Column 27	10 11 12 13	60 20 60 60	10.75-inch outside diameter, 85-Slot Screen	Depth to groundwater = 370 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 398-697 ft Top of sand pack = 378 ft
PFE-5	Row 18 Column 26	10 11 12 13	12 12 1 1	9.05-inch outside diameter, 85-Slot Screen	Depth to groundwater = 451 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 418-797 ft Top of sand pack = 400 ft
PFE-7	Row 18 Column 19	10 11 12 13	59 59 4 3	10.75-inch outside diameter, 85-Slot Screen	Depth to groundwater = 413 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 398-678 ft Top of sand pack = 379 ft
PFI-1	Row 32-33 Column 19-20	10 11 12 13	73 73 57 57	9.05-inch outside diameter, 85-Slot Screen	Depth to groundwater = 419 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 418-977 ft Top of sand pack = 399 ft
PFI-2	Row 34-35 Column 21-22	10 11 12 13	105 105 20 20	9.05-inch outside diameter, 85-Slot Screen	Depth to groundwater = 437 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 418-977 ft Top of sand pack = 396 ft
PFI-3	Row 37-38 Column 22-23	10 11 12 13	147 147 16 15	9.05-inch outside diameter, 85-Slot Screen	Depth to groundwater = 447 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 418-977 ft Top of sand pack = 398 ft
PFI-4	Row 39-40 Column 23-24	10 11 12 13	83 83 7 6	9.05-inch outside diameter, 85-Slot Screen	Depth to groundwater = 458 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 398-878 ft Top of sand pack = 378 ft



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Explanation

- Simulated contaminant pathlines
- 10 part per trillion NDMA contour
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side, dashed where inferred

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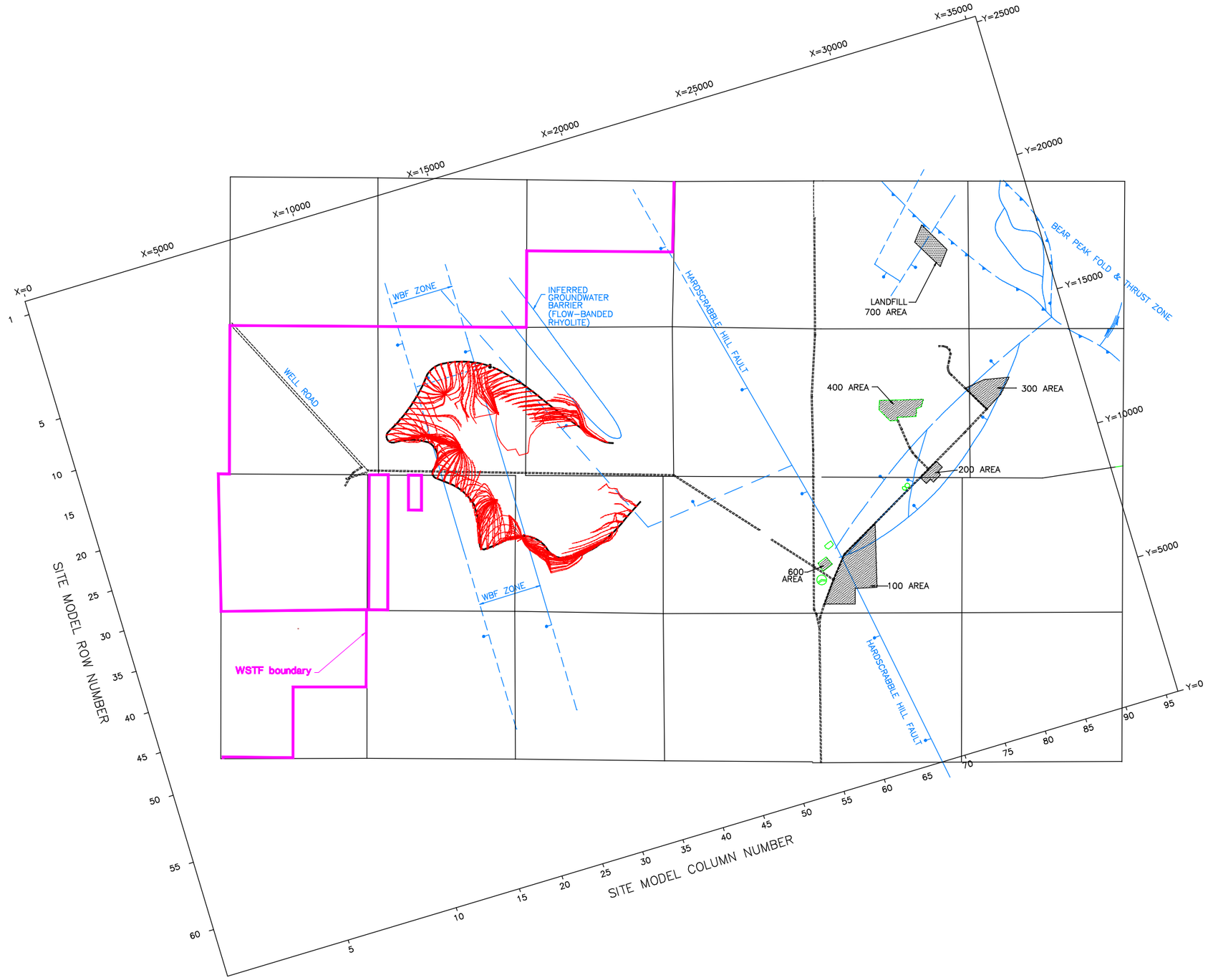
Simulated Contaminant Pathlines for NDMA Plume Front Containment

Figure 4.2



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Simulated Contaminant Pathlines for TCE Plume Front Containment

Figure 4.3

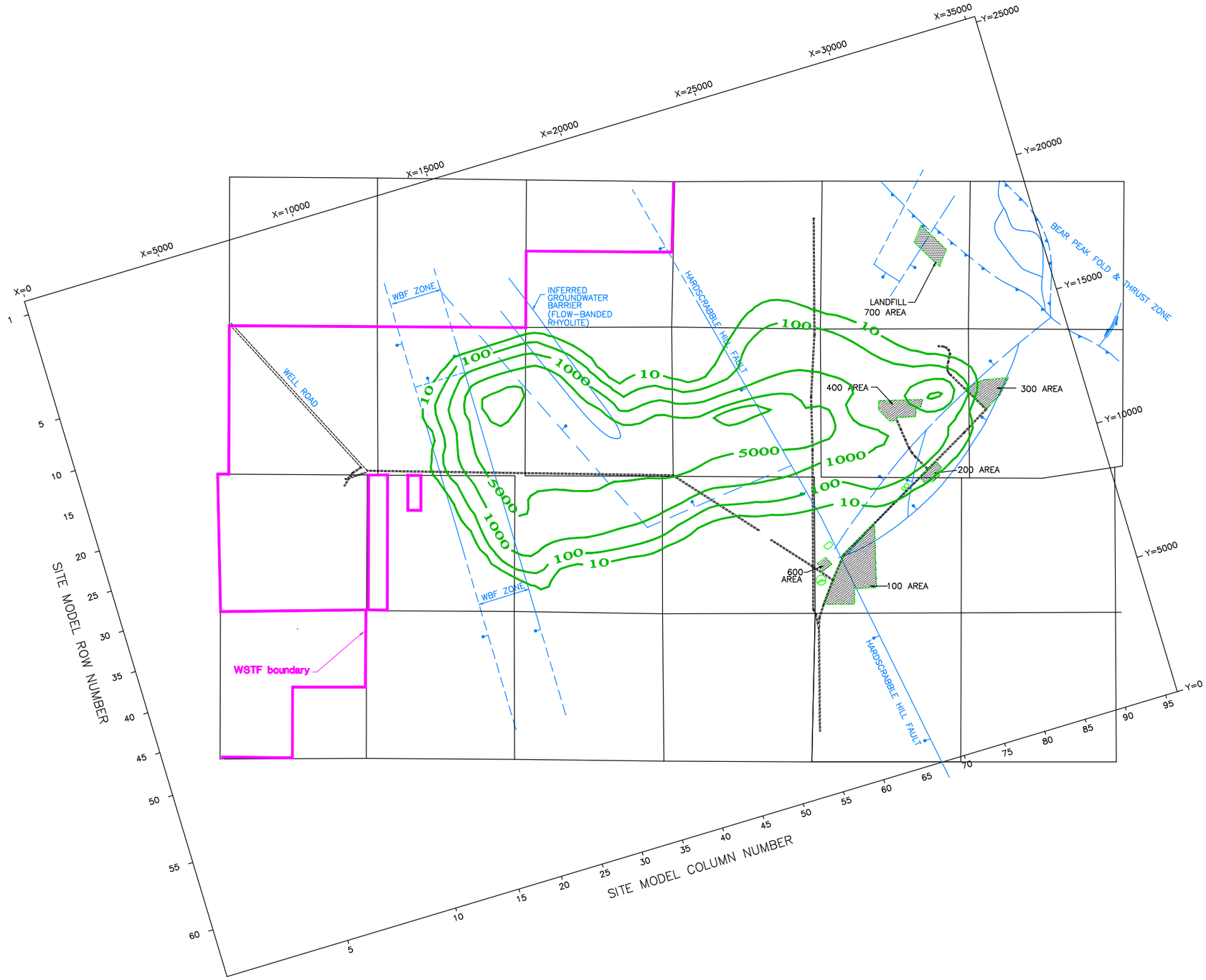
4.3.2 Predictive Plume-Front Isoconcentration Maps

Predictive plume isoconcentration maps for NDMA (to 10 ppt), TCE (to 1 ppb) and PCE (to 1 ppb) for the year 2026 are provided in Figures 4.4, 4.5 and 4.6, respectively. These predictive figures are based on the performance of the remediation system in the original Plan. Due to the similarity in well positions between the original and modified remediation systems and compatible total extraction rates, the configuration of these plumes will remain approximately the same. These figures can be compared to the current simulated plume isoconcentration maps discussed in Section 3.0 (Figures 3.1 through 3.3) to evaluate plume-front capture and mass removal. These figures illustrate that NDMA, TCE and PCE plume-front capture is achieved. Concentration reductions can be seen for each of the contaminants within the plume-front area. The leading edge of the westernmost plume, represented by the TCE plume, is retracted (a distance of approximately 2,000 feet) for the predictive simulation. The NDMA plume maps indicate stabilization of the 10 ppt contour. Differences in the retraction of the two contaminant plumes relate to the positioning of the three high volume extraction wells PFE-1 through PFE-3 designed for TCE capture, and the retardation factor input for NDMA. A significant reduction in mass over the period of the simulation occurs for NDMA, TCE and PCE (Figures 4.7, 4.8 and 4.9 respectively).

Each of the predictive simulations indicates a small zone of contaminant migration to the south in the vicinity of the eastern edge of the WBFZ. This movement is unlikely, due to the fact that contaminant particles that escape are released at greater depths in the model than current contamination observed in the field. This migration was re-evaluated as part of Scenario 11, using the 200 gpm pumping rate for extraction well PFE-4A. This rate significantly exceeded the 10 gpm pumping rate used for well PFE-4 in Scenario 10 of the original Plan. No problems for plume capture within this area were encountered.

4.3.3 Mass Extraction Calculations

Influent concentration and cumulative mass removal plots for the original Plan plume-front containment scenario for NDMA, TCE and PCE over 30 years are provided in Figures 4.7, 4.8 and 4.9, respectively. These plots are based on the simulations used to generate the plume maps in Figures 4.4, 4.5 and 4.6. The mass extraction plots for the original and modified Plans will remain approximately the same due to the similarity in well positions and compatible total extraction rates. The figures provide simulated contaminant concentrations for all extraction wells and the cumulative mass of contaminants removed. These well concentrations are indicative of concentrations that may be expected for treatment plant influent and were utilized for treatment system design. The simulated initial well concentration (or influent) for NDMA is 1,200 ppt, which gradually increases to 2,000 ppt, and is then reduced to 1,200 ppt over the period of the predictive simulation through the year 2026. Initial TCE concentrations of 130 ppb decrease relatively rapidly to less than 20 ppb during the predictive simulation, and initial PCE concentrations also show a steady decline from 4.2 ppb to less than 0.5 ppb by the end of the simulation period.



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Explanation

- 10 — Maximum simulated NDMA concentration (ppt) for 2026
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side, dashed where inferred

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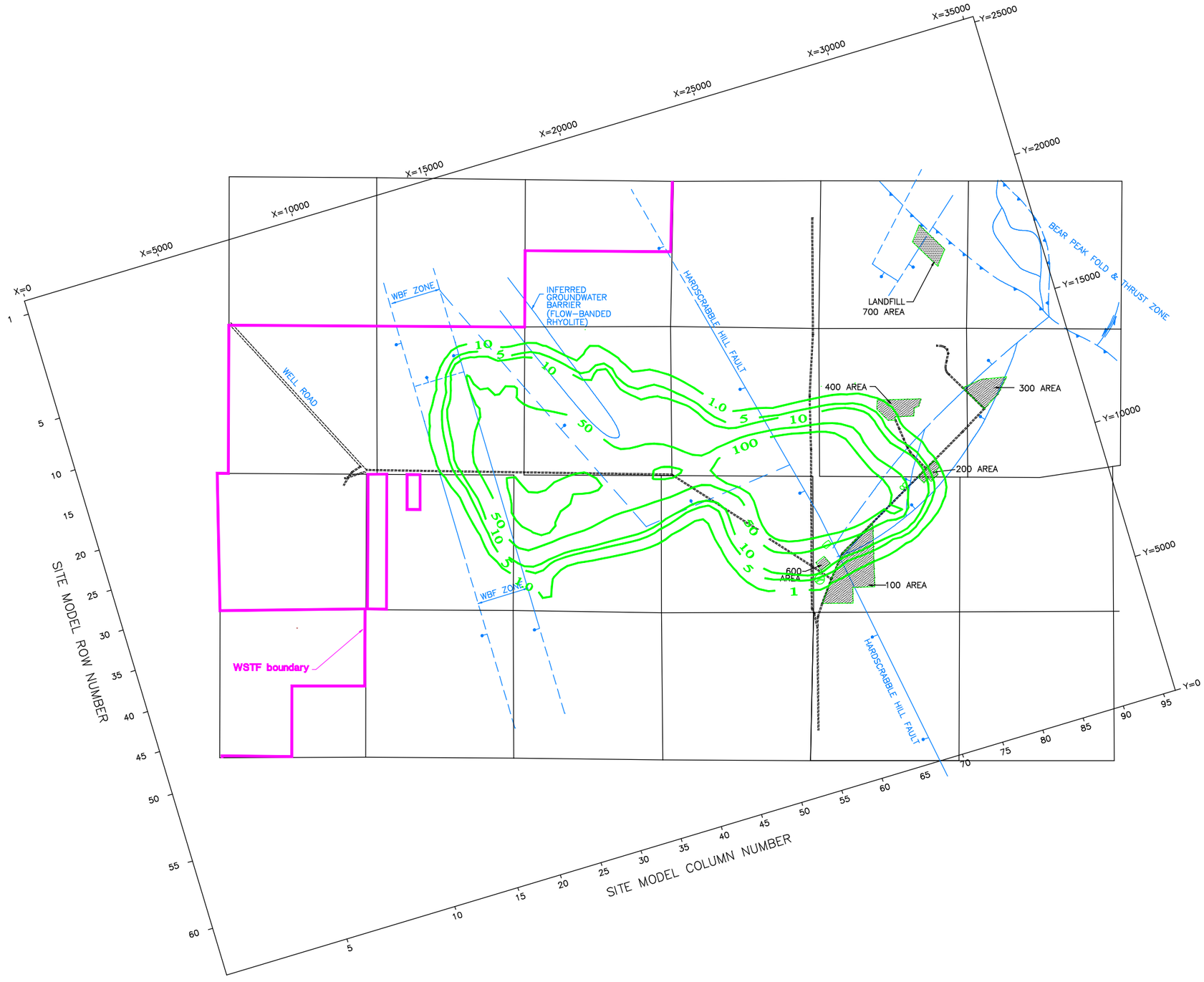
Plume Front Containment
Simulated NDMA Plume for 2026

Figure 4.4



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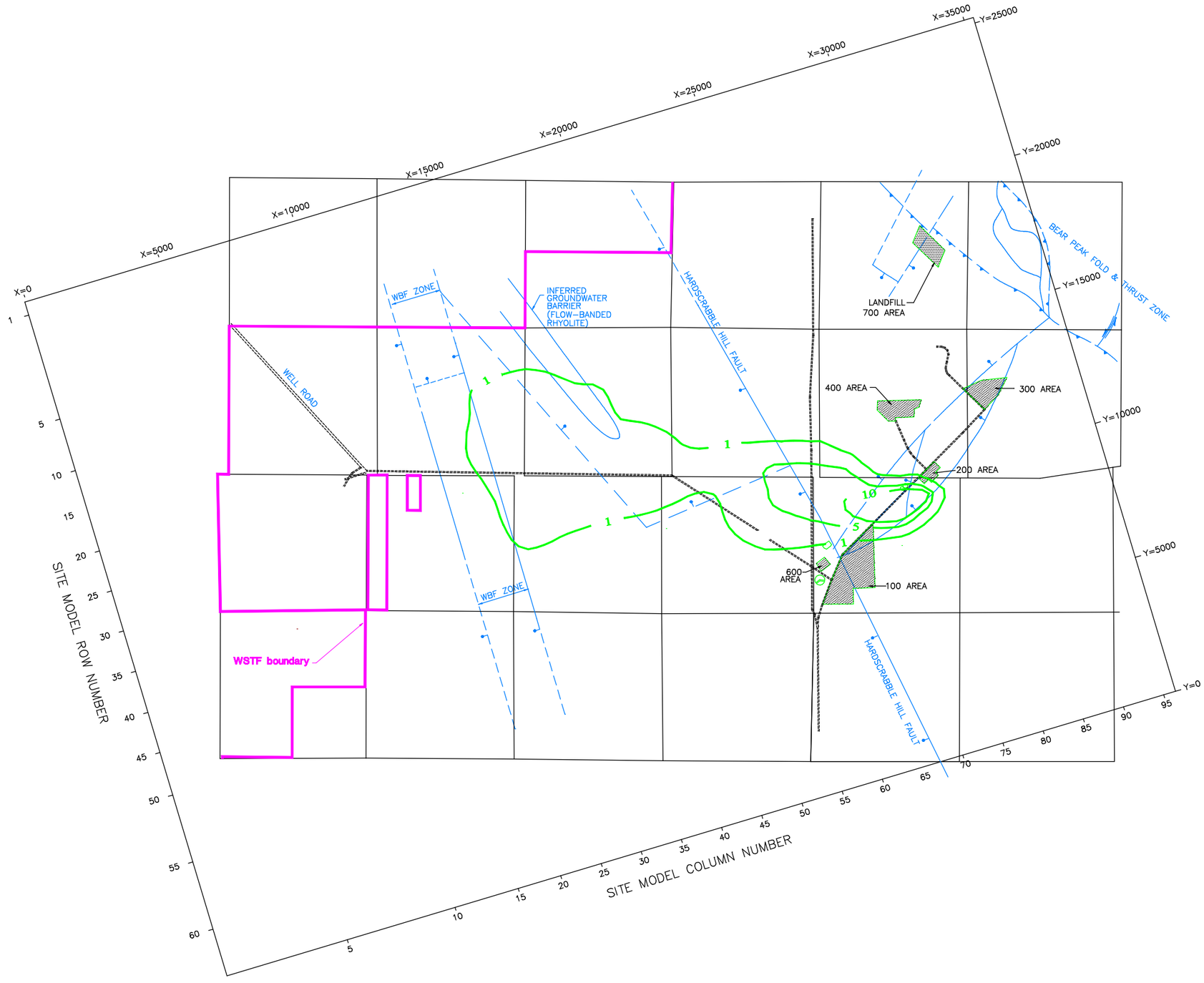
Plume Front Containment
Simulated TCE Plume for 2026

Figure 4.5



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Explanation

- 0.1 — Maximum simulated PCE concentration (ppb) for 2026
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side, dashed where inferred

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Plume Front Containment Simulated PCE Plume for 2026

Figure 4.6

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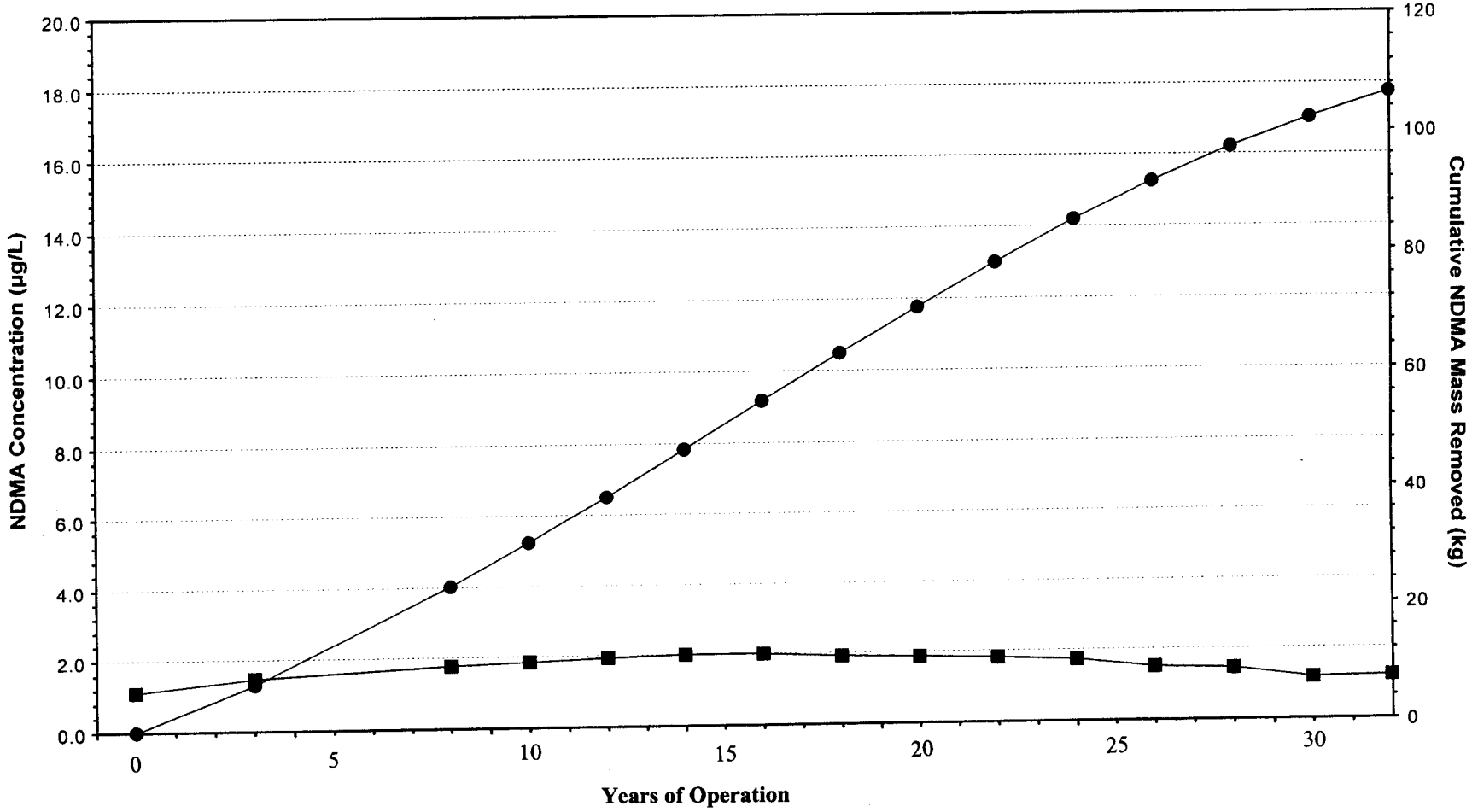

Explanation

- Well Concentration
- Cumulative Mass Removed

Figure 4.7

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Simulated NDMA Concentration and Cumulative Mass Removed for All Extraction Wells

Figure 4.7

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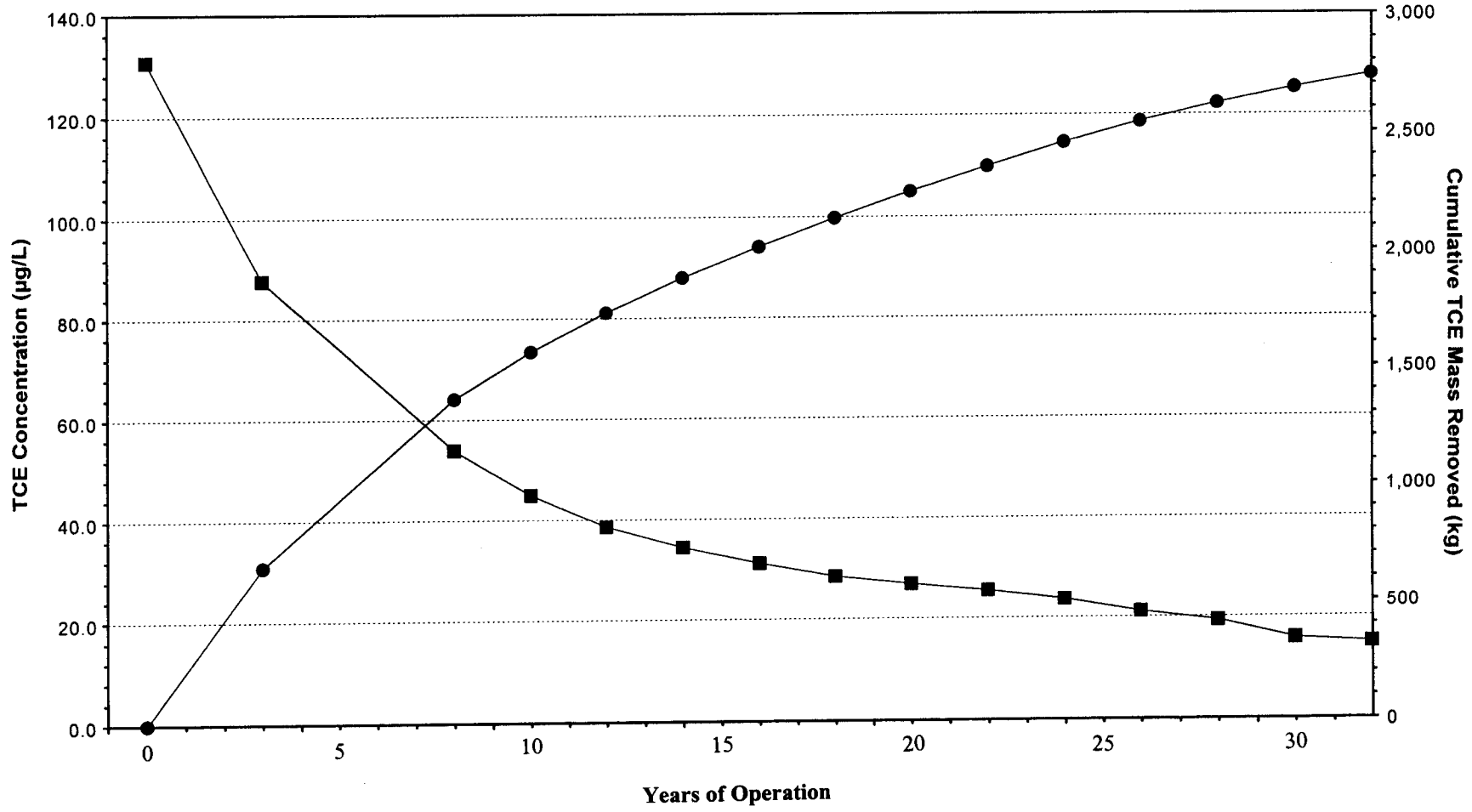

Explanation

- Well Concentration
- Cumulative Mass Removed

Figure 4.8

NASA-WSTF MODELING

Simulated TCE Concentration and Cumulative Mass Removed for All Extraction Wells

Figure 4.8

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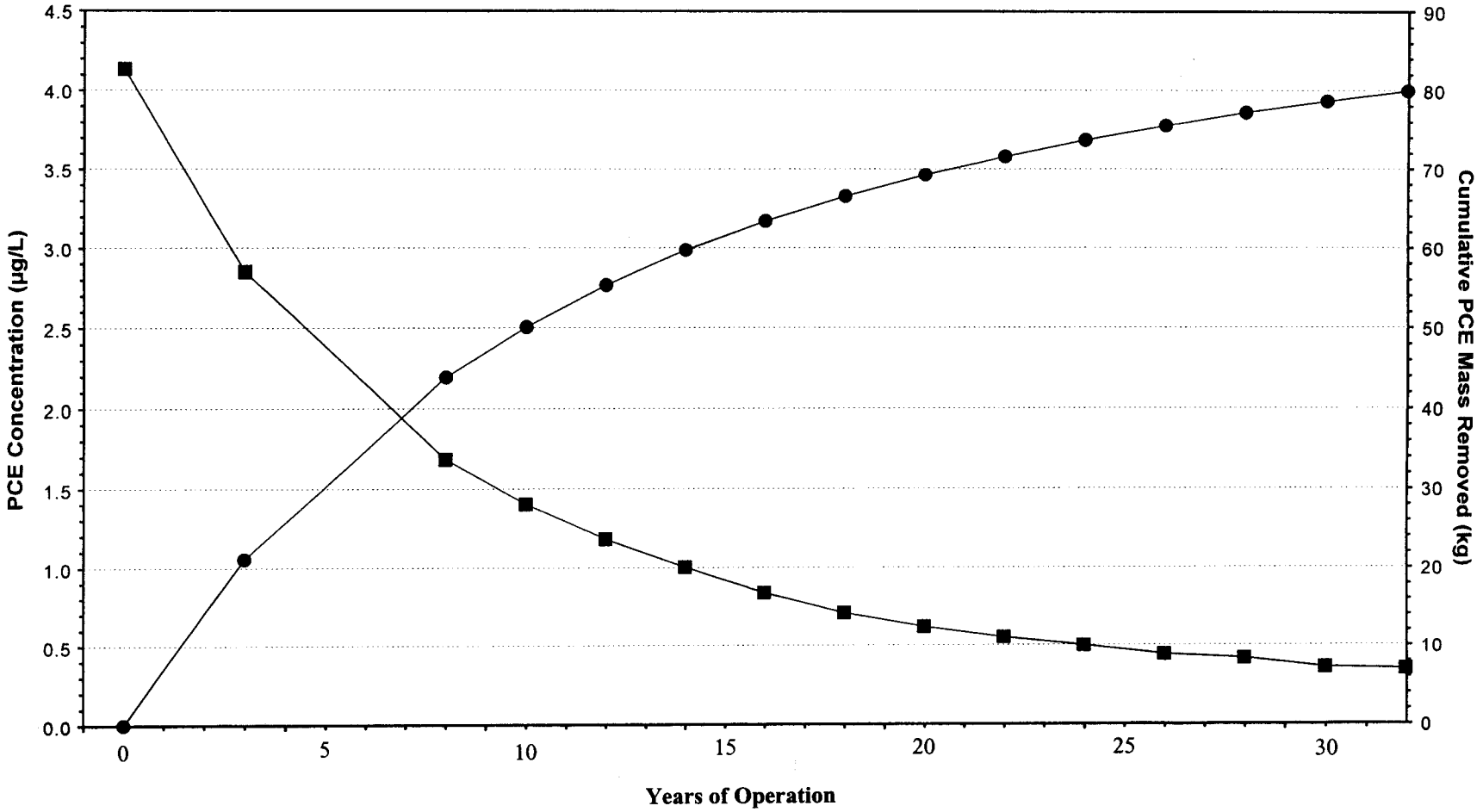

Explanation

- Well Concentration
- Cumulative Mass Removed

Figure 4.9

NASA-WSTF MODELING

Simulated PCE Concentration and Cumulative Mass Removed for All Extraction Wells

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4.3.4 Other Modeling Considerations

The 3DSWB model predictive simulation results indicate that plume-front containment can be achieved using six extraction wells (Figure 4.1) pumping at an estimated cumulative rate of 1,076 gpm. The TCE plume primarily drives the optimum placement of the five high-volume extraction wells PFE-1, PFE-2, PFE-3, PFE-4A, and PFE-7. Well PFE-4A is now considered to be a potential high volume well due to field information collected from well PFE-4. A shallow seismic survey of the area was completed in February 2001; survey results were used to confirm the position of bedrock in the area and assist in placement of the PFE-4A well. Because the TCE plume extends further west than the NDMA plume, these five wells will be located further west than the optimum location of the PFE-5 well for the NDMA plume.

Extraction well PFE-5 was added to the plume-front containment scenario to specifically address containment of the NDMA/DMN plume-front. The well was positioned within the area of highest NDMA/DMN plume-front concentrations. This well location is east of the TCE target wells adjacent to the boundary between the eastern WBFZ and the pediment slope. The placement of PFE-5 to the east of the five high-volume wells assisted with stabilization of the NDMA/DMN plume over the simulation period. Additional movement of the well to the east was restricted by the fractured-bedrock pediment aquifer, where potential extraction rates decrease by an order of magnitude.

Following installation of the remediation wells, they were evaluated to confirm that predicted water production rates were accurate and to determine groundwater contaminant concentrations. As of May 2002, extraction wells PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, PFE-7 and injection wells PFI-1 through PFI-4 had been tested for production capacity and sampled. All well capacities exceeded the required rates, and contaminant groundwater results were within the anticipated ranges. Assessments of extraction or injection wells are provided in monthly reports submitted by NASA (see section 6.3) to NMED. If any unanticipated conditions are encountered which will significantly affect water extraction or injection rates for individual wells or require movement or the addition or elimination of specified wells, the appropriate regulatory authorities will be notified in writing of the conditions and required approvals will be requested. Modeling simulations will be performed using the collected data to determine optimum pumpage rates and to determine if future injection wells are required to provide for an effective plume containment system.

4.4 TREATMENT STANDARDS

Treatment standards for this Plan have been developed following standards and guidelines from multiple Federal and State regulatory sources. Regulations and guidance documents used in the development of treatment standards include:

- the New Mexico Ground and Surface Water Protection Regulations (New Mexico Administrative Code (NMAC), 1998a);
- the New Mexico Drinking Water Regulations (NMAC, 1998b);

- concentration limits from 40 CFR 264.94 (National Archives and Records Administration (NARA), 1998a);
- Risk Assessment Guidance for Superfund (EPA, 1989);
- EPA Region 9 Preliminary Remediation Goals (EPA, 1998c); and
- other health and toxicological risk resources.

If technically achievable, the most conservative of the issued standards were selected as treatment standards. Table 4.3 provides a summary of regulatory standards and treatment goals for plume-front contaminants. EPA Region 9 has compiled a list of risk-based preliminary remediation goals (PRGs) which are used as decision-making tools for evaluating and remediating contaminated sites (EPA, 1998c). EPA indicates that PRGs are not intended as a stand-alone decision-making tool. Chemical concentrations above a PRG indicate that further evaluation of the risks posed by site contaminants is appropriate.

4.4.1 Groundwater Treatment Standards

Treatment standards for the contaminants identified at the plume-front are a combination of concentration-based and health-risk-based standards, and are summarized in Table 4.3. In selecting standards for the plume-front remediation system, three issues were addressed: the analytical reporting limits and cancer risk levels for NDMA and DMN; the concentration-based standards for TCE and PCE; and the absence of standards for the Freon compounds. The standards selected were designed to comply, as technically achievable, with state of New Mexico standards for cumulative cancer risk ($< 1 \times 10^{-5}$) and conform to a cumulative hazard index of less than 1.0.

Table 4.4 summarizes the projected influent contaminant concentrations to the plume-front remediation system, and their associated risks. The predicted influent concentrations of NDMA, TCE and PCE are taken from their respective mass extraction plots (Figures 4.7 through 4.9). The influent concentrations of DMN, Freon 11, Freon 21, and Freon 113 were assumed to be the highest historical concentrations of those compounds observed in any plume-front monitoring well. Using modeled and assumed concentrations, the cumulative cancer risk of remediation system influent is 2.23×10^{-3}, and the cumulative hazard index is 0.850. The cancer risk of the influent exceeds EPA and NMED standards, but the hazard index does not. The hazard quotients of the Freon compounds are very low, even though worst-case assumptions were made about their influent concentrations.

The proposed groundwater treatment system will utilize UV oxidation and air stripping. The UV oxidation is primarily used for NDMA/DMN treatment. TCE, PCE and the Freon compounds will be lowered to levels below treatment standards by air stripping. The removal efficiency for each VOC depends primarily on their Henry's Law constants, and solubilities. Table 3.1 summarizes those properties for each contaminant. The Henry's Law constants of TCE and PCE are 0.0117 and 0.02685 atm·m³/mole, while the Henry's Law constants of the Freon compounds range from 0.0104 to 0.526 atm·m³/mole. Similarly, the solubilities of TCE and PCE are 1,100 and 150 mg/L, while the solubilities of the Freon compounds range from 170 to 9,500 mg/L. Using the predicted influent concentration and drinking water standard for TCE, its removal efficiency must be at least

TABLE 4.3: SUMMARY OF REGULATORY STANDARDS AND REMEDIATION GOALS

Contaminant	Drinking Water Standard[1]	Groundwater Standard[2]	PRG[3]
NDMA	N/A	$<1.0 \times 10^{-5}$ Risk	1.3 ppt
DMN	N/A	$<1.0 \times 10^{-5}$ Risk	1.3 ppt[4]
TCE	5 ppb	100 ppb	1.6 ppb
PCE	5 ppb	20 ppb	1.1 ppb
Freon 11	N/A	N/A	1,288 ppb
Freon 21	N/A	N/A	N/A
Freon 113	1,200 ppb[5]	N/A	59,180 ppb
Cumulative	N/A	$<1.0 \times 10^{-5}$ Risk	N/A

1 20 NMAC 7.1-Drinking Water
2 20 NMAC 6.2-Ground and Surface Water Protection
3 EPA Region 9 Preliminary Remediation Goals (PRGs)
4 Values presented for DMN are extrapolated from published NDMA data.
5 State of California Drinking Water Standard

N/A Not Applicable

TABLE 4.4: PREDICTED INFLUENT CONTAMINANT CONCENTRATIONS TO THE PLUME-FRONT REMEDIATION SYSTEM

Contaminant	Expected Influent Concentration	Residential Cancer Risk*	Residential Hazard Quotient
NDMA	2,000 ppt [1]	1.52×10^{-3}	N/A
DMN	1,700 ppt[2]	1.29×10^{-3}	N/A
TCE	130 ppb[3]	2.13×10^{-5}	0.594
PCE	4.2 ppb[4]	3.25×10^{-6}	0.012
Freon 11	860 ppb [2]	N/A	0.079
Freon 21	60 ppb [2]	N/A	0.164
Freon 113	2,000 ppb [2]	N/A	0.002
Cumulative	---	2.84×10^{-3}	0.850

[1] Maximum concentration from Figure 4.7, Page 39.
[2] Highest historical concentration from any plume-front monitoring well.
[3] Maximum concentration from Figure 4.8, Page 40.
[4] Maximum concentration from Figure 4.9, Page 41.
N/A Not Applicable
* Residential Cancer Risk calculated using EPA age-adjusted exposure factors

$\frac{100 \times (130\ \text{ppb} - 5\ \text{ppb})}{130\ \text{ppb}} = 96.2\%$. A pilot test of a cascade air stripper was conducted by NASA in 1995. The pilot test demonstrated that VOC removal efficiencies of up to 99% could be achieved (NASA, 1996b).

Recent enhancements by a commercial analytical laboratory have resulted in the ability to achieve a 10 ppt reporting limit for NDMA and DMN using EPA Method 607. This reporting limit is lower than reporting limits established for other U. S. sites with NDMA contaminated groundwater. The current NDMA treatment standards for the Rocky Mountain Arsenal in Colorado and the GenCorp Aerojet Facility in Sacramento, California are 33 ppt (Swanick, 1998) and 100 ppt (Edson, 1998), respectively.

NASA is currently working with a commercial analytical laboratory to develop a reliable analytical method with a reporting limit more sensitive than the current 10 ppt level for NDMA and DMN. The proposal to use this method in conjunction with EPA Method 607 is in draft form and should be submitted to the NMED Hazardous Waste Bureau in the near future. At such time that the analytical method is developed to the satisfaction of both NASA and the appropriate regulatory authorities, it will be proposed as a revision to this Plan.

Table 4.5 presents the individual and cumulative risk for the proposed plume-front contaminant presumptive remedy goals. The cumulative age-adjusted cancer risk for the treatment standards is 1.98×10^{-5}, and the cumulative hazard quotient is 0.102. The projected cumulative cancer risk is slightly higher than the Ground and Surface Water Protection Regulations cancer risk level (1×10^{-5}) provided in the concentration-based standards of Table 4.3. NDMA and DMN concentrations of less than 5 ppt would achieve this cancer risk level. This level cannot currently be measured by any EPA-recommended analytical method.

The NDMA and DMN standards presented in Table 4.5 are reporting limit concentrations as received from the analytical laboratory. The EPA Method 607 allowable limits for extraction efficiency range from 13% to 109%. Per the analytical method, the laboratory cannot adjust analytical data for the observed extraction efficiencies. Typically, the off-site laboratory used by WSTF achieves an NDMA extraction efficiency of 30% to 40%. Assuming a typical extraction efficiency of 30%, a reported NDMA/DMN concentration of 10 ppt corresponds to an estimated actual concentration of 33 ppt. The residential cancer risk associated with reported NDMA and DMN concentrations of 10 ppt and an extraction efficiency of 30% are shown in Table 4.6.

In summary, the anticipated development, implementation and approval of a more sensitive analytical method for NDMA and DMN will result in lowered reporting limits for these contaminants and allow NASA to measure and verify lowered treatment levels for NDMA and DMN. Recent data received for a potential alternative method are promising, but no definitive time frame can be provided for completion.

TABLE 4.5: TREATMENT STANDARDS FOR PLUME-FRONT CONTAMINANTS

Contaminant	Treatment Standards	Residential Cancer Risk (Age Adjusted)	Residential Hazard Quotient	Basis
NDMA	10 ppt	7.6×10^{-6}	N/A	Method 607 Reporting Limit
DMN	10 ppt	7.6×10^{-6}	N/A	Method 607 Reporting Limit
TCE	5 ppb	8.2×10^{-7}	0.023	20 NMAC 7.1
PCE	5 ppb	3.8×10^{-6}	0.014	20 NMAC 7.1
Freon 11	100 ppb	N/A	0.009	Conservative Health Risk Value
Freon 21	20 ppb	N/A	0.055	Conservative Health Risk Value
Freon 113	1,200 ppb	N/A	0.0011	California Drinking Water Standard
Cumulative	---	1.98×10^{-5}	0.102	---

N/A Not Applicable

TABLE 4.6: INDIVIDUAL AND CUMULATIVE RISK ASSUMING 30% ANALYTICAL EXTRACTION EFFICIENCY FOR NDMA AND DMN

Contaminant	Treatment Standard (Estimated Actual Concentration)	Residential Cancer Risk (Age Adjusted)	Residential Hazard Quotient
NDMA	10 ppt (33 ppt actual)	2.5×10^{-5}	N/A
DMN	10 ppt (33 ppt actual)	2.5×10^{-5}	N/A
TCE	5 ppb	8.2×10^{-7}	0.023
PCE	5 ppb	3.8×10^{-6}	0.014
Freon 11	100 ppb	N/A	0.009
Freon 21	20 ppb	N/A	0.055
Freon 113	1,200 ppb	N/A	0.0011
TOTAL	---	5.4×10^{-5}	0.102

N/A Not Applicable

4.5 PRESUMPTIVE REMEDY REMEDIAL SYSTEM CONCEPTUAL DESIGN

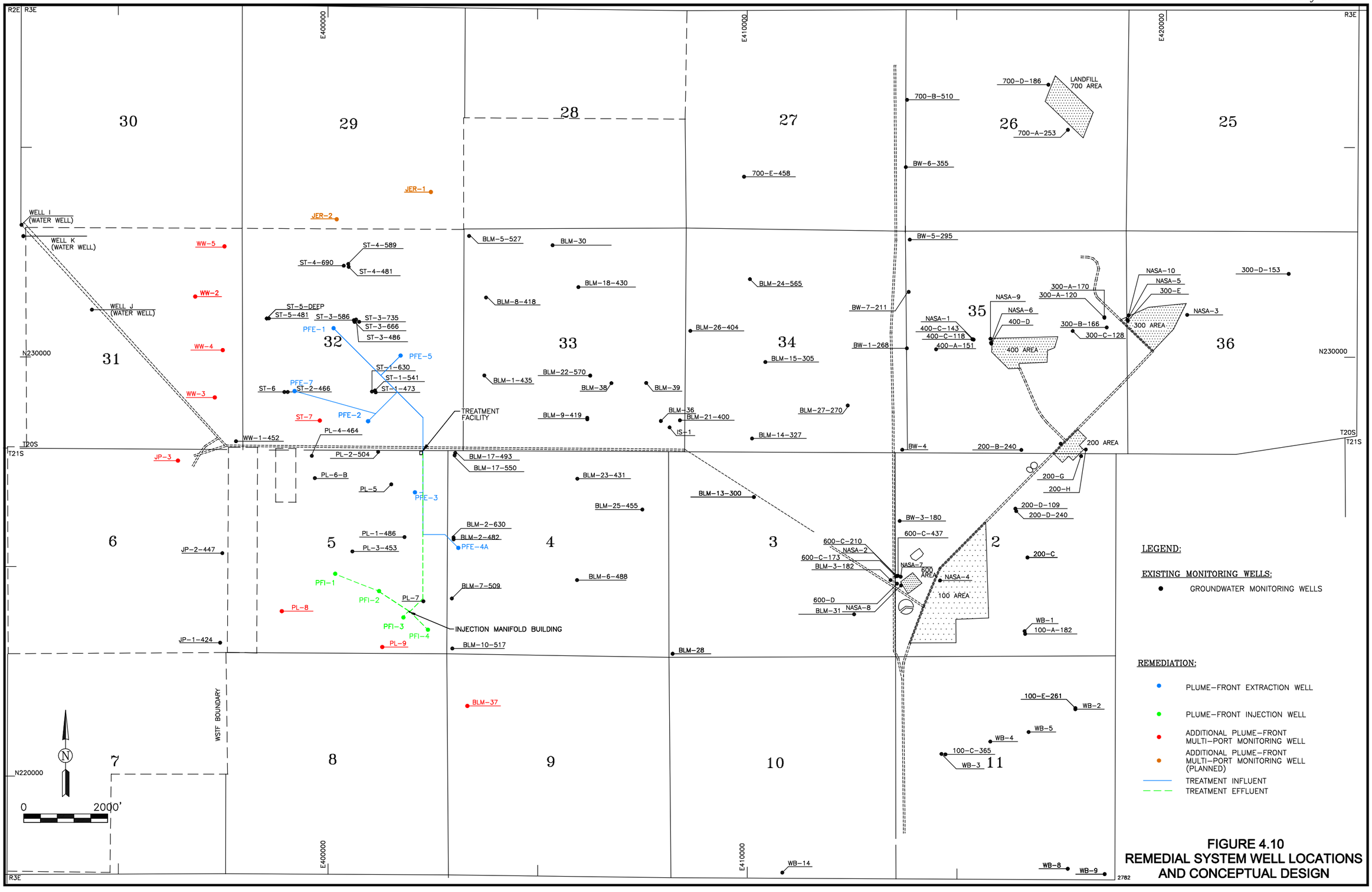
The plume-front remediation system will consist of: nine additional groundwater monitoring wells (WW-2, WW-3, WW-4, WW-5, ST-7, JP-3, PL-8, PL-9 and BLM-37); six groundwater extraction wells (PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5 and PFE-7); groundwater transport pipelines from the extraction wells to the treatment facility; air stripping and UV oxidation treatment systems; pipelines from the treatment facility to the injection wells; and four groundwater injection wells (PFI-1 through PFI-4).

The additional plume-front monitoring wells will be installed to enhance vertical delineation of the plume-front, aid in the design and location of extraction and injection wells, enhance plume-front monitoring capabilities, and support monitoring of the effectiveness of the containment system. The plume-front remediation system will be designed to remove contaminant mass at the plume-front and create a hydraulic barrier to prevent further westward migration of the plume. The locations of the monitoring wells, extraction wells, injection wells, and the treatment system are illustrated by Figure 4.10.

Treatment alternatives for NDMA, described in Volume One, Chapter Three of the Draft CMS Report (NASA, 1996b), indicate that the contaminant is recalcitrant to treatment. UV oxidation is the only practicable technology available for both NDMA and DMN. The UV oxidation treatment will not independently remediate the halogenated VOCs to acceptable levels, therefore air stripping will be initially used to complement the UV oxidation system.

The anticipated performance of the full-scale plume-front treatment system is summarized in Table 4.7. The influent NDMA, PCE and TCE concentrations are the maximum values expected during the lifetime of the presumptive remedy, based on hydrogeological modeling. The projected maximum influent concentrations of NDMA, PCE and TCE are taken from their respective mass removal plots derived from the plume-front containment modeling simulations (Figures 4.7, 4.8, and 4.9). Concentrations of DMN and the other halogenated VOCs listed in Table 4.7 are equal to the highest concentration of each contaminant measured in any of the plume-front wells. The effluent concentrations of NDMA and DMN will be below the current 10 ppt reporting limit of EPA Method 607.

The locations of the extraction wells were selected based on the results of hydrogeological modeling (Figure 4.1). The depths and diameters of the extraction wells were designed based on the plume-front containment modeling simulation (Table 4.2), and the results of a pump test previously performed on the existing NASA PT well (NASA, 1990), which is plume-front extraction well PFE-3. Hydrogeological modeling provides an extraction flow rate of 1,076 gpm for the most efficient plume-front containment scenario (Sections 4.2 and 4.3 of this Plan). NASA anticipates that additional extraction wells may be installed in the future, for either possible MPCA remedial actions or to supplement plume-front wells identified by this Plan. Therefore, the UV oxidation and VOC treatment equipment will be designed to accommodate a maximum flow rate of 1,250 gpm.



LEGEND:

EXISTING MONITORING WELLS:

- GROUNDWATER MONITORING WELLS

REMEDIATION:

- PLUME–FRONT EXTRACTION WELL
- PLUME–FRONT INJECTION WELL
- ADDITIONAL PLUME–FRONT MULTI–PORT MONITORING WELL
- ADDITIONAL PLUME–FRONT MULTI–PORT MONITORING WELL (PLANNED)
- TREATMENT INFLUENT
- TREATMENT EFFLUENT

FIGURE 4.10
REMEDIAL SYSTEM WELL LOCATIONS AND CONCEPTUAL DESIGN

TABLE 4.7: ANTICIPATED PLUME-FRONT REMEDIATION SYSTEM PERFORMANCE

Criteria	Value	
Estimated Nominal Flow Rate	1,076 gallons per minute	
Estimated Maximum Flow Rate	1,238 gallons per minute	
Predicted Influent Concentrations	NDMA DMN PCE TCE Freon 11 Freon 21 Freon 113	2,000 ppt[1] 1700 ppt[2] 4.2 ppb[3] 130 ppb[4] 860 ppb[2] 60 ppb[2] 2,000 ppb[2]
Predicted Effluent Concentrations	NDMA DMN PCE TCE Freon 11 Freon 21 Freon 113	< 10 ppt < 10 ppt 0.06 ppb [5] 3.8 ppb [5] 43 ppb [6] 3 ppb [6] 100 ppb [6]
Effluent Cancer Risk	---	$<1.25 \times 10^{-5}$ [7]

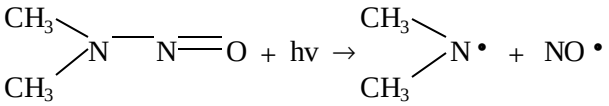
1 Maximum concentration from Figure 4.7, Page 39.
2 Highest historical concentration from any plume-front monitoring well.
3 Maximum concentration from Figure 4.8, Page 40.
4 Maxumum concentration from Figure 4.9, Page 41.
5 Based on packed-tower aeration model calculations.
6 Represents a conservative 95% reduction in influent concentrations.
7 Based on 100% NDMA/DMN analytical extraction efficiency.

The pipeline from the extraction wells to the treatment facility will be constructed of double-walled high-density polyethylene (HDPE) pipe. In the event of a leak in the inner pipe, the annular space between the inner and outer pipes will serve as secondary containment. Leak detection sensors will be installed in the annular space to aid in the detection and localization of any leaks. The extraction pipeline will be installed underground to protect against external damage, exposure to solar UV radiation, thermal expansion/contraction, and freezing.

Groundwater pre-treatment may be required to remove turbidity, suspended solids and hardness from the water. Hardness values observed in plume-front monitoring wells have ranged from 173 to 613 mg/l (as $CaCO_3$). These hardness values represent a significant potential for scaling in the treatment system, pipelines, wells, and/or the injection formation. A polyphosphate scale control chemical (AquaMag or equivalent) will be injected into the process piping, upstream of the airstrippers to prevent the formation of scale in the air strippers and UV reactor.

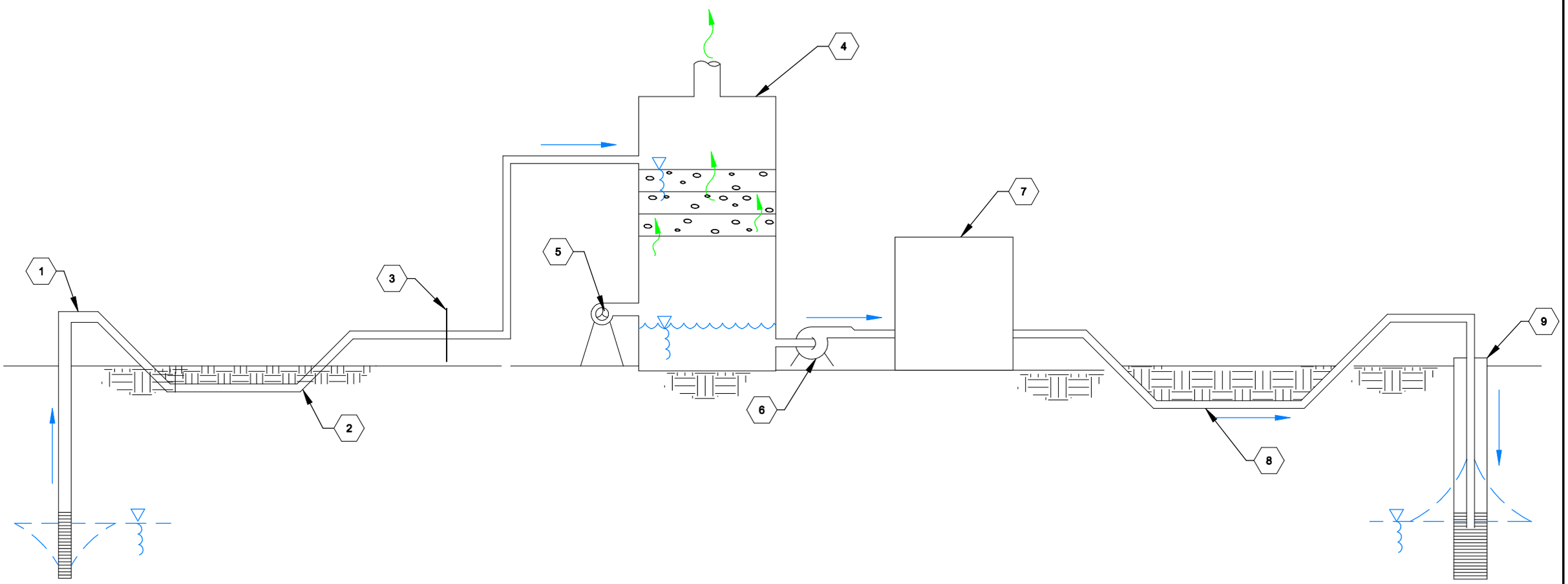
The treatment system will utilize two sieve-tray air strippers, operating in parallel, to remove VOCs from contaminated groundwater. A process flow diagram illustrating the conceptual arrangement of the treatment system is presented in Figure 4.11.

Following air stripping, UV/oxidation will be utilized to treat the NDMA and DMN. NDMA absorbs UV radiation most strongly in a band centered around 227 nm. The wavelength of the UV radiation emitted by the lamps is in the range 200-250 nm. Absorption of UV radiation breaks the N-N bond, producing a NO radical and a dimethylamino radical:



Prior to the purchase of the UV oxidation treatment equipment, bench-scale and pilot-scale testing of the equipment was performed to ensure satisfactory system performance and allow development of an engineering design basis. This testing was performed as a part of the UV oxidation system Technical Feasibility Study (discussed in Section 6.4.2). Both the bench- and pilot-scale test results indicated the UV power required would be about 1 kilowatt-hour (kW·hr) per 1000 gallons (3,785 liters) treated per order of magnitude reduction in NDMA concentration. The UV oxidation system contains twelve UV lamps (each rated at 30 kW), with a total power requirement of 360 kW. At the design flow rate of 1,076 gpm (4,073 Lpm), nine lamps will be operated to achieve the NDMA and DMN design discharge concentration of 2 ppt.

NASA has previously performed bench-scale testing of a UV oxidation system and the results were reported in Volume Two, Chapter Two the Draft CMS Report (NASA, 1996b). The pipeline to the injection wells will consist of single-wall HDPE pipe. The pipeline will be installed underground, to protect against external damage, exposure to the solar UV radiation, thermal expansion/contraction, and freezing.



1 GROUNDWATER EXTRACTION WELLS
2 EXTRACTION PIPELINE (DUAL–WALL) POLYETHYLENE
3 POLYPHOSPHATE SCALE CONTROL INJECTION
4 LOW PROFILE SIEVE TRAY AIR STRIPPER FOR VOC TREATMENT
5 AIR BLOWER
6 INJECTION PUMP
7 UV OXIDATION SYSTEM FOR NDMA TREATMENT
8 INJECTION PIPELINE (SINGLE WALL)
9 GROUNDWATER INJECTION WELLS

AIR FLOW

WATER FLOW

FIGURE 4.11
REMEDIAL SYSTEM
PROCESS FLOW DIAGRAM

Injection wells PFI-1 through PFI-4 were installed southwest of the plume-front, as shown in Figure 4.10. The locations of the injection wells were selected based on the results of hydrogeological modeling presented in Section 4.2. The well casing and annular materials specifications, design strategy and depth specifications are provided in Table 4.2. Tubing installed in the casing will allow the injection of the treated groundwater below the pre-injection static water level. Cathodic protection will be installed on extraction well PFE-3, which utilizes carbon steel casing. Flow rates and water levels will be monitored throughout the operation of the injection wells.

Installation of the monitoring wells, extraction wells, injection wells, and treatment equipment will be a staged process. This process is discussed in Section 6.2 of this Plan. Following original Plan submission in January 1999, NASA submitted a Discharge Plan (DP) application for the injection wells to the NMED GWQB (DP-1255) on February 10, 1999 which was subsequently approved on March 10, 2000. All of the necessary drilling permits for plume-front wells have been coordinated through the State Engineer's Office (SEO). As of May 2002, NASA has completed the installation of ten remediation wells (extraction wells PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, and PFE-7 and injection wells PFI-1 through PFI-4). During the drilling, installation, testing, and sampling of these wells, the treatment system design, procurement and construction has been in progress. NASA have also completed the installation of the nine additional Westbay® multi-port wells (WW-2, WW-3, WW-4, WW-5, ST-7, JP-3, PL-8, PL-9 and BLM-37) designed to assist in the monitoring of the remediation system.

4.6 SITE SAFETY AND SECURITY

Access to the WSTF site is controlled by a security force that is on duty on a 24-hour, 365 day per year basis. Security guards control access to the industrial complex and also patrol the plume-front area at least every 8 hours during non-working hours.

Due to the nature of their design, the extraction and injection wellheads are sealed to prevent the loss of untreated or treated groundwater. This design also prevents the accidental or intentional introduction of foreign materials into these wells. The water treatment equipment will be located inside a building. The treatment facility building will be locked, and access restricted to authorized WSTF employees. In addition, access to the treatment facility building will be restricted by the use of fencing and a locked gate.

The treatment building is equipped with a fire alarm, fire extinguishers, first aid kit, and eyewash. The on-site Fire Department at WSTF provides emergency response service on a 24-hour, 365 day per year basis.

4.7 SYSTEM START-UP

Final procurement specifications are being generated and procurement of the treatment system and the ancillary equipment is in progress. Upon award of all contracts, NASA will be able to complete final design packages and basic operating procedures for the remediation system.

Following installation, the full-scale treatment system will undergo a start-up period of approximately six months. During the start-up period, the system will be intermittently operated to determine the most effective conditions for contaminant treatment, identify any potential design refinements and ensure system integrity. Treated effluent collected during the start-up pumping periods will be stored in a series of holding tanks pending receipt of laboratory analyses. If the water in the holding tank does not meet treatment standards, it will be recycled through the treatment system or transferred to the permitted WSTF 200 Area Hazardous Waste Evaporation Tanks. If the effluent does meet treatment standards, the treated groundwater will be injected.

4.8 REMEDIAL SYSTEM OPERATION AND MAINTENANCE AND CONTINGENCY PLANNING

4.8.1 Operation and Maintenance

The WSTF plume-front stabilization and groundwater treatment system will require normal, periodic maintenance of various components to ensure optimum operating efficiencies and to minimize potential impacts to human health or the environment. Detailed operational and maintenance (O&M) procedures will be provided as well as design packages for the system. A description of water sampling activities is presented in Section 5.0 of this Plan.

4.8.2 Contingency Plan

Appendix A provides the most recent Contingency Plan for the NMED-approved Hazardous Waste Operating Permit for WSTF. This Contingency Plan will be incorporated into this Plan. If the NMED approves future modifications to the Contingency Plan contained within the Hazardous Waste Operating Permit, NASA will provide the modified plan for inclusion as Appendix A of this document.

The plume-front stabilization and groundwater treatment system design will incorporate several interlocks that will halt system operation when specific conditions arise. These conditions include:

- leakage within the dual-wall extraction piping;
- near-surface water levels within injection well(s);
- catastrophic failure of any major component (i.e., air stripper blower motor, injection pump, extraction pumps, UV system); and
- significant leakage from any piping or component within the treatment building facility.

In the event of a significant component failure that results in a system shut-down of more than 24 hours, NASA will notify the NMED verbally within 24 hours and in writing within 72 hours of the event. The written notification will summarize system status, cause of shut-down, response taken and/or planned, expected duration of the shut-down, and any potential impacts on human health and the environment.

4.8.3 Waste Management

Wastes generated from the construction, operation or maintenance of the system will be handled and disposed of per the WSTF Standard Instruction, Waste Management (NASA, 1998b) and the NMED-issued Hazardous Waste Operating Permit for NASA.

Rainwater accumulation and run-off are not anticipated to be a concern; the treatment building that houses the treatment equipment will be located away from existing surface drainage features. The building site will be graded to route roof drainage and precipitation run-on away from the proposed treatment facility.

5.0 SAMPLING AND ANALYSIS

5.1 INTRODUCTION, OBJECTIVES AND SCOPE

As described in previous sections of this document, NASA has determined that plume-front containment and groundwater treatment is required to prevent further migration of the contaminated groundwater at the plume-front. Nine additional plume-front monitoring wells have been installed to ensure the effectiveness of the plume-front containment system and to supplement existing monitoring wells. Figure 4.10 provides locations for these additional groundwater monitoring wells. These additional wells were completed as Westbay multi-port® wells with four sampling zones and depths of approximately 1,000 feet.

Current WSTF documentation provides detailed instructions for groundwater contamination assessment and monitoring activities. This section compliments the existing documentation with the requirements for the plume-front remediation system.

The purpose of this section is to describe the WSTF Sampling and Analysis Plan for the plume-front remediation system. This plan provides personnel with project-specific procedures for the collection and analysis of samples associated with plume-front containment activities. These will be used in conjunction with the most recently approved WSTF Groundwater Sampling and Analysis Plan (SAP) (NASA, 1997b) and the WSTF Quality Assurance Project Plan (QAPP) (NASA, 1997c). The most recently approved SAP and QAPP are provided as Appendix B and C, respectively, of this Plan. If future modifications to these Plans are approved, NASA will submit the modified versions to replace the current appendices of this Plan.

These Plans list procedures which address the following:

- collection and preservation of groundwater samples;
- quality assurance and quality control (QA/QC);
- data quality objectives;
- chain of custody documentation;
- sample shipment; and
- sample analysis.

The protocols specified in this section assure that samples are collected in a consistent manner, representative of actual environmental conditions, shipped and tracked in an acceptable manner, and analyzed using appropriate EPA-recommended analytical methods. The QA/QC portion of this Plan, used in conjunction with the WSTF QAPP, provides the quality assurance steps necessary to substantiate data collected for this project.

5.2 SAMPLING ACTIVITIES AND FIELD METHODS

WSTF personnel are responsible for conducting all sampling activities associated with the plume-front remediation project. Current WSTF sample collection and quality control procedures will be followed during all phases of the project. Samples will be collected at designated groundwater monitoring wells and sampling points within the remediation system.

All plume-front containment and remediation sampling events will be performed using the same sample collection protocols utilized for 3008(h) Consent Order groundwater assessment sampling events. All necessary safety issues will be addressed and procedures followed as directed in the relevant documentation. This includes, but is not limited to, the following:

- use of appropriate safety equipment (boots, gloves, goggles, etc.) during sampling activities;
- field logbook annotation with all relevant information as outlined in the WSTF QAPP;
- use of proper decontamination procedures;
- use of appropriate sample containers and preservation techniques as outlined in Table 5.1;
- strict adherence to QA/QC procedures; and
- strict adherence to WSTF sample documentation and chain of custody requirements as outlined in the WSTF QAPP.

5.2.1 Groundwater Monitoring

Tables 5.2 and 5.3 designate monitoring wells that will be sampled specifically for this Plan. These wells include existing conventional and Westbay multi-port® wells utilized for RFI/CMS sampling, as well as the additional Westbay monitoring wells installed as a part of this Plan.

Conventional groundwater monitoring wells will typically use non-dedicated pumps to evacuate the necessary volume of purge water and dedicated Teflon bailers to collect samples. Typically, an air driven piston pump is used to purge the well and collect indicator parameters. When the required volume of water has been purged and groundwater parameters have stabilized, the pump is withdrawn and the well is sampled using the dedicated bailer. Samples are collected in the appropriate sample containers, labeled, sealed, and prepared for shipment to the appropriate analytical laboratory. Specific instructions for purging and sampling conventional monitoring wells using this process are provided in the WSTF SAP.

TABLE 5.1: SAMPLE COLLECTION AND ANALYSIS REQUIREMENTS

TREATMENT FACILITY/GROUNDWATER ANALYTES				
Analysis	**EPA Method**	**Sample Container[1]**	**Sample Preservative[1]**	**Holding Time[1]**
Halogenated Volatile Organics	EPA Method 8021 or EPA approved/recommended equivalent	40 mL amber glass	Cool to $4^{O}C$	14 days
Volatile Organics	EPA Method 8260 or EPA approved/recommended equivalent	40 mL amber glass	Cool to $4^{O}C$	14 days
NDMA/DMN	EPA Methods 607, 8070 or EPA approved/recommended equivalent	1 L amber glass	Cool to $4^{O}C$	7 days until extraction 40 days after extraction
TREATMENT FACILITY ANALYTES FOR ENGINEERING PURPOSES				
Analysis	**Method**	**Sample Container**	**Sample Preservative**	**Holding Time**
Cations	EPA Method 6010B or EPA approved/recommended equivalent	1 L polyethylene	$4^{O}C$, 0.45 um filtration, HNO_3 to pH<2	6 months
<u>Anions</u> Total Alkalinity	EPA Method 310.1 or EPA approved/recommended equivalent	1 L polyethylene	Cool to $4^{O}C$	14 days
Chloride, Sulfate	EPA Method 300.0 or EPA approved/recommended equivalent			28 days
Fluoride	ASTM SM 4500 F C or EPA approved/recommended or equivalent			14 days
Nitrate/Nitrites	EPA Method 353.2 or EPA approved/recommended equivalent	500 mL polyethylene	$4^{O}C$, H_2SO_4 to pH<2	28 days
Total Dissolved Solids	EPA Method 160.1 or EPA approved/recommended equivalent	500 mL polyethylene	Cool to $4^{O}C$	7 days
Ammonia	EPA Method 350.1 or EPA approved/recommended equivalent	500 mL polyethylene	$4^{O}C$, H_2SO_4 to pH<2	28 days

[1] Sample containers, preservations and holding times will remain consistent with current regulatory and SW-846 guidance.

TABLE 5.2: PLUME-FRONT SAMPLING FREQUENCIES FOR CONVENTIONAL WELLS/ZONES

Well/Zone ID	Sampling Frequency
BLM-2-482	Semi-Annually[1]
BLM-2-630	Semi-Annually[1]
BLM-7-509	Semi-Annually[1]
BLM-10-517	Semi-Annually[1]
BLM-17-493	Semi-Annually[1]
BLM-17-550	Semi-Annually[1]
JP-1-424	Quarterly
JP-2-447	Quarterly
PL-1-486	Semi-Annually[1]
PL-2-504	Semi-Annually[1]
PL-3-453	Semi-Annually[1]
PL-4-464	Semi-Annually[1]
ST-1-473	Semi-Annually[1]
ST-1-541	Semi-Annually[1]
ST-1-630	Semi-Annually[1]
ST-2-466	Semi-Annually[1]
ST-3-486	Semi-Annually[1]
ST-3-586	Semi-Annually[1]
ST-3-666	Semi-Annually[1]
ST-3-735	Semi-Annually[1]
ST-4-481	Quarterly
ST-4-589	Quarterly
ST-4-690	Quarterly
WW-1-452	Annually[1]

[1] Indicates after active extraction/remediation/reinjection activities have been initiated, the well will be monitored monthly for four months, bi-monthly for eight months and revert to the sampling frequency specified in the WSTF Sampling and Analysis Plan thereafter.

TABLE 5.3: PLUME-FRONT SAMPLING FREQUENCIES FOR WESTBAY® MULTI-PORT WELLS/ZONES

WELL/ZONE ID	SAMPLING FREQUENCY
BLM-37-490	Quarterly
BLM-37-640	Quarterly
BLM-37-750	Quarterly
BLM-37-885	Quarterly
JP-3-515	Quarterly
JP-3-695	Quarterly
JP-3-825	Quarterly
JP-3-970	Quarterly
PL-5-495	Quarterly
PL-5-595	Quarterly
PL-5-715	Quarterly
PL-5-795	Quarterly
PL-5-895	Quarterly
PL-5-985	Quarterly
PL-6-545	Quarterly
PL-6-725	Quarterly
PL-6-915	Quarterly
PL-6-1035	Quarterly
PL-6-1195	Quarterly
PL-6-1335	Quarterly
PL-6-1485	Quarterly
PL-6-1645	Quarterly
PL-6-1815	Quarterly
PL-7-480	Semi-Annually[1]
PL-7-560	Semi-Annually[1]
PL-7-630	Semi-Annually[1]
PL-8-455	Quarterly
PL-8-605	Quarterly
PL-8-780	Quarterly
PL-8-965	Quarterly
PL-9-484	Quarterly
PL-9-594	Quarterly
PL-9-814	Quarterly
PL-9-964	Quarterly
ST-5-485	Semi-Annually[1]
ST-5-655	Semi-Annually[1]
ST-5-815	Semi-Annually[1]
ST-5-985	Semi-Annually[1]
ST-5-1175	Semi-Annually[1]
ST-6-535	Quarterly
ST-6-575	Quarterly
ST-6-685	Quarterly

TABLE 5.3: PLUME-FRONT SAMPLING FREQUENCIES FOR WESTBAY® MULTI-PORT WELLS/ZONES (continued)

WELL/ZONE ID	SAMPLING FREQUENCY
ST-6-830	Quarterly
ST-6-975	Quarterly
ST-7-450	Quarterly
ST-7-550	Quarterly
ST-7-785	Quarterly
ST-7-975	Quarterly
WW-2-495	Quarterly
WW-2-670	Quarterly
WW-2-845	Quarterly
WW-2-960	Quarterly
WW-3-468	Quarterly
WW-3-569	Quarterly
WW-3-710	Quarterly
WW-3-978	Quarterly
WW-4-423	Quarterly
WW-4-594	Quarterly
WW-4-853	Quarterly
WW-4-953	Quarterly
WW-5-464	Quarterly
WW-5-582	Quarterly
WW-5-814	Quarterly
WW-5-912	Quarterly

[1] Indicates after active extraction/remediation/reinjection activities have been initiated, the well/zone will be monitored monthly for four months, bi-monthly for eight months and revert to the sampling frequency specified in the WSTF Sampling and Analysis Plan thereafter.

Samples are also collected from Westbay multi-port® wells. Westbay wells are sampled with specialized equipment that collects groundwater directly from the formation through sampling ports in the Westbay casing. A MOSDAX® sampler probe, with attached sample collection bottles and electronic surface controls, can sample groundwater in-situ for uncompromised sample quality. The probe and bottles are inserted into the well, lowered to the desired sampling port and sample collection is initiated. When the sample bottles are filled, they are raised to the surface where the groundwater is dispensed into the appropriate sample container. Refer to Table 5.1 for sample container, preservation and analytical requirements. Westbay sampling procedures are provided in the WSTF SAP.

5.2.2 Treatment System Monitoring

Treatment facility efficiency will be monitored by sampling/analyzing the untreated and treated groundwater at multiple locations. Sample taps will be installed at each of the extraction wells and on the treatment facility influent and effluent piping. These sampling locations will allow monitoring of the influent and effluent contaminant concentrations and allow verification/adjustment of modeling simulations during the operational life of the treatment facility. The O&M Plan for this system will provide specific sampling instructions for influent, effluent and system monitoring port sampling. Table 5.4 provides the influent/effluent sample schedule.

5.2.3 Treatability Testing

NASA has previously performed bench-scale testing of a UV oxidation system and the results were reported in Volume Two, Chapter Two the Draft CMS Report (NASA, 1996b). NASA performed pilot-scale testing of a UV oxidation system between March 25 and April 9, 1999. The results of the testing are discussed in Section 6.4.2. Procedures in the SAP and QAP in effect at that time were utilized during the bench-scale and pilot-scale tests.

5.2.4 Treatment System Start-Up

The analyses for the treatment system operation cannot be performed on a real-time basis. Samples are analyzed by off-site laboratories and analytical data for specific sampling events will not be available until weeks after sample collection. Therefore, a high level of confidence is required to ensure that all phases of the treatment system operate effectively and consistently.

Following installation of the remediation system, high intensity start-up sampling of the treatment system will be performed. During this testing, all treated water will be contained in tanks and verified to meet the treatment standards of this Plan prior to injection. Specifics concerning this start-up testing will be provided in the forthcoming Operations and Maintenance Plan.

TABLE 5.4: INFLUENT/EFFLUENT SAMPLING SCHEDULE

Time Period	Sampling Location	Sampling Frequency	Analytes
0-3 Months (initial start-up and testing period)	Treatment Facility Influent and Effluent Piping	Twice per week (during operational periods)	NDMA, DMN, halogenated volatiles, and general inorganics
0-3 Months (initial start-up and testing period)	Each Extraction Well	Once per week (during operational periods)	NDMA, DMN, halogenated volatiles, and general inorganics
After 3 Months	Treatment Facility Influent and Effluent Piping	Once per month	NDMA, DMN, halogenated volatiles, and general inorganics
3-12 Months	Each Extraction Well	Quarterly	NDMA, DMN, halogenated volatiles, and general inorganics

5.3 SAMPLE COLLECTION, SCHEDULING, AND ANALYSIS

5.3.1 Sample Collection

Groundwater samples will be collected from specified wells prior to the installation and during operation of the treatment facility. These samples will be collected from the plume-front monitoring and extraction wells prior to system operation. These data will provide background information to evaluate the long-term effectiveness of the plume-front containment system.

5.3.2 Sampling Frequencies

Tables 5.2 and 5.3 provide sampling frequencies for all plume-front monitoring wells for volatile, halogenated volatile and nitrosamine analyses. All inorganic water quality parameters will be collected on at least a semi-annual basis.

5.3.3 Analytical Methods

Based on historical groundwater assessment data, WSTF has identified specific contaminants in the plume-front groundwater. The specific contaminants targeted for containment and remediation include halogenated volatile organics, NDMA and DMN. WSTF has incorporated the use of the most sensitive analyte-specific EPA-recommended analytical methods for the identification and quantitation of these compounds. As discussed previously, NASA is working with an off-site analytical laboratory to reliably lower the reporting limits for NDMA and DMN using a method not currently approved by EPA. If this method is approved for use by both NASA and the appropriate regulatory authorities, it will be included for use in this Plan.

5.4 QUALITY ASSURANCE PROJECT PLAN

5.4.1 Purpose

This QAPP establishes guidelines for ensuring that the monitoring data for this Plan are scientifically valid, of known quality and legally defensible. To achieve these goals, the following specific QAPP requirements are addressed:

- a consistent and acceptable framework for the collection and generation of physical and chemical data;
- data quality objectives that measure the precision, accuracy, comparability and completeness of generated data;
- acceptance criteria for the data measurements to ensure that data collection and analytical systems provide data of sufficient quality for the program;
- the early detection of deficiencies that may affect data quality and provide corrective actions;
- sufficient document control to verify data completeness; and

- a fundamental framework for the storage and management of plume-front stabilization data.

All data-generation steps, including sample collection, analyses, document control, and data review are performed using established procedures to ensure reported data quality, accuracy and completeness. This document, and adherence to guidelines outlined in specific EPA analytical methods, the WSTF SAP, the WSTF QAPP and site-specific procedural documentation, ensures that data meet the project-specific requirements for this Plan.

5.4.2 Project Organization

The contractor Environmental Department organizational structure is discussed in Section 6.1 of this Plan. All sample collection, analysis and data management activities are performed by or coordinated through the contractor Environmental Department. All personnel who collect environmental data will have access to, and a clear understanding of, this document, the WSTF SAP, the WSTF QAPP, and applicable site-specific procedural documentation.

5.4.3 Off-Site Laboratories

NASA contracts off-site laboratories to analyze groundwater samples in support of RFI/CMS activities, Post-Closure Care monitoring and other regulatory driven activities. Prior to awarding any analytical support contracts, each off-site laboratory must submit their laboratory QAPP to the contractor Environmental Department for review and approval. Appendix C contains the QAPP for laboratories currently performing analytical work for this Plan. Since contracts for analytical services are recompeted and renewed on at least an annual basis, new laboratories may be contracted. Contract laboratories may also revise their QAPPs. If either change occurs, NASA will submit to EPA and NMED the appropriate QAPP for inclusion in Appendix C.

5.4.4 Data Quality Objectives

Quantitative measurements used to estimate true physical and chemical conditions involve some level of uncertainty. Uncertainty can be attributed to natural variability, sampling handling operations and conditions, spatial and temporal patterns, and analytical variability. It is critical that levels of uncertainty are measured and acceptable limits of uncertainty established.

Several parameters are measured to estimate the level of uncertainty of generated data. Data quality is characterized by the precision, accuracy, reproducibility, completeness, and comparability parameters.

Detailed definitions and discussions of the parameters that characterize data quality are contained in Section 3.0 of the most current approved WSTF QAPP (Appendix C). The guidance contained in the WSTF QAPP will be used for this Plan.

5.4.4.1 QA/QC Samples

Several types of QA/QC samples are required to evaluate data uncertainty. A list of field and analytical QA/QC samples and a brief description of each is provided in Tables 5.5 and 5.6. Frequencies for these samples are provided in Tables 5.7 and 5.8. Frequencies represent a summary of guidance from specific EPA analytical methods and site-wide (SW) document SW-846 (EPA, 1997). EPA methods provide specific details of the verification required for each analytical process.

5.4.4.2 QA/QC Sample Requirements

It is essential that all QA/QC samples are of the highest possible quality. Reference standards will be certified prior to use. Reagent water used for field and laboratory blanks will be continuously monitored for non-interference with the analyses. Blind quality control standards will represent the types and concentrations of constituents normally found in the WSTF groundwater.

In order to alleviate bias generated by the analytical laboratories, all environmental and audit samples are submitted "blind." Samples are disguised in a manner where laboratory personnel do not recognize the sample source or composition. Identities of all samples, including QA/QC samples, are recorded in the field logbook. Documentation provided to laboratory personnel (i.e., chain of custody forms, sample labels and sample seals) does not contain any information concerning sample identities.

5.4.4.3 Data Quality Requirements

The acceptability requirements for data produced in support of this Plan are provided in Table 5.9. This table provides data quality objectives for detectability, precision, accuracy, and completeness for groundwater matrices. Table 5.10 describes the data qualifiers used to identify data that does not meet the objectives outlined in Table 5.9.

5.4.5 Sample Containers, Preservation and Holding Times

Table 5.1 specifies sample containers, preservation and holding time requirements for samples associated with this Plan. In general, samples not analyzed within the specified holding times are not acceptable for reporting purposes. If the data are crucial, samples are retaken to provide the required information. However, if resampling of the environmental source is impractical, samples that have exceeded their holding times are analyzed and reported with the appropriate data qualifier.

Blind quality control samples and analytical check standards are subject to the same holding time requirements as environmental samples. When blind quality control samples are prepared, the corresponding container is annotated with the preparation date. Blind quality control samples for volatile organics analysis are prepared immediately prior to shipment to the analytical lab.

TABLE 5.5: DESCRIPTION OF FIELD QUALITY CONTROL SAMPLES

Sample Type	Description
Equipment Blank	ASTM Type II water is transported to the sampling site, opened, poured over and/or through the sampling device, and collected in sample containers. This type of blank indicates the effectiveness of decontamination procedures and also indicates contamination in the field which may affect analytical results.
Field Blank	ASTM Type II water is transported to the sampling site, opened and poured directly into sample containers. This type of sample provides a check on reagent quality and contamination derived in the field.
Trip Blank	ASTM Type II water is poured into sampling containers in a contaminant free environment, placed in coolers, transported to the field, back to the laboratory, and analyzed. This type of sample serves as a check on sample contamination originating from sample handling, transport, shipping, and site conditions. This sample may also be used to estimate the system detection limit.
Blind QC Sample	A check standard is prepared from a source other than the calibration standard, which is provided blind to the analytical lab. This type of sample serves as an independent check of analytical techniques, handling and standards.
Field Duplicate	A second sample is taken immediately after an original sample at the same sampling location. This sample provides an estimate of the overall system precision.

TABLE 5.6: DESCRIPTION OF ANALYTICAL QUALITY CONTROL SAMPLES

Sample Type	Description
Reagent Blank	ASTM Type II water is processed through the entire analytical process which, at the time of analysis, contains the same reagent concentrations as samples that have been processed. This type of sample indicates contamination resulting from the preparation or processing of a sample. This sample can be used to establish the analytical detection limit.
Sample Matrix Spike	A predetermined amount of stock solution, containing an analyte of interest, is added to the sample matrix prior to sample extraction/digestion and analysis. This sample indicates the effects of the sample matrix on analysis and also is a measure of the accuracy of the measurement system.
QC Check Standard	A standard is obtained from a source other than the calibration standard. This sample indicates the accuracy and consistency of calibration.
Surrogate Spike	Introduction of a compound similar to the analytes of interest, but not normally found in environmental samples, blanks and standards. This type of sample provides a continuous monitor of the performance of the analytical system and the effectiveness of the method in dealing with sample matrices.
Matrix Duplicate	An intralaboratory split sample which is used to document the precision of a method in a given sample matrix.
Matrix Spike Duplicate	Intralaboratory split samples spiked with identical concentrations of target analyte(s). The spiking occurs prior to sample preparation and analysis. These samples are used to document the precision and bias of a method in a given sample matrix.

TABLE 5.7: FIELD QA/QC CONTROL SAMPLE FREQUENCIES

Control	Halogenated Volatile Organics Method	Volatile Organics Method	Nitrosamines Method
Equipment Blank	100% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	100% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	5% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.
Field Blank	Not required if equipment blanks are taken, otherwise 100% of all halogenated volatile organics sampling days.	Not required if equipment blanks are taken, otherwise 100% of all volatile organics sampling days.	Not required if equipment blanks are taken, otherwise 5% of all nitrosamine sampling days or at least once per month, whichever is the most frequent.
Duplicate Sample	10% of all halogenated volatile organics sampling events or at least once per month, whichever is the most frequent.	10% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	10% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.
Blind QC Sample	5% of all halogenated volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.
Trip Blank	5% of all halogenated volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.

TABLE 5.8: ANALYTICAL QA/QC CONTROL SAMPLE FREQUENCIES

Type Of Control	Halogenated Volatile Organics	Volatile Organics	Nitrosamines
Reagent Blank	At least daily.	At least daily.	One for each set of samples processed.
Sample Matrix Spike	10% of samples analyzed.	5% of samples analyzed.	10% of samples analyzed.
QC Check Standard	10% or less frequently if spike recoveries meet all specified QC criteria.	5% or less frequently if spike recoveries meet all specified QC criteria.	10% or less frequently if spike recoveries meet all specified QC criteria.
Surrogate Spike	100% of all blanks, samples and standards.	100% of all blanks, samples and standards.	100% of all blanks, samples and standards.
Replicate Sample	Aliquoting is not appropriate; therefore, duplicate samples must be analyzed for 5% of the samples analyzed.	Aliquoting is not appropriate; therefore, duplicate samples must be analyzed for 5% of samples analyzed.	5% of samples analyzed.

TABLE 5.9: METHOD SPECIFIC DATA ACCEPTIBILITY REQUIREMENTS

Analysis	Measurement Units	RL	Precision[1]	Accuracy[2]	Completeness[3]
Halogenated Volatile Organics	µg/L	[4]	[4]	[4]	80
Volatile Organics	µg/L	[5]	[5]	[5]	80
NDMA	µg/L	0.010	25	13-109	80
DMN	µg/L	0.010	25	13-109	80

RL - Reporting Limit.

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[1] As relative percent difference for field duplicates.
[2] As percent recovery of matrix spikes.
[3] Percentage of measurements which meet expressed data quality criteria for precision, accuracy and detectability.
[4] Specific criteria are provided in the halogenated volatile organics method.
[5] Specific criteria are provided in the volatile organics method.

TABLE 5.10: DESCRIPTION OF DATA QUALITY ASSURANCE FLAGS

Data Qualifier	Description
*	User defined flag.
A	Indicates that the result of an analyte for a check standard (LCS or CCV) was outside standard limits.
AD	Indicates that the precision for analyst duplicates was outside standard limits.
EB	Indicates that the analyte was detected in the equipment blank at or above the reporting limit.
FB	Indicates that the analyte was detected in the field blank at or above the reporting limit.
G	Indicates that the result is an estimated value greater than the calibration limit.
J	Indicates that the result is an estimated value less than the reporting limit, but greater than or equal to the detection limit.
NA	Indicates that the value/result was either not analyzed or not applicable.
ND	Indicates that the analyte was not detected at or above the detection limit.
Q	Indicates that the result for a blind control was outside standard limits.
QD	Indicates that the precision for a field duplicate was outside standard limits.
RB	Indicates that the analyte was detected in the reagent blank at or above the reporting limit.
S	Indicates that the result was determined by the method of standard addition.
SP	Indicates that either the spike recovery or the relative percent difference for spike duplicates was outside standard limits.
T	Indicates that the analyte was analyzed outside the specified holding time.
TB	Indicates that the analyte was detected in the trip blank at or above the reporting limit.
TIC	Indicates that the analyte was tentatively identified by a GC/MS library search and the amount reported is an estimated value.

CCV Continuous Calibration Verification
GC/MS Gas Chromatography/Mass Spectroscopy
LCS Laboratory Calibration Standard

6.0 PROJECT MANAGEMENT

6.1 ORGANIZATION

The NASA Environmental Program Manager directs all activities associated with WSTF environmental compliance and the plume-front remediation project. The site contractor Environmental Department, under the direction of the NASA Environmental Program Manager, performs and/or coordinates all activities associated with the project. Figure 6.1 provides an organizational chart for NASA WSTF environmental activities.

Design, implementation, operation, and maintenance of the plume-front containment project will be supported by a contractor Environmental Department staff of over 30 engineers, hydrogeologists, scientists, and technicians experienced in multiple facets of environmental compliance.

In addition, support from the existing WSTF infrastructure is available. This includes heavy equipment, engineering, drafting, and administrative support. For activities in which WSTF infrastructure is not available (well drilling services, groundwater modeling expertise, downhole geophysical logging, etc.), off-site contractors will be used.

6.2 SCHEDULE

The anticipated time-line for design and implementation of the plume-front containment project is presented as Figure 6.2. Although every effort will be made to adhere to this schedule, there are multiple factors beyond the control of NASA, which may impact it. These factors include:

- the timeframe required to provide the electrical power distribution system to the project area;
- the regulatory review/approval timeframes associated with submitted reports and plans;
- the ability to schedule subcontractor support; and
- the availability of vendor-supplied equipment and materials.

If the projected time-line elements cannot be completed in compliance with the schedule, NASA shall, as early as possible, notify the appropriate regulatory agencies with identification of the delay, contributing factors for the delay, and revised time-line projections.

6.3 REPORTING REQUIREMENTS

Progress and subsequent data reporting will be accomplished through use of the monthly RFI/CMS reports to EPA/NMED. The format of the current reports will be modified to accommodate reporting of activities and data directly applicable to plume-front containment. These reports will at a minimum provide: significant project accomplishments; activity updates; monitoring data; and significant problems and corrective actions taken. NASA will initiate use of these reports as soon as plume-front activities are initiated.

NASA White Sands Test Facility
Environmental Compliance

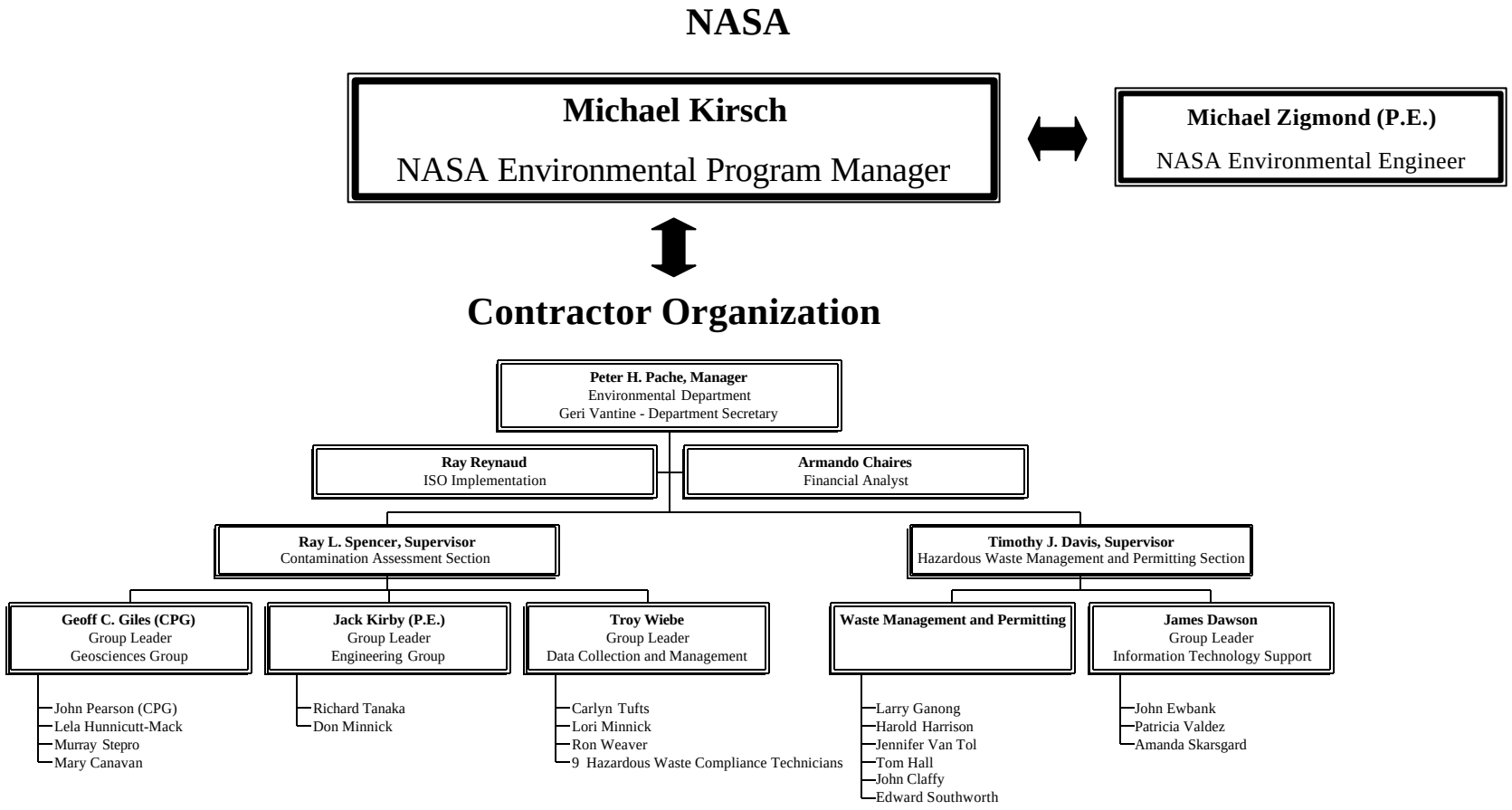


Figure 6.1

Organizational Chart for NASA WSTF Environmental Activities

NASA WSTF Plume-Front Stabilization Timeline
Fri 5/10/02

National Aeronautics and Space Administration/White Sands Test Facility
Plume-Front Stabilization Work Plan
Modified May 2002

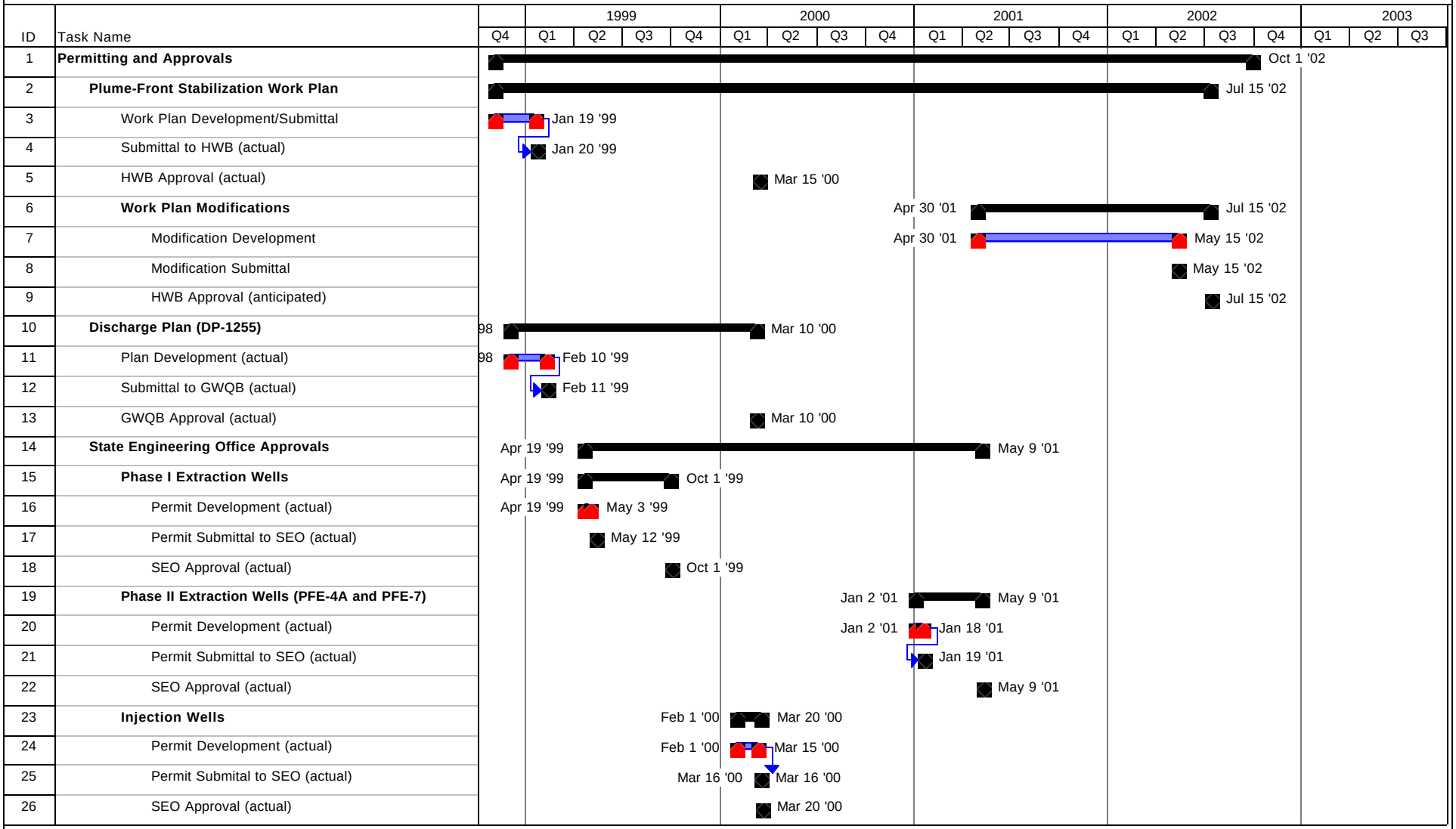
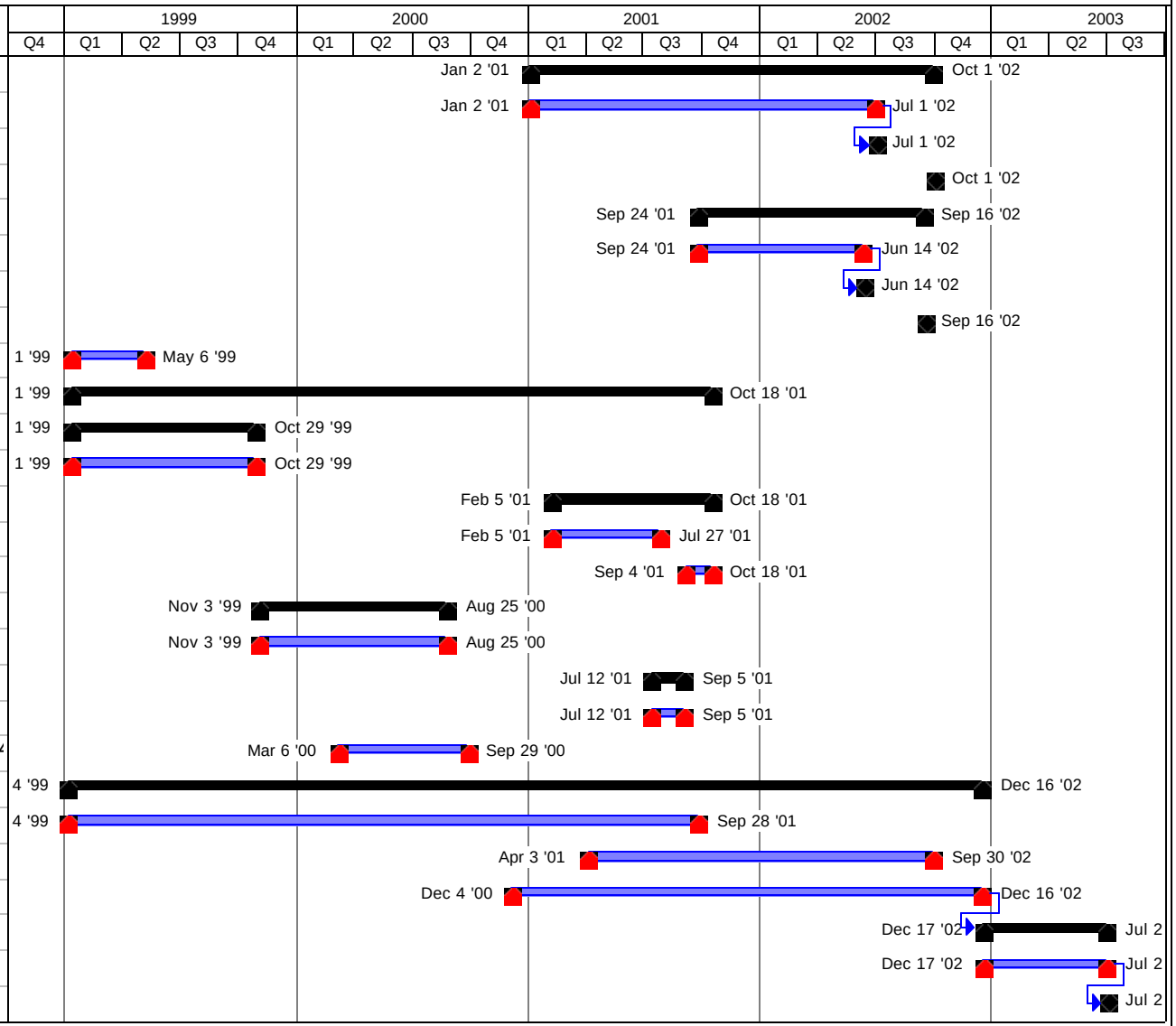


Figure 6.2

ID	Task Name
27	**System Plans and Specifications**
28	Development
29	Submittal to HWB
30	HWB Approval (anticipated)
31	**Operation and Maintenance Plan**
32	Development
33	Submittal to HWB
34	HWB Approval (anticipated)
35	Environmental Assessment (actual)
36	**Well Installation Activities**
37	**Phase I Monitor Well Installations**
38	BLM-37, JP-3, PL--8, ST-7, and WW-2
39	**Phase II Monitor Well Installations**
40	WW-3 and WW-4
41	WW-5
42	**Phase I Extraction Well Installations**
43	PFE-1, PFE-2, PFE-3, PFE-4, and PFE-5
44	**Phase II Extraction Well Installations**
45	PFE-4A and PFE-7
46	**Injection Well Installations (PFI-1, PFI-2, PFI-3, and PFI-4**
47	**Engineering Activities**
48	System Design
49	Procurement of System Hardware/Contractor Services
50	System Installation/Construction
51	**System Completion Activities**
52	System Performance Verification
53	System On-Line and Operational (anticipated)



If revisions to the format are required, revisions to the format can be implemented which are amenable to EPA, NMED and NASA.

6.4 PERMITTING ISSUES

Several permitting actions are required for implementation of the plume-front remediation system. The following outlines permitting actions required for this project.

6.4.1 Work Plans, Operations and Maintenance Plans and System Specifications

Submittal of the original Plan initiated the regulatory review and approval process for the plume-front stabilization project. The Plan was submitted to the NMED HRMB on January 20, 1999 and approved on March 15, 2000. The procurement of drilling services and installation of groundwater monitoring and remediation wells have been completed. Activities such as the Figure 6.2 installation of treatment equipment, construction of the pipelines, and installation of electrical power to the plume-front area are in progress. Future submittals to EPA/NMED will be the O&M Plan and specifications and drawings for the plume-front system.

6.4.2 Technical Feasibility Study

Following HRMB recommendations, NASA performed pilot-scale testing of a UV oxidation system as a Technical Feasibility Study. This study allowed the public to review and comment concerning pilot-scale testing. The process provided the public with information regarding UV oxidation systems, general information regarding the plume-front stabilization effort, the opportunity to discuss any relevant issues, and allowed the option to submit written comments concerning the project. No public comments were received by NASA regarding this project.

6.4.3 Groundwater Discharge Plan

A Discharge Plan was obtained in accordance with the requirements of the NMED GWQB to accommodate the injection of treated water. The Plan was prepared and submitted in accordance with Ground and Surface Water Protection Regulations (NMAC, 1998a). The Discharge Plan incorporated all the requirements of the regulations and followed guidelines received from NMED, including a public comment period. The injection well Discharge Plan (DP-1255) was submitted to the NMED GWQB on February 11, 1999 and approved on March 10, 2000.

6.4.4 Hazardous Waste Permits

Discussions with the NMED HRMB indicate that hazardous waste permitting actions will not be required for this plume-front containment project. The current WSTF Hazardous Waste Operating Permit has been reviewed and there were no issues identified that will require permit modifications. The current permitted active units on-site are appropriate to manage hazardous wastes generated from the project. Waste generation is anticipated to be minimal

and will include grease/oil, air stripper scale, UV mercury vapor lamps, and other minor waste streams. These waste streams can be managed using existing permit guidelines and the site operating procedures. Satellite accumulation areas and the permitted Container Storage Unit will be utilized to accumulate and store any generated wastes. Existing manifesting and shipping procedures will be utilized for wastes shipped off-site for disposal.

The current Post-Closure Care Permit was also reviewed for possible regulatory impacts. The Permit requires the annual reporting of information from closure units. This information includes water levels, contaminant concentrations, hydrostratigraphic units, flow rates, statistical evaluations, and other associated information. The Permit requires the eventual implementation of corrective measures as specified by the submitted and approved RFI and CMS. The plume-front remediation is considered a presumptive remedy which may be utilized in the preparation, or as a part of, the final corrective measures selection. Therefore, NASA believes that this remediation does not impact the specific reporting requirements of the Post-Closure Care Permit (Module IV, Section IV H.2).

6.4.5 Air Quality

The NMED Air Quality Bureau does not regulate emissions from stripping operations during remediation activities. These emissions are considered RCRA-related emissions that could be regulated under Subpart AA, BB and CC of 40 CFR §264 (NARA, 1998b, 1998c, and 1998d). According to the NMED Air Quality Bureau, this issue should be addressed by HRMB. The following discussion addresses each of the three subparts mentioned above.

6.4.5.1 Subpart AA

EPA has established air emissions standards which apply to owners and operators of facilities that treat, store or dispose of hazardous waste (40 CFR §264.1030; NARA, 1998b). These standards apply to process vents associated with various treatment processes, including air stripping, that manage hazardous waste with organic concentrations of at least 10 parts per million by weight (ppmw). Subpart AA standards apply to operations that are conducted in units subject to the permitting requirements of 40 CFR §270, or in hazardous waste recycling units that are located at RCRA-permitted facilities. The plume-front remediation system will not manage groundwater with 10 ppmw concentrations of regulated contaminants. An initial waste stream determination will be performed to ensure that concentrations are below 10 ppmw. This determination will be performed using process knowledge and documented in the Operating Record.

6.4.5.2 Subpart BB

EPA has established air emissions standards which apply to owners and operators of facilities that treat, store or dispose of hazardous waste (40 CFR §264.1050; NARA, 1998c). These standards apply to equipment leaks from equipment that contain or contact hazardous waste with organic concentrations of at least 10 percent by weight. Subpart BB standards apply to operations that are conducted in units subject to the permitting requirements of 40 CFR §270, or in hazardous waste recycling units that are located at RCRA-permitted facilities. The remediation system will not manage groundwater with this concentration of organics. A

process knowledge waste stream determination will be performed and documented as previously stated in section 6.4.2.1.

6.4.5.3 Subpart CC

The air emissions standards for units that treat groundwater with tanks, surface impoundments, or containers does not apply. Section §264.1080 of the Post-Closure Care Permit states that a waste management unit that is used solely for on site treatment or storage of hazardous waste that is generated as the result of implementing remedial activities is exempt from Subpart CC requirements (40 CFR §264.1080; NARA, 1998d).

6.4.6 National Environmental Policy Act

NASA will ensure the requirements of the National Environmental Policy Act will be incorporated into the plume-front containment project. An Environmental Assessment (EA) for this project was completed and presented to the public on May 6, 1999. The comment period to ensure that the public had an opportunity for direct involvement ended on June 11, 1999.

6.4.7 Well Permits

NASA will comply with all New Mexico SEO well permitting requirements (SEO, 1995). Permits will be obtained for all wells within the following three SEO categories:

1. test, exploratory or observation wells;
2. monitoring and injection wells; and
3. plume control and recovery.

Specific components of each SEO permit application will be met.

7.0 REFERENCES

Daniel B. Stephens & Associates, 1995a, "Preliminary Simulation Of Remedial Design Alternatives", White Sands Test Facility, Las Cruces, NM, September, 1995.

Daniel B. Stephens & Associates, 1995b, "Remedial Design Alternatives Letter Report," White Sands Test Facility, Las Cruces, NM, report prepared for AlliedSignal Technical Services Corporation, December, 1995.

Daniel B. Stephens & Associates, 1998, "Remedial Design Alternatives Letter Report", White Sands Test Facility, Las Cruces, NM, report prepared for AlliedSignal Technical Services Corporation, September, 1998.

Daniel B. Stephens & Associates, 2000, "ST-6 Area Optimization Results", White Sands Test Facility, Las Cruces, NM, email transmittal prepared for Honeywell Technical Services Inc., December 14, 2000.

Edson, J., 1998, Personal Communication, Colorado Department of Health, Hazardous Waste Division, Federal Facilities Section, August 25, 1998.

Environmental Protection Agency, 1986, RCRA Ground Water Monitoring Technical Enforcement Guidance Document, OSWER Directive 9950.1, Office of Solid Waste and Emergency Response (OSWER), Washington D.C., September 1986.

Environmental Protection Agency, 1989, Risk Assessment Guidance for Superfund (RAGS): Volume 1, Human Health Evaluation Manual, Part A, Interim Final, EPA/540/1-89/002, Office of Solid Waste and Emergency Response, Washington D.C., December 1989.

Environmental Protection Agency, 1993, Presumptive Remedies: Policy and Procedures, Directive 9355.0-47FS, EPA/540-F-93-047, Office of Solid Waste and Emergency Response, Washington, D.C., September, 1993.

Environmental Protection Agency, 1994, RCRA Corrective Action Plan (Final), OSWER Directive 9902.3-2A, EPA/520/R-94/004, Office of Solid Waste and Emergency Response, Washington, D.C., May, 1994.

Environmental Protection Agency, 1996, Presumptive Response Strategy and Ex-Situ Technologies for Contaminated Ground Water at CERCLA Sites, Directive 9283.1-12, EPA 540/R-96/023, Office of Solid Waste and Emergency Response, Washington, D.C., October 1996.

Environmental Protection Agency, 1997a, Comments on the NASA WSTF RCRA Facility Investigation and Corrective Measures Study Reports, February 27, 1997.

Environmental Protection Agency, 1997b, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846), Third Edition, Office of Solid Waste and Emergency

Response, Washington, D.C., June 1997, Internet at http://www.epa.gov/epaoswer/hazwaste/test/maina.htm

Environmental Protection Agency, 1998a, "Integrated Risk Information System," Up-to-date chemical-specific cancer slope factors, reference doses and toxicity information available on the Internet at http://www.epa.gov/iris.

Environmental Protection Agency, 1998b, Risk-Based Concentration Tables, EPA Region 3, October 1998 Update, Internet at http://www.epa.gov/reg3hwmd/risk.

Environmental Protection Agency, 1998c, Preliminary Remediation Goals, EPA Region 9, updated May 1998, Internet at http://www.epa.gov/region09/waste/sfund/prg.

Geoscience Consultants, Ltd., 1995, "NASA-WSTF Groundwater Modeling Report to EPA Region 6," Consultant report prepared for NASA Environmental Program Manager, NASA White Sands Test Facility, Las Cruces, NM, January, 1995.

HydroGeoLogic Inc., 1997, MODFLOW-SURFACT, "First Fully Integrated MODFLOW-Based Flow and Transport Simulator", HydroGeoLogic Inc., Herndon, Virginia, 1997.

Maciejewski, T.J., 1996, "Integrated Geophysical Interpretation of Bedrock Geology, San Andres Mountains, New Mexico", Unpublished Masters Thesis – University of Texas at El Paso, 123 p, 1996.

McDonald, M.G., and Harbaugh, A.W., 1988, "A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model", Techniques of Water-Resources Investigations 06-A, United States Geological Survey, 1988.

National Aeronautics and Space Administration, 2002, Mid-Plume Constriction Area Progress Report (in preparation).

National Aeronautics and Space Administration, 1990, "Aquifer Pumping Test Report NASA PT Well", NASA White Sands Test Facility, Las Cruces, NM, December 5, 1990.

National Aeronautics and Space Administration, 1996a, Draft RCRA Facility Investigation Report, NASA WSTF, Las Cruces, NM, March 1996.

National Aeronautics and Space Administration, 1996b, Draft Corrective Measures Study Report, NASA WSTF, Las Cruces, NM, March 1996.

National Aeronautics and Space Administration, 1997a, "Jornada del Muerto Pumpage and Mountain Recharge Rates", Letter to the U.S. EPA, Region 6, Dallas, TX, June 17, 1997.

National Aeronautics and Space Administration, 1997b, "Groundwater Sampling and Analysis Plan," WSTF, Las Cruces, NM, July 1997.

National Aeronautics and Space Administration, 1997c, "Quality Assurance Project Plan", NASA WSTF, Las Cruces, NM, July 1997.

National Aeronautics and Space Administration, 1998a, RFI/CMS Interim Measures Evaluation Report, NASA WSTF, Las Cruces, NM, March 1998.

National Aeronautics and Space Administration, 1998b, "White Sands Test Facility Standard Instruction, Waste Management", (WSI 22-W-005.A), Las Cruces, NM, June 5, 1998.

National Archives and Records Administration, Office of the Federal Register, 1998, Code of Federal Regulations (CFR), Protection of Environment, Title 40, Part 264, Washington D.C., July, 1998.

National Institute for Occupational Safety and Health (NIOSH), Pocket Guide to Chemical Hazards, NIOSH, June 1990.

New Mexico Administrative Code, 1998a, New Mexico Environment Department, Ground and Surface Water Protection, Title 20, Chapter 6, Part 2, Internet at http://www.nmenv.state.nm.us.

New Mexico Administrative Code, 1998b, New Mexico Environment Department, Drinking Water Regulations, Title 20, Chapter 7, Part 1, Internet at http://www.nmenv.state.nm.us.

Seager, W.R., 1981, Geology of the Organ Mountains and Southern San Andres Mountains, New Mexico, New Mexico Bureau of Mines and Mineral Resources, Memoir 36, Albuquerque, NM, May, 1981.

Shomaker, John & Associates, 1996, Multilayer Ground-Water Flow Model of Southern Jornada del Muerto Basin, Dona Ana county, New Mexico, and Predicted Affects of Pumping Wells LRG-430-S-29 and –S-30, City of Las Cruces, New Mexico, May 1996.

State Engineer Office (SEO), 1995, Rules and Regulations Governing Drilling of Wells and Appropriation and Use of Ground Water in New Mexico, State Engineer Office, Santa Fe, New Mexico, 1995.

Swanick, J., Personal Communication, GenCorp Aerojet, September 1, 1998.

Wilson, C.A., White, R.R., Orr, B.R., and Roybal, R.G., 1981, Water Resources of the Rincon and Mesilla Valleys and Adjacent Areas, New Mexico, New Mexico State Engineer Technical Report 43, 1981.

Zheng, C., 1989, PATH3D, Version 3.2, "A Ground-Water Path and Travel-Time Simulator", S.S. Papadopulos & Associates, Inc., Rockville, Maryland, 1989.

Zheng, C., 1992, MT3D, Version 1.5, "A Modular Three-Dimensional Transport Model for Simulation of Advection, Dispersion and Chemical Reactions of Contaminants in Groundwater Systems", S.S. Papadopulos & Associates, Inc., Rockville, Maryland, 1992.

APPENDIX A

CONTINGENCY PLAN FOR THE WSTF HAZARDOUS WASTE OPERATING PERMIT

PERMIT ATTACHMENT II - 6

CONTINGENCY PLAN

Table of Contents

for the
Contingency Plan

Contents Page

Introduction....2
Purpose....2
Definitions....2
Responsibilities....3
Organization and Duties....5
Coordinated Emergency Services....5
Training....5
Contingency Plan Distribution....5
Amendment of Plan....6
Preparedness and Prevention....7
Internal Communications and Alarm Equipment....7
External Communications and Alarm Equipment....7
Fire Control Equipment and Procedures....7
Spill Control and Equipment....8
Decontamination of Equipment....10
Water Supply....11
Arrangements with Local Authorities....11
Emergency Procedures....12
General....12
Releases From Permitted Hazardous Waste Units....14
Soil Assessment and Clean-Up Procedures....17
Fires and Explosions....18
Containment Activities....20
Decontamination Procedures....20
Evacuation Plan....21
Record Keeping and Incident Reports....22
Operating Record....22
Incident Reports....22
Compliance....23
Corrective Action....23

Appendix 1 Floor Plan of Buildings Nearest Permitted Units Showing Locations of Fire Alarms, Electric Supply Pull Boxes and Fire Extinguishers

Appendix 2 Chemical Hazard Information

Introduction

Purpose

The purpose of this plan is to establish procedures, delineate responsibilities and provide planning guidance for the following:

a. the prevention and control of discharges of hazardous waste or hazardous waste constituents to air, soil or surface water;

b. identification of resources to be used to clean-up discharges at WSTF (e.g. chemical absorbants, personal protective equipment);

c. the response activities to be conducted in the event of an emergency;

d. the protection of human health, property and the environment; and,

e. reporting spills as required.

This plan will be implemented immediately in the event of a fire, explosion, or release of hazardous waste or hazardous waste constituents which could threaten human health or the environment.

Definitions

Emergency - A fire, explosion, or release of hazardous waste or hazardous waste constituents, which could threaten health, environment or property.

Emergency Response Team - A team made up of on site personnel who have been trained in emergency response.

Environment - All surface waters, ground water, drinking water supply, land surfaces, below ground surfaces (geology) and ambient air.

First Responder - The first certified emergency response team member to arrive on site at an emergency.

Reporting Spill - Any release (other than those acceptable to regulatory agencies) into the environment of a listed hazardous substance in quantities greater than or equal to the listed quantities found in 40 CFR 302 (refers to the National Emergency Response Center, the NM State Police and the NMED), any release of hazardous waste which could threaten human health or the environment, or any release of hazardous waste from a permitted

environment, or any release of hazardous waste from a permitted unit.

Release - Any spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping, leaching, dumping, or disposing into the environment.

Spill Response Team

Responsibilities

All persons appearing on the list of emergency coordinators (Table II-6-1) are persons with a minimum of one year experience in the areas for which they are involved. They have the authority to commit necessary resources in the event of an emergency. Their responsibilities are described below.

Emergency Coordinator (**EC**) - The official predesignated by the NASA WSTF Manager to act as an emergency response commander. The specific response actions to be taken in the event of an emergency will be determined by the EC, utilizing environmental information provided to him by the EPM and the AeNC. He will coordinate and direct the actual emergency activities. He is typically head of the Quality Assurance, Reliability and Safety Office because of familiarity with availability of resources and his first hand knowledge of emergency response. In the chain of command, the EC is directly responsible to the WSTF Manager.

Environmental Program Manager (**EPM**) - The official predesignated by the NASA WSTF Manager who will act as an advisor on environmental matters to the EC. This person is the contact to the regulatory community and other outside agencies. The EPM will also be responsible for fulfilling the notification requirement referred to in this plan. In the chain of command, the EPM is directly responsible to the WSTF Manager.

Area Environmental Coordinator (**AeNC**) - The official predesignated by the NASA Manager for his familiarity with specific wastes streams in the affected Area of the facility and his ability to provide specific chemical information to the EC. After the Emergency Response Team has completed their work, the AeNC will coordinate activities of the Spill Response Team in completing the task of waste clean-up. In the chain of command the AeNC is responsible both to the EC and the EPM.

The NMED will be notified within 90 days of any personnel changes which effect the Emergency Coordinator List

Table II-6-1 Emergency Coordinators List

Emergency Coordinator (EC)

	NAME	WORK NO.	HOME NO.	PAGER NO.
Primary	J. Nelson	524-5282	524-0663	None
Alternate	T. Hogge	524-5230	522-5314	5230

Environmental Program Manager (EPM)

	NAME	WORK NO.	HOME NO.	PAGER NO.
Primary	D. Amidei	524-5517	523-4495	None
Alternate	P. Pache	524-5462	382-8643	5462
Second Alternate	C. Wolf	524-5152	526-3833	5152

Area Environmental Coordinator (AeNC)

100, 300, 400, 500, and 700 Areas	NAME	WORK NO.	HOME NO.	PAGER NO.
Primary	I.D. Smith	524-5524	522-3449	5524
Alternate	J.Mulholland	524-5516	527-4611	5516
Second Alternate	D. Gorham	524-5141	523-9005	5141

200 and 800 Areas	NAME	WORK NO.	HOME NO.	PAGER NO.
Primary	H. Johnson	524-5725	522-8137	5725
Alternate	D. Baker	524-5605	526-5480	5605
Second Alternate	H. Beeson	524-5542	521-0960	5542

Organization and Duties

The Emergency Coordinator will establish a command post for specific response to a spill and receive input from all WSTF responsible groups and make decisions on clean-up methods and resource allocations.

The on site contractor will provide an Emergency Response Team trained in the cleanup of spills of hazardous substances.

Coordinated Emergency Services

All emergency response activities will be directed by the NASA EC. In the event outside support is required, the EC will maintain authority over response activities.

Training

All personnel involved in spill response have received specialized training as outlined in the Training Plan, Permit Attachment II-4, Training Plan.

Contingency Plan Distribution

The Contingency Plan will be distributed as follows. Any changes to the original will be followed up with a change notice or revised copy to all Contingency Plan holders.

Distribution and locations of the Contingency Plan is as follows:

WSTF Site Copies:

Original Copy - NASA WSTF Manager's Office
WSTF Environmental Emergency Coordinator
On site Contractor's Environmental Section
Fire Department
200 Area Office Chief
300 Area Blockhouse
400 Area Blockhouse

800 Area Control Room

Off-site Copies:

White Sands Missile Range, White Sands, NM
Memorial General Hospital, Las Cruces, NM
Dona Ana Sheriff's Department, Las Cruces, NM
New Mexico State Police, Hazardous Material Emergency Response Division, Santa Fe

In the Part B RCRA Application and RCRA Permit:

New Mexico Environment Department, Hazardous and Radioactive Materials Bureau, Santa Fe, NM
United States Environmental Protection Agency, Region VI, Dallas

Amendment of Plan

It is the responsibility of the EC to review the Contingency Plan and amend, if necessary, whenever:

a) the facility permit is modified;

b) the plan fails during a test run or in an emergency;

c) the facility design, construction, operation, maintenance or other circumstances change to increase the potential for fires, explosions, or release of hazardous waste or hazardous waste constituents or changes in the response necessary in an emergency;

d) the list of emergency coordinators changes; or

e) the list of emergency equipment changes.

A request for a permit modification must be sent to NMED and EPA concurrently with the change. Whenever the plan is changed, all parties identified on the Contingency Plan distribution listed above will also receive copies of the changes.
II-6-1

Preparedness and Prevention

Internal Communications and Alarm Equipment (264.32(a))

All inhabited buildings at WSTF are equipped with telephone communication and fire alarm systems. Pull box alarms are available and accessible in buildings near the hazardous waste management units (Figures II-6-1 and II-6-2). Pull box alarm locations, for those buildings located nearest the hazardous waste units, are indicated in Appendix 1. In the case of an emergency, facility personnel will be notified through public address system announcements, siren wails or fire bells.

External Communications and Alarm Equipment (264.32(b))

Any site telephone may be used to summon emergency assistance from WSTF security, fire and emergency response teams. The Emergency Center, in addition to telephones, maintains a radio system which is capable to summoning assistance.

When a pull box alarm is used, an alarm signal is sent to the Emergency Center in Building 112. If the emergency involves a fire or potential fire, and off-site assistance is required, it can then be summoned by telephone.

Telephone communication is provided by U.S. West. Telephones are located at the 100 Area Container Storage Unit, at the 200 Area Evaporation Tank Unit (evaporation tanks), at the 500 Area Waste Fuel Treatment Unit, in every occupied building, and in marked boxes along the access road. The Emergency Center is immediately alerted by either lifting the receiver or by dialing 5111, depending on the type of phone.

Additional communications are provided by the use of hand-held and mobile two-way radios. In addition to the extensive telephone network available for internal and external communications, WSTF maintains 4 dedicated radio frequencies. The security personnel, the Emergency Services Center, Fire Department and personnel operation at the 700 Area Open Detonation Unit are all equipped with hand-held or mobile radios which can be utilized in the event of an emergency.

Fire Control Equipment and Procedures (264.32(c))

WSTF fire protection is provided by the use of fire hydrants, fire extinguishers, hose racks, and an on site Fire Department. Fire hydrants and water supply risers are located 700 feet south of the Container Storage Unit; there is another one ajacent to the Evaporation Tanks Unit (evaporation tanks); and one at the Waste Fuel Treatment Unit. The Container Storage Unit is located one half mile north of the WSTF Fire Department and is equipped

with fire extinguishers and a communication system that can be used to notify the appropriate personnel in the case of an emergency. All fire hydrants and fire protection water risers are inspected semiannually by the WSTF Fire Department for static pressure, flow pressure and water flow.

The WSTF Fire Department can respond with three fire trucks/pumpers in the event of an emergency. Each pumper truck carries 500 gallons of water and has an operating pressure of 150 psi. Two of the trucks pump at a rate of 750 gallons per minute and are capable of operating two 2 1/2-inch fire hoses. The other truck delivers 1,000 gallons per minute and can operate five 2 1/2-inch fire hoses. Each vehicle's operational status is checked daily and preventive maintenance is conducted on a weekly basis. Additionally, each pumper is back-flushed semi-monthly.

Portable fire extinguishers are present throughout WSTF. Fire extinguisher locations and types, for buildings near the hazardous waste units, are found in Appendix 1.

Fire control vehicles have an unobstructed path to all hazardous waste management areas and emergency procedures restrict access to authorized vehicles and personnel.

Spill Control and Equipment (264.32(c))

The WSTF contingency plan employs a spill response team, which is provided by the Environmental Section, that responds immediately to emergencies. The team is made up of professionals with experience in supervision, heavy equipment operations, fire fighting, safety engineering, contamination control, and environmental protection. This team is equipped with a portable source of self-contained breathing air, protective suits, commercial adsorbents, neutralization solutions, and assorted hand tools and containers. In the event of a spill or release at WSTF, the containment activities outlined the section on "Containment Activities" will be implemented.

A wide variety of the WSTF heavy equipment can be utilized for containment and clean-up in the event of a hazardous waste spill. In the event of a large spill, a bulldozer, backhoe and front-end loader are available for spill control.

Temporary storage tanks, portable pumps and hoses can be used to transfer and provide temporary storage for spill materials.

Absorbents and temporary construction materials, such as soil, sand and gravel, are readily available at WSTF. Other materials such as emulsifiers, specialty adsorbents, and containers can be obtained immediately from a central on site spill response stockpile. WSTF also maintains numerous hand tools, such as shovels and rakes, which can be utilized in the event of an

emergency. There is also a wide variety of protective clothing with breathing apparatus for personnel who may become engaged in spill control and clean-up operations. See Table II-6-2 for a complete list of spill control equipment.

Table II-6-2 Emergency Response Materials

Equipment	WSTF Location	Capabilities
3 Fire Truck/Pumpers	Building 112	500 gallons
Rescue Vehicle	Building 112	
2 ea Ambulance	Building 112	
Bulldozer	Landfill	
Cranes, Mobile (10-ton, 30-ton)	150 Yard	10 ton, 30 ton
Backhoe	Building 113	
2 ea Dump-Truck	150 Yard	
Diesel Semi-Truck	150 Yard	20 tons
Low-boy Trailer	150 Yard	6000 gallons
Tanker Trailer	150 Yard	
Forklift	All Areas	
4" Pump - Portable Wheel-mounted, Hitch-equipped	100 Area Sewage Lagoon	100 GPM
3 ea Heat Resistant FireKing Fire Suits	Building 112	
Sand	Site	
Livestock Storage Tanks	150 Yard	1000 Gallons
Hoses	Building 112	6000 feet
Polyurethane Foam	Building 112	
a. AFFF Alcohol Type		
b. Protein base		

Personnel Protection Equipment:	Safety Crib Building 120	
- Hard Hats		
- Goggles		
- Safety Glasses		
- Face Shields		
- Splash Suits		
- Totally Encapsulates Suits		
- SCBA's		
- Chemical Cartridges		
- Respirators		
- Escape Masks		
- Assorted Gloves		
Spill Pillows	Warehouse	
Shovels	Facilities	
Rakes	Facilities	
Rope and Line	Warehouse	
Drums	150 Yard	
Salvage Drums	150 Yard	
Drum Hoist	Facilities	
Bung Wrench	Container Storage Unit	
Hand Pumps	Warehouse	

Decontamination of Equipment

If a spill should occur, all contaminated equipment will be decontaminated as a latter part of the response process. WSTF is equipped with a cleaning unit for decontamination. Post-

emergency equipment will be serviced in the "clean room" or on the "clean pad" by the on site cleaning personnel. Decontamination will be accomplished with the use of biodegradable soap, hot water and steam. The resulting waste is expected to be of such a dilute nature that no incompatible reactions will occur. Typically these wastes will be transported and added to the evaporation tanks. Determination for the completeness of decontamination will be based on physical and chemical analysis of the particular contaminants.

Water Supply

Site water is provided by two drinking water wells. The water is pumped to fill a 1,000,000-gallon gravity storage tank by two 100 horsepower electric motors. The pumps lift the water 1,038 feet, from the water table to the tank, a distance of over 7 miles. The storage tank, located northeast of the main facility development, is monitored remotely by electronic gauges from the Emergency Center. Physically inspections are conducted at tank by security personnel a minimum of six times a day. Adequate volume and pressure will be maintained to efficiently operate all water supplied fire fighting equipment.

Arrangements with Local Authorities

WSTF has agreements with several outside agencies for support in the event of an emergency. In all cases, the support activities involve materials, personnel and equipment which will be released to the WSTF Emergency Coordinator for use at his discretion. These groups have been provided with a copy of this plan in order to familiarize them with the layout and possible hazards at WSTF. Details of these agreements can be found in the Permit Application, Part B.

AGREEMENTS

Dona Ana County Sheriff - Has been provided with a copy of this plan in order to familiarize them with the layout, and possible hazards at WSTF.

U.S. Army White Sands Missile Range - WSTF is on WSMR and therefore is addressed in the WSMR contingency plan. WSMR is capable of providing fire fighting, spill clean-up, and evacuation support. NASA also has an agreement with McAffee Medical Center on WSMR to provide medical assistance.

Memorial General Hospital - Has been made aware of the types of medical emergencies which could result at this site.

State of New Mexico - The State does not enter into agreements with individual facilities, but does have a mandated duty to assist when notified. The State has been provided with a copy of

this plan in order to familiarize them with the layout and possible hazards at WSTF.

Emergency Procedures

General

WSTF emergencies will be reported to the Emergency Center switchboard which is manned 24 hours a day. The initial notification may be automatic, such as fire alarms or manual by telephone (Emergency Center, dial 5111) or radio. Site tours by firemen every 90 minutes during off-duty hours assists in notification. In the event of an emergency situation during working hours there are personnel in all areas who are trained and authorized to act as first responders. The Emergency Center will still be notified and the rest of the chain of events followed even if a first responder is on scene at the time of the emergency.

The switchboard operator at the Emergency Center will concurrently: dispatch the Fire Department; notify the area specific EC for the area in which the emergency is located; and notify the EEC.

The Fire Department will act as the first responder when they arrive on scene.

The First Responder will obtain technical information about hazards (Appendix 2: Contains information on the chemical hazards of the most widely used chemicals on site), perform search and rescue as required, identify vapor clouds, establish the command post, set up road blocks, and evaluate and implement initial Containment Activities procedures and the Evacuation Plan procedures as needed.

The Emergency Center will relay the information on the type of emergency to the EC and the EPM. The EC will proceed to the scene of the emergency and evaluate the situation. The EC will determine actions to be taken in response to the emergency. The EC will maintain contact with the EPM during all stages of the emergency.

EMERGENCY PHONE NUMBERS

White Sands Missile Range	(505) 678-4187
Memorial General Hospital	(505) 522-8641
NMED Emergency Response	(505) 827-9329

NOTIFICATION

National Response Center (Spills and Releases)	(800) 424-8802
State of New Mexico	(505) 827-9329

CHEMICAL INFORMATION

Chemtrec (Chemical Manufacturer's Association - Washington, D.C.)	(800) 424-9300

The EC will immediately identify the character, amounts, source, and areal extent of any released material. This initial assessment will be based on documentation of materials routinely managed in each area and existing physical and chemical analyses (Permit Attachment II-1, Waste Analysis Plan). The EC will advise the AeNC of his findings.

The EC, as assisted and/or advised by the EPM and the AeNC, will also assess any direct or indirect hazards to human health and the environment which may result from any release due to the emergency situation. The assessment will consider such pertinent factors as Threshold Limit Values (TLV's) of chemical constituents, potential combustion by-products, potential incompatibilities and adverse reactions, and the necessity for providing adequate run-off control for both released materials and agents used in fire control, containment or decontamination efforts.

Based on this evaluation, the EC will activate internal alarms as needed and request assistance as outlined in the coordinated emergency response (Permit Attachment II-4, Training Plan). The EPM will notify authorities as outlined in the section on Record Keeping and Incident Report procedures if the incident involves a reportable release. The EC, as assisted and advised by the EPM and the AeNC, will assess the situation and decide on the materials and manpower required to respond to immediate threats to human health and the environment. The EC will then notify the members of the Emergency Response Team and designate a command post from which the operations will be coordinated.

The EC will take whatever actions necessary to protect human health and the environment during the emergency. This may include shutdown of operations and commitment of resources and manpower. If operation systems are shut down, the EC is responsible to see that monitoring for leaks, pressure buildup, gas generation, or rupture in valves, pipes or other equipment, wherever appropriate, is accomplished.

As soon as the immediate threat to health has been brought under

control, the EC will relinquish control of the clean-up effort to the AeNC who will oversee the clean up of the on site contractor.

Releases From Permitted Hazardous Waste Units

This section outlines some specific considerations for the units which handle hazardous waste.

Evaporation Tanks (264.56(e), 264.194(c))

The 200 Area hazardous waste evaporation tanks at WSTF provide for leak detection and secondary containment. In the event of a double failure or handling accident, the EC will make an initial assessment of fire, explosive, toxicity hazards, and potential threat to human health and the environment as previously described. The Contingency Plan will then be implemented as necessary and as outlined in the first part of the Emergency Procedures section. In the event a release from a tank is suspected or documented, the EC will be immediately notified and insure that the process flow to the tank is shut-off and the waste diverted to the stand-by tank. Because both tanks have independent leak detection systems, a leak in one tank will not preclude the use of the other independent tank. Notifications will be made as outlined in the section of this plan on Record Keeping and Incident Reports.

After the initial assessment has been made, any free-standing liquid will be contained with berms to prevent any further migration and to contain any additional releases which may occur until the tank is repaired and the remaining waste is removed. Any free-standing liquid and any hazardous waste residue which remains in the tank will then be removed and placed in another tank or container and transported off-site to a permitted disposal facility. A soil assessment and clean up-will be performed as outlined in the Soil Assessment and Clean-Up Procedures portion of the plan.

During the decontamination operation, the tanks will be inspected to determine the cause of the hazardous waste leak. If the leak cannot be repaired or the tank's integrity is so impaired that it is no longer usable, the tank will be decontaminated using appropriate decontamination solutions, removed from service and the Closure Plan implemented. If the leak is repaired, the tank will be leak tested prior to returning to service.

If the tank cannot be successfully decontaminated it will be removed from its location and transported off-site for disposal at a permitted disposal facility.

Hazardous Waste Drain Lines and Drain Line Sump (264.15(c), 264.56(e))

Releases of hazardous waste would be identified during routine inspections of the drain line, drain line sump and the associated secondary containment systems. Other areas indicative of potential leaks may be where there is subsidence, damp earth surrounding equipment, or noticeable surface spills. The EC will be notified immediately and the drain line flow will be shut down. This will be accomplished with the use of an announcement over the public address system saying that the hazardous waste drain is closed to additions and the placement of signs on all drains directing personnel that the drains are closed. During the time the drain lines are closed, the waste will be held in the individual shops until the system is reopened. Notifications will be made as outlined in the Report Keeping and Incident Report section described in the latter part of this plan.

The EC will then make an initial assessment of fire, explosive, toxicity hazards and potential threat to human health and the environment. The Contingency Plan will then be implemented as needed. Upon completion of the initial assessment, any liquid or wastes remaining in the drain line or drain line sump will be drained into tanks or containers, or taken to the evaporation tanks.

If it is suspected that a release has resulted in soil contamination, measures will be implemented as outlined in the Soil Assessment and Clean-Up Procedure portion of the plan.

The drain lines and the drainline sump will be inspected to determine the cause of the hazardous waste leak. If the leak cannot be repaired or the equipment integrity is so impaired that it is no longer usable, the equipment will be decontaminated by triple rinsing. The rinsate produced in the decontamination procedure will be handled as hazardous waste and disposed of accordingly. In the event the leak is repaired, the line will be leak tested prior to being put back in service.

If the drain line(s) and the drain line sump cannot be successfully decontaminated, defective components will be removed from their location and disposed of off-site at a permitted disposal location.

Container Storage Unit (264.15(c), 264.56(e), 264.171)

Noticeable spills or free-standing liquids inside the Container Unit may be indicative of release of hazardous waste. If a release is suspected or documented, the Emergency Center will be notified immediately. The Center sill in turn notify the EC. Notifications will be made as outlined in the plan section, Record Keeping and Incident Reports.

Initial assessment of the fire, explosive, toxicity hazards, and the potential threat to human health or the environment will be made by the EC as described in the General portion of the plan. Subsequent to the initial assessment, any spills will be cleaned up and packaged for disposal at an permitted off-site RCRA facility.

Subsequent assessment will be made to determine if any contamination has escaped from the containment system. If contamination is confirmed, the soils will be excavated to remove all contamination by measures outlined in the plan section, Soil Assessment and Clean-Up Procedures. Contaminated soils will be disposed of at an off-site permitted disposal location.

Drums in the storage area will be inspected for deterioration, leakage or improperly secured closure devices. Any drums that are deteriorated or that cannot be sealed will have the contents removed and repackaged in serviceable drums. Unserviceable drums will be removed from service, cleaned in accordance with the Decontamination Procedures or disposed of off-site at a permitted disposal location if they cannot be decontaminated.

Open Detonation Unit (264.56(e), 264.171)

Any release of hazardous waste from the Open Detonation Unit (OD) would be indicated by elevated explosive residual organics and total metals in the soil as a result of inefficient treatment (refer to the Permit Attachment II-1, Waste Analysis). If elevated hazardous wastes are detected in the soil, a soil assessment and clean-up will be performed as noted in the Soil Assessment and Clean-Up Procedures portion of the plan.

In the event of a fire involving explosives, all personnel and equipment will be evacuated to a position no closer than the entrance to the Sanitary Landfill (refer to Figure II-6-2). The fire will be observed from this position until it burns out or undergoes a transition from deflagration to detonation. A waiting period of 24 hours will be observed before explosive personnel can approach the OD Unit and assess the situation. Soils around the OD Unit, which show indications of contamination from the burning of explosives, will be managed in accordance with Soil Assessment and Clean-Up Procedures. The soil will then be analyzed for explosive residual organics and total metals as discussed in Permit Attachment II-1, Waste Analysis. Any soils exhibiting concentrations in excess of the established background will be disposed in accordance with HWMR-6.

In the event there are other emergency situation not involving fire, all unnecessary personnel will be evacuated from the OD Unit. Only the qualified personnel needed to handle the emergency and take corrective measures will remain at the site.

Waste Fuel Treatment Unit (264.56(e), 264.171)

A release of hazardous waste from the waste fuel treatment unit would be identified during routine inspections of the unit's tanks, piping and secondary containment. In the event a release from the treatment facility is suspected or documented, the EC will be notified immediately and all process equipment turned off.

The EC will then make an initial assessment of fire, explosive, toxicity hazards, and potential threat to human health and the environment as previously described. The necessary measures will then be implemented as outlined in the Emergency Procedures portion of the plan. Upon completion of the initial assessment, the waste fuel in the treatment and holding tanks will be secured by closing the tank outlet valves and if required, by transferring the waste to a tanker trailer. Any waste remaining in ancillary equipment will be drained to tanks or containers.

A subsequent assessment will be made to determine if any contamination has escaped from the containment system. If contamination is confirmed, the soils will be excavated until all contamination is removed. The extent of contamination will be assessed as outlined the Soil Assessment and Clean-Up Procedures of the plan, and to background or risk assessment levels.

The tanks and ancillary equipment will be inspected to determine the cause of the leak. If the leak cannot be repaired or the equipment integrity is so impaired that is no longer usable, the equipment will be decontaminated by triple rinsing. The rinsate produced in the decontamination procedure will be handled as a hazardous waste and disposed of accordingly. In the event the leak is repaired, the tanks or ancillary equipment will be leak tested prior to being put back in service. All waste fuel removed from the tanks and ancillary equipment will be treated and disposed of in accordance with HWMR-6.

Tanks or equipment that can not be successfully decontaminated will be removed from their location and disposed of off-site at a permitted disposal location.

Soil Assessment and Clean-Up Procedures

After a spill has been contained and all free liquid has been removed, the AeNC will conduct an assessment of the contaminated soils. This assessment will include the identity of the waste streams associated with the Unit that released the contamination. This will allow the AeNC to determine the safety precautions that will be utilized by clean-up personnel and determine what analytical methods are appropriate for determining the extent of contamination.

Using portable monitoring instrumentation and visual observations, the soils that appear to be contaminated will be excavated. All excavated soils will be properly containerized, characterized and disposed of in compliance with HWMR-6.

After all soils that appear to be contaminated are removed from the area, a sampling grid will be developed based on the size and quantity of the spill to determine the extent of horizontal and vertical contamination. Core samples will be taken and analyzed from different locations and depths within and adjacent to the spill area. Analytical parameters will be based on the knowledge of the waste stream.

Based on the analytical results, and background or risk assessment levels, the AeNC will determine if the initial clean-up removed all contaminated soils or if more excavating, sampling, and analyses are required. All equipment used for the clean-up will be washed after completing the response, in accordance with the Decontamination Procedures. Equipment that cannot be successfully decontaminated will be characterized and disposed of in accordance with HWMR-6.

Fires and Explosions (264.56(e))

In the event of a potential or actual fire or explosion at WSTF, the Emergency Center or the Fire Department will be notified through either emergency fire alarms, telephone or radio contact. The Emergency Center or Fire Department will then notify the EC and the appropriate AeNC of the Area in which the emergency exists. The EC will activate the Contingency Plan. The WSTF Fire Department will have the duty to take the necessary actions to contain and alleviate the emergency under the direction of the Fire Department Chief and the command of the EC.

If flammable materials are involved in an incident and are on fire, the EC will immediately:

1) have all non-essential personnel evacuated from the affected area;

2) ensure that the appropriate fire control measures are taken (e.g., removal of ignition sources, availability of suitable fire control agents, activation of fire suppression systems);

3) direct containment activities (e.g., dikes, berms) to control the spread of flammable materials and potentially contaminated run-off; and

4) ensure that all process control systems are shut off and monitored for any leaks or pressure build-up.

If flammable materials are involved and are not on fire, the EC will take all steps necessary to prevent ignition or recurrence of any fire.

The primary concerns during a potential or actual fire situation, whether it involves flammable or non-flammable materials, are the spread of fire to adjacent areas, exposure of personnel to toxic gases or vapors, and the potential of contaminated water run-off due to fire control activities.

The spread, or recurrence of fire, can occur through direct impingement on neighboring structures or from movement of flammable vapors to points of ignition. The EC will evaluate data on known chemical constituents in effected areas and will include such factors as flammability, vapor density, lower and upper explosive limits, wind direction and velocity, surrounding topography and possible sources of ignition when formulating emergency response activities. Possible alternatives in any fire control situation may include: water deluge on neighboring structures to prevent ignition; water mist to knock down and dissipate explosive or flammable vapors; evacuation of low lying areas where vapors may collect; and the removal of all ignition sources in potentially affected areas.

If the EC determines that evacuation of surrounding areas is necessary, he shall follow the Evacuation Plan procedures included in the greater plan. The initial evacuation will be at least ½ mile downwind from the effected area.

As part of the initial assessment, the EC will also determine the type and level of personnel protection equipment that will be necessary for emergency response activities. Both flammable and non-flammable materials which are involved in a fire can potentially emit highly toxic decomposition products when subjected to hear or flame. As part of any emergency assessment, a thorough evaluation will be made of the potential for human exposure and the levels of personnel protection that may be required for emergency response activities. Based on known toxicities and potential combustion by-products, specified equipment may include: bunker gear; splash suits; chemical cartridge respirators; self-contained breathing apparatus (SCBA's), or; SCAPE suite (self-contained atmospheric protective ensemble).

To prevent run-off of contaminated water which may be used in fire control activities, the EC will evaluate the existing topography in the effected area to determine potential flow paths. If substantial amounts of water are to be used, dikes and berms will be constructed to provide containment for any run-off. After emergency response activities are completed, the contained run-off will be analyzed to determine if it is a hazardous waste and, if required, will be managed in accordance

with all applicable regulations.

Containment Activities

In the event of a spill or release of a hazardous substance, one of the duties of the first responder is the containment of any free liquids. This is to be done with spill control booms, spill pillows, earth, or any materials available, as needed. the objective of containment activities is to first control the spread and runoff of the material, and then to absorb the contained materials to minimize infiltration into the ground.

Decontamination Procedures (264.56(h)(2))

Post clean-up decontamination of personnel will take place in a decon stations designed to prevent the spread of contamination. The clean-up personnel will wear disposable outer garments or totally encapsulated suits. Decontamination will include: the physical removal of loose contaminants using rinse water and antistatic solutions; the scraping, brushing, wiping or absorption of adhering contaminants; and the rinsing or evaporation of volatile liquids. Disposable garments will be containerized for disposal in compliance with HWMR-6 and the totally encapsulated suits will be cleaned and inspected by the WSTF contamination control facility (clean room).

WSTF is equipped with a cleaning facility for the decontamination of a wide variety of materials that are tested on site. Post-emergency equipment for decontamination can be serviced in the "clean room" or on the "clean pad" by the on site cleaning facility. The location for cleaning will depend upon the size of equipment contaminated. Decontamination will be accomplished with the use of biodegradable soap, hot water, and steam. The resulting waste will be of such a dilute nature that no incompatibilities will result. Decontamination will be determined by visual inspection or by analysis of the rinsate. The determination of decontamination will be based on the chemical and physical nature of the contaminant.

Decontaminated equipment will be inspected by the facilities maintenance group. Diaphragms, gaskets, seals, and other soft goods that require replacement will be disposed in compliance with HWMR-6. Protective breathing equipment is inspected and maintained by the WSTF Quality Assurance, Reliability Safety Office. Materials that require disposal will be restocked from with the WSTF warehouse or reordered by the WSTF Environmental Section.

Any hazardous waste generated by the decontamination process at the cleaning facility will be collected by the 200 area evaporation tanks, which services the clean room and clean pad. Any emergency response equipment or materials which cannot be

decontaminated at the WSTF cleaning facility will be shipped off-site for disposal at a permitted disposal facility.

Evacuation Plan (264.56(d))

Once the decision has been made to activate evacuation procedures, facility personnel will be notified by the following:

1. Fire

   a. 200 and 800 Areas - Local fire bell rings continuously
   b. 300 and 400 Areas - Evacuation horn is sounded

2. Liquid Spill or Release

   a. 200 Area - Public address announcement
   b. 300 and 400 Areas - Public Address Anouncement

Evacuation Routes

100 Area (Container Storage)

If it becomes necessary to evacuate the 100 Area and adjoining structures, personnel will be directed south along the main NASA WSTF access road to State Highway 70.

200 and 800 Areas (Evaporation Tank Unit)

During any emergency situation, personnel in the 200 and 800 Areas will be restricted from any affected areas and will remain inside the 200 and 800 Area Buildings. All air handling systems may be turned off to prevent any gasses from entering the building. If it becomes necessary to evacuate personnel from the buildings, personnel will be directed to leave any exits located up wind at points further from the effect area and at locations on opposite sides of the building. Depending on the location of the area affected, personnel will then be directed south on Apollo Boulevard to the 100 Area or north on Complex Road B to the 400 Area.

500 and 700 Areas (Waste Fuel Treatment Unit and Open Detonation respectively)

There is no planned evacuation plan for the 500 and 700 Areas since there are no adjacent buildings that house WSTF personnel and since personnel are not usually stationed at these hazardous waste units.

Record Keeping and Incident Reports (264.56(j))

Operating Record (264.56(j))

After any incident occurs which requires implementation of the Contingency Plan, the same information required in Incident Reports section, regarding that incident will also be entered into the NASA operating record.

Incident Reports (264.56(j))

If it is determined that the emergency situation poses a threat to human health or the environment, or that the spill is a reportable spill, the EPM will make the following notifications:

1. Immediate notification to the National Response Center (800) 424-8802;

2. Within 24 hours after any spill or release of hazardous waste, WSTF will notify the NMED Secretary or their designee. The report will include:

   a. name and telephone number of reporter;

   b. name address of facility;

   c. time and type of incident (e.g., spill, fire);

   d. name and quantity of materials involved, to the extent known;

   e. the extent of injuries, if any; and,

   f. the possible hazards to human health or the environment.

3. Within 15 days after any incident occurs, NASA will submit to the NMED Secretary a written report on the incident. The report will include:

   a. name, address, and telephone number of the owner or operator;

   b. name, address, and telephone number of the facility;

   c. date, time, and type of incident (e.g., fire, explosion);

   d. name and quantity of material(s) involved;

   e. the extent of injuries, if any;

   f. an assessment of actual or potential hazards to human health or the environment, where this is applicable; and

g. estimated quantity and disposition of recovered material that resulted from the incident.

Compliance (264.54(j))

Operation will resume only after the EPM notifies the NMED Secretary that no wastes which are incompatible with the released material have been stored, treated or disposed of in the affected Area before clean-up has been completed and that all emergency equipment used in any emergency response activity has been decontaminated and is fit for its intended use.

Corrective Action (270.14(b)(7))

After a response to a release requiring implementation of the Emergency Procedures, the EPM will initiate a review process and develop a corrective action plan to prevent spill recurrence. The corrective action plan will be reviewed and approved by management and then incorporated into operating procedures.

APPENDIX 1

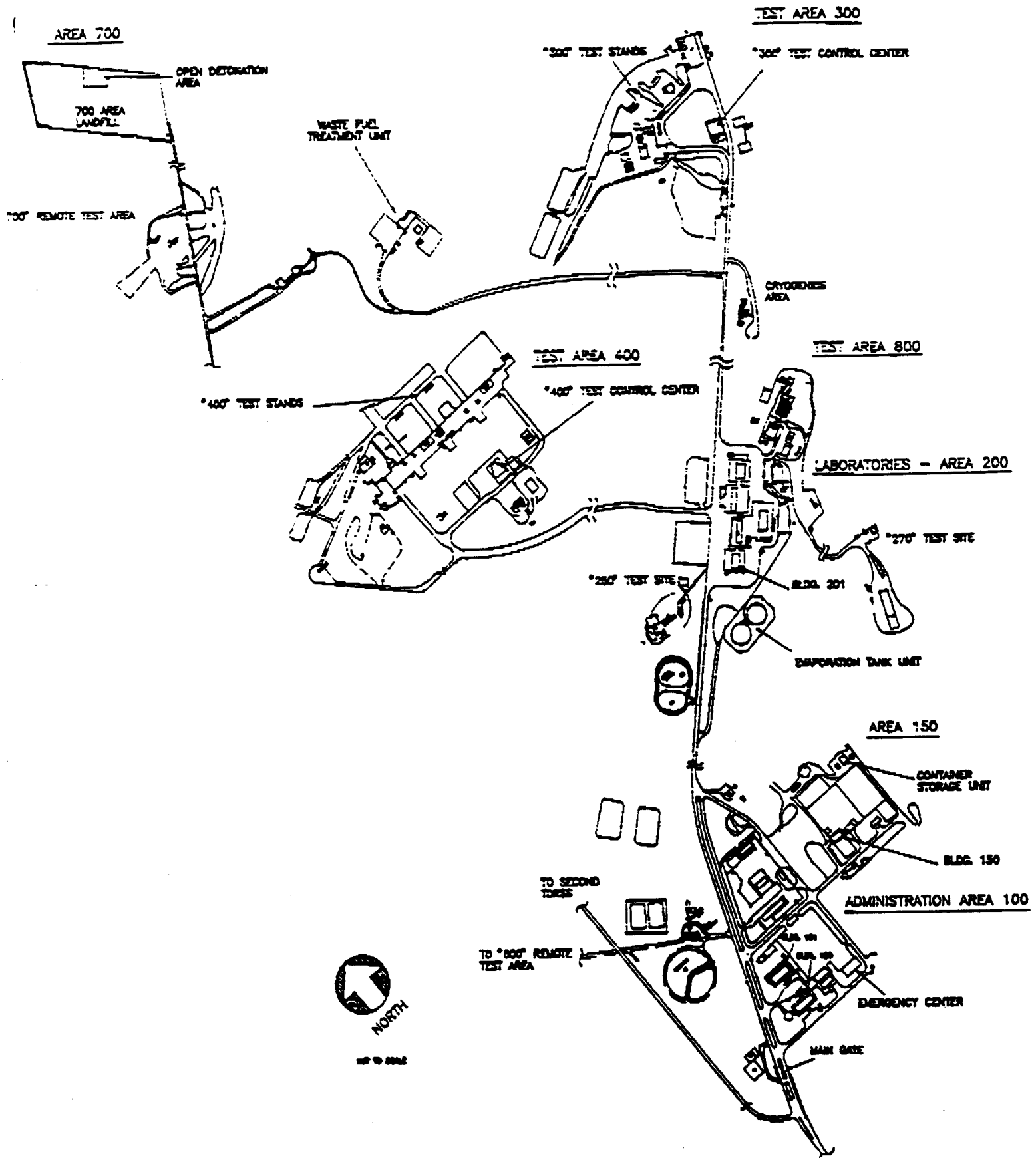
(PERMIT ATTACHMENT II-6)

FLOOR PLANS OF BUILDINGS NEAREST PERMITTED UNITS

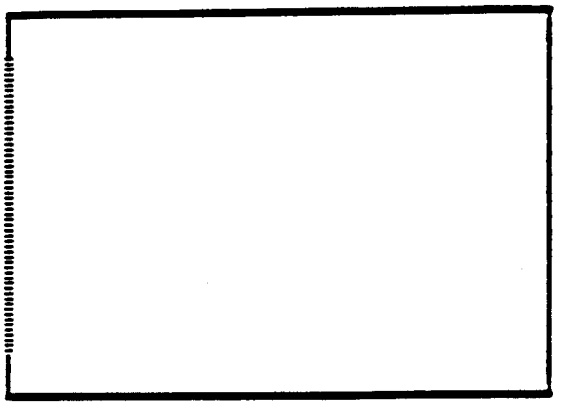
SHOWING LOCATIONS OF

FIRE ALARMS, ELECTRIC SUPPLY PULL BOXES AND FIRE EXTINGUISHERS

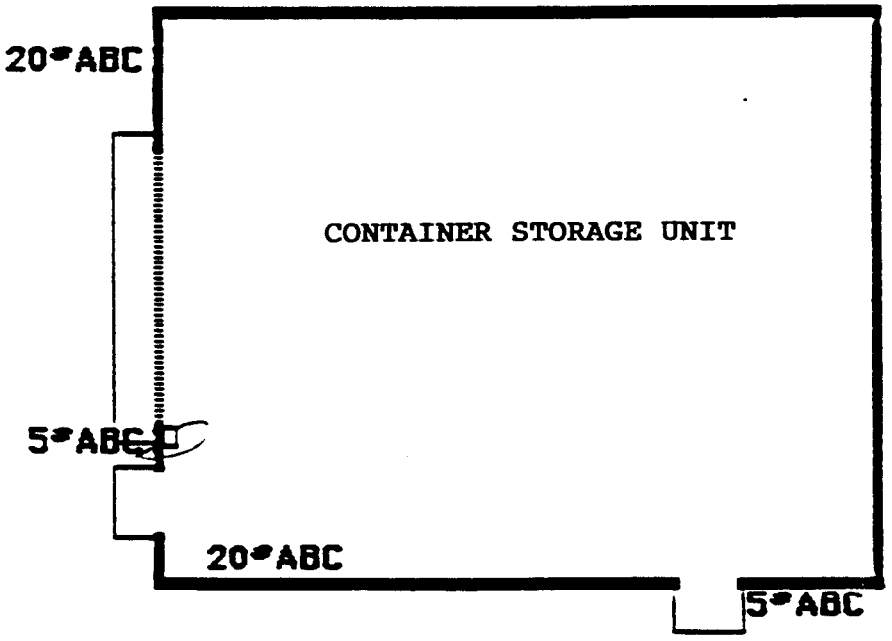
WHITE SANDS TEST FACILITY



EMERGENCY RESPONSE BUILDING

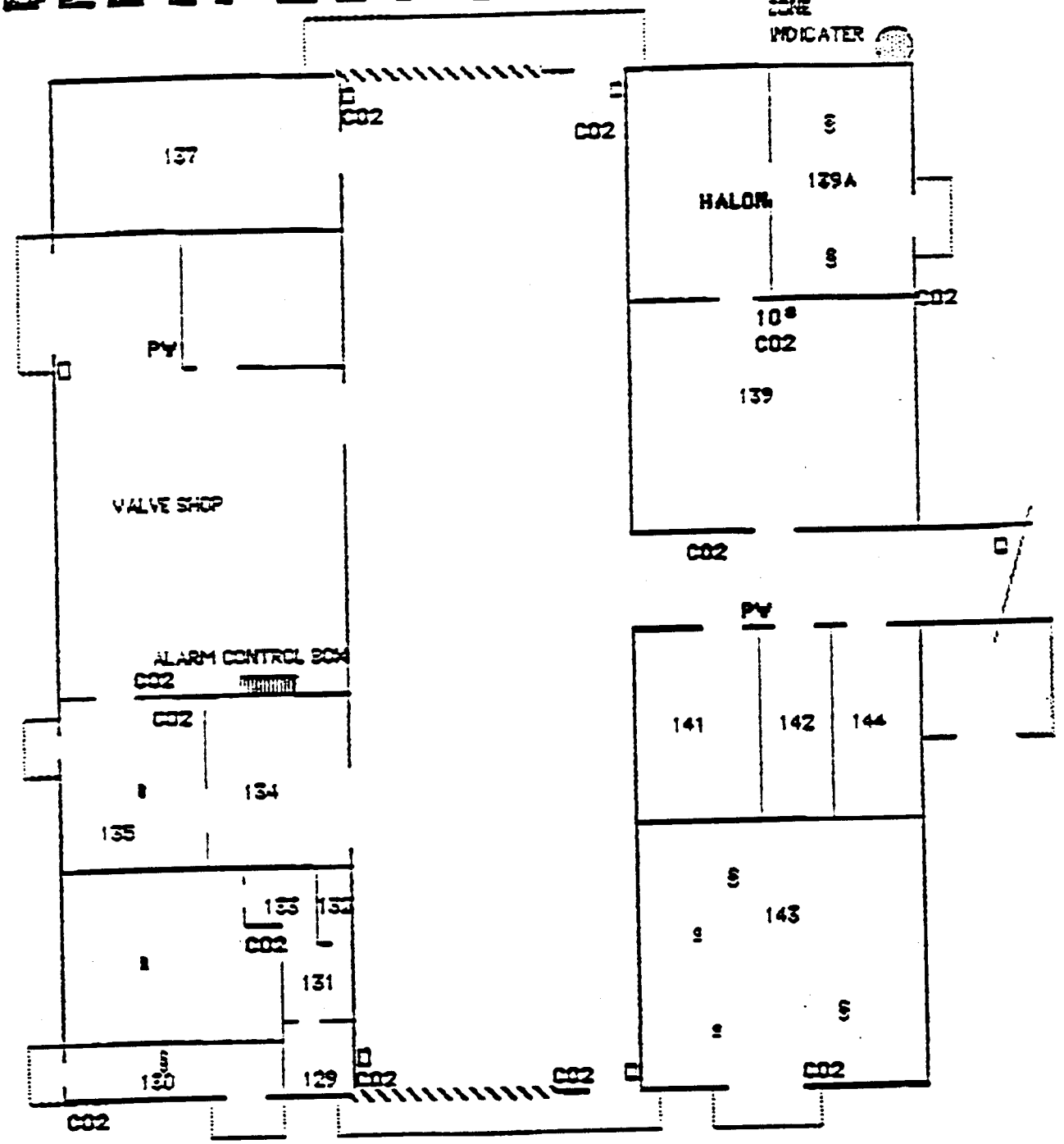


BLDG. 161



2- ABC-20# DRY POWDER FIRE EXTINGUISHERS
2- ABC- 5# DRY POWDER FIRE EXTINGUISHERS
1- □ -FIRE ALARM PULL BOX

REVISED 2/91

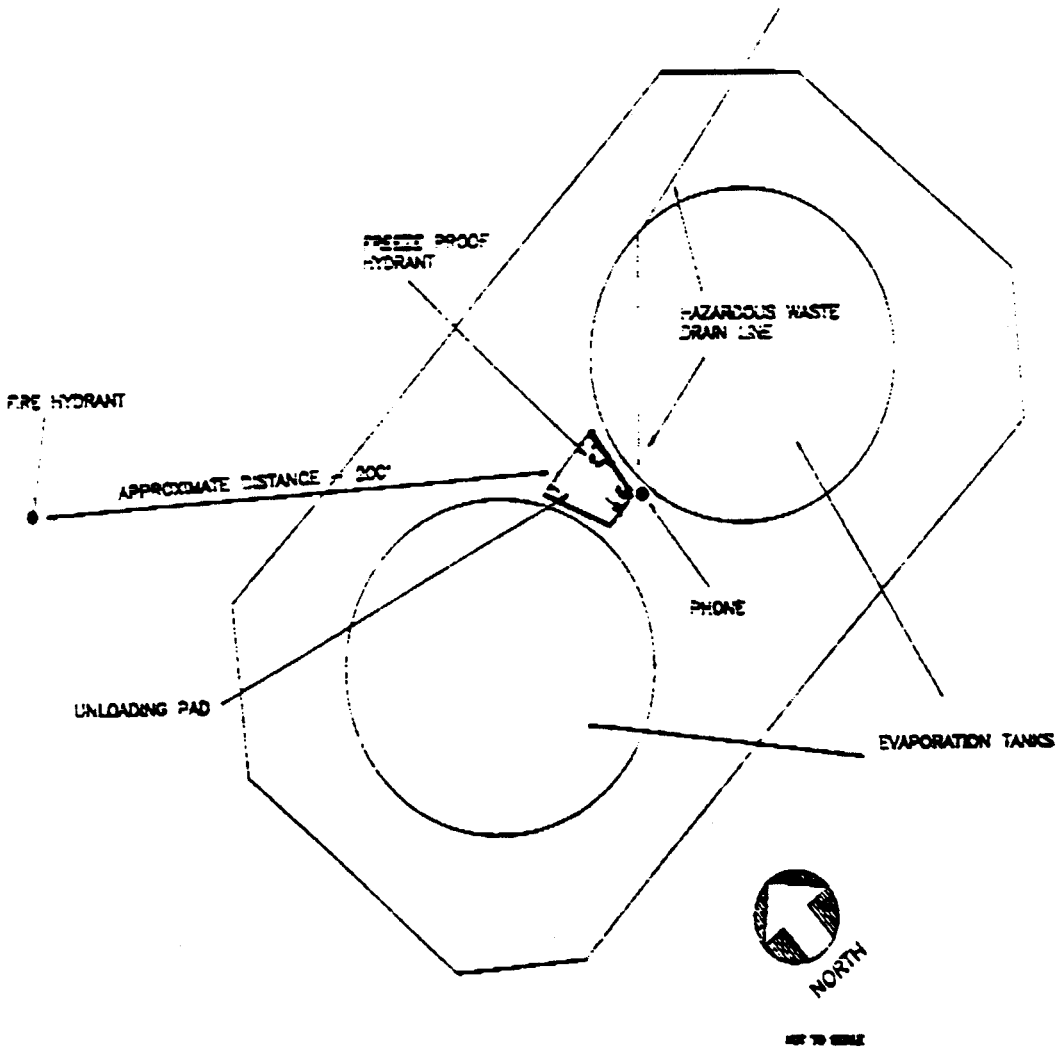


2-PW-PRESSURIZED WATER EXTING.
11-CO2-CARBON DIOXIDE EXTING.
6-□-PULL BOXES
5-S-SMOKE AND HEAT DETECTORS
4-S-HEAT DETECTORS
1- -ALARM CONTROL BOX
1- -ZONE INDICATOR

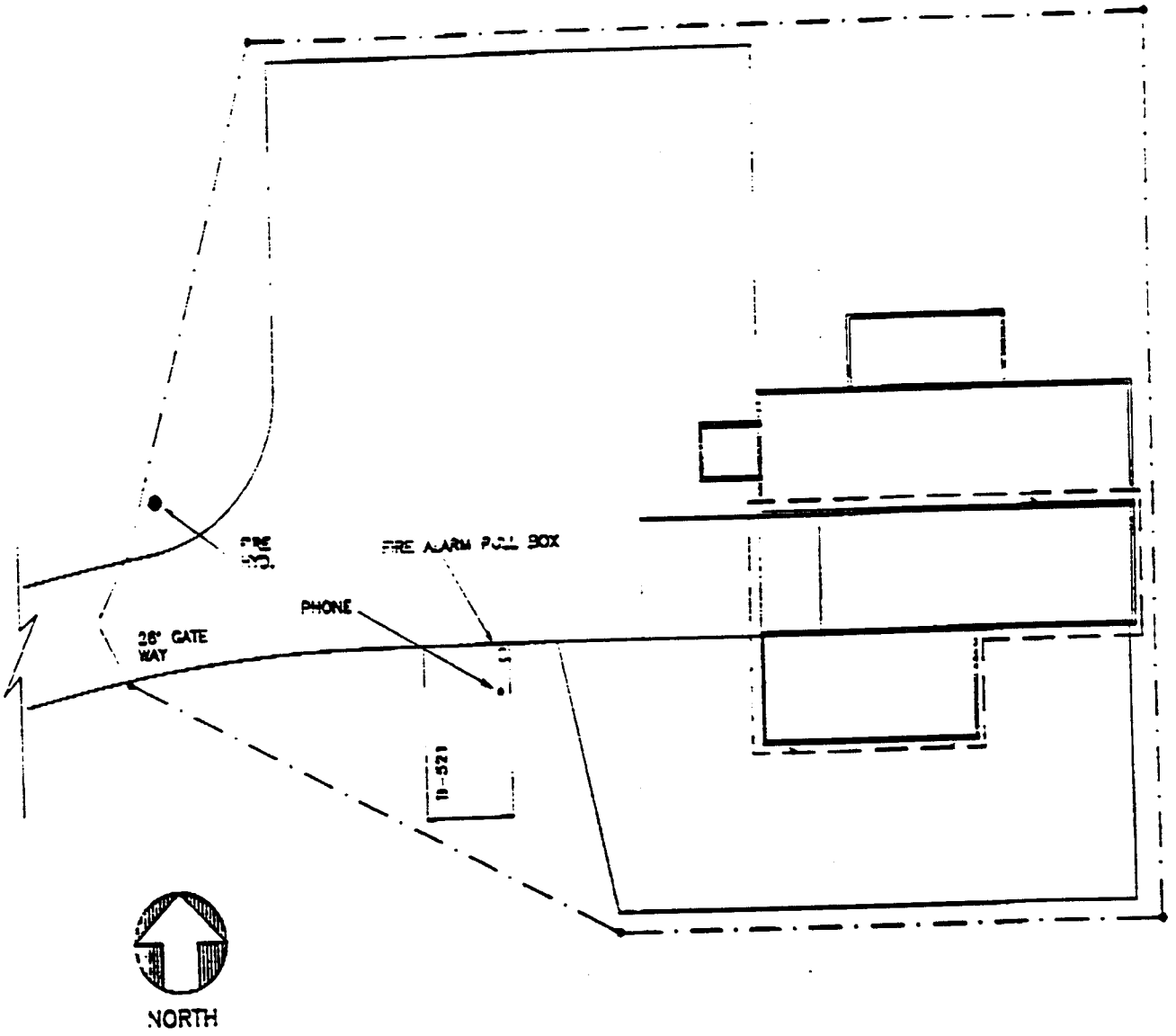
NORTH

REVISED 10/90

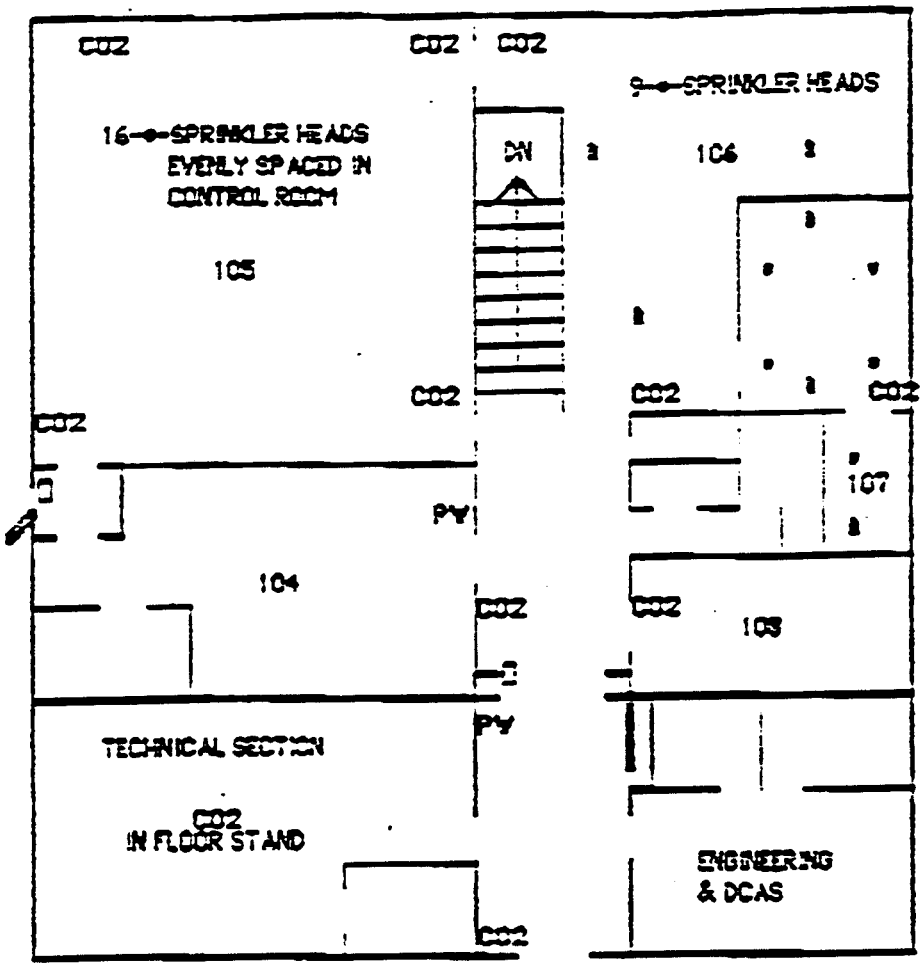
EVAPORATION TANK UNIT



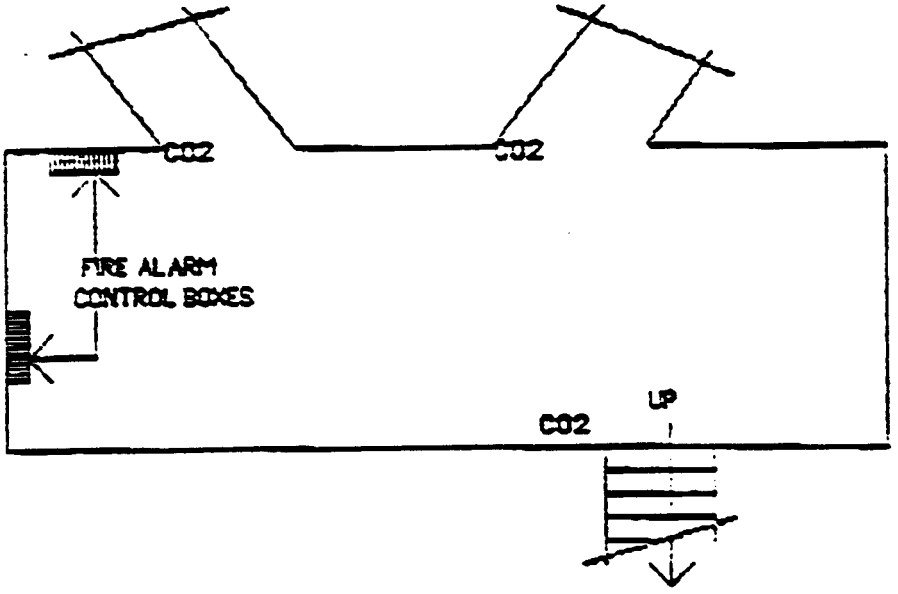
WASTE FUEL TREATMENT UNIT

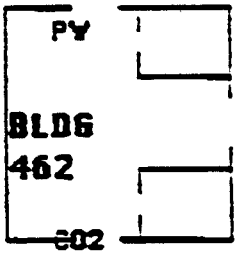


400 BLOCK HOUSE



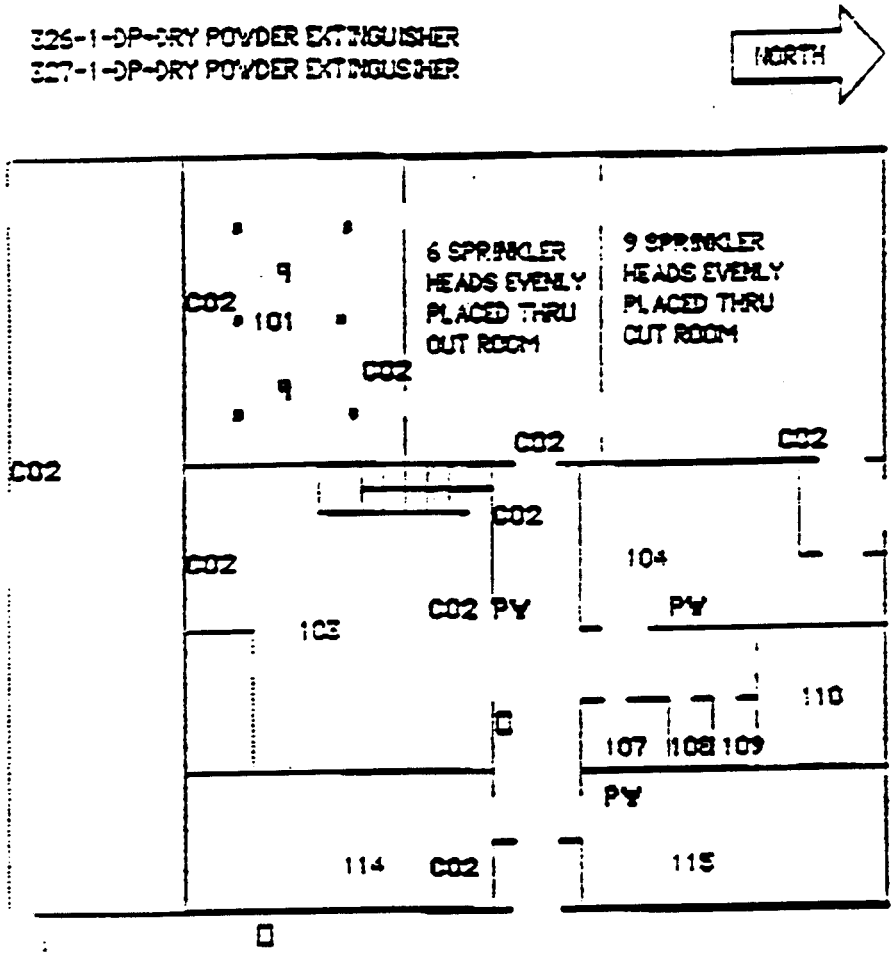
14-CO2-CARBON DIOXIDE EXTINGUISHERS
3-PW-PRESSURIZED WATER EXTINGUISHERS
30- ° -SPRINKLER HEADS
6- ■-HEAT DETECTORS
2-□-PULL BOXES

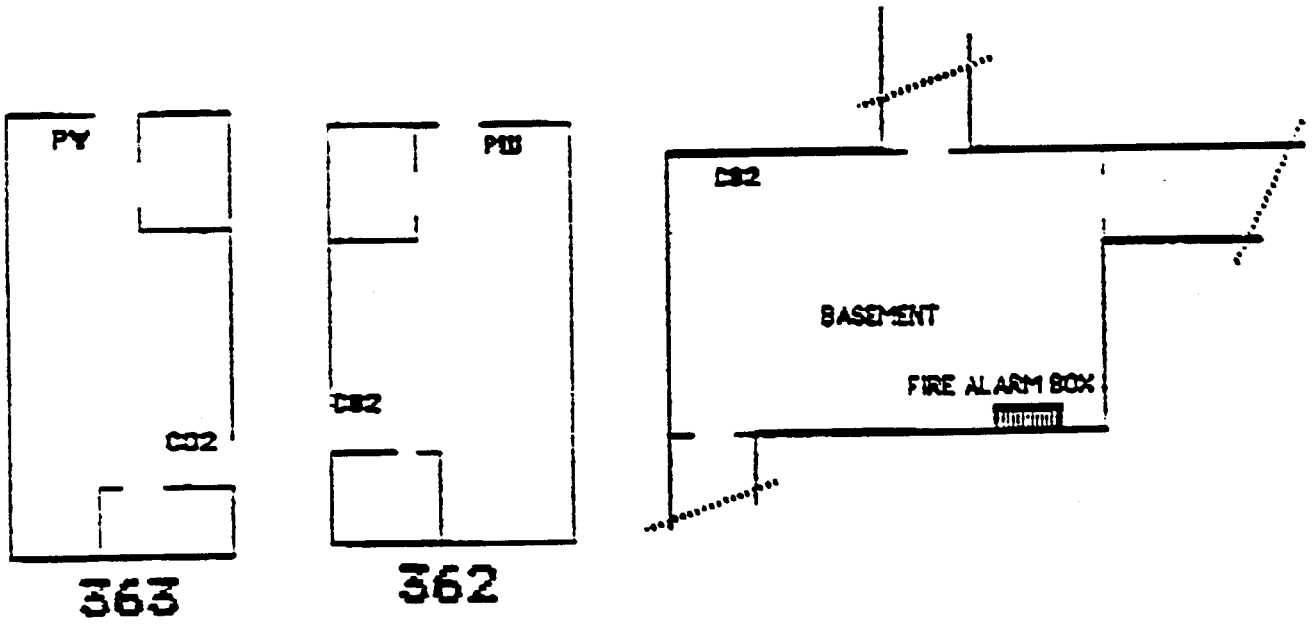




REVISED 10-90

326-1-DP-DRY POWDER EXTINGUISHER
327-1-DP-DRY POWDER EXTINGUISHER





300 BLOCK HOUSE

REVISED 10-90

APPENDIX 2

(PERMIT ATTACHMENT II-6)

CHEMICAL HAZARD INFORMATION

TABLE OF CONTENTS

CHEMICAL HAZARD INFORMATION

Chromic acid

Freon 113

Isopropyl alcohol

Methyl ethyl ketone

Phosphoric acid

Sodium hydroxide

Toluene

1,1,1-Trichloroethane

Xylene

Hydrazine

Monomethyl hydrazine

Unsymmetrical dimethyl hydrazine

Nitrogen tetroxide

Tetrafluorohydrazine

1. Chromic acid

Toxicity:

PEL 0.1mg Cr O_3/m^3 (ceiling). Very high via inhalation route. Corrosive to all tissues. Respiratory and dermal protection required.

Fire Hazard:

Non-flammable, but a powerful oxidizing agent which can react violently with reducing agents and organic matter.

Explosion Hazard:

Can cause violent explosions upon contact with powerful reducing agents.

Potential Incompatibilities:

Alconols - Heat generation

Caustics - Heat generation

Halogenated organics - Heat and toxic gas generation

Ketones - Heat generation

Toxic metals - Solubilization

2. Freon 113

Toxicity:

TLV = 1000 ppm

Fire Hazard:

Non-flammable.

When heated to decomposition may emit highly toxic fumes of phosgene and/or fluorides.

Dangerous when exposed to heat or flame.

Explosion Hazard:

Not applicable.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat and toxic gas generation.

Caustics - Heat and flammable gas generation.

3. Isopropyl alcohol

Toxicity:

TLV = 400 ppm

Moderate toxicity. An eye irritant.

Fire Hazard:

Flash point = 53° F

Vapor density = 2.07

LEL = 2.0%

UEL = 12%

Dangerous when exposed to heat, flame, or oxidizers.

Explosion Hazard:

Moderate when exposed to heat or flame.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat generation.

Organic acids - Heat generation. violent polymerization.

4. Methyl ethyl ketone

Toxicity:

TLV = 200 ppm

Moderate via oral route. A strong irritant.

Fire Hazard:

Flash point = 35° F

Vapor density = 2.42

LEL = 1.8%

UEL = 10%

Dangerous when exposed to heat or flame.

Explosion Hazard:

Moderate when exposed to flame.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat generation.

Caustics - Heat generation.

5. Phosphoric acid

Toxicity:

Corrosive via dermal and inhalation routes. Suitable respiratory and dermal protection required.

Fire Hazard:

Non-flammable.

When heated to decomposition emits toxic fumes of PO_x.

Explosion Hazard:

Not applicable.

Potential Incompatibilities:

Alcohols - Heat generation.

Caustics - Heat generation.

Halogenated organics - Heat and toxic gas generation.

Ketones - Heat generation.

Toxic metals - Solubilization.

6. Sodium hydroxide

Toxicity:

Extremely corrosive via inhalation and dermal exposures. Suitable respiratory and dermal protection may be required.

Fire Hazard:

Non-flammable.

Will react with water or steam to produce heat.

Explosion Hazard:

Not applicable.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat generation.

Organic acids - Heat generation.

Halogenated organics - Heat and flammable gas generation.

Ketones - Heat generation.

Toxic metals - Solubilization.

7. Toluene

Toxicity:

TLV(skin) = 100 ppm

Moderate via inhalation.

Fire Hazard:

Flash point = 40° F(CC)

Vapor density = 3.14

LEL = 1.27%

UEL = 7%

Slight when exposed to heat, flame, or oxidizers. Can emit toxic fumes when heated to decomposition.

Explosion Hazard:

Moderate when exposed to flame.

Potential Incompatibilities:

Oxidizers - Heat and flammable gas generation.

8. 1,1,1-Trichloroethane

Toxicity:

TLV = 350 ppm

Moderate via oral route.

Fire Hazard:

Non-flammable.

When heated to decomposition can emit highly toxic fumes of phosgene.

Explosion Hazard:

Not applicable.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat and toxic gas generation.

Caustics - Heat and flammable gas generation.

9. Xylenes

Estimated quantity:

< 0.5 liters per week

Toxicity:

TLV(skin) = 100 ppm

Moderate via innalation route.

Fire Hazard:

Flasn point = 29° F

Vapor density = 3.66

LEL = 1.0%

UEL = 7.0%

Dangerous when exposed to heat or flame. Can react with oxidizing agents.

Explosion Hazard:

Moderate in the form of vapor when exposed to neat or flame.

Potential Incompatibilities:

Oxidizers - Heat and flammable gas generation.

10. Hydrazine

Toxicity:

TLV(skin) = 1 ppm

Dermal protection and SCBA required.

Fire Hazard:

Flash Point = 126° F(CC)

Vapor density - 1.1

LEL = 4.7%

UEL = 100%

Dangerous when exposed to heat, flame or oxidizing agents. When heated to decomposition emits highly toxic fumes.

Explosion Hazard:

Severe when exposed to heat or flame or by chemical reaction.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat, innocuous and non-flammable gas generation.

Organic acids - Heat, and innocuous and non-flammable gas generation.

Alcohols - Heat, and innocuous and non-flammable gas generation.

Aldehydes - Heat generation.

11. Monomethyl hydrazine

Toxicity:

TLV(skin) = 0.2 ppm

High via inhalation and dermal route. SCBA's and dermal protection required.

Fire Hazard:

Flash point = 80° F

Vapor density = 1.6

LEL = 2.5%

UEL = 97%

Dangerous when exposed to heat, flame or oxidizers.

Explosion Hazard:

Severe when exposed to heat or flame or by chemical reaction.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat, innocuous and non-flammable gas generation.

Organic acids - Heat, and innocuous and non-flammable gas generation.

Alcohols - Heat, and innocuous and non-flammable gas generation.

Aldehydes - Heat generation.

12. Unsymmetrical dimethyl hydrazine

Toxicity:

TLV(skin) = 0.5 ppm

Highly corrosive and irritating to skin, eyes and mucous membranes.

SCBA's and dermal protection required.

Fire Hazard:

Flash point = 5° F

Vapor density = 1.94

LEL = 2%

UEL = 95%

Dangerous when exposed to heat, flame or oxidizers.

Explosion Hazard:

Severe when exposed to heat or flame or by chemical reaction.

Potential Incompatibilities:

Non-oxidizing mineral acids - Heat. innocuous and non-flammable gas generation.

Organic acids - Heat. and innocuous and non-flammable gas generation.

Alcohols - Heat, and innocuous and non-flammable gas generation.

Aldehydes - Heat generation.

13. Nitrogen tetroxide

Toxicity:

High via inhalation.

TLV 3 ppm in air as NO_2.

Fire Hazard:

Noncombustible but supports combustion.

Explosion Hazard:

Powerful oxidizing agent. can explode when in contact with reducing agents.

Potential Incompatibilities:

Reducing agents - Heat, explosions.

Bases - Heat generation.

14. Tetraflouronydrazine

Toxicity:

Irritant

Fire Hazard:

Explosion Hazard:

Powerful oxidizing agent. can explode when in contact with reducing agents.

Potential Incompatibilities:

Alkalines - Heat generation.

Reducing agent - Heat explosion.

APPENDIX B

WSTF GROUNDWATER SAMPLING AND ANALYSIS PLAN

GROUNDWATER SAMPLING AND ANALYSIS PLAN

NASA
WHITE SANDS TEST FACILITY

LAS CRUCES, NEW MEXICO

Revised July 7, 1997

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY 1

2.0 PURPOSE, SCOPE AND HISTORICAL BACKGROUND

2.1 Purpose 1
2.2 Scope 1
2.3 Historical Background 2

3.0 DESIGN AND MAINTENANCE OF CONVENTIONAL RCRA MONITOR WELLS 3

3.1 Design of Conventional RCRA Monitor Wells 3
3.2 Well Development 3
3.3 Well Security 3

4.0 CONVENTIONAL WELL SAMPLING EQUIPMENT 10

4.1 Dedicated Well Sampling Systems 10

4.1.1 Bladder Pump Systems 10
4.1.2 Inflatable Packer/Bladder Pump Systems 10
4.1.3 Purge Pump/Bladder Pump System 10
4.1.4 Inflatable Packer/Purge Pump/Bladder Pump Systems 12
4.1.5 Bailers 12

4.2 Non-dedicated Sampling Equipment

4.2.1 Pneumatically Operated Pumps 12
4.2.2 Miscellaneous Non-dedicated Sampling Equipment 12

4.3 Field Analytical Equipment 13
4.4 Sample Containers 13
4.5 Other Equipment and Supplies 13

5.0 CONVENTIONAL WELL SAMPLING PROCEDURES 13

5.1 Static Water Level Measurement 13
5.2 Well Purging 13

6.0 WESTBAY MULTI-PORT WELL MONITORING SYSTEMS 14

6.1 Design of Westbay Wells 14
6.2 Development of Westbay Wells 15
6.3 Well Security 15
6.4 Monitoring Equipment

6.4.1 MOSDAX Sampler Probe 15
6.4.2 In Situ Datalogger 15

6.5 Collection of Hydrogeological Data

6.5.1 Pressure Profiles 16
6.5.2 Hydraulic Conductivity Determinations 16

6.6 Collection of Groundwater Samples 17
6.7 Decontamination of Westbay Sampling Equipment 17

7.0 MONITOR WELL SAMPLING FREQUENCIES/ANALYTICAL PARAMETERS 18

7.1 Groundwater Assessment Sampling Schedule 18
7.2 Analytical Parameters 18

7.2.1 Initial Sampling Events 20
7.2.2 Standard Plan A Sampling Events 20
7.2.3 Standard Plan B Sampling Events 20
7.2.4 Additional Analyses 20
7.2.5 Appendix IX Sampling 27

7.3 Sample Collection

7.3.1 Sample Identification 27
7.3.2 Sample Collection 27

7.4 Field Analyses 32
7.5 Sample Preservation and Storage 32
7.6 Equipment Decontamination and Verification 32

8.0 ANALYTICAL METHODS 32

8.1 Modifications to the Referenced EPA Methods 34

9.0 QUALITY ASSURANCE PROCEDURES 34

9.1 Field Quality Control Samples 34
9.2 Documentation 34

9.2.1 Field Logbook 34
9.2.2 Sample Seals and Labels 38
9.2.3 Chain of Custody Forms 39

9.3 Sample Delivery 39

9.3.1 Shipment of Off-Site Samples 39

9.4 Analytical Quality Assurance 39

10.0 ANALYTICAL REPORTS AND DATA MANAGEMENT 39

11.0 REFERENCES 40

TABLES

TABLE 3.1	Summary of WSTF Groundwater Wells	4
TABLE 3.2	Well Designations Cross Reference	9
TABLE 4.1	Dedicated Well Sampling Equipment	11
TABLE 7.1	Sampling Frequency for WSTF Groundwater Assessment Wells/Zones	19
TABLE 7.2	Parameter Collection Frequencies	21
TABLE 7.3	Groundwater Assessment Wells and Their Corresponding Parameter Collection Plans	26
TABLE 7.4	Groundwater Assessment Containers, Preservation Methods and Holding Times	28
TABLE 7.5	Containers, Preservatives and Holding Times	29
TABLE 8.1	Analytical Methods Currently Used at WSTF	33
TABLE 8.2	Halogenated Volatile Organic Compounds	35
TABLE 9.1	Descriptions of Field Quality Control Samples	36
TABLE 9.2	Field QA/QC Controls	37

1.0 EXECUTIVE SUMMARY

Under the provisions of the Resource Conservation and Recovery Act (RCRA), specific requirements are outlined to establish groundwater sampling and analysis programs. Included in these regulations are requirements for a written Sampling and Analysis Plan. This document is written to provide the NASA White Sands Test Facility (WSTF) with a Sampling and Analysis Plan which satisfies the regulatory requirements and provides personnel involved in the groundwater assessment project with site-specific procedures for the collection and analysis of groundwater samples.

Specified by this Sampling and Analysis Plan and additional site-specific procedural documentation are written procedures concerning the following:

- collection and preservation of groundwater samples;
- chain of custody documentation;
- sample shipment; and
- analytical procedures.

The on-site environmental contractor organization is involved in the collection and processing of groundwater samples at WSTF. This document is designed to be used in conjunction with site-specific procedural documentation to ensure the consistency of all work involved in the collection and processing of groundwater samples. The current site-specific procedures include White Sands Test Facility Job Instructions (WJIs), Test Preparation Sheets (TPSs), and specific equipment Operations and Maintenance Manuals. All procedures are written to comply with requirements and guidelines found in the Technical Enforcement Guidance Document (TEGD), Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846), RCRA Ground Water Monitoring: Draft Technical Guidance, and other applicable technical guidance sources.

This Sampling and Analysis Plan is reviewed annually, and revised as necessary, to ensure that the procedures reflect the future needs of the groundwater assessment program, comply with future regulatory requirements, and are responsive to advances in scientific knowledge and technologies. Copies of all revisions of this document are retained at WSTF to provide historical documentation of methodologies used throughout the groundwater sample collection period.

2.0 PURPOSE, SCOPE AND HISTORICAL BACKGROUND

2.1 PURPOSE

This document serves as a procedural guide for personnel engaged in groundwater sampling and analysis at WSTF. It is used in conjunction with site-specific procedures and specific equipment Operations and Maintenance Manuals. Procedures outlined are consistent with those specified for use at sites subject to the requirements of RCRA, and have been adapted to meet the specific requirements of the WSTF groundwater assessment program.

2.2 SCOPE

This document is intended for use as an aid for training technical staff and as a procedural guide for trained personnel involved in the collection of WSTF groundwater samples. Adherence to the protocols presented in this document assures that samples are collected in a consistent manner, representative of actual groundwater conditions, shipped and tracked in an acceptable manner, and analyzed by appropriate EPA-recommended analytical methods.

In addition to this document, the WSTF Quality Assurance Project Plan provides the quality assurance steps necessary to substantiate collected groundwater data. The WSTF Quality Assurance Project Plan, used in conjunction with the WSTF Sampling and Analysis Plan, provides protocols for the collection and analysis of groundwater samples.

2.3 HISTORICAL BACKGROUND

During the course of operations at WSTF from the early 1960s to the early 1980s, hazardous constituents were released to the environment and eventually migrated to the groundwater. As mandated by RCRA, NASA established a detection monitoring program to investigate the presence of hazardous constituents in the groundwater. Groundwater monitoring wells were installed up gradient and down gradient of hazardous waste management units. Sampling and analysis of these wells was performed and hazardous waste contamination of the groundwater was detected.

Based on the original information obtained from these wells, a groundwater assessment program was initiated to characterize the nature and extent of contamination. Using soil gas data, seismic reflection data, soil borings, and the installation and sampling of groundwater assessment wells, sufficient information was gathered to form a conceptual visualization of the contamination problem.

Based on the analytical data collected, groundwater contamination extends as far as two miles west of the WSTF facility boundary. The types of hazardous constituents found in the groundwater include several halogenated volatile organic compounds, N-nitrosodimethylamine (NDMA), and chromium.

NASA, with the support of EPA Region 6, has incorporated the use of Westbay Multi-Port (MP) well systems to complement existing conventional groundwater assessment wells. These wells are incorporated to vertically profile specified areas where a three-dimensional understanding of the contamination plume is essential. The Westbay MP system is discussed in detail in Section 6 of this document.

Currently, more than one hundred wells and monitoring zones are sampled by WSTF personnel on a regular basis. Several additional wells are scheduled to be drilled and installed in the near future.

The present goal of the groundwater assessment program is to collect groundwater data to:

- determine the distribution and migration of hazardous constituents;
- determine potential threats to the environment and human health; and
- if required, aid in the design and location of remedial systems to mitigate the environmental contamination.

The on-site environmental contractor organization is tasked with the groundwater assessment project. This organization is staffed with both hydrogeological and groundwater personnel. Hydrogeological personnel are primarily involved in the installation of groundwater assessment wells and hydrogeologic interpretation. Groundwater personnel are primarily involved in the collection and analysis of groundwater samples. An explanation of the functions of on-site environmental contractor personnel is provided in the WSTF Quality Assurance Project Plan.

3.0 DESIGN AND MAINTENANCE OF CONVENTIONAL RCRA MONITOR WELLS

A summary of groundwater monitoring wells, piezometers, and related wells is provided in Table 3.1. Well designations presented in this Table supersede all previous designations. Groundwater wells are identified by an alphanumeric code stenciled on the protective outer casing. Well identifications, for wells installed after March 1987, are determined by location of the well-site, an alphanumeric identification digit, and the depth to the top of the screen from ground level. Wells that were installed as part of the original RCRA groundwater detection program are designated as NASA 3 through 10.

Wells completed since January 1987 have a brass cap permanently cemented in the well pad. Each brass cap contains information regarding well coordinates, casing elevations, and well identification. From January 1987 to March 1987 these wells were originally identified according to site location and relative depth to other wells in the area (e.g., 600-C (Shallow)). These wells were renamed to reflect the identification system referenced above. However, the brass caps originally installed in the well pads reflect the original designations. A cross-reference detailing original and new well designations is provided in Table 3.2.

Well installation and construction details are described in the WSTF Groundwater Monitoring Network Installation Plan (February 17, 1989).

3.1 DESIGN OF CONVENTIONAL RCRA MONITOR WELLS

The original eight detection wells installed at WSTF were two inches (5.08 cm) in diameter and constructed of PVC and stainless steel. All subsequent conventional wells are four inches (10.16 cm) in diameter and are constructed of PVC and/or stainless steel. The wells are screened at an interval which is either at, or below, the water table with 0.020-inch (0.051 cm) slotted stainless steel screen.

3.2 WELL DEVELOPMENT

Monitor wells are developed immediately following completion by bailing and/or overpumping. These processes are designed to clean the screen, the filter-pack, and the surrounding aquifer to allow representative water samples to be collected. Wells are considered fully developed when stable values for pH, temperature and specific conductance are observed. Additionally, turbidity values are monitored to ensure the turbidity is stable and less than five nephelometric turbidity units (NTUs).

Due to the possible infiltration of fine-grained sediments into the well and filter pack, occasional redevelopment may be necessary. Well recovery times and turbidity values are used to monitor the well to determine if redevelopment is required.

3.3 WELL SECURITY

Monitor wells are equipped with locking caps which are secured at all times, except for sampling and analysis procedures conducted in accordance with this document. Keys are issued only to personnel directly involved in the collection of groundwater samples or well maintenance.

TABLE 3.1
Summary of WSTF Groundwater Wells

Well I.D.	Elevation Brass Cap (feet amsl)	Screen Interval (feet)	Date Completed
100-A-182	4842.36	182.00-192.40	05/30/89
100-B(2)	4756.61	N/A	N/A
100-B	4756.79	364.59-385.32	07/12/89
100-C-365	4816.82	365.00-385.80	09/18/89
100-D-176	N/A	176.00-196.00	05/14/97
100-E-261	4900.99	260.90-271.30	07/07/89
200-A	4891.27	N/A	N/A
200-B-240	4837.77	239.80-250.10	01/11/89
200-C	4810.68	Three Screened Zones	01/21/93
200-D-109	4785.79	108.80-129.50	03/12/87
200-D-240	4785.25	239.60-250.00	07/20/88
200-E	4818.36	N/A	N/A
200-F	4879.19	Four Screened Zones	10/11/94
200-G	4875.36	Five Screened Zones	11/14/94
200-H	4882.13	Four Screened Zones	09/21/94
300-A-120	4911.67	120.00-146.00	02/03/87
300-A-170	4911.28	170.00-175.50	03/26/87
300-B-166	4931.92	165.50-175.90	10/09/87
300-C-128	4877.27	128.20-154.30	03/09/87
300-D-153	5108.71	153.10-173.80	04/04/88
300-E	4926.31	Two Screened Zones	02/12/95
400-A-151	4795.09	150.50-275.60	02/09/87
400-B	No Brass Cap	N/A	N/A
400-C-118	4808.74	118.00-143.00	02/17/87
400-C-143	4808.55	143.00-153.40	02/20/87
400-D	4824.17	Three Screened Zones	03/27/95
600-C	4743.13	N/A	N/A
600-C-173	4744.01	172.50-193.20	02/25/87
600-C-210	4744.31	210.00-220.30	02/20/87

TABLE 3.1
Summary of WSTF Groundwater Wells

Well I.D.	Elevation Brass Cap (feet amsl)	Screen Interval (feet)	Date Completed
600-C-437	4745.04	436.90-447.20	02/08/88
600-D	4747.51	Four Screened Zones	06/15/95
600-PZ-1	N/A	265.00-270.00	04/21/89
600-PZ-2	N/A	429.65-434.65	04/27/89
700-A-253	4908.14	253.00-263.40	11/09/89
700-B-510	4805.89	510.00-530.84	08/14/90
700-D-186	4885.28	186.00-196.30	12/21/89
700-E-458	4717.77	458.10-478.90	03/12/90
700-F-455	4763.62	455.00-475.03	01/31/91
BLM-1-435	4551.67	435.30-445.70	11/13/87
BLM-2-482	4535.48	482.40-492.80	10/25/87
BLM-2-630	4535.35	629.50-639.80	06/13/88
BLM-3-182	4743.93	182.30-203.00	02/10/87
BLM-4	4743.81	N/A	N/A
BLM-5-527	4551.80	527.30-537.70	04/04/88
BLM-6-488	4588.36	487.70-498.20	04/18/90
BLM-7-509	4529.80	509.30-519.70	05/17/88
BLM-8-416	4556.33	418.00-428.40	06/28/88
BLM-9-419	4692.24	419.30-440.00	11/09/88
BLM-10-517	4533.71	516.60-526.90	03/03/88
BLM-11	4677.05	N/A	N/A
BLM-12	4647.61	N/A	N/A
BLM-13-300	4665.98	300.40-310.80	09/02/88
BLM-14-327	4675.54	320.00-327.42	09/27/90
BLM-15	4702.60	N/A	N/A
BLM-15-305	4703.69	305.00-315.30	04/14/89
BLM-16	4716.07	N/A	N/A
BLM-17-493	4538.13	492.80-513.50	02/17/89
BLM-17-550	4638.24	550.44-560.86	09/10/90

TABLE 3.1
Summary of WSTF Groundwater Wells

Well I.D.	Elevation Brass Cap (feet amsl)	Screen Interval (feet)	Date Completed
BLM-18-430	4609.84	430.00-450.80	09/19/89
BLM-21-400	4648.73	400.00-410.01	07/02/91
BLM-22-570	4606.84	570.21-591.69	08/24/90
BLM-23-431	4588.06	430.82-441.25	06/25/90
BLM-24-565	4713.84	564.85-584.88	01/08/91
BLM-25-455	4619.42	454.95-464.95	10/23/91
BLM-26-404	4664.97	404.0-414.0	11/05/91
BLM-27-270	4729.75	270.01-280.27	08/08/91
BLM-28	4639.30	Three Screened Zones	05/10/94
BLM-29	No Brass Cap	N/A	N/A
BLM-30	4595.79	One Screened Zone	05/15/95
BLM-31	4726.98	Three Screened Zones	03/17/95
BW-1-268	4772.15	268.10-288.80	12/07/88
BW-2	4778.18	N/A	N/A
BW-3-180	4734.03	179.60-200.30	08/24/88
BW-4	4750.75	Three Screened Zones	02/23/93
BW-5-295	4814.52	294.90-305.20	02/04/89
BW-6-355	4815.23	355.0-375.53	01/31/92
BW-7-211	4798.64	211.30-221.60	01/12/88
J-PZ-1	N/A	416.60-421.60	02/15/89
J-PZ-2	N/A	568.00-573.00	02/12/89
J-PZ-3	N/A	416.50-421.40	02/23/89
J-PZ-4	N/A	387.60-392.61	02/17/89
J-PZ-5	N/A	416.30-421.10	02/22/89
JP-1-424	4444.09	424.00-434.30	12/05/87
JP-2-447	4446.17	446.50-456.90	08/15/88
NASA 1	4808.99	100.00-260.00	08/08/83
NASA 2	4743.85	90.00-390.00	07/13/84
NASA 3	5010.42	118.75-138.75	02/27/85

TABLE 3.1
Summary of WSTF Groundwater Wells

Well I.D.	Elevation Brass Cap (feet amsl)	Screen Interval (feet)	Date Completed
NASA 4	4770.74	146.20-166.20	03/04/85
NASA 5	4925.53	119.25-130.25	03/06/85
NASA 6	4821.03	127.60-147.60	03/07/85
NASA 7	4747.23	177.20-197.20	03/26/85
NASA 8	4751.35	172.00-192.00	04/01/85
NASA 9	4822.23	129.56-149.56	04/03/85
NASA 10	4835.48	110.00-130.00	04/12/85
NASA-PT	4522.79	507.72-828.44	03/29/90
PL-1-486	4518.14	486.00-496.40	10/08/88
PL-2-504	4508.04	504.00-514.40	11/28/88
PL-3-453	4496.89	453.40-463.80	11/09/88
PL-4-464	4480.88	463.96-474.36	01/23/90
PL-5	4512.60	Six Screened Zones	11/10/90
PL-6	4482.15	N/A	N/A
PL-6-B	4481.69	Nine Screened Zones	01/15/91
PL-7	4519.12	Three Screened Zones	12/17/92
PT-PZ-1	No Brass Cap	485.00-490.00	10/13/89
PT-PZ-2	No Brass Cap	503.85-508.85	01/18/90
PT-PZ-3	No Brass Cap	515.44-520.44	01/22/90
PT-PZ-4	No Brass Cap	508.81-513.91	01/25/90
ST-1-473	4503.64	472.70-483.10	05/30/89
ST-1-541	4502.39	541.21-551.22	11/19/91
ST-1-630	4501.61	630.38-640.38	07/21/92
ST-2-466	4467.22	465.70-476.20	08/18/89
ST-3-486	4495.98	486.00-496.42	08/08/91
ST-3-586	4494.59	585.77-595.79	04/10/92
ST-3-666	4494.36	665.88-675.84	06/12/92
ST-3-735	4496.62	735.32-755.22	08/21/92
ST-4-481	4493.16	480.78-490.78	04/23/92

TABLE 3.1
Summary of WSTF Groundwater Wells

Well I.D.	Elevation Brass Cap (feet amsl)	Screen Interval (feet)	Date Completed
ST-4-589	4493.13	588.75-598.75	05/20/92
ST-4-690	4491.16	490.42-710.42	10/05/92
ST-5-481	4459.24	480.75-490.78	05/06/92
ST-5	4458.74	Five Screened Zones	06/29/93
WB-1	4840.94	Three Screened Zones	04/12/90
WB-2	4901.00	Three Screened Zones	04/13/90
WB-3	4812.16	Four Screened Zones	04/09/90
WB-4	4844.78	Four Screened Zones	04/06/90
WB-5	4872.41	Four Screened Zones	06/14/90
WB-6	4775.34	N/A	N/A
WB-7	4745.53	N/A	N/A
WB-8	4961.68	Three Screened Zones	03/10/93
WB-9	5001.61	Three Screened Zones	02/26/92
WB-14	4731.68	One Screened Zone	03/23/92
WW-1-452	4455.09	451.90-462.20	01/21/88

N/A - Not Applicable

TABLE 3.2
Well Designations Cross Reference

Brass Cap Designation	Revised Designation
200-D (S)	200-D-109
300-A (S)	300-A-120
300-A (M)	300-A-170
300-B (S)	300-B-166
300-C (S)	300-C-128
400-A (S)	400-A-151
400-C (S)	400-C-118
400-C (M)	400-C-143
600-C (S)	600-C-173
600-C (M)	600-C-210
600-C (D)	600-C-437

4.0 CONVENTIONAL WELL SAMPLING EQUIPMENT

Equipment used for the collection of groundwater samples is designed to minimally alter sample integrity during the sample collection process. The following sections provide a brief discussion of the basic sampling equipment. Detailed procedures are provided in the site-specific procedural documentation.

4.1 DEDICATED WELL SAMPLING SYSTEMS

Several types of dedicated well sampling systems are used at WSTF due to the variability of sampling conditions encountered. Factors that influence the type of system selected for each well are depth to water, volume of water to be purged, water recovery rate, frequency of sampling, and the cost of system installation. The following sections provide an overview of the WSTF systems.

Table 4.1 provides a summary of the specific dedicated sampling systems that are installed in each of the groundwater assessment wells. Detailed instructions for the use of these systems are provided in the site-specific procedural documentation.

4.1.1 Bladder Pump Systems

Sixteen wells are equipped with dedicated positive displacement bladder pump systems. In this design, the pumps are used for both purging and sampling the wells. The pumps are constructed of stainless steel and Teflon. Teflon-lined discharge tubing is used to minimize the sorptive effects of the tubing on sample quality. The pressure required to operate the pumps is supplied by compressed nitrogen cylinders and/or dewars. This system type is used in wells where the static water levels are relatively shallow and required purge volumes are small.

4.1.2 Inflatable Packer/Bladder Pump Systems

Three wells are equipped with dedicated inflatable packer/bladder pump systems. In this system, an inflatable packer is used to isolate a zone in the well extending from just above the screened interval to the bottom of the well. This significantly reduces the amount of purge water required prior to sample collection. Water is purged and sampled from this zone using a dedicated bladder pump. The bladder pump is stainless steel/Teflon construction and Teflon-lined discharge tubing is used to ensure sample quality. This system type is used in relatively shallow wells where a large amount of purging would be required if the packer was not used.

4.1.3 Purge Pump/Bladder Pump System

One well is equipped with a purge pump/bladder pump system. An air displacement pump is installed above the bladder pump to purge the water prior to sample collection. A bladder pump is then used to sample the well. This system type minimizes the time required to sample wells where moderate purge volumes are required prior to sample collection.

TABLE 4.1
Dedicated Well Sampling Equipment

DEDICATED BLADDER PUMP SYSTEM	DEDICATED BAILERS		INFLATABLE PACKER/ BLADDER PUMP SYSTEM	PURGE PUMP/ BLADDER PUMP SYSTEM	PURGE PUMP/ INFLATABLE PACKER/ BLADDER PUMP SYSTEM
NASA 3	100-C-365	BLM-23-431	100-E-261	200-D-240	600-C-437
NASA 4	100-D-176	BLM-24-565	200-B-240		
NASA 5	200-D-109	BLM-25-455	BW-5-295		
NASA 6	300-A-170	BLM-26-404			
NASA 7	300-B-166	BLM-27-270			
NASA 8	700-A-253	BW-1-268			
NASA 9	700-B-510	BW-3-180			
NASA 10	700-D-186	BW-7-211			
100-A-182	700-E-458	JP-1-424			
300-A-120	700-F-455	JP-2-447			
300-C-128	BLM-1-435	PL-1-486			
300-D-153	BLM-2-482	PL-2-504			
400-A-151	BLM-2-630	PL-3-453			
400-C-118	BLM-3-182	PL-4-464			
400-C-143	BLM-5-527	ST-1-473			
600-C-173	BLM-6-488	ST-1-541			
	BLM-7-509	ST-1-630			
	BLM-8-418	ST-2-466			
	BLM-9-419	ST-3-486			
	BLM-10-517	ST-3-586			
	BLM-13-300	ST-3-666			
	BLM-14-327	ST-3-735			
	BLM-15-305	ST-4-481			
	BLM-17-493	ST-4-589			
	BLM-17-550	ST-4-690			
	BLM-18-430	ST-5-481			
	BLM-21-400	WW-1-452			
	BLM-22-570				

NOTE: Wells which are equipped with dedicated pump systems may periodically experience problems due to equipment malfunctions/static water level fluctuations. These problems may require WSTF to utilize the pneumatically driven pump/dedicated bailer technique for sampling until they can be corrected. If this alternate procedure is used, all corresponding documentation will reference the use of the alternate technique.

4.1.4 Inflatable Packer/Purge Pump/Bladder Pump Systems

An inflatable packer/purge pump/bladder pump system is installed in one well. The inflatable packer is used to isolate a zone from immediately above the screened interval to the bottom of the well. Due to the completion depth, a purge pump is used to purge three volumes of water from the isolated zone. After purging has been performed, a bladder pump is used to collect groundwater samples. This system type is used in wells where large purge volumes are required if the packer was not used and also at depths where the purge rate of the bladder pump would be insufficient to remove three volumes of water from the isolated zone.

4.1.5 Bailers

In wells without dedicated pump systems, dedicated Teflon bailers are used to collect samples. A non-dedicated purge pump is used to evacuate the required volume of water prior to sampling with the bailer. The bailers are constructed of Teflon and are equipped with bottom-filling check valves. Bailers are lowered into the well with non-dedicated stainless steel cable.

A bailer is dedicated to each well. Each bailer is attached to the well cap, using a length of stainless steel cable, and suspended in the well until sampling is performed. This precludes the need to decontaminate the bailer prior to each use. Dedicated bailers are installed in groundwater wells where it is neither technically nor economically feasible to install dedicated pump systems.

4.2 NON-DEDICATED SAMPLING EQUIPMENT

4.2.1 Pneumatically Operated Pumps

Wells not equipped with dedicated purging equipment are purged using a pneumatically driven pump. This pump, if required, can be used to collect samples for inorganic analytes. Due to possible effects on sample integrity, this pump is not used to collect samples with volatilization potential.

To preclude cross-contamination between wells, the pneumatic pump is decontaminated prior to each use. If the pump is used to collect inorganic samples, then equipment blanks are required for the corresponding inorganic analyses.

4.2.2 Miscellaneous Non-Dedicated Sampling Equipment

All miscellaneous non-dedicated sampling equipment is decontaminated prior to each use.

4.3 FIELD ANALYTICAL EQUIPMENT

Specific equipment necessary for the field determination of indicator parameters includes a specific conductance meter, pH/temperature meter and turbidity meter. Standard solutions are included for field calibrations and all instruments are functionally checked and calibrated according to the manufacturer's specifications and EPA-recommended protocols.

4.4 SAMPLE CONTAINERS

Sample containers are obtained from an independent supplier. The supplier provides containers which are cleaned using EPA-recommended analyte-specific cleaning procedures. A cleanliness verification is provided by the supplier before use. If unforeseen circumstances require WSTF to clean containers, the analyte-specific cleaning methods referenced in SW-846 are used.

All sample containers are rinsed with sample water prior to sample collection. The sizes and types of sample containers used for each analysis comply with the guidance provided in SW-846, the TEGD and RCRA Groundwater Monitoring: Draft Technical Guidance.

4.5 OTHER EQUIPMENT AND SUPPLIES

Lists of all equipment and supplies used for sample collection are provided in the site-specific procedural documentation.

5.0 CONVENTIONAL WELL SAMPLING PROCEDURES

Sampling procedures include: field determinations of static water level, temperature, specific conductance, pH, and turbidity; well purging; sample collection; sample preservation; sample transport and storage; and documentation of field activities. These procedures are briefly described in the following sections. Detailed procedures are provided in the site-specific procedural documentation.

5.1 STATIC WATER LEVEL MEASUREMENT

Static water level measurements are performed on at least a quarterly basis and prior to each sampling event. The static water level is measured to the nearest 0.01 meters and recorded in the field logbook. Measurements are made from the top of each well's inner casing. Detailed procedures for the measurements are described in the site-specific procedural documentation. Water level elevations are determined by subtracting the depth to water from the surveyed elevation of the measuring point.

Total well depth measurements are performed on at least an annual basis in wells without dedicated pump systems. Historical data indicate that more frequent determinations are not necessary due to observed slow rates of change over time. Wells with dedicated pump systems are measured for total depths once every five years.

5.2 WELL PURGING

All conventional groundwater assessment wells are purged prior to sample collection. Wells are purged using dedicated positive displacement bladder pumps, dedicated purge pumps or the non-dedicated pneumatically driven pump.

Evacuation rates are maintained at slow speeds to prevent the rapid withdrawal of water and the subsequent cascading of water down the sides of the well screen. Wells are pumped until a minimum of three casing volumes have been purged. The pH, temperature and specific conductance are monitored to ensure that these parameters stabilize. Turbidity values are monitored to ensure values are less than five NTUs and stable. If these criteria are not achieved after three casing volumes, the purging process continues until the values stabilize and the turbidity is less than five NTUs.

Field personnel utilize all measures possible to lower the turbidity to a value of five or less NTUs prior to sampling. If the turbidity values remain above five NTUs, and samples are collected, all data reported for the sampling event are referenced to reflect the elevated turbidity value.

Some wells have slow recovery rates which require purging to dryness. In these cases, the wells are evacuated to dryness and the volume of water purged is recorded. Wells with a recharge rate of greater than three meters/hour are allowed to recharge for at least one hour, purged to dryness, allowed to recover to a level adequate for sample collection, then sampled. Wells with a recharge rate of less than three meters/hour are allowed to recharge to an adequate level and sampled. For each case, the length of time required for the well to recover, recharge rates, pumping volumes, water levels, and corresponding times are recorded in the field logbook.

Detailed procedures for the determination of the required purge volumes are provided in the site-specific procedural documentation. For wells where inflatable packers are utilized, a casing volume is calculated as the volume of water isolated between the packer and the bottom of the well casing.

All water purged from groundwater wells is considered hazardous until analysis or characterization is performed. Water purged during sampling activities is contained in stock tanks located at each well site.

All potential interferences observed by field personnel are eliminated/minimized prior to sample collection. Actions taken to minimize interferences can include: redevelopment of wells; postponement of sampling activities due to nearby heavy equipment operations or inclement weather; or more stringent decontamination procedures.

6.0 WESTBAY MULTI-PORT WELL MONITORING SYSTEMS

As a result of the 3008(h) Consent Order agreement between EPA Region 6 and NASA, WSTF has incorporated the use of Westbay Multi-Port (MP) well systems in the groundwater assessment program. The Westbay MP systems are designed to monitor multiple water-bearing zones within a single drillhole. The systems are currently in use at WSTF to collect groundwater samples, obtain piezometric water pressures, and perform hydraulic conductivity determinations. Data obtained from these wells are used to formulate a three-dimensional conceptualization of the groundwater contamination plume in critical areas.

6.1 DESIGN OF WESTBAY WELLS

The Westbay MP system is a multiple-level groundwater monitoring system which employs a single, closed access, 1 1/2" (3.8 cm) diameter PVC casing with valved ports to perform well monitoring activities. The valved ports are used to provide controlled access to a multiple number of monitoring zones within a single drillhole.

Prior to the installation of the Westbay MP systems, the drillhole is bailed and\or pumped to remove a majority of the remaining drilling fluids. The Westbay system is then installed in the drillhole or in a multi-screened stainless steel monitoring well. Inflatable packers are integrated into the Westbay casing design and are individually inflated against the walls of the drillhole or the stainless steel casing. These packers isolate specific monitoring zones.

The Westbay wells are designed to provide direct access to formation water. This allows the collection of in situ groundwater samples and hydrogeological data. As a result of this design, the requirement to purge each zone prior to sample collection is eliminated. Specialized downhole instruments are used to access the valved ports within the well. Design specifics of the Westbay wells and the associated downhole equipment are provided in the site-specific procedural documentation and Westbay Operation and Maintenance Manuals.

6.2 DEVELOPMENT OF WESTBAY WELLS

A pumping port is installed in each Westbay sampling zone. Individual pumping ports are opened using the Westbay open/close tool and zone development is accomplished by overpumping and/or bailing the Westbay standpipe until indicator parameters (pH, temperature, conductivity, and turbidity) are constant. Additionally, the turbidity must be lowered to a value less than five NTUs. Upon development completion, the pumping port is closed using the open/close tool. Detailed instructions for the development of Westbay wells are provided in the site-specific procedural documentation. If elevated turbidity values are observed during subsequent sampling activities, redevelopment is performed.

6.3 WELL SECURITY

All Westbay wells are equipped with locking caps which are secured at all times except for sampling and analysis procedures conducted in accordance with this document. Keys are issued only to personnel directly involved in sample collection or well maintenance activities.

6.4 MONITORING EQUIPMENT

6.4.1 MOSDAX Sampler Probe

The MOSDAX sampler probe is used to measure downhole fluid pressures and obtain in situ groundwater samples from Westbay MP well systems. The system is operated by a handheld controller. The controller displays pressure readings and controls downhole fluid measurement and sample collection functions. The probe contains an electric strain-gauge pressure transducer for measuring fluid pressures through the measurement port couplings located in each monitoring zone.

The MOSDAX sampler probe is utilized to collect in situ groundwater samples. Stainless steel sample bottles are connected to the probe to transport the collected formation water from the sampling port to ground surface. The sampling functions are also operated by the handheld controller. Specific sampling zones are located by magnetic location collars which are installed as part of the Westbay MP casing system.

6.4.2 In Situ Datalogger

An in situ datalogger can be used in lieu of the electric pressure probe to perform hydraulic conductivity determinations. The datalogger is used with a downhole transducer in wells with relatively high hydraulic conductivities.

6.5 COLLECTION OF HYDROGEOLOGICAL DATA

6.5.1 Pressure Profiles

Pressure profiles of Westbay wells are performed after the monitoring zones of the well have been developed. Piezometric water pressures are collected using the MOSDAX sampler probe. Piezometric pressure profiles of each Westbay well are performed at least quarterly and prior to each sampling event.

To perform this operation, the MOSDAX sampler probe is lowered into the well and the desired zone is located. After the zone is located, the probe's location arm is activated and the probe is positioned into a helical landing ring located in the monitor port coupling. A backing shoe is then activated which presses the probe transducer against the measurement valve. This process isolates the probe from the fluid inside the standpipe and hydraulically connects it with the formation zone outside of the measurement valve. The corresponding pressure reading is displayed on the handheld controller and recorded.

Pressure readings can be converted to piezometric water levels using the calculations provided in the Westbay site-specific procedural documentation and Operation and Maintenance Manuals. Using the piezometric water pressures from the entire multi-port well, a piezometric pressure profile can be developed.

6.5.2 Hydraulic Conductivity Determinations

Hydraulic conductivity determinations (K-testing) of Westbay wells are performed at least one month after well development completion and after the initial groundwater samples have been collected from the zone. K-tests are performed by monitoring the rising head of water in the standpipe after the pumping port has been opened, resulting in hydraulic communication of the standpipe with the formation. The rising head is monitored with respect to time using the Westbay pressure probe, or the in situ datalogger with a downhole transducer.

For each K-test, the water level in the standpipe is lowered below the piezometric water level of the zone being measured, the open/close tool and the transducer or the pressure probe are positioned in the well, and the sliding pumping port coupling is opened with the open/close tool. The rising head of water in the standpipe is measured and recorded with respect to time. Upon completion of a hydraulic conductivity test, the pumping port is closed and the system is allowed to return to equilibrium. Instructions for performing this test are provided in the site-specific procedural documentation and Operations and Maintenance Manuals for the K-testing equipment. After completion of each test, the data are provided to a hydrogeologist who calculates the corresponding hydraulic conductivities using the Bouwer and Rice Method and the Papadopulos (et.al.) Method.

6.6 COLLECTION OF GROUNDWATER SAMPLES

Groundwater samples are collected using the MOSDAX sampler probe with the handheld controller. Up to four 250 ml stainless steel sample containers are attached to the sampling probe to transport formation water to the surface. The sample containers are evacuated at the surface to permit the collection of formation samples. The sampling apparatus is lowered into the well and the sampling zone is located using the magnetic collar system installed in the well casing. The location arm is then activated and the probe is positioned into the helical landing ring located in the monitor port coupling. The backing shoe is activated and the sampling port is positioned against the measurement port valve. This process isolates the sampling port from the standpipe fluids and hydraulically connects the sampling probe to the formation water. The sampling probe valve is then activated allowing formation water to collect in the evacuated sampling system. After sufficient time is allowed for filling, the sampling probe valve is deactivated, the backing shoe is retracted, and the sampling apparatus is raised to ground surface.

The first sample from each zone is used to rinse the sampling probe and stainless steel sample bottles and to measure indicator parameters (pH, temperature, conductivity, and turbidity). All excess fluid is discarded and the sample collection process is repeated to collect groundwater samples. Samples are collected in the order of their volatilization potential. After all samples are collected, final indicator parameters are measured to indicate changes in groundwater quality over time.

6.7 DECONTAMINATION OF WESTBAY SAMPLING EQUIPMENT

Upon receipt of new Westbay sampling equipment, or equipment that has been shipped off-site for servicing or repair, a steam-cleaning/deionized water rinse is performed prior to use. To ensure the absence of volatile contaminants prior to sampling, deionized water is poured into the assembled sampling probe and bottles, allowed to reside for one hour, and sampled as an equipment blank for halogenated volatile organics. If the results indicate the absence of contamination, the unit is ready for use.

Decontamination of Westbay downhole sampling equipment is performed prior to use in each well. Decontamination procedures include steam-cleaning of all metal components and a rinse of all components with deionized water. Prior to sampling a well, deionized water is poured into the assembled sampling probe and bottles and allowed to reside for at least thirty minutes. The deionized water is then sampled as an equipment blank for the analytical parameters specified by the WSTF Quality Assurance Project Plan.

Immediately prior to sampling a specific zone, the sampling probe and bottles are decontaminated by rinsing with deionized water. To obtain equipment blanks, deionized water is poured into the assembled sampling system, allowed to reside for thirty minutes, and sampled for halogenated volatile organics. In order to minimize potential cross-contamination between zones, each Westbay well is originally sampled from the lower-most sampling zone up. The results of the original sampling event are reviewed and subsequent sampling will collect samples from zones in the reverse order of their relative contaminant concentrations.

7.0 MONITOR WELL SAMPLING FREQUENCIES/ANALYTICAL PARAMETERS

Groundwater monitoring wells are installed to fulfill three basic requirements:

- provide post-closure care monitoring networks for each of the hazardous waste management units;
- permit horizontal and vertical plume definition; and
- provide chemical and physical data to predict future plume migration.

The following sections identify the sampling frequencies and analytical parameters used to fulfill these requirements.

7.1 GROUNDWATER ASSESSMENT SAMPLING SCHEDULE

Table 7.1 provides the current schedule for sampling groundwater assessment wells/zones. Sampling frequencies given in this Table are determined by well locations in relation to the hazardous waste management units, conceptualized location in the contaminant plume, spatial location in relationship to other groundwater assessment wells, and the relative chemical significance of the data.

All assessment wells are sampled quarterly for one year after installation. After this initial period, the analytical data are reviewed and a sampling frequency for each well is determined. The sampling schedule is reviewed annually to ensure that adequate information is generated to support the assessment program. If modifications to the schedule are necessary, they are included in updated versions of this document.

Due to the possible effects of drilling and well construction, at least four weeks are allowed between final well development and the initial collection of samples from a completed well. This allows the groundwater system to return to chemical equilibrium after drilling and installation.

On an annual basis, ten monitoring wells are sampled for Appendix IX parameters. This is a requirement of Post-Closure Care Permit No. NM8800019434-2 issued by NMED. As specified by the Permit, point of compliance monitoring wells in the 200, 300, 400, and 600 Areas require annual Appendix IX sampling for all parameters with the exception of dioxins and furans. Dioxins and furans are sampled every three years due to their historical non-use at the WSTF facility. Information gathered from this activity ensures that WSTF continues to direct its monitoring activities to the detection and evaluation of all hazardous constituents contained in the groundwater.

7.2 ANALYTICAL PARAMETERS

Historical analytical data from the WSTF groundwater monitoring wells indicate the presence of groundwater contamination from halogenated volatile organics, N-nitrosodimethylamine (NDMA), and chromium. On January 12, 1994 EPA Region 6 approved modifications to the January 10, 1992 WSTF Groundwater Sampling and Analysis Plan. These modifications were made to facilitate more area-specific groundwater monitoring.

TABLE 7.1
Sampling Frequencies for WSTF Groundwater Assessment Wells/Zones

QUARTERLY	SEMI-ANNUALLY	SEMI-ANNUALLY	ANNUALLY	BIENNIALLY
100-D-176	200-B-240	BLM-28-425	300-B-166	100-A-182
600-D-230	200-C-170	BLM-28-470	300-C-128	100-C-365
600-D-365	200-C-225	BLM-28-525	700-E-458	100-E-261
600-D-635	200-C-270	BLM-30-585	700-F-455	
600-D-845	200-D-109	BLM-31-350	BLM-3-182	
BLM-6-488	200-D-240	BLM-31-485	BLM-5-527	
BLM-18-430	200-F-225	BW-4-270	BLM-22-570	
PL-3-453	200-F-370	BW-4-355	BW-1-268	
PL-4-464	200-F-420	BW-4-455	BW-3-180	
PL-5-495	200-G-175	BW-7-211	BW-5-295	
PL-6-545	200-G-220	NASA 3	BW-6-355	
PL-6-725	200-G-340	NASA 5	JP-1-424	
PL-6-915	200-G-420	NASA 6	JP-2-447	
PL-6-1195	200-G-495	NASA 7	NASA 4	
PL-6-1335	200-H-150	NASA 8	WB-3-330	
PL-6-1485	200-H-225	NASA 9	WB-3-355	
PL-6-1645	200-H-331	NASA 10	WB-3-425	
PL-6-1815	200-H-433	PL-1-486	WB-3-450	
PL-7-480	300-A-120	PL-2-504	WB-8-275	
PL-7-560	300-A-170	PL-5-595	WB-8-320	
PL-7-630	300-D-153	PL-5-715	WB-8-410	
ST-1-473	300-E-138	PL-5-795	WB-9-310	
ST-1-541	300-E-183	PL-5-895	WB-9-335	
ST-1-630	400-A-151	PL-5-985	WB-9-360	
ST-2-466	400-C-118	WB-1-200	WB-14-520	
ST-3-486	400-C-143	WB-1-255	WW-1-452	
ST-3-586	400-D-195	WB-1-330		
ST-3-666	400-D-275	WB-2-245		
ST-3-735	400-D-355	WB-2-270		
ST-4-481	600-C-173	WB-2-365		
ST-4-589	600-C-473	WB-5-250		
ST-4-690	700-A-253	WB-5-280		
ST-5-481	700-B-510	WB-5-345		
ST-5-485	700-D-186			
ST-5-655	BLM-1-435			
ST-5-815	BLM-2-482			
ST-5-985	BLM-2-630			
ST-5-1175	BLM-7-509			
	BLM-8-418			
	BLM-9-419			
	BLM-10-517			
	BLM-13-300			
	BLM-14-327			
	BLM-15-305			
	BLM-17-493			
	BLM-17-550			
	BLM-21-400			
	BLM-23-431			
	BLM-24-565			
	BLM-25-455			
	BLM-26-404			
	BLM-27-270			

The parameter collection schedule is presented in Table 7.2. Wells and zones completed after issuance of this Plan will initially have samples collected for halogenated volatile organics, volatile organics, NDMA, and total metals. Based on the results of these analyses, including a statistical analysis of the first year's total metals' results, a collection schedule will be designated for each new well. NASA will notify EPA Region 6 in the monthly status reports of the collection schedule selected for each new well/zone.

Table 7.2 provides a summary of all current assessment wells/zones and their corresponding sample collection plans. All wells completed subsequent to the issuance of this Sampling and Analysis Plan will be identified in the site-specific procedural documentation, then the appropriate sampling plan will be assigned based on the location of the well in relation to the conceptualized sources of the contamination plume. If results of the initial sampling indicate the appropriate plan was not selected, the data will be reviewed and the collection plan modified as necessary.

7.2.1 Initial Sampling Events

After a well is completed and developed, initial samples are collected. Samples are analyzed for halogenated volatile organics, volatile organics, NDMA, and total RCRA metals.

7.2.2 Standard Plan A Sampling Events

After initial sample collection, wells designated as Plan A wells are sampled for halogenated volatile organics and NDMA. Total metals will be collected quarterly for the first year of sampling activities. These first year metals' results are then statistically analyzed to determine the appropriate sampling plan. Additionally, on at least an annual basis, samples are collected for volatile organics and total chromium.

7.2.3 Standard Plan B Sampling Events

After initial sample collection, wells designated as Plan B wells are sampled for halogenated volatile organics. Total metals will be collected quarterly for the first year of sampling activities. These first year metals' results are then statistically analyzed to determine the appropriate sampling plan. Additionally, on at least an annual basis, samples are collected for volatile organics and total chromium.

7.2.4 Additional Analyses

Due to elevated chromium concentrations detected in the immediate vicinity of the 600 Area, additional sampling for total chromium is performed. Table 7.3 indicates the wells for which chromium samples are collected.

In order to confirm the absence of NDMA in 100 and 600 Area wells, at least one well from each area will be sampled annually for NDMA. The well(s) selected from each area will represent the well(s) most susceptible to NDMA contamination.

TABLE 7.2

Parameter Collection Frequencies

Well I.D.	Method 8010	Method 8240	Method 607	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury
100-A-182	X	X					X				
100-C-365	X	X					X				
100-D-176	X	X	X	X	X	X	X	X	X	X	X
100-E-261	X	X					X				
200-B-240	X	X	X	X	X	X	X	X	X	X	X
200-C-170	X	Y	X	X			Y				
200-C-225	X	Y	X				Y				
200-C-270	X	Y	X				Y				
200-D-109	X	X	X	X	X	X	X	X	X	X	X
200-D-240	X	X	X	X	X	X	X	X	X	X	X
200-F-225	X	X	X	X	X	X	X	X	X	X	X
200-F-370	X	X	X	X	X	X	X	X	X	X	X
200-F-420	X	X	X	X	X	X	X	X	X	X	X
200-G-175	X	X	X	X	X	X	X	X	X	X	X
200-G-220	X	X	X	X	X	X	X	X	X	X	X
200-G-340	X	X	X	X	X	X	X	X	X	X	X
200-G-420	X	X	X	X	X	X	X	X	X	X	X
200-G-495	X	X	X	X	X	X	X	X	X	X	X
200-H-150	X	X	X	X	X	X	X	X	X	X	X
200-H-225	X	X	X	X	X	X	X	X	X	X	X
200-H-331	X	X	X	X	X	X	X	X	X	X	X
200-H-433	X	X	X	X	X	X	X	X	X	X	X
300-A-120	X	X	X	X	X	X	X	X	X	X	X
300-A-170	X	X	X	X	X	X	X	X	X	X	X
300-B-166	X	Y	X		X		Y	X			
300-C-128	X	Y	X		X		Y				
300-D-153	X	X	X	X	X	X	X	X	X	X	X
300-E-138	X	X	X	X	X	X	X	X	X	X	X
300-E-183	X	X	X	X	X	X	X	X	X	X	X
400-A-151	X	X	X				Y				
400-C-118	X	X	X	X	X	X	X	X	X	X	X
400-C-143	X	X	X	X	X	X	X	X	X	X	X
400-D-195	X	X	X	X	X	X	X	X	X	X	X
400-D-275	X	X	X	X	X	X	X	X	X	X	X
400-D-355	X	X	X	X	X	X	X	X	X	X	X
600-C-173	X	X	X	X	X	X	X	X	X	X	X

X - Indicates that samples are collected for this parameter at each scheduled sampling event.
Y - Indicates that samples are collected annually for this parameter.

TABLE 7.2

Parameter Collection Frequencies

Well I.D.	Method 8010	Method 8240	Method 607	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury
600-C-437	X	X	X	X	X	X	X	X	X	X	X
600-D-230	X	X	X	X	X	X	X	X	X	X	X
600-D-365	X	X	X	X	X	X	X	X	X	X	X
600-D-635	X	X	X	X	X	X	X	X	X	X	X
600-D-845	X	X	X	X	X	X	X	X	X	X	X
700-A-253	X	Y	X				Y				
700-B-510	X	Y	X				Y				
700-D-186	X	Y	X				Y				
700-E-458	X	Y	X				Y				
700-F-455	X	Y	X				X				
BLM-1-435	X	X	X				X				
BLM-2-482	X	X	X				X				
BLM-2-630	X	X	X				X	X			
BLM-3-182	X	Y	X		X		X				
BLM-5-527	X	Y	X				X				
BLM-6-488	X	X	X		X		X				
BLM-7-509	X	Y	X				X				
BLM-8-418	X	Y	X		X		Y				
BLM-9-419	X	X	X				Y				
BLM-10-517	X	Y	X				Y				
BLM-13-300	X	X	X				Y				
BLM-14-327	X	X	X				Y				
BLM-15-305	X	X	X		X		Y				
BLM-17-493	X	X	X				X				
BLM-17-550	X	X	X				X				
BLM-18-430	X	X	X				Y				
BLM-21-400	X	X	X				Y				
BLM-22-570	X	Y	X				Y				
BLM-23-431	X	X	X		X		X				
BLM-24-565	X	Y	X				Y				
BLM-25-455	X	Y	X				Y				
BLM-26-404	X	Y	X				Y				
BLM-27-270	X	Y	X		X		X				
BLM-28-425	X	Y	X				X		X		
BLM-28-470	X	Y	X				X				
BLM-28-525	X	Y	X				Y				

X - Indicates that samples are collected for this parameter at each scheduled sampling event.
Y - Indicates that samples are collected annually for this parameter.

TABLE 7.2

Parameter Collection Frequencies

Well I.D.	Method 8010	Method 8240	Method 607	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury
BLM-30-585	X	Y	X				Y				
BLM-31-350	X	Y	X				Y				
BLM-31-485	X	Y	X				Y				
BW-1-268	X	Y	X		X		Y				
BW-3-180	X	X					X				
BW-4-270	X	Y	X		X		Y				
BW-4-355	X	Y	X				Y				
BW-4-455	X	Y	X				Y				
BW-5-295	X	Y	X				Y				
BW-6-355	X	Y	X				Y				
BW-7-211	X	Y	X		X		Y				
JP-1-424	X	Y	X				X				
JP-2-447	X	Y	X				Y				
NASA 3	X	Y	X				Y				
NASA 4	X	Y	X		X		X				
NASA 5	X	X	X	X	X	X	X	X	X	X	X
NASA 6	X	X	X	X	X	X	X	X	X	X	X
NASA 7	X	X	X	X	X	X	X	X	X	X	X
NASA 8	X	X	X	X	X	X	X	X	X	X	X
NASA 9	X	X	X	X	X	X	X	X	X	X	X
NASA 10	X	X	X	X	X	X	X	X	X	X	X
PL-1-486	X	Y	X				X				
PL-2-504	X	X	X				X				
PL-3-453	X	Y	X				Y				
PL-4-464	X	Y	X				Y				
PL-5-495	X	X	X				Y				
PL-5-595	X	Y	X				Y				
PL-5-715	X	Y	X				Y				
PL-5-795	X	Y	X				Y				
PL-5-895	X	Y	X	X			Y				
PL-5-985	X	Y	X		X		Y				
PL-6-545	X	Y	X				Y				
PL-6-725	X	Y	X				Y				
PL-6-915	X	Y	X	X			Y				
PL-6-1195	X	Y	X				Y				
PL-6-1335	X	Y	X				Y				

X - Indicates that samples are collected for this parameter at each scheduled sampling event.
Y - Indicates that samples are collected annually for this parameter.

TABLE 7.2

Parameter Collection Frequencies

Well I.D.	Method 8010	Method 8240	Method 607	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury
PL-6-1485	X	Y	X				Y				
PL-6-1645	X	Y	X	X			Y				
PL-6-1815	X	Y	X		X		Y				
PL-7-480	X	Y	X		X		Y				
PL-7-560	X	Y	X				Y				
PL-7-630	X	Y	X				Y				
ST-1-473	X	Y	X				Y				
ST-1-541	X	X	X				Y				
ST-1-630	X	Y	X		X		Y				
ST-2-466	X	Y	X				Y				
ST-3-486	X	Y	X				X				
ST-3-586	X	Y	X		X		X				
ST-3-666	X	Y	X		X		Y				
ST-3-735	X	Y	X		X		Y				
ST-4-481	X	Y	X				Y				
ST-4-589	X	Y	X		X		Y				
ST-4-690	X	Y	X		X		X	X			
ST-5-481	X	Y	X				X				
ST-5-485	X	Y	X				Y				
ST-5-655	X	Y	X				Y				
ST-5-815	X	Y	X				Y				
ST-5-985	X	Y	X				Y				
ST-5-1175	X	Y	X	X	X		Y				
WB-1-200	X	Y	Y				Y				
WB-1-255	X	Y					Y				
WB-1-330	X	Y					Y				
WB-2-245	X	Y					Y				
WB-2-270	X	Y					Y				
WB-2-365	X	Y					Y				
WB-3-330	X	Y					Y				
WB-3-355	X	Y					Y				
WB-3-425	X	Y					Y				
WB-3-450	X	Y					Y				
WB-5-250	X	Y					Y				
WB-5-280	X	Y					Y				
WB-5-345	X	Y					Y				

X - Indicates that samples are collected for this parameter at each scheduled sampling event.
Y - Indicates that samples are collected annually for this parameter.

TABLE 7.2

Parameter Collection Frequencies

Well I.D.	Method 8010	Method 8240	Method 607	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury
WB-8-275	X	Y					Y				
WB-8-320	X	Y					Y				
WB-8-410	X	Y				X	Y				
WB-9-310	X	Y					Y				
WB-9-335	X	Y					Y				
WB-9-360	X	Y					Y				
WB-14-520	X	Y					Y				
WW-1-452	X	Y					Y				

X - Indicates that samples are collected for this parameter at each scheduled sampling event.
Y - Indicates that samples are collected annually for this parameter.

TABLE 7.3

Groundwater Assessment Wells and Their Corresponding Parameter Collection Plans

WELL I.D.	PLAN	WELL I.D.	PLAN	WELL I.D.	PLAN
100-A-182	B	BLM-17-550	A	PL-6-1195	A
100-C-365	B	BLM-18-430	A	PL-6-1335	A
100-D-176	A	BLM-21-400	A	PL-6-1485	A
100-E-261	B	BLM-22-570	A	PL-6-1645	A
200-B-240	A	BLM-23-431	A[1]	PL-6-1815	A
200-C-170	A	BLM-24-565	A	PL-7-480	A
200-C-225	A	BLM-25-455	A	PL-7-560	A
200-C-270	A	BLM-26-404	A	PL-7-630	A
200-D-109	A	BLM-27-270	A	ST-1-473	A
200-D-240	A	BLM-28-425	A	ST-1-541	A
200-F-225	A	BLM-28-470	A	ST-1-630	A
200-F-370	A	BLM-28-525	A	ST-2-466	A
200-F-420	A	BLM-30-585	A	ST-3-486	A
200-F-570	A	BLM-31-350	A	ST-3-586	A
200-G-175	A	BLM-31-485	A	ST-3-666	A
200-G-220	A	BLM-31-770	A	ST-3-735	A
200-G-340	A	BW-1-268	A	ST-4-481	A
200-G-420	A	BW-3-180	B	ST-4-589	A
200-G-495	A	BW-4-270	A	ST-4-690	A
200-H-150	A	BW-4-355	A	ST-5-481	A
200-H-225	A	BW-4-455	A	WB-1-200	B[2]
200-H-331	A	BW-5-295	A	WB-1-255	B
200-H-433	A	BW-6-355	A	WB-1-330	B
300-A-120	A	BW-7-211	A	WB-2-245	B
300-A-170	A	JP-1-424	A	WB-2-270	B
300-B-166	A	JP-2-447	A	WB-2-365	B
300-C-128	A	NASA 3	A	WB-3-330	B
300-D-153	A	NASA 4	B[2]	WB-3-355	B
300-E-138	A	NASA 5	A	WB-3-425	B
300-E-183	A	NASA 6	A	WB-3-450	B
400-A-151	A	NASA 7	B[1]	WB-5-250	B
400-C-118	A	NASA 8	B	WB-5-280	B
400-C-143	A	NASA 9	A	WB-5-345	B
400-D-195	A	NASA 10	A	WB-5-380	B
400-D-275	A	PL-1-486	A	WB-8-275	B
400-D-355	A	PL-2-504	A	WB-8-320	B
600-C-173	B	PL-3-453	A	WB-8-410	B
600-C-437	B[1]	PL-4-464	A	WB-9-310	B
600-D-230	B[1]	PL-5-495	A	WB-9-335	B
600-D-365	B[1]	PL-5-595	A	WB-9-360	B
600-D-635	B[1]	PL-5-715	A	WB-14-520	B
600-D-845	B[1]	PL-5-795	A	WW-1-452	A
700-A-253	A	PL-5-895	A		
700-B-510	A	PL-5-985	A		
700-D-186	A	PL-6-545	A		
700-E-458	A	PL-6-725	A		
700-F-455	A	PL-6-915	A		
BLM-1-435	A				
BLM-2-482	A				
BLM-2-630	A				
BLM-3-182	A				
BLM-5-527	A				
BLM-6-488	A[1]				
BLM-7-509	A				
BLM-8-418	A				
BLM-9-419	A				
BLM-10-517	A				
BLM-13-300	A[1]				
BLM-14-327	A				
BLM-15-305	A				
BLM-17-493	A				

Collection Plan A - Indicates the well is sampled for halogenated volatile organics and NDMA each time the well is scheduled for sampling. Additionally, on at least an annual basis, samples are collected for volatile organics and total chromium.

Collection Plan B - Indicates the well is sampled for halogenated volatile organics each time the well is scheduled for sampling. Additionally, on at least an annual basis, samples are collected for volatile organics and total chromium.

1 Indicates that due to the proximity on this well to the 600 Area, total chromium samples are collected each time the well is scheduled for sampling.

2 Indicates that on at least an annual basis samples are collected for NDMA.

7.2.5 Appendix IX Sampling

As required by the NMED-issued Post-Closure Care Permit No. NM8800019434-2, ten on-site monitoring wells are sampled annually for Appendix IX parameters. These point of compliance monitoring wells are located in each of the closure areas and were selected based on their proximity to known hazardous waste releases, observed concentrations of hazardous constituents, and/or anomalous concentrations of hazardous constituents in comparison to other wells in the immediate area.

Appendix IX analyses include halogenated volatile organics, volatile organics, semi-volatile organics, nitrosamines, herbicides, pesticides/PCBs, total cyanide, total sulfide, and total Appendix IX metals. Analyses for dioxins and furans are performed every three years due to their non-applicability to the site.

7.3 SAMPLE COLLECTION

7.3.1 Sample Identification

Sample numbers are assigned at the time of collection with an unique ten digit number. An example of a sample number is: 9701021030. In this example, 97 refers to the year, 0102 indicates the sample was collected on January 2nd, and 1030 indicates the sample was taken at 1030 hours. This sample identification format is used for all samples, field blanks, and quality assurance samples.

7.3.2 Sample Collection

To minimize volatilization of constituents, samples are collected in the order of their respective sensitivities to volatilization. When using dedicated bladder pumps, pumping rates during collection of volatile, semi-volatile and pH samples are adjusted to 100 ml/min or less. Care is exercised to ensure the pumping proceeds in a slow and continuous manner to minimize the aeration of samples. After samples sensitive to volatilization are collected, a higher pumping rate is used.

When bailers are used to collect samples sensitive to volatilization, aeration of the samples is minimized by slowly lowering the bailer into the water. When the bailer is brought to the surface, samples are dispensed to the appropriate containers using a bottom-emptying stop-cock device.

Sample volumes, types of containers, and preservation methods conform to the recommendations of SW-846 and the TEGD. Table 7.4 provides a summary of the information required to select the proper containers and preservatives for each required analyses. Table 7.5 provides a summary of the proper sample containers and preservatives used to collect groundwater samples.

TABLE 7.4
Standard Groundwater Assessment Containers, Preservation Methods and Holding Times

Analysis	Containers	Preservation	Maximum Holding Time
Halogenated Volatile Organics	40 ml glass vials	Zero headspace and cool to 4°C	14 days
Volatile Organics	40 ml glass vials	Zero headspace and cool to 4°C	14 days
Nitrosamines	1 liter glass bottle	Cool to 4°C	7 days until extraction 40 days after extraction
Metals	500 ml poly bottle	HNO_3 to pH <2 and cool to 4°C	6 months*

* Except for mercury which has a holding time of 28 days.

TABLE 7.5
Containers, Preservatives and Holding Times

NAME	CONTAINER[1]	PRESERVATION	MAXIMUM HOLDING TIME
Bacterial Tests:			
Coliform, fecal and total	P, G	Cool, 4°C, 0.008% $Na_2S_2O_3$	6 hours
Fecal streptococci	P, G	Cool, 4°C, 0.008% $Na_2S_2O_3$	6 hours
Inorganic Tests:			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Biochemical oxygen demand	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Biochemical oxygen demand, carbonaceous	P, G	Cool, 4°C	48 hours
Chemical oxygen demand	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Chloride	P, G	None required	28 days
Chlorine, total residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, total and amenable to chlorination	P, G	Cool, 4°C, NaOH to pH>12, 0.6g ascorbic acid	14 days
Fluoride	P	None required	28 days
Hardness	P, G	HNO_3 or H_2SO_4 to pH<2	6 months
Hydrogen ion (pH)	P, G	None required	Analyze immediately
Kjeldahl and organic nitrogen	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Residue, total	P, G	Cool, 4°C	7 days
Residue, filterable	P, G	Cool, 4°C	7 days
Residue, nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, settleable	P, G	Cool, 4°C	48 hours
Residue, volatile	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific conductance	P, G	Cool, 4°C	28 days
Sulfate	P, G	Cool, 4°C	28 days
Sulfide	P, G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH>9	7 days

TABLE 7.5
Containers, Preservatives and Holding Times

Sulfite	P, G	None required	Analyze immediately
Surfactants	P, G	Cool, 4°C	48 hours
Temperature	P, G	None required	Analyze
Turbidity	P, G	Cool, 4°C	48 hours
Metals:			
Chromium VI	P, G	Cool, 4°C	24 hours
Mercury	P, G	HNO_3 to pH<2	28 days
Metals, except chromium VI and mercury	P, G	HNO_3 to pH<2	6 months
Nitrate	P, G	Cool, 4°C	48 hours
Nitrate-nitrite	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrite	P, G	Cool, 4°C	48 hours
Oil and grease	G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic carbon	P, G	Cool, 4°C, HCl or H_2SO_4 to pH<2	28 days
Orthophosphate	P, G	Filter immediately, cool, 4°C	48 hours
Oxygen, dissolved probe	G bottle and top	None required	Analyze immediately
Winkler DO		Fix on site and store in dark	8 hours
Phenols	G only	Cool, 4°C, H_2SO_4 to pH<2	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 hours
Phosphorus, total	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Tests:			
Purgeable halocarbons	G, Teflon-lined septum	Cool, 4°C	14 days
Purgeable aromatic hydrocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$, HCl to pH2	14 days
Acrolein and acrylonitrile	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$, Adjust pH to 4-5	14 days
Phenols	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$	7 days until extraction, 40 days after extraction
Benzidines	G, Teflon-lined	Cool, 4°C, 0.008% $Na_2S_2O_3$	7 days until extraction
Phthalate esters	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitrosamines	G, Teflon-lined cap	Cool, 4°C, store in dark,	40 days after extraction

TABLE 7.5
Containers, Preservatives and Holding Times

PCBs, acrylonitrile	G, Teflon-lined cap	Cool, 4°C	40 days after extraction
Nitroaromatics and	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$,	40 days after extraction
Polynuclear aromatic	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$,	40 days after extraction
hydrocarbons		store in dark	
Haloethers	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$	40 days after extraction
Chlorinated hydrocarbons	G, Teflon-lined cap	Cool, 4°C	40 days after extraction
TCDD	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$	40 days after extraction
Total organic halogens	G, Teflon-lined cap	Cool, 4°C, H_2SO_4 to pH<2	7 days
Pesticides Tests:			
Pesticides	G, Teflon-lined cap	Cool, 4°C, pH 5-9	40 days after extraction
Radiological Tests:			
Alpha, Beta and radium	P, G	HNO_3 to pH<2	6 months

[1]Polyethylene (P) or Glass (G)

From SW-846

Nytek gloves are worn during sampling events to prevent contamination of samples and sampling equipment. The gloves also protect sampling personnel from direct contact with potentially hazardous constituents. Tyvek or equivalent protective clothing is required when sampling wells with hazardous constituents present in levels above recognized safe limits of exposure or if information concerning the contamination is unknown prior to sampling. Gloves are discarded after each sampling event. A detailed discussion of standard sampling procedures is provided in the site-specific procedural documentation.

7.4 Field Analyses

The first and last samples collected at each well are reserved for the field determinations of temperature, specific conductance, turbidity, and pH. Detailed procedures for field determinations are described in the site-specific procedural documentation and specific equipment Operations and Maintenance Manuals. The results of field analyses are recorded in the field logbook.

7.5 Sample Preservation and Storage

Samples are preserved in accordance with the methods detailed in Table 7.5. Each sample container is preserved (as necessary), labeled, sealed, and promptly placed on ice.

To prevent alteration of samples during collection, sample containers are cooled on ice prior to sample collection. Additionally, all collected volatile samples are stored with the septum facing down. This procedure minimizes possible volatilization through the septum.

7.6 Equipment Decontamination and Verification

After use at each sampling site, non-dedicated sampling equipment is decontaminated. Step-by-step decontamination procedures are included in the site-specific procedural documentation. Equipment blanks are taken at each well where non-dedicated sampling equipment is used. Equipment blanks are obtained by flushing distilled water over and/or through the steam cleaned equipment in the field immediately before sampling. The rinse water is collected in sample bottles corresponding to the analytes being sampled. Equipment blanks are labeled, assigned sample numbers, and handled in the same manner as groundwater samples. The sample number is recorded as an equipment blank in the field notebook, but is submitted "blind" to the analytical laboratories. This process allows identification of irregularities that might occur due to improper decontamination of equipment or field introduction of contaminants.

8.0 ANALYTICAL METHODS

Based on the groundwater assessment data collected to this point, WSTF has identified specific hazardous constituents in the groundwater. These hazardous constituents include halogenated volatile organics, N-nitrosodimethylamine and chromium. WSTF has incorporated the use of the most sensitive analyte-specific EPA-recommended analytical methods for identification and quantification of these compounds. Table 8.1 summarizes the analytical methods currently utilized at WSTF. The WSTF Quality Assurance Project Plan provides a detailed description of the analytical methods currently utilized in the WSTF groundwater assessment project.

TABLE 8.1
Analytical Methods Currently Used at WSTF

EPA Method Number	Analysis
Method 8021 or EPA equivalent	Halogenated Volatile Organics
Method 8260 or EPA equivalent	Volatile Organics
Method 607, 8070 or EPA equivalent	Nitrosamines
Method 6060 or EPA equivalent	Chromium
Method 8081 or EPA equivalent	Pesticides and PCBs
Method 8270 or EPA equivalent	Semi-volatile Organics
Method 8150 or EPA equivalent	Herbicides
Method 9066 or EPA equivalent	Phenolics
Method 9012 or EPA equivalent	Cyanide
Method 9030 or EPA equivalent	Sulfide
Several EPA approved Methods	Total RCRA Metals

8.1 Modifications to the Referenced EPA Methods

WSTF has identified several halogenated volatile organic compounds as hazardous constituents in the groundwater. Table 8.2 provides a list of the hazardous constituents that have been targeted for halogenated volatile organic analysis. Three of these compounds, 1,2-dichloro-1,1,2-trifluoroethane, 1,1,2-trichloro-1,2,2-trifluoroethane, and dichlorofluoromethane are not listed as standard compounds for quantification by the halogenated volatile organics method. However, calibrations for each of these compounds are made and they are quantified in the same manner as other listed compounds. The volatile organics method, which is currently used to provide mass spectral confirmation of compounds identified by the halogenated volatile organics method, has also been modified to accommodate the quantification of these additional compounds.

9.0 QUALITY ASSURANCE PROCEDURES

The WSTF Quality Assurance Project Plan provides a complete discussion of the quality assurance procedures required in the field and the laboratory. This section provides a summary of the quality assurance measures required for sample collection and processing. The WSTF Quality Assurance Project Plan provides specific details concerning these procedures.

9.1 FIELD QUALITY CONTROL SAMPLES

Table 9.1 provides a summary and description of quality control samples used in the field. These samples are required to ensure that data are collected to adequately define the accuracy, precision, representativeness, completeness, and comparability of groundwater samples. Table 9.2 provides the frequency of use for each of these controls.

9.2 DOCUMENTATION

Documentation of all procedures used in sample collection, transport, and analysis is critical to ensure that data generated in support of the groundwater assessment program are legally defensible. Documentation includes field logbooks, sample seals, sample labels, and chain of custody forms.

The WSTF Quality Assurance Project Plan provides a comprehensive description, detailed instructions, and examples of the documentation required for the groundwater assessment program.

9.2.1 Field Logbook

A serially numbered field logbook is used to record all activities, observations, and measurements that take place in the field during sampling events. Records of the field activities should be sufficient to allow an individual, not associated with the sampling event, to recreate the events by reading the logbook. These documents are a legal record of all field activities. All logbooks are kept on-site for immediate availability.

TABLE 8.2
Halogenated Volatile Organic Compounds

IUPAC Nomenclature	CAS #	Other Common Designations
Dichlorofluoromethane	75-43-4	Freon 21
Dichloromethane	75-09-2	Methylene Chloride
Trichlorofluoromethane	75-69-4	Freon 11, MF Freon
1,2-Dichloro-1,1,2-trifluoroethane	354-23-4	Freon 123A
Trichloromethane	67-66-3	Chloroform
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	Freon 113, TF Freon
1,1,1-Trichloroethane	71-55-6	1,1,1-TCA
Trichloroethene	79-01-6	Trichloroethylene, TCE
Tetrachloroethene	127-18-4	Perchloroethene, PCE

TABLE 9.1
Descriptions of Field Quality Control Samples

Sample Type	Description
Equipment Blank	ASTM Type II water is transported to the sampling site, opened, poured over and/or through the sampling device, and collected in sample containers. This type of blank indicates the effectiveness of decontamination procedures and also indicates contamination in the field which may affect analytical results.
Field Blank	ASTM Type II water is transported to the sampling site, opened, and poured directly into sample containers. This type of sample provides a check on reagent quality and contamination derived in the field.
Trip Blank	ASTM Type II water is poured into sampling containers in a contaminant free environment, placed in coolers, transported to the field, back to the laboratory, and analyzed. This type of sample serves as a check on sample contamination originating from sample handling, transport, shipping, and site conditions. This sample may also be used to estimate the system detection limit.
Blind Quality Control Sample	A check standard is prepared from a source other than the calibration standard, which is provided blind to the analytical lab. This type of sample serves as an independent check of analytical techniques, handling, and standards.
Duplicate Sample	A second sample is taken immediately after an original sample at the same sampling location. This sample provides an estimate of the overall system precision.

TABLE 9.2
Field QA/QC Controls

TYPE OF CONTROL	HALOGENATED VOLATILE ORGANICS	VOLATILE ORGANICS	NITROSAMINES	RCRA METALS
Equipment Blank	100% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	100% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	5% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	5% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.
Field Blank	Not required if equipment blanks are taken, otherwise 100% of all sampling days.	Not required if equipment blanks are taken, otherwise 100% of all sampling days.	Not required if equipment blanks are taken, otherwise 5% of all sampling days or at least once per month, whichever is the most frequent.	Not required if equipment blanks are taken, otherwise 5% of all metals' sampling days or at least once per month, whichever is the most frequent.
Duplicate Sample	10% of all sampling events or at least once per month, whichever is the most frequent.	10% of all sampling events or at least once per month, whichever is the most frequent.	10% of all sampling events or at least once per month, whichever is the most frequent.	10% of all metals' sampling events or at least once per month, whichever is the most frequent.
Blind Quality Control Sample	5% of all sampling events or at least once per month, whichever is the most frequent.	5% of all sampling events or at least once per month, whichever is the most frequent.	5% of all sampling events or at least once per month, whichever is the most frequent.	5% of all metals' sampling events or at least once per month, whichever is the most frequent.
Trip Blank	5% of all sampling events or at least once per month, whichever is the most frequent.	5% of all sampling events or at least once per month, whichever is the most frequent.	5% of all sampling events or at least once per month, whichever is the most frequent.	5% of all metals' sampling events or at least once per month, whichever is the most frequent.

Information that is recorded in the field logbook each time sampling is conducted includes:

- identification of the well;
- date;
- members of the sampling party;
- climatic conditions;
- static water level;
- calculated purge volume;
- purge rate, purge duration, purge time, and volume of water purged;
- well evacuation method and equipment;
- sample collection method and equipment;
- sample collection sequence;
- types of sample containers used and sample identification numbers;
- preservative(s) used;
- analytical parameters;
- indicator parameter determinations;
- laboratory(ies) performing the analyses; and
- any other relevant field observations.

9.2.2 Sample Seals and Labels

All samples collected in support of the groundwater assessment program are labeled and have sample seals affixed immediately after sample collection. Sample labels are necessary to ensure that samples are correctly identified and the laboratory performs the required analyses. Sample seals ensure that samples are not opened and/or chemically altered until analytical procedures are initiated.

Information which is required on sample labels includes:

- sample identification number;
- collector's name;
- date and time of collection;
- sample collection location;
- analytical method required; and
- preservation method.

Information which is required on sample seals includes:

- sample collection location;
- sample identification number; and
- collector's name.

9.2.3 Chain of Custody Forms

Chain of custody forms are used to track possession of groundwater samples from the time of collection through sample analysis. These forms provide legal documentation of possession throughout the entire sampling and analysis process. Information provided on these forms includes:

- sample number(s);
- sample matrix (groundwater);
- sample location;
- requested analysis(es);
- signature(s), date(s), and time(s) of all personnel involved in sample custody;
- container description(s); and
- preservative(s) used.

9.3 SAMPLE DELIVERY

Specific procedures are required to ensure that groundwater assessment samples are transported to the respective analytical laboratories in an acceptable manner. The following sections provide a basic overview of procedures used in transporting samples to the analytical laboratory. Specific details of the sample delivery process are provided in the WSTF Quality Assurance Project Plan.

9.3.1 Shipment of Off-Site Samples

Samples sent to independent off-site laboratories require processing prior to shipment. Samples are inspected prior to packaging for correctness and completeness. Containers are then packaged as necessary to prevent breakage, transferred to an ice chest, and packed with ice. The ice chest is then secured and shipped via next-day delivery to the analytical laboratory. The off-site laboratory custodian inspects the samples upon delivery, notifies WSTF if any irregularities are encountered, and signs and returns the chain of custody form to WSTF.

9.4 ANALYTICAL QUALITY ASSURANCE

Specific quality control procedures are provided in each of the referenced EPA analytical methods. In addition, the WSTF Quality Assurance Project Plan provides supplementary quality assurance guidance.

10.0 ANALYTICAL REPORTS AND DATA MANAGEMENT

The WSTF Quality Assurance Project Plan provides a detailed discussion of data management and analytical report generation procedures.

11.0 REFERENCES

American Society for Testing and Materials, Ground-Water Contamination: Field Methods, STP 963, Baltimore, MD, July 1988.

Barcelona, M., J. Gibb, J. Helfrich, and E. Garske, Practical Guide for Ground-Water Sampling, Illinois State Water Survey, Champaign, IL, November 1985.

Black, W., H. Smith, F. Patton, "Multiple-Level Groundwater Monitoring with the MP System", Proceedings of the Surface and Borehole Geophysical Methods and Ground Water Instrumentation Conference and Exposition, National Water Well Association, Denver, CO, October 1986.

Bouwer, H. and R. Rice, "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells", Water Resources Research, Volume 12, Number 3, Phoenix AZ, June 1976.

Driscoll, F., Groundwater and Wells, Second Edition, Johnson Division, St. Paul MN, 1986.

Ford, P., P. Turina, and D. Seely, Characterization of Hazardous Waste Sites - A Methods Manual: Volume II Available Sampling Methods, Second Edition, EPA 600/4-84-076, U.S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring Systems Laboratory, Las Vegas, NV, December 1984.

National Archives and Records Administration, Office of the Federal Register, Code of Federal Regulations, Protection of Environment, Title 40, Parts 100 to 149, Washington, D.C., July 1, 1991.

National Archives and Records Administration, Office of the Federal Register, Code of Federal Regulations, Protection of Environment, Title 40, Parts 260 to 299, Washington, D.C., July 1, 1991.

Nielson, D., Practical Handbook of Ground-Water Monitoring, Lewis Publishers Inc., Chelsea, MI, 1991.

Papadopulos, S., J. Bredehoeft, and H. Cooper, "On the Analysis of 'Slug Test Data'", Water Resources Research, Volume 9, Number 4, 1973.

Scalf, M., J. McNabb, W. Dunlap, R. Cosby, and J. Fryberger, Manual of Ground-Water Sampling Procedures, U. S. Environmental Protection Agency, Office of Research and Development, Robert S. Kerr Environmental Research Laboratory, Ada, OK, 1981.

U.S. Environmental Protection Agency, Hazardous Waste Ground Water Task Force, Protocol for Ground-Water Evaluations, OSWER 9080.0-1, September 1986.

U.S. Environmental Protection Agency, Office of Research and Development, Center for Environmental Research Information, Handbook: Ground Water Volume I: Ground Water and Contamination, EPA/625/6-90/016a, Cincinnati, OH, September 1990.

U.S. Environmental Protection Agency, Office of Research and Development, Center for Environmental Research Information, Handbook: Ground Water Volume II: Methodology and Contamination, EPA/625/6-90/016b, Cincinnati, OH, July 1991.

U.S. Environmental Protection Agency, Office of Solid Waste, RCRA Ground-Water Monitoring: Draft Technical Guidance, EPA/530-R-93-001, Washington D.C., November 1992.

U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response and Office of Waste Programs Enforcement, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, OSWER-9950-1, Washington, DC, September 1986.

U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Test Methods for Evaluating Solid Waste, Third Edition, SW-846, Washington, DC, 1986.

U.S. Environmental Protection Agency, Waste Management Division, Office of Solid Waste, Interim Final RCRA Facility Investigation Guidance Volumes I-IV, EPA 530/SW-89-031, Washington, DC, May 1989.

APPENDIX C

WSTF QUALITY ASSURANCE PROJECT PLAN

QUALITY ASSURANCE PROJECT PLAN

NASA WHITE SANDS TEST FACILITY

October 28, 1997

Table of Contents

1.0 INTRODUCTION

1.1 Project Description 1
1.2 Purpose 1
1.3 Scheduled Plan Reviews 2

2.0 PROJECT ORGANIZATION

2.1 Introduction 2
2.2 Environmental Program Manager 3
2.3 Environmental Department 3
2.4 Environmental Department Personnel 3

2.4.1 Groundwater Sampling Coordinator 3
2.4.2 Hazardous Waste Compliance Technicians 3
2.4.3 QA/QC Coordinator 4

2.5 Off-Site Laboratories 4

3.0 DATA QUALITY OBJECTIVES

3.1 Introduction 4
3.2 QA/QC Samples 5

3.2.1 QA/QC Sample Requirements 5

3.3 Precision 5

3.3.1 Relative Percent Difference 10
3.3.2 Relative Standard Deviation 10

3.4 Accuracy 10
3.5 Representativeness 11
3.6 Comparability 11
3.7 Completeness 11
3.8 Detectability 12
3.9 Data Quality Requirements 12

4.0 SAMPLE COLLECTION AND MANAGEMENT

4.1 Introduction 12
4.2 Sampling and Analysis Plan 12
4.3 Sample Collection 12

4.3.1 Groundwater Samples 16
4.3.2 Soil and Sediment Samples 16

4.4 Sample Preservation and Holding Times

4.4.1 Sample Preservation 16
4.4.2 Sample Holding Times 16

4.5 Documentation 20

4.5.1 Site-Specific Procedural Documentation 20
4.5.2 Field Logbook 20
4.5.3 Sample Labels and Seals 21
4.5.4 Chain of Custody Record 21
4.5.5 Authorizing Documentation for Sample Analysis 21

4.6 Sample Delivery 24

5.0 ANALYTICAL PROCEDURES

5.1 Introduction 24
5.2 WSTF Analytical Methods 24

5.2.1 Halogenated Volatile Organics Analytical Method 24
5.2.2 Volatile Organics Analytical Method 27
5.2.3 Nitrosamines Analytical Method 27

5.3 Documentation 27

6.0 SYSTEMS AUDITS AND QUALITY ASSURANCE REPORTS

6.1 Introduction 28
6.2 Systems Audit 28

7.0 CORRECTIVE ACTIONS AND REPORTS TO MANAGEMENT

7.1 Corrective Actions 28
7.2 Quality Assurance Report 29

8.0 DATA MANAGEMENT

8.1 Introduction 29
8.2 Data Management Module 29

8.2.1 Cover Page 30
8.2.2 Field Logbook Copies 30
8.2.3 Analytical Results 30
8.2.4 Quality Assurance Appendix 30
8.2.5 Signature Blocks 30

8.3 Environmental Database Module 30

8.3.1 Summary Report Reviews 31
8.3.2 Database Management 31
8.3.3 End-Users of Data 31

9.0 REFERENCES 32

Table of Tables

TABLE 3.1 Descriptions of Field Quality Control Samples 6
TABLE 3.2 Descriptions of Analytical Quality Control Samples 7
TABLE 3.3 Field QA/QC Controls 8
TABLE 3.4 Analytical QA/QC Controls 9
TABLE 3.5 Method Specific Data Quality Objectives 13
TABLE 3.6 Description of Data Quality Flags 15
TABLE 4.1 Containers, Preservations and Holding Times 17
TABLE 5.1 Analytical Methods Currently Used at WSTF 25
TABLE 5.2 Target Compounds 26

Table of Figures

FIGURE 4.1 WSTF Sample Label and Seal 22
FIGURE 4.2 WSTF Chain of Custody Record 23

1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

During the course of historical operations at the NASA White Sands Test Facility (WSTF), hazardous constituents were released to the environment and subsequently migrated to the groundwater. As mandated by 40 CFR Part 264 Subpart F - Releases From Solid Waste Management Units, NASA has established a Compliance Monitoring Program. The purpose of this program is to collect data required to: determine the distribution and migration of hazardous constituents; determine potential threats to the environment and public health; and, if required, to aid in the design and implementation of remediation systems.

The WSTF contamination is divided into three contaminant categories:

- The most prevalent contaminants are halogenated volatile organics. These compounds have been used throughout the site's active life for hardware precision cleaning.

- The second most widespread contaminant affecting the WSTF groundwater is N-nitrosodimethylamine (NDMA). This compound is suspected to originate as an oxidation product from the handling of rocket fuels.

- The third type of groundwater contamination is chromium. This compound is suspected to originate and be localized to the 600 Area impoundments.

1.2 PURPOSE

This Quality Assurance Project Plan (QAPP) establishes guidelines for ensuring that the NASA compliance monitoring data are scientifically valid, of known quality and legally defensible. To achieve these goals, the following specific QAPP requirements are addressed:

- A consistent and acceptable framework for the collection and generation of physical and chemical data;

- Data quality objectives that measure the precision, accuracy, representativeness, comparability, and completeness of generated data;

- Acceptance criteria for the data measurements to ensure that data collection and analytical systems provide data of sufficient quality for the program;

- The early detection of deficiencies that may affect data quality and provide corrective actions;

- Sufficient document control to verify data completeness; and

- A fundamental framework for the storage and management of environmental data.

All data generating steps, including sample collection, analyses, document control, and data reviews are performed using established procedures to ensure reported data quality, accuracy and completeness. This document, coupled with adherence to guidelines outlined in specific EPA analytical methods, the WSTF Sampling and Analysis Plan and site-specific procedural documentation, ensures that data meet the project-specific requirements of the Groundwater Assessment and Post-Closure Care Monitoring Programs.

1.3 SCHEDULED PLAN REVIEWS

This Plan is reviewed annually to ensure that it provides the level of effort necessary to support the Groundwater Assessment and Post-Closure Care Monitoring Programs. If modifications to the Plan are necessary, NASA will submit the revisions to the EPA for concurrence and approval. If elements of the modifications affect NASA compliance with the Post-Closure Care Permit, the appropriate actions will also be taken through NMED. All historical documents are archived for future reference.

2.0 PROJECT ORGANIZATION

2.1 INTRODUCTION

Groundwater assessment projects are performed by, or in conjunction with, the on-site contractor Environmental Department. This Department is staffed with scientists, engineers and hydrogeologists. The primary objectives of the Department are the installation of the groundwater monitoring network, the hydrogeologic interpretation of collected data, generation of technical reports, collection of groundwater samples for analyses, technical review of project requirements, management and review of generated environmental data, and regulatory compliance.

All personnel assigned to these projects are required to have the training and expertise necessary to perform their assigned duties. Furthermore, all personnel who collect environmental data must have access to, and a clear understanding of, the Sampling and Analysis Plan, Quality Assurance Project Plan, Post-Closure Care Permit, and applicable site-specific procedural documentation.

2.2 ENVIRONMENTAL PROGRAM MANAGER

The NASA Environmental Program Manager administers all WSTF environmental programs. The Program Manager provides environmental compliance work directives to the on-site contractor Environmental Department.

2.3 ENVIRONMENTAL DEPARTMENT

The on-site contractor Environmental Department is responsible for work authorizing document generation, monitoring well installation, hydrogeologic interpretation, establishing sampling and analytical methodologies, collecting groundwater samples, prioritizing work, and ensuring that groundwater assessment and post-closure care work is conducted within regulatory and site-specific guidelines. This Department is also responsible for interpreting, evaluating and accepting data generated in support of the Groundwater Assessment and Post-Closure Care Programs.

2.4 ENVIRONMENTAL DEPARTMENT PERSONNEL

Environmental Department personnel are the primary participants in the collection, analysis and management of environmental data. The following describes the individuals involved in the data collection and generation processes. The contractor Environmental Department is responsible for maintaining a list of qualifications for all personnel involved in the Groundwater Assessment and Post-Closure Care Programs.

2.4.1 Groundwater Sampling Coordinator

The Sampling Coordinator directs and participates with Hazardous Waste Compliance Technicians in sample collection using procedures delineated in the WSTF Sampling and Analysis Plan and site-specific procedural documentation. The Coordinator schedules all sampling events and ensures that samples are collected, preserved, documented, and shipped off-site for analysis using proper procedures.

2.4.2 Hazardous Waste Compliance Technicians

Hazardous Waste Compliance Technicians perform field sampling activities. These technicians follow procedures delineated in the WSTF Sampling and Analysis Plan and site-specific procedural documentation to obtain representative samples. In addition, these technicians perform hydrogeological data collection in support of the Groundwater Assessment and Post-Closure Care Monitoring Programs.

2.4.3 QA/QC Coordinator

The Environmental Department QA/QC Coordinator has the ultimate responsibility for ensuring the correctness, accuracy, precision, and completeness of reported data. By using field and analytical QA/QC samples, the Coordinator assesses the quality of the reported data, sets data quality flags and generates a Quality Assurance Narrative for each Summary Report.

The QA/QC Coordinator collects raw data from the contracted analytical laboratories and manipulates/formats it to create a Draft Summary Report. Prior to issuance of a Final Summary Report, it is reviewed and approved by the appropriate Environmental Department personnel.

The QA/QC Coordinator can also perform periodic audits of the data collection and generation systems. Audit results are reported to the Environmental Department Supervisor. In addition, the QA/QC Coordinator prepares a monthly summary report of quality assurance activities.

2.5 OFF-SITE LABORATORIES

NASA contracts off-site laboratories to analyze groundwater samples in support of the Groundwater Assessment and Post-Closure Care Monitoring Programs. Prior to awarding any analytical support contracts, each off-site laboratory must submit their laboratory Quality Assurance Project Plan to the contractor Environmental Department for review and approval. In addition, contractor Environmental Department personnel will supply the laboratory with a Statement of Work delineating the specific requirements for WSTF sample analyses. These documents ensure that off-site laboratories meet the data quality criteria required for the WSTF Groundwater Assessment and Post-Closure Care Programs.

3.0 DATA QUALITY OBJECTIVES

3.1 INTRODUCTION

Quantitative measurements used to estimate true physical and chemical conditions always involve some level of uncertainty. Uncertainty can be attributed to natural variability, sampling handling operations and conditions, spatial and temporal patterns, and analytical variability. It is critical that levels of uncertainty are measured and acceptable limits of uncertainty established.

Several parameters are measured to estimate the uncertainty of generated data. Data quality are characterized by the PARCC parameters (precision, accuracy, reproducibility,

completeness, and comparability). The following sections define and discuss these parameters.

3.2 QA/QC SAMPLES

Several types of QA/QC samples are required to evaluate data uncertainty. A list of field and analytical QA/QC samples and a brief description of each is provided in Tables 3.1 and 3.2. The frequencies for these samples are provided in Tables 3.3 and 3.4. The frequencies represent a summary of guidance from specific EPA analytical methods and SW-846. The EPA methods provide specific details of the verification required for each analytical process.

3.2.1 QA/QC Sample Requirements

It is essential that all QA/QC samples are of the highest possible quality. Reference standards must be certified prior to use. The reagent water used for field and laboratory blanks must be continuously monitored for non-interference with the analyses. Blind quality control standards must represent the types and concentrations of constituents normally found in the WSTF groundwater.

In order to alleviate bias generated by the analytical laboratories, all environmental and audit samples are submitted "blind". Samples are disguised in a manner where laboratory personnel do not recognize the sample source or composition. The identities of all samples, including QA/QC samples, are recorded in the field logbook. The information provided to laboratory personnel (i.e., chain of custody forms, sample labels and sample seals) does not contain any information concerning sample identities.

3.3 PRECISION

Precision is the measurement of the mutual agreement among individual measurements of the same property. Precision examines the spread of reported values about their mean. For the purposes of the Groundwater Assessment and Post-Closure Care Programs, precision is expressed as either relative percent difference, or as relative standard deviation.

The overall precision of measurement data is a mixture of sampling and analytical factors. Overall precision is determined by collecting and analyzing duplicate field samples. Analytical precision is measured by creating laboratory replicates from collected field samples. Sampling precision is estimated by subtracting the analytical precision from the overall precision.

TABLE 3.1

DESCRIPTIONS OF FIELD QUALITY CONTROL SAMPLES

Sample Type	Description
Equipment Blank	ASTM Type II water is transported to the sampling site, opened, poured over and/or through the sampling device, and collected in sample containers. This type of blank indicates the effectiveness of decontamination procedures and also indicates contamination in the field which may affect analytical results.
Field Blank	ASTM Type II water is transported to the sampling site, opened and poured directly into sample containers. This type of sample provides a check on reagent quality and contamination derived in the field.
Trip Blank	ASTM Type II water is poured into sampling containers in a contaminant free environment, placed in coolers, transported to the field, back to the laboratory, and analyzed. This type of sample serves as a check on sample contamination originating from sample handling, transport, shipping, and site conditions. This sample may also be used to estimate the system detection limit.
Blind Quality Control Sample	A check standard is prepared from a source other than the calibration standard, which is provided blind to the analytical lab. This type of sample serves as an independent check of analytical techniques, handling and standards.
Field Duplicate	A second sample is taken immediately after an original sample at the same sampling location. This sample provides an estimate of the overall system precision.

TABLE 3.2

DESCRIPTION OF ANALYTICAL QUALITY CONTROL SAMPLES

Sample Type	Description
Reagent Blank	ASTM Type II water is processed through the entire analytical process which, at the time of analysis, contains the same reagent concentrations as samples that have been processed. This type of sample indicates contamination resulting from the preparation or processing of a sample. This sample can be used to establish the analytical detection limit.
Sample Matrix Spike	A predetermined amount of stock solution, containing an analyte of interest, is added to the sample matrix prior to sample extraction/digestion and analysis. This sample indicates the effects of the sample matrix on analysis and also is a measure of the accuracy of the measurement system.
QC Check Standard	A standard is obtained from a source other than the calibration standard. This sample indicates the accuracy and consistency of calibration.
Surrogate Spike	Introduction of a compound similar to the analytes of interest, but not normally found in environmental samples, blanks and standards. This type of sample provides a continuous monitor of the performance of the analytical system and the effectiveness of the method in dealing with sample matrices.
Matrix Duplicate	An intralaboratory split sample which is used to document the precision of a method in a given sample matrix.
Matrix Spike Duplicate	Intralaboratory split samples spiked with identical concentrations of target analyte(s). The spiking occurs prior to sample preparation and analysis. These samples are used to document the precision and bias of a method in a given sample matrix.

***Note**: The Quality Assurance Project Plan of off-site contracted laboratories may contain additional, or more stringent, lab-specific requirements.*

TABLE 3.3

FIELD QA/QC CONTROLS

CONTROL	HALOGENATED VOLATILE ORGANICS METHOD	VOLATILE ORGANICS METHOD	NITROSAMINES METHOD	TOTAL CHROMIUM METHOD
Equipment Blank	100% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	100% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	5% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	5% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.
Field Blank	Not required if equipment blanks are taken, otherwise 100% of all halogenated volatile organics sampling days.	Not required if equipment blanks are taken, otherwise 100% of all volatile organics sampling days.	Not required if equipment blanks are taken, otherwise 5% of all nitrosamine sampling days or at least once per month, whichever is the most frequent.	Not required if equipment blanks are taken, otherwise 5% of all total chromium sampling days or at least once per month, whichever is the most frequent.
Duplicate Sample	10% of all halogenated volatile organics sampling events or at least once per month, whichever is the most frequent.	10% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	10% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.	10% of all total chromium sampling events or at least once per month, whichever is the most frequent.
Blind Quality Control Sample	5% of all halogenated volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.	5% of all total chromium sampling events or at least once per month, whichever is the most frequent.
Trip Blank	5% of all halogenated volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.	5% of all total chromium sampling events or at least once per month, whichever is the most frequent.

TABLE 3.4

ANALYTICAL QA/QC CONTROLS

TYPE OF CONTROL	HALOGENATED VOLATILE ORGANICS	VOLATILE ORGANICS	NITROSAMINES	TOTAL CHROMIUM
Reagent Blank	At least daily.	At least daily.	One for each set of samples processed.	One for each analytical batch.
Sample Matrix Spike	10% of samples analyzed.	5% of samples analyzed.	10% of samples analyzed.	5% of samples analyzed.
QC Check Standard	10% or less frequently if spike recoveries meet all specified QC criteria.	5% or less frequently if spike recoveries meet all specified QC criteria.	10% or less frequently if spike recoveries meet all specified QC criteria.	5% of samples analyzed.
Surrogate Spike	100% of all blanks, samples and standards.	100% of all blanks, samples and standards.	100% of all blanks, samples and standards.	Not applicable.
Replicate Sample	Aliquoting is not appropriate; therefore, duplicate samples must be analyzed for 5% of the samples analyzed.	Aliquoting is not appropriate; therefore, duplicate samples must be analyzed for 5% of samples analyzed.	5% of samples analyzed.	5% of samples analyzed.

***Note**: The Quality Assurance Project Plan of off-site contracted laboratories may contain additional, or more stringent, lab-specific requirements.*

3.3.1 Relative Percent Difference

Precision is determined on the basis of duplicate sample analytical results. When two values are used, precision is expressed in terms of relative percent difference (**RPD**). RPD is calculated as follows:

$$\mathbf{RPD} = [\,|x_1 - x_2|\,/\,((x_1 + x_2)/2)]\,(100)$$

Where:
x_1 and x_2 are the reported concentrations for each duplicate sample.

3.3.2 Relative Standard Deviation

When more than two values are used to determine precision, it is calculated as the relative standard deviation (**RSD**). The RSD is calculated as follows:

$$\mathbf{RSD} = (s/\bar{x})\,(100)$$

Where:
s is the standard deviation of a series of measurements, and
$\bar{x}$ is the mean of the series of individual measurements.

The standard deviation (s) for a set of measurements is determined as follows:

$$s = [\Sigma(x_i - \bar{x})^2 / (n - 1)]^{1/2}$$

Where:
x_i represents each of the individual measurements, and
n is the number of measurements.

The mean ($\bar{x}$) of a set of individual measurements is calculated by summing the values for the individual measurements ($x_1 \ldots x_n$), then dividing by the number of measurements (n). This calculation is as follows:

$$\bar{x} = (x_1 + x_2 + x_3 + \ldots + x_n) / n$$

3.4 ACCURACY

Accuracy is the degree of agreement between a measurement and its true value, or between the average of a number of measurements and the true or expected value. For the purposes of the groundwater assessment programs, accuracy is expressed as percent recovery. Percent recovery (**%R**) is calculated as follows:

%R = (R / S) (100)

Where:
R is the reported concentration, and
S is the spiked concentration.

Sources of error are the sampling process, field contamination, preservation, handling, sample matrix, and analysis techniques.

Sampling accuracy is assessed by evaluating the results of field/trip blanks. Analytical accuracy is assessed through the use of known and blind quality control samples and matrix spikes.

3.5 REPRESENTATIVENESS

Representativeness expresses the degree to which sample data accurately and precisely represent a population characteristic. The representativeness criteria is satisfied by ensuring that samples are collected using standard techniques. Standard techniques include procedures outlined in SW-846, the WSTF Sampling and Analysis Plan, site-specific procedural documentation, and specific equipment Operations and Maintenance Manuals.

3.6 COMPARABILITY

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Sample data should be comparable with other measurement data for similar samples and sample conditions. This goal is achieved using standard collection and analytical techniques and reporting analytical data in appropriate units.

3.7 COMPLETENESS

Completeness expresses the percentage of all measurements which are judged to be valid. Completeness (**%C**) is calculated as follows:

%C = 100 x (V/T)

Where:
V is the number of valid measurements, and
T is the total number of measurements taken.

3.8 DETECTABILITY

Detectability refers to the minimum concentration that a constituent can be measured with a stated level of confidence. It is determined by assessing the variability of replicate measurements at zero or near-zero constituent concentrations. For the purposes of this investigation, detection limits refer to the minimum concentration at which constituent calibrations can be established.

3.9 DATA QUALITY REQUIREMENTS

The acceptability requirements for data produced in support of this project are provided in Table 3.5. This Table provides data quality objectives for detectability, precision, accuracy, and completeness for both groundwater and soil matrices. Table 3.6 describes the quality assurance flags utilized to identify data that does not meet the objectives outlined in Table 3.5.

4.0 SAMPLE COLLECTION AND MANAGEMENT

4.1 INTRODUCTION

This section, in conjunction with the WSTF Sampling and Analysis Plan and site-specific procedural documentation, provides guidance for all sampling activities performed as part of the Groundwater Assessment and Post-Closure Care Programs.

4.2 SAMPLING AND ANALYSIS PLAN

The WSTF Sampling and Analysis Plan provides detailed procedures for the collection, handling and transport of environmental samples. This document is used in conjunction with site-specific procedural documentation. The site-specific procedural documentation includes WSTF Job Instructions (WJIs), Test Preparation Sheets (TPSs) and/or specific equipment Operations and Maintenance Manuals.

4.3 SAMPLE COLLECTION

In general, all samples are collected using the most currently available EPA guidelines. Specific procedures utilized for sample collection are provided in the WSTF Sampling and Analysis Plan and site-specific procedural documentation.

TABLE 3.5

METHOD SPECIFIC DATA QUALITY OBJECTIVES
Groundwater Samples

ANALYSIS	MEASUREMENT UNITS	RL*	PRECISION (3)	ACCURACY (4)	COMPLETENESS (5)
Halogenated Volatile Organics	µg/L	(1)	(1)	(1)	80
Volatile Organics	µg/L	(2)	(2)	(2)	80
N-nitrosodimethylamine	µg/L	0.1	25	13-109	80
Arsenic	mg/L	0.0050	25	75-125	80
Barium	mg/L	0.010	25	75-125	80
Cadmium	mg/L	0.0050	25	75-125	80
Chromium	mg/L	0.010	25	75-125	80
Lead	mg/L	0.0050	25	75-125	80
Mercury	mg/L	0.00020	25	75-125	80
Selenium	mg/L	0.010	25	75-125	80
Silver	mg/L	0.010	25	75-125	80

(1) Specific criteria are provided in the halogenated volatile organics method.
(2) Specific criteria are provided in the volatile organics method.
(3) As relative percent difference for field duplicates.
(4) As percent recovery of matrix spikes.
(5) Percentage of measurements which meet expressed data quality criteria for precision, accuracy and detectability.

* - Reporting Limit.

TABLE 3.5 Cont.

METHOD SPECIFIC DATA QUALITY OBJECTIVES
Soil Samples

ANALYSIS	TOTAL MEAS. UNITS	TOTAL RL*	TCLP MEAS. UNITS	TCLP RL*	PRECISION (3)	ACCURACY (4)	COMPLETENESS (5)
Halogenated Volatile Organics	µg/kg	(1)	µg/L	(1)	(1)	(1)	80
Volatile Organics	µg/kg	(2)	µg/L	(2)	(2)	(2)	80
N-nitrosodimethylamine	µg/kg	50	N/A	N/A	25	13-109	80
Arsenic	mg/kg	0.5	mg/L	1.0	30	65-130	80
Barium	mg/kg	5	mg/L	0.10	20	75-125	80
Cadmium	mg/kg	3	mg/L	0.050	20	80-120	80
Chromium	mg/kg	5	mg/L	0.10	30	70-130	80
Lead	mg/kg	30	mg/L	0.50	30	70-120	80
Mercury	mg/kg	0.1	mg/L	0.0020	35	75-120	80
Selenium	mg/kg	10	mg/L	0.05	50	35-125	80
Silver	mg/kg	5	mg/L	0.10	30	55-130	80

(1) Specific criteria are provided in the halogenated volatile organics method.
(2) Specific criteria are provided in the volatile organics method.
(3) As relative percent difference for field duplicates.
(4) As percent recovery of matrix spikes.
(5) Percentage of measurements which meet expressed data quality criteria for precision, accuracy and detectability.

* - Reporting Limit.
N/A - Not applicable.

TABLE 3.6

DESCRIPTION OF DATA QUALITY FLAGS

Data Qualifier	Description
*	User defined flag.
A	Indicates that the result of an analyte for a check standard (LCS or CCV) was outside standard limits.
AD	Indicates that the precision for analyst duplicates was outside standard limits.
EB	Indicates that the analyte was detected in the equipment blank at or above the reporting limit.
FB	Indicates that the analyte was detected in the field blank at or above the reporting limit.
G	Indicates that the result is an estimated value greater than the calibration limit.
J	Indicates that the result is an estimated value less than the reporting limit, but greater than or equal to the detection limit.
NA	Indicates that the value/result was either not analyzed or not applicable.
ND	Indicates that the analyte was not detected at or above the detection limit.
Q	Indicates that the result for a blind control was outside standard limits.
QD	Indicates that the precision for a field duplicate was outside standard limits.
RB	Indicates that the analyte was detected in the reagent blank at or above the reporting limit.
S	Indicates that the result was determined by the method of standard addition.
SP	Indicates that either the spike recovery or the relative percent difference for spike duplicates was outside standard limits.
T	Indicates that the analyte was analyzed outside the specified holding time.
TB	Indicates that the analyte was detected in the trip blank at or above the reporting limit.
TIC	Indicates that the analyte was tentatively identified by a GC/MS library search and the amount reported is an estimated value.

4.3.1 Groundwater Samples

To ensure the representativeness of groundwater samples, samples are not collected until monitoring wells have been fully developed. Due to drilling and well construction effects on the natural groundwater system, at least four weeks are allowed between final development and sampling to allow the hydrogeological system to return to chemical equilibrium.

Representativeness is ensured by purging the wells until at least three casing volumes are evacuated and all indicator parameters (pH, conductivity, turbidity, and temperature) have stabilized. All sampling equipment is constructed of materials that do not influence the quality of collected samples. Specific guidance for groundwater sample collection procedures is provided in the WSTF Sampling and Analysis Plan and the site-specific procedural documentation.

4.3.2 Soil and Sediment Samples

Soil and sediment samples are collected using the most current EPA recommended procedures. Samples are collected in a manner which minimally disrupts sample integrity. Samples for volatile organic constituents are transferred from the collection device into sample containers as quickly as possible to minimize potential losses.

4.4 SAMPLE PRESERVATION AND HOLDING TIMES

4.4.1 Sample Preservation

Sample preservation prevents or retards the chemical or biological degradation of the sample's chemical integrity. Preservation is initiated immediately after sample collection. Preservation and storage requirements are presented in Table 4.1.

4.4.2 Sample Holding Times

Holding time is based on the constituents of interest and is the maximum time allowed between sample collection and analysis/preparation. Table 4.1 provides the maximum acceptable holding times for environmental samples. All samples are, at a minimum, refrigerated at 4°C.

In general, samples not analyzed within the specified holding times generate data that are not acceptable for reporting purposes. If the data are crucial, samples are retaken to provide the required information. However, if resampling of the environmental source is impractible, samples that have exceeded their holding times are analyzed and reported with the appropriate data qualification/flagging.

TABLE 4.1

CONTAINERS, PRESERVATIONS AND HOLDING TIMES

NAME	CONTAINER[1]	PRESERVATION	MAXIMUM HOLDING TIME
Bacterial Tests:			
Coliform, fecal and total	P, G	Cool, 4°C, 0.008% $Na_2S_2O_3$	6 hours
Fecal streptococci	P, G	Cool, 4°C, 0.008% $Na_2S_2O_3$	6 hours
Inorganic Tests:			
Acidity	P, G	Cool, 4°C	14 days
Alkalinity	P, G	Cool, 4°C	14 days
Ammonia	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Biochemical oxygen demand	P, G	Cool, 4°C	48 hours
Bromide	P, G	None required	28 days
Biochemical oxygen demand, carbonaceous	P, G	Cool, 4°C	48 hours
Chemical oxygen demand	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Chloride	P, G	None required	28 days
Chlorine, total residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4°C	48 hours
Cyanide, total and amenable to chlorination	P, G	Cool, 4°C, NaOH to pH>12, 0.6g ascorbic acid	14 days
Fluoride	P	None required	28 days
Hardness	P, G	HNO_3 or H_2SO_4 to pH<2	6 months
Hydrogen ion (pH)	P, G	None required	Analyze immediately
Kjeldahl and organic nitrogen	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Residue, total	P, G	Cool, 4°C	7 days
Residue, filterable	P, G	Cool, 4°C	7 days
Residue, nonfilterable (TSS)	P, G	Cool, 4°C	7 days
Residue, settleable	P, G	Cool, 4°C	48 hours
Residue, volatile	P, G	Cool, 4°C	7 days
Silica	P	Cool, 4°C	28 days
Specific conductance	P, G	Cool, 4°C	28 days

TABLE 4.1, Cont.

Sulfate	P, G	Cool, 4°C	28 days
Sulfide	P, G	Cool, 4°C, add zinc acetate plus sodium hydroxide to pH>9	7 days
Sulfite	P, G	None required	Analyze immediately
Surfactants	P, G	Cool, 4°C	48 hours
Temperature	P, G	None required	Analyze
Turbidity	P, G	Cool, 4°C	48 hours
Metals:			
Chromium VI	P, G	Cool, 4°C	24 hours
Mercury	P, G	HNO_3 to pH<2	28 days
Metals, except chromium VI and mercury	P, G	HNO_3 to pH<2	6 months
Nitrate	P, G	Cool, 4°C	48 hours
Nitrate-nitrite	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrite	P, G	Cool, 4°C	48 hours
Oil and grease	G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic carbon	P, G	Cool, 4°C, HCl or H_2SO_4 to pH<2	28 days
Orthophosphate	P, G	Filter immediately, cool, 4°C	48 hours
Oxygen, dissolved probe	G bottle and top	None required	Analyze immediately
Winkler DO		Fix on site and store in dark	8 hours
Phenols	G only	Cool, 4°C, H_2SO_4 to pH<2	28 days
Phosphorus (elemental)	G	Cool, 4°C	48 hours
Phosphorus, total	P, G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Tests:			
Purgeable halocarbons	G, Teflon-lined septum	Cool, 4°C	14 days
Purgeable aromatic hydrocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$, HCl to <pH2	14 days
Acrolein and acrylonitrile	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2S_2O_3$, Adjust pH to 4-5	14 days

Table 4.1, Cont.

Phenols	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$	7 days until extraction, 40 days after extraction
Benzidines	G, Teflon-lined	Cool, 4°C, 0.008% $Na_2S_2O_3$	7 days until extraction
Phthalate esters	G, Teflon-lined cap	Cool, 4°C	7 days until extraction, 40 days after extraction
Nitrosamines	G, Teflon-lined cap	Cool, 4°C, store in dark,	40 days after extraction
PCBs, acrylonitrile	G, Teflon-lined cap	Cool, 4°C	40 days after extraction
Nitroaromatics	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$,	40 days after extraction
Polynuclear aromatic	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$,	40 days after extraction
Haloethers	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$	40 days after extraction
Chlorinated hydrocarbons	G, Teflon-lined cap	Cool, 4°C	40 days after extraction
TCDD	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$	40 days after extraction
Total organic halogens	G, Teflon-lined cap	Cool, 4°C, H_2SO_4 to pH<2	7 days
Pesticides Tests:			
Pesticides	G, Teflon-lined cap	Cool, 4°C, pH 5-9	40 days after extraction
Radiological Tests:			
Alpha, Beta and radium	P, G	HNO_3 to pH<2	6 months

[1]Polyethylene (P) or Glass (G)

Derived From SW-846

Blind quality control samples and analytical check standards are subject to the same holding time requirements as environmental samples. When blind quality control samples are prepared, the corresponding container is annotated with the preparation date. Blind quality control samples for volatile organics analysis are prepared immediately prior to shipment to the analytical lab.

4.5 DOCUMENTATION

An essential element of the sampling process is documentation of data collection steps. NASA requires several procedures to ensure that the collection process is adequately documented. These include: generation of site-specific procedural documentation; annotation of the field logbook with all pertinent collection information; use of sample labels and seals on sample bottles; and tracking of all samples with chain of custody documentation. Off-site laboratories are also required to include chain of custody documentation with their final reports.

4.5.1 Site-Specific Procedural Documentation

For WSTF sampling events, site-specific procedural documentation is required. This documentation currently includes Test Preparation Sheets (TPSs), WSTF Job Instructions (WJIs) and specific equipment Operations and Maintenance Manuals. This documentation is provided by the Environmental Department and is reviewed/signed by the NASA Environmental Program Manager.

4.5.2 Field Logbook

The Sampling Coordinator and Hazardous Waste Compliance Technicians are responsible for recording all pertinent information regarding field operations in a serially numbered field notebook. The quantity and quality of information recorded is considered sufficient for a third party to recreate the sampling event based on the logbook information. The specific information required in the field logbook for each sampling event is delineated in the WSTF Sampling and Analysis Plan.

To ensure that the field notebook provides a clear and complete record of field operations, the Hazardous Waste Compliance Technicians submit the field logbooks to the Sampling Coordinator for review (no less than weekly). The Sampling Coordinator verifies the information recorded is clear and provides a complete account of all field activities. After review, the Sampling Coordinator signs the bottom of each page, indicating an understanding of the information recorded, and that the information is complete and correct.

Field logbooks are an essential legal document to provide validity of collected samples. At all times logbook possession is controlled by the contractor Environmental Department.

4.5.3 Sample Labels and Seals

Sample labels are required to avoid sample misidentification, either in the field or at the laboratory. Sample labels are filled out and affixed to each sample container immediately after sample collection. Figure 4.2 provides an example of the currently used sample label.

Sample seals are required to ensure that samples are not tampered with prior to analysis. Sample seals are filled out and affixed immediately after the samples are preserved and the sample labels are affixed. Figure 4.2 provides an example of the currently used sample seal.

4.5.4 Chain of Custody Record

Sample possession from the time of collection until sample analysis is traced by a chain of custody record. The Sampling Coordinator and Hazardous Waste Compliance Technicians are responsible for generating chain of custody records for samples submitted to the off-site analytical laboratories. These forms are generated prior to sample delivery and/or shipment. Figure 4.3 provides an example of the currently used chain of custody record.

The required information for the chain of custody record is provided in the WSTF Sampling and Analysis Plan. All samples are considered in the possession of the Sampling Coordinator or Hazardous Waste Compliance Technician until the laboratory custodian or warehouse shipping coordinator signs the chain of custody record, indicating acceptance. When analytical results are received from off-site laboratories, copies of the chain of custody record are included to document the sample possession at the laboratory.

4.5.5 Authorizing Documentation for Sample Analysis

Prior to sample delivery to the analytical laboratory, the Sampling Coordinator initiates a laboratory work authorizing document. This document can be in the form of a Statement of Work and/or analytical laboratory services purchase agreements. These documents ensure the site-specific analytical requirements for all samples are achieved.

FIGURE 4.1

WSTF SAMPLE LABEL AND SEAL

WSTF

SAMPLE LABEL

Sample No. _____ Chem. Lab. Log No. _____

Collection Location _____

TPS No. _____ Analysis By: _____

Collected By: _____

Method of Preservation _____

Analysis Required _____

_____

WSTF Sample Label

NASA

JOHNSON SPACE CENTER
WHITE SANDS TEST FACILITY
LAS CRUCES, NEW MEXICO

SAMPLE # _____

COLLECTOR _____

COLLECTION LOCATION _____

DATE SEAL BROKEN

INITIALS

WSTF Sample Seal

FIGURE 4.2

WSTF CHAIN OF CUSTODY RECORD

Date _____

Page ____ of ____

Laboratory / PO #				Analysis Requirements								Special Instructions
Return Address for Analyses: NASA / WSTF / AlliedSignal P.O. Box 20 Las Cruces, NM 88004 Attn: Tom Hall		# of Containers	Sample Type (Aqueous)	Halogenated Volatile Organics Ice/No Headspace (40 ml Vial) ( )	Semi-Volatile Organics Ice/No Headspace (40 ml Vial) ( )	Nitrosamines Ice (1L Glass Bottle)	RCRA Metals (As, Ba, Cd, Cr, Pb, Hg Se, Ag) Ice / HNO, (500 ml Poly)					Please return coolers and contents of coolers as soon as possible. Return Address: NASA / WSTF / AlliedSignal Building 120 / Route 70 Las Cruces, NM 88012 Attn: Michael Embesi
Sample No.	Well Id.											Comments

Relinquished By:	Date/Time:	Accepted By:	Date/Time:

WSTF - 381B (06/97)

4.6 SAMPLE DELIVERY

Samples are delivered and/or shipped to off-site laboratories for analysis. All samples are accompanied by the appropriate chain of custody record and shipping documents.

The Sampling Coordinator and Hazardous Waste Compliance Technicians are responsible for inspecting documentation for accuracy and the samples for proper collection, preservation and labeling prior to shipment/delivery to the laboratory. If discrepancies are observed, they are researched and corrected at this time.

When the shipping coordinator and/or the off-site sample receiving department is satisfied the samples are acceptable, the chain of custody record is signed, accepting sample responsibility. Upon completion of the analyses, the off-site laboratory forwards an analytical results report with copies of the chain of custody included.

5.0 ANALYTICAL PROCEDURES

5.1 INTRODUCTION

EPA approved methods are used, when available, to identify and quantify hazardous constituents in WSTF environmental samples. In cases where EPA methods are not provided for specific hazardous constituents, the best available technology is researched, utilized and referenced. NASA currently analyzes for halogenated volatile organics, volatile organics and nitrosamines. Metals are analyzed by several different EPA-approved methods.

5.2 WSTF ANALYTICAL METHODS

During the course of the Compliance Monitoring Program, NASA has incorporated minor modifications to the referenced EPA methods. The currently utilized EPA Methods are listed in Table 5.1. The following sections outline and explain these modifications.

5.2.1 Halogenated Volatile Organics Analytical Method

NASA currently analyzes for halogenated volatile organics. Several halogenated volatiles are present in the groundwater which are not normally analyzed by the halogenated volatile organics method. However, these additional constituents are suitable for identification and quantification. Calibration standards for these compounds are used to quantify them. The supplemental compounds include dichlorofluoromethane (Freon 21), 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113) and 1,2-dichloro-1,1,2-trifluoroethane (Freon 123A). Table 5.2 provides a list of constituents most likely to be observed in WSTF groundwater samples.

TABLE 5.1

ANALYTICAL METHODS CURRENTLY USED AT WSTF

EPA Method Number	Analysis
Method 8021 or EPA equivalent	Halogenated Volatile Organics
Method 8260 or EPA equivalent	Volatile Organics
Method 607, 8070 or EPA equivalent	Nitrosamines
Method 6060 or EPA equivalent	Chromium
Method 8081 or EPA equivalent	Pesticides and PCBs
Method 8270 or EPA equivalent	Semi-volatile Organics
Method 8150 or EPA equivalent	Herbicides
Method 9066 or EPA equivalent	Phenolics
Method 9012 or EPA equivalent	Cyanide
Method 9030 or EPA equivalent	Sulfide
Method 7060 or EPA equivalent	Arsenic
Method 6010 or EPA equivalent	Barium
Method 6010 or EPA equivalent	Cadmium
Method 6010 or EPA equivalent	Chromium
Method 7421 or EPA equivalent	Lead
Method 7470 or EPA equivalent	Mercury
Method 7740 or EPA equivalent	Selenium
Method 6010 or EPA equivalent	Silver

TABLE 5.2

TARGET COMPOUNDS

IUPAC Nomenclature	CAS #	Other Common Designations
Dichlorofluoromethane	75-43-4	Freon 21
Dichloromethane	75-09-2	Methylene Chloride
Trichlorofluoromethane	75-69-4	Freon 11, MF Freon
1,2-Dichloro-1,1,2-trifluoroethane	354-23-4	Freon 123A
Trichloromethane	67-66-3	Chloroform
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	Freon 113, TF Freon
1,1,1-Trichloroethane	71-55-6	1,1,1-TCA
Trichloroethene	79-01-6	Trichloroethylene, TCE
Tetrachloroethene	127-18-4	Perchloroethene, PCE

5.2.2 Volatile Organics Analytical Method

NASA currently analyzes for volatile organics. Volatile organics analysis is performed at least annually for all WSTF groundwater monitoring wells. This analysis provides mass spectral confirmation of compounds previously identified by the halogenated volatile organics method. As with the halogenated volatile organics method, NASA has included the WSTF-specific halogenated volatile organic compounds which are not specified by the method.

The volatile organics analytical method is used as a confirmational check, therefore all parameters referenced in the method, plus the WSTF supplemental constituents, are reported.

5.2.3 Nitrosamines Analytical Method

NASA currently analyzes for N-nitrosodimethylamine (NDMA). If extraneous peaks are observed to occur in the retention windows for nitrosamine method target compounds, they are identified and quantified by using a post-run calibration.

Commencing with nitrosamine samples analyzed since January 1996, one tentatively identified compound (TIC), N-nitrodimethylamine (CAS No. 4164-28-7), has been observed and reported for samples collected from numerous WSTF groundwater monitoring wells. Efforts are underway to determine if this TIC is representative of actual groundwater contamination, is a naturally occuring groundwater constituent or is an artifact of related sampling and analysis operations. A detailed discussion of this compound and incorporation into the WSTF Sampling and Analysis Plan and Quality Assurance Project Plan will be deferred until substantiating information is obtained.

5.3 DOCUMENTATION

Documentation of the analytical effort is outlined in the Quality Assurance Project Plan submitted by the off-site laboratories. The laboratory Quality Assurance Project Plan must be submitted, reviewed, approved, and maintained on file in the site contractor Environmental Department prior to commencing analyses. In addition, site-specific requirements delineated in the Statement of Work must be met. The laboratory's Quality Assurance Project Plan must include, at a minimum, the following:

- Personnel qualifications and training plans;
- Documentation and records management procedures;
- Quality control procedures;

- Work processes, operations procedures and methods; and

- Quality assessment, standardization and response action plans.

When analytical results are received from the off-site laboratory, the QA/QC Coordinator will review the reports for compliance with the laboratory Quality Assurance Project Plan. If descrepancies are present, they are researched and rectified at this time.

6.0 SYSTEMS AUDITS AND QUALITY ASSURANCE REPORTS

6.1 INTRODUCTION

Technical system audits are an essential element in the Quality Assurance Project Plan. These audits are designed to ensure compliance with the Plan and to assess the overall quality of data collected during the measurement process. Audits evaluate sample collection, sample analysis procedures and data management techniques.

6.2 SYSTEMS AUDIT

A technical systems audit is a comprehensive qualitative evaluation of the entire data collection and generation system. This audit examines all phases of the sampling and analysis system: collection of samples; preservation and handling of samples; transport of samples; documentation of field and analytical steps; quality control procedures; data reporting; and data management.

This evaluation is performed on a quarterly basis by the QA/QC Coordinator or an independent individual with the training and expertise to perform the audit. The auditor submits a summary report to the Environmental Department Supervisor. This report presents the results of the inspection and provides recommendations for corrective actions.

7.0 CORRECTIVE ACTIONS AND REPORTS TO MANAGEMENT

7.1 CORRECTIVE ACTIONS

The QA/QC Coordinator initiates corrective actions when data evaluation, preparation of environmental reports and/or technical systems audits indicate dicrepancies. The corrective actions can include procedural changes, resampling, preparation of additional site-specific quality control samples, additional field audits, review of analytical laboratory procedures, and/or any other procedure that will mitigate the discrepancies. Corrective actions, recommendations and specific steps taken to resolve data quality discrepancies are reported in writing to the contractor Environmental Department Supervisor.

7.2 QUALITY ASSURANCE REPORT

The QA/QC Coordinator provides a monthly written Quality Assurance Report to the Environmental Department's Contamination Assessment Supervisor. At a minimum, this report includes a summary of quality assurance procedures utilized, the quantity and type of field quality assurance samples analyzed, a summary of laboratory quality assurance procedures/samples used, a list of all samples analyzed and reported using data qualifiers, an overall assessment of the quality of environmental data, and a chronology of any corrective actions initiated to resolve discrepancies.

8.0 DATA MANAGEMENT

8.1 INTRODUCTION

The amount of data produced by the Groundwater Assessment and Post-Closure Care Programs requires that standard procedures are used to manage, store and process all environmental data. This section delineates procedures used to ensure that environmental data are effectively processed.

The environmental database used by the site contractor Environmental Department is a modular database system. Modules included in this system are the data management module and the environmental database module. The contractor Environmental Department also maintains hard copies of all final analytical reports and related documentation. After three years, hard copies of Summary Reports are transferred to compact disks for long-term archival.

8.2 DATA MANAGEMENT MODULE

The data management module is used to gather and organize analytical data into a Final Summary Report. Summary reports are generated for each individual sampling event performed at WSTF. The QA/QC Coordinator organizes the raw laboratory data and the corresponding QA discussion, sets data qualifier flags and prepares the Final Summary Report. The report is reviewed, approved and signed by the Environmental Sampling Coordinator and the QA/QC Coordinator prior to release.

The analytical laboratory is required to maintain raw data, chromatographs, logbooks, and all other relevant analytical information. This information is required to ensure the validity of reported data and to rectify any discrepancies that may arise.

There are several elements incorporated into a Summary Report. These elements are: the cover page; field logbook copies; the analytical results; the quality assurance section; a table listing data qualifier flags; and the signature blocks. The following sections provide a brief description of these elements and information which is required for each section.

8.2.1 Cover Page

The cover page provides the pertinent information concerning the identification of the samples. Information required includes: sampling location/Well I.D.; sampling date; report date; analytical methods performed; and a signature block for reviewers/approvers.

8.2.2 Field Logbook Copies

Copies of the field logbook provide the pertinent information concerning sample collection in the field. Information required includes: sampling location; sampling date; field measured indicator parameters; static water level; purge device; purge rate; purge volume; sample collection device; and any other information relevant to the sample's collection.

8.2.3 Analytical Results

Analytical results are reported for each analysis performed. Information required for each report includes: analytical method used; sample ID number(s); sample location; date sampled; date extracted or digested; analytical laboratory name; date received; date analyzed; compounds analyzed for; corresponding CAS numbers; concentrations observed; reporting limits; and quality assurance flags.

8.2.4 Quality Assurance Appendix

The Quality Assurance Appendix provides the QA/QC Coordinator's evaluation of the reported data quality. Minimally, this section includes a summary of quality assurance procedures performed and the results for quality assurance samples which are observed out of specified acceptance limits. The Quality Assurance Appendix also defines flags used to identify data falling outside of WSTF established criteria (Table 3.6).

8.2.5 Signature Blocks

Summary Reports are reviewed and approved prior to release. The Sampling Coordinator and the QA/QC Coordinator sign and date the report indicating the information is complete and correct.

8.3 ENVIRONMENTAL DATABASE MODULE

The WSTF environmental database module is managed by the site contractor Environmental Department. Summary Reports are reviewed, evaluated and approved by the Environmental Department prior to incorporation into the environmental database

module. This module is the final repository for all reviewed and approved data and allows data end-users the ability to manipulate stored data for generating reports, tables, graphs, and other visual presentations.

8.3.1 Summary Report Reviews

Summary Reports are reviewed by the contractor Environmental Department for correctness and completeness. If the quality assurance criteria are not met, the Environmental Department will determine how critical the data point is and, if it is essential to the program, the sample is retaken. In either case, the original data are stored in the database.

8.3.2 Database Management

The site contractor Environmental Department is the only organization which can input or edit data in the environmental database module. All other individuals are granted "read only" access. This precludes data modification by personnel other than in the site contractor's Environmental Department.

Hard copies of all Summary Reports are maintained on file in the site contractor Environmental Department. The environmental database system is backed up on at least a weekly basis. After three years, hard copies of Summary Reports are transferred to compact disks for long-term archival.

8.3.3 End-Users of Data

The primary end-users of environmental data are the contractor Environmental Department and the NASA Environmental Program Manager. The contractor Environmental Department uses the data, in conjuction with collected geophysical data, to interpret and present technical assessments of the hydrogeological system. In addition, the contractor Environmental Department uses the data to prepare regulatory and technical reports. The NASA Environmental Program Manager uses data presentations as guidance for making managerial decisions concerning the Groundwater Assessment and Post-Closure Care Programs.

9.0 REFERENCES

Barcelona, M., J. Gibb, J. Helfrich, and E. Garske, Practical Guide for Ground-Water Sampling, Illinois State Water Survey, Champaign, IL, November 1985.

Evans, R., and E. Koglin, Ground-Water Monitoring Quality Assurance For RCRA, EPA 600/X-87/035, U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Las Vegas, NV, January 1987.

Geoscience Consultants, Ltd., Internal Data Management Plan, Albuquerque, NM, July 1988.

Geoscience Consultants, Ltd., Quality Assurance and Quality Control, Environmental Support Contract #NA59-95595, 200, 300, 400, 600 Area Contamination Assessments, for NASA-JSC-White Sands Test Facility, Albuquerque, NM, January 1987.

National Archives and Records Administration, Office of the Federal Register, Code of Federal Regulations, Protection of Environment, Title 40, Parts 100 to 149, Washington, D.C., 1997.

National Archives and Records Administration, Office of the Federal Register, Code of Federal Regulations, Protection of Environment, Title 40, Parts 260 to 299, Washington, D.C., 1997.

Nielson, D., Practical Handbook of Ground-Water Monitoring, Lewis Publishers Inc., Chelsea, MI, 1991.

Stanley, T. and S. Verner, Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, U.S. Environmental Protection Agency, Office of Exploratory Research, Washington, D.C., February 1983.

U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Handbook for Analytical Quality Control in Water and Wastewater Laboratories, EPA-600/4-79-019, Cincinnati, OH, March 1979.

U.S. Environmental Protection Agency, Office of Emergency and Remedial Response and Office of Waste Programs Enforcement, Data Quality Objectives for Remedial Response Activities: Development Process, EPA/540/G-87/003, Washington, D.C., March 1987.

U.S. Environmental Protection Agency, Office of Emergency and Remedial Response and Office of Waste Programs Enforcement, Data Quality Objectives for Remedial Response Activities, Example Scenario: RI/FS Activities at a Site With Contaminated Soils and Ground Water, EPA/540/540/G-87/004, Washington, D.C., March 1987.

U.S. Environmental Protection Agency, Office of Research and Development, Center for Environmental Research Information, Handbook: Ground Water Volume I: Ground Water and Contamination, EPA/625/6-90/016a, Cincinnati, OH, September 1990.

U.S. Environmental Protection Agency, Office of Research and Development, Center for Environmental Research Information, Handbook: Ground Water Volume II: Methodology and Contamination, EPA/625/6-87/016b, Cincinnati, OH, July 1991.

U.S. Environmental Protection Agency, Office of Research and Development, Hazardous Waste Engineering Laboratory, Preparation Aid for HWERL's Category III Quality Assurance Project Plans, PA QAPP-007-GFS, Cincinnati, OH, June 1987.

U.S. Environmental Protection Agency, Office of Solid Waste, RCRA Ground-Water Monitoring Draft Technical Guidance, EPA/530-R-93-001, Washington D.C., November 1992.

U.S. Environmental Protection Agency, Office of Solid Waste, RCRA Facility Investigation (RFI) Guidance Volume 1: Development of an RFI Work Plan and General Considerations for RCRA Facility Investigations, EPA 530/SW-87-001, Washington, D.C., July 1987.

U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Test Methods for Evaluating Solid Waste, Third Edition, SW-846, Washington D.C., 1986.

U.S. Environmental Protection Agency, Office of Waste Programs Enforcement and Office of Solid Waste and Emergency Response, RCRA Ground-Water Monitoring Technical Enforcement Guidance Document, OSWER-9950.1, Washington, D.C., September 1986.

APPENDIX D

LABORATORY QUALITY ASSURANCE/QUALITY CONTROL

Quanterra
Environmental
Services

Quality Assurance Management Plan for Environmental Services

Revision 2
June 30, 1997

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Quanterra®

Quality Assurance Management Plan

UNCONTROLLED COPY

Approved by:

Mark A. Matthews
Chief Operating Officer

Chris M. Lee
Vice President of Operations Services

Jack R. Hall
Corporate Director of Quality Assurance

Revision 2
June 30, 1997

Controlled Copy Number: _____

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Preface

The purpose of the Quanterra® Quality Assurance Management Plan (QAMP) is to provide internal quality assurance (QA) guidance to Quanterra® operating units. This guidance allows Quanterra® to operate under a standardized, rigorous quality management system (QMS) and ensures that our clients are consistently provided with data that are of known and documented quality and are legally defensible. The QAMP outlines the purpose, policies, organization, responsibilities, and operations related to ensuring high quality performance in all Quanterra® activities. The QAMP also fulfills the requirement of our clients and of government programs to document our QMS.

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The QAMP contains many references to other essential Quanterra® quality documents. These quality documents, including the QAMP, Policy Documents, and Standard Operating Procedures (SOPs), both corporate and laboratory-specific, help ensure the quality of our products and intertwine to produce a strong QMS within Quanterra®. This system is the foundation that provides our operations with guidance and ensures consistently-produced quality deliverables. The project-specific requirements delineated in project plans may supersede the general quality requirements described in this manual.

The document is designed to follow the basic outline required for a quality management plan as described by the United States Environmental Protection Agency (EPA). Table 2.3-1 cross-references the narrative sections of the QAMP to the appropriate sections of the EPA document and other nationally recognized quality standards.

There are two basic types of information included in the QAMP. General information is applicable to all Quanterra® operating units. Operation-specific information, provided in the Facility-Specific Appendix, describes the quality control (QC) requirements that apply only to a specific laboratory. The Facility-Specific Appendix includes information such as method detection limits (MDLs), performance evaluation (PE) studies, and laboratory SOPs that cannot be standardized throughout the Quanterra® laboratory network due to client-specific, laboratory-specific, or instrument-specific nature.

Forward

QAMP Revision 2 Implementation:

Quality Assurance Managers are to distribute the document and conduct training on the changes to the QAMP within 45 days of the issuance date. Implementation of the changes to the QAMP shall be completed within 120 days of the issuance date.

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Table of Contents

Page

Table of Contents
Title and Signature Page i
Copyright Statement ii
Preface iii
Forward iiii
Table of Contents v
List of Figures xi
List of Tables xii
List of Appendices xiv
Acronyms and Initialisms xv

1.0 Management Commitment and Organization 1
1.1 Vision Statement 1
1.2 Statement of Management Commitment to Quality 1
1.3 Organizational Structure 2
1.4 Quality Organization 2
1.4.1 President and Chief Executive Officer (CEO) 2
1.4.2 Chief Operating Officer 2
1.4.3 Vice President of Operations Services 4
1.4.4 Corporate Director of Quality Assurance 4
1.4.5 Assistant Quality Assurance Director 4
1.4.6 Quality Assurance (QA) Manager 5
1 4.7 Customer Service Managers (CSMs) 5
1.4.8 Regional General Manager 6
1 4.9 Laboratory Manager 6
1.4.10 Operations Manager 6
1.4.11 Systems Manager 6
1.4.12 Project Manager 7
1.4.13 Group Leader or Team Leader 7
1.4.14 Analyst 7
1.4.15 Sample Custodian 8
1.4.16 Report Production Staff 8
1.5 General Responsibilities 8
1.6 Waste, Fraud, and Abuse 8

2.0 Quality System and Description 9
2.1 Quality Management System 9
2.2 Quality Assurance 9

UNCONTROLLED COPY

Table of Contents (continued)

Page

2.0 Quality System and Description (continued)

2.3 Quality Documents 10
2.3.1 Quality Assurance Management Plan for Environmental Services 10
2.3.2 Quality Policy Documents 11
2.3.3 Standard Operating Procedures 11
2.3.4 Quality Assurance Project or Program Plans 11
2.3.4.1 Quality Assurance Summary (QAS) 12
2.3.5 Other Documents 12

3.0 Associate Qualification and Training 13
3.1 Associate Qualifications 13
3.2 Orientation and Training of Laboratory Staff 13
3.2.1 Quality Orientation 14
3.2.2 Quality Training 14
3.2.3 Health and Safety Orientation and Training 15
3.2.4 QA Manager Training 15
3.3 Training Files 15
3.3.1 Associate Resumes 15
3.3.2 Individual Training Records for the Areas of Quality, Health and Safety, and Technical 15
3.3.3 Training Records for Professional Development 16
3.3.4 Training Records for Regulatory/Compliance Information 16

4.0 Procurement of Items and Services 17
4.1 Selection of Vendors 17
4.2 Procurement of Quality-Related Items 18
4.2.1 Role of Quanterra® Purchasing 19
4.2.2 Procurement Procedures 19
4.2.3 Evaluation of QRIs 20
4.2.4 Special Requirements for Standard Reference Materials 21
4.3 Procurement of Subcontract Laboratory Services 21
4.4 Vendor Partnerships 23

5.0 Documentation and Records 23
5.1 Quality Documents and Records 23
5.2 Document Review and Revision 23
5.3 Document Control and Distribution 23

UNCONTROLLED COPY

Table of Contents (continued)

Page

5.0 Documentation and Records (continued)

5.4 Records Management 24
5.4.1 Quality Records 24
5.4.2 Project Records 25
5.5 Validation of Records 25
5.6 Retention and Disposal of Records 25
5.7 Data Confidentiality 25

6.0 Computer Hardware and Software 27
6.1 Use of Hardware 27
6.2 Security 27
6.3 Use of Software 27
6.3.1 Industry Standard Software 28
6.3.2 Quanterra® -Developed Software 28
6.3.3 Control of Software Changes 28
6.3.4 Software Revalidation 28
6.4 Documentation 29
6.5 Computer Viruses 29

7.0 Planning 31
7.1 Data Collection Process 31
7.2 Organizational Responsibilities 31
7.3 Determination of Project QC Requirements 33
7.4 Communication of Project-Specific Requirements 33
7.5 Customer Service Teams 34
7.6 Contingency Planning 34

8.0 Work Processes and Operations 39
8.1 Standard Operating Procedures 39
8.2 Analytical Methods 39
8.3 Data Quality Objectives 40
8.3.1 Precision and Accuracy 41
8.3.2 Completeness 41
8.3.3 Representitiveness 41
8.3.4 Comparability 42
8.3.5 Method Detection Limits 42
8.3.6 Instrument Detection Limits 42

UNCONTROLLED COPY

Table of Contents (continued)

Page

8.0 Work Processes and Operations (continued)

8.3.7 Reporting Limits 43
8.4 Quality Control Samples 44
8.4.1 Field QC Samples 44
8.4.1.1 Trip Blank 44
8.4.1.2 Rinsate Blank 45
8.4.1.3 Field Blank 45
8.4.1.4 Field Duplicate 45
8.4.1.5 Field Matrix Spike 45
8.4.1.6 Collocated Samples 45
8.4.1.7 Split Sample 46
8.4.2 Laboratory QC Samples 46
8.4.2.1 Quality Control (QC) Batch 47
8.4.2.2 Method Blank 47
8.4.2.3 Instrument Blank 47
8.4.2.4 Laboratory Control Sample 48
8.4.2.5 Matrix Spike 48
8.4.2.6 Matrix Spike Duplicate 48
8.4.2.7 Sample Duplicate 48
8.4.2.8 Surrogates 49
8.4.2.9 Analytical Spike 49
8.4.2.10 Interference Check Sample 49
8.4.2.11 Internal Standards 49
8.4.2.12 Radiological QC Samples 49
8.5 Data Collection Operations 50
8.5.1 Field Collection and Shipment 50
8.5.2 Sample Containers, Shipping Containers, Preservatives, and Holding Times 51
8.5.2.1 Sample Containers 51
8.5.2.2 Shipping Containers 51
8.5.2.3 Sample Preservatives 53
8.5.2.4 Sample Holding Times 53
8.5.3 Sample Handling 54
8.5.3.1 Sample Receipt 54
8.5.3.2 Sample Log-in 55
8.5.3.3 Sample Storage 55
8.5.3.4 Internal Sample Chain-of-Custody and Interlaboratory Transfers 58

UNCONTROLLED COPY

Table of Contents (continued)

Page

8.0 Work Processes and Operations (continued)

8.5.3.5 Sample Disposal and Return Chain-of-Custody 59
8.5.4 Calibration Procedures and Criteria 59
8.5.4.1 Physical Reference Standards 60
8.5.4.2 Chemical Reference Standards 60
8.5.4.3 Standard Verification/Independent Standard 60
8.5.4.4 Periodic Calibration 61
8.5.4.5 Operational Calibration 61
8.5.4.6 Calibration Failure 62
8.5.4.7 Calibration Records 62
8.6 Quality Assessment 62
8.6.1 Data Quality Assessment 62
8.6.2 Statistical Evaluation of Data 63
8.7 Data Recording Procedures 63
8.8 Data Reduction and Verification Procedures 64
8.8.1 Data Reduction and Initial Verification 64
8.8.2 Data Verification 66
8.8.3 Completeness Verification 67
8.9 Data Reporting 68
8.9.1 Data Reports 68
8.9.2 Verbal Results 68
8.9.3 Reporting Analytical Results 69
8.10 Data Validation 69
8.11 Preventive Maintenance and Service 70
8.11.1 Analytical Instrumentation and Equipment 70
8.11.2 Facilities 70
8.11.3 Frequency of Maintenance 71
8.12 Other Requirements 71
8.12.1 Water 71
8.12.2 Compressed Air and Gases 71
8.12.3 Glassware Preparation 72
8.12.4 Chemical Storage 72
8.12.5 Waste Disposal 72
8.12.6 Facility Security 72

UNCONTROLLED COPY

Table of Contents (continued)

Page

9.0 Quality Assessment and Response 73
9.1 Nonconformance and Corrective Action 73
9.1.1 Nonconformance 73
9.1.2 Corrective Action 73
9.1.3 Responsibilities 73
9.1.4 Nonconformance Memo 73
9.2 Audits 73
9.2.1 Performance Audits 74
9.2.2 Systems Audits 75
9.2.2.1 Internal Systems Audits or Evaluations 75
9.2.2.2 External Systems Audits 76
9.2.3 Data Audits 77
9.2.4 Spot Assessments 77
9.3 Client Inquiries and Complaints 77
9.4 Quality Reports to Management 77
9.5 Management Review of the QMS 78

10.0 Quality Improvement 79
10.1 Standardization of Procedures 79
10.2 Continuous Quality Improvement 79
10.3 Benchmarking 80
10.4 Quality Assessment 80
10.5 Understanding the Clients' Needs 80
10.6 Quality Measures and Standards 80

UNCONTROLLED COPY

List of Figures

Figure	Title	Page
1.3-1	Quanterra® Organizational Chart	3
7.1-1	Data Collection Process Flow Diagram	32
7.4-1	Example Quality Assurance Summary	35-36
8.5-1	Example Quanterra® Chain-of-Custody Form	52
8.5-2	Example Condition Upon Receipt Anomaly Report (CUR)	56-57
8.8-1	Data Reduction, Verification, and Reporting	65

UNCONTROLLED COPY

List of Tables

Table No.	Title	Page
2.3-1	Quanterra® Quality Assurance Management Plan Requirements Matrix	5
4.2-1	List of Quanterra® Quality-Related Items that Require Evaluation Prior to Use	9
5.1-1	Quanterra® Quality Documents and Required Approval	10
5.2-1	Quanterra® Quality Document Review Requirements	11
8.2-1	Analytical Methods Routinely Performed by Quanterra®	12
8.4-1	Field Quality Control Samples	24
8.4-2	Laboratory Quality Control Samples	25
8.4-3	Laboratory Performance Quality Control Samples	26
8.4-4	Matrix Specific Quality Control Samples	27
8.4-5	Inorganic Laboratory Quality Control Samples	28
8.4-6	Organic Laboratory Quality Control Samples	77
8.4-7	USEPA Contract Laboratory Program Statement of Work Quality Control Samples	102
8.5-1	Inorganic Sample Containers, Preservatives, and Holding Times	116
8.5-2	Organic Sample Containers, Preservatives, and Holding Times	128
8.5-3	Radiological Sample Containers, Preservatives, and Holding Times	137
8.5-4	Sample Containers, Preservatives, and Holding Times for USEPA Contract Laboratory Program Statement of Work	140
8.5-5	Sample Containers, Preservatives, and Holding Times for TCLP	142
8.5-6	Periodic Equipment Calibrations	143
8.5-7	Summary of Inorganic Method Calibrations	144
8.5-8	Summary of Organic Method Calibrations	160
8.5-9	Summary of USEPA Contract Laboratory Program Statement of Work Method Calibrations	169
8.6-1	Precision and Accuracy Measurements	173
8.11-1	Instrument Maintenance Schedule - Ion Chromatograph	175
8.11-2	Instrument Maintenance Schedule - LACHAT Auto Analyzer	175
8.11-3	Instrument Maintenance Schedule - Total Organic Halide Analyzer	176
8.11-4	Instrument Maintenance Schedule - High Pressure Liquid Chromatograph	176
8.11-5	Instrument Maintenance Schedule - Flame Atomic Absorption Spectroscopy	177
8.11-6	Instrument Maintenance Schedule - Inductively Coupled Argon Plasma/ Mass Spectrometry (ICAP/MS)	177
8.11-7	Instrument Maintenance Schedule - ICP	178
8.11-8	Instrument Maintenance Schedule - Graphite Furnace Atomic Absorption	179
8.11-9	Instrument Maintenance Schedule - Cold Vapor Atomic Absorption (Leeman PS 200)	179

UNCONTROLLED COPY

Table of Contents (continued)

Table No.	Title	Page
8.11-10	Instrument Maintenance Schedule - Cold Vapor Atomic Absorption (PE 5000)	179
8.11-11	Instrument Maintenance Schedule - Gas Chromatograph	180
8.11-12	Instrument Maintenance Schedule - Mass Spectrometer	182
8.11-13	Instrument Maintenance Schedule - TRAACS 800 Auto Analyzer	183
8.11-14	Instrument Maintenance Schedule - Sonicator	183
8.11-15	Instrument Maintenance Schedule - Analytical/Top Loading Balances	183
8.11-16	Instrument Maintenance Schedule - Refrigerators/Walk-in Coolers	183
8.11-17	Instrument Maintenance Schedule - Ovens	184
8.11-18	Instrument Maintenance Schedule - Specific Digital Ion Analyzer	184
8.11-19	Instrument Maintenance Schedule - Turbidimeter	184
8.11-20	Instrument Maintenance Schedule - Dissolved Oxygen Meter	184
8.11-21	Instrument Maintenance Schedule - Conductance Meter	185
8.11-22	Instrument Maintenance Schedule - Chemical Oxygen Demand (COD) Reactor	185
8.11-23	Instrument Maintenance Schedule - Spectrophotometer	185
8.11-24	Instrument Maintenance Schedule - pH Meter	185
8.11-25	Instrument Maintenance Schedule - Fourier Transform Infrared Spectrometry	186
8.11-26	Instrument Maintenance Schedule - Radiological Analysis Equipment	186
8.11-27	Instrument Maintenance Schedule - Total Organic Carbon Analyzer (OI 7000)	187

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List of Appendices

Appendix A — Corporate Key Personnel List and Quanterra® Operations Organizational Chart

Appendix B — Addresses of Quanterra® Locations

Appendix C — Facility-Specific Appendix: ***This appendix contains facility-specific quality-related information and requirements for*** Quanterra® ***laboratories. These laboratories are located in the following cities:***

- Anchorage, Alaska
- Austin, Texas
- City of Industry, California
- Denver, Colorado
- Knoxville, Tennessee
- North Canton, Ohio
- Pittsburgh, Pennsylvania
- Richland, Washington
- Sacramento, California
- Santa Ana, California
- St. Louis, Missouri
- Tampa, Florida

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Each laboratory section in this appendix contains information specific to that laboratory only and contains the following basic outline:

Section	Contents
0	Table of Contents
1	Organizational Chart
2	Instrument List
3	Standard Operating Procedures List
4	Analytical Methods
5	MDLs, RLs, and CRDLs
6	Performance Evaluation Studies
7	Additional Operation-Specific Information

Acronyms and Initialisms

A2LA	American Associatio for Laboratory Accreditation
AA	Atomic Absorption
ANSI	American National Standards Institute
AR/COC	Analysis Request/Chain-of-Custody
ASQC	American Society for Quality Control
ASTM	American Society for Testing and Materials
BFB	Bromofluorobenzene
BLK	Blank
BOD	Biochemical Oxygen Demand
CCC	Calibration Check Compound
CEO	Chief Executive Officer
CF	Calibration Factor
CFR	Code of Federal Regulations
CHP	Chemical Hygiene Plan
CLP	Contract Laboratory Program
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act (Superfund)
COC	Chain-of-Custody
COD	Chemical Oxygen Demand
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CSM	Customer Service Manager
CSRM	Certified Standard Reference Material
CST	Customer Service Team
CUR	Condition Upon Receipt
CV	Coefficient of Variation
CVAA	Cold Vapor Atomic Absorption (Spectroscopy)
DFTPP	Decafluorotriphenylphosphine
DOC	Dissolved Organic Carbon
DOE	Department of Energy
DOT	Department of Transportation
DQO	Data Quality Objective

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Acronyms and Initialisms (continued)

EH&S	Environmental Health and Safety
EPA	(U. S.) Environmental Protection Agency
FAS	Field Analytical Services
FLAA	Flame Atomic Absorption (Spectroscopy)
FTIR	Fourier Transform Infrared (Spectrometry)
GC	Gas Chromatograph(y)
GC/MS	Gas Chromatography/Mass Spectrometry
GFAA	Graphite Furnace Atomic Absorption (Spectroscopy)
HDPE	High Density Polyethylene
HPLC	High Performance Liquid Chromatography
HRGC	High Resolution Gas Chromatography
HRMS	High Resolution Mass Spectrometry
ICAP	Inductively Coupled Argon Plasma (Spectroscopy)
ICAP/MS	Inductively Coupled Argon Plasma/Mass Spectrometry
ICS	Interference Check Sample
IDL	Instrument Detection Limit
IR	Infrared (Spectroscopy)
IS	Information Systems
IS	Internal Standard
ISO	International Organization for Standardization
IT	Information Technology
KRI	Key Result Indicator
LAN	Local Area Network
LCL	Lower Control Limit
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LIMS	Laboratory Information Management System
LRGC	Low Resolution Gas Chromatography
LRMS	Low Resolution Mass Spectrometry
LWL	Lower Warning Limit
MBAS	Methylene Blue Active Substance

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Acronyms and Initialisms (continued)

MDA	Minimum Detectable Amount
MDL	Method Detection Limit
MS	Matrix Spike
MSA	Method of Standard Additions
MSD	Matrix Spike Duplicate
MSDS	Material Safety Data Sheet
NCM	Nonconformance Memo
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards Technology
NMOC	Non-Methane Organic Compounds
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NRM	National Reference Material
PAH	Polynuclear Aromatic Hydrocarbons (or PNA)
PC	Personal Computer
PCB	Polychlorinated Biphenyls
PDS	Post Digestion Spike
PE	Performance Evaluation
PEM	Performance Evaluation Mixture
PM	Project Manager
PQL	Practical Quantitation Limit
PSRL	Project-Specific Reporting Limit
PUF	Polyurethane Foam
QA	Quality Assurance
QAMP	Quality Assurance Management Plan
QAPP	Quality Assurance Project Plan or Quality Assurance Program Plan
QAS	Quality Assurance Summary
QC	Quality Control
QMS	Quality Management System
QuantIMS	Quanterra® Laboratory Information Management System
QRI	Quality-Related Item

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Acronyms and Initialisms (continued)

RCRA	Resource Conservation and Recovery Act
RF	Response Factor
RFP	Request for Proposal
RFQ	Request for Quote
RL	Reporting Limit
RPD	Relative Percent Difference
RRF	Relative Response Factor
RSD	Relative Standard Deviation
RSO	Radiation Safety Officer
SDG	Sample Delivery Group
SOP	Standard Operating Procedure
SOW	Statement of Work
SPCC	System Performance Check Compounds
SPLP	Synthetic Precipitation Leaching Procedure
SRL	Standard Reporting Limit
SRM	Standard Reference Material
TCLP	Toxicity Characteristic Leaching Procedure
TIC	Tentatively Identified Compound
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TOX	Total Organic Halides
UCL	Upper Control Limit
UPS	Uninterruptable Power Supply
USEPA	United States Environmental Protection Agency
UWL	Upper Warning Limit
VOA	Volatile Organic Analysis
VOST	Volatile Organic Sampling Train
WAN	Wide Area Network
WS	Water Supply
WP	Water Pollution

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1.0 Management Commitment and Organization

1.1 Vision Statement

Quanterra®'s vision is to be a world-class, profitable analytical services company providing high-value, compliant, innovative problem solutions and state-of-the-art products wherever they are required.

1.2 Statement of Management Commitment to Quality

Quanterra®'s management is committed to providing quality services that meet the requirements of our clients and satisfy applicable regulatory requirements. Management is dedicated to providing an environment that encourages the achievement of excellence, demands integrity in all aspects of its operations, and requires active participation of all associates and vendors in meeting its quality goals.

A comprehensive Quality Management System (QMS) has been developed to ensure that Quanterra®'s clients receive high-quality analytical and environmental services that are timely, reliable, and meet their intended purpose in a cost-effective manner. The QMS provides the organizational structure that ensures quality in its work processes, products, and services. The Quanterra® QMS is described in this Quanterra® Quality Assurance Management Plan (QAMP) and applies to all technical, business, and administrative functions at Quanterra®. The principles and practices described in this QAMP apply to all Quanterra® associates at every level and are fundamental to the services we provide and to the way we do business.

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The Quanterra® QAMP provides the foundation for planning, implementing, and assessing the Quanterra® QMS. It is an overall statement of quality policy as well as a plan used to implement quality programs throughout the company. Each business function of the organization shall put in place plans, policies, and procedures that will meet the requirements of the QAMP. The QAMP provides guidance to Quanterra®'s associates in fulfilling their responsibilities and serves as a statement to clients, agencies, and associates of Quanterra®'s commitment to quality.

Implementation of the QAMP is the responsibility of all Quanterra® associates. Management at every level has the responsibility and authority to lead the development and implementation of a structured management system that supports the quality programs. Management must ensure that the principles and practices of the

quality program are followed and implemented at all levels.

1.3 Organizational Structure

Quanterra® is incorporated in the state of Delaware with corporate headquarters located in Englewood, Colorado. The organizational structure for Quanterra® is presented in Figure 1.3-1. Laboratory locations are given in the List of Appendices in the Table of Contents. A list of key corporate personnel and an organizational chart for Quanterra® operations including Corporate Quality Assurance are given in Appendix A. The organizational structure for each laboratory is presented in the Facility-Specific Appendix C. The responsibilities and authorities of the members of the organization, as they relate to quality management, are outlined in Section 1.4.

At some Quanterra® laboratories, positions identified in this section may not exist due to the laboratory size or other factors. In these cases, the responsibilities and authorities described here are assigned to other positions by the Laboratory Manager or next senior level of management as appropriate.

1.4 Quality Organization

The achievement of quality in all activities is the responsibility of each Quanterra® associate and is led by management. Quality-related responsibilities within the organization provide for the implementation of the QAMP and for completion of quality control (QC) activities. The following sections describe these activities for key Quanterra® positions. The quality-related responsibilities may be reassigned by assigning the activities among different individuals or enhanced by adding activities, but they must not be eliminated. If an operation does not have the titled position outlined below, the responsibilities under that position go to next upward position. The accountability is retained by the person delegating the activity or by the person assigned the activity by the next senior level of management.

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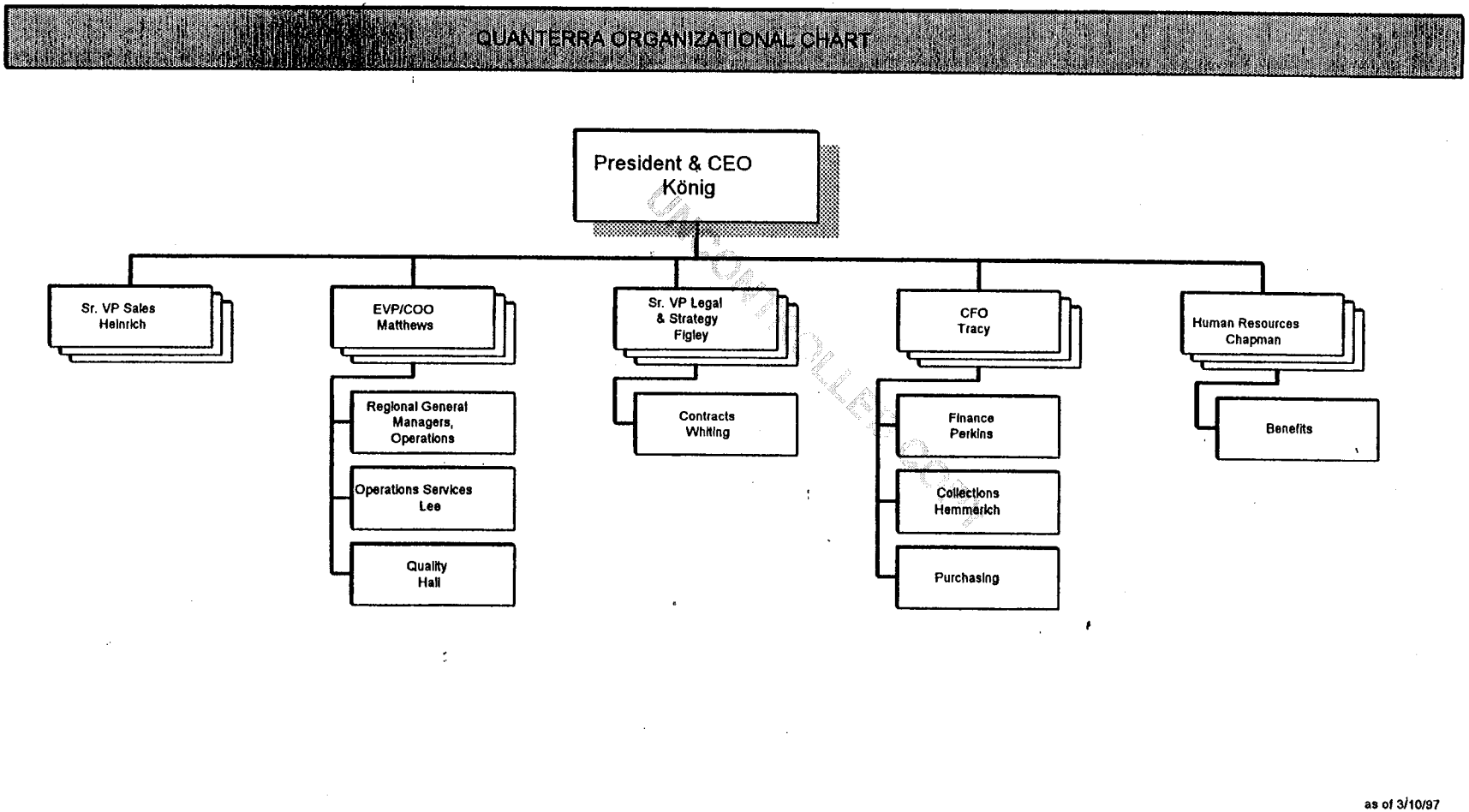
1.4.1 President and Chief Executive Officer (CEO)

- Reports directly to the Board of Directors
- Responsible for overall corporate policy and strategy for quality
- Responsible for maintaining effective quality management
- Provides the resources to implement the Quanterra® QAMP.

1.4.2 Chief Operating Officer

- Reports directly to the President and CEO
- Approves the Quanterra® QAMP

FIGURE 1.3-1


QUANTERRA ORGANIZATIONAL CHART
President & CEO
König
Sr. VP Sales
Heinrich
EVP/COO
Matthews
Regional General Managers, Operations
Operations Services
Lee
Quality
Hall
Sr. VP Legal & Strategy
Figley
Contracts
Whiting
CFO
Tracy
Finance
Perkins
Collections
Hemmerich
Purchasing
Human Resources
Chapman
Benefits
as of 3/10/97

- Responsible for implementation of an effective QMS
- Implements improvements in operations and quality programs
- Provides feedback regarding customer satisfaction.

1.4.3 Vice President of Operations Services

- Reports directly to the Chief Operating Officer
- Approves the Quanterra® QAMP and Quality Policy Documents
- Recommends improvements in operations and quality programs
- Oversees evaluation of new technology and required quality control

1.4.4 Corporate Director of Quality Assurance

- Reports directly to the Vice President of Operations Services and Chief Operating Officer on all quality issues
- Reviews and approves changes in laboratory quality assurance (QA) staff
- Maintains a strong line of communication to and provides guidance to the QA Managers
- Approves the Quanterra® QAMP, the Facility Appendices to the QAMP, Quality Policy Documents, and Corporate Standard Operating Procedures (SOP)
- Serves as a technical consultant and resource on quality issues to ensure uniform excellence in quality and regulatory analytical compliance at all Quanterra® operations
- Responsible for assessing, maintaining, and improving the Quanterra® QAMP
- Supervises and provides guidance to corporate QA staff
- Suspends processing when significant quality requirements are not met
- Oversees independent audits of Quanterra® laboratories to identify areas where improvement is needed to comply with the QAMP
- Responsible for reporting all matters of quality assurance to the President and senior management.
- Issues Corporate Quality Assurance Directives as required to clarify policy
- Duties completed by Assistant QA Director in absence of the Director

1.4.5 Assistant Quality Assurance (QA) Director

- Reports directly to the Corporate Director of Quality Assurance
- Primary duty is to fill in for the Corporate Director of Quality Assurance in their absence
- Completes special projects related to corporate QA issues

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1.4.6 Quality Assurance (QA) Manager

- Reports directly to the Laboratory Manager and indirectly for all QA matters to the Corporate Director of Quality Assurance
- Approves the Facility-Specific Appendix to the Quanterra® QAMP
- Approves operation-specific SOPs
- Responsible for assessing and maintaining the QAMP within the facility operations
- Responsible for ensuring and improving quality within facility operations
- Recommends resolutions for ongoing or recurrent nonconformances within the laboratory
- Supervises and provides guidance and training to laboratory QA staff
- Suspends sample processing when significant quality requirements are not met
- Assists in maintaining regulatory analytical compliance
- Serves as the in-house client representative on all project inquiries involving data quality issues
- Monitors data quality measures via statistical methods to verify that the laboratory routinely meets stated quality goals
- Performs QA assessments
- Tracks and closes external and internal findings of QA audits
- Reviews and approves corrective action plans for nonconformances, trends nonconformances to detect systematic problems, and initiates additional corrective actions as needed.
- Assists in the preparation of and approves Quality Assurance Project Plans (QAPPs)
- Coordinates laboratory certification and accreditation programs
- Maintains controlled quality documents
- Prepares a monthly quality report to management
- Responsible for approving reference data and changes on LIMS.

1.4.7 Customer Service Managers (CSMs)

- Reports directly to the Laboratory Manager
- Defines customer requirements through project definition
- Assesses and assures customer satisfaction
- Provides feedback to management on changing customer needs
- Brings together resources necessary to ensure customer satisfaction.

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1.4.8 Regional General Manager

- Reports directly to the Chief Operating Officer
- Implements the Quanterra® QAMP in their operating units and approves the QAMP Facility-Specific Appendices for those units.
- Assigns specific responsibilities within operational units to resolve quality-related problems within their region
- Maintains a dialogue with the Chief Operating Officer and the Corporate Director of Quality Assurance
- Assesses the effectiveness of the Quanterra® QMS within their region.

1.4.9 Laboratory Manager

- Reports directly to the Regional General Manager
- Responsible for implementing the Quanterra® QAMP and all corporate policies and procedures within the laboratory
- Approves the Facility-Specific Appendix to the Quanterra® QAMP and Facility-Specific SOPs
- Periodically assesses the effectiveness of the QAMP within the operation
- Maintains adequate staffing documented on organization charts.

1.4.10 Operations Manager

- Reports directly to the Laboratory Manager
- Supervises daily activities of the Operational Groups
- Schedules analytical operations
- Supervises QC activities performed as a part of routine analytical operations
- Implements data review procedures
- Supervises the preparation and maintenance of laboratory records
- Supervises maintenance of instruments and scheduling of repairs
- Works with the Systems Manager and Group/Team Leaders to assure the requirements of projects are met in a timely manner
- Responsible for meeting quality requirements.

1.4.11 Systems Manager

- Reports directly to the Laboratory Manager
- Supervises daily activities of the Project Management, Sample Control, Administrative, and Report Production Groups
- Works with the Operations Manager and/or Group/Team Leaders to ensure the requirements of projects are met in a timely manner

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- Responsible for meeting quality requirements.

1.4.12 Project Manager

- Monitors analytical and QA project requirements
- Acts as a liaison between the client and the laboratory staff
- Prepares Quality Assurance Summary (QAS) or equivalent summary form and communicates project-specific requirements to all parties involved
- Assists the laboratory staff with interpretation of work plans, contracts, and QAPP requirements
- Reviews project data packages for completeness and compliance to client needs
- Keeps the laboratory and client informed of project status
- Together with the QA Manager, approves customer requested variances to methods and to standard laboratory protocols
- Monitors, reviews, and evaluates the progress and performance of projects
- Reports client inquiries involving data quality issues or data acceptability to the facility QA Manager and to the operations staff
- Conducts project reviews to assess the laboratory's performance in meeting customer requirements
- Prepares reissue requests for project data
- Responsible for meeting quality requirements.

1.4.13 Group Leader or Team Leader

- Reports directly to either the Systems Manager, or Operations Manager or Laboratory Manager depending on specific laboratory organization.
- Supervises daily activities of analyses within the group
- Supervises QC activities performed as a part of routine analytical operations
- Implements data review procedures
- Supervises the preparation and maintenance of laboratory records
- Evaluates instrument performance and supervises the calibration, preventive maintenance, and scheduling of repairs
- Oversees or performs review and approval of all analytical data
- Reports nonconformances to the appropriate managers
- Responsible for meeting quality requirements.

1.4.14 Analyst

- Performs analytical methods and data recording in accordance with documented procedures

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- Performs and documents calibration and preventive maintenance
- Performs data processing and data review procedures
- Reports nonconformances to the Supervisor/Manager and QA Manager
- Ensures sample and data integrity by adhering to internal chain-of-custody procedures
- Responsible for meeting quality requirements.

1.4.15 Sample Custodian

- Ensures implementation of proper sample receipt procedures, including maintenance of chain-of-custody
- Reports anomalies associated with condition-upon-receipt of samples to the Project Manager
- Logs samples into the LIMS
- Ensures that all samples are stored in the proper environment
- Assists Environmental Health and Safety staff with sample disposal
- Responsible for meeting quality requirements.

1.4.16 Report Production Staff

- Accurately generates and compiles analytical reports and associated deliverables for delivery to the client
- Responsible for meeting quality requirements.

1.5 General Responsibilities

It is the responsibility of each Quanterra® associate to perform their job-related duties in compliance with all Quanterra® corporate and operation-specific SOPs and policies applicable to their position.

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1.6 Waste, Fraud, and Abuse

Quanterra®, through its ethics policy (Corporate Policy Number LEG-001) and ethics training, and the Quanterra® Compliance Program (Corporate Policy Number LEG-009) requires and encourages all associates to report any activity that may be considered wasteful or fraudulent. Any incidents reported are subject to a complete investigation per Quanterra® Corporate Policy Number LEG-005, "Internal Investigation". Associates involved in such activities are subject to immediate dismissal.

Substance abuse is unacceptable behavior for Quanterra® associates and abuses are subject to Human Resources disciplinary policies. Prior to hiring, all Quanterra® associates undergo drug screening and are subject to random screening on an annual basis. The Quanterra® procedures on substance abuse meet the federal contracting guidelines.

2.0 Quality System and Description

Quanterra® has defined Quality as meeting the requirements of our clients, both internal and external. The QMS provides the structure to achieve the total quality management goals necessary to obtain world class standards of performance and quality in all areas.

2.1 Quality Management System

The purpose of the QMS is to ensure the quality of products and services. The QMS is a structured management system of principles, objectives, policies, responsibilities, and implementation plans at the organizational and project-specific levels. At the organizational level, the QMS provides the framework within which project-specific planning, implementation, and performance assessment may occur. The QAMP documents the QMS and describes both the organizational and project-specific principles, goals, controls, and tools of the QMS. The QMS is described in detail in this QAMP, Quality Policy Documents, and SOPs.

The QMS steering committee is comprised of the Quanterra® President and CEO and his staff. This committee establishes the Quanterra® Vision and its strategic plan and provides leadership and support for the achievement of all quality goals and objectives. It is the responsibility of all Quanterra® directors and managers to implement the QMS elements by setting goals and objectives which lead to the achievement of the Quanterra® Vision.

2.2 Quality Assurance

Quality Assurance (QA) is defined as a system of activities which ensures a process, product, or service that meets the needs and expectations of the customer. QA is an integral part of Quanterra® 's QMS.

The organizational and project-specific systems of the Quanterra® QMS, discussed in Section 2.1, are used to define QA goals. Controls at the organizational level regulate activities that support common or standardized functions such as associate qualifications and training, document control, and material procurement. Controls at the project level regulate the definition and implementation of customer requirements to produce the desired type and quality of product. Some specific examples of quality controls are:

- Measuring lab and instrument performance on a daily basis to ensure that the measurement systems are in statistical control
- Demonstrating lab capability through data quality assessments which document the

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overall qualification of the laboratory to perform environmental analyses

- Utilizing SOPs to ensure uniformity and compliance in the measurement process
- Providing controlled flexibility in routine methodology to meet project-specific sample and data requirements
- Monitoring operational performance of the laboratory on a routine basis and providing corrective action if needed
- Recognizing and promptly correcting any factors which adversely affect quality
- Maintaining complete records of sample receipt, laboratory analysis, data evaluation and reporting, and sample disposal.

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2.3 Quality Documents

The QMS is defined by a series of documents which are described in Sections 2.3.1 through 2.3.5. The review and control of these documents are described in Section 5.0.

Following is a list of documents used to develop Quanterra®'s QAMP. The requirements of several of these documents are cross-referenced with the content of the QAMP in Table 2.3-1.

- Interim Draft EPA Requirements for Quality Management Plans, U.S. Environmental Protection Agency, EPA QA/R-2, July 1993
- EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5
- Specifications and Guidelines for Quality Systems for Environmental Data Collection and Environmental Technology Programs, American Society for Quality Control, Energy and Environmental Quality Division, Environmental Issues Group, ANSI/ASQC E4-1994 (Formerly EQA-1), January 1994
- Quality Assurance Program Requirements for Nuclear Facilities, The American Society of Mechanical Engineers, ASME NQA-1-1989 edition
- Quality Assurance, Office of Nuclear Energy & Office of Environment, Safety, and Health, United States Department of Energy, DOE ORDER 5700.6C, August 1991
- Performance Criteria for Radiobioassay, ANSI N 13.30, September 1989
- Measurement Quality Assurance for Radioassay Laboratories, ANSI N 42.2, Revised May 21, 1992, Revision 10A
- Quality Management and Quality System Elements for Laboratories - Guidelines, American National Standard, American Society for Quality Control, ANSI/ASQC Q2-1991
- International Standard ISO/IEC Guide 25-1990.

2.3.1 Quality Assurance Management Plan

This Quanterra® Quality Assurance Management Plan (QAMP), along with Quality Policy Documents and SOPs, provides the criteria and specifications for the

generation of environmental analytical data. The QAMP provides QC criteria for standard procedures and facility-specific instrumentation as well as method detection limit (MDL) information.

2.3.2 Quality Policy Documents

Quality Policy Documents provide further detail to the QAMP. They describe the requirements for a specific program on a corporate-wide level. Quality Policy Documents use the concepts and requirements contained in the QAMP and provide sufficient detail so that corporate or facility-specific SOPs can be developed.

2.3.3 Standard Operating Procedures

Standard Operating Procedures (SOPs) describe step-by-step instructions for performing a method or activity. In addition, there are SOPs which relate to other support services performed in the company. In general, SOPs will be corporate or operation specific. Corporate SOPs specify procedures that are standard across Quanterra®. Operation-specific SOPs detail procedures that pertain to a specific facility operation only. SOPs specify procedures, methods, corrective action requirements, documentation, review, and verification requirements. SOP format and document control are described in Quanterra® Policy Number QA-001, "Standard Operating Procedures." SOPs that are performed by each Quanterra® operating unit are listed in Section 3 of the Facility Appendix to this QAMP. SOPs are living documents and may supersede some requirements in this document until the QAMP update every two years.

2.3.4 Quality Assurance Project or Program Plans (QAPPs)

Regulations and contracts may contain QA requirements which are different from Quanterra® 's QAMP. To address unique or project requirements, Quality Assurance Project Plans (QAPP) may be prepared and implemented. The requirements documented in a QAPP take precedence over the Quanterra® QAMP for that project.

Similarly, some regulatory programs such as Florida Department of Environmental Protection (FDEP) and Florida Department of Health (FDH) require QA Plans specific to their program. The FDEP and FDH require that each laboratory certified in the state submit and maintain a Comprehensive QA Plan. Many state certifying agencies have reciprocal certification agreements with Florida. In these situations, the QA Plan submitted for regulatory programs takes precedence over the Quanterra® QAMP.

If requested and approved by the client, project-specific requirements may be less stringent than the Quanterra® quality program.

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Typical specifications contained in a QAPP or documentation include:

- New or modified testing methods
- Unique QC logic
- Special requirements for equipment use and maintenance
- Special handling due to safety considerations
- Project-specific detection and reporting limits
- Project-specific accuracy and precision limits or the statistical treatment of data
- Additional or unique documentation or records management requirements.

2.3.4.1 Quality Assurance Summary

Quality Assurance Summaries (QAS) are used to distill client-specific requirements onto a single table or form. The summary describes quality control samples, batching schemes, flagging conventions, deliverables, or other client requests that may differ from routine laboratory operations. The QAS is made available to laboratory operations by the Project Manager to document client needs. The QAS may be used alone or in conjunction with the QAPP.

2.3.5 Other Documents

Other documents which can affect the quality program may include the Chemical Hygiene Plan (CHP), the Quanterra® Compliance Program , memos, guidance documents, work instructions, and periodic reports. These documents may further define or guide the implementation of quality standards at Quanterra® but shall not conflict with the QAMP or diminish the effectiveness of the QMS.

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3.0 Associate Qualification and Training

All activities performed by Quanterra® shall be accomplished by qualified associates. The following definitions are relevant to the discussion of associate qualification and training presented in this section:

- Qualification - The characteristics or abilities gained through education, training, or experience that enable an individual to perform a required task.
- Orientation - The act or process of acquainting individuals with an existing situation, environment, or condition.
- Training - In-depth instruction to develop proficiency in the application of requirements, methods, and procedures. Instruction may be internal or external classroom sessions, courses, or on-the-job training.

Employee orientation and training must be performed in compliance with Quanterra® Corporate SOP Number CORP-QA-0013, "Employee Orientation and Training".

3.1 Associate Qualifications

Each operating unit shall have job descriptions for all positions. These job descriptions must specify the minimum qualifications for education and experience, knowledge, and skills which are necessary to perform at a satisfactory level. An associate's performance shall be compared with the requirements of his/her job description at least annually, in conjunction with the associate's annual performance review.

Quanterra® expects the necessary knowledge, experience, and skills to be demonstrated by formal academic training. Qualifications of professional associates shall be documented by resumes which include academic credentials, employment history, experience, and professional registrations. A copy of the resume will be placed in the associate's training file or may be maintained in electronic format.

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3.2 Orientation and Training of Laboratory Staff

Associates receive internal, external, formal, and informal training. Training is performed to maintain and develop proficiency, and to promote improvement. Training is performed by individuals knowledgeable in the subject matter.

Quanterra® associates are qualified based on the experience and training documented in the individual's training file, and are assigned duties within their experience and training.

Each new associate shall receive orientation and training in quality and health and safety. Each new associate shall be supervised in their assigned duties by their supervisor or designee. The authorization to perform independently shall be documented in the training files. In addition, training for associates may include professional, managerial, communication, and interpersonal skills as appropriate. On-going or periodic assessments will be performed to determine training needs and effectiveness of instruction.

3.2.1 *Quality Orientation*

Each newly hired Quanterra® associate receives a Quality orientation. The QA Manager or designee shall conduct this orientation within two weeks of the associate's report-to-work date. This orientation will be documented in the associate's training file. The QA Manager shall review the following topics (at a minimum) with the new associate:

- Quanterra® Quality Policy and applicable documents including the Quanterra® QAMP
- Quanterra® policies on ensuring data integrity, meeting client requirements, and ethics
- Identification and documentation of nonconformance and corrective action procedures
- Proper data recording practices
- Key elements of Quanterra® Quality Control Program Policy (No. QA-003).

The QA orientation or on-going training shall be documented using a written exam, a checklist, or a preprinted form. This documentation is required to demonstrate an understanding of the Quality orientation and to determine if any areas covered require further training.

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3.2.2 *Quality Training*

Continued training in the mission and goals of the QAMP shall be provided at least once per year. Formal training sessions are conducted and documented by the QA Manager or designee. The training program shall address relevant regulatory requirements, basic QC practices, responsibilities of the technical and QA staff, and the reporting of nonconformances.

In addition, each Quanterra® associate shall become familiar with the operating unit's quality programs by reading the relevant sections of the Quanterra® QAMP, policies, and SOPs pertinent to his/her position.

3.2.3 Health and Safety Orientation and Training

Each newly hired Quanterra® associate, contract worker, or working visitor is required to go through health and safety orientation and training as per the laboratory Chemical Hygiene Plan (CHP). The orientation must be performed as soon as possible after the associate's report-to-work date and before chemicals are handled. Quanterra® associates and contract workers shall be given comprehensive health and safety training within ninety days of the start-to-work date. Documentation is maintained in the associate's training file.

3.2.4 QA Manager Training

All QA Managers shall receive training so that they are proficient in the requirements of the Quanterra® QAMP. Continued proficiency of QA Managers shall be maintained through active participation in QA audits and the preparation and review of QA documents.

3.3 Training Files

Each Quanterra® associate has an individual training file maintained by the QA Manager or designee. The types of training documents included in the training file are the following:

- Associate's resume
- Quality
- Health and Safety
- Technical
- Professional Development
- Regulatory/Compliance.

Information is filed in the training file as training is received. Not all associates will have training records for all areas depending upon their job function or tenure with the company.

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3.3.1 Associate Resumes

A copy of the associate's current resume will be placed in the associate's training file or maintained in electronic format. Quanterra® has developed a standard format for resumes. Qualifications of associates, as documented on resumes, include academic credentials, employment history, experience, and professional memberships and registrations.

3.3.2 Individual Training Records for the Areas of Quality, Health and Safety, and Technical

Training of each associate shall be summarized and documented on training forms. These include documentation of participation in orientation training, one-on-one training, on-the-job training, or

participation in classes and other presentations, and any other formal training sessions, either internal or external. Examples of some of the forms used to document this training are provided in the Corporate SOP, "Employee Orientation and Training", SOP Number CORP-QA-0013. Technical training records shall include documentation of the ability to perform sample preparation or analysis. In addition, if any tests are given as part of the training in each of these areas, the results are filed in the individual's training file.

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3.3.3 *Training Records for Professional Development*

This category includes documentation of all courses taken relating to an individual's professional development. Examples of courses include Conflict Resolution, Time Management, Conducting Effective Meetings, and Interviewing Skills.

3.3.4 *Training Records for Regulatory/Compliance Information*

This category provides for documentation of training on topics required by law (with the exception of safety documented previously). Examples of this category are Sexual Harassment, Drug-Free Workplace, and Quanterra® ethics.

4.0 Procurement of Items and Services

This section defines the Quanterra® requirements for the procurement of items and services. Controlling the quality of items and services procured by Quanterra® will help us meet the needs of our customers. The Quanterra® procurement program requires:

- Assurance that purchased items and services meet Quanterra® -established requirements and perform as expected
- Definitions and descriptions of the documentation levels required for the applicable technical and administrative requirements
- Evaluation and qualification of vendors.

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4.1 Selection of Vendors

Prospective vendors are selected based upon criteria appropriate to the materials or services provided. For national vendors and contracts, the vendor is selected through either a competitive proposal/bid process, strategic business alliance or negotiated vendor partnership. Vendors are evaluated on the following criteria as appropriate:

- The vendor's history of providing identical or similar products that perform satisfactorily in actual use
- The vendor's service record and ability to provide a complete product line and commensurate service
- The vendor's ability to administer inventory at Quanterra® facilities through a fully developed inventory management system that will ensure correct stocking levels as well as shelf-life tracking
- Software systems that will integrate with Quanterra® systems
- Objective evaluation of the vendor's current quality records supported by documentation
- Ability of the vendor to provide service agreements for instruments that meet Quanterra® specifications
- Evaluation of the vendor's business strategy and the ability of that strategy to complement Quanterra®'s quality program
- Results of audits by Quanterra® of the vendor's technical and quality capability.

A Quanterra® quality representative shall determine the appropriate level of evaluation criteria for the item or service being purchased. Vendors that provide test and measuring equipment, solvents, standards, instrument-related service contracts, or subcontracted laboratory services shall be subject to more rigorous controls than vendors that provide off-the-shelf items. For the procurement of testing and measuring

equipment it is recognized that the environment in which the measurement system is placed may have a bearing on its performance. Therefore, in lieu of other supplier qualification activities, the quality representative shall ensure that an acceptance testing plan is in place to ensure that the measurement system is able to meet specifications in the intended operating environment.

4.2 *Procurement of Quality-Related Items*

The quality of instruments, equipment, standards, reagents, solvents, other chemicals, gases, water, and laboratory containers used in analyses must be known so that their effect upon analytical results can be defined. Quality-related items (QRIs) are items that are used in the operational unit that must meet a minimum quality requirement. All QRIs purchased by Quanterra® operating units shall be evaluated to ensure that they meet the requirements and specifications established by Quanterra®. These requirements and specifications include, but are not limited to, client contracts, project-specific QA requirements, data quality objectives (DQOs) and analytical method requirements, and defined technical specifications.

Quality specifications shall be included or referenced in the purchasing documents for the procurement of the applicable items. The quality representatives, in conjunction with the procurement team, shall approve items purchased. This approval shall be maintained by Purchasing as a "Quality Approved" list of items. If items which may affect laboratory quality are requested from non-preapproved vendors, quality approval must be obtained prior to placing the order.

When ordering QRIs, a system shall be put in place to verify the quality of the item received. Each laboratory shall assign individuals responsible for material procurement and control. Duties include:

- Specifying, in purchase orders or requisitions, suitable grades of materials (grade shall be defined by the responsible manager and detailed in SOPs)
- Verifying upon receipt that materials meet requirements (see section 4.2.3) and that, as applicable, material certificates are provided and maintained
- Identifying and storing materials
- Verifying that material storage is properly maintained, and removing materials from use when shelf life has expired.

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4.2.1 Role of Quanterra® Purchasing

Quanterra® Purchasing supports the laboratory by:

- Maintaining, issuing, and negotiating contracts
- Identifying potential vendors and subcontractors
- Identifying vendors for unique or scarce materials
- Maintaining a system to facilitate purchases made by each facility
- Maintaining lists of available items through catalogs or contract agreements with approved vendors
- Preparing and communicating corporate policies regarding purchasing and procurement
- Developing and implementing a review of the purchasing program as it pertains to procurement of QRIs.

In order to enhance the quality and consistency of the product within the laboratory network, the Director of Purchasing shall pursue national contracts for laboratory supplies, standards, and instruments of known quality and proven reliability.

4.2.2 Procurement Procedures

The specifications for standards, chemical reagents, solvents, gases, water, and other QRIs shall be documented in SOPs. In addition, each laboratory must have SOPs that cover the following:

- Checking purity of standards, reagents, reagent grade water, and other chemicals as appropriate versus intended use
- Preparation, storage and expiration of standards, reagents, and other chemicals as appropriate
- Requirements for lab containers (e.g., volumetric glassware).

Corporate SOPs will be developed for these processes where appropriate. Operation-specific SOPs shall be in place if a corporate SOP does not exist.

Corrective actions for failure of an item to meet required specifications are as follows:

- Review current supplies and eliminate from use; this must include communication to the Quanterra® laboratory network and corporate purchasing to avoid additional problems in other facilities
- Return to vendor
- Evaluate a new lot or alternate supplier

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- Evaluate the impact on product or process.

The Corporate Director of Purchasing or the Corporate Director of Quality Assurance shall be notified promptly of any quality problems with national vendors.

4.2.3 *Evaluation of QRIs*

Most QRIs will be evaluated as a function of the standard analytical process. This involves the analysis of method blanks, as well as other QC samples as described in Section 8.0. For some QRIs, small variability in the item may significantly affect analytical results. For these QRIs the analysis and evaluation must take place prior to using the item. The Corporate SOP CORP-QA-0001; "Quality Testing of Solvents, Acids, and Reagents (QRI Program)"; documents the testing procedures and acceptance criteria. A list of QRIs that require testing prior to use is listed in Table 4.2-1. If any QRI is determined during routine use to be the source of quality problems, or has demonstrated variability that affects analytical results, the QRI may be added to the list in Table 4.2-1. Facility QA Managers must forward such requests to the Corporate Director of Quality Assurance, the Director of Purchasing, and Corporate Technology.

For items that are used regularly by Quanterra® facilities where no unique requirements or specifications are required, the items may be purchased off-the-shelf. These items are ordered from the supplier on the basis of specifications set forth in the supplier's published product description. Off-the-shelf items include general laboratory supplies such as glassware, filter paper, pipettes, and chromatography columns. These items are evaluated as a function of the standard analytical process. An off-the-shelf item can be added to the list in Table 4-2.1 when it is determined that evaluation prior to use is required. Requests to add items to this list are made to the facility QA Manager.

Evaluation of instruments purchased shall be conducted according to the acceptance testing plan as established in the procurement documents. Acceptance criteria may include instrument reliability, sensitivity, stability, accuracy, and ability to interface with existing computer systems and networks.

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4.2.4 Special Requirements for Standard Reference Materials

For all standard reference materials (SRMs), Quanterra® will use materials of known quality for the intended use. Where available, SRMs will be traceable to the National Institute of Standards Technology (NIST), the American Association for Laboratory Accreditation (A2LA), or to an equivalent source. If the traceability is not commercially accessible, the best available standard for the material or isotope shall be used. Certificates for Certified Standard Reference Materials (CSRMs) shall be procured from the supplier. Documentation received with each standard shall include the following information as appropriate:

- Traceability to an approved source (where available) or other certificate of analysis
- Radionuclide identification with activity and error
- Reference Material Certificate
- Certification Report that will include pertinent information such as:
  - Starting material characteristics including purity and traceability
  - Expiration date
  - Lot number
  - Preparation date
  - Methods of measurement and associated uncertainty
  - Actual weights and measurements determined by gravimetric or volumetric measurement
  - Unique identifying number
  - Formula weight
  - Density
  - Half-life of radionuclide(s)
  - Mass and volume of standards
  - Percent of impurities

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Receipt, storage, evaluation, use, control, and disposal of all standards as well as documentation of these activities are described in operation-specific SOPs. Additional discussion of standards can be found in section 8.5.4.

4.3 Procurement of Subcontract Laboratory Services

A subcontract laboratory is defined, for the purposes of this QAMP, as a laboratory external to the Quanterra® laboratory network. However, for certain federal programs, a branch location of the Quanterra® laboratory network may also be defined as a subcontractor and require client and agency

approval prior to use on a project. If required, Quanterra® will meet those requirements. A subcontracted laboratory will be used only in the event that any of the Quanterra® laboratories do not have the capability or capacity to perform the requested testing, or as directed by the customer. A subcontracted laboratory shall be used only after approval is obtained from the client and the quality of the laboratory is determined to be acceptable according to Quanterra® Corporate SOP Number CORP-QA-0012, "Selection and Evaluation of Subcontractor Laboratories". Once these conditions are met, the subcontract laboratory will be added to an approved subcontractor list maintained in a database.

Subcontracted laboratories may be removed from approved status on the basis of a failure to perform adequately, as a result of audit findings, nationally recognized or other performance evaluation sample results, or at the request of the Corporate Director of Quality Assurance. The QA staff are responsible for evaluating, approving, and recommending subcontractors. The Project Manager of the primary laboratory is responsible for identifying and initiating prequalification of the subcontract laboratory and managing the subcontractor throughout project implementation.

4.4 Vendor Partnerships

Quanterra® may enter into partnership agreements with vendors under the auspices of the technology organization. The purpose of these vendor partnerships is to standardize instruments, data handling systems, and other products or services which enable or enhance our ability to meet or exceed the requirements of our clients. Vendor partnership agreements must meet the requirements in Section 4.1.

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SECTION 5.0

5.0 Documentation and Records

5.1 Quality Documents and Records

Quality documents are those which define the objectives, policies, and procedures that ensure the quality of items and services provided by Quanterra®. A system has been designed to revise, distribute, and control quality documents. Quanterra® quality documents are listed in Table 5.1-1 along with their approval requirements.

Records are completed documents that provide objective evidence of the performance of an item or process. Records are discussed in Sections 5.4 through 5.6.

5.2 Document Review and Revision

Quality documents have multiple levels of review and approval appropriate for the document. These reviews are demonstrated by the signature of the reviewer on the document. Quality documents are required to be periodically reviewed and, if necessary, revised. The frequency of this review is dependent upon the type of document and upon regulations and client requirements. In addition to periodic review and revision, quality documents must be revised when the activity, policy, or procedure they describe changes in a significant manner. Table 5.2-1 lists the Quanterra® quality documents along with their required frequency of review and the individuals responsible for performing those reviews.

5.3 Document Control and Distribution

Document control is necessary to ensure that associates have access to current policies and procedures at all times. Quality documents that are placed under a controlled distribution include, but are not limited to this QAMP, Quality Policy Documents, and SOPs. Format and control of SOPs are described in Quanterra® Policy Number QA-001, "Standard Operating Procedures." QAPPs are also placed under a controlled distribution when that document is generated by Quanterra®.

Quality documents are controlled by initially distributing them to the associates who need to be aware of or follow the contained information or procedures. All subsequent revisions or updates to the document are also distributed to the associate. A controlled copy distribution list is maintained with the name of each associate who received a copy along with their controlled copy number. Records of controlled distribution are maintained by

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Quanterra® and demonstrate that current policies and procedures have been issued to all appropriate personnel.

Controlled documents are marked "Controlled Copy" and are numbered according to the controlled copy distribution list. Copies of documents placed under controlled distribution are sometimes released with the understanding that no further updates or revisions of that document will be issued to that individual document holder. Those copies are marked "Uncontrolled Copy" and are not numbered.

5.4 Records Management

Information for each business function of the organization is stored appropriately according to its type of information. Details of the records management program are contained in the Quanterra® Record Retention Policy No. LEG-004 and supporting documents.

Quanterra® is committed to providing scientifically sound, legally defensible data of known and documentable quality. Legally defensible data are referred to as data which will stand against reasonable adversarial inquiry. Data must be supported by a QAPP, client agreements, or the Quanterra® QAMP. Data must also be documented so that the analytical process can be reconstructed.

Project files must be organized so that the project events can be reconstructed if necessary. Accountability for the completeness and accuracy of information must be specified. Supporting information, including data that demonstrates a facility's ability to perform specific analyses, shall be properly maintained.

Records are divided into two distinct types. Quality and project records are discussed in the following sections. Each laboratory shall have a system in place that provides for appropriate and adequate implementation of these records management requirements.

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5.4.1 Quality Records

Quality records demonstrate overall laboratory operation. Examples of quality records are the following:

- Instrument logbooks
- Equipment monitoring records
- Calibration records
- Instrument calibration data
- QC sample data
- Standard preparation logbooks
- Standard certificates
- Internal and external PE sample results
- Laboratory licenses and accreditations
- Quality reports to management

- Internal and external audit reports
- Nonconformance memos.

These records may apply to one or more projects, but in general they are applicable to many projects. Quality records must be properly maintained in the facility files.

5.4.2 Project Records

Project records are documents which are specific to a project or a group of samples within an ongoing project. Examples of project records are the following:

- Chain-of-custody forms
- Raw analytical data
- Final data reports with case narrative and cover letter
- QC and calibration results
- Project-specific nonconformance memos
- Project correspondence.

Project records shall be properly maintained.

5.5 Validation of Records

When records, as contained in files, are transferred to a records storage area or off-site storage area, they shall be placed in suitable containers and an inventory sheet prepared by the person submitting the records. The contents of each container will be compared to the inventory sheet and labeled. If there are any discrepancies, the container and inventory sheet shall be returned to the supervisor or Group/Team Leader submitting the records for resolution.

5.6 Retention and Disposal of Records

Quanterra® shall maintain and dispose of records according to the Quanterra® Policy Number LEG-004, "Record Retention".

5.7 Data Confidentiality

Quanterra® considers the data and associated information for a project to be confidential and the property of the client. In order to preserve client confidentiality, reports and supporting records are only released to third party persons or organizations after consultation with the direct client and laboratory management. If however directed by courts-of-law or other competent authorities, such as regulatory agencies, Quanterra® will provide required records and notify its clients and provide information as to the identification of the requester and the records that will be released.

When confidentiality clauses are contained in contractual documents, no information or records are released without first obtaining written approval from the client.

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6.0 Computer Hardware And Software

The purpose of defining controls for computer hardware and software is to protect the integrity of computer-resident data. SOPs shall be put in place to ensure that computer-resident data and programs are accurate, controlled, and secure. The required SOPs and their scope will be presented in the Quanterra® Software Quality Assurance Plan.

Quanterra®'s commitment to meeting good automated laboratory practices is presented in the Quanterra® Corporate Policy Number CORP-IT-013, Software Quality Assurance.

6.1 Use of Hardware

Computer hardware used in the generation, measurement, or assessment of client data shall be of appropriate design and of adequate capacity to function according to specifications. Computer hardware shall be suitably located for operation, inspection, cleaning, and maintenance. The computer shall be installed in accordance with the manufacturer's recommendations. Any changes to the equipment shall be approved by the laboratory Information Technology (IT) representative.

6.2 Security

Procedures shall be in place to insure the integrity of client data. These may include both physical and logical protection and will ensure that access is limited to authorized persons.

Data files will have backup copies made at regular intervals to protect data against accidental loss through a hardware or software failure.

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6.3 Use of Software

If computer software is used to acquire, process, or report client data, that software will be tested to ensure that it correctly performs its intended function. Software may be validated or verified, depending upon its complexity, size, and whether it was purchased or developed by Quanterra®. The following definitions are used by Quanterra®:

- Validation - the process of establishing documented evidence which provides a high degree of assurance that a specific process will consistently produce a product meeting predetermined specifications and quality attributes. This process

demonstrates and documents that the software performs correctly and meets all specified requirements.

- Verification - the process of checking the accuracy of automatically (electronically) calculated information.

6.3.1 Industry Standard Software

Industry standard software programs are defined as those which are purchased and widely used without modification to the program itself. The program is initially verified for use by using test problems with known solutions to demonstrate that the program is operational for the desired application.

All purchased software must be used in accordance with the terms of its software license. Any use of software contrary to its license terms is expressly prohibited by Quanterra®.

6.3.2 Quanterra®-Developed Software

For programs used to process client data and developed within Quanterra®, and externally prepared programs which are modified by Quanterra®, validation or verification must be performed. The process used is dependent upon the function of the software as follows:

- Large complex systems consisting of several programs operating in unison to produce an intended result must be validated.

- For smaller software which only performs numerical manipulation, sample sets of numbers for which results are known should be processed and the results verified. In this case, known results are usually generated by performing hand calculations using the same equations and procedures as the software to verify that the software produces identical results.

- Software which performs as part of instrument operation should be verified as previously described and by processing reference materials through the instrument system. Processed instrument response should be evaluated against expected instrument response and performance.

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6.3.3 Control of Software Changes

Changes to software used for processing client data shall be controlled and documented according to the procedures presented in the Quanterra® Corporate Policy Number CORP-IT-013, Software Quality Assurance.

6.3.4 Software Revalidation

Whenever a program is changed, the change will be evaluated to determine if revalidation is necessary. If the software has had features added, previous test problems should be rerun to demonstrate that their function has not been affected. New test problems should be

processed, as previously discussed, to verify added performance. If software revision changes the basic operation of the program, complete revalidation of the program may be required.

Spreadsheets and unprotected software used to acquire, process, or report client data must be documented and reverified when changes are made. The test problems used to provide initial verification shall be reprocessed and the results compared to demonstrate that performance of the software is unchanged.

Laboratory operations is responsible for the generation of the validation and verification data for instrument level software. QA will maintain the necessary documentation. Corporate Information Technology is responsible for generation and maintenance of documentation relating to verification and validation of LIMS system. This is described in the Quanterra® Corporate Policy Number CORP-IT-013, Software Quality Assurance.

6.4 Documentation

Documentation shall be established for system development, change control, validation, verification, and security. Documentation will be retained according to the Quanterra® Records Retention Policy No. LEG-004.

6.5 Computer Viruses

Quanterra® shall employ the use of anti-virus software to detect and remove viruses from software.

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7.0 Planning

The generation of environmental analytical data is an intricate process. Success is dependent upon the timely execution of interrelated steps, many of which may be project-specific. Quanterra® has an organizational system in place to ensure that all projects are properly planned prior to project initiation, and are monitored for conformance to project requirements during the course of the project. This system ensures that Quanterra®'s clients receive quality deliverables, as well as quality service.

Quanterra® communicates with its clients to identify the client's needs. Project Managers (PMs) work together with Customer Service Managers (CSMs), or designee, to assess and coordinate Quanterra®'s resources. Each client is assigned a single point of contact, usually a PM, to ensure that there is a strong line of communication between the client and Quanterra®. Projects receive technical and QA support at the laboratory or corporate level as needed to ensure that project DQOs are achievable.

7.1 Data Collection Process

The sample collection and data generation processes are designed to produce analytical data that accurately reflect the nature of the site or sampling point. Figure 7.1-1 shows the sample collection and data collection processes. To ensure our services meet client and project requirements, communication and planning with the client are emphasized. The organization described in Section 7.2 is in place to ensure that these goals are achieved.

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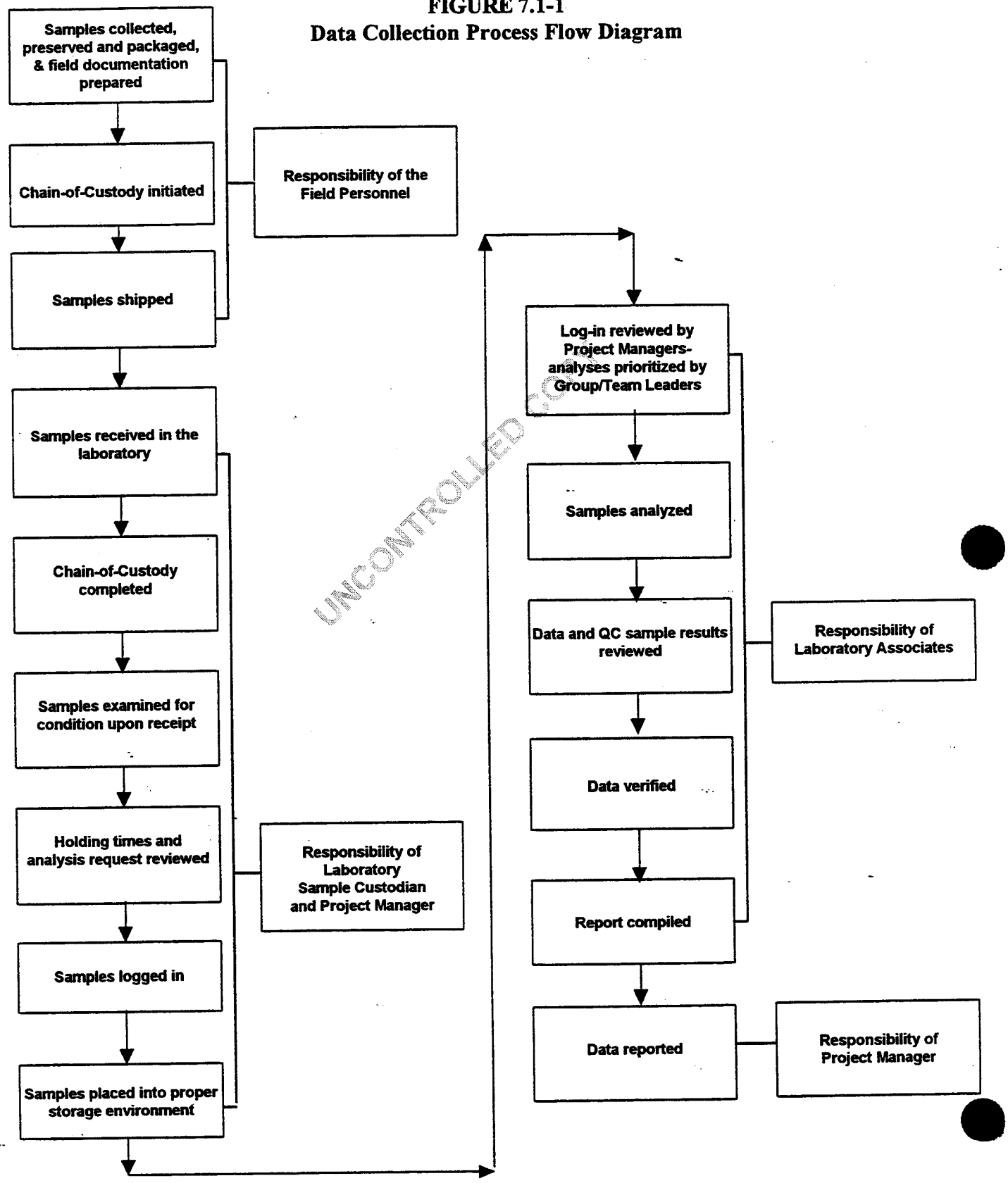
7.2 Organizational Responsibilities

Project planning is normally performed within Quanterra® by the operational units. Each operating unit also has the responsibility for customer service within their operating unit. CSMs or designee, Account Managers (AMs), PMs, Operations Managers, and Laboratory Managers play an integral part that will collectively ensure that all projects are thoroughly planned and communicated to all appropriate personnel.

Successful project planning and communication of project requirements ensures that samples will be handled appropriately and that analytical data will be reported in compliance with project requirements. CSMs or designee, AMs, PMs, Lab Managers, and Operations Managers work together to ensure that the following will occur prior to receipt of samples at the laboratory:

FIGURE 7.1-1
Data Collection Process Flow Diagram



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- Samples are scheduled for arrival at the laboratory
- All unique project requirements have been identified and communicated to all appropriate personnel
- Standardized client, state, federal, or Quanterra® programs are appropriately selected
- Fully-qualified subcontract laboratories have been selected if needed
- A review has been performed on all pre-project documents such as proposals, contracts, and/or QAPPs to identify unique project-specific requirements
- All appropriate and required preparations have been made at the laboratory to accommodate or meet project requirements as described in proposals, contracts, and/or QAPPs
- It has been determined that the laboratory has the capability and the capacity to analyze the samples
- The laboratory has been determined to be able to meet the required sample holding times and is able to report the resulting data within the time line specified by the client
- All safety hazards associated with the samples have been communicated to all appropriate personnel.

7.3 Determination of Project QC Requirements

A system must be in place to review project documents (e.g., Request for Proposals (RFP), Request for Quote (RFQ), QAPPs, technical Statements of Work (SOW), and other contractual materials) before a project begins. For larger projects this can involve an inter-laboratory Customer Service Team (CST) (see Section 7.5). Within the laboratory it generally involves the CSM or designee working in conjunction with staff from laboratory operations, QA, IT, and management. The goal of the evaluation process is to ensure that client needs and expectations are properly understood, and that the laboratory can meet those requirements. Internal and external communications should be in writing to avoid misunderstandings. The CSM or designee, with support of others in the laboratory, will work with our client to ensure that project requirements are properly aligned with laboratory capabilities.

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When QC requirements are not specified by a client, Quanterra® will follow the requirements given in Corporate Policy Number QA-003, "Quanterra® Quality Control Program".

7.4 Communication of Project-Specific Requirements

Each operating unit shall use a Quality Assurance Summary (QAS) (example shown in Figure 7.4-1) or an equivalent summary form to document all project-specific requirements. This document is prepared by the PM for all projects prior to sample receipt

FIGURE 7.4-1 (Page 1 of 2)
Example Quanterra® Quality Assurance Summary

Client: _____ Project Code: _____ Contract Name: _____ Site: _____ Project Mgr: _____ **Analysis Type:** ____ Chemical ____ Radiochemical	**RAD SCREEN** by: _____ Code _____ Client-Specific _____ Screens not needed	**SAMPLE DISPOSAL:** _____ Disposal by Lab _____ Return to Client _____ Archive	**QAS No.:** _____ Date Initiated: _____ Revision No.: _____ Date Revised: _____
		ANY SPECIAL QC DOCUMENTS? ____ Yes ____ No	

REPORTING

Report to Client: _____ Lab PQL _____ MDL/IDL/MDA _____ < Client DLs _____ Other: _____	**QC Samples to be Reported:** _____ BLK _____ MS _____ LCS _____ MSD _____ DUP _____ Other: _____	**Report Type:** _____ Certificate of Analysis _____ CLP _____ Other: _____	**Report Grouping:** _____ SDG _____ Chain-of-Custody _____ Analytical Batch _____ Other: _____

Report Deliverables: ____ No. of Hard Copies to: _____ ____ Electronic Data Deliverable to: (Diskette Type: _____) Client: _____ Address: _____ _____ ATTN: _____	**Report Deliverables:** ____ No. of Hard Copies to: ____ Electronic Data Deliverable to: (Diskette Type: _____) Client: _____ Address: _____ _____ ATTN: _____

INVOICING

Invoice to: Client: _____ Address: _____ _____ _____ _____ ATTN: _____	Supporting Documentation: _____ Certificate of Analysis _____ RFA/COC _____ Screening Records _____ Other (list): _____ _____	No. of Invoices: _____ Special Instructions: _____ _____ _____ _____

ADDITIONAL COMMENTS OR INSTRUCTIONS:

_____
_____

Project Manager's Approval: _____ Date: _____

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FIGURE 7.4-1 (Page 2 of 2)
Example Quanterra® Quality Assurance Summary

Client: _____
Project Code: _____
QAS No.: _____ **Revision No.:** _____

Number of Samples Expected by Matrix:
_____ Air (A) _____ Water (W)
_____ Soil (S) _____ Other (O): _____

Analysis/Product Code	Matrix (circle)	Method Prep/Analysis	QC Samples		Required Reporting Limit/Units/ Report as*	Holding Time (Days)	TAT** (Days)	Radiochemical-Specific	
			Type (circle)	Frequency				Count Time	Sample Size
	A W S O		B LCS DUP MS MSD	per					
	A W S O		B LCS DUP MS MSD	per					
	A W S O		B LCS DUP MS MSD	per					
	A W S O		B LCS DUP MS MSD	per					
	A W S O		B LCS DUP MS MSD	per					
	A W S O		B LCS DUP MS MSD	per					
	A W S O		B LCS DUP MS MSD	per					

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* A = "As Is" or D = Dry Weight Basis

**TAT = Turn Around Time

SAFETY HAZARDS: Chemical? _____ No _____ Yes: Define: _____
Radioactive? ____ No ____ Yes:
Isotopes Expected: _____ RSO Approval (sign/date): _____

Special Instructions: _____

Comments: _____

even if an approved QAPP is on file at the laboratory.

Each laboratory shall put into place a system that will ensure that the project-specific requirements are disseminated to all appropriate laboratory personnel prior to project initiation.

To further ensure that project-specific requirements regarding analytical methods, QC, and data reporting are thoroughly understood by the laboratory staff, the PMs may conduct project initiation meetings. For large projects that continue over time, the PMs may hold project refresher meetings to ensure that project requirements are continually being met. The PM takes the lead role in implementation of project requirements at the laboratory including changes in project requirements during the course of a project.

7.5 Customer Service Teams

Each operating unit shall establish and maintain long term and substantive relationships with our clients, identify customer needs, and seek to attain value for our customers according to our customers' definitions. An operating unit may create, at any time, client-specific Customer Service Teams (CST). A CST may be created before any discrete projects exist, during on-going projects, or even after the completion of a project. A CST generally contains a CSM, an AM, a PM, a QA representative, and an IT representative. The team may also contain associates from the operations, technical, contracts, and/or accounting organizations.

7.6 Contingency Planning

An effective QA Program must emphasize contingency planning, actions to prevent problems from reoccurring, and to ensure timely and effective completion of a measurement effort. The following are considered relative to contingency planning:

- Staffing - A primary objective is to ensure that qualified staff are always available to perform the necessary analytical work, regardless of employee turnover, vacation (personal time off), illness, or other absence. Sources of qualified staffing may include temporary agencies specializing in providing technically trained personnel and other Quanterra® facilities. Employee qualification requirements are described in Section 3.0.

- Redundant Instrumentation or Equivalent Methods - At most locations, duplicate instrumentation may be available to ensure uninterrupted work flow. A laboratory may also choose to lease equipment when there is a sufficient time window prior to arrival of samples. However, in circumstances where a catastrophic instrument failure occurs, alternative but equivalent methods may be recommended to the client for approval and implementation.

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- Preventive Maintenance - Quanterra®'s preventive maintenance program is designed to minimize analytical instrument malfunctions, permit simple adjustments, and to ensure fewer and shorter breakdowns of critical analytical equipment. (See Section 8.11, "Preventive Maintenance and Service".)

- Network Laboratories & Subcontractor Laboratories - To support the laboratory during peak periods or in the event of a critical instrument malfunction, Quanterra® has the capability to arrange the use of other network laboratories or qualified analytical laboratories as subcontractors for short-term backup analytical support. Through an extensive process, QA personnel evaluate, identify, and select qualified analytical laboratories before an analytical contract is awarded. In order to qualify, a subcontractor laboratory must pass this evaluation. Furthermore, any use of a subcontractor laboratory is approved by the client prior to award of a contract or sample shipment for existing contracts.

- Uninterruptable Power Supply - An Uninterruptable Power Supply (UPS) system which provides line conditioning and backup power to the LIMS computer system/server. This contingency plan allows sufficient time for the main computer system to be shut down and for data archival. All electronically generated data that are stored on the main computer system and on the individual personal computer (PC) hard drives are backed up at regular intervals. In the event that the main laboratory computer system fails, the analytical data can be retrieved from the PC hard drives.

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8.0 Work Processes and Operations

Much of the environmental project activity is planned and designed externally to the laboratory or field operation and presented in the form of a contract, work plan, or QAPP. Laboratory and field activities are in turn planned, implemented, and assessed to meet client requirements according to approved procedures and methodologies. The QAMP provides the systems to document and implement these activities. The execution and assessment of the implemented operational systems are detailed in Quanterra® corporate or operation-specific SOPs. The entire process is assessed on a regular basis for conformance to prescribed requirements.

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Standard practices for Quanterra® operations are detailed in this section. Specific project or program requirements which differ from those described here can be met. These must exist in approved contracts, work plans, or QAPPs.

8.1 Standard Operating Procedures

SOPs are required in all Quanterra® operating units for analytical and administrative activities from the receipt of samples in the laboratory through analysis, reporting, and subsequent sample disposition. Training, health and safety procedures, QC, method procedures, and instrument and equipment calibrations are included in SOPs. Preprinted forms, either standardized across Quanterra® through a Corporate SOP requirement, or shown as an example form when not standardized, are included in SOPs as appropriate. Standard SOP formats for all activities related to the generation and reporting of data are discussed in the Quanterra® Quality Policy Document No. QA-001, "Standard Operating Procedures". SOPs shall be reviewed by technically-qualified associates. SOPs are controlled documents and are distributed and maintained as described in this policy. SOP requirements for approval and frequency of review are given in Tables 5.1-1 and 5.2-1.

8.2 Analytical Methods

Whenever possible, Quanterra® operations use industry- and regulatory agency-recognized analytical methods from source documents published by agencies such as the Environmental Protection Agency (EPA), Department of Energy (DOE), the American Society for Testing and Materials (ASTM), and the National Institute for Occupational Safety and Health (NIOSH) as described in Quanterra®'s SOPs. The analytical methods

performed by Quanterra® are given in Section 4 of the Facility Appendix for each laboratory. A list of methods routinely performed by Quanterra® is given in Table 8.2-1.

Method performance data (i.e., detection limits, precision and accuracy data) are developed by the laboratory operations staff. The operations staff and the QA staff will evaluate and must approve the performance data before a methodology is performed routinely. The method must also be described and documented with an SOP. In the event that the laboratory staff is required to modify a procedure to meet a unique project requirement, the client will be notified to obtain written approval prior to implementing the change.

All SOPs contain Quanterra®'s interpretation of the published methods. Significant modifications to the published method are described in the SOP. Operations are performed as described in these SOPs. Changes in procedure which may occur due to sample matrix or other events shall be documented in the project-specific case narratives or in QAPPs.

8.3 Data Quality Objectives

Data quality objectives (DQOs) are qualitative and quantitative statements used to ensure the generation of the type, quantity, and quality of environmental data that will be appropriate for the intended application (EPA 1994)[1]. Typically, DQOs are identified during project scope and the development of sampling and analysis plans. In this QAMP, however, we refer to only the analytical DQOs because laboratories generally do not have any authority over sample collection, shipment, or other field-related activities that may affect the data quality of the environmental sample before the sample is received in the laboratory. The EPA has established six primary analytical DQOs for environmental studies. These DQOs are precision, accuracy, representativeness, completeness, comparability, and detectability.

The components of analytical variability (uncertainty) can be estimated when QA and QC samples of the right types and quantities are incorporated into measurement procedures at the analytical laboratory. Quanterra® incorporates numerous QA and QC samples to obtain data for comparison with the analytical DQOs and to ensure that the measurement system is functioning properly. The QA/QC samples and their applications, described in Section 8.4, are selected on the basis of method- or client-specific requirements. Field

[1] "Guidance for the Data Quality Objectives Process", EPA 600/R-96/005, September 1994.

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blanks, field duplicates, and performance evaluation (PE) samples are received from the client as unknown samples. Analytical laboratory QC samples for inorganic, organic, and radionuclide analyses may include calibration or instrument blanks, method blanks, background, duplicates, replicates, laboratory control samples (LCSs), calibration standards, matrix spikes (MSs), matrix spike duplicates (MSDs), surrogate spikes, and yield monitors.

8.3.1 Precision And Accuracy

Precision is an estimate of variability, that is, it is an estimate of agreement among individual measurements of the same physical or chemical property, under prescribed similar conditions. The precision of a measurement system is affected by random errors. Precision is expressed either as relative standard deviation (RSD) for replicate measurements greater than two or as relative percent difference (RPD) for duplicate measurements. Table 8.6-1 illustrates the formulae used to calculate units of precision (i.e., RSD and RPD).

Accuracy is the degree of agreement between a measurement and the true or expected value, or between the average of a number of measurements and the true or expected value. Systematic errors affect accuracy. For chemical properties, accuracy is expressed either as a percent recovery (R) or as a percent bias (R - 100).

The precision and accuracy DQOs that are to be used in evaluating inorganic, organic, and radionuclide constituents at Quanterra® are provided in Tables 8.4-5, 8.4-6, and 8.4-7, method-specific SOPs, and in the documentation for the analytical method of interest.

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Precision and accuracy are determined, in part, by analyzing data from matrix spike and matrix spike duplicates, unspiked duplicates, LCSs, and single blind audit samples. For radiochemical determinations, counting statistics can also provide an estimate of uncertainty. A description of these QC samples is provided in Section 8.4.

8.3.2 Completeness

Completeness is a measure of the percentage of measurements that are judged to be valid measurements. At a minimum, the objective for completeness of data is 90% for each constituent analyzed.

8.3.3 Representativeness

Representativeness is the degree to which data accurately and precisely represent a

characteristic of a population, a variation in a physical or chemical property at a sampling point, or an environmental condition. Data representativeness is primarily a function of sampling strategy; therefore, the sampling scheme must be designed to maximize representativeness. Representativeness also relates to ensuring that, through sample homogeneity, the sample analysis result (concentration) is representative of the constituent concentration in the sample matrix. At each Quanterra® laboratory, every effort must be made to analyze an aliquot that is representative of the original sample, and to ensure the homogeneity of the sample before subsampling.

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8.3.4 Comparability

Comparability is a measure of the confidence with which one data set can be compared to another. To ensure comparability, all laboratory analysts are required to use uniform procedures (i.e., SOPs) and a uniform set of units and calculations for analyzing and reporting environmental data.

8.3.5 Method Detection Limits

It is Quanterra® policy to strictly follow the specification in the U.S. EPA 40 CFR Part 136 Appendix B in determining MDLs for chemical tests. The Quanterra® requirement for this procedure is further detailed in Quanterra® Policy Number QA-005 entitled "Determination of Method Detection Limits for Chemical Tests." This policy requires that the MDLs be determined for each analyte of interest representing the aqueous and solid matrices within the capability of the primary analytical methods. Following the EPA's guidelines, Quanterra® does not provide MDLs for each instrument representing a group of constituents using the same analytical techniques. This policy is based on the statement in the scope and application of the CFR procedure which states that "The MDL procedure was designed for applicability to a broad variety of physical and chemical methods. To accomplish this the procedure was made device- or instrument-independent." Exceptions to this approach are described in Quanterra® Corporate Policy Number CORP-QA-005, "Determination of Method Detection Limits for Chemical Tests". MDLs determined by each laboratory are listed in Section 5 of the Facility Appendix to this QAMP.

8.3.6 Instrument Detection Limits

Instrument Detection Limits (IDLs) are required to be performed quarterly for metals constituents when analyses are performed in support of Comprehensive Environmental Response, Compensation and Liability Act

(CERCLA) activities or when the USEPA CLP SOW protocol is required. The requirement for this procedure is described in the Quanterra® Policy Number QA-014, "Determination of Instrument Detection Limits."

IDL samples are introduced at a later stage of the analytical process so that the IDL is a more direct indication of instrument sensitivity. The primary distinction is that the IDL estimates the detection limit of the instrument under ideal conditions, whereas the MDL estimates the detection limit in more-practical terms by subjecting a known concentration matrix to the total method process. IDLs are not required by the SW-846 methods, except for method 6020 where the IDLs are a requirement.

When required, IDLs will be performed in accordance with the procedures defined in the applicable USEPA SOW, ILMO3.0 or subsequent versions, and Quanterra® Policy Number QA-014, Determination of Instrument Detection Limits.

Prior to acceptance and use for reporting purposes, all data from detection limit studies and reporting limits must undergo technical review and approval by the laboratory management and QA staff.

8.3.7 Reporting Limits

Two reporting limit conventions are used within Quanterra®: the Reporting Limit (RL) and the Project-Specific Reporting Limit (PSRL). The RL is a uniform, Quanterra®-wide, reporting limit based on an evaluation of the Practical Quantitation Limits (PQLs) at Quanterra® laboratories and the expected method performance in routine water and soil matrices. The PQL is the lowest concentration a method can reliably achieve within limits of precision and accuracy and is derived from empirical, matrix-free method performance studies. The Quanterra® RLs and PSRLs are maintained in the LIMS.

Reporting limits are established and modified within Quanterra® according to the Corporate SOP Number QA-009, "Reporting Limits."

PSRLs are used when project data quality objectives (DQO) require a reporting limit other than the RL. PSRLs tailor Quanterra®'s product to meet customer requirements.

For radiochemistry, whether the net result is negative, zero, or positive, the actual calculated result is reported with its associated propagated uncertainty. The minimum detectable amount (MDA) is affected by many factors, such as the length of count, chemical yield, half-life, background of the instrument,

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counting efficiency, and the matrix interference. The MDA for radiochemical analyses is defined as the smallest concentration of material that yields a net count above background with a 95 percent probability (a true signal is reported 95 percent of the time) and no greater than a 5 percent probability of calling a blank a true signal. MDAs are determined according to Quanterra® Policy Number QA-007, "Determination of Minimum Detectable Amount for Radiochemical Tests."

8.4 Quality Control Samples

Two types of Quality Control (QC) samples are field QC samples and laboratory QC samples. Field QC samples are collected during the sampling event and are useful in determining sampling precision and accuracy and monitoring for contamination that may occur during collection, transport or storage of environmental samples. Laboratory QC samples are routinely added at the laboratory to the normal sample stream. Successful analysis of these samples demonstrates that the laboratory is operating within prescribed requirements for accuracy and precision. In addition, utilizing matrix-specific laboratory QC samples, information regarding the effect of the matrix or field conditions on the analytical results can be obtained. The following sections describe common field and laboratory QC samples.

8.4.1 Field QC Samples

When field QC sample collection and analysis are required for a project, it is the responsibility of the project sampling supervisor to ensure that this sampling is performed correctly and at the project-required frequencies. Field QC samples may or may not be identified as such to the laboratory and are considered by the laboratory as field samples for the purpose of QC batching, sample preparation and analysis. Field QC sample results are reported in the same manner as actual field samples, unless a specific deliverable is requested by the client. No correction of the analytical data is done in the laboratory based on the analysis of field QC samples.

Field QC sample types, applicability to organic and inorganic analyses, precision and accuracy applications and by whom they are introduced are summarized in Table 8.4-1. The following sections provide descriptions of field QC samples.

8.4.1.1 Trip Blank

Volatile organic samples are susceptible to contamination by diffusion of organic

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contaminants through the septum of the sample vial. Trip blanks, also referred to as travel blanks, are analyzed to monitor for possible sample contamination during shipment for volatile organics only. Trip blanks are prepared by filling preserved VOA vials (with no headspace) with organic-free water. Trip blanks accompany the sample bottles during collection and shipment to the laboratory and are stored with the samples.

8.4.1.2 Rinsate Blank

A rinsate blank or equipment blank is a volume of rinse solution (deionized, distilled water or organic solvent) used to rinse a sampling tool. The rinse solution is collected after the sampling equipment has been cleaned in order to demonstrate that there is no residual contamination remaining on the tool that would carry over into the next sample.

8.4.1.3 Field Blank

A field blank is a contaminant-free volume of water or soil that is provided by the sample collector to demonstrate the absence of contamination introduced during sampling. Deionized, distilled water or previously-prepared solid material (e.g., Ottawa sand) is placed into sample containers by the sample collection crew, packaged, and shipped with the other field samples.

8.4.1.4 Field Duplicate

A field duplicate sample is a replicate taken from the same sampling event for that location. The field duplicate sample is submitted to the laboratory as a separate sample by the sample collection personnel. Results of field duplicate samples can provide a measure of sampling precision.

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8.4.1.5 Field Matrix Spike

A field matrix spike sample is created by spiking target analytes into a sample in the field at the point of sample acquisition. These sample results provide information on the target analyte stability after collection and during transport and storage.

8.4.1.6 Collocated Samples

Collocated samples are independent samples collected in such a manner that they are equally representative of the variable(s) of interest at a given point in space and time. Examples of collocated samples include: samples from two air quality analyzers, sampling from a common sample manifold, or two water samples collected at the same time and from the same point in a lake.

Collocated samples processed and analyzed by the same organization provide intralaboratory precision information for the entire measurement system including sample acquisition, handling, shipping, storage, preparation, and analysis. Both samples can be carried through the steps in the measurement process together to provide an estimate of short-term precision for the entire measurement system. Likewise, the two samples, if separated and processed at different times or by different people, and/or analyzed using different instruments, provide an estimate of long-term precision of the entire measurement system. Collocated samples processed and analyzed by different organizations provide interlaboratory precision information for the entire measurement system.

8.4.1.7 Split Sample

A split sample is a sample divided into two portions at the sampling site. One portion is sent to a different organization or laboratory and subjected to the same environmental conditions and steps in the measurement process as the other portion sent to another laboratory.

A split sample can be divided into portions at different points in the sampling and analysis process to obtain precision information on the various components of the measurement system. For example, a field split sample provides precision information about all steps after sample acquisition including the effects of storage, shipment, analysis, and data processing. Field split sample results may also reflect the degree of sample homogeneity.

8.4.2 Laboratory QC Samples

Laboratory performance QC is required to ensure the laboratory systems (instrumentation, sample preparation, analysis, data reduction, etc.) are operating within acceptable QC guidelines during data generation as required to meet the client's objectives. Laboratory QC samples consist of method blanks (MB), instrument blanks, laboratory control samples (LCS) and calibration verification samples. In addition to laboratory performance QC, matrix-specific QC is utilized to determine the effect of the sample matrix on the data being generated. Typically, this includes matrix spikes (MS), matrix spike duplicates (MSD), sample duplicates, and the use of surrogate compounds.

Laboratory and matrix-spike QC sample types are summarized in Tables 8.4-2, 8.4-3 and 8.4-4. In addition, Tables 8.4-5, 8.4-6 and 8.4-7 list laboratory QC samples, acceptance criteria and corrective actions by

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reference method for inorganic methods, organic methods, and the USEPA CLP Statements of Work respectively. The following sections provide descriptions of laboratory QC samples and their frequency of use. Quanterra® Policy Number QA-003, "Quanterra® Quality Control Program", describes in detail the QC data evaluation process.

8.4.2.1 Quality Control (QC) Batch

The QC batch consists of a set of up to 20 field samples that behave similarly (i.e., same matrix) and are processed using the same procedures, reagents, and standards within the same time period. This definition of a QC batch is utilized by Quanterra® unless there is clear regulatory guidance, contract specifications, or differing client requirements that are explicitly documented. Further details and requirements for the application of the definition of QC batch are described in QA Policy Number QA-003.

8.4.2.2 Method Blank

The method blank (MB) is a QC sample that consists of all reagents specific to the method and is carried through every aspect of the procedure, including preparation, cleanup, and analysis. The method blank is used to identify any interferences or contamination of the analytical system that may lead to the reporting of elevated analyte concentrations or false positive data. Potential sources of contamination include solvent, reagents, glassware, other sample processing hardware, or the laboratory environment. In general, the method blank is a volume of deionized laboratory water for water samples, or a purified solid matrix for soil/sediment samples, that is processed as a sample. In the event that no appropriate solid matrix exists, deionized water may be used. The volume or weight of the method blank must be approximately equal to the sample volume or sample weight processed. A method blank shall be prepared with each group of samples processed.

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8.4.2.3 Instrument Blank

The instrument blank is an unprocessed aliquot of reagent used to monitor the contamination of the analytical system at the instrument. System contamination may lead to the reporting of elevated analyte concentrations or false positive data. The instrument blank does not undergo the entire analytical process and generally consists of an aliquot of the same reagent(s) used for a sample dilution. Instrument blanks are also referred to as continuing calibration blanks.

8.4.2.4 Laboratory Control Sample

A laboratory control sample (LCS) is a laboratory-generated clean matrix sample that is fortified with target analytes. Review of the LCS recovery data is used to monitor the performance of the analytical methods. Day to day performance is characterized by the measure of the accuracy of the results. On-going monitoring of the LCS results provides evidence that the laboratory is performing the method within both acceptable accuracy and precision guidelines. The results of the LCS, used in conjunction with the MS samples can provide evidence of whether the laboratory performed the method correctly or the sample matrix affected the results. When a laboratory control sample duplicate (LCSD) is required, a percent recovery may be calculated, as well as a relative percent difference (RPD) between the LCS and the LCSD.

8.4.2.5 Matrix Spike

A matrix spike (MS) is an environmental sample to which known concentrations of target analytes have been added. MS samples are analyzed to evaluate the effect of the sample matrix on the analytical methodology. MS samples are generated by taking a separate aliquot of an actual client sample and spiking it with the selected target analyte(s) prior to sample extraction. The MS sample then undergoes the same extraction and analytical procedures as the unfortified client sample. Due to the potential variability of the matrix of each sample, these results may have immediate bearing only on the specific sample spiked and not on all samples in the QC batch.

8.4.2.6 Matrix Spike Duplicate

A matrix spike duplicate (MSD) is a second aliquot of a sample that is spiked with the selected target analyte(s) and analyzed with the associated sample and MS sample. The results of the MS and MSD are used together to determine the effect of a matrix on the accuracy and precision of the analytical process. Due to the potential variability of the matrix of each sample, the MS/MSD results may have immediate bearing only on the specific sample spiked and not all samples in the QC batch.

8.4.2.7 Sample Duplicate

A sample duplicate is a second aliquot of an environmental sample taken from the same sample container that is processed identically with the first aliquot of that sample. That is, sample duplicates are processed as independent samples within the same QC batch. The results are compared

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to determine the sample homogeneity and the precision of the analytical process.

8.4.2.8 Surrogates

Surrogates are organic compounds that are similar in chemical composition and behavior to the target analytes but that are not normally found in environmental samples. Surrogates are added to all appropriate samples and QC samples being tested for organic analytes to monitor the effect of the sample matrix and the procedure on the accuracy of the process.

8.4.2.9 Analytical Spike

An analytical spike is created by spiking target analytes into a prepared portion (i.e., post digestion) of a sample just prior to analysis. It provides information on matrix effects encountered during analysis such as suppression or enhancement of instrument signal levels. It is most often used in elemental analysis involving various forms of atomic emission or atomic absorption spectroscopy. A single analytical spike serves as a single point application of the "method of standard additions" or MSA.

8.4.2.10 Interference Check Sample

An interference check sample (ICS) is a solution containing known concentrations of both interfering and analyte elements. Analysis of this sample can be used to verify background and interelement correction factors.

8.4.2.11 Internal Standards

An internal standard (IS) is a compound or element with similar chemical characteristics and behavior in the analysis process to the target analytes, but is not normally found in environmental samples. The internal standard is usually added after sample preparation. The primary function of the internal standard is quantitation, however, it also provides a short-term indication of instrument performance. For isotope dilution methods, internal standards are added during sample preparation and are used for quantitation.

8.4.2.12 Radiological QC Samples

The primary QC sample type used for radiological testing to monitor recovery is the yield monitor. The two types of yield monitors are tracers and carriers. A tracer is a radioisotope, usually of the same element and having the same mode of decay as the analyte. A carrier is a non-radioactive solution added to assist in isolating the specific isotope of an element. When

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standardized, the carrier can also provide recovery information gravimetrically.

Radiological QC samples and their required frequencies are listed in Section 7 of the Facility-Specific Appendix when applicable.

8.5 Data Collection Operations

Laboratory analyses are designed to produce data that are representative of existing conditions present at the time the sample was obtained. The data collection design includes field sampling events, sample handling and custody, analytical operations, data recording procedures, data assessments, data verification, and data reporting requirements and techniques to assess limitations of data use. These operations are discussed in Sections 8.5 through 8.10.

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8.5.1 Field Collection and Shipment

In order to provide a sample that most accurately represents the test matrix, field sample collection personnel must abide by the sample collection guidelines and procedures established by involved regulatory agencies. A significant part of the efforts of regulatory agencies include the use of "approved" sample containers, chemical and physical preservation techniques, and observance of specified holding times. It is imperative that all samples be collected and preserved according to the appropriate analytical method specified in the QAPP (if one exists). Although the sampling may be performed by non-Quanterra® personnel, the importance of sampling and transportation of the sample to the laboratory is understood and must be considered during data validation.

Sampling requirements must be communicated to the sampling team prior to field collection.

Field personnel are responsible for labeling each individual sample collected with the following information:

- Project number
- Unique sample number
- Sample location (including as appropriate: borehole and depth or grid coordinates)
- Sampling date and time
- Sample preservation
- Analysis required.

An overriding consideration for the resulting analytical data is the ability to demonstrate that the samples have been obtained from the locations stated and that they have reached the laboratory without alteration. Evidence of collection, shipment, laboratory receipt,

laboratory custody, and disposal must be documented to accomplish this. Figure 8.5-1 shows an example Chain-of-Custody (COC) form that is used by the Quanterra® laboratory network to document this evidence. Field personnel are responsible for initiating the COC form.

The prompt shipment of samples to the laboratory is necessary to ensure that required holding times are met. Samples should be shipped by an overnight carrier, be hand-delivered, or transported in a manner that assures prompt delivery to the laboratory.

Some sites require an extensive radioactive screening process before a sample may be shipped. In these cases, it is imperative for the Project Manager to maintain good communications with the client to assure proper staffing of the laboratory in response to a decreased holding time.

Radioactive samples that are shipped to Quanterra® radiochemistry operations must be screened upon receipt and found not to contain radioactivity that exceeds the level stated in the laboratory's operation license. Samples received by a Quanterra® facility containing radioactivity exceeding their license limit will immediately be returned to the project site.

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8.5.2 Sample Containers, Shipping Containers, Preservatives, and Holding Times

8.5.2.1 Sample Containers

A sample container is defined as the sealed enclosure, usually made of plastic or borosilicate glass that the sample is collected in and stored in until analysis. All sample containers provided by Quanterra® operations for environmental sampling are new, with the exception of some air sampling canisters, which must be recertified before reuse, and demonstrated to be clean for their appropriate use. All documentation certifying sample container cleanliness must be maintained by the laboratory or the vendor and can be provided to the client upon request. The sample containers to be supplied are listed in Tables 8.5-1 through 8.5-5. Sample containers provided to the client by Quanterra® are transmitted under custody.

8.5.2.2 Shipping Containers

Shipping containers are defined as the sealed enclosure in which the sample containers are stored during shipment from the sample collection site to the analytical laboratory. Shipping containers must be of sufficient number and size to accommodate the samples in an upright condition. Shipping containers must also meet all requirements for the

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FIGURE 8.5-1
Example Quanterra® Chain-of-Custody Form

Reference Document No. _____
Page 1 of _____

Project Name/No.: _____
Sample Team Members: _____
Profit Center No.: _____
Project Manager: _____
Purchase Order No.: _____
Required Report Date: _____

Sample Shipment Date: _____
Lab Destination: _____
Lab Contact: _____
Project Contact/Phone: _____
Carrier/Waybill No.: _____

Bill To: _____

Report To: _____

ONE CONTAINER PER LINE

Sample Number	Sample Description/Type	Date/Time Collected	Container Type	Sample Volume	Preservative	Requested Testing Program	Condition on Receipt	Disposal Record No.

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Special Instructions:

Possible Hazard Identification:
Non-hazard ❑ Flammable ❑ Skin Irritant ❑ Poison B ❑ Unknown ❑

Sample Disposal:
Return to Client ❑ Disposal by Lab ❑ Archive _____ (mos.)

Turnaround Time Required:
Normal ❑ Rush ❑

QC Level:

1. Relinquished by: *(Signature/Affiliation)*	Date: _____ Time:	1. Received by: *(Signature/Affiliation)*	Date: _____ Time:
2. Relinquished by: *(Signature/Affiliation)*	Date: _____ Time:	2. Received by: *(Signature/Affiliation)*	Date: _____ Time:
3. Relinquished by: *(Signature/Affiliation)*	Date: _____ Time:	3. Received by: *(Signature/Affiliation)*	Date: _____ Time:

Comments:

shipment of environmental and/or radioactive samples.

Packaged samples must be shipped to the analytical laboratory in a safe manner that preserves the integrity of the samples. The most common method of sample shipment employs coolers or ice chests that are sealed with custody tape and shipping tape. These coolers must be durable and resistant to crushing during shipment. All coolers must be well maintained and cleaned to prevent cross-contamination of the samples. It is the ultimate responsibility of the person collecting and packaging the sample for shipment to ensure that the shipping containers are clean and functional.

To help prevent sample breakage during shipment, additional consideration must be given to providing shock absorbency to all samples packaged inside the shipping container. Use of bubble-wrap around each sample container is the best way to provide this protection. Foam packing materials and vermiculite are also successfully used.

8.5.2.3 Sample Preservatives

Most analytes have a finite holding time in a given sample matrix. Sample preservation is the chemical or physical means by which samples are treated during and/or following sample collection to aid in the stability of the analytes of interest in that matrix. Sample holding times are also adversely affected when samples are improperly preserved, or shipped unpreserved. The preservation of samples at the time of sample collection will follow the requirements of the analytical methods used. This preservation includes the addition of reagents to deter chemical and biochemical degradation and the maintenance of refrigeration during transit and ultimate storage in the laboratory. The required preservatives for the analysis to be performed on each matrix are included in Tables 8.5-1 through 8.5-5.

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8.5.2.4 Sample Holding Times

Holding time is defined as the maximum allowable time a sample can be stored after sample collection and preservation (or laboratory receipt for CLP) until appropriate processing occurs (preparation or analysis). The holding time may vary according to method or client requirements. Tests designated with holding times as "analyze immediately or ASAP" are considered parameters that should be tested by field personnel or on-site. Each operation has a system in place to ensure that holding times are monitored by each group within the operating unit. It is the responsibility of each Quanterra® associate processing the sample to

assure that holding times are met. Quanterra® laboratories are responsible for meeting all holding times for properly preserved samples received within 48 hours of collection or if less than half the holding time has passed at the time of sample receipt if the sample is received after 48 hours of collection. If these conditions are not met, Quanterra® will attempt to expedite sample analysis as soon as possible.

Sample holding times are listed in Tables 8.5-1 through 8.5-5.

8.5.3 Sample Handling

Each Quanterra® laboratory has a SOP describing sample receipt and log-in in detail. The following sections describe the general program followed by all Quanterra® laboratories.

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8.5.3.1 Sample Receipt

Samples shall be received and logged in at Quanterra® operations by a designated sample custodian or other properly trained associate. Upon sample receipt, the sample custodian shall, as appropriate:

- Wear appropriate personal protective equipment. At a minimum, this consists of gloves, a lab coat, safety glasses, and in some cases a respirator
- Examine the shipping containers to verify that the custody tape is intact
- Examine all sample containers for damage
- Open shipping containers in adequately ventilated areas to assure worker safety
- Determine if the temperature required by the requested testing program has been maintained during shipment. Document the shipping container temperature on the COC
- Compare samples received against those listed on the COC
- Verify that sample holding times have not been exceeded
- Examine all sample records for accuracy and completeness
- Determine sample pH (if required for the scheduled analysis) and record on the COC
- Sign and date the COC immediately (only after shipment is accepted) and attach the waybill
- Note any problems associated with the samples on the COC, immediately initiate a Condition Upon Receipt Report, and notify the PM who in turn notifies the client
- Attach appropriate laboratory sample container labels with laboratory identification number and test
- Place the samples in proper laboratory

storage.

A CUR is generated by sample control during the sample log-in process to document anomalies identified upon the receipt of samples in the laboratory. These anomalies are outside of laboratory control and do not require corrective actions to be taken within the laboratory. The affected client shall be notified by the PM or designee of all CURs generated for their samples. The PM is responsible for resolving with the client how to proceed with the samples. CURs must be resolved prior to sample preparation and analysis. The completed CUR form shall be stored the project file. An example CUR is shown in Figure 8.5-2.

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8.5.3.2 Sample Log-in

Sample log-in activities at Quanterra® operating units are fully documented in operation-specific SOPs. The following is a general description of the log-in process:

- Enter the samples in the laboratory sample log-in book, and/or the LIMS which contains the following information at a minimum:
  - Project identification number
  - Sample numbers (both client and laboratory)
  - Type of samples
  - Required tests
  - Date received at the laboratory
- Assess sample holding times
- Notify the PM and appropriate Group/Team Leader(s) of sample arrival
- Place the completed COCs, waybills, and any additional documentation in the project file.

8.5.3.3 Sample Storage

The primary considerations for sample storage are:

- Maintenance at the prescribed temperature, if required
- Maintenance of sample integrity through adequate protection from contamination from outside sources or from cross-contamination of samples. Low-level and high-level samples, when known, must be stored separately. Samples and standards must be stored in separate refrigerators or freezers. Storage areas for volatile organic test requests should be monitored twice per month by the analysis of a holding blank (an aliquot of contaminant-free water stored in a VOA vial)
- Security of samples within the laboratory.

The requirements listed in Tables 8.5-1 through 8.5-5 for temperatures and holding times shall be used. Placing of

FIGURE 8.5-2

Example Quanterra® Condition Upon Receipt Anomaly Report (CUR)
Page 1 of 2

CUR No.: _____
Lot: _____

Client: _____
Project Name: _____

Date Received: _____
Initiated By: _____
RFA/COC Nos.: _____

Condition/Anomaly/Variance (select from legend on back):

Client Sample ID	Analysis Requested	Condition (see legend)	Comments/Actions

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Corrective Action:

- ☐ Client informed verbally on: _____ By: _____ In writing on: _____ By: _____
- ☐ Sample(s) processed "as is"
- ☐ Sample(s) ON HOLD until further notice
- ☐ Other action required (see above comments)
- ☐ No action required.

Sample Control Reviewer: _____ Project Manager: _____

SIGNED ORIGINAL MUST BE RETAINED IN THE PROJECT FILE

FIGURE 8.5-2
Example Quanterra® Condition Upon Receipt Anomaly Report (CUR)
Page 2 of 2

Legend:

Cooler:
1a Not received, COC available
1b Leaking
1c Other: _____

Temperature:
2a Temp. Blank: _____
2b Cooler Temp: _____
(cooler temp should only be used if there is no Temp. Blank)

Containers:
3a Leaking
3b Broken
3c Extra
3d No labels
3e Headspace (VOA only)
3f Other: _____

Samples:
4a Samples received but not on COC
4b Samples not received but on COC
4c Holding Time Expired
4d Sample Preservative: _____
4e Other: _____

Custody Seals:
5a None
5b Not intact
5c Other: _____

Chain of Custody (COC):
6a Not relinquished by client
6b Incomplete information
6c Other: _____

Container Labels:
7a Doesn't match COC
7b Incomplete information
7c Marking smeared
7d Label torn
7e Other: _____

Other (8): _____
_____
_____

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SIGNED ORIGINAL MUST BE RETAINED IN THE PROJECT FILE

samples in the proper storage environment is the responsibility of sample control personnel. Quanterra® operations will assign individuals the responsibility of notifying the Operations Manager and Group/Team Leaders if there are any samples which must be analyzed immediately because of holding time requirements.

8.5.3.4 *Internal Sample Chain-of-Custody and Interlaboratory Transfers*

Sample custody within Quanterra® laboratories is described in operation-specific SOPs. The sample custody documentation shall include the following minimum requirements:

- Name of associate taking custody of the sample from the sample storage area for preparation or analysis
- Dates sample removed from and returned to the sample storage area
- Identification of tests to be performed on the sample aliquot(s) selected by the associate
- Sample matrix
- Laboratory sample numbers
- Sample storage location.

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Additional custody records can be provided by a facility at the specific request of the client. Access to all Quanterra® facilities is restricted to prevent any unauthorized contact with samples, extracts, or documentation.

Samples transferred to a different laboratory than the original receiving facility are transferred under chain-of-custody (COC). The COC is maintained whether the laboratory is another Quanterra® facility or a subcontracted laboratory. If the entire sample volume is transmitted, the original copy of the client's COC form will be used to document the relinquishing of the sample and will accompany the sample to its destination. A copy of the completed COC form shall be retained in the laboratory project file. In the case where an aliquot of a sample is shipped from the laboratory, a new COC will be generated by the laboratory and shipped with the sample aliquot. The original COC will be retained in the project file at the site holding the original sample container.

Samples are not transferred to other Quanterra® facilities or to subcontractor laboratories without prior approval of the client.

8.5.3.5 Sample Disposal and Return Chain-of-Custody

After the requested analyses on the samples have been completed, any remaining portions of the samples will be maintained by the sample custodian until the samples are disposed of or returned to the client. The disposal of each sample is recorded on the client's COC form or referenced in the project file. Sample disposal procedures and documentation are described in operation-specific SOPs. Quanterra®'s routine sample retention period is at least thirty days after the analytical report is issued to the client, unless otherwise specified by the client.

For Nuclear Regulatory Commission (NRC) or state licensed laboratories, a real-time inventory of all radioactive isotopes contained in the laboratory (including radioactive samples), as required by the NRC or state, is maintained by the Radiation Safety Officer (RSO). If the quantities of radioactive materials in-house approach the limits stipulated by the laboratory NRC or state license, appropriate action must be taken to ensure the licensed level is not exceeded. This may involve returning samples to clients immediately.

If samples are returned to the client rather than disposed of by the laboratory, the original COC is used to document custody transfer back to the client from the laboratory. A copy of the completed COC is retained in the laboratory project file.

8.5.4 Calibration Procedures and Criteria

All equipment and instruments used at Quanterra® operations for quantitative measurements are controlled by a formal calibration program. Calibrations may be periodic or operational. These are described in operation-specific and corporate SOPs. At a minimum, these procedures shall include:

- Instrument to be calibrated
- Reference standards used for calibration
- Calibration technique (e.g., linear, quadratic)
- Acceptable performance tolerances and corrective actions required if specifications are not met
- Frequency of calibration
- Calibration documentation requirements.

Whenever possible, recognized procedures such as those published by ASTM or the USEPA or procedures provided by manufacturers shall be adopted. If established procedures are not available, a procedure shall be developed considering

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the type of equipment, stability characteristics of the equipment, required accuracy, and the effect of operation error on the quantities measured.

8.5.4.1 Physical Reference Standards

Physical reference standards associated with periodic calibrations include weights for calibrating balances and certified thermometers for calibrating working thermometers. Whenever possible, physical reference standards shall have known relationships to nationally recognized standards. If national standards are not available, the basis for the reference standard shall be documented.

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Physical reference standards shall be used only for calibration procedures and shall be stored separately from equipment used for analysis.

8.5.4.2 Chemical Reference Standards and Reagents

Chemical reference standards are generally associated with operational calibration. These standards include reference materials provided by recognized standards suppliers. This may include vendor-certified materials traceable to NIST or A2LA.

All chemical reference standards maintained in the laboratory for use in calibrations (or as QC spiking solutions) shall be labeled or referenced to appropriate documentation with the following information at a minimum:

- A unique identification including concentration (solutions containing several analytes can be identified such that the solution constituents and concentrations can be referenced to a logbook)
- Medium prepared in
- Preparation date
- Expiration date
- Initials of preparer.

Vials containing standard solutions that are not large enough to accommodate labels listing the above information may be referenced to a laboratory logbook or notebook entry. The expiration date of the working standard must not exceed the expiration date of the original material.

8.5.4.3 Standard Verification

When possible, reference standards are purchased from a single approved vendor. Standards are verified before use by Quanterra® or the vendor where applicable.

Prior to use, the laboratories must confirm that the lot they received from the vendor was approved. Special standards that are obtained from another source must be independently verified at the lab.

Stock and working standards are checked regularly for signs of deterioration, such as discoloration, formation of precipitates, or change in concentration. Care is exercised in the proper storage and handling of standard solutions. Standards are always stored separately from samples.

An independent standard is used to verify initial calibrations. An independent standard is defined as a standard composed of the same target constituents as, but from a different source than those used in the standards for the initial calibration. An independent standard may be a laboratory-prepared or a certified independent standard solution(s). Independence of reference material can be achieved by: (1) purchasing reference materials from two separate vendors, (2) using a different lot, or (3) having two separate individuals prepare the calibration and verification standard solutions if independent sources are not available for neat standards.

Records for all purchased standards and reagents shall include the date of receipt, the date opened, and, where applicable, the expiration date.

8.5.4.4 Periodic Calibration

Periodic calibration is performed at prescribed intervals. In general, equipment which can be calibrated periodically is a distinct, singular purpose unit and is relatively stable in performance. These include balances, micropipettors, counters, thermometers, refrigerators, freezers, and ovens. Equipment employed at Quanterra® operations requiring periodic calibration are listed along with their respective calibration requirements in Table 8.5-6. Each Quanterra® operating unit has SOPs in place for the calibration of this equipment if in use at their location.

8.5.4.5 Operational Calibration

Operational calibration is routinely performed as part of instrument usage, such as the development of a standard calibration curve. Initial calibrations must be verified and documented for each constituent by the analysis of laboratory-prepared certified independent standard solutions. Detailed requirements for operational calibration are contained in method-specific SOPs. A summary of the various operational calibrations performed at Quanterra®

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operations is shown in Tables 8.5-7 through 8.5-9.

8.5.4.6 Calibration Failure

Equipment or instruments that fail calibration or become inoperable during use shall be tagged to indicate they are out of calibration. Such instruments or equipment shall be repaired and successfully recalibrated before reuse. The procedure for tagging out such instruments or equipment is described in the Corporate SOP Number CORP-QA-0010, "Nonconformance and Corrective Action."

Recalibration may occur more frequently than scheduled. At any time, if equipment calibration becomes suspect, it shall undergo a calibration check to determine whether the current calibration is still acceptable or if recalibration is required.

8.5.4.7 Calibration Records

Calibration shall be documented for each piece of equipment subject to calibration. All calibration records (periodic and operational) directly affect data and may not be limited to one project. These records shall be stored in either the quality records or the associated project files. Project files that include sample data shall either include the calibration records or include reference to them.

8.6 Quality Assessment

The effectiveness of the QA practices at a laboratory is measured by the quality of data generated by the laboratory. Each Quanterra® operating unit shall establish, implement and document procedures to detect, prevent, and correct quality problems and to ensure quality improvement. Items and processes that do not meet established requirements must be investigated to determine their cause. Improvements must be implemented in the operations which will prevent a recurrence of these quality problems and provide overall quality performance. All phases of laboratory work should be designed with the objective of preventing problems and improving quality on a continuous basis.

8.6.1 Data Quality Assessment

Data quality is judged in terms of precision, accuracy, representativeness, completeness and comparability. The areas of representativeness, comparability, and completeness for an overall project, inclusive of sampling issues, may be beyond the control of the laboratory. The elements over which the laboratory has direct control

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are precision, accuracy, and completeness (relative to analytical testing results).

Precision and accuracy assessments are made as part of the evaluation of laboratory QC data generated during sample preparation and analysis. The QC samples employed at Quanterra® as part of routine sample analysis are summarized in Section 8.4 of this document. Table 8.6-1 shows the precision and accuracy measurements employed by Quanterra®. Analytical method SOPs and Quanterra® Policy Number QA-003, "Quanterra® Quality Control Program", include information on requirements for the type of QC samples, frequencies, and acceptance criteria. Additionally, the SOPs and Policy describe the appropriate actions to be taken when a QC sample result does not meet acceptance criteria.

8.6.2 *Statistical Evaluation of Data*

In-house limits for all QC data must be evaluated at least annually and compared to the limits published in the methods for applicable matrices. Method limits will be employed until sufficient QC data are acquired. A minimum of 20 to 30 data points are recommended to establish the limits. QC limits are normally in-house limits unless they exceed method limits, which are then adopted. Calculated results of these QC samples are evaluated by comparing against control limits or creating control charts to spot trends. Facility-wide data are accumulated for evaluation and limit determination.

Program-specific data analysis requirements for control charts are followed as required for data generated under those programs. These additional requirements shall be documented in a QAPP or QAS. It is the responsibility of each analyst to update any client-required control charts or control tables as a part of routine data reduction.

Precision and accuracy measurements employed by Quanterra® are shown in Table 8.6-1. Calculated results of these QC samples are evaluated using control tables or control charts. Facility-wide data are accumulated in the laboratory LIMS and are accessed from the database for further evaluation and limit determination.

8.7 *Data Recording Procedures*

To ensure data integrity, all documentation of data and records generated or used during the process of data generation must be performed in compliance with Quanterra® Corporate SOP Number QA-008, "Data Recording Requirements".

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8.8 Data Reduction and Verification Procedures

Data review procedures, defined as a set of computerized and manual checks applied at appropriate levels of the measurement process, will be clearly defined for all measurement systems in SOPs. Data review begins with the reduction or processing of data and continues through verification of the data and the reporting of analytical results. Calculations are checked from the raw data to the final value prior to reporting results for each group of samples. Data reduction can be performed by the analyst who obtained the data or by another analyst. Data verification starts with the analyst who performs a 100 percent review of the data to ensure the work was done correctly the first time. Data verification continues with review by a second reviewer who verifies that data reduction has been correctly performed and that the analytical results correspond to the data acquired and processed. This procedure is outlined in Figure 8.8-1.

8.8.1 Data Reduction and Initial Verification

Data reduction and initial verification may be performed by more than one analyst depending upon the analytical method employed. The preparation and analytical data may be reviewed independently by different analysts. In these instances, each item may not be applicable to the subset of the data verified or an item may be applicable in both instances. It is the responsibility of the analyst to ensure that the verification of data in his or her area is complete. The data reduction and initial verification process must ensure that:

- Sample preparation information is correct and complete including documentation of standard identification, solvent lot numbers, sample amounts, etc.
- Analysis information is correct and complete including proper identification of analysis output (charts, chromatograms, mass spectra, etc.)
- Analytical results are correct and complete including calculation or verification of instrument calibration, QC results, and qualitative and quantitative sample results with appropriate qualifiers
- The appropriate SOPs have been followed and are identified in the project records
- Proper documentation procedures have been followed
- All nonconformances have been documented
- Special sample preparation and analytical requirements have been met

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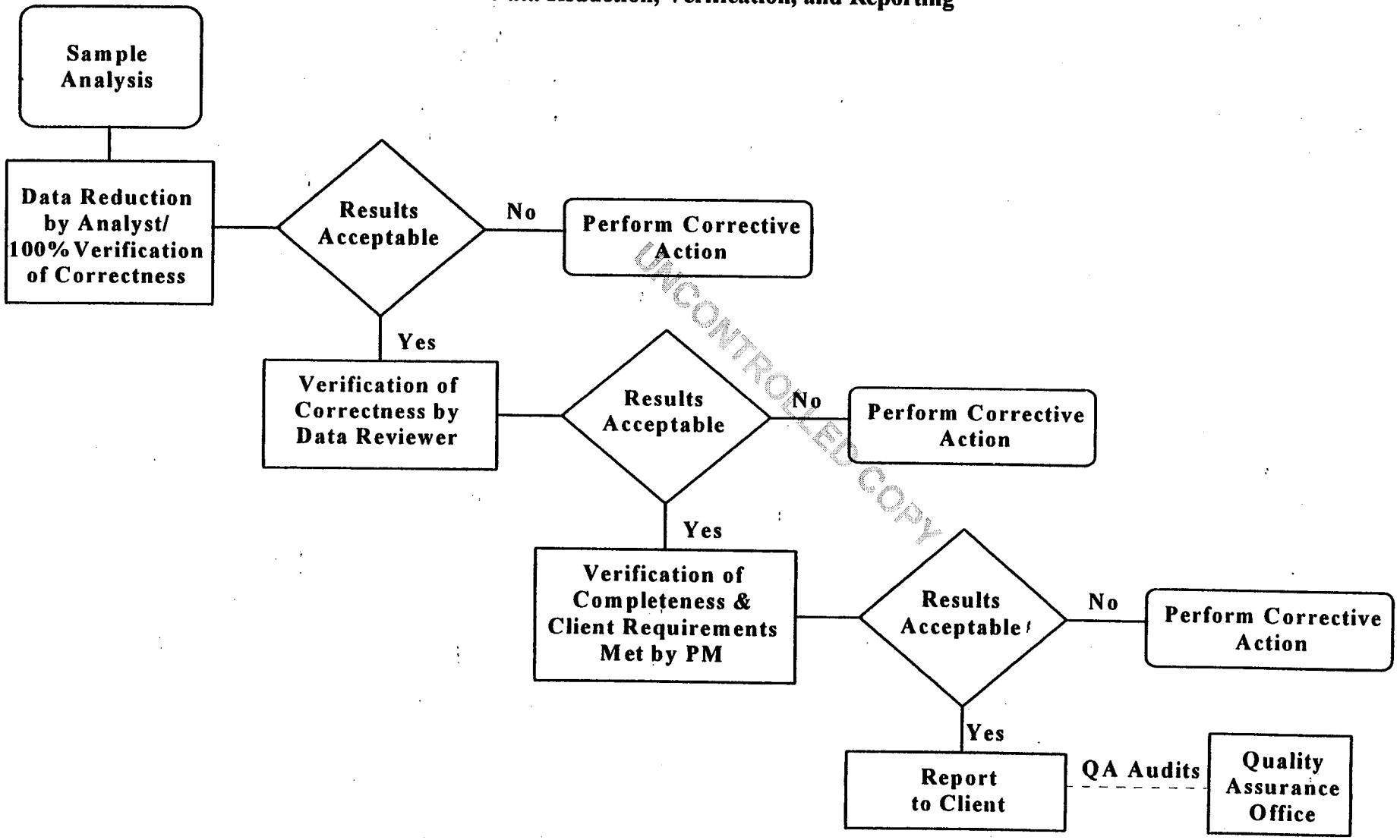
FIGURE 8.8-1
Data Reduction, Verification, and Reporting



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- The data generated have been reported with the appropriate number of significant figures as defined by the analytical method in the LIMS or otherwise specified by the client.

In general, data will be processed by an analyst in one of the following ways:

- Manual computation of results directly on the data sheet or on calculation pages attached to the data sheets
- Input of raw data for computer processing
- Direct acquisition and processing of raw data by a computer.

If data are manually processed by an analyst, all steps in the computation shall be provided including equations used and the source of input parameters such as response factors (RFs), dilution factors, and calibration constants. If calculations are not performed directly on the data sheet, they may be attached to the data sheets.

For data that are input by an analyst and processed using a computer, a copy of the input shall be kept and uniquely identified with the project number and other information as needed. The samples analyzed must be clearly identified.

If data are directly acquired from instrumentation and processed, the analyst must verify that the following are correct:

- Project and sample numbers
- Calibration constants and RFs
- Units
- Numerical values used for reporting limits.

Analysis-specific calculations for methods are provided in SOPs. In cases where computers perform the calculations, software must be validated or verified, as described in Section 6.0 of this document, before it is used to process data.

The data reduction is documented, signed and dated by the analyst completing the process. Initial verification of the data reduction by the same analyst is documented on a data review checklist, signed and dated by the analyst.

8.8.2 Data Verification

Following the completion of the initial verification by the analyst performing the data reduction, a systematic second-level verification of the data is performed by an experienced peer, supervisor, or designee. The second level reviewer examines the data

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signed by the analyst. This review includes an evaluation of all items required in the raw data package. Any exceptions noted by the analyst must be reviewed. Included in this review is an assessment of the acceptability of the data with respect to:

- Adherence of the procedure used to the requested analytical method SOP
- Correct interpretation of chromatograms, mass spectra, etc.
- Correctness of numerical input when computer programs are used (checked randomly)
- Correct identification and quantitation of constituents with appropriate qualifiers
- Numerical correctness of calculations and formulas (checked randomly)
- Acceptability of QC data
- Documentation that instruments were operating according to method specifications (calibrations, performance checks, etc.)
- Documentation of dilution factors, standard concentrations, etc.
- Sample holding time assessment.

This review also serves as verification that the process the analyst has followed is correct in regard to the following:

- The analytical procedure follows the methods and specific instructions given on the project QAS or equivalent summary form
- Nonconforming events have been addressed by corrective action as defined on a nonconformance memo
- Valid interpretations have been made during the examination of the data and the review comments of the initial reviewer are correct
- The package contains all of the necessary documentation for data review and report production and results are reported in a manner consistent with the method used for preparation of data reports.

The specific items covered in the second stage of data verification may vary according to the analytical method, but this review of the data must be documented by signing the same checklist.

8.8.3 Completeness Verification

A third-level review is performed by the PM. This review is required before results are submitted to clients. This review serves to verify the completeness of the data report and to ensure that project requirements are met for the analyses performed. The items to be reviewed are:

- Analysis results are present for every sample in the analytical batch, reporting

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group, or sample delivery group (SDG)

- Every parameter or target compound requested is reported with either a value or reporting limit
- The correct units and correct number of significant figures are utilized
- All nonconformances, including holding time violations, and data evaluation statements that impact the data quality are accompanied by clearly expressed comments from the laboratory
- The final report is legible, contains all the supporting documentation required by the project, and is in either the standard Quanterra® format or in the client-required format.

A case narrative to accompany the final report will be finalized by the PM. This narrative will include relevant comments collected during the earlier reviews.

8.9 Data Reporting

8.9.1 Data Reports

Quanterra® is capable of developing a variety of data deliverable reports. In general, Quanterra® reports contain:

- Cover Letter/Case Narrative - Information on sample types, tests performed, any problems encountered, and general comments are provided.
- Analytical Data - Data are reported by sample or by test with the appropriate significant figures and reporting limits, and have been adjusted for dilution, if appropriate. Pertinent information including dates sampled, received, prepared, extracted, and analyzed are provided.
- Laboratory Performance QC Information - The results of LCSs analyzed with the project are listed. Also, the analytical results for associated method blanks are given. Any data or QC anomalies are discussed.
- Matrix-Specific QC Information - Results of any sample duplicates and MS/MSDs analyzed with the samples as batch QC are reported. Other project-specific QC requested by the client are also reported. The results include supporting information such as amount spiked, percent recovery, or percent difference/RPD.
- Methodology - Reference for analytical methodology used is cited.
- Other Deliverables - Other deliverables available include disk deliverables, electronic data transfer, sample raw data packages, complete deliverable packages, and custom report formats.

8.9.2 Verbal Results

Quanterra®, as a policy, discourages the release of data verbally or without full data review. If however, the client requests analytical results to be communicated verbally or by facsimile prior to final review, they must

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be clearly identified as "Preliminary" results. The client must understand that the data have not undergone the required levels of review and may change.

8.9.3 Reporting Analytical Results

Sample results are reported according to analytical method SOPs or client specifications. Normally, the laboratory uses the Quanterra® Reporting Limit (RL) at which any analyte of interest detected at or above that level is reported as a positive value and any analyte of interest not detectable or detected below that level is reported as "not detected" at the RL. The laboratory will normally report results within the calibration, however, any reported results outside of the calibration range will be documented in the final report.

In some cases a contract, QAPP, or documented client request may require the laboratory to report sample results in a specified manner. Some examples are given below:

- The laboratory may be requested to report all analytes of interest that are less than the laboratory's RL but are greater than the MDL. This data will be flagged with an appropriate qualifier.
- The laboratory may be requested to report any tentatively identified compounds (TICs). This data will be flagged with an appropriate qualifier.
- The laboratory may be requested to report sample results using a RL that is higher than their normal level. In this case, only the analytes of interest found at or above that level would be reported as positive values. In this case, the laboratory will state the PSRL rather than the RL. All analytes of interest not detected or detectable below that level would be reported as "not detected" at the PSRL.

In these types of cases, the laboratory must include documentation in the project file that supports the reporting procedure employed.

It is the responsibility of the laboratory to provide for a reporting system that assures that any problems associated with an analysis are properly documented on a nonconformance memo, communicated to the appropriate Quanterra® associates, and addressed appropriately in the data report. If, after issuance of a report, Quanterra® observes any mistake that affects the results reported or the QC interpretation of those results, the client will be notified.

8.10 Data Validation

Data validation for Quanterra® refers to data reviews conducted in accordance with the USEPA CLP "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses" and "Laboratory Data Validation

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Functional Guidelines for Evaluating Inorganic Analyses", or modifications thereof, for non-CLP type analyses.

This form of data validation provides an impartial evaluation of the laboratory's results. It is usually performed by a third party, one which was not involved with the sample analysis. Qualifiers are assigned to data, when required, according to the requirements of the data validation protocol being used.

8.11 Preventive Maintenance and Service

Facilities, instruments, equipment, and parts are subject to wear, deterioration, or change in operational characteristics. Within Quanterra®, preventive maintenance, coupled with vendor service agreements, is an organized program of actions taken to maintain facilities and equipment.

8.11.1 Analytical Instrumentation and Equipment

The primary purpose of the maintenance program is to prevent instrument and equipment failure and to minimize down time. A properly implemented maintenance program increases the reliability of a measurement system.

At each laboratory each instrument or piece of equipment shall be uniquely identified. Each operating unit shall maintain the following:

- Instrument/equipment inventory list
- Instrument/equipment major spare parts list or inventory
- External service agreement documents (if applicable)
- Instrument-specific preventive maintenance logbook or file for each functional unit.

The record of maintenance shall include at a minimum:

- Actions taken, including parts replaced
- Analyst initials and the date maintenance was performed whether by the analyst or a contracted service representative.

Quanterra® documents and describes in detail instrument and equipment preventive maintenance procedures and requirements in operation-specific SOPs.

8.11.2 Facilities

Another important aspect of the laboratory operation is the existence and maintenance of adequate, safe, and clean facilities including appropriate engineering controls such as proper ventilation, lighting, dust control, hoods, air flow, protection from extreme

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temperatures, waste disposal, and a source of stable power.

The maintenance and use of these facilities and proper operations are described in the Quanterra® Chemical Hygiene Plan (CHP). The Laboratory Manager, through a facilities maintenance staff, has responsibility for ensuring a properly maintained facility. The Laboratory Manager also has the responsibility for ensuring that samples are stored properly without contamination, work areas are equipped with adequate bench, hood and operational space, and the areas are free from chemical and radiological contamination that may affect analytical results.

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8.11.3 Frequency of Maintenance

The frequency of maintenance must consider manufacturer's recommendations and previous experience. Schedules of preventive maintenance along with the recommended frequency are given in Tables 8.11-1 through 8.11-27 for analytical instrumentation and equipment. Frequency of maintenance for the facility systems is documented in the Quanterra® CHP.

8.12 Other Requirements

8.12.1 Water

High purity water (i.e., ASTM reagent grade or equivalent water) will be used in all metals, radiological, wet chemistry, and organic analyses. Proof of contaminant-free water is shown through the use of the reagent waters as method blanks which are analyzed on a daily basis for the analyte of interest. This water is obtained by the use of either a commercial ion-exchange deionizing, distillation, or reverse osmosis unit plus an appropriate polishing unit. The resulting water has a maximum conductivity of 1.0 umho-cm at 25°C or a minimum resistivity of 1.0 Mohm at 25°C. Conductivity and/or resistivity will be monitored and documented daily or on each day that water is dispensed for analytical use.

For volatile analyses the water may be further purified by purging with an inert gas before use to remove potential traces of organic solvents.

Water monitoring procedures used by Quanterra® operating units are detailed in operation-specific SOPs.

8.12.2 Compressed Air and Gases

Ultra high-purity compressed gases from preapproved vendors or in-house gas generators will be used when required for instrumentation. These air and gases must meet the requirements and specifications of the analytical methods performed. In-line filters

will be used when appropriate to minimize contamination and moisture from the gases.

8.12.3 Glassware Preparation

Glassware preparation procedures implemented at Quanterra® operating units are designed to ensure that contaminants are not introduced during sample analysis. Procedures describing glassware preparation are detailed in operation-specific SOPs.

8.12.4 Chemical Storage

Storage of chemicals shall be conducted in a manner to minimize the potential for fire or release of hazardous material resulting from an unplanned chemical reaction. Refrigerators used for storing flammable liquids must have spark-free interior construction. Flammable solvents shall be stored in appropriate cabinets meeting all necessary codes. All chemicals are stored according to chemical compatibility. Further details regarding chemical storage are provided in the Quanterra® CHP.

8.12.5 Waste Disposal

Laboratory wastes shall be disposed of safely and in a manner consistent with applicable regulations. The Laboratory Manager or designee is responsible for the development, implementation, and maintenance of site-specific procedures that will document all aspects of the disposal program. These procedures and the training requirements are described in the Quanterra® CHP.

8.12.6 Facility Security

Each Quanterra® laboratory is a limited access, secure facility. To ensure that only authorized personnel are able to enter the building from an entrance that is not monitored, entry into each building is limited in one or more of the following ways at a minimum:

- The use of key pads or electronic locks activated by swipe or magnetic cards which are issued only to authorized personnel
- Locking doors and issuing keys only to authorized personnel
- Alarm systems to detect unauthorized entrance
- During business hours, entry is possible only through the main entrance. This entrance is monitored at all times, usually by a receptionist. All guests are required to sign in by using a visitor logbook.

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9.0 Quality Assessment and Response

9.1 Nonconformance and Corrective Action

9.1.1 Nonconformance

A nonconformance is an unplanned deviation from an established protocol or plan. The deviation may be the result of Quanterra's® actions, then termed a deficiency, or the result of events beyond the control of Quanterra®, then termed an anomaly.

9.1.2 Corrective Action

Corrective actions are measures taken to rectify conditions adverse to quality and, where possible, to prevent their reoccurrence. Corrective actions should be timely, determine the root cause, and evaluate any propagation of the error or problem. Whenever a systematic error is discovered that affects the accuracy or defensibility of results reported to Quanterra®'s clients, client notification will be part of the corrective action. Corrective actions should be implemented with an understanding of the technology and work activities associated with the quality element, with appropriate training of Quanterra® associates and vendors, and should be monitored for progress and success.

9.1.3 Responsibilities

The responsibilities associated with nonconformance and corrective action, as well as the procedures to be followed, are described in the Quanterra® Corporate SOP Number CORP-QA-0010, "Nonconformance and Corrective Action."

9.1.4 Nonconformance Memo

As defined in the SOP, deficiencies and anomalies for all activities other than sample log-in or matrix related incidents shall be documented on a nonconformance memo. A log or computerized data base will be maintained for all nonconformances determined to be deficiencies. Deficiencies will be examined for trends periodically, and this evaluation will be documented and reported to management. The original or copy of the nonconformance memo will be kept in the project files along with the data it refers to. The original form or a copy shall also be kept in the quality files.

9.2 Audits

Audits of Quanterra® laboratories are performed to assess the degree of adherence to policies, procedures, and standards. These assessments are conducted internally by Quanterra® personnel, who are independent of the area being evaluated, and externally by clients and regulatory agencies. Audits can

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identify areas for improvement with regard to compliance with policies, procedures, and standards. Audits also provide a means for correction prior to system failure. The following types of audits and assessments are performed at Quanterra® laboratories:

- Performance Audits
- Systems Audits or Internal Systems Evaluations
- Data Audits
- Spot Assessments.

Internal systems audits or evaluations are generally conducted by QA staff, although periodic self-audits may be conducted by the operational units. Audits and assessments are generally conducted through the use of checklists and appropriate reference documents. Internal systems audits or evaluations are conducted with an opening meeting in which representatives from management, key operational staff, and QA staff participate. The opening meeting provides a review of the objectives of the audit and the schedule required to conduct the audit. At the completion of the audit, a debriefing is held to outline the findings, including identification of positive performance, to discuss requirements in areas of deficiencies, and to answer questions. Spot assessments are generally more informal than systems audits, and may be conducted without prior scheduling.

Internal systems audits or evaluations are conducted at a minimum yearly by QA staff external to the lab. Spot assessments are conducted per schedule by the laboratory QA group.

The findings of all audits and assessments are documented as is the laboratory response and any corrective actions. Follow-up checks are performed and the status of implementation of corrective actions is documented for all categories of audits and assessments. This cycle continues until all issues are closed.

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9.2.1 Performance Audits

Performance audits or performance evaluations (PEs) are conducted to verify the ability of the laboratory to correctly identify and quantitate compounds in PE samples. These PE samples may be supplied internally or externally as single-blind or double-blind samples. The results of internal performance audits may be used to document the proficiency of the analyst performing the work or to assess the overall performance of the facility. Double-blind performance audits are conducted by Quanterra® Corporate QA to assess the effectiveness of all aspects of laboratory performance from project initiation through analysis and reporting. In addition,

any problems detected regarding quotes, bids, and invoicing are brought to the attention of the PM and to the finance/accounting department, as appropriate.

The results of each performance audit shall be reported to laboratory management. All performance audit results which are identified as unacceptable must be investigated. The findings of the investigation and corrective action taken must be documented.

9.2.2 Systems Audits

A systems audit assesses fulfillment of the QAMP and the state of the QMS. Each laboratory undergoes numerous systems audits performed by external parties, including certifying agencies and clients.

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9.2.2.1 Internal Systems Audits or Evaluations

An annual systems evaluation will be performed under the direction of the Corporate Director of Quality Assurance and according to Corporate SOP Number, CORP-QA-0014. This evaluation is performed to assess each laboratory's adherence to the requirements of the QAMP, SOPs, internal policies, and to assess the status of corrective actions from other audits at that facility.

The Corporate Director of Quality Assurance shall appoint a lead auditor to conduct the systems evaluation. A corporate audit outline shall be used. The lead auditor has the authority to lengthen the evaluation, revise the scope of the evaluation, stop work, or specify an accelerated schedule for re-evaluation. The lead auditor shall be responsible for preparing a report detailing the results of the evaluation. The report shall be submitted to the audited Laboratory Manager, Regional General Manager, and Laboratory QA Manager within five weeks of the audit. A copy of the report shall be distributed to the Corporate QA Director. The audit report shall provide a summary of the audit results with the auditor's comments and the findings that were determined by the lead auditor.

The evaluated laboratory must respond in writing within four weeks of receiving the evaluation report. The QA Manager is responsible for coordinating the response to the evaluation report. The Laboratory Manager must approve all responses to internal evaluation reports prior to submittal to the auditor.

The evaluation may result in findings, areas needing improvement, and notable practices. Each term will be defined as such:

- Findings - are defined as those noncompliant practices or policies which have significant adverse impact on data quality, technical defensibility, or

regulatory acceptance of data. Findings require immediate attention by the laboratory management and must be resolved to comply with Quanterra®'s quality documents and laboratory-established procedures.

- Areas Needing Improvement - represent isolated instances of noncompliance or issues that are judged to have a less immediate impact on data quality. Laboratory management must correct the situation or otherwise ensure that the condition does not recur. This term will replace the previous term used "Observations."

- Notable Practices - should also be pointed out during the audit. These are defined as laboratory practices that increase effectiveness and quality and represent improvements with respect to conventional laboratory operations.

It is the responsibility of the QA Manager at each facility to verify implementation of the corrective actions and close all internal evaluation findings. This process shall be documented and provided to the recipients of the original audit report. This process is described in the Quanterra® Corporate SOP Number CORP-QA-0014, "Laboratory Internal Systems Evaluation".

Internal evaluation reports shall be maintained according to the Quanterra® Record Retention Policy (LEG-004) as confidential documents and shall not be released for use outside the laboratory. External auditors may view internal audit reports as part of their on-site audit.

9.2.2.2 *External Systems Audits*

Audits of Quanterra® laboratories are performed by external agencies and clients. All scheduled audits shall be placed on the facility's calendar with the knowledge of the Laboratory Manager and the Laboratory QA Manager to assure no scheduling conflicts occur and that appropriate staff will be available to meet the agencies' or clients' objectives.

All deficiencies reported to the laboratory must be responded to within the time line specified by the client. A plan of action to correct the deficiencies, as well as corrective actions taken, must be documented. It is the responsibility of the QA Manager to coordinate the response to the audit report. The development and implementation of the corrective actions is the responsibility of the Operations management as related to their respective areas. All responses must be approved by the Laboratory Manager prior to submittal to the auditor. A copy of the audit report and the laboratory's response must be provided to the Laboratory Manager and Corporate QA. It is the responsibility of the QA Manager to verify implementation of the corrective actions and inform the responsible

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manager of the closure of all deficiencies from the audit.

9.2.3 Data Audits

Data audits are routinely performed and documented to ensure that project records meet project requirements as described in method SOPs, project plans, or other documented requirements. The data audit is used to identify any lab errors that may have occurred. The laboratory QA Manager or designee is responsible for performing data audits as specified in Quanterra® SOP Number CORP-QA-0004, "QA Data Review".

9.2.4 Spot Assessments

Spot assessments are conducted to monitor or observe a process or activity in order to verify conformance to the SOP requirements for that activity. The frequency, normally monthly, for performing these assessments is determined by the facility QA Manager. The scope of the assessment is also determined by the QA Manager and may be directed based on information obtained from client inquiries, trends in recorded nonconformances, performance audits, or other sources. A spot assessment may be used to assess a procedure performance relative to the documented SOP. This assessment identifies deviations from requirements that may not be detected in a detailed review of the data package alone. Such an assessment is conducted by observation of the associates performing the task compared with the documented SOP. In some cases, the assessment may be conducted through interviews with the associate when observation of a task is not possible. Review of relevant documentation for the completed procedure is included in such an assessment. A checklist may be used in conducting the assessment. The results of the assessment are documented, as are the corrective actions. All deficiencies noted as a result of a spot assessment must be corrected by the responsible staff in a timely manner.

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9.3 Client Inquiries and Complaints

Client inquiries are generally received through the PM or a member of the CST. Typically, the PM communicates with the client to determine the details of the inquiries, including technical data problems, deliverable issues, turn-around-time problems, etc. Technical and deliverable issues are coordinated by the PM and usually involve input from operations, QA, and management staff. A formal written response to the client is coordinated by the PM, but may on occasion be delivered by the CSM or the Account Manager.

9.4 Quality Reports to Management

The QA Manager and Corporate Director of

Quality Assurance shall prepare and maintain copies of reports to management on a monthly basis indicating the effectiveness of the QMS. The operations monthly reports to management shall, at a minimum, include discussion of the following activities that occurred during the month:

- Internal audit findings
- Certification changes
- PE sample results
- Summary of client inquiries for which QA was asked to assist the laboratory in developing a response
- General comments or concerns.

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The corporate reports serve as executive summaries to members of senior management of the detailed information provided by the QA Managers.

9.5 Management Review of the QMS

Based upon laboratory audits or input from clients or the QA group, management may elect to assess any of the operations or processes therein. These reviews and corrective actions would be documented and followed up by management. The purpose of these assessments would be to correct systematic issues or processes before they impact data quality.

10.0 Quality Improvement

Quality improvement at Quanterra® is a critical element of our quality strategy as well as our business strategy. Quanterra® will become a world class organization through a commitment to continuous quality improvement. Every Quanterra® associate must understand that continuous improvement is a guiding principle pertinent to all aspects of our business.

The key elements of quality improvement are:

- Standardization of procedures
- Continuous quality improvement
- Benchmarking
- Quality assessment
- Understanding the clients' needs
- Quality measures and standards.

10.1 Standardization of Procedures

Due to the vast number of methods that have been introduced into the environmental analytical field, as well as revisions and proposed updates to currently promulgated methods, many methodologies contain conflicting requirements. It is through the generation and use of standard operating procedures, which contain Quanterra®'s best technical interpretation of published methods, that Quanterra® succeeds in providing quality standardized analytical testing to our clients. This standardization is achieved through the implementation of standardized or corporate SOPs and policies. Quanterra® will generate and implement new SOPs and policies as the need arises, and will train associates in their importance and use.

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The standardization of procedures, as they are implemented throughout Quanterra®, result in improved quality of our services and deliverables provided to our clients at some level at all operations.

10.2 Continuous Quality Improvement

The continuous improvement of processes throughout Quanterra® is the responsibility of each Quanterra® associate. Processes are followed in every operating unit, group, and by each individual, and each of these processes is applicable to this discussion. All associates are empowered and encouraged to bring suggestions for process improvement changes to the attention of laboratory management, as well as the

Technology and QA groups. Management is responsible for assessing the recommendation for improvement and following through with an implementation plan when appropriate.

10.3 Benchmarking

Benchmarking is a step-by-step method of improving performance by identifying and studying best practices and comparing them to industry practices. Benchmarking is performed within Quanterra®, as well as on the industry. Changes to processes resulting from benchmarking may be tested in a single laboratory under senior technical and QA management. If successful, the process change may be implemented throughout Quanterra®.

10.4 Quality Assessment

Quality improvement is also achieved through the practice of quality assessment and subsequent correction of detected quality-related problems when they occur. Quality assessment and response are described in Section 9.0.

10.5 Understanding the Client's Needs

Client satisfaction must be a goal of all Quanterra® associates. Periodic client satisfaction surveys are performed by Quanterra® customer service staff to determine if we are meeting their needs. While quality is defined as meeting the requirements of our clients, both internal and external, we must also strive to exceed our client's expectations. Every Quanterra® associate is either directly or indirectly involved in meeting our client's needs, therefore effective communication of these needs to all associates as described in this QAMP is essential.

Any inquires or complaints from clients to any associate must be addressed in a timely manner and any issue concerning data quality must be documented. (See Section 9.3).

10.6 Quality Measures and Standards

Measures and standards used by Quanterra® are fundamental to assessing and achieving our commitment to continuous improvement. With most business processes, performance is generally measured at the end. Quanterra® managers must provide continuous feedback to all associates regarding performance measures and standards.

Key Result Indicators (KRIs) provide one of Quanterra®'s measures. Additional measures and standards shall be added to track

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programs, processes, or projects, as appropriate.

KRIs measure performance in areas considered critical to achieving world class Quality in customer satisfaction and business performance. KRIs focus quality measures on the customer as well as the processes that our customers value. KRIs are intended to demonstrate continuous improvement and focus on the "vital few" issues for the business. Quanterra® KRIs include:

- On-time delivery
- Holding time violations
- Reissued reports
- Turn-around-time
- Safety.

Measurements of performance include internal and external audits, performance evaluations, and double-blind evaluations which are further described in Section 9.0. Improved results from these measurements show successfulness of process improvements.

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TABLES

Tables

Quanterra®
Quality Assurance Management Plan

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Table Section

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Table of Contents

Table No.	Title	Page
2.3-1	Quanterra® Quality Assurance Management Plan Requirements Matrix	5
4.2-1	List of Quanterra® Quality-Related Items that Require Evaluation Prior to Use	9
5.1-1	Quanterra® Quality Documents and Required Approval	10
5.2-1	Quanterra® Quality Document Review Requirements	11
8.2-1	Analytical Methods Routinely Performed by Quanterra®	12
8.4-1	Field Quality Control Samples	24
8.4-2	Laboratory Quality Control Samples	25
8.4-3	Laboratory Performance Quality Control Samples	26
8.4-4	Matrix Specific Quality Control Samples	27
8.4-5	Inorganic Laboratory Quality Control Samples	28
8.4-6	Organic Laboratory Quality Control Samples	77
8.4-7	USEPA Contract Laboratory Program Statement of Work Quality Control Samples	102
8.5-1	Inorganic Sample Containers, Preservatives, and Holding Times	116
8.5-2	Organic Sample Containers, Preservatives, and Holding Times	128
8.5-3	Radiological Sample Containers, Preservatives, and Holding Times	137
8.5-4	Sample Containers, Preservatives, and Holding Times for USEPA Contract Laboratory Program Statement of Work	140
8.5-5	Sample Containers, Preservatives, and Holding Times for TCLP	142
8.5-6	Periodic Equipment Calibrations	143
8.5-7	Summary of Inorganic Method Calibrations	144
8.5-8	Summary of Organic Method Calibrations	160
8.5-9	Summary of USEPA Contract Laboratory Program Statement of Work Method Calibrations	169
8.6-1	Precision and Accuracy Measurements	173
8.11-1	Instrument Maintenance Schedule - Ion Chromatograph	175
8.11-2	Instrument Maintenance Schedule - LACHAT Auto Analyzer	175
8.11-3	Instrument Maintenance Schedule - Total Organic Halide Analyzer	176
8.11-4	Instrument Maintenance Schedule - High Pressure Liquid Chromatograph	176
8.11-5	Instrument Maintenance Schedule - Flame Atomic Absorption Spectroscopy	177
8.11-6	Instrument Maintenance Schedule - Inductively Coupled Argon Plasma/ Mass Spectrometry (ICAP/MS)	177
8.11-7	Instrument Maintenance Schedule - ICP	178
8.11-8	Instrument Maintenance Schedule - Graphite Furnace Atomic Absorption	179
8.11-9	Instrument Maintenance Schedule - Cold Vapor Atomic Absorption (Leeman PS 200)	179

UNCONTROLLED COPY

Table of Contents (continued)

Table No.	Title	Page
8.11-10	Instrument Maintenance Schedule - Cold Vapor Atomic Absorption (PE 5000)	179
8.11-11	Instrument Maintenance Schedule - Gas Chromatograph	180
8.11-12	Instrument Maintenance Schedule - Mass Spectrometer	182
8.11-13	Instrument Maintenance Schedule - TRAACS 800 Auto Analyzer	183
8.11-14	Instrument Maintenance Schedule - Sonicator	183
8.11-15	Instrument Maintenance Schedule - Analytical/Top Loading Balances	183
8.11-16	Instrument Maintenance Schedule - Refrigerators/Walk-in Coolers	183
8.11-17	Instrument Maintenance Schedule - Ovens	184
8.11-18	Instrument Maintenance Schedule - Specific Digital Ion Analyzer	184
8.11-19	Instrument Maintenance Schedule - Turbidimeter	184
8.11-20	Instrument Maintenance Schedule - Dissolved Oxygen Meter	184
8.11-21	Instrument Maintenance Schedule - Conductance Meter	185
8.11-22	Instrument Maintenance Schedule - Chemical Oxygen Demand (COD) Reactor	185
8.11-23	Instrument Maintenance Schedule - Spectrophotometer	185
8.11-24	Instrument Maintenance Schedule - pH Meter	185
8.11-25	Instrument Maintenance Schedule - Fourier Transform Infrared Spectrometry	186
8.11-26	Instrument Maintenance Schedule - Radiological Analysis Equipment	186
8.11-27	Instrument Maintenance Schedule - Total Organic Carbon Analyzer (OI 7000)	187

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TABLE 2.3-1

Quanterra® Quality Assurance Management Plan Requirements Matrix

EPA QA/R-2	Quanterra QAMP (Rev 2)	ANSI/ASQC E4-1994	NQA-1[1]	5700.6C[2]	ANSI N 13.30	ANSI/ASQC Q2-1991[3]
1 Management and Organization	1.0 Management Commitment and Organization	2.1 Management and Organization	1 Organization	9.a. General	1.1 Introduction 1.2 Purpose 1.3 Scope	5.0 Management Responsibility
2 Quality System and Description	2.0 Quality System and Description	2.2 Quality System and Description	2 Quality Assurance Program	1 Program	2.1 Special Word Usage 2.2 Specific Terms 5.1 Quality Assurance 5.2 Quality Control	5.2 Quality System
3 Personnel Qualification and Training	3.0 Associate Qualification and Training	2.3 Personnel Training and Qualification	2 Quality Assurance Program	2 Personnel Training and Qualification	3.2 Personnel Preparation	14.0 Personnel
4 Procurement of Items and Services	4.0 Procurement of Items and Services	2.4 Procurement of Items and Services	4 Procurement Document Control 7 Control of Purchased Items and Services	7 Procurement	N/A	7.0 Quality in Procurement 13.0 Subcontracting
5 Documentation and Records	5.0 Documentation and Records	2.5 Documents and Records	6 Document Control 17 Quality Assurance Records	4 Documents and Records	3.6 Direct Bioassay-Record Retention 4.5 Indirect Bioassay-Record Retention	8.4 Quality Documentation and Records
6 Computer Hardware and Software	6.0 Computer Hardware and Software	2.6 Computer Hardware and Software	3 Design Control 11 Test Control	N/A	N/A	ISO 9000-3[4]

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TABLE 2.3-1
Quanterra® Quality Assurance Management Plan Requirements Matrix
(Continued)

EPA QA/R-2	Quanterra QAMP (Rev 2)	ANSI/ASQC E4-1994	NQA-1[1]	5700.6C[2]	ANSI N 13.30	ANSI/ASQC Q2-1991[3]
7 Planning	7.0 Planning	2.7 Planning 3.1 Planning and Scoping 3.3 Implementation of Planned Operations	2 Quality Assurance Program 3 Design Control 5 Instructions, Procedures, and Drawings 8 Identification and Control of Items 9 Control of Processes 11 Test Control 13 Handling, Storage, and Shipping	1 Program 6 Design N/A	3.1 Facility Criteria 3.4 Direct Bioassay-Performance Criteria for Service Laboratories 3.5 Direct Bioassay-Reporting Results 4.1 Indirect Bioassay-Responsibilities of the Service Laboratory Customer 4.2 Indirect Bioassay-Analytical Methodology 4.3 Indirect Bioassay-Performance Criteria for Service Laboratories 5.2 Quality Control	6.3.3 Quality Plans
8 Implementation of Work Processes	8.0 Work Processes and Operations	2.8 Implementation of Work Processes	1 Organization 5 Instructions, Procedures, and Drawings	5 Work Processes 6 Design	3.1 Facility Criteria	8.0 Laboratory Operations Quality Assurance 9.0 Control of Measuring and Test Equipment 10.0 Data Validation 15.0 Use of Statistical Methods

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TABLE 2.3-1
Quanterra® Quality Assurance Management Plan Requirements Matrix
(Continued)

EPA QA/R-2	Quanterra QAMP (Rev 2)	ANSI/ASQC E4-1994	NQA-1[1]	5700.6C[2]	ANSI N 13.30	ANSI/ASQC Q2-1991[3]
8 Implementation of Work Processes (Continued)		3.2 Design of Data Collection Operations	10 Inspection 12 Control of Measuring and Test Equipment 14 Inspection, Test, and Operating Status	8 Inspection and Acceptance Testing		
9 Assessment and Response[5]	9.0 Quality Assessment and Response	2.9 Assessment and Response 3.4 Assessment and Response 3.5 Assessment and Verification of Data Usability	2 Quality Assurance Program 13 Handling, Storage, and Shipping 15 Control of Non-conforming Items 16 Corrective Action 18 Audits	9 Management Assessment 10 Independent Assessment	3.3 Direct Bioassay-Interpretation of Measurements 3.5 Direct Bioassay-Reporting Results 4.4 Indirect Bioassay-Reporting Results 6.1 Direct Bioassay Measurements 6.2 Indirect Bioassay Measurements	16.0 Nonconformity 17.0 Corrective Action 18.0 Auditing the Quality System
9 Quality Improvement[5]	10.0 Quality Improvement	2.10 Quality Improvement	N/A	3 Quality Improvement	N/A	N/A

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TABLE 2.3-1
Quanterra® Quality Assurance Management Plan Requirements Matrix
(Continued)

Footnotes

(1) Section II, "Basic Requirements."
(2) Criterion from Section 9, "Requirements."
(3) Technically equivalent to ISO 9001.
(4) Quality Management and Quality Assurance Standards, ISO 9000, Part 3, "Guidelines for the Application of ISO 9001 to the Development, Supply and Maintenance of Software."
(5) This document has two sections numbered "9."

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TABLE 4.2-1
List of Quanterra® Quality-Related Items that Require Evaluation Prior to Use

Quality-Related Item	Standard Operating Procedure for Quality Testing
Acetone	CORP-QA-0001
Dichloromethane	CORP-QA-0001
Hexane	CORP-QA-0001
Hydrochloric acid	CORP-QA-0001
Freon	CORP-QA-0001
Methanol	CORP-QA-0001
Nitric acid	CORP-QA-0001
Sulfuric acid	CORP-QA-0001
Toluene	CORP-QA-0001

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TABLE 5.1-1
Quanterra® Quality Documents and Required Approval

Quality Document	Required Approvals
Quality Assurance Management Plan (QAMP)	• Corporate Director of Quality Assurance • Vice President of Operations Services • Chief Operating Officer
Quality Assurance Management Plan (QAMP) Facility Appendix	• Quality Assurance Manager • Laboratory Manager • Regional General Manager • Corporate Director of Quality Assurance
Corporate Standard Operating Procedures (SOPs)	• Corporate Director of Quality Assurance • Corporate Director of Environmental Health and Safety(1) • Management (generally a Vice President) • Technical Specialist
Operation-Specific Standard Operating Procedures (SOPs)	• Quality Assurance Manager • Laboratory Health and Safety Coordinator(1) • Laboratory Manager • Technical Specialist
Quality Policy Documents	• Corporate Director of Quality Assurance • Vice President of Operations Services

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(1) Required only if procedure encompasses more than standard office safety requirements.

TABLE 5.2-1
Quanterra® Quality Document Review Requirements

Document Type	Frequency of Review	Responsible Party
Quality Assurance Management Plan (QAMP)	Every Two Years	Corporate Director of Quality Assurance
Quality Assurance Management Plan (QAMP) Facility Appendix	Annual	Quality Assurance Manager
Corporate Standard Operating Procedures (SOP)	Every Two Years	Corporate Technology/QA
Operation-Specific Standard Operating Procedures (SOP)	Every Two Years	Laboratory Staff
Quality Policy Documents	Every Two Years	Corporate Director of Quality Assurance

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TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
Chapter 7	RCRA	2	September 1994	SW-846	"Section 7.3.3, "Interim Guidance for Reactive Cyanide" and Section 7.3.4, "Interim Guidance for Reactive Sulfide"
D1943-90	ASTM	N/A	1990	ASTM	"Standard Test Method for Alpha Particle Radioactivity of Water"
D3454-86	ASTM	N/A	1986	ASTM	"Test Method for Radium-226 in Water"
D3649-85	ASTM	N/A	1985	ASTM	"Practice for Gamma Ray Spectrometry"
DFLM01.1	USEPA	N/A	1991	USEPA CLP (DFLM01.1)	"Statement of Work for Analysis of Polychlorinated Dibenzo-p-Dioxins (PCDD) and Polychlorinated Dibenzofurans (PCDF)"
ILM03.0	USEPA	N/A	1992	USEPA CLP (ILM03.0)	"Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration"
OLM01.8	USEPA	N/A	1991	USEPA CLP (OLM01.8)	"Statement of Work for Organic Analysis, Multi-Media, Multi-Concentration"
TO-1	USEPA	1.0	April 1984	EPA-600/4-84-041	"Method for the Determination of Volatile Organic Compounds in Ambient Air Using Tenax® Adsorption and Gas Chromatography/Mass Spectrometry (GC/MS)"
TO-2	USEPA	1.0	April 1984	EPA-600/4-84-041	"Method for the Determination of Volatile Organic Compounds in Ambient Air by Carbon Molecular Sieve Adsorption and Gas Chromatography/Mass Spectrometry (GC/MS)"
TO-3	USEPA	1.0	April 1984	EPA-600/4-84-041	"Method for the Determination of Volatile Organic Compounds in Ambient Air Using Cryogenic Preconcentration Techniques and Gas Chromatography with Flame Ionization and Electron Capture Detection"
110.2	NPDES	N/A	1971	MCAWW	"Color" (Colorimetric-Platinum-Cobalt)
120.1	NPDES	N/A	1982	MCAWW	"Conductance" (Specific conductance, µmhos at 25°C)
130.2	NPDES	N/A	1982	MCAWW	"Hardness, Total" (mg/L as $CaCO_3$), (Titrimetric, EDTA)
140.1	NPDES	N/A	1971	MCAWW	"Odor" (Threshold Odor, Consistent Series)
150.1	NPDES	N/A	1982	MCAWW	"pH" (Electrometric)
160.1	NPDES	N/A	1971	MCAWW	"Residue, Filterable" (Gravimetric, Dried at 180°C)
160.2	NPDES	N/A	1971	MCAWW	"Residue, Non-Filterable" (Gravimetric, Dried at 103-105°C)
160.3	NPDES	N/A	1971	MCAWW	"Residue, Total" (Gravimetric, Dried at 103-105°C)
160.4	NPDES	N/A	1971	MCAWW	"Residue, Volatile" (Gravimetric, Ignition at 550°C)
160.5	NPDES	N/A	1971	MCAWW	"Residue, Settleable"
170.1	NPDES	N/A	1971	MCAWW	"Temperature" (Thermometric)
180.1	NPDES	N/A	1978	MCAWW	"Turbidity" (Nephelometric)

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TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
200.7	NPDES	N/A	December 1982	MCAWW	"Inductively Coupled Plasma-Atomic Emission Spectrometric Method for Trace Element Analysis of Water and Wastes"
200.8	USEPA	4.4	May 1994	EPA/600/R-94/111	"Determination of Trace Metals in Waters and Wastes by Inductively Coupled Plasma-Mass Spectrometry"
202.1	NPDES	N/A	1978	MCAWW	"Aluminum" (Atomic Absorption, direct aspiration)
202.2	NPDES	N/A	1978	MCAWW	"Aluminum" (Atomic Absorption, furnace technique)
204.1	NPDES	N/A	1978	MCAWW	"Antimony" (Atomic Absorption, direct aspiration)
204.2	NPDES	N/A	1978	MCAWW	"Antimony" (Atomic Absorption furnace technique)
206.2	NPDES	N/A	1978	MCAWW	"Arsenic" (Atomic Absorption furnace technique)
206.3	NPDES	N/A	1974	MCAWW	"Arsenic" (Atomic Absorption-gaseous hydride)
206.4	NPDES	N/A	1974	MCAWW	"Arsenic" (Spectrophotometric-SDDC)
206.5	NPDES	N/A	1978	MCAWW	"Arsenic" (Sample Digestion Prior to Total Arsenic Analysis by Silver Diethyldithiocarbamate or Hydride Procedures)
208.1	NPDES	N/A	1974	MCAWW	"Barium" (Atomic Absorption, direct aspiration)
208.2	NPDES	N/A	1978	MCAWW	"Barium" (Atomic Absorption furnace technique)
210.1	NPDES	N/A	1974	MCAWW	"Beryllium" (Atomic Absorption, direct aspiration)
210.2	NPDES	N/A	1978	MCAWW	"Beryllium" (Atomic Absorption furnace technique)
212.3	NPDES	N/A	1974	MCAWW	"Boron" (Colorimetric, Curcumin)
213.1	NPDES	N/A	1974	MCAWW	"Cadmium" (Atomic Absorption, direct aspiration)
213.2	NPDES	N/A	1978	MCAWW	"Cadmium" (Atomic Absorption furnace technique)
215.1	NPDES	N/A	1971	MCAWW	"Calcium" (Atomic Absorption, direct aspiration)
215.2	NPDES	N/A	1978	MCAWW	"Calcium" (Titrimetric, EDTA)
218.1	NPDES	N/A	1978	MCAWW	"Chromium" (Atomic Absorption, direct aspiration)
218.2	NPDES	N/A	1978	MCAWW	"Chromium" (Atomic Absorption, direct aspiration)
218.3	NPDES	N/A	1978	MCAWW	"Chromium" (Atomic Absorption, chelation-extraction)
218.4	NPDES	N/A	1978	MCAWW	"Chromium, Hexavalent" (Atomic Absorption, chelation-extraction)
218.5	NPDES	N/A	December 1982	MCAWW	"Chromium, Dissolved Hexavalent" (Atomic Absorption, Furnace Technique
219.1	NPDES	N/A	1978	MCAWW	"Cobalt" (Atomic Absorption, direct aspiration)
219.2	NPDES	N/A	1978	MCAWW	"Cobalt" (Atomic Absorption furnace technique)
220.1	NPDES	N/A	1978	MCAWW	"Copper" (Atomic Absorption, direct aspiration)
220.2	NPDES	N/A	1978	MCAWW	"Copper" (Atomic Absorption furnace technique)

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TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
231.1	NPDES	N/A	1978	MCAWW	"Gold" (Atomic Absorption, direct aspiration)
231.2	NPDES	N/A	1978	MCAWW	"Gold" (Atomic Absorption furnace technique)
235.1	NPDES	N/A	1978	MCAWW	"Iridium" (Atomic Absorption, direct aspiration)
235.2	NPDES	N/A	1978	MCAWW	"Iridium" (Atomic Absorption furnace technique)
236.1	NPDES	N/A	1978	MCAWW	"Iron" (Atomic Absorption, direct aspiration)
236.2	NPDES	N/A	1978	MCAWW	"Iron" (Atomic Absorption furnace technique)
239.1	NPDES	N/A	1978	MCAWW	"Lead" (Atomic Absorption, direct aspiration)
239.2	NPDES	N/A	1978	MCAWW	"Lead" (Atomic Absorption furnace technique)
242.1	NPDES	N/A	1978	MCAWW	"Magnesium" (Atomic Absorption, direct aspiration)
243.1	NPDES	N/A	1978	MCAWW	"Manganese" (Atomic Absorption, direct aspiration)
243.2	NPDES	N/A	1978	MCAWW	"Manganese" (Atomic Absorption furnace technique)
245.1	NPDES	N/A	1974	MCAWW	"Mercury" (Manual Cold Vapor Technique)
245.2	NPDES	N/A	1974	MCAWW	"Mercury" (Automated Cold Vapor Technique)
245.5	NPDES	N/A	1974	MCAWW	"Mercury in Sediment" (Manual Cold Vapor Technique)
246.1	NPDES	N/A	1978	MCAWW	"Molybdenum" (Atomic Absorption, direct aspiration)
246.2	NPDES	N/A	1978	MCAWW	"Molybdenum" (Atomic Absorption furnace technique)
249.1	NPDES	N/A	1978	MCAWW	"Nickel" (Atomic Absorption, direct aspiration)
249.2	NPDES	N/A	1978	MCAWW	"Nickel" (Atomic Absorption furnace technique)
252.1	NPDES	N/A	1978	MCAWW	"Osmium" (Atomic Absorption, direct aspiration)
252.2	NPDES	N/A	1978	MCAWW	"Osmium" (Atomic Absorption furnace technique)
253.1	NPDES	N/A	1978	MCAWW	"Palladium" (Atomic Absorption, direct aspiration)
253.2	NPDES	N/A	1978	MCAWW	"Palladium" (Atomic Absorption furnace technique)
255.1	NPDES	N/A	1978	MCAWW	"Platinum" (Atomic Absorption, direct aspiration)
255.2	NPDES	N/A	1978	MCAWW	"Platinum" (Atomic Absorption furnace technique)
258.1	NPDES	N/A	1974	MCAWW	"Potassium" (Atomic Absorption, direct aspiration)
264.1	NPDES	N/A	1978	MCAWW	"Rhenium" (Atomic Absorption, direct aspiration)
264.2	NPDES	N/A	1978	MCAWW	"Rhenium" (Atomic Absorption furnace technique)
265.1	NPDES	N/A	1978	MCAWW	"Rhodium" (Atomic Absorption, direct aspiration)
265.2	NPDES	N/A	1978	MCAWW	"Rhodium" (Atomic Absorption furnace technique)
267.1	NPDES	N/A	1978	MCAWW	"Ruthenium" (Atomic Absorption, direct aspiration)
267.2	NPDES	N/A	1978	MCAWW	"Ruthenium" (Atomic Absorption furnace technique)

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
270.2	NPDES	N/A	1978	MCAWW	"Selenium" (Atomic Absorption furnace technique)
270.3	NPDES	N/A	1974	MCAWW	"Selenium" (Atomic Absorption, gaseous hydride)
272.1	NPDES	N/A	1978	MCAWW	"Silver" (Atomic Absorption, direct aspiration)
272.2	NPDES	N/A	1978	MCAWW	"Silver" (Atomic Absorption furnace technique)
273.1	NPDES	N/A	1974	MCAWW	"Sodium" (Atomic Absorption, direct aspiration)
273.2	NPDES	N/A	December 1982	MCAWW	"Sodium" (Atomic Absorption, furnace technique)
279.1	NPDES	N/A	1978	MCAWW	"Thallium" (Atomic Absorption, direct aspiration)
279.2	NPDES	N/A	1978	MCAWW	"Thallium" (Atomic Absorption, furnace technique)
282.1	NPDES	N/A	1978	MCAWW	"Tin" (Atomic Absorption, direct aspiration)
282.2	NPDES	N/A	1978	MCAWW	"Tin" (Atomic Absorption, furnace technique)
283.1	NPDES	N/A	1974	MCAWW	"Titanium" (Atomic Absorption, direct aspiration)
283.2	NPDES	N/A	1978	MCAWW	"Titanium" (Atomic Absorption, furnace technique)
286.1	NPDES	N/A	1974	MCAWW	"Vanadium" (Atomic Absorption, direct aspiration)
286.2	NPDES	N/A	1978	MCAWW	"Vanadium" (Atomic Absorption, furnace technique)
289.1	NPDES	N/A	1974	MCAWW	"Zinc" (Atomic Absorption, direct aspiration)
289.2	NPDES	N/A	1978	MCAWW	"Zinc" (Atomic Absorption, furnace technique)
300.0	NPDES	2.1	August 1993	EPA-600/R-93/100	"Determination of Inorganic Anions by Ion Chromatography"
305.1	NPDES	N/A	1974	MCAWW	"Acidity"
310.1	NPDES	N/A	1978	MCAWW	"Alkalinity" (Titrimetric, pH 4.5)
320.1	NPDES	N/A	1974	MCAWW	"Bromide" (Titrimetric)
325.1	NPDES	N/A	1971	MCAWW	"Chloride" (Colorimetric, Automated Ferricyanide AAI)
325.2	NPDES	N/A	1978	MCAWW	"Chloride" (Colorimetric, Automated Ferricyanide AAII)
325.3	NPDES	N/A	1982	MCAWW	"Chloride" (Titrimetric, Mercuric Nitrate)
330.1	NPDES	N/A	1978	MCAWW	"Chlorine, Total Residual" (Titrimetric, Amperometric)
330.3	NPDES	N/A	1978	MCAWW	"Chlorine, Total Residual" (Titrimetric, Iodometric)
335.1	NPDES	1.0	August 1993	EPA-600/R-93/100	"Determination of Total Cyanide by Semi-Automated Colorimetry"
335.2	NPDES	N/A	1980	MCAWW	"Cyanide, Total" (Titrimetric; Spectrophotometric)
335.3	NPDES	N/A	1978	MCAWW	"Cyanide, Total" (Colorimetric, Automated UV)
340.2	NPDES	N/A	1974	MCAWW	"Fluoride" (Potentiometric, Ion Selective Electrode)
345.1	NPDES	N/A	1974	MCAWW	"Iodide" (Titrimetric)
350.1	NPDES	2.0	August 1993	EPA-600/R-93/100	"Determination of Ammonia Nitrogen by Semi-Automated Colorimetry"

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
351.2	NPDES	2.0	August 1993	EPA-600/R-93/100	"Determination of Total Kjeldahl Nitrogen by Semi-Automated Colorimetry"
351.3	NPDES	N/A	1978	MCAWW	"Nitrogen, Kjeldahl, Total" (Colorimetric; Titrimetric; Potentiometric)"
352.1	NPDES	N/A	1971	MCAWW	"Nitrogen, Nitrate" (Colorimetric, Brucine)
353.1	NPDES	N/A	1978	MCAWW	"Nitrogen, Nitrate-Nitrite" (Colorimetric, Automated, Hydrazine Reduction)
353.2	NPDES	2.0	August 1993	EPA-600/R-93/100	"Determination of Nitrate-Nitrite Nitrogen by Automated Colorimetry"
353.3	NPDES	N/A	1974	MCAWW	"Nitrogen, Nitrate-Nitrite" (Spectrophotometric, Cadmium Reduction)
354.1	NPDES	N/A	1971	MCAWW	"Nitrogen, Nitrite" (Spectrophotometric)
365.1	NPDES	2.0	August 1993	EPA-600/R-93/100	"Determination of Phosphorus by Semi-Automated Colorimetry"
365.2	NPDES	N/A	1971	MCAWW	"Phosphorus, All Forms" (Colorimetric, Ascorbic Acid, Single Reagent)
365.3	NPDES	N/A	1978	MCAWW	"Phosphorus, All Forms" (Colorimetric, Ascorbic Acid, Two Reagent)
365.4	NPDES	N/A	1974	MCAWW	"Phosphorus, Total" (Colorimetric, Automated, Block Digester AA II)
370.1	NPDES	N/A	1978	MCAWW	"Silica, Dissolved" (Colorimetric)
375.1	NPDES	N/A	1971	MCAWW	"Sulfate" (Colorimetric, Automated, Chloranilate)
375.4	NPDES	N/A	1978	MCAWW	"Sulfate" (Turbidimetric)
376.1	NPDES	N/A	1978	MCAWW	"Sulfide" (Titrimetric, Iodine)
376.2	NPDES	N/A	1978	MCAWW	"Sulfide" (Colorimetric, Methylene Blue)
377.1	NPDES	N/A	1978	MCAWW	"Sulfite" (Titrimetric)
405.1	NPDES	N/A	1974	MCAWW	"Biochemical Oxygen Demand" (5 Days, 20°C)
410.1	NPDES	N/A	1978	MCAWW	"Chemical Oxygen Demand" (Titrimetric, Mid-Level)
410.2	NPDES	N/A	1978	MCAWW	"Chemical Oxygen Demand" (Titrimetric, Low Level)
410.4	NPDES	2.0	August 1993	EPA-600/R-93/100	"Determination of Chemical Oxygen Demand by Semi-Automated Colorimetry"
413.1	NPDES	N/A	1978	MCAWW	"Oil and Grease, Total, Recoverable" (Gravimetric, Separatory Funnel Extraction)
413.2	NPDES	N/A	1978	MCAWW	"Oil and Grease, Total Recoverable" (Spectrophotometric, Infrared)
415.1	NPDES	N/A	1974	MCAWW	"Organic Carbon, Total" (Combustion or Oxidation)
410.2	NPDES	N/A	1978	MCAWW	"Chemical Oxygen Demand" (Titrimetric, Low Level)
410.4	NPDES	2.0	August 1993	EPA-600/R-93/100	"Determination of Chemical Oxygen Demand by Semi-Automated Colorimetry"

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TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
413.1	NPDES	N/A	1978	MCAWW	"Oil and Grease, Total, Recoverable" (Gravimetric, Separatory Funnel Extraction)
413.2	NPDES	N/A	1978	MCAWW	"Oil and Grease, Total Recoverable" (Spectrophotometric, Infrared)
415.1	NPDES	N/A	1974	MCAWW	"Organic Carbon, Total" (Combustion or Oxidation)
418.1	NPDES	N/A	1978	MCAWW	"Petroleum Hydrocarbons, Total Recoverable" (Spectrophotometric, Infrared)
420.1	NPDES	N/A	1978	MCAWW	"Phenolics, Total Recoverable" (Spectrophotometric, Manual 4-AAP with Distillation)
420.2	NPDES	N/A	1974	MCAWW	"Phenolics, Total Recoverable (Colorimetric, Automated 4-AAP with Distillation)
425.1	NPDES	N/A	1971	MCAWW	"Methylene Blue Active Substances (MBAS)", (Colorimetric)
450.1	N/A	N/A	November 1980	EPA 600/4-81-056	"Total Organic Halide"
601	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Purgeable Halocarbons"
602	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Purgeable Aromatics"
603	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Acrolein and Acrylonitrile"
608	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Organochlorine Pesticides and PCBs"
610	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Polynuclear Aromatic Hydrocarbons"
613	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"2,3,7,8-Tetrachlorodibenzo-p-Dioxin"
615	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Chlorinated Herbicides"
624	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Purgeables"
625	NPDES	N/A	October 8, 1991	40CFR Part 136 - Appendix A	"Base/Neutrals and Acids"
900.0	USEPA	N/A	August 1980	EPA/600/4-80-032	"Gross Alpha and Gross Beta Radioactivity in Drinking Water"
901.1	USEPA	N/A	August 1980	EPA/600/4-80-032	"Gamma Emitting Radionuclides in Drinking Water"
903.0	USEPA	N/A	August 1980	EPA/600/4-80-032	"Alpha-Emitting Radium Isotopes in Drinking Water"
903.1	USEPA	N/A	August 1980	EPA/600/4-80-032	"Radium in Drinking Water - Radium Emanation Technique"
904.0	USEPA	N/A	August 1980	EPA/600/4-80-032	"Radium-228 in Drinking Water"
905.0	USEPA	N/A	August 1980	EPA/600/4-80-032	"Radioactive Strontium in Drinking Water"
906.0	USEPA	N/A	August 1980	EPA/600/4-80-032	"Tritium in Drinking Water"
1010	RCRA	0	September 1986	SW-846	"Pensky-Martens Closed-Cup Method for Determining Ignitability"
1020A	RCRA	1	July 1992	SW-846	"Setaflash Closed-Cup Method for Determining Ignitability"
1311	RCRA	0	July 1992	SW-846	"Toxicity Characteristic Leaching Procedure"
1312	RCRA	0	September 1994	SW-846	"Synthetic Precipitation Leaching Procedure"

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
1664[4]	USEPA	N/A	April 1995	EPA-821-B-94-004b	"N-Hexane Extractable Material (HEM) and Silica Gel Treated N-Hexane Extractable Material (SGT-HEM) by Extraction and Gravimetry (Oil and Grease Total Petroleum Hydrocarbons)"
3060A	RCRA	1	January 1995	SW-846	"Alkaline Digestion for Hexavalent Chromium"
2320B	NPDES	N/A	1992	Standard Methods	"Alkalinity, Titration Method"
2340B	NPDES	N/A	1992	Standard Methods	"Hardness by Calculation"
3005A	RCRA	1	July 1992	SW-846	"Acid Digestion of Waters for Total Recoverable or Dissolved Metals for Analysis by FLAA or ICP Spectroscopy"
3010A	RCRA	1	July 1992	SW-846	"Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by FLAA or ICP Spectroscopy"
3020A	RCRA	1	July 1992	SW-846	"Acid Digestion of Aqueous Samples and Extracts for Total Metals for Analysis by GFAA Spectroscopy"
3050A	RCRA	1	July 1992	SW-846	"Acid Digestion of Sediments, Sludges, and Soils"
3500-Cr D	APHA, AWWA, and WEF	N/A	1992	Standard Methods	"Colorimetric Method" (Hexavalent Chromium - Cr^{+6}), Part 3000: "Metals"
3500-Fe D	NPDES	N/A	1992	Standard Methods	"Iron, Phenanthroline Method"
3500A	RCRA	1	July 1992	SW-846	"Organic Extraction and Sample Preparation"
3510B	RCRA	2	September 1994	SW-846	"Separatory Funnel Liquid-Liquid Extraction"
3520B	RCRA	2	September 1994	SW-846	"Continuous Liquid-Liquid Extraction"
3540B	RCRA	2	September 1994	SW-846	"Soxhlet Extraction"
3550A	RCRA	1	September 1994	SW-846	"Ultrasonic Extraction"
3580A	RCRA	1	July 1992	SW-846	"Waste Dilution"
3600B	RCRA	2	September 1994	SW-846	"Cleanup"
3610A	RCRA	1	July 1992	SW-846	"Alumina Column Cleanup"
3620A	RCRA	1	July 1992	SW-846	"Florisil Column Cleanup"
3630B	RCRA	2	September 1994	SW-846	"Silica Gel Cleanup"
3640A	RCRA	1	September 1994	SW-846	"Gel-Permeation Cleanup"
3650A	RCRA	1	July 1992	SW-846	"Acid-Base Partition Cleanup"
3660A	RCRA	1	July 1992	SW-846	"Sulfur Cleanup"
4500-H^+ B	NPDES	N/A	1992	Standard Methods	"pH Value, Electrometric Method"
4500-Cl E	NPDES	N/A	1992	Standard Methods	"Chloride, Automated Ferricyanide Method"

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TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
4500-CN E	NPDES	N/A	1992	Standard Methods	"Cyanide, Colorimetric Method"
5030A	RCRA	1	July 1992	SW-846	"Purge-and-Trap"
5320B	APHA, AWWA, and WEF	N/A	1988	Standard Methods	"Dissolved Organic Halogen, Adsorption-Pyrolysis-Titrimetric Method"
6010A	RCRA	1	July 1992	SW-846	"Inductively Coupled Plasma-Atomic Emission Spectroscopy"
6020	RCRA	0	September 1994	SW-846	"Inductively Coupled Plasma"
7020	RCRA	0	September 1986	SW-846	"Aluminum (Atomic Absorption, Direct Aspiration)"
7040	RCRA	0	September 1986	SW-846	"Antimony (Atomic Absorption, Direct Aspiration)"
7041	RCRA	0	September 1986	SW-846	"Antimony (Atomic Absorption, Furnace Technique)"
7060A	RCRA	1	September 1994	SW-846	"Arsenic (Atomic Absorption, Furnace Technique)"
7061A	RCRA	1	July 1992	SW-846	"Arsenic (Atomic Absorption, Gaseous Hydride)"
7062	RCRA	1	September 1994	SW-846	"Antimony and Arsenic (Atomic Absorption, Borohydride Reduction)"
7080A	RCRA	1	September 1994	SW-846	"Barium (Atomic Absorption, Direct Aspiration)"
7090	RCRA	0	September 1986	SW-846	"Beryllium (Atomic Absorption, Direct Aspiration)"
7091	RCRA	0	September 1986	SW-846	"Beryllium (Atomic Absorption, Furnace Technique)"
7110	APHA, AWWA, and WEF	N/A	1991	Standard Methods	"Gross Alpha and Gross Beta Radioactivity (Total, Suspended, and Dissolved)"
7130	RCRA	0	September 1986	SW-846	"Cadmium (Atomic Absorption, Direct Aspiration)"
7131A	RCRA	1	September 1994	SW-846	"Cadmium (Atomic Absorption, Furnace Technique)"
7140	RCRA	0	September 1986	SW-846	"Calcium (Atomic Absorption, Direct Aspiration)"
7190	RCRA	0	September 1986	SW-846	"Chromium (Atomic Absorption, Direct Aspiration)"
7191	RCRA	0	September 1986	SW-846	"Chromium (Atomic Absorption, Furnace Technique)"
7195	RCRA	0	September 1986	SW-846	"Chromium, Hexavalent (Coprecipitation)"
7196A	RCRA	1	July 1992	SW-846	"Chromium, Hexavalent (Colorimetric)"
7197	RCRA	0	September 1986	SW-846	"Chromium, Hexavalent (Chelation/Extraction)"
7198	RCRA	0	September 1986	SW-846	"Chromium, Hexavalent (Differential Pulse Polarography)"
7200	RCRA	0	September 1986	SW-846	"Cobalt (Atomic Absorption, Direct Aspiration)"
7201	RCRA	0	September 1986	SW-846	"Cobalt (Atomic Absorption, Furnace Technique)"
7210	RCRA	0	September 1986	SW-846	"Copper (Atomic Absorption, Direct Aspiration)"
7211	RCRA	0	July 1992	SW-846	"Copper (Atomic Absorption, Furnace Technique)"

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
7380	RCRA	0	September 1986	SW-846	"Iron (Atomic Absorption, Direct Aspiration)"
7381	RCRA	0	July 1992	SW-846	"Iron (Atomic Absorption, Furnace Technique)"
7420	RCRA	0	September 1986	SW-846	"Lead (Atomic Absorption, Direct Aspiration)"
7421	RCRA	0	September 1986	SW-846	"Lead (Atomic Absorption, Furnace Technique)"
7430	RCRA	0	July 1992	SW-846	"Lithium (Atomic Absorption, Direct Aspiration)"
7450	RCRA	0	September 1986	SW-846	"Magnesium (Atomic Absorption, Direct Aspiration)"
7460	RCRA	0	September 1986	SW-846	"Manganese (Atomic Absorption, Direct Aspiration)"
7461	RCRA	0	July 1992	SW-846	"Manganese (Atomic Absorption, Furnace Technique)"
7470A	RCRA	1	September 1994	SW-846	"Mercury in Liquid Waste (Manual Cold-Vapor Technique)"
7471A	RCRA	1	September 1994	SW-846	"Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique)"
7480	RCRA	0	September 1986	SW-846	"Molybdenum (Atomic Absorption, Direct Aspiration)"
7481	RCRA	0	September 1986	SW-846	"Molybdenum (Atomic Absorption, Furnace Technique)"
7500-^{3}H	APHA, AWWA, and WEF	N/A	1988	Standard Methods	"Tritium"
7520	RCRA	0	September 1986	SW-846	"Nickel (Atomic Absorption, Direct Aspiration)"
7550	RCRA	0	September 1986	SW-846	"Osmium (Atomic Absorption, Direct Aspiration)"
7610	RCRA	0	September 1986	SW-846	"Potassium (Atomic Absorption, Direct Aspiration)"
7740	RCRA	0	September 1986	SW-846	"Selenium (Atomic Absorption, Furnace Technique)"
7741A	RCRA	1	September 1994	SW-846	"Selenium (Atomic Absorption, Gaseous Hydride)"
7742	RCRA	0	September 1994	SW-846	"Selenium (Atomic Absorption, Borohydride Reduction)"
7760A	RCRA	1	July 1992	SW-846	"Silver (Atomic Absorption, Direct Aspiration)"
7761	RCRA	0	July 1992	SW-846	"Silver (Atomic Absorption, Furnace Technique)"
7770	RCRA	0	September 1986	SW-846	"Sodium (Atomic Absorption, Direct Aspiration)"
7780	RCRA	0	July 1992	SW-846	"Strontium (Atomic Absorption, Direct Aspiration)"
7840	RCRA	0	September 1986	SW-846	"Thallium (Atomic Absorption, Direct Aspiration)"
7841	RCRA	0	September 1986	SW-846	"Thallium (Atomic Absorption, Furnace Technique)"
7870	RCRA	0	September 1986	SW-846	"Tin (Atomic Absorption, Direct Aspiration)"
7910	RCRA	0	September 1986	SW-846	"Vanadium (Atomic Absorption, Direct Aspiration)"
7911	RCRA	0	September 1986	SW-846	"Vanadium (Atomic Absorption, Furnace Technique)"
7950	RCRA	0	September 1986	SW-846	"Zinc (Atomic Absorption, Direct Aspiration)"

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TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
7951	RCRA	0	July 1992	SW-846	"Zinc (Atomic Absorption, Furnace Technique)"
8010B	RCRA	2	September 1994	SW-846	"Halogenated Volatile Organics by Gas Chromatography"
8020A	RCRA	1	September 1994	SW-846	"Aromatic Volatile Organics by Gas Chromatography"
8021A	RCRA	1	September 1994	SW-846	"Halogenated Volatiles by Gas Chromatography Using Photoionization and Electrolytic Conductivity Detectors in Series: Capillary Column Technique"
8030A	RCRA	1	July 1992	SW-846	"Acrolein and Acrylonitrile by Gas Chromatography"
8080A	RCRA	1	September 1994	SW-846	"Organochlorine Pesticides and Polychlorinated Biphenyls by Gas Chromatography"
8100	RCRA	0	September 1986	SW-846	"Polynuclear Aromatic Hydrocarbons"
8140	RCRA	0	September 1986	SW-846	"Organophosphorus Pesticides"
8141A	RCRA	1	September 1994	SW-846	"Organophosphorus Compounds by Gas Chromatography: Capillary Column Technique"
8150B	RCRA	2	September 1994	SW-846	"Chlorinated Herbicides by Gas Chromatography"
8240B	RCRA	2	September 1994	SW-846	"Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)"
8260A	RCRA	1	September 1994	SW-846	"Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique"
8270B	RCRA	2	September 1994	SW-846	"Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique"
8280	RCRA	0	September 1986	SW-846	"The Analysis of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans"
8290	RCRA	0	September 1994	SW-846	"Polychlorinated Dibenzodioxins (PCDDs) and Polychlorinated Dibenzofurans (PCDFs) by High-Resolution Gas Chromatography/High-Resolution Mass Spectrometry (HRGC/HRMS)"
8310	RCRA	0	September 1986	SW-846	"Polynuclear Aromatic Hydrocarbons"
8330	RCRA	0	September 1994	SW-846	"Nitroaromatics and Nitramines by High Performance Liquid Chromatography (HPLC)"
9010A	RCRA	1	July 1992	SW-846	"Total and Amenable Cyanide"
9012	RCRA	0	September 1986	SW-846	"Total and Amenable Cyanide (Colorimetric, Automated UV)"
9020B	RCRA	2	September 1994	SW-846	"Total Organic Halides (TOX)"
9030A	RCRA	1	July 1992	SW-846	"Acid-Soluble and Acid-Insoluble Sulfides"

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TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

Method Number	Approved by[1]	Version Number	Version Date[2]	Source/Document Number[3]	Method Title
9038	RCRA	0	September 1986	SW-846	"Sulfate (Turbidimetric)"
9040B	RCRA	2	January 1995	SW-846	"pH Electrometric Measurement"
9045C	RCRA	3	January 1995	SW-846	"Solid and Waste pH"
9050	RCRA	0	September 1986	SW-846	"Specific Conductance"
9056	RCRA	0	September 1994	SW-846	"Determination of Inorganic Anions by Ion Chromatography"
9060	RCRA	0	September 1986	SW-846	"Total Organic Carbon"
9065	RCRA	0	September 1986	SW-846	"Phenolics (Spectrophotometric, Manual 4-AAP with Distillation)"
9066	RCRA	0	September 1986	SW-846	"Phenolics (Colorimetric, Automated 4-AAP with Distillation)"
9070	RCRA	0	September 1986	SW-846	"Total Recoverable Oil and Grease (Gravimetric, Separatory Funnel Extraction)"
9071A	RCRA	1	September 1994	SW-846	"Oil and Grease Extraction Method for Sludge and Sediment Samples"
9200	RCRA	0	September 1986	SW-846	"Nitrate"
9251	RCRA	0	September 1986	SW-846	"Chloride (Colorimetric, Automated Ferricyanide AAI)"
9252A	RCRA	1	September 1994	SW-846	"Chloride (Titrimetric, Mercuric Nitrate)"
9310	RCRA	0	September 1986	SW-846	"Gross Alpha and Gross Beta"
9315	RCRA	0	September 1986	SW-846	"Alpha-Emitting Radium Isotopes"
9320	RCRA	0	September 1986	SW-846	"Radium-228"

[1] NPDES - National Pollutant Discharge Elimination System
RCRA - Resource Conservation and Recovery Act
USEPA - United States Environmental Protection Agency
ASTM - American Society for Testing and Materials
GAC - Goodyear Atomic Corporation
APHA - American Public Health Association
AWWA - American Water Works Association
WEF - Water Environment Federation
The co-publishers for Standard Methods for the Examination of Water and Wastewater are APHA, AWWA, and WEF.

TABLE 8.2-1
Analytical Methods Routinely Performed by Quanterra®
(Continued)

[2] For the NPDES methods, the date listed is the date the method was issued if no revisions were made. If a technical or editorial revision was made, the latest of those dates is listed here.

[3] The following table provides full source references:

Source	Source Reference
40CFR Part 136 - Appendix A	40CFR Part 136 - "Guidelines Establishing Test Procedures for the Analysis of Pollutants , Appendix A: "Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater", Code of Federal Regulations, Revised July 1, 1995.
ASTM	1993 Annual Book of ASTM Standards, Section 11, Water and Environmental Technology, Volume 11.02, Water (II).
EPA-600/4-84-041	"Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air", Document No.: EPA-600/4-84-041, Environmental Monitoring System Laboratory, Office of Research and Development, United States Environmental Protection Agency, Research Triangle Park, North Carolina 27711, April 1984.
EPA-821-B-94-004b	Proposed Method 1664: "N-Hexane Extractable Material (HEM) and Silica Gel Treated N-Hexane Extractable Material (SGT-HEM) by Extraction and Gravimetry (Oil and Grease Total Petroleum Hydrocarbons)", Document No.: EPA-821-B-94-004b, Office of Water, Engineering and Analysis Division, Washington, D.C., 20460, April 1995. (This method has not been promulgated by the EPA).
EPA/600/4-80-032	"Prescribed Procedures for Measurement of Radioactivity in Drinking Water", Document No.: EPA/600/4-80-032, EMSL, Cincinnati, OH 45268, August 1980.
EPA/600/R-93/100	"Methods for the Determination of Inorganic Substances in Environmental Samples", Document Number EPA/600/R-93/100. Office of Research and Development, Washington, D.C. 20460, August 1993.
EPA/600/R-94/111	"Methods for the Determination of Metals in Environmental Samples", Supplement I, EMSL-CI, May 1994.
MCAWW	Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983, United States Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio 45268.
Standard Methods	Standard Methods for the Examination of Water and Wastewater, 18th Edition, 1992. Prepared and published jointly by: APHA, AWWA, and WEF.
SW-846	Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), and Final Update IIB (January 1995). United States Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC 20460.
USEPA CLP (DFLM01.1)	United States Environmental Protection Agency, Statement of Work for Analysis of Polychlorinated Dibenzo-p-Dioxins and Polychlorinated Dibenzofurans (PCDF).
USEPA CLP (ILM01.8)	United States Environmental Protection Agency, Statement of Work for Organics Analysis, Multi-Media, Multi-Concentration, Document Number OLM01.0 (including revisions OLM01.1 (December 1990), OLM01.2 (January 1991), OLM01.3 (February 1991), OLM01.4 (March 1991), OLM01.5 (April 1991), OLM01.6 (June 1991), OLM01.7 (July 1991), and OLM01.8 (August 1991).
USEPA CLP (ILM03.0)	United States Environmental Protection Agency, Statement of Work for Inorganics Analysis, Multi-Media, Multi-Concentration, Document Number ILM03.0.
USEPA CLP (OLM03.0)	United States Environmental Protection Agency, Statement of Work for Organics Analysis, Document Number OLM03.0.

[4] This is an SW-846 Proposed Update III method and has not been promulgated. Proposed Update III was released for public comment January 1995.

TABLE 8.4-1
Field Quality Control Samples

Type	Applicability		Accuracy and Precision Application	Introduced By
	Inorganic	Organic		
Trip Blank (volatiles)	No	Yes	Accuracy	Supplier of Containers
Field Blank	Yes	Yes	Accuracy	Field Sampler
Rinsate Blank	Yes	Yes	Accuracy	Field Sampler
Collocated Sample	Yes	Yes	Precision	Field Sampler
Split Sample	Yes	Yes	Precision	Field Sampler
Field Duplicate	Yes	Yes	Precision	Field Sampler
Field Matrix Spike	Yes	Yes	Accuracy	Field Sampler

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TABLE 8.4-2
Laboratory Quality Control Samples

Type	Frequency	Applicability		Accuracy and Precision Application	Introduced By
		Inorganic/ Radiochemical	Organic		
Analytical Spike	As specified in methods, or as needed	Yes	No	Accuracy	Analyst/ Prep
Duplicate	1 out of 20 or at least 1/month/run	Yes	Yes	Precision	Analyst/ Prep
Instrument Blank	As specified methods, or as needed	Yes	Yes	Accuracy	Analyst
Interference Check Sample	As specified in methods	Yes	No	Accuracy	Analyst
Internal Standard	Each sample and standard	Yes	Yes	Both	Analyst/ Prep
Laboratory Control Sample	1 per each group of samples processed up to 20 samples.	Yes	Yes	Accuracy	Analyst/ Prep
Matrix Spike	1 per each group of samples processed up to 20 samples.	Yes	Yes	Accuracy	Analyst/ Prep
Matrix Spike Duplicate	1 per each group of samples processed up to 20 samples.	Yes	Yes	Both	Analyst/ Prep
Method Blank	1 per each group of samples processed up to 20 samples.	Yes	Yes	Accuracy	Analyst/ Prep
Surrogate	All standards, method blanks, LCS, and samples.	No	Yes Method Dependent	Accuracy	Analyst/ Prep
Yield Monitor	Operation-specific	Yes	No	Accuracy	Prep

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TABLE 8.4-3
Laboratory Performance Quality Control Samples

Sample/Measurement	Purpose
Method Blanks	Demonstrates that the laboratory systems (*e.g.*, glassware cleaning procedures) and laboratory reagents used for the preparation and analysis of samples have not contributed to a false positive or negative measurement.
Instrument Blank	Demonstrates that the analytical system has not contributed to a false positive or negative measurement.
Laboratory Control Sample	Demonstrates the laboratory's ability to perform an analysis within the performance requirements of the method.

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TABLE 8.4-4
Matrix Specific Quality Control Samples

Quality Control Sample	Purpose
Duplicate Samples	Estimates the ability of the laboratory to obtain precise measurements on a sample. This measure is dependent on the homogeneity of the sample being duplicated. Solid samples often portray poor sample homogeneity and therefore often have poor duplication with regards to the sample result.
Matrix Spike Sample	Estimates the ability of the laboratory to obtain accurate measurements on a sample. The measure is dependent on the bias a sample matrix may cause regarding a given analyte.
Matrix Spike Duplicate Sample	In addition to verifying the accuracy of the matrix spike sample, the matrix spike duplicate can be used with the matrix spike sample as a measure of precision by calculating the relative percent difference (RPD).

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Acidity	Method Blank	305.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	305.1	Not Applicable	—	Not Applicable
	Matrix Spike	305.1	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	305.1	Not Applicable	—	Not Applicable
	Duplicate	305.1	Frequency: 1 per batch of 10 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Alkalinity	Method Blank	310.1 2320B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	310.1 2320B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	310.1 2320B	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	310.1 2320B	Not Applicable	—	Not Applicable
	Duplicate	310.1 2320B	Frequency: 1 per batch of 10 samples Criteria 310.1: ≤ 20 % RPD[3] Criteria 2320B: ≤ 25 % RPD[3] Corrective Action: Flag data outside of limit.	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
Ammonia	Method Blank	350.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	350.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	350.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	350.1	Not Applicable	—	Not Applicable
	Duplicate	350.1	Not Applicable	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Ammonia (TKN)	Method Blank	351.2 351.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	351.2 351.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	351.2 351.3	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	351.2 351.3	Not Applicable	—	Not Applicable
	Duplicate	351.2 351.3	Not Applicable	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
BOD	Method Blank	405.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	405.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	405.1	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	405.1	Not Applicable	—	Not Applicable
	Duplicate	405.1	Not Applicable	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Bromide	Method Blank	300.0[6] 320.1 D1246	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	300.0[6] 320.1 D1246	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within control limits, rerun all associated samples	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within control limits, rerun all associated samples
	Matrix Spike	300.0[6] 320.1 D1246	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data associated with MS outside of limit
	Matrix Spike Duplicate	300.0[6] 320.1 D1246	Not Applicable	9056	Not Applicable
	Duplicate	300.0[6] 320.1 D1246	Methods 300.0, 320.1: Not Applicable Frequency: Method D1246: 1 with each batch of samples processed not to exceed 20 samples	9056	Frequency: 1 with each batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data associated with duplicates outside of laboratory RPD[3] limits

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Chemical Oxygen Demand (COD)	Method Blank	410.1 410.2 410.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	410.1 410.2 410.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	410.1 410.2 410.4	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	410.1 410.2 410.4	Not Applicable	—	Not Applicable
	Duplicate	410.1 410.2 410.4	Not Applicable	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Chloride	Method Blank	300.0[6] 325.1 325.2 325.3 4500-Cl E	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9056 9251 9252A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	300.0[6] 325.1 325.2 325.3 4500-Cl E	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within control limits, rerun all associated samples	9056 9251 9252A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	300.0[6] 325.1 325.2 325.3 4500-Cl E	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9056 9251 9252A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Methods 9251/9252 Corrective Action: If not within laboratory control limits, rerun all associated samples Method 9056 Corrective Action: Flag data associated with MS outside of limits

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Chloride (continued)	Matrix Spike Duplicate	300.0[6] 325.1 325.2 325.3 4500-Cl E	Not Applicable	9056 9251 9252A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits/< 20 % RPD[3] Corrective Action: Flag data outside of limit Method 9056: MSD is not applicable
	Duplicate	300.0[6] 325.1 325.2 325.3 4500-Cl E	Methods 300.0, 325.1, 325.2, 325.3: Not Applicable Method 4500-Cl E: Frequency: 1 with each batch of samples processed not to exceed 20 samples	9056 9251 9252A	Method 9056 only: Frequency: 1 with each batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data associated with duplicates outside of laboratory RPD[3] limits
Chlorine, Residual	Method Blank	330.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Chlorine, Residual (continued)	Laboratory Control Sample	330.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	330.1 330.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	330.1 330.3	Not Applicable	—	Not Applicable
	Duplicate	330.1 330.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	—	Water

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
Chromium (Cr^{+6})	Method Blank	218.4 3500 Cr-D	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	3060A [5] 7196A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	218.4 3500 Cr-D	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	3060A [5] 7196A	Frequency: 1 with each batch of samples processed not to exceed 20 samples prepped Criteria: percent recovery for water must be within ± 15 % and for solids must be within ± 20% Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	218.4 3500 Cr-D	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag data outside of limit	3060A [5] 7196A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Advisory limits are 75% - 125% recovery Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	218.4 3500 Cr-D	Not Applicable	3060A [5] 7196A	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Chromium (Cr^{+6}) (continued)	Duplicate	218.4 3500 Cr-D	Not Applicable	3060A[5] 7196A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] limit Corrective Action: Flag data outside of limit.
Color	Method Blank	110.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	110.2	Not Applicable	—	Not Applicable
	Matrix Spike	110.2	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	110.2	Not Applicable	—	Not Applicable
	Duplicate	110.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	—	Not Applicable
Conductivity	Method Blank	120.1	Not Applicable	9050	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Conductivity (continued)	Laboratory Control Sample	120.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9050	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	120.1	Not Applicable	9050	Not Applicable
	Matrix Spike Duplicate	120.1	Not Applicable	9050	Not Applicable
	Duplicate	120.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	9050	Frequency: 1 with each batch of samples processed not to exceed 10 samples
Cyanide (Amenable)	Method Blank	335.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Cyanide (Amenable) (continued)	Laboratory Control Sample	335.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	335.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Advisory limits are 75% - 125% recovery Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	335.1	Not Applicable	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Advisory limits are 75% - 125% recovery Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	335.1	Not Applicable	9010A 9012	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Cyanide (Total)	Method Blank	335.2 335.3 4500-CN E	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	335.2 335.3 4500-CN E	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	335.2 335.3 4500-CN E	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Advisory limit is 75% - 125% recovery Corrective Action: Flag data associated with unacceptable Matrix Spike

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Cyanide (Total) (continued)	Matrix Spike Duplicate	335.2 335.3 4500-CN E	Not Applicable	9010A 9012	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Limit is 75% - 125% recovery Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	335.2 335.3	Methods 335.2, 335.3: Not Applicable Method 4500-CN E: Frequecny: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	9010A 9012	Not Applicable
Flashpoint	Method Blank	—	Not Applicable	1010 1020A	Not Applicable
	Laboratory Control Sample	—	Not Applicable	1010 1020A	Not Applicable
	Matrix Spike	—	Not Applicable	1010 1020A	Not Applicable
	Matrix Spike Duplicate	—	Not Applicable	1010 1020A	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Flashpoint (continued)	Duplicate	—	Not Applicable	1010 1020A	Frequency: 1 per batch of ≤20 samples Criteria: RPD[3] must be ≤ 20% Corrective Action: Flag data associated with unacceptable Duplicate
Fluoride	Method Blank	300.0[6] 340.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable
	Laboratory Control Sample	300.0[6] 340.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within control limits, rerun all associated samples

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Fluoride (continued)	Matrix Spike	300.0[6] 340.2	Frequency: 1 per 10 samples by IC Criteria: Must be within laboratory QC limits Corrective Action: Flag data outside of limit	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data associated with outside of limit
	Matrix Spike Duplicate	300.0[6] 340.2	Not Applicable	9056	Not Applicable
	Duplicate	300.0[6] 340.2	Not Applicable	9056	Frequency: 1 with each batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data associated with duplicates outside of laboratory RPD[3] limits
Hardness	Method Blank	130.2 2340B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Hardness (continued)	Laboratory Control Sample	130.2 2340B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	130.2 2340B	Method 130.2, Not Applicable Method 2340B: Frequency , Criteria, and Corrective Action: See ICP Metals Method 200.7 Requirements	—	Not Applicable
	Matrix Spike Duplicate	130.2 2340B	Method 130.2, Not Applicable Method 2340B: Frequency, Criteria, and Corrective Action: See ICP Metals Method 200.7 Requirements	—	Not Applicable
	Duplicate	130.2 2340B	Frequency: 1 per 20 samples, minimum of one per batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Iodide	Method Blank	345.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	345.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	345.1	Frequency: 1 per batch of 20 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag associated data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	345.1	Not Applicable	—	Not Applicable
	Duplicate	345.1	Not Applicable	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Iron	Method Blank	3500-Fe D	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	3500-Fe D	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	3500-Fe D	Frequency: 1 every 10 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag associated data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	3500-Fe D	Not Applicable	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Iron (continued)	Duplicate	3500-Fe D	Frequency: 1 per batch of 20 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag associated data outside of limit	—	Not Applicable
Methylene Blue Active Substances (MBAS)	Method Blank	425.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	425.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Methylene Blue Active Substances (MBAS) (continued)	Matrix Spike	425.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	425.1	Not Applicable	—	Not Applicable
	Duplicate	425.1	Not Applicable	—	Not Applicable
Nitrate	Method Blank	300.0[6] 352.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9056 9200	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	300.0[6] 352.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9056 9200	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitrate (continued)	Matrix Spike	300.0[6] 352.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Must be within laboratory control limits Corrective Action: Flag data outside of limit	9056 9200	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, flag all associated samples
	Matrix Spike Duplicate	300.0[6] 352.1	Not Applicable	9056 9200	Method 9056: Not applicable Method 9200: Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery and RPD[3] must be within laboratory control limits Corrective Action: If not within laboratory control limits, flag all associated samples
	Duplicate	300.0[6] 352.1	Not Applicable	9056 9200	Method 9056: Frequency: 1 per 10 samples Criteria: RPD[3] must be within laboratory control limits Corrective Action: If not within laboratory control limits, flag all associated samples Method 9200: Not applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitrite	Method Blank	300.0[6] 354.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	300.0[6] 354.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	300.0[6] 354.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Must be within laboratory control limits Corrective Action: Flag data outside of limit	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, flag all associated samples
	Matrix Spike Duplicate	300.0[6] 354.1	Not Applicable	9056	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitrite (continued)	Duplicate	300.0[6] 354.1	Not Applicable	9056	Frequency: 1 per 10 samples Criteria: RPD[3] must be within laboratory control limits Corrective Action: If not within laboratory control limits, flag all associated samples
Nitrate-Nitrite	Method Blank	353.1 353.2 353.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	353.1 353.2 353.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitrate-Nitrite (continued)	Matrix Spike	353.1 353.2 353.3	Frequency: 1 per 20 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	353.1 353.2 353.3	Not Applicable	—	Not Applicable
	Duplicate	353.1 353.2 353.3	Not Applicable	—	Not Applicable
Odor	Method Blank	140.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	140.1	Not Applicable	—	Not Applicable
	Matrix Spike	140.1	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	140.1	Not Applicable	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Odor (continued)	Duplicate	140.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	—	Not Applicable
pH	Method Blank	150.1 4500-H^+ B	Not Applicable	9040B 9045C	Not Applicable
	Laboratory Control Sample	150.1 4500-H^+ B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Sample provided by external source, must be within ± 0.05 pH units Corrective Action: If not within laboratory control limits, rerun all associated samples	9040B 9045C	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Sample provided by external source, must be within ± 0.05 pH units Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	150.1 4500-H^+ B	Not Applicable	9040B 9045C	Not Applicable
	Matrix Spike Duplicate	150.1 4500-H^+ B	Not Applicable	9040B 9045C	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
pH (continued)	Duplicate	150.1 4500-H^+ B	Method 150.1 Frequency: 1 with each batch of samples processed not to exceed 20 samples Method 4500-H^+B Frequency: 1 with each batch of 10 samples Method 150.1 Criteria: ≤ 20 % RPD[3] limit Method 4500-H^+B Criteria: ≤ 25 % RPD[3] limit Corrective Action: Flag data outside of limit.	9040B 9045C	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Advisory limits are ≤ 20% RPD[3] Corrective Action: Flag data associated with unacceptable Duplicate
Phenolics	Method Blank	420.1 420.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9065 9066	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	420.1 420.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9065 9066	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Phenolics (continued)	Matrix Spike	420.1 420.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data associated with unacceptable Matrix Spike	9065 9066	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data
	Matrix Spike Duplicate	420.1 420.2	Not Applicable	9065 9066	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data
	Duplicate	420.1 420.2	Not Applicable	9065 9066	Not Applicable
Phosphate	Method Blank	---	Not Applicable	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	---	Not Applicable	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Phosphate (continued)	Matrix Spike	—	Not Applicable	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data associated with MS outside of limits
	Matrix Spike Duplicate	—	Not Applicable	9056	Not Applicable
	Duplicate	—	Not Applicable	9056	Frequency: 1 with each batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data associated with duplicates outside of laboratory RPD[3] limits
Phosphorus (Total and Ortho-phosphate)	Method Blank	300.0[4,6] 365.1 365.2 365.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicablne

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Phosphorus (Total and Ortho-phosphate) (continued)	Laboratory Control Sample	300.0[4,6] 365.1 365.2 365.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	300.0[4,6] 365.1 365.2 365.3	Frequency: 1 per 10 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	300.0[4,6] 365.1 365.2 365.3	Not Applicable	—	Not Applicable
	Duplicate	300.0[4,6] 365.1 365.2 365.3	Not Applicable	—	Not Applicable
Reactivity (Cyanide and Sulfide)	Method Blank	—	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Reactivity (Cyanide and Sulfide) (continued)	Laboratory Control Sample	—	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	—	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	Follow QC sample requirements of determinative method
	Matrix Spike Duplicate	—	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	Follow QC sample requirements of determinative method
	Duplicate	—	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	Not Applicable
Silica, Dissolved	Method Blank	370.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Silica, Dissolved (continued)	Laboratory Control Sample	370.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	370.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	370.1	Not Applicable	—	Not Applicable
	Duplicate	370.1	Not Applicable	—	Not Applicable
Solids	Method Blank	160.1 160.2 160.3 160.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Solids (continued)	Laboratory Control Sample	160.1 160.2 160.3 160.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	160.1 160.2 160.3 160.4	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	160.1 160.2 160.3 160.4	Not Applicable	—	Not Applicable
	Duplicate	160.1 160.2 160.3 160.4 160.5	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag data outside of limit	—	Not Applicable
Specific Conductance	Method Blank	120.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9050	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Specific Conductance (continued)	Laboratory Control Sample	120.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9050	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	120.1	Not Applicable	9050	Not Applicable
	Matrix Spike Duplicate	120.1	Not Applicable	9050	Not Applicable
	Duplicate	120.1	Frequency: 1 with each batch of 20 samples processed Criteria: RPD[3] must be within laboratory QC limits Corrective Action: Flag associated data if outside of limits	9038 9050	Frequency: 1 with each batch of 20 samples processed Criteria: RPD[3] must be within laboratory QC limits Corrective Action: Flag associated data if outside of limits
Sulfate	Method Blank	300.0[6] 375.1 375.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9038 9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Sulfate (continued)	Laboratory Control Sample	300.0[6] 375.1 375.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9038 9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Method 9038 Criteria: Percent recovery must be within ± 15 % Method 9056 Criteria: Percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS (ICV)
	Matrix Spike	300.0[6] 375.1 375.4	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9038 9056	Frequency: 1 with each batch of samples processed not to exceed 10 samples (Method 9038) or 20 samples (Method 9056) Method 9038 Criteria: Limits are 75% - 125% recovery Method 9056 Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	300.0[6] 375.1 375.4	Not Applicable	9038 9056	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Sulfate (continued)	Duplicate	300.0[6] 375.1 375.4	Not Applicable	9038 9056	Frequency: 1 with each batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data associated with duplicates outside of laboratory RPD[3] limits
Sulfide	Method Blank	376.1 376.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	376.1 376.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Sulfide (continued)	Matrix Spike	376.1 376.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data
	Matrix Spike Duplicate	376.1 376.2	Not Applicable	9030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data
	Duplicate	376.1 376.2	Not Applicable	9030A	Not Applicable
Sulfite	Method Blank	377.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Sulfite (continued)	Laboratory Control Sample	377.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	377.1	Frequency: 1 per 20 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	377.1	Not Applicable	—	Not Applicable
	Duplicate	377.1	Not Applicable	—	Not Applicable
Temperature	Method Blank	170.1	Not Applicable	—	Not Applicable
	Laboratory Control Sample	170.1	Not Applicable	—	Not Applicable
	Matrix Spike	170.1	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	170.1	Not Applicable	—	Not Applicable
	Duplicate	170.1	Not Applicable	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Total Organic Carbon (TOC)	Method Blank	415.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9060	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	415.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9060	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	415.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9060	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Reanalyze if sample remaining. If not, flag data associated with unacceptable Matrix Spike

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Total Organic Carbon (TOC) (continued)	Matrix Spike Duplicate	415.1	Not Applicable	9060	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Reanalyze if sample remaining. If not, flag data associated with unacceptable Matrix Spike Duplicate
	Duplicate	415.1	Not Applicable	9060	Not Applicable
Total Organic Halides (TOX)	Method Blank	SM 5320B [6] 450.1 [6]	Frequency: 1 with each set of 8 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9020B	Frequency: Run in duplicate between each group of 8 analytical determinations Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	SM 5320B [6] 450.1 [6]	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery of analyte must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS (ICV)	9020B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery of analyte must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS (ICV)

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Total Organic Halides (TOX) (continued)	Matrix Spike	SM 5320B [6] 450.1 [6]	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Must be within laboratory control limits Corrective Action: Reanalyze if sample remaining. If not, flag data with unacceptable Matrix Spike	9020B	Frequency: 1 per batch of 10 samples Criteria: Must be within laboratory control limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	SM 5320B [6] 450.1 [6]	Not Applicable	9020B	Not Applicable
	Duplicate	SM 5320B [6] 450.1 [6]	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] limit Corrective Action: Flag data outside of limit.	9020B	Frequency: All samples will be analyzed in duplicate Criteria: ≤ 20 % RPD[3] limit Corrective Action: Flag data outside of limit.
Turbidity	Method Blank	180.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Turbidity (continued)	Laboratory Control Sample	180.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	180.1	Not applicable	—	Not Applicable
	Matrix Spike Duplicate	180.1	Not Applicable	—	Not Applicable
	Duplicate	180.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag data outside of limit Not Applicable.	—	Not Applicable
Water Content	Method Blank	—	Not Applicable	—	Not Applicable
	Laboratory Control Sample	—	Not Applicable	—	Not Applicable
	Matrix Spike	—	Not Applicable	—	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Water Content (continued)	Matrix Spike Duplicate	—	Not Applicable	—	Not Applicable
	Duplicate	—	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	—	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] limit Corrective Action: Reanalyze if sample remaining. If not, flag data outside of limit.
GFAA and Flame AA Metals, Mercury by CVAA	Method Blank	200 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	7000 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	200 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery of analyte must be within ± 20 % Corrective Action: Rerun all samples associated with unacceptable LCS	7000 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery of analyte must be within ± 20 % Corrective Action: Rerun all samples associated with unacceptable LCS

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
GFAA and Flame AA Metals, Mercury by CVAA (continued)	Matrix Spike	200 series	Frequency: with each batch of samples processed not to exceed 20 samples Criteria: Recovery must be within 80-120 % Corrective Action: Flag data associated with unacceptable MS. (See SOP for detailed corrective action procedure and for other QC procedures.)	7000 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery must be within 80-120 % Corrective Action: Flag data associated with unacceptable MS. (See SOP for detailed corrective action procedure and for other QC procedures.)
	Matrix Spike Duplicate	200 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery must be within 80-120 %, RPD[3] must be within 20 % Corrective Action: Flag data associated with unacceptable MSD	7000 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery must be within 80-120 %, RPD[3] must be within 20 % Corrective Action: Flag data associated with unacceptable MSD
	Duplicate	200 series	Not Applicable	7000 series	Not Applicable
	Post Digestion Spikes	200 series	Post Digestion Spike is conducted on all samples	7000 series	Post Digestion Spike is conducted on all samples
ICP Metals	Method Blank	200.7	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	6010A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
ICP Metals (continued)	Laboratory Control Sample	200.7	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery of analyte must be ± 20 % Corrective Action: Rerun all samples associated with unacceptable LCS	6010A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery of analyte must be ± 20 % Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	200.7	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Limits for percent recovery are 80-120% Corrective Action: Flag data associated with unacceptable Matrix Spike	6010A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Limits for percent recovery are 80-120% Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	200.7	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Limits for percent recovery are 80-120%, RPD[3] must be within 20 % Corrective Action: Flag data associated with unacceptable Matrix Spike	6010A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Limits for percent recovery are 80-120%, RPD[3] must be within 20 % Corrective Action: Flag data associated with unacceptable Matrix Spike

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
ICP Metals (continued)	Duplicate	200.7	Not Applicable	6010A	Not Applicable
	Serial Dilutions	200.7	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: 10 % Difference Corrective Action: Flag data associated with unacceptable Serial Dilution	6010A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: 10 % Difference Corrective Action: Flag data associated with unacceptable Serial Dilution
ICP/MS Metals	Method Blank	200.8	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	6020	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	200.8	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS	6020	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable blank
	Matrix Spike	200.8	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Recovery within laboratory control limits Corrective Action: Qualify data "suspect/matrix"	6020	Not Applicable

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TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
ICP/MS Metals (continued)	Matrix Spike Duplicate	200.8	Not Applicable	6020	Not Applicable
	Duplicate	200.8	Not Applicable	6020	Frequency: 1 per 20 samples, minimum of one per batch of samples processed Criteria: 20% RPD[3] Corrective Action: Re-analyze samples associated with unacceptable duplicate
	Post Duplicate Spike	200.8	Not Applicable	6020	Frequency: 1 per 20 samples Criteria: 75-125% Corrective Action: Dilute and reanalyze
	Serial 5x Dilution	200.8	Not Applicable	6020	Frequency: 1 per 20 samples Criteria: ± 10% D Corrective Action: Use alternate isotope or quality data "suspect/matrix"

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Footnotes

(1) National Pollutant Discharge Elimination System
(2) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), and Final Update IIB (January 1995).
(3) RPD-Relative Percent Difference
(4) Orthophosphate only
(5) This is an SW-846 Proposed Update III Method
(6) Method not listed in 40 CFR Part 136.

TABLE 8.4-6
Organic Laboratory Quality Control Samples

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Aromatic Volatiles by GC	Method Blank	602	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8020A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	602	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8020A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	602	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8020A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Aromatic Volatiles by GC (continued)	Matrix Spike Duplicate	602	Not Applicable	8020A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	602	Not Applicable	8020A	Not Applicable
	Surrogates	602	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria	8020A	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	602	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.	8020A	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Acrolein & Acrylonitrile by GC	Method Blank	603	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	603	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	603	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Acrolein & Acrylonitrile by GC (continued)	Matrix Spike Duplicate	603	Not Applicable	8030A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	603	Not Applicable	8030A	Not Applicable
	Surrogates	603	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria	8030A	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	603	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.	8030A	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Dioxins/ Dibenzo-furans	Method Blank	613	Frequency: 1 per batch of ≤ 20 samples extracted Criteria: Concentration less than reporting limit Corrective Action: Rerun all positive samples associated with unacceptable blank	8280 8290	Frequency: 1 per batch of ≤ 20 samples extracted Criteria: Concentration less than reporting limit Corrective Action: Rerun all positive samples associated with unacceptable blank
	Laboratory Control Sample	613	Frequency: 1 per batch of ≤ 20 samples extracted Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8280 8290	Frequency: 1 per batch of ≤ 20 samples extracted Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	613	Frequency: 1 per analytical batch of ≤ 20 samples Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8280 8290	Frequency: 1 per analytical batch of ≤ 20 samples Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	613	Frequency: 1 per analytical batch of ≤ 20 samples Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable matrix spike Duplicate	8280 8290	Frequency: 1 per analytical batch of ≤ 20 samples Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable matrix spike duplicate

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Dioxins/ Dibenzo-furans (continued)	Duplicate	613	Not Applicable	8280 8290	Not Applicable
	Surrogates	613	Not Applicable	8280 8290	Not Applicable
	Internal Standards	613	Internal standards are added to all samples (QC samples included). Internal standard recovery should be between 40 % to 120 %.	8280 8290	Internal standards are added to all samples (QC samples included). Internal standard recovery should be between 40 % - 120 % for Method 8280 and between 40 % - 135 % for Method 8290. Use limits in laboratory SOP.
Halogenated Volatiles by GC	Method Blank	--	Not Applicable	8021A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	--	Not Applicable	8021A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
Halogenated Volatiles by GC (continued)	Matrix Spike	--	Not Applicable	8021A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	--	Not Applicable	8021A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	--	Not Applicable	8021A	Not Applicable
	Surrogates	--	Not Applicable	8021A	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria.

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Halogenated Volatiles by GC (continued)	Internal Standards	--	Not Applicable	8021A	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.
Herbicides	Method Blank	615 [3]	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Re-extract all samples associated with unacceptable blank	8150B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Re-extract all samples associated with unacceptable blank
	Laboratory Control Sample	615 [3]	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Re-extract all samples associated with unacceptable LCS	8150B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte must be within historical acceptance limits Corrective Action: Re-extract all samples associated with unacceptable LCS
	Matrix Spike	615 [3]	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8150B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
Herbicides (continued)	Matrix Spike Duplicate	615 [3]	Not Applicable	8150B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within control limits Corrective Action: Flag data associated with unacceptable matrix spike sample
	Duplicate	615 [3]	Not Applicable	8150B	Not Applicable
	Surrogates	615 [3]	Not Applicable	8150B	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must fall within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	615 [3]	Not Applicable	8150B	Optional
Nitro-aromatics by HPLC	Method Blank	--	Not Applicable	8330	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitro-aromatics by HPLC (continued)	Laboratory Control Sample	--	Not Applicable	8330	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	--	Not Applicable	8330	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	--	Not Applicable	8330	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	--	Not Applicable	8330	Not Applicable
	Surrogates	--	Not Applicable	8330	Not Applicable
	Internal Standards	--	Not Applicable	8330	Not Applicable

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
Organo-phosphorus Pesticides	Method Blank	--	Not Applicable	8140 8141A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	--	Not Applicable	8140 8141A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	--	Not Applicable	8140 8141A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable MS
	Matrix Spike Duplicate	--	Not Applicable	8140 8141A	Not Applicable
	Duplicate	--	Not Applicable	8140 8141A	Not Applicable

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Organo-phosphorus Pesticides (continued)	Surrogates	--	Not Applicable	8140 8141A	Method 8140: Not Applicable Method 8141A: Surrogates spiked into method blank and all samples (QC included) Method Blank and LCS Criteria: Results must fall within laboratory-established control limits Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
PAHs by GC and HPLC	Method Blank	610	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8100 8310	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	610	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8100 8310	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
PAHs by GC and HPLC (continued)	Matrix Spike	610	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8100 8310	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	610	Not Applicable	8100 8310	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	610	Not Applicable	8100 8310	Not Applicable
	Surrogates	610	Not specified in method	8100 8310	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: Results must fall within laboratory established control limits Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	610	Optional	8100 8310	Optional

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Pesticides/ PCBs	Method Blank	608	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8080A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	608	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8080A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	608	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8080A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Pesticides/ PCBs (continued)	Matrix Spike Duplicate	608	Not Applicable	8080A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	608	Not Applicable	8080A	Not Applicable
	Surrogates	608	Not specified in method	8080A	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: Results must fall within laboratory established control limits Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	608	Optional	8080A	Optional
Petroleum Hydro-carbons/Oil and Grease	Method Blank	413.1 413.2 418.1	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank Method 413.1: Not Applicable	9070 9071A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank Method 413.1: Not Applicable

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Petroleum Hydro-carbons/Oil and Grease (continued)	Laboratory Control Sample	413.1 413.2 418.1	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples Method 413.1: Not Applicable	9070 9071A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within ± 20% Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	413.1 413.2 418.1	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data Method 413.1: Not Applicable	9070 9071A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data
	Matrix Spike Duplicate	413.1 413.2 418.1	Not Applicable	9070 9071A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated Method 9071: Not Applicable

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Petroleum Hydro-carbons/Oil and Grease (continued)	Duplicate	413.1 413.2 418.1	Not Applicable	9070 9071A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated Method 9070: Not Applicable
	Surrogates	413.1 413.2 418.1	Not Applicable	9070 9071A	Not Applicable
	Internal Standards	413.1 413.2 418.1	Not Applicable	9070 9071A	Not Applicable
Petroleum Hydro-carbons	Method Blank	1664[4]	Frequency: 1 with each preparation batch Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	---	---

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Petroleum Hydro-carbons (continued)	Laboratory Control Sample	1664[4]	Frequency: 1 with each analytical batch Criteria: Waters - See limits in Table 2 of SOP No.: CORP-WC-0003 Soils - Percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS	---	---
	Matrix Spike	1664[4]	Frequency: 1 with every 10 samples per site Criteria: See percent recovery limits in Table 2 of SOP No. CORP-WC-0003 Corrective Action: See Section 9.6.1 of SOP No. CORP-WC-0003	---	---
	Matrix Spike Duplicate	1664[4]	Frequency: 1 with every 10 samples per site Criteria: See percent recovery and RPD limits in Table 2 of SOP No. CORP-WC-0003 Corrective Action: See Section 9.6.1 of SOP No. CORP-WC-0003	---	---
	Duplicate	1664[4]	Not Applicable	---	---

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Purgeable Halocarbons by GC	Method Blank	601	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8010B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	601	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8010B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	601	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8010B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846) [2]
Purgeable Halocarbons by GC (continued)	Matrix Spike Duplicate	601	Not Applicable	8010B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	601	Not Applicable	8010B	Not Applicable
	Surrogates	601	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria	8010B	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	601	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.	8010B	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Semivolatiles	Method Blank	625	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8270B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	625	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8270B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	625	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8270B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Semivolatiles (continued)	Matrix Spike Duplicate	625	Not Applicable	8270B	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	625	Not Applicable	8270B	Not Applicable
	Surrogates	625	Surrogates spiked into method blank and all samples (QC included) Method Blank and LCS Criteria: All surrogates must be in control before sample analysis may proceed Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria	8270B	Surrogates spiked into method blank and all samples (QC included) Method Blank and LCS Criteria: All surrogates must be in control before sample analysis may proceed Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	625	Frequency: Internal standards spiked into method blank and all samples (QC included) Criteria: All internal standard recoveries must be within laboratory control limits Corrective Action: Flag sample data not meeting internal standard recovery requirements	8270B	Internal Standards are added to all samples (QC samples included). Internal standard area of daily standard must be within -50% to +100% from the last daily calibration check standard.

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Volatiles by GC/MS	Method Blank	624	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8240B 8260A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	624	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8240B 8260A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte must be within historical acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	624	Frequency: 1 per ≤ 20 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8240B 8260A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Volatiles by GC/MS (continued)	Matrix Spike Duplicate	624	Not Applicable	8240B 8260A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	624	Not Applicable	8240B 8260A	Not Applicable
	Surrogates	624	Surrogates spiked into Method Blank and all samples (QC included) Method Blank Criteria: All surrogates must be in control before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria	8240B 8260A	Surrogates spiked into Method Blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be in control before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria
	Internal Standards	624	Frequency: Internal standards spiked into method blank and all samples (QC included) Criteria: All internal standard recoveries must be within laboratory control limits Corrective Action: Flag sample data not meeting internal standard recovery requirements	8240B 8260A	Internal Standards are added to all samples (QC samples included). Internal standard area of daily standard must be within -50 % to +100 % from the last daily calibration check standard.

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TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Footnotes

(1) National Pollutant Discharge Elimination System

(2) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), and Final Update IIB (January 1995).

(3) Method not listed in 40 CFR Part 136.

(4) Method 1664 is a proposed method only, and has not been promulgated by the EPA. These requirements are from Quanterra® SOP Number CORP-WC-0003, "HEM/SGT-HEM by Method 1664".

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples

Analysis	QC Sample	Method	Requirement
Cyanide, Total	Method Blank	ILM03.0	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than CRDL or less than 10x sample concentration Corrective Action: Reprep all samples associated with unacceptable blank
	Laboratory Control Sample	ILM03.0	Frequency: 1 with each batch of samples processed or for each SDG, whichever is more frequent Criteria: Water - 80-120% Solid - Meet control limits established for solid reference material Corrective Action: Reprep all samples associated with unacceptable LCS
	Matrix Spike	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG, whichever is more frequent Criteria: 75-125% unless sample result > 4x spike amount Corrective Action: Flag data associated with unacceptable Matrix Spike, perform post distillation spike at 2 x CRDL or 2x sample concentration whichever is greater
	Matrix Spike Duplicate	ILM03.0	Not Applicable
	Duplicate	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG whichever is more frequent Criteria: RPD ≤ 20% or ± CRDL if sample or duplicate value < 5x CRDL Corrective Action: Flag all associated data associated if duplicate results outside control limits
	Surrogates	ILM03.0	Not Applicable
	Internal Standards	ILM03.0	Not Applicable

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
ICAP (excludes mercury)	Method Blank	ILM03.0	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than CRDL or less than 10x sample concentration Corrective Action: Reprep all samples associated with unacceptable blank
	Laboratory Control Sample	ILM03.0	Frequency: 1 with each batch of samples processed or for each SDG, whichever is more frequent Criteria: Water - 80-120% except silver and antimony Solid - Meet control limits established for solid reference material Corrective Action: Reprep all samples associated with unacceptable LCS
	Matrix Spike	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG whichever is more frequent Criteria: 75-125% unless sample result > 4x spike amount Corrective Action: Flag data associated with unacceptable Matrix perform post digestion spike at 2xCRDL or 2x sample concentration whichever is greater
	Matrix Spike Duplicate	ILM03.0	Not Applicable
	Duplicate	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG whichever is more frequent Criteria: RPD ≤ 20% or ± CRDL if sample or duplicate value < 5x CRDL Corrective Action: Flag all data associated with duplicate results outside control limits

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
ICAP (excludes mercury) (continued)	Serial Dilution	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG whichever is more frequent Criteria: <10% D when sample concentration > 50x IDL Corrective Action: Flag all data associated with results outside control limits
	Surrogates	ILM03.0	Not Applicable
	Internal Standards	ILM03.0	Not Applicable.
GFAA (excludes mercury)	Method Blank	ILM03.0	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than CRDL or less than 10x sample concentration Corrective Action: Reprep all samples associated with unacceptable blank
	Laboratory Control Sample	ILM03.0	Frequency: 1 with each batch of samples processed or for each SDG, whichever is more frequent Criteria: Water - 80-120% except silver and antimony Solid - Meet control limits established for solid reference material Corrective Action: Reprep all samples associated with unacceptable LCS
	Matrix Spike	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG whichever is more frequent Criteria: 75-125% unless sample result > 4x spike amount Corrective Action: Flag data associated with unacceptable Matrix
	Matrix Spike Duplicate	ILM03.0	Not Applicable

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
GFAA (excludes mercury) (continued)	Duplicate	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG whichever is more frequent Criteria: RPD ≤ 20% or ± CRDL if sample or duplicate value < 5x CRDL Corrective Action: Flag all associated data associated if duplicate results outside control limits
	Analytical Spike	ILM03.0	Frequency: 1 with each sample except matrix spike Criteria: Evaluate per method requirements Corrective action: Perform per method requirements
	Surrogates	ILM03.0	Not Applicable
	Internal Standards	ILM03.0	Not Applicable.
Mercury (CVAA)	Method Blank	ILM03.0	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than CRDL Corrective Action: Reprep all samples associated with unacceptable blank
	Laboratory Control Sample	ILM03.0	Frequency: 1 with each batch of samples processed or for each SDG, whichever is more frequent Criteria: Water - 80-120% Solid - Meet control limits established for solid reference material Corrective Action: Reprep all samples associated with unacceptable LCS
	Matrix Spike	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG Criteria: 75-125% unless sample result > 4x spike amount Corrective Action: Flag data associated with unacceptable Matrix Spike

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Mercury (CVAA) (continued)	Matrix Spike Duplicate	ILM03.0	Not Applicable
	Duplicate	ILM03.0	Frequency: 1 with each group of samples of a similar matrix type and concentration or for each SDG whichever is more frequent Criteria: RPD ≤ 20% or ± CRDL if sample or duplicate value < 5x CRDL Corrective Action: Flag all associated data associated if duplicate results outside control limits
	Surrogates	ILM03.0	Not Applicable
	Internal Standards	ILM03.0	Not Applicable.
PCDD, PCDF	Method Blank	DFLM01.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Chemical interference or electronic noise must be less than 5% of the appropriate internal standard ion A peak that meets identification criteria must be less than 2% of the signal of the appropriate internal standard ion Corrective Action: Reprep all samples with positive results or those not meeting all identification criteria associated with unacceptable blank
	Laboratory Control Sample	DFLM01.1	Not Applicable
	Matrix Spike	DFLM01.1	Frequency: 1 for each matrix analyzed for each SDG Criteria: 50-150% Corrective Action: Verify all calculations and spiking; no further action required
	Matrix Spike Duplicate	DFLM01.1	Not Applicable

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
PCDD, PCDF (continued)	Duplicate	DFLM01.1	Frequency: 1 for each matrix analyzed for each SDG Criteria: RPD ≤ 50% Corrective Action: Verify all calculations and spiking; no further action required
	Surrogates	DFLM01.1	Not Applicable
	Internal Standards	DFLM01.1	Frequency: Internal standards are spiked into all samples and QC samples Criteria: 25 - 150% Corrective Action: Re-extract and reanalyze all samples with unacceptable surrogate recoveries
Pesticides/PCBs	Method Blank	OLM03.1	Frequency: 1 with each case of samples received (up to 20 samples), for each extraction procedure within each SDG, whichever is most frequent or whenever samples are extracted Criteria: Concentration < CRQL Corrective Action: Re-extract and reanalyze all samples associated with unacceptable blank
	Laboratory Control Sample	OLM03.1	Not Applicable.
	Matrix Spike	OLM03.1	Frequency: 1 with each case of samples received (up to 20 samples), for each extraction procedure or for each SDG, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike recoveries outside of advisory limits

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Pesticides/PCBs (continued)	Matrix Spike Duplicate	OLM03.1	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each SDG, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method RPD between MS/MSD should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike recoveries or RPD outside of advisory limits
	Duplicate	OLM03.1	Not Applicable
	Surrogates	OLM03.1	Frequency: Surrogates spiked onto all samples and QC samples Criteria: Percent recovery for each surrogate in samples should be within 30-150% Percent recovery for each surrogate in the method blank must be 30-150% Corrective Action: Flag unacceptable surrogate recoveries in samples Re-extract all samples associated with unacceptable surrogate recoveries in the method blank
	Internal Standards	OLM03.1	Not Applicable.
	Method Blank	OLM01.8	Frequency: 1 with each case of samples received (up to 20 samples and including matrix spikes and reanalyses) that are of similar matrix (water or soil) or similar concentration (soil), or 1 with each 14 calendar day period (7 calendar day for 14-day data turnaround contracts) during which samples in a case are received), or 1 whenever samples are extracted by the same procedure (continuous liquid - liquid extraction or sonication) Criteria: Concentration < CRQL Corrective Action: Re-extract and re-analyze all samples associated with unacceptable blank

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Pesticides/PCBs (continued)	Laboratory Control Sample	OLM01.8	Not Applicable
	Matrix Spike	OLM01.8	Frequency: 1 with every 20 samples of each matrix Criteria: Percent recovery should be within advisory limits given in method Corrective Action: Flag data associated with matrix spike recoveries outside of advisory limits
	Matrix Spike Duplicate	OLM01.8	Frequency: 1 with every 20 samples of each matrix Criteria: Percent recovery and RPD should be within advisory limits given in method Corrective Action: Flag data associated with percent recovery or RPD outside of advisory limits
	Duplicate	OLM01.8	Not Applicable
	Surrogates	OLM01.8	Frequency: Spiked onto all samples and QC samples Criteria: Advisory limits are 60% - 150% Corrective Action: Flag surrogate recoveries outside of advisory limits
	Internal Standards	OLM01.8	Not Applicable
Semivolatiles by GC/MS	Method Blank	OLM03.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than CRQL except phthalates which must be ≤ 5x CRQL Corrective Action: Re-extract and re-analyze all samples associated with unacceptable blank
	Laboratory Control Sample	OLM03.1	Not Applicable.

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Semivolatiles by GC/MS (continued)	Matrix Spike	OLM03.1	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each SDG, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike outside of advisory limits
	Matrix Spike Duplicate	OLM03.1	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each SDG, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method RPD between MS/MSD should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike recoveries or RPD outside of advisory limits
	Duplicate	OLM03.1	Not Applicable
	Surrogates	OLM03.1	Frequency: Surrogates spiked onto all samples and QC samples Criteria: Percent recovery for each surrogate must be within limits given in method (one base/neutral and/or one acid surrogate may be outside of limits but not below 10%) Corrective Action: Flag data associated with unacceptable recoveries or reanalyze all samples with unacceptable surrogate recoveries as required in method
	Internal Standards	OLM03.1	Frequency: Internal Standards are spiked onto all samples and QC samples Criteria: Internal Standard areas must be within -50% to + 100% from the last daily calibration check standard Corrective Action: Reanalyze all samples with unacceptable areas

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Semivolatiles by GC/MS (continued)	Method Blank	OLM01.8	Frequency: 1 with each case of samples received (up to 20 samples) and including matrix spikes and reanalyses) that are of similar matrix (water or soil) or similar concentration (soil), or 1 with each 14 calendar day period (7 calendar day for 14-day data turnaround contracts) during which samples in a case are received, or 1 whenever samples are extracted by the same procedure (continuous liquid-liquid extraction or sonication) Criteria: Concentration ≤ CRQL except phthalates which must be < 5 x CRQL Corrective Action: Re-extract and re-analyze all samples associated with unacceptable blank
	Laboratory Control Sample	OLM01.8	Not Applicable
	Matrix Spike	OLM01.8	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each 14 day calendar period (7 calendar day period for 14 day data turnaround contracts) during which field samples in a case were received, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike recoveries outside of advisory limits
	Matrix Spike Duplicate	OLM01.8	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each 14 day calendar period (7 calendar day period for 14 day data turnaround contracts) during which field samples in a case were received, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method. RPD between MS/MSD should be within advisory limits given in method. Corrective Action: Flag data associated with Matrix Spike recoveries or RPD outside of advisory limits

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Semivolatiles by GC/MS (continued)	Duplicate	OLM01.8	Not Applicable
	Surrogates	OLM01.8	Frequency: Surrogates spiked onto all samples and QC samples Criteria: Percent recovery for each surrogate must be within limits given in method (one base/neutral and/or one acid surrogate may be outside of limits, but not below 10%) Corrective Action: Flag data associated with unacceptable recoveries or reanalyze all samples with unacceptable surrogate recoveries as required in method
	Internal Standards	OLM01.8	Frequency: Internal Standards are spiked onto all samples and QC samples Criteria: Internal Standard areas must be within -50% to + 100% from the last daily calibration check standard Corrective Action: Reanalyze all samples with unacceptable areas
Volatiles by GC/MS	Method Blank	OLM03.1	Frequency: 1 per 12 hours Criteria: Concentration less than CRQL except methylene chloride, acetone, 2-butanone must be ≤ 5x CRQL Corrective Action: Reanalyze all samples associated with unacceptable blank
	Laboratory Control Sample	OLM03.1	Not Applicable
	Matrix Spike	OLM03.1	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each SDG, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike outside of advisory limits

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Volatiles by GC/MS (continued)	Matrix Spike Duplicate	OLM03.1	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each SDG, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method RPD between MS/MSD should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike recoveries or RPD outside of advisory limits
	Duplicate	OLM03.1	Not Applicable
	Surrogates	OLM03.1	Frequency: Surrogates spiked onto all samples and QC samples Criteria: Percent recovery for each surrogate must be within limits given in method Corrective Action: Reanalyze all samples with unacceptable surrogate recoveries
	Internal Standards	OLM03.1	Frequency: Internal Standards are spiked onto all samples and QC samples Criteria: Internal Standard areas must be within -50% to + 100% from the last daily calibration check standard Corrective Action: Reanalyze all samples with unacceptable Internal Standard areas
	Storage Blank	OLM03.1	Frequency: 1 per SDG Criteria: Concentration less than CRQL except methylene chloride, acetone, 2-butanone must be ≤ 5x CRQL Corrective Action: Narrate with corrective action plan

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Volatiles by GC/MS (continued)	Method Blank	OLM01.8	Frequency: 1 per 12 hours Criteria: Concentration less than CRQL except methylene chloride, acetone, and 2-butanone must be ≤ 5x CRQL Corrective Action: Re-purge and re-analyze all associated samples
	Laboratory Control Sample	OLM01.8	Not Applicable
	Matrix Spike	OLM01.8	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each 14 day calendar period (7 calendar day period for 14 day data turnaround contracts) during which field samples in a case were received, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with Matrix Spike recoveries outside of advisory limits
	Matrix Spike Duplicate	OLM01.8	Frequency: 1 with each case of samples received (up to 20 samples), for each concentration level (soils) or for each 14 day calendar period (7 calendar day period for 14 day data turnaround contracts) during which field samples in a case were received, whichever is most frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method. RPD between MS/MSD should be within advisory limits given in method. Corrective Action: Flag data associated with Matrix Spike recoveries or RPD outside of advisory limits
	Duplicate	OLM01.8	Not Applicable
	Surrogates	OLM01.8	Frequency: Surrogates spiked onto all samples and QC samples Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Re-analyze all samples with unacceptable surrogate recoveries

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TABLE 8.4-7
USEPA Contract Laboratory Program Statement of Work Quality Control Samples (Continued)

Analysis	QC Sample	Method	Requirement
Volatiles by GC/MS (continued)	Internal Standards	OLM01.8	Frequency: Internal Standards are spiked onto all samples and QC samples Criteria: Internal Standard areas must be within -50% to + 100% from the last daily calibration check standard Corrective Action: Re-analyze all samples with unacceptable Internal Standard areas
	Storage Blank	OLM01.8	Not Applicable

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Notes:

SDG = Sample Delivery Group

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Acidity	Water	100 mL	305.1	250 mL plastic or glass, Cool, 4°C, 14 days	—	Not Applicable
	Solid[5]	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Alkalinity	Water	100 mL	310.1 2320B	250 mL plastic or glass, Cool, 4°C, 14 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Ammonia	Water	400 mL	350.1	500 mL plastic or glass, Cool, 4°C H_2SO_4 to pH < 2, 28 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Biochemical Oxygen Demand (BOD)	Water	200 mL	405.1	1000 mL plastic or glass, Cool, 4°C 48 hours	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Bromide	Water	100 mL	300.0[7] 320.1 ASTM D1246-88	250 mL plastic or glass, No preservative required, 28 days	9056	Cool, 4°C, analyze ASAP after collection
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Chemical Oxygen Demand (COD)	Water	100 mL	410.1 410.2 410.4	250 mL glass or plastic, Cool, 4°C, H_2SO_4 to pH < 2, 28 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable

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TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Chloride	Water	50 mL	300.0[7] 325.1 325.2 325.3 4500 Cl E	250 mL plastic or glass, No preservative required, 28 days	9056 9251 9252A	Method 9056: Cool, 4°C, analyze ASAP after collection. Method 9251/9252A: 250ml plastic or glass, no preservative required, 28 days
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Chlorine, Residual	Water	100 mL	330.1 330.3	250 mL glass or plastic, Cool, 4°C, analyze immediately	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Chromium (Cr^{+6})	Water	100 mL	218.4 3500 Cr-D	Method 218.4: 200 mL plastic or glass, Cool, 4°C, 24 hours Method 3500 Cr-D: 200 mL quartz, TFE, or polypropylene HNO_3 to pH <2 Cool, 4°C Analyze ASAP after collection	7196A	200 mL plastic or glass, Cool, 4°C, 24 hours
	Solid	Not Applicable	—	Not Applicable	3060A/ 7196A	30 days to digestion, 96 hours after digestion
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable

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TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Color	Water	100 mL	110.2	250 mL plastic or glass, Cool, 4°C, 48 hours	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Conductivity	Water	100 mL	120.1	200 mL glass or plastic, Cool, 4°C, 28 days	9050	200 mL glass or plastic, Cool, 4°C, 24 hours
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Cyanide (Amenable)	Water	IL	335.1	1 liter plastic or glass, NaOH to pH >12 0.6g ascorbic acid[6] Cool, 4°C, 14 days unless sulfide is present. Then maximum holding time is 24 hours	9010A 9012	1 liter plastic or glass, NaOH to pH >12 0.6g ascorbic acid[6] Cool, 4°C, 14 days
	Solid	50g	---	Not Applicable	9010A, 9012	Not Specified
	Waste	50g	---	Not Applicable	9010A, 9012	Not Specified
Cyanide (Total)	Water	IL	335.1 335.2 335.3 4500 CN D	1 liter plastic or glass, NaOH to pH >12 0.6g ascorbic acid[6] Cool, 4°C, 14 days unless sulfide is present. Then maximum holding time is 24 hours	9010A 9012	1 liter plastic or glass, NaOH to pH >12 0.6g ascorbic acid[6] Cool, 4°C, 14 days
	Solid	50g	--	Not Applicable	9010A 9012	8 or 16 oz glass Teflon-lined lids, Cool, 4°C, 14 days

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TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Cyanide (Total) (continued)	Waste	50g	--	Not Applicable	9010A, 9012	8 or 16 oz glass Teflon-lined lids, Cool, 4°C
Flashpoint (Ignitability)	Liquid	Not Applicable	--	Not Applicable	1010	No requirements, 250 mL amber glass, Cool, 4°C is recommended
	Solid	Not Applicable	--	Not Applicable	--	Not Applicable
	Waste	Not Applicable	--	Not Applicable	--	Not Applicable
Fluoride	Water	300 mL	300.0[7] 340.2	500 mL plastic, No preservation required, 28 days	9056	Cool, 4°C, analyze ASAP after collection
	Solid	Not Applicable	--	Not Applicable	--	Not Applicable
	Waste	Not Applicable	--	Not Applicable	--	Not Applicable
Hardness (Total)	Water	50 mL	130.2 2340B	250 mL glass or plastic, Cool, 4°C, HNO_3 to pH < 2, 6 months	--	Not Applicable
	Solid	Not Applicable	--	Not Applicable	--	Not Applicable
	Waste	Not Applicable	--	Not Applicable	--	Not Applicable
Iodide	Water	100 mL	345.1 Dionex	100 mL plastic or glass, Cool, 4°C, 24 hours		Not Applicable
	Solid	Not Applicable	--	Not Applicable	--	Not Applicable
	Waste	Not Applicable	--	Not Applicable	--	Not Applicable
Iron (Ferrous)	Water	100 mL	3500-Fe D	1 liter glass or polyethylene container, 6 months **This test should be performed in the field.**	-	Not Applicable
	Solid	Not Applicable	-	Not Applicable	-	Not Applicable
	Waste	Not Applicable	-	Not Applicable	-	Not Applicable

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TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Methylene Blue Active Substances (MBAS) (Surfactant)	Water	100 mL	425.1	250 mL plastic or glass, Cool, 4°C, 48 hours	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Nitrate	Water	100 mL	300.0[7] 352.1	Method 300.0: 250 mL plastic or glass, Cool, 4°C, 48 hours. Method 352.1: 250 mL plastic or glass, Cool, 4°C, 48 hours. For samples from non-chlorinated drinking water supplies concentrated H_2SO_4 should be added to lower sample pH to less than 2. The sample should be analyzed before 14 days.	9056 9200	Method 9056: Cool, 4°C, analyze ASAP after collection Method 9200: Cool, 4°C if analyzed within 24 hours. If > 24 hours, cool, 4°C, and 2 mL/L conc. H_2SO_4
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	9200	Not Specified
Nitrite	Water	50 mL	300.0[7] 354.1	250 mL plastic or glass Cool, 4°C, 48 hours	9056	Cool, 4°C, analyze ASAP after collection
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable

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TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Ortho-phosphate	Water	50 mL	300.0[7] 365.1 365.2 365.3 365.4	100 mL plastic or glass, Filter on site Cool, 4°C, 48 hours	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
pH	Water	50 mL	150.1 4500-H^+ B	100 mL plastic or glass. Analyze immediately. **This test should be performed in the field.**	9040B	100 mL plastic or glass. Analyze immediately. **This test should be performed in the field.**
	Solid	Not Applicable	—	Not Applicable	9045C	4 oz glass or plastic, Cool, 4°C, Analyze as soon as possible.
	Waste	Not Applicable	—	Not Applicable	9045C	4 oz glass or plastic, Cool, 4°C, Analyze as soon as possible.
Phenolics	Water	100 mL	420.1 420.2	500 mL glass, Cool, 4°C, H_2SO_4 to pH < 2, 28 days	9065 9066	1 liter glass recommended, Cool, 4°C, H_2SO_4 to pH < 2, 28 days
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	9065	Not Specified
Phosphate	Water	50 mL	—	Not Applicable	9056	Cool, 4°C, analyze ASAP collection
	Solid	Not Applicable	—	Not Applicable	9056	Not Applicable
	Waste	Not Applicable	—	Not Applicable	9056	Not Applicable
Phosphorus (Total)	Water	50 mL	365.1 365.2 365.3 365.4	100 mL plastic or glass, H_2SO_4 to pH < 2, 28 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable

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TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Nitrate-Nitrite	Water	100 mL	353.1 353.2 353.3	250 mL plastic or glass, Cool, 4°C, H_2SO_4 to pH < 2, 28 days	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Odor	Water	IL	140.1	200 mL glass only, Cool, 4°C, 24 hours		Not Applicable
	Solid	Not Applicable	--	Not Applicable	---	Not Applicable
	Waste	Not Applicable	--	Not Applicable	---	Not Applicable
Reactivity (Cyanide and Sulfide)	Liquid	10 g	---	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	10 oz amber glass, Cool, 4°C, no headspace, analyze as soon as possible.
	Solid	10 g	---	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	10 oz amber glass, Cool, 4°C, no headspace, analyze as soon as possible.
	Waste	10 g	---	Not Applicable	Chapter 7 Sections 7.3.3 and 7.3.4	10 oz amber glass, Cool, 4°C, no headspace, analyze as soon as possible.
Settleable Solids	Water	1000 mL	160.5	1000 mL plastic or glass, Cool, 4°C, 48 hours	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Silica, Dissolved	Water	50 mL	370.1	Plastic only, 100 mL, Cool, 4°C, 28 days	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable

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TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Specific Conductance	Water	50 mL	120.1	250 mL plastic or glass, Cool, 4°C, 28 days	9050	250 mL plastic or glass, Cool, 4°C, 24 hours
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Sulfate (SO_4)	Water	100 mL	300.0[7] 375.1 375.4	100 mL plastic or glass, Cool, 4°C, 28 days	9056 9038	Method 9056: Cool, 4°C, analyze ASAP collection Method 9038: 200 mL plastic or glass, Cool, 4°C, 28 days
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	100 mL	—	Not Applicable	9038	200 mL plastic or glass, Cool, 4°C, 28 days
Sulfide	Water	100 mL	376.1 376.2	500 mL plastic or glass, Cool, 4°C, Add 2 mL zinc acetate plus NaOH to pH > 9, 7 days	9030A	500 mL plastic, no headspace, Cool, 4°C, Add 2 mL zinc acetate plus NaOH to pH > 9, 7 days
	Solid	50 g	—	Not Applicable	9030A	Cool, 4°C, store headspace-free
	Waste	50 g	—	Not Applicable	9030A	Cool, 4°C, store headspace-free

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TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Sulfite (SO_3)	Water	100 mL	377.1	100 mL plastic or glass, No preservative required, analyze immediately **This test should be performed in the field.**	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Temperature	Water	200 mL	170.1	1 liter plastic or glass, analyze immediately in the field	---	Not Applicable
	Solid	Not Applicable	--	Not Applicable	--	Not Applicable
	Waste	Not Applicable	--	Not Applicable	--	Not Applicable
Total Dissolved Solids (Filterable)	Water	100 mL	160.1	250 mL plastic or glass, Cool, 4°C, 7 days	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Total Kjeldahl Nitrogen (TKN)	Water	500 mL	351.2 351.3	500 mL plastic or glass, Cool, 4°C, H_2SO_4 to pH < 2, 28 days	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Total Organic Carbon (TOC)	Water	100 mL	415.1	100 mL plastic or glass, Cool, 4°C, H_2SO_4 to pH < 2, 28 days	9060	100 mL plastic or glass, Cool, 4°C, H_2SO_4 or HCl to pH < 2, 28 days
	Solid	Not Applicable	---	Not Applicable	9060	Not Specified
	Waste	Not Applicable	---	Not Applicable	9060	Not Specified

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TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Total Organic Halides (TOX)	Water	100 mL	5320B [7] 450.1 [7]	Method 5320B: 500 mL amber glass, Teflon®-lined lid, Cool, 4°C, HNO_3 to pH <2, no headspace, 14 days Method 450.1: 500 mL amber glass, Teflon®-lined lid, Cool, 4°C, HNO_3 to pH <2, no headspace, 28 days	9020B	500 mL amber glass, Teflon®-lined lid, Cool, 4°C, H_2SO_4 to pH < 2, no headspace, 28 days
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Total Solids	Water	100 mL	160.3	250 mL plastic or glass, Cool, 4°C, 7 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Total Suspended Solids (Nonfilterable)	Water	100 mL	160.2	250 mL plastic or glass, Cool, 4°C, 7 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Turbidity	Water	50 mL	180.1	250 mL plastic or glass, Cool, 4°C, 48 hours	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable
Volatile Solids	Water	100 mL	160.4	250 mL plastic or glass, Cool, 4°C, 7 days	—	Not Applicable
	Solid	Not Applicable	—	Not Applicable	—	Not Applicable
	Waste	Not Applicable	—	Not Applicable	—	Not Applicable

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TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Water Content	Water	Not Applicable	---	Not Applicable	---	Not Applicable
	Solid	10 g	---	Refer to specific method used	---	Refer to specific method used
	Waste	10 g	---	Refer to specific method used	---	Refer to specific method used
Metals (excludes Hg)	Water	100 mL	200 series	1 liter glass or polyethylene container, HNO_3 to pH ≤ 2, 6 months	6010A, 6020, 7000 series	1 liter glass or polyethylene container, HNO_3 to pH ≤ 2, 6 months
	Solid	200 g	200 series	8 or 16 oz glass or polyethylene container storage at °C	6010A, 6020, 7000 series	8 or 16 oz glass or polyethylene container, storage at 4°C, 6 months
	Waste	200 g	200 series	Not Applicable	6010A, 6020, 7000 series	8 or 16 oz glass or polyethylene container, storage at 4°C, 6 months
Mercury (CVAA)	Water	100 mL	245.1	1 liter glass or polyethylene container, Cool, 4°C HNO_3 to pH ≤ 2, 28 days	7470A	1 liter glass or polyethylene container, HNO_3 to pH ≤ 2, 28 days
	Solid	200 g	245.5	8 or 16 oz glass or polyethylene container, Cool, 4°C, 28 days	7471A	8 or 16 oz glass or polyethylene container, Cool, 4°C, Holding Time Not Specified
	Waste	200 g	–	Not Applicable	7471A	8 or 16 oz glass or polyethylene container, Cool, 4°C, Holding Time Not Specified

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TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times (Continued)

Footnotes

(1) Minimum sample size indicates sample amount needed for a single analysis. Matrix spikes or duplicates will require an additional sample amount of at least this amount for each additional QC sample aliquot required.
(2) National Pollutant Discharge Elimination System - MCAWW, March 1983.
(3) Holding times are calculated from date of collection.
(4) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA, (August 1993), Final Update II (September 1994), and Final Update IIB (January 1995)
(5) Solid matrix type includes soil, sediment, sludge and other solid materials not classified as waste.
(6) Samples to be analyzed for cyanide should be field-tested for residual chlorine. If residual chlorine is detected, ascorbic acid should be added.
(7) Method not listed in 40 CFR Part 136.

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TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
Aromatic Volatiles	Water	40 mL	602	40 mL glass, VOA vial (in triplicate) with Teflon®-lined septa without headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine, 7 days with pH > 2, 14 days with pH ≤ 2	8020A	40 mL glass, VOA vial (in triplicate) with Teflon®-lined septa without headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine, HCl or H_2SO_4 or solid $NaHSO_4$ to pH ≤ 2, 14 days with pH ≤ 2
	Solid[5]	10 g	--	Not Applicable	8020A	4 or 8 oz glass with Teflon®-lined lid, Cool, 4°C, 14 days
	Waste	10 g	--	Not Applicable	8020A	4 or 8 oz glass with Teflon®-lined lid, Cool, 4°C, 14 days
Acrolein & Acrylonitrile by GC	Water	40 mL	603	Glass with Teflon®-lined septum, Cool, 4 °C (± 2°C), 0.008% $Na_2S_2O_3$[11], Adjust pH 4-5[8] 14 days	8030A	Glass with Teflon®-lined septum, Cool, 4 °C (± 2°C), 0.008% $Na_2S_2O_3$[11], Adjust pH 4-5[8] 14 days
	Solid	-	-	Not Applicble	-	Not Applicable
	Waste	-	-	Not Applicble	-	Not Applicable
Dioxins/ Dibenzo-furans	Water	1L	613	1 liter amber glass with Teflon®-lined lid, Cool, 4°C, Extraction, 7 days Analysis, 40 days	8280	1 liter glass amber with Teflon®-lined lid, Cool, 4°C, Extraction, 30 days Analysis, 45 days from date of collection
	Solid	10 g	--	Not Applicable	8280	8 or 16 oz glass amber wide mouth with Teflon®-lined lid, Cool, 4°C, Extraction, 30 days Analysis, 45 days from date of collection

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TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2],[3]		RCRA (SW846)[3],[4]	
			Method	Requirements	Method[6]	Requirements
Dioxins/ Dibenzo-furans (continued)	Waste	10 g	--	Not Applicable	8280	8 or 16 oz glass amber wide mouth with Teflon®-lined lid, Cool, 4°C, Extraction, 30 days Analysis, 45 days from date of collection
	Water	1L	613	1 liter amber glass with Teflon®-lined lid, Cool, 4°C, Extraction, 7 days Analysis, 40 days	8290	1 liter glass amber with Teflon®-lined lid, Cool, 4°C, Extraction, 30 days Analysis, 45 days from date of extraction
	Solid	10 g	--	Not Applicable	8290	8 or 16 oz glass amber wide mouth with Teflon®-lined lid, Cool, 4°C, Extraction, 30 days Analysis, 45 days from date of extraction
	Waste	10 g	--	Not Applicable	8290	8 or 16 oz glass amber wide mouth with Teflon®-lined lid, Cool, 4°C, Extraction, 30 days Analysis, 45 days from date of extraction
Halogenated Volatiles	Water	40 mL	--	Not Applicable	8021A	40 mL glass, VOA vial (in triplicate) with Teflon®-lined septa without headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine, HCl or H_2SO_4 or solid $NaHSO_4$ to pH ≤ 2, 14 days with pH ≤ 2
	Solid[5]	10 g	--	Not Applicable	8021A	4 or 8 oz glass with Teflon®-lined lid, Cool, 4°C, 14 days

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TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
Halogenated Volatiles (continued)	Waste	10 g	--	Not Applicable	8021A	4 or 8 oz glass with Teflon®-lined lid, Cool, 4°C, 14 days
Herbicides	Water	1L	615 [10]	1 liter amber glass with Teflon®-lined lid, Sodium thiosulfate or ascorbic acid if residual chlorine present, Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction	8150B	1 liter amber glass with Teflon®-lined lid. If residual chlorine present, add 3 mL sodium thiosulfate per gallon. Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction
	Solid	50 g	--	Not Applicable	8150B	4 or 8 oz glass widemouth with Teflon®-lined lid, no preservative required, Extraction, 14 days Analysis, 40 days after extraction
	Waste	50 g	--	Not Applicable	8150B	4 or 8 oz glass widemouth with Teflon®-lined lid. No preservative required. Extraction, 14 days Analysis, 40 days after extraction
Nitroaromatics	Water	1L	--	Not Applicable	8330	1 liter amber glass with Teflon®-lined lid. If residual chlorine present, add 3 mL sodium thiosulfate per gallon. Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction
	Solid	50 g	--	Not Applicable	8330	4 or 8 oz glass widemouth with Teflon®-lined lid Cool, 4°C

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TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
Nitroaromatics (continued)	Waste	50 g	---	Not Applicable	8330	4 or 8 oz glass widemouth with Teflon®-lined lid no preservative required
Organo-phosphorus Pesticides	Water	1L	---	Not Applicable	8140 8141A	1 liter amber glass with Teflon®-lined lid. If residual chlorine present, add 3 mL sodium thiosulfate per gallon. Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction
	Solid	50 g	---	Not Applicable	8140 8141A	4 or 8 oz glass widemouth with Teflon®-lined lid Cool, 4°C
	Waste	50 g	---	Not Applicable	8140 8141A	4 or 8 oz glass widemouth with Teflon®-lined lid no preservative required
PAHs by GC and HPLC	Water	1L	610	1 liter amber glass with Teflon®-lined lid, Adjust pH to 5-9 if extraction not to be done within 72 hours of sampling. Add sodium thiosulfate if residual chlorine present. Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction	8100 8310	1 liter amber glass with Teflon®-lined lid, If residual chlorine present, add 3 mL sodium thiosulfate per gallon, Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction

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TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
PAHs by GC and HPLC (continued)	Solid	50 g	---	Not Applicable	8100 8310	4 or 8 oz glass widemouth with Teflon®-lined lid, Cool, 4°C, Extraction, 14 days Analysis, 40 days after extraction
	Waste	50 g	---	Not Applicable	8100 8310	4 or 8 oz glass widemouth with Teflon®-lined lid, no preservative required, Extraction, 14 days Analysis, 40 days after extraction
Pesticides/ PCBs	Water	1L	608	1 liter amber glass with Teflon®-lined lid, Adjust pH to 5-9 if extraction not to be done within 72 hours of sampling. Add sodium thiosulfate if residual chlorine present and aldrin is being determined. Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction	8080A	1 liter amber glass with Teflon®-lined lid, If residual chlorine present, add 3 mL 10% sodium thiosulfate per gallon, Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction
	Solid	50 g	---	Not Applicable	8080A	4 or 8 oz glass widemouth with Teflon®-lined lid, Cool, 4°C, Extraction, 14 days Analysis, 40 days after extraction
	Waste	50 g	---	Not Applicable	8080A	4 or 8 oz glass widemouth with Teflon®-lined lid, no preservative required, Extraction, 14 days Analysis, 40 days after extraction

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TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
Petroleum Hydrocarbons /Oil and Grease	Water	1L	413.1 413.2 418.1	1 liter glass, Cool, 4°C, HCl to pH <2, 28 days	9070	1 liter glass with Cool, 4°C, HCl to pH <2, 28 days
	Solid	—	—	Not Applicable	9071A	8 oz. glass with Teflon®-lined lid, Holding Time not specified
	Waste	—	—	Not Applicable	9071A	8 oz. glass with Teflon®-lined lid, Holding Time not specified
	Water	1 L	1664[7]	1 liter glass, Cool, 0-4°C HCl or H_2SO_4 to pH <2 28 days	—	—
	Solid	30 g	1664[7]	8 or 16 oz. wide mouth glass jar, Cool, 0-4°C, 28 days	—	—
	Waste	—	—	Not Applicable	—	—
Purgeable Halocarbons	Water	40 mL	601	40 mL glass VOA vial (in triplicate) with Teflon®-lined septa with no headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine present, 14 days	8010B	40 mL glass VOA vial (in triplicate) with Teflon®-lined septa with no headspace, Cool, 4°C, HCl or H_2SO_4 or solid $NaHSO_4$ to pH ≤ 2, sodium thiosulfate if residual chlorine present, 14 days
	Solid	10 g	—	Not Applicable	8010B	4 or 8 oz glass container with Teflon®-lined lid, Cool, 4°C, 14 days

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TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
Purgeable Halocarbons (continued)	Waste	10 g	—	Not Applicable	8010B	4 or 8 oz glass container Teflon®-lined lid, no preservative required, 14 days
Semivolatiles	Water	1L	625	1 liter amber glass with Teflon®-lined lid, Cool, 4°C, Extraction, 7 days Analysis, 40 days	8270B	1 liter amber glass with Teflon®-lined lid, If residual chlorine present, add 3 mL sodium thiosulfate per gallon, Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction
	Solid	50 g	—	Not Applicable	8270B	8 or 16 oz glass wide mouth with Teflon-lined lid, Cool, 4°C, Extraction, 14 days Analysis, 40 days after extraction
	Waste	50 g	—	Not Applicable	8270B	8 or 16 oz glass wide mouth with Teflon®-lined lid, Cool, 4°C, Extraction, 14 days Analysis, 40 days after extraction

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TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
Volatile Organics	Water	40 mL	624	40 mL glass, VOA vial (in triplicate) with Teflon®-lined septa without headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine, 7 days with pH > 2, 14 days with pH ≤ 2[8]	8240B, 8260A	40 mL glass, VOA vial (in triplicate) with Teflon®-lined septa without headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine, HCl or H_2SO_4 or solid $NaHSO_4$ to pH ≤ 2, 14 days with pH ≤ 2[9]
	Solid[5]	10 g	--	Not Applicable	8240B, 8260A	4 or 8 oz glass with Teflon®-lined lid, Cool, 4°C, 14 days
	Waste	10 g	--	Not Applicable	8240B, 8260A	4 or 8 oz glass with Teflon®-lined lid, Cool, 4°C, 14 days

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TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Footnotes

(1) Minimum sample size indicates sample amount needed for a single analysis. Matrix spikes or duplicates will require an additional sample amount of at least this amount for each additional QC sample aliquot required.
(2) National Pollutant Discharge Elimination System - 40 CFR Part 136, Appendix A.
(3) Holding times are calculated from the date of collection.
(4) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), and Final Update IIB (January 1995).
(5) Solid matrix type includes soil, sediment, sludge or other solids not classified as waste.
(6) Only one determination method is listed when separate methods are required for preparation and analysis.
(7) Method 1664 is a proposed only method and has not been promulgated by the EPA.
(8) For acrolein and acrylonitrile the pH should be adjusted to 4-5. This pH adjustment is not required if acrolein is not being measured. Samples requiring analysis of acrolein that received no pH adjustment must be analyzed within three days of sampling.
(9) For acrolein and acrylonitrile the pH should be adjusted to 4-5.
(10) Method not listed in 40 CFR Part 136.
(11) Should only be used in the presence of residual chlorine.

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TABLE 8.5-3
Radiological Sample Containers, Preservatives, and Holding Times

Analytical Parameters	Matrix	Recommended Containers[1]	Preservative	Maximum Holding Time	Minimum Volume Required for Analysis[2]
Gross Alpha/Beta	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	500 mls
	Soil	P, G	None		50[4] gms
Americium-241	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Carbon-14	Water	P, G	Field adjusted to pH > 9 with NaOH[3]	180 days after collection	100 mls
	Soil	P, G	None		50[4] gms
Calcium-45	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	100 mls
Curium-242	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Gamma Emitters Actinides, as applicable, Co-60, Cs-137, K-40, Mn-54, and other fission/activation products	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		650[7] gms
Iron-55	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	50 mls
Lead-210	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	500 mls
	Soil	P, G	None		50[4] gms
Neptunium-237	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Promethium-147	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	250 mls

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TABLE 8.5-3
Radiological Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Recommended Containers[1]	Preservative	Maximum Holding Time	Minimum Volume Required for Analysis[2]
Plutonium-238, 239/240	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Radium-226	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Radium-228	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Strontium-89, 90 and Total Strontium	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Technetium-99	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	100 mls
	Soil	P, G	None		50[4] gms
Thorium-227, 228, 230, 232	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Total Uranium	Water	P,G	Field acidified to pH < 2 with HNO_3	180 days after collection	50 mls
	Soil	P, G	None		50[4] gms
Tritium	Water	P, G[6]	None	180 days after collection	100 mls
	Soil	P, G[6]	None		100 gms
Uranium-233/234, 235/236	Water	P, G	Field acidified to pH < 2 with HNO_3	180 days after collection	1000[5] mls
	Soil	P, G	None		50[4] gms
Uranium-238	Soil	P, G	None	180 days after collection	50[4] gms

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TABLE 8.5-3
Radiological Sample Containers, Preservatives, and Holding Times (Continued)

Footnotes

(1) Plastic (polyethylene), Glass

(2) Assumes that quality control samples have been assigned in the field. If duplicates, matrix spikes and/or matrix spike duplicates are to be assigned by the laboratory, additional multiple sample volumes are required. Volumes listed are for standard aliquot size. Detection limit requirements may necessitate larger volumes.

(3) Assumes that carbon is in the form of CO_3^{--}.

(4) May be aliquoted or sequentially determined from the same volume.

(5) May be aliquoted or sequentially determined from the same volume.

(6) Tritium is very volatile. Sample containers must be air tight to eliminate tritium loss.

(7) Dry weight.

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TABLE 8.5-4
Sample Containers, Preservatives, and Holding Times for USEPA Contract Laboratory Program Statement of Work

Analytical Parameters	Matrix	Minimum Sample Size	Requirements[1]
Cyanide, Total and Amenable to Chlorination	Water	500 mL	500 mL, glass or polyethylene container, 0.6 g ascorbic acid (only in presence of residual chlorine) NaOH to pH > 12, Cool, 4°C, 12 days
	Soil/Sediment	25 g	8 or 16 oz glass with Teflon-lined lids, Cool, 4°C, 12 days
ICAP and GFAA (excludes mercury)	Water	100 mL	1 liter glass or polyethylene container, HNO_3 to pH ≤2, 180 days
	Soil/Sediment	25 g	4 or 8 oz glass or polyethylene container, Cool, 4°C, 180 days
Mercury (CVAA)	Water	100 mL	1 liter glass or polyethylene container, HNO_3 to pH ≤2, 26 days
	Soil/Sediment	25 g	8 or 16 oz glass with Teflon®-lined lids, Cool, 4°C, 26 days
Pesticides/PCBs	Water	1 L	1 liter amber glass with Teflon®-lined lid, Cool, 4°C, Extraction within 5 days of sample receipt Analysis within 40 days after start of extraction
	Soil/Sediment	50 g	8 or 16 oz glass widemouth with Teflon®-lined lid, protect from light, Cool, 4°C, Extraction within 10 days of sample receipt Analysis within 40 days after start of extraction
PCDD, PCDF[2]	Water	1 L	1 liter amber glass with Teflon®-lined lid, Cool, 4°C, No holding time requirements specified
	Soil/Sediment/ Fly Ash/ Chemical Waste	25 g	4 or 8 oz glass widemouth with Teflon®-lined lid, protect from light, room temperature, No holding time requirements specified

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TABLE 8.5-4
Sample Containers, Preservatives, and Holding Times for USEPA Contract Laboratory Program Statement of Work (Continued)

Analytical Parameters	Matrix	Minimum Sample Size	Requirements[1]
Semivolatiles	Water	1L	1 liter amber glass with Teflon®-lined lid, Cool, 4°C, Extraction within 5 days of sample receipt Analysis within 40 days after start of extraction
	Soil/Sediment	50 g	8 or 16 oz glass widemouth with Teflon®-lined lid, Cool, 4°C, Extraction within 10 days of sample receipt Analysis within 40 days after start of extraction
Volatiles	Water	40 mL	40 mL glass with Teflon®-lined lid, no entrapped air bubbles pH <2[3], Cool, 4°C, 10 days
	Soil/Sediment	25 g	4 or 8 oz glass with Teflon®-lined lids, Cool, 4°C, 10 days

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Footnotes

(1) Holding times are calculated from verified time of sample receipt.

(2) PCDD: Polychlorinated Dibenzo-p-dioxins
PCDF: Polychlorinated Dibenzofurans

(3) The OLM03.0 requirement is to acidify the sample to pH<2. The OLM01.8 requirement is to determine and report the pH of the sample to check that the sample was acidified in the field.

TABLE 8.5-5
Sample Containers, Preservatives, and Holding Times for TCLP[1] and SPLP[2]

Analytical Parameters	Matrix	Minimum Sample Size[3]	TCLP Method 1311 and SPLP Method 1312 Requirements	
			From Field Collection to TCLP/SPLP Extraction	From TCLP/SPLP Extraction to Analysis
Mercury	Liquid Solid Waste	1L	1L glass, Cool, 4°C, 28 days	Glass or polyethylene 28 days
Metals (except mercury)	Liquid Solid Waste	1L	1L glass, Cool, 4°C, 180 days	Glass or polyethylene 180 days
Semivolatiles	Liquid Solid Waste	1L	1L glass, Cool 4°C, 14 days	1L glass Extraction of leachate within 7 days of TCLP extraction, Analyze extract within 40 days
Volatiles	Liquid Solid Waste	6 oz	4 oz glass, Cool 4°C, 14 days	40 mL glass, 14 days

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Footnotes

(1) TCLP = Toxicity Characteristic Leaching Procedure

(2) SPLP = Synthetic Precipitation Leaching Procedure

(3) Smaller sample size is adequate for solid samples or individual fractions. A combined volume of 32 oz. is recommended for semivolatiles and metals. A separate 4 oz. container should always be used for the volatile fraction. Volatile fractions should be stored with minimal headspace.

TABLE 8.5-6
Periodic Equipment Calibrations

Type of Equipment	Calibration Requirements
Balances	• Must be serviced and calibrated annually by a manufacturer's representative • Calibration must be checked daily or before use by analyst with weight(s) classified as Class "S" (or Class "S" traceable) by NIST per operation-specific SOPs. Acceptance criteria vary according to weight used and accuracy of balance. Acceptance criteria must be documented in log. • All Class "S" weights must be certified by an outside agency every three years.
Thermometers	• Working glass thermometers must be calibrated against a certified NIST thermometer at least annually as described in operation-specific SOPs. • Working non-glass thermometers must be calibrated against a certified NIST thermometer quarterly as described in operation-specific SOPs. • The NIST thermometer must be recertified every three years.
Refrigerators/Freezers	• Thermometers must be immersed in a liquid such as mineral oil or glycol. • Temperature of units used for sample or standard storage must be checked daily as described in operation-specific SOPs. Refrigerator acceptance limits: 4°C ± 2°C Freezer acceptance limits: < - 10°C
Ovens	• Temperature of units must be checked daily or before use. • Acceptance limits vary according to use as described in operation-specific SOPs and must be documented in the temperature log.
Micropipettors	• Calibrations are checked gravimetrically as required by the operation-specific SOP. • Must be calibrated at the frequency (normally quarterly) required by the manufacturer at a minimum.
Syringes, Volumetric Glassware and Graduated Glassware	• All syringes and volumetric glassware are purchased as Class A items. • Class A items are certified by the manufacturer to be within ± 1% of the measured volume, therefore, calibration of these items by Quanterra® laboratories is not required. • All analysts are trained in the proper use and maintenance of measuring devices to ensure the measurement of standards, reagents and sample volumes are within method tolerances.

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TABLE 8.5-7
Summary of Inorganic Method Calibrations

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Acidity	Initial	305.1	2 point calibration of pH meter (± 0.05 pH units of true value)	--	Not Applicable
	Continuing	305.1	Not Applicable	--	Not Applicable
	Ending	305.1	Not Applicable	--	Not Applicable
Alkalinity	Initial	310.1 2320B	2 point calibration of pH meter (± 0.05 pH units of true value)	--	Not Applicable
	Continuing	310.1 2320B	Not Applicable	--	Not Applicable
	Ending	310.1 2320B	Not Applicable	--	Not Applicable
Ammonia	Initial	350.1	6 levels including blank, "r"[3] ≥ 0.995	--	Not Applicable
	Continuing	350.1	1 level or LCS every 10 samples ± 10% of true value	--	Not Applicable
	Ending	350.1	1 level or LCS every 10 samples ± 10% of true value	--	Not Applicable
Biochemical Oxygen Demand (BOD)	Initial	405.1	a. Winkler titration: Iodometric with standard thiosulfate b. Membrane electrode: Read in air and in water with zero dissolved oxygen	--	Not Applicable
	Continuing	405.1	Not Applicable	--	Not Applicable
	Ending	405.1	Not Applicable	--	Not Applicable

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Bromide	Initial	300.0[4] 320.1 ASTM D1246-88	Method 300.0 & ASTM D1246-88: 5 levels plus a blank, "r"[3] ≥ 0.995 Method 320.1: Not Applicable	9056	Method 300.0: 5 levels plus a blank, "r"[3] ≥ 0.995
	Continuing	300.0[4] 320.1 ASTM D1246-88	Method 300.0 & ASTM D1246-88:1 level every 10 samples ± 10% of true value Method 320.1 Not Applicable	9056	Method 300.0: Not Applicable
	Ending	300.0[4] 320.1 ASTM D1246-88	Not Applicable	9056	Not Applicable
Chemical Oxygen Demand (COD)	Initial	410.4 410.1 410.2	Method 410.4: 5 levels plus a blank"r"[3] ≥ 0.995 Methods 410.1 & 410.2: Standardize titrant.	--	Not Applicable
	Continuing	410.4 410.1 410.2	Method 410.4: 1 level every 10 samples ± 10% of true value Methods 410.1 & 410.2: Not Applicable	--	Not Applicable
	Ending	410.4	Method 410.4: 1 level ± 10% of true value Methods 410.1 & 410.2: Not Applicable	--	Not Applicable

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Chloride	Initial	300.0[4] 325.1 325.2 325.3 4500-Cl E	Method 300.0, 325.1, and 325.2, 4500 Cl E: 5 levels plus blank "r"[3] ≥ 0.995 Method 325.3: Standardize titrant	9056 9251 9252A	Method 9056: 3 levels plus a blank Method 9251: 5 levels plus blank "r"[3] ≥ 0.995 Method 9252A: Standardize titrant
	Continuing	300.0[4] 325.1 325.2 325.3 4500-Cl E	Method 300.0, 325.1, and 325.2, 4500-Cl E: 1 level every 10 samples ± 10% of true value Method 325.3: Not Applicable	9056 9251 9252A	Method 9056: 1 per batch of 20 samples, ± 10% of true value Method 9251: 1 level every 10 samples ± 10% of true value Method 9252A: Not Applicable
	Ending	300.0[4] 325.1 325.2 325.3 4500-Cl E	Method 300.0, 325.1, and 325.2, 4500-Cl E: 1 level every 10 samples ± 10% of true value Method 325.3: Not Applicable	9056 9251 9252A	Method 9056 and 9252A: Not Applicable Method 9251: 1 level ± 10% of true value
Chromium Cr^{+6}	Initial	218.4 3500 Cr-D	Method 218.4: 5 levels plus blank "r"[3] ≥ 0.995 Method 3500 Cr-D: 3 levels plus blank	7196A	5 levels plus blank "r"[3] ≥ 0.995
	Continuing	218.4 3500 Cr-D	1 level every 10 samples ± 10% of true value	7196A	1 level every 10 samples ± 15%
	Ending	218.4 3500 Cr-D	1 level ± 10% of true value	7196A	1 level ± 15%

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Chlorine, Residual	Initial	330.1 330.3	Standardize titrant	--	Not Applicable
	Continuing	330.1 330.3	Not Applicable	--	Not Applicable
	Ending	330.1 330.3	Not Applicable	--	Not Applicable
Color	Initial	110.2	3 levels plus blank	--	Not Applicable
	Continuing	110.2	1 level every 10 samples	--	Not Applicable
	Ending	110.2	1 level	--	Not Applicable
Conductivity	Initial	120.1	Standard KCl solution	9050	1 level to determine cell constant
	Continuing	120.1	Not Applicable	9050	Not Applicable
	Ending	120.1	Not Applicable	9050	Not Applicable
Cyanide (Amenable)	Initial	335.1	7 levels plus blank "r"[3] ≥ 0.995	9010A 9012	7 levels plus blank "r"[3] ≥ 0.995
	Continuing	335.1	1 level every 10 samples ± 10% of true	9010A 9012	1 mid-level every 10 samples ± 15% of true value
	Ending	335.1	1 level ± 10 % of true value	9010A 9012	± 15% of true value
Cyanide (Total)	Initial	335.1 335.2 335.3 4500-CN E	7 levels plus blank "r"[3] ≥ 0.995	9010A 9012	7 levels plus blank "r"[3] ≥ 0.995
	Continuing	335.1 335.2 335.3 4500-CN E	1 mid-level every 10 samples ± 10 % of true value	9010A 9012	1 mid-level every 10 samples ± 15% of true value
	Ending	335.1 335.2 335.3 4500-CN E	1 mid-level ± 10 % of true value	9010A 9012	± 15% of true value

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Flashpoint	Initial	--	Not Applicable	1010	p-Xylene reference standard must have flashpoint of 27.2°C ± 1.1°C
	Continuing	--	Not Applicable	1010	Not Applicable
	Ending	--	Not Applicable	1010	Not Applicable
Fluoride	Initial	300.0[4] 340.2	Method 300.0: 5 levels plus a blank, "r"[3] ≥ 0.995 Method 340.2: 6 levels "r"[3] ≥ 0.995	9056	3 levels plus a blank
	Continuing	300.0[4] 340.2	1 mid-level every 10 samples ± 10% of true value	9056	1 per batch of 20 samples ± 10% of true value
	Ending	300.0[4] 340.2	1 mid-level ± 10% of true value	9056	Not Applicable
Hardness	Initial	130.2 2340B	Method 130.2: Standardize titrant Method 2340B: See ICP Metals 200.7	--	Not Applicable
	Continuing	130.2 2340B	Method 130.2: Not Applicable Method 2340B: See ICP Metals 200.7	--	Not Applicable
	Ending	130.2 2340B	Method 130.2: Not Applicable Method 2340B: See ICP Metals 200.7	--	Not Applicable
Iodide	Initial	345.1 Dionex[3]	Method 345.1: Standardize titrant Dionex: 4 levels plus blank "r"[3] ≥ 0.995	--	Not Applicable

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Iodide (continued)	Continuing	345.1 Dionex[3]	Method 345.1: Not Applicable Dionex: 1 mid-level every 10 samples ± 10 % of true value	--	Not Applicable
	Ending	345.1 Dionex[3]	Method 345.1: Not Applicable Dionex: 1 mid-level ± 10% of true value	--	Not Applicable
Iron (Ferrous)	Initial	3500-Fe D	3 levels plus a blank, "r"[3] ≥ 0.995	-	Not Applicable
	Continuing	3500-Fe D	1 mid-level every 10 samples ± 10% of true value	-	Not Applicable
	Ending	3500-Fe D	1 mid-level ± 10% of true value	-	Not Applicable
Methylene Blue Active Substances (MBAS)	Initial	425.1	4 levels plus blank "r"[3] ≥ 0.995	--	Not Applicable
	Continuing	425.1	1 level every 10 samples ± 10 % of true value	--	Not Applicable
	Ending	425.1	1 level ± 10 % of true value	--	Not Applicable

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Nitrate	Initial	300.0[4] 352.1	5 levels plus a blank "r"[3] ≥ 0.995	9056 9200	Method 9056: 3 levels plus a blank Method 9200: 5 levels plus a blank must be analyzed with each batch of 20 samples
	Continuing	300.0[4] 352.1	1 mid-level every 10 samples ± 10% of true value	9056 9200--	Method 9056: 1 per batch of 20 samples, ± 10% of true value Method 9200: Independently - prepared check standard every 15 samples
	Ending	300.0[4] 352.1	1 mid-level ± 10% of true value	9056 9200--	Not Applicable
Nitrite	Initial	300.0[4] 354.1	5 levels plus a blank "r"[3] ≥ 0.995	9056	3 levels plus a blank
	Continuing	300.0[4] 354.1	1 mid-level every 10 samples ± 10% of true value	9056	1 per batch of 20 samples, ± 10% of true value
	Ending	300.0[4] 354.1	1 mid-level ± 10% of true value	9056	Not Applicable
Nitrate-Nitrite	Initial	353.1 353.2 353.3	5 levels plus blank "r"[3] ≥ 0.995	--	Not Applicable
	Continuing	353.1 353.2 353.3	1 level every 10 samples ± 10% of true value	--	Not Applicable
	Ending	353.1 353.2 353.3	1 mid-level ± 10% of true value	--	Not Applicable

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Odor	Initial	140.1	No calibration	--	Not Applicable
	Continuing	140.1	Not Applicable	--	Not Applicable
	Ending	140.1	Not Applicable	--	Not Applicable
Phosphorus (total and Ortho-phosphate)	Initial	300.0[4] 365.1 365.2 365.3 365.4	Method 300.0/365.3/365.4: 3 levels plus a blank Method 365.2: 8 levels plus a blank	--	Not Applicable
	Continuing	300.0[4] 365.1 365.2 365.3 365.4	Method 300.0/365.3/365.4: 1 level every 10 samples ± 10% of true value Method 365.2: Blank and 2 standards with each series of samples, ± 2% of true value or recalibrate	--	Not Applicable
	Ending	300.0[4] 365.1 365.2 365.3 365.4	Method 300.0/365.3/365.4: ± 10% of true value Method 365.2: Not Applicable	--	Not Applicable
pH	Initial	150.1 4500-H^+ B	2 level calibration that bracket the expected pH of the sample (± 0.05 pH units of true value)	9040B 9045C	2 point calibration (± 0.05 pH units of true value)
	Continuing	150.1 4500-H^+ B	1 buffer check every 10 samples ± 5% of true value	9040B 9045C	Not Applicable
	Other	150.1 4500-H^+ B	Third point check	9040B 9045C	Third point check

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
pH (continued)	Ending	150.1 4500-H^+ B	1 buffer check ± 5% of true value	9040B 9045C	Not Applicable
Phenolics	Initial	420.1 420.2	5 levels plus a blank "r"[3] ≥ 0.995	9065	5 levels plus a blank "r"[3] 0.995
	Continuing	420.1 420.2	1 mid-level every 10 samples ± 10% true value	9065	1 mid-level ± 15% true value
	Ending	420.1 420.2	1 mid-level ± 10% true value	9065	1 mid-level ± 15% true value
Phosphate	Initial	—	Not Applicable	9056	3 levels plus a blank
	Continuing	—	Not Applicable	9056	1 per batch of 20 samples, ± 15% of true value
	Ending	—	Not Applicable	9056	Not Applicable
Reactivity	Initial	--	Not Applicable	Chap 7	See Total Cyanide and Sulfide
	Continuing	--	Not Applicable		
	Ending	--	Not Applicable		
Settleable Solids	Initial	160.5	Not Applicable	--	Not Applicable
	Continuing	160.5		--	Not Applicable
	Ending	160.5		--	Not Applicable
Silica, Dissolved	Initial	370.1	Approximately 6 levels plus blank "r"[3] ≥ 0.995	--	Not Applicable
	Continuing	370.1	1 level ± 15% of true value	--	Not Applicable
	Ending	370.1	1 level ± 15% of true value	--	Not Applicable

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Specific Conductance	Initial	120.1	Standardize meter with 0.01 M KCl	9050	Not Applicable
	Continuing	120.1	1 level every 10 samples ± 10% of true value	9050	Not Applicable
	Ending	120.1	1 level ± 10% of true value	9050	Not Applicable
Sulfate	Initial	300.0[4] 375.1 375.4	Method 300.0/375.1: 5 levels plus blank "r"[3] ≥ 0.995 Method 375.4: 3 levels plus blank "r"[3] ≥ 0.995	9038 9056	Method 9038: 3 levels plus a blank for every hour of continuous sample analysis. Method 9056: 3 levels plus a blank
	Continuing	300.0[4] 375.1 375.4	Method 300.0/375.1: 1 mid-level after every 10 samples ± 10% of true value Method 375.4: 1 level every 3 or 4 samples ± 10% of true value	9038 9056	Method 9038: Independent-prepared check standard every 15 samples Method 9056: 1 per batch of 20 samples, ± 10% of true value
	Ending	300.0[4] 375.1 375.4	± 10% of true value	9038 9056	Not Applicable
Sulfide	Initial	376.1 376.2	Method 376.1: This is a titration method. Therefore, calibrations are not applicable. Method 376.2: 5 levels plus a blank "r"[3] ≥ 0.995	9030A	This is a colorimetric titration. Therefore, calibrations are not applicable.

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Sulfide (continued)	Continuing	376.1 376.2	Method 376.1: Not Applicable Method 376.2: 1 level every 10 samples ± 10% of true value	9030A	This is a colorimetric titration. Therefore, calibrations are not applicable.
	Ending	376.1 376.2	Method 376.1: Not Applicable Method 376.2: ± 10% of true value	9030A	This is a colorimetric titration. Therefore, calibrations are not applicable.
Sulfite	Initial	377.1	This is a colorimetric titration. Therefore, calibrations are not applicable.	--	Not Applicable
	Continuing	377.1		--	Not Applicable
	Ending	377.1		--	Not Applicable
Temperature	Initial	170.1	Not Applicable	--	Not Applicable
	Continuing	170.1	Not Applicable	--	Not Applicable
	Ending	170.1	Not Applicable	--	Not Applicable
Total Dissolved Solids	Initial	160.1	This is a gravimetric determination. Calibrate balance prior to analysis	--	Not Applicable
	Continuing	160.1		--	Not Applicable
	Ending	160.1		--	Not Applicable

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Total Kjeldahl Nitrogen (TKN)	Initial	351.2 351.3	Method 351.2: 5 levels plus blank "r"[3] ≥ 0.995 Method 351.3: Titrimetric: Standardize titrant Colorimetric: 7 levels plus blank	--	Not Applicable
	Continuing	351.2 351.3	Method 351.2: 1 mid-level every 10 samples ± 10% of true value Method 351.3: Not Applicable	--	Not Applicable
	Ending	351.2 351.3	Method 351.2: ± 10% of true value Method 351.3: Not Applicable	--	Not Applicable
Total Organic Carbon (TOC)	Initial	415.1	3 levels plus blank	9060	3 levels plus blank "r"[3] ≥ 0.995
	Continuing	415.1	1 mid-level every 10 samples ± 15% of true value	9060	1 mid-level every 10 samples ± 15% of true value
	Ending	415.1	± 15% of true value	9060	± 15% of true value

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Total Organic Halides (TOX)	Initial	SM 5320B [4] 450.1 [4]	Method 5320B: 7 levels plus a blank ± 10% of true value Method 450.1: Daily instrument calibration standard and blank in duplicate ± 10% of true value (calibration std.) Verify with independently-prepared check standard	9020B	Daily instrument calibration standard and blank in duplicate ± 10% of true value (calibration std.) Verify with independently-prepared check standard
	Continuing	SM 5320B [4] 450.1 [4]	± 10% of true value	9020B	CCV ± 10% of true value
	Ending	SM 5320B [4] 450.1 [4]	± 10% of true value	9020B	CCV ± 10% of true value
Total Solids	Initial	160.3	This is a gravimetric determination. Calibrate balance before use.	--	Not Applicable
	Continuing	160.3		--	Not Applicable
	Ending	160.3		--	Not Applicable
Total Suspended Solids (Nonfilterable)	Initial	160.2	This is a gravimetric determination. Calibrate balance before use.	--	Not Applicable
	Continuing	160.2		--	Not Applicable
	Ending	160.2		--	Not Applicable

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Turbidity	Initial	180.1	Minimum of 1 level in each instrument range Follow manufacturer's instructions	--	Not Applicable
	Continuing	180.1	Not Applicable	--	Not Applicable
	Ending	180.1	Not Applicable	--	Not Applicable
Volatile Solids	Initial	160.4	This is a gravimetric determination. Calibrate balance before use.	--	Not Applicable
	Continuing	160.4		--	Not Applicable
	Ending	160.4		--	Not Applicable
Water Content	Initial	--	Calibrate Balance	--	Calibrate Balance
	Continuing	--	Not Applicable	--	Not Applicable
	Ending	--	Not Applicable	--	Not Applicable
GFAA Metals (excludes Hg)	Initial	200 series	3 levels plus blank ICV ± 10% of true value "r"[3] ≥ 0.995	7000 series	3 levels plus blank ICV ± 10% of true value "r"[3] ≥ 0.995
	Continuing	200 series	Every 10 samples ± 10% of true value	7000 series	Every 10 samples ± 20% of true value
	Ending	200 series	± 10% of true value	7000 series	± 20% of true value
	Other	200 series	Annually - Instrument detection limits	7000	Annually - Instrument detection limits

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
ICAP Metals (excludes Hg)	Initial	200.7	1 level and blank Rerun high calibration standard: verify quantitation at ± 5% of true value	6010A	1 level and blank Rerun high calibration standard: verify quantitation at ± 5% of true value
	Continuing	200.7	Every 10 samples ± 5% of true value	6010A	Mid-level calibration standard Every 10 samples ± 10% of true value
	Ending	200.7	± 5% of true value	6010A	Mid-level calibration standard ± 10% of true value
	Other	200.7	ICSA, ICSAB: Analyze at beginning and end or every 8 hours whichever is more frequent <u>Annually</u>: ICP interelement correction factors Instrument detection limits	6010A	ICSA, ICSAB: Analyze at beginning and end or every 8 hours whichever is more frequent <u>Annually</u>: ICP interelement correction factors Instrument detection limits
ICP/MS Metals	Initial	200.8	1 level and blank, ICV: ± 10% of true	6020	1 level and blank, ICV: ± 10% of true
	Continuing	200.8	Mid-level calibration standard Every 10 samples, ± 10% of true value	6020	Mid-level calibration standard Every 10 samples, ± 10% of true value
	Ending	200.8	Not specified	6020	Mid-level calibration standard, ± 10% of true value
	Other	200.8	Initial tuning standard deviation ≤ 5% for five replicates; Mass calibration ≤ 0.1 amu from true; Resolution ≤ 0.75 amu full width at 5% peak height; Analyze ICSA and ICSAB at the beginning of each run and every 12 hours	6020	Initial tuning standard deviation ≤ 5% for four replicates; Mass calibration ≤ 0.1 amu from true; Resolution ≤ 0.9 amu full width at 10% peak height; Analyze ICSA and ICSAB at the beginning of each run and every 12 hours

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TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Mercury by CVAA	Initial	245.1 245.5	5 levels plus blank ICV ± 10% of true value "r"[3] ≥ 0.995	7470A 7471A	5 levels plus blank ICV ± 10% of true value "r"[3] ≥ 0.995
	Continuing	245.1 245.5	Daily or every 10 samples, whichever is more frequent ± 20% of true value	7470A 7471A	Every 10 samples ± 20% of true value
	Ending	245.1 245.5	± 20% of true value	7470A 7471A	± 20% of original prepared standard
	Other	245.1 245.5	Annually - Instrument detection limits	7470A 7471A	Annually - Instrument detection limits

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Footnotes

(1) National Pollutant Discharge Elimination System

(2) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste. Physical/Chemical Methods. (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), and Final Update IIB (January 1995).

(3) "r" = correlation coefficient

(4) Method not listed in 40 CFR Part 136.

TABLE 8.5-8
Summary of Organic Method Calibrations

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Aromatic Volatiles by GC	Initial	602	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8020A	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.
	Continuing	602	Analyze QC check sample and evaluate per method requirements	8020A	Mid-level calibration standard analyzed every 10 samples. Evaluate per method requirements.
	Ending	602	Not Applicable	8020A	Mid-level calibration standard Evaluate per method requirements.
	Other	602	Not Applicable	8020A	Not Applicable
Acrolein & Acrylonitrile by GC	Initial	603	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8030A	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.
	Continuing	603	Analyze QC check sample and evaluate per method requirements	8030A	Mid-level calibration standard analyzed every 10 samples. Evaluate per method requirements.8
	Ending	603	Not Applicable	8030A	Mid-level calibration standard Evaluate per method requirements.
	Other	603	Not Applicable	8030A	Not Applicable
Dioxins/ Dibenzofurans by HRGC/LRMS	Initial	613	3 levels If % RSD <10%, use mean RF. Otherwise calibration curve employed	8280	5 levels in triplicate % RSD ≤ 15%

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TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Dioxins/ Dibenzofurans by HRGC/LRMS (continued)	Continuing	613	1 level each working day. % D must be ≤ 15%.	8280	1 level every 12 hours after window performance mix Standard must have RFs with %D ≤ 30% from initial
	Ending	613	Not Applicable	8280	Window performance mix
	Other	613	Establish Single Ion Monitoring conditions described in method	8280	Window mix to set congener windows every 12 hours at beginning of sequence. Isotope ratios in standard must meet criteria in method. Valley between 2,3,7,8-TCDD[3] and 1,2,3,4-TCDD must be ≤ 25% of the 2,3,7,8-TCDD[3] peak height.
Dioxins/ Dibenzofurans by HRGC/HRMS	Initial	--	Not Applicable	8290	5 levels plus window defining solution. %RSD for natives ≤ 20% for RFs; %RSD for labeled compounds ≤ 30% for RFs.
	Continuing	--	Not Applicable	8290	1 level every 12 hours after window defining solution. RFs with %D ≤ 20% for natives; %D ≤ 30% for labeled compounds from initial
	Ending	--	Not Applicable	8290	1 level: RFs with %D ≤ 20% for natives; %D ≤ 30% for labeled compounds from initial

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TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Dioxins/ Dibenzofurans by HRGC/HRMS (continued)	Other	--	Not Applicable	8290	Isotope ratios in standard must meet criteria in method. Valley between 2,3,7,8-TCDD[3] and all other TCDDs must be ≤ 25% of the 2,3,7,8-TCDD height
Herbicides by GC	Initial	615[9]	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8150B	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.
	Continuing	615[9]	1 or more calibration standards analyzed daily %D ± 15% of predicted response	8150B	Mid-level calibration standard analyzed every 10 samples. %D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.
	Ending	615[9]	Not Applicable	8150B	Mid-level calibration standard. %D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.
	Other	615[9]	Not Applicable	8150B	Not Applicable
Nitroaromatics by HPLC	Initial	--	Not Applicable	8330	Minimum of 5 levels. Curve should be linear with zero intercept.
	Continuing	--	Not Applicable	8330	Midpoint calibration standard at beginning and after the midpoint of sample run. %D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.

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TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Nitroaromatics by HPLC (continued)	Ending	--	Not Applicable	8330	Midpoint calibration standard. %D: ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.
	Other	--	Not Applicable	8330	Not Applicable
Polyaromatic Hydrocarbons by GC or HPLC	Initial	610	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8100 8310	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.
	Continuing	610	1 or more calibration standards analyzed daily % D ± 15% of predicted response	8100 8310	Mid-level calibration standard analyzed every 10 samples. % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.
	Ending	610	Not Applicable	8100 8310	Mid-level calibration standard. % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.
	Other	610	Not Applicable	8100 8310	Not Applicable
Pesticides/ PCBs by GC	Initial	608	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8080A	Minimum of 5 levels. If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.
	Continuing	608	1 or more calibration standards analyzed daily % D ± 15% of predicted response	8080A	Mid-level calibration standard analyzed every 10 samples. % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.

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TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Pesticides/ PCBs by GC (continued)	Ending	608	Not Applicable	8080A	Mid-level calibration standard. % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.
	Other	608	Not Applicable	8080A	Not Applicable
Petroleum Hydrocarbons/ Oil and Grease	Initial	413.1 413.2 418.1	Method 413.1: This is a gravimetric determination. Calibrate balance before use. Method 413.2/418.1: 3 levels plus a blank "r"-≥ 0.995	9070 9071A	This is a gravimetric determination. Calibrate balance before use
	Continuing	413.1 413.2 418.1	Not Applicable	9070 9071A	Not Applicable
	Ending	413.1 413.2 418.1	Not Applicable	9070 9071A	Not Applicable
	Initial	1664[8]	Calibrate analytical balance at 2 mg and 1000 mg Calibration must be ± 10% at 2 mg and ± 0.5% at 1000 mg or recalibrate balance	--	--
	Continuing	1664[8]	Not Applicable	--	--
	Ending	1664[8]	Not Applicable	--	--
Organophos-phorous Pesticides by GC	Initial	--	Not Applicable	8140 8141A	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.

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TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Organophos-phorous Pesticides by GC (continued)	Continuing	--	Not Applicable	8140 8141A	Mid-level calibration standard analyzed every 10 samples. % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.
	Ending	--	Not Applicable	8140 8141A	Mid-level calibration standard % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.
	Other	--	Not Applicable	8140 8141A	Not Applicable
Purgeable Halocarbons by GC	Initial	601	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8010B	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.
	Continuing	601	Analyze QC check sample and evaluate per method requirements	8010B	Mid-level calibration standard analyzed every 10 samples. Evaluate per method requirements.
	Ending	601	Not Applicable	8010B	Mid-level calibration standard Evaluate per method requirements.
	Other	601	Not Applicable	8010B	Not Applicable

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TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Halogenated Volatiles by GC	Initial	--	Not Applicable	8021A	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.
	Continuing	--	Not Applicable	8021A	Mid-level calibration standard analyzed every 10 samples. % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.
	Ending	--	Not Applicable	8021A	Mid-level calibration standard % D ± 15% of predicted response for any analyte quantitated and reported, %D + 30 to -15% for analytes not detected.
	Other	--	Not Applicable	8021A	Not Applicable
Semivolatiles	Initial	625	Minimum of 3 levels, lowest near but above MDL If % RSD ≤ 35%, use avg RF Otherwise calibration curve employed.	8270B	Minimum of 5 levels, % RSD for RF for CCCs[4] ≤ 30% SPCCs[5]: RF > 0.050
	Continuing	625	1 level every 24 hours Aceeptance criteria are found in the metnod	8270B	Mid-level standard every 12 hours (after tuning) %D for CCCs[4] < 20 % between RF from standard and avg RF from initial SPCCs[5]: RF > 0.050

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TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Semivolatiles (continued)	Ending	625	Not Applicable	8270B	Not Applicable
	Other	625	DFTPP[7] tuning every 24 hours before standard or sample runs.	8270B	DFTPP[7] tuning at the beginning of every 12 hour shift.
Volatiles	Initial	624	Minimum of 3 levels, If % RSD ≤ 35%, can use mean RF Otherwise calibration curve employed	8240B	Minimum of 5 levels, % RSD for RF for CCCs[4] ≤ 30% SPCCs[5]: RF > 0.300 (0.10 for Bromoform)
	Continuing	624	1 level every 24 hours Acceptance criteria are found in the metnod	8240B	Mid-level standard every 12 hours (after tuning) %D for CCCs[4] < 20 % between RF from standard and avg RF from initial SPCCs[5]: RF > 0.300 (0.10 for Bromoform
	Ending	624	Not Applicable	8240B	Not Applicable
	Other	624	BFB[6] tuning every 24 hours before standard or sample runs.	8240B	BFB[6] tuning at the beginning of every 12 hour shift.
	Initial	--	Not Applicable	8260A	Minimum of 5 levels, %RSD for RF for CCCs[4] < 30% SPCCs[5]: RF ≥ 0.30 for Chlorobenzene and 1,1,2,2-tetrachloroethane, RF ≥ 0.10 for Chloromethane and 1,1-dichloroethane, RF > 0.10 for Bromoform

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TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Volatiles (continued)	Continuing	--	Not Applicable	8260A	Mid-level standard every 12 hours (after tuning) %D for CCCs[4] < 30% between RF from standard and avg RF from initial SPCCs[5]: RF ≥ 0.30 for Chlorobenzene and 1,1,2,2-tetrachloroethane, RF ≥ 0.10 for Chloromethane and 1,1-dichloroethane, RF > 0.10 for Bromoform
	Ending	--	Not Applicable	8260A	Not Applicable
	Other	--	Not Applicable	8260A	BFB[6] tuning at the beginning of every 12 hour shift.

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Footnotes

(1) National Pollutant Discharge Elimination System
(2) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste. Physical/Chemical Methods. (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), and Final Update IIB (January 1995).
(3) TCDD - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
(4) CCC - Continuing Calibration Compounds
(5) SPCC - System Performance Check Compound
(6) BFB - Bromofluorobenzene
(7) DFTPP - Decafluorotriphenylphosphine
(8) Method 1664 is a proposed only method and has not been promulgated by the EPA.
(9) Method not listed in 40 CFR Part 136.

TABLE 8.5-9
Summary of USEPA Contract Laboratory Program Statement of Work Method Calibrations

Analytical Parameter	Calibration	Method	Requirement
Cyanide, Total	Initial	ILM03.0	Minimum 5 levels plus blank "r" ≥ 0.995
	Continuing	ILM03.0	1 mid-level every 10 samples ± 15 % of true value
	Ending	ILM03.0	± 15 % of true value
	Other	ILM03.0	Not Applicable
ICAP (excludes mercury)	Initial	ILM03.0	1 level and blank ICV: ± 10% of true
	Continuing	ILM03.0	Mid-level calibration standard Every 10 samples ± 10% of true value
	Ending	ILM03.0	Mid-level calibration standard ± 10% of true value
	Other	ILM03.0	ICSA, ICSAB: Analyze at beginning and end or every 8 hours whichever is more frequent CRI: Beginning and end of each run, and every 8 hours for all analytes at 2x CRDL or 2x IDL whichever is greater, except for Al, Ba, Ca, Fe, Mg, Na, K Quarterly: Instrument detection limits Linear Range Verification Annually: ICP interelement correction factors

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TABLE 8.5-9
Summary of USEPA Contract Laboratory Program Statement of Work
Method Calibrations
(Continued)

Analytical Parameter	Calibration	Method	Requirement
GFAA (excludes Hg)	Initial	ILM03.0	Minimum 3 levels plus blank ICV: ± 10%
	Continuing	ILM03.0	Every 10 samples ± 10% of true value
	Ending	ILM03.0	± 10% of true value
	Other	ILM03.0	CRA: Beginning of every analytical run (no acceptance criteria) Quarterly - Instrument detection limits
Mercury (CVAA)	Initial	ILM03.0	Minimum 3 levels plus blank "r"[4] ≥ 0.995 ICV: ± 20%
	Continuing	ILM03.0	Every 10 samples ± 20% of true value
	Ending	ILM03.0	± 20% of true value
	Other	ILM03.0	Quarterly - Instrument detection limits
Pesticides/PCBs	Initial	OLM03.1	3 levels for single component analytes, 1 level for multicomponent analytes RSD must be ≤ 20% except α-BHC and δ-BHC at 25% (allow up to 2 target analytes to be 20% ≤ 30%)
	Continuing	OLM03.1	Instrument Blank and midpoint calibration or PEM every 12 hours % D: ± 25% of predicted response

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TABLE 8.5-9
Summary of USEPA Contract Laboratory Program Statement of Work
Method Calibrations
(Continued)

Analytical Parameter	Calibration	Method	Requirement
Pesticides/PCBs (continued)	Ending	OLM03.1	Instrument Blank and midpoint calibration or PEM
	Other	OLM03.1	Resolution Check Mixture ≥ 60% PEM: ≥ 90% DDT, Endrin breakdown must each be ≤ 20% (≤ 30% combined)
	Initial	OLM01.8	3 levels for single component analytes, 1 level for multicomponent analytes RSD must be ≤20% for each single component target compounds (up to two single components target compounds per column may be > 20.0% but those compounds must have an RSD ≤30.0%.
	Continuing	OLM01.8	Instrument Blank and mid-point calibration standard or PEM every 12 hours Must meet resolution, retention time window, and RPD requirements in method
	Ending	OLM01.8	Instrument Blank and mid-point calibration standard or PEM Must meet resolution retention time window, and RPD requirements in method
PCDD, PCDF	Initial	DFLM01.1	Minimum 5 levels Resolution: 13C12-2378-TCDD and 13C12-1234-TCDD < 25% 123478-HxCDD and 123678-HxCDD ≤ 50% %RSD unlabeled PCDDs/PCDFs and internal standards ≤ 15%
	Continuing	DFLM01.1	Analyze CC3 or CPS solution every 12 hours Must meet ion abundance, S/N, and %D criteria in method
	Ending	DFLM01.1	Analyze CC1 solution at end of 12 hour period Must meet ion abundance and S/N criteria in method
	Other	DFLM01.1	Window Defining Mix: verify switching times

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TABLE 8.5-9
Summary of USEPA Contract Laboratory Program Statement of Work Method Calibrations (Continued)

Analytical Parameter	Calibration	Method	Requirement
Semivolatiles by GC/MS	Initial	OLM03.1	5 levels RRF and RSD must meet method criteria
	Continuing	OLM03.1	Mid-level every 12 hours after tuning check %D and RRF must meet minimum criteria
	Ending	OLM03.1	Not Applicable
	Other	OLM03.1	DFTPP tuning at the beginning of every 12 hour shift
	Initial	OLM01.8	5 levels RRF and RSD must meet method criteria
	Continuing	OLM01.8	1 level every 12 hours %D and RRF must meet minimum method criteria
	Ending	OLM01.8	Not Applicable
Volatiles by GC/MS	Initial	OLM03.1	5 levels RRF and RSD must meet method criteria
	Continuing	OLM03.1	Mid-level every 12 hours after tuning check %D and RRF must meet minimum criteria
	Ending	OLM03.1	Not Applicable
	Other	OLM03.1	BFB tuning at the beginning of every 12 hour shift
	Initial	OLM01.8	5 levels RRF and RSD must meet method criteria
	Continuing	OLM01.8	1 level every 12 hours %D and RRF must meet minimum method criteria
	Ending	OLM01.8	Not Applicable
	Other	OLM01.8	BFB tuning at the beginning of every 12 hour shift

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TABLE 8.6-1
Precision and Accuracy Measurements

Measurement	Definition
Accuracy	The degree of agreement of a measurement with an accepted reference or true value. The only true or known values in the laboratory are spiked samples. Expressed as laboratory control sample (LCS) percent recovery (% R): $$LCS\ \%Recovery = \frac{X}{t} x 100$$ where: X = observed concentration t = concentration of spike added Expressed as matrix spike/matrix spike duplicate (MS/MSD) sample percent recovery (% R): $$MS/MSD\ \%Recovery = \frac{X_s - X}{t} x\ 100$$ where: X_s = observed concentration in spiked sample X = observed concentration in unspiked sample t = concentration of spike added
Precision	The measure of analytical reproducibility of two values. Expressed as the relative percent difference (RPD) of two values. $$RPD = \left[\frac{\lvert X_1 - X_2 \rvert}{\left(\frac{X_1 + X_2}{2} \right)} \right] x\ 100$$ where: X_1 = first observed concentration X_2 = second observed concentration

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TABLE 8.6-1
Precision and Accuracy Measurements
(Continued)

Measurement	Definition
Arithmetic mean	The average of a set of values. $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$ where: $\bar{x}$ = the mean x_i = the ith data value n = number of data values
Standard Deviation	A measure of the random (probable) error associated with a single measurement within a data set. $s = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$ where: s = sample standard deviation $\bar{x}$ = the mean x_i = the ith data value n = number of data values
Quality Control Chart	A graphical representation of analytical accuracy. Displays the arithmetic mean of a data set, the upper and lower warning limits and the upper and lower control limits.
Upper Control Limit (UCL)	For LCS $UCL = \bar{x} + 3s$ For QC Samples UCL = mean +2s
Upper Warning Limit (UWL)	For LCS $UWL = \bar{x} + 2s$ For QC Samples UWL = mean + 1s
Lower Warning Limit (LWL)	For LCS $LWL = \bar{x} - 2s$ For QC Samples LWL = mean - 1s
Lower Control Limit (LCL)	For LCS $LCL = \bar{x} - 3s$ For QC Samples LCL = mean - 2s

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TABLE 8.11-1
Instrument Maintenance Schedule
Ion Chromatograph[1]

As Needed	Daily	Weekly	Monthly	Semi-annually
Clean micromembrane suppressor when decreases in sensitivity are observed.	Check plumbing/leaks.	Check pump heads for leaks.	Check all air and liquid lines for discoloration and crimping, if indicated.	Lubricate left hand piston.
Check fuses when power problems occur.	Check gases.	Check filter (inlet)	Check/change bed supports guard-and analytical columns, if indicated.	Clean conductivity cell.
Reactivate or change column when peak shape and resolution deteriorate or when retention time shortening indicates that exchange sites have become deactivated.	Check pump pressure.			Check conductivity cell for calibration.
De-gas pump head when flow is erratic.	Check conductivity meter.			

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TABLE 8.11-2
Instrument Maintenance Schedule
LACHAT Auto Analyzer[1]

As Needed	Daily	Monthly	Semi-annually	Annually
Prepare fresh reagents.	Clean detector cell and make sure there are no trapped bubbles in detector cell.	Replace tubing.	Lubricate pump roller.	Clean pump rollers with steel wool and lubricate.
	Check tubing.	Clean pump, diluter, and XYZ Sampler.		
	Clean sample probe shaft.			

TABLE 8.11-3
Instrument Maintenance Schedule
Total Organic Halide Analyzer[1]

Daily	As Needed
Check electrodes for damage, polish the electrodes.	Examine and clean or replace pyrolysis tube.
Replace dehydrating fluid and electrolyte fluid.	Clean titration cell.
Clean quartz boat.	Observe gas flow.
Observe check valves during use for backfeed.	Replace reference electrode fluid.
At end of each day of use, wash out absorption module, empty electrolyte and fill cell with DI water. Empty dehydrator tube	Change quartz wool.
Perform cell performance check.	Replace o-rings and seals.

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TABLE 8.11-4
Instrument Maintenance Schedule
High Pressure Liquid Chromatograph[1]

Daily	As Needed
Check level of solution in reservoirs. If adding, verify that solvent is from the same source. If changing, rinse gas and delivery lines to prevent contamination of the new solvent.	Replace columns when peak shape and resolution indicate that chromatographic performance of column is below method requirements.
Check gas supply.	Oil autosampler slides when sample does not advance.
Flush with an appropriate solvent to remove all bubbles.	Rinse flow cell with 1N nitric acid if sensitivity low.
Pre-filter all samples.	Change pump seals when flow becomes inconsistent.
	Repack front end of column Backflush column.

TABLE 8.11-5
Instrument Maintenance Schedule
Flame Atomic Absorption Spectroscopy[1]

Daily	Monthly	As Needed
Verify proper safety precautions are working.	Clean all filters and fans.	Check drain receptacle.
Verify gas box operates properly and safely.	Change capillary tubing	Check background corrector for alignment.
Verify sensitivity using elements in UV/VIS spectrum.	Clean optical windows	Clean burner head.
		Clean nebulizer.
		Clean spray chamber.
		Check sample introduction O-rings.

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TABLE 8.11-6
Instrument Maintenance Schedule
Inductively Coupled Argon Plasma/Mass Spectrometry (ICAP/MS)[1]

Daily	Weekly	Monthly	Quarterly	Annually	As Needed
Check sample waste container level.	Check peristaltic pump: proper roller pressure, sample introduction tubing, correct pump rotation, condition of drain tubing.	Clean all filters and fans.	Replace oil in roughing pumps.	Replace oil in turbo-molecular pump.	Check electronic settings for optimum sensitivity: resolution, mass calibration, ion optics, CEM, deflector voltage.
Check quartz torch condition.	Check condition of sampler and skimmer cones.	Check recirculator water level.			
Measure quartz torch for proper alignment.	Check and drain oil mist eliminator on roughing pumps.				
Clean spray chamber and nebulizer.					
Check oil level of roughing pumps.					

TABLE 8.11-7
Instrument Maintenance Schedule
ICP[1]

Daily	As Needed	Semi-annually	Annually
Check that argon tank pressure is 50-60 psi and that a spare tank is available.	Clean plasma torch assembly to remove accumulated deposits.	Change vacuum pump oil.	Notify manufacturer service engineer for scheduled preventive maintenance service.
Check vacuum pump gage. (<10 millitorr)	Clean nebulizer and drain chamber; keep free-flowing to maintain optimum performance.	Replace coolant water filter. (may require more or less frequently depending on the quality of water)	
Check that cooling water supply system is full and drain bottle is not full. Also that drain tubing is clear, tight fitting and has few bends.	Clean filters on back of power unit to remove dust.		
Check that nebulizer is not clogged.	Replace when needed: peristaltic pump tubing sample capillary tubing autosampler sipper probe		
Check that capillary tubing is clean and in good condition.	Check ytrium position.		
Check that peristaltic pump windings are secure.			
Check that high voltage switch is on.			
Check that exhaust screens are clean.			
Check that torch, glassware, aerosol injector tube, bonnet are clean.			

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TABLE 8.11-8
Instrument Maintenance Schedule
Graphite Furnace Atomic Absorption[1]

Daily	Monthly	As Needed	Annually
Check gas lines and gas supply.	Check coolant level in cooling unit. Add coolant if error message appears.	Replace contact cylinder.	Notify manufacturer service engineer to clean optics.
Clean optical windows.		Adjust autosampler arm.	
Clean contact cylinders.			
Check tubes and platform; replace if corroded, faking, or if low absorbance results.			
PE4100ZL: clean fume extraction tip, replace fume extraction filter and H_2O trap.			
As needed, trim sampling capillary.			
Check drain lines and waste containers; empty as needed.			
Check acid rinse containers; fill as needed.			

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TABLE 8.11-9
Instrument Maintenance Schedule
Cold Vapor Atomic Absorption (Leeman PS 200)[1]

Daily	As Needed	Annually
Change drying tube	Change pump tubing	Change Hg lamp.
Check pump tubing/drain tubing	Check/change Hg lamp	
Check gas pressure	Clean optical cell	
Check aperture reading	Lubricate pump	

TABLE 8.11-10
Instrument Maintenance Schedule
Cold Vapor Atomic Absorption (PE 5000)[1]

Daily	Monthly
Clean aspirator by flushing with DI water.	Clean cell in aqua regia.
Check tubing and replace if needed.	Clean aspirator in aqua regia.
Clean windows with methanol.	
Change silica gel in drying tube.	
Check argon gas supply.	
Adjust lamp.	

TABLE 8.11-11
Instrument Maintenance Schedule
Gas Chromatograph[1]

Daily	As Needed	Quarterly/Semi-annually/Annually
Check for sufficient supply of carrier and detector gases. Check for correct column flow and/or inlet pressures.	Replace front portion of column packing or break off front portion of capillary columns. Replace column if this fails to restore column performance or when column performance (e.g. peak tailing, poor resolution, high backgrounds, etc.) indicates it is required.	Quarterly ELCD: change roughing resin, clean cell assembly.
Check temperatures of injectors and detectors. Verify temperature programs.	Change glass wool plug in injection port and/or replace injection port liner when front portion of column packing is changed or front portion of capillary column is removed.	Semi-annually ECD: perform wipe test.
Check inlets, septa.	Replace septum (approximately every 100 injections).	Annually ELCD: change finishing resin, clean solvent filter.
Check baseline level.	Perform gas purity check (if high baseline indicates that impure carrier gas may be in use).	
Check reactor temperature of electrolytic conductivity detector.	Replace or repair flow controller if constant gas flow cannot be maintained.	
	Replace fuse.	
	Reactivate external carrier gas dryers.	
	Detectors: clean when baseline indicates contamination or when response is low. FID: clean/replace jet, replace ignitor. NPD: clean/replace collector assembly. PID: clean lamp window, replace seals. ELCD: check solvent flow weekly, change reaction tube, replace solvent, change reaction gas, clean/replace Teflon® transfer line. ECD: follow manufacturers suggested maintenance schedule	
	Reactivate flow controller filter dryers when presence of moisture is suspected.	

TABLE 8.11-11
Maintenance Schedule
Gas Chromatograph[1]
(Continued)

Daily	As Needed	Quarterly/Semi-annually/Annually
GC (continued)	HP 7673 Autosampler: replace syringe, fill wash bottle, dispose of waste bottle contents.	(continued)
	Purge & trap devices: periodic leak checks, replace/condition traps (when poor response or disappearance of reactive or poorly trapped compounds), clean sample lines, valves (if they become contaminated), clean glassware.	
	Purge & trap autosamplers: leak check system, clean sample lines, valves. PTA-30 autosampler also requires cleaning the syringes, frits, valves, and probe needles, adjustment of micro switches, replacement of Teflon® valve, and lubrication of components.	

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TABLE 8.11-12
Instrument Maintenance Schedule
Mass Spectrometer[1]

Daily	As Needed[2]	Semi-Annually	Annually
Check for sufficient gas supply. Check for correct column flow and/or inlet pressure.	Check level of oil in mechanical pumps and diffusion pump if vacuum is insufficient. Add oil if needed between service contract maintenance.	Change oil in the mechanical rough pump. Relubricate the turbomolecular pump bearing wick.	Replace the exhaust filters on the mechanical rough pump every 1-2 years.
Check temperatures of injector, detector. Verify temperature programs.	Replace electron multiplier when the tuning voltage approaches the maximum and/or when sensitivity falls below required levels.		
Check inlets, septa.	Clean Source, including all ceramics and lenses - the source cleaning is indicated by a variety of symptoms including inability of the analyst to tune the instrument to specifications, poor response, and high background contamination.		
Check baseline level.	Repair/replace jet separator.		
Check values of lens voltages, electron multiplier, and relative abundance and mass assignments of the calibration compounds.	Replace filaments when both filaments burn out or performance indicates need for replacement.		

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TABLE 8.11-13
Instrument Maintenance Schedule
TRAACS 800 Auto Analyzer [1]

As Needed	Daily	Monthly	Semi-annually	Annually
Replaces air filter when progressive loss of air pressure is observed.	Check air pressure gauge (22 ± 2 psi)	Change all pump tubes (or after 200 hours of pumping time)	(or after 1000 hours of pumping time)	Lightly lubricate the Linear Sample Rails (use semi-fluid lubricant)
Replace air valve tubing when occlusion in tubing is observed	Use recommended washout procedure (at end of analysis operations)	Clean sample probe shaft	Replace pump platens	Replace colorimeter lamp (or after 2500 hours of use)

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TABLE 8.11-14
Instrument Maintenance Schedule
Sonicator [1]

Daily	As Needed
Daily when used: Inspect probe tips for inconsistencies (etching/pitting).	Replace probe tip.
	Disassemble and clean sonicator probe tips.
	Tune sonicator assembly.

TABLE 8.11-15
Instrument Maintenance Schedule
Analytical/Top Loading Balances[1]

Daily	Annually
Daily when used: Calibrate with check weights.	Internal weight train serviced. Gears and electronics serviced.

TABLE 8.11-16
Instrument Maintenance Schedule
Refrigerators/Walk-in Coolers[1]

Daily	As Needed
Temperatures checked and logged.	Refrigerant system and electronics serviced.

TABLE 8.11-17
Instrument Maintenance Schedule
Ovens[1]

Daily	As Needed
Temperatures checked and logged.	Electronics serviced.

TABLE 8.11-18
Instrument Maintenance Schedule
Specific Digital Ion Analyzer[1]

Daily	As Needed
Daily when used: Calibrate with check standards.	Electronics serviced.

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TABLE 8.11-19
Instrument Maintenance Schedule
Turbidimeter[1]

Daily	As Needed
Daily when used: Calibrate with check standards.	Electronics serviced.

TABLE 8.11-20
Instrument Maintenance Schedule
Dissolved Oxygen Meter[1]

Daily	As Needed
Daily when used: Calibrate with check standards.	Electronics serviced.

TABLE 8.11-21
Instrument Maintenance Schedule
Conductance Meter[1]

Daily	As Needed
Daily when used: Calibrate with check standards.	Electronics serviced.

TABLE 8.11-22
Instrument Maintenance Schedule
Chemical Oxygen Demand (COD) Reactor

Daily	As Needed
Daily when used: Calibrate with check standards.	Electronics serviced.

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TABLE 8.11-23
Instrument Maintenance Schedule
Spectrophotometer[1]

As Needed	Daily	Monthly	Annually
Dust the lamp and front of the front lens.	Check the zero %T adjustment.	Perform wavelength calibration at 530 nm.	Oil bearings.

TABLE 8.11-24
Instrument Maintenance Schedule
pH Meter[1]

As Needed	Daily
Clean electrode.	Verify electrodes are properly connected and filled.
Refill reference electrode.	Make sure electrode is stored in buffer.

TABLE 8.11-25
Instrument Maintenance Schedule
Fourier Transform Infrared Spectrometry (FTIR)[1]

Check desiccant every 3 months.
Check KBr window every 3 months.

TABLE 8.11-26
Instrument Maintenance Schedule
Radiological Analysis Equipment[1]

Instrument	Items Checked/Service	Minimum Frequency
Alpha Proportional	Check gas flow	Daily
	Clean sample tray	Weekly
	Check bubbler oil level	Monthly
Beta Proportional	Check gas flow	Daily
	Clean sample holders	Weekly
Liquid Scintillation	Clean sample changer	Weekly
	Check condensate trays	Weekly
	Check air filters	Monthly
Quad aß Proportional	Check gas flow	Daily
	Clean sample holders	Weekly
Gamma Spectroscopy	Check LN_2 level	Bi-weekly
	Replace plastic liner	Weekly
Alpha Spectroscopy	Clean sample holder	As needed
	Change vacuum pump oil	Every six months
LIPA	Clean sample changer	Weekly
	Check laser dye performance	Weekly
Benzene Synthesizer	Check gas tubes	Weekly
	Clean instrument	Monthly
Electrolytic Enrichment	Check electrical leads	Monthly
	Clean system	Monthly
Fluorometer	Clean sample holder	Weekly

TABLE 8.11-27
Instrument Maintenance Schedule
Total Organic Carbon Analyzer (OI 7000)

Daily	Weekly	Monthly	Semi-Annually
Check: Oxygen supply Persulfate supply Acid supply Carrier gas flow rate (~ 150 cc/min) IR millivolts for stability (after 30 min. warm-up)	Check liquid-flow-rate-pump-tubing conditions on autosampler Check injection port septum	Clean digestion vessel Clean condenser column Do the leak test	Change pump tubing

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Footnotes to Preventive Maintenance Tables

(1) Refer to manufacturer's instructions for each instrument to perform maintenance operations.
(2) Also see Table 8.11-11 for applicable "As Needed" GC maintenance.

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Glossary

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Glossary (continued)

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Glossary (continued)

acceptance limits
Data quality limits specified for analytical method performance.

accuracy
Accuracy is the degree of agreement between a measurement and the true or expected value, or between the average of a number of measurements and the true or expected value. Systematic errors affect accuracy. For chemical properties, accuracy is expressed either as a percent recovery (R) or as a percent bias (R - 100).

aliquot, aliquant
A measured portion of a sample taken for analysis.

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analytical spike
A sample created by spiking target analytes into a prepared portion of a sample just prior to analysis. (Also see matrix spike.)

anomaly
See nonconformance.

areas needing improvement
Represent isolated instances of noncompliance or issues that are judged to have a less immediate impact on data quality. Laboratory management must correct the situation or otherwise ensure that the condition does not recur. This term replaces the previous term used "Observations."

arithmetic mean
The arithmetic mean ($\bar{x}$) is the average of a set of values. It is equal to the sum of the observed values divided by the number of observations. Also called "average".

where: $\bar{x}$ = the mean
x_i = the ith data value
n = number of data values

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

Glossary (continued)

assessment
The evaluation process used to measure the performance or effectiveness of a system and its elements. Assessment is used as an all-inclusive term to denote any of the following: performance, systems, data and compliance audits, management systems reviews, peer reviews, inspections, or spot assessments.

associate
Employee.

audit
A planned and documented investigative evaluation of an item or process to determine its adequacy and effectiveness as well as compliance with established procedures, instructions, drawings, quality management plans, and other applicable documents.

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benchmarking
A step-by-step method of improving performance by identifying and studying best practices and comparing them to industry practices.

bias
A systematic (consistent) error in test results. Bias is expressed as the difference between the population mean and the true or reference value, or as estimated from sample statistics, the difference between the sample average and the reference value.

blind performance evaluation sample
A sample either submitted to the laboratory or prepared in the laboratory whereby the concentrations of parameters of concern are known by the preparer and not by the laboratory.

calibration
Establishment of a relationship between various calibration standards and the measurements of them obtained by a measurement system, or portions thereof. The levels of the calibration standard should bracket the range of levels at which actual measurements are to be made. Calibration is also the act of making a scheduled comparison of instrument performance against national standards for instruments

Glossary (continued)

which measure physical parameters such as mass, time, and temperature. This type of calibration is independent of use in specific analyses and projects.

calibration curve
The graphical relationship between the known values for a series of calibration standards and instrument responses.

calibration factor (CF)
The ratio of the instrument response of an analyte to the amount injected. CFs are used in external standard calibrations.

$$CF = \frac{Total\ Area\ of\ Peak}{Mass\ Injected}$$

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calibration standard
A standard used to quantitate the relationship between the output of a sensor and a property to be measured. Calibration standards should be traceable to standard reference materials (provided by NIST, or other recognized standards agencies) or a primary standard.

Certificate of Analysis
The standard Quanterra® format for reporting analytical results.

certified reference material
A reference material accompanied by a certificate issued by an organization certifying the contents and concentration(s) of the material. (See also standard reference material.)

chain-of-custody (COC)
A system of documentation demonstrating the physical custody and traceability of samples.

Glossary (continued)

check standard analyses
A standard (often a midpoint standard) analyzed at a frequency specified in the method or in an SOP to verify the continuing calibration of the standard curve.

client
Any individual or organization for whom items or services are furnished or work is performed in response to defined requirements and expectations.

client sample
The material or collection media submitted to the laboratory for analysis. Field QC samples are considered client samples but laboratory QC samples are not counted as client samples when counting samples for QC batches.

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coefficient of variation (relative standard deviation)
A measure of precision (relative dispersion). It is equal to the standard deviation (s) divided by the mean ($\bar{x}$) and multiplied by 100 to give a percentage value.

$$CV\ (RSD) = \left(\frac{s}{\bar{x}}\right) x\ 100$$

collocated samples
Independent samples collected in such a manner that they are equally representative of the variable(s) of interest at a given point in space and time. The results will indicate sampling as well as analytical variability.

comparability
Comparability is a measure of the confidence with which one data set can be compared to another. To ensure comparability, all laboratory analysts are required to use uniform procedures (i.e., SOPs) and a uniform set of units and calculations for analyzing and reporting environmental data.

Glossary (continued)

completeness

Completeness is a measure of the percentage of measurements that are judged to be valid measurements. At a minimum, the objective for completeness of data is 90% for each constituent analyzed. It is usually expressed as a percentage:

$$\% \, Completeness = \frac{V}{n} \, x \, 100$$

where: V = number of measurements judged valid
n = total number of measurements

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composite

A sample composed of two or more increments.

control chart

A graphical representation of analytical accuracy. Displays the arithmetic mean of a data set, the upper and lower warning limits and the upper and lower control limits.

control table

A tabular presentation of test results with respect to time or sequence of measurement, together with limits within which the results are expected to lie when the analytical process is in a state of control.

controlled document

A document for which the distribution is known. Updates of the document are sent to the original recipients, unless the copy distributed is an uncontrolled copy.

corrective action

A measure taken to rectify conditions adverse to quality and, where necessary, to preclude their recurrence.

Glossary (continued)

correlation coefficient

The correlation coefficient (r) is a determination of how closely data "fits" a straight line. It is a number between -1 and 1 that indicates the degree of linear relationship between two sets of numbers. A correlation coefficient of +1 (usually calculated to three decimal places or 1.000) means the data falls exactly on a straight line with positive slope. A correlation coefficient of -1 (or -1.000) means the data falls exactly on a straight line with negative slope.

customer

See client.

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data quality objective (DQO)

Data quality objectives (DQOs) are qualitative and quantitative statements used to ensure the generation of the type, quantity, and quality of environmental data that will be appropriate for the intended application (EPA 1994). Typically, DQOs are identified during project scope and development of sampling and analysis plans. In this QA manual, however, we refer to only the analytical DQOs because laboratories generally do not have any authority over sample collection, shipment, or other field-related activities that may affect the data quality of the environmental sample before the sample is received in the laboratory. EPA has established six primary analytical DQOs for environmental studies: precision, accuracy, representativeness, completeness, comparability, and detectability.

The components of analytical variability (uncertainty) can be estimated when QA and QC samples of the right types and quantities are incorporated into measurement procedures at the analytical laboratory. Quanterra incorporates numerous QA and QC samples to obtain data for comparison with the analytical DQOs and to ensure that the measurement system is functioning properly. The QA and QC samples and their applications, described in Section 8.4 and are selected on the basis of method- or client-specific requirements. Field blanks, field duplicates, and performance evaluation (PE) samples are received from the client as unknown samples. Analytical laboratory QC samples for inorganic, organic, and radionuclide analyses may include calibration or instrument blanks, method blanks, background, duplicates, replicates, laboratory control samples (LCSs), calibration standards, matrix spikes (MSs), matrix spike duplicates (MSDs), surrogate spikes, and yield tracers.

Glossary (continued)

data validation
See validation - data.

data verification
See verification - data.

deficiency
See nonconformance.

degrees of freedom
The number of independent deviations used in calculating an estimate of the standard deviation.

double blind performance evaluation sample
A sample that contains select parameters at defined levels. The levels are unknown to the laboratory. The laboratory is also unaware that the sample is a performance evaluation sample.

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duplicate sample analyses
Different aliquots of the same sample are analyzed to evaluate the precision of an analysis.

error
The difference between an observed or measured value and its true value.

field blank
A blank that is prepared and handled in the field and analyzed in the same manner as its corresponding client samples.

field matrix spike
A sample created by spiking target analytes into a sample in the field at the point of sample acquisition.

Glossary (continued)

finding
Noncompliant practices or policies which have significant adverse impact on data quality, technical defensibility, or regulatory acceptance of data. Findings require immediate attention by the laboratory management and must be resolved to comply with Quanterra®'s quality documents and laboratory-established procedures.

geometric mean
The nth root of the product of all values in a set of n values or the antilogarithm of the arithmetic mean of the logarithms of all the values of a set of n values. The geometric mean is generally used when the logarithms of a set of values are nearly normally (Gaussian) distributed, such as is the case of much population data.

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initial calibration
Analysis of a series of analytical standards at different specified concentrations; used to define the linearity and dynamic range of the response of an instrument to the target compounds prior to the analysis of samples.

inspection
Examination or measurement of an item or activity to verify conformance to specific requirements.

instrument detection limit (IDL)
The smallest concentration or amount an instrument can reliably detect.

internal standard (IS)
A compound added to every standard, QC sample, client sample, or sample extract at a known concentration prior to analysis for the purpose of quantitation. For example, internal standards are used as the basis for quantitation of the target compounds by GC/MS.

linear regression
A statistical method for finding a straight line that best fits a set of two or more data points, thus providing a relationship between two or more variables.

Glossary (continued)

matrix
The component or substrate which contains the analyte(s) of interest. Examples of matrices are water, soil or sediment, and air. Matrix is not synonymous with phase (liquid or solid).

matrix effect
An interference in the measurement of analyte(s) in a sample that is caused by materials in the sample. Matrix effects may cause elevated reporting limits or may prevent the acquisition of acceptable results.

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matrix spike (MS)
An aliquot of a matrix fortified (spiked) with known quantities of specific compounds and subjected to an entire analytical procedure in order to indicate the appropriateness of the method for a particular matrix. The percent recovery for the respective compound(s) is then calculated.

matrix spike duplicate (MSD)
A second aliquot of the same matrix as the matrix spike (above) that is spiked in order to determine the precision of the method.

may
Denotes permission but not a requirement.

mean
See arithmetic mean.

measurement
The process or operation of ascertaining the extent, degree, quantity, dimensions, or capability with respect to a standard.

median
The middle value of a set of data when the data set is ranked in increasing or decreasing order.

Glossary (continued)

method
An assemblage of techniques.

method blank (MB)
An analytical control consisting of all reagents, which may include internal standards and surrogate standards, that is carried through the entire analytical procedure. The method blank is used to define the level of laboratory background contamination. Examples of method blanks are a volume of deionized or distilled laboratory water for water samples, a purified solid matrix for soil/sediment samples, or a generated zero air.

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method detection limit (MDL)
The minimum concentration of an analyte that, in a given matrix and with a specific method, can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero. The MDL is operationally defined as:

$$MDL = st_{(n-1,\ \alpha=0.99)}$$

where:

s = the standard deviation of a number of measurements of a blind or sample matrix containing the analyte at a concentration near the lowest standard recommended in the method and

$t_{(n-1,\ \alpha=0.99)}$ = the student's value for a one-sided t-statistic appropriate for the number of samples used to determine (s), at the 99% confidence level and n-1 degrees of freedom.

modified method
A standard or reference method which has been changed to meet project or matrix requirements.

must
Denotes a requirement is mandatory and has to be met.

Glossary (continued)

notable practices

Laboratory practices that increase effectiveness and quality and represent improvements with respect to conventional laboratory operations.

nonconformance

An unplanned deviation from an established protocol or plan. The deviation may be the result of Quanterra's® actions, then termed a deficiency. If the deviation is the result of events beyond the control of Quanterra®, it is termed an anomaly.

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operational calibration

Routinely performed as part of instrument usage, such as the development of a standard calibration curve. Operational calibration is generally performed for instrument systems.

outlier

A result excluded from the statistical calculations due to being deemed "suspicious" when applying the "Grubbs Test" (or equivalent).

parameter

A constant or coefficient that describes some characteristic of a population (e.g., standard deviation, mean, regression coefficients). Also, a chemical being measured, i.e., an analyte.

percent difference

When two independent measurements of the same characteristics are available, it is possible to use the percent difference instead of the coefficient of variation to measure precision.

$$\%D = \left| \frac{X_1 - X_2}{X_1} \right| x\ 100\%$$

where: $\%D$ = percent difference
X_1 = first value
X_2 = second value

Glossary (continued)

percent recovery
A measure of accuracy determined from the comparison of a reported spike value to its true spike concentration.

$$\%R = \frac{observed\ conc.\ -\ sample\ conc.}{true\ spike\ conc.} \times 100\%$$

performance audit
See performance evaluation.

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performance evaluation (PE)
A type of audit in which a known or characterized value is compared to the result obtained through the routine analysis of the sample in the laboratory to evaluate the proficiency of an analyst or laboratory.

periodic calibration
A calibration that is performed at prescribed intervals for equipment such as balances, thermometers, and balance weights. In general, they are performed on equipment that are distinct, singular purpose units, and are relatively stable in performance.

population
A generic term denoting any finite or infinite collection of individual things, objects, or events.

practical quantitation limit (PQL)
The lowest concentration a method can reliably achieve within limits of precision and accuracy and is derived from empirical, matrix-free method performance studies.

precision
Precision is an estimate of variability, that is, it is an estimate of agreement among individual measurements of the same physical or chemical property, under prescribed similar conditions. The precision of a measurement system is affected by random errors. Precision is expressed either as relative standard deviation (RSD) for replicate measurements greater than two or as relative percent

Glossary (continued)

difference (RPD) for duplicate measurements. Table 8.6-1 illustrates the formulae used to calculate units of precision (i.e., RSD and RPD).

preventive maintenance
An organized program within Quanterra® laboratories of actions (such as equipment cleaning, lubricating, reconditioning, adjustment and/or testing) taken to maintain proper instrument and equipment performance and to prevent instruments and equipment from failing during use.

primary standard
A material having a known, stable property that can be accurately measured or derived from established physical or chemical constants. It is readily reproducible and can be accepted (within stated limits) and used to establish the same value of another substance or item.

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procedure
Detailed instructions to permit replication of a method. (See standard operating procedure.)

proficiency testing
A series of planned tests which will determine the ability of field technicians or laboratory analysts to perform routine analyses. The results from this testing may be used for comparison against established criteria or for relative comparisons among the data from a group of technicians or analysts.

project-specific reporting limit (PSRL)
See reporting limit.

protocol
Methodology specified in regulatory, authoritative, or contractual situations.

QC batch
The QC batch consists of a set of up to 20 field samples that behave similarly (i.e., same matrix) and are processed using the same procedures, reagents, and standards within the same time period.

Glossary (continued)

QC check sample
A reference matrix containing known concentrations of parameters of interest. If prepared in the laboratory, it is made using stock standard solutions independent of those used for calibration. If the results of these parameters do not meet acceptance criteria, corrective actions are taken.

qualification (personnel)
The characteristics of abilities gained through education, training, or experience, as measured against established requirements, such as standards or tests, that qualify an individual to perform a required function.

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quality
The sum of features and properties/characteristics of a process, item, or service that bears on its ability to meet the stated needs of the user. Quanterra® has defined quality as meeting the needs of our clients, both internal and external.

quality assurance (QA)
An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the customer.

Quality Assurance Management Plan (QAMP)
The Quality Assurance Management Plan for Environmental Analyses (QAMP) is a formal document that describes quality systems in terms of organizational structure, functional responsibilities of management, and staff, and lines of authority. The QAMP documents the QMS and describes both the organizational and project-specific principles, goals, controls, and tools of the QMS. The QAMP provides the criteria and specifications for the generation of environmental analytical data.

Quality Assurance Project or Program Plan (QAPP)
A formal document describing in comprehensive detail the necessary QA, QC, and other technical activities that must be implemented to ensure the results of the work performed will satisfy the stated performance criteria.

Glossary (continued)

quality control (QC)
The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that it meets the stated requirements established by the client or by Quanterra®.

quality improvement
The process of improving the quality of operations. This process encourages worker recommendations for improvement of work processes and requires timely management evaluation and feedback or implementation.

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quality management
That aspect of the overall management system of the organization that determines and implements the quality policy. Quality management includes strategic planning, allocation of resources, and other systematic activities (e.g., planning, implementation, and assessment) pertaining to the quality management system.

quality management system (QMS)
A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, and implementation plan of an organization for ensuring quality in its work processes, products, and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required QA and QC.

random error
Variations of repeated measurements that are random in nature and individually not predictable.

range
The difference between the largest and smallest numbers in a set of numbers.

Glossary (continued)

raw data
All documentation associated with the original recording of analytical results pertinent to a specific sample or set of samples. This may include laboratory worksheets, calculation forms, instrument-generated output, analyst notes, etc., from sample receipt through final reporting.

reagent water
Water in which an interferant is not observed at or above the minimum quantitation limit of the parameters of interest. The reagent water's purity and acceptability is verified by analysis with each set of samples.

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recovery
See percent recovery.

reference method
A method of known and demonstrated accuracy.

regression coefficients
The quantities describing the slope and intercept of a regression line.

relative error
An error expressed as a percentage of the true value or accepted reference value.

relative percent different (RPD)
Statistic for evaluating the precision of a replicate set. For replicate results x_1 and x_2 :

$$RPD = \left[\frac{|X_1 - X_2|}{\left(\frac{X_1 + X_2}{2} \right)} \right] x\ 100$$

where: X_1 = first observed concentration
X_2 = second observed concentration

Glossary (continued)

relative response factor (RRF)
A measure of the relative mass spectral response of a compound compared to its internal standard. RRFs are determined by analysis of standards and are used in the calculation of concentrations of analytes in samples. Because a RRF is the comparison of two responses, it is a unitless number. RRFs are determined by the following equation:

$$RRF = \frac{A_x}{A_{IS}} x \frac{C_{IS}}{C_x}$$

where: A = area of the characteristic ion measured
C = concentration
IS = internal standard
x = analyte of interest

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relative standard deviation (RSD)
See coefficient of variation.

reporting limit (RL)
One of two types of reporting limit conventions within Quanterra®. The Reporting Limit (RL) is a uniform, Quanterra® -wide reporting limit based on an evaluation of the PQLs at Quanterra® laboratories and the expected method performance in routine water and soil matrices. Project Specific Reporting Limits (PSRLs) are reporting limits that are defined by project requirements.

representative sample
A sample taken to represent a lot or population as accurately and precisely as possible.

representativeness
Representativeness is the degree to which data accurately and precisely represent a characteristic of a population, a variation in a physical or chemical property at a sampling point, or an environmental condition. Data representativeness is primarily a function of sampling strategy; therefore, the sampling scheme must be designed to maximize representativeness. Representativeness also relates to ensuring that, through sample homogeneity, the sample analysis result (concentration) is

Glossary (continued)

representative of the constituent concentration in the sample matrix. At each Quanterra laboratory, every effort must be made to analyze an aliquot that is representative of the original sample, and to ensure the homogeneity of the sample before subsampling.

reproducibility
The precision, usually expressed as a standard deviation, measuring the variability among results of measurements of the same sample at different laboratories.

response factor (RF)
A factor derived from the calibration of a compound that is used in the quantitation calculation of sample analytes. A response factor may be derived from an external standard calibration (then called a Calibration Factor) or from an internal standard calibration (then called a Relative Response Factor).

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secondary standard
A material having a property that is calibrated against a primary standard.

self assessment
Assessments of work conducted by individuals, groups, or organizations directly responsible for overseeing or performing the work.

shall
Denotes a requirement that is mandatory and has to be met.

should
Denotes a guideline or recommendation.

standard addition
The procedure of adding known increments of the analyte of interest to a sample to cause increases in detection response to subsequently establish, by extrapolation of the plotted responses, the level of the analyte of interest present in the original sample.

Glossary (continued)

standard deviation
A measure of the dispersion about the mean of the elements in a population. The square root of the variance of a set of values:

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

where: s = standard deviation
Σ = sum of
X = observed values
n = number of observations

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standardization
The establishment of the value of a potential standard with respect to an established or known standard.

standard method
A method of known and demonstrated precision issued by an organization generally recognized as competent to do so.

standard operating procedure (SOP)
A written document that details an operation, analysis, or action, with prescribed techniques and steps, that is officially approved as the method for performing certain routine or repetitive tasks.

standard reference material (SRM)
A material produced in quantity, of which certain properties have been certified by the National Institute of Standards and Technology (NIST), formerly NBS, or other agencies to the extent possible to satisfy its intended use.

standard verification
Standard is checked by Quanterra® versus manufacturer specification. See Section 8.5.4.3.

Glossary (continued)

statistic
A constant or coefficient that describes some characteristic of a sample. Statistics are used to estimate parameters of populations.

stock solution
A concentrated solution of analyte(s) or reagent(s) prepared and verified by prescribed procedure(s), and used for preparing working standards or standard solutions.

subsample
A portion taken from a sample. A laboratory sample may be a subsample of a gross sample; similarly, a test portion may be a subsample of a laboratory sample.

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supplier
See vendor.

surrogate (surrogate standard)
Compounds, when required by a method, that are used added to every blank, sample, LCS, matrix spike, matrix spike duplicate, and standard. They are used to evaluate analytical efficiency by measuring recovery. Surrogates include brominated, fluorinated, or isotopically-labeled compounds that are not expected to be detected in environmental media.

systematic error
The condition of a consistent deviation of the results of a measurement process from the reference or known level.

systems audit or evaluation
A systematic on-site qualitative review of facilities, procedures, equipment, training, record keeping, data verification, and reporting aspects of a quality assurance system to arrive at a measure of the capability of the system. Within Quanterra®, system audits or evaluations are performed on a periodic basis under the direction of the Quanterra® Corporate Director of Quality Assurance.

Glossary (continued)

technique
Physical or chemical principle for characterizing materials of chemical systems.

traceability of data
The entire documented chain of acquired data from the original acquisition effort through to the final tabulation, synthesis, reduction, and storage activities. The documentation will allow complete reconstruction of the data.

traceability of samples
During all environmental monitoring field efforts, acquired samples will be assigned specific and unique identification numbers. These sample numbers shall be accompanied by documentation (chain-of-custody form) which clearly identifies all parameters associated with sample acquisition. All additional sample numbering systems applied to the sample must be clearly cross-referenced to the field sample number to provide for traceability of samples from acquisition to reporting of sample results.

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traceability of standards
The ability of an analytical standard material used for calibration purposes to be traced to its source. The standards used by Quanterra® must be traceable via written documentation to sources which produce or sell verified or certified standards, i.e., National Institute for Standards and Technology, or vendors preparing standards from those sources which they have certified.

validation - computer software
The process of establishing documented evidence which provides a high degree of assurance that a specific process will consistently produce a product meeting predetermined specifications and quality attributes. This process demonstrates and documents that the software performs correctly and meets all specified requirements.

validation - data
The process of a second party performing a systematic review of the raw and final data produced by a laboratory using predetermined criteria to ascertain the validity of the data with respect to the criteria (e.g., HAZWRAP data validation).

Glossary (continued)

vendor
Any individual or organization furnishing items or services or performing work according to a procurement document. This is an all-inclusive term used in place of any of the following: supplier, seller, contractor, subcontractor, or consultant.

verification - computer software
The process of checking the accuracy of manually entered or automatically (electronically) calculated information.

verification - data
The process of reviewing data to ensure that data reduction has been correctly performed and that analytical results to be reported correspond to the data acquired and processed.

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INDEX

Index

UNCONTROLLED COPY

Index (continued)

UNCONTROLLED COPY

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Index (continued)

Page/Location

Accuracy (See Precision and Accuracy Measurements)

Anomaly (See Nonconformance)

Assessment (Quality) 62, 80
- Audit (See Audit)
- Data Accuracy (See Precision and Accuracy Measurements)
- Data Completeness 41
- Data Precision (See Precision and Accuracy Measurements)
- Data Quality Objectives 40
- Management Review of the QMS 78
- Quality Reports to Management 77

Audit (Quality Assurance) 73
- Data Audit 77
- Findings 75
- Areas Needing Improvement 76
- Performance Audit 74
- Report 75
- Spot Assessment 77
- Systems Audit (Internal) 75
- Systems Audit (External) 75

Benchmarking 80

Calibration
- Contract Laboratory Program (CLP) Method Calibrations
  - Cyanide, Total ..... Table 8.5-9
  - GFAA ..... Table 8.5-9
  - ICAP ..... Table 8.5-9
  - Mercury (CVAA) ..... Table 8.5-9
  - PCDD/PCDF ..... Table 8.5-9
  - Pesticides/PCBs ..... Table 8.5-9
  - Semivolatiles ..... Table 8.5-9
  - Volatiles ..... Table 8.5-9

UNCONTROLLED COPY

Index (continued)

Page/Location

Calibration (Continued)

Criteria ..... 59, Tables 8.5-7, 8.5-8, 8.5-9
Failure 62
Inorganic Method Calibrations
Acidity ..... Table 8.5-7
Alkalinity ..... Table 8.5-7
Ammonia ..... Table 8.5-7
Biochemical Oxygen Demand (BOD) ..... Table 8.5-7
Bromide ..... Table 8.5-7
Chemical Oxygen Demand (COD) ..... Table 8.5-7
Chloride ..... Table 8.5-7
Chlorine, Residual ..... Table 8.5-7
Chromium (Hexavalent) Cr^{+6} ..... Table 8.5-7
Color ..... Table 8.5-7
Conductivity ..... Table 8.5-7
Cyanide (Amenable) ..... Table 8.5-7
Cyanide (Total) ..... Table 8.5-7
Flashpoint ..... Table 8.5-7
Fluoride ..... Table 8.5-7
Hardness ..... Table 8.5-7
Iodide ..... Table 8.5-7
Iron, Phenanthroline Method ..... Table 8.5-7
Methylene Blue Active Substances (MBAS) ..... Table 8.5-7
Metals ..... Table 8.5-7
Graphite Furnace AA ..... Table 8.5-7
ICAP ..... Table 8.5-7
ICP/MS ..... Table 8.5-7
Mercury (CVAA) ..... Table 8.5-7
Nitrate ..... Table 8.5-7
Nitrite ..... Table 8.5-7
Nitrate-Nitrite ..... Table 8.5-7
Odor ..... Table 8.5-7
pH ..... Table 8.5-7
Phenolics ..... Table 8.5-7

UNCONTROLLED COPY

Index (continued)

Page/Location

Calibration (Continued)

Phosphate ..... Table 8.5-7
Phosphorous (Total and Orthophosphate) ..... Table 8.5-7
Reactivity ..... Table 8.5-7
Settleable Solids ..... Table 8.5-7
Silica, Dissolved ..... Table 8.5-7
Specific Conductance ..... Table 8.5-7
Sulfate ..... Table 8.5-7
Sulfide ..... Table 8.5-7
Sulfite ..... Table 8.5-7
Temperature ..... Table 8.5-7
Total Dissolved Solids ..... Table 8.5-7
Total Kjeldahl Nitrogen (TKN) ..... Table 8.5-7
Total Organic Carbon (TOC) ..... Table 8.5-7
Total Organic Halides (TOX) ..... Table 8.5-7
Total Solids ..... Table 8.5-7
Total Suspended Solids ..... Table 8.5-7
Total Volatile Solids ..... Table 8.5-7
Turbidity ..... Table 8.5-7
Water Content ..... Table 8.5-7

Organic (Method Calibrations)

Aromatic Volatiles by GC ..... Table 8.5-8
Dioxins/Dibenzofurans by HRGC/HRMS ..... Table 8.5-8
Dioxins/Dibenzofurans by HRGC/LRMS ..... Table 8.5-8
Halogenated Volatiles by GC ..... Table 8.5-8
Herbicides by GC ..... Table 8.5-8
Nitroaromatics by HPLC ..... Table 8.5-8
Organophosphorous Pesticides by GC ..... Table 8.5-8
Polyaromatic Hydrocarbons (PAHs) by GC or HPLC ..... Table 8.5-8
Pesticides/PCBs by GC ..... Table 8.5-8
Petroleum Hydrocarbons/Oil and Grease ..... Table 8.5-8

Organic Method Calibrations (Continued)

Purgeable Halocarbons by GC ..... Table 8.5-8
Acrolein and Acrylonitrile ..... Table 8.5-8
Semivolatiles ..... Table 8.5-8

UNCONTROLLED COPY

Index (continued)

Page/Location

Calibration (Continued)
- Volatiles ..... Table 8.5-8
- Operational 61
- Periodic ..... 61, Table 8.5-6
  - Balance ..... Table 8.5-6
  - Freezer ..... Table 8.5-6
  - Graduated Glassware ..... Table 8.5-6
  - Micropipettor ..... Table 8.5-6
  - Oven ..... Table 8.5-6
  - Refrigerator ..... Table 8.5-6
  - Syringe ..... Table 8.5-6
  - Thermometer ..... Table 8.5-6
  - Volumetric Glassware ..... Table 8.5-6
- Procedures 59
- Records 24

Chain-of-Custody
- Chain-of-Custody Form 52
- Internal Chain-of-Custody 58
- Return Chain-of-Custody 59

Chemical Storage 72

Comparability (Data) 42

Completeness (Data) 41, 62

Computer (See also Software)
- Backup 27
- Hardware 27
- Security 27
- Viruses 29

Condition Upon Receipt (See Nonconformance)

UNCONTROLLED COPY

Index (continued)

Page/Location

Control Chart ..... Table 8.6-1

Corrective Action 73

Customer Service Team 34

Data

- Assessment 62
- Collection 31, 62
- Electronic Data Transfer 68
- Qualifiers 64, 69
- Recording Procedures 63
- Reduction 64, 65
- Reporting 68
- Reports 68
- Review 64-68
- Statistical Evaluation of Data 63
- Validation 69
- Verbal Results 68
- Verification 64-68

Data Quality Objective 40

Deficiency (See Nonconformance)

Deliverables 68

Document

- Approval ..... 23, Table 5.1-1
- Control 23
- Controlled 23
- Distribution 23
- Quality ..... 10, 23, Table 5.1-1, Table 5.2-1

UNCONTROLLED COPY

Index (continued)

Page/Location

Document (Continued)
Review ..... 23, Table 5.2-1
Revision ..... 23, Table 5.2-1
Confidentiality 25

Ethics 8

Facility Security 72

Gas, compressed (See Internal QC Requirements)

Holding Times (See Sample Containers, Preservatives, and Holding Times)

Instrument Maintenance (See Maintenance)

Internal QC Requirements
Air (Compressed) 71
Gases (Compressed) 71
Glassware 72
Water 70, 71

Key Result Indicators 80-81

Maintenance
Equipment 70
Facility 70
Preventative Maintenance 70
Instrument Maintenance 70
Instrument Maintenance Schedules
Balances (Analytical, Top Loading) ..... Table 8.11-15
Chemical Oxygen Demand (COD) Reactor ..... Table 8.11-22
Cold Vapor Atomic Absorption (CVAA) - Leeman PS 200 ..... Table 8.11-9
Cold Vapor Atomic Absorption (CVAA) - PE 5000 ..... Table 8.11-10
Conductance Meter ..... Table 8.11-21

UNCONTROLLED COPY

Index (continued)

Page/Location

Maintenance (continued)

Dissolved Oxygen Meter ..... Table 8.11-20
Flame Atomic Absorption (Flame AA) ..... Table 8.11-5
Fourier Transform Infrared Spectrometry (FTIR) ..... Table 8.11-25
Gas Chromatograph (GC) ..... Table 8.11-11
Graphite Furnace Atomic Absorption (GFAA) ..... Table 8.11-8
High Pressure Liquid Chromatography (HPLC) ..... Table 8.11-4
ICAP/MS ..... Table 8.11-6
ICP ..... Table 8.11-7
Ion Chromatograph (IC) ..... Table 8.11-1
LACHAT Auto Analyzer ..... Table 8.11-2
Mass Spectrometer (MS) ..... Table 8.11-12
Ovens ..... Table 8.11-17
pH Meter ..... Table 8.11-24
Radiological Analysis Equipment ..... Table 8.11-26
Refrigerator ..... Table 8.11-16
Sonicator ..... Table 8.11-14
Specific Digital Ion Analyzer ..... Table 8.11-18
Spectrophotometer ..... Table 8.11-23
Total Organic Carbon (TOC) Analyzer (OI 7000) ..... Table 8.11-27
Total Organic Halide (TOX) Analyzer ..... Table 8.11-3
TRAACS 800 Auto Analyzer ..... Table 8.11-13
Turbidimeter ..... Table 8.11-19
Walk-in Cooler ..... Table 8.11-16

Service Agreements 70

Method

Analytical ..... 39, Table 8.2-1
Modifications 40

Method Detection Limit (See Reporting Limit)

Method of Standard Additions 49

UNCONTROLLED COPY

Index (continued)

Page/Location

Nonconformance 73
- Anomaly 73
- Condition Upon Receipt Report (CUR) ..... 55, Figure 8.5-2
- Corrective Action 73
- Deficiency 73
- Nonconformance Log 73
- Nonconformance Memo 73
- Responsibilities 73

Organization
- Chart (Also see Section 1 of the Facility-Specific Appendix C and Appendix A) ..... Figure 1.3-1
- Structure 2

Orientation (See Training)

Performance Evaluation Samples (Also See Section 6 of the Facility-Specific Appendix C) 74

Practical Quantitation Limit (See Reporting Limit)

Precision and Accuracy Measurements
- Accuracy ..... 41, Table 8.6-1
- Arithmetic Mean ..... Table 8.6-1
- Laboratory QC Measurements ..... Table 8.4-3
- Lower Control Limit (LCL) ..... Table 8.6-1
- Lower Warning Limit (LWL) ..... Table 8.6-1
- Matrix QC Measurements ..... Table 8.4-4
- Precision ..... 41, Table 8.6-1
- Standard Deviation ..... Table 8.6-1
- Upper Warning Limit (UWL) ..... Table 8.6-1
- Upper Control Limit (UCL) ..... Table 8.6-1

Preservatives (See Sample Containers, Preservatives, and Holding Times)

Preventive Maintenance (See Maintenance)

UNCONTROLLED COPY

Index (continued)

Page/Location

Procedures (Standardization of) 79

Procurement (Also see Vendor) 17
- Procedures 19
- Reference Materials (See Standards)
- Role of Quanterra® Purchasing 19
- Selection of Vendors 17
- Subcontract Laboratory Service 21

Project Planning 31

Project-Specific Reporting Limit (See Reporting Limit)

Qualification, Associate (See Training)

Quality Assurance 9

Quality Assurance Management Plan (QAMP) 10

Quality Assurance Program or Project Plan (QAPP) 11

Quality Assurance Summary (QAS) 12

Quality Control Samples 44
- Contract Laboratory Program (CLP) QC Samples
  - Cyanide, Total ..... Table 8.4-7
  - GFAA ..... Table 8.4-7
  - ICAP ..... Table 8.4-7
  - Mercury (CVAA) ..... Table 8.4-7
  - PCDD/PCDF ..... Table 8.4-7
  - Pesticides/PCBs ..... Table 8.4-7
  - Semivolatiles by GC/MS ..... Table 8.4-7
  - Volatiles by GC/MS ..... Table 8.4-7

UNCONTROLLED COPY

Index (continued)

Page/Location

Quality Control Samples (continued)

Field ..... 44, Table 8.4-1
- Collocated Sample ..... 45, Table 8.4-1
- Field Blank ..... 45, Table 8.4-1
- Field Duplicate ..... 45, Table 8.4-1
- Field Matrix Spike ..... 45, Table 8.4-1
- Rinsate Blank ..... 45, Table 8.4-1
- Split Sample ..... 46, Table 8.4-1
- Trip Blank ..... 44, Table 8.4-1

Inorganic (QC Samples)
- Acidity ..... Table 8.4-5
- Alkalinity ..... Table 8.4-5
- Ammonia ..... Table 8.4-5
- Ammonia (TKN) ..... Table 8.4-5
- Biochemical Oxygen Demand (BOD) ..... Table 8.4-5
- Bromide ..... Table 8.4-5
- Chemical Oxygen Demand (COD) ..... Table 8.4-5
- Chloride ..... Table 8.4-5
- Chlorine, Residual ..... Table 8.4-5
- Chromium (Hexavalent) Cr^{+6} ..... Table 8.4-5
- Color ..... Table 8.4-5
- Conductivity ..... Table 8.4-5
- Cyanide (Amenable) ..... Table 8.4-5
- Cyanide (Total) ..... Table 8.4-5
- Flashpoint ..... Table 8.4-5
- Fluoride ..... Table 8.4-5
- Hardness ..... Table 8.4-5
- Iodide ..... Table 8.4-5
- Iron, Phenanthroline Method ..... Table 8.4-5
- Methylene Blue Active Substances (MBAS) ..... Table 8.4-5
- Metals ..... Table 8.4-5

UNCONTROLLED COPY

Index (continued)

Page/Location

Quality Control Samples (continued)

Flame AA ..... Table 8.4-5
Graphite Furnace AA ..... Table 8.4-5
ICP ..... Table 8.4-5
ICP/MS ..... Table 8.4-5
Mercury (CVAA) ..... Table 8.4-5
Nitrate ..... Table 8.4-5
Nitrite ..... Table 8.4-5
Nitrate-Nitrite ..... Table 8.4-5
Odor ..... Table 8.4-5
pH ..... Table 8.4-5
Phenolics ..... Table 8.4-5
Phosphate ..... Table 8.4-5
Phosphorous (Total and Orthophosphate) ..... Table 8.4-5
Reactivity (Cyanide and Sulfide) ..... Table 8.4-5
Silica, Dissolved ..... Table 8.4-5
Solids ..... Table 8.4-5
Specific Conductance ..... Table 8.4-5
Sulfate ..... Table 8.4-5
Sulfide ..... Table 8.4-5
Sulfite ..... Table 8.4-5
Temperature ..... Table 8.4-5
Total Organic Carbon (TOC) ..... Table 8.4-5
Total Organic Halides (TOX) ..... Table 8.4-5
Turbidity ..... Table 8.4-5
Water Content ..... Table 8.4-5
Laboratory QC Samples ..... 46, Table 8.4-2, Table 8.4-3
Analytical Spike ..... 49, Table 8.4-2
Duplicate ..... 48, Table 8.4-2, Table 8.4-4
Instrument Blank ..... 47, Table 8.4-2, Table 8.4-3
Interference Check Sample ..... 49, Table 8.4-2
Internal Standard ..... 49, Table 8.4-2
Laboratory Control Sample ..... 48, Table 8.4-2, Table 8.4-3
Laboratory Performance QC Samples ..... Table 8.4-3

UNCONTROLLED COPY

Index (continued)

Page/Location

Quality Control Samples (continued)
Matrix Spike ..... 48, Table 8.4-2, Table 8.4-4
Matrix Spike Duplicate ..... 48, Table 8.4-2, Table 8.4-4
Method Blank ..... 47, Table 8.4-2, Table 8.4-3
Method of Standard Additions 52
Post Digestion Spike (See Analytical Spike)
Surrogate ..... 49, Table 8.4-2
Matrix QC Samples ..... Table 8.4-4
Organic QC Samples
Aromatic Volatiles by GC ..... Table 8.4-6
Dioxins/Dibenzofurans by HRGC/HRMS ..... Table 8.4-6
Dioxins/Dibenzofurans by HRGC/LRMS ..... Table 8.4-6
Halogenated Volatiles by GC ..... Table 8.4-6
Herbicides ..... Table 8.4-6
Nitroaromatics by HPLC ..... Table 8.4-6
Organophosphorous Pesticides ..... Table 8.4-6
Polyaromatic Hydrocarbons (PAHs) by HPLC and GC ..... Table 8.4-6
Pesticides/PCBs ..... Table 8.4-6
Petroleum Hydrocarbons ..... Table 8.4-6
Purgeable Halocarbons by GC ..... Table 8.4-6
Acrolein and Acrylonitrile ..... Table 8.4-6
Semivolatiles ..... Table 8.4-6
Volatiles by GC/MS ..... Table 8.4-6
Radiological QC Samples
(Also See Section 7 of the Facility-Specific Appendix C, where applicable) 49
Carrier 49
Tracer 49
Yield Monitors ..... 49, Table 8.4-2

Quality Document (See Document, Quality)

Quality Improvement 79

Quality Management System (QMS) 1

UNCONTROLLED COPY

Index (continued)

Page/Location

Quality Organization 2

Quality Policy Document 11

Quality-Related Item (QRI) ..... 18, Table 4.2-1

Quality Report to Management 77

Radioisotope ..... 49, Table 8.5-3

Record
- Attendance (See Training, Attendance Records)
- Disposal 25
- Project 25
- Management 24
- Quality 24
- Retention 25
- Validation 25

Reference Material (See Standards)

Reference Standards (See Standards)

Reporting Limit 43
- Method Detection Limit (MDL) 42
- Minimum Detectable Amount 43
- Practical Quantitation Limit (PQL) 43
- Project-Specific Reporting Limit (PSRL) 43
- Radiochemical 43

Resume (Associate) 15

UNCONTROLLED COPY

Index (continued)

Page/Location

Sample Containers, Preservations, and Holding Times

Contract Laboratory Program (CLP)

Cyanide, Total and Amenable to Chlorination ..... Table 8.5-4
PCDD/PCDF ..... Table 8.5-4
GFAA ..... Table 8.5-4
ICAP ..... Table 8.5-4
Mercury (CVAA) ..... Table 8.5-4
Pesticides/PCBs ..... Table 8.5-4
Semivolatiles ..... Table 8.5-4
Volatiles ..... Table 8.5-4

Inorganic (Sample Containers, Preservations, and Holding Times)

Acidity ..... Table 8.5-1
Alkalinity ..... Table 8.5-1
Ammonia ..... Table 8.5-1
Biochemical Oxygen Demand (BOD) ..... Table 8.5-1
Bromide ..... Table 8.5-1
Chemical Oxygen Demand (COD) ..... Table 8.5-1
Chloride ..... Table 8.5-1
Chlorine, Residual ..... Table 8.5-1
Chromium (Hexavalent) Cr^{+6} ..... Table 8.5-1
Color ..... Table 8.5-1
Conductivity ..... Table 8.5-1
Cyanide (Amenable) ..... Table 8.5-1
Cyanide (Total) ..... Table 8.5-1
Flashpoint (Ignitability) ..... Table 8.5-1
Fluoride ..... Table 8.5-1
Hardness (Total) ..... Table 8.5-1
Iodide ..... Table 8.5-1
Iron, Phenanthroline Method ..... Table 8.5-1
Methylene Blue Active Substances (MBAS) ..... Table 8.5-1
Metals ..... Table 8.5-1
Mercury (CVAA) ..... Table 8.5-1
Nitrate ..... Table 8.5-1
Nitrite ..... Table 8.5-1

UNCONTROLLED COPY

Index (continued)

Page/Location

Sample Containers, Preservations, and Holding Times (continued)

Nitrate-Nitrite ..... Table 8.5-1
Odor ..... Table 8.5-1
Orthophosphate ..... Table 8.5-1
pH ..... Table 8.5-1
Phenolics ..... Table 8.5-1
Phosphate ..... Table 8.5-1
Phosphorous (Total) ..... Table 8.5-1
Reactivity (Cyanide and Sulfide) ..... Table 8.5-1
Settleable Solids ..... Table 8.5-1
Silica, Dissolved ..... Table 8.5-1
Specific Conductance ..... Table 8.5-1
Sulfate ..... Table 8.5-1
Sulfide ..... Table 8.5-1
Sulfite ..... Table 8.5-1
Temperature ..... Table 8.5-1
Total Dissolved Solids ..... Table 8.5-1
Total Kjeldahl Nitrogen (TKN) ..... Table 8.5-1
Total Organic Carbon (TOC) ..... Table 8.5-1
Total Organic Halides (TOX) ..... Table 8.5-1
Total Solids ..... Table 8.5-1
Total Suspended Solids ..... Table 8.5-1
Total Volatile Solids ..... Table 8.5-1
Turbidity ..... Table 8.5-1
Water Content ..... Table 8.5-1

Organic

Aromatic Volatiles ..... Table 8.5-2
Dioxins/Dibenzofurans ..... Table 8.5-2
Halogenated Volatiles ..... Table 8.5-2
Herbicides ..... Table 8.5-2
Nitroaromatics ..... Table 8.5-2
Organophosphorous Pesticides ..... Table 8.5-2
Pesticides/PCBs ..... Table 8.5-2
Petroleum Hydrocarbons/Oil and Grease ..... Table 8.5-2

UNCONTROLLED COPY

Index (continued)

Page/Location

Sample Containers, Preservations, and Holding Times (continued)

Polyaromatic Hydrocarbons (PAH) by GC and HPLC ..... Table 8.5-2
Purgeable Halocarbons ..... Table 8.5-2
Acrolein and Acrylonitrile ..... Table 8.5-2
Semivolatiles ..... Table 8.5-2
Volatiles ..... Table 8.5-2

Radiological

Alpha/Beta (Gross) ..... Table 8.5-3
Americium-241 ..... Table 8.5-3
Carbon-14 ..... Table 8.5-3
Calcium-45 ..... Table 8.5-3
Curium-242 ..... Table 8.5-3
Gamma Emitters ..... Table 8.5-3
Iron-55 ..... Table 8.5-3
Lead-210 ..... Table 8.5-3
Neptunium-237 ..... Table 8.5-3
Promethium-147 ..... Table 8.5-3
Plutonium-238, 239/240 ..... Table 8.5-3
Radium-226 ..... Table 8.5-3
Radium-228 ..... Table 8.5-3
Strontium-89, 90 and Total Strontium ..... Table 8.5-3
Technetium-99 ..... Table 8.5-3
Thorium-227, 228, 230, 232 ..... Table 8.5-3
Total Uranium ..... Table 8.5-3
Tritium ..... Table 8.5-3
Uranium-233/234, 235/236 ..... Table 8.5-3
Uranium-238 ..... Table 8.5-3

TCLP and SPLP

Mercury ..... Table 8.5-5
Metals (except mercury) ..... Table 8.5-5
Semivolatiles ..... Table 8.5-5
Volatiles ..... Table 8.5-5

UNCONTROLLED COPY

Index (continued)

Page/Location

Samples
Containers (Sample) 51
Containers (Shipping) 51
Disposal 59
Field Collection 50
Handling 54
Holding Times (Also see Sample Containers, Preservatives, and Holding Times) 53
Interlaboratory Transfers 58
Log-In 55
Preservatives (Also see Sample Containers, Preservatives, and Holding Times) 53
Quality Control Samples (See Quality Control Samples)
Radioactive 51
Receipt 54
Storage 55

Software (Also see Computer)
Changes (Control of) 28
Documentation 29
Industry Standard Software 28
Quanterra® -Developed Software 28
Revalidation 28
Security 27
Use 27
Validation 27
Verification 28
Viruses 29

Standard Operating Procedures 11, 39

Standard Reporting Limit (See Reporting Limit)

UNCONTROLLED COPY

Index (continued)

Page/Location

Standards
- Chemical Reference Standards 60
- Physical Reference Standards 60
- Reference Materials 21, 60
- Standard Verification 60

Statement of Management Position on Quality 1

Subcontractor (See Procurement)

Training
- Associate 13
- Files 15
- Health and Safety 15
- Individual Training Records 15
- Laboratory Staff 15
- Orientation 14
- QA Manager 15
- Qualification, Associate 13
- Quality 14
- Quality Orientation 14
- Records 16

Vision Statement 1

Vendor 17
- Partnerships 23
- Selection of 17

Waste Disposal 72

Water (See Internal QC Requirements)

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Appendix A

Quanterra®
Quality Assurance Management Plan

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Corporate Key Personnel List and Quanterra® Operations Organizational Chart

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Quanterra®
Corporate Key Personnel List

Associate Name	Title	Degree	Years of Experience
Gerhard F. König	President and CEO	MBA	32
Enos Tracey	Chief Financial Officer	BS, Accounting MBA, Accountancy	13
Elizabeth Chapman	Human Resources Manager	MS, Human Resources	8
Mark Matthews	Chief Operating Officer	BA, Accounting	18
Chris M. Lee	Vice President Operations Services	Business/Biology	13
Donnie Heinrich	Senior Vice President of Sales	BS, Chemistry	22
Brad S. Figley	Senior Vice President Legal and Strategy	JD in Law	16
Bill Henning	Director of Information Technology	BA, Sociology MBA, Quantitative Studies	14
Jack Hall	Corporate Director of Quality Assurance	BS, Chemistry	33
Don Dihel	Corporate Director of Environmental Health and Safety	BA, Chemistry	23
Richard Burrows	Technology/Principal Scientist	BS, Chemistry Ph.D., Analytical Chemistry	12

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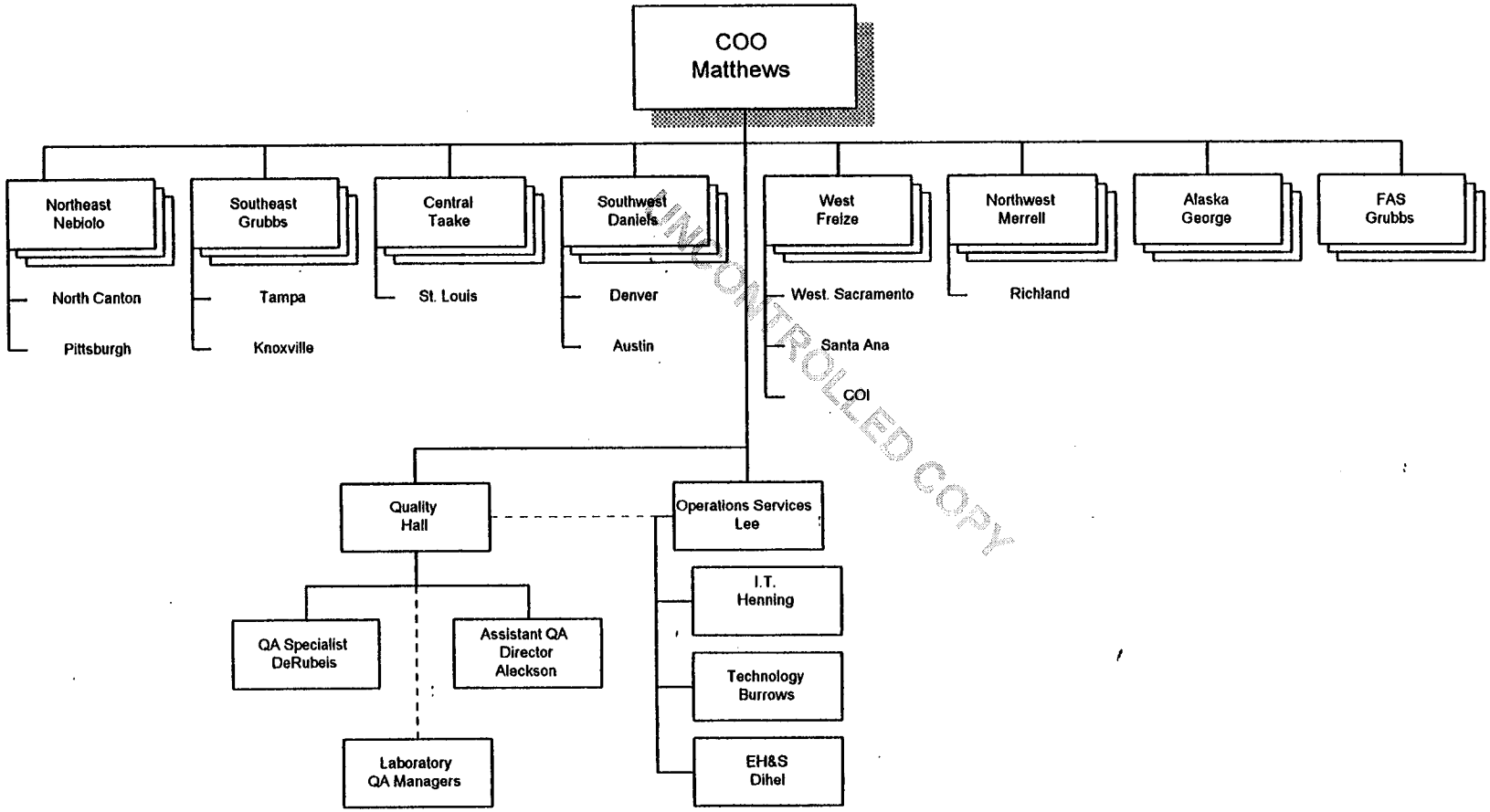
QUANTERRA OPERATIONS ORGANIZATIONAL CHART



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APPENDIX B

Appendix B

Quanterra®
Quality Assurance Management Plan

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Addresses of Quanterra® Locations

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APPENDIX B

ADDRESSES OF Quanterra® LOCATIONS

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APPENDIX C

Appendix C

Quanterra®
Quality Assurance Management Plan

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Facility-Specific Appendix

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List of Laboratory Locations

This appendix contains facility-specific, quality-related information and requirements for Quanterra® laboratories. These laboratories are located in the following cities:

- Anchorage, Alaska
- Austin, Texas
- City of Industry, California
- Denver, Colorado
- Knoxville, Tennessee
- North Canton, Ohio
- Pittsburgh, Pennsylvania
- Richland, Washington
- Sacramento, California
- Santa Ana, California
- St. Louis, Missouri
- Tampa, Florida

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Each laboratory section in this appendix contains information specific to that laboratory only and contains the following basic outline:

Section	Contents
0	Table of Contents
1	Organizational Chart
2	Instrument List
3	Standard Operating Procedures List
4	Analytical Methods
5	MDLs, RLs, and CRDLs
6	Performance Evaluation Studies
7	Additional Operation-Specific Information

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Facility Appendix

Quality Assurance Management Plan
Quanterra Incorporated

Denver Laboratory

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Approved by:

4/23/97

Larry Penfold
Quality Assurance Manager
Denver Laboratory

4/28/97

Thomas Daniels
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Denver Laboratory

4/29/97

Jack R. Hall
Corporate Director
of Quality Assurance

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Facility Appendix

Denver Laboratory

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Section Denver-0

Table of Contents,
Denver Laboratory

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List of Sections

Section No.	Contents	Page
Section Denver-0	Table of Contents, Denver Laboratory	3
Section Denver-1	Organizational Chart	9
Section Denver-2	Instrument List	13
Section Denver-3	Standard Operating Procedures (SOP) List	23
Section Denver-4	Analytical Methods	35
Section Denver-5	MDLs and RLs	65
Section Denver-6	Performance Evaluation Studies	117
Section Denver-7	Additional Operation-Specific Information	121

UNCONTROLLED COPY

List of Figures

Figure No.	Title	Page
Denver-1-1	Organizational Chart	10
Denver-7-1	Floor Plan	122

List of Tables

Table No.	Title	Page
TABLE 1-1	Key Personnel List	12
TABLE 2-1	Instrument List	15
TABLE 3-1	Standard Operating Procedures (SOP) List	25
TABLE 4-1	Wet Chemistry Methods	37
TABLE 4-2	Graphite Furnace Atomic Absorption Methods	46
TABLE 4-3	Inorganic ICAP/Trace ICP Metals Methods	48
TABLE 4-4	Inorganic ICP/MS Metals Methods	55
TABLE 4-5	Metals Sample Preparation Methods	56
TABLE 4-6	Flame Atomic Absorption Inorganic Methods	58
TABLE 4-7	Organic Sample Preparation Methods	59
TABLE 4-8	Organic Methods	62
TABLE 5-1	Wet Chemistry Methods, Method Detection Limits (MDL) and Reporting Limits (RL)	67
TABLE 5-2	GFAA Metals Contract Required Detection Limits (CRDL), Contract Laboratory Program (CLP), Method Detection Limits (MDL) and Reporting Limits	70
TABLE 5-3	ICAP Metals Contract Required Detection Limits (CRDL), Contract Laboratory Program (CLP), Method Detection Limits (MDL) and Reporting Limits	71
TABLE 5-4	Trace ICP Metals Contract Required Detection Limits (CRDL), Method 6010A Method Detection Limits (MDL) and Reporting Limits	73
TABLE 5-5	Method 6020 ICP/MS Metals Method Detection Limits (MDL) and Reporting Limits (RL)	74
TABLE 5-6	Method 601 CWA Halogenated Volatile Organics Method Detection Limits (MDL) and Reporting Limits (RL)	75
TABLE 5-7	Method 8010A Halogenated Volatile Organics Method Detection Limits (MDL) and Reporting Limits	77
TABLE 5-8	Method 8015 (Modified) for Gasoline and Diesel Range Organics Method Detection Limits (MDL) and Reporting Limits (RL)	79
TABLE 5-9	602 CWA Aromatic Volatile Organics Method Detection Limits (MDL) and Reporting Limits (RL)	80
TABLE 5-10	Method 8020 Aromatic Volatile Organics Method Detection Limits (MDL) and Reporting Limits (RL)	81
TABLE 5-11	CLP Pesticides and PCBs Contract Required Quantitation Limits (CRQL)	82
TABLE 5-12	Method 608 CWA Pesticides and PCBs Method Detection Limits (MDL) and Reporting Limits (RL)	83

UNCONTROLLED COPY

List of Tables (continued)

Table No.	Title	Page
TABLE 5-13	Method 8080 Target Compound List and Appendix IX Pesticides and PCBs Method Detection Limits (MDL) and Reporting Limits (RL)	84
TABLE 5-14	Methods 8140/8141 and Appendix IX Pesticides Method Detection Limits (MDL) and Reporting Limits (RL)	86
TABLE 5-15	Method 8150A Herbicides Method Detection Limits (MDL) and Reporting Limits (RL)	87
TABLE 5-16	Method 8330 Explosives by HPLC Method Detection Limits (MDL) and Reporting Limits (RL)	88
TABLE 5-17	Method 8310 Polynuclear Aromatic Hydrocarbons Method Detection Limits (MDL) and Reporting Limits (RL)	89
TABLE 5-18	Method 8315 Formaldehyde by HPLC Method Detection Limits (MDL) and Reporting Limits (RL)	90
TABLE 5-19	Method 524.2 Purgeable Organic Compounds in Water by GC/MS Method Detection Limits (MDL) and Reporting Limits (RL)	91
TABLE 5-20	Method 8240A Target Compound List, Appendix IX, and F039 for Volatile Organics Method Detection Limits (MDL) and Reporting Limits (RL)	94
TABLE 5-21	Method 624 CWA Volatile Organics by GC/MS Method Detection Limits (MDL) and Reporting Limits (RL)	97
TABLE 5-22	CLP Volatile Organics by GC/MS Contract Required Quantitation Limits (CRQL)	99
TABLE 5-23	Method 8260 Volatile Organics by GC/MS Method Detection Limits (MDL) and Reporting Limits (RL)	101
TABLE 5-24	CLP Semivolatile Organics by GC/MS with Contract Required Quantitation Limits (CRQL)	105
TABLE 5-25	Method 625 CWA Semivolatile Organics by GC/MS Method Detection Limits (MDL) and Reporting Limits (RL)	108
TABLE 5-26	Method 8270A Target Compound List, Appendix IX, and F039 for Semivolatile Organics by GC/MS Method Detection Limits (MDL) and Reporting Limits (RL)	111
TABLE 6-1	PE Sample Programs	119

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Facility Appendix
Denver Laboratory

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Section Denver-1

Organizational
Chart

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Quanterra Denver

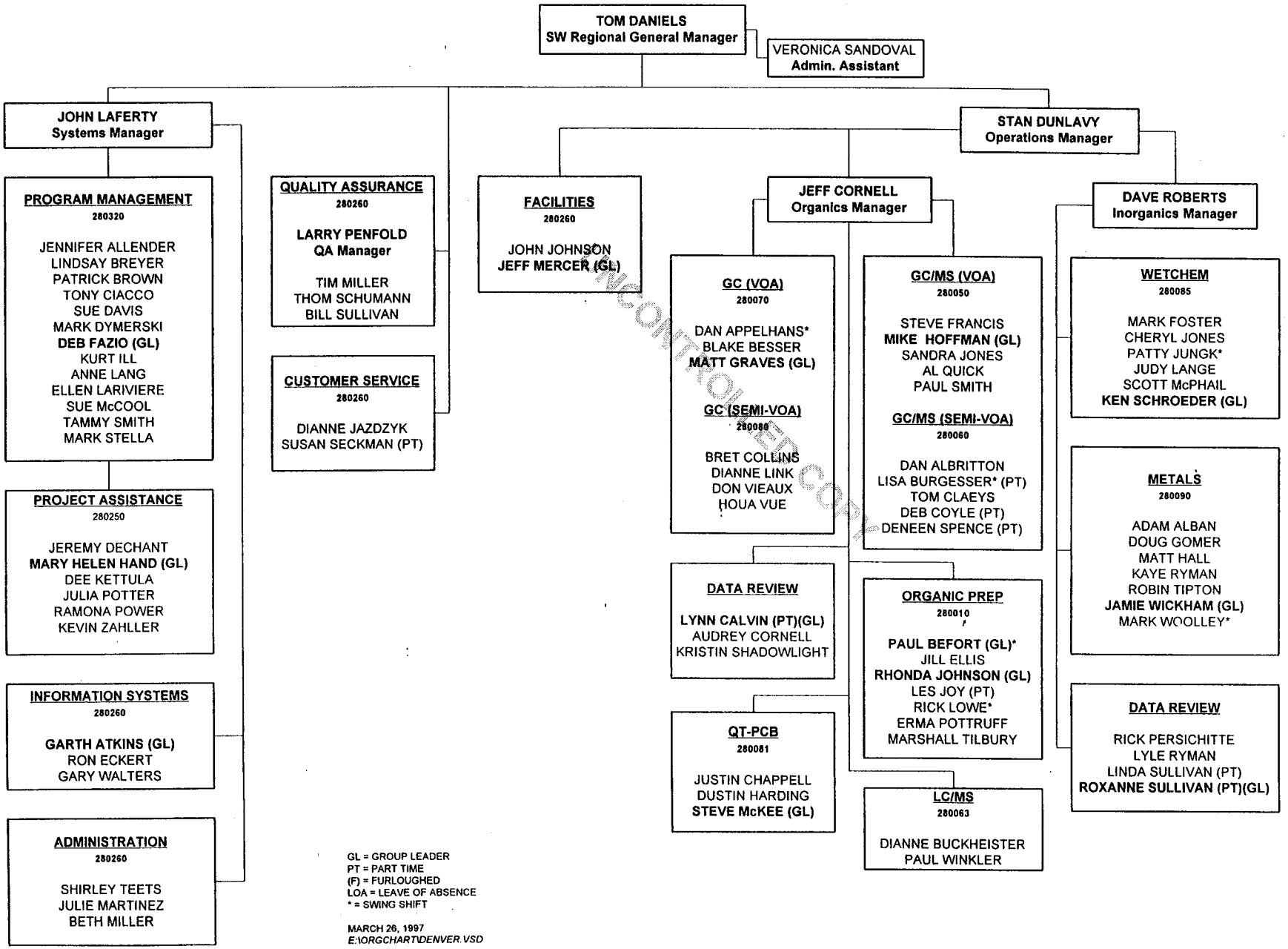

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TABLE 1-1
DENVER LABORATORY
Key Personnel List

Position	Name	Degree(s), Institution(s), Year	Years Experience Environmental Lab	Years with Company
Laboratory Director	Thomas F. Daniels	BS Biology Glassboro State College, 1981	14	13
Systems Manager	John M. Laferty, III	BS Chemistry University of Colorado, 1982	16	13
Operations Manager	Stanley L. Dunlavy	BS Forest Biology Colorado State University, 1979	8	8
Inorganics Manager	David B. Roberts, Jr.	B. S. Microbiology Colorado State University, 1977	18	10
Organics Manager	Jeffrey L. Cornell	BS Chemistry Colorado State University, 1983	11	11
Quality Assurance Manager	Larry Penfold	Chemistry California State University, 1979	22	2
Client Service Manager	Susan Seckman	BS Geology Colorado State University, 1983	12	9
Client Service Manager	Dianne Jazdzyk	BS Medical Technology Grand Valley State College, 1979	10	9
Program Manager	Ellen LaRiviere	MS Environmental Health, Colorado State University, 1983 / BS Biology/Chemistry College of Sante Fe, 1980	14	4
Program Manager	Lindsay Breyer	MS Environmental Science & Engineering, Colorado School of Mines, 1993 / BA Chemistry University of Colorado, 1975	20	8
Program Manager	Patrick Brown	BS Natural Resource Management Rutgers University, 1986	6	1
Program Manager	Mark L. Dymerski	BS Biology Metro State College, 1980	15	11
Program Manager (Group Leader)	Deborah J. Fazio	AA Medical Technician State University of New York, 1971	10	9

ENVIRONMENTAL

Facility Appendix
Denver Laboratory

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Section Denver-2

Instrument
List

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TABLE 2-1
DENVER LABORATORY
Instrument List

Instrument Type	Manufacturer	Model	Age (years)	Autosampler
GC Semivolatiles	Hewlett-Packard (B) S/N 2032A01670	5880A Dual ECD	12	Yes
	Hewlett-Packard (E) S/N 1931A90378	5880A Dual ECD	12	Yes
	Hewlett-Packard (T) S/N 2417A06692	5890A Dual ECD	12	Yes
	Hewlett-Packard (V) S/N 2303A04718	5880A Dual FID	12	Yes
	Hewlett-Packard (A) S/N 2750A16891	5890A Dual FID	9	Yes
	Hewlett-Packard (R) S/N 2413A00921	5890A Dual FID	8	Yes
	Hewlett-Packard (G) S/N 2413A01572	5890A Dual ECD	8	Yes
	Hewlett-Packard (I) S/N 2728A14510	5890A Dual ECD	8	Yes
	Hewlett-Packard (K) S/N 2541A06663	5890A Dual ECD	8	Yes
	Hewlett-Packard (M) S/N 2643A09588	5890A Dual ECD	8	Yes
	Hewlett-Packard (N) S/N 6243A19457	5890A Dual ECD	8	Yes
	Hewlett-Packard (U) S/N 2643A11844	5890A Dual ECD	8	Yes
	Hewlett-Packard (U) S/N 2413A06566	5890A Dual ECD	8	Yes
	Hewlett-Packard (S) S/N 3029A29891	5890A Dual FID	8	Yes
	Hewlett-Packard (D) S/N 2728A14239	5890 Dual FPD	8	Yes
	Hewlett-Packard (XT) S/N 2843A20053	5890A Dual FID	8	Yes

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TABLE 2-1
DENVER LABORATORY
Instrument List
(Continued)

Instrument Type	Manufacturer	Model	Age (years)	Autosampler
GC Semivolatiles (continued)	Hewlett-Packard (Z2) S/N 2618A08124	5890A Dual FID	8	Yes
	Hewlett-Packard (O) S/N 2518A04808	5890A Dual FID	8	Yes
	Hewlett-Packard (L) S/N 2950A27957	5890A Dual FID	7	Yes
	Hewlett-Packard (W) S/N 3126A36250	5890II Dual ECD	6	Yes
	Hewlett-Packard (W2) S/N 3121A35608	5890II Dual ECD	6	Yes
	Hewlett-Packard (Y) S/N 2921A23314	5890II Dual ECD	6	Yes
	Hewlett-Packard (Z) S/N 3121A35607	5890II Dual ECD	6	Yes
GC Volatiles	Hewlett-Packard (G) S/N 2244A01558	5790A PID/FID	10	Yes
	Hewlett-Packard (Y) S/N 2843A19484	5890A PID/ELCD	8	Yes
	Hewlett-Packard (I2) S/N 2643A11361	5890A Dual FID	8	Yes
	Hewlett-Packard (J) S/N 2607A07269	5890A Dual ELCD	8	Yes
	Hewlett-Packard (H) S/N 2750A16573	5890A PID	8	Yes
	Hewlett-Packard (K) S/N 2843A19497	5890A PID/FID	8	Yes
	Hewlett-Packard (L) S/N 2336A00164	5890A PID/FID	8	Yes
	Hewlett-Packard (P/Q) S/N 2518A05337	5890A PID	6	Yes
	Hewlett-Packard (A/B) S/N 3019A28634	5890II PID/FID	6	Yes

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TABLE 2-1
DENVER LABORATORY
Instrument List
(Continued)

Instrument Type	Manufacturer	Model	Age (years)	Autosampler
GC Volatiles (continued)	Hewlett-Packard (F) S/N LR47359C	5890II Dual ELCD	6	Yes
	Varian (V) S/N 5628	3400 PID/ELCD	9	Yes
HPLC	Hewlett-Packard S/N 2304G00374	1090A	12	Yes
	Hewlett-Packard S/N 2733A01573	1090A	10	Yes
	Hewlett-Packard S/N 2304G00117	1090A	8	Yes
GC/MS Semivolatiles	Hewlett-Packard (A) S/N 3018A00334	5989	6	Yes
	Hewlett-Packard (E) S/N 3524A02942	5972	2	Yes
	Hewlett-Packard (V) S/N 3232A00843	5989	3	Yes
	Hewlett-Packard (M) S/N (not available at this time)	5973	0	Yes
	Hewlett-Packard (P) S/N (not available at this time)	5973	0	Yes
	Hewlett-Packard (C) S/N US70820571	5973	0	Yes
	Hewlett-Packard (D) S/N US70820565	5973	0	Yes
	Hewlett-Packard (B) S/N US70820566	5973	0	Yes
GC/MS Volatiles	Hewlett-Packard (W) S/N 2905A12014	5970	8	Yes
	Hewlett-Packard (L) S/N 2905A11729	5970	7	Yes
	Hewlett-Packard (N) S/N 2905A11861	5970	6	Yes

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TABLE 2-1
DENVER LABORATORY
Instrument List
(Continued)

Instrument Type	Manufacturer	Model	Age (years)	Autosampler
GC/MS Volatiles (continued)	Hewlett-Packard (S) S/N 5524A03017	5972	2	Yes
	Hewlett-Packard (Z) S/N 3524A02617	5972	2	Yes
	Hewlett-Packard (H) S/N 3524A03013	5972	2	Yes
	Hewlett-Packard (J) S/N 3524A03016	5972	2	Yes
LC/MS	Finnigan S/N TS000451	TSQ 700	6	Yes
ICP	Thermo Jarrell Ash S/N 16281	9000 ICAP	14	Yes
	Thermo Jarrell Ash S/N 89090	61E ICAP	7	Yes
	Thermo Jarrell Ash S/N 200390	61E Trace	4	Yes
ICP/MS	Perkin Elmer SCIEX S/N 113920888	ELAN 5000	4	Yes
GFAA	Perkin Elmer S/N 128892	2380	18	Yes
	Perkin Elmer S/N 125214	5000	11	Yes
	Perkin Elmer S/N 128369	5000	11	Yes
	Perkin Elmer S/N 128624	5000	11	Yes
	Perkin Elmer S/N 130253	5100 PC	8	Yes
	Perkin Elmer S/N 134721	5100 PC	8	Yes
	Perkin Elmer S/N 131178	5100 PC	8	Yes

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TABLE 2-1
DENVER LABORATORY
Instrument List
(Continued)

Instrument Type	Manufacturer	Model	Age (years)	Autosampler
GFAA (continued)	Perkin Elmer S/N 132350	5100 PC	8	Yes
Mercury Analyzer	Spectro Products S/N 389/4701	HG-4	13	Yes
	Spectro Products S/N 389/4711	HG-4	13	Yes
	Leeman Labs S/N 3047	PS-200	3	Yes
	Leeman Labs S/N 1054A	PS-200	3	Yes
IC	Dionex S/N 844901	APM-2	8	Yes
	Dionex S/N 874423	GPM-2	8	Yes
TOC	O.I. S/N 1091-7-276	700 (Aqueous)	10	Yes
	LECO S/N 3032	CR-12 (Solid)	8	No
	Shimadzu S/N 30724214	TOC-5000	4	Yes
TOX	Dohrman S/N HE2143	AD-2 (Aqueous)	13	No
	Mitsubishi S/N 43R30338	TOX-10R	9	No
	Mitsubishi S/N 75R01382	TOX-10E	4	No
TKN Digestion System	Tecator System 40 S/N 662	1000-3454	11	No
FTIR	Perkin Elmer S/N 137979	FTIR 1600	7	No
UV/VIS	Milton Roy S/N 3800107006	Spectronic 301	11	No

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TABLE 2-1
DENVER LABORATORY
Instrument List
(Continued)

Instrument Type	Manufacturer	Model	Age (years)	Autosampler
UV/VIS (continued)	Bausch & Lomb S/N 1280242N	Spectronic 501	9	No
Wet Chemistry	Technicon (1) S/N (not available at this time)	AAII	13	Yes
	Technicon (2) S/N (not available at this time)	AAII	13	Yes
	Technicon (3) S/N 9310-104	AAII	13	Yes
	Technicon (4) S/N TC00026	TRAACS 800	9	Yes
	Lachat S/N 2000-0526	Quick Chem AE	4	Yes
Ion Analyzer	Orion Research S/N PX94A	EA940	11	No
Digital Ion Analyzer	Orion Research S/N 59861	701A	13	No
	Orion Research S/N 55197	701A	13	No
Autotitrator	Radiometer S/N 77R08N072	TTT85	10	Yes
	Radiometer S/N 77R08N035	TTT85	4	Yes
pH Meter	Corning S/N 5707	140	9	No
	Corning S/N 9578	240	9	No
Dissolved Oxygen Meter	YSI S/N F9003509	50	9	No
	YSI S/N 91C27855	50B	9	No
Turbidimeter	HACH S/N 881019614	2100A	13	No

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TABLE 2-1
DENVER LABORATORY
Instrument List
(Continued)

Instrument Type	Manufacturer	Model	Age (years)	Autosampler
Conductance Meter	YSI S/N 403	32	13	No
COD	HACH S/N 881211913	16500-10	13	No
	O.I (1) S/N 0489-1141	2090-01C	13	No
	O.I. (2) S/N 0489-1144	2090-01C	13	No

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Facility Appendix

Denver Laboratory

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Section Denver-3

Standard Operating
Procedures List

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TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List

SOP No.	Rev. No.	Rev. Date	Title
CORP-GC-0001	2.0	1/31/96	Gas Chromatographic Analysis Based on Methods 8000A, 8010B, 8020A, 8080A, and 8150B, SW-846
CORP-IP-0001	0	12/9/95	Acid Digestion of Waters and Soils, CLP SOW ILMO3.0
CORP-IP-0002	0	12/9/95	Acid Digestion of Soils, SW-846 Method 3050A
CORP-IP-0003	0	12/9/95	Acid Digestion of Aqueous Samples by SW-846 and 200 Series Methods
CORP-IP-0004	0	1/12/96	Toxicity Characteristic Leaching Procedure and Synthetic Leaching Procedure
CORP-IS-0001	0	3/28/95	LIMS Change Management
CORP-IS-0004	0	2/28/95	Validation and Generation of Electronic Data Transfer Files
CORP-IS-0007	0	2/17/95	LIMS Acceptance Testing
CORP-MS-0001	1.0	1/31/96	GC/MS Analysis Based on Method 8270B, SW-846
CORP-MS-0001DEN	1.1	10/25/96	GC/MS Analysis Based on Method 8270B, SW-846 - Denver Facility-Specific SOP
CORP-MS-0002	1.0	1/31/96	Determination of Volatile Organics by GC/MS Based on Methods 8240B and 8260A
CORP-MS-0002DEN	1.2	1/4/97	Volatile Organics by GC/MS Based on Methods 8240B and 8260A - Denver Facility-Specific SOP
CORP-MT-0001	1.0	9/18/95	Inductively Coupled Plasma-Atomic Emission Spectroscopy, Spectrophotometric Method for Trace Element Analysis, Method 6010A and Method 200.7
CORP-MT-0001DEN	1.1	7/26/96	(Denver-Specific) Inductively Coupled Plasma-Atomic Emission Spectroscopy, Spectrophotometric Method for Trace Element Analysis, Method 6010A and Method 200.7
CORP-MT-0002	1.0	1/31/96	Inductively Coupled Plasma-Atomic Emission Spectroscopy, Method 200.7 CLP-M, SOW ILMO3.0
CORP-MT-0002DEN	1.1	1/28/97	(Denver-Specific) Inductively Coupled Plasma-Atomic Emission Spectroscopy, Method 200.7 CLP-M, SOW ILMO3.0
CORP-MT-0003	1.0	10/18/95	Graphite Furnace Atomic Absorption Spectroscopy, SW-846 Method 7000A and MCAWW 200 Series Methods
CORP-MT-0003DEN	1.1	1/1/00	(Denver-Specific) Graphite Furnace Atomic Absorption Spectroscopy, SW-846 Method 7000A and MCAWW 200 Series Methods
CORP-MT-0004	1.0	8/22/95	Graphite Furnace Atomic Absorption Spectroscopy, Method 2XX.X - CLP-M, SOW ILMO3.0
CORP-MT-0004DEN	1.1	1/28/97	(Denver-Specific) Graphite Furnace Atomic Absorption Spectroscopy, Method 2XX.X CLP-M, SOW ILMO3.0
CORP-MT-0005	1.0	12/19/95	Preparation and Analysis of Mercury in Aqueous Samples by Cold Vapor Atomic Absorption, SW-846 7470A and MCAWW 245.1
CORP-MT-0005DEN	1.1	3/31/97	(Denver-Specific) Preparation and Analysis of Mercury in Aqueous Samples by Cold Vapor Atomic Absorption, SW-846 7470A and MCAWW 245.1
CORP-MT-0005FA	0	5/22/96	Preparation and Analysis of Mercury in Aqueous Samples by Cold Vapor Atomic Absorption, SW-846 7470A and MCAWW 245.1, Denver Facility Attachment
CORP-MT-0006	0	8/1/95	Preparation and Analysis of Mercury in Aqueous Samples by Cold Vapor Atomic Absorption, Method 245.1 CLP-M, SOW ILMO3.0

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TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
CORP-MT-0006FA	0	1/29/97	Preparation and Analysis of Mercury in Aqueous Samples by Cold Vapor Atomic Absorption, Method 245.1 CLP-M, SOW ILMO3.0, Denver Facility Attachment
CORP-MT-0007	1.0	12/19/95	Preparation and Analysis of Mercury in Solid Samples by Cold Vapor Atomic Absorption, SW-846 7471A and MCAWW 245.5
CORP-MT-0007DEN	1.1	3/31/97	(Denver-Specific) Preparation and Analysis of Mercury in Solid Samples by Cold Vapor Atomic Absorption, SW-846 7471A and MCAWW 245.5
CORP-MT-0007FA	0	6/19/96	Preparation and Analysis of Mercury in Solid Samples by Cold Vapor Atomic Absorption, SW-846 7471A and MCAWW 245.5, Denver Facility Attachment
CORP-MT-0008	0	8/1/95	Preparation and Analysis of Mercury in Solid Samples by Cold Vapor Atomic Absorption, Method 245.5 CLP-M, SOW ILMO3.0
CORP-OP-0001	2.0	1/31/96	Extraction and Cleanup of Organic Compounds from Waters and Soils, Based on SW-846 3500 Series, 3600 Series, 8150 and 600 Series Methods
CORP-OP-0001DEN	2.1	11/22/96	(Denver-Specific) Extraction and Cleanup of Organic Compounds from Waters and Soils, Based on SW-846 3500 Series, 3600 Series, 8150 and 600 Series Methods
CORP-QA-0001	1.0	5/14/96	Quality Testing of Solvents, Acids, and Reagents (QRI Program)
CORP-QA-0002	0	1/27/95	QuantIMS Reference Data Creation and Maintenance
CORP-QA-0003	0	1/1/00	Valid Component Names for QuantIMS
CORP-QA-0004	0	10/27/95	Independent QA Data Review
CORP-QA-0005	1.0	9/7/95	GC/VOA Data Assessment for 95-1
CORP-QA-0006	0	10/17/95	GC/VOA Data Recalculation or Reprocessing for 95-1
CORP-QA-0007	0	12/1/95	GC/VOA Data Recalculation or Reprocessing for 95-1 Specific to Method 8015/GRO
CORP-QA-0008	0	11/21/95	GC/VOA Data Recalculation or Reprocessing for 95-1 Specific to Method 8010
CORP-QA-0009	0	11/22/95	GC/VOA Data Recalculation or Reprocessing for 95-1 Specific to Method 8020
CORP-QA-0010	0	12/11/95	Nonconformance and Corrective Action
CORP-QA-0011	0	1/1/00	GC/VOA Data Recalculation or Reprocessing for 95-1 Phase II Report--1993 Data
CORP-QA-0012	0	4/29/96	Selection and Evaluation of Subcontractor Laboratories
CORP-QA-0013	0	10/1/96	Employee Orientation and Training
CORP-WC-0001	0	1/1/00	Total Organic Halides in Water by SW-846 Method 9020B
CORP-WC-0002	1.0	1/1/00	Determination of Solids in Waters and Wastes
CORP-WC-0003	0	2/9/96	HEM/SGT-HEM Method 1664 (Formerly Oil and Grease/TPH)
CORP-WC-0004	0	1/1/97	Ignitability of Solids for Waste Characterization, EPA SW-846 Chapter 7, Section 7.1
DEN-CHP-0001	0	9/25/95	Chemical Hygiene Plan, Denver Procedure for Waste Characterization and Categorization

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TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
DEN-CHP-0002	0	9/20/95	Chemical Hygiene Plan, Denver Procedure for Waste Collection, Accumulation, and Storage
DEN-CHP-0003	0	9/20/95	Chemical Hygiene Plan, Denver Procedure for Waste Shipping and Manifesting
DEN-CHP-0004	0	2/14/96	Radiation Protection Program
DEN-CHP-0005	0	3/8/96	Screening Coolers for Radioactivity Upon Receipt
DEN-GC-0001	0	5/24/95	Analysis of Organochlorine Pesticides and Polychlorinated Biphenyls by under USEPA CLP, March 1990 SOW
DEN-GC-0002	1.0	11/18/96	Diesel Range Organics
DEN-GC-0003	3.0	3/19/96	Determination of Polychlorinated Biphenyls
DEN-GC-0004	4.0	5/15/96	Determination of Polychlorinated Biphenyls for the State of Kentucky under SW-846 Method 8080 and USEPA Method 505
DEN-GC-0005	0	8/5/96	Preparation And Analysis Of Bis(2-chloroethyl)ether And 1,2-Bis(2-chloroethoxy)ethane In Aqueous And Soil Samples By SW-846 Method 8100
DEN-GC-0006	0	1/22/96	Analysis Of Water Miscible Solvents By GC/FID; Direct Aqueous Injection
DEN-GC-0007	0	1/1/00	Clean Up Procedures for the Analysis of PCBs
DEN-GC-0008	0	1/1/00	Polynuclear Aromatic Hydrocarbons by Methods 610 and 8310
DEN-GC-0010	0	1/1/00	Gas Range Organics by API Methodology
DEN-GC-0011	0	1/1/00	Formaldehyde By High Pressure Liquid Chromatography (HPLC)
DEN-HS-0001	0	3/6/96	Determination of Face Velocities of Fume Hoods
DEN-IP-0001	0	8/7/95	Preparation of Mercury Samples for United States Army Environmental Center Type Work
DEN-IP-0002	1.0	3/13/96	Metals Digestion for Soil Matrices for United States Army Environmental Center Type Work
DEN-IP-0003	1.0	3/12/96	Metals Digestion for Aqueous Matrices for United States Army Environmental Center Type Work
DEN-IP-0005	0	12/13/95	Inorganic Glassware Washing Procedure
DEN-IP-0006	0	1/31/97	Acid Digestion of Aqueous Samples by SW-846 and MCAWW 200 Series Methods
DEN-IS-0002	0	1/1/00	Software Quality Assurance
DEN-LC-0001	0	9/10/95	Aqueous and Soil Analysis of Nitroaromatics and Nitroamines by High Performance Liquid Chromatography under SW-846 Method 8330 (Modified) for United States Army Environmental Center Type Work
DEN-LC-0002	0	9/24/96	Nitroaromatics And Nitroamines By High Performance Liquid Chromatography (HPLC) Method 8330
DEN-LC-0003	0	1/1/00	Analysis of MCBT by 8321
DEN-LC-0004	0	1/1/00	Preparation of MCBT for Analysis by 8321
DEN-LC-0005	0	1/1/00	Analysis of Explosives by 8321
DEN-LC-0006	0	1/1/00	Preparation of Explosives for Analysis by 8321
DEN-MS-0001	0	5/15/96	Case File Assembly for Department of Energy Type Work
DEN-MS-0002	0	5/15/96	Analysis of Polynuclear Aromatic Hydrocarbons by Selective Ion Monitoring

TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
DEN-MS-0003	0	1/1/00	GC/MS Volatile Organics Analysis For Multi-Media, Multi-Concentration Samples For USAEC
DEN-MS-0004	0	1/1/00	GC/MS Volatile Analysis of Water by Method 624
DEN-MS-0005	0	10/11/96	Polynuclear Aromatic Hydrocarbons by SIM for City of St. Louis Park Work
DEN-MS-0006	0	1/27/97	Low Concentration Volatiles by GC/MS, CLP SOW OLCO2.0
DEN-MT-0001	0	1/6/95	Dupont/Delaware Soluble Organic Lead
DEN-MT-0002	1.0	1/30/97	Inductively Coupled Plasma-Mass Spectrometry, EPA Methods 6020 and 200.8
DEN-MT-0004	0	8/7/95	Analysis of Mercury Samples for United States Army Environmental Center Type Work
DEN-MT-0005	0	6/14/95	Inductively Coupled Plasma-Atomic Emission Spectroscopy Method 200.7 CLP-M, SOW ILM03.0 for the United States Army Environmental Center Type Work
DEN-MT-0006	1.0	3/13/96	Inductively Coupled Plasma-Mass Spectrometry, EPA Method 6020 CLP-M Version 9.0 for United States Army Environmental Center Type Work
DEN-MT-0007	1.0	1/19/96	Graphite Furnace Atomic Absorption Spectroscopy, SW-846 Method 7000A, for United Sates Army Environmental Center Type Work
DEN-MT-0008	0	1/1/00	Ignitability
DEN-OP-0004	0	12/13/95	Organic Glassware Washing Procedures
DEN-OP-0006	0	1/1/00	Organic Standard Stock Preparation
DEN-QA-0001	0	5/2/95	Thermometer Calibration Procedure
DEN-QA-0002	0	5/2/95	Analyst Certification Process for Department of Energy Specific Work
DEN-QA-0003	1.0	3/4/96	Sample Receipt and Chain-of-Custody
DEN-QA-0005	0	1/1/00	Document Archiving Procedure
DEN-QA-0006	0	6/1/95	Instrument Maintenance and Nonconformance
DEN-QA-0007	0	6/1/95	Nonconformance and Corrective Action
DEN-QA-0008	0	9/12/95	Calibration Verification of Mechanical Pipettes
DEN-QA-0009	0	1/1/00	Sonicator Tuning
DEN-QA-0010	0	5/3/96	Document Control
DEN-QA-0011	1.0	9/25/96	Calibration Procedure for Laboratory Ovens, Hotplates, and Furnaces
DEN-QA-0012	0	3/22/96	Monitoring Refrigerator Temperature
DEN-QA-0013	0	9/26/96	Holding Blanks
DEN-QA-0014	1.0	1/17/97	Balance Daily Check Procedure
DEN-QA-0015	1.0	3/21/96	Verification and Storage of Calibration Standards
DEN-QA-0016	0	9/30/96	Internal Trip Blanks
DEN-QA-0017	0	1/1/00	Bottle Preparation and Cooler Shipment
DEN-QA-0018	0	12/11/96	Validation and Generation of Electronic Data Deliverables
DEN-RD-0001	0	1/31/96	Screening Samples for the Presence of Radioactive Materials
DEN-RD-0002	0	8/7/96	Analysis of Gross Alpha and Beta Radioactivity in Drinking Water
DEN-RD-0003	0	8/6/96	Analysis of Tritium in Drinking Water

TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
DEN-WC-0001	0	6/11/96	Soil and Waste pH
DEN-WC-0002	0	5/24/96	Total Recoverable Phenolics - City of St. Louis Park (Manual)
DEN-WC-0003	1.0	7/24/96	Cyanide Analysis
DEN-WC-0004	0	1/1/00	Ammonia as Elemental Nitrogen (LACHAT Quikchem Autoanalyzer)
DEN-WC-0005	0	1/1/00	Total Recoverable Petroleum Hydrocarbons for the State of Arizona
DEN-WC-0006	0	11/21/95	Carbon in Water (TOC, TIC, DOC, TC)
DEN-WC-0007	0	10/25/96	Nitrate + Nitrite (LACHAT Autoanalyzer)
DEN-WC-0008	0	7/25/95	Analysis of Oil and Grease and Total Petroleum Hydrocarbons in the Aqueous Phase using MCAWW Methods 413.2 and 418.1 for United States Army Environment Center Type Work
DEN-WC-0009	0	7/25/95	Analysis of Oil and Grease and Total Petroleum Hydrocarbons in Soil and Waste Matrices using MCAWW 413.2 and 418.1 for United States Army Environmental Center Type Work
DEN-WC-0010	0	7/25/95	Analysis of Nitrate + Nitrite (Technicon Autoanalyzer) for United States Army Environmental Center Type Work
DEN-WC-0011	0	4/15/95	Analysis of Cyanide (Automated Colorimetric) for the United States Army Environmental Center Type Work
DEN-WC-0012	0	7/27/95	Preparation of Total Cyanide for the United States Army Environmental Center Type Work
DEN-WC-0013	1.0	5/24/96	Total Recoverable Phenolics
DEN-WC-0014	0	11/15/95	Total Suspended Solids
DEN-WC-0015	0	2/1/96	Hexavalent Chromium, Alkaline Digestion
DEN-WC-0016	0	11/27/95	Total Dissolved Solids
DEN-WC-0017	0	7/16/96	Total Phosphorus By Autoanalyzer
DEN-WC-0018	0	1/1/00	Chemical Oxygen Demand
DEN-WC-0019	0	1/9/96	Biochemical Oxygen Demand
DEN-WC-0020	0	1/1/00	Determination Of Inorganic Anions By Ion Chromatography
DEN-WC-0021	1.0	2/26/96	Hexavalent Chromium By Method 7196A
DEN-WC-0022	0	1/23/96	Turbidimetric Sulfate
DEN-WC-0023	0	1/12/96	Total, Fixed And Volatile Solids; % Water (Soils/Wastes)
DEN-WC-0024	0	9/30/96	Water And Sediment In Crude And Fuel Oils By Centrifuge
DEN-WC-0025	0	8/12/96	pH, Specific Conductance, and Alkalinity (Automatic Titrator)
DEN-WC-0026	0	1/1/00	Total Kjeldahl Nitrogen (TKN)
DEN-WC-0027	0	8/15/96	Oil & Grease/Total Petroleum Hydrocarbon Liquid-Liquid Extraction/IR Analysis (Aqueous)
DEN-WC-0028	0	1/1/00	Fluoride Analysis by SIE
DEN-WC-0029	0	8/21/96	CLP Cyanide Preparation and Analysis
DEN-WC-0030	0	10/29/96	Alkalinity (Manual Titration)
DEN-WC-0031	0	10/30/96	Manual pH
DEN-WC-0032	0	10/1/96	Settleable Solids
DEN-WC-0033	0	9/30/96	Corrosivity Towards Steel (NACE)
DEN-WC-0034	0	11/15/96	Chloride Analysis (Technicon AAII)

TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
DEN-WC-0035	0	9/30/96	Acidity
DEN-WC-0036	0	2/21/97	D.I. Leach
DEN-WC-0041	0	1/1/00	Sulfide Preparation and Analysis of Sulfide (Total, Dissolved Reactive, and Non-Aqueous)
DEN-WC-0042	0	1/1/00	Sulfide Analysis by EPA Method 9030A
ET-CLM-0001	0	4/27/94	Accelerated One-Step: Continuous Liquid/Liquid Extraction for Semivolatile Organics in Water Samples
LE-RMA-0018	0	11/1/88	Use of the Nitrogen Evaporation (N-Evap)
LE-RMA-0019	0	11/1/88	Use of the Kuderna-Danish Evaporative Concentrator (K-D)
LE-RMA-1001	0	12/8/87	Technicon Start-Up Procedure
LE-RMA-1002	0	12/8/87	Technicon TRAACS 800
LE-RMA-1003	0	12/8/87	DX-20 Total Organic Halide Analyzer System
LE-RMA-1004	0	12/8/87	Ion Chromatography System
LE-RMA-2005	0	4/29/88	Tuning the Heat Systems W385 Sonicator
LE-RMA-3002	1.0	4/1/88	Use of Nitrogen Gas Pressurized Column
LE-RMA-3003	0	4/1/89	Exchanging and Filling Liquid Nitrogen Dewars
LE-RMA-3004	0	4/1/89	Removing and Cleaning Sparge Cell
LE-RMA-4012	1.0	7/19/91	Gas Cylinders
LM-RMA-1006	0	4/5/88	Chemical Oxygen Demand: EPA Method 410.4
LM-RMA-1013	2.0	5/1/91	Color
LM-RMA-1022	0	4/27/88	Fluoride Analysis
LM-RMA-1024	2.0	3/5/90	Ion Balance Calculation
LM-RMA-1025	3.0	1/25/93	Anion Analysis by Ion Chromatography
LM-RMA-1025B	1.0	1/21/94	Anion Analysis by Ion Chromatography For USAEC
LM-RMA-1036	1.02	2/26/90	Ignitability: (Pensky-Martens Closed Cup)
LM-RMA-1041	2.0	5/16/91	Nitrate as N
LM-RMA-1042	1.0	9/11/89	Total Kjeldahl Nitrogen (TKN)
LM-RMA-1044	4.1	7/11/91	Oil & Grease; Total Petroleum Hydrocarbons: Sonication Prep/IR Analysis: (Soil, Wastes)
LM-RMA-1044A	4.0	8/28/91	Oil & Grease: Sonication Extraction/Gravimetric Analysis: (Soils, Wastes)
LM-RMA-1045	3.0	7/15/91	Oil & Grease/Total Petroleum Hydrocarbon: Liquid-Liquid Extraction/IR Analysis: (Aqueous)
LM-RMA-1045A	3.0	7/30/91	Oil & Grease: Liquid-Liquid Extraction/Gravimetric Analysis: (Aqueous)
LM-RMA-1049	3.0	10/27/93	Phosphorus, All Forms
LM-RMA-1059	2.0	1/16/89	Sulfite
LM-RMA-1069	1.0	3/17/89	Total Organic Halides (TOX): Dohrmann Analyzer
LM-RMA-1070	2.0	8/4/93	Turbidity
LM-RMA-1071B	1.0	1/21/94	Appendix I pH, Specific Conductance, and Alkalinity for USAEC
LM-RMA-1076	0	8/15/88	TKN TRAACS
LM-RMA-1079	0	5/2/88	Ammonia Nitrate + Nitrate TRAACS

TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
LM-RMA-1080	3.0	8/4/93	Sulfide: Total, Dissolved Reactive: (Analysis)
LM-RMA-1081	0	4/29/88	Fluoride Distillation
LM-RMA-1082	1.0	8/27/92	Reactive Cyanide and Sulfide: Sample Preparation
LM-RMA-1084	2.0	2/28/94	Methylene Blue Active Substances (MBAS)
LM-RMA-1086	1.0	3/24/89	Total Organic Halides (TOX): MCI Analyzer
LM-RMA-1088	0	11/1/88	Formaldehyde
LM-RMA-1089	0	11/1/88	Hardness, Calculation
LM-RMA-1090	0	11/7/88	Hardness, Titration
LM-RMA-1091	0	11/18/88	pH, Manual
LM-RMA-1092	0	3/6/89	Chlorine, Total Residual: (Starch Endpoint)
LM-RMA-1094	1.0	9/27/90	Sulfide, Total: (Prep-Nonaqueous)
LM-RMA-1095	0	11/18/88	Total Solids, Total Volatile Solids (Aqueous Matrix)
LM-RMA-1096	0	3/6/89	Total Organic Halides (TOX): Preparation
LM-RMA-1097	0	11/18/88	Volatile Suspended Solids
LM-RMA-1098	X	1/1/00	Specific Conductance (Manual Method)
LM-RMA-1101	0	5/1/89	Specific Gravity (Hydrometric)
LM-RMA-1102	0	5/15/89	Chloride (Titrimetric)
LM-RMA-1109	0	6/26/89	Potassium or Sodium Absorption Ratio (PAR/SAR)
LM-RMA-1110	1.0	4/2/90	Hydrazine (N_2H_4)
LM-RMA-1113	0	7/2/90	Oil/Water/Solids: Modified Oven Drying Technique: (MODT)
LM-RMA-1114	0	1/23/91	Nitrogen, Ammonia (Technicon AAII)
LM-RMA-1115	1.0	4/16/93	Oil & Grease/Total Petroleum Hydrocarbon: Soxhlet Extraction (Soils, Wastes)
LM-RMA-1116	1.0	6/9/92	Total Organic Carbon in Soils & Sediments
LM-RMA-1117	0	9/9/91	Paint Filter Liquids Test: (Percent Free Liquids)
LM-RMA-1118	0	9/11/91	Chevron Soluble Salts
LM-RMA-1119C	1.0	4/15/94	Anion Analysis by Ion Chromatography: For United States Geological Survey
LM-RMA-1120	0	1/18/93	Nitrate + Nitrite; Nitrate (Technicon AAII)
LM-RMA-1122	0	6/25/94	Acid Volatile Sulfide (AVS): Simultaneously Extracted Metals (SEM)
LM-RMA-2006	1.0	3/3/91	Metals: GFAA Analysis
LM-RMA-2034	1.0	10/23/89	Lead, Organic: Flame AA
LM-RMA-2038	0	2/5/90	Cation-Exchange Capacity: CEC
LM-RMA-3001C	3.0	4/24/90	GC/MS Analysis of Volatile Organics for Hagen Farms
LM-RMA-3013	3.0	1/20/93	GC/MS Analysis of Semivolatile Organics
LM-RMA-3022	1.0	9/1/89	Volatiles Screening Analysis by GC/FID
LM-RMA-3023	1.0	5/28/93	Volatiles Screening Analysis by Headspace GC/FID
LM-RMA-3030	1.0	2/5/91	Preparation of Refinery Wastes, Soils, and Solids for the Analysis of Refinery List Semivolatiles by GC/MS
LM-RMA-3038	1.0	1/3/92	Determination of Volatile Aromatics by GC/MS/SIM
LM-RMA-3040	1.0	2/21/94	Preparation of Water Samples to be Analyzed for Semivolatile Organic Compounds under CLP SOW OLMO1.1.1

TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
LM-RMA-3040B	1.0	1/20/94	Appendix I: Preparation of Water to be Analyzed for Semivolatiles for USAEC
LM-RMA-3041	0	9/27/91	Soil Sample Preparation for Semivolatile Organic Compounds to be Analyzed by GC/MS Under CLP Protocol SOW 3/90
LM-RMA-3041B	1.0	1/21/94	Appendix I Soil Sample Prep for Semi-VOA Organic Compounds for USAEC
LM-RMA-3042	0	9/30/91	GC/MS Analysis of Semivolatile Organics: CLP Methodology 3/90 SOW
LM-RMA-3042a	0	12/1/91	GC/MS Analysis of Semivolatile Organics: CLP Methodology 4/90 SOW
LM-RMA-3045	X	1/1/00	Preparation of Explosive Soils for Semivolatile Analysis by LC/MS
LM-RMA-3046	X	1/1/00	Preparation of Water Samples for Semivolatile Explosives Analysis by LC/MS
LM-RMA-3048	X	1/1/00	GC/MS Analysis of Semivolatile Organics in Water by Method 625
LM-RMA-3049	0	8/17/92	GC/MS Volatile Analysis of Water by Method 624
LM-RMA-3050	0	11/20/92	Determination of Polynuclear Aromatic Hydrocarbons (PAH) in Aerosols
LM-RMA-3051C	0	1/27/94	GC/MS Analysis of Semivolatile Organics for USAEC CLP SOW
LM-RMA-4001	5.1	7/20/93	Aromatic Volatile Organics (Purgable Aromatics): EPA Method 8020
LM-RMA-4003	4.0	2/7/94	Analysis of Organochlorine Pesticides and Poly Chlorinated Biphenyls EPA Method 8080
LM-RMA-4004	0	12/9/87	Polynuclear Aromatic Hydrocarbons (EPA Method 610/8310)
LM-RMA-4006	2.0	3/3/89	Organophosphorous Pesticides (EPA Method 614/8140)
LM-RMA-4007	3.0	12/10/91	Analysis of Environmental Samples for Chlorinated Phenoxyacid Herbicides (Modified EPA Method 615/8150)
LM-RMA-4008	1.0	1/31/89	Halogenated Volatile Organics - Purgable Halocarbons (EPA Method 601/8010)
LM-RMA-4017	4.0	7/9/91	Organochlorine Pesticide/Polychlorinated Biphenyl Screening Analysis by GC/ECD
LM-RMA-4038	5.0	2/7/94	Preparation of Organochlorine Pesticides and PCBs in Industrial Aqueous and Solid Samples
LM-RMA-4041	2.2	4/4/94	Determination of Aroclors in Tissue
LM-RMA-4044	2.0	3/21/91	Preparation of Chlorinated Phenoxyacid Herbicides in Industrial Aqueous and Solid Samples
LM-RMA-4045	2.0	2/1/91	Standard Product Organochlorine Pesticides (OCP) and Polychlorinated Biphenyl (PCB) in Soil and Vegetation
LM-RMA-4046	0	7/3/91	Preparation of Organophosphorus Pesticides in Industrial Aqueous Samples
LM-RMA-4059	0	9/30/91	CLP Preparation of Organochlorine Pesticides and Aroclors in Soil Organic SOW 3/90
LM-RMA-4059B	1.0	4/14/94	Appendix I CLP Prep of OCPs and Aroclors in Soil for USAEC
LM-RMA-4060	0	5/22/91	CLP Preparation of Organochlorine Pesticides in Water Organic SOW 3/90
LM-RMA-4060B	1.0	4/1/94	Appendix I CLP Prep of OCPs and Aroclors in Water

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TABLE 3-1
DENVER LABORATORY
Standard Operating Procedures (SOP) List
(Continued)

SOP No.	Rev. No.	Rev. Date	Title
LM-RMA-4070	0	8/17/92	Purgeable Aromatic Volatile Organics (EPA Method 602)
LM-RMA-4071	0	11/16/92	Analysis of Organochlorine Pesticides and Polychlorinated Biphenyls (EPA Method 608)
LM-RMA-4076	0	3/29/94	Sulfuric Acid Cleanup of Polychlorinated Biphenyls
LM-RMA-4077	0	5/9/94	PETN and Nitroglycerin by LC/UV/MS
LM-RMA-5015B	1.0	2/11/94	Analysis of Organochlorine Pesticides and Polychlorinated Biphenyls in Low Concentration Water Samples By CLP for USAEC
LM-RMA-5018	0	6/17/92	GC/MS Volatile Organics Analysis for Multi-Media Multi-Concentration Samples
LM-RMA-5018B	1.0	1/19/94	GC/MS Volatile Organics Analysis for Multi-Media Samples for USAEC
LM-RMA-5019B	1.0	2/9/94	Appendix I CLP Percent Solids Determination (Soil/Sediment) for USAEC
LP-RMA-0001	0	9/28/90	Building Security
LP-RMA-0008	1.0	4/8/88	Final Report Preparation - Industrial Projects
LP-RMA-0010	0	11/1/88	Automatic Pipette Washer
LP-RMA-0011	1.0	12/9/87	Ammonium Persulfate/H_2SO_4 Acid Bath
LP-RMA-0039	0	5/22/89	Quarantine Soils Procedures
LP-RMA-0044	1.0	5/27/93	Laboratory Data review/Industrial Inorganics Preview Report Package
LP-RMA-0051	0	1/1/91	Industrial Raw Data Packages
LP-RMA-0065	0	2/15/90	GC/MS Static Data Validation SOP
LP-RMA-0067	0	7/2/90	Laboratory Data Review Industrial Inorganics Level 2 Metals
LP-RMA-0068	0	7/2/90	Laboratory Data Review - Industrial Inorganics Level 2 Wet Chemistry
LP-RMA-0071	1.0	4/27/93	Sample Archival
LP-RMA-0080	0	8/26/91	Mobile Laboratory Sample Disposition of PCB Samples Analyzed for Texas Eastern
LP-RMA-0081	0	10/1/91	Linear and Quadratic Calibration Curves
LP-RMA-2000	0	7/1/93	ICP-MS Operation and Maintenance
LP-RMA-2001	0	3/4/94	Operation and Maintenance of TJA 61E Trace ICP
LP-RMA-5001	1.0	5/25/92	CLP Sample Receipt and Logging
LP-RMA-5010	1.0	11/15/90	Laboratory Documentation Practices and Form Generation
LP-RMA-5011	1.0	5/28/93	Organics Laboratory Data Review
TEN-GC-0003	0	6/19/96	Polychlorinated Biphenyls Based on SW-846 Method 8080 For Gas Pipeline Projects
TEX-GC-0007	0	3/19/96	Determination of Polychlorinated Biphenyls in Tissue Based on SW-846 For Pipeline Projects
U33.3	6	8/18/93	Method for Determination of Gasoline Range Organics

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Facility Appendix

Denver Laboratory

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Section Denver-4

Analytical
Methods

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TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Acidity	Water	Method 305.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 305.1 (M)	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 305.1 (M)	Not Applicable	Not Applicable	Not Applicable
Alkalinity	Water	Method 310.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Not Applicable	Not Applicable	Not Applicable
	Soil	310.1 (M)	Not Applicable	Not Applicable	Not Applicable
Biochemical Oxygen Demand	Water	Method 405.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Bromide	Water	Method 300.0	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 300.0 (M)	Not Applicable	Not Applicable	ASTM D240
	Soil	Method 300.0 (M)	Not Applicable	Not Applicable	Not Applicable
Chemical Oxygen Demand	Water	Method 410.4	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 410.4	Not Applicable	Not Applicable	Not Applicable

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TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Chloride	Water	Method 300.0 Method 325.1 Method 325.2	Method 9251 Method 9252A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 300.0 (M)	Method 9252	Not Applicable	Not Applicable
	Soil	Method 300.0 (M)	Method 9251 (M) Method 9252A	Not Applicable	Not Applicable
Chlorine (Residual)	Water	Method 330.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 330.1 (M)	Not Applicable	Not Applicable	Not Applicable
Chromium, Hexavalent	Water	Method 3500-Cr-D	Method 7196A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 3500-Cr-D (M)	Method 3060A/7196A	Not Applicable	Not Applicable
	Soil	Method 3500-CR-D (M)	Method 3060A/7196A	Not Applicable	Not Applicable
Specific Conductance	Water	Method 120.1	Method 9050	Method 120.1	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 120.1	Method 9050	Not Applicable	Not Applicable
	Soil	Method 120.1 (M)	Method 9050	Method 9050	Not Applicable

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TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Cyanide (Amenable)	Water	Method 335.1	Method 9012	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Not Applicable	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 9012	Not Applicable	Not Applicable
Cyanide (Reactive)	Water	Not Applicable	Section 7.3	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Section 7.3	Not Applicable	Not Applicable
	Soil	Not Applicable	Section 7.3	Not Applicable	Not Applicable
Cyanide (Total)	Water	Method 4500 C & E	Method 9012	Method 335.2 CLP - (M)	Not Applicable
	TCLP Leachate	Not Applicable	Method 9012	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Method 9010A Method 9012	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 9010A Method 9012	Method 335.2 CLP-(M)	Not Applicable
Cyanide (Weak and Dissociable)	Water	4500 I	Not Applicable	Not Applicable	ASTM D-2036-81
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Not Applicable	Not Applicable	ASTM D-2036-81 (M)
	Soil	Not Applicable	Not Applicable	Not Applicable	ASTM D-2036-81
Fluoride	Water	Method 300.0 Method 340.2	Not Applicable	Not Applicable	Not Applicable

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TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Fluoride (continued)	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 340.2 (M) Method 300.0 (M)	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 340.2 (M) Method 300.0 (M)	Not Applicable	Not Applicable	Not Applicable
Ignitability	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Method 1010	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 1010	Not Applicable	Not Applicable
Hardness	Water	Method 130.2	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Moisture	Soil	Not Applicable	ASTM D2216	ASTM D2216	Not Applicable
Nitrogen, Ammonia	Water	Method 350.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 350.1	Not Applicable	Not Applicable	Not Applicable
Nitrite (NO_2)	Water	Method 300.0 Method 354.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 300.0 (M) Method 354.1	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 354.1 (M)	Not Applicable	Not Applicable	Not Applicable

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TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Nitrate (NO_3)	Water	Method 300.0 Method 353.2 Method 354.1	Not Applicable	Method 353.2	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 300.0 (M) Method 353.2	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 300.0 (M) Method 353.2 (M)	Not Applicable	Not Applicable	Not Applicable
Nitrate plus Nitrate	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 353.2 (M)	Not Applicable	Not Applicable	Not Applicable
Total Kjeldahl Nitrogen (TKN)	Water	Method 351.3	Not Applicable	Method 351.3	Not Applicable
	Domestic Waste, Industrial Waste Sludge, Solid, Sediment	Method 351.3	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 351.3	Not Applicable	Not Applicable	Not Applicable
Oil and Grease	Water	Method 413.1 Method 413.2	Not Applicable	Method 413.1	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 413.1 Method 413.2	Method 9071A	Not Applicable	Not Applicable
	Soil	Method 413.1 (M) Method 413.2 (M)	Method 9071A	Not Applicable	Not Applicable
Ortho-phosphate	Water	Method 300.0 Method 365.3	Not Applicable	Not Applicable	Not Applicable

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TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Ortho-phosphate (continued)	Soil	Method 300.0 (M) Method 365.3 (M)	Not Applicable	Not Applicable	Not Applicable
pH	Water	Method 150.1	Method 9040A	Method 150.1	Not Applicable
	TCLP Leachate	Not Applicable	Method 1311	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Method 9045B	Method 9045A	Not Applicable
	Soil	Not Applicable	Method 9045B	Method CLP	Method A.2.2.1
Phenolics	Water	Method 420.1 Method 420.2	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Method 9065 Method 9066	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 9065 Method 9066	Not Applicable	Not Applicable
Phosphate	Water	Method 300.0	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 300.0 (M)	Not Applicable	Not Applicable	Not Applicable
Phosphorus (Total)	Water	Method 365.3	Not Applicable	Method 365.3	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 365.3	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 365.3	Not Applicable	Not Applicable	Not Applicable
Sulfate (SO_4)	Water	Method 300.0 Method 375.4	Method 9038	Method 375.4	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 300.0 (M) Method 375.4	Not Applicable	Not Applicable	Not Applicable

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TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Sulfate (SO_4) (continued)	Soil	Method 300.0 (M)	Method 9038 (M)	Method 375.4 (M)	Not Applicable
Sulfide	Water	Method 376.2	Not Applicable	Not Applicable	Not Applicable
Sulfide (Reactive)	Water	Not Applicable	Section 7.3	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Section 7.3	Not Applicable	Not Applicable
	Soil	Not Applicable	Section 7.3 Method 9030A	Not Applicable	Not Applicable
Sulfite (SO_3)	Water	Method 377.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 377.1 (M)	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 377.1 (M)	Not Applicable	Not Applicable	Not Applicable
Total Organic Carbon (TOC)	Water	Method 415.1 Method 415.2	Method 9060	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Method 9060	Not Applicable	Not Applicable
	Soil	Method 415.1 (M)	Method 9060 (M)	Not Applicable	Not Applicable
Total Organic Halides (TOX)	Water	Not Applicable	Method 9020B	Not Applicable	Not Applicable

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TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Total Organic Halides (TOX) (continued)	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Not Applicable	Method 9020B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 9020B	Not Applicable	Not Applicable
Total Petroleum Hydro-carbons	Water	Method 418.1 Method 1664	Not Applicable	Method 418.1	Not Applicable
	TCLP Leachate	Method 418.1	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 418.1	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 418.1	Method 9071A	Method 418.1	Not Applicable
Total Solids	Water	Method 160.3	Not Applicable	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solid, Sediment	Method 160.3	Not Applicable	Not Applicable	Not Applicable
	Soil	Method 160.3 (M)	Not Applicable	Not Applicable	Not Applicable
Total Dissolved Solids	Water	Method 160.1	Not Applicable	Not Applicable	Not Applicable
Total Suspended Solids	Water	Method 160.2	Not Applicable	Not Applicable	Not Applicable
Volatile Solids and Volatile Suspended Solids	Water	Method 160.4	Not Applicable	Not Applicable	Not Applicable
Settleable Solids	Water	Method 160.5	Not Applicable	Not Applicable	Method 2540 F

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TABLE 4-1
DENVER LABORATORY
Wet Chemistry Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Turbidity	Water	Method 180.1	Not Applicable	Not Applicable	Not Applicable

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TABLE 4-2
DENVER LABORATORY
Graphite Furnace Atomic Absorption Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Antimony	Water	Method 204.2 Method 3113B	Method 7041	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 7041	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solid, Sediment	Not Applicable	Method 7041	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7041	Method CLP	Not Applicable
Arsenic	Water	Method 206.2 Method 3113B	Method 7060A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 7060A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 7060A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7060A	Method CLP	Not Applicable
Cadmium	Water	Method 213.2 Method 3113B	Method 7131A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 7131A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 7131A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7131A	Not Applicable	Not Applicable
Chromium	Water	Method 218.2 Method 3113B	Method 7191	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 7191	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7191	Not Applicable	Not Applicable
Copper	Water	Method 220.2 Method 3113B	Method 7211	Not Applicable	Not Applicable

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TABLE 4-2
DENVER LABORATORY
Graphite Furnace Atomic Absorption Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Lead	Water	Method 239.2 Method 3113B	Method 7421	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 7421	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 7421	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7421	Method CLP	Not Applicable
Selenium	Water	Method 270.2 Method 3113B	Method 7740	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 7740	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 7740	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7740	Method CLP	Not Applicable
Silver	Water	Method 272.2 Method 3113B	Method 7761	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 7761	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment, Soil	Not Applicable	Method 7761	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7761	Method CLP	Not Applicable
Thallium	Water	Method 279.2	Method 7841	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 7841	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 7841	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7841	Method CLP	Not Applicable

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TABLE 4-3
DENVER LABORATORY
Inorganic ICAP/Trace ICP Metals Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Aluminum	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Antimony [1]	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Arsenic [1]	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Barium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Beryllium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable

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TABLE 4-3
DENVER LABORATORY
Inorganic ICAP/Trace ICP Metals Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Beryllium (continued)	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Boron	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Calcium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Cadmium [1]	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Cobalt	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable

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TABLE 4-3
DENVER LABORATORY
Inorganic ICAP/Trace ICP Metals Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Chromium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Copper	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Iron	Water	Method 200.7	Method 6010A	Method CLP	
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Lead [1]	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Lithium	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable

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TABLE 4-3
DENVER LABORATORY
Inorganic ICAP/Trace ICP Metals Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Lithium (continued)	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Magnesium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Manganese	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Molybdenum	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Nickel	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable

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TABLE 4-3
DENVER LABORATORY
Inorganic ICAP/Trace ICP Metals Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Phosphorous	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Potassium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Selenium [1]	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Silicon	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Silver	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable

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TABLE 4-3
DENVER LABORATORY
Inorganic ICAP/Trace ICP Metals Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Sodium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Strontium	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Tin	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Thallium [1]	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Titanium	Water	Method 200.7	Method 6010A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Not Applicable	Not Applicable
Vanadium	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable

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TABLE 4-3
DENVER LABORATORY
Inorganic ICAP/Trace ICP Metals Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Vanadium (continued)	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable
Zinc	Water	Method 200.7	Method 6010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 6010A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 6010A	Method CLP	Not Applicable

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Footnotes

[1] These metals can also be analyzed by Trace ICP.

TABLE 4-4
DENVER LABORATORY
Inorganic ICP/MS Metals Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Aluminum* Antimony* Arsenic* Barium* Beryllium* Boron Bromine Cadmium* Calcium Chromium* Cobalt* Copper* Iron Lead* Lithium Magnesium Manganese* Molybdenum* Nickel* Phosphorous Potassium Selenium* Silicon Silver* Sodium Strontium Thallium* Tin Thorium* Titanium Uranium* Vanadium* Zinc*	Water	Not Applicable	Method 6020	Not Applicable	200.8*
Arsenic Barium Cadmium Chromium Lead Selenium Silver Thallium	TCLP Leachate	Not Applicable	Method 6020	Not Applicable	Not Applicable

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TABLE 4-5
DENVER LABORATORY
Metals Sample Preparation Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Toxicity Characteristic Leaching Procedure (TCLP)	Water	Not Applicable	Method 1311	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 1311	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 1311	Not Applicable	Not Applicable
ICAP Metals	Water	Method 200.7	Method 3005A Method 3010A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 3010A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 3050A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3050A	Method CLP	Not Applicable
CVAA	Water	Method 245.1	Method 7470A	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 7470A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 7471A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 7471A	Method CLP	
Flame AA Metals	Water	Method 200.0	Method 3020A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 3050A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3050A	Not Applicable	Not Applicable

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TABLE 4-5
DENVER LABORATORY
Metals Sample Preparation Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
GFAA Metals	Water	Not Applicable	Arsenic 3050A/7060 Antimony 3005A/7041 Lead 3020A Selenium 3050A/7740 Silver 7761 Thallium 3050A/7841	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 3020A	Not Applicable	Not Applicable
	Domestic Waste Industrial Waste Sludge, Solids, Sediment	Not Applicable	Arsenic 3050A/7060 Antimony 7041 Lead 3020A Selenium 3050A/7740 Silver 7761 Thallium 3050A/7841	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3050A	Not Applicable	Not Applicable

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TABLE 4-6
DENVER LABORATORY
Flame Atomic Absorption Inorganic Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Lead	Water	Not Applicable	Method 7420	Not Applicable	Not Applicable
Organic Lead	Water	Not Applicable	Not Applicable	Not Applicable	CA LUFT Method
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Not Applicable	Not Applicable	CA LUFT Method
	Soil	Not Applicable	Not Applicable	Not Applicable	CA LUFT Method

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TABLE 4-7
DENVER LABORATORY
Organic Sample Preparation Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Volatiles by GC/MS	Water	Method 624	Method 5030A	Method CLP	Method 524.2
	TCLP Leachate	Not Applicable	Method 5030A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 5030A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 5030A	Method CLP	Not Applicable
Halogenated Volatiles by GC	Water	Method 601	Method 5030A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 5030A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 5030A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 5030A	Not Applicable	Not Applicable
Aromatic Volatiles by GC	Water	Method 602	Method 5030A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 5030A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 5030A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 5030A	Not Applicable	Not Applicable
Semivolatiles by GC/MS	Water	Method 625	Method 3510B Method 3520B	Method CLP	Not Applicable
	TCLP Leachate	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 3550A Method 3580A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3550A	Method CLP	Not Applicable
Pesticides/ PCBs by GC	Water	Method 608	Method 3510B Method 3520B	Method CLP	Not Applicable

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TABLE 4-7
DENVER LABORATORY
Organic Sample Preparation Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Pesticides/ PCBs by GC (continued)	TCLP Leachate	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 3550A Method 3580A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3550A	Method CLP	Not Applicable
Pesticides (Organophos-phorus) by GC	Water	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 3540B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3550A	Not Applicable	Not Applicable
PAHs by GC	Water	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3550A	Not Applicable	Not Applicable
PAHs by HPLC	Water	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3550A	Not Applicable	Not Applicable
Herbicides by GC	Water	Method 615	Method 8150B	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 8150B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 8150B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8150B	Not Applicable	Not Applicable
Gasoline Range Organics by GC	Water	Not Applicable	Method 5030A	Not Applicable	Not Applicable

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TABLE 4-7
DENVER LABORATORY
Organic Sample Preparation Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Gasoline Range Organics by GC	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 5030A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 5030A	Not Applicable	Not Applicable
Total Petroleum Hydrocarbons (diesel range) by GC	Water	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 3510B Method 3520B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 3550A Method 3580A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 3550A	Not Applicable	Not Applicable

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TABLE 4-8
DENVER LABORATORY
Organic Methods

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Volatiles by GC/MS	Water	Method 624	Method 8240B Method 8260A	Method CLP	Method 524.2
	TCLP Leachate	Not Applicable	Method 8240B Method 8260A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 8240B Method 8260A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8240B Method 8260A	Method CLP	Not Applicable
Halogenated Volatiles by GC	Water	Method 601	Method 8010B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 8010B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8010B	Not Applicable	Not Applicable
Aromatic Volatiles by GC	Water	Method 602	Method 8020A	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 8020A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 8020A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8020A	Not Applicable	Not Applicable
Semivolatiles by GC/MS	Water	Method 625	Method 8270B	Method CLP	
	TCLP Leachate	Not Applicable	Method 8270B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 8270B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8270B	Method CLP	Not Applicable

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TABLE 4-8
DENVER LABORATORY
Organic Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Pesticides/ PCBs by GC	Water	Method 608	Method 8080A	Method CLP	Method 505
	TCLP Leachate	Not Applicable	Method 8080A	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 8080A	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8080A	Method CLP	Not Applicable
Pesticides (Organophos-phorus) by GC	Water	Not Applicable	Method 8140	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 8140	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8140	Not Applicable	Not Applicable
PAHs by GC	Water	Not Applicable	Method 8100	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8100	Not Applicable	Not Applicable
PAHs by HPLC	Water	Not Applicable	Method 8310	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediments	Not Applicable	Method 8310	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8310	Not Applicable	Not Applicable
Herbicides by GC	Water	Method 615	Method 8150B	Not Applicable	Not Applicable
	TCLP Leachate	Not Applicable	Method 8150B	Not Applicable	Not Applicable
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 8150B	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8150B	Not Applicable	Not Applicable

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TABLE 4-8
DENVER LABORATORY
Organic Methods
(Continued)

Analytical Parameters	Matrix	Methods			
		NPDES	RCRA (SW846)	CLP	Other
Gasoline Range Organics by GC	Water	Not Applicable	Method 8015A (M)	Not Applicable	Method API
	Domestic Waste, Industrial Waste, Sludge, Solids, Sediment	Not Applicable	Method 8015A (M)	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8015A (M)	Not Applicable	Method API
Total Petroleum Hydrocarbons (diesel range) by GC	Water	Not Applicable	Method 8015A (M)	Not Applicable	Method API
	Domestic Waste, Industrial Waste Sludge, Solids, Sediment	Not Applicable	Method 8015A (M)	Not Applicable	Not Applicable
	Soil	Not Applicable	Method 8015A (M)	Not Applicable	Method API
Explosives by HPLC	Water	Not Applicable	Method 8330	Not Applicable	Method LW-12
	Soil	Not Applicable	Method 8330	Not Applicable	Method LW-12

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Facility Appendix

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Section Denver-5

MDLs and RLs

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TABLE 5-1
DENVER LABORATORY
Wet Chemistry Methods[1], Method Detection Limits (MDL) and Reporting Limits (RL)[2]

Parameter	CAS Number	Method	Water MDL Date	Water MDL mg/L	Soil MDL Date	Soil MDL[3] mg/kg	Water RL mg/L	Soil RL[3] mg/Kg
Acidity	76-40-0	EPA 305.1	---	---	---	---	10	50
Alkalinity	477520-60-0	EPA 310.1	4/3/97	0.69	---	N/A	5	25
Biochemical Oxygen Demand	1-00-2	EPA 405.1	1/9/97	0.20	N/A	N/A	2.0	N/A
Bromide	28-20-0	EPA 300.0	6/19/96	0.02	---	---	1.0	1.0
Chemical Oxygen Demand (COD)	1-00-4	410.4 (Hach)	9/9/96	5.63	N/A	N/A	20	N/A
Chloride	1-00-3	EPA 300.0	6/19/96	0.10	---	---	3.0	15
		SW846 9056	6/19/96	0.10	---	---	3.0	15
		SW846 9251	---	---	---	---	3.0	15
		EPA 325.3	3/31/97	0.50	---	---	3.0	15
		SW846 9252A	3/31/97	0.50	---	---	3.0	15
Chlorine (Residual)	97286-40-0	EPA 330.1	1/2/97	0.13	---	---	0.2	---
Chromium, hexavalent	18540-29-9	3500-Cr-D	7/8/96	0.0023			0.01	
		SW846 7196A	7/8/96	0.0023	3/28/69	0.14	0.01	0.40
Conductivity, specific	1-01-1	EPA 120.1	N/A	N/A	N/A	N/A	1 µmhos/cm	1 µmhos/cm
		SW846 9050	N/A	N/A	N/A	N/A		
Cyanide	5955-70-0	4500-C&E	3/13/97	0.0010	---	---	0.01	0.50
		SW846 9012	3/13/97	0.0010	1/17/97	0.18	0.01	0.50
		Section 7.3	---	---	---	---	---	---
		SW846 9010A	3/13/97	0.0010	1/17/97	0.18	0.01	0.50
		ASTM D-2036-81	---	---	---	---	0.01	0.50
Fluoride	66-30-0	EPA 300.0	6/19/96	0.07	---	---	0.5	2.5
		SM4500	3/17/97	0.01	---	---	0.1	0.5
Formaldehyde	50-00-0	NIOSH 3500	6/18/96	0.015	---	---	0.05	1.0
Hardness	35-50-0	EPA 130.2	4/5/96	4.36	---	---	5	---
Hydrazine	302-01-2	ASTM D1385	---	---	---	---	0.05	0.25
Ignitability	1-01-3	SW846 1010	---	---	---	---	---	---
Nitrogen, Ammonia	310-90-0	EPA 350.1	10/3/96	0.017	---	---	0.1	0.5

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TABLE 5-1
DENVER LABORATORY
Wet Chemistry Methods[1], Method Detection Limits (MDL) and Reporting Limits (RL)[2]
(Continued)

Parameter	CAS Number	Method	Water MDL Date	Water MDL mg/L	Soil MDL Date	Soil MDL[3] mg/kg	Water RL mg/L	Soil RL[3] mg/Kg
Nitrite as N	15-90-0	EPA 354.1	3/24/97	0.002	---	---	0.01	---
		EPA 300.0	6/19/96	0.05	---	---	0.50	2.5
Nitrate plus Nitrite	1-00-5	EPA 353.2	1/14/96	0.016	---	---	0.1	0.05
Nitrate as N	25-90-0	EPA 300.0	6/19/96	0.04	---	---	0.5	2.5
Nitrogen, Total Kjeldahl	5228003-90-0	EPA 351.2	8/16/96	0.38	---	---	0.5	50
Oil and Grease	1-00-7	EPA 413.1	3/18/97	2.52	11/21/96	65	5.0	100
		SW846 9070	3/18/97	2.52	11/21/96	65	5.0	100
		EPA 413.2	3/31/97	0.14	---	---	1.0	20
		SW846 9071A	---	---	3/19/96	77.9	1.0	200
		EPA 1664 (HEM)	12/14/95	1.07	---	---	5.0	---
Orthophosphate	226750-80-0	EPA 365.3	3/7/97	0.005	---	---	0.05	0.25
		EPA 300.0	6/19/96	0.06	---	---	0.50	2.5
Phosphorus, total	6791520-80-0	EPA 365.3	3/7/97	0.005	---	---	0.05	5
Phenolics, total recoverable	54-30-0	EPA 420.1	4/2/97	0.0028	---	---	0.005	---
		EPA 420.2	1/7/97	0.018	---	---	0.02	---
		SW846 9065	4/2/97	0.0028	---	---	0.005	1.0
		SW846 9066	1/7/97	0.018	---	---	0.02	2.0
Sulfate	3-03-5	EPA 300.0	6/19/96	0.10	---	---	5	25
		EPA 375.4	1/3/97	1.61	---	---	5	---
		SW846 9038	1/3/97	1.61	---	---	5	---
Sulfide	1055-70-0	EPA 376.2 SW846 Section 7.3	10/1/96	0.017	---	---	0.05	---
Sulfite	18-20-0	EPA 377.1	6/12/96	0.84	---	---	2	20
Total Organic Carbon (TOC)	1-01-2	EPA 415.1	11/13/96	0.18	---	---	1.0	
		EPA 415.2	---	---	---	---	1.0	0.20%
		SW846 9060	11/13/96	0.18	2/14/97	549	1.0	2000
Total Organic Halides (TOX)	59473-04-0	SW846 9020B	4/2/97	0.0075	---	---	0.03	0.3

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TABLE 5-1
DENVER LABORATORY
Wet Chemistry Methods[1], Method Detection Limits (MDL) and Reporting Limits (RL)[2]
(Continued)

Parameter	CAS Number	Method	Water MDL Date	Water MDL mg/L	Soil MDL Date	Soil MDL[3] mg/kg	Water RL mg/L	Soil RL[3] mg/Kg
Total Recoverable Petroleum Hydrocarbons	5289290-40-0	EPA 418.1	4/7/97	0.10	03/22/96	6.03	1.0	20
		SW846 9071A	---	---	03/22/96	6.03	---	40
		EPA 1664 (SGT-HEM)	12/14/95	1.68	---	---	5.0	---
Total Dissolved Solids	1-01-0	EPA 160.1	2/7/97	7.88	N/A	N/A	10	N/A
Total Suspended Solids	1-00-9	EPA 160.2	11/11/96	1.6	N/A	N/A	2.0	N/A
Total Solids	1-00-8	EPA 160.3	3/12/96	5.44	---	---	10	0.1%
Volatile Suspended Solids	8279840-70-0	EPA 160.4	---	---	N/A	N/A	1	N/A
Settleable Solids	3069938-50-0	Method 209-E	---	---	N/A	N/A	1mL/L	N/A
Turbidity	3-01-6	EPA 180.1	3/19/96	0.04 NTU	N/A	N/A	0.1 NTU	N/A

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] Reporting Limits are generally within 1 to 10 times of the MDL.

[3] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-2
DENVER LABORATORY
GFAA Metals[1],[4] Contract Required Detection Limits (CRDL), Contract Laboratory Program (CLP), Method Detection Limits (MDL),[2] and Reporting Limits (RL)[3]

Element	CAS Number	Water CRDL (µg/L)	Soil CRDL[5] (mg/Kg)	Water MDL (µg/L)	Soil MDL[5] (mg/Kg)	Water RL (µg/L)	Soil RL[5] (mg/Kg)
Arsenic	7440-38-2	10	2	1.37	0.21	5	0.5
Lead	7439-92-1	3	0.6	1.24	0.09	5	0.5
Selenium	7782-49-2	5	1	2.66	0.25	5	0.5
Thallium	7440-28-0	10	2	0.50	0.12	5	0.5
Antimony	7440-36-0	60	12	3.40	0.36	10	1
Cadmium	7440-43-9	5	1	0.10	0.011	0.5	0.05
Chromium	7440-47-3	10	2	0.86	0.01	5	0.5
Silver	7440-22-4	10	2	0.074	0.010	0.5	0.05
Mercury[6]	7439-97-6	0.2	0.04	0.11	0.056	0.2	0.1

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit studies for As, Cd, Pb, Se, and Tl were performed 12/04/96 for waters and 11/19/96 for soils, Ag was performed 03/6/97 (water) and 04/24/96 (soil), Sb was performed 06/24/96 (water) and 01/16/97 (soil), Cr was performed 02/10/97 (water), Hg was performed 1/8/97 (water) and 01/17/97 (soil).

[3] Reporting Limits are within 1 to 10 times of the MDL.

[4] Higher detection limits may be utilized under the following circumstances: If the sample concentration exceeds five (5) times the detection limit of the instrument, the values may be reported even though the instrument detection limit may not equal the contract required detection limit.

[5] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

[6] Analyzed by Cold Vapor AA.

TABLE 5-3
DENVER LABORATORY
ICAP Metals[1],[4] Contract Required Detection Limits (CRDL) Contract Laboratory Program, Methods 6010A/200.7 Method Detection Limits (MDL),[2] and Reporting Limits (RL)[3]

Element	CAS Number	Water CRDL (µg/L)	Soil CRDL[5] (mg/Kg)	Water MDL (µg/L)	Soil MDL[5] (mg/Kg)	Water RL (µg/L)	Soil RL[5] (mg/Kg)
Aluminum	7429-90-5	200	40	20	3.7	100	10
Antimony	7440-36-0	60	12	37	1.8	60	6
Arsenic[6]	7440-38-2	10	---	78	3.1	100	10
Barium	7440-39-3	200	40	1.9	0.16	10	1
Beryllium	7440-41-7	5	1	1.3	0.04	2	0.2
Boron	7440-42-8		---	29	1.5	100	10
Cadmium[6]	7440-43-9	5	1	3.3	0.37	5	0.50
Calcium	7440-70-2	5000	1000	110	5.9	200	20
Chromium	7440-47-3	10	2	5.2	0.44	10	1
Cobalt	7440-48-4	50	10	4.2	0.81	10	1
Copper	7440-50-8	25	5	3.3	0.78	20	2
Iron	7439-89-6	100	20	35	2.6	100	10
Lead[6]	7439-92-1	3	---	32	1.6	50	5
Lithium	7439-93-2	---	---	20	0.18	50	5
Magnesium	7439-95-4	5000	1000	38	17	200	20
Manganese	7439-96-5	15	3	1.6	0.54	10	1
Molybdenum	7439-98-7	---	---	12	0.79	20	2
Nickel	7440-02-0	40	8	6.9	1.7	40	4
Phosphorus	7723-14-0	---	---	120	7.3	300	30
Potassium	7440-09-7	5000	1000	660	55	5000	500
Selenium[6]	7782-49-2	5	---	79	9.5	200	20
Silica as SiO_2	7404-20-0	---	---	140	16	500	50
Silver	7440-22-4	10	2	4.1	0.33	10	1
Sodium	7440-23-5	5000	1000	1340	74	5000	500
Strontium	7440-24-6	---	---	12	2.3	50	5
Thallium[6]	7440-28-0	10	---	650	24	2000	200
Tin	7440-31-5	---	---	51	2.2	100	10

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TABLE 5-3
DENVER LABORATORY
ICAP Metals[1],[4] Contract Required Detection Limits (CRDL) Contract Laboratory Program, Methods 6010A/200.7 Method Detection Limits (MDL),[2] and Reporting Limits (RL)[3]
(Continued)

Element	CAS Number	Water CRDL (µg/L)	Soil CRDL[5] (mg/Kg)	Water MDL (µg/L)	Soil MDL[5] (mg/Kg)	Water RL (µg/L)	Soil RL[5] (mg/Kg)
Titanium	7440-32-6	---	---	6.2	0.19	15	1.5
Vanadium	7440-62-2	50	10	2.0	0.23	10	1
Zinc	7440-66-6	20	4	8.0	0.43	20	2

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 02/15/96 (water) and 12/14/95 (soil).

[3] Reporting Limits are within 1 to 10 times of the MDL.

[4] Higher detection limits may be utilized under the following circumstances: If the sample concentration exceeds five (5) times the detection limit of the instrument, the values may be reported even though the instrument detection limit may not equal the contract required detection limit.

[5] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

[6] These elements are routinely analyzed by GFAA or Trace ICP.

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TABLE 5-4
DENVER LABORATORY
Trace ICP Metals[1], [3] Contract Required Detection Limits (CRDL)
Method 6010A Method Detection Limits (MDL)[2] and Reporting Limits (RL)

Element	CAS Number	Water CRDL (µg/L)	Soil CRDL[5] (mg/Kg)	Water MDL (µg/L)	Soil MDL[5] (mg/Kg)	Water RL (µg/L)	Soil RL[5] (mg/Kg)
Antimony	7440-36-0	60	12	2.62	0.31	10	1
Arsenic	7440-38-2	10	---	3.46	0.44	10	1
Cadmium	7440-43-9	5	1	0.58	0.06	5	0.5
Lead	7439-92-1	3	---	2.72	0.21	3	0.3
Selenium	7782-49-2	5	---	3.12	0.34	5	0.5
Thallium	7440-42-8	1	---	7.11	0.66	10	1

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 2/3/97 for waters and 5/2/96 for soils.

[3] Higher detection limits may be utilized under the following circumstances: If the sample concentration exceeds five (5) times the detection limit of the instrument, the values may be reported even though the instrument detection limit may not equal the contract required detection limit.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-5
DENVER LABORATORY
Method 6020 ICP/MS Metals[1] Method Detection Limits (MDL) and Reporting Limits (RL)

Element	CAS Number	Water MDL (µg/L)	Soil MDL[2] (µg/Kg)	Water RL (µg/L)	Soil RL[2] (mg/Kg)
Aluminum	7429-90-5	2.57	---	15	1.5
Antimony	7440-36-0	0.3	---	0.50	0.050
Arsenic	7440-38-2	0.44	---	5.0	0.50
Barium	7440-39-3	0.34	---	1.0	0.10
Beryllium	7440-41-7	0.32	---	0.50	0.050
Cadmium	7440-43-9	0.055	---	0.30	0.030
Chromium	7440-47-3	0.94	---	1.0	0.10
Cobalt	7440-48-4	0.15	---	0.50	0.050
Copper	7440-50-8	0.19	---	2.0	0.20
Iron	7439-89-6	12	---	50	5.0
Lead	7439-92-1	0.74	---	1.0	0.10
Manganese	7439-96-5	0.054	---	0.20	0.020
Molybdenum	7439-98-7	0.087	---	0.25	0.025
Nickel	7440-02-0	0.050	---	0.20	0.020
Selenium	7782-49-2	0.54	---	5.0	0.50
Silver	7440-22-4	0.30	---	0.50	0.050
Thallium	7440-28-0	0.045	---	0.10	0.010
Tin	7440-31-5	2.70	---	15	1.5
Titanium	7440-32-6	0.70	---	5.0	0.50
Uranium	7440-61-1	0.034	---	0.20	0.020
Vanadium	7440-62-2	0.20	---	0.50	0.050
Zinc	7440-66-6	2.30	---	10	1.0

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

[3] The MDLs were completed on 05/09/95, 12/23/96 and 1/13/97.

TABLE 5-6
DENVER LABORATORY
Method 601 CWA Halogenated Volatile Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Bromodichloromethane	75-27-4	0.065	1.0
Bromoform	75-25-2	0.14	5.0
Bromomethane	74-83-9	0.050	5.0
Carbon Tetrachloride	56-23-5	0.050	0.5
Chlorobenzene	108-90-7	0.31	2.0
Chloroethane	75-00-3	0.091	5.0
2-Chloroethylvinyl ether	110-75-8	0.081	5.0
Chloroform	67-66-3	0.050	0.5
Chloromethane	74-87-3	0.050	5.0
1,2-Dichlorobenzene	95-50-1	0.12	2.0
1,3-Dichlorobenzene	541-73-1	0.10	2.0
1,4-Dichlorobenzene	106-46-7	0.11	2.0
Dichlorodifluoromethane	75-71-8	0.050	5.0
1,1-Dichloroethane	75-34-3	0.050	0.5
1,2-Dichloroethane	107-06-2	0.051	1.0
1,1-Dichloroethene	75-35-4	0.050	0.5
trans-1,2-Dichloroethene	156-60-5	0.050	0.5
cis-1,2-Dichloroethene	156-59-2	0.050	0.5
1,2-Dichloropropane	78-87-5	0.058	1.0
cis-1,3-Dichloropropene	10061-01-5	0.072	2.0
trans-1,3-Dichloropropene	10061-02-6	0.10	1.0
Dibromochloromethane	124-48-1	0.11	1.0
Methylene Chloride	75-09-2	0.050	5.0
1,1,2,2-Tetrachloroethane	79-34-5	0.14	1.0
Tetrachloroethene	127-18-4	0.051	0.5
1,1,1-Trichloroethane	71-55-6	0.050	0.5
1,1,2-Trichloroethane	79-00-5	0.13	1.0

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TABLE 5-6
DENVER LABORATORY
Method 601 CWA Halogenated Volatile Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Trichloroethene	79-01-6	0.050	0.5
Trichlorofluoromethane	75-69-4	0.086	5.0
Vinyl Chloride	75-01-4	0.050	1.0

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was completed on 10/21/96 for waters.

[3] Reporting Limits are within 1 to 10 times of the MDL.

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TABLE 5-7
DENVER LABORATORY
Method 8010B Halogenated Volatile Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (µg/Kg)
Bromodichloromethane	75-27-4	0.065	7.0	1.0	100
Bromoform	75-25-2	0.14	17	5.0	500
Bromomethane	74-83-9	0.050	7.2	5.0	500
Carbon Tetrachloride	56-23-5	0.050	7.4	0.5	50
Chlorobenzene	108-90-7	0.31	33	2.0	200
Chloroethane	75-00-3	0.091	11	5.0	500
2-Chloroethyl vinyl ether	110-75-8	0.081	6.9	5.0	500
Chloroform	67-66-3	0.081	5.5	0.5	50
Chloromethane	74-87-3	0.050	11	5.0	500
Dibromochloromethane	124-48-1	0.050	12	1.0	100
1,2-Dibromoethane (EDB)	106-93-4	0.10	11	2.0	100
1,2-Dichlorobenzene	95-50-1	0.12	33	2.0	100
1,3-Dichlorobenzene	541-73-1	0.10	22	2.0	100
1,4-Dichlorobenzene	106-46-7	0.11	25	2.0	100
Dichlorodifluoromethane	75-71-8	0.050	26	5.0	500
1,1-Dichloroethane	75-34-3	0.050	5.7	0.5	50
1,2-Dichloroethane	107-06-2	0.051	11	1.0	100
1,1-Dichloroethene	75-35-4	0.050	5.0	0.5	50
trans-1,2-Dichloroethene	156-60-5	0.050	8.8	0.5	50
cis-1,2-Dichloroethene	156-59-2	0.050	6.6	0.5	50
1,2-Dichloropropane	78-87-5	0.058	7.6	1.0	100
cis-1,3-Dichloropropene	10061-01-5	0.072	7.0	2.0	200
trans-1,3-Dichloropropene	10061-02-6	0.10	11	1.0	100
Methylene Chloride	75-09-2	0.050	16	5.0	500
1,1,2,2-Tetrachloroethane	79-34-5	0.14	23	1.0	100
Tetrachloroethene	127-18-4	0.051	7.5	0.5	50

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TABLE 5-7
DENVER LABORATORY
Method 8010A CWA Halogenated Volatile Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (µg/Kg)
1,1,1-Trichloroethane	71-55-6	0.050	7.6	0.5	50
1,1,2-Trichloroethane	79-00-5	0.13	12	1.0	100
Trichloroethene	79-01-6	0.050	6.3	0.5	50
Trichlorofluoromethane	75-69-4	0.086	11	5.0	500
1,1,2-Trichloro-1,2,2-trifluoromethane	76-13-1	0.096	15	5.0	100
Vinyl Chloride	75-01-4	0.050	6.4	1.0	100

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was completed on 10/21/96 for waters and soils.

[3] Reporting Limits are within 1 to 10 times of the MDL.

TABLE 5-8
DENVER LABORATORY
Method 8015(Modified) for Gasoline and Diesel Range Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[4] (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
Gasoline (by purge and trap) API Method	3999176-70-0	4.34	310	10	500
Gasoline (by purge and trap) 8015 Modified	3999176-70-0	3.59	250	25	1250
Diesel (by extraction) API Method	3948788-70-0	58	1040	100	4000
Diesel (by extraction) 8015 Modified	3948788-70-0	54	1040	100	4000

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit studies for gasoline were performed 10/2/96 for both waters and soils. The MDL studies for DRO in water were performed 4/1/97 (API) and 2/27/97 (8015M). For DRO in soil, MDLs were performed 11/17/95 (API) and 11/14/96 (8015M)

[3] Reporting Limits are within 1 to 10 times of the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-9
DENVER LABORATORY
602 CWA Aromatic Volatile Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Benzene	71-43-2	0.079	0.50
Chlorobenzene	108-90-7	0.091	0.50
Ethylbenzene	100-41-4	0.070	0.50
1,2-Dichlorobenzene	95-50-1	0.077	0.50
1,3-Dichlorobenzene	541-73-1	0.13	0.50
1,4-Dichlorobenzene	106-46-7	0.33	0.50
tert-Methyl-butyl ether (MTBE)	1634-04-4	0.27	5.0
Toluene	108-88-3	0.058	0.50
m- & p-Xylene	61-30-0	0.13	0.50
o-Xylene	95-47-6	0.26	0.50
Xylene (total)	1330-20-7	0.35	0.50

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 1/23/97 for waters.

[3] Reporting Limits are within 1 to 10 times of the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-10
DENVER LABORATORY
Method 8020A Aromatic Volatile Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[4] (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
Benzene	71-43-2	0.079	0.50	0.50	5.0
Chlorobenzene	108-90-7	0.091	0.50	0.50	5.0
1,2-Dichlorobenzene	95-50-1	0.077	0.50	0.50	5.0
1,3-Dichlorobenzene	541-73-1	0.13	0.50	0.50	5.0
1,4-Dichlorobenzene	106-46-7	0.33	0.50	0.50	5.0
Ethylbenzene	100-41-4	0.070	0.59	0.50	5.0
tert-Methyl-butyl ether (MTBE)	1634-04-4	0.27	0.79	1.13	5.0
Toluene	108-88-3	0.058	0.90	1.24	5.0
m- & p-Xylene	61-30-0	0.13	1.07	1.0	5.0
o-Xylene	95-47-6	0.26	0.63	0.50	5.0
Xylene (total)	1330-20-7	0.35	1.07	1.5	5.0

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 1/23/97 for waters and 2/28/97 for soils.

[3] Reporting Limits are within 1 to 10 times of the MDL.

[4] Quantitation limits listed for soil are based on a direct purge. The quantitation limits based on dry weight as required, will be higher.

[5] Quantitation limits listed for soil are based on a methanol extraction. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-11
DENVER LABORATORY
CLP Pesticides and PCBs Contract Required Quantitation Limits (CRQL)[1]

Analyte	CAS Number	Water CRQL (µg/L)	Soil CRQL[2] (µg/Kg)
Aldrin	309-00-2	0.05	1.7
a-BHC	319-84-6	0.05	1.7
b-BHC	319-85-7	0.05	1.7
d-BHC	319-86-8	0.05	1.7
g-BHC (Lindane)	58-89-9	0.05	1.7
a-Chlordane	5103-71-9	0.05	1.7
g-Chlordane	5103-74-2	0.05	1.7
4,4'-DDD	72-54-8	0.10	3.3
4,4'-DDE	72-55-9	0.10	3.3
4,4'-DDT	50-29-3	0.10	3.3
Dieldrin	60-57-1	0.10	3.3
Endosulfan I	959-98-8	0.05	1.7
Endosulfan II	33213-65-9	0.10	3.3
Endosulfan sulfate	1031-07-8	0.10	3.3
Endrin	72-20-8	0.10	3.3
Endrin Aldehyde	7421-93-4	0.10	3.3
Endrin Ketone	53494-70-5	0.10	3.3
Heptachlor	76-44-8	0.05	1.7
Heptachlor Epoxide	1024-57-3	0.05	1.7
Methoxychlor	72-43-5	0.50	17.0
Aroclor 1016	12674-11-2	1.0	33.0
Aroclor 1221	11104-28-2	2.0	67.0
Aroclor 1232	11141-16-5	1.0	33.0
Aroclor 1242	53469-21-9	1.0	33.0
Aroclor 1248	12672-29-6	1.0	33.0
Aroclor 1254	11097-69-1	1.0	33.0
Aroclor 1260	11096-82-5	1.0	33.0
Toxaphene	8001-35-2	5.0	170.0

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable

[2] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-12
DENVER LABORATORY
Method 608 CWA Pesticides and PCBs[1]
Method Detection Limit (MDL)[2] and Reporting Limit (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Aldrin	309-00-2	0.023	0.050
a-BHC	319-84-6	0.022	0.050
b-BHC	319-85-7	0.026	0.050
d-BHC	319-86-8	0.022	0.050
g-BHC (Lindane)	58-89-9	0.022	0.050
Chlordane, Technical	57-74-9	0.056	0.50
4,4'-DDD	72-54-8	0.012	0.10
4,4'-DDE	72-55-9	0.021	0.10
4,4'-DDT	50-29-3	0.033	0.10
Dieldrin	60-57-1	0.022	0.10
Endosulfan I	959-98-8	0.025	0.050
Endosulfan II	33213-65-9	0.022	0.10
Endosulfan sulfate	1031-07-8	0.027	0.10
Endrin	72-20-8	0.027	0.10
Endrin Aldehyde	7421-93-4	0.022	0.10
Heptachlor	76-44-8	0.023	0.050
Heptachlor Epoxide	1024-57-3	0.024	0.050
Aroclor 1016	12674-11-2	0.11	1.0
Aroclor 1221	11104-28-2	0.45	2.0
Aroclor 1232	11141-16-5	0.65	1.0
Aroclor 1242	53469-21-9	0.18	1.0
Aroclor 1248	12672-29-6	0.22	1.0
Aroclor 1254	11097-69-1	0.13	1.0
Aroclor 1260	11096-82-5	0.12	1.0
Toxaphene	8001-35-2	0.18	5.0

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on single component pesticides on 1/15/97 for waters. PCBs were performed 2/12/96. Toxaphene was performed on 05/2/96 and technical chlordane was performed on 02/17/96.

[3] Reporting Limits are within 1 to 10 times the MDL.

TABLE 5-13
DENVER LABORATORY
Method 8080 Target Compound List and Appendix IX Pesticides and PCBs[1]
Method Detection Limit (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[4] (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
Aldrin	309-00-2	0.023	0.33	0.050	1.7
a-BHC	319-84-6	0.022	0.41	0.050	1.7
b-BHC	319-85-7	0.026	0.54	0.050	1.7
d-BHC	319-86-8	0.022	0.42	0.050	1.7
g-BHC (Lindane)	58-89-9	0.022	0.43	0.050	1.7
Chlordane (Tech)	57-74-9	0.056	2.5	0.50	17
a-Chlordane	5103-71-9	0.025	0.39	0.050	1.7
g-Chlordane	5103-74-2	0.025	0.36	0.050	1.7
Chlorobenzilate	510-15-6	0.49	5.87	1.0	33
4,4'-DDD	72-54-8	0.012	0.43	0.10	3.3
4,4'-DDE	72-55-9	0.021	0.47	0.10	3.3
4,4'-DDT	50-29-3	0.033	0.37	0.10	3.3
Diallate	2303-16-4	0.42	5.66	1.0	33
Dieldrin	60-57-1	0.022	0.37	0.10	3.3
Endosulfan I	959-98-8	0.025	0.19	0.050	1.7
Endosulfan II	33213-65-9	0.022	0.24	0.10	3.3
Endosulfan sulfate	1031-07-8	0.027	0.43	0.10	3.3
Endrin	72-20-8	0.027	0.60	0.10	3.3
Endrin Aldehyde	7421-93-4	0.022	0.30	0.10	3.3
Endrin ketone	53494-70-5	0.026	0.22	0.10	3.3
Heptachlor	76-44-8	0.023	0.34	0.050	1.7
Heptachlor Epoxide	1024-57-3	0.024	0.38	0.050	1.7
Isodrin	465-73-6	0.036	0.57	0.10	3.3
Kepone	143-50-0	1.11	17.9	2.5	83
Methoxychlor	72-43-5	0.025	0.51	0.50	17
Aroclor 1016	12674-11-2	0.11	3.4	1.0	33
Aroclor 1221	11104-28-2	0.45	17	1.0	33

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TABLE 5-13
DENVER LABORATORY
Method 8080 Target Compound List and Appendix IX Pesticides and PCBs[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[4] (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
Aroclor 1232	11141-16-5	0.65	3.7	1.0	33
Aroclor 1242	53469-21-9	0.18	7.9	1.0	33
Aroclor 1248	12672-29-6	0.22	8.8	1.0	33
Aroclor 1254	11097-69-1	0.13	4.4	1.0	33
Aroclor 1260	11096-82-5	0.12	5.0	1.0	33
Toxaphene	8001-35-2	0.18	29.6	5.0	170

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 1/15/97 for waters, except for Toxaphene performed 05/02/96, PCBs performed 02/12/96, and technical chlordane performed 2/17/96. Appendix IX MDLs for both waters and soils were completed on 3/21/97. Soil MDLs completed 12/14/96 for pesticides, 1/5/96 for toxaphene, 2/28/96 for technical chlordane, and 1/4/96 for PCBs.

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-14
DENVER LABORATORY
Methods 8140/8141A and Appendix IX Pesticides[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[4] (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
Azinphos methyl (Guthion)	86-50-0	0.069	---	2.5	83
Bolstar (Sulprofos)	35400-43-2	0.056	---	0.5	17
Chlorpyrifos (Dursban)	2921-88-2	0.041	---	0.25	8.3
Coumaphos	56-72-4	0.094	---	0.5	17
Demeton, o,s	8065-48-3	0.073	---	0.25	8.3
Diazinon	333-41-5	0.038	---	0.25	8.3
Dichlorvos (Vapona)	62-73-7	0.038	---	0.5	17
Dimethoate	60-51-5	0.063	---	0.5	17
Disulfoton (Disyston)	298-04-4	0.043	---	0.25	8.3
Ethoprop	13194-48-4	0.035	---	0.25	8.3
Ethyl parathion	56-38-2	0.035	---	0.25	8.3
Famphur	52-85-7	0.060	---	1.0	33
Fensulfothion	115-90-2	0.243	---	2.5	83
Fenthion (Baytex)	55-38-9	0.047	---	0.25	8.3
Malathion	121-75-5	0.077	---	1.2	42
Merphos	150-50-5	0.043	---	0.25	8.3
Methyl parathion	298-00-0	0.040	---	0.25	8.3
Mevinphos (Phosdrin)	7786-34-7	0.033	---	6.2	210
Naled (Dibrom)	300-76-5	0.058	---	10	330
o,o,o-Triethylphosphorothioate	126-68-1	0.048	---	0.25	8.3
Phorate (Thimet)	298-02-2	0.059	---	0.25	8.3
Ronnel	299-84-3	0.070	---	0.25	8.3
Sulfotepp	3689-24-5	0.038	---	0.25	8.3
Tetrachlorovinphos (Stirophos)	961-11-5	0.095	---	2.5	83
Thionazin	297-97-2	0.048	---	0.25	8.3
Tokuthion (Prothiophos)	53-10-0	0.050	---	0.25	8.3
Trichloronate	327-98-0	0.040	---	0.25	8.3

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 4/1/96 and 03/6/97 for waters.

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-15
DENVER LABORATORY
Method 8150B Herbicides[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[4] (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
2,4-D	94-75-7	0.53	---	2.0	40
2,4-DB	94-82-6	1.14	---	5.0	100
Dalapon	75-99-0	0.50	---	5.0	100
Dicamba	1918-00-9	0.14	---	0.50	10
Dichloroprop	120-36-5	0.50	---	1.0	20
Dinoseb	88-85-7	0.36	---	1.0	20
MCPA	94-74-6	88	---	250	5000
MCPP	93-65-2	106	---	250	5000
2,4,5-T	93-76-5	0.14	---	0.50	10
2,4,5-TP (Silvex)	93-72-1	0.14	---	0.50	10

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 3/4/97 for waters.

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-16
DENVER LABORATORY
Method 8330 Explosives by HPLC[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[2] (µg/g)	Water RL (µg/L)	Soil RL[2] (µg/g)
2-Amino-4,6-dinitrobenzene	355-72-78-2	0.034	0.037	0.10	0.25
4-Amino-2,6-dinitrotoluene	1946-51-0	0.067	0.045	0.10	0.25
1,3-Dinitrobenzene	99-65-0	0.033	0.033	0.10	0.25
2,4-Dinitrotoluene	121-14-2	0.032	0.058	0.10	0.25
2,6-Dinitrotoluene	606-20-2	0.046	0.077	0.25	0.25
Ethylene glycol dinitrate	628-96-6	0.313	0.53	2.5	5.0
HMX	2691-41-0	0.024	0.050	0.25	0.25
Nitrobenzene	98-95-3	0.025	0.062	0.25	0.25
Nitroglycerin	55-63-0	0.599	0.70	2.5	5.0
2-Nitrotoluene	88-72-2	0.057	0.084	0.25	0.25
3-Nitrotoluene	99-08-1	0.058	0.082	0.25	0.25
4-Nitrotoluene	99-99-0	0.038	0.059	0.25	0.25
RDX	121-82-4	0.042	0.12	0.25	0.25
Tetryl	479-45-8	0.043	0.054	0.50	0.50
1,3,5-Trinitrobenzene	99-35-4	0.021	0.026	0.25	0.25
2,4,6-Trinitrotoluene	118-96-7	0.043	0.054	0.10	0.25

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 12/30/96 for waters and 2/17/97 for soils, except ethylene glycol dinitrate and nitroglycerin.

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-17
DENVER LABORATORY
Method 8310 Polynuclear Aromatic Hydrocarbons[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[2] (µg/Kg)	Water RL (µg/L)	Soil RL[2] (µg/Kg)
Acenaphthene	83-32-9	0.93	57.3	1.0	200
Acenaphthylene	208-96-8	0.040	95.6	1.0	200
Anthracene	120-12-7	0.030	10.4	0.10	20
Benzo(a)anthracene	56-55-3	0.060	4.43	0.10	20
Benzo(a)pyrene	50-32-8	0.065	5.26	0.10	20
Benzo(b)fluoranthene	205-99-2	0.059	3.46	0.10	20
Benzo(g,h,i)perylene	191-24-2	0.071	2.80	0.20	40
Benzo(k)fluoranthene	207-08-9	0.059	4.04	0.10	20
Chrysene	218-01-9	0.073	4.18	0.20	40
Dibenzo(a,h)anthracene	53-70-3	0.076	3.53	0.20	40
Fluoranthene	206-44-0	0.036	7.52	0.20	40
Fluorene	86-73-7	0.035	12.9	0.20	40
Indeno(1,2,3-cd)pyrene	193-39-5	0.055	2.16	0.20	40
1-Methylnaphthalene	90-12-0	0.058	68.7	1.0	200
2-Methylnaphthalene	91-57-6	0.043	55.6	1.0	200
Naphthalene	91-20-3	0.059	132	1.0	200
Phenanthrene	85-01-8	0.030	6.00	0.20	40
Pyrene	129-00-0	0.043	8.07	0.20	40

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 12/30/96 for waters and 04/17/96 for soils

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-18
DENVER LABORATORY
Method 8315 Formaldehyde by HPLC[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[2](µg/Kg)	Water RL (µg/L)	Soil RL[2] (µg/Kg)
Formaldehyde	50-00-0	1.79	---	5.0	40

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 05/01/96 for waters.

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

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TABLE 5-19
DENVER LABORATORY
Method 524.2 Purgeable Organic Compounds in Water by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Benzene	71-43-2	0.22	1.0
Bromobenzene	108-86-1	0.20	1.0
Bromochloromethane	74-97-5	0.28	1.0
Bromodichloromethane	124-48-1	0.27	1.0
Bromoform	75-25-2	0.23	1.0
Bromomethane	74-83-9	0.18	1.0
n-Butylbenzene	104-51-8	0.19	1.0
sec-Butylbenzene	135-98-8	0.20	1.0
tert-Butylbenzene	98-06-6	0.13	1.0
Carbon Tetrachloride	56-23-5	0.24	1.0
Chlorobenzene	108-90-7	0.20	1.0
Chloroethane	75-00-3	0.47	1.0
Chloroform	67-66-3	0.13	1.0
Chloromethane	74-87-3	0.21	1.0
2-Chlorotoluene	95-49-8	0.23	1.0
4-Chlorotoluene	106-43-4	0.29	1.0
Dibromochloromethane	75-27-4	0.26	1.0
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	0.71	2.0
1,2-Dibromoethane (EDB)	106-93-4	0.21	1.0
Dibromomethane	74-95-3	0.25	1.0
1,2-Dichlorobenzene	95-50-1	0.24	1.0
1,3-Dichlorobenzene	541-73-1	0.10	1.0
1,4-Dichlorobenzene	106-46-7	0.17	1.0
Dichlorodifluoromethane	75-71-8	0.33	1.0
1,1-Dichloroethane	75-34-3	0.24	1.0
cis-1,2-Dichloroethene	156-59-2	0.25	1.0
trans-1,2-Dichloroethene	156-60-5	0.24	1.0

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TABLE 5-19
DENVER LABORATORY
Method 524.2 Purgeable Organic Compounds in Water by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
1,2-Dichloroethane	107-06-2	0.29	1.0
1,1-Dichloroethene	75-35-4	0.22	1.0
1,2-Dichloropropane	78-87-5	0.15	1.0
1,3-Dichloropropane	142-28-9	0.49	1.0
2,2-Dichloropropane	594-20-7	0.29	1.0
1,1-Dichloropropene	563-58-6	0.21	1.0
cis-1,3-Dichloropropene	10061-01-5	0.20	1.0
trans-1,3-Dichloropropene	10061-02-6	0.43	1.0
Ethylbenzene	100-41-4	0.24	1.0
Hexachlorobutadiene	87-68-3	0.20	1.0
Isopropylbenzene	98-82-8	0.13	1.0
4-Isopropyltoluene	99-87-6	0.16	1.0
Methylene Chloride	75-09-2	0.29	1.0
Naphthalene	91-20-3	0.18	1.0
n-Propylbenzene	103-65-1	0.19	1.0
Styrene	100-42-5	0.10	1.0
1,1,1,2-Tetrachloroethane	630-20-6	0.26	1.0
1,1,2,2-Tetrachloroethane	79-34-5	0.42	1.0
Tetrachloroethene	127-18-4	0.13	1.0
Toluene	108-88-3	0.19	1.0
1,2,3-Trichlorobenzene	87-61-6	0.60	1.0
1,2,4-Trichlorobenzene	120-82-1	0.32	1.0
1,1,1-Trichloroethane	71-55-6	0.21	1.0
1,1,2-Trichloroethane	79-00-5	0.44	1.0
Trichloroethene	79-01-6	0.19	1.0
Trichlorofluoromethane	75-69-4	0.39	1.0
1,2,3-Trichloropropane	96-18-4	0.79	1.0

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TABLE 5-19
DENVER LABORATORY
Method 524.2 Purgeable Organic Compounds in Water by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
1,2,4-Trimethylbenzene	95-63-6	0.13	1.0
1,3,5-Trimethylbenzene	108-67-8	0.15	1.0
Vinyl Chloride	75-01-4	0.18	1.0
m&p-Xylenes	61-30-0	0.34	1.0
o-Xylene	95-47-6	0.29	1.0

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Footnotes

1 Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

2 The Method Detection Limit study was performed on 11/17/95.

3 Reporting Limits are within 1 to 10 times the MDL.

TABLE 5-20
DENVER LABORATORY
Method 8240B Target Compound List, Appendix IX, and F039 for Volatile Organics[1] Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (µg/Kg)
Acetone	67-64-1	2.15	3.78	20	20
Acetonitrile	75-05-8	12.9	32.7	100	100
Acrolein	107-02-8	9.58	3.54	100	100
Acrylonitrile	107-13-1	7.24	16.7	100	100
Allyl Chloride (3-Chloroprene)	107-05-1	2.33	0.71	10	10
Benzene	71-43-2	1.21	1.10	5.0	5.0
Bromodichloromethane	75-27-4	1.15	1.13	5.0	5.0
Bromoform	75-25-2	1.24	1.28	5.0	5.0
Bromomethane	74-83-9	1.10	2.32	10	10
2-Butanone	78-93-3	2.43	6.03	20	20
Carbon Disulfide	75-15-0	1.35	1.52	5.0	5.0
Carbon Tetrachloride	56-23-5	1.21	1.45	5.0	5.0
Chlorobenzene	108-90-7	1.16	1.24	5.0	5.0
Chloroprene (2-Chloro-1,3-butadiene)	126-99-8	0.57	0.50	5.0	5.0
Chloroethane	75-00-3	2.95	0.52	10	10
2-Chloroethylvinyl ether	110-75-8	3.01	7.68	---	50
Chloroform	67-66-3	1.22	1.10	5.0	5.0
Chloromethane	74-87-3	1.45	0.56	10	10
Cyclohexanone	108-94-1	42.3	25.0	250	250
Dibromochloromethane	124-48-1	1.20	1.11	5.0	5.0
1,2-Dibromoethane (EDB)	106-93-4	3.33	1.16	5.0	5.0
Dibromomethane	74-95-3	1.85	1.13	5.0	5.0
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	7.66	9.87	10	10
1,2-Dichlorobenzene	95-50-1	1.35	1.28	5.0	5.0
1,3-Dichlorobenzene	541-73-1	1.20	1.14	5.0	5.0
1,4-Dichlorobenzene	106-46-7	1.34	1.50	5.0	5.0

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TABLE 5-20
DENVER LABORATORY
Method 8240B Target Compound List, Appendix IX, and F039 for Volatile Organics[1] Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (µg/Kg)
trans-1,4-Dichloro-2-butene	110-57-6	1.42	1.95	5.0	5.0
Dichlorodifluoromethane	75-71-8	1.57	0.72	10	10
1,1-Dichloroethane	75-34-3	1.30	1.15	5.0	5.0
1,2-Dichloroethane	107-06-2	1.12	0.92	5.0	5.0
1,1-Dichloroethene	75-35-4	1.37	1.58	5.0	5.0
cis-1,2-Dichloroethene	156-59-2	1.32	1.25	2.5	2.5
trans-1,2-Dichloroethene	156-60-5	1.44	1.37	2.5	2.5
1,2-Dichloroethene (total)	540-59-0	3.03	2.60	5.0	5.0
1,2-Dichloropropane	78-87-5	1.23	1.21	5.0	5.0
cis-1,3-Dichloropropene	10061-01-5	1.30	1.14	5.0	5.0
trans-1,3-Dichloropropene	10061-02-6	1.27	1.10	5.0	5.0
1,4-Dioxane	123-91-1	85.57	90.3	500	500
Ethanol (Ethyl alcohol)	64-17-5	69.1	46.7	500	500
Ethyl Acetate	141-78-6	2.62	3.17	10	10
Ethylbenzene	100-41-4	1.17	1.36	5.0	5.0
Ethyl Ether	60-29-7	1.72	0.50	10	10
Ethyl Methacrylate	97-63-2	2.97	1.46	20	20
Hexane	110-54-3	2.73	1.89	5	5
2-Hexanone	591-78-6	2.16	4.02	20	20
Iodomethane	74-88-4	2.73	1.24	5.0	5.0
Isobutyl Alcohol	78-83-1	34.38	33.7	200	200
Methacrylonitrile	126-98-7	2.06	1.37	5.0	5.0
Methylene Chloride	75-09-2	1.23	1.10	5.0	5.0
Methyl Methacrylate	80-62-6	1.99	1.15	5	5
4-Methyl-2-Pentanone	108-10-1	1.73	1.47	20	20
Methyl-tert-butyl ether	1634-04-4	1.91	1.05	20	20
Propionitrile	107-12-0	18.2	3.74	20	20

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TABLE 5-20
DENVER LABORATORY
Method 8240B Target Compound List, Appendix IX, and F039 for Volatile Organics[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (µg/Kg)
Styrene	100-42-5	1.14	1.25	5.0	5.0
1,1,1,2-Tetrachloroethane	630-20-6	1.00	0.50	5.0	5.0
1,1,2,2-Tetrachloroethane	79-34-5	1.18	1.66	5.0	5.0
Tetrachloroethene	127-18-4	1.21	1.44	5.0	5.0
Tetrahydrofuran	109-99-9	2.55	1.88	20	20
Toluene	108-88-3	1.15	1.23	5.0	5.0
1,1,1-Trichloroethane	71-55-6	1.20	1.30	5.0	5.0
1,1,2-Trichloroethane	79-00-5	1.22	1.02	5.0	5.0
Trichloroethene	79-01-6	1.25	1.12	5.0	5.0
Trichlorofluoromethane	75-69-4	1.85	0.96	10	10
1,2,3-Trichloropropane	96-18-4	1.56	1.73	5.0	5.0
1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	1.82	1.58	20	20
Vinyl Acetate	108-05-4	2.01	1.83	10	10
Vinyl Chloride	75-01-4	1.64	0.56	10	10
m&p-Xylenes	61-30-0	2.87	1.37	2.5	2.5
o-Xylene	95-47-6	1.19	0.96	2.5	2.5
Xylenes (total)	1330-20-7	4.21	2.36	5.0	5.0

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 9/8/95 and 3/6/97 for waters and 2/25/97 for soils.

[3] Reporting Limits are within 1 to 10 times the MDL.

TABLE 5-21
DENVER LABORATORY
Method 624 CWA Volatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Acrolein	107-02-8	9.20	100
Acrylonitrile	107-13-1	5.10	100
Benzene	71-43-2	0.54	5.0
Bromodichloromethane	75-27-4	0.51	5.0
Bromoform	75-25-2	0.53	5.0
Bromomethane	74-83-9	4.16	10
Carbon tetrachloride	56-23-5	0.76	5.0
Chlorobenzene	108-90-7	1.87	5.0
Chloroethane	75-00-3	2.61	10
2-Chloroethylvinyl ether	110-75-8	1.03	--
Chloroform	67-66-3	0.51	5.0
Chloromethane	74-87-3	1.31	10
Dibromochloromethane	124-48-1	0.75	5.0
1,2-Dichlorobenzene	95-50-1	0.63	5.0
1,3-Dichlorobenzene	541-73-1	1.60	5.0
1,4-Dichlorobenzene	106-46-7	0.73	5.0
1,1-Dichloroethane	75-34-3	0.91	5.0
1,2-Dichloroethane	107-06-2	0.84	5.0
1,1-Dichloroethene	75-35-4	1.88	5.0
trans-1,2-Dichloroethene	156-60-5	0.50	5.0
1,2-Dichloropropane	78-87-5	0.56	5.0
cis-1,3-Dichloropropene	10061-01-5	0.59	5.0
trans-1,3-Dichloropropene	10061-02-6	0.58	5.0
Ethylbenzene	100-41-4	2.27	5.0
Methylene Chloride	75-09-2	0.72	5.0
1,1,2,2-Tetrachloroethane	79-34-5	0.50	5.0
Tetrachloroethene	127-18-4	0.72	5.0

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TABLE 5-21
DENVER LABORATORY
Method 624 CWA Volatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Toluene	108-88-3	1.51	5.0
1,1,1-Trichloroethane	71-55-6	2.08	5.0
1,1,2-Trichloroethane	79-00-5	0.90	5.0
Trichloroethene	79-01-6	0.77	5.0
Trichlorofluoromethane	75-69-4	0.77	10
Vinyl Chloride	75-01-4	0.97	10

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 02/29/96 for waters.

[3] Reporting Limits are within 1 to 10 times the MDL.

TABLE 5-22
DENVER LABORATORY
CLP Volatile Organics by GC/MS[1]
Contract Required Quantitation Limits (CRQL)

Analyte	CAS Number	Water CRQL (µg/L)	Soil CRQL[2] (µg/L)
Acetone	67-64-1	10	10
Benzene	71-43-2	10	10
Bromodichloromethane	75-27-4	10	10
Bromoform	75-25-2	10	10
Bromomethane	74-83-9	10	10
2-Butanone	78-93-3	10	10
Carbon Disulfide	75-15-0	10	10
Carbon Tetrachloride	56-23-5	10	10
Chlorobenzene	108-90-7	10	10
Chloroethane	75-00-3	10	10
Chloroform	67-66-3	10	10
Chloromethane	74-87-3	10	10
Dibromochloromethane	124-48-1	10	10
1,2-Dichloroethene (Total)	540-59-0	10	10
1,1-Dichloroethane	75-34-3	10	10
1,2-Dichloroethane	107-06-2	10	10
1,1-Dichloroethene	75-35-4	10	10
1,2-Dichloropropane	78-87-5	10	10
cis-1,3-Dichloropropene	10061-01-5	10	10
trans-1,3-Dichloropropene	10061-02-6	10	10
Ethylbenzene	100-41-4	10	10
2-Hexanone	591-78-6	10	10
Methylene Chloride	75-09-2	10	10
4-Methyl-2-Pentanone	108-10-1	10	10
Styrene	100-42-5	10	10
1,1,2,2-Tetrachloroethane	79-34-5	10	10
Tetrachloroethene	127-18-4	10	10

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TABLE 5-22
DENVER LABORATORY
CLP Volatile Organics by GC/MS[1]
Contract Required Quantitation Limits (CRQL)
(Continued)

Analyte	CAS Number	Water CRQL (µg/L)	Soil CRQL[2] (µg/L)
Toluene	108-88-3	10	10
1,1,1-Trichloroethane	71-55-6	10	10
1,1,2-Trichloroethane	79-00-5	10	10
Trichloroethene	79-01-6	10	10
Vinyl Chloride	75-01-4	10	10
Xylene (total)	1330-20-7	10	10

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-23
DENVER LABORATORY
Method 8260A Volatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
Acetone	67-64-1	3.78	3.78	10	20
Acrylonitrile	107-13-1	7.23	32.7	20	100
Benzene	71-43-2	0.12	1.10	1.0	5.0
Bromobenzene	108-86-1	0.20	1.24	1.0	5.0
Bromochloromethane	74-97-5	0.28	0.75	1.0	5.0
Bromodichloromethane	75-27-4	0.20	1.13	1.0	5.0
Bromoform	75-25-2	0.55	1.28	1.0	5.0
Bromomethane	74-83-9	0.11	2.32	2.0	10
2-Butanone (MEK)	78-93-3	0.70	6.03	5.0	20
n-Butylbenzene	104-51-8	0.19	2.55	1.0	5.0
sec-Butylbenzene	135-98-8	0.20	2.11	1.0	5.0
tert-Butylbenzene	98-06-6	0.13	1.70	1.0	5.0
Carbon disulfide	75-15-0	0.17	1.52	1.0	5.0
Carbon tetrachloride	56-23-5	0.12	1.45	1.0	5.0
Chlorobenzene	108-90-7	0.18	1.24	1.0	5.0
Chlorodibromomethane	124-48-1	0.37	1.11	1.0	5.0
Chloroethane	75-00-3	0.10	0.52	2.0	10
2-Chloroethyl vinyl ether	110-75-8	1.20	7.68	---	50
Chloroform	67-66-3	0.10	1.10	1.0	5.0
Chloromethane	74-87-3	0.10	0.56	2.0	10
2-Chlorotoluene	95-49-8	0.23	1.30	1.0	5.0
4-Chlorotoluene	106-43-4	0.29	0.84	1.0	5.0
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	0.71	9.87	2.0	10
1,2-Dibromoethane (EDB)	106-93-4	0.29	1.16	1.0	5.0
Dibromomethane	74-95-3	0.25	1.13	1.0	5.0
1,2-Dichlorobenzene	95-50-1	0.36	1.28	1.0	5.0

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TABLE 5-23
DENVER LABORATORY
Method 8260A Volatile Organics by GC/MS[1]
Method Detection Limit (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
1,3-Dichlorobenzene	541-73-1	0.31	1.14	1.0	5.0
1,4-Dichlorobenzene	106-46-7	0.28	1.50	1.0	5.0
Dichlorodifluoromethane	75-71-8	0.11	0.72	2.0	10
1,1-Dichloroethane	75-34-3	0.11	1.15	1.0	5.0
1,2-Dichloroethane	107-06-2	0.10	0.92	1.0	5.0
1,1-Dichloroethene	75-35-4	0.14	1.58	1.0	5.0
cis-1,2-Dichloroethene	156-59-2	0.10	1.25	0.5	2.5
trans-1,2-Dichloroethene	156-60-5	0.15	1.37	0.5	2.5
1,2-Dichloroethene (total)	540-59-0	0.23	2.60	1.0	5.0
1,2-Dichloropropane	78-87-5	0.20	1.21	1.0	5.0
1,3-Dichloropropane	142-28-9	0.49	1.08	1.0	5.0
2,2-Dichloropropane	594-20-7	0.29	1.16	1.0	5.0
1,1-Dichloropropene	563-58-6	0.21	1.98	1.0	5.0
cis-1,3-Dichloropropene	10061-01-5	0.18	1.14	1.0	5.0
trans-1,3-Dichloropropene	10061-02-6	0.25	1.10	1.0	5.0
Ethylbenzene	100-41-4	0.10	1.36	1.0	5.0
Hexachlorobutadiene	87-68-3	0.20	2.57	1.0	5.0
Hexane	110-54-3	0.19	1.89	1.0	5.0
2-Hexanone	591-78-6	0.63	4.02	5.0	20
Iodomethane	74-88-4	0.12	1.24	1.0	5.0
Isopropylbenzene (Cumene)	98-82-8	0.13	0.50	1.0	5.0
p-Isopropyltoluene	99-87-6	0.16	1.87	1.0	5.0
Methylene Chloride	75-09-2	0.10	1.10	1.0	5.0
4-Methyl-2-Pentanone	108-10-1	0.52	1.47	5.0	20
Methyl-tert-butyl ether (MTBE)	1634-04-4	0.13	1.05	5.0	20
Naphthalene	91-20-3	0.50	2.05	1.0	5.0

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TABLE 5-23
DENVER LABORATORY
Method 8260A Volatile Organics by GC/MS[1]
Method Detection Limit (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
n-Propylbenzene	103-65-1	0.19	1.99	1.0	5.0
Styrene	100-42-5	0.21	1.25	1.0	5.0
1,1,1,2-Tetrachloroethane	630-20-6	0.26	0.50	1.0	5.0
1,1,2,2-Tetrachloroethane	79-34-5	0.72	1.66	1.0	5.0
Tetrachloroethene	127-18-4	0.11	1.44	1.0	5.0
Tetrahydrofuran	109-99-9	1.03	1.88	5.0	20
Toluene	108-88-3	0.11	1.23	1.0	5.0
1,2,3-Trichlorobenzene	87-61-6	0.60	1.53	1.0	5.0
1,2,4-Trichlorobenzene	120-82-1	0.32	1.67	1.0	5.0
1,1,1-Trichloroethane	71-55-6	0.13	1.30	1.0	5.0
1,1,2-Trichloroethane	79-00-5	0.37	1.02	1.0	5.0
Trichloroethene	79-01-6	0.10	1.12	1.0	5.0
Trichlorofluoromethane	75-69-4	0.19	0.96	2.0	10
1,2,3-Trichloropropane	96-18-4	0.58	1.73	1.0	5.0
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	0.14	1.58	1.0	5.0
1,2,4-Trimethylbenzene	95-63-6	0.13	1.63	1.0	5.0
1,3,5-Trimethylbenzene	108-67-8	0.15	1.55	1.0	5.0
Vinyl Acetate	108-05-4	0.68	1.83	2.0	10
Vinyl Chloride	75-01-4	0.14	0.56	2.0	10
m- & p-Xylenes	5113-90-0	0.25	1.37	0.50	2.5
o-Xylene	95-47-6	0.18	0.96	0.50	2.5
Xylenes (total)	1330-20-7	0.47	2.36	1.0	5.0

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TABLE 5-23
DENVER LABORATORY
Method 8260A Volatile Organics by GC/MS[1]
Method Detection Limit (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit studies for waters were performed on 11/21/96 and 3/11/97. Soil MDLs were performed on 8/30/95 and 2/25/97.

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

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TABLE 5-24
DENVER LABORATORY
CLP Semivolatile Organics by GC/MS[1] with Contract Required Quantitation Limits (CRQL)

Analyte	CAS Number	Water CRQL (µg/L)	Soil CRQL[2] (µg/Kg)
Acenaphthene	83-32-9	10	330
Acenaphthylene	208-96-8	10	330
Anthracene	120-12-7	10	330
Benzo(a)anthracene	56-55-3	10	330
Benzo(b)fluoranthene	205-99-2	10	330
Benzo(k)fluoranthene	207-08-9	10	330
Benzo(g,h,i)perylene	191-24-2	10	330
Benzo(a)pyrene	50-32-8	10	330
4-Bromophenyl-phenylether	101-55-3	10	330
Butyl benzyl phthalate	85-68-7	10	330
Carbazole	86-74-8	10	330
4-Chloroaniline	106-47-8	10	330
bis(2-Chloroethoxy)methane	111-91-1	10	330
bis(2-Chloroethyl)ether	111-44-4	10	330
bis(2-Chloroisopropyl)ether	108-60-1	10	330
4-Chloro-3-methylphenol	59-50-7	10	330
2-Chloronaphthalene	91-58-7	10	330
2-Chlorophenol	95-57-8	10	330
4-Chlorophenyl-phenylether	7005-72-3	10	330
Chrysene	218-01-9	10	330
Dibenzo(a,h)anthracene	53-70-3	10	330
Dibenzofuran	132-64-9	10	330
Di-n-butylphthalate	84-74-2	10	330
1,2-Dichlorobenzene	95-50-1	10	330
1,3-Dichlorobenzene	541-73-1	10	330
1,4-Dichlorobenzene	106-46-7	10	330
3,3'-Dichlorobenzidine	91-94-1	10	330

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TABLE 5-24
DENVER LABORATORY
CLP Semivolatile Organics by GC/MS[1] with Contract Required Quantitation Limits (CRQL)
(Continued)

Analyte	CAS Number	Water CRQL (µg/L)	Soil CRQL[2] (µg/Kg)
2,4-Dichlorophenol	120-83-2	10	330
Diethylphthalate	84-66-2	10	330
2,4-Dimethylphenol	105-67-9	10	330
Dimethyl phthalate	131-11-3	10	330
4,6-Dinitro-2-methylphenol	534-52-1	25	800
2,4-Dinitrophenol	51-28-5	25	800
2,4-Dinitrotoluene	121-14-2	10	330
2,6-Dinitrotoluene	606-20-2	10	330
Di-n-octylphthalate	117-84-0	10	330
bis(2-Ethylhexyl) phthalate	117-81-7	10	330
Fluoranthene	206-44-0	10	330
Fluorene	86-73-7	10	330
Hexachlorobenzene	118-74-1	10	330
Hexachlorobutadiene	87-68-3	10	330
Hexachlorocyclopentadiene	77-47-4	10	330
Hexachloroethane	67-72-1	10	330
Indeno(1,2,3-cd)pyrene	193-39-5	10	330
Isophorone	78-59-1	10	330
2-Methylnaphthalene	91-57-6	10	330
2-Methylphenol	95-48-7	10	330
4-Methylphenol	106-44-5	10	330
Naphthalene	91-20-3	10	330
2-Nitroaniline	88-74-4	25	800
3-Nitroaniline	99-09-2	25	800
4-Nitroaniline	100-01-6	25	800
Nitrobenzene	98-95-3	10	330
2-Nitrophenol	88-75-5	10	330

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TABLE 5-24
DENVER LABORATORY
CLP Semivolatile Organics by GC/MS[1] with Contract Required Quantitation Limits (CRQL)
(Continued)

Analyte	CAS Number	Water CRQL (µg/L)	Soil CRQL[2] (µg/Kg)
4-Nitrophenol	100-02-7	25	800
N-Nitrosodiphenylamine	86-30-6	10	330
N-Nitroso-di-n-propylamine	621-64-7	10	330
Pentachlorophenol	87-86-5	25	800
Phenanthrene	85-01-8	10	330
Phenol	108-95-2	10	330
Pyrene	129-00-0	10	330
1,2,4-Trichlorobenzene	120-82-1	10	330
2,4,5-Tricholorphenol	95-95-4	25	800
2,4,6-Trichlorophenol	88-06-2	10	330

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

TABLE 5-25
DENVER LABORATORY
Method 625 CWA Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Acenaphthene	83-32-9	1.36	10
Acenaphthylene	208-96-8	1.37	10
Anthracene	120-12-7	1.00	10
Benzidene	92-87-5	22.2	100
Benzo(a)anthracene	56-55-3	1.00	10
Benzo(b)fluoranthene	205-99-2	3.44	10
Benzo(k)fluoranthene	207-08-9	2.61	10
Benzo(g,h,i)perylene	191-24-2	1.38	10
Benzo(a)pyrene	50-32-8	1.42	10
4-Bromophenyl-phenylether	101-55-3	1.00	10
Butyl benzyl phthalate	85-68-7	1.00	10
bis(2-Chloroethoxy)methane	111-91-1	2.11	10
bis(2-Chloroethyl) ether	111-44-4	1.30	10
bis(2-Chloroisopropyl) ether	108-60-1	1.00	10
4-Chloro-3-methylphenol	59-50-7	1.00	10
2-Chloronaphthalene	91-58-7	1.47	10
2-Chlorophenol	95-57-8	1.22	10
4-Chlorophenylphenylether	7005-72-3	1.28	10
Chrysene	218-01-9	1.87	10
Dibenzo(a,h)anthracene	53-70-3	1.00	10
Di-n-butylphthalate	84-74-2	1.00	10
1,2-Dichlorobenzene	95-50-1	1.36	10
1,3-Dichlorobenzene	541-73-1	1.11	10
1,4-Dichlorobenzene	106-46-7	1.51	10
3,3'-Dichlorobenzidine	91-94-1	7.51	20
2,4-Dichlorophenol	120-83-2	1.18	10
Diethylphthalate	84-66-2	1.00	10

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TABLE 5-25
DENVER LABORATORY
Method 625 CWA Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
2,4-Dimethylphenol	105-67-9	1.52	10
Dimethylphthalate	131-11-3	1.00	10
4,6-Dinitro-2-methylphenol	534-52-1	11.2	50
2,4-Dinitrophenol	51-28-5	18.1	50
2,4-Dinitrotoluene	121-14-2	1.00	10
2,6-Dinitrotoluene	606-20-2	1.00	10
Di-n-octylphthalate	117-84-0	1.41	10
1,2-Diphenylhydrazine	122-66-7	1.00	10
bis(2-Ethylhexyl) phthalate	117-81-7	1.00	10
Fluoranthene	206-44-0	1.75	10
Fluorene	86-73-7	1.16	10
Hexachlorobenzene	118-74-1	1.00	10
Hexachlorobutadiene	87-68-3	1.90	10
Hexachlorocyclopentadiene	77-47-4	5.38	--
Hexachloroethane	67-72-1	1.00	10
Indeno(1,2,3-cd)pyrene	193-39-5	1.27	10
Isophorone	78-59-1	1.67	10
Naphthalene	91-20-3	2.11	10
Nitrobenzene	98-95-3	1.50	10
2-Nitrophenol	88-75-5	1.09	10
4-Nitrophenol	100-02-7	8.91	50
N-Nitrosodimethylamine	62-75-9	1.00	10
N-Nitroso-di-n-propylamine	621-64-7	1.32	10
N-Nitrosodiphenylamine	86-30-6	1.00	10
Pentachlorophenol	87-86-5	11.0	50
Phenanthrene	85-01-8	1.00	10
Phenol	108-95-2	1.00	10

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TABLE 5-25
DENVER LABORATORY
Method 625 CWA Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Pyrene	129-00-0	1.00	10
1,2,4-Trichlorobenzene	120-82-1	1.96	10
2,4,6-Trichlorophenol	88-06-2	1.41	10

Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 04/08/96.

[3] Reporting Limits are within 1 to 10 times the MDL.

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TABLE 5-26
DENVER LABORATORY
Method 8270B Target Compound List, Appendix IX, and F039 for Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL[4] (µg/kg)
Acenaphthene	83-32-9	1.0	174	10	330
Acenaphthylene	208-96-8	1.2	181	10	330
Acetophenone	98-86-2	1.0	36	10	330
2-Acetylaminofluorene	53-96-3	1.0	41	100	3300
4-Aminobiphenyl	92-67-1	1.0	42	50	1600
Aniline	62-53-3	5.1	60	10	330
Anthracene	120-12-7	1.1	177	10	330
Aramite	140-57-8	1.0	30	20	660
Azobenzene	103-33-3	1.0	178	10	330
Benzenethiol	108-98-5	29	---	100	3300
Benzidine	92-87-5	43	---	100	3300
Benzo(a)anthracene	56-55-3	1.0	165	10	330
Benzo(b)fluoranthene	205-99-2	1.2	127	10	330
Benzo(j)fluoranthene	205-82-3	1.1	---	10	330
Benzo(k)fluoranthene	207-08-9	1.2	222	10	330
Benzoic acid	65-85-0	22	885	50	1600
Benzo(g,h,i)perylene	191-24-2	1.6	144	10	330
Benzo(a)pyrene	50-32-8	1.4	153	10	330
Benzyl alcohol	100-51-6	1.2	150	10	330
4-Bromophenyl-phenylether	101-55-3	1.0	170	10	330
Butyl benzyl phthalate	85-68-7	1.0	151	10	330
2-sec-Butyl 4,6-dinitrophenol Dinoseb	88-85-7	1.0	30	20	660
Carbazole	86-74-8	1.0	158	10	330
4-Chloroaniline	106-47-8	1.9	77	10	330
bis(2-Chloroethoxy)methane	111-91-1	1.1	241	10	330
bis(2-Chloroethyl) ether	111-44-4	1.1	160	10	330

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TABLE 5-26
DENVER LABORATORY
Method 8270B Target Compound List, Appendix IX, and F039 for Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL[4] (µg/kg)
bis(2-Chloroisopropyl) ether 2,2'-oxybis(1-Chloropropane)	108-60-1	1.1	210	10	330
Chlorobenzilate	510-15-6	1.0	---	10	330
4-Chloro-3-methylphenol	59-50-7	1.4	157	10	330
1-Chloronaphthalene	90-13-1	1.0	30	50	2500
2-Chloronaphthalene	91-58-7	1.2	170	10	330
2-Chlorophenol	95-57-8	1.1	166	10	330
4-Chlorophenyl-phenylether	7005-72-3	1.6	176	10	330
Chrysene	218-01-9	1.2	173	10	330
Diallate	2303-16-4	2.0	---	20	660
Dibenz(a,j)acridine	224-42-0	1.0	30	20	660
Dibenzo(a,h)anthracene	53-70-3	1.6	128	10	330
Dibenzofuran	132-64-9	1.2	179	10	330
Di-n-butylphthalate	84-74-2	1.0	151	10	330
1,2-Dichlorobenzene	95-50-1	1.3	158	10	330
1,3-Dichlorobenzene	541-73-1	1.3	154	10	330
1,4-Dichlorobenzene	106-46-7	1.5	158	10	330
3,3'-Dichlorobenzidine	91-94-1	1.6	225	50	1600
2,4-Dichlorophenol	120-83-2	1.4	153	10	330
2,6-Dichlorophenol	87-65-0	1.0	34	10	330
Diethylphthalate	84-66-2	1.0	182	10	330
Dimethoate	60-51-5	1.0	30	20	660
4-Dimethylaminoazobenzene	60-11-7	1.1	30	20	660
7,12-Dimethylbenz(a)anthracene	57-97-6	1.0	146	20	660
3,3-Dimethylbenzidine	95-53-4	3.5	103	20	660
a,a-Dimethylphenethylamine	122-09-8	19	30	50	1600

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TABLE 5-26
DENVER LABORATORY
Method 8270B Target Compound List, Appendix IX, and F039 for Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL[4] (µg/kg)
2,4-Dimethylphenol	105-67-9	1.6	198	10	330
Dimethyl phthalate	131-11-3	1.0	183	10	330
1,3-Dinitrobenzene	99-65-0	1.0	31	10	330
1,4-Dinitrobenzene	100-25-4	1.0	30	10	330
4,6-Dinitro-2-methylphenol (4,6-Dinitro-o-cresol)	534-52-1	1.0	921	50	1600
2,4-Dinitrophenol	51-28-5	1.3	904	50	1600
2,4-Dinitrotoluene	121-14-2	1.0	131	10	330
2,6-Dinitrotoluene	606-20-2	1.0	154	10	330
Di-n-octylphthalate	117-84-0	1.4	152	10	330
Diphenylamine	12-39-4	1.2	43	10	330
1,2-Diphenylhydrazine	122-66-7	1.0	56	10	330
Disulfoton	298-04-4	1.4	30	50	1600
bis(2-Ethylhexyl) phthalate	117-81-7	1.3	170	10	330
Ethyl methanesulfonate	62-50-0	1.0	39	10	330
Famphur	52-85-7	---	---	---	---
Fluoranthene	206-44-0	1.1	175	10	330
Fluorene	86-73-7	1.6	201	10	330
Hexachlorobenzene	118-74-1	1.0	166	10	330
Hexachlorobutadiene	87-68-3	1.6	158	10	330
Hexachlorocyclopentadiene	77-47-4	2.3	107	50	1600
Hexachloroethane	67-72-1	1.5	147	10	330
Hexachlorophene	70-30-4	---	---	--	--
Hexachloropropene	1888-71-7	1.0	33	100	3300
Indene	95-13-6	---	213	10	330
Indeno(1,2,3-cd)pyrene	193-39-5	1.5	138	10	330
Isodrin	465-73-6	1.0	---	10	330

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TABLE 5-26
DENVER LABORATORY
Method 8270B Target Compound List, Appendix IX, and F039 for Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL[4] (µg/kg)
Isophorone	78-59-1	1.1	175	10	330
Isosafrole	120-58-1	2.0	32	20	660
Kepone	143-50-0	---	---	---	---
Methapyrilene	91-80-5	---	30	50	1600
3-Methylcholanthrene	56-49-5	2.7	30	20	660
6-Methylchrysene	1705-85-7	1.0	---	10	330
Methyl methanesulfonate	66-27-3	1.0	42	10	330
1-Methylnapthalene	90-12-0	1.0	173	10	330
2-Methylnaphthalene	91-57-6	1.3	182	10	330
Methyl parathion	298-00-0	1.0	30	50	1600
2-Methylphenol (o-cresol)	95-48-7	1.3	173	10	330
3-Methylphenol (m-cresol)	108-39-4	1.2	182	10	330
4-Methylphenol (p-cresol)	106-44-5	1.2	182	10	330
Naphthalene	91-20-3	1.1	234	10	330
1,4-Napthoquinone	130-15-4	1.3	30	50	1600
1-Naphthylamine	134-32-7	2.0	63	10	330
2-Naphthylamine	91-59-8	1.2	53	10	330
2-Nitroaniline	88-74-4	1.2	169	50	1600
3-Nitroaniline	99-09-2	1.1	244	50	1600
4-Nitroaniline	100-01-6	1.6	369	50	1600
Nitrobenzene	98-95-3	1.4	149	10	330
2-Nitrophenol	88-75-5	1.2	181	10	330
4-Nitrophenol	100-02-7	1.5	418	50	1600
4-Nitroquinoline-1-oxide	56-57-5	10	30	100	3300
N-Nitroso-di-n-butylamine	924-16-3	1.0	30	10	330
N-Nitrosodiethylamine	55-18-5	1.0	45	10	330

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TABLE 5-26
DENVER LABORATORY
Method 8270B Target Compound List, Appendix IX, and F039 for Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL[4] (µg/kg)
N-Nitrosodimethylamine	62-75-9	1.0	145	10	330
N-Nitrosodiphenylamine (Diphenylnitrosamine)	86-30-6	1.2	301	10	330
N-Nitroso-di-n-propylamine	621-64-7	1.0	183	10	330
N-Nitrosomethylethlyamine	10595-95-6	1.0	30	10	330
N-Nitrosomorpholine	59-89-2	1.0	52	10	330
N-Nitrosopiperdine	100-75-4	1.0	30	10	330
N-Nitrosopyrolidine	930-55-2	1.0	40	10	330
5-Nitro-o-toluidine	99-55-8	1.2	60	20	660
Parathion	56-38-2	1.0	30	50	1600
Pentachlorobenzene	608-93-5	1.0	30	10	330
Pentachloroethane	76-01-7	1.0	40	50	1600
Pentachloronitrobenzene	82-68-8	1.0	30	50	1600
Pentachlorophenol	87-86-5	1.0	583	50	1600
Phenacetin	62-44-2	1.0	30	20	660
Phenanthrene	85-01-8	1.0	193	10	330
Phenol	108-95-2	1.0	152	10	330
4-Phenylenediamine	106-50-3	10	388	100	3300
Phorate	298-02-2	1.0	30	50	1600
2-Picoline	109-06-8	1.0	30	20	660
Pronamide	23950-58-5	1.0	30	20	660
Pyrene	129-00-0	1.0	184	10	330
Pyridine	110-86-1	1.0	243	20	660
Quinoline	91-22-5	5.5	---	50	330
Safrole	94-59-7	1.0	30	20	660
1,2,4,5-Tetrachlorobenzene	95-94-3	1.0	30	10	330
2,3,4,6-Tetrachlorophenol	58-90-2	1.3	30	50	1600

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TABLE 5-26
DENVER LABORATORY
Method 8270B Target Compound List, Appendix IX, and F039 for Semivolatile Organics by GC/MS[1]
Method Detection Limits (MDL)[2] and Reporting Limits (RL)[3]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL[4] (µg/kg)
Tetraethyldithiopyrophosphate (Sulfotepp)	3689-24-5	1.0	34	50	1600
Thionazin	297-97-2	1.1	30	50	1600
2-Toluidine	95-53-4	1.0	103	20	660
1,2,4-Trichlorobenzene	120-82-1	1.4	147	10	330
2,4,5-Tricholorphenol	95-95-4	1.4	141	10	330
2,4,6-Trichlorophenol	88-06-2	1.2	141	10	330
O,O,O-Triethylphosphorothioate	126-68-1	1.0	30	50	1600
1,3,5-Trinitrobenzene	99-35-4	1.0	30	50	1600

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Footnotes

[1] Specific quantitation limits are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The Method Detection Limit study was performed on 4/1/96 and 11/19/96 for waters. The MDL for soils was completed 4/2/96 and 2/3/97.

[3] Reporting Limits are within 1 to 10 times the MDL.

[4] Quantitation limits listed for soil are based on wet weight. The quantitation limits based on dry weight as required, will be higher.

Comments:

1) N-Nitrosodiphenylamine decomposes in the gas chromatographic inlet and cannot be distinguished from diphenylamine.
2) Hexachlorophene is not amenable to analysis by this method.
3) 3-Methylphenol cannot be separated from 4-methylphenol by the conditions specified in this method.
4) Azobenzene is formed by decomposition of 1,2-diphenylhydrazine. If 1,2-diphenylhydrazine is requested, it will be analyzed as azobenzene.

Facility Appendix
Denver Laboratory

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Section Denver-6

Performance
Evaluation
Studies

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TABLE 6-1
DENVER LABORATORY
PE Sample Programs

PE Sample Program Description	Analysis Performed	Frequency of Participation
US Environmental Protection Agency Water Pollution Laboratory PE Study	Trace Metals, Minerals, Nutrients, Demand, PCBs in Water, PCBs in Transformer Oil, Pesticides (Insecticides), Volatile Halocarbons, Volatile Aromatics, and Miscellaneous (TSS, Cyanide, Oil & Grease, Total Phenolics)	Semi-annually
US Environmental Protection Agency Water Supply Laboratory PE Study	Trace Metals, Nitrate/Nitrite/Fluoride, Pesticides, Herbicides, Trihalomethanes, Volatile Organics, and Miscellaneous (TDS, Hardness, pH, Alkalinity, Sodium, Sulfate, Cyanide, Residual Chlorine, Turbidity, and TOC)	Semi-annually
Analytical Products Group, Inc. (APG) Real World Matrix PE Program	Volatile Organics, Acid Extractables, Base/Neutral Extractables, Purgeable Aromatics (BTEX)	Semi-annually
Army Corp of Engineers	Project Specific Parameter List	As needed per approval period - 18 months
Quanterra Corporate Double Blind	Parameter list not announced in advance.	Annually
Quanterra Environmental Services' Denver Internal PEs	As needed	As a follow-up to unacceptable PEs on other programs.

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Facility Appendix

Denver Laboratory

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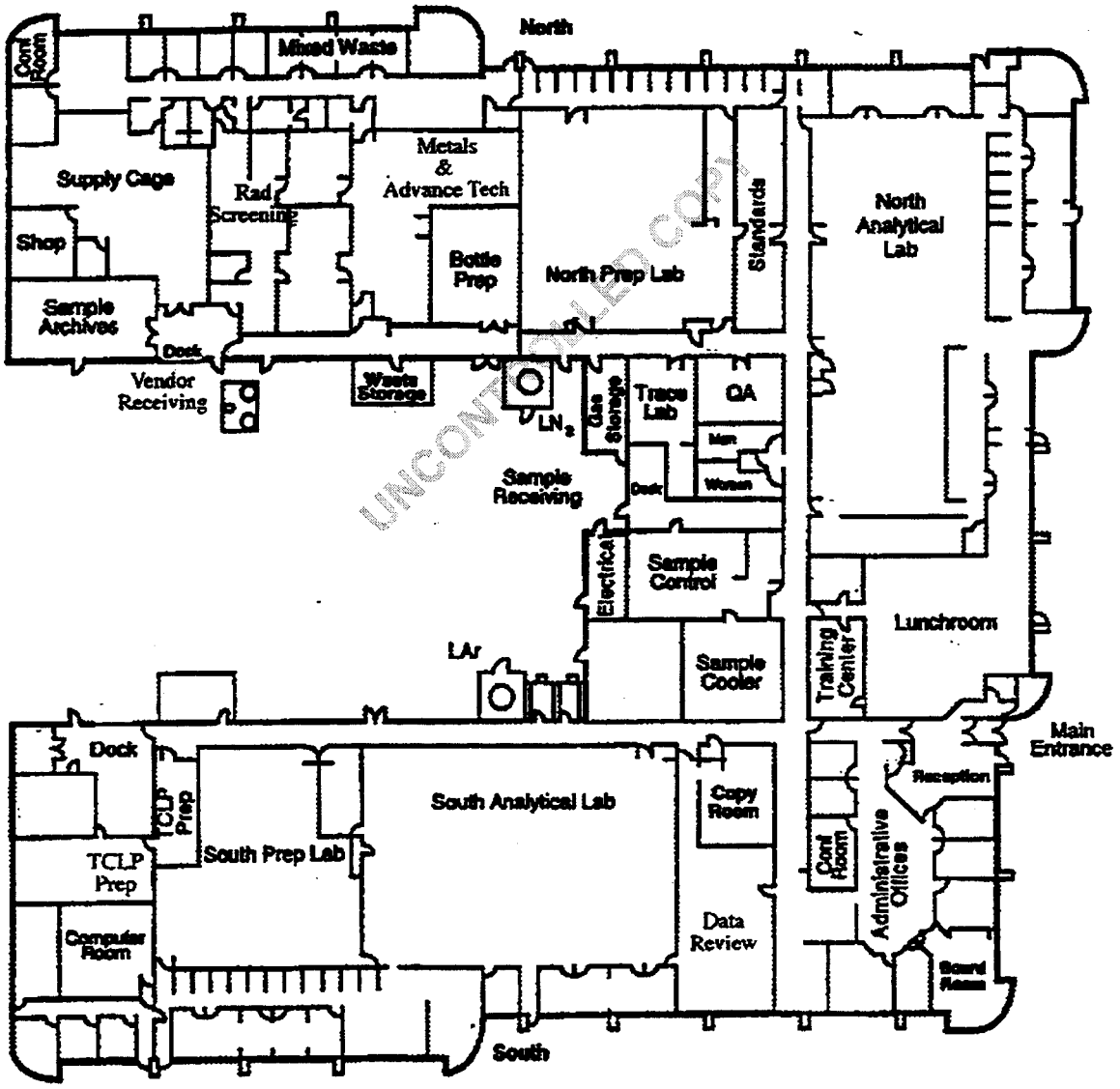
Section Denver-7

Additional
Operation-Specific
Information

FIGURE 7-1

Quanterra Denver Floor Plan



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QUALITY ASSURANCE PROGRAM PLAN

FOR
ENVIRONMENTAL SAMPLING
AND
NON-RADIOACTIVE/RADIOACTIVE ANALYSIS

by

Jo Ann Boyd

Copy No. _____

Chemistry and Chemical Engineering Division
Southwest Research Institute
San Antonio, Texas 78284

September 1996

SOUTHWEST RESEARCH INSTITUTE

TABLE OF CONTENTS

		No. of Pages	Rev	Date
1.	IDENTIFICATION OF SUBMITTAL LABORATORY	1	9	11-93
2.	INTRODUCTION	2	11	6-95
	2.1 Commitment to Quality Assurance			
	2.2 Purpose and Scope of Quality Assurance Program Plan			
	2.3 Quality Operating Plans			
3.	QUALITY ASSURANCE POLICY	1	7	1-93
4.	QUALITY ASSURANCE MANAGEMENT	33	10	5-96
	4.1 SwRI Quality Assurance Management Structure			
	4.2 Assignment of Quality Responsibilities within the Chemistry and Chemical Engineering Division			
	4.3 Communication			
	4.4 Document Control			
	4.5 QA Program Assessment			
	4.6 Tracking			
	4.7 Analytical Procedures			
5.	PERSONNEL QUALIFICATIONS	2	11	5-96
	5.1 Training			
	5.2 Personnel Safety			
6.0	FACILITIES, EQUIPMENT AND SERVICES	14	8	6.95
	6.1 Cleaning of Sample Preparation Containers			
	6.2 Instrument Calibration			
	6.3 Geophysical Testing Calibration			
	6.4 Material Procurement and Control			
	6.5 Maintenance			
	6.6 Balances, Refrigerators and Ovens			

TABLE OF CONTENTS

		No. of Pages	Rev	Date
7.0	DATA GENERATION	20	8	12-95
	7.1 Quality Assurance Project Plan			
	7.2 Quality Control Samples			
	7.3 Method Validation			
	7.4 Documentation and Sample Custody			
	7.5 Sample and Extract Storage			
	7.6 Preventing Sample Contamination			
	7.7 Security for Laboratory and Samples			
	7.8 Traceability of Standards			
	7.9 Maintaining Instrument Records and Logbooks			
	7.10 Analysis Work Order Form			
	7.11 Standard Operating Procedures			
	7.12 Study Planning and Design			
8.	DATA PROCESSING	2	6	2-93
	8.1 Collection			
	8.2 Validation			
	8.3 Data Storage			
	8.4 Data Transfer			
	8.5 Data Reduction			
9.	DATA QUALITY ASSESSMENT	1	6	11-93
10.	CORRECTIVE ACTION	2	9	9-96
11.	BIBLIOGRAPHY	2	6	11-93

Appendix A - Radioactive Material License
Appendix B - "Requirements for Quality Control of Analytical Data for the Environmental Restoration Program"
- Lockheed Martin Energy Systems (LMES)

1. IDENTIFICATION OF SUBMITTAL LABORATORY
(Effectivity and Approval)

Document Title: Quality Assurance Project Plan for Environmental Sampling and Nonradioactive/Radioactive Analysis Laboratory in San Antonio

Organization Title: Southwest Research Institute
Chemistry and Chemical Engineering Division
Department of Environmental Chemistry

Address: P.O. Drawer 28510, 6220 Culebra Road
San Antonio, Texas 78284

Responsible Officer: Donald E. Johnson, Phone: 512/522-2176
Title: Vice President, Chemistry and Chemical Engineering Division

Quality Officer: Jo Ann Boyd, Phone: 512/522-2169
Plan Coverage: Division 01
Department of Environmental Chemistry Laboratory in San Antonio

Concurrences

Name Jo Ann Boyd
Title Quality Assurance Officer
Signature Jo Ann Boyd

Name J.P. Hsu, Ph. D
Title Director, Department of Environmental Chemistry
Signature

Approval for Division
Name Donald E. Johnson, Ph.D.
Title Vice President, Chemistry and Chemical Engineering Division
Signature Donald E Johnson

Name Thomas C. Trbovich
Title SwRI Quality Assurance Manager
Signature Thomas C Trbovich

Date: 11/30/93

INTRODUCTION

REV 11

Copy No. _____

Approvals:

Division 01 Quality Assurance — Date: 6/27/95

Division 01 Management — Date: 6/28/95

SwRI QA Management — Date: 6/27/95

2.0 INTRODUCTION

2.1 Commitment to Quality Assurance (QA)

The Southwest Research Institute (SwRI) Division 01 Environmental Laboratory shall devote the necessary personnel and equipment to fulfill the quality assurance/quality control (QA/QC) requirements of all projects. The SwRI Environmental Laboratory has implemented the QA/QC program described in this document in all laboratories on the main campus in San Antonio to assure generation of monitoring and analytical measurement data of known acceptable quality to meet the requirements of each project's statement of work.

2.2 Purpose and Scope of Quality Assurance Project Plan (QAPP)

The purpose of this QAPP is to convey the philosophy, organizational structure and procedures governing the QA/QC program for environmental sampling and analysis services performed by the Environmental Laboratory in San Antonio. This plan has been prepared in accordance with "Guidelines and Specifications for Preparing Quality Assurance Program Plans, "QAMS-004/80, September 20, 1980", " QAMS-005/80, December 29, 1980; "Quality Assurance", Office of Nuclear Energy, DOE 5700.6C, August 21, 1991; ASME/NQA-1, "Quality Assurance Program Requirements for Nuclear Facilities. The Quality Assurance Department at Southwest Research Institute is an independent organizational element that reports directly to the President of SwRI. The QA support for projects has been tailored to meet the quality requirements imposed by organizations including the Department of Energy (DOE), the Department of Defense (DOD), the Nuclear Regulatory Commission (NRC), the Environmental Protection Agency (EPA), and many industrial firms. These quality programs have been designed to satisfy applicable requirements of quality documents such as MIL-Q-9858A, MIL-I-45208A, MIL-STD-45662A, and DOE Order 5700.6C, Federal Acquisition Regulations (FAR) paragraphs 52.246-1 through 52.246-8, the Food and Drug Administration (FDA) Good Laboratory Practices and Good Manufacturing Practices, and the Environmental Protection Agency (EPA) Good Laboratory Practices, and the requirements specified by the Air Force Center for Environmental Excellence (AFCEE).

SwRI's Nuclear Quality Assurance Program Manual (NQAPM) describes an effective and economical Quality Assurance (QA) Program that complies with the requirements of 10 CFR 50, Appendix B, ASME NQA-1, and DOE 5700.6C. The procedures within this manual establish the basic quality requirements for activities such as Engineering, Design, Fabrication, Inspection, and Testing performed by applicable division personnel.

2.3 Quality Operating Plans

The written quality plan for each contract will be separate from the QAPP but will ensure procedures within this QAPP for documentation and reporting requirements are satisfied. For nuclear requirements, sections of the Institute NQAPM will be invoked and applicable Standard Operating Procedures will be used to conduct the quality activity for the project.

All environmental sampling and analytical services performed within the laboratory in San Antonio, will follow the QAPP to assure compliance to the clients' requirements and validity of the data. If a workplan is required it will be established prior to the initiation of the project, the approvals will be by the Project Manager, Analytical Supervisor, and Division 01 QAU. The client will be notified of any modifications to the QA workplan during the project. Smaller projects requiring minimal QA/QC effort will be established upon initiation of the project and submission in writing from the Project Manager that the client requests to minimize QC samples.

In the event that no QA workplan is specified by the client, all environmental sampling and analytical services preformed within the laboratory at San Antonio shall be conducted in accordance with the provisions of this QAPP.

QUALITY ASSURANCE POLICY

REV 7

Copy No. _____

Approvals:

Division 01 Quality Assurance _____ Date: 11/30/93

Division 01 Management _____ Date: 11/30/93

SwRI QA Management _____ Date: 12/1/93

3.0 QUALITY ASSURANCE POLICY

The following paragraphs are quoted from Southwest Research Institute Operating Policies and Procedures 10.1.1 and present the quality assurance policy of the Institute.

> *It is the policy of Southwest Research Institute (SwRI) to ensure that the equipment and items supplied to, or services performed for, clients shall conform to the specified requirements of the applicable codes, regulations, standards, specifications, and contracts.*
>
> *The responsibility for developing, conducting, and auditing the Quality Assurance (QA) Program to ensure the implementation and enforcement at SwRI of the policy stated above, is assigned to the Quality Assurance Department. In recognition of the importance of this policy, the Director of the Quality Assurance Department will keep the Office of the President of SwRI informed on QA program performance and recommend action as necessary to ensure the required quality assurance.*
>
> *Although quality assurance programs are administered by the QA Department with oversight provided by the Office of the President of SwRI, quality assurance is a responsibility of all SwRI employees performing project activities.*
>
> *Each Division Vice President (DVP) is responsible for (1) ensuring that for each project, the need for a formal QA program is identified and (2) if a QA program is required, ensuring that the Quality Assurance Department is made aware of that requirement. In the case of programs with no formal QA requirements, the DVP or his delegate will determine the extent and application of any QA program and will request QA support as appropriate from the Manager of the QA Department. In either case, the Director of the QA Department will ensure that the QA requirements and documentation necessary to implement those requirements are identified. The Manager of the QA Department is responsible for ensuring that those activities to be performed by QA personnel are documented. The DVP is responsible for ensuring that those activities to be performed by project personnel are documented. QA personnel shall review and approve all procedures governing quality-related activities and will maintain a record copy of each procedure*

It is the policy of the Chemistry and Chemical Engineering Division (C&CED) to implement a quality assurance program in all environmental projects to ensure that all measurement data generated shall be scientifically sound, of known quality, and adequately documented.

QUALITY ASSURANCE MANAGEMENT

REV 9

Copy No. _____

Approvals:

Division 01 Quality Assurance	JoAnn Boyd	Date: 6/27/95
Division 01 Management	Donald E Johnson	Date: 6/28/95
SwRI QA Management	L.C. Silbert	Date: 6/27/95

4.0 QUALITY ASSURANCE MANAGEMENT

4.1 *SwRI Quality Assurance Management Structure*

The Director of Institute Quality Assurance has been given the responsibility of operating quality assurance programs for the Institute. The President of SwRI has given the Director of QA the authority and organizational freedom to ensure that quality activities shall be accomplished. The organization chart of the Quality Assurance Department is shown in Figure 4.1.

The Institute Quality Assurance Manager is responsible for the activities of the QA personnel and for providing direction to his staff. The QA Manager is responsible for helping to evaluate and assisting in the resolution of deficiencies and quality problems.

The Assistant Manager of Institute Quality Assurance plans, coordinates and directs the efforts of QA Engineers and Technicians to ensure that quality assurance program activities satisfy contractual quality requirements.

The Quality Assurance Engineer (QAE) is responsible for verifying that contract quality activities for projects to which he/she is assigned are be properly implemented or reported as deficiencies. A QAE will be assigned to review the requirements of this QAPP.

The Quality Assurance Technician (QAT) inspects, surveys, monitors, and audits products and services for compliance with contractual requirements. The QAT assigned will perform these functions under the guidance of the responsible QAE.

This plan defines the QA/QC program for all sampling, analytical services, and environmental measurements performed in the San Antonio laboratory (i.e., Environmental Engineering, Environmental Chemistry, Fire Technology, Applied Chemistry, and Chemical Demilitarization sections) within the C&CED Environmental Monitoring and Analysis,. The organization charts of the C&CED and the analysis and sampling group are presented in Figures 4.2, 4.3, and 4.4, respectively.

4.2 *Assignment of Quality Responsibilities within the Chemistry and Chemical Engineering Division*

4.2.1 *Organization Independence of Quality Function*

The manager of SwRI Quality Assurance maintains responsibility to oversee the quality assurance within the C&CED. He then delegates the coordination of quality activities within the division to a quality officer. This designee will supervise all quality control (QC) activities, and submit QA program assessment reports (see Section 4.5) to the manager of Quality Assurance for review. Thus, the Institute Quality Assurance Department will provide independent overview of the QA/QC effort. In addition, as shown in Figure 4.3, the quality officer reports directly to the director(s) of the division on quality matters, giving the quality officer the necessary independence to supervise quality activities within each project. The Institute Quality Assurance Department will conduct system audits and surveillances as necessary to confirm conformance to requirements or to investigate chronic deficiencies in the QA/QC program.

4.2.2 *Responsibilities in Large Projects with a Quality Assurance Project Plan*

4.2.2.1 Typical Positions

Large projects for which a quality assurance project plan is prepared will typically have the following positions:

Project Manager
Study Director
Analytical Supervisor
Analyst
Sampling Coordinator (if applicable)
Quality Assurance/Quality Control Officer (Institute QAE)
Quality Assurance/Quality Control Officer (Division)
Quality Assurance Auditor

Figure 4.1 Department of Quality Assurance and Administration

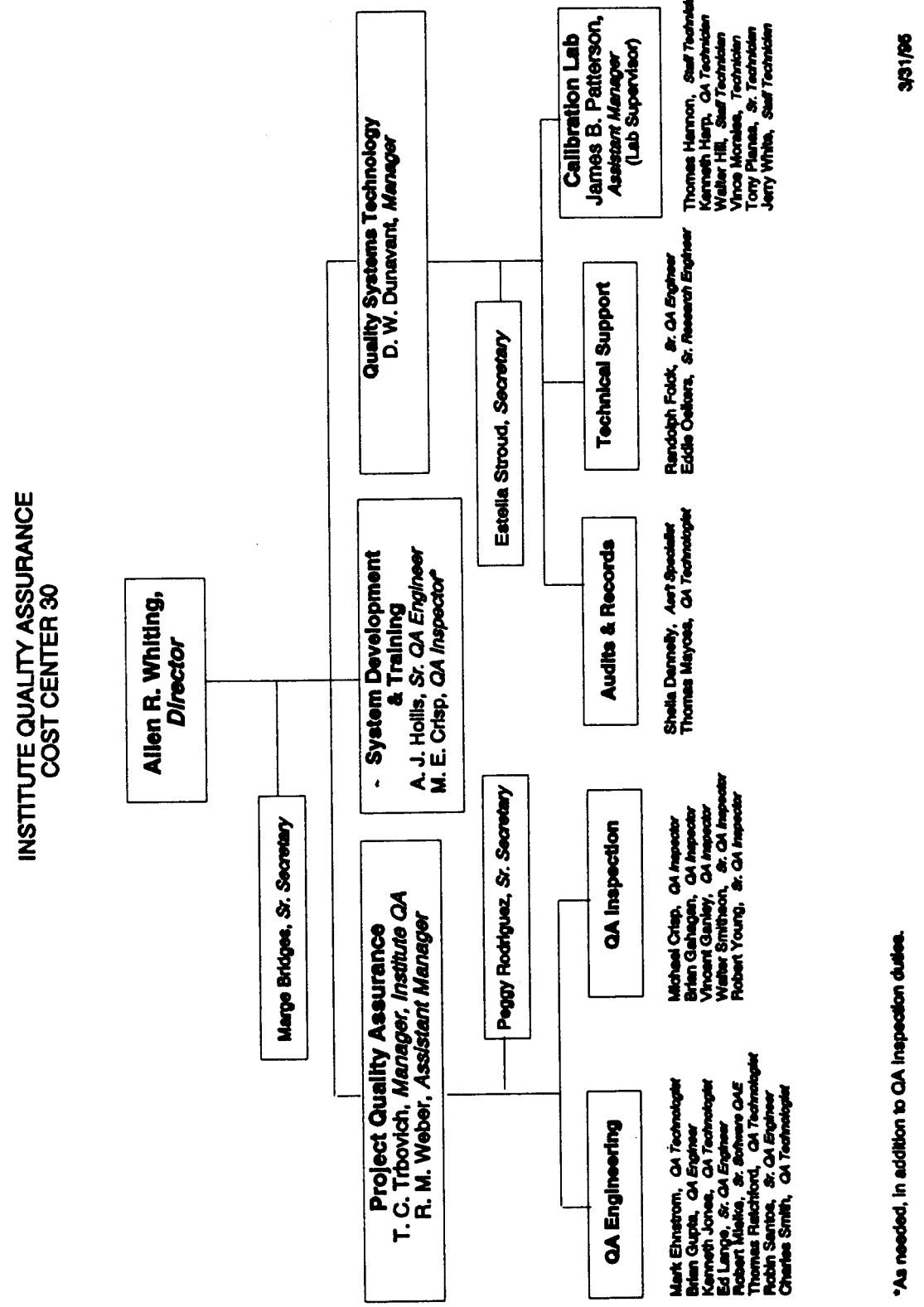
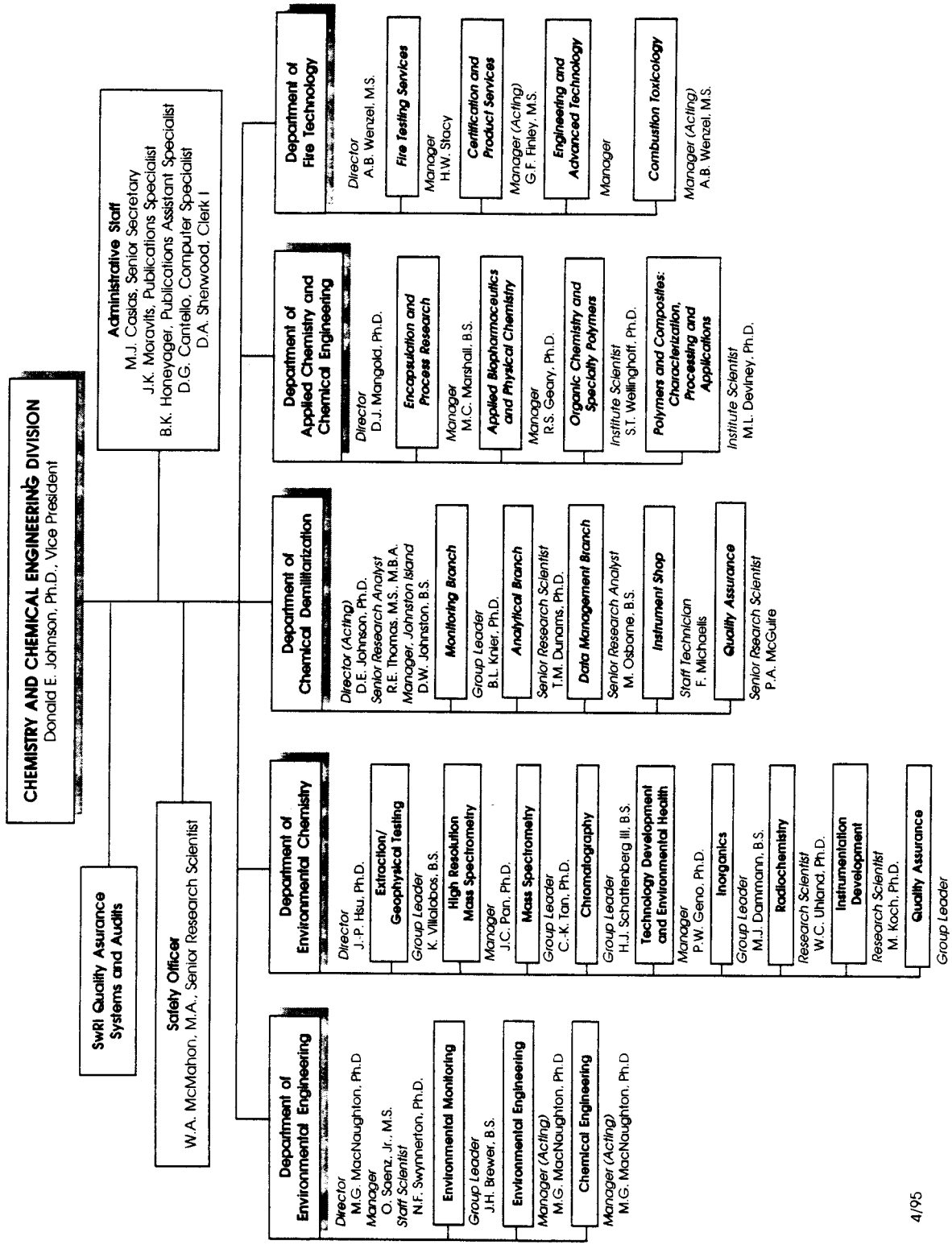


Figure 4.2 Chemistry and Chemical Engineering Division



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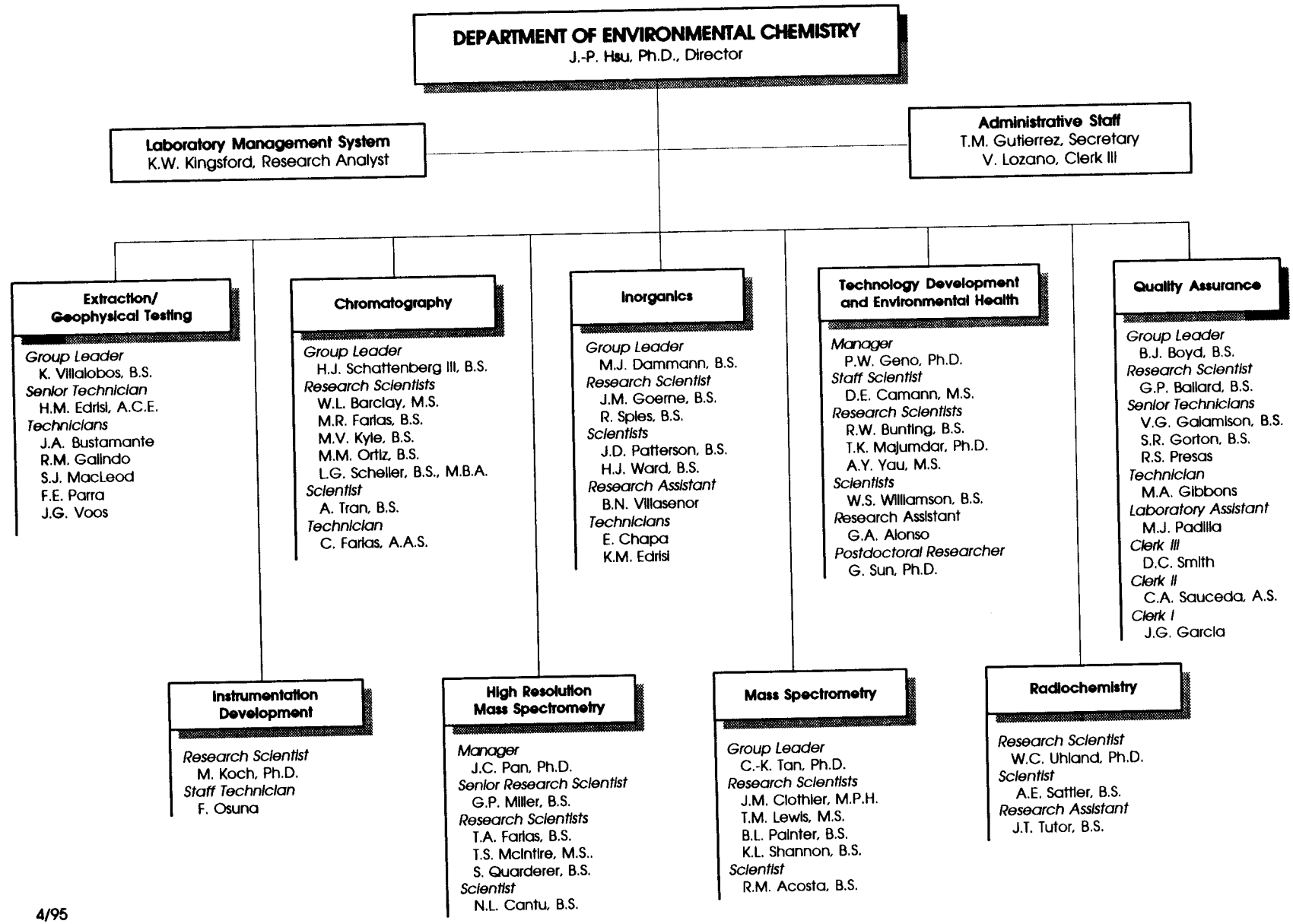
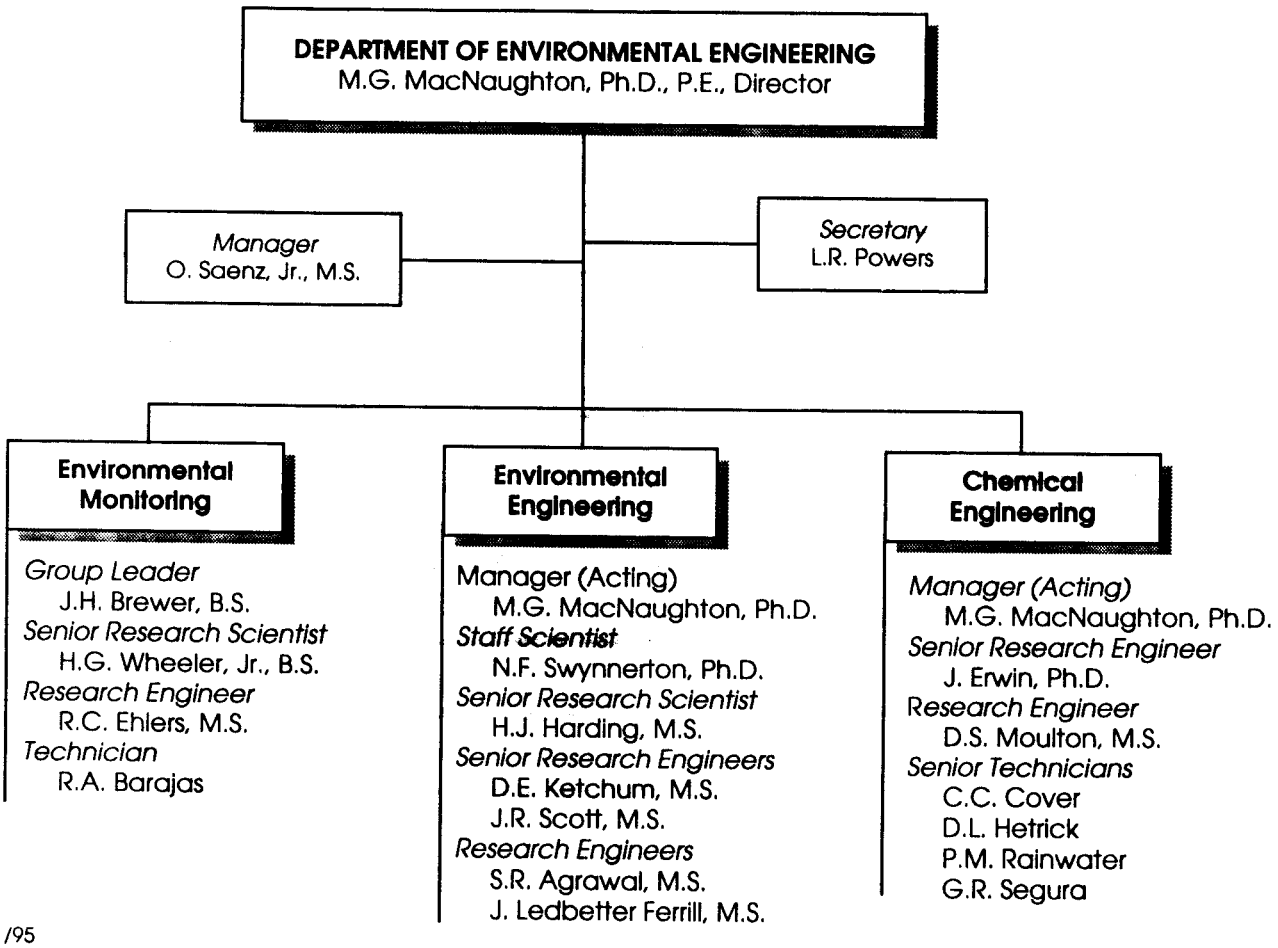


Figure 4.3 Department of Environmental Chemistry

Figure 4.4 Department of Environmental Engineering



1/95

The typical duties of these positions are given below:

Project Manager

- design the work plan/technical proposal
- general technical supervision of project personnel
- financial management
- sponsor communications
- resolve major problems and issues

Study Director

- manages projects requiring GLP regulations
- design the work plan/technical proposal
- general technical supervision of project personnel
- financial management
- sponsor communications
- resolve major problems and issues

Analytical Supervisor

- assist in developing the analytical plan/technical proposal
- assist in preparing the Quality Assurance Project Plan for analytical activities
- develop necessary analytical protocols and analytical standard operating procedures, including control charts
- review analytical results for questionable data and initiate necessary repeat analyses
- report problems to the Project Manager and the QA/QC Officer.

Analyst

- perform analyses
- calculate analytical results
- calculate quality control results
- maintain control charts
- report problems to the Analytical Supervisor for resolution

Sampling Coordinator

- develop necessary sampling protocols, standard operating procedures, and equipment requirements related to sample collection
- prepare the Quality Assurance Project Plan for sampling activities
- train and supervise field sampling personnel
- maintain and calibrate field sampling equipment
- arrange for transport of equipment and supplies to field locations
- determine logistic and custody requirements for sample transport
- document all activities associated with sample collection
- report problems to the Project Manager and the QA/QC Officer

Quality Assurance Officer (Institute QAE)

- monitors project activities and conducts surveillances
- report results of quality activities to project line and quality assurance management
- assist in problem resolution

Quality Assurance/Quality Control Officer (Division)

- assist in preparing the Quality Assurance Project Plan
- schedules internal system audits, blind spiked samples, and performance audits
- report results of quality activities to project line and quality assurance management
- establish and set up procedures for log in, documentation of samples, and data deliverable of analytical results
- coordinate sample shipments from the field to the lab
- establish QC requirement, holding times, and deliverable required by the client and communicate to the analyst through a work order
- report analytical and QC data to the sponsor
- report results of Division QA/QC activities to Institute QA/QC Officer and Division 01 Management

Quality Assurance Auditor (Division)

- periodic review of control charts
- check instrument conditions and calibrations
- report results of quality activities to Division QA/QC Officer
- conducts internal inspections/audits
- check holding times of sample extraction and analysis and track status of analytical results
- spot check QC on analytical results and report any problems to the QA/QC Officer
- provide finished data package to QA/QC Officer and Project Manager for review

All assigned project personnel shall remain diligent to identify, report, and promptly rectify problems affecting data quality as they occur. Unresolved problems must be reported to a member of the quality team.

4.2.2.2 Quality and Project Organizations

A generic organization chart for large projects which have a quality assurance project plan is presented in Figure 4.5. This chart indicates the typical reporting relationships among project management, the quality team, and senior C&CED management.

The quality team consists of the QA/QC Officer, and the QA Auditor. The QC auditor shall perform system audits, prepare the blind spiked samples and summarize their results, and monitor control charts.

4.2.3 *Responsibilities in Other Laboratory Projects*

4.2.3.1 Typical Positions

The functions of the QA/QC Officer and QA Auditor remain as specified in 4.2.2.1. However, the QA/QC scope encompasses all instrumentation and methods employed. Projects that require deviation from the QAPP shall have such deviations documented in memorandum form with the work order.

4.2.3.2 Quality and Lab Organizations

A generic organization chart showing the Chemistry and Chemical Engineering Department labs in San Antonio and their relationship to the quality team is presented in Figure 4.5. The QA/QC Officer shall supervise the quality team. The QA Auditor shall conduct all audit activities as scheduled and submit audit reports to the Division QA/QC Officer. He/she shall then interact with the section managers and report to senior management through the SwRI QA Officer regarding quality issues. The QA Auditor shall coordinate internal system audits, prepare needed blind spiked samples and summarize their results, and monitor control charts. The same QA Auditor will perform this function in Division 01 environmental laboratories in San Antonio.

4.3 Communication

The organization charts presented in Figures 4.5 and 4.6 indicate the internal and external flow of QA information and reports. Figure 4.5 illustrates typical QA information flow for projects with a QA project plan. Figure 4.6 shows the QA information flow for projects lacking a QA project plan. Reporting responsibilities are discussed in Sections 4.2 and 4.4.

4.4 Document Control

The Division QA/QC Officer and QA Auditor will maintain files of QA program assessment reports, other QA reports to management, and other vital information, plans, and directives. The pagination of every section of the QAPP shall include the number and date of all revisions. The QA Auditor will maintain distribution lists of personnel who need to receive QA reports and information.

Figure 4.5 Generic Organization Chart for Large Projects with a QA Project Plan Showing Relationships Among Project Management, Senior Management, and Quality Team

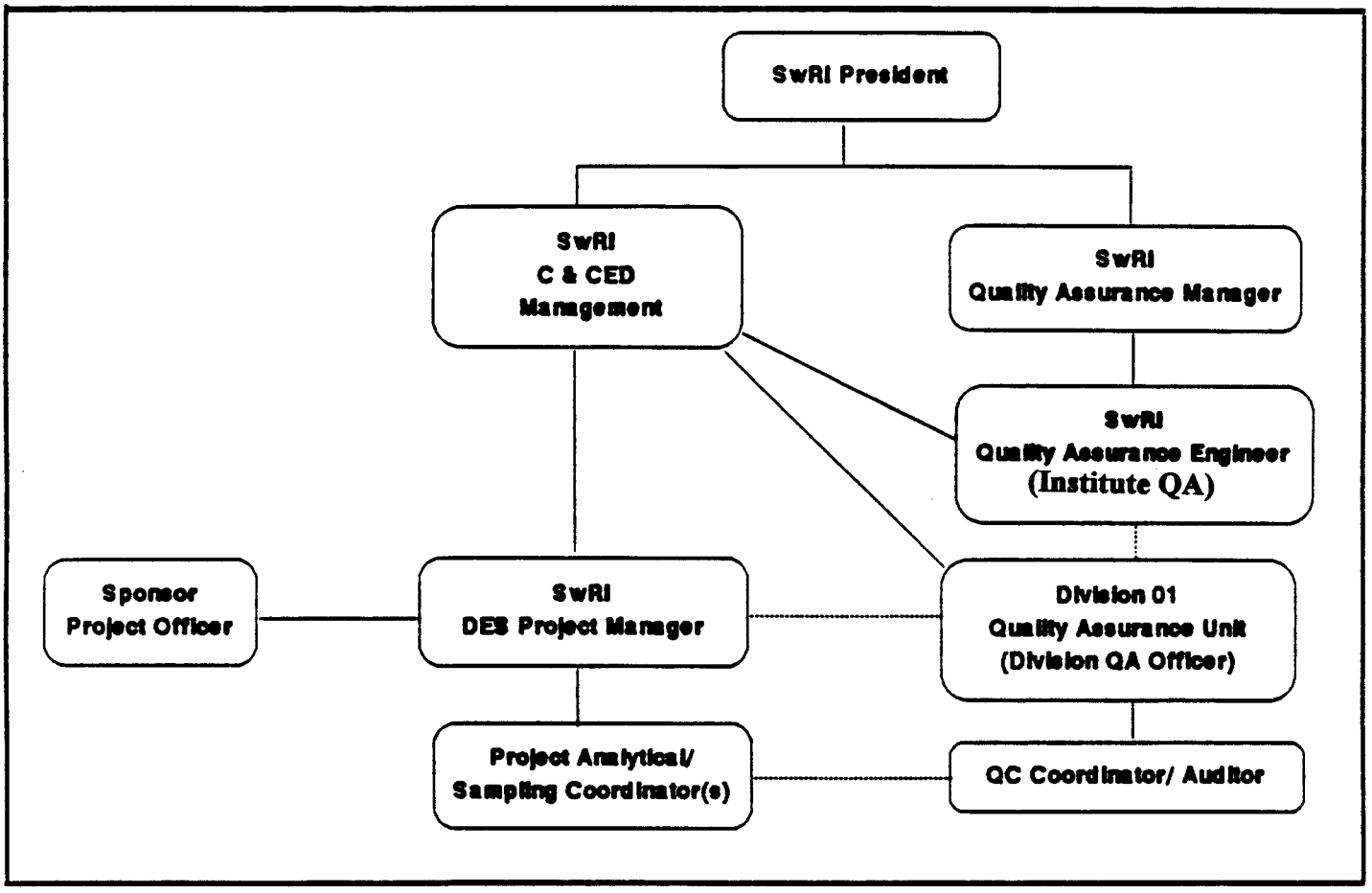
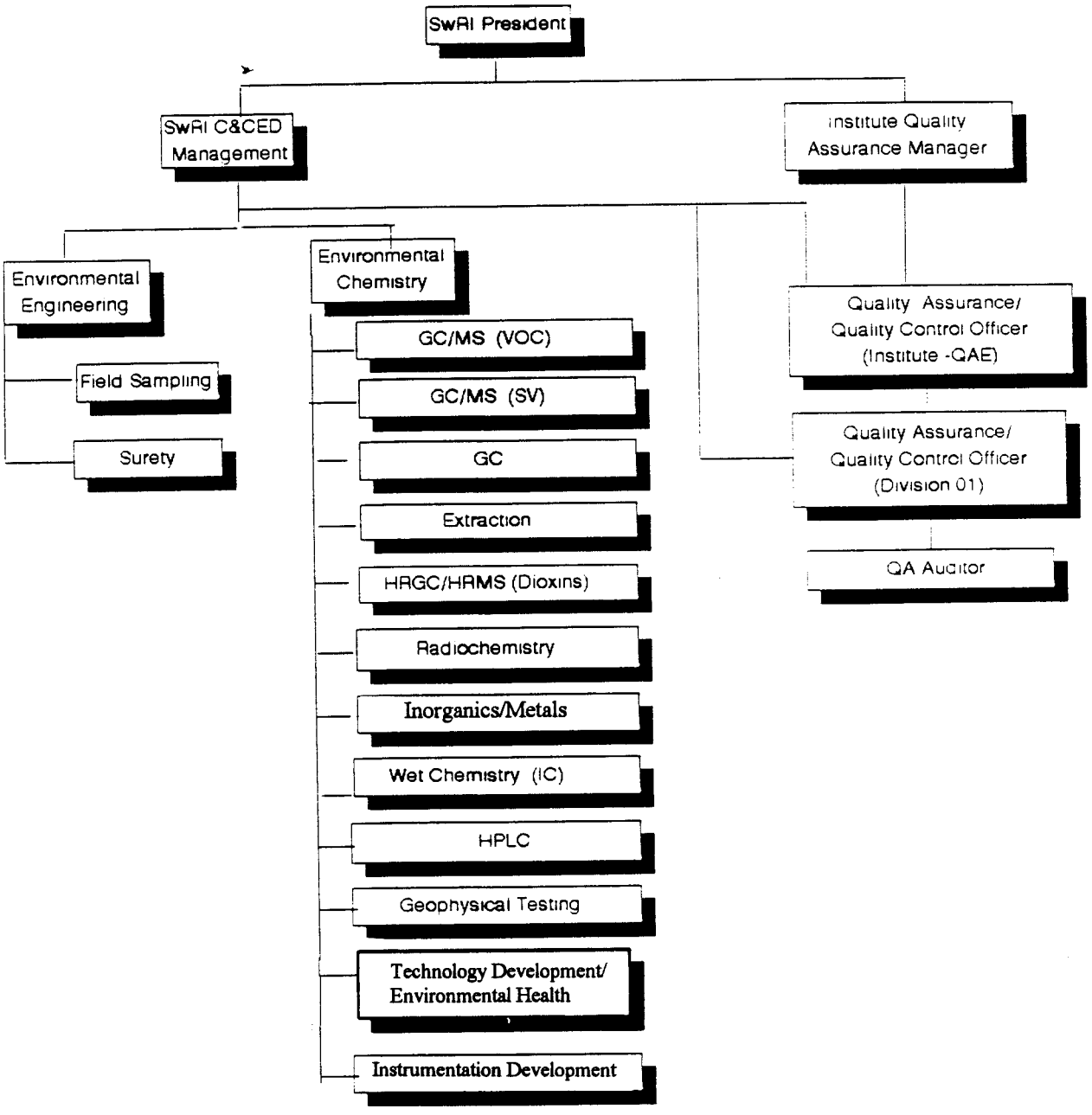


Figure 4.6 Generic Organization Chart for Laboratories in San Antonio Showing Relationships to Laboratory Supervisors, Management and Quality Team



4.5 QA Program Assessment

The QA/QC Officer shall conduct reviews of the total QA/QC program to evaluate its benefits and effectiveness. Based on these assessments, the QA/QC Officer shall prepare a written annual status report of QA activities and progress each year. This annual program assessment report will be submitted to the SwRI quality assurance manager, the directors and the C&CED vice president. This assessment report will include such information as:

1. Status of or changes to the QA/QC Project Plan
2. Significant QA problems, accomplishments, and recommendations
3. Results of Performance Audits
4. Results of Systems Audits
5. Summary of QA Training
6. External Audit Findings and Corrective Actions
7. SwRI Internal QA Audit and Surveillance Activities

The Institute QA will conduct surveillance on nuclear or Department of Defense analytical activities as well as inspection of documentation of files and assure duplicate file archives for all raw data. The QAE will also conduct periodic reviews of GLP projects. Routine project reviews shall be performed at the discretion of the Institute Quality Manager.

4.6 Tracking

Work orders are sent to all analytical areas involved, as well as individual personnel assigned to each section. The work order is reviewed against the contract or solicitation to confirm the quality control requirements. Holding times are adhered to as shown in Figures 4.7, 4.8 and 4.9 unless otherwise stated in the contract.

Tracking Forms as shown in Figure 4.10 are used as follows on every sample:

1. The case/SDG and each sample, by number, will be listed on the form.

2. Actual holding times and deliverables will be listed.

The personnel assigned to the area will use the Tracking Form to check against the logbook each morning. If the samples have not been analyzed (or extracted) within 48 hours prior to holding time, the supervisor of the section will be notified. This will enable priority adjustment, if necessary.

During the tracking the proper methods, sample preparations, equipment calibration, and quality control requirements are checked. If the samples have been analyzed and the case and quality control has met requirements, i.e., surrogates, CRQL, MS/MSD and all reanalyses, a request will be made for data transfer to the Division QA/QC Officer.

The individual assigned to the section will notify quality control of any discrepancies and non-compliance items. A correction action is submitted. Follow-up review will be done to confirm the problem has been corrected and provide narrative response.

The sample control records will remain at the storage area until the appropriate sample disposal. At this time the samples are evaluated for each specific hazard to determine the method of disposal. All samples categorized as Hazardous Waste are disposed of through the Institute's Hazardous Waste Disposal System as described in Division 01 SOP-01-01-09 and in the Institute Safety Manual. Documentation of Hazardous Waste Disposal including Waste Data Sheet (Figures 4.12 and 4.13) and a Sample Disposal Log (Figure 4.11). The Sample Control Record is documented with the Sample Disposal data and is filed. These files are kept for a period of 5 years.

Figure 4.7 Required Containers, Preservation Techniques and Holding Time

Required Containers, Preservation Techniques and Holding Times (40 CFR, Part 136, July 1, 1990)			
Parameter No/Name	Container[1]	Preservation[2,3]	Maximum Holding Time[4]
Table 1A-Bacterial Tests			
1-4. Coliform, fecal and total	P, G	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	6 hours
5. Fecal streptococci	P, G	do	Do
Table 1B-Inorganic Tests			
1. Acidity	P, G	Cool, 4°C	14 days
2. Alkalinity	P, G	do	Do
4. Ammonia	P, G	Cool, 4°C, H_2SO_4 to pH <2	28 days
9. Biochemical oxygen demand	P, G	Cool, 4°C	48 hours
11. Bromide	P, G	None required	28 days
14. Biochemical oxygen demand, carbonaceous	P, G	Cool, 4°C	48 hours
15. Chemical oxygen demand	P, G	Cool, 4°C, H_2SO_4 to pH <2	28 days
16. Chloride	P, G	None required	Do
17. Chlorine, total residual	P, G	do	Analyze immediately
21. Color	P, G	Cool, 4°C	48 hours
23-24. Cyanide, total and amenable to chlorination	P, G	Cool, 4°C, NaOH to pH >12. 0.6 g ascorbic acid[5]	14 days[6]
25. Fluoride	P	None required	28 days
27. Hardness	P, G	HNO_3 to pH <2, H_2SO_4 to pH <2	6 months
28. Hydrogen ion (pH)	P, G	None required	Analyze immediately
31, 43. Kjeldahl and organic nitrogen	P, G	Cool, 4°C, H_2SO_4 to pH <2	6 months
Metals[7]			Analyze immediately
18. Chromium VI	P, G	Cool, 4°C	24 hours
35. Mercury	P, G	HNO_3 to pH <2	28 days
3, 5-8, 10, 12, 13, 19, 20, 22, 26, 29, 30, 32-34, 36, 37, 45, 47, 51, 52, 58-60, 62, 63, 70-72, 74, 75. Metals, except chromium VI and mercury	P, G	do	6 months
38. Nitrate	P, G	Cool, 4°C	48 hours
39. Nitrate-nitrite	P, G	Cool, 4°C, H_2SO_4 to pH <2	28 days
40. Nitrite	P, G	Cool, 4°C	48 hours
41. Oil and grease	G	Cool, 4°C, H_2SO_4 to pH <2	28 days
42. Organic carbon	P, G	Cool, 4°C, HCl or H_2SO_4 to pH <2	Do
44. Orthophosphate	P, G	Filter immediately, Cool, 4°C	48 hours
46. Oxygen, Dissolved Probe	G, Bottle and top	None required	Analyze immediately
47. Winkler	do	Fix on site and store in dark	8 hours
48. Phenols	G only	Cool, 4°C, H_2SO_4 to pH <2	28 days
49. Phosphorus (elemental)	G	Cool, 4°C	48 hours
50. Phosphorus, total	P, G	Cool, 4°C, H_2SO_4 to pH <2	28 days

Required Containers, Preservation Techniques and Holding Times (40 CFR, Part 136, July 1, 1990)			
Parameter No/Name	Container[1]	Preservation[2,3]	Maximum Holding Time[4]
53. Residue, total	P, G	Cool, 4°C	7 days
54. Residue, Filterable	P, G	do	7 days
55. Residue, Nonfilterable (TSS)	P, G	do	7 days
56. Residue, Settleable	P, G	do	48 hours
57. Residue, Volatile	P, G	do	7 days
61. Silica	P	do	28 days
64. Specific conductance	P, G	do	Do
65. Sulfate	P, G	do	Do
66. Sulfide	P, G	Cool, 4°C add zinc acetate plus sodium hydroxide to pH >9	7 days
67. Sulfite	P, G	None required	Analyze immediately
68. Surfactants	P, G	Cool, 4°C	48 hours
69. Temperature	P, G	None required	Analyze
73. Turbidity	P, G	Cool, 4°C	48 hours
Table 1C-Organic Tests[8]			
13, 18-20, 22, 24-28, 34-37, 39-43, 45-47, 56, 66, 88, 89, 92-95, 97. Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4°C, 0.008% $Na_2SO_2O_3$[5]	14 days
6, 57, 90. Purgeable aromatic hydrocarbons	do	Cool, 4°C, 0.008% $Na_2S_2O_3$[5], HCl to pH 2[9]	Do
3, 4. Acrolein and acrylonitrile	do	Cool, 4°C, 0.008% $Na_2S_2O_3$[5], adjust pH to 4-5[10]	Do
23, 30, 44, 49, 53, 67, 70, 71, 83, 85, 96. Phenols[11]	G, Teflon-lined cap	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	7 days until extraction, 40 days after extraction
7, 38. Benzidines[11]	do	do	7 days until extraction[13]
14, 17, 48, 50-52. Phthalate esters[11]	do	Cool, 4°C	7 days until extraction; 40 days after extraction
72-74. Nitrosamines[11,14]	do	Cool, 4°C, store in dark, 0.008% $Na_2S_2O_3$[5]	Do
76-82. PCBs[11] acrylonitrile	do	Cool, 4°C	Do
54, 55, 65, 69. Nitroaromatics and isophorone[11]	do	Cool, 4°C, 0.008% $Na_2S_2O_3$[5] store in dark	Do
1, 2, 5, 8-12, 32, 33, 58, 59, 64, 68, 84, 86. Polynuclear aromatic hydrocarbons[11]	do	do	Do
15, 16, 21, 31, 75. Haloethers[11]	do	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	Do
29, 35-37, 60-63, 91. Chlorinated hydrocarbons[11]	do	Cool, 4°C	Do
87. TCDD[11]	do	Cool, 4°C, 0.008% $Na_2S_2O_3$[5]	Do
Table ID-Pesticides Tests:			
1-70. Pesticides[11]	do	Cool, 4°C, pH 5-9[15]	Do
Table IE-Radiological Tests			

Required Containers, Preservation Techniques and Holding Times (40 CFR, Part 136, July 1, 1990)			
Parameter No/Name	Container[1]	Preservation[2,3]	Maximum Holding Time[4]
1-5. Alpha, beta and radium	P, G	HNO_3 to pH <2	6 months

1. Polyethylene (P) or Glass (G).

2. Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4°C until compositing and sample splitting is completed.

3. When any sample is to be shipped by common carrier or sent through the United States Mails, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172). The person offering such material for transportation is responsible for ensuring such compliance. For the preservation requirements of this table, the Office of Hazardous Materials, Materials Transportation Bureau, Department of Transportation has determined that the Hazardous Materials Regulations do not apply to the following materials: hydrochloric acid (HCl) in water solutions at concentrations of 0.04% by weight or less (pH about 1.96 or greater); nitric acid (HNO_3) in water solutions at concentrations of 0.15% by weight or less (pH about 1.62 or greater); sulfuric acid (H_2SO_4) in water solutions at concentrations of 0.35% by weight or less (pH about 1.15 or greater); and sodium hydroxide (NaOH) in water solutions at concentrations of 0.080% by weight or less (pH about 12.30 or less).

4. Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer time, and has received a variance from the Regional Administrator under § 136.3(e). Some samples may not be stable for the maximum time period given in the table. A permittee, or monitoring laboratory, is obligated to hold the sample for a shorter time if knowledge exists to show that this is necessary to maintain sample stability. See § 136.3(e) for details.

5. Should only be used in the presence of residual chlorine.

6. Maximum holding time is 24 hours when sulfide is present. Optionally all samples may be tested with lead acetate paper before pH adjustments in order to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.

7. Samples should be filtered immediately on site before adding preservative for dissolved metals.

8. Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.

9. Sample receiving no pH adjustment must be analyzed within 7 days of sampling.

10. The pH adjustment is not required if acrolein will not be measured. Samples of acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.

11. When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4°C, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re the requirement for thiosulfate reduction of residual chlorine), and footnotes 12 and 13 (re the analysis of benzidine).

12. If 1,2-diphenylhydrazine is likely to be present, adjust the pH of the sample to 4.0 ± 0.2 to prevent rearrangement to benzidine.

13. Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.

14. For the analysis of diphenylnitrosamine, add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.

15. The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

Figure 4.8 Preservative and Holding Times for the Contract Laboratory Protocol

Preservative and Holding Times for the Contract Laboratory Protocol				
			Holding Times	
Parameter	Container	Preservative	Soil	Water
Volatiles by gas chromatography /mass spectroscopy (GC/MS)	Water: 40-mL glass vial with Teflon-lined septa Soil-gas with Teflon-lined septa	Cool, 4°C	10 days	10 days
PCB/Pesticides	G, Teflon-lined lid	Cool, 4°C	Extract within 10 days, analyze 40 days	Extract within 5 days, analyze 40 days
Extractable organics	G, Teflon-lined lid	Cool, 4°C	Extract within 10 days, analyze 40 days	Extract within 5 days, analyze 40 days
Metals	P, G	HNO_3 to pH <2	6 months	6 months
Mercury	P, G	HNO_3 to pH <2	26 days	26 days
Cyanide	P, G	NaOH to pH >12, cool 4°C, add 0.6 g ascorbic acid if residual chlorine present	14 days	14 days
Chromium VI	P, G	HNO_3 to pH <2	24 h	24 h

Figure 4.9 Preservative and Holding Times for the EPA Document - SW-846, 3rd Edition

Preservative and Holding Times for the Contract Laboratory Protocol				
			Holding Times	
Parameter	Container	Preservative	Soil	Water
Volatiles by gas chromatography/ mass spectroscopy (GC/MS) and GC	Water: 40-mL glass vial with Teflon-lined septa Soil-gas with Teflon-lined septa	Cool, 4°C	14 days	14 days
PCB/Pesticides	G, Teflon-lined lid	Cool, 4°C	Extract within 7 days, analyze 40 days	Extract within 7 days, analyze 40 days
Extractable organics	G, Teflon-lined lid	Cool, 4°C	Extract within 7 days, analyze 40 days	Extract within 7 days, analyze 40 days
Metals	P, G	HNO_3 to pH <2	6 months	6 months
Mercury	P, G	HNO_3 to pH <2	28 days	28 days
Cyanide	P, G	NaOH to pH >12, cool 4°C, add 0.6 g ascorbic acid if residual chlorine present	14 days	14 days
Chromium VI	P, G	HNO_3 to pH <2	24 h	24 h

Figure 4.10 Tracking Form

Division One
Enviromental Chemistry

Southwest Research Institute
Tracking Sheet

Project No.
Case
SDG
Client
Work Order

				DOXORUBICIN ANALYSIS FOR DOXORUBICIN		VX-710 ANALYSIS FOR VX-710					
Sample ID	Client Sample ID	CED	VTSR	Required	Actual	Required	Actual	Required	Actual	Required	Actual
52948	AJF0106 SD7 26-28HR	04/18/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52949	AJF0106 SD7 28-32HR	04/18/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52950	AJF0106 SD7/8 32-40	04/18/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52951	AJF0106 SD4/5 72-84	04/13/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52952	AJF0106 SD6 -8-0	04/17/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52953	AJF0106 SD6 0-8	04/17/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52954	AJF0106 SD6/7 8-16	04/17/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52955	AJF0106 SD7 16-24	04/18/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52956	AJF0106 SD5 84-96	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52957	AJF0106 SD5 96-98	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52958	AJF0106 SD5 98-100	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52959	AJF0106 SD5 100-104	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52960	AJF0106 SD5 104-108	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52961	CEH0104 SD9 72-84	04/13/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52962	CEH0104 SD9 84-96	04/13/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52963	CEH0104 SD9 96-98	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52964	CEH0104 SD9 98-100	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52965	CEH0104 SD9 100-104	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				
52966	CEH0104 SD9 104-108	04/14/95	04/20/95	05/18/95	/ /	05/18/95	/ /				

END OF REPORT

Comments or Notes:

Figure 4.11 Hazardous Waste Log

Southwest Research Institute

HAZARDOUS WASTE LOG				
Date	Compound	Quantity (mL)	Name	Project No.

Figure 4.12 Mixed Waste Data Sheet

WASTE DATA SHEET

Item No.	ID Number	Material Description	Material Quantity	Project No.
01				
02				
03				
04				
05				
06				
07				
08				
09				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

I hereby certify that the above information is complete and accurate.

Printed Name _____ Signature _____ Date _____

Figure 4.13 Bulk Waste Data Sheet

WASTE DATA SHEET

Container ID Number (Assigned at Central Storage) _____

Division Hazardous Waste Representative _____ Ext. _____

General Waste Description _____

_____

Quantity in Container(s) _____ kg, lb, cc, oz.

	Chemical Constituents	Concentration
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____
5.	_____	_____
6.	_____	_____
7.	_____	_____
8.	_____	_____

EPA Characterization Codes (D Nos.) _____ _____ _____

EPA Hazardous Waste Number (F, K, P, U Nos.) _____

OSHA: Contain listed compounds? ☐ Yes ☐ No PHS: Infectious Wastes? ☐ Yes ☐ No

Is the waste reactive with water? ☐ Yes ☐ No with air? ☐ Yes ☐ No

Viscosity ☐ Low ☐ Medium ☐ High

Layers at 70°F ☐ None ☐ Two ☐ Multilayers

Give any additional information on the hazards of the waste: pH _____ Flash pt: _____

BTU: _____ Specific Wt: _____ Color: _____

NOTICE: THIS DATA SHEET WILL NOT BE ACCEPTED WITHOUT SIGNATURE AND DATE.

I hereby certify that the above information is complete and accurate.

_____ _____ _____

Signature Title Date

NOTE: PLEASE WRITE YOUR NAME AND BUILDING NUMBER ON EACH DRUM.

4.7 Analytical Procedures

The laboratory currently handles all EPA, ASTM, SW-846, and other methods (see Figure 4.14) used for Routine Analytical Services and Special Analytical Services. These methods shall be readily available to all analysts with detection limits and matrix requirements by method. If variances will be needed the client is contacted in writing regarding these modifications and the purpose for any changes. A notation is made in the analytical report identifying the approval of modification.

Figure 4.14 Laboratory Analytical Methods

CONVENTIONAL PARAMETERS AND BACTERIOLOGICAL ANALYSES ON WATER AND WASTEWATER

Parameter	Methods	
	Std Mtds	EPA
Acidity	402	305.2
Alkalinity	403	310.1
Bicarbonate (only)	403	310.1
Calcium	314B	130.2
Carbonate (only)	403	310.2
Carbon dioxide	410A	
Chloride	407B	325.3
Chlorine demand	409	
Chlorine residual	408F	330.2
Color	204	110.3
Cyanide	412	335.2
Hardness	314B	130.2
Nitrate	418D	352.1
Nitrite	419	354,1
Nitrogen		
Ammonia with distillation	417A	350.2
Ammonia without distillation	417B	350.2
TKN	420B	351.3
Organic (only)		
Oil and Grease		
Separatory funnel technique	503A	413.1
Infrared	503B	413.2
Soxhlet extraction	503C	
Oxygen Demand		
Biochemical	507	405.1
Chemical	508	410.1
Immediate		

CONVENTIONAL PARAMETERS AND BACTERIOLOGICAL ANALYSES ON WATER AND WASTEWATER

Parameter	Methods	
	Std Mtds	EPA
pH Value	423	150.1
Phenol with distillation	410A	420.1
Phenol without distillation	510B	420.1
Phosphorus		
Ortho	424E	365.2
Total	424C	365.2
Residue		
Total	209A	160.3
Total volatile and/or fixed	209F	160.4
Settleable matter	209E	160.5
Total dissolved solids	209B	160.1
Total Suspended solids	209C	160.2
Fixed and volatile solids	209D	160.4
Silica	525	370.1
Specific conductance	205	120.1
Sulfate	426	375.4
Suflide	427	376.1
Sulfite	428	377.1
Surfactants	412B	425.1
Total carbon	505	415.2
Total organic carbon	505A	415.2
Turbidity	214	180.1

QC requirements specified in the methods will be followed

METAL ANALYSES

Metal	AAS/Furnance			AAS/Flame			ICAP/AES		
	SW-846	EPA	CLP-M	SW-846	EPA	CLP-M	SW-846	EP A	CLP-M
Aluminum (Al)		202.2		7020	202.1		6010	200.7	200.7
Antimony(Sb)	7041	204.2	204.2	7040	204.1		6010	200.7	200.7
Arsenic(As)	7060	206.2	206.2	7061	206.1		6010	200.7	200.7
Barium(Ba)		208.2		7080	208.1		6010	200.7	200.7
Beryllium(Be)	7091	210.2	210.2	7090	210.1		6010	200.7	200.7
Boron(B)							6010	200.7	200.7
Cadmium(Cd)	7131	213.2	213.2	7130	213.1		6010	200.7	200.7
Calcium(Ca)				7140	215.1	215.1	6010	200.7	200.7
Chromium(Cr)	7191	218.2	218.2	7190	218.1		6010	200.7	200.7
Cobalt(Co)	7201	219.2		7200	219.1		6010	200.7	200.7
Copper(Cu)		220.2		7210	220.1		6010	200.7	200.7
Gold(Au)		231.2			231.1				
Iron(Fe)		236.2		7380	236.1		6010	200.7	200.7
Lead(Pb)	7421	239.2	239.2	7420	239.1		6010	200.7	200.7
Lithium(Li)									
Magnesium(Mg)	7450				242.1	241.1	6010	200.7	200.7
Manganese(Mn)		243.2		7460	243.1		6010	200.7	200.7
Mercury (Hg)	7470‡ 7471‡	245.1‡ 245.1‡	245.1‡						
Molybdenum(Mo)				7480	2 46.1		6010	200.7	200.7
Nickel(Ni)		249.2		7520	249.1		6010	200.7	200.7
Potassium(K)		258.1		7610		258.1	6010	200.7	200.7
Phosphorus(P)									
Selenium(Se)	7740	270.2	270.2	7741	270.3		6010	200.7	200.7
Silicon(Si)							6010	200.7	200.7
Silver(Ag)		272.2	272.2	7760	272.1		6010	200.7	200.7
Sodium(Na)		273.2		7770	273.1	273.1	6010	200.7	200.7
Thallium(Tl)	7841	279.2	279.2	7840	279.1		6010	200.7	200.7
Tin(Sn)		282.2		7870	282.1				
Titanium(Ti)		283.2			283.1				200.7
Vanadium(V)	7911	286.2		7910	286.1		6010	200.7	200.7
Zinc(Zn)		286.2		7950	289.1		6010	200.7	200.7

* Gaseous hydride
† On request
‡ Manual cold vapor method

ORGANIC ANALYSIS

Parameter	Methods		
	CFR	SW-846	EPA
GAS CHROMATOGRAPHY(GC)			
Halogenated volatile organics	601	8010	502.1
Nonhalogenated volatile organics		8015	
Aromatic volatile organics	602	8029	
Acrolein, acrylonitrile, acetonitrile	603	8030	
Organochlorine pesticides and PCBs	608	8080	505/508
PCBs only	608	8080	508
Chlorinated hydrocarbons	612	8120	
Organophosphorus pesticides	614	8140	507
Chlorinated herbicides	615	8150	515.1
Other analyses not listed			
GAS CHROMATOGRAPHY/MASS SPECTROMETRY(GC/MS)			
Priority pollutants			
Volatile organics (VOAs)	624	8240	524.2
Semivolatile organics using fused silica capillary columns	625	8270	525.1
Up to 10 additional peaks for VOAs and semivolatiles	625	8270	
Polynuclear aromatic hydrocarbons (PAH) using the PAH retention index system	675		
2,3,7,8-Tetrachlorodibenzo-p-dioxin(TCDD) or total TCDD	613		
2,3,7,8-TCDD and 2,3,7,8-TCDF		8280	
Tetra through octa polychlorinated dibenzo-p-dioxins(PCDD) and dibenzofurans (PCDF)		8280	
Tetra through octa PCDD and PCDF		8290	
Special analysis including chemical ionization (pulsed positive ion and negative chemical ionization), PCB isomers, pyrolysis, head space, characterization, etc.			
CONTRACT LABORATORY PROGRAM (CLP) FOR ORGANICS including hazardous substances and additional compounds by GC/MS and GC/EC	Methods listed above		
EPA APPENDIX IX COMPOUNDS (Organics and Inorganics)	Part 261		
FOURIER TRANSFORM INFRARED SPECTROMETER (FTIR) Qualitative and/or quantitative characterization of various organic and inorganic compounds in aqueous and nonaqueous matrices			

ORGANIC ANALYSIS

Parameter	Methods		
	CFR	SW-846	EPA
COMPUTERIZED ULTRAVIOLET-NEAR INFRARED AND ULTRAVIOLET-VISIBLE ARRAY PROCESSOR This array processing system observes the evolution of the UV-visible spectrum at 0.1 second intervals. Data handling is similar to the FTIR (storage, subtraction, etc.). The spectrophotometer has a very large dynamic range and small quantities of chromophoric impurities can be detected.			
NUCLEAR MAGNETIC RESONANCE (NMR) ° Structure identification of organic compounds in aqueous or organic solutions ° High temperature polymer characterization ° Purity analysis of organic materials ° Analysis of ^{1}H, ^{13}C, ^{15}N, ^{17}O, ^{31}P and a number of other nuclei in organic molecules.			
HIGH PERFORMANCE LIQUID CHROMATOGRAPHY (HPLC)			
Polynuclear aromatic hydrocarbons (PAH)		8310	525.1
Explosives		8330	
Carbamate pesticides	531		
LIQUID CHROMATOGRAPHY/MASS SPECTROMETRY (LC/MS) Analysis of high molecular weight polar and nonpolar organic compounds in aqueous and nonaqueous liquids			

MISCELLANEOUS ANALYSIS

Parameter	Method(s)
ION CHROMATOGRAPHY	
Major anions (individual)	
Chloride	EPA 300.0
Fluoride	"
Nitrate-N	"
Mitrite-N	"
Ortho phosphate-P	"
Sulfate	"
Major cations (individual)	
Calcium	Dionex (IC)
Magnesium	"
Sodium	"
Potassium	"
Major anions or cations (complete)	"
Other ions Phenols	Dionex (IC)
Formate	"
Acetate	"
Cyanides	"
Sulfides	"
Others not listed	
BIOTREATABILITY - Lab Study	ASTM D2667-82
X-RAY FLUORESCENCE Metal scan of liquids and solids for elements heavier than sodium	NA
COULTER COUNTER (COMPUTERIZED) Particle size distribution of soils, sediments, dust, etc., from 1 μm to 1 mm. Instrument is capable of performing volume and/or weight distributions.	

RCRA ANALYSIS OF GROUND WATER

Parameter	Methods
INDICATORS OF DRINKING WATER SUITABILITY (IDWS)	
Metals by AAS/Furnace	
Arsenic	EPA 206.2
Barium	EPA 208.2
Cadmium	EPA 213.2
Chromium	EPA 218.2
Lead	EPA 239.2
Mercury*	EPA 245.1
Selenium	EPA 270.2
Silver	EPA 272.2
Sample Preparation	
TOTAL METALS	
PESTICIDES BY GC/ECD	
Endrin Lindane Methoxychlor Toxaphene	CFR 608
2,4-D 2,4-TP (Silvex)	CFR 615
TOTAL PESTICIDES	
RADIOACTIVITY	
Radium 226 and 288	STD 707; 708
Gross Alpha	STD 703
Gross Beta	STD 703
Strontium	STD 704
Tritium	STD 708
TOTAL RADIOACTIVITY	
OTHERS	
Nitrate as N	EPA 300.0 (IC)
Fluorides	EPA 300.0 (IC)
Turbidity	EPA 180.1;STD 214
Total coliform bacteria	STD 909
TOTAL OTHERS	
TOTAL IDWS	

AIR SAMPLES

Parameter
AMBIENT AIR**
Vost Tube (TO 1) or CMS Tube (TO 2) Analysis
Preparation
PUF (TO 10)
Analysis (GC/ECD)
Preparation
2.2 cm ID x 7.6 cm length
6.5 cm ID x 7.6 cm length
8.9 cm ID x 7.6 cm length
Canister (TO 14) Analysis
Canister cleaning
Canister sampler cleaning
Fixed Gases (O_2, N_2, CO_2) Percent
Trace
Formaldehyde† (NIOSH 3500)
Nitrogen oxides† (NO_2, NO_3) by IC
Sulfur dioxide† (total sulfur by ICAP)
Suspended particulate matter† (TSS)
Carbon monoxide
Hydrogen sulfide† (total sulfide by titration)
Asbestos (bulk identification or fiber count)
Others
INDUSTRIAL HYGIENE (PERSONAL SAMPLES)
Chemical substances in the work environment adopted by ACGIH

* The range of adsorbents used to collect contaminants for these types of analysis is broad and includes polyurethane foam (PUF), XAD resins, florisil, charcoal, Tenax and bag sampling. Preparation includes media clean-up and quality control check by an approved and analytical method. Methodology is also varied. Specific sampling and analytical plans are designed on an individual basis to accomplish the goals of each task. Methods are those sepcified by EPA and ACGIH.

** All other TO methods are also performed. Prices upon request.

† From impinger

GEOPHYSICAL TESTING

Parameter	Method
Atterberg Limits	ASTM-4318
Calcium Carbonate	ASTM-4373
Hydrometer	ASTM-D422
Moisture Retention	ASTM-D2325
Moisture Content	ASTM-D2216
Permeability	ASTM-D2434
Procter	ASTM-D69/D1557
Wet Sieve	ASTM-C117/C136
Dry Sieve	ASTM-D422
Specific Gravity	ASTM-C127/C128/C854
Unconfined Compressive Strength	ASTM-C39/C109/D2166
One-Dimensional Consolidation Properties	ASTM-D4186

PERSONNEL QUALIFICATIONS

REV 10

Copy No. _____

Approvals:

Division 01 Quality Assurance	JoAnn Boyd	Date: 6/27/95
Division 01 Management	Donald E Johnson	Date: 6/28/95
SwRI QA Management	T.C. Silovich	Date: 6/27/95

5. PERSONNEL QUALIFICATIONS

All professional staff members in the laboratory shall have a complete understanding of the requirements of the quality assurance program. A control copy of each revision of the plan and a briefing on the plan will be provided by the quality officer or his/her designee.

The QA/QC Officer and QA Auditor will review the QA requirements specific to the project with the Analytical Supervisor and Project Manager prior to starting project. The quality assurance plan for the project will be prepared in accordance with the project requirements. Upon project start-up, the remaining project assignments will be made. All personnel assignments to tasks affecting data quality shall be made on the basis of adequate education, training, and experience. Inexperienced personnel will be closely supervised and provided with standard operating procedures located on the Laboratory Information Management System (LIMS). All project personnel will be trained in QA/QC responsibilities upon assignment to the project.

5.1 Training

New laboratory technicians shall be shown location of controlled copies of the QAPP and standard operating procedures. They will be formally trained by the QA Auditor as well as the Analytical Supervisor. Documentation of any training is maintained in a training file for each employee. All revisions to procedures shall be given to staff maintaining controlled copies (in written form). A new employee training session and annual training are offered to all employees by Division Personnel. Prior to any actual work procedures requiring GLP or Nuclear procedures, employees will be trained by the QA/QC Officer for Good Laboratory Practice Procedures and by the Institute QA for Nuclear Training. Training files will be updated to show the latest training and will be re-evaluated annually.

A training seminar will be held for all new analytical personnel and random refresher trainings for all personnel performing project work will be conducted on an annual basis. This training will cover the following information:

- Quality Assurance Program Plan
- Standard Operating Procedures
- Documentation requirements
- Custody procedures
- Special analytical request procedures
- Contact personnel for questions/problems

* A handout may be provided to supplement the training information.

At the end of the initial QA training session, a Certificate of Completion will be given to the employee and a copy will be put in his/her training file. The personnel training manual will be updated annually with new training information.

5.2 Personnel Safety

The purpose of a laboratory safety program is to provide convenient information for hazard recognition and control. Fires, explosions and exposure to chemical, biological agents, and other hazards can usually be anticipated and therefore prevented.

For these reasons, Southwest Research Institute has developed a Safety Manual which is distributed to every employee. In addition to the Safety Manual, every employee is familiarized and instructed with the proper use of safety equipment in his/her laboratory. According to the Federal (OSHA) Hazard Communication standard each laboratory has a continually updated notebook of Material Safety Data Sheets.

FACILITIES, EQUIPMENT AND SERVICES

REV 8

Copy No. _____

Approvals:

Division 01 Quality Assurance	JoAnn Boyd	Date: 6/27/95
Division 01 Management	Donald E Johnson	Date: 6/28/95
SwRI QA Management	L.C. Silovich	Date: 6/27/95

6. FACILITIES, EQUIPMENT, AND SERVICES

6.1 Cleaning of Sample Preparation Containers

In analyzing for trace amounts of organic and inorganic substances, it is imperative to ensure that all materials that may come in contact with the sample will be free from contamination. Specific instructions for preparation of material will be incorporated into the project work plan, and the instructions in the laboratory SOP will be followed. All glassware used for inorganic and organic analyses shall be cleaned in accordance with the standard operating procedures. The quality of glassware cleaning procedure is checked through the use of method blank preparations with each sample set. Should the blank preparation show the presence of contamination, then the source of contamination is sought by examination of the various components of sample preparation including glassware, reagents, and sample storage containers.

6.1.1 Organic Analysis

All solvents used will be distilled in glass and glassware will be cleaned as specified in SOP-01-08-01.

6.1.2 Inorganic Analysis

During the sample preparation, contamination from the laboratory can also affect the analytes content of the samples. For this reason, all operations which require the same or some stage of its processing to be exposed to the laboratory atmosphere (i.e., weighing operations, opening digestion bombs, etc.) will be performed on clean benches. To reduce the quantity of contamination in the laboratories, routine cleaning will be scheduled into the work week. This is to consist of house cleaning duties at the end of each day and on the last work day of the week the last few minutes will be utilized in very thorough cleaning of the laboratories and equipment. This ensures a minimum of contaminants in the laboratory atmosphere at any particular time.

6.2 Instrument Calibration

6.2.1 Gas Chromatographs shall be calibrated in accordance with SOP 01-05-01.

The analytical coordinator or the analyst will prepare calibration standards that contain the compound(s) of interest. The standards will normally be prepared at concentrations covering two or more orders of magnitude that completely bracket the working range of the chromatographic system.

The analyst will assemble the chromatographic apparatus delineated in the work plan and establish the proper operating parameters for the compound(s) under study. By injecting calibration standards, the analyst will establish the sensitivity limit of the detector and the linear range of the analytical system for each compound.

Prior to using a cleanup procedure, e.g., Florisil column, the analyst will process a set of calibration standards through the system to validate the elution pattern given in the analytical method and the absence of interferences from the reagents used.

A list of equipment and capabilities is listed in Table 1.

6.2.2 Gas Chromatography/Mass Spectrometry shall be calibrated in accordance with SOP 01-05-01.

Daily calibration checks will be made using perfluorotributylamine (FC-43) as the calibration standard. When the calibration is complete, performance evaluation will be made.

For volatile organic analysis, 4-bromofluorobenzene (BFB) is used to tune the mass spectrometer. The key ion abundance criteria are shown in Table 2.

6.2.3 Dioxin shall be calibrated in accordance with SOP-01-13-01 and SOP-01-13-03.

Minimum calibration shall be performed using Native CDDs and CDFs requirements given in the above-referenced SOPs.

6.2.4 Atomic Absorption Spectrophotometry shall be calibrated in accordance with SOPs 01-07-05 and 01-07-13.

This calibration procedure is patterned after "Monitoring Industrial Wastewater," USEPA Technology Transfer, August 1973, Section 8, Preparation of Standards and Calibration. Stock solutions of the metal(s) under study will be prepared using high purity standards and reagents at concentrations of 1000 mg of the metal per liter of water. These stock solutions will be used to prepare the calibration standards.

Prepare a blank acid and calibration standard using the same type of acid as will be used for sample processing. The calibration standards should cover the range of the samples, where this is known or can be reasonably determined. Aspirate the blank, followed by the standards from highest to lowest concentration. To establish that the calibration has not changed, blanks and standards will be run not less frequently than after every 20 samples, but more frequently if in the judgment of the analyst a system change seems likely. Flameless analysis generally requires more frequent continuous calibration verification (after every 10 to 15 samples).

If the sample matrix is so complex that viscosity, surface tension, and components cannot be accurately matched with standards, the method of standard additions will be used. Standard additions will be made to portions of the sample, and the calibration curve will be prepared from the responses to these aspirations. These standards will be analyzed in the same manner and with the same frequency as the reagent standards discussed above. A complete description of the method of additions technique is given in Section 8.5 of "Monitoring Industrial Wastewater."

6.2.5 Ion Chromatograph(s) shall be calibrated in accordance with SOP-11-02

At the beginning of each work day or upon each alteration to the analysis being performed, the analyst will establish the calibration by running a series of standards at a minimum of three concentration levels: low, medium and high. The medium standard will be run after every ten samples to verify the calibration. If the response differs from the calibration response by more than 10%, the analyst will:

- repeat the standard injection to determine if the previous result was correct,
- if correct, repeat the calibration using the three standards,
- rerun all samples after the last consistent calibration check.

6.2.6 Total Organic Carbon (TOC) Analyzer shall be calibrated in accordance with SOP 01-11-01.

The TOC analyzer is internally calibrated to give a direct readout of micrograms per milliliter (μg/mL) of organic carbon. At the beginning of each work day, the analyst will prepare and inject the standard for the appropriate range:

- 10 ppm for 1 mL
- 400 ppm for 250 μl
- 2000 ppm for 40 μl

A second injection of the standard should be performed. If the two are within 5% of each other, the instrument is calibrated as such. A third injection is performed. The output should read within 5% of the standards true value. It this is so, analysis is started.

If this is not true, then calibration is repeated until the standard is adequate. A CCV (standard of original concentration) will be injected after every six sample "sets" of injections, or after six soil sample combustions. If the response differs from the true value by more than 10%, or per client, the analyst will repeat the injection to determine if previous result was correct. If correct, repeat the calibration and rerun all samples after the last consistent calibration check.

Table 1 ANALYTICAL INSTRUMENTATION

Description	Number	Year(s) Purchased
Gas Chromatographs/High Resolution Mass Spectrometer (GC/HRMS)		
■ Fisons Autospec Ultima with CTC A200S autosampler	1	1993
■ Fisons Autospec with CTC A200S autosampler	1	1991
■ Finnigan 8200	1	1989
Gas Chromatographs/Mass Spectrometers/Mass Spectrometers (GC/MS/MS)		
■ Fisons TRIO-III with Waters 600-MS HPLC connected to a Vestec particle beam interface (Universal Interface, Module B)	1	1989
■ Finnigan TSQ-4600	1	1991
Gas Chromatographs/Mass Spectrometers (GC/MS); Total: 17		
■ Finnigan 4600 with CTC A200S autosampler	2	1986
■ Finnigan 4500 with CTC A200S autosampler	1	1985
■ Finnigan 4500 with Tekmar 2000/Dynatec Precision Sampling PTA-30 autosampler	2	1985
■ Fisons TRIO-1S with Entech ELA Model 2000 canister autosampler	2	1991
■ Fisons TRIO-1000 with Tekmar LSC-2000 purge and trap unit/Dynatec Precision Sampling PTA-30 autosampler	1	1992
■ Fisons MD-800 with CTC A200S autosampler	6	1992-94
■ Fisons TRIO-II with CTC A200S autosampler	2	1989
■ Finnigan with ion trap	1	1990
Gas Chromatographs (GC); Total: 24		
■ Hewlett-Packard 5890 GC with NP/FP detectors/a HP 7673A autosampler	3	1986-91
■ Hewlett-Packard 5890 GC with NP detector/a HP 7673A autosampler	1	1988
■ Hewlett-Packard 5890 Series II GC with ion trap	1	1990
■ Hewlett-Packard 5890 GC with a FP detector/a HP 7673A autosampler	1	1991
■ Hewlett-Packard 5890 GC with dual EC detectors/a HP 7673A autosampler	9	1986-91
■ Hewlett-Packard 5890 GC with single EC detectors/a HP 7673A autosampler	1	1986
■ Hewlett-Packard 5890 Series II GC with TC/FP detectors	1	1991
■ Hewlett-Packard 5890 GC with TC detectors/a HP 7673A autosampler	1	1986
■ Fisons GC 8000 GC with dual EC detectors/a CTC A200S autosampler	3	1992
■ Hewlett-Packard 5890 GC with FI/TC detectors/a HP 7673A autosampler	1	1987
■ Hewlett-Packard 5890 GC with FI detector	1	1987
■ Hewlett-Packard 5890 GC with dual pairs of OI PI/ELC detectors/Tekmar LCS-2000 purge and trap unit/Dynatec Precision Sampling PTA-30 autosampler	1	1989

Description	Number	Year(s) Purchased
High Performance Liquid Chromatographs (HPLC); Total: 9		
■ Waters HPLC with Waters 600E multisolvent delivery system capable of generating gradients using up to four solvents, postcolumn derivatization, Waters 420-AC fluorescence, and Waters 700 Satellite Waters Intelligent Sample Processor (WISP) autosampler	2	1989
■ Waters HPLC with 600E multisolvent delivery system, 990 photodiode array detector capable of continuous spectral monitoring and acquisition from 190 to 800 nm, 410 differential refractometer, 700 Satellite WISP autosampler, and U6K manual injector	1	1988
■ Waters HPLC with 600E multisolvent delivery system, 486 tunable absorbance detector, and 600 satellite WISP autosampler	3	1991
■ Waters HPLC with 486 tunable absorbance detector, 470 scanning fluorescence detector, and 717 autosampler	3	1992
Air Sampling and Analysis (Method TO-14 and PM-10)		
■ Anderson or Scientific Instrumentation Specialist (SIS) canisters (6 liter)	210	1988-1993
■ Entech 16-canister sampling manifold	2	1990
■ SwRI canister cleaning system with 16-port manifold, canister heating unit and two diffusion pumps (capable of reaching 10^{-6} torr with 16 canisters on manifold)	1	1993
■ Wedding & Associates, Inc. critical flow high volume sampler	1	1991
Gel Permeation Chromatographs (GPC); Total: 5		
■ Waters GPC with fraction collector, 501 HPLC pump, 440 absorbance detector, and 712 WISP autosampler	4	1990-91
■ Analytical Bio-Chemistry Laboratories with Autoprep 1002A with a fixed wavelength ISCO UH-5 UV detector	1	1986
Radiochemistry		
■ Beckman LS6000TA liquid scintillation counter	1	1993
■ Canberra 2400F proportional counter	1	1993
■ Canberra CWSLC-D gamma and alpha spectroscopy system	1	1993
■ Jarrell Ash 26-000 fluorometer for uranium detection	1	1983
Ion Chromatograph (IC)		
■ Dionex 2020i two conductivity, two electrochemical, and one UV-Vis detectors and Dionex autosampler	1	1985
■ Dionex 4000i with conductivity detector, degas module, and gradient pump	1	1994

Description	Number	Year(s) Purchased
Atomic Absorption Spectrophotometers (AAS)		
■ Perkin-Elmer 4100 Zeeman with Perkin-Elmer AS-60 autosampler	1	1993
■ Perkin-Elmer 5100 Zeeman with Perkin-Elmer AS-60 autosampler	2	1989 1994
■ Perkin-Elmer Fias 400 flow injection system with hydride attachment	1	1994
Inductively Coupled Argon Plasma Atomic Emission Spectrometer (ICP)		
■ Spectro FME-50 with Spectro ultrasonic nebulizer and a microprocessor controlled random access autosampler	1	1992
■ Perkin-Elmer 6500 including a Perkin-Elmer AS-3 automatic microsampler system	2	1984
Ion Chromatograph/Inductively Coupled Plasma/Mass Spectrometer (IC/ICP/MS)		
■ Dionex 4000i IC with Dionex conducting detector and gradient pump connected to Perkin-Elmer Elan 5000 ICP/MS with graphite furnace, flow injection and chelation sample introduction systems	1	1994
Mercury Analyzers		
■ Perkin-Elmer mercury amalgam system for ultralow level mercury detection	1	1994
■ Leeman Lab PS200 automated mercury analyzer	1	1992
■ Leeman Lab AP200 automated mercury digestor	1	1992
■ Perkin-Elmer AA set up for mercury determinations	1	1978
Supercritical Fluid Chromatograph (SFC)		
■ Lee Scientific 622 with pneumatically operated valve system for split/direct SFC injection, split/splitless GC injection, and two FIDs	1	1988
Supercritical Fluid Extractor (SFE)		
■ Suplex SFE-50	1	1990
Microwave Digestor		
■ GT Instruments Milestone MLS 1200 digestor/drying module with GT Fam 35 fumes absorbing module, Em 5 exhaust module and Acm 100 automated capping module	1	1991
Total Organic Halide Analyzer		
■ Xertex Dohrman	1	1982
Total Organic Carbon Analyzer		
■ Xertex Dohrman	1	1982

Description	Number	Year(s) Purchased
Geophysical Testing		
■ Mechanical soil compactor	1	1992
■ Hydrometer jar bath	1	1992
■ US standard sieves with sieve size from 3.5" to 53 μm	1 each	1989
■ Motorized sieve shaker	1	1989
■ Specific gravity set	1	1986
■ Sand density cone	1	1989
■ Five-bar pressure plate extractor	1	1991
■ Electromagnetic vibrator table	1	1991
■ Liquid limit device with removable cup	1	1991
■ Unconfined compressor apparatus	1	1991
■ Liquid limit device with counter	1	1989
■ 12" and 18" standard compaction hammers	2	1992
■ 4" and 6" standard compaction mold	2	1992
■ Sample ejector	1	1992
■ Mechanical analysis stirrer	1	1992
■ Desiccator	4	1986
■ Hydrometer jars	12	1989
■ AASHTO grooving tool	2	1992
■ Plastic limit set	2	1989
■ Compaction permeameters	4	1991
■ Combination permeameter (constant or falling head)	4	1991
■ Table top consolidation apparatus	1	1993
■ Shrinkage limit set	1	1992
■ Multiframe compression test system	1	1980
Wet Chemistry		
■ Technicon TRAACS 800	1	1991
■ Kjeltec System 1026 distilling unit	1	1991
■ Milton Roy Spectronic 1201	1	1990
■ Perkin-Elmer Junior III spectrophotometer	1	1985
■ YSI dissolved oxygen analyzer	1	1989

Table 2 Ion Abundance Criteria

For volatile organic analysis, 4-bromofluorobenzene (BFB) is used to tune the mass spectrometer. The key ion abundance criteria are as follows:

Mass	Ion Abundance Criteria
50	8.0 - 40 % of mass 95
75	30 - 66.0 % of mass 95
95	Base Peak, 100 % of relative abundance
96	5.0 - 9.0 % of mass 95
173	< 2.0 % of mass 174
174	50.0 - 120.0 % of mass 95
175	4.0 - 9.0 % of mass 174
176	93.0 - 101.0 % of mass 174
177	5.0 - 9.0 % of mass 176

For extractable organic analysis, performance evaluation will be performed using decafluorotriphenylphosphine (DFTPP). The key ion abundance criteria are as follows.

Mass	Ion Abundance Criteria
51	30.0 - 80.0 % of mass 198
68	< 2 % of mass 69
69	Mass 69 relative abundance
70	< 2 % of mass 198
127	25.0 - 75.0 % of mass 198
197	<1 % of mass 198
198	Base peak, 100 % of relative abundance
199	5.0 - 9.0 % of mass 198
275	10.0 - 30.0 % of mass 198
365	> 0.75 % of mass 198
441	Present, but less than mass 443
442	40.0 - 110.0 % of mass 198
443	15.0 - 24.0 % of mass 442

Method blanks shall be run to determine background daily and when changing columns to avoid contamination. For quantitation, inject one or more of the appropriate standards at the initiation of each analytical exercise to ensure that the column is performing properly.

There are 10 GC/MS instruments available. The Finnigan 3000 series is 12 years old; the Finnigan 4000 series is less than 6 years old; and all VG GC/MS are less than 1 year old.

6.2.7 Atomic Emission Spectrometry shall be calibrated in accordance with SOPs 01-07-12 and 01-07-25.

Calibration Standards - This calibration procedure is patterned after Test Methods for Evaluating Solid Waste, Method 6010, Paragraph 7.2, 7.3. Stock solutions of the metal(s) under study will be prepared using high purity standards and reagents at concentrations of 1000 mg/per liter. These stock solutions will be used to prepare the calibration standards.

Daily Calibration - At the beginning of each day the instrument will be profiled and calibrated as per the manufacturer specifications. The sample introductory system is optimized before calibration begins. Prepare a blank and calibration standards using the same type of acid as will be used for sample processing. The calibration standards should cover the range of the samples where this is known or can be reasonably determined. Aspirate the blank followed by the standards from highest to lowest.

Initial Calibration Blank (ICB), Initial Calibration Verification (ICV), Continuing Calibration Blank, (CCB) and Continuing Calibration Verification (CCV) - To establish that the calibration has not changed a blank and a continuing calibration verification standard will be run immediately after calibration, then after every 10 samples, and at the end of the analytical run. The standard material for making up the continuing calibration verification standard shall be from a source different than that used to make up the calibration standards. Preferably the use of NBS Standard material shall be employed for this purpose. If one is not available then a source from a different vendor than the one from which the calibration standards were obtained shall be used.

6.2.8 Mercury Analyzer shall be calibrated in accordance with SOP-01-07-24.

The PS200 Mercury Analyzer uses a program called a MACRO. Depending on the MACRO used this instrument will run a 5 point or 6 point calibration curve.

If the curve falls out (r-value of less than .995), the PS200 will automatically re-run the curve.

The check standard must be within $\pm 20\%$ of the true value or the PS200 will automatically recalibrate and rerun the Initial Calibration Blank (ICB) and Initial Calibration Verification (ICV).

The PS200 runs a Continuing Calibration Blank (CCB) and Continuing Calibration Verification (CCV) every 10 samples. If the CCV is not within 20% of true value the instrument will re-calibrate and rerun the last 10 samples before the last CCV run and continue with the sample run.

6.2.9 Radio Chemistry

6.2.9.1 Liquid Scintillation Counter:

The calibration of the liquid scintillation counter shall be checked each day that it is to be used. This shall be performed in accordance with SOP-01-16-05, which is patterned from the procedure in the counter's manual for checking the system's calibration.

During analysis of samples, backgrounds shall be run at the beginning of a procedure and automatically subtracted from the sample's values, or shall be intermixed with the samples and manually subtracted. One background will be run for every twenty samples, and more frequently if necessary. Standards shall be run as necessary, with a minimum of one per run, and more frequently, if necessary.

6.2.9.2 Proportional Counter:

The calibration of the proportional counter shall be checked each day that it is to be used. This will be performed in accordance with SOPs 01-16-12 and 01-16-13, which is patterned from the procedure in the Los Alamos publication *Health and Environmental Chemistry: Analytical Techniques, Data Management, and Quality Assurance*, in the section referencing proportional counter calibration.

One background shall be run for every twenty samples, and more frequently, if necessary. Standards shall be run as necessary, with a minimum of one per run, and more frequently, if necessary.

6.2.9.3 Gamma Spectroscopy System:

The calibration of each gamma detector shall be checked each day that it is to be used. This shall be performed in accordance with SOP 01-16-25, depending on the type of analysis performed. Both methods are patterned from the procedure in the Los Alamos publication *Health and Environmental Chemistry: Analytical Techniques, Data Management, and Quality Assurance*, from the section referencing gamma ray spectroscopy.

While running samples, backgrounds shall be taken initially, and additional ones shall be taken later, if necessary. Standards shall be measured with the detector in question, as necessary.

6.2.9.4 Alpha Spectroscopy System:

The calibration of each alpha detector shall be checked each day that it is to be used. This shall be performed in accordance with SOP 01-16-32. This method is patterned from the procedure in the Los Alamos publication *Health and Environmental Chemistry: Analytical Techniques, Data Management, and Quality Assurance*, from the section referencing alpha ray spectroscopy.

While running samples, backgrounds shall be taken initially, and additional ones shall be taken later if necessary. Standards shall be measured with the detector in question, as necessary.

6.2.10 Other Instrumentation

Other instrumentation including Fourier transform infrared spectrophotometer, nuclear magnetic resonance analyzer, and UV/VIS spectrophotometers will be calibrated according to manufacturer's specifications. Performance checks will be run to assure that the instruments will be operating properly and that operational checks shall be run to verify proper system performance.

6.3 Geophysical Testing Calibration

6.3.1 Attenberg Limits - Method ASTM-4318:

The calibration will be accomplished in accordance with SOP 01-20-15.

6.3.2 Calcium Carbonate - Method ASTM-4373:

The calibration will be accomplished in accordance with SOP 01-20-16.

6.3.3 Hydrometer - Method ASTM-D422:

The calibration will be accomplished in accordance with SOP 01-20-09.

6.3.4 Moisture Retention - Method ASTM-D2325:

The calibration will be accomplished in accordance with SOP 01-20-13.

6.3.5 Moisture Content - Method ASTM-2216:

The calibration will be accomplished in accordance with SOP 01-20-17.

6.3.6 Permeability - Method ASTM-D2434:

The calibration will be accomplished in accordance with SOP 01-20-18.

6.3.7 Proctor - Method ASTM-D69/D1557

The calibration will be accomplished in accordance with SOP 01-20-11.

6.3.8 Wet Sieve - Method ASTM-C117/C136:

The calibration will be accomplished in accordance with SOP 01-20-03 and SOP 01-20-06.

6.3.9 Dry Seive - Method ASTM-D422:

The calibration will be accomplished in accordance with SOP 01-20-09.

6.3.10 Specific Gravity - Method ASTM-C127/C128/C136:

The calibration will be accomplished in accordance with SOP 01-20-04, SOP 01-20-05 and SOP 01-20-07.

6.3.11 Unconfined Compressive Strength - Method ASTM-C39/C109/D2166:

The calibration will be accomplished in accordance with SOP 01-20-01, SOP 01-20-02 and SOP 01-20-12.

6.3.12 One Dimensional Consolidation Properties - Method ASTM-D4186:

The calibration will be accomplished in accordance with SOP 01-20-14.

6.4 Material Procurement and Control

All standards used for analysis of samples shall be made up from neat standards or solutions traceable to standards. All neat standards shall be kept in a refrigerator specifically assigned to the storage of such standards.

All standards used for each analytical area shall be stored in a refrigerator assigned exclusively to the storage of such standards. Analytical standards shall be prepared under a designated laboratory hood.

The preparation of all standards shall be documented in a laboratory notebook. An example of an entry may be sequentially coded with a seven digit number aaa-bb-cc-(L23-STD1), where:

aaa	=	Lab location
bb	=	Notebook number
cc	=	Page number

The preparation of all standards shall be documented in a notebook reserved for this purpose.

All standards labels shall contain as a minimum the following information:

1. standard identification information (i.e., components, concentration, etc.)
2. date prepared
3. expiration date
3. initials of person preparing standard
4. solvent(s) used in preparation

Solvents shall be ordered in lots and marked with lot and date upon receipt at the laboratory. Solvents for the organic analytical area shall be monitored by the extraction laboratory. Chemicals for trace metals shall be monitored by the metals preparation laboratory. Each time an individual solvent or chemical is used the date opened and lot number shall be marked on the solvent bottle.

6.5 Maintenance

All instruments will be maintained in accordance with manufacturer's recommendations and normal laboratory practice. All maintenance will be documented and maintained in permanent records by the individual responsible for each instrument. This will include both routine, scheduled maintenance and unscheduled maintenance required by operational failures.

Each instrument shall be assigned a specific log book in which the following information is recorded:

1. samples analyzed
2. operating conditions
3. routine maintenance
4. date and signature of person(s) making entry
5. supervisory review

Major maintenance for all HP gas chromatographs shall be recorded in a separate logbook. Likewise, all major maintenance for the GC/MS and other analytical systems shall be recorded in a separate logbook.

All documentation in logbooks and other documents shall be in black water-resistent ink. If an error is made, corrections shall be made by crossing a line through the error and entering the correct information. Changes shall be dated and initialed. Inserts shall be taped on page with initials and date of insert written over both insert and logbook page. No information shall be obliterated or rendered unreadable. A copy of the instrument logbook covering all the samples of a project shall be filed in the project file.

6.6 Balances, Refrigerators, and Ovens

Calibration of all laboratory balances shall be verified and the results documented in a logbook on a weekly basis with a complete set of "S" weights by grams. There are top balances located in several of the laboratories. Calibration of balances located in the laboratories shall be verified upon use by the analyst and documented in a separate bound logbook. Balances shall be checked every six months by the Institute Calibration Group with traceable standards to the NIST. An inspection sticker shall be placed on the balance dated and initialed as well as an inspection report being filed.

The temperatures of all refrigerators, freezers, and drying ovens shall be monitored daily and the results documented in a bound logbook. Logbooks shall contain the required temperature for each refrigerator and oven with tolerance ranges. When the tolerances are exceeded, documentation shall be made and the discrepancy reported and repaired. If the ovens are being used for drying glassware, constituting a deviation from analytical temperature, this will be documented in the log.

DATA GENERATION

REV 8

Copy No. _____

Approvals:

Division 01 Quality Assurance		Date: 12/1/95
Division 01 Management		Date: 12/1/95
SwRI QA Management	S.C. Silvernail	Date: 12/6/95

7. DATA GENERATION

To provide high quality data to the sponsor, certain quality control measures must be incorporated into every scope of work and implemented. The numbers and types of quality control samples will be specified by the sponsor in the statement of work. The Proposal/Project Manager and Analytical/Sampling Coordinator shall review these requirements with the QA/QC Officer and QA Auditor and incorporate them along with any additional requirements felt necessary into the work order, the work plan, or the technical or QA project plans as they shall be developed. The QA/QC Officer will be consulted to ensure consistency with organizational goals.

7.1 Quality Assurance Project Plans

The laboratory participates in the following series of blind spiked performance evaluation samples (shipment at the stated frequency) as the external portion of its performance audit program:

- EPA Water Supply (WS) series-semiannual
- EPA Water Pollution (WP) series-semiannual
- Performance Evaluation Samples for proposals
- U.S. Army Corp of Engineers Missouri River Division - 18 months/Contract
- EPA/EMSL Radiochemistry Intercomparison Study
- AASHTO Physical Testing - Round Robin
- MAPED - DOE Performance Study
- EML - DOE Radiochemistry

The nature and frequency of additional internal blind spiked samples needed to assure the accuracy of the project data shall be specified by the analytical coordination in a specific work plan, as required, after consultation with the project manager and the quality officer.

The depth and frequency of internal system audits should depend on the familiarity of project personnel with the instrumentation, methods, and operating procedures to be employed and the frequency of sampling and analysis. The QA/QC Officer or QA Auditor will schedule the audits on an annual basis with changes made for new contracts. Typically the QA/QC Officer or a designated auditor who is not in a production capacity will conduct an initial evaluation of proposed methods and standard operating protocols. The initial systems audit will be performed by the QA/QC Officer or his designated auditor. Follow-up audits will normally be performed by the QA/QC Officer or QA Auditor.

7.2 Quality Control Samples

In each work order or plan, the numbers and types of blank, duplicate, matrix spike and matrix spike duplicate samples will be specified. The frequency of these analyses must be related to the purpose of the study, but the following serve as general guidelines for the development of the quality control portion of the work plan.

At the initiation of an analytical procedure for trace organics and inorganics, the apparatus and the reagents necessary for analysis of samples will be assembled and a Method Detection Limit (MDL) Study will be performed. These blank determinations will involve all reagent solvents and glassware as required in a standard method of analysis and will determine when background peaks are sufficiently low (or absent) to permit the analysis of the sample to proceed. If satisfactory blanks are not obtained in these initial samples, then additional steps will be taken to determine the cause and eliminate it. Once the initial methodology has been established, then blank determinations will be performed as a routine procedure throughout the program as samples are analyzed. A blank will normally be analyzed to verify non-contamination of the samples.

The following tests will normally be run with each designated batch of samples for analysis, as specified in the method/client solicitation: (Results and raw data will be available to the client upon request.

- one method blank,
- one standard at a median concentration, as a continuing calibration verification
- one matrix spike sample for determination of recovery,
- one matrix spike duplicate sample for determination of recovery for organics
- one duplicate analyses of one sample from the batch for repeatability for inorganics

Other Quality Control sample types and their uses are given in the following table.

Type	Purpose
Field Blank	Evaluate handling and shipping procedures
Field Spike	Evaluate laboratory performance
Laboratory Control Sample	Evaluate the laboratory performance (no matrix interferences)

If appropriate to the purpose of the study, these will be incorporated into the work plan and implemented, as required by the client.

7.3 Method Validation

If a method is to be used for which no accuracy and precision statements are available and with which this laboratory has no familiarity, then a series of samples will typically be run to determine these characteristics. The following suggested program is patterned after *"Analytical Quality Control."* (see Bibliography)

The study will include concentrations at three different levels: near the sensitivity limit, near the upper bound of expected values, and in between the two. Seven replicates of each concentration should be made, with all the normal procedural steps involved. The recommended order of analysis is seven sequences of low, medium, and high concentrations, which allows for the maximum interferences during operation.

Calculations of average percent recovery and associated standard deviations, will be available from the EPA Quality Control Manual or the quality officer.

7.4 Documentation and Sample Custody

The maintenance of records on the samples collected, received, and analyzed is a critical part of the laboratory's performance. The following records are normally kept for a sampling and analysis program:

- Field log
- Custody transfer sheet
- Laboratory log
- Data form

The uses of these forms are specified below.

7.4.1 Field Log for Samples Collected by SwRI

All samples taken in the field should be recorded on chain-of-custody sheets. Entries should include the date and time of sampling, intended analysis, preservation, if required, date of shipment to the analytical laboratory, and sample designation. In many programs conducted in this laboratory, the field sampling crew is provided with preprinted labels for attaching to the sample containers as the samples shall be collected. All pertinent information can be placed on the sample label and a Project Identification Number (PIN) assigned for future identification.

7.4.2 Field Chain-of-Custody Documents

The sampling coordinator will be responsible for documenting the samples collected. Documentation will consist of sample labels, field sampling log books, and chain-of-custody forms. Samples will be collected in prelabeled bottles with the appropriate information in waterproof ink. If the sampling is performed by SwRI, the Field Sampling Crew Chief will collect the samples and record the identifying numbers and other pertinent information in the field sampling log book. If the samples are collected by the client, the custody transfer form will serve as permanent documentation.

The Field Sampling Crew Chief will execute the chain-of-custody documentation utilizing the two-part SwRI custody transfer form (Figure 7.1). The disposition of the copies will be as follows:

White	Placed in shipping containers and sent with samples to laboratory
Yellow	Supplied to responsible individual at sampling site as record of samples collected.

7.4.3 Laboratory Custody Procedures

Upon arrival in the laboratory, the Sample Custodian will note the condition of the samples, verify that all sample labels correspond to the identifying numbers on the custody transfer form, and sign and date the transfer form to acknowledge receipt. The sample custodian will retain the original (yellow) part of the form and place it in the permanent project file. The original (white) form will be returned with the data report.

Unless another log-in procedure is specified in the QA Project Plan, the Sample Custodian will ensure that the samples will be registered in the electronic laboratory log book. The following information is entered into the electronic sample log: SwRI System ID number, client sample ID number, sample source, sample description, matrix type, date of receipt, and SwRI project number. The samples will be assigned a unique sample ID number, as they are received as well as the client sample number. The SwRI system ID is a six-digit number sequentially assigned by the Laboratory Information Management System.

The client ID or SwRI control number will be carried through the analytical procedures and all results will have the control number on them as a means of verifying the origin of the result.

Samples with critical holding time requirements will be transferred to the analytical lab immediately by use of the Custody Transfer Sheet (Figure 7.2).

Samples shall be delivered to the Shipping/Receiving Department at SwRI. The Sample Custodian is responsible for transferring samples to the laboratory and for obtaining the original airbill which is kept in the project file.

In the event of Saturday delivery, the Sample Custodian or his designated representative (only Sample custodian is mentioned hereafter) will pick up the samples from the guardhouse at the front gate of SwRI and transfer them to the laboratory.

At the laboratory sample log-in, the Sample Custodian initiates an **SwRI Sample Log-In Form** (Figure 7.3) for each project, or for each set of concurrently arriving samples.

- The Sample Custodian first examines the shipping container and:
  - Records any evidence of tampering or other damage on the Sample Log-In sheet (called the Sheet herein),
  - Records the presence/absence of custody seal(s) on the shipping container,
  - Records the condition of the custody seal(s) (i.e., intact, broken)
  - Removes the custody seal(s), which will be incorporated into the project file
- He/she opens the shipping container, removes the enclosed sample documents and records the following information on the sheet:
  - Log-in date
  - Presence/absence of the chain-of-custody records
  - Receipt of airbill and record airbill number
  - Project or batch number
- The Sample Custodian removes sample containers and sorts them by client sample number sequence.
- Records the condition of samples (intact, broken, leaking, etc.) presence/absence of sample tags on sheet.
- If sample tags are present, will compare them with chain of custody record(s)
- Documents whether these numbers agree, or if there is a discrepancy between tag numbers received and those listed on the chain-of-custody record.
- If sample tags are not listed on the chain-of-custody record, he/she will record this fact.

Figure 7.1 Custody Transfer Form

SOUTHWEST RESEARCH INSTITUTE

CHAIN OF CUSTODY

Client ____________ Sampled by: ____________ WO No.: ____________

Address ____________

Requested Turnaround:
- ☐ 1 Week
- ☐ 2 Weeks (Normal)
- ☐ 3 Weeks
- ☐ Other: ____________

Project No.: ____________

City ____ State/Zip ____

Project Manager: ____________

Attention ____ Telephone # ____

Sample ID	Date Sampled	Time Sampled	Matrix	# of Containers	Preservative	pH	Sample Condition	Analyses Requested

Relinquished by:	Date/Time:	Received by:	Date/Time:	Relinquished by:	Date/Time	Comments:
Received by:	Date/Time:	Relinquished by:	Date/Time:	Received by:	Date/Time	

P 1002

Figure 7.2 Custody Transfer Sheet

SwRI Sample Custody Transfer Sheet

CLIENT: _____ PROJECT NUMBER: _____
DATE: _____ VTSR: _____ TIME: _____
SAMPLE ID(s): _____ _____
_____ _____
_____ _____
_____ _____

RELINQUISHED BY: _____ OF _____
DATE: _____ TIME: _____

RECEIVED BY: _____ OF _____
DATE: _____ TIME: _____

RELINQUISHED BY: _____ OF _____
DATE: _____ TIME: _____

RECEIVED BY: _____ OF _____
DATE: _____ TIME: _____

RELINQUISHED BY: _____ OF _____
DATE: _____ TIME: _____

RECEIVED BY: _____ OF _____
DATE: _____ TIME: _____

RELINQUISHED BY: _____ OF _____
DATE: _____ TIME: _____

RECEIVED BY: _____ OF _____
DATE: _____ TIME: _____

RELINQUISHED BY: _____ OF _____
DATE: _____ TIME: _____

RECEIVED BY: _____ OF _____
DATE: _____ TIME: _____

RELINQUISHED BY: _____ OF _____
DATE: _____ TIME: _____

RECEIVED BY: _____ OF _____
DATE: _____ TIME: _____

Figure 7.3 SwRI Sample Log-In Sheet

Southwest Research Institute
Traffic Report
Sample Custodian Signature: _____

Date: 11/08/95
Project: 01-5109-30X
CASE #: CLS / SDG: 541-8031007
Airbill: 3591611494
Work Order #: 0000006012

1. Custody Seal — Not Present or Damaged
2. Chain of Custody — Not Present
3. Sample Tags — Not Present
   Sample Tag Numbers — Not on COC
4. SMO Forms — Not Present

Date RecD	Time RecD	COC Record #	SMO Sample #	Corresponding		TFIC RPT, TAGS, COC AGREE Y/N	Cond of Sample
				Sample Tag #	SwRI Lab #		
08/31/94	09:30	NONE	541-8031007	NONE	46454		INTACT
08/31/94	09:30	NONE	542-0852004	NONE	46455		INTACT
08/31/94	09:30	NONE	543-5951009	NONE	46456		INTACT
08/31/94	09:30	NONE	544-9171000	NONE	46459		INTACT
08/31/94	09:30	NONE	545-5351002	NONE	46460		INTACT
08/31/94	09:30	NONE	546-9071002	NONE	46461		INTACT
08/31/94	09:30	NONE	547-1782004	NONE	46462		INTACT
08/31/94	09:30	NONE	548-5131008	NONE	46463		INTACT
08/31/94	09:30	NONE	549-0391003	NONE	46464		INTACT
08/31/94	09:30	NONE	550-9491002	NONE	46465		INTACT

PAGE 001

- Compares the following documents to verify agreement of the information contained in them:
  - Chain-of-custody record(s)
  - Sample tags
  - Packing lists
  - Airbill

- Documents both agreement among the forms and any discrepancies found.
- Completes the custody sheets for each sample:

  - Condition of sample containers (good, broken, leaking, headspace on volatile water samples, etc.)
  - Custodian signature and date received
  - Sample delivery group identification

If all samples recorded on the chain-of-custody record were received by the laboratory and there are no problems observed with the sample shipment, the custodian signs the chain-of-custody record in the "received for laboratory by:" box on the document. If problems are noted, a Log-in Non-conformance detailing the problems is FAXED to the client. The problems and client directions shall be detailed in a telephone conversation record reported to appropriate lab personnel and stored in the project file and described in the narrative.

The information on the date and time of sample receipt, chain-of-custody record number, sample numbers, SwRI laboratory numbers, and sample tag numbers is recorded on the table of the sample log-in sheet and the inter-laboratory work order (Figure 7.4) Samples will be logged into a bound logbook documenting information needed for tracking. (Figure 7.5)

The Sample Custodian then removes sample tags from sample containers and adds them to the project file. A Sample Control Record (Figure 7.6) is filled out for each location at which samples will be stored (Volatiles in the locked refrigerators for volatiles, pesticides/semivolatiles/inorganics in the locked walk-in refrigerator). Samples will be stored in the appropriate location, and the Sample Control Record remains on a notebook by the correct storage location.

The Sample Custodian then generates and prints the Laboratory Work Order (which will be incorporated into the appropriate sample tracking file) with the holding dates, QC requirements, and deliverables deadlines, attaches a copy of the custody sheets and distributes a copy of the entire set to the appropriate personnel.

Finally, the Sample Custodian assembles all paperwork in the project file in the sequence specified in the standard project file inventory. Typically, these documents will include the airbill, chain-of-custody record, UPS records of sample cooler return, the sample tags and cooler seals, and the photocopy and carbon copies of the custody sheets.

Figure 7.4 Laboratory Work Order

Southwest Research Institute

Laboratory Work Order

Serial Number 6012

VTSR: 31 August 94 Time: 09:30

Project: 01-5109-30X
Case #: CLS
SDG : 541-6031007
Client: CHILDHOOD LEUKEMIA STUDY

Manager: CAMANN, DAVID
Logged in by: JMORIN
Creation Date: 04 October 94
Checked by: _____

Notes

SAMPLES RECEIVED AT ROOM TEMP.

EACH WORK ORDER IS A NEW SDG.

TAT IS BASED ON LAST SAMPLE RECEIVED WITHIN A MONTH.

THIS IS A TWO AND ONE HALF YEAR PROJECT, SEE PROJECT MANAGER FOR DETAILS.

System ID	#	QC	Customer ID	CED	Matrix	Required Analyses
46454	1		541-6031007	08/31/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
46455	1		542-0852004	09/01/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
46456	1		543-5951009	09/02/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
46459	1		544-9171000	09/06/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
46460	1		545-5351002	09/07/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
46461	1		546-9071002	09/08/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
46462	1		547-1762004	09/13/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
46463	1		548-5131006	09/14/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
46464	1		549-0391003	09/21/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
46465	1		550-9491002	10/03/94	DUST	CLS-PAH, CLS-PEST, ECLS, SWCLS
						Samples: 10

Data must be to QA..... 28 August 95
Absolute Latest Date..... 30 August 95

Samples Received to Date: 010
Turnaround time is 365 Days from VTSR.

Date Printed: 08 November 95 Time Printed: 13:37:47

Work Orders in this SDG:

6012

* - Indicates work group contains an MS/MSD

Thermometer: 1
Temperature: 22

Page Number: 001

ver (05/16/95)

Figure 7.4 Laboratory Work Order (cont.)

Test Code Key

Southwest Research Institute

Serial Number 6012

VTSR: 31 August 94 Time: 09:30

Manager: CAMANN, DAVID

Project: 01-6109-30X
Case #: CLS
SDG: 541-8031007
Client: CHILDHOOD LEUKEMIA STUDY

NOTES

SAMPLES RECEIVED AT ROOM TEMP.

EACH WORK ORDER IS A NEW SDG.

TAT IS BASED ON LAST SAMPLE RECEIVED WITHIN A MONTH.

THIS IS A TWO AND ONE HALF YEAR PROJECT. SEE PROJECT MANAGER FOR DETAILS.

Group	Test	Start	Method Date	Deadline	Number	Description	Fridge	Shelf
EXT	ECLS	Wer	10/30/94	10/30/94	10	EXTRACTION - DUST/SEE DAVID CAMANN (60 DAYS ADVISORY)	FRZ29	MID
EXT	SWCLS	Wer	09/30/94	09/30/94	10	SIEVE AND WEIGH SAMPLE/SPLIT (30 DAYS ADVISORY)	FRZ29	MID
TDG	CLS-PAH	Wer	02/27/95	02/27/95	10	PAH ANALYSIS - SEE DAMANN (180 DAYS ADVISORY) GC/MS (FISIONS MD800) SEE ATTACHED LIST	FRZ29	MID
TDG	CLS-PEST	Wer	02/27/95	02/27/95	10	PESTICIDE ANALYSIS - SEE CAMANN (180 DAYS ADVISORY) GC/MS (FISIONS MD800) SEE ATTACHED LIST	FRZ29	MID

Date Must be to QA Unit..... 28 August 95

Absolute Latest Date..... 30 August 95

Date Printed: 11/08/95

Time Printed: 13:39:02

Figure 7.4 Laboratory Work Order (cont.)

Distribution List

Serial Number 6012

SwRI
Division 1

BOYD, JOANN
CAMANN, DAVID
CUMMINS, WAYNE
EDRISI, HAMED
GENO, PAUL
LOGIN AREA
MAJUMDAR, TAPAN
VILLALOBOS, KEVIN
YAU, ALICE

Number of Copies: 9

Number of Work Orders: 9

Date Printed: 11/06/95

Figure 7.5 Electronic Sample Log-in

SwRI Login Area
Division 1

Sample Login Book
11/07/95

Work Order: 7960	Project: 01-2887-300	Client:HEB
VTSR Date: 11/07/95	VTSR Time: 07:59	Manager: SCHATTENBERG, HERB

System ID	Customer Sample ID	Matrix	Assay
62420	(CC-A)CUCUMBERS	CUCUMBERS	FC CA, FC OC, FC OP
62421	(GW-A)GRAPES, WHITE	GRAPES, WHIT	FC CA, FC DI, FC OC, FC OP
62422	(TN-A)TANGERINE, FAI	TANGERINE, F	FC CA, FC OC, FC OP
62423	(BR-A)BROCCOLI	BROCCOLI	FC CA, FC OC, FC OP
62424	(CT-A)CARROTS, CELLO	CARROTS, CEL	FC CA, FC OC, FC OP
62425	(RP-A)POTATOES, RUSS	POTATOES, RU	FC CA, FC OC, FC OP
62426	(RD-A)APPLES, RED DE	APPLES, RED	FC CA, FC OC, FC OP
62427	(TN-B)TANGERINE, FAI	TANGERINE, F	FC CA, FC OC, FC OP
62428	(6D-A)(KROPF)RED DEL	(KROPF)RED D	FC CA, FC OC, FC OP
62429	(EW-A)ROMA TOMATOES	ROMA TOMATOE	FC CA, FC OC, FC OP

Work Order: 7966	Project: 01-6746-259	Client:SOUTHERN PETROLEUM
VTSR Date: 11/07/95	VTSR Time: 10:00	Manager: SUN, GANG

System ID	Customer Sample ID	Matrix	Assay
62448	9511056-01A	LIQUID	ICP_MS

Work Order: 7964	Project: 01-7804-001	Client:NOAH TECH
VTSR Date: 11/07/95	VTSR Time: 10:20	Manager: DAMMANN, MIKE

System ID	Customer Sample ID	Matrix	Assay
62441	3069/1.1	LIQUID	AMMONIA, FE, MET, PH, SO4, WETCHEM

Work Order: 7969	Project: 01-7518-024	Client:SAN ANTONIO WATER
VTSR Date: 11/07/95	VTSR Time: 13:40	Manager: DAMMANN, MIKE

System ID	Customer Sample ID	Matrix	Assay
62452	511 SUSANWOOD	WATER	HG

Page Number: 1222

Printed: Tuesday, 11/07/95 at 16:56:40

Rev (9/20/95)

Figure 7.6 Sample Control Record

SwRI Sample Control Record (EXT, TDG) Client: CHILDHOOD LEUKEMIA STUDY

Required Analysis: CLS-PAH, CLS-PEST, ECLS, SWCLS Refrigerator: FRZ29 Shelf: MID

Project: 01-5199-30X
Case: CLS
SDG: 541-8031007
Work Order #: 6612
Logged In: 8/31/94 JMORIN

					DATE							
					TIME							
					BY							
					Analysis							Disposal
System ID	Customer ID	Matrix	#	Cont. Desc	Section	Lab Out	Lab In	Lab Out	Lab In	Lab Out	Lab In	OUT
46454	541-8031007	DUST	1									
46455	542-0852004	DUST	1									
46456	543-8051009	DUST	1									
46459	544-9171000	DUST	1									
46460	545-5351002	DUST	1									
46461	546-8071002	DUST	1									
46462	547-1762004	DUST	1									
46463	548-5131008	DUST	1									
46464	549-0391003	DUST	1									
46465	550-9491002	DUST	1									

For Transfer of Custody...note below on this form the date, from whom, to whom, and reason for the CoC.

Number of Samples: 10 Number of Containers: 10

7.5 Sample and Extract Storage

7.5.1 The following procedures shall be used to control the storage of samples:

1. Immediately after sample receipt and log-in, samples shall be stored in a secure area designated for samples. The samples shall be stored in their original containers unless damaged. The client is contacted regarding any problems. Damaged samples shall be disposed of in an appropriate manner and this disposal is documented.

   The following areas are designated for storage of samples:

   - Volatile soil and water samples shall be stored in a locked refrigerator/freezer located in the volatiles area.
   - Soil and water samples for semivolatiles/pesticide/inorganics analysis shall be kept in locked walk-in coolers, as designated.
   - Dioxin samples are stored in separate refrigerators.
   - Potentially radioactive samples are stored in the Radiochemistry refrigerators.

   Under no circumstances will samples be stored in the same refrigerator/freezer as standards or quality control samples. The storage areas shall be kept secure at all times. The sample custodian shall control access to the storage area through custody documentation. Control of keys is documented by a signature list.

2. Whenever samples are transferred into or out of storage, the transfer shall be documented on a SwRI Sample Control Record sheet. (Ordinarily, samples will only be removed once for the purpose of extraction, digestion, or analysis.)

3. The location of stored samples shall be recorded on the Sample Control Record.

4. Volatile, Dioxin, and Radiochemistry samples shall be stored separately from other samples.

5. The temperatures of the refrigerators and freezers shall be recorded on regular work days.

6. Samples shall be disposed of according to Standard Disposal Procedures. Samples may be disposed of 60 days after data submission of the data package. (See Standard Operating Procedures for sample and extract storage.)

7.5.2 The following procedures shall be used to control the storage of sample extracts:

1. Sample extracts shall be preserved in bottles/vials with Teflon-lined septa and maintained at 4°C. Pesticide and semivolatile extracts will be stored in a locked refrigerator devoted exclusively to the storage of sample extracts. Sample extracts shall not be stored with standards or extracts from industrial clients.

2. Immediately upon generating the sample extract, it is stored in the appropriate location and a Sample Control Record is initiated for the extracts for that project. Each Sample Control Record is used to record only samples from that particular project. Extracts remain in locked sample storage until removed for analysis.

3. Whenever sample extracts are removed from the storage area, this is documented on a Sample Control Record. After an extract has been removed for storage by an analyst, the analyst is responsible for the custody of the sample. Each analyst must return the extracts to the storage area before the end of the working day. In the event that samples or sample extracts shall be transferred from one analyst to another, this fact must be documented on a Sample Control Record documenting change of custody. If the extract is used in entirety, this shall be documented on the Sample Control Record.

4. After final submission of analytical data for the particular project, all sample extracts for the project are boxed (along with the VOA samples), and stored in a locked refrigerator. This fact is also documented on the appropriate Sample Control Records.

5. Within 60 days after data submission, SwRI will dispose of samples and sample extracts.

7.6 Preventing Sample Contamination

Preventing contamination of samples, sample extracts, and standards is a continuous process starting with the log-in and storage and continuing throughout all stages of analysis.

7.6.1 Sample Log-in and Storage

Sample containers shall be checked for damage or leakage upon arrival. Any sample showing signs of damage or contamination is disposed of in an appropriate manner. This is documented, the client is contacted, and the issue is discussed in the project narrative or report.

Soil and water samples shall be stored in a locked walk-in refrigerator devoted exclusively for the storage of these samples.

Standards shall not stored with samples.

7.6.2 Sample Extraction for Organic Analysis

To keep sample contamination to a minimum during all processes, the following laboratory procedures are followed:

1. Extraction glassware used for extraction of low level samples is kept separately from glassware used for extraction of higher level samples.

2. Phthalate contamination is minimized by avoiding the use of plastics in the organic extraction laboratory.

3. All extraction solvents will be pesticide grade or equivalent.

4. Cleaning of laboratory glassware is done according to standard operating procedures.

7.6.3 Storage of Sample Extracts

Pesticide and semivolatile extracts generated from the extraction of samples shall be kept in a locked refrigerator specifically assigned to the storage of these samples. Separate locations shall be assigned to the storage of standards and of extracts from other industrial clients.

7.7 Security for Laboratory and Samples

The National Enforcement Investigations Center (NEIC) of EPA defines custody of evidence in the following ways:

1. It is in your actual possession, or

2. It is in your view, after being in your physical possession, or

3. It was in your possession and then you locked it up or sealed it up to prevent tampering, or

4. It is in a secure area.

To satisfy these custody provisions, the following standard operating procedures are implemented by SwRI Chemistry and Chemical Engineering Division:

1. Samples and extracts shall be stored in a secure area.

2. Access to the laboratory in the main building (Bldg 70) is through a monitored reception area, and all exit doors shall be auto-locking. All other buildings follow the same security procedures. All SwRI employees must wear a picture identification badge. Any person in the lab without an employee badge or a visitor identification badge is escorted to the reception area.

3. All personnel entering or leaving the building outside of regular working hours will be required to sign-in, documenting time of arrival and/or departure.

4. Visitors must sign-in the reception area and be escorted while in the laboratory.

5. Refrigerators, freezers, and other sample storage areas will be kept locked.

6. Only the designated sample custodian and designated personnel have keys to the sample preparation or analysis.

7. Samples and extracts remain in locked sample storage until removed for sample preparation or analysis.

8. All transfers of samples and extracts into and out of storage or from one analyst to another shall be documented on a Sample Control Sheet.

9. These internal custody records will be maintained by the Sample Custodian.

10. After a sample or extract has been removed from storage by the analyst, the analyst is responsible for the custody of the sample. Each analyst must return the samples or extract to the storage area before the end of the working day. If the extract is used in entirety, this shall be documented on the Sample Control Record.

7.8 Traceability of Standards

All standards used for analysis of samples will be made up from neat standards or solutions provided by an outside source traceable to the NIST.

All neat standards shall be kept in a refrigerator specifically assigned to the storage of such standards. Only pesticide grade or equivalent solvents will be used to prepare working standards.

All standards will be stored in designated refrigerators assigned exclusively to the storage of such standards. If indicated, analytical standards shall be prepared within the laboratory hood.

The preparation of all standards shall be documented in a laboratory notebook.

All standards labels must contain as a minimum the following information:

1. Standard identification information (i.e., components, concentration, etc)
2. Date prepared
3. Expiration date
4. Initials of person preparing standard
5. Solvent(s) used in preparation

If standards will be stored in noncalibrated glassware, volumes shall be marked and monitored.

7.9 Maintaining Instrument Records and Logbooks

Each instrument is assigned a specific log book in which the information shall be recorded as shown in section 6.4.

Major maintenance for all instruments is recorded in a separate logbook.

All documentation in logbooks and other documents shall be as shown in Section 6.4.

7.10 Analysis Work Order Form

An analysis work order form (Figure 7.4) will be provided to each analyst which indicates the type of analysis and the specific parameters to be sought. The sample identifier is placed on the form to minimize the risk of the analyst assigning an analytical result to the wrong sample. Other items noted on the work order form will be the date of receipt, collection end date, holding time requirements, deliverables requirements, and the QC required for the project.

7.10.1 Data Reporting Forms

Analytical results shall be reported by the analyst who is assigned responsibility for these specific parameter(s). Included on the data will be sample identification, analytical results for blanks and samples, quality control results including matrix spikes, matrix spike duplicates, date of analysis, and signature of analyst. All supporting material for the analytical results such as strip charts, computer printouts, and copies of laboratory notebooks will be submitted with data for archive requirements.

The analytical coordinator or his/her designee reviews the data reporting form for the quality of the data. The data package then is submitted to the QA/QC officer for required QA/QC validation, narrative construction identifying the problems incurred and construction of the data package. The data is then submitted to the analytical coordinator for final review. After this review, any remaining deficiencies shall be corrected, the project manager is notified for a review of the data to be submitted, and the data is made a part of the permanent project file.

7.10.2 *Maintenance of Records*

All records will be kept on file for the duration of the project in the central files at the San Antonio laboratory. Upon completion of the project, the files shall be transferred to inactive status and maintained for a minimum of two years.

7.10.3 *Data Evaluation*

All data generated by this laboratory will undergo a thorough review and validation prior to their release to the sponsor. The review process will be specified in the work plan and will follow the guidelines delineated in Section 8 of this document.

7.11 Standard Operating Procedures

The standard procedures listed in this document and any procedures supplied by the sponsor will be incorporated into the work plan quality assurance program by reference. Additional standard operating procedures shall be prepared by the analytical coordinator to describe routine tasks which shall be delegated and/or performed frequently.

7.12 Study Planning and Design

If the data are to be useful to the client, then the studies must be designed in a manner that will provide valid defensible results. Considerations in this regard include:

- selection of numbers of samples, locations of samples and acceptable conditions for sample collection,
- sampling methodology and analytical methodology used,
- selection of parameters for study and of data to be measured concurrently,
- inclusion of quality control samples, including field blanks and spikes, samples for analysis by an alternative laboratory, and others as appropriate,
- frequency and depth of performance and systems audits,
- statistical soundness in terms of the ability of the plan to address the questions under study.

All of these factors should be considered in developing the work plan in order to allow the underlying questions to be answered in a timely and efficient manner.

DATA PROCESSING

REV 6

Copy No. _____

Approvals:

Division 01 Quality Assurance _____ Date: 11/30/93

Division 01 Management _____ Date: 11/30/93

SwRI QA Management L.C. Silovnik Date: 12/1/93

8. DATA PROCESSING

Each work plan will describe procedures to collect, validate, store, transfer, and reduce all data generated. General procedures are given below.

8.1 Collection

The Analytical Supervisor will prepare the data for the recording of data generated on each program. Each analyst will provide the analytical data pertinent to the analysis being performed and will execute these upon completion of the analysis. The analyst will be responsible for reviewing the data as it is generated to ensure that the results shall be reasonable and interpretable and that all information required for recalculation of the results is available. The analytical data sheets, chromatograms, absorbance traces, or spectra, and supporting information will be supplied to the analytical coordinator for review.

8.2 Validation

The Analytical Supervisor for each analytical task will perform a review of all data. This review will consist of the following elements: review of analytical program, examination of results, verification of results to insure the QC requested by the client. The data is then validated by the QC validator who is independent of the actual production of the analytical results.

8.2.1 Review of Analytical Program

The Analytical Supervisor will review each set of results to ensure that the required program elements, including method blanks, surrogate spikes, and QC samples, have been accomplished according to the project workplan. The supporting data will be reviewed to ensure that analyses were performed under the correct conditions and that all required procedural steps were performed.

8.2.2 Examination of Results

The Analytical Supervisor will examine the results obtained along with the pertinent chromatograms, spectra, or absorption traces to ensure that the results shall be reasonable and that the analyst has interpreted the results correctly. Any unusual or unexpected results will be reviewed and a resolution will be made as to whether the analysis should be repeated or the result recalculated.

8.2.3 Recalculation of Results

The Analytical Supervisor will selectively recalculate results to ensure that the calculation was performed properly. Emphasis will be placed on those results showing a significant concentration of one or more of the analytes of interest. As a minimum, one set of calculations will be checked for each batch of samples analyzed.

8.3 Data Storage

The QA/QC officer will have the responsibility for the control and protection of archived data. Where the project deals with material of a sensitive or confidential nature, measures will be included in the work plan to ensure that access is limited to those individuals who have agreed to be bound by terms of the confidentiality agreement and who have a need for the information.

8.4 Data Transfer

Following the analyst review, the verified data will be transferred from the analytical data sheets to reporting forms. The analyst will be responsible for ensuring that all required information is provided for validation purposes. All data will be verified against the analytical data sheets, and the completed forms will be reviewed by the Project Manager or his designee prior to submission of the results to the sponsor.

8.5 Data Reduction

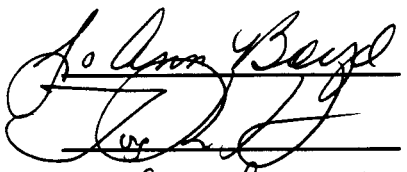
Data reduction will be carried out using prescribed documented techniques. Any statistical summaries of the data will be presented in such a manner that the reviewer can easily judge the validity of the procedure and of any conclusions drawn. Assumptions made in performing any statistical analyses will be clearly stated, as will confidence/ significance levels used for any tests of hypotheses. Data summaries will be checked against the raw data for consistency and summary statistics recalculated in the event of doubt.

DATA QUALITY ASSESSMENT

REV 6

Copy No. _____

Approvals:

Division 01 Quality Assurance  Date: 11/30/93

Division 01 Management _____ Date: 11/30/93

SwRI QA Management _____ Date: 12/1/93

9. DATA QUALITY ASSESSMENT

The data report shall include the accuracy and precision data designed during the project. Upon request, accuracy and precision will be performed from analysis of spiked samples, replicate samples, or other designated QC requests. If the samples will be collected by SwRI, a statement will be included assessing the degree to which the samples represent the entity being sampled. (e.g. 10% of sampling).

CORRECTIVE ACTION

REV 9

Copy No. _____

Approvals:

Division 01 Quality Assurance	Jo Ann Boyd	Date: 9/10/96
Division 01 Management	Donald E Johnson	Date: 9/10/96
SwRI QA Management	S. C. Silovich	Date: 9/13/96

10. CORRECTIVE ACTION

The ultimate responsibility for maintaining quality of the analyses and sampling lies with the management of the department and division. The routine operation of the quality assurance/quality control program, however, falls upon the analysts, Laboratory Supervisors, Analytical, and Sampling Coordinators, QA Auditor, Project Managers, and the QA/QC Officer. Major responsibilities are discussed in Section 4.2. Evaluation of the QA/QC Program is discussed in Section 4.5. QA/QC reporting is also discussed in Section 4. For further information refer to SwRI SOP 01-12-02 "Internal Inspections".

It is the responsibility of the project personnel to identify perceived problems which may affect data quality and to report these problems both to their project supervisor and to their quality team contact. If the supervisor regards the problem as serious enough to potentially impact data quality, he/she will initiate appropriate corrective action. Corrective action relates to the overall QA management scheme: who is responsible for taking corrective actions; when corrective actions are to be taken; and who follows-up to see that corrective actions have been taken and that they have produced the desired results. Results from the following QA activities may indicate a need for corrective action:

1. Performance audits
2. Systems audits
3. Inter-laboratory comparison studies
4. Failure to adhere to a QA Program or Project Plan or to a Standard Operating Procedure

Non-compliances will be minimized through specification (in the work plan or operating protocols) and implementation of internal controls prior to an adverse project impact. Each measurement system shall have limits to establish when corrective action must be taken. A procedure shall be established for each measurement system to show what corrective action will be followed when established limits for this procedures have been exceeded. The level within the organization that is responsible for taking corrective action shall also be specified.

The process involves corrective actions to the areas involved and management. Responses to corrective actions indicating the cause of the problem and corrective actions to prevent recurrence shall be submitted for inclusion in the final report. A copy of the corrective action form is presented in Figure 10.1

□

Figure 10.1 Corrective Action Form

CAR # _____

Southwest Research Institute
Division 01

CORRECTIVE ACTION REQUEST

(To be filled out by QAU)

Discrepancy:

Initiated by: _____ Date _____

Area Supervisor Responsible _____

Response Due Date : _____

(To be filled out by Area Supervisor/Study Director/Project Manager)

ROOT CAUSE:

- ☐ Equipment Problem
- ☐ Procedural Problems
- ☐ External Phenomena
- ☐ Analyst Error
- ☐ Management Problem
- ☐ Training Deficiency

Corrective Action Taken:

Suggested Corrective Action to Prevent Recurrence:

Date for Completion of Corrective Action: _____

Supervisor : _____ Date: _____

Proposed Corrective Action Approval: _____ Date: _____
(QAU Group Leader)

QAU Verified _____ **Date** _____

cc: **J. Boyd**
D. Johnson
T. Trbovich
Study Director/Area Supervisor

BIBLIOGRAPHY

REV 6

Copy No. _____

Approvals:

Division 01 Quality Assurance _____ Date: 11/30/93

Division 01 Management _____ Date: 11/30/93

SwRI QA Management _____ Date: 12/1/93

11. BIBLIOGRAPHY

Guidelines and Specifications for Preparing Quality Assurance Program Plans, EPA, QAMS-005/80, December 29, 1980

Handbook for Analytical Quality Control in Water and Wastewater Laboratories, EPA-600/4-79-019, March 1979

Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, EPA, QAMS-005-80, December 29, 1980

Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, EPA, QAMS-004-80, December 20, 1980

Manual of Analytical Quality Control for Pesticides and Related Compounds in Human and Environmental Samples, EPA-600/1-79-008, January 1979

Quality Assurance for Environmental Measurements, J. K. Taylor and T. W. Stanley (eds.), ASTM STP867, 1985

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I, "Principles", EPA-600/9-76-005, March 1976

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, "Ambient Air Specific Methods", EPA-600/4-77-027a, May 1977

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, "Stationary Source Specific Methods", EPA-600/4-77-027b, August 1977

Quality Assurance Requirements, DOE 5700.6C, August 21, 1991, Office of Nuclear Energy, Office of Environment, Safety, and Health.

American Society of Mechanical Engineers (ASME)/NQA-1, Quality Assurance Program Requirements for Nuclear Facilities.

American Society of Mechanical Engineers (ASME)/NQA-2, Quality Asurance Requirements for Nuclear Facility Applications

SW-846, Test Methods for Evaluating Solid Wastes, Chapter 1.

Sampling and Chemical Analysis Quality Assurance Requirements for the Navy Installation Restoration Program, NEESA 20.2-047B, June 1988.

11. BIBLIOGRAPHY

Interim Draft EPA Requirements for Quality Management Plans, EPA QA/R-2, July 1993

EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations, EPA QA/R-5, July 1993

RADIOACTIVE MATERIAL LICENSE

SOUTHWEST RESEARCH INSTITUTE

INTERNAL MEMORANDUM

November 21, 1995

TO: Radiological Health and Safety Committee

FROM: John P. Hageman, Radiation Safety Officer John P. Hageman

SUBJECT: License Renewal And Response to Several Requested License Amendments.

The Bureau of Radiation Control has renewed our Radioactive Material License, which was submitted to the Bureau on November 16, 1993. The Bureau has also approved the four pending License Amendment requests of: (i) June 15, (ii) August 2, (iii) September 18, and (iv) October 10, 1995. The good news is that our renewed license is effective until December 31, 1999 and all requested amendments were approved. A copy of the new Radioactive Material License (Amendment Number 55) is attached.

Congratulations are in order for **Mike MacNaughton**, the Bureau has approved him to be the Institute's Radiological Health and Safety Committee Chairman.

In the transmittal letter, the Bureau has requested that SwRI submit a separate Radioactive Material License request for four items listed on the attached license. These four items are:

1. Item 8P - 100,000 curies of cobalt-60 sealed sources with an authorized use of: "Irradiation of materials and lower animals for research and development. For receipt and storage in the licensee's Radiation Effects Facility and for transfer to authorized recipients."

2. Item 8S - 75,000 curies of cobalt-60 sealed sources with an authorized use of: "Receipt, storage, and transfer to authorized recipients."

3. Item 8W - 60,000 curies of cesium-137 sealed sources with an authorized use of: "For receipt and storage and for transfer to authorized recipients."

4. Item 8AI - 1 curie of nickel-63 with an authorized use of: "Clean, repair or rebuild Electron Capture Detectors (ECD) and redistribution to specifically authorized customers. Also, for redistribution of generally licensed ECDs to persons authorized by TRCR (Texas Regulations for Control of Radiation) 40.61(a)."

If this separate license is not approved by the Bureau before May 1, 1996 the radioactive material listed in these four items can only be stored at SwRI, which excludes receiving, transferring, using, cleaning, etc.

At the December 6, 1995 meeting, the Radiological Health and Safety Committee needs to recommend actions to respond to the Bureau's request. If you have any questions or comments please call me at extension 2633.

c:\doc\rhsc1195.mem

Texas Department of Health

David R. Smith, M.D.
Commissioner

1100 West 49th Street
Austin, Texas 78756-3189
(512) 458-7111

Radiation Control
(512) 834-6688

Carol S. Daniels
Deputy Commissioner for Program

Roy L. Hogan
Deputy Commissioner for Administration

November 1, 1995

RECEIVED
NOV 1995

John P. Hageman
Southwest Research Institute
P.O. Drawer 28510
San Antonio, Texas 78284

Dear Mr. Hageman:

We have enclosed Amendment No. 55 to Radioactive Material License No. L00775 in response to your requests dated November 16, 1993, November 19, 1993, June 15, 1995, August 2, 1995, September 18, 1995 and October 10, 1995. Please note that during our review, we found several authorizations that are contrary to Texas Regulations for Control of Radiation 41.26(f)(3). These items must be authorized on a separate license and we have provided application forms and the appropriate guides to assist you in applying for a new license. You will note that Condition 27 was added as an incentive.

If we may answer any questions or be of any assistance, please do not hesitate to call or write.

Sincerely,

Floyd R. Hamiter

Floyd R. Hamiter, Chief
Industrial Program
Division of Licensing, Registration
and Standards
Bureau of Radiation Control

Enclosure

Texas Department of Health
BUREAU OF RADIATION CONTROL

077376

RADIOACTIVE MATERIAL LICENSE

Pursuant to the Texas Radiation Control Act and Texas Health Department regulations on radiation, and in reliance on statements and representations heretofore made by the licensee, a license is hereby issued authorizing the licensee to receive, acquire, possess and transfer radioactive material listed below; and to use such radioactive material for the purpose(s) and at the place(s) designated below. This license is subject to all applicable rules, regulations and orders of the Texas Department of Health (Agency) now or hereafter in effect and to any conditions specified below.

LICENSEE	This license is issued pursuant to and in accordance with an application
1. Name: Southwest Research Institute ATTN: John P. Hageman	Dated: November 19, 1993 Signed by: Frank A. Iddings
2. Address: P. O. Drawer 28510 San Antonio, Texas 78284	3. License Number: L00775 / Amendment Number: 55
	PREVIOUS AMENDMENTS ARE VOID
	4. Expiration Date: **December 31, 1999**

RADIOACTIVE MATERIAL AUTHORIZED

5. Radioisotope	6. Form of Material	7. Maximum Activity*	8. Authorized Use
A. Any radioactive material with Atomic number less than 84	A. Any	A. 500 mCi of any single radioisotope. Total: 25 Ci	A. Research and Development (R&D).
B. H-3	B. Any	B. **50 Ci**	B. **Wear testing of engine parts.**
C. Cr-51	C. Any	C. 500 Ci	C. R&D.
D. Mn-54	D. Any	D. 200 Ci	D. R&D.
E. Fe-55/ Fe-59	E. Any	E. 500 Ci	E. **Wear testing of engine parts.**
F. Co-58	F. Any	F. 600 Ci	F. R&D.
G. Co-60	G. Any	G. 100 Ci	G. R&D.
H. Ni-63	H. Any	H. 1 Ci	H. R&D.
I. Po-210	I. Sealed sources	I. 500 Ci	I. R&D.
J. Ra-226	J. Sealed sources	J. 100 μCi	J. R&D.
K. Am-241	K. Any	K. 1 Ci	K. R&D.
L. U-238 and its activation products	L. Any	L. 50 mgms	L. R&D.

* Ci-Curies mCi-Millicuries μCi-Microcuries

Texas Department of Health
BUREAU OF RADIATION CONTROL

07734

RADIOACTIVE MATERIAL LICENSE

LICENSE NUMBER	AMENDMENT NUMBER
L00775	55

5. Radioisotope (continued)	6. Form of Material (continued)	7. Maximum Activity (continued)	8. Authorized Use (continued)
M. Np-237	M. Any	M. 50 mgms	M. R&D.
N. U-238	N. Depleted Uranium	N. 500 kgms	N. R&D, shielding and performance testing of sealed sources and devices as part of the "Sealed Source and Device Design Safety Testing" program with the United States Nuclear Regulatory Commission (NRC).
O. Cs-137	O. Sealed source (NC Model 850233)	O. 1 Ci	O. Survey instrument calibration.
P. Co-60	P. Sealed sources	P. 100,000 Ci	P. Irradiation of materials and lower animals for research and development. For receipt and storage in the licensee's Radiation Effects Facility and for transfer to authorized recipients.
Q. Am-241	Q. Sealed source (GI Model VD[HP])	Q. 1 source of 25 mCi	Q. R&D of well logging instrumentation.
R. Cs-137	R. Sealed source (TN Model 57157C)	R. 2 sources of 500 mCi each	R. Density measurement using Texas Nuclear Model 5202 source holder.
S. Co-60	S. Sealed sources	S. 75,000 Ci	S. **Receipt, storage and transfer to authorized recipients.**
T. Pu-238	T. Sealed source (A/S Mod. PPC2,PPC4, PPC5 or PPC-X)	T. 1 source of 30 mCi	T. X-ray fluorescence analysis in Columbia Scientific Model 700 Minilab analyzer.
U. Cf-252	U. Sealed source (IPL foil)	U. 1 source of 100 μCi	U. R&D of a time-of-flight mass spectrometer.
V. Any radioactive material	V. Any	V. 1 mCi/gm of total activity per sample	V. Possession as a consequence of laboratory analysis of hazardous material samples.

Texas Department of Health
BUREAU OF RADIATION CONTROL

077350

RADIOACTIVE MATERIAL LICENSE

LICENSE NUMBER	AMENDMENT NUMBER
L00775	55

5. Radioisotope (continued)	6. Form of Material (continued)	7. Maximum Activity (continued)	8. Authorized Use (continued)
W. Cs-137	W. Sealed sources	W. 60,000 Ci	W. For receipt and storage and for transfer to authorized recipients.
X. Any radioactive material	X. Any	X. 1 mCi/gm of total activity per sample	X. Alpha and gamma ray spectroscopy of soils.
Y. Any radioactive material	Y. Any	Y. As acquired incident to decontamination	Y. Possession incident to decontamination of sealed sources.
Z. Ir-192	Z. Any	Z. 1000 Ci	Z. Possession incident to failure and metallurgical analysis of sealed sources.
AA. Ra-226	AA. Solid	AA. 100 μCi	AA. R&D using Pylon RN-1025 Radon Generator.
AB. Rn-222	AB. Gas	AB. 100 μCi	AB. R&D using Pylon RN-1025 Radon Generator.
AC. Cs-137	AC. Sealed Source (JLS Model 6810)	AC. 130 Ci	AC. **Survey instrument calibration using J.L. Shepherd Model 81-10 Calibrator.**
AD. Cs-137	AD. Sealed source (TEL Model A-102112)	AD. 5 sources of 9 mCi each	AD. **Possession incident to failure and metallurgical testing of Troxler Electronics Laboratories Model 3400 series moisture/density gauge.**
AE. Am-241	AE. Sealed source (TEL Model A-102451)	AE. 5 sources of 44 mCi each	AE. **Possession incident to failure and metallurgical testing of Troxler Electronics Laboratories Model 3400 series moisture/density gauge.**
AF. Cs-137	AF. Sealed source (A/S Model CDC.711)	AF. 1 source of 300 mCi	AF. R&D in licensee's custom source housing.
AG. Th-230	AG. Sealed sources	AG. No source to exceed 1.1 μCi	AG. Alpha and gamma spectroscopy standards.
AH. H-3	AH. Any	AH. 25 Ci	AH. Testing of self-luminous lights.

Texas Department of Health
BUREAU OF RADIATION CONTROL

07735

RADIOACTIVE MATERIAL LICENSE

LICENSE NUMBER	AMENDMENT NUMBER
L00775	55

5. Radioisotope (continued)	6. Form of Material (continued)	7. Maximum Activity * (continued)	8. Authorized Use (continued)
AI. Ni-63	AI. Any	AI. 1 Ci	AI. Clean, repair or rebuild Electron Capture Detectors **(ECD) and redistribution to specifically authorized customers. Also, for redistribution of generally licensed ECDs to persons authorized by TRCR 40.61(a).**
AJ. Cf-252	AJ. Sealed source (FTC Model 100 ser.)	AJ. 1 source of 53.5 mCi	AJ. R&D of a waste sampling probe.
AK. Any radioactive material with Atomic number less than 84	AK. Any	AK. No single source to exceed 100 Ci Total of any isotope not to exceed 1000 Ci	AK. Performance testing of sources and devices as part of the "Sealed Source and Device Design Safety Testing" program with the NRC.
AL. Am-241	AL. Any	AL. No single source to exceed 50 mCi	AL. Performance testing of sources and devices as part of the "Sealed Source and Device Design Safety Testing" program with the NRC.
AM. Sn-113	**AM. Any**	**AM. 200 Ci**	**AM. Wear testing of engine parts.**
AN. Sb-124/ Sb-125	**AN. Any**	**AN. 400 Ci**	**AN. Wear testing of engine parts.**
AO. Zn-65	**AO. Any**	**AO. 200 Ci**	**AO. Wear testing of engine parts.**
AP. Co-60	**AP. Any**	**AP. 50 Ci**	**AP. Receipt and interim storage of the licensee's radioactive waste.**
AQ. Any radioactive material with atomic number less than 84.	**AQ. Any**	**AQ. Total not to exceed 14.33 Ci**	**AQ. Receipt and interim storage of the licensee's radioactvie waste.**

Texas Department of Health
BUREAU OF RADIATION CONTROL

077352

RADIOACTIVE MATERIAL LICENSE

LICENSE NUMBER	AMENDMENT NUMBER
L00775	55

9. Radioactive material shall be stored and used only at:

Site Number	Location
000	San Antonio - 6220 Culebra Road

10. Each site shall maintain documents and records pertinent to the operations at that site. Copies of all documents and records required by this license shall be maintained for Agency review at Site 000.

11. Radioactive material authorized in Part Q of Conditions 5, 6, 7 and 8 shall also be used at temporary sites throughout Texas.

12. The licensee shall comply with the provisions of Parts 11, 12, 13, 21, 22, 40 and 41 of the Texas Regulations for Control of Radiation (TRCR).

13. Radioactive material shall only be used by, or under the supervision of, individuals designated by the Radiological Health and Safety Committee, **Michael G. MacNaughton**, Ph.D., Chairman.

14. The licensee is hereby exempted from TRCR Part 36, provided that all downhole operations authorized by this license are accomplished in cased wells and at depths of 200 feet or less. However, the licensee shall comply with the provisions of TRCR 36.4 and 36.501.

15. The individual designated to perform the functions of Radiation Safety Officer (RSO) for activities covered by this license is John P. Hageman.

16. Sealed sources containing radioactive material shall be opened only in accordance with procedures listed in Condition 28 below.

17. Sealed sources of radioactive material, Ni-63 foil, and/or plated alpha emitting sources shall be tested for leakage and/or contamination in accordance with the provisions of TRCR 11.7.

18. In accordance with TRCR 11.7, the interval of testing for leakage of the sources described in Part R of Conditions 5, 6, 7 and 8 shall not exceed three years.

19. The licensee is authorized to perform survey instrument calibration in accordance with procedures listed in Condition 28 below.

20. Individuals involved in operations which utilize, during any 24 hour period, more than 50 mCi of I-125 and/or I-131 or unvented laboratory operations involving 10 mCi of I-125 and/or I-131 in a noncontained form shall have bioassays performed within one week. If the use of more than 50 mCi of I-125 and/or I-131 occurs during any calendar week and this level of use persists for a minimum of any two weeks during any four week period, bioassays shall be performed once every two weeks for a period of one calendar quarter. Records of action points listed below shall be observed.

RADIOACTIVE MATERIAL LICENSE

LICENSE NUMBER	AMENDMENT NUMBER
L00775	55

20. A. Whenever the thyroid burden at the time of measurement exceeds 0.12 μCi of I-125 or 0.04 μCi of I-131, the following actions shall be taken:
    1. An investigation of the operations involved, including ventilation surveys shall be carried out to determine the causes of exposure and to evaluate the potential for further exposures.
    2. If the investigation indicates that further work in the area might result in exposure of a worker to concentrations that are excessive, the licensee shall restrict the worker from further exposure until the source of exposure is discovered and corrected.
    3. Corrective actions that will eliminate or lower the potential for further exposures shall be implemented.
    4. A repeat bioassay shall be taken within one week of the previous measurement in order to confirm the effectiveness of the corrective action taken or to verify internal radioiodines present.
    5. Reports or notification shall be provided as required by TRCR Sections 21.1203 and 21.1207.

    B. If the thyroid burden at any time exceeds 0.5 μCi of I-125 or 0.14 μCi of I-131, the following actions shall be taken:
    1. Prevent the individual from any further handling of I-125 or I-131 until the thyroid burden is below the above limits.
    2. Carry out all steps described above.
    3. As soon as possible, refer the case to appropriate medical consultation for recommendations regarding therapeutic procedures that may be carried out to accelerate removal of radioactive iodine from the body. This should be done within two to three hours after exposure when the time of exposure is known so that any prescribed thyroid blocking agent would be effective.
    4. Carry out repeated measurements at approximately one week intervals at least until the thyroid burden is less than 0.12 μCi of I-125 or 0.04 μCi of I-131.

21. The licensee shall not use radioactive material in or on human beings or in any field application where such activity is released except as provided otherwise by specific condition of this license.

22. Each person using radioactive material shall be provided with a copy of the licensee's Radiological Health and Safety Manual. Proposed changes in or additions to the licensee's manual shall be submitted to the Agency for approval before being incorporated into this document.

23. The licensee is authorized to receive and load teletherapy sources into customer's teletherapy source holders.

24. A. Tritium shall not be used in such a manner as to cause any individual to receive a radiation exposure such that urinary excretion rates exceed 28 μCi of tritium per liter when averaged over a calendar quarter.

Texas Department of Health
BUREAU OF RADIATION CONTROL

077354

RADIOACTIVE MATERIAL LICENSE

LICENSE NUMBER	AMENDMENT NUMBER
L00775	55

24. B. Urinalysis shall be performed at weekly intervals on all individuals who work in the restricted areas of facilities in which tritium is used. If the average concentration of tritium in urine for any single individual during a calendar quarter is less than 10 μCi per liter, urinalysis may be performed on that individual at monthly intervals for the following calendar quarter and may continue at monthly intervals so long as the average concentration in the calendar quarter remains below 10 μCi per liter. The urine specimen shall be collected on the same day of the week if possible.
    C. A report of an average concentration in excess of the limit specified in (A) above for any individual shall be filed, in writing, within 30 days of the end of the calendar quarter with the Agency. The report shall contain the results of all urinalyses for the individual during the calendar quarter, the cause of the excessive concentrations, and the corrective steps taken or planned to assure against a recurrence.
    D. Any single urinalysis which discloses a concentration of greater than 50 μCi per liter shall be reported, in writing, within seven days of the licensee's receipt of the results.

25. The licensee is authorized to perform tests for leakage and/or contamination on teletherapy sources for customers and on their own sealed sources. Such tests shall be capable of detecting 0.005 μCi of contamination on the test sample and the results of such tests shall be provided to the customer in terms of μCi.

26. The licensee is authorized to disassemble and clean Ni-63 electron capture detector cells in accordance with procedures listed in Condition 28 below.

27. The authorized use of radioactive material listed in Conditions 8P, 8S 8W and 8AI shall be restricted to storage only after May 1, 1996.

Texas Department of Health
BUREAU OF RADIATION CONTROL

077355

RADIOACTIVE MATERIAL LICENSE

LICENSE NUMBER	AMENDMENT NUMBER
L00775	55

28. Except as specifically provided otherwise by this license, the licensee shall possess and use the radioactive material authorized by this license in accordance with statements, representations, and procedures contained in the following:

appplication dated November 19, 1993,
Radiological Health and Safety Manual received April 15, 1994, and
letters dated November 16, 1993, November 30, 1993, December 17, 1993,
March 22, 1994, April 4, 1994, August 12, 1994,
October 10, 1994, December 9, 1994, December 28, 1994,
April 10, 1995, June 15, 1995, August 2, 1995,
September 18, 1995 and October 20, 1995.

The TRCR shall prevail over statements contained in the above documents unless such statements are more restrictive than the regulations.

FRH:sw

Date November 1, 1995

FOR THE TEXAS DEPARTMENT OF HEALTH

Wesley M. Dunn, C.H.P., Administrator
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Columbia Analytical Services inc.
An Employee-Owned Company

QUALITY ASSURANCE MANUAL

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2.0 TABLE OF CONTENTS

Section	Revision	Heading	Page
1.0	9.0	Title Page with Provision Signatures	1
2.0	9.0	Table Of Contents	2
3.0	3.0	Introduction and Company Quality Assurance Policy	4
4.0	4.0	Program Description	5
5.0	0.0	Statement of Professional Conduct and Laboratory Practice	11
6.0	4.0	Project Organization and Responsibilities	12
7.0	2.0	Sampling, Sample Preservation, and Handling Procedures	14
8.0	6.0	Sample Custody	22
9.0	1.0	Quality Control Objectives (Precision, Accuracy, Sensitivity, and Completeness)	25
10.0	6.0	Quality Control Procedures	28
11.0	1.0	Calibration Procedures and Frequency	36
12.0	7.0	Data Reduction, Validation, and Reporting	39
13.0	4.0	Performance and System Audits	53
14.0	1.0	Preventive Maintenance	54
15.0	1.0	Corrective Action	56
16.0	0.0	Quality Assurance Reports	58
17.0	2.0	Personnel Training	59
18.0	1.0	References for Analytical Procedures	60

Tables		Page
Table 7-1	Sample Preservation and Holding Times	15
Table 12-1	Laboratory Data Deliverables	52

Figures Page

Figure 4-1	CAS/Rochester Laboratory Floor Plan	8
Figure 4-2	CAS/Rochester Laboratory Floor Plan	9
Figure 4-3	CAS/Rochester Laboratory Floor Plan	10
Figure 7-1	Sample Container Label and Custody Seal	20
Figure 7-2	Chain of Custody Form	21
Figure 8-1	Cooler Receipt and Preservation Form	24
Figure 12-1	Evaluation of Method Calibration	43
Figure 12-2	Evaluation of Continuing Calibration	44
Figure 12-3	Evaluation of Method Blank and Instrument Blank Results	45
Figure 12-4	Evaluation of Sample Results for Inorganic Analyses	46
Figure 12-5	Evaluation of Sample Results for Organic Analyses	47
Figure 12-6	Evaluation of Surrogate Compound Recoveries	48
Figure 12-7	Evaluation of Duplicate Sample and/or Duplicate Matrix Spike Results	49
Figure 12-8	Evaluation of Matrix Spike Recoveries	50
Figure 12-9	Evaluation of Laboratory Control Sample (LCS) Results	51
Figure 15-1	Nonconformity and Corrective Action	57

Appendices

Appendix A	Major Analytical Equipment
Appendix B	Organizational Chart and Resumes of Key Personnel
Appendix C	Data Quality Capabilities
Appendix D	Data Qualifiers
Appendix E	Preventive Maintenance Procedures
Appendix F	Certifications/Accreditations/Contracts

3.0 INTRODUCTION AND COMPANY QUALITY ASSURANCE POLICY

Columbia Analytical Services, Inc. (CAS) is a professional consulting laboratory which performs chemical and microbiological analyses on a wide variety of sample matrices, including air filters, air tubes, drinking water, groundwater, surface water, wastewater, soil, sediment, sludge, tissue, industrial and hazardous waste, and other material. CAS/Rochester is a part of an eleven Lab Network operating throughout the USA. See Corporate Organization Chart (Appendix B) for locations.

It is a policy at CAS that there will be sufficient Quality Assurance (QA) activities conducted in the laboratory to ensure that all analytical data generated and processed will be scientifically sound, legally defensible, of known and documented quality, and will accurately reflect the material being tested. This goal is achieved by ensuring that adequate Quality Control (QC) procedures are used throughout the monitoring process, and by establishing a means to assess performance of these Quality Control and other QA activities.

We recognize that quality assurance requires a commitment to quality and ethics by everyone in the organization - individually, within each operating unit, and throughout the entire laboratory. All employees of CAS undergo lengthy ethics training and are eligible to participate in CAS open door policy to ensure a quality product and protect employees from any undue pressures. CAS also has stringent requirements and signed statements from employees to protect client confidentiality and ethical agreements.

The information in this document has been organized according to the format described in *National Environmental Laboratory Accreditation Conference (NELAC) Quality Systems Standards*, July 1999, and *Interim Guidance for the Preparation of Quality Assurance Project Plans*, QAM-005, USEPA, 1980; and *Guidance on Preparation of Laboratory Quality Assurance Plans*, USEPA, February 14, 1991. This document is controlled under policies required by CAS Document Control SOP (ADM-DOCCTRL). Each CAS network laboratory maintains its own lab specific Quality Assurance Manual.

4.0 PROGRAM DESCRIPTION

The purpose of the QA program at CAS is to ensure that our clients are provided with analytical data that is scientifically sound, legally defensible, and of known and documented quality. The concept of Quality Assurance can be extended, and is expressed in the mission statement of CAS:

> "The mission of Columbia Analytical Services, Inc., is to provide high quality, cost-effective, and timely professional testing services to our customers. We recognize that our success as a company is based on our ability to maintain customer satisfaction. To do this requires constant attention to customer needs, maintenance of state-of-the-art testing capabilities and successful management of our most important asset - our people - in a way that encourages professional growth, personal development and company commitment."

In support of this mission, our QA program addresses all aspects of laboratory operations, including laboratory organization and personnel, standard operating procedures, sample management, sample and quality control data, calibration data, standards traceability data, equipment maintenance records, method proficiency data (such as method detection limit studies and control charts), document storage and staff training records.

4.1 Facilities and Equipment

CAS features over 17,000 square feet of laboratory and administrative workspace at its Rochester, NY location. The facility is secured to the rest of the building using a swipe card entry system. Upon hire, each employee is assigned an access card and security code that must be used with their card. This employee-specific card provides access to the lab. SOP's are in place to protect the integrity of samples throughout the laboratory process (SMO-GEN). A company software Quality Assurance plan exists to provide standard procedures to protect the integrity of electronic data. The laboratory has been designed and constructed to provide safeguards against cross-contamination of samples and is arranged according to work function, which enhances the efficiency of analytical operations. In addition, the segregated laboratory areas are designed for safe and efficient handling of a variety of sample types.

These specialized areas include:

- Shipping and Receiving/Purchasing
- Sample Management Office (including a separate, controlled-access sample storage area)
- Inorganic/Metals Sample Preparation Laboratories (2)
- ICP Laboratory

- AA Laboratory
- Water Chemistry & General Chemistry Laboratories
- Gas Chromatography Laboratory (including a separate sample preparation laboratory)
- Gas Chromatography/Mass Spectrometry Laboratory (including a separate sample preparation laboratory)
- Volatile Organics Laboratory (including a separate standard preparation laboratory)
- Microbiology Laboratory
- Laboratory Deionized Water System
- Laboratory Management, Client Service, Report Generation and Administration
- Data Archive
- Information Technology (IT) and LIMS
- Hazardous Waste Storage Area

In addition, the designated areas for sample receiving, refrigerated sample storage, dedicated sample container preparation and shipping provide for the efficient and safe handling of a variety of sample types. Figures 4-1, 4-2, and 4-3 shows the facility location and layout of our Rochester, NY location. The laboratory is equipped with state-of-the-art analytical and administrative support equipment. Appendix A lists the major equipment at the Rochester facility, illustrating the laboratory's depth and overall capabilities.

4.2 Technical Elements of the Quality Assurance (QA) Program

4.2.1 Standard Operating Procedures (SOPs) and Laboratory Notebooks.

CAS maintains SOPs for use in both technical and administrative functions. Included in the list of available SOPs are procedures for the preparation of an SOP document, and for enforcing the control of documents through the laboratory (ADM-SOP & ADM-DOCCTRL, respectively). Each SOP generated in the laboratory has been reviewed and approved by the Laboratory Director, the Quality Assurance Coordinator and in most cases, the appropriate laboratory supervisor. The document control process associated with an SOP ensures that only the most currently prepared version of an SOP is being used for guidance and instruction. In addition to SOPs, each laboratory supervisor maintains a current file of all the promulgated methodology used to perform analyses. This file is accessible to all laboratory staff regardless of discipline. Laboratory notebook entries have been standardized following the guidelines in the *Making Entries into Logbooks and onto Benchsheets* SOP (SOP No. ADM-DATANTRY). The entries made into laboratory notebooks are reviewed and approved by the appropriate supervisor at a regular interval (e.g. weekly, monthly, etc...)

4.2.2 Standard Reference Materials

All analytical measurements generated at CAS are performed using materials and/or processes that are traceable to a Standard Reference Material (SRM). Metrology equipment (analytical balances, thermometers, etc...) is calibrated

using SRMs traceable to the National Institute of Standards and Technology (NIST). Consumable SRMs routinely purchased by the laboratories (e.g. primary stock standards) are purchased from nationally-recognized, reputable vendors. Most vendors have fulfilled the requirements for ISO 9001 certification and/or are accredited by A_2LA. Traceability throughout the laboratory is accomplished by following the guidelines set in the SOP, ADM-SPSR (Documentation of Standard Preparation and Receipt). All sampling containers provided to the client by the laboratory are purchased as precleaned (Level 1) containers, with certificates of analysis available for each bottle type. Certifications of Analysis provided by the vendors of reference materials and bottles are kept on file by the laboratory.

4.2.3 Operational Assessments

There are a number of methods used to assess the laboratory and its daily operations. In addition to the routine quality control (QC) measurements used by a laboratory to measure quality, the senior laboratory management staff at CAS examine a number of other performance indicators to more accurately assess the overall ability of the laboratory to successfully perform analyses for its clients. On-time performance, Analytical Report defect rate and Customer Invoice defect rate are a few of the measurements performed at CAS that are used to assess performance from an external perspective (i.e. client satisfaction). A frequent, routine assessment must also be made of the laboratory's facilities and resources in anticipation of accepting an additional or increased workload. CAS utilizes a number of different methods to insure that adequate resources are available in anticipation of the demand for service. Regularly scheduled senior staff meetings, tracking of outstanding proposals and an accurate, current synopsis of incoming work all assist the senior staff in properly allocating resources to achieve the required results.

4.2.4 Deviation from Standard Operating Procedures

When a customer requests a modification to an SOP, the project chemist handling that project must discuss the proposed deviation with the departmental manager to obtain approval for the deviation. A detailed description of the deviation should be attached to the quotation in the project file and the service request upon logging in the samples.

4.3 Subcontracting

Analytical services are subcontracted when CAS/Rochester needs to balance workload and/or when the requested analyses are not performed in Rochester. However, subcontracting is only done with the knowledge and approval of the client. Subcontracting to another CAS laboratory is preferred over external-laboratory subcontracting. Further, subcontracting is only done to capable and qualified laboratories approved by the client. Subcontractors must be accredited by the applicable state or program to which apply to the samples being analyzed. Established procedures are followed to qualify external subcontract laboratories, see Qualifying Subcontract Labs SOP (ADM-SUBLAB).

Figure 4-1
CAS/Rochester Laboratory Floor Plan

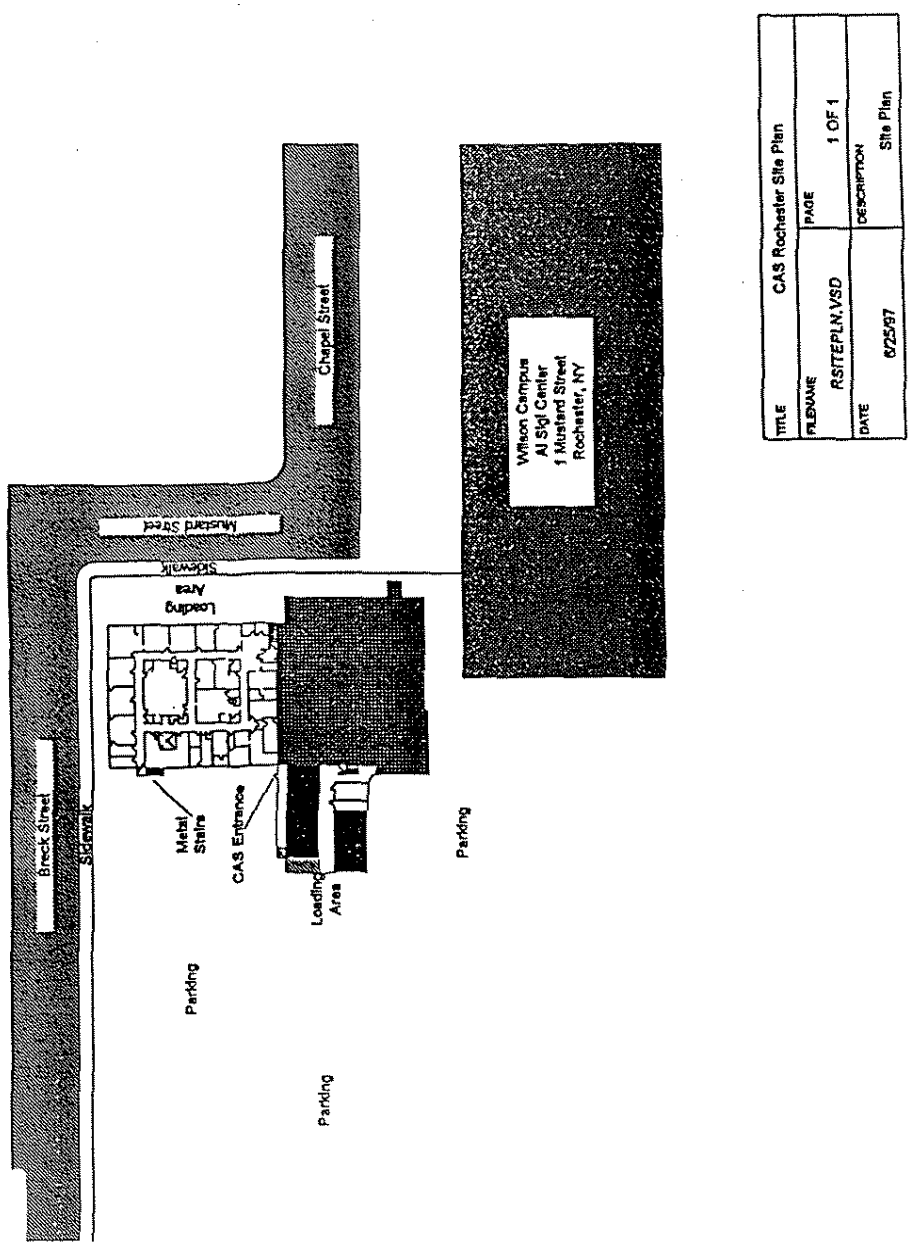
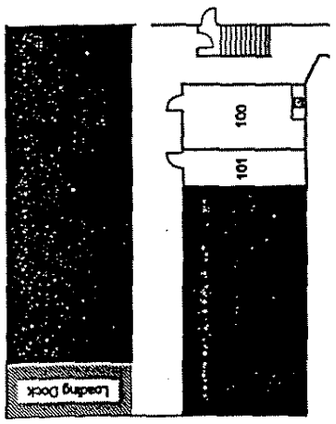


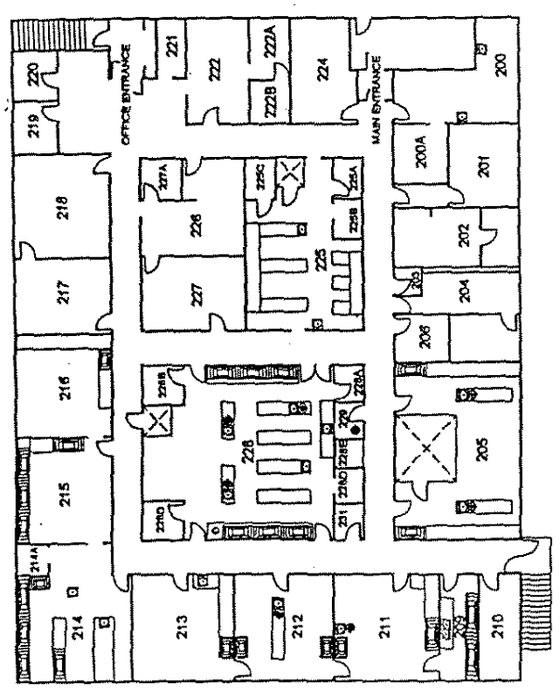
Figure 4-2
CAS/Rochester Laboratory Floor Plan



TITLE	CAS Rochester Floor Plans
FILENAME	RFLRPLAN.VSD
PAGE	1 OF 2
DATE	6/25/97
DESCRIPTION	First Floor
Legend	
Fume Hood	Sink
Emergency Shower	Sink

Room Designations
100 Field Services
101 Tank Farm

Figure 4-3
CAS/Rochester Laboratory Floor Plan



Room Designations			
201 SMO Storage	213 Metals ICP Lab	222A IT Director Office	228 General Chemistry Laboratory
202 Restroom (W)	214 SVOA Prep Laboratory	222B Computer Room	228A TOX/TOC Laboratory
203 Mop Closet	215 SVOA GC Laboratory	224 Secure On-site Record Storage	228B Deionized Water System Room
204 Restroom (M)	216 SVOA GC/MS Laboratory	225 Volatile Organics Laboratory	228C Walk-In Cooler
205 Breakdown	217 Regional Manager Office	225A Office	228D Inorganics Office
206 Restroom (ADA)	218 Project Management Office	225B Office	228E BOD Incubator
209 TCLP Lab	219 Lab Director Office	225C Prep Room	229 Microbiology Laboratory
210 Waste Storage	220 QA/Safety Coordinator Office	226 Lunch Room	231 Metals Digestates
211 Metals Prep	221 Office Supply Storage	227 Conference Room	
212 Metals Furnace Lab	223 Copy and Mail Center	227A Sales Office	

TITLE	CAS Rochester Floor Plans		
FILENAME	RFLRPLAN.VSD	PAGE	2 OF 2
DATE	6/25/97	DESCRIPTION	Second Floor

Legend

Fume Hood | Sink | Walk-In Cooler

Emergency Shower | Sink | Eyewash

5.0 STATEMENT OF PROFESSIONAL CONDUCT AND LABORATORY PRACTICE

One of the most important aspects of the success of CAS as a company is the emphasis placed on the integrity of the data that are provided and the services that are performed. To promote product quality, CAS requires certain standards of conduct and ethical performance among our employees. The following examples of documented CAS policy are representative of these standards, and are not intended to be limiting or all-inclusive:

Under no circumstances is the willful act of fraudulent manipulation of analytical data condoned. Such acts are to be reported immediately to senior management for appropriate corrective action.

Unless specifically required in writing by a client, alteration, deviation or omission of written contractual requirements is not permitted. Such changes must be in writing and approved by senior management.

Falsification of data in any form will not be tolerated. While much analytical data is subject to professional judgment and interpretation, outright falsification, whenever observed or discovered, will be documented, and appropriate remedies and punitive measures will be taken toward those individuals responsible.

Unauthorized release of confidential information about the company or its clients is taken very seriously and is subject to formal disciplinary action.

6.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The CAS/Rochester staff, consisting of approximately 50 employees, includes chemists, technicians and support personnel. They represent diverse educational backgrounds and experience, and provide the comprehensive skills that a modern, state-of-the-art analytical laboratory requires.

CAS is committed to providing an environment that encourages excellence. Everyone within CAS shares responsibility for maintaining and improving the quality of our analytical services. The responsibilities of key personnel within the laboratory are described below. An organizational chart of the laboratory, as well as the resumes of key personnel, can be found in Appendix B. Specific Job Descriptions are available and kept on file by human resources.

- The role of the **Laboratory Director** is to provide technical, operational, and administrative leadership through planning, allocation and management of personnel and equipment resources. This person is responsible for quality, overall laboratory efficiency, and financial performance of the Rochester CAS facility. The Laboratory Director also provides support for business development by identifying and developing new markets and through continuing support of the management of existing client activities.

- The responsibility of the **Quality Assurance Program Manager** (QAPM) is to provide a focus for overall QA activities within the laboratory. This person works with individual laboratory production units to establish effective quality control and assessment plans. The QAPM is also responsible for maintaining this QA Manual and performing an annual review of it, updating it if necessary; reviewing, approving, and controlling SOPs; coordinating PE sample analyses, maintaining record of PE results, preparing responses for missed PE sample results (Section 15.0); reviewing data (Section 12.0); maintaining the laboratory's certifications and approvals (Section 13.0); performing internal QA audits (Section 13.0); preparing QA reports (Section 16.0); maintaining training documentation for all employees including IDCs, CDCs, Training Plan forms, and seminar attendance; maintaining MDL study documentation, responding to QA needs, problems, and requests from technical staff. This person is a technical advisor and is responsible for summarizing and reporting overall unit performance.

- The Quality Assurance Director (Corporate Quality Assurance) is responsible for the overall QA program at all the CAS laboratories. The QA Director is responsible for performing an annual on-site audit at each CAS laboratory and preparing a written report; maintaining a data base of information about state certifications and accreditation programs; writing laboratory-wide SOPs; maintaining a data base of CAS-approved subcontract laboratories; providing assistance to QAPMs and laboratory managers; preparing an annual QA activity report; etc.

- The **Health and Safety Officer** is responsible for the administration of the laboratory health and safety policies. This includes the formulation and implementation of safety policies, the supervision of new-employee safety training, the review of accidents, incidents and prevention plans, the monitoring of hazardous waste disposal and the conducting of departmental safety inspections. The safety officer is also designated as the Chemical Hygiene Officer.
- The **Client Services Manager** is responsible for the Client Services Department (customer services/project chemists, and marketing functions). The Client Services Department provides a complete interface with clients from initial project specification to final deliverables.
- The **Project Chemist** is a senior-level, non-line scientist assigned to each client to act as a technical liaison between the client and the laboratory. The project chemist is responsible for ensuring that the analyses performed by the laboratory meet all project, contract, and regulatory-specific requirements. This entails coordinating with the CAS laboratory and administrative staff to ensure that client-specific needs are understood, and that the services CAS provides are properly executed and satisfy the requirements of the client.
- **Information Technology** (IT) staff are responsible for the administration of the Laboratory Information Management System (LIMS) and other necessary support services. Other functions of the IT staff include laboratory network maintenance, education of analytical staff in the use of scientific software, custom software development and implementation, Electronic Data Deliverable (EDD) generation and data back-up, archival and integrity operations.
- The Analytical Laboratory is divided into operational units, based upon specific disciplines. Each department is responsible for establishing, maintaining and documenting a quality control program based upon the requirements within the Quality Assurance Manual. Each **Department Supervisor/Manager** has the responsibility to ensure that quality control functions are carried out as planned, and to guarantee the production of high quality data. Supervisors have the responsibility to monitor the day-to-day operations to ensure that productivity and data quality objectives are met. Each analyst in the laboratory has the responsibility to carry out testing according to prescribed methods, standard operating procedures and quality control guidelines particular to the laboratory in which he/she is working.
- The **Sample Management Office** plays a key role in the laboratory QA program by providing documentation for all samples received by the laboratory, distributing samples, and maintaining proper storage. The sample management office staff is also responsible for the proper disposal of samples after analysis.

Analytical work will be conducted by the laboratory under the approval of the client. If any aspect of a project requires sub-contracting, CAS project chemist shall notify the client and obtain approval for any sub-contractors prior to completing the analytical program.

7.0 SAMPLING, SAMPLE PRESERVATION, AND HANDLING PROCEDURES

The quality of analytical results is highly dependent upon the quality of the procedures used to collect, preserve and store samples. CAS recommends that clients follow sampling guidelines described in specificly reference methods including EPA, NIOSH, ASTM, and SW846. Sample handling factors that must be taken into account to insure accurate, defensible analytical results include:

- Amount of sample taken
- Type of container used
- Type of sample preservation
- Sample storage time
- Proper custodial documentation

CAS uses the sample preservation, container, and holding-time recommendations published in a number of documents. The primary documents of reference are: USEPA SW-846, Third Edition (wastewater, soils, and hazardous waste samples), USEPA 600/4-79-020 and 600/4-82-057 (wastewater samples), USEPA 600/4-88-039, 600/4-91-010 and 600/R-93/100 (drinking water samples) and NIOSH, Manual of Analytical Methods 4th Edition (air samples) . The complete citation for each reference can be found in section 18.0 of this document. The container, preservation and holding time information are summarized in Table 7-1.

CAS routinely provides sample containers with appropriate preservatives for our clients. The containers are purchased as "precleaned" to a level 1 status, and conform to the requirements for analytical sample established by the USEPA. Certificates of analysis for the sampling containers are available upon request. Our sample kits typically consist of foam-lined, precleaned shipping coolers, specially prepared and labeled sample containers individually wrapped in bubble wrap, chain-of-custody (COC) forms, and custody seals. An example of a sample container label and a custody seal is shown in Figure 7-1. Figure 7-2 is a copy of the chain-of-custody form used at CAS. For extremely large sample container shipments, the containers may be shipped in their original boxes. Such shipments will consist of several boxes of labeled sample containers and sufficient materials (bubble wrap, COC forms, custody seals, shipping coolers, etc...) to allow the sampling personnel to process the sample containers and return them to CAS. The proper preservative will be always be added to the sample containers or provided in a separate vial prior to shipment, unless otherwise instructed by the client. CAS keeps client-specific shipping requirements on file and utilizes all major transportation carriers to guarantee that sample shipping requirements (same-day, overnight, etc.) are met. CAS also provides its own courier service that makes regularly scheduled trips to the Buffalo, Rochester area.

Table 7-1
Sample Preservation and Holding Times[a]

DETERMINATION	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Bacterial Tests				
Coliform, Fecal and Total	W	P,G	Cool, 4°C, 0.008% $Na_2S_2O_3$[d]	6-24 hours[e]
Inorganic Tests				
Acidity	W	P,G	Cool, 4°C	14 days
Alkalinity	W	P,G	Cool, 4°C	14 days
Ammonia	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Biochemical Oxygen Demand (BOD)	W	P,G	Cool, 4°C	48 hours
Bromide	W	P,G	None Required	28 days
Chemical Oxygen Demand (COD)	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Chloride	W	P,G	None Required	28 days
Chlorine, Total Residual	W	P,G	None Required	24 hours
Color	W	P,G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	W	P,G	Cool, 4°C, NaOH to pH>12, plus 0.6 g Ascorbic Acid	14 days
Cyanide, Weak Acid Dissociable	W	P,G	Cool, 4°C, NaOH to pH >12	14 days
Fluoride	W	P,G	None Required	28 days
Hardness	W	P,G	HNO_3 or H_2SO_4 to pH<2	6 months
Hydrogen Ion (pH)	W	P,G	None Required	24 hours
Ignitability	W	G	None Required	14 days
Kjeldahl and Organic Nitrogen	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrate	W	P,G	Cool, 4°C	48 hours
Nitrate-Nitrite	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrite	W	P,G	Cool, 4°C	48 hours
Orthophosphate	W	P,G	Filter Immediately, Cool, 4°C	48 hours
Oxygen, Dissolved (Probe)	W	G, Bottle and Top	None Required	Analyze immediately
Oxygen, Dissolved (Winkler)	W	G, Bottle and Top	Fix on Site and Store in Dark	8 hours
Phenolics, Total	W	G Only	Cool, 4°C, H_2SO_4 to pH<2	28 days
Phosphorus, Elemental	W	G Only	Cool, 4°C	48 hours
Phosphorus, Total	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Residue, Total	W	P,G	Cool, 4°C	7 days
Residue, Filterable (TDS)	W	P,G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	W	P,G	Cool, 4°C	7 days
Residue, Settleable	W	P,G	Cool, 4°C	48 hours
Residue, Volatile	W	P,G	Cool, 4°C	7 days

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Silica	W	P Only	Cool, 4°C	28 days
Specific Conductance	W	P,G	Cool, 4°C	28 days
Sulfate	W	P,G	Cool, 4°C	28 days
Sulfide	W	P,G	Cool, 4°C, Add Zinc Acetate plus Sodium Hydroxide to pH>9	7 days
Sulfite	W	P,G	None Required	24 hours
Surfactants (MBAS)	W	P,G	Cool, 4°C	48 hours
Tannin and Lignin	W	P,G	Cool, 4°C	28 days
Temperature	W	P,G	None Required	Analyze immediately
Turbidity	W	P,G	Cool, 4°C	48 hours
Metals				
Chromium VI	W	P,G	Cool, 4°C	24 hours
Mercury	W	P,G	HNO_3 to pH<2	28 days
	S	P,G	Cool, 4°C	28 days
Metals, except Chromium VI and Mercury	W	P,G	HNO_3 to pH<2	180 days
	S	G, Teflon-Lined Cap	Cool, 4°C	180 days
	A	Filters in Cassettes	None Required	180 days
Organic Tests				
Oil and Grease	W	G, Teflon-Lined Cap	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Carbon, Total (TOC)	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Halogens, Total (TOX)	W	G, Teflon-Lined Cap	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Halogens, Adsorbable (AOX)	W	G, Teflon-Lined Cap	Cool, 4°C, HNO_3 to pH<2	28 days
Petroleum Hydrocarbons, Total Recoverable	W	G, Teflon-Lined Cap	Cool, 4°C, HCl or H_2SO_4 to pH<2	28 days
Petroleum Hydrocarbons, Total	W	G, Teflon-Lined Cap	Cool, 4°C, HCl or H_2SO_4 to pH<2	7 days until extraction; 40 days after extraction
	S	G, Teflon-Lined Cap	Cool, 4°C	14 days until extraction; 40 days after extraction
Petroleum Hydrocarbons, Volatile (Gasoline-Range Organics)	W	G, Teflon-Lined Septum Cap	Cool, 4°C, HCl to pH<2 No Headspace	14 days
	S	G, Teflon-Lined Cap	Cool, 4°C Minimize Headspace	14 days

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Volatile Organics				
Purgeable Halocarbons	W	G, Teflon-Lined Septum Cap	**No Residual Chlorine Present**: HCl to pH<2, Cool, 4°C, No Headspace **Residual Chlorine Present**: 10% $Na_2S_2O_3$, HCl to pH<2, Cool, 4°C, No Headspace	14 days
	S	G, Teflon-Lined Cap	Cool, 4°C, Minimize Headspace	14 days
Purgeable Aromatic Hydrocarbons (including BTEX and MTBE)	W	G, Teflon-Lined Septum Cap	**No Residual Chlorine Present**: HCl to pH<2, Cool, 4°C, No Headspace **Residual Chlorine Present**: 10% $Na_2S_2O_3$, HCl to pH<2, Cool, 4°C, No Headspace	14 days
	S	G, Teflon-Lined Cap	Cool, 4°C, Minimize Headspace	14 days
Acrolein, Acrylonitrile, Acetonitrile	W	G, Teflon-Lined Septum Cap	Adjust pH to 4-5, Cool, 4°C, No Headspace	14 days
Semivolatile Organics				
Petroleum Hydrocarbons, Extractable (Diesel-Range Organics)	W,S	G, Teflon-Lined Cap	Cool, 4°C	7 days until extraction;[f] 40 days after extraction
EDB and DBCP	W,S	G, Teflon-Lined Cap	Cool, 4°C, HCl to pH<2, No Headspace	28 days
Alcohols and Glycols	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Phenols	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Phthalate Esters	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Nitrosamines	W,S	G, Teflon-Lined Cap	Cool, 4°C, Store in Dark[g]	7 days until extraction;[f] 40 days after extraction
Organochlorine Pesticides and PCBs	W,S	G, Teflon-Lined Cap	Cool, 4°C	7 days until extraction;[f] 40 days after extraction

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Nitroaromatics and Cyclic Ketones	W,S	G, Teflon-Lined Cap	Cool, 4°C, Store in Dark[g]	7 days until extraction;[f] 40 days after extraction
Polynuclear Aromatic Hydrocarbons	W,S	G, Teflon-Lined Cap	Cool, 4°C, Store in Dark[g]	7 days until extraction;[f] 40 days after extraction
Haloethers	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Chlorinated Hydrocarbons	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Organophosphorus Pesticides	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Nitrogen- and Phosphorus-Containing Pesticides	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Chlorinated Herbicides	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Chlorinated Phenolics	W	G, Teflon-Lined Cap	Cool, 4°C[g]	30 days
Resin and Fatty Acids	W	G, Teflon-Lined Cap	Cool, 4°C[g]	30 days
Industrial Hygiene Solvents	A	IH Air Tubes	None Required	14 days from sample collection
Toxicity Characteristic Leaching Procedure (TCLP)				
Mercury	HW	P,G	Sample: Cool, 4°C TCLP extract: HNO_3 to pH<2	28 days until extraction; 28 days after extraction
Metals, except Mercury	HW	P,G	Sample: Cool, 4°C TCLP extract: HNO_3 to pH<2	180 days until extraction; 180 days after extraction
Volatile Organics	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C Minimize Headspace TCLP extract: Cool, 4°C, HCl to pH<2, No Headspace	14 days until extraction; 14 days after extraction
Semivolatile Organics	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C, Store in Dark[g] TCLP extract: Cool, 4°C, Store in Dark[g]	14 days until TCLP ext'n; 7 days until extraction; 40 days after extraction

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Organochlorine Pesticides	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C TCLP extract: Cool, 4°C	14 days until *TCLP ext'n;* 7 days until extraction; 40 days after extraction
Chlorinated Herbicides	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C TCLP extract: Cool, 4°C	14 days until TCLP ext'n; 7 days until extraction; 40 days after *extraction*
Contract Laboratory Program (CLP)				
Cyanide, Total and Amenable to Chlorination	W	P,G	Cool, 4°C, NaOH to pH 12, plus 0.6 g Ascorbic Acid	12 days[h]
	S	P,G	Cool, 4°C	12 days[h]
Mercury	W	P,G	HNO_3 to pH<2	*26 days*[h]
	S	P,G	Cool, 4°C	26 days[h]
Metals, except Mercury	W	P,G	HNO3 to pH<2	180 days[h]
	S	P,G	Cool, 4°C	180 days[h]
Volatile Organics	W,S	G, Teflon-Lined Cap	*Cool, 4°C, Minimize* Headspace	10 days[h]
Semivolatile Organics	W,S	G, Teflon-Lined Cap	Cool, 4°C, Store in Dark[g]	5 days until extraction;[h,i] 40 days after extraction
Organochlorine Pesticides and PCBs	W,S	G, Teflon-Lined Cap	Cool, 4°C	5 days until extraction;[h,i] 40 days after extraction

a See Section 18.0 for sources of holding time information.
b W = Water; S = Soil or Sediment; HW = Hazardous Waste; A = Air
c P = Polyethylene; G = Glass
d For chlorinated water samples
e The recommended maximum holding time is variable, and is dependent upon the geographical proximity of sample source to the laboratory.
f *Fourteen days until extraction for soil, sediment, and sludge samples.*
g *If the water sample contains residual chlorine, 10% sodium thiosulfate is used to dechlorinate.*
h Number of days following sample receipt at the laboratory.
i Ten days until extraction for soil, sediment, and sludge samples.

Figure 7-1
Sample Container Label and Custody Seal

CLIENT: JOB#: 006
LOCATION:
DATE SAMPLED:
ANALYSIS:
PRESERVATIVE:
COMMENTS:

Custody Seal

Date_____ Project _____

Signature_____ Container#_____ of _____

Columbia Analytical Services, Inc.
An Employee-Owned Company
1 Mustard St., Suite 250, Rochester, NY 14609-6925
(716) 288-5380 • FAX (716) 288-8475

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

DATE _____ PAGE _____ OF _____

PROJECT NAME _____

PROJECT MANAGER/CONTACT _____

COMPANY/ADDRESS _____

_____

TEL ( ) _____ FAX ( ) _____

SAMPLER'S SIGNATURE _____

SAMPLE I.D.	DATE	TIME	FOR OFFICE USE ONLY LAB I.D.	SAMPLE MATRIX	# OF CONTAINERS	GC/MS VOA's ☐ 8260 ☐ 624 ☐ 95-1	GC/MS SVOA's ☐ 8270 ☐ 625 ☐ 95-2	GC VOA's ☐ 8021 ☐ 601/602	PESTICIDES/PCB's ☐ 8081 ☐ 608 ☐ 95-3	STAR'S LIST 8021 VOA's ☐ TOTAL ☐ TCLP	STAR'S LIST 8270 SVOA's ☐ TOTAL ☐ TCLP	TCLP ☐ METALS ☐ VOA's ☐ SVOA's ☐ H/P	WASTE CHARACTERIZATION ☐ React ☐ Corros. ☐ Ignit.	METALS, TOTAL (LIST BELOW)	METALS, DISSOLVED (LIST BELOW)	ANALYSIS REQUESTED								PRESERVATIO		
																							pH < 2.0	pH > 12	Other

RELINQUISHED BY:
Signature
Printed Name
Firm
Date/Time

RECEIVED BY:
Signature
Printed Name
Firm
Date/Time

RELINQUISHED BY:
Signature
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Signature
Printed Name
Firm
Date/Time

TURNAROUND REQUIREMENTS
___ 24 hr. ___ 48 hr. ___ 5 day
___ Standard (10-15 working days)
___ Provide Verbal Preliminary Results
___ Provide FAX Preliminary Results
Requested Report Date _____

REPORT REQUIREMENTS
___ 1. Routine Report
___ 2. Routine Rep. w/CASE Narrative
___ 3. EPA Level III Validatable Package
___ 4. N.J. Reduced Deliverables Level IV
___ 5. NY ASP/CLP Deliverables
___ 6. Site specific QC.

INVOICE INFORMATION:
P.O. #: _____
Bill To: _____

SAMPLE RECEIPT:
Shipping Via: _____
Shipping #: _____
Temperature: _____
Submission No: _____

SPECIAL INSTRUCTIONS/COMMENTS:
METALS
ORGANICS: ☐ TCL ☐ PPL ☐ AE Only ☐ BN Only ☐ Special List

Figure 7-2
Chain of Custody Form

8.0 SAMPLE CUSTODY

Standard Operating Procedures have been established for the receiving of samples into the laboratory. These procedures ensure that samples are received and properly logged into the laboratory, and that all associated documentation, including chain of custody forms, is complete and consistent with the samples received.

Sample Acceptance Policy:

Samples delivered to the CAS Sample Management Office (SMO) and are received by a Sample Custodian. The Chain of Custody (COC) is reviewed for completeness and accuracy and a Cooler Receipt and Preservation Form (CRPF) (Figure 8-1) is used to document the condition of the cooler and its contents as received by the sample custodian. Verification of sample integrity by the Sample Custodian includes the following activities:

- Assessment of custody seal presence/absence, location and signature.
- Temperature of sample containers upon receipt.
- Chain of custody documents present and properly completed.

  Entries should be made in blue or black ink and at a minimum, shall include sample identification, description, date, time, and location of sample collection, the name and signature(s) of the sample collector and intermediate sample custodian(s), date and time of each sample transfer, and signature of the CAS Sample Custodian upon receipt. For an example COC, see Figure 7-2.
- Sample containers checked for integrity (broken, leaking, etc...)
- Sample is clearly marked with the sample ID, date and time of collection.
- Appropriate containers (size, type) are received for the requested analyses.
- Sample container labels and/or tags agree with chain of custody entries (Identification, required analyses, etc...)
- Assessment of proper sample preservation (If inadequate, corrective action is employed).
- VOC containers are inspected for the presence/absence of bubbles. (No assessment of proper preservation is performed for VOC containers by SMO personnel).

Any anomalies or discrepancies observed during the initial assessment are recorded on the CRPF and/or chain of custody documents. All potential problems with a sample shipment are addressed by contacting the client and discussing the pertinent issues. When the Project Chemist and client have reached a satisfactory resolution, the log-in process may commence. The laboratory has formally accepted the samples. If resolution cannot be reached with the client or

the samples do not comply with the requirements of the CRPF, these samples may be rejected by the laboratory.

Sample Log-in;

During the log-in process, each sample is given a unique laboratory code and an analytical request form is generated. The laboratory code consists of an order number and submission number. Each sample is given an order number by the LIMS system based upon the order of log-in. A submission number is assigned to a particular job in the same manner. The submission number is coded with the lab location and year as follows:

e.g. Submission No. R20001784 = R - Rochester
20 - Year 2000
001784 - Job Number (1784th job logged in Year 2000)

The analytical request contains client information, sample descriptions, sample matrix information, required analyses, sample collection dates, analysis due dates and other pertinent information. This analytical request is reviewed by the appropriate Project Chemist for accuracy, completeness, consistency of requested analyses and for client project objectives and COC.

Laboratory Internal Chain of Custody documents are generated upon sample receipt for package reports only. The sample custodian relinquishes custody to an analyst of a particular department for which he/she is responsible to maintain the custody of that sample to each department.

All samples, except those designated for metals analyses, are kept in a refrigerated condition until they undergo analysis and disposal. CAS stores samples in one of three walk-in refrigerators. These refrigerators are segregated by method of analysis. The temperature of each storage facility used at CAS is monitored daily and the data recorded in a logbook.

Disposal:

Upon completion of all analyses, most aqueous and soil samples and sample extracts are retained at 4°C ± 2°C refrigerators for 30 days (unless other arrangements have been made in advance). Upon expiration of these time limits, the samples are either returned to the client or disposed of according to approved disposal practices. All samples are characterized according to hazardous/non-hazardous waste criteria and are segregated accordingly. All hazardous waste samples are disposed of according to formal procedures outlined in the Sample Disposal SOP (SMO-SPLDIS). It should be noted that all waste produced at the laboratory, including the laboratory's own various hazardous waste streams, is treated in accordance with all applicable local and Federal laws. Complete Internal Chain of Custody documentation is maintained for some samples from initial receipt through final disposal. This ensures that an accurate history of the sample from "cradle to grave" is generated. Internal Chain Documentation through disposal shall be in place by July 2000.

Figure 8-1
Cooler Receipt And Preservation Check Form

Project/Client_____ Submission Number_____.

Cooler received on_____ by:_____ **COURIER:** CAS UPS FEDEX CD&L CLIENT

1.	Were custody seals on outside of cooler?					YES / NO
2.	Were custody papers properly filled out (ink, signed, etc.)?					YES NO
3.	Did all bottles arrive in good condition (unbroken)?					YES NO
4.	Did any VOA vials contain significant air bubbles?					YES NO NA
5.	Were **Ice** or **Ice packs** present?					YES NO
6.	Where did the bottles originate?					CAS/ROC, CLIENT
7.	*Temperature of cooler(s)* upon receipt:	_____	_____	_____	_____	_____
	Is the temperature within 0° - 6° C?:	Yes ?	Yes ?	Yes ?	Yes ?	Yes ?
	If No, Explain Below	No ?	No ?	No ?	No ?	No ?

Date/Time Temperatures Taken: _____ _____

Thermometer ID:_____ Temp Blank *Sample Bottle* Cooler Temp. IR. Gun

If out of Temperature, Client Approval to Run Samples_____

Cooler Breakdown: Date :_____ by:_____

1.	Were all bottle labels complete (*i.e.* analysis, preservation, etc.)?		YES NO
2.	Did all bottle labels and tags agree with custody papers?		YES NO
3.	Were correct containers used for the tests indicated?		YES NO
4.	Air samples:	Cassettes/Tubes Intact Canisters Pressurized Tedlar® Bags Inflated	NA

Explain any discrepancies: _____

		YES	NO	Sample I.D.	Reagent	Vol. Added
pH	Reagent					
12	NaOH					
2	HNO_3					
2	H_2SO_4					
5-9*	P/PCBs (608 only)					

YES = All samples OK NO = Samples were preserved at lab as listed PC OK to adjust pH_____

*If pH adjustment is required, use NaOH and/or H_2SO_4

VOC Vial pH Verification (Tested after Analysis) Following Samples Exhibited pH > 2				

Other Comments:

9.0 QUALITY CONTROL OBJECTIVES (PRECISION, ACCURACY, SENSITIVITY, AND COMPLETENESS)

A primary focus of Columbia Analytical Services Quality Assurance (QA) Program is to ensure the accuracy, precision and comparability of all analytical results. CAS has established Quality Control (QC) objectives for precision and accuracy that are used to determine the acceptability of the data that is generated in its laboratories. These QC limits are either specified in the methodology or are statistically derived and are based on the laboratory's actual historical data obtained from control-charting the various QC measurements for each analytical method. The Quality Control objectives are defined below and the acceptable numeric values are shown in the table in Appendix C. The actual types of QC samples required for analysis is discussed in the specific analytical SOP.

9.1 Accuracy

Accuracy is a measure of the closeness of an individual measurement (or an average of multiple measurements) to the true or expected value. Accuracy is determined by calculating the mean value of results from ongoing analyses of standard reference materials, standard solutions and laboratory-fortified blanks. In addition, laboratory-fortified (i.e. matrix-spiked) samples are also measured; this indicates the accuracy or bias in the actual sample matrix. Accuracy is expressed as percent recovery (% REC) of the measured value, relative to the true or expected value. The acceptance limits for accuracy (shown in the table in Appendix C) originate from two different sources: Where acceptance limits are defined and stated in the individual methods, CAS has adopted the limits without modification. If no acceptance limits are given in a method, CAS adopts the limits derived from control charts that are generated for each appropriate method. These control charts are updated once a year for the appropriate Surrogate, Laboratory Control Sample, and Matrix Spike compounds.

$$\text{Accuracy } (\%REC) = \frac{A - B}{C} \times 100$$

Where A = Analyte total concentration from spiked sample
B = Analyte concentration from unspiked sample
C = Concentration of spike added

9.2 Precision

Precision is the ability of an analytical method or instrument to reproduce its own measurement. It is a measure of the variability, or random error, in sampling, sample handling and in laboratory analysis.

Precision is measured through the use of replicate sample analyses within the same batch and is expressed as the relative percent difference (RPD) between the replicate measurements.

$$RPD = \frac{D1 - D2}{(D1+D2)/2} \times 100$$

Where D1 = Original Result
D2 = Duplicate Result

9.3 Practical Quantitation Limits

The PQLs used at CAS are the routinely reported lower limits of quantitation which take into account day-to-day fluctuations in instrument sensitivity as well as other factors. These PQLs are the levels to which CAS routinely reports results in order to minimize false positive or false negative results. The PQL is normally two to ten times the method detection limit (MDL), which is determined by a procedure outlined in 40 CFR 136, Appendix B. MDLs for analytical methods routinely performed at CAS are determined annually.

9.4 Completeness

Completeness is a measure of the amount of valid data that is obtained, compared to the amount that is expected. It is expected that all analyses conducted in accordance with the approved analytical methods and standard laboratory operating procedures will meet QC acceptance criteria for 95% if the samples tested, however, the CAS objective for completeness is 100%.

$$\text{Completeness (\%)} = \frac{\text{valid data obtained}}{\text{total data planned}} \times 100$$

9.5 Representativeness

Representativeness is the degree to which a samples aliquot that is analyzed gives results identical to analysis of the whole. CAS has sample handling protocols to ensure that the sample given to the laboratory for analysis is thoroughly homogenized before the aliquot for analysis is removed. Further, analytical SOPs specify appropriate sample sizes to further ensure the sample aliquot that is analyzed is representative of the whole.

9.6 Comparability

Comparability expresses the confidence with which one data set can be compared to another. To ensure comparability, SOPs are used for the preservation, handling, and analysis of all samples. Data is reported in units specified by the customer.

10.0 QUALITY CONTROL PROCEDURES

The specific types, frequencies, and processes for quality control sample analysis are described in detail in method-specific standard operating procedures. These sample types and frequencies have been adopted for each method and a definition of each type of QC sample is provided below. In addition, a number of other quality control processes which may impact analytical results are also described below.

10.1 Modified Procedures

CAS strives to perform published methods as described in the referenced documents. If there is a material deviation from the published method, the method is cited as a "Modified" method in the analytical report. Standard operating procedures are available to analysts and are also available to our clients for review. If the modification is such that the method becomes "Performance Based," client approval is obtained for the use of the method prior to the performance of the analysis.

10.2 Procedures for Accepting New Work

Due to the increase in analytes used in the industry and found in the environment, analytes are requested to be analyzed using existing methodologies and/or new methodologies. These requests must be reviewed prior to accepting new work and creating new methodologies. These requests typically include:

1. The addition of analytes to an existing scan.
2. Complete start-up of an established method.
3. Analyte(s) requested with no established method.
4. Specific Confidentiality requests

<u>The addition of analytes to an existing scan.</u>
The analytical method is reviewed to determine if its use is appropriate for the new analyte. The standards are purchased from a commercial vendor and prepared. If the analyte is available from more than one source, a second source may be purchased to verify the calibration standard. A reference is spiked with a mid-level concentration of the appropriate standard and analyzed to determine retention time, resolution, etc. Temperature programs and instrument conditions may be modified to optimize resolution for the analyte. If the analyte may be resolved and detected by the method, an MDL study is performed to determine a detection limit suitable for the analyte. An in-house SOP may be written or modified to include the analyte.

Complete start-up of an established method
The method is obtained and reviewed by the analyst, technical manager, and/or supervisor to determine if the instrumentation and reagents needed by the method are available. If the required instrumentation is available, then reagents, standards, equipment, and supplies are gathered and purchased. If the analyte(s) are available from more than one source, a second source may be purchased to verify the calibration source. A qualified analyst performs the method, elution times are determined, temperature programs are optimized, and batch QC is performed to monitor accuracy and precision. An MDL study is performed to determine detection limit(s) and each analyst performing the method must complete an Initial Demonstration of Capability (IDC) study. An SOP is written and used by the analysts.

Analyte(s) requested with no established method.
The analyte to be analyzed is researched and reviewed by the technical manager for chemical nature, formula, and other related information. The Merck Index and CRC Handbook are reviewed for boiling point, vapor pressure to determine the type of compound. After determining the type of compound, it is assumed that it can be analyzed by an existing method. If not, perhaps a modification of a method or the creation of a method could be tried. The different approaches to testing the analyte may be tried, comparing the efficiency of the various approaches. The method, which allows for the acceptable precision and accuracy, shall be used. Follow procedures outlined in (10.1).

Specific confidentiality requests
Investigate the confidentiality requests of the client. The client may have specific requests regarding the release of the report/data, the retention of the samples and the data, and the disposal of the samples.

10.3 Analytical Batch

The basic unit for analytical quality control is the analytical batch. An analytical batch is that all the samples in a batch, both field samples and quality control samples, are to be handled and processed in exactly the same way, and all of the data from each analysis is to be manipulated in exactly the same manner.

The minimum requirements of an analytical batch are:

1. The number of field samples in a batch is not to exceed 20.

2. All field samples in a batch are of the same matrix.

3. The QC samples to be processed with the field samples include:
   - Method Blank - to determine possible laboratory contamination.
   - Laboratory Control Sample - to assess method performance.
   - Matrix Spike (field sample) - to assess possible matrix problems.

- Duplicate Matrix Spike or Duplicate (field) Sample - to assess batch precision.

4. A single lot of reagents is used to process the batch of samples.

5. Each operation within the analysis is performed by a single analyst or team of analysts.

6. Time Frame: "Open batches" may not extend more than one week (7days). "Closed batches" may not extend more than 24 hours.

7. (Field) samples are assigned to batches commencing at the time that sample processing begins. For example: for analysis of metals, sample processing begins when the samples are digested. For analysis of organic constituents, it begins when the samples are extracted.

8. The QC samples are to be analyzed in conjunction with the associated field samples prepared with them. However, for tests which have a separate sample preparation step that defines a batch, the QC samples in the batch do not require analysis each time a field sample is analyzed.

9. Batch QC refers to the QC samples that are analyzed in a batch of (field)samples.

10. Specific project, program, or method SOP requirements may be exceptions. The more stringent QC requirements shall be followed in most all cases.

10.4 Method Blank

The method blank is either analyte-free water or analyte-free soil (when available), subjected to the entire analytical process. When analyte-free soil is not available, anhydrous sodium sulfate, organic-free sand, or an acceptable substitute may be used instead. The method blank is analyzed to demonstrate that the analytical system itself is not contaminated with the analyte(s) being measured. The method blank results should be below the reporting limit for the analyte(s) being tested. A method blank is included with the analysis of every analytical batch, every 20 samples, or as stated in the method, whichever is more frequent.

For Industrial Hygiene samples, blanks shall be analyzed with each batch of samples to detect and measure possible contamination of sampling media and reagents used for analysis. Blanks should be supplied by the client as a representative sampling media of the same lot or batch as the field samples.

10.5 Calibration Blanks

Calibration blanks are prepared along with calibration standards in order to create a calibration curve. Calibration blanks are free of the analyte of interest, and provide the zero point of the calibration curve.

10.6 Continuing Calibration Blanks

Continuing calibration blanks (CCBs) are solutions of either analyte-free water or solvent that are analyzed in order to verify the zero point of the analytical system. The frequency of CCB analysis is either once every ten samples or as indicated in the method, whichever is greater.

10.7 Calibration Standards

Calibration standards are solutions of known concentration prepared from primary standard solutions which are, in turn, prepared from stock standard materials. Calibration standards are used to calibrate the instrument response with respect to analyte concentration. Standards are analyzed in accordance with the requirements stated in the particular method being used.

10.8 Initial (or Independent) Calibration Verification Standards

Initial (or independent) calibration verification standards (ICVs) are standards that are analyzed *after* calibration but *prior to* sample analysis, in order to verify the calibration of the analytical system. They are prepared from materials obtained from a source independent of that used for preparing the calibration standards. ICVs are also analyzed in accordance with method-specific requirements.

10.9 Continuing Calibration Verification Standards

Continuing calibration verification standards (CCVs) are midrange standards that are analyzed in order to verify that the calibration of the analytical system is still acceptable. The frequency of CCV analysis is either once every ten samples, or as indicated in the method, whichever is greater.

10.10 Internal Standards

Internal standards consist of known amounts of specific compounds that are added to each sample following sample preparation or extraction. Internal standards are generally used for GC/MS and ICP-MS procedures to correct sample results that have been affected by changes in instrument conditions or changes caused by certain matrix effects. The integrated area of the internal standard compared to the continuing calibration check standard should vary by no more than the limits specified in each method.

10.11 Surrogates

Surrogates are organic compounds which are similar in chemical composition and chromatographic behavior to the analytes of interest, but which are not normally found in environmental samples. Depending on the analytical method, one or more of these compounds is added to method blanks, calibration and check standards, and samples (including duplicates, matrix spike samples, duplicate matrix spike samples and laboratory control samples) prior to extraction and analysis in order to monitor the method performance on each sample. The percent recovery is calculated for each surrogate, and the recovery is a measurement of the overall method performance. The acceptance criteria for these various analytes are listed in Appendix C, along with other data quality capabilities.

10.12 Matrix Spikes

Matrix spiked samples are aliquots of samples to which a known amount of the target analyte (or analytes) has been added. The samples are then prepared and analyzed in the same analytical batch, and in exactly the same manner as are routine samples. The spike recovery measures the effects of interferences caused by the sample matrix and reflects the accuracy of the method for the particular matrix in question. Spike recoveries are calculated as follows:

$$Recovery\ (\%) = (S - A) \times 100 \div T$$

Where: S = The observed concentration of analyte in the spiked sample,

A = The analyte concentration in the original sample, and

T = The theoretical concentration of analyte added to the spiked sample.

For the appropriate methods, matrix spiked samples are prepared and analyzed at a minimum frequency of one spiked sample (and one duplicate spiked sample, if appropriate) per twenty samples.

Matrix spiks are not applicable with industrial hygiene sampling media for air analysis.

Note: A sample identified as a field blank, equipment blank, or trip blank is not to be matrix spiked.

10.13 Laboratory Duplicates and Duplicate Matrix Spikes

Duplicates are additional replicates of samples that are subjected to the same preparation and analytical scheme as the original sample. Depending on the method of analysis, either a duplicate analysis (and/or a matrix spiked sample) or a matrix spiked sample and duplicate matrix spiked sample (MS/DMS) are analyzed. The relative percent difference between duplicate analyses or between an MS and DMS is a measure of the precision for a given method and analytical batch. The relative percent difference (RPD) for these analyses is calculated as follows:

Relative Percent Difference (RPD) = (S1 - S2) x 100 ÷ S_{ave}2

Where S1 and S2 = The observed concentrations of analyte in the sample and its duplicate, or in the matrix spike and its duplicate matrix spike, and

S_{ave} = The average of observed analyte concentrations in the sample and its duplicate, or in the matrix spike and its duplicate matrix spike.

Depending on the method of analysis, either duplicates (and/or matrix spikes) or MS/DMS analyses are performed at a minimum frequency of one set per 20 samples. Duplicate analysis is not applicable to air matrices.

Duplicate analysis is not applicable with industrial hygiene sampling media for air analysis.

Note: A sample identified as a field blank, equipment blank, or trip blank is <u>not</u> to be duplicated.

10.14 Laboratory Control Samples

The laboratory control sample (LCS) is an aliquot of analyte-free water or analyte-free soil (or anhydrous sodium sulfate or equivalent) to which known amounts of the method analyte(s) is(are) added. A standard reference material (SRM) of known matrix type, containing certified amounts of target analytes, may also be used as an LCS. The LCS sample is prepared and analyzed in the same analytical batch, and in exactly the same manner, as the other routine samples. Stock solutions used for LCSs are purchased or prepared independently of calibration standards. The percent recovery (% REC.) of the target analytes in the LCS assists in determining whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements at the required reporting limit. Comparison of batch-to-batch LCS analyses enables the laboratory to evaluate batch-to-batch precision and accuracy. Acceptance criteria for LCS analyses are obtained through the use of control charts, which are generated annually. An LCS is prepared and analyzed at a minimum frequency of

one LCS per 20 samples, with every analytical batch or as stated in the method, whichever is more frequent.

For industrial hygiene samples (air) LCSs shall be performed in duplicate to assess accuracy and precision for each batch, not to exceed 10 samples. Acceptance criterion of 80 – 120% shall be used until enough data points are available to statistically generate a lab QC limit.

10.15 Interference Check Samples

An interference check sample (ICS) is a solution containing both interfering and analyte elements of known concentration that can be analyzed to verify background and interelement correction factors in metals analyses. The ICS is prepared to contain known concentrations of interfering elements that will provide an adequate test of the correction factors. The ICS is spiked with the elements of interest at concentrations of approximately ten times the instrument detection limits. The ICS is analyzed at the beginning and end of an analytical run or every eight hours, whichever is more frequent, and the results must be within ± 20% of the true values.

10.16 Post Digestion Spikes

Post digestion spikes are samples prepared for metals analyses that have an analyte spike added to determine if matrix effects may be a factor in the results. The spike addition should produce a method-specified minimum concentration above the instrument detection limit. A post digestion spike is analyzed with each batch of samples and recovery criteria are specified for each method.

10.17 *Source and Preparation of Standard Reference Materials*

CAS relies on a primary vendor for the majority of its analytical supplies. In addition, consumable primary stock standards are obtained from certified commercial sources or from sources referenced in a specific method, as discussed in section 4.2.2 of this document. Supelco, Ultra Scientific, AccuStandard, Chem Services, Inc., Aldrich Chemical Co., Baker, Spex, E. M. Science, etc. are examples of the vendors used by CAS. All reference materials that are received at CAS are recorded by the technical staff in the appropriate notebook(s) and are stored under conditions that provide maximum protection against deterioration and contamination. The notebook entry includes such information as an assigned logbook identification code, the source of the material (i.e. vendor identification), solvent (if applicable) and concentration of analyte(s), reference to the certificate of analysis and an assigned expiration date. In addition, the date that the standard is received in the laboratory is marked on the container. When the SRM container is used for the first time, the date of usage and the initials of the applicable technician are also recorded on the container. Stock solutions and/or calibration standard solutions are prepared fresh as often as necessary according to their stability. After preparation, all standard solutions are properly labeled as to name, concentration, date, preparer, and expiration date; these entries are also recorded in the

appropriate notebook. See SOP, Documentation of Standards, Preparation and Receipt (ADM-SPSR). To ensure traceability, all standards are labelled with an in-house code that can be traced back to the original stock standard received by the vendor and thus, the certificate of analysis. Prior to introduction into the analytical system/process, **all** reference materials are verified for accuracy with a second, independent source of the material. Once the reference material has been verified to be accurate, it may then be used for instrument calibration and subsequent quantitative purposes. In addition, the independent source of reference material is also used to check the calibration standards for signs of deterioration. All standards shall be stored per analytical SOP requirements.

10.18 Control Charting

The generation of control charts is performed annually at CAS. MS, LCS, and Surrogate recoveries are monitored and charted for key parameters to determine new control limits using the data generated in the previous year. After review of the data by the Quality Assurance Coordinator, the new acceptance criteria may replace the previous criteria and method conformity is assessed using the new values. See Determination of Statistical Control Limits (ADM-CRTL-LIM). Old charts are archived for a period of 10 years.

10.19 Proficiency Testing Participation

Each decipline and test method for most analytes are monitored using NIST approved vendors for Proficiency Testing on a semi-annual basis. Results of the proficiency samples are reviewed by the Laboratory Director, the QA Coordinator, the Corporate QA Director and the laboratory staff. Any problems surfacing during the review are investigated, and corrective action is taken regarding any and all deficiencies.
Interlaboratory Proficiencies are performed annually to determine continued lab performance throughout the network of CAS laboratories. Such studies are organized by Corporate QA. Proficiency test results are also used to show continued acceptable performance per analyst.

10.20 Glassware Washing

Glassware washing and maintenance play an crucial role in the daily operation of a laboratory. The glassware used at CAS undergoes a rigorous cleansing procedure prior to every usage. Departmental specific glassware washing SOP's (GEN-GC, MET-GC and EXT-GC) have been generated that outline the various procedures used at CAS; each is specific to the end-use of the equipment as well as to the overall analytical requirements of the project.

11.0 CALIBRATION PROCEDURES AND FREQUENCY

All equipment and instruments used at CAS are operated, maintained and calibrated according to the manufacturer's guidelines and recommendations, as well as to criteria set forth in the applicable analytical methodology. Operation and calibration are performed by personnel who have been properly trained in these procedures. Documentation of calibration information is maintained in appropriate reference files. The frequency of calibration and concentration of calibration standards are determined by the manufacturers guidelines, the analytical method, or the requirements of special contracts. See specific analytical SOP's for frequency and criteria. Generally, purchased standards have a shelf life of 12-36 months and prepared standards have a shelf life of 1-12 months. Recalibration is required at anytime that the instrument is not operating correctly or functioning at the proper sensitivity. Brief descriptions of the calibration procedures for our major laboratory equipment and instruments are described below.

11.1 Temperature Control Devices

Temperatures are monitored and recorded for all of our temperature-regulating devices including ovens, incubators and refrigerators. Bound record books are kept which contain recorded temperatures, identification and location of equipment, and the initials of the technician who performed the checks. All thermometers have been identified and the calibration of these thermometers is checked annually against a National Institute of Standards and Technology (NIST) certified thermometer. Calibration records are maintained by the QA Coordinator. (See SOP SMO-DALYCK).

11.2 Analytical Balances

Analytical balances are serviced on an annual basis by a professional metrology organization. New certificates of calibration for each balance are issued to the laboratory on an annual basis. The calibration of each analytical balance is checked daily with class "S" weights, which assess the accuracy of the balance at the working range. Bound record books are kept which contain the recorded measurements, identification and location of equipment, and the initials of the technician who performed the checks. (See SOP SMO-DALYCK).

11.3 Inductively Coupled Plasma (ICP)

Each emission line on the ICP is calibrated daily against a blank and against standards. Analyses of calibration standards, initial and continuing calibration verification standards, and inter-element interference check samples are carried out as specified in the applicable method being utilized (see Section 18.0 for references).

11.4 Atomic Absorption Spectrophotometers (AAS)

These instruments are calibrated daily using a minimum of four standards and a blank. Calibration is validated using reference standards, and is verified at a minimum frequency of once every ten samples.

11.5 GC/MS Systems

All GC/MS instruments are calibrated daily at five different concentration levels for the analytes of interest, using procedures outlined in Standard Operating Procedures (SOPs) and/or appropriate USEPA method citations. All SRMs used for this function are "EPA-Certified." Compounds selected as system performance check compounds (SPCCs) must show a method-specified response factor in order for the calibration to be considered valid. Calibration check compounds (CCCs) must also meet method specifications for percent difference from the multipoint calibration. Method-specific instrument tuning is regularly checked using bromofluorobenzene (BFB) for volatile organic chemical (VOC) analysis, or decafluorotriphenylphosphine (DFTPP) for semi-volatile analysis. Mass spectral peaks for the tuning compounds must conform both in mass numbers and in relative intensity criteria before analyses can proceed.

11.6 Gas Chromatographs

Calibration and standardization follow SOP guidelines and/or appropriate USEPA method citations. Initial calibration standards are prepared at three to five concentration levels for each analyte of interest. The lowest standard is near the method reporting limit; additional standards define the working range of the GC detector. Results are used to establish response factors and retention-time windows for each analyte. Calibration is verified at a minimum frequency of once every ten samples.

11.7 Infrared Analyzer

The instrument is calibrated using a blank and four standards. The calibration is validated at the beginning of each analysis, and continuing calibration is verified at a minimum frequency of once every ten samples.

11.8 UV-Visible Spectrophotometer (manual colorimetric analyses)

Routine calibrations for colorimetric and turbidimetric analyses involve generating a 5-point calibration curve including a blank. Correlation coefficients must meet method or SOP specifications before analysis can proceed. Independent calibration verification standards (ICVs) are analyzed with each batch of samples. Continuing calibration is verified at a minimum frequency of once every ten samples.

11.9 Flow Injection Analyzer (automated colorimetric analysis)

A minimum of five standards and a blank are used to calibrate the instrument daily. Standard CAS acceptance limits are used to evaluate the calibration curve prior to sample analysis. All linear regressions must have a correlation coefficient of 0.995 or better before analysis may proceed.

11.10 Ion Chromatographs

Calibration of the ion chromatograph (IC) involves generating a 5-point calibration curve. A correlation coefficient of 0.995 or better for the curve is required before analysis can proceed. Quality Control (QC) samples that are routinely analyzed include blanks and laboratory control samples. The target analytes typically determined by the IC include nitrate, nitrite, chloride, fluoride, and sulfate.

11.11 Turbidimeter

Calibration of the turbidimeter requires analysis of formazin and polymer standards measured as NTU. Quality Control samples that are routinely analyzed include blanks, and duplicates.

11.12 Ion-selective electrode

Two standards are used to calibrate the electrodes before analysis. The slope of the curve must be within acceptance limits before analysis can proceed. Quality Control samples that are routinely analyzed include blanks, LCSs and duplicates.

11.13 Other Instruments

Calibration for the total organic carbon (TOC), total organic halogen (TOX), and other instruments is performed following manufacturer's recommendations and applicable SOPs.

12.0 DATA REDUCTION, VALIDATION, AND REPORTING

CAS reports the analytical data produced in its laboratories to the client via the certified analytical report (CAR). This report typically includes a transmittal letter, a case narrative, client project information, specific test results, quality control data, chain of custody information, and any other project-specific support documentation. The following procedures describe our data reduction, validation and reporting procedures.

12.1 Laboratory Information Management System (LIMS)

CAS/Rochester currently uses StarLIMS v.6.11a throughout the laboratory. This data management and retrieval system is the PC based StarLIMS that runs on a Novell Network. The LIMS is used for sample tracking, sample workload projections, sample result storage, reporting, and invoicing. The system allows you to acquire data from instrumentation and can generate ASCII, spreadsheet, database, and/or print files.
Periodically, historical data is checked on the LIMs for authenticity and ability to recreate data files. These files are reviewed for data integrity and possible corruption. See Software Quality Assurance Plan.

12.2 Data Reduction and Custody

All data is initially reviewed and processed by analysts using appropriate methods (e.g. chromatographic software, instrument printouts, hand calculation, etc.) The resulting data set is either manually entered (e.g. general chemistry parameters) into the LIMS system or is electronically transferred into LIMS from the software used to process the original data set (e.g. chromatographic software). A file of all raw data is generated and given to the departmental supervisor for review. Once the complete data set has been transferred into LIMS, the departmental supervisor reviews all data entered into LIMS against the raw data and validates the data which allows the data to be printed in the chosen final report format. Upon approval of the data the supervisor relinquishes the raw data file to a report writer, who generates a final report from the LIMS system. The resulting final report and raw data are then reviewed by the project chemist for accuracy. Typically, all data is reported in the units and PQLs listed in Appendix C. Assessment of the analytical data includes a check on data consistency by looking for comparability of duplicate analyses, comparability of previous data from the same sampling location (if available), adherence to accuracy and precision control limits, and anomalous low or high parameter values. The results of this review will be discussed with either the departmental supervisor or lab director for resolution prior to final release of the package. Once the data has been checked for accuracy and acceptability, the final report and raw data is forwarded to the lab director or quality assurance coordinator, who further reviews the data package for errors. When the entire data set has been found to be acceptable the lab director signs the report, the report is distributed and the raw data is filed for approximately one year, then archived. All hard copy and electronic backups are archived in a

secured file room for a period of at least 5 years from the date of the final report (as discussed in section 12.6.1). It is not unusual to have various clients require a 10-year retention of records, therefore, the archivist, project chemist, and possibly the client are consulted prior to distruction of the records.

12.3 Confirmation Analysis

12.3.1 Gas Chromatographic Analyses

For gas chromatographic (GC) analyses, most positive results are confirmed by a second column, a second detector, or by GC/MS analysis, unless exempted by one of the following situations:

- The analyte of interest produces a chromatogram containing "pattern" peaks which match appropriate standards. These analytes include polychlorinated biphenyls (PCBs) and hydrocarbon fuels (e.g., gasoline and diesel).

- The sample is analyzed for benzene, toluene, ethylbenzene and xylenes (BTEX), and the sample is found, by a separate analysis, to contain gasoline. In a sample containing no gasoline, the presence of BTEX compounds will be confirmed.

- The sample meets all of the following requirements:

    1. All samples (liquid or solid) come from the same source (e.g., groundwater samples from the same well) for continuous monitoring.

    2. All analytes have been previously analyzed, identified and confirmed by a second column or by GC/MS. The documents indicating previous confirmation must be available for review.

    3. The resulting chromatogram is relatively simple and does not contain complex or overlapping peaks.

    4. The chromatogram is largely unchanged from the one for which confirmation was carried out.

12.3.2 Confirmation Data

Confirmation data will be provided as specified in the method. Identification criteria for GC or GC/MS methods are summarized below:

- GC Methods - The analyte must fall within plus or minus three times the standard deviation (SD) of the retention time of the daily midpoint standard in order to be qualitatively identified. The retention-time windows will be established and documented, as specified in the appropriate Standard Operating Procedure (SOP).

- GC/MS Methods - Two criteria are used to verify identification:

    1. Elution of the analyte in the sample will occur at the same relative retention time (RRT) as that of the analyte in the standard.

    2. The mass spectrum of the analyte in the sample must, in the opinion of a qualified analyst or the department manager, correspond to the spectrum of the analyte in the standard or the current GC/MS reference library.

12.4 Data Validation

The integrity of the data generated in the laboratory is primarily assessed by the analyst, supervisor and project chemist through the use of a variety of measures that may include reagent blanks, laboratory fortified blanks, duplicates, matrix spikes and QC samples. The numerical criteria for evaluation of these QC samples are listed in Appendix C; these various QC sample analyses are evaluated using the flow diagrams found in Figures 12-1 through 12-9. Other validation measures of the data include a check of the linearity of the calibration curve, an accuracy check of the QC standards and a check of the system sensitivity. Data transcriptions and calculations are also reviewed. Specific calculations used for determining the concentration or value of the measured parameters from the raw data are given in each of the analytical methods or CAS SOPs.

12.5 Data Reporting

When an analyst determines that the data has met the data quality objectives (and/or any client-specific data quality objectives) of the method and has qualified any anomalies in a clear, acceptable fashion, the data is validated by the supervisor. Validated data is reported from LIMS by report writers using specialized forms created by LIMS (see SOP, ADM-RG currently in process). Prior to release of the report to the client, the project chemist must also review the entire body of data for completeness and to ensure that any and all client-specified objectives were successfully achieved. If required, samples exceeding any established state/federal maximum contaminant level or reportable concentration level, must be reported to the client. A case narrative may be written by the project chemist to explain any unusual problems with a specific analysis or sample, client-specific objectives, exceedences, etc... The original raw data, along with a copy of the final report, is filed for archiving. CAS maintains control of analytical results by adhering to standard operating procedures and by observing sample custody requirements. All data are calculated and reported in units consistent with project specifications, to enable easy comparison of data from report to report. Typical qualifiers used to flag analytical results are listed in Appendix D.

12.6 Documentation

A document control system ensures that all documents are accounted for when the project is complete. A submission number is assign to each project for reporting and filing purposes. This number is associated with each order number (sample).

12.6.1 Documentation and Archiving of Routine Analysis Data

The archiving system includes all of the following items for each set of analyses performed:

- Benchsheets describing sample preparation (if appropriate)
- Instrument parameters
- Sample analysis sequence
- Analysis benchsheets and instrument printouts
- Chromatograms and peak integration reports for all samples, standards, blanks, spikes and reruns
- Log book ID number for the appropriate standards
- Copies of report submitted to the client

Individual sets of analyses are indexed by analysis date and/or submission number. Since many analyses are performed with computer-based data systems, the final sample concentrations can be automatically calculated. If additional calculations are needed, they are written on the integration report or securely stapled to the chromatogram, if done on a separate sheet. The archive room is a separte file room in which files shall be maintained for a period of at least five years (from date of report issue). It is not unusual to have various clients require a 10-year retention of records, therefore, the archivist, project chemist, and possibly the client are consulted prior to distruction of the records. The archive room is kept locked and access keys are controlled. All documents must be signed out if needed outside of the archive room and returned in a timely manner. A designated archivist monitors filing, incoming, and outgoing data from the archive.

In the event that the laboratory transfer's ownership or goes out of business, laboratory records shall be maintained for the contracted period and clients shall be notified prior to early destruction / disposal of samples or data.

12.6.2 Reporting Deliverables

In order to meet individual project needs, CAS provides several levels of analytical reports. Basic specifications for each level of deliverable are described in Table 12-1. Turnaround time and package level are negotiable on a project to project basis.

12.6.3 Electronic Data Deliverables (EDD)

CAS/Rochester offers standard Excel format as well as a variety of custom developed EDDs such as ASCII, dBase, and GISKEY. EDDs are available upon request on a project to project basis.

Figure 12-1
Evaluation of Method Calibration

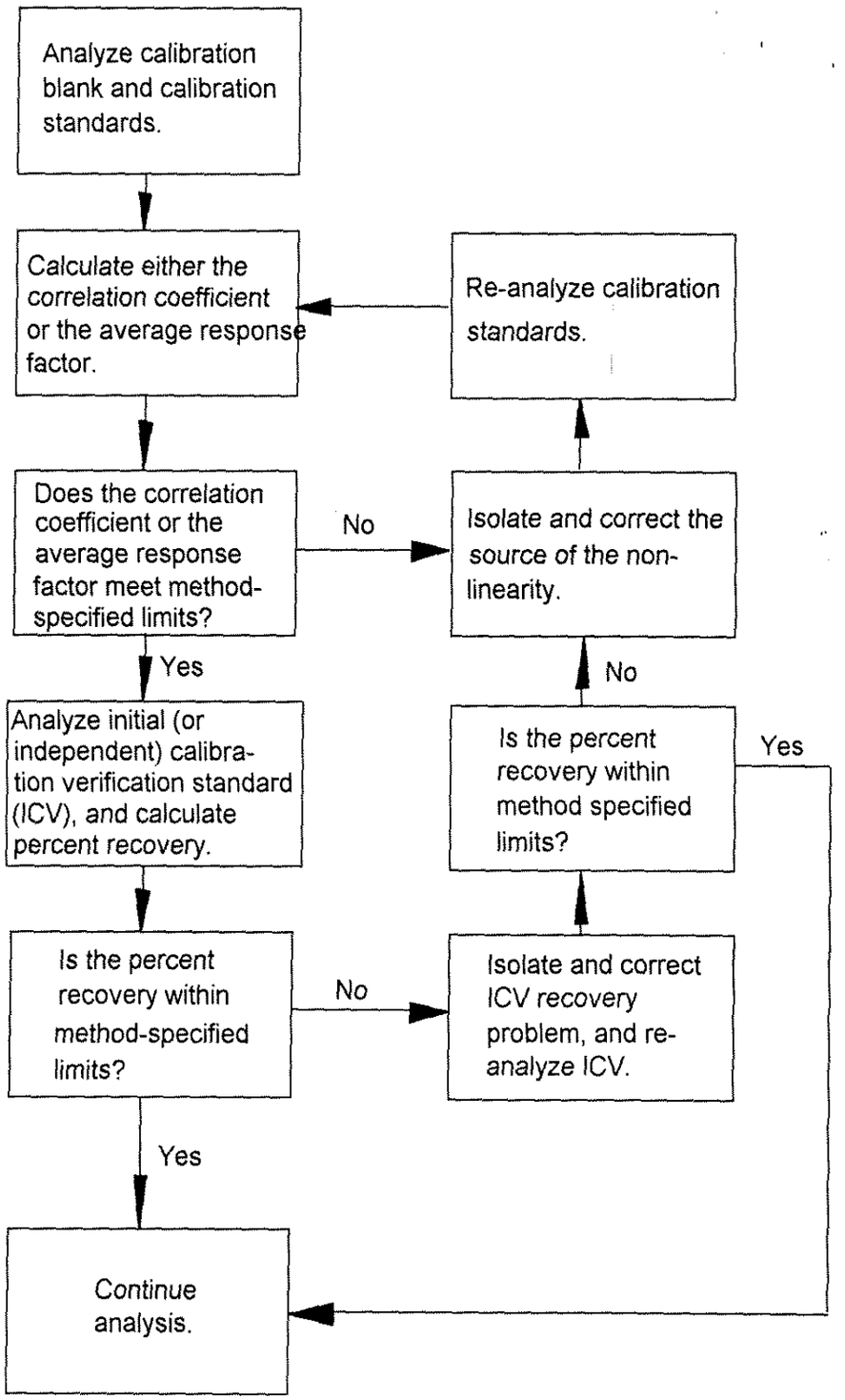


Figure 12-2
Evaluation of Continuing Calibration

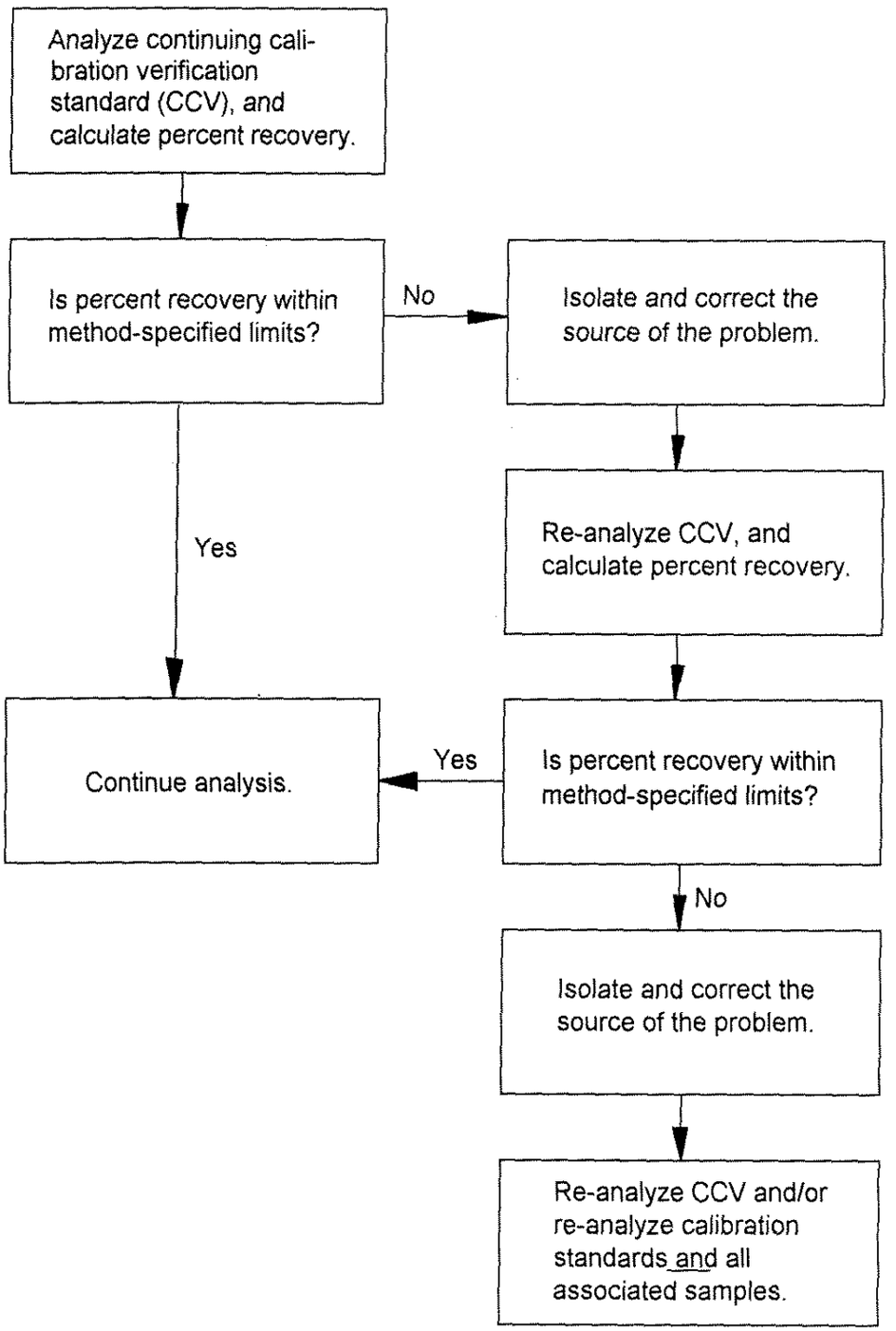


Figure 12-3
Evaluation of Method Blank and Instrument Blank Results

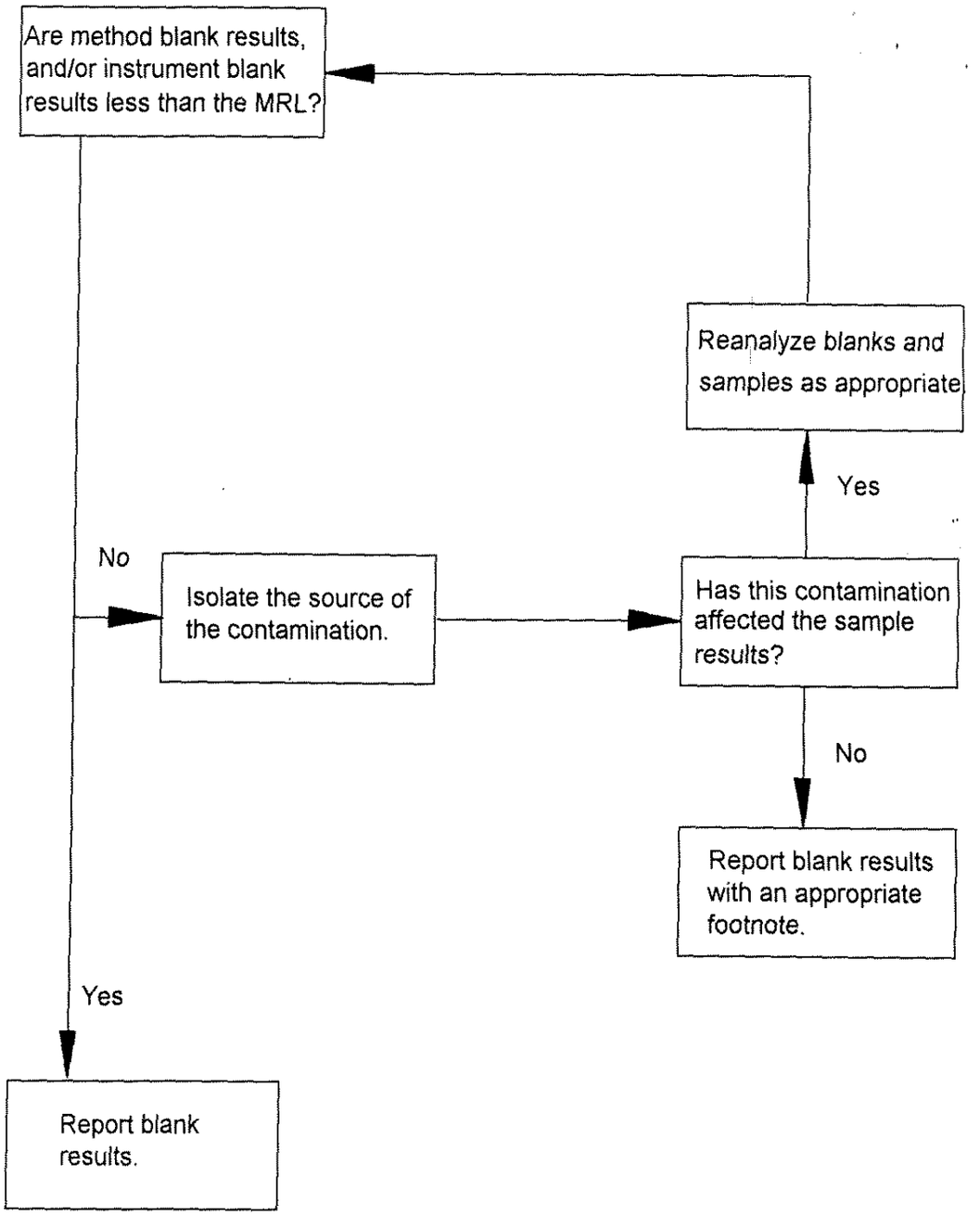


Figure 12-4
Evaluation of Sample Results for Inorganic Analyses

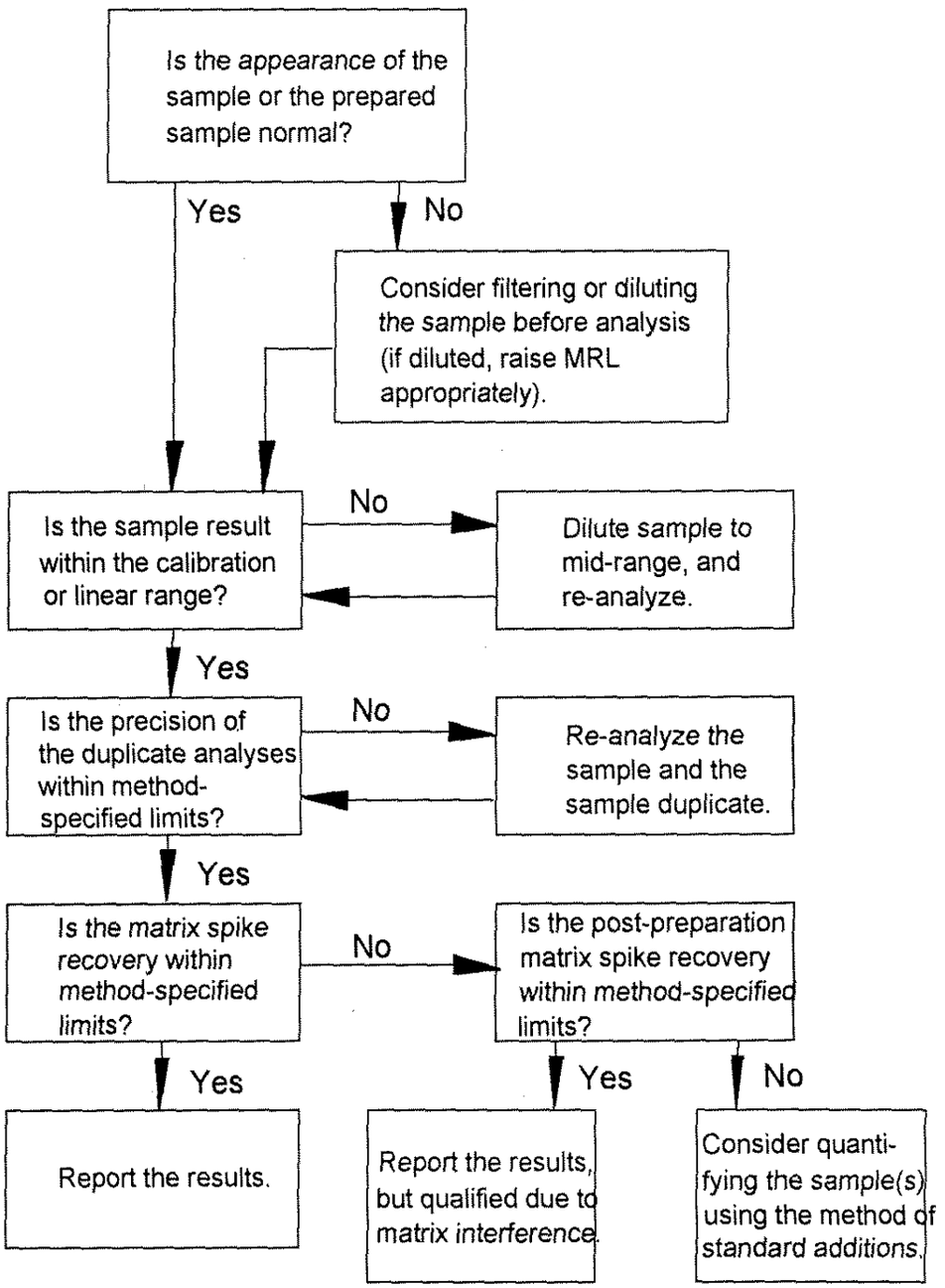


Figure 12-5
Evaluation of Sample Results for Organic Analyses

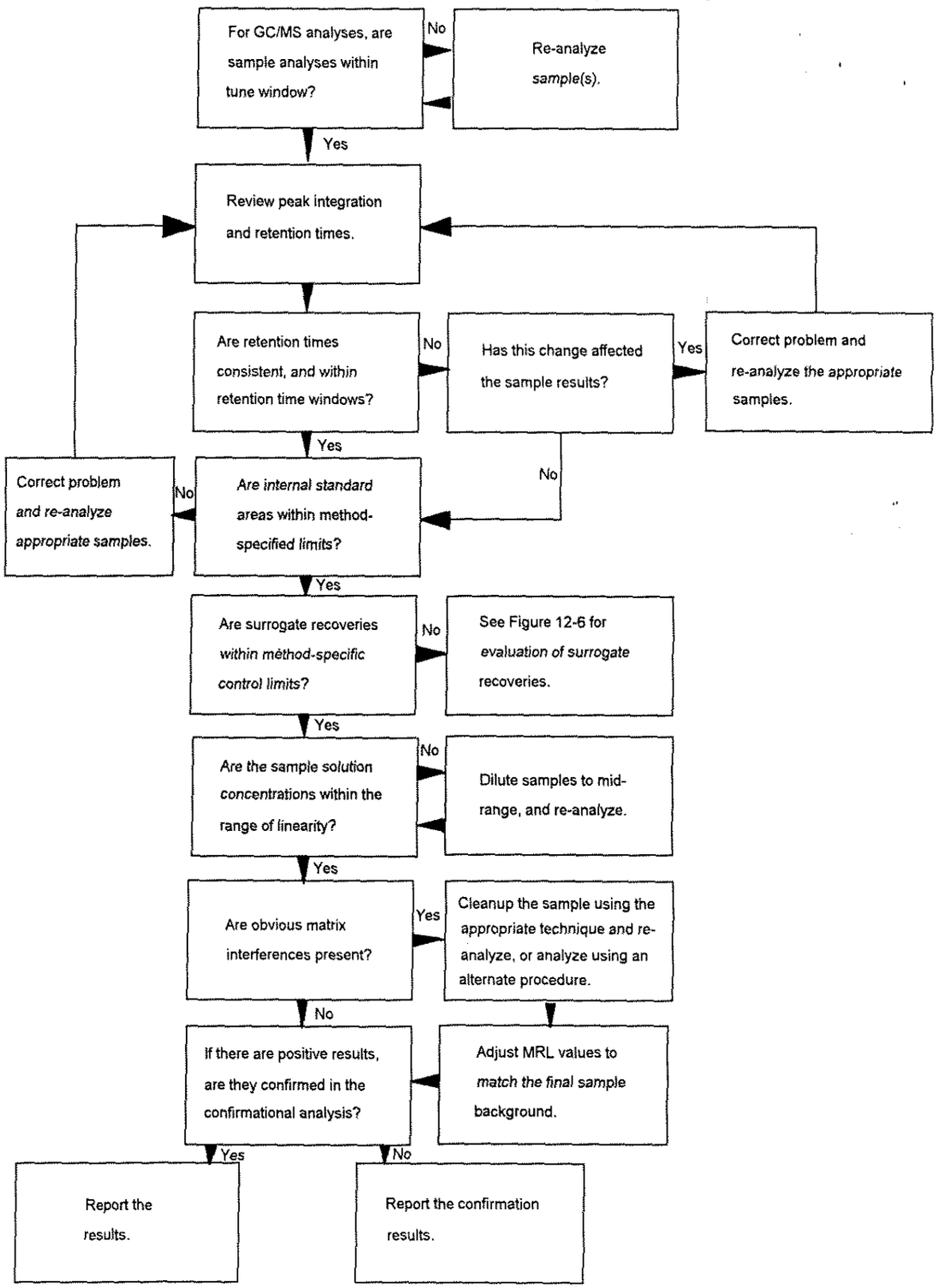


Figure 12-6
Evaluation of Surrogate Compound Recoveries

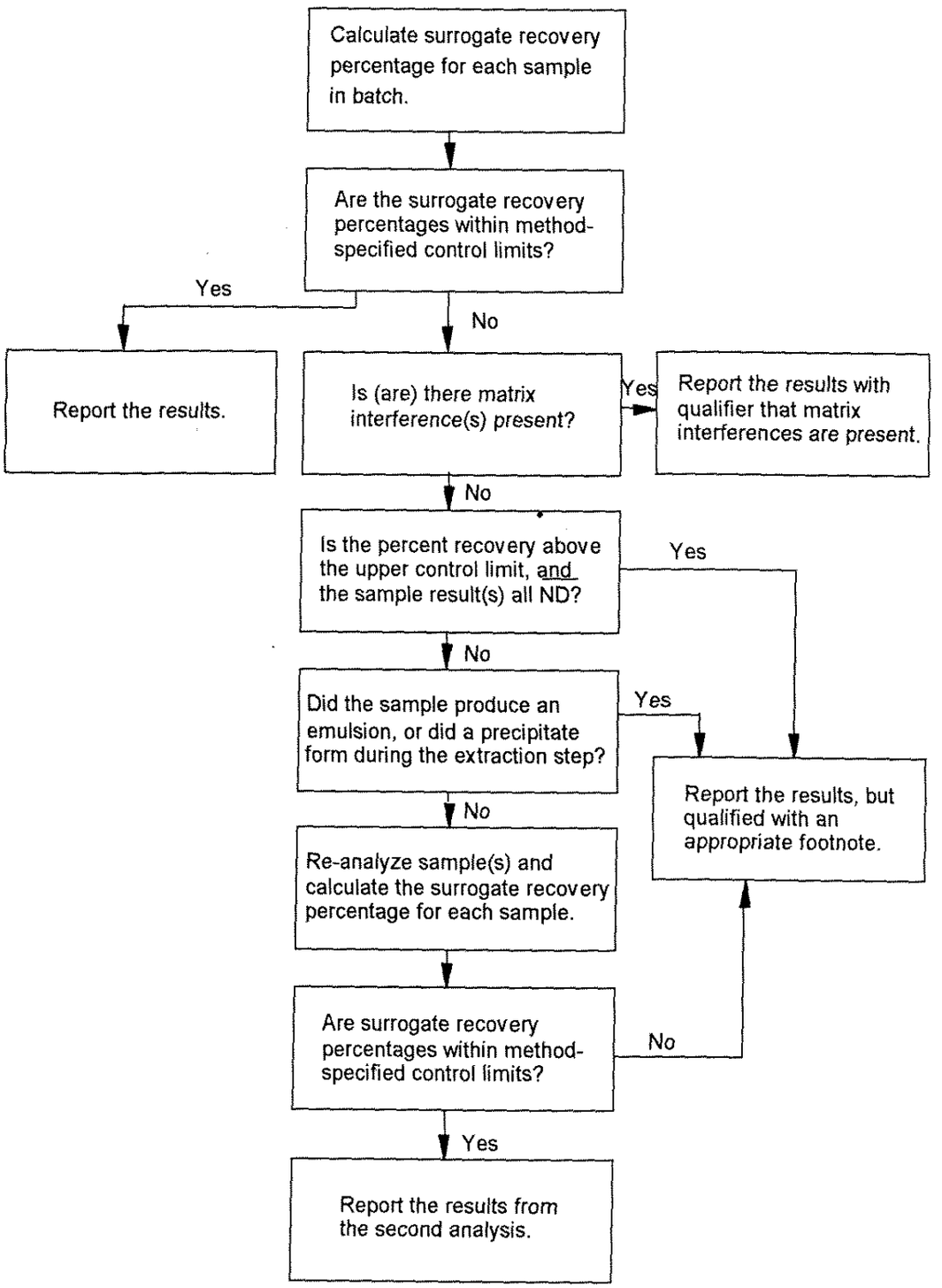


Figure 12-7
Evaluation of Duplicate Sample and/or Duplicate Matrix Spike Results

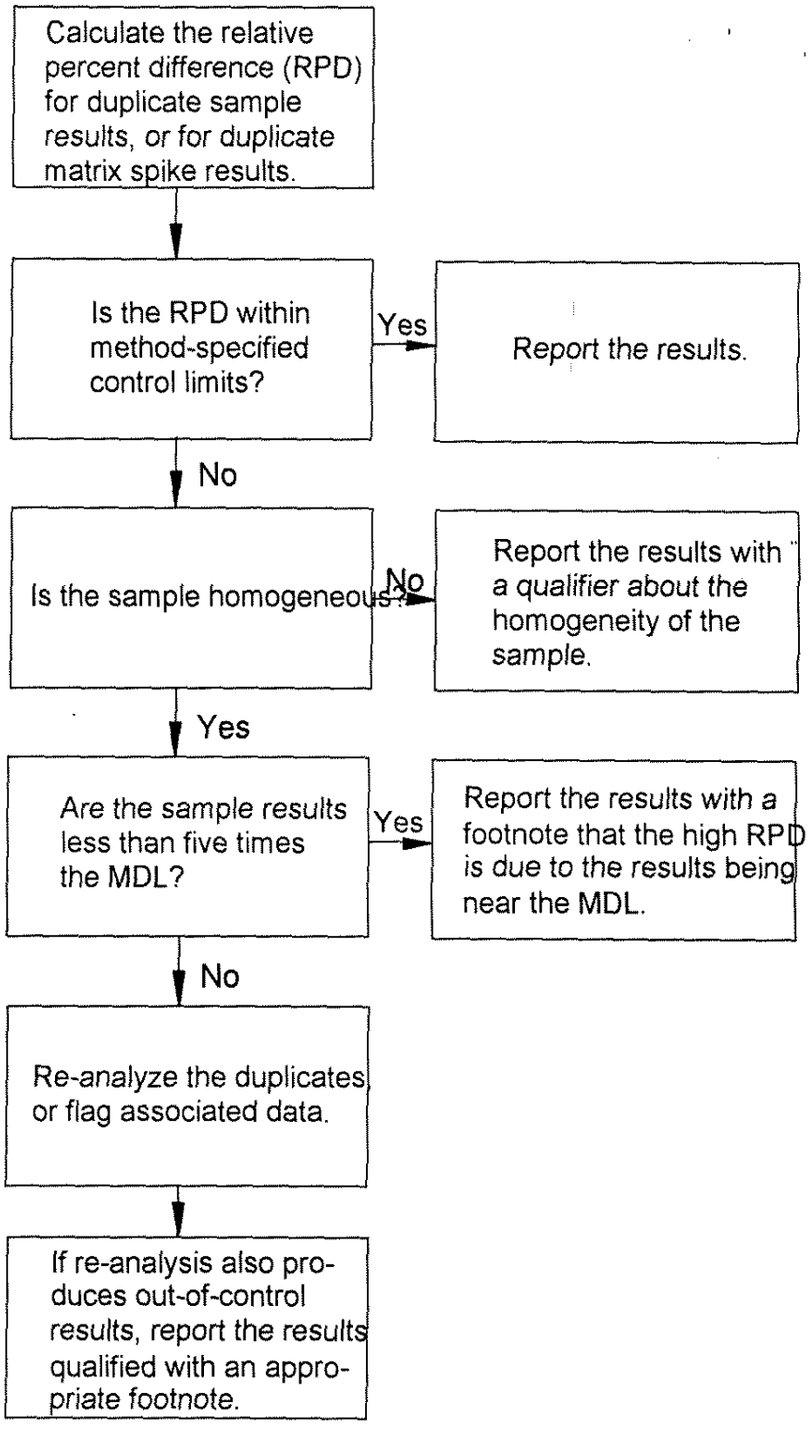


Figure 12-8
Evaluation of Matrix Spike Recoveries

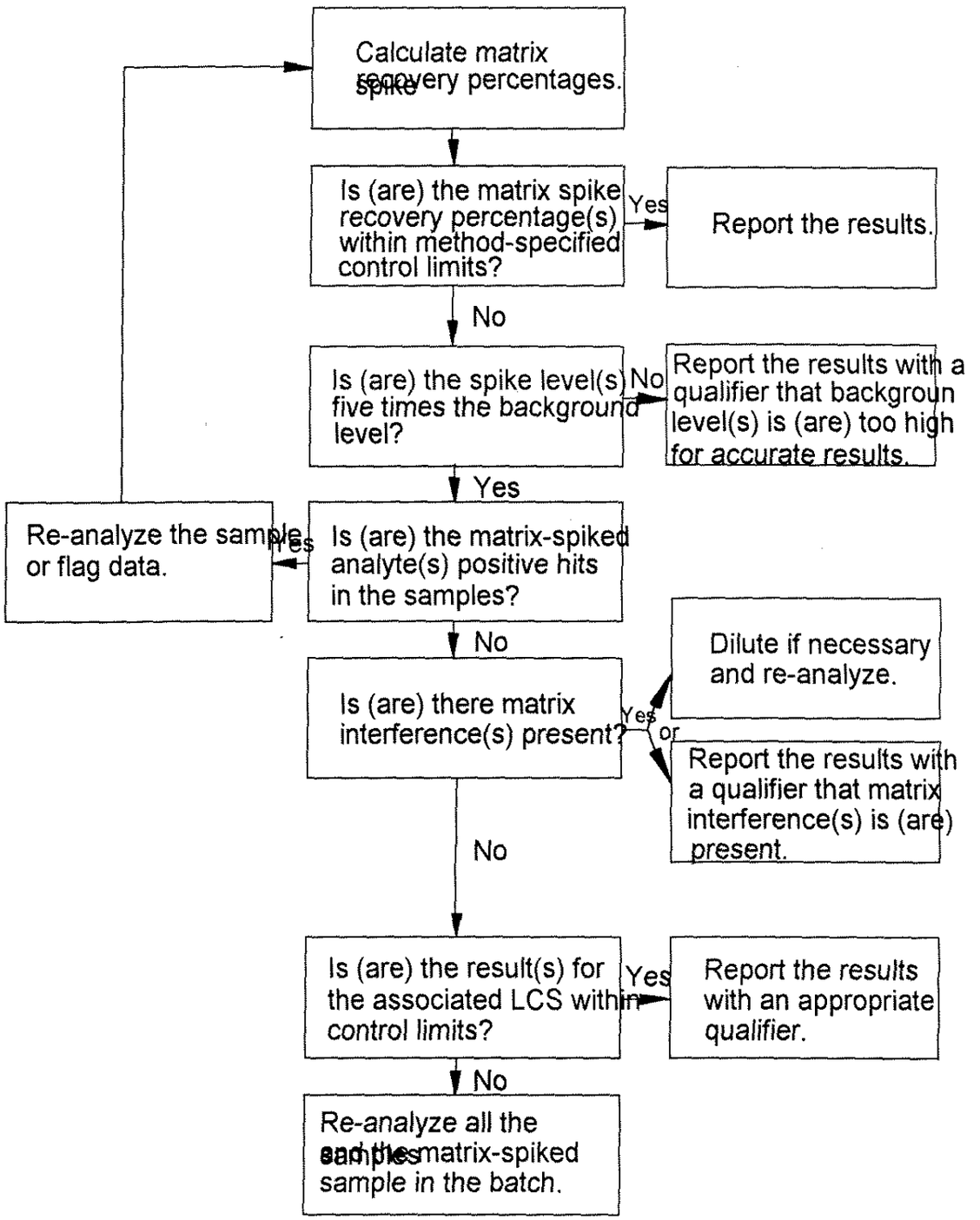


Figure 12-9
Evaluation of Laboratory Control Sample (LCS) Results

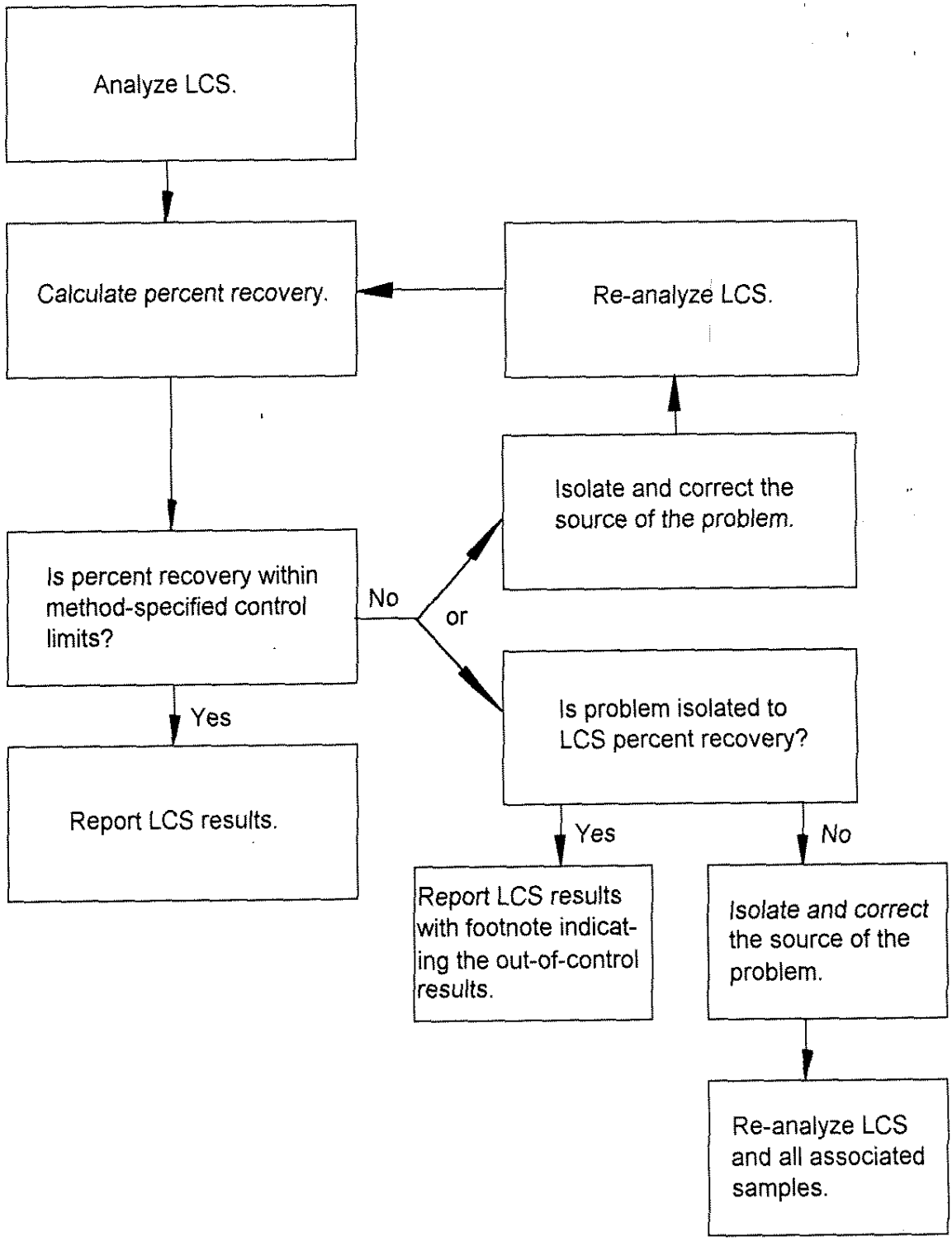


Table 12-1
Laboratory Data Deliverables

Package 1. A Routine Certified Analytical Report Includes the Following

1. Transmittal Letter
2. Sample Analytical Results
3. Method Blank Results
4. Surrogate Recovery Results for appropriate organic methods, including associated EPA or CAS acceptance criteria
5. Chain of Custody Documents

Package 2. In Addition to the Package 1 Deliverables, this Report Includes the Following:

1. Case Narrative

Package 3. In Addition to the Package 2 Deliverables, this Report Includes the Following:

1. Calibration Summaries and Results of initial and continuing calibration verification standards, with calculated recoveries
2. Method Blank Summaries

Package 4. In Addition to the Package 3 Deliverables, this Report Includes the Following:

1. Sample Quantitation Report
2. Standards Preparation Information

Package 5. Full Data Packages

A complete validatable data package, fulfills all deliverable requirements, as specified in the EPA CLP Statement of Work. The data package may include diskette deliverables, upon request.

13.0 PERFORMANCE AND SYSTEM AUDITS

Quality Control (QC) audits are an essential part of CAS's QA program. There are two types of audits used at the facility: System Audits are conducted to qualitatively evaluate the operational details of the field and laboratory QA program, while Performance Audits are conducted by analyzing performance evaluation samples in order to quantitatively evaluate the outputs of the various measurement systems.

The system audit examines the presence and appropriateness of laboratory systems. External system audits of CAS are conducted regularly by various regulatory agencies and clients. Appendix F summarizes some of the major programs in which CAS/Rochester participates. Additionally, internal system audits of CAS/Rochester are conducted regularly by the Quality Assurance Program Manager and by the CAS Quality Assurance Director. The internal system audits are scheduled as four to five auditing events:

- Comprehensive lab-wide system audit - annually
- Audits examining compliance with all QA program requirements as applied to selected projects - 2 per year.

The results of each audit are reported to the Laboratory Director and Supervisors for review and comment. Any deficiencies noted by the auditor are summarized in an audit report and corrective action is taken within a specified length of time to correct each deficiency. Should problems impacting data quality be found during an internal audit, any client whose data is adversely impacted will be given written notification if not already provided. (See SOP ADM-IAUD).

Additionally, CAS/Rochester participates in the analysis of performance evaluation (PE) samples. Results of the performance evaluation samples and audits are reviewed by the Laboratory Director, the QA Program Manager, the Corporate QA Director and the laboratory staff. Any problems surfacing during the audit are investigated, and corrective action is taken regarding any and all deficiencies.

14.0 PREVENTIVE MAINTENANCE

Preventive maintenance is a crucial element of Columbia Analytical Services Quality Assurance program. Instruments at CAS (e.g., GC/MS systems, atomic absorption spectrometers, analytical balances, gas and liquid chromatographs, etc...) are maintained under commercial service contracts or by qualified, in-house personnel. All instruments are operated and maintained according to the instrument operating manuals. All routine and special maintenance activities pertaining to the instruments are recorded in instrument maintenance logbooks. The maintenance logbooks used at CAS contain extensive information about the instruments used at the laboratory.

An initial demonstration of analytical control is required on **every** instrument used at CAS before sample analyses may proceed. If an instrument is modified or repaired, a return to analytical control is **required** before subsequent sample analyses can continue. When an instrument is acquired at the laboratory, the following information is noted in a bound maintenance notebook specifically associated with the new equipment:

- The equipment's serial number.
- Date the equipment was received.
- Date the equipment was placed into service.
- Condition of equipment when received (new, used, reconditioned, etc...)
- Prior history of damage, malfunction, modification or repair (if known).

Preventative maintenance procedures, frequencies, etc... are available for each instrument used at CAS. They may be found in the various SOPs for routine methods performed on an instrument and may also be found in the operating or maintenance manuals provided with the equipment at the time of purchase. Responsibility for ensuring that routine maintenance is performed lies with the section supervisor. Each laboratory section maintains a critical parts inventory. The parts inventories include the items needed to perform the preventative maintenance procedures listed in Appendix E. This inventory or "parts list" also includes the items needed to perform any other routine maintenance and certain in-house non-routine repairs.

When performing maintenance on an instrument (whether preventative or otherwise), additional information about the problem, attempted repairs, etc... is also recorded in the notebook. Typical logbook entries include the following information:

- Details and symptoms of the problem
- Repairs and/or maintenance performed
- Description and/or part number of replaced parts
- Source(s) of the replaced parts
- Analyst's signature and date
- Demonstration of return to analytical control

For most major equipment, back-up equipment is available to avoid downtime. All major analytical equipment is summarized in Appendix A. The section supervisor is responsible to coordinate repair with the manufacturer. The project chemist shall assess the effect of the downtime on the samples in-house and notify the appropriate clients of any delays and/or the possibilities of subcontracting.

15.0 CORRECTIVE ACTION

Failure to meet established analytical controls, such as the quality control objectives outlined in Section 9.0, prompts corrective action. In general, corrective action may take several forms and may involve a review of the calculations, a check of the instrument maintenance and operation, a review of analytical technique and methodology, and reanalysis of quality control and field samples. If a potential problem develops that cannot be solved directly by the responsible analyst, the supervisor, the department manager, and/or the quality assurance coordinator may examine and pursue alternative solutions. In addition, the appropriate project chemist may be notified in order to ascertain if contact with the client is necessary.

The quality assurance coordinator initiates corrective action due to a performance audit or a check sample problem; the affected laboratory personnel are promptly informed, as are the laboratory supervisors and managers.

In either case, a Nonconformity and Corrective Action form is generated to document and notify the appropriate personnel of the nonconformity. Nonconformity include, but are not limited to, method blank contamination, outlying batch QC (other than matrix causing effects), reporting results in the wrong format, and or lacking SOPs.

In special cases, the Laboratory Director may give permission to the analyst, Supervisor, or Project Chemist to deviate from CAS Policy. Typically, a Nonconformity form must be issued to the Director and signed off as being acceptable. Otherwise verbal instructions are given and documented on the raw data as being accepted by the Laboratory Director.

In cases were there are complaints from the clients, follow policy procedures outlined in the SOP, ADM-CMPLT (Dealing with Complaints).

Figure 15-1

Nonconformity and Corrective Action Report

SAMPLES/SYSTEM/JOB/CLIENT AFFECTED

NONCONFORMITY

Analysis/Event: _____

Instrument/System: _____ Date: _____

Detailed Description:

Originator: _____ Date: _____

Supervisor Verification: _____ Date: _____

CORRECTIVE ACTION AND OUTCOME

Detailed Description: (Re-establishment of conformity must be demonstrated and documented. Describe the steps that were taken, or are planned to be taken, to correct the problem. Describe the outcome.)

Person Responsible: _____ Date: _____

Supervisor Verification: _____ Date: _____

NOTIFICATION - CUSTOMER/CLIENT - INTERNAL/EXTERNAL

Project Chemist Notified? No Yes: Date: _____

Customer Notification Necessary? (Attach telephone record) No Yes: Date: _____

Notifier: _____ Date: _____

ACCEPTANCE OF CORRECTIVE ACTION

QA Coordinator: _____ Date: _____

16.0 QUALITY ASSURANCE REPORTS

Quality assurance requires an active, ongoing commitment by CAS personnel at all levels of the organization. Information flow and feedback mechanisms are designed so that analysts, supervisors and managers are aware of quality assurance issues in the laboratory.

Analysts performing routine tests in the laboratory are aware of the various method acceptance criteria and in-house control limits that must be met in order to generate acceptable results. Any non-conformities and corrective actions may also be attached to the data prior to review. Supervisors review all of the completed analytical batches to ensure that all QC criteria have been examined and any deficiencies noted and corrected if possible.

It is the responsibility of each laboratory unit to provide the project chemist with a final report of the data, accompanied by signature approval. Footnotes and/or narrative notes must also accompany any data package if problems were encountered that require further explanation to the client. Each data package is submitted to the appropriate project chemist, who in turn reviews the entire collection of analytical data for completeness. The project chemist must also review the entire body of data to ensure that any and all client-specified objectives were successfully achieved. A case narrative may be written by the project chemist to explain any unusual problems with a specific analysis or sample, etc...

The Quality Assurance Coordinator (QAC) provides overview support to the project chemists if required to do so (e.g. contractually specified, etc...) The QAC is also responsible for the oversight of all internal and external audits, for all performance evaluation sample and analysis programs, and for all laboratory certification/accreditation responsibilities.

The QAC also prepares quarterly reports for the Laboratory Director which summarize the various QA/QC activities that have occurred during the previous quarter. These reports may include a summary of the findings of the various audits performed during the last quarter, copies of audit-deficiency correspondence between the laboratory and external auditors, new accreditations/certifications received by the laboratory, scores of the most current performance evaluation studies, updates/revisions to controlled documents, etc... Any problems noted by the lab director are then discussed during the regularly-scheduled senior staff operations meetings with all appropriate department managers.

17.0 PERSONNEL TRAINING

Technical position descriptions are available for all employees, regardless of position or level of seniority. These documents are maintained by the QA Coordinator and Human Resources. In order to assess the technical capabilities and qualifications of a potential employee, all candidates for employment at CAS are evaluated, in part, against the appropriate technical description.

Information of previously acquired skills and abilities for a new employee is entered into a centralized database maintained by Human Resources. The database is also used to record the various technical skills and abilities acquired and maintained by an employee while employed by CAS. Information in the database includes the employee's name, a description of the skill including the appropriate method reference, the name of the supervisor who certified completion of the training, and the date the training was completed. Technical training is documented following SOP requirements discussed in ADM-TRANDOC.

Training begins the first day of employment at CAS when the company policies are presented and discussed. Training in analytical procedures typically begins with the reading of the SOP for the method. Hands-on training begins with the observation of an experienced analyst performing the method, followed by the trainee performing the method under close supervision, and culminating with independent performance of the method on quality control samples. Successful completion of the analysis must include an Initial Demonstration of Capability Study of four replicate quality control samples. Continued demonstration of capability is monitored by QA using annual single-blind proficiency samples analyzed by each analyst per method. Initial Demonstration of Capability is required anytime a new method is used, new analyst performing the method, or new instrumentation.

Safety training begins with the reading of the *Safety Manual*. All employees are recommended to attend monthly safety meetings during which the safety programs discussed and safety training is presented by the Environmental, Health and Safety Officer.

CAS encourages its personnel to continue to learn and develop new skills that will enhance their performance and value to the company. Ongoing training occurs for all employees through a variety of mechanisms. The "CAS University" education system, external and internal technical seminars and training courses, laboratory-specific training exercises and performance of external PE samples analysis are all used to provide employees with professional growth opportunities.

Safety and QA/QC requirements are integral parts of all technical SOPs and, consequently, are integral parts of all processes at CAS.

18.0 REFERENCES FOR ANALYTICAL PROCEDURES

The analytical methods used at CAS generally depend upon the end-use of the data. Since most of our work involves the analysis of environmental samples for regulatory purposes, specified federal and/or state testing methodologies are used and followed closely. Several factors are involved with the selection of analytical methods to be used in the laboratory. These include the method detection limit, the concentration of the analyte being measured, method selectivity, accuracy and precision of the method, the type of sample being analyzed, and the regulatory compliance objectives. Typical methods used at CAS are taken from the following references:

- *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, Third Edition, 1986 and Updates I (7/92), II (9/94), IIA (8/93), IIB (1/95), and III (12/96). See Chapters 1, 2, 3, and 4.
- *Methods for Chemical Analysis of Water and Wastes*, EPA 600/4-79-020, Revised March 1983.
- *Methods for the Determination of Metals in Environmental Samples*, EPA 600/4-91-010, June 1991 and Supplement I, EPA/600/R-94/111, May, 1994.
- *Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater*, EPA 600/4-82-057, July 1982 and 40 CFR Part 136, Appendix A.
- *Methods for the Determination of Inorganic Substances in Environmental Samples*, EPA 600/R-93/100, August 1993.
- *Methods for the Determination of Organic Compounds in Drinking Water*, EPA 600/4-88-039, December 1988 and Supplement I (7/90) and Supplement II (8/92).
- *Standard Methods for the Examination of Water and Wastewater*, 16th Edition, 1985; 17th Edition, 1989; 18th Edition, 1992, and 19th Edition, 1995.
- 40 CFR Part 136, Guidelines for Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act.
- 40 CFR Part 141, National Primary Driniking Water Regulations.
- State-specific total petroleum hydrocarbon methods for the analysis of samples for gasoline, diesel, and other petroleum hydrocarbon products.

- Annual Book of ASTM Standards.
- EPA Contract Laboratory Program, Statement of Work for Organics Analysis, OLM04.2. May 1999.
- EPA Contract Laboratory Program, Statement of Work for Inorganics Analysis, ILM04.0.
- *U. S. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, EPA-540/R-94/012, February 1993.
- *U. S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, EPA-540/R-94/013, February 1994.
- National Institute for Occupational Safety and Health (NIOSH) *Manual of Analytical Methods*, Third Edition, August 1987.
- *Good Automated Laboratory Practices, Priciples and Guidance to Regulations For Ensuring Data Integrity In Automated Laboratory Operations*, EPA 2185, August 1995.
- *National Environmental Laboratory Accreditation Conference, Quality Standards, Chapters 1-5*, July 1999.

APPENDIX A

MAJOR ANALYTICAL EQUIPMENT

COLUMBIA ANALYTICAL SERVICES, INC.
MAJOR ANALYTICAL EQUIPMENT
(CAS/Rochester Laboratory)

DATE ACQUIRED	INSTRUMENT	SERIAL #	ANALYSES PERFORMED
1987	HP 5890 GC MS #1	2728A13147	VOAs by MS
	HP 5970 MSD MS #1	2716A10553	
	Tekmar Auto Samp. 2016/2000	91226013+91227014	
1988	HP 5970 MSD MS #2	2716A10131	VOAs by MS
	HP 5890 GC MS#2	2613A11406	
	Tekmar Auto Samp. 2016/2000	91331001	
1989	HP 5890 GC MS #3	2750A18391	VOAs by MS
5914	HP 5970 MSD MS #3	~~2824A11243~~ 3118A02764	
	Archon Auto. Samp.	13070	
1990	HP 5890 GC MS #4	2750A15356	Semi-VOAs/
	HP 5970 MSD MS #4	2716A10793	Petroleum
1991	HP 5890II GC MS #5	3121A35679	VOAs by MS
	HP 5971 MSD MS #5	3118A0252532	
	Archon Auto Samp.	12727	
1998	HP 6890 GC MS #6	23178	VOAs by MS
	HP 5973 MSD MS #6	82311143	
	Tekmar Auto Samp. 2016/3000	94312019+94229003	
1998	HP 6890 GC MS 5973-A	US00024148	SemiVOAs
	HP 5973 MSD MS 5973-A	US82311266	CLP
1999	HP 6890 GC MS 5973-B	US00029105	SemiVOAs
	HP 5973 MSD MS 5973-B	US91911849	CLP

COLUMBIA ANALYTICAL SERVICES, INC.
MAJOR ANALYTICAL EQUIPMENT
(CAS/Rochester Laboratory)

DATE ACQUIRED	INSTRUMENT	SERIAL #	ANALYSES PERFORMED
1990	GC HP 5890II (A) FID	3203A41098	Pet Hyd by GC.
1988	GC HP5890II (B) FID	2728A14298	Pet Hyd. by GC
1989	GC HP5890II (C) Dual ECD	2643A11567	HERB/PCB
1998	GC HP 6890 (D) Dual ECD	22174	Pest/PCB/8011
1990	GC HP 5890II (F) Dual ECD	2950A26574	Pest/PCB
1990	GC HP 5890II (L) Dual ECD	2950A27718	Herb/PCB
1990	abc GPC Autoprep 1002B	800B 203	Cleanups
1998	V1 Varian 3400 GC 2016 Autosampler PID/ELCD Detectors	4808 89220008	VOA by GC
1999	V3 Varian 3400 GC Varian Archon Autosampler PID/ELCD Detectors	10989 13316	VOA by GC
1985	T2 Tracor 540 GC 2016 Autosampler PID Detector	861501 88048011	VOA by GC
1987	T1 Tracor 540 GC 2016 Autosampler PID/FID Detectors	911896 90304004	VOA/MinSp/GRO
1998	T6 Varian 3400 GC 2016 Autosampler PID/FID Detectors	4143 91298028	VOA/VPH/GRO
1999	V2 Varian 3300 GC FID Detector	4130	Alcohols/Gases

COLUMBIA ANALYTICAL SERVICES, INC.
MAJOR ANALYTICAL EQUIPMENT
(CAS/Rochester Laboratory)

DATE ACQUIRED	INSTRUMENT	SERIAL #	ANALYSES PERFORMED
1997	Perkin Elmer FIMS	1258	Mercury Analyzer
1991	Perkin Elmer AA 4100ZL	6066	Furnace Metals
1998	Perkin Elmer AA 4100ZL	6245	Furnace Metals
1990 1993	Leeman PS3000 ICP (Upgrade - simultaneous)	1078A	Metals
1994	Perkin Elmer ICP #1 Optima 3000XL	069N4060401	Metals (low-level)
1999	Perkin Elmer ICP #2 Optima 3000XL	069N6062602	Metals (low-level)

COLUMBIA ANALYTICAL SERVICES, INC.

MAJOR ANALYTICAL EQUIPMENT

(CAS/Rochester Laboratory)

DATE ACQUIRED	INSTRUMENT	SERIAL #	ANALYSES PERFORMED
1986	Lachat System IV		
	Colorimeter	125181	Choride,
	Module	125304	NO2/NO3,
	Pump	125209	TKN, NH3,
	Autosampler	125203	Phosphorus, Silica
1999	Lachat 8000 Series		
	Colorimeter	A83000-1286	Choride, TKN
	Diluter	A89000-739	NO2/NO3, NH3
	Pump	A82000-525	Alkalinity, Hardness
	Autosampler	A81010-168	Phosphorus, Silica, Hex. Chromium
Pre-1982	Technicon #1		
	Printer	199-051241	Cyanide
	Pump	TE80139	
	Colorimeter	19900670	
Pre-1982	Technicon #2		
	Autosampler	681-Rest worn off	Phenol
	Pump	PR0276	
	Module	83035	
	Colorimeter	199-006701D	
	Printer-Recorder	82A3321	
1996	Ion Chromatograph Dionex Series 4000i		Anions
	Basic Chromatography Module	871602	
	Gradient Pump	871608	
	Conductivity Detector	871242	
	Controller Pump	31528	
	4270 Integrator	037/24782	
	Autosampler	931526	
1997	Midi-Cyanide Distilation System (A)		Cyanide
	Midi-Cyanide Distilation System (B)		Cyanide
1990	Orion pH meter SA520	2305	pH, Temp.
1992	Orion Ion Meter - Model 720A	005012	
	pH Electrode - Orion		pH
	Fluoride Electr. - Orion 9409		Fluoride
	Ref. Electrode - Orion 90-01-00		

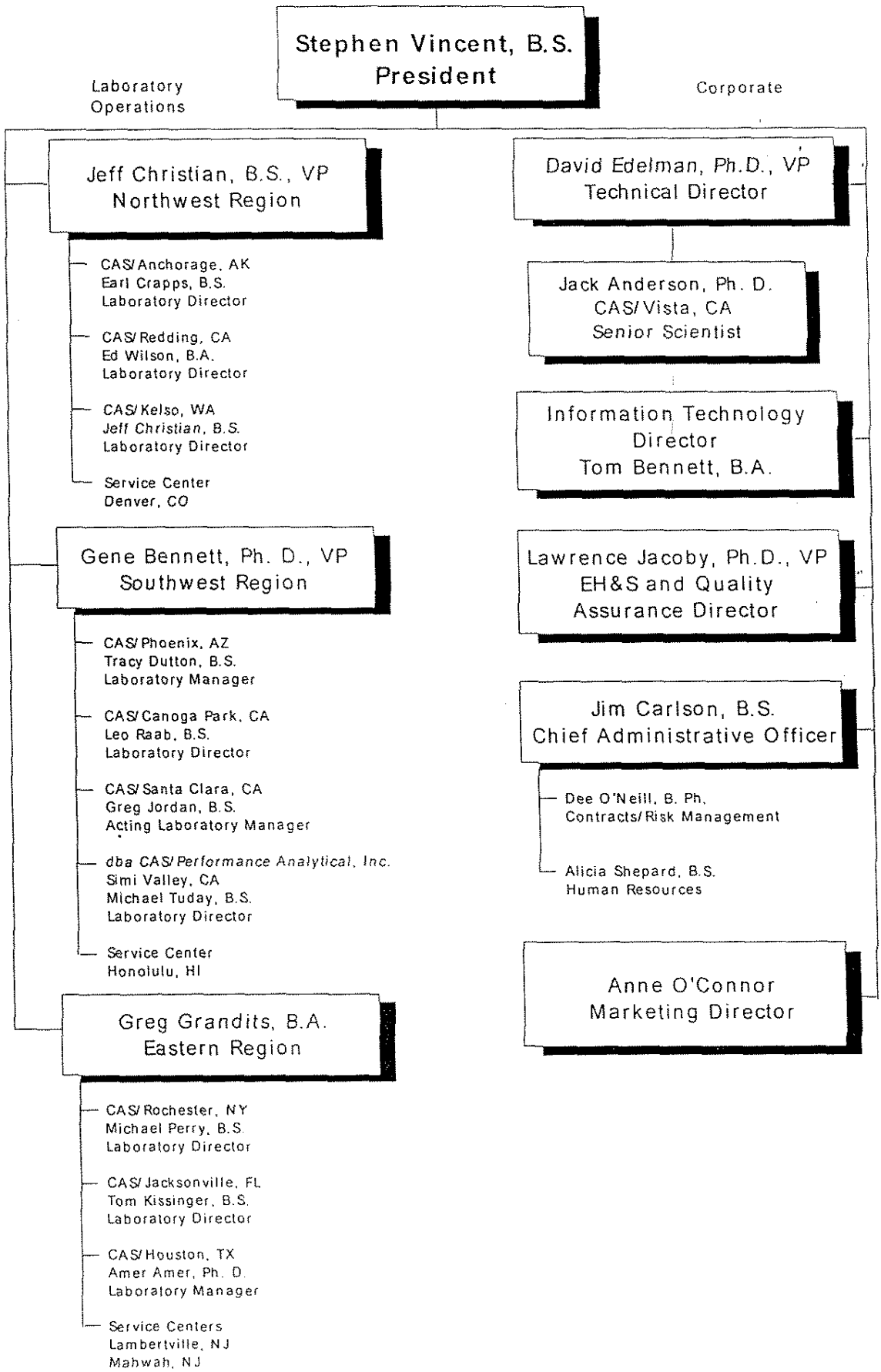
COLUMBIA ANALYTICAL SERVICES, INC.
MAJOR ANALYTICAL EQUIPMENT
(CAS/Rochester Laboratory)

DATE ACQUIRED	INSTRUMENT	SERIAL #	ANALYSES PERFORMED
2000	HF Scientific Micro 100	609246	Turbidity
2000	Jenway Conductivity/pH Meter Model 4330	1344	Conductivity pH
1990	Fisher Analytical Balance	08887	General Use
1990	Mettler Analytical Balance	F96727	General Use
	Top Loading Balances:		
2000	Mettler Toledo PB602-1	1118331281	General Use
	American Scientific PTL2500-1	20466	General Use
1988	Beckman KF4 Aquameter	none	%Water
1993	Boekel Flashpoint Tester Model 152800	none	Closed cup flash
1989	Open up Flash Tester Koehler Instr. Co. model 420	none	Open Cup Flash
Pre-1990	Oxygen Meter - YSI Model 54A	D8024621	DO, BOD
1989	B&L Spectronic 21	1225601	COD, MBAS
1987	B&L (MSR002) Spec.	114	Peroxide
1994	Buck Scientific Total Hydrocarbon Analyzer Model HC404	492	TPH
1991	TOC ModeL 700 OI	1689-8-359	TOC
2001	TOC #2 Dohrmann DC190 Boat sampler 183 s/s1	9507646 9507610	TOC
Pre1970	Amsco Autoclave		Microbiology

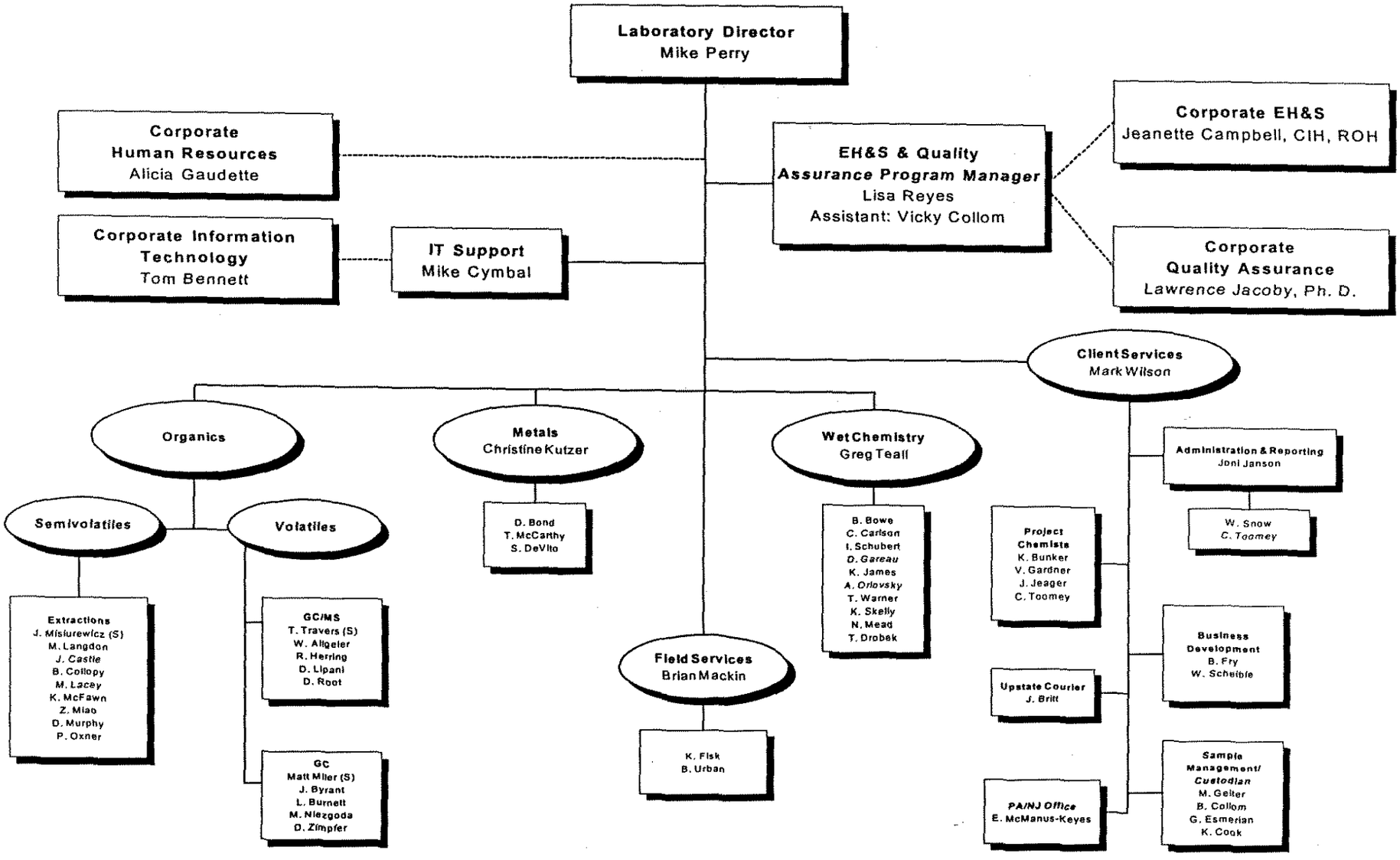
APPENDIX B

ORGANIZATIONAL CHART and RESUMES OF KEY PERSONNEL

Columbia Analytical Services, Inc.
Organization



Columbia Analytical Services, Inc.
Rochester, New York Laboratory Organization



MICHAEL K. PERRY *APRIL 1996-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (716)288-5380

Current Position

Laboratory Director. 1996-Present.

Responsibilities

Primary responsibilities include management of all laboratory departments, scheduling, productivity, reporting and evaluation of analytical methodologies, project planning and Quality Assurance/Quality Control protocols. In addition, other responsibilities include direct responsibility for contracts and consultants relating to the EPA SITE program, ACOE remediation program and the technical interface for the New York State ASP CLP program and other large national based clients.

Experience

Project Chemist Manager - General Testing Corporation, Rochester, New York. In addition to the duties of Laboratory Director listed below, responsibilities expanded to include the supervision of four teams of Project Chemists. Production management was shifted to the Laboratory Supervisors in order to increase client contact. Directly responsible for contracts and consultants relating to the EPA SITE program, ACOE remediation program and the New York State ASP CLP program. 1995-1996

Laboratory Director - General Testing Corporation, Rochester, New York. Primary responsibilities included management of all laboratory departments, scheduling, productivity, reporting and evaluation of analytical methodologies and Quality Assurance/Quality Control protocols. 1985-1995

Instrument Manager - General Testing Corporation, Rochester, New York. Responsibilities included operation and maintenance of all laboratory instruments and supervision of personnel associated with the instrumentation laboratory. Analyses included metals, volatile organics, pesticides/PCBs, and semi-volatile organics. 1979-1985

Senior Quality Assurance Technician - Coca-Cola Corporation, Atlanta, Georgia. Responsible for analysis of raw materials and finished product using both wet chemistry and instrumentation techniques. 1976-1979

Laboratory Technician - Penwalt Pharmaceutical Company, Rochester, New York. Worked in the Quality Control Department. 1975.

Education

Rochester Institute of Technology, Rochester, New York - Matriculated Course work for MS in Chemistry - 1983-1986
ACS Short Course, GC/MS - 1986
ACS Short Course, Effective Management of Chemical Analysis Laboratories - 1985
Georgia State University, Atlanta, Georgia, BS in Chemistry - 1979
State University of New York at Alfred, Alfred, New York - AAS in Chemistry - 1975

Affiliations

American Chemical Society (ACS)

MARK WILSON *APRIL 1996-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (716)288-5380

Current Position Client Service Manager. 1996-Present.

Responsibilities Responsible for supervision of Project Managers, Sales and Sample Management departments. Responsible for project management and client interface regarding analytical services.

Experience

Laboratory Manager - Columbia Analytical Services, Rochester, New York. Responsible for supervision of laboratory staff, scheduling of projects, evaluations of analytical QC procedures, and review of all analytical data. 1996.

Laboratory Manager - General Testing Corporation, Rochester, New York. Responsibilities were primarily same as above. 1992 - 1996.

Assistant Laboratory Director - General Testing Corporation, Rochester, New York. Was responsible for assisting lab director with supervision of lab staff, scheduling of projects, evaluations of analytical and QC procedures, and review of all analytical data. 1988 - 1992.

Organics Department Manager - General Testing Corporation/Columbia Analytical Services, Rochester, New York. Responsible for supervising all organics analyses including GC/MS, GC volatile organics, and GC extractables, and coordinating production and method development. 1986 - 1996.

Organic Extractables Manager - General Testing Corporation, Rochester, New York. Was responsible for GC operation and analysis, GC maintenance, trouble shooting, development, and GC/MS operation and start up. 1985 - 1992.

Staff Technician II - Medical Center University of Kentucky, Lexington, Kentucky. Was responsible for GC and AA analysis on biological fluids, drug screening and monitoring, heavy metals analysis, thin-layer chromatography, HPLC, and water testing. 1979-1985.

Education State University of New York at Buffalo, Buffalo, New York - BS in Medical Technology and 32 hours of Chemistry. 1978

JANICE M. JAEGER *APRIL 1996-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (716)228-5380

Current Position **Project Manager. 1996-Present.**

Responsibilities Assist clients to determine what analyses are required. Oversee projects from quote initiation to final report submission. Act as liason between client requirements and laboratory capabilities for projects. Update clients on progress if their project and answer any questions they may have. Respond promptly to client requests and develop new client contacts within and outside of our current client base.

Experience **Customer Service Representative/Sample Receiving** - General Testing Corporation, Rochester, New York. Primary responsibilities included client services as listed above. Also responsible for sample receipt, log in and distribution as well as bottle preparation. 1989-1996

Surgical Assistant - Penfield Veterinary Hospital Rochester, New York. Primary responsibilities included preparation of instruments, surgical area, and animal for surgery. Also responsible for monitoring the animal before and after surgery. 1984-1989

Education Ohio Wesleyan University, Delaware, Ohio - BA Pre-Veterinary Medicine and Pre-Professional Zoology (double Major), Chemistry Minor - 1983

MICHAEL W. CYMBAL *APRIL 1996-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (716)288-5380

Current Position Systems Analyst I. 1996-Present.

Responsibilities Responsible for computer systems (Novel Lan, Starlims) and instrument analysis of software. Also responsible for client spreadsheets and disk deliverables, computer maintenance and upgrades.

Experience **Computer Administration** - General Testing Corporation, Rochester, New York. Oversaw computer systems (Novel Lan, Starlims, Seven Reporting Systems) and created client spreadsheets and disk deliverables. 1995-1996

Analyst - General Testing Corporation, Rochester, New York. Responsible for Organic Analyses (Volatile and Semi-Volatile Pesticides) for GC and GC/MS. Also responsible for Instrument Maintenance and Sample Preparation. 1990 - 1995

Education Robert's Wesleyan College, Rochester, New York - BS in Chemistry - 1990

LISA M. REYES *February 1997-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (716)288-5380

Current Position

Rochester Quality Assurance/Quality Control Coordinator. 1997-Present. .

Responsibilities

Responsible for the overall coordination of the laboratory QA program and for ensuring that established quality objectives are met. Responsible for Quality Assurance functions including the Quality Assurance Manual, certifications, documenting standard operating procedures, and maintaining performance evaluation records. Oversees balance calibration and sample storage temperature control. Maintains certifications/accreditations for regulatory agencies and client certifications or approval programs. Acts as primary point of contact during laboratory audits. Provides audit responses and initiates any changes in procedures resulting from an audit. Coordinates the analysis of performance evaluation samples required for certification/accreditation programs. Reports and reviews results for these analyses. Conducts internal audits and makes recommendations for corrective action.

Provides technical assistance to laboratory staff on QA/QC issues, project feasibility, and methods interpretation/development.

Experience

Environmental Chemist - TreaTek-CRA Company/Conestoga-Rovers & Associates, Niagara Falls, New York. Data quality, assessments and validations of ASP, CLP, and SW-846 organic and inorganic analytical data. Liaison with analytical contract laboratories, CRA field personnel, and state and federal agencies. Prepared QAPPs, laboratory bidding documents, and contracts. Also responsible for performance of laboratory audits. 1992-1997.

Manager of Quality Management Office - Huntingdon Analytical Services, Middleport, New York. Manager of QA for Environmental, Agrochemical, Asbestos, and Engineering Soil laboratories. Responsible for in-house QA/QC programs, inspections, and instrument maintenance. Also responsible for employee safety and hazardous waste training, as well as manifesting hazardous waste. Routinely performed inorganic analyses, and reviewed analytical data, reports, and CLP packages. 1989-1992.

Research Assistant - Research Foundation, State University of New York College @ Brockport, Brockport, New York. Performed routine sampling of surface water and lakes. Also did inorganic analyses on water and soil matrices. Assisted in graduate projects dealing with fish, plankton, water chemistry, and crayfish. 1986-1989

Education

Westchester Community, Westchester, New York - USEPA Region II Training Course for CLP Inorganic Data Validation. 1993.
Westchester Community, Westchester, New York - USEPA Region II Training Course for CLP Organic Data Validation. 1992.
State University of New York College at Brockport, Brockport, New York - BS in Biology. 1988.

Affiliations

American Chemical Society

MATTHEW MILLER APRIL 1996-PRESENT

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (716)288-5380

Current Position Technical Manager I, GCVOA Laboratory. July 1999-Present.

Responsibilities Scheduling analyses, sample tracking, training analysts, reviewing and validating data and performing any necessary analyses. Also responsible for writing/reviewing departmental SOP's. Additional duties include troubleshooting, maintenance, and repair of instrumentation.

Experience

GCVOA Analyst-Columbia Analytical Services, Rochester, New York. Responibilities same as for GTC (see below:1994-1996). Also responsible for VPH method development and putting together instrumentation for VPH analysis and for PRECEPTII evaluation. 1997-1999.

Wet Chemistry Analyst-Columbia Analytical Services, Rochester, New York. Responsible for scheduling analyses, training new analysts, supervising analysts' work, reviewing and validating data, and performing wet chem analyses. I was also responsible for maintaining a QA/QC database for Wet Chem. parameters and writing/updating departmental SOP's. 1996-1997.

GC/VOA Analyst - General Testing Corporation, Rochester, New York. Responsibilities included analyzing soils and waters on a GC by methods 8010/8020, 601/602, and 8021. Was also responsible for TOC waters and TOX waters, soils, and oils. 1994-1996.

Metals Analyst - General Testing Corporation, Rochester, New York. Was responsible for digestion of waters and soils for analysis by GFAA, ICP, and Flame AA. Analysis of digested samples by above mentioned methods. Also responsible for performing TCLP extractions and Hg analysis. 1993-1994.

Wet Chemistry Analyst - General Testing Corporation, Rochester, New York. As mircrobiology manager, I was responsible for scheduling analyses, and for analyzing waters and sludges for total and fecal coliform, and SPC by MF, MPN and Colilert methods. I was also responsible for tracking and documenting QA/QC for all micro parameters. In wet chemistry, was responsible for analyzing soils and waters for wet chemistry parameters. 1991-1993.

Education State University of New York at Brockport, Brockport, New York - BS in Aquatic Biology. 1991. Jefferson Community College, Watertown, New York - AAS in Science/Math Curriculum. 1989.

JEANNINE MISUIREWICZ MAY 1996-PRESENT

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (716)288-5380

Current Position Supervisor - GC and GC/MS Laboratory (Semi-Volatiles). 2001-Present.

Responsibilities Responsible for preparations, extractions, and analysis of GC & GC/MS semivolatile analyses.

Experience

Scientist II, GC/GCMS Laboratory (Volatiles). - Columbia Analytical Services, Rochester, New York. Responsible for the calibration and maintenance of GC systems equipped with ELCD/PID and PID/FID detectors, and GCMS systems. This includes Tekmar autosampler/Precept/Archon setup and standard preparation. Perform analysis of soils, waters, and airs under GC methods 8021B (Priority Pollutants and Tank Lists), 601/602 and 8015B for GRO and mineral spirits, and GCMS methods 8260B, 524 low levels, and 95-1. Responsible for packages, data entry, and review of jobs before submitting them to department supervisor. Qualified to do data validation when needed. 1997-2001

Scientist I, GC Laboratory (Volatiles) - Columbia Analytical Services, Rochester, New York. Responsibilities were primarily the same as above. 1997.

Scientist I (Summer & Vacation Help), Organics Laboratory - Columbia Analytical Services, Rochester, New York. Extracted and concentrated soils and waters for evaluation. Performed herbicide clean-ups, made surrogates and spiking solutions. Performed clean-ups on concentrated samples. 1996-1997

Analyst (Metals) - General Testing Corporation, Rochester, New York.
Responsible for the digestion of soils and waters. Set up the extractions for TCLPs and ZHEs. Digested and performed mercury analysis. Kept an accurate inventory of incoming samples, and cleaned and maintained the lab environment. 1995-1996

Education University of Buffalo, Buffalo, New York - BS in Chemistry - 1997
Monroe Community College, Rochester, New York - AAS in Chemical Technology - 1995

THOMAS TRAVER *APRIL 1996-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (716)288-5380

Current Position Supervisor MS Volatiles 2000- Present Scientist V.

Responsibilities Responsible for the daily operations of the GC/MS VOA Laboratory. This includes the scheduling of department analyses, instrument calibration, and troubleshooting/maintenance activities.

Experience

Scientist V -GC/MS VOA Laboratory - Columbia Analytical Services, Inc., Rochester, New York. 1997-2000.

Scientist III - GC/MS VOA Laboratory - Columbia Analytical Services, Inc., Rochester, New York. 1996-1997

Scientist II - GC/MS VOA Laboratory - Columbia Analytical Services, Inc., Rochester, New York. 1996

Senior Chemist - GC/MS VOAs - General Testing Corporation, Rochester, New York. Responsible for the daily operations of the GC/MS VOA Laboratory. This includes the scheduling of department analyses, instrument calibration, and troubleshooting/maintenance activities. 1992-1996.

GC/MS Volatiles Operator - General Testing Corporation, Rochester, New York. Was responsible for the operation and maintenance of GC/MS equipment for volatile organics. 1988-1992.

GC Volatiles Analyst - General Testing Corporation, Rochester, New York. Was responsible for full range of analysis for volatiles organics and instrument maintenance. 1986-1988

TOC/TOX Operator - General Testing Corporation, Rochester, New York. Was responsible for initial set up and start up for O.I. TOC analyzer and Mitsubishi TOX analyzer. 1985-1986.

Organic Prep Extractables Technician - General Testing Corporation, Rochester, New York. Was responsible for preparation of environmental samples for various analytical applications including pesticides/PCBs, herbicides, fuel scans, and petroleum hydrocarbons. 1984-1985.

Chemical Environmental Technician - *IBM - East Fish Kill Facility*, Rochester, New York. Was responsible for performing field and laboratory work in air monitoring group. 1979.

Education State University of New York at Buffalo, Buffalo, New York - BA in Chemistry. 1984.

CHRISTINE KUTZER *APRIL 1996-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (716)288-5380

Current Position **Tech Manager I - Metals Laboratory. 1996-Present.**

Responsibilities Responsible for instrument operation, troubleshooting and maintenance. Supervises and schedules personnel for the digestion and analysis of samples, and TCLP extractions. Accountable for personnel training, data entry, data approval, package generation and review. Maintains standards, reagents and supplies for the department.

Experience **Chemist** - General Testing Corporation, Rochester, New York. Responsible for instrument operation, instrument troubleshooting and maintenance, digestion of samples, TCLP extractions, and organization and receipt of samples. Also responsible for data entry and data approval.

1992-1996.

Education St. Bonaventure University, Olean, New York - BS in Chemistry. 1992.

GREG TEALL *APRIL 1996-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (716)288-5380

Current Position General Chemistry Supervisor. 1996-Present.

Responsibilities Responsible for supervising all activities of wet chemistry and microbiology departments, utilizing Starlims data base, scheduling sample analysis, performing analytical tests, and reviewing and validating completed analytical runs by other department members. Maintains analytical instrument and methodology integrity.

Experience

Inorganics Manager - General Testing Corporation, Rochester, New York. Responsibilities were primarily same as above. 1992-1996.

Wet Chemistry Supervisor - General Testing Corporation, Rochester, New York. Managed general chemistry department analyses for inorganic, non-metallic parameters. 1990-1992.

Computer Services Supervisor - General Testing Corporation, Rochester, New York. Assisted in implementation and development of existing and new computer services. 1990.

QA/QC Department Supervisor - General Testing Corporation, Rochester, New York. Assisted in implementation and development of existing and new QA/QC programs. 1989-1990.

Technician - General Testing Corporation, Rochester, New York. General chemistry laboratory technician responsible for analysis of inorganics and non-metal parameters. 1987-1989.

Teaching Assistant - S.U.N.Y. at Brockport, Brockport, New York. Taught freshwater biology laboratories. 1986.

Education S.U.N.Y. at Brockport, Brockport, New York - MS in Biology. 1988.

VALENTINA GARDNER APRIL 1996-PRESENT

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (716)288-5380

Current Position Scientist III, Project Manager/ Sample Management Officer. 1998-Present.

Responsibilities Responsible for overseeing the sample receipt department, aid in logging in samples, bottles orders and completing the necessary documentation.

Assist clients to determine what analyses are required. Oversee projects from quote initiation to final report submission. Act as liaison between client requirements and laboratory capabilities for projects. Update clients on progress of their project and answer any questions they may have. Respond promptly to client requests and develop new client contacts within and outside of our current client base.

Experience **Analyst III, Sample Management Office.** - Columbia Analytical Services, Inc., Rochester, New York. Oversee the sample processing operation and personnel. This requires daily interfacing with the field, laboratory, inventory control, organization of incoming work (check for problems/errors), and client contact. Also responsible for coordination with the rest of the laboratory areas regarding scheduling, overtime, and special projects. 1996-1998

Sample Receipt Supervisor/Sample Custodian - General Testing Corporation, Rochester, New York. Responsibilities were same as above. 1987-1996.

Breakdown Technician - General Testing Corporation, Rochester, New York. Was responsible for sample processing, computer input, running physical analyses such as pH, specific conductivity, temperature, color, etc. 1986-1987.

Field Technician - General Testing Corporation, Rochester, New York. Was responsible for sample collecting, field measurements, and proper paperwork. 1986.

Education State University of New York at Brockport, Brockport, New York - BS in Biological Sciences. 1985.

APPENDIX C

DATA QUALITY CAPABILITIES

METALS ANALYSES

Method	Analyte	Matrix	Practical Quantitation Limit (PQL)	Estimated Method Detection Limit	Precision (RPD)	Matrix Spike Accuracy (%REC)	LCS Accuracy (%REC)	ICV (%REC)	CCV (%REC)
200.7 (ICP) (ug/L)	Aluminum	Water	100	50	20	70-130	85-115	95-105	90-110
	Antimony		60	6	20	70-130	85-115	95-105	90-110
	Arsenic		10	6	20	70-130	85-115	95-105	90-110
	Barium		20	15	20	70-130	85-115	95-105	90-110
	Beryllium		5	1	20	70-130	85-115	95-105	90-110
	Boron		200	100	20	70-130	85-115	95-105	90-110
	Cadmium		5	2	20	70-130	85-115	95-105	90-110
	Calcium		500	100	20	70-130	85-115	95-105	90-110
	Chromium		10	5	20	70-130	85-115	95-105	90-110
	Cobalt		50	5	20	70-130	85-115	95-105	90-110
	Copper		20	10	20	70-130	85-115	95-105	90-110
	Iron		100	50	20	70-130	85-115	95-105	90-110
	Lead		5	3	20	70-130	85-115	95-105	90-110
	Magnesium		500	200	20	70-130	85-115	95-105	90-110
	Manganese		10	5	20	70-130	85-115	95-105	90-110
	Molybdenum		25	10	20	70-130	85-115	95-105	90-110
	Nickel		40	6	20	70-130	85-115	95-105	90-110
	Potassium		2000	800	20	70-130	85-115	95-105	90-110
	Selenium		5	5	20	70-130	85-115	95-105	90-110
	Silver		10	2	20	70-130	85-115	95-105	90-110
	Sodium		500	250	20	70-130	85-115	95-105	90-110
	Thallium		10	5	20	70-130	85-115	95-105	90-110
	Tin		500	120	20	70-130	85-115	95-105	90-110
	Titanium		50	10	20	70-130	85-115	95-105	90-110
	Vanadium		50	5	20	70-130	85-115	95-105	90-110
	Zinc		20	15	20	70-130	85-115	95-105	90-110
206.2 (GFAA) ug/L	Arsenic	Water	10	2	20	75-125	80-120	90-110	90-110
220.2 (GFAA) ug/L	Copper		2	1	20	75-125	80-120	90-110	90-110
239.2 (GFAA) ug/L	Lead		5	3	20	75-125	80-120	90-110	90-110
239.2 (GFAA) ug/L	Lead - DW		1		20	75-125	80-120	90-110	90-110
245.1 (CVAA) ug/L	Mercury		0.3	0.05	20	70-130	85-115	95-105	90-110
270.2 (GFAA) ug/L	Selenium		5	3	20	75-125	80-120	90-110	90-110
279.2 (GFAA) ug/L	Thallium		10	5	20	75-125	80-120	90-110	90-110
6010B (ICP) (mg/Kg)	Aluminum	Soil	10	5	20	75-125	C of A	90-110	90-110
	Antimony		6	1	20	75-125	C of A	90-110	90-110
	Arsenic		1	1	20	75-125	C of A	90-110	90-110
	Barium		2	2	20	75-125	C of A	90-110	90-110
	Beryllium		0.5	0.1	20	75-125	C of A	90-110	90-110
	Boron		20	2	20	75-125	C of A	90-110	90-110
	Cadmium		0.5	0.1	20	75-125	C of A	90-110	90-110
	Calcium		50	20	20	75-125	C of A	90-110	90-110
	Chromium		1	0.3	20	75-125	C of A	90-110	90-110
	Cobalt		5	1	20	75-125	C of A	90-110	90-110
	Copper		2	0.5	20	75-125	C of A	90-110	90-110
	Iron		10	2	20	75-125	C of A	90-110	90-110
	Lead		0.5	0.4	20	75-125	C of A	90-110	90-110
	Magnesium		50	5	20	75-125	C of A	90-110	90-110
	Manganese		1	0.5	20	75-125	C of A	90-110	90-110
	Molybdenum		2.5	2.5	20	75-125	C of A	90-110	90-110
	Nickel		4	1	20	75-125	C of A	90-110	90-110
	Potassium		200	100	20	75-125	C of A	90-110	90-110
	Selenium		0.5	0.5	20	75-125	C of A	90-110	90-110
	Silver		1	0.2	20	75-125	C of A	90-110	90-110
	Sodium		50	30	20	75-125	C of A	90-110	90-110
	Thallium		1	0.7	20	75-125	C of A	90-110	90-110
	Tin		50	50	20	75-125	C of A	90-110	90-110
	Titanium		5	5	20	75-125	C of A	90-110	90-110
	Vanadium		5	3	20	75-125	C of A	90-110	90-110
	Zinc		2	1	20	75-125	C of A	90-110	90-110

METALS ANALYSES									
Method	Analyte	Matrix	Practical Quantitation Limit (PQL)	*Estimated* Method Detection Limit	Precision (RPD)	*Matrix* Spike Accuracy (%REC)	LCS Accuracy (%REC)	ICV (%REC)	CCV (%REC)
7060A (GFAA) mg/Kg	Arsenic	Soil	1		35	75-125	80-120	90-110	80-120
7211 (GFAA) mg/Kg	Copper		0.2		35	75-125	80-120	90-110	80-120
7421 (GFAA) mg/Kg	Lead		0.5		35	75-125	80-120	90-110	80-120
7471A (CVAA) mg/Kg	Mercury		0.05	0.03	35	75-125	80-120	90-110	80-120
7740 (GFAA) mg/Kg	Selenium		0.5		35	75-125	80-120	90-110	80-120
7841 (GFAA) mg/Kg	Thallium		1		35	75-125	80-120	90-110	80-120
6010B (ICP) (ug/L)	Aluminum	Water	100	50	20	75-125	80-120	90-110	90-110
	Antimony		60	6	20	75-125	80-120	90-110	90-110
	Arsenic		10	6	20	75-125	80-120	90-110	90-110
	Barium		20	15	20	75-125	80-120	90-110	90-110
	Beryllium		5	1	20	75-125	80-120	90-110	90-110
	Boron		200	100	20	75-125	80-120	90-110	90-110
	Cadmium		5	2	20	75-125	80-120	90-110	90-110
	Calcium		500	100	20	75-125	80-120	90-110	90-110
	Chromium		10	5	20	75-125	80-120	90-110	90-110
	Cobalt		50	5	20	75-125	80-120	90-110	90-110
	Copper		20	10	20	75-125	80-120	90-110	90-110
	Iron		100	50	20	75-125	80-120	90-110	90-110
	Lead		5	3	20	75-125	80-120	90-110	90-110
	Magnesium		500	200	20	75-125	80-120	90-110	90-110
	Manganese		10	5	20	75-125	80-120	90-110	90-110
	Molybdenum		25	10	20	75-125	80-120	90-110	90-110
	Nickel		40	6	20	75-125	80-120	90-110	90-110
	Potassium		2000	800	20	75-125	80-120	90-110	90-110
	Selenium		5	5	20	75-125	80-120	90-110	90-110
	Silver		10	2	20	75-125	80-120	90-110	90-110
	Sodium		500	250	20	75-125	80-120	90-110	90-110
	Thallium		10	5	20	75-125	80-120	90-110	90-110
	Tin		500	120	20	75-125	80-120	90-110	90-110
	Titanium		50	10	20	75-125	80-120	90-110	90-110
	Vanadium		50	5	20	75-125	80-120	90-110	90-110
	Zinc		20	15	20	75-125	80-120	90-110	90-110
7060A (GFAA) ug/L	Arsenic		10	2	20	75-125	80-120	90-110	80-120
7211 (GFAA) ug/L	Copper		2	1	20	75-125	80-120	90-110	80-120
7421 (GFAA) ug/L	Lead		5	3	20	75-125	80-120	90-110	80-120
7470A (CVAA) ug/L	Mercury		0.3	0.05	20	75-125	80-120	90-110	80-120
7740 (GFAA) ug/L	Selenium		5	3	20	75-125	80-120	90-110	80-120
7841 (GFAA) ug/L	Thallium		10	5	20	75-125	80-120	90-110	80-120
200.7 CLP-M or ILM 4.0 ** (ug/L)	Aluminum	Water	200	50	20	75-125	85-115	90-110	90-110
	Antimony		60	6	20	75-125	85-115	90-110	90-110
	Arsenic		10	6	20	75-125	85-115	90-110	90-110
	Barium		200	15	20	75-125	85-115	90-110	90-110
	Beryllium		5	1	20	75-125	85-115	90-110	90-110
	Cadmium		5	2	20	75-125	85-115	90-110	90-110
	Calcium		5000	100	20	75-125	85-115	90-110	90-110
	Chromium		10	5	20	75-125	85-115	90-110	90-110
	Cobalt		50	5	20	75-125	85-115	90-110	90-110
	Copper		25	10	20	75-125	85-115	90-110	90-110
	Iron		100	50	20	75-125	85-115	90-110	90-110
	Lead		3	3	20	75-125	85-115	90-110	90-110
	Magnesium		5000	200	20	75-125	85-115	90-110	90-110
	Manganese		15	5	20	75-125	85-115	90-110	90-110
	Nickel		40	6	20	75-125	85-115	90-110	90-110
	Potassium		5000	800	20	75-125	85-115	90-110	90-110
	Selenium		5	5	20	75-125	85-115	90-110	90-110
	Silver		10	2	20	75-125	85-115	90-110	90-110
	Sodium		5000	250	20	75-125	85-115	90-110	90-110
	Thallium		10	5	20	75-125	85-115	90-110	90-110
	Vanadium		50	5	20	75-125	85-115	90-110	90-110
	Zinc		20	15	20	75-125	85-115	90-110	90-110

METALS ANALYSES									
Method	Analyte	Matrix	Practical Quantitation Limit (PQL)	Estimated Method Detection Limit	Precision (RPD)	Matrix Spike Accuracy (%REC)	LCS Accuracy (%REC)	ICV (%REC)	CCV (%REC)
206.2 CLP-M (GFAA) ug/L	Arsenic	Water	10	2	20	75-125	85-115	90-110	80-120
239.2 CLP-M (GFAA) ug/L	Lead		3	3	20	75-125	85-115	90-110	80-120
245.1 CLP-M (CVAA) ug/L	Mercury		0.2	0.05	20	75-125	80-120	90-110	80-120
270.2 CLP-M (GFAA) ug/L	Selenium		5	3	20	75-125	85-115	90-110	80-120
279.2 CLP-M (GFAA) ug/L	Thallium		10	5	20	75-125	85-115	90-110	80-120
200.7 CLP-M or ILM 4.0 ** (mg/Kg)	Aluminum	Soils	40	10	20	75-125	C of A	90-110	90-110
	Antimony		12	1.2	20	75-125	C of A	90-110	90-110
	Arsenic		2	1.2	20	75-125	C of A	90-110	90-110
	Barium		40	3	20	75-125	C of A	90-110	90-110
	Beryllium		1	0.2	20	75-125	C of A	90-110	90-110
	Cadmium		1	0.4	20	75-125	C of A	90-110	90-110
	Calcium		1000	20	20	75-125	C of A	90-110	90-110
	Chromium		2	1	20	75-125	C of A	90-110	90-110
	Cobalt		10	1	20	75-125	C of A	90-110	90-110
	Copper		5	2	20	75-125	C of A	90-110	90-110
	Iron		20	10	20	75-125	C of A	90-110	90-110
	Lead		0.6	0.6	20	75-125	C of A	90-110	90-110
	Magnesium		1000	40	20	75-125	C of A	90-110	90-110
	Manganese		3	1	20	75-125	C of A	90-110	90-110
	Nickel		8	1.2	20	75-125	C of A	90-110	90-110
	Potassium		1000	160	20	75-125	C of A	90-110	90-110
	Selenium		1	1	20	75-125	C of A	90-110	90-110
	Silver		2	0.4	20	75-125	C of A	90-110	90-110
	Sodium		1000	50	20	75-125	C of A	90-110	90-110
	Thallium		2	1	20	75-125	C of A	90-110	90-110
	Vanadium		10	1	20	75-125	C of A	90-110	90-110
	Zinc		4	3	20	75-125	C of A	90-110	90-110
245.5 CLP-M (CVAA) mg/Kg	Mercury	Soil	0.1	0.03	20	75-125	80-120	80-120	80-120
7300 NIOSH (ug/filter)	Antimony	Air	3		20	75-125	80-120	80-120	80-120
	Arsenic		0.5		20	75-125	80-120	80-120	80-120
	Cadmium		0.25		20	75-125	80-120	80-120	80-120
	Chromium		0.5		20	75-125	80-120	80-120	80-120
	Copper		1		20	75-125	80-120	80-120	80-120
	Iron		5		20	75-125	80-120	80-120	80-120
	Lead		2.5		20	75-125	80-120	80-120	80-120
	Selenium		0.25		20	75-125	80-120	80-120	80-120
	Zinc		1		20	75-125	80-120	80-120	80-120

Legend: NA = Not Applicable

** Estimated MDL results are actually Estimated Instrument Detection Limits for CLP methods per method required Reporting Limits.

C of A Certificate of Analysis QC Limits Provided per manufacturer.

RED = Method Required

BLUE = Lab Limits

WETCHEM QC LIMITS 2000

METHOD	ANALYTE	MATRIX	UNITS	PQL	MDL (approx)	(RPD)	DUP Freq	ACCURACY MS (% REC)	MS Freq	LCS (% Rec)	LCS Frequency	ICV/CCV
310.1	ALKALINITY, TOTAL	WATER	mg/L	2.00	0.4	20	1/10	79-118	1/10	88-112	1/20	90-110
350.1	AMMONIA	WATER	mg/L	0.0500	0.01	20	1/10	65-127	1/10	90-110	1/20	90-110
350.1	AMMONIA	SOIL	mg/Kg	5.00		20	1/10	70-130	1/10	90-110	1/20	90-110
405.1	BOD/CBOD	WATER	mg/L	2.00		20	1/20	70-136	1/20	49-153	1/20	NA
300.0	BROMIDE BY IC	WATER	mg/L	0.100	0.06	20	1/10	81-127	1/10	90-110	1/20	90-110
300.0	BROMIDE BY IC	SOIL	mg/Kg	10.0		20	1/10	70-130	1/10	90-110	1/20	90-110
410.4	CHEMICAL OXYGEN DEMAND-L	WATER	mg/L	5.00	2	20	1/10	51-136	1/10	79-120	1/20	85-115
410.4	CHEMICAL OXYGEN DEMAND-H	WATER	mg/L	50	8	20	1/10	51-136	1/10	79-120	1/20	85-115
410.4	CHEMICAL OXYGEN DEMAND	SOIL	mg/Kg	100		20	1/10	17-121	1/10	73-110	1/20	85-115
325.2	CHLORIDE	WATER	mg/L	1.00	0.2	20	1/10	70-125	1/10	87-115	1/20	90-110
325.2	CHLORIDE	SOIL	mg/Kg	30.0		20	1/10	69-112	1/10	87-115	1/20	90-110
300.0	CHLORIDE BY IC	WATER	mg/L	0.100	0.06	20	1/10	70-125	1/10	90-110	1/20	90-110
300.0	CHLORIDE BY IC	SOIL	mg/Kg	30.0		20	1/10	69-112	1/10	90-110	1/20	90-110
409A	CHLORINE DEMAND	WATER	mg/L	5.00	NA	20	1/20	NA	NA	NA	NA	NA
330.4	CHLORINE RES (FREE)	WATER	mg/L	0.100		20	1/10	NA	NA	NA	NA	NA
330.4	CHLORINE RES (TOTAL)	WATER	mg/L	0.300	0.1	20	1/10	NA	NA	NA	NA	NA
110.2	COLOR (TRUE)	WATER	mg/L	5.0	NA	20	1/20	NA	NA	+/-5units	NA	NA
120.1	CONDUCTIVITY	WATER	umhos/cm		0.3	20	1/20	NA	NA	90-110	1/20	NA
7196A	CR+6 HEX-CHROM	WATER	mg/L	0.0100	0.001	20	1/10	85-115	1/10	85-117	1/20	90-110
3060/7196A	CR+6 HEX-CHROM	SOIL	mg/Kg	4.00	0.5	20	1/20	85-115	1/10	84-112	1/20	90-110
335.2M CLP	CYANIDE, TOTAL	WATER	mg/L	0.010	0.002	20	1/20	75-125	1/20	85-115	1/20	85-115
335.2M CLP	CYANIDE, TOTAL	SOIL	mg/Kg	0.500		20	1/20	24-153	1/20	85-115	1/20	85-115
335.4	CYANIDE TOTAL	WATER	mg/L	0.0100	0.002	20	1/10	67-127	1/10	90-110	HL & LL 1/20	90-110
9012A	CYANIDE, TOTAL	WATER	mg/L	0.0100	0.001	20	1/10	67-127	1/10	52-138	HL & LL 1/20	85-115
9012A	CYANIDE, TOTAL	SOIL	mg/Kg	0.500		20	1/10	24-153	1/10	52-138	HL & LL 1/20	85-115
9012A	CYANIDE, REACTIVITY	WATER	mg/L	0.0500		20	1/20	NA	1/20	0-23	1/20	85-115
9012A	CYANIDE, REACTIVITY	SOIL	mg/Kg	5.0	2	20	1/20	NA	1/20	0-23	1/20	85-115
340.2	FLUORIDE (ISE)	WATER	mg/L	0.100	0.01	20	1/20	75-125	1/20	80-120	1/20	90-110
340.2	FLUORIDE (ISE)	SOIL	mg/Kg			20	1/20	75-125	1/20	80-120	1/20	90-110
340.1/4500-F-D	FLUORIDE (SPADNS)	WATER	mg/L	0.100	0.02	NA	NA	NA	NA	85-122	1/20	90-110
300.0	FLUORIDE BY IC	WATER	mg/L	0.200	0.06	100	1/10	69-130	1/10	90-110	1/20	90-110
300.0	FLUORIDE BY IC	SOIL	mg/Kg	20.0		20	1/10	70-130	1/10	90-110	1/20	90-110
130.2	HARDNESS, TOTAL	WATER	mg/L	2.00	0.3	20	1/10	78-124	1/10	91-114	1/20	NA
CAS	HYDROGEN PEROXIDE	WATER	mg/L	1.00	0.3	20	1/10	83-102	1/10	82-104	1/20	90-110
1010	IGN - CLOSED CUP	WATER	mg/L		NA	10	1/20	NA	NA	24.3-29.7 C	1/20	NA
1010.CC	IGN - OPEN CUP	SOIL	mg/Kg		NA	20	1/20	NA	NA	NA	NA	NA

METHOD	ANALYTE	MATRIX	UNITS	PQL	MDL (approx)	(RPD)	DUP Freq	ACCURACY MS (% REC)	MS Freq	LCS (% Rec)	LCS Frequency	ICV/CCV
300.0	NITRATE BY IC	WATER	mg/L	0.0500	0.01	20	1/10	82-113	1/10	90-110	1/20	90-110
300.0	NITRATE BY IC	SOIL	mg/Kg	5.00		20	1/10	70-130	1/10	90-110	1/20	90-110
353.2	NITRATE/NITRITE AS N	WATER	mg/L	0.0500	0.002	20	1/10	41-145	1/10	90-110	1/20	90-110
353.2	NITRATE/NITRITE AS N	SOIL	mg/Kg	5.00		20	1/10	70-130	1/10	80-120	1/20	90-110
353.2	NITRITE	WATER	mg/L	0.0100	0.004	20	1/10	45-148	1/10	90-110	1/20	90-110
351.2	NITROGEN, TOTAL KJELDAHL	WATER	mg/L	0.200	0.06	20	1/10	55-128	1/10	63-116	1/20	90-110(I)85-115(C)
351.2-M	NITROGEN, TOTAL KJELDAHL	SOIL	mg/Kg	20.0		20	1/10	45-127	1/10	70-120	1/20	90-110(I)85-115(C)
351.2	NITROGEN, TOTAL KJELDAHL L	WATER	mg/L	0.0500	0.03	20	1/10	55-128	1/10	63-116	1/20	90-110(I)85-115(C)
413.1	OIL & GREASE	WATER	mg/L	5.00	4	30	1/20	41-152	1/20	63-124	1/20	NA
9071A	OIL & GREASE	SOIL	mg/Kg	500		30	1/20	41-152	1/20	80-120	1/20	NA
1664A	OIL & GREASE BY 1664	WATER	mg/L	5.00	4	20	1/20	78-114	1/20	78-114	1/20	NA
300.0	ORTHO-PHOS BY IC	WATER	mg/L	0.100	0.02	20	1/10	80-120	1/10	90-110	1/20	90-110
365.3	ORTHOPHOSPHATE	WATER	mg/L	0.0100	0.0007	20	1/10	40-147	1/10	90-110	1/20	90-110
9095	PAINT FILTER TEST	SLUDGE	mg/Kg	ND	NA	20	1/20	NA	NA	NA	NA	NA
150.1	PH	WATER	SU	1	NA	±0.10	1/10	NA	NA	NA	NA	±0.10
9040/9045.	PH/CORROSIVITY	WATER	SU	1	NA	±0.10	1/10	NA	NA	NA	NA	±0.10
9040/9045.	PH/CORROSIVITY	SOIL	SU	1	NA	±0.10	1/10	NA	NA	NA	NA	±0.10
420.2	PHENOLICS, LL (0.001)	WATER	mg/L	0.0010	0.0004	20	1/10	75-115	1/10	80-114	1/20	85-115
420.2	PHENOLICS, TOTAL	WATER	mg/L	0.00500	0.0004	20	1/10	75-115	1/10	80-114	1/20	85-115
9066.	PHENOLICS, TOTAL	WATER	mg/L	0.0050	0.0004	20	1/10	75-115	1/10	80-114	1/20	85-115
9066.	PHENOLICS, TOTAL	SOIL	mg/Kg	0.100		20	1/10	69-110	1/10	70-110	1/20	85-115
365.1 M	PHOSPHORUS, TOTAL, LL	WATER	mg/L	0.00300	0.001	20	1/10	36-140	1/10	65-119	1/20	90-110
365.1	PHOSPHORUS, TOTAL	WATER	mg/L	0.0500	0.005	20	1/10	36-140	1/10	90-110	1/20	90-110
365.1-M	PHOSPHORUS, TOTAL	SOIL	mg/Kg	5.00		20	1/20	75-125	1/10	60-136	1/20	90-110
370.1	SILICA	WATER	mg/L	0.0100	0.001	20	1/10	62-131	1/10	92-115	1/20	90-110
160.0	SOLIDS, PERCENT	SOIL	mg/Kg	1.0	NA	30	1/10	NA	NA	NA	NA	NA
160.5	SOLIDS, SETTLEABLE	WATER	mg/L	0.100	NA	20	1/20	NA	NA	NA	NA	NA
160.3	SOLIDS, TOTAL (TS)	WATER	mg/L	10.0	NA	20	1/10	NA	NA	80-120	1/20	NA
160.1	SOLIDS, TOTAL DISSOLVED	WATER	mg/L	10.0	NA	20	1/10	NA	NA	80-120	1/20	NA
160.2	SOLIDS, TOTAL SUSPENDED	WATER	mg/L	1.00	NA	20	1/10	NA	NA	80-120	1/20	NA
160.4	SOLIDS, TOTAL VOLATILE	WATER	mg/L	10.0	NA	20	1/10	NA	NA	NA	NA	NA
160.4D	SOLIDS, VOLATILE DISSOLVED	WATER	mg/L	10.0	NA	20	1/10	NA	NA	NA	NA	NA
375.4	SULFATE	WATER	mg/L	5.00	1	20	1/10	73-123	1/10	87-114	1/20	NA
300.0	SULFATE BY IC	WATER	mg/L	0.200	0.06	20	1/10	73-123	1/10	90-110	1/20	90-110
300.0	SULFATE BY IC	SOIL	mg/Kg	30.0		20	1/10	70-130	1/10	90-110	1/20	90-110

METHOD	ANALYTE	MATRIX	UNITS	PQL	MDL (approx)	(RPD)	DUP Freq	ACCURACY MS (% REC)	MS Freq	LCS (% Rec)	LCS Frequency	ICV/CCV
CH7/9030B	SULFIDE REACTIVITY	WATER	mg/L	1.00		20	1/10	NA	NA	42-213	1/20	NA
CH7/9030B	SULFIDE REACTIVITY	SOIL	mg/Kg	20.0	17	20	1/10	NA	NA	42-213	1/20	NA
9030B	SULFIDE, TOTAL	WATER	mg/L	1.00	0.05	20	1/10	33-110	1/20	44-122	1/20	NA
9030B	SULFIDE, TOTAL	SOIL	mg/Kg	20.0		20	1/10	33-110	1/20	44-122	1/20	NA
376.1	SULFIDE, TOTAL	WATER	mg/L	1.00	0.10	20	1/10	33-110	1/20	44-122	1/20	NA
377.1	SULFITE	WATER	mg/L	2.00		20	1/10	NA	NA	NA	NA	NA
425.1	SURFACTANTS	WATER	mg/L	0.0200	0.005	20	1/20	NA	NA	75-127	1/20 HL	NA
415.1	TOC - LOW LEVEL	WATER	mg/L	0.100	0.01	20	1/10	67-136	1/10	81-116	1/20	85-115
9060./415.1	TOC - REG LEVEL	WATER	mg/L	1.00	0.2	20	1/10	67-136	1/10	81-116	1/20	85-115
TOCLK	TOC SOIL - LLOYD KAHN	SOIL	mg/Kg	300	30.0	20	1/20	70-130	1/20	80-120	1/20	85-115
TOCWB	TOC - WALKLEY - BLACK	SOIL	mg/Kg	0.10	0.0002	20	1/20	69-105	1/20	83-98	1/10	NA
418.1	TPH by IR	WATER	mg/L	0.500	0.2	20	1/10	50-150	1/10	69-122	1/20	80-120
418.1	TPH by IR	SOIL	mg/Kg	33.0	13	20	1/10	49-160	1/10	79-130	1/20	80-120
180.1	TURBIDITY	WATER	NTU	0.10	0.07	10	1/20	NA	NA	NA	1/20	90-110

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
524.2	1,1,1,2-TETRACHLOROETHANE	WATER	0.50	UG/L	0.07	20	70-130	
524.2	1,1,1-TRICHLOROETHANE	WATER	0.50	UG/L	0.05	20	70-130	
524.2	1,1,2,2-TETRACHLOROETHANE	WATER	0.50	UG/L	0.08	20	70-130	
524.2	1,1,2-TRICHLOROETHANE	WATER	0.50	UG/L	0.12	20	70-130	
524.2	1,1-DICHLOROETHANE	WATER	0.50	UG/L	0.05	20	70-130	
524.2	1,1-DICHLOROETHENE	WATER	0.50	UG/L	0.04	20	70-130	70-130
524.2	1,1-DICHLOROPROPENE	WATER	0.50	UG/L	0.04	20	70-130	
524.2	1,2,3-TRICHLOROBENZENE	WATER	0.50	UG/L	0.15	20	70-130	
524.2	1,2,3-TRICHLOROPROPANE	WATER	0.50	UG/L	0.09	20	70-130	
524.2	1,2,4-TRICHLOROBENZENE	WATER	0.50	UG/L	0.12	20	70-130	
524.2	1,2,4-TRIMETHYLBENZENE	WATER	0.50	UG/L	0.05	20	70-130	
524.2	1,2-DIBROMO-3-CHLOROPROPANE	WATER	0.50	UG/L	0.31	20	70-130	
524.2	1,2-DIBROMOETHANE	WATER	0.50	UG/L	0.05	20	70-130	
524.2	1,2-DICHLOROBENZENE	WATER	0.50	UG/L	0.06	20	70-130	
524.2	1,2-DICHLOROETHANE	WATER	0.50	UG/L	0.03	20	70-130	
524.2	1,2-DICHLOROPROPANE	WATER	0.50	UG/L	0.06	20	70-130	
524.2	1,3,5-TRIMETHYLBENZENE	WATER	0.50	UG/L	0.03	20	70-130	
524.2	1,3-DICHLOROBENZENE	WATER	0.50	UG/L	0.07	20	70-130	
524.2	1,3-DICHLOROPROPANE	WATER	0.50	UG/L	0.08	20	70-130	
524.2	1,4-DICHLOROBENZENE	WATER	0.50	UG/L	0.09	20	70-130	
524.2	2,2-DICHLOROPROPANE	WATER	0.50	UG/L	0.07	20	70-130	
524.2	2-CHLOROTOLUENE	WATER	0.50	UG/L	0.06	20	70-130	
524.2	4-CHLOROTOLUENE	WATER	0.50	UG/L	0.05	20	70-130	
524.2	BENZENE	WATER	0.50	UG/L	0.05	20	70-130	70-130
524.2	BROMOBENZENE	WATER	0.50	UG/L	0.04	20	70-130	
524.2	BROMOCHLOROMETHANE	WATER	0.50	UG/L	0.10	20	70-130	
524.2	BROMODICHLOROMETHANE	WATER	0.50	UG/L	0.06	20	70-130	
524.2	BROMOFORM	WATER	0.50	UG/L	0.10	20	70-130	
524.2	BROMOMETHANE	WATER	0.50	UG/L	0.09	20	70-130	
524.2	CARBON TETRACHLORIDE	WATER	0.50	UG/L	0.04	20	70-130	
524.2	CHLOROBENZENE	WATER	0.50	UG/L	0.05	20	70-130	70-130
524.2	CHLOROETHANE	WATER	0.50	UG/L	0.06	20	70-130	
524.2	CHLOROFORM	WATER	0.50	UG/L	0.05	20	70-130	
524.2	CHLOROMETHANE	WATER	0.50	UG/L	0.15	20	70-130	
524.2	CIS-1,2-DICHLOROETHENE	WATER	0.50	UG/L	0.01	20	70-130	
524.2	CIS-1,3-DICHLOROPROPENE	WATER	0.50	UG/L	0.05	20	70-130	
524.2	DIBROMOCHLOROMETHANE	WATER	0.50	UG/L	0.08	20	70-130	
524.2	DIBROMOMETHANE	WATER	0.50	UG/L	0.07	20	70-130	
524.2	DICHLORODIFLUOROMETHANE	WATER	0.50	UG/L	0.05	20	70-130	
524.2	ETHYLBENZENE	WATER	0.50	UG/L	0.06	20	70-130	
524.2	HEXACHLOROBUTADIENE	WATER	0.50	UG/L	0.09	20	70-130	
524.2	ISOPROPYLBENZENE	WATER	0.50	UG/L	0.05	20	70-130	
524.2	M+P-XYLENE	WATER	0.50	UG/L	0.05	20	70-130	
524.2	METHYLENE CHLORIDE	WATER	0.50	UG/L	0.09	20	70-130	
524.2	NAPHTHALENE	WATER	0.50	UG/L	0.17	20	70-130	
524.2	N-BUTYLBENZENE	WATER	0.50	UG/L	0.04	20	70-130	
524.2	N-PROPYLBENZENE	WATER	0.50	UG/L	0.04	20	70-130	
524.2	O-XYLENE	WATER	0.50	UG/L	0.04	20	70-130	
524.2	P-ISOPROPYLTOLUENE	WATER	0.50	UG/L	0.05	20	70-130	
524.2	SEC-BUTYLBENZENE	WATER	0.50	UG/L	0.04	20	70-130	
524.2	STYRENE	WATER	0.50	UG/L	0.04	20	70-130	
524.2	TERT-BUTYLBENZENE	WATER	0.50	UG/L	0.04	20	70-130	
524.2	TETRACHLOROETHENE	WATER	0.50	UG/L	0.05	20	70-130	

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
524.2	TOLUENE	WATER	0.50	UG/L	0.06	20	70-130	70-130
524.2	TRANS-1,2-DICHLOROETHENE	WATER	0.50	UG/L	0.05	20	70-130	
524.2	TRANS-1,3-DICHLOROPROPENE	WATER	0.50	UG/L	0.07	20	70-130	
524.2	TRICHLOROETHENE	WATER	0.50	UG/L	0.05	20	70-130	70-130
524.2	TRICHLOROFLUOROMETHANE	WATER	0.50	UG/L	0.05	20	70-130	
524.2	VINYL CHLORIDE	WATER	0.50	UG/L	0.09	20	70-130	
524.2	BROMOFLUOROBENZENE -SURR	WATER	NA	UG/L	NA	NA	64-127	64-127
524.2	1,2-DICHLOROBENZENE-D4 -SURR	WATER	NA	UG/L	NA	NA	59-136	59-136
524.2 ADDITIONAL COMPOUNDS BY REQUEST								
	TERT-BUTYL ALCOHOL	WATER	20	UG/L		20	70-130	
	METHYL-TERT-BUTYL-ETHER	WATER	0.50	UG/L		20	70-130	
	2-BUTANONE (MEK)	WATER	5.0	UG/L		20	70-130	
	2-HEXANONE	WATER	5.0	UG/L		20	70-130	
	4-METHYL-2-PENTANONE (MIBK)	WATER	5.0	UG/L		20	70-130	
	ACETONE	WATER	5.0	UG/L		20	70-130	
601	BROMODICHLOROMETHANE	WATER	0.50	UG/L	0.16	30	42-172	42-172
601	BROMOFORM	WATER	0.50	UG/L	0.27	30	13-159	13-159
601	BROMOMETHANE	WATER	0.50	UG/L	0.43	30	d-144	d-144
601	CARBON TETRACHLORIDE	WATER	0.50	UG/L	0.22	30	43-143	43-143
601	CHLOROBENZENE	WATER	0.50	UG/L	0.17	30	38-150	38-150
601	CHLOROETHANE	WATER	0.57	UG/L	0.57	30	46-137	46-137
601	2-CHLOROETHYLVINYL ETHER	WATER	0.50	UG/L	0.45	30	14-186	14-186
601	CHLOROFORM	WATER	0.50	UG/L	0.21	30	49-133	49-133
601	CHLOROMETHANE	WATER	0.50	UG/L	0.25	30	42-172	42-172
601	DIBROMOCHLOROMETHANE	WATER	0.50	UG/L	0.21	30	13-159	13-159
601	1,2-DICHLOROBENZENE	WATER	0.50	UG/L	0.16	30	d-144	d-144
601	1,3-DICHLOROBENZENE	WATER	0.50	UG/L	0.19	30	43-143	43-143
601	1,4-DICHLOROBENZENE	WATER	0.50	UG/L	0.23	30	38-150	38-150
601	1,1-DICHLOROETHANE	WATER	0.50	UG/L	0.19	30	46-137	46-137
601	1,2-DICHLOROETHANE	WATER	0.50	UG/L	0.22	30	14-186	14-186
601	1,1-DICHLOROETHENE	WATER	0.50	UG/L	0.23	30	49-133	49-133
601	TRANS-1,2-DICHLOROETHENE	WATER	0.50	UG/L	0.23	30	d-193	d-193
601	CIS-1,2-DICHLOROETHENE	WATER	0.50	UG/L	0.22	30	24-191	24-191
601	1,2-DICHLOROPROPANE	WATER	0.50	UG/L	0.16	30	d-208	d-208
601	CIS-1,3-DICHLOROPROPENE	WATER	0.50	UG/L	0.27	30	7-187	7-187
601	TRANS-1,3-DICHLOROPROPENE	WATER	0.50	UG/L	0.33	30	42-143	42-143
601	METHYLENE CHLORIDE	WATER	0.50	UG/L	0.23	30	47-132	47-132
601	1,1,2,2-TETRACHLOROETHANE	WATER	0.50	UG/L	0.40	30	51-147	51-147
601	TETRACHLOROETHENE	WATER	0.50	UG/L	0.28	30	28-167	28-167
601	1,1,1-TRICHLOROETHANE	WATER	0.50	UG/L	0.20	30	38-155	38-155
601	1,1,2-TRICHLOROETHANE	WATER	0.50	UG/L	0.31	30	39-136	39-136
601	TRICHLOROETHENE	WATER	0.50	UG/L	0.26	30	35-146	35-146
601	TRICHLOROFLUOROMETHANE	WATER	0.50	UG/L	0.20	30	21-156	21-156
601	VINYL CHLORIDE	WATER	0.50	UG/L	0.25	30	28-163	28-163
601	BROMOCHLOROMETHANE -SURR	WATER	NA	UG/L	NA	NA	63-126	63-126
601	1,2,3 -TRICHLOROPROPANE -SURR	WATER	NA	UG/L	NA	NA	50-134	50-134
601	CHLOROFLUOROBENZENE -SURR	WATER	NA	UG/L	NA	NA	61-128	61-128
602	BENZENE	WATER	0.50	UG/L	0.14	30	39-150	39-150
602	CHLOROBENZENE	WATER	0.50	UG/L	0.22	30	55-135	55-135
602	1,3-DICHLOROBENZENE (M)	WATER	0.50	UG/L	0.18	30	50-141	50-141
602	1,2-DICHLOROBENZENE (O)	WATER	0.50	UG/L	0.18	30	37-154	37-154
602	1,4-DICHLOROBENZENE (P)	WATER	0.50	UG/L	0.21	30	42-143	42-143

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
602	ETHYLBENZENE	WATER	0.50	UG/L	0.14	30	32-160	32-160
602	TOLUENE	WATER	0.50	UG/L	0.14	30	46-148	46-148
602	M+P-XYLENE	WATER	0.50	UG/L	0.33	30	72-130	72-130
602	O-XYLENE	WATER	0.50	UG/L	0.20	30	75-130	75-130
602	CHLOROFLUOROBENZENE (PID) -SURR	WATER	NA	UG/L	NA	NA	75-122	75-122
601/602 ADDITIONAL COMPOUNDS BY REQUEST								
	DICHLORODIFLUOROMETHANE	WATER	1.00	UG/L	0.36	30	38-155	38-155
	FREON 113	WATER	0.50	UG/L	0.28	30	47-119	27-126
	METHYL-TERT-BUTYL ETHER (MTBE)	WATER	0.50	UG/L	0.27	30	48-115	31-124
	TOTAL XYLENES	WATER	0.53	UG/L	0.53	30	72-111	72-111
608	ALDRIN	WATER	0.050	UG/L	0.006	30	42-122	42-122
608	ALPHA-BHC	WATER	0.050	UG/L	0.004	30	37-134	37-134
608	BETA-BHC	WATER	0.050	UG/L	0.010	30	17-147	17-147
608	GAMMA-BHC	WATER	0.050	UG/L	0.004	30	19-140	19-140
608	DELTA-BHC	WATER	0.050	UG/L	0.005	30	32-127	32-127
608	CHLORDANE	WATER	0.25	UG/L	0.041	30	45-119	45-119
608	4,4'-DDE	WATER	0.10	UG/L	0.007	30	30-145	30-145
608	4,4'-DDT	WATER	0.10	UG/L	0.009	30	25-160	25-160
608	4,4'-DDD	WATER	0.10	UG/L	0.005	30	31-141	31-141
608	DIELDRIN	WATER	0.10	UG/L	0.005	30	36-146	36-146
608	ALPHA-ENDOSULFAN	WATER	0.050	UG/L	0.006	30	45-153	45-153
608	BETA-ENDOSULFAN	WATER	0.10	UG/L	0.006	30	d-202	d-202
608	ENDOSULFAN SULFATE	WATER	0.10	UG/L	0.005	30	26-144	26-144
608	ENDRIN	WATER	0.10	UG/L	0.016	30	30-147	30-147
608	ENDRIN ALDEHYDE	WATER	0.10	UG/L	0.005	30	10-151	10-151
608	HEPTACHLOR	WATER	0.050	UG/L	0.005	30	34-111	34-111
608	HEPTACHLOR EPOXIDE	WATER	0.050	UG/L	0.009	30	37-142	37-142
608	TOXAPHENE	WATER	1.6	UG/L	1.62	30	41-126	41-126
608	PCB 1016	WATER	1.0	UG/L	0.60	30	50-114	50-114
608	PCB 1221	WATER	2.0	UG/L	0.52	30	15-178	15-178
608	PCB 1232	WATER	1.0	UG/L	0.22	30	10-215	10-215
608	PCB 1242	WATER	1.0	UG/L	0.36	30	39-150	39-150
608	PCB 1248	WATER	1.0	UG/L	0.32	30	38-158	38-158
608	PCB 1254	WATER	1.0	UG/L	0.28	30	29-131	29-131
608	PCB 1260	WATER	1.0	UG/L	0.48	30	8-127	8-127
608	DECACHLOROBIPHENYL (DCB) -SURR	WATER	NA	UG/L	NA	NA	10-145	10-145
608	TETRACHLORO-META-XYLENE -SURR	WATER	NA	UG/L	NA	NA	10-133	10-133
624	ACROLEIN	WATER	22.5	UG/L	22.5	30	10-190	10-190
624	ACRYLONITRILE	WATER	8.1	UG/L	8.1	30	27-185	27-185
624	BENZENE	WATER	0.57	UG/L	0.57	30	37-151	37-151
624	BROMODICHLOROMETHANE	WATER	0.58	UG/L	0.58	30	35-155	35-155
624	BROMOFORM	WATER	1.35	UG/L	1.35	30	45-169	45-169
624	BROMOMETHANE	WATER	2.8	UG/L	2.8	30	d-242	d-242
624	CARBON TETRACHLORIDE	WATER	0.67	UG/L	0.67	30	70-140	70-140
624	CHLOROBENZENE	WATER	0.66	UG/L	0.66	30	37-160	37-160
624	CHLOROETHANE	WATER	0.59	UG/L	0.59	30	14-230	14-230
624	2-CHLOROETHYLVINYL ETHER	WATER	1.2	UG/L	1.2	30	d-305	d-305
624	CHLOROFORM	WATER	0.6	UG/L	0.6	30	51-138	51-138
624	CHLOROMETHANE	WATER	0.97	UG/L	0.97	30	d-273	d-273
624	DIBROMOCHLOROMETHANE	WATER	0.52	UG/L	0.52	30	53-149	53-149
624	1,1-DICHLOROETHANE	WATER	0.62	UG/L	0.62	30	59-155	59-155
624	1,2-DICHLOROETHANE	WATER	0.49	UG/L	0.49	30	49-155	49-155

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
624	1,1-DICHLOROETHENE	WATER	0.74	UG/L	0.74	30	d-234	d-234
624	TRANS-1,2-DICHLOROETHENE	WATER	0.91	UG/L	0.91	30	54-156	54-156
624	1,2-DICHLOROPROPANE	WATER	0.48	UG/L	0.48	30	d-210	d-210
624	CIS-1,3-DICHLOROPROPENE	WATER	0.58	UG/L	0.58	30	d-227	d-227
624	TRANS-1,3-DICHLOROPROPENE	WATER	0.55	UG/L	0.55	30	17-183	17-183
624	ETHYLBENZENE	WATER	0.62	UG/L	0.62	30	37-162	37-162
624	METHYLENE CHLORIDE	WATER	1.2	UG/L	1.2	30	d-221	d-221
624	1,1,2,2-TETRACHLOROETHANE	WATER	0.49	UG/L	0.49	30	46-157	46-157
624	TETRACHLOROETHENE	WATER	0.88	UG/L	0.88	30	64-148	64-148
624	TOLUENE	WATER	0.60	UG/L	0.60	30	47-150	47-150
624	1,1,1-TRICHLOROETHANE	WATER	0.58	UG/L	0.58	30	52-162	52-162
624	1,1,2-TRICHLOROETHANE	WATER	1.4	UG/L	1.4	30	52-150	52-150
624	TRICHLOROETHENE	WATER	0.69	UG/L	0.69	30	71-157	71-157
624	TRICHLOROFLUOROMETHANE	WATER	0.54	UG/L	0.54	30	17-181	17-181
624	VINYL CHLORIDE	WATER	0.70	UG/L	0.70	30	d-251	d-251
624	4-BROMOFLUOROBENZENE -SURR	WATER	NA	UG/L	NA	NA	85-113	85-113
624	1,2-DICHLOROETHANE-D4 -SURR	WATER	NA	UG/L	NA	NA	76-114	76-114
624	TOLUENE-D8 -SURR	WATER	NA	UG/L	NA	NA	87-110	87-110
625	ACENAPHTHENE	WATER	2.6	UG/L	2.6	30	47-145	47-145
625	ACENAPHTHYLENE	WATER	3.0	UG/L	3.0	30	33-145	33-145
625	ANTHRACENE	WATER	2.6	UG/L	2.6	30	27-133	27-133
625	BENZIDINE	WATER	89	UG/L	89	30	10-131	10-131
625	BENZO(A)ANTHRACENE	WATER	3.0	UG/L	3.0	30	33-143	33-143
625	BENZO(A)PYRENE	WATER	2.8	UG/L	2.8	30	17-163	17-163
625	BENZO(B)FLUORANTHENE	WATER	3.1	UG/L	3.1	30	24-159	24-159
625	BENZO(G,H,I)PERYLENE	WATER	2.8	UG/L	2.8	30	d-219	d-219
625	BENZO(K)FLUORANTHENE	WATER	3.5	UG/L	3.5	30	11-162	11-162
625	BUTYL BENZYL PHTHALATE	WATER	6.4	UG/L	6.4	30	d-152	d-152
625	DI-N-BUTYLPHTHALATE	WATER	3.0	UG/L	3.0	30	1-118	1-118
625	INDENO(1,2,3-CD)PYRENE	WATER	2.9	UG/L	2.9	30	d-171	d-171
625	BIS(-2-CHLOROETHOXY)METHANE	WATER	7.6	UG/L	7.6	30	33-184	33-184
625	BIS(2-CHLOROETHYL)ETHER	WATER	3.3	UG/L	3.3	30	12-158	12-158
625	2-CHLORONAPHTHALENE	WATER	2.7	UG/L	2.7	30	60-118	60-118
625	2-CHLOROPHENOL	WATER	2.8	UG/L	2.8	30	23-134	23-134
625	2,2'-OXYBIS(1-CHLOROPROPANE)	WATER	3.8	UG/L	3.8	30	36-166	36-166
625	CHRYSENE	WATER	2.8	UG/L	2.8	30	17-168	17-168
625	DIBENZO(A,H)ANTHRACENE	WATER	3.0	UG/L	3.0	30	d-227	d-227
625	1,3-DICHLOROBENZENE	WATER	2.4	UG/L	2.4	30	d-172	d-172
625	1,2-DICHLOROBENZENE	WATER	2.7	UG/L	2.7	30	32-129	32-129
625	1,4-DICHLOROBENZENE	WATER	2.4	UG/L	2.4	30	20-124	20-124
625	3,3'-DICHLOROBENZIDINE	WATER	6.2	UG/L	6.2	30	d-262	d-262
625	2,4-DICHLOROPHENOL	WATER	3.0	UG/L	3.0	30	39-135	39-135
625	DIETHYLPHTHALATE	WATER	3.1	UG/L	3.1	30	d-114	d-114
625	DIMETHYL PHTHALATE	WATER	3.3	UG/L	3.3	30	d-112	d-112
625	2,4-DIMETHYLPHENOL	WATER	1.3	UG/L	1.3	30	39-135	39-135
625	2,4-DINITROPHENOL	WATER	46	UG/L	46	30	d-191	d-191
625	2,4-DINITROTOLUENE	WATER	3.4	UG/L	3.4	30	39-139	39-139
625	2,6-DINITROTOLUENE	WATER	2.7	UG/L	2.7	30	50-158	50-158
625	1,2-DIPHENYLHYDRAZINE	WATER	2.5	UG/L	2.5	30	27-141	27-141
625	BIS(2-ETHYLHEXYL)PHTHALATE	WATER	3.2	UG/L	3.2	30	8-158	8-158
625	FLUORANTHENE	WATER	3.0	UG/L	3.0	30	26-137	26-137
625	FLUORENE	WATER	2.4	UG/L	2.4	30	59-121	59-121
625	HEXACHLOROBENZENE	WATER	3.2	UG/L	3.2	30	d-152	d-152

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIC (RPD)	LCS (% REC)	MS (% REC)
625	HEXACHLOROBUTADIENE	WATER	2.8	UG/L	2.8	30	24-116	24-116
625	HEXACHLOROCYCLOPENTADIENE	WATER	2.0	UG/L	2.0	30	10-110	10-110
625	HEXACHLOROETHANE	WATER	5.4	UG/L	5.4	30	40-113	40-113
625	ISOPHORONE	WATER	2.7	UG/L	2.7	30	21-196	21-196
625	4,6-DINITRO-2-METHYLPHENOL	WATER	2.8	UG/L	2.8	30	10-181	10-181
625	4-CHLORO-3-METHYLPHENOL	WATER	2.4	UG/L	2.4	30	22-147	22-147
625	NAPHTHALENE	WATER	2.4	UG/L	2.4	30	21-133	21-133
625	NITROBENZENE	WATER	2.8	UG/L	2.8	30	35-180	35-180
625	2-NITROPHENOL	WATER	3.1	UG/L	3.1	30	29-182	29-182
625	4-NITROPHENOL	WATER	17	UG/L	17	30	d-132	d-132
625	N-NITROSODIMETHYLAMINE	WATER	3.0	UG/L	3.0	30	11-102	11-102
625	N-NITROSODIPHENYLAMINE	WATER	3.4	UG/L	3.4	30	d-230	d-230
625	DI-N-OCTYL PHTHALATE	WATER	3.0	UG/L	3.0	30	4-146	4-146
625	PENTACHLOROPHENOL	WATER	3.6	UG/L	3.6	30	14-176	14-176
625	PHENANTHRENE	WATER	2.6	UG/L	2.6	30	54-120	54-120
625	PHENOL	WATER	1.3	UG/L	1.3	30	5-112	5-112
625	4-BROMOPHENYL-PHENYLETHER	WATER	2.7	UG/L	2.7	30	53-127	53-127
625	4-CHLOROPHENYL-PHENYLETHER	WATER	2.6	UG/L	2.6	30	25-158	25-158
625	N-NITROSO-DI-N-PROPYLAMINE	WATER	4.7	UG/L	4.7	30	d-230	d-230
625	PYRENE	WATER	2.9	UG/L	2.9	30	52-115	52-115
625	1,2,4-TRICHLOROBENZENE	WATER	2.7	UG/L	2.7	30	44-142	44-142
625	2,4,6-TRICHLOROPHENOL	WATER	4.0	UG/L	4.0	30	37-144	37-144
625	TERPHENYL-d14 -SURR	WATER	NA	UG/L	NA	NA	27-140	27-140
625	NITROBENZENE-d5 -SURR	WATER	NA	UG/L	NA	NA	44-111	44-111
625	PHENOL-d6 -SURR	WATER	NA	UG/L	NA	NA	7-65	7-65
625	2-FLUOROBIPHENYL -SURR	WATER	NA	UG/L	NA	NA	44-108	44-108
625	2-FLUOROPHENOL -SURR	WATER	NA	UG/L	NA	NA	7-86	7-86
625	2,4,6-TRIBROMOPHENOL -SURR	WATER	NA	UG/L	NA	NA	28-133	28-133
8015B	MINERAL SPIRITS	WATER	100	UG/L	48.3	30	55-118	55-118
8015B	MINERAL SPIRITS	SOIL	100	UG/KG		50	6-143	6-143
8015B	METHANOL	WATER	1000	UG/L	424	30	70-130	50-150
8015B	ETHANOL	WATER	1000	UG/L	235	30	70-130	50-150
8015B	ISOPROPANOL	WATER	1000	UG/L	138	30	70-130	50-150
8015B	N-BUTANOL	WATER	1000	UG/L	239	30	70-130	50-150
8015B	METHANOL	SOIL	5000	UG/KG		30	70-130	50-150
8015B	ETHANOL	SOIL	5000	UG/KG		30	70-130	50-150
8015B	ISOPROPANOL	SOIL	5000	UG/KG		30	70-130	50-150
8015B	N-BUTANOL	SOIL	5000	UG/KG		30	70-130	50-150
8015B	ISO-PENTANE	WATER	10	UG/L	4.69	30	59-127	50-150
8015B	CHLOROFLUOROBENZENE (FID) -SURR	WATER	NA	UG/L	NA	NA	66-127	66-127
8015B	2-BUTANONE (MEK)	WATER	1000	UG/L	423	30	50-150	50-150
8015B	CHLOROFLUOROBENZENE (FID) -SURR	WATER	NA	UG/L	NA	NA	66-127	66-127
8015B	GASOLINE RANGE ORGANICS	WATER	50	UG/L	3.91	30	70-130	50-150
8015B	CHLOROFLUOROBENZENE (FID) -SURR	WATER	NA	UG/L	NA	NA	66-127	66-127
8015B	GASOLINE RANGE ORGANICS	SOIL	50	UG/KG	7.19	50	70-130	50-150
8015B	CHLOROFLUOROBENZENE (FID) -SURR	SOIL	NA	UG/KG	NA	NA	51-141	51-141
8015B	DIESEL RANGE ORGANICS	WATER	100	UG/L	44	30	55-85	55-85
8015B	O-TERPHENYL -SURR	WATER	NA	UG/L	NA	NA	47-125	47-125
8015B	DIESEL RANGE ORGANICS	SOIL	50000	UG/KG	20	50	52-96	52-96
8015B	O-TERPHENYL -SURR	SOIL	NA	UG/KG	NA	NA	72-114	72-114
8021B PPL	1,1,1-TRICHLOROETHANE	WATER	1.0	UG/L	0.45	30	70-130	

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
8021B PPL	1,1,2,2-TETRACHLOROETHANE	WATER	1.0	UG/L	0.99	30	70-130	
8021B PPL	1,1,2-TRICHLOROETHANE	WATER	1.0	UG/L	0.50	30	70-130	
8021B PPL	1,1-DICHLOROETHANE	WATER	1.0	UG/L	0.49	30	70-130	
8021B PPL	1,1-DICHLOROETHENE	WATER	1.0	UG/L	0.54	30	70-130	70-130
8021B PPL	1,2-DICHLOROBENZENE	WATER	1.0	UG/L	0.41	30	70-130	
8021B PPL	1,2-DICHLOROETHANE	WATER	1.0	UG/L	0.63	30	70-130	
8021B PPL	1,2-DICHLOROPROPANE	WATER	1.0	UG/L	0.40	30	70-130	
8021B PPL	1,3-DICHLOROBENZENE	WATER	1.0	UG/L	0.33	30	70-130	
8021B PPL	1,4-DICHLOROBENZENE	WATER	1.0	UG/L	0.49	30	70-130	
8021B PPL	2-CHLOROETHYLVINYL ETHER	WATER	1.0	UG/L	0.79	30	70-130	
8021B PPL	BENZENE	WATER	1.0	UG/L	0.58	30	70-130	70-130
8021B PPL	BROMODICHLOROMETHANE	WATER	1.0	UG/L	0.45	30	70-130	
8021B PPL	BROMOFORM	WATER	1.0	UG/L	0.33	30	70-130	
8021B PPL	BROMOMETHANE	WATER	1.0	UG/L	0.40	30	50-150	
8021B PPL	CARBON TETRACHLORIDE	WATER	1.0	UG/L	0.43	30	70-130	70-130
8021B PPL	CHLOROBENZENE	WATER	1.0	UG/L	0.64	30	70-130	70-130
8021B PPL	CHLOROETHANE	WATER	1.0	UG/L	0.41	30	50-150	
8021B PPL	CHLOROFORM	WATER	1.0	UG/L	0.33	30	70-130	
8021B PPL	CHLOROMETHANE	WATER	1.0	UG/L	0.30	30	50-150	
8021B PPL	CIS-1,2-DICHLOROETHENE	WATER	1.0	UG/L	0.47	30	70-130	
8021B PPL	CIS-1,3-DICHLOROPROPENE	WATER	1.0	UG/L	0.49	30	70-130	
8021B PPL	DIBROMOCHLOROMETHANE	WATER	1.0	UG/L	0.48	30	70-130	
8021B PPL	DICHLORODIFLUOROMETHANE	WATER	1.0	UG/L	0.10	30	50-150	
8021B PPL	ETHYLBENZENE	WATER	1.0	UG/L	0.42	30	70-130	70-130
8021B PPL	FREON 113	WATER	1.0	UG/L	0.18	30	70-130	
8021B PPL	M+P-XYLENE	WATER	1.0	UG/L	1.23	30	70-130	70-130
8021B PPL	METHYLENE CHLORIDE	WATER	1.0	UG/L	0.43	30	70-130	70-130
8021B PPL	O-XYLENE	WATER	1.0	UG/L	0.49	30	70-130	70-130
8021B PPL	TETRACHLOROETHENE	WATER	1.0	UG/L	0.44	30	70-130	
8021B PPL	TOLUENE	WATER	1.0	UG/L	0.35	30	70-130	70-130
8021B PPL	TRANS-1,2-DICHLOROETHENE	WATER	1.0	UG/L	0.53	30	70-130	
8021B PPL	TRANS-1,3-DICHLOROPROPENE	WATER	1.0	UG/L	0.33	30	70-130	
8021B PPL	TRICHLOROETHENE	WATER	1.0	UG/L	0.30	30	70-130	50-125
8021B PPL	TRICHLOROFLUOROMETHANE	WATER	1.0	UG/L	0.63	30	50-150	
8021B PPL	VINYL CHLORIDE	WATER	1.0	UG/L	0.38	30	50-150	
8021B PPL	1,2,3 TRICHLOROPROPANE -SURR	WATER	NA	UG/L	NA	NA	53-140	53-140
8021B PPL	BROMOCHLOROMETHANE -SURR	WATER	NA	UG/L	NA	NA	66-132	66-132
8021B PPL	CHLOROFLUOROBENZENE-SURR	WATER	NA	UG/L	NA	NA	65-128	65-128
8021B PPL	CHLOROFLUOROBENZENE (PID) -SURR	WATER	NA	UG/L	NA	NA	75-122	75-122
8021B PPL	1,1,1-TRICHLOROETHANE	SOIL	1.0	UG/KG	0.38	30	70-130	
8021B PPL	1,1,2,2-TETRACHLOROETHANE	SOIL	2.0	UG/KG	0.71	30	70-130	
8021B PPL	1,1,2-TRICHLOROETHANE	SOIL	2.0	UG/KG	0.52	30	70-130	
8021B PPL	1,1-DICHLOROETHANE	SOIL	1.0	UG/KG	0.59	30	70-130	
8021B PPL	1,1-DICHLOROETHENE	SOIL	1.0	UG/KG	0.77	30	70-130	70-130
8021B PPL	1,2-DICHLOROBENZENE	SOIL	2.0	UG/KG	0.57	30	70-130	
8021B PPL	1,2-DICHLOROETHANE	SOIL	1.0	UG/KG	0.54	30	70-130	
8021B PPL	1,2-DICHLOROPROPANE	SOIL	1.0	UG/KG	0.58	30	70-130	
8021B PPL	1,3-DICHLOROBENZENE	SOIL	2.0	UG/KG	0.66	30	70-130	
8021B PPL	1,4-DICHLOROBENZENE	SOIL	2.0	UG/KG	0.59	30	70-130	
8021B PPL	2-CHLOROETHYLVINYL ETHER	SOIL	2.0	UG/KG	0.41	30	70-130	
8021B PPL	BENZENE	SOIL	2.0	UG/KG	0.68	30	70-130	51-123
8021B PPL	BROMODICHLOROMETHANE	SOIL	1.0	UG/KG	0.71	30	70-130	
8021B PPL	BROMOFORM	SOIL	2.0	UG/KG	0.92	30	70-130	

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIC (RPD)	LCS (% REC)	MS (% REC)
8021B PPL	BROMOMETHANE	SOIL	5.0	UG/KG	0.76	30	50-150	
8021B PPL	CARBON TETRACHLORIDE	SOIL	1.0	UG/KG	0.82	30	70-130	70-130
8021B PPL	CHLOROBENZENE	SOIL	2.0	UG/KG	0.70	30	70-130	20-135
8021B PPL	CHLOROETHANE	SOIL	2.0	UG/KG	0.88	30	50-150	
8021B PPL	CHLOROFORM	SOIL	1.0	UG/KG	0.79	30	70-130	
8021B PPL	CHLOROMETHANE	SOIL	5.0	UG/KG	0.97	30	50-150	
8021B PPL	CIS-1,2-DICHLOROETHENE	SOIL	1.0	UG/KG	0.83	30	70-130	
8021B PPL	CIS-1,3-DICHLOROPROPENE	SOIL	1.0	UG/KG	0.62	30	70-130	
8021B PPL	DIBROMOCHLOROMETHANE	SOIL	2.0	UG/KG	0.67	30	70-130	
8021B PPL	DICHLOROFLUOROMETHANE	SOIL	1.0	UG/KG	0.40	30	50-150	
8021B PPL	ETHYLBENZENE	SOIL	2.0	UG/KG	0.69	30	70-130	37-132
8021B PPL	FREON 113	SOIL	1.0	UG/KG		30	70-130	
8021B PPL	M+P-XYLENE	SOIL	1.0	UG/KG	0.93	30	70-130	34-135
8021B PPL	METHYLENE CHLORIDE	SOIL	1.0	UG/KG	0.38	30	70-130	70-130
8021B PPL	O-XYLENE	SOIL	1.0	UG/KG	0.83	30	70-130	46-125
8021B PPL	TETRACHLOROETHENE	SOIL	1.0	UG/KG	0.77	30	70-130	
8021B PPL	TOLUENE	SOIL	2.0	UG/KG	0.79	30	70-130	45-127
8021B PPL	TRANS-1,2-DICHLOROETHENE	SOIL	1.0	UG/KG	0.52	30	70-130	
8021B PPL	TRANS-1,3-DICHLOROPROPENE	SOIL	2.0	UG/KG	0.69	30	70-130	
8021B PPL	TRICHLOROETHENE	SOIL	1.0	UG/KG	0.84	30	70-130	39-127
8021B PPL	TRICHLOROFLUOROMETHANE	SOIL	1.0	UG/KG	0.81	30	50-150	
8021B PPL	VINYL CHLORIDE	SOIL	2.0	UG/KG	0.93	30	50-150	
8021B PPL	1,2,3-TRICHLOROPROPANE -SURR	SOIL	NA	UG/KG	NA	NA	44-127	44-127
8021B PPL	CHLOROFLUOROBENZENE -SURR	SOIL	NA	UG/KG	NA	NA	42-142	42-142
8021B PPL	CHLOROFLUOROBENZENE (PID) -SURR	SOIL	NA	UG/KG	NA	NA	38-138	38-138
8021B PPL	BROMOCHLOROMETHANE -SURR	SOIL	NA	UG/KG	NA	NA	55-121	55-121
8021 STARS	1,2,4-TRIMETHYLBENZENE	WATER	1.0	UG/L	0.83	30	70-130	50-150
8021 STARS	1,3,5-TRIMETHYLBENZENE	WATER	1.0	UG/L	0.44	30	70-130	50-150
8021 STARS	BENZENE	WATER	0.7	UG/L	0.58	30	70-130	70-130
8021 STARS	ETHYLBENZENE	WATER	1.0	UG/L	0.42	30	70-130	70-130
8021 STARS	ISOPROPYLBENZENE	WATER	1.0	UG/L	0.30	30	70-130	50-150
8021 STARS	M+P-XYLENE	WATER	2.0	UG/L	1.23	30	70-130	70-130
8021 STARS	METHYL-TERT-BUTYLETHER	WATER	1.0	UG/L	0.71	30	70-130	50-150
8021 STARS	NAPHTHALENE	WATER	1.0	UG/L	0.84	30	70-130	50-150
8021 STARS	N-BUTYLBENZENE	WATER	1.0	UG/L	0.60	30	70-130	50-150
8021 STARS	N-PROPYLBENZENE	WATER	1.0	UG/L	0.31	30	70-130	50-150
8021 STARS	O-XYLENE	WATER	2.0	UG/L	0.49	30	70-130	70-130
8021 STARS	P-ISOPROPYLTOLUENE	WATER	1.0	UG/L	0.36	30	70-130	50-150
8021 STARS	SEC-BUTYLBENZENE	WATER	1.0	UG/L	0.35	30	70-130	50-150
8021 STARS	TERT-BUTYLBENZENE	WATER	1.0	UG/L	0.34	30	70-130	50-150
8021 STARS	TOLUENE	WATER	1.0	UG/L	0.35	30	70-130	70-130
8021 STARS	CHLOROFLUOROBENZENE (PID) -SURR	WATER	NA	UG/L	NA	NA	75-122	75-122
8021 STARS	1,2,4-TRIMETHYLBENZENE	SOIL	1.0	UG/KG	0.54	30	70-130	50-150
8021 STARS	1,3,5-TRIMETHYLBENZENE	SOIL	1.0	UG/KG	0.39	30	70-130	50-150
8021 STARS	BENZENE	SOIL	1.0	UG/KG	0.68	30	70-130	51-123
8021 STARS	ETHYLBENZENE	SOIL	1.0	UG/KG	0.69	30	70-130	37-132
8021 STARS	ISOPROPYLBENZENE	SOIL	1.0	UG/KG	0.40	30	70-130	50-150
8021 STARS	M+P-XYLENE	SOIL	2.0	UG/KG	0.93	30	70-130	34-135
8021 STARS	METHYL-TERT-BUTYLETHER	SOIL	1.0	UG/KG	0.36	30	70-130	50-150
8021 STARS	NAPHTHALENE	SOIL	1.0	UG/KG	1.00	30	70-130	50-150
8021 STARS	N-BUTYLBENZENE	SOIL	1.0	UG/KG	0.63	30	70-130	50-150
8021 STARS	N-PROPYLBENZENE	SOIL	1.0	UG/KG	0.39	30	70-130	50-150

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD		ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIC (RPD)	LCS (% REC)	MS (% REC)
8021 STARS		O-XYLENE	SOIL	2.0	UG/KG	0.83	30	70-130	46-125
8021 STARS		P-ISOPROPYLTOLUENE	SOIL	1.0	UG/KG	0.54	30	70-130	50-150
8021 STARS		SEC-BUTYLBENZENE	SOIL	1.0	UG/KG	0.41	30	70-130	50-150
8021 STARS		TERT-BUTYLBENZENE	SOIL	1.0	UG/KG	0.38	30	70-130	50-150
8021 STARS		TOLUENE	SOIL	1.0	UG/KG	0.79	30	70-130	45-127
8021 STARS		CHLOROFLUOROBENZENE (PID) -SURR	SOIL	NA	UG/KG	NA	NA	38-138	38-138
8081A		4,4'-DDD	WATER	0.10	UG/L	0.005	30	63-107	
8081A		4,4'-DDE	WATER	0.10	UG/L	0.007	30	30-127	
8081A	*	4,4'-DDT	WATER	0.10	UG/L	0.009	30	60-108	10-136
8081A	*	ALDRIN	WATER	0.05	UG/L	0.006	30	58-101	10-138
8081A		ALPHA-BHC	WATER	0.05	UG/L	0.004	30	70-130	
8081A		ALPHA-CHLORDANE	WATER	0.05	UG/L	0.004	30	36-127	
8081A		ALPHA-ENDOSULFAN	WATER	0.05	UG/L	0.006	30	39-125	
8081A		BETA-BHC	WATER	0.05	UG/L	0.01	30	63-107	
8081A		BETA-ENDOSULFAN	WATER	0.10	UG/L	0.006	30	64-107	
8081A		DELTA-BHC	WATER	0.05	UG/L	0.005	30	49-116	
8081A	*	DIELDRIN	WATER	0.10	UG/L	0.005	30	47-122	47-122
8081A		ENDOSULFAN SULFATE	WATER	0.10	UG/L	0.005	30	17-134	
8081A	*	ENDRIN	WATER	0.10	UG/L	0.016	30	47-117	47-117
8081A		ENDRIN ALDEHYDE	WATER	0.10	UG/L	0.005	30	10-115	
8081A		ENDRIN KETONE	WATER	0.10	UG/L	0.006	30	70-110	
8081A	*	GAMMA-BHC (LINDANE)	WATER	0.05	UG/L	0.003	30	80-105	61-111
8081A		GAMMA-CHLORDANE	WATER	0.05	UG/L	0.011	30	48-122	
8081A	*	HEPTACHLOR	WATER	0.05	UG/L	0.005	30	64-101	18-133
8081A	*	HEPTACHLOR EPOXIDE	WATER	0.05	UG/L	0.009	30	60-115	60-115
8081A	*	METHOXYCHLOR	WATER	0.50	UG/L	0.01	30	62-114	62-114
8081A		TOXAPHENE	WATER	1.00	UG/L	1.62	30	46-84	
8081A		DECACHLOROBIPHENYL (DCB) -SURR	WATER	NA	UG/L	NA	NA	10-147	10-147
8081A		TETRACHLORO-META-XYLENE (TCMX) -SURR	WATER	NA	UG/L	NA	NA	24-119	24-119
8081A		4,4'-DDD	SOIL	3.3	UG/KG	0.66	30	63-107	
8081A		4,4'-DDE	SOIL	3.3	UG/KG	1.00	30	30-127	
8081A	*	4,4'-DDT	SOIL	3.3	UG/KG	0.94	30	60-108	10-132
8081A	*	ALDRIN	SOIL	1.7	UG/KG	0.21	30	58-101	37-110
8081A		ALPHA-BHC	SOIL	1.7	UG/KG	0.19	30	70-130	
8081A		ALPHA-CHLORDANE	SOIL	1.7	UG/KG	0.31	30	36-127	
8081A		ALPHA-ENDOSULFAN	SOIL	1.7	UG/KG	0.31	30	39-125	
8081A		BETA-BHC	SOIL	1.7	UG/KG	0.25	30	63-107	
8081A		BETA-ENDOSULFAN	SOIL	3.3	UG/KG	0.89	30	64-107	
8081A		DELTA-BHC	SOIL	1.7	UG/KG	0.19	30	49-116	
8081A	*	DIELDRIN	SOIL	3.3	UG/KG	1.30	30	47-122	46-107
8081A		ENDOSULFAN SULFATE	SOIL	3.3	UG/KG	0.33	30	17-134	
8081A	*	ENDRIN	SOIL	1.7	UG/KG	1.67	30	47-117	19-127
8081A		ENDRIN ALDEHYDE	SOIL	3.3	UG/KG	0.79	30	10-115	
8081A		ENDRIN KETONE	SOIL	3.3	UG/KG	1.36	30	70-110	
8081A	*	GAMMA-BHC (LINDANE)	SOIL	1.7	UG/KG	0.18	30	80-105	42-112
8081A		GAMMA-CHLORDANE	SOIL	1.7	UG/KG	1.18	30	48-122	
8081A	*	HEPTACHLOR	SOIL	1.7	UG/KG	0.26	30	64-101	40-120
8081A	*	HEPTACHLOR EPOXIDE	SOIL	1.7	UG/KG	0.88	30	60-115	60-115
8081A	*	METHOXYCHLOR	SOIL	17	UG/KG	0.39	30	62-114	62-114
8081A		TOXAPHENE	SOIL	33	UG/KG	20.6	30	46-84	
8081A		DECACHLOROBIPHENYL (DCB) -SURR	SOIL	NA	UG/KG	NA	NA	10-164	10-164
8081A		TETRACHLORO-META-XYLENE (TCMX) -SURR	SOIL	NA	UG/KG	NA	NA	36-119	36-119

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD		ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
8082	*	PCB 1016	WATER	1.0	UG/L	0.60	30	53-118	50-150
8082		PCB 1221	WATER	2.0	UG/L	0.52	30	70-130	
8082		PCB 1232	WATER	1.0	UG/L	0.22	30	70-130	
8082		PCB 1242	WATER	1.0	UG/L	0.36	30	70-130	
8082		PCB 1248	WATER	1.0	UG/L	0.33	30	70-130	
8082		PCB 1254	WATER	1.0	UG/L	0.29	30	70-130	
8082	*	PCB 1260	WATER	1.0	UG/L	0.49	30	53-118	50-150
8082		DECACHLOROBIPHENYL -SURR	WATER	NA	UG/L	NA	NA	10-138	10-138
8082		TETRACHLORO-META-XYLENE -SURR	WATER	NA	UG/L	NA	NA	16-141	16-141
8082	*	PCB 1016	SOIL	33	UG/KG	5.15	30	34-130	33-132
8082		PCB 1221	SOIL	67	UG/KG	5.43	30	70-130	
8082		PCB 1232	SOIL	33	UG/KG	3.79	30	70-130	
8082		PCB 1242	SOIL	33	UG/KG	4.99	30	70-130	
8082		PCB 1248	SOIL	33	UG/KG	9.08	30	70-130	
8082		PCB 1254	SOIL	33	UG/KG	8.05	30	70-130	
8082	*	PCB 1260	SOIL	33	UG/KG	3.30	30	34-130	33-132
8082		DECACHLOROBIPHENYL -SURR	SOIL	NA	UG/KG	NA	NA	35-131	35-131
8082		TETRACHLORO-META-XYLENE -SURR	SOIL	NA	UG/KG	NA	NA	29-141	29-141
8151A	*	2,4-D	WATER	0.5	UG/L	0.39	30	10-127	10-127
8151A		DICAMBA	WATER	0.5	UG/L	0.49	30	70-130	50-150
8151A		DINOSEB	WATER	0.5	UG/L	0.42	30	70-130	50-150
8151A	*	2,4,5-T	WATER	0.5	UG/L	0.39	30	10-126	10-126
8151A	*	2,4,5-TP (SILVEX)	WATER	0.5	UG/L	0.32	30	16-134	16-134
8151A		DCAA -SURR	WATER	NA	UG/L	NA	NA	10-149	10-149
8151A	*	2,4-D	SOIL	10	UG/KG	5.1	30	33-133	33-133
8151A		DICAMBA	SOIL	10	UG/KG	5.8	30	70-130	50-150
8151A		DINOSEB	SOIL	10	UG/KG		30	70-130	50-150
8151A	*	2,4,5-T	SOIL	10	UG/KG	6.2	30	70-130	50-150
8151A	*	2,4,5-TP (SILVEX)	SOIL	10	UG/KG	4.8	30	30-139	30-139
8151A		DCAA -SURR	SOIL	NA	UG/KG	NA	NA	42-175	42-175
8260B TCL		1,1,1-TRICHLOROETHANE	WATER	5.0	UG/L	0.50	30	70-130	
8260B TCL		1,1,2,2-TETRACHLOROETHANE	WATER	5.0	UG/L	0.88	30	70-130	
8260B TCL		1,1,2-TRICHLOROETHANE	WATER	5.0	UG/L	0.74	30	70-130	
8260B TCL		1,1-DICHLOROETHANE	WATER	5.0	UG/L	0.52	30	70-130	
8260B TCL	*	1,1-DICHLOROETHENE	WATER	5.0	UG/L	0.99	30	70-130	61-145
8260B TCL		1,2-DICHLOROETHANE	WATER	5.0	UG/L	0.98	30	70-130	
8260B TCL		1,2-DICHLOROPROPANE	WATER	5.0	UG/L	0.75	30	70-130	
8260B TCL		2-BUTANONE (MEK)	WATER	10	UG/L	1.33	30	50-150	
8260B TCL		2-HEXANONE	WATER	10	UG/L	1.73	30	70-130	
8260B TCL		4-METHYL-2-PENTANONE (MIBK)	WATER	10	UG/L	0.94	30	70-130	
8260B TCL		ACETONE	WATER	20	UG/L	2.81	30	50-150	
8260B TCL	*	BENZENE	WATER	5.0	UG/L	0.85	30	70-130	70-130
8260B TCL		BROMODICHLOROMETHANE	WATER	5.0	UG/L	0.66	30	70-130	
8260B TCL		BROMOFORM	WATER	5.0	UG/L	0.37	30	70-130	
8260B TCL		BROMOMETHANE	WATER	5.0	UG/L	2.23	30	50-150	
8260B TCL		CARBON DISULFIDE	WATER	10	UG/L	0.98	30	70-130	
8260B TCL		CARBON TETRACHLORIDE	WATER	5.0	UG/L	0.73	30	70-130	
8260B TCL	*	CHLOROBENZENE	WATER	5.0	UG/L	0.37	30	70-130	70-130
8260B TCL		CHLOROETHANE	WATER	5.0	UG/L	0.74	30	70-130	
8260B TCL		CHLOROFORM	WATER	5.0	UG/L	0.50	30	70-130	
8260B TCL		CHLOROMETHANE	WATER	5.0	UG/L	1.12	30	70-130	
8260B TCL		CIS-1,2-DICHLOROETHENE	WATER	5.0	UG/L	0.77	30	70-130	

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD		ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
8260B TCL		CIS-1,3-DICHLOROPROPENE	WATER	5.0	UG/L	0.59	30	70-130	
8260B TCL		DIBROMOCHLOROMETHANE	WATER	5.0	UG/L	0.44	30	70-130	
8260B TCL		ETHYLBENZENE	WATER	5.0	UG/L	0.47	30	70-130	
8260B TCL		M+P-XYLENE	WATER	5.0	UG/L	0.91	30	70-130	
8260B TCL		METHYLENE CHLORIDE	WATER	5.0	UG/L	1.01	30	70-130	
8260B TCL		O-XYLENE	WATER	5.0	UG/L	0.63	30	70-130	
8260B TCL		STYRENE	WATER	5.0	UG/L	0.45	30	70-130	
8260B TCL		TETRACHLOROETHENE	WATER	5.0	UG/L	0.61	30	70-130	
8260B TCL	*	TOLUENE	WATER	5.0	UG/L	0.83	30	70-130	70-130
8260B TCL		TRANS-1,2-DICHLOROETHENE	WATER	5.0	UG/L	0.99	30	70-130	
8260B TCL		TRANS-1,3-DICHLOROPROPENE	WATER	5.0	UG/L	0.56	30	70-130	
8260B TCL	*	TRICHLOROETHENE	WATER	5.0	UG/L	0.99	30	70-130	70-130
8260B TCL		VINYL CHLORIDE	WATER	5.0	UG/L	1.39	30	70-130	
8260B TCL		4-BROMOFLUOROBENZENE -SURR	WATER	NA	UG/L	NA	NA	87-111	87-111
8260B TCL		DIBROMOFLUOROMETHANE -SURR	WATER	NA	UG/L	NA	NA	86-117	86-117
8260B TCL		TOLUENE-D8 -SURR	WATER	NA	UG/L	NA	NA	87-108	87-108
8260B ADDITIONAL COMPOUNDS BY REQUEST									
8260B		1,1,1,2-TETRACHLOROETHANE	WATER	5.0	UG/L	0.57	30	70-130	
8260B		1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (Freon 113)	WATER	5.0	UG/L	0.31	30	70-130	
8260B		1,1-DICHLOROPROPENE	WATER	5.0	UG/L	0.59	30	70-130	
8260B		1,2,3-TRICHLOROBENZENE	WATER	5.0	UG/L	0.32	30	70-130	
8260B		1,2,4-TRICHLOROBENZENE	WATER	5.0	UG/L	0.81	30	70-130	
8260B		1,2,4-TRIMETHYLBENZENE	WATER	5.0	UG/L	0.25	30	70-130	
8260B		1,2-DIBROMO-3-CHLOROPROPANE	WATER	5.0	UG/L	0.54	30	50-150	
8260B		1,2-DIBROMOETHANE	WATER	5.0	UG/L	0.32	30	70-130	
8260B		1,2-DICHLOROBENZENE	WATER	5.0	UG/L	0.29	30	70-130	
8260B		1,3,5-TRIMETHYLBENZENE	WATER	5.0	UG/L	0.17	30	70-130	
8260B		1,3-DICHLOROBENZENE	WATER	5.0	UG/L	0.28	30	70-130	
8260B		1,3-DICHLOROPROPANE	WATER	5.0	UG/L	0.25	30	70-130	
8260B		1,4-DICHLOROBENZENE	WATER	5.0	UG/L	0.32	30	70-130	
8260B		1,4-DIOXANE	WATER	100	UG/L	24	30	50-150	
8260B		2,2-DICHLOROPROPANE	WATER	5.0	UG/L	0.32	30	70-130	
8260B		2-CHLORO-1,3-BUTADIENE	WATER	5.0	UG/L	3.73	30	70-130	
8260B		2-CHLOROETHYLVINYL ETHER	WATER	5.0	UG/L	3.27	30	50-150	
8260B		2-CHLOROTOLUENE	WATER	5.0	UG/L	0.20	30	70-130	
8260B		2-NITROPROPANE	WATER	5.0	UG/L	0.62	30	50-150	
8260B		4-CHLOROTOLUENE	WATER	5.0	UG/L	0.13	30	70-130	
8260B		ACETONITRILE	WATER	100	UG/L	1.34	30	70-130	
8260B		ACROLEIN	WATER	100	UG/L	15	30	50-150	
8260B		ACRYLONITRILE	WATER	100	UG/L	3.18	30	50-150	
8260B		ALLYL CHLORIDE	WATER	5.0	UG/L	1.13	30	70-130	
8260B		BROMOBENZENE	WATER	5.0	UG/L	0.45	30	70-130	
8260B		BROMOCHLOROMETHANE	WATER	5.0	UG/L	0.59	30	70-130	
8260B		BROMOFLUOROBENZENE	WATER	5.0	UG/L	2.79	30	70-130	
8260B		CYCLOHEXANE	WATER	5.0	UG/L	1.23	30	50-150	
8260B		CYCLOHEXANONE	WATER	100	UG/L	23	30	50-150	
8260B		DIBROMOMETHANE	WATER	5.0	UG/L	0.57	30	70-130	
8260B		DICHLORODIFLUOROMETHANE	WATER	5.0	UG/L	0.48	30	70-130	
8260B		DICHLOROMETHANE	WATER	5.0	UG/L	0.39	30	70-130	
8260B		ETHYL METHACRYLATE	WATER	10	UG/L	0.15	30	70-130	
8260B		FREON 113	WATER	5.0	UG/L	0.48	30	70-130	
8260B		HEXACHLOROBUTADIENE	WATER	5.0	UG/L	0.78	30	70-130	

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD		ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
8260B		IODOMETHANE	WATER	10	UG/L	2.34	30	50-150	
8260B		ISOBUTYL ALCOHOL	WATER	100	UG/L	13	30	50-150	
8260B		*ISOPROPYLBENZENE*	WATER	5.0	UG/L	0.27	30	70-130	
8260B		METHACRYLONITRILE	WATER	10	UG/L	0.87	30	50-150	
8260B		*METHYL ACETATE*	WATER	5.0	UG/L	1.76	30	50-150	
8260B		METHYL METHACRYLATE	WATER	10	UG/L	0.35	30	70-130	
8260B		*METHYLCYCLOHEXANE*	WATER	5.0	UG/L	1.89	30	70-130	
8260B		*METHYL-TERT-BUTYL ETHER (MTBE)*	WATER	5.0	UG/L	0.37	30	70-130	
8260B		NAPTHALENE	WATER	5.0	UG/L	0.27	30	50-150	
8260B		NITROBENZENE	WATER	5.0	UG/L	2.28	30	50-150	
8260B		N-BUTYLBENZENE	WATER	5.0	UG/L	0.21	30	70-130	
8260B		N-HEPTANE	WATER	5.0	UG/L	0.28	30	70-130	
8260B		N-PROPYLBENZENE	WATER	5.0	UG/L	0.22	30	70-130	
8260B		P-ISOPROPYLTOLUENE	WATER	5.0	UG/L	0.35	30	70-130	
8260B		PROPIONITRILE	WATER	100	UG/L	2.32	30	50-150	
8260B		SEC-BUTYLBENZENE	WATER	5.0	UG/L	0.11	30	70-130	
8260B		TERT-BUTYL ALCOHOL	WATER	100	UG/L	24	30	50-150	
8260B		TERT-BUTYLBENZENE	WATER	5.0	UG/L	0.09	30	70-130	
8260B		TETRA HYDROFURAN	WATER	5.0	UG/L	2.56	30	50-150	
8260B		TRANS-1,4-DICHLORO-2-BUTENE	WATER	5.0	UG/L	0.49	30	50-150	
8260B		*TRICHLOROFLUOROMETHANE*	WATER	5.0	UG/L	1.61	30	70-130	
8260B		VINYL ACETATE	WATER	10	UG/L	3.35	30	50-150	
8260B TCL		1,1,1-TRICHLOROETHANE	SOIL	5.0	UG/KG	1.10	30	70-130	
8260B TCL		1,1,2,2-TETRACHLOROETHANE	SOIL	5.0	UG/KG	1.21	30	70-130	
8260B TCL		1,1,2-TRICHLOROETHANE	SOIL	5.0	UG/KG	0.39	30	70-130	
8260B TCL		1,1-DICHLOROETHANE	SOIL	5.0	UG/KG	0.79	30	70-130	
8260B TCL	*	1,1-DICHLOROETHENE	SOIL	5.0	UG/KG	1.20	30	70-130	59-172
8260B TCL		1,2-DICHLOROETHANE	SOIL	5.0	UG/KG	0.50	30	70-130	
8260B TCL		1,2-DICHLOROPROPANE	SOIL	5.0	UG/KG	0.54	30	70-130	
8260B TCL		2-BUTANONE (MEK)	SOIL	10	UG/KG	1.16	30	50-150	
8260B TCL		2-HEXANONE	SOIL	10	UG/KG	1.33	30	70-130	
8260B TCL		4-METHYL-2-PENTANONE (MIBK)	SOIL	10	UG/KG	1.10	30	70-130	
8260B TCL		ACETONE	SOIL	20	UG/KG	1.67	30	50-150	
8260B TCL	*	BENZENE	SOIL	5.0	UG/KG	0.71	30	70-130	66-142
8260B TCL		BROMODICHLOROMETHANE	SOIL	5.0	UG/KG	0.55	30	70-130	
8260B TCL		BROMOFORM	SOIL	5.0	UG/KG	0.47	30	70-130	
8260B TCL		BROMOMETHANE	SOIL	5.0	UG/KG	2.33	30	50-150	
8260B TCL		CARBON DISULFIDE	SOIL	10	UG/KG	1.23	30	70-130	
8260B TCL		CARBON TETRACHLORIDE	SOIL	5.0	UG/KG	1.07	30	70-130	
8260B TCL	*	CHLOROBENZENE	SOIL	5.0	UG/KG	0.70	30	70-130	60-133
8260B TCL		CHLOROETHANE	SOIL	5.0	UG/KG	3.03	30	70-130	
8260B TCL		CHLOROFORM	SOIL	5.0	UG/KG	0.71	30	70-130	
8260B TCL		CHLOROMETHANE	SOIL	5.0	UG/KG	0.74	30	70-130	
8260B TCL		CIS-1,2-DICHLOROETHENE	SOIL	5.0	UG/KG	1.71	30	70-130	
8260B TCL		CIS-1,3-DICHLOROPROPENE	SOIL	5.0	UG/KG	0.57	30	70-130	
8260B TCL		DIBROMOCHLOROMETHANE	SOIL	5.0	UG/KG	0.56	30	70-130	
8260B TCL		ETHYLBENZENE	SOIL	5.0	UG/KG	0.90	30	70-130	
8260B TCL		M+P-XYLENE	SOIL	5.0	UG/KG	1.82	30	70-130	
8260B TCL		METHYLENE CHLORIDE	SOIL	5.0	UG/KG	0.99	30	70-130	
8260B TCL		O-XYLENE	SOIL	5.0	UG/KG	0.72	30	70-130	
8260B TCL		STYRENE	SOIL	5.0	UG/KG	0.69	30	70-130	
8260B TCL		TETRACHLOROETHENE	SOIL	5.0	UG/KG	1.02	30	70-130	
8260B TCL	*	TOLUENE	SOIL	5.0	UG/KG	0.76	30	70-130	59-139

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD		ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
8260B TCL		TRANS-1,2-DICHLOROETHENE	SOIL	5.0	UG/KG	1.86	30	70-130	
8260B TCL		TRANS-1,3-DICHLOROPROPENE	SOIL	5.0	UG/KG	0.38	30	70-130	
8260B TCL	*	TRICHLOROETHENE	SOIL	5.0	UG/KG	0.94	30	70-130	62-137
8260B TCL		VINYL CHLORIDE	SOIL	5.0	UG/KG	1.16	30	70-130	
8260B TCL		4-BROMOFLUOROBENZENE -SURR	SOIL	NA	UG/KG	NA	NA	42-149	42-149
8260B TCL		DIBROMOFLUOROMETHANE -SURR	SOIL	NA	UG/KG	NA	NA	70-127	70-127
8260B TCL		TOLUENE-D8 -SURR	SOIL	NA	UG/KG	NA	NA	71-128	71-128
8260B ADDITIONAL COMPOUNDS BY REQUEST									
8260B		1,1,1,2-TETRACHLOROETHANE	SOIL	5.0	UG/KG	0.34	30	70-130	
8260B		*1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON 113)*	SOIL	5.0	UG/KG	0.97	30	70-130	
8260B		1,1-DICHLOROPROPENE	SOIL	5.0	UG/KG	0.66	30	70-130	
8260B		1,2,3-TRICHLOROBENZENE	SOIL	5.0	UG/KG	1.06	30	70-130	
8260B		1,2,3-TRICHLOROPROPANE	SOIL	5.0	UG/KG	0.36	30	70-130	
8260B		*1,2,4-TRICHLOROBENZENE*	SOIL	5.0	UG/KG	1.22	30	70-130	
8260B		1,2,4-TRIMETHYLBENZENE	SOIL	5.0	UG/KG	0.56	30	70-130	
8260B		*1,2-DIBROMO-3-CHLOROPROPANE*	SOIL	5.0	UG/KG	0.57	30	50-150	
8260B		*1,2-DIBROMOETHANE*	SOIL	5.0	UG/KG	0.61	30	70-130	
8260B		*1,2-DICHLOROBENZENE*	SOIL	5.0	UG/KG	0.80	30	70-130	
8260B		1,3,5-TRIMETHYLBENZENE	SOIL	5.0	UG/KG	0.37	30	70-130	
8260B		*1,3-DICHLOROBENZENE*	SOIL	5.0	UG/KG	0.81	30	70-130	
8260B		1,3-DICHLOROPROPANE	SOIL	5.0	UG/KG	0.48	30	70-130	
8260B		*1,4-DICHLOROBENZENE*	SOIL	5.0	UG/KG	0.76	30	70-130	
8260B		1,4-DIOXANE	SOIL	100	UG/KG	16	30	50-150	
8260B		2,2-DICHLOROPROPANE	SOIL	5.0	UG/KG	0.90	30	70-130	
8260B		2-CHLOROETHYLVINYL ETHER	SOIL	5.0	UG/KG	0.27	30	50-150	
8260B		2-CHLOROTOLUENE	SOIL	5.0	UG/KG	0.49	30	70-130	
8260B		2-NITROPROPANE	SOIL	5.0	UG/KG	1.97	30	50-150	
8260B		4-CHLOROTOLUENE	SOIL	5.0	UG/KG	0.64	30	70-130	
8260B		ACROLEIN	SOIL	100	UG/KG	1.49	30	50-150	
8260B		ACRYLONITRILE	SOIL	100	UG/KG	2.96	30	50-150	
8260B		BROMOBENZENE	SOIL	5.0	UG/KG	0.20	30	70-130	
8260B		BROMOCHLOROMETHANE	SOIL	5.0	UG/KG	0.85	30	70-130	
8260B		*CYCLOHEXANE*	SOIL	5.0	UG/KG	1.61	30	50-150	
8260B		DIBROMOMETHANE	SOIL	5.0	UG/KG	0.59	30	70-130	
8260B		*DICHLORODIFLUOROMETHANE*	SOIL	5.0	UG/KG	1.54	30	70-130	
8260B		FREON 113	SOIL	5.0	UG/KG	2.09	30	70-130	
8260B		HEXACHLOROBUTADIENE	SOIL	5.0	UG/KG	0.83	30	70-130	
8260B		IODOMETHANE	SOIL	10	UG/KG	1.47	30	50-150	
8260B		ISOBUTYL ALCOHOL	SOIL	10	UG/KG	19	30	50-150	
8260B		*ISOPROPYLBENZENE*	SOIL	5.0	UG/KG	0.84	30	70-130	
8260B		METHACRYLONITRILE	SOIL	100	UG/KG	0.65	30	50-150	
8260B		*METHYL ACETATE*	SOIL	5.0	UG/KG	2.80	30	50-150	
8260B		*METHYLCYCLOHEXANE*	SOIL	5.0	UG/KG	1.29	30	70-130	
8260B		*METHYL-TERT-BUTYL ETHER (MTBE)*	SOIL	5.0	UG/KG	1.90	30	70-130	
8260B		NAPTHALENE	SOIL	5.0	UG/KG	0.40	30	50-150	
8260B		NITROBENZENE	SOIL	5.0	UG/KG		30	50-150	
8260B		N-BUTYLBENZENE	SOIL	5.0	UG/KG	0.93	30	70-130	
8260B		N-PROPYLBENZENE	SOIL	5.0	UG/KG	0.55	30	70-130	
8260B		P-ISOPROPYLTOLUENE	SOIL	5.0	UG/KG	0.61	30	70-130	
8260B		PROPIONITRILE	SOIL	100	UG/KG	3.22	30	50-150	
8260B		SEC-BUTYLBENZENE	SOIL	5.0	UG/KG	0.53	30	70-130	
8260B		TERT-BUTYL ALCOHOL	SOIL	100	UG/KG	17	30	50-150	

CAS/ROCHESTER ORGANIC QC LIMITS

ETHOD		ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIC (RPD)	LCS (% REC)	MS (% REC)
60B		TERT-BUTYLBENZENE	SOIL	5.0	UG/KG	0.41	30	70-130	
8260B		TETRA HYDROFURAN	SOIL	5.0	UG/KG		30	50-150	
8260B		TRANS-1,4-DICHLORO-2-BUTENE	SOIL	5.0	UG/KG	1.30	30	50-150	
8260B		*TRICHLOROFLUOROMETHANE*	SOIL	5.0	UG/KG	1.00	30	70-130	
8260B		VINYL ACETATE	SOIL	10	UG/KG	1.60	30	50-150	
8270C	*	1,2,4-TRICHLOROBENZENE	WATER	10	UG/L	2.43	30	36-97	35-91
8270C		1,2-DICHLOROBENZENE	WATER	10	UG/L	2.51	30	25-101	
8270C		1,3-DICHLOROBENZENE	WATER	10	UG/L	3.00	30	24-102	
8270C	*	1,4-DICHLOROBENZENE	WATER	10	UG/L	2.79	30	30-130	27-130
8270C		2,2'-OXYBIS(1-CHLOROPROPANE)	WATER	10	UG/L	2.77	30	20-98	
8270C		*2,4,5-TRICHLOROPHENOL*	WATER	10	UG/L	2.30	30	*61-101*	
8270C		2,4,6-TRICHLOROPHENOL	WATER	10	UG/L	1.72	30	57-104	
8270C		2,4-DICHLOROPHENOL	WATER	10	UG/L	2.14	30	49-107	
8270C		2,4-DIMETHYLPHENOL	WATER	10	UG/L	2.94	30	36-96	
8270C		2,4-DINITROPHENOL	WATER	50	UG/L	48.0	30	26-105	
8270C	*	2,4-DINITROTOLUENE	WATER	10	UG/L	2.17	30	52-110	38-118
8270C		2,6-DINITROTOLUENE	WATER	10	UG/L	3.01	30	58-109	
8270C		2-CHLORONAPHTHALENE	WATER	10	UG/L	2.97	30	45-105	
8270C	*	2-CHLOROPHENOL	WATER	10	UG/L	2.29	30	33-109	10-111
8270C		2-METHYLNAPHTHALENE	WATER	10	UG/L	2.87	30	43-130	
8270C		*2-METHYLPHENOL*	WATER	10	UG/L	2.48	30	*37-104*	
8270C		2-NITROANILINE	WATER	50	UG/L	1.98	30	54-103	
8270C		2-NITROPHENOL	WATER	10	UG/L	2.16	30	50-106	
270C		3,3'-DICHLOROBENZIDINE	WATER	10	UG/L	3.72	30	53-116	
270C		3-NITROANILINE	WATER	50	UG/L	2.38	30	53-109	
270C		4,6-DINITRO-2-METHYLPHENOL	WATER	50	UG/L	21.0	30	51-107	
8270C		4-BROMOPHENYL-PHENYLETHER	WATER	10	UG/L	2.28	30	64-130	
8270C	*	4-CHLORO-3-METHYLPHENOL	WATER	10	UG/L	2.02	30	37-110	10-119
8270C		4-CHLOROANILINE	WATER	10	UG/L	3.31	30	50-112	
8270C		4-CHLOROPHENYL-PHENYLETHER	WATER	10	UG/L	2.75	30	55-106	
8270C		*4-METHYLPHENOL*	WATER	10	UG/L	2.11	30	*42-94*	
8270C		4-NITROANILINE	WATER	50	UG/L	1.97	30	50-112	
8270C	*	4-NITROPHENOL	WATER	50	UG/L	17.3	30	10-130	10-130
8270C	*	ACENAPHTHENE	WATER	10	UG/L	2.48	30	48-130	28-130
8270C		ACENAPHTHYLENE	WATER	10	UG/L	3.55	30	55-130	
8270C		ANTHRACENE	WATER	10	UG/L	1.59	30	64-130	
8270C		BENZO(A)ANTHRACENE	WATER	10	UG/L	1.82	30	61-130	
8270C		BENZO(A)PYRENE	WATER	10	UG/L	1.99	30	61-130	
8270C		BENZO(B)FLUORANTHENE	WATER	10	UG/L	2.29	30	57-130	
8270C		BENZO(G,H,I)PERYLENE	WATER	10	UG/L	2.35	30	63-130	
8270C		*BENZO(K)FLUORANTHENE*	WATER	10	UG/L	2.74	30	59-109	
8270C		BENZYL ALCOHOL	WATER	10	UG/L	4.69	30	36-102	
8270C		BIS(-2-CHLOROETHOXY)METHANE	WATER	10	UG/L	2.20	30	46-105	
8270C		BIS(2-CHLOROETHYL)ETHER	WATER	10	UG/L	2.39	30	41-105	
8270C		BIS(2-ETHYLHEXYL)PHTHALATE	WATER	10	UG/L	3.11	30	62-110	
8270C		BUTYL BENZYL PHTHALATE	WATER	10	UG/L	1.99	30	53-115	
8270C		CARBAZOLE	WATER	10	UG/L	2.07	30	60-111	
8270C		CHRYSENE	WATER	10	UG/L	1.79	30	62-130	
270C		DIBENZO(A,H)ANTHRACENE	WATER	10	UG/L	2.02	30	27-130	
270C		DIBENZOFURAN	WATER	10	UG/L	2.51	30	55-130	
8270C		DIETHYLPHTHALATE	WATER	10	UG/L	2.19	30	20-122	
8270C		DIMETHYL PHTHALATE	WATER	10	UG/L	1.97	30	10-130	
8270C		DI-N-BUTYLPHTHALATE	WATER	10	UG/L	2.53	30	61-130	

CAS/ROCHESTER ORGANIC QC LIMITS

THOD		ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIC (RPD)	LCS (% REC)	MS (% REC)
8270C		DI-N-OCTYL PHTHALATE	WATER	10	UG/L	2.97	30	51-130	
8270C		FLUORANTHENE	WATER	10	UG/L	2.16	30	63-130	
8270C		FLUORENE	WATER	10	UG/L	3.22	30	52-130	
8270C		HEXACHLOROBENZENE	WATER	10	UG/L	1.93	30	58-112	
8270C		HEXACHLOROBUTADIENE	WATER	10	UG/L	2.47	30	30-107	
8270C		HEXACHLOROCYCLOPENTADIENE	WATER	10	UG/L	26.4	30	10-115	
8270C		HEXACHLOROETHANE	WATER	10	UG/L	3.48	30	21-103	
8270C		INDENO(1,2,3-CD)PYRENE	WATER	10	UG/L	2.16	30	55-130	
8270C		ISOPHORONE	WATER	10	UG/L	2.11	30	58-107	
8270C		NAPHTHALENE	WATER	10	UG/L	2.50	30	39-130	
8270C		NITROBENZENE	WATER	10	UG/L	2.24	30	49-100	
8270C		N-NITROSODIMETHYLAMINE	WATER	10	UG/L	2.49	30	26-90	
8270C	*	N-NITROSO-DI-N-PROPYLAMINE	WATER	10	UG/L	2.71	30	44-100	32-99
8270C		N-NITROSODIPHENYLAMINE	WATER	10	UG/L	2.40	30	61-109	
8270C	*	PENTACHLOROPHENOL	WATER	50	UG/L	13.1	30	21-121	10-119
8270C		PHENANTHRENE	WATER	10	UG/L	2.31	30	64-130	
8270C	*	PHENOL	WATER	10	UG/L	2.52	30	10-130	10-130
8270C	*	PYRENE	WATER	10	UG/L	2.41	30	51-130	35-120
8270C		2,4,6-TRIBROMOPHENOL -SURR	WATER	NA	UG/L	NA	NA	10-135	10-135
8270C		2-FLUOROBIPHENYL -SURR	WATER	NA	UG/L	NA	NA	38-107	38-107
8270C		2-FLUOROPHENOL -SURR	WATER	NA	UG/L	NA	NA	10-75	10-75
8270C		NITROBENZENE-d5 -SURR	WATER	NA	UG/L	NA	NA	30-116	30-116
8270C		PHENOL-d6 -SURR	WATER	NA	UG/L	NA	NA	10-130	10-130
8270C		TERPHENYL-d14 -SURR	WATER	NA	UG/L	NA	NA	15-135	15-135
8270C	*	1,2,4-TRICHLOROBENZENE	SOIL	330	UG/KG	55	30	32-99	27-112
8270C		1,2-DICHLOROBENZENE	SOIL	330	UG/KG	54	30	27-92	
8270C		1,3-DICHLOROBENZENE	SOIL	330	UG/KG	52	30	27-92	
8270C	*	1,4-DICHLOROBENZENE	SOIL	330	UG/KG	55	30	25-105	27-95
8270C		2,2'-OXYBIS(1-CHLOROPROPANE)	SOIL	330	UG/KG	95	30	22-97	
8270C		2,4,5-TRICHLOROPHENOL	SOIL	330	UG/KG	102	30	40-108	
8270C		2,4,6-TRICHLOROPHENOL	SOIL	330	UG/KG	47	30	39-106	
8270C		2,4-DICHLOROPHENOL	SOIL	330	UG/KG	43	30	36-103	
8270C		2,4-DIMETHYLPHENOL	SOIL	330	UG/KG	598	30	26-107	
8270C		2,4-DINITROPHENOL	SOIL	1700	UG/KG	1,353	30	10-119	
8270C	*	2,4-DINITROTOLUENE	SOIL	330	UG/KG	46	30	41-130	40-130
8270C		2,6-DINITROTOLUENE	SOIL	330	UG/KG	44	30	38-112	
8270C		2-CHLORONAPHTHALENE	SOIL	330	UG/KG	49	30	37-99	
8270C	*	2-CHLOROPHENOL	SOIL	330	UG/KG	56	30	18-103	10-113
8270C		2-METHYLNAPHTHALENE	SOIL	330	UG/KG	57	30	35-130	
8270C		2-METHYLPHENOL	SOIL	330	UG/KG	118	30	39-98	
8270C		2-NITROANILINE	SOIL	1700	UG/KG	71	30	37-106	
8270C		2-NITROPHENOL	SOIL	330	UG/KG	58	30	34-100	
8270C		3,3'-DICHLOROBENZIDINE	SOIL	330	UG/KG		30	10-106	
8270C		3-NITROANILINE	SOIL	1700	UG/KG	916	30	10-112	
8270C		4,6-DINITRO-2-METHYLPHENOL	SOIL	1700	UG/KG	37	30	31-111	
8270C		4-BROMOPHENYL-PHENYLETHER	SOIL	330	UG/KG	44	30	41-130	
8270C	*	4-CHLORO-3-METHYLPHENOL	SOIL	330	UG/KG	61	30	22-104	10-120
8270C		4-CHLOROANILINE	SOIL	330	UG/KG	138	30	10-98	
8270C		4-CHLOROPHENYL-PHENYLETHER	SOIL	330	UG/KG	54	30	35-111	
8270C		4-METHYLPHENOL	SOIL	330	UG/KG	104	30	37-99	
8270C		4-NITROANILINE	SOIL	1700	UG/KG	1,185	30	10-108	
8270C	*	4-NITROPHENOL	SOIL	1700	UG/KG	590	30	10-106	10-124
8270C	*	ACENAPHTHENE	SOIL	330	UG/KG	61	30	36-130	36-130

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD		ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
8270C		ACENAPHTHYLENE	SOIL	330	UG/KG	81	30	41-130	
8270C		ANTHRACENE	SOIL	330	UG/KG	64	30	36-130	
8270C		BENZO(A)ANTHRACENE	SOIL	330	UG/KG	28	30	42-130	
8270C		BENZO(A)PYRENE	SOIL	330	UG/KG	73	30	39-130	
8270C		BENZO(B)FLUORANTHENE	SOIL	330	UG/KG	196	30	43-130	
8270C		BENZO(G,H,I)PERYLENE	SOIL	330	UG/KG	121	30	45-130	
8270C		BENZO(K)FLUORANTHENE	SOIL	330	UG/KG	191	30	44-130	
8270C		BENZYL ALCOHOL	SOIL	330	UG/KG	154	30	10-110	
8270C		BIS(-2-CHLOROETHOXY)METHANE	SOIL	330	UG/KG	72	30	31-99	
8270C		BIS(2-CHLOROETHYL)ETHER	SOIL	330	UG/KG	77	30	25-105	
8270C		BIS(2-ETHYLHEXYL)PHTHALATE	SOIL	330	UG/KG	32	30	48-111	
8270C		BUTYL BENZYL PHTHALATE	SOIL	330	UG/KG	41	30	47-130	
8270C		CARBAZOLE	SOIL	330	UG/KG	179	30	17-126	
8270C		CHRYSENE	SOIL	330	UG/KG	27	30	41-130	
8270C		DIBENZO(A,H)ANTHRACENE	SOIL	330	UG/KG	167	30	22-130	
8270C		DIBENZOFURAN	SOIL	330	UG/KG	52	30	36-109	
8270C		DIETHYLPHTHALATE	SOIL	330	UG/KG	39	30	42-110	
8270C		DIMETHYL PHTHALATE	SOIL	330	UG/KG	40	30	40-110	
8270C		DI-N-BUTYLPHTHALATE	SOIL	330	UG/KG	62	30	46-130	
8270C		DI-N-OCTYL PHTHALATE	SOIL	330	UG/KG	150	30	39-130	
8270C		FLUORANTHENE	SOIL	330	UG/KG	28	30	41-130	
8270C		FLUORENE	SOIL	330	UG/KG	55	30	39-130	
8270C		HEXACHLOROBENZENE	SOIL	330	UG/KG	49	30	45-110	
8270C		HEXACHLOROBUTADIENE	SOIL	330	UG/KG	63	30	31-107	
8270C		HEXACHLOROCYCLOPENTADIENE	SOIL	330	UG/KG	64	30	10-102	
8270C		HEXACHLOROETHANE	SOIL	330	UG/KG	54	30	25-92	
8270C		INDENO(1,2,3-CD)PYRENE	SOIL	330	UG/KG	129	30	44-130	
8270C		ISOPHORONE	SOIL	330	UG/KG	98	30	36-109	
8270C		NAPHTHALENE	SOIL	330	UG/KG	58	30	37-130	
8270C		NITROBENZENE	SOIL	330	UG/KG	57	30	32-103	
8270C		N-NITROSODIMETHYLAMINE	SOIL	330	UG/KG	44	30	26-91	
8270C	*	N-NITROSO-DI-N-PROPYLAMINE	SOIL	330	UG/KG	63	30	32-97	21-116
8270C		N-NITROSODIPHENYLAMINE	SOIL	330	UG/KG	137	30	15-119	
8270C	*	PENTACHLOROPHENOL	SOIL	800	UG/KG	712	30	17-110	10-122
8270C		PHENANTHRENE	SOIL	330	UG/KG	40	30	44-130	
8270C	*	PHENOL	SOIL	330	UG/KG	52	30	13-106	10-117
8270C	*	PYRENE	SOIL	330	UG/KG	37	30	36-130	33-130
8270C		2,4,6-TRIBROMOPHENOL -SURR	SOIL	NA	UG/KG	NA	NA	10-130	10-130
8270C		2-FLUOROBIPHENYL -SURR	SOIL	NA	UG/KG	NA	NA	11-112	11-112
8270C		2-FLUOROPHENOL -SURR	SOIL	NA	UG/KG	NA	NA	10-130	10-130
8270C		NITROBENZENE-d5 -SURR	SOIL	NA	UG/KG	NA	NA	10-138	10-138
8270C		PHENOL-d6 -SURR	SOIL	NA	UG/KG	NA	NA	11-130	11-130
8270C		TERPHENYL-d14 -SURR	SOIL	NA	UG/KG	NA	NA	10-152	10-152
8270C SIM		ACENAPHTHENE	WATER	0.10	UG/L	0.07	30	48-103	28-109
8270C SIM		ACENAPHTHYLENE	WATER	0.10	UG/L	0.07	30	55-113	26-119
8270C SIM		ANTHRACENE	WATER	0.10	UG/L	0.09	30	64-106	31-128
8270C SIM		BENZO(A)ANTHRACENE	WATER	0.10	UG/L	0.04	30	61-109	34-117
8270C SIM		BENZO(A)PYRENE	WATER	0.10	UG/L	0.06	30	61-110	35-119
8270C SIM		BENZO(B)FLUORANTHENE	WATER	0.10	UG/L	0.06	30	57-109	27-115
8270C SIM		BENZO(G,H,I)PERYLENE	WATER	0.10	UG/L	0.05	30	63-109	41-112
8270C SIM		BENZO(K)FLUORANTHENE	WATER	0.10	UG/L	0.04	30	59-109	29-118
8270C SIM		CHRYSENE	WATER	0.10	UG/L	0.06	30	62-108	32-115
8270C SIM		DIBENZO(A,H)ANTHRACENE	WATER	0.10	UG/L	0.03	30	27-123	15-96

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
8270C SIM	FLUORANTHENE	WATER	0.10	UG/L	0.07	30	63-108	32-129
8270C SIM	FLUORENE	WATER	0.10	UG/L	0.06	30	63-106	22-126
8270C SIM	INDENO(1,2,3-CD)PYRENE	WATER	0.10	UG/L	0.05	30	56-111	33-105
8270C SIM	NAPHTHALENE	WATER	0.10	UG/L	0.05	30	39-101	d-107
8270C SIM	PHENANTHRENE	WATER	0.10	UG/L	0.05	30	64-108	d-129
8270C SIM	PYRENE	WATER	0.10	UG/L	0.06	30	61-116	35-120
8270C SIM	2-FLUOROBIPHENYL -SURR	WATER	NA	UG/L	NA	NA	38-107	38-107
8270C SIM	NITROBENZENE-d5 -SURR	WATER	NA	UG/L	NA	NA	30-116	30-116
8270C SIM	TERPHENYL-d14 -SURR	WATER	NA	UG/L	NA	NA	15-135	15-135
8270C SIM	ACENAPHTHENE	SOIL	33	UG/KG	61	30	36-99	36-111
8270C SIM	ACENAPHTHYLENE	SOIL	33	UG/KG	81	30	41-106	31-121
8270C SIM	ANTHRACENE	SOIL	33	UG/KG	64	30	36-111	40-115
8270C SIM	BENZO(A)ANTHRACENE	SOIL	33	UG/KG	28	30	42-111	29-122
8270C SIM	BENZO(A)PYRENE	SOIL	33	UG/KG	73	30	39-115	12-133
8270C SIM	BENZO(B)FLUORANTHENE	SOIL	33	UG/KG	196	30	43-115	17-126
8270C SIM	BENZO(G,H,I)PERYLENE	SOIL	33	UG/KG	121	30	45-113	21-127
8270C SIM	BENZO(K)FLUORANTHENE	SOIL	33	UG/KG	191	30	44-115	26-125
8270C SIM	CHRYSENE	SOIL	33	UG/KG	27	30	41-112	28-123
8270C SIM	DIBENZO(A,H)ANTHRACENE	SOIL	33	UG/KG	167	30	22-119	d-127
8270C SIM	FLUORANTHENE	SOIL	33	UG/KG	28	30	41-109	40-113
8270C SIM	FLUORENE	SOIL	33	UG/KG	55	30	39-107	23-121
8270C SIM	INDENO(1,2,3-CD)PYRENE	SOIL	33	UG/KG	129	30	44-112	9-135
8270C SIM	NAPHTHALENE	SOIL	33	UG/KG	58	30	37-91	37-97
8270C SIM	PHENANTHRENE	SOIL	33	UG/KG	40	30	44-109	35-117
8270C SIM	PYRENE	SOIL	33	UG/KG	37	30	36-115	33-119
8270C SIM	2-FLUOROBIPHENYL -SURR	SOIL	NA	UG/KG	NA	NA	11-112	11-112
8270C SIM	NITROBENZENE-d5 -SURR	SOIL	NA	UG/KG	NA	NA	d-138	d-138
8270C SIM	TERPHENYL-d14 -SURR	SOIL	NA	UG/KG	NA	NA	3-152	3-152
95-1/SOW4.2	1,1,1-TRICHLOROETHANE	WATER	10	UG/L	0.31			
95-1/SOW4.2	1,1,2,2-TETRACHLOROETHANE	WATER	10	UG/L	0.89			
95-1/SOW4.2	1,1,2-TRICHLOROETHANE	WATER	10	UG/L	0.62			
95-1/SOW4.2	1,1-DICHLOROETHANE	WATER	10	UG/L	0.51			
95-1/SOW4.2	1,1-DICHLOROETHENE	WATER	10	UG/L	0.71	14	61-145**	61-145
95-1/SOW4.2	1,2-DICHLOROETHANE	WATER	10	UG/L	0.69			
95-1/SOW4.2	1,2-DICHLOROPROPANE	WATER	10	UG/L	0.81			
95-1/SOW4.2	2-BUTANONE	WATER	10	UG/L	2.84			
95-1/SOW4.2	2-HEXANONE	WATER	10	UG/L	2.57			
95-1/SOW4.2	4-METHYL-2-PENTANONE	WATER	10	UG/L	1.17			
95-1/SOW4.2	ACETONE	WATER	10	UG/L	2.89			
95-1/SOW4.2	BENZENE	WATER	10	UG/L	0.44	11	76-127**	76-127
95-1/SOW4.2	BROMODICHLOROMETHANE	WATER	10	UG/L	0.40			
95-1/SOW4.2	BROMOFORM	WATER	10	UG/L	0.80			
95-1/SOW4.2	BROMOMETHANE	WATER	10	UG/L	1.40			
95-1/SOW4.2	CARBON DISULFIDE	WATER	10	UG/L	0.65			
95-1/SOW4.2	CARBON TETRACHLORIDE	WATER	10	UG/L	0.49			
95-1/SOW4.2	CHLOROBENZENE	WATER	10	UG/L	0.61	13	75-130**	75-130
95-1/SOW4.2	CHLOROETHANE	WATER	10	UG/L	0.49			
95-1/SOW4.2	CHLOROFORM	WATER	10	UG/L	0.43			
95-1/SOW4.2	CHLOROMETHANE	WATER	10	UG/L	0.67			
95-1/SOW4.2	CIS-1,2-DICHLOROETHENE	WATER	10	UG/L	0.37			
95-1/SOW4.2	CIS-1,3-DICHLOROPROPENE	WATER	10	UG/L	0.50			
95-1/SOW4.2	DIBROMOCHLOROMETHANE	WATER	10	UG/L	0.71			

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
[illegible]-1/SOW4.2	ETHYLBENZENE	WATER	10	UG/L	0.64			
95-1/SOW4.2	M+P-XYLENE	WATER	10	UG/L	1.52			
95-1/SOW4.2	METHYLENE CHLORIDE	WATER	10	UG/L	0.54			
95-1/SOW4.2	O-XYLENE	WATER	10	UG/L	0.46			
95-1/SOW4.2	STYRENE	WATER	10	UG/L	0.67			
95-1/SOW4.2	TETRACHLOROETHENE	WATER	10	UG/L	0.75			
95-1/SOW4.2	TOLUENE	WATER	10	UG/L	0.55	13	76-125**	76-125
95-1/SOW4.2	TRANS-1,2-DICHLOROETHENE	WATER	10	UG/L	0.91			
95-1/SOW4.2	TRANS-1,3-DICHLOROPROPENE	WATER	10	UG/L	0.26			
95-1/SOW4.2	TRICHLOROETHENE	WATER	10	UG/L	0.77	14	71-120**	71-120
95-1/SOW4.2	VINYL CHLORIDE	WATER	10	UG/L	0.53			
95-1/SOW4.2	BROMOFLUOROBENZENE -SURR	WATER	NA	UG/L	NA	NA	86-115	86-115
95-1/SOW4.2	1,2-DICHLOROETHANE-D4 -SURR	WATER	NA	UG/L	NA	NA	76-114	76-114
95-1/SOW4.2	TOLUENE-D8 -SURR	WATER	NA	UG/L	NA	NA	88-110	88-110
SOW List from above plus these additional compounds								
SOW 4.2	*DICHLORODIFLUOROMETHANE*	WATER	10	UG/L	1.49			
SOW 4.2	*TRICHLOROFLUOROMETHANE*	WATER	10	UG/L	1.22			
SOW 4.2	*1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON 113)*	WATER	10	UG/L	0.79			
SOW 4.2	*METHYL ACETATE*	WATER	10	UG/L	2.16			
SOW 4.2	*TRANS-1,2-DICHLOROETHENE*	WATER	10	UG/L	1.16			
SOW 4.2	*METHYL TERT-BUTYL ETHER*	WATER	10	UG/L	0.84			
[illegible]OW 4.2	*CIS-1,2-DICHLOROETHENE*	WATER	10	UG/L	1.17			
[illegible]W 4.2	*CYCLOHEXANE*	WATER	10	UG/L	1.23			
SOW 4.2	*METHYLCYCLOHEXANE*	WATER	10	UG/L	1.37			
SOW 4.2	*1,2-DIBROMOETHANE*	WATER	10	UG/L	1.36			
SOW 4.2	*ISOPROPYLBENZENE*	WATER	10	UG/L	1.15			
SOW 4.2	*1,3-DICHLOROBENZENE*	WATER	10	UG/L	1.22			
SOW 4.2	*1,4-DICHLOROBENZENE*	WATER	10	UG/L	1.44			
SOW 4.2	*1,2-DICHLOROBENZENE*	WATER	10	UG/L	1.29			
SOW 4.2	*1,2-DIBROMO-3-CHLOROPROPANE*	WATER	10	UG/L	1.41			
SOW 4.2	*1,2,4-TRICHLOROBENZENE*	WATER	10	UG/L	1.46			
95-1/SOW4.2	1,1,1-TRICHLOROETHANE	SOIL	10	UG/KG	2.73			
95-1/SOW4.2	1,1,2,2-TETRACHLOROETHANE	SOIL	10	UG/KG	4.27			
95-1/SOW4.2	1,1,2-TRICHLOROETHANE	SOIL	10	UG/KG	2.19			
95-1/SOW4.2	1,1-DICHLOROETHANE	SOIL	10	UG/KG	2.72			
95-1/SOW4.2	1,1-DICHLOROETHENE	SOIL	10	UG/KG	3.28	22	61-145**	59-172
95-1/SOW4.2	1,2-DICHLOROETHANE	SOIL	10	UG/KG	2.33			
95-1/SOW4.2	1,2-DICHLOROPROPANE	SOIL	10	UG/KG	2.38			
95-1/SOW4.2	2-BUTANONE	SOIL	10	UG/KG	3.82			
95-1/SOW4.2	2-HEXANONE	SOIL	10	UG/KG	4.29			
95-1/SOW4.2	4-METHYL-2-PENTANONE	SOIL	10	UG/KG	3.39			
95-1/SOW4.2	ACETONE	SOIL	10	UG/KG	6.19			
95-1/SOW4.2	BENZENE	SOIL	10	UG/KG	2.61	21	76-127**	66-142
95-1/SOW4.2	BROMODICHLOROMETHANE	SOIL	10	UG/KG	2.55			
95-1/SOW4.2	BROMOFORM	SOIL	10	UG/KG	3.22			
95-1/SOW4.2	BROMOMETHANE	SOIL	10	UG/KG	2.44			
[illegible]5-1/SOW4.2	CARBON DISULFIDE	SOIL	10	UG/KG	2.97			
[illegible]-1/SOW4.2	CARBON TETRACHLORIDE	SOIL	10	UG/KG	3.07			
95-1/SOW4.2	CHLOROBENZENE	SOIL	10	UG/KG	2.84	21	75-130**	60-133
95-1/SOW4.2	*CHLOROETHANE*	SOIL	10	UG/KG	2.98			

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
95-1/SOW4.2	CHLOROFORM	SOIL	10	UG/KG	2.68			
95-1/SOW4.2	CHLOROMETHANE	SOIL	10	UG/KG	3.18			
95-1/SOW4.2	CIS-1,2-DICHLOROETHENE	SOIL	10	UG/KG	2.83			
95-1/SOW4.2	CIS-1,3-DICHLOROPROPENE	SOIL	10	UG/KG	2.22			
95-1/SOW4.2	DIBROMOCHLOROMETHANE	SOIL	10	UG/KG	2.28			
95-1/SOW4.2	ETHYLBENZENE	SOIL	10	UG/KG	2.90			
95-1/SOW4.2	M+P-XYLENE	SOIL	10	UG/KG	5.89			
95-1/SOW4.2	METHYLENE CHLORIDE	SOIL	10	UG/KG	2.63			
95-1/SOW4.2	O-XYLENE	SOIL	10	UG/KG	3.04			
95-1/SOW4.2	STYRENE	SOIL	10	UG/KG	3.06			
95-1/SOW4.2	TETRACHLOROETHENE	SOIL	10	UG/KG	3.07			
95-1/SOW4.2	TOLUENE	SOIL	10	UG/KG	2.92	21	76-125**	59-139
95-1/SOW4.2	TRANS-1,2-DICHLOROETHENE	SOIL	10	UG/KG	3.22			
95-1/SOW4.2	TRANS-1,3-DICHLOROPROPENE	SOIL	10	UG/KG	2.52			
95-1/SOW4.2	TRICHLOROETHENE	SOIL	10	UG/KG	3.03	24	71-120**	62-137
95-1/SOW4.2	VINYL CHLORIDE	SOIL	10	UG/KG	2.93			
95-1/SOW4.2	BROMOFLUOROBENZENE -SURR	SOIL	NA	UG/KG	NA	NA	59-113	59-113
95-1/SOW4.2	1,2-DICHLOROETHANE-D4 -SURR	SOIL	NA	UG/KG	NA	NA	70-121	70-121
95-1/SOW4.2	TOLUENE-D8 -SURR	SOIL	NA	UG/KG	NA	NA	84-138	84-138
SOW List from above plus these additional compounds								
SOW 4.2	*DICHLORODIFLUOROMETHANE*	SOIL	10	UG/KG	0.69			
SOW 4.2	*TRICHLOROFLUOROMETHANE*	SOIL	10	UG/KG	0.79			
SOW 4.2	*1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE*	SOIL	10	UG/KG	0.75			
SOW 4.2	*METHYL ACETATE*	SOIL	10	UG/KG	1.76			
SOW 4.2	*TRANS-1,2-DICHLOROETHENE*	SOIL	10	UG/KG	1.01			
SOW 4.2	*METHYL TERT-BUTYL ETHER*	SOIL	10	UG/KG	1.29			
SOW 4.2	*CIS-1,2-DICHLOROETHENE*	SOIL	10	UG/KG	0.74			
SOW 4.2	*CYCLOHEXANE*	SOIL	10	UG/KG	1.01			
SOW 4.2	*METHYLCYCLOHEXANE*	SOIL	10	UG/KG	0.75			
SOW 4.2	*1,2-DIBROMOETHANE*	SOIL	10	UG/KG	1.23			
SOW 4.2	*ISOPROPYLBENZENE*	SOIL	10	UG/KG	0.90			
SOW 4.2	*1,3-DICHLOROBENZENE*	SOIL	10	UG/KG	0.81			
SOW 4.2	*1,4-DICHLOROBENZENE*	SOIL	10	UG/KG	0.96			
SOW 4.2	*1,2-DICHLOROBENZENE*	SOIL	10	UG/KG	0.77			
SOW 4.2	*1,2-DIBROMO-3-CHLOROPROPANE*	SOIL	10	UG/KG	2.15			
SOW 4.2	*1,2,4-TRICHLOROBENZENE*	SOIL	10	UG/KG	1.09			
95-2/SOW4.2	ACENAPHTHENE	WATER	10	UG/L	0.54	31	46-118**	46-118
95-2/SOW4.2	ACENAPHTHYLENE	WATER	10	UG/L	0.44			
95-2/SOW4.2	ANTHRACENE	WATER	10	UG/L	0.94			
95-2/SOW4.2	BENZO(A)ANTHRACENE	WATER	10	UG/L	0.26			
95-2/SOW4.2	BENZO(A)PYRENE	WATER	10	UG/L	0.35			
95-2/SOW4.2	BENZO(B)FLUORANTHENE	WATER	10	UG/L	3.65			
95-2/SOW4.2	BENZO(G,H,I)PERYLENE	WATER	10	UG/L	0.78			
95-2/SOW4.2	BENZO(K)FLUORANTHENE	WATER	10	UG/L	2.80			
95-2/SOW4.2	BUTYL BENZYL PHTHALATE	WATER	10	UG/L	3.39			
95-2/SOW4.2	DI-N-BUTYLPHTHALATE	WATER	10	UG/L	4.04			
95-2/SOW4.2	CARBAZOLE	WATER	10	UG/L	1.51			
95-2/SOW4.2	INDENO(1,2,3-CD)PYRENE	WATER	10	UG/L	1.92			
95-2/SOW4.2	4-CHLOROANILINE	WATER	10	UG/L	1.03			
95-2/SOW4.2	BIS(-2-CHLOROETHOXY)METHANE	WATER	10	UG/L	1.07			
95-2/SOW4.2	BIS(-2-CHLOROETHYL)ETHER	WATER	10	UG/L	1.61			

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIC (RPD)	LCS (% REC)	MS (% REC)
[illegible]-2/SOW4.2	2-CHLORONAPHTHALENE	WATER	10	UG/L	1.32			
95-2/SOW4.2	2-CHLOROPHENOL	WATER	10	UG/L	1.61	40	27-123**	27-123
95-2/SOW4.2	2,2'-OXYBIS(1-CHLOROPROPANE)	WATER	10	UG/L	1.35			
95-2/SOW4.2	CHRYSENE	WATER	10	UG/L	0.76			
95-2/SOW4.2	DIBENZ(A,H)ANTHRACENE	WATER	10	UG/L	1.19			
95-2/SOW4.2	DIBENZOFURAN	WATER	10	UG/L	1.01			
95-2/SOW4.2	1,3-DICHLOROBENZENE	WATER	10	UG/L	1.29			
95-2/SOW4.2	1,2-DICHLOROBENZENE	WATER	10	UG/L	1.09			
95-2/SOW4.2	1,4-DICHLOROBENZENE	WATER	10	UG/L	0.39	28	36-97**	36-97**
95-2/SOW4.2	3,3'-DICHLOROBENZIDINE	WATER	10	UG/L	1.43			
95-2/SOW4.2	2,4-DICHLOROPHENOL	WATER	10	UG/L	1.08			
95-2/SOW4.2	DIETHYLPHTHALATE	WATER	10	UG/L	1.83			
95-2/SOW4.2	DIMETHYL PHTHALATE	WATER	10	UG/L	1.92			
95-2/SOW4.2	2,4-DIMETHYLPHENOL	WATER	10	UG/L	1.23			
95-2/SOW4.2	2,4-DINITROPHENOL	WATER	25	UG/L	2.28			
95-2/SOW4.2	2,4-DINITROTOLUENE	WATER	10	UG/L	2.69	38	24-96**	24-96
95-2/SOW4.2	2,6-DINITROTOLUENE	WATER	10	UG/L	1.57			
95-2/SOW4.2	BIS(2-ETHYLHEXYL)PHTHALATE	WATER	10	UG/L	4.41			
95-2/SOW4.2	FLUORANTHENE	WATER	10	UG/L	3.14			
95-2/SOW4.2	FLUORENE	WATER	10	UG/L	1.00			
95-2/SOW4.2	HEXACHLOROBENZENE	WATER	10	UG/L	0.84			
95-2/SOW4.2	HEXACHLOROBUTADIENE	WATER	10	UG/L	0.94			
95-2/SOW4.2	HEXACHLOROCYCLOPENTADIENE	WATER	10	UG/L	1.29			
[illegible]-2/SOW4.2	HEXACHLOROETHANE	WATER	10	UG/L	1.09			
[illegible]-2/SOW4.2	ISOPHORONE	WATER	10	UG/L	2.07			
[illegible]-2/SOW4.2	2-METHYLNAPHTHALENE	WATER	10	UG/L	1.41			
95-2/SOW4.2	4,6-DINITRO-2-METHYLPHENOL	WATER	25	UG/L	3.47			
95-2/SOW4.2	4-CHLORO-3-METHYLPHENOL	WATER	10	UG/L	2.45	42	23-97**	23-97
95-2/SOW4.2	2-METHYLPHENOL	WATER	10	UG/L	0.73			
95-2/SOW4.2	4-METHYLPHENOL	WATER	10	UG/L	0.93			
95-2/SOW4.2	NAPHTHALENE	WATER	10	UG/L	0.50			
95-2/SOW4.2	2-NITROANILINE	WATER	25	UG/L	1.18			
95-2/SOW4.2	3-NITROANILINE	WATER	25	UG/L	2.75			
95-2/SOW4.2	4-NITROANILINE	WATER	25	UG/L	3.06			
95-2/SOW4.2	NITROBENZENE	WATER	10	UG/L	1.27			
95-2/SOW4.2	2-NITROPHENOL	WATER	10	UG/L	2.09			
95-2/SOW4.2	4-NITROPHENOL	WATER	25	UG/L	3.44	50	10-80**	10-80
95-2/SOW4.2	N-NITROSODIPHENYLAMINE	WATER	10	UG/L	0.76			
95-2/SOW4.2	DI-N-OCTYL PHTHALATE	WATER	10	UG/L	4.35			
95-2/SOW4.2	PENTACHLOROPHENOL	WATER	25	UG/L	3.62	50	9-103**	9-103
95-2/SOW4.2	PHENANTHRENE	WATER	10	UG/L	1.14			
95-2/SOW4.2	PHENOL	WATER	10	UG/L	0.54	42	12-110**	12-110
95-2/SOW4.2	4-BROMOPHENYL-PHENYLETHER	WATER	10	UG/L	1.58			
95-2/SOW4.2	4-CHLOROPHENYL-PHENYLETHER	WATER	10	UG/L	1.78			
95-2/SOW4.2	N-NITROSO-DI-N-PROPYLAMINE	WATER	10	UG/L	2.17	38	41-116**	41-116
95-2/SOW4.2	PYRENE	WATER	10	UG/L	1.72	31	26-127**	26-127
95-2/SOW4.2	1,2,4-TRICHLOROBENZENE	WATER	10	UG/L	0.53	28	39-98**	39-98**
95-2/SOW4.2	2,4,6-TRICHLOROPHENOL	WATER	10	UG/L	1.24			
[illegible]5-2/SOW4.2	2,4,5-TRICHLOROPHENOL	WATER	25	UG/L	0.95			
[illegible]-2/SOW4.2	TERPHENYL-D14 -SURR	WATER	NA	UG/L	NA	NA	33-141	33-141
95-2/SOW4.2	2-CHLOROPHENOL-D4 -SURR	WATER	NA	UG/L	NA	NA	33-110	33-110
95-2/SOW4.2	1,2-DICHLOROBENZENE-D4 -SURR	WATER	NA	UG/L	NA	NA	16-110	16-110
95-2/SOW4.2	NITROBENZENE-D5 -SURR	WATER	NA	UG/L	NA	NA	35-114	35-114

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
[illegible]-2/SOW4.2	PHENOL-D6 -SURR	WATER	NA	UG/L	NA	NA	10-110	10-110
95-2/SOW4.2	2-FLUOROBIPHENYL -SURR	WATER	NA	UG/L	NA	NA	43-116	43-116
95-2/SOW4.2	2-FLUOROPHENOL -SURR	WATER	NA	UG/L	NA	NA	21-110	21-110
95-2/SOW4.2	2,4,6-TRIBROMOPHENOL -SURR	WATER	NA	UG/L	NA	NA	10-123	10-123
SOW list from above plus these additional compounds								
SOW 4.2	*BENZALDEHYDE*	WATER	10	UG/L	0.81			
SOW 4.2	*ACETOPHENONE*	WATER	10	UG/L	1.01			
SOW 4.2	*CAPROLACTAM*	WATER	10	UG/L	0.98			
SOW 4.2	*1,1'-BIPHENYL*	WATER	10	UG/L	1.05			
SOW 4.2	*ATRAZINE*	WATER	10	UG/L	0.75			
95-2/SOW4.2	ACENAPHTHENE	SOIL	330	UG/KG	18	19	46-118**	31-137
95-2/SOW4.2	ACENAPHTHYLENE	SOIL	330	UG/KG	15			
95-2/SOW4.2	ANTHRACENE	SOIL	330	UG/KG	31			
95-2/SOW4.2	BENZO(A)ANTHRACENE	SOIL	330	UG/KG	9			
95-2/SOW4.2	BENZO(A)PYRENE	SOIL	330	UG/KG	12			
95-2/SOW4.2	BENZO(B)FLUORANTHENE	SOIL	330	UG/KG	120			
95-2/SOW4.2	BENZO(G,H,I)PERYLENE	SOIL	330	UG/KG	26			
95-2/SOW4.2	BENZO(K)FLUORANTHENE	SOIL	330	UG/KG	92			
95-2/SOW4.2	BUTYL BENZYL PHTHALATE	SOIL	330	UG/KG	112			
95-2/SOW4.2	DI-N-BUTYLPHTHALATE	SOIL	330	UG/KG	133			
95-2/SOW4.2	CARBAZOLE	SOIL	330	UG/KG	50			
95-2/SOW4.2	INDENO(1,2,3-CD)PYRENE	SOIL	330	UG/KG	63			
95-2/SOW4.2	4-CHLOROANILINE	SOIL	330	UG/KG	34			
[illegible]-2/SOW4.2	BIS(-2-CHLOROETHOXY)METHANE	SOIL	330	UG/KG	35			
[illegible]-2/SOW4.2	BIS(-2-CHLOROETHYL)ETHER	SOIL	330	UG/KG	53			
95-2/SOW4.2	2-CHLORONAPHTHALENE	SOIL	330	UG/KG	44			
95-2/SOW4.2	*2-CHLOROPHENOL*	SOIL	330	UG/KG	53	50	27-123**	25-102
95-2/SOW4.2	2,2'-OXYBIS(1-CHLOROPROPANE)	SOIL	330	UG/KG	45			
95-2/SOW4.2	*CHRYSENE*	SOIL	330	UG/KG	25			
95-2/SOW4.2	DIBENZ(A,H)ANTHRACENE	SOIL	330	UG/KG	39			
95-2/SOW4.2	DIBENZOFURAN	SOIL	330	UG/KG	33			
95-2/SOW4.2	1,3-DICHLOROBENZENE	SOIL	330	UG/KG	43			
95-2/SOW4.2	1,2-DICHLOROBENZENE	SOIL	330	UG/KG	36			
95-2/SOW4.2	1,4-DICHLOROBENZENE	SOIL	330	UG/KG	13	27	36-97**	28-104**
95-2/SOW4.2	3,3'-DICHLOROBENZIDINE	SOIL	330	UG/KG	47			
95-2/SOW4.2	2,4-DICHLOROPHENOL	SOIL	330	UG/KG	36			
95-2/SOW4.2	DIETHYLPHTHALATE	SOIL	330	UG/KG	60			
95-2/SOW4.2	DIMETHYL PHTHALATE	SOIL	330	UG/KG	63			
95-2/SOW4.2	2,4-DIMETHYLPHENOL	SOIL	330	UG/KG	41			
95-2/SOW4.2	2,4-DINITROPHENOL	SOIL	800	UG/KG	75			
95-2/SOW4.2	2,4-DINITROTOLUENE	SOIL	330	UG/KG	89	47	24-96**	28-89
95-2/SOW4.2	2,6-DINITROTOLUENE	SOIL	330	UG/KG	52			
95-2/SOW4.2	BIS(2-ETHYLHEXYL)PHTHALATE	SOIL	330	UG/KG	146			
95-2/SOW4.2	FLUORANTHENE	SOIL	330	UG/KG	104			
95-2/SOW4.2	FLUORENE	SOIL	330	UG/KG	33			
95-2/SOW4.2	HEXACHLOROBENZENE	SOIL	330	UG/KG	28			
95-2/SOW4.2	HEXACHLOROBUTADIENE	SOIL	330	UG/KG	31			
95-2/SOW4.2	HEXACHLOROCYCLOPENTADIENE	SOIL	330	UG/KG	43			
[illegible]-2/SOW4.2	HEXACHLOROETHANE	SOIL	330	UG/KG	36			
[illegible]-2/SOW4.2	ISOPHORONE	SOIL	330	UG/KG	68			
95-2/SOW4.2	2-METHYLNAPHTHALENE	SOIL	330	UG/KG	47			
95-2/SOW4.2	*4,6-DINITRO-2-METHYLPHENOL*	SOIL	800	UG/KG	115			

CAS/ROCHESTER ORGANIC QC LIMITS

THOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIC (RPD)	LCS (% REC)	MS (% REC)
5-2/SOW4.2	4-CHLORO-3-METHYLPHENOL	SOIL	330	UG/KG	81	33	23-97**	26-103
95-2/SOW4.2	2-METHYLPHENOL	SOIL	330	UG/KG	24			
95-2/SOW4.2	4-METHYLPHENOL	SOIL	330	UG/KG	31			
95-2/SOW4.2	NAPHTHALENE	SOIL	330	UG/KG	17			
95-2/SOW4.2	2-NITROANILINE	SOIL	800	UG/KG	39			
95-2/SOW4.2	3-NITROANILINE	SOIL	800	UG/KG	91			
95-2/SOW4.2	4-NITROANILINE	SOIL	800	UG/KG	101			
95-2/SOW4.2	NITROBENZENE	SOIL	330	UG/KG	42			
95-2/SOW4.2	2-NITROPHENOL	SOIL	330	UG/KG	69			
95-2/SOW4.2	4-NITROPHENOL	SOIL	800	UG/KG	114	50	10-80**	11-114
95-2/SOW4.2	N-NITROSODIPHENYLAMINE	SOIL	330	UG/KG	25			
95-2/SOW4.2	DI-N-OCTYL PHTHALATE	SOIL	330	UG/KG	144			
95-2/SOW4.2	PENTACHLOROPHENOL	SOIL	800	UG/KG	119	47	9-103**	17-109
95-2/SOW4.2	PHENANTHRENE	SOIL	330	UG/KG	38			
95-2/SOW4.2	PHENOL	SOIL	330	UG/KG	18	35	12-110**	26-90
95-2/SOW4.2	4-BROMOPHENYL-PHENYLETHER	SOIL	330	UG/KG	52			
95-2/SOW4.2	4-CHLOROPHENYL-PHENYLETHER	SOIL	330	UG/KG	59			
95-2/SOW4.2	N-NITROSO-DI-N-PROPYLAMINE	SOIL	330	UG/KG	72	38	41-116**	41-126
95-2/SOW4.2	PYRENE	SOIL	330	UG/KG	57	36	26-127**	35-142
95-2/SOW4.2	1,2,4-TRICHLOROBENZENE	SOIL	330	UG/KG	17	23	39-98**	38-107**
95-2/SOW4.2	2,4,6-TRICHLOROPHENOL	SOIL	330	UG/KG	41			
95-2/SOW4.2	2,4,5-TRICHLOROPHENOL	SOIL	800	UG/KG	31			
95-2/SOW4.2	TERPHENYL-D14 -SURR	SOIL	NA	UG/KG	NA	NA	18-137	18-137
5-2/SOW4.2	2-CHLOROPHENOL-D4 -SURR	SOIL	NA	UG/KG	NA	NA	20-130	20-130
5-2/SOW4.2	1,2-DICHLOROBENZENE-D4 -SURR	SOIL	NA	UG/KG	NA	NA	20-130	20-130
95-2/SOW4.2	NITROBENZENE-D5 -SURR	SOIL	NA	UG/KG	NA	NA	23-120	23-120
95-2/SOW4.2	PHENOL-D6 -SURR	SOIL	NA	UG/KG	NA	NA	24-113	24-113
95-2/SOW4.2	2-FLUOROBIPHENYL -SURR	SOIL	NA	UG/KG	NA	NA	30-115	30-115
95-2/SOW4.2	2-FLUOROPHENOL -SURR	SOIL	NA	UG/KG	NA	NA	25-121	25-121
95-2/SOW4.2	2,4,6-TRIBROMOPHENOL -SURR	SOIL	NA	UG/KG	NA	NA	19-122	19-122
SOW list from above plus these additional compounds								
SOW 4.2	BENZALDEHYDE	SOIL	330	UG/KG	27	NA		
SOW 4.2	ACETOPHENONE	SOIL	330	UG/KG	33	NA		
SOW 4.2	CAPROLACTAM	SOIL	330	UG/KG	32	NA		
SOW 4.2	1,1'-BIPHENYL	SOIL	330	UG/KG	35	NA		
SOW 4.2	ATRAZINE	SOIL	330	UG/KG	25	NA		

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
[illegible]-3/SOW4.2	AROCLOR-1016	WATER	1.0	UG/L	0.37			
95-3/SOW4.2	AROCLOR-1221	WATER	2.0	UG/L	0.42			
95-3/SOW4.2	AROCLOR-1232	WATER	1.0	UG/L	0.18			
95-3/SOW4.2	AROCLOR-1242	WATER	1.0	UG/L	0.21			
95-3/SOW4.2	AROCLOR-1248	WATER	1.0	UG/L	0.39			
95-3/SOW4.2	AROCLOR-1254	WATER	1.0	UG/L	0.59			
95-3/SOW4.2	AROCLOR-1260	WATER	1.0	UG/L	0.10			
95-3/SOW4.2	ALDRIN	WATER	0.050	UG/L	0.002	22	40-120**	40-120
95-3/SOW4.2	ALPHA-BHC	WATER	0.050	UG/L	0.002			
95-3/SOW4.2	BETA-BHC	WATER	0.050	UG/L	0.003			
95-3/SOW4.2	DELTA-BHC	WATER	0.050	UG/L	0.01			
95-3/SOW4.2	GAMMA-BHC (LINDANE)	WATER	0.050	UG/L	0.01	15	56-123**	56-123
95-3/SOW4.2	ALPHA-CHLORDANE	WATER	0.050	UG/L	0.01			
95-3/SOW4.2	GAMMA-CHLORDANE	WATER	0.050	UG/L	0.01			
95-3/SOW4.2	4,4'-DDD	WATER	0.10	UG/L	0.01			
95-3/SOW4.2	4,4'-DDE	WATER	0.10	UG/L	0.01			
95-3/SOW4.2	4,4'-DDT	WATER	0.10	UG/L	0.01	27	38-127**	38-127
95-3/SOW4.2	DIELDRIN	WATER	0.10	UG/L	0.002	18	52-126**	52-126
95-3/SOW4.2	ENDOSULFAN I	WATER	0.050	UG/L	0.003			
95-3/SOW4.2	ENDOSULFAN II	WATER	0.10	UG/L	0.01			
95-3/SOW4.2	ENDOSULFAN SULFATE	WATER	0.10	UG/L	0.01			
95-3/SOW4.2	ENDRIN	WATER	0.10	UG/L	0.02	21	56-121**	56-121
95-3/SOW4.2	ENDRIN ALDEHYDE	WATER	0.10	UG/L	0.01			
[illegible]-3/SOW4.2	ENDRIN KETONE	WATER	0.10	UG/L	0.01			
[illegible]-3/SOW4.2	HEPTACHLOR	WATER	0.050	UG/L	0.001	20	40-131**	40-131
95-3/SOW4.2	HEPTACHLOR EPOXIDE	WATER	0.050	UG/L	0.005			
95-3/SOW4.2	METHOXYCHLOR	WATER	0.50	UG/L	0.03			
95-3/SOW4.2	TOXAPHENE	WATER	5.0	UG/L	0.27			
95-3/SOW4.2	DECACHLOROBIPHENYL (DCB) -SURR	WATER	NA	UG/L	NA	NA	30-150	30-150
95-3/SOW4.2	TETRACHLORO-META-XYLENE (TCMX) -SURR	WATER	NA	UG/L	NA	NA	30-150	30-150
95-3/SOW4.2	AROCLOR-1016	SOIL	33	UG/KG	12.1			
95-3/SOW4.2	AROCLOR-1221	SOIL	67	UG/KG	13.7			
95-3/SOW4.2	AROCLOR-1232	SOIL	33	UG/KG	5.8			
95-3/SOW4.2	AROCLOR-1242	SOIL	33	UG/KG	6.9			
95-3/SOW4.2	AROCLOR-1248	SOIL	33	UG/KG	12.9			
95-3/SOW4.2	AROCLOR-1254	SOIL	33	UG/KG	19.5			
95-3/SOW4.2	AROCLOR-1260	SOIL	33	UG/KG	3.3			
95-3/SOW4.2	ALDRIN	SOIL	1.7	UG/KG	0.05	43	34-132**	34-132
95-3/SOW4.2	ALPHA-BHC	SOIL	1.7	UG/KG	0.1			
95-3/SOW4.2	BETA-BHC	SOIL	1.7	UG/KG	0.1			
95-3/SOW4.2	DELTA-BHC	SOIL	1.7	UG/KG	0.4			
95-3/SOW4.2	GAMMA-BHC (LINDANE)	SOIL	1.7	UG/KG	0.4	50	46-127**	46-127
95-3/SOW4.2	ALPHA-CHLORDANE	SOIL	1.7	UG/KG	0.3			
95-3/SOW4.2	GAMMA-CHLORDANE	SOIL	1.7	UG/KG	0.2			
95-3/SOW4.2	4,4'-DDD	SOIL	3.3	UG/KG	0.2			
95-3/SOW4.2	4,4'-DDE	SOIL	3.3	UG/KG	0.2			
95-3/SOW4.2	4,4'-DDT	SOIL	3.3	UG/KG	0.4	50	23-134**	23-134
95-3/SOW4.2	DIELDRIN	SOIL	3.3	UG/KG	0.1	38	31-134**	31-134
[illegible]-3/SOW4.2	ENDOSULFAN I	SOIL	1.7	UG/KG	0.1			
[illegible]-3/SOW4.2	ENDOSULFAN II	SOIL	3.3	UG/KG	0.2			
95-3/SOW4.2	ENDOSULFAN SULFATE	SOIL	3.3	UG/KG	0.4			
95-3/SOW4.2	ENDRIN	SOIL	3.3	UG/KG	0.5	45	42-139**	42-139

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIC (RPD)	LCS (% REC)	MS (% REC)
5-3/SOW4.2	ENDRIN ALDEHYDE	SOIL	3.3	UG/KG	0.2			
95-3/SOW4.2	ENDRIN KETONE	SOIL	3.3	UG/KG	0.2			
95-3/SOW4.2	HEPTACHLOR	SOIL	1.7	UG/KG	0.05	31	35-130**	35-130
95-3/SOW4.2	HEPTACHLOR EPOXIDE	SOIL	1.7	UG/KG	0.2			
95-3/SOW4.2	METHOXYCHLOR	SOIL	17	UG/KG	0.9			
95-3/SOW4.2	TOXAPHENE	SOIL	170	UG/KG	8.9			
95-3/SOW4.2	DECACHLOROBIPHENYL (DCB) -SURR	SOIL	NA	UG/KG	NA	NA	30-150	30-150
95-3/SOW4.2	TETRACHLORO-META-XYLENE (TCMX) -SURR	SOIL	NA	UG/KG	NA	NA	30-150	30-150
MAVPH	BENZENE	WATER	0.5	UG/L	0.19	50	70-130	70-130
MAVPH	METHYL-TERT-BUTYL ETHER	WATER	5.0	UG/L	0.54	50	70-130	70-130
MAVPH	C9-C10 AROMATICS	WATER	10	UG/L	4.37	50	70-130	70-130
MAVPH	C9-C12 ALIPHATICS	WATER	20	UG/L	2.12	50	70-130	70-130
MAVPH	C5-C8 ALIPHATICS	WATER	15	UG/L	14.4	50	70-130	70-130
MAVPH	ETHYLBENZENE	WATER	1.0	UG/L	0.17	50	70-130	70-130
MAVPH	NAPHTHALENE	WATER	5.0	UG/L	0.97	50	70-130	70-130
MAVPH	TOLUENE	WATER	1.0	UG/L	0.57	50	70-130	70-130
MAVPH	M+P-XYLENE	WATER	1.0	UG/L	0.68	50	70-130	70-130
MAVPH	O-XYLENE	WATER	1.0	UG/L	0.43	50	70-130	70-130
MAVPH	1,4-DIFLUOROBENZENE (FID) -SURR	WATER	NA	UG/L	NA	NA	74-138	74-138
MAVPH	1,4-DIFLUOROBENZENE (PID) -SURR	WATER	NA	UG/L	NA	NA	64-141	64-141
MAVPH	BENZENE	SOIL	25	UG/KG	9.40	50	70-130	70-130
MAVPH	METHYL-TERT-BUTYL ETHER	SOIL	250	UG/KG	26.8	50	70-130	70-130
MAVPH	C9-C10 AROMATICS	SOIL	500	UG/KG	218	50	70-130	70-130
AVPH	C9-C12 ALIPHATICS	SOIL	1000	UG/KG	106	50	70-130	70-130
VPH	C5-C8 ALIPHATICS	SOIL	750	UG/KG	722	50	70-130	70-130
MAVPH	ETHYLBENZENE	SOIL	50	UG/KG	8.30	50	70-130	70-130
MAVPH	NAPHTHALENE	SOIL	250	UG/KG	48.4	50	70-130	70-130
MAVPH	TOLUENE	SOIL	50	UG/KG	28.7	50	70-130	70-130
MAVPH	M+P-XYLENE	SOIL	50	UG/KG	33.8	50	70-130	70-130
MAVPH	O-XYLENE	SOIL	50	UG/KG	21.3	50	70-130	70-130
MAVPH	1,4-DIFLUOROBENZENE (FID) -SURR	SOIL	NA	UG/KG	NA	NA	10-145	10-145
MAVPH	1,4-DIFLUOROBENZENE (PID) -SURR	SOIL	NA	UG/KG	NA	NA	17-135	17-135
MAEPH	ACENAPHTHENE	WATER	0.50	UG/L		50	40-140	40-140
MAEPH	ACENAPHTHYLENE	WATER	0.50	UG/L		50	40-140	40-140
MAEPH	ANTHRACENE	WATER	0.50	UG/L		50	40-140	40-140
MAEPH	BENZO(A)ANTHRACENE	WATER	0.50	UG/L		50	40-140	40-140
MAEPH	BENZO(A)PYRENE	WATER	0.20	UG/L		50	40-140	40-140
MAEPH	BENZO(B)FLUORANTHENE	WATER	0.50	UG/L		50	40-140	40-140
MAEPH	BENZO(G,H,I)PERYLENE	WATER	0.50	UG/L		50	40-140	40-140
MAEPH	BENZO(K)FLUORANTHENE	WATER	0.50	UG/L		50	40-140	40-140
MAEPH	C9-C18 ALIPHATIC HYDROCARBONS	WATER	100	UG/L	NA	50	40-140	40-140
MAEPH	UNADJUSTED C11-C22 AROMATIC HYDROCAR	WATER	100	UG/L	NA	50	40-140	40-140
MAEPH	C11-C22 AROMATICS	WATER	100	UG/L	NA	50	40-140	40-140
MAEPH	C19-C36 ALIPHATIC HYDROCARBONS	WATER	100	UG/L	NA	50	40-140	40-140
MAEPH	INDENO(1,2,3-CD)PYRENE	WATER	0.50	UG/L		50	40-140	40-140
MAEPH	CHRYSENE	WATER	0.50	UG/L		50	40-140	40-140
MAEPH	DIBENZ(A,H)ANTHRACENE	WATER	0.50	UG/L		50	40-140	40-140
MAEPH	FLUORANTHENE	WATER	0.50	UG/L		50	40-140	40-140
AEPH	FLUORENE	WATER	0.50	UG/L		50	40-140	40-140
AEPH	2-METHYLNAPHTHALENE	WATER	0.50	UG/L		50	40-140	40-140
MAEPH	NAPHTHALENE	WATER	0.50	UG/L		50	40-140	40-140
MAEPH	PHENANTHRENE	WATER	0.50	UG/L		50	40-140	40-140

CAS/ROCHESTER ORGANIC QC LIMITS

ETHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
AEPH	PYRENE	WATER	0.50	UG/L		50	40-140	40-140
MAEPH	2-BROMONAPHTHALENE -SURR	WATER	NA	UG/L	NA	NA	35-130	35-130
MAEPH	2-FLUOROBIPHENYL -SURR	WATER	NA	UG/L	NA	NA	35-114	35-114
MAEPH	1-CHLORO-OCTADECANE -SURR	WATER	NA	UG/L	NA	NA	10-92	10-92
MAEPH	O-TERPHENYL -SURR	WATER	NA	UG/L	NA	NA	24-100	24-100
MAEPH	ACENAPHTHENE	SOIL	330	UG/KG	29	50	40-140	40-140
MAEPH	ACENAPHTHYLENE	SOIL	330	UG/KG	28	50	40-140	40-140
MAEPH	ANTHRACENE	SOIL	330	UG/KG	195	50	40-140	40-140
MAEPH	BENZO(A)ANTHRACENE	SOIL	330	UG/KG	43	50	40-140	40-140
MAEPH	BENZO(A)PYRENE	SOIL	330	UG/KG	79	50	40-140	40-140
MAEPH	BENZO(B)FLUORANTHENE	SOIL	330	UG/KG	44	50	40-140	40-140
MAEPH	BENZO(G,H,I)PERYLENE	SOIL	330	UG/KG	39	50	40-140	40-140
MAEPH	BENZO(K)FLUORANTHENE	SOIL	330	UG/KG	67	50	40-140	40-140
MAEPH	C9-C18 ALIPHATIC HYDROCARBONS	SOIL	660	UG/KG	NA	50	40-140	40-140
MAEPH	UNADJUSTED C11-C22 AROMATIC HYDROCAR	SOIL	660	UG/KG	NA	50	40-140	40-140
MAEPH	C11-C22 AROMATICS	SOIL	660	UG/KG	NA	50	40-140	40-140
MAEPH	C19-C36 ALIPHATIC HYDROCARBONS	SOIL	660	UG/KG	NA	50	40-140	40-140
MAEPH	INDENO(1,2,3-CD)PYRENE	SOIL	330	UG/KG	54	50	40-140	40-140
MAEPH	CHRYSENE	SOIL	330	UG/KG	93	50	40-140	40-140
MAEPH	DIBENZ(A,H)ANTHRACENE	SOIL	330	UG/KG	81	50	40-140	40-140
MAEPH	FLUORANTHENE	SOIL	330	UG/KG	83	50	40-140	40-140
MAEPH	FLUORENE	SOIL	330	UG/KG	28	50	40-140	40-140
MAEPH	2-METHYLNAPHTHALENE	SOIL	660	UG/KG	33	50	40-140	40-140
AEPH	NAPHTHALENE	SOIL	330	UG/KG	41	50	40-140	40-140
EPH	PHENANTHRENE	SOIL	330	UG/KG	162	50	40-140	40-140
AEPH	PYRENE	SOIL	330	UG/KG	50	50	40-140	40-140
MAEPH	2-BROMONAPHTHALENE -SURR	SOIL	NA	UG/KG	NA	NA	46-110	46-110
MAEPH	2-FLUOROBIPHENYL -SURR	SOIL	NA	UG/KG	NA	NA	47-97	47-97
MAEPH	1-CHLORO-OCTADECANE -SURR	SOIL	NA	UG/KG	NA	NA	27-83	27-83
MAEPH	O-TERPHENYL -SURR	SOIL	NA	UG/KG	NA	NA	17-114	17-114

* Subset of compounds used to control the acceptablitily of the QC sample for the batch. All targets are monitored against the limits provided, however outlying compounds outside of this subset may not stop analysis based upon the judgement of the analyst.

**ASP required limits only. SOW does not require any particular limits/analysis.

EST MDL = Estimated Method Detection Limit. For CLP methodologies, this value is the Instrument Detection Limit.

APPENDIX D

DATA QUALIFIERS

ORGANIC QUALIFIERS

U Indicated compound was analyzed for but not detected. The sample quantitation limit must be corrected for dilution and for percent moisture.

J Indicates an estimated value. See case narrative for details.

N Indicates presumptive evidence of a compound. This flag is only used for a tentatively identified compound, where the identification is based on a mass spectral library search.

P This flag is used for a pesticide/Aroclor target analyte when there is greater than 25% difference for detected concentrations between the two GC Columns. Typically, the lower of the two values is reported on Form I and flagged with a "P".

C This flag applies to pesticide results where the identification has been confirmed by GC/MS.

B This flag is used when the analyte is found in the associated blank as well as in the sample.

E This flag identifies compounds identified in an analysis at a secondary dilution factor.

A This flag indicates that a TIC is a suspected aldolcondensation product.

X As specified in Case Narrative.

INORGANIC QUALIFIERS

C (Concentration) qualifiers:

B The reported value was obtained from a reading that was less than the Contract Required Detection Limit (CRDL) but was greater than or equal to the Instrument Detection Limit (IDL).

U The analyte was analyzed for, but not detected.

Q (Qualification) qualifiers:

E The reported value is estimated because of the presence of interference.

N Spiked sample recovery not within control limits.

S The reported value was determined by the Method of Standard Additions (MSA).

W Post-digestion spike for Furnace AA Analysis is out of control limits (85-115), while sample absorbence is less that 50% of spike absorbence.

* Duplicate analysis not within control limits.

\+ Correlation coefficient for the MSA is less than 0.995.

M (Method) qualifiers:

"P" for ICP
"A" for Flame AA
"F" for Furnace AA
"PM" for ICP when Microwave Digestion in used
"AM" for Flame AA when Microwave Digestion is used
"FM" for Furnace M when Microwave Digestion is used
"CV" for Manual Cold Vapor AA
"AV" for Automated Cold Vapor AA
"CA" for Spectrophotometric Midi-Distillation
"AS" for Semi-Automated Spectrophotometric
"C" for Spectrophotometric Manual
"T" for Titrimetric
" "where no data has been entered
"NR" if the analyte is not required to be analyzed.

APPENDIX E

PREVENTIVE MAINTENANCE PROCEDURES

Preventive Maintenance Procedures

Instrument	Activity	Frequency
Refrigerators and Coolers	Record temperatures	Daily
	Clean coils	As needed
	Check coolant	As needed or if temperature outside limit
Fume Hoods	Face velocity measured	Quarterly
	Sash operation	As needed
Ovens	Clean	As needed or if temperature outside limit
Incubators	Record temperatures	Daily, morning and evening
Water Baths	Wash with disinfectant solution	When water is murky, dirty, or growth appears
Autoclave	Check temperature	Every month
	Clean	When mold or growth appears
Top Loading Balances	Check calibration	Before every use
Analytical Balances	Check alignment	Before every use
	Check calibration	Before every use
	Clean pans and compartment	After every use
Dissolved Oxygen Meter	Change membrane	When fluctuations occur
pH probes	Condition probe	When fluctuations occur
UV-visible Spectrophotometer	Wavelength check	Annually
Total Organic Carbon Analyzers	Check IR zero	Weekly
	Check digestion/condensation vessels	Each use
	Clean digestion chamber	Every 2000 hours, or as needed
	Clean permeation tube	Every 2000 hours, or as needed
	Clean six-port valves	Every 200 - 2000 hours, or as needed
	Clean sample pump	Every 200 - 2000 hours, or as needed
	Clean carbon scrubber	Every 200 - 2000 hours, or as needed
	Clean IR cell	Every 2000 - 4000 hours, or as needed
Total Organic Halogen Analyzers	Change cell electrolyte	Daily, or as needed
	Change electrode fluids	Daily, or as needed
	Change pyrolysis tube	As needed
	Change inlet and outlet tubes	As needed
	Change electrodes	As needed
Flow Injection Analyzer	Check valve flares	Monthly
	Check valve ports	Monthly
	Check pump tubing	Daily
	Check flow cell flares	Quarterly
	Change bulb	Every six months
	Check manifold tubing	Every six months
	Check T's and connectors	Every six months

Preventive Maintenance Procedures

Instrument	Activity	Frequency
Ion Chromatograph	Change column bed supports	Monthly or as needed
	Clean column	Monthly or as needed
	Change column	Every six months or as needed
	Change valve port face & hex nut	Every six months or as needed
	Clean valve slider	Every six months or as needed
	Change tubing	Annually or as needed
	Eluent pump	Annually
Atomic Absorption Spectro-photometers - ~~FAA and~~ CVAA	Check gases	Daily
	Clean burner head	Daily
	Check aspiration tubing	Daily
	Clean optics	Every three months
	Empty waste container	Weekly
Atomic Absorption Spectro-photometers - GFAA	Check gases	Daily
	Check argon dewar	Daily, or as needed
	Change graphite tube	Daily, or as needed
	Clean furnace windows	Monthly
ICP	Check argon dewar	Daily
	Replace peristaltic pump tubing	Daily, or as needed
	Empty waste container	Daily, or as needed
	Clean nebulizer, spray chamber, and torch	Every two weeks, or as needed
	Replace water filter	Quarterly
	Replace vacuum air filters	Monthly
Infrared Spectrophotometer, Fourier Transform	Clean sample cells	Daily, or as needed
Gel-Permeation Chromatographs	Clean and repack column	As needed
	Backflush valves	As needed
Gas Chromatographs, Semivolatiles	Check gas supplies	Daily, replace when pressure reaches 250 psi
	Change in-line filters	Quarterly or after 30 tanks of gas
	Change injection port liner	Daily or as needed
	Clip first foot of capillary column	As needed
	Change guard column	As needed
	Replace analytical column	As needed when peak resolution fails
	Check system for gas leaks	After changing columns
	Clean FID	As needed
	Leak test ECD	Annually

APPENDIX F

CERTIFICATIONS/ACCREDITATIONS/CONTRACTS

Preventive Maintenance Procedures

Instrument	Activity	Frequency
Gas Chromatograph/Mass Spectrometers, Semivolatiles	Check gas supplies	Daily, replace when pressure reaches 50 psi
	Change in-line filters	Quarterly or after 30 tanks of gas
	Change septum	Daily
	Change injection port liner	Weekly or as needed
	Clip first foot of capillary column	As needed
	Change guard column	As needed
	Replace analytical column	As needed when peak resolution fails
	Clean jet separator	As needed
	Clean source	As needed when tuning problems
	Change pump oil	Every six months
	Oil wick	Every six months
Purge and Trap Concentrators	Change trap	As needed
	Change transfer lines	As needed
	Clean purge vessel	Daily
Gas Chromatographs, Volatiles	Check gas supplies	Daily, replace when pressure reaches 200 psi
	Change in-line filters	Quarterly or after 30 tanks of gas
	Change septum	As needed
	Clip first foot of capillary column	As needed
	Change guard column	As needed
	Replace analytical column	As needed when peak resolution fails
	Check system for gas leaks	After changing columns or as needed
	Replenish ELCD solvents	Weekly
	Clean PID lamp	As needed
	Clean FID	As needed
	Change ion exchange resin	Quarterly
	Replace nickel tubing	Quarterly or as needed
Gas Chromatograph/Mass Spectrometers, Volatiles	Check gas supplies	Weekly, replace when pressure reaches 200 psi
	Change in-line filters	Quarterly or after 30 tanks of gas
	Change septum	Daily
	Clip first foot of capillary column	As needed
	Change guard column	As needed
	Replace analytical column	As needed when peak resolution fails
	Clean jet separator	As needed
	Clean source	As needed when tuning problems
	Change pump oil	Every six months per HP
	Oil wick	Every six months per HP
TCLP/SPLP Extractors	Monitor Room Temperature	Daily
	Monitor RPM of Rotators	Bi-weekly
	Grease fittings	As needed
	O-ring replacement	As needed

CAS/Rochester Certifications/Accreditations/Contracts

Federal and National Programs

- American Industrial Hygiene Association (AIHA)
  AIHA Accredited Laboratory (Rochester - No. 100314)

- NELAP Accreditation, January 2001.
  Biannual Performance Evaluation Samples for Drinking Water and wastewater Organic and Inorganic Analytes.

- NYS DEC Analytical Services Protocol Organic and Inorganic Contract (9/97-03/03).

- Naval Facilities Engineering Service Center (NFESC), Approved.

State and Local Programs

- State of Connecticut, Department of Health Services, Approved Public Health Laboratory.
  Certified Laboratory for Potable Water, Waste Water/Trade Waste, Sewage/Effluent, and Soil.
  Examination for Bacteria, Inorganic Chemicals and Organic Chemicals. Certification No. PH-0556.
  Exp. 06/30/2002.

- The Commonwealth of Massachusetts, Department of Environmental Protection
  Certified Laboratory for Potable Water and Non-Potable Water
  Certification No. M-NY032. Exp. 06/30/2002.

- State of New Jersey, Department of Environmental Protection
  State Certified Environmental Laboratory for Drinking Water and Water Pollution.
  Certification No. 73004. Exp. 10/30/2001.

- State of New York, Department of Health, Environmental Laboratory Approval Program.
  Potable Water, Non-Potable Water, Solid and Hazardous Waste, and ASP Certification.
  Certification No. 10145. Exp. 04/01/02.

- State of New Hampshire, Department of Environmental Services
  Full Certification for Non-Potable Water. Certification No. 294296. Exp. 10/2001.

- State of Rhode Island, Department of Health
  Approved for Surface Water, WasteWater, and Sewage. License No. 158. Exp. 12/2002.

- West Virginia Division of Environmental Protection
  Certification for TCL/TAL, GRO, DRO, and TPH parameters in WasteWater and Solid Hazardous Waste.
  Certification No.292 Exp. 01/01/2002.

- State of Delaware, Department of Natural Resources and Environmental Control. Approved for Delaware Hazardous Substance Cleanup Act. Exp. 04/30/2002.

CAS/Rochester Certifications/Accreditations/Contracts

Unregulated State Programs

- State of Minnesota
  Reciprocal Certification for all parameters certified under New York State.
  Exp. 04/01/02.

- State of Georgia Environmental Protection Division
  Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
  Exp. 04/01/02.

- State of Indiana Hazardous Waste Division
  Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
  Exp. 04/01/02.

- State of Michigan - Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
  Exp. 04/01/02.

- Commonwealth of Pennsylvania, Department of Environmental Resources
  Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
  Exp. 04/01/02.

- Commonwealth of Virginia, Department of General Services
  Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
  Exp. 04/01/02.

- State of Mississippi - Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
  Exp. 04/01/02.

- State of Maryland - Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
  Exp. 04/01/02.

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
White Sands Test Facility
P.O. Box 20
Las Cruces, NM 88004-0020

June 11, 2002

Reply to Attn of: RA–02–063

New Mexico Environment Department
Attn: Mr. Phillip Solano, Project Leader
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

Subject: WSTF Plume-Front Stabilization Operation and Maintenance Plan and Interim Measures Plans and Specifications

The Plume-Front Stabilization Interim Corrective Measures Work Plan (approved by NMED on March 15, 2000) specifies that an Operation and Maintenance Plan and Interim Measures Plans and Specifications be provided to NMED. The enclosed CD-ROM provides these required submittals.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

To the extent that information has been submitted electronically, I acknowledge that NMED will rely solely on the electronic information as accurate and complete information and that it is this data that will be used for compliance and enforcement purposes pursuant to the provisions set forth in the NASA WSTF Final Project Agreement.

If you have any questions, please feel free to contact Mike Kirsch at 505–524–5517.

ORIGINAL SIGNED BY
JOSEPH FRIES

Joseph Fries
Manager

Enclosure

cc:
See List

cc: (*w/o encl.)
Mr. James Bearzi, Chief*
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

Mr. John E. Kieling, Program Manager*
RCRA Permits Management Program
Hazardous Waste Bureau
New Mexico Environment Department
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Santa Fe, NM 87505

Mr. Baird Swanson
District 1
New Mexico Environment Department
4131 Montgomery NE
Albuquerque, NM 87109

bcc:
HTSI Team/P. H. Pache (w/o encl.)

RA/MKirsch:ljg:6/11/02:5517

#4 zip LTRS\Env-02-2\NMED 100% submittal letter

CONCUR	CODE →	RA	RA			
	SIGNATURE →	Mike Zygmont	Mike Kirsch			
	DATE →	6/11/02	6/11/02			

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ATTN MR PHILLIP SOLANO
HAZARDOUS WASTE BUREAU
2905 RODEO PARK DRIVE EAST BUILDING 1
SANTA FE NM 87505

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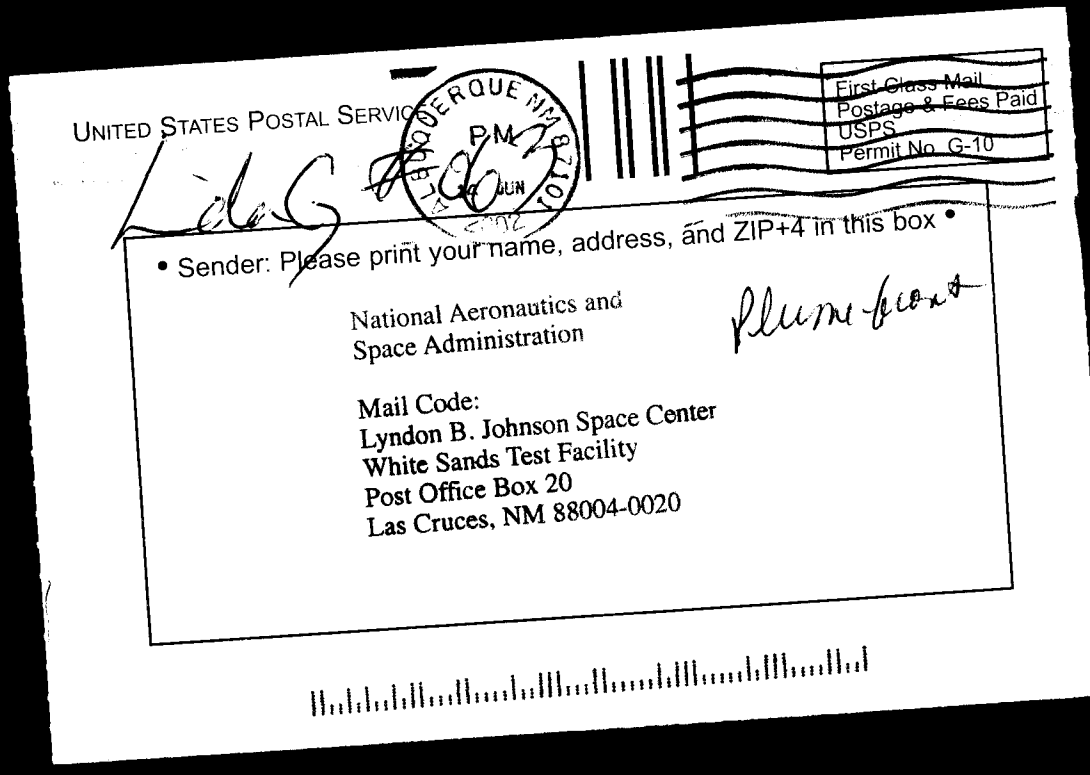
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NASA WHITE SANDS TEST FACILITY

PLUME-FRONT REMEDIATION SYSTEM

OPERATION AND MAINTENANCE PLAN

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY 1

2.0 SYSTEM DESCRIPTION..... 2

3.0 INITIAL START-UP PROCEDURES..... 5

4.0 OPERATION..... 10

5.0 INSPECTION..... 11

6.0 SAMPLING AND ANALYSIS..... 12

7.0 MAINTENANCE..... 12

8.0 WASTE MANAGEMENT..... 13

9.0 PROJECT MANAGEMENT, TRAINING AND REPORTING..... 13

10.0 CONTINGENCY PLAN..... 14

LIST OF REFERENCES

National Aeronautics and Space Administration, 1999, New Mexico Ground Water Quality Bureau Discharge Plan Application for the Plume-Front Stabilization Project, NASA WSTF, Las Cruces, NM, February 11, 1999

National Aeronautics and Space Administration, 1999, "Plume-Front Stabilization Work Plan", NASA WSTF, Las Cruces, NM, January 1999

New Mexico Ground Water Quality Bureau, 2000, NASA White Sands Test Facility (WSTF) Discharge Plan Approval, DP-1255, March 10, 2000.

New Mexico Environment Department, Hazardous Waste Bureau, 1993, Hazardous and Solid Waste Act Permit, WSTF Hazardous Waste Facility Permit No. NM8800019434-1, February 9, 1993

LIST OF ATTACHMENTS

ATTACHMENT 1	WSTF PLUME-FRONT REMEDIATION SYSTEM SITE LOCATION
ATTACHMENT 2	PLUME-FRONT REMEDIATION SYSTEM EXTRACTION AND INJECTION WELL PUMPING AND INJECTION RATES
ATTACHMENT 3	PLUME-FRONT REMEDIATION SYSTEM FLOW SCHEMATIC
ATTACHMENT 4	PLUME-FRONT REMEDIATION SYSTEM INSPECTION PLAN
ATTACHMENT 5	PLUME-FRONT REMEDIATION SYSTEM MAINTENANCE PLAN
ATTACHMENT 6	NASA WHITE SANDS TEST FACILITY ORGANIZATION CHART
ATTACHMENT 7	PLUME-FRONT REMEDIATION SYSTEM TRAINING PLAN

1.0 EXECUTIVE SUMMARY

During operations from the early 1960s to the early 1980s, hazardous constituents were released to the environment and, thereby, into the groundwater at the NASA White Sands Test Facility (WSTF). As a result, on December 12, 1989, the United States Environmental Protection Agency (U.S. EPA) Region 6 issued NASA an Administrative Order on Consent proceeding under §3008(h) of the Resource Conservation and Recovery Act (RCRA) for the White Sands Test Facility.

The §3008(h) Consent Order was subsequently incorporated into the Hazardous and Solid Waste Act (HWSA) Permit administered by the New Mexico Environment Department (NMED), Hazardous Waste Bureau (HWB). As a result of investigatory work performed, NASA proposed a voluntary presumptive remedy for plume-front stabilization to control threats to human health and/or the environment at the westernmost extent of the groundwater contaminant plume. The HWB approved the Plume-Front Stabilization Work Plan (PFSWP) on March 15, 2000 and the New Mexico Ground Water Quality Bureau (GWQB) approved Discharge Plan DP-1255 for discharges from the system on March 10, 2000.

The presumptive remedy is intended to control threats to human health and/or the environment at the westernmost extent of a groundwater contaminant plume, the plume-front area. The plume-front area covers an area of approximately 4,000 feet by 8,000 feet and has a depth of 700 feet. The contaminants of concern (COCs) at the plume-front include N-nitrosodimethylamine (NDMA), N-nitrodimethylamine (DMN) and several halogenated volatile organic compounds (VOCs).

The remediation system, ex-situ pump and treat design, consists of an extraction well network, injection well network, a monitoring well network, and the treatment facility. During the design, computer models were used to:

- Simulate the contaminant plumes;
- Determine the optimum extraction and injection well locations and the optimum pumping and injection rates; and
- Assist in the strategic location of monitoring wells.

The remediation system is designed to operate on a 24 hour, 365 day per year basis. Six plume-front extraction (PFE) wells with a combined pumping rate of approximately 1,075 gallons per minute will be utilized to capture and contain the groundwater contaminant plume. Contaminated groundwater from the extraction well network is pumped to the treatment facility and treated by an air stripper unit (for the VOCs) followed by an ultraviolet (UV) oxidation unit (for NDMA and DMN). The treated groundwater is then pumped to a network of four plume-front injection (PFI) wells and reinjected into the aquifer.

Contaminant treatment standards for the injected water have been developed following standards and guidelines from multiple Federal and State regulatory sources. The

effectiveness of treatment is monitored by sampling and analyses of the treatment facility influent and effluent. The overall effectiveness of remediation system is monitored by a monitoring well network of consisting of over sixty conventional and Westbay® multi-port groundwater monitoring wells. The following document provides an operation and maintenance plan for the plume-front remediation system.

2.0 SYSTEM DESCRIPTION

A site map showing the plume-front remediation system is presented in Attachment 1. The WSTF plume-front remediation system is a ex-situ pump and treat design, consisting of an extraction well network, injection well network, a monitoring well network, and the treatment facility. A general description of the remediation system follows.

2.1 Extraction Wells

Computer modeling was used to estimate the pumping rates and strategically locate the extraction wells to remove contaminant mass at the plume-front and create a hydraulic barrier to prevent further westward migration of the plume. The extraction wells, ranging in total depth from 770 to 896 feet below grade, consists of six (6) extraction wells; PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5 and PFE-7. PFE-1, -2, -4A, -5 and -7 are constructed of 9 to 10-inch-diameter (nominal) SDR 17 PVC with 0.085-inch-slot saw-cut openings. PFE-3 is constructed of 10-inch-diameter (nominal) SCH 40 carbon steel and utilizes a 0.080-inch-slot wire-wrapped screen. Each extraction well is hard-wired for incoming three-phase, 480 volt electrical service. The total combined flowrate of the extraction wellswill be approximately 1,070 gallons per minute (gpm). The specific well locations, and estimated pumping rates are presented in Attachments 1 and 2.

Extraction wells PFE-1, PFE-2, PFE-3, PFE-4A and PFE-7 specifically address the TCE and PCE contaminant plume. The five extraction wells will utilize an estimated combined flow rate of 1,050 gallons per minute (gpm).

Extraction well PFE-5, with an estimated flow rate of 26 gpm, specifically addresses NDMA/DMN plume containment. In the plume-front vicinity, the DMN plume has a similar extent to the NDMA plume but generally lower concentrations. To ensure stabilization of the NDMA/DMN plume-front, which does not extend as far west as the TCE plume, well PFE-5 is positioned to stabilize the NDMA/DMN plume-front concentrations east of the TCE target wells PFE-1, PFE-2 and PFE-7. Any NDMA/DMN mass not addressed by well PFE-5 or wells anticipated for installation in the mid-plume area is expected to be effectively captured by the high volume extraction wells to the west.

The pipeline from the extraction wells to the treatment facility (Building 650) is constructed of double-walled high-density polyethylene (HDPE) pipe with annular leak detection. The pipe was installed in straight segments between piping features (i.e., leak detection cable pull boxes, valve pits, and high point vent manways), to allow for inspection and drainage/drying in the event of inner pipe failure. In the event of a leak in

the inner pipe, the annular space between the inner and outer pipes will serve as secondary containment. Leak detection sensors are installed in the annular space allowing for the detection, localization and repair of any leaks.

The extraction pipeline is installed underground to protect against external damage, exposure to solar UV radiation, thermal expansion/contraction, and freezing. The extraction wells are contained in concrete well vaults and equipped with instrumentation to monitor the flowrate, pump operation and the static water level. HDPE access vaults are located along the pipeline at high-point vent, junctions and leak detection access locations. The concrete well vaults and HDPE access vaults are designed to prevent or the infiltration of precipitation into the vault.

2.2 Treatment Facility

The treatment equipment, housed in Building 650, consists of two, parallel tray style air strippers for VOC removal, followed by a UV oxidation unit for NDMA and DMN destruction. Building 650 is a 60-foot by 80-foot insulated metal building, with an electrical component room (containing the UV system power supply), a control room (with a PC for system monitoring/controlling), main treatment area, and restroom. It is designed to maintain a temperature compatible with the electronic components of the remediation equipment. Building 650 is plumbed into the WSTF potable water system, equipped with a septic tank and leach field, and is wired for incoming three-phase, 480 volt electrical service.

A flow schematic of the treatment facility is presented in Attachment 3. The facility is designed to operate at a range from 50% to 100% of the maximum design flow rate of about 1,240 gallons per minute. The treatment equipment consists of:

2.2.1 Scale Control Chemical Metering system (manufactured by North East Environmental Products, Inc.) Hardness values observed in plume-front monitoring wells have ranged from 173 to 613 mg/l (as $CaCO_3$). These hardness values provide a significant potential for scaling in the treatment system, pipelines, wells, and/or the injection formation. A polyphosphate scale control chemical (AquaMag® or equivalent) is metereded into the process piping, upstream of the air strippers to prevent the formation of scale in the air strippers and UV reactor.

2.2.2 Two stainless steel sieve-tray air strippers (Model # 61231 manufactured by North East Environmental Products, Inc.), operating in parallel for removal of VOC contaminants.

2.2.3 An UV oxidation unit (a Rayox® Advanced Oxidation System manufactured by Calgon Carbon Corporation) for treatment of NDMA/DMA contaminants. NDMA absorbs UV radiation most strongly in a band centered around 227 nm. The wavelength of the UV radiation emitted by the lamps is in the range 200-250

nm. Absorption of UV radiation breaks the N-N bond, producing a NO radical and a dimethylamino radical.

2.2.4 A scale cleaning system (manufactured by North East Environmental Products, Inc.) to remove scale from the air strippers. A citric acid solution will be circulated through the air strippers to remove scale.

2.2.5 A leak detection system to monitor leaks in the dual-wall piping system and treatment facility building

2.2.6 A process control system is incorporated into the overall design and operation of the remediation system. Operator access to the process control system is provided at the control room located in Building 650. The control system will interface with the process equipment controllers and monitor control variables that are critical to the operation of the facility. The control system will respond to:

2.2.6.1 Minor fluctuations in the flowrate by performing operations (such as increasing/reducing flow control valves) to correct the discrepancy.

2.2.6.2 An alarm condition by initiating autodialer alarms to notify responsible contractor personnel of the alarm condition. An alarm condition is defined as a deviation from set operating parameters that does not have an immediate impact on the overall treatment efficiency (or present a immediate hazard to personnel, the environment or equipment) but requires corrective action.

2.2.6.3 An emergency condition by initiating computer programmed emergency procedures to shutdown and secure the remediation system. An emergency condition is a deviation from set operating parameters that has an immediate impact on the overall treatment efficiency (or presents a immediate hazard to personnel, the environment or equipment) and requires an immediate shutdown of the remediation system. The control system would:

- Shutdown and isolate the extraction wells,
- Shutdown and isolate the treatment facility and process equipment,
- Isolate the injection wells, and
- Initiate autodialer alarm sequence to notify responsible contractor personnel and/or the WSTF Fire Department of the alarm condition.

2.2.6.4 Conditions that could warrant an emergency shutdown of the remediation system include but are not limited to:

- High or low extraction and injection well static water levels
- High or low extraction and injection well flowrates,

- High or low treatment facility influent flowrate,
- High or low air stripper gas and liquid flowrates,
- High or low air stripper sump level,
- High or low UV oxidation unit influent flowrate, and a failure of the UV source, and
- Leak detection system alarm.

2.3 Injection Wells and Injection Manifold

The treated groundwater exits on the west side of Building 650 and is conveyed to Building 651 (the Injection Manifold Building) via an underground, single-wall HDPE pipe. The flow is apportioned into four legs, via hydraulically-actuated globe control valves, in Building 651 and conveyed to the injection wells. The injection manifold building is hard-wired for incoming three-phase, 480 volt electrical service. A HDPE single-wall piping system will transport the groundwater from the treatment facility to injection manifold building and from the injection manifold building to the injection wells.

A computer simulation of the aquifer was used to determine the location and injection rates of the injection wells. The injection wells are designed to assist in the containment of the southern edge of the contaminant plume by creating a localized groundwater mound to locally reverse the natural groundwater flow direction and offset anticipated future drawdown effects by the city of Las Cruces. The remediation system utilizes four non-pressurized PVC injection wells, PFI-1, PFI-2, PFI-3 and PFI-4, for injection of the treated groundwater into the underlying aquifer. A drop pipe is installed in each injection well to below the pre-injection static water elevation to minimize air entrainment. The injection wells are contained in concrete well vaults and equipped with instrumentation to remotely monitor the static water level. HDPE access vaults are located along the pipeline at high-point vent locations. The well locations, injection rates, and well design parameters are presented in Attachments 1 and 2.

2.4 Monitoring Wells

The overall effectiveness of remediation system is monitored by a monitoring well network of consisting of over sixty conventional and Westbay® multi-port groundwater monitoring wells. A list of monitoring wells specifically designated for this plan and details regarding the sampling zones, sampling frequency, and analytical methods are presented in Attachment 5. The location of the wells is presented in Attachment 1.

3.0 INITIAL START-UP

The full-scale treatment system will undergo a start-up period of approximately three months. The objectives are to:

- Verify that the treatment system will treat impacted groundwater from the WSTF plume-front to specified treatment levels, and

- Determine the optimum operating conditions, develop and refine the treatment facility operating and maintenance procedures, and identify any required system refinements,
- Allow final set-up and testing of process control system and process equipment by manufacture representatives, and
- Support training of contractor environmental organization personnel by qualified manufacturer representatives.

A general description of the validation plan for initial start-up of the remediation system follows.

3.1 Failure Analysis, Functional and Integrity Tests

A flow schematic of the remediation system is presented in Attachment 3. Prior to performance of the remediation system start-up procedures, the following will be performed:

- Pump tests will be performed to confirm the pumping capacity of the extraction wells,
- The groundwater from the extraction wells will be sampled and analyzed to determine the contaminant concentration at each well location,
- Pressure leak tests will be performed to verify the integrity of the piping system,
- All electrical and mechanical components, motors, switches, sensors, meters, pumps, valves, etc., will be functionally tested,
- Tests will be performed to verify the operation of all communication, alarm, leak detection and monitoring equipment prior to system operation, and
- A failure modes and effects analysis (FMEA) report per White Sands Test Facility Standard Instruction WSI 04-SW-0002, "Hazard Recognition and Control" will be performed to address all single component failure modes, the effects of those failures on system operation or safety, and provide the recommended corrective actions.

3.2 Test Approach

The process control system and process equipment manufacturers will inspect the installation, and support the initial start-up and adjustment of the remediation system. The anticipated PCE, TCE, NDMA, DMN, Freon 11, Freon 21, and Freon 113 influent concentrations are listed in Table 3.1. Contaminant treatment standards for the injected water have been established in the approved Plume-Front Stabilization Work Plan (PFSWP) and Discharge Plan DP-1255.

TABLE 3.1 – CONTAMINANT DATA – (from PFSWP)

Contaminant of Concern	Predicted Influent Concentration	Treatment Level[1]	Specified EPA Analytical Method[1]
NDMA	2,000 ppt	10 ppt	607M
DMN	1,777 ppt	10 ppt	607M
PCE	4.2 ppb	5 ppb	8021
TCE	130 ppb	5 ppb	8021
Freon 11	860 ppb	100 ppb	8260
Freon 21	60 ppb	20 ppb	8260
Freon 113	2,000 ppb	1,200 ppb	8260

1 Specified by the Plume-Front Stabilization Work Plan
2 ppt - parts per trillion
3 ppb - parts per billion

The design flow rate of the treatment system is approximately 1240 gpm (the estimated combined pumping rate of the extraction wells). The validation tests will be performed in two phases. During the first phase, the treatment system will be evaluated at a reduced flow rate (approximately 620 gpm), roughly equal to one-half of the total design flow rate for the system. During this phase of testing, each of the air stripper units will be isolated and operated independently, and the UV oxidation unit will be operated at approximately one-half of system design flow. This will ensure proper operation and allow for evaluation of contaminant removal efficiency. The second phase will involve tests to evaluate operation and contaminant destruction efficiency of the treatment facility at the design flow rate.

The treatment efficiency will be monitored by sampling/analyzing the untreated and treated groundwater for the list of groundwater contaminants as presented in Table 3.1. Influent samples will be collected from the manifolded water stream from the extraction wells before it enters the treatment system. Effluent samples will be taken from the discharge stream leaving the treatment system enroute to the start-up holding tank. The specific locations of the influent and effluent sample valves are presented in the flow schematic provided in Attachment 3. The procedures for collection and analysis of the samples are provided in Section 6.0.

The two air strippers and UV oxidation unit will be operated per the procedures and recommendations of the manufacturer. During testing, critical operating parameters such as flow rate, temperature, and pressure will be monitored by the control system. The operating procedures, critical operating parameters and the recommended monitoring frequency will be available from the manufacturer. Procedures for the operation and maintenance of both unit operations will be further developed and refined during the validation tests.

CH2M Hill (the designer of the process control system) and the equipment manufacturers will provide oversight, training and support during the performance of the tests. It is anticipated that approximately three months will be required to complete the system validation and training. Each phase of testing will be repeated as required to ensure that the test objectives are achieved. A summarized test matrix is presented in Table 3.2, and a general description of the two phases follows.

TABLE 3.2 – VALIDATION PLAN TEST MATRIX

PHASE I- REDUCED FLOW RATE TESTS								
TEST	EXTRAC-TION WELLS	APPROX. FLOW RATE (gallons per minute)	AIR STRIPPER 1	AIR STRIPPER 2	UV OXIDIZER UNIT	APPROX. TEST DURATION (hours)	SAMPLING FREQ. (minutes)	TREATED EFFLUENT (gallons)
1	PFE-1 PFE-2 PFE-3 PFE-4A PFE-5 PFE-7	620	ON	OFF	ON	4	0, 30, 60, 90, 120, 180, 240	108,000
2	PFE-1 PFE-2 PFE-3 PFE-4A PFE-5 PFE-7	620	OFF	ON	ON	4	0, 30, 60, 90, 120, 180, 240	108,000
PHASE II – DESIGN FLOW RATE TESTS								
TEST	EXTRAC-TION WELLS	APPROX. FLOW RATE (gallons per minute)	AIR STRIPPER 1	AIR STRIPPER 2	UV OXIDIZER UNIT	APPROX. TEST DURATION (hours)	SAMPLIN G FREQ. (minutes)	TREATED EFFLUENT (gallons)
1	PFE-1 PFE-2 PFE-3 PFE-4A PFE-5 PFE-7	1240	ON	ON	ON	4	0, 30, 60, 90, 120, 180, 240	225,000

NOTE: Actual flow rates subject to change pending actual production rate of the extraction wells.

3.3 Phase One – Reduced Flow Rate Tests

The objective of the first test is to evaluate system operation and contaminant removal efficiency at a reduced flow rate of approximately 620 gpm. During the first test Air Stripper 1 will be operated and Air Stripper 2 will be shut off from the water flow.

The planned test duration will be four hours. Approximately 108,000 gallons of groundwater will be treated to the specified treatment levels presented in Table 3.1. Treated effluent will be collected in a 250,000 gallon holding tank pending the receipt of

laboratory analytical results. Effluent meeting the treatment standards will be pumped to the injection wells. Effluent not meeting the treatment standards will be either recycled through the treatment system and resampled, or discharged to the 200 Area Hazardous Waste Evaporation Tanks.

Influent and effluent samples will be collected upon system startup, then in thirty minute increments for analyses for the contaminants listed in Table 3.1 for the first two hours of the test, then at one hour intervals until the test is completed. If required, refinements to the sampling frequency and operating procedures will be incorporated. At this time, testing will be halted until the laboratory analytical results are received. This test will be repeated if the laboratory analytical results do not meet the treatment standards for all of the contaminants listed in Table 3.1.

Test two will then be performed with Air Stripper 1 shut off from the water flow and Air Stripper 2 in operation. The procedure used to conduct this test will be identical to the first test.

3.4 Phase Two – Design Flow Rate Tests

The objective of this test is to evaluate system operation and the contaminant removal efficiency achieved at the design flow rate of approximately 1,300 gpm, simulating full-scale operation of the remediation system. All extraction wells (PFE-1 through PFE-5) will be pumped at the nominal design capacity for the test. The test will involve the operation of both air strippers and the UV oxidation unit.

The planned test duration will be 4 hours. Approximately 225,000 gallons of groundwater will be treated to the specified treatment levels presented in the PFSWP. Treated effluent will be collected in the holding tank pending the receipt of laboratory analytical results. Effluent meeting the treatment standards will be pumped to the injection wells. Effluent not meeting the treatment standards will be either recycled through the treatment system or discharged to the 200 Area Hazardous Waste Evaporation Tanks.

Influent and effluent samples will be collected upon system startup, then in thirty minute increments for analyses for the contaminants listed in Table 3.1 for the first two hours of the test, then at one hour intervals until the test is completed. If required, refinements to the design, sampling frequency, and operating procedures will be incorporated. This test will be repeated if the treatment standards for all of the contaminants listed in Table 1 are not achieved.

The maximum PCE, TCE, NDMA, DMN, Freon 11, Freon 21, and Freon 113 influent concentrations expected during operation of the system were presented in Table 4.7 of the Plume-Front Stabilization Work Plan (NASA, 1999). These maximum predicted influent contaminant concentrations are listed in Table 3.1.

4.0 OPERATION

The operation and maintenance of the plume-front remediation system is the responsibility of the contractor environmental organization. All activities will be directed and performed by trained and qualified personnel. A description of the job titles, levels of authority, training and qualifications is provided in Section 9.0, Project Management, Training and Reporting. A description of the operation of the plume-front remediation system follows.

4.1 Security and Access

Access to the WSTF site is controlled by a security force that is on duty on a 24-hour, 365 day per year basis. Security guards control access to the industrial complex and also patrol the plume-front area at least every 8 hours during non-working hours. Specific details are outlined in Section 4.6 of the Plume-Front Stabilization Work Plan.

In addition to the WSTF site security, the extraction wells, injection wells and monitoring wells are secured by protective, locking well caps or vaults. Due to the nature of their design, the extraction wellheads are sealed to prevent the loss of untreated groundwater. This design also prevents the accidental or intentional introduction of foreign materials into these wells. The protective wells caps or vaults are locked at all times except during inspections, sampling, and maintenance operations.

The treatment facility and injection manifold building are each surrounded by seven-foot high chain link fences. The treatment facility and manifold building and all security fence gates shall remain locked at all times except during inspections, sampling and maintenance operations.

Access to all components of the plume-front remediation facility is controlled by the contractor environmental organization. Access to the monitoring wells is controlled by either the contractor environmental organization sampling coordinator or project lead engineer. Access to the extraction wells, injection wells, manifold building (Bldg. 651) and treatment facility building (Bldg. 650) will controlled by the project lead engineer.

4.2 Start-Up and Operation

Written procedures will provide detailed instructions for start-up and operation of the remediation system, identify the system configuration, and operating parameters, and identify task-specific safety requirements. The completion of all start-up procedures will be documented in a start-up check list and maintained by the contractor environmental organization as part of the facility operating record. The check list will identify the procedures performed, the personnel who performed the procedures and the date.

All process equipment and system components will be operated according to the manufacturer's procedures and recommendations. The plume-front remediation system is designed to operate over a range of flowrates from 50% to 100% of the design flowrate

(1240 gpm). Prior to operation, the manual valves at the extraction wells, piping system junctions, high-point vents, treatment facility, process equipment, injection manifold building and injection wells will be checked or setup to ensure the correct configuration of the piping system and process equipment.

The process control system interfaces with the process logic controllers of the process equipment and controls the overall operation of the remediation system. Prior to operation, the process equipment controllers will be configured per the equipment manufacturer's instructions. The process control system will be brought on-line and set-points for operation of the remediation facility checked or set and process control software validated. System inspections will be performed to ensure that the air strippers, UV oxidation unit and the other process equipment are mechanically setup for operation.

The air strippers (stripper trays, sump, transfer pump, etc.) and the UV oxidation unit are inspected to ensure the system is filled or primed with clean or treated water. A computer programmed sequence will then be initiated from the control room located in Building 650 to start the facility operation. With the UV unit filled with water, the UV lamp ignition sequence will be started and the UV lamps allowed warm-up. During the warm-up period, the effluent from the treatment facility is recirculated.

The air stripper blowers are then started and the electronic control valves at the extraction wells, treatment facility and injection manifold building opened. The sequence is then initiated to start the extraction well pumps and scale control system. The remediation system is now on-line.

Routine shutdown and emergency shutdown procedures are incorporated into the process control system. As discussed in Section 2.0, the process control system includes several interlocks that will halt system operation when specific conditions arise, such as leakage within the dual-wall extraction piping, unacceptably high water levels within injection wells, catastrophic failure of any major component (air stripper blower motor, injection pumps, extraction pumps, UV system), and any significant leakage from any piping or component within the treatment building facility. This allows operation 24-hours/day, 7-days/week with little to no human operator involvement. In the event of a shutdown, the process control system will initiate an autodialer alarm sequence to notify responsible contractor personnel. The emergency shutdown procedures can be initiated either automatically by a system alarm or manually at the control center located in Building 650.

Periodic inspection and sampling and analyses are the only activities required by personnel during operation of the facility. A discussion of the remediation system inspections and sampling and analyses is provided in Sections 5.0 and 6.0.

5.0 INSPECTION

All process equipment and system components will be operated and maintained per the manufacturer's instructions and recommendations. To assure proper operation, the

piping system, leak detection system, treatment facility, injection manifold, extraction and injection wells, system alarms, and communications will be periodically inspected or tested according to the inspection plan presented in Attachment 4, Tables 5.1 through 5.4.

All inspections of the plume-front remediation system will be documented in inspection records and maintained by the contractor environmental organization as part of the facility operating record for a minimum of three years. The inspection records will include: the personnel who performed the inspection, the items that were inspected, and condition of the item. Unsatisfactory conditions or discrepancies will be documented in a discrepancy record and the discrepancy record identification number referenced in the inspection record. The discrepancy record will describe the discrepancy, the steps or actions to correct the problem and document completion. The discrepancy records will be maintained by the contractor environmental organization as part to the facility operating record for a minimum of three years.

6.0 SAMPLING AND ANALYSIS

Details of the Sampling and Analysis Plan have been provided in Section 5.0 of the Plume-Front Stabilization Work Plan and Discharge Plan DP-1255. The Plan provides personnel with project-specific procedures for the collection and analysis of samples associated with plume-front containment activities and will be used in conjunction with the most recent revision of the WSTF Groundwater Sampling and Analysis Plan (SAP) and the WSTF Quality Assurance Project Plan (QAPP).

7.0 MAINTENANCE

All remediation system process equipment and system components will be maintained per the manufacturer's instructions and recommendations. The operation of the remediation system will be evaluated at least on a monthly basis. Sampling and analyses of the monitoring wells, treatment facility influent and effluent will be reviewed along with the operating parameters and the inspection records to evaluate the overall operation of the remediation system and to note any trends or indications of component failure or deterioration of performance. In addition to the inspection and testing performed per Section 5.0, the process equipment will be periodically inspected, tested and serviced according to the maintenance plan presented in Attachment 5, Table 7.1

All maintenance activities will be performed by the equipment manufacturer's service representatives or trained and qualified contractor personnel. A description of the job titles, levels of authority, training and qualifications is provided in Section 9.0, Project Management, Training and Reporting. Written procedures will provide detailed step-by-step instructions, identify the task-specific safety requirements, and document completion of maintenance activities. The documentation will identify the maintenance steps/actions performed, the personnel involved, and the date. All maintenance records will be maintained as part of the facility operating record.

8.0 WASTE MANAGEMENT

All waste generated from the remediation system will be managed per the WSTF Hazardous Waste Facility Permit No. NM8800019434-1 and WSTF waste management procedures. The waste streams include, but are not limited to:

- Groundwater containing ppb concentrations of WSTF groundwater contaminants generated during testing, sampling and routine equipment maintenance operations,
- Contaminated site water (potable water) generated during routine facility rinsing and cleaning operations with detergents or inorganic cleaners,
- Acid-based descaling solution containing a 5% to 50% solution of a citric acid generated during routine maintenance of the air strippers,
- Spent mercury UV lamps generated during routine maintenance of UV oxidation unit, and
- Contaminated Debris/Softgoods contaminated with groundwater contaminants, detergents, grease, oil, solvents generated during routine facility operation.

The remediation system design incorporates various structures, procedures and equipment to prevent the release of hazardous constituents to the environment. All elements of the remediation system that contain or transport untreated groundwater have secondary containment and leak detection. Bldg. 650 is designed with an elevated curb to contain any potential leaks or spills during equipment maintenance and chemical transfer operations. All above ground piping, components and equipment are inspected for evidence of leaks or corrosion. The air stripper sumps and large process tanks are equipped with automatic shut-off controls. All tanks and containers are inspected for leaks and adequate headspace.

The injection of the treated groundwater has been authorized by the NMED Ground Water Quality Bureau (GWQB) per Discharge Permit No. DP-1255. Accumulation, run-on and run-off are not anticipated to be a concern. The treatment building that houses the treatment equipment will be located away from existing surface drainage features. The Building 650 and 651 sites are graded to route roof drainage and precipitation run-on away from the buildings. Other elements of the remediation system (subgrade piping system, extraction and injection wells, etc.) are inspected per Section 5.0 for evidence of erosion or silting due to precipitation.

9.0 PROJECT MANAGEMENT, TRAINING AND REPORTING

9.1 Project Management

The NASA Environmental Program Manager directs all activities associated with WSTF environmental compliance and the plume-front remediation project. The site contractor environmental organization, under the direction of the NASA Environmental Program Manager, performs and/or coordinates all activities associated with the project. An

organizational chart for NASA WSTF environmental activities is presented in Attachment 6.

9.2 Training

The overall operation and maintenance of the Plume-Front Remediation System is the responsibility of the contractor environmental organization. The contractor environmental organization project lead engineer and designated contractor environment organization engineer(s) will receive "on-the-job" training by manufacturer representatives during the three month remediation system start-up period as described in Section 3.0. The training plan presented in Attachment 7, Table 9.1 has been developed to assure that personnel receive adequate training with respect to their job responsibilities. The training can include proficiency demonstrations, class room instruction, on-the-job training, or a series of instructions by off-site personnel or qualified contractor environmental organization personnel.

9.3 Reporting

Progress and subsequent data reporting will be accomplished through use of the monthly RFI/CMS reports to EPA/NMED. The format of the current reports will be modified to accommodate reporting of activities and data directly applicable to plume-front containment. These reports will at a minimum provide: significant project accomplishments; activity updates; monitoring data; and significant problems and corrective actions taken. NASA will initiate use of these reports as soon as plume-front remediation activities are initiated. If revisions to the format are required, revisions to the format can be implemented which are amenable to both NMED and NASA.

10.0 CONTINGENCY PLAN

NASA will utilize the Contingency Plan presented in the Hazardous Waste Operating Permit for WSTF. In addition to the elements contained in the Contingency Plan, the plume-front stabilization and groundwater treatment system design will incorporate several interlocks that will halt system operation when specific conditions arise. These conditions include:

- leakage within the dual-wall extraction piping;
- near-surface water levels within injection well(s);
- catastrophic failure of any major component (i.e., air stripper blower motor, injection pump, extraction pumps, UV system); and
- significant leakage from any piping or component within the treatment building facility.

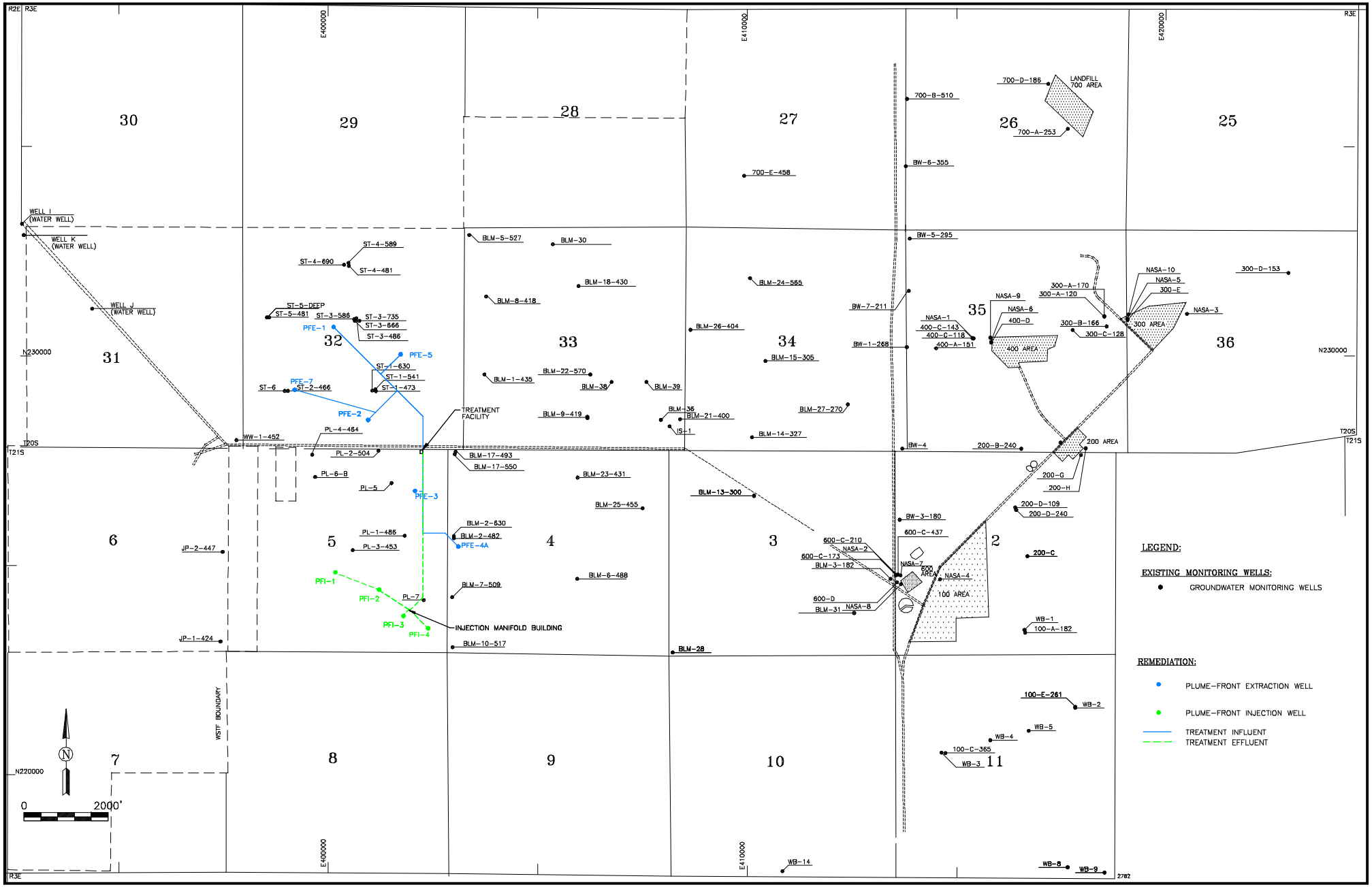
In the event of a significant component failure that results in a system shut-down of more than 24 hours, NASA will notify the NMED verbally within 24 hours and in writing within 72 hours of the event. The written notification will summarize system status,

cause of shut-down, response taken and/or planned, expected duration of the shut-down, and any potential impacts on human health and the environment.

ATTACHMENT 1

WSTF PLUME-FRONT REMEDIATION SYSTEM

SITE LOCATION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LANDFILL
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700-A-253
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(WATER WELL)
WELL K
(WATER WELL)
WELL J
(WATER WELL)
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BLM-38
BLM-39
PFE-2
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IS-1
BLM-27-270
BLM-14-327
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T21S
WW-1-452
PL-4-454
PL-2-504
BW-4
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200 AREA
200-G
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PL-5
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BW-3-180
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BLM-2-482
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600-C-210
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600-C-173
BLM-3-182
NASA-7
600 AREA
NASA-4
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PFI-2
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PL-7
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BLM-31
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WB-1
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BLM-28
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100-C-365
WB-3
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7
8
9
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WB-14
WB-8
WB-9
2782
LEGEND:
EXISTING MONITORING WELLS:
GROUNDWATER MONITORING WELLS
REMEDIATION:
PLUME-FRONT EXTRACTION WELL
PLUME-FRONT INJECTION WELL
TREATMENT INFLUENT
TREATMENT EFFLUENT

ATTACHMENT 2

PLUME-FRONT REMEDIATION SYSTEM

EXTRACTION AND INJECTION WELL

PUMPING AND INJECTION RATES

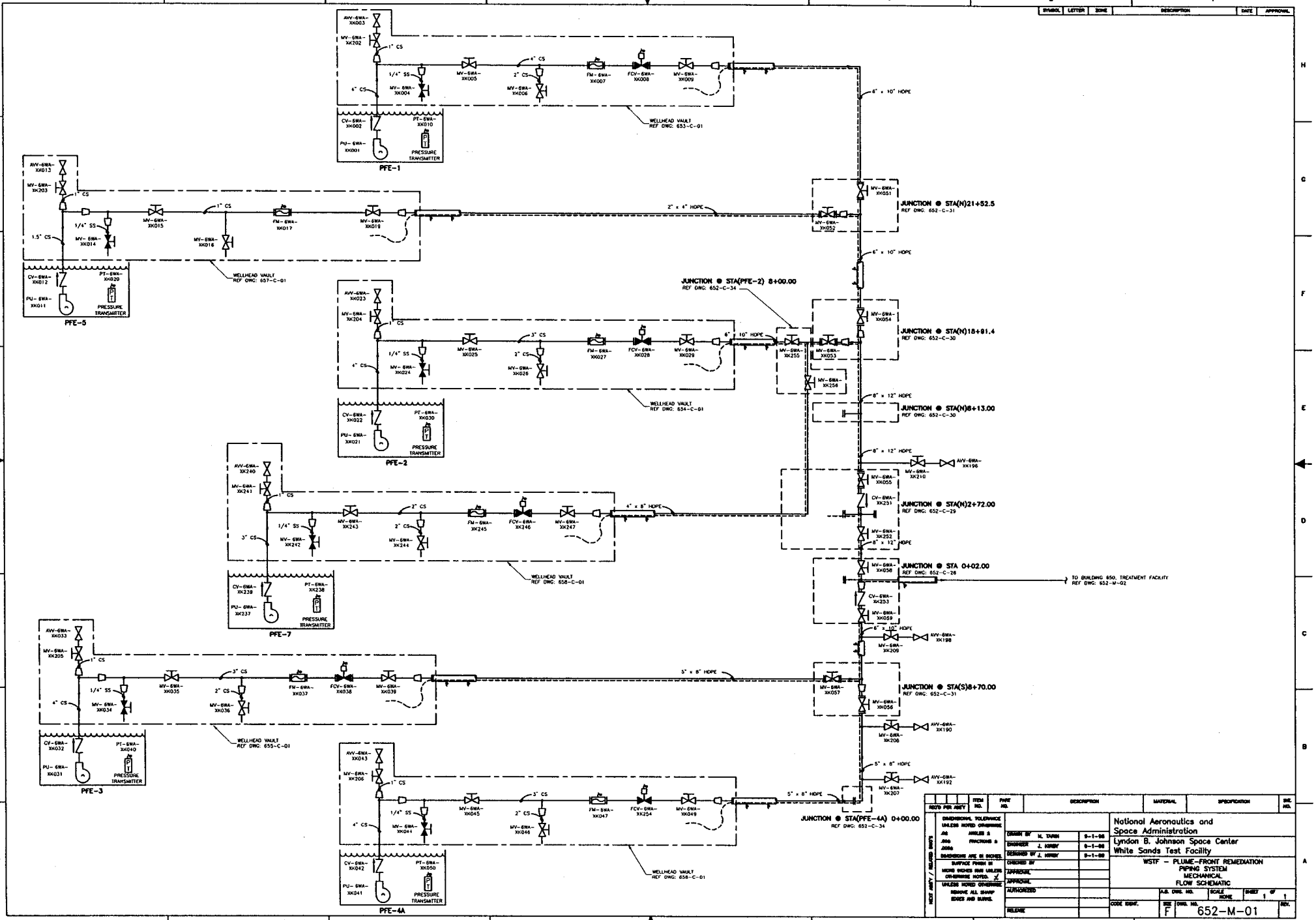
Table 2.1 – Anticipated Extraction Well, Pumping Rates		
Well #	**Nominal Pumping Rate (gpm)**	**Max. Pumping Rate (gpm**
PFE-1	288	331
PFE-2	224	258
PFE-3	213	245
PFE-4A	200	230
PFE-5	26	30
PFE-7	125	144

Table 2.2 – Anticipated Injection Well, Injection Rates		
Well #	**Nominal Injection Rate (gpm)**	**Max. Injection Rate (gpm)**
PFI-1	269	330
PFI-2	269	329
PFI-3	344	422
PFI-4	194	237

ATTACHMENT 3

PLUME-FRONT REMEDIATION SYSTEM

FLOW SCHEMATIC



SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	DWG. NO.

NOTES ARE / RELATED DWGS

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE:
.XX ANGLES ±
.XXX FRACTIONS ±
.XXXX
DIMENSIONS ARE IN INCHES
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

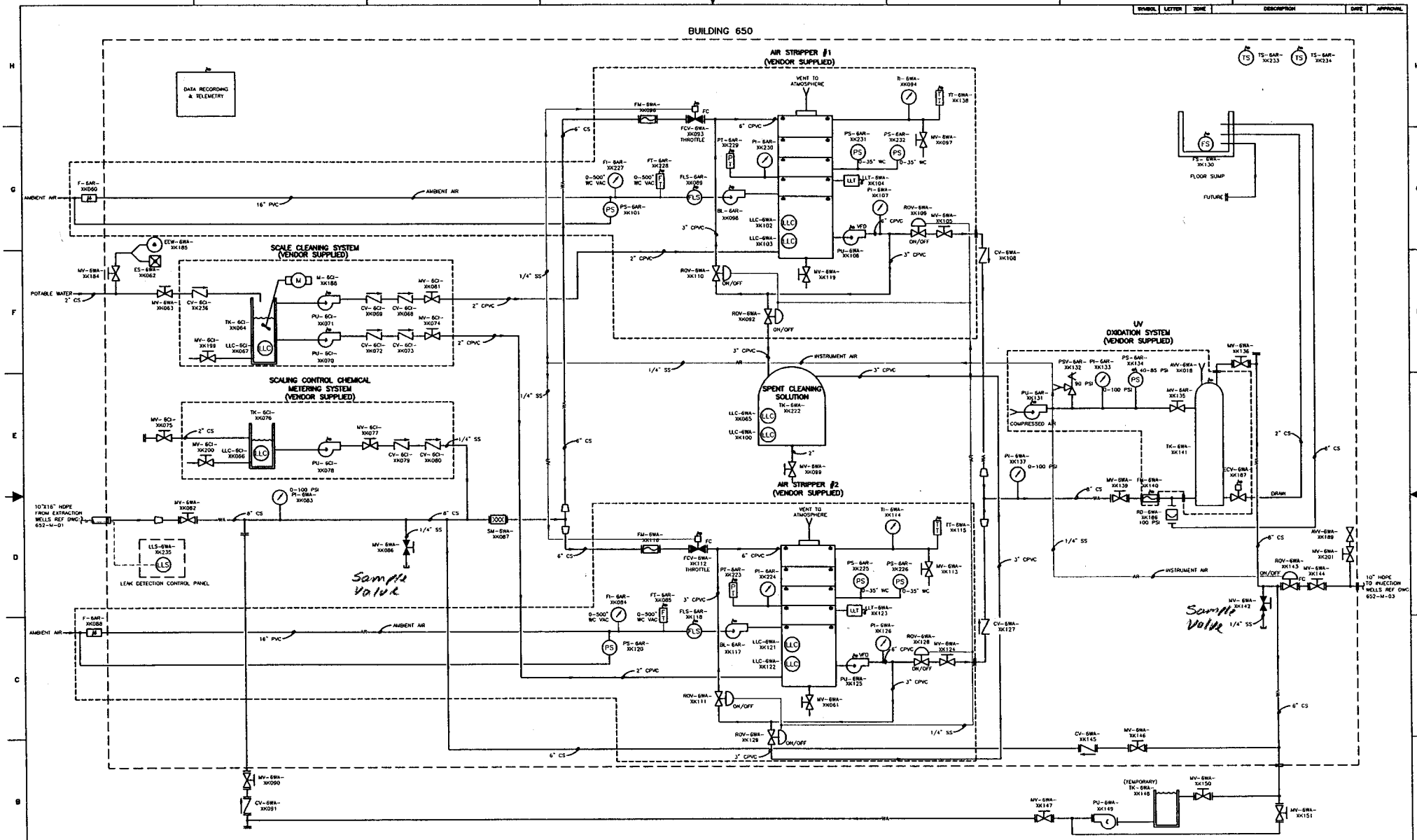
DRAWN BY	M. TARIN	9-1-98
ENGINEER	J. KIRBY	9-1-98
DESIGNED BY	J. KIRBY	9-1-98
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
PIPING SYSTEM
MECHANICAL
FLOW SCHEMATIC

A.S. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-M-01 | REV.



ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	DWG NO.

UNLESS NOTED OTHERWISE
DIMENSIONAL TOLERANCE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES
SURFACE FINISH IN
MICRO INCHES AMS UNLESS
OTHERWISE NOTED.
UNLESS NOTED OTHERWISE
REMOVE ALL SHARP
EDGES AND BURRS.

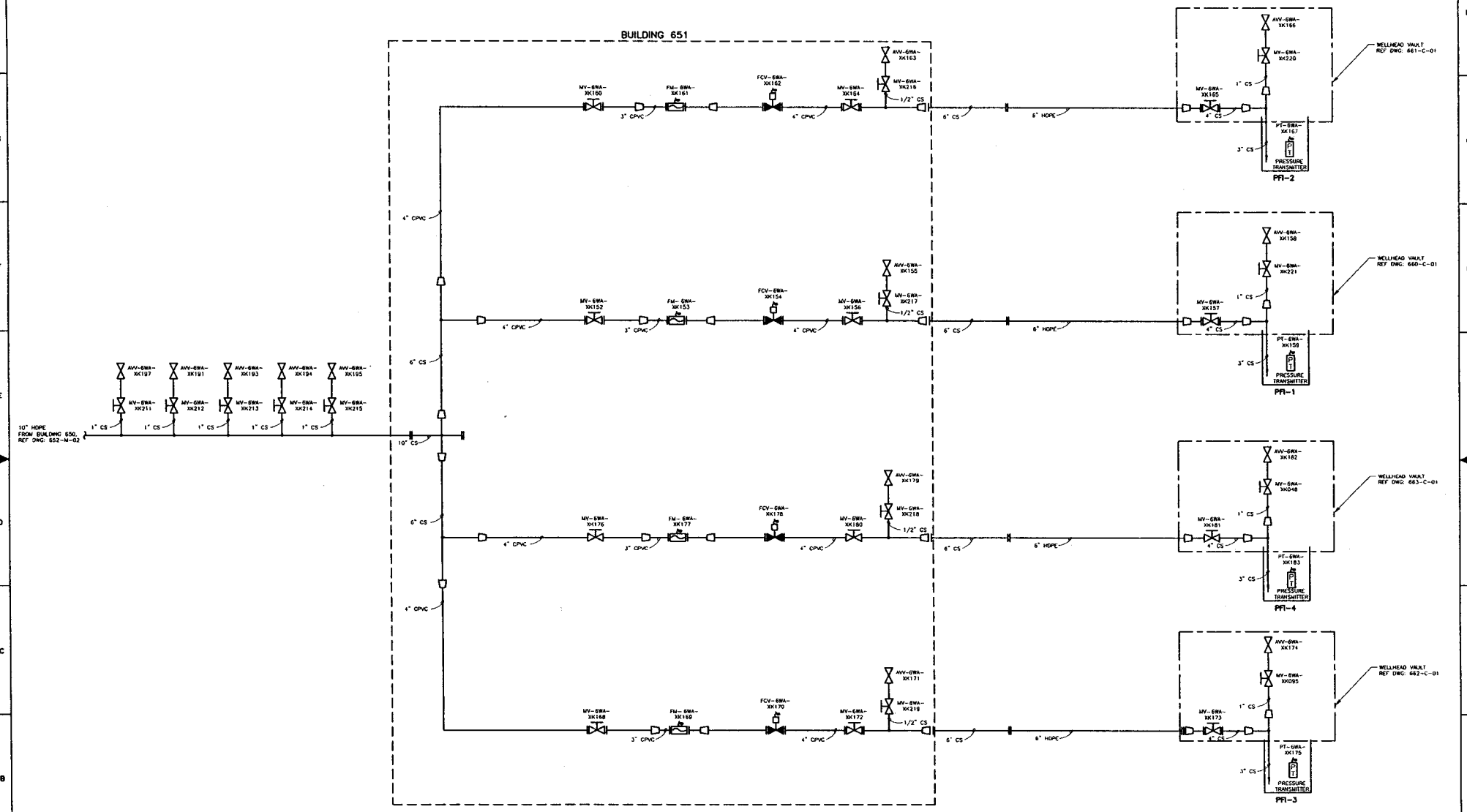
DRAWN BY	M. TARIN	9-1-99
ENGINEER	J. KIRBY	9-1-99
DESIGNED BY	J. KIRBY	9-1-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
PIPING SYSTEM
MECHANICAL
FLOW SCHEMATIC

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-M-02 | REV.



NOTES:

1. ALL CPVC PIPE SHALL BE SCH 80.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	DWG. NO.

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE: .XX ANGLES ± .XXX FRACTIONS ± .XXXX
DIMENSIONS ARE IN INCHES
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TAHIN	9-1-98
ENGINEER	J. NEELY	9-1-98
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION PIPING SYSTEM MECHANICAL FLOW SCHEMATIC

A.S. DWG. NO.	SCALE	SHEET
	NONE	1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-M-03 | REV.

ATTACHMENT 4

PLUME-FRONT REMEDIATION SYSTEM

INSPECTION PLAN

Table 5.1- Treatment Facility Inspections (Bldg. 650)		
Item	**Frequency**	**Description**
Process Control System – Status	Daily	Check the operating status of the process control system. Validate the status of all system indicator lights and alarms for the extraction wells, injection wells, treatment facility and leak detection system..
Process Control System – Air Stripper Operating Parameters	Daily	Operating parameters for the air strippers (flowrates, temperature, pressure, etc.) shall be within the normal operating range. The scale control system shall be operational and the scale control chemical flowrate within the normal operating range.
Process Control System – UV Unit Operating Parameters	Daily	Ensure that the selected UV lamps are operational. The amperage and voltage draw for each UV lamp shall be within the normal operating range. The UV unit operating parameters (flowrate, temperature, etc.) shall be within the normal operating range. The equipment and instrument air pressure shall be within the normal operating range.
Process Control System – Extraction Well Operating Parameters	Daily	The flowrates and static water levels for the extraction wells shall be within the normal operating range.
Process Control System – Injection Well Operating Parameters	Daily	The flowrates and static water levels for the injection wells shall be within the precribed operating ranges.
Access Road	Weekly	The access road shall be free of obstructions or deterioration which may cause delays or hamper the movement of vehicles or equipment.
Erosion and Run-On	Weekly	The fenced area and the surrounding area the shall be free evidence of excessive erosion or run-on due to precipitation.
Fence and Gates	Weekly	The fence, gates and doors will be in good general condition with no evidence of unauthorized entry, secured, locked and free of obstructions.
Signs	Weekly	The restricted access and other warning signs for Bldg. 650 and the fenced area surrounding Bldg. 650 shall be present and legible.
Housekeeping	Weekly	The fenced area surrounding Bldg. 650 shall be free of trash and debris. Bldg. 650 shall be free of accumulated liquids, trash and debris.
Process Equipment and Above Ground Piping	Weekly	The process equipment, process tanks, process components and the above ground piping (piping, valves, flanges, etc.) shall be free of evidence of leaks or deterioration.
Process Tank - Levels	Weekly	The process tank levels (scale control system, scale cleaning chemical tank, spent cleaning solution tank) shall be adequate for facility operation. All process tanks or containers shall maintain adequate headspace.
Heating, Cooling and Ventilation	Weekly	Ensure Bldg. 650 heating, cooling and ventilation is operational. The building temperature shall be maintained within the recommend equipment operating temperatures.
Safety Equipment	Weekly	The shower and eye wash and other safety equipment shall be tested and operational.
Communications	Weekly	The phone at the treatment facility (Bldg. 650) shall be operational.
Lighting	Weekly	The Bldg. 650 lighting shall be adequate and operational.
Alarm System - Operation	Monthly	The process control system alarms, autodialers, etc. shall be functionally tested and operational. The alarms, interlocks and emergency shutdown systems for the treatment facility (air strippers, UV unit, leak detection system, etc.) extraction wells and injection wells shall be tested and operational.
Alarm System – Autodialer	Monthly	The process control system alarms, autodialers, etc. shall be functionally tested and operational.

Table 5.2 – Injection Manifold Inspections (Bldg. 651)		
Item	**Frequency**	**Description**
Access Road	Weekly	The access road shall be free of obstructions or deterioration which may cause delays or hamper the movement of vehicles or equipment.
Erosion and Run-On	Weekly	The fenced area and the surrounding area the shall be free evidence of excessive erosion or run-on due to precipitation.
Fence and Gates	Weekly	The fence, gates and doors will be in good general condition with no evidence of unauthorized entry, secured, locked and free of obstructions.
Signs	Weekly	The restricted access and other warning signs for Bldg. 651 and the fenced area surrounding Bldg. 651 shall be present and legible.
Housekeeping	Weekly	The fenced area surrounding Bldg. 651 shall be free from trash and debris. Bldg. 651 shall be free of accumulated liquids, trash and debris.
Process Equipment and Above Ground Piping	Weekly	The above ground piping (piping, valves, flanges, etc.) shall be free of evidence of leaks or deterioration.
Lighting	Weekly	The Bldg. 651 lighting shall be adequate and operational.

Table 5.3 – Extraction and Injection Well Inspections		
Item	**Frequency**	**Description**
Access Roads	Weekly	The access roads shall be free of obstructions or deterioration which may cause delays or hamper the movement of vehicles or equipment.
Well Vaults	Weekly	The well vaults and access doors shall be in good general condition with no evidence of unauthorized entry, secured, locked and checked for obstructions.
Fence	Weekly	The bollards and/or fence surrounding the well vault shall be in good general condition with no evidence of damage.
Signs	Weekly	The restricted access and other warning signs shall be present and legible.
Housekeeping	Weekly	The general area surrounding the well vaults shall be free from trash and debris.
Erosion and Run-on	Weekly	The general area surrounding the well vaults will be free of excessive erosion or silting due to run-on from precipitation.

Table 5.4 – Subgrade Piping Inspections		
Item	**Frequency**	**Description**
Assess Roads	Monthly	The access roads along the piping route shall be free of obstructions or deterioration which may cause delays or hamper the movement of vehicles or equipment.
Subgrade Piping – Erosion	Monthly	The pipeline route shall be inspected to look for evidence of excessive erosion.
Vaults – Erosion and Run-On	Monthly	The general area surrounding the junction and access vaults shall be free of evidence of excessive erosion or silting due to run-on from precipitation.
Vaults - Closures	Monthly	The junction and access vault ports or closures shall be in good general condition with no evidence of unauthorized entry, secured, locked and checked for obstructions.
Vaults – Bollards/Fence	Monthly	The bollards or fence surrounding the junction and access vaults shall be in good general condition with no evidence of damage.
Vaults - Signs	Monthly	The restricted access and other warning signs for the junction and access vaults shall be present and legible.
Vaults - Housekeeping	Monthly	The area surrounding the junction and access vaults shall be free from trash and debris.

ATTACHMENT 5

PLUME-FRONT REMEDIATION SYSTEM

MAINTENANCE PLAN

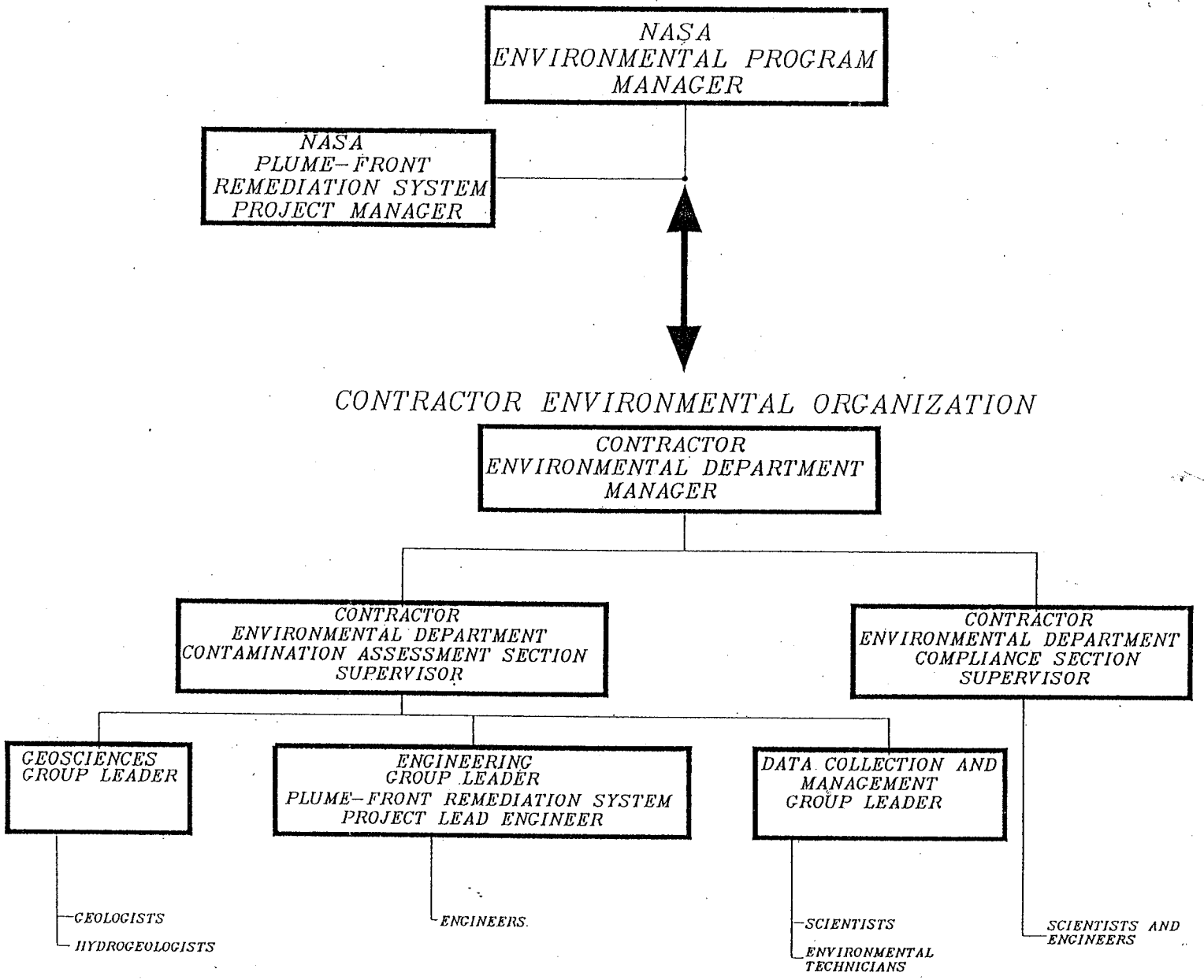
Table 7.1 – Plume-Front Remediation System Maintenance Plan		
Item	**Frequency**	**Description**
Equipment and Instrument Air	Monthly	The equipment and instrument air system will be inspected and serviced. Accumulated water will be drained from the air compressor tank and compressed air lines. The air/water separator and the supply of lubricant in the compressor and oil lubricator will be checked. Inspection record reviewed to ensure that the air pressure is within the normal operating range.
Air Stripper – Air Filters	Monthly	The air filters for the air strippers will be inspected and serviced or replaced.
Air Stripper – Stripper Trays	Monthly	The air stripper trays and spray nozzles will be inspected for excessive scale deposits that could adversely affect the system performance. If required, a citric acid solution will be circulated through the stripper to remove scale deposits.
Air Stripper - Sump	3,000 hours	The air stripper sumps will be inspected for sludge or solid material and if required, cleaned and flushed.
UV Unit – Transmittance Controllers	Monthly	The UV unit transmittance controllers will be inspected to ensure that air solenoids are operating properly and wipers transverse the entire surface of the quartz tube that houses the UV lamps and that there are no unusual vibrations or sounds. If defective, the solenoids and tube wipers will be removed and replaced.
UV Unit – Interlocks	Monthly	The UV unit emergency stop and system interlocks will be tested and operational.
UV Unit – Lamp Enclosure	Monthly	The UV lamp enclosures will be inspected for leaks. If defective, the enclosure seals will be removed and replaced.
UV Unit – Moisture Sensor	Monthly	The UV unit moisture sensors will be inspected, and verified to be in good condition and operational. If defective, the moisture sensors will be removed and replaced.
UV Unit – Quartz Tubes	Monthly	The tube seals will be inspected for burns or leaks and replaced as required. The inner and outer surfaces of the quartz tubes will be inspected for damage or fouling. If fouled, the tubes will be removed and cleaned with an acid wash or replaced.
UV Unit – UV Lamps	3,000 hours	The UV lamps will be removed and replaced approximately every 3000 hours of operation.
UV Unit – UV Tower	3,000 hours	The UV tower will be inspected for sludge or solid material and if required, cleaned and flushed. The inner and outer surfaces of the quartz tubes will be inspected for damage or fouling. If fouled, the tubes will be removed and cleaned with an acid wash or replaced.
Relief Valves	5 years	The set pressure for relief valves will be tested every 5 years.
Instrumentation (flowmeters, liquid level transmitters, pressure transducers, etc.)	2 years	Instrumentation (gauges, transducers, switches, etc.) will be calibrated to the manufacturer's specifications every 2 years or per the instrument manufacturer's recommended schedule.
Extraction Wells and Injection Wells	Case-by case basis	The performance of the extraction and injection wells (extraction and injection rates, water levels, etc.) will be reviewed on a monthly basis. Extraction well maintenance (surging, bailing, pump repair and replacement, etc.) and injection well maintenance (surging, bailing, acidifying, etc.) will be performed on a case-by-case basis.

ATTACHMENT 6

NASA WHITE SANDS TEST FACILITY

ORGANIZATIONAL CHART

NASA WHITE SANDS TEST FACILITY
ENVIRONMENTAL COMPLIANCE ORGANIZATIONAL CHART



ATTACHMENT 7

PLUME-FRONT REMEDIATION SYSTEM

TRAINING PLAN

Table 9.1 – Plume –Front Remediation System Training Plan		
Job Title	**Requirement**	**Training Description**
Hazardous Waste Technician	All WSTF personnel directing or involved in the operation, maintenance and repair of the plume-front remediation system (including inspection, sampling, operation and maintenance) where the potential for exposure to hazardous waste, hazardous waste constituents, or contaminated groundwater exists	Chemical safety, health hazards and hazard communication (29 CFR, Part 1910), Relevant state and federal environmental regulations, WSTF environmental procedures, WSTF contingency plan, WSTF permitted units, Hazardous waste container handling and shipment, WSTF waste analysis plan
Groundwater Treatment Facility Technician	All contractor environmental organization technicians involved in plume-front remediation system operation, maintenance, inspection and sampling activities (excluding monitoring well sampling).	Qualification as a Hazardous Waste Technician, confined space training, personnel protective equipment training, air monitoring training, lockout/tagout training. Familiarity with the general remediation system design, process equipment, sampling, inspection, operation and maintenance procedures, and safety requirements.
Groundwater Treatment Facility Operator	Contractor environmental organization scientists or engineers performing or directing plume-front remediation system operation, maintenance, inspection and sampling activities (excluding monitoring well sampling)	Confined space training, personnel protective equipment training, air monitoring training, lockout/tagout training. Demonstrated proficiency with the remediation system design, process equipment, sampling, inspection, operation, maintenance, routine and emergency shut-down procedures, safety requirements and communication and alarm systems.
Project Lead Engineer	Contractor environmental organization scientist or engineer responsible for the overall operation and maintenance of the plume-front remediation system.	Skills at least equivalent to a Groundwater Treatment Facility Operator and training or demonstrated proficiency with respect to set-up and operation of the process control system and computer software.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

WSTF
PLUME–FRONT REMEDIATION
WHITE SANDS TEST FACILITY
LAS CRUCES, NM

PIPING SYSTEM

DRAWING NO	DESCRIPTION
652–I–01	INDEX OF DRAWINGS
652–I–02	INDEX OF DRAWINGS
652–I–03	INDEX OF DRAWINGS
652–I–04	INDEX OF DRAWINGS, SYMBOLS, & ABBREVIATIONS
652–C–01	CIVIL, PROJECT LOCATION
652–C–02	CIVIL, WELL LOCATIONS & PIPING LAYOUT
652–C–03	CIVIL, PLAN & PROFILE PIPING ROUTE (N–1)
652–C–04	CIVIL, PLAN & PROFILE PIPING ROUTE (N–2)
652–C–05	CIVIL, PLAN & PROFILE PIPING ROUTE (N–3)
652–C–06	CIVIL, PLAN & PROFILE PIPING ROUTE (N–4)
652–C–07	CIVIL, PLAN & PROFILE PIPING ROUTE (N–5)
652–C–08	CIVIL, PLAN & PROFILE PIPING ROUTE (S–1)
652–C–09	CIVIL, PLAN & PROFILE PIPING ROUTE (S–2)
652–C–10	CIVIL, PLAN & PROFILE PIPING ROUTE (S–3)
652–C–11	CIVIL, PLAN & PROFILE PIPING ROUTE (S–4)
652–C–12	CIVIL, PLAN & PROFILE PIPING ROUTE (S–5)
652–C–13	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE–2)
652–C–14	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE–4A)
652–C–15	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE–4B)
652–C–16	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE–6)
652–C–17	CIVIL, PLAN & PROFILE PIPING ROUTE (PFI–1A)
652–C–18	CIVIL, PLAN & PROFILE PIPING ROUTE (PFI–1B)
652–C–19	CIVIL, PLAN & PROFILE PIPING ROUTE (PFI–4)
652–C–20	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE–7A)
652–C–21	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE–7B)
652–C–25	CIVIL, JUNCTION DETAILS
652–C–26	CIVIL, JUNCTION DETAILS
652–C–27	CIVIL, JUNCTION DETAILS
652–C–28	CIVIL, SECTIONS & DETAILS
652–C–29	CIVIL, SECTIONS & DETAILS
652–C–30	CIVIL, SECTIONS & DETAILS
652–C–31	CIVIL, SECTIONS & DETAILS
652–C–32	CIVIL, SECTIONS & DETAILS
652–C–33	CIVIL, SECTIONS & DETAILS
652–C–34	CIVIL, SECTIONS & DETAILS
652–C–35	CIVIL, SECTIONS & DETAILS
652–C–36	CIVIL, SECTIONS & DETAILS
652–C–37	CIVIL, SECTIONS & DETAILS
652–M–01	MECHANICAL, FLOW SCHEMATIC, EXTRACTION WELLS
652–M–02	MECHANICAL, FLOW SCHEMATIC, TREATMENT FACILITY
652–M–03	MECHANICAL, FLOW SCHEMATIC, INJECTION WELLS
652–M–04	MECHANICAL, SUBGRADE PIPE & FITTING SCHEDULES
652–M–05	MECHANICAL, SUBGRADE PIPE & FITTING SCHEDULES
652–M–06	MECHANICAL, PIPE & FITTING SCHEDULES
652–M–07	MECHANICAL, PIPE & FITTING SCHEDULES
652–M–08	MECHANICAL, PIPE & FITTING SCHEDULES

CH2MHILL SUBMITTAL

3902G0001 THRU 3902G0003	PROCESS, INSTRUMENTATION & CONTROLS
39021001 THRU 39021020	PROCESS & INSTRUMENTATION
3902E001 THRU 3902E007	ELECTRICAL
3902G003	PLC SYSTEM DIAGRAM

NOTE:
DRAWINGS IN HATCHED AREA ARE NOT INCLUDED IN THIS SUBMITTAL, BUT ARE AVAILABLE UPON REQUEST.

ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASSY					

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

NEXT ASSY / RELATED DWG'S

DRAWN BY	M. TARIN	2-25-00
ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF
PLUME–FRONT REMEDIATION
INDEX OF DRAWINGS

A.B. DWG. NO.	SCALE	SHEET	OF
	NONE	1	1

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	652–I–01	

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

WSTF
PLUME–FRONT REMEDIATION
WHITE SANDS TEST FACILITY
LAS CRUCES, NM

EXTRACTION WELL PFE–1

DRAWING NO	DESCRIPTION
653–C–01	CIVIL, SITE/UTILITIES PLAN
653–C–02	CIVIL, DETAILS AT WELLHEAD
653–C–03	CIVIL WELL COMPLETION DIAGRAM
653–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
653–E–01	ELECTRICAL, MISCELLANEOUS DETAILS
653–E–02	ELECTRICAL, MISCELLANEOUS DETAILS

EXTRACTION WELL PFE–2

DRAWING NO	DESCRIPTION
654–C–01	CIVIL, SITE/UTILITIES PLAN
654–C–02	CIVIL, DETAILS AT WELLHEAD
654–C–03	CIVIL WELL COMPLETION DIAGRAM
654–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
654–E–01	ELECTRICAL, MISCELLANEOUS DETAILS
654–E–02	ELECTRICAL, MISCELLANEOUS DETAILS

EXTRACTION WELL PFE–3

DRAWING NO	DESCRIPTION
655–C–01	CIVIL, SITE/UTILITIES PLAN
655–C–02	CIVIL, DETAILS AT WELLHEAD
655–C–03	CIVIL WELL COMPLETION DIAGRAM
655–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
655–E–01	ELECTRICAL, MISCELLANEOUS DETAILS
655–E–02	ELECTRICAL, MISCELLANEOUS DETAILS

EXTRACTION WELL PFE–4A

DRAWING NO	DESCRIPTION
656–C–01	CIVIL, SITE/UTILITIES PLAN
656–C–02	CIVIL, DETAILS AT WELLHEAD
656–C–03	CIVIL WELL COMPLETION DIAGRAM
656–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
656–E–01	ELECTRICAL, MISCELLANEOUS DETAILS
656–E–02	ELECTRICAL, MISCELLANEOUS DETAILS

EXTRACTION WELL PFE–5

DRAWING NO	DESCRIPTION
657–C–01	CIVIL, SITE/UTILITIES PLAN
657–C–02	CIVIL, DETAILS AT WELLHEAD
657–C–03	CIVIL WELL COMPLETION DIAGRAM
657–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
657–E–01	ELECTRICAL, MISCELLANEOUS DETAILS
657–E–02	ELECTRICAL, MISCELLANEOUS DETAILS

EXTRACTION WELL PFE–7

DRAWING NO	DESCRIPTION
658–C–01	CIVIL, SITE/UTILITIES PLAN
658–C–02	CIVIL, DETAILS AT WELLHEAD
658–C–03	CIVIL WELL COMPLETION DIAGRAM
658–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
658–E–01	ELECTRICAL, MISCELLANEOUS DETAILS
658–E–02	ELECTRICAL, MISCELLANEOUS DETAILS

INJECTION WELL PFI–1

DRAWING NO	DESCRIPTION
660–C–01	CIVIL, DETAILS AT WELLHEAD
660–C–02	CIVIL, WELL COMPLETION DIAGRAM
660–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT

INJECTION WELL PFI–2

DRAWING NO	DESCRIPTION
661–C–01	CIVIL, DETAILS AT WELLHEAD
661–C–02	CIVIL, WELL COMPLETION DIAGRAM
661–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT

INJECTION WELL PFI–3

DRAWING NO	DESCRIPTION
662–C–01	CIVIL, DETAILS AT WELLHEAD
662–C–02	CIVIL, WELL COMPLETION DIAGRAM
662–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT

INJECTION WELL PFI–4

DRAWING NO	DESCRIPTION
663–C–01	CIVIL, DETAILS AT WELLHEAD
663–C–02	CIVIL, WELL COMPLETION DIAGRAM
663–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2–25–00
ENGINEER	J. KIRBY	2–25–00
DESIGNED BY	J. KIRBY	2–25–00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF
PLUME–FRONT REMEDIATION
INDEX OF DRAWINGS

A.B. DWG. NO.	SCALE	SHEET	OF
	NONE	1	1

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	652–I–02	

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

WSTF
PLUME–FRONT REMEDIATION
WHITE SANDS TEST FACILITY
LAS CRUCES, NM

BUILDING 650, TREATMENT FACILITY

DRAWING NO	DESCRIPTION
650-C-01	CIVIL, PROJECT LOCATION MAP
650-C-02	CIVIL, SITE PLAN
650-C-03	CIVIL, UTILITIES PLAN
650-C-04	CIVIL, GRADING PLAN
650-C-05	CIVIL, FENCE DETAILS
650-A-01	ARCHITECTURAL, FLOOR PLAN
650-A-02	ARCHITECTURAL, ELEVATIONS
650-A-03	ARCHITECTURAL, SECTIONS & DETAILS
650-S-01	STRUCTURAL, FOUNDATION PLAN
650-S-02	STRUCTURAL, SECTIONS & DETAILS
650-M-01	MECHANICAL, PIPING & PLUMBING PLAN
650-M-02	MECHANICAL, HVAC PLAN
650-M-03	MECHANICAL, HVAC ELEVATIONS
650-M-04	MECHANICAL, SCHEDULES
650-M-05	MECHANICAL, MISCELLANEOUS DETAILS
650-M-06	MECHANICAL, EQUIPMENT LAYOUT
650-E-01	ELECTRICAL, POWER PLAN
650-E-02	ELECTRICAL, LIGHTING PLAN
650-E-03	ELECTRICAL, GROUNDING PLAN
650-E-04	ELECTRICAL, ONE LINE DIAGRAM
650-E-05	ELECTRICAL, CONDUIT SCHEDULES
650-E-06	ELECTRICAL, SECTIONS AND DETAILS
650-E-07	ELECTRICAL, SECTIONS AND DETAILS
650-E-08	ELECTRICAL, SECTIONS AND DETAILS
650-E-09	ELECTRICAL, CONTROL CONDUIT LAYOUT
650-FPS-01	FIRE PROTECTION, LAYOUT PLAN

BUILDING 651, INJECTION MANIFOLD BUILDING

DRAWING NO	DESCRIPTION
651-C-01	CIVIL, PROJECT LOCATION MAP
651-C-02	CIVIL, SITE, UTILITIES, & GRADING PLAN
651-A-01	ARCHITECTURAL, FLOOR PLAN
651-A-02	ARCHITECTURAL, ELEVATIONS
651-A-03	ARCHITECTURAL, DETAILS
651-S-01	STRUCTURAL, FOUNDATION PLAN
651-S-02	STRUCTURAL, SECTIONS & DETAILS
651-M-01	MECHANICAL, ISOMETRIC PIPING
651-E-01	ELECTRICAL, POWER & LIGHTING PLAN
651-E-02	ELECTRICAL, GROUNDING PLAN

POWER DISTRIBUTION

DRAWING NO	DESCRIPTION
Z-770-44	ELECTRICAL, POWER DISTRIBUTION, POLE LAYOUT
Z-770-MISC-28	100 AREA, MAIN SWITCHYARD, POLE DETAILS
Z-770-MISC-29	100 AREA, MAIN SWITCHYARD, POLE DETAILS
Z-770-MISC-30	100 AREA, MAIN SWITCHYARD, POLE DETAILS
Z-770-MISC-31	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-32	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-33	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-34	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-35	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-36	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-37	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-38	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-39	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-40	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-41	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-42	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-43	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-44	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-45	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-46	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-47	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-E-04, DCN B-1, 8-18-00	
	100 AREA, MAIN SWITCH STATION, NEW & EXISTING SUBSTATION PLAN
	100 AREA, MAIN SWITCH STATION, SUBSTATION PLAN & ELEVATIONS
	100 AREA, MAIN SWITCH STATION, SUBSTATION DETAILS
	100 AREA, MAIN SWITCH STATION, RECLOSER PULLBOX, BASE PLAN & DETAILS
	100 AREA, MAIN SWITCH STATION, SWITCH & RECLOSER

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-25-00
ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF
PLUME–FRONT REMEDIATION
INDEX OF DRAWINGS

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	652-I-03	

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

WSTF
PLUME–FRONT REMEDIATION
WHITE SANDS TEST FACILITY
LAS CRUCES, NM

SYMBOLS

MANUAL VALVE

MOTOR OPERATED VALVE

NEEDLE VALVE

FLOW METER

PUMP

STATIC MIXER

CHECK VALVE

ELECTRICAL CONTROL VALVE

FILTER

LLC — LIQUID LEVEL CONTROLLER

LLT — LIQUID LEVEL TRANSDUCER

PS — PRESSURE SWITCH

PRESSURE INDICATOR

FS — FLOW SWITCH

HOMERUN, SLASHES INDICATE NUMBER OF WIRES (GND, HOT, NEUTRAL, SWITCH, DUMMY) RESPECTIVELY. WHERE NO SLASHES ARE SHOWN INDICATES THREE WIRES (GND, HOT, NEUTRAL) ALL CONDUIT 3/4" UNLESS OTHER WISE NOTED. ALL WIRES #12 THHN UNLESS OTHER WISE NOTED.

GFCI — 20 AMP, 120 VOLT, GROUND FAULT CIRCUIT INTERRUPTER RECEPTACLE, 48" ABOVE FINISHED FLOOR.

GFCI WP — 20 AMP, 120 VOLT, GROUND FAULT CIRCUIT INTERRUPTER RECEPTACLE, 48" ABOVE FINISHED FLOOR, IN WEATHER–PROOF BOX.

$ — 20 AMP, 277 VOLT, SINGLE POLE LIGHT SWITCH. LOWER CASE LETTERS INDICATES LIGHT CONTROLLED BY SWITCH.

BOHANNAN–HUSTON CONTROL POINT

$b3 — 20 AMP, 277 VOLT, 3–WAY LIGHT SWITCH. LOWER CASE LETTER INDICATES LIGHT CONTROLLED BY SWITCH.

$AC1 — 20 AMP, 120 VOLT, SINGLE POLE SWITCH FOR AC UNIT

$P — 20 AMP, 120 VOLT, SINGLE POLE SWITCH FOR AC PUMP

$WP — 20 AMP, 120 VOLT, 2 POLE SWITCH IN WEATHERPROOF BOX.

IR HEATER THERMOSTAT

DUAL CONTAINMENT

J — 4" SQUARE JUNCTION BOX

120/208 VOLT PANEL

480/277 VOLT PANEL

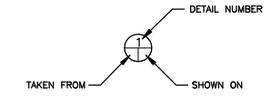
E — EMERGENCY LIGHT FIXTURE

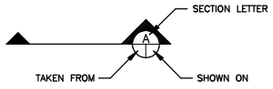
EXIT LIGHT

OUTSIDE LIGHT FIXTURE

PHONE/COMPUTER OUTLET

PHONE/COMPUTER PANEL





ABBREVIATIONS

A	AMP	MFR	MANUFACTURER
AFF	ABOVE FINISH FLOOR	MIN	MINIMUM
AFB	AIR FORCE BASE	MM	MILLIMETER
ALUM	ALUMINUM	MCC	MOTOR CONTROL CENTER
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE	N	NORTH
AR	AIR	NA	NOT APPLICABLE
ASSY	ASSEMBLY	NC	NORMALLY CLOSED
ASTM	AMERICAN STANDARDS OF TESTING & MATERIALS	NOM	NOMINAL
AWG	AMERICAN WIRE GAUGE	NPT	NATIONAL PIPE THREADS
BC	BOLT CIRCLE	OC	ON CENTER
BLDG	BUILDING	OD	OUTSIDE DIAMETER
CI	CAST IRON	OVH	OVERHEAD
CKT	CIRCUIT	PFE	PLUME–FRONT EXTRACTION
CMP	CORRUGATED METAL PIPE	PFI	PLUME–FRONT INJECTION
CONN	CONNECTION	PSI	POUNDS PER SQUARE INCH
CO	CLEANOUT	PSIG	POUNDS PER SQUARE INCH GAUGE
CPVC	CHLORINATED POLYVINYL CHLORIDE	PVC	POLYVINYL CHLORIDE
CS	CARBON STEEL	RAD	RADIUS
DIA	DIAMETER	REF	REFERENCE
DWG	DRAWING	SCH	SCHEDULE
EMT	ELECTRICAL METALLIC TUBING	SDR	STANDARD DIMENSIONAL RATIO
EXT	EXTERIOR	SS	STAINLESS STEEL
F	FAHRENHEIT	STA	STATION
FF	FINISH FLOOR	TBD	TO BE DETERMINE
FT	FOOT, FEET	TSP	TWISTED SINGLE PAIR
GA	GAUGE	TYP	TYPICAL
GFI	GROUND FAULT INTERRUPTER	UV	ULTRAVIOLET
GND	GROUND	VAC	VOLT AC
GPM	GALLONS PER MINUTE	WA	WATER
HDPE	HIGH DENSITY POLYETHYLENE	WP	WATERPROOF
J–BOX	JUNCTION BOX	WSTF	WHITE SANDS TEST FACILITY
KCMIL	KILO–CIRCULAR MILS	WWM	WELDED WIRE MESH
KVA	KILOVOLT AMPERES	XFMR	TRANSFORMER
mA	MILLIAMPS		
MAX	MAXIMUM		
MBMA	METAL BUILDING MANUFACTURER'S ASSOCIATION		

SAFETY REQUIREMENTS

1. ALL CONFINED SPACES INCLUDING, BUT NOT LIMITED TO, WELLHEAD VAULTS, JUNCTION ACCESS MANWAYS, CONDUIT ACCESS MANWAYS, AND LEAK DETECTION ACCESS MANWAYS SHALL BE LABELED IN ACCORDANCE WITH WSI–25–SW–0003.A ATTACHMENT B

2. ALL LADDERS SHALL COMPLY WITH OSHA STANDARDS AS PRESENTED IN 29 CFR 1910.27 AND SHALL BE APPROVED BY NASA OR THEIR REPRESENTATIVE PRIOR TO INSTALLATION

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED, √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	6–30–99
ENGINEER	J. KIRBY	6–30–99
DESIGNED BY	J. KIRBY	6–30–99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

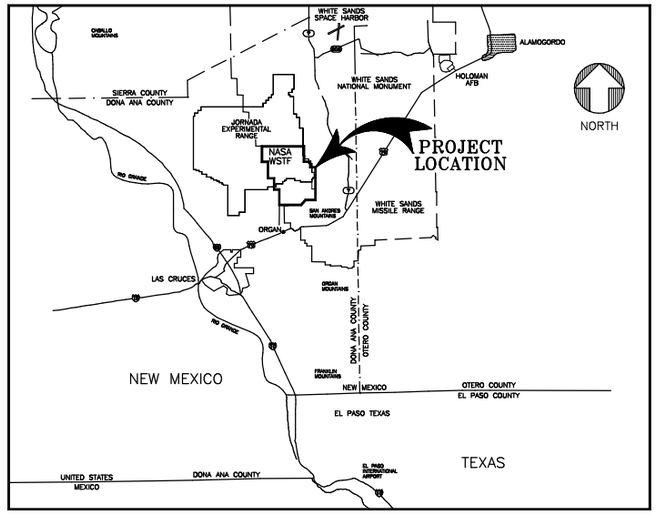
WSTF
PLUME–FRONT REMEDIATION
INDEX OF DRAWINGS
SYMBOLS & ABBREVIATION

A.B. DWG. NO.	SCALE	SHEET	OF
	NONE	1	1

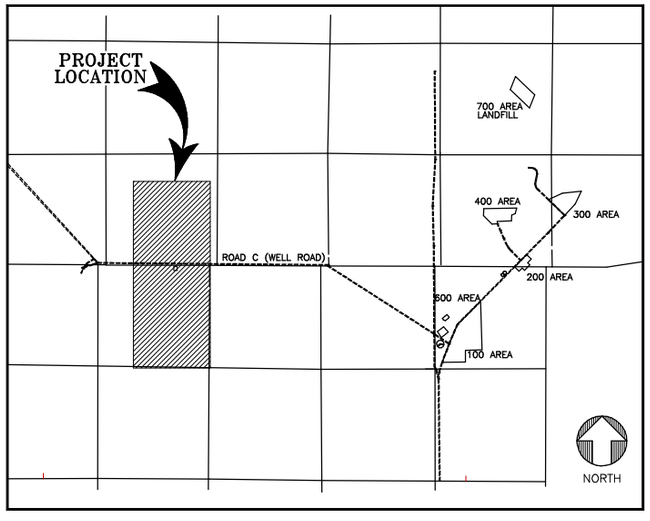
CODE IDENT.	SIZE	DWG. NO.	REV.
	F	652–I–04	

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

GENERAL LOCATION



WSTF LOCATION



SITE LOCATION

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

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.00± FRACTIONS ±
.000±
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DRAWN BY	M. TARIN	7-29-99
ENGINEER	J. KIRBY	7-29-99
DESIGNED BY	J. KIRBY	7-29-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME–FRONT REMEDIATION
PIPING SYSTEM
CIVIL
PROJECT LOCATION

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652–C–01 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

T20S, R3E, SECTION 33

T21S, R3E, SECTION 4

ROAD C (WELL ROAD)

PFE-4A

652-C-15 (PFE-4B)

652-C-14 (PFE-4A)

652-C-03 (N-1)

PFI-4

652-C-19 (PFI-4)

PFE-5

652-C-04 (N-2)

652-C-08 (S-1)

652-C-09 (S-2)

652-C-10 (S-3)

652-C-11 (S-4)

652-C-12 (S-5)

652-C-15 (PFE-4B)

PFE-3

652-C-16 (PFE-5)

652-C-05 (N-3)

652-C-13 (PFE-2)

652-C-17 (PFI-1A)

PFI-3

PFE-2

652-C-06 (N-4)

652-C-20 (PFE-7A)

652-C-18 (PFI-1B)

PFI-2

652-C-07(N-5)

652-C-21 (PFE-7B)

PFE-1

PFE-7

PFI-1

T20S, R3E, SECTION 32

T21S, R3E, SECTION 5

NORTH

750 FEET
500'
250'
0

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
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.000±
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DRAWN BY	M. TARIN	6-21-99
ENGINEER	J. KIRBY	6-21-99
DESIGNED BY	J. KIRBY	6-21-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

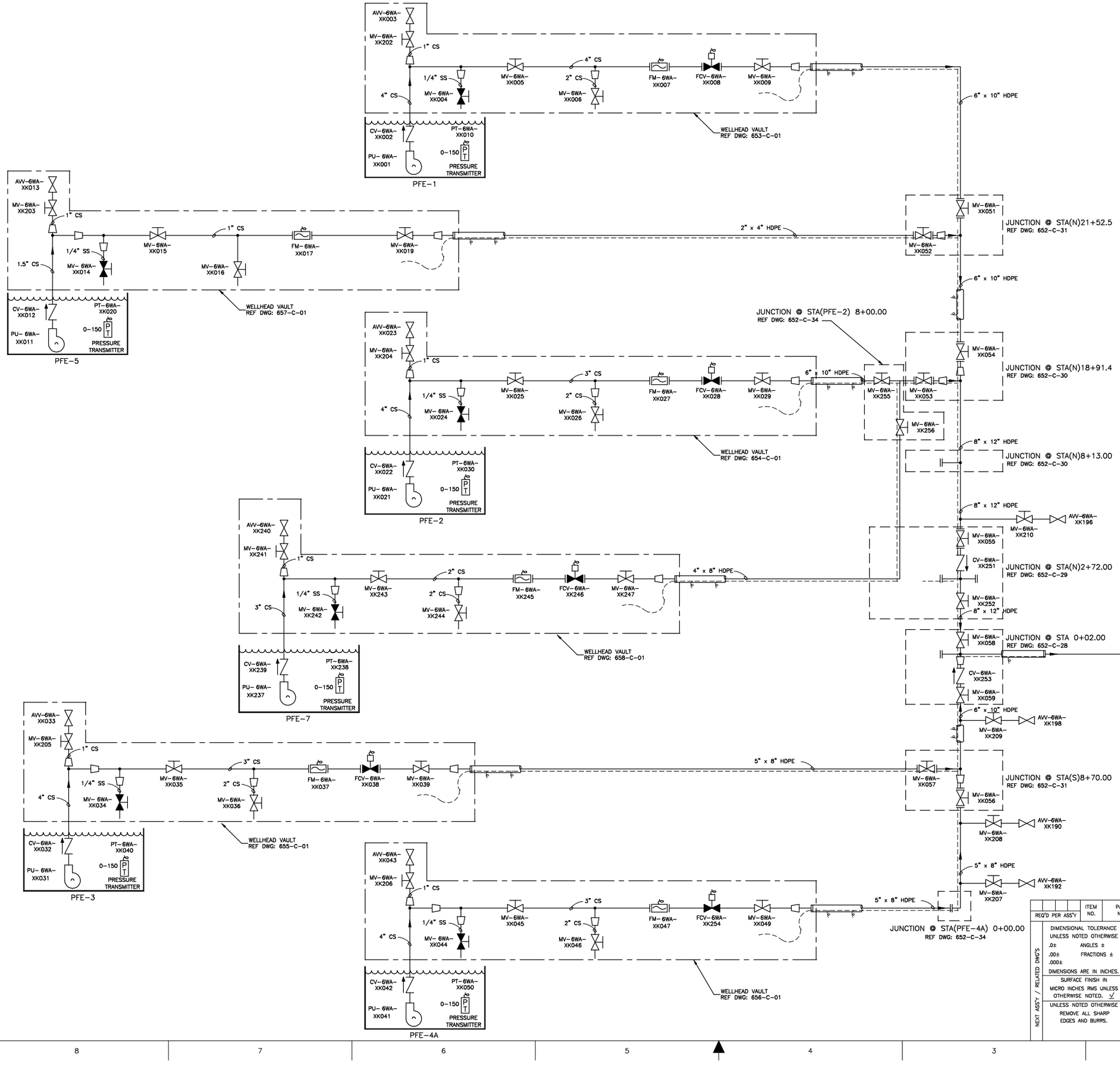
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
PIPING SYSTEM
CIVIL
WELL LOCATIONS & PIPING LAYOUT

A.B. DWG. NO. | SCALE 1"=250' | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-C-02 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASS'Y					

NEXT ASS'Y / RELATED DWG'S

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DRAWN BY	M. TARIN	9-1-99
ENGINEER	J. KIRBY	9-1-99
DESIGNED BY	J. KIRBY	9-1-99
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APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
PIPING SYSTEM
MECHANICAL
FLOW SCHEMATIC

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-M-01 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BUILDING 650

DATA RECORDING & TELEMETRY

AIR STRIPPER #1 (VENDOR SUPPLIED)

VENT TO ATMOSPHERE

TI- 6WA- XK094

TT- 6WA- XK138

FM- 6WA- XK096

FC

FCV- 6WA- XK093 THROTTLE

6" CPVC

6" CS

PT- 6AR- XK229

PI- 6AR- XK230

PS- 6AR- XK231

PS- 6AR- XK232

0-35" WC

MV- 6WA- XK097

FI- 6AR- XK227

FT- 6AR- XK228

0-500" WC VAC

FLS- 6AR- XK089

LLT

LLT- 6WA- XK104

0

PI- 6WA- XK107

PS- 6AR- XK101

BL- 6AR- XK098

LLC- 6WA- XK102

LLC- 6WA- XK103

ROV- 6WA- XK109

MV- 6WA- XK105

ON/OFF

VFD

PU- 6WA- XK106

3" CPVC

2" CPVC

ROV- 6WA- XK110

MV- 6WA- XK119

CV- 6WA- XK108

ROV- 6WA- XK092

FS- 6WA- XK130

FLOOR SUMP

FUTURE

F- 6AR- XK060

AMBIENT AIR

16" PVC

EEW- 6WA- XK185

ES- 6WA- XK062

MV- 6WA- XK184

SCALE CLEANING SYSTEM (VENDOR SUPPLIED)

POTABLE WATER 2" CS

MV- 6WA- XK063

CV- 6CI- XK236

TK- 6CI- XK064

M- 6CI- XK188

MV- 6CI- XK081

PU- 6CI- XK071

CV- 6CI- XK069

CV- 6CI- XK068

MV- 6CI- XK074

MV- 6CI- XK199

LLC- 6CI- XK067

PU- 6CI- XK070

CV- 6CI- XK072

CV- 6CI- XK073

1/4" SS

SCALING CONTROL CHEMICAL METERING SYSTEM (VENDOR SUPPLIED)

MV- 6CI- XK075

TK- 6CI- XK076

2" CS

MV- 6CI- XK200

LLC- 6CI- XK066

MV- 6CI- XK077

PU- 6CI- XK078

CV- 6CI- XK079

CV- 6CI- XK080

1/4" SS

SPENT CLEANING SOLUTION TK- 6WA- XK222

LLC- 6WA- XK065

LLC- 6WA- XK100

2"

MV- 6WA- XK099

AIR STRIPPER #2 (VENDOR SUPPLIED)

INSTRUMENT AIR

AR

UV OXIDATION SYSTEM (VENDOR SUPPLIED)

PSV- 6AR- XK132

PI- 6AR- XK133

PS- 6AR- XK134

90 PSI

0-100 PSI

40-85 PSI

AVV- 6WA- XK018

MV- 6WA- XK136

PU- 6AR- XK131

MV- 6AR- XK135

COMPRESSED AIR

TK- 6WA- XK141

PI- 6WA- XK137

0-100 PSI

ECV- 6WA- XK187

MV- 6WA- XK139

FM- 6WA- XK140

RD- 6WA- XK186 100 PSI

DRAIN

AVV- 6WA- XK189

MV- 6WA- XK201

ROV- 6WA- XK143

MV- 6WA- XK144

ON/OFF

FC

MV- 6WA- XK142

10" HDPE TO INJECTION WELLS REF DWG: 652-M-03

10"X16" HDPE FROM EXTRACTION WELLS REF DWG: 652-M-01

0-100 PSI PI- 6WA- XK083

MV- 6WA- XK082

8" CS

WA

SM- 6WA- XK087

MV- 6WA- XK086

MV- 6WA- XK258

LLS- 6WA- XK235

LEAK DETECTION CONTROL PANEL

F- 6AR- XK088

AMBIENT AIR

FM- 6WA- XK116

FCV- 6WA- XK112 THROTTLE

PT- 6AR- XK223

PI- 6AR- XK224

PS- 6AR- XK225

PS- 6AR- XK226

MV- 6WA- XK113

TI- 6WA- XK114

TT- 6WA- XK115

FI- 6AR- XK084

FT- 6AR- XK085

FLS- 6AR- XK118

PS- 6AR- XK120

BL- 6AR- XK117

LLC- 6WA- XK121

LLC- 6WA- XK122

LLT- 6WA- XK123

PI- 6WA- XK126

ROV- 6WA- XK128

MV- 6WA- XK124

PU- 6WA- XK125

ROV- 6WA- XK111

MV- 6WA- XK061

ROV- 6WA- XK129

CV- 6WA- XK127

CV- 6WA- XK145

ROV- 6WA- XK257

MV- 6WA- XK146

MV- 6WA- XK090

CV- 6WA- XK091

(TEMPORARY) TK- 6WA- XK148

MV- 6WA- XK150

MV- 6WA- XK147

PU- 6WA- XK149

MV- 6WA- XK151

TS- 6AR- XK233

TS- 6AR- XK234

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

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.000±
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UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	9-1-99
ENGINEER	J. KIRBY	9-1-99
DESIGNED BY	J. KIRBY	9-1-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

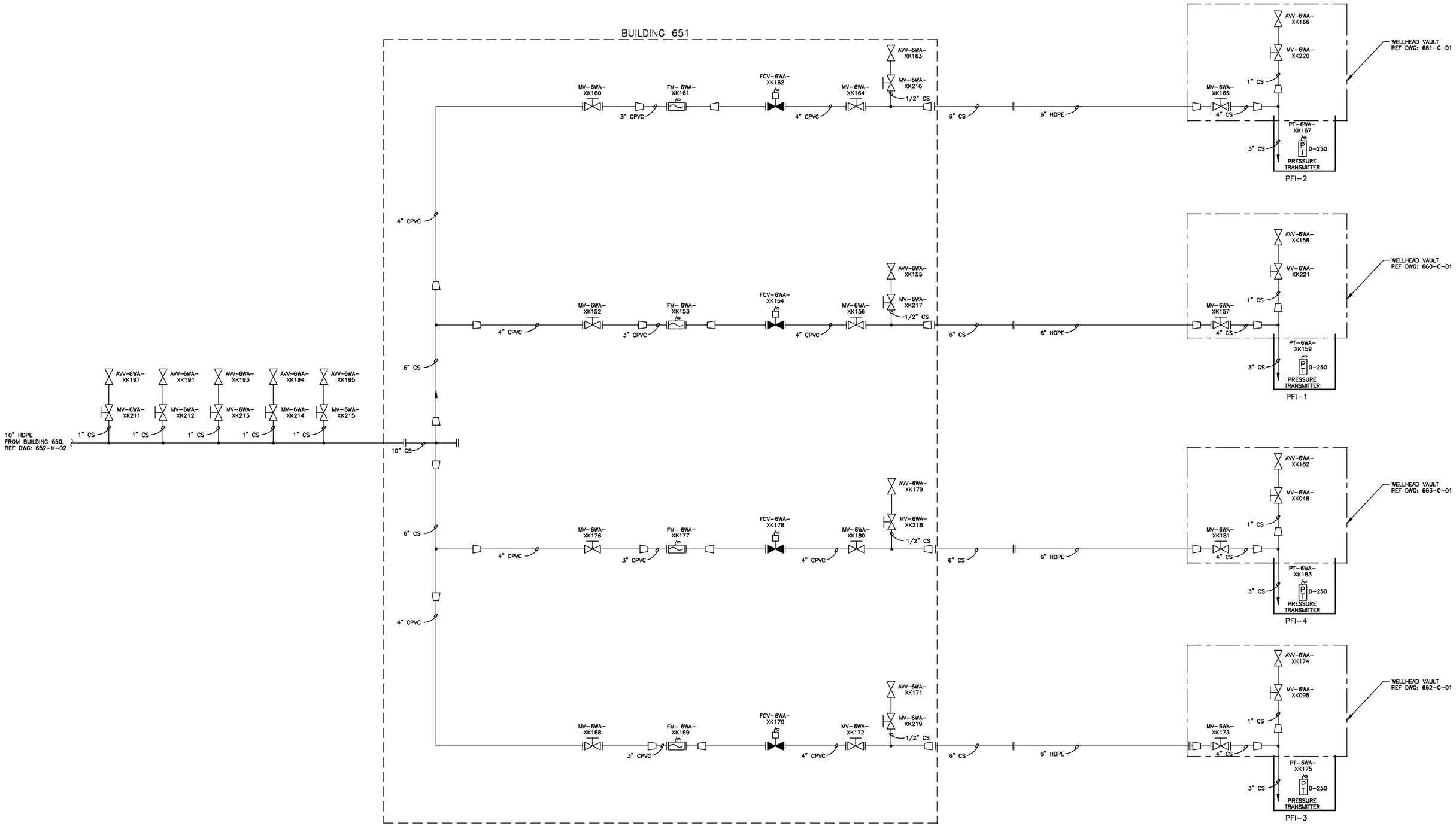
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION PIPING SYSTEM MECHANICAL FLOW SCHEMATIC

A.B. DWG. NO.	SCALE	SHEET	OF
	NONE	1	1

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	652-M-02	

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



NOTES:

1. ALL CPVC PIPE SHALL BE SCH 80.

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

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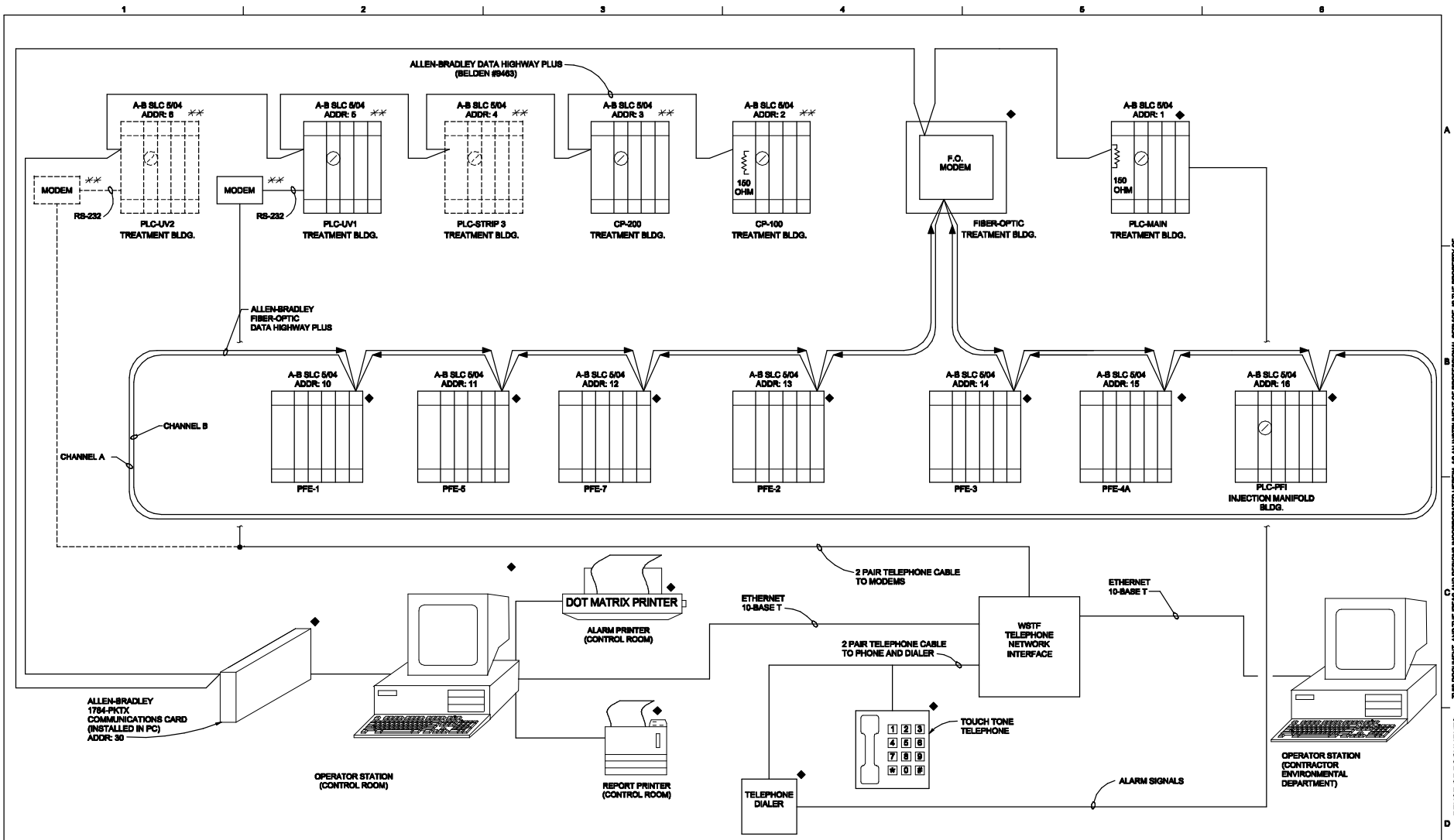
ENGINEER	J. KIRBY	9-1-99
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
PIPING SYSTEM
MECHANICAL
FLOW SCHEMATIC

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	652-M-03	

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1



90% REVIEW

PRELIMINARY

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DSGN K. MAYEUX						VERIFY SCALE	CH2MHILL
DR E. KRISTEL						BAR IS ONE INCH ON ORIGINAL DRAWING. IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.	
CHK Checked_By							
APVD Approved_By	NO.	DATE	REVISION	BY	APVD		

WHITE SANDS TEST FACILITY
PLUME FRONT
REMEDIATION SYSTEM
LYNDON B. JOHNSON SPACE CENTER

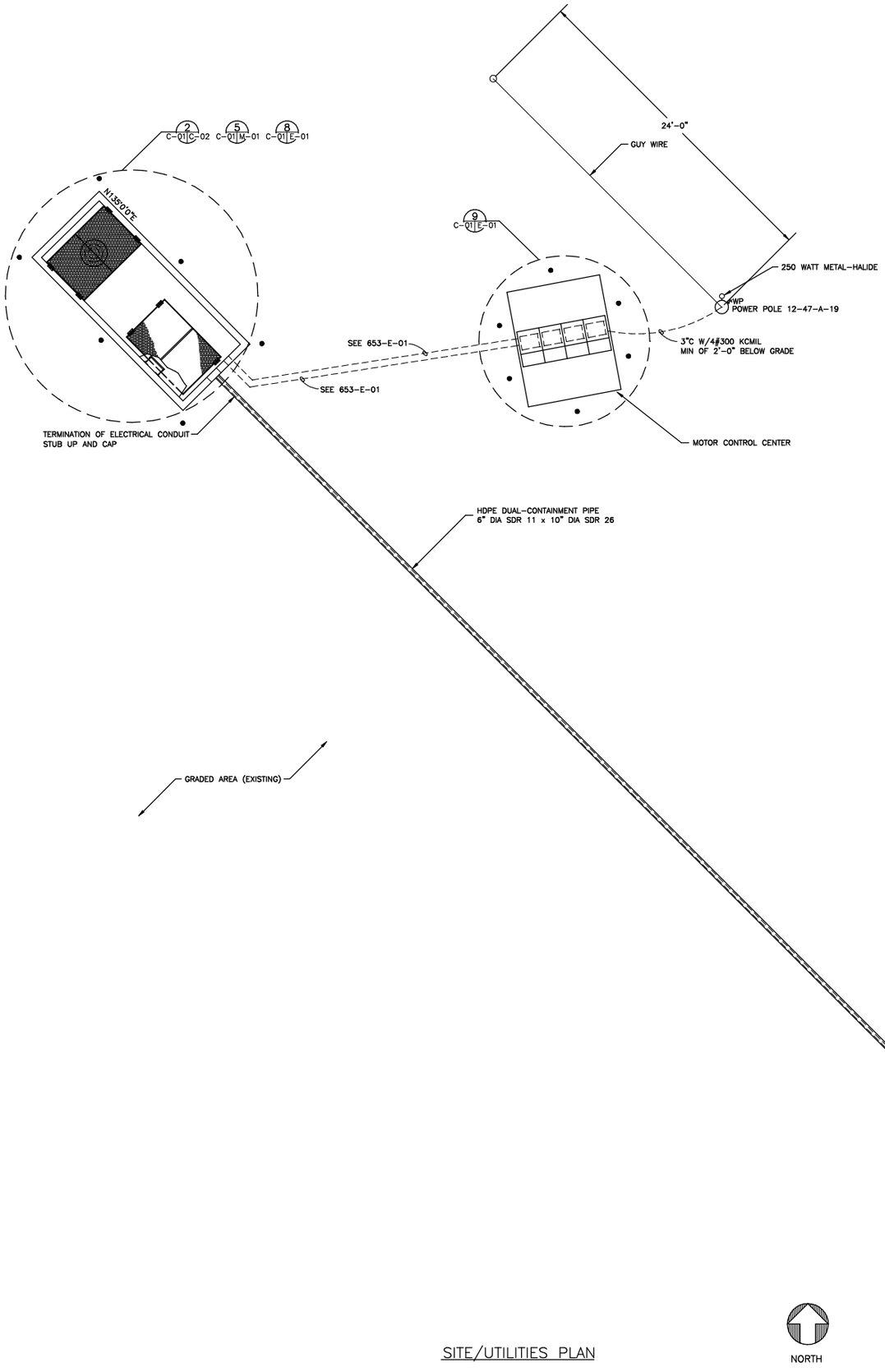
PROCESS INSTRUMENTATION AND CONTROLS

PLC SYSTEM DIAGRAM

SHEET	Sheet
DWG NO.	G-3
DATE	NOV 2000
PROJ NO.	163902

3902g003.dwg 18-Sep-2001 20:47:04

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

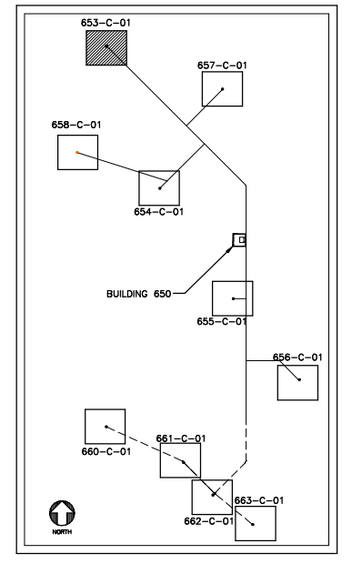


SITE/UTILITIES PLAN

NORTH

0 4 8 12 FEET

KEY



ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
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NEXT ASS'Y / RELATED DWG'S.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

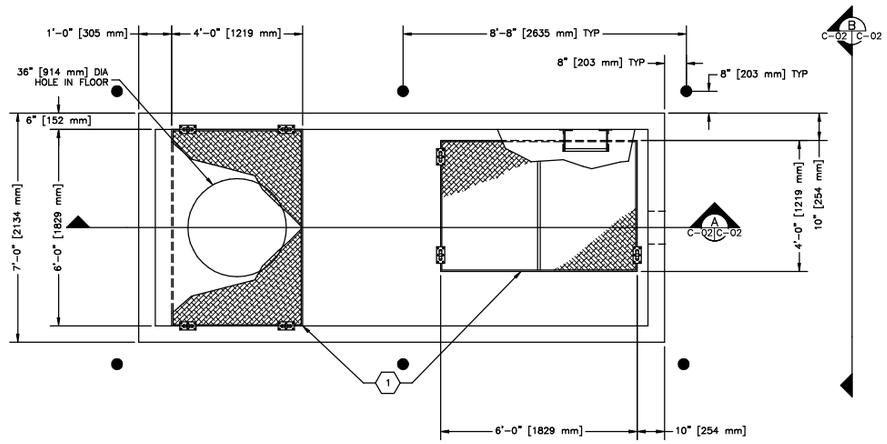
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
CIVIL
SITE/UTILITIES PLAN

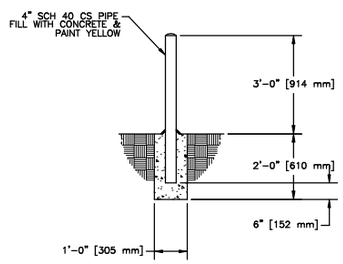
A.B. DWG. NO. | SCALE 1"=4'-0" | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 653-C-01 | REV.

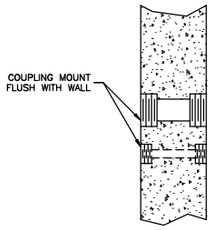
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



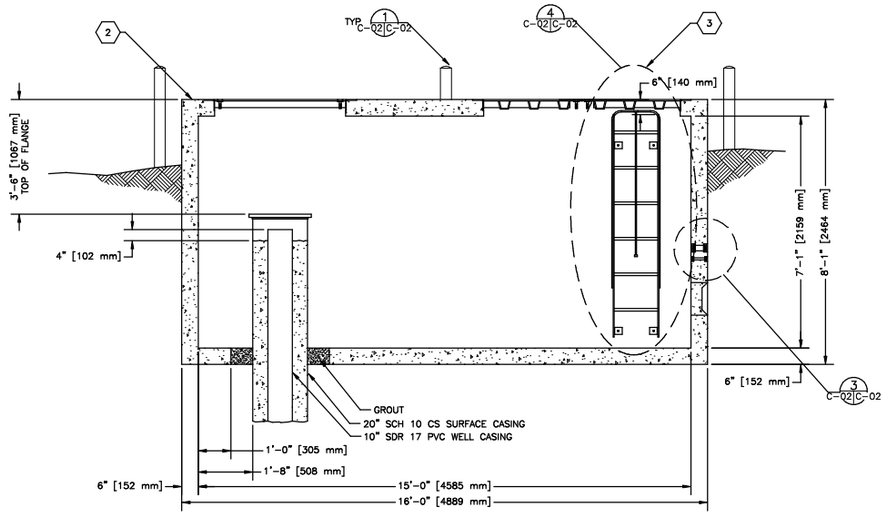
2 C-02 C-01 DETAIL: PFE-1 EXTRACTION WELL VAULT



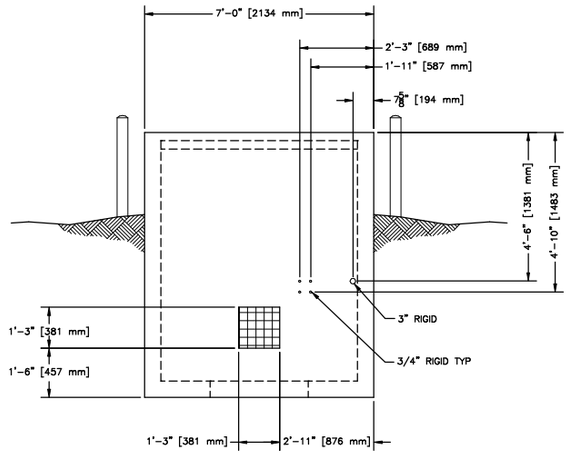
1 C-02 C-02 DETAIL: BOLLARD



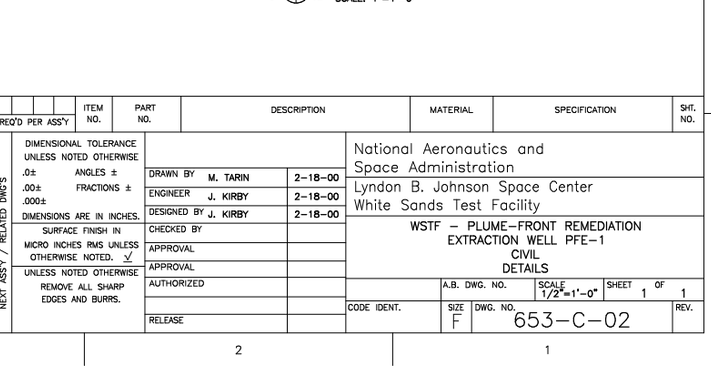
3 C-02 C-02 DETAIL: PENETRATIONS
NTS



A C-02 C-02 SECTION



B C-02 C-02 VIEW



4 C-02 C-02 DETAIL: LADDER
SCALE: 1"=1'-0"

KEYED NOTES:

1. UTILITY VAULT, CATALOG #4872 OR EQUIVALENT WEATHER-TIGHT DOUBLE TORSION DOOR
2. UTILITY VAULT, CATALOG #615-TA-M OR EQUIVALENT PRE-CAST CONCRETE VAULT
3. UTILITY VAULT, BOLT-ON ALUMINUM LADDER W/PULL-UP EXTENDER OR EQUIVALENT

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

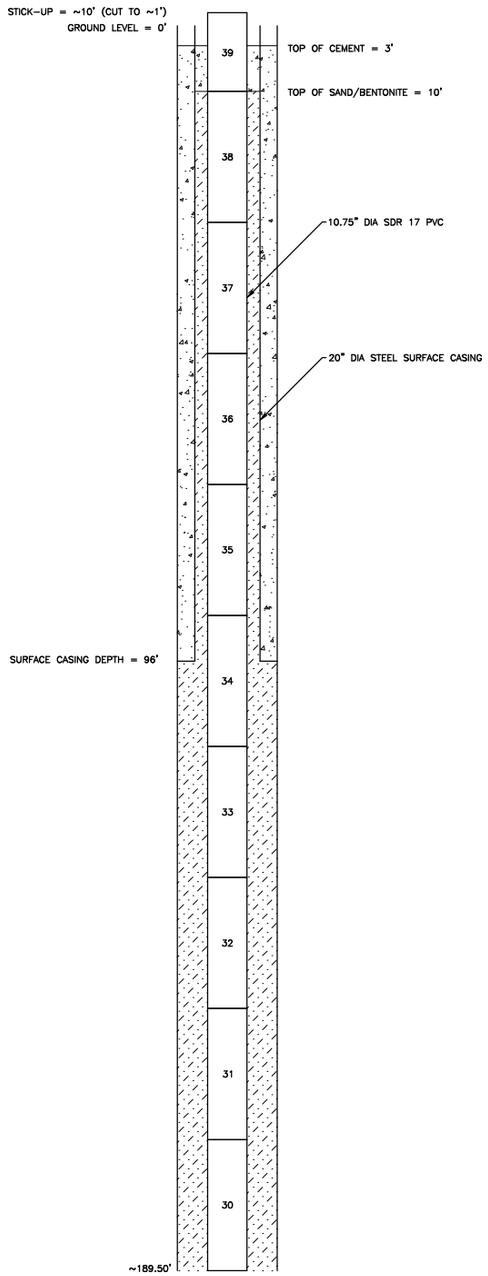
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

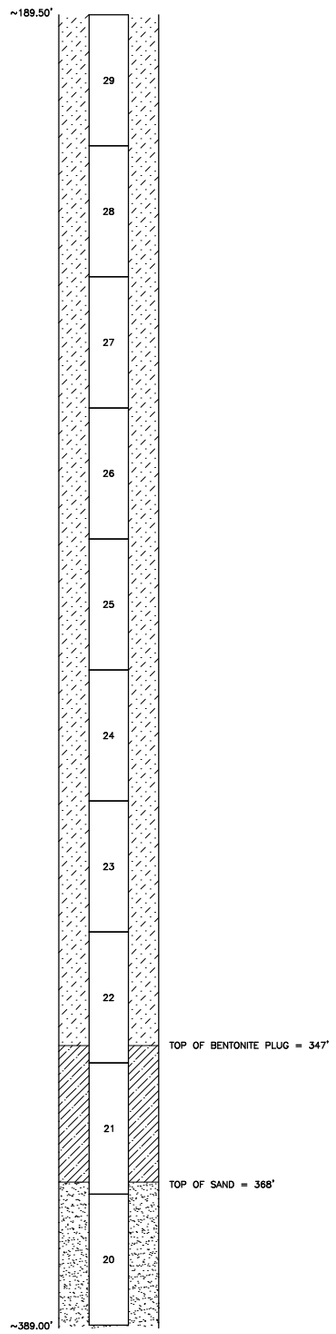
WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
CIVIL
DETAILS

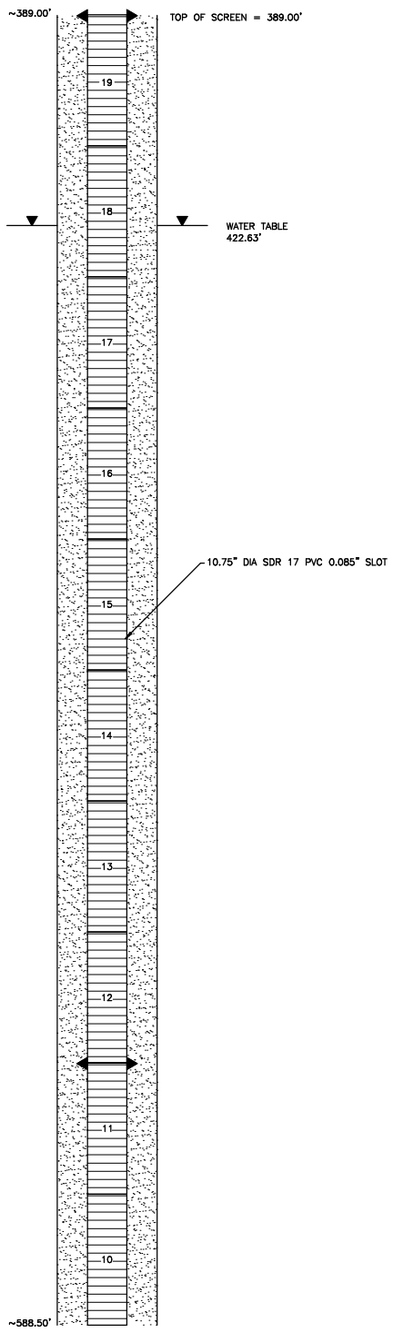
CODE IDENT.	SIZE	DWG. NO.	REV.
	F	653-C-02	

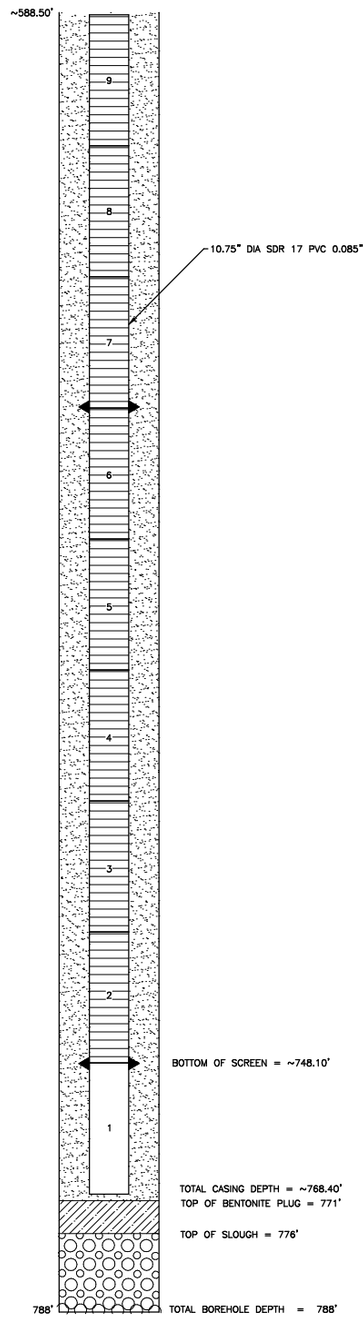
A.B. DWG. NO. | SCALE 1/2"=1'-0" | SHEET 1 OF 1

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL









NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE

4/8 SAND

SLOUGH

4/8 SAND/BENTONITE MIX

GROUT

SCREEN

STEEL, BOLT-ON CENTRALIZER

ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASS'Y					

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

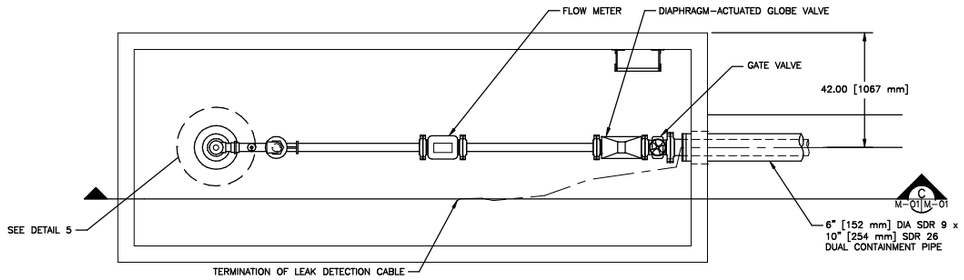
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
CIVIL
WELL COMPLETION DIAGRAM

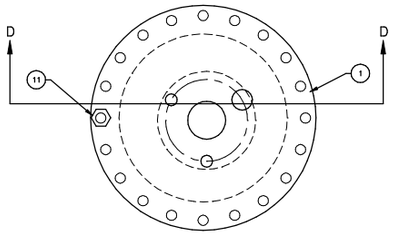
A.B. DWG. NO.	SCALE	SHEET OF
	NONE	1 1

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	653-C-03	

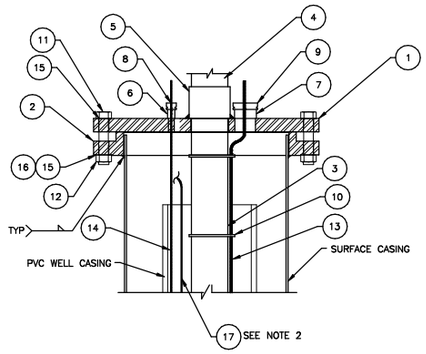
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



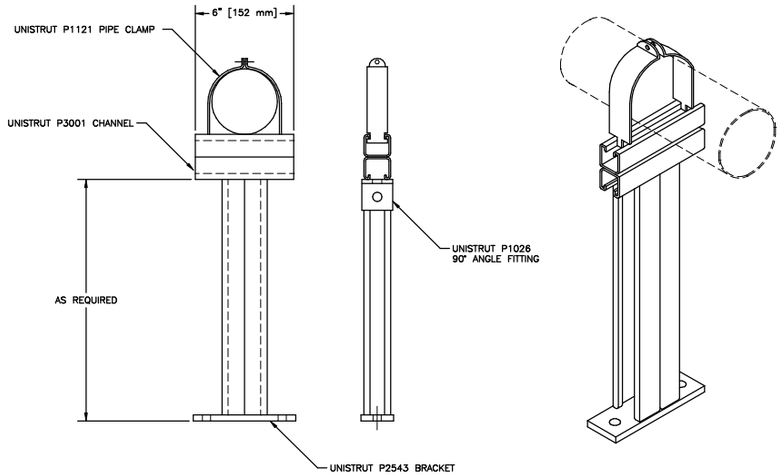
5 M-01 C-01 DETAIL: PFE-1 EXTRACTION WELL VAULT



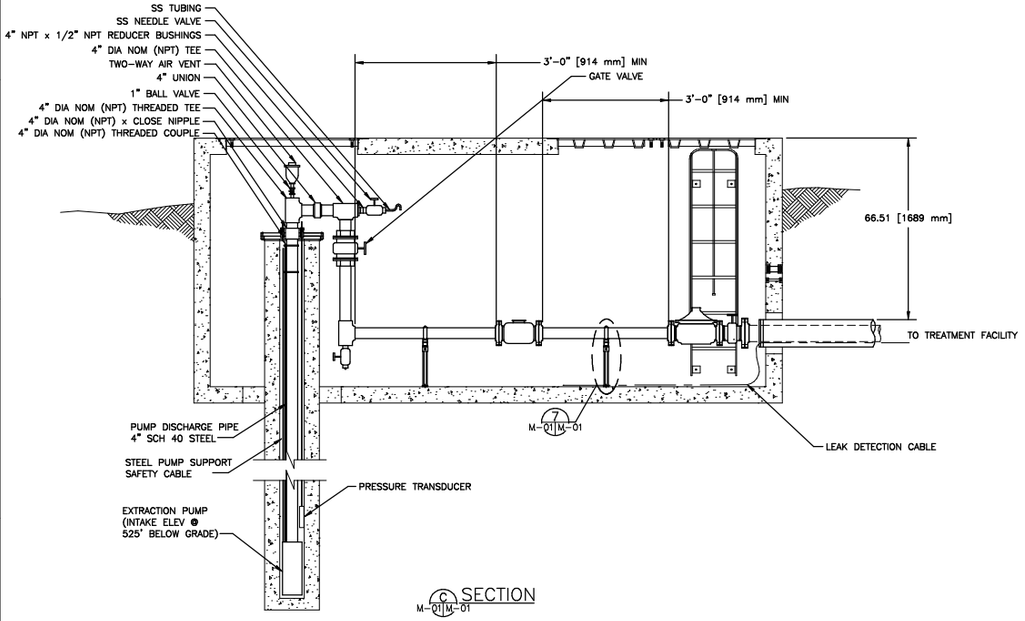
DETAIL 6: WELLHEAD ASSEMBLY
SCALE: 1/8=1



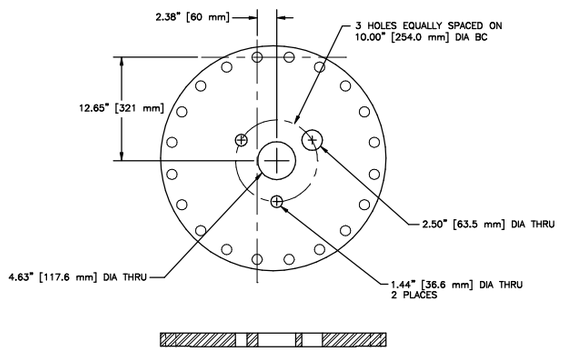
SECTION D-D



7 M-01 M-01 DETAIL: PIPE SUPPORT
SCALE: 1/4=1



C M-01 M-01 SECTION



1 BLIND FLANGE
SCALE: 1/8=1

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER
2. SAFETY CABLE TERMINATION AND SECURING METHOD SHALL BE DETERMINED BY PUMP INSTALLATION CONTRACTOR.

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
1	17		SAFETY CABLE, 0.5" DIA	CS		
4	16		WASHER, LOCK, 1.125" DIA	CS		
8	15		WASHER, FLAT, 1.125" DIA	CS		
	14		TRANSDUCER CABLE	CU		
	13		PUMP POWER CABLE	CU		
4	12		NUT, 1.125" DIA	CS		
4	11		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
	10		STRAP	SS		
1	9		STRAIN RELIEF CONNECTOR, 2"	SS		
1	8		STRAIN RELIEF CONNECTOR, 1"	SS		
1	7		COUPLING, 2" NPT, SCH 80	CS		
2	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		COUPLING, 4" ASTM	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		NIPPLE, 4" NPT x CLOSE	CS		
1	3		DROP PIPE, 4" DIA x 525', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
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.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

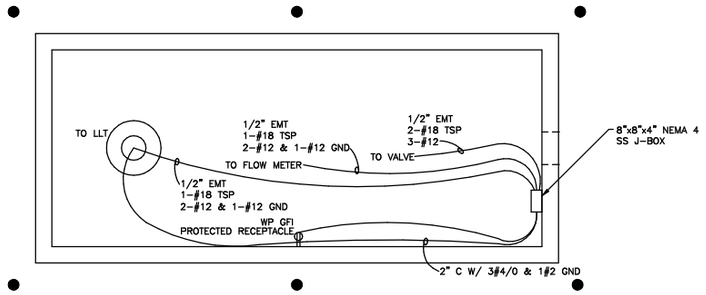
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
MECHANICAL
DETAILS

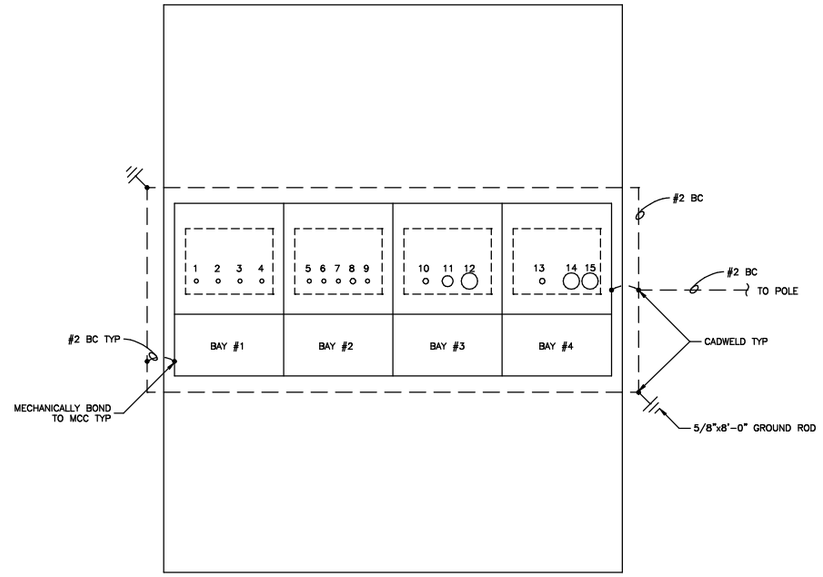
A.B. DWG. NO. | SCALE 1/2"=1'-0" | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 653-M-01 | REV.

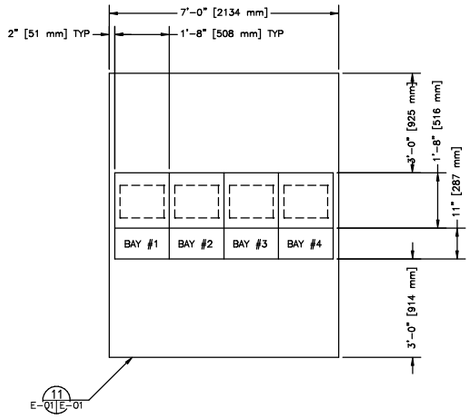
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

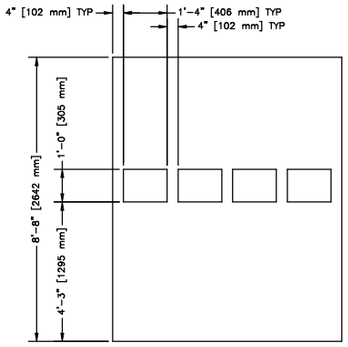


8 C-02 C-01 DETAIL: PFE-1 EXTRACTION WELL VAULT



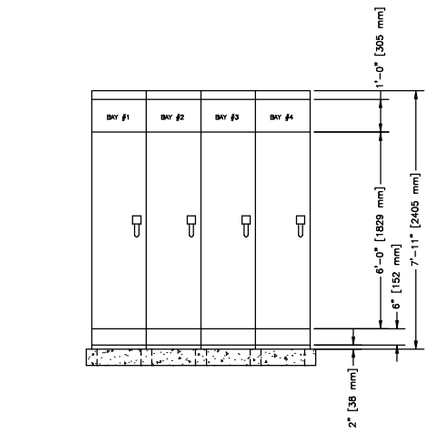
11 E-01 E-01 DETAIL: CONDUIT LOCATIONS & GROUNDING
SCALE: 1"=1'-0"



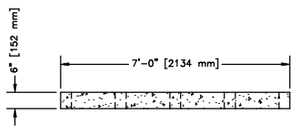


CONDUIT NUMBER	CONDUIT SIZE	FROM	TO	CONDUCTORS
1	3/4"	BAY 1	PFE-1 VAULT	2#14 AWG, 5#18 AWG TSP
2	3/4"	BAY 1	PFE-1 VAULT	SPARE
3	3/4"	BAY 1	SLAB EDGE (WEST)	SPARE
4	3/4"	BAY 1	SLAB EDGE (WEST)	SPARE
5	3/4"	BAY 2	SLAB PFE-1 VAULT	4#12 & 1#12 GND
6	3/4"	BAY 2	SLAB PFE-1 VAULT	4#12 & 1#12 GND
7	3/4"	BAY 2	SLAB PFE-1 VAULT	SPARE
8	1"	BAY 2	SLAB PFE-1 VAULT	SPARE
9	3/4"	BAY 2	POLE	2#12 & 1#12 GND
10	1"	BAY 3	SLAB EDGE (WEST)	SPARE
11	2"	BAY 3	PFE-1 PUMP	3#4/0 & 1#2 GND
12	3"	BAY 3	SLAB EDGE (WEST)	SPARE
13	1"	BAY 4	SLAB EDGE (WEST)	SPARE
14	3"	BAY 4	POLE	4#4/0
15	3"	BAY 4	POLE	4#4/0

CONDUIT SCHEDULE



9 C-01 E-01 MOTOR CONTROL CENTER ELEVATION



10 E-01 E-01 DETAIL: CONCRETE PAD

NOTES:
1. REFERENCE 653-C-02 FOR PENETRATION DETAILS
2. ALL TSP CONDUCTORS SHALL BE 18 AWG
3. ALL POWER CONDUCTORS #12 & UP SHALL BE TYPE THHN

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
ELECTRICAL
DETAILS

A.B. DWG. NO. | SCALE 1/2"=1'-0" | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 653-E-01 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BAY #1	BAY #2	BAY #3	BAY #4
RELAY CABINET FOR PLC CONTROLLER	FVNR NEMA SIZE 2	BLANK	C/B 50A COMPAC
			BLANK
	PANEL 3ø, 18 CKT 120/208V 100A MLO	SSRV CONTROLLER C/B * 150 HP	BLANK
			METER (1)
	XFMR 15 KVA 3ø 4W 25A C/B (480V) 40A C/B (208V)		TVSS 30A C/B (2)
			MAIN 450A C/B

* TO BE SIZED BY MANUFACTURER TO PROVIDE PROPER SHORT CIRCUIT PROTECTION OF MOTOR IT IS TO PROTECT.

SCHEDULE – MOTOR CONTROL CENTER
480 VAC, 3ø, 4W, 42KA, NEMA 3R
600A INCOMING, 600A HORIZONTAL, 300A VERTICAL

SECTION/UNIT LOCATION	DESC	NEMA SIZE	CB TRIP (A)	AUX INTLKS NO	AUX INTLKS NC	SELECTOR SWITCHES	INDICATING LIGHTS	IDENTIFICATIONS
1								
2A	FVNR	2	70	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	SPARE
2E	C/B		40					100A, 3ø, 18 CKT, PNL
2N	C/B		25					15 KVA, 3ø, 4W, XFMRS
3A								
3D	SSRV	N/A	*	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	PFE-1 PUMP
4A	C/B		50					SPARE
4C								
4G								
4K								METER (1)
4P			30					TVSS (2)
4T			450					MAIN

KEYED NOTES:

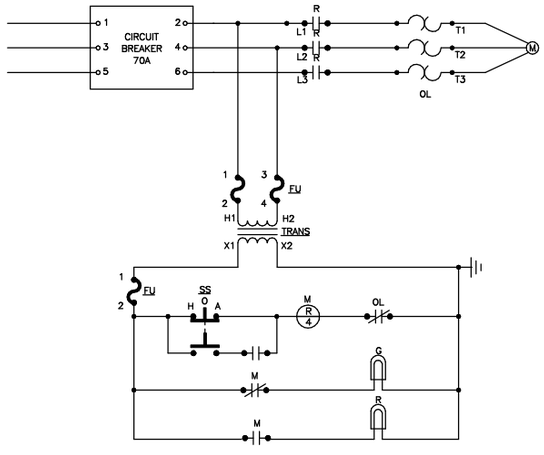
(1) FURNISH STANDARD METER SLOT OPENING IN FRONT OF MCC'S PANEL COVER. PROIVDE CLEAR PLASTIC WEATHER PROOF COVER OVER OPENING. METER DEVICE AND ASSOCIATED CT'S AND PT'S TO BE FURNISHED AND INSTALLED BY OTHERS.

(2) FURNISH MANUFACTURER'S STANDARD TVSS PROTECTION INTEGRAL WITH MCC.

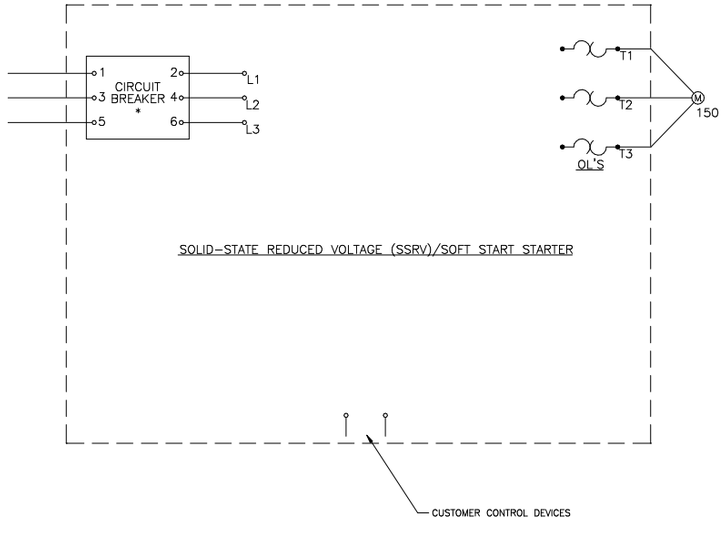
SCHEDULE – PANEL "LA"

BUILDING: PFE-1	LOCATION: MCC	PHASE: 3
TYPE:	FEED:	WIRE: 4
MANUFACTURER:	SC RATING: 10,000	VOLTAGE: 120/208
MODEL:	MAIN AMPS:	MOUNTING: INTERNAL TO MCC
CONFIGURATION:	PANEL AMPS: 100 MLO COPPER	

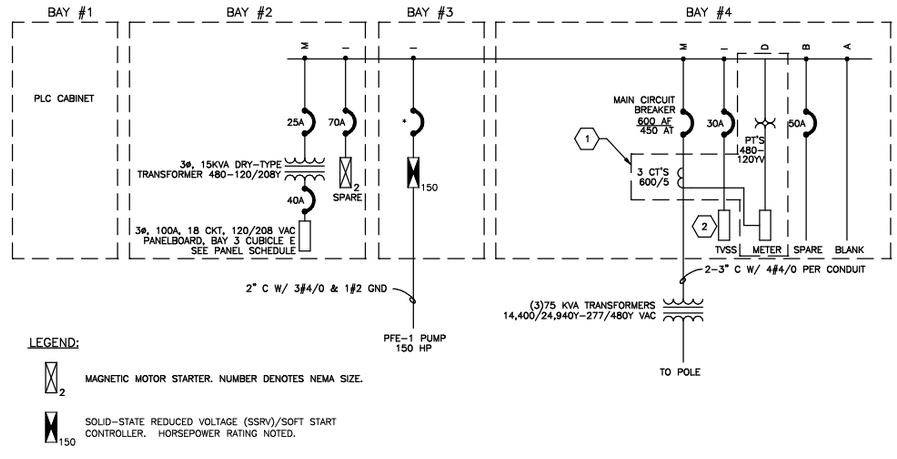
CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	ø LOAD (AMPS) A	B	C	CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	ø LOAD (AMPS) A	B	C
1	1	20	PLC POWER	10			2	1	–	SPACE ONLY			
3	1	20	PLC RECEPT		1.5		4	1	–				
5	1	20	PFE-1 VAULT RECEPT			1.5	6	1	–				
7	1	20	PFE-1 FLOW METER	.83			8	1	–				
9	1	20	MCC RECEPT		1.5		10	1	–				
11	1	20	SPARE				12	1	–				
13	1	20	SPARE				14	1	–				
15	1	–	SPACE ONLY				16	1	–				
17	1	–	↓				18	1	–	↓			
TOTAL CONNECTED LOAD PER PHASE, AMPS							TOTAL CONNECTED LOAD PER PHASE, AMPS						
TOTAL CONNECTED LOAD 3-PHASE, AMPS							TOTAL CONNECTED LOAD 3-PHASE, AMPS						



SPARE



PFE-1 PUMP



MOTOR CONTROL CENTER ONE-LINE DIAGRAM

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

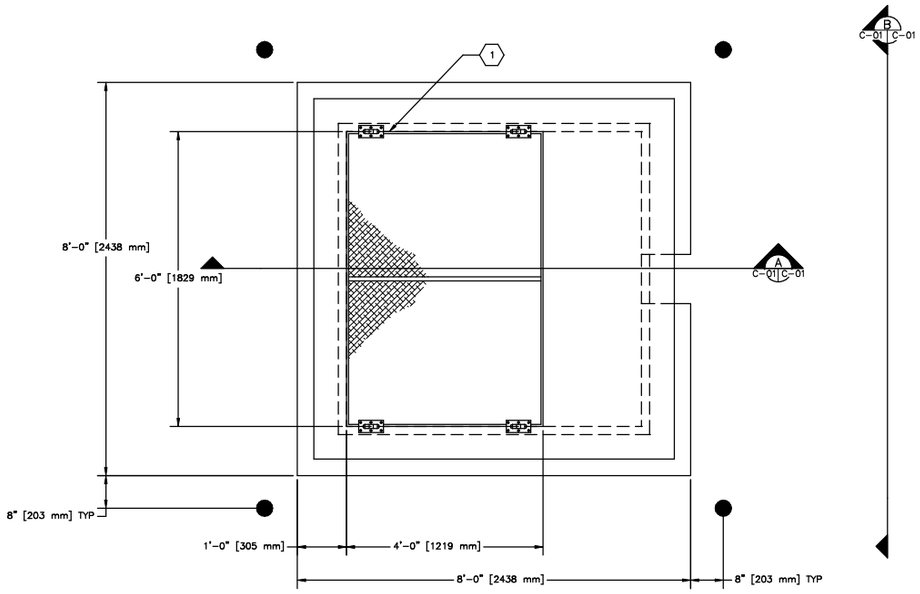
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
ELECTRICAL
DETAILS

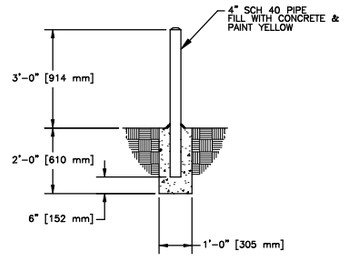
A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 653-E-02 | REV.

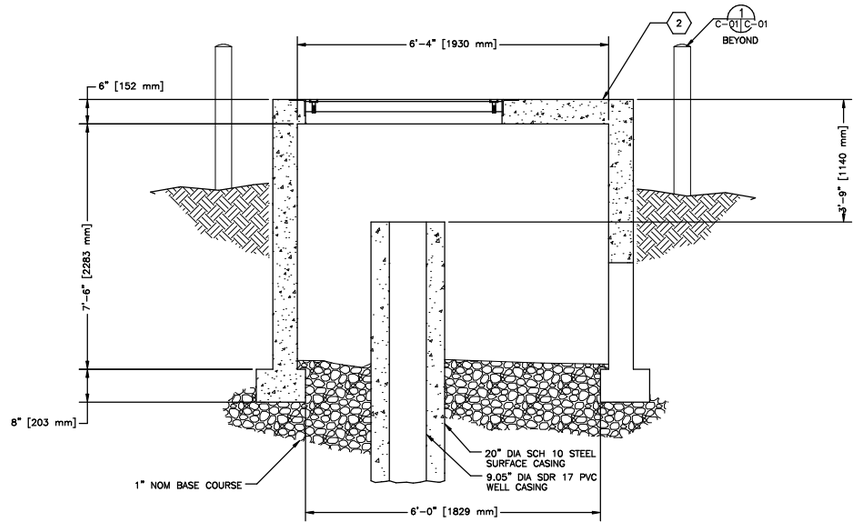
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



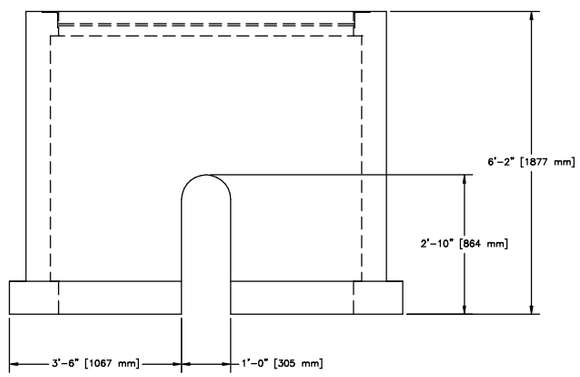
PFI-1 INJECTION WELLHEAD



1 C-01 C-01 DETAIL: BOLLARD

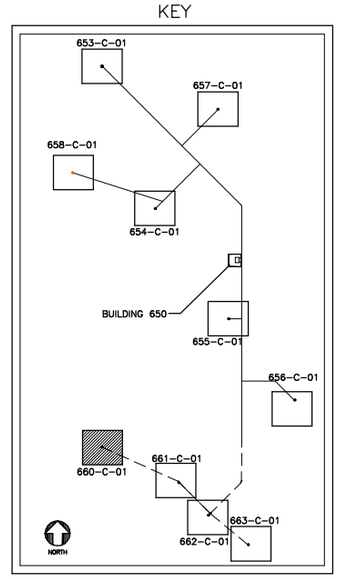


A C-01 C-01 SECTION



B C-01 C-01 VIEW

KEY



NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER

KEYED NOTES:

1. UTILITY VAULT, CATALOG #4872 OR EQUIVALENT WEATHER-TIGHT DOUBLE TORSION DOOR
2. UTILITY VAULT, CATALOG #6464-WA OR EQUIVALENT PRE-CAST CONCRETE VAULT

ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASS'Y					

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-25-00
ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

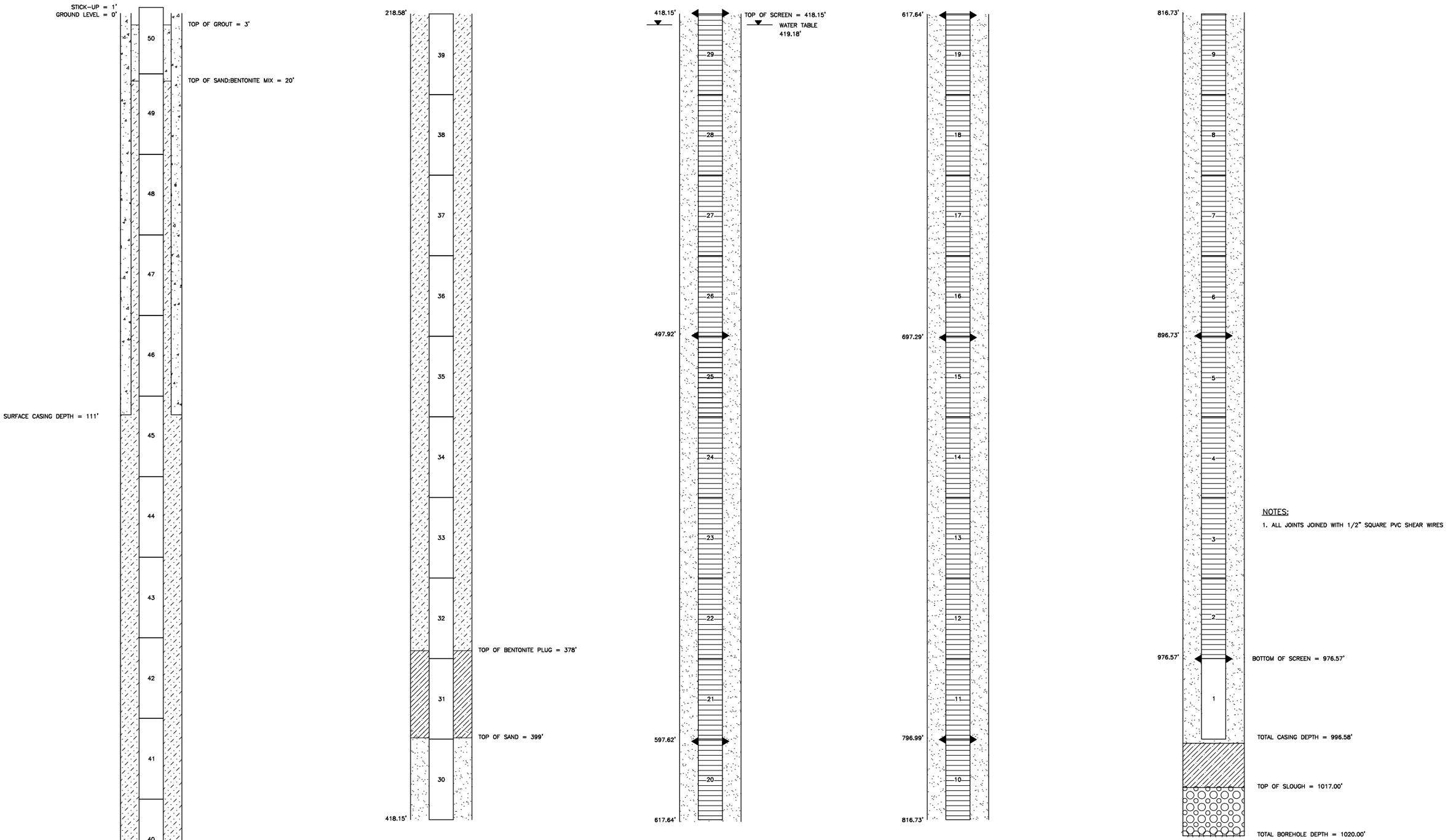
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION
INJECTION WELL PFI-1
CIVIL
DETAILS AT WELLHEAD

A.B. DWG. NO. | SCALE 3/4"=1'-0" | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 660-C-01 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
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UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

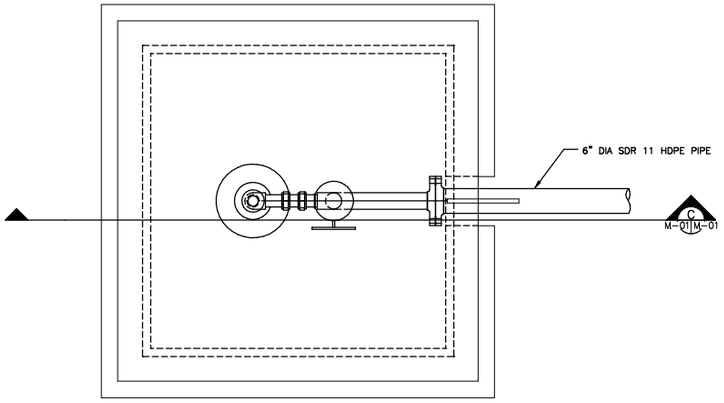
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
INJECTION WELL PFI-1
CIVIL
WELL COMPLETION DIAGRAM

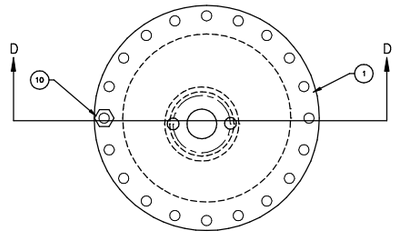
A.B. DWG. NO.	SCALE	SHEET	OF
	NONE	1	1

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	660-C-02	

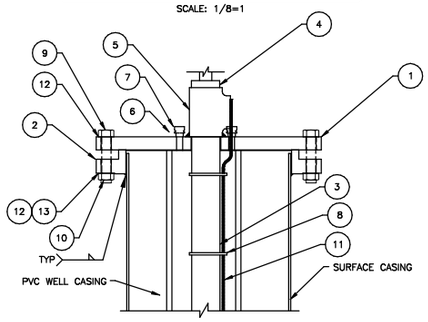
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



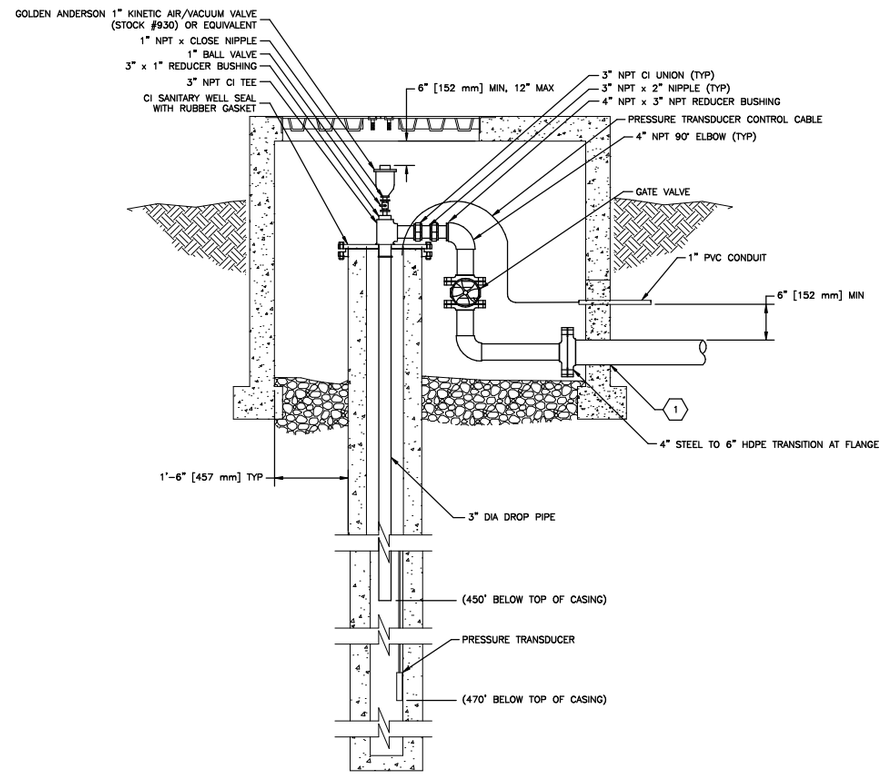
PFI-1 INJECTION WELLHEAD



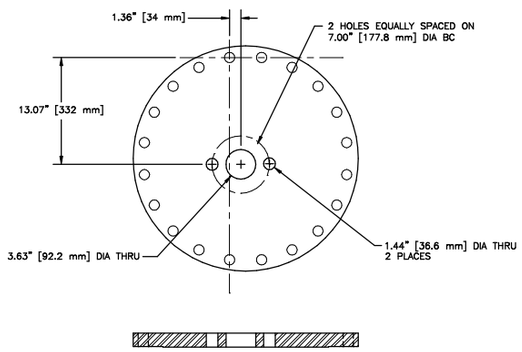
DETAIL 6: WELLHEAD ASSEMBLY
SCALE: 1/8=1



SECTION D-D



C SECTION
M-01 M-01



1 BLIND FLANGE
SCALE: 1/8=1

KEYED NOTES:

1. FOLLOWING PIPE INSTALLATION INTO VAULT, SLOTTED ENTRY SHALL BE FORMED OVER AND FILLED WITH CONCRETE

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
4	13		WASHER, LOCK, 1.125" DIA	CS		
8	12		WASHER, FLAT, 1.125" DIA	CS		
	11		TRANSDUCER CABLE	CU		
4	10		NUT, 1.125" DIA	CS		
4	9		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
	8		STRAP	SS		
2	7		STRAIN RELIEF CONNECTOR, 1"	SS		
2	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		TEE, 3"	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		REDUCER BUSHING, 3" x 1"	CS		
1	3		DROP PIPE, 3" DIA x 450', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
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UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

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ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

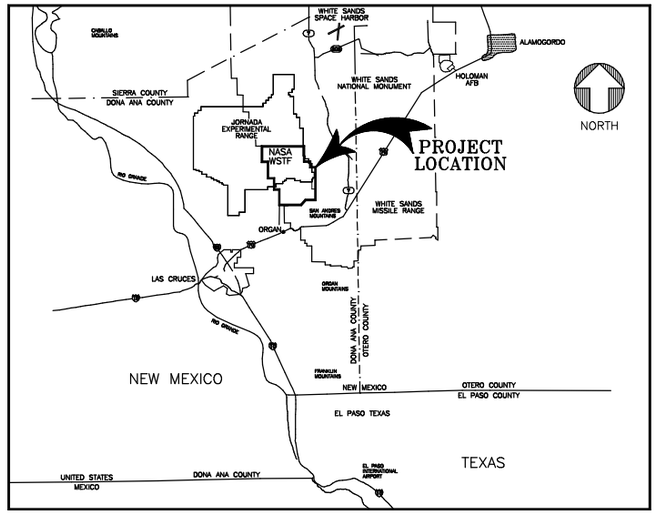
WSTF - PLUME-FRONT REMEDIATION
INJECTION WELL PFI-1
MECHANICAL
DETAILS AT WELLHEAD

A.B. DWG. NO. | SCALE 3/4"=1'-0" | SHEET 1 OF 1

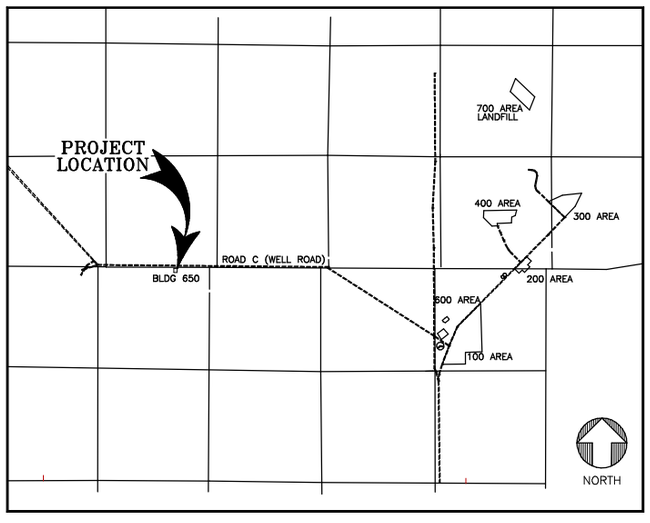
CODE IDENT. F | SIZE | DWG. NO. 660-M-01 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

GENERAL LOCATION



WSTF LOCATION



SITE LOCATION

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

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.00± FRACTIONS ±
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DRAWN BY	M. TARIN	7-29-99
ENGINEER	E. BAGWELL	7-29-99
DESIGNED BY	E. BAGWELL	7-29-99
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APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

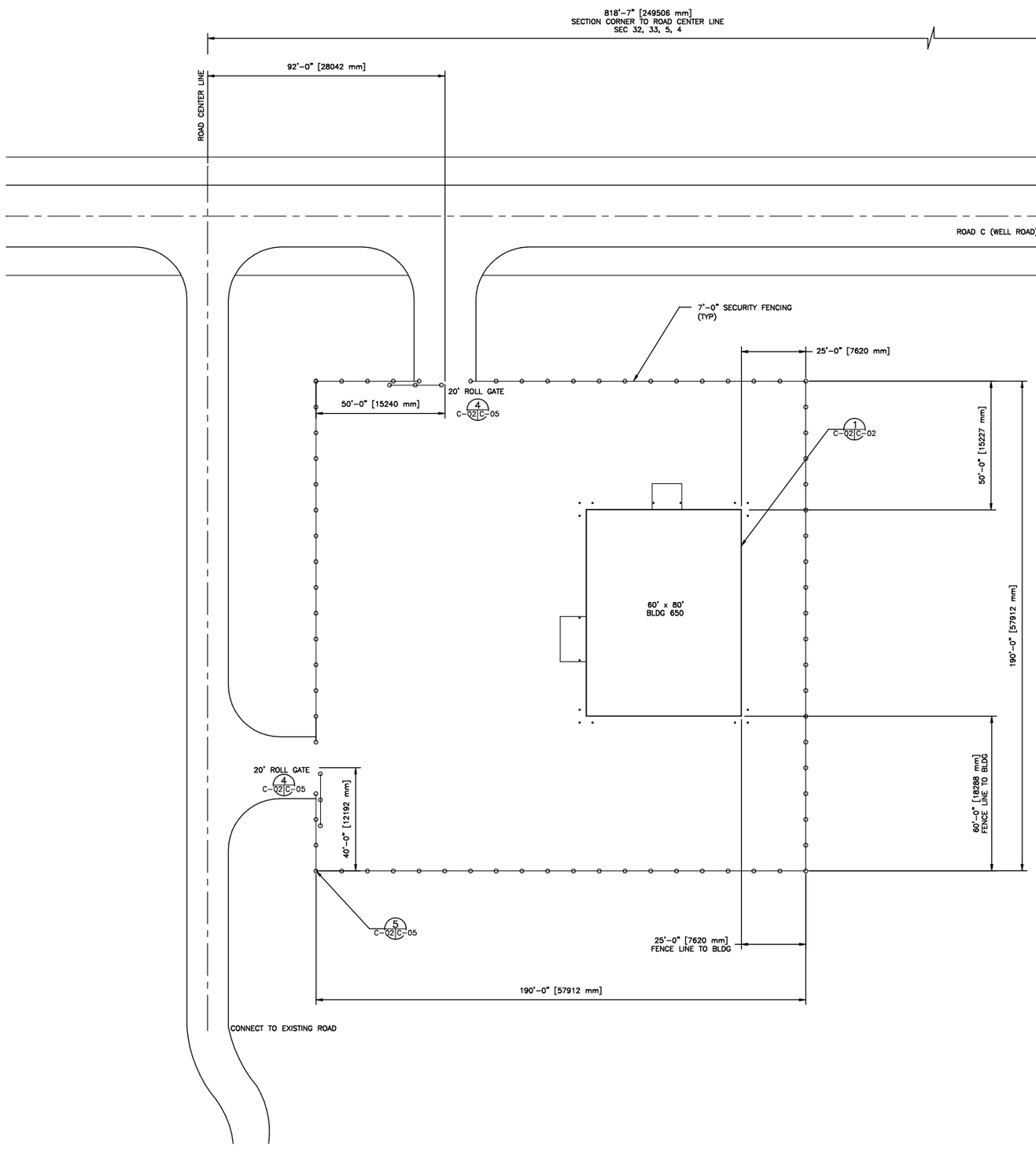
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

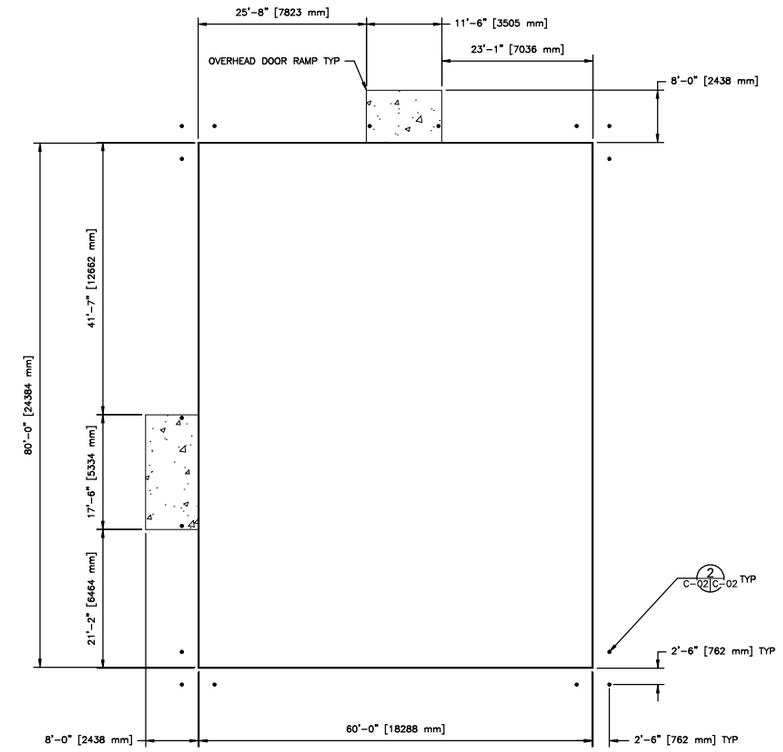
WSTF – PLUME–FRONT REMEDIATION
BUILDING 650, TREATMENT FACILITY
CIVIL
PROJECT LOCATION

A.B. DWG. NO.	SCALE	SHEET	OF
	NONE	1	1

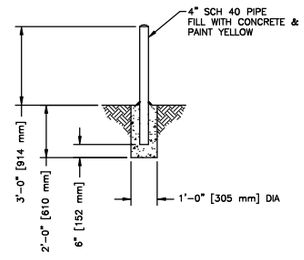
CODE IDENT.	SIZE	DWG. NO.	REV.
	F	650–C–01	

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL





1 C-02|C-02 DETAIL: RAMP & BOLLARD LOCATIONS



2 C-02|C-02 DETAIL: BOLLARD

NORTH

0 20 40 60 FEET

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

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.0± ANGLES ±
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APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

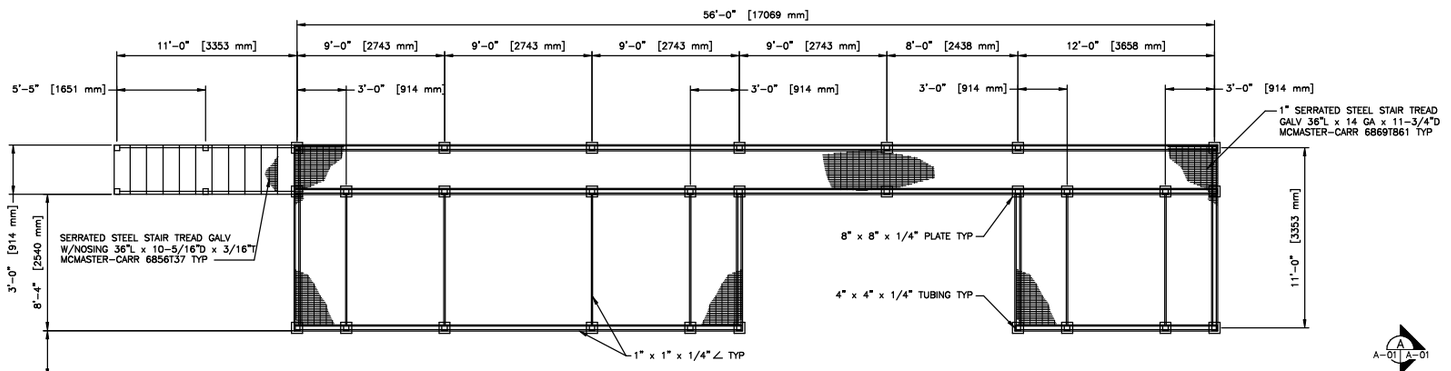
PLUME-FRONT REMEDIATION
BUILDING 650, TREATMENT FACILITY
CIVIL
SITE PLAN

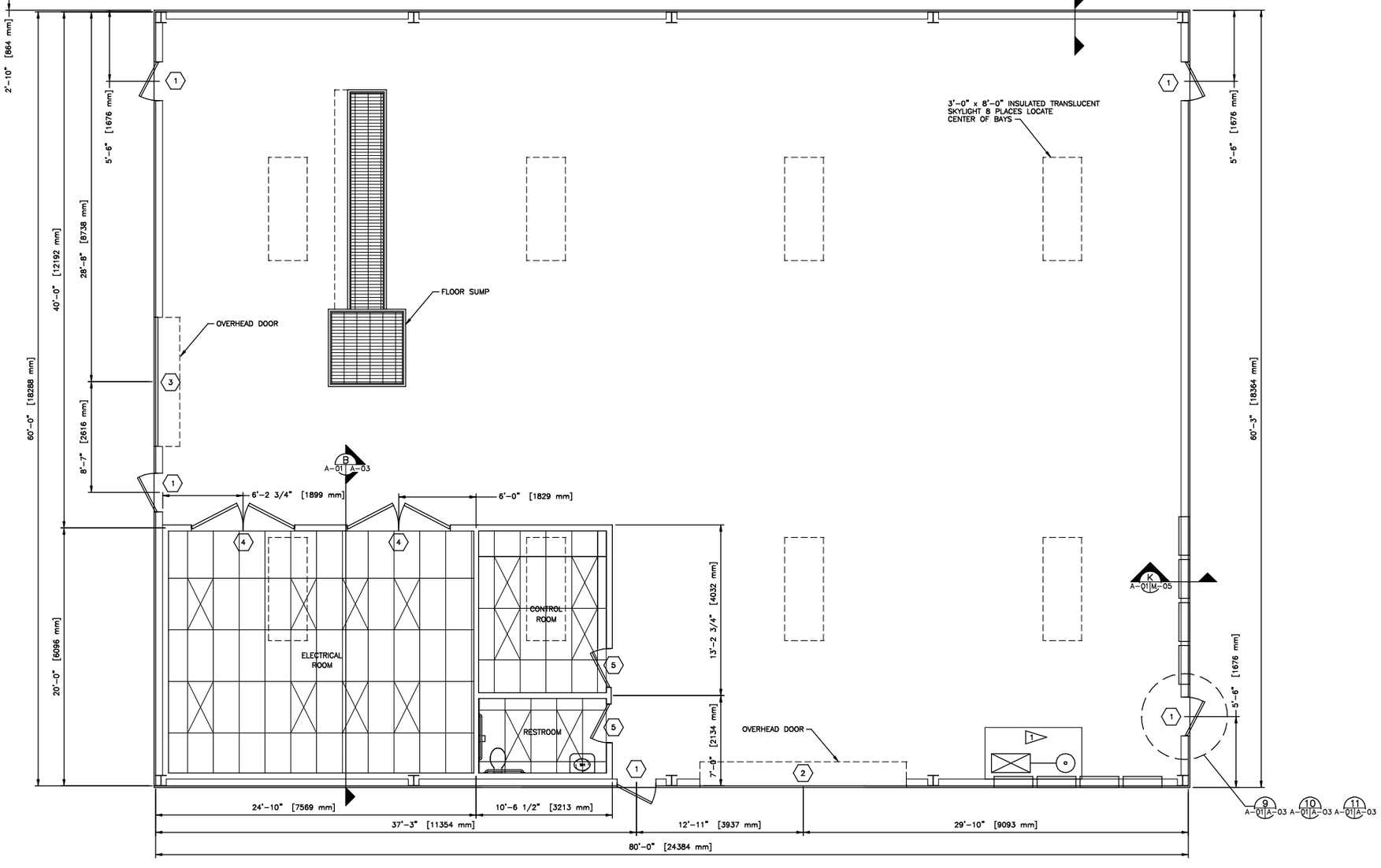
A.B. DWG. NO. | SCALE 1" = 20' | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 650-C-02 | REV.

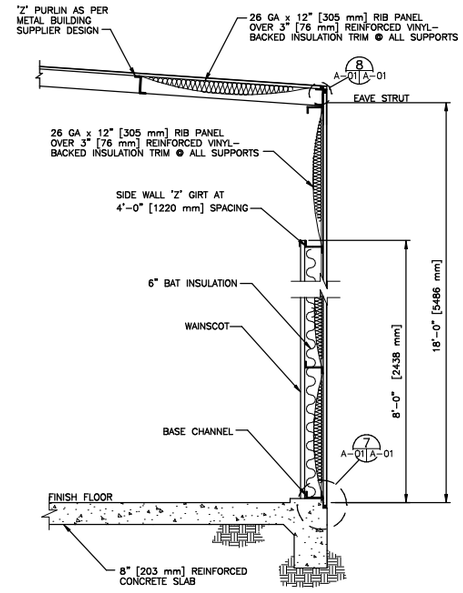
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

NORTH

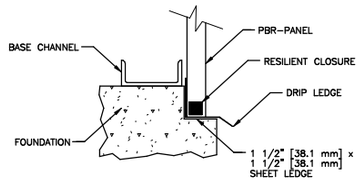




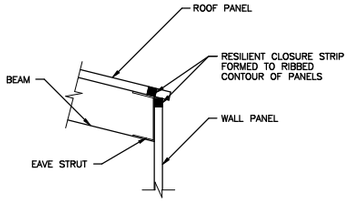
TREATMENT FACILITY FLOOR PLAN
SCALE: 1/4"=1'-0"



EXTERIOR WALL SECTION
SCALE: 1/2" = 1'-0"



DETAIL: SHEET LEDGE
NTS



EXTERIOR CORNER DETAIL
NTS

DOOR SCHEDULE (SEE 650-A-03)

NO	SIZE	TYPE	FRAME DETAIL	HARDWARE	# REQUIRED	REMARKS
1	3'-0" x 7'-0" x 1 3/4"	A	9, 10, 11	A, B, C, D, E, F, G	5	PANIC HARDWARE (EXT)
2	16'-0" x 12'-0"	B	PER MFR	PER MFR	1	CHAIN OPERATED OVERHEAD COILING DOOR
3	10'-0" x 12'-0"	B	PER MFR	PER MFR	1	CHAIN OPERATED OVERHEAD COILING DOOR
4	4'-0" x 10'-0"	A	PRE-HUNG	A, E, F	4	
5	3'-0" x 7'-0" x 1 3/4"	A	PRE-HUNG	A, E, F	2	

FINISH SCHEDULE

NO	NAME	FLOOR	BASE	WALLS	WALL FINISH	HGT	REMARKS
650	TREATMENT FACILITY BUILDING	SEALED CONCRETE	NONE	NONE	WAINSCOT-8'-0"	18'-0"	–
	RESTROOM	VINYL TILE	WOOD	SHEETROCK	PAINT	8'-0"	–
	CONTROL ROOM	PAINTED	WOOD	SHEETROCK	PAINT	8'-0"	–
	ELECTRICAL ROOM	PAINTED	VINYL	SHEETROCK	PAINT	8'-0"	–

NOTES:
1. 4'-0" x 7'-6" SAFETY RED PAINTED AREA WITH NON-SKID PARTICLES EMBEDDED INTO PAINT

0 4 8 12 FEET

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S: 650-A-03, 650-M-05

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000± DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
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DRAWN BY	M. TARIN	7-26-99
ENGINEER	E. BAGWELL	2-28-00
DESIGNED BY	E. BAGWELL	2-28-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

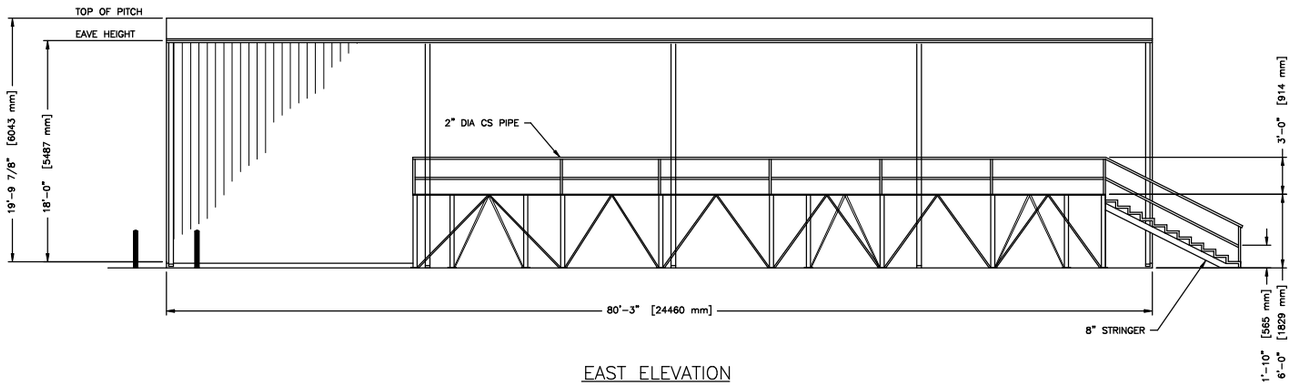
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

PLUME-FRONT REMEDIATION
BUILDING 650 TREATMENT FACILITY
ARCHITECTURAL
FLOOR PLAN

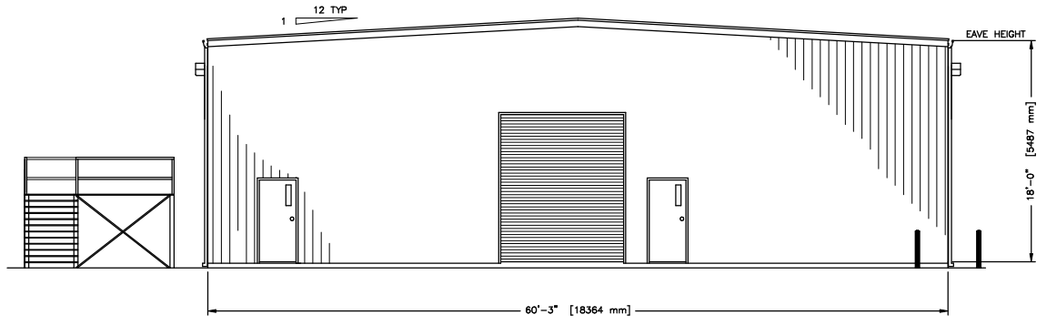
A.B. DWG. NO. | SCALE AS SHOWN | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 650-A-01 | REV.

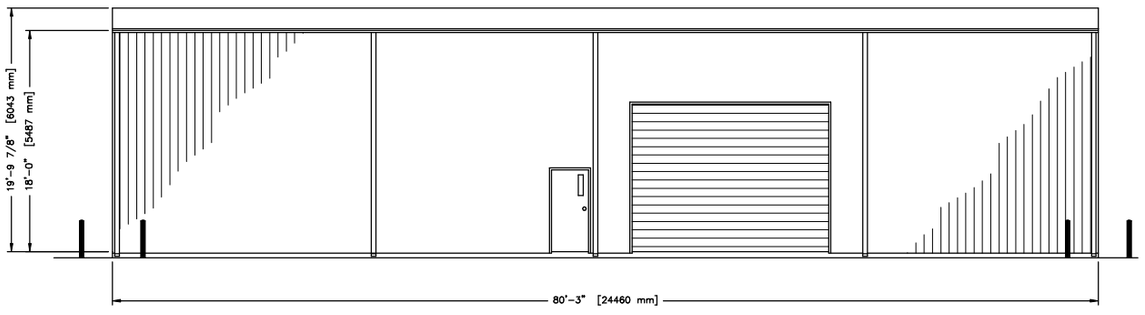
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



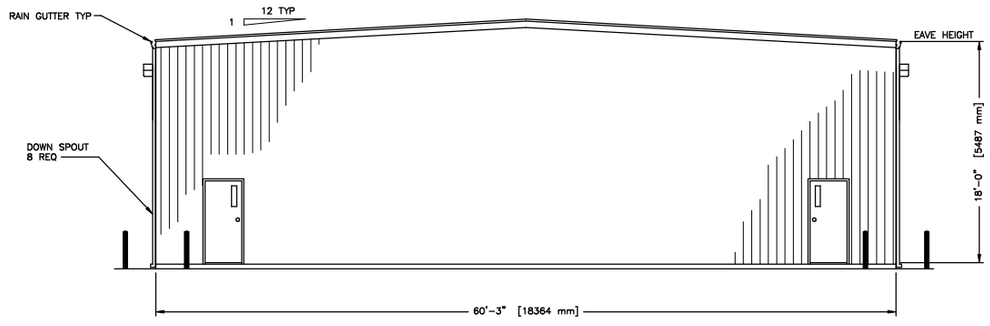
EAST ELEVATION



NORTH ELEVATION



WEST ELEVATION



SOUTH ELEVATION

BUILDING DESIGN PARAMETERS

BUILDING:	PRE-ENGINEERED BUILDING SHALL BE THE PRODUCT OF A RECOGNIZED MANUFACTURER AND COMPLY WITH REQUIREMENTS OF THE METAL BUILDING MANUFACTURER'S ASSOCIATION. THE BUILDING CONTRACTOR SHALL FURNISH COMPLETE ERECTION DRAWINGS AND DESIGN ANALYSIS/CERTIFICATE OF COMPLIANCE SIGNED BY A NEW MEXICO REGISTERED PROFESSIONAL ENGINEER CERTIFYING THAT METAL COMPONENTS COMPLY TO MBMA AND BUYER RECOMMENDATIONS.
SIZE:	60' [18288 mm] WIDE x 80' [24384 mm] LONG x 18' [4877 mm] EAVE HEIGHT
LOADING:	30 PSF LIVE LOAD. ROOF AND WALLS TO RESIST A 100 MPH WIND LOAD. (EXPOSURE C AS PER UNIFORM BUILDING CODE).
ROOF TYPE:	GABLE ROOF WITH 3" VINYL BACKED INSULATION, TRIM ⊕ ALL SUPPORTS
ROOF SLOPE:	1/12
UNFINISHED EXTERIOR WALLS:	INSULATED WITH 3" VINYL BACKED INSULATION, TRIM ⊕ ALL SUPPORTS
END WALL CONDITIONS:	EAST & WEST SIDES TO HAVE BEARING END WALL CONDITION.
PANELS:	26 GA PBR PANEL-ROOF. 26 GA PBR PANEL-WALL.
STRUCTURE:	BUILDING TO HAVE A TAPERED OR UNIFORM DEPTH RAFTER SUPPORTED ON UNIFORM DEPTH SIDE WALL COLUMNS. THE FRAME SHALL SPAN THE WIDTH OF THE BUILDING SUPPORTING THE SECONDARY MEMBERS AND THE ROOF AND WALL COVERINGS. THE SECONDARY WALL FRAMING OR GIRTS SHALL INSET INTO COLUMN LINE FOR MAXIMUM UTILIZATION OF SPACE.

0 4 8 12 16 FEET

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S.

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DRAWN BY	M. TARIN	8-9-99
ENGINEER	E. BAGWELL	8-9-99
DESIGNED BY	E. BAGWELL	8-9-99
CHECKED BY		
APPROVAL		
APPROVAL		
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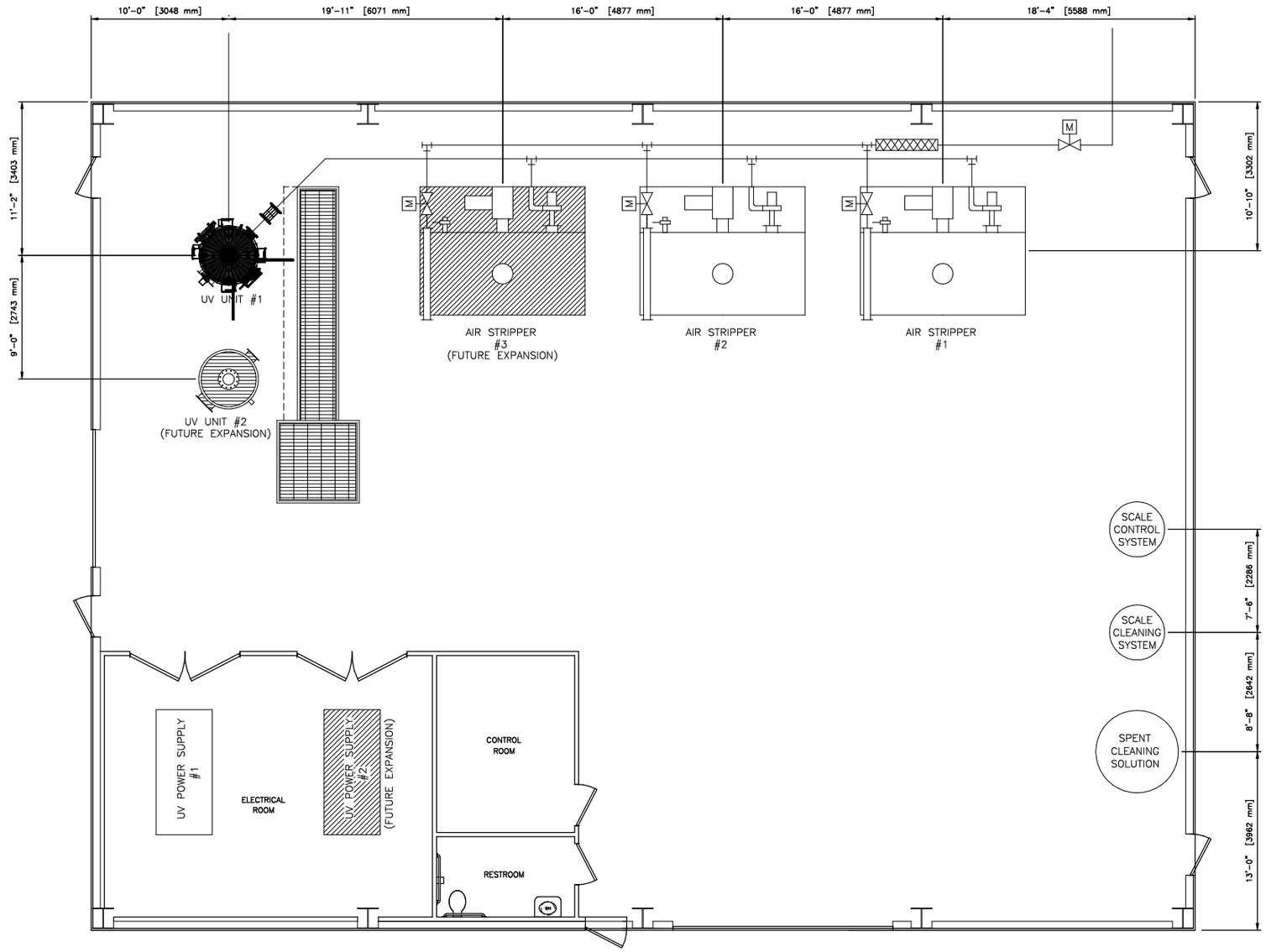
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

PLUME-FRONT REMEDIATION
BUILDING 650, TREATMENT FACILITY
ARCHITECTURAL
ELEVATIONS

A.B. DWG. NO. | SCALE 3/16" = 1'-0" | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 650-A-02 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



EQUIPMENT LAYOUT PLAN

SCALE: 1/4"=1'-0"

NORTH

0 4 8 12 FEET

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

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ENGINEER	J. KIRBY	10-21-99
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APPROVAL		
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RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

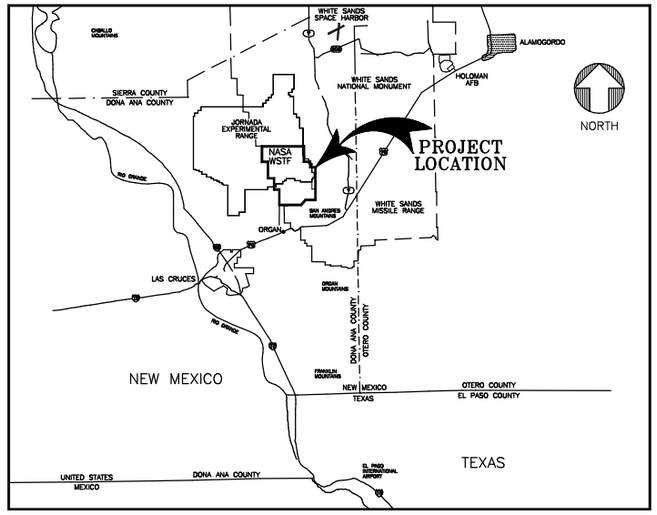
WSTF – PLUME FRONT REMEDIATION
BUILDING 650, TREATMENT FACILITY
MECHANICAL
EQUIPMENT LAYOUT

A.B. DWG. NO. | SCALE 1/4"=1'-0" | SHEET 1 OF 1

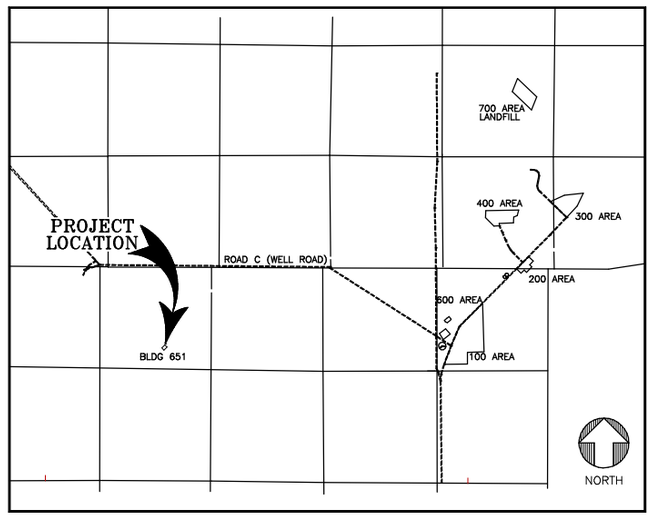
CODE IDENT. | SIZE F | DWG. NO. 650-M-06 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

GENERAL LOCATION



WSTF LOCATION



SITE LOCATION

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
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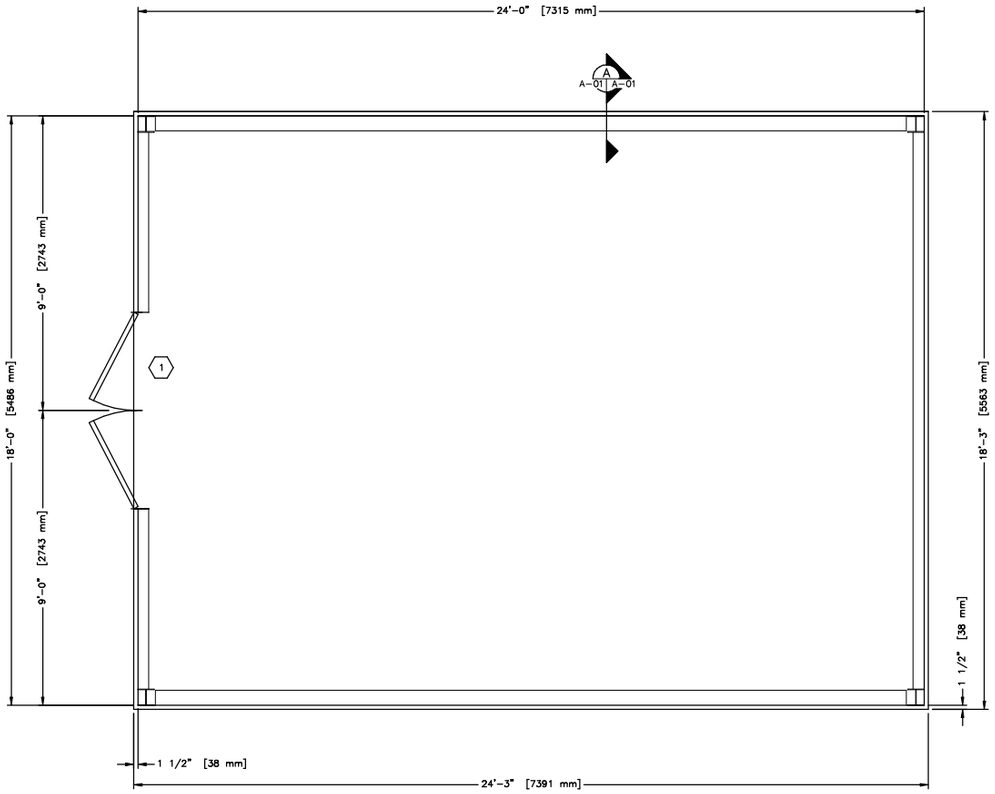
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

PLUME-FRONT REMEDIATION
BUILDING 651, INJECTION MANIFOLD BUILDING
CIVIL
PROJECT LOCATION

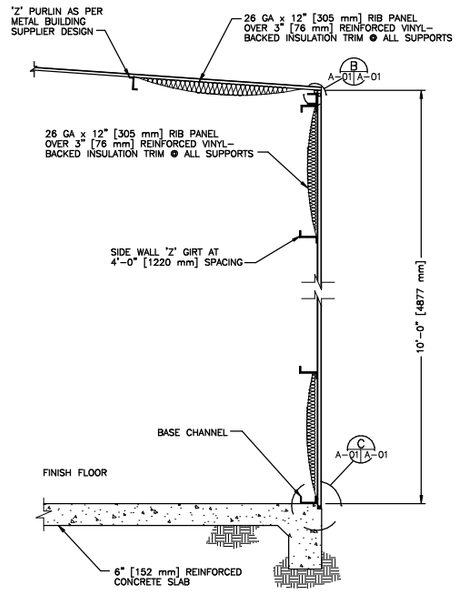
A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 651-C-01 | REV.

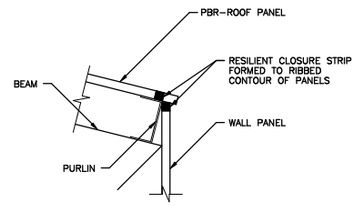
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



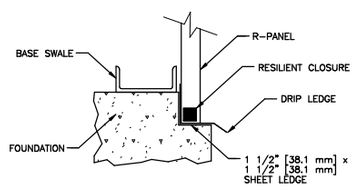
FLOOR PLAN



A A-01 A-01 TYPICAL EXT WALL SECTION
SCALE: 1/2" = 1'-0"



B A-01 A-01 TYPICAL EXT CORNER DETAIL
NTS



C A-01 A-01 DETAIL SHEET LEDGE
NTS

DOOR SCHEDULE (SEE 651-A-03)

NO	SIZE	TYPE	FRAME DETAIL	HARDWARE	# REQUIRED	REMARKS
1	3'-0" x 7'-0" x 1 3/4"	A	1, 2, 3	A, B, C, D, E, F, G	2	ENTRY LOCKSET

FINISH SCHEDULE

NO	NAME	FLOOR	BASE	WALLS	WALL FINISH	CEILING	HGT	REMARKS
651	INJECTION MANIFOLD BUILDING	SEALED CONCRETE	NONE	NONE	NONE	NONE	10'-0"	–

NORTH

0 2 4 6 FEET

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY M. TARIN	1-21-00	
ENGINEER E. BAGWELL	2-25-00	
DESIGNED BY E. BAGWELL	2-25-00	
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

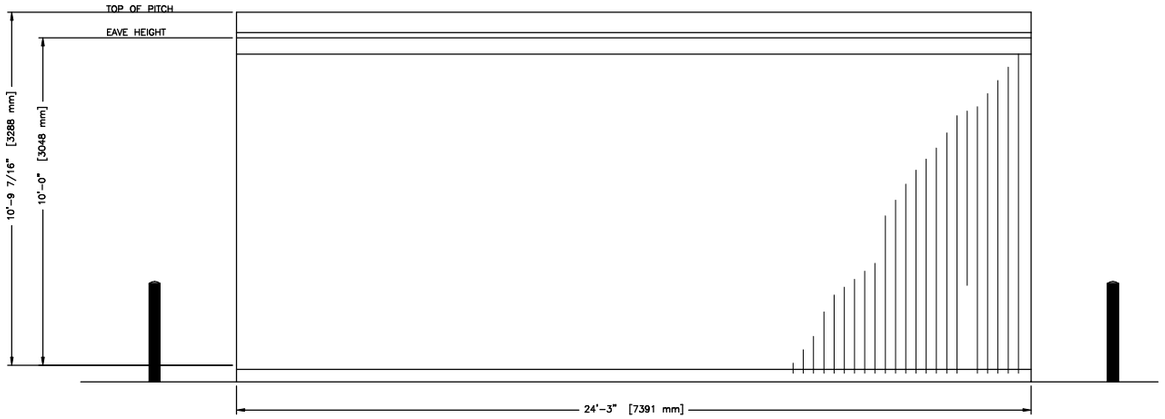
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
BUILDING 651, INJECTION MANIFOLD BUILDING
ARCHITECTURAL
FLOOR PLAN

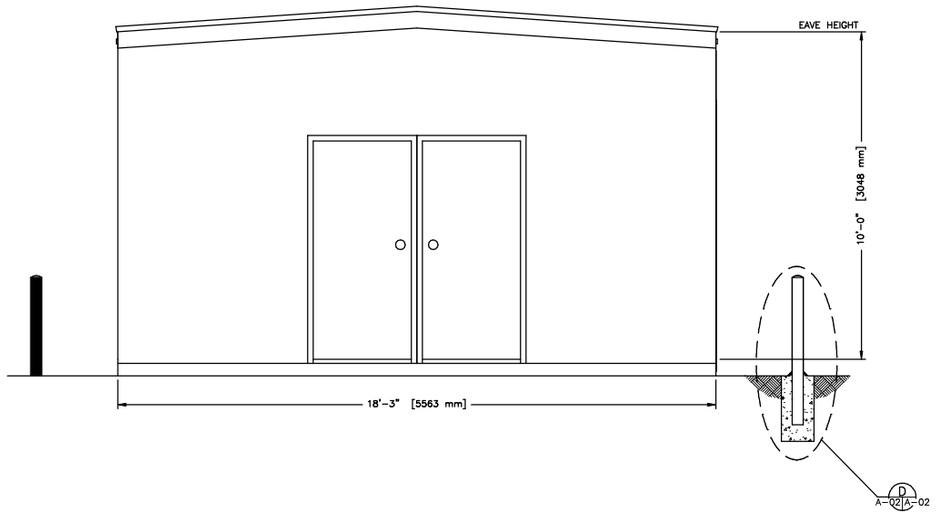
A.B. DWG. NO. | SCALE 1/2"=1'-0" | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 651-A-01 | REV.

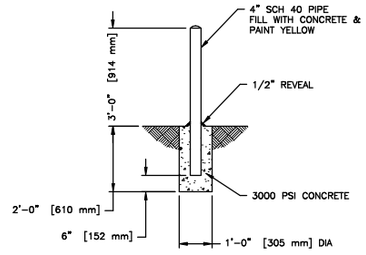
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



EAST ELEVATION



SOUTH ELEVATION



D A-02 DETAIL: BOLLARD

BUILDING DESIGN PARAMETERS

BUILDING:	PRE-ENGINEERED BUILDING SHALL BE THE PRODUCT OF A RECOGNIZED MANUFACTURER AND COMPLY WITH REQUIREMENTS OF THE METAL BUILDING MANUFACTURER'S ASSOCIATION. THE BUILDING CONTRACTOR SHALL FURNISH COMPLETE ERECTION DRAWINGS AND DESIGN ANALYSIS/CERTIFICATE OF COMPLIANCE SIGNED BY A NEW MEXICO REGISTERED PROFESSIONAL ENGINEER CERTIFYING THAT METAL COMPONENTS COMPLY TO MBMA AND BUYER RECOMMENDATIONS.
SIZE:	18' [5486 mm] WIDE x 24' [7315 mm] LONG x 10' [3048 mm] EAVE HEIGHT
LOADING:	30 PSF LIVE LOAD. ROOF AND WALLS TO RESIST A 100 MPH WIND LOAD. (EXPOSURE C AS PER UNIFORM BUILDING CODE).
ROOF TYPE:	GABLE ROOF WITH 3" VINYL BACKED INSULATION, TRIM ● ALL SUPPORTS
ROOF SLOPE:	1/12
UNFINISHED EXTERIOR WALLS:	INSULATED WITH 3" VINYL BACKED INSULATION, TRIM ● ALL SUPPORTS
END WALL CONDITIONS:	EAST & WEST SIDES TO HAVE BEARING END WALL CONDITION.
PANELS:	26 GA PBR PANEL-ROOF. 26 GA R PANEL-WALL.
STRUCTURE:	BUILDING TO HAVE A TAPERED OR UNIFORM DEPTH RAFTER SUPPORTED ON UNIFORM DEPTH SIDE WALL COLUMNS. THE FRAME SHALL SPAN THE WIDTH OF THE BUILDING SUPPORTING THE SECONDARY MEMBERS AND THE ROOF AND WALL COVERINGS. THE SECONDARY WALL FRAMING OR GIRTS SHALL INSET INTO COLUMN LINE FOR MAXIMUM UTILIZATION OF SPACE.

0 2 4 6 FEET

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

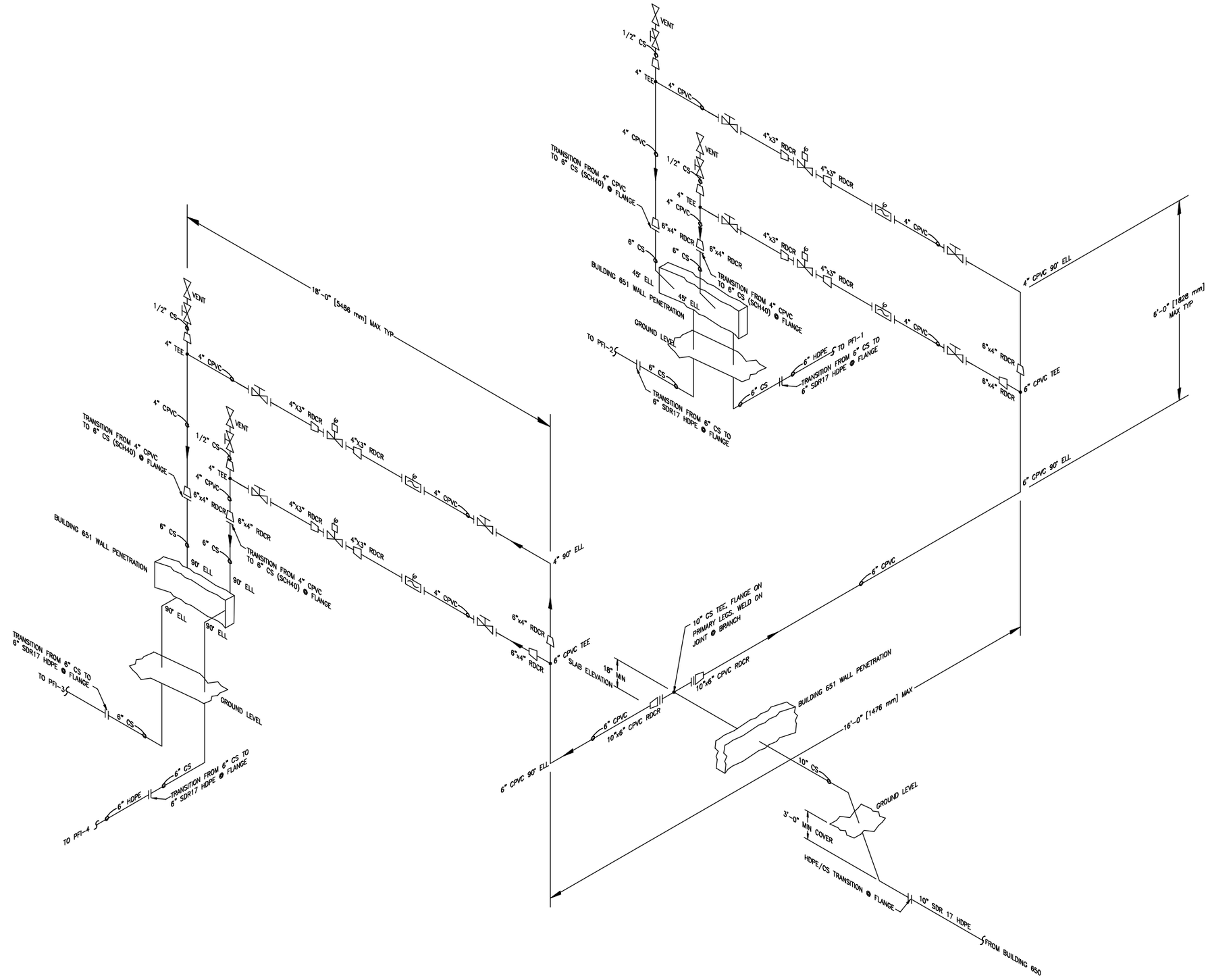
DRAWN BY	M. TARIN	1-21-00
ENGINEER	E. BAGWELL	1-21-00
DESIGNED BY	E. BAGWELL	1-21-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

PLUME-FRONT REMEDIATION
BUILDING 651, INJECTION MANIFOLD BUILDING
ARCHITECTURAL
ELEVATIONS

A.B. DWG. NO.	SCALE 1/2"=1'-0"	SHEET 1 OF 1
CODE IDENT.	SIZE F	DWG. NO. 651-A-02	REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



NOTES:

1. ALL CPVC PIPE AND FITTINGS SHALL BE SCH 80
2. PORTIONS OF PIPING OUTSIDE OF THE BUILDING AND EXPOSED TO THE ELEMENTS SHALL BE SCH 40 CARBON STEEL

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	8-15-00
ENGINEER	J. KIRBY	8-15-00
DESIGNED BY	J. KIRBY	8-15-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME FRONT REMEDIATION
BUILDING 651, INJECTION MANIFOLD BUILDING
MECHANICAL
LAYOUT PLAN

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 651-M-01 | REV.

National Aeronautics and Space Administration

White Sands Test Facility

Air Stripper Bid Specifications

Table of Contents

1. GENERAL 2
   1.1 Description 2
   1.2 Definitions 2
   1.3 Vendor Qualifications 2
   1.4 Reference Standards 3
   1.5 Inspection 3
   1.6 Submittals 3
   1.7 Approval of Equivalent Substitutions 4
   1.8 Warranty 4
   1.9 Equipment Destination 4
2. MATERIALS AND EQUIPMENT 5
   2.1 Air Stripper 5
   2.2 Optional Scale Cleaning and Control Systems 9
   2.3 Performance of Air Strippers 11
3. FABRICATION, ASSEMBLY, TESTING, AND SHIPPING 12
   3.1 Fabrication and Assembly 12
   3.2 Testing 12
   3.3 Shipping 12
4. EXECUTION 12
5. DELIVERY SCHEDULE 12

ATTACHMENTS

1. Process Flow Diagram
2. Farr Model 4P Glide/Pack® Specifications and Cut Sheet
3. Section 11240: Chemical Metering Pumps
4. Section 13390, Supplement A: Package Control System Component Specifications
5. Section 15150: Electric Valve Operators
6. Section 16405: AC Induction Motors

1. GENERAL

1.1 Description

This Bid Specification outlines the requirements for the volatile organic compound (VOC) treatment equipment needed for the plume-front remediation system currently being designed for the National Aeronautics and Space Administration's (NASA's) White Sands Test Facility (WSTF). The plume-front remediation system is a groundwater pump-and-treat system, for the treatment of n-nitrosodimethylamine (NDMA), trichloroethylene (TCE), tetrachloroethylene (PCE), and several Freon® compounds.

VENDOR shall furnish two (2) factory-assembled sieve tray air strippers, complete with discharge pumps, blowers, controls, and related equipment as required by this specification. The air strippers shall be designed for the removal of volatile organic compounds (VOCs) from groundwater, incorporating fresh air flowing through multiple perforations in the bottom of one or more trays, developing a turbulent froth in the counter-current liquid stream flowing across each tray.

1.2 Definitions

The term "NASA" used in these specifications refers to NASA and its representatives designated by the Contracting Officer. The term "Contracting Officer" refers to the procurement official or buyer administering this contract. The term "VENDOR" refers to the firm selected and contracted to supply the materials and services described in these Air Stripper Bid Specifications.

1.3 Vendor Qualifications

1.3.1 Vendors who have installed sieve tray air stripper systems for the treatment of VOCs in groundwater, at a flow rate of no less than 450 gpm per stripper, shall be considered.

1.3.2 Vendors who have installed sieve tray air stripper systems for the treatment of VOCs, for a period of no less than 5 years, shall be considered.

1.3.3 Vendors who have installed sieve tray air stripper systems for the treatment of VOCs, for no less than 50 applications, shall be considered.

1.4 Reference Standards

The manufacture of the air stripper shall comply with the applicable provisions of the following:

A. Hydraulic Standard Institute
B. National Electrical Manufacturers Association (NEMA)
C. National Electric Code (NEC)
D. Underwriters Laboratory (UL)

VENDOR shall assume complete responsibility for conformance with the Reference Standards listed above, and this Bid Specification. In the event there is an inconsistency between this Bid Specification and the attachments, it is the VENDOR's responsibility to contact NASA to resolve the inconsistency.

1.5 Inspection

The quality of all equipment and materials shall be subject to the inspection and approval of NASA. The performance testing required in Section 3 of this specification shall be subject to the inspection and approval of NASA. NASA reserves the right to conduct inspection of the equipment, materials of construction, and performance testing at VENDOR's manufacturing facility. NASA reserves the right to designate a representative to conduct the inspection and performance testing of the air strippers. VENDOR shall notify NASA a minimum of 2 weeks in advance of the day fabrication of the air strippers commences. VENDOR shall notify NASA a minimum of 2 weeks in advance of the day the performance testing required in Section 3 commences.

1.6 Submittals

1.6.1 Bid Package

VENDOR shall provide as a minimum, but not limited to, the following information in its bid package:

A. Written guarantee that the air strippers will continuously meet the performance standards listed in Section 2.3 of this specification.
B. Documentation that VENDOR meets the qualification requirements listed in Section 1.3 of this specification.
C. Manufacturers catalog data for all equipment, components, and accessories.
D. A list of common spare parts (including sources, part numbers, and recommended quantities) that may kept in inventory by NASA.
E. Characteristic curves for the pumps and blowers selected by the VENDOR.
F. An estimate of the lead-time required to commence fabrication, and the time needed to fabricate, test, and deliver the air strippers and related equipment.
G. Manufacturers cut sheets of vendor-supplied components.
H.

1.6.2 Drawings.

Within four (4) weeks of award of the purchase order, VENDOR shall provide NASA with the following information:

A. Shop drawings
B. Manufacturers cut sheets and electrical schematics.
C. Process & instrumentation drawings showing all vendor-supplied components.
D. Printed instructions and drawings sufficient for proper installation of the air strippers.

VENDOR shall not commence fabrication of the air strippers until NASA approves all drawings, cut sheets, and schematics listed in this section, and provides VENDOR with a written Notice to Proceed.

1.6.3 Operation and Maintenance Documentation

The following information shall be sent to NASA two (2) weeks prior to shipment of the air strippers:

A. Six (6) complete copies of the O&M Manual
B. Equipment and Performance warranty
C. VHS videotape demonstrating start-up, operation, maintenance, and shut-down procedures.
D. Two (2) 3.5 inch floppy disk copies of the completely documented PLC program, along with two (2) fully annotated printed copies.

1.7 Approval of Equivalent Substitutions

VENDOR may propose substitutions to the equipment or materials of construction described in this specification. NASA reserves the right to accept or reject any such proposals.

1.8 Warranty

VENDOR shall warrant the air strippers and associated equipment for a period of twelve (12) months from the date of system start-up.

1.9 Equipment Destination

The air stripper system shall be shipped to:

NASA Johnson Space Center
White Sands Test Facility (WSTF)
Building 120
U.S. Highway 70, 18 miles Northeast of Las Cruces
Las Cruces, New Mexico, 88012

2. MATERIALS AND EQUIPMENT

2.1 Air Stripper

2.1.1 Mechanical

The air strippers shall be designed and built to meet the following requirements:

2.1.1.1 Two strippers (to be plumbed in parallel) shall be capable of treating the design flow rate specified in Table 2.1. Refer to Attachment 1, Process Flow Diagram, for configuration of the Plume-Front Treatment System.

2.1.1.2 The air strippers shall be suitable for installation on an unsealed, sealed, or painted concrete floor in an industrial indoor environment maintained between 40º F and 100º F.

2.1.1.3 The air strippers shall be equipped with sieve trays, the number of which shall be determined by performance modeling performed by VENDOR. Trays shall be equipped with downcomers, weirs, sealpots, gaskets, tray cleanout and inspection ports, alignment buttons, latches, and lifting rings or tabs.

2.1.1.4 The sump, trays, and cover of each air stripper shall be constructed of 304L stainless steel.

2.1.1.5 Trays shall be sealed with gaskets to prevent air and water leaks. Tray gaskets shall be made of a material that is not degraded by the contaminants listed in Table 2.1.

2.1.1.6 A mist eliminator shall be installed in each air stripper. The mist eliminators shall be made of a material that is not degraded by the contaminants listed in Table 2.1.

2.1.1.7 All piping external to the strippers shall be schedule 80 PVC with ANSI Class 125 (150 lb.) flanges at the influent and effluent points. National Pipe

Taper (NPT) threaded connections are not considered equivalent or an acceptable substitution for ANSI flanges.

2.1.1.8 Each stripper shall be equipped with groundwater influent and effluent sample ports and valves.

2.1.1.9 Each sump shall be equipped with a manually operated normally-closed drain valve.

2.1.1.10 Electric operators for the motor operated valves shown in the Process Flow Diagram shall comply with the requirements of Section 15150.

2.1.1.11 Skid frame and stanchion (for mounting controls and instrumentation) shall be constructed of steel, with provisions for forklift access. The frame and control stanchion shall be painted with epoxy paint.

2.1.1.12 Blowers and Exhaust

2.1.1.12.1 Each blower shall be direct-driven centrifugal design, with Type B non-sparking internal construction, integrally mounted on the stripper frame with the stripper, sized and arranged to deliver a constant fresh air flow to the stripper air inlet. The air flow rate is to be determined by VENDOR modeling.

2.1.1.12.2 VENDOR shall provide all ducts, filters, dampers, and other air handling equipment for each air stripper. VENDOR shall size and cost the blower using the approximate duct lengths given below. The exhaust ducts will extend from the tops of the air strippers, through roof penetrations, to a height of approximately 10 feet above the roof. Roof height will be approximately 17 feet above the floor of the treatment building. The exhaust duct diameter will be equal to the diameter of the air stripper exhaust port. The inlet ducts will extend from the inlet flanges of the blowers, through wall penetrations, to air filters mounted outside the treatment building. The inlet duct will be approximately 20 feet in length, and will include approximately four 90º elbows.

2.1.1.12.3 VENDOR shall supply an inlet filter housing for each air stripper. Each inlet filter housing shall be a Farr Model 4P Glide/Pack®, or EQUAL, sized for the air flow recommended by VENDOR. Each inlet filter housing shall be provided with a static pressure tap and an inclined manometer air filter gage.

2.1.1.12.4 Air stripper off-gas will be discharged to the atmosphere; no off-gas treatment is required.

2.1.1.13 Discharge Pumps

2.1.1.13.1 A horizontal centrifugal discharge pump shall be supplied with each of the two air stripper skids. Each discharge pump shall be rated for the maximum hydraulic capacity of the stripper, at total head of 150 feet of water.

2.1.1.13.2 Each discharge pump shall be mounted on the air stripper skid.

2.1.1.14 Other Required Appurtenances and Features

2.1.1.14.1 VENDOR shall supply one (1) tray lifter that is designed to attach to lifting lugs or eyes on the air stripper trays. Lifter shall be fabricated for use with a standard fork truck.

2.1.1.14.2 The sump of each air stripper shall be fitted with a sump level sight glass. Isolation valves shall be provided at both the top and bottom of each sight glass.

2.1.1.14.3 The sump of each air stripper shall be fitted with at least one inspection port to facilitate visual inspection of the inside of the sumps.

2.1.1.15 Optional Appurtenances and Features

VENDOR shall include in his quotation the cost of the options listed in this subsection. The cost of each option shall be itemized separately from the costs of the required equipment, appurtenances, features, and spare parts.

2.1.1.15.1 Skid leveling feet, with a range of adjustment of 2 inches.

2.1.1.15.2 One (1) high pressure wash wand for cleaning trays.

2.1.2 Electrical

2.1.2.1 Power

Power to each skid shall be 480 Vac, 3 phase, 4 wire grounded wye, 60 Hz.

2.1.2.2 Motors

All motors used on the air stripper skids shall have the following features:

A. Enclosures of the blower and discharge pump motors shall be TEFC.
B. Duty cycle of the blower and discharge pump motors shall be 100%.
C. Motor insulation shall be Class F.
D. Motors shall be copper wound.
E. Motors shall be high efficiency rated.
F. Power factor and efficiency of the blower and discharge pump motors shall be no less than the values shown in Table 1 of Section 16405.
G. All motors shall comply with the requirements of Section 16405.

2.1.3 Controls and Instrumentation

A master control system that integrates the air strippers, UV oxidation equipment, and other components of the plume-front remediation system will be utilized. This master control system will monitor the operation of all system components, shut the system down under specific conditions, and provide for taking components off-line for maintenance. The air stripper control cabinet shall provide spare contacts for each control function so that the control functions can be monitored at the master control system.

2.1.3.1 Control Panel

Each air stripper skid shall be equipped with a control panel. The control panel shall provide for single point power connection and control of the skid components. The control panel shall be UL listed and include the following:

A. A fused safety disconnect switch with a rating of 480 Vac, 3 pole, 65,000 AIC.
B. Motor starters shall have 2 normally-open and 2 normally-closed auxiliary contacts available for customer use.
C. Motor starters shall be NEMA rated, with electronic overload blocks that provide for loss of phase protection.
D. Control panel enclosure shall be rated NEMA 4/12.
E. Control panels shall be UL listed.
F. All control panels shall comply with the requirements of Section 13390.
G. Control voltage transformer with primary and secondary protection.

H. Each air stripper shall have an individual PLC to permit completely independent operation. VENDOR shall provide Allen Bradley PLC(s) and related components, as stated in Section 13390 Supplement A

2.1.3.2 Instrumentation

A. Each air stripper shall be equipped with the following air flow instrumentation: air pressure meter, air flow meter, low air pressure switch and alarm.
B. Each air stripper shall be equipped with the following water flow instrumentation: digital flowmeter, influent water temperature and pressure gauges, high water level switch and alarm, low water level switch and alarm, and an admittance-type level transmitter complete with a stilling column.
C. Float switches shall be UL listed.
D. Air pressure switches shall be explosion-proof.
E. All instruments shall comply with the requirements of Section 13390, Supplement A.

2.2 Optional Scale Cleaning and Control Systems

VENDOR is requested to bid on scale cleaning and scale control systems as options. The cost of each option shall be itemized separately from the costs of the required equipment, appurtenances, features, and spare parts listed in Sections 2.1 and 2.1.2 of this specification. Refer to Attachment 1, Process Flow Diagram, for the configuration of the scale cleaning and control systems.

2.2.1 Scale Cleaning System

2.2.1.1 The scale cleaning system will be used to periodically dissolve hard water scale from the air stripper trays. Sequence of operation of the scale cleaning system will be to shut down an air stripper, circulate a cleaning chemical through the air stripper by pumping, and collect the cleaning chemical for future use or neutralization and disposal.

2.2.1.2 The cleaning chemical to be used may be one of the following: citric acid, sulfamic acid, tetrasodium EDTA, inhibited hydrochloric acid, or inhibited sulfuric acid. VENDOR shall design the cleaning system to be compatible with the chemicals listed above.

2.2.1.3 The scale cleaning system shall, at a minimum, include:
A. Double-wall containment tank for cleaning chemical storage
B. Cleaning chemical circulation and return pumps

C. Propeller mixer attached to the chemical storage tank, for dissolving powdered chemical in water
D. The VENDOR shall assume 80 feet of physical separation exists between the scale cleaning circulation pump and the air strippers.

A process flow diagram, including the scale cleaning system, is included as Attachment 1.

2.2.2 Scale Control System

2.2.2.1 The scale control system will be used control the amount of scale build-up in the air strippers.

2.2.2.2 The scale control chemical will be a proprietary polyphosphate blend. The scale control chemical may be one of the following:

E. BetzDearborn, Scaletrol 9319
F. Kjell Corp., AquaMag
G. Nalco Chemical Co., 7396
H. Remede Products Inc., Calsperse 500

VENDOR shall design the scale control system to inject 5 ppm to 30 ppm of any of these chemicals into the 900 gpm flow stream.

2.2.2.3 The scale control system shall include, at a minimum:

A. Single-wall tank for storage of scale control chemical.
B. Metering pump for injecting the scale control chemical into the 900 gpm flow stream. The metering pump shall comply with the requirements of Section 11240.
C. A static mixer for dispersing the scale control chemical into the 900 gpm flow stream. Static mixer shall be a Komax “A” series mixer, constructed of carbon steel, with internal diffuser.

VENDOR shall recommend equipment that is chemically compatible with any of the chemicals listed in Section 2.2.2.2.

2.3 Performance of Air Strippers

The air stripper system shall be designed to meet the following specifications:

Table 2.1 Air Stripper Performance Specifications

Criteria	Specification	
Total Hydraulic Flow Rate		950 gpm
Hydraulic Flow Rate per Air Stripper		475 gpm
Maximum Run Time		24 hours per day 365 days per year
Design Life		Not less than 15 years
Air Temperature	Minimum Annual Average Maximum	-13 ºC 17 ºC 44 ºC
Influent Water Temperature		15 to 20 ºC
Site Elevation		4,500 feet amsl
Expected Influent Concentrations	TCE PCE Freon 11 Freon 21 Freon 113	130 µg/L 4.2 µg/L 860 µg/L 60 µg/L 2,000 µg/L
Regulatory Effluent Standards	TCE PCE Freon 11 Freon 21 Freon 113	5 µg/L 5 µg/L 100 µg/L 20 µg/L 1,200 µg/L
Treatment Goals	TCE PCE Freon 11 Freon 21 Freon 113	2.5 µg/L 2.5 µg/L 50 µg/L 10 µg/L 600 µg/L

VENDOR shall document the modeled performance of air strippers using a matrix of conditions, including the range of air and water temperatures listed in Table 2.1. Air strippers shall be sized such that the concentration of each contaminant in the effluent is equal to or less than the appropriate Treatment Goal listed in Table 2.1. In his proposal, VENDOR shall also document the incremental performance and incremental cost of the recommended air stripper with the maximum number of trays available for that model.

Stripping performance for each VOC shall be guaranteed based on VENDOR's actual results demonstrated during full-scale stripping of the contaminants from water on a commercial air stripper. Performance modeling shall be provided for the specific operating conditions listed in Table 2.1.

3. FABRICATION, ASSEMBLY, TESTING, AND SHIPPING

3.1 Fabrication and Assembly

The manufacturer shall furnish all tools, materials, labor, and appurtenances necessary for the complete fabrication, testing and shipment of the air strippers and appurtenances. All equipment shall be new and unused, except for equipment used in final check-out testing.

3.2 Testing

Successful bidder shall test the assembled air strippers at design air and water flow rates to confirm proper hydraulic, electrical, control, and leak-free performance of basic system and all accessories. Documentation of test results shall be provided to NASA prior to shipment of the air strippers.

3.3 Shipping

VENDOR shall ship the system FOB destination.

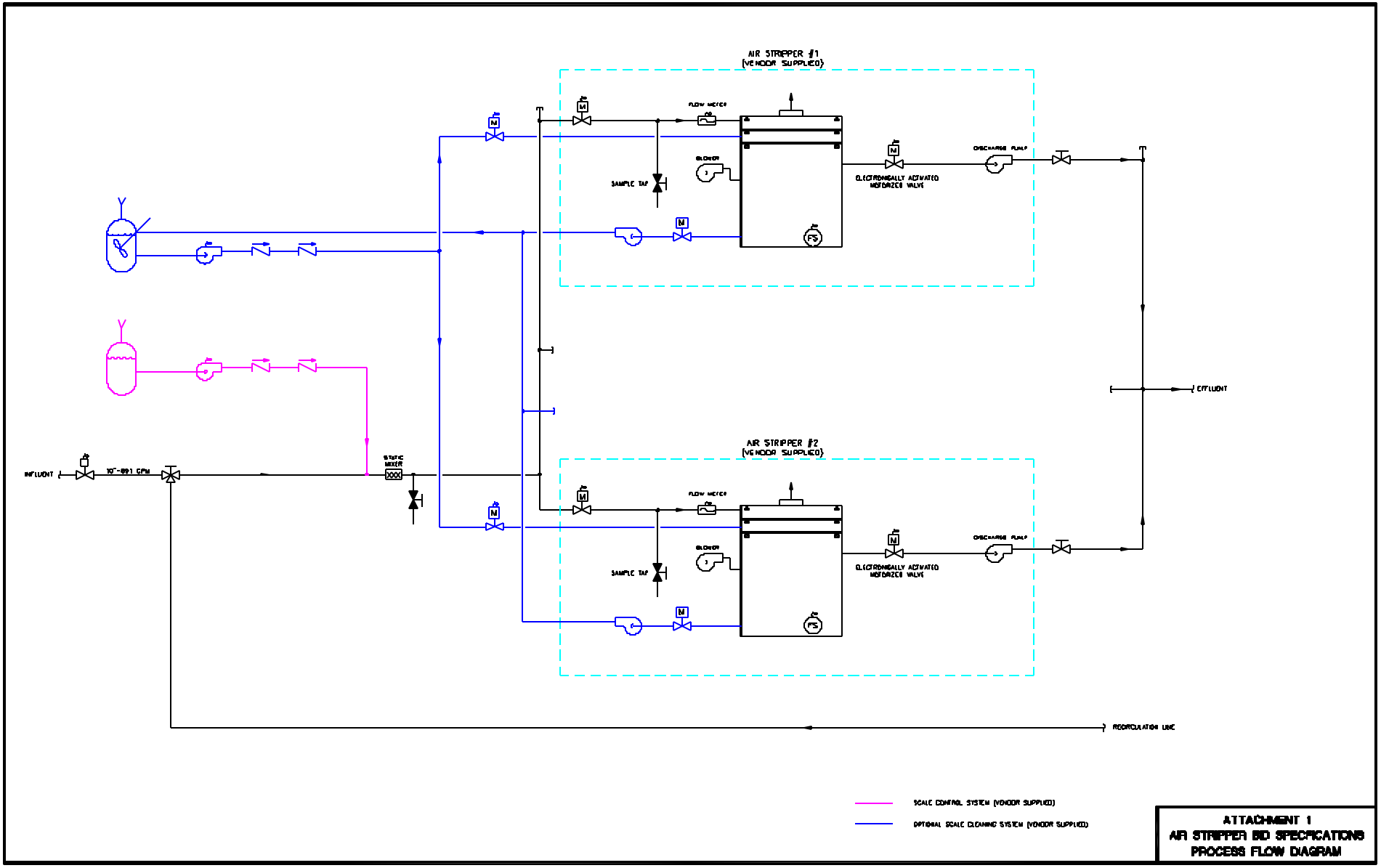
4. EXECUTION

VENDOR shall provide the start-up services of a qualified field service representative for the purpose of installation inspection, system commissioning, and instruction of NASA personnel in proper operating and maintenance procedures. Upon completion of inspection, VENDOR's field service representative shall provide written certification to NASA that the equipment has been properly installed. The proposal shall include an estimate of the number of man-days and the per diem cost for these startup services.

5. DELIVERY SCHEDULE

Air strippers and appurtenances shall be delivered to the Job Site no later than 90 days following issuance of a purchase order by NASA.

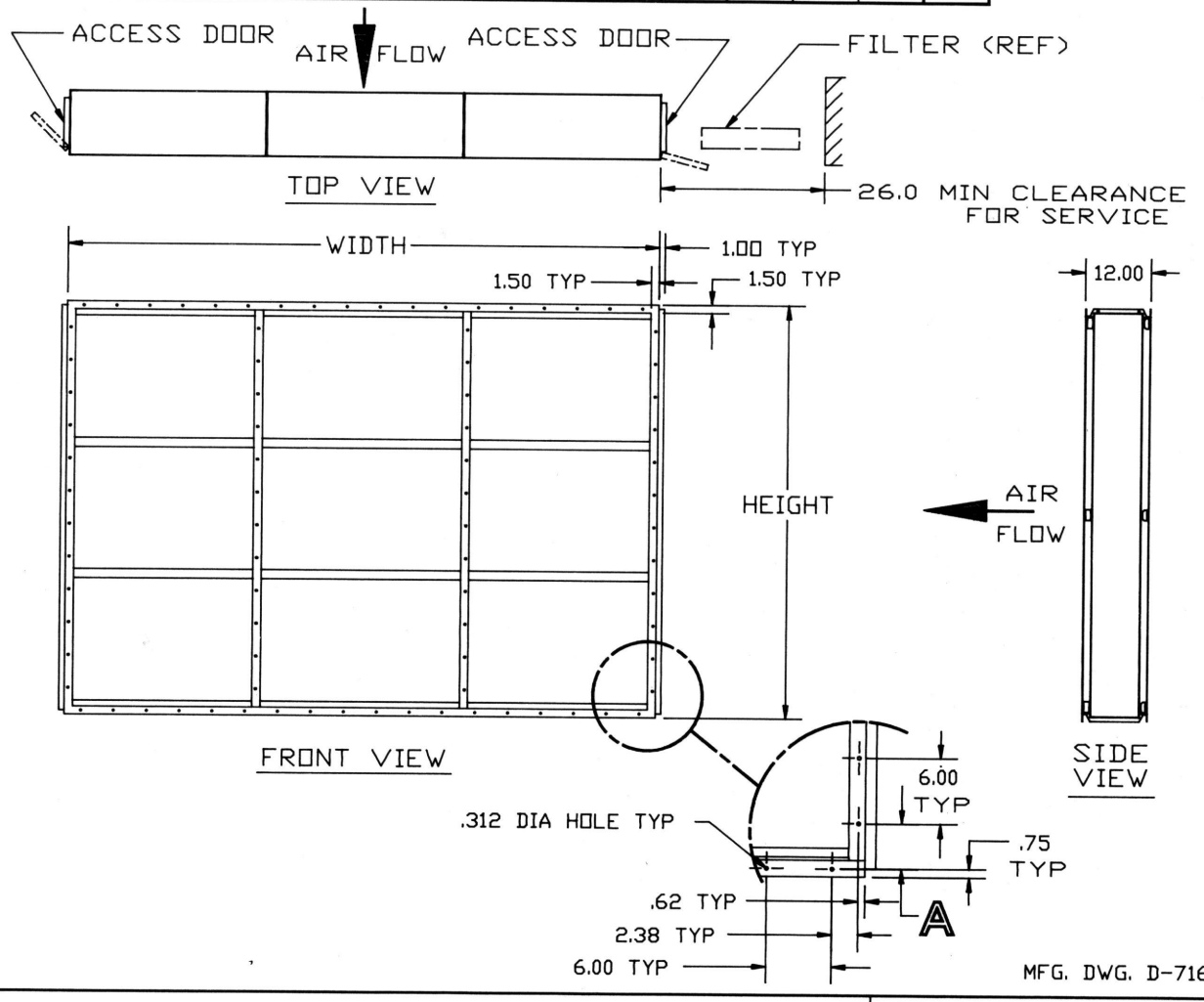
- END -



ATTACHMENT 1
AIR STRIPPER BID SPECIFICATIONS
PROCESS FLOW DIAGRAM

B-71601

NO. OF FILTERS WIDE		1/2	1	1-1/2	2	2-1/2	3	3-1/2	4	4-1/2	5	5-1/2	6	
WIDTH INCHES		12.00	24.00	36.00	48.00	60.00	72.00	84.00	96.00	108.00	120.00	132.00	144.00	
NO. OF FILTERS HIGH	HEIGHT INCHES	SIZE DESIGNATION (SEE NOTE 5)												A
1/2	15.25	–	1/2 X 1	–	1/2 X 2	–	1/2 X 3	–	1/2 X 4	–	1/2 X 5	–	1/2 X 6	3.88
1	27.25	1 X 1/2	1 X 1	1 X 1-1/2	1 X 2	1 X 2-1/2	1 X 3	1 X 3-1/2	1 X 4	1 X 4-1/2	1 X 5	1 X 5-1/2	1 X 6	3.88
1-1/2	39.50	–	1-1/2 X 1	–	1-1/2 X 2	–	1-1/2 X 3	–	1-1/2 X 4	–	1-1/2 X 5	–	1-1/2 X 6	4.00
2	51.50	2 X 1/2	2 X 1	2 X 1-1/2	2 X 2	2 X 2-1/2	2 X 3	2 X 3-1/2	2 X 4	2 X 4-1/2	2 X 5	2 X 5-1/2	2 X 6	4.00
2-1/2	63.75	–	2-1/2 X 1	–	2-1/2 X 2	–	2-1/2 X 3	–	2-1/2 X 4	–	2-1/2 X 5	–	2-1/2 X 6	4.12
3	75.75	–	3 X 1	3 X 1-1/2	3 X 2	3 X 2-1/2	3 X 3	3 X 3-1/2	3 X 4	3 X 4-1/2	3 X 5	3 X 5-1/2	3 X 6	4.12



MFG. DWG. D-71600

NOTES:

1. FOR APPLICATION INFORMATION, INSTALLED WEIGHT, CAPACITY, ETC, SEE SALES BULLETIN
2. UNIT IS COMPLETELY FACTORY ASSEMBLED
3. EXTRUDED ALUMINUM TRACKS ARE STANDARD IN ALL HOUSINGS
4. OPTIONAL AT EXTRA COST: ONE COAT OF PRIMER ON EXTERIOR SURFACES OF HOUSING AND DOORS. SPECIFY "PRIMED"
5. ORDERING INFORMATION: SPECIFY MODEL AND SIZE. ADD "PRIMED" IF DESIRED

   EXAMPLE:

   MODEL 4P GLIDE/PACK
   2 X 4-1/2 (SIZE)
6. FILTERS ARE NOT INCLUDED. ORDER SEPARATELY STATING QUANTITIES, TYPES AND SIZES

REV.	DATE		DISP.	E.W.O.	DFT	CK	DES	APP
E	4-9 90	ADDED 1/2 FILTER WIDE SIZES		11732 B	J C			
A	1-19 81	FIRST ISSUE		9434	J C			

UNLESS OTHERWISE NOTED:
DIMENSIONS ARE IN INCHES
INSIDE BEND RADII = 1 METAL THICKNESS
TOLERANCES ARE:
1 PLACE DECIMAL±
2 PLACE DECIMAL±
3 PLACE DECIMAL±
FRACTIONAL± ANGULAR±

DO NOT SCALE PRINT

PROD CODE	EST. WT.
NEXT ASSEMBLY	
SCALE: NONE	CLASSIFICATION: F-0404

MODEL 4P GLIDE/PACK
1/2 THRU 3 HIGH

FARR COMPANY
LOS ANGELES, CALIFORNIA

CODE	DRAWING NO.	REV.
	B-71601	E

B-71601

SECTION 11240
CHEMICAL METERING PUMPS

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE): 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
2. National Electrical Manufacturer's Association (NEMA): MG 1, Motors and Generators.

1.2 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction shall conform to the ratings and nomenclature of the Hydraulic Institute Standards.

1.3 SUBMITTALS

A. Shop Drawings:

1. Make, model, weight, and horsepower of each equipment assembly.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
3. Performance data showing capacity, discharge pressure, and strokes per minute.
4. Detailed mechanical and electrical drawings showing the equipment dimensions, size, locations of connections, and weights of associated equipment.
5. Complete system interconnection diagrams, including terminals and numbers.
6. Complete system operating description.
7. Complete system schematic (elementary) wiring diagrams.
8. Complete motor nameplate data, as defined by NEMA, motor manufacturer, and including any motor modifications.
9. Factory finish system.
10. Operating and maintenance manuals for the chemical metering pumps specified herein.

B. Quality Control Submittals:

1. Factory Functional and Performance Test Reports.
2. Special shipping, storage and protection, and handling instructions.
3. Manufacturer's printed installation instructions.

4. Manufacturer's Certificate of Proper Installation.
5. Suggested spare parts list to maintain the equipment in service for a period of 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
6. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
7. Operation and maintenance manual.

1.4 EXTRA MATERIALS

A. Furnish for each size pump:

1. One complete set of pump head check valve balls and springs.
2. One diaphragm back pressure control valve.
3. One complete set of any special tools required to dismantle pump.

B. Furnish for each size of controller:

1. One printed circuit board of each type.
2. Ten fuses (minimum) of each size.

C. Furnish spare pumps:

1. Complete pump, motor and check valve assemblies as indicated on the pump data sheets.
2. Spare control panels shall not be required.

PART 2 PRODUCTS

2.1 GENERAL

A. Coordinate pump requirements with drive manufacturer and be responsible for pump and drive requirements.

B. Where adjustable speed drives are required, furnish a coordinated operating system complete with pump, drive, and speed controller.

2.2 SUPPLEMENTS

A. Some specific requirements are attached to this section as supplements.

2.3 PUMP

A. Positive displacement self-compensating hydraulically activated diaphragm type consisting of simplex pumping heads, with internal automatic pressure relief valve, external manually adjustable stroke positioner from 0 to 100 percent, and with maximum stroking speed of 100 strokes per minute.

B. Diaphragm; compression-molded Teflon or compression-molded Teflon composite with internal O-ring seal. Hypalon double diaphragms may be provided where indicated on the data sheets.

C. Bearings, tapered roller or needle type. Gearing, polished steel or bronze worm type. Mount bearings and internal working parts in weather-resistant gear box with moving parts oil flooded.

D. Lubricant, nontoxic food grade quality.

E. The pumps shall be capable of running dry indefinitely.

F. The diaphragm shall be returned by hydraulic means; no spring shall be employed.

G. Pumping diaphragms and all wetted parts shall be suitable for the particular chemical being pumped.

2.4 VALVES

A. Adjustable diaphragm back pressure sustaining type installed on pump discharge pipeline. Set pressure shall be as shown on attached data sheets. This valve shall be a single function valve that provides constant upstream back pressure, even after termination of pump operation.

B. Adjustable pressure relief type installed on pump discharge pipeline. Set pressure shall be as shown on attached data sheets.

2.5 STROKE CONTROL

A. Manual stroke length adjustment.

B. Manual and remote stroke rate adjustment.

2.6 PUMP OPERATOR CONTROLS

A. Provide the following controls mounted to the face of each pump:

1. AUTO-OFF-MANUAL switch. In AUTO position, pump shall accept an external 4-20 mAdc pacing signal.
2. ON and STOP indicator lights.
3. Manual control by on-line adjustable stroke rate and length.
4. Solenoid protection by thermal overload with auto-reset.

2.7 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.

B. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer.

C. Gauge Connections: Tapped and plugged suction and discharge gauge connections on piping headers adjacent to pumps.

D. Screens or Guards: Mesh size of less than 0.5 inch, exposed rotating shafts, rotors, couplings, pulley, wheel, bolts, chains, or similar components. Where guards/screens are over grease fittings, couplings, or other items requiring maintenance, provide a means for ready access.

E. Calibrated Cylinder: Graduated in 50-ml increments, constructed of clear polypropylene and PVC with ball type shutoff valve for each pump. Cylinders shall be sized by MFR as appropriate for pumping volume.

2.8 FACTORY FINISHING

A. Manufacturer's standard baked enamel finish.

2.9 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: Test all equipment and control panels actually furnished.

C. Factory Test Report: Include test data sheets.

D. Functional Test: Perform manufacturer's standard, test on equipment.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's printed instructions .

3.2 FIELD QUALITY CONTROL

A. Conduct tests on each pump and controller.

B. Functional Test:

1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
2. Inspect controller for electrical supply termination connections, interconnections, proper installation, and quiet operation.

C. Performance Test:

1. Perform under actual or approved simulated operating conditions.
2. Test for a continuous 3-hour period without malfunction.
3. Demonstrate performance of controller by operating for a continuous period while varying the application load, as the input conditions allow, to verify system performance.

3.3 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at site or classroom designated by OWNER, for minimum person-days listed below, travel time excluded:

1. 1/2 person-day for installation assistance, inspection, and facility startup.
2. 1/2 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.

3.4 SUPPLEMENTS

A. The supplements listed below, following “END OF SECTION,” are a part of this Specification.

1. Pump Data Sheets (2).

END OF SECTION

PUMP DATA SHEET
CHEMICAL METERING PUMPS NO. _____

Project: _____ Pump Mfr.: _____

Owner: _____ Size & Type: _____

Service: _____ Serial No.: _____

Pump Name: _____ Model No.: _____

Equip. Tag Number(s):

Pump: _____ Local Control Panel: _____

Back Pressure Control Valve: _____ Pressure Relief Valve: _____

Calibration Column: _____ Outlet Pulsation Dampener: _____

No. Pumps Required: _____ Drive Type: ☐ Constant ☐ Adjustable No. Spare Parts Required: _____

LIQUID	OPERATING CONDITIONS	SERVICE CONDITIONS
Name: _____	Capacity (U.S. gph):	Temp (°F): Max _____ Min _____
Pumping Temperature (°F):	_____ to _____	Rel. Hum (%): Max _____ Min _____
Max _____ Min _____	Discharge Pressure (psig): _____	Altitude (ft): _____
Specific Gravity @ _____ °F: _____	Diff. Pressure (psi): _____	☐ Indoor ☐ Heated
Viscosity (CP) @ _____ °F: _____	Diff. Head (ft): _____	☐ Outdoor ☐ Unheated
pH: _____	Min. NPSH Available (ft): _____	Area Classification: _____
Corrosion/Erosion/Abrasion Caused by:		Other: _____
_____		
Remarks: _____	Remarks: _____	Remarks: _____
_____	_____	_____

PERFORMANCE REQUIREMENTS (manufacturer to supply missing data)

Proposal Curve No.: _____ Relief Valve Set Pressure (psig): _____ Calibration Cyl. Capacity (ml): _____

Speed (rpm): _____ ☐ As Recommended by Mfr. (psig): _____ Model No. _____

Capacity Range (gph): _____ to _____ Back Pressure Control Valve Set

Discharge Pressure (psig): _____ Pressure (psig): _____ Factory Testing:

☐ As Recommended by Mfr. (psig): _____ ☐ Required ☐ Not Required

Remarks: _____

MATERIALS (manufacturer to supply missing data)

Diaphragm: _____ Ball Check Valves: _____ Pulsation Dampener: _____

Wetted Parts: _____ Seats: _____ Inst. Isolation Diaphragm: _____

SECTION 13390
PACKAGE CONTROL SYSTEMS (PCS)
SUPPLEMENT A

COMPONENT SPECIFICATIONS

A. F1 Flow Element, Pitot-Static, Equal Annuli:

1. General:
   a. Function: Produce a pressure differential signal proportional to the square of the flow rate in an air duct.
   b. Type: Multiple port, pitot-static differential pressure producing device.
   c. Parts: Flow element, transmitter, and mounting hardware.
2. Service:
   a. Fluid: Air, unless otherwise noted.
   b. Upstream Fluid Temperature: Minus 13 degrees C to 44 degrees C.
   c. Upstream Static Pressure: As required.
3. Performance:
   a. Flow Range: As required.
   b. Pressure Differential at Full Scale Flow: As required.
   c. Accuracy: Plus or minus 0.5 percent over a flow range of 10:1, minimum.
   d. Permanent Pressure Loss (Head Loss): Less than 18 percent of measured pressure differential for sizes between 4 and 12 inches. Less than 8 percent of measured pressure differential for sizes over 12 inches.
   e. Repeatability: Plus or minus 0.1 percent.
4. Flow Element Calculations: Verify actual duct inner diameter and provide supporting calculations showing expected pressure differential at full scale flow and permanent head loss.
5. Features:
   a. Pitot Ports: Located across the duct diameter such that the differential pressures of four or more sensing ports are sensed, and averaged.
   b. Static Ports: To sense static pressure.
   c. Materials: Type 316 stainless steel, unless otherwise noted.
   d. Duct Size: As required.
   e. Duct Material: As required.
6. Element Connections:
   a. Process Connections:
      1) Type: Weld fitting and compression ferrule, unless otherwise noted.
      2) Materials: Carbon steel, unless otherwise noted.
   b. Instrument Connections: Integrally-mounted flow transmitter.

7. Signal Interface: 4 to 20mA dc output for load impedance of 0 to 500 ohms minimum without load adjustment with 24V dc supply.
8. Enclosure:
    a. Type: NEMA 4X.
    b. Mounting: Integral with sensing element.
9. Manufacturers and Products:
    a. Dieterich Standard Corp.; ProBar Series.
    b. Approved equal.

B. F2 Flow Element and Transmitter, Electromagnetic:

1. General:
   a. Function: Measure, indicate, and transmit the flow of a process liquid in a full pipe.
   b. Type: Electromagnetic flowmeter, with operation based on Faraday's Law, utilizing the pulsed dc type coil excitation principle with high impedance electrodes.
   c. Parts: Flow element, transmitter, interconnecting cables, mounting hardware, and calibrator.
2. Service:
   a. Stream Fluid: Water with trace amounts of industrial contaminants.
3. Performance:
   a. Flow Range: As noted.
   b. Accuracy: Plus or minus 1 percent of rate for all flows resulting from pipe velocities of 1 to 33 feet per second.
   c. Turndown Ratio: Minimum of 10 to 1 when flow velocity at minimum flow is at least 1 foot per second.
4. Features:
   a. Zero stability feature to eliminate the need to stop flow to check zero alignment.
   b. No obstructions to flow.
   c. Very low pressure loss.
5. Process Connection:
   a. Meter Size: As noted.
   b. Connection Type: 150-pound ANSI raised-face flanges or wafer style depending on meter size, unless otherwise noted.
   c. Flange Material: Carbon steel, unless otherwise noted.
6. Signal Interface:
   a. 4 to 20 mA dc for load impedance 0 to 800 ohms minimum for 24V dc supply.
7. Power: 120V ac, 60-Hz, unless otherwise noted.
8. Element:
   a. Meter Tube Material: 304 stainless steel, unless otherwise noted.
   b. Liner Material: Teflon, unless otherwise noted.
   c. Liner Protectors: Covers on each end to protect liner during shipment.
   d. Electrode Type: Flush or bullet nose as recommended by the manufacturer for the noted stream fluid.
   e. Electrode Material: 316 stainless steel, unless otherwise noted.
   f. Enclosure: NEMA 4, unless otherwise noted.
   g. Grounding Ring/Electrode Material: 316 stainless steel, unless otherwise noted.

9. Transmitter:
    a. Display: Indicating and totalizing.
    b. Mounting: Pipe stand, wall.
    c. Enclosure: NEMA 4X.
    d. Zero and Span: Field adjustable.
    e. Indicator: Digital 16-character display, with scale range as noted.
    f. Totalizer: Digital 16-character display, with totalizer unit digit value as noted.
10. Cables:
    a. Types: As recommended by manufacturer.
    b. Lengths: As required to accommodate device locations.
11. Calibration System:
    a. Features:
        1) Field programmable electronics.
        2) Self-diagnostics with troubleshooting codes.
        3) Ability to program electronics with full scale flow, engineering units, meter size, zero flow cutoff, desired signal damping, totalizer unit digit value, etc.
        4) Initial flow tube calibration and subsequent calibration checks.
    b. Equipment:
        1) Built-in electronics with each unit provided.
        2) Alternatively, one portable calibrator of each type required for the various electromagnetic flowmeters provided on the project.
12. Manufacturers:
    a. Endress & Hauser; Promag 33.
    b. Fischer & Porter; miniMAG, COPA-X or MAG-X, as applicable;
    c. Krohne; Altoflux.

C. F3 Flow Element and Switch, Thermal:

1. General:
   a. Function: Monitor process fluid flow and provide contact closure when flow exceeds set point.
   b. Type: Thermal dispersion flow switch using a heated active and a reference RTD temperature sensors to detect rate of flow as a function of the temperature difference between the two sensors.
2. Service:
   a. Fluid: Water.
   b. Operating Pressure: 75 psig.
   c. Operating Temperature: 15 to 20 degrees C.
3. Performance:
   a. Set Point:
      1) Adjustable throughout full range.
      2) Set as noted.
   b. Range: Choose range so that the noted set point is between 30 and 70 percent of the range.
   c. Repeatability: Plus or minus 1 percent of full range.
   d. Temperature, Operating:
      1) Sensor Element: Minus 100 to plus 350 degrees F.
      2) Electronics: Minus 40 to plus 140 degrees F.
   e. Proof Pressure: To 4,000 psig.
   f. Response Time: Field adjustable from 10 to 150 seconds.
4. Features:
   a. Wetted Surfaces Materials: 316 stainless steel with nickel-base braze, unless otherwise noted.
   b. Dry Pipe Protection: When applied to liquid process, furnish protection against the event of the liquid line going dry, unless otherwise noted.
   c. Process Temperature Compensation: Furnish.
5. Process Connections:
   a. Type: 1-1/4-inch NPT(M), unless otherwise noted.
   b. Pipe Size: As noted.
   c. Connection Type: Insertion.
   d. Connection Material: 316 stainless steel, unless otherwise noted.
6. Conduit Connection: 1-1/4-inch NPT(F) reduced to 3/4 inch with bushing.
7. Element: Insertion/Body Length (From Tip of Probe to Process Connection): Determined by the Supplier based upon pipe size and sensor mounting requirements, unless otherwise noted. The insertion length shall be noted on an application specific installation detail prepared and submitted for each unit.

8. Electronics:
    a. Location: Integral with element, unless otherwise noted.
    b. Hermetically sealed with SPDT relay.
9. Signal Interface:
    a. Contact: Single-pole, double-throw (SPDT), rated 120V ac, 2 amps.
    b. Connection: Screw terminal block.
10. Enclosure:
    a. Type: NEMA 7BCD with watertight O-ring seal.
    b. Material: Cast aluminum, unless otherwise noted.
    c. Approval: Factory Mutual for hazardous area, unless otherwise noted.
11. Power: 120V ac, 60-Hz, unless otherwise noted.
12. Cable (Furnished Only When Remote Electronics is Specified):
    a. Type: As required.
    b. Length: As required.
13. Manufacturer: Fluid Components, Inc.; Model 12-64 or Model FR72.

D. L1 Level Element and Transmitter, Submersible, Electronic:

1. General:
   a. Function: Measure well level by means of differential pressure and transmit a signal proportional to level.
   b. Type: Electronic, piezoresistive-micromachined silicon strain gauge, two wire transmitter.
   c. Operating conditions: Transmitter shall operate in water containing low levels of industrial contaminants.
   d. Warranty: Sensor/transmitter shall be warranted against corrosion for a period of 5 years.
2. Performance:
   a. Range: As noted.
   b. Maximum adjustable range: Noted range shall lie between 40 percent and 80 percent of the maximum adjustable range.
   c. Accuracy: Plus or minus 0.25 percent of calibrated span.
   d. Operating temperature range: Minus 5 degrees F to 140 degrees F.
   e. Compensated temperature range: 30 degrees F to 86 degrees F.
   f. Relative humidity: 0-100 percent.
3. Features:
   a. Type: Cable suspended level sensor
   b. Materials: Sensor body, measurement diaphragm–Titanium. Cable-polyurethane jacket with Kevlar reinforced cord.
   c. Periodic maintenance or cleaning shall NOT be required to maintain function of accuracy.
4. Signal Interface:
   a. Instrument shall be loop powered from 9-32V dc power supply.
   b. Output shall be 4-20 ma DC for load impedance of 0-500 ohms minimum over specified range.
   c. The transmitter shall be factory calibrated for the specified range(s) and shall also include provisions for field calibration through non-interactive zero and span adjustments.
5. Sensor Cable Termination:
   a. The sensor cable shall terminate in a vendor supplied termination box.
   b. The box shall be rated NEMA 4X and be lockable.
   c. Termination enclosure shall be wired complete with lightning arrestors suitable for low voltage DC transmitter circuits.
   d. Cable vent tube shall terminate in this box on desiccant cartridge. Manufacturer shall furnish 6 desiccant cartridges per transmitter.
6. Manufacturers and Products:
   a. Druck; Model PTX 1230.
   b. Approved equal.

E. L2 Level Element and Transmitter, Admittance:

1. General:
   a. Function: Measure and transmit interface level in vessel.
   b. Type: Admittance using low power radio frequency source:
      1) Two-wire transmitter.
      2) “Smart” electronics.
   c. Parts: Element, transmitter (nonintegral), calibrator (or equivalent), and interconnecting cable.
2. Service:
   a. Process Fluid: Water.
   b. Vessel Material: Type 304L stainless steel.
3. Performance:
   a. Range: As required.
   b. Linearity: Plus or minus 0.25 percent of range.
   c. Ambient Temperature: Minus 40 to plus 170 degrees F.
   d. Process Pressure and Temperature Limits: 1,000 psi at 100 degrees F, or 500 psi at 250 degrees F, unless otherwise noted.
4. Element:
   a. Type: Solid rod.
   b. Connection Type: 3/4-inch NPT, unless otherwise noted.
   c. Insertion Length: As required to accommodate specified range and vessel dimensions.
   d. Process Wetted Parts: 316 SS rod, bonded with fluorocarbon-type insulation, unless otherwise noted.
   e. Provisions for grounding if vessel is nonmetallic.
   f. 3/8-inch diameter, nominal.
5. Transmitter:
   a. Integral, unless otherwise noted.
   b. Enclosure: NEMA 4X and explosionproof.
   c. Signal Interface: 4 to 20 mA dc output with Hart protocol for load impedance 0 to 600 ohms minimum for 24V dc supply without load adjustment.
   d. Performance Response Time:
      1) With delay off,20 milliseconds.
      2) With delay on, adjustable 0.5 to 30 seconds.
   e. Indicator: Digital loop meter, NEMA 4X enclosure.
   f. Allowable Static Discharge to Sensor: 10 amps maximum, unless otherwise noted.
6. Accessories:
   a. Calibration Device:
      1) Quantity: One total for contract, unless otherwise noted.
      2) Type: Hart hand-held communicator, unless otherwise noted.

7. Manufacturers:
    a. Drexelbrook; Model 508-45-9.
    b. Endress and Hauser; Model FEC12.

F. L3 Level Switch, Float, Bulkhead:

1. General:
   a. Function: Operate contact at preset liquid level.
   b. Type: Float-actuated bulkhead-mounted; magnetic actuation.
2. Service:
   a. Fluid: Water unless otherwise noted.
   b. Specific Gravity: 1.0 unless otherwise noted.
   c. Pressure: 150 psi maximum.
   d. Temperature: 100 degrees F maximum.
3. Performance:
   a. Set Point: As noted.
   b. Dead Band: 4-inch unless otherwise noted.
4. Features: Float, stem, and other wetted parts stainless steel unless otherwise noted.
5. Process Connections: 2-inch NPT half-coupling or 3-inch, 150-pound ANSI RF flange as required.
6. Signal Interface Contact: DPDT snap action contact rated 5A continuous at 120V ac.
7. Enclosure: NEMA 4, unless otherwise noted.
8. Manufacturers:
   a. LINC; Model L471.
   b. Magnetrol; Tuffy series.
   c. Robertshaw; Series SL-500.

G. L4 Level Switch, Float, Tank Top:

1. General:
   a. Function: Operate switch at preset level in a tank.
   b. Type: Float-actuated mounted directly to tank top.
2. Service:
   a. Fluid: Water unless otherwise noted.
   b. Specific Gravity: 1.0 unless otherwise noted.
   c. Pressure: 150 psi maximum.
   d. Temperature: 100 degrees F maximum.
3. Performance:
   a. Set Point: As noted.
   b. Dead Band: 1-inch maximum.
4. Features:
   a. Float, stem, and guide tube connected to a switch enclosure.
   b. Insertion Length: As required to achieve the noted set point.
   c. Float Size: 4-1/2-inch unless otherwise noted.
   d. Materials: Wetted parts 304 or 316 stainless steel unless otherwise noted.
5. Process Connection: 1-inch NPT.
6. Signal Interface Contact: DPDT snap action rated 10A continuous at 120V ac.
7. Enclosure: NEMA 4 unless otherwise noted.
8. Manufacturers:
   a. Magnetrol; Model T20.
   b. Robertshaw; Series SL-100.

H. L5 Level Element and Switch, Electrode:

1. General:

    a. Function: Activate contact at preset liquid level.
    b. Type: Conductance; solid state relays.
    c. Parts: Electrode, electrode holder, relays, enclosure, cabling.
2. Performance:
    a. Set Point: 1/8-inch above finished floor.
    b. Accuracy: Plus or minus 1/16-inch electrode tip length.
    c. Sensitivity: As required for (conductivity of) specific liquid application.
3. Service:
    a. Water on floor sensing.
    b. Process Liquid: Water.
    c. Operating Temperature: Ambient.
    d. Operating Pressure: Atmospheric.
4. Electrode Holder:
    a. Type: External pipe threaded, unless otherwise noted.
    b. Material: 316 stainless steel, unless otherwise noted.
    c. Mounting: 3-inch NPT, unless otherwise noted.
    d. Service: Watertight, outdoor heavy duty, unless otherwise noted.
5. Electrode:
    a. Type: Rod.
    b. Number: One.
    c. Length: As required for the noted set points.
    d. Material: 316 stainless steel, unless otherwise noted.
    e. Spacers: As noted.
6. Relays:
    a. Type: Solid state, unless otherwise noted.
    b. Number: One per noted set point.
    c. Sensitivity: As required for (conductivity of) specific liquid application.
    d. Power: 120V ac, 60-Hz, or 240V ac, 60-Hz.
    e. Contacts: DPDT, rated at 10 amps continuous at 120V ac.
    f. Enclosure: NEMA 4X fiberglass, unless otherwise noted.
7. Cabling:
    a. Provide interconnecting conductors between electrode holder and relays.
    b. Type: As recommended by manufacturer.
    c. Quantity and Length: As required.
8. Ancillaries:
    a. Furnish all ancillaries for a complete and operating system.
    b. Include such items as wire connectors for wire suspension electrodes.

9. Manufacturers:
    a. B/W Controls.
    b. Charles F. Warwick Co.

I. P1 Pressure Gauge:

1. General:
   a. Function: Pressure indication.
   b. Type: Bourdon tube.
2. Performance:
   a. Range: As noted. Compound scale when noted.
   b. Accuracy: Plus or minus 0.5 percent of span.
3. Features:
   a. Mounting: Lower stem, unless otherwise noted.
   b. Dial: 4-1/2-inch diameter, unless otherwise noted.
   c. Case Material: Phenolic plastic, unless otherwise noted.
   d. Element Material: Phosphor-bronze, unless otherwise noted.
   e. Dampening: Pulsation dampener when noted, piston type with multiple choice of piston placement to vary the desired amount of dampening.
   f. Case Type: Solid front design with solid wall between window and element. Rear of case, gasketed pressure relief.
   g. Pointer: Micrometer pointer with self-locking adjustment.
   h. Movement: Stainless steel, rotor geared.
4. Process Connection:
   a. Line Size: 1/2-inch.
   b. Connection Type: Threaded.
5. Manufacturers and Products:
   a. Ashcroft; Duragauge Model 1279/1379.
   b. Robert Shaw Acragage.
   c. Marsh Mastergauge.

J. P2 Pressure Differential Gauge, Low Range Air:

1. General:
   a. Function: Indicate differential pressure locally.
   b. Type: Bellows.
2. Service:
   a. Rated Total Pressure: 20 inches Hg. to 15 psig.
   b. Temperature Limits: 20 degrees F to 140 degrees F.
   c. Air filter differential pressure, air static pressure.
3. Performance:
   a. Range: As required.
   b. Accuracy: 2 percent of full scale.
4. Features:
   a. Indictor: 4-1/2-inch diameter.
   b. Adjustments: Front accessible zero.
   c. Scale: Linear.
   d. Connections: 1/8-inch, NPT.
   e. Case: Die-cast aluminum.
   f. Mounting: Panel, surface, or pipe.
5. Manufacturers and Products:
   a. Dwyer; Series 2000 Magnehelic.
   b. ITT Barton; Model 227 or 200.

K. P3 Pressure Switch, Fixed Dead Band:

1. General:
   a. Function: Monitor pressure and provide contact closure(s) when pressure is at the noted set point.
   b. Type: Diaphragm sealed piston actuator.
2. Performance:
   a. Set Point: As required.
      1) Adjustable over the full range.
      2) Set as noted.
   b. Range: The noted set point shall fall between 30 percent and 70 percent of the range.
   c. Set Point Repeatability: Plus or minus 1 percent of range.
3. Features:
   a. Diaphragm Material: Buna-N, unless otherwise noted.
   b. Pressure Connection: Type 316 stainless steel, unless otherwise noted.
   c. Reset: Automatic, unless otherwise noted.
4. Enclosure: NEMA 4X, unless otherwise noted.
5. Signal Interface:
   a. Contact Type: SPDT, snap action switch, rated for 15 amps at 120V ac.
   b. Number of Switch Elements: One, unless otherwise noted.
6. Manufacturers and Products:
   a. Ashcroft; B Series.
   b. United Electric; Series 400.
   c. SOR.

L. P4 Pressure Switch, Low Range Air:

1. General:
   a. Function: Monitor air pressure and provide contact closure(s) when pressure is at the noted setpoint.
   b. Type: Diaphragm actuator.
2. Performance:
   a. Setpoint: As required.
   b. Range: The setpoint shall fall between 30 percent and 70 percent of the range.
   c. Setpoint Repeatability: Plus or minus 2 percent of range.
   d. Maximum Rated Pressure: 10 psig.
3. Features:
   a. Diaphragm Material: Silicone rubber.
   b. Pressure Connection: 1/8-inch NPT aluminum.
   c. Reset: Automatic.
   d. Electrical Connection: 1/2-inch NPT.
4. Enclosure: NEMA 7 (explosion proof).
5. Signal Interface:
   a. Contact Type: SPDT snap action switch, rated for 15 amps at 120V ac.
   b. Number of Switch Elements: One.
6. Manufacturers and Products:
   a. Dwyer; Model 1950.
   b. ITT Barton.

M. P5 Pressure Transmitter, Electronic:

1. General:
   a. Function: Measure pressure and transmit signal proportional to pressure.
   b. Type: Electronic variable capacitance, two-wire transmitter.
2. Performance:
   a. Range: As noted.
   b. Maximum Adjustable Range: Such that the noted range shall lie between 40 percent and 80 percent of the maximum adjustable range.
   c. Accuracy: Plus or minus 0.25 percent of calibrated span.
   d. Temperature: Minus 20 degrees F to plus 200 degrees F, minimum.
3. Features:
   a. Type: Gauge pressure, unless otherwise noted.
   b. Damping: Fluid or electronic type with adjustment.
   c. On-site LCD Display.
   d. Suppressed or Elevated Zero: When noted.
   e. Diaphragm Sensor: Ceramic; all other parts 316 stainless steel.
   f. Wetted O-Rings: Viton, unless otherwise noted.
   g. Housing: Modular with separate compartments for electronics and field connections.
   h. Fill Fluid: Silicone, unless otherwise noted.
4. Process Connections:
   a. Line Size: 1/2 inch or 1/4 inch, selectable.
   b. Connection Type: FNPT.
5. Signal Interface: 4 to 20 mA dc output for load impedance of 0 to 500 ohms minimum without load adjustment with 24V dc supply.
6. Enclosure:
   a. Type: NEMA 4X, unless otherwise noted.
   b. Mounting: Pipe or wall as noted. Provide brackets with Series 300 stainless steel bolts.
7. Manufacturer and Products:
   a. Endress & Hauser; PMC 133, PMC 134, or PMC 53X CERABAR.

N. S1 Indicator, Loop Powered, Integral Enclosure:

1. General:
   a. Function: Digital indication of an analog signal.
   b. Type:
      1) Loop powered.
      2) Integral NEMA 4X enclosure, unless otherwise noted.
2. Performance:
   a. Accuracy: plus or minus 0.1 percent of span counts, plus or minus 1 count.
   b. Temperature, Operating: minus 10 to plus 70 degrees C (14 to 158 degrees F).
   c. Temperature Coefficient:
      1) Zero: plus or minus 100 ppm/ degree C, max.
      2) Span: plus or minus 150 ppm/ degree C, max.
   d. Display Reading Update: 2.5 conversions/sec.
   e. Input Voltage Drop: 3.9 volts max at 20mA.
   f. FM and CSA approved intrinsically safe for hazardous locations.
3. Features:
   a. Readout Display:
      1) Type: 0.8-inches high, liquid crystal, 3-1/2 digits.
      2) Decimal Point Indication: Switch selectable, four positions.
      3) Dummy Zero: Switch selectable trailing zero.
   b. Wide Range Display Calibration:
      1) Zero: Adjustable from minus 1999 to 1999.
      2) Span: Adjustable from 100 to 3998 counts.
   c. Urethane coating of internal circuitry (for protection from corrosive atmospheres): If noted.
4. Signal Interface: 4-20 mA and 10-50mA, switch selectable.
5. Enclosure:
   a. Type: NEMA 4X, unless otherwise noted.
   b. Mounting: Conduit mount, ½-inch, external mounting bracket for surface mounting; unless otherwise noted.
   c. Front Cover Standard Engineering Units: SCFM.
6. Manufacturers and Products:
   a. Action Instruments; Visipak, Model V560, Loop Powered LCD Indicator.
   b. Newport Electronics: Model 508B (integral NEMA 4X housing).

O. T1 Thermometer, Gauge Type:

1. General: Provide where indicated on the Process Control Diagram.
2. Type: Bi-metal.
3. Parts: Thermometer and thermowell.
4. Range: As required.
5. Accuracy: Plus or minus 1 percent of scale ranges.
6. 3-inch dial.
7. 1/2-inch NPT connection.
8. Stem Length: 2-1/2-inch.
9. Thermometer:
    a. Type 316 stainless steel case.
    b. Externally adjustable dial.
    c. Glass window.
    d. Hermetically sealed.
    e. Adjustable viewing angle.
10. Thermowell:
    a. Type: Separable 3/4-inch NPT process connection, Type 316 stainless steel, unless otherwise noted.
11. Manufacturers and Products:
    a. Ashcroft; Series EI.
    b. 3-D Instruments.
    c. Trend Instruments, Inc.

P. T2 Temperature Element and Transmitter, Resistance:

1. General:
   a. Function: Measure the temperature of a process fluid, and transmit analog signal proportional to temperature.
   b. Type: RTD.
   c. Parts: Element, thermowell, and transmitter.
2. Service:
   a. Fluid: Water.
   b. Range: 0 to 40 degrees C.
3. Element:
   a. Type:
      1) Single-element, three-wire, RTD.
      2) Platinum, 100 ohm nominal at 0 degrees C.
   b. Performance:
      1) Accuracy: Plus or minus 1/4 percent of reading or plus or minus 1/4 degrees F, whichever is greater. Conform to SAMA Standard RC 21-4-1966.
      2) Repeatability: Plus or minus 0.1 percent of span.
      3) Response Time: Less than 10 seconds (bare bulb in agitated water).
   c. Features:
      1) Dimensions: 1/4-inch diameter.
      2) Length to accommodate thermowell insertion and extension lengths.
      3) Spring-loaded element when well is used.
      4) 316 stainless steel sheath.
4. Thermowell:
   a. Features:
      1) Inside Diameter: Sized to match element, for easy removal and maximum heat transfer.
      2) Materials: Type 316 stainless steel, unless otherwise noted.
      3) Insertion Length: As required.
      4) Extension Length: 3 inches, unless otherwise noted.
   b. Process Connections: 3/4-inch NPT connection, unless otherwise noted.
5. Transmitter:
   a. Type: Two-wire, powered by a remote power supply.
   b. Performance:
      1) Ambient Temperature Range: Minus 20 to 150 degrees F. Variations within this range shall not affect accuracy more than plus or minus 1/4 percent of range per 50 degrees F.
      2) Accuracy: Plus or minus 0.15 percent of span.
      3) Repeatability: Plus or minus 0.05 percent of span.

c. Features:
    1) Indicator: 0 to 40 degrees C.
d. Signal Interface: 4 to 20 mA dc for load impedance 0 to 600 ohms minimum for 24V dc supply without load adjustment.
e. Enclosure:
    1) Type: NEMA 4.
    2) Mounting: Wall, pipe stand, or element, as noted.

6. Manufacturers:
    a. Foxboro; Series PR element and well with 893RA transmitter.
    b. Rosemount; Series 79 thermowell, 58C, 68, 78, 88 Series platinum RTD and Model 444 transmitter.

Q. Y1 Telephone Dialer Alarm System:

1. General:
   a. Function: Continuously monitor normally open contacts and upon a contact closure shall dial preprogrammed telephone numbers, deliver a prerecorded message, and reset itself upon reception of a signal from the person being called.
   b. Type: Dialer shall be a 16-bit microprocessor based system with all programming and voice messages stored in non-volatile memory. Dialer shall be compatible with cellular telephone or standard telephone communication network.
2. Performance:
   a. Alarm Response Delay: 1 to 5,999 seconds.
   b. Telephone Numbers: Nine phone numbers up to 60 digits in length.
   c. Message Length: 10 seconds per message.
   d. Number of Alarm Channels: Four digital, expandable up to eight digital total.
   e. Power: 120V ac, 60-Hz with battery backup for 60 hours of monitoring service.
   f. The system shall be programmable locally or remotely via touch tone telephone.
   g. Operating Temperature: 20 degrees F to 130 degrees F.
   h. Humidity: 0 to 95 percent noncondensing.
3. Features:
   a. Three-year manufacturer's parts and labor warranty.
   b. Six-digit security code.
   c. Surge protection on power, telephone, and alarm lines.
   d. Direct telephone or cellular communications to FAX machines, answering machines, digital or voice radio pagers, or to computers.
   e. Call progress decoding.
   f. Separate and independent call list for each alarm channel.
   g. Visual indicators for power, fault, run, phone off-hook, line off-hook, incoming call, call in progress, and FAX in progress.
4. Enclosure: NEMA 4X fiberglass.
5. Manufacturers and Products:
   a. Microtel; Series 1000 alarm dialer.
   b. Or approved equal.

R. Y2 Programmable Logic Controller System:

1. General:
   a. Function: Used for process monitoring and control by emulating functions of conventional panel mounted equipment such as relays, timers, counters, current switches, calculation modules, PID controllers, stepping switches, and drum programmers.
   b. Type: Microprocessor based device programmable using ladder logic.
   c. Parts: Central processing unit (CPU), power supply, local and remote input/output modules, local and remote base (chassis/rack) controllers, I/O bases (chassis/rack), data highway, and factory assembled interconnecting cables. Provide components required to make a complete and totally operational system. Reference P&ID Drawings.
   d. All equipment shall be Year 2000 compliant.
2. Environmental:
   a. Temperature: Operating range 32 to 140 degrees F (0 to 60 degrees C); storage range minus 40 to 158 degrees F (0 to 70 degrees C).
   b. Humidity: Operating range 5 to 95 percent noncondensing.
   c. Vibration:
      1) Sinusoidal: IEC 68-2-6, Test Fc; 0.15 mm peak-to-peak, 10- to 57-Hz; 1 g, 57- to 150-Hz.
      2) Random: IEC 68-2-34, Test Fdc; 0.4 g^2/Hz, 80- to 350-Hz, and 3dB/octave rolloff, 80- to 20-Hz and 350- to 2-KHz at 10 min/axis.
   d. Noise: IEC 801, Part 3, Level 3 and Part 4, Level 3; MIL STD-461B.
   e. Isolation: User-side to PLC side 1,500V rms.
   f. Agency Approvals and Standards:
      1) UL listed.
      2) CSA certified.
3. Central Processing Unit (CPU):
   a. Type: Microprocessor, 16-bit minimum.
   b. Scan Time: Less than 1 ms/K words of relay ladder logic.
   c. PLC Communications:
      1) One communication ports, RS-232 or RS-422.
      2) Baud rates supported 1200, 2400, 9600, 19200.
   d. Network Communications: One Allen-Bradley Data Highway Plus port.
   e. Remote I/O Communication Links.

f. Instruction Set:
    1) Timers and counters.
    2) Math: Signed integer and floating-point math including add, subtract, multiply, divide, square root, and compare.
    3) Register Operations: Shift registers, bit shift, bit set, bit clear, data move and data format conversion.
    4) Process Loop Control: User configurable direct or reverse acting PID loop control computation with the capability of both AUTO and MANUAL modes of operation, remote access to controller tuning constants.
    5) Real Time Clock: Date and time set and compare.
    6) Miscellaneous: Jump or skip to a label, one shot, drums, preconfigured analog alarm functions, subroutines.

g. Diagnostics:
    1) Indicators: Battery status, PLC status, PLC operation mode, remote I/O communication status.
    2) Status Word: With failure status for PLC battery, scan overrun, communications, I/O, special functions.
    3) Power Up: PLC checks status of PROMs upon powerup; runs self-diagnostics on power-up; periodically runs self-diagnostics while in RUN mode, halts logic processor and sets outputs to configured state if fatal error is detected.
    4) Diagnostic Tables: Tables, displayable by programming computer, that describe nature and location (address) existing faults and errors.

h. Agency Approvals and Standards:
    1) UL listed.

4. Random Access Memory (RAM):
    a. Memory Size: 32 K words.
    b. Read only memory (ROM) for controller's operating system and diagnostics.
    c. Memory Protection: Switch.
5. Power Supply: One unit for each input/output base assembly:
    a. Voltage: 120/220 volts (user selectable), 60-Hz input; 85 to 132 volts output. Allen-Bradley No. 1746-P2 .
    b. Mounting: External to base.
6. Input/Output: Complete input/output system, including remote I/O with distances up to 10,000 feet maximum up to four remote logical racks.
    a. Discrete Input Modules:
        1) Voltage: 120 volts, 60-Hz.
        2) Operating Power: 2 watts.
        3) Points per Module: 16, maximum.
        4) LED status indicator for each point.
        5) Isolation: Between input point and PLC, 1,500 volts rms.
        6) Manufacturer: Allen-Bradley, Model No. 1746-IA16.

b. Discrete Output Modules:
   1) Voltage: 120 volts, 60-Hz.
   2) Operating Power: 2 watts.
   3) Load Rating: 2 amps continuous.
   4) Isolation: Between PLC and output point, 1,500 volts rms.
   5) Points per Module: 16, maximum.
   6) LED status indicator for each point.
   7) Manufacturer: Allen-Bradley 1746-OA16.

c. Isolated Discrete Output Modules:
   1) Type: Isolated Form A relay.
   2) Voltage: 120 volts, 60-Hz.
   3) Isolated Outputs per Module: 8.
   4) Load Rating: 5 amps continuous.
   5) Operating Power: 2.5 watts.
   6) Points Per Module: 8, maximum.
   7) LED status indicator and fuse for each point.
   8) Isolation: Between PLC and output point, 1,500 volts rms.
   9) Manufacturer: Allen-Bradley, Model No. 1746-0X8.

d. Fast Response DC Input Modules:
   1) Input “Voltage: 24V dc.
   2) Input Current: 8 ma at 24V dc.
   3) Points Per Module: 16, maximum.
   4) Maximum Input Frequency: 1,000 Hz.
   5) Manufacturers and Products: Allen Bradley; Model No. 1746-ITB16 (sink).

e. Analog Input Modules:
   1) Voltage: 24 volts dc.
   2) Power: 3 watts.
   3) Differential Analog Points Per Module: 8, maximum.
   4) Isolation: Between PLC and I/O point and between I/O points, 1,500 volts rms.
   5) Analog Input Resolution: 16 bits.
   6) Manufacturer: Allen-Bradley, Model No. 1746-NI8.

f. Analog Output Modules:
   1) Voltage: 24V dc.
   2) Power: 3 watts.
   3) Isolated Analog Points Per Module: 4 maximum.
   4) Isolation Between PLC and I/O Point and Between I/O Points: 1,500 volts rms.
   5) Manufacturer and Product: Allen-Bradley; Model No. 1746-N04I.

7. Remote Adapter Module:
   a. One remote I/O adapter module required for each remote chassis.
   b. Manufacturer and Product: Allen-Bradley; Model No. 1747-ASB.

8. Remote I/O Scanner Module:
    a. Manufacturer: Allen-Bradley Model No. 1747-SN.
9. I/O Chassis:
    a. Each remote I/O panel and SLC 5/04 panel shall be furnished with one I/O chassis.
    b. Each chassis shall have 7, 10, or 13 slots.
    c. Manufacturer and Product: Allen-Bradley; Model Nos. 1746-A7, 1746-A10 and 1746-A13.
10. Fiber Optic Module:
    a. Selectable Wavelengths: 850 nm and 1,300 nm.
    b. Compatible with multimode fiber.
    c. Panel-mounted, 120V ac power supply.
    d. Data highway plus and remote I/O communications.
    e. Fault tolerant.
    f. Interaction diagnostics.
    g. Manufacturer and Product: Phoenix Digital; Model OCM-DPR-13-P-DST-ACV.
11. I/O Placement:
    a. From Left to Right: Analog, DC I/O, AC I/O.
    b. Wired to/from PLC I/O modules or racks to/from control panel terminal blocks in all panels (direct connection of field wiring to I/O module or rack is not acceptable.
12. Identification:
    a. Nameplates installed above/below each PLC component (CPU, I/O rack, power supply, etc.).
    b. Label configured I/O points as they have been configured (addressed) in the system.
13. Programming Software:
    a. Programming software shall be manufactured by Rockwell Automation.
    b. Software shall be suitable for online and offline programming of Allen-Bradley SLC S/04. PLC programming software shall communicate with the PLCs with RS LINX software.
    c. Model Number: RSLOGIX 500 Standard offline/online—disk, latest version.
14. PLC Programming Unit:
    a. The PLC programming unit shall be used to access any PLC for purposes of monitoring the real time operation of the PLC program, and modifying both on and offline the PLC program. The programming unit shall communicate with any PLC by direct connection to the PLC or by connection over the data highway.
    b. Provide all other cabling, cards, memory, software and chips as required to enable the unit to perform its intended functions.
    c. The PLC programming unit shall be a laptop style PC with the following as a minimum requirement:

1) Pentium III processor, 450 mHz.
2) 64 MB RAM.
3) 4 GB hard drive.
4) 32X CD-rom drive.
5) 3-1/4-inch floppy drive (floppy drive and CD-Rom installed internal to PC. Both must be accessible by PC).
6) MS Windows NT (latest version).
7) Microsoft Office Professional Suite (Word, Access, Excel, Power Point).
8) Carrying case.
9) Extra battery pack.
10) Parallel cable for printing.
11) All associated manuals.
12) PCMCIA data highway plus adapter card with cable. Allen-Bradley; Model No. 1784-PCMC1.

SECTION 15150
ELECTRIC VALVE OPERATORS

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA): C540, Power-Actuating Devices for Valves and Sluice Gates.
2. Underwriters Laboratories (UL).
3. Canadian Standards Association (CSA).

1.2 SUBMITTALS

A. Shop Drawings:

1. Product data sheets for make and model.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
3. Detailed mechanical and electrical drawings showing the equipment fabrications and interface with other items.
4. Power and control wiring diagrams, including terminals and numbers.
5. Open/close and throttle actuators sizing calculations.
6. Shop and field painting systems proposed.

B. Quality Control Submittals:

1. Certificate of Compliance for electric operators; full compliance with AWWA C540.
2. Tests and inspection data.
3. Manufacturer's Certificate of Proper Installation.
4. Operation and maintenance manual.

PART 2 PRODUCTS

2.1 GENERAL

A. Valve to include operator, actuator, handwheel, and accessories as applicable for a complete operation. Operators, actuators, and other accessories shall be sized and furnished by the valve supplier and factory mounted.

B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified.

C. Valve same size as adjoining pipe, unless otherwise shown.

D. Valve ends to suit adjacent piping.

E. Size operator to operate valve for the full range of pressures and velocities.

F. In-plant service valves are to open by turning counterclockwise.

G. Factory mount operator, actuator, and accessories.

2.2 SCHEDULE

A. Requirements relative to this section are shown on Electric Operator Schedule attached as a supplement to the end of this section.

2.3 OPERATORS

A. General: All valves shall be equipped with operators. The valve operator types, as specified herein, describe only the general characteristics of the operator. The operator shall be compatible with the valve with which it will be used and shall be of the same manufacturer, or a product that is recommended by the valve manufacturer. The operator shall be sized to operate the valve for the full range of pressures and velocities imposed by the service.

B. Manual Operator:

1. General:
    a. Operator force not to exceed 40 pounds under any operating condition, including initial breakaway. Gear reduction operator when force exceeds 40 pounds.
    b. Operator: Self-locking type or equipped with self-locking device.
    c. Position indicator on quarter-turn valves.
    d. Worm and Gear Operators: One-piece design worm-gears of gear bronze material. Worm shall be hardened alloy steel with thread ground and polished. Traveling nut type operators shall have threader steel reach rods with internally threaded bronze or ductile iron nut.
2. Exposed Operator:
    a. Galvanized and painted handwheels.
    b. Lever operators allowed on quarter-turn valves 8 inches and smaller.
    c. Cranks on gear type operators.
    d. Chain wheel operator with tiebacks, extension stem, floor stands, and other accessories to permit operation from normal operation level.
    e. Valve handles to take a padlock, and wheels a chain and padlock.

f. Acceptable Manufacturers and Products (12-Inch Valve and Larger):
   1) Limitorque; T Series.
   2) EIM; WO Series.

C. Electric Operator:

1. General:
   a. Comply with AWWA C540.
   b. Size to 1-1/2 times required operating torque. Motor stall torque not to exceed torque capacity of valve.
   c. Controls integral with the actuator and fully equipped as specified in AWWA 540.
   d. Stem protection for rising stem valves.
2. Type 1E:
   a. Actuator Operation-General:
      1) Suitable for full 90-degree rotation of quarter-turn valves or for use on multiturn valves.
      2) Manual override handwheel.
      3) Valve position indication.
      4) Operate from FULL CLOSED to FULL OPEN positions or the reverse in the number of seconds given in the Electric Operator Schedule.
   b. Modulating Service:
      1) Size motors for unresistricted continuous duty.
      2) Feedback potentiometer and integral electronic positioner/comparator circuit to maintain valve position. 4-20 mA output proportional to valve position for customer use.
      3) HAND-OFF-AUTO (Local-Off-Remote) Selector Switch:
         a) OPEN-STOP-CLOSE pushbutton to control valve in HAND position.
         b) 4 to 20 mA dc input signal to control valve in AUTO position.
         c) Auxiliary contact which closes when the HAND-OFF-AUTO or LOCAL-OFF-REMOTE switch is in the AUTO or REMOTE position.
      4) Valves shall close upon loss of signal unless otherwise indicated.
      5) OPEN and CLOSED indicating lights.
      6) Ac motor with reversing starter or dc motor with solid state reversing controller, and built-in overload protection.
      7) Duty cycle limit timer and adjustable band width to prevent actuator hunting.

c. Actuator Power Supply:
   1) 480-volt, three-phase unless otherwise indicated.
   2) Control power transformer, 120-volt secondary.
   3) Externally operable power disconnect switch. Valve disconnect shall be a circuit breaker for valves 12 inches and larger and when indicated on the Drawings.

d. Enclosure:
   1) As defined in NEMA 250, Type 4X.
   2) Contain 120-volt space heaters.

e. Limit Switch:
   1) Single-pole, double-throw (SPDT) type, field adjustable cam-operated, with contacts rated for 5 amps at 120 volts ac.
   2) Each valve actuator to have a minimum of two transfer contacts at end position, one for valve FULL OPEN and one for valve FULL CLOSED. These limit switches shall be for customer use only.
   3) Housed in actuator control enclosure.

f. Manufacturers and Products:
   1) Jordan Controls, Inc..
   2) Limitorque; SMB.

3. Type 3E:

a. Actuator Operation-General:
   1) Suitable for full 90-degree rotation of quarter-turn valves.
   2) Declutchable manual override.
   3) Valve position indication.
   4) Operate from FULL CLOSED to FULL OPEN positions or the reverse in less than 10 seconds.

b. Open-Close Service:
   1) Size motors for one complete OPEN-CLOSE-OPEN cycle no less than once every 10 minutes.

c. Actuator Power Supply: 120-volt, single-phase unless otherwise indicated.

d. Enclosure:
   1) As defined in NEMA 250, Type 4X.
   2) Contain 120-volt space heaters.

e. Limit Switch:
   1) Single-pole, double-throw (SPDT) type, field adjustable cam-operated, with contacts rated for 5 amps at 120 volts ac.
   2) Each valve actuator to have a minimum of two transfer contacts at end position, one for valve FULL OPEN and one for valve FULL CLOSED. These limit switches are for customer use only.
   3) Housed in actuator control enclosure.

f. Manufacturer and Product: El-O-Matic; EL Series.

2.4 SUPPLEMENTS

A. The supplement listed below, following “END OF SECTION”, is part of this Specification.

1. Electric Operator Schedule.

END OF SECTION

ELECTRIC OPERATOR SCHEDULE

Tag Number	Valve Type	Size (inches)	Fluid	Maximum Operating Flow	Maximum DP (psi)	Service	Travel Time (Seconds)	Operator Type

SECTION 16405
AC INDUCTION MOTORS

PART 1 GENERAL

1.1 RELATED SECTIONS

A. This section applies only when referenced by a motor-driven equipment specification. Application, horsepower, enclosure type, mounting, shaft type, synchronous speed, and any deviations from this section will be listed in the equipment specification. Where such deviations occur, they shall take precedence over this section.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Anti-Friction Bearing Manufacturers' Association (AFBMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Rating and Fatigue Life for Roller Bearings.
2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 85, Test Procedure for Airborne Sound Measurements on Rotating Machines.
   b. 112, Standard Test Procedures for Polyphase Induction Motors and Generators.
   c. 114, Standard Test Procedures for Single-Phase Induction Motors.
   d. 841, Recommended Practice for Chemical Industry Severe-Duty Squirrel-Cage Induction Motors, 600V and Below.
3. National Electrical Manufacturers Association (NEMA):
   a. MG 1, Motors and Generators.
   b. MG 13, Frame Assignments for Alternating Current Integral Horsepower Induction Motors.
   c. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
4. National Fire Protection Association (NFPA): 70, National Electrical Code. (NEC)
5. Underwriters Laboratories (UL):
   a. 547, Thermal Protectors for Electric Motors.
   b. 674, Electric Motors and Generators Used in Hazardous (Classified) Locations.

1.3 DEFINITIONS

A. CISD-TEFC: Chemical industry, severe-duty enclosure.

B. EXP: Explosion-proof enclosure.

C. TEFC: Totally enclosed, fan cooled enclosure.

D. Motor Nameplate Horsepower: That rating after any derating required to allow for extra heating caused by the harmonic content in the voltage applied to the motor by its controller.

1.4 SUBMITTALS

A. Shop Drawings:

1. Descriptive information.
2. Nameplate data in accordance with NEMA MG 1.

B. Quality Control Submittals: Operation and maintenance manual.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. General Electric.

B. Reliance.

C. Siemens.

D. Baldor.

E. U.S. Motors.

F. Westinghouse.

2.2 GENERAL

A. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.

B. In order to obtain single source responsibility, utilize a single supplier to provide a drive motor, its driven equipment, and specified motor accessories.

C. Meet requirements of NEMA MG 1.

D. Frame assignments in accordance with NEMA MG 13.

E. Provide motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

F. Motors shall be specifically designed for the use and conditions intended, with a NEMA design letter classification to fit the application.

G. Lifting lugs on all motors weighing 100 pounds or more.

H. Operating Conditions:

1. Maximum ambient temperature not greater than 40 degrees C.
2. Motors shall be suitable for operating conditions without any reduction being required in the nameplate rated horsepower or exceeding the rated temperature rise.
3. Overspeed in either direction in accordance with NEMA MG 1.

I. All motors intended for use on variable frequency drives shall be designed and labeled for "Inverter Duty".

2.3 HORSEPOWER RATING

A. As designated in motor-driven equipment specifications.

B. Constant Speed Applications: Brake horsepower of the driven equipment at any operating condition not to exceed motor nameplate horsepower rating, excluding any service factor.

C. Adjustable Frequency, Adjustable Speed Applications: Driven equipment brake horsepower at any operating condition not to exceed motor nameplate horsepower rating, excluding any service factor.

2.4 SERVICE FACTOR

A. 1.15 minimum at rated ambient temperature, unless otherwise indicated.

2.5 VOLTAGE AND FREQUENCY RATING

A. System Frequency: 60-Hz.

B. Voltage Rating: Unless otherwise indicated in motor-driven equipment specifications:

Size	Voltage	Phases
1/2 hp and smaller	115	1
3/4 hp through 400 hp	460	3

C. Suitable for full voltage starting.

D. Suitable for accelerating the connected load with supply voltage at motor starter supply terminals dipping to 90 percent of motor rated voltage.

2.6 EFFICIENCY AND POWER FACTOR

A. For all motors except single-phase, under 1 hp, multispeed, short-time rated and submersible motors, or motors driving gates, valves, elevators, cranes, trolleys, and hoists:

1. Efficiency:
   a. Tested in accordance with NEMA MG 1, paragraph 12.54.1.
   b. Guaranteed minimum at full load in accordance with Table 1 or as indicated in motor-driven equipment specifications.
2. Power Factor: Guaranteed minimum at full load in accordance with Table 1 or as indicated in motor-driven equipment specifications.

2.7 LOCKED ROTOR RATINGS

A. Locked rotor kVA Code F or lower if motor horsepower not covered by NEMA MG 1 tables.

B. Safe stall time 15 seconds or greater.

2.8 INSULATION SYSTEMS

A. Single-Phase, Fractional Horsepower Motors: Manufacturer's standard winding insulation system.

B. Three-Phase and Integral Horsepower Motors, Unless Otherwise Indicated in Motor-Driven Equipment Specifications: Class F with Class B rise at nameplate horsepower and designated operating conditions.

2.9 ENCLOSURES

A. All enclosures to conform to NEMA MG 1.

B. TEFC: Furnish with a drain hole with porous drain/weather plug.

C. Explosion-Proof (EXP):

1. TEFC listed to meet UL 674 and NFPA 70 requirements for Class 1, Division 1, Group C and D hazardous locations.
2. Drain holes with drain and breather fittings.
3. Integral thermostat opening on excessive motor temperature in accordance with UL 547 and NFPA 70.
4. Thermostat leads to terminate in a terminal box separate from main terminal box.

D. Chemical Industry, Severe-Duty (CISD-TEFC): In accordance with Article SPECIAL MOTORS.

2.10 TERMINAL (CONDUIT) BOXES

A. Oversize main terminal boxes for all motors.

B. Diagonally split, rotatable to each of four 90-degree positions. Threaded hubs for conduit attachment.

C. Except ODP, furnish gaskets between box halves and between box and motor frame.

D. Minimum usable volume in percentage of that specified in NEMA MG 1-11.06 and 20.62 and NFPA 70, Article 430.

E. Terminal for connection of equipment grounding wire in each terminal box.

2.11 BEARINGS AND LUBRICATION

A. Horizontal Motors:

1. 3/4 hp and Smaller: Permanently lubricated and sealed ball bearings, or regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
2. 1 Through 400 hp: Regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
3. Minimum 100,000 hours L-10 bearing life for ball and roller bearings as defined in AFBMA 9 and 11.

B. Vertical Motors:

1. Thrust Bearings:
   a. Antifriction bearing.
   b. Manufacturer's standard lubrication 100 hp and smaller.
   c. Oil lubricated 125 hp and smaller.
   d. Minimum 50,000 hours L-10 bearing life.
2. Guide Bearings:
   a. Manufacturer's standard bearing type.
   b. Manufacturer's standard lubrication 200 hp and smaller.
   c. Oil lubricated 250 hp and smaller.
   d. Minimum 100,000 hours L-10 bearing life.

C. Regreasable Antifriction Bearings:

1. Readily accessible, grease injection fittings.
2. Readily accessible, removable grease relief plugs.

2.12 NOISE

A. Measured in accordance with IEEE 85 and NEMA MG 1.

B. Motors controlled by adjustable frequency drive systems shall not exceed sound levels of 3 dBA higher than NEMA MG 1.

2.13 BALANCE AND VIBRATION CONTROL

A. In accordance with NEMA MG 1-12.06.

2.14 EQUIPMENT FINISH

A. External Finish: Prime and finish coat manufacturer's standard.

B. Internal Finish: Bore and end turns coated with clear polyester or epoxy varnish.

2.15 SPECIAL MOTORS

A. Requirements in this article take precedence over conflicting features specified elsewhere in this section.

B. Chemical Industry, Severe-Duty (CISD-TEFC):

1. In accordance with IEEE 841.
2. TEFC in accordance with NEMA MG 1.
3. Suitable for indoor or outdoor installation in severe-duty applications including high humidity, chemical (corrosive), dirty, or salty atmospheres.
4. Motor Frame, End Shields, Terminal Box(es), and Fan Cover: Cast iron.
5. Ventilating Fan: Corrosion-resistant, nonsparking, external.
6. Drain and Breather Fittings: Stainless steel.
7. Nameplate: Stainless steel.
8. Gaskets between terminal box halves and terminal box and motor frame.
9. Extra slinger on rotor shaft to prevent moisture seepage along shaft into motor.
10. Double shielded bearings.
11. 125,000 hours minimum L-10 bearing life for direct-connected loads.
12. External Finish: Double-coated epoxy enamel.
13. Coated rotor and stator air gap surfaces.
14. Insulation System, Windings, and Connections:
    a. Class F insulation, Class B rise or better at 1.0 service factor.
    b. Multiple dips and bakes of nonhygroscopic polyester varnish.

15. Service Factor:
    a. At 40 Degrees C Ambient: 1.15.
    b. At 65 Degrees C Ambient: 1.00.
16. Safe Stall Time Without Injurious Heating: 20 seconds minimum.

C. Severe-Duty Explosion-Proof: Meet requirements for EXP enclosures and CISD-TEFC motors.

2.16 FACTORY TESTING

A. Tests:

1. In accordance with IEEE 112 for polyphase motors and IEEE 114 for single-phase motors.
2. Routine (production) tests on all motors in accordance with NEMA MG 1, plus no load power at rated voltage and polyphase, rated voltage measurement of locked rotor current. Test multispeed motors at all speeds.
3. For energy efficient motors, test efficiency at 50, 75, and 100 percent of rated horsepower:
    a. In accordance with IEEE 112, Test Method B, and NEMA MG 1, paragraphs 12.54 and 12.57.
    b. For motors 500 hp and larger where facilities are not available to test by dynamometer (Test Method B), determine efficiency by IEEE 112, Test Method F.
4. Power factor.
    a. Speed.
    b. Current at rated horsepower.
    c. kW input at rated horsepower.
    d. On motors of 100 hp and smaller, furnish a certified copy of a motor efficiency test report on an identical motor.

B. Test Report Forms: Routine Tests: IEEE 112, Form A-1.

PART 3 EXECUTION

3.1 INSTALLATION

A. In accordance with manufacturer's instructions and recommendations.

B. Align motor carefully and properly with driven equipment.

C. Secure equipment to mounting surface with anchor bolts. Provide anchor bolts meeting manufacturer's recommendations and of sufficient size and number for the specified seismic conditions.

3.2 SUPPLEMENTS

A. Table supplements, following “END OF SECTION”, are a part of this Specification.

END OF SECTION

Table 1 MOTOR PERFORMANCE REQUIREMENTS					
		% Guar. Min. Full Load Efficiency		% Guar. Min. Full Load Power Factor	
Hp	Nom. Speed rpm	Horizontal TEFC	Vertical TEFC	Horizontal TEFC	Vertical TEFC
1	1,800	81.5		Mfr.'s Std.	
	1,200	79.3		Mfr.'s Std.	
1.5	3,600	81.5		Mfr.'s Std.	
	1,800	82.0		Mfr.'s Std.	
	1,200	84.0	82.0	Mfr.'s Std.	Mfr.'s Std.
2	3,600	84.0		Mfr.'s Std.	
	1,800	83.7		Mfr.'s Std.	
	1,200	85.5	83.7	Mfr.'s Std.	Mfr.'s Std.
	900	82.5	81.7	Mfr.'s Std.	Mfr.'s Std.
3	3,600	84.0	82.0	Mfr.'s Std.	Mfr.'s Std.
	1,800	86.5	84.8	Mfr.'s Std.	Mfr.'s Std.
	1,200	88.1	86.6	Mfr.'s Std.	Mfr.'s Std.
	900	82.9	82.9	Mfr.'s Std.	Mfr.'s Std.
5	3,600	86.5	84.8	Mfr.'s Std.	Mfr.'s Std.
	1,800	86.5	84.8	Mfr.'s Std.	Mfr.'s Std.
	1,200	88.1	86.6	Mfr.'s Std.	Mfr.'s Std.
	900	86.5	86.6	Mfr.'s Std.	Mfr.'s Std.
7.5	3,600	88.1	86.6	Mfr.'s Std.	Mfr.'s Std.
	1,800	89.5	88.4	Mfr.'s Std.	Mfr.'s Std.
	1,200	88.5	87.5	Mfr.'s Std.	Mfr.'s Std.
	900	86.5	86.6	Mfr.'s Std.	Mfr.'s Std.

Table 1 MOTOR PERFORMANCE REQUIREMENTS					
		% Guar. Min. Full Load Efficiency		% Guar. Min. Full Load Power Factor	
Hp	Nom. Speed rpm	Horizontal TEFC	Vertical TEFC	Horizontal TEFC	Vertical TEFC
10	3,600	89.5	88.4	Mfr.'s Std.	Mfr.'s Std.
	1,800	89.5	88.4	Mfr.'s Std.	Mfr.'s Std.
	1,200	89.5	88.4	Mfr.'s Std.	Mfr.'s Std.
	900	88.5	88.4	Mfr.'s Std.	Mfr.'s Std.
15	3,600	89.8	88.4	Mfr.'s Std.	Mfr.'s Std.
	1,800	91.0	90.2	Mfr.'s Std.	Mfr.'s Std.
	1,200	90.2	89.3	Mfr.'s Std.	Mfr.'s Std.
	900	88.5	88.4	Mfr.'s Std.	Mfr.'s Std.
20	3,600	90.6	89.3	Mfr.'s Std.	Mfr.'s Std.
	1,800	91.7	90.9	Mfr.'s Std.	Mfr.'s Std.
	1,200	90.6	89.3	Mfr.'s Std.	Mfr.'s Std.
	900	89.5	88.4	Mfr.'s Std.	Mfr.'s Std.
25	3,600	91.0	90.2	Mfr.'s Std.	Mfr.'s Std.
	1,800	92.4	91.7	Mfr.'s Std.	Mfr.'s Std.
	1,200	91.0	89.3	Mfr.'s Std.	Mfr.'s Std.
	900	89.5	88.4	Mfr.'s Std.	Mfr.'s Std.
30	3,600	91.4	88.4	Mfr.'s Std.	Mfr.'s Std.
	1,800	92.4	91.7	Mfr.'s Std.	Mfr.'s Std.
	1,200	91.0	90.2	Mfr.'s Std.	Mfr.'s Std.
	900	91.7	90.9	Mfr.'s Std.	Mfr.'s Std.
40	3,600	91.7	89.3	86.1	89.0
	1,800	93.0	91.7	78.2	84.5
	1,200	92.4	90.9	81.5	81.5
	900	91.0	90.2	70.5	70.5

Table 1 MOTOR PERFORMANCE REQUIREMENTS					
		% Guar. Min. Full Load Efficiency		% Guar. Min. Full Load Power Factor	
Hp	Nom. Speed rpm	Horizontal TEFC	Vertical TEFC	Horizontal TEFC	Vertical TEFC
50	3,600	92.0	89.3	86.7	89.0
	1,800	93.0	91.7	79.4	82.5
	1,200	92.4	90.9	81.5	81.5
	900	91.7	90.9	72.9	80.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

JOHNSON SPACE CENTER

WHITE SANDS TEST FACILITY

TECHNICAL SPECIFICATIONS FOR THE SUPPLY AND INSTALLATION OF PROCESS PIPING, CONTROL SYSTEM, AND RELATED COMPONENTS

GROUND WATER TREATMENT SYSTEM FOR PLUME-FRONT STABILIZATION

Revised May 31, 2002

Table of Contents

List of Drawings……iii

List of References…….. vi

1. Scope……... 1

2. General Requirements…… 4
   - 2.1 Security Provisions……... 4
   - 2.2 Health and Safety Provisions……... 5
   - 2.3 Confined Spaces and Entry……... 6
   - 2.4 Environmental Concerns……...7
   - 2.5 Cultural Resources…… 7

3. Schedule Requirements……7

4. Mechanical Component Specifications……8
   - 4.1 Process Piping……... 8
   - 4.2 Valves……12
   - 4.3 Pipe Supports…… 18
   - 4.4 Piping Installation…… 20
   - 4.5 Valve Installation…….. 22
   - 4.6 Pipe Support Installation ……..23

5. Electrical and Process Component Specification…… 24
   - 5.1 Flow Meters…….. 24
   - 5.2 Float Level Switch, Tank Top…….. 25
   - 5.3 Float Level Element and Switch……... 25
   - 5.4 Pressure Indicators…… 26
   - 5.5 Telephone Dialer Alarm…….. 26
   - 5.6 Power Monitor……..…….. 27
   - 5.7 Programmable Logic Controller System..…….. 29

6. Packaged Control System…… 34
   - 6.1 General……..34
   - 6.2 Products…….34
   - 6.3 Component Identification……..47
   - 6.4 Surge and Transient Protection……49

7. Fiber Optic Data Transmission System…….. 49
   - 7.1 System Description…….. 49
   - 7.2 Submittals…… 50
   - 7.3 Products…… 51
   - 7.4 Optical Fibers……...53
   - 7.5 Fiber Optic Installation……..…….. 57

Table of Contents (continued)

7.6 Fiber Optic System Testing……...…..……60
7.7 Fiber Optic System Training……...……..……..…61

8. Certification and Warranty……... …61

9. Submittals……..62
9.1 General Requirements……62
9.2 Pre-construction Submittals……...63
9.3 Construction Progress Submittals……..…64
9.4 Construction Close-out Submittals……66

Attachments

1…….……WSI 25-SW-0003.B "Confined Space Entry Program"

2……WSI 25-SW-0013.C "Hot Work Permit for Welding-Cutting Operations"

3.....Contract Drawings

List of Drawings

PIPING SYSTEM:

652-I-01……INDEX OF DRAWINGS
652-I-02……INDEX OF DRAWINGS
652-I-04……INDEX OF DRAWINGS, SYMBOLS, & ABBREVIATIONS
652-C-01……..CIVIL, PROJECT LOCATION
652-C-02……..CIVIL, WELL LOCATIONS & PIPING LAYOUT
652-C-03……..CIVIL, PLAN & PROFILE PIPING ROUTE (N-1)
652-C-04……..CIVIL, PLAN & PROFILE PIPING ROUTE (N-2)
652-C-05……..CIVIL, PLAN & PROFILE PIPING ROUTE (N-3)
652-C-06……..CIVIL, PLAN & PROFILE PIPING ROUTE (N-4)
652-C-07……..CIVIL, PLAN & PROFILE PIPING ROUTE (N-5)
652-C-08……..CIVIL, PLAN & PROFILE PIPING ROUTE (S-1)
652-C-09……..CIVIL, PLAN & PROFILE PIPING ROUTE (S-2)
652-C-10……..CIVIL, PLAN & PROFILE PIPING ROUTE (S-3)
652-C-11……..CIVIL, PLAN & PROFILE PIPING ROUTE (S-4)
652-C-12……..CIVIL, PLAN & PROFILE PIPING ROUTE (S-5)
652-C-13……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-2)
652-C-14……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-4A)
652-C-15……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFE4B)
652-C-16……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-5)
652-C-17……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFI-1A)
652-C-18……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFI-1B)
652-C-19……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFI-4A)
652-C-20……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-7A)
652-C-21……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-7B)
652-M-01……..MECHANICAL, FLOW SCHEMATIC, EXTRACTION WELLS
652-M-02…… .MECHANICAL, FLOW SCHEMATIC, TREATMENT FACILITY
652-M-03…… .MECHANICAL, FLOW SCHEMATIC, INJECTION WELLS
652-M-04…… .MECHANICAL, SUBGRADE PIPE & FITTING SCHEDULES
652-M-05…… .MECHANICAL, SUBGRADE PIPE & FITTING SCHEDULES
652-M-06…… .MECHANICAL, PIPE & FITTING SCHEDULES
652-M-07…… .MECHANICAL, PIPE & FITTING SCHEDULES
652-M-08…… .MECHANICAL, PIPE & FITTING SCHEDULES

EXTRACTION WELLS:

653-C-01……PFE-1 CIVIL, SITE/UTILITIES PLAN
653-M-01……...PFE-1 MECHANICAL DETAILS
653-E-01……PFE-1 ELECTRICAL DETAILS
653-E-02……PFE-1 ELECTRICAL DETAILS
654-C-01……PFE-2 CIVIL, SITE/UTILITIES PLAN
654-M-01……...PFE-2 MECHANICAL DETAILS
654-E-01……PFE-2 ELECTRICAL DETAILS
654-E-02……PFE-2 ELECTRICAL DETAILS
655-C-01……PFE-3 CIVIL, SITE/UTILITIES PLAN
655-M-01……...PFE-3 MECHANICAL DETAILS
655-E-01……PFE-3 ELECTRICAL DETAILS
655-E-02……PFE-3 ELECTRICAL DETAILS
656-C-01……PFE-4A CIVIL, SITE/UTILITIES PLAN
656-M-01……...PFE-4A MECHANICAL DETAILS
656-E-01……PFE-4A ELECTRICAL DETAILS
656-E-02……PFE-4A ELECTRICAL DETAILS

List of Drawings (continued)

657-C-01……PFE-5 CIVIL, SITE/UTILITIES PLAN
657-M-01……...PFE-5 MECHANICAL DETAILS
657-E-01……PFE-5 ELECTRICAL DETAILS
657-E-02……PFE-5 ELECTRICAL DETAILS
658-C-01……PFE-7 CIVIL, SITE/UTILITIES PLAN
658-M-01……...PFE-7 MECHANICAL DETAILS
658-E-01……PFE-7 ELECTRICAL DETAILS
658-E-02……PFE-7 ELECTRICAL DETAILS

INJECTION WELLS:

660-C-01……PFI-1, CIVIL, SITE/UTILITIES PLAN
660-M-01……...PFI-1, MECHANICAL, DETAILS AT WELLHEAD
661-C-01……PF1-2, CIVIL, SITE/UTILITIES PLAN
661-M-01……...PFI-2, MECHANICAL, DETAILS AT WELLHEAD
662-C-01……PFI-3, CIVIL, SITE/UTILITIES PLAN
662-M-01……...PFI-3, MECHANICAL, DETAILS AT WELLHEAD
663-C-01……PFI-4, CIVIL, SITE/UTILITIES PLAN
663-M-01…….. PFI-4, MECHANICAL, DETAILS AT WELLHEAD

BUILDING 650, TREATMENT FACILITY

650-M-06……MECHANICAL, EQUIPMENT LAYOUT
650-E-01…….ELECTRICAL, POWER PLAN
650-E-04…….ELECTRICAL, ONE LINE DIAGRAM
650-E-08…….ELECTRICAL, CONTROL CONDUIT LAYOUT

BUILDING 651, INJECTION MANIFOLD BUILDING

651-M-01……MECHANICAL, ISOMETRIC PIPING
651-E-01…….ELECTRICAL, POWER & LIGHTING PLAN

CONTROL SYSTEM (Drawings by CH2M Hill):

G-1…….. ELECTRICAL, INSTRUM ENTATION LEGEND
G-2…….. ELECTRICAL, INSTRUMENTATION LEGEND
G-3……..ELECTRICAL, PLC SYSTEM DIAGRAM
E-1……..ELECTRICAL, INSTRUMENTATION CONDUIT SITE PLAN, EXTRACTION WELLS, NORTH
E-2……..ELECTRICAL, INSTRUMENTATION CONDUIT SITE PLAN, EXTRACTION WELLS, CENTRAL
E-3……..ELECTRICAL, INSTRUMENTATION CONDUIT SITE PLAN, EXTRACTION WELLS, SOUTH
E-4……..ELECTRICAL, INSTRUMENTATION CONDUIT SITE PLAN, INJECTION WELLS
E-5……..ELECTRICAL, TREATMENT BUILDING, INSTRUMENTATION PLAN
E-6……..ELECTRICAL, INJECTION MANIFOLD BUILDING, INSTRUMENTATION PLAN
E-7……..INSTRUMENTATION AND CONDUIT SITE PLAN, EXTRACTION WELLS WEST
I-1……...ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, EXTRACTION WELLS PFE-1 AND PFE-5
I-2……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, EXTRACTION WELLS PFE-2 AND PFE-6

List of Drawings (continued)

I-3……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, EXTRACTION WELLS PFE-3 AND PFE-4A
I-4……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, EXTRACTION WELLS PFE-7, PFE-8, & PFE-9
I-5……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, SCALE CLEANING SYSTEM
I-6……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, POTABLE WATER AND FLOOR SUMP
I-7……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, SCALE CLEANING SYSTEM
I-8……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, AIR STRIPPER UNIT NO. 1
I-9……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, AIR STRIPPER UNIT NO. 2
I-10……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, AIR STRIPPER UNIT NO. 3
I-11……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, ULTRAVIOLET OXIDATION UNIT NO. 1
I-12……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, ULTRAVIOLET OXIDATION UNIT NO. 2
I-13……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, INJECTION WELLS PFI-1 AND PFI-2
I-14……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, INJECTION WELLS PFI-3 AND PFI-4
I-15……ELECTRICAL, EXTRACTION WELL CONTROL PANEL
I-16……ELECTRICAL, EXTRACTION WELL CONTROL PANEL WIRING
I-17……ELECTRICAL, EXTRACTION WELL CONTROL PANEL WIRING
I-18……ELECTRICAL, FIBER-OPTIC MODEM PANEL
I-19……ELECTRICAL, INJECTION WELL CONTROL PANEL
I-20……ELECTRICAL, INJECTION WELL CONTROL PANEL WIRING
I-21……ELECTRICAL, INJECTION WELL CONTROL PANEL WIRING
I-22……ELECTRICAL, INJECTION WELL CONTROL PANEL WIRING
I-23……ELECTRICAL, PLC – MAIN CONTROL PANEL
I-24……ELECTRICAL, PLC – MAIN CONTROL PANEL WIRING
I-25……ELECTRICAL, PLC – MAIN CONTROL PANEL WIRING
I-26……ELECTRICAL, PLC – MAIN CONTROL PANEL WIRING
I-27……ELECTRICAL, PLC – MAIN CONTROL PANEL WIRING
I-28……ELECTRICAL, PLC – MAIN CONTROL PANEL WIRING
I-29……ELECTRICAL, FIBER-OPTIC MODEM TERMINALS

List of References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM):

ASTM A 105/A 105M (1996) Standard Specification for Forgings, Carbon Steel, for Piping Components

ASTM A 126 (1995) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

ASTM A 197 (1987; R 1992) Standard Specification for Cupola Malleable Iron

ASTM A 216 (1993) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service

ASTM A 234/A 234M (1997) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures

ASTM A 307 (1994) Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength

ASTM A 403/A 403M (1997; Rev A) Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings

ASTM A 53 (1996) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

ASTM A 563 (1994) Standard Specification for Carbon and Alloy Steel Nuts

ASTM F 104 (1995) Standard Classification System for Nonmetallic Gasket Materials

ASTM F 441/F 441M (1997) Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

ASTM F 437 (1999) Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80

ASTM F 439 (1999) Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80

ASTM F493 Solvent Cements for CPVC Plastic Pipe and Fittings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME):

ASME B16.1 (1998) Cast Iron Pipe Flanges and Flanged Fittings

ASME B16.11 (1996) Forged Steel Fittings, Socket-Welding and Threaded

ASME B16.3 (1992) Malleable-Iron Threaded Fittings, Classes 150 and 300

ASME B16.39 (1986) Malleable Iron Threaded Pipe Unions, Classes 150, 250, and 300

ASME B16.5 (1996) Pipe Flanges and Flanged Fittings

ASME B16.9 (1993) Factory-Made Wrought Steel Butt Welding Fittings

ASME B31.3 (1996) Chemical Plant and Petroleum Refinery Piping

AMERICAN WELDING SOCIETY (AWS):

AWS-02 (1990) Welding Handbook; Eighth Ed; Vol Two – Welding Process

FEDERAL SPECIFICATIONS (FS):

FS HH-I-558 (Rev C) Insulation, Blocks, Boards, Blankets, Felts, Sleeving (Pipe and Tube Covering), and Pipe Fitting Covering, Thermal (Mineral Fiber, Industrial Type)

FS FF-S-325 (Int Amd 3) Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)

MANUFACTURER'S STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS):

MSS SP-58 (1993) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-67 (1995) Butterfly Valves
MSS SP-69 (1996) Pipe Hangers and Supports - Selection and Application
MSS SP-85 (1994) Cast Iron Globe & Angle Valves Flanged and Threaded Ends

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC):

AISC S328 (1986) Specification for Structural Steel Buildings Load and Resistance Factor Design

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI):

ANSI A13.1 (1981; R 1993) Scheme for the Identification of Piping Systems
ANSI B40.1 (1991) Gauges - Pressure Indicating Dial Type - Elastic Element

INSTRUMENT SOCIETY OF AMERICA (ISA):

ISA S50.1, Compatibility of Analog Signals for Electronic Process Instruments.
ISA S7.0.01 (1996) Quality Standard for Instrument Air

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA):

NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
NEMA AB 1, Molded Case Circuit Breakers and Molded Case Switches.
NEMA ICS 2, Industrial Control Devices, Controllers and Assemblies.

ELECTRONIC INDUSTRIES ALLIANCE (EIA):

EIA ANSI/EIA/TIA-232-F(1997) Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange
EIA/TIA-455-B (1998) Test Procedures for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and other Fiber Optic Components (ANSI)
EIA ANSI/TIA/EIA-455-13A(1996) FOTP-13 Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies
EIA ANSI/EIA/TIA-455-25B(1996) FOTP-25 Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies
EIA ANSI/EIA/TIA-455-30B(1991) FOTP-30 Frequency Domain Measurement of Multimode Optical Fiber Information Transmission Capacity
EIA ANSI/TIA/EIA-455-41A(1993) FOTP-41 Compressive Loading Resistance of Fiber Optic Cables
EIA ANSI/EIA/TIA-455-46A(1990) FOTP-46 Spectral Attenuation Measurement for Long-Length, Graded-Index Optical Fibers
EIA ANSI/EIA/TIA-455-58A(1990) FOTP-58 Core Diameter Measurement of Graded-Index Optical Fibers

EIA ANSI/EIA/TIA-455-59(1989) FOTP-59 Measurement of Fiber Point Defects Using an OTDR
EIA ANSI/EIA/TIA-455-61(1989) FOTP-61 Measurement of Fiber or Cable Attenuation Using an OTDR
EIA ANSI/EIA-455-81A-91(1992) FOTP-81 Compound Flow (Drip) Test for Filled Fiber Optic Cable
EIA ANSI/EIA/TIA-455-82B(1992) FOTP-82 Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable
EIA ANSI/EIA-455-91(1986; R 1996) FOTP-91 Fiber Optic Cable Twist-Bend Test
EIA ANSI/TIA/EIA-455-104A(1993) FOTP-104 Fiber Optic Cable Cyclic Flexing Test
EIA ANSI/EIA/TIA-455-170(1989) FOTP-170 Cable Cutoff Wavelength of Single-Mode Fiber by Transmitted Power
EIA ANSI/EIA-455-171(1987) FOTP-171 Attenuation by Substitution Measurement - for Short-Length Multimode Graded-Index and Single-Mode Optical Fiber Cable Assemblies
EIA ANSI/TIA/EIA-455-177A(1992) FOTP-177 Numerical Aperture Measurement of Graded-Index Optical Fibers

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA):
NFPA 70(1999) National Electrical Code

UNDERWRITERS LABORATORIES (UL):
UL 910(1998) Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air

1. Scope

1.1. This specification defines the requirements for materials, installation, and testing of the process piping and control system for NASA White Sands Test Facility's (WSTF) groundwater remediation facility. Once the treatment system is installed, groundwater containing low parts-per-billion (ppb) concentrations of hazardous constituents will be pumped through dual-containment high density polyethylene (HDPE) piping from extraction wells to a treatment facility. Within the remediation facility, the water will be conveyed in steel piping and treated via two parallel air strippers and an ultraviolet oxidation reactor. Following treatment, single-wall HDPE piping will be used to transfer the treated groundwater from the treatment facility to injection wells. Installation of underground HDPE piping and conduit, wells, and well vaults are excluded from the scope of this project.

1.2. Maps of WSTF's location and the project location with respect to WSTF's developed areas are presented in the contract drawings. WSTF is located 18 miles northeast of Las Cruces, New Mexico (65 miles north of El Paso, Texas) with access provided through U.S. Highway 70. The project is located in an unimproved area of Sections 4 and 5 of T21S, R3E and Section 32 of T20S, R3E (see contract drawings). Access to the general project vicinity is provided by a light duty gravel road (the WSTF Well Road).

1.3. Location of each building, well vaults, and the pipeline are shown in the complete contract drawing package. Also included are the equipment schedules, dimensions, process diagrams, etc., required for the completion of this project.

1.4. The scope of this specification includes the following:

1.4.1. Extraction Well Vaults (refer to contract drawings 652-M-01, 652-E-01 through 652-E-38, 653-M-01, 653-E-01, 653-E-02, 654-M-01, 654-E-01, 654-E-02, 655-M-01, 655-E-01, 655-E-02, 656-M-01, 656-E-01, 656-E-02, 657-M-01, 657-E-01, and 657-E-02).

1.4.1.1. Supply and install various diameters of steel piping, pipe supports, flow control valve, control valve controller unit, flow meter, and manual valves in six extraction well vaults, per contract drawings. These components are located between the wellhead flange and an HDPE flange inside each vault (note: PFE-5 does not have a flow control valve or valve controller unit).

1.4.1.2. Supply and install six extraction well control panels (PLC-PFEx) at the vaults of extraction wells 1, 2, 3, 4A, 5, and 7. Complete wiring and communication connections per the contract drawings.

1.4.1.3. Supply and field install a power monitor unit in the Motor Control Center (MCC) for each respective extraction well, with all accessories including matching potential and current transformers. Complete electrical connection between the power monitors and the Allen-Bradley Data Highway Plus network installed under the scope of this project. Supply and install all

necessary accessories for a functional communication connection. MCC's will be provided and installed by the Government.

1.4.1.4. Complete and verify all wiring connections between electrical components and their respective power supply and Supervisory Control and Data Acquisition (SCADA) system connections at each well vault.

1.4.1.5. Supply and install fiber optic cable through underground conduit, between extraction well MCC's and Building 650, per the contract drawings. Complete all wiring connections and verify communication between extraction wells and Building 650 controller.

1.4.2. Building 650 – Groundwater Treatment Facility (refer to contract drawings 652-M-02, 652-E-01 through 652-E-38, 650-M-06, 650-E-01, 650-E-04, and 650-E-09)

1.4.2.1. Supply and install various diameter steel piping, pipe supports, manual valves, and pressure gauge between the influent flange from the extraction well pipeline and the inlet flanges on both air strippers, as indicated on contract drawings.

1.4.2.2. Supply and install various diameter steel piping, supports, manual valves, check valves, pressure gauge, and rupture disc between the air stripper discharge flanges and the UV system inlet flange, as indicated on contract drawings.

1.4.2.3. Install the supplied static mixer into the inlet piping to the air strippers as indicated on contract drawings.

1.4.2.4. Install the supplied electromagnetic flow meter in the UV reactor inlet piping, as indicated on contract drawings. Complete electrical connections between the UV reactor controller (PLC-UV1)and flow meter per manufacturer specifications.

1.4.2.5. Supply and install various diameter chlorinated polyvinyl chloride (CPVC) piping and supports between scale cleaning system and air strippers, and between an existing "spent cleaning solution" tank and each of the two air strippers.

1.4.2.6. Supply and install steel piping and supports between UV system drain and floor sump, and install steel piping and supports between rupture disc discharge at the UV unit inlet and the floor sump.

1.4.2.7. Supply and install steel piping, supports, manual valve, and check valve that make up the system recycle line.

1.4.2.8. Supply and install tubing between scale control system pump and pipe connection upstream of the static mixer, per the design drawings.

1.4.2.9. Supply and install compressed air tubing lines between existing air compressor unit, nine pneumatic valve actuators, and the UV reactor pneumatic wiper tubes, as indicated on contract drawings.

1.4.2.10. Supply and install Building 650 controller (PLC Main) panel. Complete wiring and communication connections per the contract drawings.

1.4.2.11. Supply, install, and connect wiring between air stripper controllers (CP-100 and CP200) and UV reactor controller (PLC-UV1) to the Building 650 controller (PLC-Main), per the contract drawings.

1.4.2.12. Supply wiring and connect Scale Cleaning System controller (CP-400) and Scale Control System controller (CP-300) to PLC-Main controller, per the contract drawings.

1.4.2.13. Install supplied air stripper blower sensors and switches in blower inlet ducting to the air strippers. Supply, install, and connect wiring between these sensors and respective control panels per the contract drawings.

1.4.2.14. Supply and install float level switch in Building 650 floor sump. Complete electrical connections between floor sump level switch and the PLC-Main controller, per the contract drawings.

1.4.2.15. Supply and connect wiring between the existing Leak Detection Control Panel in Building 650 and the PLC-Main controller, per the contract drawings.

1.4.2.16. Complete installation and electrical connection between two existing air temperature switches in Building 650 and the PLC-Main controller, per the contract drawings.

1.4.2.17. Supply, install, and/or complete electrical and fiber optic connections for a power monitor in the Building 650 motor control center. This may be done by either providing a new power monitor, or providing adequate hardware and software to allow communication and data exchange between the existing Square D Powerlogic monitor and the Allen-Bradley Data Highway Plus network installed under the scope of this project. Supply and install all necessary accessories for a functional communication connection.

1.4.2.18. Install control station personal computer supplied by NASA in the Building 650 control room. This includes an alarm printer, and a telephone dialer. HMI and control system software packages will be supplied by NASA, then installed and programmed by the contractor.

1.4.2.19. Supply wiring, install, and interconnect the SCADA system, control station PC, WSTF telephone system, and telephone dialer, per the contract drawings.

1.4.2.20. Verify proper connection and perform specified tests on wiring, fiber optic (FO) cable, FO splices, and connections for power, control, and communication system during and following the installation process. Refer to technical specifications that follow for further details.

1.4.2.21. Validate the control system and software, autodialer functions, alarms, etc. following installation. Provide a complete and functional communication network per the contract drawings. Refer to technical specifications that follow for further details.

1.4.3. Building 651 - Injection Manifold Building (refer to contract drawings 652-M-03, 652-E-01 through 652-E-38, 651-M-01, and 651-E-01).

1.4.3.1. Supply and install various diameter CPVC piping, pipe supports, flow control valves with position transmitters, valve controllers, electromagnetic flow meters, air vent valves, and manual valves, per the contract drawings. These components make up the piping manifold between the flange at the end of the pipeline from Building 650 and the four flanges on pipelines that lead to the injections wells. Refer to mechanical design drawings numbered above.

1.4.3.2. Supply and install Building 651 control (PLC-PFI) panel. Supply wire and complete wiring connections per the contract drawings.

1.4.3.3. Supply wire and complete wiring connections between flow control valves, position transmitters, valve controllers, flow meters, and PLC-PFI in Building 651, per the contract drawings.

1.4.3.4. Supply wire, install in existing underground conduit, and complete electrical connection between existing well-level pressure transducers in each injection well and Building 651 controller (PLC-PFI).

1.4.3.5. Supply and install control cable and/or fiber optic cable into existing underground conduit, between Building 651 and Building 650. Complete electrical connections on both ends per the contract drawings.

1.4.3.6. Verify wiring connections for all controls and communication following installation.

1.4.4. Injection Well Vaults (refer contract drawings 652-M-03, 652-E-01 through 652-E-38, 660-M-01, 661-M-01, 662-M-01, and 663-M-01)

1.4.4.1. Supply and install carbon steel piping, pipe supports, and manual valves, in four injection well vaults as indicated on contract drawings. These components comprise the piping connection between the steel wellhead flange and the HDPE pipeline flange. They are contained inside the injection well vaults.

1.4.4.2. Verify and/or complete electrical connections between existing well-level pressure transducers at each injection well vault and controller PLC-PFI in Building 651.

2. General Requirements

2.1. Security Provisions

2.1.1. Following award of this contract, the Contractor shall submit the names, and citizenship of all personnel scheduled to be on site to the facility point of contact at least 5 days prior to their arrival at WSTF. NASA-WSTF will only issue badges to U.S. citizens. Upon mobilization to the facility, all Contractor and sub-contractor employees are required to show valid picture identification to security personnel. At this time a temporary security badge will be issued to each employee. Contractor employees shall wear their badges at all times while present on the facility. All vehicles entering the site are required to have current license and registration documents, and are subject to search upon entering and exiting the facility. A temporary parking permit will be issued and placed on the vehicle upon its entry into the facility.

2.1.2. Contractor personnel will be restricted to the work area and will not be allowed to venture unescorted to other areas of the site. Work hours at WSTF shall not exceed 12 hours per day or 60 hours per week for any Contractor personnel. Regular work hours at WSTF are Monday through Friday, 7:00 a.m. to 3:30 p.m.

2.1.3. Contractor shall comply with all site access, safety, and security procedures prescribed for the control of persons visiting the project site. Contractor personnel shall receive necessary briefings before being allowed to enter and perform work at the Government facility. The Contractor shall advise the facility POC or designee of any safety issues with regard to his activity, so that on-site personnel can be notified.

2.1.4. Contractor personnel will be required to have means of communication while working in the plume front area at WSTF. This may consist of radios or cellular telephone. This is to allow rapid notification in the case of any emergency that might arise and require evacuation or other action on their part. Use of cellular telephones by the Contractor at WSTF is not restricted, but use of two-way radios must be pre-approved by WSTF.

2.1.5. Telephone

2.1.5.1. A telephone, for on-site and local calls and emergency use only, is installed and operational in Building 650. For work in remote locations, contractor is required to supply personnel with a means of emergency communication as mentioned in the security provisions above.

2.1.6. Temporary Storage

2.1.6.1. Several locations near the work site will be made available by the Government for use as temporary storage and/or staging areas. If needed, temporary fencing may be used for security of these locations, supplied at the Contractor's expense, and removed within 30 days following the end of project construction. Contractor may also use Building 650 for storage of equipment. NASA will issue a set of Building 650 keys to the Contractor. If Contractor loses those keys, he will be charged for the cost of all required re-keying.

2.1.6.2. The Government assumes no responsibility for security of equipment stored temporarily at or near the work site.

2.2. Health And Safety Provisions

2.2.1. Fire Protection

2.2.1.1. Contractor shall provide the appropriate temporary fire protection equipment for the protection of personnel and property during construction. Debris and flammable materials shall be removed weekly by the Contractor to minimize potential hazards. At least one 10 lb., Class A/B/C, dry chemical fire extinguisher is required within each vehicle at the work site during all operations at WSTF.

2.2.1.2. If Contractor performs any welding or spark-producing operations, Contractor shall comply with WSTF's hot work regulations. A copy of WSI 25-SW-0013.C is provided as an attachment to this document.

2.2.2. Contractor personnel will wear the following personal protective equipment:

-Hard hats in accordance with ANSI Z89.1
-Steel toed boots with metatarsal guards in accordance with ANSI Z41
-Safety glasses in accordance with ANSI Z87.1
-Work gloves while handling equipment
-Hearing protection if noise levels exceed 80 dbA (when vocal communication between persons standing three feet apart requires shouting).

2.2.3. The Government reserves the option to visually inspect equipment prior to the commencement of work. Any significant health or safety concerns will be identified and the Contractor will be allowed to address the concerns. If significant concerns cannot be rectified, this may be cause for termination of the contract.

2.2.4. Contractor shall comply with all applicable WSTF safety regulations. All Contractor personnel shall receive a 15 to 30 minute safety and security briefing immediately following their arrival at WSTF. The briefing will be given at the WSTF Safety Office prior to access to the work area. A second briefing (approximately 30 minutes) may be given at the WSTF Environmental Department that addresses any specific concerns relative to the project area.

2.2.5. Contractor employees must utilize the WSTF dispensary facilities located in Building 104 for all injury and emergency medical treatment. The dispensary number is 524-5212 and the on site emergency numbers are 5911 or 5111.

2.3. Confined Spaces and Entry

2.3.1. Contractor shall comply with the requirements in White Sands Standard Instruction WSI 25-SW-0003.B "Confined Space Entry Program", which references 29 CFR 1910.146 "Permit Required Confined Spaces", for entry into well vaults and pipeline manholes. A copy of WSI 25-SW-0003.B is provided as an attachment to this document.

2.3.2. All confined spaces at WSTF are considered Permit required until proven otherwise. Contractor shall prohibit entry into any confined space until it is reclassified as a Non-permit confined space per CFR 1910.146(c)(7) procedures. This instructs that a qualified person must conduct appropriate tests of the atmosphere to ensure the confined or enclosed space is safe for the work intended and that all potential hazards are controlled or eliminated and documented. All hazards pertaining to the space shall be reviewed with each employee during the safety review meetings mentioned previously.

2.3.3. Contractor shall provide proof of training and qualifications for employees that will be involved in confined space entry functions. These include air monitors, entrants, attendants, and supervisors. Training shall meet or exceed the requirements of 29 CFR 1910.146.

2.3.4. The Contractor shall use WSTF Form 503 "Confined Space Entry Permit", or other form with the same minimum information for the Confined Space Entry Permit, to document atmospheric test results. The permit shall be posted in a conspicuous place close to the confined space entrance. This form is provided as a part of the attached copy of document WSI 25-SW-0003.A.

2.4. Environmental Concerns

2.4.1. Discharge of potable water used for flushing or pressure testing to grade is allowed by WSTF per document WSI 22-SW-0005.B, page 2, section 4(b)(6).

2.4.2. Any ground disturbing activities performed at WSTF, including trenching, grading, and excavation, must be coordinated in advance with the base Point of Contact. Obtaining required dig permits and right of way will be the responsibility of the Government.

2.4.3. The Contractor shall be responsible, in accordance with applicable state and federal regulations and WSTF policies, to clean and dispose of waste generated during the performance of this project construction. Any release of hazardous waste shall be reported to the base point of contact immediately.

2.5. Cultural Resources

2.5.1. If at any time during construction an archeological, rare, historical, or paleontological discovery is made, the Contractor will immediately cease operations and notify the base point of contact. Construction will not be resumed until authorized by the Contracting Officer.

3. Schedule Requirements

3.1. A Project Schedule shall be prepared as described below. The project schedule shall be developed by the Contractor and approved by NASA. Contractor management personnel shall actively participate and approve of the Project Schedule elements. Subcontractors and suppliers working on the project shall be responsible for adherence to an accurate Project Schedule.

3.2. The NASA approved Project Schedule shall be used to measure the progress of the work. The subparts 3.2.1 through 3.2.5 below shall be considered a minimum appropriate level of detail to be used in the Project Schedule:

3.2.1. Project Schedule Format

3.2.1.1. The project schedule shall be prepared in MS Project and submitted in two media formats: as an *.mpp file (MS Project '98 or earlier format), and as a paper copy.

3.2.2. Activity Duration

3.2.2.1. Tasks related to the procurement of long lead materials or equipment shall be included as separate activities in the project schedule.

3.2.3. Procurement

3.2.3.1. Examples of procurement process activities include, but are not limited to: submittals, approvals, procurement, fabrication, and delivery.

3.2.4. Government Activities

3.2.4.1. Anticipated government and other agency activities that could impact progress shall be shown. These activities may include, but are not limited to: approvals, inspections, utility tie-in, installation of Government Furnished Equipment (GFE), and Notice to Proceed for phasing requirements.

3.2.5. Responsibility

3.2.5.1. All activities shall be identified in the project schedule with the party responsible for performance of the work. Responsibility includes, but is not limited to, the subcontracting firm, contractor work force, or government agency performing a given task. Activities shall not belong to more than one responsible party.

4. Mechanical Component Specification

4.1. Process Piping

4.1.1. General Requirements

4.1.1.1. All piping materials and appurtenances shall be as specified, or equivalent, and as shown on the contract drawings and shall be suitable for the service intended. The contract drawings are presented as an attachment to this document.

4.1.1.2. Applicable standards of the American National Standards Institute (ANSI), American Water Works Association (AWWA), National Association of Corrosion Engineers (NACE), American Society for Testing and Materials (ASTM), Illuminating Engineering Society (IES), National Electrical Manufacturers Association (NEMA), National Fire Protection Association

(NFPA), National Electrical Code (NEC), National Electrical Safety Code (NESC) and the Underwriters' Laboratories (UL) reflect current industry standard practice and must be used for establishing the quality of materials and equipment.

4.1.1.3. Piping materials, appurtenances and equipment supplied as part of this contract shall be new and unused, except for testing equipment. Components that serve the same function and are the same size shall be identical products of the same manufacturer. The general materials to be used for the piping systems are indicated in the contract drawings.

4.1.1.4. The absence of pipe supports and details on the contract drawings does not relieve the Contractor of responsibility for sizing and providing pipe supports where appropriate and as detailed in this document.

4.1.1.5. The Contractor shall provide all structural work and equipment required to control expansion and contraction of piping. The Contractor shall verify that the anchors, guides, and expansion joints provided adequately protect the piping systems per ASME B31.3 requirements.

4.1.1.6. The pressure ratings and materials specified represent minimum acceptable standards for piping systems. The piping systems shall be suitable for the services specified and intended. Each piping system shall be coordinated to function as a unit. Flanges, valves, fittings and appurtenances shall have a pressure rating no less than that required for the system in which they are installed.

4.1.1.7. Piping equipment and appurtenances shall be new products of equal material and ratings as the connecting pipe.

4.1.1.8. Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacturing of the products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Nominal sizes for standardized products shall be used. Pipe, valves, fittings and appurtenances shall be supportable by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

4.1.1.9. Test reports for Hydrostatic Tests, Leakage Tests, Valve-Operation Tests, Pneumatic Tests, Non-Destructive Weld Examinations and System Validation and Operation Tests shall be provided by the Contractor, in compliance with referenced standards contained within this document.

4.1.1.10. Pipe ends left for future connections, if any, shall be valved, blind flanged, or capped and anchored.

4.1.2. Process Pipe Testing

4.1.2.1. Leakage and Hydrostatic Testing

4.1.2.1.1. After the pipe installation and connection is completed, the piping shall be subjected to a 30 minute leakage test at 90% of maximum operating pressure (MOP), and a ten minute hydrostatic-pressure test at 150% of MOP.

4.1.2.1.1.1. The pressure shall be gradually increased in increments to the desired level for each test. Exposed pipe, joints, fittings, and valves shall be carefully examined during the testing. Each valve in the pressurized pipe section shall be opened and closed several times during the test.

4.1.2.1.1.2. Joints showing visible leakage shall be replaced or remade as necessary with all pressure removed from the piping system. Leaking rubber gasketed joints shall be remade using new gaskets when necessary. Pipe, mechanical joints, fittings, or valves discovered to be cracked or defective as a consequence of this pressure test shall be removed and replaced with sound material, and the test shall be repeated until the test results are approved.

4.1.2.1.1.3. If pipe installation consists of pre-manufactured pipe spools that are individually hydrostated to 150% maximum operation pressure for ten minutes, only a leakage test at 90% maximum operation pressure is required following assembly. In this case, documentation of pipe spool fabrication meeting ASME B31.3 standards, including nondestructive examination records, weld inspection records, and individual spool hydrostatic test records, shall be supplied to the Government by the Contractor.

4.1.2.1.1.4. All test plans shall be submitted and approved prior to execution, and results supplied to the Government by the Contractor. Test data shall be legible and of good quality.

4.1.2.1.2. Testing fluid shall be water unless otherwise specified and approved by NASA.

4.1.3. Pipe, Tubing, and Fittings

4.1.3.1. Black Carbon Steel Pipe (Type BCS)

4.1.3.1.1. Pipe 1/8 through 10 inches in diameter shall be Schedule 40 seamless or electric-resistance welded black carbon steel, conforming to ASTM A 53 Type S. Grade A should be used for permissible field bending in both cases.

4.1.3.1.2. All steel pipe and fittings shall be joined by butt welding, except for those flanged connections shown in the contract drawings.

4.1.3.1.3. Fittings 2 inches in diameter and smaller shall be 150-pounds per square inch, gage (psig) working steam pressure (WSP) banded black malleable iron screwed, conforming to ASTM A 197 and ASME B16.3.

4.1.3.1.4. Unions 2 inches diameter and smaller shall be 250 pounds per square inch WSP, female, screwed, black malleable iron with brass-to-iron seat and ground joint, conforming to ASME B16.39.

4.1.3.1.5. Flanges and flanged fittings of all sizes shall be forged steel ASTM A 105/A 105M faced and drilled to ASME B16.5 Class 150. Flanges shall be slip-on, socket weld, or lapped type. The internal diameter of flanges and flanged fittings shall be the same as that of the associated pipe. Bolting shall be ASTM A 193 Grade B7 alloy steel hex head bolts and ASTM A 194 Grade B7 hex head nuts. Where a steel flange mates with a cast iron flange on valves or equipment, the requirements of ASME B16.5 Paragraph 5.3.4 shall be followed. Bolts shall be provided with washers of the same material as the bolts. Flanged connections shall have the same pressure rating as the pipe or greater. The Contractor shall field check flanges for non-standard bolt hole configurations and shall design as required to assure all flanges mate properly.

4.1.3.1.6. Gaskets shall be fabricated from compressed non-asbestos sheet, conforming to ASTM F 104, Type 7-P1161A, coated on both sides with graphite or similar lubricant, with nitrile rubber composition, binder rated to 750 degrees F.

4.1.3.1.7. Steel butt weld fittings 2-1/2 inches diameter and larger shall conform to ASTM A 234 or A 234M and ASME B16.9 to match pipe wall thickness.

4.1.3.2. Chlorinated Polyvinylchloride (CPVC) Pipe

4.1.3.2.1. CPVC pipe material shall be schedule 80 and meet ASTM D1784 Material Classification Equivalents: Type 4, Grade I = Cell Classification 23477-B = CPVC 4120. Pipe sizes shall be manufactured in compliance with ASTM F441.

4.1.3.2.2. Material for Socket-Type Fittings, Schedule 80, shall be CPVC in accordance with ASTM F439.

4.1.3.2.3. Material for threaded fittings, Schedule 80, shall be CPVC in accordance with ASTM F437.

4.1.3.2.4. CPVC Solvent cement for pipe and fittings shall be in accordance with ASTM F493. Contractor shall use primer and heavy bodied CPVC cement per ASTM F493.

4.1.3.3. Stainless Steel Tubing and Tube Fittings

4.1.3.3.1. Tubing shall be fully annealed high quality type 304 stainless steel, seamless round hydraulic tubing, conforming to ASTM A269 or A213. Hardness shall be no greater than Rb 90 (Rockwell hardness, per ASTM A370). Tubing shall be free of scratches and surface imperfections and be suitable for bending and flaring. Pressure rating shall be for a minimum of 500 psi with allowable working pressure loads calculated as specified in ASME B31.3 code.

4.1.3.3.2. Fittings shall be fully annealed high quality type 304 stainless steel, conforming to ASTM A 403/A 403M (1997; Rev A). Swagelok end connections shall be used.

4.1.3.4. Piping Specialties

4.1.3.4.1. Diaelectric connections, if needed, shall have dissimilar pipe metals electrically insulated from each other by couplings, unions, or flanges commercially manufactured for that purpose and rated for the service pressure and temperature.

4.1.3.4.2. Thread lubricant shall be used on all threaded connections. Tetrafluoroethylene tape no less than 2 to 3 mils thick shall be used in potable and process water and in chemical systems for pipe sizes to and including 1-inch ips. Tetrafluoroethylene dispersions and other suitable compounds may be used for all other applications upon approval; however, no lead-containing compounds may be used.

4.1.3.4.3. Pressure relief devices shall consist of a rupture disc, rated for the pressure shown in the contract drawings, at 70 degrees F. Rupture discs shall be compatible for mounting between ASME B16.5 Class 150 flanges, and shall be suitable for water service. For each location where a rupture disc is specified, Contractor shall supply four discs, one to be installed during construction, and the remaining to be retained as spares.

4.2. Valves

4.2.1. Valves shall include actuator, handwheel, operating nut, wrench, and all other accessories required for a complete operation. The valves shall be suitable for the intended service. Renewable parts are not to be of a lower quality than those specified. Valve ends shall be compatible with adjacent piping system. Actuators shall be sized to operate the associated valve for the full range of pressures and

velocities. Actuators and accessories shall be sized and furnished by the valve supplier and factory mounted. Fluid to be handled will be water, at 70 degrees F, unless otherwise specified.

4.2.2. Valve Schedule

4.2.2.1. Requirements relative to this subpart are shown on the Flow Control Valve Schedule and Manual Valve Schedule located in attached contract drawings.

4.2.3. General Purpose Metallic Ball Valves

4.2.3.1. Ball valves, 2 inches and smaller, shall be end entry type with bronze bodies and threaded full bore ports in accordance with ASME B1.20.1.

4.2.3.2. Ball valves, 2.5 inches and larger, shall be end entry type with bronze, malleable iron, or cast iron bodies, per contract drawings, and ASME B16.5 Class 150 flanged ends.

4.2.3.3. Valves shall have polytetrafluoroethylene (PTFE) seats and packing, and a chrome plated or stainless steel ball.

4.2.3.4. The operator shall be a hand lever or square nut, per the contract drawings.

4.2.3.5. Valves shall be suitable for flow from either direction and shall seal equally tight in either direction. Valves with ball seals held in place by spring washers are not acceptable.

4.2.4. Standard Service Metallic Butterfly Valves

4.2.4.1. Butterfly valves shall meet AWWA C-504-87 requirements and have ASTM A 126 cast iron bodies and ASME B16.5 Class 150 flanged end connections. Dimensions shall conform to MSS SP-67.

4.2.4.2. Discs shall be ductile iron, stainless steel, or polyvinylidene fluoride (PVDF) coated ductile iron.

4.2.4.3. The valve shafts shall be 300 series stainless steel with self-lubricating, corrosion-resistant sleeve type bearings (PTFE or equal).

4.2.4.4. Valve seats for 24 inch and smaller valves shall be attached to the valve body and shall be of Buna-N, EPDM, or Viton construction.

4.2.4.5. The operator shall be a pneumatic actuator, hand lever, or square nut, per the contract drawings.

4.2.5. Sample Valves

4.2.5.1. Sample valves 1/8" to 1" shall be plug type, rated for 250 psig minimum. Body shall be 316 stainless steel. All wetted parts shall be either 316 stainless steel or coated with TFE. End connections shall be NPT x Swagelok tubing.

4.2.6. General Service Metallic Gate Valves

4.2.6.1. Gate valves, 2 inches diameter and smaller, shall have bronze bodies and stems, screwed or union bronze bonnets, and single solid wedge bronze discs. The stems may be rising or non-rising. Valves shall be rated for 200 psig service. End connections shall be ASME B16.11 threaded. Valves shall be equipped with handwheel operators.

4.2.6.2. Gate valves, 2.5 inches diameter and larger, shall have cast-iron bodies with iron, bronze, or stainless steel trim. Valves shall have Class 150 flanged end connections. Discs shall be wedge type of iron or bronze construction, and have either rising or non-rising stems. Valves shall be equipped with hand lever or square nut operators, per the contract drawings.

4.2.7. Swing Check Valves

4.2.7.1. Swing check valves, 2 inches diameter and smaller, shall have a cast iron, carbon steel, or stainless steel body, with ASME B16.11 threaded ends. Valves shall be rated for 200 psig service.

4.2.7.2. Swing check valves, 2.5 inches through 12 inches diameter, shall have a cast iron, carbon steel, or stainless steel body, with ASME B16.5 flanged ends. Valves shall be rated for 200 psig service minimum.

4.2.8. Ball Check Valves

4.2.8.1. Ball check valves shall be rated for 200 psig service minimum and shall be suitable for vertical or horizontal flow.

4.2.8.2. Ball check valves, 1 inch diameter and larger, shall be as shown on the contract drawings and ASME B16.11 threaded or ASME B16.5 flanged ends and cast iron, carbon steel, or stainless steel bodies with a cleanout and hollow steel ball.

4.2.9. Flow Control Valves

4.2.9.1. Flow control valves in sizes 2 inches diameter and larger shall be hydraulically operated, single diaphragm actuated, pilot controlled globe valves. Flow control valves shall be equipped with valve body, diaphragm assembly, cover, strainer, electric solenoids, electronic controller, and all other

accessories needed for a complete operation. The diaphragm assembly shall be the only moving part and shall form a sealed chamber in the upper portion of the valve, separating operating pressure from line pressure. Packing glands or stuffing boxes are not permitted and there shall be no pistons operating the main valve or pilot controls. All necessary repairs and modifications other than replacement of the main valve body shall be possible without removing the valve from the pipeline. End connections shall be ASME B16.5 Class 150 flanges. Each flow control valve shall be equipped with an internal check valve to close the flow control valve if a pressure reversal occurs in the line, regardless of the position of the stem and diaphragm. Each flow control valve shall be equipped to fail closed automatically in the event of a power outage. Flow control valve sizes and pressure rating requirements shall be as shown in the Flow Control Valve Schedule in the contract drawings. Acceptable manufacturers and models: Cla-Val Model 131-01.

4.2.9.2. Flow Control Valve materials of construction

Refer to the Flow Control Valve Schedule in the contract drawings.

4.2.9.3. Contractor shall supply one (1) rebuild kit for each unique size of flow control valve. Each rebuild kit shall include as a minimum the stem, stem nut, spring, disc, disc guide, disc retainer, diaphragm, diaphragm washer, and spacer washers.

4.2.9.4. Control Valve Pilot System

Flow control valves shall be equipped with pilot control valves. These shall consist of dual electric solenoids that position the main valve by applying or relieving pressure in its diaphragm chamber. These shall be fail closed or fail open as required to close the valve in event of a power outage. They shall have 120 VAC Class F coil insulation, with NEMA 4 enclosures. The pilot control system is to include an upstream flow strainer, solenoid bypass manual valves, and have manual opening/closing speed adjustments. Materials of construction shall be the manufacturer's standard. Acceptable manufacturers: Cla-Val.

4.2.9.5. Electronic Valve Controller

4.2.9.5.1. Flow control valves shall each include an electronic controller to provide the interface between the control system and each flow control valve. Upon receiving a remote set-point command from the computer system or local command from the operator, the controller will provide proper signals to modulate and maintain the valve at the desired set-point value. Electronic controllers shall have remote communication capability in both analog and digital format. Local manual set-point and emergency manual control shall be provided. Security key codes shall protect against unauthorized change of program memory, setpoints, and timing

parameters. Electronic controllers shall be constructed of solid-state components, with an internal chassis capable of being removed for inspection and repair. Program memory, setpoints, and timing parameters shall be protected from loss due to power outage by an internal battery. Flow rate shall be measured by the electromagnetic flow meters detailed elsewhere in this specification. Electronic controllers shall be compatible in all respects with Allen-Bradley's Data Highway Plus system. Acceptable manufacturers and models: Cla-Val Model 131VC-1.

4.2.9.5.2. Electronic controller specifications:

4.2.9.5.2.1. Input signal: 4-20 mA full scale
4.2.9.5.2.2. Proportional Bands: 1 to 999% adjustable in .1% increments independently for opening and closing.
4.2.9.5.2.3. Deadband: Adjustable 0.00 to 25.5% of span.
4.2.9.5.2.4. Cycle Time: 1 to 120 seconds in 1 second increments
4.2.9.5.2.5. Input Power: 120 VAC, 60 Hz, single phase
4.2.9.5.2.6. Flame retardant UL rated plastic or aluminum housing

4.2.9.6. Valve Position Transmitter

4.2.9.6.1. Flow control valves shall be equipped with valve position transmitters as indicated on the contract drawings. The position transmitter shall be mounted externally on the cover of the flow control valve. The position transmitter shall provide a 4-20 mA output signal that is proportional to the position of the flow control valve stem. The transmitter shall include a means for adjustment and calibration of the feedback signal to correspond with the full stroke of the valve stem. The materials of construction shall be the manufacturer's standard. The housing shall be rated as NEMA 7 Class I groups C and D . Acceptable manufacturers and models: Cla-Val Model X117C

4.2.9.6.2. Transmitter Specifications

4.2.9.6.2.1.Output Current: 4-20 mA
4.2.9.6.2.2.Span: Adjustable from 15° to 90° of angular rotation
Null: 4mA position may be set at any angular position

4.2.10. Valve Actuators

4.2.10.1. Manual Actuators

4.2.10.1.1. The force required to operate a manual actuator shall not exceed 40 pounds under any operating condition, including initial breakaway. The actuator shall be equipped with gear reduction when force exceeds 40 pounds. A position indicator shall be installed on quarter-turn valves.

4.2.10.1.2. Exposed actuators shall have galvanized and painted handwheel. Lever actuators are allowed on quarter-turn valves 8 inches diameter and smaller. Valve handles shall be capable of padlocking, and wheels shall be lockable with a chain and padlock.

4.2.10.2. Pneumatic Actuators

4.2.10.2.1. Pneumatic actuators shall be rack and pinion type, 90 degree rotation, internally lubricated, and operate with clean dry air at 50 to 150 psig pressure. Material of construction shall be the manufacturer's standard.

4.2.10.2.2. Pneumatic operators shall be suitable for full range of valve operation at air supply pressure indicated on contract drawings. Spring(s) shall return valve to the closed position upon loss of signal, unless otherwise indicated.

4.2.10.2.3. Pneumatic actuators shall be provided complete with actuators, air sets, exhaust mufflers, open/close speed adjustment, pilot solenoid, safety vented isolation valves, a visual indicator of valve position, and adjustable valve stops.

4.2.10.2.4. Manufacturers: Sure-Torque, Crane Centerline, Neles-Jamesbury.

4.2.10.3. Air Sets

4.2.10.3.1. Air sets shall include a pressure regulator with internal relief, filter, outlet pressure gauge, and adjustable reduced pressure range as required by valve actuators. The air set shall have an aluminum body and handwheel, safety vented lockout isolation valve, and gauge range 2 times maximum operating pressure.

4.2.10.3.2. Air sets shall supply instrument quality air to pneumatic components per ANSI/ISA S7.0.01 as follows:

4.2.10.3.2.1. Pressure dew point shall not exceed 39°F.

4.2.10.3.2.2. Particle size shall not exceed 40 microns.

4.2.10.3.2.3. Oil content shall not exceed 1 ppm, by either volumetric or weight ratio.

4.2.10.3.2.4. Instrument air shall be free of corrosive or hazardous contaminants.

4.2.10.4. Limit Switches

4.2.10.4.1. Limit switches shall be single-pole, double-throw (SPDT) type, rated 10 amps at 120 VAC, housed in a NEMA 250 Type 4 enclosure, and adjustable for open and closed valve positions.

4.2.10.5. Solenoid Valves

4.2.10.5.1. A solenoid valve shall pilot the control actuator in the appropriate configuration for the type of actuator being controlled. A pilot operated diaphragm type solenoid valve shall have a brass or aluminum body and resilient seat and operate with minimum operating pressure differential no greater than 10 psi and maximum operating pressure differential no less than 150 psi. Internal parts shall be corrosion-resistant. The solenoid valve shall have Class F molded coils for operation on 120 VAC, 60 Hz, unless otherwise indicated. The solenoid enclosure shall conform to NEMA 250 Type 4. Solenoids on double acting cylinders for open-close and throttling valves shall be four-way with dual coils. Solenoids on spring return cylinders for open-close and throttling valves shall be three-way, spring return. An air exhaust muffler shall be furnished in the exhaust port of all actuator pilot solenoid valves.

4.3. Pipe Supports

4.3.1. All necessary piping systems and equipment supporting elements shall be provided, including but not limited to: building structure attachments; supplementary steel; hanger rods, stanchions, and fixtures; vertical pipe attachments; horizontal pipe attachments; anchors; guides; and spring-cushion, variable, or constant supports. All supporting elements shall be suitable for stresses imposed by systems pressures and temperatures and natural and other external forces normal to this facility without damage to supporting element system or to work being supported.

4.3.2. Supporting elements shall conform to requirements of ASME B31.3, FS FF-S-325, MSS SP-58, and MSS SP-69.

4.3.3. Supporting elements exposed to weather shall be hot-dip galvanized. Materials shall be of such a nature that their apparent and latent-strength characteristics are not reduced due to galvanizing process. Supporting elements in contact with copper tubing shall be electroplated with copper.

4.3.4. Type designations specified herein are based on MSS SP-58 and MSS SP-69. Masonry anchor group-, type-, and style-combination designations shall be in accordance with FS FF-S-325. Support elements, except for supplementary steel, shall be cataloged, load rated, commercially manufactured products.

4.3.5. Building Structure Attachments

4.3.5.1. Anchor Devices, Concrete and Masonry

4.3.5.1.1. Anchor devices shall conform to FS FF-S-325 for the following types:

4.3.5.1.1.1. Group I - shield, expansion (lead, bolt and stud anchors)

4.3.5.1.1.2. Group II - shield, expansion (bolt anchors)
4.3.5.1.1.3. Type 2 - machine bolt expansion shield anchors
4.3.5.1.1.4. Class 2 - open-end expansion shield anchors
4.3.5.1.1.5. Style 1 - single-end expansion shield anchors
4.3.5.1.1.6. Style 2 - double-end expansion shield anchors
4.3.5.1.1.7. Group III - shield, expansion (self-drilling tubular expansion shell bolt anchors)
4.3.5.1.1.8. Group VIII - anchors, expansion (nondrilling)
4.3.5.1.1.9. Cast-in, floor mounted, equipment anchor devices shall provide adjustable positions.
4.3.5.1.1.10. Powder-actuated anchoring devices shall not be used to support any mechanical systems components.

4.3.5.2. Beam Clamps

4.3.5.2.1. Beam clamps shall be center-loading per Type 21, 28, 29, or 30.

4.3.5.2.2. When it is not possible to use center-loading beam clamps, eccentric-loading beam clamps, Type 20, 25, or 27 may be used for piping sizes 2 inches diameter and less and for piping sizes 2 through 10 inches diameter provided two counterbalancing clamps are used per point of pipe support. Where more than one rod is used per point of pipe support, rod diameter shall be determined in accordance with referenced standards.

4.3.5.3. C-clamps

4.3.5.3.1. C-clamps may be used to support piping sizes 1-1/2 inches diameter and smaller. C-clamps shall be FM approved and UL listed with hardened cup-tip set screw, lock nut, and retaining strap. Retaining strap section shall be not less than 1/8 by 1 inch. Beam flange thickness to which clamps are attached shall not exceed 0.60 inch.

4.3.6. Horizontal Pipe Attachments

4.3.6.1. Piping in sizes to and including 2-inch diameter shall be supported by Type 6 solid malleable iron pipe rings, except that split-band-type rings may be used in sizes up to 1-inch ips.

4.3.6.2. Piping in sizes through 8-inch diameter inclusive shall be supported by Type 1, 3, or 4 attachments.

4.3.6.3. Where thermal movement of a point in a piping system 4 inches diameter and larger would cause a hanger rod to deflect more than 4 degrees from the vertical or where a horizontal point movement exceeds 1/2 inch, Type 41 or 49 pipe rolls shall be used.

4.3.6.4. Piping in sizes larger than 8-inch diameter shall be supported with Type 44 through 47 pipe rolls.

4.3.6.5. Type 40 shields shall be used on all insulated piping. Area of the supporting surface shall be such that compression deformation of insulated surfaces does not occur. Longitudinal and transverse shield edges shall be rolled away from the insulation.

4.3.6.6. Trapeze hangers fabricated from approved structural steel shapes, with U-bolts, shall be used in congested areas and where multiple pipe runs occur. Structural steel shapes shall be of commercially available, proprietary design, rolled steel.

4.3.7. Vertical Pipe Attachments

4.3.7.1. Vertical pipe attachments shall be MSS-SP69 Type 8.

4.3.8. Hanger Rods and Fixtures

4.3.8.1. Only circular cross section rod hangers may be used to connect building structure attachments to pipe support devices. Pipe, straps, or bars of equivalent strength shall be used for hangers only where approved.

4.3.8.2. Turnbuckles, swing eyes, and clevises shall be used as required by support system to accommodate temperature change, pipe accessibility, and adjustment for load and pitch. Rod couplings are not acceptable.

4.3.9. Supplementary Steel

4.3.9.1. Where it is necessary to frame structural members between existing members or where structural members are used in lieu of commercially rated supports, such supplementary steel shall be designed and fabricated in accordance with AISC S328.

4.4. Piping Installation

4.4.1. Piping systems shall be fabricated and installed in accordance with ASME B31.3, MSS SP-69, and AWS-02. Piping systems shall be securely supported with due allowance for thrust forces, thermal expansion and contraction, and shall not be subjected to mechanical, chemical, vibrational or other damage as specified in ASME B31.3.

4.4.2. Screwed joints shall be made up with specified joint compound and not more than three threads shall show after joint is made up. Joint compound shall be applied to the male thread only and care shall be exercised to prevent compound from reaching the unthreaded interior of the pipe.

4.4.3. Screwed unions, welded unions, or bolted flanges shall be provided wherever required to permit convenient removal of equipment, valves, and piping accessories from the piping system for maintenance.

4.4.4. Flange and general purpose bolting shall be hex-head and shall conform to ASTM A 307, Grade B. Heavy hex-nuts shall conform to ASTM A 563. Square-head bolts and nuts are not acceptable. Threads shall be coarse-thread series.

4.4.5. Flange gaskets shall be compressed non-asbestos sheet, conforming to ASTM F 104, Type 7-P1161A, coated on both sides with graphite or similar lubricant, with nitrile composition, binder rated to 750 degrees F. Gaskets shall meet the requirements of ASME B16.5.

4.4.6. Tetrafluoroethylene tape not less than 2 to 3 mils thick shall be used in potable and process water and in chemical systems for threaded pipe connection sizes up to and including 1-inch ips. Tetrafluoroethylene dispersions and other suitable compounds may be used for all other applications upon approval; however, no lead-containing compounds may be used in potable water systems.

4.4.7. Field welded joints shall conform to the requirements of the AWS-02, ASME B31.3, and ASME-17. The Contractor shall supply weld documentation including nondestructive examination records, weld inspection records, and hydrostatic test records to the Government.

4.4.8. Preheat and post heat treatment of welds, if necessary, shall be done in accordance with ASME-17 and ASME B31.3. Copies of treatment records shall be supplied to the Government.

4.4.9. All necessary precautions shall be taken during installation of pipe and tubing including flushing and purging with water and/or compressed air to prevent dirt and debris from being trapped inside the piping system.

4.4.10. Component Identification and Labeling

4.4.10.1. All components in the system shall be identified by tag. The specific identification numbers, in the desired format, can be located on the contract drawing numbers 652-M-01, 652-M-02, and 652-M-03.

4.4.10.2. The tags may be fabricated by engraving on laminated plastic, impression stamping on corrosion resistant metal, or by any other process which will produce a permanent, legible tag. Lettering shall be no smaller than ¼" in height.

4.4.10.3. Tags will be mounted to components using stainless steel safety wire or to a panel face for panel-mounted components.

4.4.11. Pipe Service Labeling

4.4.11.1. All piping, including that concealed in accessible spaces; exposed, bare and painted; and insulated, shall be labeled to designate service. Each label shall include an arrow or arrows to indicate flow direction. Labels shall be in accordance with the typical examples below:

SERVICE	LABEL AND TAG DESIGNATION
Cold potable water	COLD POT. WATER
Hot potable water supply	HOT POT. WATER
Scale Control Chemical	SCALE CHEMICAL
Scale Cleaner Chemical	SCALE CLEANER
Filtered Air to Blowers	AIR
Control and instrument air	COMPRESSED AIR
Untreated Water	UNTREATED WATER
Treated Water	TREATED WATER

4.4.11.2. Similar services with different temperatures or pressures shall be identified. Where pressures may exceed 125 psi gage, the maximum system pressure shall be included in the label.

4.4.11.3. Piping shall be labeled and arrowed in accordance with the following:

4.4.11.3.1. Each point of entry and exit of pipe passing through walls
4.4.11.3.2. Each change in direction, i.e., elbows, tees
4.4.11.3.3. In congested or hidden areas and at all access panels at each point required to clarify service or indicated hazard.
4.4.11.3.4. In long straight runs, labels shall be located at distances within eyesight of each other but in no case shall the distance between labels exceed 75 feet. All labels shall be visible and legible from the primary service and operating area.
4.4.11.3.5. Labels shall be made of self-sticking, plastic film designed for permanent installation.

4.4.11.4. Color coding of all piping system labels shall be in accordance with ANSI A13.1.

4.5. Valve Installation

4.5.1. Valves shall be provided in piping mains and all branches and at equipment where indicated and as specified in the contract drawings.

4.5.2. Flange and general purpose bolting shall be hex-head and shall conform to ASTM A 307, Grade B. Heavy hex-nuts shall conform to ASTM A 563. Square-head bolts and nuts are not acceptable. Threads shall be coarse-thread series.

4.5.3. Flange gaskets shall be compressed non-asbestos sheet, conforming to ASTM F 104, Type 7-P1161A, coated on both sides with graphite or similar lubricant, with nitrile composition, binder rated to 750 degrees F. Gaskets shall meet the requirements of ASME B16.5.

4.5.4. Tetrafluoroethylene tape not less than 2 to 3 mils thick shall be used in potable and process water and in chemical systems for valve sizes up to and including 1-inch ips. Tetrafluoroethylene dispersions and other suitable compounds may be used for all other applications upon approval; however, no lead-containing compounds may be used in potable water systems.

4.6. Pipe Support Installation

4.6.1. Supporting elements shall be provided in accordance with the previously referenced codes and standards.

4.6.2. Piping may be supported from the building structure. No piping shall be supported from roof decking material or wall covering material.

4.6.3. Piping shall run parallel with the lines of the building. Piping and components shall be spaced and installed so that a threaded pipe fitting may be removed between adjacent pipes and so that there shall be no less than 1/2 inch of clear space between the finished surface and other work and between the finished surface of parallel adjacent piping. Hangers on different adjacent service lines running parallel with each other shall be arranged to be in line with each other and parallel to the lines of the building.

4.6.4. Piping support elements shall be installed at intervals specified hereinafter, at locations not more than 3 feet from the ends of each runout, and not over 1 foot from each change in direction of piping.

4.6.5. Load rating for all pipe-hanger supports shall be based on insulated weight of lines filled with water and forces imposed. Supports shall be in accordance with the following minimum rod size and maximum allowable hanger spacing for specified pipe. For concentrated loads such as valves, the allowable span shall be reduced proportionately

4.6.5.1. Hanger Spacing Requirements

PIPE SIZE (diameter, inches)	ROD SIZE (diameter, inches)	STEEL PIPE (spacing, feet)	COPPER PIPE (spacing, feet)
<1	3/8	8	6
1-1/4 to 1-1/2	3/8	10	8
2	3/8	12	10

2-1/2 to 3-1/2	1/2	12	12
4 to 5	5/8	16	14
6	3/4	16	16
8 to 12	7/8	20	20
14 to 18	1	20	20
20 and over	1-1/4	20	20

4.6.6. Vertical risers shall be supported independently of connected horizontal piping, whenever practicable, with fixed or spring supports at the base and at intervals to accommodate system range of thermal conditions. Risers shall be guided for lateral stability. For risers subject to expansion, only one rigid support shall be provided at a point approximately one-third down from the top. Clamps shall be placed under fittings unless otherwise specified. Carbon-steel pipe shall be supported at each floor and at not more than 15-foot intervals for pipe 2 inches and smaller and at not more than 20-footintervals for pipe 2-1/2 inches and larger.

5. Electrical and Process Component Specifications

5.1. Flow meters

5.1.1. Flow meters to be installed at extraction and injection well vaults shall be furnished complete with measuring tube and liner, housing, signal converter, transmitter, interconnecting cables, mounting hardware, and all other accessories required for a complete operation. The housing shall be carbon steel, and the measuring tube/liner shall be fabricated of hard rubber or Teflon. The exterior surface of the housing shall be epoxy-coated. The flow meters shall operate on 120 VAC, single phase, 60 Hz power. Flow meters shall be rated for a minimum pressure of 250 psig. Connections shall be ANSI Class 150 flanges, carbon steel per ASME B16.5 or 300 series stainless steel. Flow meters shall be equipped with local readout and controls as well as for remote data acquisition. All flow meters must be properly grounded per manufacturer's instructions. Flow meters shall be supplied with factory calibration documentation.

5.1.2. Flow Meter Performance Features:

5.1.2.1. Type: Electromagnetic flow sensor
5.1.2.2. Fluid Service: Water at 70°F.
5.1.2.3. Accuracy: Plus or minus 1 percent of rate for all flows resulting from pipe velocities of 1 to 33 feet per second.
5.1.2.4. Turndown Ratio: Minimum of 10 to 1 when flow velocity at minimum flow is at least 1 foot per second.

5.1.2.5. Zero stability feature to eliminate the need to stop flow to check zero alignment.
5.1.2.6. Flow Tube Size: As noted on contract drawings and flow meter schedule.
5.1.2.7. Signal Interface: 4 to 20 mA dc for load impedance 0 to 800 ohms minimum for 24V dc supply.
5.1.2.8. Communication: HART protocol via current output
5.1.2.9. Power supply: 120V ac, 60-Hz.
5.1.2.10. Electrode Type: Flush or bullet nose as recommended by the manufacturer
5.1.2.11. Electrode Material: 316 stainless steel, unless otherwise noted.
5.1.2.12. Enclosure: NEMA 4.
5.1.2.13. Grounding Ring/Electrode Material: 316 Stainless Steel, unless otherwise noted.
5.1.2.14. Connection Cables: As recommended by manufacturer. Length to be determined by device location.

5.1.3. Acceptable manufacturers and models: Endress & Hauser, ProMag 33;

5.2. Float Level Switch, Tank Mounted:

5.2.1. General:

5.2.1.1. Function: Operate switch at preset level in Spent Cleaner Tank.
5.2.1.2. Type: Float-actuated mounted directly to tank
5.2.1.3. Service Fluid: Water @ 70°F unless otherwise noted
5.2.1.4. Fluid Specific Gravity: 1.0 unless otherwise noted
5.2.1.5. Pressure: Atmospheric, vented tank
5.2.1.6. Temperature: 100 degrees F maximum

5.2.2. Performance and Features:

5.2.2.1. Set Point: adjustable
5.2.2.2. Dead Band: 1-inch maximum
5.2.2.3. Float, stem, and guide tube connected to a switch enclosure
5.2.2.4. Insertion Length: As required to achieve the noted set point
5.2.2.5. Float Size: 4-1/2-inch unless otherwise noted
5.2.2.6. Materials: Wetted parts 304 or 316 Stainless Steel, unless otherwise noted
5.2.2.7. Process Connection: 1-inch NPT
5.2.2.8. Signal Interface Contact: Double Pole/Double Throw (DPDT) snap action, rated 10A continuous at 120V ac
5.2.2.9. Enclosure: NEMA 4 unless otherwise noted

5.2.3. Manufacturers: Magnetrol; Model T20, Robertshaw; Series SL-100, or approved equal

5.3. Float Level Element and Switch:

5.3.1. General:

5.3.1.1. Function: Close contact at preset liquid level in facility Floor Sump
5.3.1.2. Type: Float-actuated, wall mountable
5.3.1.3. Service Fluid: Water @ 70°F, unless otherwise noted

5.3.2. Performance and Features:

5.3.2.1. Set Point: adjustable
5.3.2.2. Dead band: 1-inch maximum
5.3.2.3. Temperature: Minus 40 degrees F to 140 degrees F
5.3.2.4. Pressure: Maximum 150 psig
5.3.2.5. Float Material and Size: Buna N; 1-7/8-inch
5.3.2.6. Stem and Mounting Material: Type 304 Stainless Steel
5.3.2.7. Integral splash shield
5.3.2.8. Signal Interface: SPST snap action switch
5.3.2.8.1. Rated 20 VA at 120V ac
5.3.2.8.2. Normally open
5.3.2.9. Lead cable: 2 #18 AWG, 6 feet, neoprene jacket

5.3.3. Manufacturers: GEMS; Series LS-270, Model No. 43765, or approved equal.

5.4. Pressure Indicators:

5.4.1. General:

5.4.1.1. Function: Visual pressure indication
5.4.1.2. Type: Bourdon tube

5.4.2. Performance and Features:

5.4.2.1. Range in psig: As noted on contract drawings
5.4.2.2. Accuracy: Plus or minus 0.5 percent of span
5.4.2.3. Connection: 1/4-inch or 1/2-inch NPT
5.4.2.4. Dial: 4-1/2-inch diameter
5.4.2.5. Case Material: Phenolic plastic or Stainless Steel
5.4.2.6. Case Type: Solid front design with solid wall between window and element and integral pressure relief on rear of case. Shatterproof safety glass window.
5.4.2.7. Pointer: Micrometer pointer with self-locking adjustment
5.4.2.8. Movement: Stainless Steel, rotor geared
5.4.2.9. Dampening: Pulsation dampener when noted, piston type with multiple choice of piston placement to vary the desired amount of dampening

5.4.3. Manufacturers: Ashcroft; Duragauge Model 1279/1379, Robert Shaw Acragage, Marsh Mastergauge

5.5. Telephone Dialer Alarm:

5.5.1. General:

5.5.1.1. Function: Continuously monitor normally open contacts, and when a contact closure is detected will dial preprogrammed telephone numbers, deliver a prerecorded message, and reset itself upon reception of a signal from the person being called.

5.5.1.2. Type: Dialer shall be a 16-bit microprocessor based system with all programming and voice messages stored in non-volatile memory. Dialer shall be compatible with cellular telephone or standard telephone communication networks.

5.5.2. Performance and Features:

5.5.2.1. Alarm Response Delay: 1 to 5,999 seconds
5.5.2.2. Telephone Numbers: Nine phone numbers up to 60 digits in length
5.5.2.3. Message Length: 10 seconds per message
5.5.2.4. Number of Alarm Channels: Four digital, expandable up to eight digital total.
5.5.2.5. Power: 120V ac, 60-Hz, with battery backup for 60 hours of monitoring service.
5.5.2.6. The system shall be programmable locally or remotely via touch tone telephone.
5.5.2.7. Operating Temperature: 20 degrees F to 130 degrees F.
5.5.2.8. Humidity: 0 to 95 percent non-condensing
5.5.2.9. Minimum four-digit security code
5.5.2.10. Surge protection on power, telephone, and alarm lines.
5.5.2.11. Direct telephone or cellular communications to FAX machines, answering machines, digital or voice radio pagers, or to computers.
5.5.2.12. Separate and independent call list for each alarm channel.
5.5.2.13. Visual indicators for power, fault, run, phone off-hook, line off-hook, incoming call, call in progress, and FAX in progress.
5.5.2.14. Enclosure: NEMA 4X fiberglass

5.5.3. Manufacturers and Products: Microtel; Series 1000 alarm dialer or approved equal.

5.6. Power Monitor:

5.6.1. A power monitor unit shall be provided at each of the extraction wells. Additionally, either a new power monitor is to be provided for the motor control center in Building 650, or adequate hardware and software provided to allow communication and data exchange between the existing Square D Powerlogic® monitor and the control and data acquisition system.

5.6.2. Shall provide for three-phase power monitoring and include a front panel display and user interface. Shall be capable of real-time revenue-accurate metering, power quality analysis, and control. Thorough and economical power system analysis including disturbance recording, data logging, programmable logic control, and arithmetic calculations. The units shall be UL listed. Display shall be either a back lit LCD (liquid crystal display) or VFD (vacuum fluorescent display). Chassis to be designed for mounting inside switchgear or MCC enclosures.

5.6.3. Device to be supplied complete, including all CTs (current transformers) and PTs (potential transformers), as required, for a complete and operational system.

5.6.4. Accuracy shall comply with ANSI C12.16 class for revenue metering. The revenue settings shall be protected from unauthorized modification.

5.6.5. Operating conditions: Temperature -400°F to +140°F, (-20°C to 60°C), Humidity 5 to 95% non condensing.

5.6.6. Control Power: 120-240 V ac, 50-60 Hz

5.6.7. Accuracy

5.6.7.1. Voltage and Current: +/- 0.2% of full scale
5.6.7.2. Power and Energy: +/- 0.4% of full scale
5.6.7.3. Frequency: +/- 0.05 Hz
5.6.7.4. Power, Demand, and Energy Functions: +/- 0.4%
5.6.7.5. Power Factor: +/- 0.4% (0-100 range)

5.6.8. Current Inputs (each channel)

5.6.8.1. Nominal Current: 5 Amps ac
5.6.8.2. Metering Range: 0-10 Amps ac
5.6.8.3. Withstands 15 Amps continuous, 200 Amps 1 second per hour
5.6.8.4. Burden: no greater than 0.05 Volt-Amp
5.6.8.5. Input impedance: no greater than 0.002 Ohm

5.6.9. Voltage Inputs (each channel)

5.6.9.1. Nominal Full Scale: 0-347 VAC L-N, 0-600 VAC L-L
5.6.9.2. Input impedance: no less than 1 Meg-Ohm

5.6.10. Sampling and Metering: Continuous, with maximum 50 millisecond update rate.

5.6.11. Disturbance Detection

5.6.11.1. Continuous monitoring for sags and swell detection.
5.6.11.2. Time stamps on each occurrence in the Event Log
5.6.11.3. Response time no greater than ½ cycle

5.6.11.4. Upon detection of disturbance, it logs and saves the waveform

5.6.12. Harmonic Analysis

5.6.12.1. Individual harmonic magnitude and harmonic phase
5.6.12.2. IEEE-519 pass/fail indication
5.6.12.3. THD, Crest Factor, TIF, and K-factor

5.6.13. Setpoints

5.6.13.1. Minimum 20 configurable setpoints
5.6.13.2. Minimum six evaluation operators available
5.6.13.3. Configurable upper and lower limits
5.6.13.4. Configurable assert and release delays

5.6.14. Logging

5.6.14.1. Trend logging capability
5.6.14.2. Event logging capability
5.6.14.3. Minimum and Maximum value logging capability
5.6.14.4. All log data shall be stored in non-volatile memory
5.6.14.5. All data shall be time stamped to nearest 0.01 second
5.6.14.6. Record selected parameters at no less than 100 millisecond interval during events

5.6.15. Firmware Updating

5.6.15.1. Device shall have ability to be updated with new features by firmware download from a temporary connection with portable PC, or via network connection.

5.6.16. Communications

5.6.16.1. Device shall be equipped with necessary options for connection to a SCADA system utilizing an Allen-Bradley Data Highway Plus fiber optic network. Connection of each device shall be completed by either connection of each power monitor to the network as a stand alone device, or by connecting each one to an existing PLC panel that is connected to the network (i.e. as remote I/O).

5.6.17. Manufacturer: Rockwell Powermonitor 3000, model no.1404-M6

5.7. Programmable Logic Controller System:

5.7.1. General:

5.7.1.1. Contractor shall supply and install a system for process monitoring and control. It shall operate by emulating functions of conventional panel mounted equipment such as relays, timers, counters, current switches, calculation modules, PID controllers, stepping switches, and drum programmers. Refer to attached control system design drawings.

5.7.1.2. Type: Microprocessor based device programmable using ladder logic.

5.7.1.3. Parts: Central processing unit (CPU), power supply, local and remote input/output modules, local and remote base (chassis/rack) controllers, I/O bases (chassis/rack), data highway, and factory assembled interconnecting cables. Provide components required to make a complete and totally operational system. Reference contract P&ID Drawings.

5.7.2. Requirements for the Operating Environment are as follows:

5.7.2.1. Temperature: Operating range 32 to 140 degrees F (0 to 60 degrees C); storage range minus 40 to 158 degrees F (0 to 70 degrees C).

5.7.2.2. Humidity: Operating range 5 to 95 percent non-condensing.

5.7.2.3. Vibration:

5.7.2.3.1. Sinusoidal: IEC 68-2-6, Test Fc; 0.15 mm peak-to-peak, 10- to 57-Hz; 1 g, 57- to 150-Hz.
5.7.2.3.2. Random: IEC 68-2-34, Test Fdc; 0.4 g^2/Hz, 80- to 350-Hz, and 3dB/octave rolloff, 80- to 20-Hz and 350- to 2-KHz at 10 min/axis.

5.7.2.4. Noise: IEC 801, Part 3, Level 3 and Part 4, Level 3; MIL STD-461B
.

5.7.2.5. Isolation: User-side to PLC side 1,500V rms.

5.7.2.6. Agency Approvals and Standards: UL listed and CSA certified

5.7.3. The Central Processing Unit (CPU) shall have the following features:

5.7.3.1. Type: Microprocessor, 16-bit minimum.

5.7.3.2. Scan Time: Less than 1 ms/K words of relay ladder logic.

5.7.3.3. PLC Communications:

5.7.3.3.1. Communication ports: RS-232 or RS-422.
5.7.3.3.2. Baud rates supported: 1200, 2400, 9600, 19200.
5.7.3.3.3. Network Communications: One Allen-Bradley Data Highway Plus port.
5.7.3.3.4. Remote I/O Communication Links.

5.7.4. The control software Instruction Set shall include the following:

5.7.4.1. Timers and counters:

5.7.4.1.1. Math: Signed integer and floating-point math including add, subtract, multiply, divide, square root, and compare.
5.7.4.1.2. Register Operations: Shift registers, bit shift, bit set, bit clear, data move and data format conversion.

5.7.4.2. Process Loop Control: This shall be user configurable, direct or reverse acting, PID loop control computation with the capability of both AUTO and MANUAL modes of operation, and with remote access to controller tuning constants.

5.7.4.3. A Real Time Clock, with date and time set and compare.

5.7.5. Diagnostics capability shall include the following:

5.7.5.1. Indicators: Battery status, PLC status, PLC operation mode, remote I/O communication status.
5.7.5.2. Status Word: With failure status for PLC battery, scan overrun, communications, I/O, special functions.
5.7.5.3. Power Up: PLC checks status of internal memory upon power-up; runs self-diagnostics on power-up; periodically runs self-diagnostics while in RUN mode, halts logic processor and sets outputs to configured state if fatal error is detected.
5.7.5.4. Diagnostic Tables: Tables, displayable on a connected PC Control Station, that describe nature and location (address) of existing faults and errors.

5.7.6. Random Access Memory (RAM) requirements:

5.7.6.1. Memory Size: 32 K words minimum
5.7.6.2. Read only memory (ROM) for controller's operating system and diagnostics.
5.7.6.3. Memory Protection: Switchable

5.7.7. One Power Supply unit shall be supplied for each rack, or input/output base assembly:

5.7.7.1. Voltage: 120/220 volts (user selectable), 60-Hz input; 85 to 132 volts output.
5.7.7.2. Manufacturer and Model: Allen-Bradley, Part No. 1746-P2

5.7.8. Inputs and Outputs: A complete input/output system shall be supplied per the contract drawings, including remote I/O, with communication range of 10,000 feet minimum.

5.7.8.1. Discrete Input Modules:

5.7.8.1.1. Voltage: 120 volts, 60-Hz
5.7.8.1.2. Operating Power: 2 watts
5.7.8.1.3. Points per Module: 16, maximum
5.7.8.1.4. LED status indicator for each point
5.7.8.1.5. Isolation: Between input point and PLC, 1,500 volts rms
5.7.8.1.6. Manufacturer and Model: Allen-Bradley, Part No. 1746-IA16

5.7.8.2. Discrete Output Modules:

5.7.8.2.1. Voltage: 120 volts, 60-Hz
5.7.8.2.2. Operating Power: 2 watts
5.7.8.2.3. Load Rating: 2 amps continuous
5.7.8.2.4. Isolation: Between PLC and output point, 1,500 volts rms
5.7.8.2.5. Points per Module: 16, maximum
5.7.8.2.6. LED status indicator for each point
5.7.8.2.7. Manufacturer and Model: Allen-Bradley, Part No. 1746-OA16

5.7.8.3. Isolated Discrete Output Modules:

5.7.8.3.1. Type: Isolated Form A relay
5.7.8.3.2. Voltage: 120 volts, 60-Hz
5.7.8.3.3. Isolated Outputs per Module: 8
5.7.8.3.4. Load Rating: 5 amps continuous
5.7.8.3.5. Operating Power: 2.5 watts
5.7.8.3.6. Points Per Module: 8, maximum
5.7.8.3.7. LED status indicator and fuse for each point
5.7.8.3.8. Isolation: Between PLC and output point, 1,500 volts rms
5.7.8.3.9. Manufacturer: Allen-Bradley, Part No. 1746-0X8

5.7.8.4. Fast Response DC Input Modules:

5.7.8.4.1. Input “Voltage: 24V dc
5.7.8.4.2. Input Current: 8 ma at 24V dc
5.7.8.4.3. Points Per Module: 16, maximum
5.7.8.4.4. Maximum Input Frequency: 1,000 Hz
5.7.8.4.5. Manufacturer: Allen Bradley; Part No. 1746-ITB16 (sink)

5.7.8.5. Analog Input Modules:

5.7.8.5.1. Voltage: 24 volts dc
5.7.8.5.2. Power: 3 watts
5.7.8.5.3. Differential Analog Points Per Module: 8 or 4
5.7.8.5.4. Isolation: Between PLC and I/O point and between I/O points, 1,500 volts rms.
5.7.8.5.5. Analog Input Resolution: 16 bits

5.7.8.5.6. Manufacturer: Allen-Bradley, Part No. 1746-NI8 or 1746-NI4

5.7.8.6. Analog Output Modules:

5.7.8.6.1. Voltage: 24V dc
5.7.8.6.2. Power: 3 watts
5.7.8.6.3. Isolated Analog Points Per Module: 4 maximum
5.7.8.6.4. Isolation Between PLC and I/O Point and Between I/O Points: 1,500 volts rms
5.7.8.6.5. Manufacturer: Allen-Bradley; Part No. 1746-N04I

5.7.8.7. Remote Adapter Module:

5.7.8.7.1. One remote I/O adapter module required for each remote chassis
5.7.8.7.2. Manufacturer: Allen-Bradley; Part No. 1747-ASB

5.7.8.8. Remote I/O Scanner Module:

5.7.8.8.1. Manufacturer: Allen-Bradley Model No. 1747-SN

5.7.9. I/O Chassis (racks):

5.7.9.1. Each remote I/O panel and SLC 5/04 panel shall be furnished with one I/O chassis

5.7.9.2. Each chassis shall have either 7, 10, or 13 slots as required per controls system design

5.7.9.3. Manufacturer: Allen-Bradley; Part Nos. 1746-A7, 1746-A10 and 1746-A13.

5.7.10. Fiber Optic Module:

5.7.10.1. Selectable Wavelengths: 850 nm and 1,300 nm
5.7.10.2. Compatible with multimode fiber optic cable
5.7.10.3. Panel-mounted, 120V ac power supply
5.7.10.4. Data highway plus and remote I/O communication
5.7.10.5. Fault tolerant
5.7.10.6. Interaction diagnostics
5.7.10.7. Manufacturer: Phoenix Digital; Model OCM-DPR-13-P-DST-ACV.

5.7.11. I/O Placement in PLC racks:

5.7.11.1.1. From Left to Right: Analog, DC I/O, AC I/O.
5.7.11.1.2. Wired to/from PLC I/O modules or racks to/from control panel terminal blocks in all panels (direct connection of field wiring to I/O module or rack is not acceptable.

5.7.12. Identification and Labeling:

5.7.12.1. Nameplates installed above/below each PLC component (CPU, I/O rack, power supply, etc.)
5.7.12.2. Label configured I/O points as they have been configured (addressed) in the mechanical system.

6. PACKAGED CONTROL SYSTEM

6.1. GENERAL

6.1.1. SYSTEM DESCRIPTION

6.1.1.1. Assemble panels and install instruments, electrical conduit, and wiring for installation at a Government facility.

6.1.1.2. Test panels and panel assemblies for proper operation prior to shipment from equipment manufacturer's factory.

6.1.2. DELIVERY, STORAGE, AND HANDLING

6.1.2.1. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers and related equipment as recommended by capsule manufacturer.

6.1.3. SPARES

6.1.3.1. Selector Switch, Push Button, and Indicating Lights: one minimum of each type used.

6.1.3.2. Light Bulbs: two minimum of each type used.

6.1.3.3. Fuses: two minimum of each type used.

6.1.3.4.Surge Suppressors: one minimum, of each type used.

6.2. PRODUCTS

6.2.1. INTERFACE REQUIREMENTS

6.2.1.1. Analog Signals:

6.2.1.1.1. 4 to 20 mA dc, in accordance with compatibility requirements of ISA S50.1.
6.2.1.1.2. Unless otherwise specified or shown, use twisted shielded pair, two-wire cable and circuits.
6.2.1.1.3. Transmitters: Load resistance capability conforming to Class L.

6.2.1.1.4. Fully isolate input and output signals of transmitters and receivers.
6.2.1.1.5. Pulse Frequency Signals: dc pulses whose repetition rate is linearly proportional to process variable over 10:1 range. Generate pulses by contact closures or solid state switches.
6.2.1.1.6. Power source: Less than 30V dc.

6.2.1.2. Discrete Signals:

6.2.1.2.1. Two-state logic signals.
6.2.1.2.2. Utilize 120V ac sources for control and alarm signals.
6.2.1.2.3. Alarm signals shall be normally open, close to alarm, isolated contacts rated for 5-amps at 120V ac and 2-amps at 30V dc.

6.2.2. CONTROL PANEL ENCLOSURE

6.2.2.1. Conform to NEMA ratings as specified in individual equipment sections.
6.2.2.2. Minimum Metal Thickness: 14 gauge.
6.2.2.3. NEMA 250, Type 4X Panels: Carbon steel construction unless otherwise specified.

6.2.2.4. DOORS

6.2.2.4.1. Three-point latching mechanisms in accordance with NEMA 250, Type 1 and 12 panels with doors higher than 18 inches.
6.2.2.4.2. For other doors, stainless steel quick release clamps.
6.2.2.4.3. Cutouts shall be cut, punched, or drilled and finished smoothly with rounded edges.

6.2.2.5. ACCESS:

6.2.2.5.1. Front side, suitable for installation with back and sides adjacent to or in contact with other surfaces, unless otherwise specified.

6.2.2.6. TEMPERATURE CONTROL:

6.2.2.6.1. Size panels to adequately dissipate heat generated by equipment mounted on or in the panel.
6.2.2.6.2. Furnish cooling fans with air filters if required to dissipate heat.
6.2.2.6.3. For panels outdoors or in unheated areas, furnish thermostatically controlled heaters to maintain temperature above 40 degrees F.

6.2.2.7. LIGHTING:

6.2.2.7.1. Minimum of one hand switch controlled internal 100-watt incandescent light for panels 12 cubic feet and larger.

6.2.2.7.2. Minimum of one 120-volt duplex receptacle for panels 7 cubic feet and larger, per the contract drawings.

6.2.2.8. FINISH:

6.2.2.8.1. Metallic External Surfaces (Excluding Aluminum and Stainless Steel): Manufacturer's standard gray unless otherwise specified.

6.2.2.8.2. Internal Surfaces: White enamel paint.

6.2.3. CONTROL PANEL ELECTRICAL

6.2.3.1. Control Panels Without Motor Starters:

6.2.3.1.1. Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed from the main.

6.2.3.1.2. Locate to provide clear view of, and access to, the breakers when door is open. Group on single back panel. Provide clearly marked identification labels.

6.2.3.1.3. Circuit Breakers:

6.2.3.1.3.1. Coordinate for a fault in a branch circuit to trip the branch breaker, not the main breaker.
6.2.3.1.3.2. Branch Circuit Breaker Rating: 15 amps at 250V ac.

6.2.3.1.4. Breaker Manufacturers and Products: Heineman Electric Co.; Series AM, Airpax/North American Philips Controls Corp.; Series 205.

6.2.3.2. Control Panels with Three-Phase Power Supplies and Motor Starters:

6.2.3.2.1. Interlock main circuit breaker with panel door.

6.2.3.2.2. Mount logic controls, branch circuit breakers, overload reset switches, and other control circuit devices.

6.2.3.2.3. Mount operator controls and indications on front access door.

6.2.3.2.4. Circuit Breakers:

6.2.3.2.4.1. In accordance with NEMA AB 1.
6.2.3.2.4.2. 40,000-ampere RMS symmetrical rating, minimum at 480 volts, unless otherwise specified or required.
6.2.3.2.4.3. Breakers Except Motor Branch Breakers: Molded case thermal magnetic.

6.2.3.2.5. Motor Branch Circuit Breakers:

6.2.3.2.5.1. 50 hp and Less: Magnetic.
6.2.3.2.5.2. Larger than 50 hp: Thermal magnetic with adjustable magnetic trip units.
6.2.3.2.5.3. Ratings: Recommended by manufacturer for maximum motor protection.
6.2.3.2.5.4. Padlock Provisions: OFF position.
6.2.3.2.5.5. Tripping: Indicate with operator handle position.

6.2.3.2.6. Magnetic Motor Starters:

6.2.3.2.6.1. Starters shall be the manual reset type with reset button mounted on panel door.
6.2.3.2.6.2. Magnetic motor starters shall be designed for continuous operation of induction motors at 600 volts maximum, at 60 Hz, and shall comply with NEMA ICS 2.
6.2.3.2.6.3. All starters shall be electrically held and wired to provide low voltage power and release.
6.2.3.2.6.4. Unless otherwise specified, starters shall be 120-volt coil, 3-pole, 600V ac, 60 Hz, NEMA size 1 minimum.
6.2.3.2.6.5. All power wiring shall be straight through the starter with incoming power to the top and load wiring at the bottom. Contacts shall be double break, silver-cadmium oxide, and weld-resistant. Contacts shall be isolated to prevent arcing.
6.2.3.2.6.6. Coils, magnets, and contacts shall be capable of being removed or replaced, without special tools, in the field. The contactors shall have MOV-type, transient voltage surge suppression across the coils. Transient voltage surge suppression shall be mounted directly across the coil terminals of all magnetic starters. The suppressor shall limit voltage transients produced by the coil to 220 percent maximum peak line volts.
6.2.3.2.6.7. Solid state overload protection shall be provided unless otherwise indicated on the Drawings or approved by the Government. The solid state overload relay shall be self-powered requiring no additional wiring or control power and be self-protected from short circuits in the motor branch circuit. Each overload shall be adjustable over a full 2:1 FLA adjustment range. The overload must have a plus or minus 2 percent trip repeatability over its entire operating range. The standard overload shall provide Class 20 overload protection. The overload must provide phase loss protection by tripping in 3 seconds or less under a phase loss condition. The overload must be capable of protecting the motor in a starting, full load, or lightly loaded condition against single-phase damage. The overload and phase loss protection must not be able to be defeated by any changes to the setting of the overload. The overload must be ambient insensitive and able to

operate in a temperature range of minus 22 degrees F to plus 159 degrees F. The overload relay must have a trip-free normally closed contact rated NEMA A600 with a visible trip indication. The overload relay shall be provided with an additional normally closed auxiliary contact rated NEMA A600. The overload must have a method of being manually tripped for test purposes.

6.2.3.2.7. Power Control Transformer:

6.2.3.2.7.1. Transformers shall have sufficient capacity to serve connected load, including 200V ac for duplex outlet plus 100V ac (minimum).
6.2.3.2.7.2. Limit voltage variation to 15 percent during contact pickup.
6.2.3.2.7.3. Fuse on one side of secondary winding and ground on the other.
6.2.3.2.7.4. Furnish primary winding fuses in underground conductors.
6.2.3.2.7.5. Power Distribution Blocks: Furnish to parallel feed top on branch circuit protective devices. Do not “leap frog” power conductors.

6.2.3.3. Wiring:

6.2.3.3.1. AC Circuits:

6.2.3.3.1.1. Type: 600-volt, Type THHN/THWN stranded copper.
6.2.3.3.1.2. Size: For current to be carried, but not less than No. 16 AWG.

6.2.3.3.2. Analog Signal Circuits:

6.2.3.3.2.1. Type: 600-volt, Type 3 stranded copper, twisted shielded pairs.
6.2.3.3.2.2. Size: No. 16 AWG, minimum.

6.2.3.3.3. Other DC Circuits.

6.2.3.3.3.1. Type: 600-volt, Type THHN/THWN stranded copper.
6.2.3.3.3.2. Size: No. 16 AWG, minimum.
6.2.3.3.3.3. Separate analog and other dc circuits at least 6 inches from any ac power and control wiring.

6.2.3.3.4. Control and signal wiring in control panels shall be restrained by plastic ties or ducts. Secure hinge wiring at each end so bending or twisting will occur around the longitudinal axis of wire. Protect any bend area with a sleeve.

6.2.3.3.5. Arrange wiring neatly, cut to proper length, and remove surplus wire. Install abrasion protection for wire bundles passing through holes or across edges of sheet metal.

6.2.3.3.6. Use manufacturer's recommended tool with sized anvil for crimp terminations. No more than one wire may be terminated in a single

crimp lug. No more than two lugs may be installed on a single screw terminal.

6.2.3.3.7. Do not splice or tap wiring except at device terminals or terminal blocks.

6.2.3.4. Wire Identification:

6.2.3.4.1. Identify wiring in control panel.

6.2.3.4.2. Numbered and tagged at each termination.

6.2.3.4.3. Wire Tags: Snap-on or slip-on PVC wire markers with legible machine printed markings and numbers. Do not use adhesive or taped-on tags.

6.2.3.5. Wiring Interface:

6.2.3.5.1. For analog and discrete signal, terminate at numbered terminal blocks.

6.2.3.5.2. For special signals, terminate power (240 volts or greater) at manufacturer's standard connectors.

6.2.3.5.3. For panel, terminate at equipment on which it is mounted.

6.2.3.5.4. Terminal Blocks:

6.2.3.5.4.1. Accommodate present and spare indicated needs. One wire per terminal.
6.2.3.5.4.2. Wire spare or unused panel mounted elements to their panels' terminal blocks.
6.2.3.5.4.3. Spare Terminals: 20 percent of connected terminals, but not less than 10.
6.2.3.5.4.4. Group to keep 120V ac circuits separate from 24V dc circuits.
6.2.3.5.4.5. Insulation:
6.2.3.5.4.5.1. Thermoplastic rated for minus 55 to plus 110 degrees C.
6.2.3.5.4.5.2. Two funnel shaped inputs to facilitate wire entry.
6.2.3.5.4.6. Mounting:
6.2.3.5.4.6.1. DIN rail.
6.2.3.5.4.6.2. Terminal block can be extracted from an assembly without displacing adjacent blocks.
6.2.3.5.4.6.3. End Stops: One at each end of rail, minimum.

6.2.3.5.5. Wire Preparation: Stripping only.

6.2.3.5.6. Jumpers: Allow jumper installation without loss of space on terminal or rail.

6.2.3.5.7. Marking System:

6.2.3.5.7.1. Terminal number shown on both sides of terminal block.
6.2.3.5.7.2. Allow use of preprinted and field marked tags.
6.2.3.5.7.3. Terminal strip numbers shown on end stops.
6.2.3.5.7.4. Mark terminal block and terminal strip numbers as shown on panel control diagrams or as indicated in the Specifications.

6.2.3.5.8. Terminal Blocks for 120-Volt Power:

6.2.3.5.8.1. Rated Voltage: 600V ac.
6.2.3.5.8.2. Rated Current: 30 amp.
6.2.3.5.8.3. Wire Size: 22-10 AWG.
6.2.3.5.8.4. Rated Wire Size: 10 AWG.
6.2.3.5.8.5. Color: Gray body.
6.2.3.5.8.6. Spacing: 0.25 inch, maximum.
6.2.3.5.8.7. Manufacturer and Product: Phoenix Contact; Type UK5N and UK6N.

6.2.3.5.9. Terminal Blocks for Ground:

6.2.3.5.9.1. Wire Size: 20-1/0 AWG.
6.2.3.5.9.2. Rated Wire Size: As required.
6.2.3.5.9.3. Color: Green and yellow body.
6.2.3.5.9.4. Spacing: 0.25 inch, maximum.
6.2.3.5.9.5. Grounding: Ground terminal blocks electrically grounded to the mounting rail.
6.2.3.5.9.6. Manufacturer and Product: Phoenix Contact; Type USLKG.

6.2.3.5.10. Terminal Block Blade Disconnect Switch:

6.2.3.5.10.1. Provide one for each discrete input and output field interface wire.
6.2.3.5.10.2. Rated Voltage: 600V ac.
6.2.3.5.10.3. Rated Current: 10 amp.
6.2.3.5.10.4. Wire Size: 22-12 AWG.
6.2.3.5.10.5. Rated Wire Size: 12 AWG.
6.2.3.5.10.6. Color: Gray body, orange switch.
6.2.3.5.10.7. Spacing: 0.25 inch, maximum
6.2.3.5.10.8. Manufacturer and Product: Phoenix Contact; Type UDK 4-MTK.

6.2.3.5.11. Terminal Block, Fuse/Disconnect Plug:

6.2.3.5.11.1. Provide one for each analog input and output field interface wire.
6.2.3.5.11.2. Rated Voltage: 300V ac.
6.2.3.5.11.3. Rated Current: 15 amp.
6.2.3.5.11.4. Wire Size: 30-14 AWG.

6.2.3.5.11.5. Manufacturer and Product: Phoenix Contact; V10K 1,5-D/TG/D/PE with Type ST.

6.2.3.5.12. Terminal Block, Fused, 24V dc:

6.2.3.5.12.1. Rated Voltage: 600V dc.
6.2.3.5.12.2. Rated Current: 6.3 amp.
6.2.3.5.12.3. Wire Size: 26-8 AWG.
6.2.3.5.12.4. Rated Wire Size: 12 AWG.
6.2.3.5.12.5. Color: Black body.
6.2.3.5.12.6. Fuse: Amperage size as required.
6.2.3.5.12.7. Fuse Marking: Fuse amperage rating shown on top of terminal block.
6.2.3.5.12.8. Indication: LED diode 24V dc.
6.2.3.5.12.9. Leakage Current: 7.5 mA, maximum.
6.2.3.5.12.10. Spacing: 0.32 inch, maximum.
6.2.3.5.12.11. Manufacturer and Product: Phoenix Contact; Type UK6.3-HESi.

6.2.3.5.13. Terminal Block, Fused, 120V ac:

6.2.3.5.13.1. Rated Voltage: 600 V ac.
6.2.3.5.13.2. Rated Current: 6.3 amp.
6.2.3.5.13.3. Wire Size: 26-8 AWG.
6.2.3.5.13.4. Rated Wire Size: 12 AWG.
6.2.3.5.13.5. Color: Black body.
6.2.3.5.13.6. Fuse: Amperage size as required.
6.2.3.5.13.7. Fuse Marking: Fuse amperage rating shown on top of terminal block.
6.2.3.5.13.8. Indication: Neon lamp 110V ac.
6.2.3.5.13.9. Leakage Current: 1.0 mA, maximum.
6.2.3.5.13.10. Spacing: 0.32 inch, maximum.
6.2.3.5.13.11. Manufacturer and Product: Phoenix Contact; Type UK6.3-HESi.

6.2.3.5.14. Terminal Block, Fused, 120V ac, High Current:

6.2.3.5.14.1. Rated Voltage: 600V ac.
6.2.3.5.14.2. Rated Current: 35 amps.
6.2.3.5.14.3. Wire Size: 18-8 AWG.
6.2.3.5.14.4. Fuse: Amperage size as required.
6.2.3.5.14.5. Manufacturer: Phoenix Contact.

6.2.3.6. Grounding:

6.2.3.6.1. Enclosures, control panels, and cabinets signal and shield ground connections shall be made as shown on the Drawings, for each

enclosure, control panel, and cabinet that has a dedicated #4 AWG ground conductor from the ground grid, MCC ground bus, or switchgear ground bus. Enclosures, control panels, and cabinets that do not have a #4 AWG ground conductor shall be installed as follows:

6.2.3.6.1.1. Furnish isolated copper grounding bus for signal and shield ground connections.
6.2.3.6.1.2. Ground this ground bus at a common signal ground point in accordance with national Electrical Code requirements.

6.2.3.6.2. Single Point Ground for Each Analog Loop:

6.2.3.6.2.1. Locate at dc power supply for loop.
6.2.3.6.2.2. Use to ground wire shields for loop.

6.2.3.6.3. Ground terminal block rails to ground bus.

6.2.3.7. Analog Signal Isolators:

6.2.3.7.1. Furnish for all analog signals that are sent from each control panel and cabinet.

6.2.3.7.2. Power: 115V ac.

6.2.3.7.3. Three-way isolation; input, output, and power are isolated from each other.

6.2.3.7.4. Meets ANSI/IEEE C37.90.

6.2.3.7.5. Accuracy: Better than plus or minus 0.1 percent of output span.

6.2.3.7.6. Manufacturer: Acromag; Series 430I.

6.2.3.8. Relays:

6.2.3.8.1. All relays shall be provided with surge protection across the coils as follows:

6.2.3.8.1.1. Surge Suppressors: Magnetic control, machine tool, and industrial relays.
6.2.3.8.1.2. Metal Oxide Varistors: ac Voltage Coils.
6.2.3.8.1.3. Diodes: dc Voltage Coils.
6.2.3.8.1.4. Surge protection shall be provided and installed as recommended by the relay manufacturer.

6.2.3.8.2. Magnetic control, machine tool, and industrial relays shall be provided as indicated on the Drawings by multiple single pole, single throw

(SPST) contacts to the right of the relay coil. Signal/control circuit switching relays shall be provided as indicated on the Drawings by multiple single pole, double throw contacts (Form C) to the right of the relay coil.

6.2.3.8.3. Signal/Control Circuit Switching Relay:

6.2.3.8.3.1. Relay Mounting: Plug-in type socket.
6.2.3.8.3.2. Relay Enclosure: Furnish dust cover.
6.2.3.8.3.3. Socket Type: Screw terminal interface with wiring.
6.2.3.8.3.4. Socket Mounting: DIN rail.
6.2.3.8.3.5. Provide holddown clips.

6.2.3.8.4. Magnetic Control, Machine Tool, and Industrial Relays:

6.2.3.8.4.1. NEMA ICS 2, Class A600 (600 volts, 10 amps continuous, 7,200 VA make, 720 VA break), industrial control with a minimum of four field-convertible contacts.

6.2.3.8.5. Time Delay Attachment: Solid state

6.2.3.8.5.1. Provided and installed with manufacturer-recommended and provided surge suppressors across the coil terminals. The surge suppressor shall be designed to absorb all energy surges that appear on the line.
6.2.3.8.5.2. Manufacturer and Product: General Electric; Type CR120B.

6.2.3.8.6. Signal/Control Circuit Switching Relay, Nonlatching:

6.2.3.8.6.1. Type: Compact general purpose plug-in.
6.2.3.8.6.2. Contact Arrangement: As indicated on the Drawings, two Form C contacts minimum.
6.2.3.8.6.3. Contact Rating: 10A at 28V dc or 240V ac.
6.2.3.8.6.4. Contact Material: Silver cadmium oxide alloy.
6.2.3.8.6.5. Coil Voltage: As noted or shown.
6.2.3.8.6.6. Coil Power: 1.5 watts (dc), 2 VA (ac).
6.2.3.8.6.7. Expected Mechanical Life: 50,000,000 operations.
6.2.3.8.6.8. Expected Electrical Life at Rated Load: 500,000 operations.
6.2.3.8.6.9. Indication Type: Neon or LED indicator lamp.
6.2.3.8.6.10. Push-to-test button.
6.2.3.8.6.11. Manufacturer and Product: IDEC Corp.; Series RH.

6.2.3.8.7. Signal/Control Circuit Switching Relay, Latching:

6.2.3.8.7.1. Type: Dual coil mechanical latching relay.
6.2.3.8.7.2. Contact Arrangement: As indicated on the Drawings, two Form C contacts minimum.

6.2.3.8.7.3. Contact Rating: 10A at 28V dc or 120V ac.
6.2.3.8.7.4. Contact Material: Silver cadmium oxide alloy.
6.2.3.8.7.5. Coil Voltage: As noted or shown.
6.2.3.8.7.6. Coil Power: 2 watts (dc), 1.2 VA (ac).
6.2.3.8.7.7. Expected Mechanical Life: 10,000,000 operations.
6.2.3.8.7.8. Expected Electrical Life at Rated Load: 200,000 operations.
6.2.3.8.7.9. Manufacturer and Product: IDEC Corp.; Series RH2L.

6.2.3.8.8. Signal/Control Circuit Switching Relay, Time Delay:

6.2.3.8.8.1. Type: Adjustable time delay relay.
6.2.3.8.8.2. Contact Arrangement: As indicated on the Drawings, two Form C contacts minimum.
6.2.3.8.8.3. Contact Rating: 10A at 240V ac.
6.2.3.8.8.4. Contact Material: Silver cadmium oxide alloy.
6.2.3.8.8.5. Coil Voltage: As noted or shown.
6.2.3.8.8.6. Operating Temperature: Minus 10 to plus 55 degrees C.
6.2.3.8.8.7. Repeatability: Plus or minus 2 percent.
6.2.3.8.8.8. Delay Time Range: Select range such that time delay setpoint fall between 20 to 80 percent of range.
6.2.3.8.8.9. Time Delay Setpoint: As noted or as determined by the ENGINEER.
6.2.3.8.8.10. Mode of Operation: As noted or as determined by the ENGINEER.
6.2.3.8.8.11. Adjustment Type: Integral potentiometer with knob external to dust cover.
6.2.3.8.8.12. Manufacturer and Products: Potter and Brumfield; Series CG for 0.5-second to 100-minute delay time ranges, Series CD for 0.1- to 180-second delay time ranges.

6.2.3.9. Power Supplies:

6.2.3.9.1. Furnish as required to power instruments requiring external dc power, including two-wire transmitters and dc relays.

6.2.3.9.2. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.

6.2.3.9.3. Provide output over voltage and over current protective devices to:

6.2.3.9.3.1. Protect instruments from damage due to power supply failure.
6.2.3.9.3.2. Protect power supply from damage due to external failure.

6.2.3.9.4. Primary switched type.

6.2.3.9.5. Rail mount such that dissipated heat does not adversely affect other components.

6.2.3.9.6. Fuses: For each dc supply line to each individual two-wire transmitter.

6.2.3.9.6.1. Type: Indicating.
6.2.3.9.6.2.Mount so fuses can be easily seen and replaced.

6.2.3.9.7. Manufacturer and Product: Phoenix Contact; CM50-PS-120-230AC/24DC/5.

6.2.3.10. Front-of-panel devices shall be in conjunction with NEMA 250, Type 12 panels shall be rated NEMA 4/13, watertight/oiltight.

6.2.3.11. Potentiometer Units:

6.2.3.11.1. Three-terminal, oiltight construction, resolution of 1 percent and linearity of plus or minus 5 percent.

6.2.3.11.2. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.

6.2.3.11.3. Include legend plates with service markings.

6.2.3.11.4. Manufacturers and Products: Allen Bradley; Bulletin 800T, General Electric; Type CR104P.

6.2.3.12. Indicating Lights:

6.2.3.12.1. Heavy-duty, push-to-test type, oiltight, industrial full-voltage, high-visibility LED type for 120V ac applications.

6.2.3.12.2. Screwed on prismatic glass lenses in colors noted and factory engraved legend plates for service legend.

6.2.3.12.3. Manufacturers and Products: Allen-Bradley; Bulletin 800T, General Electric; Type CR104P, Square-D; Class 9001, Type K.

6.2.3.13. Push Button, Momentary:

6.2.3.13.1. Heavy-duty, oiltight, industrial type with full guard and momentary contacts rated for 10 amperes continuous at 120V ac.

6.2.3.13.2. Standard size legend plates with black field and white markings for service legend.

6.2.3.13.3. Manufacturers and Products: Allen-Bradley, Bulletin 800T, Square D; Class 9001, Type K, General Electric; Type CR104P.

6.2.3.14. Selector Switch:

6.2.3.14.1. Heavy-duty, oiltight, industrial type with contacts rated for 120V ac service at 10 amperes continuous.

6.2.3.14.2. Standard size, black field, legend plates with white markings, for service legend.

6.2.3.14.3. Operators: Black knob type.

6.2.3.14.4. Single-hole mounting, accommodating panel thicknesses from 1/16 to 1/4 inch.

6.2.3.14.5. Manufacturers and Products for Units with up to Four Selection Positions: Allen-Bradley; Bulletin 800T, General Electric; Type CR104P, Square D; Class 9001, Type K.

6.2.3.15. Front-of-panel devices used in conjunction with NEMA 250, Type 4X panels shall be rated NEMA 4X, corrosion-resistant/watertight.

6.2.3.16. Potentiometer, Watertight:

6.2.3.16.1. Three-terminal, heavy-duty NEMA 250, Type 4X watertight construction, resolution of 1 percent and linearity of plus or minus 5 percent.

6.2.3.16.2. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.

6.2.3.16.3. Include engraved legend plates with service markings.

6.2.3.16.4. Manufacturer and Product: Allen-Bradley; Bulletin 800H.

6.2.3.17. Indicating Lights, Watertight:

6.2.3.17.1. Heavy-duty, push-to-test type, NEMA 250, Type 4X watertight, industrial, full-voltage, high-visibility LED type, for 120V ac applications and corrosion-resistant service.

6.2.3.17.2. Screwed on prismatic lenses and factory engraved legend plates for service legend.

6.2.3.17.3. Manufacturers and Products: Allen Bradley; Bulletin 800H, Square D; Type SK.

6.2.3.18. Push Button, Momentary, Watertight:

6.2.3.18.1. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with momentary contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.

6.2.3.18.2. Standard size, black field, legend plates with white markings for service legend.

6.2.3.18.3. Manufacturers and Products: Allen Bradley; Bulletin 800H, Square D; Type SK.

6.2.3.19. Selector Switch, Watertight:

6.2.3.19.1. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.

6.2.3.19.2. Standard size, black field, legend plates with white markings, for service legend.

6.2.3.19.3. Operators: Black knob type.

6.2.3.19.4. Single-hole mounting, accommodating panel thickness from 1/16 to 1/4 inch.

6.2.3.19.5. Manufacturer and Products: Allen Bradley; Bulletin 800H, Square D; Class 9001, Type SK.

6.3. COMPONENT IDENTIFICATION

6.3.1. Panel Nameplates: For each panel, face mounted laminated nameplate inscribed with the panel name. Color shall be white with black letters ½ inch tall minimum.

6.3.2. Nametags: Permanently mounted and bearing entire identification number.

6.3.2.1. Panel Mounted: Plastic, mounted to instrument behind panel face.

6.3.2.2. Field Mounted: Engraved Type 316 stainless steel, 22-gauge minimum thickness, attach with steel safety wire.

6.3.3. Service Legends and Nameplates:

6.3.3.1. Engraved, rigid, laminated plastic type with adhesive back. Furnish service legends and nameplates to adequately describe functions of panel face mounted instruments.

6.3.3.2. Color: White surface engraved to a black core, white with black letters. Letter height 3/16 inch minimum.

6.3.3.3. Standard Light Colors and Inscriptions: Unless otherwise specified in individual equipment specifications, use the following color code and inscriptions:

Tag	Inscription(s)	Color
POWER ON	POWER ON	Green
ON	ON	Red
OFF	OFF	Green
OPEN	OPEN	Red
CLOSED	CLOSED	Green
LOW	LOW	Amber
FAIL	FAIL	Amber
HIGH	HIGH	Amber
AUTO	AUTO	White
HAND OR MANUAL	HAND OR MANUAL	Yellow
LOCAL	LOCAL	White
REMOTE	REMOTE	Yellow
FORWARD	FORWARD	Red
REVERSE	REVERSE	Blue

6.3.3.4. Lettering: Black on white or amber lenses; white on red or green lenses.

6.3.3.5.Standard Push Button Colors, Unless Otherwise Indicated:

6.3.3.5.1. STOP, OFF, EMERGENCY STOP, RESET are to be Red in color.
6.3.3.5.2. All others are to be Black in color.

6.4. SURGE AND TRANSIENT PROTECTION

6.4.1. General: All control panels are to be equipped with surge-arresting devices to protect equipment from damage due to electrical transients induced in interconnecting lines from lightning discharges and nearby electrical devices.

6.4.2. Suppressor Locations:

6.4.2.1. At point of connection between each equipment item, including ac powered transmitters and its power supply conductors (direct wired equipment).

6.4.2.2. On analog pairs at each end when the pair travels outside of building.

6.4.2.3. In other locations where equipment sensitivity to surges and transients requires additional protection beyond that inherent to design of equipment.

6.4.3. AC Power Supply Suppressor Assemblies shall be suitable for connection to 120-volt, single-phase power supplies.

6.4.4. Manufacturer and Products:

6.4.4.1.AC Power Supply Suppressor: Phoenix; MT2PE/S-120AC.
6.4.4.2.DC Signal Suppressor: Telematic; (MTL) SD 32X.
6.4.4.3.AC Signal Suppressor: Telematic; (MTL) SD 150X.
6.4.4.4.Data Highway Plus Suppressor: Telematic; (MTL) SD 16X.

6.4.5. Grounding: Coordinate surge suppressor grounding in field panels and field instrumentation per suppressor manufacturer's requirements. Furnish control panels with an integral copper grounding bus for connection of suppressors and other required instrumentation.

7. FIBER OPTIC DATA TRANSMISSION SYSTEM

7.1. SYSTEM DESCRIPTION

7.1.1. General

7.1.1.1. A fiber optics (FO) data transmission system (DTS) shall be provided as detailed for control and data acquisition between well vaults and Buildings 650 and 651. The data transmission system shall consist of fiber optic transmission media, transmitter and receiver modules, FO modems, transceiver modules, repeaters, and terminal devices (such as connectors, patch panels and breakout boxes). The data transmission system shall interconnect system components as shown on the contract drawings. Computing devices, as defined in 47 CFR 15, shall be certified to comply with the requirements for Class B computing devices and labeled as set forth in 47 CFR 15.

7.1.2. Environment

7.1.2.1. Equipment and cable to be utilized indoors shall be rated for continuous operation under ambient environmental conditions of 35 to 120 degrees F dry bulb and 10 to 95 percent relative humidity, noncondensing. Equipment shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location. Fiber optic cable for outdoor installation shall be rated for minus minus 40 to plus 176 degrees F.

7.1.2.2. Hazardous Environment

7.1.2.2.1. System components located in fire or explosion hazard areas shall be rated and installed according to Chapter 5 of NFPA 70.

7.2. SUBMITTALS

7.2.1. These specific submittals supplement the submittals requirements in section 9.0, listed later in this document.

7.2.2. Data Package

7.2.2.1. The data package shall include complete system description, and analyses and calculations used in sizing equipment required by these specifications. Descriptions and calculations shall show how the equipment will operate as a system to meet the specified performance. The data package shall include the following:

7.2.2.1.1. FO receivers, transmitters, transceivers, FO modem transmit and receive levels, and losses in decibels (dB) on each communication link.
7.2.2.1.2. Digital transmitter and receiver communication speed and protocol description.
7.2.2.1.3. Analog signal transmission method and bandwidth of the transmitter and receiver.
7.2.2.1.4. Data transmission system expansion capability and method of implementation.
7.2.2.1.5. FO system signal-to-noise ratio calculation for each communication link.
7.2.2.1.6. Flux-budget and gain margin calculation for each link.

7.2.2.2. Test Plan Procedures and Reports;

7.2.2.2.1. Test reports shall be submitted in booklet form showing field tests performed to adjust each component and field tests performed to prove compliance with the specified performance criteria. These are to be supplied upon completion and testing of the installed system.

7.2.3. Fiber Optic System Testing

7.2.3.1. Test plans shall define tests required and procedures to be followed to ensure that the system meets technical, operational, and performance specifications. The test plans shall define milestones for the tests, equipment, personnel, facilities, and supplies required. The test plans shall identify the capabilities and functions to be tested.

7.2.3.2. A test plan and test procedure shall be prepared in accordance with this specification. The test procedures shall describe the applicable tests to be performed, and other pertinent information such as specialized test equipment required, length of test, and location of the test. The procedures shall explain in detail, step-by-step actions and expected results to demonstrate compliance with the requirements of this specification, and the methods for simulating the necessary conditions of operation to demonstrate performance of the system. The Contractor shall provide written notice of the test to the Government at least 2 weeks prior to the scheduled start.

7.2.3.3. Following testing, a test report shall describe the results of testing to include the date, time, location and system component designations of material and equipment tested. Testing action shall be recorded whether successful or not. Testing work sheets, printouts, strip charts, oscilloscope or optical time domain reflectometer (OTDR) photographs, raw and analyzed data, and testing conclusions shall be included in the report. The final test report shall be delivered within 15 days after completion of the test.

7.3. PRODUCTS

7.3.1. FO MODEMS

7.3.1.1. FO modems shall be selected to meet FO system requirements. The modems shall allow full duplex, asynchronous, point-to-point digital communication using an FO pair. The operating wavelength shall be centered on 850, 1330, or 1550 nanometers.

7.3.1.2. FO modems shall accept inputs and provide outputs compatible with EIA ANSI/EIA/TIA-232-F 4-20 mA current loop. Digital data rates through each link shall be not less than 38.4 KBPS.

7.3.2. FO TRANSMITTER AND RECEIVER MODULES

7.3.2.1. FO transmitter/receiver pairs shall have signal-to-noise power ratio of 40 dB or better after photo detection at the receiver. Transmitter power output and receiver sensitivity shall not drift more than plus or minus 2 dB over their operational life.

7.3.2.2. Analog FO Transmitter and Receiver Modules

7.3.2.2.1. FO transmitter/receiver pairs used to pass analog video signals shall accept inputs and provide outputs that comply with EIA 170 and shall have a bandwidth of 6 MHz or greater.

7.3.2.3. Digital FO Transmitter and Receiver Modules

7.3.2.3.1. FO transmitter/receiver pairs used to pass digital signals shall accept inputs and provide outputs compatible with EIA ANSI/EIA/TIA-232-F 20 mA current loop. Digital data rates through each link shall be 38.4 KBPS or greater. FO transmitter and receiver modules shall be housed in field equipment enclosures. FO transmitter and receiver modules shall be compatible with each other, the FO cable, and connectors.

7.3.2.4. FO Transmitter Module

7.3.2.4.1. The FO transmitter shall accept electronic signals and shall modulate a light source. The light source shall be coupled into an FO cable. The operating wavelength shall be centered on 850, 1330, or 1550 nanometers per calculated system requirements.

7.3.2.5. FO Receiver Module

7.3.2.5.1. The FO receiver module shall receive light from the FO cable and shall convert this light into an electronic signal identical to the electronic signal applied to the FO transmitter module. The operating wavelength shall be the same as the transmitter.

7.3.3. SYSTEM REQUIREMENTS

7.3.3.1. Signal Transmission Format Code

7.3.3.2. FO equipment shall use the same transmission code format from the beginning of a circuit to the end of that circuit. Different transmission code formats may be used for different circuits as required to interconnect supported equipment.

7.3.3.3. Flux Budget/Gain Margin

7.3.3.3.1. FO links shall have a minimum gain margin of 6 dB. The flux budget is the difference between the transmitter output power and the receiver input power required for signal discrimination when both are expressed in dBm. The flux budget shall be equal to the sum of losses (such as insertion losses, connector and splice losses, and transmission losses) plus the gain margin. When a repeater or other signal regenerating device is inserted to extend the length of an FO circuit, both the circuit

between the transmitter and the repeater-receiver, and the circuit between the repeater-transmitter and the receiver are considered independent FO links for gain margin calculations.

7.3.3.4. Receiver Dynamic Range

7.3.3.4.1. The dynamic range of receivers shall be large enough to accommodate both the worst-case, minimum receiver flux density and the maximum possible, receiver flux density. The receiver dynamic range shall be at least 15 dB. Where required, optical attenuators shall be used to force the FO link power to fall within the receiver dynamic range.

7.4. OPTICAL FIBERS

7.4.1. GENERAL

7.4.1.1. Optical fibers shall be coated with a suitable material to preserve the intrinsic strength of the glass. The outside diameter of the glass-cladded fiber shall be nominally 125 microns, and shall be concentric with the fiber core. Optical fibers shall meet EIA ANSI/EIA/TIA-455-46A, and EIA ANSI/TIA/EIA-455-177A.

7.4.1.2. 62.5 Micron Multimode Fibers

7.4.1.2.1. Conductors shall be multimode, graded index, solid glass waveguides with a nominal core diameter of 62.5 microns. The fiber shall have transmission windows centered at 850 and 1330 nanometer wavelengths. The numerical aperture for each fiber shall be a minimum of 0.275. The attenuation at 850 nanometers shall be 4.0 dB/Km or less. The attenuation at 1330 nanometers shall be 1.5 dB/Km or less. The minimum bandwidth shall be 160 MHz-Km at 850 nanometers and 400 MHz-Km at 1300 nanometers. FO cable shall be certified to meet EIA ANSI/EIA/TIA-455-30B and EIA ANSI/EIA/TIA-455-58A.

7.4.1.3. 8.3 Micron Single Mode Fibers

7.4.1.3.1. Conductors shall be single-mode, graded index, solid glass waveguides with a nominal core diameter of 8.3 microns. The fiber shall have a transmission window centered at 1330, or 1550 nanometer wavelength. The numerical aperture for each optical fiber shall be a minimum of 0.10. The attenuation at 1330 nanometers shall be 0.5 dB/Km or less. The fibers shall be certified to meet EIA ANSI/EIA/TIA-455-170.

7.4.1.4. Patch Panels

7.4.1.4.1. Patch panels shall be a complete system of components by a single manufacturer, and shall provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection. Patch panel connectors and couplers shall be the same type and configuration as used elsewhere in the system. Panels shall be either a rack mount type or wall mounted.

7.4.1.5. Patch Cords

7.4.1.5.1. Patch cords shall be cable assemblies consisting of flexible optical fiber cable with connectors of the same type as used elsewhere in the system. Optical fiber shall be the same type as used elsewhere in the system. Patch cords shall be complete assemblies from manufacturer's standard products.

7.4.2. CABLE CONSTRUCTION

7.4.2.1. General

7.4.2.1.1. The cable shall contain a minimum of two fiber optic conductors for each full duplex circuit. The number of fibers in each cable shall be twenty or greater. Each fiber shall be protected by a protective tube. Cables shall have a jacketed strength member, and an exterior jacket. Cable and fiber protective covering shall be free from holes, splits, blisters, and other imperfections. The covering shall be flame retardant, moisture resistant, non-nutrient to fungus, ultraviolet light resistant as specified and nontoxic.

7.4.2.1.2. Mechanical stress present in cable shall not be transmitted to the optical fibers. Strength members shall be non-metallic and shall be an integral part of the cable construction. The combined strength of all the strength members shall be sufficient to support the stress of installation and to protect the cable in service.

7.4.2.1.3. The exterior cables shall have a minimum storage temperature range of minus 40 to plus 167 degrees F. Interior cables shall have a minimum storage temperature of minus 14 to plus 167 degrees F. All cables furnished shall meet the requirement of NFPA 70. Fire resistant characteristics of cables shall conform to Article 770, Sections 49, 50, and 51.

7.4.2.1.4. A flooding compound shall be applied into the interior of the fiber tubes, into the interstitial spaces between the tubes, to the core covering, and between the core covering and jacket of all cable to be installed aerially, underground, and in locations susceptible to moisture. Flooded cables shall comply with EIA ANSI/EIA-455-81A-91 and EIA ANSI/EIA/TIA-455-82B.

7.4.2.1.5. Cables shall be from the same manufacturer, of the same cable type, and of the same size. Each fiber and protective coverings shall be continuous with no factory splices. Fiber optic cable assemblies, including jacketing and fibers, shall be certified by the manufacturer to have a minimum life of 30 years.

7.4.2.1.6. FO cable shall be certified to meet the following: EIA ANSI/TIA/EIA-455-13A, EIA ANSI/EIA/TIA-455-25B, EIA ANSI/TIA/EIA-455-41A, EIA ANSI/EIA/TIA-455-47B, EIA ANSI/EIA/TIA-455-59, EIA ANSI/EIA/TIA-455-61, EIA-455-88, EIA ANSI/EIA-455-91, EIA ANSI/TIA/EIA-455-104A, and EIA ANSI/EIA-455-171.

7.4.2.2. Exterior Cable

7.4.2.2.1. The optical fibers shall be surrounded by a tube buffer, shall be contained in a channel or otherwise loosely packaged to provide clearance between the fibers and inside of the container. They shall be extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement.

7.4.2.2.2. The cable outer jacket shall be medium density polyethylene material containing at least 2.6 percent carbon black with only black pigment added for additional coloring.

7.4.2.2.3. Tensile strength: Cables shall withstand an installation tensile load of not less than 2700 Newtons (608 pounds) and not less than 600 Newtons (135 pounds) continuous tensile load.

7.4.2.2.4. Impact and Crush resistance: The cables shall withstand an impact of 3 Newtons/meter (1.7lbs/in) as a minimum, and shall have a crush resistance of 220 Newtons per square centimeter (317 pounds per square inch) as a minimum.

7.4.2.3. Cable Inside of Ductwork

7.4.2.3.1. The optical fibers shall be surrounded by a tube buffer, shall be contained in a channel or otherwise loosely packaged to provide clearance between the fibers and inside of the container, and shall be extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement.

7.4.2.3.2. The cable outer jacket shall be medium density polyethylene material with orange pigment added for ease of identification.

7.4.2.3.3. Tensile strength: Cables shall withstand an installation tensile load of not less than 608 pounds and not less than 135 pounds continuous tensile load.

7.4.2.3.4. Impact and Crush resistance: The cables shall withstand an impact of 1.7 lbs/in as a minimum, and shall have a crush resistance of 317 pounds per square inch as a minimum.

7.4.2.4. Direct Burial Cable

7.4.2.4.1. The optical fibers shall be surrounded by a tube buffer, shall be contained in a channel or otherwise loosely packaged to provide clearance between the fibers and inside of the container. They shall be extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement.

7.4.2.4.2. The cable outer jacket shall be medium density polyethylene material containing at least 2.6 percent carbon black with only black pigment added for additional coloring.

7.4.2.4.3. Tensile strength: Cables shall withstand an installation tensile load of not less than 608 pounds and not less than 135 pounds continuous tensile load.

7.4.2.4.4. Impact and Crush resistance: The cables shall withstand an impact of 1.7 lbs/in as a minimum, and shall have a crush resistance of 317 pounds per square inch as a minimum.

7.4.2.4.5. Direct burial cable shall be protected with plastic coated steel armor. The plastic coated steel armor shall be applied longitudinally directly over an inner jacket and have an overlap of 0.20 inch minimum.

7.4.2.5. Interior Cable

7.4.2.5.1. Loose buffer tube cable construction shall be such that the optical fibers shall be surrounded by a tube buffer, shall be contained in a channel or otherwise loosely packaged to provide clearance between the fibers and the inside of the container to allow for thermal expansions without constraining the fiber. The protective container shall be extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement. The cable outer jacket shall be flame retardant polyvinyl chloride (PVC) or fluorocopolymer (FCP), which complies with NFPA 70 for OFNP applications. Tensile strength, impact resistance, and crush resistance shall not exceed manufacturers recommendations.

7.4.2.5.2. Tight buffer tube cable construction shall be extrusion of plastic over each cladded fiber, with an outer jacket of flame retardant PVC or FCP, which complies with NFPA 70 for OFNR requirements for riser cables and vertical shaft installations. Optical fibers shall be covered in near contact with an extrusion tube and shall have an intermediate soft buffer to allow for the thermal expansions and minor pressures. Tensile strength, impact resistance, and crush resistance shall not exceed manufacturers recommendations.

7.4.2.5.3. Plenum Rated Cables: Cable to be installed inside plenums shall additionally meet the requirements of UL 910.

7.4.2.6. Pigtail Cables

7.4.2.6.1. Cable used for connections to equipment shall be flexible fiber pigtail cables having the same physical and operational characteristics as the parent cable. The cable jacket shall be flame retardant PVC or FCP, which complies with NFPA 70 for OFNP applications. Maximum dB loss for pigtail cable shall be 3.5 dB/km at 850 nanometers, and 1.0 dB/km at 1330 nanometers.

7.4.3. FO CONNECTORS

7.4.3.1. FO connectors shall be the straight tip, bayonet style, field installable, self-aligning and centering. FO connectors shall match the fiber core and cladding diameters. The connector coupler shall be stainless steel and the alignment ferrule shall be ceramic. FO equipment and cable shall use the same type connectors. Connector insertion loss shall be nominally 0.3 dB and less than 0.7 dB.

7.4.3.2. Fibers at each end of the cable shall have jumpers or pigtails installed of not less than 3 feet in length. Fibers at both ends of the cable shall have connectors installed on the jumpers. Mated pair loss, without rotational optimization, shall not exceed 1.5 dB. The pull strength between the connector and the attached fiber shall not be less than 50 pounds.

7.4.4. FIBER OPTIC CABLE SPLICES

7.4.4.1. No splices will be permitted unless the length of cable being installed exceeds the maximum standard cable length available from a manufacturer or unless fiber optic pigtails are used to connect transmitters, receivers, or other system components for terminations to the fiber.

7.4.4.2. Splices shall be made using the method recommended by the cable manufacturer. Splices shall be housed in a splice enclosure and shall be encapsulated with an epoxy, ultraviolet light cured splice encapsulant or otherwise protected against infiltration of moisture or contaminants. FO splices shall be field tested at the time of splicing. Fusion splices shall have less than 0.2 dB loss.

7.5. FIBER OPTIC INSTALLATION

7.5.1. System components and appurtenances shall be installed in accordance with the manufacturer's instructions and as indicated in contract drawings. Interconnections, services, and adjustments required for a complete and operable data transmission system shall be provided.

7.5.2. Interior Work

7.5.2.1. Conduits, tubing and cable trays for interior FO cable shall be installed as specified in contract drawings. Cable installation and applications shall meet the requirements of NFPA 70, Article 770, Sections 52 and 53. Cables not installed in conduits or wireways shall be properly secured and neat in appearance, and if installed in plenums or other spaces used for environmental air, shall comply with NFPA 70 requirements for this type of installation.

7.5.3. Exterior Underground Cable

7.5.3.1. Except as otherwise specified, conduits, ducts, and manholes for underground FO cable systems shall be installed as indicated in the contract drawings.

7.5.3.2. Buried cables shall be placed below a plastic warning tape buried in the same trench or slot. The tape shall be 12 inches above the cable. The warning tape shall be continuously imprinted with the words "WARNING – FIBER OPTIC CABLE BELOW" at not more than 48 inch intervals. The plastic tape shall be acid and alkali resistant polyethylene film, 3 inches wide with a minimum thickness of 0.004 inch.

7.5.3.3. For cables installed in ducts and conduit, a cable lubricant compatible with the cable sheathing material shall be used on all cables pulled. Pulling fixtures shall be attached to the cable strength members. If indirect attachments are used, the grip diameter and length shall be matched to the cable diameter and characteristics. If an indirect attachment is used on cables having only central strength members, the pulling forces shall be reduced to ensure that the fibers are not damaged from forces being transmitted to the strength member. The mechanical stress placed upon the cable during installation shall be such that the cable is not twisted or stretched.

7.5.3.4. The cable shall not be kinked or crushed and the manufacturer's specified minimum bend radius of the cable shall not be exceeded during installation.

7.5.3.5. Cable shall be hand fed and guided through each manhole and lubricant shall be applied at all intermediate manholes. If the cable is pulled out of a junction box or manhole the cable shall be protected from dirt and moisture by laying the cable on a ground covering.

7.5.4. Service Loops

7.5.4.1. Each fiber optic cable shall have service loops of not less than 10 feet in length at each end. The service loops shall be housed in a service loop enclosures.

7.5.5. Metallic Sheath Grounding

7.5.5.1. Fiber optic cable with metallic sheath routed in the trench with a power cable shall have the metallic sheath grounded at the cable termination points per manufacturer's instructions.

7.5.6. Identification and Labeling

7.5.6.1. Identification tags or labels shall be provided for each cable. Markers, tags and labels shall use indelible ink or etching that will not fade in sunlight or in buried or underground applications. Markers, tags, and labels shall not become brittle or deteriorate for a period of 20 years.

7.5.6.2. Label all termination blocks and panels with cable number or pair identifier for cables in accordance with EIA ANSI/TIA/EIA-606 and as specified in contract drawings. Each cable shall be identified with type of signal being carried and termination points.

7.5.6.3. The labeling format shall be identified and a complete record shall be provided to the Government with the final documentation.

7.5.7. Enclosure Sizing

7.5.7.1. Termination enclosures shall be sized to accommodate the FO equipment to be installed. Sizing shall include sufficient space for service loops to be provided and to accommodate a neat, workmanlike layout of equipment and the bend radii of fibers and cables terminated inside the enclosure.

7.5.8. Enclosure Penetrations

7.5.8.1. Enclosure penetrations shall be from the bottom and shall be sealed with rubber silicone sealant or a strain relief device to preclude the entry of water. Conduits rising from underground shall be internally sealed.

7.5.9. Conduit-Enclosure Connections

7.5.9.1. Conduit-enclosure connections shall be protected by tack welding or brazing the conduit to the enclosure. Tack welding or brazing shall be done in addition to standard conduit-enclosure connection methods as described in NFPA 70. Any damage to the enclosure or its cover's surface protection shall be cleaned and repaired using the same type of surface protection as the original enclosure.

7.6. FIBER OPTIC SYSTEM TESTING

7.6.1. General

7.6.1.1. The Contractor shall provide personnel, equipment, instrumentation, and supplies necessary to perform testing.

7.6.2. Contractor's Field Test

7.6.2.1. The Contractor shall verify the complete operation of the data transmission system in conjunction with field testing associated with systems supported by the fiber optic data transmission system as specified in earlier sections prior to formal acceptance testing. Field tests shall include a flux density test. These tests shall be performed on each link and repeated from the opposite end of each link.

7.6.3. Optical Time Domain Reflectometer Tests

7.6.3.1. Optical time domain reflectometer tests shall be performed using the FO test procedures of EIA ANSI/EIA/TIA-455-59. An optical time domain reflectometer (OTDR) test shall be performed on all fibers of the FO cable on the reel prior to installation. If this is completed by the factory, documentation must be provided to the Government. The optical time domain reflectometer device used shall be calibrated to show anomalies of 0.2 dB as a minimum.

7.6.3.2. An optical time domain reflectometer test shall be performed on all fibers of the FO cable following installation. The optical time domain reflectometer shall be calibrated to show anomalies of 0.2 dB as a minimum.

7.6.3.3. If any optical time domain reflectometer test results show anomalies greater than 1 dB, the FO cable segment is unacceptable to the Government. The unsatisfactory segments of cable shall be replaced with a new segment of cable. The new segment of cable shall then be tested to demonstrate acceptability. Photographs or copies of the traces shall be furnished to the Government for each link.

7.6.4. Power Attenuation Test

7.6.4.1. Power attenuation test shall be performed at the light wavelength of the transmitter to be used on the circuit being tested. The flux shall be measured at the FO receiver end and shall be compared to the flux injected at the transmitter end. There shall be a jumper added at each end of the circuit under test so that end connector loss shall be validated. Rotational optimization of the connectors will not be permitted. If the circuit loss exceeds the calculated circuit loss by more than 2 dB, the circuit is unsatisfactory and shall be examined to determine the problem. The Government shall be notified of the problem and what procedures the Contractor proposes to eliminate the

problem. The Contractor shall prepare and submit a report documenting the results of the test.

7.6.5. Gain Margin Test

7.6.5.1. The Contractor shall test and verify that each circuit has a gain margin that exceeds the circuit loss by at least 6 dB.

7.7. FIBER OPTIC SYSTEM TRAINING

7.7.1. General

7.7.1.1. The Contractor shall conduct a training course for designated personnel in the maintenance of the FO system. The training shall be oriented to the specific system being installed under this specification. The Contractor shall furnish training materials and supplies.

7.7.2. Maintenance Personnel Training

7.7.2.1. The system maintenance course shall be taught at the project site after completion of system testing for a period of 1 training day. Training may be combined with control system training if preferable. A maximum of five personnel designated by the Government will attend the course. Training shall include:

7.7.2.1.1. Physical layout of the system and each piece of hardware.
7.7.2.1.2. Troubleshooting and diagnostics procedures.
7.7.2.1.3. Repair instructions.
7.7.2.1.4. Preventative maintenance procedures and schedules.
7.7.2.1.5. Calibration procedures, if required.

8. CERTIFICATION AND WARRANTY

8.1. The minimum design life for materials and installation of the plume-front remediation system is thirty (30) years. The certification and warranty shall contain a written certification statement from the installation inspector(s) at testing to the proper installation and testing of the control system. The warranty shall define a warranty period and provide allowance for credit, repair or replacement of any defective valves, flow meters, or electronic components. The vendor shall provide a warranty that guarantees the installation of all pipe, valves, and fittings per this contract against defects or failures due to improper installation. At minimum, any defects or failures due to improper installation shall be repaired by the vendor at no cost to the Government for a one (1) year period. The manufacturer or vendor shall replace damaged or defective parts within a two week time frame.

9. SUBMITTALS

9.1. GENERAL REQUIREMENTS

9.1.1. Each submittal shall be permanently marked to identify it by contract number; transmittal date; Contractor's, Subcontractor's, and supplier's name, address(es) and telephone number(s); submittal name; specification or drawing reference; and similar information to distinguish it from other submittals. Submittal identification shall include space to record the review action by the Contracting Officer.

9.1.2. Required data submittals for each specific material, product, unit of work, or system shall be collected into a single submittal and marked for choices, options, and portions applicable to the submittal. Marking of each copy of product data submitted shall be identical. Partial submittals will not be accepted for expedition of construction effort.

9.1.3. Five complete sets of indexed and bound product data shall be submitted. One set, marked with review notations by the Contracting Officer, will be returned to the Contractor.

9.1.4. Within 30 days of notice to proceed, the Contractor shall provide, for approval by the Contracting Officer, the following schedule of submittals:

9.1.4.1. A schedule of shop drawings and technical submittals required by the specifications and drawings. Schedule shall indicate the specification or drawing reference requiring the submittal; the material, item, or process for which the submittal is required; identifying title of the submittal; the Contractor's anticipated submission date and the approval need date.

9.1.4.2. A separate schedule of other submittals required under the contract but not listed in the specifications or drawings. Schedule will indicate the contract requirement reference; the type or title of the submittal; the Contractor's anticipated submission date and the approved need date (if approval is required).

9.1.4.3. Submittals called for by the contract documents will be listed on one of the above schedules. If a submittal is called for but does not pertain to the contract work, the Contractor shall include it in the applicable schedule and annotate it "N/A" with a brief explanation. Approval of the schedules by the Contracting Officer does not relieve the Contractor of supplying submittals required by the contract documents but which have been omitted from the schedules or marked "N/A".

9.1.4.4. Copies of both schedules shall be re-submitted monthly annotated by the Contractor with actual submission and approval dates. When all items on a schedule have been fully approved, no further re-submittal of the schedule is required.

9.1.4.5. Contracting Officer will review submittals and provide pertinent notation within 15 calendar days after date of submission. Submittals will be returned to the Contractor with the following notations:

9.1.4.5.1. Submittals marked "approved" authorize the Contractor to proceed with the work covered.

9.1.4.5.2. Submittals marked "approved as noted" authorize the Contractor to proceed with the work covered provided he takes no exception to the corrections. Notes shall be incorporated prior to submission of the final submittal.

9.1.4.5.3. Submittals marked "return for correction" require the Contractor to make the necessary corrections and revisions and to re-submit them for approval in the same routine as before, prior to proceeding with any of the work depicted by the submittal.

9.1.4.5.4. Submittals marked "not approved" or "disapproved" indicate noncompliance with the contract requirements and shall be re-submitted with appropriate changes. No item of requiring a submittal shall be accomplished until the submittals are approved or approved as noted.

9.1.5. Contractor shall make corrections required by the Contracting Officer. If the Contractor considers any correction or notation on the returned submittals to constitute a change to the contract drawings or specifications; notice as required under the clause entitled, "Changes" shall be given to the Contracting Officer. Approval of the submittals by the Contracting Officer shall not be construed as a complete check, but will indicate only that the general method of construction and detailing is satisfactory. Contractor shall be responsible for the dimensions and design of connection details and construction of work. Failure to point out deviations may result in the Government requiring rejection and removal of such work at the Contractor's expense.

9.1.6. If changes are necessary to approved submittals, the Contractor shall make such revisions and submission of the submittals in accordance with the procedures above. No item of work requiring a submittal change shall be accomplished until the changed submittals are approved.

9.2. PRE-CONSTRUCTION SUBMITTALS

9.2.1. The Contractor shall submit the items in this section (9.2) for approval by the Contracting Officer within 15 calendar days of issuance of the Notice to Proceed.

9.2.2. Qualifications - A statement describing the Contractor’s experience installing and testing piping, flow control valves, electromagnetic flow meters, control cable, optical fiber, and electronic control equipment.

9.2.3. Project Schedule – The Offeror shall furnish a Project Schedule as described in a previous section of this specification.

9.2.4. Manufacturer's Catalog Data – Data composed of catalog cut sheets, specifications and product data, wiring diagrams, and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents. This should include catalog information on all mechanical and electrical devices furnished with system.

9.2.5. Manufacturer's Instructions – Where installation procedures, or any part thereof, are required to be in accordance with the recommendation of the manufacturer of the material being installed, printed copies of these shall be submitted prior to installation.

9.2.6. Shop Drawings and dimensional layout drawings: Diagrams of pre-wired furnished control panels and enclosures, as well as panel interconnection drawings with numbered terminal designations for external interfaces. Drawings shall show all control devices and auxiliary devices, for example: relays, alarms, fuses, lights, fans, and heaters. This shall include interconnection wiring diagrams for the control system.

9.2.7. Communication System design drawings: Details of interfaces with control system components. Fiber optic receivers, transmitters, transceivers, and fiber optic modem installation details, block diagrams, and wiring diagrams. Detail of connection to power sources, including grounding. Details of cable splicing and connector installations.

9.2.8. Control System Testing Plan – The Offeror shall furnish a written document describing in detail the procedure to be followed for testing of the entire control system. Specifically, the Control System Testing Plan shall specify the proposed testing locations, specific procedures, verification, special requirements, and any other information pertinent to control system testing. All proposed testing procedures require Government approval prior to actual testing.

9.2.9. List of proposed spares and test equipment.

9.3. CONSTRUCTION PROGRESS SUBMITTALS

9.3.1. As-Built Drawing Submittals

9.3.1.1. Drawings showing the final as-built conditions of the installation shall consist of as-built CADD drawings. The Contractor will generate the CADD versions of as-builts from his own working as-built markups of the Government's initial design drawings. The Contractor shall review and approve hard copies of the as-built revisions to ensure true as-built conditions before they are recorded on the electronic as-built drawings.

9.3.2. Working As-Built and Final As-Built Drawings

9.3.2.1. The Contractor shall revise two sets of paper drawings by red-line process to show the as-built conditions during the execution of the project (one field copy, one field-office copy). These working as-built marked drawings shall be kept current on a weekly basis and at least one set shall be available on the jobsite at all times. Changes from the contract plans, which are made in the work or additional information that might be uncovered in the course of construction, shall be accurately and neatly recorded as they occur by means of details and notes. The working and final as-built drawings shall show, but shall not be limited to, the following information:

9.3.2.1.1. Changes in details of design or additional information obtained from working drawings specified to be prepared and/or furnished by the Contractor; including but not limited to fabrication, erection, installation plans and placing details, pipe sizes, insulation material, and dimensions of equipment foundations.

9.3.2.1.2. Changes or modifications which result from the final inspection.

9.3.2.1.3. Where contract drawings or specifications present options, only the option selected for construction shall be shown on the final as-built prints.

9.3.2.1.4. Systems designed or enhanced by the Contractor.

9.3.3. Drawing Preparation

9.3.3.1. The as-built drawings shall be modified as may be necessary to correctly show the features of the project as it has been constructed by bringing the contract set into agreement with approved working as-built prints, and adding such additional drawings as may be necessary. Additional drawings generated by the Contractor shall be *.dwg files in AutoCAD (R14 or later) electronic format. The working as-built marked prints shall be neat, legible and accurate. The following color convention shall be used for the working as-built drawings: (1) red for additions, (2) green for deletions, and (3) blue for comments and/or notes.

9.3.3.2. These drawings are part of the permanent records of this project. Any drawings damaged or lost by the Contractor shall be satisfactorily replaced by the Contractor at no expense to the Government.

9.3.4. Final As-Built Drawing Submittals

9.3.4.1. Within seven days following final construction completion, the complete set of working as-built drawings shall be submitted to the Government for approval. Within 14 calendar days after Government approval of all of the working as-built drawings, the Contractor shall submit the revised electronic drawing package reflecting all as-built changes.

9.3.4.2. The Government reserves the right to reject any mark-up drawing it deems inadequate. Paper prints, drawing files and storage media submitted will become the property of the Government upon final approval. Failure to submit final electronic as-built drawing files and marked prints as specified shall be cause for withholding any payment due the Contractor under this contract. Approval and acceptance of final as-built drawings shall be accomplished before final payment is made to the Contractor.

9.3.5. As-Built Record of Equipment and Materials Submittal

9.3.5.1. The Contractor shall furnish one copy of preliminary record of equipment and materials used on the project 14 calendar days prior to final inspection. This preliminary submittal will be reviewed and returned within 4 calendar days after final inspection with Government comments.

9.3.5.2. Two sets of the final record of equipment and materials shall be submitted within 14 calendar days after final inspection. The designations shall be keyed to the related area depicted on the contract drawings. The record shall list the following data:

9.3.5.2.1. Item Description
9.3.5.2.2. Specification Section
9.3.5.2.3. Manufacturer's Catalog, Model, and Serial Number
9.3.5.2.4. Materials of construction and Size
9.3.5.2.5. Item location(s)

9.4. CONSTRUCTION CLOSE-OUT SUBMITTALS

9.4.1. Contractor shall furnish the following documentation no later than 30 days following completion of construction. Final payment will not be made until all close-out submittals are received by the Contracting Officer, and deemed to be satisfactory.

9.4.2. Statement of Satisfactory Installation - The Contractor shall furnish a signed statement certifying that the installation is satisfactory and in accordance with the contract drawings and specifications and the manufacturer's prescribed procedures and techniques, upon completion of the project and before final acceptance.

9.4.3. Copies of all system testing and validation reports, data packages, analyses, and calculations required per previous sections of this specification.

9.4.4. Operation and Maintenance (O&M) Manuals - The Contractor shall furnish four copies each of the manuals specific to all control hardware/software within 30 days after completion of the system installation and testing. Two shall be in indexed booklet form, and two on CD format. These final copies shall be updated to

include all modifications made during installation, checkout, and acceptance. Manuals delivered shall include the following sections:

9.4.4.1. Hardware Manual:

9.4.4.1.1. General description and specifications of components
9.4.4.1.2. Installation and checkout procedures
9.4.4.1.3. Equipment electrical schematics and layout drawings
9.4.4.1.4. Data transmission systems schematics
9.4.4.1.5. Alignment and calibration procedures
9.4.4.1.6. Manufacturer's repair parts list indicating sources of supply

9.4.4.2. Operator's Manual:

9.4.4.2.1. The operator's manual shall fully explain procedures and instructions for operation of the system. It shall identify the operational requirements for the data transmission system and explain the theory of operation, design philosophy, and specific functions. A description of hardware functions, interfaces, and requirements shall be included for all system operating modes.

9.4.4.3. Maintenance Manuals:

9.4.4.3.1. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventative maintenance, fault diagnosis, and repair or replacement of defective components.

9.4.5. Warranty Management Plan - The Contractor shall submit warranty information for all applicable construction and equipment. This submittal shall include a list for each warranted piece of equipment, item, feature of construction or system indicating:

9.4.5.1. Name of item.
9.4.5.2. Model and serial numbers.
9.4.5.3. Location where installed.
9.4.5.4. Name and phone numbers of manufacturers or suppliers.
9.4.5.5. Names, addresses and telephone numbers of sources of spare parts.

9.4.6. Warranties and terms of warranty. This shall include one year overall warranty of construction. Items which have warranties longer than one year shall be indicated with separate warranty expiration dates.

9.4.6.1. Cross-reference to warranty certificates as applicable.
9.4.6.2. Starting point and duration of warranty period.
9.4.6.3. Summary of maintenance procedures required to continue the warranty in force.

9.4.6.4. Cross-reference to specific pertinent Operation and Maintenance manuals (if applicable).

9.4.7. The Contractor shall furnish a list of any special tools necessary for each piping system and appurtenances furnished for adjustment, operation, maintenance and disassembly of the system.

9.4.8. Supplier shall submit classroom and field instructions in the operation and maintenance of systems equipment where required by the technical provisions. These services shall be directed by the Supplier, using the manufacturer's factory-trained personnel or qualified representatives. Contracting Officer shall be given 7 days written notice of scheduled instructional services. Instructional materials belonging to the manufacturer or vendor, such as lists, static exhibits, and visual aids, shall be made available to the Contracting Officer.

-- END --

ATTACHMENT #1

WSI 25-SW-0003.B "Confined Space Entry Program"

White Sands Test Facility
Standard Instruction

WSI: 25-SW-0003.B
Issued: 3/8/02

Confined Space Entry Program

1. PURPOSE

The purpose of this WSI is to prepare for use and control access into areas designated as a confined space.

This WSI applies to all WSTF employees. It provides hazard awareness, safety requirements, and identifies the responsibility of the immediate supervisor, entry supervisor, entrants, attendants and contractors. This WSI describes the measures necessary to:

a. Prevent unauthorized entry into permit-required confined spaces

b. Identify and evaluate permit space hazards

c. Implement the means, procedures, and practices necessary for safe entry operations.

2. REFERENCES

a. Occupational Safety and Health Administration (OSHA) 29 CFR 1910.146, "Permit-Required Confined Spaces"

b. JPG 1700.1, Chapter 310, "Entering Confined Spaces"

3. ATTACHMENTS

a. WSTF Confined Spaces

b. Confined Space Identification Placard

c. WSTF Form 503 (Sample), “Confined Space Entry Permit” (located on S:\Forms\WSTF Forms)

d. Confined Space Decision Making Chart

4. DEFINITIONS

a. *Acceptable Entry Conditions* – The conditions that must exist in a permit space to allow entry and to ensure that employees involved with a permit-required confined space entry can safely enter into and work within the space.

b. *Attendant* – An individual stationed outside a confined space that is responsible for monitoring entrants and performing assigned confined space entry duties. This person also knows the location of the fire extinguishers and safety showers. Information, such as the building number, floor number, and department name, must be known prior to the admission of any person in the confined space. In the event the location is outside, the attendant needs to accurately identify the location to rescue and emergency personnel.

c. *Authorized Entrant* – An individual that is authorized, by virtue of training and demonstrated competency, to enter a specific confined space.

d. *Confined Space* – Any space not intended for continuous occupancy that has limited means of access and egress and that is large enough and so configured that an employee can bodily enter and perform assigned work. Confined spaces include, but are not limited to, storage tanks, process vessels, pits, silos, vats, degreasers, reaction vessels, boilers, ventilation and exhaust ducts, sewers, tunnels, underground utility vaults, and pipelines.

e. *Confined Space Pre-Entry Checklist and Permit* – WSTF Form 503, completed and signed by an authorized entrant, attendant and supervisor prior to entering a confined space, that verifies appropriate safety precautions have been completed.

f. *Emergency* – Any occurrence (including any failure of hazard control or monitoring equipment) or event internal or external to the permit space that could endanger entrants.

g. *Engulfment* – The surrounding and effective capture of a person by a liquid or finely divided (flowable) solid substance that can be aspirated to cause death by filling or plugging the respiratory system or that can exert enough force on the body to cause death by strangulation, constriction or crushing.

h. *Entry* – The action by which a person passes through an opening into a permit-required confined space. Entry includes ensuing work activities in that space and is considered to have occurred as soon as any part of the entrant's body breaks the plane of an opening into the space.

i. *Entry Permit* – WSTF Form 503 used with the work authorizing document

j. *Entry Supervisor* – An individual that is responsible for determining if acceptable entry conditions are present at a confined space where entry is planned, authorizing entry, overseeing entry operations, and terminating entry.

k. *Hazardous Atmosphere* – Atmosphere that may expose employees to risk of death, incapacitation, impairment of ability to perform self-rescues (that is, not able to exit the permitted space unaided), injury, or acute illness. The following criteria defines a hazardous atmosphere:

(1) O_2 < 19.5 percent

(2) O_2 > 23.5 percent

(3) Flammable > 10 percent lower flammability limit

(4) Any substance above its Permissible Exposure Limit or Threshold Limit Value which ever is lower. An atmosphere that contains a substance at a concentration exceeding a permissible exposure limit intended solely to prevent long-term adverse health effects is not considered to be a hazardous atmosphere on that basis alone. Therefore, if the atmosphere is above the PEL, then it would not automatically be classified as a "hazardous atmosphere."

(5) Any other atmospheric condition that is immediately dangerous to life or health (IDLH)

l. *Hot Work* – Any work involving fire producing operations as well as work that produces a source of ignition such as filing, abrasive blasting, riveting, welding, cutting, burning, space heating, and brazing.

m. *Non-permit Confined Space* – A confined space that does not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm.

n. *Permit-required Confined Space* – A confined space that has one or more of the following characteristics:

(1) Contains or has the potential to contain a hazardous atmosphere

(2) Contains a material that has the potential for engulfing an entrant

(3) Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section

(4) Contains any other recognized serious safety or health hazard

5. INSTRUCTIONS

a. Equipment. The following is a list of equipment that may be necessary for safe entry and exit of the confined space:

(1) Hard hats, safety shoes, safety glasses, and ear protection
(2) Ladder, respirator, lock, key, multiple-lock hasp, tags, lights, barriers, and fire extinguishers
(3) Portable radios
(4) Harness, lifelines, tripod and winch
(5) Atmospheric testing and monitoring equipment capable of testing for oxygen content, flammability or LEL, and various toxic substances. It is recommended that a MSA Passport be used for oxygen and lower flammability limit testing. Fuel and oxidizer interscans will be used if hypergolic propellants are expected to be present. If other contaminants are expected, consult with the industrial hygienist before selecting monitoring sensors or equipment.
(6) Ventilating equipment needed to obtain acceptable entry conditions
(7) Communication equipment necessary to maintain contact with the attendant

b. Safety

(1) Entry Supervisor/Team Leader Responsibility

Ensure department/team employees are aware of the location of confined spaces in their area for control purposes.

(2) Entry Supervisor Responsibilities

(a) Provide necessary confined space equipment

(b) Confirm all employees and contractors involved in confined space entry are properly trained and physically able to perform confined space entry

(c) Ensure that confined space entry procedures are followed

(d) Ensure that all special equipment is appropriate for the confined space

(e) Ensure that all personal protective equipment is appropriate for the confined space. Employees shall be trained and certified in their use.

(f) Authorize all confined space entries

(g) Ensure adequate atmospheric testing and monitoring is performed for the duration of confined space entry. Ensure the atmospheric testing and monitoring results are documented on the permit. This will be done at a minimum of once an hour for spaces that remain permit required spaces.

(h) Review hazards with attendants and entrants

(i) Ensure that communications are maintained (i.e. telephone, radios, etc.) with the attendant for entry into confined spaces.

(j) Revoke the permit whenever any tests performed during the confined space occupancy or condition change, which show deviation from acceptable conditions to a hazardous condition.

(3) Attendants/Entrants General Responsibilities

(a) Recognize the effects of exposure to hazards reasonably expected to be present

(b) Recognize early behavioral signs of intoxication caused by contaminants whose presence could be anticipated in the space

(c) Recognize possible regenerated hazards emitting from the work in progress

(d) Ensure that all special equipment is appropriate for the confined space

(e) Ensure adequate atmospheric testing and monitoring is performed prior to entry and for the duration of confined space entry. Document the atmospheric testing and monitoring results on the permit. This will be done at a minimum of once an hour for spaces that remain permit required spaces.

(f) Revoke the permit whenever any tests performed during the confined space occupancy or conditions change, which show deviation from acceptable conditions to a hazardous condition

(g) Recognize hazards external to the confined space (e.g., vehicles, painting, fires, spills, etc.) that may affect confined space

(h) Attendants and entrants shall maintain continuous communication at all times.

(i) The attendant will remain at post while entrants remain in confined spaces.

(j) Order entrants to immediately vacate the space if a hazard exists

(k) Prevent non-authorized entrants from entering confined spaces and advise the entrants of entry by non-authorized entrants

(l) The only time the attendant is permitted to leave the job site with workers inside the confined space is to report an emergency.

(m) At no time will the attendant enter the confined space.

(n) If a worker in the space becomes ill or injured, the attendant is to call for emergency assistance

c. Training

Confined Space training and qualification is provided by the Program Assurance Department (PAD) in accordance with WSP 18-0001, "Training." Confined space categories and personnel requiring training are

(1) Confined Space Entry SAF-06 - Required by all personnel that perform confined space entry functions. This includes entrants, attendants, supervisors, and rescue personnel.

(2) Confined Space Entry (Air Monitoring) SAF-07A - Supplemental training for individuals performing air sampling activities associated with confined space entry. This includes air monitors, rescue personnel, and attendants or supervisors that perform air monitoring functions.

(3) Confined Space Rescue ES-06 - Specialized training for Fire Department personnel performing rescue operations associated with confined space entry. This includes rescue personnel.

d. Types of Confined Spaces

There are two types of confined spaces at WSTF; non-permit and permit spaces. All spaces are considered to be permit-required confined spaces until the results of hazard assessment (Attachment C) and initial atmospheric sampling is completed. Use the Confined Space Decision Making Chart found in Attachment D to determine what type of confined space you are trying to enter. If the space is determined to be a non-permit confined space, annotate it on the WSTF Form 503 and cancel the permit.

(1) No confined space at WSTF will be entered prior to atmospheric sampling.

(2) Non-permit spaces are confined spaces where hazard assessment and atmospheric sampling confirms that there are no hazards or potential hazards capable of causing death or serious harm. WSTF Form 503 (Attachment C) will be completed prior to entering these spaces.

(3) Permit spaces meet the definition of permit required confined space. Permit spaces require completion of a WSTF Form 503 (Attachment C) prior to entry.

(4) All confined spaces at WSTF will be identified using the placard identified in Attachment B.

e. Planning the Entry

The first step towards conducting a safe confined-space entry is to plan the entry. This will allow for the identification of all hazards, and for the determination of all equipment necessary, to complete the project. The following steps must be accomplished:

(1) Identify the confined space. Identify the contents of the confined space. This refers to any chemicals or other materials and energy that are usually present in the confined space.

(2) The entry supervisor will determine the oxygen content and describe the testing procedures and equipment used. The entry supervisor or designated and trained person will conduct atmospheric testing.

(3) Mechanical or natural ventilation may be used to ventilate the confined space. If mechanical ventilation is to be used, the exhaust must be pointed away from personnel or ignition sources. Mechanical ventilators must be bonded (grounded) to the confined space.

(4) Isolation of the Confined Space must be assured. All mechanical, electrical, inert gas (GN2, helium, etc.) sources or heat-producing equipment will be evaluated for potential hazards and disconnected or locked and tagged out if not specifically required to facilitate entry activities. Isolation would also include any pumps that pull fluid from or pump fluid into the confined space.

(5) Purging/Cleaning of the confined space with inert gas is not recommended except where an air purge may create an explosive environment. If a flammable atmosphere is present that would constitute an explosive hazard if additional air/oxygen is added, then an inert gas purge is acceptable provided sufficient air exchanges are conducted to increase oxygen content to an acceptable level prior to entry.

(6) Warning signs or barriers must be used to prevent unauthorized entry and to protect workers from external hazards. If the confined space will be left open and unattended for any length of time, warning signs and barriers are required.

(7) Identify all personnel that will be required to prepare the confined space and complete the work inside the space.

(8) Identify the necessary equipment needed for a safe entry and exit of the space.

f. Pre-Entry Briefing

Once the entry has been planned, designated supervisors must brief all employees who will be involved in the entry. The following briefing will be completed prior to entry:

(1) Identify the confined space and the reason(s) for entry

(2) Identify the work team

(3) Inform entrants of all known or suspected hazards

(4) Identify isolation procedures

(5) Identify purging and/or ventilation procedures

(6) Identify all equipment needed

(7) Determine necessary personal protective equipment

(8) Brief on the communication procedures that will be followed during this task

(9) Protection from external hazards

(10) Pre-plan rescue procedures

(11) Tasks required to place the confined space back into service

g. Preparing the Confined Space For Entry

Once the entry has been planned and personnel have been trained, the next step is to prepare the confined space for entry. The following steps are to be followed when preparing the confined space for entry:

(1) If warning signs or barriers are to be used to prevent unauthorized entry or to protect entrants from external hazards, they shall be placed on or around the confined space as planned and discussed in training.

(2) Place all tools, safety equipment, monitoring equipment, etc., near the confined space.

(3) Isolate and use Lockout/Tagout on all mechanical hazards and electrical hazards or inert gas sources as planned and discussed in the pre-entry briefing.

(4) Purge/ventilate the confined space as planned and discussed in pre-entry briefing. A constant source of fresh air, introduced in such a manner as to ensure a complete air change (positioning of fresh air duct to ensure the entire space is ventilated), shall be provided (i.e., air blowers, fans, etc).

(5) The entry supervisor will test the atmosphere as discussed in training. If the oxygen content is between 19.5 percent and 23.5 percent, continue entry preparation. If oxygen content is less than 19.5 percent or greater than 23.5 percent, perform additional ventilation. Then, shut off ventilation equipment and re-test the oxygen content.

(6) The entry supervisor will test for flammable gas level as planned and discussed in training. If the meter reading is less than 10 percent of the lower explosive limit (LEL), continue entry preparations. If the meter reading is above 10 percent of the LEL, continue ventilation of the confined space and re-test after one hour.

(7) The entry supervisor will determine the toxicity of the atmosphere. If a toxic atmosphere is present, no person should be permitted to enter. The site Health, Safety and Environmental representatives should be called to assist in identifying proper precautions and the protective measures to be taken.

h. Utilizing Safety Equipment

After all existing hazards within the confined space are mitigated or reduced to acceptable limits, safety equipment is utilized to provide an additional level of protection. Where practical, all personnel entering a confined space should be equipped with a retrieval line secured at one end to the entrant by a full-body harness with its other end secured to a tripod lifting hoist. The following safety related actions must be accomplished prior to and during the entry:

(1) Every person entering a permit-required confined space must wear a harness.

(2) In every tank where entry is through a manhole, or the tank is deeper than a man's shoulders, a lifeline must be attached to the workers.

(3) When a ladder is required to enter a confined space, the ladder must be made secure and must not be removed while anyone is inside.

(4) All electrical equipment to be used inside the confined space must be intrinsically safe, properly grounded, and protected.

i. Records, Reports, and Forms

Forms:

(1) Confined Space Entry Permit (WSTF Form 503) must be submitted to the Safety Office upon completion of the confined space entry (for all spaces that remain permit-required spaces). It is the entry supervisor's responsibility to complete this form in its entirety. Confined Space permits are effective for 8 hours, or until any of the entrants, entry supervisor, or attendants, not listed on the original entry permit, are replaced.

(2) One copy will be posted at the main entrance or most commonly used access to the permit-required confined space.

(3) One copy will be retained for the Safety Department files.

6. RESCISSIONS

None.

Original signed by:

David T. Loyd
Chief, Quality Assurance, Reliability,
and Safety Office

Attachment A Issued: 3/8/02

Attachment A:
WSTF Confined Spaces

A list of WSTF areas/enclosures have been identified by QARSO/PAD for confined space entry controls. Other areas may require confined space entry controls, but have not been identified as confined spaces. DESIGNATION AS "PERMIT-REQUIRED CONFINED SPACE" OR "CONFINED SPACE" WILL BE DETERMINED BASED UPON THE RESULTS OF HAZARD ASSESSMENT AND AIR MONITORING.

1. All altitude system vacuum and steam ducting from the test stand to the steam source or the discharge end of the ejector
2. All storage tanks and pressure vessels meeting the definition of a confined space hazards
3. Hazardous drain line pits
4. Valve pits
5. Test Stands (altitude chambers) 302, 303, 401, 403, and 405 do not meet the definition of confined spaces. These chambers will be treated as hazardous atmosphere and require written procedures for the first entry of the day and after each exposure to a hazardous atmosphere. Approval by a safety professional must be obtained before the procedures are modified or used for entry.
6. Hypervelocity impact chambers (target and expansion chambers). Entries following multiple shots may use the same entry permit for logging the atmospheric testing results. A new permit is required for each day entry is made.
7. Flammability chambers in cells 101 and 108. The chamber in cell 101 has been monitored sufficiently to ensure that ventilation removes all possible hazardous atmospheres and requires only entry instructions (no permit). Entries following multiple tests may use the same entry permit for logging the atmospheric testing results. A new permit is required for each day entry is made.
8. Sewage system manholes
9. Oil separator pits
10. Areas 300 and 400 altitude system boilers (drums and combustion chambers)
11. Ceiling crawl spaces with GN2 piping present
12. Communication manholes
13. HVAC system confined spaces
14. Well Vaults

Attachment B Issued: 3/8/02

Attachment B:
Confined Space Identification Placard

Attachment C Issued: 3/8/02

Attachment C:
WSTF Form 503 (Sample) -Confined Space Entry Permit

CONFINED SPACE ENTRY PERMIT

Site Location and Description:	
Work Authorizing Document:	
Entry Supervisor:	
Date & Time Issued:	
Date & Time of Expiration:	

CONFINED SPACE CLASSIFICATION DETERMINATION

If all three (3) items below are marked yes, the space is considered to be a confined space

Any items marked yes in this column makes the space a permit-required confined space unless the hazard has been removed

Can be bodily entered?	☐ Yes	☐ No		Hazardous atmosphere?	☐ Yes	☐ No
Limited access?	☐ Yes	☐ No		Potential for engulfment?	☐ Yes	☐ No
Not designed for continuous human occupancy?	☐ Yes	☐ No		Internal configuration hazard?	☐ Yes	☐ No
				Other serious safety hazard?	☐ Yes	☐ No

TESTS PERFORMED FOR ATMOSPHERIC HAZARDS

RESULTS

Oxygen content > 19.5% and < 23.5% _____

Flammable gas/vapor levels 10%LEL _____

Toxic air contaminant levels _____

CLASSIFICATION Based on the results of atmospheric tests and the hazard analysis

☐ Permit-Required Space

☐ Non-Permitted Space

If the space is classified as a non-permit space, stop here and sign the bottom of the form.

For permit required space, complete the permit.

Authorized Entrants:	1)	**Time In:**	3)	**Time In:**
	2)	**Time In:**	4)	**Time In:**
Attendants:				
Entry Supervisor:				

Hazards of permit space to be entered:

☐ Limited Exits
☐ Lack of Natural Ventilation
☐ Oxygen Deficient Atmosphere
☐ Oxygen Rich Atmosphere
☐ Airborne Combustible Dust
☐ Toxic Gas, Vapor, or Mist
☐ Jobs that may provide a source of heat (i.e., welding, riveting, cutting, turning, and heating)
☐ Other _____

Attachment C Issued: 3/8/02

Source Isolation Requirements:

Requirements	Completed	DATE	TIME
Lockout/De-energize/Tag-out			
Line(s) Broken-Capped-Blanked			
Purge-Flush and Vent			
Ventilation			
Secure Area (Post and Flag)			

NOTE: Items that do not apply enter N/A in the blank.

Acceptable Entry Conditions: _____

Results of Monitoring:

RECORD CONTINUOUS MONITORING RESULTS AND TIME EVERY _____ HR/MIN

TEST(S) TO BE TAKEN	RESULTS						
	Next Reading Time:	Next Reading Time:	Next Reading Time:	Next Reading Time:	Next Reading Time:	Next Reading Time:	Next Reading Time:
% of Oxygen > 19.5% < 23.5%							
LEL under 10%							
Toxic Gases							

Signature of Tester: _____

EMERGENCY RESCUE PROCEDURES: DIAL EXTENSION 5911 IN CASE OF EMERGENCIES

☐ Notify Fire Department of planned confined space entry

Communication Processes:

☐ Visual ☐ Voice ☐ Radio ☐ Other _____

Equipment Required:

☐ Direct Reading Gas Monitor - Tested
☐ Lifelines
☐ Explosion Proof Lighting
☐ Respiratory Protection
☐ Special Tools
☐ Communication Equipment
☐ Full Body Harness
☐ Protective Clothing
☐ Hoisting Equipment
☐ Fire Extinguishers
☐ Ankle Harness

Other Information/Specific Requirements: _____

Work authorized by this permit and the information contained here-in has been reviewed. Written instructions and the safety procedures have been received and are understood. This permit is not valid unless all appropriate items are completed.

Permit and Checklist Prepared by: _____

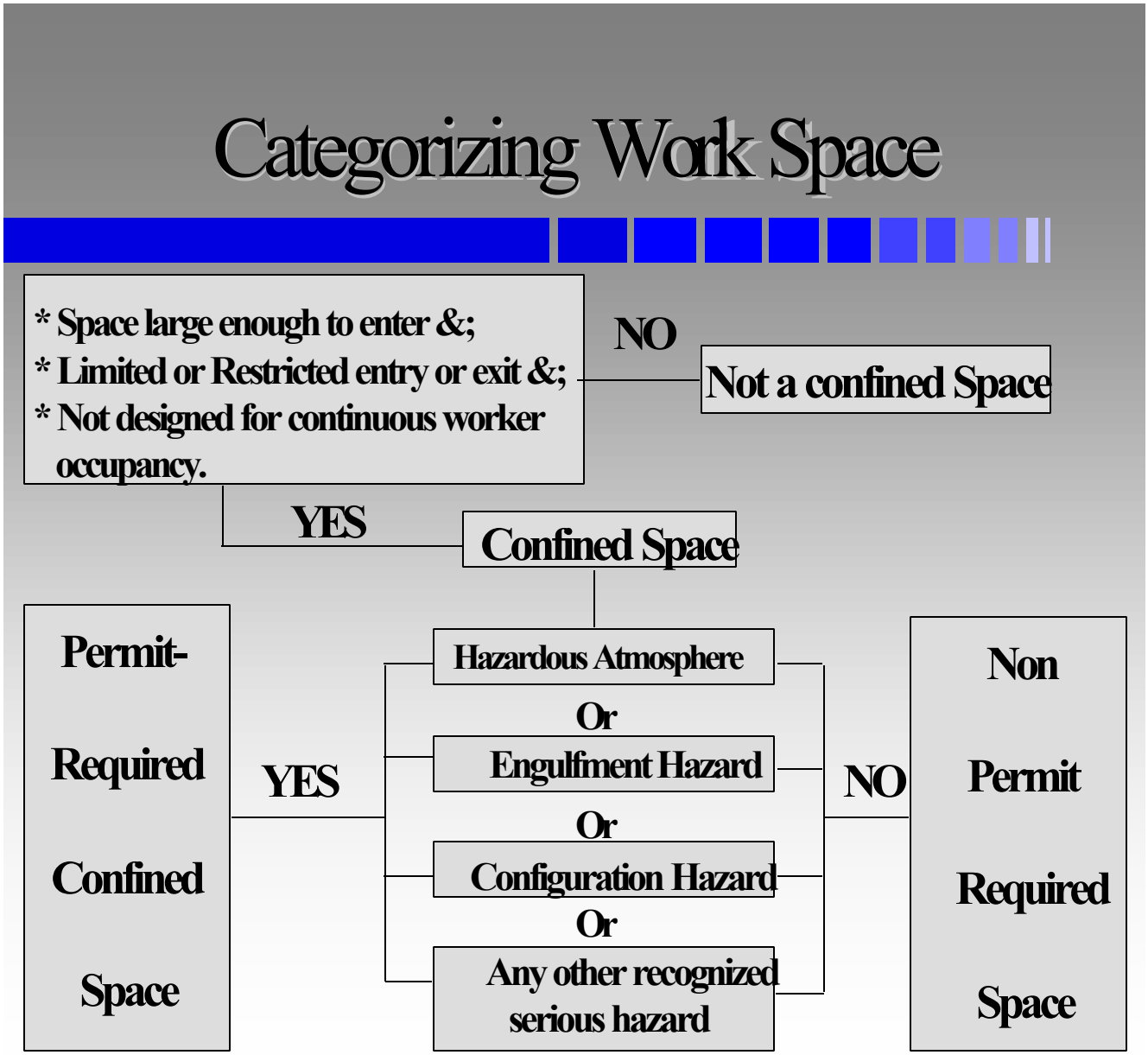
Approved by: (Entry Supervisor) _____

THIS PERMIT MUST BE KEPT POSTED AT THE JOB SITE AND KEPT ON FILE FOLLOWING JOB COMPLETION

WSTF Form 503 (2/02)

Attachment D Issued: 3/8/02

Attachment D:
Confined Space Decision Making Chart



ATTACHMENT #2

WSI 25-SW-0013.C

Hot Work Permit for Welding-Cutting Operations

White Sands Test Facility Standard Instruction

WSI: 25-SW-0013.C
Issued: 8/27/01

Hot Work Permit for Welding-Cutting Operations

1. PURPOSE

   The purpose of this WSI is to establish requirements for prevention of fires caused by welding, cutting, or open flame and spark producing operations performed outside the designed shop areas at WSTF.

2. REFERENCES

   a. 29 CFR 1910.252, Subpart Q, "Welding, Cutting, and Brazing"

   b. 29 CFR 1910.119, "Process Safety Management of Highly Hazardous Chemicals"

   c. NFPA 51B, "Standard for Fire Prevention in Use of Cutting and Welding Processes"

3. DEFINITION

   a. *Hot Work* – Work involving electric or gas welding, cutting, brazing, or similar flame or spark-producing operations.

   b. *Designated Shop Areas* – Areas on site that are set aside for the specific purpose of welding. These areas include building 113 weld shop and temporary locations on site that have been inspected for fire hazards and approved by the fire department as temporary weld shops.

4. INSTRUCTIONS

   a. A hot work permit will be completed before starting any open flame soldering, brazing, welding (gas or arc), or any other open flame or spark-producing operation (including grinding) performed outside the designed shop areas at WSTF.

   b. The individual responsible for hot work operations (test conductor, project engineer, etc.) will initiate the hot work permit (WSTF Form 418) and notify the Fire Department.

c. The job site will be physically inspected and the hot work permit signed (approved) by a WSTF Fire Department representative prior to beginning the operation.

d. The WSTF Fire Department will be notified at the beginning and at the completion of the hot work.

e. To prevent inadvertent fire alarm during hot work, the test conductor/project engineer will cover/deactivate detectors at the beginning of the workday and uncover/activate at the end of each workday. The test conductor/project engineer will notify the fire department, respective blockhouse monitor, and/or area HSE Facility Manager prior to installation and removal of covers.

f. A copy of the hot work permit will be posted at the job site, a copy retained by the fire department and a copy kept with the work authorizing document until the hot work is completed.

g. Off-site contractors working on site will comply with the requirements of this instruction.

h. Welding, cutting, or other hot work will not be performed on drums or vessels until the container has been cleaned so thoroughly as to make absolutely certain there are no flammable materials present.

i. Operations in areas complying with the process safety management of highly hazardous chemicals standard (Process Safety Management (PSM) of Highly Hazardous Chemicals) will require a hot work permit for hot work operations on or near a process covered by PSM to include spark-producing operations such as grinding and disc sanding.

j. Welders, cutters, and their supervisors will be trained in the safe operations of their equipment, to include fire prevention and protection requirements in 29 CFR 1910.252(a).

k. The hot work permit will contain the following information:

(1) Date authorized for hot work to be performed

(2) Description or identity of object on which hot work is to be performed

(3) Identification of openings, cracks, and holes through which sparks may drop or fly into combustible materials

(4) The type of fire extinguisher required to handle any emergency

(5) Assignment of fire watchers when welding is performed in locations where other than a minor fire might develop

(6) Precautions when welding on components (e.g., steel members, pipes, etc.) that could transmit heat by radiation or conduction to unobserved combustibles

(7) Special precautions to be observed when welding, cutting, or brazing around test articles, flight equipment, or critical support hardware

(8) Signature of employee responsible for cutting and welding operations or, the engineer in charge of the project

(9) Signature of a fire department representative

5. RESCISSIONS

This WSI replaces WSI 23-SW-0001.A, same title, which originally replaced WPD 23-03, Attachment 10, "Hazardous Operation Permit for Welding, Brazing, Soldering, or Open Flame Operations."

Original signed by:

David T. Loyd
Chief, Quality Assurance,
Reliability, and Safety Office

ATTACHMENT #3

Contract Drawing Package
(refer to Government supplied CD)

NASA – JOHNSON SPACE CENTER

WHITE SANDS TEST FACILITY

GROUND WATER TREATMENT SYSTEM FOR

PLUME-FRONT STABILIZATION

SUBGRADE PIPING SYSTEM
STATEMENT OF WORK
Revised SEPTEMBER 6, 2001

TABLE OF CONTENTS

I. Scope……..…….… 1

II. General…….……..…..… 3

III. Material – Piping System …….…… 4

IV. Material – Leak Detection and Electrical……..… 14

V. Schedule……..…….…….… 16

VI. Earthwork…….……..... 18

VII. Installation - Piping System ...…….. 23

VIII. Installation – Leak Detection and Electrical……. 27

IX. Testing – Piping System and Leak Detection...…… 28

X. Final Cleaning...…… 31

XI. Certification and Warranty...…… 32

XII. Submittals……. 32

LIST OF ATTACHMENTS

Attachment 1 Contract Drawings

Basic System (Drawing Number, Title)

652-C-01, Project Location
652-I-04, Index (Symbols and Abbreviations)
652-C-02, Well Locations and Piping Layout
652-C-03, Civil, Plan and Profile Piping Route (N-1)
652-C-04, Civil, Plan and Profile Piping Route (N-2)
652-C-05, Civil, Plan and Profile Piping Route (N-3)
652-C-06, Civil, Plan and Profile Piping Route (N-4)
652-C-07, Civil, Plan and Profile Piping Route (N-5)
652-C-08, Civil, Plan and Profile Piping Route (S-1)
652-C-09, Civil, Plan and Profile Piping Route (S-2)
652-C-10, Civil, Plan and Profile Piping Route (S-3)
652-C-11, Civil, Plan and Profile Piping Route (S-4)
652-C-12, Civil, Plan and Profile Piping Route (S-5)
652-C-13, Civil, Plan and Profile Piping Route (PFE-2)

652-C-15, Civil, Plan and Profile Piping Route (PFE-4B)
652-C-16, Civil, Plan and Profile Piping Route (PFE-5)
652-C-17, Civil, Plan and Profile Piping Route (PFI-1A)
652-C-18, Civil, Plan and Profile Piping Route (PFI-1B)
652-C-19, Civil, Plan and Profile Piping Route (PFI-4)

652-C-25, Civil, Sections
652-C-26, Civil, Sections
652-C-27, Civil, Sections
652-C-28, Civil, Junction Details
652-C-29, Civil, Junction Details
652-C-30, Civil, Junction Details
652-C-31, Civil, Sections and Details
652-C-32, Civil, Sections and Details
652-C-33, Civil, Sections and Details
652-C-34, Civil, Sections and Details
652-C-35, Civil, Sections and Details
652-C-36, Civil, Sections and Details
652-C-37, Civil, Sections and Details652-M-01, Mechanical, Flow Schematic, Extraction Wells
652-M-03, Mechanical, Flow Schematic, Injection Wells
652-M-04, Mechanical, Subgrade Pipe & Fitting Schedules
652-M-05, Mechanical, Subgrade Pipe & Fitting Schedules
Conduit, Electrical Conduit Layout Sketch
Control, Survey Control Sketch

Extraction Well PFE-1:
653-C-01, Civil, Site/Utilities Plan
653-M-01, Mechanical, Piping and Equipment Layout
Extraction Well PFE-2:
654-C-01, Civil, Site/Utilities Plan
654-M-01, Mechanical, Piping and Equipment Layout
Extraction Well PFE-3:
655-C-01, Civil, Site/Utilities Plan
655-M-01, Mechanical, Piping and Equipment Layout
Extraction Well PFE-5:
657-C-01, Civil, Site/Utilities Plan
657-M-01, Mechanical, Piping and Equipment Layout
Injection Well PFI-1:
660-M-01, Mechanical, Piping and Equipment Layout
Injection Well PFI-2:
661-M-01, Mechanical, Piping and Equipment Layout
Injection Well PFI-3:
662-M-01, Mechanical, Piping and Equipment Layout
Injection Well PFI-4:
663-M-01, Mechanical, Piping and Equipment Layout

Phase 1 (Drawing Number, Title)
Extraction Well PFE-4A:
652-C-14, Civil, Plan and Profile Piping Route (PFE-4A)
652-C-15, Civil, Plan and Profile Piping Route (PFE-4B)
656-C-01, Civil, Site/Utilities Plan
656-C-02, Civil, Details at Wellhead
656-M-01, Mechanical, Piping and Equipment Layout

Phase 2 (Drawing Number, Title)
Extraction Well PFE-7:
652-C-20, Civil, Plan and Profile Piping Route (PFE-7A)
652-C-21, Civil, Plan and Profile Piping Route (PFE-7B)
652-C-22, Civil, Plan and Profile Piping Route (PFE-7C)
652-C-23, Civil, Plan and Profile Piping Route (PFE-7D)
652-C-24, Civil, Plan and Profile Piping Route (PFE-7E)
658-C-01, Civil, Site/Utilities Plan
658-C-02, Civil, Details at Wellhead
658-M-01, Mechanical, Piping and Equipment Layout

Attachment 2 **References**

Attachment 3 **JSC Form 262**

I. Scope

This statement of work defines the requirements for materials, installation and testing of the NASA White Sands Test Facility's (WSTF) groundwater treatment facility subgrade piping system. Once the piping system is installed, groundwater containing parts-per-billion (ppb) concentrations of hazardous constituents will be pumped through dual-containment high density polyethylene (HDPE) piping from extraction wells to a treatment facility. After treatment, single-wall HDPE piping will be used to transfer the treated groundwater from the treatment facility to injection wells.

Maps of WSTF's location and the project location with respect to WSTF's developed areas are presented in Attachment 1. WSTF is located 18 miles northeast of Las Cruces, New Mexico (65 miles north of El Paso, Texas) with access provided through U. S. Highway 70. The project is located in an unimproved area of Sections 4 and 5 of T21S, R3E and Section 32 of T20S, R3E (see Attachment 1). Access to the general project vicinity is provided by a light duty gravel road (the WSTF Well Road).

A. The **Basic System** includes the materials, installation and testing of a subgrade HDPE piping system consisting of:

1. Approximately 10,250 feet of HDPE dual-containment pipe (pipe diameters ranging from 2-inch X 4-inch [nominal inner diameter X nominal outer diameter] to 10-inch X 16-inch) and approximately 7,600 feet of HDPE single-wall pipe (nominal pipe sizes ranging from 6- to 10-inch), installed in approximately 14,250 feet of excavated trench. Plan and profile drawings and piping system subgrade details are presented in Attachment 1.

2. Thirty-one (31) high-point vent, junction and leak detection access vaults and associated piping system components (flanges, valves, fittings, etc.). The locations of the access vaults, piping system civil sections and details including piping system components (flanges, valves, fittings, etc.) at each access vault location are presented in Attachment 1.

3. A leak detection system for 10,250 feet of dual-containment pipe as shown in Attachment 1. Leak detection access locations are presented in Attachment 1.

4. Approximately 18,000 feet of electrical conduit (conduit sizes ranging from 1-inch to 2-inch) and associated pull boxes.

B. **Phase 1** entails installation a wellhead vault and a piping system consisting of:

1. Approximately 1,550 feet of 5-inch X 8-inch sub-grade HDPE dual-containment pipe.

2. Three high-point vent, junction and leak detection access vaults and associated piping system components (flanges, fittings, etc.).

3. A leak detection system for approximately 1,550 feet of dual-containment pipe.

4. An electrical system consisting of approximately 1,550 feet of electrical conduit and pull boxes.

5. One pre-cast concrete vault at extraction well PFE-4A.

C. **Phase 2** entails installation a wellhead vault and a piping system consisting of:

1. Approximately 3,950 feet of sub-grade HDPE dual-containment pipe.

2. Ten high-point vent, junction and leak detection access vaults and associated piping system components (flanges, valves, fittings, etc.).

3. A leak detection system for approximately 3,950 feet of dual-containment pipe.

4. An electrical system consisting of approximately 3,950 feet of electrical conduit and pull boxes.

5. One pre-cast concrete vault at extraction well PFE-7.

Construction services to be provided for the basic system and the two options include:

1. Excavation;
2. Installation of pipe, vaults, leak detection system, electrical conduit, and associated components;
3. Leak testing of the pipe;
4. Backfilling and compaction; and
5. Providing as-built drawing changes.

II. General

A. Security Provisions

The Contractor is required to submit the names and citizenship for all personnel scheduled to be on site to the Contracting Officer prior to their arrival at WSTF. At least 30 days must be allowed to obtain clearance for crew members who are not United States Citizens. Temporary badges for the project will be issued at the WSTF main gate.

Contractor personnel will be restricted to the work area and will not be allowed to venture, unescorted, to other areas of the site. Contractor work hours at WSTF shall not exceed 60 hours per week for any Contractor personnel.

B. Health And Safety Provisions

At least one Class B/C CO_2 fire extinguisher is required within each vehicle at the work site during all operations at WSTF. Level D personal protective equipment will be worn by Contractor personnel:

1. Hard hats in accordance with ANSI Z89.1
2. Steel toed boots in accordance with ANSI Z41
3. Safety glasses in accordance with ANSI Z87.1
4. Work gloves while handling equipment
5. Hearing protection if noise levels exceed 80 dbA (when vocal communication between persons standing three feet apart requires shouting).

The Government reserves the option to visually inspect equipment prior to the commencement of work. Any significant health or safety concerns will be identified and the Contractor will be allowed to address the concerns. If significant concerns cannot be rectified, this may be cause for termination of the contract.

Contractor shall comply with all applicable WSTF safety regulations. All Contractor personnel shall receive two safety briefings immediately following their arrival at WSTF. A site safety briefing will be given at the WSTF Safety Office prior to access to the work area. A second safety briefing will be given at the WSTF Environmental Department that addresses any specific concerns relative to the project area.

Contractor shall comply with all procedures prescribed for the control of persons visiting the project site. The Contractor shall advise the Contracting Officer or designee of any special safety restrictions established so that on-site personnel can be notified.

Contractor employees must utilize the WSTF dispensary facilities located in Building 104 for injury and emergency medical treatment. The dispensary number is 524-5212 and the on site emergency numbers are 5911 or 5111.

Contractor shall comply with OSHA Regulation 29 CFR 1926.51 regarding all sanitation facilities. Contractor shall be responsible for the cleaning/servicing and waste disposal for portable chemical toilet(s).

C. Environmental Concerns

1. Discharge of water used for flushing or pressure testing must be coordinated in advance with the Contracting Officer.
2. Any ground disturbing activities performed at WSTF, including trenching, grading, and excavation, must be coordinated in advance with the Contracting Officer. Dig permits will be issued by the Government prior to commencement of excavation.
3. Contractor shall be responsible for supplying fuel and fuel transfer/transport equipment used during completion of the project. The Contractor may locate a portable or truck mounted fuel tank at or near the work site, so long as Government-approved spill containment measures are taken (a spill containment volume of no less than 110% of the tank volume is required). Alternatively, a fuel storage tank may be located in a secure compound at the WSTF 100 Area warehouse, again with approved spill containment. Contractor is responsible for clean-up and disposal, in accordance with applicable regulations, of overfillings or spills related to temporary fueling equipment.
4. Oil changing of vehicles will not be allowed at the work site, but may only be performed in approved areas at WSTF. The Government can supply empty storage drums for used oil and can also handle oil disposal, if needed.

D. Cultural Resources

1. At any time during construction that archeological, rare, historical, or paleontological discoveries are made, the Contractor will immediately cease operations and notify the Contracting Officer. Construction will not be resumed until authorized by the Contracting Officer.

III. Material – Piping System

A. Pipe Manufacturer Qualifications

The manufacturer shall have a minimum of eight (8) years of continuous corporate experience in the manufacture and supply of large-scale single-and dual-containment HDPE piping systems.

B. General Requirements

1. All piping materials and appurtenances shall be as specified, or equivalent, and as shown on the contract drawings, or equivalent, and shall be suitable

for the service intended. The contract drawings are presented in Attachment 1.

2. Applicable standards of the American National Standards Institute (ANSI), American Water Works Association (AWWA), National Association of Corrosion Engineers (NACE), American Society for Testing and Materials (ASTM), Illuminating Engineering Society (IES), National Electrical Manufacturers Association (NEMA), National Fire Protection Association (NFPA), National Electrical Code (NEC), National Electrical Safety Code (NESC) and the Underwriters' Laboratories (UL) reflect current industry standard practice and must be used for establishing the quality of materials and equipment.

3. Piping materials, appurtenances and equipment supplied as part of this contract shall be new and unused except for testing equipment. Components that serve the same function and are the same size shall be identical products of the same manufacturer. The general materials to be used for the piping systems are indicated by service in the Pipe Schedule in the contract drawings.

4. The absence of pipe supports and details on the contract drawings does not relieve the Contractor of responsibility for sizing and providing pipe supports where appropriate.

5. The Contractor shall provide all structural work and equipment required to control expansion and contraction of piping. The Contractor shall verify that the anchors, guides, and expansion joints provided, adequately protect the piping systems.

6. The pressure ratings and materials specified represent minimum acceptable standards for piping systems. The piping systems shall be suitable for the services specified and intended. Each piping system shall be coordinated to function as a unit. Flanges, valves, fittings and appurtenances shall have a pressure rating no less than that required for the system in which they are installed.

7. Piping equipment and appurtenances shall be new products of equal material and ratings as the connecting pipe.

8. Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacturing of the products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Nominal sizes for standardized products shall be used. Pipe, valves, fittings and appurtenances shall be supportable by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

9. Each piece of pipe shall bear the ASTM designation and all other markings required for that designation. Valves shall bear a securely attached tag with the manufacturer's name, valve model number, and WSTF component identification number permanently engraved on the tag.

C. HDPE Pipe

1. The pipe shall be extruded from polyethylene (PE) per ASTM D 3350.

2. The HDPE pipe shall be manufactured to an SDR rating in accordance with ASTM D 3035 for piping systems less than 4 inches in diameter, or in accordance with ASTM F 714 for piping systems with a diameter equal to or greater than 4 inches.

3. The primary, or carrier pipe, of the double containment piping system shall be either SDR 9 or SDR 11 HDPE, as shown on the contract drawings. The piping shall be free of flanges and other joints that are not compatible with the secondary piping installation. The piping shall be equipped with expansion loops, offsets, or direction changes as necessary to counter thermal expansion and contraction, which shall be coordinated with the secondary piping.

4. The secondary, or containment, pipe of the double containment piping system shall be SDR 21 HDPE. The secondary piping shall be resistant to weathering, impacts, and ambient temperature variations.

5. The single wall pipe, of the injection piping system, shall be SDR 17 HDPE, as shown on the contract drawings.

6. The piping shall be equipped with expansion joints, expansion loops, offsets, or direction changes as necessary to counter thermal expansion and contraction. Equipment for addressing thermal movement shall be coordinated with the primary piping.

7. The secondary piping shall be drainable and dryable. Piping shall be equipped with vents at all high points as shown on the contract drawings.

8. The piping shall be designed to allow pulling of the leak detection cable into the containment pipe both during and after piping installation. Minimum annular clearance shall be 0.75 inches. A 0.25-inch, hollow-braid, polypropylene rope shall be installed between the carrier pipe and containment pipe. Each pull rope shall be continuous, free of tangles and knots, and loose in the pipe (not pinched, glued, or melted in place). Containment pull ports shall be located as shown on the contract drawings (a maximum of 400 feet apart for straight runs and at all 90 degree direction changes).

9. HDPE pipe shall be joined by thermal butt-fusion, socket heat fusion, or socket electrofusion, except where connecting to valves and equipment that may require future disassembly, then joints shall be threaded fittings or flanged.

D. HDPE Fittings

1. HDPE fittings shall be molded. HDPE fittings shall have the same or higher pressure rating as the pipe when installed in accordance with the latest technical specifications.

2. Butt-fusion fittings shall conform to ASTM D 3261.

3. Socket-fusion fittings shall conform to ASTM D 2683 with tools meeting the requirements of ASTM F 1056.

4. Insert fittings shall conform to ASTM D 2609.

5. Couplings and saddle joints shall be joined by electrofusion in accordance with ASTM F 1055.

6. HDPE Flanged Fittings.

   a. Flanges and flanged fittings shall be ASME B16.5 Class 150.

   b. Flanges shall be complete with one-piece, molded PE stub ends.

   c. Flanged connections shall have the same pressure rating as the pipe or greater. Bolting shall be stainless steel Grade B8 hex head bolts and Grade 8 hex head nuts. Bolts shall be provided with washers of the same material as the bolts.

   d. The Contractor shall field check flanges for non-standard bolt hole configurations and shall design as required to assure all flanges mate properly.

   e. Gaskets shall be full-faced, maximum 1/8 inch thick, fabricated from ethylene propylene rubber (EPR) in accordance with ASME B16.21 or as required by the liquid application.

   f. Backing flanges for plastic piping systems may be stainless steel, ductile iron, steel (galvanized or plain), or aluminum, depending on the application.

7. HDPE end seals and other subassemblies shall be designed and factory prefabricated to prevent the ingress of moisture into the system. Subassemblies shall be designed to allow for complete draining of the secondary containment.

E. Metallic Fittings

1. Steel Flanged Fittings

a. The internal diameter bores of flanges and flanged fittings shall be the same as that of the associated pipe.

b. The flanges shall be welding neck slip-on socket welding or lapped type.

c. Flanged fittings shall be forged steel, faced and drilled to ASME B16.5 Class 150 with a 0.0625 inch raised face. Cast steel backing flanges shall be drilled in conformance with ASME B16.5 Class 150.

d. For tie-in to existing flanges, if any, the Contractor shall field check existing flanges for non-standard bolt hole configurations and shall design as required to assure new pipe and flange mate properly.

e. Where mating flange on valves or equipment is cast iron, if any, Grade B8 Class 1 bolts and heavy hex head nuts shall be used. Bolts shall be provided with washers of the same material as the bolts.

f. Gaskets shall meet the requirements of ASME B16.5.

g. All carbon steel piping components shall be coated with corrosion resistant materials.

2. Flanged Coupling Adapters

a. Flanged coupling adapters shall be fully assembled units manufactured to meet ASTM A 126.

b. The flanges shall mate with ASME B16.5 Class 150 flanges of the same nominal size.

c. The coupling shall use compatible gaskets.

d. Where pipe movement out of the adapter may occur, proper anchorage of the pipe shall be provided. The coupling shall be sized to match the associated piping.

F. Valves

1. General Requirements

a. Manual valves shall include operator, actuator, handwheel, extension stem, worm and gear operator, operating nut, wrench, and all other accessories required for a complete operation.

b. The valves shall be suitable for the intended service. Renewable parts are not to be of a lower quality than those specified.

c. Valve ends shall be compatible with adjacent piping system. An operator shall be sized to operate the associated valve for the full range of pressures and velocities.

d. Valves shall open by turning counterclockwise. Operators, actuators, and accessories shall be factory mounted.

e. The sub-grade piping Valve Schedule shall be as indicated in the contract drawings.

2. General Purpose Metallic Ball Valves

a. Ball valves, 2 inches and smaller, shall be end entry type with bronze or brass bodies and threaded, in accordance with ASME B1.20.1, full bore ports. A union shall be installed adjacent to the valves to provide access to the seat.

b. Ball valves, 2.5 inches and larger, shall be end entry type with bronze or cast iron bodies and ASME B16.5 Class 150 flanged ends.

c. Valves shall have polytetrafluoroethylene (PTFE) seats and packing, and a chrome plated or stainless steel ball.

d. The operator shall be a hand lever or square nut, per the contract drawings.

3. Thermoplastic Ball Valves

a. Thermoplastic ball valves shall not exceed 6 inches in size. Thermoplastic ball valves, 6 inches and smaller, shall be rated for 225 psig service at 120 degrees F, and have polyvinyl chloride (PVC) or chlorinated polyvinyl chloride (CPVC) bodies, balls, and stems.

b. Valves shall be end entry, double union design, with threaded or flanged end connections (per the contract drawings), an ethylene propylene diene

monomer (EPDM) seat, and fluoro-elastomer or polytetrafluoroethylene (PTFE) O-ring stem seals.

c. The operator shall be a hand lever or square nut, per the contract drawings.

4. General Service Gate Valves

a. Gate valves, 2 inches and smaller, shall have bronze bodies and stems, screwed or union bronze bonnets, and single solid wedge bronze discs. The stems may be rising or non-rising. Valves shall be rated for 175 psig service. End connections shall be ASME B16.11 threaded. Valves shall be equipped with handwheel operators.

b. Gate valves, 2.5 inches and larger, shall have cast-iron bodies with iron, bronze, or stainless steel trim. Valves have Class 250 flanged end connections. Discs shall be wedge type of iron or bronze construction, and have either rising or non-rising stems. Valves shall be equipped with hand lever or square nut operators, per the contract drawings.

5. Standard Service Butterfly Valves

a. Butterfly valves shall have ASTM A 126 cast iron bodies and ASME B16.6 Class 150 flanged end connections.

b. Discs shall be ductile iron, stainless steel, or polyvinylidene fluoride (PVDF) coated ductile iron.

c. The valve shafts shall be carbon steel or stainless steel with self-lubricating, corrosion-resistant sleeve type bearings.

d. Valve seats for 24 inch and smaller valves shall be attached to either the valve body or the disc.

e. The operator shall be a hand lever or square nut, per the contract drawings.

6. Swing Check Valves

a. Swing check valves, 2 inches and smaller, shall have a cast iron, carbon steel, or stainless steel body, with ASME B16.11 threaded ends. Valves shall be rated for 200 psig service.

b. Swing check valves, 2.5 inches through 12 inches, shall have a cast iron, carbon steel, or stainless steel body, with ASME B16.5 flanged ends. Valves shall be rated for 200 psig service.

7. Ball Check Valves

a. Ball check valves shall be rated for 200 psig service and shall be suitable for vertical or horizontal flow.

b. Ball check valves, 1 inch and larger, shall be as shown on the contract drawings and ASME B16.11 threaded or ASME B16.5 flanged ends and cast iron, carbon steel, or stainless steel bodies with a cleanout and hollow steel ball.

c. Valves shall be rated for 200 psig service and shall be suitable for vertical or horizontal flow.

G. Miscellaneous Piping Components

1. Air Release and Vacuum Breakers

a. Air release and vacuum breakers shall be located as indicated on the contract drawings.

b. The air and vacuum valve shall automatically exhaust air during the filling of a system while allowing air to re-enter during draining or when vacuum occurs.

c. The valve shall have a cast iron body and cover, with stainless steel float and trim.

d. End connections shall be one inch; bushings and adapters shall be utilized as required to thread the air release/vacuum breakers into adjacent piping. All air release and vacuum breakers shall be plumbed to an equal size ball valve (allowing isolation of the air release/vacuum breaker from the piping system).

2. Expansion Joints

The Contractor shall provide all structural work and equipment required to control expansion and contraction of piping. The Contractor shall verify that the anchors, guides, and expansion joints provided, are compatible with and adequately protect the piping system.

3. Above Grade Wall Penetrations

a. Piping which passes through fire-rated or smoke-rated walls, floors, or ceilings shall be provided with insulated and encased pipe sleeves.

b. Penetrations through an existing fire or fire barrier wall shall be sealed with a fire stop system that has an "F" rating not less than the required fire

resistance rating of the penetrated wall. The fire stopping sealant for plastic and insulated piping systems shall be a silicone based, nonslumping, premixed sealant, that is vibration and moisture resistant.

c. Vented plastic pipe penetrations shall be fitted with galvanized steel collars.

4. Automatic Flow Control Valves and Flowmeters

This contract does not include materials and installation of automatic flow control valves and flowmeters.

H. HDPE Access Vaults

1. High-point vent, junction, and leak detection HDPE access vaults with single wall and/or dual-containment stubouts shall be as specified in the contract drawings (Attachment 1) and per ASTM F1759-97. The Contractor shall adjust vault dimensions and clearances as required to accommodate valving, flanges, and other piping features.

2. The access vaults shall be manufactured from polyethylene (PE) material that conforms to ASTM D 3350.

3. The vault shall be fabricated from HDPE solid wall pipe extruded to ASTM F 714. Rotational molded sections or wall thickness less than 1 ¼" are not acceptable.

4. The bottom of the vault shall be 1½" thick HDPE and extrusion welded to the manhole cylinder using proper extrusion welding practices.

5. The vaults shall be designed and fabricated to prevent the ingress of moisture. All vaults shall have a lockable, weathertight top. The Contractor shall submit shop drawings showing the vaults proposed to be installed, including the weathertight and locking lid detail(s).

6. The access vaults shall be tested and certified to be leak-free. Data shall be submitted for review and approval by the Contracting Officer.

7. The position and pipe sizes of the dual-containment stubouts for the access vaults are presented in the contract drawings (Attachment 1). The stubouts shall be as follows:

a. The HDPE pipe used to fabricate the stubouts shall be as specified by paragraph C, Section II.

b. The absence of pipe supports, gussets and other details on the contract drawings does not relieve the Contractor of responsibility for sizing and providing pipe supports where appropriate.

c. The stubouts shall be extrusion welded on the inside and outside of the vault structure.

I. Concrete Access Vaults

1. The locations of concrete access vaults, as shown in Attachment 1, are STA 0+00 and STA (N)2+72.

2. The vaults and all materials and appurtenances shall be as specified and as shown on the contract drawings, and shall be suitable for the service intended.

3. All materials and appurtenances supplied as part of this contract shall be new and unused except for testing equipment. Components that serve the same function and are the same size shall be identical products of the same manufacturer.

4. The concrete access vaults shall meet all OSHA safety requirements and industry standards. The absence of ladders and other details on the contract drawings does not relieve the Contractor of responsibility for ensuring safe personnel access to the vault.

5. The vaults shall be precast concrete fabricated per ASTM C-857 specifications.

6. The concrete shall have a 28 day compressive strength of 4,500 psi with ASTM A-615 Grade 60 rebar and ASTM A-185 Grade 65 mesh.

7. The vaults and covers shall be designed and fabricated to prevent the ingress of moisture.

J. Material Delivery, Storage, and Handling

1. Proper protection and care of material before, during and after installation is the Contractor's responsibility. Any material found to be damaged shall be replaced at the Contractor's expense.

2. Pipe and fittings shall be handled and stored in accordance with the manufacturer's recommendation. Plastic pipe shall be packed, packaged and marked in accordance with ASTM D 3892.

3. Materials delivered and placed in storage shall be stored with protection from the weather, excessive humidity variation, excessive temperature variation,

dirt, dust and other contaminants. During installation, piping shall be capped to keep out dirt and other foreign matter.

4. Unfenced storage areas in the general job vicinity are available. Material and equipment security are the responsibility of the Contractor. Installation and removal of temporary security fencing is the Contractor's responsibility.

5. A material safety data sheet in conformance with 29 CFR 1910 Section 1200(g) shall accompany each chemical delivered for use in pipe installation. At a minimum, this includes all solvents, solvent cements, glues and other materials that may contain hazardous compounds. Handling of such chemicals shall be in accordance with ASTM F 402. Materials shall be stored with protection from puncture, dirt, grease, moisture, mechanical abrasions, excessive heat, ultraviolet (UV) radiation damage, or other damage.

IV. Material – Leak Detection and Electrical

A. General Requirements

1. The leak detection system shall monitor the interstitial space of double contained piping, all vaults and pull stations located at junctions of dual-wall piping, and all extraction well vaults, as shown in the plan and profile drawings (Attachment 1).

2. The leak detection system shall be a cable detection system and shall be equipped with an electronic monitoring and control unit. The system shall be capable of detecting groundwater containing 800 to 4000 parts per million TDS and having a conductivity of approximately 1000 µmho/cm.

3. The system shall be capable of identifying the location of breaks and shorts on the cable. When either of these faults occur, an alarm shall sound and a display visible on the front of the monitoring unit shall clearly indicate the type of fault and display the location of the fault.

4. Applicable standards of the American National Standards Institute (ANSI), American Water Works Association (AWWA), National Association of Corrosion Engineers (NACE), American Society for Testing and Materials (ASTM), Illuminating Engineering Society (IES), National Electrical Manufacturers Association (NEMA), National Fire Protection Association (NFPA), National Electrical Code (NEC), National Electrical Safety Code (NESC) and the Underwriters' Laboratories (UL) reflect current industry standard practice and must be used for establishing the quality of materials and equipment.

B. Leak Detection System

1. Leak detection system shall be a complete cable-type leak detection and location system consisting of a microprocessor based monitoring unit, sensor cable, probes, system layout map and auxiliary equipment. The leak detection system shall provide continuous monitoring of the sensing strings for leaks, shorts, breaks and probe activation shall be furnished. If any of these conditions should occur at any point along the cable, an alarm shall sound, type of condition shall be clearly identified and the location clearly displayed.

2. The monitoring unit shall be microprocessor based and shall indicate when any liquid leaks into the secondary containment piping by sounding an alarm, actuating output relays, displaying a message that a leak has been detected, and displaying the location of that leak.

3. The monitoring unit power requirements shall be 120 VAC, 60 Hz, single phase.

4. Ability to locate a leak shall not depend on battery backed up functions. In the event of power failure, system conditions and parameters shall be stored in nonvolatile memory allowing the monitoring unit to automatically resume monitoring, without resetting, upon restoration of power. An on-off switch shall be provided in the panel for servicing.

5. The system shall provide relays for remote indication of an alarm condition. The relays shall provide indication that no alarm conditions exist, an alarm condition exists but has not yet been acknowledged, and an alarm condition exists and has been acknowledged. Communications shall be available via RS-232 and ASCII communication protocols to allow central point monitoring and control via a remote computer.

6. The system shall record significant events in permanent memory. When the memory becomes full, the recorded events shall be deleted from memory in sequential order beginning with the oldest event. Each recorded event shall include the time and date that the event occurred.

7. The system shall continuously provide positive indication that it is monitoring the sensing string and the status of the sensing string.

8. The leak detection system shall have assignable password security.

9. The leak detection system shall locate the point of origin of the first liquid leak within 0.1 % of the sensor string length.

10. The leak detection system shall be capable of monitoring all dual-wall HDPE extraction piping from a single monitoring unit.

C. Leak Detection Cable

1. The leak detection cable shall be conductance type. The cable sensing principle shall provide for continuous monitoring while short lengths of the cable are in contact with liquids, without altering the system's sensitivity or accuracy.

2. The leak detection cable, connectors, and jumpers shall be supplied by the manufacturer of the monitoring unit and be suitable for use. The sensor cables shall be of coaxial construction consisting of an insulated copper center conductor, a suitable spacer material, and an outer braid.

3. Center conductors shall be not less than twenty AWG for mechanical strength. Cables shall be capable of field installation of connectors by trained technicians. The cable shall be available in bulk spools. All cables shall be field repairable by trained technicians

D. Electrical

1. The electrical system shall be as specified in the contract drawings (Attachment 1).

2. Rigid nonmetallic conduit shall be in accordance with NEMA TC 13 and UL 651, and shall be PVC with wall thickness not less than Schedule 40. Diameter and location shall be per the contract drawings (Attachment 1).

3. All electrical penetrations into high-point vent, leak detection and junction access vaults shall be designed and installed to prevent the ingress of moisture.

4. Electrical pull boxes shall be as specified in Attachment 1 and designed and installed to prevent the ingress of moisture.

V. Schedule

A. General Requirements

1. A Project Schedule as described below shall be prepared. The scheduling of construction shall be the responsibility of the Contractor. Contractor management personnel shall actively participate in the Project Schedule development. Subcontractors and suppliers working on the project shall also contribute in developing and maintaining an accurate Project Schedule.

2. The NASA approved Project Schedule shall be used to measure the progress of the work and to aid in evaluating time extensions. Failure to adhere to the NASA-approved Project Schedule may result in contract termination. The following components shall be considered a minimum appropriate level of detail to be used in the Project Schedule:

B. Project Schedule Format

The project schedule shall be prepared in MS Project and submitted in two media formats: as an *.mpp file, and as a paper copy.

C. Activity Durations

Contractor schedule submissions shall utilize reasonable activity durations. Reasonable durations are those that allow the progress of activities to proceed, without excessive float or unreasonably short durations.

C. Procurement Activities

Tasks related to the procurement of long lead materials or equipment shall be included as separate activities in the project schedule. Long lead materials and equipment are those materials that have a procurement cycle of over 45 days. Examples of procurement process activities include, but are not limited to: submittals, approvals, procurement, fabrication, and delivery.

D. Government Activities

Anticipated government and other agency activities that could impact progress shall be shown. These activities may include, but are not limited to: approvals, inspections, utility tie-in, installation of Government Furnished Equipment (GFE), and Notice to Proceed for phasing requirements.

E. Responsibility

All activities shall be identified in the project schedule by the party responsible for performance of the work. Responsibility includes, but is not limited to, the subcontracting firm, contractor work force, or government agency performing a given task. Activities shall not belong to more than one responsible party.

VI. Earthwork

A. Clearing and Grubbing

Portions of the proposed pipeline routes have been cleared and grubbed. Where clearing and grubbing is required, the following shall apply:

1. Clearing shall consist of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including down timber, snags, brush, and rubbish occurring in the areas to be cleared. Trees, roots, brush, and other vegetation in areas to be cleared shall be cut off flush with or below the original ground surface, except such trees and vegetation as may be indicated or directed to be left standing. Trees and vegetation to be left standing shall be protected from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require.

2. Grubbing shall consist of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Material to be grubbed, together with roots and other organic material not suitable for construction purposes, shall be removed to a depth of not less than 12 inches below the original surface level of the ground. Depressions made by grubbing shall be filled with suitable material and compacted to make the surface conform with the original adjacent surface of the ground.

3. Cleared and grubbed materials shall be stockpiled adjacent to the piping route.

B. Erosion Control

The Contractor shall be responsible for erosion control for the duration of the project. Additional work or damage to materials due to the Contractor's fault or neglect shall be repaired or replaced by the Contractor without additional cost to the Government.

C. Trenching

1. General Requirements

a. The trench shall be excavated as recommended by the manufacturer of the pipe to be installed and in accordance with OSHA Regulation 29 CFR Part 1926, Subpart P. In case of no manufacturer recommendations or contradiction between pipe manufacturer recommendations and 29 CFR Part 1926, Subpart P, OSHA regulations shall prevail.

b. The trench width below the top of pipe shall not exceed 28 inches plus total pipe outside diameter (O.D.). Where recommended trench widths are exceeded, redesign, stronger pipe, or special installation procedures shall be utilized by the Contractor. The cost of redesign, stronger pipe, or special installation procedures shall be borne by the Contractor without any additional cost to the Government.

c. Contractor shall field-locate all Underground Utilities, in coordination with the Contracting Officer or their designee. The location of Underground Utilities shall be verified as follows: Contractor shall excavate using mechanized equipment up to a reasonably close distance from the marked utility location, then use hand tools to carefully finish location of the utility. Utilities to be left in place shall be protected from damage. If any utility previously identified by the Government is damaged by the Contractor, that damage shall be repaired by the Contractor, without any additional cost to the Government. If any non-locatable utility is damaged by the Contractor, the Government will assume responsibility for that damage.

d. Excavations shall be done in ways that will prevent surface water and subsurface water from flowing into excavations and will also prevent flooding of the site and surrounding area.

e. Contractor shall place barricades around the trench where no work is being performed.

2. Bottom Preparation

a. The bottoms of trenches shall be accurately graded to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Stones of 3 (three) inches or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, shall be removed to avoid point bearing.

b. All trench sections between vaults, pull stations, manways, and high-point vents shall be linear, straight sections, with a slope of no less than 0.5% (or as indicated on contract drawings).

3. Removal of Unyielding Materia1

Where unyielding material is encountered in the bottom of the trench, such material shall be removed four (4) inches below the required grade and replaced with suitable materials as provided in paragraph D of this section.

Explosives shall not be used or brought to the project site without prior written approval from the Contracting Officer. Such approval shall not relieve

the Contractor of responsibility for injury to persons or for damage to property due to blasting operations.

Storage of explosives, when permitted on Government property, shall be only where directed and in approved storage facilities. These facilities shall be kept locked at all times except for inspection, delivery, and withdrawal of explosives.

Explosive work shall be performed in accordance with NTS 1740.12. This document is available at:

http://www.hq.nasa.gov/office/codeq/doctree/1740_12.pdf

4. Removal of Unstable Material

   a. Where unstable material is encountered in the bottom of the trench, such material shall be removed to the depth directed and replaced to the proper grade with clean washed sand or screened native soil as provided in paragraph D of this section.

   b. When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the resulting material shall be excavated and replaced by the Contractor without additional cost to the Government.

5. Excavation for Appurtenances

   a. Excavation for manholes, vaults, pull boxes, or similar structures shall be sufficient to leave at least 12 inches clearance between the outer structure surfaces and the face of the excavation or support members.

   b. Bottom of the excavation shall be prepared as specified by paragraph 2., Section VI.

   c. Loose disintegrated rock and thin strata shall be removed. Removal of unstable material shall be as specified above.

   d. When concrete or masonry is to be placed in an excavated area, special care shall be taken not to disturb the bottom of the excavation. Excavation to the final grade level shall not be made until just before the concrete or masonry is to be placed.

D. Backfill and Compaction

1. General Requirements

a. Backfilling shall be accomplished after inspection by the Contracting Officer or his designee. The Contractor shall exercise care when lowering pipe into the trench to prevent damage or twisting of the pipe.

b. Backfill material shall consist of clean washed sand and native soil as required. Native soil screened to minus 1-inch may be used in lieu of clean washed sand. A sieve analysis and sample of the clean washed sand shall be submitted to the Government for approval prior to trench excavation.

c. Backfill shall be placed in layers not exceeding 12 inches loose thickness for compaction by hand operated machine compactors, and 20 inches loose thickness for other than hand operated machines, unless otherwise specified.

d. Each layer of native soil backfill shall be compacted to at least 90 % maximum density, unless otherwise specified.

e. Unyielding material removed from the bottom of the trench shall be replaced with clean washed sand or screened native soil.

f. Unstable material removed from the bottom of the trench or excavation shall be replaced with clean washed sand or screened native soil placed in layers not exceeding 12 inches loose thickness.

g. Bedding and Initial Backfill - Clean washed sand shall be placed and compacted with approved tampers to a height of at least six inches above the pipe or conduit. The backfill shall be brought up evenly on both sides of the pipe for the full length of the pipe. Care shall be taken to ensure thorough compaction of the fill under the haunches of the pipe.

h. Final Backfill – The remainder of the trench shall be filled with unscreened native soil. Native backfill shall be deposited in layers of a maximum of 20 inch loose thickness, and compacted to 90 % maximum density. Water flooding or jetting methods of compaction will not be permitted.

i. Backfill for Appurtenances - After the manhole, vault, pull box, or similar structure has been installed, backfill shall be placed in such a manner that the structure will not be damaged by the shock of falling earth. The backfill material shall be deposited and compacted as specified for final backfill, and shall be brought up evenly on all sides of the structure to prevent eccentric loading and excessive stress. A minimum of four bollards shall be installed adjacent to each manhole, vault, pull box, or similar structure, per the contract drawings.

j. Trenches shall be of a depth to provide a minimum cover of three (3) feet from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe.

k. Metallic, detectable underground tape shall be installed directly above the pipe, at a depth of no less than 18 inches below finished grade unless otherwise shown on the contract drawings. Metallic, detectable underground tape shall be marked with the words “water” and “fiber optic”, or Government-approved equivalent.

2. Testing

a. Testing shall be the responsibility of the Contractor and shall be performed at no additional cost to the Government.

b. Testing of Backfill Materials - Classification of backfill materials shall be determined in accordance with ASTM D 2487; the moisture-density relations of soils shall be determined in accordance with ASTM D 1557. A minimum of one soil classification and one moisture-density relation test shall be performed on each different type of material used for bedding and backfill.

c. Field Density Tests - Tests shall be performed in sufficient numbers to ensure that the specified density is being obtained. A minimum of one field density test per lift of native soil backfill for every 1000 feet of installation shall be performed. One moisture-density relationship shall be determined for every 1500 cubic yards of material used. Field in-place density shall be determined in accordance with ASTM D 1556, ASTM D 2167, or ASTM D 2922. When ASTM D 2922 is used, the calibration curves shall be checked and adjusted using the sand cone method as described in paragraph “Calibration” of the ASTM publication. ASTM D 2922 results in a wet unit weight of soil and when using this method, ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D 3017.

d. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job, on each different type of material encountered, and at intervals as directed by the Contracting Officer. Copies of calibration curves, results of calibration tests, and field and laboratory density tests shall be furnished to the Contracting Officer within one (1) day following the completion of the density tests. Trenches improperly compacted shall be reopened to the depth directed, then refilled and compacted to the density specified at no additional cost to the Government.

VII. Installation - Piping System

A. General Requirements

1. The piping system, high-point vent, junction and leak detection access vaults with piping system dual-containment stubouts shall be installed per the contract drawings (Attachment 1). The material and installation of automatic flow control valves and flowmeters are not included in this contract. After becoming familiar with all details of the work, the Contractor shall verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

2. Pipe and equipment openings shall be closed with caps or plugs during installation. Equipment shall be protected from dirt, water, and chemical or mechanical damage.

3. Pipe and fittings shall be inspected before exposed piping is installed or buried piping is lowered into the trench. The Contractor shall clean the ends of pipes thoroughly, remove foreign matter and dirt from inside of pipes, and keep piping clean during and after laying.

4. The Contractor shall repair damaged pipe in the field with material equal to the original pipe. The Contractor shall not install damaged piping materials.

5. Field Fabrication - The Contractor shall notify the Contracting Officer at least 2 weeks prior to the field fabrication of pipe or fittings and at least 3 days prior to the start of any surface preparation or coating application work. Fabrication of fittings shall be performed in accordance with the manufacturer's instructions.

6. External Corrosion Protection - Protect all pipe and piping accessories from corrosion and adverse environmental conditions.

7. Closures - Closure pieces shall be installed as necessary to end pipe runs. Elastomer sleeves bonded to pipe ends are not acceptable. Pressure piping shall have closures of blind flanges, unless otherwise shown on contract drawings or approved by the Contracting Officer.

8. Services for the double containment leak detection monitoring systems shall be provided by a manufacturer's representative who is experienced in the installation, adjustment and operation of the equipment specified. The representative shall inspect the installation, and supervise the adjustment and testing of the equipment

B. HDPE Pipe

1. Thermoplastic piping systems shall be installed underground in accordance with ASTM D 2774. Earthwork shall be performed as specified in Section V.

2. Plastic pipe shall be cut, fabricated, and installed in strict conformance with the pipe manufacturer's recommendations.

3. Heat joining shall be performed in accordance with ASTM D 2657. Electrofusion joining shall be performed in accordance with ASTM F 1290.

4. Pipe shall not be laid when the ambient temperature is below 40 degrees F, nor above 105 degrees F.

5. Any plastic pipe installed above grade and outdoors shall be ultraviolet (UV) protected or UV resistant.

6. The pipe ends that are to be joined shall be shielded from direct sunlight prior to and during the laying operation.

7. Where plastic pipe is subjected to severe temperature fluctuations, provisions for expansion and contraction must be provided. This shall be accomplished with the use of offset piping arrangements. Offset loops from the trench centerline shall be as recommended by the manufacturer for the maximum temperature variation between the pipe temperature at the time of heat fusion and operating temperature.

8. Flexible plastic pipe connected to heavy fittings, manholes, and rigid structures shall be supported in such a manner that no subsequent relative movement between the plastic pipe at the flanged joint and the rigid structures is possible. Thrust blocking shall not be used for flexible plastic piping. The piping shall be designed and installed to withstand the compression and expansion forces imposed by the trench conditions. All pipe sections between vaults, pull stations, manways, and high-point vents shall be linear, straight sections, with a slope of no less than 0.5% (or as indicated on contract drawings).

9. All lines shall be hydrostatically tested at the maximum operating pressures recommended by the manufacturer for that DR.

10. Factory trained field representatives of the piping supplier shall provide technical field support during critical periods of piping and leak detection system installation, including final check out of the leak detection/location system, and end user training.

C. Valves

1. Valves shall be located in accordance with the contract drawings. Valves shall be located and oriented to permit easy access to the valve operator, and to avoid interferences.

2. Flanged valve bolt holes shall be installed so as to straddle the vertical centerline of pipe. Flanged faces shall be cleaned prior to inserting the gasket and bolts, and then the nuts shall be tightened progressively and uniformly. Threaded ends shall have the threads cleaned by wire brushing or swabbing prior to installation.

3. The operating stem of a manual valve shall be installed in a vertical position and in accordance with the manufacturer's instructions.

D. Miscellaneous Piping Components

1. Expansion Devices- The Contractor shall provide all structural work and equipment required to control expansion and contraction of piping. The Contractor shall verify that the anchors, guides, and expansion joints provided are compatible with and adequately protect the piping system. Expansion devices shall be installed in accordance with the manufacturer's instructions.

2. Couplings, Adapters and Service Saddles - Pipes shall be thoroughly cleaned of oil and dirt in order to provide a clean seat for gaskets. Gaskets shall be wiped clean prior to installation. Flexible couplings and flanged coupling adapter gaskets shall be lubricated with soapy water before installation on the pipe ends. Couplings and service saddles shall be installed in accordance with manufacturer's instructions. Bolts shall be tightened progressively, drawing up bolts on opposite sides a little at a time until all bolts have a uniform tightness.

3. Equipment/Components - Piping components and indicators shall be installed in accordance with manufacturer's instructions. Required upstream and downstream clearances, isolation valves, and miscellaneous devices shall be provided for an operable installation.

4. Pipe Flanges - Pipe flanges shall be set level, plumb, and aligned. Flanged fittings shall be installed true and perpendicular to the axis of the pipe. The bolt holes shall be concentric to the centerline of the pipe.

5. Pipe Tap Connections - Taps to pipe shall be per manufacturer recommendations.

6. Connecting Dissimilar Pipe - Flexible transition couplings and isolation joints shall be installed in accordance with the manufacturer's instructions.

7. Air Release Vents - Air release and vacuum breakers shall be located as indicated on the contract drawings. Air release and vacuum breakers shall be installed in accordance with the manufacturer's instructions.

9. Above Grade Wall Penetrations - Piping which passes through fire-rated or smoke-rated walls, floors, or ceilings shall be provided with insulated and encased pipe sleeves. Penetrations through an existing fire or fire barrier wall shall be sealed with a fire stop system that has an "F" rating not less than the required fire resistance rating of the penetrated wall. The fire stopping sealant for plastic and insulated piping systems shall be a silicone based, nonslumping, premixed sealant, that is vibration and moisture resistant. Vented plastic pipe penetrations shall be fitted with galvanized steel collars.

10. Automatic Flow Control Valves and Flowmeters - This contract does not include materials and installation of automatic flow control valves and flowmeters.

E. HDPE Access Vaults

1. The vaults shall be installed per the contract drawings (Attachment 1) and the vault manufacturer's instructions.

2. Earth work shall be performed as specified in Section V. Temporary closures shall be installed as required to keep the inside of the vault, dual-containment stubouts and vault penetrations clean.

3. The Contractor shall be responsible for any damage to the vaults in the field. All repairs shall be in accordance with the vault manufacturer's recommendations.

VIII. Installation – Leak Detection and Electrical

A. General Requirements

1. The electrical and leak detection system shall be installed in accordance with the manufacturer's recommended installation procedures and the contract drawings (Attachment 1).

2. A location map shall be provided with the system by the Contractor indicating the "as built" system configuration and sensing string layout. Markings along the cable length shall be provided as references to locate leaks. Markings shall be based upon calibration points.

3. The Contractor shall be responsible for taking and recording calibration points along the sensing string per the manufacturer's recommended procedures. Cable not in containment piping shall have cable tags every 50 feet.

4. All access vault and well vault penetrations shall be designed and installed to prevent the ingress of moisture.

5. The contractor shall comply with all local, state and federal electrical codes

B. Assistance and Training

The Contractor shall provide manufacturer's technical assistance for Contractor training, installation inspection, start up, and owner operating and maintenance training.

IX. Testing - Piping System and Leak Detection

A. Hydrostatic Tests

1. After the pipe is laid, the joints completed and the trench partially backfilled leaving the joints exposed for examination, the newly laid piping or any valved section of piping shall, unless otherwise specified, be subjected for 30 minutes to a hydrostatic test.

2. The test fluid shall be potable water and the test pressure shall be 110% of the design pressure. The design pressures are as follows:

Dimension Ratio (DR)	Design Pressure (psi)
9	156
11	125
17	78

3. Each valve shall be opened and closed several times during the test. Exposed pipe, joints, fittings, and valves shall be carefully examined during the partially open trench test.

4. Joints showing visible leakage shall be replaced as necessary. Defective pipe, joints, fittings, and valves found during the pressure test shall be removed and replaced with new material, and the test repeated until the test results are satisfactory.

5. The requirement for the joints to remain exposed for the hydrostatic tests may be waived by the Contracting Officer when one or more of the following conditions are encountered: (1) wet or unstable soil conditions in the trench; or (2) compliance would require maintaining barricades and walkways around and across an open trench in a heavily used area that would require continuous surveillance to assure safe conditions.

6. The Contractor may request a waiver, setting forth in writing the reasons for the request and stating the alternative procedure proposed to comply with the hydrostatic tests.

B. Pneumatic Tests

1. Pneumatic testing shall be prepared for and conducted in accordance with the requirements of ASME B31.3. Care shall be taken to minimize the chance of a brittle fracture or failure during a pneumatic leak test.

2. During pneumatic testing, a pressure relief device shall be provided for each piping section being tested. The device shall have a set pressure not higher than 110% of the test pressure.

3. The test fluid shall be atmospheric air and the test pressure shall be 110% of the design pressure. The design pressures are as follows:

Dimension Ratio (DR)	Internal Design Pressure (psi)
9	156
11	125
17	78

4. The test pressure shall be incrementally increased until the gage pressure reaches 50% of the test pressure. The Contractor shall examine piping joints for leakage.

5. If no leakage is occurring, the Contractor shall continue to increase the pressure incrementally, while maintaining each incremental increase long enough to equalize pipe strains, until the test pressure is reached.

6. The test pressure shall then be reduced to the design pressure and maintained for 10 minutes without additional energy expenditure. If the pneumatic pressure remains steady, then no leakage is indicated. The Contractor shall inspect for and repair leaks, and retest if necessary.

C. Valve Testing

1. Valves may either be tested while testing pipelines, or as a separate step. It shall be demonstrated that valves open and close smoothly with operating pressure on one side and atmospheric pressure on the other, and in both directions for two-way valve applications.

2. The Contractor shall count and record the number of turns required to open and close each valve, and account for any discrepancies with manufacturer's data.

3. Air and vacuum relief valves shall be examined as the associated pipe is being filled to verify venting and seating is fully functional.

4. The Contractor shall set, verify, and record set pressures for all relief and regulating valves.

D. Leak Detection System Test

1. Tests shall be performed to demonstrate the ability of the system to detect and locate breaks, shorts and probes on the sensor string. Leak testing shall be performed pursuant to the following procedure in order to verify operation and the ability to work with condensation pools or other static moisture.

2. The double containment piping system leak detection field test procedures shall be as follows:

a. Using potable water, wet the installed sensor cable near the start of the sensor string and acknowledge the detection/location alarm and remap the system.

b. Using potable water, wet the installed sensor cable near the end of the sensor string with the first location still wetted and acknowledge the detection/location alarm and remap the system.

c. Using potable water, wet the sensor cable in three additional locations between the first and second leak locations with each detection/location alarm being acknowledged and with all prior leak locations still wetted.

3. The Contractor shall prepare and submit a report verifying each leak location and detection accuracy. A hard copy report of the test results shall be furnished.

4. Upon completion of leak detection system testing, the dual containment annular area shall be cleaned and dried, if required. The Contractor shall ensure that the leak detection system is detecting no leaks and system is ready for operation.

X. Final Cleaning

A. Interim Cleaning

The Contractor shall prevent the accumulation of pipe cuttings and filings, gravel, cleaning rags, tools, and other foreign material within piping sections during fabrication. The piping shall be examined to assure removal of these and other foreign objects prior to assembly and installation.

B. Flushing

1. The flushing fluid shall be potable water.

2. Following assembly and testing, and prior to final acceptance, piping systems shall be flushed to remove accumulated construction debris and other foreign matter. The piping shall be flushed until all foreign matter is removed from the pipeline.

3. The Contractor shall provide all hoses, temporary pipes, ditches, and other items as required to properly dispose of flushing water without damage to adjacent properties. The minimum flushing velocity shall be 2.5 fps.

4. For large diameter pipe where it is impractical to flush the pipe at the minimum flushing velocity, the pipeline shall be cleaned in-place from the

inside by brushing and sweeping, then flushing the pipeline at a lower velocity.

5. Cone strainers shall be installed in the flushing connections of attached equipment and left in place until cleaning is completed. Accumulated debris shall be removed through drains, or by removing spools or valves.

C. Water Disposal

The water used for testing, cleaning, or flushing shall be disposed of in accordance with all applicable regulations. Disposal is solely the responsibility of the Contractor. The method proposed for disposal of testing, cleaning, or flushing water shall be provided to, and approved by, the Contracting Officer prior to performing any testing, cleaning, or flushing activities. Discharge to grade is acceptable.

D. Trash and Debris Disposal

Contractor shall provide trash container(s) and dispose of all trash and debris generated during construction activity for the duration of construction. No trash or debris shall be disposed of in the sub-grade piping trench, or on Government property.

E. Project Area

The project area shall have temporary structures, barricades, project signs, and construction facilities removed. A list of completed clean-up items shall be submitted on the day of final inspection

XI. Certification and Warranty

The minimum design life for materials and installation of the subgrade piping system is thirty (30) years. The certification and warranty shall contain a written certification statement from the installation inspector(s) attesting to the proper installation and testing of the piping system. The warranty shall define a warranty period and provide allowance for credit, repair or replacement of any defective piping, valves, fittings, or manholes. The vendor shall provide a warranty that guarantees the installation of all HDPE pipe and fittings per this PR against defects or failures due to improper installation. At minimum, any defects or failures due to improper installation shall be repaired by the vendor at no cost to the Government for a one (1) year period. The manufacturer/vendor shall replace damaged or defective parts within a two week time frame.

The certification and warranty shall contain a written certification statement from the installation inspector(s) attesting to the proper installation and testing of the leak detection system. The warranty shall define a warranty period and provide allowance for credit, repair or replacement of any defective leak detection material and components.

The vendor shall provide a warranty that guarantees the installation of the leak detection system against defects or failures due to improper installation. At minimum, any defects or failures due to improper installation shall be repaired by the vendor at no cost to the Government for a one (1) year period. The manufacturer/vendor shall replace damaged or defective parts within a two week time frame.

XII. Submittals

A. General

1. Each submittal shall be permanently marked to identify it by contract number; transmittal date; Contractor's, Subcontractor's, and supplier's name, address(es) and telephone number(s); submittal name; specification or drawing reference; and similar information to distinguish it from other submittals. Submittal identification shall include space to record the review action by the Contracting Officer. Contractor shall submit a properly executed copy of JSC Form 262 with the submittals; JSC Form 262 is shown as Attachment 3.

2. Required data submittals for each specific material, product, unit of work, or system shall be collected into a single submittal and marked for choices, options, and portions applicable to the submittal. Marking of each copy of product data submitted shall be identical. Partial submittals will not be accepted for expedition of construction effort.

3. Five complete sets of indexed and bound product data shall be submitted. One set, marked with review notations by the Contracting Officer, will be returned to the Contractor.

4. Within 30 days of notice to proceed, the Contractor shall provide, for approval by the Contracting Officer, the following schedule of submittals:

   (a) A schedule of shop drawings and technical submittals required by the specifications and drawings. Schedule shall indicate the specification or drawing reference requiring the submittal; the material, item, or process for which the submittal is required; identifying title of the submittal; the Contractor's anticipated submission date and the approval need date.

   (b) A separate schedule of other submittals required under the contract but not listed in the specifications or drawings. Schedule will indicate the contract requirement reference; the type or title of the submittal; the Contractor's anticipated submission date and the approved need date (if approval is required).

   (c) Submittals called for by the contract documents will be listed on one of the above schedules. If a submittal is called for but does not pertain to the contract work, the Contractor shall include it in the applicable schedule and

annotate it "N/A" with a brief explanation. Approval of the schedules by the Contracting Officer does not relieve the Contractor of supplying submittals required by the contract documents but which have been omitted from the schedules or marked "N/A".

(d) Copies of both schedules shall be re-submitted monthly annotated by the Contractor with actual submission and approval dates. When all items on a schedule have been fully approved, no further re-submittal of the schedule is required.

5. Contracting Officer will review submittals and provide pertinent notation within 10 calendar days after date of submission. Submittals will be returned to the Contractor with the following notations:

(a) Submittals marked "approved" authorize the Contractor to proceed with the work covered.

(b) Submittals marked "approved as noted" authorize the Contractor to proceed with the work covered provided he takes no exception to the corrections. Notes shall be incorporated prior to submission of the final submittal.

(c) Submittals marked "return for correction" require the Contractor to make the necessary corrections and revisions and to re-submit them for approval in the same routine as before, prior to proceeding with any of the work depicted by the submittal.

(d) Submittals marked "not approved" or "disapproved" indicate noncompliance with the contract requirements and shall be re-submitted with appropriate changes. No item of work requiring a submittal shall be accomplished until the submittals are approved or approved as noted.

6. Contractor shall make corrections required by the Contracting Officer. If the Contractor considers any correction or notation on the returned submittals to constitute a change to the contract drawings or specifications, notice as required under the clause entitled, "Changes" shall be given to the Contracting Officer. Approval of the submittals by the Contracting Officer shall not be construed as a complete check, but will indicate only that the general method of construction and detailing is satisfactory. Contractor shall be responsible for the dimensions and design of connection details and construction of work. Failure to point out deviations may result in the Government requiring rejection and removal of such work at the Contractor's expense.

7. If changes are necessary to approved submittals, the Contractor shall make such revisions and submission of the submittals in accordance with the procedures above. No item of work requiring a submittal change shall be accomplished until the changed submittals are approved.

B. Preconstruction Submittals

1. Qualifications - A statement describing the Contractor’s experience installing and testing single-wall and double-wall HDPE pipeline systems, leak detection systems, and associated conduit.

2. Manufacturer Qualifications - A statement describing the Manufacturer’s experience manufacturing single-wall and double-wall HDPE pipeline systems, leak detection systems,

3. Installation Instructions - The Contractor shall furnish the manufacturer's installation recommendations or instructions for each material or procedure to be utilized, including materials preparation.

4. Project Schedule – The Contractor shall furnish a Project Schedule as described in Section V of this specification.

5. Contractor's Installation - The Contractor shall furnish a statement signed by the plastic pipe manufacturer's representative certifying that the Contractor's personnel are capable of properly installing the piping system on the project.

6. Piping System Pressure Testing Plan – The Contractor shall furnish a written document describing in detail the procedure to be followed for pressure testing all piping and appurtenances. Specifically, the Piping System Pressure Testing Plan shall specify whether the proposed testing will be pneumatic, hydrostatic, or both, pipe segments and the order of testing, test pressures, durations, acceptability ranges, special requirements, and any other information pertinent to pressure testing. All proposed testing procedures require Government approval prior to actual testing.

7. Leak Detection System Testing Plan – The Contractorshall furnish a written document describing in detail the procedure to be followed for testing of the entire leak detection system. Specifically, the Leak Detection System Testing Plan shall specify the proposed testing locations, specific procedures, verification, special requirements, and any other information pertinent to leak detection system testing. All proposed testing procedures require Government approval prior to actual testing.

8. Cleaning and Flushing Plan – The Contractorshall furnish a written document describing in detail the procedure to be followed for post-installation, post-pressure-testing, cleaning and flushing. Specifically, the Cleaning and Flushing Plan shall specify pipe segments and the order of flushing, anticipated flushing water volumes, flushing water velocities, flushing durations, special requirements, and any other information pertinent to cleaning and flushing. All proposed

cleaning and flushing procedures require Government approval prior to the actual operation.

9. Waste Water Disposal - The Contractor shall furnish the method proposed for disposal of water from hydrostatic tests, and all required permits, prior to performing hydrostatic tests.

10. Materials and Equipment - The Contractor shall furnish the manufacturer's descriptive and technical literature for each piping system, including design recommendations; pressure and temperature ratings; dimensions, type, grade and strength of pipe and fittings; and thermal characteristics (coefficient of expansion and thermal conductivity).

C. Construction Progress Submittals

Field Test Reports - The Contractor shall furnish a copy of all field notes and test reports. The following field test reports are required within 24 hours following testing (the quantity that each test shall be as required elsewhere in this specification).

1. Pipe Leakage Tests
2. Hydrostatic Tests
3. Pneumatic Tests
4. Double Containment Piping Leak Detection System
5. Valve Testing

D. As-Built Drawing Submittals

Drawings showing the final as-built conditions of the installation shall consist of two sets of the working as-built drawings. The Government will be generating CADD versions of as-builts from the Contractors' hand-marked, working as-built drawings. The Contractor shall review and approve hard copies of the electronic versions, to ensure true as-built conditions are recorded on the electronic as-built drawings. This paragraph covers as-built drawings complete, as a requirement of the contract. The terms "drawings," "contract drawings," "drawing files," "working as-built drawings" and "final as-built drawings" refer to contract drawings which are revised to be used for final as-built drawings.

1. Working As-Built and Final As-Built Drawings

The Contractor shall revise two sets of paper drawings by red-line process to show the as-built conditions during the prosecution of the project (one field copy, one field-office copy). These working as-built marked drawings shall be kept current on a weekly basis and at least one set shall be available on the jobsite at all times. Changes from the contract plans which are made in the work or

additional information which might be uncovered in the course of construction shall be accurately and neatly recorded as they occur by means of details and notes. The working and final as-built drawings shall show, but shall not be limited to, the following information:

(a) The actual location, kinds and sizes of all sub-surface utility lines. In order that the location of these lines and appurtenances may be determined in the event the surface openings or indicators become covered over or obscured, the as-built drawings shall show, by offset dimensions to two permanently fixed surface features, the end of each run including each change in direction. Valves, splice boxes and similar appurtenances shall be located by dimensioning along the utility run from a reference point. The average depth below the surface of each run shall also be recorded.

(b) Correct grade, elevations, cross section, or alignment of roads, earthwork, structures or utilities if any changes were made from contract plans.

(c) Changes in details of design or additional information obtained from working drawings specified to be prepared or furnished by the Contractor; including but not limited to fabrication, erection, installation plans and placing details, pipe sizes, insulation material, and dimensions of equipment foundations.

(d) The topography, invert elevations and grades of drainage installed or affected as part of the project construction.

(e) Changes or modifications which result from the final inspection.

(f) Where contract drawings or specifications present options, only the option selected for construction shall be shown on the final as-built prints.

(g) Systems designed or enhanced by the Contractor, such as vault configuration and installation details.

2. Drawing Preparation

(a) The as-built drawings shall be modified as may be necessary to correctly show the features of the project as it has been constructed by bringing the contract set into agreement with approved working as-built prints, and adding such additional drawings as may be necessary. Additional drawings generated by the Contractor shall be *.dwg files in AutoCAD (R14 or earlier) electronic format. The working as-built marked prints shall be neat, legible and accurate. The following color convention shall be used for the working as-built drawings: (1) red for additions, (2) green for deletions, and (3) blue for comments or notes.

(b) These drawings are part of the permanent records of this project and shall be returned to the Contracting Officer after approval by the Government. Any drawings damaged or lost by the Contractor shall be satisfactorily replaced by the Contractor at no expense to the Government.

(c) One set of the field as-built drawing(s), showing the previous two week progress changes, shall be submitted to the Government on a bi-weekly basis. The bi-weekly as-built drawing submittal shall be marked either "As-Built" drawing denoting no revisions on the sheet or "Revised As-Built" denoting one or more revisions, followed by the name of the Contractor in letters at least 10 mm high. The Government will incorporate these changes into the electronic files, and return to the Contractor for their concurrence.

(d) Within seven days of final construction completion, the remaining complete set of working as-built drawings shall be submitted to the Government for approval. Within 14 calendar days after Government approval of all of the working as-built drawings for a phase of work, the Contractor shall submit corrected as-builts, if required.

3. Final As-Built Drawing Submittals

The Government reserves the right to reject any mark-up drawing it deems inadequate. Paper prints, drawing files and storage media submitted will become the property of the Government upon final approval. Failure to submit final as-built drawing files and marked prints as specified shall be cause for withholding any payment due the Contractor under this contract. Approval and acceptance of final as-built drawings shall be accomplished before final payment is made to the Contractor.

4. As-Built Record of Equipment and Materials Submittal

(a) The Contractor shall furnish one copy of preliminary record of equipment and materials used on the project 14 calendar days prior to final inspection. This preliminary submittal will be reviewed and returned within 4 calendar days after final inspection with Government comments.

(b) Two sets of final record of equipment and materials shall be submitted 14 calendar days after final inspection. The designations shall be keyed to the related area depicted on the contract drawings. The record shall list the following data:

RECORD OF DESIGNATED EQUIPMENT AND MATERIALS DATA				
Description	Specification Section	Manufacturer and Catalog, Model, and Serial Number	Composition and Size	Where Used

(c) Pipe and Equipment - The Contractor shall furnish equipment shop drawings and support system detail drawings showing piping systems and appurtenances, such as mechanical joints, valves, local indicators and hangers, including a complete list of equipment and materials. As-built drawings showing pipe anchors and guides, and layout of piping systems relative to other parts of the work including clearances for maintenance and operation. As-built piping and instrumentation diagrams (P&IDs) identifying and labeling equipment, instrumentation, valves, vents, drains, and all other inline devices.

(d) Cable System - The Contractor shall furnish an as-built location map for the cable leak detection system in double containment piping systems indicating the installed system configuration and sensing string layout. Marks in feet along the length of the cable shall be provided as references to locate leaks.

E. Contract Close-Out Submittals

Contractor shall furnish the following documentation no later than 30 days following completion of construction. Final payment will not be made until all close-out submittals are received by the Contracting Officer, and deemed to be satisfactory.

1. Statement of Satisfactory Installation - The Contractor shall furnish a signed statement certifying that the installation is satisfactory and in accordance with the contract drawings and specifications and the manufacturer's prescribed procedures and techniques, upon completion of the project and before final acceptance.

2. Operation and Maintenance (O&M) Manuals - The Contractor shall furnish four copies each of O&M manuals in indexed booklet form. Operation manuals shall detail the step-by-step procedures required for specialized startup, operation and shutdown of piping systems, and shall include the manufacturer's name, model number, parts list and brief description of piping equipment such as valves and other appurtenances and their basic operating features. Maintenance manuals shall list routine maintenance procedures and troubleshooting guides for the equipment, and shall include piping layout and valve locations.

3. Warranty Management Plan - The Contractor shall submit warranty information for all applicable construction and equipment. This submittal shall include a list for each warranted equipment, item, feature of construction or system indicating:

   (a) Name of item.
   (b) Model and serial numbers.
   (c) Location where installed.
   (d) Name and phone numbers of manufacturers or suppliers.
   (e) Names, addresses and telephone numbers of sources of spare parts.

(f) Warranties and terms of warranty. This shall include one-year overall warranty of construction. Items which have extended warranties shall be indicated with separate warranty expiration dates.
(g) Cross-reference to warranty certificates as applicable.
(h) Starting point and duration of warranty period.
(i) Summary of maintenance procedures required to continue the warranty in force.
(j) Cross-reference to specific pertinent Operation and Maintenance manuals (if applicable).

4. Pipe Schedule - The Contractor shall furnish a list of piping systems, pressure ratings and source of supply for each piping system broken out by material, size and application as indicated on the contract drawings. The Contractor shall furnish a list of any special tools necessary for each piping system and appurtenances furnished for adjustment, operation, maintenance and disassembly of the system.

5. Valve Schedule - The Contractor shall furnish a list of valve materials, pressure ratings, valve operator's materials, electrical service, location, source of supply, and reference identification as indicated in the contract drawings. The Contractor shall furnish a list of any special tools necessary for each valve type and appurtenances furnished for adjustment, operation, maintenance and disassembly.

6. Double Containment Piping System - The Contractor shall furnish the manufacturer's engineering end load calculations for anchors in double containment piping systems.

- END -

ATTACHMENT 2: References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z400.1 (1993) Hazardous Industrial Chemicals - Material Safety Color Data Sheets – Preparation

AMERICAN PETROLEUM INSTITUTE (API)

API Spec 6D (1994; Supple 1 June 1996; Supple 2 Dec 1997) Pipeline Valves (Gate, Plug, Ball, and Check Valves)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53 (1999b) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A 123/A 123M (1997ael) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A 153/A 153M (1998) Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A 181/A 181M (1995b) Carbon Steel, Forgings for General-Purpose Piping

ASTM A 307 (1997) Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength

ASTM C 920 (1998) Elastomeric Joint Sealants

ASTM D 638 Standard Test Method for Tensile Properties of Plastics

ASTM D 696 Standard Test Method for Coefficient of Thermal Expansion of Plastics Between (-30°)C and 30°C

ASTM D 746 Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact

ASTM D 790 Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

ASTM D 1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer

ASTM D 1248 (1984; R 1989) Polyethylene Plastics Molding and Extrusion Materials

ASTM D 1505 Standard Test Method for Density of Plastics by the Density-Gradient Technique

ASTM D 1556 (1990; R 1996) Density and Unit Weight of Soil in Place by the Sand-Cone Method

ASTM D 1557 (1998) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu. m.))

ASTM D 2167 (1994) Density and Unit Weight of Soil in Place by the Rubber Balloon Method

ASTM D 2487 (1998) Classification of Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D 2922 (1996) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

ASTM D 3017 (1988; R1996el) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)

ASTM D 1598 (1986; R 1997) Time-to-Failure of Plastic Pipe Under Constant Internal Pressure

ASTM D 1603 Standard Test Method for Carbon Black in Olefin Plastics

ASTM D 1693 (1998) Environmental Stress-Cracking of Ethylene Plastics

ASTM D 1928 Standard Practice for Preparation of Compression-Molded Polyethylene Test Sheets and Test Specimens

ASTM D 2321 Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

ASTM D 2447 (1999) Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter

ASTM D 2657 (1997) Heat Fusion Joining Polyolefin Pipe and Fittings

ASTM D 2683 (1998) Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing

ASTM D 2774 (1994) Underground Installation of Thermoplastic Pressure Piping

ASTM D 2837 Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials

ASTM D 3035 (1995) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter

ASTM D 3139 (1998) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

ASTM D 3261 (1997) Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing

ASTM D 3350 Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

ASTM D 3892 (1998) Packaging/Packing of Plastics

ASTM E 515 (1995) Leaks Using Bubble Emission Techniques

ASTM F 714 Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter

ASTM F 1055 (1998) Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing

ASTM F 1759-97 Standard Practice for Design of High-Density Polyethylene (HDPE) for Subsurface Applications

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1 (1983; R 1992) Pipe Threads, General Purpose (Inch)

ASME B16.5 (1996; B16.5a) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24

ASME B16.9 (1993) Factory-Made Wrought Steel Buttwelding Fittings

ASME B16.11 (1996) Forged Fittings, Socket-Welding and Threaded

ASME B16.21 (1992) Nonmetallic Flat Gaskets for Pipe Flanges

AMERICAN WATER WORKS ASSOCIATION (AWWA)

C218 Coating the Exterior of Aboveground Steel Water Pipelines and Fittings

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25 (1998) Standard Marking System for Valves, Fittings, Flanges and Unions

MSS SP-58 (1993) Pipe Hangers and Supports - Materials, Design and Manufacture

MSS SP-69 (1996) Pipe Hangers and Supports - Selection and Application

MSS SP-72 (1992) Ball Valves with Flanged or Butt-Welding Ends for General Service

MSS SP-89 (1998) Pipe Hangers and Supports - Fabrication and Installation Practices

NACE INTERNATIONAL (NACE)

NACE RP0185 (1996) Extruded, Polyolefin Resin Coating Systems with Soft Adhesives for Underground or Submerged Pipe

NACE RP0274 (1998) High Voltage Electrical Inspection of Pipeline Coatings Prior to Installation

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 49 (1994) Hazardous Chemicals Data

NFPA 325-1 (1994) Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids

PLASTICS PIPE INSTITUTE (PPI)

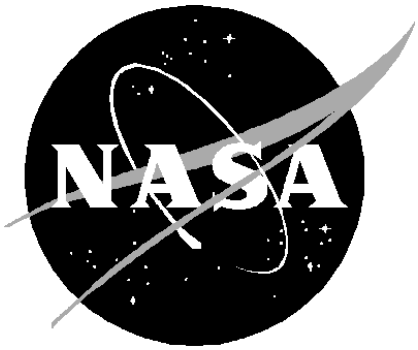
PPI TR31-9/79 Underground Installation of Polyolefin Piping

PPI AW-32 TR21 (1974) Thermal Expansion and Contraction of Plastic Pipe

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE 3 (1994) Commercial Blast Cleaning

ATTACHMENT 3: JSC Form 262



NASA – JOHNSON SPACE CENTER

WHITE SANDS TEST FACILITY

GROUND WATER TREATMENT SYSTEM FOR

PLUME-FRONT STABILIZATION

May 6, 2002

EXTRACTION PUMPS, DISCHARGE PIPING AND INJECTION PIPING TECHNICAL SPECIFICATIONS

TABLE OF CONTENTS

I. General....3
A. Scope....3
B. Qualifications....3
C. Certification and Warranty....4
D. Submittals....4
1. General....4
2. Data....5
3. Drawings....6
4. Statements....6
5. Reports....7
E. References....7
II. Material....10
A. Pumping Unit....10
1. General Design Requirements....10
2. Computations and Discharge System....10
3. Operating Conditions....10
4. Performance Requirements....10
5. Capacities....11
6. Submersible Pump Design....11
7. Materials....13
8. Safety Cable....14
9. Check Valves....14
10. Air Release and Vacuum Breakers....14
B. Injection Piping....15
C. Submersible Level Element and Transmitter....15
1. General....15
2. Performance and Features:....15
3. Suggested Manufacturer and Model....16
III. Execution....17
A. Pumping System....17
1. Submersible Pump – Factory Tests....17
2. Attachment at Surface....18
3. Pumping Unit Installation....18
4. Pump Field Tests....20
B. Injection Piping....20
1. Installation....20
C. Submersible Level Element and Transmitter....21
1. Installation....21
IV. Best Value Evaluation Criteria....22

LIST OF ATTACHMENTS

Attachment 1 WSTF Groundwater Treatment Facility Project Location

Drawing 652-C-01, Project Location

Attachment 2 Extraction and Injection Well Construction Diagrams

Drawing 653-C-03, PFE-1 Well Construction Diagram
Drawing 654-C-03, PFE-2 Well Construction Diagram
Drawing 655-C-03, PFE-3 Well Construction Diagram
Drawing 656-C-03, PFE-4A Well Construction Diagram
Drawing 657-C-03, PFE-5 Well Construction Diagram
Drawing 658-C-03, PFE-7 Well Construction Diagram
Drawing 660-C-02, PFI-1 Well Completion Diagram
Drawing 661-C-02, PFI-2 Well Completion Diagram
Drawing 662-C-02, PFI-3 Well Completion Diagram
Drawing 663-C-02, PFI-4 Well Completion Diagram

Attachment 3 Pump Performance, Design and Hydraulic Data

Attachment 4 Wellhead Details

Drawing 653-M-01, Extraction Well PFE-1 Mechanical Details
Drawing 654-M-01, Extraction Well PFE-2 Mechanical Details
Drawing 655-M-01, Extraction Well PFE-3 Mechanical Details
Drawing 656-M-01, Extraction Well PFE-4A Mechanical Details
Drawing 657-M-01, Extraction Well PFE-5 Mechanical Details
Drawing 658-M-01, Extraction Well PFE-7 Mechanical Details
Drawing 660-M-01, Injection Well PFI-1 Mechanical Details
Drawing 661-M-01, Injection Well PFI-2 Mechanical Details
Drawing 662-M-01, Injection Well PFI-3 Mechanical Details
Drawing 663-M-01, Injection Well PFI-4 Mechanical Details

Attachment 5 Electrical Details

Drawing 653-E-02, Extraction Well PFE-1 Electrical Details
Drawing 654-E-02, Extraction Well PFE-2 Electrical Details
Drawing 655-E-02, Extraction Well PFE-3 Electrical Details
Drawing 656-E-02, Extraction Well PFE-4A Electrical Details
Drawing 657-E-02, Extraction Well PFE-5 Electrical Details
Drawing 658-E-02, Extraction Well PFE-7 Electrical Details

Attachment 6 JSC Form 262 Transmittal of Shop Drawings, Equipment Data, Material Samples, or Manufacturer's Certificates of Compliance for Approval

I. General

A. Scope

This specification defines the requirements for the following materials and services to be supplied to the NASA-Johnson Space Center White Sands Test Facility:

1. materials, installation and testing of submersible pumps, associated discharge piping, check valves, power cables, and vent-vacuum valves for six [6] existing groundwater extraction wells;
2. materials and installation of injection piping for four [4] existing injection wells, and;
3. materials and installation of ten [10] pressure transducers (one per each extraction and injection well).

Well construction diagrams for the six [6] extraction wells (PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, and PFE-7) and the four [4] injection wells (PFI-1, PFI-2, PFI-3, and PFI-4) are presented in Attachment 2. The design and performance requirements and hydrologic measurements for the extraction and injection wells are presented in Attachment 3. Wellhead and electrical details are presented in Attachments 4 and 5.

WSTF is located 18 miles northeast of Las Cruces, New Mexico, with access provided through U. S. Highway 70. Maps of WSTF's location and the specific well locations with respect to WSTF's developed areas are presented in Attachment 1. The project is located in a remote area, Sections 4 and 5 of T21S, R3E and Section 32 of T20S, R3E of Attachment 1. A light duty gravel road (the WSTF Well Road) provides access to the general project vicinity.

B. Qualifications

The pump installation contractor's ("Contractor") work experience shall include experience in the supply, installation and testing of four-inch [4] to six-inch [6] diameter submersible pumps in 500-foot to 1000-foot-deep groundwater wells. The Contractor shall supply a list of installations at which the Contractor has installed pumps similar to those specified.

The Contractor shall furnish a qualified installation engineer/inspector who is knowledgeable and experienced with the installation, testing, and start-up procedures for submersible pumps and the associated equipment specified. The installation engineer/inspector shall have training and experience as recommended by the pump Manufacturer. The installation engineer shall be responsible for providing complete and correct direction during installation, initial starting, and subsequent operation of equipment until field tests are completed

The Contractor shall have overall responsibility to supply the pumping unit (submersible pump/motor, cables, and accessories) that meet the requirements of this specification. Additionally, the Contractor is the sole responsible party during start-up, installation, and performance evaluation.

The Contractor shall comply with all applicable OSHA, NASA, JSC and WSTF safety and security requirements. All Contractor safety training, equipment and work practices are subject to review and approval by WSTF Safety personnel and the WSTF

Environmental Department. Specific safety compliance requirements include, but are not limited to, a one-time, approximately one hour site safety and security briefing required for all Contractor personnel, and confined space (wellhead vaults) access. Contractor employees required to enter any confined space, including extraction and injection well vaults must supply proof of 29 CFR 1910.146 “Confined Spaces” training.

C. Certification and Warranty

The certification and warranty shall contain a written certification statement from the installation engineer/inspector attesting to the correct installation and operation of the pumping unit at each extraction well site and to the correct installation of the injection piping at each injection well site. The warranty shall define a warranty period and provide allowance for credit, repair or replacement of any defective components or material. The Contractor shall provide a warranty that guarantees the installation of the pumping unit and injection piping against defects or failures due to improper installation. At minimum, any defects or failures due to improper installation shall be repaired by the Contractor at no cost to the Government for a [1] one-year period from the date of installation.

D. Submittals

1. General

Government approval is required for all submittals with a "GA" designation (due dates listed below); submittals having an "FIO" designation are for information only and shall be submitted no later than thirty [30] calendar days after Government issuance of the Notice of Award.

Each submittal shall be permanently marked to identify it by contract number; transmittal date; Contractor's, Subcontractor's, and supplier's name, address(es) and telephone number(s); submittal name; specification or drawing reference; and similar information to distinguish it from other submittals. Submittal packages shall include a properly executed JSC Form 262; a copy of this form is shown in Attachment 6.

Contracting Officer will review submittals and provide pertinent notation within 20 calendar days after date of submission. Submittals will be returned to the Contractor with one or more of the following notations:

a. Submittals marked "Approved as Submitted" authorize the Contractor to proceed with the work covered.

b. Submittals marked "Approved as Noted" authorize the Contractor to proceed with the work covered provided he takes no exception to the corrections. Resubmission is not required. Notes shall be incorporated prior to submission of the final submittal.

c. Submittals marked "Return for Correction" require the Contractor to make the necessary corrections and revisions and to re-submit them for approval in the same routine as before, prior to proceeding with any of the work depicted by the submittal.

d. Submittals marked "Disapproved" indicate noncompliance with the contract requirements and shall be re-submitted with appropriate changes. No work requiring a submittal shall be accomplished until the submittals are approved or approved as noted.

e. Submittals marked "Acknowledge receipt" require the Contractor or supplier to provide the Contracting Officer a written acknowledgement of receipt of letter, material or submittal.

Contractor shall make corrections required by the Contracting Officer. If the Contractor considers any correction or notation on the returned submittals to constitute a change to the contract drawings or specifications; notice as required under the clause entitled, "Changes" shall be given to the Contracting Officer. Approval of the submittals by the Contracting Officer shall not be construed as a complete check, but will indicate only that the general method of construction and detailing is satisfactory. Contractor shall be responsible for the dimensions and design of connection details and construction of work. Failure to point out deviations may result in the Government requiring rejection and removal of such work at the Contractor's expense.

If changes are necessary to approved submittals, the Contractor shall make such revisions and submission of the submittals in accordance with the procedures above. No item of work requiring a submittal change shall be accomplished until the changed submittals are approved.

2. Data

a) Equipment Supplies and Performance; GA.

Within fifteen [15] calendar days of Notice of Award, submit five [5] copies of pump curves, final motor horsepower rating, and sufficient hydraulic computations to substantiate pump selection and demonstrate that the selected pump can meet the project design and operating requirements as specified. The pump capacity-head curve shall indicate efficiency, bhp (brake horsepower), and NPSHR. Motor characteristic curves or tabulated data (test or calculated) shall indicate the speed, power factor, efficiency, current, and kilowatt input, all plotted or tabulated against percent load as abscissas.

This submittal shall also include manufacturer information sheets for each pump and motor, and other relevant information for the machinery, injection piping, and other equipment contemplated to be incorporated into the work.

If deviation from specified materials is proposed by the Contractor, submit complete specifications for the proposed deviating materials.

b) Spare Parts; FIO.

Submit four [4] copies of Manufacturers complete parts list showing all parts, spare parts, and bulletins for pump. Clearly show all details, parts, and adequately describe parts or have proper identification marks. Photographs or catalog cuts of components may be included for identification.

c) Instructions - Installation Instruction Manual; GA.

Within thirty [30] calendar days of Contractor receipt of the Notice of Contract Award, submit five [5] copies of a typed and bound manual describing procedures that will be followed by the installation engineer in assembling, installing, and dry- and wet-testing the pump. The Contracting Officer may request changes or modifications to the manuals deemed necessary or desirable.

3. Drawings

a) Submersible Pump; GA.

Within thirty [30] calendar days of Notice of Award, submit five [5] copies of drawings listed below. Dimensions shall be in English with metric conversion.

(1) Outline drawings of the pump showing dimensions and weight of the pump/motor, and total estimated hanging weight.
(2) Drawings showing details and dimensions of pump mounting design and layout including any embedded items.
(3) Cross-sectional drawings of the pump, showing each component, should show major or complicated sections of the pump in detail. On each drawing indicate an itemized list of components showing type, grade, class of material used, and make and model of the standard component used.

b) Pump Safety Cable; GA.

Within thirty [30] calendar days of Notice of Award, submit two [2] copies of cut sheets, specifications, or similar descriptive documents, for the steel pump support cables. This cable information shall be accompanied with a description and scaled engineering drawings showing the Contractor-proposed method of safety cable attachment at the wellhead.

4. Statements

a) Factory Test Plan; GA.

Submit a description of the factory test setup and test procedure proposed. Submit five [5] copies of the Factory Test Plan within thirty [30] calendar days of Contractor receipt of the Notice of Contract Award. Submit data and drawings sufficient to demonstrate that testing is in compliance with HI 2.6.

b) Field Test Plan; GA.

Submit a description of the field test setup and test procedure proposed. Submit five [5] copies of the Field Test Plan within thirty [30] calendar days of Contractor receipt of the Notice of Contract Award.

5. Reports

a) Factory Test Report; GA.

Within twenty [20] calendar days of completion of the Factory Test Plan procedures, submit five [5] bound copies of a report covering test setup and performance test results. The factory test report shall include the information required by paragraph III.A.1.b.

b) Field Test; GA.

Submit five [5] copies of the field test report within twenty [20] calendar days of completion of the Field Test Plan procedures.

c) Installation Report; GA.

Submit the installation report and written certification as required in Section III. A. 3. This report shall be submitted within twenty [20] calendar days following completion of all pump installation activities.

d) Operation and Maintenance Manuals - Operating and Maintenance Instruction; GA.

Within twenty [20] calendar days of completion of all field tests, submit five [5] copies of the manual containing complete information on operation, lubrication, adjustment, routine and special maintenance disassembly, repair, reassembly, and trouble diagnostics of pump and auxiliary equipment. The operation and maintenance manual shall be printed on good quality 8 1/2 in. by 11 in. paper, bound separately from the parts list, and bound between a flexible, durable cover. Drawings incorporated in manual may be reduced to page size provided they are clear and legible, or they may be folded into the manual to page size. Photographs or catalog cuts of components may be included for identification.

E. References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABEMA)

ABEMA Std 9 (1990) Load Ratings and Fatigue Life for Ball Bearings

ABEMA Std 11(1990) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S2.19 (1989; R 1992) Mechanical Vibration - Balance Quality Requirements of Rigid Rotors, Part 1: Determination of Permissible Residual Unbalance

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 27/A 27M (1995) Steel Castings, Carbon, for General Application

ASTM A 36/A 36M (1997a) Carbon Structural Steel

ASTM A 48 (1994a) Gray Iron Castings

ASTM A 48M (1994) Gray Iron Castings (Metric)

ASTM A 108 (1999) Steel Bars, Carbon, Cold Finished, Standard Quality

ASTM A 167 (1996) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

ASTM A 176 (1997) Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip

ASTM A 242/A 242M (1998) High-Strength Low-Alloy Structural Steel

ASTM A 276 (1998b) Stainless Steel Bars and Shapes

ASTM A 297/A 297M (1997; R 1998) Steel Casting, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application

ASTM A 312/A 312M (1999) Seamless and Welded Austenitic Stainless Steel Pipes

ASTM A 516/A 516M (1990; R 1996) Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service

ASTM A 576 (1990b; R 1995) Steel Bars, Carbon, Hot-Wrought, Special Quality

ASTM A 668/A 668M (1996) Steel Forgings, Carbon and Alloy, for General Industrial Use

ASTM B 148 (1997) Aluminum-Bronze Sand Castings

ASTM B 584 (1998a) Copper Alloy Sand Castings for General Applications

ASME INTERNATIONAL (ASME)

ASME B46.1 (1995) Surface Texture (Surface Roughness, Waviness, and Lay)

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1 (1998) Structural Welding Code - Steel

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C208 (1996) Dimensions for Fabricated Steel Water Pipe Fittings

HYDRAULIC INSTITUTE (HI)

HI 2.1-2.5 (1994) Vertical Pumps

HI 2.6 (1994) Vertical Pump Test

HI 9.1-9.5 (1994) Pumps - General Guidelines

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (1993; Rev 1-1993; Rev 2-1995; Rev 3-1996; Rev 4-1997) Motors and Generators

NEMA WC 7 (1988; R 1991; Rev 1-1991; Rev 2-1992; Rev 3-1996) Cross-Linked-Thermosetting- Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

II. Material

A. Pumping Unit

1. General Design Requirements

A pumping unit will consist of: a submersible pump complete with submersible motor, discharge piping and required fittings, vent/vacuum valve, electrical power cable, a safety cable, and any other hardware required for proper installation. The pump/motor shall be electrically operated and supported by the discharge pipe (also referred to as "drop pipe").

One pumping unit will be installed at each of the six (6) extraction well locations (PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, and PFE-7) presented in Attachment 1. Well construction diagrams are presented in Attachment 2. The wells are fully developed and free of cuttings and sand. The specific design and performance requirements and hydrologic measurements for each extraction well are presented in Attachment 3. Wellhead and electrical details are presented in Attachments 4 and 5.

Except as otherwise stated or noted, the term pump refers to a pump/motor integral unit. The general design requirements are:

a) The pump shall meet the requirements as specified throughout this document, including Attachment 3.
b) The pump shall, as a minimum, meet the applicable design, material, and manufacture requirements of this specification and Hydraulic Institute standards (HI), HI 2.1-2.5, "Vertical Pumps", and HI 9.1-9.5, "Pumps – General Guidelines".

2. Computations and Discharge System

Head losses within the pumping unit shall be determined by the Contractor.

3. Operating Conditions

The pump shall be capable of operating in the dry (for the purpose of conducting operating checks) for short periods of time **or** as stated in the Manufacturer's operating instructions. The pump Manufacturer shall establish and state in the operating manual the procedures for starting and stopping the pumps, including any sequential operations.

4. Performance Requirements

a) The pump shall be capable of operating without instability over the required range of head.

b) The pump shall have a hydraulic efficiency of not less than 65 percent at total design head.

5. Capacities

    a) Head and volumetric flow requirements are presented in Attachment 3.

6. Submersible Pump Design

    a) Acceptable pumps are listed in Attachment 3.

    b) Motor

The motor shall be submersible and conform to the requirements of NEMA MG 1. The motor shall be sized to avoid overload when operating at any point along the characteristic curve of the pump. The motors shall be 3-phase, 60-Hz, 480 V, squirrel cage induction type, NEMA Design B Type. The stator windings and stator leads shall be insulated with a moisture-resistant Class F insulation with temperature resistance of 311 degrees F. The service factor shall be 1.0. The temperature rise above ambient for continuous full load rated conditions and for the class of insulation used shall not exceed the values in NEMA MG 1. The motor shall be rated for continuous duty when submerged and shall also be capable of operation in the dry for short periods of time for testing and maintenance purposes.

Per minimum motor efficiency standards which were issued as final regulations by the Secretary of Energy in 10 CFR Part 431, electric motors manufactured alone or as a component of another piece of equipment shall have a nominal full load efficiency of not less than that indicated below:

Number of Poles	Nominal Full Load Efficiency					
	Open Motors			Enclosed Motors		
	6	4	2	6	4	2
Motor Horsepower/Standard Kilowatt Equivalent						
1/.75……..……..	80.0	82.5	--	80.0	82.5	75.5
1.5/1.1……..……	84.0	84.0	82.5	85.5	84.0	82.5
2/1.5……..….	85.5	84.0	84.0	86.5	84.0	84.0
3/2.2……..….	86.5	86.5	84.0	87.5	87.5	85.5
5/3.7……..….	87.5	87.5	85.5	87.5	87.5	87.5
7.5/5.5……..….	88.5	88.5	87.5	89.5	89.5	88.5
10/7.5……	90.2	89.5	88.5	89.5	89.5	89.5
15/11……	90.2	91.0	89.5	90.2	91.0	90.2
20/15……	91.0	91.0	90.2	90.2	91.0	90.2
25/18.5……..….	91.7	91.7	91.0	91.7	92.4	91.0
30/22……	92.4	92.4	91.0	91.7	92.4	91.0
40/30……	93.0	93.0	91.7	93.0	93.0	91.7
50/37……	93.0	93.0	92.4	93.0	93.0	92.4
60/45……	93.6	93.6	93.0	93.6	93.6	93.0
75/55……	93.6	94.1	93.0	93.6	94.1	93.0
100/75……..….	94.1	94.1	93.0	94.1	94.5	93.6
125/90……..……	94.1	94.5	93.6	94.1	94.5	94.5
150/110……	94.5	95.0	93.6	95.0	95.0	94.5
200/150……..……	94.5	95.0	94.5	95.0	95.0	95.0

Starting torque shall be sufficient to start the pump, but in no case less than 60 percent of full-load torque. Break-down torque shall not be less than 200 percent of full-load torque. Thrust bearing support shall have sufficient strength and rigidity to support the weight of the entire rotating element of the motor, pump impeller and shaft, and the hydraulic thrust.

c) Cable

Power and instrumentation cable (if applicable) shall be specifically designed for use with a submersible pump application and shall conform to the requirements of NEMA WC 7. Submersible cable shall be suitable for continuous immersion in water at the maximum depth encountered. The power cable shall be continuous and not spliced. Power cable shall have an ampacity of not less than 125 percent of the motor full load current and shall be sized such that the voltage drop is less than 10% of the nominal voltage rating. The minimum power cable length shall correspond to the pump intake depths shown in the table below, plus twenty (20) feet:

Well	**Depth to Pump Intake** (from grade)	**Minimum Cable Length**
PFE-1	525 feet	545 feet
PFE-2	515 feet	535 feet
PFE-3	522 feet	542 feet
PFE-4A	575 feet	595 feet
PFE-5	650 feet	670 feet
PFE-7	475 feet	495 feet

Power and instrumentation cables (if applicable) shall enter the motor through a sealing system that prevents water entry into the unit and provides strain relief. The cable entry may be comprised of rubber bushings, flanked by stainless steel washers, having a close tolerance fit against the cable outside diameter and the entry inside diameter for sealing by compression of the bushing, or the entry may be sealed by other gland compression methods.

d) Motor Starters and Pump Overload Protection, Control, and Monitoring

(1) Motor starters will be furnished by others and are ***not*** part of this procurement. <u>For information purposes only</u>: Motor Starters to be of the Solid-State Reduced Voltage (SSRV)/ Soft Start type for motors rated 75 horsepower and above; the overload relay shall be NEMA ICS 2, solid state type with adjustable trip settings. Motor Starters of the Full Voltage, Non-Reversing (FVNR) type for motors rated below 75 horsepower; the overload relay shall be NEMA ICS 2, solid state type with adjustable trip settings.
(2) Unless required by the manufacturer, the extraction pump motors shall not be provided with self-resetting bi-metallic thermal overloads in the motor windings.

7. Materials

a) Submersible Pumps

The extraction well pumps shall be stainless steel submersible pumps with submersible pump motors. All major pump components (pump housing, impeller, pump shaft, etc.) shall be stainless steel or other Government-approved corrosion resistant materials. Material selection shall be guided by HI 9.1-9.5 for corrosion, erosion, and abrasion resistance. Deviations from the specified materials shall be submitted in accordance with paragraph SUBMITTALS. The materials of construction shall comply with the following, as applicable:

PART	MATERIAL
Impeller	304 Stainless steel
Pump shaft	431 Stainless steel
Impeller seal ring	Manufacturer's standard
Bolts, key, etc.	Stainless steel
O-rings	Nitrile rubber
Mechanical seals	316 Stainless steel/tungsten carbide

(1) Designated Material

Designated materials shall conform to the following specifications, grades, and classifications.

MATERIALS	SPECIFICATION, GRADE, CLASS
Aluminum-Bronze Castings	ASTM B 148, Alloy No. C95500
Cast Iron	ASTM A 48, Class Nos. 30A, 30B, and 30C
Cast Steel, annealed	ASTM A 27/A 27M Grade 65-35
Coal Tar Protective Coatings	AWWA C203
Cold-Rolled Steel Bars	ASTM A 108, min, Wt. Strm 65,000 psi
Copper Alloy Castings	ASTM B 584, Alloy No. C93700
Corrosion-Resistant Alloy Castings	ASTM A 297/A 297M, Grade CA-15, CAGNN and CF-8M
Dimensions for Steel Water Pipe Fittings	AWWA C208
Hot-Rolled Stainless	ASTM A 576, Graded G10200, G10450, and G11410
Ring Flanges	AWWA C207, Class B
Seamless and Welded Austenitic Stainless Steel Pipe	ASTM A 312/A 312M
Stainless Bars and Shapes	ASTM A 276, Grades S30400 and S41000
Steel Forging	ASTM A 668/A 668M, Class F
Steel Pipe 6 in. and Larger	AWWA C200
Steel Plates, Pressure Vessel	ASTM A 516/A 516M, Grade 55
Steel Plate	ASTM A 242/A 242M
Stainless Steel Plate	ASTM A 167, UNS S30400 or ASTM A 176, UNS S40500
Quality Steel	ASTM A 36/A 36M
Surface Texture	ASME B46.1

b) Pump Discharge Pipe

The pump discharge pipe shall be ASTM A500 or A501 schedule 40 carbon steel pipe joined with NPT threaded couples, or as recommended by the pump Manufacturer and/or pump installation Contractor. Each pipe section length shall not exceed twenty-two [22] feet. Each assembled discharge pipe shall be able to support the pump, pipe, water, safety cable, and power cable during normal operation (Attachment 3). The pipe sizes and lengths for each well location are listed in Attachments 3 and 4.

The design, manufacture and installation of the discharge pipe shall be in accordance with the pump Manufacturer's instructions. For purposes of performance and this specification it shall be treated as part of the pumping unit. The discharge pipe shall be of such size to accommodate the dimensions of the pump supplied in accordance with the Manufacturer's requirements. A locking device shall be provided that prohibits rotational movement of the pump relative to the discharge pipe. The pumps shall be removable for inspection or service.

8. Safety Cable

The pumping unit shall be secured with a steel safety cable assembly. The Contractor shall recommend a method of securing the steel safety cable at the wellhead. All methods shall be submitted to and approved by the Government prior to hardware purchase and installation. The safety cable assembly shall be in accordance with industry standards and meet the applicable requirements of the Occupational Safety and Health Administration (OSHA) and American National Standards Institute (ANSI). The steel safety cable for PFE-5 shall be no less than 0.375-inch diameter; all other wells shall utilize at least a 0.5-inch diameter steel safety cable. Wellhead details are presented in Attachment 4.

9. Check Valves

The pumping unit shall be designed and installed to prevent damage to the submersible pump and/or motor. Check valves shall be installed per the pump Manufacturer's recommendations to prevent potential damage due to backspin, upthrust, water hammer, pumping against a closed valve, etc.

10. Air Release and Vacuum Breakers

a) The air release - vacuum breakers shall be Golden Anderson one-inch kinetic air/vacuum valves (stock #930) or equivalent.

b) One air release - vacuum breaker shall be located as indicated on the contract drawings. The valve shall be a minimum 125 lb. class.

c) The air and vacuum valve shall automatically exhaust air during the filling of a system while allowing air to re-enter during draining or when vacuum occurs.

d) The valve shall be cast iron for the valve body; stainless steel for the internal linkage, float, and float stem; and Buna-N for the needle and seat.

e) End connections shall be one inch; bushings and adapters shall be utilized as required to thread the air release/vacuum breakers into

adjacent piping. All air release and vacuum breakers shall be plumbed to an equal size ball valve (allowing isolation of the air release/vacuum breaker from the piping system).

B. Injection Piping

Injection piping shall be installed at the four [4] injection well locations (PFI-1, PFI-2, PFI-3 and PFI-4) presented in Attachment 1.

Well construction diagrams for the four [4] injection wells (PFI-1, PFI-2, PFI-3, and PFI-4) are presented in Attachment 2. The wells are fully developed and free of cuttings and sand. The design and performance requirements and hydrologic measurements for each injection well are presented in Attachment 4. Wellhead details are presented in Attachments 4.

The injection pipe shall be ASTM A500 or A501 schedule 40 carbon steel pipe joined with NPT threaded couples. The Contractor may recommend a different injection piping material, along with a rationale as to why the different material is superior to schedule 40 carbon steel pipe. The Contracting Officer reserves the right to accept or reject Contractor-recommended materials. The pipe sizes and lengths for each well location are listed in Attachments 3 and 4.

C. Submersible Level Element and Transmitter

1. General

   a) Function: Measure well subgrade water level by means of differential pressure and transmit a signal proportional to the level.
   b) Type: Electronic, piezoresistive-micromachined silicon strain gauge, two wire transmitter. Cable suspended sensor.
   c) Operating conditions: Transmitter shall operate in water containing low levels of industrial contaminants.
   d) Warranty: Sensor and transmitter shall be warranted against corrosion for a period of five [5] years.

2. Performance and Features:

a) Range: Noted actual working range shall lie between 40 percent and 80 percent of the maximum adjustable range. Refer to table below.
b) Accuracy: Plus or minus 0.10 percent of calibrated span.
c) Serviceable sensor.
d) Operating temperature range: Minus 5 degrees F to 140 degrees F.
e) Compensated temperature range: 30 degrees F to 86 degrees F.
f) Relative humidity: 0-100 percent.
g) Materials: Sensor body, 316 stainless steel. Cable-polyurethane jacket with Kevlar reinforced cord.
h) Periodic maintenance or cleaning shall NOT be required to maintain function or accuracy.
i) Signal Interface: Instrument shall be loop powered from 9-32V dc power supply. Output shall be 4-20 ma DC for load impedance of 0-500 ohms minimum over specified range.
j) Sensor shall have reverse polarity protection.
k) The transmitter shall be factory calibrated for the specified range(s) and shall also include provisions for field calibration through non-interactive zero and span adjustments.
l) The Vendor shall supply a sensor cable termination box. The box shall be rated NEMA 4X. All manufacturer-required termination hardware shall be supplied as part of this contract.
m) Minimum sensor cable length: as tabulated below. In no case shall the sensor cable be less than the depth from grade to bottom of injection piping , plus forty [40] feet for injection wells, and depth to pump outlet (from grade), plus ten [10] feet for extraction wells.

Well	Actual Working Head Range	Minimum Sensor Cable Length
PFE-1	0 – 150 feet water	535 feet
PFE-2	0 – 150 feet water	525 feet
PFE-3	0 – 150 feet water	535 feet
PFE-4A	0 – 150 feet water	585 feet
PFE-5	0 – 250 feet water	660 feet
PFE-7	0 – 150 feet water	485 feet
PFI-1	0 – 250 feet water	490 feet
PFI-2	0 – 250 feet water	510 feet
PFI-3	0 – 250 feet water	520 feet
PFI-4	0 – 250 feet water	530 feet

3. Suggested Manufacturer and Model

a) Instrumentation Northwest, Inc.; PS 9800 series or approved equal.

III. Execution

A. Pumping System

1. Submersible Pump – Factory Tests

a) Performance Test

The pumps shall be tested at the Manufacturer's shop to demonstrate that each submersible pump operates without instability and complies with specified performance requirements (gpm at discharge head, ft.) for the six (6) extraction wells (as specified by Attachment 3). Instability is defined when any point in usable range of the head-capacity curve cannot be repeated within three percent. When this occurs, the test shall be rerun. Compliance with specifications will be determined from curves required by the paragraph I.D.2.a. Test procedures, except as herein specified, shall be in accordance with applicable provisions of HI 2.6. The temperature of the water used for testing shall be approximately the same for all tests run and shall be recorded during test runs.

(1) Performance of the Pump

Performance of the pump shall be determined by a series of test points sufficient in number to develop a constant speed curve over the range of total heads corresponding to the requirements of Attachment 3. The test range shall include additional testing at total heads higher and equal to or lower than the total head requirement. Testing shall be inclusive for the speed involved. Test results shall meet all specified conditions of capacity, head, and bhp. In no case shall less than eight [8] points be plotted in the pumping range. If the plot of data indicates a possibility of instability or a dip in the head-capacity curve, a sufficient number of additional points on each side of the instability shall be made to clearly define the head-capacity characteristics.

(2) Test Results

Test results shall be plotted to show the total head, static heads, bhp, and efficiency as ordinates. The results should be plotted against pump discharge in gpm as the abscissa. Curves shall be plotted showing pump performance to a scale that will permit reading the head directly to twenty five [25] feet, capacity to no greater than 500 gpm, efficiency to one percent [1%], and power input to twenty-five [25] bhp. The performance test shall be made with the pump and motor assembled as an operating unit to simulate field installation unless otherwise approved in writing by the Contracting Officer. Readings shall include one point each within two [2] percent of the rated total head, minimum expected head, and maximum expected head. The test shall be conducted in accordance with accepted practices at full speed; and, unless otherwise specified, the procedure and instruments used shall conform to HI 2.6.

b) Factory Test Report

Each factory test report shall include, as a minimum, the following:

(1) Statement of the purpose of test, name of project, contract number, and design conditions. Instances where guaranteed values differ from specified values should be given.
(2) Description of pump and motor, including serial numbers, if available.
(3) Description of test procedure used, including dates, test personnel, any retest events, and witness test data.
(4) List of all test instruments with model numbers and serial numbers.
(5) A discussion of test results.
(6) Conclusions.
(7) Photographic evidence in the form of either 24 color photographs of test equipment, test setup and representative test segments. All photographic evidence shall be labeled with contract number, location, date and time, and test activity.
(8) Copies of instrument calibration.
(9) Copies of all recorded test data.
(10) Curves required by paragraph I.D. 2.a.
(11) Curves showing the performance of the pump.
(12) Drawings of the test set-up showing all pertinent dimensions and elevations.

2. Attachment at Surface

An extraction wellhead blind flange assembly, as shown in Attachment 4, will be provided by the Government for attachment to the discharge piping at the surface. The Contractor shall provide all other fittings, nuts, bolts, etc. as shown on the contract drawings and per these specifications.

3. Pumping Unit Installation

Proper installation and assembly of the pumping unit shall be the Contractor's responsibility and shall be in accordance with the drawings, the Manufacturer's installation instructions, industry standards and all applicable local, state and federal electrical codes and regulations. All deviations from the design as presented in the attachments to this scope of work are subject to Government approval. The Contractor shall identify all deviations and provide detailed drawings or a written description that shows describes the deviation(s) and a justification for the deviation.

a) Shipping and Storage

The pumps, discharge piping, and appurtenances shall be inspected by the Contractor qualified pump installation engineer/inspector when received at the project site. The pump and associated equipment shall be stored as recommended by the pump Manufacturer and protected from construction or weather hazards at the project site. Proper equipment for handling the pump shall be supplied and shall be considered as special tools if not completely standard.

b) Tools and Equipment

The Contractor shall furnish all tools and other devices necessary for installing the pumping units. The Manufacturer's representative(s) familiar with the equipment being installed shall supervise the handling, installation, start-up, and testing of the equipment as required in the paragraph I.B. The Contractor shall furnish one set of all special tools required to completely assemble, disassemble, or maintain the pumps. *Special tools* refers to oversized or specially dimensioned tools, special attachment or fixtures, or any similar items. Lifting devices required for use in conjunction with a winch or crane shall be furnished.

The Contractor shall bring power and instrumentation cable (if applicable) into the wellhead vault, and neatly coil the excess cable; the cable will be terminated by others. The Contractor shall specify power cable size in the material list. Electrical power (3-phase/60 Hz/460 volt alternating current) will ***eventually*** be available at each extraction well location; the Contractor shall supply an electrical generator of sufficient capacity to test each pump installed at the target depth in each well (per III.A.4.). The power cable to each pump shall be affixed to the discharge piping by means of metal banding or similar. All electrical work and the electrical design shall comply with the current edition of the National Electrical Code and National Electrical Safety Code. Wellhead and electrical details are presented in Attachments 4 and 5.

A qualified installation engineer/inspector shall oversee the installation of the pumping units, inspect critical elements of the pump installation, and provide a written certification attesting to the correct installation and operation of the pumping units. The Contractor shall be obligated to provide all sketches, field notes and other information to accurately document the installation of the pumping unit at each extraction well location.

The Contractor shall provide an operating and maintenance manual for the extraction well pumping units. The Contractor shall identify any operational constraints and establish and state in the operating manual the recommended procedures for starting and stopping the extraction well pumps.

Any damage to the groundwater wells, ancillary equipment, facility utilities, or other Government property, during installation shall be repaired and returned to the original configuration at no cost to the Government.

c) Cleanup Prior to Start

After the pumping unit is installed and prior to start-up, Contractor shall remove any accumulated construction debris from the work area. A representative of the Government will witness this final cleaning of the work area. Any damage to the pumping units or related equipment during initial start-up due to foreign objects left in the work area shall be corrected at no cost to the Government.

4. Pump Field Tests

Field-testing shall be conducted by an experienced field test engineer and will be witnessed by the Contracting Officer or their designee. Contractor shall provide an electrical generator sufficient for testing pumps. Before initially energizing the pump/motors, the Contractor shall have successfully tested all pumping plant control, monitoring, and protective circuits. This thorough electrical checkout procedure shall have followed a detailed step-by-step approved test plan. The motor and other pumping unit elements undergoing tests should also be checked at this time.

a) Dry Test

If allowed per the Manufacturer's instructions, each pumping unit shall be tested in the dry to determine whether it has been properly installed. The pump shall be operated at full rated speed. Should tests reveal a design or installation deficiency or a manufacturing error in pumping unit components, the problem shall be promptly corrected by, and at the expense of, the Contractor.

b) Wet Test

Each unit shall be given an operating test under load for a period of at least ten minutes or as directed by the Contracting Officer. The Contractor shall supply sufficient pipe, hose, or piping to convey pumped water to a Government-supplied temporary containment tank no further than 100 feet from the well head. Disposal of water generated during the wet test will be disposed by the Government at no cost to the Contractor. The wet tests shall be conducted by the Contractor and will be witnessed by the Government. Without additional cost to the Government, the Contractor shall make all changes and correct any errors for which the Contractor is responsible.

c) Field Test Report

A test report of the field-testing shall be prepared and submitted in accordance with Section I.D..5.b.

B. Injection Piping

1. Installation

The injection piping shall be installed in accordance with industry standards and all applicable local, state and federal codes and regulations. All deviations from the design as presented in the attachments to this scope of work are subject to the Government's approval. The Contractor shall identify all deviations and provide detailed drawings and/or a written description that shows the magnitude of the deviations and a justification for the deviation.

A qualified installation engineer/inspector shall oversee the installation of the injection piping, inspect critical elements of the installation and provide a written certification attesting to the proper installation of the injection piping at each well site. The Contractor shall provide all sketches, field notes and other information to accurately document the installation of the injection piping at each well location.

Any damage to the groundwater wells, ancillary equipment, facility utilities, etc., during installation shall be repaired and returned to the original configuration at no cost to the Government.

C. Submersible Level Element and Transmitter

1. Installation

a) The submersible level element shall be carefully lowered into the well during pump installation. The target depth shall be twenty [20] feet below the bottom of the injection piping (for injection wells), and ten [10] feet above the submersible pump outlet (for extraction wells). The submersible level element cable shall not be tangled with or affixed to the discharge piping or injection piping and shall be suspended from the wellhead flange only. Any remaining above-grade signal cable shall be neatly coiled, secured, and suspended in its respective well vault (for connection by others).

IV. Best Value Evaluation Criteria

The aforementioned specifications (Sections I through III) are the minimum specifications that the Government must have to satisfy the requirement. The Government will evaluate Offeror's response in accordance with "Best Value to the Government" using specifically the following Best Value criteria:

A. Prior corporate experience of the offeror (including any major subcontractors).

B. Scheduled completion date of the work.

C. Quality of proposed hardware components.

D. Soundness of the technical approach to accomplishing the design requirements with particular attention to operability, reliability and maintainability.

E. Proposed solutions to technical and schedule risks.

F. Terms of the contractor's performance warranty.

G. Life-Cycle Cost Comparison.

All proposals will be evaluated using a life cycle cost comparison based on total life-cycle cost (LCC), as described in this section.

(1) The offeror shall provide the following data in their proposal:

(a) The present cost of the pumping units.
(b) The steady-state operational power requirement (kW) to successfully meet Government requirements (rates, pressures, capacity/amounts, water composition, etc.) Provide marked pump and motor curves and indicate the points used for determining loads.
(c) The maximum power demand (kW) for the month required to meet the Government requirement. Provide marked pump and motor curves and indicate the points used for determining loads.
(d) The useable life expectancy of the pumping units based on meeting Government requirements.
(e) The annual cost of repair or replacement parts required to keep the unit operational for the stated life of the pump and motor and satisfying Government requirements, including but not limited to bearings, seals, impellers, packing, motor, drive-shafts, and couplings.

(2) Life Cycle Cost (LCC) will be computed by NASA, using information provided by the offeror, and using the formula shown below.

$$LCC = PV(\Sigma MC) + PV(\Sigma EC) + PV(\Sigma OM) + PV(\Sigma REP)$$ where

(a) PV(x) is the present value/cost of (item x).
(b) Σ indicates the cost data will be summed for all six pumping units.

(c) MC is the material cost of the pumping units (not including New Mexico gross receipts tax).
(d) EC is the annual energy cost for the stated life of the pump and motor or the least common multiple of stated life. NASA will assume 8,760 hours of operation per year, for the purpose of computing EC.
(e) OM is the annual cost of repair or replacement parts required to keep the unit operational for the stated life of the pump and motor or the least common multiple of stated life, including but not limited to bearings, seals, impellers, packing, motor, drive-shafts, and couplings.
(f) REP is the future replacement cost. The REP will be the future value of the present cost taken at the end of the useable life period or the least common multiple of the stated life.

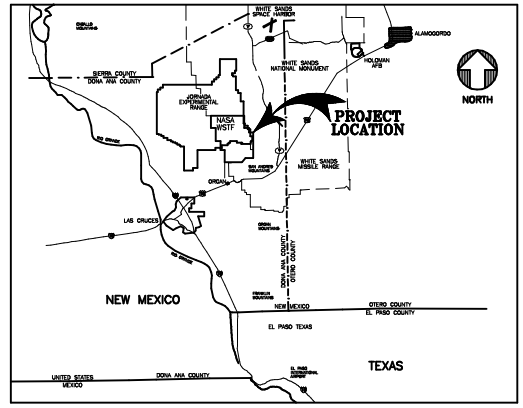
(3) A least common multiple of stated usage life will be used to evaluate alternatives, e.g., in comparing alternatives with a useable life of 5, 7, or 10 years, the life cycle comparison would be made using a period of 70-years. A 1-per cent per year increase will be used for all calculations throughout the life cycle period to be evaluated.

ATTACHMENT 1

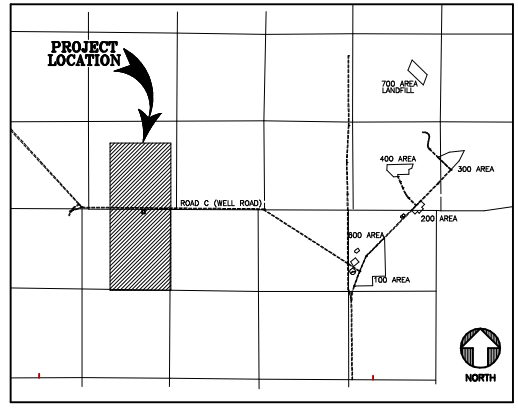
WSTF GROUNDWATER TREATMENT FACILITY

PROJECT LOCATION

GENERAL LOCATION



WSTF LOCATION



SITE LOCATION

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.
NEXT ASSY / RELATED DWG'S

DRAWN BY	M. TARIN	7-29-99
ENGINEER	J. KIRBY	7-29-99
DESIGNED BY	J. KIRBY	7-29-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION
PIPING SYSTEM
CIVIL
PROJECT LOCATION

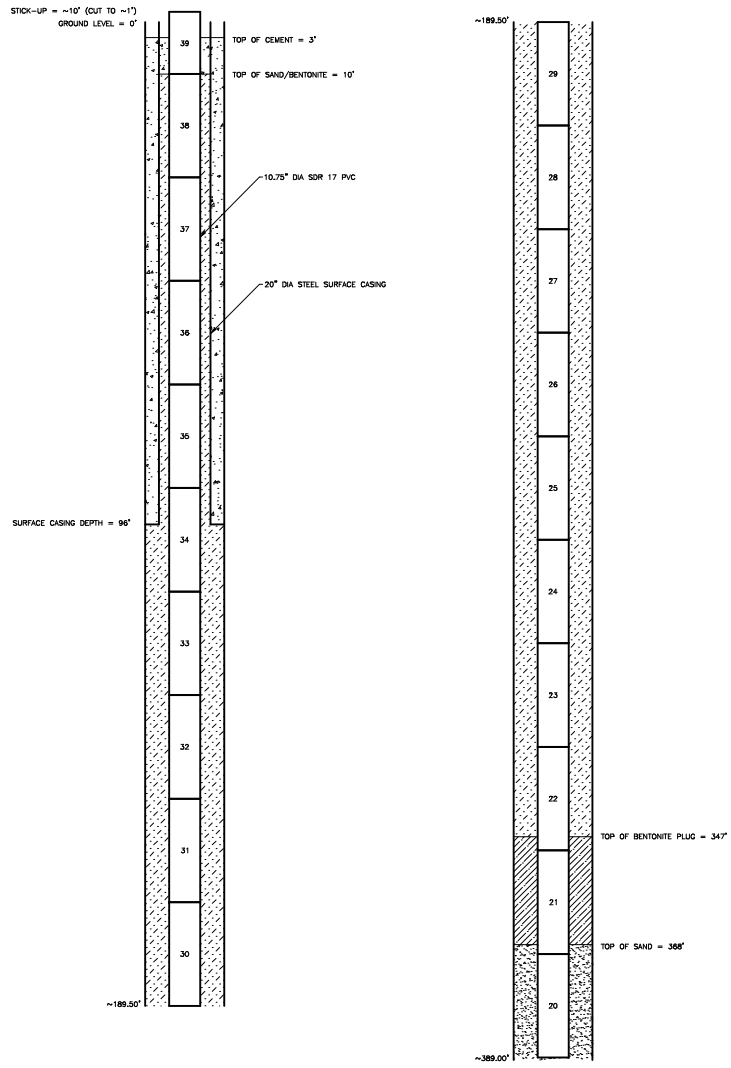
A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1
CODE IDENT. | SIZE F | DWG. NO. 652-C-01 | REV.

ATTACHMENT 2

EXTRACTION AND INJECTION WELL

CONSTRUCTION DIAGRAMS

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE

4/8 SAND

SLOUGH

4/8 SAND/BENTONITE MIX

GROUT

SCREEN

STEEL, BOLT-ON CENTRALIZER

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / REVISED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xx± FRACTIONS ±
.xxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
CIVIL
WELL COMPLETION DIAGRAM

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 653-C-03 | REV.

ATTACHMENT 3

PUMP PERFORMANCE, DESIGN AND HYDRAULIC DATA

DESIGN AND PERFORMANCE REQUIREMENTS AND HYDROLOGIC MEASUREMENTS

Well ID	Approx. Depth to Static Water (feet below grade)	Pump Performance, GPM @ Head (feet H_2O at 72 deg F.)	Approx. Pump Intake Depth (feet below grade)	Drop Pipe Diameter (nominal inches, Schedule 40 Carbon Steel)	Acceptable Make/Model
PFE-1	423	331 GPM @ 793 feet	525	4"	Grundfos/300S, 385S, or approved equal
PFE-2	435	258 GPM @ 738 feet	515	4"	Grundfos/230S, 300S, or approved equal
PFE-3	453	245 GPM @ 685 feet	525	4"	Grundfos/230S, or approved equal
PFE-4A	470	230 GPM @ 750 feet	575	4"	Grundfos/230S, or approved equal
PFE-5	451	30 GPM @ 763 feet	650	1 1/2"	Grundfos/40S, or approved equal
PFE-7	411	144 GPM @ 803 feet	475	3"	Grundfos/135S, or approved equal

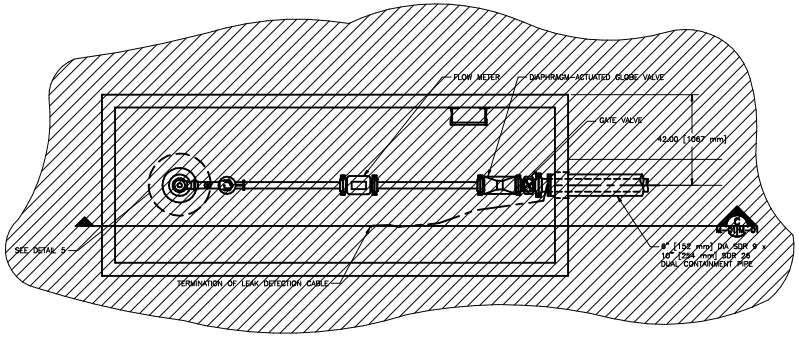
DESIGN AND PERFORMANCE REQUIREMENTS AND HYDROLOGIC MEASUREMENTS

Well ID	Depth to Water (feet below grade)	Flow Rate (GPM)	Approx. Injection Piping Total Depth (feet below grade)	Injection Piping Diameter (nominal inches)
PFI-1	440'	310	450'	3"
PFI-2	450'	309	467'	3"
PFI-3	460'	396	477'	3"
PFI-4	465'	223	488'	3"

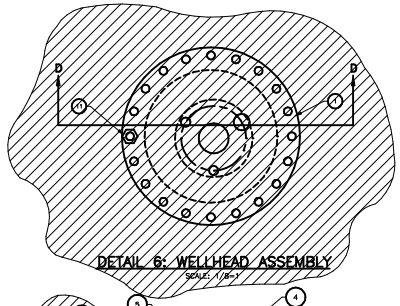
ATTACHMENT 4

WELLHEAD DETAILS

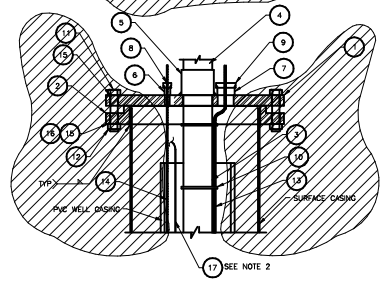
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



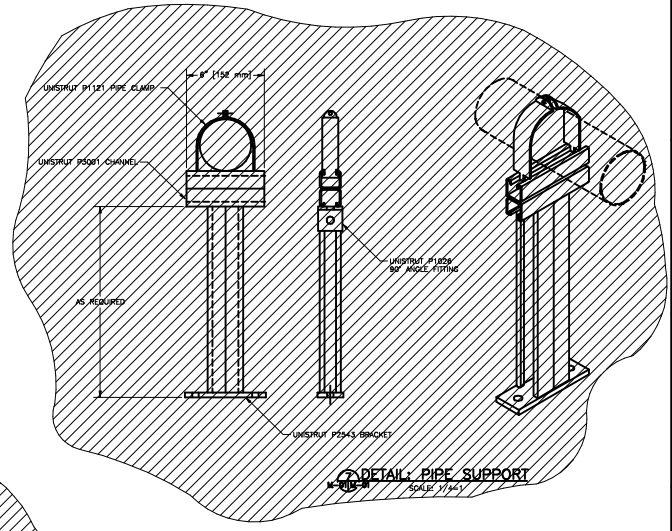
8 DETAIL: PFE-1 EXTRACTION WELL VAULT
M-PLUME-01



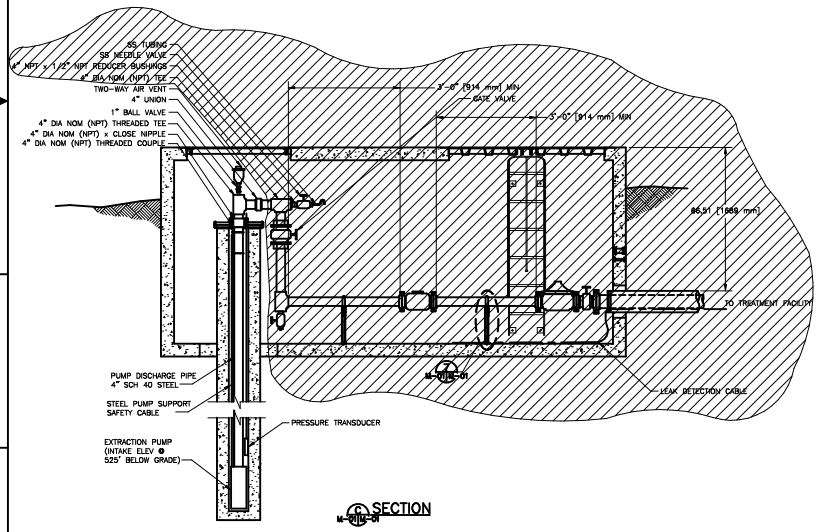
DETAIL 6: WELLHEAD ASSEMBLY
SCALE: 1/8=1



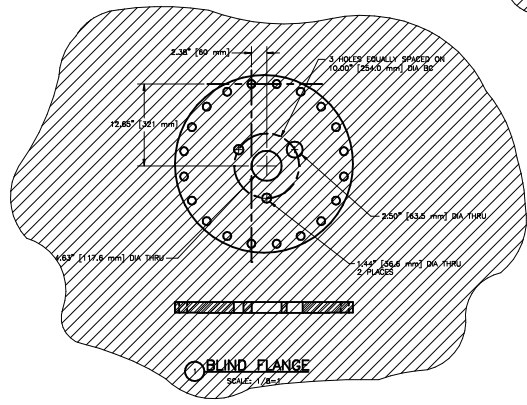
SECTION D-D



7 DETAIL: PIPE SUPPORT
M-PLUME-01
SCALE: 1"=1



SECTION
M-PLUME-01



1 BLIND FLANGE
SCALE: 1/8=1

SUPPLIED BY OTHERS
WELL, WELL HEAD VAULT, BLIND FLANGE AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY PUMP/MOTOR ASSEMBLY POWER CABLE, TRANSDUCER, TEE, REDUCER BUSHING, BALL VALVE, VENT-VACUUM VALVE STRAIN RELIEF CONNECTORS AND ASSOCIATED FITTINGS

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER
2. SAFETY CABLE TERMINATION AND SECURING METHOD SHALL BE DETERMINED BY PUMP INSTALLATION CONTRACTOR.

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
	17		SAFETY CABLE, 0.5" DIA	CS		
4	16		WASHER, LOCK, 1.125" DIA	CS		
8	15		WASHER, FLAT, 1.125" DIA	CS		
	14		TRANSDUCER CABLE	CU		
	13		PUMP POWER CABLE	CU		
4	12		NUT, 1.125" DIA	CS		
4	11		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
	10		STRAP	SS		
1	9		STRAIN RELIEF CONNECTOR, 2"	SS		
1	8		STRAIN RELIEF CONNECTOR, 1"	SS		
1	7		COUPLING, 2" NPT, SCH 80	CS		
2	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		COUPLING, 4" ASTM	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		NIPPLE, 4" NPT x CLOSE	CS		
1	3		DROP PIPE, 4" DIA x 525', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	

NEXT ASSY / REUSED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xx± FRACTIONS ±
.xxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
MECHANICAL DETAILS

A.E. DWG. NO.
SCALE 1/2"=1'-0"
SHEET 1 OF 1
CODE IDENT. F
SIZE D
DWG. NO. 653-M-01
REV.

ATTACHMENT 5

ELECTRICAL DETAILS

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BAY #1	BAY #2	BAY #3	BAY #4
RELAY CABINET FOR PLC CONTROLLER	FVNR NEMA SIZE 2	BLANK	C/B 50A COMPAC
			BLANK
	PANEL 3ø, 18 CKT 120/208V 100A MLO	SSRV CONTROLLER C/B * 150 HP	BLANK
			METER (1)
	XFMR 15 KVA 3ø 4W 25A C/B (480V) 40A C/B (208V)		TVSS 30A C/B (2)
			MAIN 450A C/B

* TO BE SIZED BY MANUFACTURER TO PROVIDE PROPER SHORT CIRCUIT PROTECTION OF MOTOR IT IS TO PROTECT.

SCHEDULE – MOTOR CONTROL CENTER
480 VAC, 3ø, 4W, 42KA, NEMA 3R
600A INCOMING, 600A HORIZONTAL, 300A VERTICAL

SECTION/UNIT LOCATION	DESC	NEMA SIZE	CB TRIP (A)	AUX INTLKS NO	AUX INTLKS NC	SELECTOR SWITCHES	INDICATING LIGHTS	IDENTIFICATIONS
1								
2A	FVNR	2	70	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	SPARE
2E	C/B		40					100A, 3ø, 18 CKT, PNL
2N	C/B		25					15 KVA, 3ø, 4W, XFMRS
3A								
3D	SSRV	N/A	*	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	PFE-1 PUMP
4A	C/B		50					SPARE
4C								
4G								
4K								METER (1)
4P			30					TVSS (2)
4T			450					MAIN

KEYED NOTES:

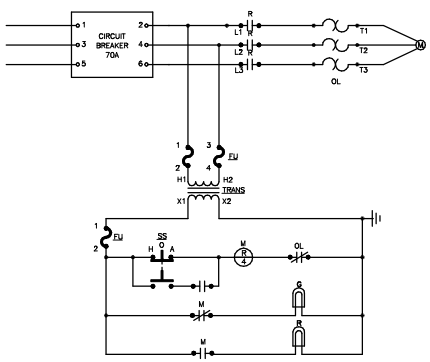
(1) FURNISH STANDARD METER SLOT OPENING IN FRONT OF MCC'S PANEL COVER. PROVIDE CLEAR PLASTIC WEATHER PROOF COVER OVER OPENING. METER DEVICE AND ASSOCIATED CT'S AND PT'S TO BE FURNISHED AND INSTALLED BY OTHERS.

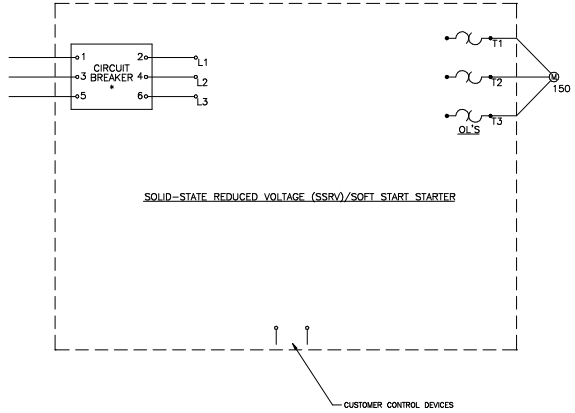
(2) FURNISH MANUFACTURER'S STANDARD TVSS PROTECTION INTEGRAL WITH MCC.

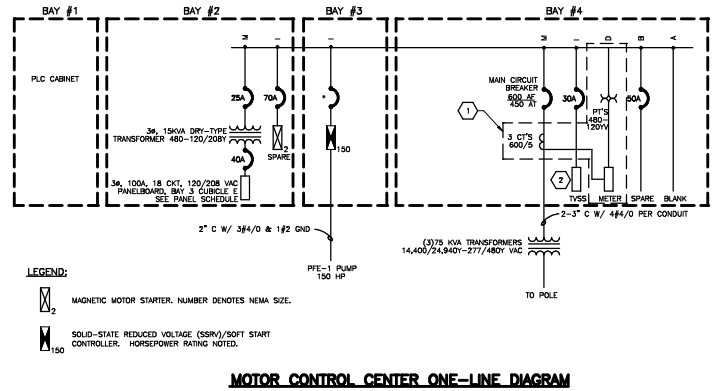
SCHEDULE – PANEL "LA"

BUILDING: PFE-1	LOCATION: MCC	PHASE: 3	
TYPE:	FEED:	WIRE: 4	
MANUFACTURER:	SC RATING: 10,000	VOLTAGE: 120/208	
MODEL:	MAIN AMPS:	MOUNTING: INTERNAL TO MCC	
CONFIGURATION:	PANEL AMPS: 100 MLO COPPER		

CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	ø LOAD (AMPS) A	B	C	CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	ø LOAD (AMPS) A	B	C
1	1	20	PLC POWER	10			2	1	–	SPACE ONLY			
3	1	20	PLC RECEPT		1.5		4	1	–				
5	1	20	PFE-1 VAULT RECEPT			1.5	6	1	–				
7	1	20	PFE-1 FLOW METER	.83			8	1	–				
9	1	20	MCC RECEPT		1.5		10	1	–				
11	1	20	SPARE				12	1	–				
13	1	20	SPARE				14	1	–				
15	1	–	SPACE ONLY				16	1	–				
17	1	–					18	1	–				
TOTAL CONNECTED LOAD PER PHASE, AMPS							TOTAL CONNECTED LOAD PER PHASE, AMPS						
TOTAL CONNECTED LOAD 3-PHASE, AMPS							TOTAL CONNECTED LOAD 3-PHASE, AMPS						







LEGEND:

$\boxtimes_2$ MAGNETIC MOTOR STARTER. NUMBER DENOTES NEMA SIZE.

$\boxtimes_{150}$ SOLID-STATE REDUCED VOLTAGE (SSRV)/SOFT START CONTROLLER. HORSEPOWER RATING NOTED.

MOTOR CONTROL CENTER ONE-LINE DIAGRAM

SPARE

PFE-1 PUMP

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / RELATED ASSYS

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000± DECIMALS ±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
ELECTRICAL DETAILS

A.S. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 653-E-02 | REV.

ATTACHMENT 6

JSC Form 262

National Aeronautics and Space Administration

White Sands Test Facility

UV Oxidation System Procurement Specifications

Table of Contents

1. GENERAL 2
   1.1 Description 2
   1.2 Definitions 2
   1.3 Vendor Qualifications 2
   1.4 Reference Standards 3
   1.5 Inspection 3
   1.6 Proposal Submittal 3
   1.7 Drawing Package 3
   1.8 Submittals Prior to Equipment Delivery 4
   1.9 Approval of Equivalent Substitutions 4
   1.10 Warranty 4
   1.11 Equipment Destination 5
2. MATERIALS AND EQUIPMENT 5
   2.1 Mechanical 5
   2.2 Controls and Instrumentation 6
   2.3 Electrical 7
   2.4 Spare Parts Kit 8
   2.5 Performance of UV Oxidation System 8
3. FABRICATION, ASSEMBLY, AND TESTING 9
   3.1 Fabrication and Assembly 9
   3.2 Testing 9
4. EXECUTION 9
   4.1 Required Services 9
   4.2 Optional Services 9
5. DELIVERY SCHEDULE 10

ATTACHMENTS

1. Section 13390: Package Control Systems
2. Section 13390, Supplement A: Package Control System Component Specifications

1. GENERAL

1.1 Description

This Procurement Specification outlines the requirements for the UV oxidation equipment needed for the plume-front remediation system currently being designed for the National Aeronautics and Space Administration's (NASA's) White Sands Test Facility (WSTF). The plume-front remediation system is being designed by NASA-WSTF's environmental sub-contractor (Lynx Ltd.), and is being procured by NASA. The plume-front remediation system is a groundwater pump-and-treat system, for the treatment of n-nitrosodimethylamine (NDMA), n-nitrodimethylamine (DMN or DMA), trichloroethylene (TCE), tetrachloroethylene (PCE), and several Freon® compounds. Sieve tray air strippers will be utilized to remove the TCE, PCE, and Freons® from the groundwater, prior to UV oxidation treatment.

VENDOR shall furnish one (1) factory-assembled UV oxidation reactor, complete with lamps, power supplies, related equipment, and spare parts as required by this specification. The UV oxidation reactor(s) shall be designed for the destruction of n-nitrosodimethylamine (NDMA, CASRN 62-75-9) and n-nitrodimethylamine (DMN, CASRN 4164-28-7) in groundwater, incorporating mercury-vapor UV lamps that are designed to emit UV radiation in the 200 to 260 nm absorbance spectrum range.

1.2 Definitions

The term "NASA" used in these specifications refers to NASA and its representatives designated by the Contracting Officer. The term "Contracting Officer" refers to the procurement official or buyer administering this contract. The term "VENDOR" refers to Calgon Carbon Oxidation Technologies.

1.3 Vendor Qualifications

1.3.1 Vendors who have installed UV oxidation systems for the destruction of NDMA and/or DMN in groundwater, at a flow rate greater than or equal to 900 gpm, shall be considered.

1.3.2 Vendors who have installed UV oxidation systems for the destruction of NDMA and/or DMN, for a period of no less than 5 years, shall be considered.

1.3.3 Vendors who have installed UV oxidation systems for the destruction of NDMA and/or DMN, for no less than 10 applications, shall be considered.

1.4 Reference Standards

The manufacture of the UV oxidation system shall comply with the applicable provisions and recommendations of the following:

A. Hydraulic Standard Institute
B. National Electrical Manufacturers Association (NEMA)
C. National Electric Code (NEC)
D. Underwriters Laboratory (UL)
E. Canadian Standards Association (CSA)

VENDOR shall assume complete responsibility for conformance with the Reference Standards listed above, and this Bid Specification.

1.5 Inspection

The quality of all equipment and materials shall be subject to the inspection and approval of NASA. The performance testing required in Section 2.5 of this specification shall be subject to the inspection and approval of NASA. NASA reserves the right to conduct inspection of the equipment, materials of construction, and performance testing at VENDOR's manufacturing facility. NASA reserves the right to designate a representative to conduct the inspection and performance testing of the UV oxidation system. VENDOR shall notify NASA, a minimum of 2 weeks in advance of the day fabrication of the UV oxidation system commences.

1.6 Proposal Submittal

VENDOR shall provide as a minimum, but not limited to, the following information in its bid package:

A. Equipment and Performance warranty, including a written guarantee that the UV oxidation system will continuously meet the performance standards listed in Section 2.5 of this specification.
B. Documentation that VENDOR meets the qualification requirements listed in Section 1.3 of this specification.
C. An estimate of the lead-time required to commence fabrication, and the time needed to fabricate, test, and deliver the UV oxidation system and related equipment.

1.7 Drawing Package

Within 3 weeks following award by NASA, VENDOR shall submit a drawing package to include:

A. Manufacturer cut sheets of vendor-supplied components.
B. Shop drawings.
C. Manufacturers catalog data for all equipment, components, and accessories.

D. A list of common spare parts (including sources, part numbers, and recommended quantities) that may kept in inventory by NASA.
E. Process & instrumentation drawings showing all vendor-supplied components.
F. Tank-mounted air compressors in excess of 2 horsepower must have an ASME Manufacturer's Data Report (ASME form U-1 or U-1A) which states that the compressor and its mount have been accounted for in the vessel design and fabrication processes. This document is available from the vessel supplier.

VENDOR shall not commence fabrication of the UV oxidation system until NASA approves all shop drawings and provides VENDOR with a written Notice to Proceed.

1.8 Submittals Prior to Equipment Delivery

Vendor shall submit the following information and documents to NASA prior to shipment of the UV oxidation system:

A. Documentation of results of hydraulic testing required under Section 3.2.
B. Two (2) 3.5 inch floppy disk copies of the completely documented PLC program, along with two (2) fully annotated printed copies.
C. Printed instructions and drawings sufficient for proper installation of the UV oxidation system.
D. Two copies of the UV oxidation system Operation and Maintenance manual.

1.9 Approval of Equivalent Substitutions

VENDOR may propose substitutions to the equipment or materials of construction described in this specification. NASA reserves the right to accept or reject any such proposals.

1.10 Warranty

VENDOR shall warrant the UV oxidation and associated equipment for a period of twelve (12) months from the date of system start-up.

1.11 Equipment Destination

The UV oxidation system shall be shipped to:

NASA Johnson Space Center
White Sands Test Facility (WSTF)
Building 120
U.S. Highway 70, 18 miles Northeast of Las Cruces
Las Cruces, New Mexico, 88012

2. MATERIALS AND EQUIPMENT

2.1 Mechanical

2.1.1 General

The UV oxidation reactor shall be suitable for installation on an unsealed, sealed, or painted concrete floor in an industrial indoor environment maintained between 40º F and 100º F. The UV oxidation power supply shall be suitable for installation on an unsealed, sealed, or painted concrete floor in an industrial indoor environment maintained between 50º F and 85º F.

2.1.2 Reactor

The UV oxidation reactor shall contain a sufficient number of UV lamps to meet the performance specifications listed in Section 2.5. Wetted parts shall be constructed of 316L stainless steel, quartz, or fluoropolymers.

2.1.3 UV Lamps

The UV lamps used in the UV oxidation reactor shall be specifically designed to provide a broad spectrum of light emission between 200 nanometer (nm) and 300 nm to maximize photochemical destruction of NDMA and DMN. A minimum of 30% of the total lamp output must be below 300 nm. The lamps must be capable of providing 3,000 hours of operation with no more than a 20% decrease in emissions in the 200 to 300 nm spectrum range.

2.1.4 Quartz Sleeve Cleaning Mechanism

A cleaning mechanism shall be provided for each quartz sleeve to maintain efficient transmittance of UV light. The mechanism shall be constructed of materials that are not affected by high intensity UV radiation. The cleaning system must operate automatically with an adjustable time interval. The wiper assembly shall be driven by a pneumatic system providing positive action. Limit switches shall be provided at both ends of wiper travel for fail-safe indication of proper operation. Operation of the cleaning mechanism must not divert or otherwise disrupt water flow to the reactor, or reduce the effectiveness of the treatment.

2.2 Controls and Instrumentation

2.2.1 Interface with Master Control System

A master control system that integrates the air strippers, UV oxidation system, and other components of the plume-front remediation system will be utilized. This master control system will monitor the operation of all system components, shut the system down under specific conditions, and provide for taking components off-line for maintenance. The UV oxidation control cabinet shall provide spare contacts for each control function so that the control functions can be monitored at the master control system.

2.2.2 UV Oxidation Reactor Control System

2.2.2.1 The UV Oxidation system shall be controlled by a reliable programmable logic controller (PLC). The PLC shall be factory programmed and tested prior to shipment. The PLC must be listed by a Nationally Recognized Testing Laboratory (NRTL), and comply with the requirements of Section 13390, Supplement A.

2.2.2.2 The system shall be operated from a main control console with system status and operational data shown on an interface display with an alphanumeric screen. Data entry shall be made from a keypad. The operator interface shall be programmed with test and diagnostic functions to permit testing of all equipment while the system is off line for maintenance. This shall include, but not is limited to, operation of all cooling fans, operation of quartz wiper mechanisms, and operation of interlocks.

2.2.2.3 The PLC shall have sufficient capacity and contacts for control and interface with all standard and optional features and equipment provided with the UV oxidation system. The PLC shall have sufficient capacity and contacts for control and interface with the master control system discussed in Section 2.2.1 of this specification. In case of power outage, the PLC memory must be maintained by a continuously charged lithium battery.

2.2.2.4 Each UV oxidation system shall have an individual PLC and control panel to permit completely independent operation.

2.2.2.5 VENDOR shall use Allen Bradley PLC(s) and related components, as stated in Section 13390 Supplement A.

2.2.2.6 The control panel(s) housing the PLC(s) shall be a NEMA 4/12 enclosure.

2.2.2.7 Interlocks will be provided to alarm and/or shutdown the UV/Oxidation system under the following conditions:

A. High temperature in lamp drive enclosure.
B. Low water flow rate.
C. High temperature in the UV oxidation tower.
D. Leak from UV oxidation tower.
E. Lamp failure.
F. High voltage cabinet door is open.
G. Reactor access covers are open.
H. Transmittance controller failure.

2.2.2.8 A modem shall be installed to allow remote monitoring and diagnosis by the manufacturer, and to allow for programming changes to the system.

2.2.2.9 The control panel shall comply with all requirements of Section 13390.

2.2.2.10 The quartz sleeve cleaning mechanism shall be actuated by a vendor-supplied reciprocating air compressor. The air compressor shall meet the following criteria:

A. System pressure relief set point shall not exceed 150 psig.
B. Air compressor tank shall be ASME code stamped for 150 psig or higher at 0º F to 650º F and have a volume capacity of 240 gallons (32.1 ft^3) or less.
C. Air compressor tank shall be registered with the National Board of Boiler and Pressure Vessel Inspectors.
D. All plastic components to be steel reinforced or contained within a metal housing.

2.3 Electrical

2.3.1 A power supply shall be provided for each UV lamp. The power supplies shall be installed in a NEMA 3R ventilated / drip-proof enclosure. All internal wiring must comply with NEC and be certified by a US OSHA accredited Nationally Recognized Testing Laboratory (NRTL). Efficiency of the power supplies must be at least 92% and the power factor must be greater than 0.9 at full power.

2.3.2 The power supply system shall be provided with cooling fans, thermal protection, safety access interlock, lamp run meters, lamp ammeters, lamp voltmeters, and main power disconnect. If the power supply system is physically separate from the UV oxidation reactor, power disconnects shall be provided on both the power supply system and the UV oxidation reactor.

2.3.3 VENDOR's power supply shall be wired for 480 Vac, 3 phase, 4 wire, 60 Hz.

2.4 Spare Parts Kit

2.4.1 Vendor shall include a spare parts kit with the UV oxidation system. The spare parts kit shall include:

A. Three (3) UV lamps.
B. Three (3) quartz tubes.
C. Three (3) sets of ceramic lamp insulators.
D. Three (3) sets of quartz tube seals.

2.5 Performance of UV Oxidation System

2.5.1 The UV oxidation system will be designed to meet the following performance specifications:

Table 2.1 UV Oxidation System Performance Specifications

Criteria	Specification	
Total Hydraulic Flow Rate		1,100 gpm
Minimum Flow Rate		200 gpm
Design life		No less than 15 years
Influent Water Temperature		15º to 20 ºC
Maximum System Pressure		100 psig
Maximum Pressure Drop		10 psig
Expected Influent Concentrations	NDMA DMN	2,000 ppt 450 ppt
Regulatory Effluent Standards	NDMA DMN	10 ppt 10 ppt
Treatment Goals	NDMA DMN	2 ppt 2 ppt

2.5.2 The UV oxidation system shall be sized such that the concentration of each contaminant in the effluent is equal to or less than the appropriate Treatment Goal listed in Table 2.1.

3. FABRICATION, ASSEMBLY, AND TESTING

3.1 Fabrication and Assembly

The manufacturer shall furnish all tools, materials, labor, and appurtenances necessary for the complete fabrication, testing and shipment of the UV oxidation system and appurtenances. All equipment shall be new and unused, except for equipment used in final check-out testing.

3.2 Testing

VENDOR shall test the assembled UV oxidation system at design water flow rate to confirm proper hydraulic, electrical, control, and leak-free performance of basic system and all accessories.

4. EXECUTION

4.1 Required Services

VENDOR shall provide the start-up services of a qualified field service representative for the purpose of installation inspection, system commissioning, and instruction of facility personnel in proper operating and maintenance procedures. Upon completion of inspection, VENDOR's field service representative shall provide written certification to NASA that the equipment has been properly installed. The proposal shall include an estimate of the number of mandays and the per diem cost for these startup services.

4.2 Optional Services

VENDOR is requested to bid a Periodic Maintenance Contract as an option. The optional Periodic Maintenance Contract must include as a minimum:

4.2.1 Visits to the job site to perform preventative maintenance, (i.e., check the performance of, examine, adjust and calibrate, as may be required, the UV oxidation system), and replacement of the lamps if needed. Visits to the job site shall be scheduled to coincide with replacement of lamps at expiration of their warranted life.

4.2.2 Emergency service including all non-scheduled repair labor. Travel, labor, lodging, and per diem expenses for non-scheduled visits shall be invoiced to a purchase order to be issued in a separate procurement action.

4.2.3 All parts and labor (other than emergency or non-scheduled labor) for maintenance of the system including replacement of UV lamps.

5. DELIVERY SCHEDULE

The complete UV oxidation system shall be delivered to the Job Site no later than 18 weeks following issuance of a written notice to proced by NASA, as discussed in Section 1.7.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BAY #1	BAY #2	BAY #3	BAY #4
RELAY CABINET FOR PLC CONTROLLER	FVNR NEMA SIZE 2	BLANK	C/B 50A COMPAC
	PANEL 3ø, 18 CKT 120/208V 100A MLO	SSRV CONTROLLER C/B * 100 HP	BLANK
			BLANK
			METER (1)
	XFMR 15 KVA 3ø 4W 25A C/B (480V) 40A C/B (208V)		TVSS 30A C/B (2)
			MAIN 300A C/B

* TO BE SIZED BY MANUFACTURER TO PROVIDE PROPER SHORT CIRCUIT PROTECTION OF MOTOR IT IS TO PROTECT.

SCHEDULE – MOTOR CONTROL CENTER
480 VAC, 3ø, 4W, 42KA, NEMA 3R
600A INCOMING, 600A HORIZONTAL, 300A VERTICAL

SECTION/UNIT LOCATION	DESC	NEMA SIZE	CB TRIP (A)	AUX INTLKS NO	AUX INTLKS NC	SELECTOR SWITCHES	INDICATING LIGHTS	IDENTIFICATIONS
1								
2A	FVNR	2	70	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	SPARE
2E			40					100A, 3ø, 24 CKT, PNL
2N			25					15 KVA, 3ø, 4W, XFMRS
3A								
3D	SSRV	N/A	*	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	PFE-2 PUMP
4A	C/B		50					SPARE
4C								
4G								
4K								METER (1)
4P			30					TVSS (2)
4T			300					MAIN

SCHEDULE – PANEL "LA"

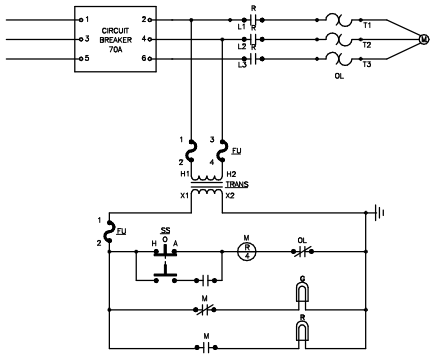
BUILDING: PFE-2	LOCATION: MCC		PHASE: 3
TYPE:	FEED:		WIRE: 4
MANUFACTURER:	SC RATING: 10,000		VOLTAGE: 120/208
MODEL:	MAIN AMPS:		MOUNTING: INTERNAL TO MCC
CONFIGURATION:	PANEL AMPS: 100 MLO COPPER		

CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	* LOAD (AMPS) A	B	C	CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	* LOAD (AMPS) A	B	C
1	1	20	PLC POWER	10			2	1	–	SPACE ONLY			
3	1	20	PLC RECEPT		1.5		4	1	–				
5	1	20	PFE-2 VAULT RECEPT			1.5	6	1	–				
7	1	20	PFE-2 FLOW METER	.83			8	1	–				
9	1	20	MCC RECEPT		1.5		10	1	–				
11	1	20	SPARE				12	1	–				
13	1	20	SPARE				14	1	–				
15	1	–	SPACE ONLY				16	1	–				
17	1	–	↓				18	1	–	↓			
TOTAL CONNECTED LOAD PER PHASE, AMPS							TOTAL CONNECTED LOAD PER PHASE, AMPS						
TOTAL CONNECTED LOAD 3-PHASE, AMPS							TOTAL CONNECTED LOAD 3-PHASE, AMPS						

KEYED NOTES:

(1) FURNISH STANDARD METER SLOT OPENING IN FRONT OF MCC'S PANEL COVER. PROVIDE CLEAR PLASTIC WEATHER PROOF COVER OVER OPENING. METER DEVICE AND ASSOCIATED CT'S AND PT'S TO BE FURNISHED AND INSTALLED BY OTHERS.

(2) FURNISH MANUFACTURER'S STANDARD TVSS PROTECTION INTEGRAL WITH MCC.



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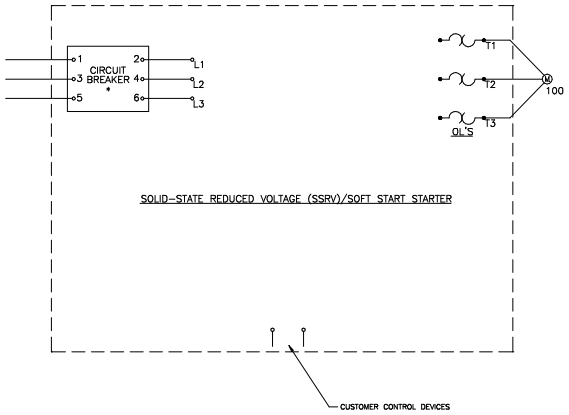
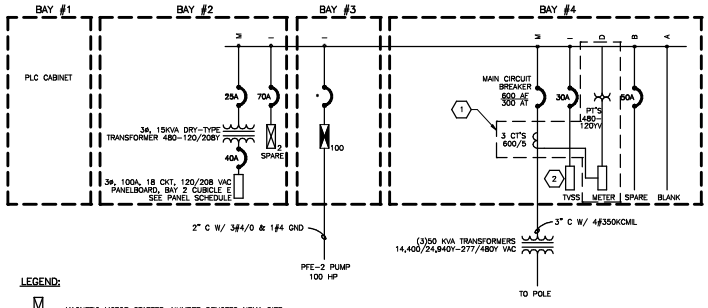


PFE-2 PUMP



LEGEND:

$\boxtimes_2$ MAGNETIC MOTOR STARTER. NUMBER DENOTES NEMA SIZE.

$\boxtimes_{100}$ SOLID-STATE REDUCED VOLTAGE (SSRV)/SOFT START CONTROLLER. HORSEPOWER RATING NOTED.

MOTOR CONTROL CENTER ONE-LINE DIAGRAM

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SKE NO.

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-2
ELECTRICAL
DETAILS

A.B. DWG. NO.
SCALE NONE
SHEET 1 OF 1
CODE IDENT.
SIZE F
DWG. NO. 654-E-02
REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BAY #1	BAY #2	BAY #3	BAY #4
			C/B 50A COMPAC
	FVNR NEMA SIZE 2	BLANK	BLANK
RELAY CABINET FOR PLC CONTROLLER	PANEL 30, 1Ø CKT 120/208V 100A MLO	SSRV CONTROLLER C/B * 100 HP	BLANK
			METER (1)
	XFMR 15 KVA 3Ø 4W 25A C/B (480V) 40A C/B (208V)		TVSS 30A C/B (2)
			MAIN 300A C/B

* TO BE SIZED BY MANUFACTURER TO PROVIDE PROPER SHORT CIRCUIT PROTECTION OF MOTOR IT IS TO PROTECT.

SCHEDULE – MOTOR CONTROL CENTER
480 VAC, 3Ø, 4W, 42KA, NEMA 3R
600A INCOMING, 600A HORIZONTAL, 300A VERTICAL

SECTION/UNIT LOCATION	DESIG	NEMA SIZE	CB TRIP (A)	AUX INTLKS NO	AUX INTLKS NC	SELECTOR SWITCHES	INDICATING LIGHTS	IDENTIFICATIONS
1								
2A	FVNR	2	70	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	SPARE
2E			40					100A, 3Ø, 24 CKT, PNL
2N			25					15 KVA, 3Ø, 4W, XFMRS
3A								
3D	SSRV	N/A	*	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	PFE-3 PUMP
4A	C/B		50					SPARE
4C								
4G								
4K								METER (1)
4P			30					TVSS (2)
4T			300					MAIN

KEYED NOTES:

(1) FURNISH STANDARD METER SLOT OPENING IN FRONT OF MCC'S PANEL COVER. PROVIDE CLEAR PLASTIC WEATHER PROOF COVER OVER OPENING. METER DEVICE AND ASSOCIATED CT'S AND PT'S TO BE FURNISHED AND INSTALLED BY OTHERS.

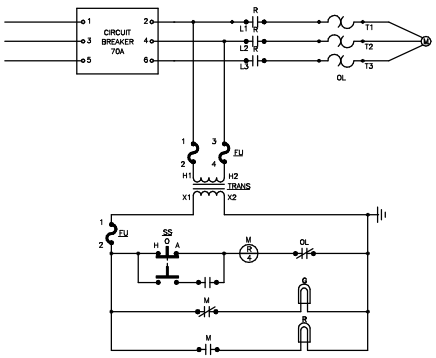
(2) FURNISH MANUFACTURER'S STANDARD TVSS PROTECTION INTEGRAL WITH MCC.

SCHEDULE – PANEL "LA"

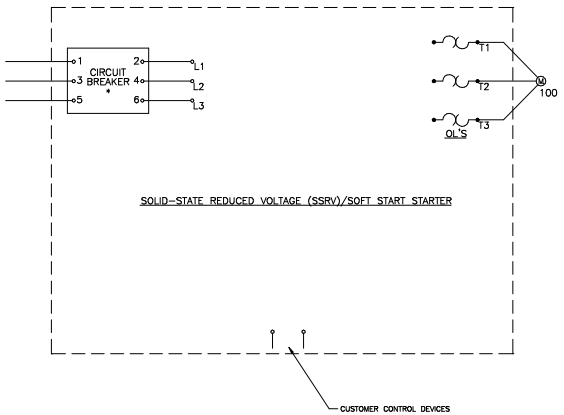
BUILDING: PFE-3 | LOCATION: MCC | PHASE: 3
TYPE: | FEED: | WIRE: 4
MANUFACTURER: | SC RATING: 10,000 | VOLTAGE: 120/208
MODEL: | MAIN AMPS: | MOUNTING: INTERNAL TO MCC
CONFIGURATION: | PANEL AMPS: 100 MLO COPPER

CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	φ LOAD (AMPS) A	B	C	CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	φ LOAD (AMPS) A	B	C
1	1	20	PLC POWER	10			2	1	–	SPACE ONLY			
3	1	20	PLC RECEPT		1.5		4	1	–				
5	1	20	PFE-3 VAULT RECEPT			1.5	6	1	–				
7	1	20	PFE-3 FLOW METER	.83			8	1	–				
9	1	20	MCC RECEPT		1.5		10	1	–				
11	1	20	SPARE				12	1	–				
13	1	20	SPARE				14	1	–				
15	1	–	SPACE ONLY				16	1	–				
17	1	–					18	1	–				
TOTAL CONNECTED LOAD PER PHASE, AMPS							TOTAL CONNECTED LOAD PER PHASE, AMPS						
TOTAL CONNECTED LOAD 3-PHASE, AMPS							TOTAL CONNECTED LOAD 3-PHASE, AMPS						

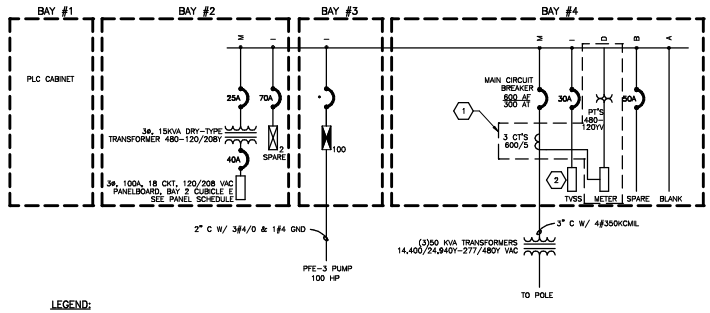
BAY #3



SPARE



PFE-3 PUMP



LEGEND:

N_2 MAGNETIC MOTOR STARTER. NUMBER DENOTES NEMA SIZE.

M_{100} SOLID-STATE REDUCED VOLTAGE (SSRV)/SOFT START CONTROLLER. HORSEPOWER RATING NOTED.

MOTOR CONTROL CENTER ONE-LINE DIAGRAM

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SKE NO.

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE:
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-3
ELECTRICAL
DETAILS

A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 655-E-02 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BAY #1	BAY #2	BAY #3	BAY #4
RELAY CABINET FOR PLC CONTROLLER	FVNR NEMA SIZE 2	BLANK	C/B 50A COMPAC
	PANEL 3ø, 1Ø CKT 120/208V 100A MLO	SSRV CONTROLLER C/B * 100 HP	BLANK
			BLANK
			METER (1)
	XFMR 15 KVA 3ø 4W 25A C/B (480V) 40A C/B (208V)		TVSS 30A C/B (2)
			MAIN 300A C/B

* TO BE SIZED BY MANUFACTURER TO PROVIDE PROPER SHORT CIRCUIT PROTECTION OF MOTOR IT IS TO PROTECT.

SCHEDULE – MOTOR CONTROL CENTER
480 VAC, 3ø, 4W, 42KA, NEMA 3R
600A INCOMING, 600A HORIZONTAL, 300A VERTICAL

SECTION/UNIT LOCATION	DESC	NEMA SIZE	CB TRIP (A)	AUX INTLKS NO	AUX INTLKS NC	SELECTOR SWITCHES	INDICATING LIGHTS	IDENTIFICATIONS
1								
2A	FVNR	2	70	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	SPARE
2E			40					100A, 3ø, 24 CKT, PNL
2N			25					15 KVA, 3ø, 4W, XFMRS
3A								
3D	SSRV	N/A	*	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	PFE-4A PUMP
4A	C/B		50					SPARE
4C								
4G								
4K								METER (1)
4P			30					TVSS (2)
4T			300					MAIN

SCHEDULE – PANEL "LA"

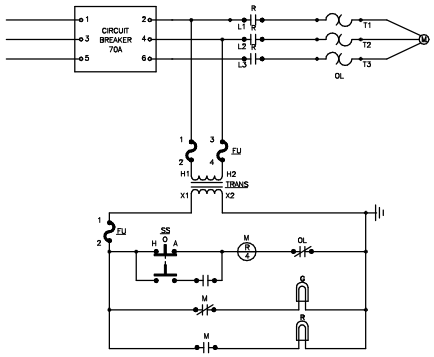
BUILDING: PFE-4A	LOCATION: MCC		PHASE: 3
TYPE:	FEED:		WIRE: 4
MANUFACTURER:	SC RATING: 10,000		VOLTAGE: 120/208
MODEL:	MAIN AMPS:		MOUNTING: INTERNAL TO MCC
CONFIGURATION:	PANEL AMPS: 100 MLO COPPER		

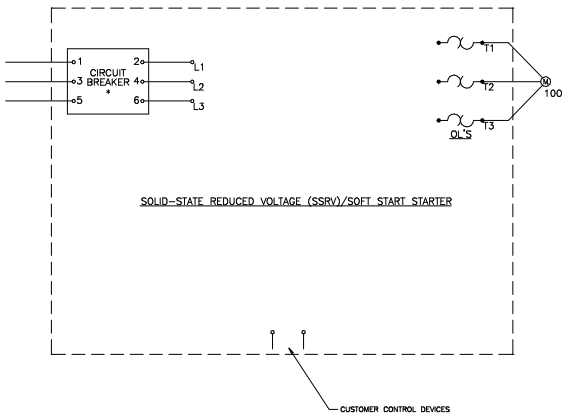
CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	* LOAD (AMPS) A	B	C	CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	* LOAD (AMPS) A	B	C
1	1	20	PLC POWER	10			2	1	–	SPACE ONLY			
3	1	20	PLC RECEPT		1.5		4	1	–				
5	1	20	PFE-4A VAULT RECEPT			1.5	6	1	–				
7	1	20	PFE-4A FLOW METER	.83			8	1	–				
9	1	20	MCC RECEPT		1.5		10	1	–				
11	1	20	SPARE				12	1	–				
13	1	20	SPARE				14	1	–				
15	1	–	SPACE ONLY				16	1	–				
17	1	–	↓				18	1	–	↓			
TOTAL CONNECTED LOAD PER PHASE, AMPS							TOTAL CONNECTED LOAD PER PHASE, AMPS						
TOTAL CONNECTED LOAD 3-PHASE, AMPS							TOTAL CONNECTED LOAD 3-PHASE, AMPS						

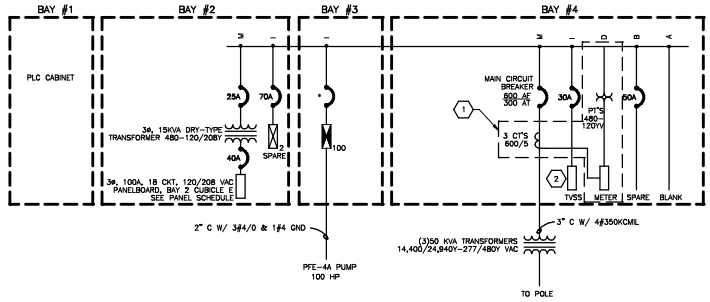
KEYED NOTES:

(1) FURNISH STANDARD METER SLOT OPENING IN FRONT OF MCC'S PANEL COVER. PROVIDE CLEAR PLASTIC WEATHER PROOF COVER OVER OPENING. METER DEVICE AND ASSOCIATED CT'S AND PT'S TO BE FURNISHED AND INSTALLED BY OTHERS.

(2) FURNISH MANUFACTURER'S STANDARD TVSS PROTECTION INTEGRAL WITH MCC.







LEGEND:

$\boxtimes_2$ MAGNETIC MOTOR STARTER. NUMBER DENOTES NEMA SIZE.

$\boxtimes_{100}$ SOLID-STATE REDUCED VOLTAGE (SSRV)/SOFT START CONTROLLER. HORSEPOWER RATING NOTED.

MOTOR CONTROL CENTER ONE-LINE DIAGRAM

SPARE

PFE-4A PUMP

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SKE. NO.

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-4A
ELECTRICAL
DETAILS

A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 656-E-02 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BAY #1	BAY #2	BAY #3
RELAY CABINET FOR PLC CONTROLLER	FVNR NEMA SIZE 2	C/B 50A COMPAC
		BLANK
	PANEL 3ø, 12 CKT 120/208V	BLANK
		METER (1)
	XFMR 15 KVA 3ø 4W 25A C/B (480V) 45A C/B (208V)	TVSS 30A C/B (2)
		MAIN 100A C/B

SCHEDULE – MOTOR CONTROL CENTER
480 VAC, 3ø, 4W, 42KA, NEMA 3R
600A INCOMING, 600A HORIZONTAL, 300A VERTICAL

SECTION/UNIT LOCATION	DESC	NEMA SIZE	CB TRIP (A)	AUX INTLKS NO	AUX INTLKS NC	SELECTOR SWITCHES	INDICATING LIGHTS	IDENTIFICATIONS
1								PLC PANEL
2A	FVNR	2	45	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	PFE-5 PUMP
2E			45					100A, 3ø, 12 CKT, PNL
2N			25					15 KVA, 3ø, 4W, XFMRS
3A			50					SPARE
3D								METER (1)
3I			30					TVSS (2)
3M			100					MAIN

SCHEDULE – PANEL "LA"

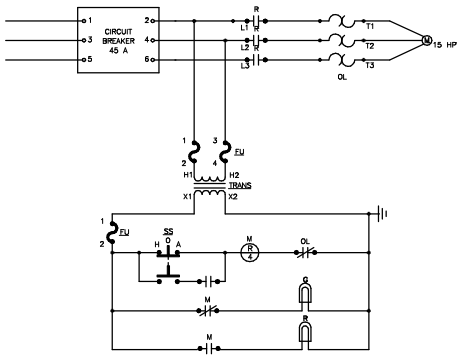
BUILDING: PFE-5	LOCATION: MCC	PHASE: 3	
TYPE:	FEED:	WIRE: 4	
MANUFACTURER:	SC RATING: 10,000	VOLTAGE: 120/208	
MODEL:	MAIN AMPS:	MOUNTING: INTERNAL TO MCC	
CONFIGURATION:	PANEL AMPS: 100 MLO COPPER		

CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	* LOAD (AMPS) A	B	C	CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	* LOAD (AMPS) A	B	C
1	1	20	PLC POWER	10			2	1	–	SPACE ONLY			
3	1	20	PLC RECEPT		1.5		4	1	–				
5	1	20	PFE-5 VAULT RECEPT			1.5	6	1	–				
7	1	20	PFE-5 FLOW METER	.83			8	1	–				
9	1	20	MCC RECEPT		1.5		10	1	–				
11	1	20	SPARE				12	1	–				
TOTAL CONNECTED LOAD PER PHASE, AMPS							TOTAL CONNECTED LOAD PER PHASE, AMPS						
TOTAL CONNECTED LOAD 3-PHASE, AMPS							TOTAL CONNECTED LOAD 3-PHASE, AMPS						

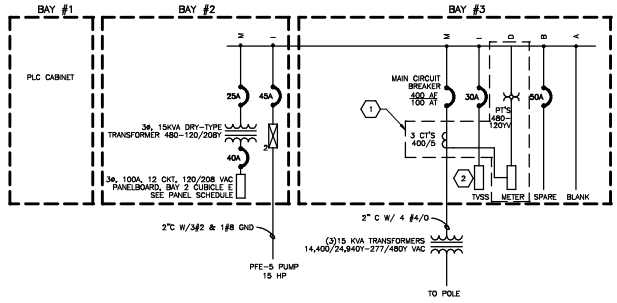
KEYED NOTES:

(1) FURNISH STANDARD METER SLOT OPENING IN FRONT OF MCC'S PANEL COVER. PROVIDE CLEAR PLASTIC WEATHER PROOF COVER OVER OPENING. METER DEVICE AND ASSOCIATED CT'S AND PT'S TO BE FURNISHED AND INSTALLED BY OTHERS.

(2) FURNISH MANUFACTURER'S STANDARD TVSS PROTECTION INTEGRAL WITH MCC.



PFE-5 PUMP



LEGEND:

(2) MAGNETIC MOTOR STARTER. NUMBER DENOTES NEMA SIZE.

MOTOR CONTROL CENTER ONE-LINE DIAGRAM

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SKE NO.

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX± DIMENSIONS ARE IN INCHES
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-5
ELECTRICAL
DETAILS

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 657-E-02 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BAY #1	BAY #2	BAY #3	BAY #4
RELAY CABINET FOR PLC CONTROLLER	FVNR NEMA SIZE 2	BLANK	C/B 50A COMPAC
			BLANK
	PANEL 3ø, 18 CKT 120/208V 100A MLO	SSRV CONTROLLER C/B * 75 HP	BLANK
			METER (1)
	XFMR 15 KVA 3ø 4W 25A C/B (480V) 40A C/B (208V)		TVSS 30A C/B (2)
			MAIN 250A C/B

* TO BE SIZED BY MANUFACTURER TO PROVIDE PROPER SHORT CIRCUIT PROTECTION OF MOTOR IT IS TO PROTECT.

SCHEDULE – MOTOR CONTROL CENTER
480 VAC, 3ø, 4W, 42KA, NEMA 3R
600A INCOMING, 600A HORIZONTAL, 300A VERTICAL

SECTION/UNIT LOCATION	DESC	NEMA SIZE	CB TRIP (A)	AUX INTLKS NO	AUX INTLKS NC	SELECTOR SWITCHES	INDICATING LIGHTS	IDENTIFICATIONS
1								
2A	FVNR	2	70	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	SPARE
2E			40					100A, 3ø, 18 CKT, PNL
2N			25					15 KVA, 3ø, 4W, XFMRS
3A								
3D	SSRV	N/A	*	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	PFE-7 PUMP
4A	C/B		50					SPARE
4C								
4G								
4K								METER (1)
4P			30					TVSS (2)
4T			250					MAIN

KEYED NOTES:

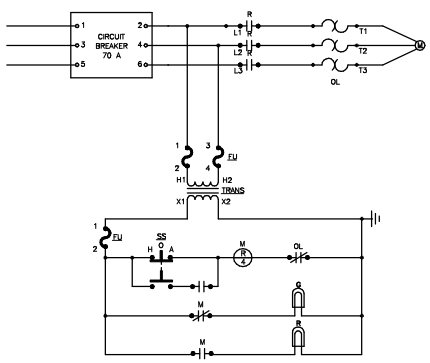
(1) FURNISH STANDARD METER SLOT OPENING IN FRONT OF MCC'S PANEL COVER. PROVIDE CLEAR PLASTIC WEATHER PROOF COVER OVER OPENING. METER DEVICE AND ASSOCIATED CT'S AND PT'S TO BE FURNISHED AND INSTALLED BY OTHERS.

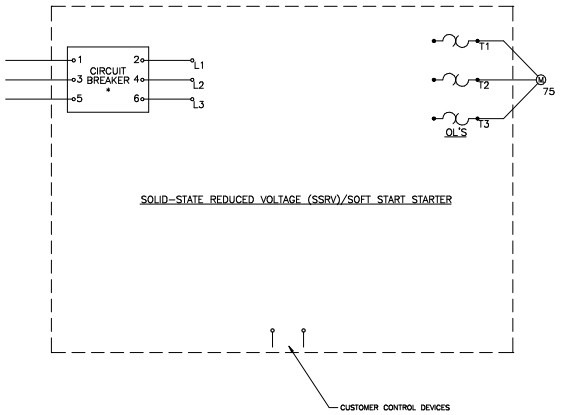
(2) FURNISH MANUFACTURER'S STANDARD TVSS PROTECTION INTEGRAL WITH MCC.

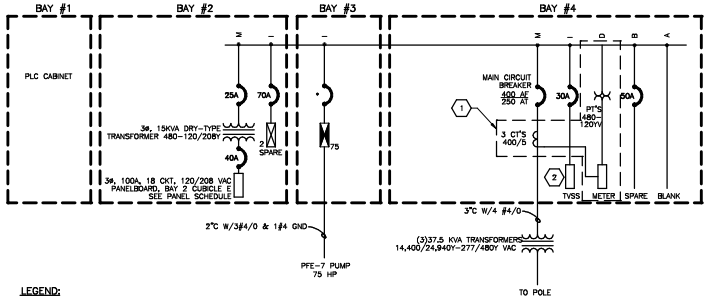
SCHEDULE – PANEL "LA"

BUILDING: PFE-7	LOCATION: MCC	PHASE: 3	
TYPE:	FEED:	WIRE: 4	
MANUFACTURER:	SC RATING: 10,000	VOLTAGE: 120/208	
MODEL:	MAIN AMPS:	MOUNTING: INTERNAL TO MCC	
CONFIGURATION:	PANEL AMPS: 100 MLO COPPER		

CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	ø LOAD (AMPS) A	B	C	CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	ø LOAD (AMPS) A	B	C
1	1	20	PLC POWER	10			2	1	–	SPACE ONLY			
3	1	20	PLC RECEPT		1.5		4	1	–				
5	1	20	PFE-7 VAULT RECEPT			1.5	6	1	–				
7	1	20	PFE-7 FLOW METER	.83			8	1	–				
9	1	20	MCC RECEPT		1.5		10	1	–				
11	1	20	SPARE				12	1	–				
13	1	20	SPARE				14	1	–				
15	1	–	SPACE ONLY				16	1	–				
17	1	–					18	1	–				
TOTAL CONNECTED LOAD PER PHASE, AMPS							TOTAL CONNECTED LOAD PER PHASE, AMPS						
TOTAL CONNECTED LOAD 3-PHASE, AMPS							TOTAL CONNECTED LOAD 3-PHASE, AMPS						







LEGEND:

2 MAGNETIC MOTOR STARTER. NUMBER DENOTES NEMA SIZE.

75 SOLID-STATE REDUCED VOLTAGE (SSRV)/SOFT START CONTROLLER. HORSEPOWER RATING NOTED.

MOTOR CONTROL CENTER ONE-LINE DIAGRAM

SPARE

PFE-7 PUMP

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SKE NO.

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX± DECIMALS ±
DIMENSIONS ARE IN INCHES
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

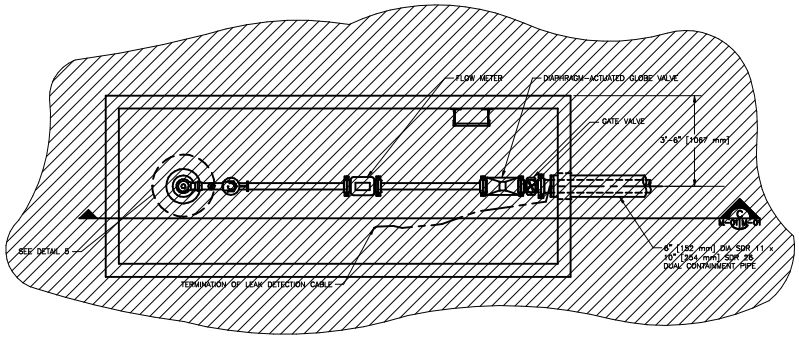
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-7
ELECTRICAL
DETAILS

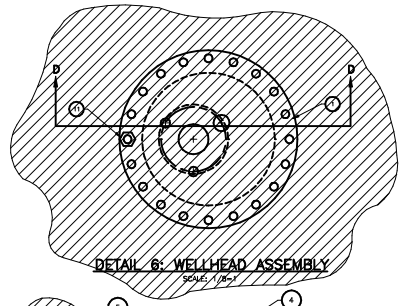
A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 658-E-02 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

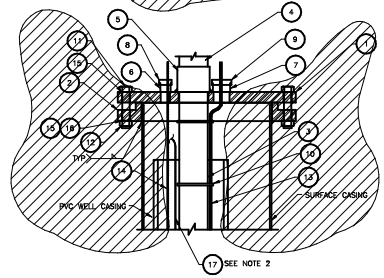


DETAIL: PFE-2 EXTRACTION WELL VAULT

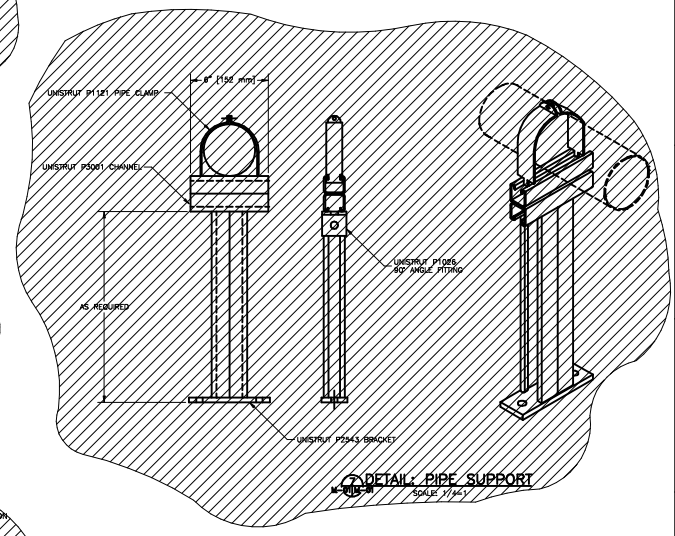


DETAIL 6: WELLHEAD ASSEMBLY

SCALE: 1/8=1

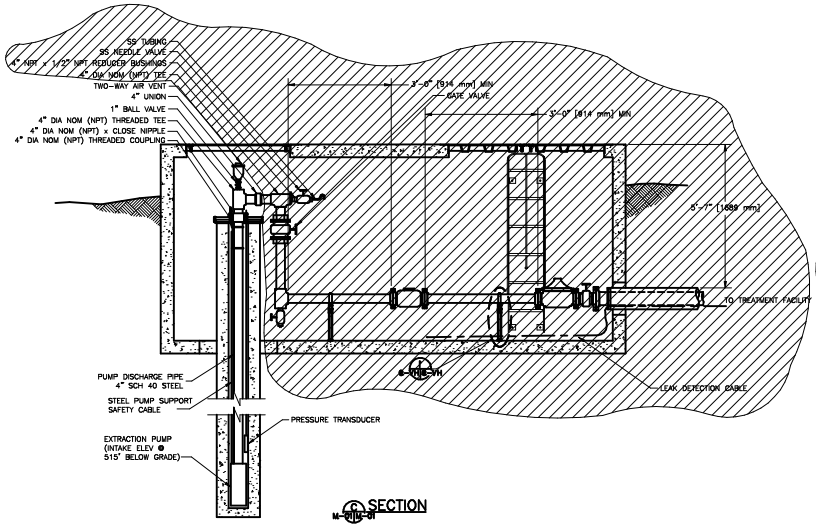


SECTION D-D

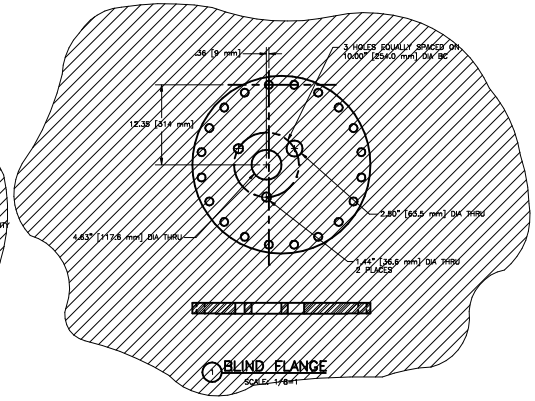


DETAIL: PIPE SUPPORT

SCALE: 1/4=1



SECTION



BLIND FLANGE

SCALE: 1/8=1

SUPPLIED BY OTHERS
WELL, WELL HEAD VAULT, BLIND FLANGE AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY PUMP/MOTOR ASSEMBLY POWER CABLE, TRANSDUCER, TEE, REDUCER BUSHING, BALL VALVE, VENT-VACUUM VALVE STRAIN RELIEF CONNECTORS AND ASSOCIATED FITTINGS

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER
2. SAFETY CABLE TERMINATION AND SECURING METHOD SHALL BE DETERMINED BY PUMP INSTALLATION CONTRACTOR.

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
1	17		SAFETY CABLE, 0.5" DIA	CS		
4	16		WASHER, LOCK, 1.125" DIA	CS		
8	15		WASHER, FLAT, 1.125" DIA	CS		
	14		TRANSDUCER CABLE	CU		
	13		PUMP POWER CABLE	CU		
4	12		NUT, 1.125" DIA	CS		
4	11		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
	10		STRAP	SS		
1	9		STRAIN RELIEF CONNECTOR, 2"	SS		
1	8		STRAIN RELIEF CONNECTOR, 1"	SS		
1	7		COUPLING, 2" NPT, SCH 80	CS		
2	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		COUPLING, 4"	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		NIPPLE, 4" NPT x CLOSE	CS		
1	3		DROP PIPE, 4" DIA x 515', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASTM CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASTM CLASS 150	CS	ASTM 181, GRADE I	

NEXT ASSY / REVISED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xx± FRACTIONS ±
.xxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

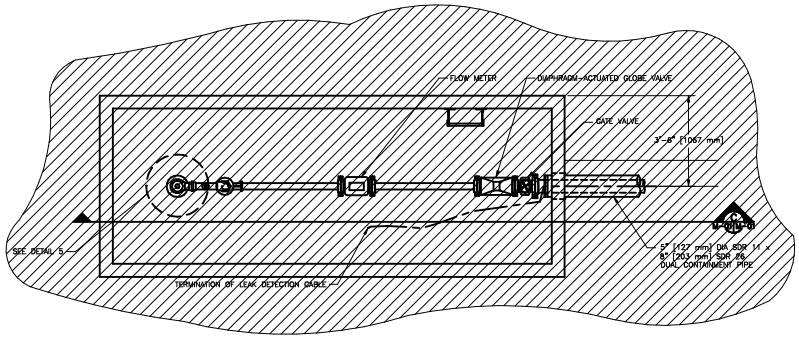
DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

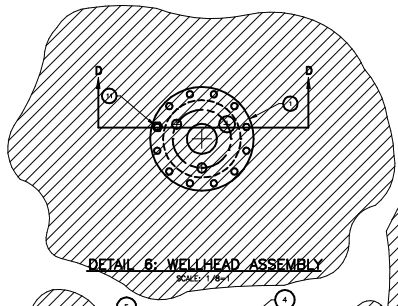
WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-2
MECHANICAL
DETAILS

CODE IDENT. | SIZE F | DWG. NO. 654-M-01 | A.E. DWG. NO. | SCALE 1/2"=1'-0" | SHEET 1 OF 1 | REV.

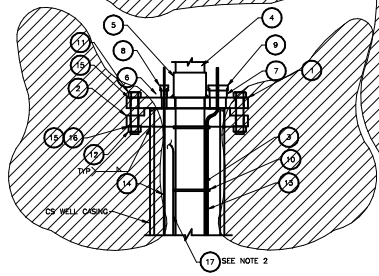
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



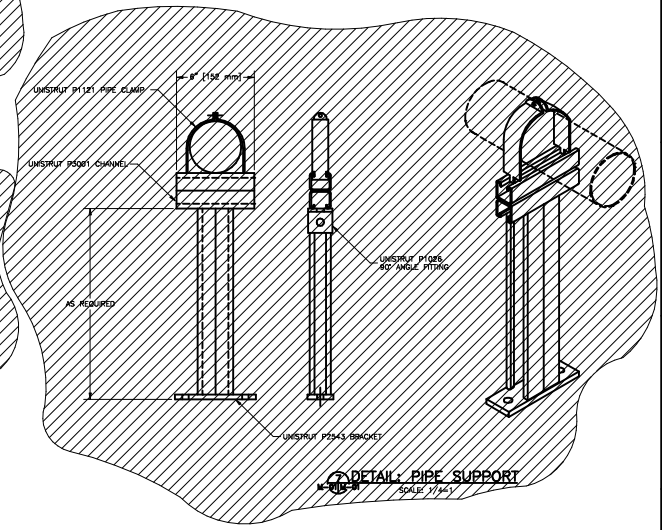
5 DETAIL: PFE-3 EXTRACTION WELL VAULT
M-FILE-01



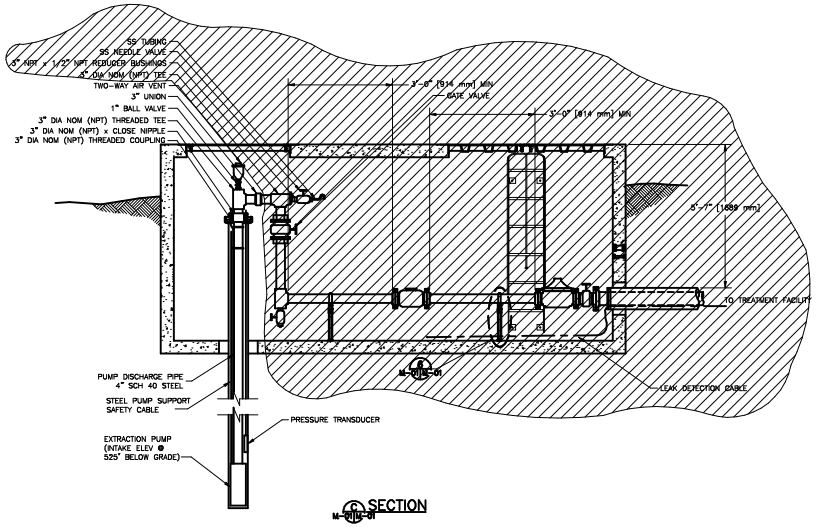
DETAIL 6: WELLHEAD ASSEMBLY
SCALE: 1/8=1



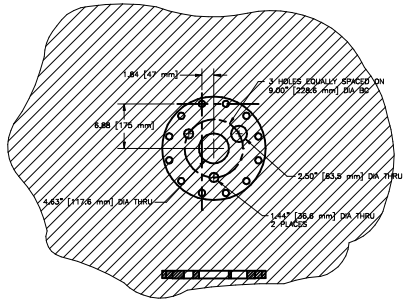
SECTION D-D



7 DETAIL: PIPE SUPPORT
M-FILE-01
SCALE: 1/4=1



6 SECTION
M-FILE-01



1 BLIND FLANGE
SCALE: 1/8=1

SUPPLIED BY OTHERS
WELL, WELL HEAD VAULT, BLIND FLANGE AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY PUMP/MOTOR ASSEMBLY POWER CABLE, TRANSDUCER, TEE, REDUCER BUSHING, BALL VALVE, VENT-VACUUM VALVE STRAIN RELIEF CONNECTORS AND ASSOCIATED FITTINGS

NOTES:

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8	15		WASHER, FLAT, 1.125" DIA	CS		
1	14		TRANSDUCER CABLE	CU		
1	13		PUMP POWER CABLE	CU		
4	12		NUT, 1.00" DIA	CS		
4	11		BOLT, 1.00" DIA x 5-1/2" [139 mm]	CS		
1	10		STRAP	SS		
1	9		STRAIN RELIEF CONNECTOR, 2"	SS		
1	8		STRAIN RELIEF CONNECTOR, 1"	SS		
1	7		COUPLING, 2" NPT, SCH 80	CS		
2	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		COUPLING, 4" NPT, SCH 80	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		NIPPLE, 4" NPT x CLOSE	CS		
1	3		DROP PIPE, 4" DIA x 525', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	

NEXT ASSY / REUSED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

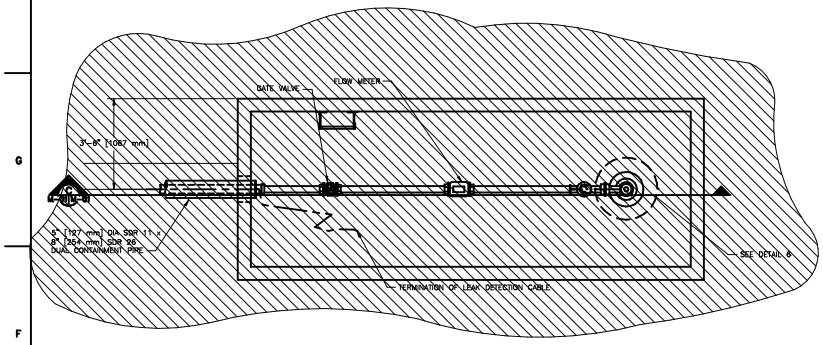
DRAWN BY	M. TARN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

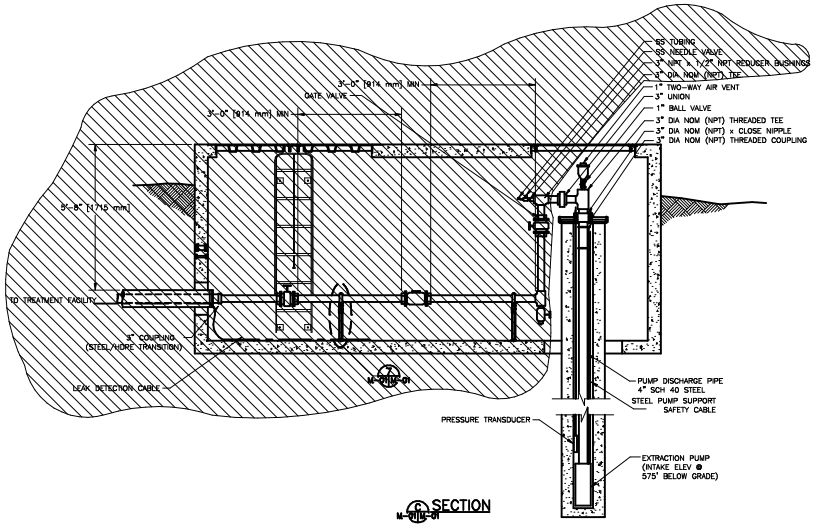
WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-3
MECHANICAL
DETAILS

A.E. DWG. NO.
SCALE 1/2"=1'-0"
SHEET 1 OF 1
CODE IDENT. F
SIZE
DWG. NO. 655-M-01
REV.

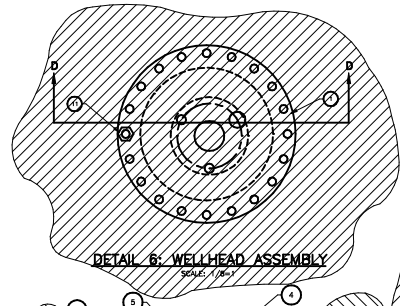
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

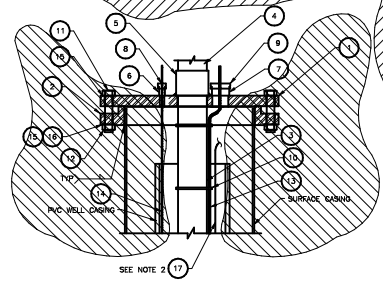


DETAIL: PFE-4A EXTRACTION WELL VAULT

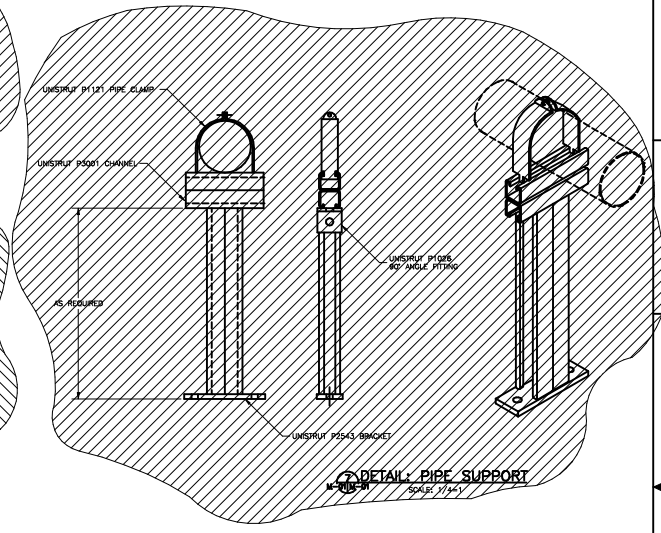


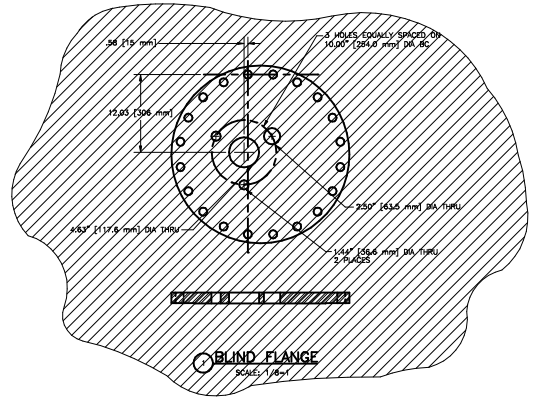
SECTION





SECTION D-D





SUPPLIED BY OTHERS
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8	15		WASHER, FLAT, 1.125" DIA	CS		
	14		TRANSDUCER CABLE	CU		
	13		PUMP POWER CABLE	CU		
4	12		NUT, 1.125" DIA	CS		
4	11		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
	10		STRAP	SS		
1	9		STRAIN RELIEF CONNECTOR, 2"	SS		
1	8		STRAIN RELIEF CONNECTOR, 1"	SS		
1	7		COUPLING, 2" NPT, SCH 80	CS		
1	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		COUPLING, 4" ASTM	CS	ASTM 105, GRADE I, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		NIPPLE, 4" NPT x CLOSE	CS		
1	3		DROP PIPE, 4" DIA x 575', SCH 40	CS		
1	2		SOCKET FLANGE, 20", 150 PSI	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", 150 PSI	CS	ASTM 181, GRADE I	

NEXT ASSY / REVISED DWG'S

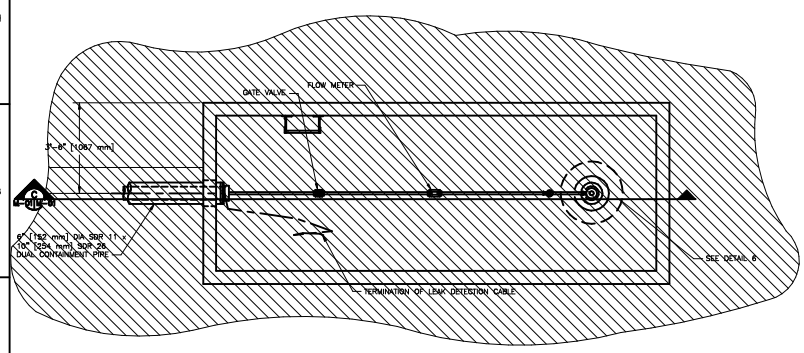
DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xxx± FRACTIONS ±
.xxxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

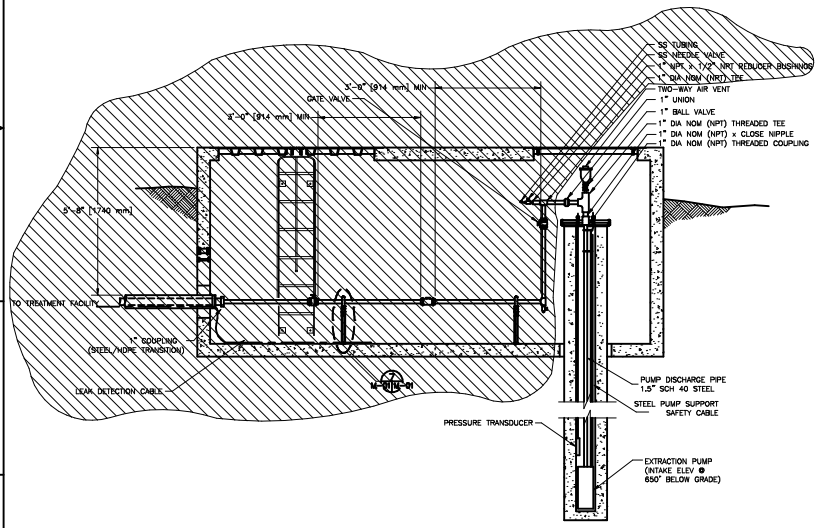
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-4A
MECHANICAL
DETAILS

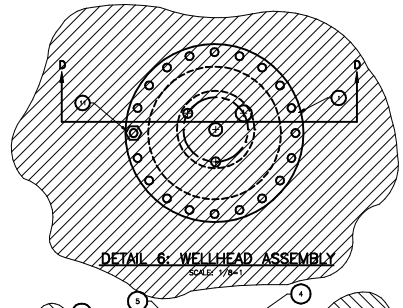
A.E. DWG. NO.
SCALE 1/2"=1'-0"
SHEET 1 OF 1
CODE IDENT. F
SIZE D
DWG. NO. 656-M-01
REV.



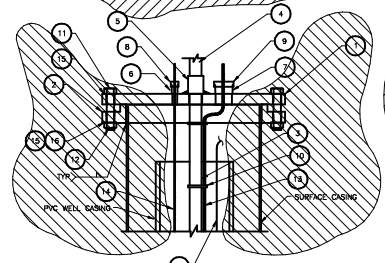
5 DETAIL: PFE-5 EXTRACTION WELL VAULT
M-01S-01



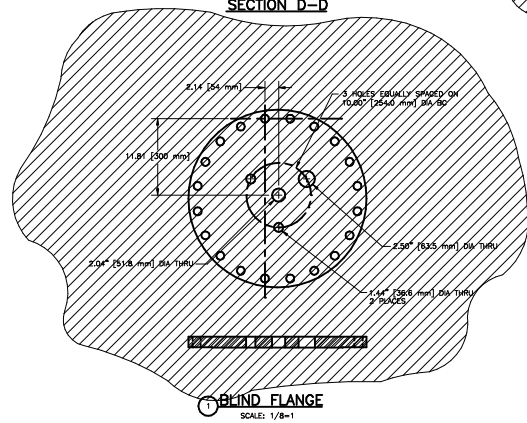
SECTION
M-01S-01



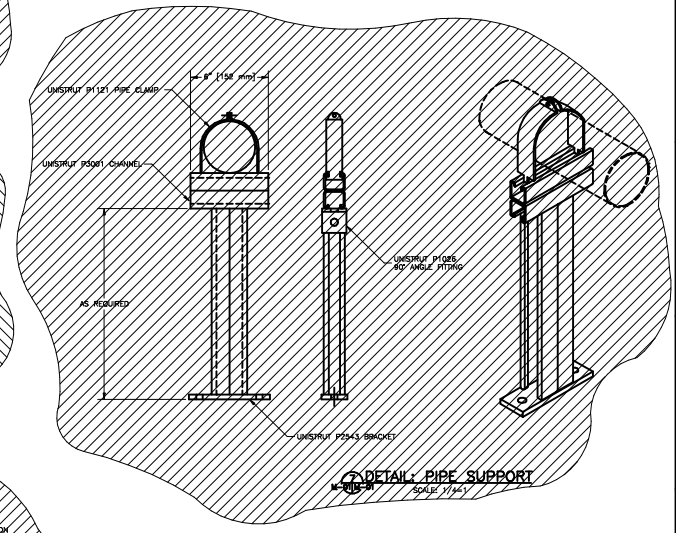
DETAIL 6: WELLHEAD ASSEMBLY
SCALE: 1/8=1



SECTION D-D



1 BLIND FLANGE
SCALE: 1/8=1



7 DETAIL: PIPE SUPPORT
M-01S-01
SCALE: 1/4=1

				17		SAFETY CABLE, 0.375" DIA	CS		
			4	16		WASHER, LOCK, 1.125" DIA	CS		
			8	15		WASHER, FLAT, 1.125" DIA	CS		
				14		TRANSDUCER CABLE	CU		
				13		PUMP POWER CABLE	CU		
			4	12		NUT, 1.125" DIA	CS		
			4	11		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
				10		STRAP	SS		
			1	9		STRAIN RELIEF CONNECTOR, 2"	SS		
			1	8		STRAIN RELIEF CONNECTOR, 1"	SS		
			1	7		COUPLING, 2" NPT, SCH 80	CS		
			2	6		COUPLING, 1" NPT, SCH 80	CS		
			1	5		COUPLING, 1.5" NPT, SCH 80	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
			1	4		NIPPLE, 4" NPT x CLOSE	CS		
			1	3		DROP PIPE, 1.5" DIA x 650', SCH 40	CS		
			1	2		SOCKET FLANGE, 9.05", ASME CLASS 150	CS	ASTM 181, GRADE I	
			1	1		BLIND FLANGE, 9.05", ASME CLASS 150	CS	ASTM 181, GRADE I	
			1	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASSY									

SUPPLIED BY OTHERS
WELL, WELL HEAD VAULT, BLIND FLANGE AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY PUMP/MOTOR ASSEMBLY POWER CABLE, TRANSDUCER, TEE, REDUCER BUSHING, BALL VALVE, VENT-VACUUM VALVE STRAIN RELIEF CONNECTORS AND ASSOCIATED FITTINGS

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER
2. SAFETY CABLE TERMINATION AND SECURING METHOD SHALL BE DETERMINED BY PUMP INSTALLATION CONTRACTOR.

NEXT ASSY / REUSED ON'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xx± FRACTIONS ±
.xxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURR.

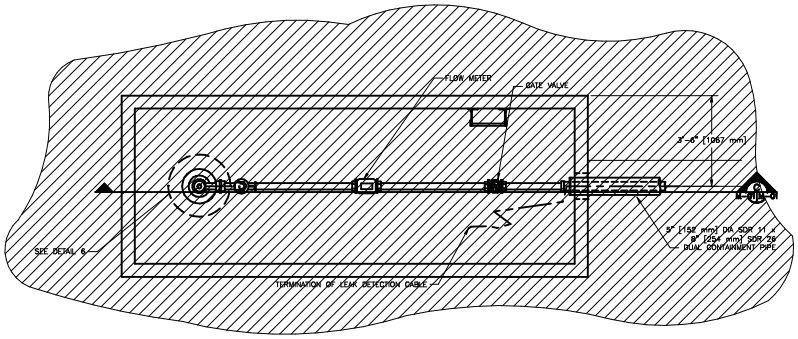
DRAWN BY	M. TARN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

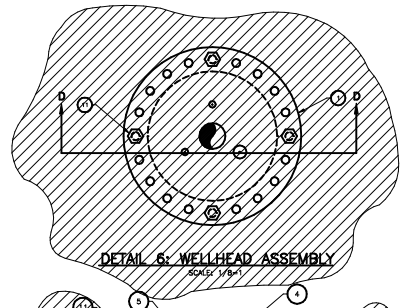
WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-5
MECHANICAL DETAILS

CODE IDENT. | SIZE F | DWG. NO. 657-M-01 | REV.
A.E. DWG. NO. | SCALE 1/2"=1'-0" | SHEET 1 OF 1

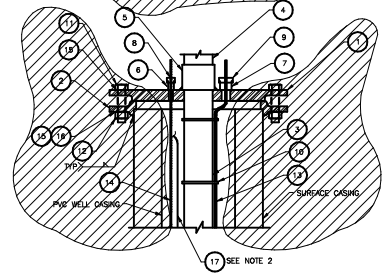
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



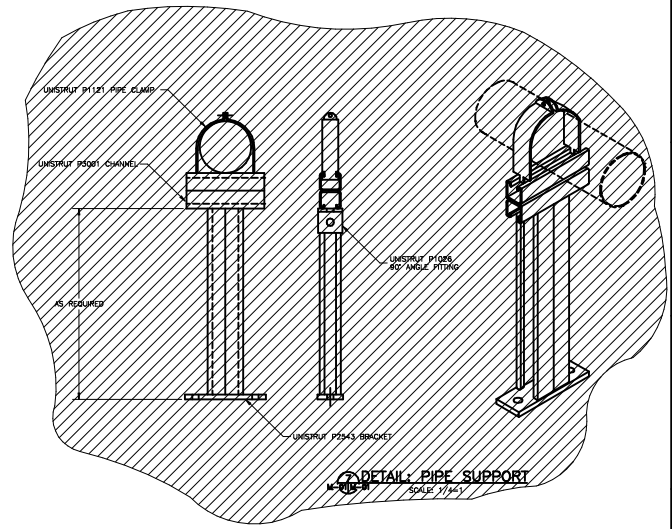
DETAIL: PFE-7 EXTRACTION WELL VAULT
C-M11E-01



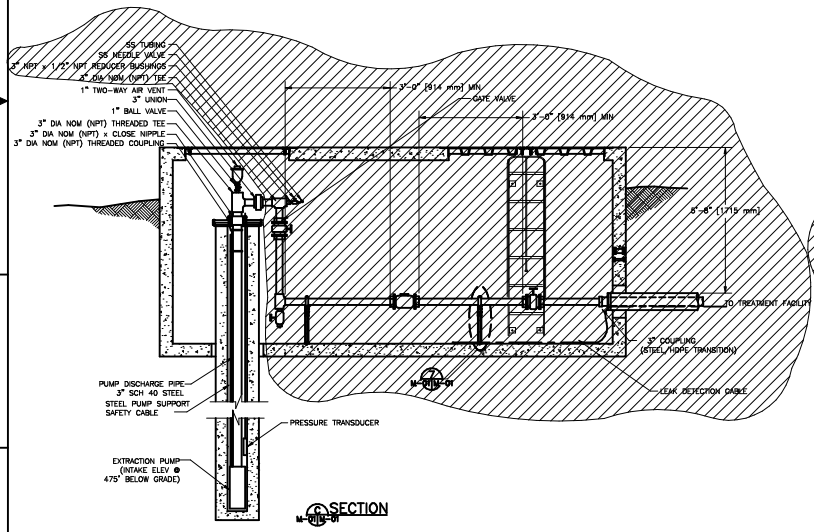
DETAIL 6: WELLHEAD ASSEMBLY
SCALE: 1/8=1



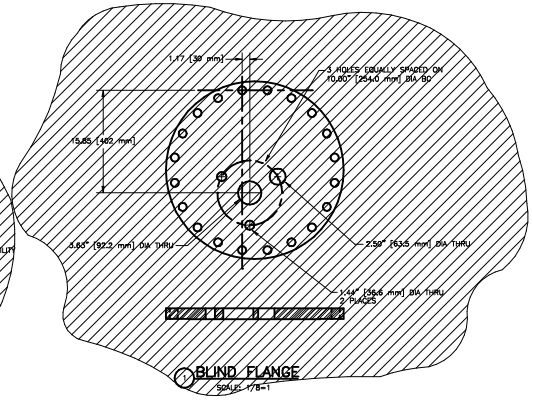
SECTION D-D



DETAIL: PIPE SUPPORT
M-M11E-01
SCALE: 1/4=1



SECTION
M-M11E-01



BLIND FLANGE
SCALE: 1/8=1

SUPPLIED BY OTHERS
WELL, WELL HEAD VAULT, BLIND FLANGE AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY PUMP/MOTOR ASSEMBLY POWER CABLE, TRANSDUCER, TEE, REDUCER BUSHING, BALL VALVE, VENT-VACUUM VALVE STRAIN RELIEF CONNECTORS AND ASSOCIATED FITTINGS

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER
2. SAFETY CABLE TERMINATION AND SECURING METHOD SHALL BE DETERMINED BY PUMP INSTALLATION CONTRACTOR.

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
1	17		SAFETY CABLE, 0.05" DIA	CS		
4	16		WASHER, LOCK, 1.125" DIA	CS		
8	15		WASHER, FLAT, 1.125" DIA	CS		
	14		TRANSDUCER CABLE	CU		
	13		PUMP POWER CABLE	CU		
4	12		NUT, 1.125" DIA	CS		
4	11		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
	10		STRAP	SS		
1	9		STRAIN RELIEF CONNECTOR, 2"	SS		
1	8		STRAIN RELIEF CONNECTOR, 1"	SS		
1	7		COUPLING, 2" NPT, SCH 80	CS		
1	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		COUPLING, 3" ASTM	CS	ASTM 105, GRADE I, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		NIPPLE, 3" NPT x CLOSE	CS		
1	3		DROP PIPE, 3" DIA x 475', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	

NEXT ASSY / REVISED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xx± FRACTIONS ±
.xxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

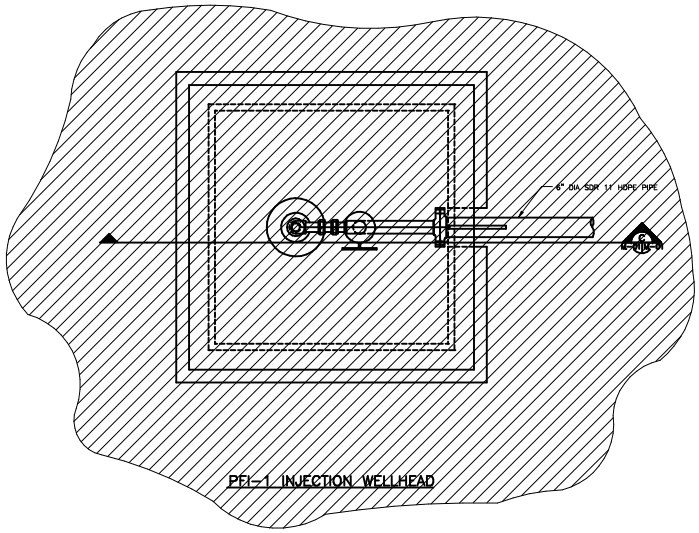
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

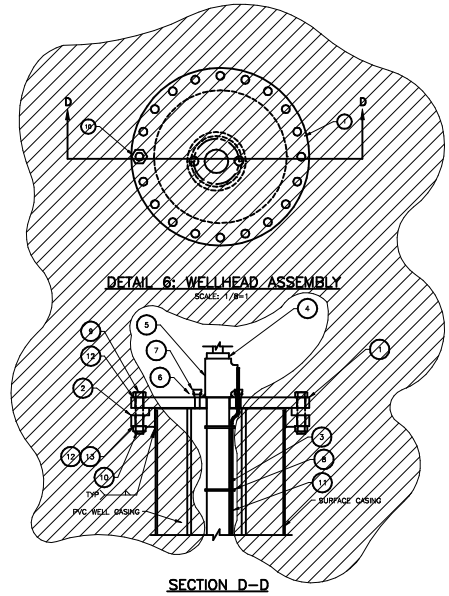
WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-7
MECHANICAL
DETAILS

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	658-M-01	

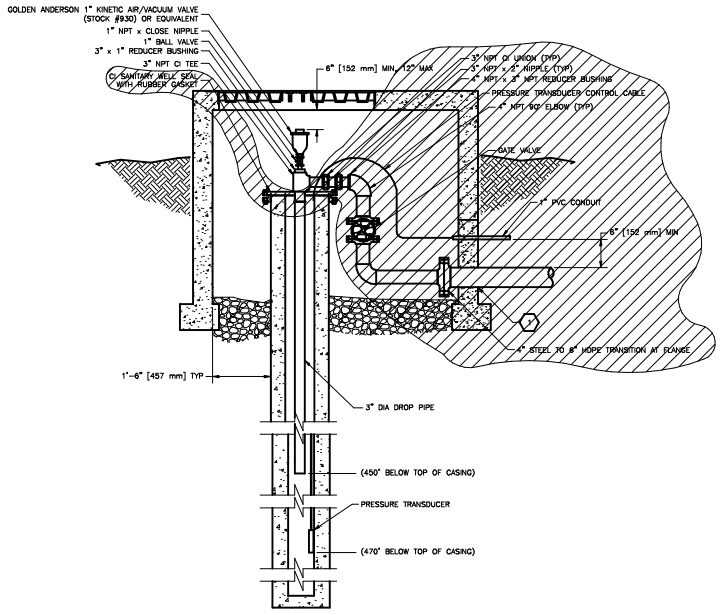
A.S. DWG. NO. | SCALE 1/2"=1'-0" | SHEET 1 OF 1

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

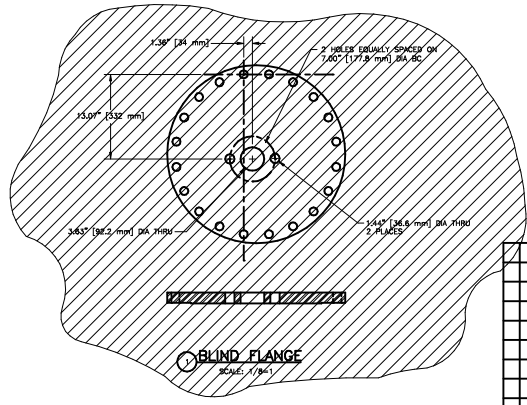




SECTION D–D



SECTION



SUPPLIED BY OTHERS
WELL, WELL SEAL, WELL HEAD VAULT, AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY INJECTION TUBING, TEE, REDUCER BUSHING, BALL VALVE, AIR/VACUUM VALVE, AND ASSOCIATED FITTINGS

KEYED NOTES:

(1) FOLLOWING PIPE INSTALLATION INTO VAULT, SLOTTED ENTRY SHALL BE FORMED OVER AND FILLED WITH CONCRETE

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER

			4	13		WASHER, LOCK, 1.125" DIA	CS		
			8	12		WASHER, FLAT, 1.125" DIA	CS		
			11			TRANSDUCER CABLE	CU		
			4	10		NUT, 1.125" DIA	CS		
			4	9		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
			8			STRAP	SS		
			2	7		STRAIN RELIEF CONNECTOR, 1"	SS		
			2	6		COUPLING, 1" NPT, SCH 80	CS		
			1	5		TEE, 3"	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
			1	4		REDUCER BUSHING, 3" x 1"	CS		
			1	3		DROP PIPE, 3" DIA x 450', SCH 40	CS		
			1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
			1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
REVD PER ASS'Y			ITEM NO.	PART NO.		DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / REVISED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xx± FRACTIONS ±
.xxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

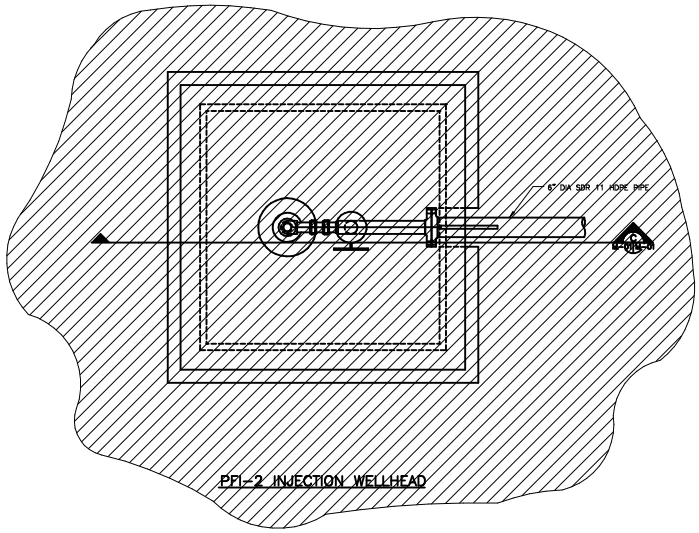
DRAWN BY	M. TARIN	2-25-00
ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

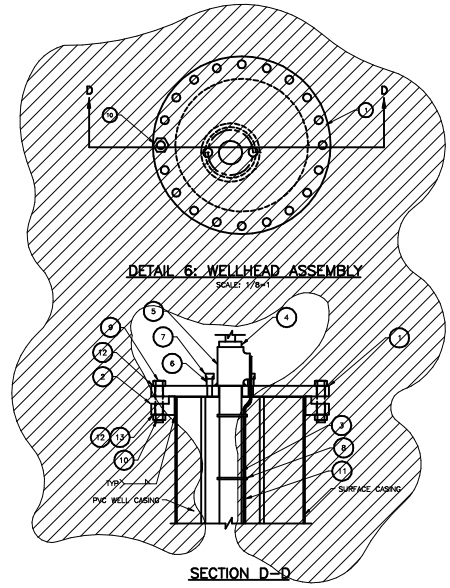
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

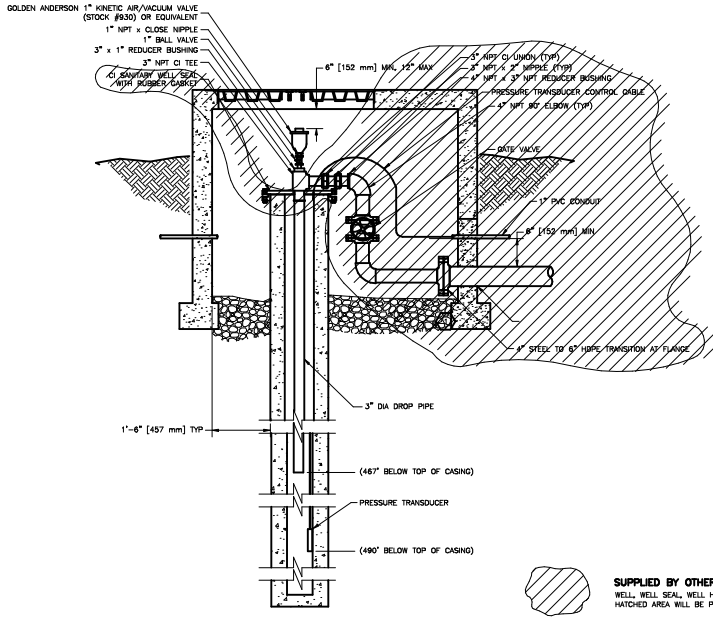
WSTF – PLUME–FRONT REMEDIATION
INJECTION WELL PFI–1
MECHANICAL
DETAILS AT WELLHEAD

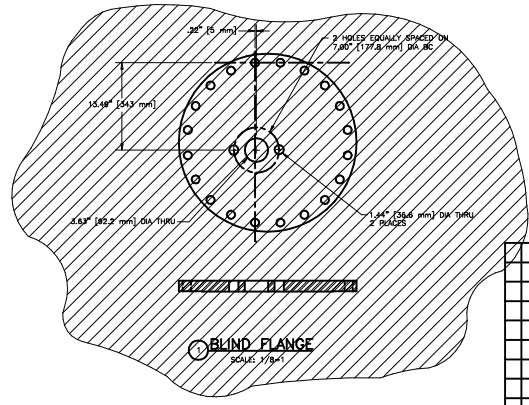
CODE IDENT. F | SIZE | DWG. NO. 660–M–01 | A.E. DWG. NO. | SCALE 3/4"=1'-0" | SHEET 1 OF 1 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL









SUPPLIED BY OTHERS

WELL, WELL SEAL, WELL HEAD VAULT, AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY INJECTION TUBING, TEE, REDUCER BUSHING, BALL VALVE, AIR/VACUUM VALVE, AND ASSOCIATED FITTINGS

KEYED NOTES:

1. FOLLOWING PIPE INSTALLATION INTO VAULT, SLOTTED ENTRY SHALL BE FORMED OVER AND FILLED WITH CONCRETE

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
4	13		WASHER, LOCK, 1.125" DIA	CS		
8	12		WASHER, FLAT, 1.125" DIA	CS		
11			TRANSDUCER CABLE	CU		
4	10		NUT, 1.125" DIA	CS		
4	9		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
8			STRAP	SS		
2	7		STRAIN RELIEF CONNECTOR, 1"	SS		
2	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		TEE, 3"	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		REDUCER BUSHING, 3"x1"	CS		
1	3		DROP PIPE, 3" DIA x 467', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

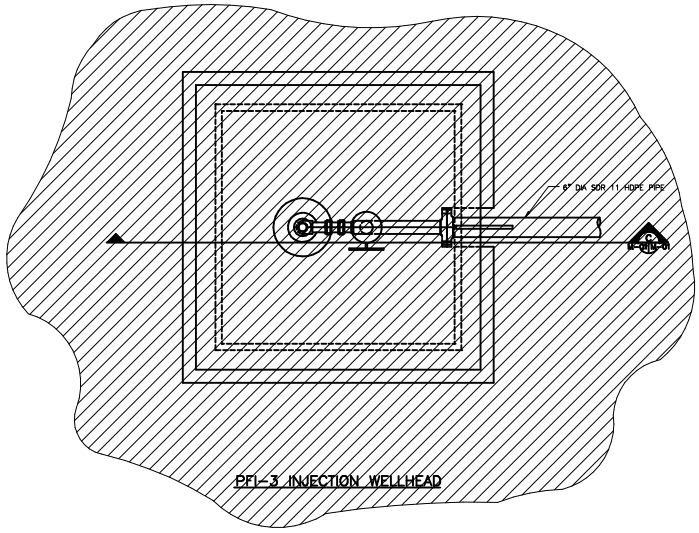
DRAWN BY	M. TARIN	2-25-00
ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

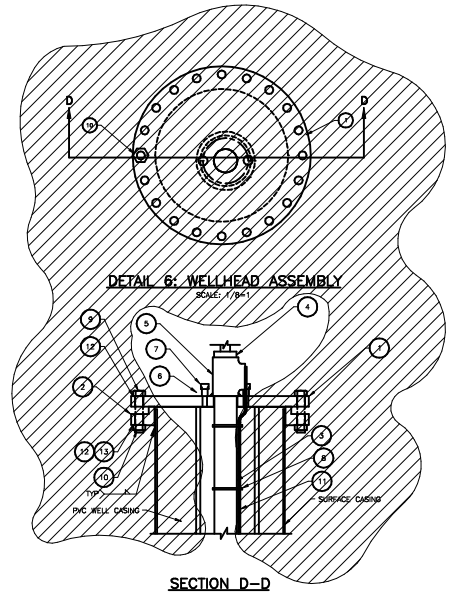
WSTF – PLUME-FRONT REMEDIATION
INJECTION WELL PFI-2
MECHANICAL
DETAILS AT WELLHEAD

CODE IDENT. | SIZE F | DWG. NO. 661-M-01 | A.B. DWG. NO. | SCALE 3/4"=1'-0" | SHEET 1 OF 1 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

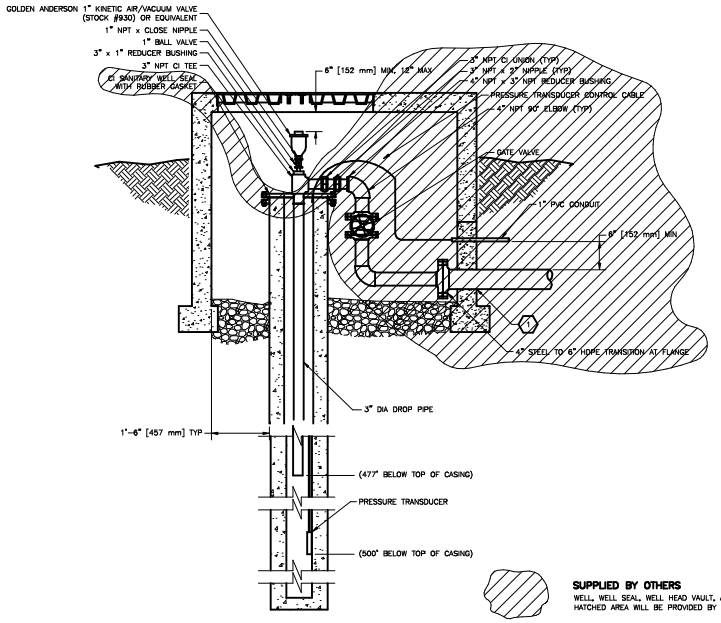


PFI-3 INJECTION WELLHEAD

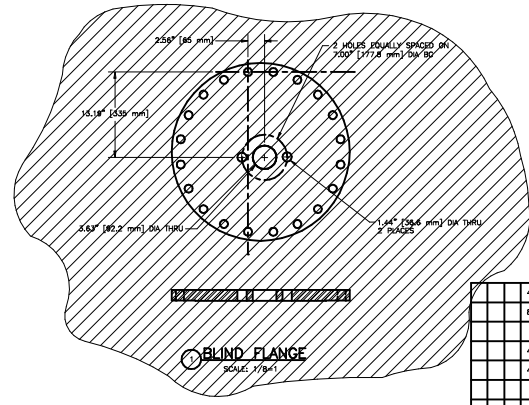


DETAIL 6: WELLHEAD ASSEMBLY
SCALE: 1/8=1

SECTION D-D



SECTION
M-01-01



1 BLIND FLANGE
SCALE: 1/8=1

SUPPLIED BY OTHERS

WELL, WELL SEAL, WELL HEAD VAULT, AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY INJECTION TUBING, TEE, REDUCER BUSHING, BALL VALVE, AIR/VACUUM VALVE, AND ASSOCIATED FITTINGS

KEYED NOTES:

1. FOLLOWING PIPE INSTALLATION INTO VAULT, SLOTTED ENTRY SHALL BE FORMED OVER AND FILLED WITH CONCRETE

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER

			4	13		WASHER, LOCK, 1.125" DIA	CS		
			8	12		WASHER, FLAT, 1.125" DIA	CS		
				11		TRANSDUCER CABLE	CU		
			4	10		NUT, 1.125" DIA	CS		
			4	9		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
				8		STRAP	SS		
			2	7		STRAIN RELIEF CONNECTOR, 1"	SS		
			2	6		COUPLING, 1" NPT, SCH 80	CS		
			1	5		TEE, 3"	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
			1	4		REDUCER BUSHING, 3"x1"	CS		
			1	3		DROP PIPE, 3" DIA x 477', SCH 40	CS		
			1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
			1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASYM 181, GRADE I	
			1	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASSY									

NEXT ASSY / RELATED DWGS

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-25-00
ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

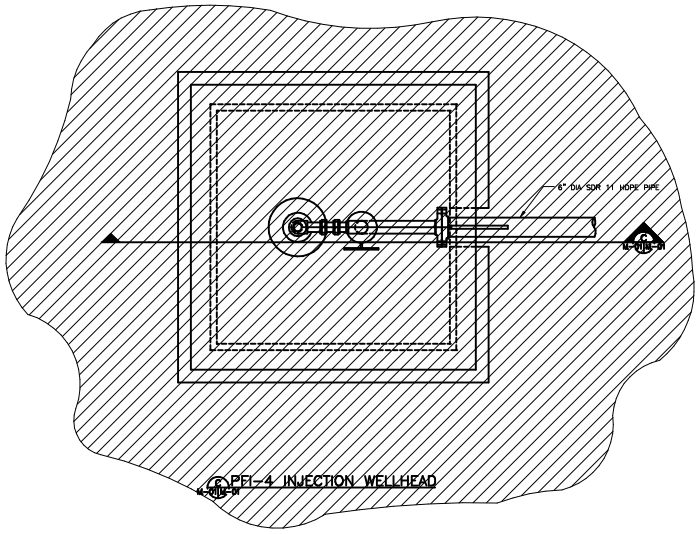
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

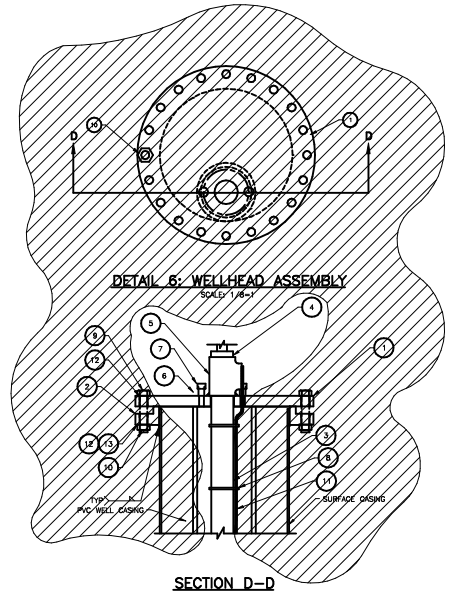
WSTF - PLUME-FRONT REMEDIATION
INJECTION WELL PFI-3
MECHANICAL
DETAILS AT WELLHEAD

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	662-M-01	

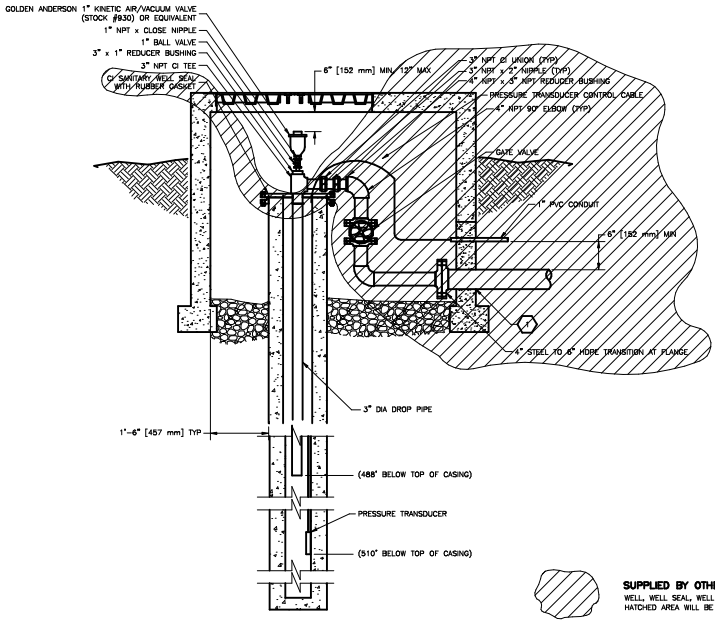
A.B. DWG. NO.
SCALE 3/4"=1'-0"
SHEET 1 OF 1

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

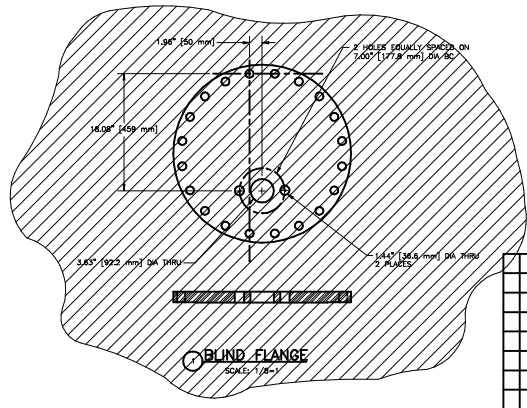




SECTION D–D



SECTION



REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHC. NO.
4	13		WASHER, LOCK, 1.125" DIA	CS		
8	12		WASHER, FLAT, 1.125" DIA	CS		
11			TRANSDUCER CABLE	CU		
4	10		NUT, 1.125" DIA	CS		
4	9		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
8			STRAP	SS		
2	7		STRAIN RELIEF CONNECTOR, 1"	SS		
2	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		TEE, 3"	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		REDUCER BUSHING, 3"x1"	CS		
1	3		DROP PIPE, 3" DIA x 488', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	

SUPPLIED BY OTHERS

WELL, WELL SEAL, WELL HEAD VAULT, AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY INJECTION TUBING, TEE, REDUCER BUSHING, BALL VALVE, AIR/VACUUM VALVE, AND ASSOCIATED FITTINGS

KEYED NOTES:

1. FOLLOWING PIPE INSTALLATION INTO VAULT, SLOTTED ENTRY SHALL BE FORMED OVER AND FILLED WITH CONCRETE

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.XX± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

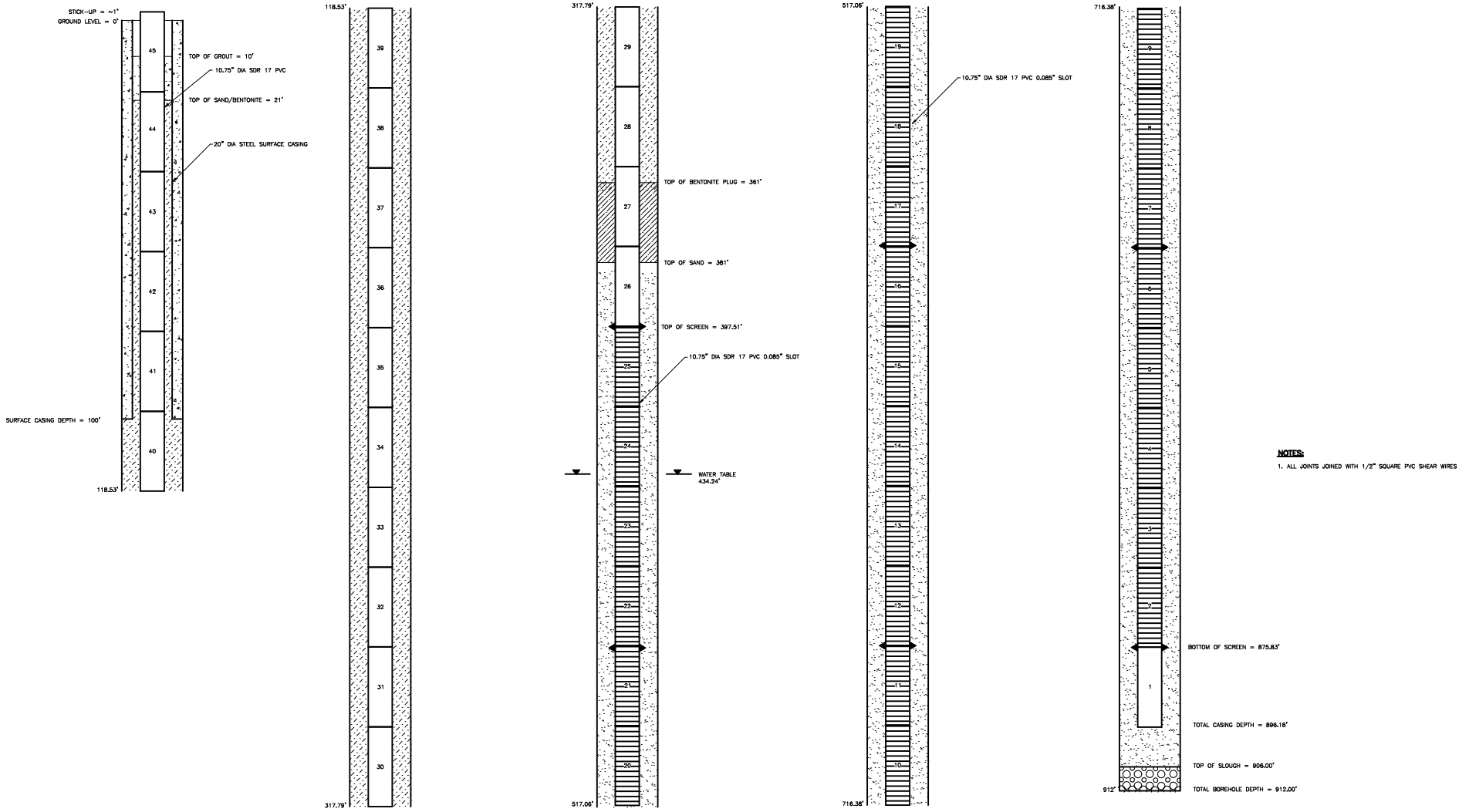
DRAWN BY	M. TARIN	2-25-00
ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME–FRONT REMEDIATION
INJECTION WELL PFI–4
MECHANICAL
DETAILS AT WELLHEAD

A.B. DWG. NO.
SCALE: 3/4"=1'-0"
SHEET 1 OF 1
CODE IDENT. SIZE F DWG. NO. 663–M–01 REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE
4/8 SAND
SLOUGH
4/8 SAND/BENTONITE MIX
GROUT
SCREEN
STEEL, BOLT-ON CENTRALIZER

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xxx± FRACTIONS ±
.xxxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

NEXT ASSY / REUSED ON#'S

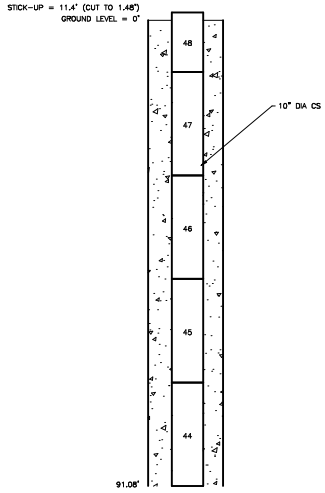
DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

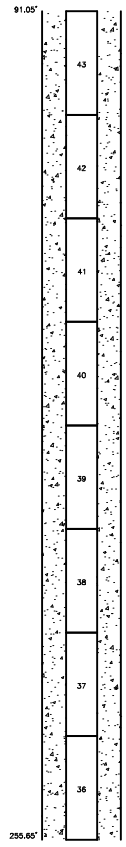
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

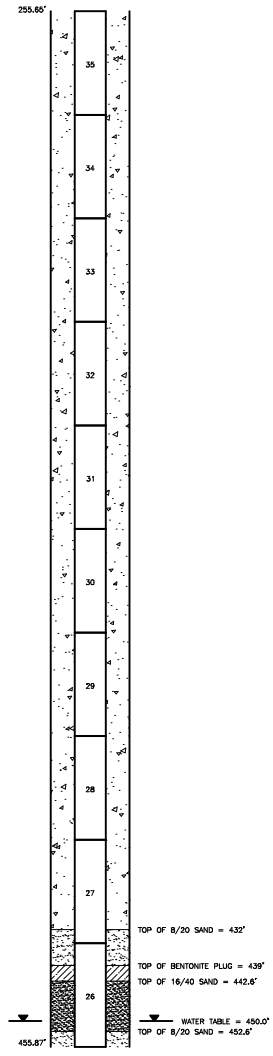
WSTF – PLUME–FRONT REMEDIATION
EXTRACTION WELL PFE–2
CIVIL
WELL COMPLETION DIAGRAM

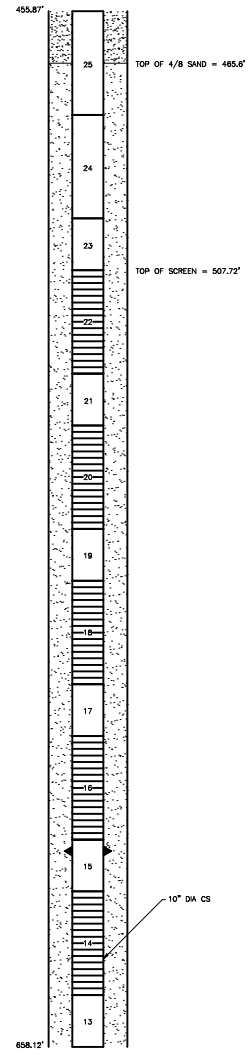
CODE IDENT. | A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1 | SIZE F | DWG. NO. 654–C–03 | REV.

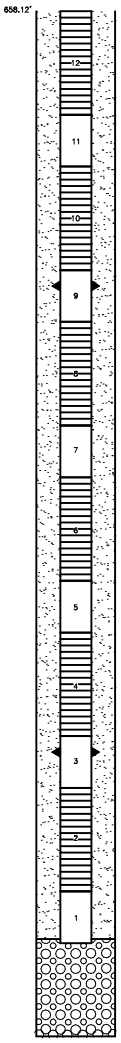
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL











NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE
8/20 SAND
SLOUGH
STEEL, BOLT-ON CENTRALIZER
4/8 SAND
GROUT
16/40 SAND
SCREEN

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / REUSED ON

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xxx± FRACTIONS ±
.xxxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

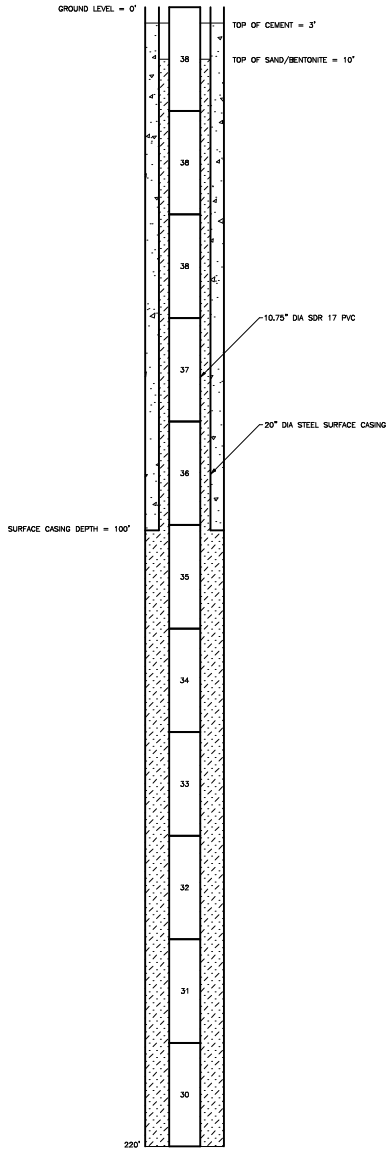
DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

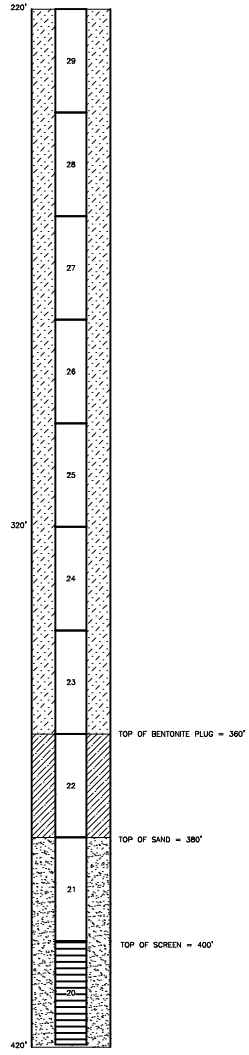
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

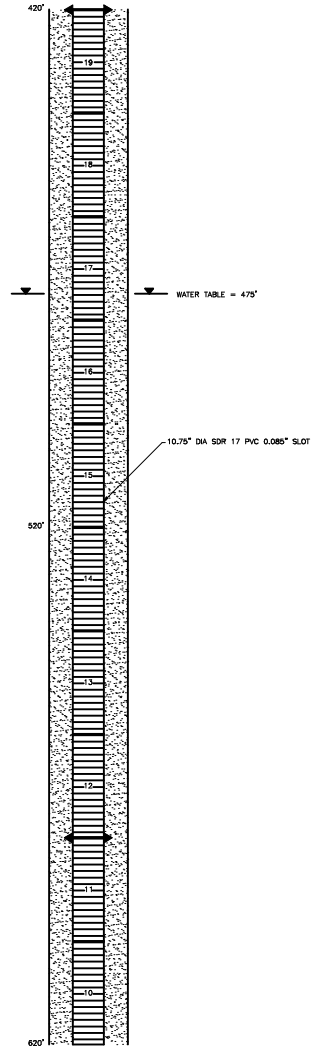
WSTF – PLUME–FRONT REMEDIATION
EXTRACTION WELL PFE-3
CIVIL
WELL COMPLETION DIAGRAM

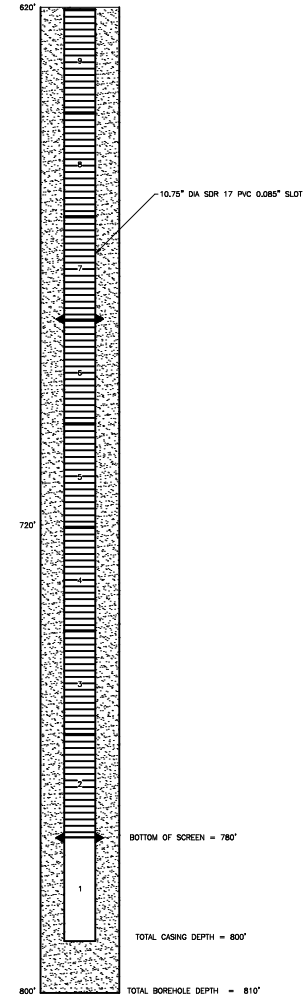
A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1
CODE IDENT. | SIZE F | DWG. NO. 655-C-03 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL









NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE

4/8 SAND

4/8 SAND/BENTONITE MIX

GROUT

SCREEN

STEEL, BOLT-ON CENTRALIZER

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / REVISED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx ANGLES ±
.xxx FRACTIONS ±
.xxxx
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

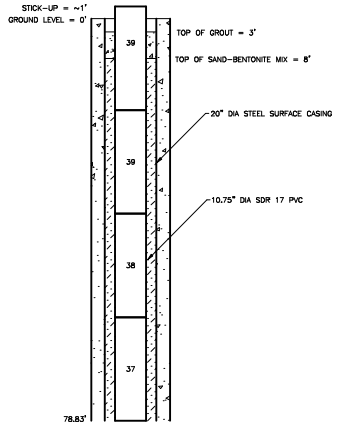
DRAWN BY	M. TARN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

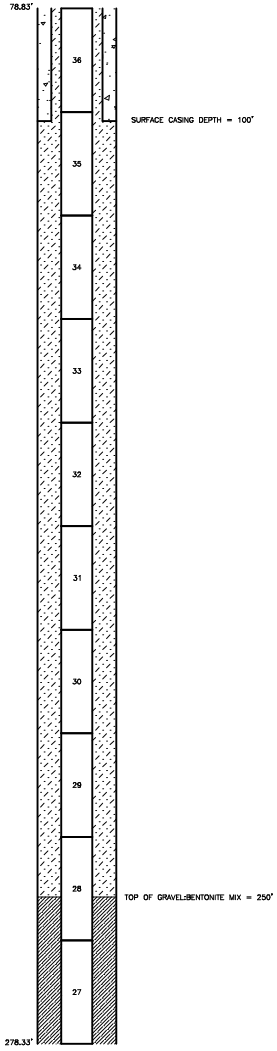
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

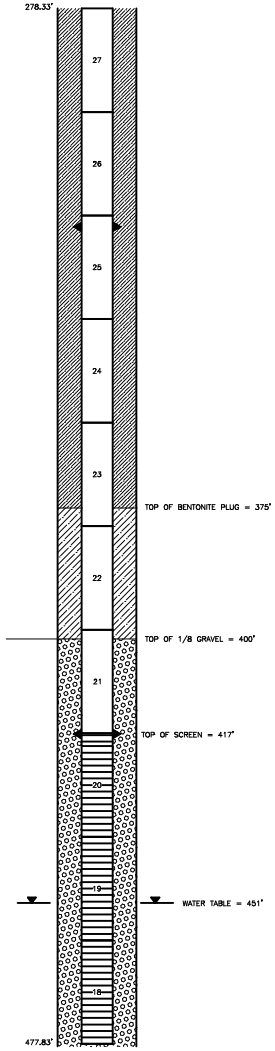
WSTF – PLUME–FRONT REMEDIATION
EXTRACTION WELL PFE–4A
CIVIL
WELL COMPLETION DIAGRAM

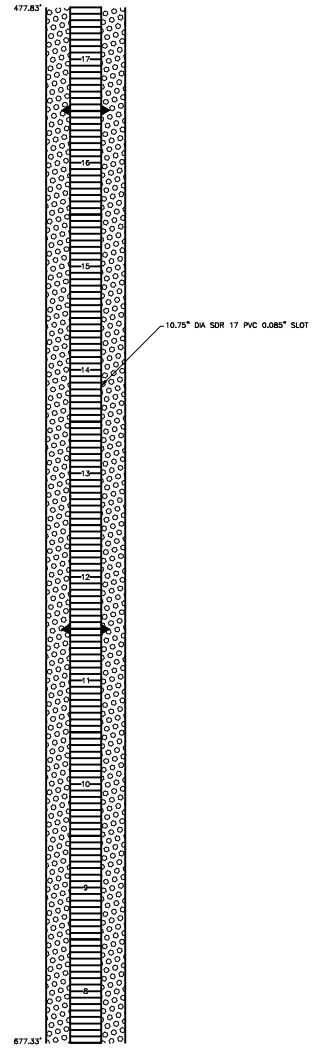
A.E. DWG. NO.
SCALE NONE
SHEET 1 OF 1
CODE IDENT.
SIZE F
DWG. NO. 656-C-03
REV.

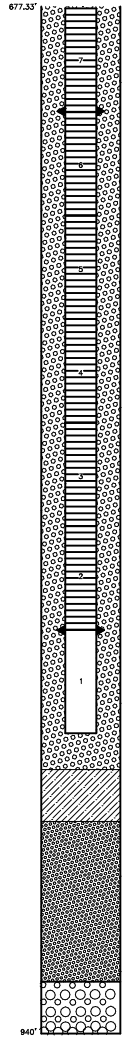
SYMBOL	LETTER ZONE	DESCRIPTION	DATE	APPROVAL











NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE | 8/20 SAND | 8/20 SAND/BENTONITE MIX | SLOUGH | STEEL, BOLT-ON CENTRALIZER

1/8 GRAVEL | GROUT | 1/8 GRAVEL/BENTONITE MIX | SCREEN

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / REUSED ON'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx ± ANGLES ±
.xxx ± FRACTIONS ±
.xxxx ±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

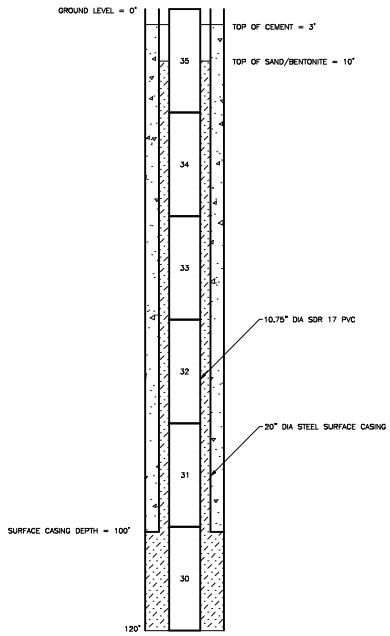
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

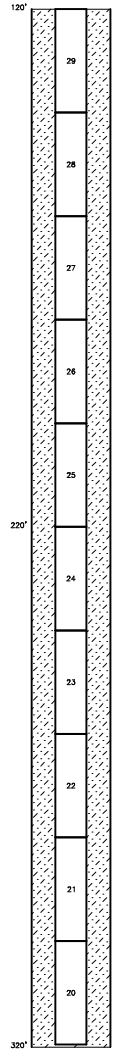
WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-5
CIVIL
WELL COMPLETION DIAGRAM

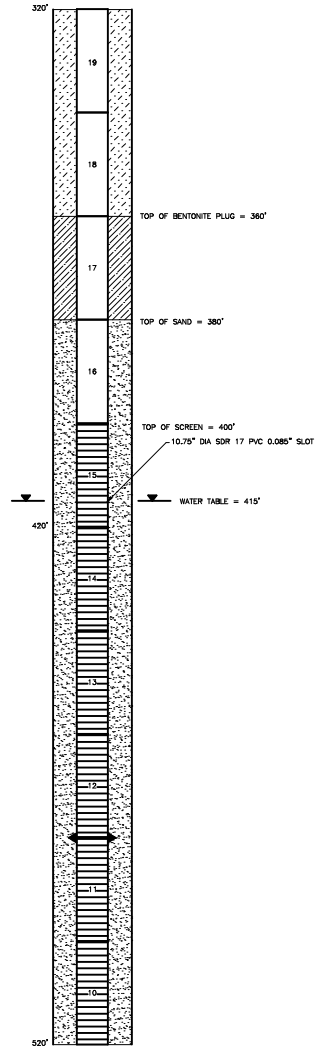
A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1

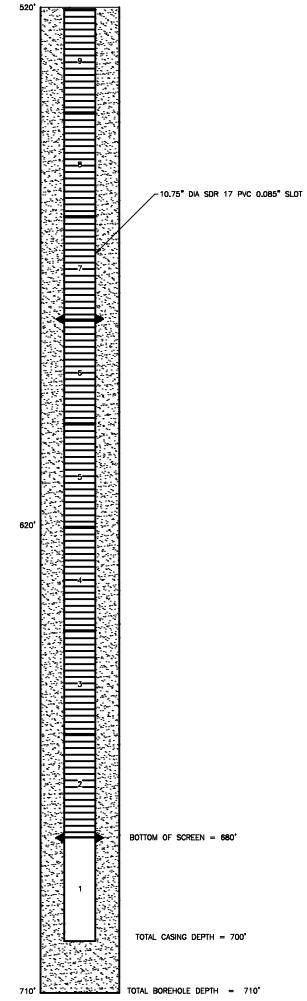
CODE IDENT. | SIZE F | DWG. NO. 657-C-03 | REV.

SYMBOL	LETTER ZONE	DESCRIPTION	DATE	APPROVAL









NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE

4/8 SAND

4/8 SAND/BENTONITE MIX

GROUT

SCREEN

STEEL, BOLT-ON CENTRALIZER

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / REVISED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx ± ANGLES ±
.xxx ± FRACTIONS ±
.xxxx ±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

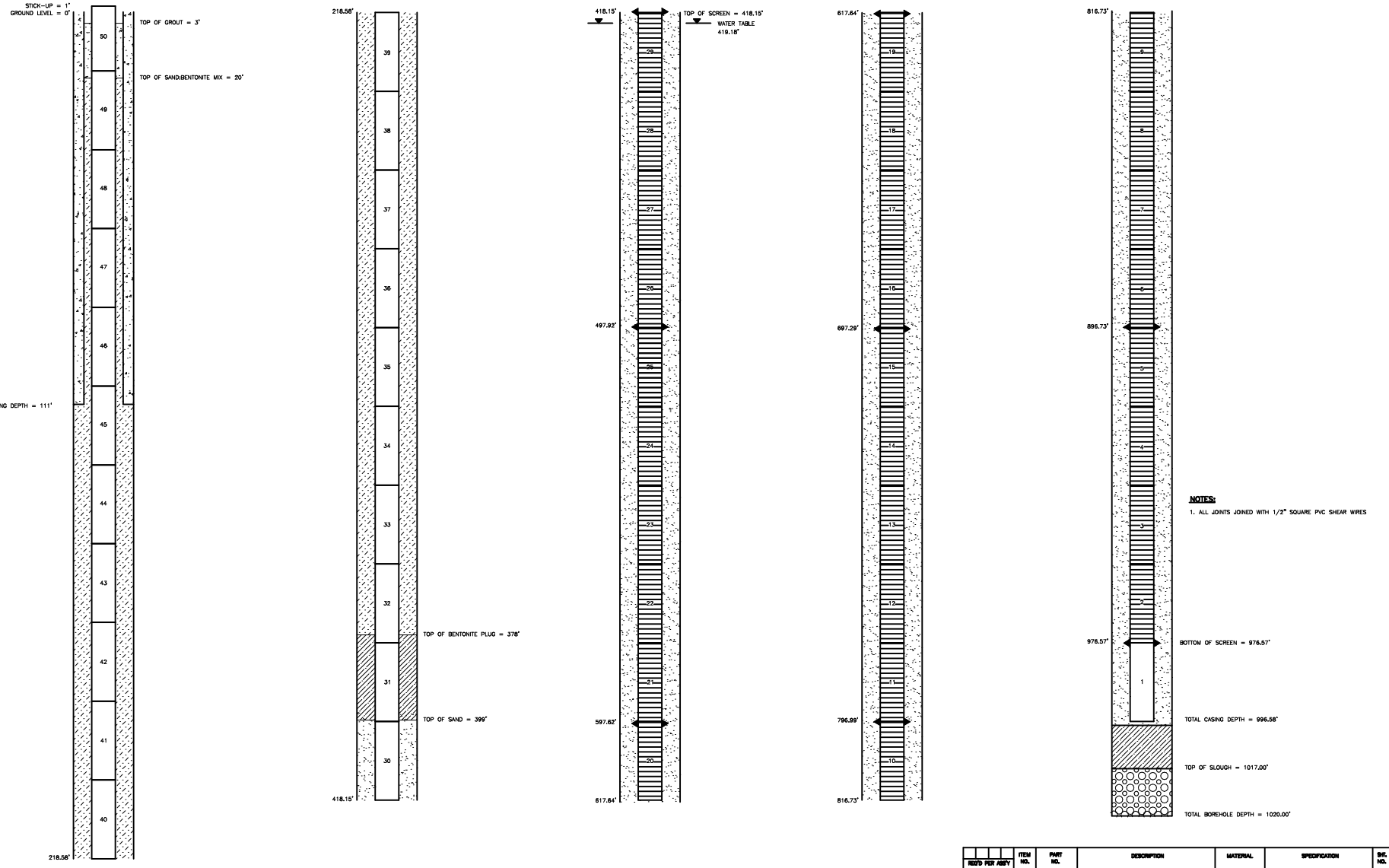
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME–FRONT REMEDIATION
EXTRACTION WELL PFE–7
CIVIL
WELL COMPLETION DIAGRAM

A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 658–C–03 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / REUSED ON'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

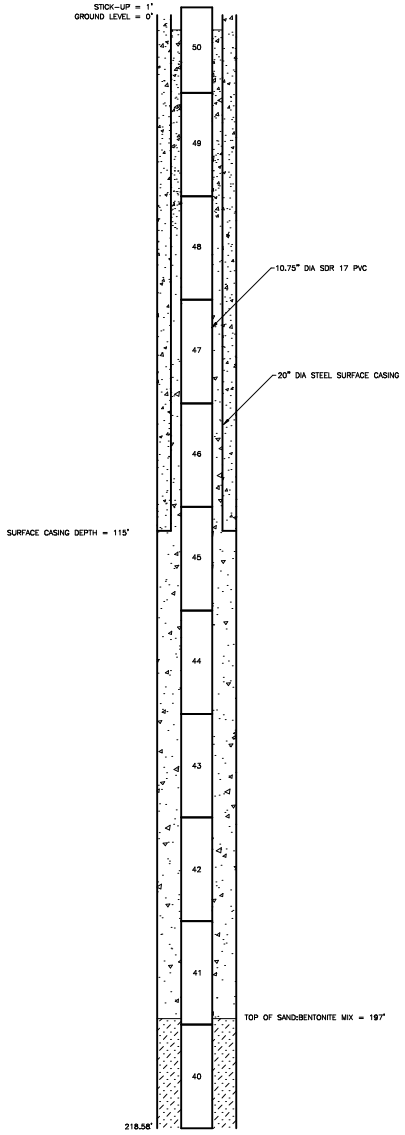
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

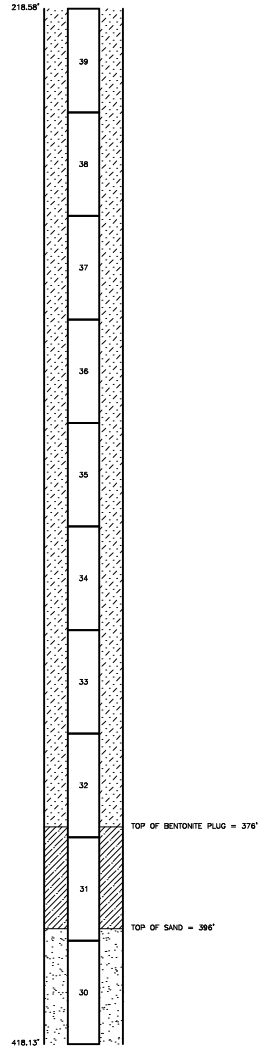
WSTF – PLUME-FRONT REMEDIATION
INJECTION WELL PFI-1
CIVIL
WELL COMPLETION DIAGRAM

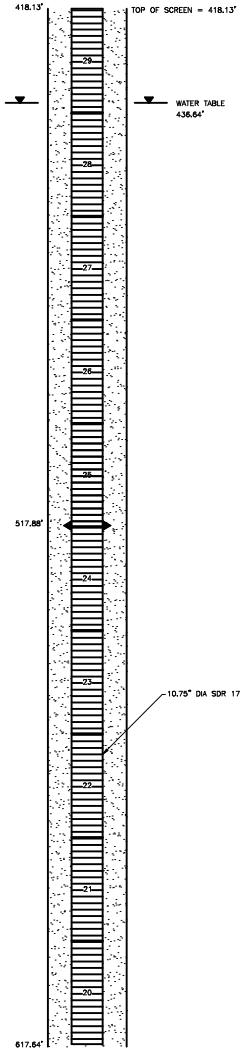
CODE IDENT.	SIZE	DWG. NO.	REV.
	F	660-C-02	

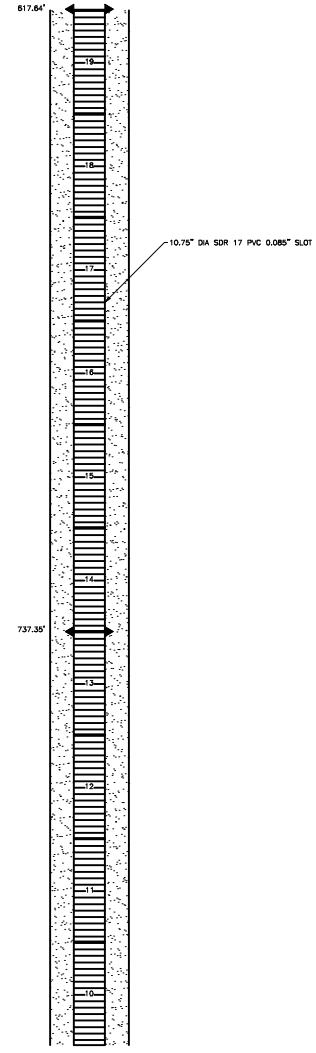
A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

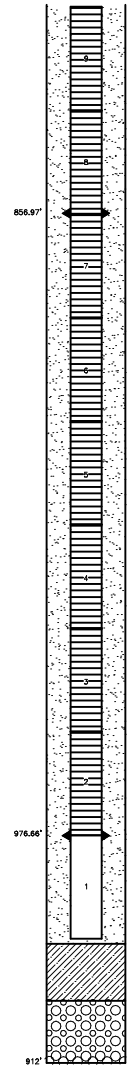
SYMBOL	LETTER ZONE	DESCRIPTION	DATE	APPROVAL











NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE
8/20 SAND/BENTONITE MIX
SLOUGH
4/8 SAND
GROUT
SCREEN
STEEL, BOLT-ON CENTRALIZER

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / REUSED ON#'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.XX± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

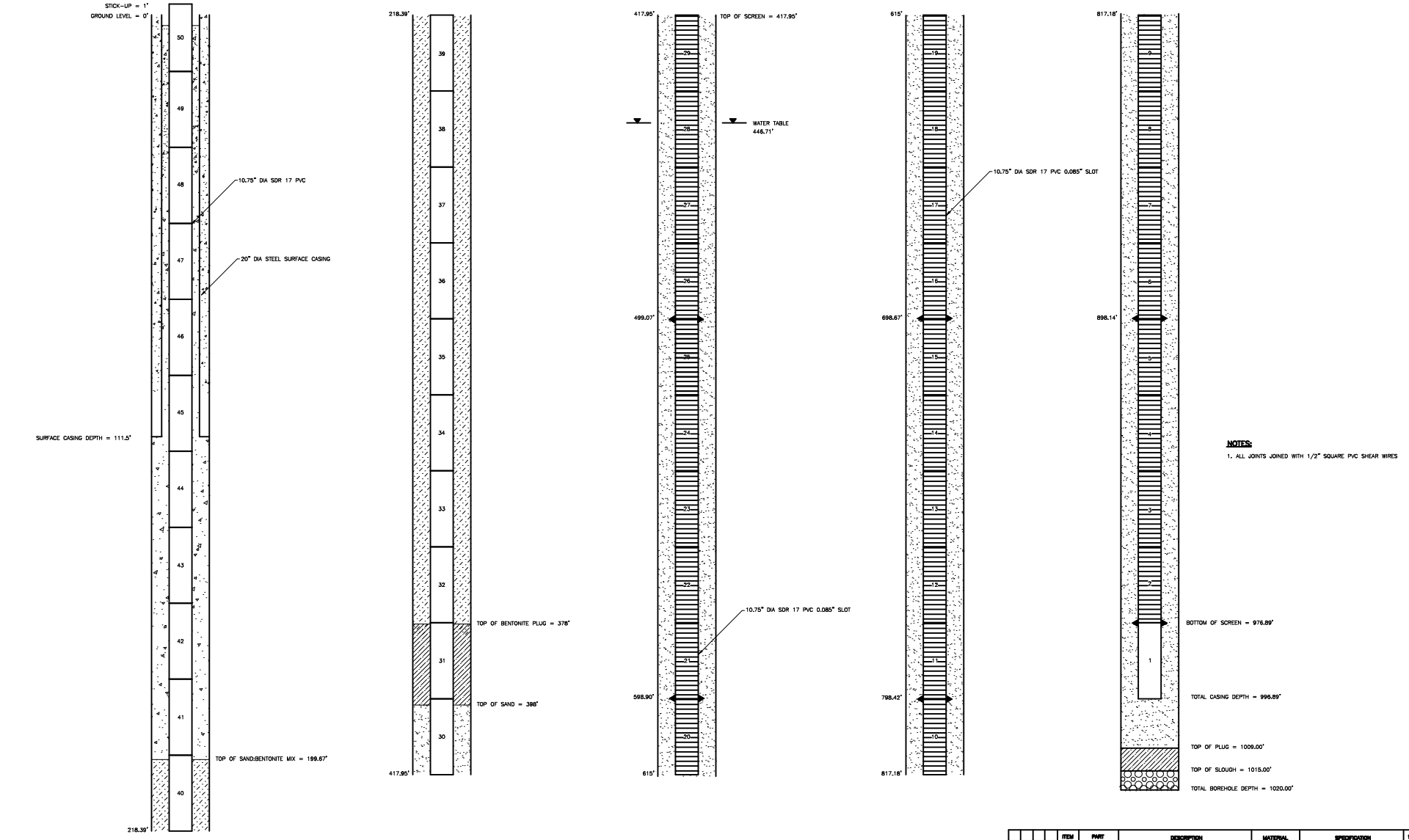
DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME–FRONT REMEDIATION
INJECTION WELL PFI–2
CIVIL
WELL COMPLETION DIAGRAM

A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1
CODE IDENT. | SIZE F | DWG. NO. 661–C–02 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE
8/20 SAND/BENTONITE MIX
SLOUGH
4/8 SAND
GROUT
SCREEN
STEEL, BOLT-ON CENTRALIZER

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xx± FRACTIONS ±
.xxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

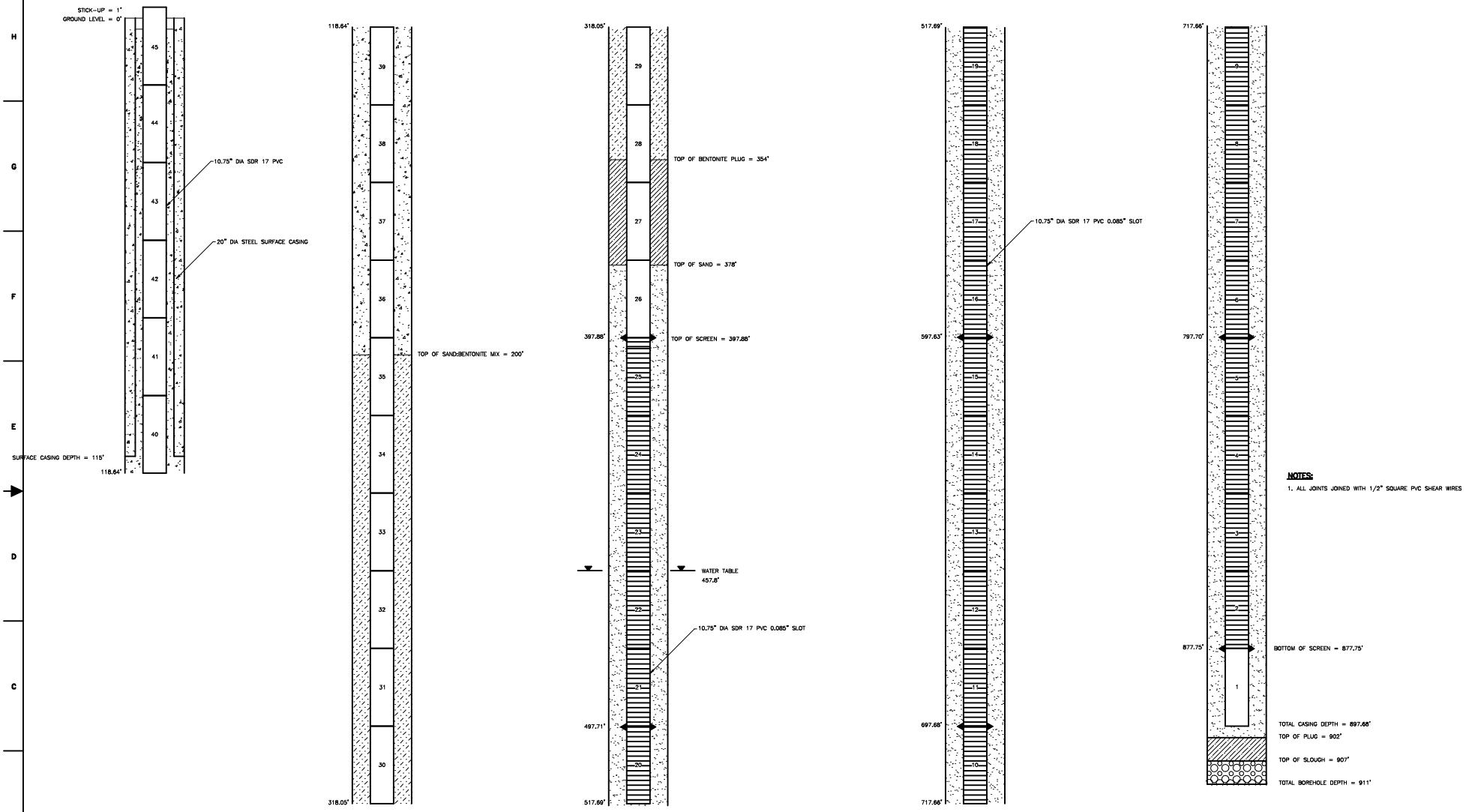
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME–FRONT REMEDIATION
INJECTION WELL PFI–3
CIVIL
WELL COMPLETION DIAGRAM

A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. F | SIZE | DWG. NO. 662-C-02 | REV.

SYMBOL	LETTER ZONE	DESCRIPTION	DATE	APPROVAL



REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	REF. NO.

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.XX± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME–FRONT REMEDIATION
INJECTION WELL PFI–4
CIVIL
WELL COMPLETION DIAGRAM

A.S. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 663-C-02 | REV.

SECTION 13390
PACKAGE CONTROL SYSTEMS (PCS)

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Instrument Society of America (ISA): S50.1, Compatibility of Analog Signals for Electronic Process Instruments.
2. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. AB 1, Molded Case Circuit Breakers and Molded Case Switches.
   c. ICS 2, Industrial Control Devices, Controllers and Assemblies.

1.2 SYSTEM DESCRIPTION

A. Assemble panels and install instruments, plumbing, and wiring in equipment manufacturer's factories.

B. Test panels and panel assemblies for proper operation prior to shipment from equipment manufacturer's factory.

1.3 SUBMITTALS

A. Shop Drawings:

1. Bill of material, catalog information, descriptive literature, wiring diagrams, and Shop Drawings for components of control system.
2. Catalog information on electrical devices furnished with system.
3. Shop Drawings, catalog material, and dimensional layout drawings for control panels and enclosures.
4. Panel elementary diagrams of prewired panels. Include in diagrams control devices and auxiliary devices, for example, relays, alarms, fuses, lights, fans, and heaters.
5. Plumbing diagrams of preplumbed panels and interconnecting plumbing diagrams.
6. Interconnection wiring diagrams that include numbered terminal designations showing external interfaces.

B. Quality Control Submittals:

1. Manufacturer's Certificate of Proper Installation.
2. Manufacturer's list of proposed spares, expandables, and test equipment.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers and related equipment as recommended by capsule manufacturer.

1.5 SPARES, EXPENDABLES, AND TEST EQUIPMENT

A. Selector Switch, Push Button, and Indicating Light: 20 percent, one minimum, of each type used.

B. Light Bulb: 100 percent, two minimum, of each type used.

C. Fuse: 100 percent, two minimum, of each type used.

D. Surge Suppressors: 20 percent, one minimum, of each type used.

PART 2 PRODUCTS

2.1 GENERAL

A. Interface requirements for Package Control Systems.

2.2 SIGNAL CHARACTERISTICS

A. Analog Signals:

1. 4 to 20 mA dc, in accordance with compatibility requirements of ISA S50.1.
2. Unless otherwise specified or shown, use twisted shielded pair, two-wire circuits.
3. Transmitters: Load resistance capability conforming to Class L.
4. Fully isolate input and output signals of transmitters and receivers.

B. Pulse Frequency Signals: dc pulses whose repetition rate is linearly proportional to process variable over 10:1 range. Generate pulses by contact closures or solid state switches.

1. Power source: Less than 30V dc.

C. Discrete Signals:

1. Two-state logic signals.
2. Utilize 120V ac sources for control and alarm signals.
3. Alarm signals shall be normally open, close to alarm isolated contacts rated for 5-ampere at 120V ac and 2-ampere at 30V dc.

2.3 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsule Manufacturers and Products:

1. Northern Instruments; Model Zerust VC.
2. Hoffmann Engineering; Model A-HCI.

2.4 CONTROL PANEL

A. Conform to NEMA ratings as specified in individual equipment sections.

B. Minimum Metal Thickness: 14 gauge.

C. NEMA 250, Type 4X Panels: Type 316 stainless steel construction unless otherwise specified.

D. Doors:

1. Three-point latching mechanisms in accordance with NEMA 250, Type 1 and 12 panels with doors higher than 18 inches.
2. For other doors, stainless steel quick release clamps.

E. Cutouts shall be cut, punched, or drilled and finished smoothly with rounded edges.

F. Access: Front, suitable for installation with back and sides adjacent to or in contact with other surfaces, unless otherwise specified.

G. Temperature Control:

1. Size panels to adequately dissipate heat generated by equipment mounted on or in the panel.
2. Furnish cooling fans with air filters if required to dissipate heat.
3. For panels outdoors or in unheated areas, furnish thermostatically controlled heaters to maintain temperature above 40 degrees F.

H. Lighting: Minimum of one hand switch controlled internal 100-watt incandescent light for panels 12 cubic feet and larger.

I. Minimum of one 120-volt duplex receptacle for panels 7 cubic feet and larger, or when indicated.

J. Finish:

1. Metallic External Surfaces (Excluding Aluminum and Stainless Steel): Manufacturer's standard gray unless otherwise specified.
2. Internal Surfaces: White enamel.

K. Panel Manufacturers:

1. Hoffman.
2. H.F. Cox.

L. Breather and Drains: Furnish with NEMA 250, Type X panels.

1. Manufacturer and Product: Crouse-Hinds; Model ECD18.

2.5 CONTROL PANEL ELECTRICAL

A. Control Panels Without Motor Starters:

1. Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed from main.
2. Locate to provide clear view of and access to breakers when door is open. Group on single back panel. Provide typed directory.
3. Circuit Breakers:
   a. Coordinate for fault in branch circuit trips, branch breaker, and not main breaker.
   b. Branch Circuit Breakers: 15 amps at 250V ac.
   c. Breaker Manufacturers and Products:
      1) Heineman Electric Co.; Series AM.
      2) Airpax/North American Philips Controls Corp.; Series 205.

B. Control Panels with Three-Phase Power Supplies and Motor Starters:

1. Interlock main circuit breaker with panel door.
   a. Mount logic controls, branch circuit breakers, overload reset switches, and other control circuit devices.
   b. Mount operator controls and indications on front access door.
2. Circuit Breakers:
   a. In accordance with NEMA AB 1.
   b. 40,000-ampere RMS symmetrical rating, minimum at 480 volts, unless otherwise specified or required.
   c. Breakers Except Motor Branch Breakers: Molded case thermal magnetic.
   d. Motor Branch Circuit Breakers:
      1) 50 hp and Less: Magnetic.
      2) Larger than 50 hp: Thermal magnetic with adjustable magnetic trip units.
      3) Ratings: Recommended by manufacturer for maximum motor protection.
      4) Padlock Provisions: OFF position.
   e. Tripping: Indicate with operator handle position.

3. Magnetic Motor Starters:
    a. Magnetic motor starters shall be designed for continuous operation of induction motors at 600 volts maximum, at 60 Hz, and shall comply with NEMA ICS 2. All starters shall be electrically held and wired to provide low voltage power and release. Coil and contact kit replacement parts shall be shown on the label or coil of the contactor. Unless otherwise specified, starters shall be 120-volt coil, 3-pole, 600V ac, 60 Hz, NEMA size 1 minimum. All power wiring shall be straight through the starter with incoming power to the top and load wiring at the bottom. Contacts shall be double break, silver-cadmium oxide, and weld-resistant. Contacts shall be isolated to prevent arcing. Coils, magnets, and contacts shall be capable of being removed or replaced, without special tools, in the field. The contactors shall have MOV-type, transient voltage surge suppression across the coils. Transient voltage surge suppression shall be mounted directly across the coil terminals of all magnetic starters. The suppressor shall limit voltage transients produced by the coil to 220 percent maximum peak line volts.
    b. Solid State Overload Protection: Solid state overload protection shall be provided unless otherwise indicated on the Drawings or approved by the ENGINEER. The solid state overload relay shall be self-powered requiring no additional wiring or control power and be self-protected from short circuits in the motor branch circuit. Each overload shall be adjustable over a full 2:1 FLA adjustment range. The overload must have a plus or minus 2 percent trip repeatability over its entire operating range. The standard overload shall provide Class 20 overload protection. The overload must provide phase loss protection by tripping in 3 seconds or less under a phase loss condition. The overload must be capable of protecting the motor in a starting, full load, or lightly loaded condition against single-phase damage. The overload and phase loss protection must not be able to be defeated by any changes to the setting of the overload. The overload must be ambient insensitive and able to operate in a temperature range of minus 22 degrees F to plus 159 degrees F. The overload relay must have a trip-free normally closed contact rated NEMA A600 with a visible trip indication. The overload relay shall be provided with an additional normally closed auxiliary contact rated NEMA A600. The overload must have a method of being manually tripped for test purposes.
    c. Manual reset type with reset button mounted on panel door.
4. Motor Control: 120V ac (except intrinsically safe circuits where applicable).

a. Power Control Transformer:
1) Sufficient capacity to serve connected load, including 200V ac for duplex outlet plus 100V ac (minimum).
2) Limit voltage variation to 15 percent during contact pickup.
3) Fuse one side of secondary winding and ground the other.
4) Furnish primary winding fuses in underground conductors.

5. Power Distribution Blocks: Furnish to parallel feed top on branch circuit protective devices. Do not “leap frog” power conductors.

C. Wiring:

1. All control panel wiring shall meet the requirements of this Section.
2. ac Circuits:
a. Type: 600-volt, Type THHN/THWN stranded copper.
b. Size: For current to be carried, but not less than No. 16 AWG.
3. Analog Signal Circuits:
a. Type: 600-volt, Type 3 stranded copper, twisted shielded pairs.
b. Size: No. 16 AWG, minimum.
4. Other dc Circuits.
a. Type: 600-volt, Type THHN/THWN stranded copper.
b. Size: No. 16 AWG, minimum.
5. Separate analog and other dc circuits at least 6 inches from any ac power and control wiring.
6. Enclose wiring in sheet metal raceways or plastic wiring ducts.
7. Wire Identification:
a. Identify wiring in control panel.
b. Numbered and tagged at each termination.
c. Wire Tags: Snap-on or slip-on PVC wire markers with legible machine printed markings and numbers. Do not use adhesive or taped-on tags.

D. Wiring Interface:

1. For analog and discrete signal, terminate at numbered terminal blocks.
2. For special signals, terminate power (240 volts or greater) at manufacturer's standard connectors.
3. For panel, terminate at equipment on/with which it is mounted.

E. Terminal Blocks:

1. Quantity:
a. Accommodate present and spare indicated needs. One wire per terminal.
b. Wire spare or unused panel mounted elements to their panels' terminal blocks.

c. Spare Terminals: 20 percent of connected terminals, but not less than 10.

2. General: Group to keep 120V ac circuits separate from 24V dc circuits.
   a. Connection Type: Screw connection clamp.
   b. Compression Clamp:
      1) Hardened steel clamp with transversal grooves penetrating wire strands providing a vibration-proof connection.
      2) Guides strands of wire into terminal.
   c. Screws: Hardened steel, captive and self-locking.
   d. Current Bar: Copper or treated brass.
   e. Insulation:
      1) Thermoplastic rated for minus 55 to plus 110 degrees C.
      2) Two funnel shaped inputs to facilitate wire entry.
   f. Mounting:
      1) DIN rail.
      2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
      3) End Stops: One at each end of rail, minimum.
   g. Wire Preparation: Stripping only.
   h. Jumpers: Allow jumper installation without loss of space on terminal or rail.
   i. Marking System:
      1) Terminal number shown on both sides of terminal block.
      2) Allow use of preprinted and field marked tags.
      3) Terminal strip numbers shown on end stops.
      4) Mark terminal block and terminal strip numbers as shown on panel control diagrams or as indicated in the Specifications.
3. Terminal Block, 120-Volt Power:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 30 amp.
   c. Wire Size: 22-10 AWG.
   d. Rated Wire Size: 10 AWG.
   e. Color: Gray body.
   f. Spacing: 0.25 inch, maximum.
   g. Manufacturer and Product: Phoenix Contact; Type UK5N and UK6N.
4. Terminal Block, Ground:
   a. Wire Size: 20-1/0 AWG.
   b. Rated Wire Size: As required.
   c. Color: Green and yellow body.
   d. Spacing: 0.25 inch, maximum.
   e. Grounding: Ground terminal blocks electrically grounded to the mounting rail.
   f. Manufacturer and Product: Phoenix Contact; Type USLKG.
5. Terminal Block, Blade Disconnect Switch:

a. Use: Provide one for each discrete input and output field interface wire.
b. Rated Voltage: 600V ac.
c. Rated Current: 10 amp.
d. Wire Size: 22-12 AWG.
e. Rated Wire Size: 12 AWG.
f. Color: Gray body, orange switch.
g. Spacing: 0.25 inch, maximum
h. Manufacturer and Product: Phoenix Contact; Type UDK 4-MTK.

6. Terminal Block, Fuse/Disconnect Plug:
   a. Use: Provide one for each analog input and output field interface wire.
   b. Rated Voltage: 300V ac.
   c. Rated Current: 15 amp.
   d. Wire Size: 30-14 AWG.
   e. Manufacturer and Product: Phoenix Contact; V10K 1,5-D/TG/D/PE with Type ST.
7. Terminal Block, Fused, 24V dc:
   a. Rated Voltage: 600V dc.
   b. Rated Current: 6.3 amp.
   c. Wire Size: 26-8 AWG.
   d. Rated Wire Size: 12 AWG.
   e. Color: Black body.
   f. Fuse: Amperage size as required.
   g. Fuse Marking: Fuse amperage rating shown on top of terminal block.
   h. Indication: LED diode 24V dc.
   i. Leakage Current: 7.5 mA, maximum.
   j. Spacing: 0.32 inch, maximum
   k. Manufacturer and Product: Phoenix Contact; Type UK6.3-HESi.
8. Terminal Block, Fused, 120V ac:
   a. Rated Voltage: 600 V ac.
   b. Rated Current: 6.3 amp.
   c. Wire Size: 26-8 AWG.
   d. Rated Wire Size: 12 AWG.
   e. Color: Black body.
   f. Fuse: Amperage size as required.
   g. Fuse Marking: Fuse amperage rating shown on top of terminal block.
   h. Indication: Neon lamp 110V ac.
   i. Leakage Current: 1.0 mA, maximum.
   j. Spacing: 0.32 inch, maximum
   k. Manufacturer and Product: Phoenix Contact; Type UK6.3-HESi.

9. Terminal Block, Fused, 120V ac, High Current:
    a. Rated Voltage: 600V ac.
    b. Rated Current: 35 amps.
    c. Wire Size: 18-8 AWG.
    d. Fuse: Amperage size as required.
    e. Manufacturer: Phoenix Contact.

F. Grounding:

1. Enclosures, control panels, and cabinets signal and shield ground connections shall be made as shown on the Drawings, for each enclosure, control panel, and cabinet that has a dedicated #4 AWG ground conductor from the ground grid, MCC ground bus, or switchgear ground bus. Enclosures, control panels, and cabinets that do not have a #4 AWG ground conductor shall be installed as follows:
    a. Furnish isolated copper grounding bus for signal and shield ground connections.
    b. Ground this ground bus at a common signal ground point in accordance with national Electrical Code requirements.
    c. Single Point Ground for Each Analog Loop:
        1) Locate at dc power supply for loop.
        2) Use to ground wire shields for loop.
    d. Ground terminal block rails to ground bus.

G. Analog Signal Isolators:

1. Furnish for all analog signals that are sent from each control panel and cabinet.
2. Power: 115V ac.
3. Three-way isolation; input, output, and power are isolated from each other.
4. Meets ANSI/IEEE C37.90.
5. Accuracy: Better than plus or minus 0.1 percent of output span.
6. Manufacturer and Product: Acromag; Series 430I.

H. Relays:

1. General:
    a. All relays shall be provided with surge protection across the coils as follows:
        1) Surge Suppressors: Magnetic control, machine tool, and industrial relays.
        2) Metal Oxide Varistors: ac Voltage Coils.
        3) Diodes: dc Voltage Coils.
        4) Surge protection shall be provided and installed as recommended by the relay manufacturer.

b. Magnetic control, machine tool, and industrial relays shall be provided as indicated on the Drawings by multiple single pole, single throw contacts to the right of the relay coil. Signal/control circuit switching relays shall be provided as indicated on the Drawings by multiple single pole, double throw contacts (Form C) to the right of the relay coil.

2. Signal/Control Circuit Switching Relay:
   a. Relay Mounting: Plug-in type socket.
   b. Relay Enclosure: Furnish dust cover.
   c. Socket Type: Screw terminal interface with wiring.
   d. Socket Mounting: DIN rail.
   e. Provide holddown clips.
3. Magnetic Control, Machine Tool, and Industrial Relays:
   a. NEMA ICS 2, Class A600 (600 volts, 10 amps continuous, 7,200 VA make, 720 VA break), industrial control with a minimum of four field-convertible contacts.
   b. Time Delay Attachment: Solid state.
   c. Provided and installed with manufacturer-recommended and provided surge suppressors across the coil terminals. The surge suppressor shall be designed to absorb all energy surges that appear on the line.
   d. Manufacturer and Product: General Electric; Type CR120B.
4. Signal/Control Circuit Switching Relay, Nonlatching:
   a. Type: Compact general purpose plug-in.
   b. Contact Arrangement: As indicated on the Drawings, two Form C contacts minimum.
   c. Contact Rating: 10A at 28V dc or 240V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 1.5 watts (dc), 2 VA (ac).
   g. Expected Mechanical Life: 50,000,000 operations.
   h. Expected Electrical Life at Rated Load: 500,000 operations.
   i. Indication Type: Neon or LED indicator lamp.
   j. Push-to-test button.
   k. Manufacturer and Product: IDEC Corp.; Series RH.
5. Signal/Control Circuit Switching Relay, Latching:
   a. Type: Dual coil mechanical latching relay.
   b. Contact Arrangement: As indicated on the Drawings, two Form C contacts minimum.
   c. Contact Rating: 10A at 28V dc or 120V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 2 watts (dc), 1.2 VA (ac).
   g. Expected Mechanical Life: 10,000,000 operations.

h. Expected Electrical Life at Rated Load: 200,000 operations.
i. Manufacturer and Product: IDEC Corp.; Series RH2L.

6. Signal/Control Circuit Switching Relay, Time Delay:
   a. Type: Adjustable time delay relay.
   b. Contact Arrangement: As indicated on the Drawings, two Form C contacts minimum.
   c. Contact Rating: 10A at 240V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Operating Temperature: Minus 10 to plus 55 degrees C.
   g. Repeatability: Plus or minus 2 percent.
   h. Delay Time Range: Select range such that time delay setpoint fall between 20 to 80 percent of range.
   i. Time Delay Setpoint: As noted or as determined by the ENGINEER.
   j. Mode of Operation: As noted or as determined by the ENGINEER.
   k. Adjustment Type: Integral potentiometer with knob external to dust cover.
   l. Manufacturer and Products: Potter and Brumfield; Series CG for 0.5-second to 100-minute delay time ranges, Series CD for 0.1- to 180-second delay time ranges.

I. Power Supplies:

1. Furnish as required to power instruments requiring external dc power, including two-wire transmitters and dc relays.
2. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.
3. Provide output over voltage and over current protective devices to:
   a. Protect instruments from damage due to power supply failure.
   b. Protect power supply from damage due to external failure.
4. Primary switched type.
5. Rail mount such that dissipated heat does not adversely affect other components.
6. Fuses: For each dc supply line to each individual two-wire transmitter.
   a. Type: Indicating.
   b. Mount so fuses can be easily seen and replaced.
7. Manufacturer and Product: Phoenix Contact; CM50-PS-120-230AC/24DC/5.

J. Front-of-panel devices in conjunction with NEMA 250, Type 12 panels shall be rated NEMA 4/13, watertight/oiltight.

1. Potentiometer Units:
    a. Three-terminal, oiltight construction, resolution of 1 percent and linearity of plus or minus 5 percent.
    b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.
    c. Include legend plates with service markings.
    d. Manufacturers and Products:
        1) Allen Bradley; Bulletin 800T.
        2) General Electric; Type CR104P.
2. Indicating Lights:
    a. Heavy-duty, push-to-test type, oiltight, industrial full-voltage, high-visibility LED type for 120V ac applications.
    b. Screwed on prismatic glass lenses in colors noted and factory engraved legend plates for service legend.
    c. Manufacturers and Products:
        1) Allen-Bradley; Bulletin 800T.
        2) General Electric; Type CR104P.
        3) Square-D; Class 9001, Type K.
3. Push Button, Momentary:
    a. Heavy-duty, oiltight, industrial type with full guard and momentary contacts rated for 10 amperes continuous at 120V ac.
    b. Standard size legend plates with black field and white markings for service legend.
    c. Manufacturers and Products:
        1) Allen-Bradley, Bulletin 800T.
        2) Square D; Class 9001, Type K.
        3) General Electric; Type CR104P.
4. Selector Switch:
    a. Heavy-duty, oiltight, industrial type with contacts rated for 120V ac service at 10 amperes continuous.
    b. Standard size, black field, legend plates with white markings, for service legend.
    c. Operators: Black knob type.
    d. Single-hole mounting, accommodating panel thicknesses from 1/16 to 1/4 inch.
    e. Manufacturers and Products for Units with up to Four Selection Positions:
        1) Allen-Bradley; Bulletin 800T.
        2) General Electric; Type CR104P.
        3) Square D; Class 9001, Type K.

K. Front-of-panel devices used in conjunction with NEMA 250, Type 4X panels shall be rated NEMA 4X, corrosion-resistant/watertight.

1. Potentiometer, Watertight:
    a. Three-terminal, heavy-duty NEMA 250, Type 4X watertight construction, resolution of 1 percent and linearity of plus or minus 5 percent.
    b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.
    c. Include engraved legend plates with service markings.
    d. Manufacturer and Product: Allen-Bradley; Bulletin 800H.
2. Indicating Lights, Watertight:
    a. Heavy-duty, push-to-test type, NEMA 250, Type 4X watertight, industrial, full-voltage, high-visibility LED type, for 120V ac applications and corrosion-resistant service.
    b. Screwed on prismatic lenses and factory engraved legend plates for service legend.
    c. Manufacturers and Products:
        1) Allen Bradley; Bulletin 800H.
        2) Square D; Type SK.
3. Push Button, Momentary, Watertight:
    a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with momentary contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
    b. Standard size, black field, legend plates with white markings for service legend.
    c. Manufacturers and Products:
        1) Allen Bradley; Bulletin 800H.
        2) Square D; Type SK.
4. Selector Switch, Watertight:
    a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
    b. Standard size, black field, legend plates with white markings, for service legend.
    c. Operators: Black knob type.
    d. Single-hole mounting, accommodating panel thicknesses from 1/16 to 1/4 inch.
    e. Manufacturer and Products:
        1) Allen Bradley; Bulletin 800H.
        2) Square D; Class 9001, Type SK.

2.6 INSTRUMENT TAG NUMBERS

A. Example:

FM-6WA-XK100

Notation	Explanation
FM	Flow meter
6	Area 600
WA	Water
XK	Unit number
100	Loop number

2.7 NAMEPLATES, NAMETAGS, AND SERVICE LEGENDS

A. Nametags: Permanently mounted bearing entire ISA tag number.

1. Panel Mounted: Plastic, mounted to instrument behind panel face.
2. Field Mounted: Engraved Type 316 stainless steel, 22-gauge minimum thickness, attach with stainless steel.

B. Service Legends (Integrally Mounted with Instrument) and Nameplates:

1. Engraved, rigid, laminated plastic type with adhesive back. Furnish service legends and nameplates to adequately describe functions of panel face mounted instruments.
2. Color: White surface engraved to a black core, white with black letters. Letter height 3/16 inch.
3. For each panel, face mounted laminated nameplate inscribed with the panel name and tag number. Color shall be white with black letters 1/2-inch high.

C. Standard Light Colors and Inscriptions: Unless otherwise specified in individual equipment specifications, use the following color code and inscriptions:

Tag	**Inscription(s)**	**Color**
POWER ON	POWER ON	Green
ON	ON	Red
OFF	OFF	Green
OPEN	OPEN	Red

Tag	Inscription(s)	Color
CLOSED	CLOSED	Green
LOW	LOW	Amber
FAIL	FAIL	Amber
HIGH	HIGH	Amber
AUTO	AUTO	White
HAND OR MANUAL	HAND OR MANUAL	Yellow
LOCAL	LOCAL	White
REMOTE	REMOTE	Yellow
FORWARD	FORWARD	Red
REVERSE	REVERSE	Blue

1. Lettering: Black on white and amber lenses; white on red and green lenses.
2. Standard Push Button Colors, Unless Otherwise Indicated:
   a. STOP, OFF, EMERGENCY STOP, RESET: Red.
   b. All Others: Black.

2.8 ELECTRICAL SURGE AND TRANSIENT PROTECTION

A. General: Equip control panels with surge-arresting devices to protect equipment from damage due to electrical transients induced in interconnecting lines from lightning discharges and nearby electrical devices.

B. Suppressor Locations:

1. At point of connection between each equipment item, including ac powered transmitters and its power supply conductors (direct wired equipment).
2. On analog pairs at each end when the pair travels outside of building.
3. In other locations where equipment sensitivity to surges and transients requires additional protection beyond that inherent to design of equipment.

C. AC Power Supply Suppressor Assemblies:

1. Suitable for connection to 120-volt, single-phase power supplies: Phoenix; MT2PE/S-120AC.

D. DC Signal Suppressor: Telematic; (MTL) SD 32X.

E. AC Signal Suppressor: Telematic; (MTL) SD 150X.

F. Data Highway Plus Suppressor: Telematic; (MTL) SD 16X.

G. Grounding: Coordinate surge suppressor grounding in field panels and field instrumentation per suppressor manufacturer's requirements. Furnish control panels with an integral copper grounding bus for connection of suppressors and other required instrumentation.

PART 3 EXECUTION

3.1 ELECTRICAL POWER AND SIGNAL WIRING

A. Restrain control and signal wiring in control panels by plastic ties or ducts. Secure hinge wiring at each end so bending or twisting will occur around the longitudinal axis of wire. Protect bend area with a sleeve.

B. Arrange wiring neatly, cut to proper length, and remove surplus wire. Install abrasion protection for wire bundles passing through holes or across edges of sheet metal.

C. Use manufacturer's recommended tool with sized anvil for crimp terminations. No more than one wire may be terminated in a single crimp lug. No more than two lugs may be installed on a single screw terminal.

D. Do not splice or tap wiring except at device terminals or terminal blocks.

3.2 PROTECTION

A. Protect enclosures and other equipment containing electrical, instrumentation and control devices, including spare parts, from corrosion through the use of corrosion-inhibiting vapor capsules.

B. During Work, periodically replace capsules in accordance with capsule manufacturer's recommendations. Replace capsules at completion of project.

END OF SECTION

SUPPLEMENT A

COMPONENT SPECIFICATIONS

A. F1 Flow Element, Pitot-Static, Equal Annuli:

1. General:
   a. Function: Produce a pressure differential signal proportional to the square of the flow rate in an air duct.
   b. Type: Multiple port, pitot-static differential pressure producing device.
   c. Parts: Flow element, transmitter, and mounting hardware.
2. Service:
   a. Fluid: Air, unless otherwise noted.
   b. Upstream Fluid Temperature: Minus 13 degrees C to 44 degrees C.
   c. Upstream Static Pressure: As required.
3. Performance:
   a. Flow Range: As required.
   b. Pressure Differential at Full Scale Flow: As required.
   c. Accuracy: Plus or minus 0.5 percent over a flow range of 10:1, minimum.
   d. Permanent Pressure Loss (Head Loss): Less than 18 percent of measured pressure differential for sizes between 4 and 12 inches. Less than 8 percent of measured pressure differential for sizes over 12 inches.
   e. Repeatability: Plus or minus 0.1 percent.
4. Flow Element Calculations: Verify actual duct inner diameter and provide supporting calculations showing expected pressure differential at full scale flow and permanent head loss.
5. Features:
   a. Pitot Ports: Located across the duct diameter such that the differential pressures of four or more sensing ports are sensed, and averaged.
   b. Static Ports: To sense static pressure.
   c. Materials: Type 316 stainless steel, unless otherwise noted.
   d. Duct Size: As required.
   e. Duct Material: As required.
6. Element Connections:
   a. Process Connections:
      1) Type: Weld fitting and compression ferrule, unless otherwise noted.
      2) Materials: Carbon steel, unless otherwise noted.
   b. Instrument Connections: Integrally-mounted flow transmitter.
7. Signal Interface: 4 to 20mA dc output for load impedance of 0 to 500 ohms minimum without load adjustment with 24V dc supply.

8. Enclosure:
    a. Type: NEMA 4X.
    b. Mounting: Integral with sensing element.
9. Manufacturers and Products:
    a. Dieterich Standard Corp.; ProBar Series.
    b. Approved equal.

B. F2 Flow Element and Transmitter, Electromagnetic:

1. General:
   a. Function: Measure, indicate, and transmit the flow of a process liquid in a full pipe.
   b. Type: Electromagnetic flowmeter, with operation based on Faraday's Law, utilizing the pulsed dc type coil excitation principle with high impedance electrodes.
   c. Parts: Flow element, transmitter, interconnecting cables, mounting hardware, and calibrator.
2. Service:
   a. Stream Fluid: Water with trace amounts of industrial contaminants.
3. Performance:
   a. Flow Range: As noted.
   b. Accuracy: Plus or minus 1 percent of rate for all flows resulting from pipe velocities of 1 to 33 feet per second.
   c. Turndown Ratio: Minimum of 10 to 1 when flow velocity at minimum flow is at least 1 foot per second.
4. Features:
   a. Zero stability feature to eliminate the need to stop flow to check zero alignment.
   b. No obstructions to flow.
   c. Very low pressure loss.
5. Process Connection:
   a. Meter Size: As noted.
   b. Connection Type: 150-pound ANSI raised-face flanges or wafer style depending on meter size, unless otherwise noted.
   c. Flange Material: Carbon steel, unless otherwise noted.
6. Signal Interface:
   a. 4 to 20 mA dc for load impedance 0 to 800 ohms minimum for 24V dc supply.
7. Power: 120V ac, 60-Hz, unless otherwise noted.
8. Element:
   a. Meter Tube Material: 304 stainless steel, unless otherwise noted.
   b. Liner Material: Teflon, unless otherwise noted.
   c. Liner Protectors: Covers on each end to protect liner during shipment.
   d. Electrode Type: Flush or bullet nose as recommended by the manufacturer for the noted stream fluid.
   e. Electrode Material: 316 stainless steel, unless otherwise noted.
   f. Enclosure: NEMA 4, unless otherwise noted.
   g. Grounding Ring/Electrode Material: 316 stainless steel, unless otherwise noted.

9. Transmitter:
    a. Display: Indicating and totalizing.
    b. Mounting: Pipe stand, wall.
    c. Enclosure: NEMA 4X.
    d. Zero and Span: Field adjustable.
    e. Indicator: Digital 16-character display, with scale range as noted.
    f. Totalizer: Digital 16-character display, with totalizer unit digit value as noted.
10. Cables:
    a. Types: As recommended by manufacturer.
    b. Lengths: As required to accommodate device locations.
11. Calibration System:
    a. Features:
        1) Field programmable electronics.
        2) Self-diagnostics with troubleshooting codes.
        3) Ability to program electronics with full scale flow, engineering units, meter size, zero flow cutoff, desired signal damping, totalizer unit digit value, etc.
        4) Initial flow tube calibration and subsequent calibration checks.
    b. Equipment:
        1) Built-in electronics with each unit provided.
        2) Alternatively, one portable calibrator of each type required for the various electromagnetic flowmeters provided on the project.
12. Manufacturers:
    a. Endress & Hauser; Promag 33.
    b. Fischer & Porter; miniMAG, COPA-X or MAG-X, as applicable;
    c. Krohne; Altoflux.

C. F3 Flow Element and Switch, Thermal:

1. General:
   a. Function: Monitor process fluid flow and provide contact closure when flow exceeds set point.
   b. Type: Thermal dispersion flow switch using a heated active and a reference RTD temperature sensors to detect rate of flow as a function of the temperature difference between the two sensors.
2. Service:
   a. Fluid: Water.
   b. Operating Pressure: 75 psig.
   c. Operating Temperature: 15 to 20 degrees C.
3. Performance:
   a. Set Point:
      1) Adjustable throughout full range.
      2) Set as noted.
   b. Range: Choose range so that the noted set point is between 30 and 70 percent of the range.
   c. Repeatability: Plus or minus 1 percent of full range.
   d. Temperature, Operating:
      1) Sensor Element: Minus 100 to plus 350 degrees F.
      2) Electronics: Minus 40 to plus 140 degrees F.
   e. Proof Pressure: To 4,000 psig.
   f. Response Time: Field adjustable from 10 to 150 seconds.
4. Features:
   a. Wetted Surfaces Materials: 316 stainless steel with nickel-base braze, unless otherwise noted.
   b. Dry Pipe Protection: When applied to liquid process, furnish protection against the event of the liquid line going dry, unless otherwise noted.
   c. Process Temperature Compensation: Furnish.
5. Process Connections:
   a. Type: 1-1/4-inch NPT(M), unless otherwise noted.
   b. Pipe Size: As noted.
   c. Connection Type: Insertion.
   d. Connection Material: 316 stainless steel, unless otherwise noted.
6. Conduit Connection: 1-1/4-inch NPT(F) reduced to 3/4 inch with bushing.
7. Element: Insertion/Body Length (From Tip of Probe to Process Connection): Determined by the Supplier based upon pipe size and sensor mounting requirements, unless otherwise noted. The insertion length shall be noted on an application specific installation detail prepared and submitted for each unit.

8. Electronics:
    a. Location: Integral with element, unless otherwise noted.
    b. Hermetically sealed with SPDT relay.
9. Signal Interface:
    a. Contact: Single-pole, double-throw (SPDT), rated 120V ac, 2 amps.
    b. Connection: Screw terminal block.
10. Enclosure:
    a. Type: NEMA 7BCD with watertight O-ring seal.
    b. Material: Cast aluminum, unless otherwise noted.
    c. Approval: Factory Mutual for hazardous area, unless otherwise noted.
11. Power: 120V ac, 60-Hz, unless otherwise noted.
12. Cable (Furnished Only When Remote Electronics is Specified):
    a. Type: As required.
    b. Length: As required.
13. Manufacturer: Fluid Components, Inc.; Model 12-64 or Model FR72.

D. L1 Level Element and Transmitter, Submersible, Electronic:

1. General:
   a. Function: Measure well level by means of differential pressure and transmit a signal proportional to level.
   b. Type: Electronic, piezoresistive-micromachined silicon strain gauge, two wire transmitter.
   c. Operating conditions: Transmitter shall operate in water containing low levels of industrial contaminants.
   d. Warranty: Sensor/transmitter shall be warranted against corrosion for a period of 5 years.
2. Performance:
   a. Range: As noted.
   b. Maximum adjustable range: Noted range shall lie between 40 percent and 80 percent of the maximum adjustable range.
   c. Accuracy: Plus or minus 0.25 percent of calibrated span.
   d. Operating temperature range: Minus 5 degrees F to 140 degrees F.
   e. Compensated temperature range: 30 degrees F to 86 degrees F.
   f. Relative humidity: 0-100 percent.
3. Features:
   a. Type: Cable suspended level sensor
   b. Materials: Sensor body, measurement diaphragm–Titanium. Cable-polyurethane jacket with Kevlar reinforced cord.
   c. Periodic maintenance or cleaning shall NOT be required to maintain function of accuracy.
4. Signal Interface:
   a. Instrument shall be loop powered from 9-32V dc power supply.
   b. Output shall be 4-20 ma DC for load impedance of 0-500 ohms minimum over specified range.
   c. The transmitter shall be factory calibrated for the specified range(s) and shall also include provisions for field calibration through non-interactive zero and span adjustments.
5. Sensor Cable Termination:
   a. The sensor cable shall terminate in a vendor supplied termination box.
   b. The box shall be rated NEMA 4X and be lockable.
   c. Termination enclosure shall be wired complete with lightning arrestors suitable for low voltage DC transmitter circuits.
   d. Cable vent tube shall terminate in this box on desiccant cartridge. Manufacturer shall furnish 6 desiccant cartridges per transmitter.
6. Manufacturers and Products:
   a. Druck; Model PTX 1230.
   b. Approved equal.

E. L2 Level Element and Transmitter, Admittance:

1. General:
   a. Function: Measure and transmit interface level in vessel.
   b. Type: Admittance using low power radio frequency source:
      1) Two-wire transmitter.
      2) “Smart” electronics.
   c. Parts: Element, transmitter (nonintegral), calibrator (or equivalent), and interconnecting cable.
2. Service:
   a. Process Fluid: Water.
   b. Vessel Material: Type 304L stainless steel.
3. Performance:
   a. Range: As required.
   b. Linearity: Plus or minus 0.25 percent of range.
   c. Ambient Temperature: Minus 40 to plus 170 degrees F.
   d. Process Pressure and Temperature Limits: 1,000 psi at 100 degrees F, or 500 psi at 250 degrees F, unless otherwise noted.
4. Element:
   a. Type: Solid rod.
   b. Connection Type: 3/4-inch NPT, unless otherwise noted.
   c. Insertion Length: As required to accommodate specified range and vessel dimensions.
   d. Process Wetted Parts: 316 SS rod, bonded with fluorocarbon-type insulation, unless otherwise noted.
   e. Provisions for grounding if vessel is nonmetallic.
   f. 3/8-inch diameter, nominal.
5. Transmitter:
   a. Integral, unless otherwise noted.
   b. Enclosure: NEMA 4X and explosionproof.
   c. Signal Interface: 4 to 20 mA dc output with Hart protocol for load impedance 0 to 600 ohms minimum for 24V dc supply without load adjustment.
   d. Performance Response Time:
      1) With delay off,20 milliseconds.
      2) With delay on, adjustable 0.5 to 30 seconds.
   e. Indicator: Digital loop meter, NEMA 4X enclosure.
   f. Allowable Static Discharge to Sensor: 10 amps maximum, unless otherwise noted.
6. Accessories:
   a. Calibration Device:
      1) Quantity: One total for contract, unless otherwise noted.
      2) Type: Hart hand-held communicator, unless otherwise noted.

7. Manufacturers:
    a. Drexelbrook; Model 508-45-9.
    b. Endress and Hauser; Model FEC12.

F. L3 Level Switch, Float, Bulkhead:

1. General:
   a. Function: Operate contact at preset liquid level.
   b. Type: Float-actuated bulkhead-mounted; magnetic actuation.
2. Service:
   a. Fluid: Water unless otherwise noted.
   b. Specific Gravity: 1.0 unless otherwise noted.
   c. Pressure: 150 psi maximum.
   d. Temperature: 100 degrees F maximum.
3. Performance:
   a. Set Point: As noted.
   b. Dead Band: 4-inch unless otherwise noted.
4. Features: Float, stem, and other wetted parts stainless steel unless otherwise noted.
5. Process Connections: 2-inch NPT half-coupling or 3-inch, 150-pound ANSI RF flange as required.
6. Signal Interface Contact: DPDT snap action contact rated 5A continuous at 120V ac.
7. Enclosure: NEMA 4, unless otherwise noted.
8. Manufacturers:
   a. LINC; Model L471.
   b. Magnetrol; Tuffy series.
   c. Robertshaw; Series SL-500.

G. L4 Level Switch, Float, Tank Top:

1. General:
   a. Function: Operate switch at preset level in a tank.
   b. Type: Float-actuated mounted directly to tank top.
2. Service:
   a. Fluid: Water unless otherwise noted.
   b. Specific Gravity: 1.0 unless otherwise noted.
   c. Pressure: 150 psi maximum.
   d. Temperature: 100 degrees F maximum.
3. Performance:
   a. Set Point: As noted.
   b. Dead Band: 1-inch maximum.
4. Features:
   a. Float, stem, and guide tube connected to a switch enclosure.
   b. Insertion Length: As required to achieve the noted set point.
   c. Float Size: 4-1/2-inch unless otherwise noted.
   d. Materials: Wetted parts 304 or 316 stainless steel unless otherwise noted.
5. Process Connection: 1-inch NPT.
6. Signal Interface Contact: DPDT snap action rated 10A continuous at 120V ac.
7. Enclosure: NEMA 4 unless otherwise noted.
8. Manufacturers:
   a. Magnetrol; Model T20.
   b. Robertshaw; Series SL-100.

H. L5 Level Element and Switch, Float:

1. General:
   a. Function: Actuate contact at preset liquid level.
   b. Type: Float-actuated mounted directly to sump wall.
2. Service: Liquid; water.
3. Performance:
   a. Set Point: As noted.
   b. Differential: 1-inch maximum.
   c. Temperature: Minus 40 degrees F to 140 degrees F.
   d. Pressure: Maximum 150 psig.
4. Features:
   a. Bracket mounting.
   b. Float Material and Size: Buna N; 1-7/8-inch.
   c. Stem and Mounting Material: Type 304 stainless steel.
   d. Integral splash shield.
5. Signal Interface:
   a. Switch Type: SPST snap action.
   b. Switch Contacts:
      1) Rated 20 VA at 120V ac.
      2) Normally open.
      3) Lead cable 2 #18 AWG, 6 feet, neoprene jacket.
6. Manufacturer and Product: GEMS; Series LS-270, Model No. 43765.

I. P1 Pressure Gauge:

1. General:
   a. Function: Pressure indication.
   b. Type: Bourdon tube.
2. Performance:
   a. Range: As noted. Compound scale when noted.
   b. Accuracy: Plus or minus 0.5 percent of span.
3. Features:
   a. Mounting: Lower stem, unless otherwise noted.
   b. Dial: 4-1/2-inch diameter, unless otherwise noted.
   c. Case Material: Phenolic plastic, unless otherwise noted.
   d. Element Material: Phosphor-bronze, unless otherwise noted.
   e. Dampening: Pulsation dampener when noted, piston type with multiple choice of piston placement to vary the desired amount of dampening.
   f. Case Type: Solid front design with solid wall between window and element. Rear of case, gasketed pressure relief.
   g. Pointer: Micrometer pointer with self-locking adjustment.
   h. Movement: Stainless steel, rotor geared.
4. Process Connection:
   a. Line Size: 1/2-inch.
   b. Connection Type: Threaded.
5. Manufacturers and Products:
   a. Ashcroft; Duragauge Model 1279/1379.
   b. Robert Shaw Acragage.
   c. Marsh Mastergauge.

J. P2 Pressure Differential Gauge, Low Range Air:

1. General:
   a. Function: Indicate differential pressure locally.
   b. Type: Bellows.
2. Service:
   a. Rated Total Pressure: 20 inches Hg. to 15 psig.
   b. Temperature Limits: 20 degrees F to 140 degrees F.
   c. Air filter differential pressure, air static pressure.
3. Performance:
   a. Range: As required.
   b. Accuracy: 2 percent of full scale.
4. Features:
   a. Indictor: 4-1/2-inch diameter.
   b. Adjustments: Front accessible zero.
   c. Scale: Linear.
   d. Connections: 1/8-inch, NPT.
   e. Case: Die-cast aluminum.
   f. Mounting: Panel, surface, or pipe.
5. Manufacturers and Products:
   a. Dwyer; Series 2000 Magnehelic.
   b. ITT Barton; Model 227 or 200.

K. P3 Pressure Switch, Fixed Dead Band:

1. General:
   a. Function: Monitor pressure and provide contact closure(s) when pressure is at the noted set point.
   b. Type: Diaphragm sealed piston actuator.
2. Performance:
   a. Set Point: As required.
      1) Adjustable over the full range.
      2) Set as noted.
   b. Range: The noted set point shall fall between 30 percent and 70 percent of the range.
   c. Set Point Repeatability: Plus or minus 1 percent of range.
3. Features:
   a. Diaphragm Material: Buna-N, unless otherwise noted.
   b. Pressure Connection: Type 316 stainless steel, unless otherwise noted.
   c. Reset: Automatic, unless otherwise noted.
4. Enclosure: NEMA 4X, unless otherwise noted.
5. Signal Interface:
   a. Contact Type: SPDT, snap action switch, rated for 15 amps at 120V ac.
   b. Number of Switch Elements: One, unless otherwise noted.
6. Manufacturers and Products:
   a. Ashcroft; B Series.
   b. United Electric; Series 400.
   c. SOR.

L. P4 Pressure Switch, Low Range Air:

1. General:
    a. Function: Monitor air pressure and provide contact closure(s) when pressure is at the noted setpoint.
    b. Type: Diaphragm actuator.
2. Performance:
    a. Setpoint: As required.
    b. Range: The setpoint shall fall between 30 percent and 70 percent of the range.
    c. Setpoint Repeatability: Plus or minus 2 percent of range.
    d. Maximum Rated Pressure: 10 psig.
3. Features:
    a. Diaphragm Material: Silicone rubber.
    b. Pressure Connection: 1/8-inch NPT aluminum.
    c. Reset: Automatic.
    d. Electrical Connection: 1/2-inch NPT.
4. Enclosure: NEMA 7 (explosion proof).
5. Signal Interface:
    a. Contact Type: SPDT snap action switch, rated for 15 amps at 120V ac.
    b. Number of Switch Elements: One.
6. Manufacturers and Products:
    a. Dwyer; Model 1950.
    b. ITT Barton.

M. P5 Pressure Transmitter, Electronic:

1. General:
   a. Function: Measure pressure and transmit signal proportional to pressure.
   b. Type: Electronic variable capacitance, two-wire transmitter.
2. Performance:
   a. Range: As noted.
   b. Maximum Adjustable Range: Such that the noted range shall lie between 40 percent and 80 percent of the maximum adjustable range.
   c. Accuracy: Plus or minus 0.25 percent of calibrated span.
   d. Temperature: Minus 20 degrees F to plus 200 degrees F, minimum.
3. Features:
   a. Type: Gauge pressure, unless otherwise noted.
   b. Damping: Fluid or electronic type with adjustment.
   c. On-site LCD Display.
   d. Suppressed or Elevated Zero: When noted.
   e. Diaphragm Sensor: Ceramic; all other parts 316 stainless steel.
   f. Wetted O-Rings: Viton, unless otherwise noted.
   g. Housing: Modular with separate compartments for electronics and field connections.
   h. Fill Fluid: Silicone, unless otherwise noted.
4. Process Connections:
   a. Line Size: 1/2 inch or 1/4 inch, selectable.
   b. Connection Type: FNPT.
5. Signal Interface: 4 to 20 mA dc output for load impedance of 0 to 500 ohms minimum without load adjustment with 24V dc supply.
6. Enclosure:
   a. Type: NEMA 4X, unless otherwise noted.
   b. Mounting: Pipe or wall as noted. Provide brackets with Series 300 stainless steel bolts.
7. Manufacturer and Products:
   a. Endress & Hauser; PMC 133, PMC 134, or PMC 53X CERABAR.

N. S1 Indicator, Loop Powered, Integral Enclosure:

1. General:
   a. Function: Digital indication of an analog signal.
   b. Type:
      1) Loop powered.
      2) Integral NEMA 4X enclosure, unless otherwise noted.
2. Performance:
   a. Accuracy: plus or minus 0.1 percent of span counts, plus or minus 1 count.
   b. Temperature, Operating: minus 10 to plus 70 degrees C (14 to 158 degrees F).
   c. Temperature Coefficient:
      1) Zero: plus or minus 100 ppm/ degree C, max.
      2) Span: plus or minus 150 ppm/ degree C, max.
   d. Display Reading Update: 2.5 conversions/sec.
   e. Input Voltage Drop: 3.9 volts max at 20mA.
   f. FM and CSA approved intrinsically safe for hazardous locations.
3. Features:
   a. Readout Display:
      1) Type: 0.8-inches high, liquid crystal, 3-1/2 digits.
      2) Decimal Point Indication: Switch selectable, four positions.
      3) Dummy Zero: Switch selectable trailing zero.
   b. Wide Range Display Calibration:
      1) Zero: Adjustable from minus 1999 to 1999.
      2) Span: Adjustable from 100 to 3998 counts.
   c. Urethane coating of internal circuitry (for protection from corrosive atmospheres): If noted.
4. Signal Interface: 4-20 mA and 10-50mA, switch selectable.
5. Enclosure:
   a. Type: NEMA 4X, unless otherwise noted.
   b. Mounting: Conduit mount, ½-inch, external mounting bracket for surface mounting; unless otherwise noted.
   c. Front Cover Standard Engineering Units: SCFM.
6. Manufacturers and Products:
   a. Action Instruments; Visipak, Model V560, Loop Powered LCD Indicator.
   b. Newport Electronics: Model 508B (integral NEMA 4X housing).

O. T1 Thermometer, Gauge Type:

1. General: Provide where indicated on the Process Control Diagram.
2. Type: Bi-metal.
3. Parts: Thermometer and thermowell.
4. Range: As required.
5. Accuracy: Plus or minus 1 percent of scale ranges.
6. 3-inch dial.
7. 1/2-inch NPT connection.
8. Stem Length: 2-1/2-inch.
9. Thermometer:
    a. Type 316 stainless steel case.
    b. Externally adjustable dial.
    c. Glass window.
    d. Hermetically sealed.
    e. Adjustable viewing angle.
10. Thermowell:
    a. Type: Separable 3/4-inch NPT process connection, Type 316 stainless steel, unless otherwise noted.
11. Manufacturers and Products:
    a. Ashcroft; Series EI.
    b. 3-D Instruments.
    c. Trend Instruments, Inc.

P. T2 Temperature Element and Transmitter, Resistance:

1. General:
   a. Function: Measure the temperature of a process fluid, and transmit analog signal proportional to temperature.
   b. Type: RTD.
   c. Parts: Element, thermowell, and transmitter.
2. Service:
   a. Fluid: Water.
   b. Range: 0 to 40 degrees C.
3. Element:
   a. Type:
      1) Single-element, three-wire, RTD.
      2) Platinum, 100 ohm nominal at 0 degrees C.
   b. Performance:
      1) Accuracy: Plus or minus 1/4 percent of reading or plus or minus 1/4 degrees F, whichever is greater. Conform to SAMA Standard RC 21-4-1966.
      2) Repeatability: Plus or minus 0.1 percent of span.
      3) Response Time: Less than 10 seconds (bare bulb in agitated water).
   c. Features:
      1) Dimensions: 1/4-inch diameter.
      2) Length to accommodate thermowell insertion and extension lengths.
      3) Spring-loaded element when well is used.
      4) 316 stainless steel sheath.
4. Thermowell:
   a. Features:
      1) Inside Diameter: Sized to match element, for easy removal and maximum heat transfer.
      2) Materials: Type 316 stainless steel, unless otherwise noted.
      3) Insertion Length: As required.
      4) Extension Length: 3 inches, unless otherwise noted.
   b. Process Connections: 3/4-inch NPT connection, unless otherwise noted.
5. Transmitter:
   a. Type: Two-wire, powered by a remote power supply.
   b. Performance:
      1) Ambient Temperature Range: Minus 20 to 150 degrees F. Variations within this range shall not affect accuracy more than plus or minus 1/4 percent of range per 50 degrees F.
      2) Accuracy: Plus or minus 0.15 percent of span.
      3) Repeatability: Plus or minus 0.05 percent of span.

c. Features:
    1) Indicator: 0 to 40 degrees C.
d. Signal Interface: 4 to 20 mA dc for load impedance 0 to 600 ohms minimum for 24V dc supply without load adjustment.
e. Enclosure:
    1) Type: NEMA 4.
    2) Mounting: Wall, pipe stand, or element, as noted.

6. Manufacturers:
    a. Foxboro; Series PR element and well with 893RA transmitter.
    b. Rosemount; Series 79 thermowell, 58C, 68, 78, 88 Series platinum RTD and Model 444 transmitter.

Q. Y1 Telephone Dialer Alarm System:

1. General:
   a. Function: Continuously monitor normally open contacts and upon a contact closure shall dial preprogrammed telephone numbers, deliver a prerecorded message, and reset itself upon reception of a signal from the person being called.
   b. Type: Dialer shall be a 16-bit microprocessor based system with all programming and voice messages stored in non-volatile memory. Dialer shall be compatible with cellular telephone or standard telephone communication network.
2. Performance:
   a. Alarm Response Delay: 1 to 5,999 seconds.
   b. Telephone Numbers: Nine phone numbers up to 60 digits in length.
   c. Message Length: 10 seconds per message.
   d. Number of Alarm Channels: Four digital, expandable up to eight digital total.
   e. Power: 120V ac, 60-Hz with battery backup for 60 hours of monitoring service.
   f. The system shall be programmable locally or remotely via touch tone telephone.
   g. Operating Temperature: 20 degrees F to 130 degrees F.
   h. Humidity: 0 to 95 percent noncondensing.
3. Features:
   a. Three-year manufacturer's parts and labor warranty.
   b. Six-digit security code.
   c. Surge protection on power, telephone, and alarm lines.
   d. Direct telephone or cellular communications to FAX machines, answering machines, digital or voice radio pagers, or to computers.
   e. Call progress decoding.
   f. Separate and independent call list for each alarm channel.
   g. Visual indicators for power, fault, run, phone off-hook, line off-hook, incoming call, call in progress, and FAX in progress.
4. Enclosure: NEMA 4X fiberglass.
5. Manufacturers and Products:
   a. Microtel; Series 1000 alarm dialer.
   b. Or approved equal.

R. Y2 Programmable Logic Controller System:

1. General:
   a. Function: Used for process monitoring and control by emulating functions of conventional panel mounted equipment such as relays, timers, counters, current switches, calculation modules, PID controllers, stepping switches, and drum programmers.
   b. Type: Microprocessor based device programmable using ladder logic.
   c. Parts: Central processing unit (CPU), power supply, local and remote input/output modules, local and remote base (chassis/rack) controllers, I/O bases (chassis/rack), data highway, and factory assembled interconnecting cables. Provide components required to make a complete and totally operational system. Reference P&ID Drawings.
   d. All equipment shall be Year 2000 compliant.
2. Environmental:
   a. Temperature: Operating range 32 to 140 degrees F (0 to 60 degrees C); storage range minus 40 to 158 degrees F (0 to 70 degrees C).
   b. Humidity: Operating range 5 to 95 percent noncondensing.
   c. Vibration:
      1) Sinusoidal: IEC 68-2-6, Test Fc; 0.15 mm peak-to-peak, 10- to 57-Hz; 1 g, 57- to 150-Hz.
      2) Random: IEC 68-2-34, Test Fdc; 0.4 g^2/Hz, 80- to 350-Hz, and 3dB/octave rolloff, 80- to 20-Hz and 350- to 2-KHz at 10 min/axis.
   d. Noise: IEC 801, Part 3, Level 3 and Part 4, Level 3; MIL STD-461B.
   e. Isolation: User-side to PLC side 1,500V rms.
   f. Agency Approvals and Standards:
      1) UL listed.
      2) CSA certified.
3. Central Processing Unit (CPU):
   a. Type: Microprocessor, 16-bit minimum.
   b. Scan Time: Less than 1 ms/K words of relay ladder logic.
   c. PLC Communications:
      1) One communication ports, RS-232 or RS-422.
      2) Baud rates supported 1200, 2400, 9600, 19200.
   d. Network Communications: One Allen-Bradley Data Highway Plus port.
   e. Remote I/O Communication Links.

f. Instruction Set:
    1) Timers and counters.
    2) Math: Signed integer and floating-point math including add, subtract, multiply, divide, square root, and compare.
    3) Register Operations: Shift registers, bit shift, bit set, bit clear, data move and data format conversion.
    4) Process Loop Control: User configurable direct or reverse acting PID loop control computation with the capability of both AUTO and MANUAL modes of operation, remote access to controller tuning constants.
    5) Real Time Clock: Date and time set and compare.
    6) Miscellaneous: Jump or skip to a label, one shot, drums, preconfigured analog alarm functions, subroutines.

g. Diagnostics:
    1) Indicators: Battery status, PLC status, PLC operation mode, remote I/O communication status.
    2) Status Word: With failure status for PLC battery, scan overrun, communications, I/O, special functions.
    3) Power Up: PLC checks status of PROMs upon powerup; runs self-diagnostics on power-up; periodically runs self-diagnostics while in RUN mode, halts logic processor and sets outputs to configured state if fatal error is detected.
    4) Diagnostic Tables: Tables, displayable by programming computer, that describe nature and location (address) existing faults and errors.

h. Agency Approvals and Standards:
    1) UL listed.

4. Random Access Memory (RAM):
    a. Memory Size: 32 K words.
    b. Read only memory (ROM) for controller's operating system and diagnostics.
    c. Memory Protection: Switch.
5. Power Supply: One unit for each input/output base assembly:
    a. Voltage: 120/220 volts (user selectable), 60-Hz input; 85 to 132 volts output. Allen-Bradley No. 1746-P2 .
    b. Mounting: External to base.
6. Input/Output: Complete input/output system, including remote I/O with distances up to 10,000 feet maximum up to four remote logical racks.
    a. Discrete Input Modules:
        1) Voltage: 120 volts, 60-Hz.
        2) Operating Power: 2 watts.
        3) Points per Module: 16, maximum.
        4) LED status indicator for each point.
        5) Isolation: Between input point and PLC, 1,500 volts rms.
        6) Manufacturer: Allen-Bradley, Model No. 1746-IA16.

b. Discrete Output Modules:
   1) Voltage: 120 volts, 60-Hz.
   2) Operating Power: 2 watts.
   3) Load Rating: 2 amps continuous.
   4) Isolation: Between PLC and output point, 1,500 volts rms.
   5) Points per Module: 16, maximum.
   6) LED status indicator for each point.
   7) Manufacturer: Allen-Bradley 1746-OA16.

c. Isolated Discrete Output Modules:
   1) Type: Isolated Form A relay.
   2) Voltage: 120 volts, 60-Hz.
   3) Isolated Outputs per Module: 8.
   4) Load Rating: 5 amps continuous.
   5) Operating Power: 2.5 watts.
   6) Points Per Module: 8, maximum.
   7) LED status indicator and fuse for each point.
   8) Isolation: Between PLC and output point, 1,500 volts rms.
   9) Manufacturer: Allen-Bradley, Model No. 1746-0X8.

d. Fast Response DC Input Modules:
   1) Input “Voltage: 24V dc.
   2) Input Current: 8 ma at 24V dc.
   3) Points Per Module: 16, maximum.
   4) Maximum Input Frequency: 1,000 Hz.
   5) Manufacturers and Products: Allen Bradley; Model No. 1746-ITB16 (sink).

e. Analog Input Modules:
   1) Voltage: 24 volts dc.
   2) Power: 3 watts.
   3) Differential Analog Points Per Module: 8 or 4
   4) Isolation: Between PLC and I/O point and between I/O points, 1,500 volts rms.
   5) Analog Input Resolution: 16 bits.
   6) Manufacturer: Allen-Bradley, Model No. 1746-NI8 or 1746-NI4.

f. Analog Output Modules:
   1) Voltage: 24V dc.
   2) Power: 3 watts.
   3) Isolated Analog Points Per Module: 4 maximum.
   4) Isolation Between PLC and I/O Point and Between I/O Points: 1,500 volts rms.
   5) Manufacturer and Product: Allen-Bradley; Model No. 1746-N04I.

7. Remote Adapter Module:
   a. One remote I/O adapter module required for each remote chassis.
   b. Manufacturer and Product: Allen-Bradley; Model No. 1747-ASB.

8. Remote I/O Scanner Module:
    a. Manufacturer: Allen-Bradley Model No. 1747-SN.
9. I/O Chassis:
    a. Each remote I/O panel and SLC 5/04 panel shall be furnished with one I/O chassis.
    b. Each chassis shall have 7, 10, or 13 slots.
    c. Manufacturer and Product: Allen-Bradley; Model Nos. 1746-A7, 1746-A10 and 1746-A13.
10. Fiber Optic Module:
    a. Selectable Wavelengths: 850 nm and 1,300 nm.
    b. Compatible with multimode fiber.
    c. Panel-mounted, 120V ac power supply.
    d. Data highway plus and remote I/O communications.
    e. Fault tolerant.
    f. Interaction diagnostics.
    g. Manufacturer and Product: Phoenix Digital; Model OCM-DPR-13-P-DST-ACV.
11. I/O Placement:
    a. From Left to Right: Analog, DC I/O, AC I/O.
    b. Wired to/from PLC I/O modules or racks to/from control panel terminal blocks in all panels (direct connection of field wiring to I/O module or rack is not acceptable.
12. Identification:
    a. Nameplates installed above/below each PLC component (CPU, I/O rack, power supply, etc.).
    b. Label configured I/O points as they have been configured (addressed) in the system.
13. Programming Software:
    a. Programming software shall be manufactured by Rockwell Automation.
    b. Software shall be suitable for online and offline programming of Allen-Bradley SLC S/04. PLC programming software shall communicate with the PLCs with RS LINX software.
    c. Model Number: RSLOGIX 500 Standard offline/online—disk, latest version.
14. PLC Programming Unit:
    a. The PLC programming unit shall be used to access any PLC for purposes of monitoring the real time operation of the PLC program, and modifying both on and offline the PLC program. The programming unit shall communicate with any PLC by direct connection to the PLC or by connection over the data highway.
    b. Provide all other cabling, cards, memory, software and chips as required to enable the unit to perform its intended functions.
    c. The PLC programming unit shall be a laptop style PC with the following as a minimum requirement:

1) Pentium III processor, 450 mHz.
2) 64 MB RAM.
3) 4 GB hard drive.
4) 32X CD-rom drive.
5) 3-1/4-inch floppy drive (floppy drive and CD-Rom installed internal to PC. Both must be accessible by PC).
6) MS Windows NT (latest version).
7) Microsoft Office Professional Suite (Word, Access, Excel, Power Point).
8) Carrying case.
9) Extra battery pack.
10) Parallel cable for printing.
11) All associated manuals.
12) PCMCIA data highway plus adapter card with cable. Allen-Bradley; Model No. 1784-PCMC1.

NASA – JOHNSON SPACE CENTER

WHITE SANDS TEST FACILITY

TREATMENT SYSTEM FOR

PLUME-FRONT STABILIZATION

WELL VAULT INSTALLATION TECHNICAL SPECIFICATIONS

TABLE OF CONTENTS

I. Scope……1

II. Schedule……...1

III. Earthwork……1

IV. Installation ……..3

V. Certification and Warranty……..4

VI. Submittals……4

LIST OF ATTACHMENTS

Attachment 1 WSTF Groundwater Treatment Facility Project Location

- Dwg # 652-C-01, Project Location
- Dwg # 652-C-02, Well Locations and Piping Layout

Attachment 2 Well Vault Civil Details

Extraction Well PFE-1
- Dwg # 653-C-02, Extraction Well PFE-1 Civil Details

Extraction Well PFE-2
- Dwg # 654-C-02, Extraction Well PFE-2 Civil Details

Extraction Well PFE-3
- Dwg # 655-C-02, Extraction Well PFE-3 Civil Details

Extraction Well PFE-5
- Dwg # 657-C-02, Extraction Well PFE-5 Civil Details

Injection Well PFI-1
- Dwg # 660-C-01, Injection Well PFI-1 Civil Details

Injection Well PFI-2
- Dwg # 661-C-01, Injection Well PFI-2 Civil Details

Injection Well PFI-3
- Dwg # 662-C-01, Injection Well PFI-3 Civil Details

Injection Well PFI-4
- Dwg # 663-C-01, Injection Well PFI-4 Civil Details

I. Scope

This specification defines the requirements for installation of precast concrete well vaults at eight (8) groundwater well locations at the NASA White Sands Test Facility. Maps of WSTF's location and the project location with respect to WSTF's developed areas are presented in Attachment 1. WSTF is located 18 miles northeast of Las Cruces, New Mexico (65 miles north of El Paso, Texas) with access provided through U. S. Highway 70. The project is located in an unimproved area of Sections 4 and 5 of T21S, R3E and Section 32 of T20S, R3E, see Attachment 1. Access to the general project vicinity is provided by a light duty gravel road (the WSTF Well Road).

The contract drawings are presented in Attachment 2. The location of each well vault is shown in Attachment 1. This specification pertains to the installation of four (4) extraction well and four (4) injection well precast concrete vaults, and does not include vault materials.

II. Schedule

A. General Requirements

1. Project Schedule as described below shall be prepared. The scheduling of construction shall be the responsibility of the Contractor. Contractor management personnel shall actively participate in its development. Subcontractors and suppliers working on the project shall also contribute in developing and maintaining an accurate Project Schedule.

2. The proposed Project Schedule shall be approved by the Facilities Engineering Requester and incorporated into an Environmental Department delivery order prior to proceeding with vault installation. The approved Project Schedule shall be used to measure the progress of the work and to aid in evaluating time extensions. The following components shall be considered a minimum appropriate level of detail to be used in the Project Schedule.

B. Activity Durations

Contractor schedule submissions shall utilize reasonable activity durations. Reasonable durations are those that allow the progress of activities to proceed, without excessive float or unreasonably short durations.

C. Government Activities

Anticipated government and other agency activities that could impact progress shall be shown. These activities may include, but are not limited to: approvals, inspections, utility tie-in, Government Furnished Equipment (GFE) and Notice to Proceed for phasing requirements.

D. Responsibility

All activities shall be identified in the project schedule by the party responsible to perform the work. Responsibility includes, but is not limited to, the subcontracting firm, contractor work force, or government agency performing a given task. Activities shall not belong to more than one responsible party.

III. Earthwork

A. Clearing and Grubbing

The proposed vault installation areas have been cleared and grubbed. Minimal to no clearing and/or grubbing is required. Should the Contractor encounter conditions where clearing and grubbing is required, the following shall apply:

1. Clearing shall consist of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including down timber, snags, brush, and rubbish occurring in the areas to be cleared. Trees, roots, brush, and other vegetation in areas to be cleared shall be cut off flush with or below the original ground surface, except such trees and vegetation as may be indicated or directed to be left standing. Trees and vegetation to be left standing shall be protected from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require.

2. Grubbing shall consist of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Material to be grubbed, together with roots and other organic material not suitable for construction purposes, shall be removed to a depth of not less than 12 inches below the original surface level of the ground. Depressions made by grubbing shall be filled with suitable material and compacted to make the surface conform to the original adjacent surface of the ground.

3. Cleared and grubbed materials shall be stockpiled adjacent to the cleared well pad area.

B. Erosion Control

The Contractor shall be responsible for erosion control throughout the duration of the project. Additional work or damage to materials due to the Contractor's fault or neglect shall be repaired or replaced by the Contractor without additional cost to the Government.

C. Excavation

1. Excavation shall be as recommended by the manufacturer of the vault and in accordance with OSHA Regulation 29 CFR Part 1926, Subpart P. In case of no manufacturer recommendations or contradiction between vault manufacturer recommendations and 29 CFR Part 1926, Subpart P, OSHA regulations shall prevail.

2. Excavation shall be sufficient to leave at least 12 inches clear between the outer structure surfaces and the face of the excavation or support members.

3. The bottoms of the excavation shall be accurately graded to provide uniform bearing and support for the bottom section or footer of each vault. Stones of three (3) inches or greater in any dimension shall be removed to avoid point bearing.

4. Loose disintegrated rock and thin strata shall be removed. Removal of unstable material shall be as specified below. When concrete or masonry is to be placed in an excavated area, special care shall be taken not to disturb the bottom of the excavation. Excavation to the final grade level shall not be made until just before the concrete or masonry is to be placed.

5. Where unstable material is encountered, such material shall be removed to the depth directed and replaced to the proper grade with Engineer-approved native backfill. **Note: required excavation areas may coincide with former mud-pit areas (remnant of drilling activities). Allow for this possibility in the schedule and cost estimate.**

6. When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the resulting material shall be excavated and replaced by the Contractor without additional cost to the Government.

D. Backfill and Compaction

1. Backfilling shall be accomplished after inspection by the Contracting Officer. Backfill shall be placed in such a manner that the structure will not be damaged by the shock of falling earth. The backfill material shall be deposited, compacted and brought up evenly on all sides of the structure to prevent eccentric loading and excessive stress

2. Backfill material shall consist of satisfactory material, select granular material, or initial backfill material as required.

3. Backfill shall be placed in layers not exceeding 12 inches loose thickness for compaction by hand operated machine compactors, and 16 inches loose thickness for other than hand operated machines, unless otherwise specified.

4. Each layer shall be compacted to at least 95 percent maximum density for cohesionless soils and 90 percent maximum density for cohesive soils, unless otherwise specified.

5. The vault excavation shall not be backfilled until all specified tests are performed.

6. Unyielding material removed from the bottom of the excavation shall be replaced with select granular material or initial backfill material.

7. Unstable material removed from the bottom of the excavation shall be replaced with select granular material placed in layers not exceeding 6 inches loose thickness.

8. Testing

   a. Testing shall be the responsibility of the Contractor and shall be performed at no additional cost to the Government.

   b. Tests shall be performed by an approved commercial testing laboratory or may be tested by facilities furnished by the Contractor. No work requiring testing will be permitted until the facilities have been inspected and approved by the Contracting Officer

   c. Testing of Backfill Materials - Classification of backfill materials shall be determined in accordance with ASTM D 2487 and the moisture-density relations of soils shall be determined in accordance with ASTM D 1557. A minimum of one soil classification and one moisture-density relation test shall be performed on each different type of material used for bedding and backfill.

IV. Installation

A. Vendor Qualifications

1. The Contractor shall have successfully completed at least 3 projects of the same scope and size or larger within the last 6 years. Contractor shall demonstrate specific experience in regard to the system installation to be performed.

2. The Contractor shall comply with all applicable OSHA, NASA, JSC and WSTF safety requirements. The Contractor shall provide trained/licensed/certified personnel and safety equipment as required. All Contractor training/certifications and equipment are subject to review, inspection and approval by the Contracting Officer.

3. The Contractor shall comply with all WSTF site security requirements.

B. General Requirements

1. The vaults shall be installed per the contract drawings (Attachment 2) and the vault manufacturer's instructions. After becoming familiar with all details of the work, the Contractor shall verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

2. Earthwork shall be performed per Section IV. Temporary closures shall be installed as required to keep the inside of the vault and the vault penetrations clean.

3. The Contractor shall not install any damaged materials. The Contractor shall be responsible for any damage to the vaults in the field. All repairs shall be in accordance with the vault manufacturer's recommendations.

C. Project Area

The project area shall have temporary structures, barricades, project signs, and construction facilities removed. A list of completed clean-up items shall be submitted on the day of final inspection.

V. Certification and Warranty

The minimum design life for installation procured per this PR is thirty (30) years. The certification and warranty shall contain a written certification statement from the installation inspector(s) attesting to the proper installation and testing vaults. The vendor shall provide a warranty that guarantees the installation against defects or failures due to improper installation. At minimum, any defects or failures due to improper installation shall be repaired by the vendor at no cost to WSTF for a (1) one year period. The manufacturer/vendor shall be obligated to replace damaged or defective parts or materials within a two week time frame.

VI. Submittals

Drawings showing final as-built conditions of the project. The final as-built drawings shall consist of one set of electronic drawing files (*.dwg) in AutoCAD V.14 format and one set of the working as-built drawings.

This paragraph covers as-built drawings complete, as a requirement of the contract. The terms "drawings," "contract drawings," "drawing files," "working as-built drawings" and "final as-built drawings" refer to contract drawings that are revised and shall be used as final as-built drawings.

A. Working As-Built and Final As-Built Drawings

The Contractor shall revise two sets of paper drawings by red-line process to show the as-built conditions during the execution of the project. These working as-built marked drawings shall be kept current on a weekly basis and at least one set shall be available on the jobsite at all times. Changes from the design drawings, which might be uncovered in the course of construction, shall be accurately and neatly recorded as they occur by means of details and notes. The working and final as-built drawings shall show, but shall not be limited to, the following information:

1. Correct grade, elevations, cross section, or alignment of roads, earthwork, structures or utilities if any changes were made from contract plans.

2. Changes in details of design or additional information obtained from working drawings specified to be prepared and/or furnished by the Contractor; including but not limited to

fabrication, erection, installation plans and placing details, pipe sizes, insulation material, dimensions of equipment foundations, etc.

3. The topography, invert elevations and grades of drainage installed or affected as part of the project construction.

4. Changes or modifications which result from the final inspection.

5. Where contract drawings or specifications present options, only the option selected for construction shall be shown on the final as-built prints.

6. Systems designed or enhanced by the Contractor, such as vault configuration and installation details.

B. Drawing Preparation

1. The as-built drawings shall be modified as may be necessary to correctly show the features of the project as it has been constructed by bringing the contract set into agreement with approved working as-built prints, and adding such additional drawings as may be necessary. These working as-built marked prints shall be neat, legible and accurate.

2. These drawings are part of the permanent records of this project and shall be returned to the Contracting Officer after approval by the Government. Any drawings damaged or lost by the Contractor shall be satisfactorily replaced by the Contractor at no expense to the Government.

C. Computer Aided Design and Drafting (CADD) Drawings

1. Only personnel proficient in the preparation of CADD drawings shall be employed to modify the contract drawings or prepare additional new drawings.

2. Additions and corrections to the contract drawings shall be equal in quality and detail to that of the originals. Line colors, line weights, lettering, layering conventions, and symbols shall be the same as the original line colors, line weights, lettering, layering conventions, and symbols.

3. If additional drawings are required, they shall be prepared using the specified electronic file format applying the same graphic standards specified for original drawings. The title block and drawing border to be used for any new final as-built drawings shall be identical to that used on the contract drawings.

4. Additions and corrections to the contract drawings shall be accomplished using CADD files. The electronic files will be supplied on 3-1/2 inch high density floppy disks or compact disc.

5. The Contractor shall be responsible for providing all program files and hardware necessary to prepare final as-built drawings. The Contracting Officer will review final as-built drawings for accuracy and the Contractor shall make required corrections, changes, additions, and deletions.

6. CADD colors shall be the "base" colors of red, green, and blue. Color code for changes shall be as follows:

    a. Deletions (red) - Deleted graphic items (lines) shall be colored red with red lettering in notes and leaders.

    b. Additions (Green) - Added items shall be drawn in green with green lettering in notes and leaders.

    c. Special (Blue) - Items requiring special information, coordination, or special detailing or detailing notes shall be in blue.

7. The Contract Drawing files shall be renamed in a manner related to the project name (i.e., Plume-Front Remediation System). Marked-up changes shall be made only to those renamed files. All changes shall be made on the layer/level as the original item. There shall be no deletions of existing lines; existing lines shall be over struck in red. Additions shall be in green with line weights the same as the drawing. Special notes shall be in blue on layer #63.

8. When final revisions have been completed, the cover sheet drawing shall show the wording "RECORD DRAWING AS-BUILT" followed by the name of the Contractor in letters at least 5 mm high. All other contract drawings shall be marked either "As-Built" drawing denoting no revisions on the sheet or "Revised As-Built" denoting one or more revisions. Original contract drawings shall be dated in the revision block.

D. Final As-Built Drawing Submittals

1. Within 14 calendar days after Government approval of all of the working as-built drawings for a phase of work, the Contractor shall prepare the final CADD as-built drawings for that phase of work and submit two sets of blue-lined prints of these drawings for Government review and approval. The Government will promptly return one set of prints annotated with any necessary corrections.

2. Within 7 calendar days the Contractor shall revise the CADD files accordingly at no additional cost and submit one set of final prints for the completed phase of work to the Government.

3. Within 14 calendar days of substantial completion of all phases of work, the Contractor shall submit the final as-built drawing package for the entire project. The submittal shall consist of one set of electronic files on 3-1/2 inch high density floppy disks (for projects with electronic digital files or sets of files less than or equal to 4 diskettes or compact disc, two sets of blue-line prints and one set of the approved working as-built drawings). They shall be complete in all details and identical in form and function to the contract drawing files supplied by the Government. Any transactions or adjustments necessary to accomplish this are the responsibility of the Contractor.

4. The Government reserves the right to reject any drawing files it deems incompatible with the customer's CADD system. Paper prints, drawing files and storage media submitted will become the property of the Government upon final approval. Failure to submit final as-built drawing files and marked prints as specified shall be cause for withholding any payment due the Contractor under this contract. Approval and acceptance of final as-built drawings shall be accomplished before final payment is made to the Contractor.

E. As-Built Record of Equipment and Materials Submittal

1. Installation Instructions - The Contractor shall furnish the manufacturer's installation recommendations or instructions for each material or procedure to be utilized, including materials preparation.

2. Qualifications - A statement certifying that the Contractor has the specified experience.

3. Statement of Satisfactory Installation - The Contractor shall furnish a signed statement certifying that the installation is satisfactory and in accordance with the contract drawings and specifications and the manufacturer's prescribed procedures and techniques, upon completion of the project and before final acceptance.

4. Field Test Reports - The Contractor shall furnish a copy of all field notes and test reports.

F. Final Approved Shop Drawings

The Contractor shall furnish final approved project shop drawings 30 calendar days after transfer of the completed facility.

G. Warranty Management Plan

The Contractor shall submit warranty information for all applicable construction and equipment. This submittal shall include a list for each warranted equipment, item, feature of construction or system indicating:

1. Name of item.
2. Model and serial numbers.
3. Location where installed.
4. Name and phone numbers of manufacturers or suppliers.
5. Names, addresses and telephone numbers of sources of spare parts.
6. Warranties and terms of warranty. This shall include one-year overall warranty of construction. Items that have extended warranties shall be indicated with separate warranty expiration dates.
7. Cross-reference to warranty certificates as applicable.
8. Starting point and duration of warranty period.
9. Summary of maintenance procedures required to continue the warranty in force.
10. Cross-reference to specific pertinent Operation and Maintenance manuals (if applicable).

ATTACHMENT 1

WSTF GROUNDWATER TREATMENT FACILITY

PROJECT LOCATION

ATTACHMENT 2

WSTF GROUNDWATER TREATMENT FACILITY

WELL VAULT DETAILS

NASA – JOHNSON SPACE CENTER

WHITE SANDS TEST FACILITY

GROUND WATER TREATMENT SYSTEM FOR

PLUME-FRONT STABILIZATION

WELL VAULT MATERIAL TECHNICAL SPECIFICATIONS

TABLE OF CONTENTS

I. Scope……..1

II. Material……...1

III. Schedule……..2

IV. Certification and Warranty……..2

V. Submittals……2

LIST OF ATTACHMENTS

Attachment 1 WSTF Groundwater Treatment Facility Project Location

- Dwg # 652-C-01, Project Location
- Dwg # 652-C-02, Well Locations and Piping Layout

Attachment 2 Well Vault Details

Extraction Well PFE-1

- Dwg # 653-C-02, Extraction Well PFE-1 Civil Details

Extraction Well PFE-2

- Dwg # 654-C-02, Extraction Well PFE-2 Civil Details

Extraction Well PFE-3

- Dwg # 655-C-02, Extraction Well PFE-3 Civil Details

Extraction Well PFE-5

- Dwg # 657-C-02, Extraction Well PFE-5 Civil Details

Injection Well PFI-1

- Dwg # 660-C-01, Injection Well PFI-1 Civil Details

Injection Well PFI-2

- Dwg # 661-C-01, Injection Well PFI-2 Civil Details

Injection Well PFI-3

- Dwg # 662-C-01, Injection Well PFI-3 Civil Details

Injection Well PFI-4

- Dwg # 663-C-01, Injection Well PFI-4 Civil Details

I. Scope

This specification defines the requirements for materials of precast concrete well vaults at eight (8) groundwater well locations at the NASA White Sands Test Facility. Maps of WSTF's location and the project location with respect to WSTF's developed areas are presented in Attachment 1. WSTF is located 18 miles northeast of Las Cruces, New Mexico (65 miles north of El Paso, Texas) with access provided through U. S. Highway 70. The project is located in an unimproved area of Sections 4 and 5 of T21S, R3E and Section 32 of T20S, R3E, Attachment 1. Access to the general project vicinity is provided by a light duty gravel road (the WSTF Well Road).

The contract drawings are presented in Attachment 2. The installation location of the well vaults is shown in Attachment 1. This document pertains to the materials of four (4) extraction well and four (4) injection well precast concrete vaults, and does not include the piping system components (pipe, valves, flanges, etc.) located inside the wellhead vaults. This specification does not cover installation of components, and pertains only to construction of eight (8) precast concrete vaults.

II. Material

A. Vendor Qualifications

The manufacturer/vendor of the precast concrete wellhead vaults shall have a minimum of six (6) years of continuous experience. Prior to the award of this procurement, all potential vendors will be required to submit a company profile or Statement of Qualifications that summarizes their capabilities and work experience on similar projects.

B. Well Vaults

1. The location of the wellhead vaults is shown in Attachment 1. Vault details are presented in Attachment 2. The project will include the materials for four (4) extraction well and four (4) injection well precast concrete vaults. The project does not include the materials and installation of piping system components (valves, flanges, and flowmeters) or electrical equipment located inside the well vaults.

2. The vaults and all materials and appurtenances shall be as specified and as shown on the contract drawings, and shall be suitable for the service intended.

3. All materials and appurtenances supplied as part of this contract shall be new and unused except for testing equipment. Components that serve the same function and are the same size shall be identical products of the same manufacturer.

4. The well vaults shall meet all OSHA safety requirements and industry standards. The absence of ladders and other details on the contract drawings does not relieve the Contractor of responsibility for ensuring safe personnel access to the vault.

5. The well vaults, vault penetrations, and vault covers shall be as specified in the contract drawings (Attachment 2), or equivalent.

6. The vaults shall be precast concrete fabricated per ASTM C-857 specifications.

7. The concrete shall have a 28 day compressive strength of 4,500 psi with ASTM A-615 Grade 60 rebar and ASTM A-185 Grade 65 mesh.

8. The vaults and covers shall be designed and fabricated to prevent the ingress of moisture.

C. Material Delivery, Storage, and Handling

1. Proper protection and care of material during fabrication and delivery is the Vendor's responsibility. Any material found to be damaged shall be replaced at the Vendor's expense.

2. Vaults shall be delivered and off-loaded at each well site shown in Attachment 1. In the event weather conditions make the roads to each well site impassable, vaults shall be delivered and off-loaded at the Building 650 location shown in Attachment 1. Vendor shall provide transportation from vendor's facility to the job site. Vendor shall provide suitable means for off-loading the vaults at the job site.

3. Provisions shall be made for the attachment of a fixture or harness to the vaults to facilitate the lifting of the vault by means of a crane. If the fixtures involve the use of a lug or key, the manufacturer will supply with the vault a harness suitable for lifting.

III. Schedule

A fabrication and delivery schedule shall be submitted with the vendor's proposal.

A. Delivery Date

Vendor shall deliver all vaults, materials, and appurtenances to WSTF within 30 calendar days of contract award.

IV. Certification and Warranty

The minimum design life for materials procured per this specification is (30) thirty years. The vendor shall provide a warranty that guarantees the vaults against defects in materials or workmanship. At minimum, any defects in materials or workmanship shall be repaired by the vendor at no cost to WSTF for a one (1) year period. Vendor shall repair or replace damaged or defective parts or materials within two weeks of notification by customer.

V. Submittals

A. Drawings showing final as-built conditions of each well vault. The final as-built drawings shall consist of one set of electronic drawing files (*.dwg) in AutoCAD V.14 format and one set of the working as-built drawings.

B. Installation Instructions - The Contractor shall furnish the manufacturer's installation recommendations or instructions for each material or procedure to be utilized, including materials preparation.

C. Qualifications - A statement certifying that the Contractor has the specified experience.

D. Final Approved Shop Drawings - The Contractor shall furnish NASA with final approved project shop drawings prior to release of a *notice to proceed with fabrication* by NASA.

ATTACHMENT 1

WSTF GROUNDWATER TREATMENT FACILITY

PROJECT LOCATION

ATTACHMENT 2

WSTF GROUNDWATER TREATMENT FACILITY

WELL VAULT DETAILS

State of New Mexico
ENVIRONMENT DEPARTMENT
Ground Water Quality Bureau
Harold Runnels Building
1190 St. Francis Drive, P.O. Box 26110
Santa Fe, New Mexico 87502
(505) 827-2918 phone
(505) 827-2965 fax

GARY E. JOHNSON
GOVERNOR

PETER MAGGIORE
SECRETARY

PAUL RITZMA
DEPUTY SECRETARY

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

March 10, 2000

Joseph Fries, Manager
NASA White Sands Test Facility
P. O. Box 20
Las Cruces, NM 88004

RE: **Discharge Plan Approval, DP-1255, NASA White Sands Test Facility(WSTF)**

Dear Mr. Fries:

Pursuant to Water Quality Control Commission (WQCC) Regulation 3109, the discharge plan application for DP-1255, submitted by you for the discharge of 1.872 million gallons per day of treated contaminated groundwater from the NASA WSTF groundwater remediation system is hereby approved, subject to the condition listed below. The facility is located approximately 18 miles northeast of Las Cruces in Section 5, T21S, R3E, Dona Ana County. In approving this discharge plan, the New Mexico Environment Department (NMED) has determined that the requirements of WQCC Regulation 3109.C have been met.

The approved NASA WSTF treatment and disposal system is briefly described as follows:

Up to 1.872 million gallons per day of ground water contaminated with organic compounds will be extracted using six plume front extraction wells. Contaminated ground water will then be treated using UV oxidation/hydrogen peroxide and air stripping. Treated groundwater will be reinjected via four injection wells located southwest of the plume front to create a ground water mound to prevent further migration of the contaminant plume. Ground water below the site is at a depth of

approximately 420 feet and has a total dissolved solids concentration ranging from 490 to 1,230 milligrams per liter.

The approved discharge plan consists of the January, 1999 Plume-Front Stabilization Work Plan and the materials submitted by NASA WSTF dated February 18, 1999, April 26, 1999, September 20, 1999, October 28, 1999, November 24, 1999, February 9, 2000, and February 28, 2000. The discharge shall be managed in accordance with the approved plan and is subject to the conditions listed below.

However, approval of this discharge plan does not relieve you of your responsibility to comply with the New Mexico Water Quality Act, WQCC Regulations, any other applicable federal, state and/or local laws and regulations, such as zoning requirements and nuisance ordinances.

CONDITIONS FOR APPROVAL

This discharge plan approval is subject to the following conditions for the following reasons:

1. In addition to the monitoring plan outlined in Specific Requirement # 5 below, NASA WSTF shall meter the volume of treated groundwater discharged to the injection wells on a weekly basis and report the volumes to NMED on a quarterly basis. Quarterly reports will be submitted to NMED on or before April 30, July 31, October 30, and January 30.

   The reason for this condition is to comply with WQCC Regulation 3107.A.

2. NASA WSTF shall sample the following Westbay monitoring wells after installation and development, and prior to discharge of treated groundwater to the injection wells: WW-2, JP-3, PL-8, BLM-37, PL-9, and BLM-37. The monitor wells shall be sampled and analyzed for the following constituents: N-nitrosodimethylamine (NDMA) and N-nitrodimethylamine (DMN) using modified EPA Method 607; Freon 11, 21, and 113 using EPA Method 8260; and tetrachloroethene (PCE), and trichloroethene (TCE) using EPA Method 8021.

   The reason for this condition is to establish water quality outside of the contaminated groundwater plume, and to comply with WQCC Regulation 3107.

3. In addition to the contingency plan outlined in Specific Requirement #6 and #7, NASA WSTF shall implement the following contingency plan:

   In the event that a spill occurs, NASA WSTF shall comply with WQCC Regulation 1203. This includes corrective actions to contain or mitigate the damage as soon as possible, notification of NMED within 24 hours, and submittal of a corrective action plan for NMED approval within 15 days.

The reason for this condition is to comply with WQCC Regulation 1203.

4. In the event of closure of any components of the NASA WSTF groundwater remediation system, NASA WSTF shall submit to NMED for approval a closure plan which ensures that no unregulated discharge to groundwater may occur. Closure plans shall include, but not be limited to, removal and/or capping of any pipelines which convey treated or untreated effluent, post-closure monitoring, and plugging and abandonment of monitoring wells and/or injection wells as per NMED Monitor Well Construction and Abandonment Guidelines (copy enclosed).

   The reason for this condition is to comply with WQCC Regulation 3107.A.11.

SPECIFIC REQUIREMENTS

The terms and conditions of this approval contain specific requirements which are summarized below.

1. Groundwater contaminated with organic compounds will be extracted using six plume front extraction wells and then treated using UV oxidation/hydrogen peroxide and air stripping. NASA WSTF will discharge up to 1.872 million gallons of treated groundwater in four Class V injection wells, located in Section 5, T21S, R3E. Treated groundwater will not exceed the following concentrations: NDMA-10 ppt, DMN-10 ppt, PCE-5 ppb, TCE-5 ppb, Freon 11-100 ppb, Freon 21-20 ppb, Freon 113-1,200 ppb

2. NASA WSTF will follow the operations and maintenance plan as outlined in Enclosure 6 of the discharge plan application dated February 12, 1999.

3. NASA WSTF will abide by the Memorandum of Understanding, submitted to NMED on February 28, 2000, with the Bureau of Land Management which provides for a buffer zone for lands adjacent to the NASA WSTF.

4. NASA WSTF will install a Westbay Multiport monitor well (designated as PL-9) equidistant between monitor wells PL-8 and BLM-37. The monitor well construction and location will be as indicated in the response to NMED dated September 16, 1999.

5. NASA WSTF will implement the following monitoring plan:

   A. GROUNDWATER MONITORING SCHEDULE:

      NASA will sample and analyze groundwater for NDMA and DMN using modified EPA Method 607; Freon 11, 21, and 113 using EPA Method 8260;

and PCE, and TCE using EPA Method 8021, from the following wells and submit results to NMED on a quarterly basis: WW-2, JP-3, JP-2-447, BLM-37, PL-8, and PL-9. Quarterly reports will be submitted to NMED on or before April 30, July 31, October 30, and January 30.

B. INFLUENT/EFFLUENT SAMPLING SCHEDULE

Time Period	**Sampling Location**	**Sampling Frequency**	**Analytes** (Analytical methods as specified in S. R. 4.A.)
0-3 Months (initial start-up and testing period)	Treatment Facility Influent and Effluent Piping	Twice per week (during operational periods)	NDMA, DMN, Freon 11, 21, and 113, PCE, and TCE
0-3 Months (initial start-up and testing period)	Each Extraction Well	Once per week (during operational periods)	NDMA, DMN, Freon 11, 21, and 113, PCE, and TCE
3-12 Months	Treatment Facility Influent and Effluent Piping	Once per month	NDMA, DMN, Freon 11, 21, and 113, PCE, and TCE
3-12 Months	Each Extraction Well	Quarterly	NDMA, DMN, Freon 11, 21, and 113, PCE, and TCE
After 12 Months	At the end of each year of operation, NASA will evaluate influent/effluent sampling results and submit to NMED a proposed influent/effluent monitoring schedule for approval.		

6. NASA WSTF will implement the contingency plan outlined in Enclosure 6, section 4.8.2 of the discharge plan application dated February 12, 1999. This contingency plan includes a system of interlocks which halt system operation when specific conditions arise, and notify appropriate personnel with visual and/or audio alarms. These conditions include: leakage within the dual-wall extraction piping; near-surface water levels within the injection wells; catastrophic failure of any major component; and significant leakage from any piping or component within the treatment building.

7. In the event that contaminant concentrations are observed to exceed the standards outlined in Specific Requirement #1 for effluent monitoring points or downgradient monitoring wells, NASA will notify NMED in writing within 24 hours of receiving the analytical data which indicate exceedance. A system engineer will visually

inspect the treatment system within 24 hours of analytical results receipt to ensure tretament system integrity. NASA will perform resampling of the sampling point/well within 5 days of receiving the analytical data. If the repeat sampling indicates concentrations above the aforementioned standards, NASA will contact NMED within 24 hours of receipt of the analytical data to determine appropriate actions to be taken.

GENERAL DISCHARGE PLAN REQUIREMENTS

In addition to any other requirements provided by law, approval of discharge plan, DP-1255, is subject to the following general requirements:

Monitoring and Reporting

Monitoring and reporting shall be as specified in the discharge plan and supplements thereto. These requirements are summarized on the attached sheet(s). Any inadvertent omissions from this summary of a discharge plan monitoring or reporting requirement shall not relieve you of responsibility for compliance with that requirement.

Record Keeping

1. The discharger shall maintain at the facility, a written record of ground water and wastewater quality analyses.

The following information shall be recorded and shall be made available to the NMED upon request.

a. The dates, exact place and times of sampling or field measurements.

b. The name and job title of the individuals who performed the sampling or measurements.

c. The dates the analyses were performed.

d. The name and job title of the individuals who performed the analyses.

e. The analytical techniques or methods used.

f. The results of such analyses, and

g. The results of any split sampling, spikes or repeat sampling.

2. The discharger shall maintain a written record of any spills, seeps, and/or leaks of effluent, leachate and/or process fluids not authorized by this discharge plan.

3. The discharger shall maintain a written record of the operation, maintenance and repair of facilities/equipment used to treat, store and/or dispose of wastewater; to measure flow rates; and/or to monitor water quality. This will include repairs, replacement or calibration of any monitoring equipment and repairs or replacement of any equipment used in NASA WSTFs' waste or wastewater treatment and disposal system.

4. The discharger shall maintain a written record of the amount of treated groundwater discharged to the injection wells.

Inspection and Entry

In accordance with § 74-6-9.B & E NMSA 1978 and WQCC Regulation 3107.D., the discharger shall allow the Secretary or his authorized representative, upon the presentation of credentials, to:

1. Enter at regular business hours or at other reasonable times upon the discharger's premises or where records must be kept under the conditions of this discharge plan.

2. Inspect and copy, during regular business hours or at other reasonable times, any records required to be kept under the conditions of the discharge plan.

3. Inspect, at regular business hours or at other reasonable times, any facility, equipment (including monitoring and control equipment), practices or operations regulated or required under this discharge plan.

4. Sample or monitor, at reasonable times for the purpose of assuring discharge plan compliance or as otherwise authorized by the New Mexico Water Quality Act, any effluent at any location before or after discharge.

Duty to Provide Information

In accordance with § 74-6-9.B NMSA 1978 and WQCC Regulation 3107.D., the discharger shall furnish to the NMED, within a reasonable time, any relevant information which it may request to determine whether cause exists for modifying, terminating and/or renewing this discharge plan or to determine compliance with this plan. The discharger shall furnish to the NMED, upon request, copies of records required to be kept by this discharge plan.

Spills, Leaks and Other Unauthorized Discharges

This approval authorizes only those discharges specified in the discharge plan. Any unauthorized discharges violate WQCC Regulation 3104, and must be reported to the NMED and remediated as required by WQCC Regulation 1203. This requirement applies to all seeps, spills, and/or leaks

discovered from the extraction well piping, injection well piping, or the groundwater treatment system.

Retention of Records

The discharger shall retain records of all monitoring information, including all calibration and maintenance records, copies of all reports required by this discharge plan, and records of all data used to complete the application for this discharge plan, for a period of at least five years from the date of the sample collection, measurement, report or application. This period may be extended by request of the Secretary at any time.

Enforcement

Failure to grant the Secretary or his authorized representative access to the records required to be kept by this discharge plan or to allow an inspection of the discharge facilities or to the collection of samples is a violation of this discharge plan and the WQCC Regulations. Such violations as well as other violations of the discharge plan, may subject the discharger to a compliance order, a compliance order assessing a civil penalty or an action in district court pursuant to § 74-6-10 NMSA 1978, and/or modification or termination of this discharge plan pursuant to § 74-6-5.L NMSA 1978. Penalties assessed as part of a compliance order shall not exceed $15,000 per day for violations of the terms of this permit or the requirements of § 74-6-5 NMSA 1978, and shall not exceed $10,000 per day for violations of other sections of the Water Quality Act.

Modifications and/or Amendments

The discharger shall notify NMED, pursuant to WQCC Regs. 3107.C, of any modifications or additions to the NASA WSTF's wastewater disposal system, including any increase in wastewater flow rate or wastewater storage and disposal management changes to the system as approved under this discharge plan. The discharger shall obtain NMED's approval, as a discharge plan modification, prior to any increase in the quantity or concentration of constituents in the leachate above those approved in this plan. Please note that WQCC Regs. 3109.E and F provide for possible future amendment of the plan.

Other Requirements

Please be advised that the approval of this plan does not relieve NASA WSTF of liability should your operation result in actual pollution of surface or ground water which may be actionable under other laws and/or regulations.

RIGHT TO APPEAL

If NASA WSTF is dissatisfied with this action taken by NMED, NASA WSTF may file a petition for hearing before the WQCC. This petition shall be in writing to the Water Quality Control Commission within thirty (30) days of the receipt of this letter. Unless a timely request for hearing

is made, the decision of the NMED shall be final.

TRANSFER OF DISCHARGE PLAN

Pursuant to WQCC Regulation 3111, prior to any transfer of ownership, the discharger shall provide the transferee a copy of the discharge plan, including a copy of this approval letter and shall document such to the NMED.

PERIOD OF APPROVAL

Pursuant to WQCC Reg. 3109.G.4., this discharge plan approval is for a period of 5 years. This approval will expire March 10, 2005, and you must submit an application for renewal at least 120 days before that date.

Sincerely,

Marcy Leavitt, Chief
Ground Water Quality Bureau

ML:KV

Enclosures: NMED Monitor Well Construction and Abandonment Guidelines

xc: Ken Smith, NMED Dist. 3
Paul Saavedra, Office of the State Engineer
Mike Johnson, State Engineer Office, Las Cruces

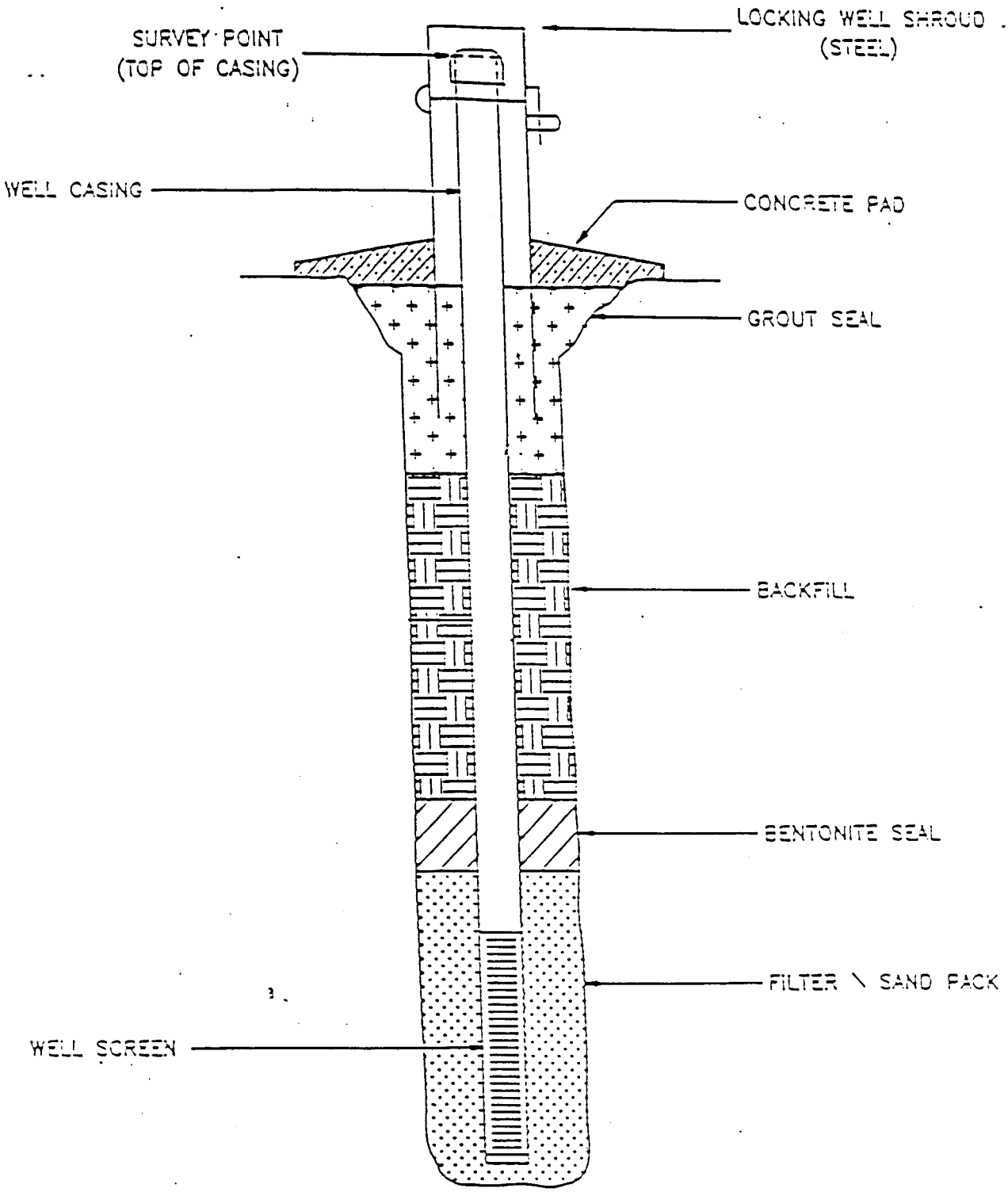
NMED, GROUND WATER SECTION, DISCHARGE PLAN SUMMARY

Discharge Plan Number	1255
Date Report Generated	6-MAR-00
Staff Reviewer	Kurt Vollbrecht
Legally Responsible Party	Joseph Fries
Owner	Joseph Fries P. O. Box 20 Las Cruces, NM 88004
Facility	NASA White Sands Test Facility
Primary Waste Type	Industrial
Treatment	Ground Water Remediation
Discharge	Class V Injection Wells
Discharge Location	Section 5, T21S, R3E
Application Received	05-FEB-99
Public Notice Published	10-MAY-99
Discharge Plan Approved	10-MAR-00
Discharge Plan Expires	10-MAR-05
Discharge Volume	1.872 mgd
Depth to Ground Water	420
TDS	490-1,230 mg/L

Monitoring Reports due 30-APR, 31-JUL, 30-OCT, 30-JAN

Annual Frequency	No. of Sites	Sampling Description
4	1	Volume of effluent discharged from treatment system recorded weekly, submitted quarterly.
4	6	Momitoring wells WW-2, JP-3, JP-2-447, BLM-37, PL-8, and PL-9 sampled and analyzed for NDMA, DMN, Freon 11, 21, 113, TCE, and PCE.
4	N/A	Influent and effluent monitoring as outlined in Specific Requirement 5.B.

Send all monitoring reports and correspondence to: Kurt Vollbrecht
Ground Water Pollution Prevention Section
P.O. Box 26110
Santa Fe, New Mexico 87502
(505)827-2900



GENERALIZED MONITORING WELL SCHEMATIC

(Not To Scale)

N M ENVIRONMENT DEPARTMENT - GROUND WATER SECTION
MONITOR WELL CONSTRUCTION AND ABANDONMENT GUIDELINES

rpose: These guidelines provide minimum construction and abandonment andards for drilled monitor wells which are to be sampled for general emistry analyses. There may be additional requirements if hydrocarbons or her chemicals are involved. Also different guidelines may apply for other pes of well construction such as driven wells.

neral Drilling Specifications

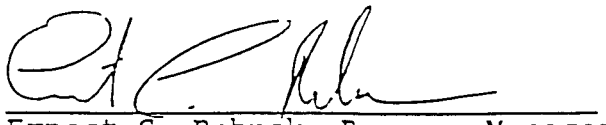
The bore hole shall be drilled a minimum of 4 inches larger than the casing diameter to allow for the emplacement of sand and sealant.
No contaminants shall be present in the drilling mud.
All drill bits, drill rods, and down-hole tools shall be thoroughly cleaned prior to the start of drilling.
After completing the well casing installation, the well shall be developed so that formation water flows freely through the screen and is not turbid, and all sediment has been removed from the well.

ell Specifications (Refer to figure on reverse side.)

1. Use Schedule 40 or heavier PVC pipe, not less than 2 inches ID, as casing. The casing shall extend from the top of the screen to at least one foot above ground surface. The top of the casing must be protected by a cap, and the exposed casing must be protected by a locking shroud. The shroud shall be large enough in diameter to allow easy access for removal of the plastic cap on the PVC casing.
2. Use a minimum 20-foot section of machine slotted or other manufactured screen. A slot size of 0.010-inch generally is adequate for most installations. (No on-site, hack-saw slotting.)
3. The top of the screen shall be 5 feet above the water table, allowing for seasonal fluctuations.
4. The screen section should have centralizers at the top and bottom.
5. The annular space from the bottom of the screen (2 feet below the bottom of the screen if a blank section of casing is placed below the screen) to 2 feet above the screen shall be packed with sand. Clean, medium to coarse sand is recommended. The sand pack should be properly sized to prevent fines in the formation from entering the well. For deeper wells the sand shall be placed by a tremmie pipe.
6. The annular space above the gravel pack shall be grouted or sealed. Pressure grouting with bentonite or cement using a tremmie pipe is preferred. The alternative is to form a bentonite seal by placing bentonite pellets (1/4 or 1/2 inch in size) for at least 2 feet above the gravel pack and proceding in accordance with Item 7 below.
7. The annular space above the bentonite seal can be filled with drill cuttings, or clean sandy clay or tighter soil to within 10 feet of the ground surface. The remaining 10 feet must be sealed with a bentonite-cement grout seal (two to eight percent bentonite by weight).
8. A two-foot minimum radius, four inch minimum thickness concrete pad shall be poured around the shroud. The concrete shall be sloped that rainfall and runoff flows away from the shroud.

Abandonment: Monitor wells no longer in use shall be plugged in such a manner as to preclude migration of surface runoff or ground water along the length of the well. Where possible, this shall be accomplished by removing the well casing and pumping expanding cement from the bottom to the top of the well using a tremmie pipe. If the casing cannot be removed, the casing shall be ripped or perforated along its entire length if possible, and grouted. Filling with bentonite pellets from the bottom to the top is an acceptable alternative to pressure grouting.

Variances: Requests for variances from these guidelines shall be in writing to the Program Manager, NMED Ground Water Section, 1190 St. Francis Drive, P. O. Box 26110, Santa Fe, NM 87502. Each request shall explain in detail the evidence supporting the request. The GWS approval also shall be in writing.

Signed:  Date: 8/15/92

Ernest C. Rebuck, Program Manager, Ground Water Section

ROUTING SLIP

Date: 3-10	ACTION	INFO
RA/J. Fries		
RA/		
RA/P. Baker		
RA/R. F. Melton		
RA/D. A. Amidei MA		
RC/Engineering Office		
RD/Propulsion Test Office		
RE/Administration Office		
RF/Laboratories Office		
NT4/QARSO		
Linda		

Copy to Peter

File: DF-125

Appendix B - Plume-Front Stabilization Treatment System Operation and Maintenance Manual (WJI ENV-0065)

White Sands Test Facility
Job Instruction

Issued: 02/06/04
Expires: N/A

WJI ENV-0065.A

PLUME-FRONT STABILIZATION TREATMENT SYSTEM OPERATION AND MAINTENANCE MANUAL

Work Authorizing Document: Charge No., TPS, DR, Environmental Task Memo

Prepared By: 10/9/03
D. Tanaka, Engineer Lynx, Ltd.

Prepared By:
D. Minnick, Engineer, Lynx, Ltd.

Reviewed By:
R. Reynaud, Engineer, Lynx, Ltd.

Reviewed By:
D. Burnham, Safety Engineer, PAD

Reviewed By: 15 oct 2003
T. Moore, Technician, Lynx, Ltd.

Reviewed By:
R. Pache, IH, Lynx, Ltd.

Approved By: 10-9-2003
Jack Kirby, Project Leader, Lynx, Ltd.

Approved By: 10/16/2003
Ray Spencer, Supervisor, Lynx, Ltd.

Approved By: 2/6/04
Mike Zigmond, NASA Project Manager

Record of Revisions

Issue	Pages Affected	Reason for Revision	Date Revised

TABLE OF CONTENTS

SECTION I – GENERAL INFORMATION

1. PURPOSE
2. LIST OF ATTACHMENTS
3. DEFINITIONS
4. ACRONYMS
5. REFERENCES
6. FACILITY DESCRIPTION
7. LIST OF DRAWINGS
8. MANUFACTURER'S O&M LITERATURE
9. SECURITY AND FACILITY ACCESS
10. GENERAL METHOD OF OPERATION
11. MANAGEMENT RESPONSIBILITY
12. PERSONNEL QUALIFICATIONS
13. SPARE PARTS INVENTORY
14. SAFETY REQUIREMENTS
15. REGULATORY BACKGROUND AND PERMIT REQUIREMENTS
16. SPECIAL INSTRUCTIONS

SECTION II - OPERATING PROCEDURES

1. FACILITY START-UP AND OPERATION
2. FACILITY INSPECTIONS
3. FACILITY SHUT-DOWN
4. FACILITY SAMPLING

SECTION III - MAINTENANCE PROCEDURES

1. TREATMENT FACILITY

2. EXTRACTION AND INJECTION WELL MAINTENANCE

3. LOCK-OUT/TAGOUT

4. COMPUTER AND INSTRUMENTATION SYSTEM

5. PRESSURE VESSELS AND PRESSURIZED SYSTEMS (PV/S)

SECTION IV - ALARM PROTOCOL AND EMERGENCY PROCEDURES

1. EMERGENCY RELEASE

2. INCIDENTAL RELEASE

SECTION I – GENERAL INFORMATION

1. PURPOSE

This WJI provides instructions for the routine operation and maintenance of the Plume-Front Treatment Facility.

2. LIST OF ATTACHMENTS

2.1 Attachment A, "List of References"
2.2 Attachment B, "List of Drawings"
2.3 Attachment C, "Hazard Assessment and Job Hazard Analyses"
2.4 Attachment D, "Anomaly Log"
2.5 Attachment E, "Facility Mechanical Setup"
2.6 Attachment F, "Spares Inventory"
2.7 Attachment G, "Facility Maintenance Plan"
2.8 Attachment H, "System Process Control"
2.9 Attachment I, "Emergency Shutdown Procedures"
2.10 Attachment J, "Alarm Protocol"
2.11 Attachment K, "Sampling Schedule"
2.12 Attachment L, "Treatment Facility and Extraction Well Sampling"
2.13 Attachment M, "Facility Inspection Plan"
2.14 Attachment N, "Spill Response Procedures for Incidental Releases"

3.0 DEFINITIONS

BART - A patented biological activity reaction test biodetection system which can be customized to determine the aggressivity and composition of selected consortia of microorganisms.

Biofouling - Any deleterious event in which a definable biological activity causes a deterioration in an engineered or natural process or system.

Buddy System - A system of organizing personnel into work groups that meet the following criteria: (1) One person does the job while a standby person watches from the immediate area of the job to ensure the worker is safe; or (2) Two persons do the job and are in constant contact with a standby person either electronically, mechanically, or visually. The standby person shall remain in the immediate work area.

CAUTION - Used in work instructions prior to operations that could result in damage to equipment if not followed.

Certified Hazardous Waste Handler - Personnel certified to handle hazardous waste in accordance with the WSTF Certification Plan (maintained on the WSTF Training Database).

Clogging - The generation of a mass which interferes with physical functioning (e.g., hydraulic conductivity) of a porous medium (e.g., gravel pack, sand filter) or transmitting capacity of a device or pipe.

Configuration - Functional arrangement or assembly of elements, parts, or components comprising a mechanical, electrical, electronic, or operational system.

Constraint - A state, quality, or event that will limit or restrict continued or future operations or testing.

Emergency Release - The release of a hazardous substance that occurs outside of WSTF-controlled work areas or, within those areas, goes beyond the scope of the local area emergency procedures, controls or resources.

Encrustation - A relatively solid plate-like or crystalline structure coating a surface.

Incidental Release - The release of a substance that can be handled within the scope of the local area emergency procedures, controls, and resources.

Freeboard - The distance between the liquid level and the top of the container.

Maximum Allowable Working Pressure (MAWP) - The maximum operating pressure authorized under the approved conditions of design and operation.

Maintenance Monitoring - As part of a preventive maintenance strategy, monitoring of system parameters to detect indicators of deteriorating conditions.

NOTE - Used in work instructions to call attention to useful additional information that is not a specific procedural instruction.

Personnel Protective Equipment (PPE) - Equipment used for the protection of eyes, face, head, and extremities, including protective clothing, fall protection equipment, respiratory devices, protective shields, and barriers, which safely protects an individual from hazards capable of causing injury or illness.

Project Leader - The person designated by contractor management or supervision to be the primary coordinator for the project.

Run-off - Rainwater, leachate, or other liquid that drains overland from any part of the facility.

Run-on - Rainwater, leachate, or other liquid that drains overland onto any part of the facility.

Specific capacity - Term used to express the productivity of a well, and is defined as Q/s, where Q is the discharge rate and s is the drawdown in the well.

Two or More Person Operation - a job or task that requires two or more workers.

WARNING - Used in work instructions prior to operations that could result in injury or death to personnel if not followed.

WSTF Standard Instructions (WSI) - General directions on how to perform a type of job or task.

WSTF Standard Procedure (WSP) - A WSTF document describing the activities, responsibilities, authorities, and interrelationships of personnel which implement WSTF policies.

Work Authorizing Document (WAD) - WSTF documents used by NASA to authorize the performance of work by the contractor.

WSTF Job Instructions (WJI) - Step-by-step directions on how to perform a specific job or task.

WIWPS - WSTF Individual Waste Profile Sheet. The WIWPS form is available on the WSTF Network subdirectory \WSTFForm\445.

4.0 ACRONYMS

BART - Biological Activity Reaction Test
CFR - Code of Federal Regulations
DMN - N-Nitrodimethylamine
DP - Discharge Plan
DR - Discrepancy Record
EPA - U.S. Environmental Protection Agency
F-11 - Trichlorofluoromethane (Freon 11)
F-21 - Dichlorofluoromethane (Freon 21)
F-113 - 1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
GC/MS - Gas Chromatography/Mass Spectroscopy
GPM - Gallons Per Minute
GWQB – New Mexico Environment Department's Ground Water Quality Bureau
HDPE - High-Density Polyethylene
HRMB – New Mexico Environment Department's Hazardous and Radioactive Materials Bureau
HVAC - Heating Ventilation and Air Conditioning
I&C – Instrumentation and Control System
IDLH - Immediately Dangerous to Life or Health
JHA - Job Hazards Analysis
JSC - Johnson Space Center
MCC - Motor Control Center
MAWP - Maximum Allowable Working Pressure
MSDS - Material Safety Data Sheet
N/A - Not Applicable
NASA - National Aeronautics and Space Administration
NDMA - N-Nitrosodimethylamine
NIOSH - National Institute for Occupational Safety and Health
NMED - New Mexico Environment Department
O&M - Operation and Maintenance
OSHA - Occupational Safety and Health Act

PCE - Tetrachloroethene (perchloroethene)
PEL - Permissible Exposure Limit
PFE - Plume-Front Extraction (well)
PFI - Plume-Front Injection (well)
PLC - Programmable Logic Controller
ppb - Parts Per Billion
PPE - Personnel Protective Equipment
ppm - Parts Per Million
ppmw - Parts Per Million by Weight
ppt - Parts Per Trillion
psig - Pounds Per Square Inch Gauge
psi - Pounds Per Square Inch
PVC - Polyvinyl Chloride
PV/S - Pressure Vessels and Pressurized Systems
QA/QC - Quality Assurance/Quality Control
SCBA - Self-Contained Breathing Apparatus
SCH - Schedule
SDR - Standard Dimension Ratio
TCE - Trichloroethene
TDS - Total Dissolved Solids
TLV - Threshold Limit Value
TPS - Test Preparation Sheet
UV – Ultraviolet
USACE – U.S. Army Corps of Engineers
VFD - Variable Frequency Drive
VOC - Volatile Organic Compound
WQCC – New Mexico Water Quality Control Commission
WSTF - White Sands Test Facility
WSI - WSTF Standard Instruction
WSP - WSTF Standard Procedure
WAD - Work Authorizing Document
WJI - WSTF Job Instruction
WIWPS - WSTF Individual Waste Profile Sheet

5.0 REFERENCES

A list of references is provided in Attachment A.

6.0 FACILITY DESCRIPTION

The Plume-Front Treatment Facility is an ex-situ pump-and-treat treatment system designed to stabilize future plume migration and remove contaminant mass at the westernmost extent of the WSTF groundwater contamination plume. Details are presented in the Plume-Front Stabilization Work Plan (NASA, 1999).

The treatment facility consists of:

- six groundwater extraction wells;
- an underground piping network;

- the treatment building;
- injection piping and wells; and
- groundwater monitoring wells.

6.1 Extraction Wells

The plume-front extraction wells (PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, and PFE-7) range in total depth from 770 to 896 feet below grade. PFE-1, -2, -4A, -5, and –7 are constructed with SDR 17 PVC casing and 0.085-inch-slot saw-cut PVC screen. PFE-3 is constructed of 10-inch-diameter (nominal) SCH 40 carbon steel casing and a 0.080-inch-slot wire-wrapped screen. Each extraction well is hard-wired for incoming three-phase, 480 volt electrical service. The well locations and piping layout are presented in WSTF drawing number 652-C-02. Well completion diagrams and civil, mechanical and electrical details for the wells are presented in the drawings listed in Attachment B, Section 8.

6.2 Underground Extraction Piping Network

The underground extraction piping network is constructed of dual-wall HDPE with annular leak detection. The pipe was installed in straight segments between piping features (i.e., leak detection cable pull boxes, junctions, and high point vent vaults).

6.3 Treatment Facility

The treatment equipment, housed in Building 650, consists of two, parallel tray style air strippers for VOC removal, followed by a UV reactor unit for NDMA and DMN destruction. A scale control chemical is injected into the treatment stream, prior to the air strippers, to minimize inorganic scale deposit on the wetted portions of the treatment equipment.

Building 650 is a 60-foot by 80-foot insulated metal building, with an electrical component room (containing the UV reactor system power supply), a control room (with a PC for system monitoring/controlling), main treatment area, and restroom. It is designed to maintain a temperature compatible with the electronic components of the treatment equipment.

Building 650 is supplied with potable water, equipped with a septic tank and leach field, and is wired for incoming three-phase, 480 volt electrical service. These features are shown on drawings listed in Attachment B.

6.4 Injection Wells, Injection Manifold and Underground Injection Piping

The treated groundwater exits on the east side of Building 650 and is conveyed to Building 651 (the Injection Manifold Building) via an underground, single-wall HDPE pipe. The flow is apportioned into four legs, via hydraulically-modulating globe control valves in Building 651 and conveyed to the injection wells. The injection manifold building (Building 651), is hard-wired for incoming three-phase, 480 volt electrical service.

The plume-front stabilization system utilizes four non-pressurized PVC injection wells for injection of the treated groundwater into the underlying aquifer. The

injection wells are constructed with SDR 17 PVC casing and 0.085-inch-slot saw-cut PVC screen. The O.D. is 9.05 inches. A drop pipe is installed in each injection well to below the pre-injection static water elevation to minimize air entrainment.

6.5 Groundwater Monitoring Wells

System performance is monitored, among other methods, via sampling and analysis of groundwater from adjacent, downgradient monitor wells WW-2, WW-3, WW-4, WW-5, ST-7, JP-3, PL-8, PL-9, and BLM-37.

7.0 LIST OF DRAWINGS

The Plume-Front Treatment Facility as-built drawings are maintained by the contractor Drafting Group per WJI ENGR-DFT-0001, "Drawing Manual". A hard copy is available through the contractor Environmental Department. A list of drawings for the Plume-Front Treatment Facility is provided in Attachment B.

8.0 MANUFACTURER'S LITERATURE

Copies of the manufacturer's operation and maintenance manuals, cut sheets, material specifications, warranties, etc. for all facility equipment and components will be maintained by the contractor Environmental Department. A list of operation and equipment manuals is provided in the List of References, Attachment A.

9.0 SECURITY AND FACILITY ACCESS

9.1 Access to the WSTF site is controlled by a security force that is on duty on a 24-hour, 365 day per year basis. Security guards control access to the industrial complex and also patrol the plume-front area at least every 8 hours during non-working hours.

9.2 The extraction wells, injection wells and monitoring wells are secured by protective well caps or vaults. The protective well caps or vaults shall be locked at all times except during inspections, sampling, and maintenance operations.

9.3 The treatment facility and manifold building shall remain locked at all times except during inspections, sampling, and maintenance operations. The treatment facility (building. 650) and the injection manifold building (building 651) is surrounded by a seven-foot high chain link fence and two gates. All gates shall remain locked at all times except during inspections, sampling, and maintenance operations.

9.4 Access to all components of the Plume-Front Treatment Facility (injection wells, extraction wells, Bldgs. 650 and 651, etc.) is controlled by the contractor Environmental Department.

10.0 GENERAL METHOD OF OPERATION

The plume-front treatment system is primarily controlled by programmable logic controllers and is designed to operate 24-hours/day, 7-days/week with little to no human operator involvement (this does not include required inspections and operation/maintenance activities). The control system program code allows for operator change of physical setpoints

and notification methods (email, fax, phone, etc.). This flexible arrangement allows for system growth and tailoring of the process to best meet current conditions now and into the future.

11.0 MANAGEMENT RESPONSIBILITY

11.1 The overall operation and maintenance of the Plume-Front Treatment System shall be the responsibility of the contractor Environmental Department.

11.2 The contractor Environmental Department shall support training and ensure a sufficient number of qualified Groundwater Treatment Facility Technicians are readily available to support operations per this WJI. The contractor Environment Department will designate qualified personnel as the Project Leader, Certifying/Qualifying Instructor, and Groundwater Treatment Facility Operators. The contractor Environmental Department shall ensure that a sufficient number of qualified Groundwater Treatment Facility Operators are maintained to allow operation of the system 24-hour/day, 7 days/week

11.3 Per WSI 05-SW-0004, "WSTF Job Instruction (WJI) Control," review and, if required, revision of this WJI is required on an interval not to exceed two years.

12.0 PERSONNEL QUALIFICATIONS

12.1 Hazardous Waste Handlers

All contractor Environmental Department personnel involved in the operation, maintenance and repair of the plume-front treatment system (including inspection, sampling, operations and maintenance) where the potential for exposure to hazardous materials, hazardous waste, hazardous waste constituents, or contaminated groundwater exists will be qualified Hazardous Waste Handlers (per the WSTF Training Database).

12.2 Groundwater Treatment Facility Operator, Project Leader and Certifying/Qualifying Instructor

12.2.1 All operations per this WJI will be performed or directed by a qualified contractor Environmental Department Groundwater Treatment Facility Operator(s) (per the WSTF Training Database). Qualified Groundwater Treatment Facility Operators are the contractor Environmental Department organization project leader and qualified contractor Environmental Department engineers or scientists who, by means of their working knowledge of the treatment system, the operating and maintenance procedures, safety measures, alarm protocol and emergency procedures have been appointed by the contractor Environmental Department Manager as Groundwater Treatment Facility Operators.

12.2.2 The Project Leader and Certifying/Qualifying Instructor are qualified Groundwater Treatment Facility Operators who, by means of their with training and demonstrated proficiency with respect to all aspects of the overall operation and maintenance of the facility, have been appointed by the

contractor Environmental Department supervisor as the Project Leader and Certifying/Qualifying Instructor.

12.3 Groundwater Treatment Facility Technicians

Unless otherwise specified per this WJI, all Environmental Department technicians actively involved in the operation and maintenance (except for groundwater monitoring well sampling) of the Plume-Front Treatment Facility per this WJI shall be qualified Groundwater Treatment Facility Technicians (per the WSTF Training Database). At the discretion of the contractor Environmental Department section supervisor or project leader, the operations can be performed by personnel per steps 12.3.1 and 12.3.2:

12.3.1 Contractor Environmental Department technicians receiving “on-the-job” training for qualification as a Groundwater Treatment Facility Technicians under the direct supervision of the facility Project Leader or Certifying/Qualifying Instructor who is also qualified as a Groundwater Treatment Facility Operator (per the WSTF Training Database). Personnel receiving "on-the-job" training are required to have completed WSTF Hazardous Waste Handler Training and training requirements 12.4, 12.5, and 12.6.

12.3.2 A qualified Groundwater Treatment Facility Technician (per the WSTF Training Database) who is assisted by personnel receiving "on-the-job" training for qualification as a Groundwater Treatment Facility Technician(s). Personnel receiving "on-the-job" training are required to have completed WSTF Hazardous Waste Handler Training and training requirements per 12.4, 12.5 and 12.6.

12.4 All personnel actively involved in facility operations are required to have current confined space training per WSI 25-SW-0003, “Confined Space Entry Program”, categories Confined Space Entry SAF-06 and Confined Space Entry (Air Monitoring) SAF-07A (per the WSTF Training Database).

12.5 All personnel actively involved in facility operations are required to have current PPE Training (per the WSTF Training Database) for the specified PPE required by this WJI.

12.6 All personnel actively involved in facility operations are required to have current Lockout/Tagout training per WSI 25-SW-0004, “Lockout/Tagout, The Control of Hazardous Energy” (per the WSTF Training Database).

12.7 Additional personnel qualification/training requirements are contained in the body of the WJI preceding the applicable step(s).

12.8 For off-site personnel, all training, certifications, qualification, work practices, and equipment are subject to review, inspection and approval by WSTF contractor safety and environmental organizations. Specific security and safety issues include but are not limited to:

12.8.1 The procedures of WSI 24-SW-0002, "Processing Visitors, Vendors, and Suppliers", for all off-site personnel; and

12.8.2 Area specific and job specific safety training and hazard communication per WSI 25-SW-0002, "Hazard Communication Program" for all off-site personnel.

13.0 SPARE PARTS INVENTORY

Copies of the manufacturer's operation and maintenance manuals, cut sheets, material specifications, warranties, etc. for all facility equipment and components and materials will be maintained by the contractor Environmental Department. Based on the equipment manufacturer's recommendations, the contractor Environmental Department project leader shall maintain an inventory of spare parts, recall items and treatment process chemicals/materials as required to assure routine operation of the facility per this WJI. The inventory shall include, but is not limited to the items and materials identified per Attachment F.

14.0 SAFETY REQUIREMENTS

14.1 Specific safety requirements and instructions are provided in the safety section of each attachment and are also listed in the form of WARNINGS, CAUTIONS and NOTES preceding the applicable step(s). A certification of hazard assessment for personal protective equipment per WSI 25-SW-0007, "Personal Protective Equipment" and job hazard analysis per WSI 25-SW-0032, "Job Hazard Analysis Instructions" are included in Attachment C.

14.2 The *"Buddy System"* is designed to provide rapid assistance to personnel in the event of an emergency. For operations per this WJI, the *"Buddy System"* shall be defined as a system of organizing personnel into work groups that meet the following criteria (per JPG 1700.1, "JSC Safety and Health Handbook", Chapter 5.8):

14.2.1 One person does the job while a standby person watches from the immediate area of the job to ensure the worker is safe.

14.2.2 Two persons do the job and are in constant contact with a standby person either electronically, mechanically, or visually. The standby person shall remain in the immediate work area.

14.3 For operations per this WJI, a *"Two or More Person Operation"* is defined as a job or task that requires two or more workers.

15.0 REGULATORY BACKGROUND AND PERMIT REQUIREMENTS

During operations from the early 1960s to the early 1980s, hazardous constituents were released to the environment and, thereby, into the groundwater at the NASA White Sands Test Facility (WSTF). As a result, on December 12, 1989, the United States Environmental Protection Agency (U.S. EPA) Region 6 issued NASA an Administrative Order on Consent proceeding under §3008(h) of the Resource Conservation and Recovery Act (RCRA) for the White Sands Test Facility. The §3008(h) Consent Order was incorporated into the HSWA Permit administered by the New Mexico Environment Department (NMED), Hazardous and

Radioactive Materials Bureau (HRMB). NASA proposed an interim measures voluntary presumptive remedy for plume-front stabilization to control threats to human health and/or the environment at the westernmost extent of the groundwater contaminant plume. Details of the corrective action were submitted to NMED HRMB in the *Plume-Front Stabilization Work Plan NASA-JSC White Sands Test Facility,* dated January, 1999. Approval of NASA's work plan was granted on March 15, 2000 per NMED HRMB's letter, *NASA Plume Front Stabilization Interim Corrective Measure Work Plan*.

Permit requirements are as specified by the latest approved revision of *Plume-Front Stabilization Work Plan NASA-JSC White Sands Test Facility*. All waste generated from the treatment system will be managed per WSI 22-SW-0005.B, *Waste Management*, and the *WSTF Hazardous Waste Facility Permit No. NM8800019434-1*. By design, all elements of the treatment system that contain or transport untreated groundwater have secondary containment and leak detection to prevent the release of groundwater contaminants to the environment. The injection of the treated groundwater has been authorized by the NMED Ground Water Quality Bureau (GWQB) per *Discharge Permit No. DP-1255*.

16.0 SPECIAL INSTRUCTIONS

16.1 An electronic, password protected Groundwater Treatment Facility Operating Log will be utilized to record facility activities and operating parameters. Qualified Groundwater Treatment Facility Operators will enter relevant information as necessary to provide a record of major activities such as system start-up and shutdown, operating parameters/requirements (wells on-line, equipment on-line, set points, etc.), contingency operations, maintenance sequences, repair, and other relevant information. The log is part of the facility operating record.

16.2 In addition to the Groundwater Treatment Facility Operating Log, individual checklists and logsheets (e.g., inspection checklists, maintenance logsheet, valve logs) defined in the attachments to this WJI provide documented evidence of activities and operations. These checklists and logsheets are maintained by the contractor Environmental Department as part of the facility operating record.

16.3 Discrepancies and Anomalies:

16.3.1 Anomaly Log (Attachment D) - An Anomaly Log, controlled by the Groundwater Treatment Facility Operator and used in either hardcopy or electronic format, is used to record discrepancies and anomalies. The Anomaly Log is part of the facility operating record.

16.3.2 Discrepancies and anomalies of a relatively minor nature are recorded by the Groundwater Treatment Facility Operator on the Anomaly Log (Attachment D). This includes minor discrepancies and anomalies discovered during inspection and maintenance activities, which are recorded on the respective checklist/logsheet and reported to the Groundwater Treatment Facility Operator.

16.3.3 Discrepancies and anomalies of a significant nature are recorded on the Anomaly Log and if warranted (as determined by the Groundwater Treatment Facility Operator), recorded on a DR per WSI 13-SW-0001, "Discrepancy Record (DR)." DRs are a part of the facility operating record.

16.4 Non – routine operations (operations beyond the scope of this WJI) will be documented and performed on a case-by-case basis per a separate work authorizing document (a TPS, DR or Environmental Task Memo). Specific sections or procedures of this WJI may be referenced/performed per the TPS, DR, or Environmental Task Memo in support of these operations.

16.5 The contractor Environmental Department shall document all operations per this WJI as part of the facility operating record.

16.6 The following definitions per WSI 05-SW-0004, "WSTF Job Instruction (WJI) Control" apply:

16.6.1 The term "VERIFY" will be used to check system configuration.

16.6.2 The term "PERFORM" will be used to require a specific action or sequence of actions.

16.6.3 The term "VERIFY/PERFORM" will be used to first check the configuration and then perform the required action if the configuration is not as specified.

SECTION II - OPERATING PROCEDURES

1.0 FACILITY SETUP

1.1 Facility Utilities, Fire Alarms and Communications

1.1.1 As required, contact the contractor Engineering Department and verify that electrical power is setup at the location(s) indicated below. The Groundwater Treatment Facility Operating Log will specify the operating parameters/requirements (wells on-line, equipment on-line, set points, etc.), identify the applicable procedures of this WJI, and provide any additional task-specific instructions, information or requirements. Completion/verification of specific steps in this WJI will be noted on set-up sheets as directed by the Groundwater Treatment Facility Operator.

1.1.1.1 Building 650 (Treatment Facility) and associated instrumentation and equipment.
1.1.1.2 Extraction well PFE-1 and associated instrumentation and equipment (unless otherwise directed).
1.1.1.3 Extraction well PFE-2 and associated instrumentation and equipment (unless otherwise directed).
1.1.1.4 Extraction well PFE-3 and associated instrumentation and equipment (unless otherwise directed).
1.1.1.5 Extraction well PFE-4A and associated instrumentation and equipment (unless otherwise directed).
1.1.1.6 Extraction well PFE-5 and associated instrumentation and equipment (unless otherwise directed).
1.1.1.7 Extraction well PFE-7 and associated instrumentation and equipment (unless otherwise directed).

1.1.1.8 Building 651 (Injection Manifold Building) and associated instrumentation and equipment.

1.1.2 Contact the contractor Engineering Department and verify that the HVAC system is operational and potable water is supplied to Building 650 (the Treatment Facility). Ensure the safety shower and eyewash (Bldg. 650) are operational per Attachment M.

1.1.3 Contact the WSTF Fire Department and verify that the fire alarm system at Building 650 is operational. Ensure that telephone communications (Bldg. 650) are operational.

1.2 Computer and Alarm System

Setup and verify the operation of the computer and instrumentation system per Attachment H of this WJI.

1.3 Piping System Setup

1.3.1 The Groundwater Treatment Facility Operator will identify the extraction and injection wells that will be on-line, the applicable procedures of this WJI, and if required, any deviations from procedures per this WJI along with alternate instructions on the electronic Groundwater Treatment Facility Operating Log.

1.3.2 The contractor Environmental Department shall ensure that the piping system valve configuration (position (OPEN/CLOSED) of all piping system manual valves) is documented and maintained to accurately reflect the existing system configuration.

1.3.3 The Groundwater Treatment Facility Operator will authorize the OPENING/CLOSING of all piping system valves and define the piping system configuration, and record this on the electronic Groundwater Treatment Facility Operating Log.

1.3.4 At the discretion of the contractor Environmental Department, engineering controls per WSI 25-SW-0035, "Use of Engineering Control Devices for Fluid, Gaseous and Electrical Systems at WSTF" may be used to maintain the system configuration at valve locations such as well and piping system access vaults. After initial verification of valve position (OPEN/CLOSED verification by visual examination of the position of valve operator), verification of system configuration at these locations can be performed by the use of engineering controls per WSI 25-SW-0035 (locks and/or tags) and a review of the operating record (the operating log and other valve logs that document valve position/system configuration changes).

1.3.5 Perform mechanical setup of the extraction wells, injection wells, treatment facility, injection manifold and subgrade piping system junctions and high-point vents per Attachment E.

1.4 Piping System Process Control

1.4.1 The Groundwater Treatment Facility Operator will identify or provide the extraction and injection wells that will be on-line, the applicable procedures of this WJI and if required, any deviations from procedures per this WJI along with alternate instructions on the facility operating log.

1.4.2 Perform setup/validation of the piping system process control software per Attachment H.

1.5 Air Stripper System Mechanical

1.5.1 The Groundwater Treatment Facility Operator will identify or provide the air stripper(s) that will be on-line, the applicable procedures of this WJI and if required, any deviations from procedures per this WJI along with alternate instructions on the facility operating log.

1.5.2 Perform mechanical setup of the air stripper(s) and the scale control system per Attachment H.

1.6 Air Stripper System Process Control

1.6.1 The Groundwater Treatment Facility Operator will identify the air stripper(s) that will be on-line, the applicable procedures of this WJI, process control operating parameters/set-points and if required, any deviations from procedures per this WJI along with alternate instructions on the facility operating log.

1.6.2 Perform setup/validation of the air stripper system process control software per Attachment H.

1.7 UV Reactor System Mechanical

1.7.1 The Groundwater Treatment Facility Operator will identify the applicable procedures of this WJI, and if required, any deviations from procedures per this WJI along with alternate instructions on the facility operating log.

1.7.2 Perform mechanical setup of the UV Reactor System per Attachment E.

1.8 UV Reactor System Process Control

1.8.1 The Groundwater Treatment Facility Operator will identify the applicable procedures of this WJI, process control operating parameters/set-points, and if required, any deviations from procedures per this WJI along with alternate instructions on the facility operating record.

1.8.2 Perform setup/validation of the UV Reactor System process control software per Attachment H.

1.9 Open Paper Report

1.9.1 At the discretion of the contractor Environmental Department or Groundwater Treatment Facility Operator, “PERFORM” steps as required to initiate and

obtain an "Open Paper Report" per WSI 09-SW-0007, "Open Paper Review Process" to identify any constraints to operation of the facility.

2.0 STARTUP AND OPERATION

2.1 Startup

"PERFORM" the following sequence to start operation of the Plume-Front Treatment Facility. (Note: Attachment H contains detailed System Process Control information)

2.1.1 At the Instrumentation and Control System (I&C), select the STARTUP/SHUTDOWN screen on the HMI.

2.1.2 Select the STARTUP button on the lower left of the screen to begin the automated sequence that brings the treatment system online.

2.1.3 Monitor the startup sequence, verifying that the steps proceed in sequence as indicated on the **STARTUP/SHUTDOWN** screen until the **SYSTEM RUNNING** (Step 13) indication is highlighted. If a problem becomes apparent, click on the **EMERGENCY SHUTDOWN** button on the lower right of the screen. A normal startup sequence consists of the following steps:

- Starting Air Stripper No. 1;
- Starting Air Stripper No. 2;
- Equalizing Plant Recirculation Flow;
- Starting UV Reactor System;
- Opening Effluent Block Valve;
- Starting PFE-1 Pump;
- Starting PFE-5 Pump;
- Starting PFE-7 Pump;
- Starting PFE-2 Pump;
- Starting PFE-3 Pump;
- Starting PFE-4A Pump;
- Closing Recirculation Block Valve; and
- System Running.

2.2 Facility Inspections

During operation of the Plume-Front Treatment Facility, routine inspection of the facility will be performed per the "Facility Inspection Plan":

2.2.1 The "Facility Inspection Plan," Attachment M, provides a list of inspection items, a schedule and instructions for the performance of routine inspection of the Plume-Front Treatment Facility extraction wells, injection wells, treatment facility, injection manifold, and the subgrade piping system vaults.

2.2.2 The contractor Environmental Department will ensure that facility inspections are performed per the schedule presented in "Facility Inspection Plan".

2.2.3 All facility inspections shall be documented and filed as part the facility operating record.

2.2.4 In addition to the inspections performed per "Facility Inspection Plan," the WSTF Fire Department will perform inspection and testing of safety, security, emergency and fire control equipment. All fire extinguishers are inspected monthly. The WSTF perimeter fence is inspected semi-monthly for breaks or other deficiencies.

2.3 Facility Sampling

During operation of the Plume-Front Treatment Facility, the performance of the treatment system will be monitored by sampling and analysis of adjacent, downgradient monitoring wells, groundwater from the extraction wells, and the treatment facility influent and effluent. The following provides instruction for the sampling and analyses per the Plume-Front Stabilization Work Plan (NASA, 1999) and GWQB-approved Discharge Plan (DP-1255, March 2000).

2.3.1 The sample collection and analysis requirements, the monitoring well sampling schedule, the extraction well sampling schedule and the treatment influent/effluent sampling schedule are presented in Attachment K, Tables 1 through 4.

2.3.2 Monitoring well sampling and analysis will be performed per WJI ENV-0013, "Conventional Well Sampling Instructions", WJI ENV-0053, "Low-Flow Sampling Instructions" and WJI ENV-0020, "Westbay Well Sampling Instructions". The contractor Environmental Department will schedule and ensure performance of the monitoring well sampling and analyses per Attachment K.

2.3.3 Treatment facility influent and effluent sampling and analyses will be performed per Attachment L. The contractor Environmental Department shall schedule and ensure performance of extraction well and treatment facility influent and effluent sampling and analysis per Attachment L, and the schedule presented in Attachment K.

2.3.4 Extraction well sampling and analyses will be performed per Attachment L. The contractor Environmental shall schedule and ensure performance of extraction well and treatment facility influent and effluent sampling and analysis per Attachment L, and the schedule presented in Attachment K.

2.3.5 The extraction well vaults have been identified as a confined space. The contractor Environmental Department shall ensure that all confined space entries are performed per WSI-25-0003, "Confined Space Entry Program".

3.0 Facility Shut-Down

The Groundwater Treatment Facility Operator is responsible for facility shut-down and operations at the Instrumentation and Control System (I&C). The sequence of control events for routine facility shut-down and an emergency shut-down is contained in Attachments H and I.

SECTION III - MAINTENANCE PROCEDURES

1.0 Treatment Facility

1.1 All treatment system process equipment and system components shall be maintained per the manufacturer's instructions and recommendations.

1.2 The operation of the treatment system will be evaluated on a monthly basis. Analyses of the monitoring wells, treatment facility influent and effluent will be reviewed, along with operating parameters and inspection records, to evaluate the overall operation of the treatment system and to note any trends or indications of component failure or deterioration of performance.

1.3 In addition to the inspection and testing performed per Section II, paragraph 2.2 and the "Facility Inspection Plan" per Attachment M, the process equipment will be periodically inspected, tested and serviced monthly and every 3,000 hours according to the "Facility Maintenance Plan" presented in Attachment G. The procedures include detailed step-by-step instructions and task-specific safety requirements.

1.3.1 All maintenance activities per this WJI will be performed by the equipment manufacturer's service representatives, qualified Groundwater Treatment Facility Operators, and/or Groundwater Treatment Facility Technicians under the direction of qualified Groundwater Treatment Operators, unless otherwise specified by the contractor Environmental Department Project Leader or section supervisor.

1.3.2 A Groundwater Treatment Facility Operator will authorize the performance of maintenance activities per this WJI and document the maintenance steps/actions performed, the personnel involved, and the date of completion. Upon closure, all work authorizing documents, checklists, and logsheets will be maintained as part of the facility operating record.

2.0 Extraction Well and Injection Well Maintenance

The contractor Environmental Department shall ensure that the performance of the extraction and injection wells is evaluated on a monthly and quarterly basis, according to the maintenance schedule presented in Attachment G. Extraction well maintenance (surging, bailing, pump repair and replacement, etc.) and injection well maintenance (surging, bailing, acidifying, etc.) will be performed on a case-by-case basis, as directed by a Groundwater Treatment Facility Operator.

3.0 Lock-Out/Tag-Out

All maintenance activities shall be performed in accordance with WSI 25-SW-0004. Lock-Out/Tag-Out procedures for the plume-front treatment system are included in Attachment G.

4.0 Computer and Instrumentation System Maintenance

4.1 Process instrumentation critical to the operation of the facility (flowmeters, liquid level transmitters, pressure transducers, switches, etc.) will be calibrated to the manufacturer's specifications every two years, or per the instrument manufacturer's recommended schedule.

4.2 The contractor Environmental Department will identify all critical process instrumentation and maintain a general recall list. Removal, recalibration or replacement of critical instrumentation will be performed per a separate work authorizing document (a TPS, DR, or Environmental Task Memo).

5.0 Pressure Vessels and Pressurized Systems (PV/S)

5.1 The four treatment facility subsystems, the plume-front treatment water system, scale control system, scale cleaning system, and equipment air system are classified as exempt systems per WSI 09-SW-0005.F, Attachment L. A pressure system engineer (PSE) review to ensure compliance with WSP 09-0011, "Managing the WSTF Pressure Vessel and Pressurized Program," and WSI 09-SW-0005, "Certification, Recertification, and Deactivation of WSTF Pressure Vessels and Pressurized Systems (PV/S)" has been completed. A copy is maintained by the contractor Environmental Department as part of the facility operating record.

5.2 The contractor Environmental Department will maintain a general recall list of all recall items (relief valves, etc.). Removal, recalibration, retesting or replacement of PV/S recall items will be performed per a separate work authorizing document (a TPS, DR, or Environmental Task Memo).

SECTION IV - ALARM PROTOCOL AND EMERGENCY PROCEDURES

1.0 Emergency and Incidental Releases

WSP 25-0009, "WSTF Emergency Preparedness Plan," establishes procedures and responsibilities for development, maintenance, and exercise of the WSTF Emergency Preparedness Plan (Program). Per WSP 25-0009, the following definitions apply.

Emergency Release - The release of a hazardous substance that occurs outside of WSTF-controlled work areas or, within those areas, that goes beyond the scope of the local area emergency procedures, controls or resources.

Emergency Response - A response effort by the WSTF Fire Department to an occurrence that results, or is likely to result, in an uncontrolled release of a hazardous substance. Responses to incidental releases of hazardous substances in which the substance can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area, or by maintenance personnel, are not considered to be emergency responses. Responses to releases of hazardous substances in which there is no potential safety or health hazard (i.e. fire, explosion, or chemical exposure) are not considered to be emergency responses.

Incidental Release - the release of a substance that can be handled within the scope of the local area emergency procedures, controls, and resources.

Incidental Response: a response effort by trained employees from within the immediate release area to a hazardous material release.

1.1 Plume-Front Treatment Facility Emergency Releases

An emergency release from the Plume-Front Treatment Facility is a leak or spill of untreated groundwater or hazardous material that is not contained by the secondary containment system, and presents an immediate threat to human health and/or the environment. WSP 25-0009, establishes the policies and procedures for responding to emergency releases of hazardous substances at WSTF. All responses to emergency releases from the Plume-Front Treatment Facility will be in accordance with WSP 25-0009.

1.2 Plume-Front Treatment Facility Incidental Releases

An incidental release from the Plume-Front Treatment Facility is a leak or spill of untreated groundwater or hazardous material that is contained by the piping system and

Building 650 secondary containment system and does not present an immediate threat to human health and/or the environment. The treatment system process control includes a system of interlocks which halts system operation when specific conditions arise, and notifies appropriate personnel with visual and/or audio alarms and, thereby, minimizes the potential for an emergency release. Releases from the plume-front treatment system would typically be identified by the leak detection alarm system or during routine facility inspection and maintenance operations. Spill response procedures for incidental releases from the plume-front treatment system are presented in Attachment N.

Authorization Page

Name	Signature	Initials	Stamp

Permanent Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

Temporary Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

ATTACHMENT A

LIST OF REFERENCES

1.0 AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z358.1, Emergency Eyewash and Shower Equipment
ANSI Z41, Personal Protection – Protective Footwear
ANSI Z87.1, Practice for Occupational and Educational Eye and Face Protection
ANSI Z89.1, Personal Protection - Protective Headwear for Industrial Workers

2.0 AMERICAN PUBLIC HEALTH ASSOCIATION (APHA) METHOD

Standard Methods for the Examination of Water and Wastewater
Standard Method 4500–F^- C. Fluoride Ion-Selective Electrode Method

3.0 ENVIRONMENTAL PROTECTION AGENCY (EPA) METHODS

Methods for Chemical Analysis of Water and Wastes - EPA/600/4-79-020
Method 160.1, Residue, Filterable (Gravimetric, Dried at 180°C) – Total Dissolved Solids (TDS)
Method 310.1, Alkalinity (Titrimetric, pH 4.5)
Method 350.1, Nitrogen, Ammonia (Colorimetric, Automated Phenate)
Method 353.2, Nitrogen, Nitrate-Nitrite (Colorimetric, Automated, Cadmium Reduction)

Methods for the Determination of Inorganic Substances in Environmental Samples - EPA/600/R-93-100
Method 300.0, Determination of Inorganic Anions by Ion Chromatography

Methods for the Determination of Organic and Inorganic Compounds in Drinking Water, Volume 1 – EPA/815/R-00-014
Method 314.0, Determination of Perchlorate in Drinking Water using Ion Chromatography

Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater, Code of Federal Regulations (CFR) 40, Part 136, Appendix A to Part 136
Method 607 (Modified), Nitrosamines

Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846*)*
Method 6010B, Inductively Coupled Plasma-Atomic Emission Spectrometry
Method 6020, Inductively Coupled Plasma-Mass Spectrometry
Method 7470A, Mercury in Liquid Waste (Manual Cold-Vapor Technique)
Method 8021B, Aromatic and Halogenated Volatiles by Gas Chromatography using Photoionization and/or Electrolytic Conductivity Detectors
Method 8260B, Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)
Method 8270C, Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS)

4.0 WHITE SANDS TEST FACILITY JOB INSTRUCTIONS (WJIs)

WJI ENGR-DFT-0001, "Drawing Manual"
WJI ENV-0013, "Conventional Well Sampling Instructions"
WJI ENV-0015, "Portable Liquid Nitrogen Dewar Operations"
WJI ENV-0018, "Groundwater Level and Well Depth Determinations"
WJI ENV-0020, "Westbay Well Sampling Instructions"
WJI ENV-0021, "200 Area Evaporation Tank System Operation"
WJI ENV-0038, "Waste Movement"
WJI ENV-0053, "Low Flow Sampling Instructions"
WJI-PAD-SAF-0002, "MSA Passport Personal Alarm Calibration"
WJI SVC-MCAL-3060, "Calibration of Torque Handles, Hand Operated"

5.0 WHITE SANDS TEST FACILITY STANDARD PROCEDURES (WSPs)

WSP 09-0011, Managing the WSTF Pressure Vessel and Pressurized System (PV/S) Program
WSP 11-0001, Control of Inspection, Measuring, and Test Equipment
WSP 25-0009, WSTF Emergency Preparedness Plan

6.0 WHITE SANDS TEST FACILITY STANDARD INSTRUCTIONS (WSIs)

WSI 05-SW-0004, WSTF Job Instruction (WJI) Control
WSI 09-SW-0001, Test Preparation Sheet (TPS)
WSI 09-SW-0002, Process Control Using Work Instructions and Work Authorizing Documents
WSI 09-SW-0007, Open Paper Review Process
WSI 09-SW-0005, Certification, Recertification, and Deactivation of WSTF Pressure Vessels and Pressurized Systems (PV/S)
WSI 13-SW-0001, Discrepancy Record
WSI 22-SW-0005, Waste Management
WSI 24-SW-0002, Processing Visitors, Vendors, and Suppliers
WSI 25-SW-0001, Respiratory Protection
WSI 25-SW-0002, Hazard Communication Program
WSI 25-SW-0003, Confined Space Entry Program
WSI 25-SW-0004, Lockout/Tagout "The Control of Hazardous Energy"
WSI 25-SW-0007, Personal Protective Equipment
WSI 25-SW-0024, Lightning Protection
WSI 25-SW-0032, Job Hazard Analysis Instructions
WSI 25-SW-0035, Use of Engineering Control Devices For Fluid, Gaseous, and Electrical Systems at WSTF
WSI 25-SW-0037, Ladder Safety/Inspection Program

7.0 JSC REFERENCES

Johnson Space Center Procedures and Guidelines (JPG) 1700.1, JSC Safety and Health Handbook:
Chapter 5.8, Hazardous operations: safe practices and certification
Chapter 8.2, Lockout/tagout practices

Chapter 8.6, Power and hand tool safety
Chapter 8.7, Ladders, scaffolds, and elevated platforms: how to work with them safely

8.0 GOVERNMENT REGULATIONS

29 Code of Federal Regulations (CFR) Part 1910, Occupational Safety and Health Standards
29 Code of Federal Regulations (CFR) Part 1926, Safety and Health Regulations for Construction
40 Code of Federal Regulations (CFR) Subchapter I, Solid Wastes
49 Code of Federal Regulations (CFR) Subchaper C, Hazardous Materials Regulations

9.0 REGULATORY – RELATED DOCUMENTATION/SUBMITTALS

Plume-Front Stabilization Work Plan, NASA-JSC White Sands Test Facility, January 1999
WSTF Hazardous Waste Facility Permit No. NM8800019434-1
WSTF Post-Closure Care Permit No. NM8800019434-2
WSTF Plume-Front Stabilization Operation and Maintenance Plan and Interim Measures Plans and Specifications, June 11, 2002
New Mexico Ground Water Quality Bureau, 2000, NASA White Sands Test Facility (WSTF), Discharge Plan Approval, DP-1255, March 10, 2000

10.0 MANUFACTURER'S EQUIPMENT MANUALS & INFORMATION

North East Environmental Products, Inc. Operation and Maintenance Manual – Air Stripper, Scale Clean, and Scale Control Systems and Control Panels.
Calgon Carbon Corporation. Rayox® Advanced Oxidation System Operation and Maintenance Manual. Publication Number: 393-D-800382.

11.0 OTHER REFERENCES

U.S. Army Corps of Engineers – Engineer Pamphlet 1110-1-27, Operation and Maintenance of Extraction and Injection Wells at HTRW Sites

Driscoll, F.G. 1986, "Groundwater and Wells"

ATTACHMENT B

PLUME-FRONT TREATMENT SYSTEM

LIST OF DRAWINGS

1. INDEX

Drawing #	Drawing Title
652-I-01	INDEX OF DRAWINGS
652-I-02	INDEX OF DRAWINGS
652-I-03	INDEX OF DRAWINGS, SYMBOLS, & ABBREVIATIONS

2. PROJECT LOCATION AND PIPING LAYOUT

Drawing #	Drawing Title
652-C-01	CIVIL, PROJECT LOCATION
652-C-02	CIVIL, WELL LOCATIONS & PIPING LAYOUT

3. PIPING SYSTEM PLAN AND PROFILE

Drawing #	Drawing Title
652-C-03	CIVIL, PLAN & PROFILE PIPING ROUTE (N-1)
652-C-04	CIVIL, PLAN & PROFILE PIPING ROUTE (N-2)
652-C-05	CIVIL, PLAN & PROFILE PIPING ROUTE (N-3)
652-C-06	CIVIL, PLAN & PROFILE PIPING ROUTE (N-4)
652-C-07	CIVIL, PLAN & PROFILE PIPING ROUTE (N-5)
652-C-08	CIVIL, PLAN & PROFILE PIPING ROUTE (S-1)
652-C-09	CIVIL, PLAN & PROFILE PIPING ROUTE (S-2)
652-C-10	CIVIL, PLAN & PROFILE PIPING ROUTE (S-3)
652-C-11	CIVIL, PLAN & PROFILE PIPING ROUTE (S-4)
652-C-12	CIVIL, PLAN & PROFILE PIPING ROUTE (S-5)
652-C-13	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-2)
652-C-14	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-4A)
652-C-15	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-4B)
652-C-16	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-5)
652-C-17	CIVIL, PLAN & PROFILE PIPING ROUTE (PFI-1A)
652-C-18	CIVIL, PLAN & PROFILE PIPING ROUTE (PFI-1B)
652-C-19	CIVIL, PLAN & PROFILE PIPING ROUTE (PFI-4)
652-C-20	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-7A)
652-C-21	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-7B)
652-C-22	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-7C)
652-C-23	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-7D)
652-C-24	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-7E)

4. PIPING SYSTEM SECTIONS AND DETAILS

Drawing #	Drawing Title
652-C-25	CIVIL, SECTION
652-C-26	CIVIL, SECTION
652-C-27	CIVIL, SECTION
652-C-28	CIVIL, JUNCTION DETAILS
652-C-29	CIVIL, JUNCTION DETAILS
652-C-30	CIVIL, JUNCTION DETAILS
652-C-31	CIVIL, SECTIONS & DETAILS
652-C-32	CIVIL, SECTIONS & DETAILS
652-C-33	CIVIL, SECTIONS & DETAILS
652-C-34	CIVIL, SECTIONS & DETAILS
652-C-35	CIVIL, SECTIONS & DETAILS
652-C-36	CIVIL, SECTIONS & DETAILS

5. PIPING SYSTEM MECHANICAL FLOW SHCEMATICS

Drawing #	Drawing Title
652-M-01	MECHANICAL, FLOW SCHEMATIC, EXTRACTION WELLS
652-M-02	MECHANICAL, FLOW SCHEMATIC, TREATMENT FACILITY
652-M-03	MECHANICAL, FLOW SCHEMATIC, INJECTION WELLS

6. PIPING SYSTEM SCHEDULES

Drawing #	Drawing Title
652-M-04	MECHANICAL, SUBGRADE PIPE & FITTING SCHEDULES
652-M-05	MECHANICAL, SUBGRADE PIPE & FITTING SCHEDULES
652-M-06	MECHANICAL, PIPE & FITTING SCHEDULES
652-M-07	MECHANICAL, PIPE & FITTING SCHEDULES
652-M-08	MECHANICAL, PIPE & FITTING SCHEDULES

7. ELECTRICAL CONTROL SYSTEM

Drawing #	Drawing Title
652-E-01	ELECTRICAL, CONTROL SYSTEM
652-E-02	ELECTRICAL, CONTROL SYSTEM
652-E-03	ELECTRICAL, CONTROL SYSTEM
652-E-04	ELECTRICAL, CONTROL SYSTEM
652-E-05	ELECTRICAL, CONTROL SYSTEM
652-E-06	ELECTRICAL, CONTROL SYSTEM
652-E-07	ELECTRICAL, CONTROL SYSTEM
652-E-08	ELECTRICAL, CONTROL SYSTEM
652-E-09	ELECTRICAL, CONTROL SYSTEM
652-E-10	ELECTRICAL, CONTROL SYSTEM

652-E-11	ELECTRICAL, CONTROL SYSTEM
652-E-12	ELECTRICAL, CONTROL SYSTEM
652-E-13	ELECTRICAL, CONTROL SYSTEM
652-E-14	ELECTRICAL, CONTROL SYSTEM
652-E-15	ELECTRICAL, CONTROL SYSTEM
652-E-16	ELECTRICAL, CONTROL SYSTEM
652-E-17	ELECTRICAL, CONTROL SYSTEM
652-E-18	ELECTRICAL, CONTROL SYSTEM
652-E-19	ELECTRICAL, CONTROL SYSTEM
652-E-20	ELECTRICAL, CONTROL SYSTEM
652-E-21	ELECTRICAL, CONTROL SYSTEM
652-E-22	ELECTRICAL, CONTROL SYSTEM
652-E-23	ELECTRICAL, CONTROL SYSTEM
652-E-24	ELECTRICAL, CONTROL SYSTEM
652-E-25	ELECTRICAL, CONTROL SYSTEM
652-E-26	ELECTRICAL, CONTROL SYSTEM
652-E-27	ELECTRICAL, CONTROL SYSTEM
652-E-28	ELECTRICAL, CONTROL SYSTEM
652-E-29	ELECTRICAL, CONTROL SYSTEM
652-E-30	ELECTRICAL, CONTROL SYSTEM
652-E-31	ELECTRICAL, CONTROL SYSTEM
652-E-32	ELECTRICAL, CONTROL SYSTEM
652-E-33	ELECTRICAL, CONTROL SYSTEM
652-E-34	ELECTRICAL, CONTROL SYSTEM
652-E-35	ELECTRICAL, CONTROL SYSTEM
652-E-36	ELECTRICAL, CONTROL SYSTEM
652-E-37	ELECTRICAL, CONTROL SYSTEM
652-E-38	ELECTRICAL, CONTROL SYSTEM

8. EXTRACTION AND INJECTION WELLS

A. EXTRACTION WELL PFE-1

Drawing #	Drawing Title
653-C-01	CIVIL, SITE/UTILITIES PLAN
653-C-02	CIVIL, DETAILS AT WELLHEAD
653-C-03	CIVIL, WELL COMPLETION DIAGRAM
653-M-01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
653-E-01	ELECTRICAL, MISCELLANEOUS DETAILS
653-E-02	ELECTRICAL, MISCELLANEOUS DETAILS

B. EXTRACTION WELL PFE-2

Drawing #	Drawing Title
654-C-01	CIVIL, SITE/UTILITIES PLAN
654-C-02	CIVIL, DETAILS AT WELLHEAD

654-C-03	CIVIL WELL COMPLETION DIAGRAM
654-M-01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
654-E-01	ELECTRICAL, MISCELLANEOUS DETAILS
654-E-02	ELECTRICAL, MISCELLANEOUS DETAILS

C. EXTRACTION WELL PFE-3

Drawing #	**Drawing Title**
655-C-01	CIVIL, SITE/UTILITIES PLAN
655-C-02	CIVIL, DETAILS AT WELLHEAD
655-C-03	CIVIL, WELL COMPLETION DIAGRAM
655-M-01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
655-E-01	ELECTRICAL, MISCELLANEOUS DETAILS
655-E-02	ELECTRICAL, MISCELLANEOUS DETAILS

D. EXTRACTION WELL PFE-4A

Drawing #	**Drawing Title**
656-C-01	CIVIL, SITE/UTILITIES PLAN
656-C-02	CIVIL, DETAILS AT WELLHEAD
656-C-03	CIVIL, WELL COMPLETION DIAGRAM
656-M-01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
656-E-01	ELECTRICAL, MISCELLANEOUS DETAILS
656-E-02	ELECTRICAL, MISCELLANEOUS DETAILS

E. EXTRACTION WELL PFE-5

Drawing #	**Drawing Title**
657-C-01	CIVIL, SITE/UTILITIES PLAN
657-C-02	CIVIL, DETAILS AT WELLHEAD
657-C-03	CIVIL, WELL COMPLETION DIAGRAM
657-M-01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
657-E-01	ELECTRICAL, MISCELLANEOUS DETAILS
657-E-02	ELECTRICAL, MISCELLANEOUS DETAILS

F. EXTRACTION WELL PFE-7

Drawing #	**Drawing Title**
658-C-01	CIVIL, SITE/UTILITIES PLAN
658-C-02	CIVIL, DETAILS AT WELLHEAD
658-C-03	CIVIL, WELL COMPLETION DIAGRAM
658-M-01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
658-E-01	ELECTRICAL, MISCELLANEOUS DETAILS
658-E-02	ELECTRICAL, MISCELLANEOUS DETAILS

G. INJECTION WELL PFI-1

Drawing #	**Drawing Title**

660-C-01	CIVIL, DETAILS AT WELLHEAD
660-C-02	CIVIL, WELL COMPLETION DIAGRAM
660-M-01	MECHANICAL, PIPING & EQUIPMENT LAYOUT

H. INJECTION WELL PFI-2

Drawing #	Drawing Title
661-C-01	CIVIL, DETAILS AT WELLHEAD
661-C-02	CIVIL, WELL COMPLETION DIAGRAM
661-M-01	MECHANICAL, PIPING & EQUIPMENT LAYOUT

I. INJECTION WELL PFI-3

Drawing #	Drawing Title
662-C-01	CIVIL, DETAILS AT WELLHEAD
662-C-02	CIVIL, WELL COMPLETION DIAGRAM
662-M-01	MECHANICAL, PIPING & EQUIPMENT LAYOUT

J. INJECTION WELL PFI-4

Drawing #	Drawing Title
663-C-01	CIVIL, DETAILS AT WELLHEAD
663-C-02	CIVIL, WELL COMPLETION DIAGRAM
663-M-01	MECHANICAL, PIPING & EQUIPMENT LAYOUT

9. BUILDING 650 TREATMENT FACILITY

Drawing #	Drawing Title
650-C-01	CIVIL, PROJECT LOCATION MAP
650-C-02	CIVIL, SITE PLAN
650-C-03	CIVIL, UTILITIES PLAN
650-C-04	CIVIL, GRADING PLAN
650-C-05	CIVIL, FENCE DETAILS
650-A-01	ARCHITECTURAL, FLOOR PLAN
650-A-02	ARCHITECTURAL, ELEVATIONS
650-A-03	ARCHITECTURAL, SECTIONS & DETAILS
650-S-01	STRUCTURAL, FOUNDATION PLAN
650-S-02	STRUCTURAL, SECTIONS & DETAILS
650-M-01	MECHANICAL, PIPING & PLUMBING PLAN
650-M-02	MECHANICAL, HVAC PLAN
650-M-03	MECHANICAL, HVAC ELEVATIONS
650-M-04	MECHANICAL, SCHEDULES
650-M-05	MECHANICAL, MISCELLANEOUS DETAILS
650-M-06	MECHANICAL, EQUIPMENT LAYOUT
650-M-07	MECHANICAL, ISOMETRIC PIPING
650-E-01	ELECTRICAL, POWER PLAN

650-E-02	ELECTRICAL, LIGHTING PLAN
650-E-03	ELECTRICAL, GROUNDING PLAN
650-E-04	ELECTRICAL, ONE LINE DIAGRAM
650-E-05	ELECTRICAL, PANEL SCHEDULES
650-E-06	ELECTRICAL, SECTIONS AND DETAILS
650-E-07	ELECTRICAL, SECTIONS AND DETAILS
650-E-08	ELECTRICAL, SECTIONS AND DETAILS
650-E-09	ELECTRICAL, CONTROL CONDUIT LAYOUT
650-FPS-01	FIRE PROTECTION, LAYOUT PLAN

10. BUILDING 651 INJECTION MANIFOLD BLDG

Drawing #	Drawing Title
651-C-01	CIVIL, PROJECT LOCATION MAP
651-C-02	CIVIL, SITE, UTILITIES & GRADING PLAN
651-A-01	ARCHITECTURAL, FLOOR PLAN
651-A-02	ARCHITECTURAL, ELEVATIONS
651-A-03	ARCHITECTURAL, SECTIONS & DETAILS
651-S-01	STRUCTURAL, FOUNDATION PLAN
651-S-02	STRUCTURAL, SECTION & DETAILS
651-M-01	MECHANICAL, ISOMETRIC PIPING
651-E-01	ELECTRICAL, POWER & LIGHTING PLAN
651-E-02	ELECTRICAL, GROUNDING PLAN

11. POWER DISTRIBUTION

Drawing #	Drawing Title
Z-770-43	100 AREA, MAIN SWITCH STATION, NEW POLES & RENUMBERING
Z-770-44	ELECTRICAL, POWER DISTRIBUTION, POLE LAYOUT
Z-770-MISC-28	100 AREA, MAIN SWITCH STATION, POLE DETAILS
Z-770-MISC-29	100 AREA, MAIN SWITCH STATION, POLE DETAILS
Z-770-MISC-30	100 AREA, MAIN SWITCH STATION, POLE DETAILS
Z-770-MISC-31	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS: 12-44, 12-45
Z-770-MISC-32	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS: 12-46, 12-47
Z-770-MISC-33	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS: 12-47-A, 12-48
Z-770-MISC-34	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS: 12-49
Z-770-MISC-35	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS: 12-47-A-10, 12-47-A-7
Z-770-MISC-36	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS: 12-47-A-3, 12-47-1
Z-770-MISC-37	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS: 12-47-7, 12-47-14

Z-770-MISC-38 ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS: 12-47-19, 12-47-2
Z-770-MISC-39 ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS: TANGENT POLE
Z-770-E-04 DCN B-1, 8-18-00
100 AREA, MAIN SWITCH STATION, NEW & EXISTING SUBSTATION PLAN
100 AREA, MAIN SWITCH STATION, SUBSTATION PLAN & ELEVATIONS
100 AREA, MAIN SWITCH STATION, SUBSTATION DETAILS
100 AREA, MAIN SWITCH STATION, PLAN & PROFILE
100 AREA, MAIN SWITCH STATION, RECLOSER PULLBOX, BASE PLAN & DETAILS
100 AREA, MAIN SWITCH STATION, SWITCH & RECLOSER

ATTACHMENT C

CERTIFICATION OF HAZARD ASSESSMENT

1.0 GENERAL INFORMATION

This Attachment provides the certification of hazard assessment for personal protective equipment per WSI 25-SW-0007, "Personal Protective Equipment" and job hazard analysis per WSI 25-SW-0032," Job Hazard Analysis Instructions".

The scope of the hazard assessment is the Plume-Front Remediation System that includes but is not limited to: the treatment facility (Bldg. 650; injection manifold (Bldg. 651); subgrade piping system; extraction wells; injection wells; and monitoring wells.

2.0 CERTIFICATION OF HAZARD ASSESSMENT

A certification of hazard assessment for the Plume-Front Treatment System has been performed in accordance with 29 CFR 1910.132 Subpart I. The certification of hazard assessment as required by WSI 25-SW-0007 is contained in the Job Hazard Analysis (JHA) for Plume-Front Remediation System Operations and Maintenance (JHA HW-042). The authorized signatures of individuals approving this WJI indicate their concurrence with the safety hazard assessment and prescribed safety requirements in this document and the referenced JHA.

Job Hazard Analysis HW-042 is available and posted in Bldg. 650 and is on file electronically with the Program Assurance Department. Contractor Environmental Department personnel are responsible for ensuring that all personnel abide by the JHA and the following additional safety requirements and considerations.

3.0 ADDITIONAL SAFETY REQUIREMENTS

3.1 Steel-toed boots (with meta-tarsal protection) in accordance with the most recent version of ANSI Z41 (MT I/75 C/75) will be worn at the Plume-Front Remediation System job sites to protect feet from potential drop hazards.

3.2 During the months of March through September, ambient temperatures at WSTF frequently exceed 90°F. This extreme environment creates the potential for heat stress and overexposure to ultraviolet (UV) radiation. Field personnel shall be familiar with heat stress prevention procedures and will implement them when required by elevated temperatures. Additionally, to protect exposure to UV radiation, sunscreen with a protection factor of at least 30 shall be worn while working in direct, intense sunlight. Umbrellas will be used when working conditions permit.

3.3 Inclement Weather (winds, floods, lightning, etc.) Considerations - Use situational awareness and remain alert for approaching storms. Contractor Environmental Department personnel shall be in contact with Department personnel in remote areas through a communication system consisting of a phone located in the treatment facility building, hand-held two-way radios and the remote area paging system per the current edition of WSP 25-0009, "WSTF Emergency Preparedness Plan". For lightning, follow instructions provided by the current edition of WSI 25-SW-0024, "Lightning Protection".

3.4 Wildlife Considerations - Various species of wildlife at WSTF (including snakes, insects, and rodents) can often be found near the Plume-Front Treatment System. Caution will be used to avoid contact with potentially dangerous wildlife at all times while in the field. If any potential natural dangers are detected, contact the sampling coordinator or other responsible contractor Environmental Department personnel for further instructions.

Attachment D – Example Anomaly Log

WJI No._____ Anomaly Log Page No. _____ of _____

Date	No.	Anomaly	Disposition	Initial

Note: Copy this Log Sheet as required to document anomalies. Electronic versions acceptable.

ATTACHMENT E

FACILITY MECHANICAL SETUP

1.0 GENERAL INFORMATION

This Attachment provides instructions for the mechanical setup of the extraction wells and subgrade piping system junctions, injection wells and injection manifold, subgrade piping system high point vents, treatment facility piping system, treatment facility air strippers, treatment facility, UV Reactor, treatment facility scale control system, air stripper scale cleaning system, and treatment facility instrument and equipment air system. The mechanical setup is presented in the following sections:

8.0 Extraction Wells and Piping System Junctions
9.0 Injection Wells and Injection Manifold
10.0 Subgrade Piping System High-Point Vents
11.0 Treatment Facility Piping
12.0 Air Stripper Mechanical Setup
13.0 UV Reactor Mechanical Setup
14.0 Scale Control System, Scale Cleaning System, Equipment, and Instrument Air System Mechanical Setup

2.0 DRAWINGS AND REFERENCES

2.1 A flow schematic is provided by WSTF drawing numbers 652-M-01, 652-M-02 and 652-M-03. Piping route plan and profile drawings and sections and details are presented in WSTF drawing numbers 652-C-01 through 652-C-26.

2.2 A list of references is provided in Attachment A of this WJI. Copies of manufacturer's (North East Environmental Products, Inc. and Calgon Carbon Corporation) operation and maintenance manuals, cut sheets, material specifications, warranties, etc. are maintained by the contractor Environmental Department.

3.0 ENCLOSURES

3.1 Enclosure 1, "Extraction Well and Subgrade Piping System Junctions Valve Log"
3.2 Enclosure 2, "Injection Well and Injection Manifold Valve Log"
3.3 Enclosure 3, "Subgrade Piping System High Point Vent Valve Log"
3.4 Enclosure 4, "Treatment Facility Piping System Valve Log and Equipment Checklists"

4.0 SAFETY REQUIREMENTS

The following safety requirements and warnings are applicable to this entire attachment. Additionally, follow all warnings and notes that precede certain steps in this procedure. All

PPE and other safety requirements specified in JHA HW-042 apply to facility mechanical setup operations.

4.1 Communications – phone or two-way radio required for operations.

4.2 In the event of minor cuts, scrapes, and abrasions, first aid will be administered in the field. In the event of any non-first aid injury, suspend operations, if appropriate, proceed to the dispensary and contact the WSTF Fire Department for assistance.

4.3 Confined Space Hazard Requirements/Warnings:

- Prior to entry into the extraction well and junction access vaults, qualified personnel will test and record the oxygen level to ensure that the vault atmosphere is safe.

- Under no circumstance is entry into the vaults authorized per this WJI when a hazardous atmosphere exists. Back out and contact the contractor environmental department if a hazardous atmosphere exists. Hazardous atmospheres are defined as:
  - Oxygen levels are less than 19.5%, or greater than 23.5%;
  - The atmosphere contains greater than 10% of the lower flammability limit;
  - The PEL or TLV is exceeded; or
  - An IDLH condition exists.

4.4 UV Reactor - Ensure that all access covers are in the closed position before working near the UV reactor.

5.0 PERSONNEL REQUIREMENTS

A minimum of two Hazardous Waste Compliance Technicians trained as Groundwater Treatment Facility Technicians or Groundwater Treatment Facility Operators (per the WSTF Training Database). At the discretion of the contractor Environmental Department section supervisor or project leader, the operations can be performed by:

5.1 Contractor Environmental Department personnel receiving “on-the-job” training for qualification as a Groundwater Treatment Facility Technicians under the direct supervision of the facility Project Leader or Certifying/Qualifying Instructor who is also qualified as a Groundwater Treatment Facility Operator (per the WSTF Training Database). Personnel receiving "on-the-job" training are required to have completed WSTF Hazardous Waste Handler Training (per the WSTF Training Database) and requirements 5.3, 5.4 and 5.5 listed below.

5.2 A qualified Groundwater Treatment Facility Technician (per the WSTF Training Database) who is assisted by personnel receiving "on-the-job" training for qualification as a Groundwater Treatment Facility Technician(s). Personnel

receiving "on-the-job" training are required to have completed WSTF Hazardous Waste Handler Training and requirements 5.3, 5.4 and 5.5 listed below.

5.3 All personnel actively involved in facility operations are required to have current confined space training per WSI 25-SW-0003, "Confined Space Entry Program", categories Confined Space Entry SAF-06 and Confined Space Entry (Air Monitoring) SAF-07A (per the WSTF Training Database).

5.4 All personnel actively involved in facility operations are required to have current PPE Training (per the WSTF Training Database).

5.5 All personnel actively involved in facility operations are required to have current Lockout/Tagout training per WSI 25-SW-004, "Lockout/Tagout, The Control of Hazardous Energy" (per the WSTF Training Database).

6.0 EQUIPMENT

6.1 Hand tools
6.2 Ladder as required
6.3 MSA Passport Personal Alarm (or equivalent) as required for confined space entry
6.4 Keys to Bldg. 650/651, well vaults, manways as required

7.0 SPECIAL REQUIREMENTS

7.1 The contractor Environmental Department shall ensure that the facility system configuration (position (OPEN/CLOSED) of all piping system manual valves) and mechanical setup is documented per the enclosures of this Attachment. The reference drawings for valve configuration are WSTF drawing numbers 652-M-01 through 652-M-03. A copy of all valve logs and checklists shall be filed and maintained as part of the facility operating record.

7.2 The Groundwater Treatment Facility Operator will authorize the OPENING/CLOSING of all piping system valves and define the mechanical setup of the facility. A copy of all valve logs, checklists, and enclosures shall be maintained as part of the facility operating record.

7.3 At the discretion of the contractor Environmental Department, engineering controls per WSI 25-SW-0035, "Use of Engineering Control Devices for Fluid, Gaseous and Electrical Systems at WSTF" may be used to maintain the system configuration at valve locations such as well and piping system access vaults that require confined space entry or periods of short shutdown (less than eight hours). After initial verification of valve position (OPEN/CLOSED verification by visual examination of the position of valve operator), verification of system configuration at these locations can be performed by the use of engineering controls per WSI 25-SW-0035 (locks and/or tags) and a review of the operating record.

7.4 Access to the extraction and injection well and junction access vaults is controlled by the contractor Environmental Department. The well and access vaults shall remain locked/closed at all times except during inspections, and sampling and maintenance operations.

7.5 For this attachment, the following definitions apply:
- the term "VERIFY" will be used to check system configuration;
- the term "PERFORM" will be used to require a specific action or sequence of actions; and
- the term "VERIFY/PERFORM" will be used to first check the configuration and then perform the required action if the configuration is not as specified.

7.6 Anomalies and discrepant conditions will be recorded on the Anomaly Log (Attachment D). At the discretion of the Groundwater Treatment Facility Operator, a DR per WSI 13-SW-0001, "Discrepancy Record (DR)" will be initiated.

8.0 EXTRACTION WELLS AND PIPING SYSTEM JUNCTIONS

This section provides instructions for the mechanical setup of the plume-front extraction wells (PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, and PFE-7) and piping system junctions (STA(N) 21+52, STA(N) 18+91, STA(PFE-2) 8+00, STA(N) 2+72, STA(N) 0+02, and STA(S) 8+70). The contractor Environmental Department will identify the extraction wells that will be on-line. The valve log for this section is presented in Enclosure 1.

8.1 The contractor Environmental Department will:

8.1.1 Review the flow schematic (WSTF drawing number 652-M-01) that documents the operation, inspection, servicing and maintenance of the Plume-Front Treatment Facility, and the valve logs that document the existing system configuration.

8.1.2 Determine the valve locations where verification of system configuration will be performed by visual inspections, and the locations where the system configuration is controlled by the use of engineering controls per WSI 25-SW-0035 (locks and/or tags).

8.1.3 "VERIFY" that inspection, servicing and maintenance activities are completed, and the extraction wells and subgrade piping junctions are ready to be returned to normal service or will be off-line during facility operation.

8.1.4 "VERIFY" that "Lockout/Tagout" in support of other inspection, servicing and maintenance activities have been removed in accordance with WSI 25-SW-0004 (if applicable).

8.1.5 "VERIFY" that the mechanical setup (valve configuration) is consistent with the particular system operation and update the valve logs (Enclosure 1), as required to document the piping system.

8.2 Perform the following for the valve locations where visual examination of the valve position (OPEN/CLOSED) is required or locations where the valve position (OPEN/CLOSED) will be changed.

NOTE

CERTAIN BUTTERFLY VALVES IN THE PIPING SYSTEM JUNCTIONS ARE FITTED WITH A 2-INCH SQUARE NUT OPERATOR. THESE SHOULD BE OPERATED WITH A "KEY" WITHOUT HAVING TO PERFORM A CONFINED SPACE ENTRY.

8.2.1 Review the flow schematic for the plume-front extraction wells (WSTF drawing number 652-M-01) and piping route plan and profile drawings, sections and details presented in WSTF drawing numbers 652-C-1 through 652-C-26.

8.2.2 Contact the contractor Environmental Department for access to the respective extraction well vaults and junction access vaults.

8.2.3 The extraction well and junction access vaults have been identified as a confined space. If vault entry is required, perform the following prior to the operation:

8.2.3.1 Obtain a confined space entry permit for the extraction well or junction access vaults from the contractor Environmental Department . The contractor Environmental Department shall provide a confined space entry permit per WSI-25-0003, "Confined Space Entry Program" (WSTF Form 503).

8.2.3.2 Obtain an MSA Passport Personal Alarm (or equivalent) from the contractor Environmental Department.

8.2.3.3 Read, and follow the manufacturer's instructions for the use and calibration of the MSA Passport alarm system (or equivalent). For the Passport system, the manufacturer's calibration and operating instructions are included with the equipment and maintained in WJI-PAD-SAF-0002, "MSA Passport Personal Alarm Calibration" and in the contractor Technical Library. Contact the contractor Environmental

Department section for calibration and operating instructions when using other air monitoring systems.

8.2.3.4 Test and verify that the extraction well or junction access vault atmosphere is safe per instructions provided in the confined space entry permit (WSTF Form 503). Under no circumstance is entry into the vaults authorized per this WJI when a hazardous atmosphere exists. Back out and contact the contractor Environmental Department if a hazardous atmosphere exists (oxygen levels are less than 19.5% or greater than 23.5%, greater than 10% of the lower flammability limit, greater than the PEL or TLV, or an IDLH condition exists).

NOTES:

PERFORM THE FOLLOWING STEPS IF THE EXTRACTION WELLS ARE TO BE PLACED OR VERIFIED ON-LINE.

CERTAIN BUTTERFLY VALVES IN THE PIPING SYSTEM JUNCTIONS ARE FITTED WITH A 2-INCH SQUARE NUT OPERATOR. THESE CAN BE OPERATED WITH A "KEY" WITHOUT HAVING TO PERFORM A CONFINED SPACE ENTRY.

8.3 "VERIFY/PERFORM" the following if extraction well PFE-1 is ON-LINE:

8.3.1 MV-6WA-XK202 (high-point vent isolation valve) is OPEN. (unless otherwise specified by the Groundwater Treatment Facility Operator).
8.3.2 MV-6WA-XK004 (extraction well sample valve) is CLOSED.
8.3.3 MV-6WA-XK005 and MV-6WA-XK009 (extraction well main isolation valves) are OPEN.
8.3.4 MV-6WA-XK006 (extraction well piping drain valve) is CLOSED.
8.3.5 MV-6WA-XK051 (PFE-1 subgrade piping system isolation valve located at junction STA(N) 21+52) is OPEN.
8.3.6 MV-6WA-XK054 (subgrade piping system isolation valve located at junction STA(N) 18+91) is OPEN.
8.3.7 MV-6WA-XK055 and MV-6WA-XK252 (subgrade piping system isolation valves located at junction STA(N) 2+72) are OPEN.
8.3.8 MV-6WA-XK058 (subgrade piping system isolation valve located at junction STA 0+02) is OPEN.
8.3.9 Update the valve logs (Enclosure 1) as required to document the current piping system configuration.

8.4 "VERIFY/PERFORM" the following if extraction well PFE-2 is ON-LINE:

8.4.1 MV-6WA-XK204 (high-point vent isolation valve) is OPEN. (unless otherwise specified by the Groundwater Treatment Facility Operator).
8.4.2 MV-6WA-XK024 (extraction well sample valve) is CLOSED.
8.4.3 MV-6WA-XK025 and MV-6WA-XK029 (extraction well main isolation valves) are OPEN.
8.4.4 MV-6WA-XK026 (extraction well piping drain valve) is CLOSED.
8.4.5 MV-6WA-XK-053 (PFE-2/PFE-7 subgrade piping system isolation valve located at junction STA(N) 18+91) is OPEN.
8.4.6 MV-6WA-XK-255 (PFE-2 subgrade piping system isolation valve located at junction STA(PFE-2) 8+00) is OPEN.
8.4.7 MV-6WA-XK055 and MV-6WA-XK252 (subgrade piping system isolation valves located at junction STA(N) 2+72) are OPEN.
8.4.8 MV-6WA-XK058 (subgrade piping system isolation valve located at junction STA(N) 0+02) is OPEN.
8.4.9 Update the valve logs Enclosure 1 as required to document the current piping system configuration.

8.5 "VERIFY/PERFORM" the following if extraction well PFE-3 is ON-LINE:

8.5.1 MV-6WA-XK205 (high-point vent isolation valve) is OPEN. (unless otherwise specified by the Groundwater Treatment Facility Operator).
8.5.2 MV-6WA-XK034 (extraction well sample valve) is CLOSED.
8.5.3 MV-6WA-XK035 and MV-6WA-XK039 (extraction well main isolation valves) are OPEN.
8.5.4 MV-6WA-XK036 (extraction well piping drain valve) is CLOSED.
8.5.5 MV-6WA-XK-057 (PFE-3 subgrade piping system isolation valve located at junction STA(S) 8+70) is OPEN.
8.5.6 MV-6WA-XK-059 (subgrade piping system isolation valve located at junction STA(N) 0+02) is OPEN.
8.5.7 Update the valve logs (Enclosure 1) as required to document the current piping system configuration.

8.6 "VERIFY/PERFORM" the following if extraction well PFE-4A is ON-LINE:

8.6.1 MV-6WA-XK206 (high-point vent isolation valve) is OPEN. (unless otherwise specified by the Groundwater Treatment Facility Operator).
8.6.2 MV-6WA-XK044 (extraction well sample valve) is CLOSED.
8.6.3 MV-6WA-XK045 and MV-6WA-XK049 (extraction well main isolation valves) are OPEN.
8.6.4 MV-6WA-XK046 (extraction well piping drain valve) is CLOSED.
8.6.5 MV-6WA-XK-056 (PFE-4A subgrade piping system isolation valve located at junction STA(S) 8+70) is OPEN.

8.6.6 MV-6WA-XK-059 (subgrade piping system isolation valve located at junction STA(N) 0+02) is OPEN.
8.6.7 Update the valve logs (Enclosure 1) as required to document the current piping system configuration.

8.7 "VERIFY/PERFORM" the following if extraction well PFE-5 is ON-LINE:

8.7.1 MV-6WA-XK203 (high-point vent isolation valve) is OPEN. (unless otherwise specified by the Groundwater Treatment Facility Operator).
8.7.2 MV-6WA-XK014 (extraction well sample valve) is CLOSED.
8.7.3 MV-6WA-XK015 and MV-6WA-XK019 (extraction well main isolation valves) are OPEN.
8.7.4 MV-6WA-XK016 (extraction well piping drain valve) is CLOSED.
8.7.5 MV-6WA-XK-052 (PFE-5 subgrade piping system isolation valve located at junction STA(N) 21+52) is OPEN.
8.7.6 MV-6WA-XK054 (subgrade piping system isolation valve located at junction STA(N) 18+91) is OPEN.
8.7.7 MV-6WA-XK055 and MV-6WA-XK252 (subgrade piping system isolation valves located at junction STA(N) 2+72) are OPEN.
8.7.8 MV-6WA-XK058 (subgrade piping system isolation valve located at junction STA(N) 0+02) is OPEN.
8.7.9 Update the valve logs (Enclosure 1) as required to document the current piping system configuration.

8.8 "VERIFY/PERFORM" the following if extraction well PFE-7 is ON-LINE:

8.8.1 MV-6WA-XK241 (high-point vent isolation valve) is OPEN. (unless otherwise specified by the Groundwater Treatment Facility Operator).
8.8.2 MV-6WA-XK242 (extraction well sample valve) is CLOSED.
8.8.3 MV-6WA-XK243 and MV-6WA-XK247 (extraction well main isolation valves) are OPEN.
8.8.4 MV-6WA-XK244 (extraction well piping drain valve) is CLOSED.
8.8.5 MV-6WA-XK053 (PFE-2/PFE-7 subgrade piping system isolation valve located at junction STA(N) 18+91) is OPEN.
8.8.6 MV-6WA-XK-256 (PFE-7 subgrade piping system isolation valve located at junction STA(PFE-2) 8+00) is OPEN.
8.8.7 MV-6WA-XK053 (subgrade piping system isolation valve located at junction STA(N)18+91) is OPEN.
8.8.8 MV-6WA-XK055 and MV-6WA-XK252 (subgrade piping system isolation valves located at junction STA(N) 2+72) are OPEN.
8.8.9 MV-6WA-XK058 (subgrade piping system isolation valve located at junction STA(N) 0+02) is OPEN.
8.8.10 Update the valve logs (Enclosure 1) as required to document the current piping system configuration.

NOTE:

PERFORM THE FOLLOWING STEPS IF THE EXTRACTION WELLS ARE TO BE PLACED OR VERIFIED OFF-LINE.

8.9 "VERIFY/PERFORM" the following if extraction well PFE-1 is OFF-LINE:

8.9.1 MV-6WA-XK202 (high-point vent isolation valve) is OPEN. (unless otherwise specified by the "Drive TPS" and other WADs).
8.9.2 MV-6WA-XK004 (extraction well sample valve) is CLOSED.
8.9.3 MV-6WA-XK005 and MV-6WA-XK009 (extraction well main isolation valves) are CLOSED.
8.9.4 MV-6WA-XK006 (extraction well piping drain valve) is CLOSED.
8.9.5 MV-6WA-XK-051 (PFE-1 subgrade piping system isolation valve located at junction STA(N) 21+52) is CLOSED.
8.9.6 Update the valve logs (Enclosure 1) as required to document the current piping system configuration.

8.10 "VERIFY/PERFORM" the following if extraction well PFE-2 is OFF-LINE:

8.10.1 MV-6WA-XK204 (high-point vent isolation valve) is OPEN. (unless otherwise specified by the Groundwater Treatment Facility Operator).
8.10.2 MV-6WA-XK024 (extraction well sample valve) is CLOSED.
8.10.3 MV-6WA-XK025 and MV-6WA-XK029 (extraction well main isolation valves) are CLOSED.
8.10.4 MV-6WA-XK026 (extraction well piping drain valve) is CLOSED.
8.10.5 MV-6WA-XK255 (PFE-2 subgrade piping system isolation valve located at junction STA(PFE-2) 8+00) is CLOSED.
8.10.6 Update the valve logs (Enclosure 1) as required to document the current piping system configuration

8.11 "VERIFY/PERFORM" the following if extraction well PFE-3 is OFF-LINE:

8.11.1 MV-6WA-XK205 (high-point vent isolation valve) is OPEN. (unless otherwise specified by the Groundwater Treatment Facility Operator).
8.11.2 MV-6WA-XK034 (extraction well sample valve) is CLOSED.
8.11.3 MV-6WA-XK035 and MV-6WA-XK039 (extraction well main isolation valves) are CLOSED.
8.11.4 MV-6WA-XK036 (extraction well piping drain valve) is CLOSED.
8.11.5 MV-6WA-XK-057 (PFE-3 subgrade piping system isolation valve located at junction STA(S) 8+70) is CLOSED
8.11.6 Update the valve logs (Enclosure 1) as required to document the current piping system configuration

8.12 "VERIFY/PERFORM" the following if extraction well PFE-4A is OFF-LINE:

8.12.1 MV-6WA-XK206 (high-point vent isolation valve) is OPEN. (unless otherwise specified by the Groundwater Treatment Facility Operator).

8.12.2 MV-6WA-XK044 (extraction well sample valve) is CLOSED.
8.12.3 MV-6WA-XK045 and MV-6WA-XK049 (extraction well main isolation valves) are CLOSED.
8.12.4 MV-6WA-XK046 (extraction well piping drain valve) is CLOSED.
8.12.5 MV-6WA-XK-056 (PFE-4A subgrade piping system isolation valve located at junction STA(S) 8+70) is CLOSED.
8.12.6 Update the valve logs (Enclosure 1) as required to document the current piping system configuration

8.13 "VERIFY/PERFORM" the following if extraction well PFE-5 is OFF-LINE:

8.13.1 MV-6WA-XK203 (high-point vent isolation valve) is OPEN. (unless otherwise specified by the Groundwater Treatment Facility Operator).
8.13.2 MV-6WA-XK014 (extraction well sample valve) is CLOSED.
8.13.3 MV-6WA-XK015 and MV-6WA-XK019 (extraction well main isolation valves) are CLOSED.
8.13.4 MV-6WA-XK016 (extraction well piping drain valve) is CLOSED.
8.13.5 MV-6WA-XK052 (PFE-5 subgrade piping system isolation valve located at junction STA(N) 21+52) is CLOSED.
8.13.6 Update the valve logs (Enclosure 1) as required to document the current piping system configuration.

8.14 "VERIFY/PERFORM" the following if extraction well PFE-7 is OFF-LINE:

8.14.1 MV-6WA-XK241 (high-point vent isolation valve) is OPEN. (unless otherwise specified by the "Drive TPS" and other WADs).
8.14.2 MV-6WA-XK242 (extraction well sample valve) is CLOSED.
8.14.3 MV-6WA-XK243 and MV-6WA-XK247 (extraction well main isolation valves) are CLOSED.
8.14.4 MV-6WA-XK244 (extraction well piping drain valve) is CLOSED.
8.14.5 MV-6WA-XK256 (PFE-7 subgrade piping system isolation valve located at junction STA(PFE-2) 8+00) is CLOSED.
8.14.6 Update the valve logs (Enclosure 1) as required to document the current piping system configuration

9.0 INJECTION WELLS AND INJECTION MANIFOLD

This section provides instructions the mechanical setup of the plume-front injection wells (PFI-1, PFI-2, PFI-3, and PFI-4) and the injection manifold (Bldg. 651). The Groundwater Treatment Facility Operator will identify the injection wells that will be on-line. The valve log for this section is presented in Enclosure 2.

9.1 The contractor Environmental Department will review the flow schematic (WSTF drawing number 652-M-03), operating log, and other WADs that document the operation, inspection, servicing, and maintenance of the Plume-Front Treatment Facility, and the valve logs that document the existing system configuration.

9.1.1 Determine the valve locations where verification of system configuration will be performed by visual inspections and the locations where the system configuration is controlled by the use of engineering controls per WSI 25-SW-0035 (locks and/or tags) and a review of the operating record.

9.1.2 "VERIFY" that inspection, servicing and maintenance activities are completed and the injection wells and injection manifold are ready to be returned to normal service or will be off-line during facility operation.

9.1.3 "VERIFY" that "Lockout/Tagout" in support of other inspection, servicing and maintenance activities have been removed in accordance with WSI 25-SW-0004 (if applicable).

9.1.4 "VERIFY" that the mechanical setup (valve configuration) is consistent with the system configuration and update the valve logs (Enclosure 2) as required to document the current piping system configuration. Perform steps 9.2 through 9.10 as required.

NOTE:

PERFORM STEP 9.2 IN PREPARATION FOR VALVE LOCATIONS WHERE THE VALVE POSITIONS WILL BE CHANGED OR VISUAL EXAMINATION IS REQUIRED.

9.2 Perform the following for the valve locations where visual examination of the valve position (OPEN/CLOSED) is required or locations where the valve position (OPEN/CLOSED) will be changed.

9.2.1 Review the flow schematic for the plume-front injection wells and injection manifold (WSTF drawing number 652-M-03).

9.2.2 Contact the contractor Environmental Department for access to the respective injection well vaults and injection manifold building.

9.2.3 The injection well vaults have been identified as a confined space. If vault entry is required, perform the following prior to the operation:

9.2.3.1 Obtain a confined space entry permit for the injection well vaults from the contractor Environmental Department (per WSI-25-0003, "Confined Space Entry Program" (WSTF Form 503)).

9.2.3.2 Obtain a MSA Passport Personal Alarm (or equivalent) from the contractor Environmental Department .

9.2.3.3 Read and follow the manufacturer's instructions for the use and calibration of the MSA Passport alarm system (or equivalent). For the Passport system, the manufacturer's calibration and

operating instructions are included with the equipment and maintained in WJI-PAD-SAF-0002, "MSA Passport Personal Alarm Calibration" and in the WSTF Technical Library. Contact the contractor Environmental Department for calibration and operating instructions when using other air monitoring systems.

9.2.3.4 Test and verify that the injection well vault atmosphere is safe per instructions provided in the confined space entry permit (WSTF Form 503). Under no circumstance is entry into the vaults authorized per this WJI when a hazardous atmosphere exists. Back out and contact the contractor Environmental Department if a hazardous atmosphere exists (oxygen levels are less than 19.5% or greater than 23.5%, greater than 10% of the lower flammability limit, greater than the PEL or TLV, or an IDLH condition exists).

NOTES:

PERFORM THE FOLLOWING STEPS IF THE INJECTION WELLS ARE TO BE PLACED OR VERIFIED ON-LINE.

9.3 "VERIFY/PERFORM" the following if injection well PFI-1 is ON-LINE:

9.3.1 MV-6WA-XK221 (high-point vent isolation valve) is OPEN.
9.3.2 MV-6WA-XK157 (injection well main isolation valve) is OPEN.
9.3.3 MV-6WA-XK217 (injection manifold PFI-1 high-point vent isolation valve) is OPEN.
9.3.4 MV-6WA-XK152 and MV-6WA-XK156 (injection manifold PFI-1 main isolation valves) are OPEN.
9.3.5 Update the valve logs Enclosure 2 as required to document the current piping system configuration.

9.4 VERIFY/PERFORM" the following if injection well PFI-2 is ON-LINE:

9.4.1 MV-6WA-XK220 (high-point vent isolation valve) is OPEN.
9.4.2 MV-6WA-XK165 (injection well main isolation valve) are OPEN.
9.4.3 MV-6WA-XK216 (injection manifold PFI-2 high-point vent isolation valve) is OPEN.
9.4.4 MV-6WA-XK160 and MV-6WA-XK164 (injection manifold PFI-2 main isolation valves) are OPEN.
9.4.5 Update the valve logs (Enclosure 2) as required to document the current piping system configuration.

9.5 VERIFY/PERFORM" the following if injection well PFI-3 is ON-LINE:

9.5.1 MV-6WA-XK095 (high-point vent isolation valve) is OPEN.
9.5.2 MV-6WA-XK173 (injection well main isolation valve) are OPEN.
9.5.3 MV-6WA-XK219 (injection manifold PFI-3 high-point vent isolation valve) is OPEN.
9.5.4 MV-6WA-XK168 and MV-6WA-XK172 (injection manifold PFI-3 main isolation valves) are OPEN.
9.5.5 Update the valve logs (Enclosure 2) as required to document the current piping system configuration.

9.6 VERIFY/PERFORM" the following if injection well PFI-4 is ON-LINE:

9.6.1 MV-6WA-XK048 (high-point vent isolation valve) is OPEN.
9.6.2 MV-6WA-XK181 (injection well main isolation valve) are OPEN.
9.6.3 MV-6WA-XK218 (injection manifold PFI-4 high-point vent isolation valve) is OPEN.
9.6.4 MV-6WA-XK176 and MV-6WA-XK180 (injection manifold PFI-4 main isolation valves) are OPEN.
9.6.5 Update the valve logs (Enclosure 2) as required to document the current piping system configuration.

NOTE:

PERFORM THE FOLLOWING STEPS IF THE INJECTION WELLS ARE TO BE PLACED OR VERIFIED OFF-LINE.

9.7 "VERIFY/PERFORM" the following if injection well PFI-1 is OFF-LINE:
9.7.1 MV-6WA-XK221 (high-point vent isolation valve) is OPEN. (unless otherwise specified by the Groundwater Treatment Facility Operator).
9.7.2 MV-6WA-XK157 (injection well main isolation valve) is CLOSED.
9.7.3 MV-6WA-XK217 (injection manifold PFI-1 high-point vent isolation valve) is OPEN (unless otherwise specified by the "Drive TPS" and other WADs).
9.7.4 MV-6WA-XK152 and MV-6WA-XK156 (injection manifold PFI-1 main isolation valves) are CLOSED.
9.7.5 Update the valve logs (Enclosure 2) as required to document the current piping system configuration.

9.8 "VERIFY/PERFORM" the following if injection well PFI-2 is OFF-LINE:

9.8.1 MV-6WA-XK220 (high-point vent isolation valve) is OPEN.
9.8.2 MV-6WA-XK165 (injection well main isolation valve) are CLOSED.
9.8.3 MV-6WA-XK216 (injection manifold PFI-2 high-point vent isolation valve) is OPEN (unless otherwise specified by the "Drive TPS" and other WADs).
9.8.4 MV-6WA-XK160 and MV-6WA-XK164 (injection manifold PFI-2 main isolation valves) are CLOSED.
9.8.5 Update the valve logs (Enclosure 2) as required to document the current piping system configuration.

9.9 "VERIFY/PERFORM" the following if injection well PFI-3 is OFF-LINE:

9.9.1 MV-6WA-XK095 (high-point vent isolation valve) is OPEN.
9.9.2 MV-6WA-XK173 (injection well main isolation valve) are CLOSED.
9.9.3 MV-6WA-XK219 (injection manifold PFI-3 high-point vent isolation valve) is OPEN (unless otherwise specified by the "Drive TPS" and other WADs).
9.9.4 MV-6WA-XK168 and MV-6WA-XK172 (injection manifold PFI-3 main isolation valves) are CLOSED.
9.9.5 Update the valve logs (Enclosure 2) as required to document the current piping system configuration.

9.10 "VERIFY/PERFORM" the following if injection well PFI-4 is OFF-LINE:

9.10.1 MV-6WA-XK048 (high-point vent isolation valve) is OPEN.
9.10.2 MV-6WA-XK181 (injection well main isolation valve) are CLOSED.
9.10.3 MV-6WA-XK218 (injection manifold PFI-4 high-point vent isolation valve) is OPEN (unless otherwise specified by the "Drive TPS" and other WADs).
9.10.4 MV-6WA-XK176 and MV-6WA-XK180 (injection manifold PFI-4 main isolation valves) are CLOSED.
9.10.5 Update the valve logs (Enclosure 2) as required to document the current piping system configuration.

10.0 SUBGRADE PIPING SYSTEM HIGH-POINT VENTS

This section provides instructions for the mechanical setup of the plume-front subgrade piping system high-point vents. The valve log for this section is presented in Enclosure 3.

10.1 The contractor Environmental Department will:

10.1.1 Review the flow schematic (WSTF drawing numbers 652-M-01 and 652-M-03) and valve logs that document the existing system configuration.

10.1.2 Determine the valve locations where verification of system configuration will be performed by visual inspections and the locations where the system configuration is controlled by the use of engineering controls per WSI 25-SW-0035 (locks and/or tags).

10.1.3 ”VERIFY” that inspection, servicing and maintenance activities are completed and the subgrade highpoint vents are ready to be returned to normal service or will be off-line during facility operation.

10.1.4 “VERIFY” that “Lockout/Tagout” in support of other inspection, servicing and maintenance activities have been removed in accordance with WSI 25-SW-0004 (if applicable).

10.1.5 “VERIFY” that the system configuration is consistent with the system configuration as required by the operation. Perform steps 10.2 through 10.4 as required.

NOTE:

PERFORM STEP 10.2 IN PREPARATION FOR VALVE LOCATIONS WHERE THE VALVE POSITIONS WILL BE CHANGED OR VISUAL EXAMINATION IS REQUIRED.

10.2 Perform the following for the valve locations where visual examination of the valve position (OPEN/CLOSED) is required or locations where the valve position (OPEN/CLOSED) will be changed.

10.2.1 Review the flow schematic for the the subgrade piping system high point vents (DWG # 652-M-01 and 652-M-03).

10.2.2 Contact the contractor Environmental Department for access to the respective the subgrade piping system high point vents.

10.2.3 The subgrade piping system high point vent vaults have been identified as a confined space. If vault entry is required, perform the following prior to the operation:

10.2.3.1 Obtain a confined space entry permit for the the subgrade piping system high point vents from the contractor Environmental Department (per WSI-25-0003, “Confined Space Entry Program” (WSTF Form 503)).

10.2.3.2 Obtain a MSA Passport Personal Alarm (or equivalent) from the contractor Environmental Department .

10.2.3.3 Read and follow the manufacturer's instructions for the use and calibration of the MSA Passport alarm system (or equivalent). For the Passport system, the manufacturer's calibration and operating instructions are included with the equipment and maintained in WJI-PAD-SAF-0002, "MSA Passport Personal Alarm Calibration" and in the WSTF Technical Library. Contact the contractor Environmental Department for calibration and operating instructions when using other air monitoring systems.

10.2.4.4 Test and verify that the vault atmosphere is safe per instructions provided in the confined space entry permit (WSTF Form 503). Under no circumstance is entry into the vaults authorized per this WJI when a hazardous atmosphere exists. Back out and contact the contractor Environmental Department if a hazardous atmosphere exists (oxygen levels are less than 19.5% or greater than 23.5%, greater than 10% of the lower flammability limit, greater than the PEL or TLV, or an IDLH conditions exists).

NOTES:

PERFORM THE FOLLOWING STEPS TO SETUP THE HIGH POINT VENTS.

CONFINED SPACE ENTRY NOT REQUIRED FOR STEPS THAT INVOLVE SETUP OF THE INJECTION MANIFOLD (BLDG. 651).

10.3 "VERIFY/PERFORM" the following:

10.3.1 MV-6WA-XK210 (located at STA(N)4+12, Dwg. # 652-M-01) is OPEN.
10.3.2 MV-6WA-XK209 (located at STA(S)3+00, Dwg. # 652-M-01) is OPEN.
10.3.3 MV-6WA-XK211 (located at STA(S)3+00, Dwg. # 652-M-03) is OPEN.
10.3.4 MV-6WA-XK208 (located at STA(S)10+80, Dwg. # 652-M-01) is OPEN.
10.3.5 MV-6WA-XK191 (located at STA(S)10+80, Dwg. # 652-M-01) is OPEN.
10.3.6 MV-6WA-XK207 (located at STA(S)14+90, Dwg. # 652-M-01) is OPEN.
10.3.7 MV-6WA-XK213 (located at STA(S)14+90, Dwg. # 652-M-03) is OPEN.
10.3.8 MV-6WA-XK214 (located at STA(S)31+40, Dwg. # 652-M-03) is OPEN.
10.3.9 MV-6WA-XK215 (located at STA(S)34+10, Dwg. # 652-M-03) is OPEN.

10.4 Update the valve logs (Enclosure 3) as required to document the current piping system configuration.

11.0 TREATMENT FACILITY PIPING

11.01 This section provides instructions for the mechanical setup of the treatment facility piping system. The valve log for this section is presented in Enclosure 4.

11.1 The contractor Environmental Department will:

11.1.1 Review the flow schematic (Dwg # 652-M-02) and the valve logs that document the existing system configuration.

11.1.2 "VERIFY" that inspection, servicing and maintenance activities are completed and the treatment facility is ready to be returned to service.

11.1.3 "VERIFY" that "Lockout/Tagout" in support of other inspection, servicing and maintenance activities have been removed in accordance with WSI 25-SW-0004 (if applicable).

11.1.4 Ensure the valve log (Enclosure 4) is updated as required to document the current piping system configuration. Perform steps 11.2 through 11.9 as required.

11.2 "VERIFY/PERFORM" the following if treatment facility influent from the extraction wells is ON-LINE:

11.2.1 MV-6WA-XK082 (treatment facility influent from extraction wells main isolation valve) is OPEN.
11.2.2 MV-6WA-XK090 and MV-6WA-XK147 (treatment facility influent from TK-6WA-XK148 main isolation valve) is CLOSED.
11.2.3 MV-6WA-XK146 and MV-6WA-XK258 (treatment facility influent from recirculation loop main isolation valves) are CLOSED.

11.3 "VERIFY/PERFORM" the following if treatment facility influent from TK-6WA-XK-148 is ON-LINE:

11.3.1 MV-6WA-XK082 (treatment facility influent from extraction wells main isolation valve) is CLOSED.
11.3.2 MV-6WA-XK090 and MV-6WA-XK147 (treatment facility influent from TK-6WA-XK148 isolation valves) are OPEN.
11.3.3 MV-6WA-XK146 and MV-6WA-XK258 (treatment facility influent from recirculation loop main isolation valves) are CLOSED.

11.4 "VERIFY/PERFORM" the following if treatment facility influent from the recirculation loop is ON-LINE:

11.4.1 MV-6WA-XK082 (treatment facility influent from extraction wells main isolation valve) is CLOSED.

11.4.2 MV-6WA-XK090 and MV-6WA-XK147 (treatment facility influent from TK-6WA-XK148 main isolation valves) is CLOSED.
11.4.3 MV-6WA-XK146 and MV-6WA-XK258 (treatment facility influent from recirculation loop main isolation valves) is OPEN.

11.5 "VERIFY/PERFORM" the following if treatment facility effluent to the injection wells is ON-LINE:

11.5.1 MV-6WA-XK144 (treatment facility effluent to the injection wells main isolation valve) is OPEN.
11.5.2 MV-6WA-XK201 (treatment facility effluent piping high-point vent isolation valve) is OPEN.
11.5.3 MV-6WA-XK150 (isolation valve to TK-6WA-XK148) is CLOSED.
11.5.4 MV-6WA-XK151 (TK-6WA-XK148 bypass valve) is CLOSED
11.5.5 MV-6WA-XK146 (treatment facility influent from recirculation loop main isolation valve) is CLOSED.

11.6 "VERIFY/PERFORM" the following if treatment facility effluent to TK-6WA-XK148 is ON-LINE:

11.6.1 MV-6WA-XK144 (treatment facility effluent to the injection wells main isolation valve) is CLOSED.
11.6.2 MV-6WA-XK201 (treatment facility effluent piping high-point vent isolation valve) is OPEN.
11.6.3 MV-6WA-XK150 (isolation valve to TK-6WA-XK148) is OPEN.
11.6.4 MV-6WA-XK151 (TK-6WA-XK148 bypass valve) is CLOSED.
11.6.5 MV-6WA-XK146 (treatment facility influent from recirculation loop main isolation valve) is CLOSED.

11.7 "VERIFY/PERFORM" the following if treatment facility effluent to the recirculation loop is ON-LINE:

11.7.1 MV-6WA-XK144 (treatment facility effluent to the injection wells main isolation valve) is CLOSED.
11.7.2 MV-6WA-XK201 (treatment facility effluent piping high-point vent isolation valve) is OPEN.
11.7.3 MV-6WA-XK150 (isolation valve to TK-6WA-XK148) is CLOSED.
11.7.4 MV-6WA-XK151 (TK-6WA-XK148 bypass valve) is CLOSED.
11.7.5 MV-6WA-XK146 (treatment facility influent from recirculation loop main isolation valve) is OPEN.

11.8 "VERIFY/PERFORM" the following:

11.8.1 MV-6WA-XK086 (treatment facility influent sample valve) is CLOSED.
11.8.2 MV-6WA-XK142 (treatment facility effluent sample valve) is CLOSED.
11.8.3 MV-6WA-XK139 (UV Reactor influent isolation valve) is OPEN.
11.8.4 MV-6WA-XK136 (UV Reactor effluent isolation valve) is OPEN.
11.8.5 MV-6WA-XK099 (TK-6WA-XK222 drain valve) is CLOSED.
11.8.6 MV-6WA-XK184 (isolation valve-facility water to safety shower) is OPEN.
11.8.7 MV-6WA-XK063 (isolation valve – facility water to TK-6WA-XK064) is CLOSED.
11.8.8 MV-6WA-XK075 (TK-6CI-XK076 fill valve) is CLOSED.

11.9 Update the valve log (Enclosure 4) (valve position, TPS/DR/comments, initials, date) as required to document the current piping system configuration.

12.0 AIR STRIPPER MECHANICAL SETUP

This section provides instructions for the mechanical setup of the treatment facility air strippers. The checklist for this section is presented in Enclosure 4.

NOTES:

A DASHED LINE (DWG # 652-M-02) SURROUNDS COMPONENTS THAT MAKE UP THE RESPECTIVE AIR STRIPPERS. THE MAJORITY OF THE COMPONENTS REFERENCED PER THIS SECTION ARE WITHIN THE DEFINED AREA.

THE SETUP OF COMPONENTS LOCATED OUTSIDE THE DASHED LINE ARE PERFORMED PER SECTION 11.0, TREATMENT FACILITY PIPING.

12.1 The contractor Environmental Department will:

12.1.1 "VERIFY" that inspection, servicing and maintenance activities are completed and the air stripper is ready to be returned to normal service or will be off-line during facility operation (if applicable).

12.1.2 "VERIFY" that "Lockout/Tagout" in support of other inspection, servicing and maintenance activities have been removed in accordance with WSI 25-SW-0004 (if applicable).

12.1.3 Review the treatment facility flow schematic (Dwg. # 652-M-02) and the air stripper mechnaical setup checklist, Enclosure 4.

12.1.4 Ensure the air stripper mechanical setup checklist, Enclosure 4 is updated as required to document the completion of the mechanical setup.

NOTE:

IT IS NOT NECESSARY TO PERFORM INITIAL START-UP PROCEDURES (STEPS 12.2.5 THROUGH 12.2.9 AND 12.3.5 THROUGH 12.3.9) EACH TIME THE SYSTEM IS SHUT DOWN. HOWEVER, NOTE THAT ANYTIME WATER IS COMPLETELY REMOVED FROM THE SEAL POTS OR SUMP TANK, THE INITIAL START-UP PROCEDURE MUST BE DONE AGAIN. FOR EXAMPLE, AFTER THE SYSTEM HAS BEEN TAKEN APART FOR CLEANING, OR AFTER AN EXTENDED SHUTDOWN WHERE THE WATER MAY HAVE EVAPORATED FROM THE TANK OR SEAL POTS. MARK STEPS "NA" ON THE CHECKLIST AS DIRECTED BY THE CONTRACTOR ENVIRONMENTAL DEPARTMENT.

12.2 "VERIFY/PERFORM" the following if Air Stripper # 1 is ON-LINE:

12.2.1 "VERIFY" that "Lockout/Tagout" in support of other inspection, servicing and maintenance activities have been removed in accordance with WSI 25-SW-0004 (if applicable). A checkmark indicates that the item is satisfactory. Mark "NA" if not applicable.

12.2.2 MV-6WA-XK105 (Air Stripper # 1 effluent isolation valve) is OPEN.

12.2.3 MV-6WA-XK119 (Air Stripper # 1 sump drain valve) is CLOSED.

12.2.4 MV-6WA-XK097 (Air Stripper # 1influent header drain valve) is CLOSED. Air Stripper # 1 sump is filled to 24 inches with potable water or treated groundwater. The sump tank is filled via the clean-out ports or through the water inlet port located on the cover. A checkmark indicates that the item is satisfactory.

12.2.5 PU-6WA-XK106 (Air Stripper # 1 effluent discharge pump) is PRIMED. If required, pour clean water in the pump's inlet port until it has filled the entire pump chamber. A check valve is supplied to keep the pump primed. Remove the top air bleed plug on the pump housing to let the air bleed out, then replace the plug and tighten. A checkmark indicates that the item is satisfactory.

12.2.6 F-6AR-XK060 (Air Stripper # 1 air filter) is in-place, in good condition and all inspection, servicing or maintenance per

Attachment G has been completed. A checkmark indicates that the item is satisfactory.

12.2.7 The air flow is 3600 cfm with no water running. Place the blower switch on "HAND" and adjust air flow to 3600 cfm with no water running. The blower damper handle is on the exhaust of the blower. A checkmark indicates that the item is satisfactory.

12.2.8 The inlet chamber to each stripper tray (referred to by the manufacturer as seal pots) is filled with potable or treated groundwater. The seal pots can be filled manually through the 1-inch inlet chamber filling ports or through the 4-inch clean out ports located on the end of the unit. The seal pots can also be filled by filling the stripper sump with clean water and running the stripper in the "CLEAN" cycle. A checkmark indicates that the item is satisfactory.

12.2.9 Document the air stripper status on the checklist. Air Stripper # 1 is now ready for normal operation.

12.3 "VERIFY/PERFORM" the following if Air Stripper # 2 is ON-LINE:

12.3.1 "VERIFY" that "Lockout/Tagout" in support of other inspection, servicing and maintenance activities have been removed in accordance with WSI 25-SW-0004 (if applicable). A checkmark indicates that the item is satisfactory. Mark "NA" if not applicable.

12.3.2 MV-6WA-XK124 (Air Stripper # 2 effluent isolation valve) is OPEN.

12.3.3 MV-6WA-XK061 (Air Stripper # 2 sump drain valve) is CLOSED.

12.3.4 MV-6WA-XK113 (Air Stripper # 2 influent header drain valve) is CLOSED.

12.3.5 Air Stripper # 2 sump is filled to 24 inches with potable water or treated groundwater. The sump tank is filled via the clean-out ports or through the water inlet port located on the cover. A checkmark indicates that the item is satisfactory.

12.3.6 PU-6WA-XK125 (Air Stripper # 2 effluent discharge pump) is PRIMED. A checkmark indicates that the item is satisfactory. If required, pour clean water in the pump's inlet port until it has filled the entire pump chamber. A check valve is supplied to keep the pump primed. Remove the top air bleed plug on the pump housing to let the air bleed out, then replace the plug and tighten.

12.3.7 F-6AR-XK088 (Air Stripper # 2 air filter) is in-place, in good condition and all inspection, servicing or maintenance per Attachment G has been completed. A checkmark indicates that the item is satisfactory.

12.3.8 The air flow is 3600 cfm with no water running. Place the blower switch on "HAND" and adjust air flow to 3600 cfm with no water

running. The blower damper handle is on the exhaust of the blower. A checkmark indicates that the item is satisfactory.

12.3.9 The inlet chambers to the stripper trays (referred to by the manufacturer as seal pots) is filled with potable or treated groundwater. The seal pots can be filled manually through the 1-inch inlet chamber filling ports or through the 4-inch clean out ports located on the end of the unit. The seal pots can also be filled by filling the stripper sump with clean water and running the stripper in the "CLEAN" cycle. A checkmark indicates that the item is satisfactory.

12.3.10 Document the air stripper status on the checklist. Air Stripper # 2 is now ready for normal operation.

12.4 "VERIFY/PERFORM" the following if Air Stripper # 1 is OFF-LINE:

12.4.1 MV-6WA-XK105 (Air Stripper # 1 effluent isolation valve) is CLOSED.

12.4.2 MV-6WA-XK119 (Air Stripper # 1 sump drain valve) is CLOSED.

12.4.3 MV-6WA-XK097 (Air Stripper # 1influent header drain valve) is CLOSED.

12.4.4 Document the air stripper status on the checklist. For other checklist items identified per steps12.2.4 through 12.2.10, mark "NA" if Air Stripper # 1 is OFF-LINE.

12.5 "VERIFY/PERFORM" the following if Air Stripper # 2 is OFF-LINE:

12.5.1 MV-6WA-XK124 (Air Stripper # 1 effluent isolation valve) is CLOSED.

12.5.2 MV-6WA-XK061 (Air Stripper # 1 sump drain valve) is CLOSED.

12.5.3 MV-6WA-XK113 (Air Stripper # 1influent header drain valve) is CLOSED.

12.5.4 Document the air stripper status on the checklist. For other checklist items identified per steps12.2.4 through 12.2.10, mark "NA" if Air Stripper # 1 is OFF-LINE.

13.0 UV REACTOR MECHANICAL SETUP

This section provides instructions for the mechanical setup of the treatment facility UV Reactor. The checklist for this section is presented in Enclosure 4.

NOTES:

A DASHED LINE (Dwg # 652-M-02) SURROUNDS COMPONENTS THAT MAKE UP THE UV REACTOR. THE MAJORITY OF THE COMPONENTS REFERENCED PER THIS SECTION ARE WITHIN THE DEFINED AREA.

THE SETUP OF COMPONENTS LOCATED OUTSIDE THE DASHED LINE ARE PERFORMED PER SECTION 11.0, TREATMENT FACILITY PIPING.

13.1 The contractor Environmental Department will:

13.1.1 "VERIFY" that inspection, servicing and maintenance activities are completed and the UV Reactor is ready to be returned to normal service.

13.1.2 "VERIFY" that "Lockout/Tagout" in support of other inspection, servicing and maintenance activities have been removed in accordance with WSI 25-SW-0004 (if applicable).

13.1.3 Review the treatment facility flow schematic (WSTF drawing number 652-M-02) and the UV Reactor mechanical setup checklist (Enclosure 4).

13.1.4 Ensure the UV Reactor mechanical setup checklist (Enclosure 4) is updated as required to document the completion of the mechanical setup.

13.2 "VERIFY" that "Lockout/Tagout" in support of other inspection, servicing and maintenance activities have been removed in accordance with WSI 25-SW-0004 (if applicable). A checkmark indicates that the item is satisfactory. Mark "NA" if not applicable.

13.3 Visually inspect the UV Reactor. "VERIFY" that the UV Reactor and the general area are dry and free of obstructions. A check mark on the check list indicates a satisfactory condition. Contact the contractor Environmental Department if the conditions are unsatisfactory.

WARNING:

THE PERFORMANCE OF STEPS 13.5, 13.6 AND 13.7 REQUIRES "LOCKOUT/TAGOUT" OF THE UV REACTOR.

13.4 "PERFORM" "Lockout/Tagout" of the UV Reactor per Attachment G, Section 9.0 of this WJI. A check mark on the check list indicates completion of the step.

13.5 "VERIFY" that the UV Reactor is filled with water. If required connect facility water supply to UV Reactor drain line at a location downstream of

ECV-6WA-XK187 (UV Reactor drain valve). OPEN. ECV-6WA-XK187 and fill the UV Reactor with water. CLOSE ECV-6WA-XK187 upon completion. A check mark on the check list indicates a satisfactory condition or completion of the step.

NOTE:

REFER TO ATTACHMENT G, ENCLOSURE 5, "UV REACTOR EQUIPMENT DRAWINGS" DURING THE PERFORMANCE OF STEPS 13.6 AND 13.7.

13.6 OPEN. the lamp enclosure lids (lamp #'s 1 through 12). Visually inspect the quartz tube seals and end plate seals at each location (lamp #'s 1 through 12). The seals shall be in-place, secure with no evidence of leaks. A check mark on the check list indicates a satisfactory condition.

13.7 Visually inspect the UV Reactor lamps and lamp wires/connections at each location (lamp #'s 1 through 12). The UV Reactor lamps shall be properly installed and the lamp wires in good condition and properly connected. Refer to drawings provided in Attachment G, Enclosure 5. A check mark on the check list indicates a satisfactory condition.

13.8 "VERIFY/PERFORM" that the maintenance covers, lamp enclosure lids, power supply doors, etc. are in place and secured.

13.9 Remove "Lockout/Tagout" in accordance with WSI 25-SW-0004. A check mark on the check list indicates completion of the step.

13.10 "VERIFY/PERFORM" that ECV-6WA-XK187 (UV Reactor drain valve) is CLOSED. Document the valve position on the checklist.

13.11 "VERIFY/PERFORM" that the recirculation loop is setup per step 11.7. The UV Reactor is ready for system warm-up. A check mark on the check list indicates a satisfactory condition.

13.12 Document completion of the mechanical setup of the UV Reactor on the checklist (TPS/DR/comments, initials, date). The UV Reactor is now ready for normal operation.

14.0 SCALE CONTROL SYSTEM, SCALE CLEANING SYSTEM, EQUIPMENT AND INSTRUMENT AIR SYSTEM MECHANICAL SETUP

NOTES:

SPECIFIC INFORMATION REQUIRED TO ADJUST PU-6CI-XK078 (MAXIMUM PUMP OUTPUT, % SPEED, % STROKE, ETC.) WILL BE PROVIDED BY THE CONTRACTOR ENVIRONMENTAL DEPARTMENT.

A DASHED LINE (DWG # 652-M-02) SURROUNDS COMPONENTS THAT MAKE UP THE SCALE CONTROL SYSTM, SCALE CLEANING SYSTEM AND THE EQUIPMENT AND INSTRUMENT AIR SYSTEM. THE MAJORITY OF THE COMPONENTS REFERENCED PER THIS SECTION ARE WITHIN THE DEFINED AREA.

THE SETUP OF COMPONENTS LOCATED OUTSIDE THE DASHED LINE ARE PERFORMED PER SECTION 11.0, TREATMENT FACILITY PIPING.

NOTE:

"VERIFY/PERFORM" STEPS 14.1 THROUGH 14.3 AS REQUIRED FOR MECHANICAL SETUP OF THE SCALE CONTROL SYSTEM.

14.1 "VERIFY" that PU-6CI-XK078 (scale control chemical metering pump) is PRIMED. A check mark on the check list indicates a satisfactory condition. If required, perform the following to prime the pump:

14.1.1 "VERIFY/PERFORM" that MV-6CI-XK200 (scale control chemical tank drain valve) is CLOSED.

14.1.2 "VERIFY" that TK-6CI-XK076 (scale control chemical tank) has a sufficient amount of water or scale control chemical to submerge the foot valve located in the bottom of TK-6CI-XK076. If required add water or perform steps per Attachment G to add scale control chemical to TK-6CI-XK076 as directed by the contractor Environmental Department.

14.1.3 START PU-6CI-XK078.

14.1.4 While PU-6CI-XK078 is running set the speed knob to 80% and the stroke knob to 100%.

14.1.5 Turn the pump pressure control FULLY CLOCKWISE.

14.1.6 On the multi-function valve, turn the relief side (black knob) ¼ turn OPEN.

14.1.7 With a screw driver, rotate the bleed adjustment screw COUNTER-CLOCKWISE two full turns. When solution begins

to flow through the translucent bleed tubing, the pump is primed. STOP PU-6CI-XK078.

14.1.8 START PU-6CI-XK078 and let the pump inject solution into the discharge line.

14.1.9 CLOSE the bleed adjustment screw (rotate clockwise with a screwdriver).

14.1.10 Adjust the pump stroke length and/or speed (frequency) to a range approximately 25% higher than required for the process.

14.1.11 Slowly rotate the bleed adjustment screw COUNTER-CLOCKWISE until a small amount of solution begins to trickle down inside the bleed return tube. A small amount of solution pumped back to the tank with each stroke of the pump will allow gas and air to escape without air or gas locking in the pump head.

14.2 "VERIFY" that TK-6CI-XK076 (scale control chemical tank) has at least 10% headspace and a sufficient amount of scale control chemical to start operation of the treatment facility. If required perform steps to add scale control chemical to TK-6CI-XK076 as directed by the contractor Environmental Department. A check mark on the checklist indicates a satisfactory condition.

14.3 "VERIFY/PERFORM" the following to setup the valve configuration for the scale control system (document valve position on the checklist):

14.3.1 MV-6CI-XK077 (scale control chemical isolation valve) is OPEN.

14.3.2 MV-6CI-XK200 (TK-6CI-XK076 drain valve) is CLOSED.

14.3.3 MV-6CI-XK075 (TK-6CI-XK076 fill valve) is CLOSED.

NOTE:

"VERIFY/PERFORM" STEP 14.4 AND 14.5 FOR MECHANICAL SETUP OF THE SCALE CLEANING SYSTEM.

14.4 "VERIFY/PERFORM" the following to setup the valve configuration for the scale cleaning system (document valve position on the checklist):

14.4.1 ROV-6WA-XK092 (Air Stripper # 1 spent scale cleaning effluent isolation valve) is CLOSED.

14.4.2 ROV-6WA-XK129 (Air Stripper # 2 spent scale cleaning effluent isolation valve) is CLOSED.

14.4.3 MV-6WA-XK099 (TK-6WA-XK222 spent cleaning solution tank drain valve) is CLOSED.

14.4.4 MV-6CI-XK081 (scale cleaning solution isolation valve to Air Stripper # 1) is CLOSED.

14.4.5 MV-6CI-XK074 (scale cleaning solution isolation valve to Air Stripper # 2) is CLOSED.

14.4.6 MV-6CI-XK199 (TK-6CI-XK064 scale cleaning solution tank drain valve) is CLOSED.

14.5 "VERIFY" that TK-6WA-XK222 (spent cleaning solution tank) has at least 10% headspace. If required, coordinate and schedule disposal of the spent solution per Attachment G.

NOTE:

"VERIFY/PERFORM" STEPS 14.6 THROUGH 14.9 FOR MECHANICAL SETUP OF THE EQUIPMENT AND INSTRUMENT AIR SYSTEM.

14.6 **"**VERIFY/PERFORM" that the equipment and instrument air supply (component # PU-6AR-XK131) is setup and operational**.** Review the maintainance log and ensure that the required inspection, servicing and maintenance has been completed. A checkmark indicates that the item is satisfactory

14.7 "VERIFY/PERFORM" that the air dryer valves are configured to enable the system. Review the maintainance log and ensure that the required inspection, servicing and maintenance has been completed. A checkmark indicates that the item is satisfactory.

14.8 "VERIFY" that "Lockout/Tagout" in support of other inspection, servicing and maintenance activities have been removed in accordance with WSI 25-SW-0004 (if applicable). A checkmark indicates that the item is satisfactory. Mark "NA" if not applicable.

14.9 **"**VERIFY/PERFORM" that MV-6AR-XK135 (isolation valve, equipment/instrument air to UV OX Unit) is OPEN. Document valve position on the checklist.

14.10 Document completion of the mechanical setup (section 14.0) the checklist.

ENCLOSURE 1

EXTRACTION WELL AND SUBGRADE PIPING SYTEM JUNCTIONS

VALVE LOG

Enclosure 1 - EXTRACTION WELL VALVE LOG

PFE-1 Wellhead Vault							PFE-5 Wellhead Vault						
MV-6WA-XK202	MV-6WA-XK004	MV-6WA-XK005	MV-6WA-XK006	MV-6WA-XK009	TPS/DR /Comments	Initials/Date	MV-6WA-XK203	MV-6WA-XK014	MV-6WA-XK015	MV-6WA-XK016	MV-6WA-XK019	TPS/DR /Comments	Initials/Date

Enclosure 1 - EXTRACTION WELL VALVE LOG

PFE-2 Wellhead Vault							PFE-7 Wellhead Vault						
MV-6WA-XK204	MV-6WA-XK024	MV-6WA-XK025	MV-6WA-XK026	MV-6WA-XK029	TPS/DR /Comments	Initials/Date	MV-6WA-XK241	MV-6WA-XK242	MV-6WA-XK243	MV-6WA-XK244	MV-6WA-XK247	TPS/DR /Comments	Initials/Date

EXTRACTION WELL VALVE LOG

PFE-3 Wellhead Vault							PFE-4A Wellhead Vault						
MV-6WA-XK205	MV-6WA-XK034	MV-6WA-XK035	MV-6WA-XK036	MV-6WA-XK039	TPS/DR /Comments	Initials/Date	MV-6WA-XK206	MV-6WA-XK044	MV-6WA-XK045	MV-6WA-XK046	MV-6WA-XK049	TPS/DR /Comments	Initials/Date

Enclosure 1 - SUBGRADE PIPING JUNCTION VAULT VALVE LOG

STA(N)21+52				STA(N)18+91				STA(PFE-2)8+00			
MV-6WA-XK051	MV-6WA-XK052	TPS/DR /Comments	Initials/Date	MV-6WA-XK053	MV-6WA-XK054	TPS/DR /Comments	Initials/Date	MV-6WA-XK255	MV-6WA-XK256	TPS/DR /Comments	Initials/Date

Enclosure 1 - SUBGRADE PIPING SYSTEM JUNCTION VAULT VALVE LOG

STA(N)2+72				STA 0+02				STA(S)8+70			
MV-6WA-XK055	MV-6WA-XK252	TPS/DR /Comments	Initials/Date	MV-6WA-XK058	MV-6WA-XK059	TPS/DR /Comments	Initials/Date	MV-6WA-XK256	MV-6WA-XK257	TPS/DR /Comments	Initials/Date

ENCLOSURE 2

INJECTION WELL AND INJECTION MANIFOLD

VALVE LOG

Enclosure 2 - INJECTION WELL VALVE LOG

PFI-2				PFI-1				PFI-4			
MV-6WA-XK165	MV-6WA-XK220	TPS/DR /Comments	Initials/Date	MV-6WA-XK157	MV-6WA-XK221	TPS/DR /Comments	Initials/Date	MV-6WA-XK181	MV-6WA-XK048	TPS/DR /Comments	Initials/Date

Enclosure 2 - INJECTION WELL VALVE LOG

PFI-3											
MV-6WA-XK173	MV-6WA-XK095	TPS/DR /Comments	Initials/Date								

Enclosure 2 - INJECTION MANIFOLD VALVE LOG

Piping System to PFI-2			Piping System to PFI-1				
MV-6WA-XK160	MV-6WA-XK164	MV-6WA-XK216	MV-6WA-XK152	MV-6WA-XK156	MV-6WA-XK217	TPS/DR /Comments	Initials/Date

Enclosure 2 - INJECTION MANIFOLD VALVE LOG

Piping System to PFI-4			Piping System to PFI-3				
MV-6WA-XK176	MV-6WA-XK180	MV-6WA-XK218	MV-6WA-XK168	MV-6WA-XK172	MV-6WA-XK219	TPS/DR /Comments	Initials/Date

ENCLOSURE 3

SUBGRADE PIPING SYSTEM
HIGH POINT VENTS

VALVE LOG

Enclosure 3 - SUBGRADE PIPING HIGH POINT VENT VALVE LOG

STA(N)4+12			STA(S)3+00				STA(S)10+80			
MV-6WA-XK210	TPS/DR /Comments	Initials/Date	MV-6WA-XK209	MV-6WA-XK211	TPS/DR /Comments	Initials/Date	MV-6WA-XK208	MV-6WA-XK191	TPS/DR /Comments	Initials/Date

Enclosure 3 - SUBGRADE PIPING HIGH POINT VENT VALVE LOG

STA(S)14+90				STA(S)31+40			STA(S)34+10		
MV-6WA-XK207	MV-6WA-XK213	TPS/DR /Comments	Initials/Date	MV-6WA-XK214	TPS/DR /Comments	Initials/Date	MV-6WA-XK215	TPS/DR /Comments	Initials/Date

ENCLOSURE 4

TREATMENT FACILITY

PIPING SYSTEM VALVE LOG

AND

EQUIPMENT CHECKLISTS

Enclosure 4 - TREATMENT FACILITY PIPING VALVE LOG

Influent Isolation Valve-Facility Influent from Extraction Wells	Treatment Facility Sample Valve	Influent Isolation Valve-Facility Influent from Recirculation Loop	Influent Isolation Valve-Facility Influent from TK-6WA-XK148	Effluent Isolation Valve-Facility Effluent to Recirculation Loop	Isolation Valve downstream of PU-6WA-XK149	UV Reactor Influent Isolation Valve	UV Reactor Effluent Isolation Valve		
MV-6WA-XK082	MV-6WA-XK086	MV-6WA-XK258	MV-6WA-XK090	MV-6WA-XK146	MV-6WA-XK147	MV-6WA-XK139	MV-6WA-XK136	TPS/DR /Comments	Initials/Date

Enclosure 4 - TREATMENT FACILITY PIPING VALVE LOG

Effluent Isolation Valve-Facility Effluent to TK-6WA-XK148 Bypass	Treatment Facility Effluent Sample Valve	Effluent Isolation Valve-Facility Effluent to Injection Wells	Isolation Valve to AVV-6WA-XK189	Drain Valve - TK-6WA-XK222 (Spent Cleaning Solution)	Isolation Valve-Facility Water to Safety Shower/Eye Wash	Isolation Valve-Facility Water to TK-6WA-XK064	TK-6CI-XK076 Fill Valve		
MV-6WA-XK151	MV-6WA-XK142	MV-6WA-XK144	MV-6WA-XK201	MV-6WA-XK099-	MV-6WA-XK184	MV-6WA-XK063	MV-6CI-XK075	TPS/DR /Comments	Initials/Date

Enclosure 4 - UV REACTOR MECHANICAL SETUP

Lockout/Tagout (other operations)	General Area	Lockout/Tagout of UV Reactor	UV ReactorWater Level	UV Lamp Enclosure Seals	UV Lamps and Lamp Wires	UV ReactorCovers, Lids, Doors, etc.	UV Reactor Lockout/Tagout Removal	ECV-6WA-XK187 (UV Reactor drain valve)	Recirculation Loop for System Warmup	TPS/DR /Comments	Date	Initials

Enclosure 4 - AIR STRIPPER MECHANICAL SETUP

AIR STRIPPER # 1

On-Line/Off-Line	Lockout/Tagout	MV-6WA-XK105 (effluent isolation valve)	MV-6WA-XK119 (sump drain valve)	MV-6WA-XK097 (influent header drain valve)	Sump Level	PU-6WA-XK106 (effluent discharge pump)	F-6AR-XK060 (air filter)	Air Flow	Stripper Trays	TPS/DR /Comments	Date	Initials

AIR STRIPPER MECHANICAL SETUP

AIR STRIPPER # 2

On-Line/Off-Line	Lockout/Tagout	MV-6WA-XK124 (effluent isolation valve)	MV-6WA-XK061 (sump drain valve)	MV-6WA-XK113 (influent header drain valve)	Sump Level	PU-6WA-XK125 (effluent discharge pump)	F-6AR-XK088 (air filter)	Air Flow	Stripper Trays	TPS/DR /Comments	Date	Initials

Enclosure 4 - SCALE CONTROL SYSTEM MECHANICAL SETUP

PU-6CI-XK078 (scale control chemical metering pump) PRIMED.	TK-6CI-XK076 (scale control chemical tank)	MV-6CI-XK077 (scale control chemical isolation valve)	MV-6CI-XK200 (TK-6CI-XK076 drain valve)	MV-6CI-XK075 (TK-6CI-XK076 fill valve)					TPS/DR /Comments	Date	Initials

Enclosure 4 - SCALE CLEANING SYSTEM MECHANICAL SETUP

ROV-6WA-XK092 (Air Stripper # 1 spent scale cleaining effluent isolation valve)	ROV-6WA-XK129 (Air Stripper # 2 spent scale cleaning effluent isolation valve)	MV-6WA-XK099 (TK-6WA-XK222 spent cleaning solution tank drain valve)	MV-6CI-XK081 (scale cleaning solution isolation valve to Air Stripper # 1)	MV-6CI-XK074 (scale cleaning solution isolation valve to Air Stripper # 2)	MV-6CI-XK199 (TK-6CI-XK064 scale cleaning solution tank drain valve)	TK-6WA-XK222 (spent cleaning solution tank)			TPS/DR /Comments	Date	Initials

Enclosure 4 - EQUIP. & INSTRUMENT AIR MECH. SETUP

Air Compressor Maintenance	Lockout/Tagout (other operations)	MV-6AR-XK135 (isolation valve, equipment/instrument air to UV OX Unit)	Air Dryer Setup	TPS/DR /Comments	Date	Initials

Attachment F – Spares Inventory

UV Reactor Unit Spare Parts

9-UV lamps
3-Quartz tubes
12-Quartz tube seal kits
24-UV lamp holder assembly wing nuts
50-Quartz tube seal ring cap screws
50-Lamp enclosure endplate hex bolts
3-Transmittance controller assemblies
3-UV Reactor and endplate seals
2-Fuses of each type used in PLC enclosures

Air Stripper Spare Parts

1-Air stripper nozzles (set)
1-Softgoods kit for FCV-6WA-XK093/112
1-Softgoods kit for ROV-6WA-XK111/129/110/092
1-Softgoods kit for ROV-6WA-XK109/128
2-Fuses of each type used in PLC enclosures
1-Pump, motor, bearing, crankcase oil and grease (lot)

Process Piping Spare Parts

1-Rebuild kit for each size of Cla-Val flow control valve
3-Flange gaskets and bolt kits, for each size of flange
1-Spare liquid level switch of each type
1-Pressure gauge of each type
1-Temperature gauge of each type
1-Rebuild kit for each size of swing check valve
1-Rebuild kit for each size of gate valve
3-Rupture disks of each size and type
1-Air set (filter-regulator)
4-Blower inlet filter elements

Control System Spare Parts

1-SLC 5/04 processor module
1-SLC P2 power supply module
1-Allen-Bradley IA16 discrete input module
1-Allen-Bradley OA16 discrete output module
1-Allen-Bradley NI8 analog input module
1-Allen-Bradley NO4I analog output module
1-Allen-Bradley ASB remote I/O adapter module
1-Allen-Bradley SN scanner module
1-Phoenix Digital OCM fiber optic module

1-Selector switch, push button, and indicator light of each type used
2-Light bulbs of each type used
2-Fuses of each type used in PLC enclosures
1-Surge suppressor of each type used
5-Terminal blocks of each type used
2-Control relays of each type used, with bases

Leak Detection System Spare Parts

1-Sensor Interface Module, TTSIM-1
5-Fuse, 200mA, 250V, fast acting, TTDM-FUSE
1-Relay, TTDM-RELAY
1-Female End Termination, TT-FET-MC
1-Male End Termination, TT-MET-MC
5-Pin Connectors, TT-CK-MC-M
1-Connector Kit, TT3000-CK-MC-M/F
1-Box of Splice Buttons, 100 ea., TT-JSK-SL
1-Assorted Heat Shrink Tubing of Various Diameters

Consumables

1,500 pounds – citric acid
1000 gallons – polyphosphate scale control chemical

Special Tools

1-Quartz tube insertion tool
1-Cable Pulling Tool, TT-KELLUM-GRIP
1-Wire Stripping Tool, 16-26 AWG, TT-STRIPPER
1-Raychem portable text box
1-Pin and Socket connector, TT-TEST-TOOL,
1-Heat Shrink Crimp Tool, TT-CT-SCT-3000
1-Flameless Heating Tool, TT-ULTRATORCH

ATTACHMENT G

FACILITY MAINTENANCE PLAN

1.0 GENERAL INFORMATION

This attachment provides procedures for the maintenance of the Plume-Front Treatment Facility. The plan incorporates a preventative maintenance strategy that consists of:

- monitoring, inspection and periodic performance reviews designed to chart trends and detect changing system performance; and
- a preventative maintenance schedule that includes servicing, repair and replacement of components to minimize facility down-time and repair and maintenance activities.

The maintenance plan is presented in the following sections:

8.0 Baseline Data
9.0 Extraction and Injection Well Maintenance
10.0 Treatment Facility Maintenance and Review
11.0 Lockout/Tagout
12.0 Routine and Emergency Shutdown Tests
13.0 UV Reactor – Monthly Maintenance
14.0 UV Reactor Power Supply – Monthly Maintenance
15.0 UV Lamp Replacement – 3,000 Hour Maintenance
16.0 Quartz Tubes - 3,000 Hour Maintenance
17.0 Air Stripper Maintenance
18.0 Scale Cleaning System
19.0 Air Stripper – Scale Control Chemical System
20.0 Instrument And Equipment Air - Monthly Maintenance

2.0 DRAWINGS AND REFERENCES

2.1 All treatment system process equipment and system components will be maintained per the manufacturer's instructions and recommendations. Copies of the manufacturer's operation and maintenance manuals, cut sheets, material specifications, and warranties for all facility equipment and components will be maintained by the contractor Environmental Department. A list of operation and equipment manuals is provided in Attachment A.

2.2 The extraction and injection wells will be maintained using Engineer Pamphlet 1110-1-27 as a guidance document. The latest copy of this publication will be maintained by the contractor Environmental Department. A list of other references is provided in Attachment A.

2.3 A flow schematic is provided by WSTF drawing number's 652-M-01, 652-M-02 and 652-M-03. Piping route plan and profile drawings and sections and details are presented in WSTF drawing number's 652-C-01 through 652-C-26. Building 650 electrical details are presented in WSTF drawing number's 650-E-01 through 650-E-09. A list of drawings is provided in Attachment B.

2.4 Well completion diagrams for the extraction and injection wells are provided in WSTF drawing number's 653-C-03, 654-C-03, 655-C-03, 656-C-03, 657-C-03 658-C-03, 660-C-02, 661-C-02, 662-C-02, and 663-C-02. The extraction well electrical details are presented in WSTF drawing number's 653-E-01, 653-E-02, 654-E-01, 654-E-02, 655-E-01, 655-E-02, 656-E-01, 656-E-02, 657-E-01, 657-E-02, 658-E-01, and 658-E-02. A list of drawings is provided in Attachment B.

3.0 ENCLOSURES

Enclosure 1, "Extraction and Injection Well Baseline Data"
Enclosure 2, "Extraction and Injection Well Maintenance Schedule"
Enclosure 3, "Treatment Facility Maintenance Schedule"
Enclosure 4, "Air Stripper Equipment Drawings and Electrical Schematics"
Enclosure 5, "UV Reactor Equipment Drawings and Electrical Schematics"
Enclosure 6, "Monthly Maintenance Checklist"
Enclosure 7, "3,000 Hour Maintenance Checklist"

4.0 SAFETY REQUIREMENTS

The following safety requirements and warnings are applicable to this entire attachment. Additionally, follow all warnings and notes that precede certain steps in this procedure. All PPE and other safety requirements specified in JHA HW-042 apply to facility maintenance operations.

4.1 Communications – phone or two-way radio required for operations.

4.2 In the event of minor cuts, scrapes, and abrasions, first aid will be administered in the field. In the event of any non-first aid injury, suspend operations, if appropriate, proceed to the dispensary and contact the WSTF Fire Department for assistance.

4.3 Confined Space Hazard Requirements/Warnings:

- Prior to entry into the extraction well and junction access vaults, qualified personnel will test and record the oxygen level to ensure that the vault atmosphere is safe.

- Under no circumstance is entry into the vaults authorized per this WJI when a hazardous atmosphere exists. Back out and contact the contractor environmental

department if a hazardous atmosphere exists. Hazardous atmospheres are defined as:
- Oxygen levels are less than 19.5%, or greater than 23.5%;
- The atmosphere contains greater than 10% of the lower flammability limit;
- The PEL or TLV is exceeded; or
- An IDLH condition exists.

4.4 UV Reactor - Ensure that all access covers are in the closed position before working near the UV reactor.

4.5 The contractor Environmental Department shall ensure that all ladders, scaffolds, work platforms, walking and working surfaces, etc., are in accordance with WSI 25-SW-0037, “Ladder Safety/Inspection Program”, WSI 25-SW-0007, “Personal Protective Equipment”, JPG 1700.1, Chapter 8.7, “Ladders, Scaffolds, and Elevated Platforms: How to Work with Them Safely”.

4.6 Certain operations within this attachment will involve working at greater than four foot potential elevation. The contractor Environmental Department shall ensure that fall protection is provided for all personnel performing work at elevations equal to or greater than four (4) feet above ground level. Contact contractor PAD Safety personnel for fall protection requirements when working at elevations over four feet.

4.7 Control access to the work area when performing maintenance. Only authorized personnel shall be in the general work area.

5.0 PERSONNEL REQUIREMENTS

5.1 A minimum of two Hazardous Waste Compliance Technicians trained as Groundwater Treatment Facility Technicians (per the WSTF Training Database). At the discretion of the contractor Environmental Department Section Supervisor or Project Leader, the operations can be performed by personnel per Steps 5.1.1 and 5.1.2:

5.1.1 Contractor Environmental Department technicians receiving “on-the-job” training for qualification as a Groundwater Treatment Facility Technicians under the direct supervision of the facility Project Leader or Certifying/Qualifying instructor who is also qualified as a Groundwater Treatment Facility Operator (per the WSTF Training Database). Personnel receiving "on-the-job" training are required to have completed WSTF Hazardous Waste Handler Training and training requirements 5.2, 5.3 and 5.4.

5.1.2 A qualified Groundwater Treatment Facility Technician (per the WSTF Training Database) who is assisted by personnel receiving "on-the-job" training for qualification as a Groundwater Treatment Facility Technician(s).

Personnel receiving "on-the-job" training are required to have completed WSTF Hazardous Waste Handler Training and training requirements per 5.2, 5.3 and 5.4.

5.2 All personnel actively involved in facility operations are required to have current confined space training per WSI 25-SW-0003, “Confined Space Entry Program,” categories Confined Space Entry SAF-06 and Confined Space Entry (Air Monitoring) SAF-07A (per the WSTF Training Database).

5.3 All personnel actively involved in facility operations are required to have current PPE Training (per the WSTF Training Database).

5.4 All personnel actively involved in facility operations are required to have current Lockout/Tagout training per WSI 25-SW-004, “Lockout/Tagout, The Control of Hazardous Energy” (per the WSTF Training Database).

6.0 EQUIPMENT

The equipment requirements are contained within the procedures preceding the applicable step(s).

7.0 SPECIAL REQUIREMENTS

7.1 The contractor Environmental Department Project Leader or Groundwater Treatment Facility Operator is responsible for scheduling the tasks in this Attachment.

7.2 The maintenance checklists are provided in Enclosures 6 and 7. The following Steps will be performed to document completion of the maintenance activity.

7.3 The checklists for the required maintenance items will be completed as follows:

7.3.1 A checkmark to indicate that the item is satisfactory and/or a number or description as directed by this WJI.

7.3.2 An “X” to indicate that the item is unsatisfactory, and/or a description of the unsatisfactory condition as directed by this WJI.

7.3.3 The personnel who performed the maintenance activity will initial the checklist verifying that he/she has completed the Steps/actions.

7.3.4 The personnel who performed the maintenance activity will record the time and date that the Steps/actions were performed on the checklist.

7.3.5 The maintenance checklists will be filed as part of the facility operating record.

7.4 Maintenance procedures for non-routine items are not included as part of this attachment. These items will be corrected through a TPS, DR, or contractor Environmental Department Department Task Memo.

8.0 BASELINE DATA

Baseline data and maintenance monitoring are essential parts of an effective preventative maintenance program. This section provides details for the baseline data requirements for the Plume-Front Treatment Facility.

8.1 Extraction and Injection Wells

8.1.1 Reliable baseline data are required to evaluate extraction and injection well performance. The contractor Environmental Department Department shall develop baseline data listed in Enclosure 1 as required to accurately evaluate well performance and detect performance trends over time. Throughout the life of the project, all baseline data shall be maintained as part of the facility operating record or other site environmental archives.

8.1.2 Technical guidance with respect to baseline data requirements is provided by USACE Pamphlet 1110-1-27.

8.2 Treatment Process

8.2.1 The majority of the baseline data (with respect to the treatment process) will be obtained from a series of tests performed during the initial start-up of the treatment system. Details are presented in the WSTF Plume-Front Stabilization Operation and Maintenance Plan and Interim Measures Plans and Specifications, June 11, 2002.

8.2.2 The object of the Validation Plan presented within the WSTF Plume-Front Stabilization Operation and Maintenance Plan and Interim Measures Plans and Specifications is to verify the treatment efficiency and determine the optimum operating parameters/conditions for the treatment process. These data (treatment efficiency, flowrates, temperatures, pressures, etc.) will serve as the baseline data for the treatment facility.

8.2.3 Throughout the life of the project, all baseline data shall be maintained as part of the facility operating record or other site environmental archives.

8.3 Groundwater Monitoring Wells

8.3.1 The overall performance of the treatment system will be monitored by analysis of samples from adjacent, downgradient monitoring wells. The

specific wells, the specified analyses, and the sampling frequency are identified in the Sampling Schedule per Attachment K.

8.3.2 During the initial stages of the project, the contractor Environmental Department shall develop baseline data as required to accurately evaluate the overall performance of the treatment system, and detect performance trends over time.

8.3.3 Throughout the life of the project, all baseline data shall be maintained as part of the facility operating record or other site environmental archives.

9.0 EXTRACTION AND INJECTION WELL MAINTENANCE

This section provides instructions for the maintenance of the Plume-Front Treatment Facility extraction and injection wells.

9.1 Extraction and injection well baseline data and the maintenance schedule are provided in Enclosures 1 and 2. Sampling and analyses for baseline data and maintenance monitoring will be performed per:

9.1.1 Extraction Well Effluent - Attachment L, Section 11.0, “Extraction Well Sampling” or per a separate Work Authorizing Document (WAD) (a TPS per WSI-09-SW-0001 or a DR per WSI 13-SW-0001)

9.1.2 Injection Well Influent – Attachment L, Section 10.0, “Treatment Facility Sampling” (using treatment facility effluent sample valve, MV-6WA-XK142) or per a separate WAD (a TPS per WSI-09-SW-0001 or a DR per WSI 13-SW-0001).

9.2 The contractor Environmental Department will schedule, coordinate and ensure the performance of extraction and injection well maintenance activities according to the schedule presented in Enclosure 2.

9.3 Throughout the life of the project, all maintenance activities shall be documented and maintained as part of the facility operating record or other site environmental archives.

9.4 Evaluation of well maintenance data and troubleshooting covers several areas of technical expertise including, but not limited to: geology; hydrogeology; microbiology; biogeochemistry; water chemistry; electrical engineering; corrosion engineering; and general well field maintenance. The contractor Environmental Department Manager, shall ensure that technically qualified personnel (WSTF personnel or off-site consultants) are readily available to interpret and evaluate data, and identify and chart trends to provide early detection of change in system performance.

9.5 Monthly Extraction and Injection Well Performance Review

On a monthly basis, the contractor Environmental Department shall evaluate the performance of the extraction and injection wells. The contractor Environmental Department will:

9.5.1 Review the flowrate and water level/drawdown data (per the Inspection Plan, Attachment M, Section 8.0).

9.5.2 Input/process data as required for long-term graphical analysis of the well performance, e.g., voltage/current, flowrate, drawdown vs. time.

9.5.3 Evaluate the data with respect to the baseline data (specific capacity, pump current draw, seasonal piezometric or water table data, etc.) and note any changes in specific capacity. Document any discrepancies. Provide an explanation for the discrepant condition.

9.5.4 Document or update the total gallons pumped during the life of the well and total hours on-line. Input/process the data as required for long-term graphical analysis of the well performance.

9.5.5 Evaluate the electrical power data (per the Inspection Plan, Attachment M, Section 13.0) with respect to the baseline data (the pump motor manufacturer's specifications for current draw, voltage, etc.). Note any discrepant conditions. Provide an explanation for the discrepant condition. Input/process the data as required for long-term graphical analysis of the well performance.

9.5.6 Review the weekly inspection record per the Inspection Plan, Attachment M, Sections 12.0 and 13.0. Ensure the general area is well maintained. Ensure WADs (a TPS per WSI-09-SW-0001, a DR per WSI 13-SW-0001, Environmental Department Task Memos, WSTF Form 456 and/or other site work orders) have been initiated to resolve any discrepant conditions.

9.5.7 The results of the monthly performance review shall be documented, signed and dated by the contractor Environmental Department. The report shall assesses the overall performance of the extraction and injection wells, document any discrepant conditions, and include any conclusions or recommendations. The report shall be submitted to the NASA Project Manager, and filed as part of the facility operating record or other site archives.

9.6 Quarterly System Well Performance Review

On a quarterly basis, the contractor Environmental Department shall assemble a team of technically qualified personnel as described per paragraph 9.4. The team

and the contractor Environmental Department Project Leader shall evaluate the performance of the extraction and injection wells, interpret and evaluate data, identify and chart trends as required to provide early detection of changes in system performance. The Project Leader will input/process the baseline data and maintenance monitoring data (identified per Enclosure 2) as required for long-term graphical and/or statistical analysis of the wells performance.

9.6.1 Visual Inspections – The team and Project Leader (or designated alternate) will examine, review and evaluate all visual inspections (video logs, documented inspection reports, photographs, etc.) in support of extraction and injection well activities performed during the quarter. When possible, they will evaluate the overall condition of the well by examining the as-built, baseline video log of the well with subsequent video logs. Identify and locate any areas of damage or deterioration. Identify any types of clogging conditions/mechanisms that could impair hydraulic efficiency.

9.6.2 Hydraulic Performance - The team and Project Leader (or designated alternate) will examine, review and evaluate the maintenance monitoring hydraulic performance data (including, but not limited to flowrates, drawdown/water levels, seasonal piezometric or water table data, gallons pumped, hours of service, well tests, etc.) with respect to the baseline data. They will identify any changes in specific capacity of the wells and if feasible, provide an explanation, basis or reasoning for the discrepancies. Develop and provide recommendations with respect to additional testing or inspection (well/pump performance testing, visual inspection of well/pump, etc.) and/or well rehabilitation activities required to resolve the discrepancy.

9.6.3 Electrical Power - The team and Project Leader (or designated alternate) will examine, review and evaluate the maintenance monitoring electrical data with respect to the baseline data. They will identify potential problems with the pump or electrical system and if required, provide recommendations as to testing and scheduling of service or maintenance.

9.6.4 Corrosion Issues - The team and Project Leader (or designated alternate) will examine, review and evaluate the maintenance monitoring groundwater chemistry data (including, but not limited to chemical data relating to well corrosion such as Eh, pH, conductivity, cations and anions, etc.) with respect to the baseline data (USACE Pamphlet 1110-1-27). They will identify chemical constituents, ionic states, shifts or transformations that are indicators of potential corrosion problems or material incompatibilities. If required, they will identify the potential corrosion mechanisms and provide recommendations with respect to additional corrosion assessment activities, additional visual examination and/or scheduling of well maintenance and repair activities.

9.6.5 Inorganic Chemistry - The team and Project Leader (or designated alternate) will examine, review and evaluate the maintenance monitoring groundwater chemistry data (including, but not limited to analyses and parameters related to scaling, inorganic encrustation, inorganic precipitation, etc. such as Eh, pH, conductivity, cations and anions, turbidity, sand/silt, temperature, etc.) with respect to the baseline data (reference USACE Pamphlet 1110-1-27). They will identify constituent concentrations (carbonate minerals, Fe, Ca, Mg, etc.) that are indicators of potential encrustation problems or inorganic precipitation problems in the wells or process equipment. If required, they will provide recommendations with respect to additional visual examination and/or scheduling of well/equipment maintenance, rehabilitation and repair activities.

9.6.6 Biological Testing - The team and Project Leader (or designated alternate) will examine, review and evaluate the maintenance monitoring biodetection test data (including, but not limited to biological activity reaction test (BART) and other biological tests) and groundwater chemistry data (including, but not limited to chemical data related to biofouling such as Fe, Mn, S, Eh, pH, etc.) with respect to the baseline data. They will identify chemical shifts or transformations that are indicators of potential biofouling problems. They will identify the indicators of potential biological activity and if required, provide recommendations for additional biological testing, visual examination or well rehabilitation.

9.6.7 The results of the quarterly performance review shall be in the form of a summary report signed and dated by the contractor Environmental Department. The report shall assesses the overall performance of the system wells, document any discrepant conditions, and any conclusions or recommendations. The report shall be submitted to the NASA Project Manager, and filed as part of the facility operating record or other site archives. This report may be combined with the Treatment Facility Maintenance Quarterly Review report described in Section 10.0 below.

9.7 Well rehabilitation and pump repair activities will be evaluated on a case-by-case basis using guidance provided by the USACE Pamphlet 1110-1-27 and/or other references. These activities will be performed per a separate WAD (a TPS, DR or contractor Environmental Department Department Task Memo) and maintained as part of the facility operating record.

10.0 TREATMENT FACILITY MAINTENANCE AND REVIEW

This section provides instructions for the maintenance of the Plume-Front Treatment Treatment Facility process equipment located in Building 650.

10.1 The contractor Environmental Department shall ensure that the treatment facility process equipment is maintained according the maintenance schedule presented in Enclosure 3.

10.2 The contractor Environmental Department is responsible for scheduling and coordinating the performance of maintenance activities.

10.3 Maintenance checklists are provided in Enclosures 6 and 7. Throughout the life of the project, all maintenance activities shall be maintained as part of the facility operating record or other site environmental archives.

10.4 Evaluation and troubleshooting covers several areas of technical expertise. The contractor Environmental Department shall ensure that technically qualified personnel (WSTF personnel or off-site consultants) are readily available to interpret and evaluate data, and identify and chart trends to provide early detection of deteriorating system performance.

10.5 All analytical data shall be filed and maintained as part of the facility operating record or other site environmental archives. Baseline data (contaminants of concern, treatment efficiency, treatment levels, optimum operating parameters, etc) are presented in the WSTF Plume-Front Stabilization Operation and Maintenance Plan and Interim Measures Plans and Specifications, June 11, 2002. Sampling and analyses for baseline and performance monitoring data will be performed per:

10.5.1 WJI ENV-0013, “Conventional Well Sampling Instructions”;

10.5.2 WJI ENV-0053, “Low-Flow Sampling Instructions” and WJI ENV-0020, “Westbay Well Sampling Instructions”; and

10.5.3 Attachment L, “Treatment Facility and Extraction Well Sampling”.

10.6 Performance Monitoring

10.6.1 The contractor Environmental Department shall ensure that analytical results are reviewed by QA within 24 hours of receipt

10.6.2 Following QA data review, if contaminants of concern are above specified treatment levels per DP-1255, the contractor Environmental Department Manager/Supervisor will notify the NASA WSTF Environmental Office, who in turn will notify NMED within 24 hrs. for analytical data exceedence.

10.6.3 Following QA data review, if contaminants of concern from groundwater monitoring wells identified in Attachment K exceed maximum contaminant levels (MCLs), the contractor Environmental Department

Manager/Supervisor will notify the NASA WSTF Environmental Office, who in turn will notify NMED within 24 hrs. for analytical data exceedence.

10.7 Monthly Treatment Facility Performance Review

On a monthly basis, the contractor Environmental Department Project Leader (or designated alternate) shall evaluate the performance and operation of the treatment facility. The Project Leader (or designated alternate) will:

10.7.1 Air Strippers - Review the gas and liquid flowrate data. Input/process the data as required for long-term graphical analysis of the equipment performance.

10.7.2 Air Strippers – Review the air stripper column pressure, water temperature and sump level and verify that the parameters are within manufacturer's specifications. Input/process the data as required for long-term graphical analysis of the equipment performance.

10.7.3 Air Strippers - Document or update the total gallons treated, total hours on-line, and total gallons pumped and hours on-line during the month (not required if data are collected by the instrumentation and control system instrumentation and control system). Input/process the data as required for long-term graphical analysis of the equipment performance.

10.7.4 UV Reactor - Review the influent flowrate data. Input/process the data as required for long-term graphical analysis of the equipment performance.

10.7.5 UV Reactor – Review the operation of the transmittance controllers and the UV lamps. Input/process the data as required for long-term graphical analysis of the equipment performance.

10.7.6 UV Reactor - Document or update the total gallons treated and total hours on-line during the month (not required if data are collected by the instrumentation and control system). Input/process the data as required for long-term graphical analysis of the well performance.

10.7.7 Treatment Facility - Review the weekly and monthly inspection records per the Inspection Plan, Attachment M, Sections 9.0, 10.0 and 11.0. Check data with respect to the equipment and instrument air that would indicate deteriorating system performance.

10.7.8 Review the flow data for the extraction wells, treatment facility influent, treatment facility effluent, and the injection wells (total gallons). The sum of effluent data (total gallons) from the extraction wells should approximately equal the influent to the treatment facility. The effluent

from the treatment facility shall approximately equal the sum of the influent (total gallons) to the injection wells.

10.7.9 The results of the monthly performance review shall be documented, signed and dated by the contractor Environmental Department Project Leader (or designated alternate). The report shall assesses the overall performance of the treatment facility, document any discrepancies, include any conclusions or recommendations, and shall be submitted to the NASA Project Manager, and filed as part of the facility operating record or other site archives. Document any discrepancies. Provide an explanation or reasoning for the discrepant condition.

10.7.10 The contractor Environmental Department Permit Compliance Officer will report monthly reports to the New Mexico State Engineer Office.

10.8 Quarterly Treatment Facility Performance Review

On a quarterly basis, the contractor Environmental Department shall assemble a team of technically qualified personnel to evaluate the overall performance of the treatment facility.

10.8.1 The Project Leader (or designated alternate) will input/process the baseline data, analytical data and performance monitoring data (operating parameters, treatment efficiency, analytical results, etc.) as required for long-term graphical and/or statistical analysis of the treatment system performance.

10.8.2 The team and the contractor Environmental Department Project Leader (or designated alternate) will review the extraction well, treatment facility, injection well, and monitoring well data (flowrate, total gallons, analytical results, etc.). They will interpret and evaluate the data, assess the overall performance of the treatment system, and identify and chart trends as required to provide early detection of deteriorating system performance.

10.8.3 The team and Project Leader (or designated alternate) will evaluate the results predicted by the groundwater model with the actual results (predicted vs actual contaminant mass removed, predicted vs actual contaminant concentrations at the plume-front, predicted vs actual contaminant concentrations within the plume, etc.).

10.8.4 The team and Project Leader (or designated alternate) will evaluate the Anomaly Log (Attachment D) to ascertain if adverse trends are indicated. The contractor Environmental Department Project Leader will take necessary corrective action to remedy identified adverse trends.

10.8.5 The results of the quarterly performance review shall be in the form of a report signed and dated by the contractor Environmental Department Project Leader (or designated alternate) and the team members. The report shall assesses the overall performance of the treatment system, document any discrepant conditions, and any conclusions or recommendations. The report shall be submitted to the NASA Project Manager, and filed as part of the facility operating record or other site archives.

10.8.6 The contractor Environmental Department Permit Compliance Officer will report quarterly to NMED HWB, Ground Water Quality Bureau and the State Land Commission.

11.0 LOCKOUT/TAGOUT

This section provides instruction for the Lockout/Tagout of the treatment facility process equipment.

11.1 General Requirements

The following subsection presents the general requirements for Lockout/Tagout.

11.1.1 All maintenance and servicing activities shall be conducted in accordance with WSI 25-SW-0004, "Lockout/Tagout, The Control of Hazardous Energy", JPG 1700.1, "JSC Safety and Health Handbook", Chapter 8.2, "Lockout/Tagout Practices" and OSHA Standard 29 CFR 1910.147, "The Control of Hazardous Energy (Lockout/Tagout)".

11.1.2 If an off-site contractor performs service or maintenance on equipment or systems at WSTF, the contractor's Lockout/Tagout procedure will be used unless the procedure does not comply with this WSI 25-SW-0004. Before the outside contractor's Lockout/Tagout procedure is used, the contractor Environmental Department Project Leader (or designated alternate) and the contractor PAD Safety personnel shall perform the following:

- Review WSI 25-SW-0004 with the outside contractor;
- Become familiar with the outside contractor's Lockout/Tagout procedure and evaluate it for compliance with this WSI 25-SW-0004;
- Inform the outside contractor of any significant differences between the two procedures; if anomalies exist that cannot be corrected, the WSTF procedure will be followed; and
- The contractor Environmental Department Project Leader (or designated alternate) will inform the affected employees that the equipment or system is to be locked or tagged out and inform them of any Steps that may cause confusion.

11.1.3 Per WSI 25-SW-0004, the "Authorized Employee" is defined as a person who locks out or tag out machines or equipment in order to perform servicing or maintenance. For operations per this WJI, authorized employees can include: the contractor Environmental Department Project Leader (or designated alternate Groundwater Treatment Facility Operator who is directing the activities), WSTF personnel (contractor Environmental Department and other site personnel) performing maintenance or support operations, and off-site personnel performing maintenance or support operations.

11.1.4 Per WSI 25-SW-0004, the "Affected Employee" is defined as an employee whose job requires him/her to operate or use a machine or equipment on which servicing or maintenance is being performed under Lockout or Tagout, or whose job requires him/her to work in an area in which such servicing or maintenance is being performed. For operations per this WJI, affected employees can include: NASA Environmental Program Manager and NASA Project Manager, the contractor Environmental Department Manager, Section Supervisor, contractor Environmental Sampling Coordinator, Project Leader and other Groundwater Treatment Facility Operators not involved in the maintenance operation as an authorized employee, and other site personnel (section supervisors, etc.) and off-site personnel as determined by the contractor Environmental Department Project Leader. Notification of affected employees can be made by the employer (the contractor Environmental Department Section Supervisor, Project Leader or designated alternate) or an authorized employee. The notification can be made by direct verbal communication, phone message, e-mail, or written notification.

11.1.5 Only tags and locks issued through contractor Work Control personnel shall be used at WSTF (refer to Attachments A and B of WSI 25-SW-0004). The contractor Environmental Department Project Leader (or designated alternate) will ensure that all Lockout/Tagout devices (installed by both WSTF and off-site contractor personnel) are in accordance with WSI 25-SW-0004.

11.1.6 The contractor Environmental Department Project Leader (or designated alternate) shall develop an internal system to serialize the Lockout/Tagout tags and document or log the tag serial # with respect to the authorized employee. The Lockout/Tagout log shall be filed and maintained as part of the facility operating record.

11.1.7 Only the person that contractor Work Control personnel issues the Lockout/Tagout device to is authorized to use that specific device. It will not be applied by another authorized person. The person who applies the

device is the one who removes it. When an authorized employee is unavailable, the Lockout/Tagout device can be removed upon concurrence by contractor PAD Safety personnel, contractor Environmental Department Section Supervisor, and Project Leader. The contractor Environmental Department Section shall:

- Verify that the authorized employee is not on-site. The contractor Environmental Department Project Leader shall inspect the general work area and contact the responsible Department Manager/Section Supervisor as to the whereabouts of the authorized employee and verify that the employee is not at WSTF. For off-site personnel, the Section Supervisor or Project Leader shall contact the off-site contractor and verify that the employee is not at WSTF;

- Make all reasonable efforts to contact the authorized employee to inform him/her that the Lockout/Tagout device will be/has been removed. The contractor Environmental Department Project Leader shall call the authorized employee's home phone, cellular phone, etc. and/or page the authorized employee using the remote area paging system per the current edition of WSP 25-0009, "WSTF Emergency Preparedness Plan" and inform the personnel that his/her Lockout/Tagout device has been or will be removed; and

- The contractor Environmental Department Project Leader shall ensure that the authorized employee has knowledge of the removal of the Lockout/Tagout device before he/she resumes work at WSTF.

11.1.8 When servicing and/or maintenance is performed by more than one authorized employee, they shall utilize a group Lockout or Tagout device. Each authorized employee shall attach a personal Lockout or Tagout device to the group Lockout device, group lockbox, or comparable mechanism when he/she begins work, and shall remove those devices when he/she stops working on the machine or equipment being serviced or maintained.

11.1.9 If the servicing or maintenance operation lasts into a second shift, the Lockout/Tagout will not be interrupted. The Lockout/Tagout that is in place will not be removed until the relieving authorized employee has received a "status briefing" from the responsible supervisor/system engineer and is ready to install his/her Lockout/Tagout.

11.1.10 The contractor Environmental Department has evaluated the treatment system equipment and the treatment system as a whole to identify the

energy sources, hazards and methods of control associated with maintenance and servicing of the facility. The energy sources, hazards and methods of control were evaluated with respect to the exemption per 29 CFR 1910.147 (c)(4)(i) as referenced by the JSC Safety & Health Handbook, JPG 1700.1, Chapter 8-2, Section 2, and to identify the maintenance and servicing activities where equipment-specific written procedures are not required. Written Lockout/Tagout are required for servicing and maintenance of the Air Strippers and the UV Reactor. Lockout/Tagout for all other actives will be performed per the general procedures listed in WSI 25-SW-0004 by an employee who is currently certified in Lockout/Tagout per the WSTF Training Data Base.

11.1.11 For maintenance and servicing activities where written procedures are required, the contractor Environmental Department Project Leader shall ensure periodic inspections are performed and documented per the requirements of WSI 25-SW-0004 and 29 CFR 1910.147(c)(6)(ii). All Lockout/Tagout inspection records shall be filed and maintained as part of the facility operating record.

11.1.12 The contractor Environmental Department Project Leader (or designated alternate) shall ensure that all electrical disconnects are clearly labeled/identified.

11.1.13 Testing or positioning of equipment or components thereof shall be performed in accordance with 29 CFR 1910.147(f)(1). In situations in which Lockout or Tagout devices must be temporarily removed from the energy isolating device and the machine or equipment energized to test or position the machine, equipment, or component thereof, the following sequence of actions shall be followed:

- Clear the machine or equipment of tools and materials in accordance with 29 CFR 1910.147 (e)(1). The work area shall be inspected to ensure that all nonessential items have been removed and to ensure that machine or equipment components are operationally intact;
- Remove employees in accordance with 29 CFR 1910.147 (e)(2). The work area shall be inspected to ensure that all employees have been safely positioned or removed;
- Remove the Lockout Tagout devices in accordance with 29 CFR 1910.147 (e)(2), per paragraph 11.1.7 of this Attachment.
- Energize and proceed with testing or positioning; and
- Deenergize all systems and reapply the energy control measures in accordance with 29 CFR 1910.147 (d), reinstall Lockout/Tagout devices per the respective Lockout/Tagout procedure and continue with maintenance and/or servicing.

11.2 Air Stripper Lockout/Tagout

11.2.1 Electrical details for Building 650 are presented in WSTF drawing number's 650-E-01 through 650-E-09. An electrical schematic for the air strippers is presented in Enclosure 4.

11.2.2 Notification of Employees - "PERFORM" notification of "Affected Employees" per paragraph 11.1.4.

NOTE
TREATMENT FACILITY MAY BE SHUTDOWN PER EMERGENCY SHUTDOWN PROCEDURES AS PART OF A TEST OF THE INSTRUMENTATION AND CONTROL SYSTEM EMERGENCY SHUTDOWN SOFTWARE.

11.2.3 Machine or Equipment Shutdown - "PERFORM" routine facility shutdown or "PERFORM" a test of the emergency facility shutdown per Attachment H or I of this WJI.

11.2.4 Energy Isolation - Deactivate the energy isolating devices so that the air stripper (pump motor and blower motor) is isolated from the energy sources. "VERIFY/PERFORM" that manual electrical disconnect switch or manual operated circuit breakers (refer to NEEP drawing number 8167-CP100/200 EL SCH, Enclosure 4) to Air Stripper # 1 and/or Air Stripper # 2 are in the "OFF" position. Install Lockout/Tagout devices per paragraph 11.1.8.

11.2.5 Energy Isolation - Isolate the system from inadvertent startup of the extraction well pumps (large volume flow, up to 1,300 gpm).

- "VERIFY/PERFORM" that the treatment influent isolation valve (MV-6WA-XK082) is CLOSED.
- Install Lockout/Tagout devices per paragraph 11.1.8.

11.2.6 Energy Isolation - Isolate the system from inadvertent discharge of scale cleaning solution (up to a 50% citric acid solution).

- "VERIFY/PERFORM" that the scale cleaning solution effluent isolation valve is CLOSED (MV-6CI-XK081 for Air Stripper # 1 and/or MV-6CI-XK074 for Air Stripper # 2; and
- Install Lockout/Tagout devices per paragraph 11.1.8.

NOTE:

THE AIR STRIPPERS DO NOT CONTAIN ANY POTENTIALLY HAZARDOUS STORED OR RESIDUAL ENERGY.

11.2.7 The general work area shall be visually inspected to verify that all employees have been safely positioned or removed.

11.2.8 Verification of Isolation

- At the air stripper blower local control, turn the local control switch to the manual or hand position and attempt to start the blower (BL-6AR-XK098 for Air Stripper # 1 and BL-6AR-XK117 for Air Stripper # 2). Refer to NEEP drawing number 8167-CP100/200 EL SCH, Enclosure 4; and
- Turn the control switch to the "OFF" position upon completion.

11.2.9 Verification of Isolation

– At the air stripper effluent discharge pump local control turn the local control switch to the manual or hand position and attempt to start the blower (PU-6WA-XK106 for Air Stripper # 1 and PU-6WA-XK125 for Air Stripper # 2). Refer to NEEP drawing number 8167-CP100/200 EL SCH, Enclosure 4; and
– Turn the control switch to the "OFF" position upon completion.

11.2.10 Document completion of Lockout/Tagout per the Lockout/Tagout checklist. Perform maintenance and servicing as directed.

11.2.11 Lockout/Tagout Device Removal - When the servicing or maintenance is completed, and the machine or equipment is ready to return to normal operating condition, the following Steps shall be taken:

- Check the machine or equipment and the immediate area around the machine or equipment to ensure that nonessential items have been removed, and that the machine or equipment components are operationally intact;
- Check the work area to ensure that all employees have been safely positioned or removed from the area;
- Verify that the controls are in neutral or off position;
- Remove the Lockout devices and reenergize the machine or equipment; and
- Notify affected employees per paragraph 11.1.4 that the servicing or maintenance is completed, and the machine or equipment is ready for use. Notification shall be given before the controls are applied, and after they are removed from the machine or equipment.

11.2.12 Document completion of Lockout/Tagout removal per the Lockout/Tagout checklist.

11.3 UV Reactor Unit Lockout/Tagout

11.3.1 Electrical details for Building 650 are presented in WSTF drawing number's 650-E-01 through 650-E-09. Equipment drawings and electrical schematics for the UV Reactor are presented in Enclosure 5.

11.3.2 Notification of Employees - "PERFORM" notification of "Affected Employees" per paragraph 11.1.4.

NOTE

TREATMENT FACILITY MAY BE SHUTDOWN PER EMERGENCY SHUTDOWN PROCEDURES AS PART OF A TEST OF THE INSTRUMENTATION AND CONTROL SYSTEM EMERGENCY SHUTDOWN SOFTWARE.

11.3.3 Machine or Equipment Shutdown - "PERFORM" routine facility shutdown or "PERFORM" a test of the emergency facility shutdown per Attachment H or I of this WJI.

11.3.4 Energy Isolation - Deactivate the energy isolating devices so that the UV Reactor Power Supply is isolated from the energy sources.

"VERIFY/PERFORM" that manual electrical disconnect switch or manual operated circuit breakers to Power Supply # 1 and Power Supply # 2 are in the "OFF" position.

- Install Lockout/Tagout devices per paragraph 11.1.8.

11.3.5 Energy Isolation - Isolate the system from inadvertent startup of the air stripper effluent discharge pumps (PU-6WA-XK106 and PU-6WA-XK125, large volume flow).

- VERIFY/PERFORM" that the UV Reactor influent isolation valve (MV-6WA-XK139) is CLOSED; and
- Install Lockout/Tagout devices per paragraph 11.1.8.

WARNING

DURING THE PERFORMANCE OF VENTING PER 11.3.6 THE FOLLOWING ARE REQUIRED:

SAFETY GLASSES (ANSI Z87.1-1989).

DURING VENTING, ENSURE THAT HEARING PROTECTION IS USED.

CONTROL ACCESS TO THE GENERAL WORK AREA.

11.3.6 Energy Isolation - Isolate the system from inadvertent actuation of UV Reactor pneumatic equipment (transmittance controllers).

- "VERIFY/PERFORM" that equipment and instrument air isolation valve to the UV Reactor (MV-6AR-XK135) is CLOSED.
- "VERIFY/PERFORM" that equipment and instrument air compressor tank is vented to ambient pressure as indicated by PI-6WA-XK133.
- "VERIFY/PERFORM" that the residual pressure in the air lines to the UV Reactor are vented to ambient pressure. Residual pressure in the air lines can be vented by engaging and disengaging the air solenoid drain valve. Refer to Calgon drawing number's 000-X-100069, "Pneumatic – UV Tower", and 000-D-900200, "Rayox UV Tower – External" and the manufacturer's information provided in Enclosure 5;
- "VERIFY/PERFORM" that manual electrical disconnect switch or manual operated circuit breaker to air compressor motor (PU-6AR-XK131 is in the "OFF" position; and
- Install Lockout/Tagout devices per paragraph 11.1.8 on the electrical disconnect and MV-6AR-XK135.

11.3.7 Stored or Residual Energy – Allow 1 hour for the Power Supply capacitors to discharge and the system to cool down.

11.3.8 The general work area shall be visually inspected to verify that all employees have been safely positioned or removed.

11.3.9 Verification of Isolation

- At the UV Reactor local control turn the local control, switch to the local position and attempt to start the UV Reactor; and
- Turn the control switch to the "OFF" position upon completion.

11.3.10 Document completion of Lockout/Tagout per the Lockout/Tagout checklist. Perform maintenance and servicing as directed.

11.3.11 Lockout/Tagout Device Removal - When the servicing or maintenance is completed, and the machine or equipment is ready to return to normal operating condition, the following Steps shall be taken:

- Check the machine or equipment and the immediate area around the machine or equipment to ensure that nonessential items have been removed and that the machine or equipment components are operationally intact;
- Check the work area to ensure that all employees have been safely positioned or removed from the area;
- Verify that the controls are in neutral or off position
- Remove the Lockout devices and reenergize the machine or equipment; and
- Notify affected employees per paragraph 11.1.4 that the servicing or maintenance is completed, and the machine or equipment is ready for use. Notification shall be given before the controls are applied, and after they are removed from the machine or equipment.

11.3.12 Document completion of Lockout/Tagout removal per the Lockout/Tagout checklist.

12.0 ROUTINE AND EMERGENCY SHUTDOWN TESTS

This section provides instructions for a test of the routine and emergency shutdown sequence.

12.1 Routine Shutdown

Perform the following as directed by the contractor Environmental Department Project Leader (or designated alternate) during a routine shutdown of the Plume-Front Treatment System:

12.1.1 On the startup/shutdown HMI screen, initiate routine shutdown by selecting “SHUTDOWN” tab.

12.1.2 “VERIFY” that the System Control step cycles from “13” (System Running) to “14” (Opening Recirc Block Valve) as indicated on the HMI screen.

12.1.3 “VERIFY” that the step cycles from “14” (Opening Recirc Block Valve) to “15” (Closing Effluent Block Valve) as indicated on the HMI screen.

12.1.4 “VERIFY” that the step cycles from “15” (Closing Effluent Block Valve) to “16” (Stopping Well Pumps & Treating Plant Water). NOTE: Steps 15 and 16 may be combined in the final production system.

12.1.5 "VERIFY" that the final two steps, "17" (Stopping UV Reactor system) and "18" (Stopping Air Strippers), of the shutdown sequence are completed and the system returns to Step 0 "System Shutdown".

12.1.6 Document completion of the above in the maintenance checklist. Mark N/A if the Steps are not performed.

12.2 Emergency Shutdown

At the instrumentation and control system, perform an emergency shutdown of the treatment system per Attachment H and I or push the EMERGENCY STOP button on the UV Reactor control panel as directed by the contractor Environmental Department Project Leader. "VERIFY" the following:

12.2.1 The EMERGENCY STOP alarm message is displayed at the UV Reactor display screen, I&C System computer, and the buzzer alarm sounds.

12.2.2 All pumps and equipment stop immediately.

12.2.3 All UV lamps are OFF immediately.

12.2.4 All Bldg. 650 automatic valves go the "fail safe" position (fails open/fails closed position).

FCV-6WA-XK093 is CLOSED
FCV-6WA-XK112 is CLOSED
ROV-6WA-XK143 is CLOSED
ROV-6WA-XK257 is OPEN

12.2.5 Acknowledge the Emergency Stop condition. "VERIFY" that the system checks the various interlocks and if clear, displays.

12.2.6 Document completion of the above in the maintenance checklist. Mark N/A if the Steps are not performed.

13.0 UV REACTOR TOWER – MONTHLY MAINTENANCE

This section provides instructions for monthly maintenance of the UV Reactor Tower.

13.1 "VERIFY/PERFORM" that Lockout/Tagout of the UV Reactor per Section 11.0 has been completed by the "Authorized Employees" (the personnel involved in servicing and maintenance of the UV Reactor).

13.2 Refer to Enclosure 5, Calgon drawing number 000-D-900200, "Rayox UV Tower – External". The UV lamp location #s are as indicated on sheet 2 of 2 of drawing number 000-D-900200.

13.3 Lamp Enclosures - Open the lids for the lamp enclosures on the UV Reactor. Visually inspect the twelve (12) lamp enclosures. The lamp enclosures shall be in good general condition and free from corrosion, deterioration, evidence of leaks with no evidence of unauthorized entry or tampering. Repeat Step as required for Lamp Enclosure #s 1 through 12.

13.4 Moisture Sensors – Visually inspect and ensure moisture sensors are in good condition, installed properly, and that no water moisture or dirt is obstructing their operation. Repeat Step as required for the moisture sensors for Lamp Enclosure #s 1 through 12.

13.5 Quartz Tubes - With a flashlight to view through the opened Lamp Enclosure lids, visually inspect the quartz tube inner and outer surfaces to ensure that they are clean and not damaged. If the quartz appears clouded, contact and proceed as directed by the contractor Environmental Department Project Leader (or designated alternate) to Section 16.0 for quartz tube removal and replacement of quartz tube.

13.6 O-Rings - Visually inspect O-rings for damage or burnout. Repeat Step as required for Lamp Enclosure #s 1 through 12.

13.7 When maintenance and servicing operations are complete, remove Lockout/Tagout per paragraph 11.3.11.

13.8 Document completion of the above in the maintenance checklist.

14.0 UV REACTOR POWER SUPPLY – MONTHLY MAINTENANCE

This section provides instructions for the monthly maintenance of the UV Reactor Power Supply.

14.1 “VERIFY/PERFORM” that Lockout/Tagout of the UV Reactor per Section 11.0 has been completed by the “Authorized Employees” (the personnel involved in servicing and maintenance of the UV Reactor).

14.2 Refer to Enclosure 3, Calgon drawing number’s 000-D-102043, “Control Panel Front View”, 000-D-102044, “Control Panel Door Rear View”, 000-D-101219, “Rayox Power Supply External”, and 393-D-102335, “Rayox Power Supply Internal”.

14.3 Open doors of the Rayox® Power Supply cabinet. Visually inspect for dirt buildup. Clean the interior of cabinet with a vacuum cleaner if necessary.

14.4 Visually inspect the fan exhausts and ensure airflow is not restricted.

14.5 When maintenance and servicing operations are complete, remove Lockout/Tagout per paragraph 11.3.11.

14.6 Document completion of the above in the maintenance checklist.

15.0 UV LAMP REPLACEMENT – 3,000 HOUR MAINTENANCE

This section provides instructions for the replacement of the UV Reactor UV lamps.

15.1 General Information

15.1.1 The UV lamps inside the UV Reactor emit the ultraviolet radiation required to break down the contaminants. Lamps deteriorate with usage and require replacement.

15.1.2 The total run-time of each lamp is recorded by the I&C software. The replacement frequency reveals information about the running load in the system and is useful in scheduling maintenance sessions and determining spares requirements. The UV Lamps must be replaced after they have been operating for 3,000 hours (125 days total).

15.1.3 This schedule must be adhered to in order to ensure effective water treatment. At the time when the UV lamps are being replaced, 3,000 hour maintenance to inspect the quartz tubes and transmittance controller wipers will be performed per Section 16.0. The following procedure outlines the Steps for replacing the UV Lamps.

15.2 "VERIFY/PERFORM" that Lockout/Tagout of the UV Reactor per Section 11.0 has been completed by the "Authorized Employees" (the personnel involved in servicing and maintenance of the UV Reactor).

15.3 Refer to Enclosure 3, Calgon drawing number's 000-D-900200, "Rayox UV Tower - External", and 000-D-900201, "Lamp Enclosure Component Detail". A flow schematic is provided by WSTF drawing number's 652-M-01, 652-M-02 and 652-M-03.

15.4 Refer to spill response procedures for incidental releases of inorganic and metallic mercury provided in Attachment N, Section 10.

WARNING

IN THE EVENT OF A BROKEN UV LAMP, IMMEDIATELY EVACUATE THE AREA AND CONTACT THE CONTRACTOR ENVIRONMENTAL DEPARTMENT PROJECT LEADER (OR DESIGNATED ALTERNATE). THE CONTRACTOR ORGANIZATION

PROJECT LEADER (OR DESIGNATED ALTERNATE) WILL INITIATE SPILL RESPONSE PROCEDURES PER ATTACHMENT N, SECTION 10.

Lamp Enclosures Opened, Connections Removed

15.5 The UV unit contains twelve (12) UV lamps. UV lamp location or position numbers are provided Enclosure 5, Calgon drawing number 000-D-900200. Under routine operation nine (9) lamps are operational.

15.6 Open the lamp enclosure lids and obtain access to the ends of the desired lamp(s) as directed by the contractor Environmental Department Project Leader (or designated alternate).

15.7 Disconnect the end lamp connections.

15.8 Loosen the wing nut on the end of the ceramic standoff where the lamp wire is terminated.

15.9 Lift the ring terminal end off of the screw.

15.10 Remove the wingnuts holding the ceramic crosspiece to the ceramic posts and then remove the lamp holder assembly, resting the lamp on the bottom of the quartz.

15.11 Repeat Steps 15.5 through 15.11 for the other end of the lamp and as directed by the contractor Environmental Department Project Leader (or designated alternate).

NOTE

IT IS IMPORTANT THAT UV LAMPS BE HANDLED PROPERLY TO PROTECT FROM BREAKAGE AND POTENTIAL CONTAMINATION. THE LAMP BULB MUST BE FREE OF ANY FOREIGN MATTER SUCH AS DUST, GLOVE POWDER, AND BODY OILS, BEFORE IT IS PLACED IN THE UV TOWER.

FOLLOW THESE GUIDELINES TO ENSURE LAMPS ARE NOT CONTAMINATED OR BROKEN WHILE HANDLING.

ALWAYS HANDLE UV LAMPS WITH EXTREME CARE AS THEY ARE FRAGILE AND EXPENSIVE.

SURVEY THE GENERAL WORK AREA AND ENSURE AT LEAST 60" OF UNOBSTRUCTED CLEANANCE IS AVAILABLE TO REMOVE THE UV LAMPS AND QUARTZ TUBES.

CLEAN GLOVES (EITHER LINT-FREE COTTON OR POWDER-FREE SURGICAL) MUST BE WORN AT ALL TIMES WHEN HANDLING UV LAMPS. DO NOT USE SURGICAL-TYPE GLOVES THAT HAVE BEEN TREATED WITH POWDER. THE POWDER CAN DAMAGE THE LAMPS.

Lamp Removal

15.12 Ensure that at least 60" of clearance is maintained to allow removal of the UV lamps and quartz tube. Wearing clean gloves (either lint-free cotton or powder-free surgical), carefully slide the old lamp through the quartz tube and out of the UV Tower.

15.13 Note the UV lamp serial # and the UV lamp position or location as identified by Enclosure 5, Calgon drawing number 000-D-900200. If the lamp is removed for service, ensure that the UV lamp is reinstalled in the same UV lamp location.

15.14 The contractor Environmental Department Project Leader (or designated alternate) shall ensure a designated storage area and packaging material is readily available for storage of the UV lamps. Store UV lamps in a protective cardboard sleeve as directed by the contractor Environmental Department Project Leader. Place the lamp in a safe, clean place and continue with the maintenance work as directed by the Project Leader (or designated alternate).

Quartz Tube Seals Inspection

15.15 Visually inspect the quartz tube O-ring seals for burns or leaks. Document completion and results of the inspection in the maintenance checklist. The quartz tube seals should be replaced whenever the UV Lamp is replaced. Contact the contractor Environmental Department Project Leader (or designated alternate) if the O-ring seals are defective or there is evidence of leaks. Proceed to Section 16.0 as directed by the Project Leader (or designated alternate) for replacement of the O-ring seals.

UV Lamp Replacement

15.16 Wearing gloves, place the new lamp (or the lamp being returned to service) into the quartz sleeve and slide the lamp until it is centered in the UV Tower, ensuring that the injection nipple on the side of the lamp is not pointing up. As the lamp is placed into the quartz tube, wipe the lamp with a lint-free cloth or kimwipe wetted with reagent grade or better methanol to remove any dust or dirt on the lamp.

15.17 Replace the lamp holder assembly, ensuring that the lamp end is seated correctly in the lamp holder, and secure with the wingnuts and hardware removed earlier.

15.18 Refer to Enclosure 5, Calgon drawing number 000-D-900200, "Lamp Enclosure Component Detail" and visually inspect the lamp installation. The UV lamp is correctly positioned when there is 1/8" gap between the top of the lamp and the top inner surface of the quartz tube.

15.19 Reconnect the electrical connections at both ends of the lamp. Make sure the high voltage wire and the lamp lead wire are both attached.

15.20 Close the Lamp Enclosure lids.

15.21 Old lamps will disposed of in accordance with WIWPS # 10-20-17.

Lockout/Tagout Removal

15.22 If maintenance and servicing operations are complete, remove Lockout/Tagout per paragraph 11.3.11.

15.23 Record the lamp running time in the inspection checklist as shown on the time lapse counter on the Rayox Power Supply or as given by the Operator Interface at the Control Panel.

15.24 At the instrumentation and control system (I&C) reset the lamp hours.

15.25 Contact responsible contractor Environmental Department personnel to schedule and coordinate disposal of spent UV lamps per WIWPS # 10-20-17, "Spent Ultraviolet Mercury Lamps".

15.26 Dispose of all contaminated debris (solvent contaminated rags, wipes, gloves, etc.) per WIWPS # 10-20-18, "Building 650 Contaminated Refuse".

15.27 When a lamp is removed from service, the information regarding its life should be sent or faxed to:

Calgon Carbon Corporation
P.O. Box 717
Pittsburgh, PA 15230
Fax: 412-787-6824

The documentation required is as follows:

- Customer name;
- Customer reference number;
- Lamp serial number;
- Lamp installation date;
- Lamp failure date (when applicable);
- Hour meter reading when lamp installed;

- Hour meter reading when lamp failed (when applicable);
- Number of starts;
- Brief history detailing circumstances leading up to lamp; and failure (when applicable).

This information can be recorded on the yellow Lamp Cards supplied with every lamp and faxed to Calgon Carbon Corporation.

15.28 Record details of the inspection, replacement of UV lamps, etc. in the maintenance checklist. Initial, sign and date as required to document completion and deliver the maintenance checklist to the contractor Environmental Department Project Leader (or designated alternate) for filing as part of the facility operating record.

16.0 QUARTZ TUBES - 3,000 HOUR MAINTENANCE

This section provides instructions for the removal and replacement of the UV Unit quartz tubes.

16.1 General Information

16.1.1 The quartz tubes inside the UV Reactor perform the vital task of encasing the UV Lamp while transmitting ultraviolet light. This section describes removal and replacement of: the quartz tube for maintenance to the quartz tube; the seals holding the quartz tube firmly in place; the transmittance controller wiper which keeps the quartz tube surface clean; and the transmittance controller air cylinder that drives the wiper assembly.

16.1.2 The quartz tube seals should be replaced whenever the UV Lamp is replaced. The ability of the transmittance controller to keep the quartz tube clean will vary depending on the water quality. When the quartz tube becomes heavily fouled, such that flushing the UV Reactor with clean water and even acid wash is ineffective, the transmittance controller may have to be replaced.

16.2 “VERIFY/PERFORM” that Lockout/Tagout of the UV Unit per Section 11.0 has been completed by the “Authorized Employees” (the personnel involved in servicing and maintenance of the UV Unit).

16.3 Refer to Enclosure 5, Calgon drawing number’s 000-D-102043, “Control Panel Front View”, 000-D-102044, “Control Panel Door Rear View”, 000-D-101219, “Rayox Power Supply External”, 393-D-102335, “Rayox Power Supply Internal” and 000-D-900201, “Lamp Enclosure Component Detail”. A flow schematic is provided by WSTF drawing number’s 652-M-01, 652-M-02 and 652-M-03.

16.4 Special Tools

Obtain the following special tools:

16.4.1 Quartz Tube Insertion Tool p/n D300732

16.4.2 Anti-seize spray for SS threads p/n 650524

16.4.3 Torque Wrench, 0-50 ft-lbs. or equivalent, 1 ft-lb graduations (calibrated per WJI SVC-MCAL-3060, "Calibration of Torque Handles, Hand Operated")

16.4.4 Torque Wrench, 0-5 ft-lbs. or equivalent, ½ ft-lb graduations (calibrated in inch-pounds per WJI SVC-MCAL-3060, "Calibration of Torque Handles, Hand Operated")

16.4.5 Leak Test Assembly consisting of:

- Pressure Gauge, minimum range 0-100 psig (calibrated per WSP 11-0001, "Control of Inspection, Measuring, and Test Equipment");
- Water Pressure Regulator; and
- Pressure Relief Valve (set pressure 80 psig).

NOTE

USE KRYTOX LUBRICANT OR EQUIVALENT AS DIRECTED BY THE CONTRACTOR ENVIRONMENTAL DEPARTMENT PROJECT LEADER (OR DESIGNATED ALTERNATE) TO PREVENT STAINSTEEL THREADED COMPONENTS FROM GALLING.

WARNING

CHEMICAL RESISTANT GLOVES (NYTEX) ARE REQUIRED AT ALL TIMES DURING THE PERFORMANCE OF THIS SECTION WHENEVER GROUNDWATER CONTAMINATED (NDMA AND DMN) MATERIALS/COMPONENTS ARE HANDLED.

CONTROLLED ACCESS TO THE GENERAL WORK AREA.

16.5 Draining the UV Reactor

Perform the following Steps as directed by the contractor Environmental Department Project Leader (or designated alternate) to drain the UV tower (TK-6WA-XK141):

16.5.1 The contractor Environmental Department waste transfer equipment is listed in Attachment N, Enclosure 1, Table 6.3. Transport the required

waste transfer equipment to the general work area and set up as directed by the contractor Environmental Department Project Leader (or designated alternate).

16.5.2 Contact responsible contractor Environmental Department personnel and coordinate/schedule disposal of contaminated groundwater in the 200 Area Evaporation Tanks per WIWPS # 10-20-13, "GW Treatment Aqueous Waste".

WARNING

THE FOLLOWING ARE THE MINIMUM SAFETY REQUIREMENTS FOR THE PERFORMANCE OF THE FOLLOWING STEPS

CHEMICAL RESISTANT GLOVES (NYTEX)

CHEMICAL RESISTANT, FULL-LENGTH, BIB-TYPE, BUTYL RUBBER APRONS.

FACE SHIELDS AND SPASH GOGGLES (IN COMPLIANCE WITH ANSI-Z87.1-1989).

CONTROLLED ACCESS – ONLY AUTHORIZED PERSONNEL ALLOWED IN THE GENERAL WORK AREA.

16.5.3 OPEN ECV-6WA-XK187 and start the waste transfer operation to drain the UV tower (TK-6WA-XK141). Continue operation until the UV tower (TK-6WA-XK141) is drained.

16.5.4 Contact the responsible contractor Environmental Department personnel and transport and discharge the waste/contaminated groundwater to the 200 Area Evaporation Tanks per WIWPS # 10-20-13, "GW Treatment Aqueous Waste".

Quartz Tube Removal

16.6 "VERIFY/PERFORM" that the drain valve (ECV-6WA-XK187) is OPEN.

16.7 "VERIFY/PERFORM" that the Lamp Enclosure lids on both ends of the desired UV lamp or quartz tube have been opened per Steps 15.5 through 15.11.

16.8 "VERIFY/PERFORM" that the UV lamps have been removed per Steps 15.12 through 15.14.

16.9 Check to ensure the transmittance controller has returned to the "Home Position". It should have retracted the wiper assembly back to the endplate that supports the air cylinder.

16.10 Remove the cap screws from the quartz tube seal ring on each end. There are six screws in each ring. The metal seal rings can be removed when all screws are out. Visually inspect the cap screws for thread damage.

NOTE

AVOID HITTING THE QUARTZ TUBE WITH ANY TOOL OR METAL PART. IT IS IMPORTANT THAT QUARTZ TUBES BE HANDLED PROPERLY TO PROTECT FROM BREAKAGE AND POTENTIAL CONTAMINATION. THE QUARTZ TUBE MUST BE FREE OF ANY FOREIGN MATTER SUCH AS DUST, GLOVE POWDER, AND BODY OILS, BEFORE IT IS PLACED IN THE UV TOWER.

FOLLOW THESE GUIDELINES TO ENSURE LAMPS ARE NOT CONTAMINATED OR BROKEN WHILE HANDLING.

ALWAYS HANDLE QUARTZ TUBES WITH EXTREME CARE AS THEY ARE FRAGILE AND EXPENSIVE.

SURVEY THE GENERAL WORK AREA AND ENSURE AT LEAST 60" OF UNOBSTRUCTED CLEANANCE IS AVAILABLE TO REMOVE THE UV LAMPS AND QUARTZ TUBES.

CLEAN GLOVES (EITHER LINT-FREE COTTON OR POWDER-FREE SURGICAL) MUST BE WORN AT ALL TIMES WHEN HANDLING UV LAMPS. DO NOT USE SURGICAL-TYPE GLOVES THAT HAVE BEEN TREATED WITH POWDER. THE POWDER CAN DAMAGE THE LAMPS.

16.11 Insert the Quartz Tube Insertion Tool into the quartz tube from the end opposite to the transmittance controller. Position it such that it is centered in the tower. It should protrude past both ends of the quartz sleeve. Use the screw in the end if desired to prevent the insertion tool from falling into the tower.

16.12 Remove the O-ring seal on the end of the quartz sleeve.

16.13 Gently push the quartz tube into the tower until it is almost flush with the endplate. Ensure the insertion tool remains in place.

16.14 Move around to the other side of the tower and remove the other quartz tube seal.

16.15 Gently pull the quartz tube through the tower unit until it is free. Keep the insertion tool in place to guide the travel of the quartz sleeve and support the transmittance controller wiper assembly.

16.16 The contractor Environmental Department Project Leader (or designated alternate) shall ensure a designated storage area and packaging material is readily available for storage of the UV Unit Quartz Tubes. Ensure the Quartz Tubes are stored in a secure safe place at all times while out of the UV Tower.

Quartz Tube Inspection

16.17 Inspect the inner and outer surfaces of the quartz tube for cleanliness. Remove any dust using methanol on kimwipes.

16.18 Inspect the quartz tube for chips or damage. The quartz tube should be replaced if cracked or badly scored. Initiate a DR per WSI 13-SW-0001. Determine and eliminate the cause of damage. Consult Calgon Carbon Corporation as required.

16.19 If the Quartz Tubes are heavily fouled or cloudy, chemical (acid) cleaning or hand scrubbing is necessary. Initiate a DR per WSI 13-SW-0001. Determine the cause of fouling. Contact contractor Work Control and initiate a Component Services Section (CSS) work order as required to clean the UV Tower Quartz Tubes.

Quartz Tube Seals Replaced

16.20 Remove and replace the quartz tube seals.

NOTE

MAINTENANCE PROCEDURES FOR THE UV REACTOR TRANSMITTANCE CONTROLLERS ARE PROVIDED IN STEPS 16.21 THROUGH 16.44. IF THE TRANSMITTANCE CONTROLLERS WERE NOT OPERATING PROPERLY, PERFORM STEPS 16.23 AND 16.44 AS DIRECTED BY THE CONTRACTOR ENVIRONMENTAL DEPARTMENT PROJECT LEADER (OR DESIGNATED ALTERNATE). OTHERWISE, PROCEED TO STEP 16.45 TO INSTALL THE QUARTZ TUBES IN THE UV UNIT.

NOTE

IF THE QUARTZ TUBES WERE FOULED, THE CONTRACTOR DEPARTMENT PROJECT LEADER (OR DESIGNATED ALTERNATE) WILL INVESTIGATE CAUSE AND IF NECESSARY REPLACE THE TRANSMITTANCE CONTROLLER WIPER AS DESCRIBED IN STEPS 16.21 THROUGH 16.42.

Transmittance Controller Wiper Assembly/Lamp Enclosure Assembly Removal

16.21 Remove the Quartz Tube Insertion Tool from the tower.

16.22 Remove the Lamp Enclosure and endplate (where the air cylinder is mounted).

16.23 Ensure Lockout/Tagout per subsection 11.3 (air supply to transmittance controllers).

16.24 Disconnect the moisture line tubing from the Lamp Enclosure.

16.25 Disconnect the high voltage conduit from the side of the Lamp Enclosure. Disconnect and pull the high voltage lamp wire back through the side of the enclosure. Disconnect the low voltage cable connecting the Lamp Enclosure to the low voltage termination box by disengaging the multiple connector.

16.26 Disconnect the inner and outer air lines from the air cylinder. Unhook the air cylinder from the support stand.

NOTE

THE LAMP ENCLOSURE AND ENDPLATE ASSEMBLY ARE HEAVY SO CARE MUST BE TAKEN WHEN REMOVING THE LAST HEX BOLT DURING THE PERFORMANCE OF STEPS 16.27 THROUGH 16.31. DO NOT LET THE ASSEMBLY FALL. DO NOT LIFT THE ASSEMBLY BY EITHER THE AIR CYLINDER OR THE WIPER ASSEMBLY.

WARNING

GET ADDITIONAL PERSONNEL AS REQUIRED TO SUPPORT LIFITING AND HANDLING OF HEAVY OR AWKWARD OBJECTS. ENSURE APPROPRIATE LIFTING TECHNIQUES ARE USED TO MINIMIZE THE POTENTIAL FOR MUSCLE/BACK STRAINS.

16.27 Remove the Lamp Enclosure and endplate together from the UV Tower by undoing the ten hex bolts at the endplate. There are two studs that will support the Lamp Enclosure and endplate assembly while removing the hex bolts. The ten hex bolts must be loosened first in a crisscross pattern and then completely removed.

16.28 When all hex bolts are removed, lift and pull the assembly away from the tower until the transmittance controller wiper has cleared the port in the tower.

16.29 Keep the transmittance controller wiper retracted to prevent damage to the air cylinder rod since a scratched or scored rod will damage the seals and cause air and/or water leaks.

16.30 Remove the old transmittance controller wiper assembly from the end of the rod of the air cylinder. This action requires the removal of the cap screw and washer at the base of the wiper assembly which retains the nut on the air cylinder rod.

16.31 Inspect the seals of the transmittance controller and the rod of the air cylinder for damage. Remove and replace as directed by the contractor Environmental Department Project Leader (or designated alternate).

Transmittance Controller Seals and Air Cylinder Inspection and Replacement

16.32 If a new transmittance controller air cylinder is required, follow Steps 16.33 through 16.36. Otherwise proceed to Step 16.37.

16.33 Note the position of the air cylinder and the proximity switches. The air fittings are opposite the Lamp Enclosure and the proximity switches are flat against the cylinder barrel. The proximity switches on the cylinder must be removed first by undoing two set screws.

16.34 The transmittance controller air cylinder can now be removed by undoing the two cap screws that fasten the holder blocks to the endplate. Inspect threads for damage and replace if necessary.

16.35 Install new transmittance controller air cylinder assembly by fastening the cap screws through the holder blocks into the endplate. The air cylinder may have to be rotated to ensure that the air fittings are opposite the Lamp Enclosure. This is done by loosening the jam nut at the nose of the air cylinder and then rotating the air cylinder in the holder blocks.

NOTE

ROTATION OF THE AIR CYLINDER INTO THE HOLDER BLOCKS SHOULD ONLY BE DONE BY GRIPPING THE FLATS AT THE NOSE OF THE CYLINDER. NEVER ROTATE THE CYLINDER BY GRIPPING THE BARREL AS THIS WILL DAMAGE THE CYLINDER INTERNAL SEAL BEYOND REPAIR.

16.36 Ensure the nut at the end of the rod on the air cylinder protrudes past the endplate enough so that it can be inserted into the wiper assembly. Replace the proximity switches on the cylinder. Their location may have to be verified when power is restored to ensure proper operation of the transmittance controller. (Refer to Section 4.2 of the Calgon manual on Troubleshooting as required.)

Transmittance Controller Wiper Assembly Installation

16.37 Install the new wiper assembly. It should be properly inserted into the end of the air cylinder rod and the retainer screw and washer replaced. The wiper assembly should then be fully retracted and centered with the quartz hole for easy installation back into the UV Tower. Centering the wiper assembly will prevent it from swinging once inside the tower, and make the quartz installation easier.

Tower and Endplate Seal Inspection and Replacement

16.38 Inspect the seal between the tower and the endplate for damage. Replace if necessary.

Lamp Enclosure Installation

16.39 Reinstall the Lamp Enclosure assembly on the UV Tower. Great care must be taken when using stainless steel screws as they will gall very easily damaging the threads beyond use. A general rule of thumb is that if a screw requires a tool to apply it then there is dirt or a damaged thread present. The screw should be replaced or the internal thread should be repaired.

16.40 Ensure that an anti-seize compound (p/n 650524) is applied on the hex bolts before reinstallation of the assembly. This has been previously done at the time of assembly of UV Tower but re-application may be necessary after continued service.

16.41 Secure the assembly to the tower by tightening opposite hex bolts to 20 foot-pounds (maximum 30 foot-pounds). Proper tightening pattern should be used to ensure even gasket seating. Refer to the torque pattern presented in Enclosure 5.

16.42 Reconnect the low voltage cable, the high voltage lamp wire and the eIectrica1 conduit, the air lines, and the moisture line. Reconnect the air cylinder to the support stand.

Quartz Tube Installation

16.43 From the transmittance controller side of the tower, guide the insertion tool through both the hole in the end plate and the wiper assembly right through the tower and out the other side. Carefully insert the quartz tube into the UV Tower from the opposite side of the tower to the air cylinder. Guide the quartz tube along the insertion tool. Do not use excessive force; a twisting motion is very effective. Be very careful not to have the end of the quartz tube make contact with any metal surfaces such as the wiper ring or tower endplate. The quartz may chip or break. Return the quartz tube to its normal position (centered horizontally in the tower).

16.44 Loosely install the quartz tube seals, seal rings, and cap screws.

NOTE

GREAT CARE MUST BE TAKEN WHEN USING STAINLESS STEEL SCREWS AS THEY WILL GALL VERY EASILY DAMAGING THE THREADS BEYOND USE. A GENERAL RULE OF THUMB IS THAT IF A SCREW REQUIRES A TOOL TO APPLY IT THEN THERE IS DIRT OR A DAMAGED THREAD PRESENT. THE NUT OR SCREW SHOULD BE REPLACED OR THE INTERNAL THREAD SHOULD BE REPAIRED. USE KYRTOX LUBRICANT OR EQUIVALENT AS DIRECTED BY THE CONTRACTOR ENVIRONMENTAL DEPARTMENT PROJECT LEADER (OR DESIGNATED ALTERNATE) TO PREVENT STAINLESS STEEL THREADED COMPONENTS FROM GALLING.

16.45 It is recommended that an anti-gall compound (pin 6505243) be applied on the cap screws before reinstallation of the assembly. This has been previously done at the time of assembly of UV Tower but re-application may be necessary after continued service. Excessive pressure when tightening screws can cause the Quartz Tube to break. Do not over-tighten (approximately 2 in-lb).

16.46 Apply hand pressure evenly to the quartz seal ring to evenly seat it on the quartz seal. Try to keep the quartz in the center of the hole in the endplate (prevent bottoming out) and also keep the quartz seal ring in the center of the quartz (prevent metal contact). While maintaining hand pressure on quartz seal ring, tighten cap screws on seal ring by hand. Begin to tighten the cap screws with a hex driver a quarter turn per cycle following the pattern shown in the figure below. The screw may have to be tightened by hand again before using the driver. THIS IS CRITICAL TO MAINTAINING AN EVEN LEAK-PROOF SEAL.

16.47 Very little torque need be applied to tighten the cap screws (approx. 2 in-lb). Inspect the quartz seal through the quartz tube. Flat even application should be evident. If leaking occurs, increase the torque by 2 in-lb on each cap screw of the leaking connection.

UV Reactor Leak Check

16.48 "PERFORM" the following:

16.48.1 Close MV-6WA-XK139 (UV influent isolation valve); and

16.48.2 Close MV-6WA-XK136 (UV effluent isolation valve) or ROV-6WA-XK143, and MV-6WA-XK146, MV-6WA-XK150, MV-6WA-XK151, and MV-6WA-XK142.

16.49 "PERFORM" the following for a leak test of the UV Reactor.

16.49.1 Configure the UV Reactor for leak check by first isolating the burst disk (RD-6SW-XK185) by inserting a blind flange "pancake" at the UV Reactor inlet. CLOSE MV-6WA-XK136, located on the Reactor discharge.

16.49.2 Connect the leak test equipment (as described per 16.6.5) to the UV Tower and facility water supply as directed by the contractor Environmental Department Project Leader (or designated alternate).

16.49.3 OPEN the facility water supply valve and slowly fill the tower with water. During the filling process visually inspect all mechanical connections (O-rings, gaskets, etc.) for evidence of leaks. If required, drain the tower per Step 16.7 and repeat Steps per Section 16.0 as directed by the contractor Environmental Department Project Leader (or designated alternate) to repair the leaks.

16.49.4 Slowly pressurize the system to about 50 psig. Visually inspect all mechanical connections (O-rings, gaskets, etc.) for evidence of leaks. If required, drain the tower per Step 16.7 and repeat Steps per Section 16.0 as directed by the contractor Environmental Department Project Leader (or designated alternate) to repair the leaks.

16.49.5 Slowly pressurize the system to about 80 psig using an external pressure source. Hold pressure for at least 10 minutes. Visually inspect all mechanical connections (O-rings, gaskets, etc.) for evidence of leaks. If required, drain the tower per Step 16.7 and repeat Steps per Section 16.0 as directed by the contractor Environmental Department Project Leader (or designated alternate) to repair the leaks.

UV Lamp Replacement

16.50 Replace the UV Lamp as per Steps 15.16 through 15.21.

16.51 If maintenance and servicing operations are complete, remove Lockout/Tagout per paragraph 11.3.11. Dispose of all contaminated debris (solvent contaminated rags, wipes, gloves, etc.) per WIWPS # 10-20-18, "Building 650 Contaminated Refuse". Dispose of mercury lamps in accordance with WIWPS # 10-20-17.

16.52 Record details of the inspection, replacement of wipers, quartz tube seals, etc. in the maintenance checklist. Initial, sign and date as required to document completion and deliver the maintenance checklist to the contractor Environmental Department Project Leader (or designated alternate) for filing as part of the facility operating record.

17.0 AIR STRIPPER MAINTENANCE

The following section provides instructions for the maintenance of the treatment system air strippers.

17.1 "VERIFY/PERFORM" that Lockout/Tagout of the Air Strippers per Section 11.0 has been completed by the "Authorized Employees" (the personnel involved in servicing and maintenance of the Air Strippers).

17.2 Refer to Enclosure 4, "Air Stripper Equipment Drawings and Electrical Schematics". A flow schematic is provided by WSTF drawing number's 652-M-01, 652-M-02 and 652-M-03.

NOTE

USE KYRTOX LUBRICANT OR EQUIVALENT AS DIRECTED BY THE CONTRACTOR ENVIRONMENTAL DEPARTMENT PROJECT LEADER (OR DESIGNATED ALTERNATE) TO PREVENT STAINSTEEL THREADED COMPONENTS FROM GALLING.

WARNING

CHEMICAL RESISTANT GLOVES (NITRILE, NYTEX OR BUTYL RUBBER) WHENEVER CONTAMINATED MATERIALS ARE HANDLED.

17.3 Remove the cleanout ports/access ports (Air Stripper #s 1 and 2) and visually inspect air stripper trays and spray nozzles for scale buildup. Upon completion, close all open ports and perform air stripper cleaning per Section 18.0 as directed by the contractor Environmental Department Project Leader (or designated alternate).

17.4 Remove the cleanout ports/access ports (Air Stripper #s 1 and 2) and visually inspect sump for sludge and scale buildup. Drain and clean the air stripper sumps per Step 17.7 as directed by the contractor Environmental Department Project Leader (or designated alternate).

17.7 Perform the following Steps as directed by the contractor Environmental Department Project Leader (or designated alternate) to drain and clean the air stripper sumps:

17.5.1 The contractor Environmental Department waste transfer equipment is listed in Attachment Q, Enclosure 1, Table 6.3. Transport the required waste transfer equipment to the general work area and set up as directed by the contractor Environmental Department Project Leader (or designated alternate).

17.5.2 Transport a contractor Environmental Department pressure washer to the general work area.

17.5.3 Contact responsible contractor Environmental Department personnel and coordinate/schedule disposal of contaminated groundwater in the 200 Area Evaporation Tanks.

WARNING

THE FOLLOWING ARE THE MINIMUM SAFETY REQUIREMENTS FOR THE PERFORMANCE OF THE FOLLOWING STEPS:

CHEMICAL RESISTANT, FULL-LENGTH, BIB-TYPE, BUTYL RUBBER APRONS.

CHEMICAL RESISTANT GLOVES (NITRILE, NYTEX OR BUTYL RUBBER).

FACE SHIELDS AND SPASH GOGGLES (IN COMPLIANCE WITH ANSI-Z87.1-1989).

CONTROLLED ACCESS – ONLY AUTHORIZED PERSONNEL ALLOWED IN THE GENERAL WORK AREA.

17.5.4 Start the transfer equipment (vacuum trailer, transfer pump, etc.) and drain the air stripper sump. Clean the interior of the air stripper sump with a power washer as directed by the contractor Environmental Department Project Leader (or designated alternate).

17.5.5 Upon completion, close all open ports/valves. Contact the responsible contractor Environmental Department personnel and transport the waste to the 200 Area Evaporation Tanks for disposal per WIWPS # 10-20-13, "GW Treatment Aqueous Waste".

WARNING

THE FOLLOWING SAFETY ITEMS ARE REQUIRED FOR THE PERFORMANCE OF THE FOLLOWING STEPS

SAFETY GLASSES WITH SIDE SHIELDS OR NON-VENTED GOGGLES.

OPTIONAL AIR FILTERING RESPIRATOR IN ACCORDANCE WITH THE CURRENT EDITION OF WSI-SW-0007, "PERSONAL PROTECTIVE EQUIPMENT" (OSHA 1910.134/ANSI Z88.2) TRAINING/FIT TESTING PER THE CURRENT EDITION OF WSI 25-SW-0001, "RESPIRATORY PROTECTION".

17.6 Remove and replace the air stripper air filters as directed by the contractor Environmental Department Project Leader (or designated alternate) to service the air stripper air filters.

17.7 Lubricate air stripper motors, blower, pump, etc. bearings, per the manufacturer's maintenance schedule (refer to Attachment A).

17.8 If maintenance and servicing operations are complete, remove Lockout/Tagout per paragraph 11.3.11. Dispose of all contaminated debris (solvent contaminated rags, wipes, gloves, etc.) per WIWPS # 10-20-18, "Building 650 Contaminated Refuse".

17.9 Record details of the inspection, air stripper cleaning, sump cleaning etc. in the maintenance checklist. Initial, sign and date as required to document completion and deliver the maintenance checklist to the contractor Environmental Department Project Leader (or designated alternate) for filing as part of the facility operating record.

18.0 SCALE CLEANING SYSTEM

This section provides instructions for setup and operation of the scale cleaning system in support of air stripper maintenance operations.

18.1 For Air Stripper # 1 chemical cleaning operations, "VERIFY" that PU-6CI-XK071 (Air Stripper # 1 scale cleaning chemical transfer pump) is PRIMED (free of air and suction pipe is full of liquid) and TK-6CI-XK064 has sufficient cleaning solution to complete the operation. If required, perform the following:

18.1.1 "VERIFY/PERFORM" that MV-6CI-XK199 (scale cleaning chemical tank drain valve) is CLOSED.

18.1.2 Check the liquid level of TK-6CI-XK064 (scale cleaning chemical tank). Ensure the level is above the discharge outlet of PU-6CI-XK071 (Air Stripper # 1 scale cleaning chemical transfer pump and the tank has sufficient cleaning chemical to complete the operation.

18.1.3 If required, OPEN MV-6WA-XK063 (potable water isolation valve) and add water to TK-6CI-XK064 or mix additional cleaning chemical per Step 18.5 as directed by the contractorEnvironmental Department Project Leader (or designated alternate). CLOSE MV-6WA-XK063 (potable water isolation valve).

WARNING

THE FOLLOWING IS REQUIRED FOR THE PERFORMANCE OF THE FOLLOWING STEPS.

CHEMICAL AND ACID RESISTANT GLOVES (NYTES, NITRILE, NEOPRENE OR BUTYL RUBBER).

FACE SHIELD AND SPLASH GOGGLES (IN COMPLIANCE WITH ANSI-Z87.1-1989).

CHEMICAL RESISTANT APRON.

CONTROLLED ACCESS TO THE GENERAL WORK AREA.

18.1.4 If required, remove the top air bleed plug on the pump housing to let the air bleed out, then replace the plug and tighten. The pump is now PRIMED. Collect and dispose of all solid waste (PPE, wipes, spill absorbent, etc.) per WIWPS # 10-20-18, "Building 650 Contaminated Refuse".

18.2 For Air Stripper # 2 chemical cleaning operations, "VERIFY" that PU-6CI-XK070 (Air Stripper # 2 scale cleaning chemical transfer pump) is PRIMED (free of air and suction pipe is full of liquid) and TK-6CI-XK064 has sufficient cleaning solution to complete the operation. If required, perform the following:

18.2.1 "VERIFY/PERFORM" that MV-6CI-XK199 (scale cleaning chemical tank drain valve) is CLOSED.

18.2.2 Check the liquid level of TK-6CI-XK064 (scale cleaning chemical tank) is above the discharge outlet of PU-6CI-XK070 (Air Stripper # 2 scale cleaning chemical transfer pump and the tank has sufficient cleaning chemical to complete the operation.

18.2.3 If required, OPEN MV-6WA-XK063 (potable water isolation valve) and add water to TK-6CI-XK064 or mix additional cleaning chemical per Step 18.5 as directed by the contractor Environmental Department Project Leader (or designated alternate). CLOSE MV-6WA-XK063 (potable water isolation valve).

18.2.4 Remove the top air bleed plug on the pump housing to let the air bleed out, then replace the plug and tighten. The pump is now PRIMED. Collect and dispose of all solid waste (PPE, wipes, spill absorbent, etc.) per WIWPS # 10-20-18, "Building 650 Contaminated Refuse".

18.3 "VERIFY/PERFORM" that the scale cleaning discharge is OPEN (as directed by the contractor Environmental Department Project Leader (or designated alternate)):

18.3.1 For Air Stripper # 1, MV-6CI-XK081 is partially OPEN and MV-6CI-XK074 is CLOSED.

18.3.2 For Air Stripper # 2, MV-6CI-XK074 is partially OPEN and MV-6CI-XK081 is CLOSED.

18.4 "VERIFY/PERFORM" the following to setup TK-6WA-XK222 (spent cleaning solution tank):

18.4.1 MV-6WA-XK099 (spent cleaning solution tank drain valve) is CLOSED.

18.4.2 Check the liquid level in TK-6WA-XK222 (spent scale cleaning solution tank) to ensure that the tank has sufficient capacity to support the operation and still maintain 10% head space. If required drain spent cleaning solution from TK-6WA-XK222 per Step 18.6.

18.5 "PERFORM" the following to add cleaning solution to TX-6CI-XK064 (scale cleaning solution tank):

NOTE

SPECIFIC INFORMATION FOR STRENGTH (MIXING OF THE SCALE CONTROL CHEMICAL) WILL BE PROVIDED BY THE CONTRACTOR ENVIRONMENTAL DEPARTMENT PROJECT LEADER. ENSURE 10% HEADSPACE IS MAINTAINED IN TK-6CI-XK064.

18.5.1 Check the amount of scale cleaning solution in TK-6CI-XK064 (scale cleaning system tank) and OPEN TK-6CI-XK064 access port.

18.5.2 OPEN MV-6WA-XK063 (potable water isolation valve) and add water to TK-6CI-XK064 as directed by the contractor Environmental Department Project Leader (or designated alternate).

18.5.3 START PM-6CI-XK188 (scale cleaning chemical mixer).

18.5.4 Slowly add scale cleaning chemical to TK-6CI-XK064 (scale cleaning system tank. Continue mixing until all scale cleaning chemical is dissolved. Ensure MV-6WA-XK063 (potable water isolation valve) is CLOSED.

18.5.5 STOP PM-6CI-XK188 (scale cleaning chemical mixer)

18.5.6 Secure the general work area. Collect and dispose of all solid waste (PPE, wipes, spill absorbent, etc.) per WIWPS # 10-20-18, "Building 650 Contaminated Refuse".

18.6 "PERFORM" the following as required to drain TK-6WA-XK222 (spent cleaning solution tank):

18.6.1 Contact responsible contractor Environmental Department personnel, schedule and coordinate movement of the spent cleaning solution to the 200 Area Evaporation Tank System per WSI 22-SW-0005, "Waste Management", WJI ENV-0038, "Waste Movement", WJI ENV-0021, "200 Area Evaporation Tank System Operation", and WIWPS # 10-20-13, "GW Treatment Aqueous Waste".

18.6.2 Setup the transport container (vacuum trailer, tank trailer, etc.) and waste transfer equipment (pumps, hoses, etc.) as directed by the contractor Environmental Department Project Leader (or designated alternate).

18.6.3 Install containment pans, plastic sheet, absorbent, etc. as required under mechanical hose connections, transfer pump, etc.

18.6.4 Ensure all transfer hoses are secured.

18.6.5 "VERIFY/PERFORM" that TK-6WA-XK076 is adequately vented.

18.6.6 OPEN MV-6WA-XK099 (spent cleaning solution drain valve).

18.6.7 If required, "VERIFY/PERFORM" that the transfer pump is primed.

18.6.8 START the transfer pump (or vacuum trailer) and start the transfer operation. During the operation, monitor the liquid level in the transport container (vacuum trailer, tank trailer, etc.). Ensure that 10% headspace is maintained (vacuum trailer, tank trailer, etc.).

18.6.9 Repeat Steps 18.6.6 through 18.6.8 as required to complete the waste transfer operation. STOP the transfer pumps (or vacuum trailer) and CLOSE MV-6WA-XK099 (spent cleaning solution drain valve) when the transport container is full or waste transfer operation is completed. Drain hoses, transfer pumps, etc. as

directed by the contractor Environmental Department Project Leader (or designated alternate).

18.6.10 Contact responsible contractor Environmental Department personnel. Collect and dispose of all liquid waste per appropriate WIWPS # 10-20-13, "GW Treatment Aqueous Waste".

18.6.11 Secure the general work area. Collect and dispose of all solid waste (PPE, absorbent, plastic sheet, etc.) per WIWPS # 10-20-18, "Building 650 Contaminated Refuse".

18.7 At the instrumentation and control system (I&C) initiate air stripper cleaning cycle as directed by the contractor Environmental Department Project Leader (or designated alternate).

18.8 Record details of the inspection (tank levels), gallons water added, pounds descaler added, etc., in the maintenance checklist. Initial, sign and date as required to document completion and deliver the maintenance checklist to the contractor Environmental Department Project Leader (or designated alternate) for filing as part of the facility operating record.

19.0 AIR STRIPPER – SCALE CONTROL CHEMICAL SYSTEM

19.1 "PERFORM" the following to add scale control chemical to scale control chemical tank (TK-6CI-XK-076):

19.1.1 The contractor Environmental Department Project Leader (or designated alternate) will initiate contractor Environmental Department Task Memo (WSTF Form 456) to add scale control chemical to TK-6CI-XK076.

19.1.2 Contact the contractor Environmental Department Project Leader (or designated alternate) for access to the treatment facility (Bldg. 650). The contractor Environmental Department Project Leader (or designated alternate) shall coordinate access and ensure that other facility operations do not present any safety hazards.

NOTE

THE CONTRACTOR ENVIRONMENTAL DEPARTMENT PROJECT LEADER (OR DESIGNATED ALTERNATE) SHALL ENSURE THAT THE CHEMICAL TRANSFER EQUIPMENT HAS BEEN THROUGHLY DECONTAMINATED OR HAS NOT BEEN USED TO TRANSFER ANY HAZARDOUS WASTE OR CONSTITUENTS.

19.1.3 The chemical transfer equipment (transfer pump and hoses) and any additional instructions or safety requirements will be as specified on the contractor Environmental Department Task Memo (WSTF Form 456).

19.1.4 Transport scale control chemical (55 gallon drums or bulk containers/tanker), transfer pumps, hoses and other support equipment to the treatment facility (Bldg. 650). Setup work station and transfer pump as directed by the contractor Environmental Department Project Leader (or designated alternate).

WARNING

THE FOLLOWING IS REQUIRED FOR THE PERFORMANCE OF THE FOLLOWING STEPS.

CHEMICAL AND ACID RESISTANT GLOVES (NYTES, NITRILE, NEOPRENE OR BUTYL RUBBER) ARE REQUIRED.

FACE SHIELD AND SPLASH GOGGLES (IN COMPLIANCE WITH ANSI-Z87.1-1989).

CHEMICAL RESISTANT APRON.

SAFETY SHOWER AND EYE WASH IN COMPLIANCE WITH ANSI-Z358.1-1990.

CONTROLLED ACCESS TO THE GENERAL WORK AREA.

19.1.5 OPEN MV-6CI-XK075 (scale control chemical fill valve) and transfer the scale control chemical to TK-6CI-XK076 (scale control chemical tank) as directed by the contractor Environmental Department Project Leader (or designated alternate). Ensure 10% headspace is maintained.

19.1.6 Upon completion, CLOSE MV-6CI-XK075 (TK-6CI-XK076 fill valve).

19.1.7 Secure the general work area. Clean and rinse empty containers and transfer equipment as directed by the contractor Environmental Department Project Leader (or designated alternate).

19.1.8 Contact responsible contractor environmenal organization personnel. Collect and dispose of all rinsate and liquid waste per WIWPS # 10-20-13, “GW Treatment Aqueous Waste”.

19.1.9 Collect and dispose of all solid waste (PPE, wipes, spill absorbent, etc.) per WIWPS # 10-20-18, “Building 650 Contaminated Refuse”.

19.2 Record details (tank levels), gallons control chemical added, etc. in the maintenance checklist. Initial, sign and date as required to document completion and deliver the maintenance checklist to the contractor Environmental Department Project Leader (or designated alternate) for filing as part of the facility operating record.

20.0 INSTRUMENT AND EQUIPMENT AIR - MONTHLY MAINTENANCE

20.1 Refer to the flow schematic (WSTF drawing number 652-M-02).

20.2 "VERIFY/PERFORM" that the air/water separator is drained.

20.3 "VERIFY/PERFORM" that any water in the air compressor tank has been vented.

20.4 "VERIFY/PERFORM" that the supply of lubricant in the oil lubricator is sufficient. Ensure appropriate pneumatic lubricating oil is used.

20.5 "VERIFY/PERFORM" that the supply of lubricant in the air compressor crankcase is sufficient. Ensure appropriate lubricating oil is used.

20.6 Document completion of the above in the maintenance checklist. Record details (large quantities of water, very low lubricant levels) in the maintenance checklist. Initial, sign and date as required to document completion and deliver the maintenance checklist to the contractor Environmental Department Project Leader (or designated alternate) for filing as part of the facility operating record.

ENCLOSURE 1

EXTRACTION AND INJECTION WELL BASELINE DATA

ENCLOSURE 1 - EXTRACTION AND INJECTION WELL BASELINE DATA

Data	Use/Purpose
Well Completion Diagrams	"As constructed" well construction records are used in well maintenance to provide a basis for comparison of past and present conditions, and for use in other calculations. At a minimum, diagrams shall contain an accurate geographic location and precise designation used by the project, accurate depth, diameter, casing and screen material type, screen slot size and screen length, filter pack type, particle size and dimension, grout type and dimensions, and well equipment descriptions and dates drilled and developed.
Boring Logs/Lithologic Logs	The precise geographic location and boring identification (with cross reference to subsequent well designations), accurate formation descriptions (including sediment and rock descriptions provided according to uniform accepted standards with accurate depths), and particle size descriptions of water-producing/accepting zones.
	A record of the character, depths, and thickness of geologic materials encountered by the drill as the borehole is advanced, with emphasis given to hydraulic properties of the materials. The depth at which geologic changes occur and at which samples are collected and described. A description of cutting samples collected at every change of geologic materials and at specified intervals.
	Changes in drilling action, that is, penetration rate, fluid loss, drilling noise, etc. Descriptions of unconsolidated sediments should note dominant grain size, sorting, and estimates of relative percentages of sizes. Grain shape and rounding are useful for estimating hydraulic properties. Color related to degree of weathering and oxidation-reduction is useful in determining degree of saturation. Descriptions of consolidated bedrock should note degree of cementation, induration, and fracturing. The depth at which saturated conditions occur should be noted. Changes in drilling fluid properties (gains or losses of fluids, changing specific gravity, etc.) should be noted, as they provide information on water-bearing zones.
Video Logs	Video documents the as-built condition and timing of subsequent well damage and deterioration. Types of clogging conditions can be identified visually with some background. A progression of videos in any particular well, especially from the original construction condition, provides a direct way to monitor changing conditions in the well (e.g., progressing screen corrosion or biofouling development).
Well Tests (step-drawdown, constant rate, slug test, etc.)	Used to determine aquifer characteristics (transmissivity, hydraulic conductivity, storage coefficient, etc.).
Specific Capacity Data, *Q/s*	Used to express the productivity of a well in terms of the discharge rate, Q, and the drawdown in the well, s. Specific capacity and specific acceptance are relatively sensitive indicators of hydraulic performance change in wells ("Groundwater and Wells," Driscoll, F.G. 1986).
Development Data	Detailed descriptions of well development (methods, time, acceptance tests, etc.).
Wellhead Pressure	Increase in system head pressure results in reduced pump output.

ENCLOSURE 1 - EXTRACTION AND INJECTION WELL BASELINE DATA

Data	Use/Purpose
Water Level Data	Water level data combined with flow data can be used to chart changes in the well specific capacity (aquifer and well loss) with respect to time.
Piezometric Data/Maps	Piezometric or water table maps provide information on "regional" head data that influence specific capacity, and help to illustrate anomalies around pumping wells. Since the water table or potentiometric surface varies seasonally and with outside stresses, a deeper pumping water level for a given discharge rate may not reflect a change in the well performance.
Electrical Power Data	Total kilowatt-hour (kWh) can be used to calculate and chart changes in motor or system performance. Power data along with flow and pressure data can be used to detect problems with either the pump or electrical system.
Biodetection Tests	BART and other biological testing used to determine the agressivity and composition of microorganisms associated with biofouling. Used to provide an early warning method of predicting the biological effects and a means of monitoring biological activity over time.
Groundwater Chemistry	Physical and chemical parameters necessary to predict clogging and corrosive conditions, and plot environmental change.
Fe (total, Fe^{2+}/Fe^{3+}, Fe minerals and complexes)	Indications of clogging potential, presence of biofouling, Eh shifts. Fe transformations are most common among redox-sensitive metals in the environment.
Mn (total, Mn^{2+}/Mn^{3+}, Mn minerals and complexes)	Indications of clogging potential, presence of biofouling, Eh shifts.
S (total, S^{2-}/S^{0}/SO_4^{2-}, S minerals and complexes)	Indications of clogging potential, presence of biofouling, Eh shifts.
Eh (redox potential)	Direct indication of probable metallic ion states, microbial activity.
pH	Indication of the acidity/basicity and likelihood of corrosion and/or mineral encrustation. Combined with Eh to determine likely mineral states present.
Conductivity	Indication of TDS content and a component of corrosivity assessment.
Major Ions	Carbonate, bicarbonate, F, Ca, Mg, Na, Cl determine the types of encrusting minerals that may be present and are used in saturation indices.
Turbidity	Indication of suspended particles content, suitable for assessment of relative changes indicating changes in particle pumping or fouling.
Sand/Silt Content	Indication of the success of development/redevelopment, potential for abrasion and clogging.

ENCLOSURE 2

EXTRACTION AND INJECTION WELL MAINTENANCE SCHEDULE

ENCLOSURE 2 - EXTRACTION AND INJECTION WELL MAINTENANCE SCHEDULE	
Maintenance	**Schedule**
Visual Inspection (extraction and injection wells)	
Video Logs	On all new wells, during pump service/maintenance, before and after well maintenance/well rehabilitation or every five years (whichever is sooner).
Down-Well Components	Documented visual inspection with photographs whenever well/pump components are pulled.
General Area	Weekly inspection per the Inspection Plan, Attachment M, Section 13.0.
Hydraulic Performance (extraction and injection wells)	
Flowrate/Water Leve	Per the Inspection Plan, Attachment M, Section 8.0 data are logged to the HMI harddrive for monthly review by the contractor environmental organization project leader (or designated alternate).
Graphical Analysis	Quarterly graphical review of data by designated contractor Environmental Department personnel.
Electrical Power Data (extraction wells)	
Current Draw (amps), Circuit	Quarterly review.
Circuit Resistance, Imbalance	
Groundwater Chemistry (extraction well effluent and injection well influent)	
Fe (total, Fe^{2+}/Fe^{3+}, Fe minerals and complexes)	Upon initial development of well and quarterly.
Mn (total, Mn^{2+}/Mn^{3+}, Mn minerals and	Upon initial development of well and quarterly.
S (total, S^{2-}/S^{0}/SO_4^{2-}, S minerals and complexes)	Upon initial development of well and quarterly.
Eh (redox potential)	Upon initial development of well and quarterly.
pH	Upon initial development of well and quarterly.
Conductivity	Upon initial development of well and quarterly.
Major Ions	Carbonate, bicarbonate, F, Ca, Mg, Na, Cl, etc. upon initial development and quarterly.
Turbidity	
Sand/Silt Content (evaluation)	Upon initial development of well and at pump test intervals.
Biodetection Test (extraction well effluent and injection well influent)	
BART (biological activity reaction	Upon initial development of well and quarterly, or at the discretion of the contractor Environmental Department Project Leader.
Other Biological Tes	As recommended by the contractor environmental organization project leader
Maintenance and Service (extraction wells and injection wells)	
Hydraulic/Pump Performance	As recommended by the contractor Environmental Department Project Leader.
Instrument Calibratic	Every two years or per the instrument manufacturer's schedule.

ENCLOSURE 3

TREATMENT FACILITY MAINTENANCE SCHEDULE

ENCLOSURE 3 - TREATMENT FACILITY MAINTENANCE SCHEDULE

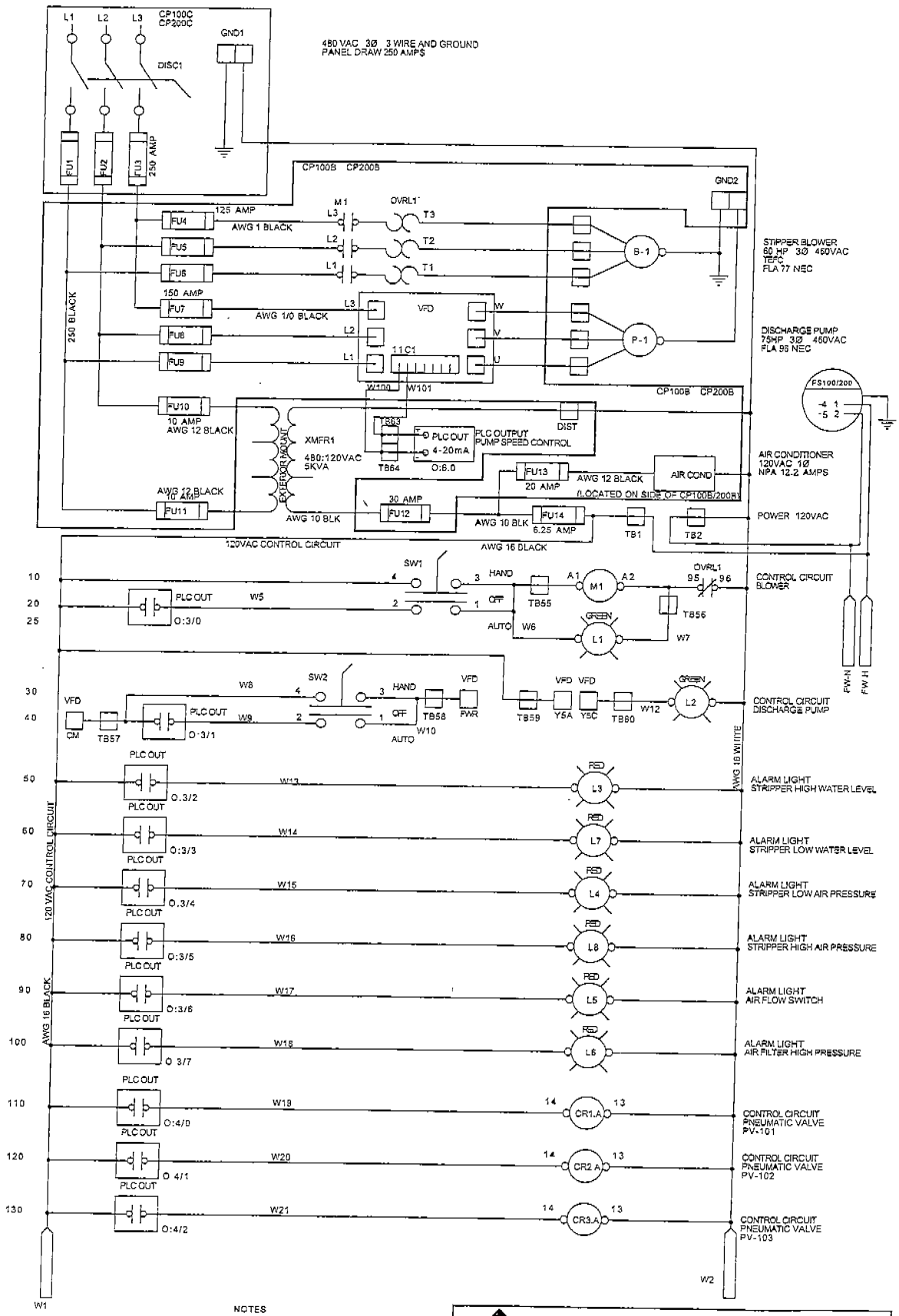
Item	Frequency	Description
Routine and/or Emergency Shutdown	Monthly Maintenance	Section 12.0 - A check/verification of the process control system (computer system, air stripper and UV Reactor PLC's, etc.) emergency and/or routine shutdown sequence and system interlocks.
UV Reactor	Monthly Maintenance	Section 13.0 - Visual inspection of the UV Reactor lamp enclosures, moisture sensors, quartz tubes, o-rings, etc.
UV Reactor Power Supply	Monthly Maintenance	Section 14.0 - Visual inspection and cleaning of the power supply unit.
UV Reactor - UV Lamp Replacement	3,000 Hour Maintenance	Section 15.0 - Removal and replacement of the UV lamps after every 3,000 hours of service.
UV Reactor - Tower	3,000 Hour Maintenance	Section 16.0 - Draining and inspection every 3,000 hours. Cleaning and flushing as required
UV Reactor - Quartz Tube Seals	3,000 Hour Maintenance	Section 16.0 - Removal and replacement of quartz tube seals every 3,000 hours or whenever UV lamps replaced.
UV Reactor - Quartz Tubes	3,000 Hour Maintenance	Section 16.0 - Removal and inspection every 3,000 hours or whenever UV lamps replaced. Quartz tube replacement or cleaning (as required)
UV Reactor - Transmittance Controllers	As Required	Section 16.0 - Removal and maintenance of the transmittance controller wipers and the transmittance controller air cylinders (as required).
Air Stripper – Stripper Trays	Monthly Maintenance	Section 17.0 - The air stripper trays and spray nozzles will be inspected for excessive scale deposits that could adversely affect the system performance. If required, a citric acid solution will be circulated through the stripper to remove scale
Air Stripper - Sump	Monthly Maintenance	Section 17.0 - The air stripper sumps will be inspected for sludge or solid material and if required, cleaned with pressure washer and flushed.
Air Stripper – Air Filters	Monthly Maintenance	Section 17.0 - The air filters for the air strippers will be inspected and serviced or replaced (in accordance with the filter manufacturer's recommendations).
Air Stripper - Lubrication	Monthly Maintenance	Section 17.0 - The air stripper blowers, motors, pumps, etc. will be lubricated/serviced in accordance with the filter manufacturer's recommendations.
Air Stripper - Scale Cleaning System	Monthly Maintenance	Section 18.0 - Monthly check of product and spent descaler tank levels and as required, a citric acid solution will be mixed, and circulated through the stripper to remove scale deposits. The spent descaler solution will be discharged to the evaporation tanks per site environmental procedures.
Air Stripper - Scale Control System	Monthly Maintenance	Section 19.0 - Monthly check of product tank level and as required, scale control chemical in 55 gallon drums or other containers will be transferred to the scale control system product tank.
Equipment and Instrument Air	Monthly Maintenance	Section 20.0 - The equipment and instrument air system will be inspected and serviced.

ENCLOSURE 3 - TREATMENT FACILITY MAINTENANCE SCHEDULE

Item	Frequency	Description
Treatment Facility - Performance	Monthly and Quarterly	Section 10.0 - The operation of the treatment facility will be evaluated on a monthly basis. The overall performance of the plume-front remediation system will be evaluated on a quarterly basis.
Relief Valves	5 years	Per a separate WAD (an Environmental Department Task Memo, TPS or DR) - The set pressure for relief valves will be tested every 5 years as required per WSI 09-SW-0005. PV/S recall items maintained on a general recall database.
Instrumentation	2 years or per manufacturer's recommended schedule.	Per a separate WAD (an Environmental Department Task Memo, TPS or DR) - Instrumentation (gauges, transducers, switches, etc.) will be calibrated to the manufacturer's specifications every 2 years or per the instrument manufacturer's recommended schedule. Recall items maintained on the site calibration recall database.

ENCLOSURE 4

AIR STRIPPER EQUIPMENT DRAWINGS
AND
ELECTRICAL SCHEMATICS



NOTES

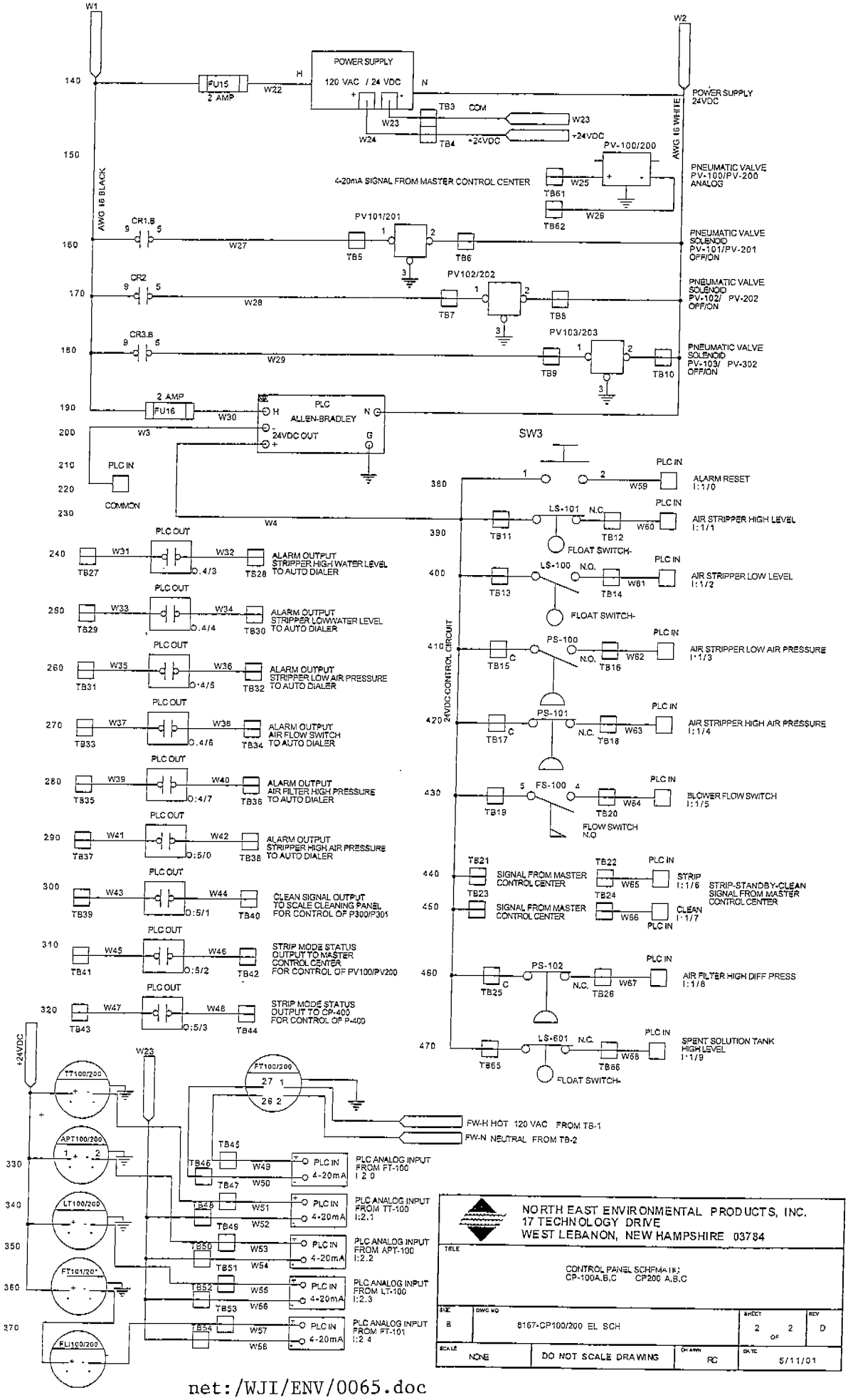
1) ALL WIRES ARE AWG 16 RED UNLESS OTHERWISE SPECIFIED

NORTH EAST ENVIRONMENTAL PRODUCTS, INC.
17 TECHNOLOGY DRIVE
WEST LEBANON, NEW HAMPSHIRE 03784

TITLE: CONTROL PANEL SCHEMATIC
CP-100A,B C CP200 A B,C

SIZE	DWG NO.	SHEET	REV
B	8167-CP100/200 EL SCH	1 OF 2	D

SCALE		DRAWN	DATE
NONE	DO NOT SCALE DRAWING	RC	5/11/01



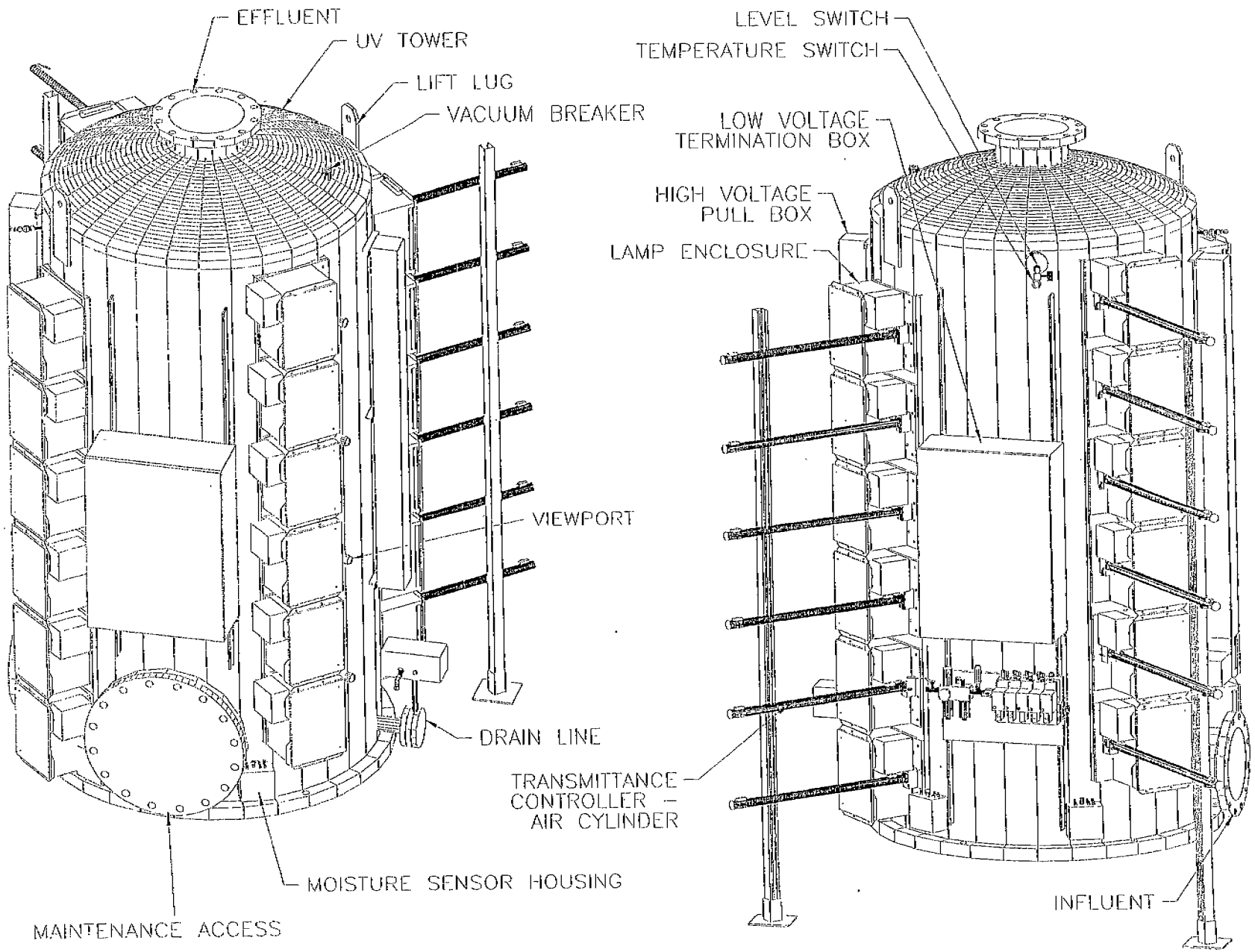
NORTH EAST ENVIRONMENTAL PRODUCTS, INC.
17 TECHNOLOGY DRIVE
WEST LEBANON, NEW HAMPSHIRE 03784

TITLE: CONTROL PANEL SCHEMATIC
CP-100A,B,C CP200 A,B,C

SIZE	DWG NO	SHEET	REV
B	6167-CP100/200 EL SCH	2 OF 2	D
SCALE: NONE	DO NOT SCALE DRAWING	CH APVD: RC	DATE: 5/11/01

ENCLOSURE 5

UV OXIDATION UNIT EQUIPMENT DRAWINGS
AND
ELECTRICAL SCHEMATICS



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REVISIONS

REV	DESCRIPTION	DATE	APPVD
A			
B			
C			
D			
E			
F			

NOTES

FINISH

MATERIAL

DIMENSIONS IN INCHES (unless otherwise specified)

TOLERANCES (unless otherwise specified)

ANGULAR	±0°30'	DECIMAL 2 PLACES ± .010
FRACTIONAL	± 1/32	DECIMAL 3 PLACES ± .005
DECIMAL 1 PLACE	± .015	DECIMAL 4 PLACES ± .0005

CALGON

CALGON CARBON CORPORATION

	NAME	SIGN	DATE
DRAFT.	T. Riddle		23 Jan/98
DESIGN			
CHECK			
APPVL			

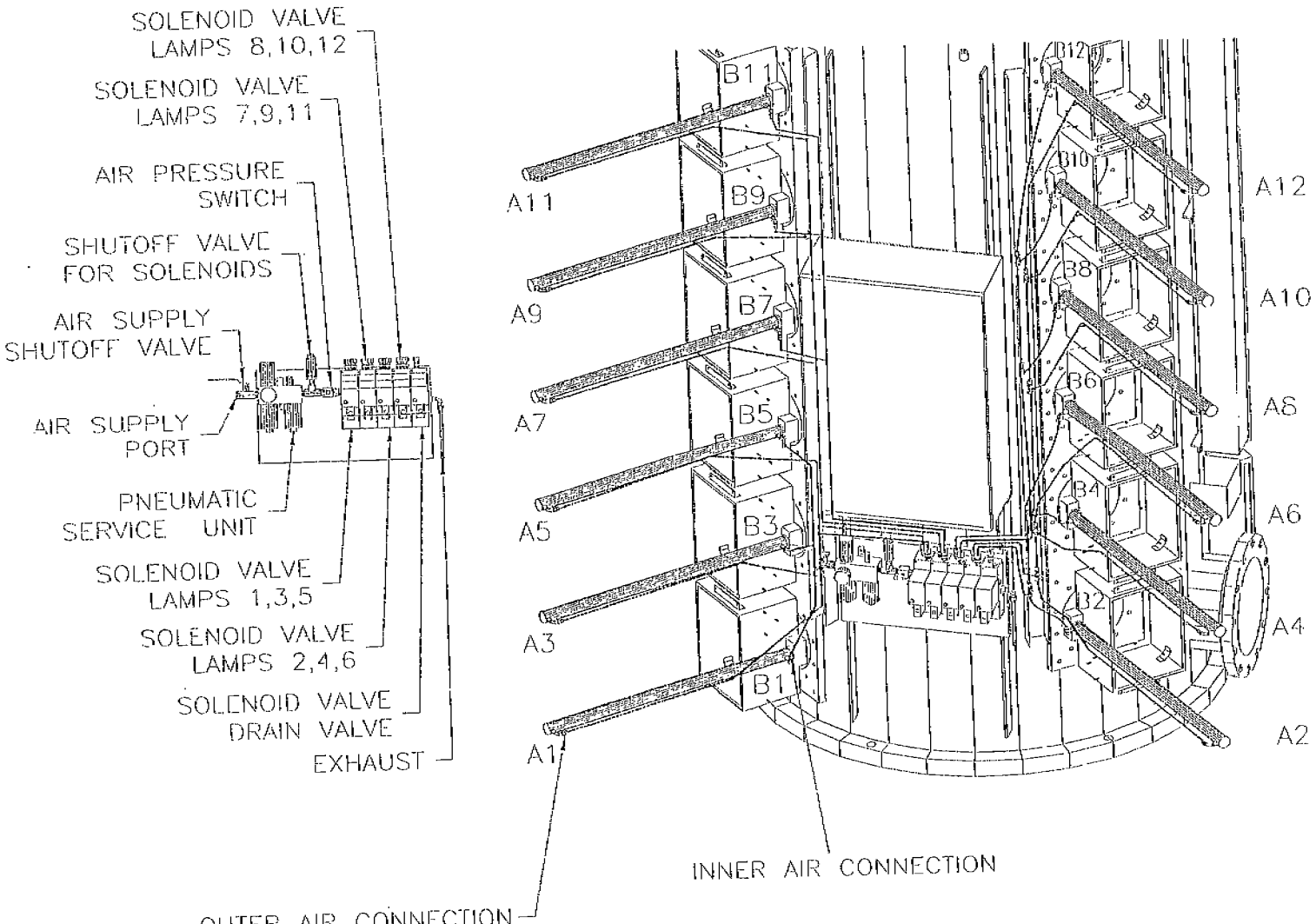
TITLE: RAYOX UV TOWER – EXTERNAL

SHEET No.: SHEET 1 OF 2

SIZE: MONE

DWG No.: 000-0-900200

REV: –



FOR PNEUMATIC SCHEMATIC SEE DWG 000-X-100069

SCALE 1.2

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REVISIONS

REV	DESCRIPTION	DATE	APP'D
A			
B			
C			
D			
E			

NOTES

FINISH

MATERIAL

DIMENSIONS IN INCHES (unless otherwise specified)

TOLERANCES (unless otherwise specified)

ANGULAR	±0°30'	DECIMAL 2 PLACES ±.010
FRACTIONS	±1/32	DECIMAL 3 PLACES ±.005
DECIMAL 1 PLACE	±.015	DECIMAL 4 PLACES ±.0025

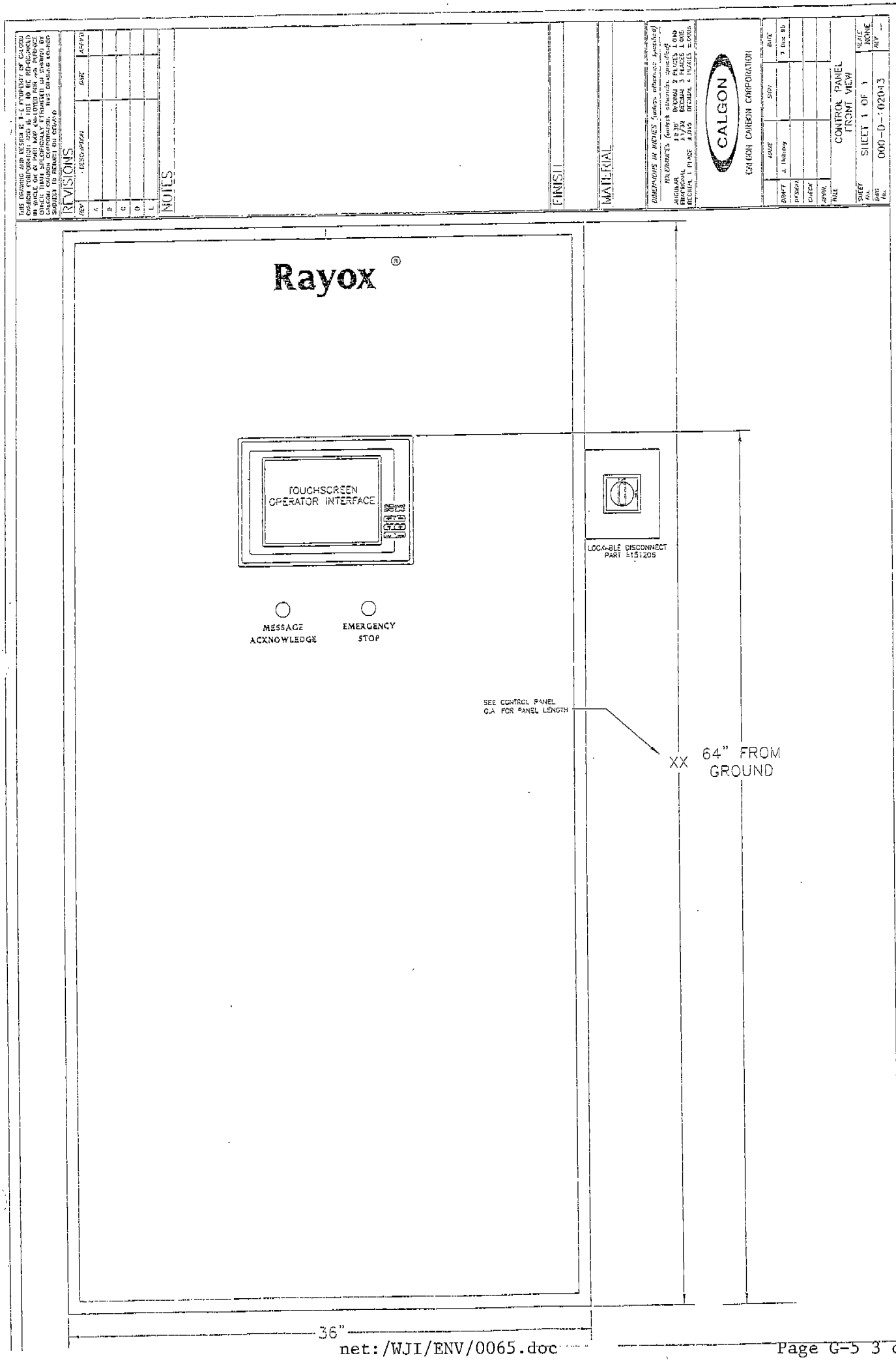
CALGON

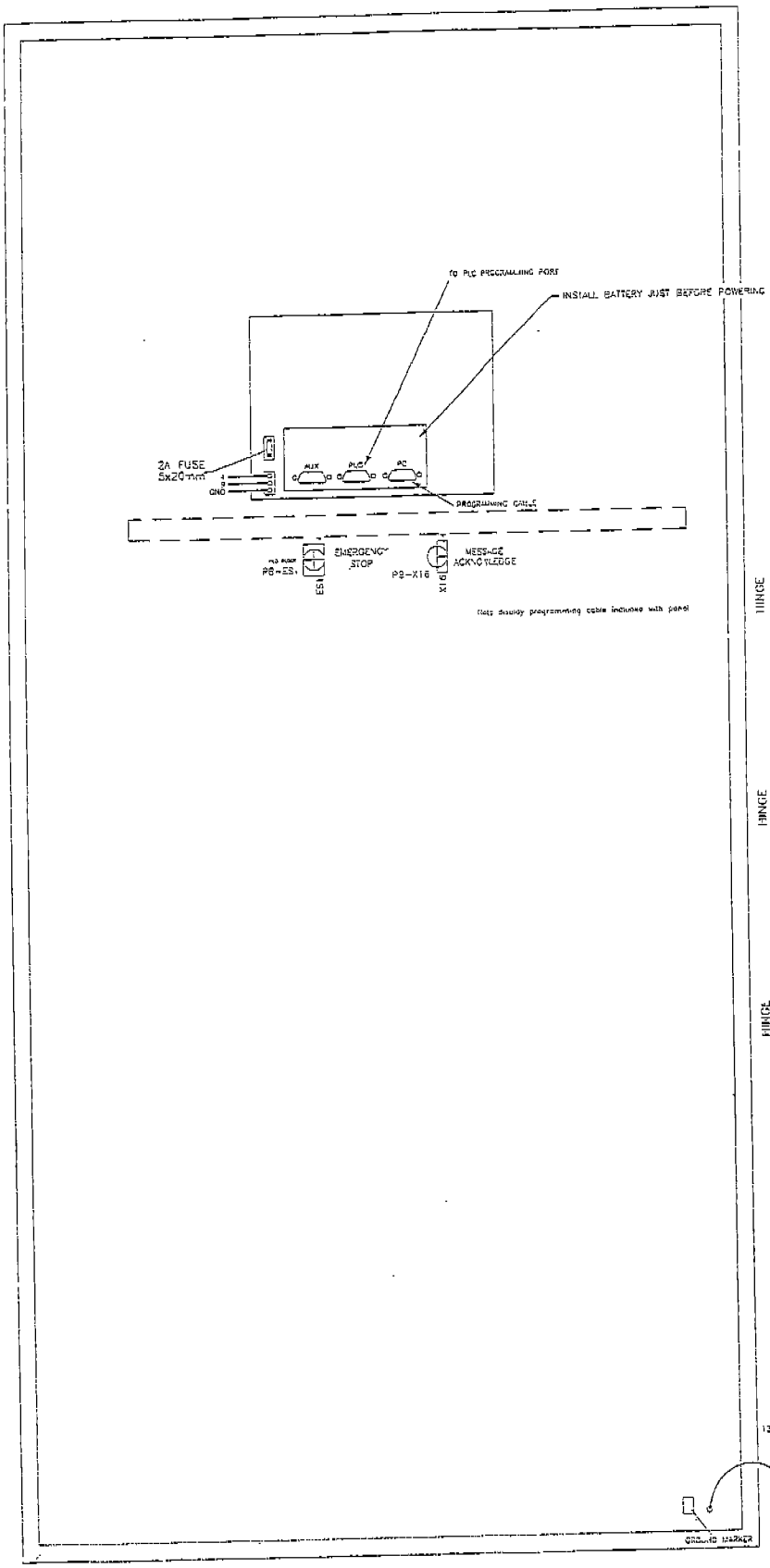
CALGON CARBON CORPORATION

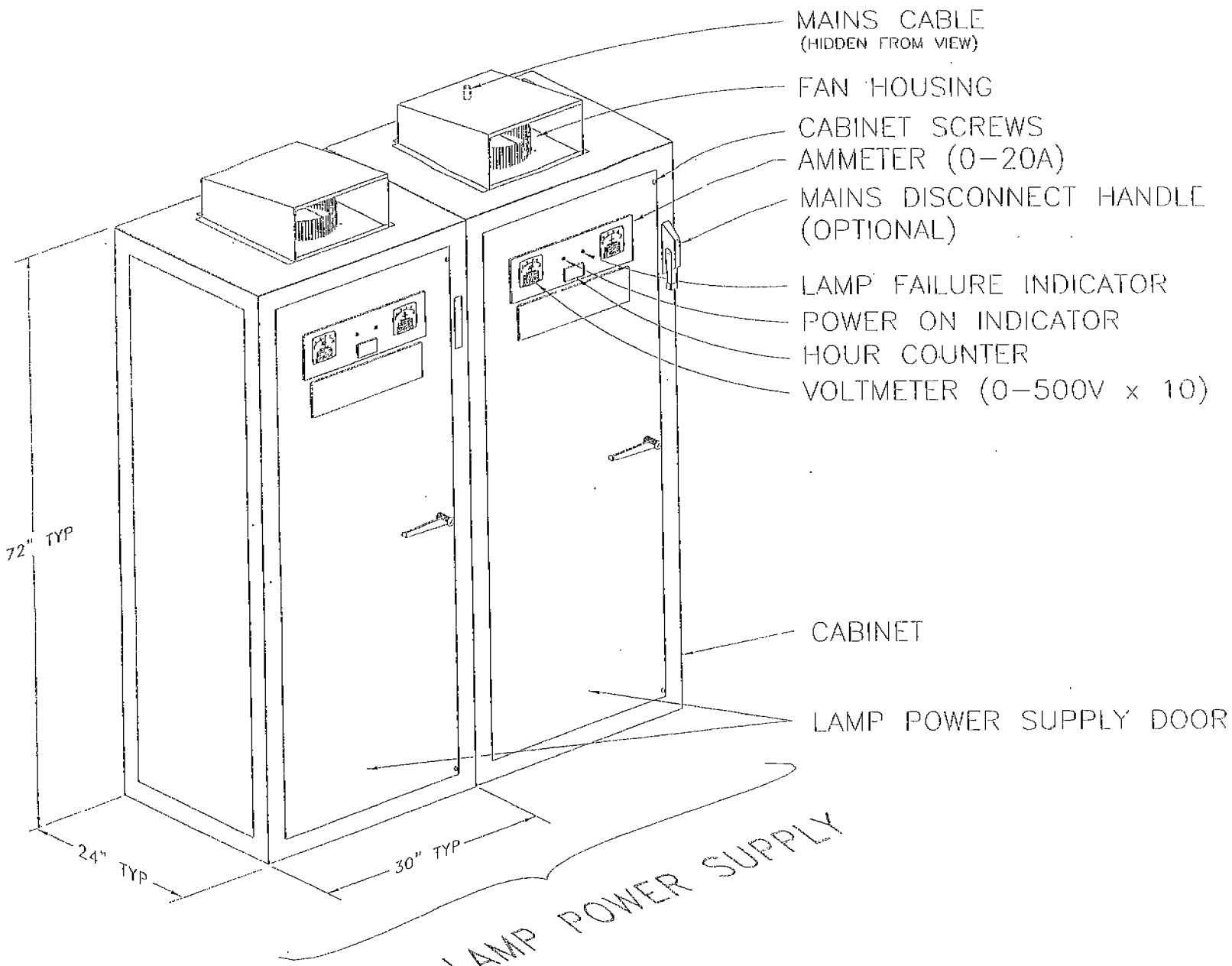
	NAME	SIGN	DATE
DRAFT	T. Rhodes		23 Jan/96
DESIGN			
CHECK			
APPR.			
DATE			

RAYOX UV TOWER - EXTERNAL

SHEET No.	SHEET 2 OF 2	SCALE NONE
DRG. No.	000-0-960200	REV -


REVISIONS
NOTES
FINISH
MATERIAL
CALGON
CALGON CARBON CORPORATION
CONTROL PANEL
FRONT VIEW
SHEET 1 OF 1
000-D-02043
Rayox ®
TOUCHSCREEN
OPERATOR INTERFACE
LOCKABLE DISCONNECT
PART #151205
MESSAGE
ACKNOWLEDGE
EMERGENCY
STOP
SEE CONTROL PANEL
O.A. FOR PANEL LENGTH
XX
64" FROM
GROUND
36"


to PLC PROGRAMMING PORT
INSTALL BATTERY JUST BEFORE POWERING
2A FUSE 5x20 mm
AUX
PLC
PC
GND
PROGRAMMING CABLE
no name
PB-ES1
EMERGENCY STOP
ES1
PB-X16
X16
MESSAGE ACKNOWLEDGE
Note: Supply programming cable included with panel
HINGE
HINGE
HINGE
12g GRN FLEXIBLE GROUND STRAP
STARRED WASHER UNDER NUT
GROUND MARKER



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REVISIONS

REV	DESCRIPTION	DATE	APPVD
A	ECO #105 – JAW	30 JUNE 97	
B			
C			
D			
E			

NOTES

FINISH

MATERIAL

DIMENSIONS IN INCHES (unless otherwise specified)

TOLERANCES (unless otherwise specified)

ANGULAR	±0 30'	DECIMAL 2 PLACES	±.010
FRACTIONAL	±1/32	DECIMAL 3 PLACES	±.005
DECIMAL 1 PLACE	±.015	DECIMAL 4 PLACES	±.0005

CALGON

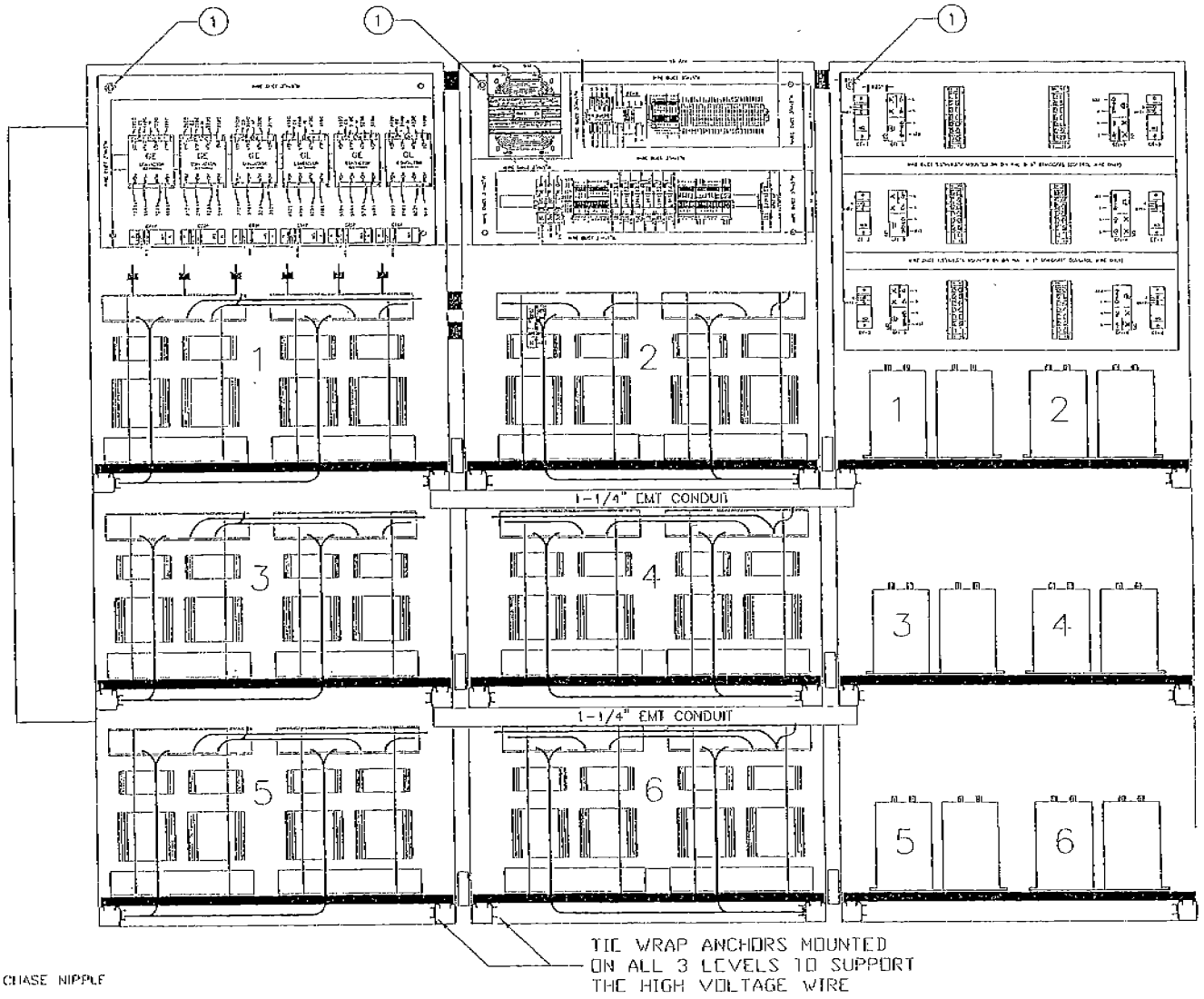
CALGON CARBON CORPORATION

	NAME	SIGN	DATE
DRAFT	S.P.		17 JUL 95
DESIGN			
CHECK			
APPR			

TITLE: RAYOX POWER SUPPLY – EXTERNAL 2 X 30kW

SHEET No: SHEET 1 OF 1 | SCALE: NONE

DWG No: 000-D-101219 | REV: A



1-1/4" CHASE NIPPLE

TIE WRAP ANCHOR - SCREW MOUNT TYPE

POWER SUPPLY #1
INTERNAL WIRING LAYOUT

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REV	DESCRIPTION	DATE	APPVD
A			
B			
C			
D			
E			

NOTES

1. SCRAPE PAINT AT BACK PANEL MOUNTING NUT AND ALL GROUND CONNECTIONS.

FINISH

MATERIAL

DIMENSIONS IN INCHES (unless otherwise specified)

TOLERANCES (unless otherwise specified)

ANGULAR	±.03°	DECIMAL 2 PLACES ± .010
FRACTIONAL	±1/32	DECIMAL 3 PLACES ± .005
DECIMAL 1 PLACE	±.015	DECIMAL 4 PLACES ± .0005

CALGON

CALGON CARBON CORPORATION

	NAME	SIGN	DATE
DRAFT	RJP		13 JULY 00
DESIGN	RJP		13 JULY 00
CHECK			
APPVL			

TITLE: POWER SUPPLY - INTERNAL

SHEET No. SHEET 1 OF 2 | SCALE NONE

DWG No. 393-D-102535 | REV —

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REVISIONS

REV	DESCRIPTION	DATE	APPR'D
A			
B			
C			
D			
E			

NOTES

1. SCRAPE PAINT AT BACK PANEL MOUNTING NUT AND ALL GROUND CONNECTIONS.

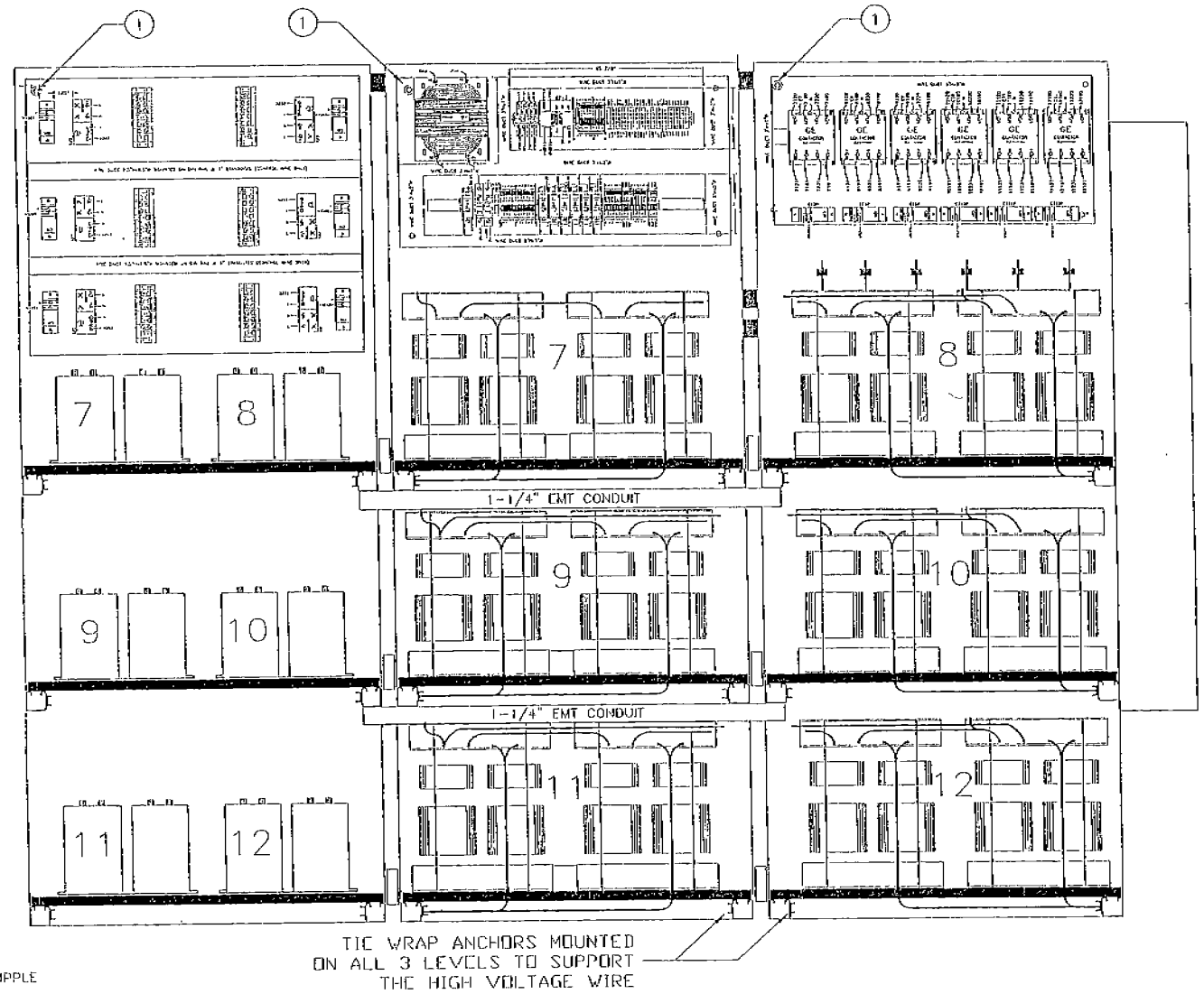
FINISH

MATERIAL

DIMENSIONS IN INCHES (unless otherwise specified)

TOLERANCES (unless otherwise specified)

ANGULAR	±0°30'	DECIMAL 2 PLACES	± 0.01
FRACTIONAL	1 1/32	DECIMAL 3 PLACES	± 0.005
DECIMAL 1 PLACE	± 0.1	DECIMAL 4 PLACES	± 0.0001



1-1/4" CHASE NIPPLE

TIE WRAP ANCHOR - SCREW MOUNT TYPE

POWER SUPPLY #2
INTERNAL WIRING LAYOUT

CALGON

CALGON CARBON CORPORATION

	NAME	SIGN	DATE
DRAFT.	RP		13 JULY 00
DESIGN	RJP		13 JULY 00
CHECK			
APPR			

TITLE: POWER SUPPLY - INTERNAL

SHEET NO: SHEET 2 OF 2

SCALE: NONE

DWG NO: 393-D-102335

REV: -

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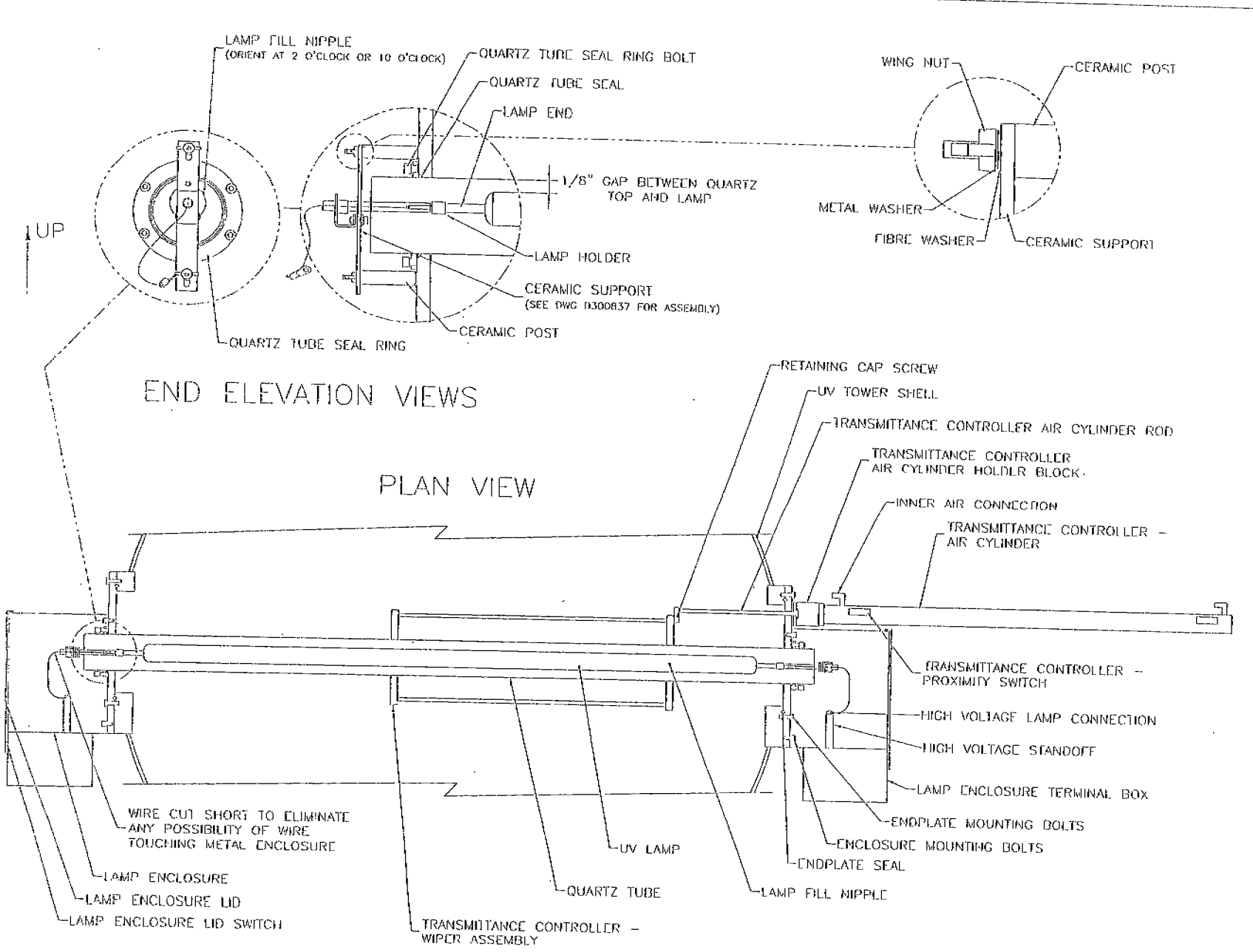

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REVISIONS

REV	DESCRIPTION	DATE	APPVD
A	ECO 1425 - J. D.	18 Mar 98	
B	ECO 1495 - T. O. R.	12 Jun/98	
C	ECO 1531 - J. H.	20 Aug 98	
D			
E			

NOTES

FINISH

MATERIAL

DIMENSIONS IN INCHES (unless otherwise specified)

TOLERANCES (unless otherwise specified)

ANGULAR	±0.30°	DECIMAL 2 PLACES	± 010
FRACTIONAL	±1/32	DECIMAL 3 PLACES	± 005
DECIMAL 1 PLACE	± 015	DECIMAL 4 PLACES	± 0005

CALGON

CALGON CARBON CORPORATION

	NAME	SIGN.	DATE
DRAFT	T. O. R.		23 Jan/96
DESIGN			
CHECK			
APPR.			

TITLE: LAMP ENCLOSURE COMPONENT DETAIL

SHEET No: SHEET 1 OF 1

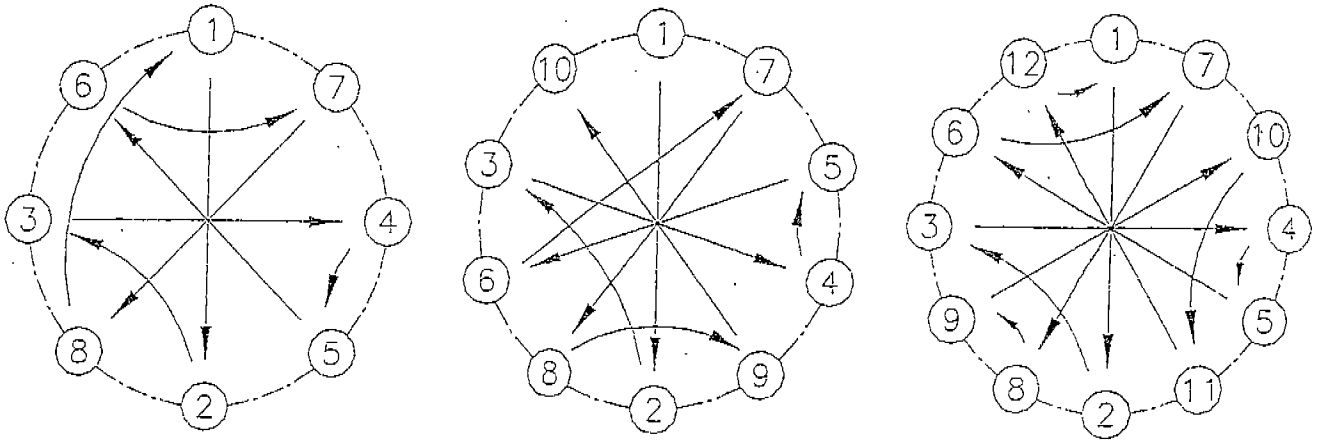
SCALE: NONE

DWG No: 000-D 900201

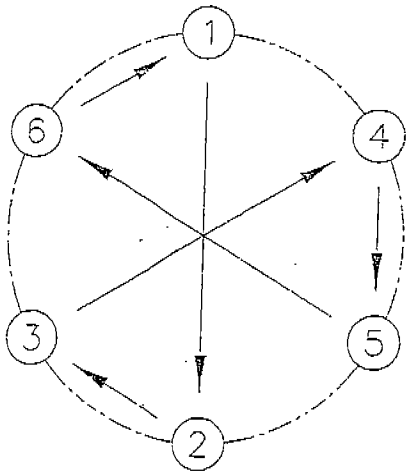
REV: C

net:/WJI/ENV/0065.doc

UV LAMP ENCLOSURE ASSEMBLY AND QUARTZ TUBE SEAL RING TORQUE SEQUENCE



UV LAMP ENCLOSURE ASSEMBLY TORQUE SEQUENCE
(Calgon Carbon Corporation. Rayox® Advanced Oxidation System Operation and Maintenance Manual. Publication Number: 393-D-800382, Section 4.5, page 6)



QUARTZ TUBE SEAL RING TORQUE SEQUENCE
(Calgon Carbon Corporation. Rayox® Advanced Oxidation System Operation and Maintenance Manual. Publication Number: 393-D-800382, Section 4.5, page 7)

ENCLOSURE 6

MONTHLY MAINTENANCE CHECKLISTS

ENCLOSURE 6 - MONTHLY ROUTINE SHUTDOWN TEST

System Status "System Shutdown (Step 0)	UV Lamps OFF	Effluent Isolation Valve (ROV-6WA-XK144) CLOSED.	Ensure Isolation Valve (ROV-6SW-XK257) OPEN	Extraction well and air stripper pumps STOP.	UV unit transmittance controllers STOP	TPS/DR /Comments	Initials/Date

ENCLOSURE 6 - EMERGENCY SHUTDOWN TEST

System Status "Emergency Stop" - MCC, Stripper PLC's, UV PLC's	Pumps and Equipment STOP	UV Lamps - OFF	FCV-6WA-XK093 is CLOSED	FCV-6WA-XK112 is CLOSED	ROV-6WA-XK143 is CLOSED	Interlocks	TPS/DR /Comments	Initials/Date

ENCLOSURE 6 - AIR STRIPPER LOCKOUT/TAGOUT CHECKLIST

Air Stripper # 1

Lockout/Tagout Installation								Lockout/Tagout Removal						
Notification of Affected Employees	Equipment Shutdown	Energy Isolation - Air Stripper Electrical Disconnects lockout/tagout	Energy Isolation - Treatment Facility Influent lockout/tagout	Energy Isolation - Scale Cleaning System Influent lockout/tagout	Verification of Electrical Disconnect - Blower	Verification of Electrical Disconnect - Discharge Pump	Initials/Date	Equipment and General Area Inspection - Non-Essential Items	Equipment and General Area Inspection - Personnel	Controls - Neutral or Off	Remove lockout/tagout Devices and Reenergize Equipment	Notification of Affected Employees	Initials/Date	Authorized Employees/ Comments

ENCLOSURE 6 - AIR STRIPPER LOCKOUT/TAGOUT CHECKLIST

Air Stripper # 2

Lockout/Tagout Installation								Lockout/Tagout Removal						
Notification of Affected Employees	Equipment Shutdown	Energy Isolation - Air Stripper Electrical Disconnects lockout/tagout	Energy Isolation - Treatment Facility Influent lockout/tagout	Energy Isolation - Scale Cleaning System Influent lockout/tagout	Verification of Electrical Disconnect - Blower	Verification of Electrical Disconnect - Discharge Pump	Initials/Date	Equipment and General Area Inspection - Non-Essential Items	Equipment and General Area Inspection - Personnel	Controls - Neutral or Off	Remove lockout/tagout Devices and Reenergize Equipment	Notification of Affected Employees	Initials/Date	Authorized Employees/ Comments

ENCLOSURE 6 - UV UNIT LOCKOUT/TAGOUT CHECKLIST

Lockout/Tagout Installation								Lockout/Tagout Removal						page 1 of 1
Notification of Affected Employees	Equipment Shutdown	Energy Isolation - UV Unit Electrical Disconnects lockout/tagout	Energy Isolation - Air Stripper Effluent Discharge lockout/tagout	Energy Isolation - Pneumatic Energy lockout/tagout	Dissipate Stored or Residual Energy	Verification of Electrical Disconnect - UV Unit	Initials/Date	Equipment and General Area Inspection - Non-Essential Items	Equipment and General Area Inspection - Personnel	Controls - Neutral or Off	Remove lockout/tagout Devices and Reenergize Equipment	Notification of Affected Employees	Initials/Date	Authorized Employees/ Comments

ENCLOSURE 6 - UV UNIT MONTHLY MAINTENANCE CHECKLIST

UV Reactor					UV Power Supply		page 1 of 1		
Lockout/Tagout	Lamp Enclosures	Moisture Sensors	Quartz Tubes	O-Rings	Visual Inspection (dirt, dust, etc.)	Air Exhaust	Lockout Tagout Removal	TPS/DR /Comments	Initials/Date

ENCLOSURE 6 - AIR STRIPPER MONTHLY MAINTENANCE

	Air Stripper # 1					Air Stripper # 2							
Lockout/Tagout	Stripper Trays/ Spray Nozzles	Sump	Filters	Lubrication	Initials/Date	Stripper Trays/ Spray Nozzles	Sump	Filters	Lubrication	Initials/Date	Lockout Tagout Removal	TPS/DR /Comments	Initials/Date

ENCLOSURE 6 - SCALE CLEANING, SCALE CONTROL AND EQUIPMENT AIR MONTHLY MAINTENANCE

TK-6CI-XK064 - Scale Cleaning Chemical Tank Level)	TK-6WA-XK222 - Spent Cleaning Solution Tank Level	TK-6CI-XK076 - Scale Control Chemical Tank Level	Air/Water Separator - Drained	Water in the Air Compressor Tank - Vented	Pneumatic Oil Lubricator - Lubricant Level	Air Compressor Crankcase - Lubricant Level	TPS/DR /Comments	Initials/Date

ENCLOSURE 7

3,000 HOUR MAINTENANCE CHECKLISTS

ENCLOSURE 7 - UV UNIT 3,000 HOUR MAINTENANCE CHECKLIST

Lockout/Tagout **Completed By (initials/date)**:			**Authorized Employees (print names):**				
Lamp Position #'s	**1**	**2**	**3**	**4**	**5**	**6**	**Comments/TPS/DR**
Lamp Serial #							
Lamp Enclosures Open, Connections Removed							
Lamp Removal							
Quartz Tube Seals Inspection							
Completed By (initials/date):							
Lamp Position #'s	**7**	**8**	**9**	**10**	**11**	**12**	**Comments/TPS/DR**
Lamp Serial #							
Lamp Enclosures Open, Connections Removed							
Lamp Removal							
Quartz Tube Seals Inspection							
Completed By (initials/date):							
UV Tower Drained	**Completed By (initials/date):**						
Lamp Position #'s	**1**	**2**	**3**	**4**	**5**	**6**	**Comments/TPS/DR**
Quartz Tube Removal							
Quartz Tube Inspection							
Completed By (initials/date):							
Lamp Position #'s	**7**	**8**	**9**	**10**	**11**	**12**	**Comments/TPS/DR**
Quartz Tube Removal							
Quartz Tube Inspection							
Completed By (initials/date):							
Lamp Position #'s	**1**	**2**	**3**	**4**	**5**	**6**	**Comments/TPS/DR**
Quartz Tube Seals Replaced							
Completed By (initials/date):							
Lamp Position #'s	**7**	**8**	**9**	**10**	**11**	**12**	**Comments/TPS/DR**
Quartz Tube Seals Replaced							
Completed By (initials/date):							

ENCLOSURE 7 - UV UNIT 3,000 HOUR MAINTENANCE CHECKLIST

Lamp Position #'s	1	2	3	4	5	6	Comments/TPS/DR
Transmittance Controller Wiper Assembly/ Lamp Enclosure Assembly Removal. Mark "NR" if not required							
Transmittance Controller Seals and Air Cylinder Inspection and Replacement. Mark "NR" if not required							
Transmittance Controller Wiper Assembly Installation. Mark "NR" if not required							
Tower and Endplate Seal Inspection and Replacement. Mark "NR" if not required							
Lamp Enclosure Installation. Mark "NR" if not required							
Completed By (initials/date):							
Lamp Position #'s	**7**	**8**	**9**	**10**	**11**	**12**	**Comments/TPS/DR**
Transmittance Controller Wiper Assembly/ Lamp Enclosure Assembly Removal. Mark "NR" if not required							
Transmittance Controller Seals and Air Cylinder Inspection and Replacement. Mark "NR" if not required							
Transmittance Controller Wiper Assembly Installation. Mark "NR" if not required							
Tower and Endplate Seal Inspection and Replacement. Mark "NR" if not required							
Lamp Enclosure Installation. Mark "NR" if not required							
Completed By (initials/date):							

ENCLOSURE 7 - UV UNIT 3,000 HOUR MAINTENANCE CHECKLIST

Lamp Position #'s	**1**	**2**	**3**	**4**	**5**	**6**	**Comments/TPS/DR**
Quarts Tube Installation							
Completed By (initials/date):							
Lamp Position #'s	**7**	**8**	**9**	**10**	**11**	**12**	**Comments/TPS/DR**
Quarts Tube Installation							
Completed By (initials/date):							
UV Tower Leak Check. **Completed By (initials/date):**							
Lamp Position #'s	**1**	**2**	**3**	**4**	**5**	**6**	**Comments/TPS/DR**
UV Lamp Replacement							
Lamp Serial #							
Completed By (initials/date):							
Lamp Position #'s	**7**	**8**	**9**	**10**	**11**	**12**	**Comments/TPS/DR**
UV Lamp Replacement							
Lamp Serial #							
Completed By (initials/date):							
Lockout/Tagout Removal **Completed By (initials/date)**:							

ATTACHMENT H

TREATMENT SYSTEM PROCESS CONTROL

1. GENERAL INFORMATION

   This Attachment provides instructions for the setup and operation of the Plume-Front Treatment Instrumentation and Control System.

2. DRAWINGS AND REFERENCES

   A flow schematic of the treatment facility is provided by drawing number 652-M-02. Drawings and schematics of the Instrumentation and Control System are provided in drawing numbers 652-E-01 through 652-E-38. Copies of the manufacturer's operation and maintenance manuals, cut sheets, material specifications, warranties, etc. are maintained by the contractor environmental department, and are available through the contractor Environmental Department Project Leader (or designated alternate). A list of operation and equipment manuals is provided in the List of References, Attachment A.

3. ENCLOSURES

   3.1 Enclosure 1, "System Process Control Setup Sheets"

4. SAFETY REQUIREMENTS

   Specific safety requirements and instructions in the form of WARNINGS, CAUTIONS and NOTES are contained within the procedures preceding the applicable step(s). A hazard assessment for personal protective equipment per WSI 25-SW-0007 is included in Attachment C. A job hazard analysis per WSI 25-SW-0032 is also included in Attachment C.

5. PERSONNEL REQUIREMENTS

   All Instrumentation and Control System (I&C) computer/control station operations per this WJI will be performed by a qualified contractor Environmental Department Groundwater Treatment Facility Operator(s) (per the WSTF Training Database).

   A. Qualified Groundwater Treatment Facility Operators are the contractor Environmental Department Project Leader and qualified contractor Environmental Department Department personnel, who by means of their working knowledge of the treatment system, the operating and maintenance procedures, safety measures, alarm protocol and emergency procedures, have been appointed by the contractor Environmental Department Manager as Groundwater Treatment Facility Operators.

B. At the discretion of the contractor Environmental Department Project Leader, the operations can be performed by contractor Environmental Department personnel who are receiving “on-the-job” training for qualification as a Groundwater Treatment Facility Operator under the direct supervision of the facility Project Leader or Certifying/Qualifying instructor who is also qualified as a Groundwater Treatment Facility Operator (per the WSTF Training Database). Personnel receiving "on-the-job" training are required to have completed WSTF Hazardous Waste Handler Training and the requirements (1), (2), (3), and (4) listed below.

1) All personnel actively involved in facility operations are required to have current Confined Space Training (per the WSTF Training Database).

2) All personnel actively involved in facility operations are required to have current PPE Training (per the WSTF Training Database).

3) All personnel actively involved in facility operations are required to have current training in the use of a Passport air monitor (or equivalent) (per the WSTF Training Database).

4) All personnel actively involved in facility operations are required to have current Lockout/Tagout Training (per the WSTF Training Database).

5. EQUIPMENT

The treatment system is composed of six extraction wells, five major pieces of water treatment equipment, and four injection wells, each with its own control panel(s). The two air stripper systems are connected in parallel (water only) and can be operated individually or together. The basic equipment includes:

A. Six Plume-front Extraction Wells (PLC controls);
B. Air Stripper # 1 (PLC controls);
C. Air Stripper #2 (PLC controls);
D. Scale Cleaning System (relay logic controls);
E. Scale Control System (relay logic controls);
F. UV Reactor Tower (PLC controls); and
G. Four Plume Front Injection Wells (PLC controls).

6. SPECIAL REQUIREMENTS

Process control functions can be initiated only from the Instrumentation and Control System (I&C) located in the control room in Bldg. 650. Although the status of the treatment system can be monitored from either the NASA Project Manager’s office or the contractor Environmental Department office (in Bldg. 101), these two stations cannot perform any control functions.

The Groundwater Treatment Facility Operating Log will specify whether the system will be run at 50% or 100% of capacity, and the appropriate steps/actions of this Attachment to be completed.

7. SYSTEM STARTUP PROCEDURE

Complete the Treatment System Electrical Setup Sheet. This will ensure that the electrical power supply and I&C are in the correct configuration for system operation. Initial and date the sheet as indicated.

Complete the Treatment System Mechanical Setups per Attachment E of this WJI. This will ensure that all hand switches, the piping system, and the treatment equipment are configured for system operation. Initial and date the sheet as indicated.

Complete the Treatment System HMI (Human Machine Interface) Configuration Setup Sheet. This will log the operator on to the I&C, ensure that all set points are correct, select extraction and injection wells that will be operating, select operation mode for system (50% or 100%), and select operation mode for air strippers (Clean, Stop, or Strip). Initial and date the sheet as indicated.

Select the **STARTUP/SHUTDOWN** screen on the HMI.

Select the **STARTUP** button on the lower left of the screen to begin the automated sequence that brings the treatment system online.

Monitor the startup sequence, verifying that the steps proceed in sequence as indicated on the **STARTUP/SHUTDOWN** screen until the **SYSTEM RUNNING** (Step 13) indication is highlighted. If a problem becomes apparent, click on the **EMERGENCY SHUTDOWN** button on the lower right of the screen. A normal startup sequence consists of the following steps:

A. Starting Air Stripper No. 1;
B. Starting Air Stripper No. 2;
C. Equalizing Plant Recirculation Flow;
D. Starting UV Reactor System;
E. Opening Effluent Block Valve;
F. Starting PFE-1 Pump;
G. Starting PFE-5 Pump;
H. Starting PFE-7 Pump;
I. Starting PFE-2 Pump;
J. Starting PFE-3 Pump;
K. Starting PFE-4A Pump;
L. Closing Recirculation Block Valve; and
M. System Running.

NOTE

A MINIMUM OF FOUR EXTRACTION WELLS AND TWO INJECTION WELLS MUST BE CONFIGURED FOR OPERATION OR THE CONTROL SYSTEM WILL NOT ALLOW TREATMENT SYSTEM STARTUP.

8. SYSTEM OPERATION

AIR STRIPPER'S OPERATION

The two air stripper systems are connected in parallel and can be operated individually or simultaneously in a parallel configuration. The stripper control panels have interlocks to the control panels of the Scale Cleaning System and Scale Control System. The logic in each of the stripper control panels is the same. The stripper control panels and scale control system panel receives a signal from the I&C.

Each stripper system has four cycles (modes) of operation. The stripper operation governs the operation of the Scale Control System and the Scale Cleaning System via interlocks between the system control panels and the I&C. The four system operating cycles are:

A. Strip Cycle - Water flows through the stripper in normal operation. The flow rate into stripper is controlled by the air stripper influent control valve(s) (ECV-6WA-XK093 for Stripper # 1 and ECV-6WA-XK112 for Stripper # 2) via a signal from the I&C. The water is pumped out of the stripper by the discharge pump(s) PU-6WA-XK106 for Stripper # 1 and (PU-6WA-XK125 for Stripper # 2) to the UV Reactor system. The discharge pump speed is controlled by a variable frequency drive (VFD) to maintain the appropriate level in the sump tank. The water flow into the stripper is shut off when the strip signal from the I&C is taken away and the blower shuts down five minutes later. The scale control system is allowed to operate only when either or both strippers are in a strip cycle. The rate of the scale control metering pump (PU-6CI-XK078) is controlled by the I&C. The I&C sums the flow rate signal(s) from the air stripper influent flow meter(s) (FM-6WA-XK096 for Stripper # 1 and FM-6WA-XK116 for Stripper # 2) and sends a 4 to 20ma signal to the scale control metering pump (PU-6CI-XK078). Either stripper can be in strip cycle mode alone, or simultaneously with the other stripper.

B. Standby Cycle - When a Dump, Clean or Strip cycle is not present. The blower does not operate. The discharge pump is allowed to operate and keep a minimum water level in the stripper. The VFD controls the discharge pump speed. The minimum water level is required for running a clean cycle. One or both strippers can be in a standby cycle.

C. Clean Cycle - Water flows in a closed loop with the discharge pump recirculating the water into stripper. The circulation flow rate is fixed. The blower operates to

maintain water in the trays during a clean cycle. A signal is given to the scale clean system to start one of its transfer pumps after a clean cycle startup delay. The cleaning solution in the tank of the scale cleaning system is injected into the stripper sump tank, becoming part of the cleaning loop. The cleaning solution transfer pump stops when the low level switch FS-6CI-XK067 is tripped. The clean cycle terminates when the clean signal from the I&C is removed. A dump cycle is immediately started after the clean cycle signal is removed. The clean cycle can only be initiated after finishing a strip cycle to ensure that enough water remains to fill the trays. The blower shuts down after a clean cycle and does not have a time out. Only one stripper can be in a clean cycle at any time.

D. Dump Cycle – The dump cycle is started whenever a clean cycle signal is removed. The dump cycle empties the cleaning solution from the stripper sump. The discharge pump operates at a fixed speed until the sump low level setting (measured on level transmitter) is tripped. The discharge pump shuts off and the system is returned to the standby cycle. The blower does not operate during a dump cycle. The following cycle must be a strip cycle since there is not enough water to restart a clean cycle. Only one stripper can be in a dump cycle at any time.

The control panels are labeled CP-100 (Air Stripper # 1), CP-200 (Air Stripper # 2), CP-300 (Scale Cleaning System), and CP-400 (Scale Control System). Control panels CP-100 and CP-200 are equipped with their own PLC. Panels CP-300 and CP-400 utilize relay logic.

Control panel CP-100 (Air Stripper # 1) and/or CP-200 (Air Stripper # 2) inputs a "cycle signal" from the main control center. These cycle signals are STRIP CYCLE, CLEAN CYCLE and STANDBY. The process control actions are presented in Sections 9, 10, 11, and 12 of this Attachment.

9. STRIP CYCLE

A START signal is sent from I&C to the stripper PLC, which then performs the following:

A. Air stripper effluent discharge electrical control valve(s) (ECV-6WA-XK109 for Stripper # 1 and ECV-6WA-XK128 for Stripper # 2) are OPENED;

B. Cleaning loop electrical control isolation valve(s) (ECV-6WA-XK110 for Stripper # 1 and ECV-6WA-XK111 for Stripper # 2) is CLOSED;

C. Discharge to spent cleaning tank electrical control isolation valve(s) (ECV-6WA-XK092 for Stripper # 1 and ECV-6WA-XK129 for Stripper # 2) is CLOSED;

D. START air stripper blower(s) (BL-6AR-XK098 for Stripper # 1 and BL-6AR-XK117 for Stripper # 2);

E. Low air pressure switches in the stripper housing (PS-6AR-XK231 for Stripper # 1 and PS-6AR-XK225 for Stripper # 2), and the blower inlet low air flow switches (FLS-6AR-XK089 for Stripper # 1 and FLS-6AR-XK118 for Stripper # 2) are ignored for the first 10 seconds when the blower is starting;

F. The air stripper influent control valves (FCV-6WA-XK093 for Stripper # 1 and FCV-6WA-XK112 for Stripper # 2) modulate based on water flow rate signal from the air stripper influent flow meters (FM-6WA-XK096 for Stripper # 1 and FM-6WA-XK116 for Stripper # 2). The signal to the air stripper influent flow control valves (ECV-6WA-XK093 for Stripper # 1 and ECV-6WA-XK112 for Stripper # 2) is received from the MCC;

G. The air stripper effluent discharge pump(s) (PU-6WA-XK106 for Stripper # 1 and PU-6WA-XK125 for Stripper # 2) are allowed to operate anytime. The air stripper discharge pumps speed (PU-6WA-XK106 for Stripper # 1 and PU-6WA-XK125 for Stripper # 2) is controlled by a VFD based on a signal from air stripper sump level transmitters (LLT-6WA-XK104 for Stripper # 1 and LLT-6WA-XK123 for Stripper # 2);

H. The air stripper sump low level switches (LLC-6WA-XK103 for Stripper # 1 and LLC-6WA-XK122 for Stripper # 2) shut down the air stripper effluent discharge pump(s) (PU-6WA-XK106 for Stripper # 1 and PU-6WA-XK125 for Stripper # 2) in a low level condition;

I. An alarm signal is sent to the MCC to CLOSE the air stripper influent control valves (ECV-6WA-XK093 for Stripper # 1 and ECV-6WA-XK112 for Stripper # 2) shutting off the water flow if the following alarm switches are tripped:

   1) Air stripper sump high level switches (LLC-6WA-XK102 for Stripper # 1 and LLC-6WA-XK121 for Stripper # 2);

   2) Air stripper low pressure switches (PS-6AR-XK231 for Stripper # 1 and PS-6AR-XK225 for Stripper # 2);

   3) Air stripper high pressure switches (PS-6AR-XK232 for Stripper # 1 and PS-6AR-XK226 for Stripper # 2); and

   4) Blower inlet low pressure switches (PS-6AR-XK101 for Stripper # 1 and PS-6AR-XK120 for Stripper # 2).

J. In an alarm condition or operational shutdown from the main control center:

1) The air stripper influent electrical control valves CLOSE (ECV-6WA-XK093 for Stripper # 1 and ECV-6WA-XK112 for Stripper # 2). Under normal shut down the MCC initiates a five-minute timeout for the blower when OFF cycle signal is received from I&C. The blowers will shut down immediately in case of an emergency shut down;

2) During a normal system shut down, the air stripper effluent discharge pumps (PU-6WA-XK106 for Stripper # 1 and PU-6WA-XK125 for Stripper # 2) operate until the STANDBY cut-out level is reached in the stripper sump, as sensed by the air stripper sump level transmitters (LLT-6WA-XK104 for Stripper # 1 and LLT-6WA-XK123 for Stripper # 2). Under emergency shut down the pumps shut off immediately;

3) The air stripper discharge control valves CLOSE (ECV-6WA-XK109 for Stripper # 1 and ECV-6WA-XK128 for Stripper # 2). This happens immediately during emergency shut down, and after the air stripper blowers (BL-6AR-XK098 for Stripper # 1 and BL-6AR-XK117 for Stripper # 2) complete their 5-minute time out during normal shut down; and

4) Following a normal shut down, the air stripper can be restarted again in either CLEAN or STRIP cycle or left in the OFF position while the other stripper system operates. Following emergency shut down, all alarms must be cleared before the strippers will be allowed to operate.

9. STRIP CYCLE (Scale Control System):

A. The scale control system is controlled by CP-400 (Scale Control System). CP-400 (Scale Control System) receives signals from CP-100 (Air Stripper # 1), CP-200 (Air Stripper # 2), and the I&C.

B. The scale control system is always operational if either stripper system is in a STRIP cycle.

C. The scale control chemical metering pump (PU-6CI-XK078) operates from an on/off signal from both CP-100 (Air Stripper # 1) and CP-200 (Air Stripper # 2).

D. The scale control chemical metering pump (PU-6CI-XK078) SHUTS DOWN on low chemical level signal from the scale control chemical tank low level switch (LLC-6CI-XK066). Neither stripper system will shut down in case of low chemical level alarm.

E. The scale control chemical metering pump (PU-6CI-XK078) pulse rate is controlled by a rate signal (4-2OmA) from the I&C. The signal is based on the sum of the water flow rates set by both air stripper influent flow meters (FM-6WA-XK096 for Stripper # 1 and FM-6WA-XK116 for Stripper # 2).

10. STRIP CYCLE (Scale Cleaning System):

    A. The scale cleaning system is controlled by CP-300 (Scale Cleaning System).

    B. If the CP-300 (Scale Cleaning System) panel receives a CLEAN signal from either CP-100 (Air Stripper # 1) or CP-200 (Air Stripper # 2), a CLEAN cycle is initiated, and the respective pump will operate transferring chemical to the appropriate stripper. The CP-300 panel will not respond to any additional CLEAN signals while a CLEAN cycle is in process.

    C. CP-300 (Scale Cleaning System) only allows the scale cleaning chemical mixer (M-6CI-XK188) to operate (manual switch) when neither stripper is in a CLEAN cycle.

11. CLEAN CYCLE (Stripper System):

    A. Control panel CP-100 (Air Stripper # 1) or CP-200 (Air Stripper # 2) receives a CLEAN signal from the I&C.

    B. The CLEAN cycle is only allowed to initiate if sufficient residual water is in the stripper sump tank as indicated by air stripper sump level transmitter(s) (LLT-6WA-XK104 for Stripper # 1 and LLT-6WA-XK123 for Stripper # 2). Residual water level is established in the stripper sump at STRIP cycle shutdown by the equipment vendor.

    C. The CLEAN cycle also will not start unless the spent cleaning solution tank TK-6WA-XK22 is empty as indicated by LLC-6WA-XK100 (spent cleaning solution low level switch).

    D. A “CLEAN” signal from the I&C “VERIFY/PERFORMS” the following:

        1) Air stripper effluent electrical control valve (ECV-6WA-XK109 for Stripper # 1 or ECV-6WA-XK128 for Stripper # 2) is CLOSED;

        2) Air stripper influent electrical control valve (ECV-6WA-XK093 for Stripper # 1 or ECV-6WA-XK112 for Stripper # 2) is CLOSED;

        3) Discharge to spent cleaning tank electrical control isolation valve (ECV-6WA-XK092 for Stripper # 1 or ECV-6WA-XK129 for Stripper # 2) is CLOSED;

        4) Cleaning loop electrical control isolation valve (ECV-6WA-XK110 for Stripper # 1 or ECV-6WA-XK111 for Stripper # 2) is OPEN;

5) Air stripper blower (BL-6AR-XK098 for Stripper # 1 or BL-6AR-XK117 for Stripper # 2) STARTS;

6) Air stripper effluent discharge pump (PU-6WA-XK106 for Stripper # 1 or PU-6WA-XK125 for Stripper # 2) ramps up to preset CLEAN cycle operating speed (aprox. 100 to 200 gpm). During the CLEAN cycle, the air stripper effluent discharge pump (PU-6WA-XK106 for Stripper # 1 or PU-6WA-XK125 for Stripper # 2) is controlled by a speed set from the VFD, and is not controlled by the air stripper sump level transmitters (LLT-6WA-XK104 for Stripper # 1 and LLT-6WA-XK123 for Stripper # 2);

7) Air stripper effluent discharge pump (PU-6WA-XK106 for Stripper # 1 or PU-6WA-XK125 for Stripper # 2) will shut down if the air stripper sump low level switch (LLC-6WA-XK103 for Stripper # 1 or LLC-6WA-XK122 for Stripper # 2) trips;

8) The cleaning loop is fully initiated after a few minutes and ready to receive the cleaning solution. A signal is sent to CP-300 (Scale Cleaning System) to START the scale cleaning system transfer pump (PU-6CI-XK071 for Stripper # 1 or PU-6CI-XK070 for Stripper # 2). The cleaning solution is injected into the stripper sump and becomes part of the cleaning loop; and

9) The CLEAN cycle is stopped if an alarm from any of the following sensors is detected:

   a) Air stripper sump low level switch (LLC-6WA-XK103 for Stripper # 1 or LLC-6WA-XK122 for Stripper # 2);

   b) Air stripper sump high level switch (LLC-6WA-XK102 for Stripper # 1 or LLC-6WA-XK121 for Stripper # 2);

   c) Air stripper low pressure switch, (PS-6AR-XK231 for Stripper # 1 or PS-6AR-XK225 for Stripper # 2);

   d) Air stripper high pressure switch, (PS-6AR-XK232 for Stripper # 1 and PS-6AR-XK226 for Stripper # 2); and

   e) Blower inlet low pressure switch, (PS-6AR-XK101 for Stripper # 1 and PS-6AR-XK120.

E. Dump Cycle

The fluid in the stripper is dumped into the spent cleaning solution tank once the CLEAN cycle is complete (preset amount of time) or when an alarm condition is encountered during a clean cycle. The I&C "VERIFY/PERFORMS" the following:

A. Discharge to spent cleaning tank electrical control isolation valve (ECV-6WA-XK092 for Stripper # 1 or ECV-6WA-XK129 for Stripper # 2) is OPEN;

B. Cleaning loop electrical control isolation valve (ECV-6WA-XK110 for Stripper # 1 or ECV-6WA-XK111 for Stripper # 2) is CLOSED;

C. Air stripper blower (BL-6AR-XK098 for Stripper # 1 or BL-6AR-XK117 for Stripper # 2) STOPS (no timeout needed);

D. Air stripper effluent discharge pump (PU-6WA-XK106 for Stripper # 1 or PU-6WA-XK125 for Stripper # 2) continues to operate and transfers the spent cleaning solution to TK-6WA-XK222 (spent cleaning solution tank). The pump rate is controlled by the air stripper sump level transmitter (LLT-6WA-XK104 for Stripper # 1 or LLT-6WA-XK123 for Stripper # 2);

E. During the transfer operation, the air stripper effluent discharge pump (PU-6WA-XK106 for Stripper #1 or PU-6WA-XK125 for Stripper # 2) STOPS when

   1) The air stripper sump low level switch (LLC-6WA-XK103 for Stripper # 1 or LLC-6WA-XK122 for Stripper # 2) is tripped or

   2) The high level switch for the spent cleaning solution tank (LLC-6WA-XK065) is tripped;

F. Air stripper effluent discharge pump (PU-6WA-XK106 for Stripper # 1 and PU-6WA-XK125 for Stripper # 2) STOPS when the liquid level in the stripper sump reaches a low level as indicated by the air stripper sump level transmitter (LLT-6WA-XK104 for Stripper # 1 and LLT-6WA-XK123 for Stripper # 2). The clean/dump cycle is complete;

G. PU-6CI-XK078 operates from an ON/OFF signal from both CP-100 (Air Stripper # 1) and CP-200 (Air Stripper # 2). CP-400 (Scale Control System) only allows operation of the scale control chemical metering pump PU-6CI-XK078 if one or both strippers are in STRIP cycle; and

H. CLEAN CYCLE (Scale Cleaning System): CP-300 receives a signal from either CP-100 (Air Stripper # 1) or CP-200 (Air Stripper # 2) (not both) to turn ON either PU-6CI-XK071 for Stripper # 1 or PU-6CI-XK070 for Stripper # 2. The pre-measured, pre-mixed cleaning solution is pumped into either air

stripper until the cleaning system tank low level sensor (LLC-6CI-XK067) LS-300 is tripped and STOPS the scale cleaning system transfer pump (PU-6CI-XK071 for Stripper # 1 and PU-6CI-XK070 for Stripper # 2).

12. REMOVING AN AIR STRIPPER FROM SERVICE

These instructions apply when the treatment system is running in 100% mode, utilizing both air strippers.

Log on to the Instrumentation and Control System HMI in the Building 650 control room and navigate to the screen showing the air stripper (either #1 or #2) to be taken out of service. Select the **MANUAL** tab on the right side of the air stripper screen, then Select the red **STOP** button to halt stripper operation.

Verify that the control system automatically switches to 50% mode through the remaining air stripper. Note that the stripper blower remains operational for five minutes.

Verify that the **STOP** button results in the selected air stripper shutting down and remaining idle.

13. INITIATING A STRIPPER CLEANING CYCLE

Verify/place the hand switch on the control panel of the CP-300 Scale Cleaning Skid to the **AUTO** position.

Verify/place the pump hand switches on the control panel of the CP-300 Scale Cleaning Skid to the **AUTO** position.

Verify that the proper quantity of cleaning solution is available in the storage tank TK-6CI-XK064. If not, prepare the chemical solution in the tank per the instructions located in Attachment G this WJI.

Verify that there is adequate volume available in the Spent Cleaning Solution tank TK-6CI-XK222 to contain the fluid of one cleaning cycle. If there is not, follow the procedures to empty the tank detailed in Attachment G this WJI.

Log on to the Instrumentation and Control System HMI in the Building 650 control room and navigate to the screen showing the air stripper to be taken out of service. Click on the **CLEAN** tab in the lower right corner of that air stripper screen.

Verify that the control system automatically switches to 50% mode through the remaining air stripper.

Verify that the **CLEAN** button results in the selected air stripper beginning its automated cleaning sequence.

14. BRINGING AN AIR STRIPPER ONLINE

These instructions apply when the treatment system is running in 50% mode, utilizing a single air stripper.

Log on to the Instrumentation and Control System HMI in the Building 650 control room and navigate to the screen showing the air stripper to be put into service.

Verify/enter the proper values for the **AUTO** and **MANUAL** mode flow rate set points in the appropriate locations on the screen.

Select the **AUTO** tab on the right side of the screen for automatic operation.

Select the **START** tab in the lower right hand corner of the screen to start the stripper.

Verify that the **START** button results in the selected air stripper beginning its automated startup sequence, and that the I&C automatically switches into 100% mode utilizing both air strippers.

15. REMOVING AN EXTRACTION WELL FROM SERVICE

Log onto the Instrumentation and Control System HMI in the Building 650 control room and navigate to the screen showing the particular well that is to be removed from service.

On the left side of the screen where the pump controls are shown, click on the **DO NOT RUN AT 50%** and the **DO NOT RUN AT 100%** tabs. Alternatively, click on the **MANUAL** tab, followed quickly by the **OFF** tab in the lower left corner of the screen.

On the right side of the screen where the well flow controls are shown, click on the **MANUAL** tab, then enter a zero ("0") in the **MANUAL SP** field.

NOTE

THE TREATMENT SYSTEM IS PROGRAMMED TO SHUT DOWN IF MORE THAN TWO EXTRACTION OR TWO INJECTION WELLS ARE OUT OF SERVICE FOR ANY REASON.

16. BRINGING AN EXTRACTION WELL ONLINE

These instructions apply regardless of whether the treatment system is operating in 50% or 100% mode.

Log onto the Instrumentation and Control System HMI in the Building 650 control room and navigate to the screen showing the particular well that is to be put placed in service.

On the right side of the screen, enter the proper flow rate set points for 50% and 100% modes. Select the **AUTO** tab for automatic operation of the flow control for this well. Refer to the most recent HMI Configuration Setup Sheets for the proper flow rate set points for the respective well.

On the left side of the screen, verify/select the **MANUAL** tab for the well pump. Now select the **RUN AT 50%** and/or the **RUN AT 100%** tabs. Refer to the most recent HMI Configuration Setup Sheets for information on whether the well is in operation in 50% mode, 100% mode, or both.

Select the **REMOTE** tab on the left side of the screen to start the pump and bring the well back into service.

Verify that the well pump starts properly and the flow rate stabilizes at the proper set point.

17. REMOVING AN INJECTION WELL FROM SERVICE

Log onto the Instrumentation and Control System HMI in the Building 650 control room and navigate to the screen showing the particular well that is to be removed from service.

On the right side of the screen where the well flow controls are shown, click on the **MANUAL** tab, then enter a zero ("0") in the **MANUAL SP** field.

NOTE

THE TREATMENT SYSTEM IS PROGRAMMED TO SHUT DOWN IF MORE THAN TWO EXTRACTION OR TWO INJECTION WELLS ARE OUT OF SERVICE FOR ANY REASON.

18. BRINGING AN INJECTION WELL ONLINE

Log onto the Instrumentation and Control System HMI in the Building 650 control room and navigate to the screen showing the particular well that is to be placed in service.

On the right side of the screen, enter the proper flow rate set points for 50% and 100% modes. Refer to the most recent HMI Configuration Setup Sheets for the proper set points for the respective well.

Select the **AUTO** tab to resume automatic operation of the flow control for this well.

Verify that the well flow control begins operation and the flow rate stabilizes at the proper set point.

19. UV REACTOR SYSTEM ALARMS AND INTERLOCKS

There are a number of conditions that must be met before the UV Reactor system will begin operating and/or continue operating. An alarm will be displayed on the Rayox interface panel, which is located on the front panel of the UV power supply in the Building 650 electrical room. When the UV Reactor system shuts down due to one of these alarms, the I&C initiates a complete treatment system shut down.

The startup interlocks are as follows:

A. Pneumatic air pressure is insufficient;
B. Lamp enclosure lid is open;
C. Temperature in UV reactor vessel is high;
D. Moisture detected in UV lamp enclosure;
E. Temperature in UV power supply cabinet is high;
F. Emergency stop button is engaged;

Should any of the above conditions occur during system operation, they will result in a system shut down.

The additional emergency (shut down) alarms are as follows:

A. Lamp auxiliary contact failure;
B. Lamp using high amperage;
C. Lamp has insufficient amperage;
D. Lamp has insufficient voltage;
E. Power cabinet door is open;
F. Lamp power shorting to ground;
G. Reactor water level is low;
H. Service wipers are not operating;
I. Flow rate through reactor is low; and
J. Power supply transformer is overheating.

20. UV REACTOR SYSTEM STARTUP

Switch the main disconnect on the UV power supply to the **ON** position. The message **AC POWER UP** will display on the Rayox interface panel while previously mentioned interlocks are checked, followed by **SYSTEM READY**, and finally the Calgon logo is displayed.

Verify/complete the Treatment System Mechanical Setups by working appropriate sections of Attachment E of this WJI.

At the Rayox interface panel, touch the **GO TO MENU** button in the lower right hand corner of the touch screen to open the **MAIN MENU** screen.

Navigate to the **SYSTEM PARAMETERS** screen on the Rayox interface panel. Verify/select the **REMOTE** operation mode on the Rayox interface panel. This selects the option where the unit can be started by a remote signal only.

Navigate to the **LAMP START & STOP** screen on the Rayox interface panel and verify/select the UV lamps that are to be turned on per work authorizing document instructions.

The UV Reactor system is now ready for startup via a remote signal from the PLC-MAIN. Once there is the required minimum water flow through the vessel, the lamp ignition sequence will begin for the lamps selected in the above steps. During this time the message **SYSTEM WARM-UP** will be displayed on the Rayox interface panel. Ignition takes approximately two minutes per lamp and starts with the lowest lamp in the tower working upward.

NOTE

THE UV REACTOR WILL SHUT DOWN IF THE FLOW THROUGH THE VESSEL DROPS BELOW THE REQUIRED MINIMUM OF 200 GPM.

After startup of the reactor, verify that the transmittance controllers begin to cycle, wiping the exterior of the quartz UV lamp tubes inside the vessel. This is indicated by the solenoids cycling on the south side of the vessel.

When all lamps are operating correctly, the system is treating the water and the message **TREATING** is displayed on the Rayox interface panel.

Once the UV Reactor is operating it can be left running unattended for extended periods of time. There are built-in safety features and interlocks to ensure that it safely and automatically shuts down should certain parameters fall out of range.

21. SYSTEM SHUTDOWN PROCEDURE

A. Log on to the Instrumentation and Control System HMI in the Building 650 control room and navigate to the **STARTUP/SHUTDOWN** screen.

B. Click on the **SHUTDOWN** tab located in the lower left corner of the screen to begin the automated sequence that takes the treatment system offline.

C. Monitor the shutdown sequence, verifying that the steps proceed in sequence as indicated on the **STARTUP/SHUTDOWN** screen until the **SHUTDOWN** indication is hi-lighted. If a problem becomes apparent, click on the

EMERGENCY SHUTDOWN button on the lower right of the screen. Shutdown sequence consists of the following steps:

1) Stopping PFE-1 Pump;
2) Stopping PFE-2 Pump;
3) Stopping PFE-3 Pump;
4) Stopping PFE-4A Pump;
5) Stopping PFE-5 Pump;
6) Stopping PFE-7 Pump;
7) Opening Recycle Block Valve;
8) Closing Effluent Block Valve;
9) Recycling for 10 minutes;
10) Stopping UV;
11) Stopping Air Strippers;
12) Closing Recycle Block Valve; and
13) Shutdown.

22. SYSTEM SECURING – SHORT TERM

If the treatment system is to be shut down for less than 90 days follow the steps in this section to secure the equipment.

Complete the appropriate sections of Attachment E to secure mechanical systems for the short term. Initial and date the sheet as indicated.

Complete the Treatment System HMI Securing sheet. Initial and date the sheet as indicated.

Complete the Treatment System Electrical Securing sheet. This will ensure that the electrical power supply is removed from the major equipment and the control system. Initial and date the sheet as indicated.

23. SYSTEM SECURING – LONG TERM

If the treatment system is to be shut down for more than 90 days follow the steps in this section to lay up the equipment.

Complete all steps of the SYSTEM SECURING -- SHORT TERM section of this WJI.

Request a work ticket through the contractor Work Control office for the contractor Engineering Department personnel to secure the large HVAC system that controls the temperature in the Building 650 electrical room.

Open valve MV-6WA-XK119, the sump drain valve on Air Stripper #1. Drain the sump to its lowest level, then close the valve.

Open valve MV-6WA-XK061, the sump drain valve on Air Stripper #2. Drain the sump to its lowest level, then close the valve.

Manually open valve ECV-6WA-XK187, the drain valve on the air stripper. Drain the reactor vessel to its lowest level, then close the valve.

If the Spent Cleaning Solution tank TK-6WA-XK222 is not empty, complete a contracor Environmental Department Task Memo to have the tank drained to its lowest level.

If the Building 650 sump contains a measurable amount of water, complete a task memo to have the sump tank drained to the lowest level possible.

Turn off all outdoor lighting at Building 650 and Building 651, verify/lock all doors and gates.

ENCLOSURE 1

SYSTEM PROCESS CONTROL

SETUP SHEETS

Treatment System Electrical Setup Sheet

Main Breaker Panel - 480 VAC/2500 Amp (NW corner of B650 Electrical Room)

Note: Place a check mark in blocks as they are completed or verified.

DATE	MASTER CUTOFF SWITCH (LOWER RHS)	CIRCUIT MONITORING UNIT (UPPER RHS)	CKT NO 5,7,9 - AHU (Air Handling Unit)	CKT NO 4,6,8 - AC-1	CKT NO 11,13,15 - AIR STRIPPER #1	CKT NO 10,12,14 - AC-2	CKT. NO. 17,19,21 - AIR STRIPPER #2	CKT. NO. 16,18,20 - AC-3	CKT. NO. 28,30,32 - UNIT HEATER #1	CKT. NO. 34,36,38 - UNIT HEATER #2	CKT. NO. 46,48,50 - AIR COMPRESSOR	Scale Cleaning Skid	OPERATOR INITIALS
	ON	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	

Treatment System Electrical Setup Sheet

Panel LA-1 120VAC (West Wall in B650 Electrical Room)

Note: Place a check mark in blocks as they are completed or verified.

DATE	CKT. NO. 1 - ELECTRICAL ROOM LIGHTS	CKT. NO. 2 - HI-BAY S.W. CORNER RECEPTACLE	CKT. NO. 3 - CONTROL ROOM LIGHTS	CKT. NO. 4 - HI-BAY S.E. CORNER RECEPTACLE	CKT. NO. 5 - RESTROOM LIGHTS	CKT. NO. 6 - HI-BAY S. CENTRAL LIGHTS	CKT. NO. 7 - HI-BAY N. CENTRAL LIGHTS	CKT. NO. 8 - HI-BAY CENTRAL LIGHTS	CKT. NO. 9 - HI-BAY NORTH LIGHTS	CKT. NO. 10 - HI-BAY SOUTH LIGHTS	CKT. NO. 11 - OUTSIDE LIGHTS	CKT. NO 12 - EMERGENCY LIGHTS AT WEST EXIT	CKT. NO. 13 - WATER HEATER	CKT. NO. 14 - HI-BAY SOUTH WALL RECEPTACLE	CKT. NO. 15 - SPARE	CKT. NO. 16 - LEAK DETECTION S.E. CORNER	CKT. NO. 17 - S.W. EMERGENCY LIGHTS	OPERATOR INITIALS
	ON	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**OFF**	**ON**	**ON**	

Treatment System Electrical Setup Sheet

Panel LA-2 120 VAC (West Wall in B650 Electrical Room)

Note: Place a check mark in blocks as they are completed or verified.

DATE	CKT. NO. 1 - CONTROL ROOM S WALL RECEPTACLE	CKT. NO. 2 - ELECTRICAL ROOM S WALL RECEPTACLE	CKT. NO. 3 - CONTROL ROOM E WALL RECEPTACLE	CKT. NO. 4 - BATHROOM RECEPTACLE	CKT. NO. 5 - CONTROL ROOM E WALL RECEPTACLE	CKT. NO. 6 - CONTROL ROOM N & W RECEPTACLES	CKT. NO. 7 - ELECTRICAL ROOM N WALL RECEPTACLE	CKT. NO. 8 - HI-BAY NE SIDE EXIT & EMERGENCY LIGHT	CKT. NO. 9 - EMERGENCY LIGHT	CKT. NO. 10 - HI-BAY SE CENTER RECEPTACLE	CKT. NO. 11 - HI-BAY NE WALL RECEPTACLE (SIDE)	CKT. NO 12 - HI-BAY NE CENTER RECEPTACLES	CKT. NO. 13 - HI-BAY NE WALL RECEPTACLE (FRONT)	CKT. NO. 14 - 120 VAC - SCALE CONTROL SKIDS	CKT. NO. 15 - FIRE ALARM PANEL	CKT. NO. 16 - 120 VAC - UV UNIT #1	CKT. NO. 17 - PHONE PANEL	OPERATOR INITIALS
	ON	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	

Treatment System Electrical Setup Sheet

Panel PS-1 (West End of UV Power Supply Cabinet)

Note: Place a check mark in blocks as they are completed or verified.

DATE	MAIN BREAKER (BOTTOM OF PANEL)	CKT NO 1 - LAMP 1, CB 1A	CKT NO 2 - LAMP 1, CB 1B	CKT NO 3 - LAMP 2, CB 2A	CKT NO 4 - LAMP 2, CB 2B	CKT NO 5 - LAMP 3, CB 3A	CKT NO 6 - LAMP 3, CB 3B	CKT NO 7 - LAMP 4, CB 4A	CKT NO 8 - LAMP 4, CB 4B	CKT NO 9 - LAMP 5, CB 5A	CKT NO 10 - LAMP 5, CB 5B	CKT NO 11 - LAMP 6, CB 6A	CKT NO 12 - LAMP 6, CB 6B	CKT. NO. 13 - T1CB, CONTROL TR				OPERATOR INITIALS
	ON	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**				

Treatment System Electrical Setup Sheet

Panel PS-2 (West End of UV Power Supply Cabinet)

Note: Place a check mark in blocks as they are completed or verified.

DATE	MAIN BREAKER (BOTTOM OF PANEL)	CKT NO 1 - LAMP 7, CB 7A	CKT NO 2 - LAMP 7, CB 7B	CKT NO 3 - LAMP 8, CB 8A	CKT NO 4 - LAMP 8, CB 8B	CKT. NO. 5 - LAMP 9, CB 9A	CKT. NO. 6 - LAMP 9, CB 9B	CKT. NO. 7 - LAMP 10, CB 10A	CKT. NO. 8 - LAMP 10, CB 10B	CKT. NO. 9 - LAMP 11, CB 11A	CKT. NO. 10 - LAMP 11, CB 11B	CKT. NO. 11 - LAMP 12, CB 12A	CKT. NO 12 - LAMP 12, CB 12B	CKT. NO. 13 - T1CB, CONTROL TR				OPERATOR INITIALS
	ON	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**	**ON**				

Treatment System Electrical Securing Sheet

Main Breaker Panel - 480 VAC/2500 Amp (NW corner of B650 Electrical Room)

Note: Place a check mark in blocks as they are completed or verified.

DATE	CKT NO 11,13,15 - AIR STRIPPER #1	CKT. NO. 17,19,21 - AIR STRIPPER #2	CKT. NO. 46,48,50 - AIR COMPRESSOR	CKT NO 5,7,9 - AHU (Air Handling Unit)	OPERATOR INITIALS
	OFF	**OFF**	**OFF**	**OFF**	

DATE	CKT NO 11,13,15 - AIR STRIPPER #1	CKT. NO. 17,19,21 - AIR STRIPPER #2	CKT. NO. 46,48,50 - AIR COMPRESSOR	CKT NO 5,7,9 - AHU (Air Handling Unit)	OPERATOR INITIALS
	OFF	**OFF**	**OFF**	**OFF**	

Treatment System Electrical Securing Sheet

Panel LA-2 (West Wall in B650 Electrical Room)

Note: Place a check mark in blocks as they are completed or verified.

DATE	CKT. NO. 14 - 120 VAC FOR SCALE CONTROL SKIDS	CKT. NO. 16 - 120 VAC FOR UV UNIT #1	OPERATOR INITIALS
	OFF	**OFF**	

DATE	CKT. NO. 14 - 120 VAC FOR SCALE CONTROL SKIDS	CKT. NO. 16 - 120 VAC FOR UV UNIT #1	OPERATOR INITIALS
	OFF	**OFF**	

DATE	CKT. NO. 14 - 120 VAC FOR SCALE CONTROL SKIDS	CKT. NO. 16 - 120 VAC FOR UV UNIT #1	OPERATOR INITIALS
	OFF	**OFF**	

Treatment System Electrical Securing Sheet

Panel PS-1 and PS-2 (West End of UV Power Supply Cabinet)

Note: Place a check mark in blocks as they are completed or verified.

DATE	Main Breaker for PS-1	Main Breaker for PS-2	OPERATOR INITIALS	DATE	Main Breaker for PS-1	Main Breaker for PS-2	OPERATOR INITIALS	DATE	Main Breaker for PS-1	Main Breaker for PS-2	OPERATOR INITIALS
	OFF	**OFF**			**OFF**	**OFF**			**OFF**	**OFF**	

Treatment System HMI Setup Sheet

ITEM #	INSTRUCTION	VALUE	INITIALS
	HMI Startup Configuration Setup and Login		
1	Switch on the power and boot up Master Control Center PC	N/A	_____
2	Log onto the WSTF network	N/A	_____
3	Launch the RSView32 HMI software package located at the address below: Start/Programs/Rockwell Software/RSView32/RSView32 Works ****NOTE**** **The RSView32 software has completed loading when the hourglass mouse-pointer icon is replaced by the normal arrow mouse-pointer icon.**	N/A	_____
4	Click on the File pulldown menu, then select the project file below: D:/Plume Front/PlumeFront.rsv ****NOTE**** **The Plume Front project file has completed loading when the "PLUME FRONT.RSV - Project" window is displayed on the screen inside the RSView32 window.**	N/A	_____
5	Select the **Run Mode** tab in the **PLUME FRONT.RSV - Project** window, then click on the Run Project button to launch the HMI program. ****NOTE**** **The HMI program has completed loading when the "Starting Project - please wait" window is no longer displayed on the screen.**	N/A	_____
6	Click on the **SECURITY** tab on the left hand side of the screen, then select the **LOGIN** tab. Type in user name and password supplied by system administrator where prompted and click the **OKAY** button.	N/A	_____
7	Click on the **OVERVIEW** tab on the left hand side of the screen and verify that the HMI program is operational as reflected by the following: Operational Mode is OFF (no mode indicated) System Flow Rate is 0.0 GPM Extraction Well Pumps are off (RED color) Effluent Block Valve is closed (RED color) Recycle Block Valve is closed (RED color) Air Stripper 1 is off (RED color) Air Stripper 2 is off (RED color)	N/A	_____

Treatment System HMI Setup Sheet

ITEM #	INSTRUCTION	VALUE	INITIALS
	Extraction Well PFE-1 Configuration ****NOTE**** **The following steps are to be completed only if the PFE-1 well is to operate in the treatment scheme. Refer to WAD for this information.**		
8	At the well motor control center, verify/place the HAND-OFF-AUTO switch for the PFE-1 *well pump* in the AUTO position.	AUTO	_____
9	At the well motor control center, verify/place the HAND-OFF-AUTO switch for the PFE-1 *flow control* in the AUTO position.	AUTO	_____
10	Navigate to the PFE-1 screen in the HMI software in the B650 control room. Verify that the REMOTE tab is highlighted for the well pump operation, and that the CONTROLLER IN AUTO tab is highlighted for the flow control operation.	N/A	_____
11	Enter the appropriate values for PFE-1 operation in the 50% mode and 100% mode on the right side of the screen. Units are GPM. 50% mode flow rate 100% mode flow rate	 144 288	 _____ _____
	Extraction Well PFE-2 Configuration ****NOTE**** **The following steps are to be completed only if the PFE-2 well is to operate in the treatment scheme. Refer to WAD for this information.**		
12	At the well motor control center, verify/place the HAND-OFF-AUTO switch for the PFE-2 *well pump* in the AUTO position.	AUTO	_____
13	At the well motor control center, verify/place the HAND-OFF-AUTO switch for the PFE-2 *flow control* in the AUTO position.	AUTO	_____
14	Navigate to the PFE-2 screen in the HMI software in the B650 control room. Verify that the REMOTE tab is highlighted for the well pump operation, and that the CONTROLLER IN AUTO tab is highlighted for the flow control operation.	N/A	_____

Treatment System HMI Setup Sheet

ITEM #	INSTRUCTION	VALUE	INITIALS
15	Enter the appropriate values for PFE-2 operation in the 50% mode and 100% mode on the right side of the screen. Units are GPM.		
	50% mode flow rate	112	_____
	100% mode flow rate	224	_____
	Extraction Well PFE-3 Configuration		
	****NOTE**** **The following steps are to be completed only if the PFE-3 well is to operate in the treatment scheme. Refer to WAD for this information.**		
16	At the well motor control center, verify/place the HAND-OFF-AUTO switch for the PFE-3 *well pump* in the AUTO position.	AUTO	_____
17	At the well motor control center, verify/place the HAND-OFF-AUTO switch for the PFE-3 *flow control* in the AUTO position.	AUTO	_____
18	Navigate to the PFE-3 screen in the HMI software in the B650 control room. Verify that the REMOTE tab is highlighted for the well pump operation, and that the CONTROLLER IN AUTO tab is highlighted for the flow control operation.	N/A	_____
19	Enter the appropriate values for PFE-3 operation in the 50% mode and 100% mode on the right side of the screen. Units are GPM.		
	50% mode flow rate	107	_____
	100% mode flow rate	213	_____
	Extraction Well PFE-4A Configuration		
	****NOTE**** **The following steps are to be completed only if the PFE-4A well is to operate in the treatment scheme. Refer to WAD for this information.**		
20	At the well motor control center, verify/place the HAND-OFF-AUTO switch for the PFE-4A *well pump* in the AUTO position.	AUTO	_____
21	At the well motor control center, verify/place the HAND-OFF-AUTO switch for the PFE-4A *flow control* in the AUTO position.	AUTO	_____

Treatment System HMI Setup Sheet

ITEM #	INSTRUCTION	VALUE	INITIALS
22	Navigate to the PFE-4A screen in the HMI software in the B650 control room. Verify that the REMOTE tab is highlighted for the well pump operation, and that the CONTROLLER IN AUTO tab is highlighted for the flow control operation.	N/A	_____
23	Enter the appropriate values for PFE-4A operation in the 50% mode and 100% mode on the right side of the screen. Units are GPM. 50% mode flow rate 100% mode flow rate	 100 200	 _____ _____
	Extraction Well PFE-5 Configuration ****NOTE**** **The following steps are to be completed only if the PFE-5 well is to operate in the treatment scheme. Refer to WAD for this information.**		
24	At the well motor control center, verify/place the HAND-OFF-AUTO switch for the PFE-5 *well pump* in the AUTO position.	AUTO	_____
25	Navigate to the PFE-5 screen in the HMI software in the B650 control room. Verify that the REMOTE tab is highlighted for the well pump operation. ****NOTE**** **PFE-5 is the only extraction well that does not have flow control capability, therefore its configuration is different.**	N/A	_____
	Extraction Well PFE-7 Configuration ****NOTE**** **The following steps are to be completed only if the PFE-7 well is to operate in the treatment scheme. Refer to WAD for this information.**		
26	At the well motor control center, verify/place the HAND-OFF-AUTO switch for the PFE-7 *well pump* in the AUTO position.	AUTO	_____
27	At the well motor control center, verify/place the HAND-OFF-AUTO switch for the PFE-7 *flow control* in the AUTO position.	AUTO	_____
28	Navigate to the PFE-7 screen in the HMI software in the B650 control room. Verify that the REMOTE tab is highlighted for the well pump operation, and that the CONTROLLER IN AUTO tab is highlighted for the flow control operation.	N/A	_____

Treatment System HMI Setup Sheet

ITEM #	INSTRUCTION	VALUE	INITIALS
29	Enter the appropriate values for PFE-7 operation in the 50% mode and 100% mode on the right side of the screen. Units are GPM.		
	50% mode flow rate	63	_____
	100% mode flow rate	125	_____
	Injection Well PFI-1 Configuration:		
	****NOTE**** **The following steps are to be completed only if the PFI-1 well is to operate in the treatment scheme. Refer to WAD for this information.**		
30	At the B651 control panel, verify/place the HAND-OFF-AUTO switch for the PFI-1 flow control in the AUTO position.	AUTO	_____
31	Navigate to the PFI-1 screen in the HMI software in the B650 control room. Verify that the CONTROLLER IN AUTO tab is highlighted for the flow control operation.	N/A	_____
32	Enter the appropriate values for PFI-1 operation in the 50% mode and 100% mode on the right side of the screen. Units are GPM.		
	50% mode flow rate	135	_____
	100% mode flow rate	269	_____
	Injection Well PFI-2 Configuration:		
	****NOTE**** **The following steps are to be completed only if the PFI-2 well is to operate in the treatment scheme. Refer to WAD for this information.**		
33	At the B651 control panel, verify/place the HAND-OFF-AUTO switch for the PFI-2 flow control in the AUTO position.	AUTO	_____
34	Navigate to the PFI-2 screen in the HMI software in the B650 control room. Verify that the CONTROLLER IN AUTO tab is highlighted for the flow control operation.	N/A	_____
35	Enter the appropriate values for PFI-2 operation in the 50% mode and 100% mode on the right side of the screen. Units are GPM.		
	50% mode flow rate	134	_____
	100% mode flow rate	268	_____

Treatment System HMI Setup Sheet

ITEM #	INSTRUCTION	VALUE	INITIALS
	Injection Well PFI-3 Configuration:		
	****NOTE**** **The following steps are to be completed only if the PFI-3 well is to operate in the treatment scheme. Refer to WAD for this information.**		
36	At the B651 control panel, verify/place the HAND-OFF-AUTO switch for the PFI-3 flow control in the AUTO position.	AUTO	_____
37	Navigate to the PFI-3 screen in the HMI software in the B650 control room. Verify that the CONTROLLER IN AUTO tab is highlighted for the flow control operation.	N/A	_____
38	Enter the appropriate values for PFI-3 operation in the 50% mode and 100% mode on the right side of the screen. Units are GPM.		
	50% mode flow rate	172	_____
	100% mode flow rate	345	_____
	Injection Well PFI-4 Configuration:		
	****NOTE**** **The following steps are to be completed only if the PFI-4 well is to operate in the treatment scheme. Refer to WAD for this information.**		
39	At the B651 control panel, verify/place the **HAND-OFF-AUTO** switch for the PFI-4 flow control in the **AUTO** position.	AUTO	_____
40	Navigate to the PFI-4 screen in the HMI software in the B650 control room. Verify that the **CONTROLLER IN AUTO** tab is highlighted for the flow control operation.	N/A	_____
41	Enter the appropriate values for PFI-4 operation in the 50% mode and 100% mode on the right side of the screen. Units are GPM.		
	50% mode flow rate	97	_____
	100% mode flow rate	194	_____
	Scale Control Configuration:		
42	Verify/place the electrical disconnect switch on the Scale Control skid control panel enclosure to the **ON** position.	ON	_____

Treatment System HMI Setup Sheet

ITEM #	INSTRUCTION	VALUE	INITIALS
43	Verify/place the Scale Control skid chemical pump **HAND-OFF-AUTO** switch into the **AUTO** position.	AUTO	_____
44	Navigate to the Scale Control screen in the HMI software in the B650 control room. Verify/selct the **AUTO** tab on the right side of the screen.	AUTO	_____
45	**Air Stripper #1 Configuration:** Verify/place the electrical disconnect switch on Air Stripper #1 skid control panel enclosure to the **ON** position.	ON	_____
46	Verify/place the Air Stripper #1 blower **HAND-OFF-AUTO** switch into the **AUTO** position.	AUTO	_____
47	Verify/place the Air Stripper #1 discharge pump **HAND-OFF-AUTO** switch into the **AUTO** position.	AUTO	_____
48	Navigate to the Stripper #1 screen in the HMI software in the B650 control room. On the left side of the screen, enter the value shown at right for the **AUTO SP** in GPM, then select the **AUTO** tab for automatic operation.	537 AUTO	_____ _____
49	Select the **STRIPPER 1 RUN AT 50**% button on the screen and verify that it changes color.	RUN	_____
50	Select the AUTO tab on the screen and verify that it changes color.	AUTO	_____
51	**Air Stripper #2 Configuration:** Verify/place the electrical disconnect switch on Air Stripper #2 skid control panel enclosure to the **ON** position.	ON	_____
52	Verify/place the Air Stripper #2 blower **HAND-OFF-AUTO** switch into the **AUTO** position.	AUTO	_____
53	Verify/place the Air Stripper #2 discharge pump **HAND-OFF-AUTO** switch into the **AUTO** position.	AUTO	_____
54	Navigate to the Stripper #2 screen in the HMI software in the B650 control room. On the left side of the screen, enter the value shown at right for the **AUTO SP** in GPM, then select the **AUTO** tab for automatic operation.	537 AUTO	_____

Treatment System HMI Setup Sheet

ITEM #	INSTRUCTION	VALUE	INITIALS
55	Select the **STRIPPER 2 RUN AT 50%** button on the right side of the screen, and verify that it changes color.	RUN	_____
56	Select the **AUTO** tab on the screen and verify that it changes color.	AUTO	_____
57	**UV #1 Configuration:** Verify/place the UV #1 main disconnect on the front of the Rayox control cabinet, in the B650 electrical room, to the **ON** position.	ON	_____
58	At the front of the Rayox interface panel, in B650, verify that it indicates **SYSTEM READY** and is configured for **REMOTE** operation.	REMOTE	_____
59	Navigate to the UV #1 screen in the HMI software in the B650 control room. Select the **AUTO** tab on the left side of the screen.	AUTO	_____
60	**Alarm Acknowledgement:** Navigate to the Alarms screen of the HMI by selecting the **ALARMS** tab in the lower left corner tab of all screens.	N/A	_____
61	Select the **ACK ALL** tab in the lower left corner of the Alarms screen to acknowledge all alarm conditions. If alarm conditions still exist, consult the Alarms attachment of this WJI.	N/A	_____

Treatment System HMI Securing Sheet

ITEM #	INSTRUCTION	VALUE	INITIALS
1	Select the **TREATMENT BUILDING** tab on the left side of any HMI screen. Verify that the remediation system is not operating, e.g. flow meters indicate no flow.	N/A	_____
2	Select the **ADMIN** tab on the left side of the HMI screen	N/A	_____
3	Select the **STOP PROJECT** tab on the left side of the HMI screen to stop the HMI software. There should now be the "RSView32 Works" main window with the smaller "PLUME FRONT.RSV - Project" window nested inside it on the MCC screen.	N/A	_____
4	Select the "File" pull down menu on the RSView32 Works window, then click on the "Exit RSView32" submenu. Verify that the software closes and the I&C system defaults to MS Windows.	N/A	_____

ATTACHMENT I

EMERGENCY SHUTDOWN PROCEDURES

An emergency shutdown can be manually initiated in one of two ways:

A. In the Building 650 control room Instrumentation and control system (I&C), navigate to the STARTUP/SHUTDOWN screen in the HMI software. Click on the EMER SHUTDOWN tab in the lower right corner of the screen to initiate the process. This will be verified by the blinking message at the bottom of the screen indicating "EMERGENCY SHUTDOWN INITIATED".

B. On the west exterior wall of Building 650, to the right side of the entrance door, there is a small electrical box labeled "EMERGENCY POWER SHUTOFF" with a push button on it. To initiate an emergency shutdown, press this button firmly to kill all power to the equipment in the building. Note that the loss of communication with the PLC-MAIN will initiate shutdowns of all extraction wells and B651 equipment, although power will not be off at these locations. This button requires a key to reset it. The key resides in the contractor Environmental Department Project Leader's office.

WARNING
WHEN THE "EMERGENCY POWER SHUTOFF" BUTTON ON THE EXTERIOR OF Building 650 IS UTILIZED, POWER REMAINS ON AT ALL EXTRACTION WELL PADS AND IN BUILDING 651.

Automatic control is incorporated into the overall design and operation of the treatment system. The system will include instrumentation to monitor control variables that are critical to the operation of the facility. The I&C will respond to:

A. Minor fluctuations in the flow rate by performing operations (such as increasing/reducing flow control valves) to correct the discrepancy;

B. An alarm condition by initiating auto-dialer alarms to notify responsible contractor Environmental Department personnel of the alarm condition. An alarm condition is defined as a deviation from set operating parameters that does not have an immediate impact on the overall treatment efficiency (or present a immediate hazard to personnel, the environment or equipment) but requires corrective action; and

C. Emergency conditions by initiating computer programmed emergency procedures to shutdown and secure the treatment system. An emergency condition is a deviation from set operating parameters that has an immediate impact on the overall treatment efficiency (or presents an immediate hazard to personnel, the environment or equipment) and requires an immediate shutdown of the treatment system. The I&C would:

1. Shutdown and isolate the extraction wells;
2. Shutdown and isolate the treatment facility and process equipment;
3. Isolate the injection wells; and
4. Initiate auto-dialer alarm sequence to notify responsible contractor Environmental Department personnel and/or the WSTF Fire Department of the alarm condition.

Conditions that warrant emergency shutdowns of the treatment system include the following (refer also to Attachment J – Alarm Protocol):

1. Low-low water level alarm for each extraction well
2. Failure to start pump for an extraction well
3. Failure to stop pump for an extraction well
4. Water level high-high for an injection well
5. Low air flow into the air strippers
6. High air flow alarm for air strippers
7. High-high water level alarm for air strippers
8. Low water level alarm for air strippers
9. UV Reactor system shutdown (includes all UV Reactor "emergency" alarms)
10. System discharge block valve fails to open
11. System discharge block valve fails to close
12. System recycle block valve fails to open
13. System recycle block valve fails to close
14. High level alarm for building 650 floor sump
15. Pipeline leak detection system alarm
16. Main emergency shut down button activated
17. Major communication failure with remote PLC's

The process equipment, the air strippers, UV Reactor, chemical metering system, and leak detection system, are purchased from off-site vendors. All units have the capability of some level of automatic process control. The design of the I&C system is shown in drawings 652-E-01 through 652-E-38.

NOTE

REFER TO THE PROCESS CONTROL SECTION OF THIS WJI FOR INSTRUCTION ON HOW TO EXECUTE A ROUTINE SYSTEM SHUTDOWN PROCEDURE.

ATTACHMENT J

ALARM PROTOCOL

1. GENERAL INFORMATION

   This Attachment provides details of the treatment system alarms, what they indicate, and required responses.

2. DRAWINGS AND REFERENCES

   A flow schematic of the treatment facility is provided by DWG # 652-M-02. Drawings and schematics of the instrumentation and control system are provided in DWGs 652-E-01 through 652-E-38. Copies of the manufacturer's operation and maintenance manuals, cut sheets, material specifications, warranties, etc. are maintained by the contractor Environmental Department and are available through the contractor Environmental Department Project Leader (or designated alternate). A list of operation and equipment manuals is provided in the List of References, Attachment A.

3. SAFETY REQUIREMENTS

   Specific safety requirements and instructions in the form of WARNINGS, CAUTIONS and NOTES are contained within the procedures preceding the applicable step(s). A hazard assessment for personal protective equipment per WSI 25-SW-0007 is included in Attachment C. A job hazard analysis per WSI 25-SW-0032 is also included in Attachment C.

4. PERSONNEL REQUIREMENTS

   All Instrumentation and control system (I&C) computer/control station operations per this WJI will be performed by a qualified contractor Environmental Department Groundwater Treatment Facility Operator(s) (per the WSTF Training Database).

   A. Qualified Groundwater Treatment Facility Operators are the contractor Environmental Department Project Leader and qualified contractor Environmental Department engineers or scientists who by means of their working knowledge of the treatment system, the operating and maintenance procedures, safety measures, alarm protocol and emergency procedures have been appointed by the contractor Environmental Department Manager as Groundwater Treatment Facility Operators.

   B. At the discretion of the contractor Environmental Department Project Leader, the operations can be performed by contractor Environmental Department personnel who are receiving "on-the-job" training for qualification as a Groundwater Treatment Facility Operator under the direct supervision of the contractor

Environmental department Project Leader or Certifying/Qualifying instructor who is also qualified as a Groundwater Treatment Facility Operator (per the WSTF Training Database). Personnel receiving "on-the-job" training are required to have completed WSTF Hazardous Waste Handler Training and requirements (1), (2), (3) and (4) listed below.

1) All personnel actively involved in facility operations are required to have current Confined Space Training (per the WSTF Training Database).

2) All personnel actively involved in facility operations are required to have current PPE Training (per the WSTF Training Database).

3) All personnel actively involved in facility operations are required to have current training in the use of a Passport air monitor (or equivalent) (per the WSTF Training Database).

4) All personnel actively involved in facility operations are required to have current Lockout/Tagout Training (per the WSTF Training Database).

5. EQUIPMENT

Equipment involved with activity regarding system alarms is the treatment system Instrumentation and control system (I&C), and the alarm auto-dialer that will be used to notify operators of alarm conditions via telephone and/or pager.

6. SPECIAL REQUIREMENTS

Process control functions can be initiated only from the I&C system located in the control room in Building 650. Operators are unable to manipulate any control functions from any other location. When notified of an alarm condition via the auto-dialer, the operator can only acknowledge that the message was received and nothing more. Operators must then decide if an immediate visit to the treatment system site is warranted. Although the status of the treatment system can be monitored from either the NASA Project Manager office or the contractor Environmental Department office (in Building 101), these two stations cannot perform any control functions.

7. ALARM SYSTEM DESCRIPTION

Depending on the severity of the alarm condition, the system can go into either amber or red alarm mode. In the less severe amber alarm mode, the treatment system will continue functioning. It either attempts to recover from the condition according to its programming, or waits for some operator action. If the alarm condition could result in inadequate water treatment, a water spill, or damage to equipment, the system will go into red alarm mode. In red alarm mode, the system controller automatically initiates a system shut down in the quickest and safest way according to its programming.

Some amber alarm mode conditions can progress into red alarm modes. This will happen in some cases if the system controller is unable to correct the problem according to its programming, or if the operator does not take action to address the situation in a timely manner.

All alarms will be displayed on the I&C screen by the HMI software program. When an alarm condition is detected, a beeping audio alarm will be sounded and a blinking alarm message will be displayed on the HMI **ALARMS** screen. Once the operator selects the **ACK ALARMS** tab, the beeping stops and the alarm message goes from blinking to solid for that alarm. Once an alarm condition is resolved, the displayed message is removed, if it has been acknowledged. Note that if a different alarm condition is detected, the audio alarm again will begin to sound again, until that alarm is acknowledged.

The HMI software will log all system alarms with a time and date stamp, as well as time and date when acknowledged and time and date when the alarm condition is resolved.

The alarm auto-dialer will be programmed to call specified Environmental Department personnel whenever any Red alarm mode is detected. The auto-dialer will call these personnel in a pre-determined sequence until it reaches one that acknowledges receipt of the message.

The HMI software has been programmed to include the alarms listed below:

- Amber Alarm Modes
  1. High flow in an extraction well
  2. Low flow in an extraction well
  3. Low water level in an extraction well
  4. High flow alarm for each injection well
  5. Low flow alarm for each injection well
  6. High water level in an injection well
  7. High air pressure alarm for an air stripper
  8. Filter pressure high for an air stripper
  9. High flow alarm for an air stripper
  10. Low water flow for an air stripper
  11. Low level in anti-scale solution tank
  12. Spent cleaning solution tank high
  13. Low air compressor pressure
  14. Limited communication failure with remote PLC's
  15. Low UV inlet flow
  16. UV Reactor system alarm (includes all UV Reactor "warning" alarms)
- Red Alarm Modes
  1. Low-low water level alarm for each extraction well
  2. Failure to start pump for an extraction well

3. Failure to stop pump for an extraction well
4. Water level high-high for an injection well
5. Low air flow into the air strippers
6. High air flow alarm for air strippers
7. High-high water level alarm for air strippers
8. Low water level alarm for air strippers
9. UV Reactor system shutdown (includes all UV Reactor "emergency" alarms)
10. System discharge block valve fails to open
11. System discharge block valve fails to close
12. System recycle block valve fails to open
13. System recycle block valve fails to close
14. High level alarm for building 650 floor sump
15. Pipeline leak detection system alarm
16. Main emergency shut down button activated
17. Major communication failure with remote PLC's

NOTE

THIS LIST OF ALARMS IS SUBJECT TO CHANGE BASED ON NASA APPROVED DESIGN REVISIONS AS A RESULT OF SYSTEM VERIFICATION BY THE I&C DESIGN CONTRACTOR.

PLUME-FRONT TREATMENT SYSTEM SAMPLING SCHEDULE
SAMPLE COLLECTION AND ANALYSIS REQUIREMENTS

TREATMENT FACILITY/GROUNDWATER ANALYTES				
Analysis	**EPA Method**	**Sample Container[1]**	**Sample Preservative[1]**	**Holding Time[1]**
Volatile Organics in Influent and Monitoring Wells	EPA Method 8260 or EPA approved/recommended equivalent	40 mL glass	HCl and Cool to $4^{O}C \pm 2^{O}C$	14 days
Volatile Organics in Effluent	EPA Method 524.2 or EPA approved/recommended equivalent	40 mL glass	HCl and Cool to $4^{O}C \pm 2^{O}C$	14 days
NDMA/DMN/ Bromacil	EPA Methods 607 or EPA approved/recommended equivalent	1 L amber glass	Cool to $4^{O}C \pm 2^{O}C$	7 days until extraction 40 days after extraction
Metals	Various EPA Methods as indicated in Section 3.1.3.1 of the PFSPP	500 mL polyethylene	HNO_3 to pH < 2	6 months (Mercury has hold time of 28 days)
Semivolatiles	EPA Method 8270 or EPA approved/recommended equivalent	1 L amber glass	Cool to $4^{O}C \pm 2^{O}C$	7 days until extraction
Cations (Ca, Mg, Na, K, and Fe)	EPA Method 6010B or EPA approved/recommended equivalent	1 L polyethylene	$4^{O}C \pm 2^{O}C$, 0.45 um filtration, HNO_3 to pH<2	6 months
<u>Anions</u> Total Alkalinity Chloride, Fluoride, Sulfate	EPA Method 310.1 or EPA approved/recommended equivalent EPA Method 300.0 or EPA approved/recommended equivalent	1 L polyethylene	Cool to $4^{O}C \pm 2^{O}C$	28 days
Nitrate/Nitrites	EPA Method 353.2 or EPA approved/recommended equivalent	500 mL polyethylene	$4^{O}C \pm 2^{O}C$, H_2SO_4 to pH<2	28 days

PLUME-FRONT TREATMENT SYSTEM SAMPLING SCHEDULE
SAMPLE COLLECTION AND ANALYSIS REQUIREMENTS (CONT.)

TREATMENT FACILITY ANALYTES FOR ENGINEERING PURPOSES				
Analysis	**Method**	**Sample Container**	**Sample Preservative**	**Holding Time**
Total Dissolved Solids	EPA Method 160.1 or EPA approved/recommended equivalent	500 mL polyethylene	Cool to $4^{O}C \pm 2^{O}C$	7 days
Ammonia	EPA Method 350.1 or EPA approved/recommended equivalent	500 mL polyethylene	$4^{O}C \pm 2^{O}C$, H_2SO_4 to pH<2	28 days
Perchlorate[2]	EPA Method 314.0 or EPA approved/recommend equivalent	250 mL polyethylene	None required	28 days
Hydrazines[2]	High Performance Liquid Chromatography/Electro-Chemical Detection per WSTF Laboratory SOP	40 ml amber glass	Cool to $4^{O}C \pm 2^{O}C$	28 days

1 Sample containers, preservations and holding times will remain consistent with current regulatory and SW-846 guidance.

2 Indicates that samples will be collected for analysis of perchlorate and hydrazines during the initial start-up and testing phase of the treatment system. If no detections occur, sample collection will be discontinued.

PLUME-FRONT SAMPLING FREQUENCIES FOR CONVENTIONAL WELLS/ZONES

Well/Zone ID	Sampling Frequency
BLM-2-482	Quarterly[1]
BLM-2-630	Quarterly[1]
BLM-7-509	Quarterly[1]
BLM-10-517	Quarterly
BLM-17-493	Quarterly[1]
BLM-17-550	Quarterly[1]
JP-1-424	Quarterly
JP-2-447	Quarterly
PL-1-486	Quarterly
PL-2-504	Quarterly
PL-3-453	Quarterly[1]
PL-4-464	Quarterly[1]
ST-1-473	Quarterly[1]
ST-1-541	Quarterly[1]
ST-1-630	Quarterly[1]
ST-2-466	Annually
ST-3-486	Quarterly[1]
ST-3-586	Quarterly[1]
ST-3-666	Quarterly[1]
ST-3-735	Quarterly[1]
ST-4-481	Quarterly
ST-4-589	Quarterly
ST-4-690	Quarterly
WW-1-452	Quarterly

[1] Indicates after active extraction/treatment/reinjection activities have been initiated, the well will be monitored monthly for four months, bi-monthly for eight months and quarterly thereafter.

PLUME-FRONT SAMPLING FREQUENCIES FOR WESTBAY® MULTI-PORT WELLS/ZONES

WELL/ZONE ID	SAMPLING FREQUENCY
BLM-37-490	Quarterly[1]
BLM-37-640	Quarterly[1]
BLM-37-750	Quarterly[1]
BLM-37-885	Quarterly[1]
JP-3-515	Quarterly[1]
JP-3-695	Quarterly[1]
JP-3-825	Quarterly[1]
JP-3-970	Quarterly[1]
PL-5-495	Quarterly[1]
PL-5-595	Quarterly[1]
PL-5-715	Quarterly[1]
PL-5-795	Quarterly[1]
PL-5-895	Quarterly[1]
PL-5-985	Quarterly[1]
PL-6-545	Quarterly
PL-6-725	Quarterly
PL-6-915	Quarterly
PL-6-1035	Quarterly
PL-6-1195	Quarterly
PL-6-1335	Quarterly
PL-6-1485	Quarterly
PL-6-1645	Quarterly
PL-6-1815	Quarterly
PL-7-480	Quarterly1
PL-7-560	Quarterly[1]
PL-7-630	Quarterly[1]
PL-8-455	Quarterly[1]
PL-8-605	Quarterly[1]
PL-8-780	Quarterly[1]
PL-8-965	Quarterly[1]
PL-10-484	Quarterly[1]
PL-10-592	Quarterly[1]
PL-10-813	Quarterly[1]
PL-10-962	Quarterly[1]
ST-5-485	Annually
ST-5-655	Quarterly[1]
ST-5-815	Quarterly[1]
ST-5-985	Quarterly[1]
ST-5-1175	Quarterly[1]
ST-6-535	Quarterly
ST-6-575	Quarterly

PLUME-FRONT SAMPLING FREQUENCIES FOR WESTBAY® MULTI-PORT WELLS/ZONES (cont.)

ST-6-685	Quarterly
ST-6-830	Quarterly
ST-6-975	Quarterly
ST-7-450	Quarterly[1]
ST-7-550	Quarterly[1]
ST-7-785	Quarterly[1]
ST-7-975	Quarterly[1]
WW-2-495	Quarterly[1]
WW-2-670	Quarterly[1]
WW-2-845	Quarterly[1]
WW-2-960	Quarterly[1]
WW-3-469	Quarterly[1]
WW-3-569	Quarterly[1]
WW-3-710	Quarterly[1]
WW-3-978	Quarterly[1]
WW-4-423	Quarterly[1]
WW-4-594	Quarterly[1]
WW-4-853	Quarterly[1]
WW-4-953	Quarterly[1]
WW-5-464	Quarterly[1]
WW-5-582	Quarterly[1]
WW-5-814	Quarterly[1]
WW-5-912	Quarterly[1]

[1] Indicates after active extraction/treatment/reinjection activities have been initiated, the well/zone will be monitored monthly for four months, bi-monthly for eight months and quarterly thereafter.

Attachment K Issued: 02/06/04

INFLUENT/EFFLUENT SAMPLING SCHEDULE

Time Period	Sampling Location	Sampling Frequency	Analytes
0-3 Months (initial start-up and testing period)	Treatment Facility Influent Piping	Twice per week (during operational periods)	NDMA, DMN, volatiles, semivolatiles, general inorganics, metals, perchlorate, and hydrazines
0-3 Months (initial start-up and testing period)	Treatment Facility Effluent Piping	Twice per week (during operational periods)	NDMA, DMN, volatiles (by Method 524.2 or equivalent), semivolatiles, general inorganics, metals, perchlorate, and hydrazines
0-3 Months (initial start-up and testing period)	Each Extraction Well	Once per week (during operational periods)	NDMA, DMN, halogenated volatiles, metals, and general inorganics
3-12 Months	Treatment Facility Influent Piping	Once per month	NDMA, DMN, volatiles, semivolatiles, metals, and general inorganics
3-12 Months	Treatment Facility Effluent Piping	Once per month	NDMA, DMN, volatiles (by Method 524.2 or equivalent), semivolatiles, metals, and general inorganics
3-12 Months	Each Extraction Well	Quarterly	NDMA, DMN, volatiles, metals, and general inorganics
After 12 Months	Treatment Facility Influent Piping	Quarterly	NDMA, DMN, volatiles, metals, and general inorganics
After 12 Months	Treatment Facility Effluent Piping	Quarterly	NDMA, DMN, volatiles (by Method 524.2or equivalent), semivolatiles, metals, and general inorganics

ATTACHMENT L

TREATMENT FACILITY AND EXTRACTION WELL SAMPLING

1. GENERAL INFORMATION

This attachment provides instructions for the collection, handling, and analysis of groundwater samples at the treatment facility and the extraction wells. All sampling techniques and equipment used to sample the treatment facility influent and effluent will conform to the instructions provided in the US EPA Document SW-846, Test Methods for Evaluating Solid Waste, Physical and Chemical Methods, Third Edition, June 1997. The instructions provided in this attachment are used in conjunction with the most current versions of the WSTF Groundwater Sampling and Analysis Plan, the WSTF Quality Assurance Project Plan, and other site-specific procedural documentation as required.

2. DRAWINGS AND REFERENCES

A flow schematic for the treatment facility and extraction wells is provided by drawing number 652-M-02 and drawing number 652-M-01. A list of references is provided in Attachment A.

3. ENCLOSURES

Enclosure 1, “Sampling Record and QC Sheet”.

4. SAFETY REQUIREMENTS

Specific safety requirements and instructions in the form of WARNINGS, CAUTIONS and NOTES are contained within the procedures preceding the applicable step(s). A hazard assessment for personal protective equipment per WSI 25-SW-0007 is included in Attachment C. A job hazard analysis per WSI 25-SW-0032 is also included in Attachment C.

5. PERSONNEL REQUIREMENTS

A minimum of two (2) Hazardous Waste Compliance Technicians trained as Groundwater Treatment Facility Technicians (per the WSTF Training Database). At the discretion of the contractor Environmental Department Section Supervisor or Project Leader, the operations can be performed by:

A. Contractor Environmental Department Hazardous Waste Compliance Technicians receiving “on-the-job” training for qualification as a Groundwater Treatment Facility Technicians under the direct supervision of the facility Project Leader or Crtifying/Qalifying instructor who is also qualified as a Groundwater Treatment Facility Operator (per the WSTF Training Database). Personnel receiving "on-the-job" training

are required to have completed WSTF Hazardous Waste Handler Training and requirements C, D, E and F listed below.

B. A qualified Hazardous Waste Compliance Technician trained as a Groundwater Treatment Facility Technician (per the WSTF Training Database) who is assisted by personnel receiving "on-the-job" training for qualification as a Groundwater Treatment Facility Technician(s). Personnel receiving "on-the-job" training are required to have completed WSTF Hazardous Waste Handler Training and requirements C, D, E and F listed below.

C. All personnel actively involved in facility operations are required to have current Confined Space Training (per the WSTF Training Database).

D. All personnel actively involved in facility operations are required to have current PPE Training (per the WSTF Training Database).

E. All personnel actively involved in facility operations are required to have current training in the use of a Passport (or the current WSTF equivalent) air monitor (per the WSTF Training Database).

F. All personnel actively involved in facility operations are required to have current Lockout/Tagout Training (per the WSTF Training Database).

1. EQUIPMENT

A. Sampling Equipment

1. Teflon tubing and connectors (as required).

2. Portable purge water collection container(s).

3. Field logbook to record all field activities.

4. Portable meters for the collection of indicator parameters.

(a) pH/temperature or pH/temperature/conductivity meter.

(b) Appropriate pH buffer for pre- and post- calibration.

(c) DI water for pH probe rinse.

(d) Conductivity meter (if not included in (a)).

(e) Turbidity meter.

5. Five gallon plastic bucket for sample and parameter collection.

6. Graduated beaker for parameter collection.

7. Goggles, faceshield, apron, and Nytek sampling gloves.

8. Poly baggies (small and large) for sample storage.

9. Sample bottles as required for each sampling event.

10. Ice chests and ice for sample storage.

11. MSA Passport Personal Alarm as required for confined space entry.

B. Reagents/Chemicals

WARNING

ALL CONCENTRATED ACIDS AND BASES ARE STORED IN THE CORROSIVES STORAGE CABINET.

1. Reagent grade (blank) water.

2. Concentrated nitric, sulfuric, and hydrochloric acids, sodium hydroxide, zinc acetate, and other appropriate chemicals required for sample preservation.

3. Standards for meter calibration (pH buffers, conductivity, and turbidity).

7. SPECIAL REQUIREMENTS

A. Only sample containers that have been cleaned to the levels appropriate for sample collection can be used. If the integrity of any sample container is questionable, it will be discarded.

B. Historical analytical data indicate that specific wells at WSTF are contaminated with trace amounts of hazardous compounds. Therefore, all groundwater brought to the surface will be handled with extreme care to avoid discharge to the environment. All handling of groundwater will be performed over the concrete well pad or over the appropriate purge water collection container to ensure all purge water is contained appropriately.

8. CALIBRATION, MAINTENANCE, AND USE OF FIELD INSTRUMENTS

This section provides instruction for the calibration, maintenance and use of field instruments associated with groundwater sampling activities.

NOTE

UNLESS OTHERWISE STATED, CALIBRATION ACTIVITIES AND RELATED INFORMATION WILL BE RECORDED IN A SEPARATE "CALIBRATION LOGBOOK" TO BE MAINTAINED BY FIELD PERSONNEL. ALL FIELD INSTRUMENTS WILL BE LABELED WITH THE MOST APPLICABLE WSTF CALIBRATION DECAL.

A. pH Meter Calibration and Use

NOTE

WSTF CURRENTLY USES VARIOUS MODELS OF pH METERS. ALTHOUGH THE GENERAL STEP-BY-STEP DIRECTIONS FOR SETTING UP THE METERS MAY VARY, THE CALIBRATION AND USE REQUIREMENTS ARE THE SAME. REFER TO THE INDIVIDUAL MANUFACTURER'S OPERATIONS MANUAL FOR SPECIFIC INSTRUMENT CALIBRATION AND USE INSTRUCTIONS.

1. Turn the meter on and perform a two-point calibration as directed in the manufacturer's operation manual for the specific meter in use. This initial calibration will be performed with 7.00 and 10.00 buffers that have not exceeded their expiration dates. Ensure that pH buffers and their secondary containers are clean and free of debris prior to use. Record the calibration readings and pertinent buffer information in the field logbook.

2. Obtain sample water for initial parameter determination by slowly dispensing collected well water into a clean graduated beaker.

3. Switch the meter to measure mode, submerge the probe in the beaker, and obtain a pH of the sample after equilibration. If the measured pH is outside of the 7 to 10 pH range, recalibrate with buffers that bracket the measured pH and perform sample measurement again.

NOTE

SOME MODELS OF pH METERS ARE NOT EQUIPPED FOR TEMPERATURE MEASUREMENT. WHEN USING A pH METER THAT CANNOT MEASURE TEMPERATURE, A CONDUCTIVITY METER WITH THE ABILITY TO MEASURE TEMPERATURE MUST BE USED.

4. If required, switch the meter to temperature mode and obtain a temperature reading.

5. Record the pH and temperature readings in the field logbook.

6. After sampling procedures are complete, a post sampling calibration check of the appropriate buffers is performed to identify instrument drift during purging and

sampling procedures. Enter these readings in the field logbook with the final indicator parameters. If meter readings have drifted more than 5% from initial calibration readings, recalibrate the instrument, measure the sample media, and annotate the logbook with all relevant information.

7. If extended purging and sampling procedures are required, periodic checks of the buffers during the day are performed to check for instrument drift. If meter readings have drifted more than 5%, recalibrate the instrument, measure the sample media, and annotate the logbook with all relevant information.

B. Turbidity Meter Calibration and Use

NOTE

BECAUSE WSTF MAY USE VARIOUS TURBIDITY METERS, SAMPLING PERSONNEL WILL UTILIZE THE APPROPRIATE MANUFACTURER'S OPERATIONS MANUAL TO ENSURE THAT METERS ARE MAINTAINED, CALIBRATED, STORED, AND USED IN A MANNER THAT ENSURES RELIABLE COLLECTION OF ACCURATE MEASUREMENTS.

1. Ensure the turbidity meter is calibrated at least monthly according to the manufacturer's specifications prior to measurement activities. These periodic calibration values, in addition to all pertinent information regarding the calibration activity, must be recorded in the calibration logbook.

2. Verify meter calibration in the field immediately prior to sample turbidity measurement by using the formazin gel standard prepared by the manufacturer. This standard will be carried with the turbidity meter to all field sampling events. The meter reading should be within ±5% of the secondary standard.

3. Obtain an aliquot of sample water in the glass measurement cell. Dry the outside of the cell thoroughly, place it in the meter, and close the lid.

4. Turn the meter on, initiate the measurement cycle, and wait for the digital turbidity reading to equilibrate. Record the turbidity measurement in the field logbook. Do not store the glass turbidity cells in the measurement compartment of the meter. Scratches on the cells could distort turbidity measurements. If visible scratches are detected on a turbidity cell, discard the measurement cell and replace it.

C. Conductivity Meter Calibration and Use

NOTE

SAMPLING PERSONNEL WILL UTILIZE THE APPROPRIATE MANUFACTURER'S OPERATIONS MANUAL TO ENSURE THAT

CONDUCTIVITY METERS ARE MAINTAINED, CALIBRATED, STORED, AND USED IN A MANNER THAT ENSURES RELIABLE COLLECTION OF ACCURATE MEASUREMENTS.

Ensure the conductivity meter is calibrated and maintained at least monthly according to the manufacturer's specifications prior to measurement activities. Perform all required function tests at time of calibration to ensure proper meter operation. These periodic calibration values and maintenance activities will be recorded in the calibration logbook.

1. Insert the conductivity probe into the beaker of treatment facility influent/effluent water that was used for pH and temperature determination. Turn the meter on, tune it to the proper conductivity scale, and set the temperature scale to match the temperature of the sample as previously determined with the pH meter.

2. Wait for the display to equilibrate and record the conductivity reading in the field logbook.

NOTE

SOME MODELS OF CONDUCTIVITY METERS ARE NOT EQUIPPED FOR TEMPERATURE MEASUREMENT. WHEN USING A CONDUCTIVITY METER THAT CANNOT MEASURE TEMPERATURE, A PH METER WITH THE ABILITY TO MEASURE TEMPERATURE MUST BE USED.

3. If required, switch the meter to temperature mode and obtain a temperature reading.

9. TREATMENT FACILITY SAMPLING

This section provides instructions for influent and effluent sampling of the treatment facility (Bldg. 650).

NOTE:

ACCESS TO THE TREATMENT FACILITY BUILDING (BLDG. 650) IS CONTROLLED BY THE CONTRACTOR ENVIRONMENTAL DEPARTMENT PROJECT LEADER. THE TREATMENT FACILITY SHALL REMAIN LOCKED AT ALL TIMES EXCEPT DURING INSPECTIONS, SAMPLING AND MAINTENANCE OPERATIONS.

A. Review the treatment facility flow schematic (drawing number 652-M-02). The influent sampling valve is MV-6WA-XK086 and the effluent sampling valve is MV-6WA-XK142.

B. Contact the contractor Environmental Department Project Leader (or designated alternate) for access to the treatment facility (Bldg. 650).

C. Immediately after arriving at the sample location, the logbook will be annotated with all pertinent information including date, time, location, weather conditions, sampler identification, equipment used and confirmation of decontamination and calibration, indicator parameters, sample information, and any other useful or unusual information concerning the sampling event. The logbook will provide a complete enough record of the entire sampling procedure that a person not associated with the sampling event can recreate the day's procedures from the logbook entries.

NOTES

1. **THE SPECIFIC SAMPLES, INDICATOR PARAMETERS, AND REQUIRED QUALITY ASSURANCE SAMPLES ARE AS SPECIFIED ON THE CONTRACTOR ENVIRONMENTAL DEPARTMENT TASK MEMO (WSTF FORM 456).**

2. **INSPECT EACH SAMPLE CONTAINER USED IN THE FIELD FOR VISUAL CONTAMINATION. IF CONTAMINATION IS DETECTED, DISCARD THE CONTAINER.**

3. **TO PREVENT VOLATILIZATION OF SAMPLES, STORE ALL SAMPLE CONTAINERS ON ICE UNTIL TIME OF SAMPLING. ALL SAMPLES THAT REQUIRE PRESERVATION ARE PRESERVED IN THE FIELD AT THE TIME OF COLLECTION.**

D. Setup work station and connect Teflon tubing to the sampling valve as required.

WARNING

THE FOLLOWING IS REQUIRED FOR THE PERFORMANCE OF STEPS 9.D THROUGH 9.K

1. **COMMUNICATIONS – PHONE OR TWO-WAY RADIO REQUIRED. IN THE EVENT OF MINOR CUTS, SCRAPES, AND ABRASIONS, FIRST AID WILL BE ADMINISTERED IN THE FIELD. IN THE EVENT OF ANY NON-FIRST AID INJURY, SAMPLING ACTIVITIES WILL BE IMMEDIATELY SUSPENDED, PERSONNEL TAKEN TO THE DISPENSARY, AND THE WSTF FIRE DEPARTMENT WILL BE NOTIFIED FOR ASSISTANCE IF NECESSARY.**

2. **CHEMICAL AND ACID RESISTANT GLOVES (NYTEK, NITRILE, NEOPRENE OR BUTYL RUBBER) ARE REQUIRED (NOT REQUIRED FOR PERSONNEL COMPLETING ENTRIES IN THE FIELD LOGBOOK).**

3. **FACE SHIELD AND SPLASH GOGGLES THAT MEET THE REQUIREMENTS OF THE MOST CURRENT VERSION OF ANSI-Z87.1-**

1989 (NOT REQUIRED FOR PERSONNEL COMPLETING ENTRIES IN THE FIELD LOGBOOK).

4. CHEMICAL RESISTANT APRON.

5. A PERSONAL EYE WASH UNIT THAT MEETS THE REQUIREMENTS OF THE MOST RECENT VERSION OF ANSI-Z358.1-1990.

6. CONTROLLED ACCESS TO THE GENERAL WORK AREA.

E. Slowly OPEN the sample valve and purge the sample valve and sampling line for about one minute (at least four liters of fluid). Collect all rinsate and liquid waste in the appropriate purge water containers for disposal per WIWPS # 10-20-13, "GW Treatment Aqueous Waste".

- MV-6WA-XK086 (influent sample valve)
- MV-6WA-XK142 (effluent sample valve)

F. Slowly CLOSE the respective sample valve and reduce the flow from the sample line to about 100 ml/min.

G. Collect samples in descending order of sensitivity to volatilization. Perform the following to collect volatile organic samples.

1. Ensure all sample vials are rinsed with sample media.

2. Position the sample vial under the sample line at an angle that allows the vial to be filled with a minimum of turbulence.

3. As the vial fills, rotate it to an upright position, and fill until a reverse meniscus is visible. If the vial is prepreserved from the laboratory of an off-site vendor, preservative loss should be minimized, but not at the expense of headspace.

4. Cap the vial and ensure the absence or minimization of headspace by inverting the vial and observing for the presence of bubbles. If headspace is detected in a non-prepreserved sample vial, discard the sample and refill the vial. Bubbles that indicate the presence of headspace in a prepreserved vial must be less than ¼" in diameter.

5. Store the sample on ice.

H. Collect and dispose of all rinsate, liquid waste and purged fluids for disposal per WIWPS # 10-20-13, "GW Treatment Aqueous Waste".

I. Collect the remaining samples in descending order of sensitivity to volatilization. For collection of the remaining samples, the discharge rate can be increased by OPENING the sample valve.

- MV-6WA-XK086 (influent sample valve)
- MV-6WA-XK142 (effluent sample valve)

NOTE

TYPICALLY, SAMPLES FOR NDMA/DMN ANALYSES ARE COLLECTED AFTER VOLATILE SAMPLES. EPA METHOD 607 FOR NDMA REQUIRES THE SAMPLE TO BE PRESERVED WITH SODIUM THIOSULFATE IF RESIDUAL CHLORINE IS PRESENT IN THE SAMPLE WATER. HOWEVER, PREVIOUS SAMPLING EVENTS HAVE INDICATED THAT NO RESIDUAL CHLORINE IS PRESENT IN WSTF GROUNDWATER, MAKING SAMPLE PRESERVATION UNNECESSARY. IF ANOTHER ANALYTICAL METHOD IS TO BE USED, THE APPROPRIATE PRESERVATION STEPS MUST BE FOLLOWED.

1. Ensure the sample containers are rinsed with sample media.

2. Fill the appropriate sample container from the sample tube. Use care not to submerge the tube in the sample water in the container. Minimize headspace and cap the bottle.

J. Immediately after taking each sample, prepare a label and chain of custody seal with a sample number representing the year, month, day, and time it was collected (i.e. 0302140815 indicates a sample collected on February 14, 2003 at 8:15 am).

K. Preserve the sample as indicated in the WSTF SAP or the work authorizing document, attach a completed label and chain of custody seal, place in a poly bag, and store on ice or refrigerate until delivery or shipment to the appropriate laboratory.

L. Ensure the sample valve is CLOSED and secure the general work area.

- MV-6WA-XK086 (influent sample valve)
- MV-6WA-XK142 (effluent sample valve)

M. Ensure that all sampling equipment is collected and loaded. Complete all necessary information in the logbook and sign and date it. After each sampling event, annotate the sampling activities in the Sampling Record and QC Sheet. An example of this sheet is provided in Enclosure 1 of this instruction.

N. Deliver the field logbook to the contractor Environmental Department Project Leader (or designated contractor Environmental Department personnel) to be reviewed and signed. Reviewed and signed sampling logbooks will be appropriately archived in the Department's files for future reference.

10. EXTRACTION WELL SAMPLING

This section provides instructions for sampling of the plume-front extraction wells (PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, and PFE-7).

NOTE

ACCESS TO THE EXTRACTION WELLS IS CONTROLLED BY THE CONTRACTOR ENVIRONMENTAL DEPARTMENT PROJECT LEADER (OR DESIGNATED ALTERNATE). THE TREATMENT FACILITY AND EXTRACTION WELL VAULTS SHALL REMAIN LOCKED AT ALL TIMES EXCEPT DURING INSPECTIONS, SAMPLING AND MAINTENANCE OPERATIONS.

A. Review the flow schematic for the plume-front extraction wells (drawing number 652-M-01). The respective sampling valves are as follows:

- MV-6WA-XK004 (PFE-1)
- MV-6WA-XK024 (PFE-2)
- MV-6WA-XK034 (PFE-3)
- MV-6WA-XK044 (PFE-4A)
- MV-6WA-XK014 (PFE-5)
- MV-6WA-XK242 (PFE-7)

B. Contact the contractor Environmental Department Project Leader (or designated alternate) for access to the respective extraction well vaults.

C. The extraction well vaults have been identified as a confined space. Perform the following prior to the sampling event:

1. Obtain a confined space entry permit for the extraction well vaults from the contractor Environmental Department Project Leader (or designated alternate). The contractor Environmental Department Project Leader (or designated contractor Environmental Department personnel) shall provide a confined space entry permit per WSI-25-0003, “Confined Space Entry Program” (WSTF Form 503).

2. Obtain a MSA Passport Personal Alarm from the contractor Environmental Department Project Leader (or designated contractor Environmental Department personnel).

3. Read and follow the manufacturer’s instructions for the use and calibration of the MSA Passport alarm system (or equivalent). The manufacturer’s calibration and operating instructions are included with the equipment and maintained in WJI-PAD-SAF-0002, “MSA Passport Personal Alarm Calibration” and in the WSTF Technical Library.

D. Immediately after arriving at the sample location, the logbook will be annotated with all pertinent information including date, time, location, weather conditions, sampler identification, equipment used and confirmation of decontamination and calibration, indicator parameters, sample information, and any other useful or unusual information concerning the sampling event. The logbook will provide a complete enough record of the entire sampling procedure that a person not associated with the sampling event can recreate the day's procedures from the logbook entries.

WARNING

1. **PRIOR TO ENTRY INTO ANY EXTRACTION WELL VAULT, QUALIFIED PERSONNEL WILL TEST AND RECORD THE OXYGEN LEVEL TO ENSURE THAT THE VALVE PIT ATMOSPHERE IS SAFE.**

2. **UNDER NO CIRCUMSTANCE IS ENTRY INTO ANY VAULT AUTHORIZED PER THIS WJI WHEN A HAZARDOUS ATMOSPHERE EXISTS. BACK OUT AND CONTACT THE CONTRACTOR ENVIRONMENTAL DEPARTMENT PROJECT LEADER (OR DESIGNATED ALTERNATE) IF OXYGEN LEVELS ARE LESS THAN 19.5% OR GREATER THAN 23.5%.**

E. Test and verify that the vault atmosphere is safe per instructions provided in the confined space entry permit (WSTF Form 503). Under no circumstance is entry into any vault authorized per this WJI when a hazardous atmosphere exists. Back out and contact the contractor Environmental Department Project Leader (or designated alternate) if oxygen levels are less than 19.5% or greater than 23.5%.

NOTES

1. **THE SPECIFIC SAMPLES, INDICATOR PARAMETERS, AND REQUIRED QUALITY ASSURANCE SAMPLES ARE AS SPECIFIED BY THE PLUME-FRONT PROJECT LEADER (MAY BE DIRECTED BYA CONTRACTOR ENVIRONMENTAL DEPARTMENT PROJECT LEADER (TASK MEMO - WSTF FORM 456).**

2. **INSPECT EACH SAMPLE CONTAINER USED IN THE FIELD FOR VISUAL CONTAMINATION. IF CONTAMINATION IS DETECTED, DISCARD THE CONTAINER.**

3. **TO PREVENT VOLATILIZATION OF SAMPLES, STORE ALL SAMPLE CONTAINERS ON ICE UNTIL TIME OF SAMPLING. ALL SAMPLES THAT REQUIRE PRESERVATION ARE PRESERVED IN THE FIELD AT THE TIME OF COLLECTION.**

WARNING

THE FOLLOWING IS REQUIRED FOR THE PERFORMANCE OF STEPS 10.F THROUGH 10.N.

1. **COMMUNICATIONS – PHONE OR TWO-WAY RADIO REQUIRED. IN THE EVENT OF MINOR CUTS, SCRAPES, AND ABRASIONS, FIRST AID WILL BE ADMINISTERED IN THE FIELD. IN THE EVENT OF ANY NON-FIRST AID INJURY, SAMPLING ACTIVITIES WILL BE IMMEDIATELY SUSPENDED, PERSONNEL TAKEN TO THE DISPENSARY, AND THE WSTF FIRE DEPARTMENT WILL BE NOTIFIED FOR ASSISTANCE IF REQUIRED.**

2. **CHEMICAL AND ACID RESISTANT GLOVES (NYTEK, NITRILE, NEOPRENE OR BUTYL RUBBER) ARE REQUIRED (NOT REQUIRED FOR PERSONNEL COMPLETING ENTRIES IN THE FIELD LOGBOOK).**

3. **FACE SHIELD AND SPLASH GOGGLES THAT MEET THE REQUIREMENTS OF THE MOST CURRENT VERSION OF ANSI-Z87.1-1989 (NOT REQUIRED FOR PERSONNEL COMPLETING ENTRIES IN THE FIELD LOGBOOK).**

4. **CHEMICAL RESISTANT APRON.**

5. **A PERSONAL EYE WASH UNIT THAT MEETS THE REQUIREMENTS OF THE MOST RECENT VERSION OF ANSI-Z358.1-1990.**

6. **CONTROLLED ACCESS TO THE GENERAL WORK AREA.**

F. Setup the work station adjacent to the well vault. Connect new Teflon tubing (to prevent cross contamination) at each sampling valve as required to allow samples to be taken outside the vault.

- MV-6WA-XK006 (PFE-1);
- MV-6WA-XK026 (PFE-2);
- MV-6WA-XK036 (PFE-3);
- MV-6WA-XK046 (PFE-4A);
- MV-6WA-XK016 (PFE-5); and
- MV-6WA-XK242 (PFE-7).

G. Slowly OPEN the sample valve and purge the sample valve and sampling line for about one minute (a minimum of four liters of fluid). Collect all rinsate and liquid waste in the appropriate purge water container for disposal per WIWPS # 10-20-13, "GW Treatment Aqueous Waste".

H. Slowly CLOSE sample valve and reduce the flow from the sample line to about 100 ml/min.

I. Collect samples in descending order of sensitivity to volatilization. Perform the following to collect volatile organic samples.

1. Ensure all sample vials are rinsed with sample media (unless they contain laboratory preservatives).

2. Position the sample vial under the sample line at an angle that allows the vial to be filled with a minimum of turbulence.

3. As the vial fills, rotate it to an upright position, and fill until a reverse meniscus is visible. If the vial is prepreserved from the laboratory of off-site vendor, preservative loss should be minimized, but not at the expense of headspace.

4. Cap the vial and ensure the absence or minimization of headspace by inverting the vial and observing for the presence of bubbles. If headspace is detected in a non-prepreserved sample vial, discard the sample and refill the vial. Bubbles that indicate the presence of headspace in a prepreserved vial must be less than ¼" in diameter.

5. Store the sample on ice.

6. Collect all rinsate and liquid waste in the appropriate purge water containers for disposal per WIWPS # 10-20-13, "GW Treatment Aqueous Waste".

J. Collect the remaining samples in descending order of sensitivity to volatilization. For collection of the remaining samples, the discharge rate can be increased by OPENING the sample valve.

- MV-6WA-XK006 (PFE-1);
- MV-6WA-XK026 (PFE-2);
- MV-6WA-XK036 (PFE-3);
- MV-6WA-XK046 (PFE-4A);
- MV-6WA-XK016 (PFE-5); and
- MV-6WA-XK242 (PFE-7).

NOTE

TYPICALLY, SAMPLES FOR NDMA/DMN ANALYSES ARE COLLECTED AFTER VOLATILE SAMPLES. EPA METHOD 607 FOR NDMA REQUIRES THE SAMPLE TO BE PRESERVED WITH SODIUM THIOSULFATE IF RESIDUAL CHLORINE IS PRESENT IN THE SAMPLE WATER. HOWEVER, PREVIOUS SAMPLING EVENTS HAVE INDICATED THAT NO RESIDUAL CHLORINE IS PRESENT IN WSTF GROUNDWATER, MAKING SAMPLE PRESERVATION UNNECESSARY. IF ANOTHER ANALYTICAL METHOD IS TO BE USED, THE APPROPRIATE PRESERVATION STEPS MUST BE FOLLOWED.

1. Ensure the sample containers are rinsed with sample media.

2. Fill the appropriate sample container from the sample tube. Use care not to submerge the tube in the sample water in the container. Minimize headspace and cap the bottle.

K. Immediately after taking each sample, prepare a label and chain of custody seal with a sample number representing the year, month, day, and time it was collected (i.e. 0302140815 indicates a sample collected on February 14, 2003 at 8:15 am).

L. Preserve the sample as indicated in the WSTF SAP or the work authorizing document, attach a completed label and chain of custody seal, place in a poly bag, and store on ice or refrigerate until delivery or shipment to the appropriate laboratory.

M. Ensure the sample valve is CLOSED.

- MV-6WA-XK006 (PFE-1);
- MV-6WA-XK026 (PFE-2);
- MV-6WA-XK036 (PFE-3)
- MV-6WA-XK046 (PFE-4A);
- MV-6WA-XK016 (PFE-5); and
- MV-6WA-XK242 (PFE-7).

N. Secure the general work area. Dispose of all contaminated PPE, softgoods, etc. per WIWPS # 10-20-18, "Building 650 Contaminated Refuse"/

O. Ensure that all sampling equipment is collected and loaded. Complete all necessary information in the logbook and sign and date it. After each sampling event, annotate the sampling activities in the Sampling Record and QC Sheet. An example of this sheet is provided in Enclosure 1 of this instruction.

P. Deliver the field logbook to the contractor Environmental Department Project Leader (or designated contractor Environmental Department personnel) to be reviewed and signed. Reviewed and signed sampling logbooks will be appropriately archived in the contractor Environmental Department's files for future reference.

12. SAMPLE SHIPMENT INSTRUCTIONS

NOTE

BETWEEN SAMPLE COLLECTION AND SAMPLE SHIPMENT, ALL SAMPLES SHALL BE REFRIGERATED AT 4°C TO MAINTAIN SAMPLE INTEGRITY. THE TEMPERATURE OF THE REFRIGERATOR MUST BE MONITORED AND KEPT WITHIN +/-2^{O}C OF REQUIRED TEMPERATURE. SAMPLES WILL BE

SHIPPED TO THE LABORATORY FOR ANALYSIS WITHIN THE HOLDING TIMES SPECIFIED IN THE SAMPLING AND ANALYSIS PLAN.

A. Obtain appropriate shipping documents from the responsible contractor Environmental Department personnel. Complete the required chain of custody paperwork and WSTF shipping documents for each sample.

B. Wrap or package all samples as appropriate for sample container. Pack samples securely with ice and packing material in an adequately sized ice chest.

C. Deliver packaged samples to the WSTF warehouse personnel or other designated shipper. Shipping personnel will accept custody of the samples by signing the chain of custody form(s). Copies of the WSTF shipping document and the signed chain of custody form(s) will be included with the samples during shipment.

D. Deliver copies of the shipping document(s), chain(s) of custody, and logbook entry(ies) for that sampling event to the contractor Environmental Department Project Leader (or designated alternate). In order to track past sample shipments in case of lab or shipper error, these documents will be maintained for at least six months. After this period, only original documentation (no copies) will be retained. These documents may be kept as hard copies or transferred to electronic format as appropriate and maintained as part of the facility operating record.

ENCLOSURE 1

Sampling Record and QC Sheet

Well ID/Sample Location	Date Sampled	Logbook #	HVOA (8021)	VOA (8260)	NDMA (607)	RCRA Metals	Samplers' Initials	Sample Comments / QA Collected

– Indicates sample was collected.
* Indicates duplicate samples collected.
MS Indicates matrix spike samples collected.
NA Indicates no samples collected.

ATTACHMENT M

FACILITY INSPECTION PLAN

1.0 GENERAL INFORMATION

This attachment provides instructions for the performance of routine inspection of the Plume-Front Treatment Facility extraction wells, injection wells, treatment facility, injection manifold, and the subgrade piping system vaults.

2.0 DRAWINGS AND REFERENCES

A flow schematic is provided by WSTF drawing number's 652-M-01, 652-M-02 and 652-M-03. Piping route plan and profile drawings and sections and details are presented in WSTF drawing numbers 652-C-01 through 652-C-26. A list of references is provided in Attachment A.

3.0 ENCLOSURES

3.1 Enclosure 1, "Weekly and Monthly Inspection Records".

4.0 SAFETY REQUIREMENTS

The following safety requirements and warnings are applicable to this entire attachment. Additionally, follow all warnings and notes that precede certain steps in this procedure. All PPE and other safety requirements specified in JHA HW-042 apply to facility inspections.

4.1 Communications – phone or two-way radio required for operations.

4.2 In the event of minor cuts, scrapes, and abrasions, first aid will be administered in the field. In the event of any non-first aid injury, suspend operations, if appropriate, proceed to the dispensary and contact the WSTF Fire Department for assistance.

4.3 Confined Space Hazard Requirements/Warnings. NOTE: inspections outlined in this procedure do not require confined space entry. The following requirements/warning are listed only in the event that a vault must be accessed to properly perform the inspection. In this case, a separate work authorizing document will be generated to document the entry.

- Prior to entry into the extraction well and junction access vaults, qualified personnel will test and record the oxygen level to ensure that the vault atmosphere is safe.

- Under no circumstance is entry into the vaults authorized per this WJI when a hazardous atmosphere exists. Back out and contact the contractor environmental department if a hazardous atmosphere exists. Hazardous atmospheres are defined as:

  - Oxygen levels are less than 19.5%, or greater than 23.5%;
  - The atmosphere contains greater than 10% of the lower flammability limit;
  - The PEL or TLV is exceeded; or
  - An IDLH condition exists.

4.4 UV Reactor - Ensure that all access covers are in the closed position before working near the UV reactor.

5.0 PERSONNEL REQUIREMENTS

The Plume-Front Treatment Facility inspections per this WJI must be performed by a qualified contractor Environmental Department Groundwater Treatment Facility Operator (per the WSTF Training Database). At the discretion of the contractor Environmental Department Section Supervisor or Project Leader, inspections specifically identified per this WJI attachment can also be performed by a qualified Hazardous Waste Compliance Technician trained as a Groundwater Treatment Facility Technician (per the WSTF Training Database).

At the discretion of the contractor Environmental Department inspections in remote areas may be classified as a "Two or More Person Operation". Qualification as a Groundwater Treatment Facility Operator or Groundwater Treatment Facility Technician is not required for personnel serving as an attendant.

6.0 EQUIPMENT

No special equipment is required.

7.0 SPECIAL REQUIREMENTS

The following steps must be performed to document completion of the inspection.

7.1 The checklists for the required inspection items must be completed after each inspection as follows:

- A checkmark to indicate that the item is satisfactory and/or a number or description as directed by this WJI;
- An "X" to indicate that the item is unsatisfactory, and/or a description of the unsatisfactory condition as directed by this WJI;
- The inspector who performed the inspections must initial the checklist verifying that he/she has completed the inspections; and
- The inspector who performed the inspections must record the time and date

- that the inspection was performed on the checklist.

7.2 The checklists must be filed as part of the facility operating record.

7.3 Unsatisfactory conditions must be annotated in the Anomaly Log (Attachment D). At the discretion of the Groundwater Treatment Facility Operator, major discrepancies and unsatisfactory conditions may be recorded and corrected on a DR per WSI-13-SW-0001, "Discrepancy Record (DR)". The disposition of the DRs are the responsibility of the contractor Environmental Department.

8.0 INSTRUMENTATION AND CONTROL SYSTEM – DAILY INSPECTIONS

The following "inspections" must be performed daily by Instrumentation and Control System (I&C) software. Instrumentation and Control System status is continuously monitored by the I&C software. Selected data are logged to the I&C hard drive for evaluation by a qualified contractor Environmental Department Groundwater Treatment Facility Operator.

8.1 Instrumentation and Control System - Status

The I&C software continuously monitors the status of the Instrumentation and Control System. The system must alarm for any conditions that are out of range for the extraction wells, injection wells, treatment facility, and leak detection system. Alarms are described in Attachment J. The control system parameters must be consistent with the operating parameters specified by the contractor Environmental Department Project Leader.

8.2 Instrumentation and Control System – Air Stripper Operating Parameters

8.2.1 The I&C checks influent flowrate to the air strippers with respect to the operating parameters provided by contractor Environmental Department Project Leader. The I&C records the influent flowrate for the air strippers as indicated by FM-6WA-XK096 for Air Stripper # 1 and FM-6WA-XK116 for Air Stripper # 2. The influent flowrates for the air strippers must be within flowrates specified by the contractor Environmental Department Project Leader.

8.2.2 The I&C checks the air flowrate to the air strippers with respect to the operating parameters provided by the contractor Environmental Department Project Leader. The I&C records the air flowrate for the air strippers as indicated by FT-6AR-XK228 for Air Stripper # 1 and FT-6AR-XK085 for Air Stripper # 2 .

8.2.3 The I&C checks the column pressure for the air strippers as indicated by PT-6AR-XK229 for Air Stripper # 1 and PT-6AR-XK223 for Air Stripper # 2. The column pressure must be within manufacturer's

specifications or as specified by the contractor Environmental Department Project Leader.

8.2.4 The I&C checks the air stripper influent water temperature as indicated by TT-6WA-XK138 for Air Stripper # 1 and TT-6WA-XK115 for Air Stripper # 2. The water temperature should be between 50 and 60 degrees Fahrenheit.

8.2.5 The I&C monitors the sump level for the air strippers as indicated by LLT-6WA-XK104 for Air Stripper # 1 and LLT-6WA-XK123 for Air Stripper # 2. The sump level must be within manufacturer's specifications or as specified by the contractor Environmental Department Project Leader.

8.3 Instrumentation and Control System – UV Reactor Operating Parameters

The I&C provides an alarm for any of the parameters below if they are out of range:

8.3.1 The I&C monitors and verifies that the UV lamps are operational via interface with the UV controller.

8.3.2 The I&C monitors and verifies that the transmittance controllers are operational via interface with the UV controller. The transmittance controllers must cycle once every 15 minutes.

8.3.3 The I&C checks and records the kVA, volts, amperes and hours for each UV lamp via interface with the UV controller.

8.3.4 The influent flowrate to the UV Reactor as indicated by FM-6WA-XK140 is monitored by I&C via interface with the UV controller. The influent flowrate must be within the operating parameters as specified by the contractor Environmental Department Project Leader.

8.4 Instrumentation and Control System – Extraction Well Operating Parameters

The I&C continuously monitors water levels and effluent flowrates and water levels for each extraction well as follows:

8.4.1 FM-6WA-XK007 and PT-6WA-XK010 for PFE-1. The flowrate and water level must be consistent with the operating parameters per the contractor Environmental Department Project Leader.

8.4.2 FM-6WA-XK027 and PT-6WA-XK030 for PFE-2. The flowrate and water level must be consistent with the operating parameters per the contractor Environmental Department Project Leader.

8.4.3 FM-6WA-XK037 and PT-6WA-XK040 for PFE-3. The flowrate and water level must be consistent with the operating parameters per the contractor Environmental Department Project Leader.

8.4.4 FM-6WA-XK047 and PT-6WA-XK050 for PFE-4A. The flowrate and water level must be consistent with the operating parameters per the contractor Environmental Department Project Leader.

8.4.5 FM-6WA-XK017 and PT-6WA-XK020 for PFE-5. The flowrate and water level must be consistent with the operating parameters per the contractor Environmental Department Project Leader.

8.4.6 FM-6WA-XK245 and PT-6WA-XK238 for PFE-7. The flowrate and water level must be consistent with the operating parameters per the contractor Environmental Department Project Leader.

8.5 Instrumentation and Control System – Injection Well Operating Parameters

The I&C monitors the following flowrates and water levels for each injection well as follows:

8.5.1 FM-6WA-XK153 and PT-6WA-XK159 for PFI-1. The flowrate and water level must be consistent with the operating parameters per the contractor Environmental Department Project Leader.

8.5.2 FM-6WA-XK161 and PT-6WA-XK167 for PFI-2. The flowrate and water level must be consistent with the operating parameters per the contractor Environmental Department Project Leader.

8.5.3 FM-6WA-XK169 and PT-6WA-XK175 for PFI-3. The flowrate and water level must be consistent with the operating parameters per the contractor Environmental Department Project Leader.

8.5.4 FM-6WA-XK177 and PT-6WA-XK183 for PFI-4. The flowrate and water level must be consistent with the operating parameters specified per the contractor Environmental Department Project Leader.

9.0 TREATMENT EQUIPMENT – WEEKLY INSPECTIONS

The following inspections must be performed weekly by a contractor Environmental Department Groundwater Treatment Facility Operator (per the WSTF Training Database) or Hazardous Waste Compliance Technician trained as a Groundwater Treatment Facility Technician (per the WSTF Training Database) as directed by the contractor Environmental Project Leader. The

checklist for these items is shown in Enclosure 1. Any discrepancies or observations must be noted in the comments section of the checklist.

9.1 Verify that the scale control system is on-line and operational.

9.2 Check and record the equipment and instrument air pressure as indicated by PI-6AR-XK133. The air pressure must be between 80 and 100 psig.

9.3 Verify that the selected UV lamps are operational.

9.4 Ensure UV Reactor solenoids are operating properly. Check that the transmittance controller is firing normally by observing solenoids being actuated and looking on the touchscreen for the position sensor indication the wiper has traveled the length of its stroke. The transmittance controller has been factory set to wipe the quartz tube once every fifteen minutes. It must cycle whenever there is water flow through the tower.

9.5 Check and record the influent water pressure to the UV Reactor as indicated by PI-6WA-XK137. The water pressure must be less than 90 psig.

9.6 At the UV Reactor power supply, ensure the indicator lights are "on" and the exhaust fan is operating.

9.7 Visually inspect Bldg. 650 above ground piping. The above ground piping (piping, valves, flanges, etc.) and the surrounding area must be free from corrosion, deterioration, or leaks.

9.8 Visually inspect the Scale Cleaning System. The Scale Cleaning System (tanks, valves, etc.) and the surrounding area must be free from corrosion, deterioration, or leaks.

9.9 Verify operation and visually inspect the Scale Control System. The Scale Control System (tanks, valves, etc.) and the surrounding area must be free from corrosion, deterioration, or leaks.

9.10 Verify operation and visually inspect Air Stripper # 1. The Air Stripper # 1 (sump, valves, etc.) and the surrounding area must be free from corrosion, deterioration, or leaks. Note any unusual sounds or vibrations.

9.11 Verify operation and visually inspect Air Stripper # 2. The Air Stripper # 2 (sump, valves, etc.) and the surrounding area must be free from corrosion, deterioration, or leaks. Note any unusual sounds or vibrations.

9.12 Verify operation and visually inspect the UV Reactor system. The UV Reactor system (tank, valves, etc.) and the surrounding area must be free from corrosion, deterioration, or leaks. Note any unusual sounds or vibrations.

9.13 Verify operation and visually inspect the Spent Cleaning Solution Tank (TK-6WA-XK222). The Spent Cleaning Solution Tank (tank, valves, etc.) and the surrounding area must be free from corrosion, deterioration, or leaks.

10.0 TREATMENT FACILITY (Building 650) – WEEKLY INSPECTIONS

The following inspections will be performed weekly by a contractor Environmental Department Groundwater Treatment Facility Operator (per the WSTF Training Database) or Hazardous Waste Compliance Technician trained as a Groundwater Treatment Facility Technician (per the WSTF Training Database) as directed by the contractor Environmental Department Project Leader. The checklist for these items is shown in Enclosure 1. Any discrepancies must be noted in the comments section of the checklist and reported to the Groundwater Treatment Facility Operator. Discrepancies and anomalies must be recorded on the Anomaly Log (Attachment D).

10.1 Visually inspect the area surrounding the treatment facility for evidence of erosion or run-on. The access road must be free of obstructions or deteriorations which may cause delays or hamper the movement of vehicles or equipment.

10.2 Visually inspect the treatment facility fence, gates and doors. The fence, gates and doors must be in good general condition with no evidence of unauthorized entry. All gates and doors must be secured, locked and checked for obstructions.

10.3 Visually inspect the "NO SMOKING" sign, restricted access and other warning signs for Bldg. 650 and the fenced area surrounding Bldg. 650. Signs must be present and legible.

10.4 Visually inspect the housekeeping inside the fenced area surrounding Bldg. 650. The area must be free from trash and debris.

10.5 Visually inspect the electrical service. The electrical service (electrical boxes, conduit, etc.) must be in good general condition with no evidence of unauthorized entry.

10.6 Check the lighting at the treatment facility (Bldg. 650) and surrounding area. The lighting must be adequate and operational.

10.7 Visually inspect the housekeeping inside Bldg. 650. The area must be free from trash and debris.

10.8 Visually inspect the secondary containment sump for Bldg. 650. The containment sump must be free of spills and standing water. Any unusual odors must be noted on the inspection checklist.

10.9 Functionally check the treatment facility (Bldg. 650) shower and eye wash. The shower and eye wash must be operational.

10.10 Verify that the phone at the treatment facility (Bldg. 650) is operational by calling the support contractor Environmental Department at 5464, or the WSTF Fire Department Control Center at 5641.

10.11 Visually inspect the Scale Cleaning System. Ensure at least 10% head space is maintained in the Spent Cleaning Solution Tank (TK-6WA-XK222). Note the tank level on the inspection checklist. If required, schedule and coordinate the disposal of spent cleaning solution. This is required if the "TK-6CI-XK222 LEVEL HIHI" alarm is displayed on control system HMI.

10.12 Visually inspect the Scale Cleaning System skid. Ensure at least 10% head space is maintained in the Scale Cleaning Solution Tank (TK-6CI-XK064). Note the tank level on the inspection checklist. If required, initiate a WSTF Form 473, "Environmental Task Memo" to schedule and coordinate filling the tank.

10.13 Visually inspect the Scale Control System skid. Ensure at least 10% head space is maintained in the Scale Control Chemical Tank (TK-6CI-XK076). Ensure that the tank level is adequate to allow 24 hour per day, 7 days per week operation of the facility. Note the tank level on the inspection checklist. If required, schedule and coordinate filling of Scale Control Chemical Tank (TK-6CI-XK064). This is required if the "TK-6CI-XK076 LEVEL LOW" alarm is displayed on control system HMI.

11.0 TREATMENT FACILITY ALARM SYSTEM – MONTHLY INSPECTIONS

The following inspections must be performed by a qualified contractor Environmental Department Groundwater Treatment Facility Operator (per the WSTF Training Database). Any discrepancies must be noted in the comments section of the checklist and reported to the Groundwater Treatment Facility Operator. Discrepancies and anomalies must be recorded on the Anomaly Log (Attachment D).

11.1 Perform test of the alarm system to ensure that the autodialer, interlocks, and emergency shutdown systems for the treatment facility (air strippers, UV Reactor, leak detection system, etc.) are operational.

11.2 Perform autodialer functional test to ensure that Instrumentation and Control System alarm conditions and autodialer are operational.

12.0 INJECTION MANIFOLD (BLDG. 651) – WEEKLY INSPECTIONS

The following inspections must be performed weekly by a contractor Environmental Department Groundwater Treatment Facility Operator (per the WSTF Training Database) or Hazardous Waste Compliance Technician trained as Groundwater Treatment Facility Technician (per the WSTF Training Database) as directed by the contractor Environmental Department Project Leader. The checklist for these items is shown in Enclosure 1. Any discrepancies must be noted in the comments section of the checklist and reported to the Groundwater Treatment Facility Operator. Discrepancies and anomalies must be recorded on the Anomaly Log (Attachment D).

12.1 Visually inspect the area surrounding Bldg. 651 for evidence of erosion or run-on. The access road must be free of obstructions or deteriorations which may cause delays or hamper the movement of vehicles or equipment.

12.2 Visually inspect the Bldg. 651 doors. The doors must be in good general condition with no evidence of unauthorized entry. All doors must be secured, locked and checked for obstructions.

12.3 Visually inspect the "NO SMOKING" sign, restricted access and other warning signs for Bldg. 651. Signs must be present and legible.

12.4 Visually inspect the housekeeping of the area surrounding Bldg. 651. The area must be free from trash and debris.

12.5 Check the lighting at the treatment facility (Bldg. 651) and surrounding area. The lighting must be adequate and operational.

12.6 Visually inspect the housekeeping inside Bldg. 651. The area must be free from trash and debris.

12.7 Visually inspect the injection manifold (Bldg. 651) above ground piping. The above ground piping (piping, valves, flanges, etc.) and the surrounding area must be free from corrosion, deterioration or leaks.

13.0 EXTRACTION AND INJECTION WELLS – WEEKLY INSPECTIONS

The following inspections must be performed weekly by a Groundwater Treatment Facility Operator (per the WSTF Training Database) or Hazardous Waste Compliance Technician trained as a Groundwater Treatment Facility Technician (per the WSTF Training Database) as directed by the contractor environmental Project Leader. The checklist for these items is Enclosure 1. Any discrepancies must be noted in the comments section of the checklist and reported to the

Groundwater Treatment Facility Operator. Discrepancies and anomalies must be recorded on the Anomaly Log (Attachment D).

WARNING

THE EXTRACTION AND INJECTION WELL VAULTS HAVE BEEN IDENTIFIED AS A CONFINED SPACE. UNDER NO CIRCUMSTANCE IS ENTRY INTO THE WELL VAULTS AUTHORIZED PER THIS ATTACHMENT. ALL EXTRACTION AND INJECTION WELL VAULT INSPECTIONS MUST BE PERFORMED BY PERSONNEL LOCATED OUTSIDE THE WELL VAULT.

13.1 Check the electrical power (current draw (amps), circuit voltage (v), etc.) for the extraction well pumps (PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, and PFE-7). The current draw and voltage must be within manufacturer's specifications. Record data if data are not collected by the Instrumentation and Control System. Mark "NA" if the well is off-line.

13.2 Visually inspect the access road(s) to the extraction and injection wells (PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, PFE-7, PFI-1, PFI-2, PFI-3, PFI-4). The access road(s) must be free of obstructions or deteriorations which may cause delays or hamper the movement of vehicles or equipment. Unsatisfactory conditions must be noted in the comments block and the contractor Environmental Department Project Leader notified.

13.3 Visually inspect the well vaults and access doors (extraction and injection wells PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, PFE-7, PFI-1, PFI-2, PFI-3, PFI-4). The doors must be in good general condition with no evidence of unauthorized entry. All doors must be secured, locked and checked for obstructions. Unsatisfactory conditions must be noted in the comments block and the contractor Environmental Department Project Leader notified.

13.4 Visually inspect the bollards and/or fence surrounding the well vaults (extraction and injection wells PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, PFE-7, PFI-1, PFI-2, PFI-3, PFI-4). The manholes, and bollards/fence must be in good general condition with no evidence of damage. Unsatisfactory conditions must be noted in the comments block and the contractor Environmental Department Project Leader notified.

13.5 Visually inspect the electrical service for the extraction wells (extraction wells PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, PFE-7). The electrical service (electrical boxes, conduit, etc.) must be in good general condition with no evidence of unauthorized entry. Mark N/A for the injection wells. Unsatisfactory conditions must be noted in the comments block and the contractor Environmental Department Project Leader notified.

13.6 Visually inspect the well identification, restricted access and other warning signs/labels for well vaults (extraction and injection wells PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, PFE-7, PFI-1, PFI-2, PFI-3, PFI-4). They must be present and legible. Unsatisfactory conditions must be noted in the comments block and the contractor Environmental Department Project Leader notified.

13.7 Visually inspect the housekeeping of the area surrounding the well vaults (extraction and injection wells PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, PFE-7, PFI-1, PFI-2, PFI-3, PFI-4). The area must be free from trash and debris. Unsatisfactory conditions must be noted in the comments block and the contractor Environmental Department Project Leader notified.

13.8 Visually inspect the general area surrounding the well vaults (extraction and injection wells PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, PFE-7, PFI-1, PFI-2, PFI-3, PFI-4) for signs of erosion due to precipitation, settling, etc. The general area of the well vault must be free of excessive erosion or silting due to run-on and signs of settling due to inadequate compaction. Unsatisfactory conditions must be noted in the comments block and the contractor Environmental Department Project Leader notified.

14.0 SUBGRADE PIPING SYSTEM – MONTHY INSPECTIONS

The following inspections must be performed monthly. The checklist for these items is Enclosure 1. Any discrepancies must be noted in the comments section of the checklist.

NOTE

A LIST OF SUBGRADE PIPING SYSTEM JUNCTION AND ACCESS VAULT LOCATIONS IS PRESENTED IN ENCLOSURE 1. THE PIPING ROUTE PLAN AND PROFILE DRAWINGS, SECTIONS AND DETAILS ARE PRESENTED IN WSTF DRAWING NUMBERS 652-C-1 THROUGH 652-C-26.

WARNING

THE PIPELINE VAULTS HAVE BEEN IDENTIFIED AS A CONFINED SPACE. UNDER NO CIRCUMSTANCE IS ENTRY INTO THE WELL VAULTS AUTHORIZED PER THIS ATTACHMENT. ALL VAULT INSPECTIONS MUST BE PERFORMED BY PERSONNEL LOCATED OUTSIDE THE WELL VAULT.

14.1 Visually inspect the access road(s) along the subgrade piping route. The access road(s) must be free of obstructions or deteriorations which may cause delays or hamper the movement of vehicles or equipment.

14.2 Visually inspect the subgrade piping route for exposed piping or signs of erosion due to precipitation. The subgrade piping must be buried a minimum of three feet deep and free of excessive erosion.

14.3 Visually inspect the general area surrounding the junction, conduit and access vaults for signs of erosion due to precipitation. The general area of the vaults must be free of excessive erosion or silting due to precipitation.

14.4 Visually inspect the junction, conduit and access vaults. Vault lids/doors must be in good general condition with no evidence of unauthorized entry. All access ports/closures must be secured, locked and checked for obstructions.

14.5 Visually inspect the bollards and/or fence surrounding the junction and access vaults. The bollards/fence must be in good general condition with no evidence of damage.

14.6 Visually inspect the restricted access and other warning signs for the junction and access vaults. They must be present and legible.

14.7 Visually inspect the housekeeping of the area surrounding the junction and access vaults. The area must be free from trash and debris.

Enclosure 1

Weekly and Monthly Inspection Records

Subgrade Piping Access Vaults

Location	Configuration	Drawing #
STA 0+00	Junction/Leak Det. Access	652-C -03
STA(N)2+72	Junction Access	652-C -03
STA(N)4+72	Leak Det. Access/ HP Vent	652-C -03
STA(N)8+13	Junction/Leak Det. Access	652-C -03
STA(N)11+80	Leak Det. Access	652-C -04
STA(N)15+40	Leak Det. Access	652-C -04
STA(N)19+00	Junction/Leak Det. Access	652-C -05
STA(N)21+50	Junction/Leak Det. Access	652-C -05
STA(N)25+34	Leak Det. Access	652-C -05
STA(N)27+14	Leak Det. Access	652-C -06
{STA(N)27+14}/ {STA(N)31+14	Drainage/Errosion Control	652-C -06
STA(N)31+14	Leak Det. Access	652-C -06
STA(N)35+14	Leak Det. Access	652-C -06
STA(S)8+70/ (PFE-3)0+00	Junction/Leak Det. Access	652-C -08
{STA(S)8+70}/ {STA(S)6+00}	Drainage/Errosion Control	652-C -08
STA(S)6+00	Leak Det. Access	652-C -08
STA(S)3+00	Leak Det. Access/ HP Vent	652-C -08
STA(S)14+90	Leak Det. Access/ HP Vent	652-C -09
STA(S)12+00	Leak Det. Access	652-C -09
STA(S)10+80	Leak Det. Access/ HP Vent	652-C -09
STA(S)26+90	Conduit Access	652-C -10
STA(S)22+90	Conduit Access	652-C -10
STA(S)19+00	Leak Det. Access	652-C -10
STA(S)34+10	HP Vent	652-C -11
{STA(S)34+10}/ {STA(S)31+40}	Drainage/Errosion Control	652-C -11
STA(S)31+40	HP Vent	652-C -11
STA(S)37+35	Conduit Access	652-C -12
(PFE-2)8+00	Leak Det. Access	652-C -13
(PFE-2)4+00	Leak Det. Access	652-C -13
(PFE-2)0+00	Access	652-C -13
{(PFE-4A)0+00}/ {(S)19+00}	Low Pt/ Leak Det. Access	652-C -14
(PFE-4A)3+30	Leak Det. Access	652-C -14
(PFE-4A)6+60	Leak Det. Access	652-C -15
{(PFE-3)0+00}/ {(S)8+70}	Access	652-C -15
{(PFE-5)0+00}/ {(N)19+00}	Access	652-C -16
(PFE-5)4+00	Leak Det. Access	652-C -16
(PFI-1)3+50	Conduit Access	652-C -17
(PFI-1)15+50	Conduit Access	652-C -18
(PFI-1)11+50	Conduit Access	652-C -18
(PFI-4)4+00	Conduit Access	652-C -19
(PFE-7)7+80	Leak Det. Access	652-C -20
(PFE-7)3+90	Leak Det. Access	652-C -20
{(PFE-7)0+00}/ {(PFE-2)8+00}	Access	652-C -20
(PFE-7)11+70	Leak Det. Access	652-C -21

Subgrade Piping Monthly Inspection Record

Location	Access Roads	Exposed Piping/Erosion	Vault Area Erosion	Vault Lid/Door	Bollards/Fence	Signs	Housekeeping	Date	Time	Inspector's Initials	Comments
STA 0+02											
STA(N)2+72											
STA(N)4+72											
STA(N)8+13											
STA(N)11+80											
STA(N)15+40											
STA(N)19+00											
STA(N)21+50											
STA(N)25+34											
STA(N)27+14											
STA(N)31+14											
STA(N)35+14											
STA(S)8+70/ (PFE-3)0+00											
STA(S)6+00											
STA(S)3+00											
STA(S)14+90											
STA(S)12+00											
STA(S)10+80											
STA(S)26+90											
STA(S)22+90											
STA(S)19+00											
STA(S)34+10											
STA(S)31+40											
STA(S)37+35											
(PFE-2)8+00											
(PFE-2)4+00											
(PFE-2)0+00											
{(PFE-4A)0+00}/ {(S)19+00}											
(PFE-4A)3+30											
(PFE-4A)6+60											
{(PFE-3)0+00}/ {(S)8+70}											
{(PFE-5)0+00}/ {(N)19+00}											
(PFE-5)4+00											
(PFI-1)3+50											
(PFI-1)15+50											
(PFI-1)11+50											
(PFI-4)4+00											
(PFE-7)7+80											
(PFE-7)3+90											
{(PFE-7)0+00}/ {(PFE-2)8+00}											
(PFE-7)11+70											

Treatment Facility Weekly Inspection Record

Erosion and Run-On/ Access Road	Fence, Gates, Doors	Signs	Housekeeping (Fenced area surrounding Bldg. 650)	Electrical Service	Lighting	Housekeeping inside Bldg. 650	Secondary Containment Sump	Shower/ Eyewash	Phone	Comments	Date	Inspector's Initials

Treatment Facility Weekly Inspection Record

Bldg.650 Above Ground Piping	Scale Cleaning System Surrounding Area	Scale Control System Ops. & Surrounding Area	Air Stripper # 1 Ops. & Surrounding Area	Air Stripper # 2 Ops. & Surrounding Area	UV Oxidation System Ops. & Surrounding Area	Spent Cleaning Solution Tank Surrounding Area	Spent Cleaning Solution Tank - TK-6WA-XK222 (gallons)	Scale Cleaning Solution Tank - TK-6CI-XK064 (gallons)	Scale Control Chemical Tank - TK-CI-XK076 (gallons)	Comments	Date	Inspector's Initials

Extraction & Injection Well Weekly Inspection Record

Well ID #

Access Road	Vault & Doors	Bollards and/or Fence	Electrical Service	Signs	Housekeeping (general area surrounding the vault)	Erosion or Silting	Comments	Date	Time	Inspector's Initials

Injection Manifold (Bldg. 651) Weekly Inspection Record

Erosion and Run-On/ Access Road	Doors	Signs	Housekeeping (general area surrounding Bldg. 651)	Lighting	Housekeeping (inside Bldg. 651)	Above Ground Piping	Comments	Date	Inspector's Initials

ATTACHMENT N

SPILL RESPONSE PROCEDURES FOR INCIDENTAL RELEASES

1.0 GENERAL INFORMATION

This Attachment provides procedures for response to an incidental release or spill of a hazardous material or hazardous waste at the plume-front treatment system, and includes Buildings 650 and 651, the injection and extraction wells, the sub-grade piping system, and all associated well vaults.

NOTE

IF A SPILL BECOMES AN EMERGENCY RELEASE THEN EMERGENCY SERVICES (X-5911) SHALL BE CALLED IMMEDIATELY.

AN EMERGENCY RELEASE IS ONE THAT GOES BEYOND THE SCOPE OF THE SPILL RESPONSE PROCEDURES, CONTROLS AND/OR RESOURCES DESCRIBED IN THIS ATTACHMENT.

2.0 DRAWINGS AND REFERENCES

A flow schematic is provided by drawing numbers 652-M-01, 652-M-02 and 652-M-03. Piping route plan and profile drawings and sections and details are presented in drawing numbers 652-C-01 through 652-C-26. Building 650 drawings are presented in drawing numbers 650-C-01 through 650-C-05, 650-M-01 through 650-M-06, 650-E-01 through 650-E-09, and 650-FPS-01.

3.0 ENCLOSURES

Enclosure 1, “Plume-Front Treatment System Spill Response and Personal Protective Equipment”.

4.0 SAFETY REQUIREMENTS

Specific safety requirements and instructions in the form of WARNINGS, CAUTIONS and NOTES are contained within the procedures preceding the applicable step(s). A hazard assessment for personal protective equipment per WSI 25-SW-0007 is included in Attachment C. A job hazard analysis per WSI 25-SW-0032 is included in Attachment C.

5.0 PERSONNEL REQUIREMENTS

Per WSP 25-0009, “WSTF Emergency Preparedness Plan”, the contractor Environmental Department is responsible for training personnel in local area hazards, emergency procedures, incidental spill cleanup, and completion of spill reports, reviewing area

procedures for adequacy in the event of an emergency release, and assisting the IC, where possible, during HAZMAT responses in their areas.

At minimum, all personnel actively involved in operations per this attachment where the potential for exposure to hazardous materials, hazardous waste, hazardous waste constituents, or contaminated groundwater exists will be qualified Hazardous Waste Handlers (per the WSTF Training Database).

6.0 EQUIPMENT

The contractor Environmental Department shall ensure the spill response and personal protective equipment listed in Enclosure 1, Tables 6.1, 6.2 and 6.3 are inventoried, inspected for damage or wear and readily available.

7.0 SPECIAL REQUIREMENTS

7.1 Per WSP 25-0009, "WSTF Emergency Preparedness Plan", the following definitions apply.

Emergency Release - The release of a hazardous substance that occurs outside of WSTF-controlled work areas or, within those areas, goes beyond the scope of the local area emergency procedures, controls or resources.

Emergency Response - A response effort by the WSTF Fire Department to an occurrence that results, or is likely to result, in an uncontrolled release of a hazardous substance. Responses to incidental releases of hazardous substances in which the substance can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area, or by maintenance personnel, are not considered to be emergency responses. Responses to releases of hazardous substances in which there is no potential safety or health hazard (i.e. fire, explosion, or chemical exposure) are not considered to be emergency responses.

Incidental Release - the release of a substance that can be handled within the scope of the local area emergency procedures, controls, and resources.

Incidental Response - a response effort by trained employees from within the immediate release area to a hazardous material release.

7.2 The procedures per this Attachment are applicable to the following incidental releases:

Goundwater containing ppm/ppb/ppt concentrations of WSTF groundwater contaminants released to and contained within the Building 650 secondary containment, the piping system leak detection and junction access vaults, and the extraction and injection well vaults (less than 10,000 gallons).

Polyphosphate scale control chemical (less than 200 gallons) and acid-based descaling solution (less than 3000 gallons of a 5% to 50% solution of citric acid) contained within the Building 650 secondary containment.

Mercury contaminated materials (UV lamps, softgoods, PPE, etc.) and liquid mercury (less than gram quantities).

Solid chemicals (citric acid, dry acid descalers, etc.) (less than 50 pound quantities).

8.0 CONTAMINATED GROUND WATER (LESS THAN 10,000 GALLONS)

The following procedures apply to the removal of groundwater containing ppm/ppb/ppt concentrations of WSTF groundwater contaminants from the Building 650 secondary containment and piping system leak detection and junction access vaults and well vaults (anticipated to be less than 10,000 gallons).

8.1 Prior to entry into the general work area, the contractor Environmental Department Project Leader (or designated alternate) shall evaluate the operational status of the plume-front treatment system and ensure that concurrent operations, energy sources and other potential hazards are secured and will not present any hazards to personnel during the spill response and cleanup operation.

8.2 The contractor Environmental Department Project Leader (or designated alternate) shall control access to the spill area. The Project Leader (or designated alternate) shall evaluate the magnitude of the release and if required, coordinate/schedule transportation of the required spill response waste transfer equipment (Enclosure 1, Table 6.3) to the general work area.

8.3 If required, the contractor Environmental Department Project Leader (or designated alternate) shall contact responsible contractor Environmental Department personnel and schedule/coordinate transfer and disposal of the waste/spill material to the 200 Area Evaporation Tanks per WSI 22-SW-0005, "Waste Management". The Project Leader (or designated alternate) shall coordinate setup of the waste transfer equipment (vacuum trailer or transfer pumps and tank trailers).

WARNING

THE FOLLOWING ARE THE MINIMUM SAFETY REQUIREMENTS FOR THE PERFORMANCE OF STEP 8.4.

1) CHEMICAL RESISTANT, FULL-LENGTH, BIB-TYPE, BUTYL RUBBER APRONS;

2) CHEMICAL RESISTANT GLOVES (NITRILE, NYTEX OR BUTYL RUBBER); AND

3) CONTROLLED ACCESS – ONLY AUTHORIZED PERSONNEL ALLOWED IN THE GENERAL WORK AREA;

8.4 For small spills in Building 650 or well vaults, use spill pillows or absorbent material as required to contain and absorb the release. Double bag spent absorbent material in plastic bags. Ensure that there are no free-standing liquids. Clean/decontaminate the area as directed by the contractor Environmental Department Project Leader (or designated alternate). Contact responsible contractor Environmental Department personnel and dispose of waste per WSI 22-SW-0005.

NOTE

SMALL SPILLS AND FINAL CLEAN-UP OF RELEASES TO THE ACCESS AND WELL VAULTS REQUIRE CONFINED SPACE ENTRY. THESE OPERATIONS WILL BE PERFORMED PER A SEPARATE WORK AUTHORIZING DOCUMENT AND WRITTEN INSTRUCTIONS.

WARNING

THE FOLLOWING ARE THE MINIMUM SAFETY REQUIREMENTS FOR THE PERFORMANCE OF STEPS 8.5 THROUGH 8.8:

1) WSTF APPROVED SPLASH SUITS (COMPLETE WITH HOOD, TOP, ETC.);

2) FACE SHIELDS AND SPASH GOGGLES (IN COMPLIANCE WITH ANSI-Z87.1-1989);

3) RUBBER BOOTS;

4) CHEMICAL RESISTANT GLOVES (NITRILE, NYTEX OR BUTYL RUBBER);

5) THE LEAK DETECTION AND JUNCTION ACCESS VAULTS, AND THE EXTRACTION AND INJECTION WELL VAULTS HAVE BEEN IDENTIFIED AS A CONFINED SPACE. UNDER NO CIRCUMSTANCE IS ENTRY INTO THE VAULTS AUTHORIZED PER THIS ATTACHMENT. ALL SPILL RESPONSE EFFORTS PER THIS ATTACHMENT SHALL BE PERFORMED BY PERSONNEL LOCATED OUTSIDE THE VAULTS;

6) TWO-PERSON OPERATION UNDER THE DIRECTION OF THE CONTRACTOR ENVIRONMENTAL DEPARTMENT PROJECT LEADER (OR DESIGNATED ALTERNATE); AND

7) CONTROLLED ACCESS – ONLY AUTHORIZED PERSONNEL ALLOWED IN THE GENERAL WORK AREA.

8.5 For larger releases in Building 650, remove the grating and lower the transfer hose into the floor sump. For well and access vaults, remove the access cover and lower the transfer hose into the leak detection, junction access or well vault.

8.6 Start the transfer operation. Transfer the waste/contaminated groundwater from the vault or sump to the vacuum trailer or tank trailer as directed by the contractor Environmental Department Project Leader (or designated alternate). Contact the responsible contractor Environmental Department personnel and transport and discharge the waste/contaminated groundwater to the 200 Area Evaporation Tanks per WSI 22-SW-0005.

8.7 Continue operation as directed by the contractor Environmental Department Project Leader (or designated alternate) until all the waste/contaminated groundwater is removed from the vault or sump. For the Building 650, clean and rinse the floor and wetted surfaces with potable water as directed by the contractor Environmental Department Project Leader (or designated alternate). Mop or squeegee the floor as required to remove all standing water.

8.8 Contact the responsible contractor Environmental Department personnel and dispose all liquid waste/contaminated groundwater/rinsate groundwater in the 200 Area Evaporation Tanks per WSI 22-SW-0005.

8.9 Contact the responsible contractor Environmental Department personnel and dispose of spill cleanup materials (softgoods, absorbents, PPE, etc.) as contaminated softgoods per WSI 22-SW-0005.

9.0 SCALE CONTROL AND SCALE CLEANING CHEMICAL RELEASES

The following provides procedures in response to a release of scale control or scale cleaning chemicals, a polyphosphate scale control chemical (less than 200 gallons) and acid-based descaling solution (less than 3,000 gallons of a 5% to 50% solution of citric acid) contained within the Building 650 secondary containment.

9.1 Prior to entry into the general work area, the contractor Environmental Department Project Leader (or designated alternate) shall evaluate the operational status of the plume-front treatment system and ensure that concurrent operations, energy sources and other potential hazards are secured and will not present any hazards to personnel during the spill response and cleanup operation.

9.2 The contractor Envirionmental Department Project Leader (or designated alternate) shall control access to the spill area. The Project Leader (or designated alternate) shall evaluate the magnitude of the release and if required, coordinate/schedule transportation of the required spill response waste transfer equipment (Enclosure 1, Table 6.3) to the general work area.

9.3 If required, the contractor Environmental Department shall schedule/coordinate transfer and disposal of the waste/spill material to the 200 Area Evaporation Tanks per WSI 22-SW-0005, "Waste Management". The Project Leader (or designated alternate) shall direct setup of the waste transfer equipment (vacuum trailer or transfer pumps and tank trailers).

WARNING

THE FOLLOWING ARE THE MINIMUM SAFETY REQUIREMENTS FOR THE PERFORMANCE OF STEP 9.4;

1) CHEMICAL RESISTANT, FULL-LENGTH, BIB-TYPE, BUTYL RUBBER APRONS;

2) CHEMICAL RESISTANT GLOVES (NITRILE, NYTEX OR BUTYL RUBBER); AND

3) CONTROLLED ACCESS – ONLY AUTHORIZED PERSONNEL ALLOWED IN THE GENERAL WORK AREA.

9.4 For small spills, use spill pillows or absorbent material as required to contain and absorb the release. Double bag spent absorbent material in plastic bags. Ensure that there is no free-standing liquid. Clean/decontaminate the area as directed by the contractor Environmental Department Project Leader (or designated alternate). Contact responsible contractor Environmental Department personnel and dispose of waste per WSI 22-SW-0005.

9.5 For larger spills, perform Steps 9.5.1 through 9.5.5 as directed by the the contractor Environmental Department Project Leader (or designated alternate).

WARNING

THE FOLLOWING ARE THE MINIMUM SAFETY REQUIREMENTS FOR THE PERFORMANCE OF STEPS 9.5.1 THROUGH 9.5.5:

1) WSTF APPROVED SPLASH SUITS (COMPLETE WITH HOOD, TOP, ETC.);

2) FACE SHIELDS AND SPLASH GOGGLES (IN COMPLIANCE WITH ANSI-Z87.1-1989) AS DIRECTED BY THE CONTRACTOR

ENVIRONMENTAL DEPARTMENT PROJECT LEADER (OR DESIGNATED ALTERNATE);

3) RUBBER BOOTS;

4) CHEMICAL RESISTANT GLOVES (NITRILE, NYTEX OR BUTYL RUBBER);

5) TWO-PERSON OPERATION UNDER THE DIRECTION OF THE CONTRACTOR ENVIRONMENTAL DEPARTMENT PROJECT LEADER (OR DESIGNATED ALTERNATE); AND

6) CONTROLLED ACCESS – ONLY AUTHORIZED PERSONNEL ALLOWED IN THE GENERAL WORK AREA.

9.5.1 Remove the sump grating and lower the transfer hose into the Building 650 floor sump. With a water hose and squeegee, rinse/squeegee the spill material to the the floor sump as directed by the contractor Environmental Department Project Leader (or designated alternate).

9.5.2 Start the transfer operation and transfer the waste (rinsate and spill material) from the sump to the vacuum trailer, tank trailer, 55 gallon drums, etc. as directed by the Project Leader (or designated alternate). Transport and discharge the waste/contaminated groundwater into the 200 Area Evaporation Tanks.

9.5.3 Continue operation as directed by the contractor Environmental Department Project Leader (or designated alternate) until all the spill material/rinsate is removed from the sump. Clean and rinse the floor and wetted surfaces with potable water as directected by the contractor Environmental Department Project Leader (or designated alternate). Mop or squeegee the floor as required to remove all standing water.

9.5.4 Contact the responsible contractor Environmental Department personnel and dispose of all liquid waste/contaminated groundwater/rinsate groundwater to the 200 Area Evaporation Tanks per WSI 22-SW-0005.

9.5.5 Contact the responsible contractor Environmental Department personnel and dispose of all spill cleanup materials (softgoods, absorbents, PPE, etc.) as contaminated softgoods per WSI 22-SW-0005.

10.0 INORGANIC AND METALLIC MERCURY RELEASES

The following provides procedures for the response and clean up of mercury (less than gram quantities) and mercury contaminated materials (broken UV lamps, softgoods, PPE, etc.) in Building 650.

10.1 Prior to entry into the general work area, the contractor Environmental Department Project Leader (or designated alternate) shall evaluate the operational status of the plume-front treatment system and ensure that all concurrent operations, energy sources and other potential hazards are secured and will not present any hazards during the spill response and cleanup operation. The Project Leader (or designated alternate) will control access and secure the facility ventilation system as required to ensure mecury contamination is not spread to other areas of the building.

WARNING

THE FOLLOWING ARE THE MINIMUM SAFETY REQUIREMENTS FOR THE PERFORMANCE OF STEPS 10.2 THROUGH 10.5:

1) TYVEK COVERALLS (COMPLETE WITH HOOD, TOP, BOOTIES, ETC.);

2) UTILIZE IMPERVIOUS-TYPE GLOVES SUCH AS SARANAXÔ OR BARRICADEÔ;

3) TWO-PERSON OPERATION UNDER THE DIRECTION OF THE CONTRACTOR ENVIRONMENTAL DEPARTMENT PROJECT LEADER (OR DESIGNATED ALTERNATE);

4) BREATHING AIR (SCBA OR AIRLINE) OR FULL-FACE RESPIRATOR WITH CANNISTER CARTRIDGES FOR PARTICULATES AND MERCURY VAPORS AS DIRECTED BY THE WSTF INDUSTRIAL HYGIENIST; AND

5) CONTROLLED ACCESS – ONLY AUTHORIZED PERSONNEL ALLOWED IN THE GENERAL WORK AREA.

10.2 Evaluate the severity of the situation while donning appropriate PPE described above. Report the extent of the spill and any other relevant information to the contractor Environmental Department Project Leader.

10.3 Obtain the mercury spill kit. Use mercury spill spray to suppress airborne mercury vapors in the general area. Use mercury suppressant/absorbent materials e.g., (Cinnasorb, Resisorb, etc.) as required to suppress mercury vapors at the source. Use mercury aspirator as required to collect any liquid mercury.

10.4 The mercury spill kit contains a small dust pan and brush. Collect all mercury contaminated material and double bag in plastic.

10.5 Clean/decontaminate the general area as directed by the contractor Environmental Department Project Leader (or designated alternate). The mercury spill kit contains mercury indicator powder. Use mercury indicator powder to identify

areas where additional cleaning/decontamination are required. All PPE shall be worn until contamination is contained and non-threatening.

10.6 The contractor Environmental Department Project Leader (or designated alternate) will contact the WSTF Industrial Hygienist. The Industrial Hygienist will test/sample the general area as required to verify the area is safe.

10.7 Contact responsible contractor Environmental Department personnel and dispose of all liquid mercury, spill material, absorbents, PPE, softgoods, etc. per WSI 22-SW-0005.

11.0 SOLID CHEMICAL RELEASES

The following provides procedures for the response and clean-up of a solid chemical release (less than 50 pounds of citric acid).

NOTE

THE PROJECT LEADER WILL MAKE THE DETERMINATION WHETHER TO RE-USE SPILLED CITRIC ACID AS PRODUCT OR TO DISPOSE OF IT AS HAZARDOUS WASTE.

11.1 Prior to entry into the general work area, the contractor Environmental Department Project Leader (or designated alternate) shall evaluate the operational status of the plume-front treatment system and ensure that all concurrent operations, energy sources and other potential hazards are secured and will not present any hazards during the spill response and cleanup operation. The Project Leader (or designated alternate) will control access and secure the facility ventilation system as required to ensure spill material is not spread to other areas of the building.

WARNING

THE FOLLOWING ARE THE MINIMUM SAFETY REQUIREMENTS FOR THE PERFORMANCE OF STEP 11.2:

1) TYVEK COVERALLS (COMPLETE WITH HOOD, TOP, BOOTIES, ETC.);

2) FACE SHIELDS (IN COMPLIANCE WITH ANSI-Z87.1-1989);

3) CHEMICAL RESISTANT GLOVES (NITRILE, NYTEX OR BUTYL RUBBER);

4) TWO-PERSON OPERATION UNDER THE DIRECTION OF THE CONTRACTOR ENVIRONMENTAL DEPARTMENT PROJECT LEADER (OR DESIGNATED ALTERNATE);

5) HALF-FACE RESPIRATOR WITH CANISTER CARTRIDGES FOR PARTICULATES; AND

6) CONTROLLED ACCESS – ONLY AUTHORIZED PERSONNEL ALLOWED IN THE GENERAL WORK AREA.

11.2 Using a broom and dust pan sweep up the spill material and double-bag in plastic. Clean and rinse the floor and other contaminated surfaces as directed by the contractor Environmental Department Project Leader (or designated alternate).

11.3 Collect all solid and liquid waste. Contact responsible contractor Environmental Department personnel and dispose of solid and liquid waste per WSI 22-SW-0005.

12.0 SPILL REPORTING

Following an emergency or incidental release or spill the contractor Environmental Department shall complete a "Spill Report" (WSTF Form 410) as required per WSI 22-SW-0005.

ENCLOSURE 1

PLUME-FRONT TREATMENT SYSTEM

SPILL RESPONSE AND

PERSONAL PROTECTIVE EQUIPMENT

Table 6.1 – Plume-Front Treatment System – Spill Response Equipment	
Equipment	**Responsible Section/Location**
10 – 48" x 3" absorbent socks for non-aggressive fluids	Environmental Department/Bldg. 650
50 pounds of clay absorbent	Environmental Department/Bldg. 650
50 – 12" x 12" absorbent towels or wipes	Environmental Department/Bldg. 650
1 – 36" x 24" x 4" stainless steel or plastic drip pan (or equivalent)	Environmental Department/Bldg. 650
2 – polyethylene or carbon steel open-top 55 gallon drums	Environmental Department/ 150 yard
2 – polyethylene 55 gallon drums	Environmental Department/ 150 yard
1 – 3 gallon stainless steel bucket	Environmental Department/Bldg. 650
12 – 3 gallon plastic bags	Environmental Department/Bldg. 650
6 – 55 gallon drum liners	Environmental Department/Bldg. 650
6 – 55 gallon plasitc bags	Environmental Department/Bldg. 650
12 – 12" x 12" polyethylene ziplock bags	Environmental Department/Bldg. 650
2 – floor squeegees	Environmental Department/Bldg. 650
2 – floor mops	Environmental Department/Bldg. 650
1 – polyethylene plastic shovel	Environmental Department/Bldg. 650
1 – polyethylene dust pan	Environmental Department/Bldg. 650
1 – plastic or corn broom	Environmental Department/Bldg. 650
1 – pair of 18" safety tongs	Environmental Department/Bldg. 650
1 – roll of 2" polyethylene/Calpico tape	Environmental Department/Bldg. 650
1 – flashlight with spare batteries	Environmental Department/Bldg. 650
2 – spill warning signs	Environmental Department/Bldg. 650
1 – 100' baricade marker	Environmental Department/Bldg. 650
1 – mercury spill kit containing - spray to suppress airborne mercury vapors - mercury vapor suppressant material (Cinnasorb, Resisorb etc.) - decontamination towelettes - 2 pair of Saranax™ or Barricade™ gloves - pick-up scoop and small brush - mercury aspirator or suction bottle - mercury spill cleaning solution - mercury indicator powder	Environmental Department/Bldg. 650

Table 6.2 – Plume-Front Treatment System – Personal Protective Equipment	
Equipment	**Responsible Section/Location**
4 – sets of WSTF approved splash suits (complete, top, bottom, etc.)	Environmental Department/Bldg. 638
4 – face shields in compliance with ANSI-Z87.1-1989	Environmental Department/Bldg. 638
4 – pair of rubber boots	Environmental Department/Bldg. 638
4 – pair of splash goggles in compliance with ANSI-Z87.1-1989	Environmental Department/Bldg. 638
4 – chemical resistant, full-length, bib-type, butyl rubber aprons	Environmental Department/Bldg. 638
10 – pair of chemical resistant gloves (nitrile, nytex or butyl rubber)	Environmental Department/Bldg. 638
4 –4 pair of white Tyvex coveralls	Environmental Department/Bldg. 638
4 – half-face air purifying respirators with canister cartidges for protection for organic vapor, acid fumes, and particulates.	Environmental Department/Bldg. 638
4 – full-face air purifying respirators with canister cartidges for protection for organic vapor, acid fumes, mercury vapors and particulates.	Environmental Department/Bldg. 638
2 – full face self-contained breathing apparatus (SCBA)	Environmental Department/150 Area, Bldg. 161A
10 – pair of disposable plastic boots	Environmental Department/Bldg. 638

Table 6.3 – Plume-Front Treatment System – Waste Transfer Equipment	
Equipment	**Responsible Section/Location**
1 – 1,000 gallon vacuum trailer –gasoline powered and 4x4 pickup equipped to pull 1000 gallon vacuum trailer	Environmental Department/ 150 yard
2 – 700 gallon tank trailers and 4x4 pickup	Environmental Department/Bldg. 637/638
6,000 gallon tanker trailer	Facilities Heavy Equipment/ 150 yard
1 – three inch gas powered trash pumps with quick-disconnect couplings.	Environmental Department/ 150 yard
1 – two inch gas powered diaphragm pump with quick-disconnect couplings	Environmental Department/ 150 yard
1 – two inch gas powered peristaltic pump with quick-disconnect couplings	Environmental Department/ 150 yard
1 – pneumatic diaphragm pump with 150 psig nitrogen supply	Environmental Department/ 150 yard and Bldg. 638
100 feet of two inch PVC hose with quick-disconnect couplings.	Environmental Department/ 150 yard
100 feet of three inch PVC hose with quick-disconnect couplings	Environmental Department/ 150 yard
100 feet of garden hose	Environmental Department/Bldg. 637/638
2” PVC check valve or foot valve	Environmental Department/ 150 yard
3” PVC check valve or foot valve	Environmental Department/ 150 yard
2” x 3” quick-disconnect coupling adapters	Environmental Department/ 150 yard

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

PFE-1
AVV-6WA-XK003
MV-6WA-XK202
1" CS
1/4" SS
4" CS
NV-6WA-XK004
MV-6WA-XK005
4" CS
2" CS
MV-6WA-XK006
FM-6WA-XK007
FCV-6WA-XK008
MV-6WA-XK009
CV-6WA-XK002
PT-6WA-XK010
PU-6WA-XK001
0-150 PSIG
PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 653-C-01
6" x 10" HDPE

PFE-5
AVV-6WA-XK013
MV-6WA-XK203
1" CS
1/4" SS
1.5" CS
NV-6WA-XK014
MV-6WA-XK015
1" CS
MV-6WA-XK016
FM-6WA-XK017
MV-6WA-XK019
CV-6WA-XK012
PT-6WA-XK020
PU-6WA-XK011
0-150 PSIG
PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 657-C-01
2" x 4" HDPE
MV-6WA-XK051
JUNCTION @ STA (N) 21+52.51
REF DWG: 652-C-31
MV-6WA-XK052
6" x 10" HDPE

PFE-2
AVV-6WA-XK023
MV-6WA-XK204
1" CS
1/4" SS
4" CS
NV-6WA-XK024
MV-6WA-XK025
3" CS
2" CS
MV-6WA-XK026
FM-6WA-XK027
FCV-6WA-XK028
MV-6WA-XK029
CV-6WA-XK022
PT-6WA-XK030
PU-6WA-XK021
0-150 PSIG
PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 654-C-01
JUNCTION @ STA(PFE-2) 8+00.00
REF DWG: 652-C-34
6" x 10" HDPE
MV-6WA-XK255
MV-6WA-XK053
MV-6WA-XK054
JUNCTION @ STA (N) 18+91.4
REF DWG: 652-C-30
MV-6WA-XK256
8" x 12" HDPE
JUNCTION @ STA (N) 8+13
REF DWG: 652-C-30
8" x 12" HDPE
AVV-6WA-XK196
MV-6WA-XK210

PFE-7
AVV-6WA-XK240
MV-6WA-XK241
1" CS
1/4" SS
3" CS
NV-6WA-XK242
MV-6WA-XK243
2" CS
2" CS
MV-6WA-XK244
FM-6WA-XK245
FCV-6WA-XK246
MV-6WA-XK247
CV-6WA-XK239
PT-6WA-XK238
PU-6WA-XK237
0-150 PSIG
PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 658-C-01
4" x 8" HDPE
MV-6WA-XK055
CV-6WA-XK251
JUNCTION @ STA (N) 2+72
REF DWG: 652-C-29
MV-6WA-XK252
8" x 12" HDPE
MV-6WA-XK058
JUNCTION @ STA 0+02
REF DWG: 652-C-28
TO BUILDING 650, TREATMENT FACILITY
REF DWG: 652-M-02
CV-6WA-XK253
MV-6WA-XK059
6" x 10" HDPE
AVV-6WA-XK198
MV-6WA-XK209

PFE-3
AVV-6WA-XK033
MV-6WA-XK205
1" CS
1/4" SS
4" CS
NV-6WA-XK034
MV-6WA-XK035
3" CS
2" CS
MV-6WA-XK036
FM-6WA-XK037
FCV-6WA-XK038
MV-6WA-XK039
CV-6WA-XK032
PT-6WA-XK040
PU-6WA-XK031
0-150 PSIG
PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 655-C-01
5" x 8" HDPE
MV-6WA-XK057
JUNCTION @ STA (S) 8+70
REF DWG: 652-C-30
MV-6WA-XK056
AVV-6WA-XK190
MV-6WA-XK208

PFE-4A
AVV-6WA-XK043
MV-6WA-XK206
1" CS
1/4" SS
4" CS
NV-6WA-XK044
MV-6WA-XK045
3" CS
2" CS
MV-6WA-XK046
FM-6WA-XK047
FCV-6WA-XK254
MV-6WA-XK049
CV-6WA-XK042
PT-6WA-XK050
PU-6WA-XK041
0-150 PSIG
PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 656-C-01
5" x 8" HDPE
JUNCTION @ STA (PFE-4A) 0+00.00
REF DWG: 652-C-34
AVV-6WA-XK192
MV-6WA-XK207

ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASS'Y					

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	9-1-99
ENGINEER	J. KIRBY	9-1-99
DESIGNED BY	J. KIRBY	9-1-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

PLUME-FRONT REMEDIATION
PIPING SYSTEM
MECHANICAL
FLOW SCHEMATIC

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-M-01 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

DATA RECORDING & TELEMETRY

INSTRUMENT AIR — 6" CS — FM-6WA-XK096 — FCV-6WA-XK093 THROTTLE — FC — 6" CPVC

VENT TO ATMOSPHERE

TI-6WA-XK094 0-200° F — TT-6WA-XK138

PS-6AR-XK231 0-35" WC — PS-6AR-XK232 0-35" WC — MV-6WA-XK097

PT-6AR-XK229 — PI-6AR-XK230 0-30" WC

FI-6AR-XK227 0-500" WC VAC — FT-6AR-XK228 0-500" WC VAC — FLS-6AR-XK089

LLT-6WA-XK104 — PI-6WA-XK107

PS-6AR-XK101 0.4-1.6" WC — BL-6AR-XK098

0-200 PSIG — ROV-6WA-XK109 ON/OFF — MV-6WA-XK105

LLC-6WA-XK102 — LLC-6WA-XK103 — VFD — PU-6WA-XK106

3" CPVC — 2" CPVC — 6" CPVC — 3" CPVC

ROV-6WA-XK110 ON/OFF — MV-6WA-XK119 — CV-6WA-XK108

ROV-6WA-XK092 ON/OFF

AIR STRIPPER #1

TS-6AR-XK233 — TS-6AR-XK234

FS-6WA-XK130 — FLOOR SUMP — FUTURE

F-6AR-XK060 — AMBIENT AIR — 16" PVC — AMBIENT AIR

EEW-6WA-XK185 — ES-6WA-XK062 — MV-6WA-XK184 — POTABLE WATER 2" CS — MV-6WA-XK063 — CV-6CI-XK236

M-6CI-XK188 — TK-6CI-XK064 — MV-6CI-XK199 — LLC-6CI-XK067

PU-6CI-XK071 — CV-6CI-XK069 — CV-6CI-XK068 — MV-6CI-XK081

PU-6CI-XK070 — CV-6CI-XK072 — CV-6CI-XK073 — MV-6CI-XK074

1/4" SS — 2" CPVC

SCALE CLEANING SYSTEM

SPENT CLEANING SOLUTION TK-6WA-XK222 — LLC-6WA-XK065 — LLC-6WA-XK100 — 2" — MV-6WA-XK099

INSTRUMENT AIR — 3" CPVC — 1/4" SS

UV OXIDATION SYSTEM

SP 90 PSIG — PSV-6AR-XK132 — PI-6AR-XK133 — PS-6AR-XK134 40-85 PSIG — 0-100 PSIG — AVV-6WA-XK018 — MV-6WA-XK136 — MV-6AR-XK135

PU-6AR-XK131 — COMPRESSED AIR

TK-6WA-XK141 — PI-6WA-XK137 0-100 PSIG — ECV-6WA-XK187

MV-6WA-XK139 — FM-6WA-XK140 — RD-6WA-XK186 BP 100 PSIG — DRAIN

TK-6CI-XK076 — MV-6CI-XK075 — 2" CS — MV-6CI-XK200 — LLC-6CI-XK066

PU-6CI-XK078 — MV-6CI-XK077 — CV-6CI-XK079 — CV-6CI-XK080 — 1/4" SS

SCALING CONTROL CHEMICAL METERING SYSTEM

6" CS — 2" CS — 8" CS

10"X16" HDPE FROM EXTRACTION WELLS REF DWG: 652-M-01

MV-6WA-XK082 — 0-100 PSIG PI-6WA-XK083 — 8" CS — SM-6WA-XK087

MV-6WA-XK086 — 1/4" SS — MV-6WA-XK258

LLS-6WA-XK235 — LLS — LEAK DETECTION CONTROL PANEL

AVV-6WA-XK189 — MV-6WA-XK201 — ROV-6WA-XK143 ON/OFF — FC — MV-6WA-XK144 — 10" HDPE TO INJECTION WELLS REF DWG: 652-M-03

MV-6WA-XK142 — 1/4" SS

VENT TO ATMOSPHERE

TI-6WA-XK114 0-200° F — TT-6WA-XK115

PS-6AR-XK225 0-35" WC — PS-6AR-XK226 0-35" WC — MV-6WA-XK113

PT-6AR-XK223 — PI-6AR-XK224 0-30" WC

FI-6AR-XK084 0-500" WC VAC — FT-6AR-XK085 0-500" WC VAC — FLS-6AR-XK118

LLT-6WA-XK123 — PI-6WA-XK126

PS-6AR-XK120 0.4-1.6" WC — BL-6AR-XK117

0-200 PSIG — MV-6WA-XK124 — ROV-6WA-XK128 ON/OFF

LLC-6WA-XK121 — LLC-6WA-XK122 — VFD — PU-6WA-XK125

3" CPVC — 2" CPVC — 6" CPVC — 3" CPVC

ROV-6WA-XK111 ON/OFF — MV-6WA-XK061 — CV-6WA-XK127

ROV-6WA-XK129 ON/OFF

AIR STRIPPER #2

F-6AR-XK088 — AMBIENT AIR — 16" PVC — AMBIENT AIR

MV-6WA-XK090 — CV-6WA-XK091

CV-6WA-XK145 — ROV-6WA-XK257 — MV-6WA-XK146

MV-6WA-XK147 — PU-6WA-XK149 — TK-6WA-XK148 — MV-6WA-XK150 — MV-6WA-XK151

BUILDING 650

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	9-1-99
ENGINEER	J. KIRBY	9-1-99
DESIGNED BY	J. KIRBY	9-1-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

PLUME-FRONT REMEDIATION
PIPING SYSTEM
MECHANICAL
FLOW SCHEMATIC

A.B. DWG. NO. — SCALE NONE — SHEET 1 OF 1

CODE IDENT. — SIZE F — DWG. NO. 652-M-02 — REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

10" HDPE
FROM BUILDING 650
REF DWG: 652-M-02

AVV-6WA-XK197 · AVV-6WA-XK191 · AVV-6WA-XK193 · AVV-6WA-XK194 · AVV-6WA-XK195
MV-6WA-XK211 · MV-6WA-XK212 · MV-6WA-XK213 · MV-6WA-XK214 · MV-6WA-XK215
1" CS

10" CS

6" CS

4" CPVC

BUILDING 651

PFI-2

AVV-6WA-XK163 · MV-6WA-XK216 · 1/2" CS
MV-6WA-XK160 · FM-6WA-XK161 · FCV-6WA-XK162 · MV-6WA-XK164
3" CPVC · 4" CPVC · 4" CPVC
6" CS · 6" HDPE
MV-6WA-XK165 · 4" CS
AVV-6WA-XK166 · MV-6WA-XK220 · 1" CS
PT-6WA-XK167 · 3" CS · P T 0-250 PSIG · PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 661-C-01

PFI-1

AVV-6WA-XK155 · MV-6WA-XK217 · 1/2" CS
MV-6WA-XK152 · FM-6WA-XK153 · FCV-6WA-XK154 · MV-6WA-XK156
4" CPVC · 3" CPVC · 4" CPVC
6" CS · 6" HDPE
MV-6WA-XK157 · 4" CS
AVV-6WA-XK158 · MV-6WA-XK221 · 1" CS
PT-6WA-XK159 · 3" CS · P T 0-250 PSIG · PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 660-C-01

PFI-4

AVV-6WA-XK179 · MV-6WA-XK218 · 1/2" CS
MV-6WA-XK176 · FM-6WA-XK177 · FCV-6WA-XK178 · MV-6WA-XK180
4" CPVC · 3" CPVC · 4" CPVC
6" CS · 6" HDPE
MV-6WA-XK181 · 4" CS
AVV-6WA-XK182 · MV-6WA-XK048 · 1" CS
PT-6WA-XK183 · 3" CS · P T 0-250 PSIG · PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 663-C-01

PFI-3

AVV-6WA-XK171 · MV-6WA-XK219 · 1/2" CS
MV-6WA-XK168 · FM-6WA-XK169 · FCV-6WA-XK170 · MV-6WA-XK172
3" CPVC · 4" CPVC
6" CS · 6" HDPE
MV-6WA-XK173 · 4" CS
AVV-6WA-XK174 · MV-6WA-XK095 · 1" CS
PT-6WA-XK175 · 3" CS · P T 0-250 PSIG · PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 662-C-01

NOTES:

1. ALL CPVC PIPE SHALL BE SCH 80.

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

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.0± ANGLES ±
.00± FRACTIONS ±
.000±
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UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

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ENGINEER	J. KIRBY	9-1-99
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APPROVAL		
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RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

PLUME-FRONT REMEDIATION
PIPING SYSTEM
MECHANICAL
FLOW SCHEMATIC

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-M-03 | REV.

Appendix C - Public Notice Information

State of New Mexico
ENVIRONMENT DEPARTMENT
Hazardous & Radioactive Materials Bureau
2044 Galisteo Street
P.O. Box 26110
Santa Fe, New Mexico 87502
(505) 827-1557
Fax (505) 827-1544

GARY E. JOHNSON
GOVERNOR

PETER MAGGIORE
SECRETARY

CERTIFIED MAIL No. Z 108 891 826
RETURN RECEIPT REQUESTED

February 10, 1999

Mr. Joseph Fries, Manager
National Aeronautics and Space Administration
White Sands Test Facility
P.O. Box 20
Las Cruces, New Mexico 88004

RE: NASA PUBLIC NOTICE FOR IMPLEMENTATION OF A PRESUMPTIVE REMEDY
EPA ID NO. NM8800019434

Dear Mr. Fries:

The New Mexico Environment Department **(NMED)** Hazardous and Radioactive Materials Bureau **(HRMB)** has received the National Aeronautics and Space Administration **(NASA)**, *PLUME-FRONT STABILIZATION WORK PLAN NASA-JSC WHITE SANDS TEST FACILITY*, dated January 1999.

To further expedite these procedures and to conform with established guidance proposed in the Environmental Protection Agency *PRESUMPTIVE REMEDIES: POLICY AND PROCEDURES*, Directive: 9355.0-47FS, dated September 1993, HRMB requests that NASA propose the presumptive remedy for a 60-day public comment period. Furthermore, HRMB believes that NASA should public notice the planned use of the presumptive remedy early on, thereby giving the State, the community and others the opportunity to express any concerns that they may have about the proposed presumptive remedy.

Therefore, HRMB strongly recommends that NASA incorporate public participation into the presumptive remedy process through:

- the submittal of a notice of the presumptive remedy to all persons on the facility mailing list maintained by

NMED (enclosed) and, to the appropriate units of state and local government; and,

- the publication of this notice in a major local newspaper of general circulation.

The notice should include:

- Announcement of a 60-day comment period, and a name and address of a facility contact to whom comments must be sent;
- Announcement of a date, time, and place for a public meeting on the presumptive remedy;
- Name and telephone number of the permittee's contact person;
- Location where copies of the presumptive remedy and any supporting documents can be viewed and copied.

NASA should place a copy of the presumptive remedy and supporting documents in a location accessible to the public in the vicinity of the permitted facility. NASA should hold a public meeting no earlier than 15 days after the publication of the notice and no later than 15 days before the close of the 60-day comment period. The meeting should be held to the extent practicable in the vicinity of the facility. The public should be provided at least 60 days to comment on the presumptive remedy. The comment period should begin on the date the facility publishes the notice in the local newspaper. Comments should be submitted to the facility contact identified in the notice. The facility should consider and respond to all written comments received during the 60-day comment period. NASA must provide HRMB with a copy of the comments received during the 60-day public comment period and its responses to those comments.

If you have any questions regarding this matter you may contact Mr. Phillip Solano of my staff at 505/827-1561 ext. 1021.

Sincerely,

Dr. Robert S. (Stu) Dinwiddie, Manager
RCRA Permits Management Program
Hazardous and Radioactive Materials Bureau

cc w/o encls: Benito Garcia, Chief HRMB
Steve Pullen, Supervisor RPMP/DOD
Phillip Solano, RPMP/DOD
Jennifer Parker, GWQB
Barbara Hoditschek, SWQB
Jerry Bober, SWB
David Neleigh, Chief, EPA (6PD-N)

File: Red,NASA,99
Track: NASA,02/10/99,NASA/Fries,HRMB/PJS,RE
lr990210.pblc

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Environmental Public Affairs Office
2000 Wyoming Blvd. SE, 377 ABW/PA
Kirkland AFB, NM 87117-5606 *

RA

APR 0 6 1999

New Mexico Environment Department
Attn: Mr. Phillip Solano
RCRA Permits Management Program
Hazardous and Radioactive Materials Bureau
2044 Galisteo Street
Santa Fe, NM 87505-2100

Subject: NASA White Sands Test Facility Notification for a Groundwater Remediation System

NASA White Sands Test Facility intends to construct a plume-front pump and treat groundwater remediation system. Enclosed is the public notification statement, published on March 28, 1999, which identifies this system as a presumptive remedy. The goal of this system will be to prevent future plume-front migration of groundwater contaminants.

The enclosed public notification statement provides a more detailed description of the system and includes facility contact information. A public meeting has been scheduled for May 6, 1999, from 5 to 7 p.m. in the Dresp B Room of the Thomas Branigan Memorial Library in Las Cruces, New Mexico.

If you have any questions or comments concerning this matter, please call David Amidei at (505) 524–5517.

ORIGINAL SIGNED BY
JOSEPH FRIES

bc:
ATSC Team/P. H. Pache

Joseph Fries
Manager

RA/DAmidei:ljg:4/5/99:5517

#3 E:\LTRS\ENV99-1\remedy.doc & publicnotice.doc

Enclosure

cc:
See List

CONCUR	CODE →	RA				
	SIGNATURE →	DA				
	DATE →	4/5/99				

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ATTN MR PHILLIP SOLANO
RCRA PERMITS MANAGEMENT PROGRAM
HAZARDOUS AND RADIOACTIVE MATERIALS BUREAU
2044 GALISTEO STREET
SANTA FE NM 87505-2100

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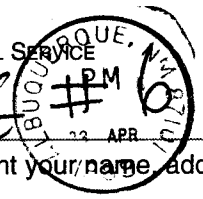

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White Sands Test Facility
P.O. Drawer MM
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cc:

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Kirkland AFB, NM 87117-5606

NOTICE OF PLUME-FRONT GROUNDWATER REMEDIATION

NASA White Sands Test Facility (WSTF) hereby announces its intent to implement a pump and treat groundwater remediation system to prevent further migration of contaminated groundwater caused by historic site operations. This remedy will pump groundwater from six extraction wells, treat the water using ultraviolet/oxidation and air stripping technologies, and reintroduce the treated groundwater into the aquifer through a network of four injection wells.

System construction is expected to commence in the summer of 1999 and is anticipated to operate 24 hours a day following an initial start-up phase. Approximately 1,000 gallons per minute will be treated and injected during the operational life of the system. WSTF expects the system to be operational in the year 2000.

The owner and operator of the system is NASA White Sands Test Facility, P.O. Box 20, Las Cruces, New Mexico 88004. WSTF is located approximately 16 miles northeast of Las Cruces, New Mexico.

This notice initiates a 60-day comment period to address public comments and questions regarding this interim groundwater treatment remedy. Inquiries regarding this activity should be directed to:

David A. Amidei
NASA Environmental Manager
White Sands Test Facility
P.O. Box 20
Las Cruces, New Mexico 88004
(505) 524-5517

A public meeting has been scheduled for Thursday, May 6, 1999, from 5 p.m. to 7 p.m. in the Dresp B Room of the Thomas Branigan Memorial Library to encourage public participation in the presumptive remedy process. WSTF personnel will be available to address any questions or comments. Copies of the proposed Work Plan and supporting documentation (including a pilot-scale ultraviolet/oxidation testing schedule) can be viewed at the Thomas Branigan Memorial Library.

Enclosure

PUBLIC MEETING SIGN-IN
NASA WHITE SANDS TEST FACILITY
PLUME-FRONT STABILIZATION WORK PLAN

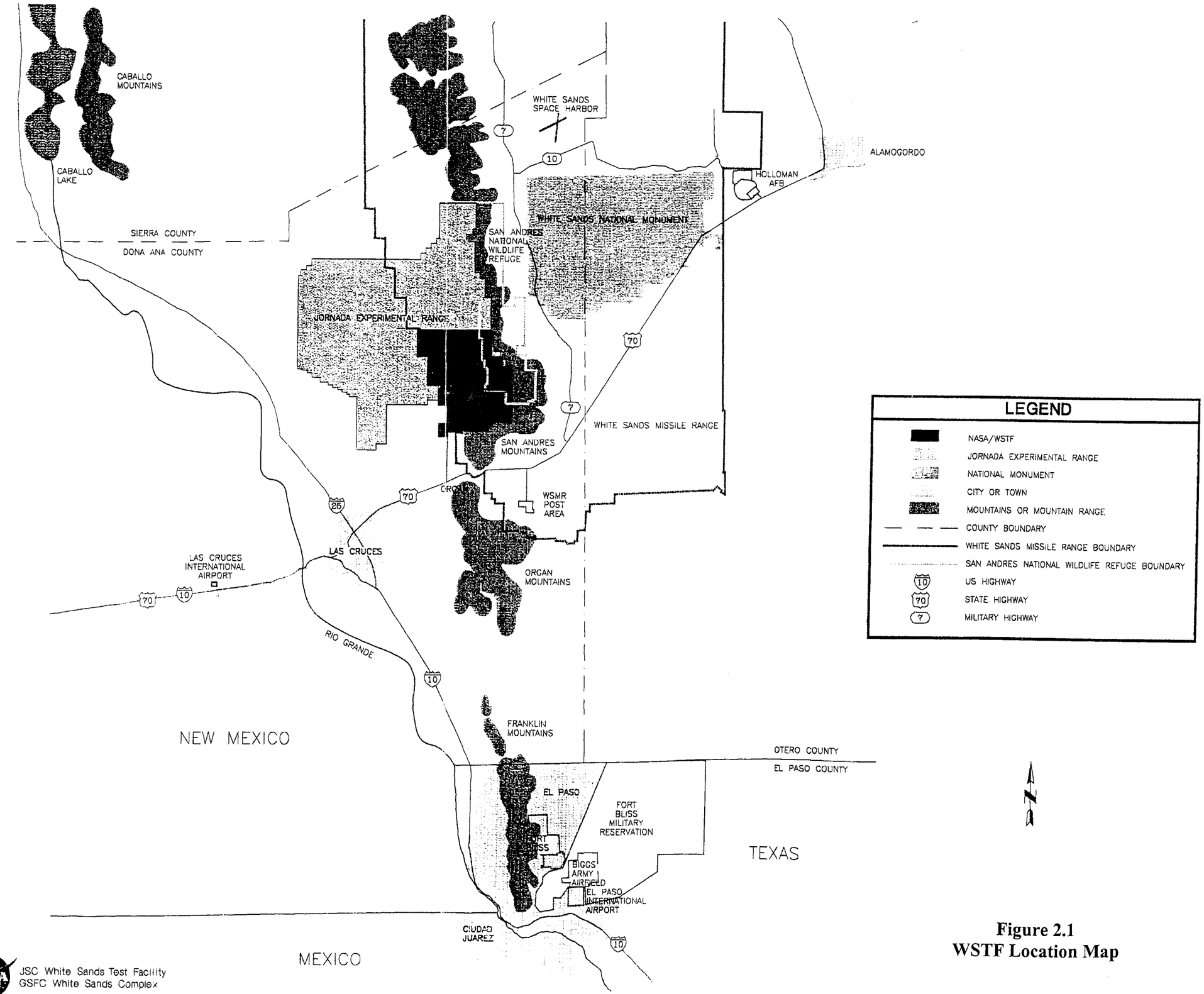
Branigan Memorial Library
Las Cruces, New Mexico
May 6, 1999 5:00 to 7:00 pm

ATTENDEE'S NAME (PLEASE PRINT)	AFFILIATION (OPTIONAL)	ADDRESS, PHONE NUMBER AND E-MAIL (OPTIONAL)
JACK KIRBY	ATSC / WSTF	
Jennifer Parker	NMED / GWQB	
Brigitte Burchfield	White Sands/MEVATEC	
Jon Wolverton	White Sands/MEVATEC	415 Dart White Sands Missile Range, New Mexico 88002
Robin Smith	White Sands	
JANINE DIVYAK	Planning Dept DONA ANA COUNTY 430 S. Main	647-7237 janined@co.dona-ana.nm.us
Phillip Solano	NMED/HRMB	2044 Galisteo St. Santa Fe, NM 505/827-1561 ext 1021 87505

PUBLIC MEETING SIGN-IN
NASA WHITE SANDS TEST FACILITY
PLUME-FRONT STABILIZATION WORK PLAN

Branigan Memorial Library
Las Cruces, New Mexico
May 6, 1999 5:00 to 7:00 pm

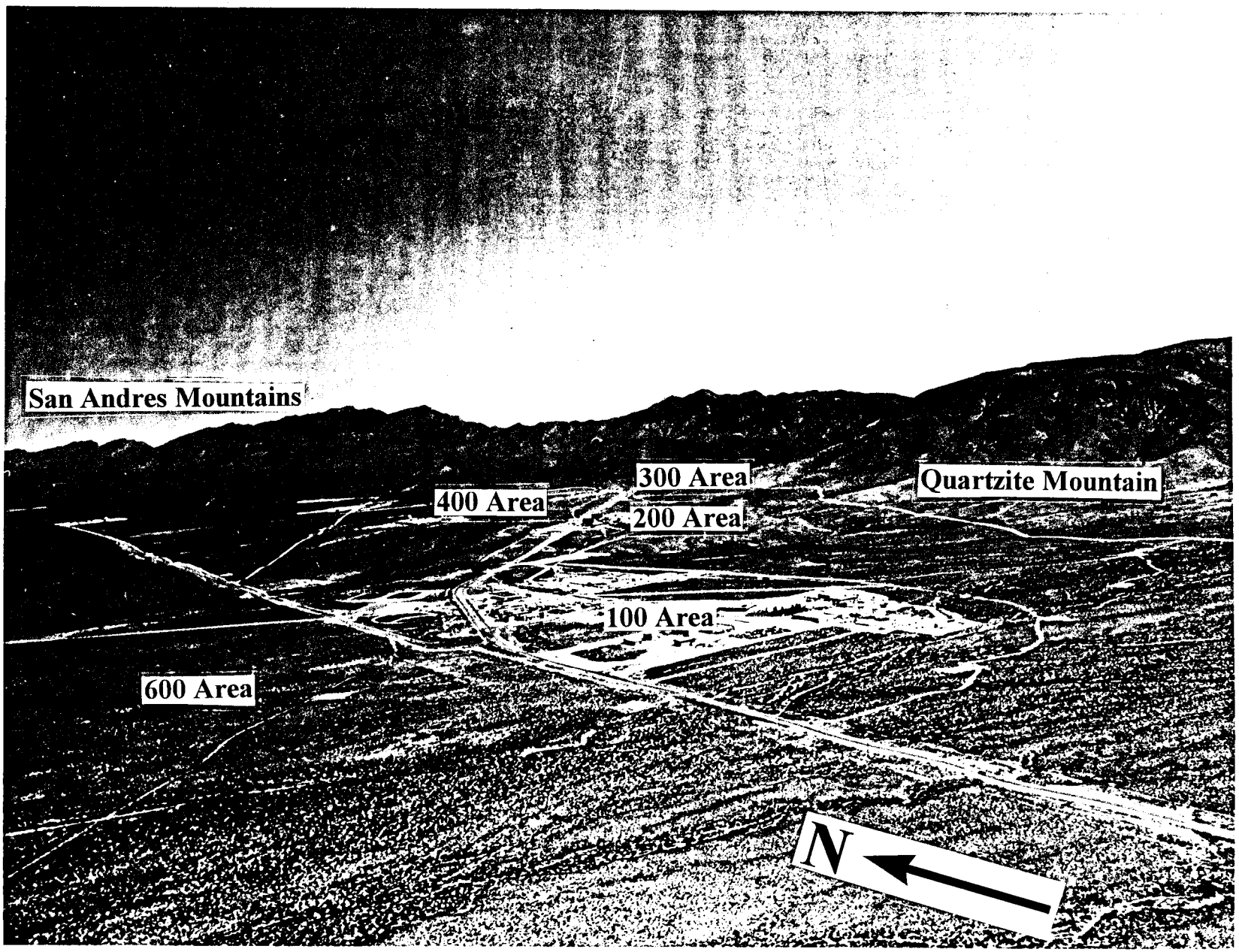
ATTENDEE'S NAME (PLEASE PRINT)	AFFILIATION (OPTIONAL)	ADDRESS, PHONE NUMBER AND E-MAIL (OPTIONAL)
PETER H PACHE	ATSC / WSTF	
MARIANO LEGARRETTA	Watch.	
TIM DAVIS	ATSC / WSTF	
KAY SPENCER	ATSC/WSTF	
GEOFF GILES	ATSC/ WSTF	
Mark McClure	ATSC/WSTF	
Molly McClure	"	



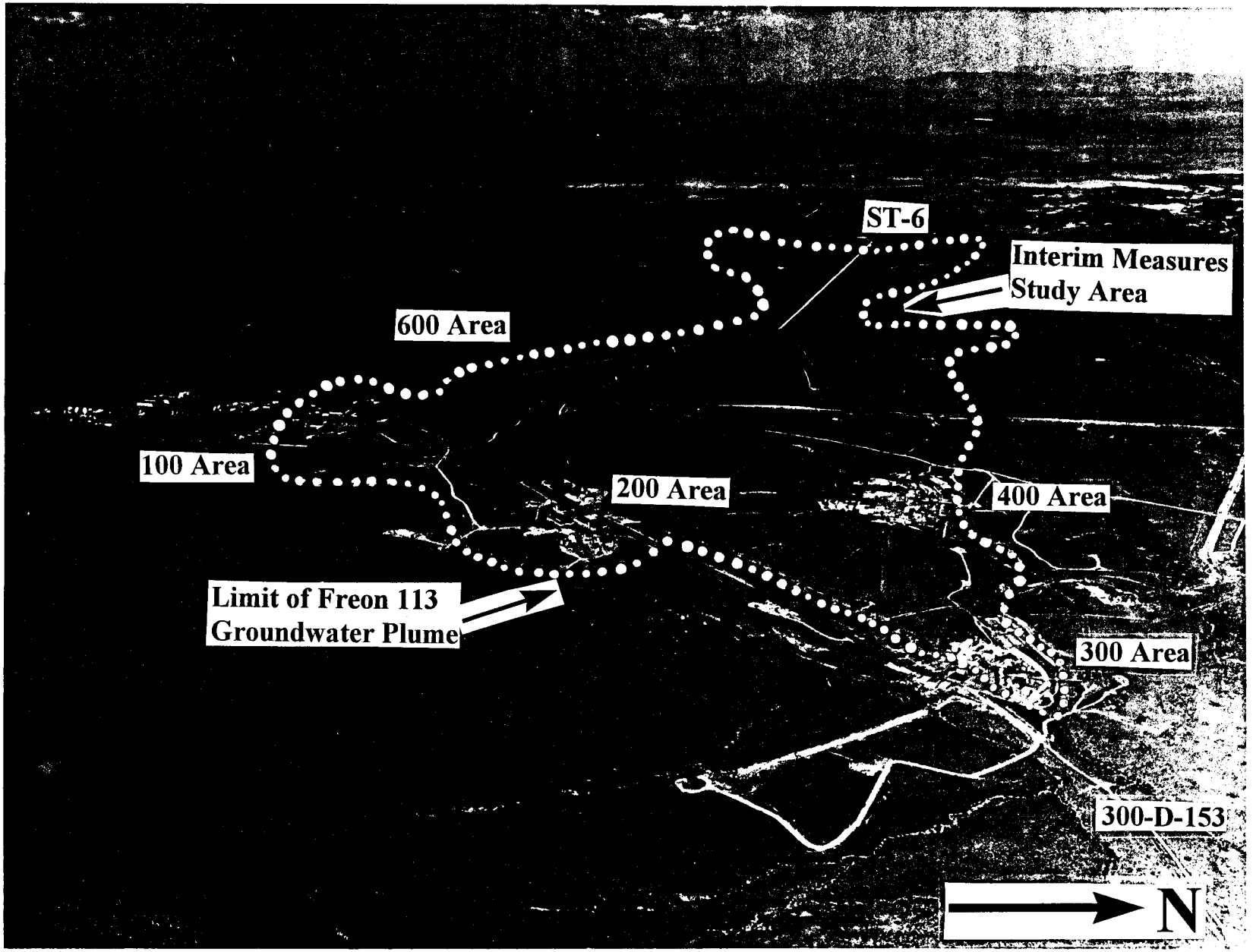
JSC White Sands Test Facility
GSFC White Sands Complex

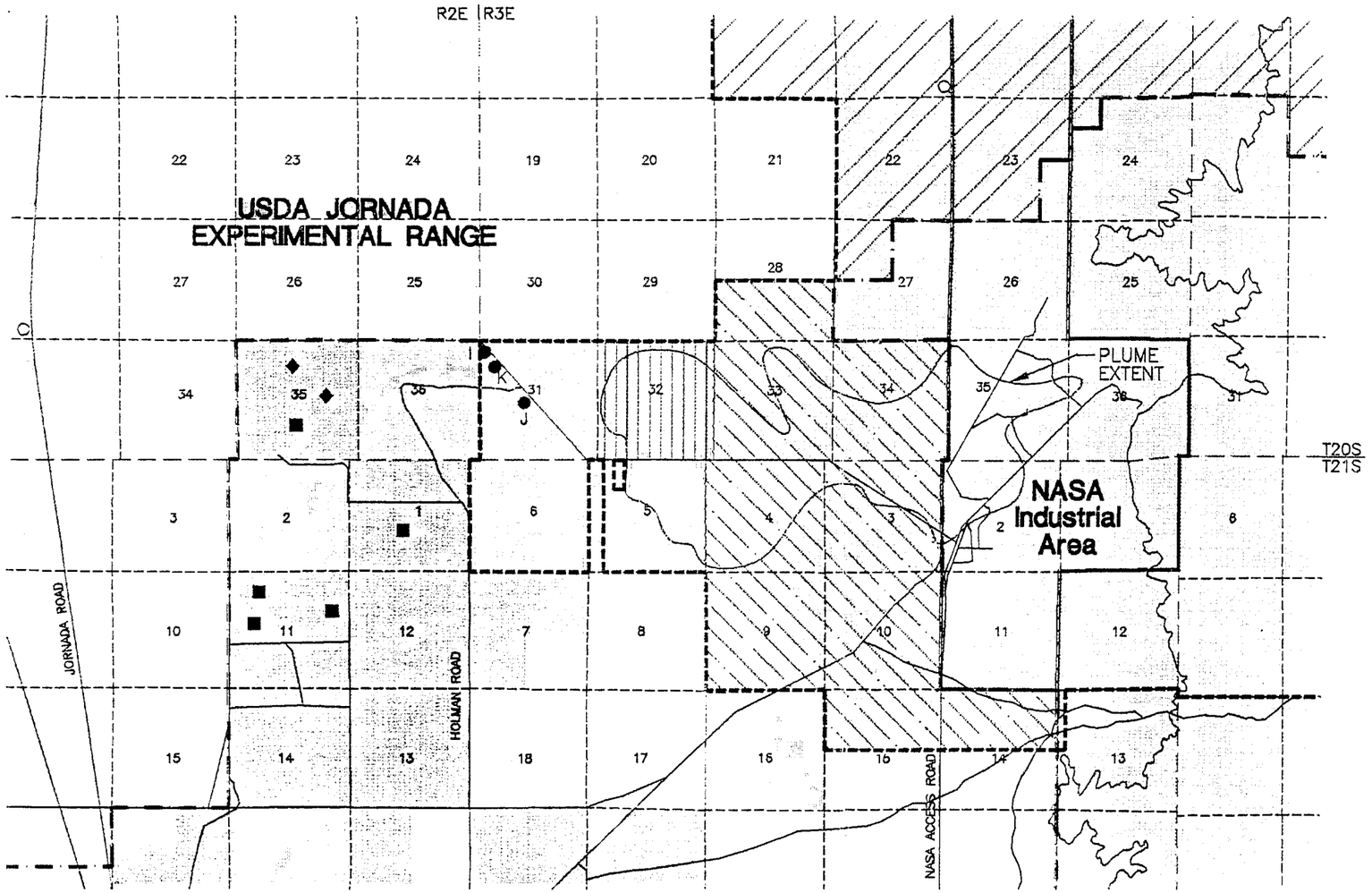
Figure 2.1
WSTF Location Map

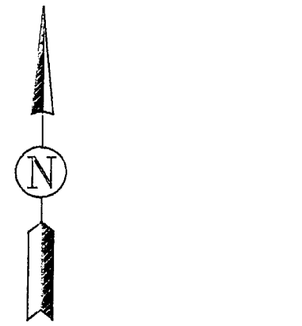
NARA-WBTF
0595-1055



NASA-WSTF
0993-2992







SCALE: 1" = 6000'

FIGURE 3.4

WSTF VICINITY WELL LOCATION MAP

CLIENT: NASA–WSTF

DATE: 8/2/95

DRAWN BY: A SILVA REVISED BY: R. CARPENTER

CHECKED BY: M. RUSSELL

DWG. NO. 2139

- STATE LAND
- FEDERAL LAND
- BLM LAND
- PRIVATE LAND
- INTER–AGENCY (STATE LAND COMMISSION–NASA Joint Use Agreement)
- INTER–AGENCY (USDA–DOD Joint Use Agreement)
- INTER–AGENCY (BLM–NASA Joint Use Agreement)
- NASA INDUSTRIAL AREA BOUNDARY
- JORNADA EXPERIMENTAL BOUNDARY
- WHITE SANDS MISSILE RANGE BOUNDARY
- NASA FACILITY BOUNDARY
- WSTF SUPPLY WELL
- IRRIGATION WELL
- DOMESTIC WELL
- LIVESTOCK WELL

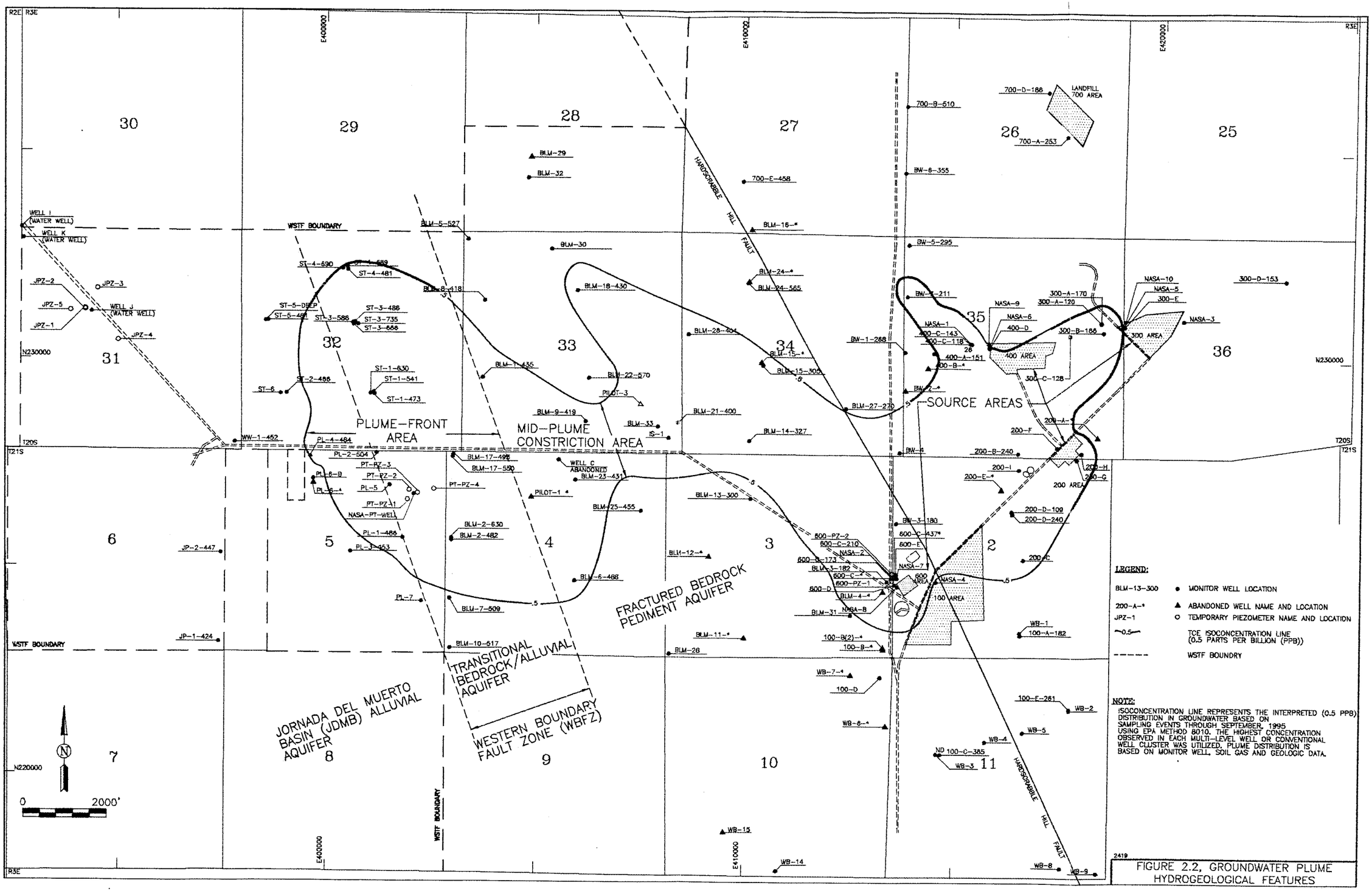


FIGURE 2.2, GROUNDWATER PLUME HYDROGEOLOGICAL FEATURES

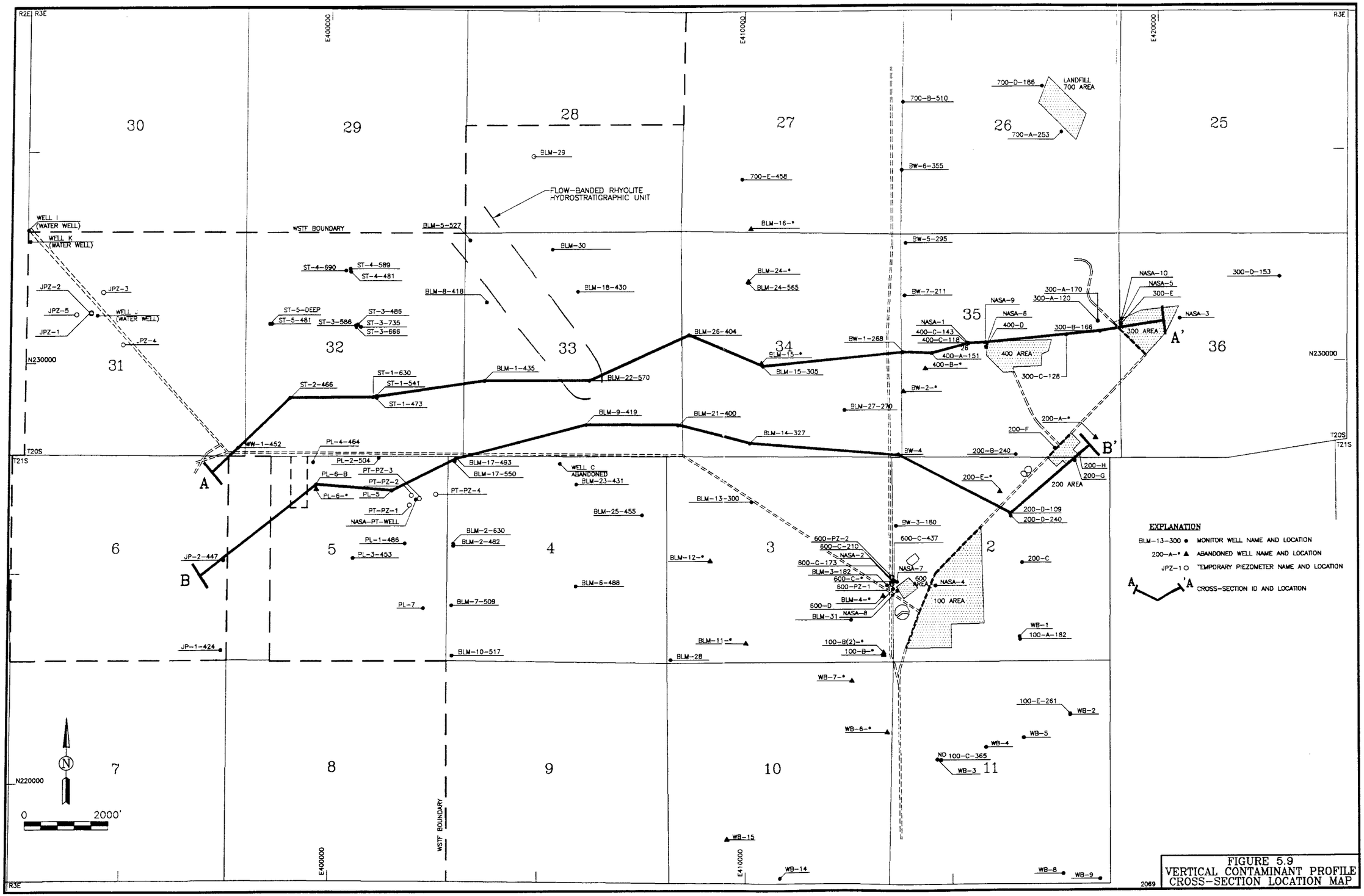


FIGURE 5.9
VERTICAL CONTAMINANT PROFILE
CROSS-SECTION LOCATION MAP

WEST
A

EAST
A'

SECTION 32

SECTION 33

300 AREA

400 AREA

FLOW BANDED
RHYOLITE UNIT

ELEVATION (FEET AMSL)

5000
4800
4600
4400
4200
4000
3800
3600

QTa_1
QTa_2
Tvr
Tvt
Tvo
Pl

INFERRED
LOCATION OF
HARDSCRABBLE
HILL FAULT

WESTERN BOUNDARY FAULT ZONE

SCALE:
1"=200'
1"=2000'

VERTICAL EXAGGERATION =x10

LEGEND:

GENERAL:

- MONITOR WELL ID
- SCREENED INTERVAL GROUNDWATER SAMPLING ZONE
- TOTAL DEPTH OF BOREHOLE
- POTENTIOMETRIC SURFACE (SEPTEMBER 1995)

GEOLOGY:

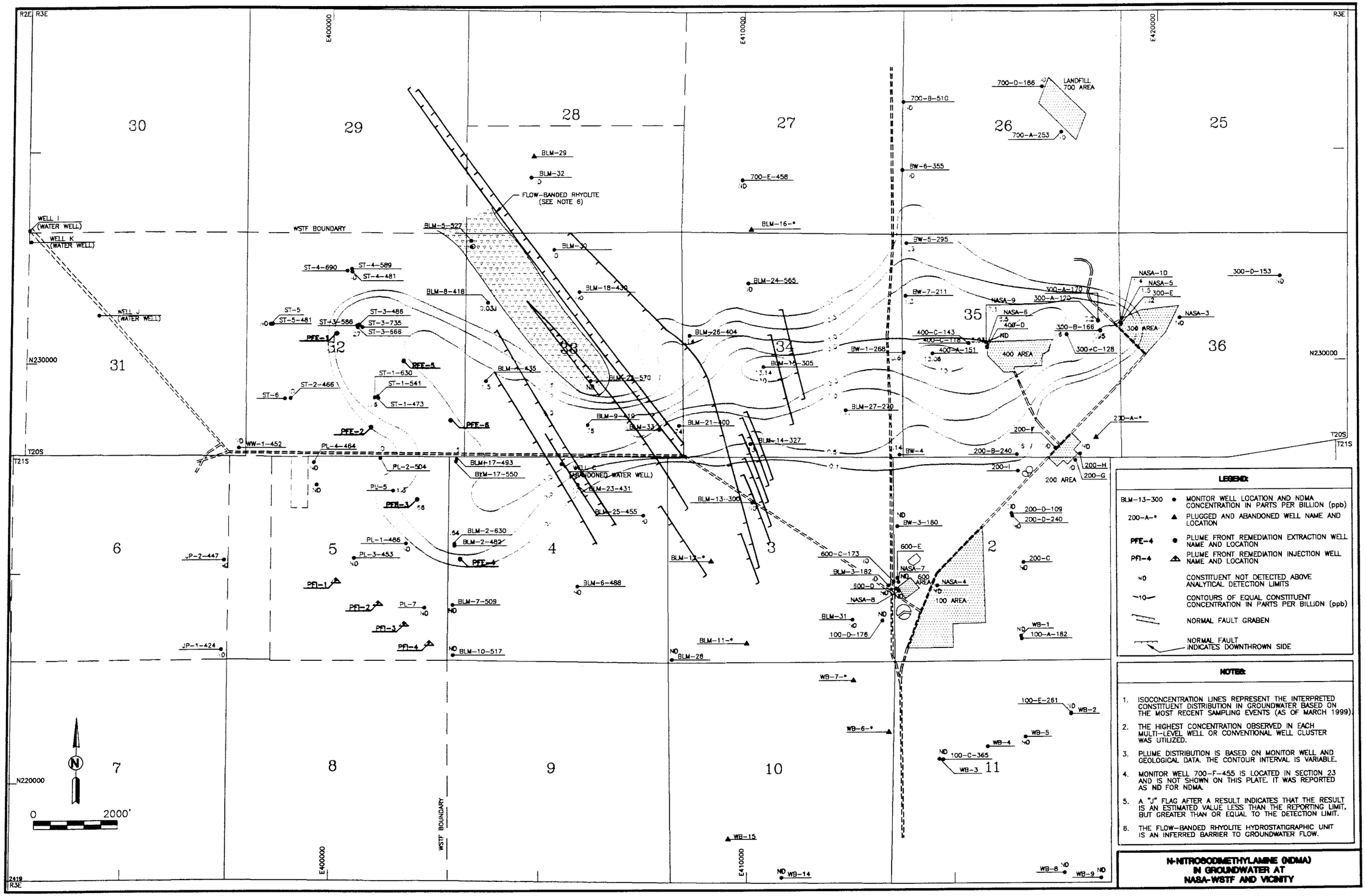
- BEDROCK SURFACE
- FAULT WITH RELATIVE DISPLACEMENT (DASHED WHERE INFERRED, BASED ON UTEP, 1995)
- QTa_1 QUATERNARY SANTA FE ALLUVIUM (FINE-GRAINED DISTAL FAN TO PLAYA)
- QTa_2 QUATERNARY SANTA FE ALLUVIUM (COARSE-GRAINED PROXIMAL TO MID FAN)
- Tvr OLIGOCENE FLOW-BANDED RHYOLITE
- Tvt OLIGOCENE ASH-FLOW TUFF
- Tvo OLIGOCENE/EOCENE OREJON ANDESITE
- Pl PALEOZOIC LIMESTONE

CONTAMINATION:

- 22 NDMA CONCENTRATION (PPB) 1995 RESULTS
- EQUICONCENTRATION LINE (DASHED WHERE INFERRED)
- ND NON-DETECT
- NA NOT ANALYZED

FIGURE 5.10
VERTICAL PROFILE OF NDMA
ALONG CROSS-SECTION A-A' SHOWING
HYDROGEOLOGY AND POINT OF COMPLIANCE

2061



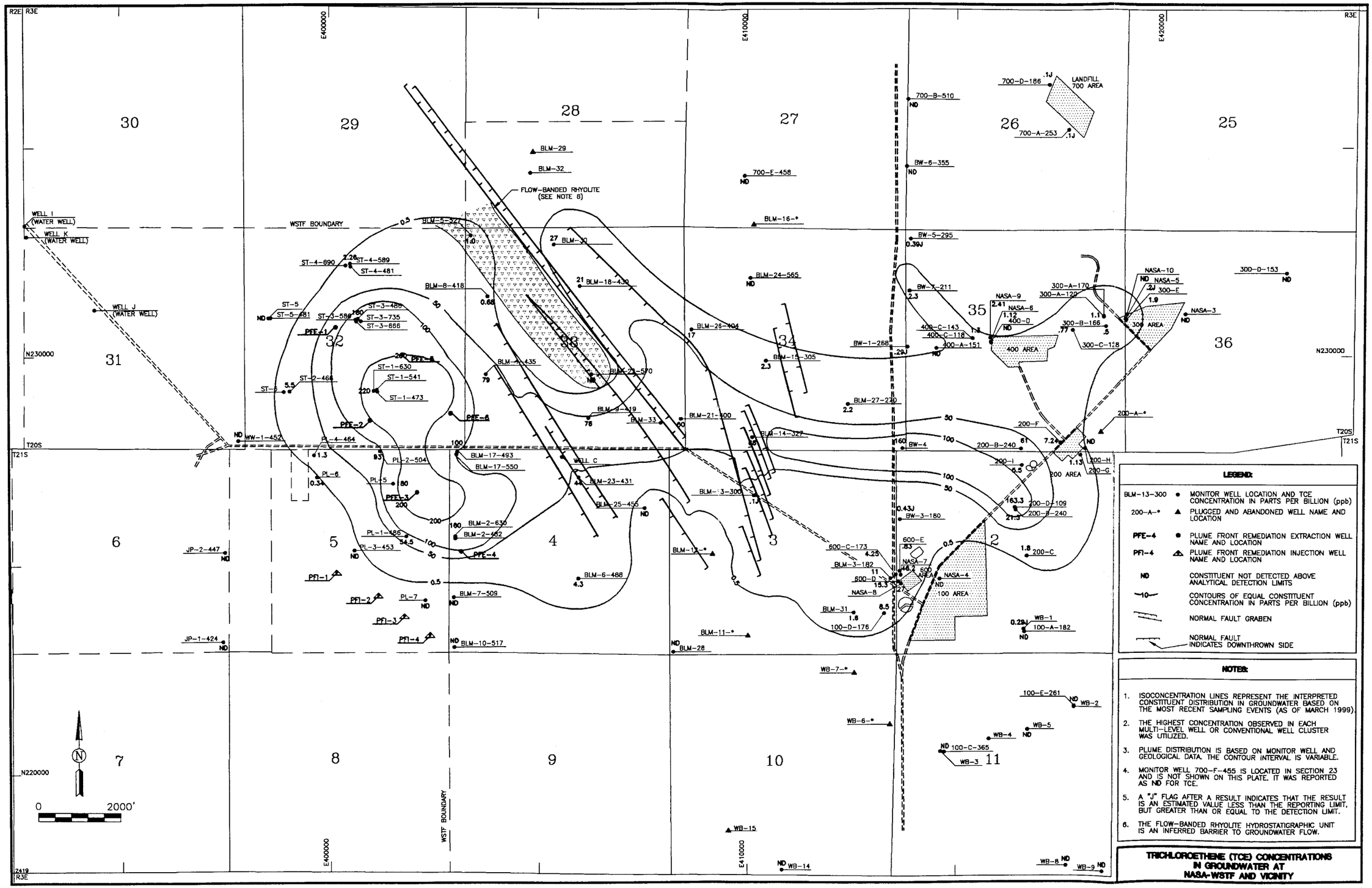
LEGEND:

BLM-13-300	•	MONITOR WELL LOCATION AND NDMA CONCENTRATION IN PARTS PER BILLION (ppb)
200-A-*	▲	PLUGGED AND ABANDONED WELL NAME AND LOCATION
PFE-4	•	PLUME FRONT REMEDIATION EXTRACTION WELL NAME AND LOCATION
PFI-4	▲	PLUME FRONT REMEDIATION INJECTION WELL NAME AND LOCATION
ND		CONSTITUENT NOT DETECTED ABOVE ANALYTICAL DETECTION LIMITS
-10-		CONTOURS OF EQUAL CONSTITUENT CONCENTRATION IN PARTS PER BILLION (ppb)
		NORMAL FAULT GRABEN
		NORMAL FAULT INDICATES DOWNTHROWN SIDE

NOTES:

1. ISOCONCENTRATION LINES REPRESENT THE INTERPRETED CONSTITUENT DISTRIBUTION IN GROUNDWATER BASED ON THE MOST RECENT SAMPLING EVENTS (AS OF MARCH 1999).
2. THE HIGHEST CONCENTRATION OBSERVED IN EACH MULTI-LEVEL WELL OR CONVENTIONAL WELL CLUSTER WAS UTILIZED.
3. PLUME DISTRIBUTION IS BASED ON MONITOR WELL AND GEOLOGICAL DATA. THE CONTOUR INTERVAL IS VARIABLE.
4. MONITOR WELL 700-F-455 IS LOCATED IN SECTION 23 AND IS NOT SHOWN ON THIS PLATE. IT WAS REPORTED AS ND FOR NDMA.
5. A "J" FLAG AFTER A RESULT INDICATES THAT THE RESULT IS AN ESTIMATED VALUE LESS THAN THE REPORTING LIMIT, BUT GREATER THAN OR EQUAL TO THE DETECTION LIMIT.
6. THE FLOW-BANDED RHYOLITE HYDROSTATIGRAPHIC UNIT IS AN INFERRED BARRIER TO GROUNDWATER FLOW.

N-NITROSODIMETHYLAMINE (NDMA) IN GROUNDWATER AT NASA-WSTF AND VICINITY



LEGEND:

BLM-13-300	•	MONITOR WELL LOCATION AND TCE CONCENTRATION IN PARTS PER BILLION (ppb)
200-A-*	▲	PLUGGED AND ABANDONED WELL NAME AND LOCATION
PFE-4	•	PLUME FRONT REMEDIATION EXTRACTION WELL NAME AND LOCATION
PFI-4	▲	PLUME FRONT REMEDIATION INJECTION WELL NAME AND LOCATION
ND		CONSTITUENT NOT DETECTED ABOVE ANALYTICAL DETECTION LIMITS
~10~		CONTOURS OF EQUAL CONSTITUENT CONCENTRATION IN PARTS PER BILLION (ppb)
		NORMAL FAULT GRABEN
		NORMAL FAULT INDICATES DOWNTHROWN SIDE

NOTES:

1. ISOCONCENTRATION LINES REPRESENT THE INTERPRETED CONSTITUENT DISTRIBUTION IN GROUNDWATER BASED ON THE MOST RECENT SAMPLING EVENTS (AS OF MARCH 1999).
2. THE HIGHEST CONCENTRATION OBSERVED IN EACH MULTI-LEVEL WELL OR CONVENTIONAL WELL CLUSTER WAS UTILIZED.
3. PLUME DISTRIBUTION IS BASED ON MONITOR WELL AND GEOLOGICAL DATA. THE CONTOUR INTERVAL IS VARIABLE.
4. MONITOR WELL 700-F-455 IS LOCATED IN SECTION 23 AND IS NOT SHOWN ON THIS PLATE. IT WAS REPORTED AS ND FOR TCE.
5. A "J" FLAG AFTER A RESULT INDICATES THAT THE RESULT IS AN ESTIMATED VALUE LESS THAN THE REPORTING LIMIT, BUT GREATER THAN OR EQUAL TO THE DETECTION LIMIT.
6. THE FLOW-BANDED RHYOLITE HYDROSTATIGRAPHIC UNIT IS AN INFERRED BARRIER TO GROUNDWATER FLOW.

TRICHLOROETHENE (TCE) CONCENTRATIONS IN GROUNDWATER AT NASA-WSTF AND VICINITY

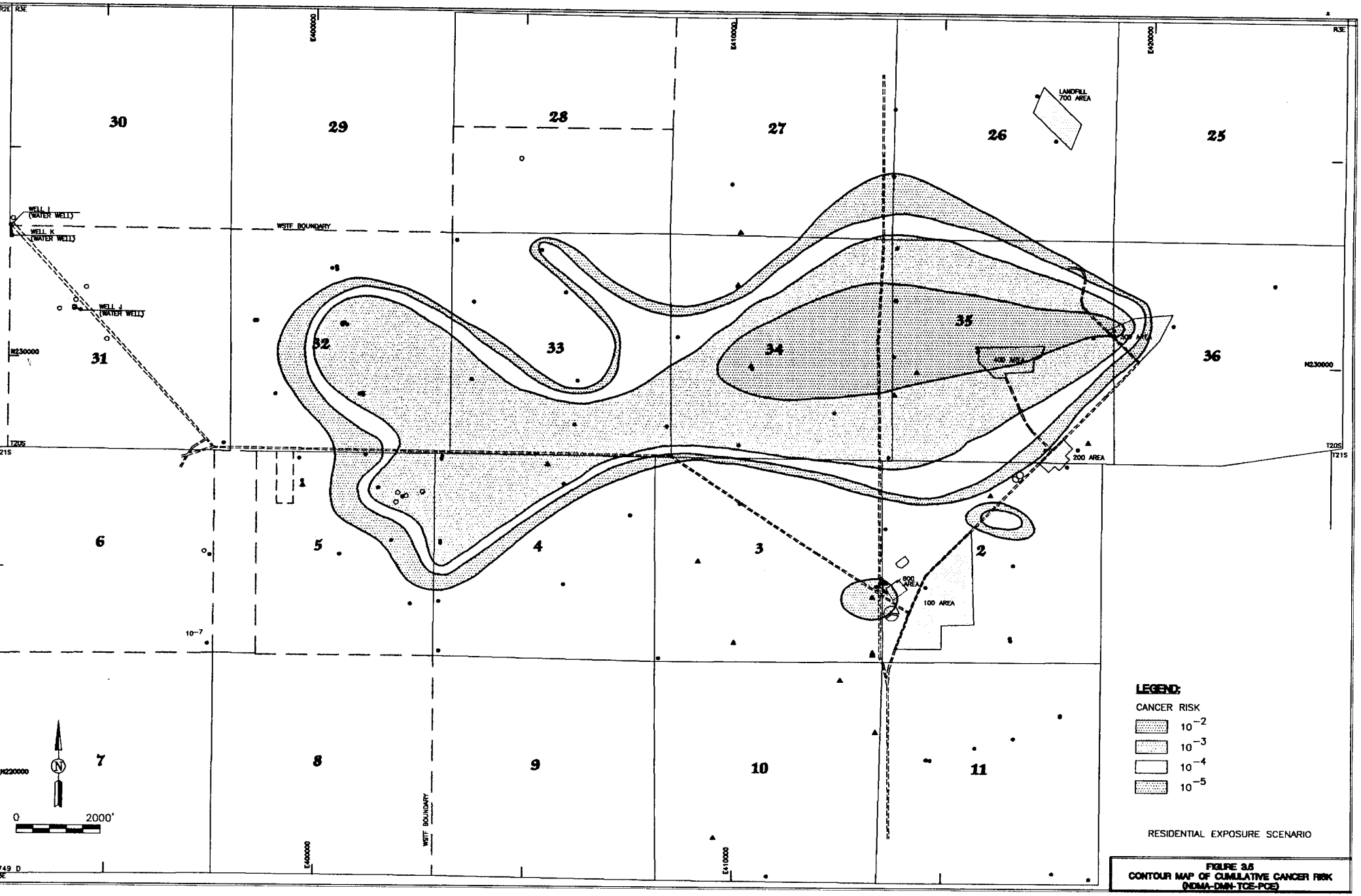
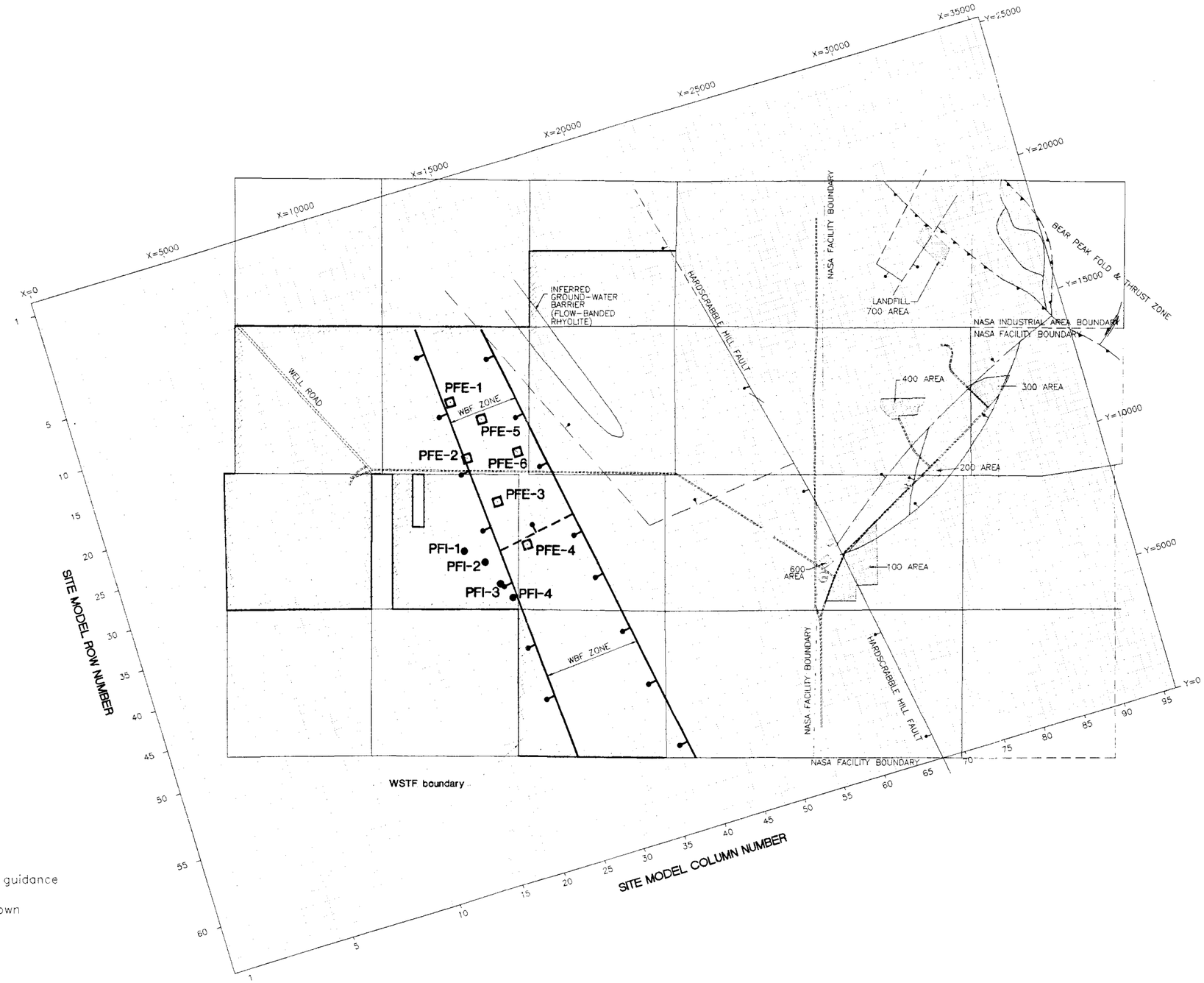


FIGURE 3.6
CONTOUR MAP OF CUMULATIVE CANCER RISK (NDMA-DMN-TCE-PCE)



N

0 4000 ft

Explanation

- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side (dashed where inferred)
- Extraction well
- Injection well

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4-29-99 JN 8010

NASA–WSTF MODELING

Plume Front Containment Well Locations

Figure 4

R2E R3E E400000 E410000 E420000 R3E

30 29 28 27 26 25

31 32 33 34 35 36

6 5 4 3 2 1

7 8 9 10 11

T20S T21S

N230000 N220000

WELL 1 (WATER WELL)
WELL K (WATER WELL)
WELL J (WATER WELL)
JPZ-1 JPZ-2 JPZ-3 JPZ-4 JPZ-5
WW-2
WSTF BOUNDARY
ST-4-589 ST-4-690 ST-4-481
ST-5-DEEP ST-5-481 ND ST-3-586 ST-3-735 ST-3-666 ST-3-486
PFE-1 PFE-5 ST-1-630 ST-1-541 ST-1-473
ST-6 ST-2-466
ST-7 PFE-2 PFE-6 TREATMENT FACILITY
PL-4-464
WW-1-452
PL-2-504
PT-PZ-3 PT-PZ-2 PL-6-B PL-6-* PL-5 PT-PZ-1 NASA-PT-WELL PFE-3 PT-PZ-4
PL-1-486 PL-3-453 BLM-2-630 BLM-2-482 PFE-4
PFI-1 PFI-2 PFI-3 PFI-4 PL-7 PL-8
INJECTION MANIFOLD BUILDING
BLM-10-517
JP-3 JP-2-447 JP-1-424
BLM-37
WSTF BOUNDARY
BLM-29
BLM-5-527 BLM-30
BLM-18-430
BLM-8-418
BLM-1-435
BLM-9-419
BLM-17-493 BLM-17-550
BLM-23-431
BLM-25-455
BLM-6-488
BLM-7-509
WELL C ABANDONED
BLM-16-*
700-E-458
BLM-24-* BLM-24-565
BLM-26-404
BLM-15-* BLM-15-305
BLM-22-570
BLM-21-400
BLM-27-270
BLM-14-327
BLM-13-300
BLM-12-*
BLM-11-*
BLM-28
BLM-4-*
BLM-31
NASA-8
600-PZ-2 600-C-210 NASA-2 600-C-173 BLM-3-162 600-C-* 600-PZ-1 600-D
WB-7-*
WB-6-*
WB-15
WB-14 ND
700-B-510
BW-6-355
BW-8-295
BW-7-211
BW-1-268
BW-2-*
BW-3-180
600-C-437
NASA-7 600 AREA NASA-4 100 AREA
BW-4
700-D-186 LANDFILL 700 AREA
700-A-253
NASA-1 400-C-143 400-C-118 400-A-151 400-B-*
NASA-9 NASA-6 400-D 400 AREA
300-A-170 300-A-120 300-B-166 300-C-128
NASA-10 NASA-5 300-E 300 AREA NASA-3
300-D-153
200-A-* 200-F 200-B-240 200 AREA 200-G 200-H 200-F-* 200-D-109 200-D-240 200-C
WB-1 100-A-182
100-B(2)-* 100-B-*
100-E-261 WB-2
WB-5
WB-4
ND 100-C-365 WB-3
WB-8 WB-9

0 2000'

LEGEND:

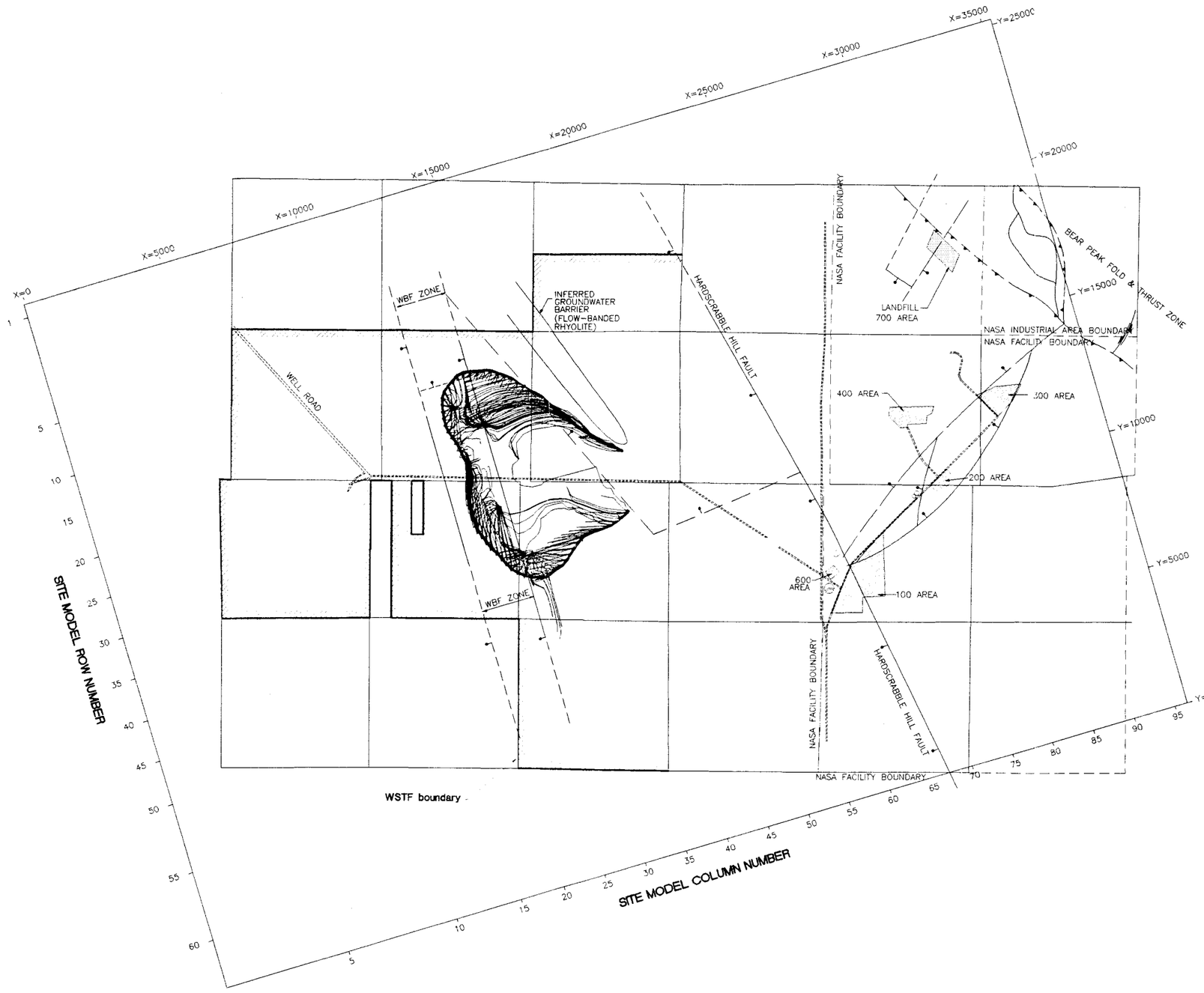
EXISTING MONITORING WELLS:
- GROUNDWATER MONITORING WELLS
- ABANDONED WELL
- PIEZOMETER

REMEDIATION:
- PLUME-FRONT EXTRACTION WELL
- PLUME-FRONT INJECTION WELL
- ADDITIONAL PLUME-FRONT MULTI-PORT MONITORING WELL
- TREATMENT INFLUENT
- TREATMENT EFFLUENT

2782

FIGURE 4.11
REMEDIAL SYSTEM WELL LOCATIONS AND CONCEPTUAL DESIGN

2035 R3E



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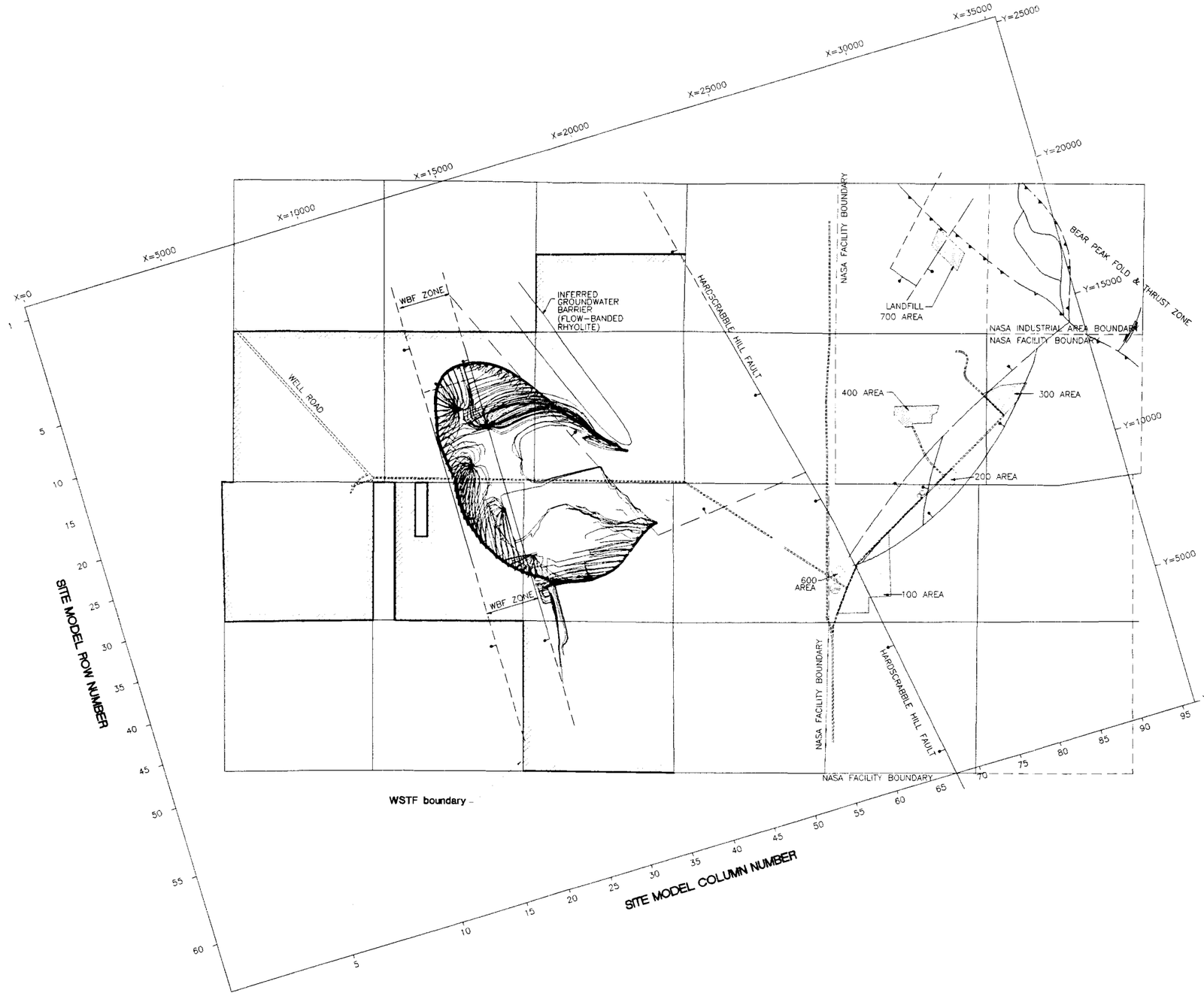
Daniel B. Stephens & Associates, Inc.
11-3-98 JN 8010

NASA–WSTF MODELING

Simulated Contaminant Pathlines for NDMA Plume Front Containment

Figure 4.2



N

0 4,000 ft

Explanation

- Simulated contaminant pathlines
- 0.5 part per billion TCE contour
- WSTF boundary under RCRA Subpart S guidance
- Normal fault, ball and bar on downthrown side, dashed where inferred

Daniel B. Stephens & Associates, Inc.
11-3-98 JN 8010

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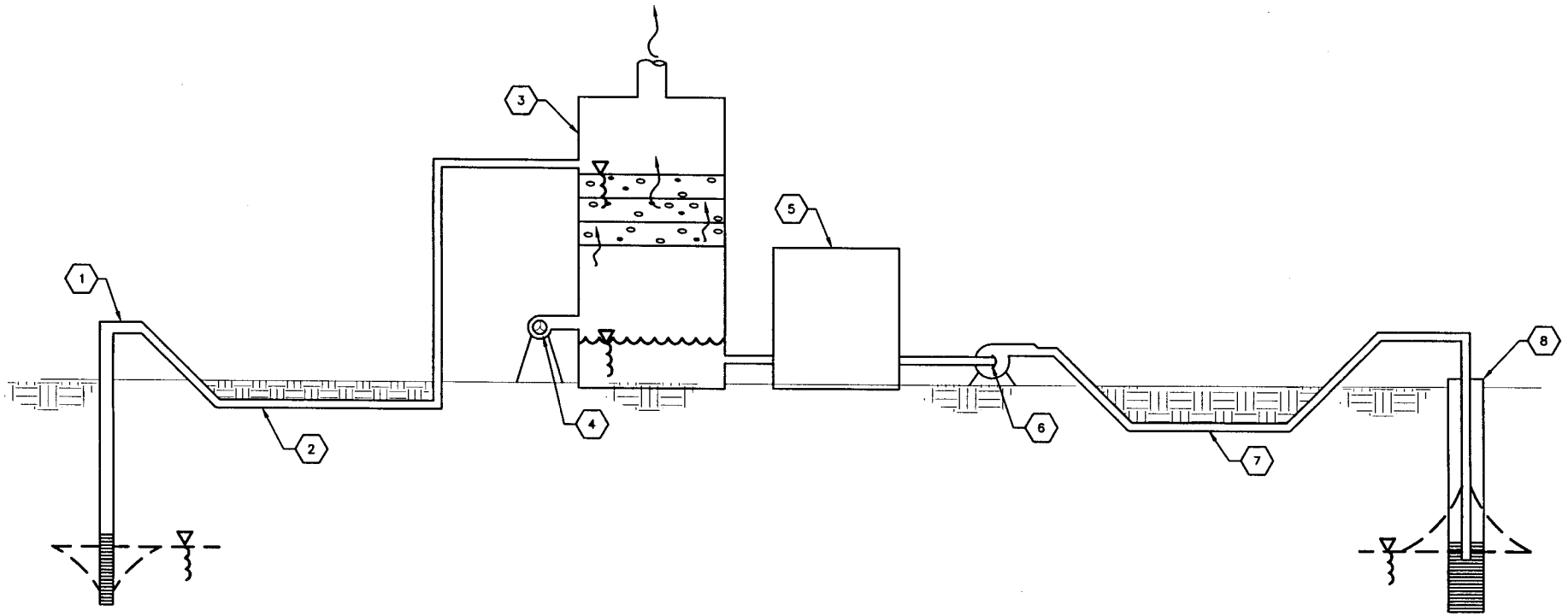
NASA-WSTF MODELING

Simulated Contaminant Pathlines for TCE Plume Front Containment

Figure 4.3

TABLE 4.2: PLUME-FRONT CONTAINMENT WELL LOCATIONS, PUMPING RATES AND DESIGN PARAMETERS

Remedial Well	Well Coordinates relative to Model Grid	Layer	Anticipated Pumping/ Injection Rates (gpm)	Well Casing Specifications	Well Design Strategy & Depth Specifications
PFE-1	Row 15 Column 23	10 11 12 13	104 104 104 26	8-inch diameter, 60-Slot Screen	Depth to groundwater = 430 ft Anticipated pumping drawdown = <25 Screened interval (to total depth) = 425-900 ft Anticipated top of sand pack = 410 ft
PFE-2	Row 22 Column 23	10 11 12 13	104 104 26 16	8-inch diameter, 60-Slot Screen	Depth to groundwater = 435 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 430-900 ft Anticipated top of sand pack = 415 ft
PFE-3 (Existing NASA-PT Well)	Row 28 Column 25	10 11 12 13	104 104 5 0	10-inch diameter, 80-Slot Screen	Depth to groundwater = 453 ft Anticipated pumping drawdown = <15 ft Screened interval (to total depth) = 507-828 ft Actual top of sand pack = 443 ft
PFE-4	Row 34 Column 27	10 11 12 13	3 1 3 3	6-inch diameter, 60-Slot Screen	Depth to groundwater = 469 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 465-900 ft Anticipated top of sand pack = 450 ft
PFE-5	Row 18 Column 26	10 11 12 13	48 48 3 3	8-inch diameter, 60-Slot Screen	Depth to groundwater = 432 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 430-900 ft Anticipated top of sand pack = 412 ft
PFE-6	Row 23 Column 29	10 11 12 13	48 48 3 2	8-inch diameter, 60-Slot Screen	Depth to groundwater = 460 ft Anticipated pumping drawdown = <25 ft Screened interval (to total depth) = 455-900 ft Anticipated top of sand pack = 440 ft
PFI-1	Row 32-33 Column 19-20	10 11 12 13	73 73 57 57	8-inch diameter, 80-Slot Screen	Depth to groundwater = 450 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 460-1,000 ft Anticipated top of sand pack = 430 ft
PFI-2	Row 34-35 Column 21-22	10 11 12 13	105 105 20 20	8-inch diameter, 80-Slot Screen	Depth to groundwater = 450 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 460-1,000 ft Anticipated top of sand pack = 430 ft
PFI-3	Row 37-38 Column 22-23	10 11 12 13	147 147 16 15	8-inch diameter, 80-Slot Screen	Depth to groundwater = 450 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 460-1,000 ft Anticipated top of sand pack = 430 ft
PFI-4	Row 39-40 Column 23-24	10 11 12 13	83 83 7 6	8-inch diameter, 80-Slot Screen	Depth to groundwater = 450 ft Anticipated injection mounding = <25 ft Screened interval (to total depth) = 460-1,000 ft Anticipated top of sand pack = 430 ft



1. GROUNDWATER EXTRACTION WELLS
2. EXTRACTION PIPELINE (DUAL–WALL) POLYETHYLENE
3. LOW PROFILE SIEVE TRAY AIR STRIPPER FOR VOC TREATMENT
4. AIR BLOWER
5. UV / PEROXIDE OXIDATION SYSTEM FOR NDMA TREATMENT
6. INJECTION PUMP
7. INJECTION PIPELINE (SINGLE WALL)
8. GROUNDWATER INJECTION WELLS

AIR FLOW

2758

FIGURE 4.11
REMEDIAL SYSTEM
PROCESS FLOW DIAGRAM

PLUME-FRONT REMEDIATION TREATMENT STANDARDS AND INFUENT/EFFLUENT CONCENTRATIONS

Contaminant	Treatment Standard	Treatment Standard Source	Drinking Water Standard[1]	Groundwater Standard[2]	PRG[3]	Predicted Influent Concentration	Predicted Effluent Concentration
NDMA	10 ppt	Method 607 Reporting Limit	NA	$<1.0 \times 10^{-5}$ Risk	1.3 ppt	2,000 ppt	<10 ppt
DMN	10 ppt	Method 607 Reporting Limit	NA	$<1.0 \times 10^{-5}$ Risk	1.3 ppt[5]	1,700 ppt	<10 ppt
TCE	5 ppb	20 NMAC 7.1	5 ppb	100 ppb	1.6 ppb	4.2 ppb	0.06 ppb
PCE	5 ppb	20 NMAC 7.1	5 ppb	20 ppb	1.1 ppb	130 ppb	3.8 ppb
Freon 11	100 ppb	Conservative Health Risk Value	NA	NA	1,288 ppb	860 ppb	43 ppb
Freon 21	20 ppb	Conservative Health Risk Value	NA	NA	NA	60 ppb	3 ppb
Freon 113	1,200 ppb	California Standard	1,200 ppb[4]	NA	59,180 ppb	2,000 ppb	100 ppb

NOTES

NA Not Applicable
ppb Parts per billion
ppt Parts per trillion

1 20 NMAC 7.1 Drinking Water
2 20 NMAC 6.2 Ground and Surface Water Protection
3 EPA Region 9 Preliminary Remediation Goals
4 State of California Drinking Water Standard
5 Values presented for DMN are extrapolated from published NDMA data

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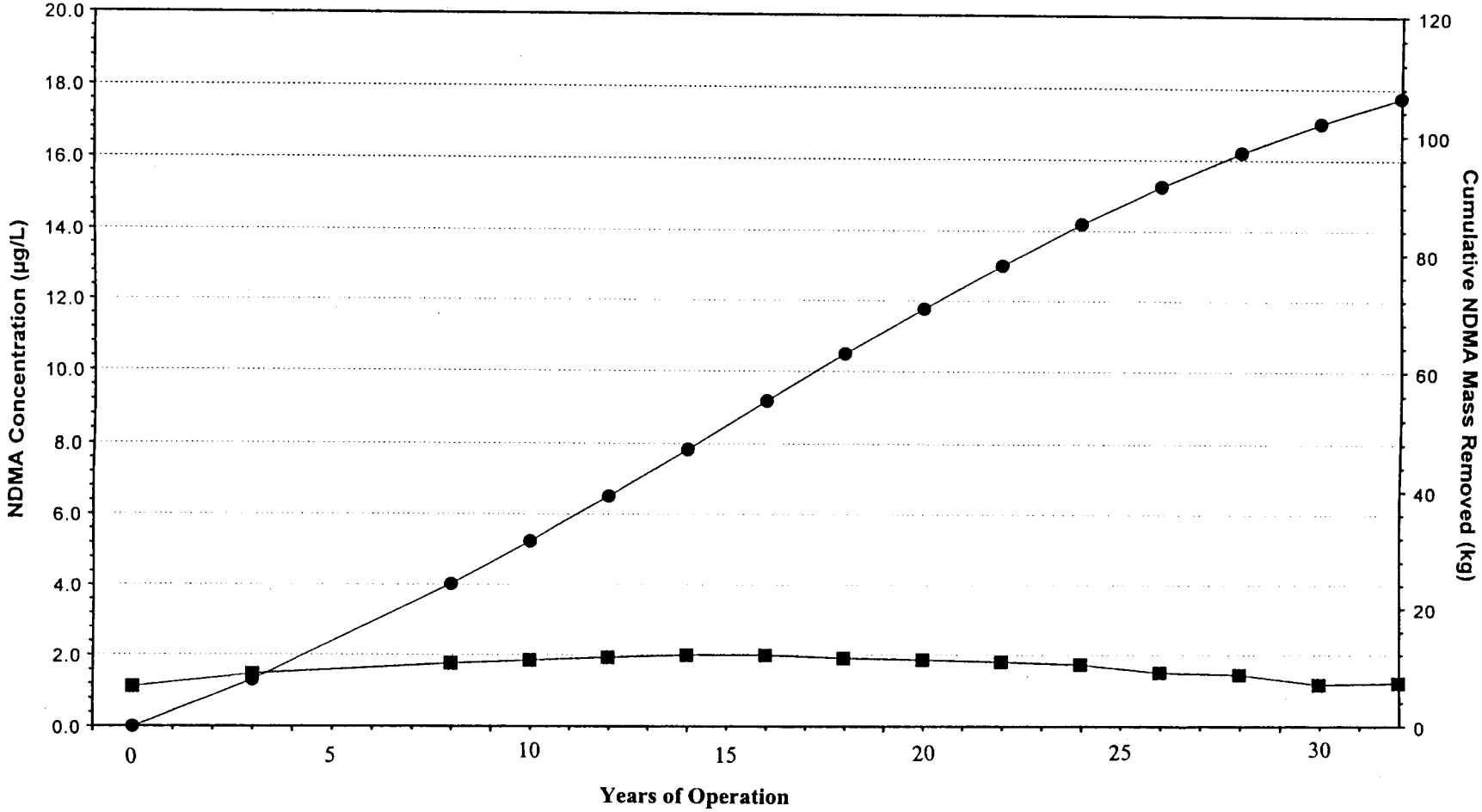

Explanation

- Well Concentration
- Cumulative Mass Removed

Figure 4.7

NASA-WSTF MODELING

Simulated NDMA Concentration and Cumulative Mass Removed for All Extraction Wells

Figure 4.7

Daniel B. Stephens & Associates, Inc.

11-3-98 JN 8010

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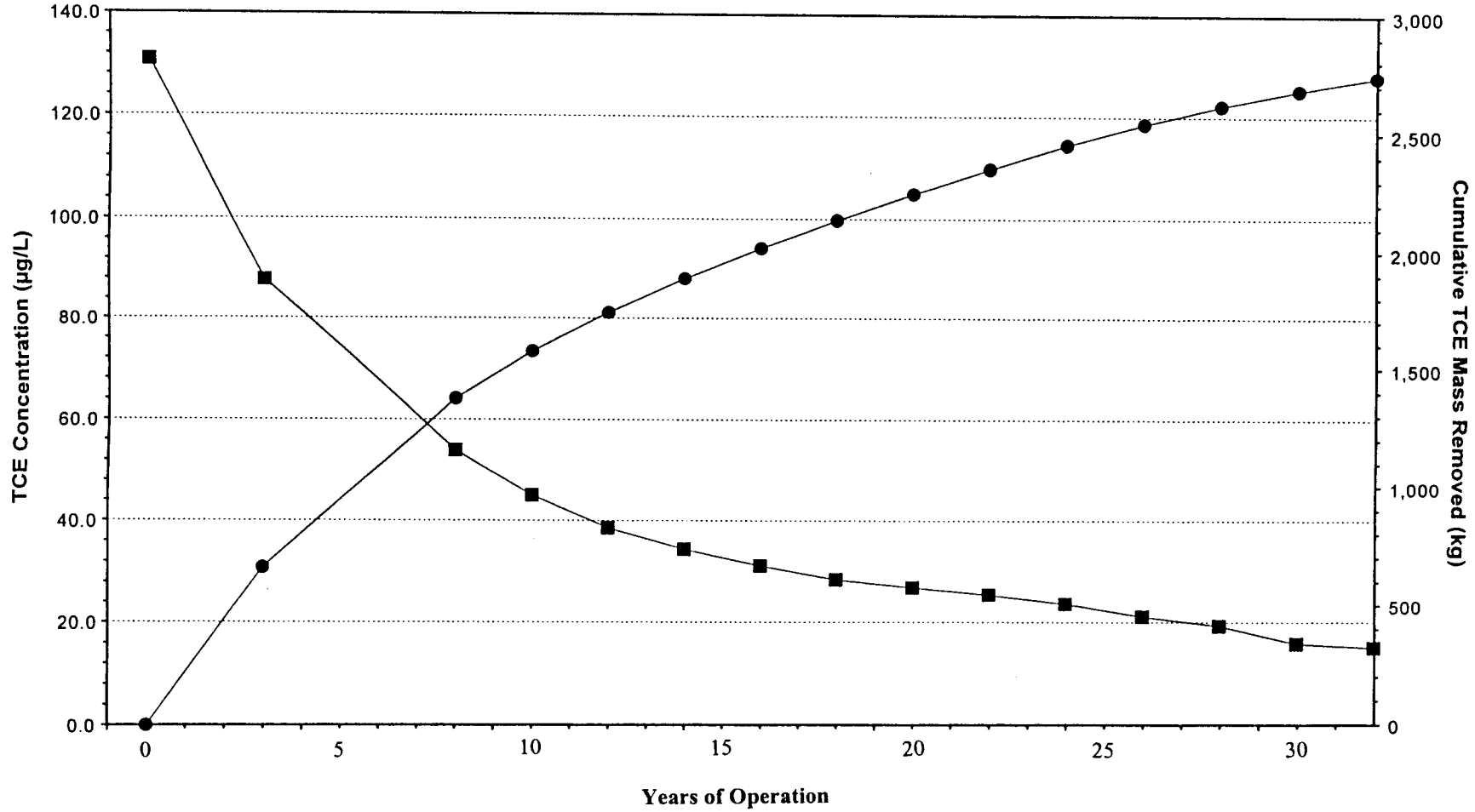


Explanation

- Well Concentration
- Cumulative Mass Removed

Figure 4.8

Figure 4.8

NASA-WSTF MODELING

Simulated TCE Concentration and Cumulative Mass Removed for All Extraction Wells

Daniel B. Stephens & Associates, Inc.

11-3-98 JN 8010

MAY 2 8 1999

RA

New Mexico Environment Department
Attn: Mr. James Bearzi, Chief
Hazardous and Radioactive Materials Bureau
2044 Galisteo Street
Santa Fe, NM 87505

Subject: Notice of Plume-Front Groundwater Remediation and Public Meeting

As requested by the New Mexico Environment Department (NMED) Hazardous and Radioactive Materials Bureau (HRMB) in February 1999, the NASA White Sands Test Facility (WSTF) notified the public of its intent to implement a presumptive remedy. The public notice was submitted to all persons on the facility mailing list and published in the Sunday, March 28, 1999, edition of the Las Cruces Sun-News in both English and Spanish. As specified in the HRMB letter, the public notice included:

1. Announcement of a 60-day public comment period

2. Announcement of a date, time, and place for a public meeting to discuss the presumptive remedy

3. Name, address, and telephone number of the WSTF contact person

4. Location where copies of the presumptive remedy and supporting documents could be reviewed and copied

The 60-day comment period was initiated on March 28, 1999, and ends May 27, 1999. The public meeting was held on May 6, 1999. The enclosure provides a copy of the notarized Proof of Publication received from the Las Cruces Sun-News and copies of the public notice in both English and Spanish.

If you have any further questions or comments concerning this submittal, please call David Amidei at (505) 524-5517.

ORIGINAL SIGNED BY
JOSEPH FRIES

Joseph Fries
Manager

Enclosure

cc:
See List

cc:
New Mexico Environment Department
Attn: Mr. Phillip Solano
Hazardous and Radioactive Materials Bureau
2044 Galisteo Street
Santa Fe, NM 87505

bc:
ATSC Team/P. H. Pache (w/o encl.)

RA/DAmidei:ljg:5/26/99:5517

#3 Zip \LTRS\ENV99-1\Proof Letter.doc

CONCUR						
	CODE →	RA				
	SIGNATURE →	DA				
	DATE →	5/27/99				

NASA FORM 1267A SEP 91 PREVIOUS EDITION MAY BE USED.

SENDER:

- Complete items 1 and/or 2 for additional services.
- Complete items 3, 4a, and 4b.
- Print your name and address on the reverse of this form so that we can return this card to you.
- Attach this form to the front of the mailpiece, or on the back if space does not permit.
- Write *"Return Receipt Requested"* on the mailpiece below the article number.
- The Return Receipt will show to whom the article was delivered and the date delivered.

I also wish to receive the following services (for an extra fee):

1. ☐ Addressee's Address
2. ☐ Restricted Delivery

Consult postmaster for fee.

3. Article Addressed to:

New Mexico Environment Department
Attn: Mr. James Bearzi, Chief
Hazardous and Radioactive Materials Bureau
2044 Galisteo Street
Santa Fe, NM 87505

4a. Article Number
Z 552 992 482

4b. Service Type
☐ Registered ☑ Certified
☐ Express Mail ☐ Insured
☑ Return Receipt for Merchandise ☐ COD

7. Date of Delivery
DEC 7 1999

5. Received By: *(Print Name)*

8. Addressee's Address *(Only if requested and fee is paid)*

6. Signature: *(Addressee or Agent)*
X

PS Form 3811, December 1994 102595-97-B-0179 Domestic Return Receipt

Is your RETURN ADDRESS completed on the reverse side?

Thank you for using Return Receipt Service.

UNITED STATES POSTAL SERVICE

Link C-#5

First-Class Mail
Postage & Fees Paid
USPS
Permit No. G-10

● Print your name, address, and ZIP Code in this box ●

National Aeronautics and
Space Administration

Mail Code: RA
Lyndon B. Johnson Space Center
White Sands Test Facility
Post Office Box 20
Las Cruces, NM 88004-0020

ENCLOSURE

Proof of Publication and Copies of the Public Notice

PROOF OF PUBLICATION

David E. McCollum, being duly sworn, deposes and says that he is the Publisher of the Las Cruces Sun-News, a newspaper published daily in the county of Dona Ana, State of New Mexico; that the notice # 21885 per clipping attached was published once a week/day in regular and entire issue of said newspaper and not in any supplement thereof for ____ consecutive days, the first publication was in the issue dated March 28, 1999 and the last publication was March 28, 1999.

Deponent further states this newspaper is duly qualified to publish legal notices or advertisements within the meaning of Sec. Chapter 167, Laws of 1937.

Signed David E. McCollum

Publisher
Official Position

STATE OF NEW MEXICO
ss.
County of Dona Ana

Subscribed and sworn before me this 30 day of March.

Luz A. Esparza

Notary Public in and for
Dona Ana County, NM

OFFICIAL SEAL
Luz A. Esparza
NOTARY PUBLIC
STATE OF NEW MEXICO
My Commission Expires: 6/28/00

NOTICE OF PLUME-FRONT GROUNDWATER REMEDIATION

NASA White Sands Test Facility (WSTF) hereby announces its intent to implement a pump and treat grounwater remediation system to prevent further migration of contaminated groundwater caused by historic site operations. This remedy will pump groundwater from six extraction wells, treat the water using ultraviolet /oxidation and air stripping technologies, and reintroduce the treated groundwater into the aquifer through a network of four injection wells. System construction is expected to commence in the summer of 1999 and is anticipated to operate 24 hours a day following an initial start-up phase. Approximately 1,000 gallons per minute will be treated and injected during the operational life of the system. WSTF expects the system to be operational in the year 2000.

The owner and operator of the system is NASA White Sands Test Facility, P.O. Box 20, Las Cruces, New Mexico.

This notice initiates a 60-day comment period to address public comments and questions regarding this interim groundwater treatment remedy. Inquiries regarding this activity should be directed to: David A. Amidei NASA Environmental Manager White Sands Test Facility P.O. Box 20 Las Cruces, New Mexico 88004 (505) 524-5517.

A Public meeting has been scheduled for Thursday May 6, 1999 from 5p.m. to 7p.m. in the Dresp B room of the Thomas Branigan Memorial Library to encourage public participation in the presumptive remedy process. WSTF personnel will be available to address any questions or comments. Copies of the proposed Work Plan and supporting documentation (including a pilot-scale ultraviolet/oxidation testing schedule) can be viewed at the Thomas Bringan Memorial Library.

Pub No. 21885
Publish March 28, 1999

RECEIVED
APR 8 1999

PROOF OF PUBLICATION

David E. McCollum, being duly sworn, deposes and says that he is the Publisher of the Las Cruces Sun-News, a newspaper published daily in the county of Dona Ana, State of New Mexico; that the notice # 21886 per clipping attached was published once a week/day in regular and entire issue of said newspaper and not in any supplement thereof for ____ consecutive days, the first publication was in the issue dated March 28, 1999 and the last publication was March 28, 1999.

Deponent further states this newspaper is duly qualified to publish legal notices or advertisements within the meaning of Sec. Chapter 167, Laws of 1937.

Signed David E. McCollum

Publisher
Official Position

STATE OF NEW MEXICO
ss.
County of Dona Ana

Subscribed and sworn before me this 30 day of March.

Luz A. Esparza

Notary Public in and for
Dona Ana County, NM

OFFICIAL SEAL
Luz A. Esparza
NOTARY PUBLIC
STATE OF NEW MEXICO
My Commission Expires: 4/24/00

AVISO DE REMEDIACION DE UNA FRENTE DE ONDA DE AGUA SUBTERRANEA (EN FORMA DE PENACHO)

NASA White Sands Test Facility (WSTF) por este medio anuncia su intento para llevar acabo un sistema de remediacion del agua subterranea de bomba-y-tratamiento para prevenir aun mas la migracion de la contaminacion del agua subterranea causada por operaciones historicas del sitio. Este remedio bombeara el aqua subterranea de seis posos de extraccion, tratara el aqua usando tecnologias ultravioletas/oxidantes, y eliminates aero-ventiladoras, y introducira de nuevo a la capa acquifera el agua subterrania tratada a traves de una red de cautro pozos de inyeccion.

La construcion del sistema se espera comenzar en el verano de 1999 ya se anticipa operar 24-horas al dia despues de la fase inicial de lanzamiento. Aproximadamente 1,000 galones por minuto seran tratados e inyectados durante the vida operacional del sistema. WSTF espera que el sistema sea operacional en el ano 2000.

El dueno y operador del sistema es NASA White Sands Test Facility, P.O. Box 20, Las Cruces, New Mexico 88004. WSTF esta loclizado aproximadamente 16 millas al noresta de Las Cruces, Nuevo Mejico.

Este aviso inicia un periodo de comentario de 60-dias para dirigir comentarios y preguntas del publico genral con respecto a este remedio interino del tratamiento del agua subterranea. Preguntas respectas a esta actividad deben ser dirijidas a:

David A. Amidei
NASA Enviromental Manger
White Sands Test Facility
P.O. Box 20
Las Cruces, New Mexico
88004
(505) 524-5517

Una reunion publica ha sido programada para el jueves sies de mayo, 1999, de las 5:00 p.m.-7:00 p.m. en la biblioteca *Thomas Branigan Memorial Library*, caurto Dresp B, para animar participacion publica en este proceso de remedio presumtivo. Personales de WSTF seran disponibles para tratar cualesquieras preguntas o comentarios. Copias de los Planes de Trabajo propuestos y documentacion de apoyo (incluso el programa de preuba de la escala de pilото de ultravioleta/oxidacion) se podran ver en la biblioteca *Thomas Branigan Memorial Library*.

Pub No.21886
Publish March 28, 1999

RECEIVED
APR 8 1999

State of New Mexico
ENVIRONMENT DEPARTMENT
Ground Water Quality Bureau
Harold Runnels Building
1190 St. Francis Drive, P.O. Box 26110
Santa Fe, New Mexico 87502-6110
Telephone (505) 827-2918
Fax (505) 827-2965

GARY E. JOHNSON
GOVERNOR

PETER MAGGIORE
SECRETARY

CERTIFIED MAIL RETURN RECEIPT REQUESTED

DP-1255 (KV)

May 10, 1999

Joseph Fries, Manager
NASA White Sands Test Facility
P.O. Box 20
Las Cruces, New Mexico 88004

Dear Mr. Fries:

Enclosed is a copy of the public notice pertaining to your proposed discharge plan(s) which is being published by the New Mexico Environment Department in a newspaper of general circulation.

If you have any questions, please do not hesitate to contact me at the address listed above or at 827-2900.

Sincerely,

Karen McCormack for Dale M. Doremus

Dale M. Doremus
Program Manager
Ground Water Pollution Prevention Section

DMD:cjv

Enclosures

TO BE PUBLISHED ON OR BEFORE MAY 12, 1999

NEW MEXICO ENVIRONMENT DEPARTMENT

Notice is hereby given that, pursuant to New Mexico Water Quality Control Commission Regulations, the following proposed ground water discharge plan (s) have been submitted for approval to the New Mexico Environment Department. The information in this notice generally has been supplied by the applicant and may or may not have been confirmed by the NM Environment Department.

DP-79, CLOVIS WASTEWATER TREATMENT PLANT, Mr. Harry Wang, Utilities Director, proposes to modify its discharge plan for the discharge of up to 5,000,000 gallons per day of treated domestic wastewater. The facility is located approximately two miles southeast of Clovis in Section 33.1 and 33.2, T2N, R36E, Curry County. Domestic wastewater is treated using a counter-current, extended aeration activated sludge system. Treated wastewater is stored in eleven clay and synthetically lined holding ponds prior to discharge to 1,430 acres of agricultural crop lands or to Williams Playa. The land application areas are in Sections 28.3, 28.4, 29.4, 32.1, 32.2, 32.3, 32.4, 33.2, 33.4, 34.4, 35.1, 35.3. and 36.1 (Williams Playa) of T2N, R36E. The modification is to add 160 acres of agricultural crop lands in Section 29.1 and 29.3, T2N, R36E. Ground water below the wastewater treatment plant and land application areas is at a depth of approximately 230-270 feet and has a total dissolved solids concentration of approximately 500 milligrams per liter.

DP-290, ABO DAIRY; Ken Miller, Owner, proposes to renew and modify its discharge of up to 3,236 gallons per day of wastewater from milking operations. The dairy is located approximately one mile east of Veguita, NM, in projected Section 4, T3N, R2E in the Casa Colorado Land Grant, Socorro County. Wash water from milking operations is discharged from the milking parlor to a concrete solids separation system, and gravity flows from the separator to a synthetically-lined lagoon for storage and evaporation. Modification of DP-290 increases the discharge volume from 3,236 gallons per day to 5,000 gallons per day. Ground water below the site is at a depth of approximately 70 feet, and has a total dissolved solids concentration of approximately 650 milligrams per liter.

DP-470, JUNIPER MOBILE HOME PARK, N. Rae Calvert, Owner, proposes to renew the discharge of up to 10,000 gallons per day of domestic effluent from a thirty-space mobile home park located approximately 8 miles northeast of Alamogordo, Section 5, T 16 S, R11 E, Otero County. Wastewater is collected and disposed through a septic tank and leach field system. Ground water below the site occurs at a depth of approximately sixty feet, and has a total dissolved solids concentration of approximately 2,036 milligrams per liter.

DP-529, RIO GRANDE UTILITY WASTEWATER TREATMENT PLANT, Fredrick J. Sandoval, General Manager, Rio Grande Utility Corporation, proposes to renew and modify its discharge plan which currently allows the discharge of up to 750 gallons per day of liquid sewage sludge from the Rio Grande Utilities Wastewater Treatment Plant. The sludge is land applied to 45 acres of undeveloped rangeland located approximately 4 miles northeast of Rio Communities in Section 18, T5N, R3E and Section 13, T5N, R2E (projected), Valencia County. The modification reduces the land application area to 38 acres and allows the disposal of up to 14,000 gallons per day of wastewater treatment plant sewage sludge. Ground water below the site is at a depth of approximately 200 feet and has a total dissolved solids concentration of approximately 290 milligrams per liter.

DP-667, EASTRIDGE DAIRY, Raymond McAnally, Owner, proposes to renew and modify its discharge plan which allows the discharge of 80,000 gallons per day of dairy washdown from the Eastridge Dairy. The facility is located 5 miles southeast Portales in Section 29, T2S, R35E, Roosevelt County. Up to 80,000 gallons per day of dairy parlor wastewater will be discharged from Eastridge Dairy to a 5,000 gallon concrete lined tank for solid settling. Wastewater will then flow to a clay-lined lagoon where it will be used to irrigate 110 acres of cropland by sprinkler system. The modification will increase the discharge from 10,000 gallons per day to 80,000 gallons per day and the irrigation 110 acres of cropland by sprinkler system. Ground water below the site is at a depth of approximately 90 feet and has a total dissolved solids concentration of approximately 850 milligrams per liter.

DP-717, VER HOVEN DAIRY, Gary Ver Hoven, Owner, proposes to renew the discharge plan for the discharge of 72,000 gallons per day of dairy wastewater. The dairy is located approximately 4 miles west of Hagerman in Section 12, T14S, R25E, Chaves County. Dairy parlor washwater is collected in a concrete holding tank then pumped to a manure-lined storage lagoon. Wastewater from the storage lagoon will be land applied to 75 acres of cropland. Ground water below the site is at a depth of approximately 55 to 75 and has a total dissolved solids concentration of approximately 1,200 milligrams per liter.

DP-1134, THE NEW MEXICO STATE HIGHWAY AND TRANSPORTATION DEPT.; proposes to discharge up to 2,088 gallons per day of domestic effluent from La Bajada Rest Area. The rest area is located on Interstate 25, approximately fifteen miles southwest of Santa Fe in projected Section 13, T15N, R7E, Mesita de Juana Lopez Grant, Santa Fe County. Domestic wastewater from restrooms is collected and disposed through a septic tank and leach field system. Depth to ground water below the facility is approximately 150 feet and has an unknown total dissolved solids concentration..

DP-1185, LAKESIDE MOBILE HOME PARK, Timoteo and Helen Romero, Owners, proposes to discharge up to 11,500 gallons per day of domestic wastewater from up to 52 residences into a septic tank and synthetically lined lagoon followed by mixing with irrigation water and land application to 37 acres of land used to grow alfalfa. The facility is located approximately 6 miles north of Las Vegas on NM State Highway 518 in Section 3, T16N, R16E, San Miguel County. Ground water below the site is at a depth of approximately 12 feet and has a total dissolved solids concentration of approximately 2,510 milligrams per liter.

DP-1189, JOHNNY'S SEPTIC TANK, Bobbie Suggs, Owner, proposes to discharge up to 15,000 gallons per day of domestic septage and restaurant grease at a land application site. The facility is located southwest of Cambray in N½SW¼ of Section 14, and Section 15, T24S, R5W, Luna County. Up to 15,000 gallons of domestic septage and restaurant grease will be land applied to 120 acres of alfalfa. Solids will be removed from wastewater prior to land application and disposed of at a landfill. Ground water below the site is at a depth of approximately 167 feet and has a total dissolved solids concentration of approximately 600 milligrams per liter.

DP-1233, MICKEY'S DAIRY, Danny McMahon, Owner, proposes to discharge up to 3,000 gallons per day of dairy wastewater. The dairy is located in Albuquerque (projected) in Section 15, T9N, R2E, Bernalillio County. Milking parlor wash water is collected in a concrete sump and pumped to one of two synthetically lined lagoons where wastewater will be disposed of by evaporation. Ground water below the site is at a depth of 30 feet with a total dissolved solids of 800 milligrams per liter.

DP-1255, NASA WHITE SANDS TEST FACILITY (WSTF), Joseph Fries, NASA WSTF Site Manager, proposes to discharge up to 1,872,000 gallons of treated contaminated ground water per day from the NASA WSTF ground water remediation system. The NASA WSTF ground water remediation system is located approximately 18 miles northeast of Las Cruces, NM in Section 5, T21S, R3E. Up to 1,872,000 gallons per day of ground water contaminated with organic compounds will be extracted using several plume front extraction wells. Contaminated ground water will then be treated using UV oxidation/hydrogen peroxide and air stripping. Treated ground water will be reinjected via injection wells located southwest of the plume front to create a ground water mound to prevent further migration of the contaminant plume. Ground water below the site is at a depth of approximately 420 feet and has a total dissolved solids concentration ranging from 490 to 1,230 milligrams per liter.

DP-1257, MARIPOSA FARMS DAIRY, Lawrence K. Shelley, Owner, proposes to discharge up to 10,000 gallons per day of dairy parlor wastewater from the Mariposa Farms Dairy. The facility is located four miles southeast of Causey in Section 31 & 32, T5S, R37E, Roosevelt County. Up to 10,000 gallons per day of dairy parlor wastewater will be discharged from the Mariposa Farms Dairy to a 20,000 gallon concrete lined tank for temporary storage. Wastewater will then be pumped into 5,000 gallon tank pulled by a tracker equipped with a spray bar and land applied to 450 acres cropland. Ground water below the site is at a depth of approximately 100 feet and has a total dissolved solids concentration of approximately 1,691 millligrams per liter.

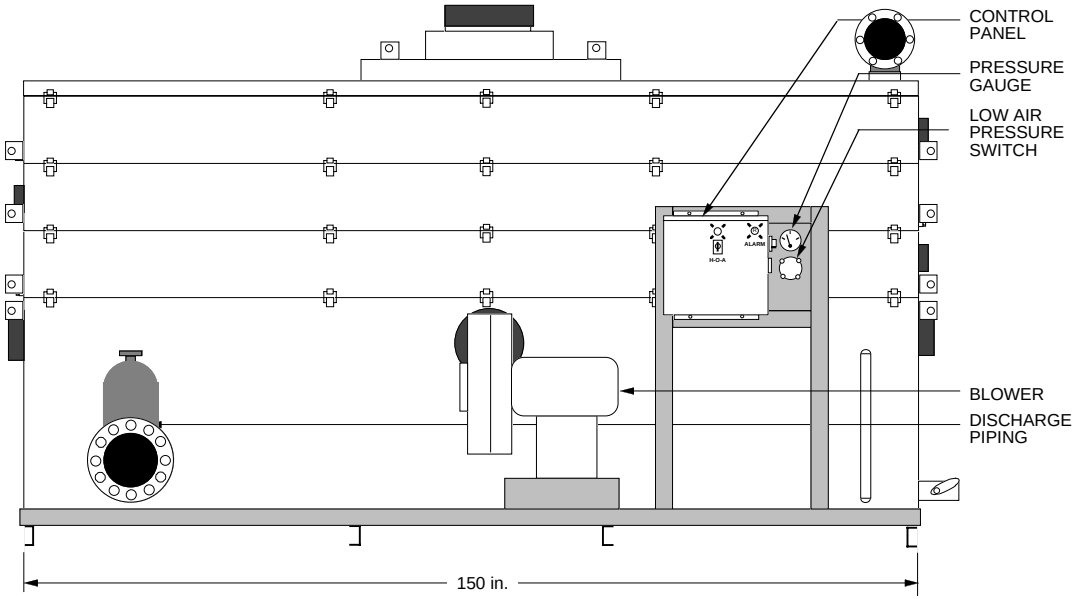
Any interested person may obtain further information from the Ground Water Pollution Prevention Section of the NM Environment Department, telephone (505) 827-2900, and may submit written comments to the Ground Water Pollution Prevention Section, NM Environment Department, P.O. Box 26110, Santa Fe, NM 87502. Prior to ruling on any proposed discharge plan or its modification, the NM Environment Department will allow thirty (30) days after the date of publication of this notice to receive written comments and during which a public hearing may be requested by any interested person. Requests for public hearing shall set forth the reasons why the hearing should be held. A hearing will be held if the NM Environment Department determines that there is significant public interest.

Appendix D - Specific Engineering Information

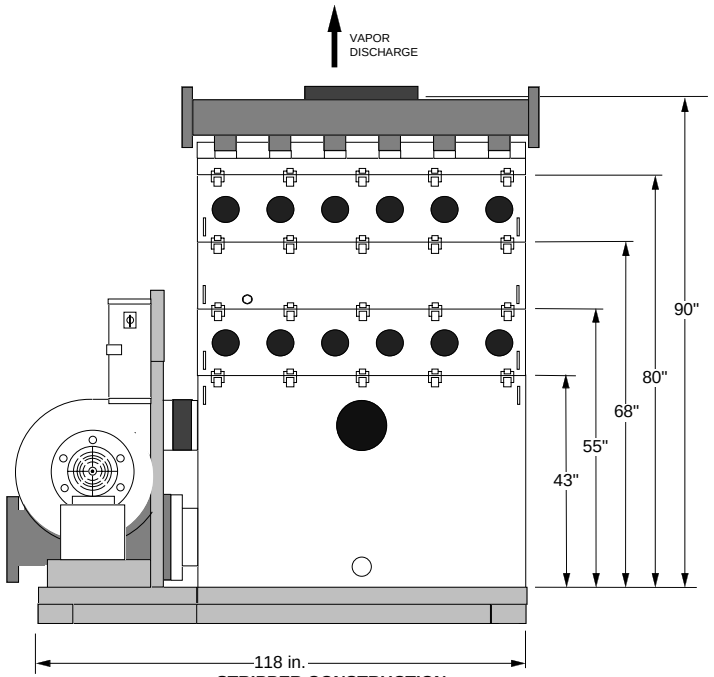
MINIMUM CLEARANCE

FRONT	1.5 ft.
TOP	12 in.
REAR	N/A
LEFT	6.5 ft.
RIGHT	6.5 ft.

FRONT



RIGHT SIDE



OPTIONAL ITEMS:

- ✓ SKID & STANCHION
- ✓ AIR PRESSURE GAUGE
- ✓ GRAVITY DISCHARGE PIPING
- ___ DISCHARGE PUMP
- ___ FEED PUMP
- ___ ADDITIONAL BLOWER
- ___ EXPLOSION-PROOF MOTORS
- ___ LOCAL DISCONNECT NEMA 7
- ✓ CONTROL PANEL
- ✓ MAIN DISCONNECT SWITCH
- ___ I.S. COMPONENTS/REMOTE MOUNT
- ✓ INTERMITTENT OPERATION
- ___ STROBE LIGHT
- ___ ALARM HORN
- ___ POWER LAPSE INDICATOR
- ✓ LOW AIR PRESSURE ALARM SWITCH(ES)
- ✓ HIGH WATER LEVEL ALARM SWITCH
- ___ DISCHARGE PUMP LEVEL SWITCH
- ___ WATER PRESSURE GAUGE(S)
- ___ DIGITAL WATER FLOW INDICATOR
- ___ AIR FLOW METER
- ___ TEMPERATURE GAUGE(S)
- ___ LINE SAMPLING PORT(S)
- ___ AIR BLOWER SILENCER
- ✓ WASHER WAND
- ___ AUTO DIALER

BASIC SYSTEM

- ✓ SUMP TANK
- ✓ STRIPPER TRAYS
- ✓ BLOWER
- ✓ MIST ELIMINATOR
- ✓ PIPING
- ✓ SPRAY NOZZLE
- ✓ WATER LEVEL SIGHT TUBE
- ✓ GASKETS
- ✓ LATCHES

NOTE: THIS DRAWING IS REPRESENTATIVE OF A STANDARD SHALLOWTRAY CONFIGURATION, AND IS NOT INTENDED FOR ENGINEERING DESIGN OR LAYOUT. ACTUAL ARRANGEMENT AND DIMENSIONS MAY VARY DEPENDING ON BLOWER SELECTION OR OTHER ACCESSORIES. PLEASE CONTACT NEEP FOR DETAILED DESIGN INFORMATION.

CONNECTION INFORMATION

ITEM	SIZE
GRAVITY DISCHARGE	12"Ø FLANGED
DISCHARGE PUMP	8"Ø FLANGED
WATER INLET	8"Ø FLANGED
AIR EXHAUST NOZZLE	18"Ø STUB w/18" CPLG

STRIPPER CONSTRUCTION:
304L STAINLESS STEEL

POWER: 3Ø, 460 volt, 3 WIRE + GROUND, 60 Hz

*CONSULT N.E.E.P. FOR AMPACITIES AND OTHER VOLTAGE OPTIONS

NORTH EAST ENVIRONMENTAL PRODUCTS, INC.
7 COMMERCE AVENUE
WEST LEBANON, NEW HAMPSHIRE 03784
PHONE: 603-298-7061 FAX: 603-298-7063
http://www.neepsystems.com

© 2002 NEEP

TOLERANCES UNLESS OTHERWISE SPECIFIED: ± 1 INCH

DRAWING NAME: ShallowTray® Model 61231

DRAWING #: Proposal #Typical

DRAWN: *DCS*

CUSTOMER: NEEPSYSTEMS.com

DATE: 09/07/02

SCALE: NTS | **SIZE:** A | **SHEET :** 1 **OF :** 1

Summary Lab Report

for

VOC removal efficiency
White Sands Testing Facility
Air stripping System

Test #1

Air stripper model used - 1331
Water flow rate -13.8 gpm
Air flow rate - 150 scfm
Sump air pressure - 15 "wc
# of trays - 3
Water temperature - 56°F
Batch tank volume - 440 gallons
Calculated Contaminant Concentrations, ppb

TCE	1000
PCE	1000
F11	1000
F21	1000
F113	2000

The liquid chemicals were measured out to provide the calculated concentration and dumped into the batch tank.. The gaseous chemical was bubbled in the batch tank. The tank contents were recirculated at 20 gpm for 20 minutes to mix and dissolve the chemicals. The water was then processed through the ShallowTray. Duplicate samples were collected near the end of the 400-gallon batch from both the influent and effluent. The samples were sent to an independent lab for analysis.

The water flow rate for this experiment is directly proportional to the flowrate of the Model 61231 operating at 475 gpm.

The lab test results are as follows

Compound name Sample #	Influent Conc., ug/l 13.8G3TI	Effluent Conc., ug/l 13.8G3TO
TCE	288	<2
PCE	215	<2
Trichlorofluoromethane	167	<4
1,1,2-1,2,2-Trichloro-tricfluoroethane	179	<4

Test #2

Air stripper model used - 1341
Water flow rate -18.2 gpm
Air flow rate - 150 scfm
Sump air pressure - 18.2 "wc
# of trays - 4
Water temperature - 56°F
Batch tank volume - 440 gallons
Calculated Contaminant Concentrations, ppb

TCE	1000
PCE	1000
F11	1000
F21	1000
F113	2000

The liquid chemicals were measured out to provide the calculated concentration and dumped into the batch tank.. The gaseous chemical was bubbled in the batch tank. The tank contents were recirculated at 20 gpm for 20 minutes to mix and dissolve the chemicals. The water was then processed through the ShallowTray. Duplicate samples were collected near the end of the 400-gallon batch from both the influent and effluent. The samples were sent to an independent lab for analysis.

The water flow rate for this experiment is directly proportional to the flowrate of the Model 61241 operating at 625 gpm.

The lab test results are as follows

Compound name Sample #	Influent Conc., ug/l 18.2G4TI	Effluent Conc., ug/l 18.2G4TO
TCE	465	<2
PCE	182	<2
Trichlorofluoromethane	273	<4
1,1,2-1,2,2-Trichloro-tricfluoroethane	256	<4

Conclusion: The two Freons that I was able to dissolve in the test batch were readily stripped as predicted by the Modeler design program.

Kathy Mann

KATHY J. MANN
COMMISSIONER OF DEEDS
STATE OF NEW HAMPSHIRE
My commission expires Aug 11 2003

Bruce L. Lamson
8/10/00

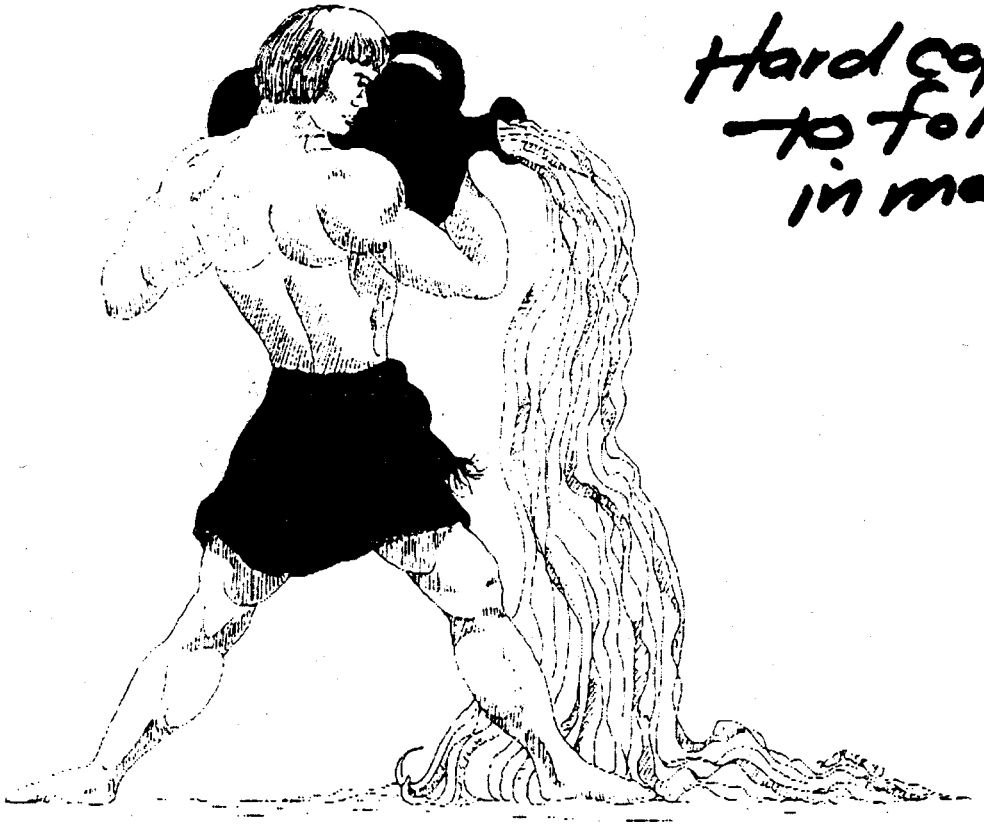
FAX TITLE PAGE

DATE: 8-10-2000 Total Number of Pages: 6

TO:

The Attention of: N.E. Env. Products

Company Name: Bruce Lomarre



Hard copies to follow in mail

- [x] REPORT(S)
- [ ] PRICE QUOTE
- [ ] OTHER

AQUARIAN ANALYTICAL INC.

Laboratory Services

P.O. Box 186

Canterbury, N.H. 03224

603-783-9097

AQUARIAN ANALYTICAL INC.
Laboratory Services
P.O. Box 186
Canterbury, N.H. 03224
Ph. 603-783-9097 • Fax 603-783-0360

Chlorinated Volatile Organic Report

08-10-2000,10:38
Sample 56072

Sample Matrix = Water
Project = 100499-2 / N.A.S.A.

Date Sampled = 08-05-2000,12:00
Date Logged In = 08-07-2000,09:41
Date of Analysis = 08-08-2000
Sampler = B. LAMARRE
Location = 13.8G3TI
Town =

Organic Compound	Result ug/L	Det. Lim. ug/L
Bromodichloromethane	BD	80
Chlorodibromomethane	BD	80
Bromoform	BD	80
Chloroform	90	80
Carbon Tetrachloride	BD	80
dichloromethane	BD	240
1,1-dichloroethane	BD	80
1,2-dichloroethane	BD	80
1,1,1-trichloroethane	BD	80
1,1,2-trichloroethane	BD	80
1,1-dichloroethylene	BD	80
Trichloroethylene	288	80
Tetrachloroethylene	215	80
1,2-Dichloroethylene (c)	BD	80
1,2-Dichloroethylene (t)	BD	80
Chloroethane	BD	80
Vinylchloride	BD	80
Bromomethane	BD	80
Chloromethane	BD	120
Trichlorofluoromethane	167	160
Chlorobenzene	BD	80
1,2-dichlorobenzene	BD	80
1,3-dichlorobenzene	BD	80
1,4-dichlorobenzene	BD	80
1,2,4-trichlorobenzene	BD	160
1,1,2-1,2,2-trichloro-trifluoroethane	179	160

Comments:

Method of Analyses = EPA-8260, chlorinated only.
Results are expressed in ppb.
BD = Below Detection Limit

AQUARIAN ANALYTICAL INC.
Laboratory Services
P.O. Box 186
Canterbury, N.H. 03224
Ph. 603-783-9097 • Fax 603-783-0360

Chlorinated
Volatile Organic Report
08-10 2000,10:38
Sample 56073

Sample Matrix = Water
Project = 100499-2 / N.A.S.A.

Date Sampled = 08-05-2000,12:00
Sampler = B. LAMARRE
Date Logged In = 08-07-2000,09:44
Location = 13.8G3TO
Date of Analysis = 08-05-2000
Town =

Organic Compound	Result ug/L	Det. Lim. ug/L
Bromodichloromethane	BD	2
Chlorodibromomethane	BD	2
Bromoform	BD	2
Chloroform	BD	2
Carbon Tetrachloride	BD	2
dichloromethane	BD	6
1,1-dichloroethane	BD	2
1,2-dichloroethane	BD	2
1,1,1-trichloroethane	BD	2
1,1,2-trichloroethane	BD	2
1,1-dichloroethylene	BD	2
Trichloroethylene	BD	2
Tetrachloroethylene	BD	2
1,2 Dichloroethylene (c)	BD	2
1,2-Dichloroethylene (t)	BD	2
Chloroethane	BD	2
Vinylchloride	BD	2
Bromomethane	BD	2
Chloromethane	BD	3
Trichlorofluoromethane	BD	4
Chlorobenzene	BD	2
1,2-dichlorobenzene	BD	2
1,3-dichlorobenzene	BD	2
1,4-dichlorobenzene	BD	2
1,2,4-trichlorobenzene	BD	4
1,1,2-1,2,2-trichloro-trifluoroethane	BD	4

Comments:

Method of Analyses = EPA-8260, chlorinated only.
Results are expressed in ppb.
BD = Below Detection Limit

AQUARIAN ANALYTICAL INC.
Laboratory Services
P.O. Box 186
Canterbury, N.H. 03224
Ph. 603-783-9097 • Fax 603-783-0360

Chlorinated
Volatile Organic Report
08 10-2000,10:49
Sample 56074

Sample Matrix = Water
Project = 100499-2 / N.A.S.A.

Date Sampled = 08-05-2000,13:30
Date Logged In = 08-07-2000,09:44
Date of Analysis = 08-08-2000
Sampler = B. LAMARRE
Location = 18.2G4TI
Town =

Organic Compound	Result ug/L	Det. Lim. ug/L
Bromodichloromethane	BD	80
Chlorodibromomethane	BD	80
Bromoform	BD	80
Chloroform	97	80
Carbon Tetrachloride	BD	80
dichloromethane	BD	240
1,1-dichloroethane	BD	80
1,2-dichloroethane	BD	80
1,1,1-trichloroethane	BD	80
1,1,2-trichloroethane	BD	80
1,1-dichloroethylene	BD	80
Trichloroethylene	465	80
Tetrachloroethylene	182	80
1,2-Dichloroethylene (c)	BD	80
1,2-Dichloroethylene (t)	BD	80
Chloroethane	BD	80
Vinylchloride	BD	80
Bromomethane	BD	80
Chloromethane	BD	120
Trichlorofluoromethane	273	160
Chlorobenzene	BD	80
1,2-dichlorobenzene	BD	80
1,3-dichlorobenzene	BD	80
1,4-dichlorobenzene	BD	80
1,2,4-trichlorobenzene	BD	160
1,1,2-1,2,2-trichloro-trifluoroethane	256	160

Comments:

Method of Analyses = EPA-8260, chlorinated only.
Results are expressed in ppb.
BD = Below Detection Limit

AQUARIAN ANALYTICAL INC.
Laboratory Services
P.O. Box 186
Canterbury, N.H. 03224
Ph. 603-783-9097 • Fax 603-783-0360

Chlorinated
Volatile Organic Report
08-10-2000,10:38
Sample 56075

Sample Matrix = Water
Project = 100499-2 / N.A.S.A.

Date Sampled = 08-05-2000,13:30
Sampler = B. LAMARRE
Date Logged In = 08-07-2000,09:45
Location = 18.2G4TO
Date of Analysis = 08-08-2000
Town =

Organic Compound	Result ug/L	Det. Lim. ug/L
Bromodichloromethane	BD	2
Chlorodibromomethane	BD	2
Bromoform	BD	2
Chloroform	BD	2
Carbon Tetrachloride	BD	2
dichloromethane	BD	6
1,1-dichloroethane	BD	2
1,2-dichloroethane	BD	2
1,1,1-trichloroethane	BD	2
1,1,2-trichloroethane	BD	2
1,1-dichloroethylene	BD	2
Trichloroethylene	BD	2
Tetrachloroethylene	BD	2
1,2-Dichloroethylene (c)	BD	2
1,2-Dichloroethylene (t)	BD	2
Chloroethane	BD	2
Vinylchloride	BD	2
Bromomethane	BD	2
Chloromethane	BD	3
Trichlorofluoromethane	BD	4
Chlorobenzene	BD	2
1,2-dichlorobenzene	BD	2
1,3-dichlorobenzene	BD	2
1,4-dichlorobenzene	BD	2
1,2,4-trichlorobenzene	BD	4
1,1,2-1,2,2-trichloro-trifluoroethane	BD	4

Comments:

Method of Analyses = EPA-8260, chlorinated only.
Results are expressed in ppb.
BD = Below Detection Limit

RUSH!

24 (48) HOURS

AQUARIAN ANALYTICAL, INC.

Laboratory Services

Canterbury, NH 03224
Phone: (603)783-9097
FAX: (603)783-0360

P.06 603 783 0360 Aquarian Analytical Aug-10-00 10:30

ATION

Turn-around-time: Same Day____(100% upcharg
Turn-around-time: 24 Hrs____(50% upcharge)
Turn-around-time: 48 Hrs. X (25% upcharge)
Turn-around-time: Normal____ by 8/9
Account #: 77880

PROJECT INFORMATION

Project #: 100499-2
Project Name: NASA
Town/Site: NM
Sampler: Bruce L. Lamarre
Company: North East Environmental

Project Manager: Bruce Lamarre
Report to: Bruce Lamarre
Invoice to: NEE, 17 Technology Dr. W. Lebanon NH 03784
Phone: 603 298 7061
FAX: 603 298 7063

SAMPLE INFORMATION					VOC's-SVOC's											TPH	METALS						OTHER (List)													
AAI ID#	Sample ID	Date/Time	Sample Matrix (S-soil / W-water / O-other)	Number of Containers	EPA 524.2 Drinking Water	EPA 8260___/ EPA 8260B	EPA 8260B with TIC's	EPA 8240___/ EPA 624	BTEX / MTBE	Chlorinated Compounds Only	EPA 8270 (A-B/N)	EPA 8270 (PAH)	EPA 8015M (Gasoline)	EPA 8100M (Fuel Oil)	Fingerprint	13 Priority Poultant	8 RCRA	Misc.	Field Filtered	Lab Filtered	Total	EPA 608/8081 PCBS or Pesticid	EPA 8150 Herbicides	EPA SW846-7 Reactivity	EPA 1010 Ignitability/Flashpoint	EPA 150.1/9045 pH	EPA 120.1 Conductivity	Alkalinity	Methane	EPA 300.0 Nitrate	EPA 300.0 Sulfate	EPA 300.0 Chloride					
~~13.863TI-1~~		~~8/5 12:00~~																																		
S6072	13.863TI-1	8/5 12:00	W	2						X																										
	13.863TI-2	" "	W																																	
S6073	13.863TO-1	" "	W	2						X																										
	13.863TO-2	" "	W																																	
S6074	18.264TI-1	" 13:30	W	2						X																										
	18.264TI-2	" "	W																																	
S6075	18.264TO-1	" "	W	2						X																										
	18.264TO-2	" "	W																																	

Relinquished By: Bruce L. Lamarre	Date: 8/7/00 Time: 8:35	Received By:	Notes: See Original note
Relinquished By:	Date: Time:	Received By:	
Relinquished By:	Date: Time:	Received By:	Please fax by Wed

Please refer to back side for sampling guidelines.

Typical Flow Rate
Total Flow = 1076 GPM

PFE-1 = 288 gpm
PFE-2 = 224 gpm
PFE-3 = 213 gpm
PFE-4A = 200 gpm
PFE-5 = 26 gpm
PFE-7 = 125 gpm
Midplume = 80 gpm

NOTE: For the Maximum Flow Scenario, all extraction wells, except midplume wells, take on an additional flow of 15% over nominal flowrates.

Title: Extraction System Typical CaseFlow Scenario
Analysis run on: 10/20/03 9:00:51 AM
Application version: AFT Fathom Version 4.0 (2000.09.01)
Input File: N:\AFT Products\AFT Fathom\PF Extraction\Newroute,midplume.fth
Scenario: Base Scenario (nominal)

Constant Fluid Property Model
Fluid Database: AFT Standard
Fluid: Water at 1 atm
Max Fluid Temperature Data= 212 deg. F
Min Fluid Temperature Data= 32 deg. F
Temperature= 70 deg. F
Density= 62.30841 lbm/ft3
Viscosity= 2.36004 lbm/hr-ft
Vapor Pressure= .3619804 psia

Atmospheric Pressure= 0.82 atm
Gravitational Acceleration= 1 g
Turbulent Flow Above Reynolds Number= 4000
Laminar Flow Below Reynolds Number= 2300
Total Inflow= 1076. gal/min
Total Outflow= 1076. gal/min
Maximum Pressure is 366.9 psig at Junction 6 Outlet
Minimum Pressure is 5.625 psig at Junction 24 Inlet

Pump Summary

Jct	Flow (gal/min)	DP (psid)	DH (feet)	Efficiency (%)	Speed (%)	Power (Btu/s)	BEP (gal/min)	% of BEP	NPSHA (feet)	NPSHR (feet)
2	288.0	325.5	752.2	N/A	100.0	(ideal) 38.64	N/A	N/A	55.02	N/A
6	26.00	312.9	723.3	N/A	100.0	(ideal) 3.355	N/A	N/A	152.0	N/A

Jct	Flow (gal/min)	DP (psid)	DH (feet)	Efficiency (%)	Speed (%)	Power (Btu/s)	BEP (gal/min)	% of BEP	NPSHA (feet)	NPSHR (feet)
11	224.0	304.8	704.5	N/A	100.0	(ideal) 28.15	N/A	N/A	48.03	N/A
17	125.0	327.0	755.7	N/A	100.0	(ideal) 16.85	N/A	N/A	43.03	N/A
24	213.0	287.1	663.5	N/A	100.0	(ideal) 25.21	N/A	N/A	40.03	N/A
30	200.0	312.1	721.2	N/A	100.0	(ideal) 25.73	N/A	N/A	48.03	N/A

Pipe Output Table

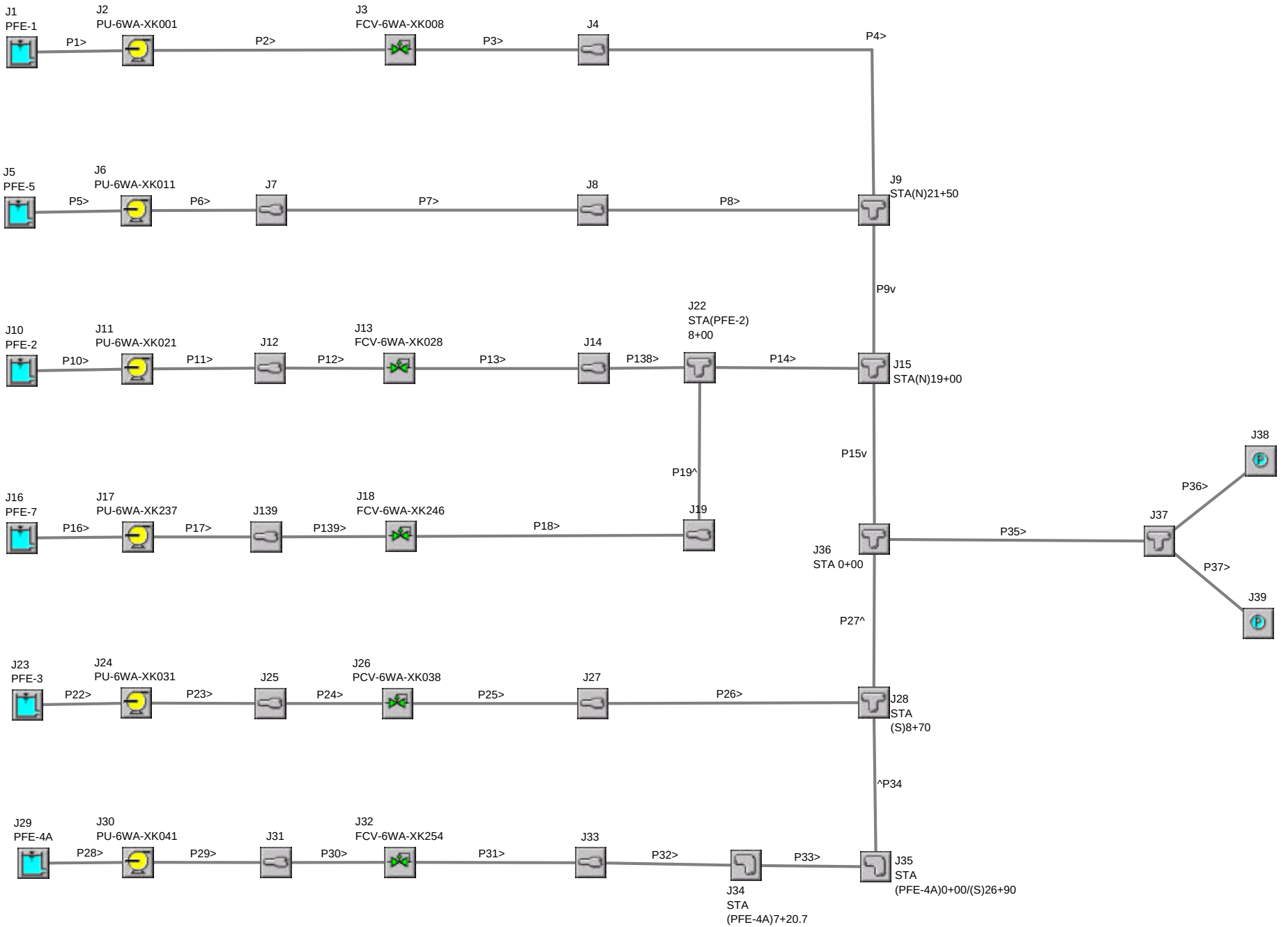
Pipe	Pipe Nominal Size	Pipe Material	Pipe Type-Schedule	Length (feet)	Vol. Flow (gal/min)	Velocity (feet/sec)	dH (feet)	dP Stag. Total (psid)	P Stag. In (psig)	P Stag. Out (psig)	P Static Out (psig)
1	10 inch	Steel	schedule 40	2.000	288.00	1.1718	0.000979629	-0.86497068	11.254	12.119	12.109
2	4 inch	Steel	schedule 40	525.000	288.00	7.2583	28.866636839	239.65658569	337.577	97.920	97.566
3	4 inch	Steel	schedule 40	6.000	288.00	7.2583	0.406936828	0.17608047	87.920	87.744	87.390
4	6 inch	HDPE	DR 7.3	1714.000	288.00	5.3235	30.289310935	23.92353439	87.719	63.795	63.605
5	10 inch	Steel	schedule 40	1.000	26.00	0.1058	0.000009980	0.43270162	54.528	54.095	54.095
6	1-1/2 inch	Steel	schedule 40	650.000	26.00	4.0974	32.482793201	295.30844116	367.045	71.737	71.624
7	1 inch	Steel	schedule 40	16.000	26.00	9.6519	7.450267348	1.06022406	71.530	70.469	69.843
8	2 inch	HDPE	DR 11	788.000	26.00	2.8893	14.040906646	6.50815964	70.162	63.654	63.598
9	6 inch	HDPE	DR 9	250.000	314.00	5.0010	3.668695010	3.31822348	63.758	60.440	60.271
10	10 inch	Steel	schedule 40	1.000	224.00	0.9114	0.000310402	0.00013431	9.092	9.092	9.086
11	4 inch	Steel	schedule 40	515.000	224.00	5.6453	17.311326909	230.32968140	313.936	83.607	83.392
12	3 inch	Steel	schedule 40	3.000	224.00	9.7214	0.988113021	-0.43784076	83.441	83.879	83.243
13	3 inch	Steel	schedule 40	6.000	224.00	9.7214	0.904110997	-1.77228010	73.879	75.651	75.016
14	6 inch	HDPE	DR 7.3	800.000	349.00	6.4510	20.063290693	11.71021271	72.289	60.579	60.299
15	8 inch	HDPE	DR 7.3	1900.000	663.00	7.2306	46.981424503	23.79031372	60.062	36.272	35.920
16	10 inch	Steel	schedule 40	1.000	125.00	0.5086	0.000108681	0.00004703	6.930	6.930	6.929
17	3 inch	Steel	schedule 40	475.000	125.00	5.4249	19.977115641	214.17526245	333.940	119.764	119.566
18	2 inch	Steel	schedule 40	12.000	125.00	11.9514	3.552706980	2.40264130	109.549	107.146	106.186
19	4 inch	HDPE	DR 7.3	1546.000	125.00	5.0080	38.969439032	34.16986084	106.822	72.652	72.484
22	10 inch	Steel	schedule 40	3.000	213.00	0.8666	0.000848879	1.29845917	6.929	5.630	5.625
23	4 inch	Steel	schedule 40	525.000	213.00	5.3681	15.972458542	234.07731628	292.713	58.636	58.442
24	3 inch	Steel	schedule 40	3.000	213.00	9.2440	0.894597336	-0.47830474	58.486	58.964	58.390
25	3 inch	Steel	schedule 40	6.000	213.00	9.2440	0.819791249	-1.80876505	48.964	50.773	50.199
26	5 inch	HDPE	DR 9	199.000	213.00	4.8113	3.357378569	5.34700441	50.641	45.294	45.138
27	6 inch	HDPE	DR 9	870.000	413.00	6.5777	24.456329510	8.85139847	45.123	36.272	35.981

Pipe	Pipe Nominal Size	Pipe Material	Pipe Type-Schedule	Length (feet)	Vol. Flow (gal/min)	Velocity (feet/sec)	dH (feet)	dP Stag. Total (psid)	P Stag. In (psig)	P Stag. Out (psig)	P Static Out (psig)
28	10 inch	Steel	schedule 40	1.000	200.00	0.8137	0.000252894	0.00010943	9.093	9.092	9.088
29	4 inch	Steel	schedule 40	575.000	200.00	5.0405	15.277585538	255.41151428	321.163	65.752	65.581
30	3 inch	Steel	schedule 40	3.000	200.00	8.6798	0.790049282	-0.95623970	65.620	66.576	66.069
31	3 inch	Steel	schedule 40	6.000	200.00	8.6798	0.725415100	0.31388515	56.576	56.262	55.755
32	5 inch	HDPE	DR 11	450.000	200.00	4.0510	5.190245660	1.81310797	56.118	54.305	54.194
33	5 inch	HDPE	DR 11	522.000	200.00	4.0510	5.942542251	0.84053278	54.276	53.435	53.325
34	5 inch	HDPE	DR 11	1820.000	200.00	4.0510	20.782950127	8.12733173	53.406	45.279	45.168
35	10 inch	HDPE	DR 11	50.000	1076.00	5.8364	0.844881696	3.39445901	36.272	32.878	32.648
36	6 inch	Steel	schedule 40	35.000	538.00	5.9747	1.650246933	2.87754393	32.878	30.000	29.760
37	6 inch	Steel	schedule 40	35.000	538.00	5.9747	1.650246933	2.87754393	32.878	30.000	29.760
138	6 inch	HDPE	DR 11	169.000	224.00	3.1991	1.047022187	2.61653018	75.365	72.749	72.680
139	2 inch	Steel	schedule 40	3.000	125.00	11.9514	1.792720832	-0.08968914	119.459	119.549	118.588

All Junction Table

Jct	Name	Vol. Flow Thru Junction (gal/min)	Elevation (feet)	Vol. Flow Into System (gal/min)	P Stag. In (psig)	P Stag. Out (psig)	P Static Out (psig)
1	PFE-1	288.00	3985.	288.00	0.4409	11.258	11.258
2	PU-6WA-XK001	288.00	3958.	0.00	12.1187	337.577	337.223
3	FCV-6WA-XK008	288.00	4483.	0.00	97.9203	87.920	87.566
4	Area Change	288.00	4483.	0.00	87.7442	87.719	87.528
5	PFE-5	26.00	3986.	26.00	0.4409	54.528	54.528
6	PU-6WA-XK011	26.00	3862.	0.00	54.0953	367.045	366.932
7	Area Change	26.00	4512.	0.00	71.7366	71.530	70.903
8	Area Change	26.00	4507.	0.00	70.4694	70.162	70.106
9	STA(N)21+50	N/A	4508.	0.00	63.7578	63.758	63.627
10	PFE-2	224.00	4012.	224.00	0.4409	9.095	9.095
11	PU-6WA-XK021	224.00	3992.	0.00	9.0919	313.936	313.722
12	Area Change	224.00	4507.	0.00	83.6066	83.441	82.806
13	FCV-6WA-XK028	224.00	4505.	0.00	83.8788	73.879	73.243
14	Area Change	224.00	4500.	0.00	75.6511	75.365	75.296
15	STA(N)19+00	N/A	4512.	0.00	60.0623	60.062	59.802
16	PFE-7	125.00	4005.	125.00	0.4409	6.931	6.931

Jct	Name	Vol. Flow Thru Junction (gal/min)	Elevation (feet)	Vol. Flow Into System (gal/min)	P Stag. In (psig)	P Stag. Out (psig)	P Static Out (psig)
17	PU-6WA-XK237	125.00	3990.	0.00	6.9304	333.940	333.742
18	FCV-6WA-XK246	125.00	4463.	0.00	119.5489	109.549	108.588
19	Area Change	125.00	4465.	0.00	107.1463	106.822	106.653
22	STA(PFE-2) 8+00	N/A	4505.	0.00	72.2894	72.289	72.129
23	PFE-3	213.00	4009.	213.00	0.4409	6.931	6.931
24	PU-6WA-XK031	213.00	3997.	0.00	5.6304	292.713	292.519
25	Area Change	213.00	4522.	0.00	58.6357	58.486	57.911
26	PCV-6WA-XK038	213.00	4520.	0.00	58.9643	48.964	48.390
27	Area Change	213.00	4515.	0.00	50.7731	50.641	50.485
28	STA (S)8+70	N/A	4524.	0.00	45.1234	45.123	44.945
29	PFE-4A	200.00	3979.	200.00	0.4409	9.095	9.095
30	PU-6WA-XK041	200.00	3959.	0.00	9.0925	321.163	320.992
31	Area Change	200.00	4534.	0.00	65.7515	65.620	65.113
32	FCV-6WA-XK254	200.00	4531.	0.00	66.5758	56.576	56.069
33	Area Change	200.00	4531.	0.00	56.2619	56.118	56.007
34	STA (PFE-4A)7+20.7	200.00	4530.	0.00	54.3047	54.276	54.165
35	STA (PFE-4A)0+00/(S)26+90	200.00	4526.	0.00	53.4351	53.406	53.296
36	STA 0+00	N/A	4520.	0.00	36.2720	36.272	35.984
37	Tee/Wye	N/A	4527.	0.00	32.8775	32.878	32.641
38	Assigned Pressure	538.00	4532.	-538.00	30.0000	30.000	29.760
39	Assigned Pressure	538.00	4532.	-538.00	30.0000	30.000	29.760
139	Area Change	125.00	4465.	0.00	119.7643	119.459	118.499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P32>
J34
STA
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P33>
J35
STA
(PFE-4A)0+00/(S)26+90

MAXIMUM FLOW= 1076 gpm

PFI-1 = 269 gpm
PFI-2 = 269 gpm
PFI-3 = 344 gpm
PFI-4 = 194 gpm

Title: Injection Headlosses
Analysis run on: 2/19/04 9:35:18 AM
Application version: AFT Fathom Version 4.0 (2000.09.01)
Input File: N:\AFT Products\AFT Fathom\PF Injection\PF Injection piping H.fth
Scenario: Base (nominal)

Constant Fluid Property Model
Fluid Database: AFT Standard
Fluid: Water at 1 atm
Max Fluid Temperature Data= 212 deg. F
Min Fluid Temperature Data= 32 deg. F
Temperature= 60 deg. F
Density= 62.37215 lbm/ft3
Viscosity= 2.72848 lbm/hr-ft
Vapor Pressure= .25024 psia

Atmospheric Pressure= 0.849 atm
Gravitational Acceleration= 1 g
Turbulent Flow Above Reynolds Number= 4000
Laminar Flow Below Reynolds Number= 2300
Total Inflow= 1076 gal/min
Total Outflow= 1076 gal/min
Maximum Pressure is 142 psia at Junction 3 Outlet
Minimum Pressure is 5.0 psia at Junction 10 Inlet

Pump Summary

Jct	Flow (gal/min)	DP (psid)	DH (feet)	Efficiency (%)	Speed (%)	Power (Btu/s)	BEP (gal/min)	% of BEP	NPSHA (feet)	NPSHR (feet)
3	538	138	318	100	100	31.	N/A	N/A	12.	N/A
10	538	138	318	N/A	100	(ideal) 31.	N/A	N/A	12.	N/A

Valve Summary

Injection Headlosses

Jct	Type	Flow (gal/min)	DP (psid)	DH (feet)	P Inlet (psia)	Cv	K	State
2	PDCV	538	7.0	16.	13.	202	24.	Open
4	CHECK	538	3.0	7.0	139	309	2.0	Open
5	REGULAR	538	1.0	2.4	133	530	0.68	Open
9	PDCV	538	7.0	16.	12.	202	24.	Open
11	CHECK	538	3.0	7.0	139	309	2.0	Open
12	REGULAR	538	1.0	2.4	133	530	0.68	Open
14	PDCV	1076	8.0	18.	128	380	25.	Open
15	PDCV	1076	7.0	16.	123	405	22.	Open
21	PDCV	194	5.0	12.	106	87.	31.	Open
24	PDCV	269	5.0	12.	105	121	13.	Open
27	PDCV	269	5.0	12.	104	121	13.	Open
30	PDCV	344	5.0	12.	104	154	9.9	Open

Pipe Output Table

Pipe	Pipe Material	Pipe Nominal Size	Pipe Type-Schedule	Length (feet)	Vol. Flow (gal/min)	Velocity (feet/sec)	dH (feet)	dP Stag. Total (psid)	K	P Stag. In (psig)	P Stag. Out (psig)
1	PVC	6 inch	schedule 80	4.0	538	6.6	1.164	-0.362	1.58	0.00	0.36
2	PVC	6 inch	schedule 80	6.0	538	6.6	0.866	0.375	1.08	-6.64	-7.01
3	PVC	4 inch	schedule 80	10.0	538	15.0	5.142	2.227	1.03	130.65	128.43
4	PVC	4 inch	schedule 80	8.0	538	15.0	4.835	3.394	1.03	125.39	122.00
5	PVC	4 inch	schedule 80	6.0	538	15.0	2.724	-0.120	0.52	120.97	121.09
6	Steel	8 inch	schedule 40	20.0	538	3.5	0.206	0.089	0.59	120.19	120.10
7	PVC	6 inch	schedule 80	4.0	538	6.6	1.164	0.504	1.58	0.72	0.21
8	PVC	6 inch	schedule 80	6.0	538	6.6	0.866	0.375	1.08	-6.79	-7.16
9	PVC	4 inch	schedule 80	10.0	538	15.0	5.142	2.227	1.03	130.65	128.43
10	PVC	4 inch	schedule 80	8.0	538	15.0	4.835	3.394	1.03	125.39	122.00
11	PVC	4 inch	schedule 80	6.0	538	15.0	2.724	-0.120	0.52	120.97	121.09
12	Steel	8 inch	schedule 40	20.0	538	3.5	0.206	0.089	0.59	120.19	120.10
13	Steel	8 inch	schedule 40	25.0	1076	6.9	1.128	4.387	0.92	119.89	115.50
14	Steel	8 inch	schedule 40	10.0	1076	6.9	0.860	-3.526	0.92	107.50	111.03
15	Steel	8 inch	schedule 40	30.0	1076	6.9	1.956	-1.318	1.92	104.03	105.35
16	HDPE	10 inch	DR 17	4100.0	1076	5.0	29.142	9.591	1.33	105.32	95.73
17	Steel	6 inch	schedule 40	10.0	538	6.0	0.467	1.935	0.50	95.40	93.47
19	PVC	4 inch	schedule 40	10.0	194	4.9	0.578	-0.183	1.05	93.22	93.40
20	PVC	4 inch	schedule 80	10.0	194	5.4	1.069	-0.836	1.82	88.40	89.24

Injection Headlosses

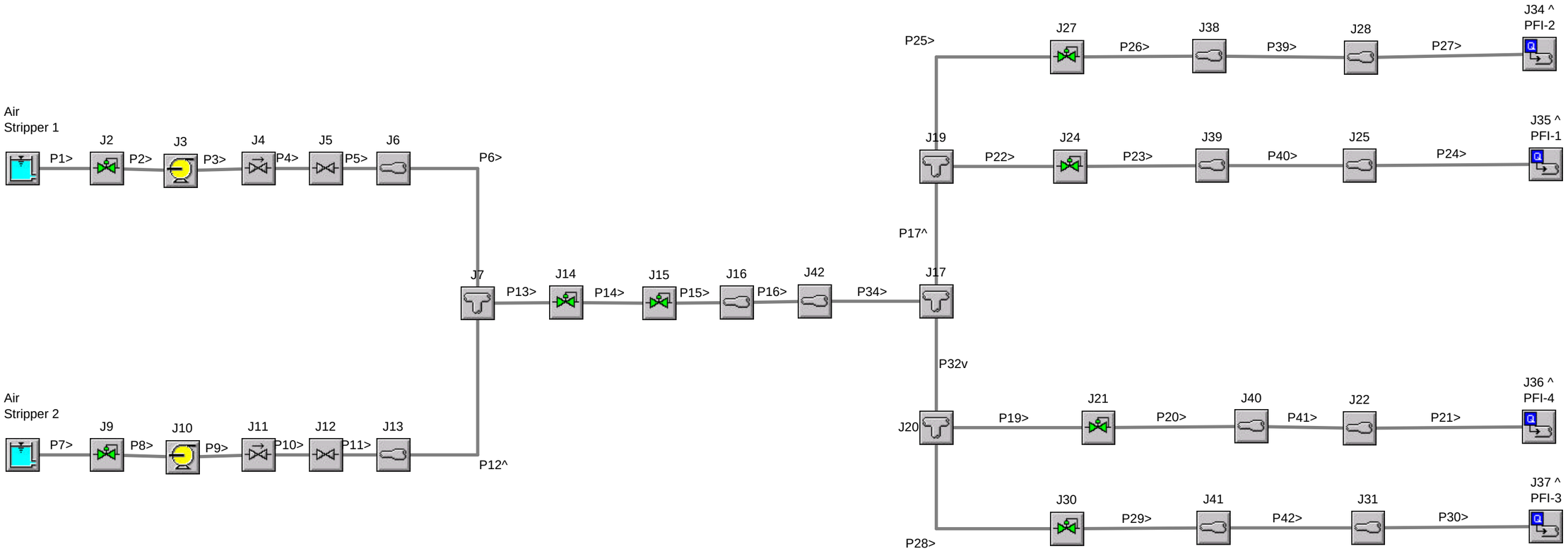
Pipe	Pipe Material	Pipe Nominal Size	Pipe Type-Schedule	Length (feet)	Vol. Flow (gal/min)	Velocity (feet/sec)	dH (feet)	dP Stag. Total (psid)	K	P Stag. In (psig)	P Stag. Out (psig)
21	HDPE	4 inch	DR 17	375.0	194	5.1	8.707	6.803	2.22	89.14	82.33
22	PVC	4 inch	schedule 80	10.0	269	7.5	1.403	0.175	1.11	93.04	92.86
23	PVC	4 inch	schedule 80	8.0	269	7.5	1.885	-0.483	1.76	87.86	88.34
24	HDPE	4 inch	DR 17	975.0	269	7.1	38.298	3.594	2.22	88.15	84.56
25	PVC	4 inch	schedule 80	10.0	269	7.5	1.210	1.390	0.89	93.44	92.05
26	PVC	4 inch	schedule 80	8.0	269	7.5	1.885	-1.782	1.76	87.05	88.84
27	HDPE	6 inch	DR 17	375.0	269	3.3	2.528	-4.536	1.99	88.67	93.21
28	PVC	4 inch	schedule 40	10.0	344	8.7	1.558	1.541	0.88	93.59	92.05
29	PVC	4 inch	schedule 40	8.0	344	8.7	2.454	-1.536	1.74	87.05	88.58
30	HDPE	4 inch	DR 17	30.0	344	9.1	4.581	1.118	2.22	88.28	87.16
32	PVC	6 inch	schedule 80	10.0	538	6.6	0.212	1.824	0.00	95.40	93.58
34	Steel	10 inch	schedule 40	5.0	1076	4.4	0.424	0.184	1.33	95.73	95.55
39	Steel	6 inch	schedule 40	10.0	269	3.0	0.052	0.022	0.00	88.70	88.68
40	Steel	4 inch	schedule 40	10.0	269	6.8	0.397	0.172	0.00	88.34	88.17
41	Steel	4 inch	schedule 40	10.0	194	4.9	0.214	0.093	0.00	89.24	89.15
42	Steel	4 inch	schedule 40	10.0	344	8.7	0.635	0.275	0.00	88.58	88.31

All Junction Table

Jct	Name	Junction Type	Elevation (feet)	Vol. Flow Thru Junction (gal/min)	dH (feet)	Loss Factor (K)	P Stag. In (psig)	P Stag. Out (psig)	dP Stag. (psid)	Vol. Flow Into System (gal/min)
1	Air Stripper 1	Reservoir	4529	538	0.0000	0.0	0.00	0.00	0.0000	538
2	ECV-6WA-XK109	Control Valve	4527	538	16.1611	24.	0.36	-6.64	7.0000	0
3	PU-6WA-XK106	Pump	4527	538	-317.8346	0.0	-7.01	130.65	-137.6668	0
4	One-Way Valve	One Way Valve	4527	538	7.0058	2.0	128.43	125.39	3.0345	0
5	6" Manual Butterfly Valve	Valve	4530	538	2.3788	0.68	122.00	120.97	1.0304	0
6	Area Change	Area Change	4527	538	2.0779	0.59	121.09	120.19	0.9000	0
7	Tee/Wye	Tee or Wye	4527	N/A	See Losses	See Losses	119.89	119.89	See Losses	0
8	Air Stripper 2	Reservoir	4529	538	0.3407	0.50	0.00	0.87	0.1476	538
9	ECV-6WA-XK109	Control Valve	4527	538	16.1611	24.	0.21	-6.79	7.0000	0
10	PU-6WA-XK106	Pump	4527	538	-318.1753	0.0	-7.16	130.65	-137.8144	0
11	One-Way Valve	One Way Valve	4527	538	7.0058	2.0	128.43	125.39	3.0345	0
12	6" Manual Butterfly Valve	Valve	4530	538	2.3788	0.68	122.00	120.97	1.0304	0
13	Area Change	Area Change	4527	538	2.0779	0.59	121.09	120.19	0.9000	0
14	Control Valve	Control Valve	4536	1076	18.4698	25.	115.50	107.50	8.0000	0

Injection Headlosses

Jct	Name	Junction Type	Elevation (feet)	Vol. Flow Thru Junction (gal/min)	dH (feet)	Loss Factor (K)	P Stag. In (psig)	P Stag. Out (psig)	dP Stag. (psid)	Vol. Flow Into System (gal/min)
15	Control Valve	Control Valve	4527	1076	16.1611	22.	111.03	104.03	7.0000	0
16	Area Change	Area Change	4522	1076	0.0583	0.079	105.35	105.32	0.0252	0
17	Tee/Wye	Tee or Wye	4515	N/A	See Losses	See Losses	95.55	95.55	See Losses	0
19	Tee/Wye	Tee or Wye	4519	N/A	See Losses	See Losses	93.47	93.47	See Losses	0
20	Tee/Wye	Tee or Wye	4519	N/A	See Losses	See Losses	93.58	93.58	See Losses	0
21	Control Valve	Control Valve	4518	194	11.5436	31.	93.40	88.40	5.0000	0
22	Area Change	Area Change	4515	194	0.0191	0.051	89.15	89.14	0.0083	0
24	Control Valve	Control Valve	4518	269	11.5436	13.	92.86	87.86	5.0000	0
25	Area Change	Area Change	4515	269	0.0367	0.051	88.17	88.15	0.0159	0
27	Control Valve	Control Valve	4521	269	11.5436	13.	92.05	87.05	5.0000	0
28	Area Change	Area Change	4515	269	0.0132	0.095	88.68	88.67	0.0057	0
30	Control Valve	Control Valve	4521	344	11.5436	9.9	92.05	87.05	5.0000	0
31	Area Change	Area Change	4515	344	0.0600	0.051	88.31	88.28	0.0260	0
34	PFI-2	Assigned Flow	4502	269	0.0000	0.0	93.21	93.21	0.0000	-269
35	PFI-1	Assigned Flow	4485	269	0.0000	0.0	84.56	84.56	0.0000	-269
36	PFI-4	Assigned Flow	4522	194	0.0000	0.0	82.33	82.33	0.0000	-194
37	PFI-3	Assigned Flow	4513	344	0.0000	0.0	87.16	87.16	0.0000	-344
38	Area Change	Area Change	4515	269	0.3174	0.36	88.84	88.70	0.1375	0
39	Area Change	Area Change	4515	269	0.0082	9.4E-03	88.34	88.34	0.0036	0
40	Area Change	Area Change	4515	194	0.0043	9.4E-03	89.24	89.24	0.0019	0
41	Area Change	Area Change	4515	344	0.0000	0.0	88.58	88.58	0.0000	0
42	Area Change	Area Change	4515	1076	0.0054	0.014	95.73	95.73	0.0023	0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J37 ^
PFI-3

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Confidential

Design Report on the

UV/Oxidation Design Test to Treat

NDMA at the NASA White Sands Test Facility

Prepared for

AlliedSignal Technical Services Corporation

by

Calgon Carbon Corporation

P-393

JAN. 4/99

TABLE OF CONTENTS

1.0 SUMMARY

2.0 BACKGROUND

2.1 Photolysis of NDMA

2.2 Advanced Oxidation Processes (AOP)

2.3 UV Dose

2.4 Electrical Energy per Order (EE/O)

3.0 DESIGN TEST RESULTS

3.1 Pilot Unit

3.2 Experimental Procedure

3.3 Groundwater Characterization

3.4 Sample Analysis

3.5 Test Results

3.6 Discussion of Results

3.7 Extrapolation of Results

4.0 FULL SCALE DESIGN

SUPPLEMENTAL INFORMATION

Figure 1

Cutsheets and Drawings

1.0 SUMMARY

This report outlines the design testing results for the UV/Oxidation treatment of groundwater containing NDMA received from the NASA White Sands Test Facility in Las Cruces, NM. A design test was performed to demonstrate the effectiveness of Calgon Carbon Corporation's (CCC) UV/Oxidation process for the destruction of NDMA in the groundwater. The objectives of the design test were:

- to confirm the effectiveness of the UV/oxidation process for reducing NDMA down to the required effluent limit of < 10 ppt.
- to determine the optimal system along with respective capital and operating costs for a 1,000 USgpm full scale system.

The test work completed on the groundwater has confirmed that:

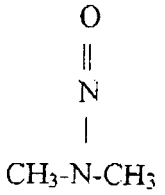
- destruction of NDMA down to the required limit can be obtained using CCC's UV process.
- to meet the treatment objectives for a 1,000 USgpm flow rate, the optimal system would consist of a 180 kW **Rayox**® system.

The estimated selling price for a 2x90 kW **Rayox**® system is US$268,000. Total operating costs are estimated at $0.19/1000 gal or $95,760/yr.

2.0 BACKGROUND

2.1 PHOTOLYSIS OF NDMA

N-Nitrosodimethylamine (NDMA) is a carcinogenic compound which has the following chemical structure:



NDMA is a polar molecule which cannot be treated using conventional technologies such as air stripping or activated carbon. NDMA absorbs UV light strongly in a band centered around 227 nm. Absorption of light in this band results in efficient breaking of the nitrogen-nitrogen bond in the molecule leading to production of an NO radical and a dimethylamino radical as shown in the following equation:

$$(CH_3)_2NNO \xrightarrow{h\nu} (CH_3)_2N\cdot + \cdot NO$$

The NO radical will react with oxidants (i.e. oxygen) to give nitrite which can be further oxidized to nitrate.

Since NDMA absorbs light strongly and dissociates with high efficiency, UV treatment is a cost effective treatment approach. This requires a UV lamp which has good output around 230 nm, where NDMA absorbs most strongly. CCOT's UV lamps are a proprietary design which offer increased output in the region between 200 nm and 250 nm and thus are well suited for photolysis, or light driven destruction mechanism critical for NDMA destruction.

2.2 UV/OXIDATION THEORY

2.2.1 Advanced Oxidation Processes (AOP)

In advanced oxidation processes, the primary treatment mechanism involves the reaction of UV light with hydrogen peroxide to generate highly reactive hydroxyl radicals (•OH) as shown below:

$$H_2O_2 + \text{UV light} \longrightarrow 2\ \cdot OH \qquad [1]$$

The OH radical initiates a rapid cascade of oxidation reactions which, if allowed to proceed to completion, result in carbon dioxide and water as end products. This oxidation can be greatly enhanced by the addition of homogenous catalysts (i.e. CCC's ENOX 910 iron-based catalyst) which increase the efficiency of the UV light reactions.

In some cases, other mechanistic pathways can also be identified such as direct photolysis (as described above) of the contaminants by UV light or direct reaction of oxygen radicals with the target contaminants or their intermediate byproducts.

UV Light

The formation of hydroxyl radicals relies on the absorbance of UV light in the range of 200 to 240 nm. In CCC's UV/oxidation system, this light is provided by high intensity medium pressure mercury vapor lamps. The lamps are housed in quartz tubes and a patented device is used to prevent fouling of the quartz tubes. Calgon Carbon Corporation's medium pressure UV lamps have been designed to give out significantly more UV light in the 200 to 240 nm range than any other UV light source. While UV light is needed for the formation of hydroxyl radicals from hydrogen peroxide, it may also serve to break or weaken the chemical bonds of many organic compounds (i.e. NDMA as is the case here) by direct photolysis. This is important for compounds that react slowly with hydroxyl radicals.

Hydrogen Peroxide

Hydrogen peroxide is a commonly used chemical oxidant in advanced oxidation processes. It is normally supplied in concentrations of 35 or 50% in water and is metered into the flow line upstream of the UV lamps. The combination of high intensity UV light and hydrogen peroxide produces an oxidative environment that is effective for the treatment of a broad range of organic compounds.

2.2.2 *UV Dose*

In the UV oxidation process, a high powered lamp emits UV radiation through a quartz sleeve into the contaminated water. The photons of light activate hydrogen peroxide and generate highly reactive hydroxyl radicals which destroy the organic contaminants. The destruction of organic contaminants is therefore dependent upon the amount of UV light which is applied to the contaminated water.

Calgon Carbon Corporation's design parameter for the scale-up of UV oxidation systems is the "UV dose" which is defined as the amount of UV lamp energy (in kWh) applied to 1000 gallons of water. This design parameter can be calculated from either flow through or batch situations as follows;

$$\text{UV Dose (Batch)} = \frac{\text{Lamp Size(kW)} \times \text{Time(min)} \times 3785\ \text{(L/1000gal)}}{\text{Volume (L)} \times 60\ \text{(min/hr)}}$$

and

$$\text{UV Dose (Flow)} = \frac{\text{Lamp Size (kW)} \times 1000\ \text{(gal/ 1000gal)}}{\text{Flow Rate (gpm)} \times 60\ \text{(min/h)}}$$

The UV Dose is typically used to scale-up from a batch design test to a full scale system. For full scale systems using 30 kW lamps, the calculation uses the 27.5 kW nominal running power instead of the 30 kW maximum power.

2.2.3 *Electrical Energy per Order (EE/O)*

The destruction of a contaminant by a UV/Oxidation process involves a complex series of chemical reactions. Experience has shown that this destruction generally follows a first order relationship with the amount of energy input into a unit volume of water (UV Dose). A simple design parameter, which incorporates the UV Dose input to the system and the number of orders of contaminant destruction, can be used to compare and scale-up processes. This design parameter is defined as the Electrical Energy per Order or the EE/O and its units are in kWh/1000gal/order.

For example, if it takes 10 kWh of electrical energy to reduce the concentration of a target compound from 10 ppm to 1 ppm (1 order of magnitude or 90% destruction) in 1000 gallons of water, then the EE/O is 10 kWh/1000gal/order for this compound. It will take another 10 kWh/1000gal of UV Dose to reduce the compound from 1 ppm to 0.1 ppm (another 90% reduction).

The EE/O values obtained in a batch system can be applied directly to a full scale flowthrough system. The equation for the EE/O which applies to both batch and flow through situations is:

$$\text{EE/O} = \frac{\text{UV Dose}}{\log (C_i/C_f),} \qquad [3]$$

where C_i is the initial concentration and C_f is the final concentration.

In scaling up from bench scale results to a full scale system the EE/O value is calculated. In systems with more than one compound of interest the EE/O for each compound must be determined in the batch testing. The effluent concentration for each compound can then be calculated for the full scale design

3.0 DESIGN TEST RESULTS

3.1 Pilot Unit

Design testing at Calgon Carbon Corporation is performed using a 1 kW pilot unit. The pilot unit consists of a 10 gallon cylindrical stainless steel reactor equipped with a 1 kW lamp. The lamp used has an identical UV output to the 30 kW lamps which are used in a full scale system so that scale-up using the design parameter, UV Dose, is extremely accurate. The 1 kW lamp is mounted vertically in the reactor and separated from the water by a quartz sleeve. An air-actuated transmittance controller automatically wipes the quartz sleeve at regular intervals to ensure that the quartz remains clean throughout the entire run. A mixer in the reactor ensures complete mixing of the sample during the tests. The pilot unit also has a steel shutter which, when closed, serves to block the transmittance of UV light into the sample.

3.2 Experimental Procedure

For the test run, approximately seven (7) gallons of groundwater was added to the pilot unit. An initial sample was taken. The UV Lamp was then ignited with the steel shutter closed. After several minutes of mixing and lamp warm-up, the shutter was opened and the run timer was started. Samples were taken at periodic intervals corresponding to increasing UV doses and were analyzed for NDMA at an outside analytical laboratory.

Results of the test run were compared by plotting the concentration of NDMA as a function of UV dose (expressed as total lamp energy per thousand gallons of water).

3.3 Groundwater Characterization

One 55 gallon drum of water was received on November 27, 1998. Analysis of the water gave the following results shown in Table 1.

Table 1: Results of Preliminary Analysis

Parameter	Mixed Water
Appearance	Clear
TSS, mg/L	< 5
pH	8.6
COD, mg/L	68
Alkalinity, mg/L	110
Total Fe, mg/L	< 1
Chloride, mg/L	21
Nitrate, mg/L	4.5
Bromide, mg/L	< 1

The UV absorbance of the water was measured with values at different wavelengths shown in Table 2.

Table 2: Measured UV Absorbance Values

Wavelength (nm)	Absorbance
200	0.89
210	0.65
220	0.30
230	0.10
240	0.05
250	0.04
260	0.04
270	0.04
280	0.04
290	0.03
300	0.03

In general, a high UV absorbance indicates that non-target water constituents are competing for UV light energy against the target contaminants, thus decreasing treatment efficiency. The absorbance levels of the water were very low, thus indicating little competition for UV light by background contaminants.

3.4 Sample Analysis

Samples were analyzed by Southwest Research Institute for NDMA using EPA Method 607.

3.5 Test Results

Calgon Carbon Corporation carried out one treatment run on the groundwater. The test matrix is summarized in Table 3 and the design test results are presented in Table 4.

Table 3: Design Test Matrix

Run #	Treatment	pH
1	UV Only	As received

Table 4: Analytical Data from Run

Run # 1: UV Only, pH as received

Sample No.	UV Dose kWh/1000gal	NDMA ppt
1-0	0	2750
1-1	1.3	100
1-2	2.6	< 5
1-3	3.9	< 5
1-4	5.2	< 5

3.6 *Discussion of Results*

Figure 1 shows the destruction of NDMA from 2,750 ppt down to < 5 ppt using a UV dose of 2.6 kWh/1000gal. The EE/O for NDMA was calculated to be 0.95 kWh/1000gal/order. The full scale system was sized based on these results. A 180 kW **Rayox®** system consisting of two (2) 90 kW skids would treat the 1,000 gpm flow down to the required NDMA level.

3.7 *Extrapolation of Results*

In scaling up from bench scale results to a full-scale system the EE/O value is calculated. The larger the EE/O the more energy required and hence treatment is less efficient. By comparing EE/O values from each run one can easily see the reduction in electrical power required for treatment as the conditions are varied. By multiplying the EE/O by the number of orders of magnitude of destruction required, the UV dose is obtained.

From Run 1, a UV dose of 2.6 kWh/1000 gallons reduced the NDMA concentration from 2,750 ppt to < 5 ppt. The EE/O, using equation [3] is thus calculated as:

$$EE/O = \frac{2.6}{\log (2{,}750/5)} = 0.95$$

Using this EE/O value, the full size system is easily scaled to any flowrate or concentration required using equation [2]. For example, at 1,000 gpm and 2,750 ppt NDMA influent concentration, the system size to go down to 10 ppt is:

$$\text{UV Dose} = 0.95 \times \log (2{,}750/10) = 2.3 \text{ kWh/1000 gal}$$

$$kW = \frac{2.3 \text{ (kWh/1000 gal)} \times 1{,}000 \text{ (gpm)} \times 60 \text{ (min/h)}}{1000 \text{ (gal/1000 gal)}} = 138 \text{ kW}$$

Each UV lamp operates at a nominal power of 27.5 kW. Using a standard six (6) lamp **Rayox®** system, consisting of two 90 kW skids, will achieve the treatment requirements.

4.0 FULL SCALE DESIGN

For the treatment of NDMA from 2,750 ppt down to < 10 ppt, two 90 kW **Rayox**® skids (180 kW total) is recommended based on a flowrate of 1,000 USgpm.

The estimated capital cost of the proposed system is US$268,000.

The capital cost of the system includes:

- two 90 kW **Rayox**® skids including Quartz Cleaners and Power Supplies
- Programmable Logic Controller (PLC)
- Set of Engineering Drawings and Operating and Maintenance Manuals

The operating costs for a 180 kW system have been estimated as follows:

	$/1000 USgal	*$/year*
Electrical Power (@ $0.06/kWh)	$0.14	$70,560
Lamp Replacement	$0.05	$25,200
Total	**$0.19**	**$95,760**

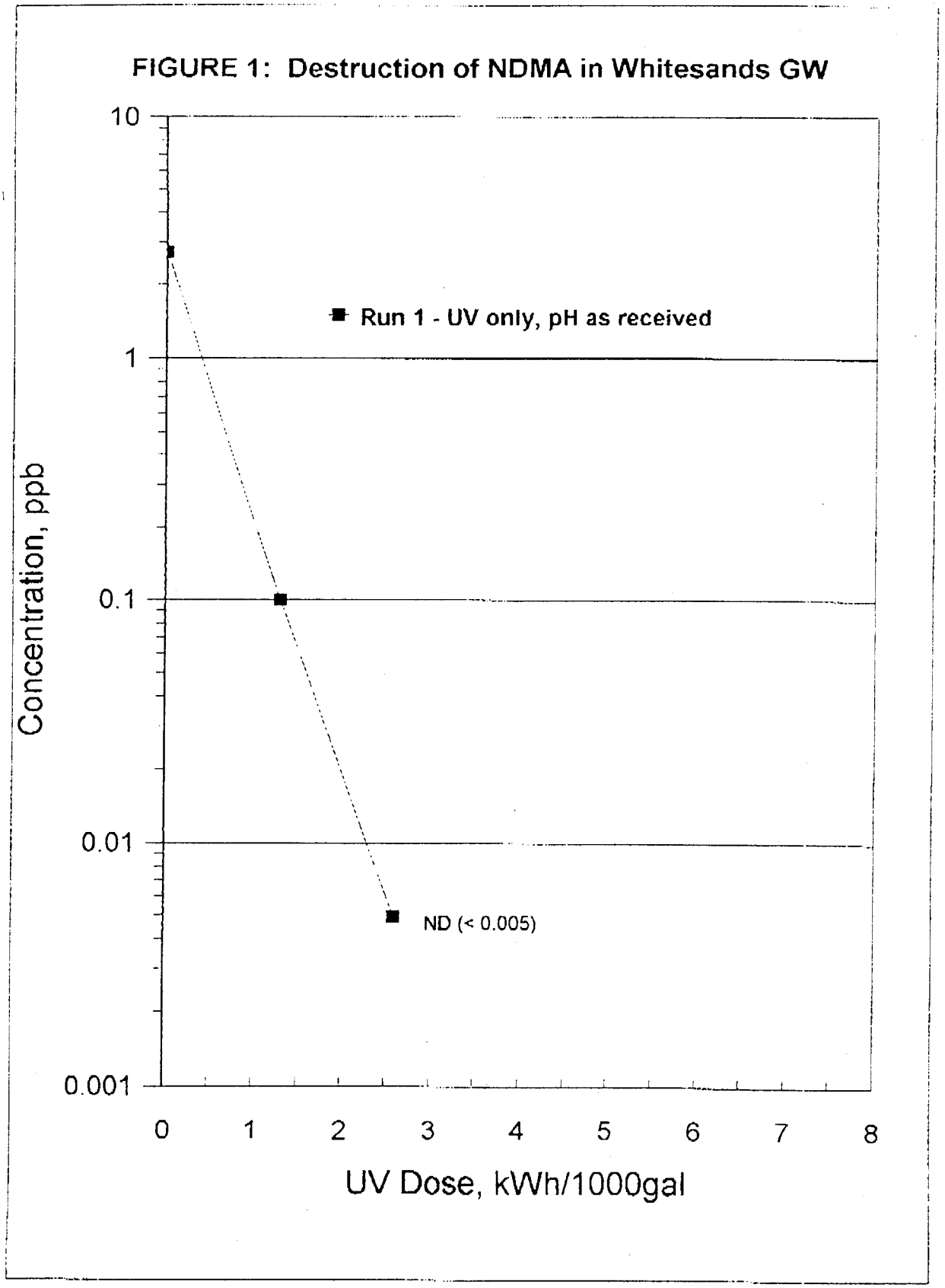
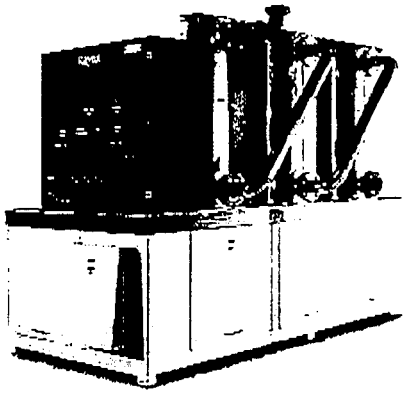


FIGURE 1: Destruction of NDMA in Whitesands GW
10
1
0.1
0.01
0.001
Concentration, ppb
Run 1 - UV only, pH as received
ND (< 0.005)
0
1
2
3
4
5
6
7
8
UV Dose, kWh/1000gal

Rayox® Modular Treatment System

Model 90 (90 kW System)

Calgon Carbon Corporation
Advanced Oxidation Technologies



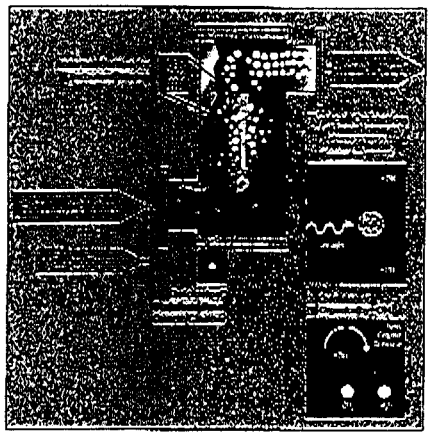
OVERVIEW

The Rayox® system supplied by Calgon Carbon Corporation Advanced Oxidation Technologies (CCAOT) destroys dissolved organic contaminants in contaminated water. In this system, a proprietary high-powered, medium-pressure lamp emits high-energy UV radiation through a quartz sleeve into the contaminated water. An oxidizing agent, typically hydrogen peroxide, is added to the contaminated water and is activated by the UV light to form oxidizing species called hydroxyl radicals, via:

$$H_2O_2 + UV \longrightarrow 2(\bullet OH)$$

The hydroxyl radical then reacts with the dissolved contaminants, initiating a rapid cascade of oxidation reactions that ultimately fully oxidizes (mineralizes) the contaminants. The success of the system is based on the fact that the rate constants for the reaction of •OH radicals with most organic pollutants are very high. The hydroxyl radical typically reacts a million to a billion times faster than chemical oxidants such as ozone and hydrogen peroxide. In addition, many organic contaminants are split into smaller components by the direct absorption of UV light in the UV-C spectral range emitted by proprietary medium-pressure UV lamps.

The Rayox® system and its components are covered by numerous issued and pending patents.



SYSTEM SPECIFICATIONS

- Configuration: 3 x 30 kW Reactor
- Power Supply: 480 VAC, 3ph, 60 Hz (alternate power supplies available)
- Control System: PLC KOYO 405
- Materials: Wetted Parts - 316SS, Quartz, Fluoropolymers
  External Parts - Epoxy Coated Steel, 316SS
- Shipping Weight: 7,000 lbs/3,200 kg
- L x W x H: 107"x 49"x 88"

MODEL FEATURES

- Skid-Mounted Module
- Proven, Fully Automated PLC System Control
- Patented, Field Proven Lamp Cleaning Device
- OSHA Approved
- NEC Approved
- CSA Certified
- 3,000 Hours Lamp Warranty
- State-of-the-Art Lamp Power Supply
- Safety Interlock Switches
- Magnetic Flowmeters
- Easy Installation
- NEMA 3R Available

Rayox® is a registered trademark of Calgon Carbon Corporation.

CALGON
CALGON CARBON CORPORATION

FOR MORE INFORMATION, CALL 800-422-7266

Brussels, Belgium Pittsburgh, PA, USA Toronto, Canada

LEOT-R90-6/98

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-1**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115315	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**2.63 ppb**	
N-Nitrodimethylamine	4164-28-7	< 0.01ppb	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-2**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115316	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**2.89 ppb**	
N-Nitrodimethylamine	4164-28-7	< 0.01ppb	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-4**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115318	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.11 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.12 ppb**	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-5**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115319	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01ppb	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-6**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115320	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01ppb	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-7**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115321	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01ppb	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-8**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115322	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01ppb	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**Field Blank**	Sample Volume:	1000 mL
Well ID:		Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115324	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01ppb	

Southwest Research Institute

Matrix Spike Recovery Report

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-3 MS**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115317	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.05 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Compared Sample #:	**981202-2**

ANALYTE	CAS #	Spike Level	MS recovery
N-Nitrosodimethylamine	62-75-9	0.50 ppb	68 %
N-Nitrodimethylamine	4164-28-7	0.50 ppb	61 %

Southwest Research Institute

Matrix Spike Recovery Report

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-9 MS**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115323	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.05 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Compared Sample #:	**981202-8**

ANALYTE	CAS #	Spike Level	MS recovery
N-Nitrosodimethylamine	62-75-9	0.50 ppb	41 %
N-Nitrodimethylamine	4164-28-7	0.50 ppb	60 %

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-1**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115315	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**2.63 ppb**	
N-Nitrodimethylamine	4164-28-7	< 0.01ppb	

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Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-2**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115316	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**2.89 ppb**	
N-Nitrodimethylamine	4164-28-7	< 0.01ppb	

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Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-4**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115318	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.11 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.12 ppb**	

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Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-5**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115319	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01ppb	

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Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-6**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115320	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01ppb	

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Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-7**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115321	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01ppb	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-8**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115322	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01ppb	

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Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**Field Blank**	Sample Volume:	1000 mL
Well ID:		Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115324	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.01 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Extraction Efficiency:	NDMA 68%
			DMN 61%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01ppb	

Southwest Research Institute

Matrix Spike Recovery Report

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-3 MS**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115317	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.05 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Compared Sample #:	**981202-2**

ANALYTE	CAS #	Spike Level	MS recovery
N-Nitrosodimethylamine	62-75-9	0.50 ppb	68 %
N-Nitrodimethylamine	4164-28-7	0.50 ppb	61 %

Southwest Research Institute

Matrix Spike Recovery Report

SwRI Project #:	01-1608-001	Reporting Data:	12/28/1998
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**981202-9 MS**	Sample Volume:	1000 mL
Well ID:	**Bench Test**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	14715-115323	Analytical Method:	Mod-607
Receiving Data:	12/03/1998	Reporting Limit:	0.05 ppb
Extraction Data:	12/07/1998	MDL:	0.005 ppb
GC/MS Analysis Data:	12/18/1998	Compared Sample #:	**981202-8**

ANALYTE	CAS #	Spike Level	MS recovery
N-Nitrosodimethylamine	62-75-9	0.50 ppb	41 %
N-Nitrodimethylamine	4164-28-7	0.50 ppb	60 %

Confidential

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Design Report on the

UV/Oxidation Pilot to Treat NASA PT Well Groundwater

at the

NASA Whitesands Testing Facility

Prepared for

AlliedSignal Technical Services Corporation
Las Cruces, NM

by

Calgon Carbon Corporation

P-393 ***MAY 20, 1999***

TABLE OF CONTENTS

1.0 SUMMARY

2.0 UV/OXIDATION THEORY

- *2.1 Photolysis of NDMA*
- *2.2 Advanced Oxidation Processes (AOP)*
- *2.3 UV Dose*
- *2.4 Electrical Energy per Order (EE/O)*

3.0 DESIGN TEST RESULTS

- *3.1 perox-pure™ Pilot Unit*
- *3.2 Peroxide Dosing System*
- *3.3 Test Procedure*
- *3.4 Groundwater Characterization*
- *3.5 Sample Analysis*
- *3.6 Test Results*
- *3.7 Discussion of Results*
- *3.8 Extrapolation of Results*

4.0 FULL SCALE DESIGN

ATTACHED FIGURES

Figure 1 - Destruction of NDMA
Figure 2 - Destruction of DMA

APPENDIX

I - Equipment
perox-pure™ Pilot Unit Schematic

II - Treatment Data
Raw Data from Outside Laboratory

1.0 SUMMARY

This report outlines the pilot testing results and full scale system design recommended for the UV/oxidation treatment of N-Nitrosodimethylamine (NDMA) and N-Nitrodimethylamine (DMA) from the NASA-PT Well at the Whitesands Test Facility in Las Cruces, NM. Pilot tests were conducted between April 2 and April 3, 1999, with the actual groundwater stream. The purpose of the pilot test was to confirm the effectiveness of Calgon Carbon Corporation's (CCC) UV/oxidation process for the destruction of NDMA and DMA in groundwater. Previous bench testing at Calgon's Markham, Ontario, facility with actual groundwater demonstrated the destruction of NDMA. The objectives of the tests were:

- to confirm the effectiveness of UV/oxidation for reducing the NDMA and DMA concentrations in the groundwater from 2,000 ppt each down to the required effluent limit of < 10 ppt each.

- to replicate as closely as possible the destruction efficiency of NDMA in the pilot to that observed during bench testing. The EE/O for NDMA during bench testing was 0.95 kWh/1000gal/order.

- to determine the improvement in treatment efficiency, if any, with the use of peroxide as an oxidant.

- to determine the optimal treatment system along with respective capital and operating costs for a 900 USgpm full scale system.

The pilot test completed on the groundwater has confirmed that:

- successful treatment of NDMA and DMA down to the required limit was obtained using UV only.

- the EE/O for NDMA obtained in the pilot was 1.3 kWh/1000gal/order. This agreed well with an EE/O of 0.95 kWh/1000gal/order which was obtained in bench tests.

- hydrogen peroxide showed little to no improvement for the destruction of NDMA and DMA. In fact, a high dose of peroxide seemed to inhibit oxidation of the target compounds.

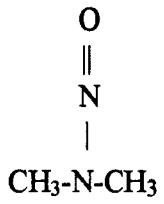
- a 12 lamp **Rayox®** Tower is adequate for treatment of the NDMA and DMA down to the required levels.

The estimated selling price for the 12 lamp **Rayox®** Tower is $420,000. Operating costs are estimated at $0.34/1000gal or $154,000 per year.

2.0 UV/OXIDATION THEORY

2.1 Photolysis of NDMA

N-Nitrosodimethylamine (NDMA) is a carcinogenic compound which has the following chemical structure:



NDMA is a polar molecule which cannot be treated using conventional technologies such as air stripping or activated carbon. NDMA absorbs UV light strongly in a band centered around 227 nm. Absorption of light in this band results in efficient breaking of the nitrogen-nitrogen bond in the molecule leading to production of an NO radical and a dimethylamino radical as shown in the following equation:

$$(CH_3)_2NNO \xleftrightarrow{h\nu} (CH_3)_2N\bullet + \bullet NO$$

The NO radical will react with oxidants (i.e. oxygen) to give nitrite which can be further oxidized to nitrate.

Since NDMA absorbs light strongly and dissociates with high efficiency, UV treatment is a cost effective treatment approach. This requires a UV lamp which has good output around 230 nm, where NDMA absorbs most strongly. CCOT's UV lamps are a proprietary design which offer increased output in the region between 200 nm and 250 nm and thus are well suited for photolysis, or light driven destruction mechanism critical for NDMA destruction. The photolysis of N-nitrodimethylamine (DMA) follows a similar destruction mechanism as NDMA.

2.2 Advanced Oxidation Processes (AOP)

In advanced oxidation processes, the primary treatment mechanism involves the reaction of UV light with hydrogen peroxide or ozone to generate highly reactive hydroxyl radicals (•OH) as shown below:

$$H_2O_2 + \text{UV light} \longrightarrow 2\ \bullet OH \qquad [1]$$

The OH radical initiates a rapid cascade of oxidation reactions which, if allowed to proceed to completion, result in carbon dioxide and water as end products. This oxidation can be greatly enhanced by the addition of homogenous catalysts which increase the efficiency of the UV light reactions.

In some cases, other mechanistic pathways can also be identified such as direct photolysis of the contaminants by UV light or direct reaction of ozone or oxygen radicals with the target contaminants or their intermediate byproducts.

UV Light

The formation of hydroxyl radicals relies on the absorbance of UV light in the range of 200 to 240 nm. In CCOT's UV/oxidation system, this light is provided by high intensity medium pressure mercury vapor lamps. The lamps are housed in quartz tubes and a patented device is used to prevent fouling of the quartz tubes. Calgon Carbon Oxidation Technologies' medium pressure UV lamps have been designed to give out significantly more UV light in the 200 to 240 nm range than any other UV light source. While UV light is needed for the formation of hydroxyl radicals from hydrogen peroxide, it may also serve to break or weaken the chemical bonds of many organic compounds by direct photolysis. This is important for compounds that react slowly with hydroxyl radicals.

Hydrogen Peroxide

Hydrogen peroxide is a commonly used chemical oxidant in advanced oxidation processes. It is normally supplied in concentrations of 35 or 50% in water and is metered into the flow line upstream of the UV lamps. The combination of high intensity UV light and hydrogen peroxide produces an oxidative environment that is effective for the treatment of a broad range of organic compounds.

2.3 UV Dose

In the UV oxidation process, a high powered lamp emits UV radiation through a quartz sleeve into the contaminated water. The photons of light activate hydrogen peroxide, ozone or a catalyst and generate highly reactive radicals which destroy the organic contaminants. The destruction of organic contaminants is therefore dependent upon the amount of UV light which is applied to the contaminated water.

Calgon Carbon Oxidation Technologies' design parameter for the scale-up of UV oxidation systems is the "UV dose" which is defined as the amount of UV lamp energy (in kWh) applied to 1000 gallons of water. This design parameter can be calculated as follows;

$$\text{UV Dose} = \frac{\text{Lamp Size (kW)} \times 1000\ \text{(gal/ 1000gal)}}{\text{Flow Rate (gpm)} \times 60\ \text{(min/h)}} \qquad [1]$$

The UV Dose is used to scale up to a full scale system. For full scale Tower systems using 30 kW lamps, the calculation uses the 23 kW nominal running power for Tower systems instead of the 30 kW maximum power.

2.4 Electrical Energy per Order (EE/O)

The destruction of a contaminant by a UV/Oxidation process involves a complex series of chemical reactions. Experience has shown that this destruction generally follows a first order relationship with the amount of energy input into a unit volume of water (UV Dose). A simple design parameter, which incorporates the UV Dose input to the system and the number of orders of contaminant destruction, can be used to compare and scale-up processes. This design parameter is defined as the Electrical Energy per Order or the EE/O and its units are in kWh/1000gal/order.

For example, if it takes 10 kWh of electrical energy to reduce the concentration of a target compound from 10 ppm to 1 ppm (1 order of magnitude or 90% destruction) in 1000 gallons of water, then the EE/O is 10 kWh/1000gal/order for this compound. It will take another 10 kWh/1000gal of UV Dose to reduce the compound from 1 ppm to 0.1 ppm (another 90% reduction).

The EE/O values obtained in a batch system can be applied directly to a full scale flowthrough system. The equation for the EE/O which applies to both batch and flow through situations is:

$$EE/O = \frac{\text{UV Dose}}{\log (C_i/C_f),} \qquad [2]$$

where C_i is the initial concentration and C_f is the final concentration.

In scaling up from pilot scale results to a full scale system the EE/O value is calculated. In systems with more than one compound of interest the EE/O for each compound must be determined. The effluent concentration for each compound can then be calculated for the full scale design.

3.0 DESIGN TEST RESULTS

3.1 perox-pure™ Pilot Unit

CCC's on-site tests were performed using a 3x5 kW perox-pure™ pilot unit. This unit consisted of three 5 kW lamps each mounted horizontally above one another in separate 6" reactor chambers. The water flowed in series through a serpentine pattern into each reactor chamber. Each 5 kW lamp was enclosed in a quartz sleeve to prevent water from coming in direct contact with the lamp. Each lamp also had an identical UV output to the UV lamps which would be used in a full scale system so that scale-up using the design parameter, UV Dose, was extremely accurate. The reactor chambers were made of aluminum with an inner Teflon lining. Around each quartz was a Teflon ring which served to clean the quartz tube. The ring would travel the length of the quartz tube and wipe the quartz clean. Automated valves would be actuated to reverse the flow of water when the cleaning sequence was initiated. The wiper was manually activated by a push button. The cycle time for quartz cleaning was approximately one minute. The unit along with all the controls and interconnecting piping was skid mounted on a painted steel frame. The unit was controlled via a PC controller housed inside the control panel.

Sample ports for water were located before and after the UV unit. In addition, there were intermediate sample points after each 5 kW lamp. A water totalizer was used to measure the water flowrate. The influent flowrate to the reactor was controlled by a manual valve (supplied by AlliedSignal) external to the pilot unit.

3.2 Peroxide Dosing System

For some of the test runs, hydrogen peroxide was metered into influent stream with a Prominent metering pump. The peroxide concentration used was 35% wt. The peroxide flowrate typically ranged between 13 to 35 mL/min during testing. The peroxide was supplied from a 15 gal drum.

3.3 Test Procedure

The groundwater was pumped from the NASA-PT Well at the Whitesands site. The groundwater stream was pumped at a flowrate of 60-90 gpm into the pilot unit with all three 5 kW lamps on. Prior to entering the first UV reactor chamber, the water was mixed with hydrogen peroxide (if used) supplied from a metering pump. A minimum of three reactor volumes (90 USgal) of water were required before the reactor reached a steady state condition. After this time, water samples were taken at the reactor inlet and after each lamp. By

sampling after each lamp, a relationship was made between the UV dose required and the amount of NDMA and DMA destroyed.

3.4 Groundwater Characterization

Analysis of the groundwater gave the following results shown in Table 1.

Table 1: Results of Preliminary Analysis

Parameter	1 um Filtered
Appearance	Clear, colourless
TSS, mg/L	< 5
pH	7-8
COD, mg/L	Not analyzed
Alkalinity, mg/L	220
Total Fe, mg/L	< 1
Chloride, mg/L	55
Nitrate, mg/L	2.1
Bromide, mg/L	< 1
[NDMA], ppt	800
[DMA], ppt	500

The UV absorbance of the groundwater was measured with values at different wavelengths shown in Table 2.

Table 2: Measured UV Absorbance Values

Wavelength (nm)	Absorbance
200	1.95
210	1.54
220	0.63
230	0.09
240	0.0004
250	0.0032
260	0.0046
270	0.0049
280	0.0055
290	0.0068

With the UV/peroxide process, peroxide absorbs UV light predominantly in the 200 to 240 nm region. In general, a high UV absorbance by the water matrix indicates that non-target water constituents are competing for UV light energy against the target contaminants and hydrogen peroxide, thus decreasing treatment efficiency. The absorbance levels of the water were low, thus indicating there would be little interference from competing species.

3.5 Sample Analysis

Samples were taken in 1L amber bottles for NDMA and DMA analysis using the standard 607 Method and hi-res 607 Method. Additional samples were collected for alkalinity, chloride, TDS, fluoride, VOCs, halogenated VOCs, and sulfate. Field blanks and blind controls were collected for lab QA/QC purposes. All collected samples were immediately stored in a cooler with ice packs for preservation. Samples were sent to an outside laboratory, Southwest Research Institute, Denver, CO. for analysis.

3.6 Test Results

Calgon Carbon carried out seven (7) treatment runs on the groundwater, 6 of which will be discussed in this report. Run 1, 2, and 5 used UV only. Run 3, 4, and 6 used UV/peroxide. Run 7 was conducted for internal purposes and will not be discussed in this report. The test matrix is summarized in Table 3 and the design test results are presented in Table 4.

Table 3: Test Matrix for NASA-PT Well Pilot Test

Run #	Flowrate (USgpm)	Peroxide Dose (ppm)	Analysis
1	60	NA	NDMA, DMA, halogenated VOCs, VOCs
2	80	NA	NDMA, DMA, halogenated VOCs, VOCs
3	60	20	NDMA, DMA, halogenated VOCs, VOCs
4	80	40	NDMA, DMA, halogenated VOCs, VOCs
5	90	NA	NDMA, DMA, halogenated VOCs, VOCs, anions, cations, TDS
6	90	20	NDMA, DMA, halogenated VOCs, VOCs, anions, cations, TDS

Table 4: Analytical Data from Runs

Run 1 - 60 gpm, UV only, no peroxide

CCC Sample No.	AlliedSignal Sample No.*	UV Dose (kWh/1000gal)	[NDMA] (ppt)	[DMA] (ppt)
1-0	9904020845	0	750	550
1-1	9904020847	1.2	80	110
1-2	9904020849	2.3	336	348
1-3	9904020851	3.5	67	67

Run 2 - 80 gpm, UV only, no peroxide

CCC Sample No.	AlliedSignal Sample No.*	UV Dose (kWh/1000gal)	[NDMA] (ppt)	[DMA] (ppt)
2-0	9904020909	0	790	570
2-1	9904020911	0.9	230	240
2-2	9904020913	1.8	939	908
2-3	9904020915	2.6	579	646

Run 3 - 60 gpm, UV/20 ppm peroxide

CCC Sample No.	AlliedSignal Sample No.*	UV Dose (kWh/1000gal)	[NDMA] (ppt)	[DMA] (ppt)
3-0	9904030912	0	800	550
3-1	9904030914	1.2	130	60
3-2	9904030916	2.3	220	150
3-3	9904030918	3.5	63.2	12.2

Run 4 - 80 gpm, UV/40 ppm peroxide

CCC Sample No.	AlliedSignal Sample No.*	UV Dose (kWh/1000gal)	[NDMA] (ppt)	[DMA] (ppt)
4-0	9904030840	0	840	560
4-1	9904030842	0.9	330	160
4-2	9904030844	1.8	1010	726
4-3	9904030846	2.6	455	240

Run 5 - 90 gpm, UV only, no peroxide

CCC Sample No.	AlliedSignal Sample No.+	UV Dose (kWh/1000gal)	[NDMA] (ppt)	[DMA] (ppt)
5-0	9904020933	0	830	565
5-1	9904020941	0.8	195	195
5-2	9904020949	1.6	55	65
5-3	9904020957	2.3	15	20

Run 6 - 90 gpm, UV/20 ppm peroxide

CCC Sample No.	AlliedSignal Sample No.*	UV Dose (kWh/1000gal)	[NDMA] (ppt)	[DMA] (ppt)
6-0	9904030720	0	830	565
6-1	9904030724	0.8	195	195
6-2	9904030728	1.6	55	65
6-3	9904030732	2.3	15	20

+ All analytical correspond to the standard 607 method.

* The first two samples (-0, -1) correspond to the standard 607 method. The last two samples (-2, -3) correspond to the 607 hi-res method.

The Appendix also contains analytical data for the following:

- anions and cations from Run 5 and Run 6
- VOCs detected in the groundwater. Only the VOCs which were detected were reported.
- phthalates and bromacil from Run 5 and Run 6

3.7 Discussion of Results

The tests results showed the extent of NDMA and DMA destruction in the groundwater for increasing UV doses. Results were compared by plotting the concentration of NDMA and DMA as a function of UV dose (calculated as total lamp energy per thousand USgallons of water). From the data presented in Table 4, the initial (influent) sample corresponds to the x-0 sample. Subsequent sample numbers correspond to samples collected after each of three 5 kW lamp.

The raw data showed that there was a large discrepancy between the standard 607 method and the hi-res 607 method for NDMA and DMA analysis. The duplicates collected in Run 5 for both analytical methods showed this discrepancy (up to a factor of 25x). In addition, in all the test runs, the first two samples collected were analyzed using the standard 607 method with the last two using the hi-res method. For every run, the first two data points showed good destruction of NDMA and DMA. However, the third data point in every run using the hi-res method showed an increase in NDMA and DMA concentration. Photochemically, it is not possible to have reformation of NDMA and DMA at these levels from UV photolysis. Thus, it was concluded with confidence that the hi-res method did not provide reliable analytical data in this pilot test. All data from the hi-res 607 method were not used in sizing the full scale UV system. This was not surprising as NDMA is a compound which is completely soluble making it very difficult to extract and analyze. Furthermore, new methods which have not been perfected, are sometimes used to attempt to analyze this compound down to stringent levels imposed by regulatory agencies.

The data from the UV only runs (Run 1, 2, and 5) were compared with those using UV/peroxide (Run 3, 4, and 6) for NDMA and DMA destruction efficiency. The use of peroxide provided little (< 7%) added efficiency in destroying the NDMA and DMA compared with UV alone. In fact, with high peroxide doses (40 ppm) in Run 4, destruction of the target compounds was slower than with using UV alone. This was due to the fact that the destruction of NDMA and DMA occurred by UV photolysis and not hydroxyl radical attack. With the presence of peroxide, more of the UV light was absorbed by peroxide, leaving less available for breaking down the NDMA and DMA, thus slowing down the destruction rate of these compounds. As a result, it is recommended that peroxide not be used for the destruction of NDMA and DMA. For compounds which are oxidized via the hydroxyl radical (ie. VOCs), the use of UV/peroxide would enhance the rate of their destruction. If there are trace VOCs which must be removed in the groundwater, it is recommended that pretreatment with GAC or air stripping be implemented. Using

UV/peroxide to destroy the VOCs would likely slow the destruction rate of NDMA and DMA by about as much as 70%.

The data which was used in sizing the full scale system was taken from Run 1, 2, and 5. The standard 607 analytical data from these runs were plotted and is shown in Figure 1 and Figure 2.

Figure 1 shows the destruction of NDMA. The rate of destruction of this compound was very fast with an EE/O of 1.3 kWh/1000gal/order. This was due to the low concentration of NDMA combined with the low background UV absorbance of the water in the 220 to 230 nm region, where NDMA absorbs UV light.

Figure 2 shows the destruction of DMA. Again, the rate of destruction of this compound was very fast with an EE/O of 1.6 kWh/1000gal/order. This was also due to its low concentration and the low background UV absorbance of the water.

The EE/O for NDMA at 1.3 kWh/1000gal/order agreed very well with the EE/O of 0.95 kWh/1000gal/order obtained from lab scale bench testing in January 1999. The difference in EE/O could be attributed to a combination of finer control of testing parameters in the lab and a lower absorbance water tested in the lab.

The anion and cation data showed that all parameters were well below the limits for UV/oxidation. Primarily, dissolved iron is of the biggest concern as iron absorbs UV light at natural pH. The dissolved iron concentration at <1 ppm was acceptable.

The VOC data (included halogenated VOCs) showed that there was typically low levels of TCE (100-500 ppb) and halogenated VOCs (<1100 ppb). If required, these could be removed using an upstream air stripper or GAC vessel. The VOC data did not reveal any compounds which would seem to affect treatment of the NDMA and DMA.

The phthalate and bromacil data showed no definite presence of these compounds. There were two samples with flagged "j-values" for phthalates, but subsequent irradiated samples showed that these compounds were not detected.

3.8 Extrapolation of Results

In scaling up from pilot scale results to a full-scale system the EE/O value is calculated. The larger the EE/O the more energy required and hence treatment is less efficient. By multiplying the EE/O by the number of orders of magnitude of destruction required, the UV dose is obtained.

From the pilot test data below, a UV dose of 2.3 kWh/1000 gallons reduced the DMA (controlling compound) concentration from 562 ppt to 20 ppt.

Figure 1 Data, UV only, no peroxide

UV Dose (kWh/1000gal)	[NDMA]$^{+}$ (ppt)	[DMA]$^{+}$ (ppt)
0	790	562
0.8	195	195
0.9	230	240
1.2	80	110
1.6	55	65
2.3	15	20

$^{+}$ All analytical correspond to the standard 607 method.

The EE/O, using equation [2] is thus calculated as:

$$EE/O = \frac{2.3}{\log (562/20)} = 1.6$$

Using this EE/O value, the full size system is easily scaled to any flowrate or concentration required using equation [1]. For example, at the design influent of 900 USgpm and 2,000 ppt DMA, the system size to go down to <10 ppt is:

$$\text{UV Dose} = 1.6 \times \log (2000/10) = 3.7 \text{ kWh/1000 gal}$$

$$kW = \frac{3.7 \text{ (kWh/1000 gal)} \times 900 \text{ (USgpm)} \times 60 \text{ (min/h)}}{1000 \text{ (gal/1000 gal)}} = 200 \text{ kW}$$

Thus a total lamp power of 200 kW is required. In the **Rayox®** Tower, each lamp operates at 23 kW; thus a 12 lamp **Rayox®** Tower utilizing 9 lamps in operation will be adequate. With 9 lamps operating, the NDMA concentration

will also be treated from 2,000 ppt down to < 10 ppt. The additional lamps supplied with the system can be turned on in the event of higher contaminant concentrations or a higher anticipated flow.

4.0 FULL SCALE DESIGN

For treatment of NDMA and DMA to the specified discharge requirement of <10 ppt each, a 12 lamp **Rayox®** Tower is recommended based on a flowrate of 900 USgpm.

The estimated capital cost of the **Rayox®** Tower is US$420,000.

The capital cost of the system includes:

- **Rayox®** Tower with 12 lamps including quartz cleaners and power supplies
- Magnetic flow meter/totalizer
- PLC System Controller.
- Set of Engineering Drawings and Operating and Maintenance Manuals.

The estimated operating costs of the system can be broken out as follows:

	$/1000 USgal	*$/year*
Electrical Power (@ $0.06/kWh)	$0.24	$108,864
Replacement UV lamps	$0.10	$ 45,360
Total	**$0.34**	**$154,224**

If required, the treatment of trace VOCs could be implemented with an air stripper or GAC upfront of the UV Tower. If an air stripper is used, the pH is typically lowered down to an acidic range to control scaling. If pH adjustment is required, it is recommended that sulfuric acid be used as sulphates do not affect UV/oxidation. Alternatively, if a phosphate-bearing sequestering agent is used at a low concentration (ie. < 5 ppm) for scaling, it is also unlikely that these types of compounds would affect the treatment of NDMA and DMA with UV.

ATTACHED FIGURES

FIGURE 1: Destruction of NDMA in Whitesands Water

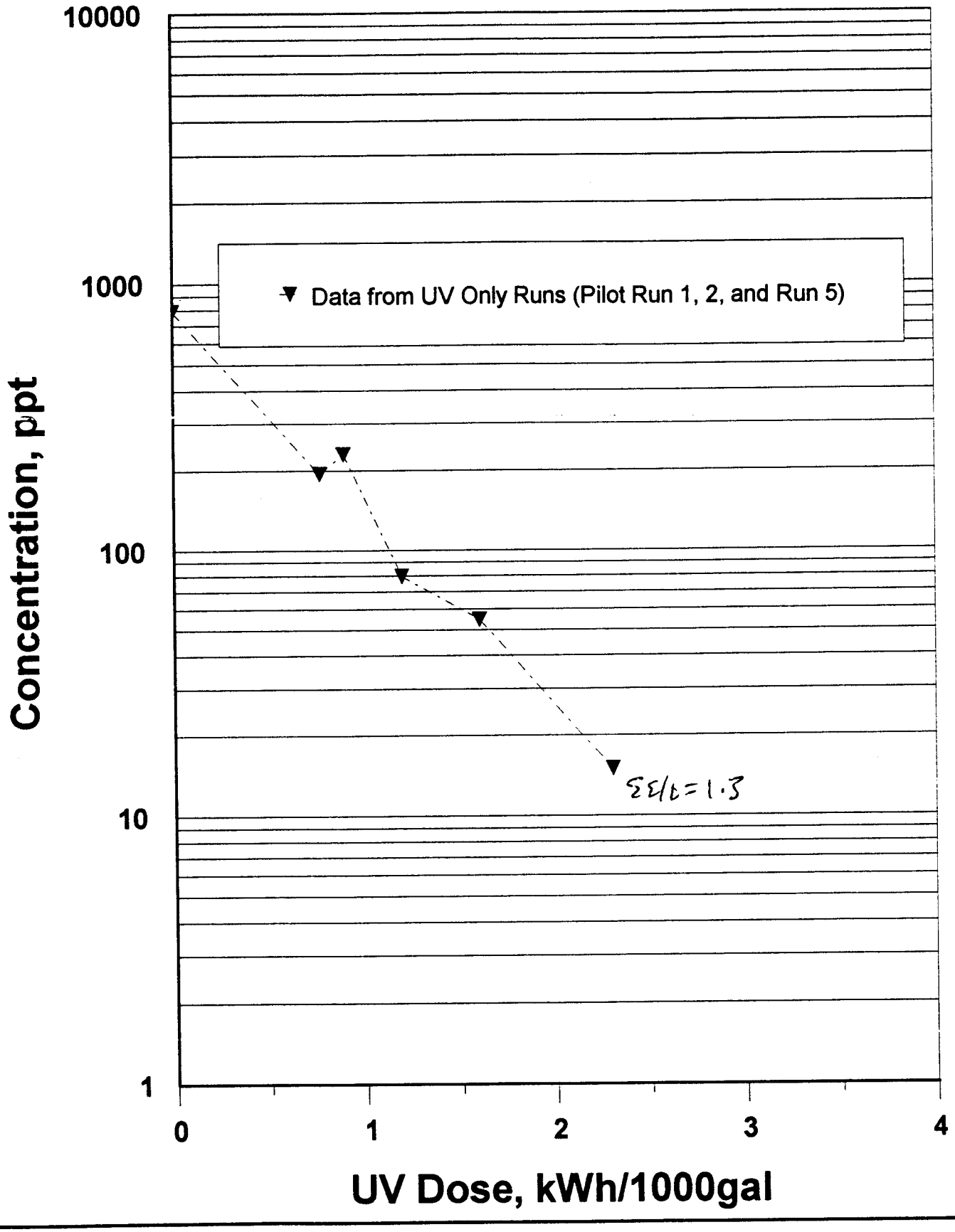
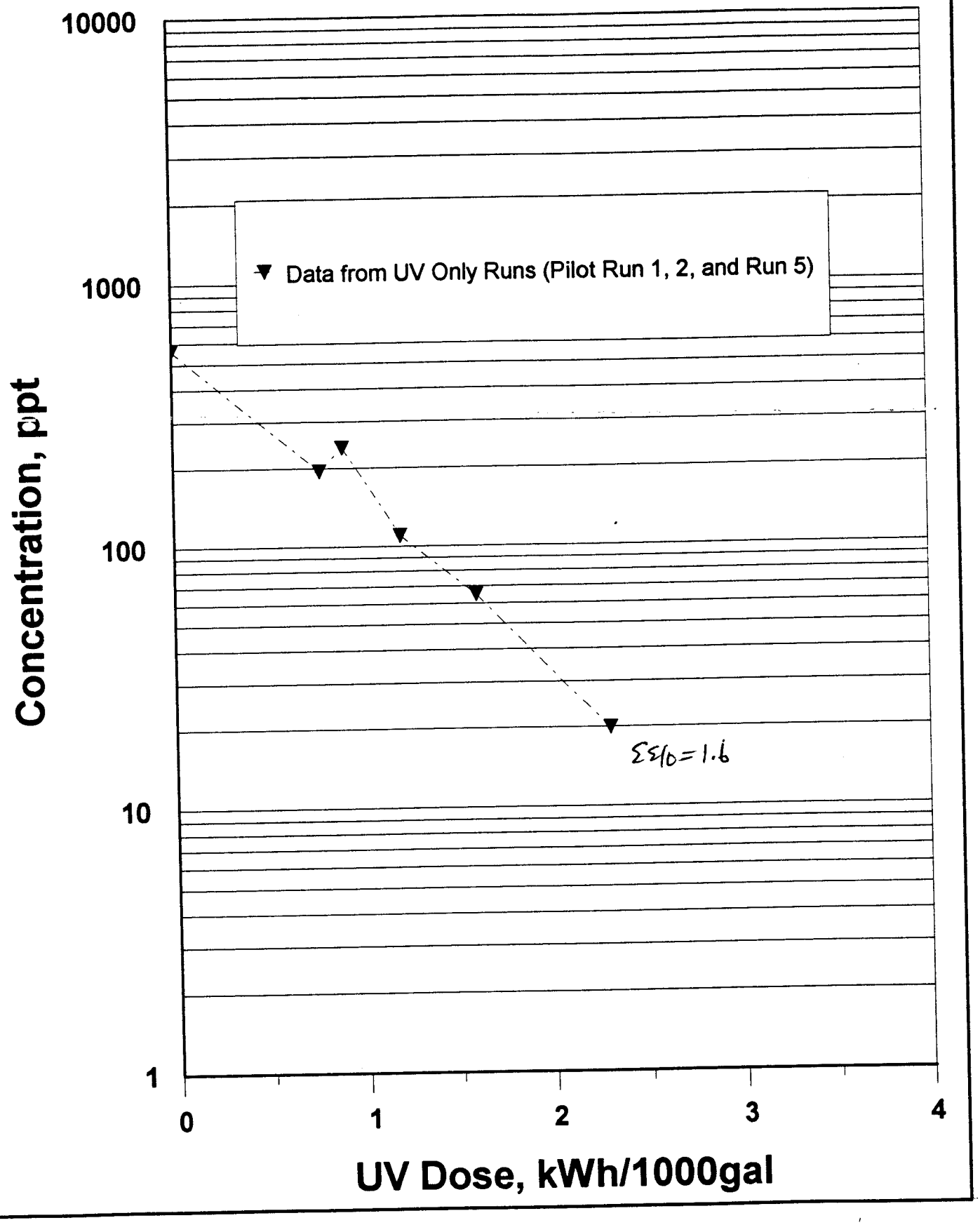
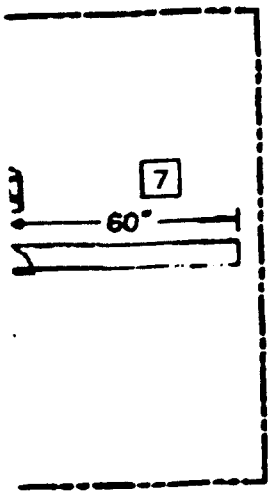


FIGURE 2: Destruction of DMA in Whitesands Water



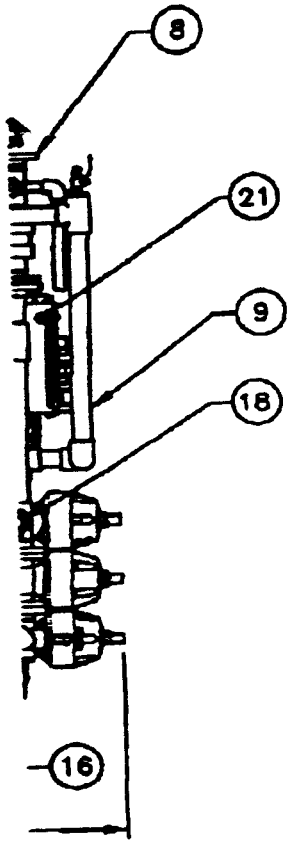
APPENDIX



IIREMENTS

NOTES:

1. PIPING CONNECTION LOCATIONS MAY VARY FROM LOCATIONS SHOWN 1/2" IN ANY DIRECTION.
2. OPERATING PRESSURE: 15 PSIG MAX.
3. POWER SUPPLY: 3Ø/60/480V, 30 KW
   CONTROL POWER: 1Ø/60 120V
   (SEE ELECTRICAL SERVICE DIAGRAM)
4. OPERATING WEIGHT: 2000 LBS.
   SHIPPING WEIGHT: 1500 LBS.
5. ELECTRICAL ENCLOSURES ARE WEATHERPROOF WITH NEMA 4 DOOR SEALS.
6. (4) ANCHOR BOLTS REQUIRED, Ø5/8" X 2" MIN PROJECTION. NOT BY CCOT.
7. CLEAR SPACE FOR LAMP REMOVAL REQUIRED AT ONLY ONE END.
8. CLEARANCES IN FRONT OF ENCLOSURES AS REQUIRED BY LOCAL ELECTRICAL CODES.
9. COMPRESSED AIR REQUIRED: 4 ACFM, 80–120 PSIG. (DURING CLEANING CYCLE ONLY)

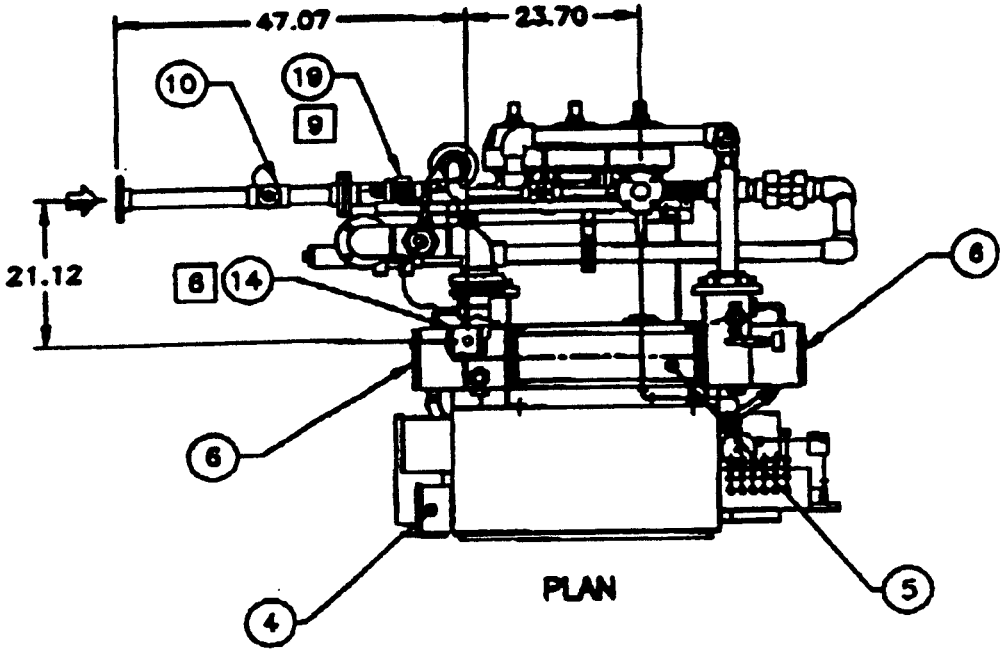


LEGEND

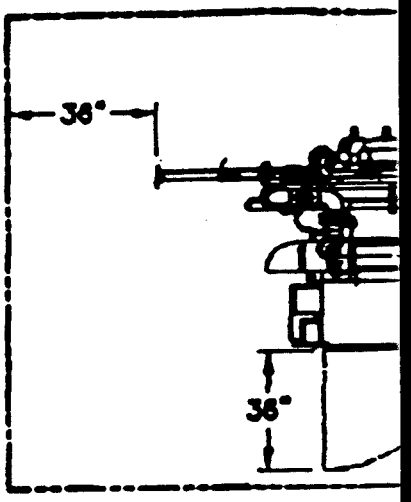
1. SKID
2. CONTROL ENCLOSURE
3. LAMP DRIVE ENCLOSURE
4. POWER DISTRIBUTION PANEL
5. OXIDATION CHAMBER
6. LAMP END ENCLOSURE
7. INLET (2" – 150#)
8. OUTLET (2" – 150#)
9. TUBE CLEANER PIPING
10. FLOW SENSOR
11. SWITCHGEAR ENCLOSURE
12. EMERGENCY STOP BUTTON
13. TOUCHSCREEN (PC INTERFACE)
14. (4) 4 X 4 A.B. PAD WITH Ø1-1/4" HOLE
15. FAN (EXHAUST)
16. 3/4" NFPT DRAIN
17. 1/2" NFPT INLET SAMPLE
18. 1/2" NFPT OUTLET SAMPLE
19. 1/4" NMPT COMPRESSED AIR
20. CONTROL POWER SWITCH
21. TUBE CLEANER CONTROL PANEL

ORIGINAL

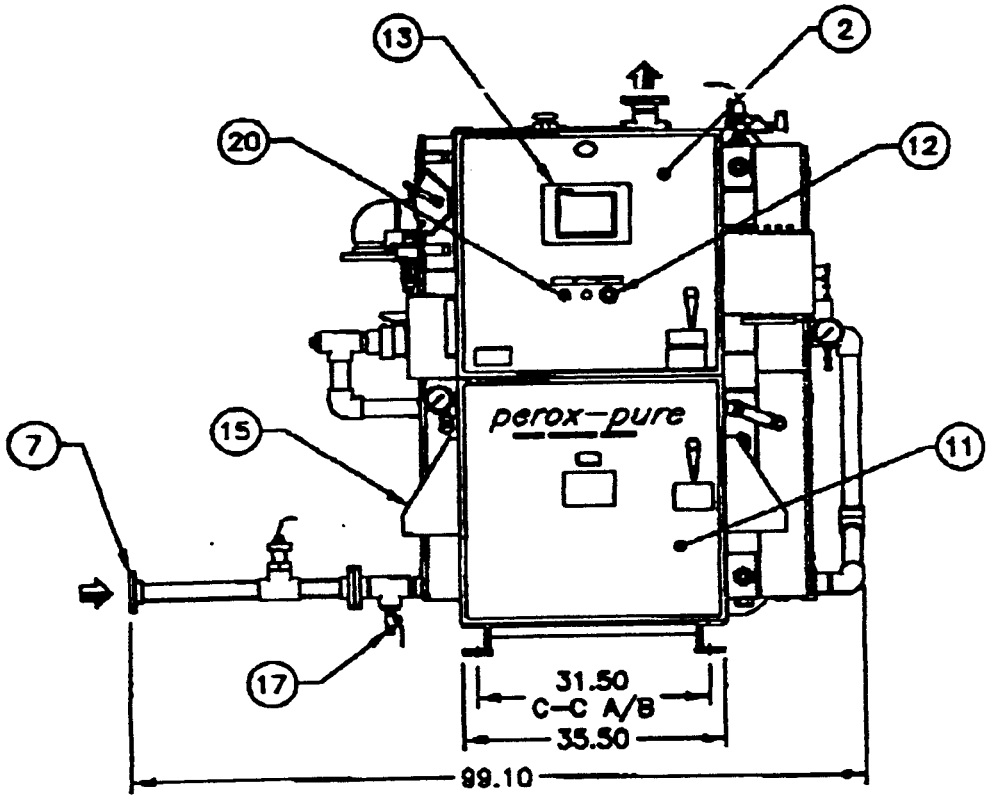
					DR. KC	CALGON CARBON OXIDATION TECHNOLOGIES
					CHD. BLK	PROJECT: CCOT DEMO TRAILER SN 3008
					APPR. BLK	TITLE ARRANGEMENT, perox-pure MODEL SSBFBX-15/30RRPCA
					QA BLK	
					DATE: 9/25/96	DWG NO: PQ362S0-300 REV
	DSGN BY	CHK BY	FINL ENGR APPR	QA	SCALE: 1/26	



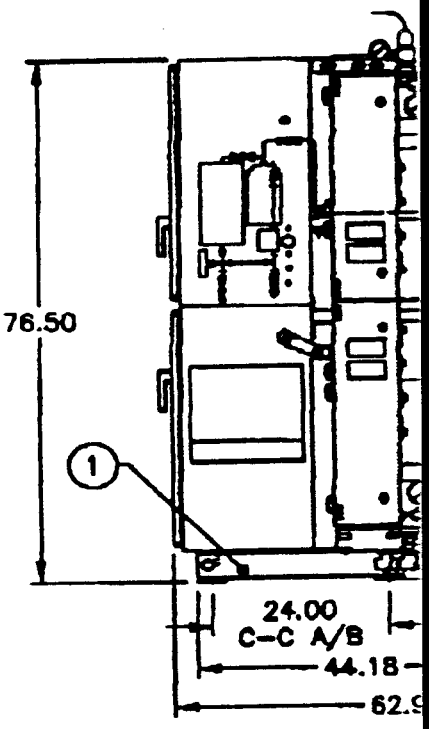
PLAN



MINIMUM SPACE



ELEVATION



SIDE

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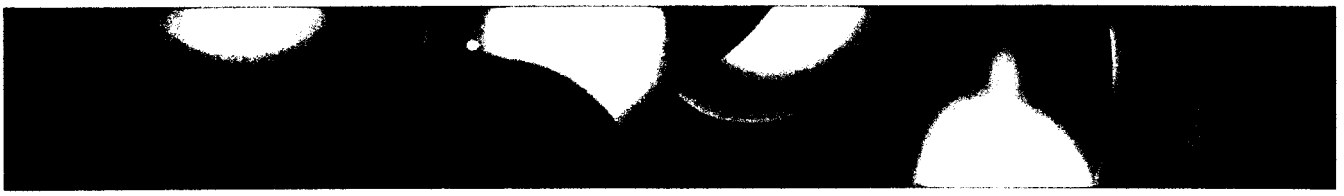
REV.	DATE	

UV Photolysis of N-Nitrosodimethylamine (NDMA) in Contaminated Water

Calgon Carbon Corporation
Advanced Oxidation Technologies

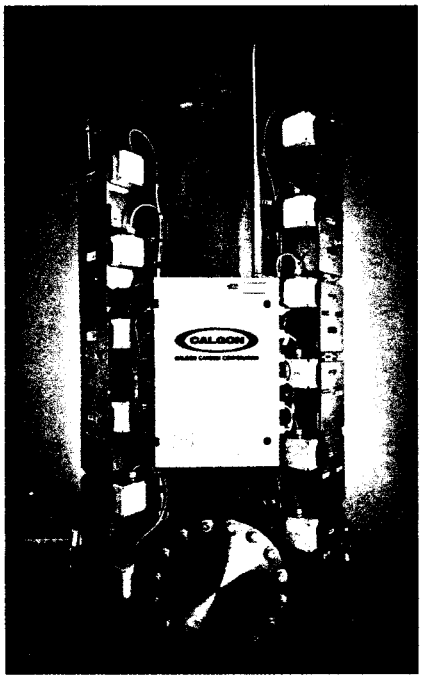


Best Available Technology (BAT) for NDMA (A Proven Solution for Drinking Water)

PROBLEM

Until recently, N-Nitrosodimethylamine (NDMA), was neither particularly well known, nor was it generally included when contaminated waters were analyzed for pollutants. However, the widespread occurrence of NDMA precursors in both industry and the environment, as well as its high mobility in groundwater and its toxicity, has resulted in increasing concern about this potentially harmful substance. Its presence has recently been reported in drinking water supplies, contaminated groundwaters, and industrial wastewaters.

NDMA has been classified as a probable human carcinogen, based on findings from animal studies. The United States Environmental Protection Agency estimates a 10^{-5} cancer risk (one case in 100,000) from NDMA in water at 0.02 parts per billion (ppb). After discovering NDMA in drinking water supplies, the Ontario Ministry of the Environment in Canada recommended an interim drinking water guideline of 0.009 ppb. The state of California has set an "action level" of 0.002 ppb.



Rayox® Tower System
Flow Rate: 3,000 gpm
Tower Dimensions: 88"L x 68"W x 122"H
Power Supply: 105"L x 49"W x 88"H

NDMA is formed by the nitrosation of dimethylamine (DMA) with the nitrite ion (NO_2^-). It is reportedly found as a by-product in the production or use of unsymmetrical dimethylhydrazine (UDMH), which is a rocket propellant, and dimethylamine (DMA), an accelerator used in vulcanizing rubber and in manufacturing detergents.

NDMA cannot be treated economically by conventional technologies—it does not efficiently air strip and is resistant to biodegradation.

KEY ADVANTAGES OF UV PHOTOLYSIS

- Best Available Technology (BAT) for NDMA
- Cost-effective
- On-site destruction treatment technology
- No formation of bromate ion in bromide ion-bearing waters
- Nondetectable levels achieved
- No secondary wastes
- No off-gases
- Quiet, compact and unobtrusive equipment
- Low maintenance and operating requirements
- No chemical addition
- Flexibility if other organics present

CALGON
CALGON CARBON CORPORATION

FOR MORE INFORMATION, CALL 800-422-7266
Brussels, Belgium Pittsburgh, PA, USA Toronto, Canada

ABOT-007-8/98

Calgon Carbon Announces

CALGON CARBON AWARDED CONTRACT TO REMOVE NDMA

PITTSBURGH, PA -- January 7, 1999 -- Calgon Carbon Corporation announced today that it has been awarded a contract from Suburban Water Systems of Covina, California, for a Rayox® Tower to destroy N-nitrosodimethylamine (NDMA) in water from one of its wells that has been shut down since NDMA was detected earlier this year. The installation is also being supported by Southern California Edison under its Showcase Opportunity and Economic Kilowatt Incentive programs. The contract is valued at $565,000.

The Rayox® Tower, which will utilize Calgon Carbon's proprietary, high-power, ultraviolet (UV) lamps, will treat approximately 3,000 gallons of water per minute and reduce the concentration of NDMA from 90 parts per trillion to less than 2 parts per trillion. The system is scheduled for delivery in the second quarter of 1999.

A suspected carcinogen, NDMA is often associated with the use of liquid rocket fuel and the manufacture of rubber or certain chemical intermediates. NDMA has been found in a number of groundwater aquifers in Canada and the U.S., and in recent years, improved analytical testing methods have permitted the detection of NDMA in low concentrations in drinking water.

Commenting on Calgon Carbon's expertise in destroying NDMA, John Mickler, managing director of Calgon Carbon's Advanced Oxidation Technologies group, said, "Our high-power UV lamps have proven to be very effective in destroying waterborne NDMA. Over the past nine years, Calgon Carbon has installed more than 10 Rayox® systems for the destruction of NDMA in groundwater, drinking water, industrial wastewater, and rocket washwater."

Calgon Carbon Corporation is a leader in the production, supply and design of products, services, and technologies for the purification, separation, and concentration of liquids and gases.

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For more information, please contact Gail Gerono (412) 787-6795

Previous news

Calgon Carbon Announces

CALGON CARBON AWARDED CONTRACT TO REMOVE PERCHLORATE AND NDMA

PITTSBURGH, PA – February 9, 1999 – Calgon Carbon Corporation announced today that it has been awarded a contract from the La Puente Valley County Water District in Southern California to supply the first commercial ISEP® system to remove perchlorate and to provide a Rayox® Tower to destroy N-nitrosodimethylamine (NDMA) in water from three of its wells. The wells have been shut down since 1997, when the contaminants were first detected. The contract is valued at over $3.0 million. Partial funding for the project will be provided by grants from the Main San Gabriel Basin Watermaster, the San Gabriel Basin Water Quality Authority, and the Upper San Gabriel Valley Municipal Water District.

The ISEP system utilizes Calgon Carbon's patented continuous ion exchange contactor which removes the perchlorate from drinking water. The Rayox Tower employs Calgon Carbon's proprietary, medium-pressure, ultraviolet (UV) lamps to destroy NDMA on-site. The two systems will treat approximately 2,500 gallons of water per minute. The ISEP will reduce the concentration of perchlorate from 200 parts per billion (ppb) to less than 5 ppb, while the Rayox Tower will reduce the NDMA from 900 parts per trillion (ppt) to less than 5 ppt.

Perchlorate, which prevents proper functioning of the thyroid gland, is a component of rocket fuels, fireworks, and explosives. NDMA, a suspected carcinogen, is a by-product of liquid rocket fuel combustion and has been found as a by-product in the manufacture of rubber products and certain chemical intermediates. Improved analytical testing methods in recent years have permitted the detection of the contaminants in low concentrations in drinking water.

Calgon Carbon has been utilizing its UV technology to treat NDMA since 1991. However, no method for removing perchlorate from drinking water had been demonstrated until the ISEP successfully removed perchlorate in trials at two separate sites in the Greater Los Angeles Area last year. The La Puente installation will be the world's first commercial application of the ISEP to remove perchlorate from drinking water. In addition to removing perchlorate and NDMA, the Calgon Carbon systems will also reduce nitrates and sulfates in the treated water.

Benjamin F. Ward, Calgon Carbon's senior vice president, technology, commented, "The use of the ISEP and Rayox systems at La Puente exemplifies Calgon Carbon's ability to apply its technical expertise to create innovative solutions to complex water treatment problems."

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For more information, please contact Gail Gerono (412) 787-6795

UV/Oxidation Installations Summary

Calgon Carbon
Advanced Oxidation Technologies

CCOT currently has more than 250 UV/Oxidation installations worldwide treating a variety of contaminants in industrial wastewater, groundwater, process water, ultrapure water, and drinking water. The following is a summary of some of these installations:

DESCRIPTION/INDUSTRY TYPE	LOCATION	APPLICATION	CONTAMINANT(S)
Aerospace Manufacturer	Florida	PW	Hydrazine, NDMA
Nuclear Power Plant	Canada	PW	TOC
Municipal Drinking Water Authority	California	DW	Natural Organic Matter (NOM), Color
Cosmetic Manufacturer	Puerto Rico	IW	COD
Chemical Manufacturer	Taiwan	IW	COD
Chemical Manufacturer	South Africa	IW	TOC
Gas Utility	Minnesota	GW	Naphthalene, Cyanides
Wood Treater	New Zealand	GW	Pentachlorophenol (PCP)
Chemical Manufacturer	Germany	GW	DCE
Chemical Manufacturer	Ohio	PW	Disinfection, Phenol, Formaldehyde
Pharmaceutical Manufacturer	Connecticut	PW	Chlorobenzene
U.S. Navy	Virginia	IW	Phenols
Chemical Manufacturer	Canada	IW	Formaldehyde
Wood Treater	Alabama	GW	PAHs, PCP
Pharmaceutical Manufacturer	New Jersey	GW	Methanol
U.S. Army Depot	California	GW	DCE, TCE, PCE, TCA, Methylene Chloride
Semiconductor Manufacturer	Arizona	UPW	TOC
Municipal Drinking Water Authority	Kansas	DW	TOC, THMFP
Chemical Manufacturer	Ohio	GW	Cyanides
Membrane Manufacturer	Michigan	GW	1,4-Dioxane
Automotive Parts Manufacturer	New York	GW	Vinyl Chloride, (VC), DCE, TCE
Explosives Manufacturer	Canada	IW	TNT
Treatment Facility Contractor	Pennsylvania	IW	Ethylene Glycol
Aerospace Manufacturer	Texas	IW	Acetone, Methyl Ethyl Ketone (MEK)
Indian Reserve Drinking Water Facility	Canada	DW	NDMA
Plastics Industry	Spain	IW	1,4-Dioxane
Aerospace Manufacturer	California	GW	Tetrahydrofuran (THF)
Service Station (LUST)	North Carolina	GW	BTEX
Automotive Manufacturer	Michigan	GW	VC, PCBs
Semiconductor Manufacturer	Texas	UPW	IPA, Acetic Acid
Chemical Manufacturer	North Carolina	GW	1,4-Dioxane
Explosives Manufacturer	West Virginia	IW	Nitroglycerine
Wood Treater	Alabama	IW	PCP

PW = Process Water IW = Industrial Wastewater DW = Drinking Water GW = Groundwater UPW = Ultrapure Water

CALGON
CALGON CARBON CORPORATION

FOR MORE INFORMATION, CALL 800-422-7266

Brussels, Belgium Pittsburgh, PA, USA Toronto, Canada Tucson, AZ, USA

PROJECT Calgon UV Pilot Test

NOTEBOOK NO. 771

Continued From Page NA

4-2-99

0630 set up small generator

0800 Arrived at site

Personnel: M. Zigmond M. Dunford G. Kidd
W. Lem D. Mulholland

Run 1 Q = 60 ppm

H_2O_2 = 0 ppm

FB	990402 0835		607	field blank	
	990402 0831		8010	field blank	
	" 0833		8240	field blank	
	" 08381		8010	Influent	
	" 0839		8010	Lamp 3	
	" 083941		8240	Influent	
	" 0843		8240	Lamp 3	
✓	" 0845	Stan 607		Influent	
✓	" 08457	Stan 607		Lamp 1	
✓	" 0849	Hi-Res 607		Lamp 2	
✓	" 084951	High-Res 607		Lamp 3	
✓	" 08543	Stan 607		Blind Control	KAH 221A 50
✓	" 0855	Hi-Res 607		Blind Control	KAH 221B 10
	" 08587	8010	Blind	Control	
MJ	" 0859	8240	Blind	Control	
	085941				

Continued on Page 12

Read and Understood By

Mike Zigmond 4-5-99

Signed Date

Signed Date

4-2-99

Run 2
Q = 80 gpm
H_2O_2 = 0 ppm

9904020901		8010 Influent
	0903	8010 Lamp 3
	0905	8240 Influent
	0907	8240 Lamp 3
✓	0909	Stan 607 Influent
✓	0911	Stan 607 Lamp 1
✓	0913	Hi-Res 607 Lamp 2
✓	0915	Hi-Res 607 Lamp 3

R. Spencer, J. Kirby, T. Davis arrived about 0900 hrs

Run 5 90 min
Q = 100 gpm → Could not get > 90 gpm, due to head loss caused by mechanical flow meter
H_2O_2 = 0 ppm

990402	0917	8010 Influent
	0919	8010 Lamp 1
	0921	8010 Lamp 2
	0923	8010 Lamp 3
	0925	8240 Influent
	0927	8240 Lamp 1
	0929	8240 Lamp 2
	0931	8240 Lamp 3
✓	0933	Stan 607 Influent
✓	0935	Stan 607 Influent Dup
✓	0937	Hi-Res 607 Influent
✓	0939	Hi-Res 607 Influent Dup
✓	0941	Stan 607 Lamp 1
✓	0943	Stan 607 Lamp 1 Dup
✓	0945	Hi-Res 607 Lamp 1
✓	0947	Hi-Res 607 Lamp 1 Dup

Continued on Page 13

Read and Understood By

Mike Sigmond — Signed — 4-5-99 — Date

Signed — Date

OJECT Calgon UV Pilot Test

4-2-99

Run 5 continued

✓990402 0949	Stan 607	Lamp 2
✓ 0951	Stan 607	Lamp 2 Dup
✓ 0953	Hi-Res 607	Lamp 2
✓ 0955	Hi-Res 607	Lamp 2 Dup
✓ 0957	Stan 607	Lamp 3
✓ 0959	Stan 607	Lamp 3 Dup
✓ 1001	Hi-Res 607	Lamp 3
✓ 1003	Hi-Res 607	Lamp 3 Dup
1005	Cations	Influent
1007	Cations	Lamp 1
1009	Cations	Lamp 2
1011	Cations	Lamp 3
1013	Anions	Influent
1015	Anions	Lamp 1
1017	Anions	Lamp 2
1019	Anions	Lamp 3
1021	TDS	Influent
1023	TDS	Lamp 1
1025	TDS	Lamp 2
1027	TDS	Lamp 3

Discontinued sampling at 1045 hrs due to high winds
Steady winds to 40-45 mph, gusting to 62 mph

✓990402 1029	Stan 607 Blind Control	KAH221A	500ppt
1031	Hi-Res 607 Blind Control	KAH221B	10ppt
1033	Hi-Res 607 Blind Control	KAH221C	2ppt

Continued on Page 14

Read and Understood By

Mike Jigmond — 4-5-99
Signed — Date

Signed — Date

4-3-99 Weather: Clear, cold, calm, no clouds
Present at Site: M. Zigmond M. Dunford
D. Parra W. Lam
D. Mulholland

Run 6 90 mJ
Q = ~~100~~ gpm
H_2O_2 = 20 ppm

990403	0700		8010	Influent		
	0702		8010	Lamp 1		
	0704		8010	Lamp 2		
	0706		8010	Lamp 3		
mJ	~~0708~~		~~8010~~	~~Blind Control~~		
	0710		8240	Influent		
	0712		8240	Lamp 1		
	0714		8240	Lamp 2		
	0716		8240	Lamp 3		
mJ	~~0718~~		~~8240~~	~~Blind Control~~		
✓	0720	Stan	607	Influent		
✓	0722	Stan	607	Influent Dup		
✓	0724	Stan	607	Lamp 1		
✓	0726	Stan	607	Lamp 1 Dup		
✓	0728	Hi-Res	607	Lamp 2		
✓	0730	Hi-Res	607	Lamp 2 Dup		
✓	0732	Hi-Res	607	Lamp 3		
✓	0734	Hi-Res	607	Lamp 3 Dup		
	0736		8010	Field Blank		
	0738		8240	Field Blank		
✓	0740		Stan 607	Field Blank		
→ ✓	0742		Stan 607	Blind Control	KAH 221 A	500 ppb
✓	0744		Hi-Res 607	Blind Control	KAH 221 C	2 ppb

Continued on Page 15

Read and Understood By

Mike Zigmond — Signed
4-5-99 — Date
Signed
Date

Run 4 Continued

990403	0746	Anions	Influent	
	0748	Anions	Lamp 1	
	0750	Anions	Lamp 2	
	0752	Anions	Lamp 3	
	0754	Cations	Influent	
	0756	Cations	Lamp 1	
	0758	Cations	Lamp 2	
	0800	Cations	Lamp 3	
	0802	TDS	Influent	
	0804	TDS	Lamp 1	
	0806	TDS	Lamp 2	
	0808	TDS	Lamp 3	
✓ ✓	0810	Stan 607 Blind Control	KAH 221 A	500ppb
✓	0812	H_2O_2 - Res 607 Blind Control	KAH 221 B	10ppb

Run 4

Q = 80 gpm

H_2O_2 = 40 ppm

990403	0820	8010	Influent
	0822	8010	Lamp 1
	0824	8010	Lamp 2
	0826	8010	Lamp 3
MJ	~~0828~~	~~8010~~	~~Blind Control~~
	0830	8240	Influent
	0832	8240	Lamp 1
	0834	8240	Lamp 2
	0836	8240	Lamp 3
MJ	~~0838~~	~~8240~~	~~Blind Control~~

Continued on Page 16

Read and Understood By

Mike Sigmond — 4-5-99

Signed — Date — Signed — Date

Run 4 Continued

✓ 990403	0840	Stan 607 Influent
✓	0842	Stan 607 Lamp 1
✓	0844	Hi-Res 607 Lamp 2
✓	0846	Hi-Res 607 Lamp 3
✓	0848	Hi-Res 607 Blind Control KAH 221 B 10ppt

Run 7
Q = 80 gpm
H_2O_2 = 0 ppm
Reverse Flow

✓ 990403	0850	Stan 607 Influent
✓	0852	Stan 607 Lamp 1
✓	0854	Hi-Res 607 Lamp 2
✓	0856	Hi-Res 607 Lamp 3
✓	0858	Hi-Res 607 Blind Control KAH 221C 2ppt

Run 3
Q = 60 gpm
H_2O_2 = 20 ppm

990403	0900	8010 Influent
	0902	8010 Lamp 3
mj	~~0904~~	~~8010 Blind Control~~
	0906	8240 Influent
	0908	8240 Lamp 3
mj	~~0910~~	~~8240 Blind Control~~

Continued on Page 17

Read and Understood By

Mike Zigmond — Signed — 4-5-99 — Date

Signed — Date

4-3-99 0900 hrs wind starting to blow (Light Breeze)

Run 3 continued

990403	0912	Stan 607 Influent
	0914	Stan 607 Lamp 1
	0916	Hi-Res 607 Lamp 2
	0918	Hi-Res 607 Lamp 3
	0920	Hi-Res 607 Blind Control
		→ KAH 221C 2ppt

8010 + 8240 Blind Controls

	0329		
990403	0901	8010	B. Control KAH 220A
MJ	0903	8010	B. Control KAH 220A
	0905	"	"
	0907	"	"
MJ	0909	8240	Blind Control KAH 220B
	0911	"	" "
	0913	"	" "
	0915	"	" "

4-5-99 M. Zigmond M. Dunford Carlos.
Picked up blind controls from K. Harts lab.
Completed labels, seals, chains of custody
Packed ice chests, delivered to Whse.
at 1300 hrs for overnight shipment.

Frac tanks contained a total of 670 bbls (28,140 gals) of water. This is a mixture of both treated & untreated water.
Learned that P. Amidei has not yet signed the TPS for this project.

Continued on Page ~~17~~ 17

Read and Understood By

Mike Zigmond 4-5-99
Signed Date

Signed Date

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904020845**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121059	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.75 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.55 ppb**	

Run 1 - Influent

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904020847**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121061	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.08 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.11 ppb**	

Run 1 – Lamp 1

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**9904020849**	Final Extract Volume:	0.1 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15431-121092	Reporting Limit:	0.5 ppt
Receiving Data:	04/06/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/08/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/15/1999	Matrix Spike Recov.:	NDMA 151%
Reporting Data:	04/28/1999		DMN 115%
		Dilution Factor:	50X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**336 ppt**	
N-Nitrodimethylamine	4164-28-7	**348 ppt**	

Run 1 - Lamp 2 HR

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904020909**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121063	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.79 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.57 ppb**	

Run 2 - Influent

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904020911**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121064	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.23 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.24 ppb**	

Run 2 - Lamp 1

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**9904020913**	Final Extract Volume:	0.1 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15431-121095	Reporting Limit:	0.5 ppt
Receiving Data:	04/06/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/09/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/16/1999	Matrix Spike Recov.:	NDMA 173%
Reporting Data:	04/28/1999		DMN 107%
		Dilution Factor:	140X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**939 ppt**	
N-Nitrodimethylamine	4164-28-7	**908 ppt**	

Run 2 - Lamp 2 HR

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**9904020915**	Final Extract Volume:	0.1 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15431-121086	Reporting Limit:	0.5 ppt
Receiving Data:	04/06/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/08/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/14/1999	Matrix Spike Recov.:	NDMA 151%
Reporting Data:	04/28/1999		DMN 115%
		Dilution Factor:	75X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**579 ppt**	
N-Nitrodimethylamine	4164-28-7	**646 ppt**	

Run 2 - Lamp 3 HR

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904030912**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121075	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.80 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.55 ppb**	

Run 3 - Influent

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904030914**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121076	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.13 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.06 ppb**	

Run 3 - Lamp 1

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904030840**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121068	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.84 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.56 ppb**	

Run 4 - Influent

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**9904030844**	Final Extract Volume:	0.1 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15431-121080	Reporting Limit:	0.5 ppt
Receiving Data:	04/06/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/09/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/15/1999	Matrix Spike Recov.:	NDMA 173%
Reporting Data:	04/28/1999		DMN 107%
		Dilution Factor:	150X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**1010 ppt**	
N-Nitrodimethylamine	4164-28-7	**726 ppt**	

Run 4 - Lamp 2 HR

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904020933**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121048	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.82 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.56 ppb**	

Run 5 - Influent

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904020935**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121050	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.84 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.57 ppb**	

Run 5 - Influent (Duplicate)

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904020941**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121052	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.23 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.22 ppb**	

Run 5- Lamp 1

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904020943**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121054	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.16 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.17 ppb**	

Run 5 - Lamp 1 (Duplicate)

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904020949**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121056	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.06 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.07 ppb**	

Run 5 - Lamp 2

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904020951**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121038	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.05 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.06 ppb**	

Run 5 - Lamp 2 (Dup.)

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904020957**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121039	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.02 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.02 ppb**	

Run 5 Lamp 3

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904020959**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121040	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.01 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.02 ppb**	

Run 5 - Lamp 3 (Dup.)

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**9904020937**	Final Extract Volume:	0.1 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15431-121087	Reporting Limit:	0.5 ppt
Receiving Data:	04/06/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/08/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/14/1999	Matrix Spike Recov.:	NDMA 151%
Reporting Data:	04/28/1999		DMN 115%
		Dilution Factor:	2100X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**15494 ppt**	
N-Nitrodimethylamine	4164-28-7	**14965 ppt**	

Run 5 - Influent @ HR

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**9904020939**	Final Extract Volume:	0.1 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15431-121088	Reporting Limit:	0.5 ppt
Receiving Data:	04/08/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/14/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/16/1999	Matrix Spike Recov.:	NDMA 151%
Reporting Data:	04/28/1999		DMN 115%
		Dilution Factor:	2000X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**19047 ppt**	
N-Nitrodimethylamine	4164-28-7	**19666 ppt**	

Run 5 – Influent (Duplicate) HR

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**9904020945**	Final Extract Volume:	0.1 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15431-121089	Reporting Limit:	0.5 ppt
Receiving Data:	04/06/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/08/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/14/1999	Matrix Spike Recov.:	NDMA 151%
Reporting Data:	04/28/1999		DMN 115%
		Dilution Factor:	550X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**3548 ppt**	
N-Nitrodimethylamine	4164-28-7	**3383 ppt**	

Run 5 — Lamp 1 HR

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**9904020947**	Final Extract Volume:	0.1 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15431-121090	Reporting Limit:	0.5 ppt
Receiving Data:	04/06/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/08/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/15/1999	Matrix Spike Recov.:	NDMA 151%
Reporting Data:	04/28/1999		DMN 115%
		Dilution Factor:	350X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**3400 ppt**	
N-Nitrodimethylamine	4164-28-7	**3390 ppt**	

Run 5 - Lamp 1 (Dup). HR

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**9904020953**	Final Extract Volume:	0.1 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15431-121082	Reporting Limit:	0.5 ppt
Receiving Data:	04/06/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/08/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/14/1999	Matrix Spike Recov.:	NDMA 151%
Reporting Data:	04/28/1999		DMN 115%
		Dilution Factor:	150X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**644 ppt**	
N-Nitrodimethylamine	4164-28-7	**975 ppt**	

Run 5 - Lamp 2 HR

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**9904020955**	Final Extract Volume:	0.1 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15431-121083	Reporting Limit:	0.5 ppt
Receiving Data:	04/06/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/08/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/14/1999	Matrix Spike Recov.:	NDMA 151%
Reporting Data:	04/28/1999		DMN 115%
		Dilution Factor:	150X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**614 ppt**	
N-Nitrodimethylamine	4164-28-7	**1585 ppt**	

Run 5 - Lamp 2 HR (Dup)

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**9904021001**	Final Extract Volume:	0.1 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15431-121084	Reporting Limit:	0.5 ppt
Receiving Data:	04/06/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/08/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/14/1999	Matrix Spike Recov.:	NDMA 151%
Reporting Data:	04/28/1999		DMN 115%
		Dilution Factor:	40X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**203 ppt**	
N-Nitrodimethylamine	4164-28-7	**277 ppt**	

Run 5 - Lamp 3 HR

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**9904021003**	Final Extract Volume:	0.1 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15431-121085	Reporting Limit:	0.5 ppt
Receiving Data:	04/06/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/08/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/14/1999	Matrix Spike Recov.:	NDMA 151%
Reporting Data:	04/28/1999		DMN 115%
		Dilution Factor:	40X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**295 ppt**	
N-Nitrodimethylamine	4164-28-7	**397 ppt**	

Run 5 - Lamp 3 HR (Dup.)

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904030720**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121041	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.83 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.58 ppb**	

Run 6 Influent

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904030722**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121043	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.82 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.58 ppb**	

Rinse Influent (Duplicate)

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904030724**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121045	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.31 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.16 ppb**	

Run 6 - Lamp 1

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Reporting Data:	04/21/1999
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**9904030726**	Sample Volume:	1000 mL
Well ID:	**NASA-PT Well**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	15429-121065	Analytical Method:	Mod-607
Receiving Data:	04/06/1999	Reporting Limit:	0.01 ppb
Extraction Data:	04/07/1999	MDL:	0.005 ppb
GC/MS Analysis Data:	04/14/1999	Extraction Efficiency:	NDMA 40%
			DMN 68%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.19 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.11 ppb**	

Run 6 - Lamp 1 (Dup).

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	0.5 L
AlliedSignal Sample #:	**9904030728**	Final Extract Volume:	0.05 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15429-121066	Reporting Limit:	0.5 ppt
Receiving Data:	04/06/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/09/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/16/1999	Matrix Spike Recov.:	NDMA 173%
Reporting Data:	04/28/1999		DMN 107%
		Dilution Factor:	240X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**1304 ppt**	
N-Nitrodimethylamine	4164-28-7	**536 ppt**	

Run 6 - Lamp 2 HR

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**9904030730**	Final Extract Volume:	0.1 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15431-121078	Reporting Limit:	0.5 ppt
Receiving Data:	04/06/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/09/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/15/1999	Matrix Spike Recov.:	NDMA 173%
Reporting Data:	04/28/1999		DMN 107%
		Dilution Factor:	150X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**991 ppt**	
N-Nitrodimethylamine	4164-28-7	**688 ppt**	

Run 6 - Lamp 2 HR (Dup)

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	0.5 L
AlliedSignal Sample #:	**9904030732**	Final Extract Volume:	0.05 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15429-121067	Reporting Limit:	0.5 ppt
Receiving Data:	04/06/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/09/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/16/1999	Matrix Spike Recov.:	NDMA 173%
Reporting Data:	04/28/1999		DMN 107%
		Dilution Factor:	40X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**326 ppt**	
N-Nitrodimethylamine	4164-28-7	**225 ppt**	

Run 6 - L3 HR

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**9904030734**	Final Extract Volume:	0.1 mL
Well ID:	**NASA-PT Well**	Analytical Method:	SwRI SOP-01-13-04
SwRI WO#-ID:	15431-121079	Reporting Limit:	0.5 ppt
Receiving Data:	04/06/1999	Method Detect Limit:	0.22 ppt for NDMA
Extraction Data:	04/09/1999		0.34 ppt for DMN
GC/MS Analysis Data:	04/15/1999	Matrix Spike Recov.:	NDMA 173%
Reporting Data:	04/28/1999		DMN 107%
		Dilution Factor:	150X

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**1070 ppt**	
N-Nitrodimethylamine	4164-28-7	**1290 ppt**	

Rmb-L3 HR (Dup)

EXECUTIVE SUMMARY - Detection Highlights

D9D060149

	PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
	9904020833 (NASA-PTWELL) 04/02/99 08:33 002				
SAMPLE BLANK	Acetone	18 J	20	ug/L	SW846 8240B
	9904020837 (NASA-PTWELL) 04/02/99 08:37 003				
SAMPLE 1-0	Trichlorofluoromethane	260	12	ug/L	SW846 8010B
	Trichlorofluoromethane	240 E	0.50	ug/L	SW846 8010B
	Tetrachloroethene	11	0.50	ug/L	SW846 8010B
	Trichloroethene	310	12	ug/L	SW846 8010B
	Trichloroethene	150 E	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	690	12	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	120 E	0.50	ug/L	SW846 8010B
	9904020839 (NASA-PTWELL) 04/02/99 08:39 004				
SAMPLE 1-3	Trichlorofluoromethane	330	12	ug/L	SW846 8010B
	Trichlorofluoromethane	260 E	0.50	ug/L	SW846 8010B
	Tetrachloroethene	3.2	0.50	ug/L	SW846 8010B
	Trichloroethene	150	12	ug/L	SW846 8010B
	Trichloroethene	110 E	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	880	12	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	390 E	0.50	ug/L	SW846 8010B
	9904020841 (NASA-PTWELL) 04/02/99 08:41 005				
SAMPLE 1-0	Trichlorofluoromethane	370 E	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	320	50	ug/L	SW846 8240B
	Tetrachloroethene	21	5.0	ug/L	SW846 8240B
	Trichloroethene	370 E	5.0	ug/L	SW846 8240B
	Trichloroethene	390	50	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1000 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1000	50	ug/L	SW846 8240B
	Xylenes (total)	34 J	50	ug/L	SW846 8240B
	1,2-Dichloro-1,1,2-trifluoroethane	2.1 J	5.0	ug/L	SW846 8240B

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MAY 17 1999 14:31 FR FISF ASTF 505 524 5106 TO 918008981263905 P.11

EXECUTIVE SUMMARY - Detection Highlights

D9D060149

	PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
9904020843 (NASA-PTWELL) 04/02/99 08:43 006					
SAMPLE 1-3	Dichlorofluoromethane	1.9 J	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	360 E	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	290	50	ug/L	SW846 8240B
	Tetrachloroethene	4.8 J	5.0	ug/L	SW846 8240B
	Trichloroethene	150	5.0	ug/L	SW846 8240B
	Trichloroethene	130	50	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	980 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	960	50	ug/L	SW846 8240B
	1,2-Dichloro-1,1,2-trifluoroethane	2.0 J	5.0	ug/L	SW846 8240B
9904020901 (NASA-PTWELL) 04/02/99 09:01 007					
SAMPLE 2-0	Trichlorofluoromethane	280	12	ug/L	SW846 8010B
	Trichlorofluoromethane	260 E	0.50	ug/L	SW846 8010B
	Tetrachloroethene	13	0.50	ug/L	SW846 8010B
	Trichloroethene	300	12	ug/L	SW846 8010B
	Trichloroethene	150 E	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	730	12	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	270 E	0.50	ug/L	SW846 8010B
9904020903 (NASA-PTWELL) 04/02/99 09:03 008					
SAMPLE 2-3	Trichlorofluoromethane	440	12	ug/L	SW846 8010B
	Trichlorofluoromethane	250 E	0.50	ug/L	SW846 8010B
	Tetrachloroethene	5.4	0.50	ug/L	SW846 8010B
	Trichloroethene	220	12	ug/L	SW846 8010B
	Trichloroethene	120 E	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1100	12	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	300 E	0.50	ug/L	SW846 8010B
9904020905 (NASA-PTWELL) 04/02/99 09:05 009					
SAMPLE 2-0	Trichlorofluoromethane	340 E	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	290	50	ug/L	SW846 8240B
	Tetrachloroethene	19	5.0	ug/L	SW846 8240B
	Trichloroethene	360 E	5.0	ug/L	SW846 8240B

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EXECUTIVE SUMMARY - Detection Highlights

D9D060149

	PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
9904020905 (NASA-PTWELL) 04/02/99 09:05 009					
SAMPLE 2-0	Trichloroethene	360	50	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	950 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	930	50	ug/L	SW846 8240B
	1,2-Dichloro-1,1,2-trifluoroethane	1.5 J	5.0	ug/L	SW846 8240B
9904020907 (NASA-PTWELL) 04/02/99 09:07 010					
SAMPLE 2-3	Trichlorofluoromethane	360 E	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	330	50	ug/L	SW846 8240B
	Tetrachloroethene	7.3	5.0	ug/L	SW846 8240B
	Trichloroethene	180	5.0	ug/L	SW846 8240B
	Trichloroethene	190	50	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1000 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1100	50	ug/L	SW846 8240B
	1,2-Dichloro-1,1,2-trifluoroethane	1.6 J	5.0	ug/L	SW846 8240B
9904020917 (NASA-PTWELL) 04/02/99 09:17 011					
SAMPLE 5-0	Trichlorofluoromethane	320	12	ug/L	SW846 8010B
	Trichlorofluoromethane	230 E	0.50	ug/L	SW846 8010B
	Tetrachloroethene	13	0.50	ug/L	SW846 8010B
	Trichloroethene	380	12	ug/L	SW846 8010B
	Trichloroethene	150 E	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	880	12	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	270 E	0.50	ug/L	SW846 8010B
9904020919 (NASA-PTWELL) 04/02/99 09:19 012					
SAMPLE 5-1	Trichlorofluoromethane	330	12	ug/L	SW846 8010B
	Trichlorofluoromethane	240 E	0.50	ug/L	SW846 8010B
	Tetrachloroethene	8.3	0.50	ug/L	SW846 8010B
	Trichloroethene	270	12	ug/L	SW846 8010B
	Trichloroethene	130 E	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	880	12	ug/L	SW846 8010B

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EXECUTIVE SUMMARY - Detection Highlights

D9D060149

	PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
9904020919 (NASA-PTWELL) 04/02/99 09:19 012					
SAMPLE 5-1	1,1,2-Trichloro-1,2,2-trifluoroethane	310 E	0.50	ug/L	SW846 8010B
9904020921 (NASA-PTWELL) 04/02/99 09:21 013					
	Trichlorofluoromethane	410	12	ug/L	SW846 8010B
SAMPLE 5-2	Trichlorofluoromethane	260 E	0.50	ug/L	SW846 8010B
	Tetrachloroethene	7.1	0.50	ug/L	SW846 8010B
	Trichloroethene	250	12	ug/L	SW846 8010B
	Trichloroethene	130 E	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1100	12	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	300 E	0.50	ug/L	SW846 8010B
9904020923 (NASA-PTWELL) 04/02/99 09:23 014					
SAMPLE 5-3	Trichlorofluoromethane	400	12	ug/L	SW846 8010B
	Trichlorofluoromethane	270 E	0.50	ug/L	SW846 8010B
	Tetrachloroethene	5.2	0.50	ug/L	SW846 8010B
	Trichloroethene	210	12	ug/L	SW846 8010B
	Trichloroethene	120 E	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1100	12	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	300 E	0.50	ug/L	SW846 8010B
9904020925 (NASA-PTWELL) 04/02/99 09:25 015					
SAMPLE 5-0	Dichlorofluoromethane	1.9 J	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	340 E	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	290	50	ug/L	SW846 8240B
	Tetrachloroethene	20	5.0	ug/L	SW846 8240B
	Trichloroethene	360 E	5.0	ug/L	SW846 8240B
	Trichloroethene	360	50	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	960 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	930	50	ug/L	SW846 8240B
	1,2-Dichloro-1,1,2-trifluoroethane	1.8 J	5.0	ug/L	SW846 8240B

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MAY 17 1999 14:51 FR HISF WS:- 505 524 5106 TO 91800898126520534 P.14

EXECUTIVE SUMMARY - Detection Highlights

D9D060149

	PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
9904020927 (NASA-PTWELL) 04/02/99 09:27 016					
SAMPLE 5-1	Dichlorofluoromethane	1.9 J	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	370 E	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	290	50	ug/L	SW846 8240B
	Tetrachloroethene	14	5.0	ug/L	SW846 8240B
	Trichloroethene	280 E	5.0	ug/L	SW846 8240B
	Trichloroethene	270	50	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1000 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	970	50	ug/L	SW846 8240B
	1,2-Dichloro-1,1,2-trifluoroethane	1.8 J	5.0	ug/L	SW846 8240B
9904020929 (NASA-PTWELL) 04/02/99 09:29 017					
SAMPLE 5-2	Dichlorofluoromethane	1.8 J	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	370 E	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	290	50	ug/L	SW846 8240B
	Tetrachloroethene	9.4	5.0	ug/L	SW846 8240B
	Trichloroethene	220 E	5.0	ug/L	SW846 8240B
	Trichloroethene	210	50	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1000 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	960	50	ug/L	SW846 8240B
	1,2-Dichloro-1,1,2-trifluoroethane	1.8 J	5.0	ug/L	SW846 8240B
9904020931 (NASA-PTWELL) 04/02/99 09:31 018					
SAMPLE 5-3	Trichlorofluoromethane	360 E	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	290	50	ug/L	SW846 8240B
	Tetrachloroethene	6.8	5.0	ug/L	SW846 8240B
	Trichloroethene	180	5.0	ug/L	SW846 8240B
	Trichloroethene	170	50	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1000 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	970	50	ug/L	SW846 8240B
	1,2-Dichloro-1,1,2-trifluoroethane	1.9 J	5.0	ug/L	SW846 8240B

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EXECUTIVE SUMMARY - Detection Highlights

D9D060149

	PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
9904021005 (NASA-PTWELL) 04/02/99 10:05 019					
SAMPLE 5-0	Calcium - DISSOLVED	119	0.20	mg/L	SW846 6010B
	Iron - DISSOLVED	0.26	0.10	mg/L	SW846 6010B
	Potassium - DISSOLVED	3.0 B	5.0	mg/L	SW846 6010B
	Magnesium - DISSOLVED	68.0	0.20	mg/L	SW846 6010B
	Sodium - DISSOLVED	36.6	5.0	mg/L	SW846 6010B
9904021007 (NASA-PTWELL) 04/02/99 10:07 020					
SAMPLE 5-1	Calcium - DISSOLVED	119	0.20	mg/L	SW846 6010B
	Iron - DISSOLVED	0.067 B	0.10	mg/L	SW846 6010B
	Potassium - DISSOLVED	3.2 B	5.0	mg/L	SW846 6010B
	Magnesium - DISSOLVED	67.3	0.20	mg/L	SW846 6010B
	Sodium - DISSOLVED	36.6	5.0	mg/L	SW846 6010B
9904021009 (NASA-PTWELL) 04/02/99 10:09 021					
SAMPLE 5-2	Calcium - DISSOLVED	118	0.20	mg/L	SW846 6010B
	Iron - DISSOLVED	0.015 B	0.10	mg/L	SW846 6010B
	Potassium - DISSOLVED	3.1 B	5.0	mg/L	SW846 6010B
	Magnesium - DISSOLVED	66.5	0.20	mg/L	SW846 6010B
	Sodium - DISSOLVED	35.8	5.0	mg/L	SW846 6010B
9904021011 (NASA-PTWELL) 04/02/99 10:11 022					
SAMPLE 5-3	Calcium - DISSOLVED	122	0.20	mg/L	SW846 6010B
	Iron - DISSOLVED	0.021 B	0.10	mg/L	SW846 6010B
	Potassium - DISSOLVED	3.2 B	5.0	mg/L	SW846 6010B
	Magnesium - DISSOLVED	68.3	0.20	mg/L	SW846 6010B
	Sodium - DISSOLVED	37.3	5.0	mg/L	SW846 6010B

MAY 17 1999 14:52 FR HISP US F 505 524 5106 TO 918008981263905 4 P.16

Project Narrative
(D9D060154)

Twenty-one samples were received at Quanterra Environmental Services' Denver Laboratory from NASA/WSTF/Allied Signal on April 6, 1999. The samples were received in good condition and appropriately preserved.

With exceptions noted on the data sheets, standard analytical protocols were followed in the analyses of the samples and no problems were encountered or anomalies observed. All laboratory quality control samples analyzed in conjunction with the samples in this project were within acceptable limits.

Volatiles by Method 8010

Several samples were re-analyzed diluted due to elevated concentrations of target compounds. Both sets of data are reported herein.

The 4-chlorotoluene surrogate recoveries were slightly below QC limits for the following samples: -010 (3%), -011 (1%), and 0012DL (2%). The data are not adversely affected by the slightly low recoveries and are included unqualified.

Volatiles by Method 8240

Several samples were re-analyzed diluted due to elevated concentrations of target compounds. Both sets of data are reported herein.

EXECUTIVE SUMMARY - Detection Highlights

D9D060154

	PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
9904021013 (NASA-PTWELL) 04/02/99 10:13 001					
SAMPLE 5-0	Fluoride	0.85	0.10	mg/L	SM18 4500-F C
	Chloride	54.1 Q	15.0	mg/L	MCAWW 300.0A
	Sulfate	317 Q	100	mg/L	MCAWW 300.0A
	Total Alkalinity	210	5.0	mg/L	MCAWW 310.1
9904021015 (NASA-PTWELL) 04/02/99 10:15 002					
SAMPLE 5-1	Fluoride	0.87	0.10	mg/L	SM18 4500-F C
	Chloride	54.5 Q	15.0	mg/L	MCAWW 300.0A
	Sulfate	315 Q	100	mg/L	MCAWW 300.0A
	Total Alkalinity	211	5.0	mg/L	MCAWW 310.1
9904021017 (NASA-PTWELL) 04/02/99 10:17 003					
SAMPLE 5-2	Fluoride	0.90	0.10	mg/L	SM18 4500-F C
	Chloride	54.9 Q	15.0	mg/L	MCAWW 300.0A
	Sulfate	312 Q	100	mg/L	MCAWW 300.0A
	Total Alkalinity	220	5.0	mg/L	MCAWW 310.1
9904021019 (NASA-PTWELL) 04/02/99 10:19 004					
SAMPLE 5-3	Fluoride	0.87	0.10	mg/L	SM18 4500-F C
	Chloride	53.9 Q	15.0	mg/L	MCAWW 300.0A
	Sulfate	312 Q	100	mg/L	MCAWW 300.0A
	Total Alkalinity	217	5.0	mg/L	MCAWW 310.1
9904021021 (NASA-PTWELL) 04/02/99 10:21 005					
SAMPLE 5-0	Total Dissolved Solids	878	10.0	mg/L	MCAWW 160.1
9904021023 (NASA-PTWELL) 04/02/99 10:23 006					
SAMPLE 5-1	Total Dissolved Solids	871	10.0	mg/L	MCAWW 160.1
9904021025 (NASA-PTWELL) 04/02/99 10:25 007					
SAMPLE 5-2	Total Dissolved Solids	900	10.0	mg/L	MCAWW 160.1

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MAY 17 1999 14:52 FR HISF WST 505 524 5106 TO 918000981263900 P.18

EXECUTIVE SUMMARY - Detection Highlights

D9D060154

	PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
9904021027 (NASA-PTWELL) 04/02/99 10:27 008					
SAMPLE 5-3	Total Dissolved Solids	859	10.0	mg/L	MCAWW 160.1
9904030700 (NASA-PTWELL) 04/03/99 07:00 009					
SAMPLE 6-0	Trichlorofluoromethane	280 E	0.50	ug/L	SW846 8010B
	Trichlorofluoromethane	360	12	ug/L	SW846 8010B
	Tetrachloroethene	13	0.50	ug/L	SW846 8010B
	Trichloroethene	170 E	0.50	ug/L	SW846 8010B
	Trichloroethene	370	12	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	390 E	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	900	12	ug/L	SW846 8010B
9904030702 (NASA-PTWELL) 04/03/99 07:02 010					
SAMPLE 6-1	Trichlorofluoromethane	310 E	0.50	ug/L	SW846 8010B
	Trichlorofluoromethane	360	12	ug/L	SW846 8010B
	Tetrachloroethene	8.2	0.50	ug/L	SW846 8010B
	Trichloroethene	100 E	0.50	ug/L	SW846 8010B
	Trichloroethene	120	12	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	370 E	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	900	12	ug/L	SW846 8010B
9904030704 (NASA-PTWELL) 04/03/99 07:04 011					
SAMPLE 6-2	Trichlorofluoromethane	290 E	0.50	ug/L	SW846 8010B
	Trichlorofluoromethane	340	12	ug/L	SW846 8010B
	Tetrachloroethene	3.4	0.50	ug/L	SW846 8010B
	Trichloroethene	36	0.50	ug/L	SW846 8010B
	Trichloroethene	38	12	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	360 E	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	880	12	ug/L	SW846 8010B

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MAY 17 1999 14:33 FR HISF WSI 505 524 5106 TO 918008981263905 P.19

EXECUTIVE SUMMARY - Detection Highlights

D9D060154

	PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
9904030706 (NASA-PTWELL) 04/03/99 07:06 012					
SAMPLE 6-3	Trichlorofluoromethane	220 E	0.50	ug/L	SW846 8010B
	Trichlorofluoromethane	360	12	ug/L	SW846 8010B
	Tetrachloroethene	1.4	0.50	ug/L	SW846 8010B
	Trichloroethene	13	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	910	12	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	270 E	0.50	ug/L	SW846 8010B
9904030710 (NASA-PTWELL) 04/03/99 07:10 013					
SAMPLE 6-0	Trichlorofluoromethane	360 E	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	310	50	ug/L	SW846 8240B
	Tetrachloroethene	19	5.0	ug/L	SW846 8240B
	Trichloroethene	350	50	ug/L	SW846 8240B
	Trichloroethene	350 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1000	50	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1000 E	5.0	ug/L	SW846 8240B
	1,2-Dichloro-1,1,2-trifluoroethane	1.4 J	5.0	ug/L	SW846 8240B
9904030712 (NASA-PTWELL) 04/03/99 07:12 014					
SAMPLE 6-1	Trichlorofluoromethane	380 E	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	320	50	ug/L	SW846 8240B
	Tetrachloroethene	11	5.0	ug/L	SW846 8240B
	Trichloroethene	120	5.0	ug/L	SW846 8240B
	Trichloroethene	120	50	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1000 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1000	50	ug/L	SW846 8240B
	1,2-Dichloro-1,1,2-trifluoroethane	1.8 J	5.0	ug/L	SW846 8240B
9904030714 (NASA-PTWELL) 04/03/99 07:14 015					
SAMPLE 6-2	Trichlorofluoromethane	390 E	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	310	50	ug/L	SW846 8240B
	Tetrachloroethene	5.1	5.0	ug/L	SW846 8240B
	Trichloroethene	38	5.0	ug/L	SW846 8240B

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MAY 17 1999 14:33 FR AT&F WSTF 505 524 5106 TO 91800898126539534 P.20

EXECUTIVE SUMMARY - Detection Highlights

D9D060154

	PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
9904030714 (NASA-PTWELL) 04/03/99 07:14 015					
SAMPLE 6-2	Trichloroethene	35 J	50	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1000 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1000	50	ug/L	SW846 8240B
	1,2-Dichloro-1,1,2-trifluoroethane	1.4 J	5.0	ug/L	SW846 8240B
9904030716 (NASA-PTWELL) 04/03/99 07:16 016					
	Trichlorofluoromethane	390 E	5.0	ug/L	SW846 8240B
SAMPLE 6-3	Trichlorofluoromethane	320	50	ug/L	SW846 8240B
	Tetrachloroethene	3.1 J	5.0	ug/L	SW846 8240B
	Trichloroethene	17	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1100 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1100	50	ug/L	SW846 8240B
	1,2-Dichloro-1,1,2-trifluoroethane	1.5 J	5.0	ug/L	SW846 8240B
9904030738 (NASA-PTWELL) 04/03/99 07:38 018					
BLANK	Acetone	210	20	ug/L	SW846 8240B
	2-Butanone	33	20	ug/L	SW846 8240B
	2-Hexanone	2.1 J	20	ug/L	SW846 8240B
9904030746 (NASA-PTWELL) 04/03/99 07:46 019					
SAMPLE 6-0	Fluoride	0.87	0.10	mg/L	SM18 4500-F C
	Chloride	52.4 Q	15.0	mg/L	MCAWW 300.0A
	Sulfate	314 Q	100	mg/L	MCAWW 300.0A
	Total Alkalinity	215	5.0	mg/L	MCAWW 310.1
9904030748 (NASA-PTWELL) 04/03/99 07:48 020					
SAMPLE 6-1	Fluoride	0.88	0.10	mg/L	SM18 4500-F C
	Chloride	52.8 Q	15.0	mg/L	MCAWW 300.0A
	Sulfate	312 Q	100	mg/L	MCAWW 300.0A
	Total Alkalinity	222	5.0	mg/L	MCAWW 310.1

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EXECUTIVE SUMMARY - Detection Highlights

D9D060154

	PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
9904030750 (NASA-PTWELL) 04/03/99 07:50 021					
SAMPLE 6-2	Fluoride	0.88	0.10	mg/L	SM18 4500-F C
	Chloride	55.0 Q	15.0	mg/L	MCAWW 300.0A
	Sulfate	316 Q	100	mg/L	MCAWW 300.0A
	Total Alkalinity	222	5.0	mg/L	MCAWW 310.1

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ANALYTICAL METHODS SUMMARY

D9D060154

PARAMETER	ANALYTICAL METHOD
Alkalinity	MCAWW 310.1
Chloride	MCAWW 300.0A
Filterable Residue (TDS)	MCAWW 160.1
Fluoride	SM18 4500-F C
Halogenated Volatile Organics by GC	SW846 8010B
Sulfate	MCAWW 300.0A
Volatile Organics by GC/MS	SW846 8240B

References:

MCAWW "Methods for Chemical Analysis of Water and Wastes", EPA-600/4-79-020, March 1983 and subsequent revisions.

SM18 "Standard Methods for the Examination of Water and Wastewater", 18th Edition, 1992.

SW846 "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 and its updates.

EXECUTIVE SUMMARY - Detection Highlights

D9D060157

	PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
9904030752 (NASA-PTWELL) 04/03/99 07:52 001					
SAMPLE 6-3	Fluoride	0.86	0.10	mg/L	SM18 4500-F C
	Chloride	54.8 Q	15.0	mg/L	MCAWW 300.0A
	Sulfate	316 Q	100	mg/L	MCAWW 300.0A
	Total Alkalinity	222	5.0	mg/L	MCAWW 310.1
9904030754 (NASA-PTWELL) 04/03/99 07:54 002					
SAMPLE 6-0	Calcium - DISSOLVED	116	0.20	mg/L	SW846 6010B
	Iron - DISSOLVED	0.040 B	0.10	mg/L	SW846 6010B
	Potassium - DISSOLVED	3.0 B	5.0	mg/L	SW846 6010B
	Magnesium - DISSOLVED	65.0	0.20	mg/L	SW846 6010B
	Sodium - DISSOLVED	35.1	5.0	mg/L	SW846 6010B
9904030756 (NASA-PTWELL) 04/03/99 07:56 003					
SAMPLE 6-1	Calcium - DISSOLVED	123	0.20	mg/L	SW846 6010B
	Iron - DISSOLVED	0.039 B	0.10	mg/L	SW846 6010B
	Potassium - DISSOLVED	3.1 B	5.0	mg/L	SW846 6010B
	Magnesium - DISSOLVED	67.2	0.20	mg/L	SW846 6010B
	Sodium - DISSOLVED	36.9	5.0	mg/L	SW846 6010B
9904030758 (NASA-PTWELL) 04/03/99 07:58 004					
SAMPLE 6-2	Calcium - DISSOLVED	122	0.20	mg/L	SW846 6010B
	Iron - DISSOLVED	0.025 B	0.10	mg/L	SW846 6010B
	Potassium - DISSOLVED	3.1 B	5.0	mg/L	SW846 6010B
	Magnesium - DISSOLVED	67.0	0.20	mg/L	SW846 6010B
	Sodium - DISSOLVED	36.1	5.0	mg/L	SW846 6010B
9904030800 (NASA-PTWELL) 04/03/99 08:00 005					
SAMPLE 6-3	Calcium - DISSOLVED	123	0.20	mg/L	SW846 6010B
	Iron - DISSOLVED	0.040 B	0.10	mg/L	SW846 6010B
	Potassium - DISSOLVED	3.3 B	5.0	mg/L	SW846 6010B
	Magnesium - DISSOLVED	67.6	0.20	mg/L	SW846 6010B
	Sodium - DISSOLVED	37.0	5.0	mg/L	SW846 6010B
9904030802 (NASA-PTWELL) 04/03/99 08:02 006					
SAMPLE 6-0	Total Dissolved Solids	860	10.0	mg/L	MCAWW 160.1

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EXECUTIVE SUMMARY - Detection Highlights

D9D060157

	PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
9904030804 (NASA-PTWELL) 04/03/99 08:04 007					
SAMPLE 6-1	Total Dissolved Solids	871	10.0	mg/L	MCAWW 160.1
9904030806 (NASA-PTWELL) 04/03/99 08:06 008					
SAMPLE 6-2	Total Dissolved Solids	840	10.0	mg/L	MCAWW 160.1
9904030808 (NASA-PTWELL) 04/03/99 08:08 009					
SAMPLE 6-3	Total Dissolved Solids	885	10.0	mg/L	MCAWW 160.1
9904030820 (NASA-PTWELL) 04/03/99 08:20 010					
SAMPLE 4-0	Trichlorofluoromethane	64	12	ug/L	SW846 8010B
	Trichlorofluoromethane	110 E	0.50	ug/L	SW846 8010B
	Tetrachloroethene	2.5	0.50	ug/L	SW846 8010B
	Trichloroethene	110	12	ug/L	SW846 8010B
	Trichloroethene	93 E	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	190	12	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	89 E	0.50	ug/L	SW846 8010B
9904030822 (NASA-PTWELL) 04/03/99 08:22 011					
SAMPLE 4-1	Trichlorofluoromethane	25	12	ug/L	SW846 8010B
	Trichlorofluoromethane	74 E	0.50	ug/L	SW846 8010B
	Tetrachloroethene	0.61	0.50	ug/L	SW846 8010B
	Trichloroethene	21	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	130	12	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	80 E	0.50	ug/L	SW846 8010B
9904030824 (NASA-PTWELL) 04/03/99 08:24 012					
	Trichlorofluoromethane	45	12	ug/L	SW846 8010B
SAMPLE 4-2	Trichlorofluoromethane	69 E	0.50	ug/L	SW846 8010B
	Trichloroethene	4.5	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	150	12	ug/L	SW846 8010B

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EXECUTIVE SUMMARY - Detection Highlights

D9D060157

	PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
9904030824 (NASA-PTWELL) 04/03/99 08:24 012					
SAMPLE 4-2	1,1,2-Trichloro-1,2,2-trifluoroethane	77 E	0.50	ug/L	SW846 8010B
9904030826 (NASA-PTWELL) 04/03/99 08:26 013					
SAMPLE 4-3	Trichlorofluoromethane	410	12	ug/L	SW846 8010B
	Trichlorofluoromethane	260 E	0.50	ug/L	SW846 8010B
	Tetrachloroethene	0.93	0.50	ug/L	SW846 8010B
	Trichloroethene	5.7	0.50	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1000	12	ug/L	SW846 8010B
	1,1,2-Trichloro-1,2,2-trifluoroethane	330 E	0.50	ug/L	SW846 8010B
9904030830 (NASA-PTWELL) 04/03/99 08:30 014					
SAMPLE 4-0	Dichlorofluoromethane	1.8 J	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	330 E	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	360	50	ug/L	SW846 8240B
	Tetrachloroethene	18	5.0	ug/L	SW846 8240B
	Trichloroethene	320 E	5.0	ug/L	SW846 8240B
	Trichloroethene	370	50	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	940 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1200	50	ug/L	SW846 8240B
	1,2-Dichloro-1,1,2-trifluoroethane	1.8 J	5.0	ug/L	SW846 8240B
9904030832 (NASA-PTWELL) 04/03/99 08:32 015					
SAMPLE 4-1	Trichlorofluoromethane	330 E	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	340	50	ug/L	SW846 8240B
	Tetrachloroethene	8.5	5.0	ug/L	SW846 8240B
	Trichloroethene	90	5.0	ug/L	SW846 8240B
	Trichloroethene	89	50	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	960 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1100	50	ug/L	SW846 8240B

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EXECUTIVE SUMMARY - Detection Highlights

D9D060157

	PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
9904030906 (NASA-PTWELL) 04/03/99 09:06 020					
SAMPLE 3-0	Dichlorofluoromethane	2.0 J	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	330 E	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	320	50	ug/L	SW846 8240B
	Tetrachloroethene	18	5.0	ug/L	SW846 8240B
	Trichloroethene	340 E	5.0	ug/L	SW846 8240B
	Trichloroethene	340	50	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	990 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1100	50	ug/L	SW846 8240B
	1,2-Dichloro-1,1,2-trifluoroethane	2.0 J	5.0	ug/L	SW846 8240B
9904030908 (NASA-PTWELL) 04/03/99 09:08 021					
SAMPLE 3-3	Trichlorofluoromethane	330 E	5.0	ug/L	SW846 8240B
	Trichlorofluoromethane	310	50	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	980 E	5.0	ug/L	SW846 8240B
	1,1,2-Trichloro-1,2,2-trifluoroethane	1000	50	ug/L	SW846 8240B
	1,2-Dichloro-1,1,2-trifluoroethane	2.0 J	5.0	ug/L	SW846 8240B

EXECUTIVE SUMMARY - Detection Highlights

D9D060162

Blind Controls

PARAMETER	RESULT	REPORTING LIMIT	UNITS	ANALYTICAL METHOD
9903290901 (NASA-PTWELL) 03/29/99 09:01 001				
Trichlorofluoromethane	4.2	0.50	ug/L	SW846 8010B
Tetrachloroethene	5.0	0.50	ug/L	SW846 8010B
Trichloroethene	3.6	0.50	ug/L	SW846 8010B
1,1,2-Trichloro-1,2,2-trifluoroethane	3.8	0.50	ug/L	SW846 8010B
1,2-Dichloro-1,1,2-trifluoroethane	3.3 J	5.0	ug/L	SW846 8010B
9903290903 (NASA-PTWELL) 03/29/99 09:03 002				
Trichlorofluoromethane	5.7	0.50	ug/L	SW846 8010B
Tetrachloroethene	5.7	0.50	ug/L	SW846 8010B
Trichloroethene	4.3	0.50	ug/L	SW846 8010B
1,1,2-Trichloro-1,2,2-trifluoroethane	4.4	0.50	ug/L	SW846 8010B
1,2-Dichloro-1,1,2-trifluoroethane	4.5 J	5.0	ug/L	SW846 8010B
9903290905 (NASA-PTWELL) 03/29/99 09:05 003				
Trichlorofluoromethane	6.2	0.50	ug/L	SW846 8010B
Tetrachloroethene	7.3	0.50	ug/L	SW846 8010B
Trichloroethene	5.3	0.50	ug/L	SW846 8010B
1,1,2-Trichloro-1,2,2-trifluoroethane	5.3	0.50	ug/L	SW846 8010B
1,2-Dichloro-1,1,2-trifluoroethane	5.5	5.0	ug/L	SW846 8010B
9903290907 (NASA-PTWELL) 03/29/99 09:07 004				
Trichlorofluoromethane	12	0.50	ug/L	SW846 8010B
Tetrachloroethene	12	0.50	ug/L	SW846 8010B
Trichloroethene	9.5	0.50	ug/L	SW846 8010B
1,1,2-Trichloro-1,2,2-trifluoroethane	10	0.50	ug/L	SW846 8010B
1,2-Dichloro-1,1,2-trifluoroethane	10	5.0	ug/L	SW846 8010B
9903290909 (NASA-PTWELL) 03/29/99 09:09 005				
Trichlorofluoromethane	46	5.0	ug/L	SW846 8240B
Methylene chloride	2.7 J	5.0	ug/L	SW846 8240B
Tetrachloroethene	49	5.0	ug/L	SW846 8240B

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Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	GC/MS Analysis Data:	04/16/1999
Sponsor:	AlliedSignal	Reporting Data:	04/21/1999
AlliedSignal Sample #:	**9904020957** SAMPLE	Sample Matrix:	Water
Well ID:	**NASA-PT Well** 5-3	Sample Volume:	1000 mL
SwRI WO#-ID:	15429-121039	Final Extract Volume:	1.0 mL
Receiving Data:	04/06/1999	Analytical Method:	M-8061A
Extraction Data:	04/07/1999	Reporting Limit:	1 ppb

ANALYTE	MDL (ppb)	Result	J-Value
Dimethyl phthalate	0.311	< 1 ppb	
Diethyl phthalate	0.214	< 1 ppb	
Diisobutyl phthalate	0.128	< 1 ppb	
Di-n-butyl phthalate	0.213	< 1 ppb	
Bis(4-methyl-2-pentyl) phthalate	0.353	< 1 ppb	
Bis(2-methoxyethyl) phthalate	0.308	< 1 ppb	
Diamyl phthalate	0.190	< 1 ppb	
Bis(2-ethoxyethyl) phthalate	0.591	< 1 ppb	
Hexyl 2-ethylhexyl phthalate	0.198	< 1 ppb	
Dihexyl phthalate	0.120	< 1 ppb	
Butyl benzyl phthalate	0.358	< 1 ppb	
Bis(2-n-butoxyethyl) phthalate	0.414	< 1 ppb	
Bis(2-ethylhexyl) phthlate	0.441	< 1 ppb	
Dicyclohexyl phthalate	0.432	< 1 ppb	
Di-n-octyl phthalate	0.363	< 1 ppb	
Dinonyl phthalate	0.339	< 1 ppb	
Bromacil	0.234	< 1 ppb	
Surrogate:		*Recovery*	
Diphenyl phthalate (surr.)		105 %	
Diphenyl isophthalate (surr.)		183 %	
Dibenzyl phthalate (surr.)		148 %	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	GC/MS Analysis Data:	04/16/1999
Sponsor:	AlliedSignal	Reporting Data:	04/21/1999
AlliedSignal Sample #:	**9904030720** SAMPLE	Sample Matrix:	Water
Well ID:	**NASA-PT Well** 6-0	Sample Volume:	1000 mL
SwRI WO#-ID:	15429-121041	Final Extract Volume:	1.0 mL
Receiving Data:	04/06/1999	Analytical Method:	M-8061A
Extraction Data:	04/07/1999	Reporting Limit:	1 ppb

ANALYTE	MDL (ppb)	Result	J-Value
Dimethyl phthalate	0.311	< 1 ppb	
Diethyl phthalate	0.214	< 1 ppb	
Diisobutyl phthalate	0.128	< 1 ppb	
Di-n-butyl phthalate	0.213	< 1 ppb	
Bis(4-methyl-2-pentyl) phthalate	0.353	< 1 ppb	
Bis(2-methoxyethyl) phthalate	0.308	< 1 ppb	
Diamyl phthalate	0.190	< 1 ppb	
Bis(2-ethoxyethyl) phthalate	0.591	< 1 ppb	
Hexyl 2-ethylhexyl phthalate	0.198	< 1 ppb	
Dihexyl phthalate	0.120	< 1 ppb	
Butyl benzyl phthalate	0.358	< 1 ppb	
Bis(2-n-butoxyethyl) phthalate	0.414	< 1 ppb	
Bis(2-ethylhexyl) phthlate	0.441	< 1 ppb	
Dicyclohexyl phthalate	0.432	< 1 ppb	
Di-n-octyl phthalate	0.363	< 1 ppb	
Dinonyl phthalate	0.339	< 1 ppb	
Bromacil	0.234	< 1 ppb	
Surrogate:		*Recovery*	
Diphenyl phthalate (surr.)		120 %	
Diphenyl isophthalate (surr.)		195 %	
Dibenzyl phthalate (surr.)		168 %	

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Analytical Data Report Sheet

SwRI Project #:	01-1608-001	GC/MS Analysis Data:	04/16/1999
Sponsor:	AlliedSignal	Reporting Data:	04/21/1999
AlliedSignal Sample #:	**9904030724** SAMPLE 6-1	Sample Matrix:	Water
Well ID:	**NASA-PT Well**	Sample Volume:	1000 mL
SwRI WO#-ID:	15429-121045	Final Extract Volume:	1.0 mL
Receiving Data:	04/06/1999	Analytical Method:	M-8061A
Extraction Data:	04/07/1999	Reporting Limit:	1 ppb

ANALYTE	MDL (ppb)	Result	J-Value
Dimethyl phthalate	0.311	< 1 ppb	
Diethyl phthalate	0.214	< 1 ppb	
Diisobutyl phthalate	0.128	< 1 ppb	
Di-n-butyl phthalate	0.213	< 1 ppb	
Bis(4-methyl-2-pentyl) phthalate	0.353	< 1 ppb	
Bis(2-methoxyethyl) phthalate	0.308	< 1 ppb	
Diamyl phthalate	0.190	< 1 ppb	
Bis(2-ethoxyethyl) phthalate	0.591	< 1 ppb	
Hexyl 2-ethylhexyl phthalate	0.198	< 1 ppb	
Dihexyl phthalate	0.120	< 1 ppb	
Butyl benzyl phthalate	0.358	< 1 ppb	
Bis(2-n-butoxyethyl) phthalate	0.414	< 1 ppb	
Bis(2-ethylhexyl) phthlate	0.441	< 1 ppb	
Dicyclohexyl phthalate	0.432	< 1 ppb	
Di-n-octyl phthalate	0.363	< 1 ppb	
Dinonyl phthalate	0.339	< 1 ppb	
Bromacil	0.234	< 1 ppb	
Surrogate:		*Recovery*	
Diphenyl phthalate (surr.)		116 %	
Diphenyl isophthalate (surr.)		190 %	
Dibenzyl phthalate (surr.)		160 %	

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Analytical Data Report Sheet

SwRI Project #:	01-1608-001		GC/MS Analysis Data:	04/16/1999
Sponsor:	AlliedSignal		Reporting Data:	04/21/1999
AlliedSignal Sample #:	**9904020933**	SAMPLE 5-0	Sample Matrix:	Water
Well ID:	**NASA-PT Well**		Sample Volume:	1000 mL
SwRI WO#-ID:	15429-121048		Final Extract Volume:	1.0 mL
Receiving Data:	04/06/1999		Analytical Method:	M-8061A
Extraction Data:	04/07/1999		Reporting Limit:	1 ppb

ANALYTE	MDL (ppb)	Result	J-Value
Dimethyl phthalate	0.311	< 1 ppb	
Diethyl phthalate	0.214	< 1 ppb	
Diisobutyl phthalate	0.128	< 1 ppb	
Di-n-butyl phthalate	0.213	< 1 ppb	
Bis(4-methyl-2-pentyl) phthalate	0.353	< 1 ppb	
Bis(2-methoxyethyl) phthalate	0.308	< 1 ppb	
Diamyl phthalate	0.190	< 1 ppb	
Bis(2-ethoxyethyl) phthalate	0.591	< 1 ppb	
Hexyl 2-ethylhexyl phthalate	0.198	< 1 ppb	
Dihexyl phthalate	0.120	< 1 ppb	
Butyl benzyl phthalate	0.358	< 1 ppb	
Bis(2-n-butoxyethyl) phthalate	0.414	< 1 ppb	
Bis(2-ethylhexyl) phthlate	0.441	< 1 ppb	**0.48 ppb**
Dicyclohexyl phthalate	0.432	< 1 ppb	
Di-n-octyl phthalate	0.363	< 1 ppb	
Dinonyl phthalate	0.339	< 1 ppb	
Bromacil	0.234	< 1 ppb	
Surrogate:		*Recovery*	
Diphenyl phthalate (surr.)		114 %	
Diphenyl isophthalate (surr.)		183 %	
Dibenzyl phthalate (surr.)		143 %	

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Analytical Data Report Sheet

SwRI Project #:	01-1608-001	GC/MS Analysis Data:	04/16/1999
Sponsor:	AlliedSignal	Reporting Data:	04/21/1999
AlliedSignal Sample #:	**9904020941** SAMPLE	Sample Matrix:	Water
Well ID:	**NASA-PT Well** 5-1	Sample Volume:	1000 mL
SwRI WO#-ID:	15429-121052	Final Extract Volume:	1.0 mL
Receiving Data:	04/06/1999	Analytical Method:	M-8061A
Extraction Data:	04/07/1999	Reporting Limit:	1 ppb

ANALYTE	MDL (ppb)	Result	J-Value
Dimethyl phthalate	0.311	< 1 ppb	
Diethyl phthalate	0.214	< 1 ppb	
Diisobutyl phthalate	0.128	< 1 ppb	
Di-n-butyl phthalate	0.213	< 1 ppb	
Bis(4-methyl-2-pentyl) phthalate	0.353	< 1 ppb	
Bis(2-methoxyethyl) phthalate	0.308	< 1 ppb	
Diamyl phthalate	0.190	< 1 ppb	
Bis(2-ethoxyethyl) phthalate	0.591	< 1 ppb	
Hexyl 2-ethylhexyl phthalate	0.198	< 1 ppb	
Dihexyl phthalate	0.120	< 1 ppb	
Butyl benzyl phthalate	0.358	< 1 ppb	
Bis(2-n-butoxyethyl) phthalate	0.414	< 1 ppb	
Bis(2-ethylhexyl) phthlate	0.441	< 1 ppb	
Dicyclohexyl phthalate	0.432	< 1 ppb	
Di-n-octyl phthalate	0.363	< 1 ppb	
Dinonyl phthalate	0.339	< 1 ppb	
Bromacil	0.234	< 1 ppb	
Surrogate:		*Recovery*	
Diphenyl phthalate (surr.)		114 %	
Diphenyl isophthalate (surr.)		188 %	
Dibenzyl phthalate (surr.)		158 %	

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Analytical Data Report Sheet

SwRI Project #:	01-1608-001	GC/MS Analysis Data:	04/16/1999
Sponsor:	AlliedSignal	Reporting Data:	04/21/1999
AlliedSignal Sample #:	**9904020949** SAMPLE	Sample Matrix:	Water
Well ID:	**NASA-PT Well** 5-1	Sample Volume:	1000 mL
SwRI WO#-ID:	15429-121056	Final Extract Volume:	1.0 mL
Receiving Data:	04/06/1999	Analytical Method:	M-8061A
Extraction Data:	04/07/1999	Reporting Limit:	1 ppb

ANALYTE	MDL (ppb)	Result	J-Value
Dimethyl phthalate	0.311	< 1 ppb	
Diethyl phthalate	0.214	< 1 ppb	
Diisobutyl phthalate	0.128	< 1 ppb	
Di-n-butyl phthalate	0.213	< 1 ppb	
Bis(4-methyl-2-pentyl) phthalate	0.353	< 1 ppb	
Bis(2-methoxyethyl) phthalate	0.308	< 1 ppb	
Diamyl phthalate	0.190	< 1 ppb	
Bis(2-ethoxyethyl) phthalate	0.591	< 1 ppb	
Hexyl 2-ethylhexyl phthalate	0.198	< 1 ppb	
Dihexyl phthalate	0.120	< 1 ppb	
Butyl benzyl phthalate	0.358	< 1 ppb	
Bis(2-n-butoxyethyl) phthalate	0.414	< 1 ppb	
Bis(2-ethylhexyl) phthlate	0.441	< 1 ppb	
Dicyclohexyl phthalate	0.432	< 1 ppb	
Di-n-octyl phthalate	0.363	< 1 ppb	
Dinonyl phthalate	0.339	< 1 ppb	
Bromacil	0.234	< 1 ppb	
Surrogate:		*Recovery*	
Diphenyl phthalate (surr.)		111 %	
Diphenyl isophthalate (surr.)		182 %	
Dibenzyl phthalate (surr.)		158 %	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001	GC/MS Analysis Data:	04/16/1999
Sponsor:	AlliedSignal	Reporting Data:	04/21/1999
AlliedSignal Sample #:	**9904030728** SAMPLE	Sample Matrix:	Water
Well ID:	**NASA-PT Well** 6-2	Sample Volume:	500 mL
SwRI WO#-ID:	15429-121066	Final Extract Volume:	0.5 mL
Receiving Data:	04/06/1999	Analytical Method:	M-8061A
Extraction Data:	04/07/1999	Reporting Limit:	1 ppb

ANALYTE	MDL (ppb)	Result	J-Value
Dimethyl phthalate	0.311	< 1 ppb	
Diethyl phthalate	0.214	< 1 ppb	**0.70 ppb**
Diisobutyl phthalate	0.128	< 1 ppb	
Di-n-butyl phthalate	0.213	< 1 ppb	
Bis(4-methyl-2-pentyl) phthalate	0.353	< 1 ppb	
Bis(2-methoxyethyl) phthalate	0.308	< 1 ppb	
Diamyl phthalate	0.190	< 1 ppb	
Bis(2-ethoxyethyl) phthalate	0.591	< 1 ppb	
Hexyl 2-ethylhexyl phthalate	0.198	< 1 ppb	
Dihexyl phthalate	0.120	< 1 ppb	
Butyl benzyl phthalate	0.358	< 1 ppb	
Bis(2-n-butoxyethyl) phthalate	0.414	< 1 ppb	
Bis(2-ethylhexyl) phthlate	0.441	< 1 ppb	
Dicyclohexyl phthalate	0.432	< 1 ppb	
Di-n-octyl phthalate	0.363	< 1 ppb	
Dinonyl phthalate	0.339	< 1 ppb	
Bromacil	0.234	< 1 ppb	
Surrogate:		*Recovery*	
Diphenyl phthalate (surr.)		116 %	
Diphenyl isophthalate (surr.)		188 %	
Dibenzyl phthalate (surr.)		178 %	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01-1608-001		GC/MS Analysis Data:	04/16/1999
Sponsor:	AlliedSignal		Reporting Data:	04/21/1999
AlliedSignal Sample #:	**9904030732**	SAMPLE 6-3	Sample Matrix:	Water
Well ID:	**NASA-PT Well**		Sample Volume:	500 mL
SwRI WO#-ID:	15429-121067		Final Extract Volume:	0.5 mL
Receiving Data:	04/06/1999		Analytical Method:	M-8061A
Extraction Data:	04/07/1999		Reporting Limit:	1 ppb

ANALYTE	MDL (ppb)	Result	J-Value
Dimethyl phthalate	0.311	< 1 ppb	
Diethyl phthalate	0.214	< 1 ppb	
Diisobutyl phthalate	0.128	< 1 ppb	
Di-n-butyl phthalate	0.213	< 1 ppb	
Bis(4-methyl-2-pentyl) phthalate	0.353	< 1 ppb	
Bis(2-methoxyethyl) phthalate	0.308	< 1 ppb	
Diamyl phthalate	0.190	< 1 ppb	
Bis(2-ethoxyethyl) phthalate	0.591	< 1 ppb	
Hexyl 2-ethylhexyl phthalate	0.198	< 1 ppb	
Dihexyl phthalate	0.120	< 1 ppb	
Butyl benzyl phthalate	0.358	< 1 ppb	
Bis(2-n-butoxyethyl) phthalate	0.414	< 1 ppb	
Bis(2-ethylhexyl) phthlate	0.441	< 1 ppb	
Dicyclohexyl phthalate	0.432	< 1 ppb	
Di-n-octyl phthalate	0.363	< 1 ppb	
Dinonyl phthalate	0.339	< 1 ppb	
Bromacil	0.234	< 1 ppb	
Surrogate:		*Recovery*	
Diphenyl phthalate (surr.)		114 %	
Diphenyl isophthalate (surr.)		185 %	
Dibenzyl phthalate (surr.)		170 %	

Confidential

Design Report on the

UV/Oxidation Design Test to Treat

NDMA and DMN at the NASA White Sands Test Facility

prepared for

Honeywell Technology Solutions, Inc.

by

Calgon Carbon Corporation

TABLE OF CONTENTS

1.0 SUMMARY

2.0 BACKGROUND

2.1 Photolysis of NDMA

2.2 Advanced Oxidation Processes (AOP)

2.3 UV Dose

2.4 Electrical Energy per Order (EE/O)

3.0 DESIGN TEST RESULTS

3.1 Pilot Unit

3.2 Experimental Procedure

3.3 Groundwater Characterization

3.4 Sample Analysis

3.5 Test Results

3.6 Discussion of Results

3.7 Extrapolation of Results – Treatment with Existing 12 Lamp Rayox Tower

3.8 Conclusions

1.0 SUMMARY

This report outlines the design testing results for the UV/Oxidation treatment of groundwater containing N-nitrosodimethylamine (NDMA) and N-nitrodimethylamine (DMN) received from the Mid-Plume Area of NASA's White Sands Test Facility (WSTF) in Las Cruces, NM. A design test was performed to demonstrate the effectiveness of Calgon Carbon Corporation's (CCC) UV/Oxidation process for the destruction of NDMA and DMN in the groundwater. The objectives of the design test were:

- to confirm the effectiveness of the UV/oxidation process for reducing NDMA and DMN down to the required effluent limit of < 2 ppt each on the waste stream.

- to determine if the existing 12 lamp Rayox Tower can adequately treat the additional stream from the Mid-Plume area.

The test work completed on the groundwater has confirmed that:

- destruction of NDMA and DMN down to the required limit can be obtained using CCC's UV process.

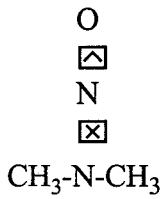
- the existing 12 lamp Tower will be able to handle the design flow from the Plume Front Area in addition to the water from the Mid-Plume Area.

- treatment of the combined Plume Front and Mid-Plume Area waste streams from 2,700 ppt NDMA and 1,500 ppt DMN down to < 2 ppt each of NDMA and DMN at a total flowrate of 1,070 gpm can be met with the existing Tower.

2.0 BACKGROUND

2.1 Photolysis of NDMA

N-Nitrosodimethylamine (NDMA) is a carcinogenic compound which has the following chemical structure:



NDMA is a polar molecule which cannot be treated using conventional technologies such as air stripping or activated carbon. NDMA absorbs UV light strongly in a band centered around 227 nm. Absorption of light in this band results in efficient breaking of the nitrogen-nitrogen bond in the molecule leading to production of an NO radical and a dimethylamino radical as shown in the following equation:

$$(CH_3)_2NNO \xrightarrow{h\nu} (CH_3)_2N\bullet + \bullet NO$$

The NO radical will react with oxidants (i.e. oxygen) to give nitrite which can be further oxidized to nitrate.

Since NDMA absorbs light strongly and dissociates with high efficiency, UV treatment is a cost effective treatment approach. This requires a UV lamp which has good output around 230 nm, where NDMA absorbs most strongly. CCC's UV lamps are a proprietary design which offer increased output in the region between 200 nm and 250 nm and thus are well suited for photolysis, or light driven destruction mechanism critical for NDMA destruction.

2.2 Advanced Oxidation Processes (AOP)

In advanced oxidation processes, the primary treatment mechanism involves the reaction of UV light with hydrogen peroxide to generate highly reactive hydroxyl radicals (•OH) as shown below:

$$H_2O_2 + \text{UV light} \longrightarrow 2\ \bullet OH \qquad [1]$$

The OH radical initiates a rapid cascade of oxidation reactions which, if allowed to proceed to completion, result in carbon dioxide and water as end products. This oxidation can be greatly enhanced by the addition of homogenous catalysts (i.e. CCC's ENOX 910 iron-based catalyst) which increase the efficiency of the UV light reactions.

In some cases, other mechanistic pathways can also be identified such as direct photolysis (as described above) of the contaminants by UV light or direct reaction of oxygen radicals with the target contaminants or their intermediate byproducts.

UV Light

The formation of hydroxyl radicals relies on the absorbance of UV light in the range of 200 to 240 nm. In CCC's UV/oxidation system, this light is provided by high intensity medium pressure mercury vapor lamps. The lamps are housed in quartz tubes and a patented device is used to prevent fouling of the quartz tubes. Calgon Carbon Corporation's medium pressure UV lamps have been designed to give out significantly more UV light in the 200 to 240 nm range than any other UV light source. While UV light is needed for the formation of hydroxyl radicals from hydrogen peroxide, it may also serve to break or weaken the chemical bonds of many organic compounds (i.e. NDMA as is the case here) by direct photolysis. This is important for compounds that react slowly with hydroxyl radicals.

Hydrogen Peroxide

Hydrogen peroxide is a commonly used chemical oxidant in advanced oxidation processes. It is normally supplied in concentrations of 35 or 50% in water and is metered into the flow line upstream of the UV lamps. The combination of high intensity UV light and hydrogen peroxide produces an oxidative environment that is effective for the treatment of a broad range of organic compounds.

2.3 UV Dose

In the UV oxidation process, a high powered lamp emits UV radiation through a quartz sleeve into the contaminated water. The photons of light activate hydrogen peroxide and generate highly reactive hydroxyl radicals which destroy the organic contaminants. The destruction of organic contaminants is therefore dependent upon the amount of UV light which is applied to the contaminated water.

Calgon Carbon Corporation's design parameter for the scale-up of UV oxidation systems is the "UV dose" which is defined as the amount of UV lamp energy (in kWh) applied to 1000 gallons of water. This design parameter can be calculated from either flow through or batch situations as follows;

$$\text{UV Dose (Batch)} = \frac{\text{Lamp Size(kW) x Time(min) x 3785 (L/1000gal)}}{\text{Volume (L) x 60 (min/hr)}}$$

and

$$\text{UV Dose (Flow)} = \frac{\text{Lamp Size (kW) x 1000 (gal/ 1000gal)}}{\text{Flow Rate (gpm) x 60 (min/h)}} \qquad [2]$$

The UV Dose is typically used to scale-up from a batch design test to a full scale system. For the full-scale system, 20 kW lamps are used in the calculations.

2.4 Electrical Energy per Order (EE/O)

The destruction of a contaminant by a UV/Oxidation process involves a complex series of chemical reactions. Experience has shown that this destruction generally follows a first order relationship with the amount of energy input into a unit volume of water (UV Dose). A simple design parameter, which incorporates the UV Dose input to the system and the number of orders of contaminant destruction, can be used to compare and scale-up processes. This design parameter is defined as the Electrical Energy per Order or the EE/O and its units are in kWh/1000gal/order.

For example, if it takes 10 kWh of electrical energy to reduce the concentration of a target compound from 10 ppm to 1 ppm (1 order of magnitude or 90% destruction) in 1000 gallons of water, then the EE/O is 10 kWh/1000gal/order for this compound. It will take another 10 kWh/1000gal of UV Dose to reduce the compound from 1 ppm to 0.1 ppm (another 90% reduction).

The EE/O values obtained in a batch system can be applied directly to a full-scale flowthrough system. The equation for the EE/O which applies to both batch and flow through situations is:

$$EE/O = \frac{\text{UV Dose}}{\log (C_i/C_f),} \qquad [3]$$

where C_i is the initial concentration and C_f is the final concentration.

In scaling up from bench scale results to a full scale system the EE/O value is calculated. In systems with more than one compound of interest the EE/O for each compound must be determined in the batch testing. The effluent concentration for each compound can then be calculated for the full scale design

3.0 DESIGN TEST RESULTS

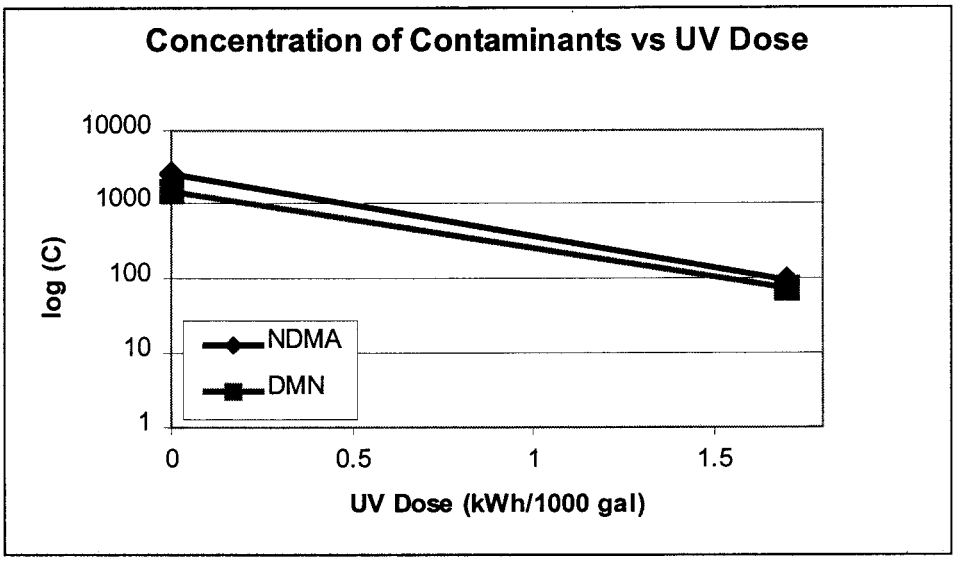
3.1 Pilot Unit

Design testing at Calgon Carbon Corporation is performed using a 1 kW pilot unit. The pilot unit consists of a 10 gallon cylindrical stainless steel reactor equipped with a 1 kW lamp. The lamp used has an identical UV output spectrum to the lamps which are used in a full scale system so that scale-up using the design parameter, UV Dose, is extremely accurate. The 1 kW lamp is mounted vertically in the reactor and separated from the water by a quartz sleeve. An air-actuated transmittance controller automatically wipes the quartz sleeve at regular intervals to ensure that the quartz remains clean throughout the entire run. A mixer in the reactor ensures complete mixing of the sample during the tests. The pilot unit also has a steel shutter which, when closed, serves to block the transmittance of UV light into the sample.

3.2 Experimental Procedure

For the test run, approximately seven (7) gallons of groundwater were added to the pilot unit. An initial sample was taken. The UV Lamp was then ignited with the steel shutter closed. After several minutes of mixing and lamp warm-up, the shutter was opened and the run timer was started. Samples were taken at periodic intervals corresponding to increasing UV doses and were analyzed for NDMA and DMN at an outside analytical laboratory.

Results of the test run were compared by plotting the concentration of NDMA and DMN as a function of UV dose (expressed as total lamp energy per thousand gallons of water).



3.3 *Groundwater Characterization*

Five 5 gal sample containers of the waste water were received on February 12, 2003. The UV absorbance of the water was measured with values at different wavelengths shown in Table 1.

Table 1: Measured UV Absorbance Values

Wavelength (nm)	Absorbance
200	3.090
210	2.412
220	1.044
230	0.236
240	0.043
250	0.015
260	0.010
270	0.013
280	0.010
290	0.008
300	0.009

In general, a high UV absorbance indicates that non-target water constituents are competing for UV light energy against the target contaminants, thus decreasing treatment efficiency. The absorbance levels of the water were low, thus indicating little competition for UV light by background contaminants.

3.4 *Sample Analysis*

Samples were analyzed by Southwest Research Institute (San Antonio, TX) for NDMA and DMN using EPA Method 607 (modified). See Appendix A.

3.5 *Test Results*

Calgon Carbon Corporation carried out two treatment runs on the groundwater. The test matrix is summarized in Table 2 and the test results are presented in Table 3.

Table 2: Design Test Matrix

Run #	**Treatment**	**pH**
1	UV Only	As received
2	UV/5 ppm H2O2	As received

Table 3: Analytical Data from Run

Run #1: UV Only, pH as received

Sample No.	UV Dose kWh/1000gal	NDMA ppt	DMN ppt
1-0	0	2505*	1515*
1-1	1.7	90	70
1-2	3.4	< 10	< 10
1-3	5.1	< 10	< 10

* *Samples of duplicate averages*

Run #2: UV/5 ppm H_2O_2, pH as received

Sample No.	UV Dose kWh/1000gal	NDMA ppt	DMN ppt
2-0	0	2700	1370
2-1	1.7	190	90
2-2	3.4	< 10	< 10
2-3	5.1	< 10	< 10

3.6 *Discussion of Results*

The destruction of NDMA in Run 1 dropped from 2,505 ppt down to 90 ppt using a UV dose of 1.7 kWh/1000gal. The destruction of DMN in Run 1 dropped from 1,515 ppt down to 70 ppt using The EE/O for each compound can be calculated with the use of equation [3].

$$\text{NDMA:} \quad EE/O = \frac{1.7}{\log(2{,}505/90)} = 1.2 \quad \text{kWh/1000 gal/order}$$

$$\text{DMN:} \quad EE/O = \frac{1.7}{\log(1{,}515/70)} = 1.3 \quad \text{kWh/1000 gal/order}$$

Since EE/O is a measure of the energy required for contamination destruction, DMN appears to be the controlling compound.

The use of UV/peroxide in Run 2 did not improve the treatment efficiency. This may be due to the fact that the presence of peroxide absorbs a significant fraction of UV light making less available for NDMA photolysis. In waters with a significant fraction of organics, the presence of hydroxyl radicals (generated from the photolysis of peroxide) may destroy these background competing organics and enhance the rate of NDMA destruction. This was not observed with the waste stream, indicating that the most efficient treatment process for NDMA and DMN is direct UV photolysis. The EE/O for NDMA in Run 2 was 1.5 kWh/1000gal/order; higher than that in Run 1 (using UV only). This indicates that the treatment efficiency using UV/peroxide was approximately 20-30% slower than compared to using UV only.

3.7 Extrapolation of Results – Treatment with Existing 12 Lamp Rayox Tower

In scaling up from bench scale results to a full-scale system the EE/O value is calculated. The larger the EE/O the more energy required and hence treatment is less efficient. By comparing EE/O values from each run one can easily see the reduction in electrical power required for treatment as the conditions are varied. By using the controlling contaminant's EE/O value, 1.3 kWh/1000 gallons/order, the full size system's UV dose is obtained by rearranging equation [3].

$$\text{UV Dose} = EE/O * \log(C_i/C_f)$$

$$= 1.3 * \log(1500/2)$$

$$= 3.74 \text{ kWh/1000gal}$$

This UV dose is required for treatment of the combined Plume Front and Mid-Plume Area waste streams.

From the previous Plume Front Area design basis with the existing 12 lamp Tower, a total lamp power of 154 kW was required for treatment of NDMA and DMN down to the required level of < 2 ppt each at the design flow of 900 gpm (see Calgon Carbon Proposal# P-393-2 dated April 19, 2000). Based on the previous NDMA EE/O of 0.95, treatment required only eight (8) lamps on the Tower in operation (each lamp is operated at ~20 kW), with four (4) lamps serving as spares. Therefore, the existing system's possible output is 240 kW (12 lamps x 20 kW/lamp).

The full size system is easily scaled to any flowrate or concentration required by rearranging equation [2].

$$kW = \frac{EE/O \times Flow\ (gpm) \times 60 \times \log (C_i/C_f)}{1000}$$

$$240 = \frac{1.3 \times Flowrate \times 60 \times \log (1{,}500/2)}{1000}$$

Flowrate = 1,070 gpm

This flowrate represents the combined Plume Front and Mid-Plume Area streams which can be treated with the existing Rayox 12 lamp Tower operating at full power.

3.8 Conclusions

With the Plume Front Area water tested in 1998 and the Mid-Plume Area water tested in February 2003, the existing 12 lamp Rayox Tower can handle a total combined flow of 1,070 US gpm. Treatment of N-nitrosodimethylamine (NDMA) and N-nitrodimethylamine (DMN) from 2,700 ppt and 1,500 ppt respectively, down to < 2 ppt each is expected.

CLIENT: ALLIEDSIGNAL TECHNICAL SERVICES CORPORATION
SwRI PROJECT: 01.01608.200
WORK ORDERS: 23806

ANALYTICAL DATA REPORT SHEETS

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01.01608.203	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1000 mL
AlliedSignal Sample #:	**1-0**	Final Extract Volume:	1.0 mL
Well ID:	**Bench Test Run 1**	Analytical Method:	Mod-607
SwRI WO#-ID:	23806-220321	Reporting Limit:	0.01 ppb
Receiving Date:	02/14/2003	MDL:	0.005 ppb
Extraction Date:	02/19/2003	Extraction Efficiency:	NDMA 36%
GC/MS Analysis Date:	03/07/2003		DMN 78%
Reporting Date:	03/10/2003		

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**2.63 ppb**	
N-Nitrodimethylamine	4164-28-7	**1.50 ppb**	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01.01608.203	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1000 mL
AlliedSignal Sample #:	**1-0 Duplicate**	Final Extract Volume:	1.0 mL
Well ID:	**Bench Test Run 1**	Analytical Method:	Mod-607
SwRI WO#-ID:	23806-220321	Reporting Limit:	0.01 ppb
Receiving Date:	02/14/2003	MDL:	0.005 ppb
Extraction Date:	02/19/2003	Extraction Efficiency:	NDMA 36%
GC/MS Analysis Date:	03/07/2003		DMN 78%
Reporting Date:	03/10/2003		

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**2.38 ppb**	
N-Nitrodimethylamine	4164-28-7	**1.53 ppb**	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01.01608.203	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1000 mL
AlliedSignal Sample #:	**1-1**	Final Extract Volume:	1.0 mL
Well ID:	**Bench Test Run 1**	Analytical Method:	Mod-607
SwRI WO#-ID:	23806-220322	Reporting Limit:	0.01 ppb
Receiving Date:	02/14/2003	MDL:	0.005 ppb
Extraction Date:	02/19/2003	Extraction Efficiency:	NDMA 36%
GC/MS Analysis Date:	03/07/2003		DMN 78%
Reporting Date:	03/10/2003		

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.09 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.07 ppb**	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01.01608.203	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1000 mL
AlliedSignal Sample #:	**1-2**	Final Extract Volume:	1.0 mL
Well ID:	**Bench Test Run 1**	Analytical Method:	Mod-607
SwRI WO#-ID:	23806-220323	Reporting Limit:	0.01 ppb
Receiving Date:	02/14/2003	MDL:	0.005 ppb
Extraction Date:	02/19/2003	Extraction Efficiency:	NDMA 36%
GC/MS Analysis Date:	03/07/2003		DMN 78%
Reporting Date:	03/10/2003		

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01 ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01 ppb	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01.01608.203	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1000 mL
AlliedSignal Sample #:	**1-3**	Final Extract Volume:	1.0 mL
Well ID:	**Bench Test Run 1**	Analytical Method:	Mod-607
SwRI WO#-ID:	23806-220324	Reporting Limit:	0.01 ppb
Receiving Date:	02/14/2003	MDL:	0.005 ppb
Extraction Date:	02/19/2003	Extraction Efficiency:	NDMA 36%
GC/MS Analysis Date:	03/07/2003		DMN 78%
Reporting Date:	03/10/2003		

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01 ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01 ppb	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01.01608.203	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1000 mL
AlliedSignal Sample #:	**1-3 Duplicate**	Final Extract Volume:	1.0 mL
Well ID:	**Bench Test Run 1**	Analytical Method:	Mod-607
SwRI WO#-ID:	23806-220324	Reporting Limit:	0.01 ppb
Receiving Date:	02/14/2003	MDL:	0.005 ppb
Extraction Date:	02/19/2003	Extraction Efficiency:	NDMA 36%
GC/MS Analysis Date:	03/07/2003		DMN 78%
Reporting Date:	03/10/2003		

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01 ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01 ppb	

010014

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01.01608.204	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**1-3**	Final Extract Volume:	0.1 mL
Well ID:	**Bench Test Run 1**	Analytical Method:	TAP-01-0403-015
SwRI WO#-ID:	23806-220324	Reporting Limit:	0.5 ppt
Receiving Date:	02/14/2003	Method Detect Limit:	0.2 ppt for NDMA
Extraction Date:	02/19/2003		0.5 ppt for DMN
GC/MS Analysis Date:	03/14/2003	Matrix Spike Recov.:	NDMA 114%
Reporting Date:	03/17/2003		DMN 142%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**8.8 ppt**	
N-Nitrodimethylamine	4164-28-7	< 0.5 ppt	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01.01608.203	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1000 mL
AlliedSignal Sample #:	**2-0**	Final Extract Volume:	1.0 mL
Well ID:	**Bench Test Run 1**	Analytical Method:	Mod-607
SwRI WO#-ID:	23806-220325	Reporting Limit:	0.01 ppb
Receiving Date:	02/14/2003	MDL:	0.005 ppb
Extraction Date:	02/19/2003	Extraction Efficiency:	NDMA 36%
GC/MS Analysis Date:	03/07/2003		DMN 78%
Reporting Date:	03/10/2003		

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**2.70 ppb**	
N-Nitrodimethylamine	4164-28-7	**1.37 ppb**	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01.01608.203	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1000 mL
AlliedSignal Sample #:	**2-1**	Final Extract Volume:	1.0 mL
Well ID:	**Bench Test Run 1**	Analytical Method:	Mod-607
SwRI WO#-ID:	23806-220326	Reporting Limit:	0.01 ppb
Receiving Date:	02/14/2003	MDL:	0.005 ppb
Extraction Date:	02/19/2003	Extraction Efficiency:	NDMA 36%
GC/MS Analysis Date:	03/07/2003		DMN 78%
Reporting Date:	03/10/2003		

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**0.19 ppb**	
N-Nitrodimethylamine	4164-28-7	**0.09 ppb**	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01.01608.203	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1000 mL
AlliedSignal Sample #:	**2-2**	Final Extract Volume:	1.0 mL
Well ID:	**Bench Test Run 1**	Analytical Method:	Mod-607
SwRI WO#-ID:	23806-220327	Reporting Limit:	0.01 ppb
Receiving Date:	02/14/2003	MDL:	0.005 ppb
Extraction Date:	02/19/2003	Extraction Efficiency:	NDMA 36%
GC/MS Analysis Date:	03/07/2003		DMN 78%
Reporting Date:	03/10/2003		

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01 ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01 ppb	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01.01608.203	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1000 mL
AlliedSignal Sample #:	**2-3**	Final Extract Volume:	1.0 mL
Well ID:	**Bench Test Run 1**	Analytical Method:	Mod-607
SwRI WO#-ID:	23806-220328	Reporting Limit:	0.01 ppb
Receiving Date:	02/14/2003	MDL:	0.005 ppb
Extraction Date:	02/19/2003	Extraction Efficiency:	NDMA 36%
GC/MS Analysis Date:	03/07/2003		DMN 78%
Reporting Date:	03/10/2003		

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01 ppb	**0.009 ppb**
N-Nitrodimethylamine	4164-28-7	< 0.01 ppb	**0.007 ppb**

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01.01608.203	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1000 mL
AlliedSignal Sample #:	**2-3 Duplicate**	Final Extract Volume:	1.0 mL
Well ID:	**Bench Test Run 1**	Analytical Method:	Mod-607
SwRI WO#-ID:	23806-220328	Reporting Limit:	0.01 ppb
Receiving Date:	02/14/2003	MDL:	0.005 ppb
Extraction Date:	02/19/2003	Extraction Efficiency:	NDMA 36%
GC/MS Analysis Date:	03/07/2003		DMN 78%
Reporting Date:	03/10/2003		

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01 ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01 ppb	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01.01608.204	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1 L
AlliedSignal Sample #:	**2-3**	Final Extract Volume:	0.1 mL
Well ID:	**Bench Test Run 1**	Analytical Method:	TAP-01-0403-015
SwRI WO#-ID:	23806-220328	Reporting Limit:	0.5 ppt
Receiving Date:	02/14/2003	Method Detect Limit:	0.2 ppt for NDMA
Extraction Date:	02/19/2003		0.5 ppt for DMN
GC/MS Analysis Date:	03/14/2003	Matrix Spike Recov.:	NDMA 114%
Reporting Date:	03/17/2003		DMN 142%

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	**17.6 ppt**	
N-Nitrodimethylamine	4164-28-7	< 0.5 ppt	

Southwest Research Institute

Analytical Data Report Sheet

SwRI Project #:	01.01608.203	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1000 mL
AlliedSignal Sample #:	**Field Blank**	Final Extract Volume:	1.0 mL
Well ID:		Analytical Method:	Mod-607
SwRI WO#-ID:	23806-220329	Reporting Limit:	0.01 ppb
Receiving Date:	02/14/2003	MDL:	0.005 ppb
Extraction Date:	02/19/2003	Extraction Efficiency:	NDMA 36%
GC/MS Analysis Date:	03/07/2003		DMN 78%
Reporting Date:	03/10/2003		

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01 ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01 ppb	

CLIENT: ALLIEDSIGNAL TECHNICAL SERVICES CORPORATION
SwRI PROJECT: 01.01608.200
WORK ORDERS: 23806

QA DATA SHEETS

(STANDARD, METHOD BLANK, MATRIX SPIKE)

Southwest Research Institute

Method Blank Data Sheet

SwRI Project #:	01.01608.203	Sample Matrix:	Water
Sponsor:	AlliedSignal	Sample Volume:	1000 mL
SwRI ID #:	**Blank 220498**	Final Extract Volume:	1.0 mL
Extraction Date:	02/19/2003	Analytical Method:	Mod-607
GC/MS Analysis Date:	03/07/2003	Reporting Limit:	0.01 ppb
Reporting Date:	03/10/2003	MDL:	0.005 ppb

ANALYTE	CAS #	Result	J-Value
N-Nitrosodimethylamine	62-75-9	< 0.01 ppb	
N-Nitrodimethylamine	4164-28-7	< 0.01 ppb	

Southwest Research Institute

Matrix Spike Recovery Report

SwRI Project #:	01.01608.203	Reporting Date:	03/10/2003
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:		Sample Volume:	1000 mL
Well ID:		Final Extract Volume:	1.0 mL
SwRI WO#-ID:	**Blank MS 220499**	Analytical Method:	Mod-607
Receiving Date:		Reporting Limit:	0.01 ppb
Extraction Date:	02/19/2003	MDL:	0.005 ppb
GC/MS Analysis Date:	03/07/2003	Compared Sample #:	**Blank 220498**

ANALYTE	CAS #	Spike Level	MS recovery
N-Nitrosodimethylamine	62-75-9	0.5 ppb	36%
N-Nitrodimethylamine	4164-28-7	0.5 ppb	78%

Southwest Research Institute

Matrix Spike Recovery Report

SwRI Project #:	01.01608.203	Reporting Date:	03/10/2003
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**1-0 MS**	Sample Volume:	1000 mL
Well ID:	**Bench Test Run 1**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	23806-220321	Analytical Method:	Mod-607
Receiving Date:	02/14/2003	Reporting Limit:	0.01 ppb
Extraction Date:	02/19/2003	MDL:	0.005 ppb
GC/MS Analysis Date:	03/07/2003	Compared Sample #:	**1-0 Duplicate**

ANALYTE	CAS #	Spike Level	MS recovery
N-Nitrosodimethylamine	62-75-9	0.5 ppb	39%
N-Nitrodimethylamine	4164-28-7	0.5 ppb	53%

Southwest Research Institute

Matrix Spike Recovery Report

SwRI Project #:	01.01608.203	Reporting Date:	03/10/2003
Sponsor:	AlliedSignal	Sample Matrix:	Water
AlliedSignal Sample #:	**1-3 MS**	Sample Volume:	1000 mL
Well ID:	**Bench Test Run 1**	Final Extract Volume:	1.0 mL
SwRI WO#-ID:	23806-220324	Analytical Method:	Mod-607
Receiving Date:	02/14/2003	Reporting Limit:	0.01 ppb
Extraction Date:	02/19/2003	MDL:	0.005 ppb
GC/MS Analysis Date:	03/07/2003	Compared Sample #:	**1-3 Duplicate**

ANALYTE	CAS #	Spike Level	MS recovery
N-Nitrosodimethylamine	62-75-9	0.5 ppb	35%
N-Nitrodimethylamine	4164-28-7	0.5 ppb	59%

Southwest Research Institute

Continuing Calibration Check Sheet

SwRI Project #:	01-1608-203	Calibration Date:	03/07/2003
Sponsor:	AlliedSignal	Analytical Method:	Mod-607
SwRI Standard ID:	85-03-98BIO-020	Std Concentration:	0.2 ug/mL
Standard Preparing Date:	02/12/2002	Initial Calibration Date	02/20/2003

ANALYTE	Mean RRF	RRF 0.050	% Dif.
N-Nitrosodimethylamine	0.621	0.633	-2
N-Nitrodimethylamine	0.23	0.24	-4.2

Southwest Research Institute

Initial Calibration Data Sheet

SwRI Project #:	01.01608.203	Calibration Data:	02/20/2003
Sponsor:	AlliedSignal	Analytical Method:	Mod-607
SwRI Standard ID:	85-03-98BIO-020	Std Concentration:	0.01-10 ug/mL
Standard Preparing Data:	02/12/2002	Standard Volume:	1.0 mL of each

ANALYTE	RRF 0.01	RRF 0.2	RRF 1	RRF 5	RRF 10	Ave. RRF	**RSD%**
N-Nitrosodimethylamine	0.462	0.58	0.687	0.737	0.701	0.621	**19.7**
N-Nitrodimethylamine	0.187	0.216	0.257	0.250	0.241	0.23	**12.5**

SIMPLIFIED AOP MECHANISMS

N-Nitrosodimethylamine (NDMA):

$(CH_3)_2$-N-N=O + hν → $(CH_3)_2$-N• + •N=O

↓ •OH/O_2 ↓ H_2O/O_2

CH_3-N=CH_2 NO_2^-

↓ •OH/O_2 ↓ H_2O_2

CH_3-N=O + H_2CO NO_3^-

↓ •OH/O_2 ↓ •OH/O_2

H_2CO + •N=O $HCOO^-$

↓ •OH/O_2 ↓ •OH/O_2

$HCOO^-$ + •OH/O_2 → HCO_3^-

Overall:

$h\nu + (CH_3)_2NNO + \begin{matrix} 11\,O \\ 11\,H_2O_2 \\ 11\,O_3 \end{matrix} \Rightarrow 2HCO_3^- + 2NO_3^-$

WSTF Individual Waste Profile Sheet (WIWPS)

Reviewed By **Date of Review**

WIWPS # 10-20-13

Facility Area 600 **Work Area** 650 **Responsible Section** 1620

Name of Waste GW REMEDIATION AQUEOUS WASTE

Describe the Process Generating the Waste

GROUNDWATER CONTAINING WSTF GROUNDWATER CONTAMINANTS. WASTE IS GENERATED DURING ROUTINE OPERATION AND MAINTENANCE OF THE PLUME FRONT REMEDIATION FACILITY PER WJI ENV-0065, "PLUME FRONT STABILIZATION TREATMENT SYSTEM OPERATION AND MAINTENANCE MANUAL".

List of Known Hazardous Constituents and their Concentrations

WSTF GROUNDWATER CONTAMINANTS

Waste Description **Physical State** LIQUID **pH** 7 **Solubility**

Spec Grav 1 **Flash Point** N/A **Reactivity**

Other Comments: (phases, clarity, color, consistency, etc)

WIWPS HARD COPY FILE CONTAINS APPLICABLE MSDS'S.

Annual Quantity Generated 5000 **Units** GALLONS

MSDS# NA **Task Order(s)** J85

Generator Name Jack Kirby **Date Completed** 7/13/04

I certify that the waste described on this from is generated as described ***NASA Authorized Representative*** **Date Completed**

Status A

Waste Category Haz Waste WW

(a = Active, i = Inactive)

Environmental Department's Representative EFS

Accumulate Waste in Container Labeled GW REMEDIATION AQUEOUS WASTE

EPA Waste ID Number(s) F001, F002

Specific/Non-Specific Source, Listed Waste Name

UHC Determination

Supporting Documents WJI ENV-0065, "PLUME FRONT STABILIZATION TREATMENT SYSTE

Waste Collection Method (at the point of generation)

WASTE COLLECTION METHODS WILL VARY DEPENDING ON THE WASTE AND THE QUANTITY. AFTER WASTE IS COLLECTED IT WILL BE TRANSFERRED TO THE EVPORATION TANKS. WASTE ADDITIONS TO THE EVAPORATION TANKS ARE RECORDED IN THE ETU LOGBOOK.

Waste/Satellite Accumulation Area NA **On-site Storage Area** ETU

Evap Tank waste that requires Subpart CC compliance? YES **Has Process or Concentration Changed?** NO

Subpart CC Compliance

THIS WASTE IS SUBJECT TO SUBPART CC. VOC CONCENTRATION SHALL BE DETERMINED BY PROCESS KNOWLEDGE (ANALYSIS OF THE TREATMENT FACILITY INFLUENT BY METHODS OTHER THAN EPA METHOD 25D). IF ANALYTICAL RESULTS SHOW THAT THE VOC CONCENTRATION IS LESS THAN 500 PPMW THE WASTE CAN BE DISCHARGED TO THE ETU. OTHERWISE, ALTERNATED DISPOSAL IS REQUIRED.

Disposal Method Evap Tanks **Vendor Profile Number** NONE

WSTF Individual Waste Profile Sheet (WIWPS)

Reviewed By **Date of Review**

Comments

REMEDIATION SYSTEM WILL BE OPERATIONAL DURING CY 2004.

WSTF Individual Waste Profile Sheet (WIWPS)

Reviewed By **Date of Review**

WIWPS # 10-20-17

Facility Area 600 **Work Area** 650 **Responsible Section** 1620

Name of Waste SPENT UV MERCURY LAMPS

Describe the Process Generating the Waste

SPENT ULTRAVIOLET MERCURY LAMPS ARE GENERATED DURING ROUTINE OPERATION OF THE PLUME-FRONT REMEDIATION FACILITY UV TREATMENT UNIT.

List of Known Hazardous Constituents and their Concentrations

2.2 GRAMS OF Hg/HgO .

Waste Description	**Physical State**	SOLID	**pH**	N/A	**Solubility**	
	Spec Grav	N/A	**Flash Point**	N/A	**Reactivity**	

Other Comments: (phases, clarity, color, consistency, etc)

Annual Quantity Generated	36	**Units**	EACH
MSDS#	N/A	**Task Order(s)**	J85
Generator Name	Jack Kirby	**Date Completed**	7/13/04
I certify that the waste described on this from is generated as described	***NASA Authorized Representative***	**Date Completed**	

Status A

Waste Category Universal Waste

(a = Active, i = Inactive)

Environmental Department's Representative	EFS
Accumulate Waste in Container Labeled	SPENT MERCURY LAMPS
EPA Waste ID Number(s)	NONE
Specific/Non-Specific Source, Listed Waste Name	NONE
UHC Determination	40 CFR 273 UNIVERSAL WASTE, DETERMINATION NOT REQUIRED
Supporting Documents	ACCEPTABLE KNOWLEDGE

Waste Collection Method (at the point of generation)

LAMPS REMOVED FROM REMEDIATION SYSTEM WILL BE TRANSFERRED TO THE MERCURY LAMP ACCUMULATION AREA LOCATED BY THE BUILDING 121 EAST ENTRANCE.

Waste/Satellite Accumulation Area		**On-site Storage Area**	BLDG 161
Evap Tank waste that requires Subpart CC compliance?	NO	**Has Process or Concentration Changed?**	NO

Subpart CC Compliance

N/A

Disposal Method Recycle **Vendor Profile Number** N/A

Comments

UV LAMPS WILL BE MANAGED BY A CALGON CARBON THROUGH THE SERVICE CONTRACT FOR THE UV UNIT

WSTF Individual Waste Profile Sheet (WIWPS)

Reviewed By **Date of Review**

WIWPS # 10-20-18

Facility Area 600 **Work Area** 650 **Responsible Section** 1620

Name of Waste CONTAMINATED REFUSE

Describe the Process Generating the Waste

CONTAMINATED REFUSE GENERATED DURING ROUTINE OPERATION OF THE PLUME-FRONT REMEDIATION FACILITY CONSISTING OF SOFTGOODS (WIPES, ABSORBANTS AND PPE) CONTAMINATED WITH WSTF GROUNDWATER CONTAMINANTS, POLY PHOSPHATES, ACIDS, BASES, SOLVENTS, OILS, GREASE.

List of Known Hazardous Constituents and their Concentrations

WSTF GROUNDWATER CONTAMINANTS, POLY PHOSPHATES, ACIDS, BASES, SOLVENTS, OILS, GREASE.

Waste Description **Physical State** SOLID **pH** N/A **Solubility**

Spec Grav N/A **Flash Point** N/A **Reactivity**

Other Comments: (phases, clarity, color, consistency, etc)

Annual Quantity Generated 20 **Units** LBS

MSDS# 503, 7456 **Task Order(s)** J85

Generator Name **Date Completed**

I certify that the waste described on this from is generated as described TANAKA **Date Completed** 8/6/03

NASA Authorized Representative

Status A

Waste Category Haz Waste NWW

(a = Active, i = Inactive)

Environmental Department's Representative EFS

Accumulate Waste in Container Labeled CONTAMINATED REFUSE

EPA Waste ID Number(s)

Specific/Non-Specific Source, Listed Waste Name

UHC Determination

Supporting Documents

Waste Collection Method (at the point of generation)

pH OF WASTE SCALE CLEANING SOLUTION WILL BE DETERMINED. IF WASTE EXHIBITS A pH LOWER THAN 2, WASTE WIPES WILL BE COLLECTED AND CONTAINERIZED. WIPES CONTAMINATED WITH WASTE WITH A pH HIGHER THAT 2 MAY BE DISPOSED OF IN THE TRASH. GLOVES SHOULD BE DECONTAMINATED INTO THE WASTE STREAM 10-20-13 AND THEN THROWN IN TRASH.

Waste/Satellite Accumulation Area **On-site Storage Area**

Evap Tank waste that requires Subpart CC compliance? NO **Has Process or Concentration Changed?** NO

Subpart CC Compliance

N/A

Disposal Method Combustion **Vendor Profile Number** CH2175352

Comments

WASTE WILL BE COLLECTED AND BAGGED, THEN TRANSFERREDTO AN APPROPRIATE CONTAINER. FOR ASSISTANCE CONTACT E. SOUTHWORTH @ X5721 OR H. HARRISON @ X5461.

Environmental Department WIWPS Tracking Database (per WSI 22-SW-0005)

WSTF Individual Waste Profile Sheet (WIWPS)

Reviewed By **Date of Review**

WIWPS # 10-20-21

Facility Area 600 **Work Area** 650 **Responsible Section** 1620

Name of Waste Spent Citric Acid Descaler

Describe the Process Generating the Waste

Routine descaling of the Plume-Front Remediation Facility air strippers per WJI ENV-0065, "Plume Front Stabilization Treatment System Operation and Maintenance Manual". Up to a 10 % citric acid solution will be used during the descaling process.

List of Known Hazardous Constituents and their Concentrations

10 % citric acid solution

Waste Description **Physical State** liquid **pH** 2 **Solubility**

Spec Grav 1 **Flash Point** **Reactivity**

Other Comments: (phases, clarity, color, consistency, etc)

WIWPS HARD COPY CONTAINS APPLICABLE MSDS's

Annual Quantity Generated 5000 **Units**

MSDS# 503 **Task Order(s)**

Generator Name **Date Completed**

I certify that the waste described on this from is generated as described **Date Completed**

NASA Authorized Representative

Status A

Waste Category Haz Waste NWW

(a = Active, i = Inactive)

Environmental Department's Representative

Accumulate Waste in Container Labeled SPENT CITRIC ACID

EPA Waste ID Number(s) D002

Specific/Non-Specific Source, Listed Waste Name

UHC Determination

Supporting Documents WJI ENV-0065, "Plume Front Stabilization Treatment System Operation an

Waste Collection Method (at the point of generation)

WASTE TO BE COLLECTED IN TANK, THEN TRANSFERRED TO THE ETU. ADDITIONS TO THE ETU ARE RECOREDED IN THE ETU LOG BOOK

Waste/Satellite Accumulation Area NA **On-site Storage Area** ETU

Evap Tank waste that requires Subpart CC compliance? YES **Has Process or Concentration Changed?** NO

Subpart CC Compliance

RCRA SUBPART CC WASTE DETERMINATION BY DIRECT MEASUREMENT (SAMPLING AND ANALYSIS BY EPA METHOD 25D) REQUIRED. DISCHAGE TO THE ETU AUTHORIZED ONLY IF THE VOC CONCENTRATION IS LESS THAN 500 PPMW

Disposal Method Evap Tanks **Vendor Profile Number** NONE

Comments

WSTF Individual Waste Profile Sheet (WIWPS)

Reviewed By **Date of Review**

Comments

REMEDIATION SYSTEM WILL BE OPERATIONAL DURING CY 2004.

AQUA MAG® C-10

MATERIAL SAFETY DATA SHEET

Information: 815-223-1500 **Emergency: 800-435-6856** **CHEMTREC: 800-424-9300**

I. IDENTIFICATION

PRODUCT NAME:	Aqua Mag® C-10	**REVISION DATE:** 5/30/01			
CHEMICAL NAME:	Sodium Polyphosphate	**FORMULA:** Proprietary			
SYNONYMS:	Sodium Polyphosphates, Glassy	**PACKING GROUP:** NA			
D.O.T. HAZARD CLASS:	Non-Hazardous	**UN NO.**	NA	**CAS NO.**	NA
D.O.T. SHIPPING NAME:	Not Regulated			**CAS NAME**	NA

II. PHYSICAL DATA

PHYSICAL STATE: Clear liquid	**SPECIFIC GRAVITY:** 1.37	**pH**: 6.0
BOILING POINT, ºC: > 100°C (212° F)	**SOLUBILITY IN WATER:** Soluble in all proportions.	
FREEZING POINT, °C: -5° C (23°F)	**VOLATILES VOLUME %:** NA	
VAPOR PRESSURE AT 20^0C. Mm Hg: NA	**EVAPORATION RATE:** NA	

III. HAZARDOUS COMPONENTS GREATER THAN 1%

MATERIAL	PEL	TLV	CAS.NO.	%

This product contains no toxic chemicals subject to the reporting requirements of Section 313 – Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372.

CARCINOGENICITY: Not listed by NTP, IARC, or OSHA

IV. FIRE AND EXPLOSIVE HAZARD DATA

FLAMMABILITY:	Non-flammable.
NORMAL EXTINGUISHING AGENT:	Suitable for surrounding materials.
SPECIAL FIRE FIGHTING PROCEDURES:	Not Applicable.
USUAL FIRE AND EXPLOSION HAZARDS:	None known.

V. REACTIVITY DATA

STABILITY:	Stable.	**CONDITIONS TO AVOID:**	Heat and freezing.
INCOMPATIBILITY (materials to avoid):	No specific data.		
HAZARDOUS COMBUSTION / DECOMPOSITION PRODUCTS:	May liberate oxides of sodium or phosphorus if involved in fire.		

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VI. HEALTH HAZARD DATA

ACUTE EFFECTS OF EXPOSURE	
INGESTION:	May cause irritation to mouth and throat, or nausea and vomiting.
SKIN CONTACT:	May cause skin irritation.
INHALATION:	May cause irritation to the respiratory tract.
EYE CONTACT:	May cause eye injury.
CHRONIC EFFECTS OF EXPOSURE:	No specific information.
OTHER HEALTH DATA:	No specific information. Maximum use level per NSF Standard 60: 28mg/L

EMERGENCY AND FIRST AID PROCEDURES	
INGESTION:	Burning of mouth area may be reduced or eliminated through continued rinsing with water. Do not induce vomiting. Drink large quantities of water. Consult a physician.
SKIN :	Flush exposed area with water. Rinse thoroughly. Consult a physician.
INHALATION:	Remove to fresh air. Consult a physician.
EYES:	Flush eyes with copious amounts of water for at least 15 minutes. Consult a physician.

VII. SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED:	Contain all spills. Absorb with inert media and dispose of properly. Flush area with large amounts of water.
WASTE DISPOSAL METHOD:	Disposal of all materials shall be in full and strict compliance with all federal, state, and local regulations pertaining to phosphates.

VIII. SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION:	Approved NIOSH/MSHA mist respirator.		
PROTECTIVE GLOVES:	Chemical resistant.	**EYE PROTECTION:**	Chemical safety goggles.
VENTILATION:	Well ventilated area.	**SPECIAL EQUIPMENT:**	Impervious apron, eyewash fountain, safety shower.

IX. SPECIAL PRECAUTIONS

HANDLING AND STORAGE:	Store in cool, dry place. Protect container from physical damage.
OTHER:	None known.

Chithambarathanu Pillai (S.O.F.)

CARUS

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Peru, IL 61354
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Fax (815) 224-6697

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Remede Products

MATERIAL SAFETY DATA SHEET

IDENTITY - **Redux-380**

SECTION I - PRODUCT INFORMATION

MANUFACTURER'S NAME -

Remede Products
550 VT Rte. 30
Newfane, VT 05345

TELEPHONE NUMBER FOR INFORMATION - 802-365-7200

EMERGENCY TELEPHONE NUMBER - CHEMTREC (800) 424-9300

DATE PREPARED - March 28, 1989

PREPARED BY -
Technical Manager
Remede Products

SECTION II - HAZARDOUS INGREDIENTS/IDENTITY INFORMATION

COMPONENT	OSHA PEL	ACGIH TLV	Other Limits Recommended
Organic phosphorus compound	NDA	NDA	-

N/A = Not Applicable NDA = No Data Available

550 Vermont Rte.30, P.O. Box 331, Newfane, Vermont 05345
Phone: 802-365-7200 Fax: 802-365-4652 remedeproducts.com

SECTION III - PHYSICAL/CHEMICAL CHARACTERISTICS

Boiling Point, (oF):	210 - 220
Specific Gravity, (water=1):	1.00 - 1.05
Vapor Pressure, (mm Hg.):	NDA
Melting Point, (oF):	N/A
Vapor Density, (air=1):	NDA
Evaporation Rate, (Butyl Acetate = 1):	NDA
Solubility in Water:	Complete
Appearance and Odor:	Pale straw to yellow, odorless liquid.

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

Flash Point, (Method Used): Non-flammable/aqueous solution.

Flammable Limits: N/A

LEL: N/A

UEL: N/A

Extinguishing Media:

N/A

Special Fire Fighting Procedures:

Firefighters should wear self-contained breathing apparatus and body covering protective clothing.

Unusual Fire and Explosion Hazards:

None

SECTION V - REACTIVITY DATA

Stability:

Stable X Unstable ____

Conditions to Avoid: NONE

Incompatibility (Materials to Avoid):

Quaternary amines, acids, sulfides and strong oxidizers.

Hazardous Decomposition or Byproducts:

Carbon dioxide and carbon monoxide.

Hazardous Polymerization:

May Occur ____ Will Not Occur X

Conditions to Avoid: NONE

SECTION VI - HEALTH HAZARD DATA

Route(s) of Entry:

Inhalation? YES Skin? YES Ingestion? YES

Health Hazards (Acute and Chronic):

Mild irritant. May be harmful or fatal if swallowed.

Carcinogenicity:

NTP? NO IARC Monographs? NO OSHA Regulated? NO

Signs and Symptons of Exposure:

Eye and skin irritant. Material may cause burns on exposed tissues with corneal injury which may result in permanent impairment of vision, or even blindness. Prolonged or repeated skin contact may cause irritation or even a burn.

Medical Conditions Generally Aggravated by Exposure:

Skin conditions

Emergency and First Aid Procedures:

Ingestion:

NEVER give anything by mouth to an unconscious person. If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. If available, give several glasses of milk. If vomiting occurs spontaneously, keep airway clear. Seek medical attention immediately.

Inhalation:

Remove person to fresh air. If breathing has stopped, resuscitate and give oxygen if readily available. Seek medical attention immediately.

Eye Contact:

Immediately flush eyes with large amounts of water for at least 15 minutes, holding lids apart to ensure flushing of the entire surface. Washing eyes within 1 minute is essential to achieve maximum effectiveness. Seek medical attention immediately.

Skin Contact:

Immediately wash contaminated areas with plenty of water. Remove contaminated clothing and footwear and wash clothing before reuse. Discard footwear which cannot be decontaminated. Seek medical attention immediately.

SECTION VII - PRECAUTIONS FOR SAFE HANDLING AND USE:

Steps To Be Taken in Case Material is Released or Spilled:

Wear protective equipment outlined below. Absorb with inert ingredient such as sand or vermiculite, shovel into closeable container for disposal. Thoroughly flush residual with water.

Waste Disposal Method:

By methods consistant with applicable federal, state and local regulations.

Precautions to be Taken in Handling and Storing:

Wear recommended protective equipment when handling. Store in a cool, dry and well ventilated area.

Other Precautions:

None

SECTION VIII - CONTROL MEASURES:

Respiratory Protection:

NONE REQUIRED

Ventilation:

Local Exhaust - NONE

Mechanical - NONE

Special - NONE

Other - General Dilution

Protective Gloves :

RUBBER or NEOPRENE gloves.

Eye Protection:

Safety goggles or full face shield.

Other Protective Equipment:

Protective clothing or rubber apron.

Work/Hygienic Practices:

Wash hands thoroughly after handling.

==========

All information, recommendations and suggestions appearing herein concerning our product are based upon tests and data believed to be reliable. However, it is the user's responsibility to determine the safety, toxicity, and suitability for his own use of the product described herein. Since the actual use by others is beyond our control, no guarantee, expressed or implied, is made by Remede Products, Inc. as to the effects of such use, the results to be obtained, or the safety and toxicity of the product, nor does Remede Products, Inc. assume any liability arising out of use, by others, of the product referred to herein. The information herein is not be construed as absolutely complete since additional information may be necessary or desirable when particular or exceptional conditions or circumstances exist or because of applicable laws or government regulations.

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
White Sands Test Facility
P.O. Box 20
Las Cruces, NM 88004-0020

August 11, 2003

Reply to Attn of: RA-03-094

New Mexico Environment Department
Attn: Mr. Mike Fowler
New Source Review Unit
Air Quality Bureau
2048 Galisteo Street
Santa Fe, NM 87505

Subject: NASA White Sands Test Facility (WSTF) Plume-Front Remediation System
Air Emissions Notice of Intent (NOI)

Enclosure 1 is the plume-front NOI as requested in your letter of July 2, 2003. Enclosure 2 contains the hard copy certification page with appropriate signatures. No filing fee is required for, nor submitted with, this NOI pursuant to NMAC 20.2.73.200. This NOI submittal is provided on a CD-ROM in Adobe PDF format. An Access database, containing applicable groundwater analytical results, is also included on the CD.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment for knowing violations.

To the extent that information has been submitted electronically, I acknowledge that NMED will rely solely on the electronic information as accurate and complete information and that it is this data that will be used for compliance and enforcement purposes pursuant to the provisions set forth in the NASA WSTF Final Project Agreement.

If you have any questions or comments concerning this submittal, please call me at 505–524–5484.

Original Signed By:

Michael Zigmond, P.E.
Environmental Engineer

2 Enclosures

bcc:
HTSI Team/P. H. Pache (w/o encls.)

RA/MZigmond:ljg:8/11/03:5484

D:\Data\Word 2003\Ltrs\Env-03-2\Plume Front NOI Cover Letter

CONCUR						
	CODE →	RA				
	SIGNATURE →					
	DATE →	8-11-03				

NASA FORM 1267A SEP 91 PREVIOUS EDITION MAY BE USED.

SENDER: *COMPLETE THIS SECTION*

- Complete items 1, 2, and 3. Also complete item 4 if Restricted Delivery is desired.
- Print your name and address on the reverse so that we can return the card to you.
- Attach this card to the back of the mailpiece, or on the front if space permits.

1. Article Addressed to:

NEW MEXICO ENVIRONMENT DEPARTMENT
ATTN MR MIKE FOWLER
NEW SOURCE REVIEW UNIT
AIR QUALITY BUREAU
2048 GALISTEO STREET
SANTA FE NM 87505

COMPLETE THIS SECTION ON DELIVERY

A. Received by *(Please Print Clearly)* DC 8-30-03 | B. Date of

C. Signature
X L. L. Ramos ☐ A ☐ A

D. Is delivery address different from item 1? ☐ Ye
If YES, enter delivery address below: ☐ N

20

3. Service Type
☑ Certified Mail ☐ Express Mail
☐ Registered ☐ Return Receipt for M
☐ Insured Mail ☐ C.O.D.

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2. Article N 7002 3150 0005 2261 7375

PS Form 3811, July 1999 Domestic Return Receipt 1025:

UNITED STATES POSTAL SERVICE

LLG #094

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• Sender: Please print your name, address, and ZIP+4 in this box •

National Aeronautics and
Space Administration

Mail Code:
Lyndon B. Johnson Space Center
White Sands Test Facility
Post Office Box 20
Las Cruces, NM 88004-0020

Part VIII – Certification

Company Name: NASA JSC White Sands Test Facility

I, Stephen C. Nunez, hereby certify that the information and data submitted in this application are true and as accurate as possible, to the best of my knowledge and professional expertise and experience.

Signed this 19th day of August, 2003, upon my oath or affirmation, before a notary of the State of New Mexico.

Stephen C. Nunez
Signature

8/19/03
Date

STEPHEN C. NUNEZ
Printed Name

MANAGER, NASA JSC WSTF
Title

Scribed and sworn before me on this 19th day of August, 2003.

My authorization as a notary of the State of New Mexico expires on the 5th day of October, 2004.

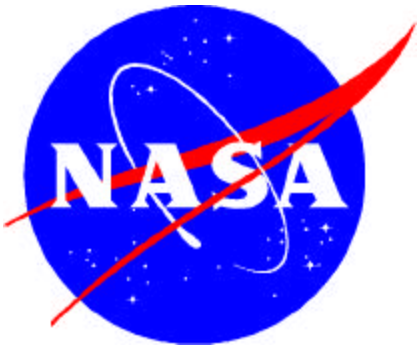
Linda J. Green
Notary's Signature

8-19-03
Date

LINDA J. GREEN
Notary's Printed Name

Seal

Rev 7/18/02



Johnson Space Center
NASA White Sands Test Facility

Notice of Intent
Plume-Front Remediation System

July 31, 2003

GENERAL INFORMATION

This Notice of Intent (NOI) is submitted by NASA White Sands Test Facility (WSTF) to address concerns, expressed by the New Mexico Environment Department (NMED) Hazardous Waste Bureau, that air emissions from the plume-front remediation system may need an air permit. NASA has concluded that none of the air emissions from the plume-front remediation system trigger any requirement to obtain an air permit. NASA requests the Air Quality Bureau (AQB) to issue a No Permit Required (NPR) letter in response to this NOI.

NASA WSTF is a research and development facility specializing in the testing of space flight materials and propulsion systems. There are two propulsion test areas at WSTF: the 300 and the 400 Areas. Tests of rocket engines and propulsion systems are conducted at simulated altitude and/or ambient conditions. The 200 Area Laboratories supports propulsion system and material testing with related research projects and chemical analyses, including the operations of the 700 Area High Energy Blast Facility. The plume-front remediation system, located in the 600 Area, is intended to treat contaminated groundwater from historical releases in the 200, 300, 400, and 500 Areas.

The plume-front remediation system is a pump-and-treat system that extracts groundwater and treats it by air stripping the volatile organic compounds (VOC) and ultra-violet (UV) oxidation of the N-nitrosodimethylamine (NDMA). The treated water is then injected back into the groundwater aquifer from which it was extracted (see Attachment G).

The worst case mass emissions, i.e. 100% of the organic contaminants are stripped to the atmosphere, are used in the analysis, based on the plume-front all time high concentrations, as presented in the groundwater database summary information in Attachment D.

Based on the emission calculations, no dispersion modeling was executed for this NOI.

Mail Application To:		**Application No.** _____
New Mexico Environment Department Air Quality Bureau New Source Review Unit 2048 Galisteo Santa Fe, NM 87505 Phone (505) 827-1494 http://www.nmenv.state.nm.us		**AIRS No.** _____-_____-_____ *For NMED use only*

Air Quality Permit Application And Notice Of Intent
Universal (General) to Construct or Modify

Acknowledgement: v I acknowledge that a pre-application meeting is available to me upon request

Permit filing fee enclosed, Check No.: _____

Part I – General Information

I-A: Company Information

1	Company name: **National Aeronautics and Space Administration (NASA)**		Date application notarized: **N/A**
2	Facility name: **White Sands Test Facility (WSTF): Plume Front Remediation Facility**		SIC code (4 digits): **9661**
3	Company mailing address: **P. O. Box 20, Las Cruces, New Mexico 88004**		
4	Contact person: **Michael Zigmond, P.E.**		Title: **Environmental Engineer**
5	Phone No: **505.524.5484**	Fax No: **505.524.5798**	E-mail: **mzigmond@wstf.nasa.gov**

I-B: Current Facility Status

1	This application is for (check one): v New Facility, Modification to an existing facility, or Revision	
2	Has this facility already been constructed? v Yes No	If yes, is it currently operating in New Mexico? Yes v No
3	Is the plant currently shut down? Yes v No	If yes, give month and year of shut down (MM/YY):
4	Was this facility constructed before 1972 and operated since 1972? Yes v No	
5	Does this facility have an operating permit under 20 NMAC 2.70? Yes v No	If yes, the permit No. is: P-____
6	Has this facility been issued a No Permit Required (NPR)? Yes v No	If yes, the NPR number is:
7	Has this facility been issued a Notice of Intent (NOI)? Yes v No	If yes, the NOI Number is:
8	Does this facility have a construction permit (20 NMAC 2.72, Section 200.A or 200.B) Yes v No	
•	If yes, the permit No. is: ____	
9	Has this facility been issued a general permit (GCP-1, GCP-2,…)? Yes v No	If yes, the registration No. is: ____
10	Is this a "major source" under the PSD rules? Yes v No Unsure.	Is this a "major source" under Title V (20 NMAC
•	2.70)? Yes v No Unsure.	Is this a major modification under the PSD rules (20 NMAC 2.74)? Yes v No Unsure.
11	If *Yes* or *Unsure* to any of the questions in question No. 10, contact the AQB to see if a pre-application meeting is required.	

Table I-B: Current Facility Status (continued)

12	What is the facility's maximum input capacity, specify units (reference here and list capacities in Attachment L if more room is required)			
•	Current	Hourly:	Daily:	Annually:
•	Proposed	Hourly: 64,560 gallons contaminated groundwater	Daily: 1,549,440 gallons contaminated groundwater	Annually: 565,545,600 gallons contaminated groundwater
13	What is the facility's maximum production rate, specify units (reference here and list capacities in Attachment L, if more room is required)			
•	Current	Hourly:	Daily:	Annually:
•	Proposed	Hourly: 64,560 gallons treated groundwater	Daily: 1,549,440 gallons treated groundwater	Annually: 565,545,600 gallons treated groundwater

Table I-C: Facility Location Information

1	Section: **5**	Range: **3 E**	Township: **21 S**	County: **Dona Ana**	Elevation (ft): **4522**
2	UTM Zone: 12 or v 13	UTMH (record to one tenth of a km): **3599.0**		UTMV (record to one tenth of a km): **344.9**	
OR	Latitude (deg., min., sec.):		Longitude (deg., min., sec.):		
3a	Name and zip code of nearest New Mexico town: **Organ 88052**				
3b	Distance and Direction from nearest New Mexico town: **8 miles NW**				
4	Detailed Driving Instructions from nearest NM town (attach a road map if necessary): **1. Start at Organ, NM on US Hwy 70** **2. Drive West one (1) mile on US Hwy 70** **3. Turn North on NASA Road.** **4. Drive six (6) miles North to WSTF** **5. Drive two (2) miles west on WSTF well road.** The facility is ___**8**_____ (distance) miles _**NW**_____ (direction) of _____**Organ**_____ (nearest town).				
5	Status of land at facility (check one): Private Indian/Pueblo v Government				
6	Name of nearest Class I area to the facility (see Figure 1.0): **White Mountain Wilderness**				
7	Shortest distance from facility boundary to the boundary of the nearest Class I area (record to one tenth of a km): **102.1**				

Table I-D: Proposed Operating Schedule (Note: the operating schedule (D1, D2) shall become a condition of the permit)

1	Facility **maximum** operating ($\frac{\text{hours}}{\text{day}}$): **24**	($\frac{\text{days}}{\text{week}}$): **7**	($\frac{\text{weeks}}{\text{year}}$): **52**	($\frac{\text{hours}}{\text{year}}$): **8760**		
2	Facility's maximum daily operating schedule (if less than 24 $\frac{\text{hours}}{\text{day}}$)? Start:		AM PM	End:		? AM ? P M
3	Month and year of anticipated start of construction: **January 2000**					
4	Month and year of anticipated construction completion: **December 2003**					
5	Month and year of anticipated startup of new or modified facility: **December 2003**					
6	Will this facility operate at this site for more than one year? v Yes No					

Table I-E: Other

1	Is this application in response to a Notice of Violation (NOV)? Yes v No	
•	If yes, NOV date:	NOV Tracking No:
2	Is air quality dispersion modeling being submitted with this application? Yes v No	
3	Does this facility require an "Air Toxics" permit under 20 NMAC 2.72, Part IV, Tables A and/or B in Part V? Yes v No	

4	Will this facility be a source of federal Hazardous Air Pollutants? Yes v No
•	If yes, list applicable subparts in 40 CFR 61 & 63:

Part III – Production and Control Equipment

Table III-A: Regulated Equipment (Unit and stack numbering must correspond throughout the application package.)
Note: If applying for a NOI under 20 NMAC 2.73, equipment exemptions under 2.72, 202 do not apply, and all equipment should be listed here.

Unit No.	Manufac-turer / Date of Manufacture /Reconstruction. (MM/DD/YY)	Model No. / Serial No.	Type (Source Description)	Capacity (Specify Units)	For Each Piece of Equipment, Check One	Applicable State Reg. (s) 20 NMAC 2.X, …	Replacing Unit No.
1	NEEP	61231	Air Stripper	625 gpm	? Existing (unchanged) ? To be Removed V New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
2	NEEP	61231	Air Stripper	625 gpm	? Existing (unchanged) ? To be Removed V New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		

Table III-B: 20 NMAC 2.72, 202.B Exempted Equipment (If exempt under 20 NMAC 2.72, 202.B.5, list emission rates in Table IV-A.)

(Unit and stack numbering must correspond throughout the application package.)

Note: This table is applicable only if applying for a 20 NMAC 2.72 permit. Exemptions under 20 NMAC 2.72, 202 do not apply to facilities requesting a NOI under 20 NMAC 2.73. See application form instructions and Exemptions Procedure for instructions on this form.

Unit No.	Manufac-turer / Date of Mfg. (MM/DD/YY)	Model No. / Serial No.	Type (Source Description)	Capacity (Specify Units)	For Each Piece of Equipment, Check One	Site Specific 20 NMAC 2.72.202 Exemption (e.g. 2.72.202.B.5)	Other Required Information
N/A					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		
					? Existing (unchanged) ? To be Removed ? New/Additional ? Replacement Unit ? To be Modified ? To be Replaced		

Table III-C: Emissions Control Equipment (Additional information)
(Unit and stack numbering must correspond throughout the application package.)

Unit No.	Control Equipment Description	Controlled Pollutant(s)	Controlling Emissions for Unit(s) No.	% Control by Weight	Estimation Method
N/A					

Only list control equipment for TAPs if the TAP's PER is over its respective threshold as listed in 20 NMAC 2.72 Subpart V Tables A and B

Part IV - Emission Calculations

Table IV-A: Unit Emissions Rates List Toxic Air Pollutants (TAPs) In Table IV-C
(Unit and stack numbering must correspond throughout the application package.) Include tank-flashing emissions estimates.

	Potential emission rate (PER)[1]							Potential to emit (PTE)[2]						
Unit No.	TSP lb/hr ton/yr	PM10 lb/hr ton/yr	NOx lb/hr ton/yr	CO lb/hr ton/yr	VOC lb/hr ton/yr	SOx lb/hr ton/yr	? Lead ? H_2S lb/hr ton/yr	TSP lb/hr ton/yr	PM10 lb/hr ton/yr	NOx lb/hr ton/yr	CO lb/hr ton/yr	VOC lb/hr ton/yr	SOx lb/hr ton/yr	? Lead ? H_2S lb/hr ton/yr
					1.159							1.159		
1					5.078							5.078		
					1.159							1.159		
2					5.078							5.078		
Totals →					2.318							2.318		
					10.156							10.156		

[1] (PER) or "Potential Emission Rate" means the emission rate of a source at its maximum capacity to emit a regulated air contaminant under its physical and operational design, provided any physical or operational limitation on the capacity of the source to emit a regulated air contaminant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored or processed, shall be treated as part of its physical and operational design only if the limitation or the effect it would have on emissions is enforceable by the Department pursuant to the Air Quality Control Act or the federal Act.

[2] (PTE) or "Potential to emit" means the maximum capacity of a stationary source to emit a regulated air contaminant under its physical and operational design. Any physical or operational limitation on the capacity of the source to emit a regulated air contaminant, including air pollution control equipment and restrictions on hours of operation or on the type or amount of material combusted, stored, or processed, shall be treated as part of its design if the limitations or the effect it would have on emissions is federally enforceable. Secondary emissions do not count in determining the potential to emit of a stationary source. 20 NMAC 2.72, 300.E PTE does include reductions in emissions due to federally enforceable limits.

Table IV-B: Stack Exit and Fugitive[1] Emission (PTE) Rates for Pollutants and Stack Exit Conditions List Toxic Air Pollutants (TAPs) and Hazardous Air Pollutants (HAPs) In Table IV-C (Unit and stack numbering must correspond throughout the application package.) Include tank-flashing emissions estimates.

		Stack Exit Emission Rates for Criteria Pollutants							Stack Exit Conditions (Not Applicable for Fugitives)				
		TSP lb/hr	PM10 lb/hr	NOx lb/hr	CO lb/hr	VOC lb/hr	SOx lb/hr	? Lead ? H_2S lb/hr	Orientation (H=Horizontal V=Vertical)	Height Above Ground (ft)	Flow Rate (acfm)	Moisture by Volume (%)	Inside Diameter or L ´ W (ft)
Stack No.	Unit No.(s) from Table III-A	ton/yr	ton/yr	ton/yr	ton/yr	ton/yr	ton/yr	ton/yr	Rain Caps (Yes or No)	Temp. (F)	(dscfm)	Velocity (ft/sec)	
1	1					1.159			V	30	3600	1.43	1.5
						5.078			N	80	4722	42.3	
2	2					1.159			V	30	3600	1.43	1.5
						5.078			N	80	4722	42.3	
Totals →						2.318							
						10.156							

[1] List all fugitives that are associated with the normal, routine, or non-emergency operation of the facility.

Table IV-C: Stack Exit Emission Rates for HAPs and TAPs (Describe Stack Exit Conditions in Table IV-B)
(Unit and stack numbering must correspond throughout the application package.) Include tank-flashing emissions estimates

Stack No.	Unit No.(s)	Specify the name of the HAP or TAP as it appears in Section 112. (b) of the 1990 CAAA or 20 NMAC 2.72 Subpart V in the space provided below.							
		N-nitroso dimethlyamine	Trichloroethene	Tetrachloroethene	1,1,1 Trichloroethane	1,1,2 Trichloroethane	Methylene Chloride	Ethylbenzene	Styrene
		HAP ☒ TAP ☒	HAP ☒ TAP ☒	HAP ☒ TAP ☒	HAP ☒ TAP ☒	HAP ☒ TAP ☒	HAP ☒ TAP ☒	HAP ☒ TAP ☒	HAP ☒ TAP ☒
		lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr
		ton/yr	Ton/yr	ton/yr	ton/yr	ton/yr	ton/yr	ton/yr	ton/yr
1	1	0.0020	0.2139	0.0115	0.0005	0.0004	0.0022	0.0002	0.0015
		0.0086	0.9374	0.0503	0.0020	0.0016	0.0095	0.0008	0.0064
2	2	0.0020	0.2139	0.0115	0.0005	0.0004	0.0022	0.0002	0.0015
		0.0086	0.9374	0.0503	0.0020	0.0016	0.0095	0.0008	0.0064
TOTAL ®		0.0040	0.4278	0.0230	0.0010	0.0008	0.0044	0.0004	0.0030
		0.0172	1.8748	0.1006	0.0040	0.0032	0.0190	0.0016	0.0128

Only list TAPs that have a PER greater than the threshold emission rate listed in 20 NMAC 2.72 Subpart V, Tables A and B

Table IV-C: Stack Exit Emission Rates for HAPs and TAPs (Describe Stack Exit Conditions in Table IV-B)
(Unit and stack numbering must correspond throughout the application package.) Include tank-flashing emissions estimates

Stack No.	Unit No.(s)	Specify the name of the HAP or TAP as it appears in Section 112. (b) of the 1990 CAAA or 20 NMAC 2.72 Subpart V in the space provided below.							
		Acrylonitrile	Carbon Tetrachloride	Bezene	Chloromethane	Vinyl Chloride	Carbon Disulfide		
		HAP ☒ TAP ☒	HAP ☒ TAP ☒	HAP ☒ TAP ☒	HAP ☒ TAP ☒	HAP ☒ TAP ☒	HAP ☒ TAP ☒	HAP ☒ TAP ☒	HAP ☒ TAP ☒
		lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr	lb/hr
		ton/yr	Ton/yr	ton/yr	ton/yr	ton/yr	ton/yr	ton/yr	ton/yr
1	1	0.0005	0.0001	0.00004	0.0008	0.0009	0.0008		
		0.0046	0.0005	0.0004	0.0071	0.0076	0.0037		
2	2	0.0005	0.0001	0.00004	0.0008	0.0009	0.0008		
		0.0046	0.0005	0.0004	0.0071	0.0076	0.0037		
TOTAL ®		0.0010	0.0002	0.00008	0.0016	0.0018	0.0016		
		0.0092	0.0010	0.0008	0.0142	0.0152	0.0074		

Only list TAPs that have a PER greater than the threshold emission rate listed in 20 NMAC 2.72 Subpart V, Tables A and B

Part V – Fuel

Table V-A: Fuel Characteristics and Usage (Unit and stack numbering must correspond throughout the application package.)

Unit No.	Fuel Type (No. 2 Diesel, Natural Gas, Coal, …)	Specify Units				
		Lower Heating Value	Hourly Usage	Annual Usage	% Sulfur	% Ash
N/A						

Part VI – Material Storage and Handling

Table VI-A: Liquid Storage Data[1] (Use additional sheets if necessary.) . (Unit and stack numbering must correspond throughout the application package.)
Include appropriate tank-flashing modeling input data. Use an addendum to this table for unlisted data categories

Tank No.	Material Name	Composition	Liquid Density (lb/gal)	Vapor Molecular Weight (lb/(lb*mol))	Average Storage Conditions		Max Storage Conditions	
					Temp-erature (°F)	True Vapor Pressure (psia)	Temp-erature (°F)	True Vapor Pressure (psia)
N/A								

[1] If tank is to be used for storage of different materials, list all the materials, run the newest version of TANKS on each and use the material with the highest emission rate to determine PER and PTE .

Table VI-B: Liquid Storage Tank Data (Use additional sheets if necessary.) (Unit and stack numbering must correspond throughout the application package.)
Include appropriate tank-flashing modeling input data. Use an addendum to this table for unlisted data categories.

Tank No.	Date Installed/ Modified (MM/YY)	Materials Stored	Roof Type (Table VI-C)	Seal Type (Table VI-C)	Capacity[1] (bbl)	Capacity[1] (M^3)	Diameter (M)	Vapor Space (M)	Color (Table VI-C) Roof	Color (Table VI-C) Shell	Paint Condition (Table VI-C)	Annual Through-put (gal/yr)	Turn-overs per year
N/A													

Table VI-C: Liquid Storage Tank Data Codes

Roof Type	Seal Type, Welded Tank Seal Type		Seal Type, Riveted Tank Seal Type		Roof, Shell Color	Paint Cond.
FX, Fixed Roof	1, Mechanical Shoe Seal	2, Liquid-mounted resilient seal	3, Vapor-mounted resilient seal	4, Seal Type	WH, White	Good
IF, Internal Floating Roof	A, Primary only	A, Primary only	A, Primary only	A, Mechanical shoe, primary only	AS, Aluminum (specular)	Poor
EF, External Floating Roof	B, Shoe-mounted secondary	B, Weather shield	B, Weather shield	B, Shoe mounted secondary	AD, Aluminum (diffuse)	
P, Pressure	C, Rim-mounted secondary	C, Rim-mounted secondary	C, Rim-mounted secondary	C, Rim-mounted secondary	LG, Light Gray	
					MG, Medium Gray	
					BL, Black	
					OT, Other	

[1] 0.159 M^3 = 42.0 gal = 1.00 bbl

Table VI-D: Materials Processed and Produced (Use additional sheets if necessary.)

Material Processed				Material Produced			
Description	Chemical Composition	Phase[1]	Quantity (specify units)	Description	Chemical Composition	Phase[1]	Quantity (specify units)
N/A							

[1]G =Gas, L = Liquid, or S = Solid

Part VII – Emissions Measurement

Table VII-A: Continuous Emissions Measurement (CEM) Equipment (Use additional sheets if necessary.)
(Unit and stack numbering must correspond throughout the application package.)

Stack No.	Pollutant(s)	Manufacturer	Model No.	Serial No.	Sample Frequency	Averaging Time	Range	Sensitivity	Accuracy
N/A									

Note: If CEM data will be used as part of a federally enforceable permit condition, or used to satisfy the requirements of a state or federal regulation, include a copy of the CEM's manufacturer specification sheet in Attachment D.

Table VII-B: Parametric Emissions Measurement Equipment (Use additional sheets if necessary.)

(Unit and stack numbering must correspond throughout the application package.)

Unit No.	Parameter/ Pollutant Measured	Location of Measurement	Unit of Measure	Acceptable Range	Frequency of Maintenance	Nature of Maintenance	Method of Recording	Averaging Time
N/A								

ATTACHMENT A

PROCESS FLOW SHEETS

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

PFE-1
AVV-6WA-XK003
MV-6WA-XK202
1" CS
1/4" SS
4" CS
NV-6WA-XK004
MV-6WA-XK005
4" CS
2" CS
MV-6WA-XK006
FM-6WA-XK007
FCV-6WA-XK008
MV-6WA-XK009
CV-6WA-XK002
PT-6WA-XK010
PU-6WA-XK001
0-150 PSIG
PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 653-C-01
6" x 10" HDPE

PFE-5
AVV-6WA-XK013
MV-6WA-XK203
1" CS
1/4" SS
1.5" CS
NV-6WA-XK014
MV-6WA-XK015
1" CS
MV-6WA-XK016
FM-6WA-XK017
MV-6WA-XK019
CV-6WA-XK012
PT-6WA-XK020
PU-6WA-XK011
0-150 PSIG
PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 657-C-01
2" x 4" HDPE
MV-6WA-XK051
JUNCTION @ STA (N) 21+52.51
REF DWG: 652-C-31
MV-6WA-XK052
6" x 10" HDPE

PFE-2
AVV-6WA-XK023
MV-6WA-XK204
1" CS
1/4" SS
4" CS
NV-6WA-XK024
MV-6WA-XK025
3" CS
2" CS
MV-6WA-XK026
FM-6WA-XK027
FCV-6WA-XK028
MV-6WA-XK029
CV-6WA-XK022
PT-6WA-XK030
PU-6WA-XK021
0-150 PSIG
PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 654-C-01
JUNCTION @ STA(PFE-2) 8+00.00
REF DWG: 652-C-34
6" x 10" HDPE
MV-6WA-XK255
MV-6WA-XK053
MV-6WA-XK054
JUNCTION @ STA (N) 18+91.4
REF DWG: 652-C-30
MV-6WA-XK256
8" x 12" HDPE
JUNCTION @ STA (N) 8+13
REF DWG: 652-C-30
8" x 12" HDPE
AVV-6WA-XK196
MV-6WA-XK210

PFE-7
AVV-6WA-XK240
MV-6WA-XK241
1" CS
1/4" SS
3" CS
NV-6WA-XK242
MV-6WA-XK243
2" CS
2" CS
MV-6WA-XK244
FM-6WA-XK245
FCV-6WA-XK246
MV-6WA-XK247
CV-6WA-XK239
PT-6WA-XK238
PU-6WA-XK237
0-150 PSIG
PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 658-C-01
4" x 8" HDPE
MV-6WA-XK055
CV-6WA-XK251
JUNCTION @ STA (N) 2+72
REF DWG: 652-C-29
MV-6WA-XK252
8" x 12" HDPE
MV-6WA-XK058
JUNCTION @ STA 0+02
REF DWG: 652-C-28
TO BUILDING 650, TREATMENT FACILITY
REF DWG: 652-M-02
CV-6WA-XK253
MV-6WA-XK059
6" x 10" HDPE
AVV-6WA-XK198
MV-6WA-XK209

PFE-3
AVV-6WA-XK033
MV-6WA-XK205
1" CS
1/4" SS
4" CS
NV-6WA-XK034
MV-6WA-XK035
3" CS
2" CS
MV-6WA-XK036
FM-6WA-XK037
FCV-6WA-XK038
MV-6WA-XK039
CV-6WA-XK032
PT-6WA-XK040
PU-6WA-XK031
0-150 PSIG
PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 655-C-01
5" x 8" HDPE
MV-6WA-XK057
JUNCTION @ STA (S) 8+70
REF DWG: 652-C-30
MV-6WA-XK056
AVV-6WA-XK190
MV-6WA-XK208

PFE-4A
AVV-6WA-XK043
MV-6WA-XK206
1" CS
1/4" SS
4" CS
NV-6WA-XK044
MV-6WA-XK045
3" CS
2" CS
MV-6WA-XK046
FM-6WA-XK047
FCV-6WA-XK254
MV-6WA-XK049
CV-6WA-XK042
PT-6WA-XK050
PU-6WA-XK041
0-150 PSIG
PRESSURE TRANSMITTER
WELLHEAD VAULT REF DWG: 656-C-01
5" x 8" HDPE
JUNCTION @ STA (PFE-4A) 0+00.00
REF DWG: 652-C-34
AVV-6WA-XK192
MV-6WA-XK207

ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASS'Y					

NEXT ASS'Y / RELATED DWG'S

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.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

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National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

PLUME-FRONT REMEDIATION
PIPING SYSTEM
MECHANICAL
FLOW SCHEMATIC

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-M-01 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

STACK 1

UNIT 1

STACK 2

UNIT 2

DATA RECORDING & TELEMETRY

TS- 6AR- XK233

TS- 6AR- XK234

VENT TO ATMOSPHERE

TI- 6WA- XK094

0-200° F

TT- 6WA- XK138

INSTRUMENT AIR

6" CS

FM- 6WA- XK096

FC

FCV- 6WA- XK093 THROTTLE

6" CPVC

PT- 6AR- XK229

PI- 6AR- XK230

0-30" WC

PS- 6AR- XK231

PS- 6AR- XK232

0-35" WC

MV- 6WA- XK097

FS- 6WA- XK130

FLOOR SUMP

FUTURE

FI- 6AR- XK227

0-500" WC VAC

FT- 6AR- XK228

FLS- 6AR- XK089

LLT

LLT- 6WA- XK104

PI- 6WA- XK107

AMBIENT AIR

F- 6AR- XK060

16" PVC

PS- 6AR- XK101 0.4-1.6" WC

BL- 6AR- XK098

0-200 PSIG

ROV- 6WA- XK109

MV- 6WA- XK105

ON/OFF

3" CPVC

LLC- 6WA- XK102

LLC- 6WA- XK103

VFD

PU- 6WA- XK106

CV- 6WA- XK108

EEW- 6WA- XK185

ES- 6WA- XK062

MV- 6WA- XK184

POTABLE WATER 2" CS

MV- 6WA- XK063

CV- 6CI- XK236

M

M- 6CI- XK188

MV- 6CI- XK081

1/4" SS

2" CPVC

ROV- 6WA- XK110

MV- 6WA- XK119

ROV- 6WA- XK092

AIR STRIPPER #1

TK- 6CI- XK064

MV- 6CI- XK199

LLC- 6CI- XK067

PU- 6CI- XK071

PU- 6CI- XK070

CV- 6CI- XK069

CV- 6CI- XK068

CV- 6CI- XK072

CV- 6CI- XK073

MV- 6CI- XK074

SCALE CLEANING SYSTEM

UV OXIDATION SYSTEM

SP 90 PSIG

PSV- 6AR- XK132

PI- 6AR- XK133

PS- 6AR- XK134

40-85 PSIG

0-100 PSIG

AVV- 6WA- XK018

MV- 6WA- XK136

MV- 6AR- XK135

PU- 6AR- XK131

COMPRESSED AIR

SPENT CLEANING SOLUTION

TK- 6WA- XK222

LLC- 6WA- XK065

LLC- 6WA- XK100

2"

MV- 6WA- XK099

MV- 6CI- XK075

2" CS

TK- 6CI- XK076

MV- 6CI- XK200

LLC- 6CI- XK066

MV- 6CI- XK077

PU- 6CI- XK078

CV- 6CI- XK079

CV- 6CI- XK080

1/4" SS

SCALING CONTROL CHEMICAL METERING SYSTEM

PI- 6WA- XK137

0-100 PSIG

8" CS

MV- 6WA- XK139

FM- 6WA- XK140

RD- 6WA- XK186 BP 100 PSIG

TK- 6WA- XK141

ECV- 6WA- XK187

DRAIN

2" CS

8" CS

10"X16" HDPE FROM EXTRACTION WELLS REF DWG: 652-M-01

0-100 PSIG PI- 6WA- XK083

MV- 6WA- XK082

8" CS

SM- 6WA- XK087

MV- 6WA- XK086

1/4" SS

MV- 6WA- XK258

LLS-6WA- XK235

LLS

LEAK DETECTION CONTROL PANEL

AVV- 6WA- XK189

MV- 6WA- XK201

ROV- 6WA- XK143

MV- 6WA- XK144

ON/OFF

FC

10" HDPE TO INJECTION WELLS REF DWG: 652-M-03

MV- 6WA- XK142

1/4" SS

INSTRUMENT AIR

VENT TO ATMOSPHERE

TI- 6WA- XK114

0-200° F

TT- 6WA- XK115

6" CS

FM- 6WA- XK116

FC

FCV- 6WA- XK112 THROTTLE

6" CPVC

PT- 6AR- XK223

PI- 6AR- XK224

0-30" WC

PS- 6AR- XK225

PS- 6AR- XK226

0-35" WC

MV- 6WA- XK113

3" CPVC

FI- 6AR- XK084

0-500" WC VAC

FT- 6AR- XK085

FLS- 6AR- XK118

LLT

LLT- 6WA- XK123

PI- 6WA- XK126

AMBIENT AIR

F- 6AR- XK088

16" PVC

PS- 6AR- XK120 0.4-1.6" WC

BL- 6AR- XK117

0-200 PSIG

LLC- 6WA- XK121

LLC- 6WA- XK122

VFD

PU- 6WA- XK125

6" CPVC

MV- 6WA- XK124

ON/OFF

ROV- 6WA- XK128

CV- 6WA- XK127

2" CPVC

ROV- 6WA- XK111

MV- 6WA- XK061

ROV- 6WA- XK129

3" CPVC

1/4" SS

CV- 6WA- XK145

ROV- 6WA- XK257

MV- 6WA- XK146

6" CS

AIR STRIPPER #2

BUILDING 650

MV- 6WA- XK090

CV- 6WA- XK091

MV- 6WA- XK147

PU- 6WA- XK149

TK- 6WA- XK148

MV- 6WA- XK150

MV- 6WA- XK151

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
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UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

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ENGINEER	J. KIRBY	9-1-99
DESIGNED BY	J. KIRBY	9-1-99
CHECKED BY		
APPROVAL		
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RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

PLUME-FRONT REMEDIATION
PIPING SYSTEM
MECHANICAL
FLOW SCHEMATIC

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-M-02 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

10" HDPE
FROM BUILDING 650,
REF DWG: 652-M-02

1" CS
AVV-6WA-XK197
MV-6WA-XK211
AVV-6WA-XK191
MV-6WA-XK212
AVV-6WA-XK193
MV-6WA-XK213
AVV-6WA-XK194
MV-6WA-XK214
AVV-6WA-XK195
MV-6WA-XK215

10" CS
6" CS
4" CPVC

BUILDING 651

MV-6WA-XK160
3" CPVC
FM-6WA-XK161
FCV-6WA-XK162
4" CPVC
MV-6WA-XK164
AVV-6WA-XK163
MV-6WA-XK216
1/2" CS
6" CS
6" HDPE
MV-6WA-XK165
4" CS
AVV-6WA-XK166
MV-6WA-XK220
1" CS
PT-6WA-XK167
3" CS
P T 0-250 PSIG
PRESSURE TRANSMITTER
PFI-2
WELLHEAD VAULT
REF DWG: 661-C-01

MV-6WA-XK152
3" CPVC
FM-6WA-XK153
FCV-6WA-XK154
4" CPVC
MV-6WA-XK156
AVV-6WA-XK155
MV-6WA-XK217
1/2" CS
6" CS
6" HDPE
MV-6WA-XK157
4" CS
AVV-6WA-XK158
MV-6WA-XK221
1" CS
PT-6WA-XK159
3" CS
P T 0-250 PSIG
PRESSURE TRANSMITTER
PFI-1
WELLHEAD VAULT
REF DWG: 660-C-01

MV-6WA-XK176
3" CPVC
FM-6WA-XK177
FCV-6WA-XK178
4" CPVC
MV-6WA-XK180
AVV-6WA-XK179
MV-6WA-XK218
1/2" CS
6" CS
6" HDPE
MV-6WA-XK181
4" CS
AVV-6WA-XK182
MV-6WA-XK048
1" CS
PT-6WA-XK183
3" CS
P T 0-250 PSIG
PRESSURE TRANSMITTER
PFI-4
WELLHEAD VAULT
REF DWG: 663-C-01

MV-6WA-XK168
3" CPVC
FM-6WA-XK169
FCV-6WA-XK170
4" CPVC
MV-6WA-XK172
AVV-6WA-XK171
MV-6WA-XK219
1/2" CS
6" CS
6" HDPE
MV-6WA-XK173
4" CS
AVV-6WA-XK174
MV-6WA-XK095
1" CS
PT-6WA-XK175
3" CS
P T 0-250 PSIG
PRESSURE TRANSMITTER
PFI-3
WELLHEAD VAULT
REF DWG: 662-C-01

NOTES:
1. ALL CPVC PIPE SHALL BE SCH 80.

ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASS'Y					

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	9-1-99
ENGINEER	J. KIRBY	9-1-99
DESIGNED BY	J. KIRBY	9-1-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

PLUME-FRONT REMEDIATION
PIPING SYSTEM
MECHANICAL
FLOW SCHEMATIC

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-M-03 | REV.

ATTACHMENT B

PLOT PLAN

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

T20S, R3E, SECTION 33

T21S, R3E, SECTION 4

UNITS 1 & 2
AND
STACKS 1 & 2

ROAD C (WELL ROAD)

PFE-4A

652-C-15 (PFE-4B)

652-C-14 (PFE-4A)

652-C-03 (N-1)

652-C-04 (N-2)

652-C-08 (S-1)

652-C-09 (S-2)

652-C-10 (S-3)

652-C-11 (S-4)

652-C-19 (PFI-4)

652-C-12 (S-5)

PFI-4

PFE-5

652-C-16 (PFE-5)

652-C-05 (N-3)

652-C-13 (PFE-2)

652-C-15 (PFE-4B)

PFE-3

652-C-17 (PFI-1A)

PFI-3

652-C-06 (N-4)

652-C-20 (PFE-7A)

PFE-2

652-C-18 (PFI-1B)

PFI-2

652-C-07(N-5)

652-C-21 (PFE-7B)

PFE-1

PFE-7

PFI-1

T20S, R3E, SECTION 32

T21S, R3E, SECTION 5

NORTH

750 FEET
500'
250'
0

ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASS'Y					

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

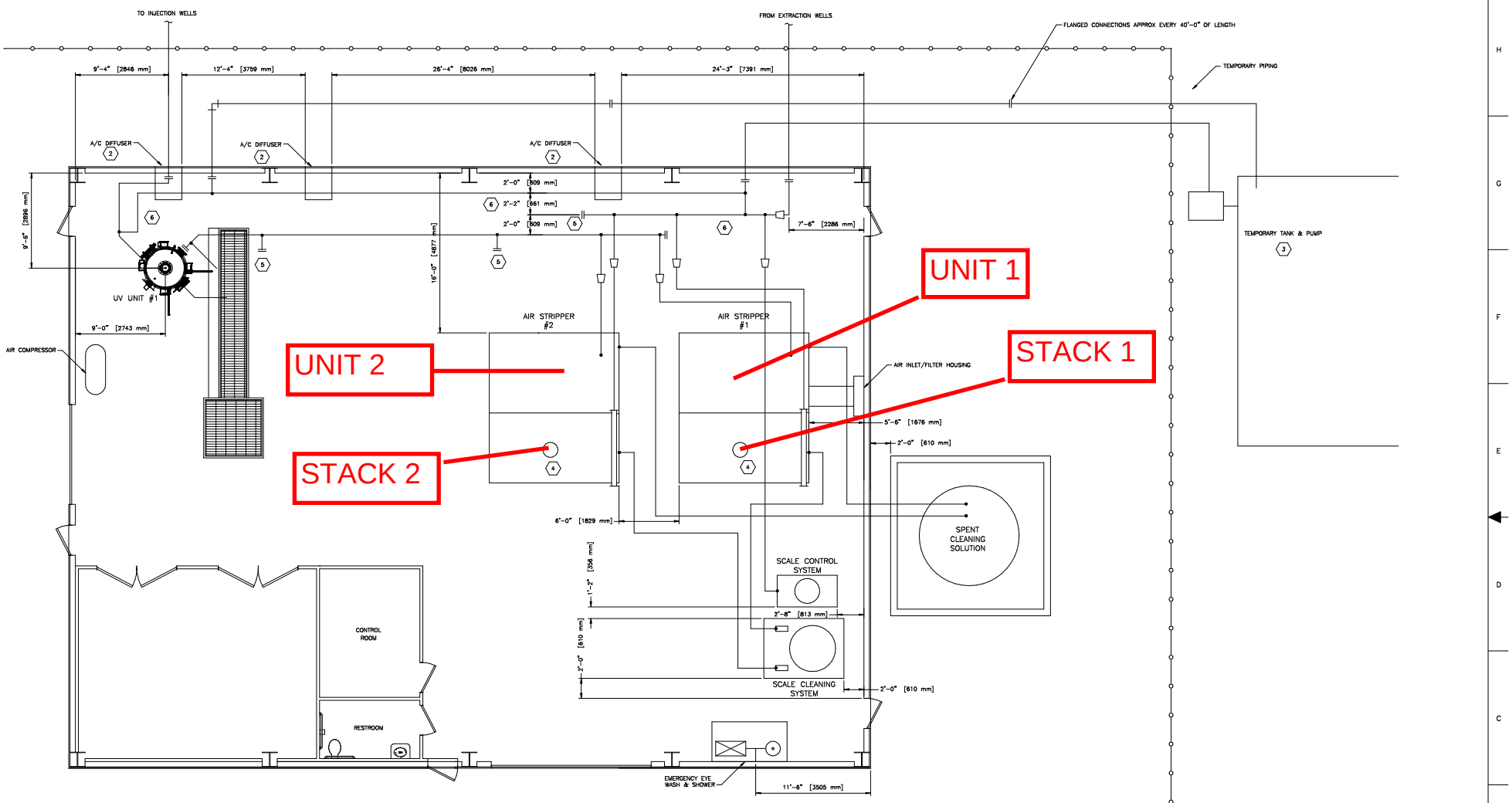
DRAWN BY	M. TARIN	6-21-99
ENGINEER	J. KIRBY	6-21-99
DESIGNED BY	J. KIRBY	6-21-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
PIPING SYSTEM
CIVIL
WELL LOCATIONS & PIPING LAYOUT

A.B. DWG. NO. | SCALE 1"=250' | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-C-02 | REV.



NOTES:

1. COMPONENTS ARE NOT SHOWN FOR CLARITY REFER TO FLOW SCHEMATICS FOR COMPONENTS & LOCATIONS
2. A/C DIFFUSERS ARE 32"x32"x32" MOUNTED 8'-0" [2438 mm] ABOVE FINISH FLOOR
3. ACTUAL LOCATION YET TO BE DETERMINED
4. RIGID PIPING NOT TO BE RUN OVER STRIPPER TRAYS AS THEY REQUIRE REMOVAL FOR MAINTENANCE
5. STUBOUTS FOR FUTURE EQUIPMENT INSTALLATION
6. THIS IS A PRELIMINARY PIPE LAYOUT SOME FIELD ADJUSTMENT WILL BE NECESSARY
7. COMPRESSED AIR TUBING NOT SHOWN, REFER TO MECHANICAL FLOW SCHEMATICS FOR LOCATIONS

EQUIPMENT LAYOUT PLAN
SCALE: 1/4"=1'-0"

NORTH

0 4 8 12 FEET

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

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.00± FRACTIONS ±
.000±
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ENGINEER	J. KIRBY	10-21-99
DESIGNED BY	J. KIRBY	10-21-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

NEXT ASSY / RELATED DWG'S

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME FRONT REMEDIATION
BUILDING 650, TREATMENT FACILITY
MECHANICAL
EQUIPMENT LAYOUT

A.B. DWG. NO. | SCALE 1/4"=1'-0" | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 650-M-06 | REV.

ATTACHMENT C

EMISSION CALCULATIONS

CALCULATION OF THE MASS AIR EMISSION RATES OF CONTAMINANTS FROM ONE AIR STRIPPER, THE TOTAL ORGANIC CONCENTRATION OF THE INFLUENT FLUID FROM THE NASA/WSTF PLUME-FRONT PUMP-AND-TREAT SYSTEM, AND THE COMPARISON OF THE RESULTS AGAINST REGULATORY LIMITS FOR COMPLIANCE DECISION MAKING.

Derived Units:

$$gpm := \frac{gal}{min} \qquad \mu g := \frac{mg}{1000}$$

GIVEN:

1. A pump-and-treat system air strips organics from groundwater at a rate of

$$Q := 619 \cdot gpm$$; per stripper, and

2. A list of the constituents and their worst case plume-front analytical concentrations:

Constituent	Concentration
N-nitrosodimethylamine (NDMA)	$C_{ndma} := 6.3 \cdot \frac{\mu g}{liter}$
Trichloroethene (TCE)	$C_{tce} := 690 \cdot \frac{\mu g}{liter}$
Tetrachloroethene (PCE)	$C_{pce} := 37 \cdot \frac{\mu g}{liter}$
1,1,1 Trichloroethane (TCA1)	$C_{tca1} := 1.5 \cdot \frac{\mu g}{liter}$
1,1,2 Trichloroethane (TCA2)	$C_{tca2} := 1.2 \cdot \frac{\mu g}{liter}$
Methylene Chloride (MC)	$C_{mc} := 7 \cdot \frac{\mu g}{liter}$
Trichloromethane (CF)	$C_{cf} := 1.8 \cdot \frac{\mu g}{liter}$
Trichlorofluoromethane (11)	$C_{11} := 860 \cdot \frac{\mu g}{liter}$
Dichlorofluoromethane (21)	$C_{21} := 60 \cdot \frac{\mu g}{liter}$
1,1,2 Trichloro-1,2,2 Trifluoroethane (113)	$C_{113} := 2000 \cdot \frac{\mu g}{liter}$

2,2 Dichloro-1,1,1 Trifluoroethane (123)	$C_{123} := 2.9 \cdot \frac{\mu g}{liter}$
1,2 Dichloro-1,1,2 Trifluoroethane (123a)	$C_{123a} := 54 \cdot \frac{\mu g}{liter}$
Ethylbenzene (eb)	$C_{eb} := 0.58 \cdot \frac{\mu g}{liter}$
Styrene (s)	$C_{s} := 4.7 \cdot \frac{\mu g}{liter}$
Acrylonitrile (a)	$C_{a} := 1.7 \cdot \frac{\mu g}{liter}$
Fluoride (f)	$C_{f} := 0.98 \cdot \frac{\mu g}{liter}$
Bromacil (b)	$C_{b} := 0.6 \cdot \frac{\mu g}{liter}$
Carbon Tetrachloride (ct)	$C_{ct} := 0.38 \cdot \frac{\mu g}{liter}$
Benzene (bz)	$C_{bz} := 0.14 \cdot \frac{\mu g}{liter}$
Chloromethane (cm)	$C_{cm} := 2.6 \cdot \frac{\mu g}{liter}$
Vinyl Chloride (vc)	$C_{vc} := 2.8 \cdot \frac{\mu g}{liter}$
Carbon Disulfide (cd)	$C_{cd} := 2.7 \cdot \frac{\mu g}{liter}$
Ammonia (am)	$C_{am} := 0.65 \cdot \frac{\mu g}{liter}$
Selenium (sl)	$C_{sl} := 6.2 \cdot \frac{\mu g}{liter}$

TO FIND:

1.) The mass air emission rate for each constituent from a single unit air stripping operation.

2.) The difference between the dual unit system emission rate and the 20.2.72.500 NMAC regulatory permitting limits for minor sources for the regulated air toxic constituents.

3.) The total volatile organic concentration of the air stripping feed.

4.) The difference between the total feed concentration and the 40 CFR 264 Subpart AA regulatory threshhold of 10 ppmw (40 CFR 264.1030 (a)) for emissions controls.

SOLUTION:

Assumptions:

a. All of the extraction wells have the worst case concentration of all constituents, and the influent to the stripping process is well mixed.

b. All constituents, except Ammonia, Fluoride, and Selenium, are considered volatile organics.

c. The air stripping process is 100% efficient (i.e. worst case air emissions). NOTE: NDMA IS NOT EFFECTIVELY STRIPPED FROM THE FLUID. IT IS INCLUDED AS A VOLATILE ORGANIC FOR WORST CASE. NDMA IS TREATED BY ULTRA-VIOLET OXIDZATON DOWNSTREAM OF THE STRIPPING SYSTEM.

The mass transport rate of each constituent is the product of the concentration and volumetric flow rate. Using assumption (c.) above, this transport rate is also the emission rate. Therefore:

$$M_{ndma} := C_{ndma} \cdot Q$$

$$M_{ndma} = 0.00195 \cdot \frac{lb}{hr} \qquad M_{ndma} = 0.00856 \cdot \frac{ton}{yr}$$

$$M_{tce} := C_{tce} \cdot Q$$

$$M_{tce} = 0.21386 \cdot \frac{lb}{hr} \qquad M_{tce} = 0.93735 \cdot \frac{ton}{yr}$$

$$M_{pce} := C_{pce} \cdot Q$$

$$M_{pce} = 0.01147 \cdot \frac{lb}{hr} \qquad M_{pce} = 0.05026 \cdot \frac{ton}{yr}$$

$M_{tca1} := C_{tca1} \cdot Q$

$M_{tca1} = 0.00046 \circ \frac{lb}{hr}$ $M_{tca1} = 0.00204 \circ \frac{ton}{yr}$

$M_{tca2} := C_{tca2} \cdot Q$

$M_{tca2} = 0.00037 \circ \frac{lb}{hr}$ $M_{tca2} = 0.00163 \circ \frac{ton}{yr}$

$M_{mc} := C_{mc} \cdot Q$

$M_{mc} = 0.00217 \circ \frac{lb}{hr}$ $M_{mc} = 0.00951 \circ \frac{ton}{yr}$

$M_{cf} := C_{cf} \cdot Q$

$M_{cf} = 0.00056 \circ \frac{lb}{hr}$ $M_{cf} = 0.00245 \circ \frac{ton}{yr}$

$M_{11} := C_{11} \cdot Q$

$M_{11} = 0.26656 \circ \frac{lb}{hr}$ $M_{11} = 1.16829 \circ \frac{ton}{yr}$

$M_{21} := C_{21} \cdot Q$

$M_{21} = 0.0186 \circ \frac{lb}{hr}$ $M_{21} = 0.08151 \circ \frac{ton}{yr}$

Dichlorofluoromethane is a NMAC 20.2.72.500 TAP, therefore:

$M_{21.total} := M_{21} \cdot 2$ $M_{21.total} = 0.037 \circ \frac{lb}{hr}$ NMAC 20.2.72.500 PER = 2.67 lb/hr

$M_{113} := C_{113} \cdot Q$

$M_{113} = 0.61990 \cdot \frac{lb}{hr}$ $M_{113} = 2.71695 \cdot \frac{ton}{yr}$

$M_{123} := C_{123} \cdot Q$

$M_{123} = 0.00090 \cdot \frac{lb}{hr}$ $M_{123} = 0.00394 \cdot \frac{ton}{yr}$

$M_{123a} := C_{123a} \cdot Q$

$M_{123a} = 0.01674 \cdot \frac{lb}{hr}$ $M_{123a} = 0.07336 \cdot \frac{ton}{yr}$

$M_{eb} := C_{eb} \cdot Q$

$M_{eb} = 0.00018 \cdot \frac{lb}{hr}$ $M_{eb} = 0.00079 \cdot \frac{ton}{yr}$

$M_{s} := C_{s} \cdot Q$

$M_{s} = 0.00146 \cdot \frac{lb}{hr}$ $M_{s} = 0.00638 \cdot \frac{ton}{yr}$

$M_{a} := C_{a} \cdot Q$

$M_{a} = 0.00053 \cdot \frac{lb}{hr}$ $M_{a} = 0.00231 \cdot \frac{ton}{yr}$

$M_f := C_f \cdot Q$

$M_f = 0.000304 \cdot \frac{lb}{hr}$ $M_f = 0.00133 \cdot \frac{ton}{yr}$

Fluoride is a NMAC 20.2.72.500 TAP, therefore:

$M_{f.total} := M_f \cdot 2$ $M_{f.total} = 0.00061 \cdot \frac{lb}{hr}$ NMAC 20.2.72.500 PER = 0.167 lb/hr

$M_b := C_b \cdot Q$

$M_b = 0.00019 \cdot \frac{lb}{hr}$ $M_b = 0.00082 \cdot \frac{ton}{yr}$

Bromacil is a NMAC 20.2.72.500 TAP, therefore:

$M_{b.total} := M_b \cdot 2$ $M_{b.total} = 0.00037 \cdot \frac{lb}{hr}$ NMAC 20.2.72.500 PER = 0.667 lb/hr

$M_{ct} := C_{ct} \cdot Q$

$M_{ct} = 0.00012 \cdot \frac{lb}{hr}$ $M_{ct} = 0.00052 \cdot \frac{ton}{yr}$

$M_{bz} := C_{bz} \cdot Q$

$M_{bz} = 0.00004 \cdot \frac{lb}{hr}$ $M_{bz} = 0.00019 \cdot \frac{ton}{yr}$

$M_{cm} := C_{cm} \cdot Q$

$M_{cm} = 0.00081 \cdot \frac{lb}{hr}$ $M_{cm} = 0.00353 \cdot \frac{ton}{yr}$

$M_{vc} := C_{vc} \cdot Q$

$M_{vc} = 0.00087 \cdot \frac{lb}{hr}$ $M_{vc} = 0.00380 \cdot \frac{ton}{yr}$

$M_{cd} := C_{cd} \cdot Q$

$M_{cd} = 0.00084 \cdot \frac{lb}{hr}$ $M_{cd} = 0.00367 \cdot \frac{ton}{yr}$

$M_{am} := C_{am} \cdot Q$

$M_{am} = 0.00020 \cdot \frac{lb}{hr}$ $M_{am} = 0.00088 \cdot \frac{ton}{yr}$

Ammonia is a NMAC 20.2.72.500 TAP, therefore:

$M_{am.total} := M_{am} \cdot 2$ $M_{am.total} = 0.00040 \cdot \frac{lb}{hr}$ NMAC 20.2.72.500 PER = 1.20 lb/hr

$M_{sl} := C_{sl} \cdot Q$

$M_{sl} = 0.00192 \cdot \frac{lb}{hr}$ $M_{sl} = 0.00842 \cdot \frac{ton}{yr}$

Selenium is a NMAC 20.2.72.500 TAP, therefore:

$M_{sl.total} := M_{sl} \cdot 2$ $M_{sl.total} = 0.00384 \cdot \frac{lb}{hr}$ NMAC 20.2.72.500 PER = 0.0133 lb/hr

Since there is no air toxic permit driving constituent of concern, NASA does not have to obtain a 20.2.72 NMAC air toxic permit for the system.

The total VO mass emission rate is:

$M_{total1} := M_{ndma} + M_{tce} + M_{pce} + M_{tca1} + M_{tca2} + M_{mc} + M_{cf} + M_{11} + M_{21} + M_{113} + M_{123} + M_{123a}$

$M_{total2} := M_{eb} + M_{s} + M_{a} + M_{b} + M_{ct} + M_{bz} + M_{cm} + M_{vc} + M_{cd}$

$M_{total} := M_{total1} + M_{total2}$

$M_{total} = 1.159 \cdot \frac{lb}{hr}$ $M_{total} = 5.078 \cdot \frac{ton}{yr}$

Since the total mass emission rate is below 10 pounds per hour for both air strippers, NASA does not have to obtain a 20.2.72 NMAC criteria pollutant (non-methane hydrocarbons) permit for the system.

Since no single regulated air contaminant is released at greater than 10 tons per year, NASA does not have to submit an NOI pursuant to NMAC 20.2.73.A.1.

The sum of the individual organic constituent concentrations is equal to the total volatile organic influent concentration. Therefore:

$C_{total1} := C_{ndma} + C_{tce} + C_{pce} + C_{tca1} + C_{tca2} + C_{mc} + C_{cf} + C_{11} + C_{21} + C_{113} + C_{123} + C_{123a}$

$C_{total2} := C_{eb} + C_{s} + C_{a} + C_{b} + C_{ct} + C_{bz} + C_{cm} + C_{vc} + C_{cd}$

$C_{total} := C_{total1} + C_{total2}$ $C_{total} = 3.738 \cdot \frac{mg}{liter}$

Since the total organic feed concentration is below 10 ppmw, no emission controls are required on the air stripping process vents of the system, pursuant to RCRA Subpart AA.

TABLE 1

REGULATORY CLASSIFICATION OF CONTAMINANTS OF CONCERN

CONTAMINANT OF CONCERN	REGULATED FEDERAL HAZARDOUS AIR POLLUTANT: 112 (b)	REGULATED NEW MEXICO AIR TOXIC: NMAC 20.2.72.500
N-nitrosodimethylamine	**X**	
Trichloroethene	**X**	
Tetrachloroethene	**X**	
1,1,1 Trichloroethane	**X**	
1,1,2 Trichloroethane	**X**	
Methylene Chloride	**X**	
Trichloromethane		
Trichlorofluoromethane		
Dichlorofluoromethane		**X**
1,1,2 Trichloro-1,2,2 Trifluoroethane		
2,2 Dichloro-1,1,1 Trifluoroethane		
1,2 Dichloro-1,1,2 Trifluoroethane		

TABLE 2

REGULATORY CLASSIFICATION OF OTHER CONTAMINANTS

CONTAMINANT OF CONCERN	REGULATED FEDERAL HAZARDOUS AIR POLLUTANT: 112 (b)	REGULATED NEW MEXICO AIR TOXIC: NMAC 20.2.72.500
Ethylbenzene	**X**	
Styrene	**X**	
Acrylonitrile	**X**	
Fluoride		**X**
Bromacil		**X**
Carbon Tetrachloride	**X**	
Benzene	**X**	
Chloromethane	**X**	
Vinyl Chloride	**X**	
Carbon Disulfide	**X**	
Ammonia		**X**
Selenium		**X**

TABLE 3

EMISSIONS RATE vs. REGULATORY THRESHOLD LIMIT FOR CONTAMINANTS

CONTAMINANT OF CONCERN	MASS EMISSION RATE	REGULATORY THRESHOLD	ACTION REQUIRED
N-nitrosodimethylamine	0.004 lb/hr 0.017 ton/yr	NO REGULATORY HOURLY RATE LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
Trichloroethene	0.428 lb/hr 1.875 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
Tetrachloroethene	0.023 lb/hr 0.101 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
1,1,1 Trichloroethane	0.001 lb/hr 0.004 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
1,1,2 Trichloroethane	0.001 lb/hr 0.003 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
Methylene Chloride	0.004 lb/hr 0.019 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
Trichloromethane	0.001 lb/hr 0.005 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
Trichlorofluoromethane	0.533 lb/hr 2.337 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
Dichlorofluoromethane	0.037 lb/hr 0.163 ton/yr	2.67 lb/hr (NMAC 20.2.72.500)	NO ACTION
1,1,2 Trichloro-1,2,2 Trifluoroethane	1.240 lb/hr 5.434 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
2,2 Dichloro-1,1,1 Trifluoroethane	0.002 lb/hr 0.008 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
1,2 Dichloro-1,1,2 Trifluoroethane	0.033 lb/hr 0.147 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
Ethylbenzene	0.0004 lb/hr 0.002 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
Styrene	0.003 lb/hr 0.013ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
Acrylonitrile	0.001 lb/hr 0.009 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
Fluoride	0.0006 lb/hr 0.003 ton/yr	0.167 lb/hr (NMAC 20.2.72.500)	NO ACTION
Bromacil	0.0004 lb/hr 0.002 ton/yr	0.667 lb/hr (NMAC 20.2.72.500)	NO ACTION
Carbon Tetrachloride	0.0002 lb/hr 0.001 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION

Benzene	0.0001 lb/hr 0.001 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
Chloromethane	0.002 lb/hr 0.014 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
Vinyl Chloride	0.002 lb/hr 0.015 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
Carbon Disulfide	0.002 lb/hr 0.007 ton/yr	NO REGULATORY LIMIT FOR MINOR SOURCE CATEGORY.	NO ACTION
Ammonia	0.0004 lb/hr 0.002 ton/yr	1.20 lb/hr (NMAC 20.2.72.500)	NO ACTION
Selenium	0.004 lb/hr 0.017 ton/yr	0.0133 lb/hr (NMAC 20.2.72.500)	NO ACTION

ATTACHMENT D

INFORMATION USED TO DETERMINE EMISSIONS

INFORMATION USED TO DETERMINE EMISSIONS

Emissions were calculated using the plume-front's most reasonable all time highest well concentrations of the contaminants of concern (Attachment C,Table 1). Several Federal HAPs, listed pursuant to §112 (b) of the Clean Air Act as amended (1990), and State TAPs, listed pursuant to NMAC 20.2.72.500, have been detected and included in the analysis (Attachment C, Table 2). The analysis for these contaminants also used the plume-front's most reasonable all time highest well concentrations of the contaminants as summarized in the spreadsheets below.

The complete NASA WSTF well samples analysis database is included with this submittal, as requested, as an access database.

All other listed Federal HAPs and State TAPs have been omitted based on sound engineering judgment that there is no evidence that they might be present in the groundwater.

Note: Methylene Chloride is included as a contaminant of concern because it is detected in most samples. However, these detections appear to be false positives from the analytical separation processes and not evidence of Methylene Chloride in the groundwater.

	Site Wide		Plume Front	
Analyte	All Time	Last 5 yrs	All Time	Last 5 yrs
N-Nitrosodimethylamine	169	62	6.3	3.9
Trichloroethene	2600	660	690	540
Tetrachloroethene	89	39	37	23
1,1,1-Trichloroethane	16	0.44 J	1.5 J	0.21 J
1,1,2-Trichloroethane	1.2	1.2	1.2	1.2
Methylene chloride	85	82	7	4.2 J
Chloroform	3.7	2.7	1.8	1.8
Trichlorofluoromethane	6000	1600	860	640
Dichlorofluoromethane	290	60	60	25
1,1,2-Trichloro-1,2,2-trifluoroethane	11000	1200	2000	1000
2,2-Dichloro-1,1,1-Trifluoroethane	5.5	4.2 J	2.9	0.53 J
1,2-Dichloro-1,1,2-Trifluoroethane	200	78	54	8.7

Note: All values are in ug/L.

All-Time

wellname	event_date	casno	analyte	result	units	ep_lim	ct_effic	et_lim	qa_flag	Adjusted Result
400-A-151	01-Aug-97	62-75-9	N-Nitrosodimethylamine	76	ug/L	1	102	0		74.5
400-A-151	24-Oct-97	62-75-9	N-Nitrosodimethylamine	66	ug/L	1	108	0		61.1
400-A-151	03-Apr-92	62-75-9	N-Nitrosodimethylamine	59	ug/L	0.1	42	0		140.5
400-A-151	20-Jan-92	62-75-9	N-Nitrosodimethylamine	56	ug/L	0.1	39	0		143.6
400-A-151	12-Mar-90	62-75-9	N-Nitrosodimethylamine	54	ug/L	0.1	32	0		168.8
400-A-151	18-Jun-90	62-75-9	N-Nitrosodimethylamine	54	ug/L	0.1	37	0		145.9
400-A-151	03-Apr-92	62-75-9	N-Nitrosodimethylamine	51	ug/L	0.1	42	0		121.4
400-A-151	24-Aug-89	62-75-9	N-Nitrosodimethylamine	50	ug/L	0.1	39	0		128.2
400-A-151	06-May-97	62-75-9	N-Nitrosodimethylamine	48	ug/L	2	45	0		106.7
400-A-151	21-Jul-92	62-75-9	N-Nitrosodimethylamine	47	ug/L	0.1	32	0		146.9
400-A-151	21-Aug-91	62-75-9	N-Nitrosodimethylamine	44	ug/L	0.1	39	0		112.8

Last 5 Years

wellname	event_date	casno	analyte	result	units	ep_lim	ct_effic	et_lim	qa_flag	Adjusted Result
400-A-151	17-Jul-00	62-75-9	N-Nitrosodimethylamine	23.8	ppb	0.01	58	0.01		41.0
400-A-151	09-Jan-01	62-75-9	N-Nitrosodimethylamine	21.4	ppb	0.01	38	0.01		56.3
BLM-15-305	08-Mar-00	62-75-9	N-Nitrosodimethylamine	21.3	ppb	0.01	76	0.01	QD	28.0
400-A-151	17-Jul-00	62-75-9	N-Nitrosodimethylamine	20.4	ppb	0.01	58	0.01		35.2
400-A-151	09-Jan-01	62-75-9	N-Nitrosodimethylamine	20	ppb	0.01	38	0.01		52.6
BLM-15-305	13-Sep-99	62-75-9	N-Nitrosodimethylamine	19.4	ppb	0.01	35	0.01		55.4
BLM-15-305	05-Mar-99	62-75-9	N-Nitrosodimethylamine	18.5	ppb	0.01	84	0.01		22.0
400-A-151	16-Jul-99	62-75-9	N-Nitrosodimethylamine	16.9	ppb	0.01	58	0.01		29.1
NASA 6	27-Apr-00	62-75-9	N-Nitrosodimethylamine	16.8	ppb	0.01	27	0.01		62.2
400-A-151	28-Jun-02	62-75-9	N-Nitrosodimethylamine	16.5	ppb	0.01	48	0.01		34.3

Plume Front All time

wellname	event_date	casno	analyte	result	units	ep_lim	ct_effic	et_lim	qa_flag	Adjusted Result
BLM-1-435	27-Oct-97	62-75-9	N-Nitrosodimethylamine	6.4	ug/L	0.1	108	0		5.9
BLM-1-435	27-Oct-97	62-75-9	N-Nitrosodimethylamine	6.1	ug/L	0.1	108	0		5.6
BLM-17-493	08-Oct-97	62-75-9	N-Nitrosodimethylamine	3.4	ug/L	0.09	55	0		6.2
BLM-17-493	08-Oct-97	62-75-9	N-Nitrosodimethylamine	3	ug/L	0.09	55	0		5.5
BLM-17-550	02-Oct-97	62-75-9	N-Nitrosodimethylamine	3	ug/L	0.09	88	0		3.4
ST-1-541	09-Mar-00	62-75-9	N-Nitrosodimethylamine	3	ppb	0.01	76	0.01		3.9
BLM-17-493	18-May-90	62-75-9	N-Nitrosodimethylamine	2	ug/L	0.1	32	0		6.3
BLM-1-435	29-Mar-90	62-75-9	N-Nitrosodimethylamine	2	ug/L	0.1	45	0		4.4
BLM-1-435	27-Sep-89	62-75-9	N-Nitrosodimethylamine	2	ug/L	0.1	47	0		4.3

Plume Front - 5 Yrs

wellname	event_date	casno	analyte	result	units	ep_lim	ct_effic	et_lim	qa_flag	Adjusted Result
ST-1-541	09-Mar-00	62-75-9	N-Nitrosodimethylamine	3	ppb	0.01	76	0.01		3.9
ST-3-586	02-Mar-01	62-75-9	N-Nitrosodimethylamine	1.68	ppb	0.01	51	0.01		3.3
ST-3-586	02-Mar-01	62-75-9	N-Nitrosodimethylamine	1.67	ppb	0.01	51	0.01		3.3
BLM-17-493	12-Jan-01	62-75-9	N-Nitrosodimethylamine	1.57	ppb	0.01	56	0.01		2.8
BLM-17-493	24-Jul-00	62-75-9	N-Nitrosodimethylamine	1.52	ppb	0.01	52	0.01	QD	2.9
ST-1-541	19-Mar-03	62-75-9	N-Nitrosodimethylamine	1.49	ppb	0.01	56	0.01		2.7
ST-1-541	19-Mar-03	62-75-9	N-Nitrosodimethylamine	1.49	ppb	0.01	56	0.01		2.7
ST-1-541	15-Mar-01	62-75-9	N-Nitrosodimethylamine	1.46	ppb	0.01	54	0.01		2.7

All-Time

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag	
200-D-109	22-Apr-93	79-01-6	Trichloroethene	2600	ug/L	0.5	0		
200-D-109	27-Oct-92	79-01-6	Trichloroethene	2200	ug/L	0.5	0		
BLM-39-385	08-Mar-01	79-01-6	Trichloroethene	2000	ug/L	120	0.16	EB *	
200-D-109	29-Jan-93	79-01-6	Trichloroethene	1700	ug/L	0.5	0		
200-D-109	22-Apr-93	79-01-6	Trichloroethene	1600	ug/L	5	0		
200-D-109	19-Oct-90	79-01-6	Trichloroethene	1500	ug/L	0.5	0		
200-D-109	29-Jan-93	79-01-6	Trichloroethene	1500	ug/L	5	0	QD	
200-D-109	27-Jul-92	79-01-6	Trichloroethene	1400	ug/L	0.5	0		
200-D-109	07-May-92	79-01-6	Trichloroethene	1400	ug/L	0.5	0		
200-D-109	27-Oct-92	79-01-6	Trichloroethene	1300	ug/L	5	0		
200-D-109	27-Jul-92	79-01-6	Trichloroethene	1300	ug/L	0.5	0		
200-D-109	07-May-92	79-01-6	Trichloroethene	1300	ug/L	0.5	0		
200-D-109	16-Nov-88	79-01-6	Trichloroethene	1300	ug/L	5	0		

Last 5 Years

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag	
BLM-39-385	08-Mar-01	79-01-6	Trichloroethene	2000	ug/L	120	0.16	EB *	Laboratory Dilution Error
BLM-39-560	07-Mar-01	79-01-6	Trichloroethene	1000	ug/L	120	0.16	*	Laboratory Dilution Error
200-D-109	01-Oct-99	79-01-6	Trichloroethene	660	ug/L	50	0.1		
200-D-109	01-Oct-99	79-01-6	Trichloroethene	640	ug/L	5	0.16		
200-D-109	01-Oct-99	79-01-6	Trichloroethene	610	ug/L	5	0.16		
200-D-109	01-Oct-99	79-01-6	Trichloroethene	580	ug/L	100	0.1		
200-D-109	01-Oct-99	79-01-6	Trichloroethene	570	ug/L	12	0.16		
ST-1-630	09-Mar-00	79-01-6	Trichloroethene	540	ug/L	5	0.16		
200-D-109	01-Oct-99	79-01-6	Trichloroethene	520	ug/L	50	0.1		

Plume Front All time

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag	
ST-3-486	24-Sep-91	79-01-6	Trichloroethene	690	ug/L	5	0		
ST-1-541	18-Aug-95	79-01-6	Trichloroethene	650	ug/L	5	0		
ST-1-541	15-Nov-94	79-01-6	Trichloroethene	640	ug/L	0.5	0		
ST-1-541	05-May-94	79-01-6	Trichloroethene	630	ug/L	0.5	0		
ST-1-541	05-Oct-92	79-01-6	Trichloroethene	580	ug/L	0.5	0		
ST-1-541	13-Jul-92	79-01-6	Trichloroethene	580	ug/L	0.5	0		
ST-1-541	05-Oct-92	79-01-6	Trichloroethene	570	ug/L	0.5	0		
ST-1-541	05-May-94	79-01-6	Trichloroethene	560	ug/L	5	0	T	
ST-1-630	09-Mar-00	79-01-6	Trichloroethene	540	ug/L	5	0.16		

Plume Front - 5 Yrs

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag	
ST-1-630	09-Mar-00	79-01-6	Trichloroethene	540	ug/L	5	0.16		
ST-1-541	09-Aug-99	79-01-6	Trichloroethene	460	ug/L	10	0.1		
ST-1-541	19-Nov-99	79-01-6	Trichloroethene	450	ug/L	20	0.1		
ST-1-541	09-Mar-00	79-01-6	Trichloroethene	450	ug/L	20	0.1		
ST-1-541	19-Nov-99	79-01-6	Trichloroethene	440	ug/L	5	0.16		
ST-1-630	12-Sep-00	79-01-6	Trichloroethene	440	ug/L	20	0.22		

All-Time

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
200-D-109	27-Oct-92	127-18-4	Tetrachloroethene	89	ug/L	1	0	
200-D-109	22-Apr-93	127-18-4	Tetrachloroethene	86	ug/L	1	0	
200-D-109	19-Oct-90	127-18-4	Tetrachloroethene	81	ug/L	1	0	
BLM-1-435	28-Sep-88	127-18-4	Tetrachloroethene	78	ug/L	1	0	A
200-D-109	29-Jan-93	127-18-4	Tetrachloroethene	76	ug/L	1	0	
200-D-109	16-Nov-88	127-18-4	Tetrachloroethene	76	ug/L	5	0	
200-D-109	27-Oct-92	127-18-4	Tetrachloroethene	71	ug/L	5	0	
200-D-109	27-Jul-92	127-18-4	Tetrachloroethene	67	ug/L	1	0	
200-D-109	11-Jan-91	127-18-4	Tetrachloroethene	67	ug/L	1	0	
200-D-109	16-Nov-88	127-18-4	Tetrachloroethene	65	ug/L	5	0	
200-D-109	22-Apr-93	127-18-4	Tetrachloroethene	63	ug/L	5	0	

Last 5 Years

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
200-D-109	01-Oct-99	127-18-4	Tetrachloroethene	39	ug/L	1	0.1	
200-D-109	01-Oct-99	127-18-4	Tetrachloroethene	39	ug/L	0.5	0.178	
200-D-109	01-Oct-99	127-18-4	Tetrachloroethene	39	ug/L	1	0.1	
200-D-109	01-Oct-99	127-18-4	Tetrachloroethene	36	ug/L	0.5	0.178	
200-D-109	01-Oct-99	127-18-4	Tetrachloroethene	32	ug/L	1	0.1	
200-D-109	01-Oct-99	127-18-4	Tetrachloroethene	29	ug/L	0.5	0.178	
200-D-109	01-Oct-99	127-18-4	Tetrachloroethene	27	ug/L	1	0.1	
ST-1-541	25-Sep-98	127-18-4	Tetrachloroethene	23	ug/L	5	2.05	
ST-1-541	13-Sep-02	127-18-4	Tetrachloroethene	22	ug/l	1	0.57	
ST-1-541	11-Dec-02	127-18-4	Tetrachloroethene	21	ug/l	0.5	0.27	
ST-1-541	25-Sep-98	127-18-4	Tetrachloroethene	21	ug/L	5	2.05	

Plume Front All time

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
BLM-1-435	28-Sep-88	127-18-4	Tetrachloroethene	78	ug/L	1	0	A
ST-1-541	18-Aug-95	127-18-4	Tetrachloroethene	37	ug/L	5	0	
BLM-17-493	07-Jun-89	127-18-4	Tetrachloroethene	31	ug/L	5	0	
BLM-2-630	26-Sep-88	127-18-4	Tetrachloroethene	30	ug/L	1	0	A
BLM-17-493	07-Sep-89	127-18-4	Tetrachloroethene	26	ug/L	5	0	
ST-1-541	19-May-95	127-18-4	Tetrachloroethene	25	ug/L	1	0	
BLM-17-493	30-Mar-89	127-18-4	Tetrachloroethene	24	ug/L	1	0	
BLM-17-493	30-Mar-89	127-18-4	Tetrachloroethene	24	ug/L	1	0	
ST-1-541	06-Aug-96	127-18-4	Tetrachloroethene	24	ug/L	1	0	

Plume Front - 5 Yrs

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
ST-1-541	25-Sep-98	127-18-4	Tetrachloroethene	23	ug/L	5	2.05	
ST-1-541	13-Sep-02	127-18-4	Tetrachloroethene	22	ug/l	1	0.57	
ST-1-541	25-Sep-98	127-18-4	Tetrachloroethene	21	ug/L	5	2.05	
ST-1-541	11-Dec-02	127-18-4	Tetrachloroethene	21	ug/l	0.5	0.27	

All-Time

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag	
ST-5-481	14-May-97	71-55-6	1,1,1-Trichloroethane	18	ug/L	0.5	0.05	*	Lab Switch
200-D-109	16-Nov-88	71-55-6	1,1,1-Trichloroethane	16	ug/L	5	0		
200-D-109	16-Nov-88	71-55-6	1,1,1-Trichloroethane	15	ug/L	0.5	0		
BLM-2-630	23-Jun-88	71-55-6	1,1,1-Trichloroethane	11	ug/L	5	0		
NASA 8	17-Nov-88	71-55-6	1,1,1-Trichloroethane	10	ug/L	5	0		
200-D-109	15-Feb-89	71-55-6	1,1,1-Trichloroethane	9	ug/L	0.5	0		
NASA 8	17-Nov-88	71-55-6	1,1,1-Trichloroethane	8	ug/L	0.5	0		
200-D-109	19-Oct-90	71-55-6	1,1,1-Trichloroethane	7	ug/L	0.5	0		

Last 5 Years

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
BW-5-295	19-Sep-00	71-55-6	1,1,1-Trichloroethane	0.44	ug/L	0.5	0.11	J
NASA 8	11-Aug-99	71-55-6	1,1,1-Trichloroethane	0.28	ug/L	1	0.1	J
JP-1-424	31-Aug-98	71-55-6	1,1,1-Trichloroethane	0.27	ug/L	0.5	0.05	J *
NASA 8	23-Mar-00	71-55-6	1,1,1-Trichloroethane	0.22	ug/L	1	0.1	J
NASA 8	07-Dec-99	71-55-6	1,1,1-Trichloroethane	0.22	ug/L	1	0.1	J
NASA 8	07-Dec-99	71-55-6	1,1,1-Trichloroethane	0.22	ug/L	1	0.1	J
NASA 8	07-Dec-99	71-55-6	1,1,1-Trichloroethane	0.22	ug/L	1	0.1	J
PL-5-715	18-Feb-00	71-55-6	1,1,1-Trichloroethane	0.21	ug/L	0.5	0.11	J
NASA 8	23-Mar-00	71-55-6	1,1,1-Trichloroethane	0.21	ug/L	1	0.1	J
NASA 8	23-Mar-00	71-55-6	1,1,1-Trichloroethane	0.21	ug/L	1	0.1	J
NASA 8	07-Dec-99	71-55-6	1,1,1-Trichloroethane	0.21	ug/L	1	0.1	J

Plume Front All time

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag	
ST-5-481	14-May-97	71-55-6	1,1,1-Trichloroethane	18	ug/L	0.5	0.05	*	Lab Switch
BLM-2-630	23-Jun-88	71-55-6	1,1,1-Trichloroethane	11	ug/L	5	0		
PL-6-1485	30-Sep-96	71-55-6	1,1,1-Trichloroethane	1.5	ug/L	5	1.2	J	
BLM-17-493	27-Feb-90	71-55-6	1,1,1-Trichloroethane	1	ug/L	0.5	0		
BLM-17-493	30-Mar-89	71-55-6	1,1,1-Trichloroethane	1	ug/L	0.5	0		
BLM-17-493	30-Mar-89	71-55-6	1,1,1-Trichloroethane	1	ug/L	0.5	0		
BLM-1-435	31-Mar-89	71-55-6	1,1,1-Trichloroethane	1	ug/L	0.5	0		
BLM-17-493	07-Jun-89	71-55-6	1,1,1-Trichloroethane	1	ug/L	0.5	0		
BLM-17-493	07-Sep-89	71-55-6	1,1,1-Trichloroethane	1	ug/L	0.5	0		
BLM-17-493	06-Dec-89	71-55-6	1,1,1-Trichloroethane	1	ug/L	0.5	0		

Plume Front - 5 Yrs

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
PL-5-715	18-Feb-00	71-55-6	1,1,1-Trichloroethane	0.21	ug/L	0.5	0.11	J

All-Time

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag	
BLM-2-630	23-Jun-88	79-00-5	1,1,2-Trichloroethane	13	ug/L	5	0		Outlier - 1(
ST-3-735	05-Dec-00	79-00-5	1,1,2-Trichloroethane	1.2	ug/L	1	0.3		
ST-3-486	14-Jun-01	79-00-5	1,1,2-Trichloroethane	1.2	ug/L	1	0.3		
BLM-17-493	03-Jul-01	79-00-5	1,1,2-Trichloroethane	1.1	ug/L	1	0.3		
ST-1-541	09-Mar-00	79-00-5	1,1,2-Trichloroethane	0.66	ug/L	1	0.3	J	
BLM-17-493	12-Jan-01	79-00-5	1,1,2-Trichloroethane	0.55	ug/L	1	0.39	J	
BLM-17-493	12-Jan-01	79-00-5	1,1,2-Trichloroethane	0.48	ug/L	1	0.3	J	
300-B-166	15-Feb-00	79-00-5	1,1,2-Trichloroethane	0.26	ug/L	1	0.18	J	
ST-1-541	19-Nov-99	79-00-5	1,1,2-Trichloroethane	0.22	ug/L	1	0.18	J	

Last 5 Years

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
ST-3-735	05-Dec-00	79-00-5	1,1,2-Trichloroethane	1.2	ug/L	1	0.3	
ST-3-486	14-Jun-01	79-00-5	1,1,2-Trichloroethane	1.2	ug/L	1	0.3	
BLM-17-493	03-Jul-01	79-00-5	1,1,2-Trichloroethane	1.1	ug/L	1	0.3	
ST-1-541	09-Mar-00	79-00-5	1,1,2-Trichloroethane	0.66	ug/L	1	0.3	J
BLM-17-493	12-Jan-01	79-00-5	1,1,2-Trichloroethane	0.55	ug/L	1	0.39	J
BLM-17-493	12-Jan-01	79-00-5	1,1,2-Trichloroethane	0.48	ug/L	1	0.3	J
300-B-166	15-Feb-00	79-00-5	1,1,2-Trichloroethane	0.26	ug/L	1	0.18	J
ST-1-541	19-Nov-99	79-00-5	1,1,2-Trichloroethane	0.22	ug/L	1	0.18	J

Plume Front All time

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag	
BLM-2-630	23-Jun-88	79-00-5	1,1,2-Trichloroethane	13	ug/L	5	0		Outlier - 1(
ST-3-486	14-Jun-01	79-00-5	1,1,2-Trichloroethane	1.2	ug/L	1	0.3		
ST-3-735	05-Dec-00	79-00-5	1,1,2-Trichloroethane	1.2	ug/L	1	0.3		
BLM-17-493	03-Jul-01	79-00-5	1,1,2-Trichloroethane	1.1	ug/L	1	0.3		
ST-1-541	09-Mar-00	79-00-5	1,1,2-Trichloroethane	0.66	ug/L	1	0.3	J	
BLM-17-493	12-Jan-01	79-00-5	1,1,2-Trichloroethane	0.55	ug/L	1	0.39	J	
BLM-17-493	12-Jan-01	79-00-5	1,1,2-Trichloroethane	0.48	ug/L	1	0.3	J	
ST-1-541	19-Nov-99	79-00-5	1,1,2-Trichloroethane	0.22	ug/L	1	0.18	J	

Plume Front - 5 Yrs

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
ST-3-486	14-Jun-01	79-00-5	1,1,2-Trichloroethane	1.2	ug/L	1	0.3	
ST-3-735	05-Dec-00	79-00-5	1,1,2-Trichloroethane	1.2	ug/L	1	0.3	
BLM-17-493	03-Jul-01	79-00-5	1,1,2-Trichloroethane	1.1	ug/L	1	0.3	
ST-1-541	09-Mar-00	79-00-5	1,1,2-Trichloroethane	0.66	ug/L	1	0.3	J
BLM-17-493	12-Jan-01	79-00-5	1,1,2-Trichloroethane	0.55	ug/L	1	0.39	J
BLM-17-493	12-Jan-01	79-00-5	1,1,2-Trichloroethane	0.48	ug/L	1	0.3	J
ST-1-541	19-Nov-99	79-00-5	1,1,2-Trichloroethane	0.22	ug/L	1	0.18	J

All-Time

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
BLM-2-630	23-Jun-88	75-09-2	Dichloromethane	220	ug/L	25	0	
BLM-32-715	13-Dec-97	75-09-2	Methylene chloride	85	ug/L	5	2.07	
PL-7-480	15-Aug-98	75-09-2	Methylene chloride	82	ug/L	25	0.093	
BLM-32-715	13-Dec-97	75-09-2	Methylene chloride	60	ug/L	20	0.093	
BLM-9-419	09-Dec-92	75-09-2	Dichloromethane	27	ug/L	25	0	
300-E-138	25-Sep-01	75-09-2	Methylene chloride	25	ug/l	5	0.18	
BLM-32-715	08-Apr-98	75-09-2	Methylene chloride	19	ug/L	5	0.093	
200-D-240	26-Sep-96	75-09-2	Methylene chloride	18	ug/L	83	1.23	J
ST-5-481	14-May-97	75-09-2	Methylene chloride	16	ug/L	5	0.093	*

Last 5 Years

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
PL-7-480	15-Aug-98	75-09-2	Methylene chloride	82	ug/L	25	0.093	
300-E-138	25-Sep-01	75-09-2	Methylene chloride	25	ug/l	5	0.18	
300-E-138	25-Sep-01	75-09-2	Methylene chloride	15	ug/l	5	0.18	
WW-2-960	07-Jun-01	75-09-2	Methylene chloride	7.1	ug/L	5	0.18	RB TB EB
BW-7-211	07-Nov-00	75-09-2	Methylene chloride	7	ug/L	5	0.18	
BLM-39-560	07-Jun-01	75-09-2	Methylene chloride	6.8	ug/L	5	0.18	RB Q
400-C-118	10-May-01	75-09-2	Methylene chloride	6.3	ug/L	5	1.7	RB
600-D-845	07-Jun-01	75-09-2	Methylene chloride	6.3	ug/L	5	0.18	RB EB
400-C-118	22-Nov-99	75-09-2	Methylene chloride	5.9	ug/L	5	0.18	

Plume Front All time

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
BLM-2-630	23-Jun-88	75-09-2	Dichloromethane	220	ug/L	25	0	
ST-5-481	14-May-97	75-09-2	Methylene chloride	16	ug/L	5	0.093	*
ST-1-473	11-Jul-89	75-09-2	Dichloromethane	7	ug/L	5	0	
PL-6-1195	16-Apr-98	75-09-2	Methylene chloride	4.3	ug/L	5	2.07	J
ST-1-541	21-Jun-01	75-09-2	Methylene chloride	4.2	ug/L	5	0.18	J
PL-2-504	19-Jan-99	75-09-2	Methylene chloride	4.2	ug/L	5	2.07	J
BLM-17-550	09-Apr-97	75-09-2	Methylene chloride	4.1	ug/L	5	1.16	J
PL-3-453	22-Apr-98	75-09-2	Methylene chloride	4.1	ug/L	5	2.07	J
ST-3-666	17-Jul-98	75-09-2	Methylene chloride	3.6	ug/L	5	2.07	J
ST-5-485	19-Mar-98	75-09-2	Methylene chloride	3.5	ug/L	5	2.07	J
PL-6-1335	12-Sep-97	75-09-2	Methylene chloride	3.4	ug/L	5	1.16	J
BLM-2-482	18-Mar-98	75-09-2	Methylene chloride	3.2	ug/L	5	2.07	J

Plume Front - 5 Yrs

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
PL-2-504	19-Jan-99	75-09-2	Methylene chloride	4.2	ug/L	5	2.07	J
ST-1-541	21-Jun-01	75-09-2	Methylene chloride	4.2	ug/L	5	0.18	J
ST-6-685	20-Jul-99	75-09-2	Methylene chloride	3.1	ug/L	5	2.07	J
ST-6-975	19-Jul-99	75-09-2	Methylene chloride	3.1	ug/L	5	2.07	J
ST-6-535	20-Apr-00	75-09-2	Methylene chloride	3.1	ug/L	5	0.18	J EB
PL-4-464	11-Oct-01	75-09-2	Methylene chloride	2.8	ug/L	5	0.18	J RB
PL-4-464	11-Oct-01	75-09-2	Methylene chloride	2.7	ug/L	5	0.18	J RB
PL-4-464	24-Apr-01	75-09-2	Methylene chloride	2.6	ug/L	5	1.7	J
ST-1-473	16-Aug-99	75-09-2	Methylene chloride	2.6	ug/L	5	0.18	J

All-Time

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
BLM-2-630	23-Jun-88	67-66-3	Trichloromethane	70	ug/L	5	0	
ST-5-481	14-May-97	67-66-3	Chloroform	20	ug/L	0.5	0.056	*
NASA 9	25-Apr-95	67-66-3	Trichloromethane	19	ug/L	0.5	0	
300-A-120	14-Sep-88	67-66-3	Trichloromethane	3.7	ug/L	0.5	0	
200-D-240	20-Mar-89	67-66-3	Trichloromethane	3	ug/L	0.5	0	
300-A-120	17-Oct-89	67-66-3	Trichloromethane	3	ug/L	0.5	0	
200-D-240	06-Nov-89	67-66-3	Trichloromethane	3	ug/L	0.5	0	
200-D-240	06-Nov-89	67-66-3	Trichloromethane	3	ug/L	0.5	0	
300-A-120	26-Jun-90	67-66-3	Trichloromethane	3	ug/L	0.5	0	
300-A-120	26-Jun-90	67-66-3	Trichloromethane	3	ug/L	0.5	0	
BLM-31-350	16-Apr-96	67-66-3	Trichloromethane	3	ug/L	10	0	J

Last 5 Years

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
NASA 7	01-Oct-01	67-66-3	Chloroform	2.7	ug/L	0.5	0.34	
NASA 7	01-Oct-01	67-66-3	Chloroform	2.7	ug/L	0.5	0.34	
NASA 7	01-Oct-01	67-66-3	Chloroform	2.7	ug/L	0.5	0.34	
NASA 6	27-Apr-00	67-66-3	Chloroform	2.2	ug/L	0.5	0.17	
ST-3-486	10-Oct-00	67-66-3	Chloroform	1.8	ug/L	0.5	0.17	
BW-4-270	19-Aug-99	67-66-3	Chloroform	1.8	ug/L	0.5	0.17	
BW-4-355	20-Aug-99	67-66-3	Chloroform	1.8	ug/L	0.5	0.17	
BW-1-268	12-Oct-99	67-66-3	Chloroform	1.8	ug/L	0.5	0.17	
ST-1-541	19-Nov-99	67-66-3	Chloroform	1.8	ug/L	0.5	0.17	
ST-1-630	19-Nov-99	67-66-3	Chloroform	1.8	ug/L	0.5	0.17	

Plume Front All time

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
BLM-2-630	23-Jun-88	67-66-3	Trichloromethane	70	ug/L	5	0	
ST-5-481	14-May-97	67-66-3	Chloroform	20	ug/L	0.5	0.056	*
ST-3-486	10-Oct-00	67-66-3	Chloroform	1.8	ug/L	0.5	0.17	
ST-1-541	19-Nov-99	67-66-3	Chloroform	1.8	ug/L	0.5	0.17	
ST-1-630	19-Nov-99	67-66-3	Chloroform	1.8	ug/L	0.5	0.17	
ST-3-735	07-Mar-01	67-66-3	Chloroform	1.7	ug/L	0.5	0.17	
PL-4-464	07-Sep-99	67-66-3	Chloroform	1.7	ug/L	0.5	0.17	QD
PL-6-1485	30-Sep-96	67-66-3	Chloroform	1.4	ug/L	5	1.22	J
ST-1-541	15-Mar-01	67-66-3	Chloroform	1.2	ug/L	0.5	0.17	
BLM-2-630	04-Oct-01	67-66-3	Chloroform	1.1	ug/l	0.5	0.34	
ST-1-630	14-Mar-01	67-66-3	Chloroform	1.1	ug/L	0.5	0.17	

Plume Front - 5 Yrs

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
ST-3-486	10-Oct-00	67-66-3	Chloroform	1.8	ug/L	0.5	0.17	
ST-1-541	19-Nov-99	67-66-3	Chloroform	1.8	ug/L	0.5	0.17	
ST-1-630	19-Nov-99	67-66-3	Chloroform	1.8	ug/L	0.5	0.17	
ST-3-735	07-Mar-01	67-66-3	Chloroform	1.7	ug/L	0.5	0.17	
PL-4-464	07-Sep-99	67-66-3	Chloroform	1.7	ug/L	0.5	0.17	QD
ST-1-541	15-Mar-01	67-66-3	Chloroform	1.2	ug/L	0.5	0.17	
ST-1-630	14-Mar-01	67-66-3	Chloroform	1.1	ug/L	0.5	0.17	

BLM-2-630	04-Oct-01	67-66-3	Chloroform	1.1	ug/l	0.5	0.34	

All-Time

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
300-A-170	15-Sep-88	75-69-4	Trichlorofluoromethane	6000	ug/L	10	0	
300-C-128	14-Sep-88	75-69-4	Trichlorofluoromethane	5600	ug/L	340	0	
300-A-120	14-Sep-88	75-69-4	Trichlorofluoromethane	5200	ug/L	50	0	
300-A-170	15-Sep-88	75-69-4	Trichlorofluoromethane	4900	ug/L	335	0	
300-A-120	02-Dec-96	75-69-4	Trichlorofluoromethane	4300	ug/L	250	0.3	FB
300-A-170	11-Sep-91	75-69-4	Trichlorofluoromethane	4200	ug/L	5	0	
300-A-120	02-Dec-96	75-69-4	Trichlorofluoromethane	4100	ug/L	250	0.3	FB
300-A-120	02-Dec-96	75-69-4	Trichlorofluoromethane	4000	ug/L	250	0.3	FB

Last 5 Years

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
BLM-39-385	08-Mar-01	75-69-4	Trichlorofluoromethane	1800	ug/L	120	0.055	EB *
300-C-128	24-Sep-98	75-69-4	Trichlorofluoromethane	1600	ug/L	50	1.25	Q
300-A-120	22-May-01	75-69-4	Trichlorofluoromethane	1400	ug/L	12	0.2	
300-A-170	02-Dec-99	75-69-4	Trichlorofluoromethane	1400	ug/L	12	0.055	
ST-1-541	24-Sep-01	75-69-4	Trichlorofluoromethane	1300	ug/l	0.5	0.2	G *
300-A-120	08-Dec-99	75-69-4	Trichlorofluoromethane	1300	ug/L	12	0.055	
Plume Front All time								
wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
ST-1-541	24-Sep-01	75-69-4	Trichlorofluoromethane	1300	ug/l	0.5	0.2	G *
ST-1-630	25-Sep-01	75-69-4	Trichlorofluoromethane	1200	ug/l	0.5	0.2	G *
ST-1-473	16-Jul-98	75-69-4	Trichlorofluoromethane	860	ug/L	120	0.06	QD
ST-3-486	08-Nov-96	75-69-4	Trichlorofluoromethane	800	ug/L	50	0.3	
ST-1-541	18-Aug-95	75-69-4	Trichlorofluoromethane	790	ug/L	5	0	
ST-3-586	23-Sep-01	75-69-4	Trichlorofluoromethane	730	ug/l	0.5	0.2	G *
ST-3-586	07-Nov-96	75-69-4	Trichlorofluoromethane	640	ug/L	50	0.3	T TB Q
ST-1-630	09-Mar-00	75-69-4	Trichlorofluoromethane	640	ug/L	5	0.055	
ST-1-473	23-Oct-96	75-69-4	Trichlorofluoromethane	610	ug/L	50	0.3	
ST-1-473	23-Oct-96	75-69-4	Trichlorofluoromethane	600	ug/L	50	0.3	
Plume Front - 5 Yrs								
wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
ST-1-541	24-Sep-01	75-69-4	Trichlorofluoromethane	1300	ug/l	0.5	0.2	G *
ST-1-630	25-Sep-01	75-69-4	Trichlorofluoromethane	1200	ug/l	0.5	0.2	G *
ST-3-586	23-Sep-01	75-69-4	Trichlorofluoromethane	730	ug/l	0.5	0.2	G *
ST-1-630	09-Mar-00	75-69-4	Trichlorofluoromethane	640	ug/L	5	0.055	
ST-1-630	09-Aug-99	75-69-4	Trichlorofluoromethane	410	ug/L	5	0.055	
ST-1-541	09-Mar-00	75-69-4	Trichlorofluoromethane	400	ug/L	5	0.055	
ST-1-541	11-Dec-01	75-69-4	Trichlorofluoromethane	390	ug/l	20	1.61	
ST-1-541	11-Dec-01	75-69-4	Trichlorofluoromethane	390	ug/l	20	1.61	
ST-1-541	19-Jun-02	75-69-4	Trichlorofluoromethane	380	ug/l	10	1.61	
ST-1-541	12-Mar-02	75-69-4	Trichlorofluoromethane	380	ug/l	20	1.61	
ST-1-541	09-Aug-99	75-69-4	Trichlorofluoromethane	370	ug/L	20	0.15	
ST-1-541	11-Dec-02	75-69-4	Trichlorofluoromethane	370	ug/l	10	1.61	
ST-1-630	12-Sep-00	75-69-4	Trichlorofluoromethane	370	ug/L	12	0.055	

All-Time

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
400-C-143	09-Oct-91	75-43-4	Dichlorofluoromethane	290	ug/L	5	0	QD
400-C-143	09-Oct-91	75-43-4	Dichlorofluoromethane	210	ug/L	5	0	QD
400-C-118	08-Oct-91	75-43-4	Dichlorofluoromethane	150	ug/L	5	0	
400-C-143	09-Oct-91	75-43-4	Dichlorofluoromethane	140	ug/L	0.5	0	
400-C-118	22-Feb-89	75-43-4	Dichlorofluoromethane	120	ug/L	5	0	QD
400-C-118	12-Dec-91	75-43-4	Dichlorofluoromethane	95	ug/L	5	0	
400-C-118	22-Feb-89	75-43-4	Dichlorofluoromethane	91	ug/L	5	0	QD
400-C-118	12-Dec-91	75-43-4	Dichlorofluoromethane	89	ug/L	5	0	
400-C-143	08-Feb-89	75-43-4	Dichlorofluoromethane	88	ug/L	5	0	
400-C-118	12-Dec-91	75-43-4	Dichlorofluoromethane	84	ug/L	0.5	0	
400-C-143	05-Feb-93	75-43-4	Dichlorofluoromethane	84	ug/L	5	0	

Last 5 Years

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
BLM-36-350	19-Apr-02	75-43-4	Dichlorofluoromethane	60	ug/l	2	0.34	
BLM-36-350	25-Oct-02	75-43-4	Dichlorofluoromethane	54	ug/l	0.5	0.37	
BLM-36-350	25-Oct-02	75-43-4	Dichlorofluoromethane	51	ug/l	2	0.34	
BLM-36-350	25-Jul-02	75-43-4	Dichlorofluoromethane	49	ug/l	0.5	0.37	
600-D-230	20-Nov-98	75-43-4	Dichlorofluoromethane	49	ug/L	5	1.76	
BLM-36-350	22-Apr-03	75-43-4	Dichlorofluoromethane	48	ug/l	2	0.32	
BLM-36-350	31-Jan-02	75-43-4	Dichlorofluoromethane	47	ug/l	2	0.34	
BLM-36-350	25-Jul-02	75-43-4	Dichlorofluoromethane	47	ug/l	2	0.34	
BLM-36-350	16-Jan-03	75-43-4	Dichlorofluoromethane	47	ug/l	2	0.34	
BLM-36-350	19-Apr-02	75-43-4	Dichlorofluoromethane	44	ug/l	0.5	0.37	

Plume Front All time

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
PL-5-495	26-May-98	75-43-4	Dichlorofluoromethane	60	ug/L	5	1.76	
PL-5-495	26-May-98	75-43-4	Dichlorofluoromethane	46	ug/L	0.5	0.05	
ST-6-575	28-Jun-02	75-43-4	Dichlorofluoromethane	25	ug/l	2	0.34	
ST-6-575	09-Jul-01	75-43-4	Dichlorofluoromethane	25	ug/L	2	0.12	
ST-6-575	03-Apr-02	75-43-4	Dichlorofluoromethane	25	ug/l	2	0.34	
ST-6-575	04-Apr-03	75-43-4	Dichlorofluoromethane	25	ug/l	2	0.27	
ST-6-575	02-Oct-02	75-43-4	Dichlorofluoromethane	23	ug/l	0.5	0.37	
ST-6-575	04-Apr-03	75-43-4	Dichlorofluoromethane	23	ug/l	2	0.27	
ST-6-575	07-Jan-02	75-43-4	Dichlorofluoromethane	23	ug/l	2	0.34	
ST-6-575	06-Jan-03	75-43-4	Dichlorofluoromethane	22	ug/l	2	0.34	
ST-6-575	03-Apr-02	75-43-4	Dichlorofluoromethane	22	ug/l	0.5	0.37	
ST-6-575	02-Oct-02	75-43-4	Dichlorofluoromethane	21	ug/l	2	0.34	

Plume Front - 5 Yrs

wellname	event_date	casno	analyte	result	units	rep_limit	det_limit	qa_flag
ST-6-575	28-Jun-02	75-43-4	Dichlorofluoromethane	25	ug/l	2	0.34	
ST-6-575	09-Jul-01	75-43-4	Dichlorofluoromethane	25	ug/L	2	0.12	
ST-6-575	04-Apr-03	75-43-4	Dichlorofluoromethane	25	ug/l	2	0.27	
ST-6-575	03-Apr-02	75-43-4	Dichlorofluoromethane	25	ug/l	2	0.34	
ST-6-575	04-Apr-03	75-43-4	Dichlorofluoromethane	23	ug/l	2	0.27	
ST-6-575	02-Oct-02	75-43-4	Dichlorofluoromethane	23	ug/l	0.5	0.37	
ST-6-575	07-Jan-02	75-43-4	Dichlorofluoromethane	23	ug/l	2	0.34	

All-Time

wellname	event_date	casno	analyte	result	units	ep_lim	et_lim	qa_flag
200-D-240	26-Jul-88	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	11000	ug/L	250	0	Q
200-D-240	13-Sep-88	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	8800	ug/L	5	0	
200-D-240	26-Jul-88	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	8300	ug/L	50	0	
200-D-240	13-Sep-88	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	7800	ug/L	50	0	
200-D-240	12-Dec-91	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	7700	ug/L	5	0	
200-D-240	22-Aug-91	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	6500	ug/L	0.5	0	
200-D-109	07-May-92	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	6200	ug/L	0.5	0	
200-D-240	20-Mar-89	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	6000	ug/L	0.5	0	FB RB
200-D-240	16-Oct-90	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	5800	ug/L	0.5	0	
200-D-240	22-Aug-91	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	5800	ug/L	0.5	0	
200-D-240	05-Feb-90	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	5800	ug/L	0.5	0	
200-D-109	22-Apr-93	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	5600	ug/L	0.5	0	
200-D-240	07-Dec-90	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	5600	ug/L	0.5	0	

Last 5 Years

wellname	event_date	casno	analyte	result	units	ep_lim	et_lim	qa_flag
BLM-39-385	08-Mar-01	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	2600	ug/L	120	0.2	EB *
BLM-39-560	07-Mar-01	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1300	ug/L	120	0.2	*
200-D-240	06-Jun-00	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1200	ug/L	12	0.2	
BLM-14-327	15-Nov-02	76-13-1	1,1,2-Trichloro-1,2,2-Trifluoroethane	1200	ug/l	10	0.7	
BLM-14-327	07-Jun-00	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1100	ug/L	20	0.2	
BLM-14-327	31-May-02	76-13-1	1,1,2-Trichloro-1,2,2-Trifluoroethane	1100	ug/l	10	0.7	
200-D-109	01-Oct-99	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1100	ug/L	25	0.2	
200-D-109	01-Oct-99	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1100	ug/L	12	0.2	
Plume Front All time								

wellname	event_date	casno	analyte	result	units	ep_lim	et_lim	qa_flag
BLM-17-493	19-Aug-91	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	2000	ug/L	0.5	0	
BLM-17-550	21-Aug-91	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1700	ug/L	5	0	
BLM-17-493	30-Mar-89	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1600	ug/L	0.5	0	
BLM-17-550	29-Oct-92	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1600	ug/L	0.5	0	
BLM-17-493	30-Mar-89	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1600	ug/L	0.5	0	
BLM-17-493	07-Jun-89	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1600	ug/L	0.5	0	
BLM-17-550	21-Aug-91	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1500	ug/L	5	0	
BLM-17-493	07-Jun-89	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1500	ug/L	5	0	
BLM-17-493	30-Mar-89	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1500	ug/L	5	0	
BLM-17-493	30-Mar-89	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1500	ug/L	5	0	
Plume Front - 5 Yrs								

wellname	event_date	casno	analyte	result	units	ep_lim	et_lim	qa_flag
BLM-17-493	03-Jul-01	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1000	ug/L	20	0.2	
BLM-17-550	10-Aug-99	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1000	ug/L	12	0.2	T
ST-1-541	09-Mar-00	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1000	ug/L	5	0.2	
BLM-17-493	03-Jul-01	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	900	ug/L	20	0.2	
ST-1-541	12-Mar-02	76-13-1	1,1,2-Trichloro-1,2,2-Trifluoroethane	880	ug/l	10	0.7	
BLM-17-550	03-Mar-00	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	880	ug/L	12	0.2	
ST-1-541	24-Sep-01	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	840	ug/l	0.5	0.2	G *
ST-1-541	11-Dec-01	76-13-1	1,1,2-Trichloro-1,2,2-Trifluoroethane	830	ug/l	10	0.7	
ST-1-541	15-Mar-01	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	830	ug/L	25	0.2	

All-Time

wellname	event_date	casno	analyte	result	units	ep_limit	det_limit	qa_flag
600-D-845	04-Apr-97	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	16	ug/L	0.5	0.05	
BLM-1-435	28-Sep-88	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	6	ug/L	1	0	
BLM-27-270	16-May-97	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	5.5	ug/L	0.5	0.05	
600-D-230	20-Nov-98	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	4.2	ug/L	10	1.46	J
BW-4-270	08-Jan-03	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	4.1	ug/l	1	0.82	
600-D-230	26-Sep-97	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	3.3	ug/L	10	1.46	J
600-D-230	04-Dec-01	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	3.2	ug/l	1	0.82	QD

Last 5 Years

wellname	event_date	casno	analyte	result	units	ep_limit	det_limit	qa_flag
600-D-230	20-Nov-98	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	4.2	ug/L	10	1.46	J
BW-4-270	08-Jan-03	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	4.1	ug/l	1	0.82	
600-D-230	04-Dec-01	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	3.2	ug/l	1	0.82	QD
600-D-845	10-Sep-01	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	3	ug/L	1	0.32	
600-D-845	04-Dec-01	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	2.9	ug/l	1	0.82	
600-D-230	07-Sep-01	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	2.8	ug/L	1	0.32	
600-D-230	01-Mar-02	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	2.6	ug/l	1	0.74	
BLM-36-350	08-May-01	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	2.2	ug/L	1	0.32	
600-D-365	20-Nov-98	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	2.1	ug/L	10	1.46	J

Plume Front All time

wellname	event_date	casno	analyte	result	units	ep_limit	det_limit	qa_flag
BLM-1-435	28-Sep-88	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	6	ug/L	1	0	
BLM-17-550	09-Apr-97	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	2.9	ug/L	0.5	0.05	
BLM-17-493	16-Apr-98	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	2.2	ug/L	10	1.46	J
BLM-17-493	07-Jun-89	306-83-2	2,2-Dichloro-1,1,1-trifluoroethane	2	ug/L	0.5	0	
BLM-17-493	27-Feb-90	306-83-2	2,2-Dichloro-1,1,1-trifluoroethane	1	ug/L	0.5	0	
ST-1-541	10-Feb-95	306-83-2	2,2-Dichloro-1,1,1-trifluoroethane	1	ug/L	0.5	0	
BLM-2-482	29-Mar-90	306-83-2	2,2-Dichloro-1,1,1-trifluoroethane	1	ug/L	0.5	0	
BLM-17-493	30-Mar-89	306-83-2	2,2-Dichloro-1,1,1-trifluoroethane	1	ug/L	0.5	0	
BLM-17-493	07-Apr-95	306-83-2	2,2-Dichloro-1,1,1-trifluoroethane	1	ug/L	0.5	0	
BLM-17-550	10-Apr-95	306-83-2	2,2-Dichloro-1,1,1-trifluoroethane	1	ug/L	0.5	0	
BLM-17-493	26-Oct-92	306-83-2	2,2-Dichloro-1,1,1-trifluoroethane	1	ug/L	0.5	0	
ST-3-486	17-Apr-95	306-83-2	2,2-Dichloro-1,1,1-trifluoroethane	1	ug/L	0.5	0	
ST-3-586	18-Apr-95	306-83-2	2,2-Dichloro-1,1,1-trifluoroethane	1	ug/L	0.5	0	
ST-1-541	19-May-95	306-83-2	2,2-Dichloro-1,1,1-trifluoroethane	1	ug/L	0.5	0	
BLM-17-550	10-Apr-95	306-83-2	2,2-Dichloro-1,1,1-trifluoroethane	1	ug/L	0.5	0	

Plume Front - 5 Yrs

wellname	event_date	casno	analyte	result	units	ep_limit	det_limit	qa_flag
ST-1-541	11-Dec-02	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0.53	ug/l	1	0.74	J
ST-1-541	15-Mar-01	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0.5	ug/L	1	0.32	J
ST-1-541	11-Dec-00	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0.49	ug/L	1	0.32	J
ST-1-541	11-Dec-00	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0.47	ug/L	1	0.32	J
ST-1-541	12-Sep-00	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0.47	ug/L	1	0.32	J
ST-1-541	09-Jun-00	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0.45	ug/L	1	0.32	J
ST-1-541	09-Jun-00	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0.44	ug/L	0.5	0.35	J

All-Time

wellname	event_date	casno	analyte	result	units	ep_lim	det_limi	qa_flag
400-C-143	09-Oct-91	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	200	ug/L	5	0	
400-C-118	08-Oct-91	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	160	ug/L	5	0	
400-C-143	09-Oct-91	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	160	ug/L	5	0	
WB-1-330	06-Nov-96	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	160	ug/L	5	0	
WB-1-330	06-Nov-96	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	140	ug/L	5	0	
400-C-118	12-Dec-91	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	120	ug/L	5	0	
400-C-118	12-Dec-91	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	110	ug/L	5	0	
400-C-118	22-Feb-89	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	100	ug/L	5	0	

Last 5 Years

wellname	event_date	casno	analyte	result	units	ep_lim	det_limi	qa_flag
BLM-36-350	22-Apr-03	354-23-4	1,2-Dichloro-1,1,2-Trifluoroethane	78	ug/l	1	0.66	
600-D-845	25-Feb-03	354-23-4	1,2-Dichloro-1,1,2-Trifluoroethane	76	ug/l	1	0.18	EB
600-D-230	18-Nov-02	354-23-4	1,2-Dichloro-1,1,2-Trifluoroethane	72	ug/l	1	0.36	
600-D-845	19-Nov-02	354-23-4	1,2-Dichloro-1,1,2-Trifluoroethane	70	ug/l	1	0.36	
600-D-845	07-Jun-01	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	68	ug/L	5	0.35	
600-D-845	29-May-02	354-23-4	1,2-Dichloro-1,1,2-Trifluoroethane	67	ug/l	1	0.36	
600-D-230	11-Apr-00	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	66	ug/L	25	0.35	

Plume Front All time

wellname	event_date	casno	analyte	result	units	ep_lim	det_limi	qa_flag
PL-5-495	26-May-98	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	54	ug/L	5	0.8	
PL-5-495	26-May-98	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	41	ug/L	5	0.084	
PL-6-725	22-Mar-93	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	29	ug/L	5	0	AD Q
PL-5-495	10-Jan-96	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	18	ug/L	5	0	
PL-5-495	10-Jan-96	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	18	ug/L	5	0	
ST-3-486	08-Nov-96	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	16	ug/L	5	0	
BLM-17-493	21-Oct-96	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	13	ug/L	0.5	0.4	
PL-5-495	10-Jan-96	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	11	ug/L	5	0	
ST-3-586	07-Nov-96	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	9	ug/L	5	0	
ST-6-575	04-Apr-03	354-23-4	1,2-Dichloro-1,1,2-Trifluoroethane	8.7	ug/l	5	0.56	
ST-6-575	02-Oct-02	354-23-4	1,2-Dichloro-1,1,2-Trifluoroethane	8.1	ug/l	5	0.82	

Plume Front - 5 Yrs

wellname	event_date	casno	analyte	result	units	ep_lim	det_limi	qa_flag
ST-6-575	04-Apr-03	354-23-4	1,2-Dichloro-1,1,2-Trifluoroethane	8.7	ug/l	5	0.56	
ST-6-575	02-Oct-02	354-23-4	1,2-Dichloro-1,1,2-Trifluoroethane	8.1	ug/l	5	0.82	
ST-6-575	04-Apr-03	354-23-4	1,2-Dichloro-1,1,2-Trifluoroethane	7.8	ug/l	1	0.18	
ST-6-575	02-Oct-02	354-23-4	1,2-Dichloro-1,1,2-Trifluoroethane	7.6	ug/l	5	0.82	
ST-6-575	06-Jan-03	354-23-4	1,2-Dichloro-1,1,2-Trifluoroethane	7.5	ug/l	5	0.82	
ST-6-575	04-Apr-03	354-23-4	1,2-Dichloro-1,1,2-Trifluoroethane	7.5	ug/l	1	0.18	
ST-6-575	06-Jan-03	354-23-4	1,2-Dichloro-1,1,2-Trifluoroethane	7.3	ug/l	1	0.36	
ST-6-575	07-Jan-02	354-23-4	1,2-Dichloro-1,1,2-Trifluoroethane	7.1	ug/l	5	0.82	

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag	NOTES:
PL-6-1485	30-Sep-96	8240	100-41-4	Ethylbenzene	5.5	5	1.17		
PL-5-985	23-Jul-02	8260	100-41-4	Ethylbenzene	0.58	1	0.46	J	"J" Flag is
PL-6-1195	22-Jan-02	8260	100-41-4	Ethylbenzene	0.58	1	0.46	J	an estimate
PL-6-1195	07-Feb-00	8260	100-41-4	Ethylbenzene	0.53	1	0.1	J	
PL-5-985	18-Jan-02	8260	100-41-4	Ethylbenzene	0.48	1	0.46	J	
PL-5-985	19-Jul-01	8260	100-41-4	Ethylbenzene	0.43	1	0.28	J	
PL-6-1195	23-Jan-01	8260	100-41-4	Ethylbenzene	0.43	1	0.28	J	
PL-5-985	19-Jul-01	8260	100-41-4	Ethylbenzene	0.43	1	0.28	J	
PL-6-1195	18-Apr-01	8260	100-41-4	Ethylbenzene	0.41	1	0.28	J	

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag	
PL-6-1485	30-Sep-96	8240	100-42-5	Styrene	4.7	5	1.14	J	"J" Flag is
ST-5-1175	10-Oct-00	8260	100-42-5	Styrene	3.4	1	0.27		an estimate
ST-5-1175	24-Feb-97	8240	100-42-5	styrene	2	5	0.2	J	
ST-5-1175	11-Sep-98	8240	100-42-5	Styrene	1.8	5	2.01	J	
ST-5-1175	11-Dec-02	8260	100-42-5	Styrene	1.8	1	0.29		
ST-5-1175	26-Oct-99	8260	100-42-5	Styrene	1.8	1	0.1		
ST-5-985	20-Nov-96	8240	100-42-5	STYRENE	1.8	5	0.2	J	
ST-5-1175	18-Jul-00	8260	100-42-5	Styrene	1.7	1	0.27		
ST-5-1175	26-Oct-99	8260	100-42-5	Styrene	1.7	1	0.1		
ST-5-1175	25-Mar-02	8260	100-42-5	Styrene	1.7	1	0.29		

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag	
ST-5-1175	10-Oct-00	8260	107-13-1	Acrylonitrile	55	20	2.4		
ST-7-450	13-Oct-99	8260	107-13-1	Acrylonitrile	1.7	20	1.4	J	"J" Flag is
ST-5-1175	26-Oct-99	8260	107-13-1	Acrylonitrile	1.5	20	1.4	J	an estimate

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag
BLM-2-482	27-Sep-88	8240	108-88-3	Toluene	80	10	0	
BLM-2-482	27-Sep-88	8240	108-88-3	Toluene	67	5	0	
ST-1-473	20-Sep-93	8240	108-88-3	Toluene	48	10	0	
BLM-2-482	06-Mar-01	8260	108-88-3	Toluene	30	1	0.29	
ST-1-630	15-Sep-93	8240	108-88-3	Toluene	28	10	0	
ST-1-630	15-Sep-93	8240	108-88-3	Toluene	17	10	0	
BLM-2-630	23-Jun-88	8240	108-88-3	Toluene	15	5	0	
BLM-2-630	26-Sep-88	8240	108-88-3	Toluene	15	10	0	QD

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag	
PL-6-1485	30-Sep-96	8240	108-90-7	Chlorobenzene	6.5	5	1.16		NO

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag
BLM-2-630	13-Feb-98	607	117-81-7	Bis (2-ethylhexyl) phthalate	712	0	0	TIC
PL-2-504	19-Jan-99	8061	117-81-7	Bis(2-ethylhexyl) phthalate	73	1	0.441	QD
ST-2-466	11-Dec-98	8061	117-81-7	Bis(2-ethylhexyl) phthalate	68.2	1	0.441	
ST-4-481	12-Mar-99	8061	117-81-7	Bis(2-ethylhexyl) phthalate	58.6	1	0.441	
ST-3-486	02-Feb-99	8061	117-81-7	Bis(2-ethylhexyl) phthalate	47.2	1	0.441	
PL-2-504	19-Jan-99	8061	117-81-7	Bis(2-ethylhexyl) phthalate	37	1	0.441	QD
BLM-17-550	05-Mar-99	8061	117-81-7	Bis(2-ethylhexyl) phthalate	33.8	1	0.441	
PL-4-464	09-Dec-98	8061	117-81-7	Bis(2-ethylhexyl) phthalate	33.7	1	0.441	
ST-3-586	05-Mar-98	607	117-81-7	Bis(2-ethylhexyl)phthalate	32.5	0	0	TIC

This was an artifact of sampling process

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag
ST-3-735	21-Sep-01	8260	123-91-1	1,4-Dioxane	38	200	17	J RB
ST-4-589	23-Sep-01	8260	123-91-1	1,4-Dioxane	37	200	17	J RB
ST-3-666	21-Sep-01	8260	123-91-1	1,4-Dioxane	31	200	17	J RB
ST-1-541	21-Jun-01	8260	123-91-1	1,4-Dioxane	18	200	17	J RB

NO

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag
PL-6-1485	30-Sep-96	8240	1330-20-7	Xylenes (total)	17	5	2.03	
ST-4-690	30-Nov-99	8260	1330-20-7	Xylenes (total)	0.66	1	0.3	J

NO

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag
PL-5-715	05-Jun-91	GI	16984-48-8	Fluoride	7.2	0.1	0	
PL-1-486	22-Apr-98	ANIONS	16984-48-8	Fluoride (Direct SIE)	0.98	0.1	0	
ST-3-486	14-May-98	ANIONS	16984-48-8	Fluoride	0.98	0.1	0.01	
ST-3-586	16-Jun-98	ANIONS	16984-48-8	Fluoride	0.96	1	0.01	J
BLM-17-493	05-Dec-98	ANIONS	16984-48-8	Fluoride	0.91	0.1	0.01	
BLM-2-482	20-Oct-98	ANIONS	16984-48-8	Fluoride	0.9	0.1	0.01	
BLM-17-493	30-Mar-89	GI	16984-48-8	Fluoride	0.9	0.1	0	Q

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag
PL-6-1485	15-Sep-97	8240	2432-11-3	1,1':3',1''-Terphenyl]-2'-ol	14	0	0	TIC

NO

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag
BLM-17-550	14-Feb-02	607	314-40-9	Bromacil	0.6	0.01	0.005	
BLM-17-550	16-Aug-02	607	314-40-9	Bromacil	0.58	0.01	0.005	
BLM-17-550	05-Mar-99	8061	314-40-9	Bromacil	0.4	1	0.234	J
BLM-17-550	05-Mar-99	8061	314-40-9	Bromacil	0.4	1	0.234	J
BLM-17-493	03-Jan-02	607	314-40-9	Bromacil	0.38	0.01	0.005	
BLM-17-550	17-Aug-01	607	314-40-9	Bromacil	0.32	0.01	0.005	
BLM-17-550	17-Aug-01	607	314-40-9	Bromacil	0.27	0.01	0.005	

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag	
PL-6-1485	30-Sep-96	8240	540-59-0	1,2-Dichloroethene (total)	1	5	0	J	NO
BLM-17-493	24-Jan-00	8260	540-59-0	1,2-Dichloroethene (total)	0.21	1	0.2	J	

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag	
PL-6-1485	30-Sep-96	8240	56-23-5	Carbon tetrachloride	2.2	5	1.21	J	
BLM-2-482	18-Oct-99	8260	56-23-5	Carbon tetrachloride	0.38	1	0.1	J	"J" Flag is
BLM-17-550	02-Oct-97	8010	56-23-5	Carbon tetrachloride	0.38	0.5	0.05	J	an estimate
BLM-2-482	18-Oct-99	8260	56-23-5	Carbon tetrachloride	0.36	1	0.1	J	
ST-1-541	09-Aug-99	8260	56-23-5	Carbon tetrachloride	0.36	1	0.1	J	
ST-1-630	09-Aug-99	8260	56-23-5	Carbon tetrachloride	0.33	1	0.1	J	
BLM-17-550	10-Aug-99	8260	56-23-5	Carbon tetrachloride	0.16	1	0.1	J	
BLM-17-550	10-Aug-99	8260	56-23-5	Carbon tetrachloride	0.16	1	0.1	J	

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag	
PL-6-1485	30-Sep-96	8240	71-43-2	Benzene	4	5	1.21	J	
ST-1-541	19-Nov-99	8260	71-43-2	Benzene	0.14	1	0.1	J	"J" Flag is
ST-1-541	09-Aug-99	8260	71-43-2	Benzene	0.13	1	0.1	J	an estimate
PL-6-1815	11-Feb-00	8260	71-43-2	Benzene	0.13	1	0.1	J	
PL-6-1645	09-Aug-99	8260	71-43-2	Benzene	0.12	1	0.1	J	
ST-3-586	17-Nov-99	8260	71-43-2	Benzene	0.11	1	0.1	J	
ST-1-630	09-Aug-99	8260	71-43-2	Benzene	0.11	1	0.1	J	
ST-1-541	09-Mar-00	8260	71-43-2	Benzene	0.11	1	0.1	J	
ST-1-541	09-Mar-00	8260	71-43-2	Benzene	0.11	1	0.1	J	

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag	
ST-6-975	10-Feb-99	RCRA	7440-22-4	Silver	0.0052	0.01	0.0028	J	
ST-6-535	05-Feb-99	RCRA	7440-22-4	Silver	0.0043	0.01	0.0028	J	(mg/l)
ST-6-575	08-Feb-99	RCRA	7440-22-4	Silver	0.0038	0.01	0.0028	J	
ST-6-830	09-Feb-99	RCRA	7440-22-4	Silver	0.0033	0.01	0.0028	J	
ST-6-685	08-Feb-99	RCRA	7440-22-4	Silver	0.003	0.01	0.0028	J	

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag	
PL-5-495	02-Feb-01	8021	74-87-3	Chloromethane	2.6	5	0.16	J	"J" Flag is
ST-2-466	01-Feb-01	8021	74-87-3	Chloromethane	2.6	5	0.16	J	an estimate
ST-5-655	04-Apr-01	8260	74-87-3	Chloromethane	1.9	2	0.3	J	
PL-6-1195	07-Feb-00	8021	74-87-3	Chloromethane	1.6	5	0.16	J	
ST-5-985	10-Jan-01	8260	74-87-3	Chloromethane	1.5	2	0.3	J	
ST-5-485	16-Jan-01	8260	74-87-3	Chloromethane	1.4	2	0.3	J	
PL-3-453	04-Jan-01	8260	74-87-3	Chloromethane	1.2	2	0.3	J	

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag	
PL-5-985	19-Jul-01	8260	74-93-1	Methanethiol	1.4	0	0	TIC	NO
PL-5-985	19-Jul-01	8260	74-93-1	Methanethiol	1.1	0	0	TIC	

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag
PL-6-1815	10-Aug-99	8021	75-01-4	Vinyl chloride	2.8	1	0.15	
ST-5-1175	10-Oct-00	8021	75-01-4	Vinyl chloride	2.7	1	0.15	
ST-5-1175	14-Jan-00	8021	75-01-4	Vinyl chloride	1.4	1	0.15	
PL-6-1815	21-Nov-99	8021	75-01-4	Vinyl chloride	1.2	1	0.15	
PL-5-715	18-Feb-00	8021	75-01-4	Vinyl chloride	0.99	1	0.15	J
PL-6-1815	02-Nov-00	8021	75-01-4	Vinyl chloride	0.92	1	0.15	J
ST-5-1175	20-Aug-97	8010	75-01-4	Vinyl chloride	0.8	1	0.05	J
ST-5-1175	21-May-97	8010	75-01-4	Vinyl chloride	0.8	1	0.05	J
ST-5-1175	10-Oct-00	8260	75-01-4	Vinyl chloride	0.75	2	0.21	J
ST-5-1175	26-Oct-99	8260	75-01-4	Vinyl chloride	0.69	2	0.13	J
ST-5-1175	02-Jan-02	8260	75-01-4	Vinyl Chloride	0.64	2	0.98	J

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag
PL-5-985	19-Jul-01	8260	75-15-0	Carbon disulfide	2.7	1	0.19	
PL-5-985	19-Jul-01	8260	75-15-0	Carbon disulfide	2.7	1	0.19	
PL-5-985	23-Jul-02	8260	75-15-0	Carbon Disulfide	2.1	1	0.56	
PL-5-985	15-Jan-99	8240	75-15-0	Carbon disulfide	2.1	5	2.08	J
PL-5-985	18-Jan-02	8260	75-15-0	Carbon Disulfide	1.7	1	0.56	

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag	
ST-5-481	14-May-97	8010	75-25-2	Bromoform	21	5	0.166	*	NO
ST-3-486	14-May-99	8010	75-25-2	Bromoform	0.84	5	0.166	J	

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag
PL-5-595	13-Mar-91	GI	7664-41-7	Ammonia as N	2.7	0.1	0	
ST-3-486	24-Sep-91	GI	7664-41-7	Ammonia as N	0.65	0.1	0	
ST-4-690	05-Nov-92	GI	7664-41-7	Ammonia as N	0.5	0.1	0	
ST-7-450	17-Aug-01	350.1	7664-41-7	Ammonia as N	0.39	0.1	0.031	
ST-4-481	12-Mar-99	350.1	7664-41-7	Ammonia as N	0.32	0.1	0.29	
ST-4-690	10-Feb-93	GI	7664-41-7	Ammonia as N	0.31	0.2	0	
ST-5-1175	20-Oct-93	gi	7664-41-7	Ammonia as N	0.25	0.1	0	
ST-7-975	22-Aug-01	350.1	7664-41-7	Ammonia as N	0.24	0.1	0.031	
ST-6-535	16-Jun-98	350.1	7664-41-7	Ammonia as N	0.23	0.1	0	
PL-6-1815	22-Apr-98	350.1	7664-41-7	Ammonia as N	0.22	0.1	0	

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag	
ST-4-589	01-Jul-92	RCRA	7782-49-2	Selenium	0.023	0.01	0		
PL-5-795	26-May-92	RCRA	7782-49-2	Selenium	0.018	0.005	0		
ST-6-830	09-Feb-99	RCRA	7782-49-2	Selenium	0.0062	0.005	0.003		(mg/L)
ST-7-975	22-Aug-01	RCRA	7782-49-2	Selenium	0.0031	0.01	0.0016	J	
ST-7-550	14-Oct-99	RCRA	7782-49-2	Selenium	0.0024	0.005	0.003	J SP RB	
ST-1-630	19-Nov-99	RCRA	7782-49-2	Selenium	0.0021	0.005	0.0012	J	
ST-6-975	30-Sep-02	RCRA	7782-49-2	Selenium	0.0021	0.005	0.00176	J	

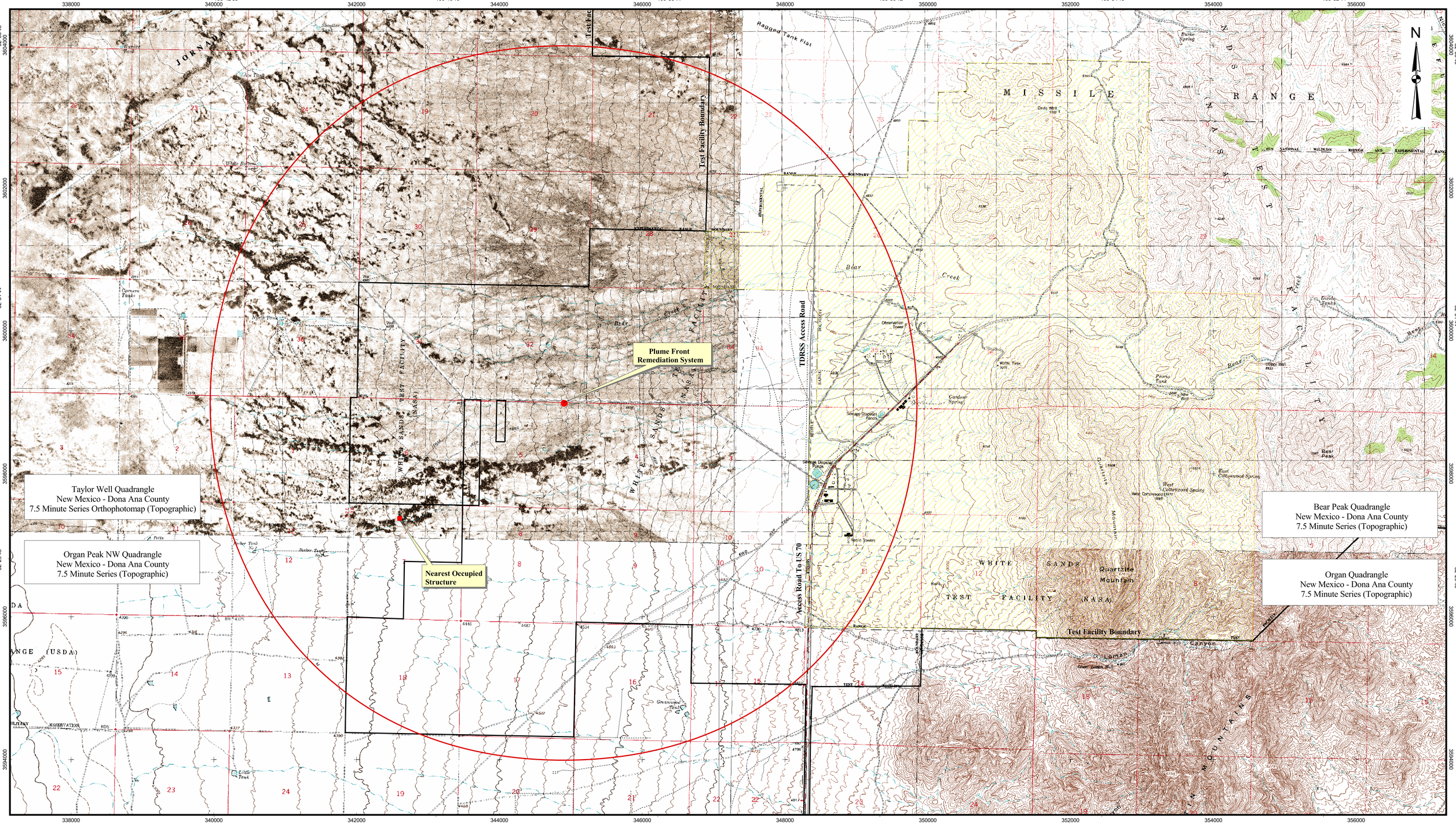
wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag	
ST-2-466	11-Dec-98	8061	84-66-2	Diethyl phthalate	0.252	1	0.214	J	NO

wellname	event_date	analysis	casno	analyte	result	rep_limit	det_limit	qa_flag	
BLM-2-630	29-Jan-97	8240	95-50-1	1,2-dichlorobenzene	1.1	5	0.2	J	NO

flagtype	flagtext
*	User defined flag.
A	Indicates that the result of an analyte for a check standard (LCS or CCV) was outside standard limits.
AD	Indicates that the precision for analyst duplicates was outside standard limits.
EB	Indicates that the analyte was detected in the equipment blank at or above the reporting limit.
FB	Indicates that the analyte was detected in the field blank at or above the reporting limit.
G	Indicates that the result of the analyte is greater than the calibration limit.
J	Indicates that the result is an estimated value less than the reporting limit, but greater than or equal to the detection limit.
NA	Indicates that the value/result was either not analyzed or not applicable.
ND	Indicates that the analyte was not detected above the detection limit.
Q	Indicates that the result for a blind control was outside standard limits.
QD	Indicates that the precision for a field duplicate was outside standard limits.
RB	Indicates that the analyte was detected in the reagent blank at or above the reporting limit.
S	Indicates that the result was determined by the method of standard addition.
SP	Indicates that either the spike recovery or the relative percent difference for spike duplicates was outside standard limits.
T	Indicates that the analyte was analyzed outside the specified holding time.
TB	Indicates that the analyte was detected in the trip blank at or above the detection limit.
TIC	Indicates that the analyte was tentatively identified by a GC/MS libary search and the amount reported is an estimated value.

ATTACHMENT E

SITE LOCATION MAP



Location of Plume Front Remediation System

WSTF Industrial Zone (Restricted Access)

1 0 1 2 Miles

ATTACHMENT F

PROOF OF PUBLIC NOTICE

PROOF OF PUBLIC NOTICE

No proof of public notice is required for this NOI.

ATTACHMENT G

DESCRIPTION OF ROUTINE OPERATIONS AND MAINTENANCE

DESCRIPTION OF ROUTINE OPERATIONS AND MAINTENANCE

The following operations and maintenance plan is that presented to the NMED Hazardous Waste Bureau.

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
White Sands Test Facility
P.O. Box 20
Las Cruces, NM 88004-0020

June 11, 2002

Reply to Attn of: RA–02–063

New Mexico Environment Department
Attn: Mr. Phillip Solano, Project Leader
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

Subject: WSTF Plume-Front Stabilization Operation and Maintenance Plan and Interim Measures Plans and Specifications

The Plume-Front Stabilization Interim Corrective Measures Work Plan (approved by NMED on March 15, 2000) specifies that an Operation and Maintenance Plan and Interim Measures Plans and Specifications be provided to NMED. The enclosed CD-ROM provides these required submittals.

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

To the extent that information has been submitted electronically, I acknowledge that NMED will rely solely on the electronic information as accurate and complete information and that it is this data that will be used for compliance and enforcement purposes pursuant to the provisions set forth in the NASA WSTF Final Project Agreement.

If you have any questions, please feel free to contact Mike Kirsch at 505–524–5517.

ORIGINAL SIGNED BY
JOSEPH FRIES

Joseph Fries
Manager

Enclosure

cc:
See List

cc: (*w/o encl.)
Mr. James Bearzi, Chief*
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New Mexico Environment Department
4131 Montgomery NE
Albuquerque, NM 87109

bcc:
HTSI Team/P. H. Pache (w/o encl.)

RA/MKirsch:ljg:6/11/02:5517

#4 zip LTRS\Env-02-2\NMED 100% submittal letter

CONCUR	CODE →	RA	RA			
	SIGNATURE →	Mike Zygmont	Mike Kirsch			
	DATE →	6/11/02	6/11/02			

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2905 RODEO PARK DRIVE EAST BUILDING 1
SANTA FE NM 87505

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X Vanessa Barros ☐ Agent ☐ Addressee

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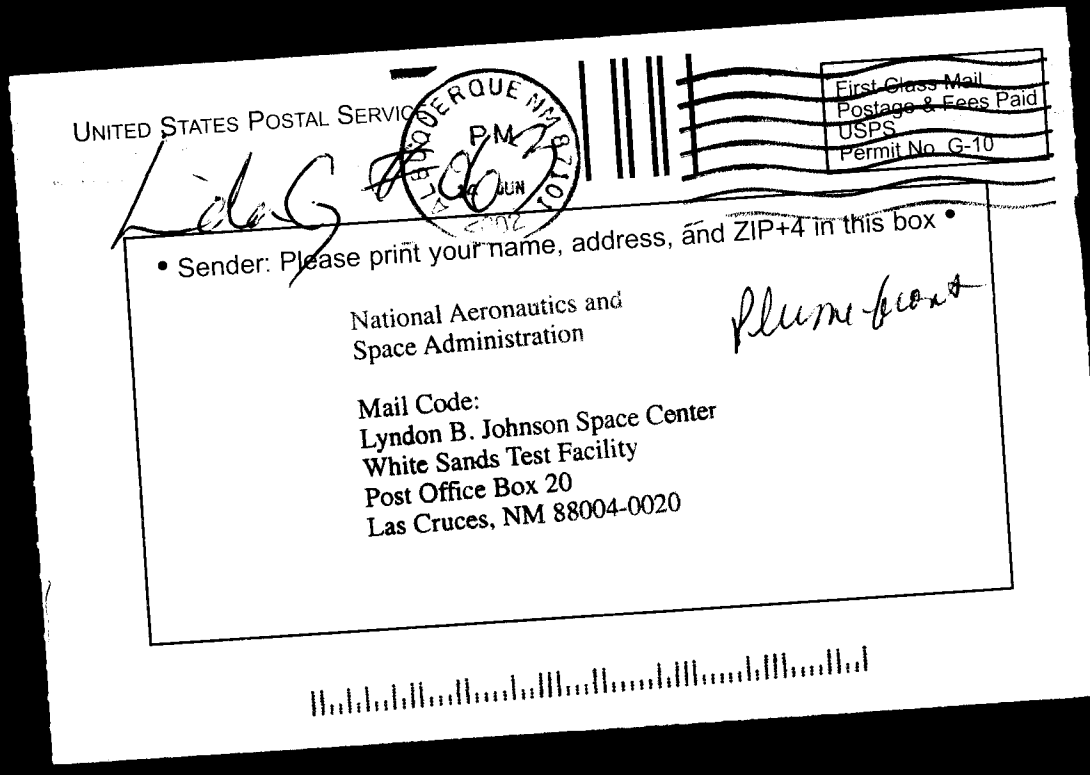
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NASA WHITE SANDS TEST FACILITY

PLUME-FRONT REMEDIATION SYSTEM

OPERATION AND MAINTENANCE PLAN

TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY 1

2.0 SYSTEM DESCRIPTION..... 2

3.0 INITIAL START-UP PROCEDURES..... 5

4.0 OPERATION..... 10

5.0 INSPECTION..... 11

6.0 SAMPLING AND ANALYSIS..... 12

7.0 MAINTENANCE..... 12

8.0 WASTE MANAGEMENT..... 13

9.0 PROJECT MANAGEMENT, TRAINING AND REPORTING..... 13

10.0 CONTINGENCY PLAN..... 14

LIST OF REFERENCES

National Aeronautics and Space Administration, 1999, New Mexico Ground Water Quality Bureau Discharge Plan Application for the Plume-Front Stabilization Project, NASA WSTF, Las Cruces, NM, February 11, 1999

National Aeronautics and Space Administration, 1999, "Plume-Front Stabilization Work Plan", NASA WSTF, Las Cruces, NM, January 1999

New Mexico Ground Water Quality Bureau, 2000, NASA White Sands Test Facility (WSTF) Discharge Plan Approval, DP-1255, March 10, 2000.

New Mexico Environment Department, Hazardous Waste Bureau, 1993, Hazardous and Solid Waste Act Permit, WSTF Hazardous Waste Facility Permit No. NM8800019434-1, February 9, 1993

LIST OF ATTACHMENTS

ATTACHMENT 1	WSTF PLUME-FRONT REMEDIATION SYSTEM SITE LOCATION
ATTACHMENT 2	PLUME-FRONT REMEDIATION SYSTEM EXTRACTION AND INJECTION WELL PUMPING AND INJECTION RATES
ATTACHMENT 3	PLUME-FRONT REMEDIATION SYSTEM FLOW SCHEMATIC
ATTACHMENT 4	PLUME-FRONT REMEDIATION SYSTEM INSPECTION PLAN
ATTACHMENT 5	PLUME-FRONT REMEDIATION SYSTEM MAINTENANCE PLAN
ATTACHMENT 6	NASA WHITE SANDS TEST FACILITY ORGANIZATION CHART
ATTACHMENT 7	PLUME-FRONT REMEDIATION SYSTEM TRAINING PLAN

1.0 EXECUTIVE SUMMARY

During operations from the early 1960s to the early 1980s, hazardous constituents were released to the environment and, thereby, into the groundwater at the NASA White Sands Test Facility (WSTF). As a result, on December 12, 1989, the United States Environmental Protection Agency (U.S. EPA) Region 6 issued NASA an Administrative Order on Consent proceeding under §3008(h) of the Resource Conservation and Recovery Act (RCRA) for the White Sands Test Facility.

The §3008(h) Consent Order was subsequently incorporated into the Hazardous and Solid Waste Act (HWSA) Permit administered by the New Mexico Environment Department (NMED), Hazardous Waste Bureau (HWB). As a result of investigatory work performed, NASA proposed a voluntary presumptive remedy for plume-front stabilization to control threats to human health and/or the environment at the westernmost extent of the groundwater contaminant plume. The HWB approved the Plume-Front Stabilization Work Plan (PFSWP) on March 15, 2000 and the New Mexico Ground Water Quality Bureau (GWQB) approved Discharge Plan DP-1255 for discharges from the system on March 10, 2000.

The presumptive remedy is intended to control threats to human health and/or the environment at the westernmost extent of a groundwater contaminant plume, the plume-front area. The plume-front area covers an area of approximately 4,000 feet by 8,000 feet and has a depth of 700 feet. The contaminants of concern (COCs) at the plume-front include N-nitrosodimethylamine (NDMA), N-nitrodimethylamine (DMN) and several halogenated volatile organic compounds (VOCs).

The remediation system, ex-situ pump and treat design, consists of an extraction well network, injection well network, a monitoring well network, and the treatment facility. During the design, computer models were used to:

- Simulate the contaminant plumes;
- Determine the optimum extraction and injection well locations and the optimum pumping and injection rates; and
- Assist in the strategic location of monitoring wells.

The remediation system is designed to operate on a 24 hour, 365 day per year basis. Six plume-front extraction (PFE) wells with a combined pumping rate of approximately 1,075 gallons per minute will be utilized to capture and contain the groundwater contaminant plume. Contaminated groundwater from the extraction well network is pumped to the treatment facility and treated by an air stripper unit (for the VOCs) followed by an ultraviolet (UV) oxidation unit (for NDMA and DMN). The treated groundwater is then pumped to a network of four plume-front injection (PFI) wells and reinjected into the aquifer.

Contaminant treatment standards for the injected water have been developed following standards and guidelines from multiple Federal and State regulatory sources. The

effectiveness of treatment is monitored by sampling and analyses of the treatment facility influent and effluent. The overall effectiveness of remediation system is monitored by a monitoring well network of consisting of over sixty conventional and Westbay® multi-port groundwater monitoring wells. The following document provides an operation and maintenance plan for the plume-front remediation system.

2.0 SYSTEM DESCRIPTION

A site map showing the plume-front remediation system is presented in Attachment 1. The WSTF plume-front remediation system is a ex-situ pump and treat design, consisting of an extraction well network, injection well network, a monitoring well network, and the treatment facility. A general description of the remediation system follows.

2.1 Extraction Wells

Computer modeling was used to estimate the pumping rates and strategically locate the extraction wells to remove contaminant mass at the plume-front and create a hydraulic barrier to prevent further westward migration of the plume. The extraction wells, ranging in total depth from 770 to 896 feet below grade, consists of six (6) extraction wells; PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5 and PFE-7. PFE-1, -2, -4A, -5 and -7 are constructed of 9 to 10-inch-diameter (nominal) SDR 17 PVC with 0.085-inch-slot saw-cut openings. PFE-3 is constructed of 10-inch-diameter (nominal) SCH 40 carbon steel and utilizes a 0.080-inch-slot wire-wrapped screen. Each extraction well is hard-wired for incoming three-phase, 480 volt electrical service. The total combined flowrate of the extraction wellswill be approximately 1,070 gallons per minute (gpm). The specific well locations, and estimated pumping rates are presented in Attachments 1 and 2.

Extraction wells PFE-1, PFE-2, PFE-3, PFE-4A and PFE-7 specifically address the TCE and PCE contaminant plume. The five extraction wells will utilize an estimated combined flow rate of 1,050 gallons per minute (gpm).

Extraction well PFE-5, with an estimated flow rate of 26 gpm, specifically addresses NDMA/DMN plume containment. In the plume-front vicinity, the DMN plume has a similar extent to the NDMA plume but generally lower concentrations. To ensure stabilization of the NDMA/DMN plume-front, which does not extend as far west as the TCE plume, well PFE-5 is positioned to stabilize the NDMA/DMN plume-front concentrations east of the TCE target wells PFE-1, PFE-2 and PFE-7. Any NDMA/DMN mass not addressed by well PFE-5 or wells anticipated for installation in the mid-plume area is expected to be effectively captured by the high volume extraction wells to the west.

The pipeline from the extraction wells to the treatment facility (Building 650) is constructed of double-walled high-density polyethylene (HDPE) pipe with annular leak detection. The pipe was installed in straight segments between piping features (i.e., leak detection cable pull boxes, valve pits, and high point vent manways), to allow for inspection and drainage/drying in the event of inner pipe failure. In the event of a leak in

the inner pipe, the annular space between the inner and outer pipes will serve as secondary containment. Leak detection sensors are installed in the annular space allowing for the detection, localization and repair of any leaks.

The extraction pipeline is installed underground to protect against external damage, exposure to solar UV radiation, thermal expansion/contraction, and freezing. The extraction wells are contained in concrete well vaults and equipped with instrumentation to monitor the flowrate, pump operation and the static water level. HDPE access vaults are located along the pipeline at high-point vent, junctions and leak detection access locations. The concrete well vaults and HDPE access vaults are designed to prevent or the infiltration of precipitation into the vault.

2.2 Treatment Facility

The treatment equipment, housed in Building 650, consists of two, parallel tray style air strippers for VOC removal, followed by a UV oxidation unit for NDMA and DMN destruction. Building 650 is a 60-foot by 80-foot insulated metal building, with an electrical component room (containing the UV system power supply), a control room (with a PC for system monitoring/controlling), main treatment area, and restroom. It is designed to maintain a temperature compatible with the electronic components of the remediation equipment. Building 650 is plumbed into the WSTF potable water system, equipped with a septic tank and leach field, and is wired for incoming three-phase, 480 volt electrical service.

A flow schematic of the treatment facility is presented in Attachment 3. The facility is designed to operate at a range from 50% to 100% of the maximum design flow rate of about 1,240 gallons per minute. The treatment equipment consists of:

2.2.1 Scale Control Chemical Metering system (manufactured by North East Environmental Products, Inc.) Hardness values observed in plume-front monitoring wells have ranged from 173 to 613 mg/l (as $CaCO_3$). These hardness values provide a significant potential for scaling in the treatment system, pipelines, wells, and/or the injection formation. A polyphosphate scale control chemical (AquaMag® or equivalent) is metereded into the process piping, upstream of the air strippers to prevent the formation of scale in the air strippers and UV reactor.

2.2.2 Two stainless steel sieve-tray air strippers (Model # 61231 manufactured by North East Environmental Products, Inc.), operating in parallel for removal of VOC contaminants.

2.2.3 An UV oxidation unit (a Rayox® Advanced Oxidation System manufactured by Calgon Carbon Corporation) for treatment of NDMA/DMA contaminants. NDMA absorbs UV radiation most strongly in a band centered around 227 nm. The wavelength of the UV radiation emitted by the lamps is in the range 200-250

nm. Absorption of UV radiation breaks the N-N bond, producing a NO radical and a dimethylamino radical.

2.2.4 A scale cleaning system (manufactured by North East Environmental Products, Inc.) to remove scale from the air strippers. A citric acid solution will be circulated through the air strippers to remove scale.

2.2.5 A leak detection system to monitor leaks in the dual-wall piping system and treatment facility building

2.2.6 A process control system is incorporated into the overall design and operation of the remediation system. Operator access to the process control system is provided at the control room located in Building 650. The control system will interface with the process equipment controllers and monitor control variables that are critical to the operation of the facility. The control system will respond to:

2.2.6.1 Minor fluctuations in the flowrate by performing operations (such as increasing/reducing flow control valves) to correct the discrepancy.

2.2.6.2 An alarm condition by initiating autodialer alarms to notify responsible contractor personnel of the alarm condition. An alarm condition is defined as a deviation from set operating parameters that does not have an immediate impact on the overall treatment efficiency (or present a immediate hazard to personnel, the environment or equipment) but requires corrective action.

2.2.6.3 An emergency condition by initiating computer programmed emergency procedures to shutdown and secure the remediation system. An emergency condition is a deviation from set operating parameters that has an immediate impact on the overall treatment efficiency (or presents a immediate hazard to personnel, the environment or equipment) and requires an immediate shutdown of the remediation system. The control system would:

- Shutdown and isolate the extraction wells,
- Shutdown and isolate the treatment facility and process equipment,
- Isolate the injection wells, and
- Initiate autodialer alarm sequence to notify responsible contractor personnel and/or the WSTF Fire Department of the alarm condition.

2.2.6.4 Conditions that could warrant an emergency shutdown of the remediation system include but are not limited to:

- High or low extraction and injection well static water levels
- High or low extraction and injection well flowrates,

- High or low treatment facility influent flowrate,
- High or low air stripper gas and liquid flowrates,
- High or low air stripper sump level,
- High or low UV oxidation unit influent flowrate, and a failure of the UV source, and
- Leak detection system alarm.

2.3 Injection Wells and Injection Manifold

The treated groundwater exits on the west side of Building 650 and is conveyed to Building 651 (the Injection Manifold Building) via an underground, single-wall HDPE pipe. The flow is apportioned into four legs, via hydraulically-actuated globe control valves, in Building 651 and conveyed to the injection wells. The injection manifold building is hard-wired for incoming three-phase, 480 volt electrical service. A HDPE single-wall piping system will transport the groundwater from the treatment facility to injection manifold building and from the injection manifold building to the injection wells.

A computer simulation of the aquifer was used to determine the location and injection rates of the injection wells. The injection wells are designed to assist in the containment of the southern edge of the contaminant plume by creating a localized groundwater mound to locally reverse the natural groundwater flow direction and offset anticipated future drawdown effects by the city of Las Cruces. The remediation system utilizes four non-pressurized PVC injection wells, PFI-1, PFI-2, PFI-3 and PFI-4, for injection of the treated groundwater into the underlying aquifer. A drop pipe is installed in each injection well to below the pre-injection static water elevation to minimize air entrainment. The injection wells are contained in concrete well vaults and equipped with instrumentation to remotely monitor the static water level. HDPE access vaults are located along the pipeline at high-point vent locations. The well locations, injection rates, and well design parameters are presented in Attachments 1 and 2.

2.4 Monitoring Wells

The overall effectiveness of remediation system is monitored by a monitoring well network of consisting of over sixty conventional and Westbay® multi-port groundwater monitoring wells. A list of monitoring wells specifically designated for this plan and details regarding the sampling zones, sampling frequency, and analytical methods are presented in Attachment 5. The location of the wells is presented in Attachment 1.

3.0 INITIAL START-UP

The full-scale treatment system will undergo a start-up period of approximately three months. The objectives are to:

- Verify that the treatment system will treat impacted groundwater from the WSTF plume-front to specified treatment levels, and

- Determine the optimum operating conditions, develop and refine the treatment facility operating and maintenance procedures, and identify any required system refinements,
- Allow final set-up and testing of process control system and process equipment by manufacture representatives, and
- Support training of contractor environmental organization personnel by qualified manufacturer representatives.

A general description of the validation plan for initial start-up of the remediation system follows.

3.1 Failure Analysis, Functional and Integrity Tests

A flow schematic of the remediation system is presented in Attachment 3. Prior to performance of the remediation system start-up procedures, the following will be performed:

- Pump tests will be performed to confirm the pumping capacity of the extraction wells,
- The groundwater from the extraction wells will be sampled and analyzed to determine the contaminant concentration at each well location,
- Pressure leak tests will be performed to verify the integrity of the piping system,
- All electrical and mechanical components, motors, switches, sensors, meters, pumps, valves, etc., will be functionally tested,
- Tests will be performed to verify the operation of all communication, alarm, leak detection and monitoring equipment prior to system operation, and
- A failure modes and effects analysis (FMEA) report per White Sands Test Facility Standard Instruction WSI 04-SW-0002, "Hazard Recognition and Control" will be performed to address all single component failure modes, the effects of those failures on system operation or safety, and provide the recommended corrective actions.

3.2 Test Approach

The process control system and process equipment manufacturers will inspect the installation, and support the initial start-up and adjustment of the remediation system. The anticipated PCE, TCE, NDMA, DMN, Freon 11, Freon 21, and Freon 113 influent concentrations are listed in Table 3.1. Contaminant treatment standards for the injected water have been established in the approved Plume-Front Stabilization Work Plan (PFSWP) and Discharge Plan DP-1255.

TABLE 3.1 – CONTAMINANT DATA – (from PFSWP)

Contaminant of Concern	Predicted Influent Concentration	Treatment Level[1]	Specified EPA Analytical Method[1]
NDMA	2,000 ppt	10 ppt	607M
DMN	1,777 ppt	10 ppt	607M
PCE	4.2 ppb	5 ppb	8021
TCE	130 ppb	5 ppb	8021
Freon 11	860 ppb	100 ppb	8260
Freon 21	60 ppb	20 ppb	8260
Freon 113	2,000 ppb	1,200 ppb	8260

1 Specified by the Plume-Front Stabilization Work Plan
2 ppt - parts per trillion
3 ppb - parts per billion

The design flow rate of the treatment system is approximately 1240 gpm (the estimated combined pumping rate of the extraction wells). The validation tests will be performed in two phases. During the first phase, the treatment system will be evaluated at a reduced flow rate (approximately 620 gpm), roughly equal to one-half of the total design flow rate for the system. During this phase of testing, each of the air stripper units will be isolated and operated independently, and the UV oxidation unit will be operated at approximately one-half of system design flow. This will ensure proper operation and allow for evaluation of contaminant removal efficiency. The second phase will involve tests to evaluate operation and contaminant destruction efficiency of the treatment facility at the design flow rate.

The treatment efficiency will be monitored by sampling/analyzing the untreated and treated groundwater for the list of groundwater contaminants as presented in Table 3.1. Influent samples will be collected from the manifolded water stream from the extraction wells before it enters the treatment system. Effluent samples will be taken from the discharge stream leaving the treatment system enroute to the start-up holding tank. The specific locations of the influent and effluent sample valves are presented in the flow schematic provided in Attachment 3. The procedures for collection and analysis of the samples are provided in Section 6.0.

The two air strippers and UV oxidation unit will be operated per the procedures and recommendations of the manufacturer. During testing, critical operating parameters such as flow rate, temperature, and pressure will be monitored by the control system. The operating procedures, critical operating parameters and the recommended monitoring frequency will be available from the manufacturer. Procedures for the operation and maintenance of both unit operations will be further developed and refined during the validation tests.

CH2M Hill (the designer of the process control system) and the equipment manufacturers will provide oversight, training and support during the performance of the tests. It is anticipated that approximately three months will be required to complete the system validation and training. Each phase of testing will be repeated as required to ensure that the test objectives are achieved. A summarized test matrix is presented in Table 3.2, and a general description of the two phases follows.

TABLE 3.2 – VALIDATION PLAN TEST MATRIX

PHASE I- REDUCED FLOW RATE TESTS								
TEST	EXTRAC-TION WELLS	APPROX. FLOW RATE (gallons per minute)	AIR STRIPPER 1	AIR STRIPPER 2	UV OXIDIZER UNIT	APPROX. TEST DURATION (hours)	SAMPLING FREQ. (minutes)	TREATED EFFLUENT (gallons)
1	PFE-1 PFE-2 PFE-3 PFE-4A PFE-5 PFE-7	620	ON	OFF	ON	4	0, 30, 60, 90, 120, 180, 240	108,000
2	PFE-1 PFE-2 PFE-3 PFE-4A PFE-5 PFE-7	620	OFF	ON	ON	4	0, 30, 60, 90, 120, 180, 240	108,000
PHASE II – DESIGN FLOW RATE TESTS								
TEST	EXTRAC-TION WELLS	APPROX. FLOW RATE (gallons per minute)	AIR STRIPPER 1	AIR STRIPPER 2	UV OXIDIZER UNIT	APPROX. TEST DURATION (hours)	SAMPLIN G FREQ. (minutes)	TREATED EFFLUENT (gallons)
1	PFE-1 PFE-2 PFE-3 PFE-4A PFE-5 PFE-7	1240	ON	ON	ON	4	0, 30, 60, 90, 120, 180, 240	225,000

NOTE: Actual flow rates subject to change pending actual production rate of the extraction wells.

3.3 Phase One – Reduced Flow Rate Tests

The objective of the first test is to evaluate system operation and contaminant removal efficiency at a reduced flow rate of approximately 620 gpm. During the first test Air Stripper 1 will be operated and Air Stripper 2 will be shut off from the water flow.

The planned test duration will be four hours. Approximately 108,000 gallons of groundwater will be treated to the specified treatment levels presented in Table 3.1. Treated effluent will be collected in a 250,000 gallon holding tank pending the receipt of

laboratory analytical results. Effluent meeting the treatment standards will be pumped to the injection wells. Effluent not meeting the treatment standards will be either recycled through the treatment system and resampled, or discharged to the 200 Area Hazardous Waste Evaporation Tanks.

Influent and effluent samples will be collected upon system startup, then in thirty minute increments for analyses for the contaminants listed in Table 3.1 for the first two hours of the test, then at one hour intervals until the test is completed. If required, refinements to the sampling frequency and operating procedures will be incorporated. At this time, testing will be halted until the laboratory analytical results are received. This test will be repeated if the laboratory analytical results do not meet the treatment standards for all of the contaminants listed in Table 3.1.

Test two will then be performed with Air Stripper 1 shut off from the water flow and Air Stripper 2 in operation. The procedure used to conduct this test will be identical to the first test.

3.4 Phase Two – Design Flow Rate Tests

The objective of this test is to evaluate system operation and the contaminant removal efficiency achieved at the design flow rate of approximately 1,300 gpm, simulating full-scale operation of the remediation system. All extraction wells (PFE-1 through PFE-5) will be pumped at the nominal design capacity for the test. The test will involve the operation of both air strippers and the UV oxidation unit.

The planned test duration will be 4 hours. Approximately 225,000 gallons of groundwater will be treated to the specified treatment levels presented in the PFSWP. Treated effluent will be collected in the holding tank pending the receipt of laboratory analytical results. Effluent meeting the treatment standards will be pumped to the injection wells. Effluent not meeting the treatment standards will be either recycled through the treatment system or discharged to the 200 Area Hazardous Waste Evaporation Tanks.

Influent and effluent samples will be collected upon system startup, then in thirty minute increments for analyses for the contaminants listed in Table 3.1 for the first two hours of the test, then at one hour intervals until the test is completed. If required, refinements to the design, sampling frequency, and operating procedures will be incorporated. This test will be repeated if the treatment standards for all of the contaminants listed in Table 1 are not achieved.

The maximum PCE, TCE, NDMA, DMN, Freon 11, Freon 21, and Freon 113 influent concentrations expected during operation of the system were presented in Table 4.7 of the Plume-Front Stabilization Work Plan (NASA, 1999). These maximum predicted influent contaminant concentrations are listed in Table 3.1.

4.0 OPERATION

The operation and maintenance of the plume-front remediation system is the responsibility of the contractor environmental organization. All activities will be directed and performed by trained and qualified personnel. A description of the job titles, levels of authority, training and qualifications is provided in Section 9.0, Project Management, Training and Reporting. A description of the operation of the plume-front remediation system follows.

4.1 Security and Access

Access to the WSTF site is controlled by a security force that is on duty on a 24-hour, 365 day per year basis. Security guards control access to the industrial complex and also patrol the plume-front area at least every 8 hours during non-working hours. Specific details are outlined in Section 4.6 of the Plume-Front Stabilization Work Plan.

In addition to the WSTF site security, the extraction wells, injection wells and monitoring wells are secured by protective, locking well caps or vaults. Due to the nature of their design, the extraction wellheads are sealed to prevent the loss of untreated groundwater. This design also prevents the accidental or intentional introduction of foreign materials into these wells. The protective wells caps or vaults are locked at all times except during inspections, sampling, and maintenance operations.

The treatment facility and injection manifold building are each surrounded by seven-foot high chain link fences. The treatment facility and manifold building and all security fence gates shall remain locked at all times except during inspections, sampling and maintenance operations.

Access to all components of the plume-front remediation facility is controlled by the contractor environmental organization. Access to the monitoring wells is controlled by either the contractor environmental organization sampling coordinator or project lead engineer. Access to the extraction wells, injection wells, manifold building (Bldg. 651) and treatment facility building (Bldg. 650) will controlled by the project lead engineer.

4.2 Start-Up and Operation

Written procedures will provide detailed instructions for start-up and operation of the remediation system, identify the system configuration, and operating parameters, and identify task-specific safety requirements. The completion of all start-up procedures will be documented in a start-up check list and maintained by the contractor environmental organization as part of the facility operating record. The check list will identify the procedures performed, the personnel who performed the procedures and the date.

All process equipment and system components will be operated according to the manufacturer's procedures and recommendations. The plume-front remediation system is designed to operate over a range of flowrates from 50% to 100% of the design flowrate

(1240 gpm). Prior to operation, the manual valves at the extraction wells, piping system junctions, high-point vents, treatment facility, process equipment, injection manifold building and injection wells will be checked or setup to ensure the correct configuration of the piping system and process equipment.

The process control system interfaces with the process logic controllers of the process equipment and controls the overall operation of the remediation system. Prior to operation, the process equipment controllers will be configured per the equipment manufacturer's instructions. The process control system will be brought on-line and set-points for operation of the remediation facility checked or set and process control software validated. System inspections will be performed to ensure that the air strippers, UV oxidation unit and the other process equipment are mechanically setup for operation.

The air strippers (stripper trays, sump, transfer pump, etc.) and the UV oxidation unit are inspected to ensure the system is filled or primed with clean or treated water. A computer programmed sequence will then be initiated from the control room located in Building 650 to start the facility operation. With the UV unit filled with water, the UV lamp ignition sequence will be started and the UV lamps allowed warm-up. During the warm-up period, the effluent from the treatment facility is recirculated.

The air stripper blowers are then started and the electronic control valves at the extraction wells, treatment facility and injection manifold building opened. The sequence is then initiated to start the extraction well pumps and scale control system. The remediation system is now on-line.

Routine shutdown and emergency shutdown procedures are incorporated into the process control system. As discussed in Section 2.0, the process control system includes several interlocks that will halt system operation when specific conditions arise, such as leakage within the dual-wall extraction piping, unacceptably high water levels within injection wells, catastrophic failure of any major component (air stripper blower motor, injection pumps, extraction pumps, UV system), and any significant leakage from any piping or component within the treatment building facility. This allows operation 24-hours/day, 7-days/week with little to no human operator involvement. In the event of a shutdown, the process control system will initiate an autodialer alarm sequence to notify responsible contractor personnel. The emergency shutdown procedures can be initiated either automatically by a system alarm or manually at the control center located in Building 650.

Periodic inspection and sampling and analyses are the only activities required by personnel during operation of the facility. A discussion of the remediation system inspections and sampling and analyses is provided in Sections 5.0 and 6.0.

5.0 INSPECTION

All process equipment and system components will be operated and maintained per the manufacturer's instructions and recommendations. To assure proper operation, the

piping system, leak detection system, treatment facility, injection manifold, extraction and injection wells, system alarms, and communications will be periodically inspected or tested according to the inspection plan presented in Attachment 4, Tables 5.1 through 5.4.

All inspections of the plume-front remediation system will be documented in inspection records and maintained by the contractor environmental organization as part of the facility operating record for a minimum of three years. The inspection records will include: the personnel who performed the inspection, the items that were inspected, and condition of the item. Unsatisfactory conditions or discrepancies will be documented in a discrepancy record and the discrepancy record identification number referenced in the inspection record. The discrepancy record will describe the discrepancy, the steps or actions to correct the problem and document completion. The discrepancy records will be maintained by the contractor environmental organization as part to the facility operating record for a minimum of three years.

6.0 SAMPLING AND ANALYSIS

Details of the Sampling and Analysis Plan have been provided in Section 5.0 of the Plume-Front Stabilization Work Plan and Discharge Plan DP-1255. The Plan provides personnel with project-specific procedures for the collection and analysis of samples associated with plume-front containment activities and will be used in conjunction with the most recent revision of the WSTF Groundwater Sampling and Analysis Plan (SAP) and the WSTF Quality Assurance Project Plan (QAPP).

7.0 MAINTENANCE

All remediation system process equipment and system components will be maintained per the manufacturer's instructions and recommendations. The operation of the remediation system will be evaluated at least on a monthly basis. Sampling and analyses of the monitoring wells, treatment facility influent and effluent will be reviewed along with the operating parameters and the inspection records to evaluate the overall operation of the remediation system and to note any trends or indications of component failure or deterioration of performance. In addition to the inspection and testing performed per Section 5.0, the process equipment will be periodically inspected, tested and serviced according to the maintenance plan presented in Attachment 5, Table 7.1

All maintenance activities will be performed by the equipment manufacturer's service representatives or trained and qualified contractor personnel. A description of the job titles, levels of authority, training and qualifications is provided in Section 9.0, Project Management, Training and Reporting. Written procedures will provide detailed step-by-step instructions, identify the task-specific safety requirements, and document completion of maintenance activities. The documentation will identify the maintenance steps/actions performed, the personnel involved, and the date. All maintenance records will be maintained as part of the facility operating record.

8.0 WASTE MANAGEMENT

All waste generated from the remediation system will be managed per the WSTF Hazardous Waste Facility Permit No. NM8800019434-1 and WSTF waste management procedures. The waste streams include, but are not limited to:

- Groundwater containing ppb concentrations of WSTF groundwater contaminants generated during testing, sampling and routine equipment maintenance operations,
- Contaminated site water (potable water) generated during routine facility rinsing and cleaning operations with detergents or inorganic cleaners,
- Acid-based descaling solution containing a 5% to 50% solution of a citric acid generated during routine maintenance of the air strippers,
- Spent mercury UV lamps generated during routine maintenance of UV oxidation unit, and
- Contaminated Debris/Softgoods contaminated with groundwater contaminants, detergents, grease, oil, solvents generated during routine facility operation.

The remediation system design incorporates various structures, procedures and equipment to prevent the release of hazardous constituents to the environment. All elements of the remediation system that contain or transport untreated groundwater have secondary containment and leak detection. Bldg. 650 is designed with an elevated curb to contain any potential leaks or spills during equipment maintenance and chemical transfer operations. All above ground piping, components and equipment are inspected for evidence of leaks or corrosion. The air stripper sumps and large process tanks are equipped with automatic shut-off controls. All tanks and containers are inspected for leaks and adequate headspace.

The injection of the treated groundwater has been authorized by the NMED Ground Water Quality Bureau (GWQB) per Discharge Permit No. DP-1255. Accumulation, run-on and run-off are not anticipated to be a concern. The treatment building that houses the treatment equipment will be located away from existing surface drainage features. The Building 650 and 651 sites are graded to route roof drainage and precipitation run-on away from the buildings. Other elements of the remediation system (subgrade piping system, extraction and injection wells, etc.) are inspected per Section 5.0 for evidence of erosion or silting due to precipitation.

9.0 PROJECT MANAGEMENT, TRAINING AND REPORTING

9.1 Project Management

The NASA Environmental Program Manager directs all activities associated with WSTF environmental compliance and the plume-front remediation project. The site contractor environmental organization, under the direction of the NASA Environmental Program Manager, performs and/or coordinates all activities associated with the project. An

organizational chart for NASA WSTF environmental activities is presented in Attachment 6.

9.2 Training

The overall operation and maintenance of the Plume-Front Remediation System is the responsibility of the contractor environmental organization. The contractor environmental organization project lead engineer and designated contractor environment organization engineer(s) will receive "on-the-job" training by manufacturer representatives during the three month remediation system start-up period as described in Section 3.0. The training plan presented in Attachment 7, Table 9.1 has been developed to assure that personnel receive adequate training with respect to their job responsibilities. The training can include proficiency demonstrations, class room instruction, on-the-job training, or a series of instructions by off-site personnel or qualified contractor environmental organization personnel.

9.3 Reporting

Progress and subsequent data reporting will be accomplished through use of the monthly RFI/CMS reports to EPA/NMED. The format of the current reports will be modified to accommodate reporting of activities and data directly applicable to plume-front containment. These reports will at a minimum provide: significant project accomplishments; activity updates; monitoring data; and significant problems and corrective actions taken. NASA will initiate use of these reports as soon as plume-front remediation activities are initiated. If revisions to the format are required, revisions to the format can be implemented which are amenable to both NMED and NASA.

10.0 CONTINGENCY PLAN

NASA will utilize the Contingency Plan presented in the Hazardous Waste Operating Permit for WSTF. In addition to the elements contained in the Contingency Plan, the plume-front stabilization and groundwater treatment system design will incorporate several interlocks that will halt system operation when specific conditions arise. These conditions include:

- leakage within the dual-wall extraction piping;
- near-surface water levels within injection well(s);
- catastrophic failure of any major component (i.e., air stripper blower motor, injection pump, extraction pumps, UV system); and
- significant leakage from any piping or component within the treatment building facility.

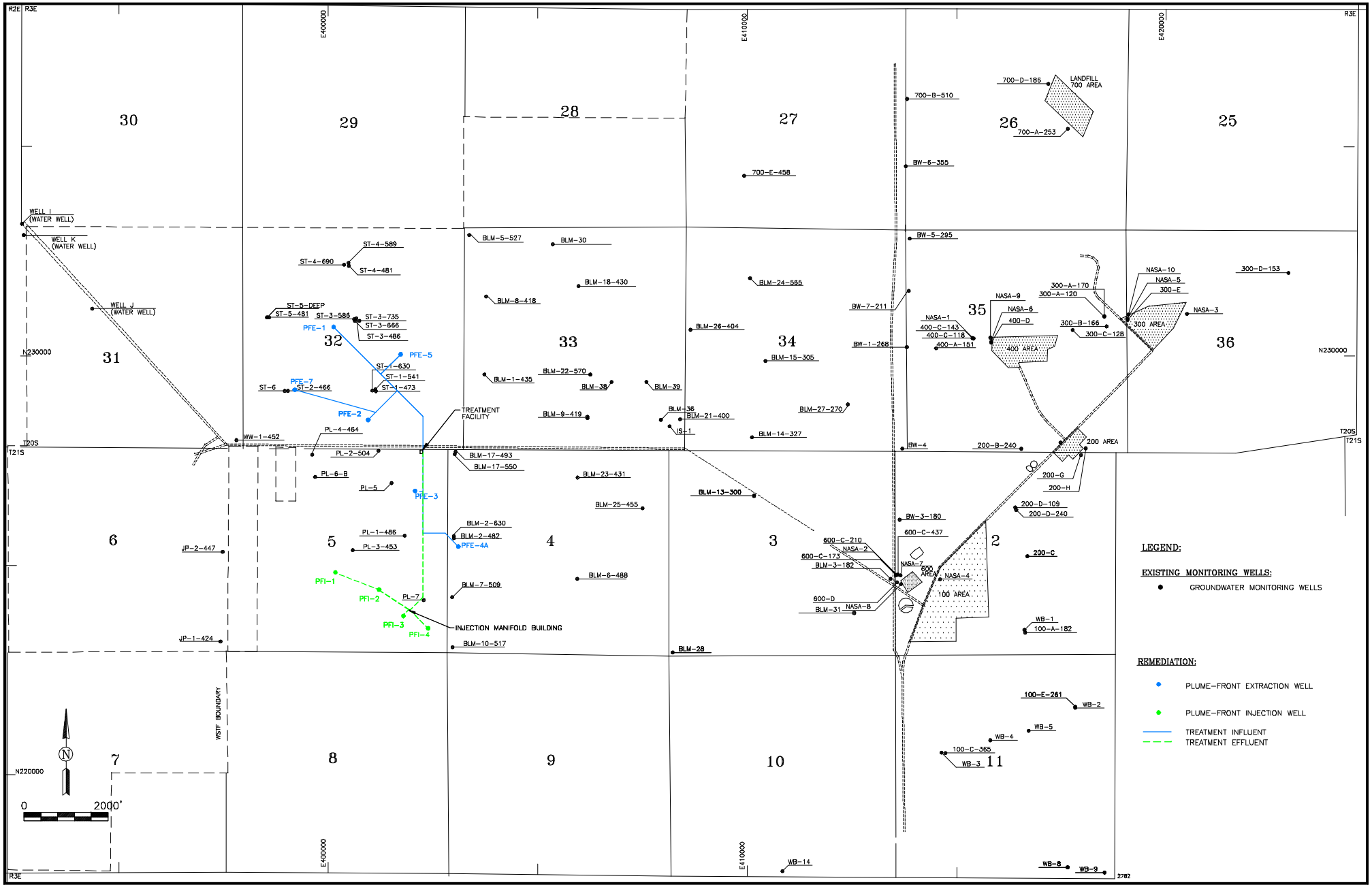
In the event of a significant component failure that results in a system shut-down of more than 24 hours, NASA will notify the NMED verbally within 24 hours and in writing within 72 hours of the event. The written notification will summarize system status,

cause of shut-down, response taken and/or planned, expected duration of the shut-down, and any potential impacts on human health and the environment.

ATTACHMENT 1

WSTF PLUME-FRONT REMEDIATION SYSTEM

SITE LOCATION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E400000
E410000
E420000
30
29
28
27
26
25
LANDFILL
700 AREA
700-D-186
700-B-510
700-A-253
700-E-458
BW-6-355
WELL I
(WATER WELL)
WELL K
(WATER WELL)
WELL J
(WATER WELL)
BW-5-295
BLM-5-527
BLM-30
ST-4-589
ST-4-690
ST-4-481
BLM-18-430
BLM-24-555
BLM-8-418
ST-5-DEEP
ST-5-481
ST-3-588
ST-3-735
ST-3-566
ST-3-485
PFE-1
BW-7-211
NASA-9
NASA-6
400-D
NASA-1
400-C-143
400-C-118
400-A-151
35
400 AREA
300-A-170
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300-B-166
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300-E
NASA-3
300-D-153
BLM-26-404
BW-1-268
BLM-15-305
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BLM-38
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PFE-2
TREATMENT
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BLM-36
BLM-21-400
IS-1
BLM-27-270
BLM-14-327
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T21S
WW-1-452
PL-4-454
PL-2-504
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PFI-2
PFI-3
PFI-4
PL-7
BLM-7-509
BLM-6-488
600-D
BLM-31
NASA-8
WB-1
100-A-182
INJECTION MANIFOLD BUILDING
JP-1-424
BLM-10-517
BLM-28
WSTF BOUNDARY
100-E-261
WB-2
WB-5
WB-4
100-C-365
WB-3
11
7
8
9
10
N220000
0
2000'
WB-14
WB-8
WB-9
2782
LEGEND:
EXISTING MONITORING WELLS:
GROUNDWATER MONITORING WELLS
REMEDIATION:
PLUME-FRONT EXTRACTION WELL
PLUME-FRONT INJECTION WELL
TREATMENT INFLUENT
TREATMENT EFFLUENT

ATTACHMENT 2

PLUME-FRONT REMEDIATION SYSTEM

EXTRACTION AND INJECTION WELL

PUMPING AND INJECTION RATES

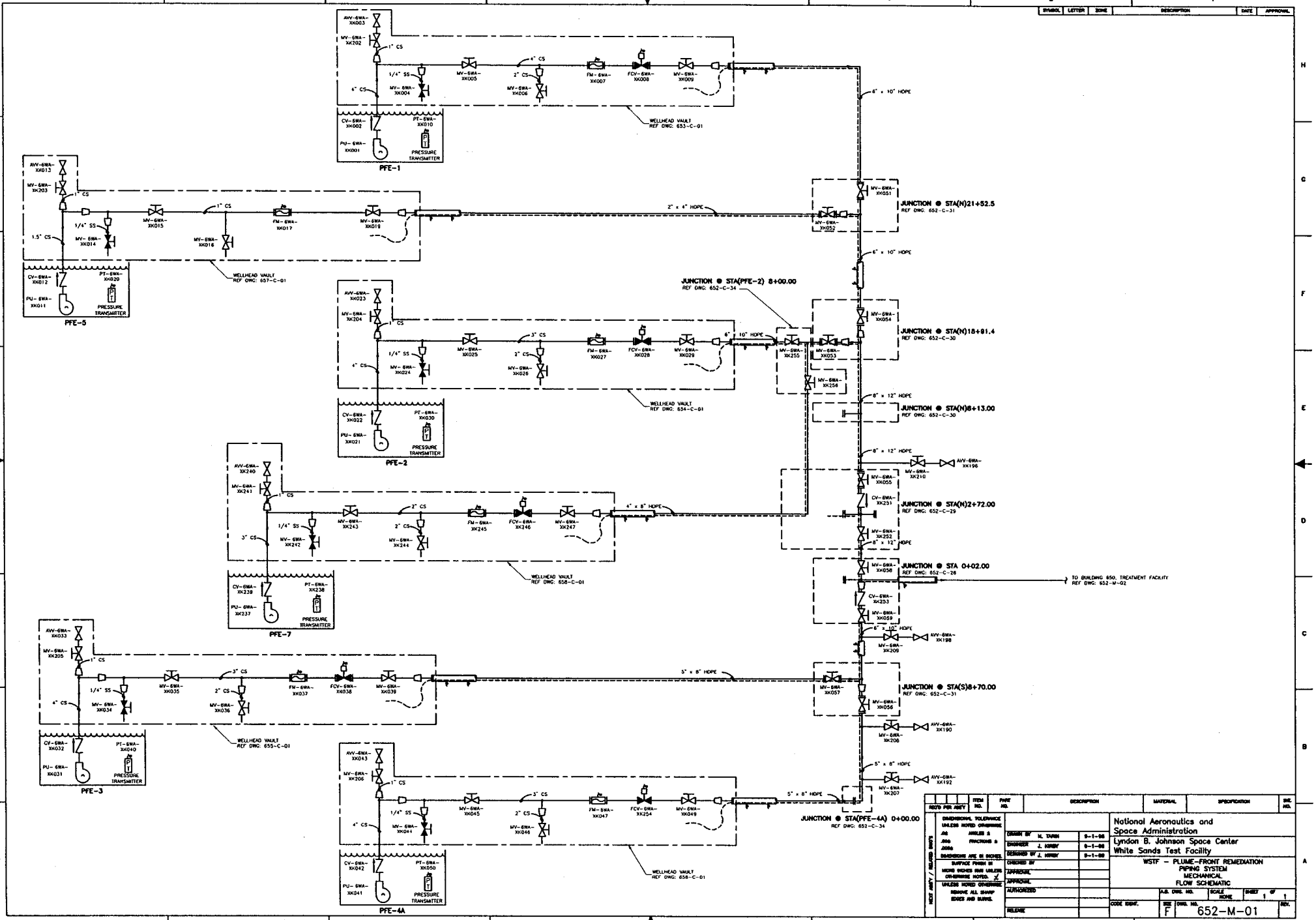
Table 2.1 – Anticipated Extraction Well, Pumping Rates		
Well #	**Nominal Pumping Rate (gpm)**	**Max. Pumping Rate (gpm**
PFE-1	288	331
PFE-2	224	258
PFE-3	213	245
PFE-4A	200	230
PFE-5	26	30
PFE-7	125	144

Table 2.2 – Anticipated Injection Well, Injection Rates		
Well #	**Nominal Injection Rate (gpm)**	**Max. Injection Rate (gpm)**
PFI-1	269	330
PFI-2	269	329
PFI-3	344	422
PFI-4	194	237

ATTACHMENT 3

PLUME-FRONT REMEDIATION SYSTEM

FLOW SCHEMATIC



SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	DWG. NO.

NOTES ARE / RELATED DWGS

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE:
.XX ANGLES ±
.XXX FRACTIONS ±
.XXXX
DIMENSIONS ARE IN INCHES
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

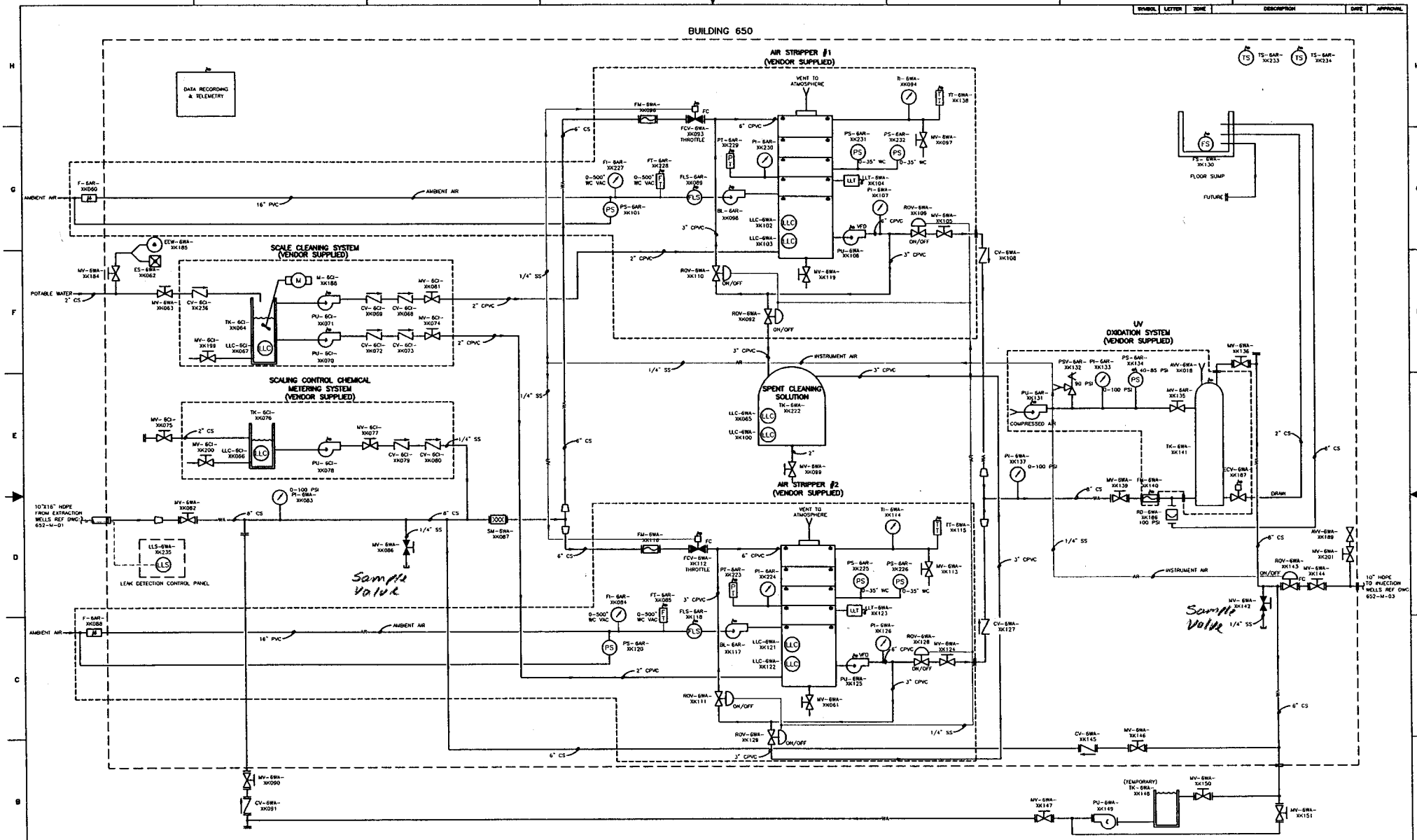
DRAWN BY	M. TARIN	9-1-98
ENGINEER	J. KIRBY	9-1-98
DESIGNED BY	J. KIRBY	9-1-98
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
PIPING SYSTEM
MECHANICAL
FLOW SCHEMATIC

A.S. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-M-01 | REV.



ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	DWG NO.

UNLESS NOTED OTHERWISE
DIMENSIONAL TOLERANCE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES
SURFACE FINISH IN
MICRO INCHES AMS UNLESS
OTHERWISE NOTED.
UNLESS NOTED OTHERWISE
REMOVE ALL SHARP
EDGES AND BURRS.

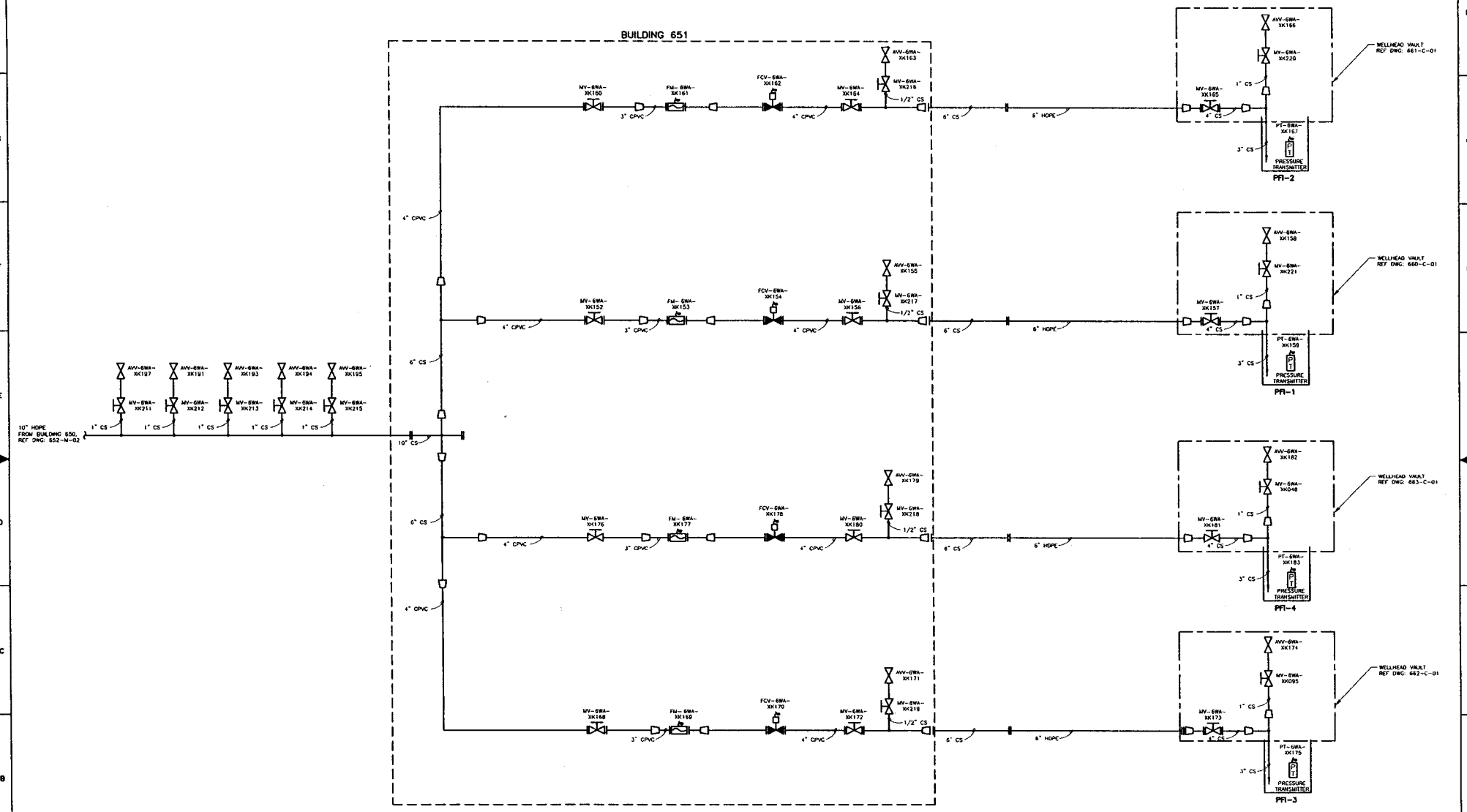
DRAWN BY	M. TARIN	9-1-99
ENGINEER	J. KIRBY	9-1-99
DESIGNED BY	J. KIRBY	9-1-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and
Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
PIPING SYSTEM
MECHANICAL
FLOW SCHEMATIC

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-M-02 | REV.



NOTES:

1. ALL CPVC PIPE SHALL BE SCH 80.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	DWG. NO.

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE: .XX ANGLES ± .XXX FRACTIONS ± .XXXX
DIMENSIONS ARE IN INCHES
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TAHIN	9-1-98
ENGINEER	J. NEELY	9-1-98
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION PIPING SYSTEM MECHANICAL FLOW SCHEMATIC

A.S. DWG. NO.	SCALE	SHEET
	NONE	1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-M-03 | REV.

ATTACHMENT 4

PLUME-FRONT REMEDIATION SYSTEM

INSPECTION PLAN

Table 5.1- Treatment Facility Inspections (Bldg. 650)		
Item	**Frequency**	**Description**
Process Control System – Status	Daily	Check the operating status of the process control system. Validate the status of all system indicator lights and alarms for the extraction wells, injection wells, treatment facility and leak detection system..
Process Control System – Air Stripper Operating Parameters	Daily	Operating parameters for the air strippers (flowrates, temperature, pressure, etc.) shall be within the normal operating range. The scale control system shall be operational and the scale control chemical flowrate within the normal operating range.
Process Control System – UV Unit Operating Parameters	Daily	Ensure that the selected UV lamps are operational. The amperage and voltage draw for each UV lamp shall be within the normal operating range. The UV unit operating parameters (flowrate, temperature, etc.) shall be within the normal operating range. The equipment and instrument air pressure shall be within the normal operating range.
Process Control System – Extraction Well Operating Parameters	Daily	The flowrates and static water levels for the extraction wells shall be within the normal operating range.
Process Control System – Injection Well Operating Parameters	Daily	The flowrates and static water levels for the injection wells shall be within the precribed operating ranges.
Access Road	Weekly	The access road shall be free of obstructions or deterioration which may cause delays or hamper the movement of vehicles or equipment.
Erosion and Run-On	Weekly	The fenced area and the surrounding area the shall be free evidence of excessive erosion or run-on due to precipitation.
Fence and Gates	Weekly	The fence, gates and doors will be in good general condition with no evidence of unauthorized entry, secured, locked and free of obstructions.
Signs	Weekly	The restricted access and other warning signs for Bldg. 650 and the fenced area surrounding Bldg. 650 shall be present and legible.
Housekeeping	Weekly	The fenced area surrounding Bldg. 650 shall be free of trash and debris. Bldg. 650 shall be free of accumulated liquids, trash and debris.
Process Equipment and Above Ground Piping	Weekly	The process equipment, process tanks, process components and the above ground piping (piping, valves, flanges, etc.) shall be free of evidence of leaks or deterioration.
Process Tank - Levels	Weekly	The process tank levels (scale control system, scale cleaning chemical tank, spent cleaning solution tank) shall be adequate for facility operation. All process tanks or containers shall maintain adequate headspace.
Heating, Cooling and Ventilation	Weekly	Ensure Bldg. 650 heating, cooling and ventilation is operational. The building temperature shall be maintained within the recommend equipment operating temperatures.
Safety Equipment	Weekly	The shower and eye wash and other safety equipment shall be tested and operational.
Communications	Weekly	The phone at the treatment facility (Bldg. 650) shall be operational.
Lighting	Weekly	The Bldg. 650 lighting shall be adequate and operational.
Alarm System - Operation	Monthly	The process control system alarms, autodialers, etc. shall be functionally tested and operational. The alarms, interlocks and emergency shutdown systems for the treatment facility (air strippers, UV unit, leak detection system, etc.) extraction wells and injection wells shall be tested and operational.
Alarm System – Autodialer	Monthly	The process control system alarms, autodialers, etc. shall be functionally tested and operational.

Table 5.2 – Injection Manifold Inspections (Bldg. 651)		
Item	**Frequency**	**Description**
Access Road	Weekly	The access road shall be free of obstructions or deterioration which may cause delays or hamper the movement of vehicles or equipment.
Erosion and Run-On	Weekly	The fenced area and the surrounding area the shall be free evidence of excessive erosion or run-on due to precipitation.
Fence and Gates	Weekly	The fence, gates and doors will be in good general condition with no evidence of unauthorized entry, secured, locked and free of obstructions.
Signs	Weekly	The restricted access and other warning signs for Bldg. 651 and the fenced area surrounding Bldg. 651 shall be present and legible.
Housekeeping	Weekly	The fenced area surrounding Bldg. 651 shall be free from trash and debris. Bldg. 651 shall be free of accumulated liquids, trash and debris.
Process Equipment and Above Ground Piping	Weekly	The above ground piping (piping, valves, flanges, etc.) shall be free of evidence of leaks or deterioration.
Lighting	Weekly	The Bldg. 651 lighting shall be adequate and operational.

Table 5.3 – Extraction and Injection Well Inspections		
Item	**Frequency**	**Description**
Access Roads	Weekly	The access roads shall be free of obstructions or deterioration which may cause delays or hamper the movement of vehicles or equipment.
Well Vaults	Weekly	The well vaults and access doors shall be in good general condition with no evidence of unauthorized entry, secured, locked and checked for obstructions.
Fence	Weekly	The bollards and/or fence surrounding the well vault shall be in good general condition with no evidence of damage.
Signs	Weekly	The restricted access and other warning signs shall be present and legible.
Housekeeping	Weekly	The general area surrounding the well vaults shall be free from trash and debris.
Erosion and Run-on	Weekly	The general area surrounding the well vaults will be free of excessive erosion or silting due to run-on from precipitation.

Table 5.4 – Subgrade Piping Inspections		
Item	**Frequency**	**Description**
Assess Roads	Monthly	The access roads along the piping route shall be free of obstructions or deterioration which may cause delays or hamper the movement of vehicles or equipment.
Subgrade Piping – Erosion	Monthly	The pipeline route shall be inspected to look for evidence of excessive erosion.
Vaults – Erosion and Run-On	Monthly	The general area surrounding the junction and access vaults shall be free of evidence of excessive erosion or silting due to run-on from precipitation.
Vaults - Closures	Monthly	The junction and access vault ports or closures shall be in good general condition with no evidence of unauthorized entry, secured, locked and checked for obstructions.
Vaults – Bollards/Fence	Monthly	The bollards or fence surrounding the junction and access vaults shall be in good general condition with no evidence of damage.
Vaults - Signs	Monthly	The restricted access and other warning signs for the junction and access vaults shall be present and legible.
Vaults - Housekeeping	Monthly	The area surrounding the junction and access vaults shall be free from trash and debris.

ATTACHMENT 5

PLUME-FRONT REMEDIATION SYSTEM

MAINTENANCE PLAN

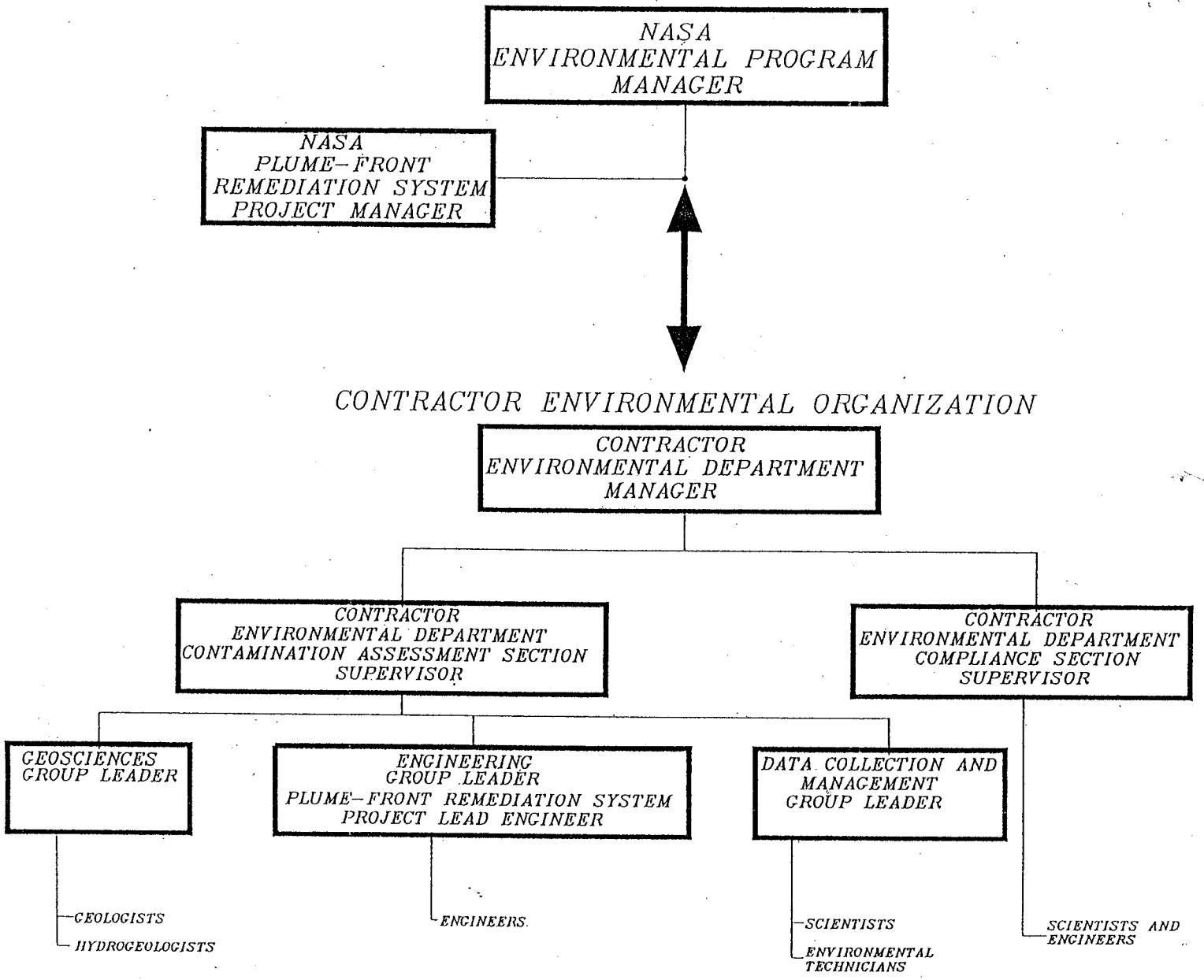
Table 7.1 – Plume-Front Remediation System Maintenance Plan		
Item	**Frequency**	**Description**
Equipment and Instrument Air	Monthly	The equipment and instrument air system will be inspected and serviced. Accumulated water will be drained from the air compressor tank and compressed air lines. The air/water separator and the supply of lubricant in the compressor and oil lubricator will be checked. Inspection record reviewed to ensure that the air pressure is within the normal operating range.
Air Stripper – Air Filters	Monthly	The air filters for the air strippers will be inspected and serviced or replaced.
Air Stripper – Stripper Trays	Monthly	The air stripper trays and spray nozzles will be inspected for excessive scale deposits that could adversely affect the system performance. If required, a citric acid solution will be circulated through the stripper to remove scale deposits.
Air Stripper - Sump	3,000 hours	The air stripper sumps will be inspected for sludge or solid material and if required, cleaned and flushed.
UV Unit – Transmittance Controllers	Monthly	The UV unit transmittance controllers will be inspected to ensure that air solenoids are operating properly and wipers transverse the entire surface of the quartz tube that houses the UV lamps and that there are no unusual vibrations or sounds. If defective, the solenoids and tube wipers will be removed and replaced.
UV Unit – Interlocks	Monthly	The UV unit emergency stop and system interlocks will be tested and operational.
UV Unit – Lamp Enclosure	Monthly	The UV lamp enclosures will be inspected for leaks. If defective, the enclosure seals will be removed and replaced.
UV Unit – Moisture Sensor	Monthly	The UV unit moisture sensors will be inspected, and verified to be in good condition and operational. If defective, the moisture sensors will be removed and replaced.
UV Unit – Quartz Tubes	Monthly	The tube seals will be inspected for burns or leaks and replaced as required. The inner and outer surfaces of the quartz tubes will be inspected for damage or fouling. If fouled, the tubes will be removed and cleaned with an acid wash or replaced.
UV Unit – UV Lamps	3,000 hours	The UV lamps will be removed and replaced approximately every 3000 hours of operation.
UV Unit – UV Tower	3,000 hours	The UV tower will be inspected for sludge or solid material and if required, cleaned and flushed. The inner and outer surfaces of the quartz tubes will be inspected for damage or fouling. If fouled, the tubes will be removed and cleaned with an acid wash or replaced.
Relief Valves	5 years	The set pressure for relief valves will be tested every 5 years.
Instrumentation (flowmeters, liquid level transmitters, pressure transducers, etc.)	2 years	Instrumentation (gauges, transducers, switches, etc.) will be calibrated to the manufacturer's specifications every 2 years or per the instrument manufacturer's recommended schedule.
Extraction Wells and Injection Wells	Case-by case basis	The performance of the extraction and injection wells (extraction and injection rates, water levels, etc.) will be reviewed on a monthly basis. Extraction well maintenance (surging, bailing, pump repair and replacement, etc.) and injection well maintenance (surging, bailing, acidifying, etc.) will be performed on a case-by-case basis.

ATTACHMENT 6

NASA WHITE SANDS TEST FACILITY

ORGANIZATIONAL CHART

NASA WHITE SANDS TEST FACILITY
ENVIRONMENTAL COMPLIANCE ORGANIZATIONAL CHART



ATTACHMENT 7

PLUME-FRONT REMEDIATION SYSTEM

TRAINING PLAN

Table 9.1 – Plume –Front Remediation System Training Plan		
Job Title	**Requirement**	**Training Description**
Hazardous Waste Technician	All WSTF personnel directing or involved in the operation, maintenance and repair of the plume-front remediation system (including inspection, sampling, operation and maintenance) where the potential for exposure to hazardous waste, hazardous waste constituents, or contaminated groundwater exists	Chemical safety, health hazards and hazard communication (29 CFR, Part 1910), Relevant state and federal environmental regulations, WSTF environmental procedures, WSTF contingency plan, WSTF permitted units, Hazardous waste container handling and shipment, WSTF waste analysis plan
Groundwater Treatment Facility Technician	All contractor environmental organization technicians involved in plume-front remediation system operation, maintenance, inspection and sampling activities (excluding monitoring well sampling).	Qualification as a Hazardous Waste Technician, confined space training, personnel protective equipment training, air monitoring training, lockout/tagout training. Familiarity with the general remediation system design, process equipment, sampling, inspection, operation and maintenance procedures, and safety requirements.
Groundwater Treatment Facility Operator	Contractor environmental organization scientists or engineers performing or directing plume-front remediation system operation, maintenance, inspection and sampling activities (excluding monitoring well sampling)	Confined space training, personnel protective equipment training, air monitoring training, lockout/tagout training. Demonstrated proficiency with the remediation system design, process equipment, sampling, inspection, operation, maintenance, routine and emergency shut-down procedures, safety requirements and communication and alarm systems.
Project Lead Engineer	Contractor environmental organization scientist or engineer responsible for the overall operation and maintenance of the plume-front remediation system.	Skills at least equivalent to a Groundwater Treatment Facility Operator and training or demonstrated proficiency with respect to set-up and operation of the process control system and computer software.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

WSTF
PLUME–FRONT REMEDIATION
WHITE SANDS TEST FACILITY
LAS CRUCES, NM

PIPING SYSTEM

DRAWING NO	DESCRIPTION
652–I–01	INDEX OF DRAWINGS
652–I–02	INDEX OF DRAWINGS
652–I–03	INDEX OF DRAWINGS
652–I–04	INDEX OF DRAWINGS, SYMBOLS, & ABBREVIATIONS
652–C–01	CIVIL, PROJECT LOCATION
652–C–02	CIVIL, WELL LOCATIONS & PIPING LAYOUT
652–C–03	CIVIL, PLAN & PROFILE PIPING ROUTE (N–1)
652–C–04	CIVIL, PLAN & PROFILE PIPING ROUTE (N–2)
652–C–05	CIVIL, PLAN & PROFILE PIPING ROUTE (N–3)
652–C–06	CIVIL, PLAN & PROFILE PIPING ROUTE (N–4)
652–C–07	CIVIL, PLAN & PROFILE PIPING ROUTE (N–5)
652–C–08	CIVIL, PLAN & PROFILE PIPING ROUTE (S–1)
652–C–09	CIVIL, PLAN & PROFILE PIPING ROUTE (S–2)
652–C–10	CIVIL, PLAN & PROFILE PIPING ROUTE (S–3)
652–C–11	CIVIL, PLAN & PROFILE PIPING ROUTE (S–4)
652–C–12	CIVIL, PLAN & PROFILE PIPING ROUTE (S–5)
652–C–13	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE–2)
652–C–14	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE–4A)
652–C–15	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE–4B)
652–C–16	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE–6)
652–C–17	CIVIL, PLAN & PROFILE PIPING ROUTE (PFI–1A)
652–C–18	CIVIL, PLAN & PROFILE PIPING ROUTE (PFI–1B)
652–C–19	CIVIL, PLAN & PROFILE PIPING ROUTE (PFI–4)
652–C–20	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE–7A)
652–C–21	CIVIL, PLAN & PROFILE PIPING ROUTE (PFE–7B)
652–C–25	CIVIL, JUNCTION DETAILS
652–C–26	CIVIL, JUNCTION DETAILS
652–C–27	CIVIL, JUNCTION DETAILS
652–C–28	CIVIL, SECTIONS & DETAILS
652–C–29	CIVIL, SECTIONS & DETAILS
652–C–30	CIVIL, SECTIONS & DETAILS
652–C–31	CIVIL, SECTIONS & DETAILS
652–C–32	CIVIL, SECTIONS & DETAILS
652–C–33	CIVIL, SECTIONS & DETAILS
652–C–34	CIVIL, SECTIONS & DETAILS
652–C–35	CIVIL, SECTIONS & DETAILS
652–C–36	CIVIL, SECTIONS & DETAILS
652–C–37	CIVIL, SECTIONS & DETAILS
652–M–01	MECHANICAL, FLOW SCHEMATIC, EXTRACTION WELLS
652–M–02	MECHANICAL, FLOW SCHEMATIC, TREATMENT FACILITY
652–M–03	MECHANICAL, FLOW SCHEMATIC, INJECTION WELLS
652–M–04	MECHANICAL, SUBGRADE PIPE & FITTING SCHEDULES
652–M–05	MECHANICAL, SUBGRADE PIPE & FITTING SCHEDULES
652–M–06	MECHANICAL, PIPE & FITTING SCHEDULES
652–M–07	MECHANICAL, PIPE & FITTING SCHEDULES
652–M–08	MECHANICAL, PIPE & FITTING SCHEDULES

CH2MHILL SUBMITTAL

3902G0001 THRU 3902G0003	PROCESS, INSTRUMENTATION & CONTROLS
39021001 THRU 39021020	PROCESS & INSTRUMENTATION
3902E001 THRU 3902E007	ELECTRICAL
3902G003	PLC SYSTEM DIAGRAM

NOTE:
DRAWINGS IN HATCHED AREA ARE NOT INCLUDED IN THIS SUBMITTAL, BUT ARE AVAILABLE UPON REQUEST.

ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASSY					

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

NEXT ASSY / RELATED DWG'S

DRAWN BY	M. TARIN	2-25-00
ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF
PLUME–FRONT REMEDIATION
INDEX OF DRAWINGS

A.B. DWG. NO.	SCALE	SHEET	OF
	NONE	1	1

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	652–I–01	

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

WSTF
PLUME–FRONT REMEDIATION
WHITE SANDS TEST FACILITY
LAS CRUCES, NM

EXTRACTION WELL PFE–1

DRAWING NO	DESCRIPTION
653–C–01	CIVIL, SITE/UTILITIES PLAN
653–C–02	CIVIL, DETAILS AT WELLHEAD
653–C–03	CIVIL WELL COMPLETION DIAGRAM
653–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
653–E–01	ELECTRICAL, MISCELLANEOUS DETAILS
653–E–02	ELECTRICAL, MISCELLANEOUS DETAILS

EXTRACTION WELL PFE–2

DRAWING NO	DESCRIPTION
654–C–01	CIVIL, SITE/UTILITIES PLAN
654–C–02	CIVIL, DETAILS AT WELLHEAD
654–C–03	CIVIL WELL COMPLETION DIAGRAM
654–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
654–E–01	ELECTRICAL, MISCELLANEOUS DETAILS
654–E–02	ELECTRICAL, MISCELLANEOUS DETAILS

EXTRACTION WELL PFE–3

DRAWING NO	DESCRIPTION
655–C–01	CIVIL, SITE/UTILITIES PLAN
655–C–02	CIVIL, DETAILS AT WELLHEAD
655–C–03	CIVIL WELL COMPLETION DIAGRAM
655–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
655–E–01	ELECTRICAL, MISCELLANEOUS DETAILS
655–E–02	ELECTRICAL, MISCELLANEOUS DETAILS

EXTRACTION WELL PFE–4A

DRAWING NO	DESCRIPTION
656–C–01	CIVIL, SITE/UTILITIES PLAN
656–C–02	CIVIL, DETAILS AT WELLHEAD
656–C–03	CIVIL WELL COMPLETION DIAGRAM
656–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
656–E–01	ELECTRICAL, MISCELLANEOUS DETAILS
656–E–02	ELECTRICAL, MISCELLANEOUS DETAILS

EXTRACTION WELL PFE–5

DRAWING NO	DESCRIPTION
657–C–01	CIVIL, SITE/UTILITIES PLAN
657–C–02	CIVIL, DETAILS AT WELLHEAD
657–C–03	CIVIL WELL COMPLETION DIAGRAM
657–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
657–E–01	ELECTRICAL, MISCELLANEOUS DETAILS
657–E–02	ELECTRICAL, MISCELLANEOUS DETAILS

EXTRACTION WELL PFE–7

DRAWING NO	DESCRIPTION
658–C–01	CIVIL, SITE/UTILITIES PLAN
658–C–02	CIVIL, DETAILS AT WELLHEAD
658–C–03	CIVIL WELL COMPLETION DIAGRAM
658–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT
658–E–01	ELECTRICAL, MISCELLANEOUS DETAILS
658–E–02	ELECTRICAL, MISCELLANEOUS DETAILS

INJECTION WELL PFI–1

DRAWING NO	DESCRIPTION
660–C–01	CIVIL, DETAILS AT WELLHEAD
660–C–02	CIVIL, WELL COMPLETION DIAGRAM
660–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT

INJECTION WELL PFI–2

DRAWING NO	DESCRIPTION
661–C–01	CIVIL, DETAILS AT WELLHEAD
661–C–02	CIVIL, WELL COMPLETION DIAGRAM
661–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT

INJECTION WELL PFI–3

DRAWING NO	DESCRIPTION
662–C–01	CIVIL, DETAILS AT WELLHEAD
662–C–02	CIVIL, WELL COMPLETION DIAGRAM
662–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT

INJECTION WELL PFI–4

DRAWING NO	DESCRIPTION
663–C–01	CIVIL, DETAILS AT WELLHEAD
663–C–02	CIVIL, WELL COMPLETION DIAGRAM
663–M–01	MECHANICAL, PIPING & EQUIPMENT LAYOUT

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2–25–00
ENGINEER	J. KIRBY	2–25–00
DESIGNED BY	J. KIRBY	2–25–00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF
PLUME–FRONT REMEDIATION
INDEX OF DRAWINGS

A.B. DWG. NO.	SCALE	SHEET	OF
	NONE	1	1

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	652–I–02	

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

WSTF
PLUME–FRONT REMEDIATION
WHITE SANDS TEST FACILITY
LAS CRUCES, NM

BUILDING 650, TREATMENT FACILITY

DRAWING NO	DESCRIPTION
650-C-01	CIVIL, PROJECT LOCATION MAP
650-C-02	CIVIL, SITE PLAN
650-C-03	CIVIL, UTILITIES PLAN
650-C-04	CIVIL, GRADING PLAN
650-C-05	CIVIL, FENCE DETAILS
650-A-01	ARCHITECTURAL, FLOOR PLAN
650-A-02	ARCHITECTURAL, ELEVATIONS
650-A-03	ARCHITECTURAL, SECTIONS & DETAILS
650-S-01	STRUCTURAL, FOUNDATION PLAN
650-S-02	STRUCTURAL, SECTIONS & DETAILS
650-M-01	MECHANICAL, PIPING & PLUMBING PLAN
650-M-02	MECHANICAL, HVAC PLAN
650-M-03	MECHANICAL, HVAC ELEVATIONS
650-M-04	MECHANICAL, SCHEDULES
650-M-05	MECHANICAL, MISCELLANEOUS DETAILS
650-M-06	MECHANICAL, EQUIPMENT LAYOUT
650-E-01	ELECTRICAL, POWER PLAN
650-E-02	ELECTRICAL, LIGHTING PLAN
650-E-03	ELECTRICAL, GROUNDING PLAN
650-E-04	ELECTRICAL, ONE LINE DIAGRAM
650-E-05	ELECTRICAL, CONDUIT SCHEDULES
650-E-06	ELECTRICAL, SECTIONS AND DETAILS
650-E-07	ELECTRICAL, SECTIONS AND DETAILS
650-E-08	ELECTRICAL, SECTIONS AND DETAILS
650-E-09	ELECTRICAL, CONTROL CONDUIT LAYOUT
650-FPS-01	FIRE PROTECTION, LAYOUT PLAN

BUILDING 651, INJECTION MANIFOLD BUILDING

DRAWING NO	DESCRIPTION
651-C-01	CIVIL, PROJECT LOCATION MAP
651-C-02	CIVIL, SITE, UTILITIES, & GRADING PLAN
651-A-01	ARCHITECTURAL, FLOOR PLAN
651-A-02	ARCHITECTURAL, ELEVATIONS
651-A-03	ARCHITECTURAL, DETAILS
651-S-01	STRUCTURAL, FOUNDATION PLAN
651-S-02	STRUCTURAL, SECTIONS & DETAILS
651-M-01	MECHANICAL, ISOMETRIC PIPING
651-E-01	ELECTRICAL, POWER & LIGHTING PLAN
651-E-02	ELECTRICAL, GROUNDING PLAN

POWER DISTRIBUTION

DRAWING NO	DESCRIPTION
Z-770-44	ELECTRICAL, POWER DISTRIBUTION, POLE LAYOUT
Z-770-MISC-28	100 AREA, MAIN SWITCHYARD, POLE DETAILS
Z-770-MISC-29	100 AREA, MAIN SWITCHYARD, POLE DETAILS
Z-770-MISC-30	100 AREA, MAIN SWITCHYARD, POLE DETAILS
Z-770-MISC-31	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-32	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-33	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-34	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-35	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-36	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-37	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-38	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-39	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-40	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-41	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-42	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-43	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-44	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-45	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-46	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-MISC-47	ELECTRICAL, POWER DISTRIBUTION, POLE DETAILS
Z-770-E-04, DCN B-1, 8-18-00	
	100 AREA, MAIN SWITCH STATION, NEW & EXISTING SUBSTATION PLAN
	100 AREA, MAIN SWITCH STATION, SUBSTATION PLAN & ELEVATIONS
	100 AREA, MAIN SWITCH STATION, SUBSTATION DETAILS
	100 AREA, MAIN SWITCH STATION, RECLOSER PULLBOX, BASE PLAN & DETAILS
	100 AREA, MAIN SWITCH STATION, SWITCH & RECLOSER

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-25-00
ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF
PLUME–FRONT REMEDIATION
INDEX OF DRAWINGS

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	652-I-03	

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

WSTF
PLUME–FRONT REMEDIATION
WHITE SANDS TEST FACILITY
LAS CRUCES, NM

SYMBOLS

MANUAL VALVE

MOTOR OPERATED VALVE

NEEDLE VALVE

FLOW METER

PUMP

STATIC MIXER

CHECK VALVE

ELECTRICAL CONTROL VALVE

FILTER

LLC — LIQUID LEVEL CONTROLLER

LLT — LIQUID LEVEL TRANSDUCER

PS — PRESSURE SWITCH

PRESSURE INDICATOR

FS — FLOW SWITCH

HOMERUN, SLASHES INDICATE NUMBER OF WIRES (GND, HOT, NEUTRAL, SWITCH, DUMMY) RESPECTIVELY. WHERE NO SLASHES ARE SHOWN INDICATES THREE WIRES (GND, HOT, NEUTRAL) ALL CONDUIT 3/4" UNLESS OTHER WISE NOTED. ALL WIRES #12 THHN UNLESS OTHER WISE NOTED.

GFCI — 20 AMP, 120 VOLT, GROUND FAULT CIRCUIT INTERRUPTER RECEPTACLE, 48" ABOVE FINISHED FLOOR.

GFCI WP — 20 AMP, 120 VOLT, GROUND FAULT CIRCUIT INTERRUPTER RECEPTACLE, 48" ABOVE FINISHED FLOOR, IN WEATHER–PROOF BOX.

$ — 20 AMP, 277 VOLT, SINGLE POLE LIGHT SWITCH. LOWER CASE LETTERS INDICATES LIGHT CONTROLLED BY SWITCH.

BOHANNAN–HUSTON CONTROL POINT

$b3 — 20 AMP, 277 VOLT, 3–WAY LIGHT SWITCH. LOWER CASE LETTER INDICATES LIGHT CONTROLLED BY SWITCH.

$AC1 — 20 AMP, 120 VOLT, SINGLE POLE SWITCH FOR AC UNIT

$P — 20 AMP, 120 VOLT, SINGLE POLE SWITCH FOR AC PUMP

$WP — 20 AMP, 120 VOLT, 2 POLE SWITCH IN WEATHERPROOF BOX.

IR HEATER THERMOSTAT

DUAL CONTAINMENT

J — 4" SQUARE JUNCTION BOX

120/208 VOLT PANEL

480/277 VOLT PANEL

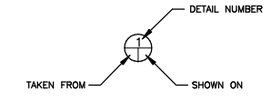
E — EMERGENCY LIGHT FIXTURE

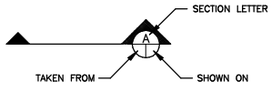
EXIT LIGHT

OUTSIDE LIGHT FIXTURE

PHONE/COMPUTER OUTLET

PHONE/COMPUTER PANEL





ABBREVIATIONS

A	AMP	MFR	MANUFACTURER
AFF	ABOVE FINISH FLOOR	MIN	MINIMUM
AFB	AIR FORCE BASE	MM	MILLIMETER
ALUM	ALUMINUM	MCC	MOTOR CONTROL CENTER
ANSI	AMERICAN NATIONAL STANDARDS INSTITUTE	N	NORTH
AR	AIR	NA	NOT APPLICABLE
ASSY	ASSEMBLY	NC	NORMALLY CLOSED
ASTM	AMERICAN STANDARDS OF TESTING & MATERIALS	NOM	NOMINAL
AWG	AMERICAN WIRE GAUGE	NPT	NATIONAL PIPE THREADS
BC	BOLT CIRCLE	OC	ON CENTER
BLDG	BUILDING	OD	OUTSIDE DIAMETER
CI	CAST IRON	OVH	OVERHEAD
CKT	CIRCUIT	PFE	PLUME–FRONT EXTRACTION
CMP	CORRUGATED METAL PIPE	PFI	PLUME–FRONT INJECTION
CONN	CONNECTION	PSI	POUNDS PER SQUARE INCH
CO	CLEANOUT	PSIG	POUNDS PER SQUARE INCH GAUGE
CPVC	CHLORINATED POLYVINYL CHLORIDE	PVC	POLYVINYL CHLORIDE
CS	CARBON STEEL	RAD	RADIUS
DIA	DIAMETER	REF	REFERENCE
DWG	DRAWING	SCH	SCHEDULE
EMT	ELECTRICAL METALLIC TUBING	SDR	STANDARD DIMENSIONAL RATIO
EXT	EXTERIOR	SS	STAINLESS STEEL
F	FAHRENHEIT	STA	STATION
FF	FINISH FLOOR	TBD	TO BE DETERMINE
FT	FOOT, FEET	TSP	TWISTED SINGLE PAIR
GA	GAUGE	TYP	TYPICAL
GFI	GROUND FAULT INTERRUPTER	UV	ULTRAVIOLET
GND	GROUND	VAC	VOLT AC
GPM	GALLONS PER MINUTE	WA	WATER
HDPE	HIGH DENSITY POLYETHYLENE	WP	WATERPROOF
J–BOX	JUNCTION BOX	WSTF	WHITE SANDS TEST FACILITY
KCMIL	KILO–CIRCULAR MILS	WWM	WELDED WIRE MESH
KVA	KILOVOLT AMPERES	XFMR	TRANSFORMER
mA	MILLIAMPS		
MAX	MAXIMUM		
MBMA	METAL BUILDING MANUFACTURER'S ASSOCIATION		

SAFETY REQUIREMENTS

1. ALL CONFINED SPACES INCLUDING, BUT NOT LIMITED TO, WELLHEAD VAULTS, JUNCTION ACCESS MANWAYS, CONDUIT ACCESS MANWAYS, AND LEAK DETECTION ACCESS MANWAYS SHALL BE LABELED IN ACCORDANCE WITH WSI–25–SW–0003.A ATTACHMENT B

2. ALL LADDERS SHALL COMPLY WITH OSHA STANDARDS AS PRESENTED IN 29 CFR 1910.27 AND SHALL BE APPROVED BY NASA OR THEIR REPRESENTATIVE PRIOR TO INSTALLATION

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED, √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	6–30–99
ENGINEER	J. KIRBY	6–30–99
DESIGNED BY	J. KIRBY	6–30–99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

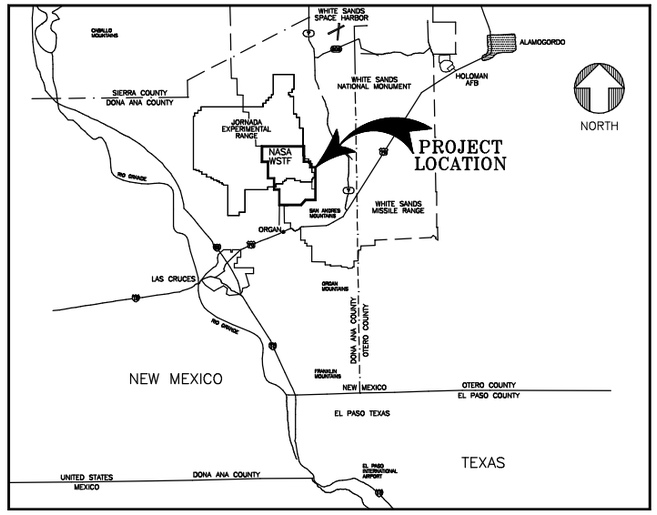
WSTF
PLUME–FRONT REMEDIATION
INDEX OF DRAWINGS
SYMBOLS & ABBREVIATION

A.B. DWG. NO.	SCALE	SHEET	OF
	NONE	1	1

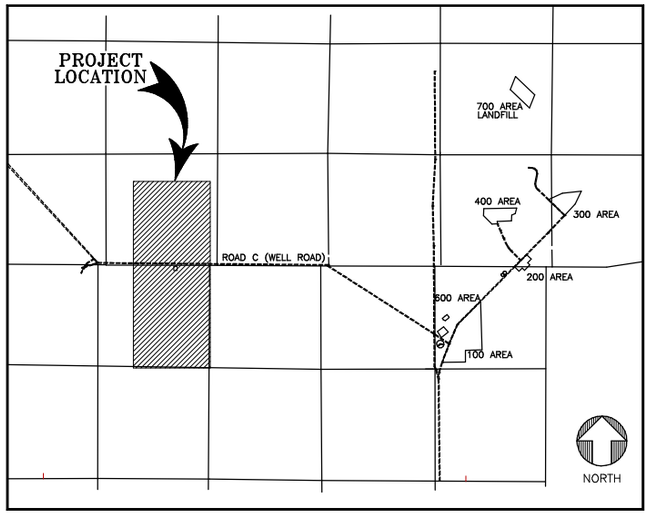
CODE IDENT.	SIZE	DWG. NO.	REV.
	F	652–I–04	

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

GENERAL LOCATION



WSTF LOCATION



SITE LOCATION

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
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DRAWN BY	M. TARIN	7-29-99
ENGINEER	J. KIRBY	7-29-99
DESIGNED BY	J. KIRBY	7-29-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME–FRONT REMEDIATION
PIPING SYSTEM
CIVIL
PROJECT LOCATION

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652–C–01 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

T20S, R3E, SECTION 33

T21S, R3E, SECTION 4

ROAD C (WELL ROAD)

PFE-4A

652-C-15 (PFE-4B)

652-C-14 (PFE-4A)

652-C-03 (N-1)

PFI-4

652-C-19 (PFI-4)

PFE-5

652-C-04 (N-2)

652-C-08 (S-1)

652-C-09 (S-2)

652-C-10 (S-3)

652-C-11 (S-4)

652-C-12 (S-5)

652-C-15 (PFE-4B)

PFE-3

652-C-16 (PFE-5)

652-C-05 (N-3)

652-C-13 (PFE-2)

652-C-17 (PFI-1A)

PFI-3

PFE-2

652-C-06 (N-4)

652-C-20 (PFE-7A)

652-C-18 (PFI-1B)

PFI-2

652-C-07(N-5)

652-C-21 (PFE-7B)

PFE-1

PFE-7

PFI-1

T20S, R3E, SECTION 32

T21S, R3E, SECTION 5

NORTH

750 FEET
500'
250'
0

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	6-21-99
ENGINEER	J. KIRBY	6-21-99
DESIGNED BY	J. KIRBY	6-21-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

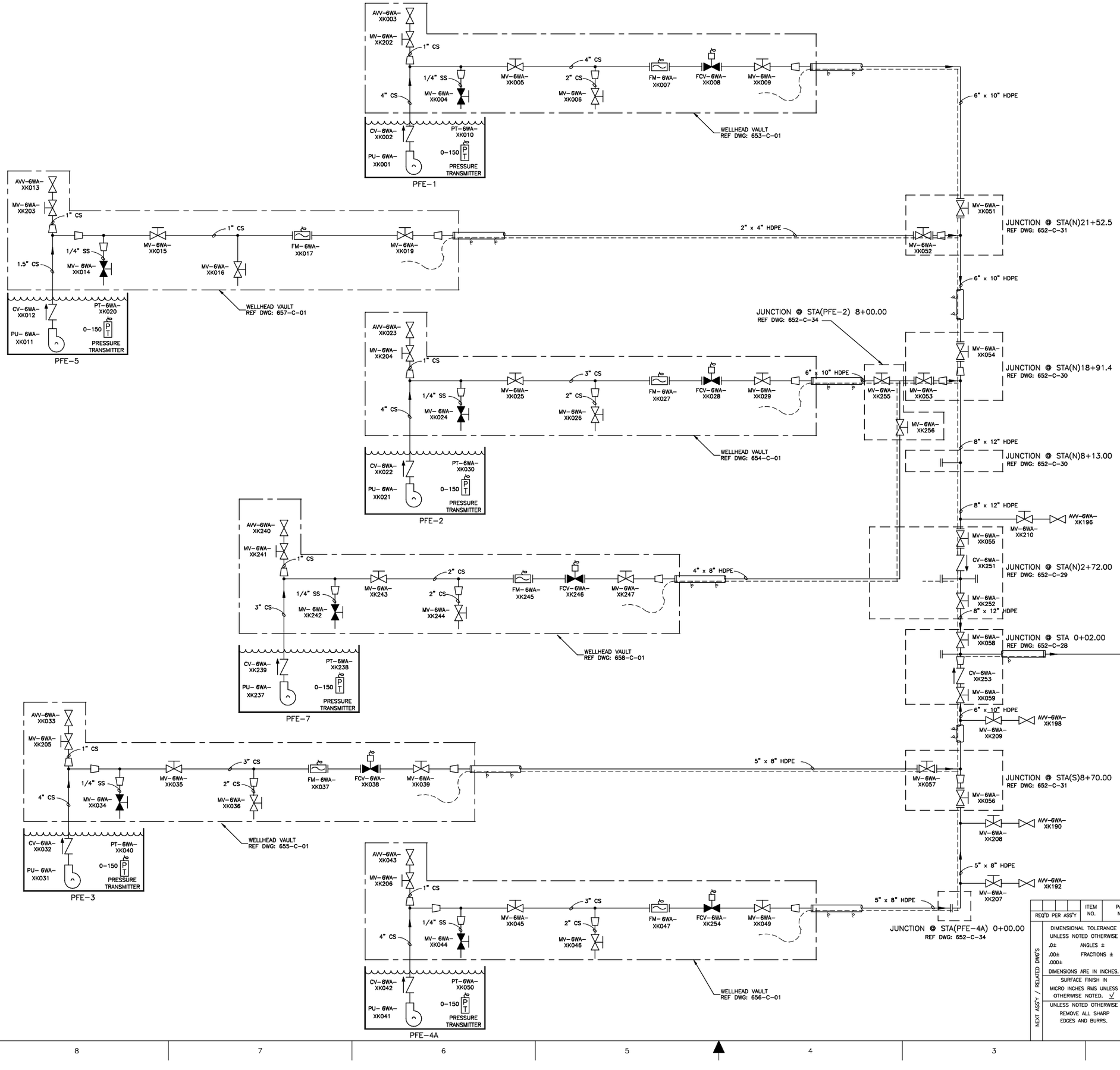
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
PIPING SYSTEM
CIVIL
WELL LOCATIONS & PIPING LAYOUT

A.B. DWG. NO. | SCALE 1"=250' | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-C-02 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASS'Y					

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
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DRAWN BY	M. TARIN	9-1-99
ENGINEER	J. KIRBY	9-1-99
DESIGNED BY	J. KIRBY	9-1-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
PIPING SYSTEM
MECHANICAL
FLOW SCHEMATIC

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 652-M-01 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BUILDING 650

DATA RECORDING & TELEMETRY

AIR STRIPPER #1 (VENDOR SUPPLIED)

VENT TO ATMOSPHERE

TI- 6WA- XK094

TT- 6WA- XK138

FM- 6WA- XK096

FC

FCV- 6WA- XK093 THROTTLE

6" CPVC

6" CS

PT- 6AR- XK229

PI- 6AR- XK230

PS- 6AR- XK231

PS- 6AR- XK232

0-35" WC

MV- 6WA- XK097

FI- 6AR- XK227

FT- 6AR- XK228

0-500" WC VAC

FLS- 6AR- XK089

LLT

LLT- 6WA- XK104

0

PI- 6WA- XK107

PS- 6AR- XK101

BL- 6AR- XK098

LLC- 6WA- XK102

LLC- 6WA- XK103

ROV- 6WA- XK109

MV- 6WA- XK105

ON/OFF

VFD

PU- 6WA- XK106

3" CPVC

2" CPVC

ROV- 6WA- XK110

MV- 6WA- XK119

CV- 6WA- XK108

ROV- 6WA- XK092

FS- 6WA- XK130

FLOOR SUMP

FUTURE

F- 6AR- XK060

AMBIENT AIR

16" PVC

EEW- 6WA- XK185

ES- 6WA- XK062

MV- 6WA- XK184

SCALE CLEANING SYSTEM (VENDOR SUPPLIED)

POTABLE WATER 2" CS

MV- 6WA- XK063

CV- 6CI- XK236

TK- 6CI- XK064

M- 6CI- XK188

MV- 6CI- XK081

PU- 6CI- XK071

CV- 6CI- XK069

CV- 6CI- XK068

MV- 6CI- XK074

MV- 6CI- XK199

LLC- 6CI- XK067

PU- 6CI- XK070

CV- 6CI- XK072

CV- 6CI- XK073

1/4" SS

SCALING CONTROL CHEMICAL METERING SYSTEM (VENDOR SUPPLIED)

MV- 6CI- XK075

TK- 6CI- XK076

2" CS

MV- 6CI- XK200

LLC- 6CI- XK066

MV- 6CI- XK077

PU- 6CI- XK078

CV- 6CI- XK079

CV- 6CI- XK080

1/4" SS

SPENT CLEANING SOLUTION TK- 6WA- XK222

LLC- 6WA- XK065

LLC- 6WA- XK100

2"

MV- 6WA- XK099

AIR STRIPPER #2 (VENDOR SUPPLIED)

INSTRUMENT AIR

AR

UV OXIDATION SYSTEM (VENDOR SUPPLIED)

PSV- 6AR- XK132

PI- 6AR- XK133

PS- 6AR- XK134

90 PSI

0-100 PSI

40-85 PSI

AVV- 6WA- XK018

MV- 6WA- XK136

PU- 6AR- XK131

MV- 6AR- XK135

COMPRESSED AIR

TK- 6WA- XK141

PI- 6WA- XK137

0-100 PSI

ECV- 6WA- XK187

MV- 6WA- XK139

FM- 6WA- XK140

RD- 6WA- XK186 100 PSI

DRAIN

AVV- 6WA- XK189

MV- 6WA- XK201

ROV- 6WA- XK143

MV- 6WA- XK144

ON/OFF

FC

MV- 6WA- XK142

10" HDPE TO INJECTION WELLS REF DWG: 652-M-03

10"X16" HDPE FROM EXTRACTION WELLS REF DWG: 652-M-01

0-100 PSI PI- 6WA- XK083

MV- 6WA- XK082

8" CS

WA

SM- 6WA- XK087

MV- 6WA- XK086

MV- 6WA- XK258

LLS- 6WA- XK235

LEAK DETECTION CONTROL PANEL

F- 6AR- XK088

AMBIENT AIR

FM- 6WA- XK116

FCV- 6WA- XK112 THROTTLE

PT- 6AR- XK223

PI- 6AR- XK224

PS- 6AR- XK225

PS- 6AR- XK226

MV- 6WA- XK113

TI- 6WA- XK114

TT- 6WA- XK115

FI- 6AR- XK084

FT- 6AR- XK085

FLS- 6AR- XK118

PS- 6AR- XK120

BL- 6AR- XK117

LLC- 6WA- XK121

LLC- 6WA- XK122

LLT- 6WA- XK123

PI- 6WA- XK126

ROV- 6WA- XK128

MV- 6WA- XK124

PU- 6WA- XK125

ROV- 6WA- XK111

MV- 6WA- XK061

ROV- 6WA- XK129

CV- 6WA- XK127

CV- 6WA- XK145

ROV- 6WA- XK257

MV- 6WA- XK146

MV- 6WA- XK090

CV- 6WA- XK091

(TEMPORARY) TK- 6WA- XK148

MV- 6WA- XK150

MV- 6WA- XK147

PU- 6WA- XK149

MV- 6WA- XK151

TS- 6AR- XK233

TS- 6AR- XK234

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	9-1-99
ENGINEER	J. KIRBY	9-1-99
DESIGNED BY	J. KIRBY	9-1-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

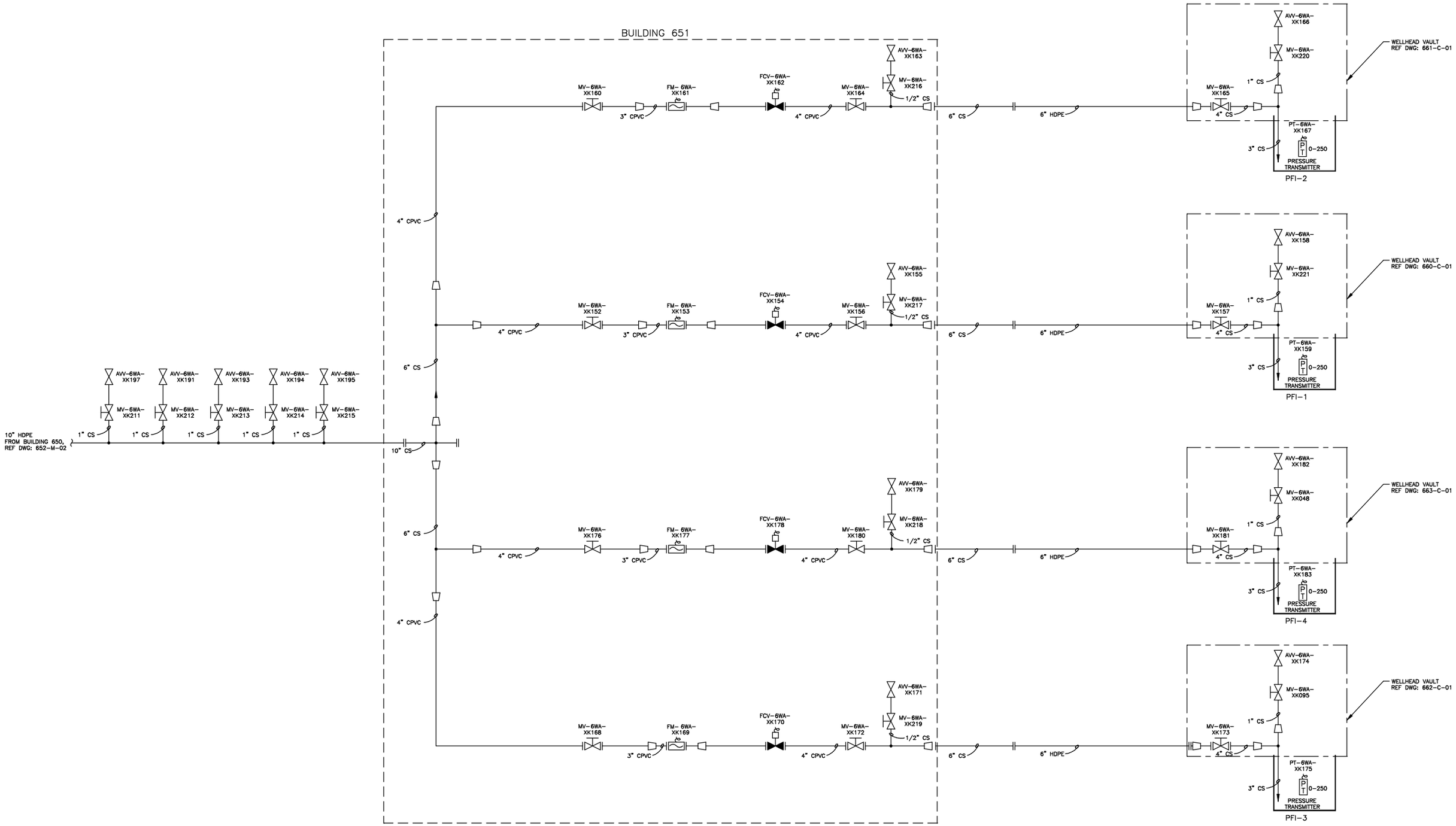
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION PIPING SYSTEM MECHANICAL FLOW SCHEMATIC

A.B. DWG. NO.	SCALE	SHEET	OF
	NONE	1	1

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	652-M-02	

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



NOTES:

1. ALL CPVC PIPE SHALL BE SCH 80.

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
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.00± FRACTIONS ±
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DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
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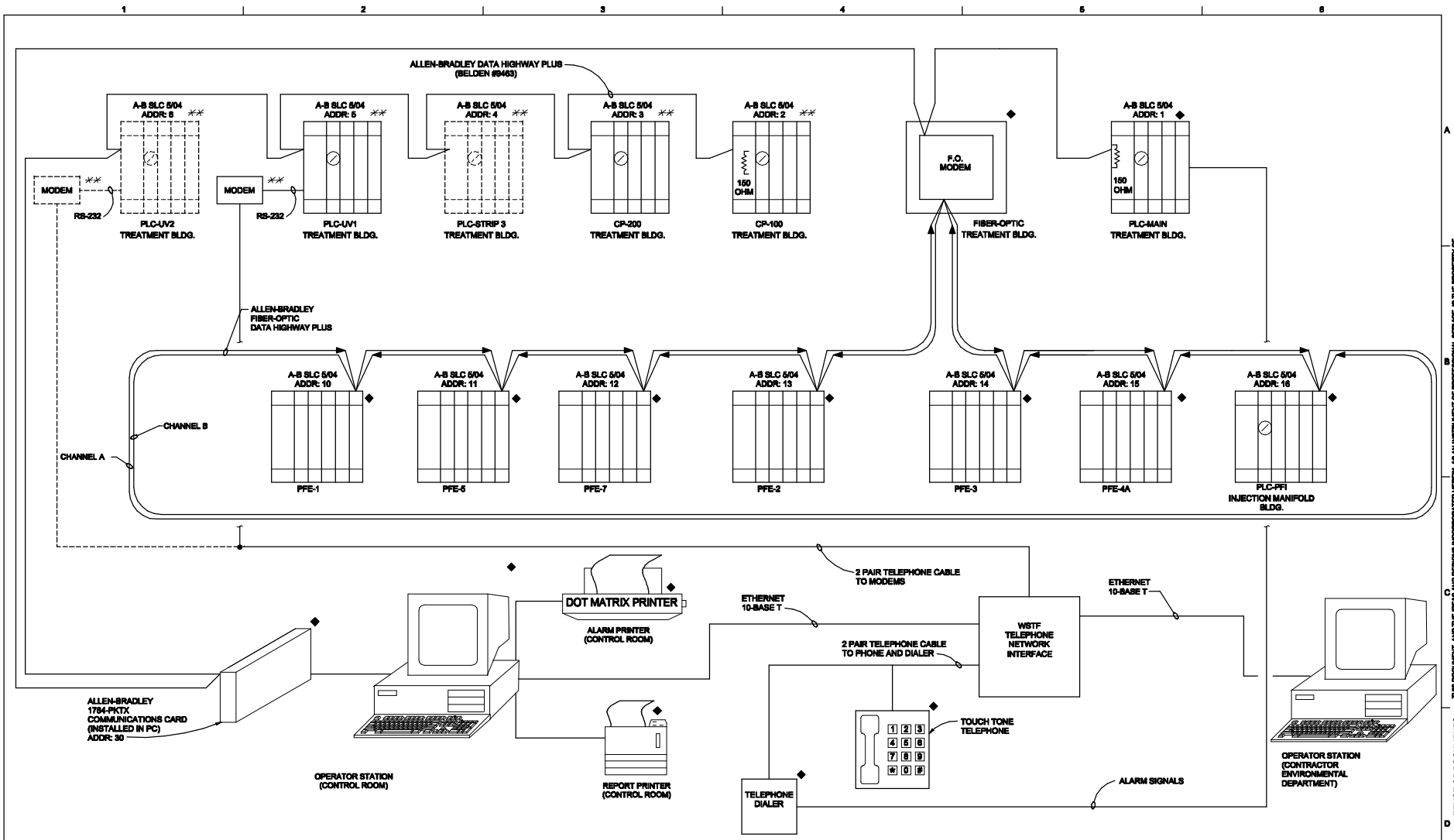
DRAWN BY	M. TARIN	9-1-99
ENGINEER	J. KIRBY	9-1-99
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
PIPING SYSTEM
MECHANICAL
FLOW SCHEMATIC

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	652-M-03	

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1



90% REVIEW

PRELIMINARY

REUSE OF DOCUMENTS: THIS DOCUMENT, AND THE IDEAS AND DESIGNS INCORPORATED HEREIN, AS AN INSTRUMENT OF PROFESSIONAL SERVICE, IS THE PROPERTY OF CH2M HILL AND IS NOT TO BE USED, IN WHOLE OR IN PART, FOR ANY OTHER PROJECT WITHOUT THE WRITTEN AUTHORIZATION OF CH2M HILL

DSGN K. MAYEUX						VERIFY SCALE	CH2MHILL
DR E. KRISTEL						BAR IS ONE INCH ON ORIGINAL DRAWING. IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.	
CHK Checked_By							
APVD Approved_By	NO.	DATE	REVISION	BY	APVD		

WHITE SANDS TEST FACILITY
PLUME FRONT
REMEDIATION SYSTEM
LYNDON B. JOHNSON SPACE CENTER

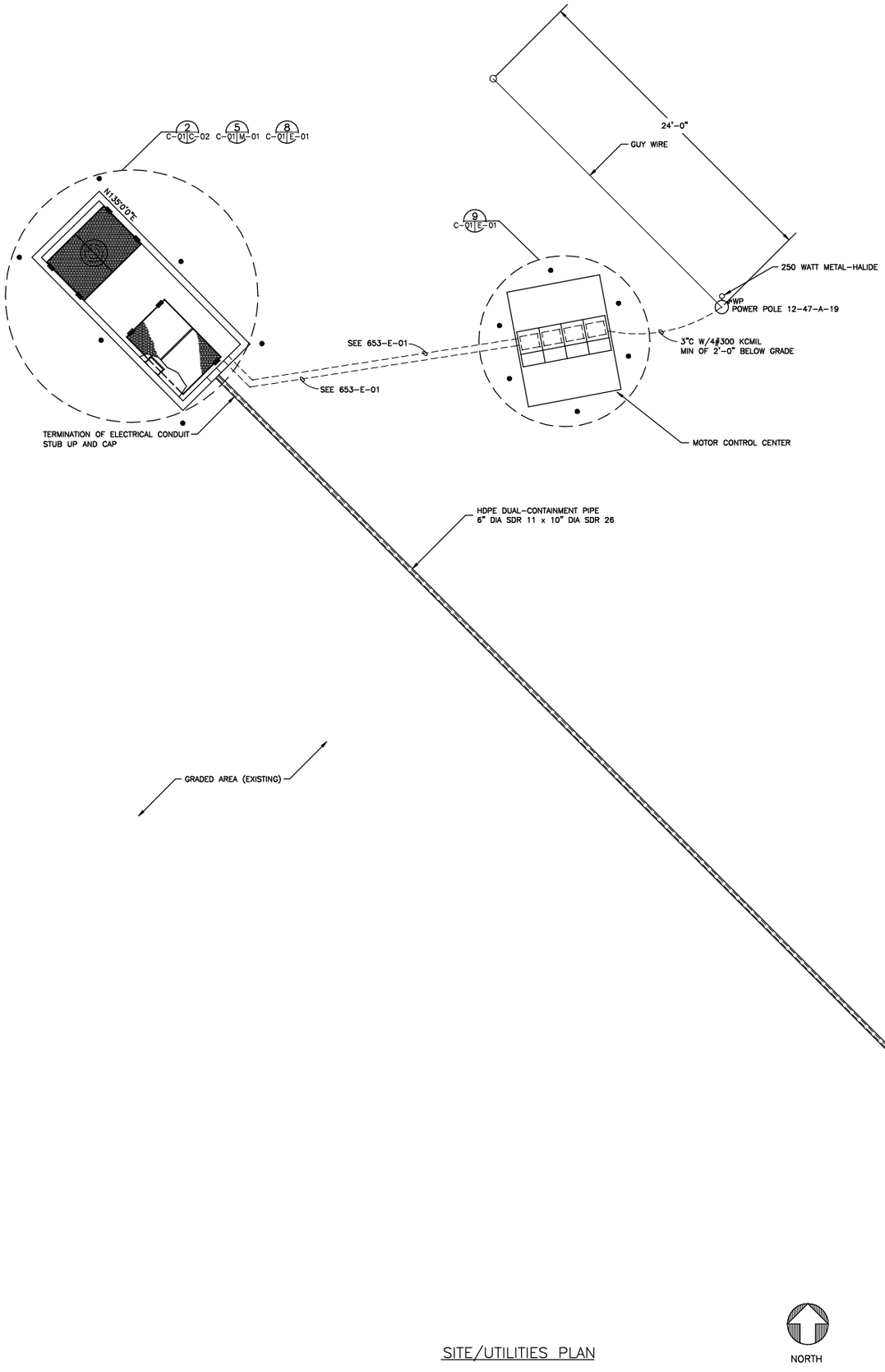
PROCESS INSTRUMENTATION AND CONTROLS

PLC SYSTEM DIAGRAM

SHEET	Sheet
DWG NO.	G-3
DATE	NOV 2000
PROJ NO.	163902

3902g003.dwg 18-Sep-2001 20:47:04

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

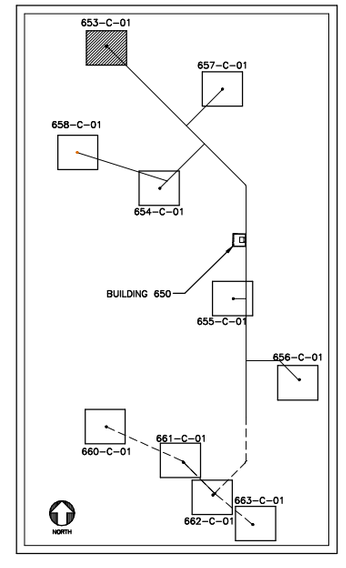


SITE/UTILITIES PLAN

NORTH

0 4 8 12 FEET

KEY



ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASS'Y					

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

NEXT ASS'Y / RELATED DWG'S.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

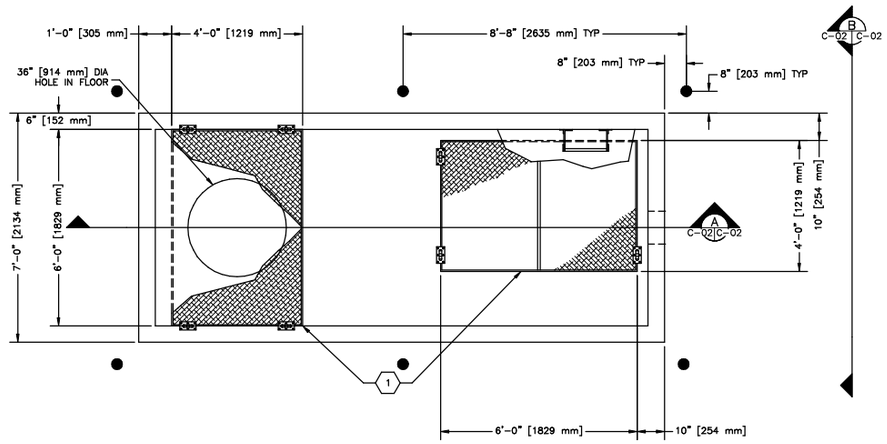
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
CIVIL
SITE/UTILITIES PLAN

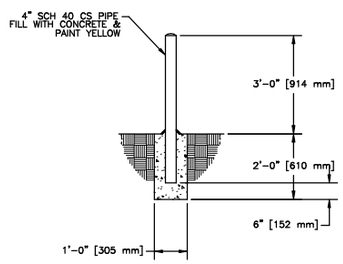
A.B. DWG. NO. | SCALE 1"=4'-0" | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 653-C-01 | REV.

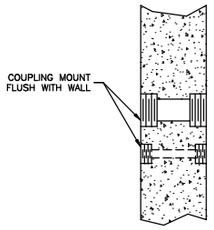
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



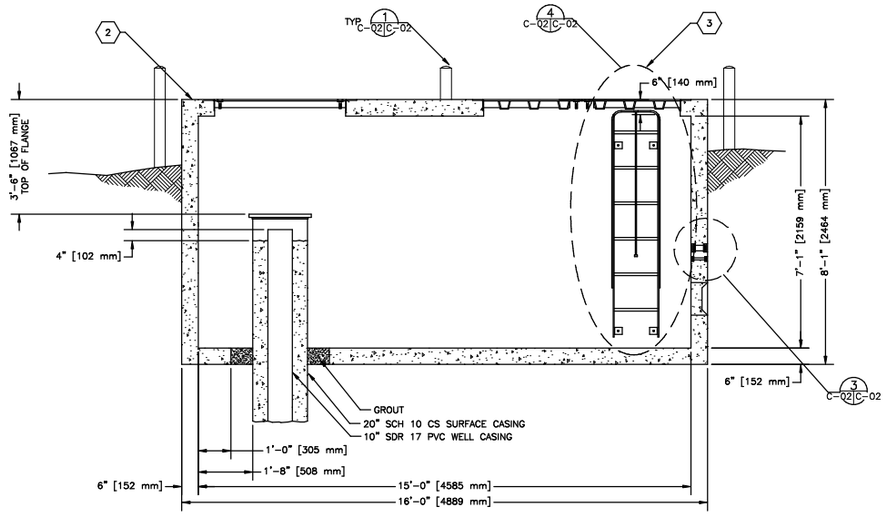
2 C-02 C-01 DETAIL: PFE-1 EXTRACTION WELL VAULT



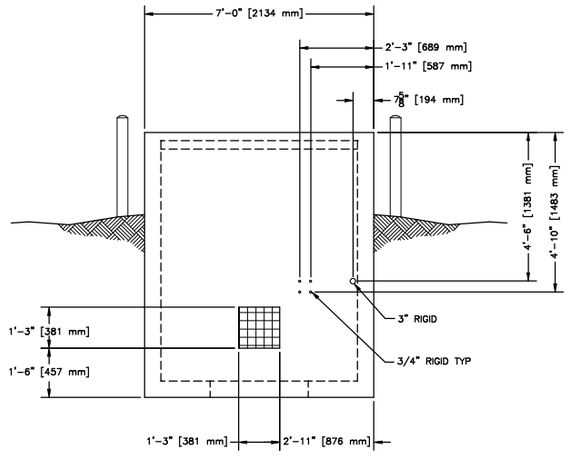
1 C-02 C-02 DETAIL: BOLLARD



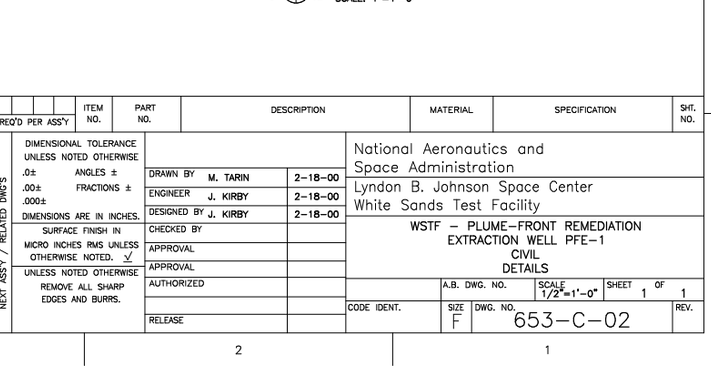
3 C-02 C-02 DETAIL: PENETRATIONS
NTS



A C-02 C-02 SECTION



B C-02 C-02 VIEW



4 C-02 C-02 DETAIL: LADDER
SCALE: 1"=1'-0"

KEYED NOTES:

1. UTILITY VAULT, CATALOG #4872 OR EQUIVALENT WEATHER-TIGHT DOUBLE TORSION DOOR
2. UTILITY VAULT, CATALOG #615-TA-M OR EQUIVALENT PRE-CAST CONCRETE VAULT
3. UTILITY VAULT, BOLT-ON ALUMINUM LADDER W/PULL-UP EXTENDER OR EQUIVALENT

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

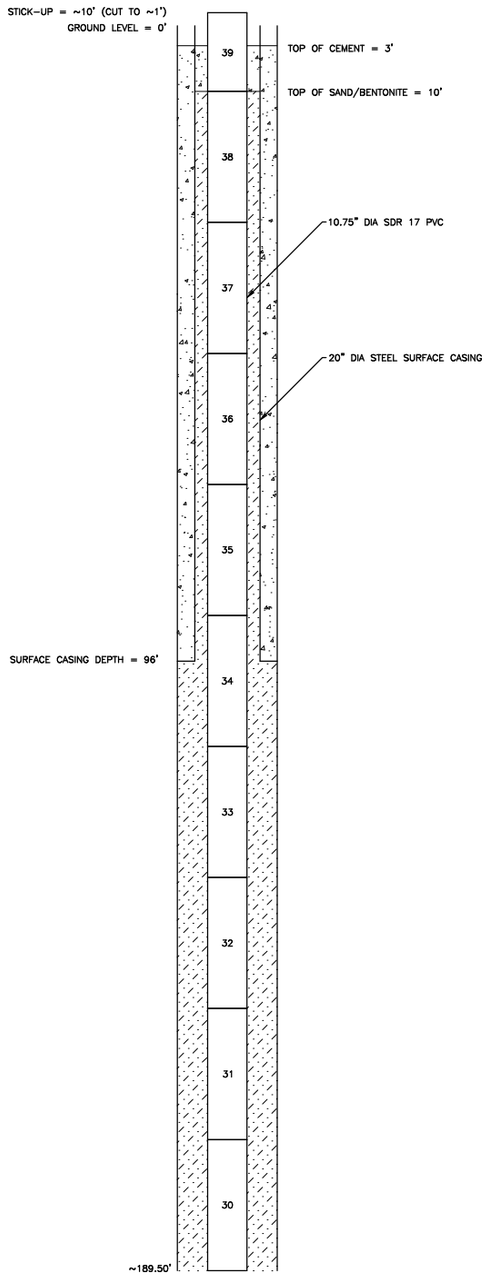
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

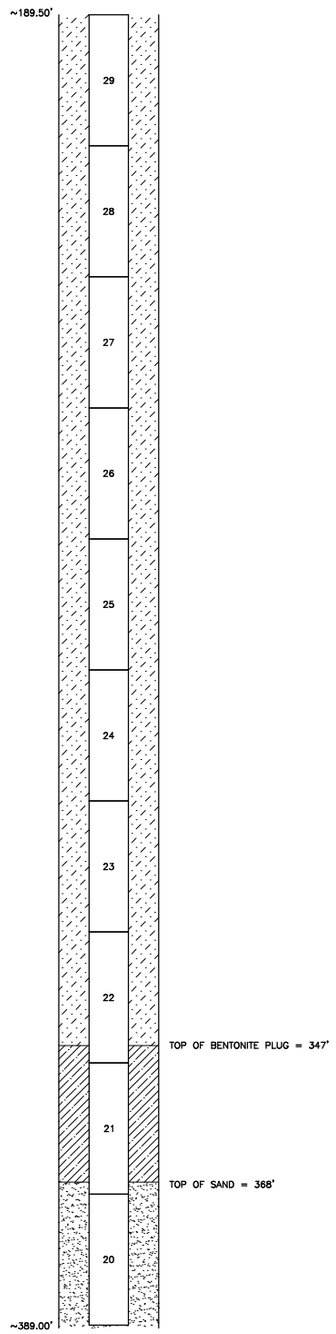
WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
CIVIL
DETAILS

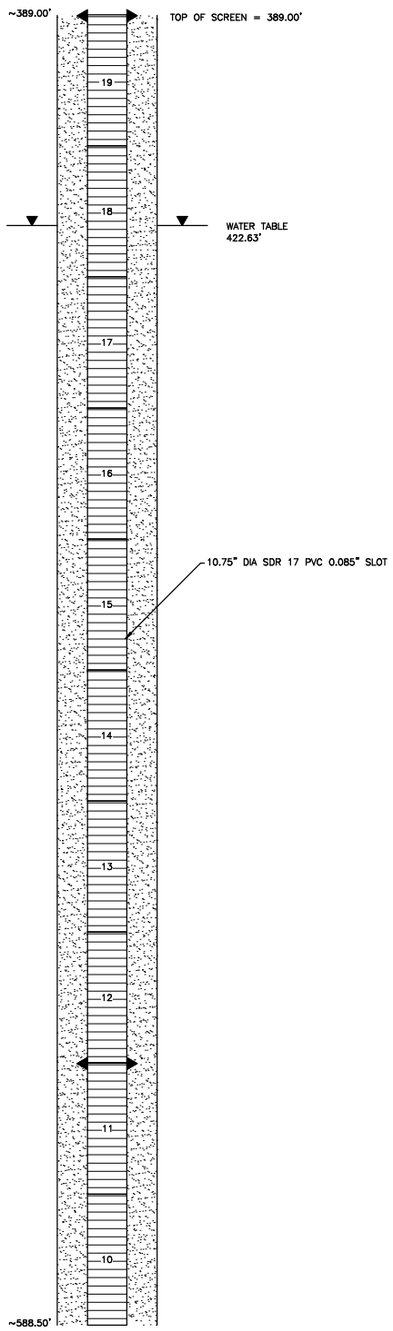
CODE IDENT.	SIZE	DWG. NO.	REV.
	F	653-C-02	

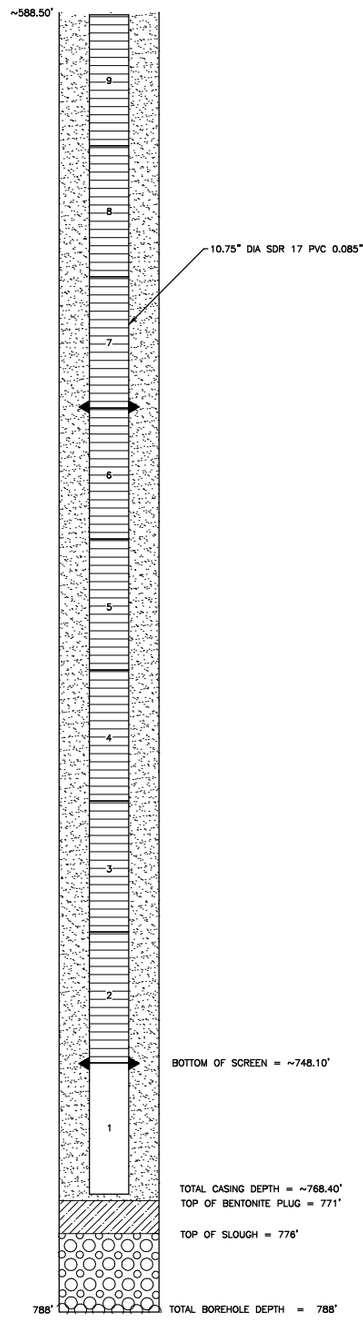
A.B. DWG. NO. | SCALE 1/2"=1'-0" | SHEET 1 OF 1

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL









NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE

4/8 SAND

SLOUGH

4/8 SAND/BENTONITE MIX

GROUT

SCREEN

STEEL, BOLT-ON CENTRALIZER

ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASS'Y					

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

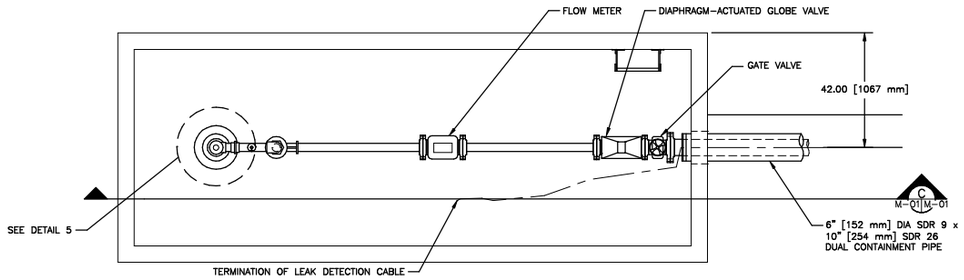
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
CIVIL
WELL COMPLETION DIAGRAM

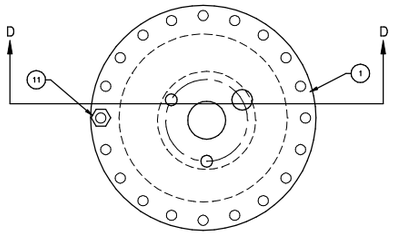
A.B. DWG. NO.	SCALE	SHEET OF
	NONE	1 1

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	653-C-03	

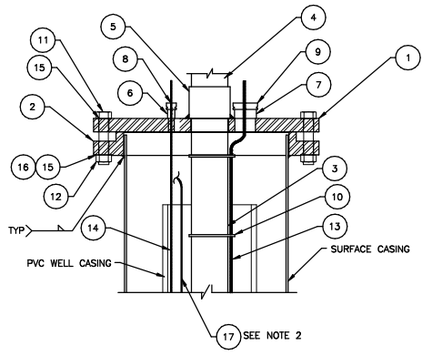
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



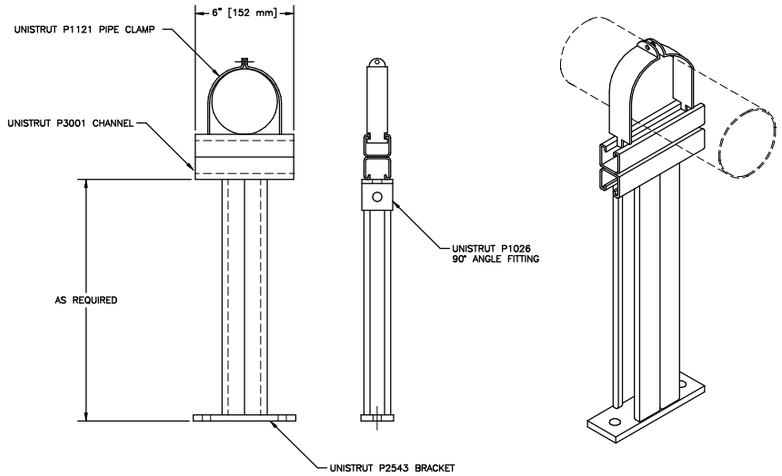
5 M-01 C-01 DETAIL: PFE-1 EXTRACTION WELL VAULT



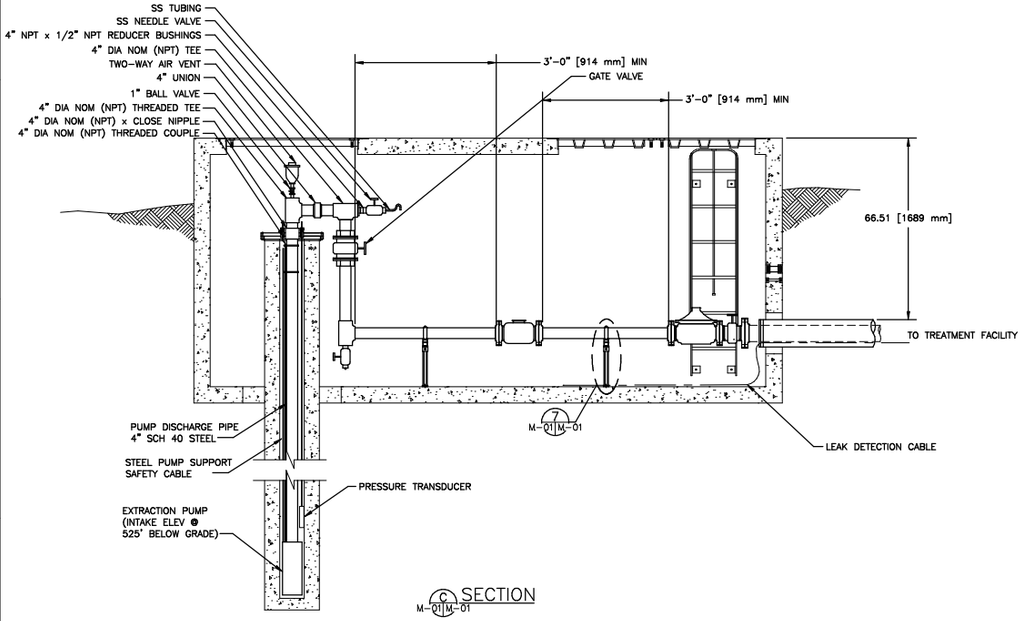
DETAIL 6: WELLHEAD ASSEMBLY
SCALE: 1/8=1



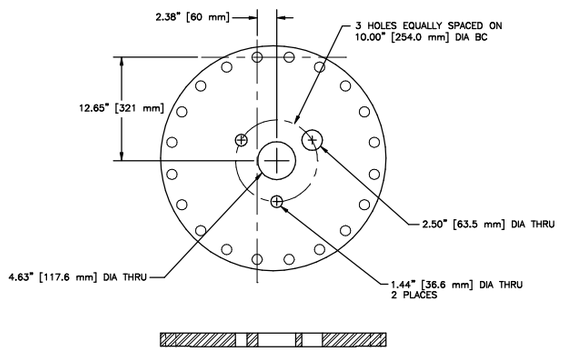
SECTION D-D



7 M-01 M-01 DETAIL: PIPE SUPPORT
SCALE: 1/4=1



C M-01 M-01 SECTION



1 BLIND FLANGE
SCALE: 1/8=1

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER
2. SAFETY CABLE TERMINATION AND SECURING METHOD SHALL BE DETERMINED BY PUMP INSTALLATION CONTRACTOR.

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
1	17		SAFETY CABLE, 0.5" DIA	CS		
4	16		WASHER, LOCK, 1.125" DIA	CS		
8	15		WASHER, FLAT, 1.125" DIA	CS		
	14		TRANSDUCER CABLE	CU		
	13		PUMP POWER CABLE	CU		
4	12		NUT, 1.125" DIA	CS		
4	11		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
	10		STRAP	SS		
1	9		STRAIN RELIEF CONNECTOR, 2"	SS		
1	8		STRAIN RELIEF CONNECTOR, 1"	SS		
1	7		COUPLING, 2" NPT, SCH 80	CS		
2	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		COUPLING, 4" ASTM	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		NIPPLE, 4" NPT x CLOSE	CS		
1	3		DROP PIPE, 4" DIA x 525', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

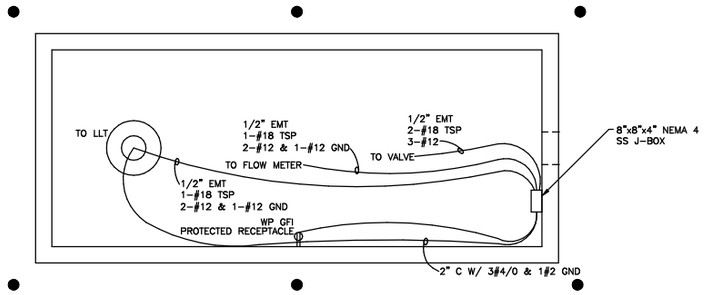
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
MECHANICAL
DETAILS

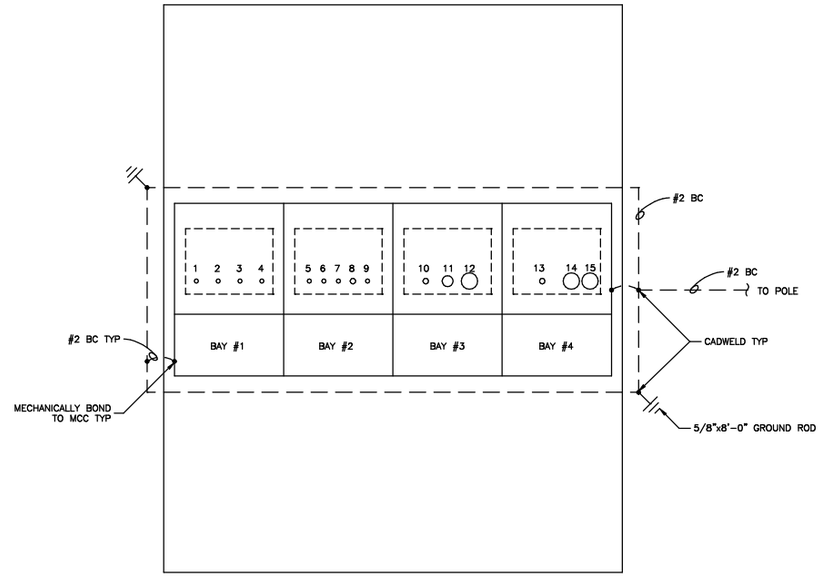
A.B. DWG. NO. | SCALE 1/2"=1'-0" | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 653-M-01 | REV.

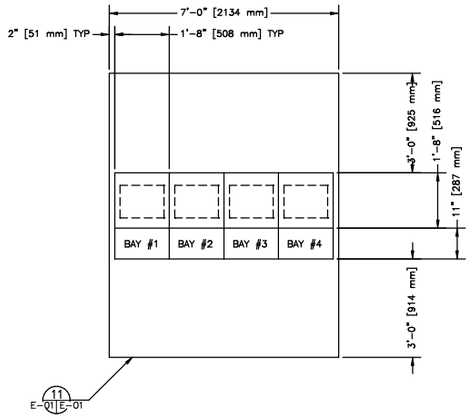
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

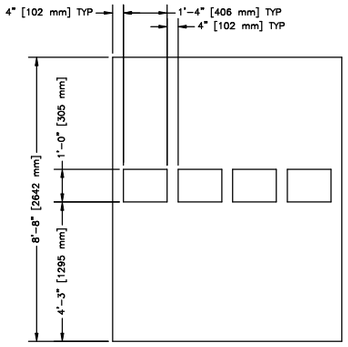


8 C-02 C-01 DETAIL: PFE-1 EXTRACTION WELL VAULT



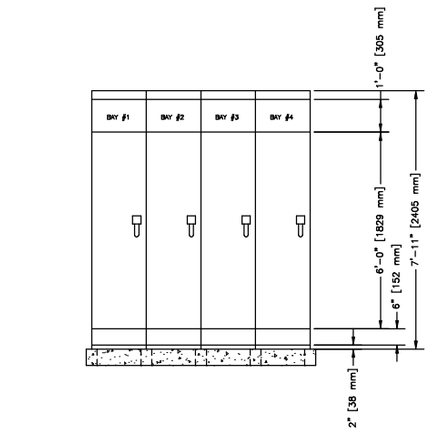
11 E-01 E-01 DETAIL: CONDUIT LOCATIONS & GROUNDING
SCALE: 1"=1'-0"



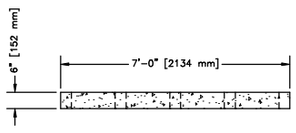


CONDUIT NUMBER	CONDUIT SIZE	FROM	TO	CONDUCTORS
1	3/4"	BAY 1	PFE-1 VAULT	2#14 AWG, 5#18 AWG TSP
2	3/4"	BAY 1	PFE-1 VAULT	SPARE
3	3/4"	BAY 1	SLAB EDGE (WEST)	SPARE
4	3/4"	BAY 1	SLAB EDGE (WEST)	SPARE
5	3/4"	BAY 2	SLAB PFE-1 VAULT	4#12 & 1#12 GND
6	3/4"	BAY 2	SLAB PFE-1 VAULT	4#12 & 1#12 GND
7	3/4"	BAY 2	SLAB PFE-1 VAULT	SPARE
8	1"	BAY 2	SLAB PFE-1 VAULT	SPARE
9	3/4"	BAY 2	POLE	2#12 & 1#12 GND
10	1"	BAY 3	SLAB EDGE (WEST)	SPARE
11	2"	BAY 3	PFE-1 PUMP	3#4/0 & 1#2 GND
12	3"	BAY 3	SLAB EDGE (WEST)	SPARE
13	1"	BAY 4	SLAB EDGE (WEST)	SPARE
14	3"	BAY 4	POLE	4#4/0
15	3"	BAY 4	POLE	4#4/0

CONDUIT SCHEDULE



9 C-01 E-01 MOTOR CONTROL CENTER ELEVATION



10 E-01 E-01 DETAIL: CONCRETE PAD

NOTES:
1. REFERENCE 653-C-02 FOR PENETRATION DETAILS
2. ALL TSP CONDUCTORS SHALL BE 18 AWG
3. ALL POWER CONDUCTORS #12 & UP SHALL BE TYPE THHN

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
ELECTRICAL
DETAILS

A.B. DWG. NO. | SCALE 1/2"=1'-0" | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 653-E-01 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BAY #1	BAY #2	BAY #3	BAY #4
RELAY CABINET FOR PLC CONTROLLER	FVNR NEMA SIZE 2	BLANK	C/B 50A COMPAC
			BLANK
	PANEL 3ø, 18 CKT 120/208V 100A MLO	SSRV CONTROLLER C/B * 150 HP	BLANK
			METER (1)
	XFMR 15 KVA 3ø 4W 25A C/B (480V) 40A C/B (208V)		TVSS 30A C/B (2)
			MAIN 450A C/B

* TO BE SIZED BY MANUFACTURER TO PROVIDE PROPER SHORT CIRCUIT PROTECTION OF MOTOR IT IS TO PROTECT.

SCHEDULE – MOTOR CONTROL CENTER
480 VAC, 3ø, 4W, 42KA, NEMA 3R
600A INCOMING, 600A HORIZONTAL, 300A VERTICAL

SECTION/UNIT LOCATION	DESC	NEMA SIZE	CB TRIP (A)	AUX INTLKS NO	AUX INTLKS NC	SELECTOR SWITCHES	INDICATING LIGHTS	IDENTIFICATIONS
1								
2A	FVNR	2	70	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	SPARE
2E	C/B		40					100A, 3ø, 18 CKT, PNL
2N	C/B		25					15 KVA, 3ø, 4W, XFMRS
3A								
3D	SSRV	N/A	*	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	PFE-1 PUMP
4A	C/B		50					SPARE
4C								
4G								
4K								METER (1)
4P			30					TVSS (2)
4T			450					MAIN

KEYED NOTES:

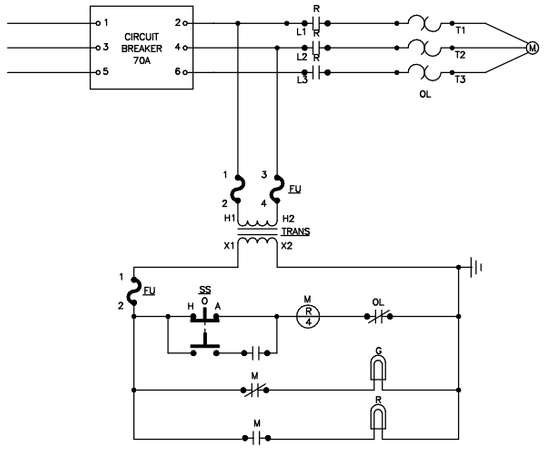
(1) FURNISH STANDARD METER SLOT OPENING IN FRONT OF MCC'S PANEL COVER. PROIVDE CLEAR PLASTIC WEATHER PROOF COVER OVER OPENING. METER DEVICE AND ASSOCIATED CT'S AND PT'S TO BE FURNISHED AND INSTALLED BY OTHERS.

(2) FURNISH MANUFACTURER'S STANDARD TVSS PROTECTION INTEGRAL WITH MCC.

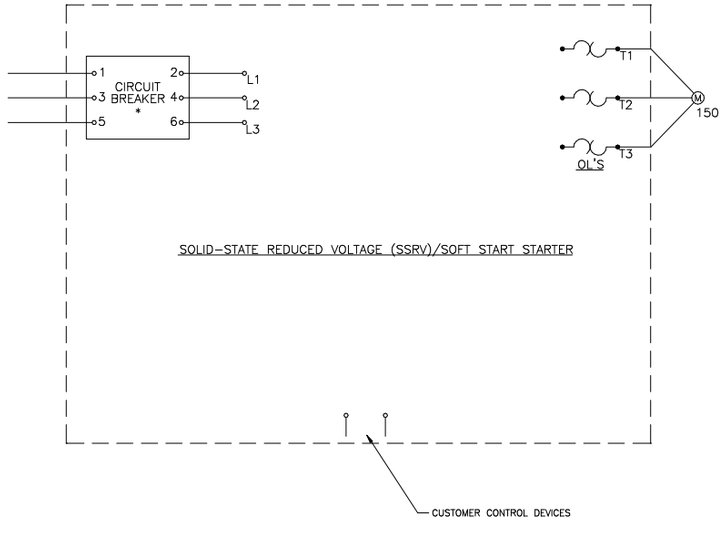
SCHEDULE – PANEL "LA"

BUILDING: PFE-1	LOCATION: MCC	PHASE: 3
TYPE:	FEED:	WIRE: 4
MANUFACTURER:	SC RATING: 10,000	VOLTAGE: 120/208
MODEL:	MAIN AMPS:	MOUNTING: INTERNAL TO MCC
CONFIGURATION:	PANEL AMPS: 100 MLO COPPER	

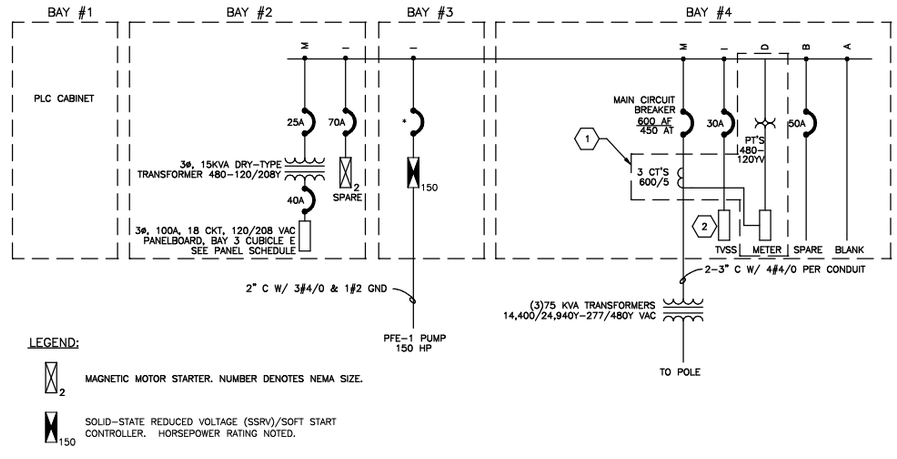
CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	ø LOAD (AMPS) A	B	C	CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	ø LOAD (AMPS) A	B	C
1	1	20	PLC POWER	10			2	1	–	SPACE ONLY			
3	1	20	PLC RECEPT		1.5		4	1	–				
5	1	20	PFE-1 VAULT RECEPT			1.5	6	1	–				
7	1	20	PFE-1 FLOW METER	.83			8	1	–				
9	1	20	MCC RECEPT		1.5		10	1	–				
11	1	20	SPARE				12	1	–				
13	1	20	SPARE				14	1	–				
15	1	–	SPACE ONLY				16	1	–				
17	1	–	↓				18	1	–	↓			
TOTAL CONNECTED LOAD PER PHASE, AMPS							TOTAL CONNECTED LOAD PER PHASE, AMPS						
TOTAL CONNECTED LOAD 3-PHASE, AMPS							TOTAL CONNECTED LOAD 3-PHASE, AMPS						



SPARE



PFE-1 PUMP



MOTOR CONTROL CENTER ONE-LINE DIAGRAM

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

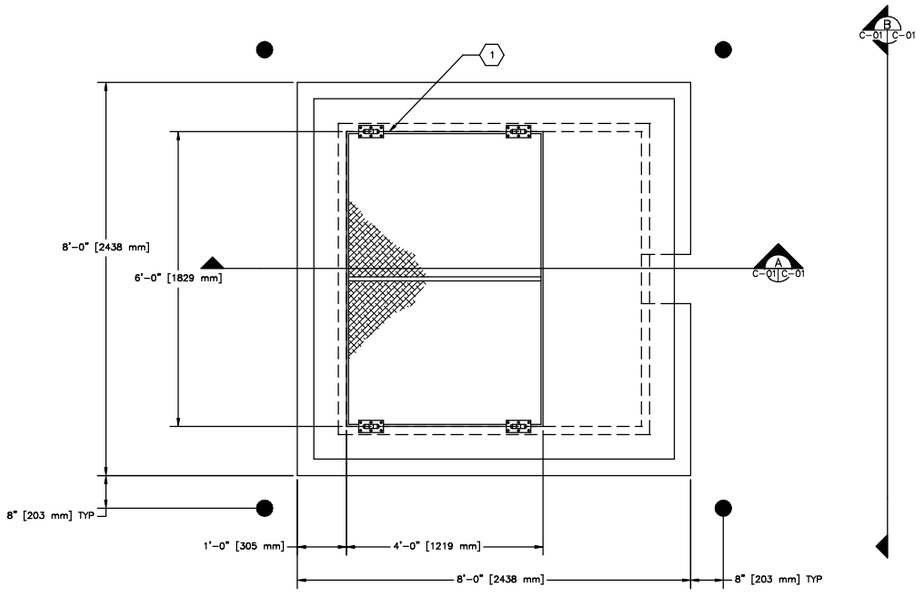
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
ELECTRICAL
DETAILS

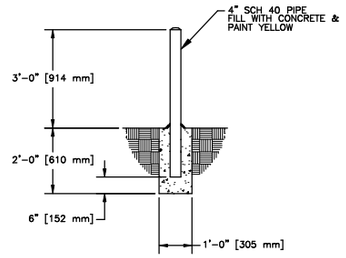
A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 653-E-02 | REV.

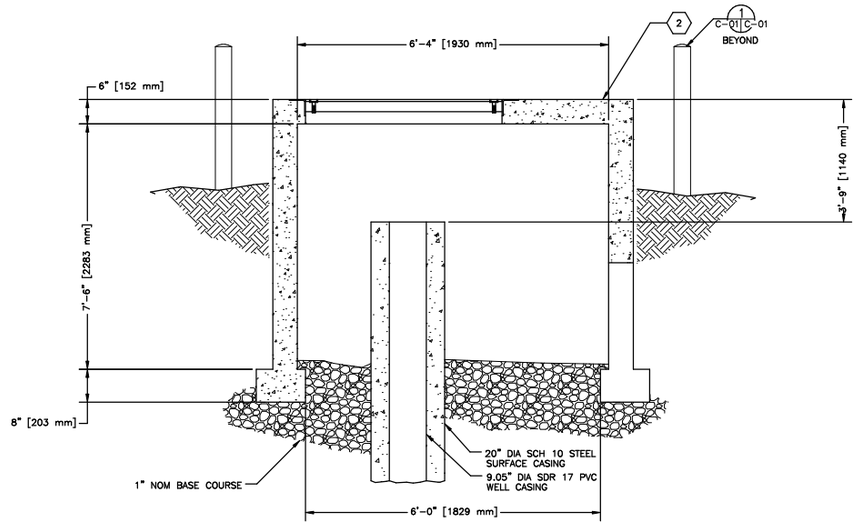
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



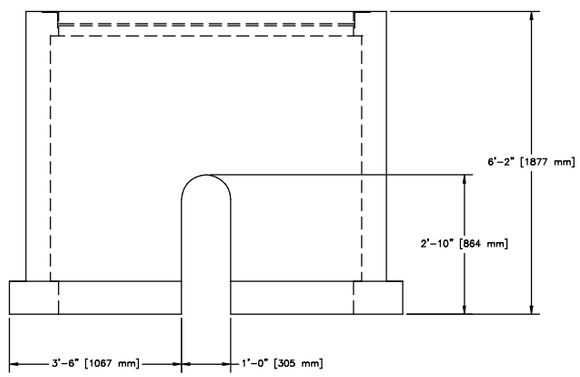
PFI-1 INJECTION WELLHEAD



1 C-01 C-01 DETAIL: BOLLARD

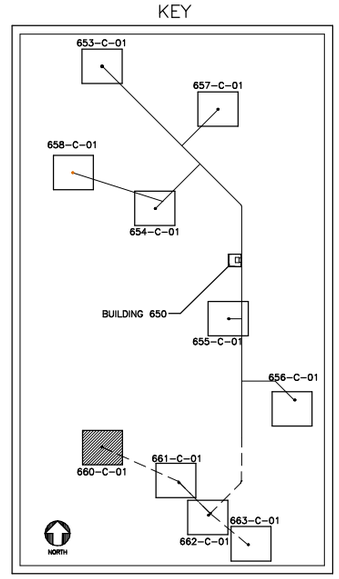


A C-01 C-01 SECTION



B C-01 C-01 VIEW

KEY



NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER

KEYED NOTES:

1. UTILITY VAULT, CATALOG #4872 OR EQUIVALENT WEATHER-TIGHT DOUBLE TORSION DOOR
2. UTILITY VAULT, CATALOG #6464-WA OR EQUIVALENT PRE-CAST CONCRETE VAULT

ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASS'Y					

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-25-00
ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

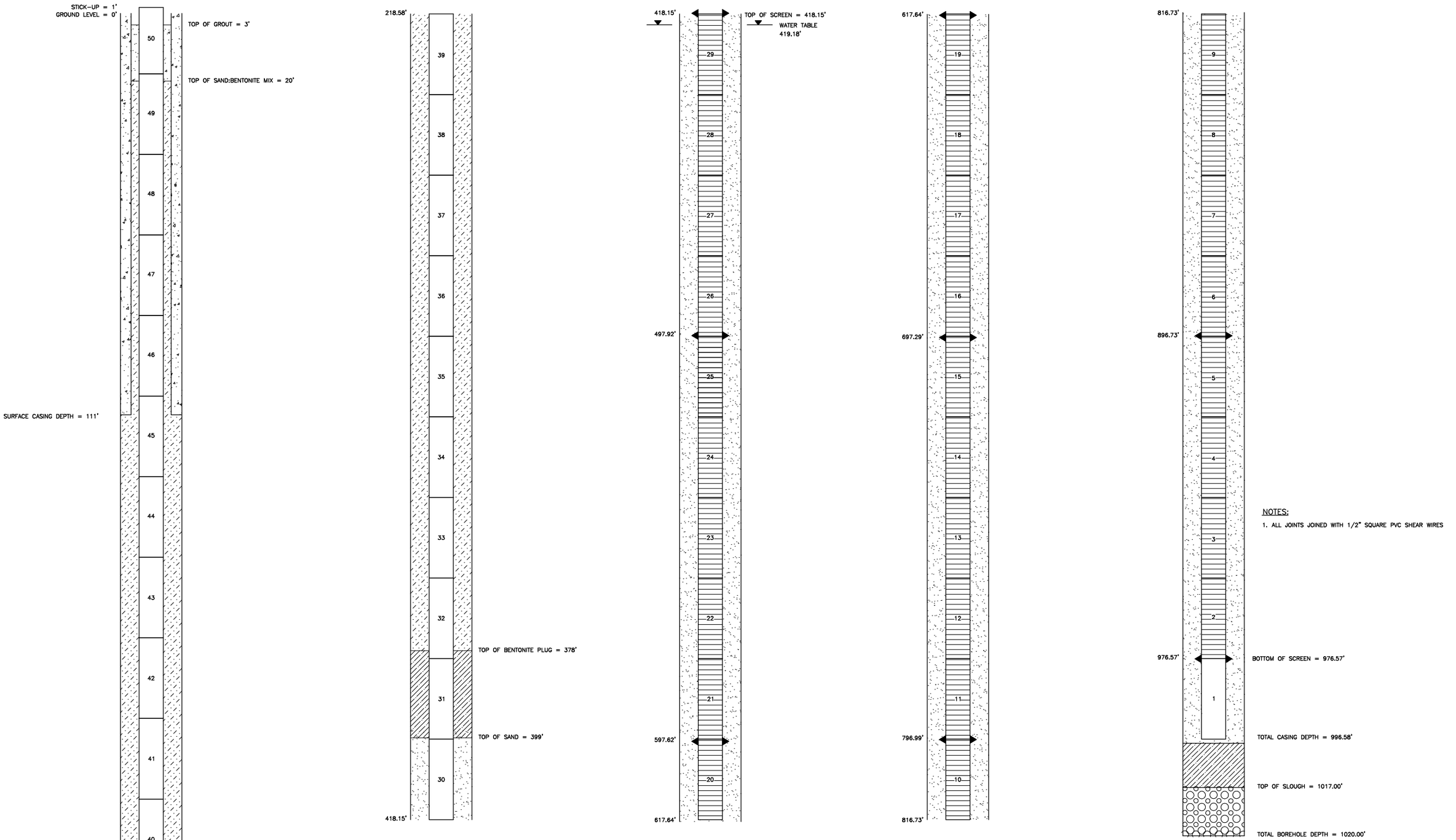
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION
INJECTION WELL PFI-1
CIVIL
DETAILS AT WELLHEAD

A.B. DWG. NO. | SCALE 3/4"=1'-0" | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 660-C-01 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

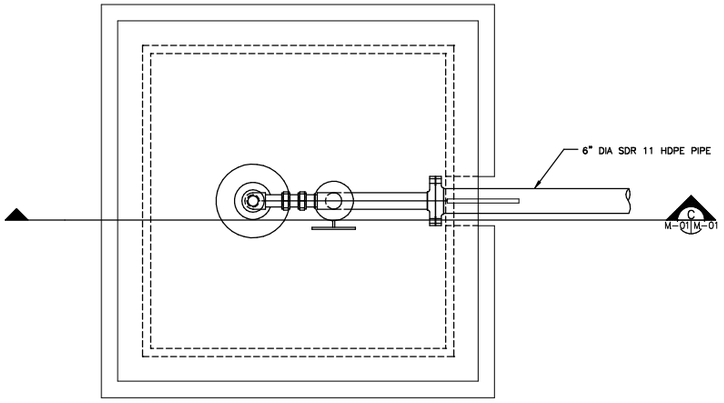
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
INJECTION WELL PFI-1
CIVIL
WELL COMPLETION DIAGRAM

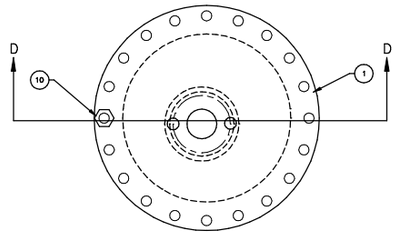
A.B. DWG. NO.	SCALE	SHEET	OF
	NONE	1	1

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	660-C-02	

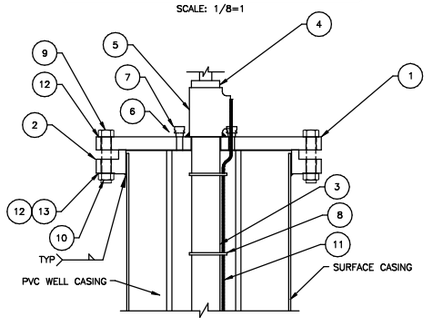
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



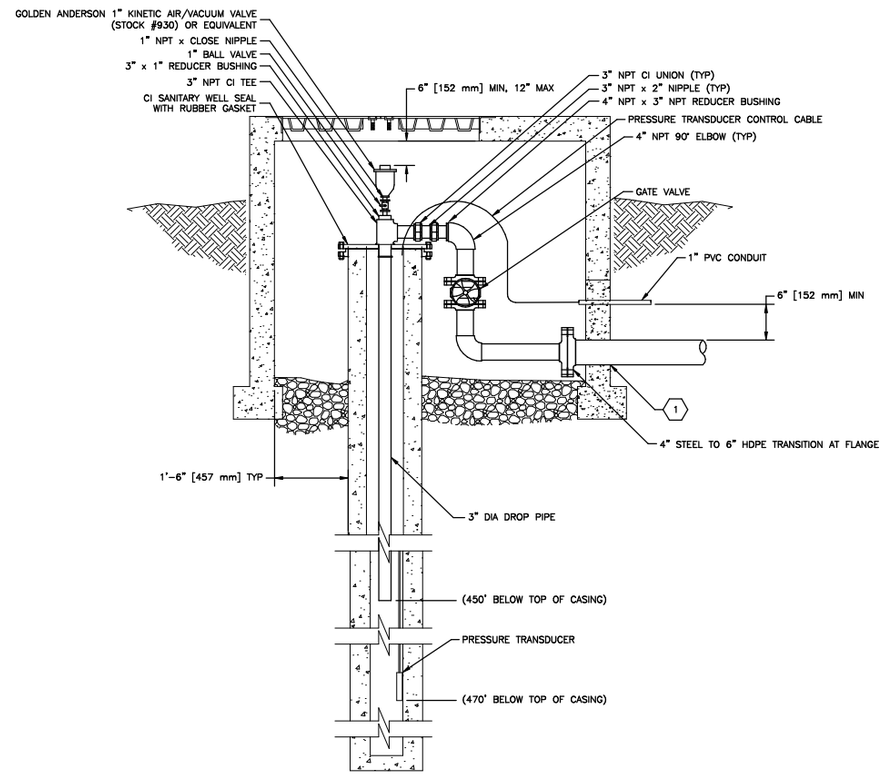
PFI-1 INJECTION WELLHEAD



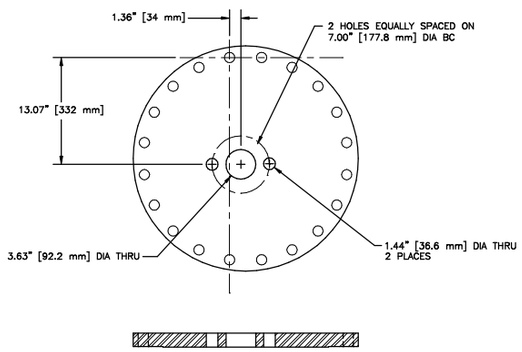
DETAIL 6: WELLHEAD ASSEMBLY
SCALE: 1/8=1



SECTION D-D



C SECTION
M-01 M-01



1 BLIND FLANGE
SCALE: 1/8=1

KEYED NOTES:

1. FOLLOWING PIPE INSTALLATION INTO VAULT, SLOTTED ENTRY SHALL BE FORMED OVER AND FILLED WITH CONCRETE

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
4	13		WASHER, LOCK, 1.125" DIA	CS		
8	12		WASHER, FLAT, 1.125" DIA	CS		
	11		TRANSDUCER CABLE	CU		
4	10		NUT, 1.125" DIA	CS		
4	9		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
	8		STRAP	SS		
2	7		STRAIN RELIEF CONNECTOR, 1"	SS		
2	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		TEE, 3"	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		REDUCER BUSHING, 3" x 1"	CS		
1	3		DROP PIPE, 3" DIA x 450', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-25-00
ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

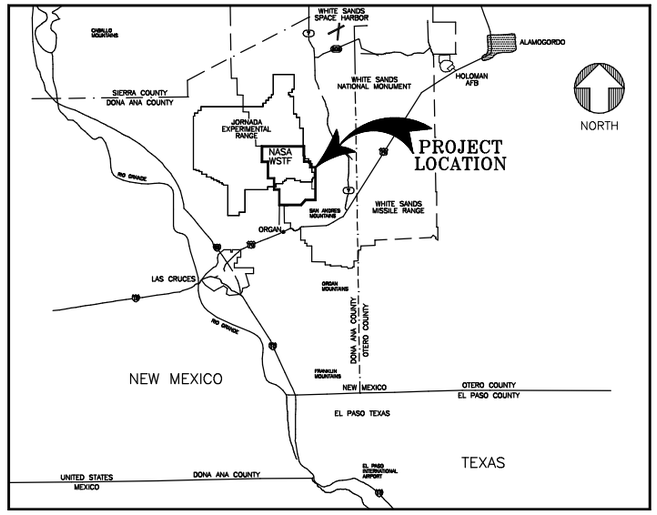
WSTF - PLUME-FRONT REMEDIATION
INJECTION WELL PFI-1
MECHANICAL
DETAILS AT WELLHEAD

A.B. DWG. NO. | SCALE 3/4"=1'-0" | SHEET 1 OF 1

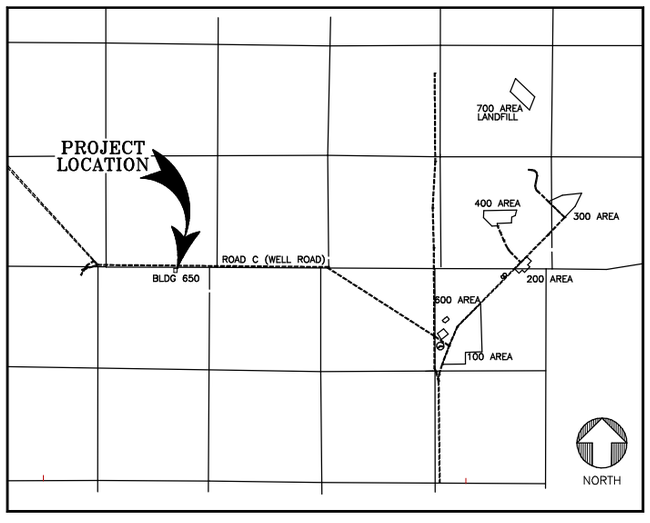
CODE IDENT. F | SIZE | DWG. NO. 660-M-01 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

GENERAL LOCATION



WSTF LOCATION



SITE LOCATION

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	7-29-99
ENGINEER	E. BAGWELL	7-29-99
DESIGNED BY	E. BAGWELL	7-29-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

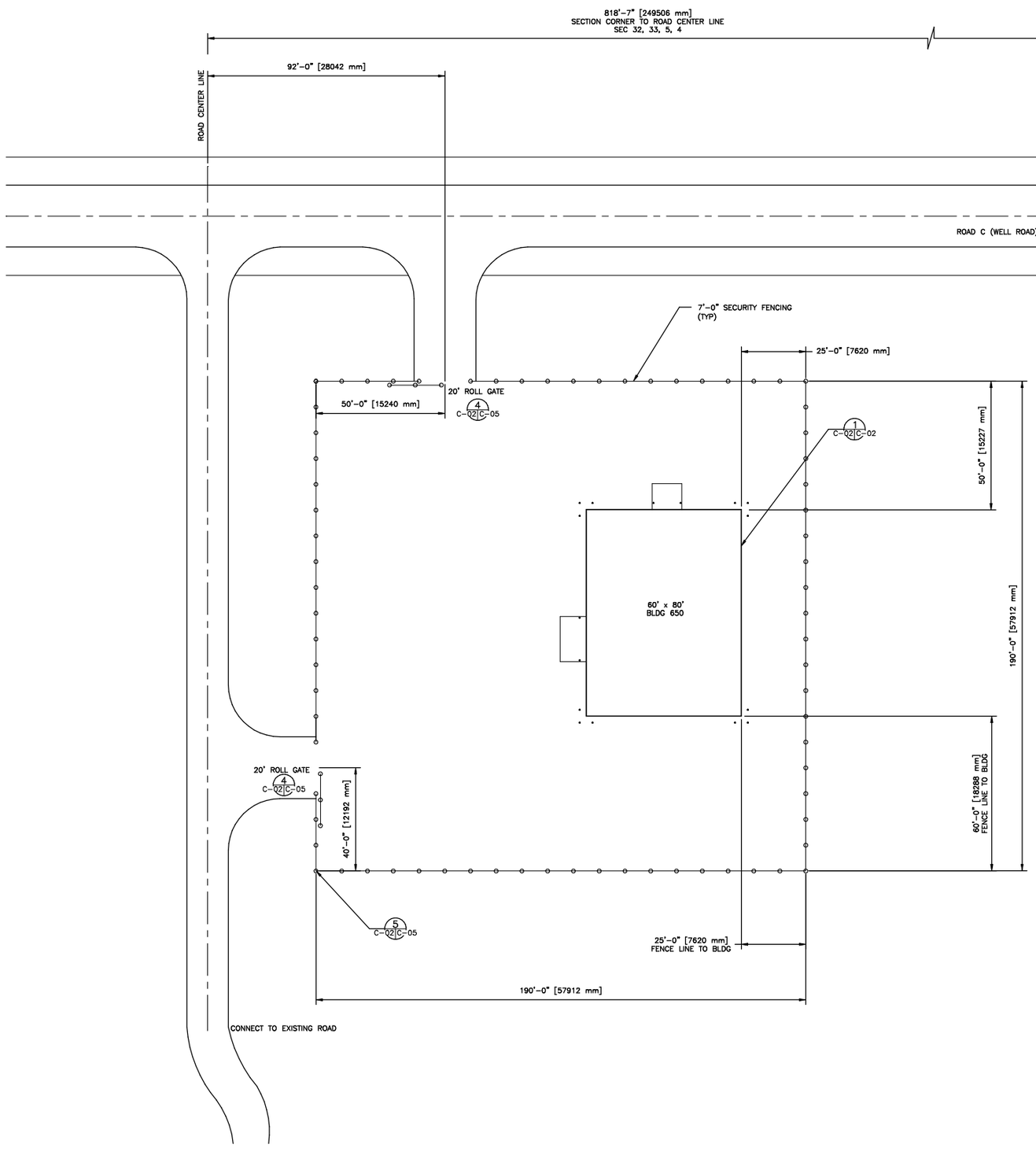
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

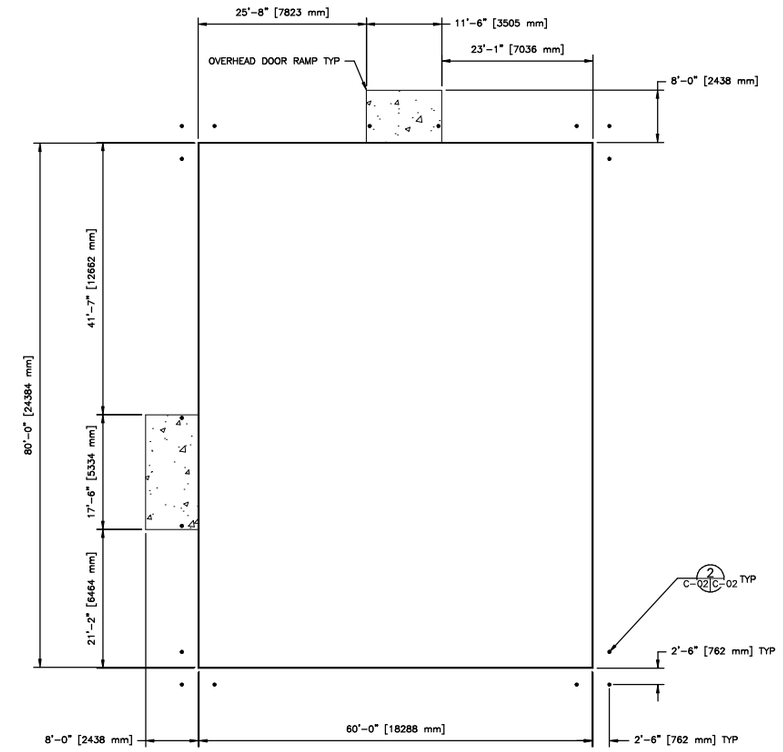
WSTF – PLUME–FRONT REMEDIATION
BUILDING 650, TREATMENT FACILITY
CIVIL
PROJECT LOCATION

A.B. DWG. NO.	SCALE	SHEET	OF
	NONE	1	1

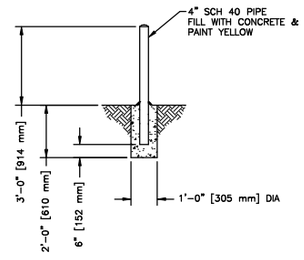
CODE IDENT.	SIZE	DWG. NO.	REV.
	F	650–C–01	

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL





1 C-02|C-02 DETAIL: RAMP & BOLLARD LOCATIONS



2 C-02|C-02 DETAIL: BOLLARD

NORTH

0 20 40 60 FEET

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	7-29-99
ENGINEER	E. BAGWELL	7-29-99
DESIGNED BY	E. BAGWELL	7-29-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

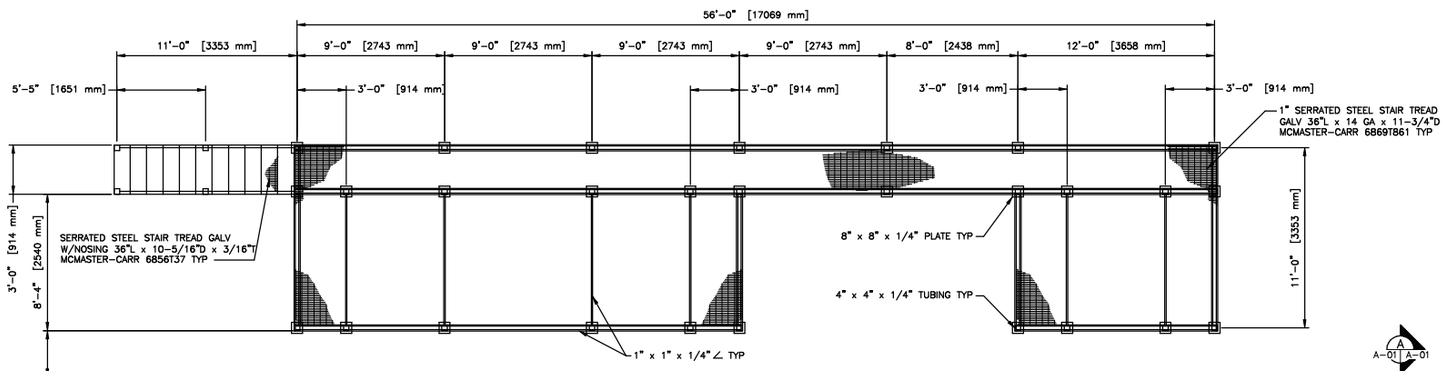
PLUME-FRONT REMEDIATION
BUILDING 650, TREATMENT FACILITY
CIVIL
SITE PLAN

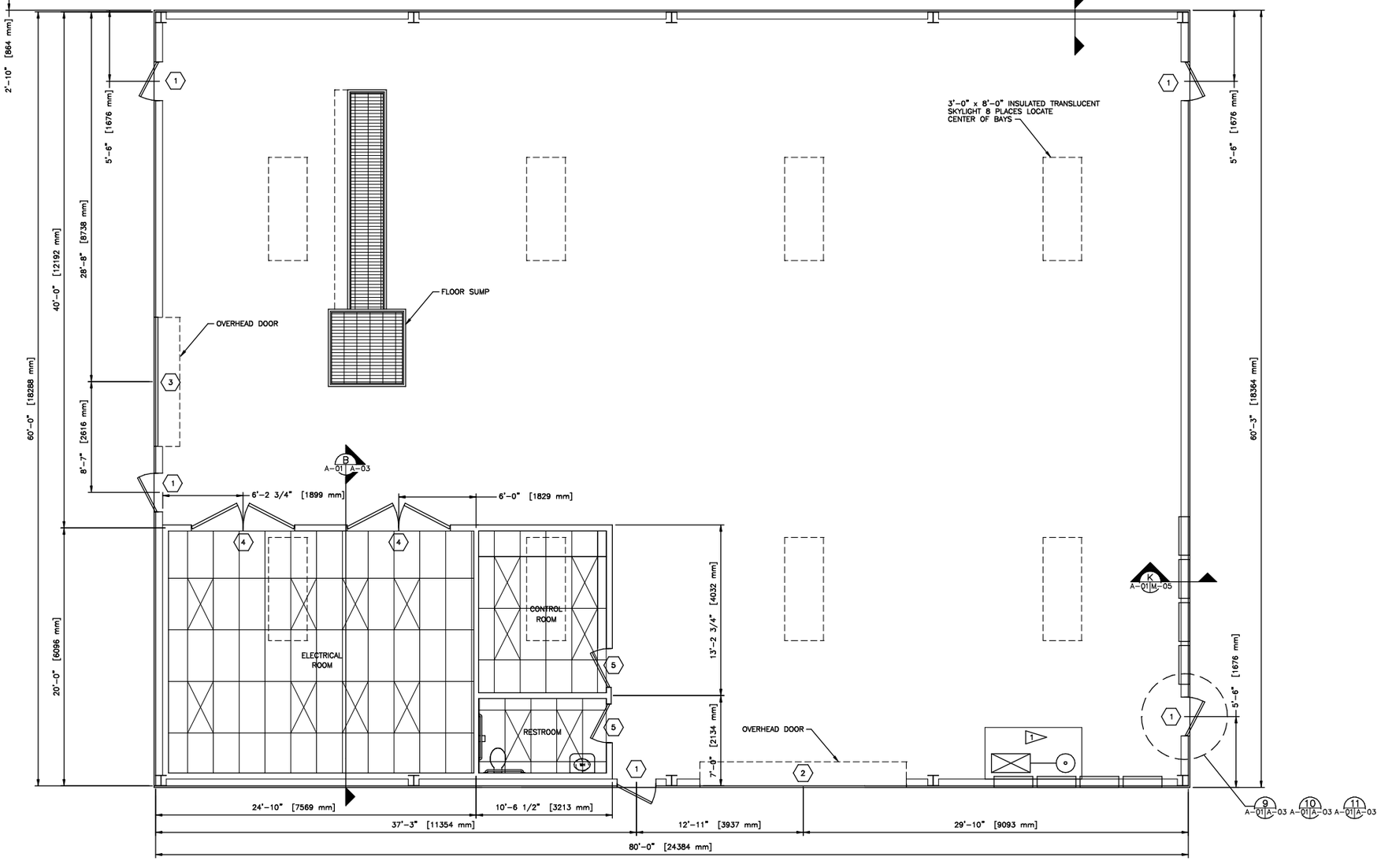
A.B. DWG. NO. | SCALE 1" = 20' | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 650-C-02 | REV.

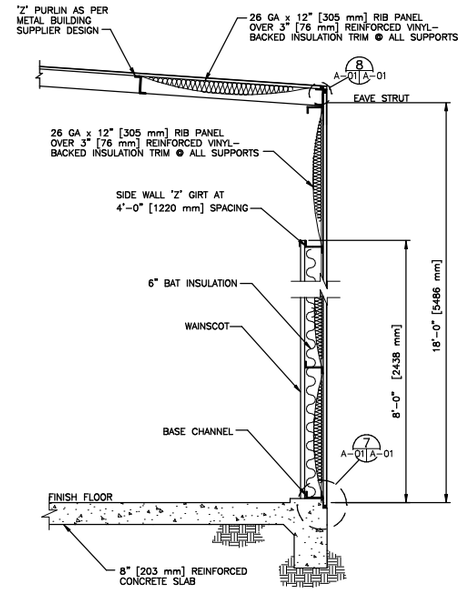
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

NORTH

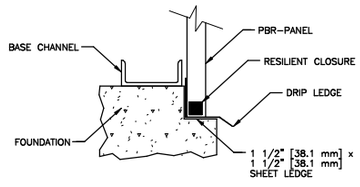




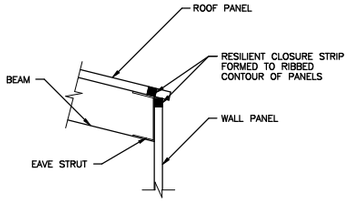
TREATMENT FACILITY FLOOR PLAN
SCALE: 1/4"=1'-0"



EXTERIOR WALL SECTION
SCALE: 1/2" = 1'-0"



DETAIL: SHEET LEDGE
NTS



EXTERIOR CORNER DETAIL
NTS

DOOR SCHEDULE (SEE 650-A-03)

NO	SIZE	TYPE	FRAME DETAIL	HARDWARE	# REQUIRED	REMARKS
1	3'-0" x 7'-0" x 1 3/4"	A	9, 10, 11	A, B, C, D, E, F, G	5	PANIC HARDWARE (EXT)
2	16'-0" x 12'-0"	B	PER MFR	PER MFR	1	CHAIN OPERATED OVERHEAD COILING DOOR
3	10'-0" x 12'-0"	B	PER MFR	PER MFR	1	CHAIN OPERATED OVERHEAD COILING DOOR
4	4'-0" x 10'-0"	A	PRE-HUNG	A, E, F	4	
5	3'-0" x 7'-0" x 1 3/4"	A	PRE-HUNG	A, E, F	2	

FINISH SCHEDULE

NO	NAME	FLOOR	BASE	WALLS	WALL FINISH	HGT	REMARKS
650	TREATMENT FACILITY BUILDING	SEALED CONCRETE	NONE	NONE	WAINSCOT-8'-0"	18'-0"	–
	RESTROOM	VINYL TILE	WOOD	SHEETROCK	PAINT	8'-0"	–
	CONTROL ROOM	PAINTED	WOOD	SHEETROCK	PAINT	8'-0"	–
	ELECTRICAL ROOM	PAINTED	VINYL	SHEETROCK	PAINT	8'-0"	–

NOTES:
1. 4'-0" x 7'-6" SAFETY RED PAINTED AREA WITH NON-SKID PARTICLES EMBEDDED INTO PAINT

0 4 8 12 FEET

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S: 650-A-03, 650-M-05

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000± DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	7-26-99
ENGINEER	E. BAGWELL	2-28-00
DESIGNED BY	E. BAGWELL	2-28-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

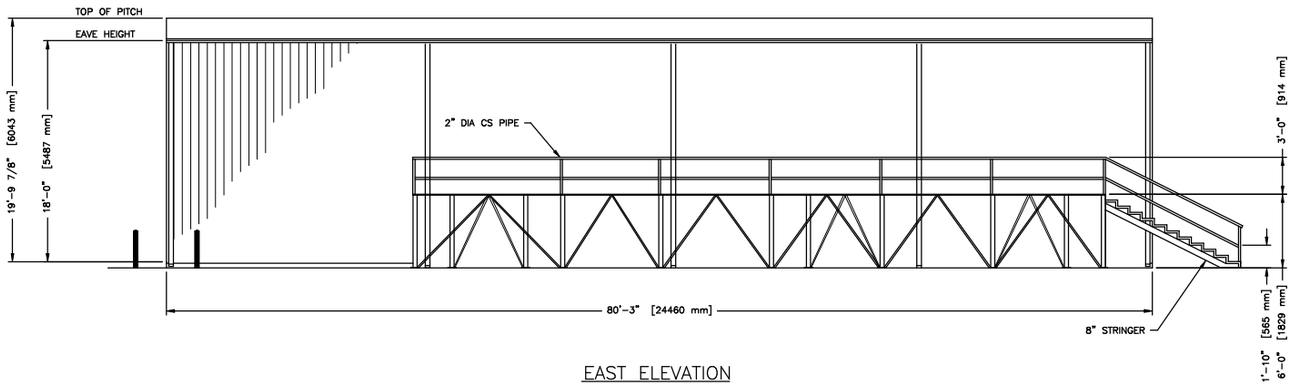
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

PLUME-FRONT REMEDIATION
BUILDING 650 TREATMENT FACILITY
ARCHITECTURAL
FLOOR PLAN

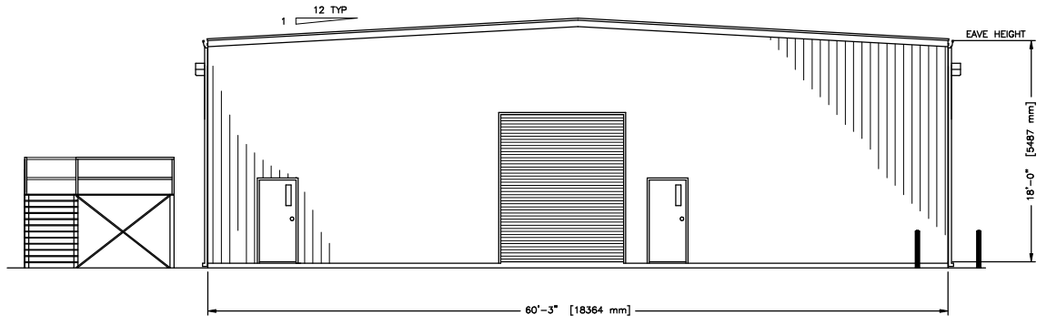
A.B. DWG. NO. | SCALE AS SHOWN | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 650-A-01 | REV.

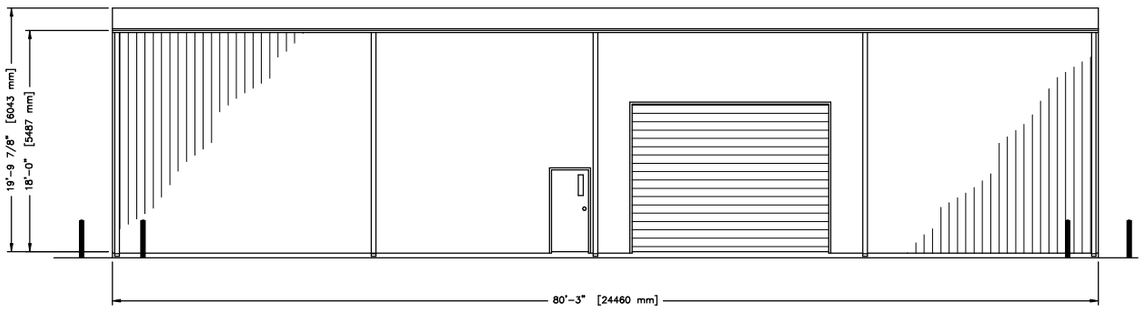
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



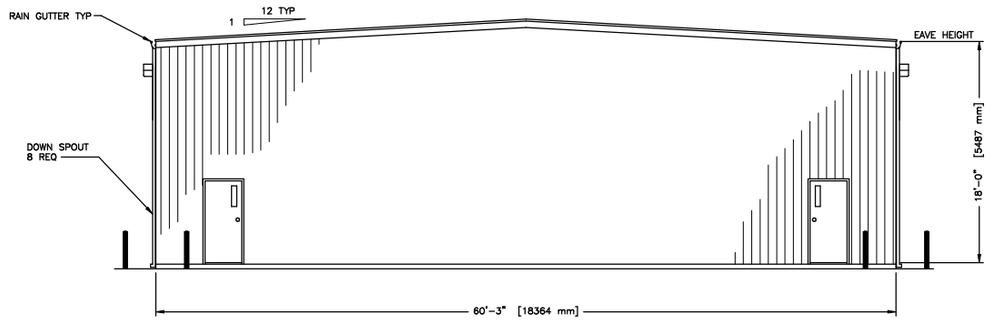
EAST ELEVATION



NORTH ELEVATION



WEST ELEVATION



SOUTH ELEVATION

BUILDING DESIGN PARAMETERS

BUILDING:	PRE-ENGINEERED BUILDING SHALL BE THE PRODUCT OF A RECOGNIZED MANUFACTURER AND COMPLY WITH REQUIREMENTS OF THE METAL BUILDING MANUFACTURER'S ASSOCIATION. THE BUILDING CONTRACTOR SHALL FURNISH COMPLETE ERECTION DRAWINGS AND DESIGN ANALYSIS/CERTIFICATE OF COMPLIANCE SIGNED BY A NEW MEXICO REGISTERED PROFESSIONAL ENGINEER CERTIFYING THAT METAL COMPONENTS COMPLY TO MBMA AND BUYER RECOMMENDATIONS.
SIZE:	60' [18288 mm] WIDE x 80' [24384 mm] LONG x 18' [4877 mm] EAVE HEIGHT
LOADING:	30 PSF LIVE LOAD. ROOF AND WALLS TO RESIST A 100 MPH WIND LOAD. (EXPOSURE C AS PER UNIFORM BUILDING CODE).
ROOF TYPE:	GABLE ROOF WITH 3" VINYL BACKED INSULATION, TRIM ⊕ ALL SUPPORTS
ROOF SLOPE:	1/12
UNFINISHED EXTERIOR WALLS:	INSULATED WITH 3" VINYL BACKED INSULATION, TRIM ⊕ ALL SUPPORTS
END WALL CONDITIONS:	EAST & WEST SIDES TO HAVE BEARING END WALL CONDITION.
PANELS:	26 GA PBR PANEL-ROOF. 26 GA PBR PANEL-WALL.
STRUCTURE:	BUILDING TO HAVE A TAPERED OR UNIFORM DEPTH RAFTER SUPPORTED ON UNIFORM DEPTH SIDE WALL COLUMNS. THE FRAME SHALL SPAN THE WIDTH OF THE BUILDING SUPPORTING THE SECONDARY MEMBERS AND THE ROOF AND WALL COVERINGS. THE SECONDARY WALL FRAMING OR GIRTS SHALL INSET INTO COLUMN LINE FOR MAXIMUM UTILIZATION OF SPACE.

0 4 8 12 16 FEET

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S.

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	8-9-99
ENGINEER	E. BAGWELL	8-9-99
DESIGNED BY	E. BAGWELL	8-9-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

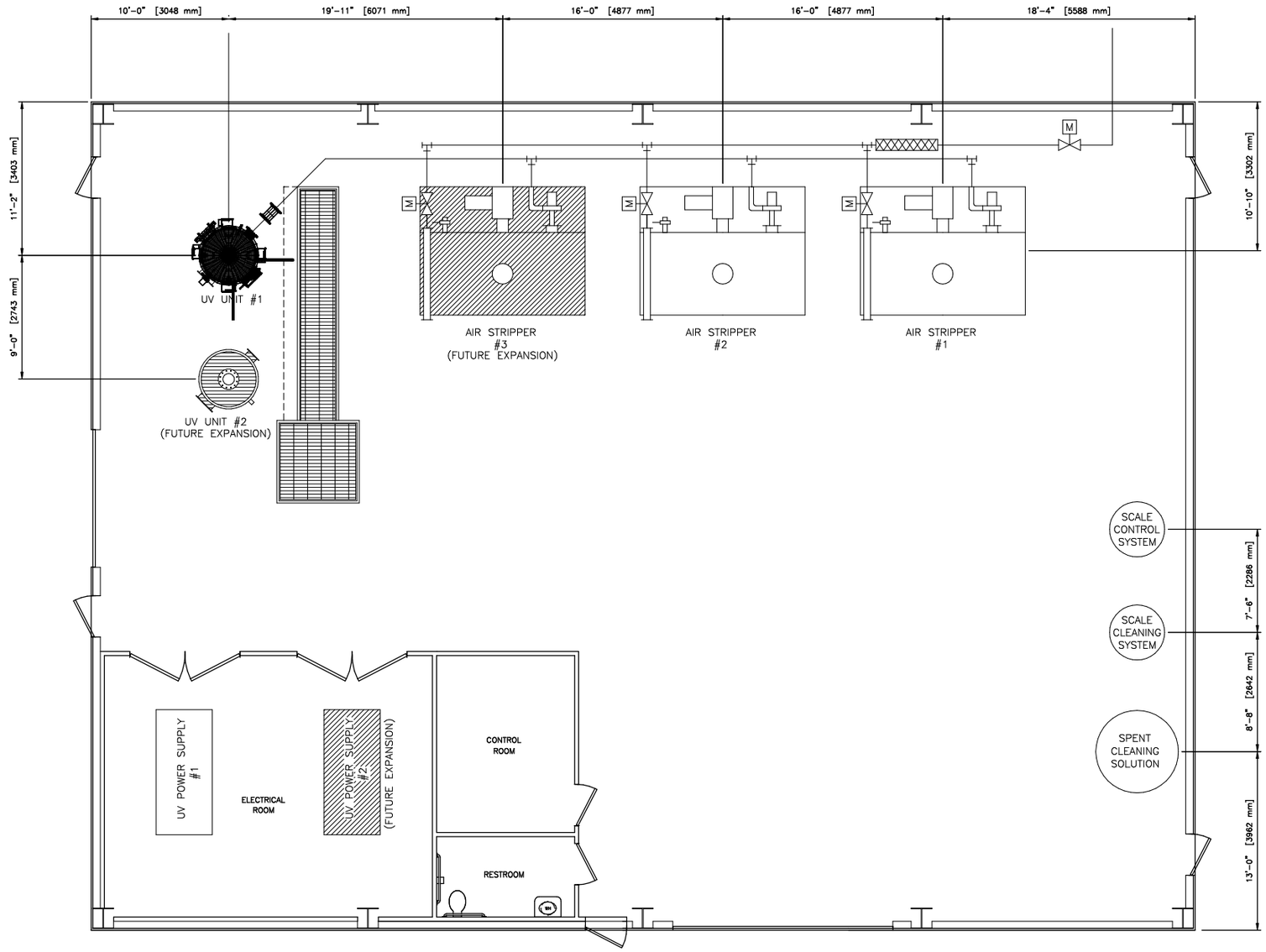
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

PLUME-FRONT REMEDIATION
BUILDING 650, TREATMENT FACILITY
ARCHITECTURAL
ELEVATIONS

A.B. DWG. NO. | SCALE 3/16" = 1'-0" | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 650-A-02 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



EQUIPMENT LAYOUT PLAN

SCALE: 1/4"=1'-0"

NORTH

0 4 8 12 FEET

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	10-21-99
ENGINEER	J. KIRBY	10-21-99
DESIGNED BY	J. KIRBY	10-21-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

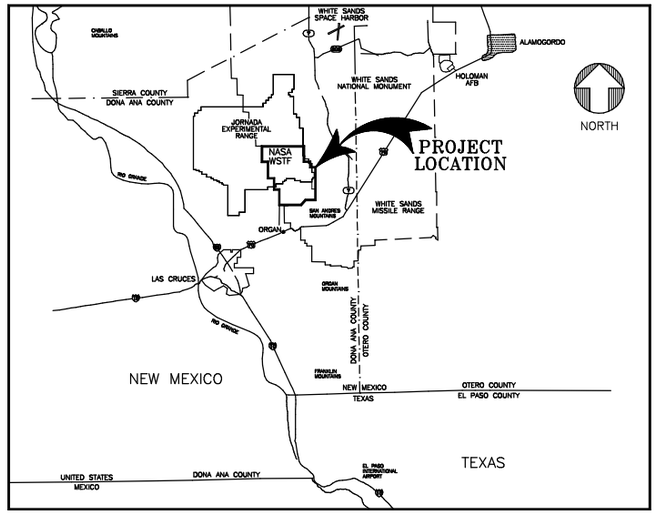
WSTF – PLUME FRONT REMEDIATION
BUILDING 650, TREATMENT FACILITY
MECHANICAL
EQUIPMENT LAYOUT

A.B. DWG. NO. | SCALE 1/4"=1'-0" | SHEET 1 OF 1

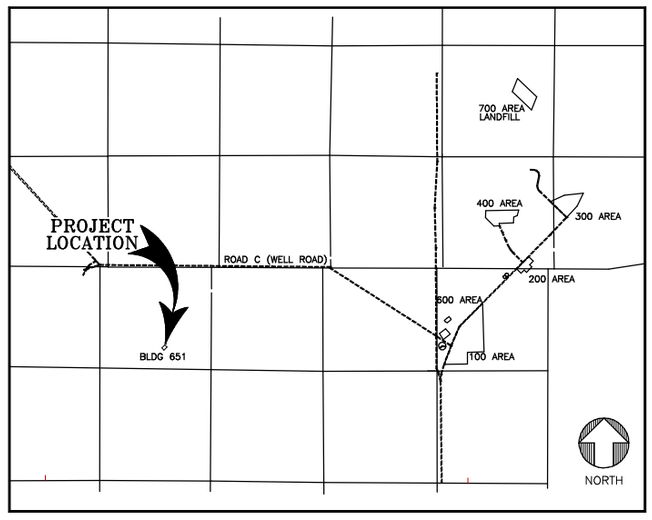
CODE IDENT. | SIZE F | DWG. NO. 650-M-06 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

GENERAL LOCATION



WSTF LOCATION



SITE LOCATION

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	7-29-99
ENGINEER	E. BAGWELL	7-29-99
DESIGNED BY	E. BAGWELL	7-29-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

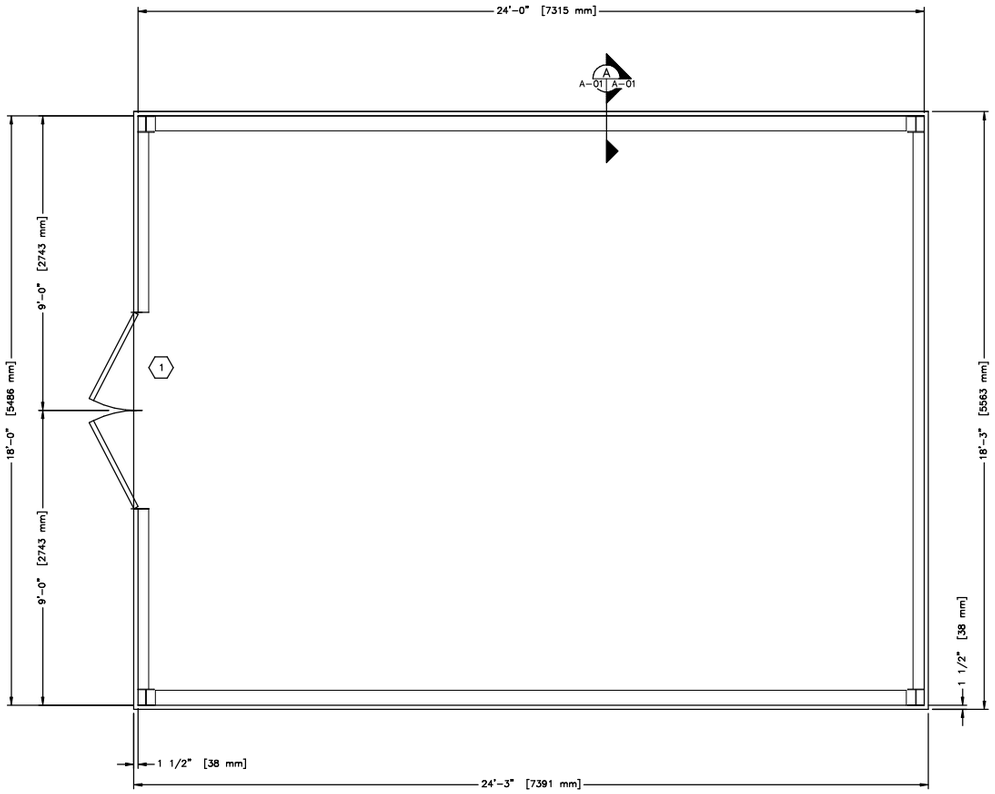
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

PLUME-FRONT REMEDIATION
BUILDING 651, INJECTION MANIFOLD BUILDING
CIVIL
PROJECT LOCATION

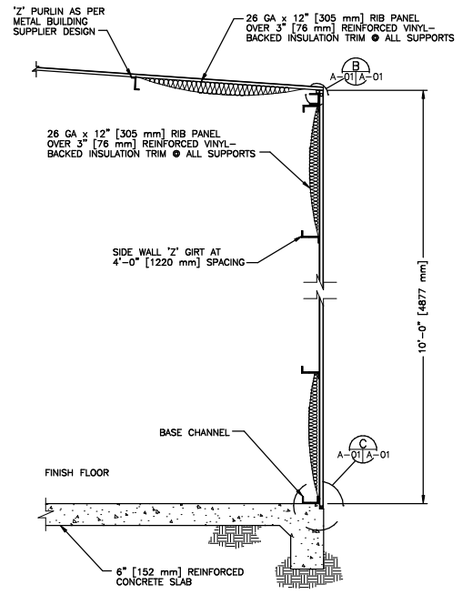
A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 651-C-01 | REV.

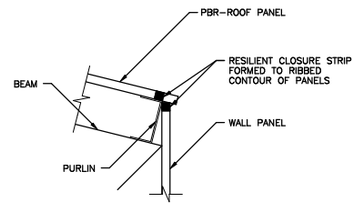
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



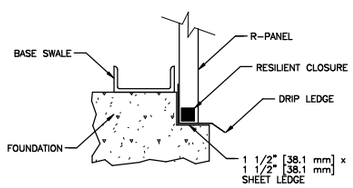
FLOOR PLAN



A A-01 A-01 TYPICAL EXT WALL SECTION
SCALE: 1/2" = 1'-0"



B A-01 A-01 TYPICAL EXT CORNER DETAIL
NTS



C A-01 A-01 DETAIL SHEET LEDGE
NTS

DOOR SCHEDULE (SEE 651-A-03)

NO	SIZE	TYPE	FRAME DETAIL	HARDWARE	# REQUIRED	REMARKS
1	3'-0" x 7'-0" x 1 3/4"	A	1, 2, 3	A, B, C, D, E, F, G	2	ENTRY LOCKSET

FINISH SCHEDULE

NO	NAME	FLOOR	BASE	WALLS	WALL FINISH	CEILING	HGT	REMARKS
651	INJECTION MANIFOLD BUILDING	SEALED CONCRETE	NONE	NONE	NONE	NONE	10'-0"	–

NORTH

0 2 4 6 FEET

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	1-21-00
ENGINEER	E. BAGWELL	2-25-00
DESIGNED BY	E. BAGWELL	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

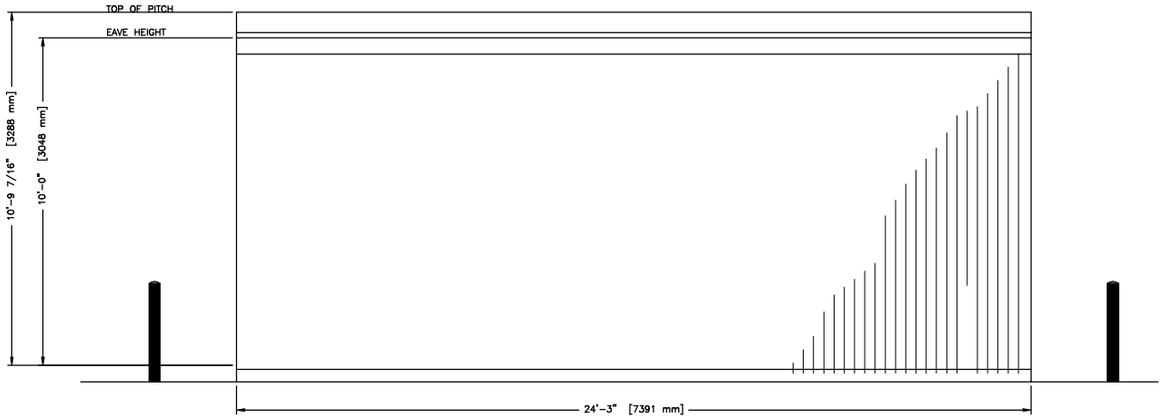
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
BUILDING 651, INJECTION MANIFOLD BUILDING
ARCHITECTURAL
FLOOR PLAN

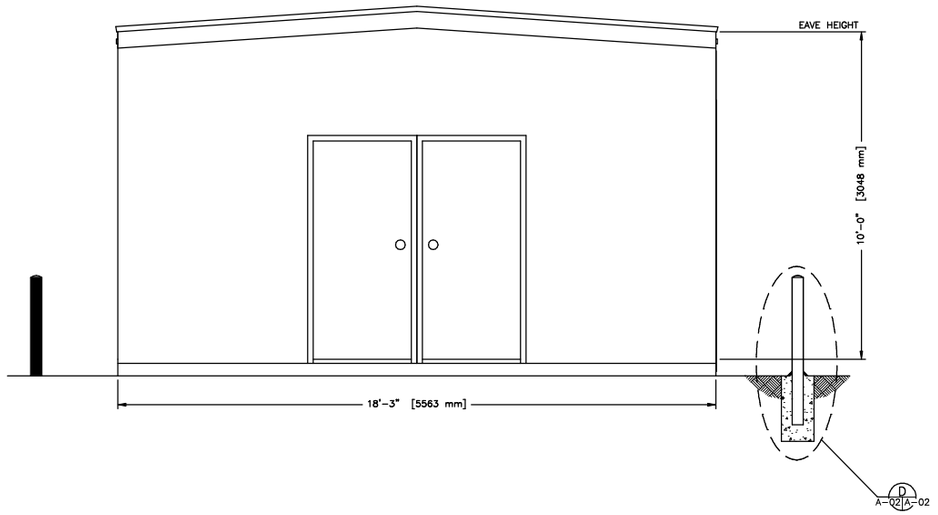
A.B. DWG. NO. | SCALE 1/2"=1'-0" | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 651-A-01 | REV.

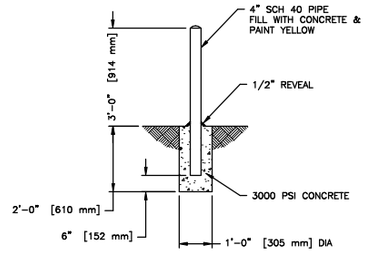
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



EAST ELEVATION



SOUTH ELEVATION



D A-02 DETAIL: BOLLARD

BUILDING DESIGN PARAMETERS

BUILDING:	PRE-ENGINEERED BUILDING SHALL BE THE PRODUCT OF A RECOGNIZED MANUFACTURER AND COMPLY WITH REQUIREMENTS OF THE METAL BUILDING MANUFACTURER'S ASSOCIATION. THE BUILDING CONTRACTOR SHALL FURNISH COMPLETE ERECTION DRAWINGS AND DESIGN ANALYSIS/CERTIFICATE OF COMPLIANCE SIGNED BY A NEW MEXICO REGISTERED PROFESSIONAL ENGINEER CERTIFYING THAT METAL COMPONENTS COMPLY TO MBMA AND BUYER RECOMMENDATIONS.
SIZE:	18' [5486 mm] WIDE x 24' [7315 mm] LONG x 10' [3048 mm] EAVE HEIGHT
LOADING:	30 PSF LIVE LOAD. ROOF AND WALLS TO RESIST A 100 MPH WIND LOAD. (EXPOSURE C AS PER UNIFORM BUILDING CODE).
ROOF TYPE:	GABLE ROOF WITH 3" VINYL BACKED INSULATION, TRIM ● ALL SUPPORTS
ROOF SLOPE:	1/12
UNFINISHED EXTERIOR WALLS:	INSULATED WITH 3" VINYL BACKED INSULATION, TRIM ● ALL SUPPORTS
END WALL CONDITIONS:	EAST & WEST SIDES TO HAVE BEARING END WALL CONDITION.
PANELS:	26 GA PBR PANEL-ROOF. 26 GA R PANEL-WALL.
STRUCTURE:	BUILDING TO HAVE A TAPERED OR UNIFORM DEPTH RAFTER SUPPORTED ON UNIFORM DEPTH SIDE WALL COLUMNS. THE FRAME SHALL SPAN THE WIDTH OF THE BUILDING SUPPORTING THE SECONDARY MEMBERS AND THE ROOF AND WALL COVERINGS. THE SECONDARY WALL FRAMING OR GIRTS SHALL INSET INTO COLUMN LINE FOR MAXIMUM UTILIZATION OF SPACE.

0 2 4 6 FEET

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

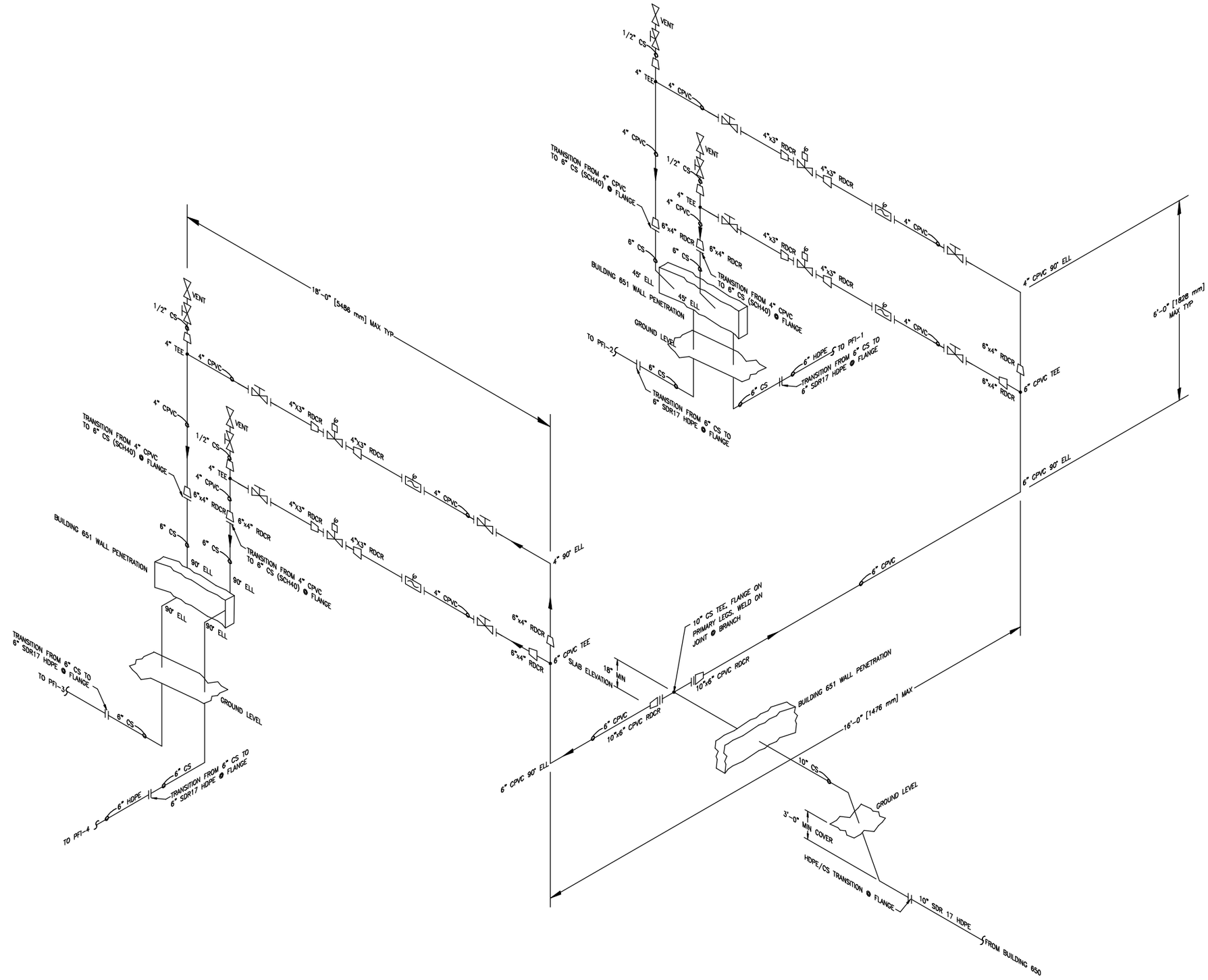
DRAWN BY	M. TARIN	1-21-00
ENGINEER	E. BAGWELL	1-21-00
DESIGNED BY	E. BAGWELL	1-21-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

PLUME-FRONT REMEDIATION
BUILDING 651, INJECTION MANIFOLD BUILDING
ARCHITECTURAL
ELEVATIONS

A.B. DWG. NO.	SCALE 1/2"=1'-0"	SHEET 1 OF 1
CODE IDENT.	SIZE F	DWG. NO. 651-A-02	REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



NOTES:

1. ALL CPVC PIPE AND FITTINGS SHALL BE SCH 80
2. PORTIONS OF PIPING OUTSIDE OF THE BUILDING AND EXPOSED TO THE ELEMENTS SHALL BE SCH 40 CARBON STEEL

REQ'D PER ASS'Y	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	8-15-00
ENGINEER	J. KIRBY	8-15-00
DESIGNED BY	J. KIRBY	8-15-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME FRONT REMEDIATION
BUILDING 651, INJECTION MANIFOLD BUILDING
MECHANICAL
LAYOUT PLAN

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 651-M-01 | REV.

National Aeronautics and Space Administration

White Sands Test Facility

Air Stripper Bid Specifications

Table of Contents

1. GENERAL 2
   1.1 Description 2
   1.2 Definitions 2
   1.3 Vendor Qualifications 2
   1.4 Reference Standards 3
   1.5 Inspection 3
   1.6 Submittals 3
   1.7 Approval of Equivalent Substitutions 4
   1.8 Warranty 4
   1.9 Equipment Destination 4
2. MATERIALS AND EQUIPMENT 5
   2.1 Air Stripper 5
   2.2 Optional Scale Cleaning and Control Systems 9
   2.3 Performance of Air Strippers 11
3. FABRICATION, ASSEMBLY, TESTING, AND SHIPPING 12
   3.1 Fabrication and Assembly 12
   3.2 Testing 12
   3.3 Shipping 12
4. EXECUTION 12
5. DELIVERY SCHEDULE 12

ATTACHMENTS

1. Process Flow Diagram
2. Farr Model 4P Glide/Pack® Specifications and Cut Sheet
3. Section 11240: Chemical Metering Pumps
4. Section 13390, Supplement A: Package Control System Component Specifications
5. Section 15150: Electric Valve Operators
6. Section 16405: AC Induction Motors

1. GENERAL

1.1 Description

This Bid Specification outlines the requirements for the volatile organic compound (VOC) treatment equipment needed for the plume-front remediation system currently being designed for the National Aeronautics and Space Administration's (NASA's) White Sands Test Facility (WSTF). The plume-front remediation system is a groundwater pump-and-treat system, for the treatment of n-nitrosodimethylamine (NDMA), trichloroethylene (TCE), tetrachloroethylene (PCE), and several Freon® compounds.

VENDOR shall furnish two (2) factory-assembled sieve tray air strippers, complete with discharge pumps, blowers, controls, and related equipment as required by this specification. The air strippers shall be designed for the removal of volatile organic compounds (VOCs) from groundwater, incorporating fresh air flowing through multiple perforations in the bottom of one or more trays, developing a turbulent froth in the counter-current liquid stream flowing across each tray.

1.2 Definitions

The term "NASA" used in these specifications refers to NASA and its representatives designated by the Contracting Officer. The term "Contracting Officer" refers to the procurement official or buyer administering this contract. The term "VENDOR" refers to the firm selected and contracted to supply the materials and services described in these Air Stripper Bid Specifications.

1.3 Vendor Qualifications

1.3.1 Vendors who have installed sieve tray air stripper systems for the treatment of VOCs in groundwater, at a flow rate of no less than 450 gpm per stripper, shall be considered.

1.3.2 Vendors who have installed sieve tray air stripper systems for the treatment of VOCs, for a period of no less than 5 years, shall be considered.

1.3.3 Vendors who have installed sieve tray air stripper systems for the treatment of VOCs, for no less than 50 applications, shall be considered.

1.4 Reference Standards

The manufacture of the air stripper shall comply with the applicable provisions of the following:

A. Hydraulic Standard Institute
B. National Electrical Manufacturers Association (NEMA)
C. National Electric Code (NEC)
D. Underwriters Laboratory (UL)

VENDOR shall assume complete responsibility for conformance with the Reference Standards listed above, and this Bid Specification. In the event there is an inconsistency between this Bid Specification and the attachments, it is the VENDOR's responsibility to contact NASA to resolve the inconsistency.

1.5 Inspection

The quality of all equipment and materials shall be subject to the inspection and approval of NASA. The performance testing required in Section 3 of this specification shall be subject to the inspection and approval of NASA. NASA reserves the right to conduct inspection of the equipment, materials of construction, and performance testing at VENDOR's manufacturing facility. NASA reserves the right to designate a representative to conduct the inspection and performance testing of the air strippers. VENDOR shall notify NASA a minimum of 2 weeks in advance of the day fabrication of the air strippers commences. VENDOR shall notify NASA a minimum of 2 weeks in advance of the day the performance testing required in Section 3 commences.

1.6 Submittals

1.6.1 Bid Package

VENDOR shall provide as a minimum, but not limited to, the following information in its bid package:

A. Written guarantee that the air strippers will continuously meet the performance standards listed in Section 2.3 of this specification.
B. Documentation that VENDOR meets the qualification requirements listed in Section 1.3 of this specification.
C. Manufacturers catalog data for all equipment, components, and accessories.
D. A list of common spare parts (including sources, part numbers, and recommended quantities) that may kept in inventory by NASA.
E. Characteristic curves for the pumps and blowers selected by the VENDOR.
F. An estimate of the lead-time required to commence fabrication, and the time needed to fabricate, test, and deliver the air strippers and related equipment.
G. Manufacturers cut sheets of vendor-supplied components.
H.

1.6.2 Drawings.

Within four (4) weeks of award of the purchase order, VENDOR shall provide NASA with the following information:

A. Shop drawings
B. Manufacturers cut sheets and electrical schematics.
C. Process & instrumentation drawings showing all vendor-supplied components.
D. Printed instructions and drawings sufficient for proper installation of the air strippers.

VENDOR shall not commence fabrication of the air strippers until NASA approves all drawings, cut sheets, and schematics listed in this section, and provides VENDOR with a written Notice to Proceed.

1.6.3 Operation and Maintenance Documentation

The following information shall be sent to NASA two (2) weeks prior to shipment of the air strippers:

A. Six (6) complete copies of the O&M Manual
B. Equipment and Performance warranty
C. VHS videotape demonstrating start-up, operation, maintenance, and shut-down procedures.
D. Two (2) 3.5 inch floppy disk copies of the completely documented PLC program, along with two (2) fully annotated printed copies.

1.7 Approval of Equivalent Substitutions

VENDOR may propose substitutions to the equipment or materials of construction described in this specification. NASA reserves the right to accept or reject any such proposals.

1.8 Warranty

VENDOR shall warrant the air strippers and associated equipment for a period of twelve (12) months from the date of system start-up.

1.9 Equipment Destination

The air stripper system shall be shipped to:

NASA Johnson Space Center
White Sands Test Facility (WSTF)
Building 120
U.S. Highway 70, 18 miles Northeast of Las Cruces
Las Cruces, New Mexico, 88012

2. MATERIALS AND EQUIPMENT

2.1 Air Stripper

2.1.1 Mechanical

The air strippers shall be designed and built to meet the following requirements:

2.1.1.1 Two strippers (to be plumbed in parallel) shall be capable of treating the design flow rate specified in Table 2.1. Refer to Attachment 1, Process Flow Diagram, for configuration of the Plume-Front Treatment System.

2.1.1.2 The air strippers shall be suitable for installation on an unsealed, sealed, or painted concrete floor in an industrial indoor environment maintained between 40º F and 100º F.

2.1.1.3 The air strippers shall be equipped with sieve trays, the number of which shall be determined by performance modeling performed by VENDOR. Trays shall be equipped with downcomers, weirs, sealpots, gaskets, tray cleanout and inspection ports, alignment buttons, latches, and lifting rings or tabs.

2.1.1.4 The sump, trays, and cover of each air stripper shall be constructed of 304L stainless steel.

2.1.1.5 Trays shall be sealed with gaskets to prevent air and water leaks. Tray gaskets shall be made of a material that is not degraded by the contaminants listed in Table 2.1.

2.1.1.6 A mist eliminator shall be installed in each air stripper. The mist eliminators shall be made of a material that is not degraded by the contaminants listed in Table 2.1.

2.1.1.7 All piping external to the strippers shall be schedule 80 PVC with ANSI Class 125 (150 lb.) flanges at the influent and effluent points. National Pipe

Taper (NPT) threaded connections are not considered equivalent or an acceptable substitution for ANSI flanges.

2.1.1.8 Each stripper shall be equipped with groundwater influent and effluent sample ports and valves.

2.1.1.9 Each sump shall be equipped with a manually operated normally-closed drain valve.

2.1.1.10 Electric operators for the motor operated valves shown in the Process Flow Diagram shall comply with the requirements of Section 15150.

2.1.1.11 Skid frame and stanchion (for mounting controls and instrumentation) shall be constructed of steel, with provisions for forklift access. The frame and control stanchion shall be painted with epoxy paint.

2.1.1.12 Blowers and Exhaust

2.1.1.12.1 Each blower shall be direct-driven centrifugal design, with Type B non-sparking internal construction, integrally mounted on the stripper frame with the stripper, sized and arranged to deliver a constant fresh air flow to the stripper air inlet. The air flow rate is to be determined by VENDOR modeling.

2.1.1.12.2 VENDOR shall provide all ducts, filters, dampers, and other air handling equipment for each air stripper. VENDOR shall size and cost the blower using the approximate duct lengths given below. The exhaust ducts will extend from the tops of the air strippers, through roof penetrations, to a height of approximately 10 feet above the roof. Roof height will be approximately 17 feet above the floor of the treatment building. The exhaust duct diameter will be equal to the diameter of the air stripper exhaust port. The inlet ducts will extend from the inlet flanges of the blowers, through wall penetrations, to air filters mounted outside the treatment building. The inlet duct will be approximately 20 feet in length, and will include approximately four 90º elbows.

2.1.1.12.3 VENDOR shall supply an inlet filter housing for each air stripper. Each inlet filter housing shall be a Farr Model 4P Glide/Pack®, or EQUAL, sized for the air flow recommended by VENDOR. Each inlet filter housing shall be provided with a static pressure tap and an inclined manometer air filter gage.

2.1.1.12.4 Air stripper off-gas will be discharged to the atmosphere; no off-gas treatment is required.

2.1.1.13 Discharge Pumps

2.1.1.13.1 A horizontal centrifugal discharge pump shall be supplied with each of the two air stripper skids. Each discharge pump shall be rated for the maximum hydraulic capacity of the stripper, at total head of 150 feet of water.

2.1.1.13.2 Each discharge pump shall be mounted on the air stripper skid.

2.1.1.14 Other Required Appurtenances and Features

2.1.1.14.1 VENDOR shall supply one (1) tray lifter that is designed to attach to lifting lugs or eyes on the air stripper trays. Lifter shall be fabricated for use with a standard fork truck.

2.1.1.14.2 The sump of each air stripper shall be fitted with a sump level sight glass. Isolation valves shall be provided at both the top and bottom of each sight glass.

2.1.1.14.3 The sump of each air stripper shall be fitted with at least one inspection port to facilitate visual inspection of the inside of the sumps.

2.1.1.15 Optional Appurtenances and Features

VENDOR shall include in his quotation the cost of the options listed in this subsection. The cost of each option shall be itemized separately from the costs of the required equipment, appurtenances, features, and spare parts.

2.1.1.15.1 Skid leveling feet, with a range of adjustment of 2 inches.

2.1.1.15.2 One (1) high pressure wash wand for cleaning trays.

2.1.2 Electrical

2.1.2.1 Power

Power to each skid shall be 480 Vac, 3 phase, 4 wire grounded wye, 60 Hz.

2.1.2.2 Motors

All motors used on the air stripper skids shall have the following features:

A. Enclosures of the blower and discharge pump motors shall be TEFC.
B. Duty cycle of the blower and discharge pump motors shall be 100%.
C. Motor insulation shall be Class F.
D. Motors shall be copper wound.
E. Motors shall be high efficiency rated.
F. Power factor and efficiency of the blower and discharge pump motors shall be no less than the values shown in Table 1 of Section 16405.
G. All motors shall comply with the requirements of Section 16405.

2.1.3 Controls and Instrumentation

A master control system that integrates the air strippers, UV oxidation equipment, and other components of the plume-front remediation system will be utilized. This master control system will monitor the operation of all system components, shut the system down under specific conditions, and provide for taking components off-line for maintenance. The air stripper control cabinet shall provide spare contacts for each control function so that the control functions can be monitored at the master control system.

2.1.3.1 Control Panel

Each air stripper skid shall be equipped with a control panel. The control panel shall provide for single point power connection and control of the skid components. The control panel shall be UL listed and include the following:

A. A fused safety disconnect switch with a rating of 480 Vac, 3 pole, 65,000 AIC.
B. Motor starters shall have 2 normally-open and 2 normally-closed auxiliary contacts available for customer use.
C. Motor starters shall be NEMA rated, with electronic overload blocks that provide for loss of phase protection.
D. Control panel enclosure shall be rated NEMA 4/12.
E. Control panels shall be UL listed.
F. All control panels shall comply with the requirements of Section 13390.
G. Control voltage transformer with primary and secondary protection.

H. Each air stripper shall have an individual PLC to permit completely independent operation. VENDOR shall provide Allen Bradley PLC(s) and related components, as stated in Section 13390 Supplement A

2.1.3.2 Instrumentation

A. Each air stripper shall be equipped with the following air flow instrumentation: air pressure meter, air flow meter, low air pressure switch and alarm.
B. Each air stripper shall be equipped with the following water flow instrumentation: digital flowmeter, influent water temperature and pressure gauges, high water level switch and alarm, low water level switch and alarm, and an admittance-type level transmitter complete with a stilling column.
C. Float switches shall be UL listed.
D. Air pressure switches shall be explosion-proof.
E. All instruments shall comply with the requirements of Section 13390, Supplement A.

2.2 Optional Scale Cleaning and Control Systems

VENDOR is requested to bid on scale cleaning and scale control systems as options. The cost of each option shall be itemized separately from the costs of the required equipment, appurtenances, features, and spare parts listed in Sections 2.1 and 2.1.2 of this specification. Refer to Attachment 1, Process Flow Diagram, for the configuration of the scale cleaning and control systems.

2.2.1 Scale Cleaning System

2.2.1.1 The scale cleaning system will be used to periodically dissolve hard water scale from the air stripper trays. Sequence of operation of the scale cleaning system will be to shut down an air stripper, circulate a cleaning chemical through the air stripper by pumping, and collect the cleaning chemical for future use or neutralization and disposal.

2.2.1.2 The cleaning chemical to be used may be one of the following: citric acid, sulfamic acid, tetrasodium EDTA, inhibited hydrochloric acid, or inhibited sulfuric acid. VENDOR shall design the cleaning system to be compatible with the chemicals listed above.

2.2.1.3 The scale cleaning system shall, at a minimum, include:
A. Double-wall containment tank for cleaning chemical storage
B. Cleaning chemical circulation and return pumps

C. Propeller mixer attached to the chemical storage tank, for dissolving powdered chemical in water
D. The VENDOR shall assume 80 feet of physical separation exists between the scale cleaning circulation pump and the air strippers.

A process flow diagram, including the scale cleaning system, is included as Attachment 1.

2.2.2 Scale Control System

2.2.2.1 The scale control system will be used control the amount of scale build-up in the air strippers.

2.2.2.2 The scale control chemical will be a proprietary polyphosphate blend. The scale control chemical may be one of the following:

E. BetzDearborn, Scaletrol 9319
F. Kjell Corp., AquaMag
G. Nalco Chemical Co., 7396
H. Remede Products Inc., Calsperse 500

VENDOR shall design the scale control system to inject 5 ppm to 30 ppm of any of these chemicals into the 900 gpm flow stream.

2.2.2.3 The scale control system shall include, at a minimum:

A. Single-wall tank for storage of scale control chemical.
B. Metering pump for injecting the scale control chemical into the 900 gpm flow stream. The metering pump shall comply with the requirements of Section 11240.
C. A static mixer for dispersing the scale control chemical into the 900 gpm flow stream. Static mixer shall be a Komax “A” series mixer, constructed of carbon steel, with internal diffuser.

VENDOR shall recommend equipment that is chemically compatible with any of the chemicals listed in Section 2.2.2.2.

2.3 Performance of Air Strippers

The air stripper system shall be designed to meet the following specifications:

Table 2.1 Air Stripper Performance Specifications

Criteria	Specification	
Total Hydraulic Flow Rate		950 gpm
Hydraulic Flow Rate per Air Stripper		475 gpm
Maximum Run Time		24 hours per day 365 days per year
Design Life		Not less than 15 years
Air Temperature	Minimum Annual Average Maximum	-13 ºC 17 ºC 44 ºC
Influent Water Temperature		15 to 20 ºC
Site Elevation		4,500 feet amsl
Expected Influent Concentrations	TCE PCE Freon 11 Freon 21 Freon 113	130 µg/L 4.2 µg/L 860 µg/L 60 µg/L 2,000 µg/L
Regulatory Effluent Standards	TCE PCE Freon 11 Freon 21 Freon 113	5 µg/L 5 µg/L 100 µg/L 20 µg/L 1,200 µg/L
Treatment Goals	TCE PCE Freon 11 Freon 21 Freon 113	2.5 µg/L 2.5 µg/L 50 µg/L 10 µg/L 600 µg/L

VENDOR shall document the modeled performance of air strippers using a matrix of conditions, including the range of air and water temperatures listed in Table 2.1. Air strippers shall be sized such that the concentration of each contaminant in the effluent is equal to or less than the appropriate Treatment Goal listed in Table 2.1. In his proposal, VENDOR shall also document the incremental performance and incremental cost of the recommended air stripper with the maximum number of trays available for that model.

Stripping performance for each VOC shall be guaranteed based on VENDOR's actual results demonstrated during full-scale stripping of the contaminants from water on a commercial air stripper. Performance modeling shall be provided for the specific operating conditions listed in Table 2.1.

3. FABRICATION, ASSEMBLY, TESTING, AND SHIPPING

3.1 Fabrication and Assembly

The manufacturer shall furnish all tools, materials, labor, and appurtenances necessary for the complete fabrication, testing and shipment of the air strippers and appurtenances. All equipment shall be new and unused, except for equipment used in final check-out testing.

3.2 Testing

Successful bidder shall test the assembled air strippers at design air and water flow rates to confirm proper hydraulic, electrical, control, and leak-free performance of basic system and all accessories. Documentation of test results shall be provided to NASA prior to shipment of the air strippers.

3.3 Shipping

VENDOR shall ship the system FOB destination.

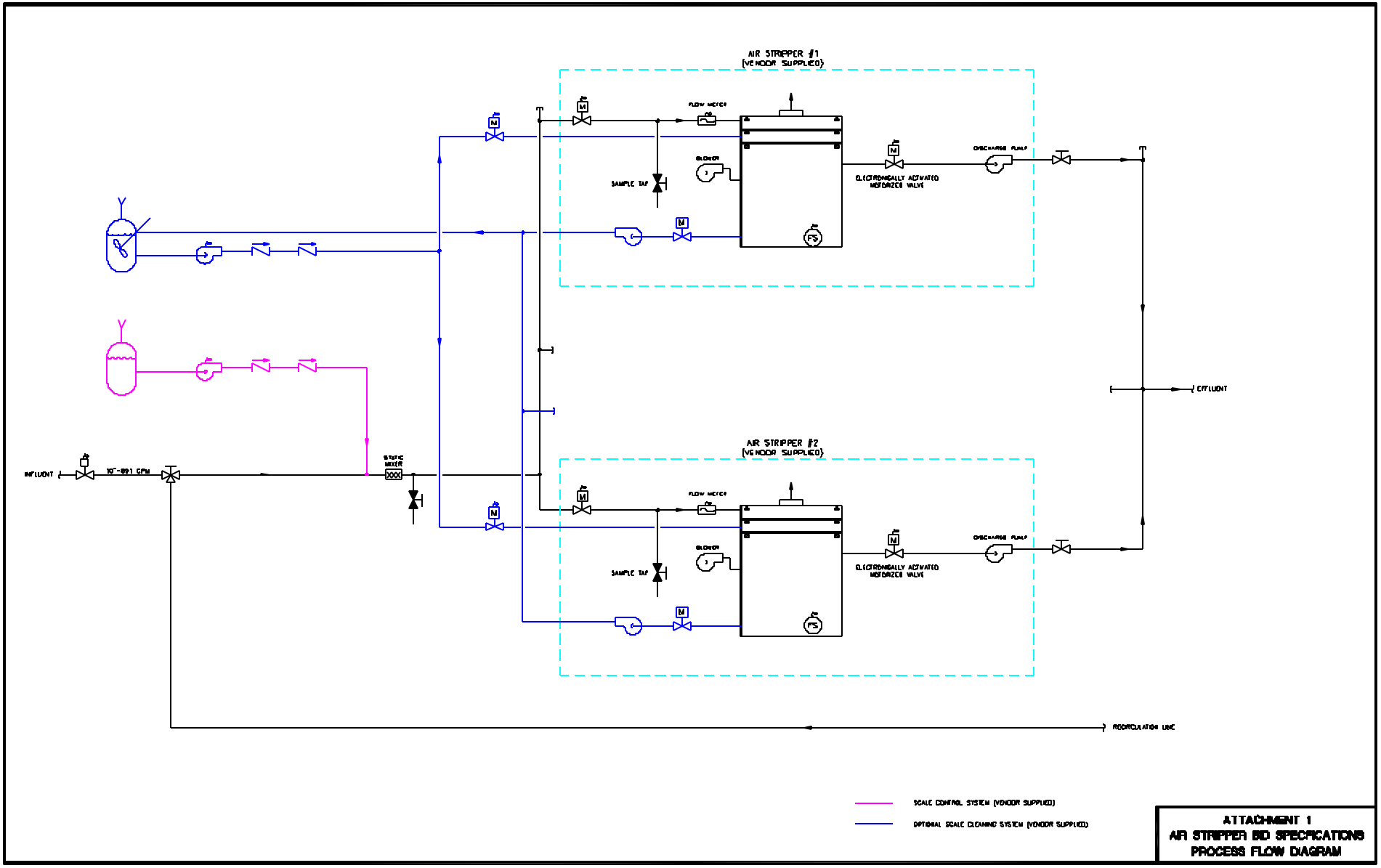
4. EXECUTION

VENDOR shall provide the start-up services of a qualified field service representative for the purpose of installation inspection, system commissioning, and instruction of NASA personnel in proper operating and maintenance procedures. Upon completion of inspection, VENDOR's field service representative shall provide written certification to NASA that the equipment has been properly installed. The proposal shall include an estimate of the number of man-days and the per diem cost for these startup services.

5. DELIVERY SCHEDULE

Air strippers and appurtenances shall be delivered to the Job Site no later than 90 days following issuance of a purchase order by NASA.

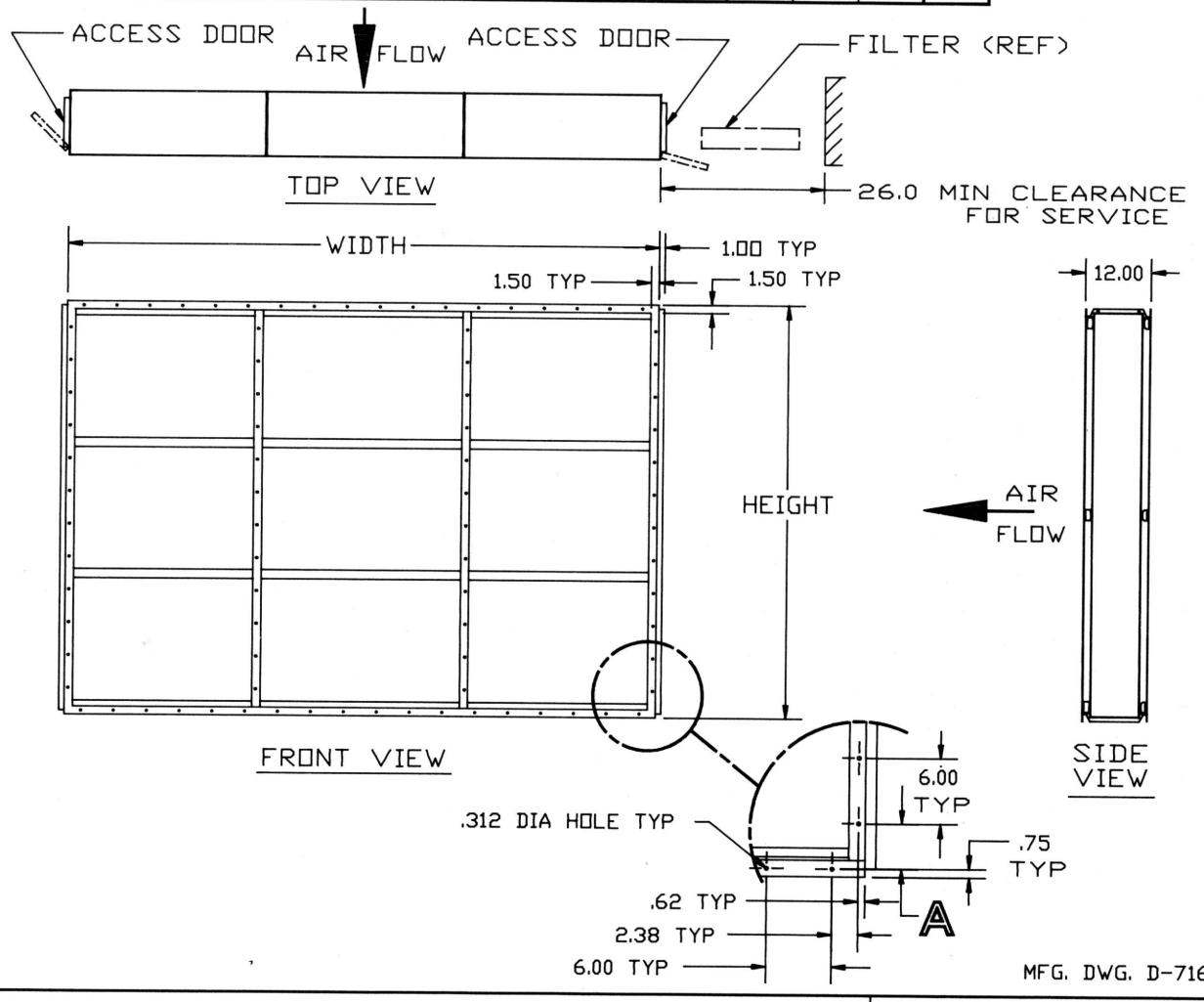
- END -



ATTACHMENT 1
AIR STRIPPER BID SPECIFICATIONS
PROCESS FLOW DIAGRAM

B-71601

NO. OF FILTERS WIDE		1/2	1	1-1/2	2	2-1/2	3	3-1/2	4	4-1/2	5	5-1/2	6	
WIDTH INCHES		12.00	24.00	36.00	48.00	60.00	72.00	84.00	96.00	108.00	120.00	132.00	144.00	
NO. OF FILTERS HIGH	HEIGHT INCHES	SIZE DESIGNATION (SEE NOTE 5)												A
1/2	15.25	–	1/2 X 1	–	1/2 X 2	–	1/2 X 3	–	1/2 X 4	–	1/2 X 5	–	1/2 X 6	3.88
1	27.25	1 X 1/2	1 X 1	1 X 1-1/2	1 X 2	1 X 2-1/2	1 X 3	1 X 3-1/2	1 X 4	1 X 4-1/2	1 X 5	1 X 5-1/2	1 X 6	3.88
1-1/2	39.50	–	1-1/2 X 1	–	1-1/2 X 2	–	1-1/2 X 3	–	1-1/2 X 4	–	1-1/2 X 5	–	1-1/2 X 6	4.00
2	51.50	2 X 1/2	2 X 1	2 X 1-1/2	2 X 2	2 X 2-1/2	2 X 3	2 X 3-1/2	2 X 4	2 X 4-1/2	2 X 5	2 X 5-1/2	2 X 6	4.00
2-1/2	63.75	–	2-1/2 X 1	–	2-1/2 X 2	–	2-1/2 X 3	–	2-1/2 X 4	–	2-1/2 X 5	–	2-1/2 X 6	4.12
3	75.75	–	3 X 1	3 X 1-1/2	3 X 2	3 X 2-1/2	3 X 3	3 X 3-1/2	3 X 4	3 X 4-1/2	3 X 5	3 X 5-1/2	3 X 6	4.12



MFG. DWG. D-71600

NOTES:

1. FOR APPLICATION INFORMATION, INSTALLED WEIGHT, CAPACITY, ETC, SEE SALES BULLETIN
2. UNIT IS COMPLETELY FACTORY ASSEMBLED
3. EXTRUDED ALUMINUM TRACKS ARE STANDARD IN ALL HOUSINGS
4. OPTIONAL AT EXTRA COST: ONE COAT OF PRIMER ON EXTERIOR SURFACES OF HOUSING AND DOORS. SPECIFY "PRIMED"
5. ORDERING INFORMATION: SPECIFY MODEL AND SIZE. ADD "PRIMED" IF DESIRED

   EXAMPLE:

   MODEL 4P GLIDE/PACK
   2 X 4-1/2 (SIZE)
6. FILTERS ARE NOT INCLUDED. ORDER SEPARATELY STATING QUANTITIES, TYPES AND SIZES

REV.	DATE		DISP.	E.W.O.	DFT	CK	DES	APP
E	4-9 90	ADDED 1/2 FILTER WIDE SIZES		11732 B	J C			
A	1-19 81	FIRST ISSUE		9434	J C			

UNLESS OTHERWISE NOTED:
DIMENSIONS ARE IN INCHES
INSIDE BEND RADII = 1 METAL THICKNESS
TOLERANCES ARE:
1 PLACE DECIMAL±
2 PLACE DECIMAL±
3 PLACE DECIMAL±
FRACTIONAL± ANGULAR±

DO NOT SCALE PRINT

PROD CODE	EST. WT.
NEXT ASSEMBLY	
SCALE: NONE	CLASSIFICATION: F-0404

MODEL 4P GLIDE/PACK
1/2 THRU 3 HIGH

FARR COMPANY
LOS ANGELES, CALIFORNIA

CODE	DRAWING NO.	REV.
	B-71601	E

B-71601

SECTION 11240
CHEMICAL METERING PUMPS

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE): 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
2. National Electrical Manufacturer's Association (NEMA): MG 1, Motors and Generators.

1.2 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction shall conform to the ratings and nomenclature of the Hydraulic Institute Standards.

1.3 SUBMITTALS

A. Shop Drawings:

1. Make, model, weight, and horsepower of each equipment assembly.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
3. Performance data showing capacity, discharge pressure, and strokes per minute.
4. Detailed mechanical and electrical drawings showing the equipment dimensions, size, locations of connections, and weights of associated equipment.
5. Complete system interconnection diagrams, including terminals and numbers.
6. Complete system operating description.
7. Complete system schematic (elementary) wiring diagrams.
8. Complete motor nameplate data, as defined by NEMA, motor manufacturer, and including any motor modifications.
9. Factory finish system.
10. Operating and maintenance manuals for the chemical metering pumps specified herein.

B. Quality Control Submittals:

1. Factory Functional and Performance Test Reports.
2. Special shipping, storage and protection, and handling instructions.
3. Manufacturer's printed installation instructions.

4. Manufacturer's Certificate of Proper Installation.
5. Suggested spare parts list to maintain the equipment in service for a period of 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
6. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
7. Operation and maintenance manual.

1.4 EXTRA MATERIALS

A. Furnish for each size pump:

1. One complete set of pump head check valve balls and springs.
2. One diaphragm back pressure control valve.
3. One complete set of any special tools required to dismantle pump.

B. Furnish for each size of controller:

1. One printed circuit board of each type.
2. Ten fuses (minimum) of each size.

C. Furnish spare pumps:

1. Complete pump, motor and check valve assemblies as indicated on the pump data sheets.
2. Spare control panels shall not be required.

PART 2 PRODUCTS

2.1 GENERAL

A. Coordinate pump requirements with drive manufacturer and be responsible for pump and drive requirements.

B. Where adjustable speed drives are required, furnish a coordinated operating system complete with pump, drive, and speed controller.

2.2 SUPPLEMENTS

A. Some specific requirements are attached to this section as supplements.

2.3 PUMP

A. Positive displacement self-compensating hydraulically activated diaphragm type consisting of simplex pumping heads, with internal automatic pressure relief valve, external manually adjustable stroke positioner from 0 to 100 percent, and with maximum stroking speed of 100 strokes per minute.

B. Diaphragm; compression-molded Teflon or compression-molded Teflon composite with internal O-ring seal. Hypalon double diaphragms may be provided where indicated on the data sheets.

C. Bearings, tapered roller or needle type. Gearing, polished steel or bronze worm type. Mount bearings and internal working parts in weather-resistant gear box with moving parts oil flooded.

D. Lubricant, nontoxic food grade quality.

E. The pumps shall be capable of running dry indefinitely.

F. The diaphragm shall be returned by hydraulic means; no spring shall be employed.

G. Pumping diaphragms and all wetted parts shall be suitable for the particular chemical being pumped.

2.4 VALVES

A. Adjustable diaphragm back pressure sustaining type installed on pump discharge pipeline. Set pressure shall be as shown on attached data sheets. This valve shall be a single function valve that provides constant upstream back pressure, even after termination of pump operation.

B. Adjustable pressure relief type installed on pump discharge pipeline. Set pressure shall be as shown on attached data sheets.

2.5 STROKE CONTROL

A. Manual stroke length adjustment.

B. Manual and remote stroke rate adjustment.

2.6 PUMP OPERATOR CONTROLS

A. Provide the following controls mounted to the face of each pump:

1. AUTO-OFF-MANUAL switch. In AUTO position, pump shall accept an external 4-20 mAdc pacing signal.
2. ON and STOP indicator lights.
3. Manual control by on-line adjustable stroke rate and length.
4. Solenoid protection by thermal overload with auto-reset.

2.7 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.

B. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer.

C. Gauge Connections: Tapped and plugged suction and discharge gauge connections on piping headers adjacent to pumps.

D. Screens or Guards: Mesh size of less than 0.5 inch, exposed rotating shafts, rotors, couplings, pulley, wheel, bolts, chains, or similar components. Where guards/screens are over grease fittings, couplings, or other items requiring maintenance, provide a means for ready access.

E. Calibrated Cylinder: Graduated in 50-ml increments, constructed of clear polypropylene and PVC with ball type shutoff valve for each pump. Cylinders shall be sized by MFR as appropriate for pumping volume.

2.8 FACTORY FINISHING

A. Manufacturer's standard baked enamel finish.

2.9 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: Test all equipment and control panels actually furnished.

C. Factory Test Report: Include test data sheets.

D. Functional Test: Perform manufacturer's standard, test on equipment.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's printed instructions .

3.2 FIELD QUALITY CONTROL

A. Conduct tests on each pump and controller.

B. Functional Test:

1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
2. Inspect controller for electrical supply termination connections, interconnections, proper installation, and quiet operation.

C. Performance Test:

1. Perform under actual or approved simulated operating conditions.
2. Test for a continuous 3-hour period without malfunction.
3. Demonstrate performance of controller by operating for a continuous period while varying the application load, as the input conditions allow, to verify system performance.

3.3 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at site or classroom designated by OWNER, for minimum person-days listed below, travel time excluded:

1. 1/2 person-day for installation assistance, inspection, and facility startup.
2. 1/2 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.

3.4 SUPPLEMENTS

A. The supplements listed below, following “END OF SECTION,” are a part of this Specification.

1. Pump Data Sheets (2).

END OF SECTION

PUMP DATA SHEET
CHEMICAL METERING PUMPS NO. _____

Project: _____ Pump Mfr.: _____

Owner: _____ Size & Type: _____

Service: _____ Serial No.: _____

Pump Name: _____ Model No.: _____

Equip. Tag Number(s):

Pump: _____ Local Control Panel: _____

Back Pressure Control Valve: _____ Pressure Relief Valve: _____

Calibration Column: _____ Outlet Pulsation Dampener: _____

No. Pumps Required: _____ Drive Type: ☐ Constant ☐ Adjustable No. Spare Parts Required: _____

LIQUID	OPERATING CONDITIONS	SERVICE CONDITIONS
Name: _____	Capacity (U.S. gph):	Temp (°F): Max _____ Min _____
Pumping Temperature (°F):	_____ to _____	Rel. Hum (%): Max _____ Min _____
Max _____ Min _____	Discharge Pressure (psig): _____	Altitude (ft): _____
Specific Gravity @ _____ °F: _____	Diff. Pressure (psi): _____	☐ Indoor ☐ Heated
Viscosity (CP) @ _____ °F: _____	Diff. Head (ft): _____	☐ Outdoor ☐ Unheated
pH: _____	Min. NPSH Available (ft): _____	Area Classification: _____
Corrosion/Erosion/Abrasion Caused by:		Other: _____
_____		
Remarks: _____	Remarks: _____	Remarks: _____
_____	_____	_____

PERFORMANCE REQUIREMENTS (manufacturer to supply missing data)

Proposal Curve No.: _____ Relief Valve Set Pressure (psig): _____ Calibration Cyl. Capacity (ml): _____

Speed (rpm): _____ ☐ As Recommended by Mfr. (psig): _____ Model No. _____

Capacity Range (gph): _____ to _____ Back Pressure Control Valve Set

Discharge Pressure (psig): _____ Pressure (psig): _____ Factory Testing:

☐ As Recommended by Mfr. (psig): _____ ☐ Required ☐ Not Required

Remarks: _____

MATERIALS (manufacturer to supply missing data)

Diaphragm: _____ Ball Check Valves: _____ Pulsation Dampener: _____

Wetted Parts: _____ Seats: _____ Inst. Isolation Diaphragm: _____

SECTION 13390
PACKAGE CONTROL SYSTEMS (PCS)
SUPPLEMENT A

COMPONENT SPECIFICATIONS

A. F1 Flow Element, Pitot-Static, Equal Annuli:

1. General:
   a. Function: Produce a pressure differential signal proportional to the square of the flow rate in an air duct.
   b. Type: Multiple port, pitot-static differential pressure producing device.
   c. Parts: Flow element, transmitter, and mounting hardware.
2. Service:
   a. Fluid: Air, unless otherwise noted.
   b. Upstream Fluid Temperature: Minus 13 degrees C to 44 degrees C.
   c. Upstream Static Pressure: As required.
3. Performance:
   a. Flow Range: As required.
   b. Pressure Differential at Full Scale Flow: As required.
   c. Accuracy: Plus or minus 0.5 percent over a flow range of 10:1, minimum.
   d. Permanent Pressure Loss (Head Loss): Less than 18 percent of measured pressure differential for sizes between 4 and 12 inches. Less than 8 percent of measured pressure differential for sizes over 12 inches.
   e. Repeatability: Plus or minus 0.1 percent.
4. Flow Element Calculations: Verify actual duct inner diameter and provide supporting calculations showing expected pressure differential at full scale flow and permanent head loss.
5. Features:
   a. Pitot Ports: Located across the duct diameter such that the differential pressures of four or more sensing ports are sensed, and averaged.
   b. Static Ports: To sense static pressure.
   c. Materials: Type 316 stainless steel, unless otherwise noted.
   d. Duct Size: As required.
   e. Duct Material: As required.
6. Element Connections:
   a. Process Connections:
      1) Type: Weld fitting and compression ferrule, unless otherwise noted.
      2) Materials: Carbon steel, unless otherwise noted.
   b. Instrument Connections: Integrally-mounted flow transmitter.

7. Signal Interface: 4 to 20mA dc output for load impedance of 0 to 500 ohms minimum without load adjustment with 24V dc supply.
8. Enclosure:
    a. Type: NEMA 4X.
    b. Mounting: Integral with sensing element.
9. Manufacturers and Products:
    a. Dieterich Standard Corp.; ProBar Series.
    b. Approved equal.

B. F2 Flow Element and Transmitter, Electromagnetic:

1. General:
   a. Function: Measure, indicate, and transmit the flow of a process liquid in a full pipe.
   b. Type: Electromagnetic flowmeter, with operation based on Faraday's Law, utilizing the pulsed dc type coil excitation principle with high impedance electrodes.
   c. Parts: Flow element, transmitter, interconnecting cables, mounting hardware, and calibrator.
2. Service:
   a. Stream Fluid: Water with trace amounts of industrial contaminants.
3. Performance:
   a. Flow Range: As noted.
   b. Accuracy: Plus or minus 1 percent of rate for all flows resulting from pipe velocities of 1 to 33 feet per second.
   c. Turndown Ratio: Minimum of 10 to 1 when flow velocity at minimum flow is at least 1 foot per second.
4. Features:
   a. Zero stability feature to eliminate the need to stop flow to check zero alignment.
   b. No obstructions to flow.
   c. Very low pressure loss.
5. Process Connection:
   a. Meter Size: As noted.
   b. Connection Type: 150-pound ANSI raised-face flanges or wafer style depending on meter size, unless otherwise noted.
   c. Flange Material: Carbon steel, unless otherwise noted.
6. Signal Interface:
   a. 4 to 20 mA dc for load impedance 0 to 800 ohms minimum for 24V dc supply.
7. Power: 120V ac, 60-Hz, unless otherwise noted.
8. Element:
   a. Meter Tube Material: 304 stainless steel, unless otherwise noted.
   b. Liner Material: Teflon, unless otherwise noted.
   c. Liner Protectors: Covers on each end to protect liner during shipment.
   d. Electrode Type: Flush or bullet nose as recommended by the manufacturer for the noted stream fluid.
   e. Electrode Material: 316 stainless steel, unless otherwise noted.
   f. Enclosure: NEMA 4, unless otherwise noted.
   g. Grounding Ring/Electrode Material: 316 stainless steel, unless otherwise noted.

9. Transmitter:
    a. Display: Indicating and totalizing.
    b. Mounting: Pipe stand, wall.
    c. Enclosure: NEMA 4X.
    d. Zero and Span: Field adjustable.
    e. Indicator: Digital 16-character display, with scale range as noted.
    f. Totalizer: Digital 16-character display, with totalizer unit digit value as noted.
10. Cables:
    a. Types: As recommended by manufacturer.
    b. Lengths: As required to accommodate device locations.
11. Calibration System:
    a. Features:
        1) Field programmable electronics.
        2) Self-diagnostics with troubleshooting codes.
        3) Ability to program electronics with full scale flow, engineering units, meter size, zero flow cutoff, desired signal damping, totalizer unit digit value, etc.
        4) Initial flow tube calibration and subsequent calibration checks.
    b. Equipment:
        1) Built-in electronics with each unit provided.
        2) Alternatively, one portable calibrator of each type required for the various electromagnetic flowmeters provided on the project.
12. Manufacturers:
    a. Endress & Hauser; Promag 33.
    b. Fischer & Porter; miniMAG, COPA-X or MAG-X, as applicable;
    c. Krohne; Altoflux.

C. F3 Flow Element and Switch, Thermal:

1. General:
   a. Function: Monitor process fluid flow and provide contact closure when flow exceeds set point.
   b. Type: Thermal dispersion flow switch using a heated active and a reference RTD temperature sensors to detect rate of flow as a function of the temperature difference between the two sensors.
2. Service:
   a. Fluid: Water.
   b. Operating Pressure: 75 psig.
   c. Operating Temperature: 15 to 20 degrees C.
3. Performance:
   a. Set Point:
      1) Adjustable throughout full range.
      2) Set as noted.
   b. Range: Choose range so that the noted set point is between 30 and 70 percent of the range.
   c. Repeatability: Plus or minus 1 percent of full range.
   d. Temperature, Operating:
      1) Sensor Element: Minus 100 to plus 350 degrees F.
      2) Electronics: Minus 40 to plus 140 degrees F.
   e. Proof Pressure: To 4,000 psig.
   f. Response Time: Field adjustable from 10 to 150 seconds.
4. Features:
   a. Wetted Surfaces Materials: 316 stainless steel with nickel-base braze, unless otherwise noted.
   b. Dry Pipe Protection: When applied to liquid process, furnish protection against the event of the liquid line going dry, unless otherwise noted.
   c. Process Temperature Compensation: Furnish.
5. Process Connections:
   a. Type: 1-1/4-inch NPT(M), unless otherwise noted.
   b. Pipe Size: As noted.
   c. Connection Type: Insertion.
   d. Connection Material: 316 stainless steel, unless otherwise noted.
6. Conduit Connection: 1-1/4-inch NPT(F) reduced to 3/4 inch with bushing.
7. Element: Insertion/Body Length (From Tip of Probe to Process Connection): Determined by the Supplier based upon pipe size and sensor mounting requirements, unless otherwise noted. The insertion length shall be noted on an application specific installation detail prepared and submitted for each unit.

8. Electronics:
    a. Location: Integral with element, unless otherwise noted.
    b. Hermetically sealed with SPDT relay.
9. Signal Interface:
    a. Contact: Single-pole, double-throw (SPDT), rated 120V ac, 2 amps.
    b. Connection: Screw terminal block.
10. Enclosure:
    a. Type: NEMA 7BCD with watertight O-ring seal.
    b. Material: Cast aluminum, unless otherwise noted.
    c. Approval: Factory Mutual for hazardous area, unless otherwise noted.
11. Power: 120V ac, 60-Hz, unless otherwise noted.
12. Cable (Furnished Only When Remote Electronics is Specified):
    a. Type: As required.
    b. Length: As required.
13. Manufacturer: Fluid Components, Inc.; Model 12-64 or Model FR72.

D. L1 Level Element and Transmitter, Submersible, Electronic:

1. General:
   a. Function: Measure well level by means of differential pressure and transmit a signal proportional to level.
   b. Type: Electronic, piezoresistive-micromachined silicon strain gauge, two wire transmitter.
   c. Operating conditions: Transmitter shall operate in water containing low levels of industrial contaminants.
   d. Warranty: Sensor/transmitter shall be warranted against corrosion for a period of 5 years.
2. Performance:
   a. Range: As noted.
   b. Maximum adjustable range: Noted range shall lie between 40 percent and 80 percent of the maximum adjustable range.
   c. Accuracy: Plus or minus 0.25 percent of calibrated span.
   d. Operating temperature range: Minus 5 degrees F to 140 degrees F.
   e. Compensated temperature range: 30 degrees F to 86 degrees F.
   f. Relative humidity: 0-100 percent.
3. Features:
   a. Type: Cable suspended level sensor
   b. Materials: Sensor body, measurement diaphragm–Titanium. Cable-polyurethane jacket with Kevlar reinforced cord.
   c. Periodic maintenance or cleaning shall NOT be required to maintain function of accuracy.
4. Signal Interface:
   a. Instrument shall be loop powered from 9-32V dc power supply.
   b. Output shall be 4-20 ma DC for load impedance of 0-500 ohms minimum over specified range.
   c. The transmitter shall be factory calibrated for the specified range(s) and shall also include provisions for field calibration through non-interactive zero and span adjustments.
5. Sensor Cable Termination:
   a. The sensor cable shall terminate in a vendor supplied termination box.
   b. The box shall be rated NEMA 4X and be lockable.
   c. Termination enclosure shall be wired complete with lightning arrestors suitable for low voltage DC transmitter circuits.
   d. Cable vent tube shall terminate in this box on desiccant cartridge. Manufacturer shall furnish 6 desiccant cartridges per transmitter.
6. Manufacturers and Products:
   a. Druck; Model PTX 1230.
   b. Approved equal.

E. L2 Level Element and Transmitter, Admittance:

1. General:
   a. Function: Measure and transmit interface level in vessel.
   b. Type: Admittance using low power radio frequency source:
      1) Two-wire transmitter.
      2) “Smart” electronics.
   c. Parts: Element, transmitter (nonintegral), calibrator (or equivalent), and interconnecting cable.
2. Service:
   a. Process Fluid: Water.
   b. Vessel Material: Type 304L stainless steel.
3. Performance:
   a. Range: As required.
   b. Linearity: Plus or minus 0.25 percent of range.
   c. Ambient Temperature: Minus 40 to plus 170 degrees F.
   d. Process Pressure and Temperature Limits: 1,000 psi at 100 degrees F, or 500 psi at 250 degrees F, unless otherwise noted.
4. Element:
   a. Type: Solid rod.
   b. Connection Type: 3/4-inch NPT, unless otherwise noted.
   c. Insertion Length: As required to accommodate specified range and vessel dimensions.
   d. Process Wetted Parts: 316 SS rod, bonded with fluorocarbon-type insulation, unless otherwise noted.
   e. Provisions for grounding if vessel is nonmetallic.
   f. 3/8-inch diameter, nominal.
5. Transmitter:
   a. Integral, unless otherwise noted.
   b. Enclosure: NEMA 4X and explosionproof.
   c. Signal Interface: 4 to 20 mA dc output with Hart protocol for load impedance 0 to 600 ohms minimum for 24V dc supply without load adjustment.
   d. Performance Response Time:
      1) With delay off,20 milliseconds.
      2) With delay on, adjustable 0.5 to 30 seconds.
   e. Indicator: Digital loop meter, NEMA 4X enclosure.
   f. Allowable Static Discharge to Sensor: 10 amps maximum, unless otherwise noted.
6. Accessories:
   a. Calibration Device:
      1) Quantity: One total for contract, unless otherwise noted.
      2) Type: Hart hand-held communicator, unless otherwise noted.

7. Manufacturers:
    a. Drexelbrook; Model 508-45-9.
    b. Endress and Hauser; Model FEC12.

F. L3 Level Switch, Float, Bulkhead:

1. General:
   a. Function: Operate contact at preset liquid level.
   b. Type: Float-actuated bulkhead-mounted; magnetic actuation.
2. Service:
   a. Fluid: Water unless otherwise noted.
   b. Specific Gravity: 1.0 unless otherwise noted.
   c. Pressure: 150 psi maximum.
   d. Temperature: 100 degrees F maximum.
3. Performance:
   a. Set Point: As noted.
   b. Dead Band: 4-inch unless otherwise noted.
4. Features: Float, stem, and other wetted parts stainless steel unless otherwise noted.
5. Process Connections: 2-inch NPT half-coupling or 3-inch, 150-pound ANSI RF flange as required.
6. Signal Interface Contact: DPDT snap action contact rated 5A continuous at 120V ac.
7. Enclosure: NEMA 4, unless otherwise noted.
8. Manufacturers:
   a. LINC; Model L471.
   b. Magnetrol; Tuffy series.
   c. Robertshaw; Series SL-500.

G. L4 Level Switch, Float, Tank Top:

1. General:
   a. Function: Operate switch at preset level in a tank.
   b. Type: Float-actuated mounted directly to tank top.
2. Service:
   a. Fluid: Water unless otherwise noted.
   b. Specific Gravity: 1.0 unless otherwise noted.
   c. Pressure: 150 psi maximum.
   d. Temperature: 100 degrees F maximum.
3. Performance:
   a. Set Point: As noted.
   b. Dead Band: 1-inch maximum.
4. Features:
   a. Float, stem, and guide tube connected to a switch enclosure.
   b. Insertion Length: As required to achieve the noted set point.
   c. Float Size: 4-1/2-inch unless otherwise noted.
   d. Materials: Wetted parts 304 or 316 stainless steel unless otherwise noted.
5. Process Connection: 1-inch NPT.
6. Signal Interface Contact: DPDT snap action rated 10A continuous at 120V ac.
7. Enclosure: NEMA 4 unless otherwise noted.
8. Manufacturers:
   a. Magnetrol; Model T20.
   b. Robertshaw; Series SL-100.

H. L5 Level Element and Switch, Electrode:

1. General:

    a. Function: Activate contact at preset liquid level.
    b. Type: Conductance; solid state relays.
    c. Parts: Electrode, electrode holder, relays, enclosure, cabling.
2. Performance:
    a. Set Point: 1/8-inch above finished floor.
    b. Accuracy: Plus or minus 1/16-inch electrode tip length.
    c. Sensitivity: As required for (conductivity of) specific liquid application.
3. Service:
    a. Water on floor sensing.
    b. Process Liquid: Water.
    c. Operating Temperature: Ambient.
    d. Operating Pressure: Atmospheric.
4. Electrode Holder:
    a. Type: External pipe threaded, unless otherwise noted.
    b. Material: 316 stainless steel, unless otherwise noted.
    c. Mounting: 3-inch NPT, unless otherwise noted.
    d. Service: Watertight, outdoor heavy duty, unless otherwise noted.
5. Electrode:
    a. Type: Rod.
    b. Number: One.
    c. Length: As required for the noted set points.
    d. Material: 316 stainless steel, unless otherwise noted.
    e. Spacers: As noted.
6. Relays:
    a. Type: Solid state, unless otherwise noted.
    b. Number: One per noted set point.
    c. Sensitivity: As required for (conductivity of) specific liquid application.
    d. Power: 120V ac, 60-Hz, or 240V ac, 60-Hz.
    e. Contacts: DPDT, rated at 10 amps continuous at 120V ac.
    f. Enclosure: NEMA 4X fiberglass, unless otherwise noted.
7. Cabling:
    a. Provide interconnecting conductors between electrode holder and relays.
    b. Type: As recommended by manufacturer.
    c. Quantity and Length: As required.
8. Ancillaries:
    a. Furnish all ancillaries for a complete and operating system.
    b. Include such items as wire connectors for wire suspension electrodes.

9. Manufacturers:
    a. B/W Controls.
    b. Charles F. Warwick Co.

I. P1 Pressure Gauge:

1. General:
   a. Function: Pressure indication.
   b. Type: Bourdon tube.
2. Performance:
   a. Range: As noted. Compound scale when noted.
   b. Accuracy: Plus or minus 0.5 percent of span.
3. Features:
   a. Mounting: Lower stem, unless otherwise noted.
   b. Dial: 4-1/2-inch diameter, unless otherwise noted.
   c. Case Material: Phenolic plastic, unless otherwise noted.
   d. Element Material: Phosphor-bronze, unless otherwise noted.
   e. Dampening: Pulsation dampener when noted, piston type with multiple choice of piston placement to vary the desired amount of dampening.
   f. Case Type: Solid front design with solid wall between window and element. Rear of case, gasketed pressure relief.
   g. Pointer: Micrometer pointer with self-locking adjustment.
   h. Movement: Stainless steel, rotor geared.
4. Process Connection:
   a. Line Size: 1/2-inch.
   b. Connection Type: Threaded.
5. Manufacturers and Products:
   a. Ashcroft; Duragauge Model 1279/1379.
   b. Robert Shaw Acragage.
   c. Marsh Mastergauge.

J. P2 Pressure Differential Gauge, Low Range Air:

1. General:
   a. Function: Indicate differential pressure locally.
   b. Type: Bellows.
2. Service:
   a. Rated Total Pressure: 20 inches Hg. to 15 psig.
   b. Temperature Limits: 20 degrees F to 140 degrees F.
   c. Air filter differential pressure, air static pressure.
3. Performance:
   a. Range: As required.
   b. Accuracy: 2 percent of full scale.
4. Features:
   a. Indictor: 4-1/2-inch diameter.
   b. Adjustments: Front accessible zero.
   c. Scale: Linear.
   d. Connections: 1/8-inch, NPT.
   e. Case: Die-cast aluminum.
   f. Mounting: Panel, surface, or pipe.
5. Manufacturers and Products:
   a. Dwyer; Series 2000 Magnehelic.
   b. ITT Barton; Model 227 or 200.

K. P3 Pressure Switch, Fixed Dead Band:

1. General:
   a. Function: Monitor pressure and provide contact closure(s) when pressure is at the noted set point.
   b. Type: Diaphragm sealed piston actuator.
2. Performance:
   a. Set Point: As required.
      1) Adjustable over the full range.
      2) Set as noted.
   b. Range: The noted set point shall fall between 30 percent and 70 percent of the range.
   c. Set Point Repeatability: Plus or minus 1 percent of range.
3. Features:
   a. Diaphragm Material: Buna-N, unless otherwise noted.
   b. Pressure Connection: Type 316 stainless steel, unless otherwise noted.
   c. Reset: Automatic, unless otherwise noted.
4. Enclosure: NEMA 4X, unless otherwise noted.
5. Signal Interface:
   a. Contact Type: SPDT, snap action switch, rated for 15 amps at 120V ac.
   b. Number of Switch Elements: One, unless otherwise noted.
6. Manufacturers and Products:
   a. Ashcroft; B Series.
   b. United Electric; Series 400.
   c. SOR.

L. P4 Pressure Switch, Low Range Air:

1. General:
   a. Function: Monitor air pressure and provide contact closure(s) when pressure is at the noted setpoint.
   b. Type: Diaphragm actuator.
2. Performance:
   a. Setpoint: As required.
   b. Range: The setpoint shall fall between 30 percent and 70 percent of the range.
   c. Setpoint Repeatability: Plus or minus 2 percent of range.
   d. Maximum Rated Pressure: 10 psig.
3. Features:
   a. Diaphragm Material: Silicone rubber.
   b. Pressure Connection: 1/8-inch NPT aluminum.
   c. Reset: Automatic.
   d. Electrical Connection: 1/2-inch NPT.
4. Enclosure: NEMA 7 (explosion proof).
5. Signal Interface:
   a. Contact Type: SPDT snap action switch, rated for 15 amps at 120V ac.
   b. Number of Switch Elements: One.
6. Manufacturers and Products:
   a. Dwyer; Model 1950.
   b. ITT Barton.

M. P5 Pressure Transmitter, Electronic:

1. General:
   a. Function: Measure pressure and transmit signal proportional to pressure.
   b. Type: Electronic variable capacitance, two-wire transmitter.
2. Performance:
   a. Range: As noted.
   b. Maximum Adjustable Range: Such that the noted range shall lie between 40 percent and 80 percent of the maximum adjustable range.
   c. Accuracy: Plus or minus 0.25 percent of calibrated span.
   d. Temperature: Minus 20 degrees F to plus 200 degrees F, minimum.
3. Features:
   a. Type: Gauge pressure, unless otherwise noted.
   b. Damping: Fluid or electronic type with adjustment.
   c. On-site LCD Display.
   d. Suppressed or Elevated Zero: When noted.
   e. Diaphragm Sensor: Ceramic; all other parts 316 stainless steel.
   f. Wetted O-Rings: Viton, unless otherwise noted.
   g. Housing: Modular with separate compartments for electronics and field connections.
   h. Fill Fluid: Silicone, unless otherwise noted.
4. Process Connections:
   a. Line Size: 1/2 inch or 1/4 inch, selectable.
   b. Connection Type: FNPT.
5. Signal Interface: 4 to 20 mA dc output for load impedance of 0 to 500 ohms minimum without load adjustment with 24V dc supply.
6. Enclosure:
   a. Type: NEMA 4X, unless otherwise noted.
   b. Mounting: Pipe or wall as noted. Provide brackets with Series 300 stainless steel bolts.
7. Manufacturer and Products:
   a. Endress & Hauser; PMC 133, PMC 134, or PMC 53X CERABAR.

N. S1 Indicator, Loop Powered, Integral Enclosure:

1. General:
   a. Function: Digital indication of an analog signal.
   b. Type:
      1) Loop powered.
      2) Integral NEMA 4X enclosure, unless otherwise noted.
2. Performance:
   a. Accuracy: plus or minus 0.1 percent of span counts, plus or minus 1 count.
   b. Temperature, Operating: minus 10 to plus 70 degrees C (14 to 158 degrees F).
   c. Temperature Coefficient:
      1) Zero: plus or minus 100 ppm/ degree C, max.
      2) Span: plus or minus 150 ppm/ degree C, max.
   d. Display Reading Update: 2.5 conversions/sec.
   e. Input Voltage Drop: 3.9 volts max at 20mA.
   f. FM and CSA approved intrinsically safe for hazardous locations.
3. Features:
   a. Readout Display:
      1) Type: 0.8-inches high, liquid crystal, 3-1/2 digits.
      2) Decimal Point Indication: Switch selectable, four positions.
      3) Dummy Zero: Switch selectable trailing zero.
   b. Wide Range Display Calibration:
      1) Zero: Adjustable from minus 1999 to 1999.
      2) Span: Adjustable from 100 to 3998 counts.
   c. Urethane coating of internal circuitry (for protection from corrosive atmospheres): If noted.
4. Signal Interface: 4-20 mA and 10-50mA, switch selectable.
5. Enclosure:
   a. Type: NEMA 4X, unless otherwise noted.
   b. Mounting: Conduit mount, ½-inch, external mounting bracket for surface mounting; unless otherwise noted.
   c. Front Cover Standard Engineering Units: SCFM.
6. Manufacturers and Products:
   a. Action Instruments; Visipak, Model V560, Loop Powered LCD Indicator.
   b. Newport Electronics: Model 508B (integral NEMA 4X housing).

O. T1 Thermometer, Gauge Type:

1. General: Provide where indicated on the Process Control Diagram.
2. Type: Bi-metal.
3. Parts: Thermometer and thermowell.
4. Range: As required.
5. Accuracy: Plus or minus 1 percent of scale ranges.
6. 3-inch dial.
7. 1/2-inch NPT connection.
8. Stem Length: 2-1/2-inch.
9. Thermometer:
    a. Type 316 stainless steel case.
    b. Externally adjustable dial.
    c. Glass window.
    d. Hermetically sealed.
    e. Adjustable viewing angle.
10. Thermowell:
    a. Type: Separable 3/4-inch NPT process connection, Type 316 stainless steel, unless otherwise noted.
11. Manufacturers and Products:
    a. Ashcroft; Series EI.
    b. 3-D Instruments.
    c. Trend Instruments, Inc.

P. T2 Temperature Element and Transmitter, Resistance:

1. General:
   a. Function: Measure the temperature of a process fluid, and transmit analog signal proportional to temperature.
   b. Type: RTD.
   c. Parts: Element, thermowell, and transmitter.
2. Service:
   a. Fluid: Water.
   b. Range: 0 to 40 degrees C.
3. Element:
   a. Type:
      1) Single-element, three-wire, RTD.
      2) Platinum, 100 ohm nominal at 0 degrees C.
   b. Performance:
      1) Accuracy: Plus or minus 1/4 percent of reading or plus or minus 1/4 degrees F, whichever is greater. Conform to SAMA Standard RC 21-4-1966.
      2) Repeatability: Plus or minus 0.1 percent of span.
      3) Response Time: Less than 10 seconds (bare bulb in agitated water).
   c. Features:
      1) Dimensions: 1/4-inch diameter.
      2) Length to accommodate thermowell insertion and extension lengths.
      3) Spring-loaded element when well is used.
      4) 316 stainless steel sheath.
4. Thermowell:
   a. Features:
      1) Inside Diameter: Sized to match element, for easy removal and maximum heat transfer.
      2) Materials: Type 316 stainless steel, unless otherwise noted.
      3) Insertion Length: As required.
      4) Extension Length: 3 inches, unless otherwise noted.
   b. Process Connections: 3/4-inch NPT connection, unless otherwise noted.
5. Transmitter:
   a. Type: Two-wire, powered by a remote power supply.
   b. Performance:
      1) Ambient Temperature Range: Minus 20 to 150 degrees F. Variations within this range shall not affect accuracy more than plus or minus 1/4 percent of range per 50 degrees F.
      2) Accuracy: Plus or minus 0.15 percent of span.
      3) Repeatability: Plus or minus 0.05 percent of span.

c. Features:
    1) Indicator: 0 to 40 degrees C.
d. Signal Interface: 4 to 20 mA dc for load impedance 0 to 600 ohms minimum for 24V dc supply without load adjustment.
e. Enclosure:
    1) Type: NEMA 4.
    2) Mounting: Wall, pipe stand, or element, as noted.

6. Manufacturers:
    a. Foxboro; Series PR element and well with 893RA transmitter.
    b. Rosemount; Series 79 thermowell, 58C, 68, 78, 88 Series platinum RTD and Model 444 transmitter.

Q. Y1 Telephone Dialer Alarm System:

1. General:
   a. Function: Continuously monitor normally open contacts and upon a contact closure shall dial preprogrammed telephone numbers, deliver a prerecorded message, and reset itself upon reception of a signal from the person being called.
   b. Type: Dialer shall be a 16-bit microprocessor based system with all programming and voice messages stored in non-volatile memory. Dialer shall be compatible with cellular telephone or standard telephone communication network.
2. Performance:
   a. Alarm Response Delay: 1 to 5,999 seconds.
   b. Telephone Numbers: Nine phone numbers up to 60 digits in length.
   c. Message Length: 10 seconds per message.
   d. Number of Alarm Channels: Four digital, expandable up to eight digital total.
   e. Power: 120V ac, 60-Hz with battery backup for 60 hours of monitoring service.
   f. The system shall be programmable locally or remotely via touch tone telephone.
   g. Operating Temperature: 20 degrees F to 130 degrees F.
   h. Humidity: 0 to 95 percent noncondensing.
3. Features:
   a. Three-year manufacturer's parts and labor warranty.
   b. Six-digit security code.
   c. Surge protection on power, telephone, and alarm lines.
   d. Direct telephone or cellular communications to FAX machines, answering machines, digital or voice radio pagers, or to computers.
   e. Call progress decoding.
   f. Separate and independent call list for each alarm channel.
   g. Visual indicators for power, fault, run, phone off-hook, line off-hook, incoming call, call in progress, and FAX in progress.
4. Enclosure: NEMA 4X fiberglass.
5. Manufacturers and Products:
   a. Microtel; Series 1000 alarm dialer.
   b. Or approved equal.

R. Y2 Programmable Logic Controller System:

1. General:
   a. Function: Used for process monitoring and control by emulating functions of conventional panel mounted equipment such as relays, timers, counters, current switches, calculation modules, PID controllers, stepping switches, and drum programmers.
   b. Type: Microprocessor based device programmable using ladder logic.
   c. Parts: Central processing unit (CPU), power supply, local and remote input/output modules, local and remote base (chassis/rack) controllers, I/O bases (chassis/rack), data highway, and factory assembled interconnecting cables. Provide components required to make a complete and totally operational system. Reference P&ID Drawings.
   d. All equipment shall be Year 2000 compliant.
2. Environmental:
   a. Temperature: Operating range 32 to 140 degrees F (0 to 60 degrees C); storage range minus 40 to 158 degrees F (0 to 70 degrees C).
   b. Humidity: Operating range 5 to 95 percent noncondensing.
   c. Vibration:
      1) Sinusoidal: IEC 68-2-6, Test Fc; 0.15 mm peak-to-peak, 10- to 57-Hz; 1 g, 57- to 150-Hz.
      2) Random: IEC 68-2-34, Test Fdc; 0.4 g^2/Hz, 80- to 350-Hz, and 3dB/octave rolloff, 80- to 20-Hz and 350- to 2-KHz at 10 min/axis.
   d. Noise: IEC 801, Part 3, Level 3 and Part 4, Level 3; MIL STD-461B.
   e. Isolation: User-side to PLC side 1,500V rms.
   f. Agency Approvals and Standards:
      1) UL listed.
      2) CSA certified.
3. Central Processing Unit (CPU):
   a. Type: Microprocessor, 16-bit minimum.
   b. Scan Time: Less than 1 ms/K words of relay ladder logic.
   c. PLC Communications:
      1) One communication ports, RS-232 or RS-422.
      2) Baud rates supported 1200, 2400, 9600, 19200.
   d. Network Communications: One Allen-Bradley Data Highway Plus port.
   e. Remote I/O Communication Links.

f. Instruction Set:
    1) Timers and counters.
    2) Math: Signed integer and floating-point math including add, subtract, multiply, divide, square root, and compare.
    3) Register Operations: Shift registers, bit shift, bit set, bit clear, data move and data format conversion.
    4) Process Loop Control: User configurable direct or reverse acting PID loop control computation with the capability of both AUTO and MANUAL modes of operation, remote access to controller tuning constants.
    5) Real Time Clock: Date and time set and compare.
    6) Miscellaneous: Jump or skip to a label, one shot, drums, preconfigured analog alarm functions, subroutines.

g. Diagnostics:
    1) Indicators: Battery status, PLC status, PLC operation mode, remote I/O communication status.
    2) Status Word: With failure status for PLC battery, scan overrun, communications, I/O, special functions.
    3) Power Up: PLC checks status of PROMs upon powerup; runs self-diagnostics on power-up; periodically runs self-diagnostics while in RUN mode, halts logic processor and sets outputs to configured state if fatal error is detected.
    4) Diagnostic Tables: Tables, displayable by programming computer, that describe nature and location (address) existing faults and errors.

h. Agency Approvals and Standards:
    1) UL listed.

4. Random Access Memory (RAM):
    a. Memory Size: 32 K words.
    b. Read only memory (ROM) for controller's operating system and diagnostics.
    c. Memory Protection: Switch.
5. Power Supply: One unit for each input/output base assembly:
    a. Voltage: 120/220 volts (user selectable), 60-Hz input; 85 to 132 volts output. Allen-Bradley No. 1746-P2 .
    b. Mounting: External to base.
6. Input/Output: Complete input/output system, including remote I/O with distances up to 10,000 feet maximum up to four remote logical racks.
    a. Discrete Input Modules:
        1) Voltage: 120 volts, 60-Hz.
        2) Operating Power: 2 watts.
        3) Points per Module: 16, maximum.
        4) LED status indicator for each point.
        5) Isolation: Between input point and PLC, 1,500 volts rms.
        6) Manufacturer: Allen-Bradley, Model No. 1746-IA16.

b. Discrete Output Modules:
   1) Voltage: 120 volts, 60-Hz.
   2) Operating Power: 2 watts.
   3) Load Rating: 2 amps continuous.
   4) Isolation: Between PLC and output point, 1,500 volts rms.
   5) Points per Module: 16, maximum.
   6) LED status indicator for each point.
   7) Manufacturer: Allen-Bradley 1746-OA16.

c. Isolated Discrete Output Modules:
   1) Type: Isolated Form A relay.
   2) Voltage: 120 volts, 60-Hz.
   3) Isolated Outputs per Module: 8.
   4) Load Rating: 5 amps continuous.
   5) Operating Power: 2.5 watts.
   6) Points Per Module: 8, maximum.
   7) LED status indicator and fuse for each point.
   8) Isolation: Between PLC and output point, 1,500 volts rms.
   9) Manufacturer: Allen-Bradley, Model No. 1746-0X8.

d. Fast Response DC Input Modules:
   1) Input “Voltage: 24V dc.
   2) Input Current: 8 ma at 24V dc.
   3) Points Per Module: 16, maximum.
   4) Maximum Input Frequency: 1,000 Hz.
   5) Manufacturers and Products: Allen Bradley; Model No. 1746-ITB16 (sink).

e. Analog Input Modules:
   1) Voltage: 24 volts dc.
   2) Power: 3 watts.
   3) Differential Analog Points Per Module: 8, maximum.
   4) Isolation: Between PLC and I/O point and between I/O points, 1,500 volts rms.
   5) Analog Input Resolution: 16 bits.
   6) Manufacturer: Allen-Bradley, Model No. 1746-NI8.

f. Analog Output Modules:
   1) Voltage: 24V dc.
   2) Power: 3 watts.
   3) Isolated Analog Points Per Module: 4 maximum.
   4) Isolation Between PLC and I/O Point and Between I/O Points: 1,500 volts rms.
   5) Manufacturer and Product: Allen-Bradley; Model No. 1746-N04I.

7. Remote Adapter Module:
   a. One remote I/O adapter module required for each remote chassis.
   b. Manufacturer and Product: Allen-Bradley; Model No. 1747-ASB.

8. Remote I/O Scanner Module:
    a. Manufacturer: Allen-Bradley Model No. 1747-SN.
9. I/O Chassis:
    a. Each remote I/O panel and SLC 5/04 panel shall be furnished with one I/O chassis.
    b. Each chassis shall have 7, 10, or 13 slots.
    c. Manufacturer and Product: Allen-Bradley; Model Nos. 1746-A7, 1746-A10 and 1746-A13.
10. Fiber Optic Module:
    a. Selectable Wavelengths: 850 nm and 1,300 nm.
    b. Compatible with multimode fiber.
    c. Panel-mounted, 120V ac power supply.
    d. Data highway plus and remote I/O communications.
    e. Fault tolerant.
    f. Interaction diagnostics.
    g. Manufacturer and Product: Phoenix Digital; Model OCM-DPR-13-P-DST-ACV.
11. I/O Placement:
    a. From Left to Right: Analog, DC I/O, AC I/O.
    b. Wired to/from PLC I/O modules or racks to/from control panel terminal blocks in all panels (direct connection of field wiring to I/O module or rack is not acceptable.
12. Identification:
    a. Nameplates installed above/below each PLC component (CPU, I/O rack, power supply, etc.).
    b. Label configured I/O points as they have been configured (addressed) in the system.
13. Programming Software:
    a. Programming software shall be manufactured by Rockwell Automation.
    b. Software shall be suitable for online and offline programming of Allen-Bradley SLC S/04. PLC programming software shall communicate with the PLCs with RS LINX software.
    c. Model Number: RSLOGIX 500 Standard offline/online—disk, latest version.
14. PLC Programming Unit:
    a. The PLC programming unit shall be used to access any PLC for purposes of monitoring the real time operation of the PLC program, and modifying both on and offline the PLC program. The programming unit shall communicate with any PLC by direct connection to the PLC or by connection over the data highway.
    b. Provide all other cabling, cards, memory, software and chips as required to enable the unit to perform its intended functions.
    c. The PLC programming unit shall be a laptop style PC with the following as a minimum requirement:

1) Pentium III processor, 450 mHz.
2) 64 MB RAM.
3) 4 GB hard drive.
4) 32X CD-rom drive.
5) 3-1/4-inch floppy drive (floppy drive and CD-Rom installed internal to PC. Both must be accessible by PC).
6) MS Windows NT (latest version).
7) Microsoft Office Professional Suite (Word, Access, Excel, Power Point).
8) Carrying case.
9) Extra battery pack.
10) Parallel cable for printing.
11) All associated manuals.
12) PCMCIA data highway plus adapter card with cable. Allen-Bradley; Model No. 1784-PCMC1.

SECTION 15150
ELECTRIC VALVE OPERATORS

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA): C540, Power-Actuating Devices for Valves and Sluice Gates.
2. Underwriters Laboratories (UL).
3. Canadian Standards Association (CSA).

1.2 SUBMITTALS

A. Shop Drawings:

1. Product data sheets for make and model.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
3. Detailed mechanical and electrical drawings showing the equipment fabrications and interface with other items.
4. Power and control wiring diagrams, including terminals and numbers.
5. Open/close and throttle actuators sizing calculations.
6. Shop and field painting systems proposed.

B. Quality Control Submittals:

1. Certificate of Compliance for electric operators; full compliance with AWWA C540.
2. Tests and inspection data.
3. Manufacturer's Certificate of Proper Installation.
4. Operation and maintenance manual.

PART 2 PRODUCTS

2.1 GENERAL

A. Valve to include operator, actuator, handwheel, and accessories as applicable for a complete operation. Operators, actuators, and other accessories shall be sized and furnished by the valve supplier and factory mounted.

B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified.

C. Valve same size as adjoining pipe, unless otherwise shown.

D. Valve ends to suit adjacent piping.

E. Size operator to operate valve for the full range of pressures and velocities.

F. In-plant service valves are to open by turning counterclockwise.

G. Factory mount operator, actuator, and accessories.

2.2 SCHEDULE

A. Requirements relative to this section are shown on Electric Operator Schedule attached as a supplement to the end of this section.

2.3 OPERATORS

A. General: All valves shall be equipped with operators. The valve operator types, as specified herein, describe only the general characteristics of the operator. The operator shall be compatible with the valve with which it will be used and shall be of the same manufacturer, or a product that is recommended by the valve manufacturer. The operator shall be sized to operate the valve for the full range of pressures and velocities imposed by the service.

B. Manual Operator:

1. General:
    a. Operator force not to exceed 40 pounds under any operating condition, including initial breakaway. Gear reduction operator when force exceeds 40 pounds.
    b. Operator: Self-locking type or equipped with self-locking device.
    c. Position indicator on quarter-turn valves.
    d. Worm and Gear Operators: One-piece design worm-gears of gear bronze material. Worm shall be hardened alloy steel with thread ground and polished. Traveling nut type operators shall have threader steel reach rods with internally threaded bronze or ductile iron nut.
2. Exposed Operator:
    a. Galvanized and painted handwheels.
    b. Lever operators allowed on quarter-turn valves 8 inches and smaller.
    c. Cranks on gear type operators.
    d. Chain wheel operator with tiebacks, extension stem, floor stands, and other accessories to permit operation from normal operation level.
    e. Valve handles to take a padlock, and wheels a chain and padlock.

f. Acceptable Manufacturers and Products (12-Inch Valve and Larger):
   1) Limitorque; T Series.
   2) EIM; WO Series.

C. Electric Operator:

1. General:
   a. Comply with AWWA C540.
   b. Size to 1-1/2 times required operating torque. Motor stall torque not to exceed torque capacity of valve.
   c. Controls integral with the actuator and fully equipped as specified in AWWA 540.
   d. Stem protection for rising stem valves.
2. Type 1E:
   a. Actuator Operation-General:
      1) Suitable for full 90-degree rotation of quarter-turn valves or for use on multiturn valves.
      2) Manual override handwheel.
      3) Valve position indication.
      4) Operate from FULL CLOSED to FULL OPEN positions or the reverse in the number of seconds given in the Electric Operator Schedule.
   b. Modulating Service:
      1) Size motors for unresistricted continuous duty.
      2) Feedback potentiometer and integral electronic positioner/comparator circuit to maintain valve position. 4-20 mA output proportional to valve position for customer use.
      3) HAND-OFF-AUTO (Local-Off-Remote) Selector Switch:
         a) OPEN-STOP-CLOSE pushbutton to control valve in HAND position.
         b) 4 to 20 mA dc input signal to control valve in AUTO position.
         c) Auxiliary contact which closes when the HAND-OFF-AUTO or LOCAL-OFF-REMOTE switch is in the AUTO or REMOTE position.
      4) Valves shall close upon loss of signal unless otherwise indicated.
      5) OPEN and CLOSED indicating lights.
      6) Ac motor with reversing starter or dc motor with solid state reversing controller, and built-in overload protection.
      7) Duty cycle limit timer and adjustable band width to prevent actuator hunting.

c. Actuator Power Supply:
   1) 480-volt, three-phase unless otherwise indicated.
   2) Control power transformer, 120-volt secondary.
   3) Externally operable power disconnect switch. Valve disconnect shall be a circuit breaker for valves 12 inches and larger and when indicated on the Drawings.

d. Enclosure:
   1) As defined in NEMA 250, Type 4X.
   2) Contain 120-volt space heaters.

e. Limit Switch:
   1) Single-pole, double-throw (SPDT) type, field adjustable cam-operated, with contacts rated for 5 amps at 120 volts ac.
   2) Each valve actuator to have a minimum of two transfer contacts at end position, one for valve FULL OPEN and one for valve FULL CLOSED. These limit switches shall be for customer use only.
   3) Housed in actuator control enclosure.

f. Manufacturers and Products:
   1) Jordan Controls, Inc..
   2) Limitorque; SMB.

3. Type 3E:

a. Actuator Operation-General:
   1) Suitable for full 90-degree rotation of quarter-turn valves.
   2) Declutchable manual override.
   3) Valve position indication.
   4) Operate from FULL CLOSED to FULL OPEN positions or the reverse in less than 10 seconds.

b. Open-Close Service:
   1) Size motors for one complete OPEN-CLOSE-OPEN cycle no less than once every 10 minutes.

c. Actuator Power Supply: 120-volt, single-phase unless otherwise indicated.

d. Enclosure:
   1) As defined in NEMA 250, Type 4X.
   2) Contain 120-volt space heaters.

e. Limit Switch:
   1) Single-pole, double-throw (SPDT) type, field adjustable cam-operated, with contacts rated for 5 amps at 120 volts ac.
   2) Each valve actuator to have a minimum of two transfer contacts at end position, one for valve FULL OPEN and one for valve FULL CLOSED. These limit switches are for customer use only.
   3) Housed in actuator control enclosure.

f. Manufacturer and Product: El-O-Matic; EL Series.

2.4 SUPPLEMENTS

A. The supplement listed below, following “END OF SECTION”, is part of this Specification.

1. Electric Operator Schedule.

END OF SECTION

ELECTRIC OPERATOR SCHEDULE

Tag Number	Valve Type	Size (inches)	Fluid	Maximum Operating Flow	Maximum DP (psi)	Service	Travel Time (Seconds)	Operator Type

SECTION 16405
AC INDUCTION MOTORS

PART 1 GENERAL

1.1 RELATED SECTIONS

A. This section applies only when referenced by a motor-driven equipment specification. Application, horsepower, enclosure type, mounting, shaft type, synchronous speed, and any deviations from this section will be listed in the equipment specification. Where such deviations occur, they shall take precedence over this section.

1.2 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Anti-Friction Bearing Manufacturers' Association (AFBMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Rating and Fatigue Life for Roller Bearings.
2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 85, Test Procedure for Airborne Sound Measurements on Rotating Machines.
   b. 112, Standard Test Procedures for Polyphase Induction Motors and Generators.
   c. 114, Standard Test Procedures for Single-Phase Induction Motors.
   d. 841, Recommended Practice for Chemical Industry Severe-Duty Squirrel-Cage Induction Motors, 600V and Below.
3. National Electrical Manufacturers Association (NEMA):
   a. MG 1, Motors and Generators.
   b. MG 13, Frame Assignments for Alternating Current Integral Horsepower Induction Motors.
   c. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
4. National Fire Protection Association (NFPA): 70, National Electrical Code. (NEC)
5. Underwriters Laboratories (UL):
   a. 547, Thermal Protectors for Electric Motors.
   b. 674, Electric Motors and Generators Used in Hazardous (Classified) Locations.

1.3 DEFINITIONS

A. CISD-TEFC: Chemical industry, severe-duty enclosure.

B. EXP: Explosion-proof enclosure.

C. TEFC: Totally enclosed, fan cooled enclosure.

D. Motor Nameplate Horsepower: That rating after any derating required to allow for extra heating caused by the harmonic content in the voltage applied to the motor by its controller.

1.4 SUBMITTALS

A. Shop Drawings:

1. Descriptive information.
2. Nameplate data in accordance with NEMA MG 1.

B. Quality Control Submittals: Operation and maintenance manual.

PART 2 PRODUCTS

2.1 MANUFACTURERS

A. General Electric.

B. Reliance.

C. Siemens.

D. Baldor.

E. U.S. Motors.

F. Westinghouse.

2.2 GENERAL

A. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.

B. In order to obtain single source responsibility, utilize a single supplier to provide a drive motor, its driven equipment, and specified motor accessories.

C. Meet requirements of NEMA MG 1.

D. Frame assignments in accordance with NEMA MG 13.

E. Provide motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

F. Motors shall be specifically designed for the use and conditions intended, with a NEMA design letter classification to fit the application.

G. Lifting lugs on all motors weighing 100 pounds or more.

H. Operating Conditions:

1. Maximum ambient temperature not greater than 40 degrees C.
2. Motors shall be suitable for operating conditions without any reduction being required in the nameplate rated horsepower or exceeding the rated temperature rise.
3. Overspeed in either direction in accordance with NEMA MG 1.

I. All motors intended for use on variable frequency drives shall be designed and labeled for "Inverter Duty".

2.3 HORSEPOWER RATING

A. As designated in motor-driven equipment specifications.

B. Constant Speed Applications: Brake horsepower of the driven equipment at any operating condition not to exceed motor nameplate horsepower rating, excluding any service factor.

C. Adjustable Frequency, Adjustable Speed Applications: Driven equipment brake horsepower at any operating condition not to exceed motor nameplate horsepower rating, excluding any service factor.

2.4 SERVICE FACTOR

A. 1.15 minimum at rated ambient temperature, unless otherwise indicated.

2.5 VOLTAGE AND FREQUENCY RATING

A. System Frequency: 60-Hz.

B. Voltage Rating: Unless otherwise indicated in motor-driven equipment specifications:

Size	Voltage	Phases
1/2 hp and smaller	115	1
3/4 hp through 400 hp	460	3

C. Suitable for full voltage starting.

D. Suitable for accelerating the connected load with supply voltage at motor starter supply terminals dipping to 90 percent of motor rated voltage.

2.6 EFFICIENCY AND POWER FACTOR

A. For all motors except single-phase, under 1 hp, multispeed, short-time rated and submersible motors, or motors driving gates, valves, elevators, cranes, trolleys, and hoists:

1. Efficiency:
   a. Tested in accordance with NEMA MG 1, paragraph 12.54.1.
   b. Guaranteed minimum at full load in accordance with Table 1 or as indicated in motor-driven equipment specifications.
2. Power Factor: Guaranteed minimum at full load in accordance with Table 1 or as indicated in motor-driven equipment specifications.

2.7 LOCKED ROTOR RATINGS

A. Locked rotor kVA Code F or lower if motor horsepower not covered by NEMA MG 1 tables.

B. Safe stall time 15 seconds or greater.

2.8 INSULATION SYSTEMS

A. Single-Phase, Fractional Horsepower Motors: Manufacturer's standard winding insulation system.

B. Three-Phase and Integral Horsepower Motors, Unless Otherwise Indicated in Motor-Driven Equipment Specifications: Class F with Class B rise at nameplate horsepower and designated operating conditions.

2.9 ENCLOSURES

A. All enclosures to conform to NEMA MG 1.

B. TEFC: Furnish with a drain hole with porous drain/weather plug.

C. Explosion-Proof (EXP):

1. TEFC listed to meet UL 674 and NFPA 70 requirements for Class 1, Division 1, Group C and D hazardous locations.
2. Drain holes with drain and breather fittings.
3. Integral thermostat opening on excessive motor temperature in accordance with UL 547 and NFPA 70.
4. Thermostat leads to terminate in a terminal box separate from main terminal box.

D. Chemical Industry, Severe-Duty (CISD-TEFC): In accordance with Article SPECIAL MOTORS.

2.10 TERMINAL (CONDUIT) BOXES

A. Oversize main terminal boxes for all motors.

B. Diagonally split, rotatable to each of four 90-degree positions. Threaded hubs for conduit attachment.

C. Except ODP, furnish gaskets between box halves and between box and motor frame.

D. Minimum usable volume in percentage of that specified in NEMA MG 1-11.06 and 20.62 and NFPA 70, Article 430.

E. Terminal for connection of equipment grounding wire in each terminal box.

2.11 BEARINGS AND LUBRICATION

A. Horizontal Motors:

1. 3/4 hp and Smaller: Permanently lubricated and sealed ball bearings, or regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
2. 1 Through 400 hp: Regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
3. Minimum 100,000 hours L-10 bearing life for ball and roller bearings as defined in AFBMA 9 and 11.

B. Vertical Motors:

1. Thrust Bearings:
   a. Antifriction bearing.
   b. Manufacturer's standard lubrication 100 hp and smaller.
   c. Oil lubricated 125 hp and smaller.
   d. Minimum 50,000 hours L-10 bearing life.
2. Guide Bearings:
   a. Manufacturer's standard bearing type.
   b. Manufacturer's standard lubrication 200 hp and smaller.
   c. Oil lubricated 250 hp and smaller.
   d. Minimum 100,000 hours L-10 bearing life.

C. Regreasable Antifriction Bearings:

1. Readily accessible, grease injection fittings.
2. Readily accessible, removable grease relief plugs.

2.12 NOISE

A. Measured in accordance with IEEE 85 and NEMA MG 1.

B. Motors controlled by adjustable frequency drive systems shall not exceed sound levels of 3 dBA higher than NEMA MG 1.

2.13 BALANCE AND VIBRATION CONTROL

A. In accordance with NEMA MG 1-12.06.

2.14 EQUIPMENT FINISH

A. External Finish: Prime and finish coat manufacturer's standard.

B. Internal Finish: Bore and end turns coated with clear polyester or epoxy varnish.

2.15 SPECIAL MOTORS

A. Requirements in this article take precedence over conflicting features specified elsewhere in this section.

B. Chemical Industry, Severe-Duty (CISD-TEFC):

1. In accordance with IEEE 841.
2. TEFC in accordance with NEMA MG 1.
3. Suitable for indoor or outdoor installation in severe-duty applications including high humidity, chemical (corrosive), dirty, or salty atmospheres.
4. Motor Frame, End Shields, Terminal Box(es), and Fan Cover: Cast iron.
5. Ventilating Fan: Corrosion-resistant, nonsparking, external.
6. Drain and Breather Fittings: Stainless steel.
7. Nameplate: Stainless steel.
8. Gaskets between terminal box halves and terminal box and motor frame.
9. Extra slinger on rotor shaft to prevent moisture seepage along shaft into motor.
10. Double shielded bearings.
11. 125,000 hours minimum L-10 bearing life for direct-connected loads.
12. External Finish: Double-coated epoxy enamel.
13. Coated rotor and stator air gap surfaces.
14. Insulation System, Windings, and Connections:
    a. Class F insulation, Class B rise or better at 1.0 service factor.
    b. Multiple dips and bakes of nonhygroscopic polyester varnish.

15. Service Factor:
    a. At 40 Degrees C Ambient: 1.15.
    b. At 65 Degrees C Ambient: 1.00.
16. Safe Stall Time Without Injurious Heating: 20 seconds minimum.

C. Severe-Duty Explosion-Proof: Meet requirements for EXP enclosures and CISD-TEFC motors.

2.16 FACTORY TESTING

A. Tests:

1. In accordance with IEEE 112 for polyphase motors and IEEE 114 for single-phase motors.
2. Routine (production) tests on all motors in accordance with NEMA MG 1, plus no load power at rated voltage and polyphase, rated voltage measurement of locked rotor current. Test multispeed motors at all speeds.
3. For energy efficient motors, test efficiency at 50, 75, and 100 percent of rated horsepower:
    a. In accordance with IEEE 112, Test Method B, and NEMA MG 1, paragraphs 12.54 and 12.57.
    b. For motors 500 hp and larger where facilities are not available to test by dynamometer (Test Method B), determine efficiency by IEEE 112, Test Method F.
4. Power factor.
    a. Speed.
    b. Current at rated horsepower.
    c. kW input at rated horsepower.
    d. On motors of 100 hp and smaller, furnish a certified copy of a motor efficiency test report on an identical motor.

B. Test Report Forms: Routine Tests: IEEE 112, Form A-1.

PART 3 EXECUTION

3.1 INSTALLATION

A. In accordance with manufacturer's instructions and recommendations.

B. Align motor carefully and properly with driven equipment.

C. Secure equipment to mounting surface with anchor bolts. Provide anchor bolts meeting manufacturer's recommendations and of sufficient size and number for the specified seismic conditions.

3.2 SUPPLEMENTS

A. Table supplements, following “END OF SECTION”, are a part of this Specification.

END OF SECTION

Table 1 MOTOR PERFORMANCE REQUIREMENTS					
		% Guar. Min. Full Load Efficiency		% Guar. Min. Full Load Power Factor	
Hp	Nom. Speed rpm	Horizontal TEFC	Vertical TEFC	Horizontal TEFC	Vertical TEFC
1	1,800	81.5		Mfr.'s Std.	
	1,200	79.3		Mfr.'s Std.	
1.5	3,600	81.5		Mfr.'s Std.	
	1,800	82.0		Mfr.'s Std.	
	1,200	84.0	82.0	Mfr.'s Std.	Mfr.'s Std.
2	3,600	84.0		Mfr.'s Std.	
	1,800	83.7		Mfr.'s Std.	
	1,200	85.5	83.7	Mfr.'s Std.	Mfr.'s Std.
	900	82.5	81.7	Mfr.'s Std.	Mfr.'s Std.
3	3,600	84.0	82.0	Mfr.'s Std.	Mfr.'s Std.
	1,800	86.5	84.8	Mfr.'s Std.	Mfr.'s Std.
	1,200	88.1	86.6	Mfr.'s Std.	Mfr.'s Std.
	900	82.9	82.9	Mfr.'s Std.	Mfr.'s Std.
5	3,600	86.5	84.8	Mfr.'s Std.	Mfr.'s Std.
	1,800	86.5	84.8	Mfr.'s Std.	Mfr.'s Std.
	1,200	88.1	86.6	Mfr.'s Std.	Mfr.'s Std.
	900	86.5	86.6	Mfr.'s Std.	Mfr.'s Std.
7.5	3,600	88.1	86.6	Mfr.'s Std.	Mfr.'s Std.
	1,800	89.5	88.4	Mfr.'s Std.	Mfr.'s Std.
	1,200	88.5	87.5	Mfr.'s Std.	Mfr.'s Std.
	900	86.5	86.6	Mfr.'s Std.	Mfr.'s Std.

Table 1 MOTOR PERFORMANCE REQUIREMENTS					
		% Guar. Min. Full Load Efficiency		% Guar. Min. Full Load Power Factor	
Hp	Nom. Speed rpm	Horizontal TEFC	Vertical TEFC	Horizontal TEFC	Vertical TEFC
10	3,600	89.5	88.4	Mfr.'s Std.	Mfr.'s Std.
	1,800	89.5	88.4	Mfr.'s Std.	Mfr.'s Std.
	1,200	89.5	88.4	Mfr.'s Std.	Mfr.'s Std.
	900	88.5	88.4	Mfr.'s Std.	Mfr.'s Std.
15	3,600	89.8	88.4	Mfr.'s Std.	Mfr.'s Std.
	1,800	91.0	90.2	Mfr.'s Std.	Mfr.'s Std.
	1,200	90.2	89.3	Mfr.'s Std.	Mfr.'s Std.
	900	88.5	88.4	Mfr.'s Std.	Mfr.'s Std.
20	3,600	90.6	89.3	Mfr.'s Std.	Mfr.'s Std.
	1,800	91.7	90.9	Mfr.'s Std.	Mfr.'s Std.
	1,200	90.6	89.3	Mfr.'s Std.	Mfr.'s Std.
	900	89.5	88.4	Mfr.'s Std.	Mfr.'s Std.
25	3,600	91.0	90.2	Mfr.'s Std.	Mfr.'s Std.
	1,800	92.4	91.7	Mfr.'s Std.	Mfr.'s Std.
	1,200	91.0	89.3	Mfr.'s Std.	Mfr.'s Std.
	900	89.5	88.4	Mfr.'s Std.	Mfr.'s Std.
30	3,600	91.4	88.4	Mfr.'s Std.	Mfr.'s Std.
	1,800	92.4	91.7	Mfr.'s Std.	Mfr.'s Std.
	1,200	91.0	90.2	Mfr.'s Std.	Mfr.'s Std.
	900	91.7	90.9	Mfr.'s Std.	Mfr.'s Std.
40	3,600	91.7	89.3	86.1	89.0
	1,800	93.0	91.7	78.2	84.5
	1,200	92.4	90.9	81.5	81.5
	900	91.0	90.2	70.5	70.5

Table 1 MOTOR PERFORMANCE REQUIREMENTS					
		% Guar. Min. Full Load Efficiency		% Guar. Min. Full Load Power Factor	
Hp	Nom. Speed rpm	Horizontal TEFC	Vertical TEFC	Horizontal TEFC	Vertical TEFC
50	3,600	92.0	89.3	86.7	89.0
	1,800	93.0	91.7	79.4	82.5
	1,200	92.4	90.9	81.5	81.5
	900	91.7	90.9	72.9	80.0

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

JOHNSON SPACE CENTER

WHITE SANDS TEST FACILITY

TECHNICAL SPECIFICATIONS FOR THE SUPPLY AND INSTALLATION OF PROCESS PIPING, CONTROL SYSTEM, AND RELATED COMPONENTS

GROUND WATER TREATMENT SYSTEM FOR PLUME-FRONT STABILIZATION

Revised May 31, 2002

Table of Contents

List of Drawings……iii

List of References…….. vi

1. Scope……... 1

2. General Requirements…… 4
   - 2.1 Security Provisions……... 4
   - 2.2 Health and Safety Provisions……... 5
   - 2.3 Confined Spaces and Entry……... 6
   - 2.4 Environmental Concerns……...7
   - 2.5 Cultural Resources…… 7

3. Schedule Requirements……7

4. Mechanical Component Specifications……8
   - 4.1 Process Piping……... 8
   - 4.2 Valves……12
   - 4.3 Pipe Supports…… 18
   - 4.4 Piping Installation…… 20
   - 4.5 Valve Installation…….. 22
   - 4.6 Pipe Support Installation ……..23

5. Electrical and Process Component Specification…… 24
   - 5.1 Flow Meters…….. 24
   - 5.2 Float Level Switch, Tank Top…….. 25
   - 5.3 Float Level Element and Switch……... 25
   - 5.4 Pressure Indicators…… 26
   - 5.5 Telephone Dialer Alarm…….. 26
   - 5.6 Power Monitor……..…….. 27
   - 5.7 Programmable Logic Controller System..…….. 29

6. Packaged Control System…… 34
   - 6.1 General……..34
   - 6.2 Products…….34
   - 6.3 Component Identification……..47
   - 6.4 Surge and Transient Protection……49

7. Fiber Optic Data Transmission System…….. 49
   - 7.1 System Description…….. 49
   - 7.2 Submittals…… 50
   - 7.3 Products…… 51
   - 7.4 Optical Fibers……...53
   - 7.5 Fiber Optic Installation……..…….. 57

Table of Contents (continued)

7.6 Fiber Optic System Testing……...…..……60
7.7 Fiber Optic System Training……...……..……..…61

8. Certification and Warranty……... …61

9. Submittals……..62
9.1 General Requirements……62
9.2 Pre-construction Submittals……...63
9.3 Construction Progress Submittals……..…64
9.4 Construction Close-out Submittals……66

Attachments

1…….……WSI 25-SW-0003.B "Confined Space Entry Program"

2……WSI 25-SW-0013.C "Hot Work Permit for Welding-Cutting Operations"

3.....Contract Drawings

List of Drawings

PIPING SYSTEM:

652-I-01……INDEX OF DRAWINGS
652-I-02……INDEX OF DRAWINGS
652-I-04……INDEX OF DRAWINGS, SYMBOLS, & ABBREVIATIONS
652-C-01……..CIVIL, PROJECT LOCATION
652-C-02……..CIVIL, WELL LOCATIONS & PIPING LAYOUT
652-C-03……..CIVIL, PLAN & PROFILE PIPING ROUTE (N-1)
652-C-04……..CIVIL, PLAN & PROFILE PIPING ROUTE (N-2)
652-C-05……..CIVIL, PLAN & PROFILE PIPING ROUTE (N-3)
652-C-06……..CIVIL, PLAN & PROFILE PIPING ROUTE (N-4)
652-C-07……..CIVIL, PLAN & PROFILE PIPING ROUTE (N-5)
652-C-08……..CIVIL, PLAN & PROFILE PIPING ROUTE (S-1)
652-C-09……..CIVIL, PLAN & PROFILE PIPING ROUTE (S-2)
652-C-10……..CIVIL, PLAN & PROFILE PIPING ROUTE (S-3)
652-C-11……..CIVIL, PLAN & PROFILE PIPING ROUTE (S-4)
652-C-12……..CIVIL, PLAN & PROFILE PIPING ROUTE (S-5)
652-C-13……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-2)
652-C-14……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-4A)
652-C-15……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFE4B)
652-C-16……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-5)
652-C-17……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFI-1A)
652-C-18……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFI-1B)
652-C-19……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFI-4A)
652-C-20……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-7A)
652-C-21……..CIVIL, PLAN & PROFILE PIPING ROUTE (PFE-7B)
652-M-01……..MECHANICAL, FLOW SCHEMATIC, EXTRACTION WELLS
652-M-02…… .MECHANICAL, FLOW SCHEMATIC, TREATMENT FACILITY
652-M-03…… .MECHANICAL, FLOW SCHEMATIC, INJECTION WELLS
652-M-04…… .MECHANICAL, SUBGRADE PIPE & FITTING SCHEDULES
652-M-05…… .MECHANICAL, SUBGRADE PIPE & FITTING SCHEDULES
652-M-06…… .MECHANICAL, PIPE & FITTING SCHEDULES
652-M-07…… .MECHANICAL, PIPE & FITTING SCHEDULES
652-M-08…… .MECHANICAL, PIPE & FITTING SCHEDULES

EXTRACTION WELLS:

653-C-01……PFE-1 CIVIL, SITE/UTILITIES PLAN
653-M-01……...PFE-1 MECHANICAL DETAILS
653-E-01……PFE-1 ELECTRICAL DETAILS
653-E-02……PFE-1 ELECTRICAL DETAILS
654-C-01……PFE-2 CIVIL, SITE/UTILITIES PLAN
654-M-01……...PFE-2 MECHANICAL DETAILS
654-E-01……PFE-2 ELECTRICAL DETAILS
654-E-02……PFE-2 ELECTRICAL DETAILS
655-C-01……PFE-3 CIVIL, SITE/UTILITIES PLAN
655-M-01……...PFE-3 MECHANICAL DETAILS
655-E-01……PFE-3 ELECTRICAL DETAILS
655-E-02……PFE-3 ELECTRICAL DETAILS
656-C-01……PFE-4A CIVIL, SITE/UTILITIES PLAN
656-M-01……...PFE-4A MECHANICAL DETAILS
656-E-01……PFE-4A ELECTRICAL DETAILS
656-E-02……PFE-4A ELECTRICAL DETAILS

List of Drawings (continued)

657-C-01……PFE-5 CIVIL, SITE/UTILITIES PLAN
657-M-01……...PFE-5 MECHANICAL DETAILS
657-E-01……PFE-5 ELECTRICAL DETAILS
657-E-02……PFE-5 ELECTRICAL DETAILS
658-C-01……PFE-7 CIVIL, SITE/UTILITIES PLAN
658-M-01……...PFE-7 MECHANICAL DETAILS
658-E-01……PFE-7 ELECTRICAL DETAILS
658-E-02……PFE-7 ELECTRICAL DETAILS

INJECTION WELLS:

660-C-01……PFI-1, CIVIL, SITE/UTILITIES PLAN
660-M-01……...PFI-1, MECHANICAL, DETAILS AT WELLHEAD
661-C-01……PF1-2, CIVIL, SITE/UTILITIES PLAN
661-M-01……...PFI-2, MECHANICAL, DETAILS AT WELLHEAD
662-C-01……PFI-3, CIVIL, SITE/UTILITIES PLAN
662-M-01……...PFI-3, MECHANICAL, DETAILS AT WELLHEAD
663-C-01……PFI-4, CIVIL, SITE/UTILITIES PLAN
663-M-01…….. PFI-4, MECHANICAL, DETAILS AT WELLHEAD

BUILDING 650, TREATMENT FACILITY

650-M-06……MECHANICAL, EQUIPMENT LAYOUT
650-E-01…….ELECTRICAL, POWER PLAN
650-E-04…….ELECTRICAL, ONE LINE DIAGRAM
650-E-08…….ELECTRICAL, CONTROL CONDUIT LAYOUT

BUILDING 651, INJECTION MANIFOLD BUILDING

651-M-01……MECHANICAL, ISOMETRIC PIPING
651-E-01…….ELECTRICAL, POWER & LIGHTING PLAN

CONTROL SYSTEM (Drawings by CH2M Hill):

G-1…….. ELECTRICAL, INSTRUM ENTATION LEGEND
G-2…….. ELECTRICAL, INSTRUMENTATION LEGEND
G-3……..ELECTRICAL, PLC SYSTEM DIAGRAM
E-1……..ELECTRICAL, INSTRUMENTATION CONDUIT SITE PLAN, EXTRACTION WELLS, NORTH
E-2……..ELECTRICAL, INSTRUMENTATION CONDUIT SITE PLAN, EXTRACTION WELLS, CENTRAL
E-3……..ELECTRICAL, INSTRUMENTATION CONDUIT SITE PLAN, EXTRACTION WELLS, SOUTH
E-4……..ELECTRICAL, INSTRUMENTATION CONDUIT SITE PLAN, INJECTION WELLS
E-5……..ELECTRICAL, TREATMENT BUILDING, INSTRUMENTATION PLAN
E-6……..ELECTRICAL, INJECTION MANIFOLD BUILDING, INSTRUMENTATION PLAN
E-7……..INSTRUMENTATION AND CONDUIT SITE PLAN, EXTRACTION WELLS WEST
I-1……...ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, EXTRACTION WELLS PFE-1 AND PFE-5
I-2……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, EXTRACTION WELLS PFE-2 AND PFE-6

List of Drawings (continued)

I-3……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, EXTRACTION WELLS PFE-3 AND PFE-4A
I-4……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, EXTRACTION WELLS PFE-7, PFE-8, & PFE-9
I-5……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, SCALE CLEANING SYSTEM
I-6……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, POTABLE WATER AND FLOOR SUMP
I-7……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, SCALE CLEANING SYSTEM
I-8……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, AIR STRIPPER UNIT NO. 1
I-9……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, AIR STRIPPER UNIT NO. 2
I-10……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, AIR STRIPPER UNIT NO. 3
I-11……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, ULTRAVIOLET OXIDATION UNIT NO. 1
I-12……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, ULTRAVIOLET OXIDATION UNIT NO. 2
I-13……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, INJECTION WELLS PFI-1 AND PFI-2
I-14……ELECTRICAL, PROCESS & INSTRUMENTATION DIAGRAM, INJECTION WELLS PFI-3 AND PFI-4
I-15……ELECTRICAL, EXTRACTION WELL CONTROL PANEL
I-16……ELECTRICAL, EXTRACTION WELL CONTROL PANEL WIRING
I-17……ELECTRICAL, EXTRACTION WELL CONTROL PANEL WIRING
I-18……ELECTRICAL, FIBER-OPTIC MODEM PANEL
I-19……ELECTRICAL, INJECTION WELL CONTROL PANEL
I-20……ELECTRICAL, INJECTION WELL CONTROL PANEL WIRING
I-21……ELECTRICAL, INJECTION WELL CONTROL PANEL WIRING
I-22……ELECTRICAL, INJECTION WELL CONTROL PANEL WIRING
I-23……ELECTRICAL, PLC – MAIN CONTROL PANEL
I-24……ELECTRICAL, PLC – MAIN CONTROL PANEL WIRING
I-25……ELECTRICAL, PLC – MAIN CONTROL PANEL WIRING
I-26……ELECTRICAL, PLC – MAIN CONTROL PANEL WIRING
I-27……ELECTRICAL, PLC – MAIN CONTROL PANEL WIRING
I-28……ELECTRICAL, PLC – MAIN CONTROL PANEL WIRING
I-29……ELECTRICAL, FIBER-OPTIC MODEM TERMINALS

List of References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM):

ASTM A 105/A 105M (1996) Standard Specification for Forgings, Carbon Steel, for Piping Components

ASTM A 126 (1995) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings

ASTM A 197 (1987; R 1992) Standard Specification for Cupola Malleable Iron

ASTM A 216 (1993) Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High Temperature Service

ASTM A 234/A 234M (1997) Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and Elevated Temperatures

ASTM A 307 (1994) Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength

ASTM A 403/A 403M (1997; Rev A) Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings

ASTM A 53 (1996) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

ASTM A 563 (1994) Standard Specification for Carbon and Alloy Steel Nuts

ASTM F 104 (1995) Standard Classification System for Nonmetallic Gasket Materials

ASTM F 441/F 441M (1997) Chlorinated Poly (Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80

ASTM F 437 (1999) Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80

ASTM F 439 (1999) Socket-Type Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80

ASTM F493 Solvent Cements for CPVC Plastic Pipe and Fittings

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME):

ASME B16.1 (1998) Cast Iron Pipe Flanges and Flanged Fittings

ASME B16.11 (1996) Forged Steel Fittings, Socket-Welding and Threaded

ASME B16.3 (1992) Malleable-Iron Threaded Fittings, Classes 150 and 300

ASME B16.39 (1986) Malleable Iron Threaded Pipe Unions, Classes 150, 250, and 300

ASME B16.5 (1996) Pipe Flanges and Flanged Fittings

ASME B16.9 (1993) Factory-Made Wrought Steel Butt Welding Fittings

ASME B31.3 (1996) Chemical Plant and Petroleum Refinery Piping

AMERICAN WELDING SOCIETY (AWS):

AWS-02 (1990) Welding Handbook; Eighth Ed; Vol Two – Welding Process

FEDERAL SPECIFICATIONS (FS):

FS HH-I-558 (Rev C) Insulation, Blocks, Boards, Blankets, Felts, Sleeving (Pipe and Tube Covering), and Pipe Fitting Covering, Thermal (Mineral Fiber, Industrial Type)

FS FF-S-325 (Int Amd 3) Shield, Expansion; Nail, Expansion; and Nail, Drive Screw (Devices, Anchoring, Masonry)

MANUFACTURER'S STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS):

MSS SP-58 (1993) Pipe Hangers and Supports - Materials, Design and Manufacture
MSS SP-67 (1995) Butterfly Valves
MSS SP-69 (1996) Pipe Hangers and Supports - Selection and Application
MSS SP-85 (1994) Cast Iron Globe & Angle Valves Flanged and Threaded Ends

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC):

AISC S328 (1986) Specification for Structural Steel Buildings Load and Resistance Factor Design

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI):

ANSI A13.1 (1981; R 1993) Scheme for the Identification of Piping Systems
ANSI B40.1 (1991) Gauges - Pressure Indicating Dial Type - Elastic Element

INSTRUMENT SOCIETY OF AMERICA (ISA):

ISA S50.1, Compatibility of Analog Signals for Electronic Process Instruments.
ISA S7.0.01 (1996) Quality Standard for Instrument Air

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA):

NEMA 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
NEMA AB 1, Molded Case Circuit Breakers and Molded Case Switches.
NEMA ICS 2, Industrial Control Devices, Controllers and Assemblies.

ELECTRONIC INDUSTRIES ALLIANCE (EIA):

EIA ANSI/EIA/TIA-232-F(1997) Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange
EIA/TIA-455-B (1998) Test Procedures for Fiber Optic Fibers, Cables, Transducers, Sensors, Connecting and Terminating Devices, and other Fiber Optic Components (ANSI)
EIA ANSI/TIA/EIA-455-13A(1996) FOTP-13 Visual and Mechanical Inspection of Fiber Optic Components, Devices, and Assemblies
EIA ANSI/EIA/TIA-455-25B(1996) FOTP-25 Repeated Impact Testing of Fiber Optic Cables and Cable Assemblies
EIA ANSI/EIA/TIA-455-30B(1991) FOTP-30 Frequency Domain Measurement of Multimode Optical Fiber Information Transmission Capacity
EIA ANSI/TIA/EIA-455-41A(1993) FOTP-41 Compressive Loading Resistance of Fiber Optic Cables
EIA ANSI/EIA/TIA-455-46A(1990) FOTP-46 Spectral Attenuation Measurement for Long-Length, Graded-Index Optical Fibers
EIA ANSI/EIA/TIA-455-58A(1990) FOTP-58 Core Diameter Measurement of Graded-Index Optical Fibers

EIA ANSI/EIA/TIA-455-59(1989) FOTP-59 Measurement of Fiber Point Defects Using an OTDR
EIA ANSI/EIA/TIA-455-61(1989) FOTP-61 Measurement of Fiber or Cable Attenuation Using an OTDR
EIA ANSI/EIA-455-81A-91(1992) FOTP-81 Compound Flow (Drip) Test for Filled Fiber Optic Cable
EIA ANSI/EIA/TIA-455-82B(1992) FOTP-82 Fluid Penetration Test for Fluid-Blocked Fiber Optic Cable
EIA ANSI/EIA-455-91(1986; R 1996) FOTP-91 Fiber Optic Cable Twist-Bend Test
EIA ANSI/TIA/EIA-455-104A(1993) FOTP-104 Fiber Optic Cable Cyclic Flexing Test
EIA ANSI/EIA/TIA-455-170(1989) FOTP-170 Cable Cutoff Wavelength of Single-Mode Fiber by Transmitted Power
EIA ANSI/EIA-455-171(1987) FOTP-171 Attenuation by Substitution Measurement - for Short-Length Multimode Graded-Index and Single-Mode Optical Fiber Cable Assemblies
EIA ANSI/TIA/EIA-455-177A(1992) FOTP-177 Numerical Aperture Measurement of Graded-Index Optical Fibers

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA):
NFPA 70(1999) National Electrical Code

UNDERWRITERS LABORATORIES (UL):
UL 910(1998) Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fiber Cables Used in Spaces Transporting Environmental Air

1. Scope

1.1. This specification defines the requirements for materials, installation, and testing of the process piping and control system for NASA White Sands Test Facility's (WSTF) groundwater remediation facility. Once the treatment system is installed, groundwater containing low parts-per-billion (ppb) concentrations of hazardous constituents will be pumped through dual-containment high density polyethylene (HDPE) piping from extraction wells to a treatment facility. Within the remediation facility, the water will be conveyed in steel piping and treated via two parallel air strippers and an ultraviolet oxidation reactor. Following treatment, single-wall HDPE piping will be used to transfer the treated groundwater from the treatment facility to injection wells. Installation of underground HDPE piping and conduit, wells, and well vaults are excluded from the scope of this project.

1.2. Maps of WSTF's location and the project location with respect to WSTF's developed areas are presented in the contract drawings. WSTF is located 18 miles northeast of Las Cruces, New Mexico (65 miles north of El Paso, Texas) with access provided through U.S. Highway 70. The project is located in an unimproved area of Sections 4 and 5 of T21S, R3E and Section 32 of T20S, R3E (see contract drawings). Access to the general project vicinity is provided by a light duty gravel road (the WSTF Well Road).

1.3. Location of each building, well vaults, and the pipeline are shown in the complete contract drawing package. Also included are the equipment schedules, dimensions, process diagrams, etc., required for the completion of this project.

1.4. The scope of this specification includes the following:

1.4.1. Extraction Well Vaults (refer to contract drawings 652-M-01, 652-E-01 through 652-E-38, 653-M-01, 653-E-01, 653-E-02, 654-M-01, 654-E-01, 654-E-02, 655-M-01, 655-E-01, 655-E-02, 656-M-01, 656-E-01, 656-E-02, 657-M-01, 657-E-01, and 657-E-02).

1.4.1.1. Supply and install various diameters of steel piping, pipe supports, flow control valve, control valve controller unit, flow meter, and manual valves in six extraction well vaults, per contract drawings. These components are located between the wellhead flange and an HDPE flange inside each vault (note: PFE-5 does not have a flow control valve or valve controller unit).

1.4.1.2. Supply and install six extraction well control panels (PLC-PFEx) at the vaults of extraction wells 1, 2, 3, 4A, 5, and 7. Complete wiring and communication connections per the contract drawings.

1.4.1.3. Supply and field install a power monitor unit in the Motor Control Center (MCC) for each respective extraction well, with all accessories including matching potential and current transformers. Complete electrical connection between the power monitors and the Allen-Bradley Data Highway Plus network installed under the scope of this project. Supply and install all

necessary accessories for a functional communication connection. MCC's will be provided and installed by the Government.

1.4.1.4. Complete and verify all wiring connections between electrical components and their respective power supply and Supervisory Control and Data Acquisition (SCADA) system connections at each well vault.

1.4.1.5. Supply and install fiber optic cable through underground conduit, between extraction well MCC's and Building 650, per the contract drawings. Complete all wiring connections and verify communication between extraction wells and Building 650 controller.

1.4.2. Building 650 – Groundwater Treatment Facility (refer to contract drawings 652-M-02, 652-E-01 through 652-E-38, 650-M-06, 650-E-01, 650-E-04, and 650-E-09)

1.4.2.1. Supply and install various diameter steel piping, pipe supports, manual valves, and pressure gauge between the influent flange from the extraction well pipeline and the inlet flanges on both air strippers, as indicated on contract drawings.

1.4.2.2. Supply and install various diameter steel piping, supports, manual valves, check valves, pressure gauge, and rupture disc between the air stripper discharge flanges and the UV system inlet flange, as indicated on contract drawings.

1.4.2.3. Install the supplied static mixer into the inlet piping to the air strippers as indicated on contract drawings.

1.4.2.4. Install the supplied electromagnetic flow meter in the UV reactor inlet piping, as indicated on contract drawings. Complete electrical connections between the UV reactor controller (PLC-UV1)and flow meter per manufacturer specifications.

1.4.2.5. Supply and install various diameter chlorinated polyvinyl chloride (CPVC) piping and supports between scale cleaning system and air strippers, and between an existing "spent cleaning solution" tank and each of the two air strippers.

1.4.2.6. Supply and install steel piping and supports between UV system drain and floor sump, and install steel piping and supports between rupture disc discharge at the UV unit inlet and the floor sump.

1.4.2.7. Supply and install steel piping, supports, manual valve, and check valve that make up the system recycle line.

1.4.2.8. Supply and install tubing between scale control system pump and pipe connection upstream of the static mixer, per the design drawings.

1.4.2.9. Supply and install compressed air tubing lines between existing air compressor unit, nine pneumatic valve actuators, and the UV reactor pneumatic wiper tubes, as indicated on contract drawings.

1.4.2.10. Supply and install Building 650 controller (PLC Main) panel. Complete wiring and communication connections per the contract drawings.

1.4.2.11. Supply, install, and connect wiring between air stripper controllers (CP-100 and CP200) and UV reactor controller (PLC-UV1) to the Building 650 controller (PLC-Main), per the contract drawings.

1.4.2.12. Supply wiring and connect Scale Cleaning System controller (CP-400) and Scale Control System controller (CP-300) to PLC-Main controller, per the contract drawings.

1.4.2.13. Install supplied air stripper blower sensors and switches in blower inlet ducting to the air strippers. Supply, install, and connect wiring between these sensors and respective control panels per the contract drawings.

1.4.2.14. Supply and install float level switch in Building 650 floor sump. Complete electrical connections between floor sump level switch and the PLC-Main controller, per the contract drawings.

1.4.2.15. Supply and connect wiring between the existing Leak Detection Control Panel in Building 650 and the PLC-Main controller, per the contract drawings.

1.4.2.16. Complete installation and electrical connection between two existing air temperature switches in Building 650 and the PLC-Main controller, per the contract drawings.

1.4.2.17. Supply, install, and/or complete electrical and fiber optic connections for a power monitor in the Building 650 motor control center. This may be done by either providing a new power monitor, or providing adequate hardware and software to allow communication and data exchange between the existing Square D Powerlogic monitor and the Allen-Bradley Data Highway Plus network installed under the scope of this project. Supply and install all necessary accessories for a functional communication connection.

1.4.2.18. Install control station personal computer supplied by NASA in the Building 650 control room. This includes an alarm printer, and a telephone dialer. HMI and control system software packages will be supplied by NASA, then installed and programmed by the contractor.

1.4.2.19. Supply wiring, install, and interconnect the SCADA system, control station PC, WSTF telephone system, and telephone dialer, per the contract drawings.

1.4.2.20. Verify proper connection and perform specified tests on wiring, fiber optic (FO) cable, FO splices, and connections for power, control, and communication system during and following the installation process. Refer to technical specifications that follow for further details.

1.4.2.21. Validate the control system and software, autodialer functions, alarms, etc. following installation. Provide a complete and functional communication network per the contract drawings. Refer to technical specifications that follow for further details.

1.4.3. Building 651 - Injection Manifold Building (refer to contract drawings 652-M-03, 652-E-01 through 652-E-38, 651-M-01, and 651-E-01).

1.4.3.1. Supply and install various diameter CPVC piping, pipe supports, flow control valves with position transmitters, valve controllers, electromagnetic flow meters, air vent valves, and manual valves, per the contract drawings. These components make up the piping manifold between the flange at the end of the pipeline from Building 650 and the four flanges on pipelines that lead to the injections wells. Refer to mechanical design drawings numbered above.

1.4.3.2. Supply and install Building 651 control (PLC-PFI) panel. Supply wire and complete wiring connections per the contract drawings.

1.4.3.3. Supply wire and complete wiring connections between flow control valves, position transmitters, valve controllers, flow meters, and PLC-PFI in Building 651, per the contract drawings.

1.4.3.4. Supply wire, install in existing underground conduit, and complete electrical connection between existing well-level pressure transducers in each injection well and Building 651 controller (PLC-PFI).

1.4.3.5. Supply and install control cable and/or fiber optic cable into existing underground conduit, between Building 651 and Building 650. Complete electrical connections on both ends per the contract drawings.

1.4.3.6. Verify wiring connections for all controls and communication following installation.

1.4.4. Injection Well Vaults (refer contract drawings 652-M-03, 652-E-01 through 652-E-38, 660-M-01, 661-M-01, 662-M-01, and 663-M-01)

1.4.4.1. Supply and install carbon steel piping, pipe supports, and manual valves, in four injection well vaults as indicated on contract drawings. These components comprise the piping connection between the steel wellhead flange and the HDPE pipeline flange. They are contained inside the injection well vaults.

1.4.4.2. Verify and/or complete electrical connections between existing well-level pressure transducers at each injection well vault and controller PLC-PFI in Building 651.

2. General Requirements

2.1. Security Provisions

2.1.1. Following award of this contract, the Contractor shall submit the names, and citizenship of all personnel scheduled to be on site to the facility point of contact at least 5 days prior to their arrival at WSTF. NASA-WSTF will only issue badges to U.S. citizens. Upon mobilization to the facility, all Contractor and sub-contractor employees are required to show valid picture identification to security personnel. At this time a temporary security badge will be issued to each employee. Contractor employees shall wear their badges at all times while present on the facility. All vehicles entering the site are required to have current license and registration documents, and are subject to search upon entering and exiting the facility. A temporary parking permit will be issued and placed on the vehicle upon its entry into the facility.

2.1.2. Contractor personnel will be restricted to the work area and will not be allowed to venture unescorted to other areas of the site. Work hours at WSTF shall not exceed 12 hours per day or 60 hours per week for any Contractor personnel. Regular work hours at WSTF are Monday through Friday, 7:00 a.m. to 3:30 p.m.

2.1.3. Contractor shall comply with all site access, safety, and security procedures prescribed for the control of persons visiting the project site. Contractor personnel shall receive necessary briefings before being allowed to enter and perform work at the Government facility. The Contractor shall advise the facility POC or designee of any safety issues with regard to his activity, so that on-site personnel can be notified.

2.1.4. Contractor personnel will be required to have means of communication while working in the plume front area at WSTF. This may consist of radios or cellular telephone. This is to allow rapid notification in the case of any emergency that might arise and require evacuation or other action on their part. Use of cellular telephones by the Contractor at WSTF is not restricted, but use of two-way radios must be pre-approved by WSTF.

2.1.5. Telephone

2.1.5.1. A telephone, for on-site and local calls and emergency use only, is installed and operational in Building 650. For work in remote locations, contractor is required to supply personnel with a means of emergency communication as mentioned in the security provisions above.

2.1.6. Temporary Storage

2.1.6.1. Several locations near the work site will be made available by the Government for use as temporary storage and/or staging areas. If needed, temporary fencing may be used for security of these locations, supplied at the Contractor's expense, and removed within 30 days following the end of project construction. Contractor may also use Building 650 for storage of equipment. NASA will issue a set of Building 650 keys to the Contractor. If Contractor loses those keys, he will be charged for the cost of all required re-keying.

2.1.6.2. The Government assumes no responsibility for security of equipment stored temporarily at or near the work site.

2.2. Health And Safety Provisions

2.2.1. Fire Protection

2.2.1.1. Contractor shall provide the appropriate temporary fire protection equipment for the protection of personnel and property during construction. Debris and flammable materials shall be removed weekly by the Contractor to minimize potential hazards. At least one 10 lb., Class A/B/C, dry chemical fire extinguisher is required within each vehicle at the work site during all operations at WSTF.

2.2.1.2. If Contractor performs any welding or spark-producing operations, Contractor shall comply with WSTF's hot work regulations. A copy of WSI 25-SW-0013.C is provided as an attachment to this document.

2.2.2. Contractor personnel will wear the following personal protective equipment:

-Hard hats in accordance with ANSI Z89.1
-Steel toed boots with metatarsal guards in accordance with ANSI Z41
-Safety glasses in accordance with ANSI Z87.1
-Work gloves while handling equipment
-Hearing protection if noise levels exceed 80 dbA (when vocal communication between persons standing three feet apart requires shouting).

2.2.3. The Government reserves the option to visually inspect equipment prior to the commencement of work. Any significant health or safety concerns will be identified and the Contractor will be allowed to address the concerns. If significant concerns cannot be rectified, this may be cause for termination of the contract.

2.2.4. Contractor shall comply with all applicable WSTF safety regulations. All Contractor personnel shall receive a 15 to 30 minute safety and security briefing immediately following their arrival at WSTF. The briefing will be given at the WSTF Safety Office prior to access to the work area. A second briefing (approximately 30 minutes) may be given at the WSTF Environmental Department that addresses any specific concerns relative to the project area.

2.2.5. Contractor employees must utilize the WSTF dispensary facilities located in Building 104 for all injury and emergency medical treatment. The dispensary number is 524-5212 and the on site emergency numbers are 5911 or 5111.

2.3. Confined Spaces and Entry

2.3.1. Contractor shall comply with the requirements in White Sands Standard Instruction WSI 25-SW-0003.B "Confined Space Entry Program", which references 29 CFR 1910.146 "Permit Required Confined Spaces", for entry into well vaults and pipeline manholes. A copy of WSI 25-SW-0003.B is provided as an attachment to this document.

2.3.2. All confined spaces at WSTF are considered Permit required until proven otherwise. Contractor shall prohibit entry into any confined space until it is reclassified as a Non-permit confined space per CFR 1910.146(c)(7) procedures. This instructs that a qualified person must conduct appropriate tests of the atmosphere to ensure the confined or enclosed space is safe for the work intended and that all potential hazards are controlled or eliminated and documented. All hazards pertaining to the space shall be reviewed with each employee during the safety review meetings mentioned previously.

2.3.3. Contractor shall provide proof of training and qualifications for employees that will be involved in confined space entry functions. These include air monitors, entrants, attendants, and supervisors. Training shall meet or exceed the requirements of 29 CFR 1910.146.

2.3.4. The Contractor shall use WSTF Form 503 "Confined Space Entry Permit", or other form with the same minimum information for the Confined Space Entry Permit, to document atmospheric test results. The permit shall be posted in a conspicuous place close to the confined space entrance. This form is provided as a part of the attached copy of document WSI 25-SW-0003.A.

2.4. Environmental Concerns

2.4.1. Discharge of potable water used for flushing or pressure testing to grade is allowed by WSTF per document WSI 22-SW-0005.B, page 2, section 4(b)(6).

2.4.2. Any ground disturbing activities performed at WSTF, including trenching, grading, and excavation, must be coordinated in advance with the base Point of Contact. Obtaining required dig permits and right of way will be the responsibility of the Government.

2.4.3. The Contractor shall be responsible, in accordance with applicable state and federal regulations and WSTF policies, to clean and dispose of waste generated during the performance of this project construction. Any release of hazardous waste shall be reported to the base point of contact immediately.

2.5. Cultural Resources

2.5.1. If at any time during construction an archeological, rare, historical, or paleontological discovery is made, the Contractor will immediately cease operations and notify the base point of contact. Construction will not be resumed until authorized by the Contracting Officer.

3. Schedule Requirements

3.1. A Project Schedule shall be prepared as described below. The project schedule shall be developed by the Contractor and approved by NASA. Contractor management personnel shall actively participate and approve of the Project Schedule elements. Subcontractors and suppliers working on the project shall be responsible for adherence to an accurate Project Schedule.

3.2. The NASA approved Project Schedule shall be used to measure the progress of the work. The subparts 3.2.1 through 3.2.5 below shall be considered a minimum appropriate level of detail to be used in the Project Schedule:

3.2.1. Project Schedule Format

3.2.1.1. The project schedule shall be prepared in MS Project and submitted in two media formats: as an *.mpp file (MS Project '98 or earlier format), and as a paper copy.

3.2.2. Activity Duration

3.2.2.1. Tasks related to the procurement of long lead materials or equipment shall be included as separate activities in the project schedule.

3.2.3. Procurement

3.2.3.1. Examples of procurement process activities include, but are not limited to: submittals, approvals, procurement, fabrication, and delivery.

3.2.4. Government Activities

3.2.4.1. Anticipated government and other agency activities that could impact progress shall be shown. These activities may include, but are not limited to: approvals, inspections, utility tie-in, installation of Government Furnished Equipment (GFE), and Notice to Proceed for phasing requirements.

3.2.5. Responsibility

3.2.5.1. All activities shall be identified in the project schedule with the party responsible for performance of the work. Responsibility includes, but is not limited to, the subcontracting firm, contractor work force, or government agency performing a given task. Activities shall not belong to more than one responsible party.

4. Mechanical Component Specification

4.1. Process Piping

4.1.1. General Requirements

4.1.1.1. All piping materials and appurtenances shall be as specified, or equivalent, and as shown on the contract drawings and shall be suitable for the service intended. The contract drawings are presented as an attachment to this document.

4.1.1.2. Applicable standards of the American National Standards Institute (ANSI), American Water Works Association (AWWA), National Association of Corrosion Engineers (NACE), American Society for Testing and Materials (ASTM), Illuminating Engineering Society (IES), National Electrical Manufacturers Association (NEMA), National Fire Protection Association

(NFPA), National Electrical Code (NEC), National Electrical Safety Code (NESC) and the Underwriters' Laboratories (UL) reflect current industry standard practice and must be used for establishing the quality of materials and equipment.

4.1.1.3. Piping materials, appurtenances and equipment supplied as part of this contract shall be new and unused, except for testing equipment. Components that serve the same function and are the same size shall be identical products of the same manufacturer. The general materials to be used for the piping systems are indicated in the contract drawings.

4.1.1.4. The absence of pipe supports and details on the contract drawings does not relieve the Contractor of responsibility for sizing and providing pipe supports where appropriate and as detailed in this document.

4.1.1.5. The Contractor shall provide all structural work and equipment required to control expansion and contraction of piping. The Contractor shall verify that the anchors, guides, and expansion joints provided adequately protect the piping systems per ASME B31.3 requirements.

4.1.1.6. The pressure ratings and materials specified represent minimum acceptable standards for piping systems. The piping systems shall be suitable for the services specified and intended. Each piping system shall be coordinated to function as a unit. Flanges, valves, fittings and appurtenances shall have a pressure rating no less than that required for the system in which they are installed.

4.1.1.7. Piping equipment and appurtenances shall be new products of equal material and ratings as the connecting pipe.

4.1.1.8. Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacturing of the products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Nominal sizes for standardized products shall be used. Pipe, valves, fittings and appurtenances shall be supportable by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

4.1.1.9. Test reports for Hydrostatic Tests, Leakage Tests, Valve-Operation Tests, Pneumatic Tests, Non-Destructive Weld Examinations and System Validation and Operation Tests shall be provided by the Contractor, in compliance with referenced standards contained within this document.

4.1.1.10. Pipe ends left for future connections, if any, shall be valved, blind flanged, or capped and anchored.

4.1.2. Process Pipe Testing

4.1.2.1. Leakage and Hydrostatic Testing

4.1.2.1.1. After the pipe installation and connection is completed, the piping shall be subjected to a 30 minute leakage test at 90% of maximum operating pressure (MOP), and a ten minute hydrostatic-pressure test at 150% of MOP.

4.1.2.1.1.1. The pressure shall be gradually increased in increments to the desired level for each test. Exposed pipe, joints, fittings, and valves shall be carefully examined during the testing. Each valve in the pressurized pipe section shall be opened and closed several times during the test.

4.1.2.1.1.2. Joints showing visible leakage shall be replaced or remade as necessary with all pressure removed from the piping system. Leaking rubber gasketed joints shall be remade using new gaskets when necessary. Pipe, mechanical joints, fittings, or valves discovered to be cracked or defective as a consequence of this pressure test shall be removed and replaced with sound material, and the test shall be repeated until the test results are approved.

4.1.2.1.1.3. If pipe installation consists of pre-manufactured pipe spools that are individually hydrostated to 150% maximum operation pressure for ten minutes, only a leakage test at 90% maximum operation pressure is required following assembly. In this case, documentation of pipe spool fabrication meeting ASME B31.3 standards, including nondestructive examination records, weld inspection records, and individual spool hydrostatic test records, shall be supplied to the Government by the Contractor.

4.1.2.1.1.4. All test plans shall be submitted and approved prior to execution, and results supplied to the Government by the Contractor. Test data shall be legible and of good quality.

4.1.2.1.2. Testing fluid shall be water unless otherwise specified and approved by NASA.

4.1.3. Pipe, Tubing, and Fittings

4.1.3.1. Black Carbon Steel Pipe (Type BCS)

4.1.3.1.1. Pipe 1/8 through 10 inches in diameter shall be Schedule 40 seamless or electric-resistance welded black carbon steel, conforming to ASTM A 53 Type S. Grade A should be used for permissible field bending in both cases.

4.1.3.1.2. All steel pipe and fittings shall be joined by butt welding, except for those flanged connections shown in the contract drawings.

4.1.3.1.3. Fittings 2 inches in diameter and smaller shall be 150-pounds per square inch, gage (psig) working steam pressure (WSP) banded black malleable iron screwed, conforming to ASTM A 197 and ASME B16.3.

4.1.3.1.4. Unions 2 inches diameter and smaller shall be 250 pounds per square inch WSP, female, screwed, black malleable iron with brass-to-iron seat and ground joint, conforming to ASME B16.39.

4.1.3.1.5. Flanges and flanged fittings of all sizes shall be forged steel ASTM A 105/A 105M faced and drilled to ASME B16.5 Class 150. Flanges shall be slip-on, socket weld, or lapped type. The internal diameter of flanges and flanged fittings shall be the same as that of the associated pipe. Bolting shall be ASTM A 193 Grade B7 alloy steel hex head bolts and ASTM A 194 Grade B7 hex head nuts. Where a steel flange mates with a cast iron flange on valves or equipment, the requirements of ASME B16.5 Paragraph 5.3.4 shall be followed. Bolts shall be provided with washers of the same material as the bolts. Flanged connections shall have the same pressure rating as the pipe or greater. The Contractor shall field check flanges for non-standard bolt hole configurations and shall design as required to assure all flanges mate properly.

4.1.3.1.6. Gaskets shall be fabricated from compressed non-asbestos sheet, conforming to ASTM F 104, Type 7-P1161A, coated on both sides with graphite or similar lubricant, with nitrile rubber composition, binder rated to 750 degrees F.

4.1.3.1.7. Steel butt weld fittings 2-1/2 inches diameter and larger shall conform to ASTM A 234 or A 234M and ASME B16.9 to match pipe wall thickness.

4.1.3.2. Chlorinated Polyvinylchloride (CPVC) Pipe

4.1.3.2.1. CPVC pipe material shall be schedule 80 and meet ASTM D1784 Material Classification Equivalents: Type 4, Grade I = Cell Classification 23477-B = CPVC 4120. Pipe sizes shall be manufactured in compliance with ASTM F441.

4.1.3.2.2. Material for Socket-Type Fittings, Schedule 80, shall be CPVC in accordance with ASTM F439.

4.1.3.2.3. Material for threaded fittings, Schedule 80, shall be CPVC in accordance with ASTM F437.

4.1.3.2.4. CPVC Solvent cement for pipe and fittings shall be in accordance with ASTM F493. Contractor shall use primer and heavy bodied CPVC cement per ASTM F493.

4.1.3.3. Stainless Steel Tubing and Tube Fittings

4.1.3.3.1. Tubing shall be fully annealed high quality type 304 stainless steel, seamless round hydraulic tubing, conforming to ASTM A269 or A213. Hardness shall be no greater than Rb 90 (Rockwell hardness, per ASTM A370). Tubing shall be free of scratches and surface imperfections and be suitable for bending and flaring. Pressure rating shall be for a minimum of 500 psi with allowable working pressure loads calculated as specified in ASME B31.3 code.

4.1.3.3.2. Fittings shall be fully annealed high quality type 304 stainless steel, conforming to ASTM A 403/A 403M (1997; Rev A). Swagelok end connections shall be used.

4.1.3.4. Piping Specialties

4.1.3.4.1. Diaelectric connections, if needed, shall have dissimilar pipe metals electrically insulated from each other by couplings, unions, or flanges commercially manufactured for that purpose and rated for the service pressure and temperature.

4.1.3.4.2. Thread lubricant shall be used on all threaded connections. Tetrafluoroethylene tape no less than 2 to 3 mils thick shall be used in potable and process water and in chemical systems for pipe sizes to and including 1-inch ips. Tetrafluoroethylene dispersions and other suitable compounds may be used for all other applications upon approval; however, no lead-containing compounds may be used.

4.1.3.4.3. Pressure relief devices shall consist of a rupture disc, rated for the pressure shown in the contract drawings, at 70 degrees F. Rupture discs shall be compatible for mounting between ASME B16.5 Class 150 flanges, and shall be suitable for water service. For each location where a rupture disc is specified, Contractor shall supply four discs, one to be installed during construction, and the remaining to be retained as spares.

4.2. Valves

4.2.1. Valves shall include actuator, handwheel, operating nut, wrench, and all other accessories required for a complete operation. The valves shall be suitable for the intended service. Renewable parts are not to be of a lower quality than those specified. Valve ends shall be compatible with adjacent piping system. Actuators shall be sized to operate the associated valve for the full range of pressures and

velocities. Actuators and accessories shall be sized and furnished by the valve supplier and factory mounted. Fluid to be handled will be water, at 70 degrees F, unless otherwise specified.

4.2.2. Valve Schedule

4.2.2.1. Requirements relative to this subpart are shown on the Flow Control Valve Schedule and Manual Valve Schedule located in attached contract drawings.

4.2.3. General Purpose Metallic Ball Valves

4.2.3.1. Ball valves, 2 inches and smaller, shall be end entry type with bronze bodies and threaded full bore ports in accordance with ASME B1.20.1.

4.2.3.2. Ball valves, 2.5 inches and larger, shall be end entry type with bronze, malleable iron, or cast iron bodies, per contract drawings, and ASME B16.5 Class 150 flanged ends.

4.2.3.3. Valves shall have polytetrafluoroethylene (PTFE) seats and packing, and a chrome plated or stainless steel ball.

4.2.3.4. The operator shall be a hand lever or square nut, per the contract drawings.

4.2.3.5. Valves shall be suitable for flow from either direction and shall seal equally tight in either direction. Valves with ball seals held in place by spring washers are not acceptable.

4.2.4. Standard Service Metallic Butterfly Valves

4.2.4.1. Butterfly valves shall meet AWWA C-504-87 requirements and have ASTM A 126 cast iron bodies and ASME B16.5 Class 150 flanged end connections. Dimensions shall conform to MSS SP-67.

4.2.4.2. Discs shall be ductile iron, stainless steel, or polyvinylidene fluoride (PVDF) coated ductile iron.

4.2.4.3. The valve shafts shall be 300 series stainless steel with self-lubricating, corrosion-resistant sleeve type bearings (PTFE or equal).

4.2.4.4. Valve seats for 24 inch and smaller valves shall be attached to the valve body and shall be of Buna-N, EPDM, or Viton construction.

4.2.4.5. The operator shall be a pneumatic actuator, hand lever, or square nut, per the contract drawings.

4.2.5. Sample Valves

4.2.5.1. Sample valves 1/8" to 1" shall be plug type, rated for 250 psig minimum. Body shall be 316 stainless steel. All wetted parts shall be either 316 stainless steel or coated with TFE. End connections shall be NPT x Swagelok tubing.

4.2.6. General Service Metallic Gate Valves

4.2.6.1. Gate valves, 2 inches diameter and smaller, shall have bronze bodies and stems, screwed or union bronze bonnets, and single solid wedge bronze discs. The stems may be rising or non-rising. Valves shall be rated for 200 psig service. End connections shall be ASME B16.11 threaded. Valves shall be equipped with handwheel operators.

4.2.6.2. Gate valves, 2.5 inches diameter and larger, shall have cast-iron bodies with iron, bronze, or stainless steel trim. Valves shall have Class 150 flanged end connections. Discs shall be wedge type of iron or bronze construction, and have either rising or non-rising stems. Valves shall be equipped with hand lever or square nut operators, per the contract drawings.

4.2.7. Swing Check Valves

4.2.7.1. Swing check valves, 2 inches diameter and smaller, shall have a cast iron, carbon steel, or stainless steel body, with ASME B16.11 threaded ends. Valves shall be rated for 200 psig service.

4.2.7.2. Swing check valves, 2.5 inches through 12 inches diameter, shall have a cast iron, carbon steel, or stainless steel body, with ASME B16.5 flanged ends. Valves shall be rated for 200 psig service minimum.

4.2.8. Ball Check Valves

4.2.8.1. Ball check valves shall be rated for 200 psig service minimum and shall be suitable for vertical or horizontal flow.

4.2.8.2. Ball check valves, 1 inch diameter and larger, shall be as shown on the contract drawings and ASME B16.11 threaded or ASME B16.5 flanged ends and cast iron, carbon steel, or stainless steel bodies with a cleanout and hollow steel ball.

4.2.9. Flow Control Valves

4.2.9.1. Flow control valves in sizes 2 inches diameter and larger shall be hydraulically operated, single diaphragm actuated, pilot controlled globe valves. Flow control valves shall be equipped with valve body, diaphragm assembly, cover, strainer, electric solenoids, electronic controller, and all other

accessories needed for a complete operation. The diaphragm assembly shall be the only moving part and shall form a sealed chamber in the upper portion of the valve, separating operating pressure from line pressure. Packing glands or stuffing boxes are not permitted and there shall be no pistons operating the main valve or pilot controls. All necessary repairs and modifications other than replacement of the main valve body shall be possible without removing the valve from the pipeline. End connections shall be ASME B16.5 Class 150 flanges. Each flow control valve shall be equipped with an internal check valve to close the flow control valve if a pressure reversal occurs in the line, regardless of the position of the stem and diaphragm. Each flow control valve shall be equipped to fail closed automatically in the event of a power outage. Flow control valve sizes and pressure rating requirements shall be as shown in the Flow Control Valve Schedule in the contract drawings. Acceptable manufacturers and models: Cla-Val Model 131-01.

4.2.9.2. Flow Control Valve materials of construction

Refer to the Flow Control Valve Schedule in the contract drawings.

4.2.9.3. Contractor shall supply one (1) rebuild kit for each unique size of flow control valve. Each rebuild kit shall include as a minimum the stem, stem nut, spring, disc, disc guide, disc retainer, diaphragm, diaphragm washer, and spacer washers.

4.2.9.4. Control Valve Pilot System

Flow control valves shall be equipped with pilot control valves. These shall consist of dual electric solenoids that position the main valve by applying or relieving pressure in its diaphragm chamber. These shall be fail closed or fail open as required to close the valve in event of a power outage. They shall have 120 VAC Class F coil insulation, with NEMA 4 enclosures. The pilot control system is to include an upstream flow strainer, solenoid bypass manual valves, and have manual opening/closing speed adjustments. Materials of construction shall be the manufacturer's standard. Acceptable manufacturers: Cla-Val.

4.2.9.5. Electronic Valve Controller

4.2.9.5.1. Flow control valves shall each include an electronic controller to provide the interface between the control system and each flow control valve. Upon receiving a remote set-point command from the computer system or local command from the operator, the controller will provide proper signals to modulate and maintain the valve at the desired set-point value. Electronic controllers shall have remote communication capability in both analog and digital format. Local manual set-point and emergency manual control shall be provided. Security key codes shall protect against unauthorized change of program memory, setpoints, and timing

parameters. Electronic controllers shall be constructed of solid-state components, with an internal chassis capable of being removed for inspection and repair. Program memory, setpoints, and timing parameters shall be protected from loss due to power outage by an internal battery. Flow rate shall be measured by the electromagnetic flow meters detailed elsewhere in this specification. Electronic controllers shall be compatible in all respects with Allen-Bradley's Data Highway Plus system. Acceptable manufacturers and models: Cla-Val Model 131VC-1.

4.2.9.5.2. Electronic controller specifications:

4.2.9.5.2.1. Input signal: 4-20 mA full scale
4.2.9.5.2.2. Proportional Bands: 1 to 999% adjustable in .1% increments independently for opening and closing.
4.2.9.5.2.3. Deadband: Adjustable 0.00 to 25.5% of span.
4.2.9.5.2.4. Cycle Time: 1 to 120 seconds in 1 second increments
4.2.9.5.2.5. Input Power: 120 VAC, 60 Hz, single phase
4.2.9.5.2.6. Flame retardant UL rated plastic or aluminum housing

4.2.9.6. Valve Position Transmitter

4.2.9.6.1. Flow control valves shall be equipped with valve position transmitters as indicated on the contract drawings. The position transmitter shall be mounted externally on the cover of the flow control valve. The position transmitter shall provide a 4-20 mA output signal that is proportional to the position of the flow control valve stem. The transmitter shall include a means for adjustment and calibration of the feedback signal to correspond with the full stroke of the valve stem. The materials of construction shall be the manufacturer's standard. The housing shall be rated as NEMA 7 Class I groups C and D . Acceptable manufacturers and models: Cla-Val Model X117C

4.2.9.6.2. Transmitter Specifications

4.2.9.6.2.1.Output Current: 4-20 mA
4.2.9.6.2.2.Span: Adjustable from 15° to 90° of angular rotation
Null: 4mA position may be set at any angular position

4.2.10. Valve Actuators

4.2.10.1. Manual Actuators

4.2.10.1.1. The force required to operate a manual actuator shall not exceed 40 pounds under any operating condition, including initial breakaway. The actuator shall be equipped with gear reduction when force exceeds 40 pounds. A position indicator shall be installed on quarter-turn valves.

4.2.10.1.2. Exposed actuators shall have galvanized and painted handwheel. Lever actuators are allowed on quarter-turn valves 8 inches diameter and smaller. Valve handles shall be capable of padlocking, and wheels shall be lockable with a chain and padlock.

4.2.10.2. Pneumatic Actuators

4.2.10.2.1. Pneumatic actuators shall be rack and pinion type, 90 degree rotation, internally lubricated, and operate with clean dry air at 50 to 150 psig pressure. Material of construction shall be the manufacturer's standard.

4.2.10.2.2. Pneumatic operators shall be suitable for full range of valve operation at air supply pressure indicated on contract drawings. Spring(s) shall return valve to the closed position upon loss of signal, unless otherwise indicated.

4.2.10.2.3. Pneumatic actuators shall be provided complete with actuators, air sets, exhaust mufflers, open/close speed adjustment, pilot solenoid, safety vented isolation valves, a visual indicator of valve position, and adjustable valve stops.

4.2.10.2.4. Manufacturers: Sure-Torque, Crane Centerline, Neles-Jamesbury.

4.2.10.3. Air Sets

4.2.10.3.1. Air sets shall include a pressure regulator with internal relief, filter, outlet pressure gauge, and adjustable reduced pressure range as required by valve actuators. The air set shall have an aluminum body and handwheel, safety vented lockout isolation valve, and gauge range 2 times maximum operating pressure.

4.2.10.3.2. Air sets shall supply instrument quality air to pneumatic components per ANSI/ISA S7.0.01 as follows:

4.2.10.3.2.1. Pressure dew point shall not exceed 39°F.

4.2.10.3.2.2. Particle size shall not exceed 40 microns.

4.2.10.3.2.3. Oil content shall not exceed 1 ppm, by either volumetric or weight ratio.

4.2.10.3.2.4. Instrument air shall be free of corrosive or hazardous contaminants.

4.2.10.4. Limit Switches

4.2.10.4.1. Limit switches shall be single-pole, double-throw (SPDT) type, rated 10 amps at 120 VAC, housed in a NEMA 250 Type 4 enclosure, and adjustable for open and closed valve positions.

4.2.10.5. Solenoid Valves

4.2.10.5.1. A solenoid valve shall pilot the control actuator in the appropriate configuration for the type of actuator being controlled. A pilot operated diaphragm type solenoid valve shall have a brass or aluminum body and resilient seat and operate with minimum operating pressure differential no greater than 10 psi and maximum operating pressure differential no less than 150 psi. Internal parts shall be corrosion-resistant. The solenoid valve shall have Class F molded coils for operation on 120 VAC, 60 Hz, unless otherwise indicated. The solenoid enclosure shall conform to NEMA 250 Type 4. Solenoids on double acting cylinders for open-close and throttling valves shall be four-way with dual coils. Solenoids on spring return cylinders for open-close and throttling valves shall be three-way, spring return. An air exhaust muffler shall be furnished in the exhaust port of all actuator pilot solenoid valves.

4.3. Pipe Supports

4.3.1. All necessary piping systems and equipment supporting elements shall be provided, including but not limited to: building structure attachments; supplementary steel; hanger rods, stanchions, and fixtures; vertical pipe attachments; horizontal pipe attachments; anchors; guides; and spring-cushion, variable, or constant supports. All supporting elements shall be suitable for stresses imposed by systems pressures and temperatures and natural and other external forces normal to this facility without damage to supporting element system or to work being supported.

4.3.2. Supporting elements shall conform to requirements of ASME B31.3, FS FF-S-325, MSS SP-58, and MSS SP-69.

4.3.3. Supporting elements exposed to weather shall be hot-dip galvanized. Materials shall be of such a nature that their apparent and latent-strength characteristics are not reduced due to galvanizing process. Supporting elements in contact with copper tubing shall be electroplated with copper.

4.3.4. Type designations specified herein are based on MSS SP-58 and MSS SP-69. Masonry anchor group-, type-, and style-combination designations shall be in accordance with FS FF-S-325. Support elements, except for supplementary steel, shall be cataloged, load rated, commercially manufactured products.

4.3.5. Building Structure Attachments

4.3.5.1. Anchor Devices, Concrete and Masonry

4.3.5.1.1. Anchor devices shall conform to FS FF-S-325 for the following types:

4.3.5.1.1.1. Group I - shield, expansion (lead, bolt and stud anchors)

4.3.5.1.1.2. Group II - shield, expansion (bolt anchors)
4.3.5.1.1.3. Type 2 - machine bolt expansion shield anchors
4.3.5.1.1.4. Class 2 - open-end expansion shield anchors
4.3.5.1.1.5. Style 1 - single-end expansion shield anchors
4.3.5.1.1.6. Style 2 - double-end expansion shield anchors
4.3.5.1.1.7. Group III - shield, expansion (self-drilling tubular expansion shell bolt anchors)
4.3.5.1.1.8. Group VIII - anchors, expansion (nondrilling)
4.3.5.1.1.9. Cast-in, floor mounted, equipment anchor devices shall provide adjustable positions.
4.3.5.1.1.10. Powder-actuated anchoring devices shall not be used to support any mechanical systems components.

4.3.5.2. Beam Clamps

4.3.5.2.1. Beam clamps shall be center-loading per Type 21, 28, 29, or 30.

4.3.5.2.2. When it is not possible to use center-loading beam clamps, eccentric-loading beam clamps, Type 20, 25, or 27 may be used for piping sizes 2 inches diameter and less and for piping sizes 2 through 10 inches diameter provided two counterbalancing clamps are used per point of pipe support. Where more than one rod is used per point of pipe support, rod diameter shall be determined in accordance with referenced standards.

4.3.5.3. C-clamps

4.3.5.3.1. C-clamps may be used to support piping sizes 1-1/2 inches diameter and smaller. C-clamps shall be FM approved and UL listed with hardened cup-tip set screw, lock nut, and retaining strap. Retaining strap section shall be not less than 1/8 by 1 inch. Beam flange thickness to which clamps are attached shall not exceed 0.60 inch.

4.3.6. Horizontal Pipe Attachments

4.3.6.1. Piping in sizes to and including 2-inch diameter shall be supported by Type 6 solid malleable iron pipe rings, except that split-band-type rings may be used in sizes up to 1-inch ips.

4.3.6.2. Piping in sizes through 8-inch diameter inclusive shall be supported by Type 1, 3, or 4 attachments.

4.3.6.3. Where thermal movement of a point in a piping system 4 inches diameter and larger would cause a hanger rod to deflect more than 4 degrees from the vertical or where a horizontal point movement exceeds 1/2 inch, Type 41 or 49 pipe rolls shall be used.

4.3.6.4. Piping in sizes larger than 8-inch diameter shall be supported with Type 44 through 47 pipe rolls.

4.3.6.5. Type 40 shields shall be used on all insulated piping. Area of the supporting surface shall be such that compression deformation of insulated surfaces does not occur. Longitudinal and transverse shield edges shall be rolled away from the insulation.

4.3.6.6. Trapeze hangers fabricated from approved structural steel shapes, with U-bolts, shall be used in congested areas and where multiple pipe runs occur. Structural steel shapes shall be of commercially available, proprietary design, rolled steel.

4.3.7. Vertical Pipe Attachments

4.3.7.1. Vertical pipe attachments shall be MSS-SP69 Type 8.

4.3.8. Hanger Rods and Fixtures

4.3.8.1. Only circular cross section rod hangers may be used to connect building structure attachments to pipe support devices. Pipe, straps, or bars of equivalent strength shall be used for hangers only where approved.

4.3.8.2. Turnbuckles, swing eyes, and clevises shall be used as required by support system to accommodate temperature change, pipe accessibility, and adjustment for load and pitch. Rod couplings are not acceptable.

4.3.9. Supplementary Steel

4.3.9.1. Where it is necessary to frame structural members between existing members or where structural members are used in lieu of commercially rated supports, such supplementary steel shall be designed and fabricated in accordance with AISC S328.

4.4. Piping Installation

4.4.1. Piping systems shall be fabricated and installed in accordance with ASME B31.3, MSS SP-69, and AWS-02. Piping systems shall be securely supported with due allowance for thrust forces, thermal expansion and contraction, and shall not be subjected to mechanical, chemical, vibrational or other damage as specified in ASME B31.3.

4.4.2. Screwed joints shall be made up with specified joint compound and not more than three threads shall show after joint is made up. Joint compound shall be applied to the male thread only and care shall be exercised to prevent compound from reaching the unthreaded interior of the pipe.

4.4.3. Screwed unions, welded unions, or bolted flanges shall be provided wherever required to permit convenient removal of equipment, valves, and piping accessories from the piping system for maintenance.

4.4.4. Flange and general purpose bolting shall be hex-head and shall conform to ASTM A 307, Grade B. Heavy hex-nuts shall conform to ASTM A 563. Square-head bolts and nuts are not acceptable. Threads shall be coarse-thread series.

4.4.5. Flange gaskets shall be compressed non-asbestos sheet, conforming to ASTM F 104, Type 7-P1161A, coated on both sides with graphite or similar lubricant, with nitrile composition, binder rated to 750 degrees F. Gaskets shall meet the requirements of ASME B16.5.

4.4.6. Tetrafluoroethylene tape not less than 2 to 3 mils thick shall be used in potable and process water and in chemical systems for threaded pipe connection sizes up to and including 1-inch ips. Tetrafluoroethylene dispersions and other suitable compounds may be used for all other applications upon approval; however, no lead-containing compounds may be used in potable water systems.

4.4.7. Field welded joints shall conform to the requirements of the AWS-02, ASME B31.3, and ASME-17. The Contractor shall supply weld documentation including nondestructive examination records, weld inspection records, and hydrostatic test records to the Government.

4.4.8. Preheat and post heat treatment of welds, if necessary, shall be done in accordance with ASME-17 and ASME B31.3. Copies of treatment records shall be supplied to the Government.

4.4.9. All necessary precautions shall be taken during installation of pipe and tubing including flushing and purging with water and/or compressed air to prevent dirt and debris from being trapped inside the piping system.

4.4.10. Component Identification and Labeling

4.4.10.1. All components in the system shall be identified by tag. The specific identification numbers, in the desired format, can be located on the contract drawing numbers 652-M-01, 652-M-02, and 652-M-03.

4.4.10.2. The tags may be fabricated by engraving on laminated plastic, impression stamping on corrosion resistant metal, or by any other process which will produce a permanent, legible tag. Lettering shall be no smaller than ¼" in height.

4.4.10.3. Tags will be mounted to components using stainless steel safety wire or to a panel face for panel-mounted components.

4.4.11. Pipe Service Labeling

4.4.11.1. All piping, including that concealed in accessible spaces; exposed, bare and painted; and insulated, shall be labeled to designate service. Each label shall include an arrow or arrows to indicate flow direction. Labels shall be in accordance with the typical examples below:

SERVICE	LABEL AND TAG DESIGNATION
Cold potable water	COLD POT. WATER
Hot potable water supply	HOT POT. WATER
Scale Control Chemical	SCALE CHEMICAL
Scale Cleaner Chemical	SCALE CLEANER
Filtered Air to Blowers	AIR
Control and instrument air	COMPRESSED AIR
Untreated Water	UNTREATED WATER
Treated Water	TREATED WATER

4.4.11.2. Similar services with different temperatures or pressures shall be identified. Where pressures may exceed 125 psi gage, the maximum system pressure shall be included in the label.

4.4.11.3. Piping shall be labeled and arrowed in accordance with the following:

4.4.11.3.1. Each point of entry and exit of pipe passing through walls
4.4.11.3.2. Each change in direction, i.e., elbows, tees
4.4.11.3.3. In congested or hidden areas and at all access panels at each point required to clarify service or indicated hazard.
4.4.11.3.4. In long straight runs, labels shall be located at distances within eyesight of each other but in no case shall the distance between labels exceed 75 feet. All labels shall be visible and legible from the primary service and operating area.
4.4.11.3.5. Labels shall be made of self-sticking, plastic film designed for permanent installation.

4.4.11.4. Color coding of all piping system labels shall be in accordance with ANSI A13.1.

4.5. Valve Installation

4.5.1. Valves shall be provided in piping mains and all branches and at equipment where indicated and as specified in the contract drawings.

4.5.2. Flange and general purpose bolting shall be hex-head and shall conform to ASTM A 307, Grade B. Heavy hex-nuts shall conform to ASTM A 563. Square-head bolts and nuts are not acceptable. Threads shall be coarse-thread series.

4.5.3. Flange gaskets shall be compressed non-asbestos sheet, conforming to ASTM F 104, Type 7-P1161A, coated on both sides with graphite or similar lubricant, with nitrile composition, binder rated to 750 degrees F. Gaskets shall meet the requirements of ASME B16.5.

4.5.4. Tetrafluoroethylene tape not less than 2 to 3 mils thick shall be used in potable and process water and in chemical systems for valve sizes up to and including 1-inch ips. Tetrafluoroethylene dispersions and other suitable compounds may be used for all other applications upon approval; however, no lead-containing compounds may be used in potable water systems.

4.6. Pipe Support Installation

4.6.1. Supporting elements shall be provided in accordance with the previously referenced codes and standards.

4.6.2. Piping may be supported from the building structure. No piping shall be supported from roof decking material or wall covering material.

4.6.3. Piping shall run parallel with the lines of the building. Piping and components shall be spaced and installed so that a threaded pipe fitting may be removed between adjacent pipes and so that there shall be no less than 1/2 inch of clear space between the finished surface and other work and between the finished surface of parallel adjacent piping. Hangers on different adjacent service lines running parallel with each other shall be arranged to be in line with each other and parallel to the lines of the building.

4.6.4. Piping support elements shall be installed at intervals specified hereinafter, at locations not more than 3 feet from the ends of each runout, and not over 1 foot from each change in direction of piping.

4.6.5. Load rating for all pipe-hanger supports shall be based on insulated weight of lines filled with water and forces imposed. Supports shall be in accordance with the following minimum rod size and maximum allowable hanger spacing for specified pipe. For concentrated loads such as valves, the allowable span shall be reduced proportionately

4.6.5.1. Hanger Spacing Requirements

PIPE SIZE (diameter, inches)	ROD SIZE (diameter, inches)	STEEL PIPE (spacing, feet)	COPPER PIPE (spacing, feet)
<1	3/8	8	6
1-1/4 to 1-1/2	3/8	10	8
2	3/8	12	10

2-1/2 to 3-1/2	1/2	12	12
4 to 5	5/8	16	14
6	3/4	16	16
8 to 12	7/8	20	20
14 to 18	1	20	20
20 and over	1-1/4	20	20

4.6.6. Vertical risers shall be supported independently of connected horizontal piping, whenever practicable, with fixed or spring supports at the base and at intervals to accommodate system range of thermal conditions. Risers shall be guided for lateral stability. For risers subject to expansion, only one rigid support shall be provided at a point approximately one-third down from the top. Clamps shall be placed under fittings unless otherwise specified. Carbon-steel pipe shall be supported at each floor and at not more than 15-foot intervals for pipe 2 inches and smaller and at not more than 20-footintervals for pipe 2-1/2 inches and larger.

5. Electrical and Process Component Specifications

5.1. Flow meters

5.1.1. Flow meters to be installed at extraction and injection well vaults shall be furnished complete with measuring tube and liner, housing, signal converter, transmitter, interconnecting cables, mounting hardware, and all other accessories required for a complete operation. The housing shall be carbon steel, and the measuring tube/liner shall be fabricated of hard rubber or Teflon. The exterior surface of the housing shall be epoxy-coated. The flow meters shall operate on 120 VAC, single phase, 60 Hz power. Flow meters shall be rated for a minimum pressure of 250 psig. Connections shall be ANSI Class 150 flanges, carbon steel per ASME B16.5 or 300 series stainless steel. Flow meters shall be equipped with local readout and controls as well as for remote data acquisition. All flow meters must be properly grounded per manufacturer's instructions. Flow meters shall be supplied with factory calibration documentation.

5.1.2. Flow Meter Performance Features:

5.1.2.1. Type: Electromagnetic flow sensor
5.1.2.2. Fluid Service: Water at 70°F.
5.1.2.3. Accuracy: Plus or minus 1 percent of rate for all flows resulting from pipe velocities of 1 to 33 feet per second.
5.1.2.4. Turndown Ratio: Minimum of 10 to 1 when flow velocity at minimum flow is at least 1 foot per second.

5.1.2.5. Zero stability feature to eliminate the need to stop flow to check zero alignment.
5.1.2.6. Flow Tube Size: As noted on contract drawings and flow meter schedule.
5.1.2.7. Signal Interface: 4 to 20 mA dc for load impedance 0 to 800 ohms minimum for 24V dc supply.
5.1.2.8. Communication: HART protocol via current output
5.1.2.9. Power supply: 120V ac, 60-Hz.
5.1.2.10. Electrode Type: Flush or bullet nose as recommended by the manufacturer
5.1.2.11. Electrode Material: 316 stainless steel, unless otherwise noted.
5.1.2.12. Enclosure: NEMA 4.
5.1.2.13. Grounding Ring/Electrode Material: 316 Stainless Steel, unless otherwise noted.
5.1.2.14. Connection Cables: As recommended by manufacturer. Length to be determined by device location.

5.1.3. Acceptable manufacturers and models: Endress & Hauser, ProMag 33;

5.2. Float Level Switch, Tank Mounted:

5.2.1. General:

5.2.1.1. Function: Operate switch at preset level in Spent Cleaner Tank.
5.2.1.2. Type: Float-actuated mounted directly to tank
5.2.1.3. Service Fluid: Water @ 70°F unless otherwise noted
5.2.1.4. Fluid Specific Gravity: 1.0 unless otherwise noted
5.2.1.5. Pressure: Atmospheric, vented tank
5.2.1.6. Temperature: 100 degrees F maximum

5.2.2. Performance and Features:

5.2.2.1. Set Point: adjustable
5.2.2.2. Dead Band: 1-inch maximum
5.2.2.3. Float, stem, and guide tube connected to a switch enclosure
5.2.2.4. Insertion Length: As required to achieve the noted set point
5.2.2.5. Float Size: 4-1/2-inch unless otherwise noted
5.2.2.6. Materials: Wetted parts 304 or 316 Stainless Steel, unless otherwise noted
5.2.2.7. Process Connection: 1-inch NPT
5.2.2.8. Signal Interface Contact: Double Pole/Double Throw (DPDT) snap action, rated 10A continuous at 120V ac
5.2.2.9. Enclosure: NEMA 4 unless otherwise noted

5.2.3. Manufacturers: Magnetrol; Model T20, Robertshaw; Series SL-100, or approved equal

5.3. Float Level Element and Switch:

5.3.1. General:

5.3.1.1. Function: Close contact at preset liquid level in facility Floor Sump
5.3.1.2. Type: Float-actuated, wall mountable
5.3.1.3. Service Fluid: Water @ 70°F, unless otherwise noted

5.3.2. Performance and Features:

5.3.2.1. Set Point: adjustable
5.3.2.2. Dead band: 1-inch maximum
5.3.2.3. Temperature: Minus 40 degrees F to 140 degrees F
5.3.2.4. Pressure: Maximum 150 psig
5.3.2.5. Float Material and Size: Buna N; 1-7/8-inch
5.3.2.6. Stem and Mounting Material: Type 304 Stainless Steel
5.3.2.7. Integral splash shield
5.3.2.8. Signal Interface: SPST snap action switch
5.3.2.8.1. Rated 20 VA at 120V ac
5.3.2.8.2. Normally open
5.3.2.9. Lead cable: 2 #18 AWG, 6 feet, neoprene jacket

5.3.3. Manufacturers: GEMS; Series LS-270, Model No. 43765, or approved equal.

5.4. Pressure Indicators:

5.4.1. General:

5.4.1.1. Function: Visual pressure indication
5.4.1.2. Type: Bourdon tube

5.4.2. Performance and Features:

5.4.2.1. Range in psig: As noted on contract drawings
5.4.2.2. Accuracy: Plus or minus 0.5 percent of span
5.4.2.3. Connection: 1/4-inch or 1/2-inch NPT
5.4.2.4. Dial: 4-1/2-inch diameter
5.4.2.5. Case Material: Phenolic plastic or Stainless Steel
5.4.2.6. Case Type: Solid front design with solid wall between window and element and integral pressure relief on rear of case. Shatterproof safety glass window.
5.4.2.7. Pointer: Micrometer pointer with self-locking adjustment
5.4.2.8. Movement: Stainless Steel, rotor geared
5.4.2.9. Dampening: Pulsation dampener when noted, piston type with multiple choice of piston placement to vary the desired amount of dampening

5.4.3. Manufacturers: Ashcroft; Duragauge Model 1279/1379, Robert Shaw Acragage, Marsh Mastergauge

5.5. Telephone Dialer Alarm:

5.5.1. General:

5.5.1.1. Function: Continuously monitor normally open contacts, and when a contact closure is detected will dial preprogrammed telephone numbers, deliver a prerecorded message, and reset itself upon reception of a signal from the person being called.

5.5.1.2. Type: Dialer shall be a 16-bit microprocessor based system with all programming and voice messages stored in non-volatile memory. Dialer shall be compatible with cellular telephone or standard telephone communication networks.

5.5.2. Performance and Features:

5.5.2.1. Alarm Response Delay: 1 to 5,999 seconds
5.5.2.2. Telephone Numbers: Nine phone numbers up to 60 digits in length
5.5.2.3. Message Length: 10 seconds per message
5.5.2.4. Number of Alarm Channels: Four digital, expandable up to eight digital total.
5.5.2.5. Power: 120V ac, 60-Hz, with battery backup for 60 hours of monitoring service.
5.5.2.6. The system shall be programmable locally or remotely via touch tone telephone.
5.5.2.7. Operating Temperature: 20 degrees F to 130 degrees F.
5.5.2.8. Humidity: 0 to 95 percent non-condensing
5.5.2.9. Minimum four-digit security code
5.5.2.10. Surge protection on power, telephone, and alarm lines.
5.5.2.11. Direct telephone or cellular communications to FAX machines, answering machines, digital or voice radio pagers, or to computers.
5.5.2.12. Separate and independent call list for each alarm channel.
5.5.2.13. Visual indicators for power, fault, run, phone off-hook, line off-hook, incoming call, call in progress, and FAX in progress.
5.5.2.14. Enclosure: NEMA 4X fiberglass

5.5.3. Manufacturers and Products: Microtel; Series 1000 alarm dialer or approved equal.

5.6. Power Monitor:

5.6.1. A power monitor unit shall be provided at each of the extraction wells. Additionally, either a new power monitor is to be provided for the motor control center in Building 650, or adequate hardware and software provided to allow communication and data exchange between the existing Square D Powerlogic® monitor and the control and data acquisition system.

5.6.2. Shall provide for three-phase power monitoring and include a front panel display and user interface. Shall be capable of real-time revenue-accurate metering, power quality analysis, and control. Thorough and economical power system analysis including disturbance recording, data logging, programmable logic control, and arithmetic calculations. The units shall be UL listed. Display shall be either a back lit LCD (liquid crystal display) or VFD (vacuum fluorescent display). Chassis to be designed for mounting inside switchgear or MCC enclosures.

5.6.3. Device to be supplied complete, including all CTs (current transformers) and PTs (potential transformers), as required, for a complete and operational system.

5.6.4. Accuracy shall comply with ANSI C12.16 class for revenue metering. The revenue settings shall be protected from unauthorized modification.

5.6.5. Operating conditions: Temperature -400°F to +140°F, (-20°C to 60°C), Humidity 5 to 95% non condensing.

5.6.6. Control Power: 120-240 V ac, 50-60 Hz

5.6.7. Accuracy

5.6.7.1. Voltage and Current: +/- 0.2% of full scale
5.6.7.2. Power and Energy: +/- 0.4% of full scale
5.6.7.3. Frequency: +/- 0.05 Hz
5.6.7.4. Power, Demand, and Energy Functions: +/- 0.4%
5.6.7.5. Power Factor: +/- 0.4% (0-100 range)

5.6.8. Current Inputs (each channel)

5.6.8.1. Nominal Current: 5 Amps ac
5.6.8.2. Metering Range: 0-10 Amps ac
5.6.8.3. Withstands 15 Amps continuous, 200 Amps 1 second per hour
5.6.8.4. Burden: no greater than 0.05 Volt-Amp
5.6.8.5. Input impedance: no greater than 0.002 Ohm

5.6.9. Voltage Inputs (each channel)

5.6.9.1. Nominal Full Scale: 0-347 VAC L-N, 0-600 VAC L-L
5.6.9.2. Input impedance: no less than 1 Meg-Ohm

5.6.10. Sampling and Metering: Continuous, with maximum 50 millisecond update rate.

5.6.11. Disturbance Detection

5.6.11.1. Continuous monitoring for sags and swell detection.
5.6.11.2. Time stamps on each occurrence in the Event Log
5.6.11.3. Response time no greater than ½ cycle

5.6.11.4. Upon detection of disturbance, it logs and saves the waveform

5.6.12. Harmonic Analysis

5.6.12.1. Individual harmonic magnitude and harmonic phase
5.6.12.2. IEEE-519 pass/fail indication
5.6.12.3. THD, Crest Factor, TIF, and K-factor

5.6.13. Setpoints

5.6.13.1. Minimum 20 configurable setpoints
5.6.13.2. Minimum six evaluation operators available
5.6.13.3. Configurable upper and lower limits
5.6.13.4. Configurable assert and release delays

5.6.14. Logging

5.6.14.1. Trend logging capability
5.6.14.2. Event logging capability
5.6.14.3. Minimum and Maximum value logging capability
5.6.14.4. All log data shall be stored in non-volatile memory
5.6.14.5. All data shall be time stamped to nearest 0.01 second
5.6.14.6. Record selected parameters at no less than 100 millisecond interval during events

5.6.15. Firmware Updating

5.6.15.1. Device shall have ability to be updated with new features by firmware download from a temporary connection with portable PC, or via network connection.

5.6.16. Communications

5.6.16.1. Device shall be equipped with necessary options for connection to a SCADA system utilizing an Allen-Bradley Data Highway Plus fiber optic network. Connection of each device shall be completed by either connection of each power monitor to the network as a stand alone device, or by connecting each one to an existing PLC panel that is connected to the network (i.e. as remote I/O).

5.6.17. Manufacturer: Rockwell Powermonitor 3000, model no.1404-M6

5.7. Programmable Logic Controller System:

5.7.1. General:

5.7.1.1. Contractor shall supply and install a system for process monitoring and control. It shall operate by emulating functions of conventional panel mounted equipment such as relays, timers, counters, current switches, calculation modules, PID controllers, stepping switches, and drum programmers. Refer to attached control system design drawings.

5.7.1.2. Type: Microprocessor based device programmable using ladder logic.

5.7.1.3. Parts: Central processing unit (CPU), power supply, local and remote input/output modules, local and remote base (chassis/rack) controllers, I/O bases (chassis/rack), data highway, and factory assembled interconnecting cables. Provide components required to make a complete and totally operational system. Reference contract P&ID Drawings.

5.7.2. Requirements for the Operating Environment are as follows:

5.7.2.1. Temperature: Operating range 32 to 140 degrees F (0 to 60 degrees C); storage range minus 40 to 158 degrees F (0 to 70 degrees C).

5.7.2.2. Humidity: Operating range 5 to 95 percent non-condensing.

5.7.2.3. Vibration:

5.7.2.3.1. Sinusoidal: IEC 68-2-6, Test Fc; 0.15 mm peak-to-peak, 10- to 57-Hz; 1 g, 57- to 150-Hz.
5.7.2.3.2. Random: IEC 68-2-34, Test Fdc; 0.4 g^2/Hz, 80- to 350-Hz, and 3dB/octave rolloff, 80- to 20-Hz and 350- to 2-KHz at 10 min/axis.

5.7.2.4. Noise: IEC 801, Part 3, Level 3 and Part 4, Level 3; MIL STD-461B
.

5.7.2.5. Isolation: User-side to PLC side 1,500V rms.

5.7.2.6. Agency Approvals and Standards: UL listed and CSA certified

5.7.3. The Central Processing Unit (CPU) shall have the following features:

5.7.3.1. Type: Microprocessor, 16-bit minimum.

5.7.3.2. Scan Time: Less than 1 ms/K words of relay ladder logic.

5.7.3.3. PLC Communications:

5.7.3.3.1. Communication ports: RS-232 or RS-422.
5.7.3.3.2. Baud rates supported: 1200, 2400, 9600, 19200.
5.7.3.3.3. Network Communications: One Allen-Bradley Data Highway Plus port.
5.7.3.3.4. Remote I/O Communication Links.

5.7.4. The control software Instruction Set shall include the following:

5.7.4.1. Timers and counters:

5.7.4.1.1. Math: Signed integer and floating-point math including add, subtract, multiply, divide, square root, and compare.
5.7.4.1.2. Register Operations: Shift registers, bit shift, bit set, bit clear, data move and data format conversion.

5.7.4.2. Process Loop Control: This shall be user configurable, direct or reverse acting, PID loop control computation with the capability of both AUTO and MANUAL modes of operation, and with remote access to controller tuning constants.

5.7.4.3. A Real Time Clock, with date and time set and compare.

5.7.5. Diagnostics capability shall include the following:

5.7.5.1. Indicators: Battery status, PLC status, PLC operation mode, remote I/O communication status.
5.7.5.2. Status Word: With failure status for PLC battery, scan overrun, communications, I/O, special functions.
5.7.5.3. Power Up: PLC checks status of internal memory upon power-up; runs self-diagnostics on power-up; periodically runs self-diagnostics while in RUN mode, halts logic processor and sets outputs to configured state if fatal error is detected.
5.7.5.4. Diagnostic Tables: Tables, displayable on a connected PC Control Station, that describe nature and location (address) of existing faults and errors.

5.7.6. Random Access Memory (RAM) requirements:

5.7.6.1. Memory Size: 32 K words minimum
5.7.6.2. Read only memory (ROM) for controller's operating system and diagnostics.
5.7.6.3. Memory Protection: Switchable

5.7.7. One Power Supply unit shall be supplied for each rack, or input/output base assembly:

5.7.7.1. Voltage: 120/220 volts (user selectable), 60-Hz input; 85 to 132 volts output.
5.7.7.2. Manufacturer and Model: Allen-Bradley, Part No. 1746-P2

5.7.8. Inputs and Outputs: A complete input/output system shall be supplied per the contract drawings, including remote I/O, with communication range of 10,000 feet minimum.

5.7.8.1. Discrete Input Modules:

5.7.8.1.1. Voltage: 120 volts, 60-Hz
5.7.8.1.2. Operating Power: 2 watts
5.7.8.1.3. Points per Module: 16, maximum
5.7.8.1.4. LED status indicator for each point
5.7.8.1.5. Isolation: Between input point and PLC, 1,500 volts rms
5.7.8.1.6. Manufacturer and Model: Allen-Bradley, Part No. 1746-IA16

5.7.8.2. Discrete Output Modules:

5.7.8.2.1. Voltage: 120 volts, 60-Hz
5.7.8.2.2. Operating Power: 2 watts
5.7.8.2.3. Load Rating: 2 amps continuous
5.7.8.2.4. Isolation: Between PLC and output point, 1,500 volts rms
5.7.8.2.5. Points per Module: 16, maximum
5.7.8.2.6. LED status indicator for each point
5.7.8.2.7. Manufacturer and Model: Allen-Bradley, Part No. 1746-OA16

5.7.8.3. Isolated Discrete Output Modules:

5.7.8.3.1. Type: Isolated Form A relay
5.7.8.3.2. Voltage: 120 volts, 60-Hz
5.7.8.3.3. Isolated Outputs per Module: 8
5.7.8.3.4. Load Rating: 5 amps continuous
5.7.8.3.5. Operating Power: 2.5 watts
5.7.8.3.6. Points Per Module: 8, maximum
5.7.8.3.7. LED status indicator and fuse for each point
5.7.8.3.8. Isolation: Between PLC and output point, 1,500 volts rms
5.7.8.3.9. Manufacturer: Allen-Bradley, Part No. 1746-0X8

5.7.8.4. Fast Response DC Input Modules:

5.7.8.4.1. Input “Voltage: 24V dc
5.7.8.4.2. Input Current: 8 ma at 24V dc
5.7.8.4.3. Points Per Module: 16, maximum
5.7.8.4.4. Maximum Input Frequency: 1,000 Hz
5.7.8.4.5. Manufacturer: Allen Bradley; Part No. 1746-ITB16 (sink)

5.7.8.5. Analog Input Modules:

5.7.8.5.1. Voltage: 24 volts dc
5.7.8.5.2. Power: 3 watts
5.7.8.5.3. Differential Analog Points Per Module: 8 or 4
5.7.8.5.4. Isolation: Between PLC and I/O point and between I/O points, 1,500 volts rms.
5.7.8.5.5. Analog Input Resolution: 16 bits

5.7.8.5.6. Manufacturer: Allen-Bradley, Part No. 1746-NI8 or 1746-NI4

5.7.8.6. Analog Output Modules:

5.7.8.6.1. Voltage: 24V dc
5.7.8.6.2. Power: 3 watts
5.7.8.6.3. Isolated Analog Points Per Module: 4 maximum
5.7.8.6.4. Isolation Between PLC and I/O Point and Between I/O Points: 1,500 volts rms
5.7.8.6.5. Manufacturer: Allen-Bradley; Part No. 1746-N04I

5.7.8.7. Remote Adapter Module:

5.7.8.7.1. One remote I/O adapter module required for each remote chassis
5.7.8.7.2. Manufacturer: Allen-Bradley; Part No. 1747-ASB

5.7.8.8. Remote I/O Scanner Module:

5.7.8.8.1. Manufacturer: Allen-Bradley Model No. 1747-SN

5.7.9. I/O Chassis (racks):

5.7.9.1. Each remote I/O panel and SLC 5/04 panel shall be furnished with one I/O chassis

5.7.9.2. Each chassis shall have either 7, 10, or 13 slots as required per controls system design

5.7.9.3. Manufacturer: Allen-Bradley; Part Nos. 1746-A7, 1746-A10 and 1746-A13.

5.7.10. Fiber Optic Module:

5.7.10.1. Selectable Wavelengths: 850 nm and 1,300 nm
5.7.10.2. Compatible with multimode fiber optic cable
5.7.10.3. Panel-mounted, 120V ac power supply
5.7.10.4. Data highway plus and remote I/O communication
5.7.10.5. Fault tolerant
5.7.10.6. Interaction diagnostics
5.7.10.7. Manufacturer: Phoenix Digital; Model OCM-DPR-13-P-DST-ACV.

5.7.11. I/O Placement in PLC racks:

5.7.11.1.1. From Left to Right: Analog, DC I/O, AC I/O.
5.7.11.1.2. Wired to/from PLC I/O modules or racks to/from control panel terminal blocks in all panels (direct connection of field wiring to I/O module or rack is not acceptable.

5.7.12. Identification and Labeling:

5.7.12.1. Nameplates installed above/below each PLC component (CPU, I/O rack, power supply, etc.)
5.7.12.2. Label configured I/O points as they have been configured (addressed) in the mechanical system.

6. PACKAGED CONTROL SYSTEM

6.1. GENERAL

6.1.1. SYSTEM DESCRIPTION

6.1.1.1. Assemble panels and install instruments, electrical conduit, and wiring for installation at a Government facility.

6.1.1.2. Test panels and panel assemblies for proper operation prior to shipment from equipment manufacturer's factory.

6.1.2. DELIVERY, STORAGE, AND HANDLING

6.1.2.1. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers and related equipment as recommended by capsule manufacturer.

6.1.3. SPARES

6.1.3.1. Selector Switch, Push Button, and Indicating Lights: one minimum of each type used.

6.1.3.2. Light Bulbs: two minimum of each type used.

6.1.3.3. Fuses: two minimum of each type used.

6.1.3.4.Surge Suppressors: one minimum, of each type used.

6.2. PRODUCTS

6.2.1. INTERFACE REQUIREMENTS

6.2.1.1. Analog Signals:

6.2.1.1.1. 4 to 20 mA dc, in accordance with compatibility requirements of ISA S50.1.
6.2.1.1.2. Unless otherwise specified or shown, use twisted shielded pair, two-wire cable and circuits.
6.2.1.1.3. Transmitters: Load resistance capability conforming to Class L.

6.2.1.1.4. Fully isolate input and output signals of transmitters and receivers.
6.2.1.1.5. Pulse Frequency Signals: dc pulses whose repetition rate is linearly proportional to process variable over 10:1 range. Generate pulses by contact closures or solid state switches.
6.2.1.1.6. Power source: Less than 30V dc.

6.2.1.2. Discrete Signals:

6.2.1.2.1. Two-state logic signals.
6.2.1.2.2. Utilize 120V ac sources for control and alarm signals.
6.2.1.2.3. Alarm signals shall be normally open, close to alarm, isolated contacts rated for 5-amps at 120V ac and 2-amps at 30V dc.

6.2.2. CONTROL PANEL ENCLOSURE

6.2.2.1. Conform to NEMA ratings as specified in individual equipment sections.
6.2.2.2. Minimum Metal Thickness: 14 gauge.
6.2.2.3. NEMA 250, Type 4X Panels: Carbon steel construction unless otherwise specified.

6.2.2.4. DOORS

6.2.2.4.1. Three-point latching mechanisms in accordance with NEMA 250, Type 1 and 12 panels with doors higher than 18 inches.
6.2.2.4.2. For other doors, stainless steel quick release clamps.
6.2.2.4.3. Cutouts shall be cut, punched, or drilled and finished smoothly with rounded edges.

6.2.2.5. ACCESS:

6.2.2.5.1. Front side, suitable for installation with back and sides adjacent to or in contact with other surfaces, unless otherwise specified.

6.2.2.6. TEMPERATURE CONTROL:

6.2.2.6.1. Size panels to adequately dissipate heat generated by equipment mounted on or in the panel.
6.2.2.6.2. Furnish cooling fans with air filters if required to dissipate heat.
6.2.2.6.3. For panels outdoors or in unheated areas, furnish thermostatically controlled heaters to maintain temperature above 40 degrees F.

6.2.2.7. LIGHTING:

6.2.2.7.1. Minimum of one hand switch controlled internal 100-watt incandescent light for panels 12 cubic feet and larger.

6.2.2.7.2. Minimum of one 120-volt duplex receptacle for panels 7 cubic feet and larger, per the contract drawings.

6.2.2.8. FINISH:

6.2.2.8.1. Metallic External Surfaces (Excluding Aluminum and Stainless Steel): Manufacturer's standard gray unless otherwise specified.

6.2.2.8.2. Internal Surfaces: White enamel paint.

6.2.3. CONTROL PANEL ELECTRICAL

6.2.3.1. Control Panels Without Motor Starters:

6.2.3.1.1. Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed from the main.

6.2.3.1.2. Locate to provide clear view of, and access to, the breakers when door is open. Group on single back panel. Provide clearly marked identification labels.

6.2.3.1.3. Circuit Breakers:

6.2.3.1.3.1. Coordinate for a fault in a branch circuit to trip the branch breaker, not the main breaker.
6.2.3.1.3.2. Branch Circuit Breaker Rating: 15 amps at 250V ac.

6.2.3.1.4. Breaker Manufacturers and Products: Heineman Electric Co.; Series AM, Airpax/North American Philips Controls Corp.; Series 205.

6.2.3.2. Control Panels with Three-Phase Power Supplies and Motor Starters:

6.2.3.2.1. Interlock main circuit breaker with panel door.

6.2.3.2.2. Mount logic controls, branch circuit breakers, overload reset switches, and other control circuit devices.

6.2.3.2.3. Mount operator controls and indications on front access door.

6.2.3.2.4. Circuit Breakers:

6.2.3.2.4.1. In accordance with NEMA AB 1.
6.2.3.2.4.2. 40,000-ampere RMS symmetrical rating, minimum at 480 volts, unless otherwise specified or required.
6.2.3.2.4.3. Breakers Except Motor Branch Breakers: Molded case thermal magnetic.

6.2.3.2.5. Motor Branch Circuit Breakers:

6.2.3.2.5.1. 50 hp and Less: Magnetic.
6.2.3.2.5.2. Larger than 50 hp: Thermal magnetic with adjustable magnetic trip units.
6.2.3.2.5.3. Ratings: Recommended by manufacturer for maximum motor protection.
6.2.3.2.5.4. Padlock Provisions: OFF position.
6.2.3.2.5.5. Tripping: Indicate with operator handle position.

6.2.3.2.6. Magnetic Motor Starters:

6.2.3.2.6.1. Starters shall be the manual reset type with reset button mounted on panel door.
6.2.3.2.6.2. Magnetic motor starters shall be designed for continuous operation of induction motors at 600 volts maximum, at 60 Hz, and shall comply with NEMA ICS 2.
6.2.3.2.6.3. All starters shall be electrically held and wired to provide low voltage power and release.
6.2.3.2.6.4. Unless otherwise specified, starters shall be 120-volt coil, 3-pole, 600V ac, 60 Hz, NEMA size 1 minimum.
6.2.3.2.6.5. All power wiring shall be straight through the starter with incoming power to the top and load wiring at the bottom. Contacts shall be double break, silver-cadmium oxide, and weld-resistant. Contacts shall be isolated to prevent arcing.
6.2.3.2.6.6. Coils, magnets, and contacts shall be capable of being removed or replaced, without special tools, in the field. The contactors shall have MOV-type, transient voltage surge suppression across the coils. Transient voltage surge suppression shall be mounted directly across the coil terminals of all magnetic starters. The suppressor shall limit voltage transients produced by the coil to 220 percent maximum peak line volts.
6.2.3.2.6.7. Solid state overload protection shall be provided unless otherwise indicated on the Drawings or approved by the Government. The solid state overload relay shall be self-powered requiring no additional wiring or control power and be self-protected from short circuits in the motor branch circuit. Each overload shall be adjustable over a full 2:1 FLA adjustment range. The overload must have a plus or minus 2 percent trip repeatability over its entire operating range. The standard overload shall provide Class 20 overload protection. The overload must provide phase loss protection by tripping in 3 seconds or less under a phase loss condition. The overload must be capable of protecting the motor in a starting, full load, or lightly loaded condition against single-phase damage. The overload and phase loss protection must not be able to be defeated by any changes to the setting of the overload. The overload must be ambient insensitive and able to

operate in a temperature range of minus 22 degrees F to plus 159 degrees F. The overload relay must have a trip-free normally closed contact rated NEMA A600 with a visible trip indication. The overload relay shall be provided with an additional normally closed auxiliary contact rated NEMA A600. The overload must have a method of being manually tripped for test purposes.

6.2.3.2.7. Power Control Transformer:

6.2.3.2.7.1. Transformers shall have sufficient capacity to serve connected load, including 200V ac for duplex outlet plus 100V ac (minimum).
6.2.3.2.7.2. Limit voltage variation to 15 percent during contact pickup.
6.2.3.2.7.3. Fuse on one side of secondary winding and ground on the other.
6.2.3.2.7.4. Furnish primary winding fuses in underground conductors.
6.2.3.2.7.5. Power Distribution Blocks: Furnish to parallel feed top on branch circuit protective devices. Do not “leap frog” power conductors.

6.2.3.3. Wiring:

6.2.3.3.1. AC Circuits:

6.2.3.3.1.1. Type: 600-volt, Type THHN/THWN stranded copper.
6.2.3.3.1.2. Size: For current to be carried, but not less than No. 16 AWG.

6.2.3.3.2. Analog Signal Circuits:

6.2.3.3.2.1. Type: 600-volt, Type 3 stranded copper, twisted shielded pairs.
6.2.3.3.2.2. Size: No. 16 AWG, minimum.

6.2.3.3.3. Other DC Circuits.

6.2.3.3.3.1. Type: 600-volt, Type THHN/THWN stranded copper.
6.2.3.3.3.2. Size: No. 16 AWG, minimum.
6.2.3.3.3.3. Separate analog and other dc circuits at least 6 inches from any ac power and control wiring.

6.2.3.3.4. Control and signal wiring in control panels shall be restrained by plastic ties or ducts. Secure hinge wiring at each end so bending or twisting will occur around the longitudinal axis of wire. Protect any bend area with a sleeve.

6.2.3.3.5. Arrange wiring neatly, cut to proper length, and remove surplus wire. Install abrasion protection for wire bundles passing through holes or across edges of sheet metal.

6.2.3.3.6. Use manufacturer's recommended tool with sized anvil for crimp terminations. No more than one wire may be terminated in a single

crimp lug. No more than two lugs may be installed on a single screw terminal.

6.2.3.3.7. Do not splice or tap wiring except at device terminals or terminal blocks.

6.2.3.4. Wire Identification:

6.2.3.4.1. Identify wiring in control panel.

6.2.3.4.2. Numbered and tagged at each termination.

6.2.3.4.3. Wire Tags: Snap-on or slip-on PVC wire markers with legible machine printed markings and numbers. Do not use adhesive or taped-on tags.

6.2.3.5. Wiring Interface:

6.2.3.5.1. For analog and discrete signal, terminate at numbered terminal blocks.

6.2.3.5.2. For special signals, terminate power (240 volts or greater) at manufacturer's standard connectors.

6.2.3.5.3. For panel, terminate at equipment on which it is mounted.

6.2.3.5.4. Terminal Blocks:

6.2.3.5.4.1. Accommodate present and spare indicated needs. One wire per terminal.
6.2.3.5.4.2. Wire spare or unused panel mounted elements to their panels' terminal blocks.
6.2.3.5.4.3. Spare Terminals: 20 percent of connected terminals, but not less than 10.
6.2.3.5.4.4. Group to keep 120V ac circuits separate from 24V dc circuits.
6.2.3.5.4.5. Insulation:
6.2.3.5.4.5.1. Thermoplastic rated for minus 55 to plus 110 degrees C.
6.2.3.5.4.5.2. Two funnel shaped inputs to facilitate wire entry.
6.2.3.5.4.6. Mounting:
6.2.3.5.4.6.1. DIN rail.
6.2.3.5.4.6.2. Terminal block can be extracted from an assembly without displacing adjacent blocks.
6.2.3.5.4.6.3. End Stops: One at each end of rail, minimum.

6.2.3.5.5. Wire Preparation: Stripping only.

6.2.3.5.6. Jumpers: Allow jumper installation without loss of space on terminal or rail.

6.2.3.5.7. Marking System:

6.2.3.5.7.1. Terminal number shown on both sides of terminal block.
6.2.3.5.7.2. Allow use of preprinted and field marked tags.
6.2.3.5.7.3. Terminal strip numbers shown on end stops.
6.2.3.5.7.4. Mark terminal block and terminal strip numbers as shown on panel control diagrams or as indicated in the Specifications.

6.2.3.5.8. Terminal Blocks for 120-Volt Power:

6.2.3.5.8.1. Rated Voltage: 600V ac.
6.2.3.5.8.2. Rated Current: 30 amp.
6.2.3.5.8.3. Wire Size: 22-10 AWG.
6.2.3.5.8.4. Rated Wire Size: 10 AWG.
6.2.3.5.8.5. Color: Gray body.
6.2.3.5.8.6. Spacing: 0.25 inch, maximum.
6.2.3.5.8.7. Manufacturer and Product: Phoenix Contact; Type UK5N and UK6N.

6.2.3.5.9. Terminal Blocks for Ground:

6.2.3.5.9.1. Wire Size: 20-1/0 AWG.
6.2.3.5.9.2. Rated Wire Size: As required.
6.2.3.5.9.3. Color: Green and yellow body.
6.2.3.5.9.4. Spacing: 0.25 inch, maximum.
6.2.3.5.9.5. Grounding: Ground terminal blocks electrically grounded to the mounting rail.
6.2.3.5.9.6. Manufacturer and Product: Phoenix Contact; Type USLKG.

6.2.3.5.10. Terminal Block Blade Disconnect Switch:

6.2.3.5.10.1. Provide one for each discrete input and output field interface wire.
6.2.3.5.10.2. Rated Voltage: 600V ac.
6.2.3.5.10.3. Rated Current: 10 amp.
6.2.3.5.10.4. Wire Size: 22-12 AWG.
6.2.3.5.10.5. Rated Wire Size: 12 AWG.
6.2.3.5.10.6. Color: Gray body, orange switch.
6.2.3.5.10.7. Spacing: 0.25 inch, maximum
6.2.3.5.10.8. Manufacturer and Product: Phoenix Contact; Type UDK 4-MTK.

6.2.3.5.11. Terminal Block, Fuse/Disconnect Plug:

6.2.3.5.11.1. Provide one for each analog input and output field interface wire.
6.2.3.5.11.2. Rated Voltage: 300V ac.
6.2.3.5.11.3. Rated Current: 15 amp.
6.2.3.5.11.4. Wire Size: 30-14 AWG.

6.2.3.5.11.5. Manufacturer and Product: Phoenix Contact; V10K 1,5-D/TG/D/PE with Type ST.

6.2.3.5.12. Terminal Block, Fused, 24V dc:

6.2.3.5.12.1. Rated Voltage: 600V dc.
6.2.3.5.12.2. Rated Current: 6.3 amp.
6.2.3.5.12.3. Wire Size: 26-8 AWG.
6.2.3.5.12.4. Rated Wire Size: 12 AWG.
6.2.3.5.12.5. Color: Black body.
6.2.3.5.12.6. Fuse: Amperage size as required.
6.2.3.5.12.7. Fuse Marking: Fuse amperage rating shown on top of terminal block.
6.2.3.5.12.8. Indication: LED diode 24V dc.
6.2.3.5.12.9. Leakage Current: 7.5 mA, maximum.
6.2.3.5.12.10. Spacing: 0.32 inch, maximum.
6.2.3.5.12.11. Manufacturer and Product: Phoenix Contact; Type UK6.3-HESi.

6.2.3.5.13. Terminal Block, Fused, 120V ac:

6.2.3.5.13.1. Rated Voltage: 600 V ac.
6.2.3.5.13.2. Rated Current: 6.3 amp.
6.2.3.5.13.3. Wire Size: 26-8 AWG.
6.2.3.5.13.4. Rated Wire Size: 12 AWG.
6.2.3.5.13.5. Color: Black body.
6.2.3.5.13.6. Fuse: Amperage size as required.
6.2.3.5.13.7. Fuse Marking: Fuse amperage rating shown on top of terminal block.
6.2.3.5.13.8. Indication: Neon lamp 110V ac.
6.2.3.5.13.9. Leakage Current: 1.0 mA, maximum.
6.2.3.5.13.10. Spacing: 0.32 inch, maximum.
6.2.3.5.13.11. Manufacturer and Product: Phoenix Contact; Type UK6.3-HESi.

6.2.3.5.14. Terminal Block, Fused, 120V ac, High Current:

6.2.3.5.14.1. Rated Voltage: 600V ac.
6.2.3.5.14.2. Rated Current: 35 amps.
6.2.3.5.14.3. Wire Size: 18-8 AWG.
6.2.3.5.14.4. Fuse: Amperage size as required.
6.2.3.5.14.5. Manufacturer: Phoenix Contact.

6.2.3.6. Grounding:

6.2.3.6.1. Enclosures, control panels, and cabinets signal and shield ground connections shall be made as shown on the Drawings, for each

enclosure, control panel, and cabinet that has a dedicated #4 AWG ground conductor from the ground grid, MCC ground bus, or switchgear ground bus. Enclosures, control panels, and cabinets that do not have a #4 AWG ground conductor shall be installed as follows:

6.2.3.6.1.1. Furnish isolated copper grounding bus for signal and shield ground connections.
6.2.3.6.1.2. Ground this ground bus at a common signal ground point in accordance with national Electrical Code requirements.

6.2.3.6.2. Single Point Ground for Each Analog Loop:

6.2.3.6.2.1. Locate at dc power supply for loop.
6.2.3.6.2.2. Use to ground wire shields for loop.

6.2.3.6.3. Ground terminal block rails to ground bus.

6.2.3.7. Analog Signal Isolators:

6.2.3.7.1. Furnish for all analog signals that are sent from each control panel and cabinet.

6.2.3.7.2. Power: 115V ac.

6.2.3.7.3. Three-way isolation; input, output, and power are isolated from each other.

6.2.3.7.4. Meets ANSI/IEEE C37.90.

6.2.3.7.5. Accuracy: Better than plus or minus 0.1 percent of output span.

6.2.3.7.6. Manufacturer: Acromag; Series 430I.

6.2.3.8. Relays:

6.2.3.8.1. All relays shall be provided with surge protection across the coils as follows:

6.2.3.8.1.1. Surge Suppressors: Magnetic control, machine tool, and industrial relays.
6.2.3.8.1.2. Metal Oxide Varistors: ac Voltage Coils.
6.2.3.8.1.3. Diodes: dc Voltage Coils.
6.2.3.8.1.4. Surge protection shall be provided and installed as recommended by the relay manufacturer.

6.2.3.8.2. Magnetic control, machine tool, and industrial relays shall be provided as indicated on the Drawings by multiple single pole, single throw

(SPST) contacts to the right of the relay coil. Signal/control circuit switching relays shall be provided as indicated on the Drawings by multiple single pole, double throw contacts (Form C) to the right of the relay coil.

6.2.3.8.3. Signal/Control Circuit Switching Relay:

6.2.3.8.3.1. Relay Mounting: Plug-in type socket.
6.2.3.8.3.2. Relay Enclosure: Furnish dust cover.
6.2.3.8.3.3. Socket Type: Screw terminal interface with wiring.
6.2.3.8.3.4. Socket Mounting: DIN rail.
6.2.3.8.3.5. Provide holddown clips.

6.2.3.8.4. Magnetic Control, Machine Tool, and Industrial Relays:

6.2.3.8.4.1. NEMA ICS 2, Class A600 (600 volts, 10 amps continuous, 7,200 VA make, 720 VA break), industrial control with a minimum of four field-convertible contacts.

6.2.3.8.5. Time Delay Attachment: Solid state

6.2.3.8.5.1. Provided and installed with manufacturer-recommended and provided surge suppressors across the coil terminals. The surge suppressor shall be designed to absorb all energy surges that appear on the line.
6.2.3.8.5.2. Manufacturer and Product: General Electric; Type CR120B.

6.2.3.8.6. Signal/Control Circuit Switching Relay, Nonlatching:

6.2.3.8.6.1. Type: Compact general purpose plug-in.
6.2.3.8.6.2. Contact Arrangement: As indicated on the Drawings, two Form C contacts minimum.
6.2.3.8.6.3. Contact Rating: 10A at 28V dc or 240V ac.
6.2.3.8.6.4. Contact Material: Silver cadmium oxide alloy.
6.2.3.8.6.5. Coil Voltage: As noted or shown.
6.2.3.8.6.6. Coil Power: 1.5 watts (dc), 2 VA (ac).
6.2.3.8.6.7. Expected Mechanical Life: 50,000,000 operations.
6.2.3.8.6.8. Expected Electrical Life at Rated Load: 500,000 operations.
6.2.3.8.6.9. Indication Type: Neon or LED indicator lamp.
6.2.3.8.6.10. Push-to-test button.
6.2.3.8.6.11. Manufacturer and Product: IDEC Corp.; Series RH.

6.2.3.8.7. Signal/Control Circuit Switching Relay, Latching:

6.2.3.8.7.1. Type: Dual coil mechanical latching relay.
6.2.3.8.7.2. Contact Arrangement: As indicated on the Drawings, two Form C contacts minimum.

6.2.3.8.7.3. Contact Rating: 10A at 28V dc or 120V ac.
6.2.3.8.7.4. Contact Material: Silver cadmium oxide alloy.
6.2.3.8.7.5. Coil Voltage: As noted or shown.
6.2.3.8.7.6. Coil Power: 2 watts (dc), 1.2 VA (ac).
6.2.3.8.7.7. Expected Mechanical Life: 10,000,000 operations.
6.2.3.8.7.8. Expected Electrical Life at Rated Load: 200,000 operations.
6.2.3.8.7.9. Manufacturer and Product: IDEC Corp.; Series RH2L.

6.2.3.8.8. Signal/Control Circuit Switching Relay, Time Delay:

6.2.3.8.8.1. Type: Adjustable time delay relay.
6.2.3.8.8.2. Contact Arrangement: As indicated on the Drawings, two Form C contacts minimum.
6.2.3.8.8.3. Contact Rating: 10A at 240V ac.
6.2.3.8.8.4. Contact Material: Silver cadmium oxide alloy.
6.2.3.8.8.5. Coil Voltage: As noted or shown.
6.2.3.8.8.6. Operating Temperature: Minus 10 to plus 55 degrees C.
6.2.3.8.8.7. Repeatability: Plus or minus 2 percent.
6.2.3.8.8.8. Delay Time Range: Select range such that time delay setpoint fall between 20 to 80 percent of range.
6.2.3.8.8.9. Time Delay Setpoint: As noted or as determined by the ENGINEER.
6.2.3.8.8.10. Mode of Operation: As noted or as determined by the ENGINEER.
6.2.3.8.8.11. Adjustment Type: Integral potentiometer with knob external to dust cover.
6.2.3.8.8.12. Manufacturer and Products: Potter and Brumfield; Series CG for 0.5-second to 100-minute delay time ranges, Series CD for 0.1- to 180-second delay time ranges.

6.2.3.9. Power Supplies:

6.2.3.9.1. Furnish as required to power instruments requiring external dc power, including two-wire transmitters and dc relays.

6.2.3.9.2. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.

6.2.3.9.3. Provide output over voltage and over current protective devices to:

6.2.3.9.3.1. Protect instruments from damage due to power supply failure.
6.2.3.9.3.2. Protect power supply from damage due to external failure.

6.2.3.9.4. Primary switched type.

6.2.3.9.5. Rail mount such that dissipated heat does not adversely affect other components.

6.2.3.9.6. Fuses: For each dc supply line to each individual two-wire transmitter.

6.2.3.9.6.1. Type: Indicating.
6.2.3.9.6.2.Mount so fuses can be easily seen and replaced.

6.2.3.9.7. Manufacturer and Product: Phoenix Contact; CM50-PS-120-230AC/24DC/5.

6.2.3.10. Front-of-panel devices shall be in conjunction with NEMA 250, Type 12 panels shall be rated NEMA 4/13, watertight/oiltight.

6.2.3.11. Potentiometer Units:

6.2.3.11.1. Three-terminal, oiltight construction, resolution of 1 percent and linearity of plus or minus 5 percent.

6.2.3.11.2. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.

6.2.3.11.3. Include legend plates with service markings.

6.2.3.11.4. Manufacturers and Products: Allen Bradley; Bulletin 800T, General Electric; Type CR104P.

6.2.3.12. Indicating Lights:

6.2.3.12.1. Heavy-duty, push-to-test type, oiltight, industrial full-voltage, high-visibility LED type for 120V ac applications.

6.2.3.12.2. Screwed on prismatic glass lenses in colors noted and factory engraved legend plates for service legend.

6.2.3.12.3. Manufacturers and Products: Allen-Bradley; Bulletin 800T, General Electric; Type CR104P, Square-D; Class 9001, Type K.

6.2.3.13. Push Button, Momentary:

6.2.3.13.1. Heavy-duty, oiltight, industrial type with full guard and momentary contacts rated for 10 amperes continuous at 120V ac.

6.2.3.13.2. Standard size legend plates with black field and white markings for service legend.

6.2.3.13.3. Manufacturers and Products: Allen-Bradley, Bulletin 800T, Square D; Class 9001, Type K, General Electric; Type CR104P.

6.2.3.14. Selector Switch:

6.2.3.14.1. Heavy-duty, oiltight, industrial type with contacts rated for 120V ac service at 10 amperes continuous.

6.2.3.14.2. Standard size, black field, legend plates with white markings, for service legend.

6.2.3.14.3. Operators: Black knob type.

6.2.3.14.4. Single-hole mounting, accommodating panel thicknesses from 1/16 to 1/4 inch.

6.2.3.14.5. Manufacturers and Products for Units with up to Four Selection Positions: Allen-Bradley; Bulletin 800T, General Electric; Type CR104P, Square D; Class 9001, Type K.

6.2.3.15. Front-of-panel devices used in conjunction with NEMA 250, Type 4X panels shall be rated NEMA 4X, corrosion-resistant/watertight.

6.2.3.16. Potentiometer, Watertight:

6.2.3.16.1. Three-terminal, heavy-duty NEMA 250, Type 4X watertight construction, resolution of 1 percent and linearity of plus or minus 5 percent.

6.2.3.16.2. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.

6.2.3.16.3. Include engraved legend plates with service markings.

6.2.3.16.4. Manufacturer and Product: Allen-Bradley; Bulletin 800H.

6.2.3.17. Indicating Lights, Watertight:

6.2.3.17.1. Heavy-duty, push-to-test type, NEMA 250, Type 4X watertight, industrial, full-voltage, high-visibility LED type, for 120V ac applications and corrosion-resistant service.

6.2.3.17.2. Screwed on prismatic lenses and factory engraved legend plates for service legend.

6.2.3.17.3. Manufacturers and Products: Allen Bradley; Bulletin 800H, Square D; Type SK.

6.2.3.18. Push Button, Momentary, Watertight:

6.2.3.18.1. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with momentary contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.

6.2.3.18.2. Standard size, black field, legend plates with white markings for service legend.

6.2.3.18.3. Manufacturers and Products: Allen Bradley; Bulletin 800H, Square D; Type SK.

6.2.3.19. Selector Switch, Watertight:

6.2.3.19.1. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.

6.2.3.19.2. Standard size, black field, legend plates with white markings, for service legend.

6.2.3.19.3. Operators: Black knob type.

6.2.3.19.4. Single-hole mounting, accommodating panel thickness from 1/16 to 1/4 inch.

6.2.3.19.5. Manufacturer and Products: Allen Bradley; Bulletin 800H, Square D; Class 9001, Type SK.

6.3. COMPONENT IDENTIFICATION

6.3.1. Panel Nameplates: For each panel, face mounted laminated nameplate inscribed with the panel name. Color shall be white with black letters ½ inch tall minimum.

6.3.2. Nametags: Permanently mounted and bearing entire identification number.

6.3.2.1. Panel Mounted: Plastic, mounted to instrument behind panel face.

6.3.2.2. Field Mounted: Engraved Type 316 stainless steel, 22-gauge minimum thickness, attach with steel safety wire.

6.3.3. Service Legends and Nameplates:

6.3.3.1. Engraved, rigid, laminated plastic type with adhesive back. Furnish service legends and nameplates to adequately describe functions of panel face mounted instruments.

6.3.3.2. Color: White surface engraved to a black core, white with black letters. Letter height 3/16 inch minimum.

6.3.3.3. Standard Light Colors and Inscriptions: Unless otherwise specified in individual equipment specifications, use the following color code and inscriptions:

Tag	Inscription(s)	Color
POWER ON	POWER ON	Green
ON	ON	Red
OFF	OFF	Green
OPEN	OPEN	Red
CLOSED	CLOSED	Green
LOW	LOW	Amber
FAIL	FAIL	Amber
HIGH	HIGH	Amber
AUTO	AUTO	White
HAND OR MANUAL	HAND OR MANUAL	Yellow
LOCAL	LOCAL	White
REMOTE	REMOTE	Yellow
FORWARD	FORWARD	Red
REVERSE	REVERSE	Blue

6.3.3.4. Lettering: Black on white or amber lenses; white on red or green lenses.

6.3.3.5.Standard Push Button Colors, Unless Otherwise Indicated:

6.3.3.5.1. STOP, OFF, EMERGENCY STOP, RESET are to be Red in color.
6.3.3.5.2. All others are to be Black in color.

6.4. SURGE AND TRANSIENT PROTECTION

6.4.1. General: All control panels are to be equipped with surge-arresting devices to protect equipment from damage due to electrical transients induced in interconnecting lines from lightning discharges and nearby electrical devices.

6.4.2. Suppressor Locations:

6.4.2.1. At point of connection between each equipment item, including ac powered transmitters and its power supply conductors (direct wired equipment).

6.4.2.2. On analog pairs at each end when the pair travels outside of building.

6.4.2.3. In other locations where equipment sensitivity to surges and transients requires additional protection beyond that inherent to design of equipment.

6.4.3. AC Power Supply Suppressor Assemblies shall be suitable for connection to 120-volt, single-phase power supplies.

6.4.4. Manufacturer and Products:

6.4.4.1.AC Power Supply Suppressor: Phoenix; MT2PE/S-120AC.
6.4.4.2.DC Signal Suppressor: Telematic; (MTL) SD 32X.
6.4.4.3.AC Signal Suppressor: Telematic; (MTL) SD 150X.
6.4.4.4.Data Highway Plus Suppressor: Telematic; (MTL) SD 16X.

6.4.5. Grounding: Coordinate surge suppressor grounding in field panels and field instrumentation per suppressor manufacturer's requirements. Furnish control panels with an integral copper grounding bus for connection of suppressors and other required instrumentation.

7. FIBER OPTIC DATA TRANSMISSION SYSTEM

7.1. SYSTEM DESCRIPTION

7.1.1. General

7.1.1.1. A fiber optics (FO) data transmission system (DTS) shall be provided as detailed for control and data acquisition between well vaults and Buildings 650 and 651. The data transmission system shall consist of fiber optic transmission media, transmitter and receiver modules, FO modems, transceiver modules, repeaters, and terminal devices (such as connectors, patch panels and breakout boxes). The data transmission system shall interconnect system components as shown on the contract drawings. Computing devices, as defined in 47 CFR 15, shall be certified to comply with the requirements for Class B computing devices and labeled as set forth in 47 CFR 15.

7.1.2. Environment

7.1.2.1. Equipment and cable to be utilized indoors shall be rated for continuous operation under ambient environmental conditions of 35 to 120 degrees F dry bulb and 10 to 95 percent relative humidity, noncondensing. Equipment shall be rated for continuous operation under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location. Fiber optic cable for outdoor installation shall be rated for minus minus 40 to plus 176 degrees F.

7.1.2.2. Hazardous Environment

7.1.2.2.1. System components located in fire or explosion hazard areas shall be rated and installed according to Chapter 5 of NFPA 70.

7.2. SUBMITTALS

7.2.1. These specific submittals supplement the submittals requirements in section 9.0, listed later in this document.

7.2.2. Data Package

7.2.2.1. The data package shall include complete system description, and analyses and calculations used in sizing equipment required by these specifications. Descriptions and calculations shall show how the equipment will operate as a system to meet the specified performance. The data package shall include the following:

7.2.2.1.1. FO receivers, transmitters, transceivers, FO modem transmit and receive levels, and losses in decibels (dB) on each communication link.
7.2.2.1.2. Digital transmitter and receiver communication speed and protocol description.
7.2.2.1.3. Analog signal transmission method and bandwidth of the transmitter and receiver.
7.2.2.1.4. Data transmission system expansion capability and method of implementation.
7.2.2.1.5. FO system signal-to-noise ratio calculation for each communication link.
7.2.2.1.6. Flux-budget and gain margin calculation for each link.

7.2.2.2. Test Plan Procedures and Reports;

7.2.2.2.1. Test reports shall be submitted in booklet form showing field tests performed to adjust each component and field tests performed to prove compliance with the specified performance criteria. These are to be supplied upon completion and testing of the installed system.

7.2.3. Fiber Optic System Testing

7.2.3.1. Test plans shall define tests required and procedures to be followed to ensure that the system meets technical, operational, and performance specifications. The test plans shall define milestones for the tests, equipment, personnel, facilities, and supplies required. The test plans shall identify the capabilities and functions to be tested.

7.2.3.2. A test plan and test procedure shall be prepared in accordance with this specification. The test procedures shall describe the applicable tests to be performed, and other pertinent information such as specialized test equipment required, length of test, and location of the test. The procedures shall explain in detail, step-by-step actions and expected results to demonstrate compliance with the requirements of this specification, and the methods for simulating the necessary conditions of operation to demonstrate performance of the system. The Contractor shall provide written notice of the test to the Government at least 2 weeks prior to the scheduled start.

7.2.3.3. Following testing, a test report shall describe the results of testing to include the date, time, location and system component designations of material and equipment tested. Testing action shall be recorded whether successful or not. Testing work sheets, printouts, strip charts, oscilloscope or optical time domain reflectometer (OTDR) photographs, raw and analyzed data, and testing conclusions shall be included in the report. The final test report shall be delivered within 15 days after completion of the test.

7.3. PRODUCTS

7.3.1. FO MODEMS

7.3.1.1. FO modems shall be selected to meet FO system requirements. The modems shall allow full duplex, asynchronous, point-to-point digital communication using an FO pair. The operating wavelength shall be centered on 850, 1330, or 1550 nanometers.

7.3.1.2. FO modems shall accept inputs and provide outputs compatible with EIA ANSI/EIA/TIA-232-F 4-20 mA current loop. Digital data rates through each link shall be not less than 38.4 KBPS.

7.3.2. FO TRANSMITTER AND RECEIVER MODULES

7.3.2.1. FO transmitter/receiver pairs shall have signal-to-noise power ratio of 40 dB or better after photo detection at the receiver. Transmitter power output and receiver sensitivity shall not drift more than plus or minus 2 dB over their operational life.

7.3.2.2. Analog FO Transmitter and Receiver Modules

7.3.2.2.1. FO transmitter/receiver pairs used to pass analog video signals shall accept inputs and provide outputs that comply with EIA 170 and shall have a bandwidth of 6 MHz or greater.

7.3.2.3. Digital FO Transmitter and Receiver Modules

7.3.2.3.1. FO transmitter/receiver pairs used to pass digital signals shall accept inputs and provide outputs compatible with EIA ANSI/EIA/TIA-232-F 20 mA current loop. Digital data rates through each link shall be 38.4 KBPS or greater. FO transmitter and receiver modules shall be housed in field equipment enclosures. FO transmitter and receiver modules shall be compatible with each other, the FO cable, and connectors.

7.3.2.4. FO Transmitter Module

7.3.2.4.1. The FO transmitter shall accept electronic signals and shall modulate a light source. The light source shall be coupled into an FO cable. The operating wavelength shall be centered on 850, 1330, or 1550 nanometers per calculated system requirements.

7.3.2.5. FO Receiver Module

7.3.2.5.1. The FO receiver module shall receive light from the FO cable and shall convert this light into an electronic signal identical to the electronic signal applied to the FO transmitter module. The operating wavelength shall be the same as the transmitter.

7.3.3. SYSTEM REQUIREMENTS

7.3.3.1. Signal Transmission Format Code

7.3.3.2. FO equipment shall use the same transmission code format from the beginning of a circuit to the end of that circuit. Different transmission code formats may be used for different circuits as required to interconnect supported equipment.

7.3.3.3. Flux Budget/Gain Margin

7.3.3.3.1. FO links shall have a minimum gain margin of 6 dB. The flux budget is the difference between the transmitter output power and the receiver input power required for signal discrimination when both are expressed in dBm. The flux budget shall be equal to the sum of losses (such as insertion losses, connector and splice losses, and transmission losses) plus the gain margin. When a repeater or other signal regenerating device is inserted to extend the length of an FO circuit, both the circuit

between the transmitter and the repeater-receiver, and the circuit between the repeater-transmitter and the receiver are considered independent FO links for gain margin calculations.

7.3.3.4. Receiver Dynamic Range

7.3.3.4.1. The dynamic range of receivers shall be large enough to accommodate both the worst-case, minimum receiver flux density and the maximum possible, receiver flux density. The receiver dynamic range shall be at least 15 dB. Where required, optical attenuators shall be used to force the FO link power to fall within the receiver dynamic range.

7.4. OPTICAL FIBERS

7.4.1. GENERAL

7.4.1.1. Optical fibers shall be coated with a suitable material to preserve the intrinsic strength of the glass. The outside diameter of the glass-cladded fiber shall be nominally 125 microns, and shall be concentric with the fiber core. Optical fibers shall meet EIA ANSI/EIA/TIA-455-46A, and EIA ANSI/TIA/EIA-455-177A.

7.4.1.2. 62.5 Micron Multimode Fibers

7.4.1.2.1. Conductors shall be multimode, graded index, solid glass waveguides with a nominal core diameter of 62.5 microns. The fiber shall have transmission windows centered at 850 and 1330 nanometer wavelengths. The numerical aperture for each fiber shall be a minimum of 0.275. The attenuation at 850 nanometers shall be 4.0 dB/Km or less. The attenuation at 1330 nanometers shall be 1.5 dB/Km or less. The minimum bandwidth shall be 160 MHz-Km at 850 nanometers and 400 MHz-Km at 1300 nanometers. FO cable shall be certified to meet EIA ANSI/EIA/TIA-455-30B and EIA ANSI/EIA/TIA-455-58A.

7.4.1.3. 8.3 Micron Single Mode Fibers

7.4.1.3.1. Conductors shall be single-mode, graded index, solid glass waveguides with a nominal core diameter of 8.3 microns. The fiber shall have a transmission window centered at 1330, or 1550 nanometer wavelength. The numerical aperture for each optical fiber shall be a minimum of 0.10. The attenuation at 1330 nanometers shall be 0.5 dB/Km or less. The fibers shall be certified to meet EIA ANSI/EIA/TIA-455-170.

7.4.1.4. Patch Panels

7.4.1.4.1. Patch panels shall be a complete system of components by a single manufacturer, and shall provide termination, splice storage, routing, radius limiting, cable fastening, storage, and cross-connection. Patch panel connectors and couplers shall be the same type and configuration as used elsewhere in the system. Panels shall be either a rack mount type or wall mounted.

7.4.1.5. Patch Cords

7.4.1.5.1. Patch cords shall be cable assemblies consisting of flexible optical fiber cable with connectors of the same type as used elsewhere in the system. Optical fiber shall be the same type as used elsewhere in the system. Patch cords shall be complete assemblies from manufacturer's standard products.

7.4.2. CABLE CONSTRUCTION

7.4.2.1. General

7.4.2.1.1. The cable shall contain a minimum of two fiber optic conductors for each full duplex circuit. The number of fibers in each cable shall be twenty or greater. Each fiber shall be protected by a protective tube. Cables shall have a jacketed strength member, and an exterior jacket. Cable and fiber protective covering shall be free from holes, splits, blisters, and other imperfections. The covering shall be flame retardant, moisture resistant, non-nutrient to fungus, ultraviolet light resistant as specified and nontoxic.

7.4.2.1.2. Mechanical stress present in cable shall not be transmitted to the optical fibers. Strength members shall be non-metallic and shall be an integral part of the cable construction. The combined strength of all the strength members shall be sufficient to support the stress of installation and to protect the cable in service.

7.4.2.1.3. The exterior cables shall have a minimum storage temperature range of minus 40 to plus 167 degrees F. Interior cables shall have a minimum storage temperature of minus 14 to plus 167 degrees F. All cables furnished shall meet the requirement of NFPA 70. Fire resistant characteristics of cables shall conform to Article 770, Sections 49, 50, and 51.

7.4.2.1.4. A flooding compound shall be applied into the interior of the fiber tubes, into the interstitial spaces between the tubes, to the core covering, and between the core covering and jacket of all cable to be installed aerially, underground, and in locations susceptible to moisture. Flooded cables shall comply with EIA ANSI/EIA-455-81A-91 and EIA ANSI/EIA/TIA-455-82B.

7.4.2.1.5. Cables shall be from the same manufacturer, of the same cable type, and of the same size. Each fiber and protective coverings shall be continuous with no factory splices. Fiber optic cable assemblies, including jacketing and fibers, shall be certified by the manufacturer to have a minimum life of 30 years.

7.4.2.1.6. FO cable shall be certified to meet the following: EIA ANSI/TIA/EIA-455-13A, EIA ANSI/EIA/TIA-455-25B, EIA ANSI/TIA/EIA-455-41A, EIA ANSI/EIA/TIA-455-47B, EIA ANSI/EIA/TIA-455-59, EIA ANSI/EIA/TIA-455-61, EIA-455-88, EIA ANSI/EIA-455-91, EIA ANSI/TIA/EIA-455-104A, and EIA ANSI/EIA-455-171.

7.4.2.2. Exterior Cable

7.4.2.2.1. The optical fibers shall be surrounded by a tube buffer, shall be contained in a channel or otherwise loosely packaged to provide clearance between the fibers and inside of the container. They shall be extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement.

7.4.2.2.2. The cable outer jacket shall be medium density polyethylene material containing at least 2.6 percent carbon black with only black pigment added for additional coloring.

7.4.2.2.3. Tensile strength: Cables shall withstand an installation tensile load of not less than 2700 Newtons (608 pounds) and not less than 600 Newtons (135 pounds) continuous tensile load.

7.4.2.2.4. Impact and Crush resistance: The cables shall withstand an impact of 3 Newtons/meter (1.7lbs/in) as a minimum, and shall have a crush resistance of 220 Newtons per square centimeter (317 pounds per square inch) as a minimum.

7.4.2.3. Cable Inside of Ductwork

7.4.2.3.1. The optical fibers shall be surrounded by a tube buffer, shall be contained in a channel or otherwise loosely packaged to provide clearance between the fibers and inside of the container, and shall be extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement.

7.4.2.3.2. The cable outer jacket shall be medium density polyethylene material with orange pigment added for ease of identification.

7.4.2.3.3. Tensile strength: Cables shall withstand an installation tensile load of not less than 608 pounds and not less than 135 pounds continuous tensile load.

7.4.2.3.4. Impact and Crush resistance: The cables shall withstand an impact of 1.7 lbs/in as a minimum, and shall have a crush resistance of 317 pounds per square inch as a minimum.

7.4.2.4. Direct Burial Cable

7.4.2.4.1. The optical fibers shall be surrounded by a tube buffer, shall be contained in a channel or otherwise loosely packaged to provide clearance between the fibers and inside of the container. They shall be extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement.

7.4.2.4.2. The cable outer jacket shall be medium density polyethylene material containing at least 2.6 percent carbon black with only black pigment added for additional coloring.

7.4.2.4.3. Tensile strength: Cables shall withstand an installation tensile load of not less than 608 pounds and not less than 135 pounds continuous tensile load.

7.4.2.4.4. Impact and Crush resistance: The cables shall withstand an impact of 1.7 lbs/in as a minimum, and shall have a crush resistance of 317 pounds per square inch as a minimum.

7.4.2.4.5. Direct burial cable shall be protected with plastic coated steel armor. The plastic coated steel armor shall be applied longitudinally directly over an inner jacket and have an overlap of 0.20 inch minimum.

7.4.2.5. Interior Cable

7.4.2.5.1. Loose buffer tube cable construction shall be such that the optical fibers shall be surrounded by a tube buffer, shall be contained in a channel or otherwise loosely packaged to provide clearance between the fibers and the inside of the container to allow for thermal expansions without constraining the fiber. The protective container shall be extruded from a material having a coefficient of friction sufficiently low to allow the fiber free movement. The cable outer jacket shall be flame retardant polyvinyl chloride (PVC) or fluorocopolymer (FCP), which complies with NFPA 70 for OFNP applications. Tensile strength, impact resistance, and crush resistance shall not exceed manufacturers recommendations.

7.4.2.5.2. Tight buffer tube cable construction shall be extrusion of plastic over each cladded fiber, with an outer jacket of flame retardant PVC or FCP, which complies with NFPA 70 for OFNR requirements for riser cables and vertical shaft installations. Optical fibers shall be covered in near contact with an extrusion tube and shall have an intermediate soft buffer to allow for the thermal expansions and minor pressures. Tensile strength, impact resistance, and crush resistance shall not exceed manufacturers recommendations.

7.4.2.5.3. Plenum Rated Cables: Cable to be installed inside plenums shall additionally meet the requirements of UL 910.

7.4.2.6. Pigtail Cables

7.4.2.6.1. Cable used for connections to equipment shall be flexible fiber pigtail cables having the same physical and operational characteristics as the parent cable. The cable jacket shall be flame retardant PVC or FCP, which complies with NFPA 70 for OFNP applications. Maximum dB loss for pigtail cable shall be 3.5 dB/km at 850 nanometers, and 1.0 dB/km at 1330 nanometers.

7.4.3. FO CONNECTORS

7.4.3.1. FO connectors shall be the straight tip, bayonet style, field installable, self-aligning and centering. FO connectors shall match the fiber core and cladding diameters. The connector coupler shall be stainless steel and the alignment ferrule shall be ceramic. FO equipment and cable shall use the same type connectors. Connector insertion loss shall be nominally 0.3 dB and less than 0.7 dB.

7.4.3.2. Fibers at each end of the cable shall have jumpers or pigtails installed of not less than 3 feet in length. Fibers at both ends of the cable shall have connectors installed on the jumpers. Mated pair loss, without rotational optimization, shall not exceed 1.5 dB. The pull strength between the connector and the attached fiber shall not be less than 50 pounds.

7.4.4. FIBER OPTIC CABLE SPLICES

7.4.4.1. No splices will be permitted unless the length of cable being installed exceeds the maximum standard cable length available from a manufacturer or unless fiber optic pigtails are used to connect transmitters, receivers, or other system components for terminations to the fiber.

7.4.4.2. Splices shall be made using the method recommended by the cable manufacturer. Splices shall be housed in a splice enclosure and shall be encapsulated with an epoxy, ultraviolet light cured splice encapsulant or otherwise protected against infiltration of moisture or contaminants. FO splices shall be field tested at the time of splicing. Fusion splices shall have less than 0.2 dB loss.

7.5. FIBER OPTIC INSTALLATION

7.5.1. System components and appurtenances shall be installed in accordance with the manufacturer's instructions and as indicated in contract drawings. Interconnections, services, and adjustments required for a complete and operable data transmission system shall be provided.

7.5.2. Interior Work

7.5.2.1. Conduits, tubing and cable trays for interior FO cable shall be installed as specified in contract drawings. Cable installation and applications shall meet the requirements of NFPA 70, Article 770, Sections 52 and 53. Cables not installed in conduits or wireways shall be properly secured and neat in appearance, and if installed in plenums or other spaces used for environmental air, shall comply with NFPA 70 requirements for this type of installation.

7.5.3. Exterior Underground Cable

7.5.3.1. Except as otherwise specified, conduits, ducts, and manholes for underground FO cable systems shall be installed as indicated in the contract drawings.

7.5.3.2. Buried cables shall be placed below a plastic warning tape buried in the same trench or slot. The tape shall be 12 inches above the cable. The warning tape shall be continuously imprinted with the words "WARNING – FIBER OPTIC CABLE BELOW" at not more than 48 inch intervals. The plastic tape shall be acid and alkali resistant polyethylene film, 3 inches wide with a minimum thickness of 0.004 inch.

7.5.3.3. For cables installed in ducts and conduit, a cable lubricant compatible with the cable sheathing material shall be used on all cables pulled. Pulling fixtures shall be attached to the cable strength members. If indirect attachments are used, the grip diameter and length shall be matched to the cable diameter and characteristics. If an indirect attachment is used on cables having only central strength members, the pulling forces shall be reduced to ensure that the fibers are not damaged from forces being transmitted to the strength member. The mechanical stress placed upon the cable during installation shall be such that the cable is not twisted or stretched.

7.5.3.4. The cable shall not be kinked or crushed and the manufacturer's specified minimum bend radius of the cable shall not be exceeded during installation.

7.5.3.5. Cable shall be hand fed and guided through each manhole and lubricant shall be applied at all intermediate manholes. If the cable is pulled out of a junction box or manhole the cable shall be protected from dirt and moisture by laying the cable on a ground covering.

7.5.4. Service Loops

7.5.4.1. Each fiber optic cable shall have service loops of not less than 10 feet in length at each end. The service loops shall be housed in a service loop enclosures.

7.5.5. Metallic Sheath Grounding

7.5.5.1. Fiber optic cable with metallic sheath routed in the trench with a power cable shall have the metallic sheath grounded at the cable termination points per manufacturer's instructions.

7.5.6. Identification and Labeling

7.5.6.1. Identification tags or labels shall be provided for each cable. Markers, tags and labels shall use indelible ink or etching that will not fade in sunlight or in buried or underground applications. Markers, tags, and labels shall not become brittle or deteriorate for a period of 20 years.

7.5.6.2. Label all termination blocks and panels with cable number or pair identifier for cables in accordance with EIA ANSI/TIA/EIA-606 and as specified in contract drawings. Each cable shall be identified with type of signal being carried and termination points.

7.5.6.3. The labeling format shall be identified and a complete record shall be provided to the Government with the final documentation.

7.5.7. Enclosure Sizing

7.5.7.1. Termination enclosures shall be sized to accommodate the FO equipment to be installed. Sizing shall include sufficient space for service loops to be provided and to accommodate a neat, workmanlike layout of equipment and the bend radii of fibers and cables terminated inside the enclosure.

7.5.8. Enclosure Penetrations

7.5.8.1. Enclosure penetrations shall be from the bottom and shall be sealed with rubber silicone sealant or a strain relief device to preclude the entry of water. Conduits rising from underground shall be internally sealed.

7.5.9. Conduit-Enclosure Connections

7.5.9.1. Conduit-enclosure connections shall be protected by tack welding or brazing the conduit to the enclosure. Tack welding or brazing shall be done in addition to standard conduit-enclosure connection methods as described in NFPA 70. Any damage to the enclosure or its cover's surface protection shall be cleaned and repaired using the same type of surface protection as the original enclosure.

7.6. FIBER OPTIC SYSTEM TESTING

7.6.1. General

7.6.1.1. The Contractor shall provide personnel, equipment, instrumentation, and supplies necessary to perform testing.

7.6.2. Contractor's Field Test

7.6.2.1. The Contractor shall verify the complete operation of the data transmission system in conjunction with field testing associated with systems supported by the fiber optic data transmission system as specified in earlier sections prior to formal acceptance testing. Field tests shall include a flux density test. These tests shall be performed on each link and repeated from the opposite end of each link.

7.6.3. Optical Time Domain Reflectometer Tests

7.6.3.1. Optical time domain reflectometer tests shall be performed using the FO test procedures of EIA ANSI/EIA/TIA-455-59. An optical time domain reflectometer (OTDR) test shall be performed on all fibers of the FO cable on the reel prior to installation. If this is completed by the factory, documentation must be provided to the Government. The optical time domain reflectometer device used shall be calibrated to show anomalies of 0.2 dB as a minimum.

7.6.3.2. An optical time domain reflectometer test shall be performed on all fibers of the FO cable following installation. The optical time domain reflectometer shall be calibrated to show anomalies of 0.2 dB as a minimum.

7.6.3.3. If any optical time domain reflectometer test results show anomalies greater than 1 dB, the FO cable segment is unacceptable to the Government. The unsatisfactory segments of cable shall be replaced with a new segment of cable. The new segment of cable shall then be tested to demonstrate acceptability. Photographs or copies of the traces shall be furnished to the Government for each link.

7.6.4. Power Attenuation Test

7.6.4.1. Power attenuation test shall be performed at the light wavelength of the transmitter to be used on the circuit being tested. The flux shall be measured at the FO receiver end and shall be compared to the flux injected at the transmitter end. There shall be a jumper added at each end of the circuit under test so that end connector loss shall be validated. Rotational optimization of the connectors will not be permitted. If the circuit loss exceeds the calculated circuit loss by more than 2 dB, the circuit is unsatisfactory and shall be examined to determine the problem. The Government shall be notified of the problem and what procedures the Contractor proposes to eliminate the

problem. The Contractor shall prepare and submit a report documenting the results of the test.

7.6.5. Gain Margin Test

7.6.5.1. The Contractor shall test and verify that each circuit has a gain margin that exceeds the circuit loss by at least 6 dB.

7.7. FIBER OPTIC SYSTEM TRAINING

7.7.1. General

7.7.1.1. The Contractor shall conduct a training course for designated personnel in the maintenance of the FO system. The training shall be oriented to the specific system being installed under this specification. The Contractor shall furnish training materials and supplies.

7.7.2. Maintenance Personnel Training

7.7.2.1. The system maintenance course shall be taught at the project site after completion of system testing for a period of 1 training day. Training may be combined with control system training if preferable. A maximum of five personnel designated by the Government will attend the course. Training shall include:

7.7.2.1.1. Physical layout of the system and each piece of hardware.
7.7.2.1.2. Troubleshooting and diagnostics procedures.
7.7.2.1.3. Repair instructions.
7.7.2.1.4. Preventative maintenance procedures and schedules.
7.7.2.1.5. Calibration procedures, if required.

8. CERTIFICATION AND WARRANTY

8.1. The minimum design life for materials and installation of the plume-front remediation system is thirty (30) years. The certification and warranty shall contain a written certification statement from the installation inspector(s) at testing to the proper installation and testing of the control system. The warranty shall define a warranty period and provide allowance for credit, repair or replacement of any defective valves, flow meters, or electronic components. The vendor shall provide a warranty that guarantees the installation of all pipe, valves, and fittings per this contract against defects or failures due to improper installation. At minimum, any defects or failures due to improper installation shall be repaired by the vendor at no cost to the Government for a one (1) year period. The manufacturer or vendor shall replace damaged or defective parts within a two week time frame.

9. SUBMITTALS

9.1. GENERAL REQUIREMENTS

9.1.1. Each submittal shall be permanently marked to identify it by contract number; transmittal date; Contractor's, Subcontractor's, and supplier's name, address(es) and telephone number(s); submittal name; specification or drawing reference; and similar information to distinguish it from other submittals. Submittal identification shall include space to record the review action by the Contracting Officer.

9.1.2. Required data submittals for each specific material, product, unit of work, or system shall be collected into a single submittal and marked for choices, options, and portions applicable to the submittal. Marking of each copy of product data submitted shall be identical. Partial submittals will not be accepted for expedition of construction effort.

9.1.3. Five complete sets of indexed and bound product data shall be submitted. One set, marked with review notations by the Contracting Officer, will be returned to the Contractor.

9.1.4. Within 30 days of notice to proceed, the Contractor shall provide, for approval by the Contracting Officer, the following schedule of submittals:

9.1.4.1. A schedule of shop drawings and technical submittals required by the specifications and drawings. Schedule shall indicate the specification or drawing reference requiring the submittal; the material, item, or process for which the submittal is required; identifying title of the submittal; the Contractor's anticipated submission date and the approval need date.

9.1.4.2. A separate schedule of other submittals required under the contract but not listed in the specifications or drawings. Schedule will indicate the contract requirement reference; the type or title of the submittal; the Contractor's anticipated submission date and the approved need date (if approval is required).

9.1.4.3. Submittals called for by the contract documents will be listed on one of the above schedules. If a submittal is called for but does not pertain to the contract work, the Contractor shall include it in the applicable schedule and annotate it "N/A" with a brief explanation. Approval of the schedules by the Contracting Officer does not relieve the Contractor of supplying submittals required by the contract documents but which have been omitted from the schedules or marked "N/A".

9.1.4.4. Copies of both schedules shall be re-submitted monthly annotated by the Contractor with actual submission and approval dates. When all items on a schedule have been fully approved, no further re-submittal of the schedule is required.

9.1.4.5. Contracting Officer will review submittals and provide pertinent notation within 15 calendar days after date of submission. Submittals will be returned to the Contractor with the following notations:

9.1.4.5.1. Submittals marked "approved" authorize the Contractor to proceed with the work covered.

9.1.4.5.2. Submittals marked "approved as noted" authorize the Contractor to proceed with the work covered provided he takes no exception to the corrections. Notes shall be incorporated prior to submission of the final submittal.

9.1.4.5.3. Submittals marked "return for correction" require the Contractor to make the necessary corrections and revisions and to re-submit them for approval in the same routine as before, prior to proceeding with any of the work depicted by the submittal.

9.1.4.5.4. Submittals marked "not approved" or "disapproved" indicate noncompliance with the contract requirements and shall be re-submitted with appropriate changes. No item of requiring a submittal shall be accomplished until the submittals are approved or approved as noted.

9.1.5. Contractor shall make corrections required by the Contracting Officer. If the Contractor considers any correction or notation on the returned submittals to constitute a change to the contract drawings or specifications; notice as required under the clause entitled, "Changes" shall be given to the Contracting Officer. Approval of the submittals by the Contracting Officer shall not be construed as a complete check, but will indicate only that the general method of construction and detailing is satisfactory. Contractor shall be responsible for the dimensions and design of connection details and construction of work. Failure to point out deviations may result in the Government requiring rejection and removal of such work at the Contractor's expense.

9.1.6. If changes are necessary to approved submittals, the Contractor shall make such revisions and submission of the submittals in accordance with the procedures above. No item of work requiring a submittal change shall be accomplished until the changed submittals are approved.

9.2. PRE-CONSTRUCTION SUBMITTALS

9.2.1. The Contractor shall submit the items in this section (9.2) for approval by the Contracting Officer within 15 calendar days of issuance of the Notice to Proceed.

9.2.2. Qualifications - A statement describing the Contractor’s experience installing and testing piping, flow control valves, electromagnetic flow meters, control cable, optical fiber, and electronic control equipment.

9.2.3. Project Schedule – The Offeror shall furnish a Project Schedule as described in a previous section of this specification.

9.2.4. Manufacturer's Catalog Data – Data composed of catalog cut sheets, specifications and product data, wiring diagrams, and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents. This should include catalog information on all mechanical and electrical devices furnished with system.

9.2.5. Manufacturer's Instructions – Where installation procedures, or any part thereof, are required to be in accordance with the recommendation of the manufacturer of the material being installed, printed copies of these shall be submitted prior to installation.

9.2.6. Shop Drawings and dimensional layout drawings: Diagrams of pre-wired furnished control panels and enclosures, as well as panel interconnection drawings with numbered terminal designations for external interfaces. Drawings shall show all control devices and auxiliary devices, for example: relays, alarms, fuses, lights, fans, and heaters. This shall include interconnection wiring diagrams for the control system.

9.2.7. Communication System design drawings: Details of interfaces with control system components. Fiber optic receivers, transmitters, transceivers, and fiber optic modem installation details, block diagrams, and wiring diagrams. Detail of connection to power sources, including grounding. Details of cable splicing and connector installations.

9.2.8. Control System Testing Plan – The Offeror shall furnish a written document describing in detail the procedure to be followed for testing of the entire control system. Specifically, the Control System Testing Plan shall specify the proposed testing locations, specific procedures, verification, special requirements, and any other information pertinent to control system testing. All proposed testing procedures require Government approval prior to actual testing.

9.2.9. List of proposed spares and test equipment.

9.3. CONSTRUCTION PROGRESS SUBMITTALS

9.3.1. As-Built Drawing Submittals

9.3.1.1. Drawings showing the final as-built conditions of the installation shall consist of as-built CADD drawings. The Contractor will generate the CADD versions of as-builts from his own working as-built markups of the Government's initial design drawings. The Contractor shall review and approve hard copies of the as-built revisions to ensure true as-built conditions before they are recorded on the electronic as-built drawings.

9.3.2. Working As-Built and Final As-Built Drawings

9.3.2.1. The Contractor shall revise two sets of paper drawings by red-line process to show the as-built conditions during the execution of the project (one field copy, one field-office copy). These working as-built marked drawings shall be kept current on a weekly basis and at least one set shall be available on the jobsite at all times. Changes from the contract plans, which are made in the work or additional information that might be uncovered in the course of construction, shall be accurately and neatly recorded as they occur by means of details and notes. The working and final as-built drawings shall show, but shall not be limited to, the following information:

9.3.2.1.1. Changes in details of design or additional information obtained from working drawings specified to be prepared and/or furnished by the Contractor; including but not limited to fabrication, erection, installation plans and placing details, pipe sizes, insulation material, and dimensions of equipment foundations.

9.3.2.1.2. Changes or modifications which result from the final inspection.

9.3.2.1.3. Where contract drawings or specifications present options, only the option selected for construction shall be shown on the final as-built prints.

9.3.2.1.4. Systems designed or enhanced by the Contractor.

9.3.3. Drawing Preparation

9.3.3.1. The as-built drawings shall be modified as may be necessary to correctly show the features of the project as it has been constructed by bringing the contract set into agreement with approved working as-built prints, and adding such additional drawings as may be necessary. Additional drawings generated by the Contractor shall be *.dwg files in AutoCAD (R14 or later) electronic format. The working as-built marked prints shall be neat, legible and accurate. The following color convention shall be used for the working as-built drawings: (1) red for additions, (2) green for deletions, and (3) blue for comments and/or notes.

9.3.3.2. These drawings are part of the permanent records of this project. Any drawings damaged or lost by the Contractor shall be satisfactorily replaced by the Contractor at no expense to the Government.

9.3.4. Final As-Built Drawing Submittals

9.3.4.1. Within seven days following final construction completion, the complete set of working as-built drawings shall be submitted to the Government for approval. Within 14 calendar days after Government approval of all of the working as-built drawings, the Contractor shall submit the revised electronic drawing package reflecting all as-built changes.

9.3.4.2. The Government reserves the right to reject any mark-up drawing it deems inadequate. Paper prints, drawing files and storage media submitted will become the property of the Government upon final approval. Failure to submit final electronic as-built drawing files and marked prints as specified shall be cause for withholding any payment due the Contractor under this contract. Approval and acceptance of final as-built drawings shall be accomplished before final payment is made to the Contractor.

9.3.5. As-Built Record of Equipment and Materials Submittal

9.3.5.1. The Contractor shall furnish one copy of preliminary record of equipment and materials used on the project 14 calendar days prior to final inspection. This preliminary submittal will be reviewed and returned within 4 calendar days after final inspection with Government comments.

9.3.5.2. Two sets of the final record of equipment and materials shall be submitted within 14 calendar days after final inspection. The designations shall be keyed to the related area depicted on the contract drawings. The record shall list the following data:

9.3.5.2.1. Item Description
9.3.5.2.2. Specification Section
9.3.5.2.3. Manufacturer's Catalog, Model, and Serial Number
9.3.5.2.4. Materials of construction and Size
9.3.5.2.5. Item location(s)

9.4. CONSTRUCTION CLOSE-OUT SUBMITTALS

9.4.1. Contractor shall furnish the following documentation no later than 30 days following completion of construction. Final payment will not be made until all close-out submittals are received by the Contracting Officer, and deemed to be satisfactory.

9.4.2. Statement of Satisfactory Installation - The Contractor shall furnish a signed statement certifying that the installation is satisfactory and in accordance with the contract drawings and specifications and the manufacturer's prescribed procedures and techniques, upon completion of the project and before final acceptance.

9.4.3. Copies of all system testing and validation reports, data packages, analyses, and calculations required per previous sections of this specification.

9.4.4. Operation and Maintenance (O&M) Manuals - The Contractor shall furnish four copies each of the manuals specific to all control hardware/software within 30 days after completion of the system installation and testing. Two shall be in indexed booklet form, and two on CD format. These final copies shall be updated to

include all modifications made during installation, checkout, and acceptance. Manuals delivered shall include the following sections:

9.4.4.1. Hardware Manual:

9.4.4.1.1. General description and specifications of components
9.4.4.1.2. Installation and checkout procedures
9.4.4.1.3. Equipment electrical schematics and layout drawings
9.4.4.1.4. Data transmission systems schematics
9.4.4.1.5. Alignment and calibration procedures
9.4.4.1.6. Manufacturer's repair parts list indicating sources of supply

9.4.4.2. Operator's Manual:

9.4.4.2.1. The operator's manual shall fully explain procedures and instructions for operation of the system. It shall identify the operational requirements for the data transmission system and explain the theory of operation, design philosophy, and specific functions. A description of hardware functions, interfaces, and requirements shall be included for all system operating modes.

9.4.4.3. Maintenance Manuals:

9.4.4.3.1. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventative maintenance, fault diagnosis, and repair or replacement of defective components.

9.4.5. Warranty Management Plan - The Contractor shall submit warranty information for all applicable construction and equipment. This submittal shall include a list for each warranted piece of equipment, item, feature of construction or system indicating:

9.4.5.1. Name of item.
9.4.5.2. Model and serial numbers.
9.4.5.3. Location where installed.
9.4.5.4. Name and phone numbers of manufacturers or suppliers.
9.4.5.5. Names, addresses and telephone numbers of sources of spare parts.

9.4.6. Warranties and terms of warranty. This shall include one year overall warranty of construction. Items which have warranties longer than one year shall be indicated with separate warranty expiration dates.

9.4.6.1. Cross-reference to warranty certificates as applicable.
9.4.6.2. Starting point and duration of warranty period.
9.4.6.3. Summary of maintenance procedures required to continue the warranty in force.

9.4.6.4. Cross-reference to specific pertinent Operation and Maintenance manuals (if applicable).

9.4.7. The Contractor shall furnish a list of any special tools necessary for each piping system and appurtenances furnished for adjustment, operation, maintenance and disassembly of the system.

9.4.8. Supplier shall submit classroom and field instructions in the operation and maintenance of systems equipment where required by the technical provisions. These services shall be directed by the Supplier, using the manufacturer's factory-trained personnel or qualified representatives. Contracting Officer shall be given 7 days written notice of scheduled instructional services. Instructional materials belonging to the manufacturer or vendor, such as lists, static exhibits, and visual aids, shall be made available to the Contracting Officer.

-- END --

ATTACHMENT #1

WSI 25-SW-0003.B "Confined Space Entry Program"

White Sands Test Facility
Standard Instruction

WSI: 25-SW-0003.B
Issued: 3/8/02

Confined Space Entry Program

1. PURPOSE

The purpose of this WSI is to prepare for use and control access into areas designated as a confined space.

This WSI applies to all WSTF employees. It provides hazard awareness, safety requirements, and identifies the responsibility of the immediate supervisor, entry supervisor, entrants, attendants and contractors. This WSI describes the measures necessary to:

a. Prevent unauthorized entry into permit-required confined spaces

b. Identify and evaluate permit space hazards

c. Implement the means, procedures, and practices necessary for safe entry operations.

2. REFERENCES

a. Occupational Safety and Health Administration (OSHA) 29 CFR 1910.146, "Permit-Required Confined Spaces"

b. JPG 1700.1, Chapter 310, "Entering Confined Spaces"

3. ATTACHMENTS

a. WSTF Confined Spaces

b. Confined Space Identification Placard

c. WSTF Form 503 (Sample), “Confined Space Entry Permit” (located on S:\Forms\WSTF Forms)

d. Confined Space Decision Making Chart

4. DEFINITIONS

a. *Acceptable Entry Conditions* – The conditions that must exist in a permit space to allow entry and to ensure that employees involved with a permit-required confined space entry can safely enter into and work within the space.

b. *Attendant* – An individual stationed outside a confined space that is responsible for monitoring entrants and performing assigned confined space entry duties. This person also knows the location of the fire extinguishers and safety showers. Information, such as the building number, floor number, and department name, must be known prior to the admission of any person in the confined space. In the event the location is outside, the attendant needs to accurately identify the location to rescue and emergency personnel.

c. *Authorized Entrant* – An individual that is authorized, by virtue of training and demonstrated competency, to enter a specific confined space.

d. *Confined Space* – Any space not intended for continuous occupancy that has limited means of access and egress and that is large enough and so configured that an employee can bodily enter and perform assigned work. Confined spaces include, but are not limited to, storage tanks, process vessels, pits, silos, vats, degreasers, reaction vessels, boilers, ventilation and exhaust ducts, sewers, tunnels, underground utility vaults, and pipelines.

e. *Confined Space Pre-Entry Checklist and Permit* – WSTF Form 503, completed and signed by an authorized entrant, attendant and supervisor prior to entering a confined space, that verifies appropriate safety precautions have been completed.

f. *Emergency* – Any occurrence (including any failure of hazard control or monitoring equipment) or event internal or external to the permit space that could endanger entrants.

g. *Engulfment* – The surrounding and effective capture of a person by a liquid or finely divided (flowable) solid substance that can be aspirated to cause death by filling or plugging the respiratory system or that can exert enough force on the body to cause death by strangulation, constriction or crushing.

h. *Entry* – The action by which a person passes through an opening into a permit-required confined space. Entry includes ensuing work activities in that space and is considered to have occurred as soon as any part of the entrant's body breaks the plane of an opening into the space.

i. *Entry Permit* – WSTF Form 503 used with the work authorizing document

j. *Entry Supervisor* – An individual that is responsible for determining if acceptable entry conditions are present at a confined space where entry is planned, authorizing entry, overseeing entry operations, and terminating entry.

k. *Hazardous Atmosphere* – Atmosphere that may expose employees to risk of death, incapacitation, impairment of ability to perform self-rescues (that is, not able to exit the permitted space unaided), injury, or acute illness. The following criteria defines a hazardous atmosphere:

(1) O_2 < 19.5 percent

(2) O_2 > 23.5 percent

(3) Flammable > 10 percent lower flammability limit

(4) Any substance above its Permissible Exposure Limit or Threshold Limit Value which ever is lower. An atmosphere that contains a substance at a concentration exceeding a permissible exposure limit intended solely to prevent long-term adverse health effects is not considered to be a hazardous atmosphere on that basis alone. Therefore, if the atmosphere is above the PEL, then it would not automatically be classified as a "hazardous atmosphere."

(5) Any other atmospheric condition that is immediately dangerous to life or health (IDLH)

l. *Hot Work* – Any work involving fire producing operations as well as work that produces a source of ignition such as filing, abrasive blasting, riveting, welding, cutting, burning, space heating, and brazing.

m. *Non-permit Confined Space* – A confined space that does not contain or, with respect to atmospheric hazards, have the potential to contain any hazard capable of causing death or serious physical harm.

n. *Permit-required Confined Space* – A confined space that has one or more of the following characteristics:

(1) Contains or has the potential to contain a hazardous atmosphere

(2) Contains a material that has the potential for engulfing an entrant

(3) Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor that slopes downward and tapers to a smaller cross-section

(4) Contains any other recognized serious safety or health hazard

5. INSTRUCTIONS

a. Equipment. The following is a list of equipment that may be necessary for safe entry and exit of the confined space:

(1) Hard hats, safety shoes, safety glasses, and ear protection
(2) Ladder, respirator, lock, key, multiple-lock hasp, tags, lights, barriers, and fire extinguishers
(3) Portable radios
(4) Harness, lifelines, tripod and winch
(5) Atmospheric testing and monitoring equipment capable of testing for oxygen content, flammability or LEL, and various toxic substances. It is recommended that a MSA Passport be used for oxygen and lower flammability limit testing. Fuel and oxidizer interscans will be used if hypergolic propellants are expected to be present. If other contaminants are expected, consult with the industrial hygienist before selecting monitoring sensors or equipment.
(6) Ventilating equipment needed to obtain acceptable entry conditions
(7) Communication equipment necessary to maintain contact with the attendant

b. Safety

(1) Entry Supervisor/Team Leader Responsibility

Ensure department/team employees are aware of the location of confined spaces in their area for control purposes.

(2) Entry Supervisor Responsibilities

(a) Provide necessary confined space equipment

(b) Confirm all employees and contractors involved in confined space entry are properly trained and physically able to perform confined space entry

(c) Ensure that confined space entry procedures are followed

(d) Ensure that all special equipment is appropriate for the confined space

(e) Ensure that all personal protective equipment is appropriate for the confined space. Employees shall be trained and certified in their use.

(f) Authorize all confined space entries

(g) Ensure adequate atmospheric testing and monitoring is performed for the duration of confined space entry. Ensure the atmospheric testing and monitoring results are documented on the permit. This will be done at a minimum of once an hour for spaces that remain permit required spaces.

(h) Review hazards with attendants and entrants

(i) Ensure that communications are maintained (i.e. telephone, radios, etc.) with the attendant for entry into confined spaces.

(j) Revoke the permit whenever any tests performed during the confined space occupancy or condition change, which show deviation from acceptable conditions to a hazardous condition.

(3) Attendants/Entrants General Responsibilities

(a) Recognize the effects of exposure to hazards reasonably expected to be present

(b) Recognize early behavioral signs of intoxication caused by contaminants whose presence could be anticipated in the space

(c) Recognize possible regenerated hazards emitting from the work in progress

(d) Ensure that all special equipment is appropriate for the confined space

(e) Ensure adequate atmospheric testing and monitoring is performed prior to entry and for the duration of confined space entry. Document the atmospheric testing and monitoring results on the permit. This will be done at a minimum of once an hour for spaces that remain permit required spaces.

(f) Revoke the permit whenever any tests performed during the confined space occupancy or conditions change, which show deviation from acceptable conditions to a hazardous condition

(g) Recognize hazards external to the confined space (e.g., vehicles, painting, fires, spills, etc.) that may affect confined space

(h) Attendants and entrants shall maintain continuous communication at all times.

(i) The attendant will remain at post while entrants remain in confined spaces.

(j) Order entrants to immediately vacate the space if a hazard exists

(k) Prevent non-authorized entrants from entering confined spaces and advise the entrants of entry by non-authorized entrants

(l) The only time the attendant is permitted to leave the job site with workers inside the confined space is to report an emergency.

(m) At no time will the attendant enter the confined space.

(n) If a worker in the space becomes ill or injured, the attendant is to call for emergency assistance

c. Training

Confined Space training and qualification is provided by the Program Assurance Department (PAD) in accordance with WSP 18-0001, "Training." Confined space categories and personnel requiring training are

(1) Confined Space Entry SAF-06 - Required by all personnel that perform confined space entry functions. This includes entrants, attendants, supervisors, and rescue personnel.

(2) Confined Space Entry (Air Monitoring) SAF-07A - Supplemental training for individuals performing air sampling activities associated with confined space entry. This includes air monitors, rescue personnel, and attendants or supervisors that perform air monitoring functions.

(3) Confined Space Rescue ES-06 - Specialized training for Fire Department personnel performing rescue operations associated with confined space entry. This includes rescue personnel.

d. Types of Confined Spaces

There are two types of confined spaces at WSTF; non-permit and permit spaces. All spaces are considered to be permit-required confined spaces until the results of hazard assessment (Attachment C) and initial atmospheric sampling is completed. Use the Confined Space Decision Making Chart found in Attachment D to determine what type of confined space you are trying to enter. If the space is determined to be a non-permit confined space, annotate it on the WSTF Form 503 and cancel the permit.

(1) No confined space at WSTF will be entered prior to atmospheric sampling.

(2) Non-permit spaces are confined spaces where hazard assessment and atmospheric sampling confirms that there are no hazards or potential hazards capable of causing death or serious harm. WSTF Form 503 (Attachment C) will be completed prior to entering these spaces.

(3) Permit spaces meet the definition of permit required confined space. Permit spaces require completion of a WSTF Form 503 (Attachment C) prior to entry.

(4) All confined spaces at WSTF will be identified using the placard identified in Attachment B.

e. Planning the Entry

The first step towards conducting a safe confined-space entry is to plan the entry. This will allow for the identification of all hazards, and for the determination of all equipment necessary, to complete the project. The following steps must be accomplished:

(1) Identify the confined space. Identify the contents of the confined space. This refers to any chemicals or other materials and energy that are usually present in the confined space.

(2) The entry supervisor will determine the oxygen content and describe the testing procedures and equipment used. The entry supervisor or designated and trained person will conduct atmospheric testing.

(3) Mechanical or natural ventilation may be used to ventilate the confined space. If mechanical ventilation is to be used, the exhaust must be pointed away from personnel or ignition sources. Mechanical ventilators must be bonded (grounded) to the confined space.

(4) Isolation of the Confined Space must be assured. All mechanical, electrical, inert gas (GN2, helium, etc.) sources or heat-producing equipment will be evaluated for potential hazards and disconnected or locked and tagged out if not specifically required to facilitate entry activities. Isolation would also include any pumps that pull fluid from or pump fluid into the confined space.

(5) Purging/Cleaning of the confined space with inert gas is not recommended except where an air purge may create an explosive environment. If a flammable atmosphere is present that would constitute an explosive hazard if additional air/oxygen is added, then an inert gas purge is acceptable provided sufficient air exchanges are conducted to increase oxygen content to an acceptable level prior to entry.

(6) Warning signs or barriers must be used to prevent unauthorized entry and to protect workers from external hazards. If the confined space will be left open and unattended for any length of time, warning signs and barriers are required.

(7) Identify all personnel that will be required to prepare the confined space and complete the work inside the space.

(8) Identify the necessary equipment needed for a safe entry and exit of the space.

f. Pre-Entry Briefing

Once the entry has been planned, designated supervisors must brief all employees who will be involved in the entry. The following briefing will be completed prior to entry:

(1) Identify the confined space and the reason(s) for entry

(2) Identify the work team

(3) Inform entrants of all known or suspected hazards

(4) Identify isolation procedures

(5) Identify purging and/or ventilation procedures

(6) Identify all equipment needed

(7) Determine necessary personal protective equipment

(8) Brief on the communication procedures that will be followed during this task

(9) Protection from external hazards

(10) Pre-plan rescue procedures

(11) Tasks required to place the confined space back into service

g. Preparing the Confined Space For Entry

Once the entry has been planned and personnel have been trained, the next step is to prepare the confined space for entry. The following steps are to be followed when preparing the confined space for entry:

(1) If warning signs or barriers are to be used to prevent unauthorized entry or to protect entrants from external hazards, they shall be placed on or around the confined space as planned and discussed in training.

(2) Place all tools, safety equipment, monitoring equipment, etc., near the confined space.

(3) Isolate and use Lockout/Tagout on all mechanical hazards and electrical hazards or inert gas sources as planned and discussed in the pre-entry briefing.

(4) Purge/ventilate the confined space as planned and discussed in pre-entry briefing. A constant source of fresh air, introduced in such a manner as to ensure a complete air change (positioning of fresh air duct to ensure the entire space is ventilated), shall be provided (i.e., air blowers, fans, etc).

(5) The entry supervisor will test the atmosphere as discussed in training. If the oxygen content is between 19.5 percent and 23.5 percent, continue entry preparation. If oxygen content is less than 19.5 percent or greater than 23.5 percent, perform additional ventilation. Then, shut off ventilation equipment and re-test the oxygen content.

(6) The entry supervisor will test for flammable gas level as planned and discussed in training. If the meter reading is less than 10 percent of the lower explosive limit (LEL), continue entry preparations. If the meter reading is above 10 percent of the LEL, continue ventilation of the confined space and re-test after one hour.

(7) The entry supervisor will determine the toxicity of the atmosphere. If a toxic atmosphere is present, no person should be permitted to enter. The site Health, Safety and Environmental representatives should be called to assist in identifying proper precautions and the protective measures to be taken.

h. Utilizing Safety Equipment

After all existing hazards within the confined space are mitigated or reduced to acceptable limits, safety equipment is utilized to provide an additional level of protection. Where practical, all personnel entering a confined space should be equipped with a retrieval line secured at one end to the entrant by a full-body harness with its other end secured to a tripod lifting hoist. The following safety related actions must be accomplished prior to and during the entry:

(1) Every person entering a permit-required confined space must wear a harness.

(2) In every tank where entry is through a manhole, or the tank is deeper than a man's shoulders, a lifeline must be attached to the workers.

(3) When a ladder is required to enter a confined space, the ladder must be made secure and must not be removed while anyone is inside.

(4) All electrical equipment to be used inside the confined space must be intrinsically safe, properly grounded, and protected.

i. Records, Reports, and Forms

Forms:

(1) Confined Space Entry Permit (WSTF Form 503) must be submitted to the Safety Office upon completion of the confined space entry (for all spaces that remain permit-required spaces). It is the entry supervisor's responsibility to complete this form in its entirety. Confined Space permits are effective for 8 hours, or until any of the entrants, entry supervisor, or attendants, not listed on the original entry permit, are replaced.

(2) One copy will be posted at the main entrance or most commonly used access to the permit-required confined space.

(3) One copy will be retained for the Safety Department files.

6. RESCISSIONS

None.

Original signed by:

David T. Loyd
Chief, Quality Assurance, Reliability,
and Safety Office

Attachment A Issued: 3/8/02

Attachment A:
WSTF Confined Spaces

A list of WSTF areas/enclosures have been identified by QARSO/PAD for confined space entry controls. Other areas may require confined space entry controls, but have not been identified as confined spaces. DESIGNATION AS "PERMIT-REQUIRED CONFINED SPACE" OR "CONFINED SPACE" WILL BE DETERMINED BASED UPON THE RESULTS OF HAZARD ASSESSMENT AND AIR MONITORING.

1. All altitude system vacuum and steam ducting from the test stand to the steam source or the discharge end of the ejector
2. All storage tanks and pressure vessels meeting the definition of a confined space hazards
3. Hazardous drain line pits
4. Valve pits
5. Test Stands (altitude chambers) 302, 303, 401, 403, and 405 do not meet the definition of confined spaces. These chambers will be treated as hazardous atmosphere and require written procedures for the first entry of the day and after each exposure to a hazardous atmosphere. Approval by a safety professional must be obtained before the procedures are modified or used for entry.
6. Hypervelocity impact chambers (target and expansion chambers). Entries following multiple shots may use the same entry permit for logging the atmospheric testing results. A new permit is required for each day entry is made.
7. Flammability chambers in cells 101 and 108. The chamber in cell 101 has been monitored sufficiently to ensure that ventilation removes all possible hazardous atmospheres and requires only entry instructions (no permit). Entries following multiple tests may use the same entry permit for logging the atmospheric testing results. A new permit is required for each day entry is made.
8. Sewage system manholes
9. Oil separator pits
10. Areas 300 and 400 altitude system boilers (drums and combustion chambers)
11. Ceiling crawl spaces with GN2 piping present
12. Communication manholes
13. HVAC system confined spaces
14. Well Vaults

Attachment B Issued: 3/8/02

Attachment B:
Confined Space Identification Placard

Attachment C Issued: 3/8/02

Attachment C:
WSTF Form 503 (Sample) -Confined Space Entry Permit

CONFINED SPACE ENTRY PERMIT

Site Location and Description:	
Work Authorizing Document:	
Entry Supervisor:	
Date & Time Issued:	
Date & Time of Expiration:	

CONFINED SPACE CLASSIFICATION DETERMINATION

If all three (3) items below are marked yes, the space is considered to be a confined space

Any items marked yes in this column makes the space a permit-required confined space unless the hazard has been removed

Can be bodily entered?	☐ Yes	☐ No		Hazardous atmosphere?	☐ Yes	☐ No
Limited access?	☐ Yes	☐ No		Potential for engulfment?	☐ Yes	☐ No
Not designed for continuous human occupancy?	☐ Yes	☐ No		Internal configuration hazard?	☐ Yes	☐ No
				Other serious safety hazard?	☐ Yes	☐ No

TESTS PERFORMED FOR ATMOSPHERIC HAZARDS

RESULTS

Oxygen content > 19.5% and < 23.5% _____

Flammable gas/vapor levels 10%LEL _____

Toxic air contaminant levels _____

CLASSIFICATION Based on the results of atmospheric tests and the hazard analysis

☐ Permit-Required Space

☐ Non-Permitted Space

If the space is classified as a non-permit space, stop here and sign the bottom of the form.

For permit required space, complete the permit.

Authorized Entrants:	1)	**Time In:**	3)	**Time In:**
	2)	**Time In:**	4)	**Time In:**
Attendants:				
Entry Supervisor:				

Hazards of permit space to be entered:

☐ Limited Exits
☐ Lack of Natural Ventilation
☐ Oxygen Deficient Atmosphere
☐ Oxygen Rich Atmosphere
☐ Airborne Combustible Dust
☐ Toxic Gas, Vapor, or Mist
☐ Jobs that may provide a source of heat (i.e., welding, riveting, cutting, turning, and heating)
☐ Other _____

Attachment C Issued: 3/8/02

Source Isolation Requirements:

Requirements	Completed	DATE	TIME
Lockout/De-energize/Tag-out			
Line(s) Broken-Capped-Blanked			
Purge-Flush and Vent			
Ventilation			
Secure Area (Post and Flag)			

NOTE: Items that do not apply enter N/A in the blank.

Acceptable Entry Conditions: _____

Results of Monitoring:

RECORD CONTINUOUS MONITORING RESULTS AND TIME EVERY _____ HR/MIN

TEST(S) TO BE TAKEN	RESULTS						
	Next Reading Time:	Next Reading Time:	Next Reading Time:	Next Reading Time:	Next Reading Time:	Next Reading Time:	Next Reading Time:
% of Oxygen > 19.5% < 23.5%							
LEL under 10%							
Toxic Gases							

Signature of Tester: _____

EMERGENCY RESCUE PROCEDURES: DIAL EXTENSION 5911 IN CASE OF EMERGENCIES

☐ Notify Fire Department of planned confined space entry

Communication Processes:

☐ Visual ☐ Voice ☐ Radio ☐ Other _____

Equipment Required:

☐ Direct Reading Gas Monitor - Tested
☐ Lifelines
☐ Explosion Proof Lighting
☐ Respiratory Protection
☐ Special Tools
☐ Communication Equipment
☐ Full Body Harness
☐ Protective Clothing
☐ Hoisting Equipment
☐ Fire Extinguishers
☐ Ankle Harness

Other Information/Specific Requirements: _____

Work authorized by this permit and the information contained here-in has been reviewed. Written instructions and the safety procedures have been received and are understood. This permit is not valid unless all appropriate items are completed.

Permit and Checklist Prepared by: _____

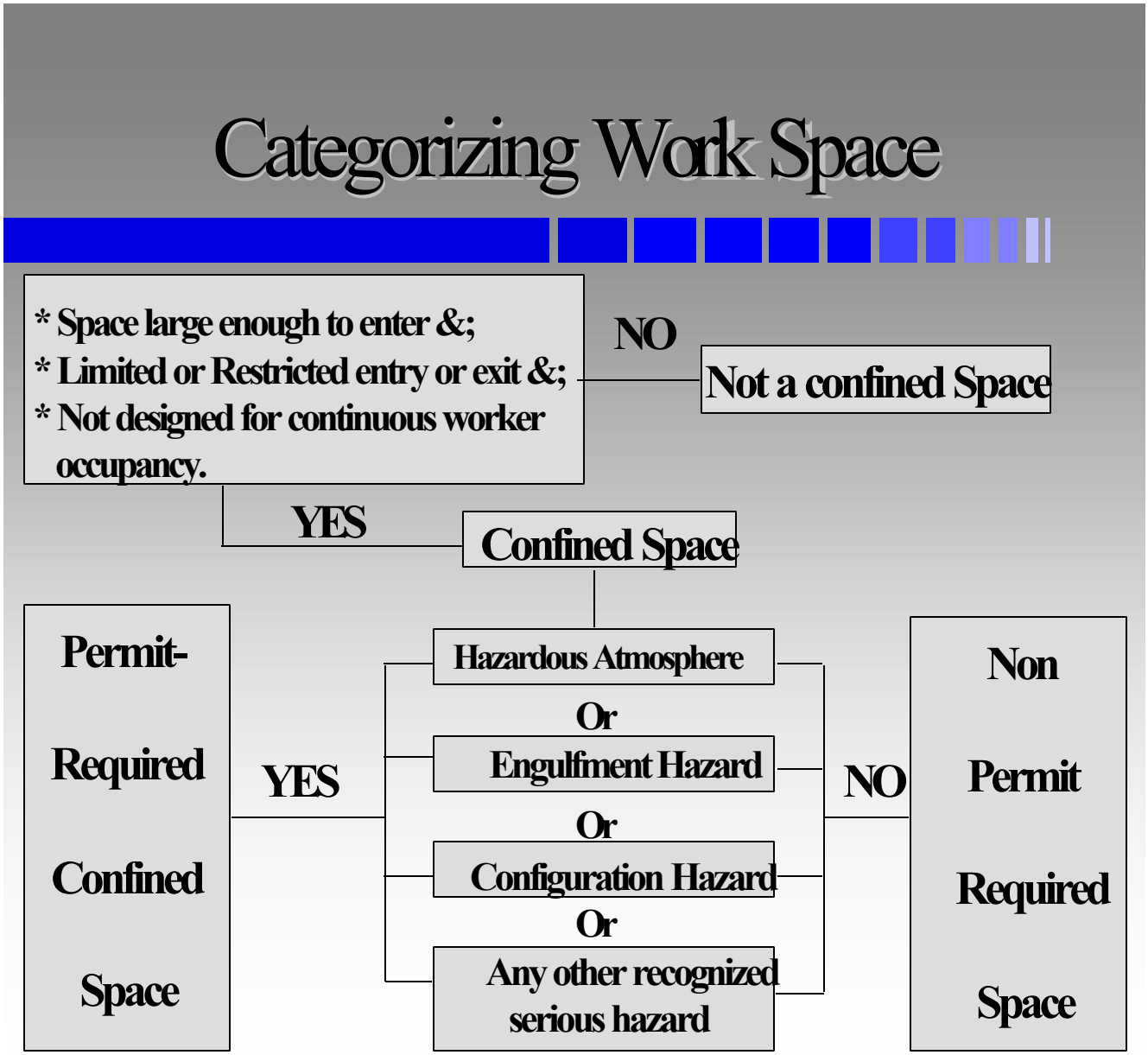
Approved by: (Entry Supervisor) _____

THIS PERMIT MUST BE KEPT POSTED AT THE JOB SITE AND KEPT ON FILE FOLLOWING JOB COMPLETION

WSTF Form 503 (2/02)

Attachment D Issued: 3/8/02

Attachment D:
Confined Space Decision Making Chart



ATTACHMENT #2

WSI 25-SW-0013.C

Hot Work Permit for Welding-Cutting Operations

White Sands Test Facility Standard Instruction

WSI: 25-SW-0013.C
Issued: 8/27/01

Hot Work Permit for Welding-Cutting Operations

1. PURPOSE

   The purpose of this WSI is to establish requirements for prevention of fires caused by welding, cutting, or open flame and spark producing operations performed outside the designed shop areas at WSTF.

2. REFERENCES

   a. 29 CFR 1910.252, Subpart Q, "Welding, Cutting, and Brazing"

   b. 29 CFR 1910.119, "Process Safety Management of Highly Hazardous Chemicals"

   c. NFPA 51B, "Standard for Fire Prevention in Use of Cutting and Welding Processes"

3. DEFINITION

   a. *Hot Work* – Work involving electric or gas welding, cutting, brazing, or similar flame or spark-producing operations.

   b. *Designated Shop Areas* – Areas on site that are set aside for the specific purpose of welding. These areas include building 113 weld shop and temporary locations on site that have been inspected for fire hazards and approved by the fire department as temporary weld shops.

4. INSTRUCTIONS

   a. A hot work permit will be completed before starting any open flame soldering, brazing, welding (gas or arc), or any other open flame or spark-producing operation (including grinding) performed outside the designed shop areas at WSTF.

   b. The individual responsible for hot work operations (test conductor, project engineer, etc.) will initiate the hot work permit (WSTF Form 418) and notify the Fire Department.

c. The job site will be physically inspected and the hot work permit signed (approved) by a WSTF Fire Department representative prior to beginning the operation.

d. The WSTF Fire Department will be notified at the beginning and at the completion of the hot work.

e. To prevent inadvertent fire alarm during hot work, the test conductor/project engineer will cover/deactivate detectors at the beginning of the workday and uncover/activate at the end of each workday. The test conductor/project engineer will notify the fire department, respective blockhouse monitor, and/or area HSE Facility Manager prior to installation and removal of covers.

f. A copy of the hot work permit will be posted at the job site, a copy retained by the fire department and a copy kept with the work authorizing document until the hot work is completed.

g. Off-site contractors working on site will comply with the requirements of this instruction.

h. Welding, cutting, or other hot work will not be performed on drums or vessels until the container has been cleaned so thoroughly as to make absolutely certain there are no flammable materials present.

i. Operations in areas complying with the process safety management of highly hazardous chemicals standard (Process Safety Management (PSM) of Highly Hazardous Chemicals) will require a hot work permit for hot work operations on or near a process covered by PSM to include spark-producing operations such as grinding and disc sanding.

j. Welders, cutters, and their supervisors will be trained in the safe operations of their equipment, to include fire prevention and protection requirements in 29 CFR 1910.252(a).

k. The hot work permit will contain the following information:

(1) Date authorized for hot work to be performed

(2) Description or identity of object on which hot work is to be performed

(3) Identification of openings, cracks, and holes through which sparks may drop or fly into combustible materials

(4) The type of fire extinguisher required to handle any emergency

(5) Assignment of fire watchers when welding is performed in locations where other than a minor fire might develop

(6) Precautions when welding on components (e.g., steel members, pipes, etc.) that could transmit heat by radiation or conduction to unobserved combustibles

(7) Special precautions to be observed when welding, cutting, or brazing around test articles, flight equipment, or critical support hardware

(8) Signature of employee responsible for cutting and welding operations or, the engineer in charge of the project

(9) Signature of a fire department representative

5. RESCISSIONS

This WSI replaces WSI 23-SW-0001.A, same title, which originally replaced WPD 23-03, Attachment 10, "Hazardous Operation Permit for Welding, Brazing, Soldering, or Open Flame Operations."

Original signed by:

David T. Loyd
Chief, Quality Assurance,
Reliability, and Safety Office

ATTACHMENT #3

Contract Drawing Package
(refer to Government supplied CD)

NASA – JOHNSON SPACE CENTER

WHITE SANDS TEST FACILITY

GROUND WATER TREATMENT SYSTEM FOR

PLUME-FRONT STABILIZATION

SUBGRADE PIPING SYSTEM
STATEMENT OF WORK
Revised SEPTEMBER 6, 2001

TABLE OF CONTENTS

I. Scope……..…….… 1

II. General…….……..…..… 3

III. Material – Piping System …….…… 4

IV. Material – Leak Detection and Electrical……..… 14

V. Schedule……..…….…….… 16

VI. Earthwork…….……..... 18

VII. Installation - Piping System ...…….. 23

VIII. Installation – Leak Detection and Electrical……. 27

IX. Testing – Piping System and Leak Detection...…… 28

X. Final Cleaning...…… 31

XI. Certification and Warranty...…… 32

XII. Submittals……. 32

LIST OF ATTACHMENTS

Attachment 1 Contract Drawings

Basic System (Drawing Number, Title)

652-C-01, Project Location
652-I-04, Index (Symbols and Abbreviations)
652-C-02, Well Locations and Piping Layout
652-C-03, Civil, Plan and Profile Piping Route (N-1)
652-C-04, Civil, Plan and Profile Piping Route (N-2)
652-C-05, Civil, Plan and Profile Piping Route (N-3)
652-C-06, Civil, Plan and Profile Piping Route (N-4)
652-C-07, Civil, Plan and Profile Piping Route (N-5)
652-C-08, Civil, Plan and Profile Piping Route (S-1)
652-C-09, Civil, Plan and Profile Piping Route (S-2)
652-C-10, Civil, Plan and Profile Piping Route (S-3)
652-C-11, Civil, Plan and Profile Piping Route (S-4)
652-C-12, Civil, Plan and Profile Piping Route (S-5)
652-C-13, Civil, Plan and Profile Piping Route (PFE-2)

652-C-15, Civil, Plan and Profile Piping Route (PFE-4B)
652-C-16, Civil, Plan and Profile Piping Route (PFE-5)
652-C-17, Civil, Plan and Profile Piping Route (PFI-1A)
652-C-18, Civil, Plan and Profile Piping Route (PFI-1B)
652-C-19, Civil, Plan and Profile Piping Route (PFI-4)

652-C-25, Civil, Sections
652-C-26, Civil, Sections
652-C-27, Civil, Sections
652-C-28, Civil, Junction Details
652-C-29, Civil, Junction Details
652-C-30, Civil, Junction Details
652-C-31, Civil, Sections and Details
652-C-32, Civil, Sections and Details
652-C-33, Civil, Sections and Details
652-C-34, Civil, Sections and Details
652-C-35, Civil, Sections and Details
652-C-36, Civil, Sections and Details
652-C-37, Civil, Sections and Details652-M-01, Mechanical, Flow Schematic, Extraction Wells
652-M-03, Mechanical, Flow Schematic, Injection Wells
652-M-04, Mechanical, Subgrade Pipe & Fitting Schedules
652-M-05, Mechanical, Subgrade Pipe & Fitting Schedules
Conduit, Electrical Conduit Layout Sketch
Control, Survey Control Sketch

Extraction Well PFE-1:
653-C-01, Civil, Site/Utilities Plan
653-M-01, Mechanical, Piping and Equipment Layout
Extraction Well PFE-2:
654-C-01, Civil, Site/Utilities Plan
654-M-01, Mechanical, Piping and Equipment Layout
Extraction Well PFE-3:
655-C-01, Civil, Site/Utilities Plan
655-M-01, Mechanical, Piping and Equipment Layout
Extraction Well PFE-5:
657-C-01, Civil, Site/Utilities Plan
657-M-01, Mechanical, Piping and Equipment Layout
Injection Well PFI-1:
660-M-01, Mechanical, Piping and Equipment Layout
Injection Well PFI-2:
661-M-01, Mechanical, Piping and Equipment Layout
Injection Well PFI-3:
662-M-01, Mechanical, Piping and Equipment Layout
Injection Well PFI-4:
663-M-01, Mechanical, Piping and Equipment Layout

Phase 1 (Drawing Number, Title)
Extraction Well PFE-4A:
652-C-14, Civil, Plan and Profile Piping Route (PFE-4A)
652-C-15, Civil, Plan and Profile Piping Route (PFE-4B)
656-C-01, Civil, Site/Utilities Plan
656-C-02, Civil, Details at Wellhead
656-M-01, Mechanical, Piping and Equipment Layout

Phase 2 (Drawing Number, Title)
Extraction Well PFE-7:
652-C-20, Civil, Plan and Profile Piping Route (PFE-7A)
652-C-21, Civil, Plan and Profile Piping Route (PFE-7B)
652-C-22, Civil, Plan and Profile Piping Route (PFE-7C)
652-C-23, Civil, Plan and Profile Piping Route (PFE-7D)
652-C-24, Civil, Plan and Profile Piping Route (PFE-7E)
658-C-01, Civil, Site/Utilities Plan
658-C-02, Civil, Details at Wellhead
658-M-01, Mechanical, Piping and Equipment Layout

Attachment 2 **References**

Attachment 3 **JSC Form 262**

I. Scope

This statement of work defines the requirements for materials, installation and testing of the NASA White Sands Test Facility's (WSTF) groundwater treatment facility subgrade piping system. Once the piping system is installed, groundwater containing parts-per-billion (ppb) concentrations of hazardous constituents will be pumped through dual-containment high density polyethylene (HDPE) piping from extraction wells to a treatment facility. After treatment, single-wall HDPE piping will be used to transfer the treated groundwater from the treatment facility to injection wells.

Maps of WSTF's location and the project location with respect to WSTF's developed areas are presented in Attachment 1. WSTF is located 18 miles northeast of Las Cruces, New Mexico (65 miles north of El Paso, Texas) with access provided through U. S. Highway 70. The project is located in an unimproved area of Sections 4 and 5 of T21S, R3E and Section 32 of T20S, R3E (see Attachment 1). Access to the general project vicinity is provided by a light duty gravel road (the WSTF Well Road).

A. The **Basic System** includes the materials, installation and testing of a subgrade HDPE piping system consisting of:

1. Approximately 10,250 feet of HDPE dual-containment pipe (pipe diameters ranging from 2-inch X 4-inch [nominal inner diameter X nominal outer diameter] to 10-inch X 16-inch) and approximately 7,600 feet of HDPE single-wall pipe (nominal pipe sizes ranging from 6- to 10-inch), installed in approximately 14,250 feet of excavated trench. Plan and profile drawings and piping system subgrade details are presented in Attachment 1.

2. Thirty-one (31) high-point vent, junction and leak detection access vaults and associated piping system components (flanges, valves, fittings, etc.). The locations of the access vaults, piping system civil sections and details including piping system components (flanges, valves, fittings, etc.) at each access vault location are presented in Attachment 1.

3. A leak detection system for 10,250 feet of dual-containment pipe as shown in Attachment 1. Leak detection access locations are presented in Attachment 1.

4. Approximately 18,000 feet of electrical conduit (conduit sizes ranging from 1-inch to 2-inch) and associated pull boxes.

B. **Phase 1** entails installation a wellhead vault and a piping system consisting of:

1. Approximately 1,550 feet of 5-inch X 8-inch sub-grade HDPE dual-containment pipe.

2. Three high-point vent, junction and leak detection access vaults and associated piping system components (flanges, fittings, etc.).

3. A leak detection system for approximately 1,550 feet of dual-containment pipe.

4. An electrical system consisting of approximately 1,550 feet of electrical conduit and pull boxes.

5. One pre-cast concrete vault at extraction well PFE-4A.

C. **Phase 2** entails installation a wellhead vault and a piping system consisting of:

1. Approximately 3,950 feet of sub-grade HDPE dual-containment pipe.

2. Ten high-point vent, junction and leak detection access vaults and associated piping system components (flanges, valves, fittings, etc.).

3. A leak detection system for approximately 3,950 feet of dual-containment pipe.

4. An electrical system consisting of approximately 3,950 feet of electrical conduit and pull boxes.

5. One pre-cast concrete vault at extraction well PFE-7.

Construction services to be provided for the basic system and the two options include:

1. Excavation;
2. Installation of pipe, vaults, leak detection system, electrical conduit, and associated components;
3. Leak testing of the pipe;
4. Backfilling and compaction; and
5. Providing as-built drawing changes.

II. General

A. Security Provisions

The Contractor is required to submit the names and citizenship for all personnel scheduled to be on site to the Contracting Officer prior to their arrival at WSTF. At least 30 days must be allowed to obtain clearance for crew members who are not United States Citizens. Temporary badges for the project will be issued at the WSTF main gate.

Contractor personnel will be restricted to the work area and will not be allowed to venture, unescorted, to other areas of the site. Contractor work hours at WSTF shall not exceed 60 hours per week for any Contractor personnel.

B. Health And Safety Provisions

At least one Class B/C CO_2 fire extinguisher is required within each vehicle at the work site during all operations at WSTF. Level D personal protective equipment will be worn by Contractor personnel:

1. Hard hats in accordance with ANSI Z89.1
2. Steel toed boots in accordance with ANSI Z41
3. Safety glasses in accordance with ANSI Z87.1
4. Work gloves while handling equipment
5. Hearing protection if noise levels exceed 80 dbA (when vocal communication between persons standing three feet apart requires shouting).

The Government reserves the option to visually inspect equipment prior to the commencement of work. Any significant health or safety concerns will be identified and the Contractor will be allowed to address the concerns. If significant concerns cannot be rectified, this may be cause for termination of the contract.

Contractor shall comply with all applicable WSTF safety regulations. All Contractor personnel shall receive two safety briefings immediately following their arrival at WSTF. A site safety briefing will be given at the WSTF Safety Office prior to access to the work area. A second safety briefing will be given at the WSTF Environmental Department that addresses any specific concerns relative to the project area.

Contractor shall comply with all procedures prescribed for the control of persons visiting the project site. The Contractor shall advise the Contracting Officer or designee of any special safety restrictions established so that on-site personnel can be notified.

Contractor employees must utilize the WSTF dispensary facilities located in Building 104 for injury and emergency medical treatment. The dispensary number is 524-5212 and the on site emergency numbers are 5911 or 5111.

Contractor shall comply with OSHA Regulation 29 CFR 1926.51 regarding all sanitation facilities. Contractor shall be responsible for the cleaning/servicing and waste disposal for portable chemical toilet(s).

C. Environmental Concerns

1. Discharge of water used for flushing or pressure testing must be coordinated in advance with the Contracting Officer.
2. Any ground disturbing activities performed at WSTF, including trenching, grading, and excavation, must be coordinated in advance with the Contracting Officer. Dig permits will be issued by the Government prior to commencement of excavation.
3. Contractor shall be responsible for supplying fuel and fuel transfer/transport equipment used during completion of the project. The Contractor may locate a portable or truck mounted fuel tank at or near the work site, so long as Government-approved spill containment measures are taken (a spill containment volume of no less than 110% of the tank volume is required). Alternatively, a fuel storage tank may be located in a secure compound at the WSTF 100 Area warehouse, again with approved spill containment. Contractor is responsible for clean-up and disposal, in accordance with applicable regulations, of overfillings or spills related to temporary fueling equipment.
4. Oil changing of vehicles will not be allowed at the work site, but may only be performed in approved areas at WSTF. The Government can supply empty storage drums for used oil and can also handle oil disposal, if needed.

D. Cultural Resources

1. At any time during construction that archeological, rare, historical, or paleontological discoveries are made, the Contractor will immediately cease operations and notify the Contracting Officer. Construction will not be resumed until authorized by the Contracting Officer.

III. Material – Piping System

A. Pipe Manufacturer Qualifications

The manufacturer shall have a minimum of eight (8) years of continuous corporate experience in the manufacture and supply of large-scale single-and dual-containment HDPE piping systems.

B. General Requirements

1. All piping materials and appurtenances shall be as specified, or equivalent, and as shown on the contract drawings, or equivalent, and shall be suitable

for the service intended. The contract drawings are presented in Attachment 1.

2. Applicable standards of the American National Standards Institute (ANSI), American Water Works Association (AWWA), National Association of Corrosion Engineers (NACE), American Society for Testing and Materials (ASTM), Illuminating Engineering Society (IES), National Electrical Manufacturers Association (NEMA), National Fire Protection Association (NFPA), National Electrical Code (NEC), National Electrical Safety Code (NESC) and the Underwriters' Laboratories (UL) reflect current industry standard practice and must be used for establishing the quality of materials and equipment.

3. Piping materials, appurtenances and equipment supplied as part of this contract shall be new and unused except for testing equipment. Components that serve the same function and are the same size shall be identical products of the same manufacturer. The general materials to be used for the piping systems are indicated by service in the Pipe Schedule in the contract drawings.

4. The absence of pipe supports and details on the contract drawings does not relieve the Contractor of responsibility for sizing and providing pipe supports where appropriate.

5. The Contractor shall provide all structural work and equipment required to control expansion and contraction of piping. The Contractor shall verify that the anchors, guides, and expansion joints provided, adequately protect the piping systems.

6. The pressure ratings and materials specified represent minimum acceptable standards for piping systems. The piping systems shall be suitable for the services specified and intended. Each piping system shall be coordinated to function as a unit. Flanges, valves, fittings and appurtenances shall have a pressure rating no less than that required for the system in which they are installed.

7. Piping equipment and appurtenances shall be new products of equal material and ratings as the connecting pipe.

8. Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacturing of the products and shall essentially duplicate items that have been in satisfactory use for at least 2 years prior to bid opening. Nominal sizes for standardized products shall be used. Pipe, valves, fittings and appurtenances shall be supportable by a service organization that is, in the opinion of the Contracting Officer, reasonably convenient to the site.

9. Each piece of pipe shall bear the ASTM designation and all other markings required for that designation. Valves shall bear a securely attached tag with the manufacturer's name, valve model number, and WSTF component identification number permanently engraved on the tag.

C. HDPE Pipe

1. The pipe shall be extruded from polyethylene (PE) per ASTM D 3350.

2. The HDPE pipe shall be manufactured to an SDR rating in accordance with ASTM D 3035 for piping systems less than 4 inches in diameter, or in accordance with ASTM F 714 for piping systems with a diameter equal to or greater than 4 inches.

3. The primary, or carrier pipe, of the double containment piping system shall be either SDR 9 or SDR 11 HDPE, as shown on the contract drawings. The piping shall be free of flanges and other joints that are not compatible with the secondary piping installation. The piping shall be equipped with expansion loops, offsets, or direction changes as necessary to counter thermal expansion and contraction, which shall be coordinated with the secondary piping.

4. The secondary, or containment, pipe of the double containment piping system shall be SDR 21 HDPE. The secondary piping shall be resistant to weathering, impacts, and ambient temperature variations.

5. The single wall pipe, of the injection piping system, shall be SDR 17 HDPE, as shown on the contract drawings.

6. The piping shall be equipped with expansion joints, expansion loops, offsets, or direction changes as necessary to counter thermal expansion and contraction. Equipment for addressing thermal movement shall be coordinated with the primary piping.

7. The secondary piping shall be drainable and dryable. Piping shall be equipped with vents at all high points as shown on the contract drawings.

8. The piping shall be designed to allow pulling of the leak detection cable into the containment pipe both during and after piping installation. Minimum annular clearance shall be 0.75 inches. A 0.25-inch, hollow-braid, polypropylene rope shall be installed between the carrier pipe and containment pipe. Each pull rope shall be continuous, free of tangles and knots, and loose in the pipe (not pinched, glued, or melted in place). Containment pull ports shall be located as shown on the contract drawings (a maximum of 400 feet apart for straight runs and at all 90 degree direction changes).

9. HDPE pipe shall be joined by thermal butt-fusion, socket heat fusion, or socket electrofusion, except where connecting to valves and equipment that may require future disassembly, then joints shall be threaded fittings or flanged.

D. HDPE Fittings

1. HDPE fittings shall be molded. HDPE fittings shall have the same or higher pressure rating as the pipe when installed in accordance with the latest technical specifications.

2. Butt-fusion fittings shall conform to ASTM D 3261.

3. Socket-fusion fittings shall conform to ASTM D 2683 with tools meeting the requirements of ASTM F 1056.

4. Insert fittings shall conform to ASTM D 2609.

5. Couplings and saddle joints shall be joined by electrofusion in accordance with ASTM F 1055.

6. HDPE Flanged Fittings.

   a. Flanges and flanged fittings shall be ASME B16.5 Class 150.

   b. Flanges shall be complete with one-piece, molded PE stub ends.

   c. Flanged connections shall have the same pressure rating as the pipe or greater. Bolting shall be stainless steel Grade B8 hex head bolts and Grade 8 hex head nuts. Bolts shall be provided with washers of the same material as the bolts.

   d. The Contractor shall field check flanges for non-standard bolt hole configurations and shall design as required to assure all flanges mate properly.

   e. Gaskets shall be full-faced, maximum 1/8 inch thick, fabricated from ethylene propylene rubber (EPR) in accordance with ASME B16.21 or as required by the liquid application.

   f. Backing flanges for plastic piping systems may be stainless steel, ductile iron, steel (galvanized or plain), or aluminum, depending on the application.

7. HDPE end seals and other subassemblies shall be designed and factory prefabricated to prevent the ingress of moisture into the system. Subassemblies shall be designed to allow for complete draining of the secondary containment.

E. Metallic Fittings

1. Steel Flanged Fittings

a. The internal diameter bores of flanges and flanged fittings shall be the same as that of the associated pipe.

b. The flanges shall be welding neck slip-on socket welding or lapped type.

c. Flanged fittings shall be forged steel, faced and drilled to ASME B16.5 Class 150 with a 0.0625 inch raised face. Cast steel backing flanges shall be drilled in conformance with ASME B16.5 Class 150.

d. For tie-in to existing flanges, if any, the Contractor shall field check existing flanges for non-standard bolt hole configurations and shall design as required to assure new pipe and flange mate properly.

e. Where mating flange on valves or equipment is cast iron, if any, Grade B8 Class 1 bolts and heavy hex head nuts shall be used. Bolts shall be provided with washers of the same material as the bolts.

f. Gaskets shall meet the requirements of ASME B16.5.

g. All carbon steel piping components shall be coated with corrosion resistant materials.

2. Flanged Coupling Adapters

a. Flanged coupling adapters shall be fully assembled units manufactured to meet ASTM A 126.

b. The flanges shall mate with ASME B16.5 Class 150 flanges of the same nominal size.

c. The coupling shall use compatible gaskets.

d. Where pipe movement out of the adapter may occur, proper anchorage of the pipe shall be provided. The coupling shall be sized to match the associated piping.

F. Valves

1. General Requirements

a. Manual valves shall include operator, actuator, handwheel, extension stem, worm and gear operator, operating nut, wrench, and all other accessories required for a complete operation.

b. The valves shall be suitable for the intended service. Renewable parts are not to be of a lower quality than those specified.

c. Valve ends shall be compatible with adjacent piping system. An operator shall be sized to operate the associated valve for the full range of pressures and velocities.

d. Valves shall open by turning counterclockwise. Operators, actuators, and accessories shall be factory mounted.

e. The sub-grade piping Valve Schedule shall be as indicated in the contract drawings.

2. General Purpose Metallic Ball Valves

a. Ball valves, 2 inches and smaller, shall be end entry type with bronze or brass bodies and threaded, in accordance with ASME B1.20.1, full bore ports. A union shall be installed adjacent to the valves to provide access to the seat.

b. Ball valves, 2.5 inches and larger, shall be end entry type with bronze or cast iron bodies and ASME B16.5 Class 150 flanged ends.

c. Valves shall have polytetrafluoroethylene (PTFE) seats and packing, and a chrome plated or stainless steel ball.

d. The operator shall be a hand lever or square nut, per the contract drawings.

3. Thermoplastic Ball Valves

a. Thermoplastic ball valves shall not exceed 6 inches in size. Thermoplastic ball valves, 6 inches and smaller, shall be rated for 225 psig service at 120 degrees F, and have polyvinyl chloride (PVC) or chlorinated polyvinyl chloride (CPVC) bodies, balls, and stems.

b. Valves shall be end entry, double union design, with threaded or flanged end connections (per the contract drawings), an ethylene propylene diene

monomer (EPDM) seat, and fluoro-elastomer or polytetrafluoroethylene (PTFE) O-ring stem seals.

c. The operator shall be a hand lever or square nut, per the contract drawings.

4. General Service Gate Valves

a. Gate valves, 2 inches and smaller, shall have bronze bodies and stems, screwed or union bronze bonnets, and single solid wedge bronze discs. The stems may be rising or non-rising. Valves shall be rated for 175 psig service. End connections shall be ASME B16.11 threaded. Valves shall be equipped with handwheel operators.

b. Gate valves, 2.5 inches and larger, shall have cast-iron bodies with iron, bronze, or stainless steel trim. Valves have Class 250 flanged end connections. Discs shall be wedge type of iron or bronze construction, and have either rising or non-rising stems. Valves shall be equipped with hand lever or square nut operators, per the contract drawings.

5. Standard Service Butterfly Valves

a. Butterfly valves shall have ASTM A 126 cast iron bodies and ASME B16.6 Class 150 flanged end connections.

b. Discs shall be ductile iron, stainless steel, or polyvinylidene fluoride (PVDF) coated ductile iron.

c. The valve shafts shall be carbon steel or stainless steel with self-lubricating, corrosion-resistant sleeve type bearings.

d. Valve seats for 24 inch and smaller valves shall be attached to either the valve body or the disc.

e. The operator shall be a hand lever or square nut, per the contract drawings.

6. Swing Check Valves

a. Swing check valves, 2 inches and smaller, shall have a cast iron, carbon steel, or stainless steel body, with ASME B16.11 threaded ends. Valves shall be rated for 200 psig service.

b. Swing check valves, 2.5 inches through 12 inches, shall have a cast iron, carbon steel, or stainless steel body, with ASME B16.5 flanged ends. Valves shall be rated for 200 psig service.

7. Ball Check Valves

a. Ball check valves shall be rated for 200 psig service and shall be suitable for vertical or horizontal flow.

b. Ball check valves, 1 inch and larger, shall be as shown on the contract drawings and ASME B16.11 threaded or ASME B16.5 flanged ends and cast iron, carbon steel, or stainless steel bodies with a cleanout and hollow steel ball.

c. Valves shall be rated for 200 psig service and shall be suitable for vertical or horizontal flow.

G. Miscellaneous Piping Components

1. Air Release and Vacuum Breakers

a. Air release and vacuum breakers shall be located as indicated on the contract drawings.

b. The air and vacuum valve shall automatically exhaust air during the filling of a system while allowing air to re-enter during draining or when vacuum occurs.

c. The valve shall have a cast iron body and cover, with stainless steel float and trim.

d. End connections shall be one inch; bushings and adapters shall be utilized as required to thread the air release/vacuum breakers into adjacent piping. All air release and vacuum breakers shall be plumbed to an equal size ball valve (allowing isolation of the air release/vacuum breaker from the piping system).

2. Expansion Joints

The Contractor shall provide all structural work and equipment required to control expansion and contraction of piping. The Contractor shall verify that the anchors, guides, and expansion joints provided, are compatible with and adequately protect the piping system.

3. Above Grade Wall Penetrations

a. Piping which passes through fire-rated or smoke-rated walls, floors, or ceilings shall be provided with insulated and encased pipe sleeves.

b. Penetrations through an existing fire or fire barrier wall shall be sealed with a fire stop system that has an "F" rating not less than the required fire

resistance rating of the penetrated wall. The fire stopping sealant for plastic and insulated piping systems shall be a silicone based, nonslumping, premixed sealant, that is vibration and moisture resistant.

c. Vented plastic pipe penetrations shall be fitted with galvanized steel collars.

4. Automatic Flow Control Valves and Flowmeters

This contract does not include materials and installation of automatic flow control valves and flowmeters.

H. HDPE Access Vaults

1. High-point vent, junction, and leak detection HDPE access vaults with single wall and/or dual-containment stubouts shall be as specified in the contract drawings (Attachment 1) and per ASTM F1759-97. The Contractor shall adjust vault dimensions and clearances as required to accommodate valving, flanges, and other piping features.

2. The access vaults shall be manufactured from polyethylene (PE) material that conforms to ASTM D 3350.

3. The vault shall be fabricated from HDPE solid wall pipe extruded to ASTM F 714. Rotational molded sections or wall thickness less than 1 ¼" are not acceptable.

4. The bottom of the vault shall be 1½" thick HDPE and extrusion welded to the manhole cylinder using proper extrusion welding practices.

5. The vaults shall be designed and fabricated to prevent the ingress of moisture. All vaults shall have a lockable, weathertight top. The Contractor shall submit shop drawings showing the vaults proposed to be installed, including the weathertight and locking lid detail(s).

6. The access vaults shall be tested and certified to be leak-free. Data shall be submitted for review and approval by the Contracting Officer.

7. The position and pipe sizes of the dual-containment stubouts for the access vaults are presented in the contract drawings (Attachment 1). The stubouts shall be as follows:

a. The HDPE pipe used to fabricate the stubouts shall be as specified by paragraph C, Section II.

b. The absence of pipe supports, gussets and other details on the contract drawings does not relieve the Contractor of responsibility for sizing and providing pipe supports where appropriate.

c. The stubouts shall be extrusion welded on the inside and outside of the vault structure.

I. Concrete Access Vaults

1. The locations of concrete access vaults, as shown in Attachment 1, are STA 0+00 and STA (N)2+72.

2. The vaults and all materials and appurtenances shall be as specified and as shown on the contract drawings, and shall be suitable for the service intended.

3. All materials and appurtenances supplied as part of this contract shall be new and unused except for testing equipment. Components that serve the same function and are the same size shall be identical products of the same manufacturer.

4. The concrete access vaults shall meet all OSHA safety requirements and industry standards. The absence of ladders and other details on the contract drawings does not relieve the Contractor of responsibility for ensuring safe personnel access to the vault.

5. The vaults shall be precast concrete fabricated per ASTM C-857 specifications.

6. The concrete shall have a 28 day compressive strength of 4,500 psi with ASTM A-615 Grade 60 rebar and ASTM A-185 Grade 65 mesh.

7. The vaults and covers shall be designed and fabricated to prevent the ingress of moisture.

J. Material Delivery, Storage, and Handling

1. Proper protection and care of material before, during and after installation is the Contractor's responsibility. Any material found to be damaged shall be replaced at the Contractor's expense.

2. Pipe and fittings shall be handled and stored in accordance with the manufacturer's recommendation. Plastic pipe shall be packed, packaged and marked in accordance with ASTM D 3892.

3. Materials delivered and placed in storage shall be stored with protection from the weather, excessive humidity variation, excessive temperature variation,

dirt, dust and other contaminants. During installation, piping shall be capped to keep out dirt and other foreign matter.

4. Unfenced storage areas in the general job vicinity are available. Material and equipment security are the responsibility of the Contractor. Installation and removal of temporary security fencing is the Contractor's responsibility.

5. A material safety data sheet in conformance with 29 CFR 1910 Section 1200(g) shall accompany each chemical delivered for use in pipe installation. At a minimum, this includes all solvents, solvent cements, glues and other materials that may contain hazardous compounds. Handling of such chemicals shall be in accordance with ASTM F 402. Materials shall be stored with protection from puncture, dirt, grease, moisture, mechanical abrasions, excessive heat, ultraviolet (UV) radiation damage, or other damage.

IV. Material – Leak Detection and Electrical

A. General Requirements

1. The leak detection system shall monitor the interstitial space of double contained piping, all vaults and pull stations located at junctions of dual-wall piping, and all extraction well vaults, as shown in the plan and profile drawings (Attachment 1).

2. The leak detection system shall be a cable detection system and shall be equipped with an electronic monitoring and control unit. The system shall be capable of detecting groundwater containing 800 to 4000 parts per million TDS and having a conductivity of approximately 1000 µmho/cm.

3. The system shall be capable of identifying the location of breaks and shorts on the cable. When either of these faults occur, an alarm shall sound and a display visible on the front of the monitoring unit shall clearly indicate the type of fault and display the location of the fault.

4. Applicable standards of the American National Standards Institute (ANSI), American Water Works Association (AWWA), National Association of Corrosion Engineers (NACE), American Society for Testing and Materials (ASTM), Illuminating Engineering Society (IES), National Electrical Manufacturers Association (NEMA), National Fire Protection Association (NFPA), National Electrical Code (NEC), National Electrical Safety Code (NESC) and the Underwriters' Laboratories (UL) reflect current industry standard practice and must be used for establishing the quality of materials and equipment.

B. Leak Detection System

1. Leak detection system shall be a complete cable-type leak detection and location system consisting of a microprocessor based monitoring unit, sensor cable, probes, system layout map and auxiliary equipment. The leak detection system shall provide continuous monitoring of the sensing strings for leaks, shorts, breaks and probe activation shall be furnished. If any of these conditions should occur at any point along the cable, an alarm shall sound, type of condition shall be clearly identified and the location clearly displayed.

2. The monitoring unit shall be microprocessor based and shall indicate when any liquid leaks into the secondary containment piping by sounding an alarm, actuating output relays, displaying a message that a leak has been detected, and displaying the location of that leak.

3. The monitoring unit power requirements shall be 120 VAC, 60 Hz, single phase.

4. Ability to locate a leak shall not depend on battery backed up functions. In the event of power failure, system conditions and parameters shall be stored in nonvolatile memory allowing the monitoring unit to automatically resume monitoring, without resetting, upon restoration of power. An on-off switch shall be provided in the panel for servicing.

5. The system shall provide relays for remote indication of an alarm condition. The relays shall provide indication that no alarm conditions exist, an alarm condition exists but has not yet been acknowledged, and an alarm condition exists and has been acknowledged. Communications shall be available via RS-232 and ASCII communication protocols to allow central point monitoring and control via a remote computer.

6. The system shall record significant events in permanent memory. When the memory becomes full, the recorded events shall be deleted from memory in sequential order beginning with the oldest event. Each recorded event shall include the time and date that the event occurred.

7. The system shall continuously provide positive indication that it is monitoring the sensing string and the status of the sensing string.

8. The leak detection system shall have assignable password security.

9. The leak detection system shall locate the point of origin of the first liquid leak within 0.1 % of the sensor string length.

10. The leak detection system shall be capable of monitoring all dual-wall HDPE extraction piping from a single monitoring unit.

C. Leak Detection Cable

1. The leak detection cable shall be conductance type. The cable sensing principle shall provide for continuous monitoring while short lengths of the cable are in contact with liquids, without altering the system's sensitivity or accuracy.

2. The leak detection cable, connectors, and jumpers shall be supplied by the manufacturer of the monitoring unit and be suitable for use. The sensor cables shall be of coaxial construction consisting of an insulated copper center conductor, a suitable spacer material, and an outer braid.

3. Center conductors shall be not less than twenty AWG for mechanical strength. Cables shall be capable of field installation of connectors by trained technicians. The cable shall be available in bulk spools. All cables shall be field repairable by trained technicians

D. Electrical

1. The electrical system shall be as specified in the contract drawings (Attachment 1).

2. Rigid nonmetallic conduit shall be in accordance with NEMA TC 13 and UL 651, and shall be PVC with wall thickness not less than Schedule 40. Diameter and location shall be per the contract drawings (Attachment 1).

3. All electrical penetrations into high-point vent, leak detection and junction access vaults shall be designed and installed to prevent the ingress of moisture.

4. Electrical pull boxes shall be as specified in Attachment 1 and designed and installed to prevent the ingress of moisture.

V. Schedule

A. General Requirements

1. A Project Schedule as described below shall be prepared. The scheduling of construction shall be the responsibility of the Contractor. Contractor management personnel shall actively participate in the Project Schedule development. Subcontractors and suppliers working on the project shall also contribute in developing and maintaining an accurate Project Schedule.

2. The NASA approved Project Schedule shall be used to measure the progress of the work and to aid in evaluating time extensions. Failure to adhere to the NASA-approved Project Schedule may result in contract termination. The following components shall be considered a minimum appropriate level of detail to be used in the Project Schedule:

B. Project Schedule Format

The project schedule shall be prepared in MS Project and submitted in two media formats: as an *.mpp file, and as a paper copy.

C. Activity Durations

Contractor schedule submissions shall utilize reasonable activity durations. Reasonable durations are those that allow the progress of activities to proceed, without excessive float or unreasonably short durations.

C. Procurement Activities

Tasks related to the procurement of long lead materials or equipment shall be included as separate activities in the project schedule. Long lead materials and equipment are those materials that have a procurement cycle of over 45 days. Examples of procurement process activities include, but are not limited to: submittals, approvals, procurement, fabrication, and delivery.

D. Government Activities

Anticipated government and other agency activities that could impact progress shall be shown. These activities may include, but are not limited to: approvals, inspections, utility tie-in, installation of Government Furnished Equipment (GFE), and Notice to Proceed for phasing requirements.

E. Responsibility

All activities shall be identified in the project schedule by the party responsible for performance of the work. Responsibility includes, but is not limited to, the subcontracting firm, contractor work force, or government agency performing a given task. Activities shall not belong to more than one responsible party.

VI. Earthwork

A. Clearing and Grubbing

Portions of the proposed pipeline routes have been cleared and grubbed. Where clearing and grubbing is required, the following shall apply:

1. Clearing shall consist of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including down timber, snags, brush, and rubbish occurring in the areas to be cleared. Trees, roots, brush, and other vegetation in areas to be cleared shall be cut off flush with or below the original ground surface, except such trees and vegetation as may be indicated or directed to be left standing. Trees and vegetation to be left standing shall be protected from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require.

2. Grubbing shall consist of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Material to be grubbed, together with roots and other organic material not suitable for construction purposes, shall be removed to a depth of not less than 12 inches below the original surface level of the ground. Depressions made by grubbing shall be filled with suitable material and compacted to make the surface conform with the original adjacent surface of the ground.

3. Cleared and grubbed materials shall be stockpiled adjacent to the piping route.

B. Erosion Control

The Contractor shall be responsible for erosion control for the duration of the project. Additional work or damage to materials due to the Contractor's fault or neglect shall be repaired or replaced by the Contractor without additional cost to the Government.

C. Trenching

1. General Requirements

a. The trench shall be excavated as recommended by the manufacturer of the pipe to be installed and in accordance with OSHA Regulation 29 CFR Part 1926, Subpart P. In case of no manufacturer recommendations or contradiction between pipe manufacturer recommendations and 29 CFR Part 1926, Subpart P, OSHA regulations shall prevail.

b. The trench width below the top of pipe shall not exceed 28 inches plus total pipe outside diameter (O.D.). Where recommended trench widths are exceeded, redesign, stronger pipe, or special installation procedures shall be utilized by the Contractor. The cost of redesign, stronger pipe, or special installation procedures shall be borne by the Contractor without any additional cost to the Government.

c. Contractor shall field-locate all Underground Utilities, in coordination with the Contracting Officer or their designee. The location of Underground Utilities shall be verified as follows: Contractor shall excavate using mechanized equipment up to a reasonably close distance from the marked utility location, then use hand tools to carefully finish location of the utility. Utilities to be left in place shall be protected from damage. If any utility previously identified by the Government is damaged by the Contractor, that damage shall be repaired by the Contractor, without any additional cost to the Government. If any non-locatable utility is damaged by the Contractor, the Government will assume responsibility for that damage.

d. Excavations shall be done in ways that will prevent surface water and subsurface water from flowing into excavations and will also prevent flooding of the site and surrounding area.

e. Contractor shall place barricades around the trench where no work is being performed.

2. Bottom Preparation

a. The bottoms of trenches shall be accurately graded to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Stones of 3 (three) inches or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, shall be removed to avoid point bearing.

b. All trench sections between vaults, pull stations, manways, and high-point vents shall be linear, straight sections, with a slope of no less than 0.5% (or as indicated on contract drawings).

3. Removal of Unyielding Materia1

Where unyielding material is encountered in the bottom of the trench, such material shall be removed four (4) inches below the required grade and replaced with suitable materials as provided in paragraph D of this section.

Explosives shall not be used or brought to the project site without prior written approval from the Contracting Officer. Such approval shall not relieve

the Contractor of responsibility for injury to persons or for damage to property due to blasting operations.

Storage of explosives, when permitted on Government property, shall be only where directed and in approved storage facilities. These facilities shall be kept locked at all times except for inspection, delivery, and withdrawal of explosives.

Explosive work shall be performed in accordance with NTS 1740.12. This document is available at:

http://www.hq.nasa.gov/office/codeq/doctree/1740_12.pdf

4. Removal of Unstable Material

   a. Where unstable material is encountered in the bottom of the trench, such material shall be removed to the depth directed and replaced to the proper grade with clean washed sand or screened native soil as provided in paragraph D of this section.

   b. When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the resulting material shall be excavated and replaced by the Contractor without additional cost to the Government.

5. Excavation for Appurtenances

   a. Excavation for manholes, vaults, pull boxes, or similar structures shall be sufficient to leave at least 12 inches clearance between the outer structure surfaces and the face of the excavation or support members.

   b. Bottom of the excavation shall be prepared as specified by paragraph 2., Section VI.

   c. Loose disintegrated rock and thin strata shall be removed. Removal of unstable material shall be as specified above.

   d. When concrete or masonry is to be placed in an excavated area, special care shall be taken not to disturb the bottom of the excavation. Excavation to the final grade level shall not be made until just before the concrete or masonry is to be placed.

D. Backfill and Compaction

1. General Requirements

a. Backfilling shall be accomplished after inspection by the Contracting Officer or his designee. The Contractor shall exercise care when lowering pipe into the trench to prevent damage or twisting of the pipe.

b. Backfill material shall consist of clean washed sand and native soil as required. Native soil screened to minus 1-inch may be used in lieu of clean washed sand. A sieve analysis and sample of the clean washed sand shall be submitted to the Government for approval prior to trench excavation.

c. Backfill shall be placed in layers not exceeding 12 inches loose thickness for compaction by hand operated machine compactors, and 20 inches loose thickness for other than hand operated machines, unless otherwise specified.

d. Each layer of native soil backfill shall be compacted to at least 90 % maximum density, unless otherwise specified.

e. Unyielding material removed from the bottom of the trench shall be replaced with clean washed sand or screened native soil.

f. Unstable material removed from the bottom of the trench or excavation shall be replaced with clean washed sand or screened native soil placed in layers not exceeding 12 inches loose thickness.

g. Bedding and Initial Backfill - Clean washed sand shall be placed and compacted with approved tampers to a height of at least six inches above the pipe or conduit. The backfill shall be brought up evenly on both sides of the pipe for the full length of the pipe. Care shall be taken to ensure thorough compaction of the fill under the haunches of the pipe.

h. Final Backfill – The remainder of the trench shall be filled with unscreened native soil. Native backfill shall be deposited in layers of a maximum of 20 inch loose thickness, and compacted to 90 % maximum density. Water flooding or jetting methods of compaction will not be permitted.

i. Backfill for Appurtenances - After the manhole, vault, pull box, or similar structure has been installed, backfill shall be placed in such a manner that the structure will not be damaged by the shock of falling earth. The backfill material shall be deposited and compacted as specified for final backfill, and shall be brought up evenly on all sides of the structure to prevent eccentric loading and excessive stress. A minimum of four bollards shall be installed adjacent to each manhole, vault, pull box, or similar structure, per the contract drawings.

j. Trenches shall be of a depth to provide a minimum cover of three (3) feet from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe.

k. Metallic, detectable underground tape shall be installed directly above the pipe, at a depth of no less than 18 inches below finished grade unless otherwise shown on the contract drawings. Metallic, detectable underground tape shall be marked with the words “water” and “fiber optic”, or Government-approved equivalent.

2. Testing

a. Testing shall be the responsibility of the Contractor and shall be performed at no additional cost to the Government.

b. Testing of Backfill Materials - Classification of backfill materials shall be determined in accordance with ASTM D 2487; the moisture-density relations of soils shall be determined in accordance with ASTM D 1557. A minimum of one soil classification and one moisture-density relation test shall be performed on each different type of material used for bedding and backfill.

c. Field Density Tests - Tests shall be performed in sufficient numbers to ensure that the specified density is being obtained. A minimum of one field density test per lift of native soil backfill for every 1000 feet of installation shall be performed. One moisture-density relationship shall be determined for every 1500 cubic yards of material used. Field in-place density shall be determined in accordance with ASTM D 1556, ASTM D 2167, or ASTM D 2922. When ASTM D 2922 is used, the calibration curves shall be checked and adjusted using the sand cone method as described in paragraph “Calibration” of the ASTM publication. ASTM D 2922 results in a wet unit weight of soil and when using this method, ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall be checked along with density calibration checks as described in ASTM D 3017.

d. The calibration checks of both the density and moisture gauges shall be made at the beginning of a job, on each different type of material encountered, and at intervals as directed by the Contracting Officer. Copies of calibration curves, results of calibration tests, and field and laboratory density tests shall be furnished to the Contracting Officer within one (1) day following the completion of the density tests. Trenches improperly compacted shall be reopened to the depth directed, then refilled and compacted to the density specified at no additional cost to the Government.

VII. Installation - Piping System

A. General Requirements

1. The piping system, high-point vent, junction and leak detection access vaults with piping system dual-containment stubouts shall be installed per the contract drawings (Attachment 1). The material and installation of automatic flow control valves and flowmeters are not included in this contract. After becoming familiar with all details of the work, the Contractor shall verify dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

2. Pipe and equipment openings shall be closed with caps or plugs during installation. Equipment shall be protected from dirt, water, and chemical or mechanical damage.

3. Pipe and fittings shall be inspected before exposed piping is installed or buried piping is lowered into the trench. The Contractor shall clean the ends of pipes thoroughly, remove foreign matter and dirt from inside of pipes, and keep piping clean during and after laying.

4. The Contractor shall repair damaged pipe in the field with material equal to the original pipe. The Contractor shall not install damaged piping materials.

5. Field Fabrication - The Contractor shall notify the Contracting Officer at least 2 weeks prior to the field fabrication of pipe or fittings and at least 3 days prior to the start of any surface preparation or coating application work. Fabrication of fittings shall be performed in accordance with the manufacturer's instructions.

6. External Corrosion Protection - Protect all pipe and piping accessories from corrosion and adverse environmental conditions.

7. Closures - Closure pieces shall be installed as necessary to end pipe runs. Elastomer sleeves bonded to pipe ends are not acceptable. Pressure piping shall have closures of blind flanges, unless otherwise shown on contract drawings or approved by the Contracting Officer.

8. Services for the double containment leak detection monitoring systems shall be provided by a manufacturer's representative who is experienced in the installation, adjustment and operation of the equipment specified. The representative shall inspect the installation, and supervise the adjustment and testing of the equipment

B. HDPE Pipe

1. Thermoplastic piping systems shall be installed underground in accordance with ASTM D 2774. Earthwork shall be performed as specified in Section V.

2. Plastic pipe shall be cut, fabricated, and installed in strict conformance with the pipe manufacturer's recommendations.

3. Heat joining shall be performed in accordance with ASTM D 2657. Electrofusion joining shall be performed in accordance with ASTM F 1290.

4. Pipe shall not be laid when the ambient temperature is below 40 degrees F, nor above 105 degrees F.

5. Any plastic pipe installed above grade and outdoors shall be ultraviolet (UV) protected or UV resistant.

6. The pipe ends that are to be joined shall be shielded from direct sunlight prior to and during the laying operation.

7. Where plastic pipe is subjected to severe temperature fluctuations, provisions for expansion and contraction must be provided. This shall be accomplished with the use of offset piping arrangements. Offset loops from the trench centerline shall be as recommended by the manufacturer for the maximum temperature variation between the pipe temperature at the time of heat fusion and operating temperature.

8. Flexible plastic pipe connected to heavy fittings, manholes, and rigid structures shall be supported in such a manner that no subsequent relative movement between the plastic pipe at the flanged joint and the rigid structures is possible. Thrust blocking shall not be used for flexible plastic piping. The piping shall be designed and installed to withstand the compression and expansion forces imposed by the trench conditions. All pipe sections between vaults, pull stations, manways, and high-point vents shall be linear, straight sections, with a slope of no less than 0.5% (or as indicated on contract drawings).

9. All lines shall be hydrostatically tested at the maximum operating pressures recommended by the manufacturer for that DR.

10. Factory trained field representatives of the piping supplier shall provide technical field support during critical periods of piping and leak detection system installation, including final check out of the leak detection/location system, and end user training.

C. Valves

1. Valves shall be located in accordance with the contract drawings. Valves shall be located and oriented to permit easy access to the valve operator, and to avoid interferences.

2. Flanged valve bolt holes shall be installed so as to straddle the vertical centerline of pipe. Flanged faces shall be cleaned prior to inserting the gasket and bolts, and then the nuts shall be tightened progressively and uniformly. Threaded ends shall have the threads cleaned by wire brushing or swabbing prior to installation.

3. The operating stem of a manual valve shall be installed in a vertical position and in accordance with the manufacturer's instructions.

D. Miscellaneous Piping Components

1. Expansion Devices- The Contractor shall provide all structural work and equipment required to control expansion and contraction of piping. The Contractor shall verify that the anchors, guides, and expansion joints provided are compatible with and adequately protect the piping system. Expansion devices shall be installed in accordance with the manufacturer's instructions.

2. Couplings, Adapters and Service Saddles - Pipes shall be thoroughly cleaned of oil and dirt in order to provide a clean seat for gaskets. Gaskets shall be wiped clean prior to installation. Flexible couplings and flanged coupling adapter gaskets shall be lubricated with soapy water before installation on the pipe ends. Couplings and service saddles shall be installed in accordance with manufacturer's instructions. Bolts shall be tightened progressively, drawing up bolts on opposite sides a little at a time until all bolts have a uniform tightness.

3. Equipment/Components - Piping components and indicators shall be installed in accordance with manufacturer's instructions. Required upstream and downstream clearances, isolation valves, and miscellaneous devices shall be provided for an operable installation.

4. Pipe Flanges - Pipe flanges shall be set level, plumb, and aligned. Flanged fittings shall be installed true and perpendicular to the axis of the pipe. The bolt holes shall be concentric to the centerline of the pipe.

5. Pipe Tap Connections - Taps to pipe shall be per manufacturer recommendations.

6. Connecting Dissimilar Pipe - Flexible transition couplings and isolation joints shall be installed in accordance with the manufacturer's instructions.

7. Air Release Vents - Air release and vacuum breakers shall be located as indicated on the contract drawings. Air release and vacuum breakers shall be installed in accordance with the manufacturer's instructions.

9. Above Grade Wall Penetrations - Piping which passes through fire-rated or smoke-rated walls, floors, or ceilings shall be provided with insulated and encased pipe sleeves. Penetrations through an existing fire or fire barrier wall shall be sealed with a fire stop system that has an "F" rating not less than the required fire resistance rating of the penetrated wall. The fire stopping sealant for plastic and insulated piping systems shall be a silicone based, nonslumping, premixed sealant, that is vibration and moisture resistant. Vented plastic pipe penetrations shall be fitted with galvanized steel collars.

10. Automatic Flow Control Valves and Flowmeters - This contract does not include materials and installation of automatic flow control valves and flowmeters.

E. HDPE Access Vaults

1. The vaults shall be installed per the contract drawings (Attachment 1) and the vault manufacturer's instructions.

2. Earth work shall be performed as specified in Section V. Temporary closures shall be installed as required to keep the inside of the vault, dual-containment stubouts and vault penetrations clean.

3. The Contractor shall be responsible for any damage to the vaults in the field. All repairs shall be in accordance with the vault manufacturer's recommendations.

VIII. Installation – Leak Detection and Electrical

A. General Requirements

1. The electrical and leak detection system shall be installed in accordance with the manufacturer's recommended installation procedures and the contract drawings (Attachment 1).

2. A location map shall be provided with the system by the Contractor indicating the "as built" system configuration and sensing string layout. Markings along the cable length shall be provided as references to locate leaks. Markings shall be based upon calibration points.

3. The Contractor shall be responsible for taking and recording calibration points along the sensing string per the manufacturer's recommended procedures. Cable not in containment piping shall have cable tags every 50 feet.

4. All access vault and well vault penetrations shall be designed and installed to prevent the ingress of moisture.

5. The contractor shall comply with all local, state and federal electrical codes

B. Assistance and Training

The Contractor shall provide manufacturer's technical assistance for Contractor training, installation inspection, start up, and owner operating and maintenance training.

IX. Testing - Piping System and Leak Detection

A. Hydrostatic Tests

1. After the pipe is laid, the joints completed and the trench partially backfilled leaving the joints exposed for examination, the newly laid piping or any valved section of piping shall, unless otherwise specified, be subjected for 30 minutes to a hydrostatic test.

2. The test fluid shall be potable water and the test pressure shall be 110% of the design pressure. The design pressures are as follows:

Dimension Ratio (DR)	Design Pressure (psi)
9	156
11	125
17	78

3. Each valve shall be opened and closed several times during the test. Exposed pipe, joints, fittings, and valves shall be carefully examined during the partially open trench test.

4. Joints showing visible leakage shall be replaced as necessary. Defective pipe, joints, fittings, and valves found during the pressure test shall be removed and replaced with new material, and the test repeated until the test results are satisfactory.

5. The requirement for the joints to remain exposed for the hydrostatic tests may be waived by the Contracting Officer when one or more of the following conditions are encountered: (1) wet or unstable soil conditions in the trench; or (2) compliance would require maintaining barricades and walkways around and across an open trench in a heavily used area that would require continuous surveillance to assure safe conditions.

6. The Contractor may request a waiver, setting forth in writing the reasons for the request and stating the alternative procedure proposed to comply with the hydrostatic tests.

B. Pneumatic Tests

1. Pneumatic testing shall be prepared for and conducted in accordance with the requirements of ASME B31.3. Care shall be taken to minimize the chance of a brittle fracture or failure during a pneumatic leak test.

2. During pneumatic testing, a pressure relief device shall be provided for each piping section being tested. The device shall have a set pressure not higher than 110% of the test pressure.

3. The test fluid shall be atmospheric air and the test pressure shall be 110% of the design pressure. The design pressures are as follows:

Dimension Ratio (DR)	Internal Design Pressure (psi)
9	156
11	125
17	78

4. The test pressure shall be incrementally increased until the gage pressure reaches 50% of the test pressure. The Contractor shall examine piping joints for leakage.

5. If no leakage is occurring, the Contractor shall continue to increase the pressure incrementally, while maintaining each incremental increase long enough to equalize pipe strains, until the test pressure is reached.

6. The test pressure shall then be reduced to the design pressure and maintained for 10 minutes without additional energy expenditure. If the pneumatic pressure remains steady, then no leakage is indicated. The Contractor shall inspect for and repair leaks, and retest if necessary.

C. Valve Testing

1. Valves may either be tested while testing pipelines, or as a separate step. It shall be demonstrated that valves open and close smoothly with operating pressure on one side and atmospheric pressure on the other, and in both directions for two-way valve applications.

2. The Contractor shall count and record the number of turns required to open and close each valve, and account for any discrepancies with manufacturer's data.

3. Air and vacuum relief valves shall be examined as the associated pipe is being filled to verify venting and seating is fully functional.

4. The Contractor shall set, verify, and record set pressures for all relief and regulating valves.

D. Leak Detection System Test

1. Tests shall be performed to demonstrate the ability of the system to detect and locate breaks, shorts and probes on the sensor string. Leak testing shall be performed pursuant to the following procedure in order to verify operation and the ability to work with condensation pools or other static moisture.

2. The double containment piping system leak detection field test procedures shall be as follows:

a. Using potable water, wet the installed sensor cable near the start of the sensor string and acknowledge the detection/location alarm and remap the system.

b. Using potable water, wet the installed sensor cable near the end of the sensor string with the first location still wetted and acknowledge the detection/location alarm and remap the system.

c. Using potable water, wet the sensor cable in three additional locations between the first and second leak locations with each detection/location alarm being acknowledged and with all prior leak locations still wetted.

3. The Contractor shall prepare and submit a report verifying each leak location and detection accuracy. A hard copy report of the test results shall be furnished.

4. Upon completion of leak detection system testing, the dual containment annular area shall be cleaned and dried, if required. The Contractor shall ensure that the leak detection system is detecting no leaks and system is ready for operation.

X. Final Cleaning

A. Interim Cleaning

The Contractor shall prevent the accumulation of pipe cuttings and filings, gravel, cleaning rags, tools, and other foreign material within piping sections during fabrication. The piping shall be examined to assure removal of these and other foreign objects prior to assembly and installation.

B. Flushing

1. The flushing fluid shall be potable water.

2. Following assembly and testing, and prior to final acceptance, piping systems shall be flushed to remove accumulated construction debris and other foreign matter. The piping shall be flushed until all foreign matter is removed from the pipeline.

3. The Contractor shall provide all hoses, temporary pipes, ditches, and other items as required to properly dispose of flushing water without damage to adjacent properties. The minimum flushing velocity shall be 2.5 fps.

4. For large diameter pipe where it is impractical to flush the pipe at the minimum flushing velocity, the pipeline shall be cleaned in-place from the

inside by brushing and sweeping, then flushing the pipeline at a lower velocity.

5. Cone strainers shall be installed in the flushing connections of attached equipment and left in place until cleaning is completed. Accumulated debris shall be removed through drains, or by removing spools or valves.

C. Water Disposal

The water used for testing, cleaning, or flushing shall be disposed of in accordance with all applicable regulations. Disposal is solely the responsibility of the Contractor. The method proposed for disposal of testing, cleaning, or flushing water shall be provided to, and approved by, the Contracting Officer prior to performing any testing, cleaning, or flushing activities. Discharge to grade is acceptable.

D. Trash and Debris Disposal

Contractor shall provide trash container(s) and dispose of all trash and debris generated during construction activity for the duration of construction. No trash or debris shall be disposed of in the sub-grade piping trench, or on Government property.

E. Project Area

The project area shall have temporary structures, barricades, project signs, and construction facilities removed. A list of completed clean-up items shall be submitted on the day of final inspection

XI. Certification and Warranty

The minimum design life for materials and installation of the subgrade piping system is thirty (30) years. The certification and warranty shall contain a written certification statement from the installation inspector(s) attesting to the proper installation and testing of the piping system. The warranty shall define a warranty period and provide allowance for credit, repair or replacement of any defective piping, valves, fittings, or manholes. The vendor shall provide a warranty that guarantees the installation of all HDPE pipe and fittings per this PR against defects or failures due to improper installation. At minimum, any defects or failures due to improper installation shall be repaired by the vendor at no cost to the Government for a one (1) year period. The manufacturer/vendor shall replace damaged or defective parts within a two week time frame.

The certification and warranty shall contain a written certification statement from the installation inspector(s) attesting to the proper installation and testing of the leak detection system. The warranty shall define a warranty period and provide allowance for credit, repair or replacement of any defective leak detection material and components.

The vendor shall provide a warranty that guarantees the installation of the leak detection system against defects or failures due to improper installation. At minimum, any defects or failures due to improper installation shall be repaired by the vendor at no cost to the Government for a one (1) year period. The manufacturer/vendor shall replace damaged or defective parts within a two week time frame.

XII. Submittals

A. General

1. Each submittal shall be permanently marked to identify it by contract number; transmittal date; Contractor's, Subcontractor's, and supplier's name, address(es) and telephone number(s); submittal name; specification or drawing reference; and similar information to distinguish it from other submittals. Submittal identification shall include space to record the review action by the Contracting Officer. Contractor shall submit a properly executed copy of JSC Form 262 with the submittals; JSC Form 262 is shown as Attachment 3.

2. Required data submittals for each specific material, product, unit of work, or system shall be collected into a single submittal and marked for choices, options, and portions applicable to the submittal. Marking of each copy of product data submitted shall be identical. Partial submittals will not be accepted for expedition of construction effort.

3. Five complete sets of indexed and bound product data shall be submitted. One set, marked with review notations by the Contracting Officer, will be returned to the Contractor.

4. Within 30 days of notice to proceed, the Contractor shall provide, for approval by the Contracting Officer, the following schedule of submittals:

   (a) A schedule of shop drawings and technical submittals required by the specifications and drawings. Schedule shall indicate the specification or drawing reference requiring the submittal; the material, item, or process for which the submittal is required; identifying title of the submittal; the Contractor's anticipated submission date and the approval need date.

   (b) A separate schedule of other submittals required under the contract but not listed in the specifications or drawings. Schedule will indicate the contract requirement reference; the type or title of the submittal; the Contractor's anticipated submission date and the approved need date (if approval is required).

   (c) Submittals called for by the contract documents will be listed on one of the above schedules. If a submittal is called for but does not pertain to the contract work, the Contractor shall include it in the applicable schedule and

annotate it "N/A" with a brief explanation. Approval of the schedules by the Contracting Officer does not relieve the Contractor of supplying submittals required by the contract documents but which have been omitted from the schedules or marked "N/A".

(d) Copies of both schedules shall be re-submitted monthly annotated by the Contractor with actual submission and approval dates. When all items on a schedule have been fully approved, no further re-submittal of the schedule is required.

5. Contracting Officer will review submittals and provide pertinent notation within 10 calendar days after date of submission. Submittals will be returned to the Contractor with the following notations:

(a) Submittals marked "approved" authorize the Contractor to proceed with the work covered.

(b) Submittals marked "approved as noted" authorize the Contractor to proceed with the work covered provided he takes no exception to the corrections. Notes shall be incorporated prior to submission of the final submittal.

(c) Submittals marked "return for correction" require the Contractor to make the necessary corrections and revisions and to re-submit them for approval in the same routine as before, prior to proceeding with any of the work depicted by the submittal.

(d) Submittals marked "not approved" or "disapproved" indicate noncompliance with the contract requirements and shall be re-submitted with appropriate changes. No item of work requiring a submittal shall be accomplished until the submittals are approved or approved as noted.

6. Contractor shall make corrections required by the Contracting Officer. If the Contractor considers any correction or notation on the returned submittals to constitute a change to the contract drawings or specifications, notice as required under the clause entitled, "Changes" shall be given to the Contracting Officer. Approval of the submittals by the Contracting Officer shall not be construed as a complete check, but will indicate only that the general method of construction and detailing is satisfactory. Contractor shall be responsible for the dimensions and design of connection details and construction of work. Failure to point out deviations may result in the Government requiring rejection and removal of such work at the Contractor's expense.

7. If changes are necessary to approved submittals, the Contractor shall make such revisions and submission of the submittals in accordance with the procedures above. No item of work requiring a submittal change shall be accomplished until the changed submittals are approved.

B. Preconstruction Submittals

1. Qualifications - A statement describing the Contractor’s experience installing and testing single-wall and double-wall HDPE pipeline systems, leak detection systems, and associated conduit.

2. Manufacturer Qualifications - A statement describing the Manufacturer’s experience manufacturing single-wall and double-wall HDPE pipeline systems, leak detection systems,

3. Installation Instructions - The Contractor shall furnish the manufacturer's installation recommendations or instructions for each material or procedure to be utilized, including materials preparation.

4. Project Schedule – The Contractor shall furnish a Project Schedule as described in Section V of this specification.

5. Contractor's Installation - The Contractor shall furnish a statement signed by the plastic pipe manufacturer's representative certifying that the Contractor's personnel are capable of properly installing the piping system on the project.

6. Piping System Pressure Testing Plan – The Contractor shall furnish a written document describing in detail the procedure to be followed for pressure testing all piping and appurtenances. Specifically, the Piping System Pressure Testing Plan shall specify whether the proposed testing will be pneumatic, hydrostatic, or both, pipe segments and the order of testing, test pressures, durations, acceptability ranges, special requirements, and any other information pertinent to pressure testing. All proposed testing procedures require Government approval prior to actual testing.

7. Leak Detection System Testing Plan – The Contractorshall furnish a written document describing in detail the procedure to be followed for testing of the entire leak detection system. Specifically, the Leak Detection System Testing Plan shall specify the proposed testing locations, specific procedures, verification, special requirements, and any other information pertinent to leak detection system testing. All proposed testing procedures require Government approval prior to actual testing.

8. Cleaning and Flushing Plan – The Contractorshall furnish a written document describing in detail the procedure to be followed for post-installation, post-pressure-testing, cleaning and flushing. Specifically, the Cleaning and Flushing Plan shall specify pipe segments and the order of flushing, anticipated flushing water volumes, flushing water velocities, flushing durations, special requirements, and any other information pertinent to cleaning and flushing. All proposed

cleaning and flushing procedures require Government approval prior to the actual operation.

9. Waste Water Disposal - The Contractor shall furnish the method proposed for disposal of water from hydrostatic tests, and all required permits, prior to performing hydrostatic tests.

10. Materials and Equipment - The Contractor shall furnish the manufacturer's descriptive and technical literature for each piping system, including design recommendations; pressure and temperature ratings; dimensions, type, grade and strength of pipe and fittings; and thermal characteristics (coefficient of expansion and thermal conductivity).

C. Construction Progress Submittals

Field Test Reports - The Contractor shall furnish a copy of all field notes and test reports. The following field test reports are required within 24 hours following testing (the quantity that each test shall be as required elsewhere in this specification).

1. Pipe Leakage Tests
2. Hydrostatic Tests
3. Pneumatic Tests
4. Double Containment Piping Leak Detection System
5. Valve Testing

D. As-Built Drawing Submittals

Drawings showing the final as-built conditions of the installation shall consist of two sets of the working as-built drawings. The Government will be generating CADD versions of as-builts from the Contractors' hand-marked, working as-built drawings. The Contractor shall review and approve hard copies of the electronic versions, to ensure true as-built conditions are recorded on the electronic as-built drawings. This paragraph covers as-built drawings complete, as a requirement of the contract. The terms "drawings," "contract drawings," "drawing files," "working as-built drawings" and "final as-built drawings" refer to contract drawings which are revised to be used for final as-built drawings.

1. Working As-Built and Final As-Built Drawings

The Contractor shall revise two sets of paper drawings by red-line process to show the as-built conditions during the prosecution of the project (one field copy, one field-office copy). These working as-built marked drawings shall be kept current on a weekly basis and at least one set shall be available on the jobsite at all times. Changes from the contract plans which are made in the work or

additional information which might be uncovered in the course of construction shall be accurately and neatly recorded as they occur by means of details and notes. The working and final as-built drawings shall show, but shall not be limited to, the following information:

(a) The actual location, kinds and sizes of all sub-surface utility lines. In order that the location of these lines and appurtenances may be determined in the event the surface openings or indicators become covered over or obscured, the as-built drawings shall show, by offset dimensions to two permanently fixed surface features, the end of each run including each change in direction. Valves, splice boxes and similar appurtenances shall be located by dimensioning along the utility run from a reference point. The average depth below the surface of each run shall also be recorded.

(b) Correct grade, elevations, cross section, or alignment of roads, earthwork, structures or utilities if any changes were made from contract plans.

(c) Changes in details of design or additional information obtained from working drawings specified to be prepared or furnished by the Contractor; including but not limited to fabrication, erection, installation plans and placing details, pipe sizes, insulation material, and dimensions of equipment foundations.

(d) The topography, invert elevations and grades of drainage installed or affected as part of the project construction.

(e) Changes or modifications which result from the final inspection.

(f) Where contract drawings or specifications present options, only the option selected for construction shall be shown on the final as-built prints.

(g) Systems designed or enhanced by the Contractor, such as vault configuration and installation details.

2. Drawing Preparation

(a) The as-built drawings shall be modified as may be necessary to correctly show the features of the project as it has been constructed by bringing the contract set into agreement with approved working as-built prints, and adding such additional drawings as may be necessary. Additional drawings generated by the Contractor shall be *.dwg files in AutoCAD (R14 or earlier) electronic format. The working as-built marked prints shall be neat, legible and accurate. The following color convention shall be used for the working as-built drawings: (1) red for additions, (2) green for deletions, and (3) blue for comments or notes.

(b) These drawings are part of the permanent records of this project and shall be returned to the Contracting Officer after approval by the Government. Any drawings damaged or lost by the Contractor shall be satisfactorily replaced by the Contractor at no expense to the Government.

(c) One set of the field as-built drawing(s), showing the previous two week progress changes, shall be submitted to the Government on a bi-weekly basis. The bi-weekly as-built drawing submittal shall be marked either "As-Built" drawing denoting no revisions on the sheet or "Revised As-Built" denoting one or more revisions, followed by the name of the Contractor in letters at least 10 mm high. The Government will incorporate these changes into the electronic files, and return to the Contractor for their concurrence.

(d) Within seven days of final construction completion, the remaining complete set of working as-built drawings shall be submitted to the Government for approval. Within 14 calendar days after Government approval of all of the working as-built drawings for a phase of work, the Contractor shall submit corrected as-builts, if required.

3. Final As-Built Drawing Submittals

The Government reserves the right to reject any mark-up drawing it deems inadequate. Paper prints, drawing files and storage media submitted will become the property of the Government upon final approval. Failure to submit final as-built drawing files and marked prints as specified shall be cause for withholding any payment due the Contractor under this contract. Approval and acceptance of final as-built drawings shall be accomplished before final payment is made to the Contractor.

4. As-Built Record of Equipment and Materials Submittal

(a) The Contractor shall furnish one copy of preliminary record of equipment and materials used on the project 14 calendar days prior to final inspection. This preliminary submittal will be reviewed and returned within 4 calendar days after final inspection with Government comments.

(b) Two sets of final record of equipment and materials shall be submitted 14 calendar days after final inspection. The designations shall be keyed to the related area depicted on the contract drawings. The record shall list the following data:

RECORD OF DESIGNATED EQUIPMENT AND MATERIALS DATA				
Description	Specification Section	Manufacturer and Catalog, Model, and Serial Number	Composition and Size	Where Used

(c) Pipe and Equipment - The Contractor shall furnish equipment shop drawings and support system detail drawings showing piping systems and appurtenances, such as mechanical joints, valves, local indicators and hangers, including a complete list of equipment and materials. As-built drawings showing pipe anchors and guides, and layout of piping systems relative to other parts of the work including clearances for maintenance and operation. As-built piping and instrumentation diagrams (P&IDs) identifying and labeling equipment, instrumentation, valves, vents, drains, and all other inline devices.

(d) Cable System - The Contractor shall furnish an as-built location map for the cable leak detection system in double containment piping systems indicating the installed system configuration and sensing string layout. Marks in feet along the length of the cable shall be provided as references to locate leaks.

E. Contract Close-Out Submittals

Contractor shall furnish the following documentation no later than 30 days following completion of construction. Final payment will not be made until all close-out submittals are received by the Contracting Officer, and deemed to be satisfactory.

1. Statement of Satisfactory Installation - The Contractor shall furnish a signed statement certifying that the installation is satisfactory and in accordance with the contract drawings and specifications and the manufacturer's prescribed procedures and techniques, upon completion of the project and before final acceptance.

2. Operation and Maintenance (O&M) Manuals - The Contractor shall furnish four copies each of O&M manuals in indexed booklet form. Operation manuals shall detail the step-by-step procedures required for specialized startup, operation and shutdown of piping systems, and shall include the manufacturer's name, model number, parts list and brief description of piping equipment such as valves and other appurtenances and their basic operating features. Maintenance manuals shall list routine maintenance procedures and troubleshooting guides for the equipment, and shall include piping layout and valve locations.

3. Warranty Management Plan - The Contractor shall submit warranty information for all applicable construction and equipment. This submittal shall include a list for each warranted equipment, item, feature of construction or system indicating:

   (a) Name of item.
   (b) Model and serial numbers.
   (c) Location where installed.
   (d) Name and phone numbers of manufacturers or suppliers.
   (e) Names, addresses and telephone numbers of sources of spare parts.

(f) Warranties and terms of warranty. This shall include one-year overall warranty of construction. Items which have extended warranties shall be indicated with separate warranty expiration dates.
(g) Cross-reference to warranty certificates as applicable.
(h) Starting point and duration of warranty period.
(i) Summary of maintenance procedures required to continue the warranty in force.
(j) Cross-reference to specific pertinent Operation and Maintenance manuals (if applicable).

4. Pipe Schedule - The Contractor shall furnish a list of piping systems, pressure ratings and source of supply for each piping system broken out by material, size and application as indicated on the contract drawings. The Contractor shall furnish a list of any special tools necessary for each piping system and appurtenances furnished for adjustment, operation, maintenance and disassembly of the system.

5. Valve Schedule - The Contractor shall furnish a list of valve materials, pressure ratings, valve operator's materials, electrical service, location, source of supply, and reference identification as indicated in the contract drawings. The Contractor shall furnish a list of any special tools necessary for each valve type and appurtenances furnished for adjustment, operation, maintenance and disassembly.

6. Double Containment Piping System - The Contractor shall furnish the manufacturer's engineering end load calculations for anchors in double containment piping systems.

- END -

ATTACHMENT 2: References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI Z400.1 (1993) Hazardous Industrial Chemicals - Material Safety Color Data Sheets – Preparation

AMERICAN PETROLEUM INSTITUTE (API)

API Spec 6D (1994; Supple 1 June 1996; Supple 2 Dec 1997) Pipeline Valves (Gate, Plug, Ball, and Check Valves)

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 53 (1999b) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A 123/A 123M (1997ael) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A 153/A 153M (1998) Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A 181/A 181M (1995b) Carbon Steel, Forgings for General-Purpose Piping

ASTM A 307 (1997) Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength

ASTM C 920 (1998) Elastomeric Joint Sealants

ASTM D 638 Standard Test Method for Tensile Properties of Plastics

ASTM D 696 Standard Test Method for Coefficient of Thermal Expansion of Plastics Between (-30°)C and 30°C

ASTM D 746 Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact

ASTM D 790 Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials

ASTM D 1238 Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer

ASTM D 1248 (1984; R 1989) Polyethylene Plastics Molding and Extrusion Materials

ASTM D 1505 Standard Test Method for Density of Plastics by the Density-Gradient Technique

ASTM D 1556 (1990; R 1996) Density and Unit Weight of Soil in Place by the Sand-Cone Method

ASTM D 1557 (1998) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu. m.))

ASTM D 2167 (1994) Density and Unit Weight of Soil in Place by the Rubber Balloon Method

ASTM D 2487 (1998) Classification of Soils for Engineering Purposes (Unified Soil Classification System)

ASTM D 2922 (1996) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

ASTM D 3017 (1988; R1996el) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)

ASTM D 1598 (1986; R 1997) Time-to-Failure of Plastic Pipe Under Constant Internal Pressure

ASTM D 1603 Standard Test Method for Carbon Black in Olefin Plastics

ASTM D 1693 (1998) Environmental Stress-Cracking of Ethylene Plastics

ASTM D 1928 Standard Practice for Preparation of Compression-Molded Polyethylene Test Sheets and Test Specimens

ASTM D 2321 Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications

ASTM D 2447 (1999) Polyethylene (PE) Plastic Pipe, Schedules 40 and 80, Based on Outside Diameter

ASTM D 2657 (1997) Heat Fusion Joining Polyolefin Pipe and Fittings

ASTM D 2683 (1998) Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing

ASTM D 2774 (1994) Underground Installation of Thermoplastic Pressure Piping

ASTM D 2837 Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials

ASTM D 3035 (1995) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter

ASTM D 3139 (1998) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals

ASTM D 3261 (1997) Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing

ASTM D 3350 Standard Specification for Polyethylene Plastics Pipe and Fittings Materials

ASTM D 3892 (1998) Packaging/Packing of Plastics

ASTM E 515 (1995) Leaks Using Bubble Emission Techniques

ASTM F 714 Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter

ASTM F 1055 (1998) Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing

ASTM F 1759-97 Standard Practice for Design of High-Density Polyethylene (HDPE) for Subsurface Applications

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

ASME B1.20.1 (1983; R 1992) Pipe Threads, General Purpose (Inch)

ASME B16.5 (1996; B16.5a) Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24

ASME B16.9 (1993) Factory-Made Wrought Steel Buttwelding Fittings

ASME B16.11 (1996) Forged Fittings, Socket-Welding and Threaded

ASME B16.21 (1992) Nonmetallic Flat Gaskets for Pipe Flanges

AMERICAN WATER WORKS ASSOCIATION (AWWA)

C218 Coating the Exterior of Aboveground Steel Water Pipelines and Fittings

MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)

MSS SP-25 (1998) Standard Marking System for Valves, Fittings, Flanges and Unions

MSS SP-58 (1993) Pipe Hangers and Supports - Materials, Design and Manufacture

MSS SP-69 (1996) Pipe Hangers and Supports - Selection and Application

MSS SP-72 (1992) Ball Valves with Flanged or Butt-Welding Ends for General Service

MSS SP-89 (1998) Pipe Hangers and Supports - Fabrication and Installation Practices

NACE INTERNATIONAL (NACE)

NACE RP0185 (1996) Extruded, Polyolefin Resin Coating Systems with Soft Adhesives for Underground or Submerged Pipe

NACE RP0274 (1998) High Voltage Electrical Inspection of Pipeline Coatings Prior to Installation

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 49 (1994) Hazardous Chemicals Data

NFPA 325-1 (1994) Fire Hazard Properties of Flammable Liquids, Gases, and Volatile Solids

PLASTICS PIPE INSTITUTE (PPI)

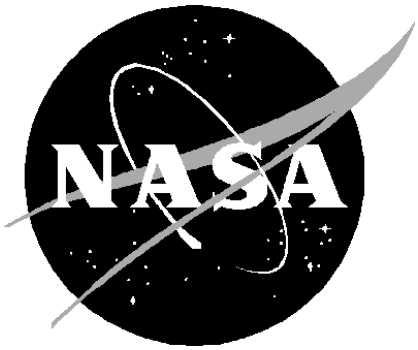
PPI TR31-9/79 Underground Installation of Polyolefin Piping

PPI AW-32 TR21 (1974) Thermal Expansion and Contraction of Plastic Pipe

THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)

SSPC SP 6/NACE 3 (1994) Commercial Blast Cleaning

ATTACHMENT 3: JSC Form 262



NASA – JOHNSON SPACE CENTER

WHITE SANDS TEST FACILITY

GROUND WATER TREATMENT SYSTEM FOR

PLUME-FRONT STABILIZATION

May 6, 2002

EXTRACTION PUMPS, DISCHARGE PIPING AND INJECTION PIPING TECHNICAL SPECIFICATIONS

TABLE OF CONTENTS

I. General....3
A. Scope....3
B. Qualifications....3
C. Certification and Warranty....4
D. Submittals....4
1. General....4
2. Data....5
3. Drawings....6
4. Statements....6
5. Reports....7
E. References....7
II. Material....10
A. Pumping Unit....10
1. General Design Requirements....10
2. Computations and Discharge System....10
3. Operating Conditions....10
4. Performance Requirements....10
5. Capacities....11
6. Submersible Pump Design....11
7. Materials....13
8. Safety Cable....14
9. Check Valves....14
10. Air Release and Vacuum Breakers....14
B. Injection Piping....15
C. Submersible Level Element and Transmitter....15
1. General....15
2. Performance and Features:....15
3. Suggested Manufacturer and Model....16
III. Execution....17
A. Pumping System....17
1. Submersible Pump – Factory Tests....17
2. Attachment at Surface....18
3. Pumping Unit Installation....18
4. Pump Field Tests....20
B. Injection Piping....20
1. Installation....20
C. Submersible Level Element and Transmitter....21
1. Installation....21
IV. Best Value Evaluation Criteria....22

LIST OF ATTACHMENTS

Attachment 1 WSTF Groundwater Treatment Facility Project Location

Drawing 652-C-01, Project Location

Attachment 2 Extraction and Injection Well Construction Diagrams

Drawing 653-C-03, PFE-1 Well Construction Diagram
Drawing 654-C-03, PFE-2 Well Construction Diagram
Drawing 655-C-03, PFE-3 Well Construction Diagram
Drawing 656-C-03, PFE-4A Well Construction Diagram
Drawing 657-C-03, PFE-5 Well Construction Diagram
Drawing 658-C-03, PFE-7 Well Construction Diagram
Drawing 660-C-02, PFI-1 Well Completion Diagram
Drawing 661-C-02, PFI-2 Well Completion Diagram
Drawing 662-C-02, PFI-3 Well Completion Diagram
Drawing 663-C-02, PFI-4 Well Completion Diagram

Attachment 3 Pump Performance, Design and Hydraulic Data

Attachment 4 Wellhead Details

Drawing 653-M-01, Extraction Well PFE-1 Mechanical Details
Drawing 654-M-01, Extraction Well PFE-2 Mechanical Details
Drawing 655-M-01, Extraction Well PFE-3 Mechanical Details
Drawing 656-M-01, Extraction Well PFE-4A Mechanical Details
Drawing 657-M-01, Extraction Well PFE-5 Mechanical Details
Drawing 658-M-01, Extraction Well PFE-7 Mechanical Details
Drawing 660-M-01, Injection Well PFI-1 Mechanical Details
Drawing 661-M-01, Injection Well PFI-2 Mechanical Details
Drawing 662-M-01, Injection Well PFI-3 Mechanical Details
Drawing 663-M-01, Injection Well PFI-4 Mechanical Details

Attachment 5 Electrical Details

Drawing 653-E-02, Extraction Well PFE-1 Electrical Details
Drawing 654-E-02, Extraction Well PFE-2 Electrical Details
Drawing 655-E-02, Extraction Well PFE-3 Electrical Details
Drawing 656-E-02, Extraction Well PFE-4A Electrical Details
Drawing 657-E-02, Extraction Well PFE-5 Electrical Details
Drawing 658-E-02, Extraction Well PFE-7 Electrical Details

Attachment 6 JSC Form 262 Transmittal of Shop Drawings, Equipment Data, Material Samples, or Manufacturer's Certificates of Compliance for Approval

I. General

A. Scope

This specification defines the requirements for the following materials and services to be supplied to the NASA-Johnson Space Center White Sands Test Facility:

1. materials, installation and testing of submersible pumps, associated discharge piping, check valves, power cables, and vent-vacuum valves for six [6] existing groundwater extraction wells;
2. materials and installation of injection piping for four [4] existing injection wells, and;
3. materials and installation of ten [10] pressure transducers (one per each extraction and injection well).

Well construction diagrams for the six [6] extraction wells (PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, and PFE-7) and the four [4] injection wells (PFI-1, PFI-2, PFI-3, and PFI-4) are presented in Attachment 2. The design and performance requirements and hydrologic measurements for the extraction and injection wells are presented in Attachment 3. Wellhead and electrical details are presented in Attachments 4 and 5.

WSTF is located 18 miles northeast of Las Cruces, New Mexico, with access provided through U. S. Highway 70. Maps of WSTF's location and the specific well locations with respect to WSTF's developed areas are presented in Attachment 1. The project is located in a remote area, Sections 4 and 5 of T21S, R3E and Section 32 of T20S, R3E of Attachment 1. A light duty gravel road (the WSTF Well Road) provides access to the general project vicinity.

B. Qualifications

The pump installation contractor's ("Contractor") work experience shall include experience in the supply, installation and testing of four-inch [4] to six-inch [6] diameter submersible pumps in 500-foot to 1000-foot-deep groundwater wells. The Contractor shall supply a list of installations at which the Contractor has installed pumps similar to those specified.

The Contractor shall furnish a qualified installation engineer/inspector who is knowledgeable and experienced with the installation, testing, and start-up procedures for submersible pumps and the associated equipment specified. The installation engineer/inspector shall have training and experience as recommended by the pump Manufacturer. The installation engineer shall be responsible for providing complete and correct direction during installation, initial starting, and subsequent operation of equipment until field tests are completed

The Contractor shall have overall responsibility to supply the pumping unit (submersible pump/motor, cables, and accessories) that meet the requirements of this specification. Additionally, the Contractor is the sole responsible party during start-up, installation, and performance evaluation.

The Contractor shall comply with all applicable OSHA, NASA, JSC and WSTF safety and security requirements. All Contractor safety training, equipment and work practices are subject to review and approval by WSTF Safety personnel and the WSTF

Environmental Department. Specific safety compliance requirements include, but are not limited to, a one-time, approximately one hour site safety and security briefing required for all Contractor personnel, and confined space (wellhead vaults) access. Contractor employees required to enter any confined space, including extraction and injection well vaults must supply proof of 29 CFR 1910.146 “Confined Spaces” training.

C. Certification and Warranty

The certification and warranty shall contain a written certification statement from the installation engineer/inspector attesting to the correct installation and operation of the pumping unit at each extraction well site and to the correct installation of the injection piping at each injection well site. The warranty shall define a warranty period and provide allowance for credit, repair or replacement of any defective components or material. The Contractor shall provide a warranty that guarantees the installation of the pumping unit and injection piping against defects or failures due to improper installation. At minimum, any defects or failures due to improper installation shall be repaired by the Contractor at no cost to the Government for a [1] one-year period from the date of installation.

D. Submittals

1. General

Government approval is required for all submittals with a "GA" designation (due dates listed below); submittals having an "FIO" designation are for information only and shall be submitted no later than thirty [30] calendar days after Government issuance of the Notice of Award.

Each submittal shall be permanently marked to identify it by contract number; transmittal date; Contractor's, Subcontractor's, and supplier's name, address(es) and telephone number(s); submittal name; specification or drawing reference; and similar information to distinguish it from other submittals. Submittal packages shall include a properly executed JSC Form 262; a copy of this form is shown in Attachment 6.

Contracting Officer will review submittals and provide pertinent notation within 20 calendar days after date of submission. Submittals will be returned to the Contractor with one or more of the following notations:

a. Submittals marked "Approved as Submitted" authorize the Contractor to proceed with the work covered.

b. Submittals marked "Approved as Noted" authorize the Contractor to proceed with the work covered provided he takes no exception to the corrections. Resubmission is not required. Notes shall be incorporated prior to submission of the final submittal.

c. Submittals marked "Return for Correction" require the Contractor to make the necessary corrections and revisions and to re-submit them for approval in the same routine as before, prior to proceeding with any of the work depicted by the submittal.

d. Submittals marked "Disapproved" indicate noncompliance with the contract requirements and shall be re-submitted with appropriate changes. No work requiring a submittal shall be accomplished until the submittals are approved or approved as noted.

e. Submittals marked "Acknowledge receipt" require the Contractor or supplier to provide the Contracting Officer a written acknowledgement of receipt of letter, material or submittal.

Contractor shall make corrections required by the Contracting Officer. If the Contractor considers any correction or notation on the returned submittals to constitute a change to the contract drawings or specifications; notice as required under the clause entitled, "Changes" shall be given to the Contracting Officer. Approval of the submittals by the Contracting Officer shall not be construed as a complete check, but will indicate only that the general method of construction and detailing is satisfactory. Contractor shall be responsible for the dimensions and design of connection details and construction of work. Failure to point out deviations may result in the Government requiring rejection and removal of such work at the Contractor's expense.

If changes are necessary to approved submittals, the Contractor shall make such revisions and submission of the submittals in accordance with the procedures above. No item of work requiring a submittal change shall be accomplished until the changed submittals are approved.

2. Data

a) Equipment Supplies and Performance; GA.

Within fifteen [15] calendar days of Notice of Award, submit five [5] copies of pump curves, final motor horsepower rating, and sufficient hydraulic computations to substantiate pump selection and demonstrate that the selected pump can meet the project design and operating requirements as specified. The pump capacity-head curve shall indicate efficiency, bhp (brake horsepower), and NPSHR. Motor characteristic curves or tabulated data (test or calculated) shall indicate the speed, power factor, efficiency, current, and kilowatt input, all plotted or tabulated against percent load as abscissas.

This submittal shall also include manufacturer information sheets for each pump and motor, and other relevant information for the machinery, injection piping, and other equipment contemplated to be incorporated into the work.

If deviation from specified materials is proposed by the Contractor, submit complete specifications for the proposed deviating materials.

b) Spare Parts; FIO.

Submit four [4] copies of Manufacturers complete parts list showing all parts, spare parts, and bulletins for pump. Clearly show all details, parts, and adequately describe parts or have proper identification marks. Photographs or catalog cuts of components may be included for identification.

c) Instructions - Installation Instruction Manual; GA.

Within thirty [30] calendar days of Contractor receipt of the Notice of Contract Award, submit five [5] copies of a typed and bound manual describing procedures that will be followed by the installation engineer in assembling, installing, and dry- and wet-testing the pump. The Contracting Officer may request changes or modifications to the manuals deemed necessary or desirable.

3. Drawings

a) Submersible Pump; GA.

Within thirty [30] calendar days of Notice of Award, submit five [5] copies of drawings listed below. Dimensions shall be in English with metric conversion.

(1) Outline drawings of the pump showing dimensions and weight of the pump/motor, and total estimated hanging weight.
(2) Drawings showing details and dimensions of pump mounting design and layout including any embedded items.
(3) Cross-sectional drawings of the pump, showing each component, should show major or complicated sections of the pump in detail. On each drawing indicate an itemized list of components showing type, grade, class of material used, and make and model of the standard component used.

b) Pump Safety Cable; GA.

Within thirty [30] calendar days of Notice of Award, submit two [2] copies of cut sheets, specifications, or similar descriptive documents, for the steel pump support cables. This cable information shall be accompanied with a description and scaled engineering drawings showing the Contractor-proposed method of safety cable attachment at the wellhead.

4. Statements

a) Factory Test Plan; GA.

Submit a description of the factory test setup and test procedure proposed. Submit five [5] copies of the Factory Test Plan within thirty [30] calendar days of Contractor receipt of the Notice of Contract Award. Submit data and drawings sufficient to demonstrate that testing is in compliance with HI 2.6.

b) Field Test Plan; GA.

Submit a description of the field test setup and test procedure proposed. Submit five [5] copies of the Field Test Plan within thirty [30] calendar days of Contractor receipt of the Notice of Contract Award.

5. Reports

a) Factory Test Report; GA.

Within twenty [20] calendar days of completion of the Factory Test Plan procedures, submit five [5] bound copies of a report covering test setup and performance test results. The factory test report shall include the information required by paragraph III.A.1.b.

b) Field Test; GA.

Submit five [5] copies of the field test report within twenty [20] calendar days of completion of the Field Test Plan procedures.

c) Installation Report; GA.

Submit the installation report and written certification as required in Section III. A. 3. This report shall be submitted within twenty [20] calendar days following completion of all pump installation activities.

d) Operation and Maintenance Manuals - Operating and Maintenance Instruction; GA.

Within twenty [20] calendar days of completion of all field tests, submit five [5] copies of the manual containing complete information on operation, lubrication, adjustment, routine and special maintenance disassembly, repair, reassembly, and trouble diagnostics of pump and auxiliary equipment. The operation and maintenance manual shall be printed on good quality 8 1/2 in. by 11 in. paper, bound separately from the parts list, and bound between a flexible, durable cover. Drawings incorporated in manual may be reduced to page size provided they are clear and legible, or they may be folded into the manual to page size. Photographs or catalog cuts of components may be included for identification.

E. References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABEMA)

ABEMA Std 9 (1990) Load Ratings and Fatigue Life for Ball Bearings

ABEMA Std 11(1990) Load Ratings and Fatigue Life for Roller Bearings

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI S2.19 (1989; R 1992) Mechanical Vibration - Balance Quality Requirements of Rigid Rotors, Part 1: Determination of Permissible Residual Unbalance

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 27/A 27M (1995) Steel Castings, Carbon, for General Application

ASTM A 36/A 36M (1997a) Carbon Structural Steel

ASTM A 48 (1994a) Gray Iron Castings

ASTM A 48M (1994) Gray Iron Castings (Metric)

ASTM A 108 (1999) Steel Bars, Carbon, Cold Finished, Standard Quality

ASTM A 167 (1996) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip

ASTM A 176 (1997) Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip

ASTM A 242/A 242M (1998) High-Strength Low-Alloy Structural Steel

ASTM A 276 (1998b) Stainless Steel Bars and Shapes

ASTM A 297/A 297M (1997; R 1998) Steel Casting, Iron-Chromium and Iron-Chromium-Nickel, Heat Resistant, for General Application

ASTM A 312/A 312M (1999) Seamless and Welded Austenitic Stainless Steel Pipes

ASTM A 516/A 516M (1990; R 1996) Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service

ASTM A 576 (1990b; R 1995) Steel Bars, Carbon, Hot-Wrought, Special Quality

ASTM A 668/A 668M (1996) Steel Forgings, Carbon and Alloy, for General Industrial Use

ASTM B 148 (1997) Aluminum-Bronze Sand Castings

ASTM B 584 (1998a) Copper Alloy Sand Castings for General Applications

ASME INTERNATIONAL (ASME)

ASME B46.1 (1995) Surface Texture (Surface Roughness, Waviness, and Lay)

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1 (1998) Structural Welding Code - Steel

AMERICAN WATER WORKS ASSOCIATION (AWWA)

AWWA C208 (1996) Dimensions for Fabricated Steel Water Pipe Fittings

HYDRAULIC INSTITUTE (HI)

HI 2.1-2.5 (1994) Vertical Pumps

HI 2.6 (1994) Vertical Pump Test

HI 9.1-9.5 (1994) Pumps - General Guidelines

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA MG 1 (1993; Rev 1-1993; Rev 2-1995; Rev 3-1996; Rev 4-1997) Motors and Generators

NEMA WC 7 (1988; R 1991; Rev 1-1991; Rev 2-1992; Rev 3-1996) Cross-Linked-Thermosetting- Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

II. Material

A. Pumping Unit

1. General Design Requirements

A pumping unit will consist of: a submersible pump complete with submersible motor, discharge piping and required fittings, vent/vacuum valve, electrical power cable, a safety cable, and any other hardware required for proper installation. The pump/motor shall be electrically operated and supported by the discharge pipe (also referred to as "drop pipe").

One pumping unit will be installed at each of the six (6) extraction well locations (PFE-1, PFE-2, PFE-3, PFE-4A, PFE-5, and PFE-7) presented in Attachment 1. Well construction diagrams are presented in Attachment 2. The wells are fully developed and free of cuttings and sand. The specific design and performance requirements and hydrologic measurements for each extraction well are presented in Attachment 3. Wellhead and electrical details are presented in Attachments 4 and 5.

Except as otherwise stated or noted, the term pump refers to a pump/motor integral unit. The general design requirements are:

a) The pump shall meet the requirements as specified throughout this document, including Attachment 3.
b) The pump shall, as a minimum, meet the applicable design, material, and manufacture requirements of this specification and Hydraulic Institute standards (HI), HI 2.1-2.5, "Vertical Pumps", and HI 9.1-9.5, "Pumps – General Guidelines".

2. Computations and Discharge System

Head losses within the pumping unit shall be determined by the Contractor.

3. Operating Conditions

The pump shall be capable of operating in the dry (for the purpose of conducting operating checks) for short periods of time **or** as stated in the Manufacturer's operating instructions. The pump Manufacturer shall establish and state in the operating manual the procedures for starting and stopping the pumps, including any sequential operations.

4. Performance Requirements

a) The pump shall be capable of operating without instability over the required range of head.

b) The pump shall have a hydraulic efficiency of not less than 65 percent at total design head.

5. Capacities

    a) Head and volumetric flow requirements are presented in Attachment 3.

6. Submersible Pump Design

    a) Acceptable pumps are listed in Attachment 3.

    b) Motor

The motor shall be submersible and conform to the requirements of NEMA MG 1. The motor shall be sized to avoid overload when operating at any point along the characteristic curve of the pump. The motors shall be 3-phase, 60-Hz, 480 V, squirrel cage induction type, NEMA Design B Type. The stator windings and stator leads shall be insulated with a moisture-resistant Class F insulation with temperature resistance of 311 degrees F. The service factor shall be 1.0. The temperature rise above ambient for continuous full load rated conditions and for the class of insulation used shall not exceed the values in NEMA MG 1. The motor shall be rated for continuous duty when submerged and shall also be capable of operation in the dry for short periods of time for testing and maintenance purposes.

Per minimum motor efficiency standards which were issued as final regulations by the Secretary of Energy in 10 CFR Part 431, electric motors manufactured alone or as a component of another piece of equipment shall have a nominal full load efficiency of not less than that indicated below:

Number of Poles	Nominal Full Load Efficiency					
	Open Motors			Enclosed Motors		
	6	4	2	6	4	2
Motor Horsepower/Standard Kilowatt Equivalent						
1/.75……..……..	80.0	82.5	--	80.0	82.5	75.5
1.5/1.1……..……	84.0	84.0	82.5	85.5	84.0	82.5
2/1.5……..….	85.5	84.0	84.0	86.5	84.0	84.0
3/2.2……..….	86.5	86.5	84.0	87.5	87.5	85.5
5/3.7……..….	87.5	87.5	85.5	87.5	87.5	87.5
7.5/5.5……..….	88.5	88.5	87.5	89.5	89.5	88.5
10/7.5……	90.2	89.5	88.5	89.5	89.5	89.5
15/11……	90.2	91.0	89.5	90.2	91.0	90.2
20/15……	91.0	91.0	90.2	90.2	91.0	90.2
25/18.5……..….	91.7	91.7	91.0	91.7	92.4	91.0
30/22……	92.4	92.4	91.0	91.7	92.4	91.0
40/30……	93.0	93.0	91.7	93.0	93.0	91.7
50/37……	93.0	93.0	92.4	93.0	93.0	92.4
60/45……	93.6	93.6	93.0	93.6	93.6	93.0
75/55……	93.6	94.1	93.0	93.6	94.1	93.0
100/75……..….	94.1	94.1	93.0	94.1	94.5	93.6
125/90……..……	94.1	94.5	93.6	94.1	94.5	94.5
150/110……	94.5	95.0	93.6	95.0	95.0	94.5
200/150……..……	94.5	95.0	94.5	95.0	95.0	95.0

Starting torque shall be sufficient to start the pump, but in no case less than 60 percent of full-load torque. Break-down torque shall not be less than 200 percent of full-load torque. Thrust bearing support shall have sufficient strength and rigidity to support the weight of the entire rotating element of the motor, pump impeller and shaft, and the hydraulic thrust.

c) Cable

Power and instrumentation cable (if applicable) shall be specifically designed for use with a submersible pump application and shall conform to the requirements of NEMA WC 7. Submersible cable shall be suitable for continuous immersion in water at the maximum depth encountered. The power cable shall be continuous and not spliced. Power cable shall have an ampacity of not less than 125 percent of the motor full load current and shall be sized such that the voltage drop is less than 10% of the nominal voltage rating. The minimum power cable length shall correspond to the pump intake depths shown in the table below, plus twenty (20) feet:

Well	**Depth to Pump Intake** (from grade)	**Minimum Cable Length**
PFE-1	525 feet	545 feet
PFE-2	515 feet	535 feet
PFE-3	522 feet	542 feet
PFE-4A	575 feet	595 feet
PFE-5	650 feet	670 feet
PFE-7	475 feet	495 feet

Power and instrumentation cables (if applicable) shall enter the motor through a sealing system that prevents water entry into the unit and provides strain relief. The cable entry may be comprised of rubber bushings, flanked by stainless steel washers, having a close tolerance fit against the cable outside diameter and the entry inside diameter for sealing by compression of the bushing, or the entry may be sealed by other gland compression methods.

d) Motor Starters and Pump Overload Protection, Control, and Monitoring

(1) Motor starters will be furnished by others and are ***not*** part of this procurement. <u>For information purposes only</u>: Motor Starters to be of the Solid-State Reduced Voltage (SSRV)/ Soft Start type for motors rated 75 horsepower and above; the overload relay shall be NEMA ICS 2, solid state type with adjustable trip settings. Motor Starters of the Full Voltage, Non-Reversing (FVNR) type for motors rated below 75 horsepower; the overload relay shall be NEMA ICS 2, solid state type with adjustable trip settings.
(2) Unless required by the manufacturer, the extraction pump motors shall not be provided with self-resetting bi-metallic thermal overloads in the motor windings.

7. Materials

a) Submersible Pumps

The extraction well pumps shall be stainless steel submersible pumps with submersible pump motors. All major pump components (pump housing, impeller, pump shaft, etc.) shall be stainless steel or other Government-approved corrosion resistant materials. Material selection shall be guided by HI 9.1-9.5 for corrosion, erosion, and abrasion resistance. Deviations from the specified materials shall be submitted in accordance with paragraph SUBMITTALS. The materials of construction shall comply with the following, as applicable:

PART	MATERIAL
Impeller	304 Stainless steel
Pump shaft	431 Stainless steel
Impeller seal ring	Manufacturer's standard
Bolts, key, etc.	Stainless steel
O-rings	Nitrile rubber
Mechanical seals	316 Stainless steel/tungsten carbide

(1) Designated Material

Designated materials shall conform to the following specifications, grades, and classifications.

MATERIALS	SPECIFICATION, GRADE, CLASS
Aluminum-Bronze Castings	ASTM B 148, Alloy No. C95500
Cast Iron	ASTM A 48, Class Nos. 30A, 30B, and 30C
Cast Steel, annealed	ASTM A 27/A 27M Grade 65-35
Coal Tar Protective Coatings	AWWA C203
Cold-Rolled Steel Bars	ASTM A 108, min, Wt. Strm 65,000 psi
Copper Alloy Castings	ASTM B 584, Alloy No. C93700
Corrosion-Resistant Alloy Castings	ASTM A 297/A 297M, Grade CA-15, CAGNN and CF-8M
Dimensions for Steel Water Pipe Fittings	AWWA C208
Hot-Rolled Stainless	ASTM A 576, Graded G10200, G10450, and G11410
Ring Flanges	AWWA C207, Class B
Seamless and Welded Austenitic Stainless Steel Pipe	ASTM A 312/A 312M
Stainless Bars and Shapes	ASTM A 276, Grades S30400 and S41000
Steel Forging	ASTM A 668/A 668M, Class F
Steel Pipe 6 in. and Larger	AWWA C200
Steel Plates, Pressure Vessel	ASTM A 516/A 516M, Grade 55
Steel Plate	ASTM A 242/A 242M
Stainless Steel Plate	ASTM A 167, UNS S30400 or ASTM A 176, UNS S40500
Quality Steel	ASTM A 36/A 36M
Surface Texture	ASME B46.1

b) Pump Discharge Pipe

The pump discharge pipe shall be ASTM A500 or A501 schedule 40 carbon steel pipe joined with NPT threaded couples, or as recommended by the pump Manufacturer and/or pump installation Contractor. Each pipe section length shall not exceed twenty-two [22] feet. Each assembled discharge pipe shall be able to support the pump, pipe, water, safety cable, and power cable during normal operation (Attachment 3). The pipe sizes and lengths for each well location are listed in Attachments 3 and 4.

The design, manufacture and installation of the discharge pipe shall be in accordance with the pump Manufacturer's instructions. For purposes of performance and this specification it shall be treated as part of the pumping unit. The discharge pipe shall be of such size to accommodate the dimensions of the pump supplied in accordance with the Manufacturer's requirements. A locking device shall be provided that prohibits rotational movement of the pump relative to the discharge pipe. The pumps shall be removable for inspection or service.

8. Safety Cable

The pumping unit shall be secured with a steel safety cable assembly. The Contractor shall recommend a method of securing the steel safety cable at the wellhead. All methods shall be submitted to and approved by the Government prior to hardware purchase and installation. The safety cable assembly shall be in accordance with industry standards and meet the applicable requirements of the Occupational Safety and Health Administration (OSHA) and American National Standards Institute (ANSI). The steel safety cable for PFE-5 shall be no less than 0.375-inch diameter; all other wells shall utilize at least a 0.5-inch diameter steel safety cable. Wellhead details are presented in Attachment 4.

9. Check Valves

The pumping unit shall be designed and installed to prevent damage to the submersible pump and/or motor. Check valves shall be installed per the pump Manufacturer's recommendations to prevent potential damage due to backspin, upthrust, water hammer, pumping against a closed valve, etc.

10. Air Release and Vacuum Breakers

a) The air release - vacuum breakers shall be Golden Anderson one-inch kinetic air/vacuum valves (stock #930) or equivalent.

b) One air release - vacuum breaker shall be located as indicated on the contract drawings. The valve shall be a minimum 125 lb. class.

c) The air and vacuum valve shall automatically exhaust air during the filling of a system while allowing air to re-enter during draining or when vacuum occurs.

d) The valve shall be cast iron for the valve body; stainless steel for the internal linkage, float, and float stem; and Buna-N for the needle and seat.

e) End connections shall be one inch; bushings and adapters shall be utilized as required to thread the air release/vacuum breakers into

adjacent piping. All air release and vacuum breakers shall be plumbed to an equal size ball valve (allowing isolation of the air release/vacuum breaker from the piping system).

B. Injection Piping

Injection piping shall be installed at the four [4] injection well locations (PFI-1, PFI-2, PFI-3 and PFI-4) presented in Attachment 1.

Well construction diagrams for the four [4] injection wells (PFI-1, PFI-2, PFI-3, and PFI-4) are presented in Attachment 2. The wells are fully developed and free of cuttings and sand. The design and performance requirements and hydrologic measurements for each injection well are presented in Attachment 4. Wellhead details are presented in Attachments 4.

The injection pipe shall be ASTM A500 or A501 schedule 40 carbon steel pipe joined with NPT threaded couples. The Contractor may recommend a different injection piping material, along with a rationale as to why the different material is superior to schedule 40 carbon steel pipe. The Contracting Officer reserves the right to accept or reject Contractor-recommended materials. The pipe sizes and lengths for each well location are listed in Attachments 3 and 4.

C. Submersible Level Element and Transmitter

1. General

   a) Function: Measure well subgrade water level by means of differential pressure and transmit a signal proportional to the level.
   b) Type: Electronic, piezoresistive-micromachined silicon strain gauge, two wire transmitter. Cable suspended sensor.
   c) Operating conditions: Transmitter shall operate in water containing low levels of industrial contaminants.
   d) Warranty: Sensor and transmitter shall be warranted against corrosion for a period of five [5] years.

2. Performance and Features:

a) Range: Noted actual working range shall lie between 40 percent and 80 percent of the maximum adjustable range. Refer to table below.
b) Accuracy: Plus or minus 0.10 percent of calibrated span.
c) Serviceable sensor.
d) Operating temperature range: Minus 5 degrees F to 140 degrees F.
e) Compensated temperature range: 30 degrees F to 86 degrees F.
f) Relative humidity: 0-100 percent.
g) Materials: Sensor body, 316 stainless steel. Cable-polyurethane jacket with Kevlar reinforced cord.
h) Periodic maintenance or cleaning shall NOT be required to maintain function or accuracy.
i) Signal Interface: Instrument shall be loop powered from 9-32V dc power supply. Output shall be 4-20 ma DC for load impedance of 0-500 ohms minimum over specified range.
j) Sensor shall have reverse polarity protection.
k) The transmitter shall be factory calibrated for the specified range(s) and shall also include provisions for field calibration through non-interactive zero and span adjustments.
l) The Vendor shall supply a sensor cable termination box. The box shall be rated NEMA 4X. All manufacturer-required termination hardware shall be supplied as part of this contract.
m) Minimum sensor cable length: as tabulated below. In no case shall the sensor cable be less than the depth from grade to bottom of injection piping , plus forty [40] feet for injection wells, and depth to pump outlet (from grade), plus ten [10] feet for extraction wells.

Well	Actual Working Head Range	Minimum Sensor Cable Length
PFE-1	0 – 150 feet water	535 feet
PFE-2	0 – 150 feet water	525 feet
PFE-3	0 – 150 feet water	535 feet
PFE-4A	0 – 150 feet water	585 feet
PFE-5	0 – 250 feet water	660 feet
PFE-7	0 – 150 feet water	485 feet
PFI-1	0 – 250 feet water	490 feet
PFI-2	0 – 250 feet water	510 feet
PFI-3	0 – 250 feet water	520 feet
PFI-4	0 – 250 feet water	530 feet

3. Suggested Manufacturer and Model

a) Instrumentation Northwest, Inc.; PS 9800 series or approved equal.

III. Execution

A. Pumping System

1. Submersible Pump – Factory Tests

a) Performance Test

The pumps shall be tested at the Manufacturer's shop to demonstrate that each submersible pump operates without instability and complies with specified performance requirements (gpm at discharge head, ft.) for the six (6) extraction wells (as specified by Attachment 3). Instability is defined when any point in usable range of the head-capacity curve cannot be repeated within three percent. When this occurs, the test shall be rerun. Compliance with specifications will be determined from curves required by the paragraph I.D.2.a. Test procedures, except as herein specified, shall be in accordance with applicable provisions of HI 2.6. The temperature of the water used for testing shall be approximately the same for all tests run and shall be recorded during test runs.

(1) Performance of the Pump

Performance of the pump shall be determined by a series of test points sufficient in number to develop a constant speed curve over the range of total heads corresponding to the requirements of Attachment 3. The test range shall include additional testing at total heads higher and equal to or lower than the total head requirement. Testing shall be inclusive for the speed involved. Test results shall meet all specified conditions of capacity, head, and bhp. In no case shall less than eight [8] points be plotted in the pumping range. If the plot of data indicates a possibility of instability or a dip in the head-capacity curve, a sufficient number of additional points on each side of the instability shall be made to clearly define the head-capacity characteristics.

(2) Test Results

Test results shall be plotted to show the total head, static heads, bhp, and efficiency as ordinates. The results should be plotted against pump discharge in gpm as the abscissa. Curves shall be plotted showing pump performance to a scale that will permit reading the head directly to twenty five [25] feet, capacity to no greater than 500 gpm, efficiency to one percent [1%], and power input to twenty-five [25] bhp. The performance test shall be made with the pump and motor assembled as an operating unit to simulate field installation unless otherwise approved in writing by the Contracting Officer. Readings shall include one point each within two [2] percent of the rated total head, minimum expected head, and maximum expected head. The test shall be conducted in accordance with accepted practices at full speed; and, unless otherwise specified, the procedure and instruments used shall conform to HI 2.6.

b) Factory Test Report

Each factory test report shall include, as a minimum, the following:

(1) Statement of the purpose of test, name of project, contract number, and design conditions. Instances where guaranteed values differ from specified values should be given.
(2) Description of pump and motor, including serial numbers, if available.
(3) Description of test procedure used, including dates, test personnel, any retest events, and witness test data.
(4) List of all test instruments with model numbers and serial numbers.
(5) A discussion of test results.
(6) Conclusions.
(7) Photographic evidence in the form of either 24 color photographs of test equipment, test setup and representative test segments. All photographic evidence shall be labeled with contract number, location, date and time, and test activity.
(8) Copies of instrument calibration.
(9) Copies of all recorded test data.
(10) Curves required by paragraph I.D. 2.a.
(11) Curves showing the performance of the pump.
(12) Drawings of the test set-up showing all pertinent dimensions and elevations.

2. Attachment at Surface

An extraction wellhead blind flange assembly, as shown in Attachment 4, will be provided by the Government for attachment to the discharge piping at the surface. The Contractor shall provide all other fittings, nuts, bolts, etc. as shown on the contract drawings and per these specifications.

3. Pumping Unit Installation

Proper installation and assembly of the pumping unit shall be the Contractor's responsibility and shall be in accordance with the drawings, the Manufacturer's installation instructions, industry standards and all applicable local, state and federal electrical codes and regulations. All deviations from the design as presented in the attachments to this scope of work are subject to Government approval. The Contractor shall identify all deviations and provide detailed drawings or a written description that shows describes the deviation(s) and a justification for the deviation.

a) Shipping and Storage

The pumps, discharge piping, and appurtenances shall be inspected by the Contractor qualified pump installation engineer/inspector when received at the project site. The pump and associated equipment shall be stored as recommended by the pump Manufacturer and protected from construction or weather hazards at the project site. Proper equipment for handling the pump shall be supplied and shall be considered as special tools if not completely standard.

b) Tools and Equipment

The Contractor shall furnish all tools and other devices necessary for installing the pumping units. The Manufacturer's representative(s) familiar with the equipment being installed shall supervise the handling, installation, start-up, and testing of the equipment as required in the paragraph I.B. The Contractor shall furnish one set of all special tools required to completely assemble, disassemble, or maintain the pumps. *Special tools* refers to oversized or specially dimensioned tools, special attachment or fixtures, or any similar items. Lifting devices required for use in conjunction with a winch or crane shall be furnished.

The Contractor shall bring power and instrumentation cable (if applicable) into the wellhead vault, and neatly coil the excess cable; the cable will be terminated by others. The Contractor shall specify power cable size in the material list. Electrical power (3-phase/60 Hz/460 volt alternating current) will ***eventually*** be available at each extraction well location; the Contractor shall supply an electrical generator of sufficient capacity to test each pump installed at the target depth in each well (per III.A.4.). The power cable to each pump shall be affixed to the discharge piping by means of metal banding or similar. All electrical work and the electrical design shall comply with the current edition of the National Electrical Code and National Electrical Safety Code. Wellhead and electrical details are presented in Attachments 4 and 5.

A qualified installation engineer/inspector shall oversee the installation of the pumping units, inspect critical elements of the pump installation, and provide a written certification attesting to the correct installation and operation of the pumping units. The Contractor shall be obligated to provide all sketches, field notes and other information to accurately document the installation of the pumping unit at each extraction well location.

The Contractor shall provide an operating and maintenance manual for the extraction well pumping units. The Contractor shall identify any operational constraints and establish and state in the operating manual the recommended procedures for starting and stopping the extraction well pumps.

Any damage to the groundwater wells, ancillary equipment, facility utilities, or other Government property, during installation shall be repaired and returned to the original configuration at no cost to the Government.

c) Cleanup Prior to Start

After the pumping unit is installed and prior to start-up, Contractor shall remove any accumulated construction debris from the work area. A representative of the Government will witness this final cleaning of the work area. Any damage to the pumping units or related equipment during initial start-up due to foreign objects left in the work area shall be corrected at no cost to the Government.

4. Pump Field Tests

Field-testing shall be conducted by an experienced field test engineer and will be witnessed by the Contracting Officer or their designee. Contractor shall provide an electrical generator sufficient for testing pumps. Before initially energizing the pump/motors, the Contractor shall have successfully tested all pumping plant control, monitoring, and protective circuits. This thorough electrical checkout procedure shall have followed a detailed step-by-step approved test plan. The motor and other pumping unit elements undergoing tests should also be checked at this time.

a) Dry Test

If allowed per the Manufacturer's instructions, each pumping unit shall be tested in the dry to determine whether it has been properly installed. The pump shall be operated at full rated speed. Should tests reveal a design or installation deficiency or a manufacturing error in pumping unit components, the problem shall be promptly corrected by, and at the expense of, the Contractor.

b) Wet Test

Each unit shall be given an operating test under load for a period of at least ten minutes or as directed by the Contracting Officer. The Contractor shall supply sufficient pipe, hose, or piping to convey pumped water to a Government-supplied temporary containment tank no further than 100 feet from the well head. Disposal of water generated during the wet test will be disposed by the Government at no cost to the Contractor. The wet tests shall be conducted by the Contractor and will be witnessed by the Government. Without additional cost to the Government, the Contractor shall make all changes and correct any errors for which the Contractor is responsible.

c) Field Test Report

A test report of the field-testing shall be prepared and submitted in accordance with Section I.D..5.b.

B. Injection Piping

1. Installation

The injection piping shall be installed in accordance with industry standards and all applicable local, state and federal codes and regulations. All deviations from the design as presented in the attachments to this scope of work are subject to the Government's approval. The Contractor shall identify all deviations and provide detailed drawings and/or a written description that shows the magnitude of the deviations and a justification for the deviation.

A qualified installation engineer/inspector shall oversee the installation of the injection piping, inspect critical elements of the installation and provide a written certification attesting to the proper installation of the injection piping at each well site. The Contractor shall provide all sketches, field notes and other information to accurately document the installation of the injection piping at each well location.

Any damage to the groundwater wells, ancillary equipment, facility utilities, etc., during installation shall be repaired and returned to the original configuration at no cost to the Government.

C. Submersible Level Element and Transmitter

1. Installation

a) The submersible level element shall be carefully lowered into the well during pump installation. The target depth shall be twenty [20] feet below the bottom of the injection piping (for injection wells), and ten [10] feet above the submersible pump outlet (for extraction wells). The submersible level element cable shall not be tangled with or affixed to the discharge piping or injection piping and shall be suspended from the wellhead flange only. Any remaining above-grade signal cable shall be neatly coiled, secured, and suspended in its respective well vault (for connection by others).

IV. Best Value Evaluation Criteria

The aforementioned specifications (Sections I through III) are the minimum specifications that the Government must have to satisfy the requirement. The Government will evaluate Offeror's response in accordance with "Best Value to the Government" using specifically the following Best Value criteria:

A. Prior corporate experience of the offeror (including any major subcontractors).

B. Scheduled completion date of the work.

C. Quality of proposed hardware components.

D. Soundness of the technical approach to accomplishing the design requirements with particular attention to operability, reliability and maintainability.

E. Proposed solutions to technical and schedule risks.

F. Terms of the contractor's performance warranty.

G. Life-Cycle Cost Comparison.

All proposals will be evaluated using a life cycle cost comparison based on total life-cycle cost (LCC), as described in this section.

(1) The offeror shall provide the following data in their proposal:

(a) The present cost of the pumping units.
(b) The steady-state operational power requirement (kW) to successfully meet Government requirements (rates, pressures, capacity/amounts, water composition, etc.) Provide marked pump and motor curves and indicate the points used for determining loads.
(c) The maximum power demand (kW) for the month required to meet the Government requirement. Provide marked pump and motor curves and indicate the points used for determining loads.
(d) The useable life expectancy of the pumping units based on meeting Government requirements.
(e) The annual cost of repair or replacement parts required to keep the unit operational for the stated life of the pump and motor and satisfying Government requirements, including but not limited to bearings, seals, impellers, packing, motor, drive-shafts, and couplings.

(2) Life Cycle Cost (LCC) will be computed by NASA, using information provided by the offeror, and using the formula shown below.

$$LCC = PV(\Sigma MC) + PV(\Sigma EC) + PV(\Sigma OM) + PV(\Sigma REP)$$ where

(a) PV(x) is the present value/cost of (item x).
(b) Σ indicates the cost data will be summed for all six pumping units.

(c) MC is the material cost of the pumping units (not including New Mexico gross receipts tax).
(d) EC is the annual energy cost for the stated life of the pump and motor or the least common multiple of stated life. NASA will assume 8,760 hours of operation per year, for the purpose of computing EC.
(e) OM is the annual cost of repair or replacement parts required to keep the unit operational for the stated life of the pump and motor or the least common multiple of stated life, including but not limited to bearings, seals, impellers, packing, motor, drive-shafts, and couplings.
(f) REP is the future replacement cost. The REP will be the future value of the present cost taken at the end of the useable life period or the least common multiple of the stated life.

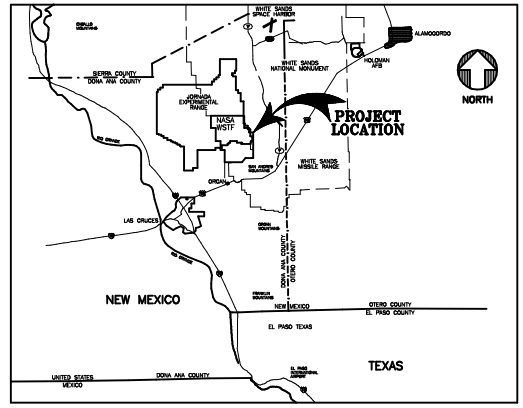
(3) A least common multiple of stated usage life will be used to evaluate alternatives, e.g., in comparing alternatives with a useable life of 5, 7, or 10 years, the life cycle comparison would be made using a period of 70-years. A 1-per cent per year increase will be used for all calculations throughout the life cycle period to be evaluated.

ATTACHMENT 1

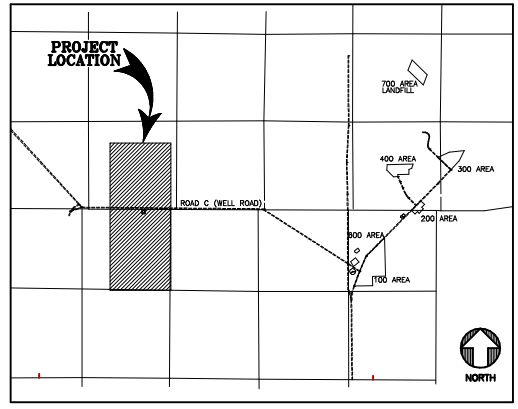
WSTF GROUNDWATER TREATMENT FACILITY

PROJECT LOCATION

GENERAL LOCATION



WSTF LOCATION



SITE LOCATION

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.
NEXT ASSY / RELATED DWG'S

DRAWN BY	M. TARIN	7-29-99
ENGINEER	J. KIRBY	7-29-99
DESIGNED BY	J. KIRBY	7-29-99
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION
PIPING SYSTEM
CIVIL
PROJECT LOCATION

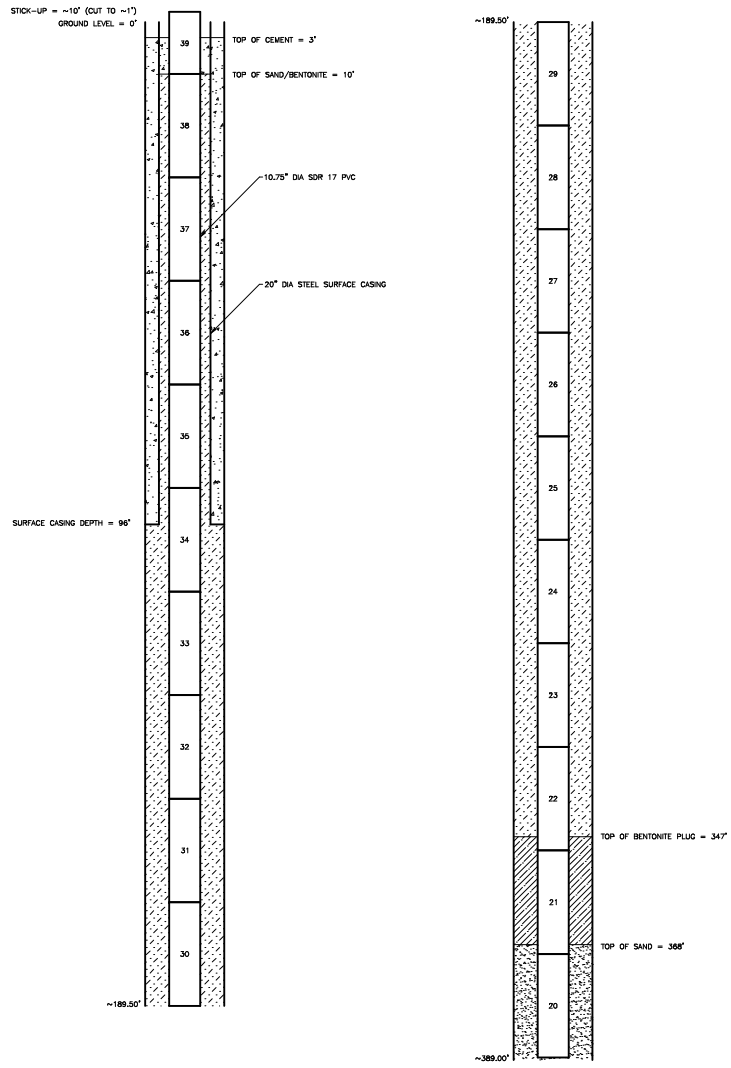
A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1
CODE IDENT. | SIZE F | DWG. NO. 652-C-01 | REV.

ATTACHMENT 2

EXTRACTION AND INJECTION WELL

CONSTRUCTION DIAGRAMS

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE

4/8 SAND

SLOUGH

4/8 SAND/BENTONITE MIX

GROUT

SCREEN

STEEL, BOLT-ON CENTRALIZER

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / REVISED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xx± FRACTIONS ±
.xxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
CIVIL
WELL COMPLETION DIAGRAM

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 653-C-03 | REV.

ATTACHMENT 3

PUMP PERFORMANCE, DESIGN AND HYDRAULIC DATA

DESIGN AND PERFORMANCE REQUIREMENTS AND HYDROLOGIC MEASUREMENTS

Well ID	Approx. Depth to Static Water (feet below grade)	Pump Performance, GPM @ Head (feet H_2O at 72 deg F.)	Approx. Pump Intake Depth (feet below grade)	Drop Pipe Diameter (nominal inches, Schedule 40 Carbon Steel)	Acceptable Make/Model
PFE-1	423	331 GPM @ 793 feet	525	4"	Grundfos/300S, 385S, or approved equal
PFE-2	435	258 GPM @ 738 feet	515	4"	Grundfos/230S, 300S, or approved equal
PFE-3	453	245 GPM @ 685 feet	525	4"	Grundfos/230S, or approved equal
PFE-4A	470	230 GPM @ 750 feet	575	4"	Grundfos/230S, or approved equal
PFE-5	451	30 GPM @ 763 feet	650	1 1/2"	Grundfos/40S, or approved equal
PFE-7	411	144 GPM @ 803 feet	475	3"	Grundfos/135S, or approved equal

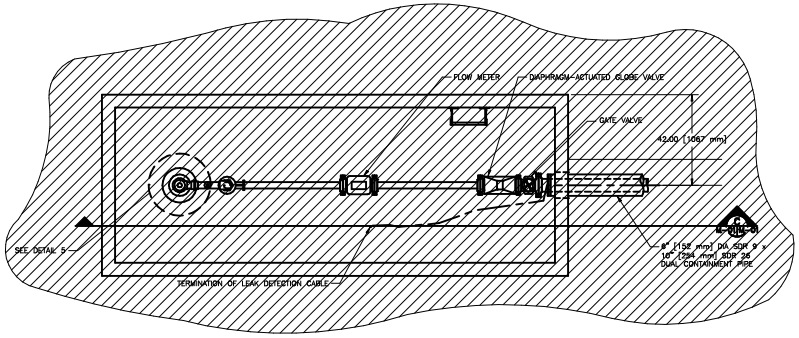
DESIGN AND PERFORMANCE REQUIREMENTS AND HYDROLOGIC MEASUREMENTS

Well ID	Depth to Water (feet below grade)	Flow Rate (GPM)	Approx. Injection Piping Total Depth (feet below grade)	Injection Piping Diameter (nominal inches)
PFI-1	440'	310	450'	3"
PFI-2	450'	309	467'	3"
PFI-3	460'	396	477'	3"
PFI-4	465'	223	488'	3"

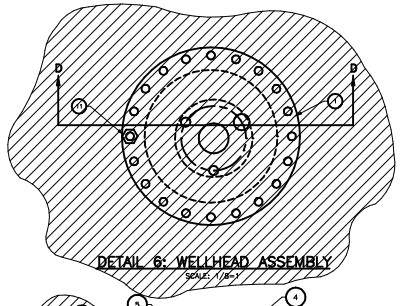
ATTACHMENT 4

WELLHEAD DETAILS

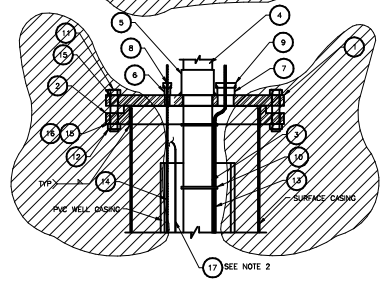
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



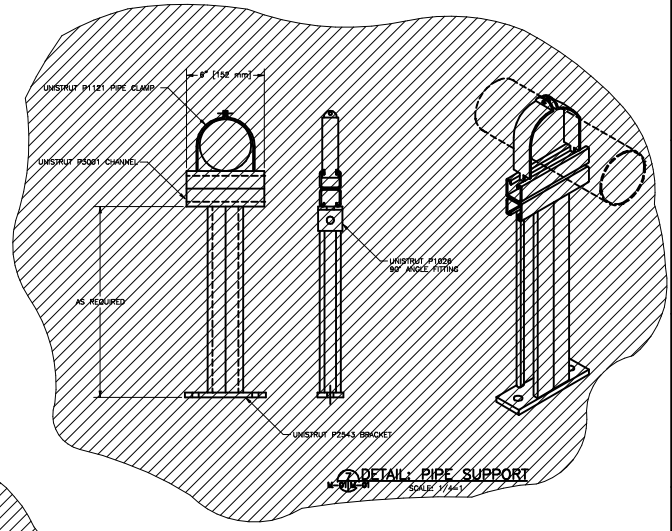
8 DETAIL: PFE-1 EXTRACTION WELL VAULT
M-PLUME-01



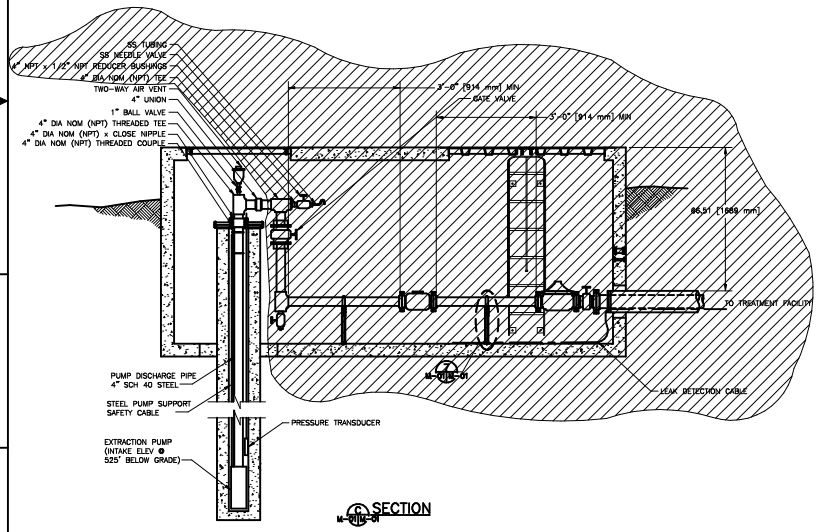
DETAIL 6: WELLHEAD ASSEMBLY
SCALE: 1/8=1



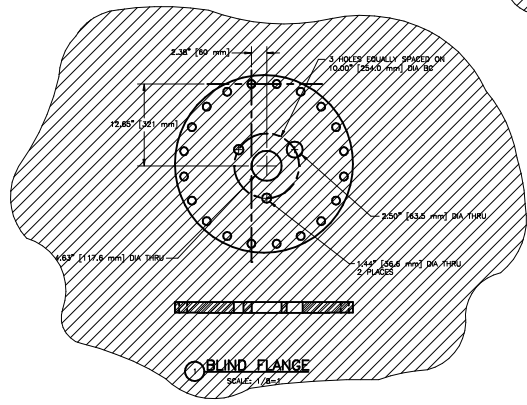
SECTION D-D



7 DETAIL: PIPE SUPPORT
M-PLUME-01
SCALE: 1"=1



SECTION
M-PLUME-01



1 BLIND FLANGE
SCALE: 1/8=1

SUPPLIED BY OTHERS
WELL, WELL HEAD VAULT, BLIND FLANGE AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY PUMP/MOTOR ASSEMBLY POWER CABLE, TRANSDUCER, TEE, REDUCER BUSHING, BALL VALVE, VENT-VACUUM VALVE STRAIN RELIEF CONNECTORS AND ASSOCIATED FITTINGS

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER
2. SAFETY CABLE TERMINATION AND SECURING METHOD SHALL BE DETERMINED BY PUMP INSTALLATION CONTRACTOR.

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
	17		SAFETY CABLE, 0.5" DIA	CS		
4	16		WASHER, LOCK, 1.125" DIA	CS		
8	15		WASHER, FLAT, 1.125" DIA	CS		
	14		TRANSDUCER CABLE	CU		
	13		PUMP POWER CABLE	CU		
4	12		NUT, 1.125" DIA	CS		
4	11		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
	10		STRAP	SS		
1	9		STRAIN RELIEF CONNECTOR, 2"	SS		
1	8		STRAIN RELIEF CONNECTOR, 1"	SS		
1	7		COUPLING, 2" NPT, SCH 80	CS		
2	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		COUPLING, 4" ASTM	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		NIPPLE, 4" NPT x CLOSE	CS		
1	3		DROP PIPE, 4" DIA x 525', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	

NEXT ASSY / REUSED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xx± FRACTIONS ±
.xxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
MECHANICAL DETAILS

A.E. DWG. NO.
SCALE 1/2"=1'-0"
SHEET 1 OF 1
CODE IDENT. F
SIZE D
DWG. NO. 653-M-01
REV.

ATTACHMENT 5

ELECTRICAL DETAILS

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BAY #1	BAY #2	BAY #3	BAY #4
RELAY CABINET FOR PLC CONTROLLER	FVNR NEMA SIZE 2	BLANK	C/B 50A COMPAC
			BLANK
	PANEL 3ø, 18 CKT 120/208V 100A MLO	SSRV CONTROLLER C/B * 150 HP	BLANK
			METER (1)
	XFMR 15 KVA 3ø 4W 25A C/B (480V) 40A C/B (208V)		TVSS 30A C/B (2)
			MAIN 450A C/B

* TO BE SIZED BY MANUFACTURER TO PROVIDE PROPER SHORT CIRCUIT PROTECTION OF MOTOR IT IS TO PROTECT.

SCHEDULE – MOTOR CONTROL CENTER
480 VAC, 3ø, 4W, 42KA, NEMA 3R
600A INCOMING, 600A HORIZONTAL, 300A VERTICAL

SECTION/UNIT LOCATION	DESC	NEMA SIZE	CB TRIP (A)	AUX INTLKS NO	AUX INTLKS NC	SELECTOR SWITCHES	INDICATING LIGHTS	IDENTIFICATIONS
1								
2A	FVNR	2	70	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	SPARE
2E	C/B		40					100A, 3ø, 18 CKT, PNL
2N	C/B		25					15 KVA, 3ø, 4W, XFMRS
3A								
3D	SSRV	N/A	*	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	PFE-1 PUMP
4A	C/B		50					SPARE
4C								
4G								
4K								METER (1)
4P			30					TVSS (2)
4T			450					MAIN

KEYED NOTES:

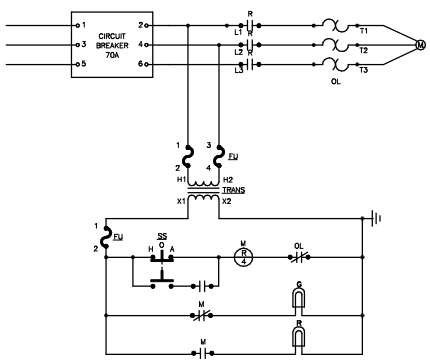
(1) FURNISH STANDARD METER SLOT OPENING IN FRONT OF MCC'S PANEL COVER. PROVIDE CLEAR PLASTIC WEATHER PROOF COVER OVER OPENING. METER DEVICE AND ASSOCIATED CT'S AND PT'S TO BE FURNISHED AND INSTALLED BY OTHERS.

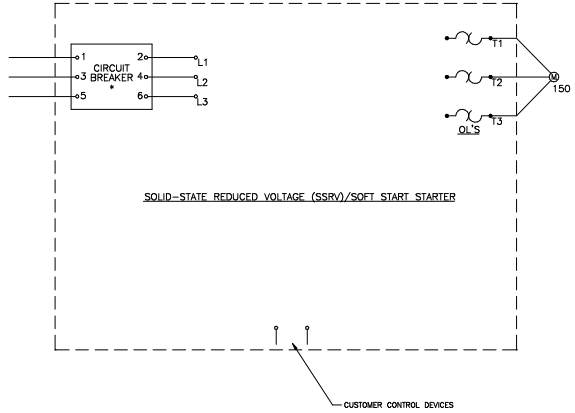
(2) FURNISH MANUFACTURER'S STANDARD TVSS PROTECTION INTEGRAL WITH MCC.

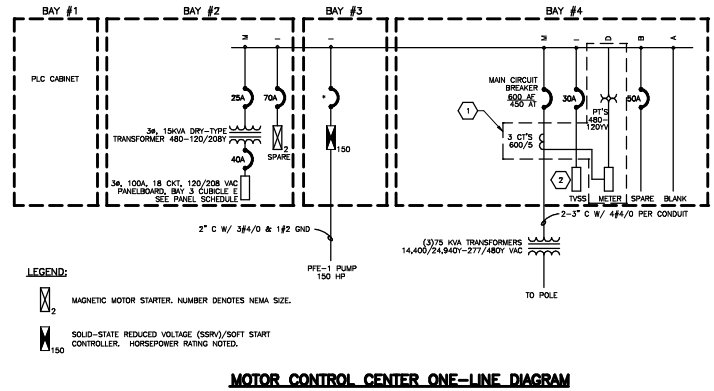
SCHEDULE – PANEL "LA"

BUILDING: PFE-1	LOCATION: MCC	PHASE: 3	
TYPE:	FEED:	WIRE: 4	
MANUFACTURER:	SC RATING: 10,000	VOLTAGE: 120/208	
MODEL:	MAIN AMPS:	MOUNTING: INTERNAL TO MCC	
CONFIGURATION:	PANEL AMPS: 100 MLO COPPER		

CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	ø LOAD (AMPS) A	B	C	CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	ø LOAD (AMPS) A	B	C
1	1	20	PLC POWER	10			2	1	–	SPACE ONLY			
3	1	20	PLC RECEPT		1.5		4	1	–				
5	1	20	PFE-1 VAULT RECEPT			1.5	6	1	–				
7	1	20	PFE-1 FLOW METER	.83			8	1	–				
9	1	20	MCC RECEPT		1.5		10	1	–				
11	1	20	SPARE				12	1	–				
13	1	20	SPARE				14	1	–				
15	1	–	SPACE ONLY				16	1	–				
17	1	–					18	1	–				
TOTAL CONNECTED LOAD PER PHASE, AMPS							TOTAL CONNECTED LOAD PER PHASE, AMPS						
TOTAL CONNECTED LOAD 3-PHASE, AMPS							TOTAL CONNECTED LOAD 3-PHASE, AMPS						







LEGEND:

$\boxtimes_2$ MAGNETIC MOTOR STARTER. NUMBER DENOTES NEMA SIZE.

$\boxtimes_{150}$ SOLID-STATE REDUCED VOLTAGE (SSRV)/SOFT START CONTROLLER. HORSEPOWER RATING NOTED.

MOTOR CONTROL CENTER ONE-LINE DIAGRAM

SPARE

PFE-1 PUMP

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / RELATED ASSYS

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000± DECIMALS ±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-1
ELECTRICAL DETAILS

A.S. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 653-E-02 | REV.

ATTACHMENT 6

JSC Form 262

National Aeronautics and Space Administration

White Sands Test Facility

UV Oxidation System Procurement Specifications

Table of Contents

1. GENERAL 2
   1.1 Description 2
   1.2 Definitions 2
   1.3 Vendor Qualifications 2
   1.4 Reference Standards 3
   1.5 Inspection 3
   1.6 Proposal Submittal 3
   1.7 Drawing Package 3
   1.8 Submittals Prior to Equipment Delivery 4
   1.9 Approval of Equivalent Substitutions 4
   1.10 Warranty 4
   1.11 Equipment Destination 5
2. MATERIALS AND EQUIPMENT 5
   2.1 Mechanical 5
   2.2 Controls and Instrumentation 6
   2.3 Electrical 7
   2.4 Spare Parts Kit 8
   2.5 Performance of UV Oxidation System 8
3. FABRICATION, ASSEMBLY, AND TESTING 9
   3.1 Fabrication and Assembly 9
   3.2 Testing 9
4. EXECUTION 9
   4.1 Required Services 9
   4.2 Optional Services 9
5. DELIVERY SCHEDULE 10

ATTACHMENTS

1. Section 13390: Package Control Systems
2. Section 13390, Supplement A: Package Control System Component Specifications

1. GENERAL

1.1 Description

This Procurement Specification outlines the requirements for the UV oxidation equipment needed for the plume-front remediation system currently being designed for the National Aeronautics and Space Administration's (NASA's) White Sands Test Facility (WSTF). The plume-front remediation system is being designed by NASA-WSTF's environmental sub-contractor (Lynx Ltd.), and is being procured by NASA. The plume-front remediation system is a groundwater pump-and-treat system, for the treatment of n-nitrosodimethylamine (NDMA), n-nitrodimethylamine (DMN or DMA), trichloroethylene (TCE), tetrachloroethylene (PCE), and several Freon® compounds. Sieve tray air strippers will be utilized to remove the TCE, PCE, and Freons® from the groundwater, prior to UV oxidation treatment.

VENDOR shall furnish one (1) factory-assembled UV oxidation reactor, complete with lamps, power supplies, related equipment, and spare parts as required by this specification. The UV oxidation reactor(s) shall be designed for the destruction of n-nitrosodimethylamine (NDMA, CASRN 62-75-9) and n-nitrodimethylamine (DMN, CASRN 4164-28-7) in groundwater, incorporating mercury-vapor UV lamps that are designed to emit UV radiation in the 200 to 260 nm absorbance spectrum range.

1.2 Definitions

The term "NASA" used in these specifications refers to NASA and its representatives designated by the Contracting Officer. The term "Contracting Officer" refers to the procurement official or buyer administering this contract. The term "VENDOR" refers to Calgon Carbon Oxidation Technologies.

1.3 Vendor Qualifications

1.3.1 Vendors who have installed UV oxidation systems for the destruction of NDMA and/or DMN in groundwater, at a flow rate greater than or equal to 900 gpm, shall be considered.

1.3.2 Vendors who have installed UV oxidation systems for the destruction of NDMA and/or DMN, for a period of no less than 5 years, shall be considered.

1.3.3 Vendors who have installed UV oxidation systems for the destruction of NDMA and/or DMN, for no less than 10 applications, shall be considered.

1.4 Reference Standards

The manufacture of the UV oxidation system shall comply with the applicable provisions and recommendations of the following:

A. Hydraulic Standard Institute
B. National Electrical Manufacturers Association (NEMA)
C. National Electric Code (NEC)
D. Underwriters Laboratory (UL)
E. Canadian Standards Association (CSA)

VENDOR shall assume complete responsibility for conformance with the Reference Standards listed above, and this Bid Specification.

1.5 Inspection

The quality of all equipment and materials shall be subject to the inspection and approval of NASA. The performance testing required in Section 2.5 of this specification shall be subject to the inspection and approval of NASA. NASA reserves the right to conduct inspection of the equipment, materials of construction, and performance testing at VENDOR's manufacturing facility. NASA reserves the right to designate a representative to conduct the inspection and performance testing of the UV oxidation system. VENDOR shall notify NASA, a minimum of 2 weeks in advance of the day fabrication of the UV oxidation system commences.

1.6 Proposal Submittal

VENDOR shall provide as a minimum, but not limited to, the following information in its bid package:

A. Equipment and Performance warranty, including a written guarantee that the UV oxidation system will continuously meet the performance standards listed in Section 2.5 of this specification.
B. Documentation that VENDOR meets the qualification requirements listed in Section 1.3 of this specification.
C. An estimate of the lead-time required to commence fabrication, and the time needed to fabricate, test, and deliver the UV oxidation system and related equipment.

1.7 Drawing Package

Within 3 weeks following award by NASA, VENDOR shall submit a drawing package to include:

A. Manufacturer cut sheets of vendor-supplied components.
B. Shop drawings.
C. Manufacturers catalog data for all equipment, components, and accessories.

D. A list of common spare parts (including sources, part numbers, and recommended quantities) that may kept in inventory by NASA.
E. Process & instrumentation drawings showing all vendor-supplied components.
F. Tank-mounted air compressors in excess of 2 horsepower must have an ASME Manufacturer's Data Report (ASME form U-1 or U-1A) which states that the compressor and its mount have been accounted for in the vessel design and fabrication processes. This document is available from the vessel supplier.

VENDOR shall not commence fabrication of the UV oxidation system until NASA approves all shop drawings and provides VENDOR with a written Notice to Proceed.

1.8 Submittals Prior to Equipment Delivery

Vendor shall submit the following information and documents to NASA prior to shipment of the UV oxidation system:

A. Documentation of results of hydraulic testing required under Section 3.2.
B. Two (2) 3.5 inch floppy disk copies of the completely documented PLC program, along with two (2) fully annotated printed copies.
C. Printed instructions and drawings sufficient for proper installation of the UV oxidation system.
D. Two copies of the UV oxidation system Operation and Maintenance manual.

1.9 Approval of Equivalent Substitutions

VENDOR may propose substitutions to the equipment or materials of construction described in this specification. NASA reserves the right to accept or reject any such proposals.

1.10 Warranty

VENDOR shall warrant the UV oxidation and associated equipment for a period of twelve (12) months from the date of system start-up.

1.11 Equipment Destination

The UV oxidation system shall be shipped to:

NASA Johnson Space Center
White Sands Test Facility (WSTF)
Building 120
U.S. Highway 70, 18 miles Northeast of Las Cruces
Las Cruces, New Mexico, 88012

2. MATERIALS AND EQUIPMENT

2.1 Mechanical

2.1.1 General

The UV oxidation reactor shall be suitable for installation on an unsealed, sealed, or painted concrete floor in an industrial indoor environment maintained between 40º F and 100º F. The UV oxidation power supply shall be suitable for installation on an unsealed, sealed, or painted concrete floor in an industrial indoor environment maintained between 50º F and 85º F.

2.1.2 Reactor

The UV oxidation reactor shall contain a sufficient number of UV lamps to meet the performance specifications listed in Section 2.5. Wetted parts shall be constructed of 316L stainless steel, quartz, or fluoropolymers.

2.1.3 UV Lamps

The UV lamps used in the UV oxidation reactor shall be specifically designed to provide a broad spectrum of light emission between 200 nanometer (nm) and 300 nm to maximize photochemical destruction of NDMA and DMN. A minimum of 30% of the total lamp output must be below 300 nm. The lamps must be capable of providing 3,000 hours of operation with no more than a 20% decrease in emissions in the 200 to 300 nm spectrum range.

2.1.4 Quartz Sleeve Cleaning Mechanism

A cleaning mechanism shall be provided for each quartz sleeve to maintain efficient transmittance of UV light. The mechanism shall be constructed of materials that are not affected by high intensity UV radiation. The cleaning system must operate automatically with an adjustable time interval. The wiper assembly shall be driven by a pneumatic system providing positive action. Limit switches shall be provided at both ends of wiper travel for fail-safe indication of proper operation. Operation of the cleaning mechanism must not divert or otherwise disrupt water flow to the reactor, or reduce the effectiveness of the treatment.

2.2 Controls and Instrumentation

2.2.1 Interface with Master Control System

A master control system that integrates the air strippers, UV oxidation system, and other components of the plume-front remediation system will be utilized. This master control system will monitor the operation of all system components, shut the system down under specific conditions, and provide for taking components off-line for maintenance. The UV oxidation control cabinet shall provide spare contacts for each control function so that the control functions can be monitored at the master control system.

2.2.2 UV Oxidation Reactor Control System

2.2.2.1 The UV Oxidation system shall be controlled by a reliable programmable logic controller (PLC). The PLC shall be factory programmed and tested prior to shipment. The PLC must be listed by a Nationally Recognized Testing Laboratory (NRTL), and comply with the requirements of Section 13390, Supplement A.

2.2.2.2 The system shall be operated from a main control console with system status and operational data shown on an interface display with an alphanumeric screen. Data entry shall be made from a keypad. The operator interface shall be programmed with test and diagnostic functions to permit testing of all equipment while the system is off line for maintenance. This shall include, but not is limited to, operation of all cooling fans, operation of quartz wiper mechanisms, and operation of interlocks.

2.2.2.3 The PLC shall have sufficient capacity and contacts for control and interface with all standard and optional features and equipment provided with the UV oxidation system. The PLC shall have sufficient capacity and contacts for control and interface with the master control system discussed in Section 2.2.1 of this specification. In case of power outage, the PLC memory must be maintained by a continuously charged lithium battery.

2.2.2.4 Each UV oxidation system shall have an individual PLC and control panel to permit completely independent operation.

2.2.2.5 VENDOR shall use Allen Bradley PLC(s) and related components, as stated in Section 13390 Supplement A.

2.2.2.6 The control panel(s) housing the PLC(s) shall be a NEMA 4/12 enclosure.

2.2.2.7 Interlocks will be provided to alarm and/or shutdown the UV/Oxidation system under the following conditions:

A. High temperature in lamp drive enclosure.
B. Low water flow rate.
C. High temperature in the UV oxidation tower.
D. Leak from UV oxidation tower.
E. Lamp failure.
F. High voltage cabinet door is open.
G. Reactor access covers are open.
H. Transmittance controller failure.

2.2.2.8 A modem shall be installed to allow remote monitoring and diagnosis by the manufacturer, and to allow for programming changes to the system.

2.2.2.9 The control panel shall comply with all requirements of Section 13390.

2.2.2.10 The quartz sleeve cleaning mechanism shall be actuated by a vendor-supplied reciprocating air compressor. The air compressor shall meet the following criteria:

A. System pressure relief set point shall not exceed 150 psig.
B. Air compressor tank shall be ASME code stamped for 150 psig or higher at 0º F to 650º F and have a volume capacity of 240 gallons (32.1 ft^3) or less.
C. Air compressor tank shall be registered with the National Board of Boiler and Pressure Vessel Inspectors.
D. All plastic components to be steel reinforced or contained within a metal housing.

2.3 Electrical

2.3.1 A power supply shall be provided for each UV lamp. The power supplies shall be installed in a NEMA 3R ventilated / drip-proof enclosure. All internal wiring must comply with NEC and be certified by a US OSHA accredited Nationally Recognized Testing Laboratory (NRTL). Efficiency of the power supplies must be at least 92% and the power factor must be greater than 0.9 at full power.

2.3.2 The power supply system shall be provided with cooling fans, thermal protection, safety access interlock, lamp run meters, lamp ammeters, lamp voltmeters, and main power disconnect. If the power supply system is physically separate from the UV oxidation reactor, power disconnects shall be provided on both the power supply system and the UV oxidation reactor.

2.3.3 VENDOR's power supply shall be wired for 480 Vac, 3 phase, 4 wire, 60 Hz.

2.4 Spare Parts Kit

2.4.1 Vendor shall include a spare parts kit with the UV oxidation system. The spare parts kit shall include:

A. Three (3) UV lamps.
B. Three (3) quartz tubes.
C. Three (3) sets of ceramic lamp insulators.
D. Three (3) sets of quartz tube seals.

2.5 Performance of UV Oxidation System

2.5.1 The UV oxidation system will be designed to meet the following performance specifications:

Table 2.1 UV Oxidation System Performance Specifications

Criteria	Specification	
Total Hydraulic Flow Rate		1,100 gpm
Minimum Flow Rate		200 gpm
Design life		No less than 15 years
Influent Water Temperature		15º to 20 ºC
Maximum System Pressure		100 psig
Maximum Pressure Drop		10 psig
Expected Influent Concentrations	NDMA DMN	2,000 ppt 450 ppt
Regulatory Effluent Standards	NDMA DMN	10 ppt 10 ppt
Treatment Goals	NDMA DMN	2 ppt 2 ppt

2.5.2 The UV oxidation system shall be sized such that the concentration of each contaminant in the effluent is equal to or less than the appropriate Treatment Goal listed in Table 2.1.

3. FABRICATION, ASSEMBLY, AND TESTING

3.1 Fabrication and Assembly

The manufacturer shall furnish all tools, materials, labor, and appurtenances necessary for the complete fabrication, testing and shipment of the UV oxidation system and appurtenances. All equipment shall be new and unused, except for equipment used in final check-out testing.

3.2 Testing

VENDOR shall test the assembled UV oxidation system at design water flow rate to confirm proper hydraulic, electrical, control, and leak-free performance of basic system and all accessories.

4. EXECUTION

4.1 Required Services

VENDOR shall provide the start-up services of a qualified field service representative for the purpose of installation inspection, system commissioning, and instruction of facility personnel in proper operating and maintenance procedures. Upon completion of inspection, VENDOR's field service representative shall provide written certification to NASA that the equipment has been properly installed. The proposal shall include an estimate of the number of mandays and the per diem cost for these startup services.

4.2 Optional Services

VENDOR is requested to bid a Periodic Maintenance Contract as an option. The optional Periodic Maintenance Contract must include as a minimum:

4.2.1 Visits to the job site to perform preventative maintenance, (i.e., check the performance of, examine, adjust and calibrate, as may be required, the UV oxidation system), and replacement of the lamps if needed. Visits to the job site shall be scheduled to coincide with replacement of lamps at expiration of their warranted life.

4.2.2 Emergency service including all non-scheduled repair labor. Travel, labor, lodging, and per diem expenses for non-scheduled visits shall be invoiced to a purchase order to be issued in a separate procurement action.

4.2.3 All parts and labor (other than emergency or non-scheduled labor) for maintenance of the system including replacement of UV lamps.

5. DELIVERY SCHEDULE

The complete UV oxidation system shall be delivered to the Job Site no later than 18 weeks following issuance of a written notice to proced by NASA, as discussed in Section 1.7.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BAY #1	BAY #2	BAY #3	BAY #4
RELAY CABINET FOR PLC CONTROLLER	FVNR NEMA SIZE 2	BLANK	C/B 50A COMPAC
	PANEL 3ø, 18 CKT 120/208V 100A MLO	SSRV CONTROLLER C/B * 100 HP	BLANK
			BLANK
			METER (1)
	XFMR 15 KVA 3ø 4W 25A C/B (480V) 40A C/B (208V)		TVSS 30A C/B (2)
			MAIN 300A C/B

* TO BE SIZED BY MANUFACTURER TO PROVIDE PROPER SHORT CIRCUIT PROTECTION OF MOTOR IT IS TO PROTECT.

SCHEDULE – MOTOR CONTROL CENTER
480 VAC, 3ø, 4W, 42KA, NEMA 3R
600A INCOMING, 600A HORIZONTAL, 300A VERTICAL

SECTION/UNIT LOCATION	DESC	NEMA SIZE	CB TRIP (A)	AUX INTLKS NO	AUX INTLKS NC	SELECTOR SWITCHES	INDICATING LIGHTS	IDENTIFICATIONS
1								
2A	FVNR	2	70	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	SPARE
2E			40					100A, 3ø, 24 CKT, PNL
2N			25					15 KVA, 3ø, 4W, XFMRS
3A								
3D	SSRV	N/A	*	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	PFE-2 PUMP
4A	C/B		50					SPARE
4C								
4G								
4K								METER (1)
4P			30					TVSS (2)
4T			300					MAIN

SCHEDULE – PANEL "LA"

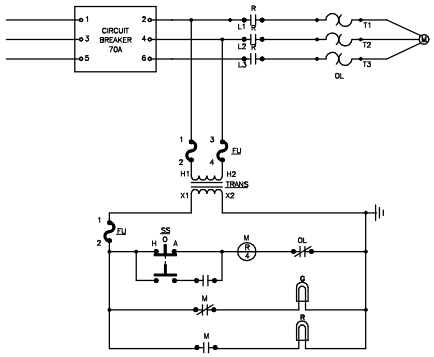
BUILDING: PFE-2	LOCATION: MCC		PHASE: 3
TYPE:	FEED:		WIRE: 4
MANUFACTURER:	SC RATING: 10,000		VOLTAGE: 120/208
MODEL:	MAIN AMPS:		MOUNTING: INTERNAL TO MCC
CONFIGURATION:	PANEL AMPS: 100 MLO COPPER		

CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	* LOAD (AMPS) A	B	C	CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	* LOAD (AMPS) A	B	C
1	1	20	PLC POWER	10			2	1	–	SPACE ONLY			
3	1	20	PLC RECEPT		1.5		4	1	–				
5	1	20	PFE-2 VAULT RECEPT			1.5	6	1	–				
7	1	20	PFE-2 FLOW METER	.83			8	1	–				
9	1	20	MCC RECEPT		1.5		10	1	–				
11	1	20	SPARE				12	1	–				
13	1	20	SPARE				14	1	–				
15	1	–	SPACE ONLY				16	1	–				
17	1	–	↓				18	1	–	↓			
TOTAL CONNECTED LOAD PER PHASE, AMPS							TOTAL CONNECTED LOAD PER PHASE, AMPS						
TOTAL CONNECTED LOAD 3-PHASE, AMPS							TOTAL CONNECTED LOAD 3-PHASE, AMPS						

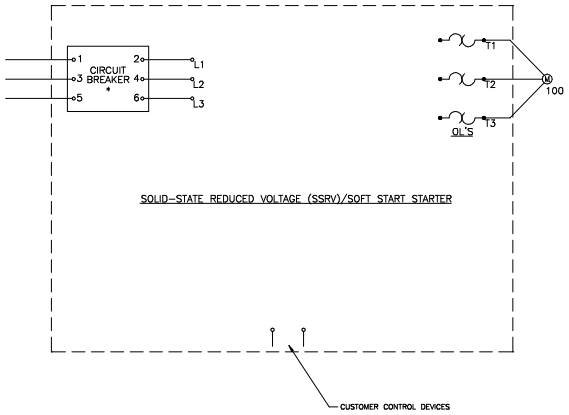
KEYED NOTES:

(1) FURNISH STANDARD METER SLOT OPENING IN FRONT OF MCC'S PANEL COVER. PROVIDE CLEAR PLASTIC WEATHER PROOF COVER OVER OPENING. METER DEVICE AND ASSOCIATED CT'S AND PT'S TO BE FURNISHED AND INSTALLED BY OTHERS.

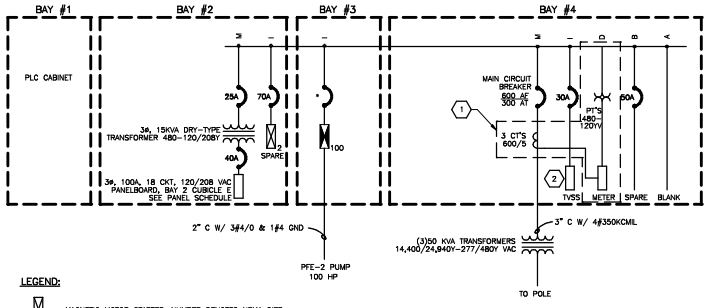
(2) FURNISH MANUFACTURER'S STANDARD TVSS PROTECTION INTEGRAL WITH MCC.



SPARE



PFE-2 PUMP



LEGEND:

$\boxtimes_2$ MAGNETIC MOTOR STARTER. NUMBER DENOTES NEMA SIZE.

$\boxtimes_{100}$ SOLID-STATE REDUCED VOLTAGE (SSRV)/SOFT START CONTROLLER. HORSEPOWER RATING NOTED.

MOTOR CONTROL CENTER ONE-LINE DIAGRAM

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SKE NO.

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-2
ELECTRICAL
DETAILS

A.B. DWG. NO.
SCALE NONE
SHEET 1 OF 1
CODE IDENT.
SIZE F
DWG. NO. 654-E-02
REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BAY #1	BAY #2	BAY #3	BAY #4
			C/B 50A COMPAC
	FVNR NEMA SIZE 2	BLANK	BLANK
RELAY CABINET FOR PLC CONTROLLER	PANEL 30, 1Ø CKT 120/208V 100A MLO	SSRV CONTROLLER C/B * 100 HP	BLANK
			METER (1)
	XFMR 15 KVA 3Ø 4W 25A C/B (480V) 40A C/B (208V)		TVSS 30A C/B (2)
			MAIN 300A C/B

* TO BE SIZED BY MANUFACTURER TO PROVIDE PROPER SHORT CIRCUIT PROTECTION OF MOTOR IT IS TO PROTECT.

SCHEDULE – MOTOR CONTROL CENTER
480 VAC, 3Ø, 4W, 42KA, NEMA 3R
600A INCOMING, 600A HORIZONTAL, 300A VERTICAL

SECTION/UNIT LOCATION	DESIG	NEMA SIZE	CB TRIP (A)	AUX INTLKS NO	AUX INTLKS NC	SELECTOR SWITCHES	INDICATING LIGHTS	IDENTIFICATIONS
1								
2A	FVNR	2	70	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	SPARE
2E			40					100A, 3Ø, 24 CKT, PNL
2N			25					15 KVA, 3Ø, 4W, XFMRS
3A								
3D	SSRV	N/A	*	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	PFE-3 PUMP
4A	C/B		50					SPARE
4C								
4G								
4K								METER (1)
4P			30					TVSS (2)
4T			300					MAIN

KEYED NOTES:

(1) FURNISH STANDARD METER SLOT OPENING IN FRONT OF MCC'S PANEL COVER. PROVIDE CLEAR PLASTIC WEATHER PROOF COVER OVER OPENING. METER DEVICE AND ASSOCIATED CT'S AND PT'S TO BE FURNISHED AND INSTALLED BY OTHERS.

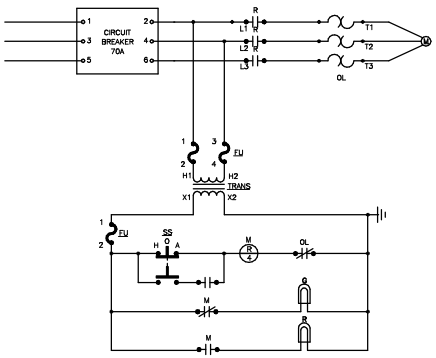
(2) FURNISH MANUFACTURER'S STANDARD TVSS PROTECTION INTEGRAL WITH MCC.

SCHEDULE – PANEL "LA"

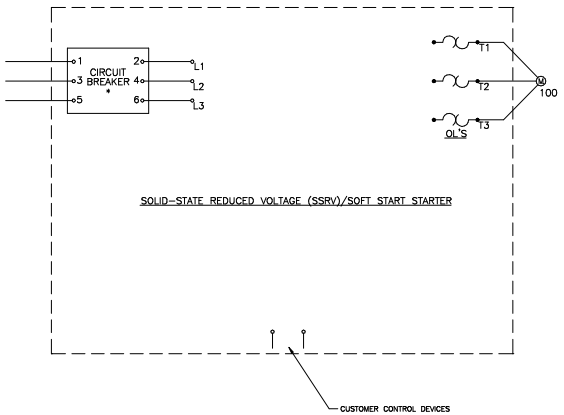
BUILDING: PFE-3 | LOCATION: MCC | PHASE: 3
TYPE: | FEED: | WIRE: 4
MANUFACTURER: | SC RATING: 10,000 | VOLTAGE: 120/208
MODEL: | MAIN AMPS: | MOUNTING: INTERNAL TO MCC
CONFIGURATION: | PANEL AMPS: 100 MLO COPPER

CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	φ LOAD (AMPS) A	B	C	CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	φ LOAD (AMPS) A	B	C
1	1	20	PLC POWER	10			2	1	–	SPACE ONLY			
3	1	20	PLC RECEPT		1.5		4	1	–				
5	1	20	PFE-3 VAULT RECEPT			1.5	6	1	–				
7	1	20	PFE-3 FLOW METER	.83			8	1	–				
9	1	20	MCC RECEPT		1.5		10	1	–				
11	1	20	SPARE				12	1	–				
13	1	20	SPARE				14	1	–				
15	1	–	SPACE ONLY				16	1	–				
17	1	–					18	1	–				
TOTAL CONNECTED LOAD PER PHASE, AMPS							TOTAL CONNECTED LOAD PER PHASE, AMPS						
TOTAL CONNECTED LOAD 3-PHASE, AMPS							TOTAL CONNECTED LOAD 3-PHASE, AMPS						

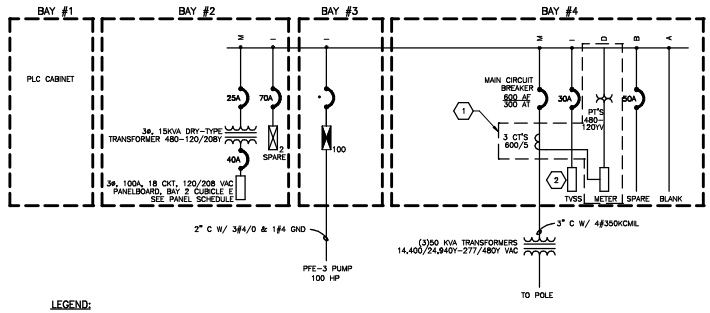
BAY #3



SPARE



PFE-3 PUMP



LEGEND:

N_2 MAGNETIC MOTOR STARTER. NUMBER DENOTES NEMA SIZE.

M_{100} SOLID-STATE REDUCED VOLTAGE (SSRV)/SOFT START CONTROLLER. HORSEPOWER RATING NOTED.

MOTOR CONTROL CENTER ONE-LINE DIAGRAM

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SKE NO.

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE:
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-3
ELECTRICAL
DETAILS

A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 655-E-02 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BAY #1	BAY #2	BAY #3	BAY #4
RELAY CABINET FOR PLC CONTROLLER	FVNR NEMA SIZE 2	BLANK	C/B 50A COMPAC
	PANEL 3ø, 1Ø CKT 120/208V 100A MLO	SSRV CONTROLLER C/B * 100 HP	BLANK
			BLANK
			METER (1)
	XFMR 15 KVA 3ø 4W 25A C/B (480V) 40A C/B (208V)		TVSS 30A C/B (2)
			MAIN 300A C/B

* TO BE SIZED BY MANUFACTURER TO PROVIDE PROPER SHORT CIRCUIT PROTECTION OF MOTOR IT IS TO PROTECT.

SCHEDULE – MOTOR CONTROL CENTER
480 VAC, 3ø, 4W, 42KA, NEMA 3R
600A INCOMING, 600A HORIZONTAL, 300A VERTICAL

SECTION/UNIT LOCATION	DESC	NEMA SIZE	CB TRIP (A)	AUX INTLKS NO	AUX INTLKS NC	SELECTOR SWITCHES	INDICATING LIGHTS	IDENTIFICATIONS
1								
2A	FVNR	2	70	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	SPARE
2E			40					100A, 3ø, 24 CKT, PNL
2N			25					15 KVA, 3ø, 4W, XFMRS
3A								
3D	SSRV	N/A	*	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	PFE-4A PUMP
4A	C/B		50					SPARE
4C								
4G								
4K								METER (1)
4P			30					TVSS (2)
4T			300					MAIN

SCHEDULE – PANEL "LA"

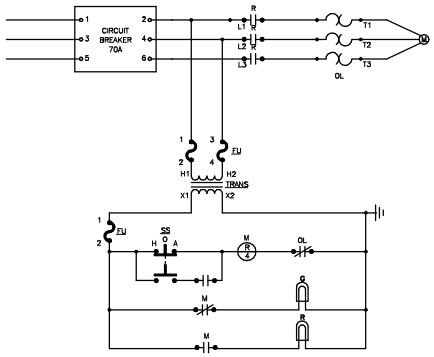
BUILDING: PFE-4A	LOCATION: MCC		PHASE: 3
TYPE:	FEED:		WIRE: 4
MANUFACTURER:	SC RATING: 10,000		VOLTAGE: 120/208
MODEL:	MAIN AMPS:		MOUNTING: INTERNAL TO MCC
CONFIGURATION:	PANEL AMPS: 100 MLO COPPER		

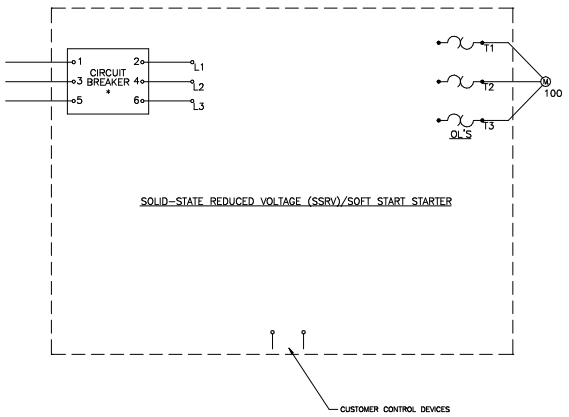
CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	* LOAD (AMPS) A	B	C	CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	* LOAD (AMPS) A	B	C
1	1	20	PLC POWER	10			2	1	–	SPACE ONLY			
3	1	20	PLC RECEPT		1.5		4	1	–				
5	1	20	PFE-4A VAULT RECEPT			1.5	6	1	–				
7	1	20	PFE-4A FLOW METER	.83			8	1	–				
9	1	20	MCC RECEPT		1.5		10	1	–				
11	1	20	SPARE				12	1	–				
13	1	20	SPARE				14	1	–				
15	1	–	SPACE ONLY				16	1	–				
17	1	–	↓				18	1	–	↓			
TOTAL CONNECTED LOAD PER PHASE, AMPS							TOTAL CONNECTED LOAD PER PHASE, AMPS						
TOTAL CONNECTED LOAD 3-PHASE, AMPS							TOTAL CONNECTED LOAD 3-PHASE, AMPS						

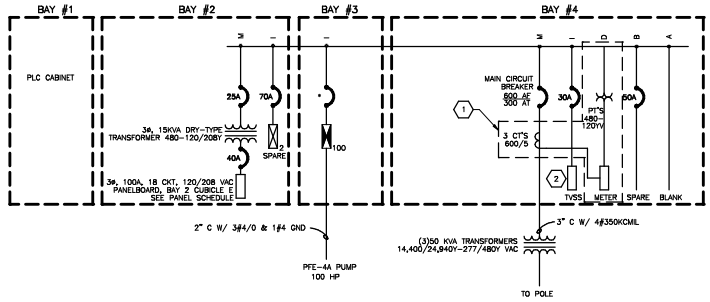
KEYED NOTES:

(1) FURNISH STANDARD METER SLOT OPENING IN FRONT OF MCC'S PANEL COVER. PROVIDE CLEAR PLASTIC WEATHER PROOF COVER OVER OPENING. METER DEVICE AND ASSOCIATED CT'S AND PT'S TO BE FURNISHED AND INSTALLED BY OTHERS.

(2) FURNISH MANUFACTURER'S STANDARD TVSS PROTECTION INTEGRAL WITH MCC.







LEGEND:

$\boxtimes_2$ MAGNETIC MOTOR STARTER. NUMBER DENOTES NEMA SIZE.

$\boxtimes_{100}$ SOLID-STATE REDUCED VOLTAGE (SSRV)/SOFT START CONTROLLER. HORSEPOWER RATING NOTED.

MOTOR CONTROL CENTER ONE-LINE DIAGRAM

SPARE

PFE-4A PUMP

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SKE. NO.

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-4A
ELECTRICAL
DETAILS

A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 656-E-02 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BAY #1	BAY #2	BAY #3
RELAY CABINET FOR PLC CONTROLLER	FVNR NEMA SIZE 2	C/B 50A COMPAC
		BLANK
	PANEL 3ø, 12 CKT 120/208V	BLANK
		METER (1)
	XFMR 15 KVA 3ø 4W 25A C/B (480V) 45A C/B (208V)	TVSS 30A C/B (2)
		MAIN 100A C/B

SCHEDULE – MOTOR CONTROL CENTER
480 VAC, 3ø, 4W, 42KA, NEMA 3R
600A INCOMING, 600A HORIZONTAL, 300A VERTICAL

SECTION/UNIT LOCATION	DESC	NEMA SIZE	CB TRIP (A)	AUX INTLKS NO	AUX INTLKS NC	SELECTOR SWITCHES	INDICATING LIGHTS	IDENTIFICATIONS
1								PLC PANEL
2A	FVNR	2	45	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	PFE-5 PUMP
2E			45					100A, 3ø, 12 CKT, PNL
2N			25					15 KVA, 3ø, 4W, XFMRS
3A			50					SPARE
3D								METER (1)
3I			30					TVSS (2)
3M			100					MAIN

SCHEDULE – PANEL "LA"

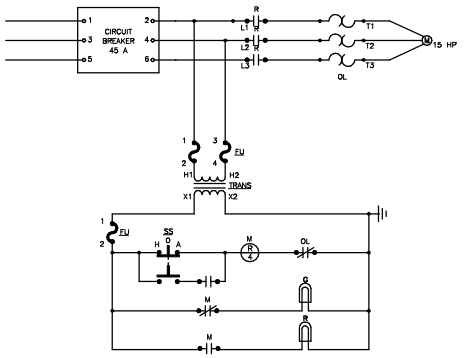
BUILDING: PFE-5	LOCATION: MCC	PHASE: 3	
TYPE:	FEED:	WIRE: 4	
MANUFACTURER:	SC RATING: 10,000	VOLTAGE: 120/208	
MODEL:	MAIN AMPS:	MOUNTING: INTERNAL TO MCC	
CONFIGURATION:	PANEL AMPS: 100 MLO COPPER		

CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	* LOAD (AMPS) A	B	C	CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	* LOAD (AMPS) A	B	C
1	1	20	PLC POWER	10			2	1	–	SPACE ONLY			
3	1	20	PLC RECEPT		1.5		4	1	–				
5	1	20	PFE-5 VAULT RECEPT			1.5	6	1	–				
7	1	20	PFE-5 FLOW METER	.83			8	1	–				
9	1	20	MCC RECEPT		1.5		10	1	–				
11	1	20	SPARE				12	1	–				
TOTAL CONNECTED LOAD PER PHASE, AMPS							TOTAL CONNECTED LOAD PER PHASE, AMPS						
TOTAL CONNECTED LOAD 3-PHASE, AMPS							TOTAL CONNECTED LOAD 3-PHASE, AMPS						

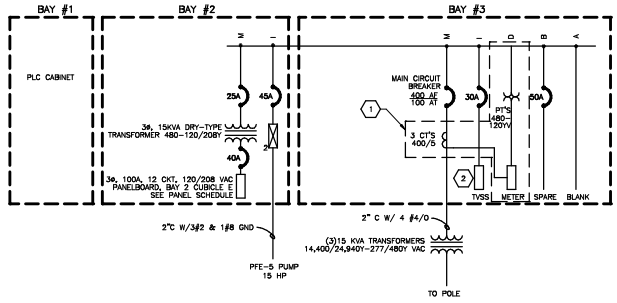
KEYED NOTES:

(1) FURNISH STANDARD METER SLOT OPENING IN FRONT OF MCC'S PANEL COVER. PROVIDE CLEAR PLASTIC WEATHER PROOF COVER OVER OPENING. METER DEVICE AND ASSOCIATED CT'S AND PT'S TO BE FURNISHED AND INSTALLED BY OTHERS.

(2) FURNISH MANUFACTURER'S STANDARD TVSS PROTECTION INTEGRAL WITH MCC.



PFE-5 PUMP



LEGEND:

(2) MAGNETIC MOTOR STARTER. NUMBER DENOTES NEMA SIZE.

MOTOR CONTROL CENTER ONE-LINE DIAGRAM

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SKE NO.

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX± DIMENSIONS ARE IN INCHES
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-5
ELECTRICAL
DETAILS

A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 657-E-02 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

BAY #1	BAY #2	BAY #3	BAY #4
RELAY CABINET FOR PLC CONTROLLER	FVNR NEMA SIZE 2	BLANK	C/B 50A COMPAC
			BLANK
	PANEL 3ø, 18 CKT 120/208V 100A MLO	SSRV CONTROLLER C/B * 75 HP	BLANK
			METER (1)
	XFMR 15 KVA 3ø 4W 25A C/B (480V) 40A C/B (208V)		TVSS 30A C/B (2)
			MAIN 250A C/B

* TO BE SIZED BY MANUFACTURER TO PROVIDE PROPER SHORT CIRCUIT PROTECTION OF MOTOR IT IS TO PROTECT.

SCHEDULE – MOTOR CONTROL CENTER
480 VAC, 3ø, 4W, 42KA, NEMA 3R
600A INCOMING, 600A HORIZONTAL, 300A VERTICAL

SECTION/UNIT LOCATION	DESC	NEMA SIZE	CB TRIP (A)	AUX INTLKS NO	AUX INTLKS NC	SELECTOR SWITCHES	INDICATING LIGHTS	IDENTIFICATIONS
1								
2A	FVNR	2	70	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	SPARE
2E			40					100A, 3ø, 18 CKT, PNL
2N			25					15 KVA, 3ø, 4W, XFMRS
3A								
3D	SSRV	N/A	*	2	2	H-O-A	PUSH-TO-TEST GREEN, RED	PFE-7 PUMP
4A	C/B		50					SPARE
4C								
4G								
4K								METER (1)
4P			30					TVSS (2)
4T			250					MAIN

KEYED NOTES:

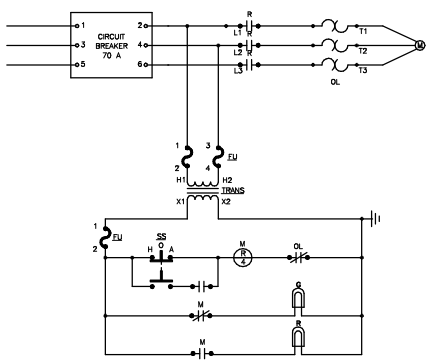
(1) FURNISH STANDARD METER SLOT OPENING IN FRONT OF MCC'S PANEL COVER. PROVIDE CLEAR PLASTIC WEATHER PROOF COVER OVER OPENING. METER DEVICE AND ASSOCIATED CT'S AND PT'S TO BE FURNISHED AND INSTALLED BY OTHERS.

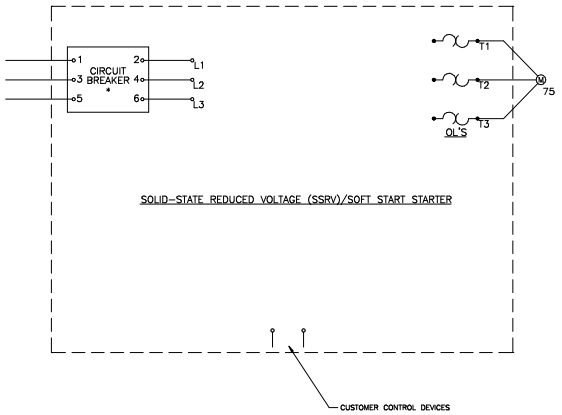
(2) FURNISH MANUFACTURER'S STANDARD TVSS PROTECTION INTEGRAL WITH MCC.

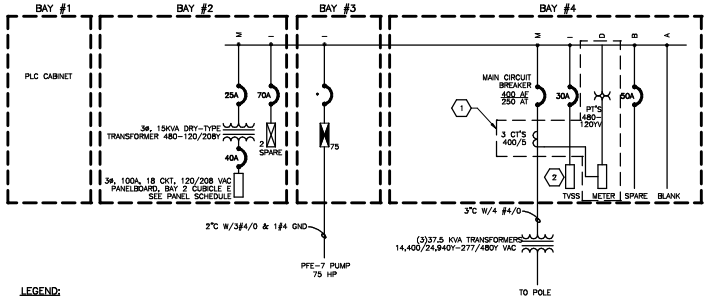
SCHEDULE – PANEL "LA"

BUILDING: PFE-7	LOCATION: MCC	PHASE: 3	
TYPE:	FEED:	WIRE: 4	
MANUFACTURER:	SC RATING: 10,000	VOLTAGE: 120/208	
MODEL:	MAIN AMPS:	MOUNTING: INTERNAL TO MCC	
CONFIGURATION:	PANEL AMPS: 100 MLO COPPER		

CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	ø LOAD (AMPS) A	B	C	CKT NO	POLE	BKR TRIP	LOAD DESCRIPTION	ø LOAD (AMPS) A	B	C
1	1	20	PLC POWER	10			2	1	–	SPACE ONLY			
3	1	20	PLC RECEPT		1.5		4	1	–				
5	1	20	PFE-7 VAULT RECEPT			1.5	6	1	–				
7	1	20	PFE-7 FLOW METER	.83			8	1	–				
9	1	20	MCC RECEPT		1.5		10	1	–				
11	1	20	SPARE				12	1	–				
13	1	20	SPARE				14	1	–				
15	1	–	SPACE ONLY				16	1	–				
17	1	–					18	1	–				
TOTAL CONNECTED LOAD PER PHASE, AMPS							TOTAL CONNECTED LOAD PER PHASE, AMPS						
TOTAL CONNECTED LOAD 3-PHASE, AMPS							TOTAL CONNECTED LOAD 3-PHASE, AMPS						







LEGEND:

2 MAGNETIC MOTOR STARTER. NUMBER DENOTES NEMA SIZE.

75 SOLID-STATE REDUCED VOLTAGE (SSRV)/SOFT START CONTROLLER. HORSEPOWER RATING NOTED.

MOTOR CONTROL CENTER ONE-LINE DIAGRAM

SPARE

PFE-7 PUMP

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SKE NO.

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX± DECIMALS ±
DIMENSIONS ARE IN INCHES
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	A. HERNANDEZ	2-18-00
DESIGNED BY	A. HERNANDEZ	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
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RELEASE		

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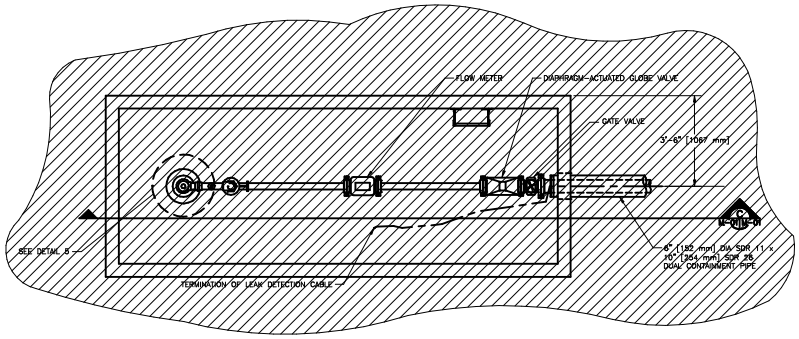
WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-7
ELECTRICAL
DETAILS

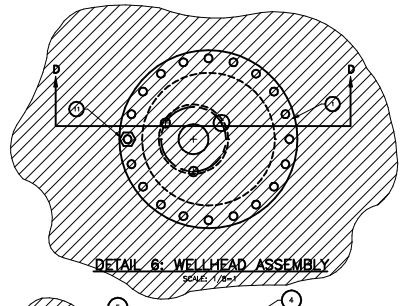
A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 658-E-02 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

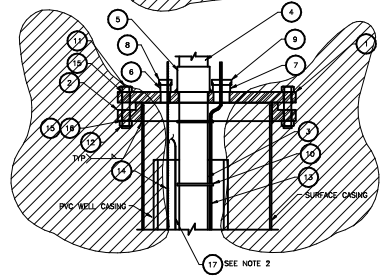


DETAIL: PFE-2 EXTRACTION WELL VAULT

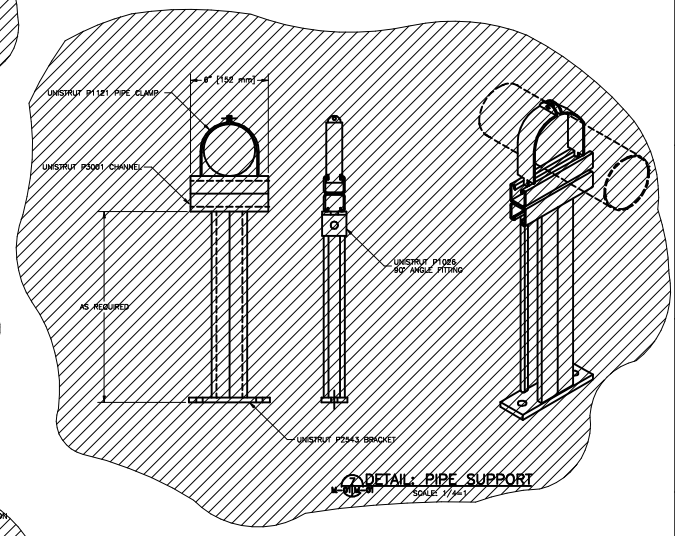


DETAIL 6: WELLHEAD ASSEMBLY

SCALE: 1/8=1

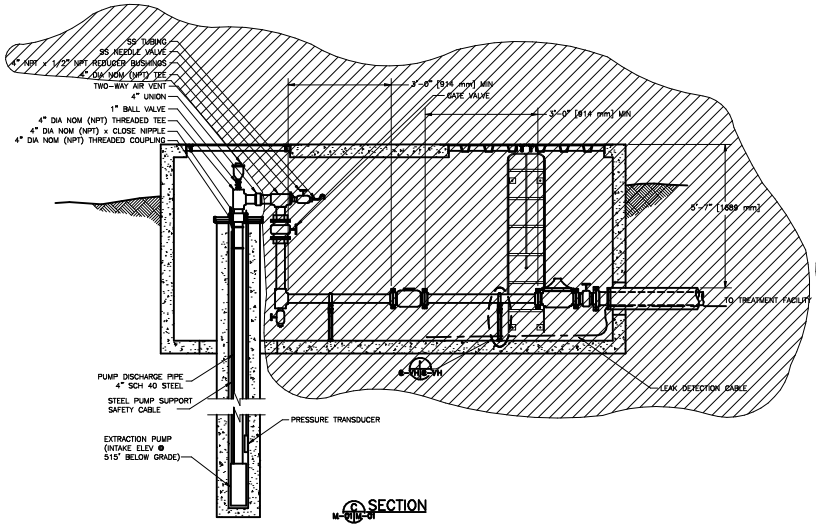


SECTION D-D



DETAIL: PIPE SUPPORT

SCALE: 1/4=1



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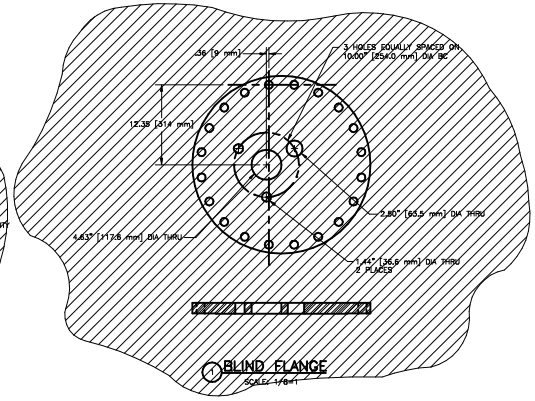


BLIND FLANGE

SCALE: 1/8=1

SUPPLIED BY OTHERS
WELL, WELL HEAD VAULT, BLIND FLANGE AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY PUMP/MOTOR ASSEMBLY POWER CABLE, TRANSDUCER, TEE, REDUCER BUSHING, BALL VALVE, VENT-VACUUM VALVE STRAIN RELIEF CONNECTORS AND ASSOCIATED FITTINGS

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER
2. SAFETY CABLE TERMINATION AND SECURING METHOD SHALL BE DETERMINED BY PUMP INSTALLATION CONTRACTOR.

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
1	17		SAFETY CABLE, 0.5" DIA	CS		
4	16		WASHER, LOCK, 1.125" DIA	CS		
8	15		WASHER, FLAT, 1.125" DIA	CS		
	14		TRANSDUCER CABLE	CU		
	13		PUMP POWER CABLE	CU		
4	12		NUT, 1.125" DIA	CS		
4	11		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
	10		STRAP	SS		
1	9		STRAIN RELIEF CONNECTOR, 2"	SS		
1	8		STRAIN RELIEF CONNECTOR, 1"	SS		
1	7		COUPLING, 2" NPT, SCH 80	CS		
2	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		COUPLING, 4"	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		NIPPLE, 4" NPT x CLOSE	CS		
1	3		DROP PIPE, 4" DIA x 515', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASTM CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASTM CLASS 150	CS	ASTM 181, GRADE I	

NEXT ASSY / REVISED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xx± FRACTIONS ±
.xxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

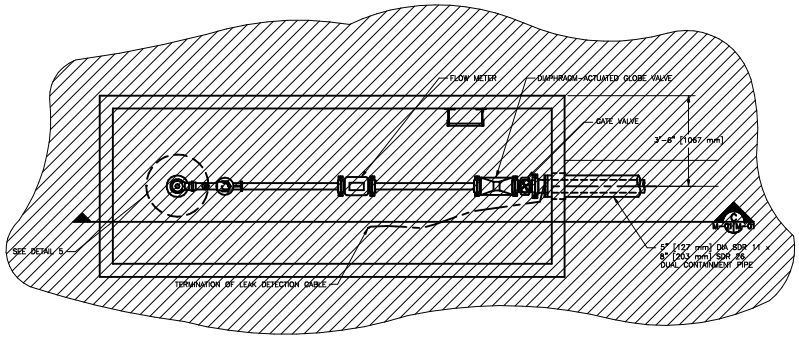
DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

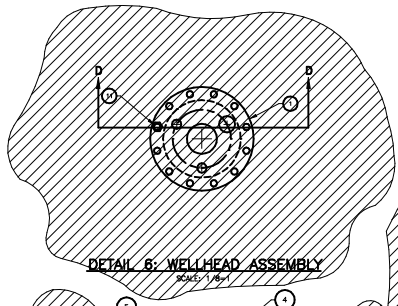
WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-2
MECHANICAL
DETAILS

CODE IDENT. | SIZE F | DWG. NO. 654-M-01 | A.E. DWG. NO. | SCALE 1/2"=1'-0" | SHEET 1 OF 1 | REV.

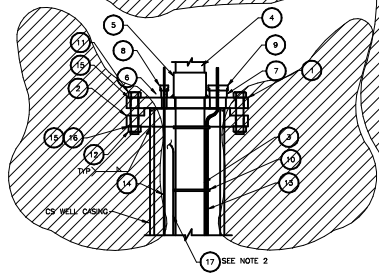
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



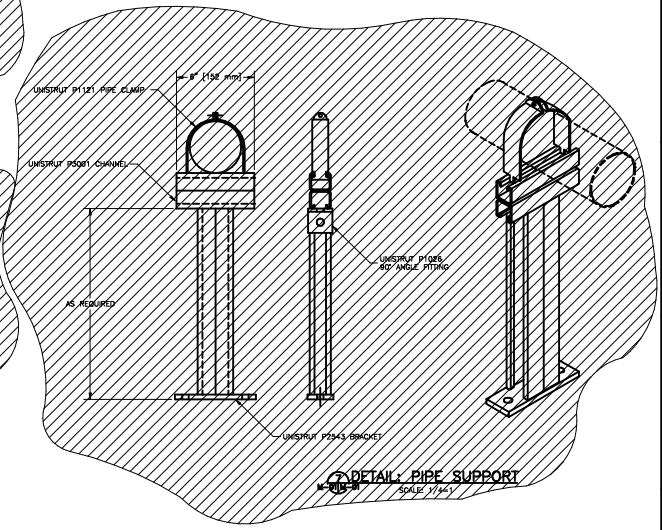
5 DETAIL: PFE-3 EXTRACTION WELL VAULT
M-FILE-01



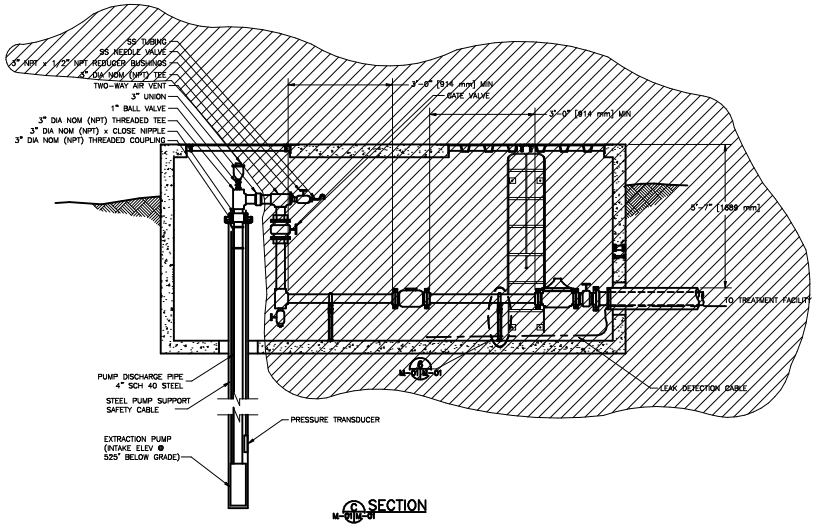
DETAIL 6: WELLHEAD ASSEMBLY
SCALE: 1/8=1



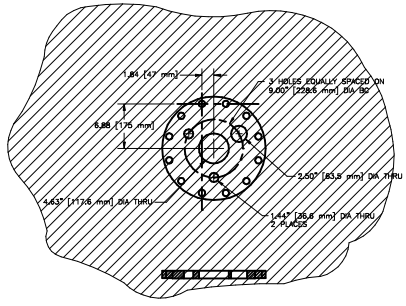
SECTION D-D



7 DETAIL: PIPE SUPPORT
M-FILE-01
SCALE: 1/4=1



6 SECTION
M-FILE-01



1 BLIND FLANGE
SCALE: 1/8=1

SUPPLIED BY OTHERS
WELL, WELL HEAD VAULT, BLIND FLANGE AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY PUMP/MOTOR ASSEMBLY POWER CABLE, TRANSDUCER, TEE, REDUCER BUSHING, BALL VALVE, VENT-VACUUM VALVE STRAIN RELIEF CONNECTORS AND ASSOCIATED FITTINGS

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER
2. SAFETY CABLE TERMINATION AND SECURING METHOD SHALL BE DETERMINED BY PUMP INSTALLATION CONTRACTOR.

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
1	17		SAFETY CABLE, 0.5" DIA	CS		
4	16		WASHER, LOCK, 1.125" DIA	CS		
8	15		WASHER, FLAT, 1.125" DIA	CS		
1	14		TRANSDUCER CABLE	CU		
1	13		PUMP POWER CABLE	CU		
4	12		NUT, 1.00" DIA	CS		
4	11		BOLT, 1.00" DIA x 5-1/2" [139 mm]	CS		
1	10		STRAP	SS		
1	9		STRAIN RELIEF CONNECTOR, 2"	SS		
1	8		STRAIN RELIEF CONNECTOR, 1"	SS		
1	7		COUPLING, 2" NPT, SCH 80	CS		
2	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		COUPLING, 4" NPT, SCH 80	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		NIPPLE, 4" NPT x CLOSE	CS		
1	3		DROP PIPE, 4" DIA x 525', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	

NEXT ASSY / REUSED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

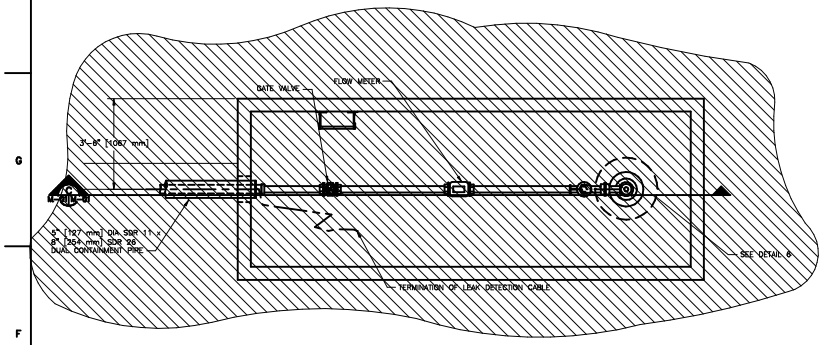
DRAWN BY	M. TARN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

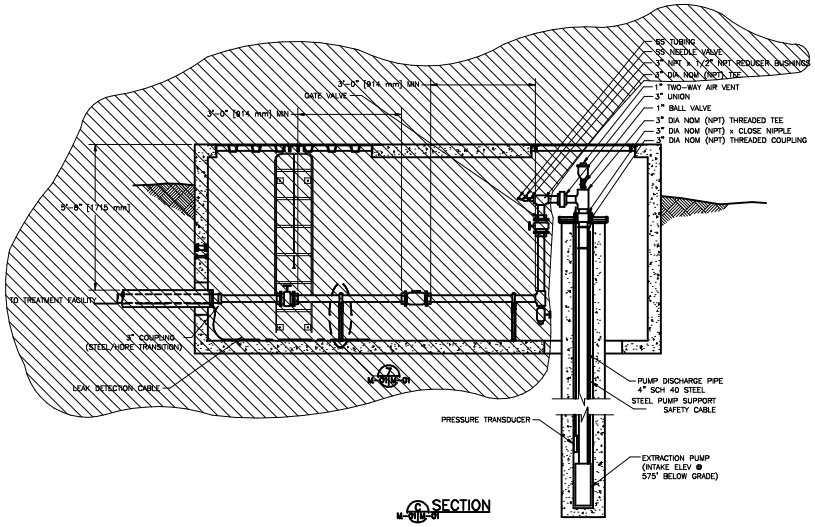
WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-3
MECHANICAL
DETAILS

A.E. DWG. NO.
SCALE 1/2"=1'-0"
SHEET 1 OF 1
CODE IDENT. F
SIZE
DWG. NO. 655-M-01
REV.

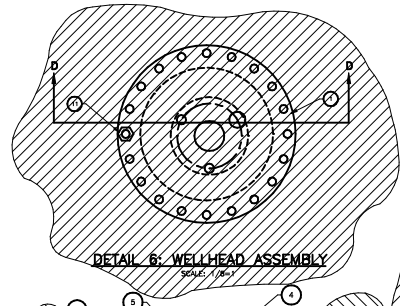
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

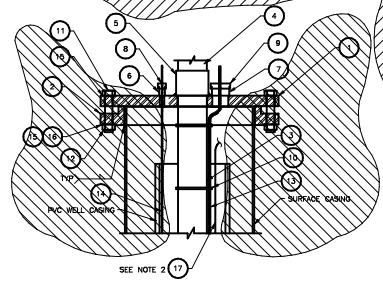


DETAIL: PFE-4A EXTRACTION WELL VAULT

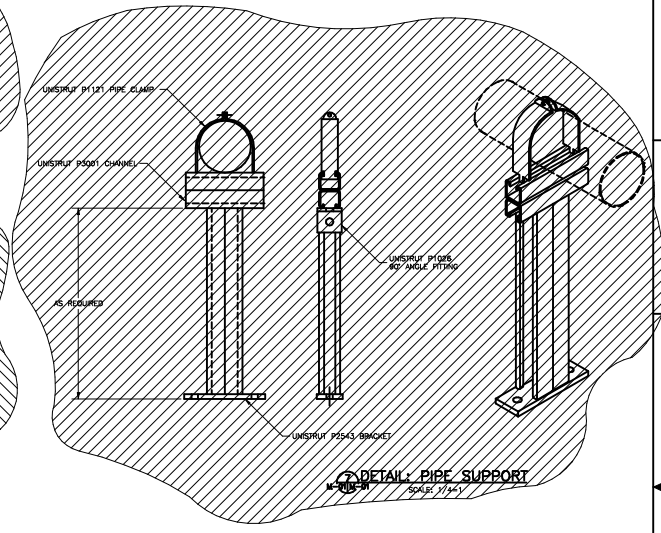


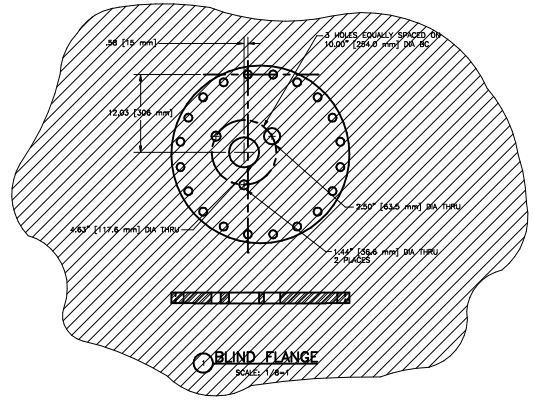
SECTION





SECTION D-D





SUPPLIED BY OTHERS
WELL, WELL HEAD VAULT, BLIND FLANGE AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY PUMP/MOTOR ASSEMBLY POWER CABLE, TRANSDUCER, TEE, REDUCER BUSHING, BALL VALVE, VENT-VACUUM VALVE STRAIN RELIEF CONNECTORS AND ASSOCIATED FITTINGS

NOTES:

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REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
1	17		SAFETY CABLE, 0.5" DIA	CS		
4	16		WASHER, LOCK, 1.125" DIA	CS		
8	15		WASHER, FLAT, 1.125" DIA	CS		
	14		TRANSDUCER CABLE	CU		
	13		PUMP POWER CABLE	CU		
4	12		NUT, 1.125" DIA	CS		
4	11		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
	10		STRAP	SS		
1	9		STRAIN RELIEF CONNECTOR, 2"	SS		
1	8		STRAIN RELIEF CONNECTOR, 1"	SS		
1	7		COUPLING, 2" NPT, SCH 80	CS		
1	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		COUPLING, 4" ASTM	CS	ASTM 105, GRADE I, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		NIPPLE, 4" NPT x CLOSE	CS		
1	3		DROP PIPE, 4" DIA x 575', SCH 40	CS		
1	2		SOCKET FLANGE, 20", 150 PSI	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", 150 PSI	CS	ASTM 181, GRADE I	

NEXT ASSY / REVISED DWG'S

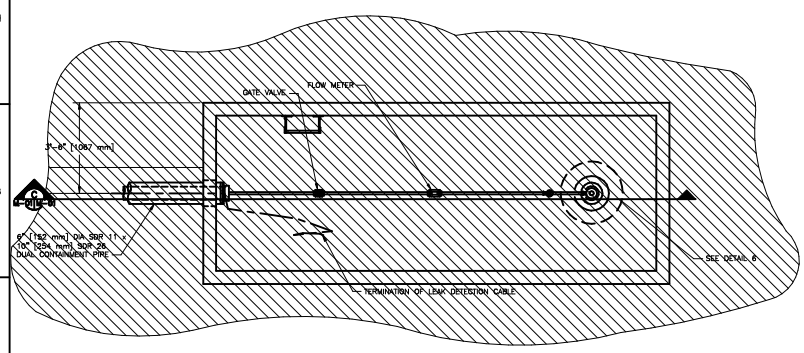
DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xxx± FRACTIONS ±
.xxxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

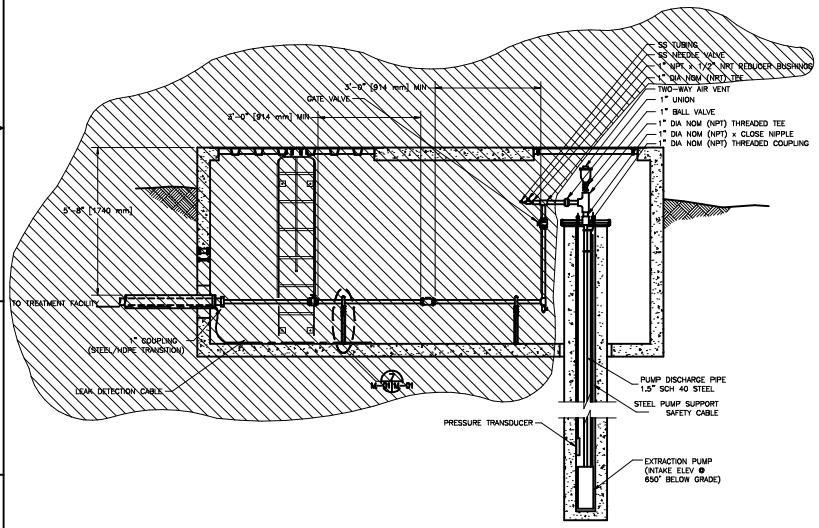
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-4A
MECHANICAL
DETAILS

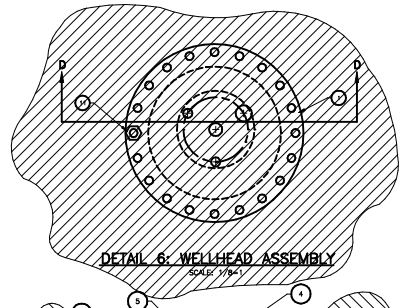
A.E. DWG. NO.
SCALE 1/2"=1'-0"
SHEET 1 OF 1
CODE IDENT. F
SIZE D
DWG. NO. 656-M-01
REV.



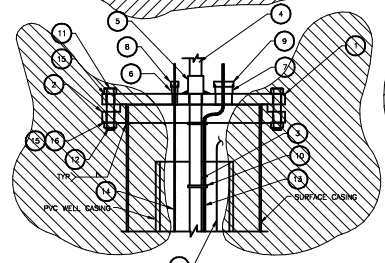
5 DETAIL: PFE-5 EXTRACTION WELL VAULT
M-01S-01



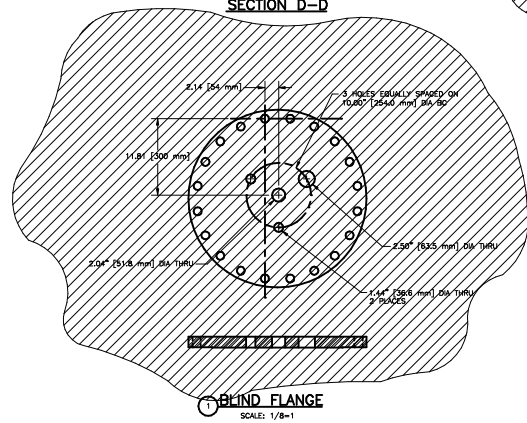
SECTION
M-01S-01



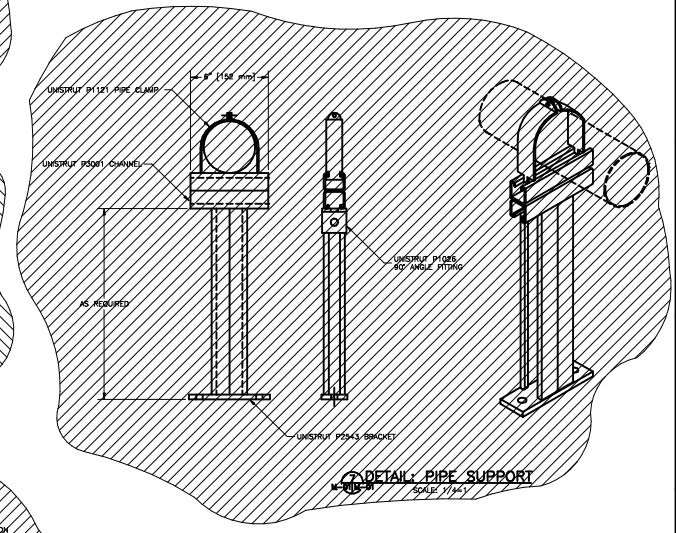
DETAIL 6: WELLHEAD ASSEMBLY
SCALE: 1/8=1



SECTION D-D



1 BLIND FLANGE
SCALE: 1/8=1



7 DETAIL: PIPE SUPPORT
M-01S-01
SCALE: 1/4=1

				17		SAFETY CABLE, 0.375" DIA	CS		
			4	16		WASHER, LOCK, 1.125" DIA	CS		
			8	15		WASHER, FLAT, 1.125" DIA	CS		
				14		TRANSDUCER CABLE	CU		
				13		PUMP POWER CABLE	CU		
			4	12		NUT, 1.125" DIA	CS		
			4	11		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
				10		STRAP	SS		
			1	9		STRAIN RELIEF CONNECTOR, 2"	SS		
			1	8		STRAIN RELIEF CONNECTOR, 1"	SS		
			1	7		COUPLING, 2" NPT, SCH 80	CS		
			2	6		COUPLING, 1" NPT, SCH 80	CS		
			1	5		COUPLING, 1.5" NPT, SCH 80	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
			1	4		NIPPLE, 4" NPT x CLOSE	CS		
			1	3		DROP PIPE, 1.5" DIA x 650', SCH 40	CS		
			1	2		SOCKET FLANGE, 9.05", ASME CLASS 150	CS	ASTM 181, GRADE I	
			1	1		BLIND FLANGE, 9.05", ASME CLASS 150	CS	ASTM 181, GRADE I	
			1	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASSY									

SUPPLIED BY OTHERS
WELL, WELL HEAD VAULT, BLIND FLANGE AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY PUMP/MOTOR ASSEMBLY POWER CABLE, TRANSDUCER, TEE, REDUCER BUSHING, BALL VALVE, VENT-VACUUM VALVE STRAIN RELIEF CONNECTORS AND ASSOCIATED FITTINGS

NOTES:

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NEXT ASSY / REUSED ON'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xx± FRACTIONS ±
.xxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURR.

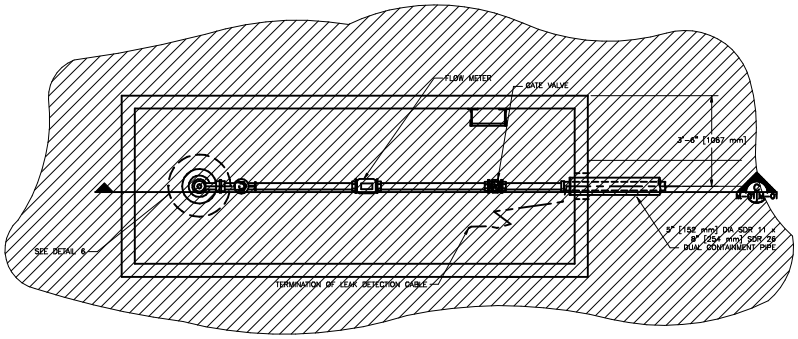
DRAWN BY	M. TARN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

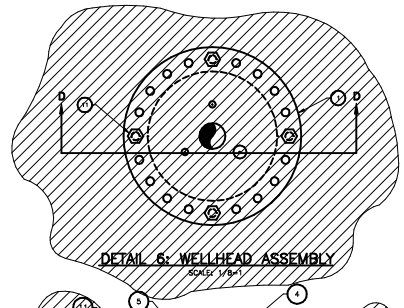
WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-5
MECHANICAL DETAILS

CODE IDENT. | SIZE F | DWG. NO. 657-M-01 | REV.
A.E. DWG. NO. | SCALE 1/2"=1'-0" | SHEET 1 OF 1

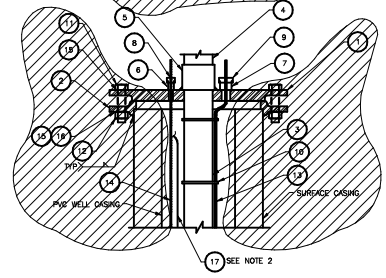
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



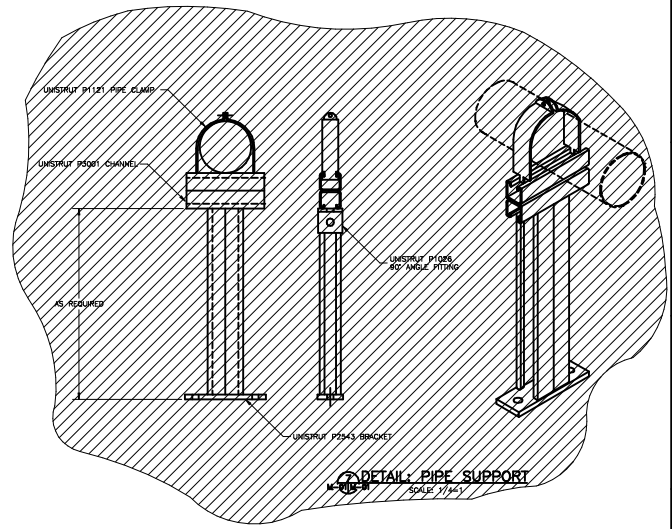
DETAIL: PFE-7 EXTRACTION WELL VAULT
C-M11E-01



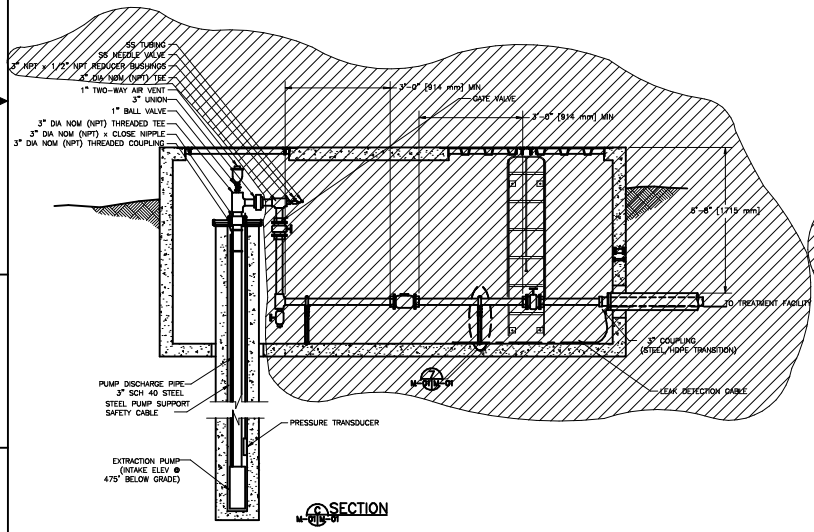
DETAIL 6: WELLHEAD ASSEMBLY
SCALE: 1/8=1



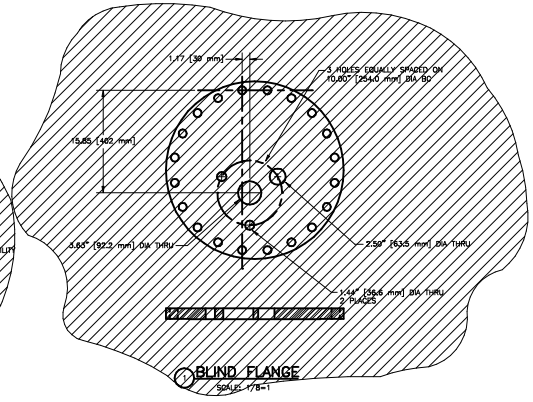
SECTION D-D



DETAIL: PIPE SUPPORT
M-M11E-01
SCALE: 1/4=1



SECTION
M-M11E-01



BLIND FLANGE
SCALE: 1/8=1

SUPPLIED BY OTHERS
WELL, WELL HEAD VAULT, BLIND FLANGE AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY PUMP/MOTOR ASSEMBLY POWER CABLE, TRANSDUCER, TEE, REDUCER BUSHING, BALL VALVE, VENT-VACUUM VALVE STRAIN RELIEF CONNECTORS AND ASSOCIATED FITTINGS

NOTES:

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REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
1	17		SAFETY CABLE, 0.05" DIA	CS		
4	16		WASHER, LOCK, 1.125" DIA	CS		
8	15		WASHER, FLAT, 1.125" DIA	CS		
	14		TRANSDUCER CABLE	CU		
	13		PUMP POWER CABLE	CU		
4	12		NUT, 1.125" DIA	CS		
4	11		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
	10		STRAP	SS		
1	9		STRAIN RELIEF CONNECTOR, 2"	SS		
1	8		STRAIN RELIEF CONNECTOR, 1"	SS		
1	7		COUPLING, 2" NPT, SCH 80	CS		
1	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		COUPLING, 3" ASTM	CS	ASTM 105, GRADE I, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		NIPPLE, 3" NPT x CLOSE	CS		
1	3		DROP PIPE, 3" DIA x 475', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	

NEXT ASSY / REVISED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xx± FRACTIONS ±
.xxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY	J. KIRBY	2-18-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

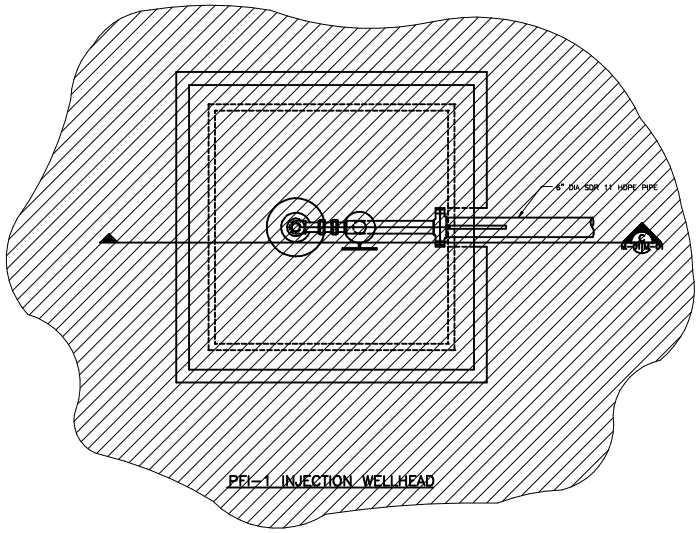
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

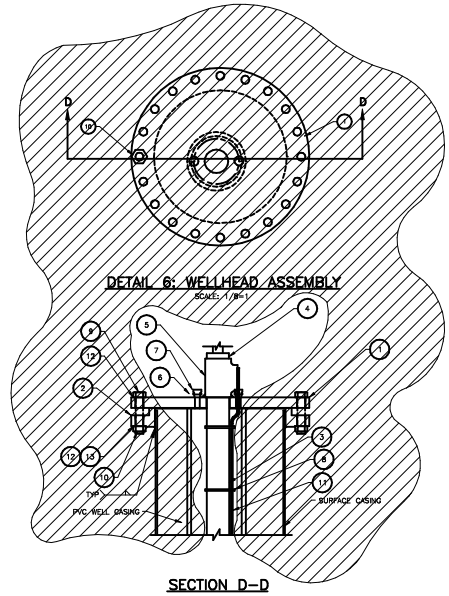
WSTF - PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-7
MECHANICAL
DETAILS

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	658-M-01	

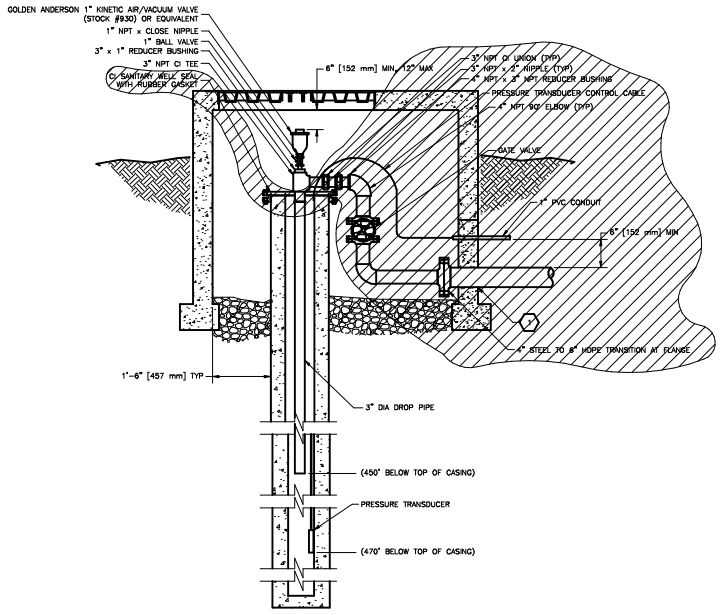
A.S. DWG. NO. | SCALE 1/2"=1'-0" | SHEET 1 OF 1

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

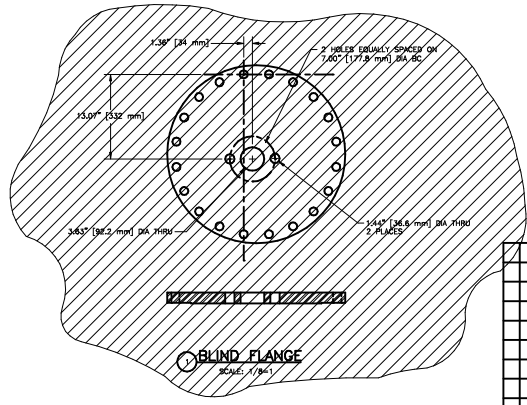




SECTION D–D



SECTION



SUPPLIED BY OTHERS
WELL, WELL SEAL, WELL HEAD VAULT, AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY INJECTION TUBING, TEE, REDUCER BUSHING, BALL VALVE, AIR/VACUUM VALVE, AND ASSOCIATED FITTINGS

KEYED NOTES:

(1) FOLLOWING PIPE INSTALLATION INTO VAULT, SLOTTED ENTRY SHALL BE FORMED OVER AND FILLED WITH CONCRETE

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER

			4	13		WASHER, LOCK, 1.125" DIA	CS		
			8	12		WASHER, FLAT, 1.125" DIA	CS		
			11			TRANSDUCER CABLE	CU		
			4	10		NUT, 1.125" DIA	CS		
			4	9		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
			8			STRAP	SS		
			2	7		STRAIN RELIEF CONNECTOR, 1"	SS		
			2	6		COUPLING, 1" NPT, SCH 80	CS		
			1	5		TEE, 3"	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
			1	4		REDUCER BUSHING, 3" x 1"	CS		
			1	3		DROP PIPE, 3" DIA x 450', SCH 40	CS		
			1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
			1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
REVD PER ASS'Y			ITEM NO.	PART NO.		DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASS'Y / REVISED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xx± FRACTIONS ±
.xxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

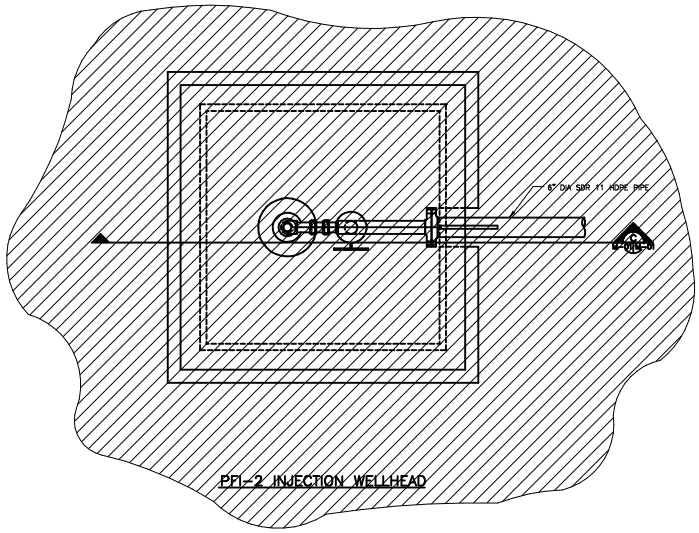
DRAWN BY	M. TARIN	2-25-00
ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

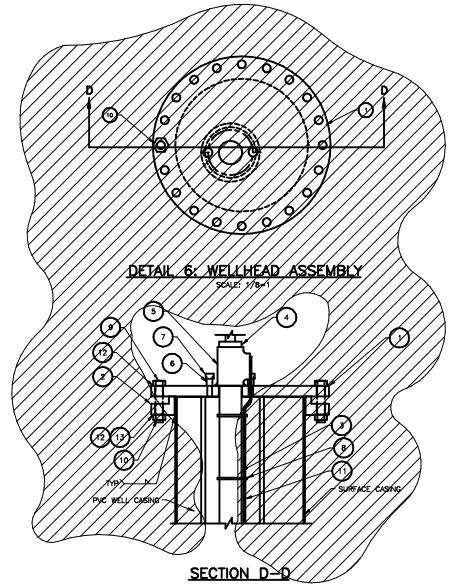
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

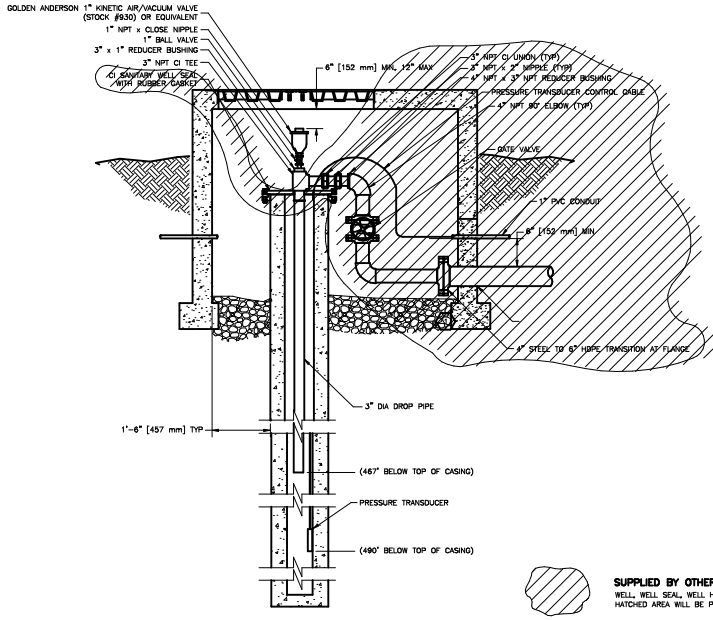
WSTF – PLUME–FRONT REMEDIATION
INJECTION WELL PFI–1
MECHANICAL
DETAILS AT WELLHEAD

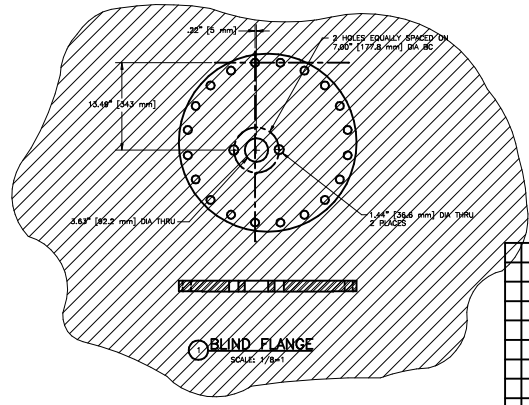
CODE IDENT. F | SIZE | DWG. NO. 660–M–01 | A.E. DWG. NO. | SCALE 3/4"=1'-0" | SHEET 1 OF 1 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL









SUPPLIED BY OTHERS

WELL, WELL SEAL, WELL HEAD VAULT, AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY INJECTION TUBING, TEE, REDUCER BUSHING, BALL VALVE, AIR/VACUUM VALVE, AND ASSOCIATED FITTINGS

KEYED NOTES:

1. FOLLOWING PIPE INSTALLATION INTO VAULT, SLOTTED ENTRY SHALL BE FORMED OVER AND FILLED WITH CONCRETE

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
4	13		WASHER, LOCK, 1.125" DIA	CS		
8	12		WASHER, FLAT, 1.125" DIA	CS		
11			TRANSDUCER CABLE	CU		
4	10		NUT, 1.125" DIA	CS		
4	9		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
8			STRAP	SS		
2	7		STRAIN RELIEF CONNECTOR, 1"	SS		
2	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		TEE, 3"	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		REDUCER BUSHING, 3"x1"	CS		
1	3		DROP PIPE, 3" DIA x 467', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.0± ANGLES ±
.00± FRACTIONS ±
.000±
DIMENSIONS ARE IN INCHES
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

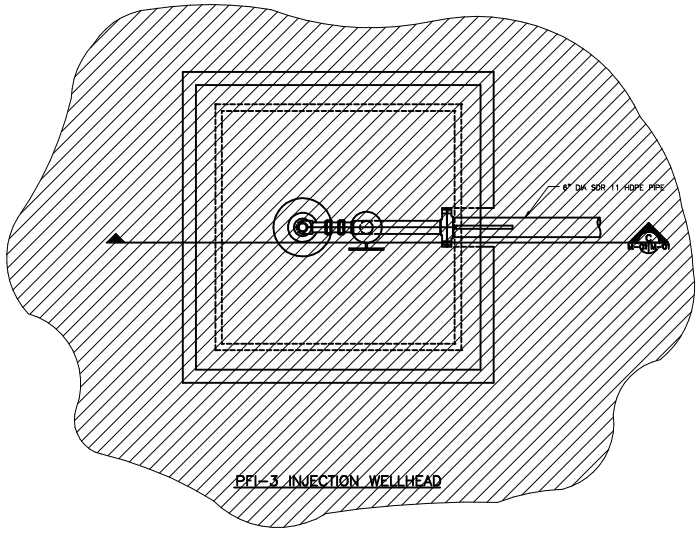
DRAWN BY	M. TARIN	2-25-00
ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

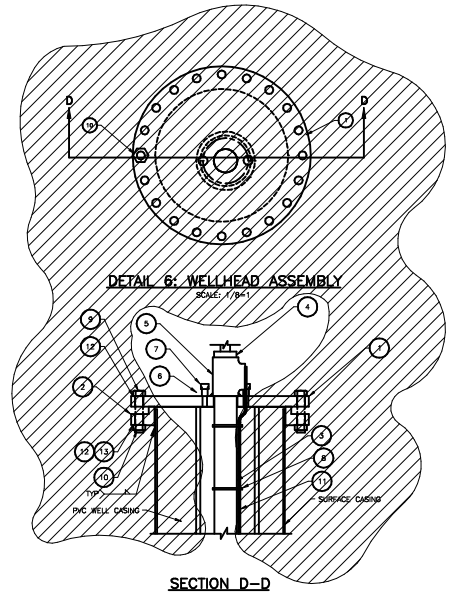
WSTF – PLUME-FRONT REMEDIATION
INJECTION WELL PFI-2
MECHANICAL
DETAILS AT WELLHEAD

CODE IDENT. | SIZE F | DWG. NO. 661-M-01 | A.B. DWG. NO. | SCALE 3/4"=1'-0" | SHEET 1 OF 1 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

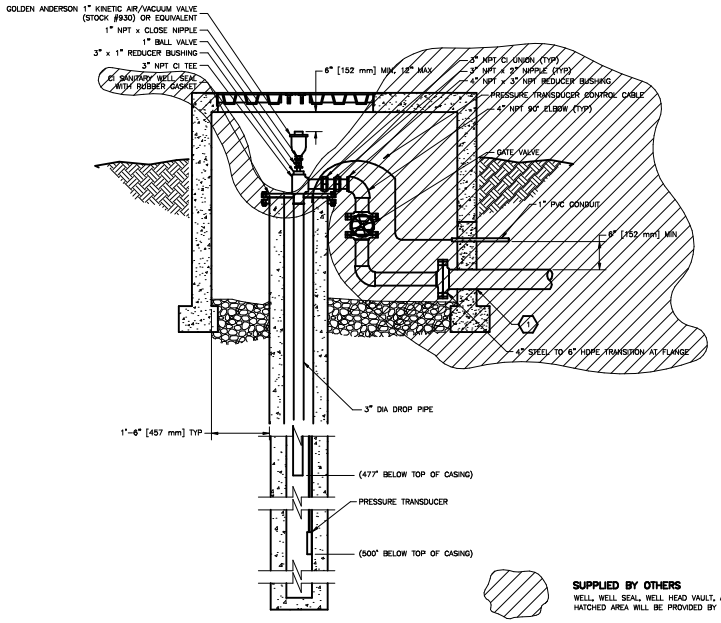


PFI-3 INJECTION WELLHEAD

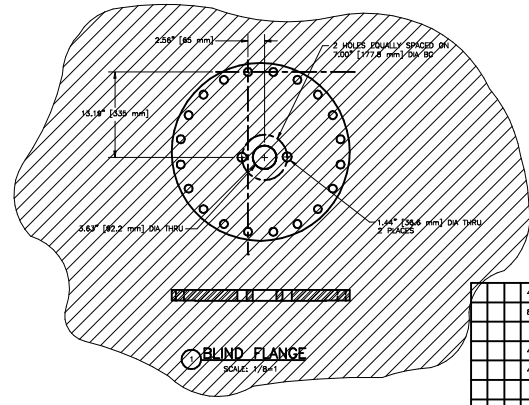


DETAIL 6: WELLHEAD ASSEMBLY
SCALE: 1/8=1

SECTION D-D



SECTION
M-01-01



1 BLIND FLANGE
SCALE: 1/8=1

SUPPLIED BY OTHERS

WELL, WELL SEAL, WELL HEAD VAULT, AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY INJECTION TUBING, TEE, REDUCER BUSHING, BALL VALVE, AIR/VACUUM VALVE, AND ASSOCIATED FITTINGS

KEYED NOTES:

1. FOLLOWING PIPE INSTALLATION INTO VAULT, SLOTTED ENTRY SHALL BE FORMED OVER AND FILLED WITH CONCRETE

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER

			4	13		WASHER, LOCK, 1.125" DIA	CS		
			8	12		WASHER, FLAT, 1.125" DIA	CS		
				11		TRANSDUCER CABLE	CU		
			4	10		NUT, 1.125" DIA	CS		
			4	9		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
				8		STRAP	SS		
			2	7		STRAIN RELIEF CONNECTOR, 1"	SS		
			2	6		COUPLING, 1" NPT, SCH 80	CS		
			1	5		TEE, 3"	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
			1	4		REDUCER BUSHING, 3"x1"	CS		
			1	3		DROP PIPE, 3" DIA x 477', SCH 40	CS		
			1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
			1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASYM 181, GRADE I	
			1	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.
REQ'D PER ASSY									

NEXT ASSY / RELATED DWGS

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-25-00
ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

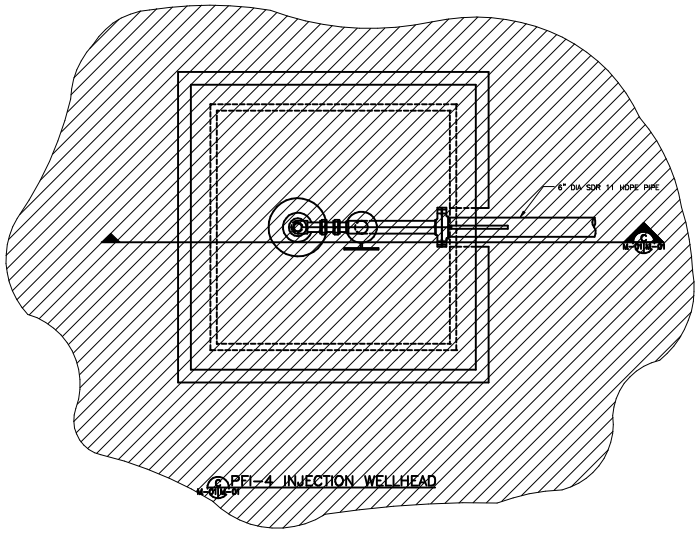
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

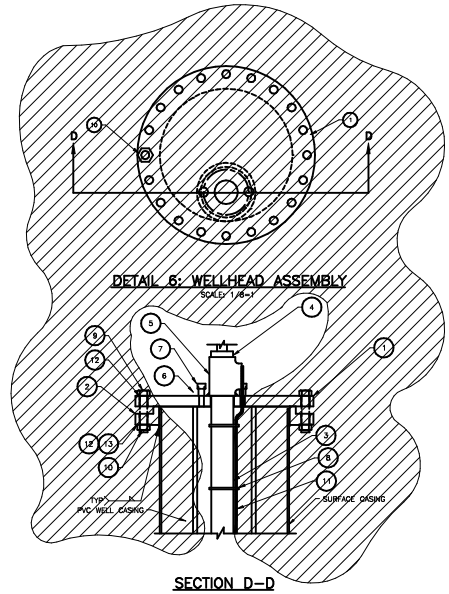
WSTF - PLUME-FRONT REMEDIATION
INJECTION WELL PFI-3
MECHANICAL
DETAILS AT WELLHEAD

CODE IDENT.	SIZE	DWG. NO.	REV.
	F	662-M-01	

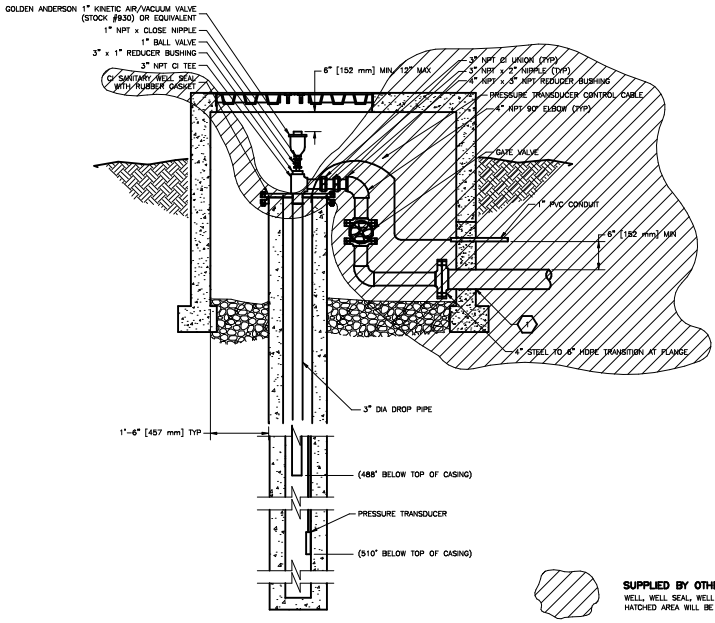
A.B. DWG. NO.
SCALE 3/4"=1'-0"
SHEET 1 OF 1

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL

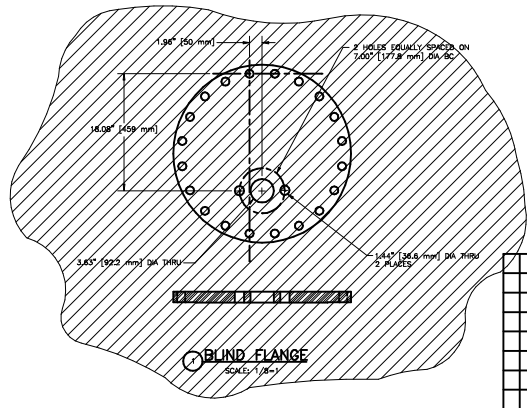




SECTION D–D



SECTION



REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHC. NO.
4	13		WASHER, LOCK, 1.125" DIA	CS		
8	12		WASHER, FLAT, 1.125" DIA	CS		
11			TRANSDUCER CABLE	CU		
4	10		NUT, 1.125" DIA	CS		
4	9		BOLT, 1.125" DIA x 5-1/2" [139 mm]	CS		
8			STRAP	SS		
2	7		STRAIN RELIEF CONNECTOR, 1"	SS		
2	6		COUPLING, 1" NPT, SCH 80	CS		
1	5		TEE, 3"	CS	ASTM 105, GRADE II, MACHINED FROM SOLID STEEL OR FORGINGS	
1	4		REDUCER BUSHING, 3"x1"	CS		
1	3		DROP PIPE, 3" DIA x 488', SCH 40	CS		
1	2		SOCKET FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	
1	1		BLIND FLANGE, 20", ASME CLASS 150	CS	ASTM 181, GRADE I	

SUPPLIED BY OTHERS

WELL, WELL SEAL, WELL HEAD VAULT, AND PIPING WITHIN THE HATCHED AREA WILL BE PROVIDED BY OTHERS

PUMP INSTALLATION CONTRACTOR SHALL SUPPLY INJECTION TUBING, TEE, REDUCER BUSHING, BALL VALVE, AIR/VACUUM VALVE, AND ASSOCIATED FITTINGS

KEYED NOTES:

1. FOLLOWING PIPE INSTALLATION INTO VAULT, SLOTTED ENTRY SHALL BE FORMED OVER AND FILLED WITH CONCRETE

NOTES:

1. DEVIATIONS FROM DESIGN AND/OR DESIGNATED VENDOR PART NUMBERS MUST BE APPROVED BY ENGINEER/OWNER

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.XX± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

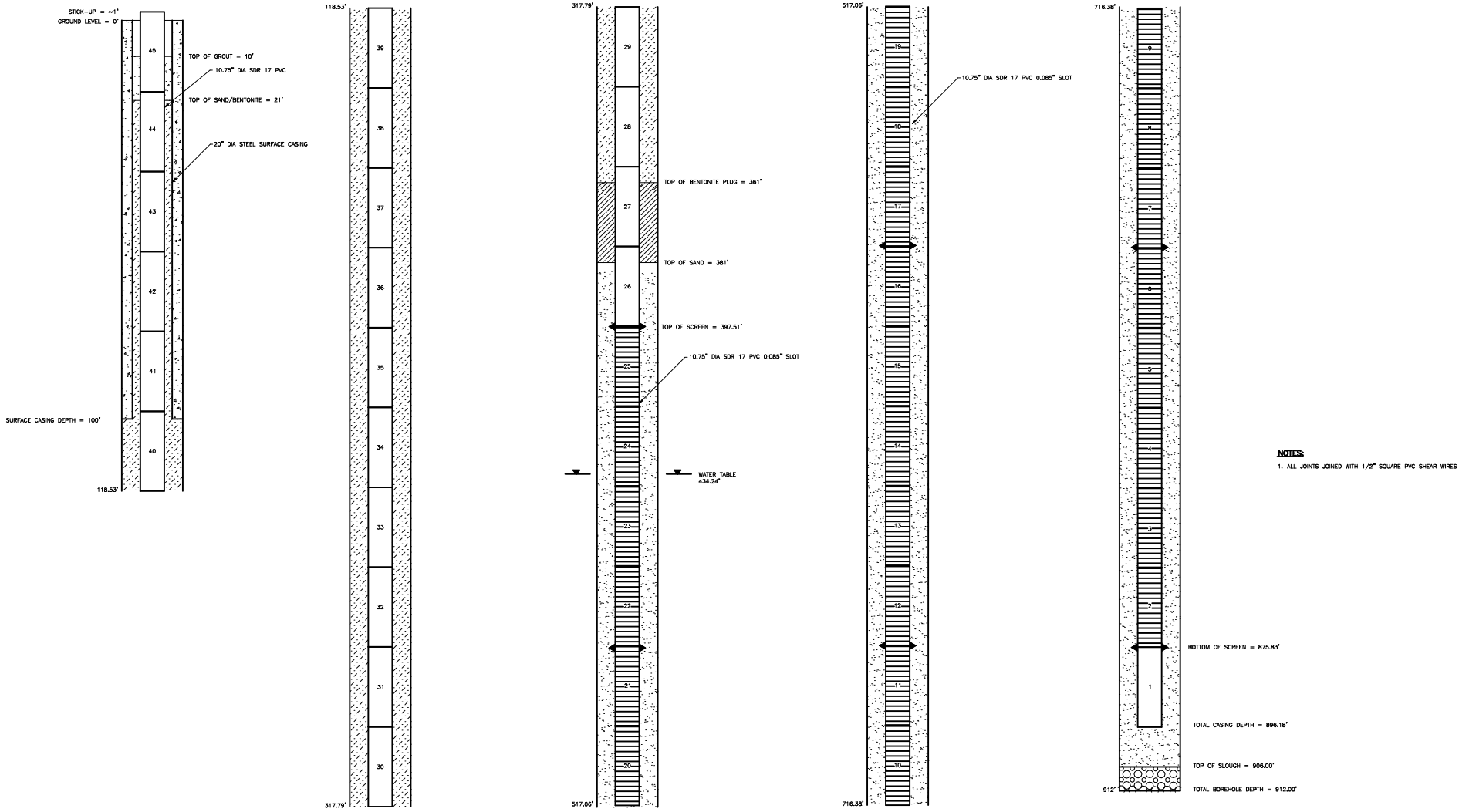
DRAWN BY	M. TARIN	2-25-00
ENGINEER	J. KIRBY	2-25-00
DESIGNED BY	J. KIRBY	2-25-00
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME–FRONT REMEDIATION
INJECTION WELL PFI–4
MECHANICAL
DETAILS AT WELLHEAD

A.B. DWG. NO.
SCALE: 3/4"=1'-0"
SHEET 1 OF 1
CODE IDENT. SIZE F DWG. NO. 663–M–01 REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE
4/8 SAND
SLOUGH
4/8 SAND/BENTONITE MIX
GROUT
SCREEN
STEEL, BOLT-ON CENTRALIZER

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xxx± FRACTIONS ±
.xxxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

NEXT ASSY / REUSED ON#'S

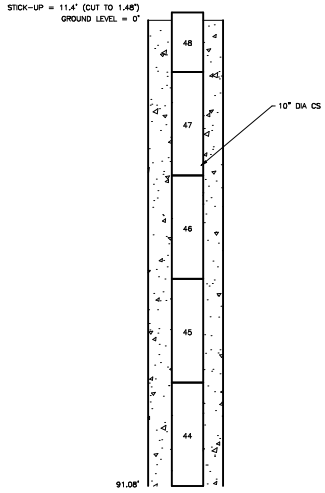
DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

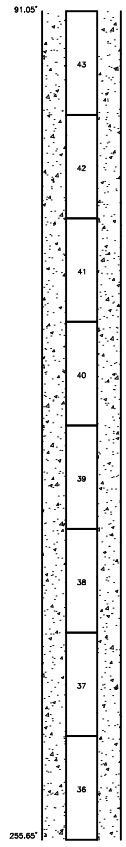
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

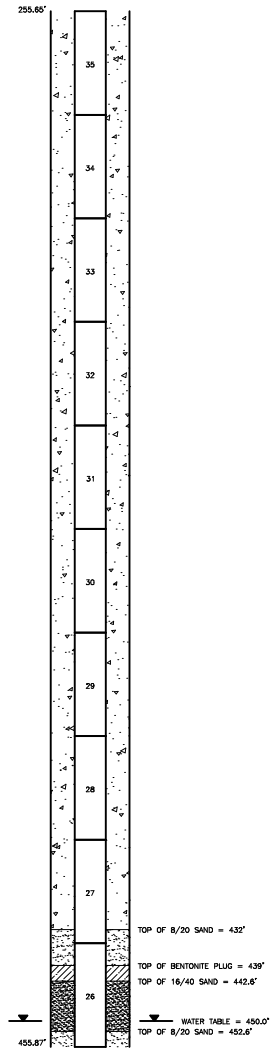
WSTF – PLUME–FRONT REMEDIATION
EXTRACTION WELL PFE–2
CIVIL
WELL COMPLETION DIAGRAM

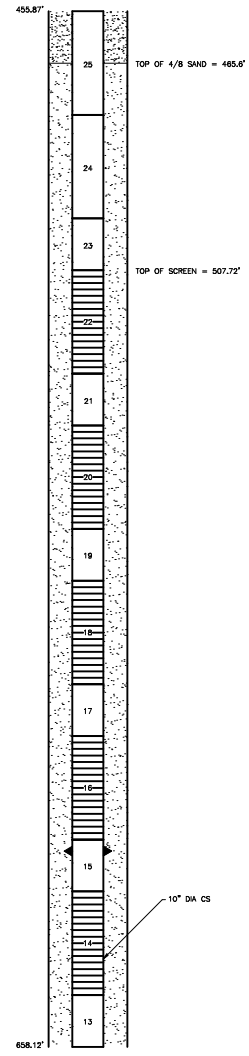
CODE IDENT. | A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1 | SIZE F | DWG. NO. 654–C–03 | REV.

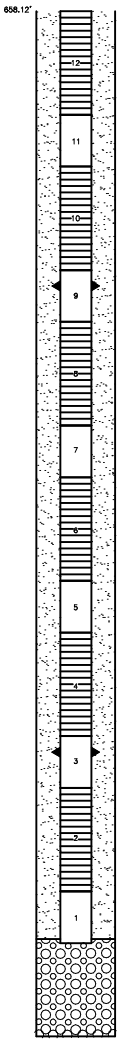
SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL











NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE
8/20 SAND
SLOUGH
STEEL, BOLT-ON CENTRALIZER
4/8 SAND
GROUT
16/40 SAND
SCREEN

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / REUSED ON

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xxx± FRACTIONS ±
.xxxx±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

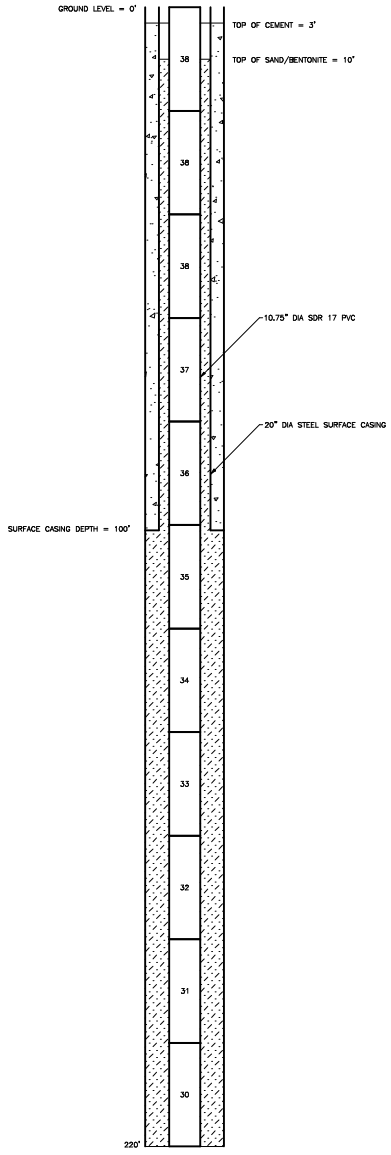
DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

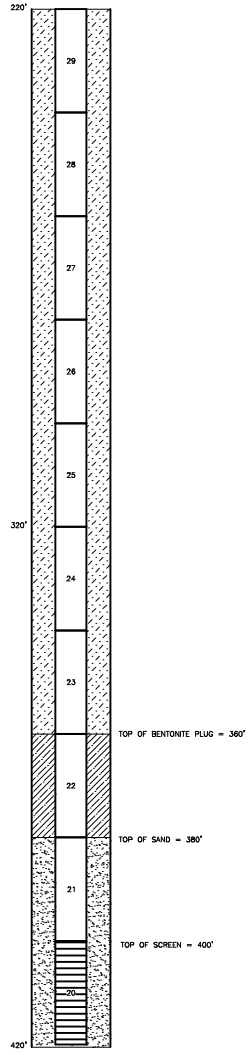
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

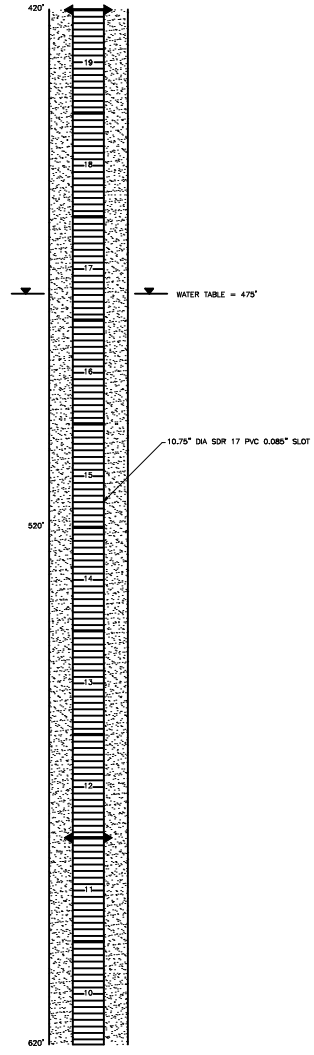
WSTF – PLUME–FRONT REMEDIATION
EXTRACTION WELL PFE-3
CIVIL
WELL COMPLETION DIAGRAM

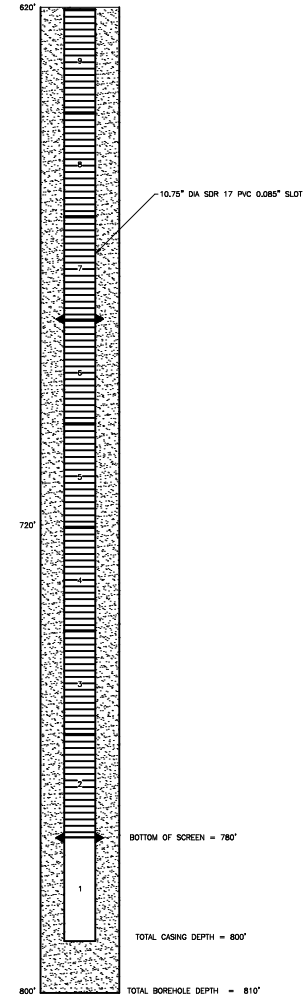
A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1
CODE IDENT. | SIZE F | DWG. NO. 655-C-03 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL









NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE

4/8 SAND

4/8 SAND/BENTONITE MIX

GROUT

SCREEN

STEEL, BOLT-ON CENTRALIZER

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / REVISED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx ANGLES ±
.xxx FRACTIONS ±
.xxxx
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

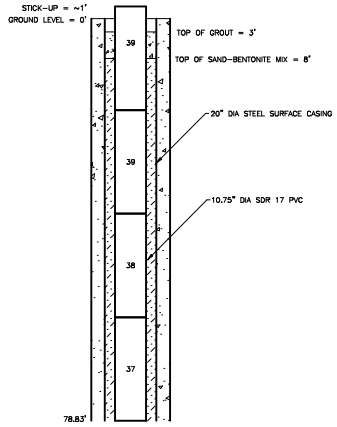
DRAWN BY	M. TARN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

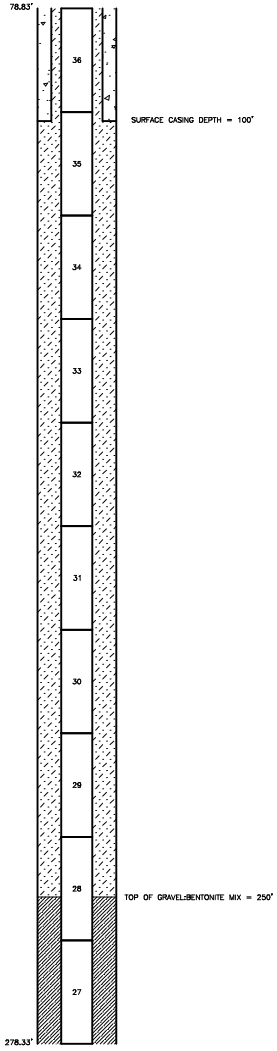
National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
White Sands Test Facility

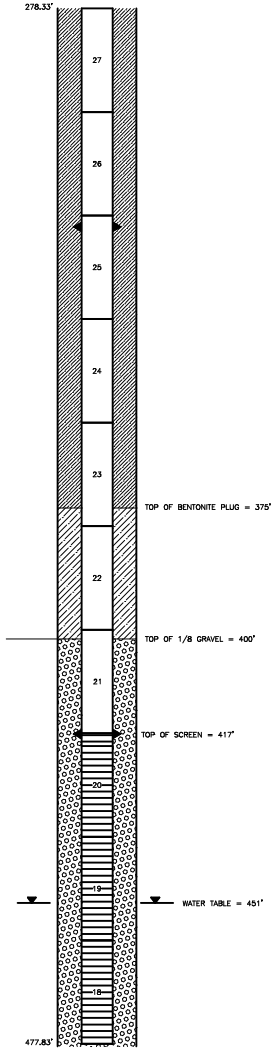
WSTF – PLUME–FRONT REMEDIATION
EXTRACTION WELL PFE–4A
CIVIL
WELL COMPLETION DIAGRAM

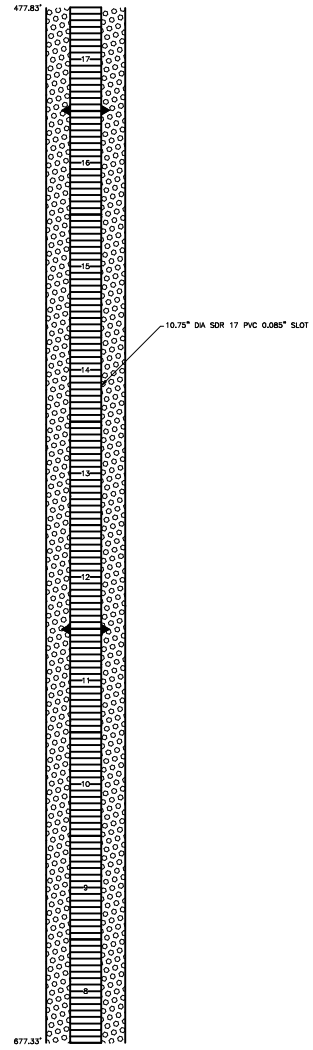
A.E. DWG. NO.
SCALE NONE
SHEET 1 OF 1
CODE IDENT.
SIZE F
DWG. NO. 656-C-03
REV.

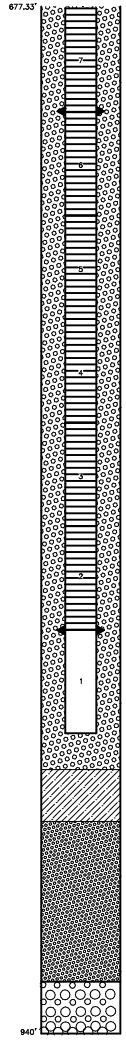
SYMBOL	LETTER ZONE	DESCRIPTION	DATE	APPROVAL











NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE | 8/20 SAND | 8/20 SAND/BENTONITE MIX | SLOUGH | STEEL, BOLT-ON CENTRALIZER

1/8 GRAVEL | GROUT | 1/8 GRAVEL/BENTONITE MIX | SCREEN

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / REUSED ON'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx ± ANGLES ±
.xxx ± FRACTIONS ±
.xxxx ±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
DESIGNED BY		
CHECKED BY		
APPROVAL		
APPROVAL		
AUTHORIZED		
RELEASE		

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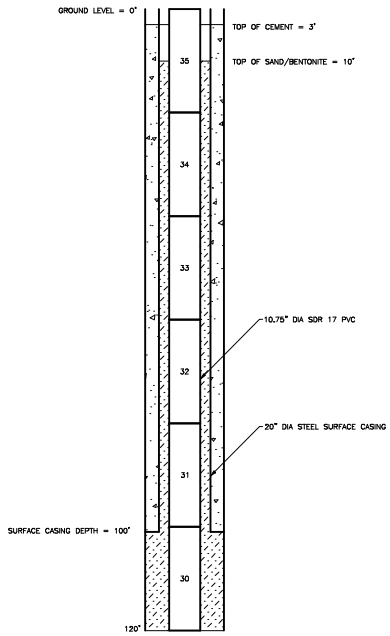
Lyndon B. Johnson Space Center
White Sands Test Facility

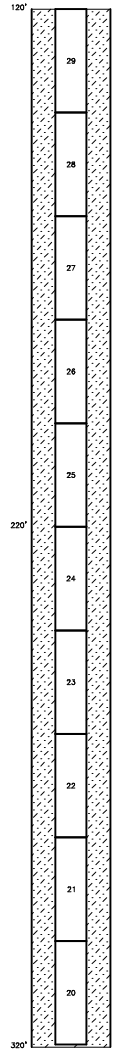
WSTF – PLUME-FRONT REMEDIATION
EXTRACTION WELL PFE-5
CIVIL
WELL COMPLETION DIAGRAM

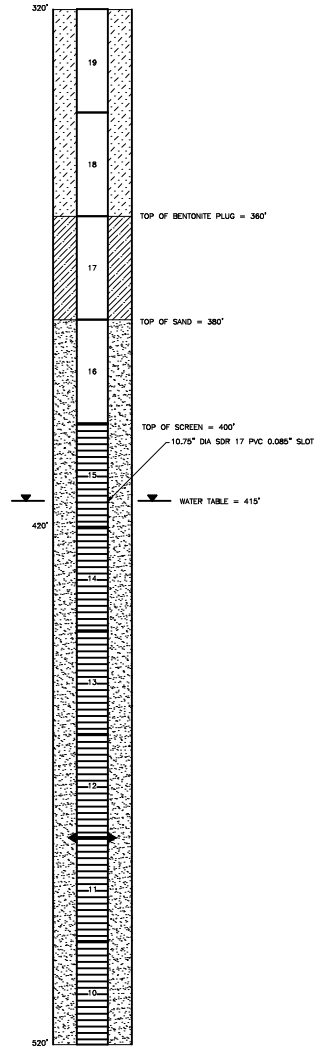
A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1

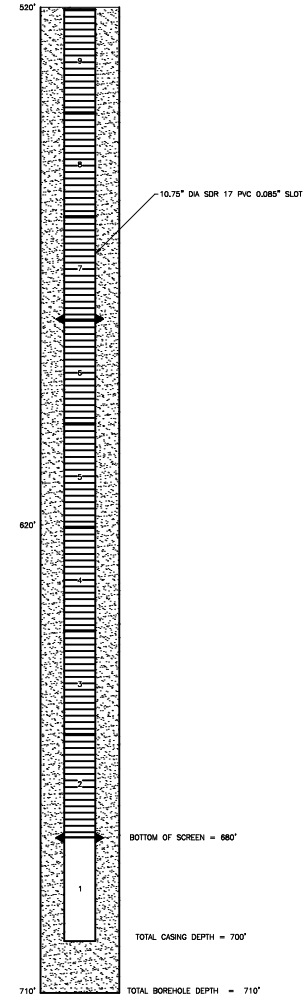
CODE IDENT. | SIZE F | DWG. NO. 657-C-03 | REV.

SYMBOL	LETTER ZONE	DESCRIPTION	DATE	APPROVAL









NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE

4/8 SAND

4/8 SAND/BENTONITE MIX

GROUT

SCREEN

STEEL, BOLT-ON CENTRALIZER

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / REVISED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx ± ANGLES ±
.xxx ± FRACTIONS ±
.xxxx ±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED. √
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

DRAWN BY	M. TARIN	2-18-00
ENGINEER	J. KIRBY	2-18-00
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AUTHORIZED		
RELEASE		

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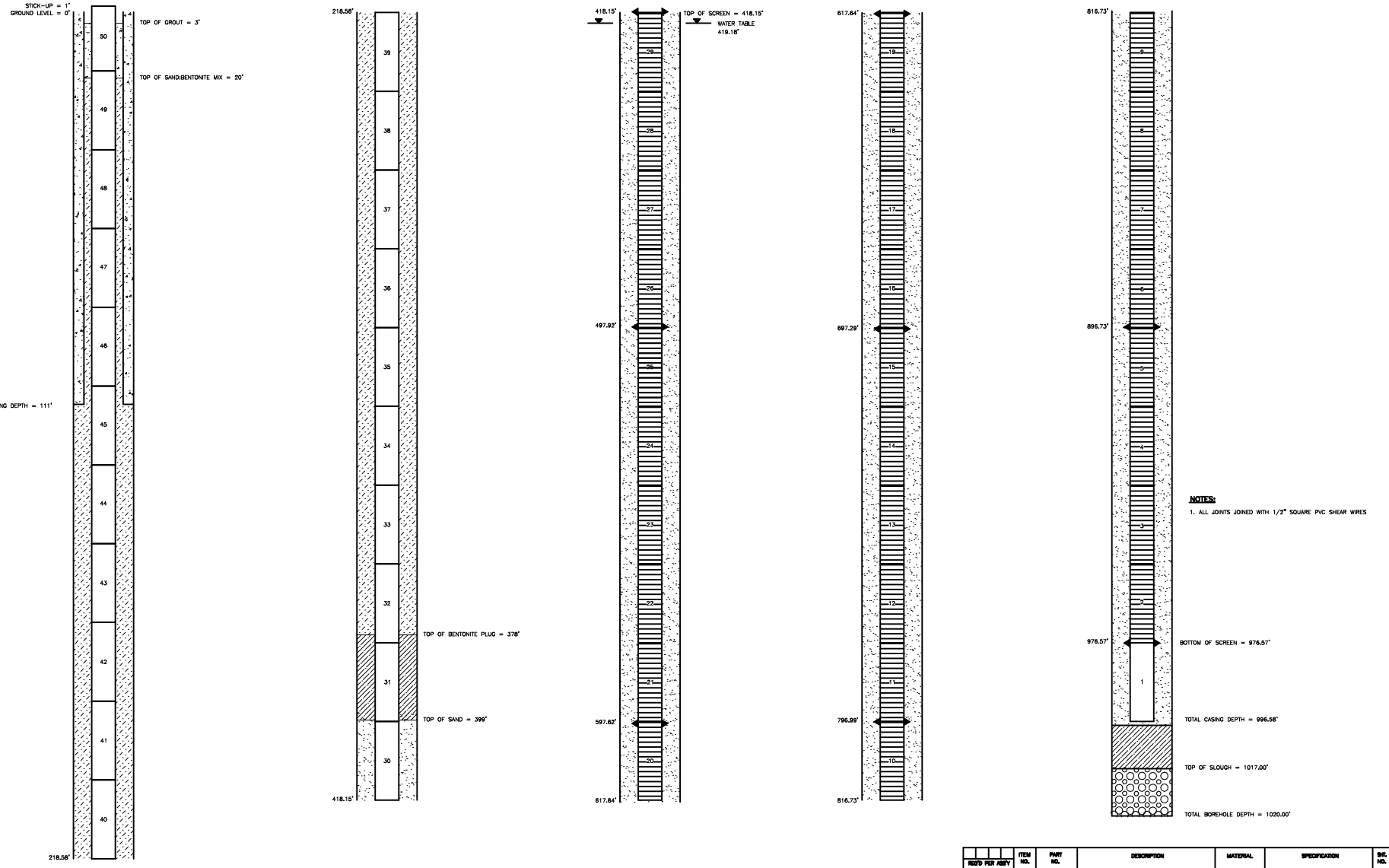
Lyndon B. Johnson Space Center
White Sands Test Facility

WSTF – PLUME–FRONT REMEDIATION
EXTRACTION WELL PFE–7
CIVIL
WELL COMPLETION DIAGRAM

A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 658–C–03 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / REUSED ON'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.X± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
UNLESS NOTED OTHERWISE REMOVE ALL SHARP EDGES AND BURRS.

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APPROVAL		
AUTHORIZED		
RELEASE		

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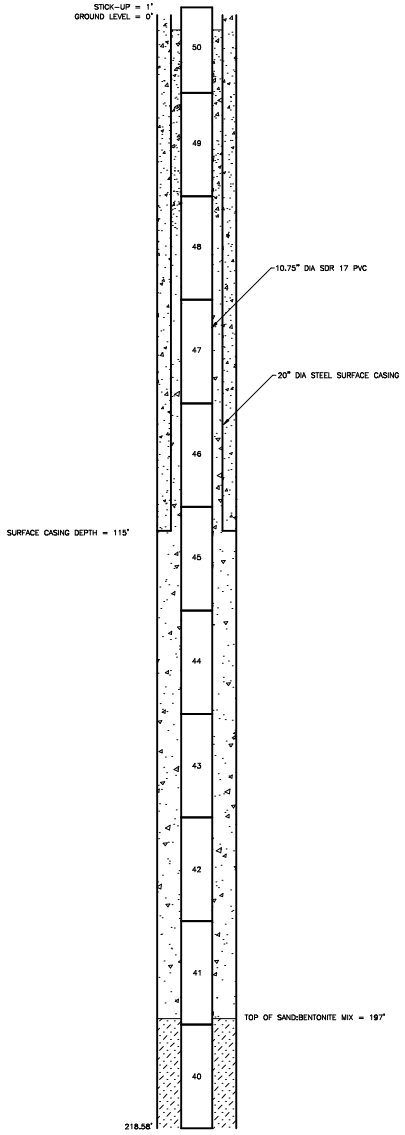
Lyndon B. Johnson Space Center
White Sands Test Facility

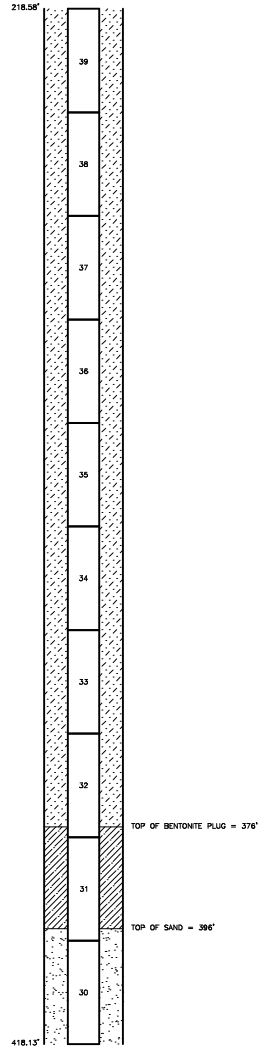
WSTF – PLUME-FRONT REMEDIATION
INJECTION WELL PFI-1
CIVIL
WELL COMPLETION DIAGRAM

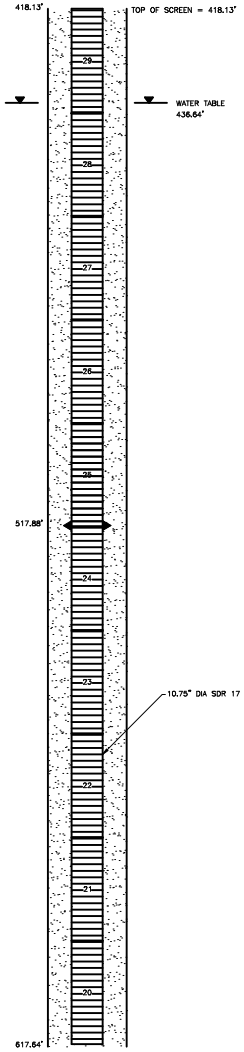
CODE IDENT.	SIZE	DWG. NO.	REV.
	F	660-C-02	

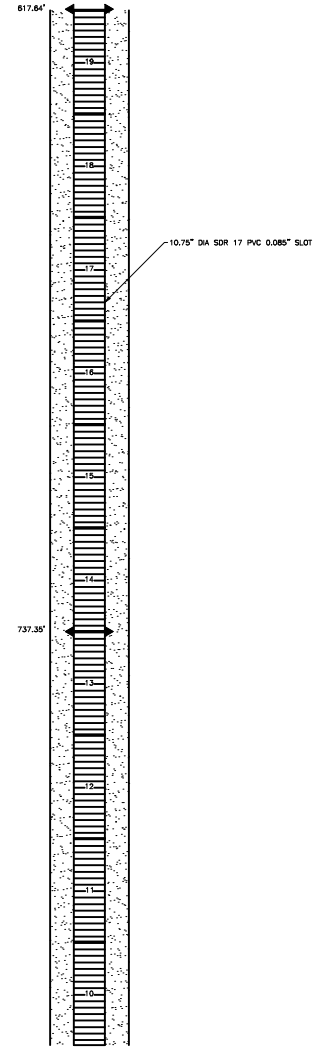
A.B. DWG. NO. | SCALE NONE | SHEET 1 OF 1

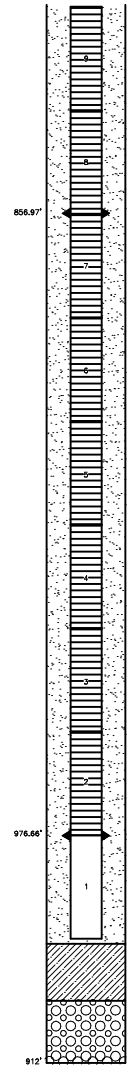
SYMBOL	LETTER ZONE	DESCRIPTION	DATE	APPROVAL











NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE
8/20 SAND/BENTONITE MIX
SLOUGH
4/8 SAND
GROUT
SCREEN
STEEL, BOLT-ON CENTRALIZER

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / REUSED ON#'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.XX± ANGLES ±
.XX± FRACTIONS ±
.XXX±
DIMENSIONS ARE IN INCHES.
SURFACE FINISH IN MICRO INCHES RMS UNLESS OTHERWISE NOTED.
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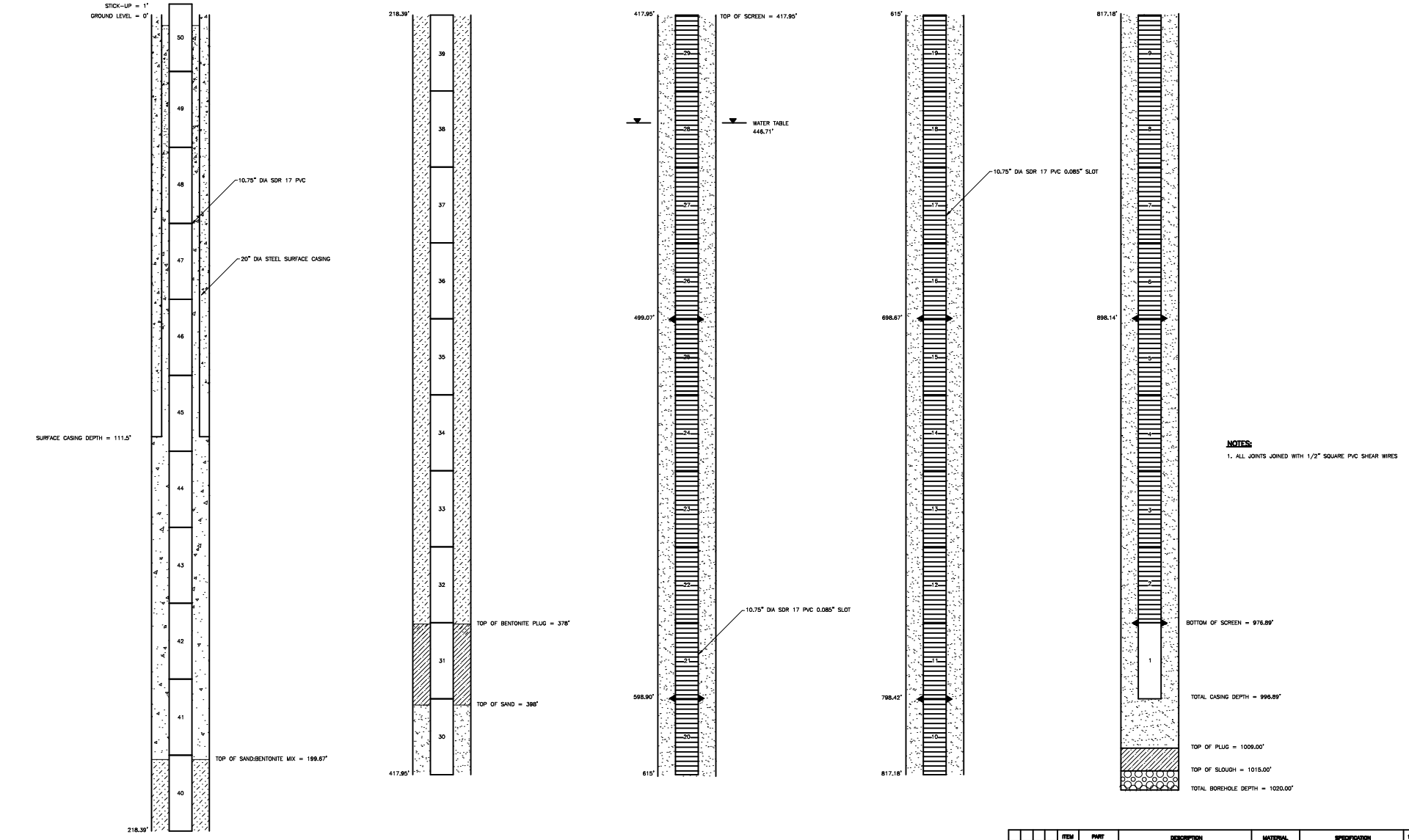
WSTF – PLUME–FRONT REMEDIATION
INJECTION WELL PFI–2
CIVIL
WELL COMPLETION DIAGRAM

A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1
CODE IDENT. | SIZE F | DWG. NO. 661–C–02 | REV.

SYMBOL	LETTER	ZONE	DESCRIPTION	DATE	APPROVAL



NOTES:

1. ALL JOINTS JOINED WITH 1/2" SQUARE PVC SHEAR WIRES

BENTONITE
8/20 SAND/BENTONITE MIX
SLOUGH
4/8 SAND
GROUT
SCREEN
STEEL, BOLT-ON CENTRALIZER

REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	SHT. NO.

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
.xx± ANGLES ±
.xx± FRACTIONS ±
.xxx±
DIMENSIONS ARE IN INCHES.
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AUTHORIZED		
RELEASE		

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Lyndon B. Johnson Space Center
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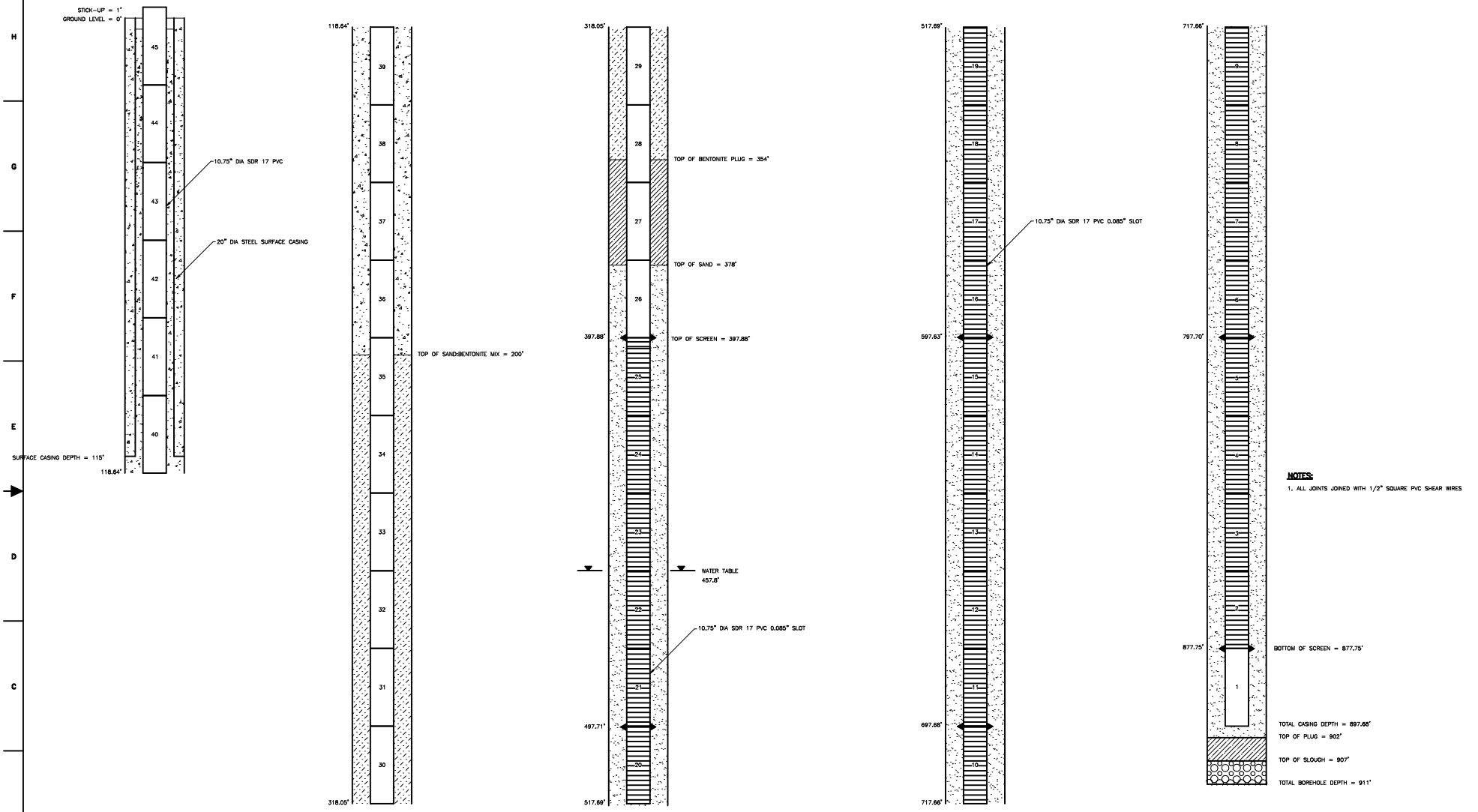
WSTF – PLUME–FRONT REMEDIATION
INJECTION WELL PFI–3
CIVIL
WELL COMPLETION DIAGRAM

A.E. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. F | SIZE | DWG. NO. 662-C-02 | REV.

SYMBOL	LETTER ZONE	DESCRIPTION	DATE	APPROVAL



REQ'D PER ASSY	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL	SPECIFICATION	REF. NO.

NEXT ASSY / RELATED DWG'S

DIMENSIONAL TOLERANCE UNLESS NOTED OTHERWISE
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.XXX±
DIMENSIONS ARE IN INCHES.
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WSTF – PLUME–FRONT REMEDIATION
INJECTION WELL PFI–4
CIVIL
WELL COMPLETION DIAGRAM

A.S. DWG. NO. | SCALE NONE | SHEET 1 OF 1

CODE IDENT. | SIZE F | DWG. NO. 663-C-02 | REV.

SECTION 13390
PACKAGE CONTROL SYSTEMS (PCS)

PART 1 GENERAL

1.1 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Instrument Society of America (ISA): S50.1, Compatibility of Analog Signals for Electronic Process Instruments.
2. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. AB 1, Molded Case Circuit Breakers and Molded Case Switches.
   c. ICS 2, Industrial Control Devices, Controllers and Assemblies.

1.2 SYSTEM DESCRIPTION

A. Assemble panels and install instruments, plumbing, and wiring in equipment manufacturer's factories.

B. Test panels and panel assemblies for proper operation prior to shipment from equipment manufacturer's factory.

1.3 SUBMITTALS

A. Shop Drawings:

1. Bill of material, catalog information, descriptive literature, wiring diagrams, and Shop Drawings for components of control system.
2. Catalog information on electrical devices furnished with system.
3. Shop Drawings, catalog material, and dimensional layout drawings for control panels and enclosures.
4. Panel elementary diagrams of prewired panels. Include in diagrams control devices and auxiliary devices, for example, relays, alarms, fuses, lights, fans, and heaters.
5. Plumbing diagrams of preplumbed panels and interconnecting plumbing diagrams.
6. Interconnection wiring diagrams that include numbered terminal designations showing external interfaces.

B. Quality Control Submittals:

1. Manufacturer's Certificate of Proper Installation.
2. Manufacturer's list of proposed spares, expandables, and test equipment.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers and related equipment as recommended by capsule manufacturer.

1.5 SPARES, EXPENDABLES, AND TEST EQUIPMENT

A. Selector Switch, Push Button, and Indicating Light: 20 percent, one minimum, of each type used.

B. Light Bulb: 100 percent, two minimum, of each type used.

C. Fuse: 100 percent, two minimum, of each type used.

D. Surge Suppressors: 20 percent, one minimum, of each type used.

PART 2 PRODUCTS

2.1 GENERAL

A. Interface requirements for Package Control Systems.

2.2 SIGNAL CHARACTERISTICS

A. Analog Signals:

1. 4 to 20 mA dc, in accordance with compatibility requirements of ISA S50.1.
2. Unless otherwise specified or shown, use twisted shielded pair, two-wire circuits.
3. Transmitters: Load resistance capability conforming to Class L.
4. Fully isolate input and output signals of transmitters and receivers.

B. Pulse Frequency Signals: dc pulses whose repetition rate is linearly proportional to process variable over 10:1 range. Generate pulses by contact closures or solid state switches.

1. Power source: Less than 30V dc.

C. Discrete Signals:

1. Two-state logic signals.
2. Utilize 120V ac sources for control and alarm signals.
3. Alarm signals shall be normally open, close to alarm isolated contacts rated for 5-ampere at 120V ac and 2-ampere at 30V dc.

2.3 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsule Manufacturers and Products:

1. Northern Instruments; Model Zerust VC.
2. Hoffmann Engineering; Model A-HCI.

2.4 CONTROL PANEL

A. Conform to NEMA ratings as specified in individual equipment sections.

B. Minimum Metal Thickness: 14 gauge.

C. NEMA 250, Type 4X Panels: Type 316 stainless steel construction unless otherwise specified.

D. Doors:

1. Three-point latching mechanisms in accordance with NEMA 250, Type 1 and 12 panels with doors higher than 18 inches.
2. For other doors, stainless steel quick release clamps.

E. Cutouts shall be cut, punched, or drilled and finished smoothly with rounded edges.

F. Access: Front, suitable for installation with back and sides adjacent to or in contact with other surfaces, unless otherwise specified.

G. Temperature Control:

1. Size panels to adequately dissipate heat generated by equipment mounted on or in the panel.
2. Furnish cooling fans with air filters if required to dissipate heat.
3. For panels outdoors or in unheated areas, furnish thermostatically controlled heaters to maintain temperature above 40 degrees F.

H. Lighting: Minimum of one hand switch controlled internal 100-watt incandescent light for panels 12 cubic feet and larger.

I. Minimum of one 120-volt duplex receptacle for panels 7 cubic feet and larger, or when indicated.

J. Finish:

1. Metallic External Surfaces (Excluding Aluminum and Stainless Steel): Manufacturer's standard gray unless otherwise specified.
2. Internal Surfaces: White enamel.

K. Panel Manufacturers:

1. Hoffman.
2. H.F. Cox.

L. Breather and Drains: Furnish with NEMA 250, Type X panels.

1. Manufacturer and Product: Crouse-Hinds; Model ECD18.

2.5 CONTROL PANEL ELECTRICAL

A. Control Panels Without Motor Starters:

1. Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed from main.
2. Locate to provide clear view of and access to breakers when door is open. Group on single back panel. Provide typed directory.
3. Circuit Breakers:
   a. Coordinate for fault in branch circuit trips, branch breaker, and not main breaker.
   b. Branch Circuit Breakers: 15 amps at 250V ac.
   c. Breaker Manufacturers and Products:
      1) Heineman Electric Co.; Series AM.
      2) Airpax/North American Philips Controls Corp.; Series 205.

B. Control Panels with Three-Phase Power Supplies and Motor Starters:

1. Interlock main circuit breaker with panel door.
   a. Mount logic controls, branch circuit breakers, overload reset switches, and other control circuit devices.
   b. Mount operator controls and indications on front access door.
2. Circuit Breakers:
   a. In accordance with NEMA AB 1.
   b. 40,000-ampere RMS symmetrical rating, minimum at 480 volts, unless otherwise specified or required.
   c. Breakers Except Motor Branch Breakers: Molded case thermal magnetic.
   d. Motor Branch Circuit Breakers:
      1) 50 hp and Less: Magnetic.
      2) Larger than 50 hp: Thermal magnetic with adjustable magnetic trip units.
      3) Ratings: Recommended by manufacturer for maximum motor protection.
      4) Padlock Provisions: OFF position.
   e. Tripping: Indicate with operator handle position.

3. Magnetic Motor Starters:
    a. Magnetic motor starters shall be designed for continuous operation of induction motors at 600 volts maximum, at 60 Hz, and shall comply with NEMA ICS 2. All starters shall be electrically held and wired to provide low voltage power and release. Coil and contact kit replacement parts shall be shown on the label or coil of the contactor. Unless otherwise specified, starters shall be 120-volt coil, 3-pole, 600V ac, 60 Hz, NEMA size 1 minimum. All power wiring shall be straight through the starter with incoming power to the top and load wiring at the bottom. Contacts shall be double break, silver-cadmium oxide, and weld-resistant. Contacts shall be isolated to prevent arcing. Coils, magnets, and contacts shall be capable of being removed or replaced, without special tools, in the field. The contactors shall have MOV-type, transient voltage surge suppression across the coils. Transient voltage surge suppression shall be mounted directly across the coil terminals of all magnetic starters. The suppressor shall limit voltage transients produced by the coil to 220 percent maximum peak line volts.
    b. Solid State Overload Protection: Solid state overload protection shall be provided unless otherwise indicated on the Drawings or approved by the ENGINEER. The solid state overload relay shall be self-powered requiring no additional wiring or control power and be self-protected from short circuits in the motor branch circuit. Each overload shall be adjustable over a full 2:1 FLA adjustment range. The overload must have a plus or minus 2 percent trip repeatability over its entire operating range. The standard overload shall provide Class 20 overload protection. The overload must provide phase loss protection by tripping in 3 seconds or less under a phase loss condition. The overload must be capable of protecting the motor in a starting, full load, or lightly loaded condition against single-phase damage. The overload and phase loss protection must not be able to be defeated by any changes to the setting of the overload. The overload must be ambient insensitive and able to operate in a temperature range of minus 22 degrees F to plus 159 degrees F. The overload relay must have a trip-free normally closed contact rated NEMA A600 with a visible trip indication. The overload relay shall be provided with an additional normally closed auxiliary contact rated NEMA A600. The overload must have a method of being manually tripped for test purposes.
    c. Manual reset type with reset button mounted on panel door.
4. Motor Control: 120V ac (except intrinsically safe circuits where applicable).

a. Power Control Transformer:
1) Sufficient capacity to serve connected load, including 200V ac for duplex outlet plus 100V ac (minimum).
2) Limit voltage variation to 15 percent during contact pickup.
3) Fuse one side of secondary winding and ground the other.
4) Furnish primary winding fuses in underground conductors.

5. Power Distribution Blocks: Furnish to parallel feed top on branch circuit protective devices. Do not “leap frog” power conductors.

C. Wiring:

1. All control panel wiring shall meet the requirements of this Section.
2. ac Circuits:
a. Type: 600-volt, Type THHN/THWN stranded copper.
b. Size: For current to be carried, but not less than No. 16 AWG.
3. Analog Signal Circuits:
a. Type: 600-volt, Type 3 stranded copper, twisted shielded pairs.
b. Size: No. 16 AWG, minimum.
4. Other dc Circuits.
a. Type: 600-volt, Type THHN/THWN stranded copper.
b. Size: No. 16 AWG, minimum.
5. Separate analog and other dc circuits at least 6 inches from any ac power and control wiring.
6. Enclose wiring in sheet metal raceways or plastic wiring ducts.
7. Wire Identification:
a. Identify wiring in control panel.
b. Numbered and tagged at each termination.
c. Wire Tags: Snap-on or slip-on PVC wire markers with legible machine printed markings and numbers. Do not use adhesive or taped-on tags.

D. Wiring Interface:

1. For analog and discrete signal, terminate at numbered terminal blocks.
2. For special signals, terminate power (240 volts or greater) at manufacturer's standard connectors.
3. For panel, terminate at equipment on/with which it is mounted.

E. Terminal Blocks:

1. Quantity:
a. Accommodate present and spare indicated needs. One wire per terminal.
b. Wire spare or unused panel mounted elements to their panels' terminal blocks.

c. Spare Terminals: 20 percent of connected terminals, but not less than 10.

2. General: Group to keep 120V ac circuits separate from 24V dc circuits.
   a. Connection Type: Screw connection clamp.
   b. Compression Clamp:
      1) Hardened steel clamp with transversal grooves penetrating wire strands providing a vibration-proof connection.
      2) Guides strands of wire into terminal.
   c. Screws: Hardened steel, captive and self-locking.
   d. Current Bar: Copper or treated brass.
   e. Insulation:
      1) Thermoplastic rated for minus 55 to plus 110 degrees C.
      2) Two funnel shaped inputs to facilitate wire entry.
   f. Mounting:
      1) DIN rail.
      2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
      3) End Stops: One at each end of rail, minimum.
   g. Wire Preparation: Stripping only.
   h. Jumpers: Allow jumper installation without loss of space on terminal or rail.
   i. Marking System:
      1) Terminal number shown on both sides of terminal block.
      2) Allow use of preprinted and field marked tags.
      3) Terminal strip numbers shown on end stops.
      4) Mark terminal block and terminal strip numbers as shown on panel control diagrams or as indicated in the Specifications.
3. Terminal Block, 120-Volt Power:
   a. Rated Voltage: 600V ac.
   b. Rated Current: 30 amp.
   c. Wire Size: 22-10 AWG.
   d. Rated Wire Size: 10 AWG.
   e. Color: Gray body.
   f. Spacing: 0.25 inch, maximum.
   g. Manufacturer and Product: Phoenix Contact; Type UK5N and UK6N.
4. Terminal Block, Ground:
   a. Wire Size: 20-1/0 AWG.
   b. Rated Wire Size: As required.
   c. Color: Green and yellow body.
   d. Spacing: 0.25 inch, maximum.
   e. Grounding: Ground terminal blocks electrically grounded to the mounting rail.
   f. Manufacturer and Product: Phoenix Contact; Type USLKG.
5. Terminal Block, Blade Disconnect Switch:

a. Use: Provide one for each discrete input and output field interface wire.
b. Rated Voltage: 600V ac.
c. Rated Current: 10 amp.
d. Wire Size: 22-12 AWG.
e. Rated Wire Size: 12 AWG.
f. Color: Gray body, orange switch.
g. Spacing: 0.25 inch, maximum
h. Manufacturer and Product: Phoenix Contact; Type UDK 4-MTK.

6. Terminal Block, Fuse/Disconnect Plug:
   a. Use: Provide one for each analog input and output field interface wire.
   b. Rated Voltage: 300V ac.
   c. Rated Current: 15 amp.
   d. Wire Size: 30-14 AWG.
   e. Manufacturer and Product: Phoenix Contact; V10K 1,5-D/TG/D/PE with Type ST.
7. Terminal Block, Fused, 24V dc:
   a. Rated Voltage: 600V dc.
   b. Rated Current: 6.3 amp.
   c. Wire Size: 26-8 AWG.
   d. Rated Wire Size: 12 AWG.
   e. Color: Black body.
   f. Fuse: Amperage size as required.
   g. Fuse Marking: Fuse amperage rating shown on top of terminal block.
   h. Indication: LED diode 24V dc.
   i. Leakage Current: 7.5 mA, maximum.
   j. Spacing: 0.32 inch, maximum
   k. Manufacturer and Product: Phoenix Contact; Type UK6.3-HESi.
8. Terminal Block, Fused, 120V ac:
   a. Rated Voltage: 600 V ac.
   b. Rated Current: 6.3 amp.
   c. Wire Size: 26-8 AWG.
   d. Rated Wire Size: 12 AWG.
   e. Color: Black body.
   f. Fuse: Amperage size as required.
   g. Fuse Marking: Fuse amperage rating shown on top of terminal block.
   h. Indication: Neon lamp 110V ac.
   i. Leakage Current: 1.0 mA, maximum.
   j. Spacing: 0.32 inch, maximum
   k. Manufacturer and Product: Phoenix Contact; Type UK6.3-HESi.

9. Terminal Block, Fused, 120V ac, High Current:
    a. Rated Voltage: 600V ac.
    b. Rated Current: 35 amps.
    c. Wire Size: 18-8 AWG.
    d. Fuse: Amperage size as required.
    e. Manufacturer: Phoenix Contact.

F. Grounding:

1. Enclosures, control panels, and cabinets signal and shield ground connections shall be made as shown on the Drawings, for each enclosure, control panel, and cabinet that has a dedicated #4 AWG ground conductor from the ground grid, MCC ground bus, or switchgear ground bus. Enclosures, control panels, and cabinets that do not have a #4 AWG ground conductor shall be installed as follows:
    a. Furnish isolated copper grounding bus for signal and shield ground connections.
    b. Ground this ground bus at a common signal ground point in accordance with national Electrical Code requirements.
    c. Single Point Ground for Each Analog Loop:
        1) Locate at dc power supply for loop.
        2) Use to ground wire shields for loop.
    d. Ground terminal block rails to ground bus.

G. Analog Signal Isolators:

1. Furnish for all analog signals that are sent from each control panel and cabinet.
2. Power: 115V ac.
3. Three-way isolation; input, output, and power are isolated from each other.
4. Meets ANSI/IEEE C37.90.
5. Accuracy: Better than plus or minus 0.1 percent of output span.
6. Manufacturer and Product: Acromag; Series 430I.

H. Relays:

1. General:
    a. All relays shall be provided with surge protection across the coils as follows:
        1) Surge Suppressors: Magnetic control, machine tool, and industrial relays.
        2) Metal Oxide Varistors: ac Voltage Coils.
        3) Diodes: dc Voltage Coils.
        4) Surge protection shall be provided and installed as recommended by the relay manufacturer.

b. Magnetic control, machine tool, and industrial relays shall be provided as indicated on the Drawings by multiple single pole, single throw contacts to the right of the relay coil. Signal/control circuit switching relays shall be provided as indicated on the Drawings by multiple single pole, double throw contacts (Form C) to the right of the relay coil.

2. Signal/Control Circuit Switching Relay:
   a. Relay Mounting: Plug-in type socket.
   b. Relay Enclosure: Furnish dust cover.
   c. Socket Type: Screw terminal interface with wiring.
   d. Socket Mounting: DIN rail.
   e. Provide holddown clips.
3. Magnetic Control, Machine Tool, and Industrial Relays:
   a. NEMA ICS 2, Class A600 (600 volts, 10 amps continuous, 7,200 VA make, 720 VA break), industrial control with a minimum of four field-convertible contacts.
   b. Time Delay Attachment: Solid state.
   c. Provided and installed with manufacturer-recommended and provided surge suppressors across the coil terminals. The surge suppressor shall be designed to absorb all energy surges that appear on the line.
   d. Manufacturer and Product: General Electric; Type CR120B.
4. Signal/Control Circuit Switching Relay, Nonlatching:
   a. Type: Compact general purpose plug-in.
   b. Contact Arrangement: As indicated on the Drawings, two Form C contacts minimum.
   c. Contact Rating: 10A at 28V dc or 240V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 1.5 watts (dc), 2 VA (ac).
   g. Expected Mechanical Life: 50,000,000 operations.
   h. Expected Electrical Life at Rated Load: 500,000 operations.
   i. Indication Type: Neon or LED indicator lamp.
   j. Push-to-test button.
   k. Manufacturer and Product: IDEC Corp.; Series RH.
5. Signal/Control Circuit Switching Relay, Latching:
   a. Type: Dual coil mechanical latching relay.
   b. Contact Arrangement: As indicated on the Drawings, two Form C contacts minimum.
   c. Contact Rating: 10A at 28V dc or 120V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Coil Power: 2 watts (dc), 1.2 VA (ac).
   g. Expected Mechanical Life: 10,000,000 operations.

h. Expected Electrical Life at Rated Load: 200,000 operations.
i. Manufacturer and Product: IDEC Corp.; Series RH2L.

6. Signal/Control Circuit Switching Relay, Time Delay:
   a. Type: Adjustable time delay relay.
   b. Contact Arrangement: As indicated on the Drawings, two Form C contacts minimum.
   c. Contact Rating: 10A at 240V ac.
   d. Contact Material: Silver cadmium oxide alloy.
   e. Coil Voltage: As noted or shown.
   f. Operating Temperature: Minus 10 to plus 55 degrees C.
   g. Repeatability: Plus or minus 2 percent.
   h. Delay Time Range: Select range such that time delay setpoint fall between 20 to 80 percent of range.
   i. Time Delay Setpoint: As noted or as determined by the ENGINEER.
   j. Mode of Operation: As noted or as determined by the ENGINEER.
   k. Adjustment Type: Integral potentiometer with knob external to dust cover.
   l. Manufacturer and Products: Potter and Brumfield; Series CG for 0.5-second to 100-minute delay time ranges, Series CD for 0.1- to 180-second delay time ranges.

I. Power Supplies:

1. Furnish as required to power instruments requiring external dc power, including two-wire transmitters and dc relays.
2. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.
3. Provide output over voltage and over current protective devices to:
   a. Protect instruments from damage due to power supply failure.
   b. Protect power supply from damage due to external failure.
4. Primary switched type.
5. Rail mount such that dissipated heat does not adversely affect other components.
6. Fuses: For each dc supply line to each individual two-wire transmitter.
   a. Type: Indicating.
   b. Mount so fuses can be easily seen and replaced.
7. Manufacturer and Product: Phoenix Contact; CM50-PS-120-230AC/24DC/5.

J. Front-of-panel devices in conjunction with NEMA 250, Type 12 panels shall be rated NEMA 4/13, watertight/oiltight.

1. Potentiometer Units:
    a. Three-terminal, oiltight construction, resolution of 1 percent and linearity of plus or minus 5 percent.
    b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.
    c. Include legend plates with service markings.
    d. Manufacturers and Products:
        1) Allen Bradley; Bulletin 800T.
        2) General Electric; Type CR104P.
2. Indicating Lights:
    a. Heavy-duty, push-to-test type, oiltight, industrial full-voltage, high-visibility LED type for 120V ac applications.
    b. Screwed on prismatic glass lenses in colors noted and factory engraved legend plates for service legend.
    c. Manufacturers and Products:
        1) Allen-Bradley; Bulletin 800T.
        2) General Electric; Type CR104P.
        3) Square-D; Class 9001, Type K.
3. Push Button, Momentary:
    a. Heavy-duty, oiltight, industrial type with full guard and momentary contacts rated for 10 amperes continuous at 120V ac.
    b. Standard size legend plates with black field and white markings for service legend.
    c. Manufacturers and Products:
        1) Allen-Bradley, Bulletin 800T.
        2) Square D; Class 9001, Type K.
        3) General Electric; Type CR104P.
4. Selector Switch:
    a. Heavy-duty, oiltight, industrial type with contacts rated for 120V ac service at 10 amperes continuous.
    b. Standard size, black field, legend plates with white markings, for service legend.
    c. Operators: Black knob type.
    d. Single-hole mounting, accommodating panel thicknesses from 1/16 to 1/4 inch.
    e. Manufacturers and Products for Units with up to Four Selection Positions:
        1) Allen-Bradley; Bulletin 800T.
        2) General Electric; Type CR104P.
        3) Square D; Class 9001, Type K.

K. Front-of-panel devices used in conjunction with NEMA 250, Type 4X panels shall be rated NEMA 4X, corrosion-resistant/watertight.

1. Potentiometer, Watertight:
    a. Three-terminal, heavy-duty NEMA 250, Type 4X watertight construction, resolution of 1 percent and linearity of plus or minus 5 percent.
    b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.
    c. Include engraved legend plates with service markings.
    d. Manufacturer and Product: Allen-Bradley; Bulletin 800H.
2. Indicating Lights, Watertight:
    a. Heavy-duty, push-to-test type, NEMA 250, Type 4X watertight, industrial, full-voltage, high-visibility LED type, for 120V ac applications and corrosion-resistant service.
    b. Screwed on prismatic lenses and factory engraved legend plates for service legend.
    c. Manufacturers and Products:
        1) Allen Bradley; Bulletin 800H.
        2) Square D; Type SK.
3. Push Button, Momentary, Watertight:
    a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with momentary contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
    b. Standard size, black field, legend plates with white markings for service legend.
    c. Manufacturers and Products:
        1) Allen Bradley; Bulletin 800H.
        2) Square D; Type SK.
4. Selector Switch, Watertight:
    a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
    b. Standard size, black field, legend plates with white markings, for service legend.
    c. Operators: Black knob type.
    d. Single-hole mounting, accommodating panel thicknesses from 1/16 to 1/4 inch.
    e. Manufacturer and Products:
        1) Allen Bradley; Bulletin 800H.
        2) Square D; Class 9001, Type SK.

2.6 INSTRUMENT TAG NUMBERS

A. Example:

FM-6WA-XK100

Notation	Explanation
FM	Flow meter
6	Area 600
WA	Water
XK	Unit number
100	Loop number

2.7 NAMEPLATES, NAMETAGS, AND SERVICE LEGENDS

A. Nametags: Permanently mounted bearing entire ISA tag number.

1. Panel Mounted: Plastic, mounted to instrument behind panel face.
2. Field Mounted: Engraved Type 316 stainless steel, 22-gauge minimum thickness, attach with stainless steel.

B. Service Legends (Integrally Mounted with Instrument) and Nameplates:

1. Engraved, rigid, laminated plastic type with adhesive back. Furnish service legends and nameplates to adequately describe functions of panel face mounted instruments.
2. Color: White surface engraved to a black core, white with black letters. Letter height 3/16 inch.
3. For each panel, face mounted laminated nameplate inscribed with the panel name and tag number. Color shall be white with black letters 1/2-inch high.

C. Standard Light Colors and Inscriptions: Unless otherwise specified in individual equipment specifications, use the following color code and inscriptions:

Tag	**Inscription(s)**	**Color**
POWER ON	POWER ON	Green
ON	ON	Red
OFF	OFF	Green
OPEN	OPEN	Red

Tag	Inscription(s)	Color
CLOSED	CLOSED	Green
LOW	LOW	Amber
FAIL	FAIL	Amber
HIGH	HIGH	Amber
AUTO	AUTO	White
HAND OR MANUAL	HAND OR MANUAL	Yellow
LOCAL	LOCAL	White
REMOTE	REMOTE	Yellow
FORWARD	FORWARD	Red
REVERSE	REVERSE	Blue

1. Lettering: Black on white and amber lenses; white on red and green lenses.
2. Standard Push Button Colors, Unless Otherwise Indicated:
   a. STOP, OFF, EMERGENCY STOP, RESET: Red.
   b. All Others: Black.

2.8 ELECTRICAL SURGE AND TRANSIENT PROTECTION

A. General: Equip control panels with surge-arresting devices to protect equipment from damage due to electrical transients induced in interconnecting lines from lightning discharges and nearby electrical devices.

B. Suppressor Locations:

1. At point of connection between each equipment item, including ac powered transmitters and its power supply conductors (direct wired equipment).
2. On analog pairs at each end when the pair travels outside of building.
3. In other locations where equipment sensitivity to surges and transients requires additional protection beyond that inherent to design of equipment.

C. AC Power Supply Suppressor Assemblies:

1. Suitable for connection to 120-volt, single-phase power supplies: Phoenix; MT2PE/S-120AC.

D. DC Signal Suppressor: Telematic; (MTL) SD 32X.

E. AC Signal Suppressor: Telematic; (MTL) SD 150X.

F. Data Highway Plus Suppressor: Telematic; (MTL) SD 16X.

G. Grounding: Coordinate surge suppressor grounding in field panels and field instrumentation per suppressor manufacturer's requirements. Furnish control panels with an integral copper grounding bus for connection of suppressors and other required instrumentation.

PART 3 EXECUTION

3.1 ELECTRICAL POWER AND SIGNAL WIRING

A. Restrain control and signal wiring in control panels by plastic ties or ducts. Secure hinge wiring at each end so bending or twisting will occur around the longitudinal axis of wire. Protect bend area with a sleeve.

B. Arrange wiring neatly, cut to proper length, and remove surplus wire. Install abrasion protection for wire bundles passing through holes or across edges of sheet metal.

C. Use manufacturer's recommended tool with sized anvil for crimp terminations. No more than one wire may be terminated in a single crimp lug. No more than two lugs may be installed on a single screw terminal.

D. Do not splice or tap wiring except at device terminals or terminal blocks.

3.2 PROTECTION

A. Protect enclosures and other equipment containing electrical, instrumentation and control devices, including spare parts, from corrosion through the use of corrosion-inhibiting vapor capsules.

B. During Work, periodically replace capsules in accordance with capsule manufacturer's recommendations. Replace capsules at completion of project.

END OF SECTION

SUPPLEMENT A

COMPONENT SPECIFICATIONS

A. F1 Flow Element, Pitot-Static, Equal Annuli:

1. General:
   a. Function: Produce a pressure differential signal proportional to the square of the flow rate in an air duct.
   b. Type: Multiple port, pitot-static differential pressure producing device.
   c. Parts: Flow element, transmitter, and mounting hardware.
2. Service:
   a. Fluid: Air, unless otherwise noted.
   b. Upstream Fluid Temperature: Minus 13 degrees C to 44 degrees C.
   c. Upstream Static Pressure: As required.
3. Performance:
   a. Flow Range: As required.
   b. Pressure Differential at Full Scale Flow: As required.
   c. Accuracy: Plus or minus 0.5 percent over a flow range of 10:1, minimum.
   d. Permanent Pressure Loss (Head Loss): Less than 18 percent of measured pressure differential for sizes between 4 and 12 inches. Less than 8 percent of measured pressure differential for sizes over 12 inches.
   e. Repeatability: Plus or minus 0.1 percent.
4. Flow Element Calculations: Verify actual duct inner diameter and provide supporting calculations showing expected pressure differential at full scale flow and permanent head loss.
5. Features:
   a. Pitot Ports: Located across the duct diameter such that the differential pressures of four or more sensing ports are sensed, and averaged.
   b. Static Ports: To sense static pressure.
   c. Materials: Type 316 stainless steel, unless otherwise noted.
   d. Duct Size: As required.
   e. Duct Material: As required.
6. Element Connections:
   a. Process Connections:
      1) Type: Weld fitting and compression ferrule, unless otherwise noted.
      2) Materials: Carbon steel, unless otherwise noted.
   b. Instrument Connections: Integrally-mounted flow transmitter.
7. Signal Interface: 4 to 20mA dc output for load impedance of 0 to 500 ohms minimum without load adjustment with 24V dc supply.

8. Enclosure:
    a. Type: NEMA 4X.
    b. Mounting: Integral with sensing element.
9. Manufacturers and Products:
    a. Dieterich Standard Corp.; ProBar Series.
    b. Approved equal.

B. F2 Flow Element and Transmitter, Electromagnetic:

1. General:
   a. Function: Measure, indicate, and transmit the flow of a process liquid in a full pipe.
   b. Type: Electromagnetic flowmeter, with operation based on Faraday's Law, utilizing the pulsed dc type coil excitation principle with high impedance electrodes.
   c. Parts: Flow element, transmitter, interconnecting cables, mounting hardware, and calibrator.
2. Service:
   a. Stream Fluid: Water with trace amounts of industrial contaminants.
3. Performance:
   a. Flow Range: As noted.
   b. Accuracy: Plus or minus 1 percent of rate for all flows resulting from pipe velocities of 1 to 33 feet per second.
   c. Turndown Ratio: Minimum of 10 to 1 when flow velocity at minimum flow is at least 1 foot per second.
4. Features:
   a. Zero stability feature to eliminate the need to stop flow to check zero alignment.
   b. No obstructions to flow.
   c. Very low pressure loss.
5. Process Connection:
   a. Meter Size: As noted.
   b. Connection Type: 150-pound ANSI raised-face flanges or wafer style depending on meter size, unless otherwise noted.
   c. Flange Material: Carbon steel, unless otherwise noted.
6. Signal Interface:
   a. 4 to 20 mA dc for load impedance 0 to 800 ohms minimum for 24V dc supply.
7. Power: 120V ac, 60-Hz, unless otherwise noted.
8. Element:
   a. Meter Tube Material: 304 stainless steel, unless otherwise noted.
   b. Liner Material: Teflon, unless otherwise noted.
   c. Liner Protectors: Covers on each end to protect liner during shipment.
   d. Electrode Type: Flush or bullet nose as recommended by the manufacturer for the noted stream fluid.
   e. Electrode Material: 316 stainless steel, unless otherwise noted.
   f. Enclosure: NEMA 4, unless otherwise noted.
   g. Grounding Ring/Electrode Material: 316 stainless steel, unless otherwise noted.

9. Transmitter:
    a. Display: Indicating and totalizing.
    b. Mounting: Pipe stand, wall.
    c. Enclosure: NEMA 4X.
    d. Zero and Span: Field adjustable.
    e. Indicator: Digital 16-character display, with scale range as noted.
    f. Totalizer: Digital 16-character display, with totalizer unit digit value as noted.
10. Cables:
    a. Types: As recommended by manufacturer.
    b. Lengths: As required to accommodate device locations.
11. Calibration System:
    a. Features:
        1) Field programmable electronics.
        2) Self-diagnostics with troubleshooting codes.
        3) Ability to program electronics with full scale flow, engineering units, meter size, zero flow cutoff, desired signal damping, totalizer unit digit value, etc.
        4) Initial flow tube calibration and subsequent calibration checks.
    b. Equipment:
        1) Built-in electronics with each unit provided.
        2) Alternatively, one portable calibrator of each type required for the various electromagnetic flowmeters provided on the project.
12. Manufacturers:
    a. Endress & Hauser; Promag 33.
    b. Fischer & Porter; miniMAG, COPA-X or MAG-X, as applicable;
    c. Krohne; Altoflux.

C. F3 Flow Element and Switch, Thermal:

1. General:
   a. Function: Monitor process fluid flow and provide contact closure when flow exceeds set point.
   b. Type: Thermal dispersion flow switch using a heated active and a reference RTD temperature sensors to detect rate of flow as a function of the temperature difference between the two sensors.
2. Service:
   a. Fluid: Water.
   b. Operating Pressure: 75 psig.
   c. Operating Temperature: 15 to 20 degrees C.
3. Performance:
   a. Set Point:
      1) Adjustable throughout full range.
      2) Set as noted.
   b. Range: Choose range so that the noted set point is between 30 and 70 percent of the range.
   c. Repeatability: Plus or minus 1 percent of full range.
   d. Temperature, Operating:
      1) Sensor Element: Minus 100 to plus 350 degrees F.
      2) Electronics: Minus 40 to plus 140 degrees F.
   e. Proof Pressure: To 4,000 psig.
   f. Response Time: Field adjustable from 10 to 150 seconds.
4. Features:
   a. Wetted Surfaces Materials: 316 stainless steel with nickel-base braze, unless otherwise noted.
   b. Dry Pipe Protection: When applied to liquid process, furnish protection against the event of the liquid line going dry, unless otherwise noted.
   c. Process Temperature Compensation: Furnish.
5. Process Connections:
   a. Type: 1-1/4-inch NPT(M), unless otherwise noted.
   b. Pipe Size: As noted.
   c. Connection Type: Insertion.
   d. Connection Material: 316 stainless steel, unless otherwise noted.
6. Conduit Connection: 1-1/4-inch NPT(F) reduced to 3/4 inch with bushing.
7. Element: Insertion/Body Length (From Tip of Probe to Process Connection): Determined by the Supplier based upon pipe size and sensor mounting requirements, unless otherwise noted. The insertion length shall be noted on an application specific installation detail prepared and submitted for each unit.

8. Electronics:
    a. Location: Integral with element, unless otherwise noted.
    b. Hermetically sealed with SPDT relay.
9. Signal Interface:
    a. Contact: Single-pole, double-throw (SPDT), rated 120V ac, 2 amps.
    b. Connection: Screw terminal block.
10. Enclosure:
    a. Type: NEMA 7BCD with watertight O-ring seal.
    b. Material: Cast aluminum, unless otherwise noted.
    c. Approval: Factory Mutual for hazardous area, unless otherwise noted.
11. Power: 120V ac, 60-Hz, unless otherwise noted.
12. Cable (Furnished Only When Remote Electronics is Specified):
    a. Type: As required.
    b. Length: As required.
13. Manufacturer: Fluid Components, Inc.; Model 12-64 or Model FR72.

D. L1 Level Element and Transmitter, Submersible, Electronic:

1. General:
   a. Function: Measure well level by means of differential pressure and transmit a signal proportional to level.
   b. Type: Electronic, piezoresistive-micromachined silicon strain gauge, two wire transmitter.
   c. Operating conditions: Transmitter shall operate in water containing low levels of industrial contaminants.
   d. Warranty: Sensor/transmitter shall be warranted against corrosion for a period of 5 years.
2. Performance:
   a. Range: As noted.
   b. Maximum adjustable range: Noted range shall lie between 40 percent and 80 percent of the maximum adjustable range.
   c. Accuracy: Plus or minus 0.25 percent of calibrated span.
   d. Operating temperature range: Minus 5 degrees F to 140 degrees F.
   e. Compensated temperature range: 30 degrees F to 86 degrees F.
   f. Relative humidity: 0-100 percent.
3. Features:
   a. Type: Cable suspended level sensor
   b. Materials: Sensor body, measurement diaphragm–Titanium. Cable-polyurethane jacket with Kevlar reinforced cord.
   c. Periodic maintenance or cleaning shall NOT be required to maintain function of accuracy.
4. Signal Interface:
   a. Instrument shall be loop powered from 9-32V dc power supply.
   b. Output shall be 4-20 ma DC for load impedance of 0-500 ohms minimum over specified range.
   c. The transmitter shall be factory calibrated for the specified range(s) and shall also include provisions for field calibration through non-interactive zero and span adjustments.
5. Sensor Cable Termination:
   a. The sensor cable shall terminate in a vendor supplied termination box.
   b. The box shall be rated NEMA 4X and be lockable.
   c. Termination enclosure shall be wired complete with lightning arrestors suitable for low voltage DC transmitter circuits.
   d. Cable vent tube shall terminate in this box on desiccant cartridge. Manufacturer shall furnish 6 desiccant cartridges per transmitter.
6. Manufacturers and Products:
   a. Druck; Model PTX 1230.
   b. Approved equal.

E. L2 Level Element and Transmitter, Admittance:

1. General:
   a. Function: Measure and transmit interface level in vessel.
   b. Type: Admittance using low power radio frequency source:
      1) Two-wire transmitter.
      2) “Smart” electronics.
   c. Parts: Element, transmitter (nonintegral), calibrator (or equivalent), and interconnecting cable.
2. Service:
   a. Process Fluid: Water.
   b. Vessel Material: Type 304L stainless steel.
3. Performance:
   a. Range: As required.
   b. Linearity: Plus or minus 0.25 percent of range.
   c. Ambient Temperature: Minus 40 to plus 170 degrees F.
   d. Process Pressure and Temperature Limits: 1,000 psi at 100 degrees F, or 500 psi at 250 degrees F, unless otherwise noted.
4. Element:
   a. Type: Solid rod.
   b. Connection Type: 3/4-inch NPT, unless otherwise noted.
   c. Insertion Length: As required to accommodate specified range and vessel dimensions.
   d. Process Wetted Parts: 316 SS rod, bonded with fluorocarbon-type insulation, unless otherwise noted.
   e. Provisions for grounding if vessel is nonmetallic.
   f. 3/8-inch diameter, nominal.
5. Transmitter:
   a. Integral, unless otherwise noted.
   b. Enclosure: NEMA 4X and explosionproof.
   c. Signal Interface: 4 to 20 mA dc output with Hart protocol for load impedance 0 to 600 ohms minimum for 24V dc supply without load adjustment.
   d. Performance Response Time:
      1) With delay off,20 milliseconds.
      2) With delay on, adjustable 0.5 to 30 seconds.
   e. Indicator: Digital loop meter, NEMA 4X enclosure.
   f. Allowable Static Discharge to Sensor: 10 amps maximum, unless otherwise noted.
6. Accessories:
   a. Calibration Device:
      1) Quantity: One total for contract, unless otherwise noted.
      2) Type: Hart hand-held communicator, unless otherwise noted.

7. Manufacturers:
    a. Drexelbrook; Model 508-45-9.
    b. Endress and Hauser; Model FEC12.

F. L3 Level Switch, Float, Bulkhead:

1. General:
   a. Function: Operate contact at preset liquid level.
   b. Type: Float-actuated bulkhead-mounted; magnetic actuation.
2. Service:
   a. Fluid: Water unless otherwise noted.
   b. Specific Gravity: 1.0 unless otherwise noted.
   c. Pressure: 150 psi maximum.
   d. Temperature: 100 degrees F maximum.
3. Performance:
   a. Set Point: As noted.
   b. Dead Band: 4-inch unless otherwise noted.
4. Features: Float, stem, and other wetted parts stainless steel unless otherwise noted.
5. Process Connections: 2-inch NPT half-coupling or 3-inch, 150-pound ANSI RF flange as required.
6. Signal Interface Contact: DPDT snap action contact rated 5A continuous at 120V ac.
7. Enclosure: NEMA 4, unless otherwise noted.
8. Manufacturers:
   a. LINC; Model L471.
   b. Magnetrol; Tuffy series.
   c. Robertshaw; Series SL-500.

G. L4 Level Switch, Float, Tank Top:

1. General:
   a. Function: Operate switch at preset level in a tank.
   b. Type: Float-actuated mounted directly to tank top.
2. Service:
   a. Fluid: Water unless otherwise noted.
   b. Specific Gravity: 1.0 unless otherwise noted.
   c. Pressure: 150 psi maximum.
   d. Temperature: 100 degrees F maximum.
3. Performance:
   a. Set Point: As noted.
   b. Dead Band: 1-inch maximum.
4. Features:
   a. Float, stem, and guide tube connected to a switch enclosure.
   b. Insertion Length: As required to achieve the noted set point.
   c. Float Size: 4-1/2-inch unless otherwise noted.
   d. Materials: Wetted parts 304 or 316 stainless steel unless otherwise noted.
5. Process Connection: 1-inch NPT.
6. Signal Interface Contact: DPDT snap action rated 10A continuous at 120V ac.
7. Enclosure: NEMA 4 unless otherwise noted.
8. Manufacturers:
   a. Magnetrol; Model T20.
   b. Robertshaw; Series SL-100.

H. L5 Level Element and Switch, Float:

1. General:
   a. Function: Actuate contact at preset liquid level.
   b. Type: Float-actuated mounted directly to sump wall.
2. Service: Liquid; water.
3. Performance:
   a. Set Point: As noted.
   b. Differential: 1-inch maximum.
   c. Temperature: Minus 40 degrees F to 140 degrees F.
   d. Pressure: Maximum 150 psig.
4. Features:
   a. Bracket mounting.
   b. Float Material and Size: Buna N; 1-7/8-inch.
   c. Stem and Mounting Material: Type 304 stainless steel.
   d. Integral splash shield.
5. Signal Interface:
   a. Switch Type: SPST snap action.
   b. Switch Contacts:
      1) Rated 20 VA at 120V ac.
      2) Normally open.
      3) Lead cable 2 #18 AWG, 6 feet, neoprene jacket.
6. Manufacturer and Product: GEMS; Series LS-270, Model No. 43765.

I. P1 Pressure Gauge:

1. General:
   a. Function: Pressure indication.
   b. Type: Bourdon tube.
2. Performance:
   a. Range: As noted. Compound scale when noted.
   b. Accuracy: Plus or minus 0.5 percent of span.
3. Features:
   a. Mounting: Lower stem, unless otherwise noted.
   b. Dial: 4-1/2-inch diameter, unless otherwise noted.
   c. Case Material: Phenolic plastic, unless otherwise noted.
   d. Element Material: Phosphor-bronze, unless otherwise noted.
   e. Dampening: Pulsation dampener when noted, piston type with multiple choice of piston placement to vary the desired amount of dampening.
   f. Case Type: Solid front design with solid wall between window and element. Rear of case, gasketed pressure relief.
   g. Pointer: Micrometer pointer with self-locking adjustment.
   h. Movement: Stainless steel, rotor geared.
4. Process Connection:
   a. Line Size: 1/2-inch.
   b. Connection Type: Threaded.
5. Manufacturers and Products:
   a. Ashcroft; Duragauge Model 1279/1379.
   b. Robert Shaw Acragage.
   c. Marsh Mastergauge.

J. P2 Pressure Differential Gauge, Low Range Air:

1. General:
   a. Function: Indicate differential pressure locally.
   b. Type: Bellows.
2. Service:
   a. Rated Total Pressure: 20 inches Hg. to 15 psig.
   b. Temperature Limits: 20 degrees F to 140 degrees F.
   c. Air filter differential pressure, air static pressure.
3. Performance:
   a. Range: As required.
   b. Accuracy: 2 percent of full scale.
4. Features:
   a. Indictor: 4-1/2-inch diameter.
   b. Adjustments: Front accessible zero.
   c. Scale: Linear.
   d. Connections: 1/8-inch, NPT.
   e. Case: Die-cast aluminum.
   f. Mounting: Panel, surface, or pipe.
5. Manufacturers and Products:
   a. Dwyer; Series 2000 Magnehelic.
   b. ITT Barton; Model 227 or 200.

K. P3 Pressure Switch, Fixed Dead Band:

1. General:
   a. Function: Monitor pressure and provide contact closure(s) when pressure is at the noted set point.
   b. Type: Diaphragm sealed piston actuator.
2. Performance:
   a. Set Point: As required.
      1) Adjustable over the full range.
      2) Set as noted.
   b. Range: The noted set point shall fall between 30 percent and 70 percent of the range.
   c. Set Point Repeatability: Plus or minus 1 percent of range.
3. Features:
   a. Diaphragm Material: Buna-N, unless otherwise noted.
   b. Pressure Connection: Type 316 stainless steel, unless otherwise noted.
   c. Reset: Automatic, unless otherwise noted.
4. Enclosure: NEMA 4X, unless otherwise noted.
5. Signal Interface:
   a. Contact Type: SPDT, snap action switch, rated for 15 amps at 120V ac.
   b. Number of Switch Elements: One, unless otherwise noted.
6. Manufacturers and Products:
   a. Ashcroft; B Series.
   b. United Electric; Series 400.
   c. SOR.

L. P4 Pressure Switch, Low Range Air:

1. General:
    a. Function: Monitor air pressure and provide contact closure(s) when pressure is at the noted setpoint.
    b. Type: Diaphragm actuator.
2. Performance:
    a. Setpoint: As required.
    b. Range: The setpoint shall fall between 30 percent and 70 percent of the range.
    c. Setpoint Repeatability: Plus or minus 2 percent of range.
    d. Maximum Rated Pressure: 10 psig.
3. Features:
    a. Diaphragm Material: Silicone rubber.
    b. Pressure Connection: 1/8-inch NPT aluminum.
    c. Reset: Automatic.
    d. Electrical Connection: 1/2-inch NPT.
4. Enclosure: NEMA 7 (explosion proof).
5. Signal Interface:
    a. Contact Type: SPDT snap action switch, rated for 15 amps at 120V ac.
    b. Number of Switch Elements: One.
6. Manufacturers and Products:
    a. Dwyer; Model 1950.
    b. ITT Barton.

M. P5 Pressure Transmitter, Electronic:

1. General:
   a. Function: Measure pressure and transmit signal proportional to pressure.
   b. Type: Electronic variable capacitance, two-wire transmitter.
2. Performance:
   a. Range: As noted.
   b. Maximum Adjustable Range: Such that the noted range shall lie between 40 percent and 80 percent of the maximum adjustable range.
   c. Accuracy: Plus or minus 0.25 percent of calibrated span.
   d. Temperature: Minus 20 degrees F to plus 200 degrees F, minimum.
3. Features:
   a. Type: Gauge pressure, unless otherwise noted.
   b. Damping: Fluid or electronic type with adjustment.
   c. On-site LCD Display.
   d. Suppressed or Elevated Zero: When noted.
   e. Diaphragm Sensor: Ceramic; all other parts 316 stainless steel.
   f. Wetted O-Rings: Viton, unless otherwise noted.
   g. Housing: Modular with separate compartments for electronics and field connections.
   h. Fill Fluid: Silicone, unless otherwise noted.
4. Process Connections:
   a. Line Size: 1/2 inch or 1/4 inch, selectable.
   b. Connection Type: FNPT.
5. Signal Interface: 4 to 20 mA dc output for load impedance of 0 to 500 ohms minimum without load adjustment with 24V dc supply.
6. Enclosure:
   a. Type: NEMA 4X, unless otherwise noted.
   b. Mounting: Pipe or wall as noted. Provide brackets with Series 300 stainless steel bolts.
7. Manufacturer and Products:
   a. Endress & Hauser; PMC 133, PMC 134, or PMC 53X CERABAR.

N. S1 Indicator, Loop Powered, Integral Enclosure:

1. General:
   a. Function: Digital indication of an analog signal.
   b. Type:
      1) Loop powered.
      2) Integral NEMA 4X enclosure, unless otherwise noted.
2. Performance:
   a. Accuracy: plus or minus 0.1 percent of span counts, plus or minus 1 count.
   b. Temperature, Operating: minus 10 to plus 70 degrees C (14 to 158 degrees F).
   c. Temperature Coefficient:
      1) Zero: plus or minus 100 ppm/ degree C, max.
      2) Span: plus or minus 150 ppm/ degree C, max.
   d. Display Reading Update: 2.5 conversions/sec.
   e. Input Voltage Drop: 3.9 volts max at 20mA.
   f. FM and CSA approved intrinsically safe for hazardous locations.
3. Features:
   a. Readout Display:
      1) Type: 0.8-inches high, liquid crystal, 3-1/2 digits.
      2) Decimal Point Indication: Switch selectable, four positions.
      3) Dummy Zero: Switch selectable trailing zero.
   b. Wide Range Display Calibration:
      1) Zero: Adjustable from minus 1999 to 1999.
      2) Span: Adjustable from 100 to 3998 counts.
   c. Urethane coating of internal circuitry (for protection from corrosive atmospheres): If noted.
4. Signal Interface: 4-20 mA and 10-50mA, switch selectable.
5. Enclosure:
   a. Type: NEMA 4X, unless otherwise noted.
   b. Mounting: Conduit mount, ½-inch, external mounting bracket for surface mounting; unless otherwise noted.
   c. Front Cover Standard Engineering Units: SCFM.
6. Manufacturers and Products:
   a. Action Instruments; Visipak, Model V560, Loop Powered LCD Indicator.
   b. Newport Electronics: Model 508B (integral NEMA 4X housing).

O. T1 Thermometer, Gauge Type:

1. General: Provide where indicated on the Process Control Diagram.
2. Type: Bi-metal.
3. Parts: Thermometer and thermowell.
4. Range: As required.
5. Accuracy: Plus or minus 1 percent of scale ranges.
6. 3-inch dial.
7. 1/2-inch NPT connection.
8. Stem Length: 2-1/2-inch.
9. Thermometer:
    a. Type 316 stainless steel case.
    b. Externally adjustable dial.
    c. Glass window.
    d. Hermetically sealed.
    e. Adjustable viewing angle.
10. Thermowell:
    a. Type: Separable 3/4-inch NPT process connection, Type 316 stainless steel, unless otherwise noted.
11. Manufacturers and Products:
    a. Ashcroft; Series EI.
    b. 3-D Instruments.
    c. Trend Instruments, Inc.

P. T2 Temperature Element and Transmitter, Resistance:

1. General:
   a. Function: Measure the temperature of a process fluid, and transmit analog signal proportional to temperature.
   b. Type: RTD.
   c. Parts: Element, thermowell, and transmitter.
2. Service:
   a. Fluid: Water.
   b. Range: 0 to 40 degrees C.
3. Element:
   a. Type:
      1) Single-element, three-wire, RTD.
      2) Platinum, 100 ohm nominal at 0 degrees C.
   b. Performance:
      1) Accuracy: Plus or minus 1/4 percent of reading or plus or minus 1/4 degrees F, whichever is greater. Conform to SAMA Standard RC 21-4-1966.
      2) Repeatability: Plus or minus 0.1 percent of span.
      3) Response Time: Less than 10 seconds (bare bulb in agitated water).
   c. Features:
      1) Dimensions: 1/4-inch diameter.
      2) Length to accommodate thermowell insertion and extension lengths.
      3) Spring-loaded element when well is used.
      4) 316 stainless steel sheath.
4. Thermowell:
   a. Features:
      1) Inside Diameter: Sized to match element, for easy removal and maximum heat transfer.
      2) Materials: Type 316 stainless steel, unless otherwise noted.
      3) Insertion Length: As required.
      4) Extension Length: 3 inches, unless otherwise noted.
   b. Process Connections: 3/4-inch NPT connection, unless otherwise noted.
5. Transmitter:
   a. Type: Two-wire, powered by a remote power supply.
   b. Performance:
      1) Ambient Temperature Range: Minus 20 to 150 degrees F. Variations within this range shall not affect accuracy more than plus or minus 1/4 percent of range per 50 degrees F.
      2) Accuracy: Plus or minus 0.15 percent of span.
      3) Repeatability: Plus or minus 0.05 percent of span.

c. Features:
    1) Indicator: 0 to 40 degrees C.
d. Signal Interface: 4 to 20 mA dc for load impedance 0 to 600 ohms minimum for 24V dc supply without load adjustment.
e. Enclosure:
    1) Type: NEMA 4.
    2) Mounting: Wall, pipe stand, or element, as noted.

6. Manufacturers:
    a. Foxboro; Series PR element and well with 893RA transmitter.
    b. Rosemount; Series 79 thermowell, 58C, 68, 78, 88 Series platinum RTD and Model 444 transmitter.

Q. Y1 Telephone Dialer Alarm System:

1. General:
   a. Function: Continuously monitor normally open contacts and upon a contact closure shall dial preprogrammed telephone numbers, deliver a prerecorded message, and reset itself upon reception of a signal from the person being called.
   b. Type: Dialer shall be a 16-bit microprocessor based system with all programming and voice messages stored in non-volatile memory. Dialer shall be compatible with cellular telephone or standard telephone communication network.
2. Performance:
   a. Alarm Response Delay: 1 to 5,999 seconds.
   b. Telephone Numbers: Nine phone numbers up to 60 digits in length.
   c. Message Length: 10 seconds per message.
   d. Number of Alarm Channels: Four digital, expandable up to eight digital total.
   e. Power: 120V ac, 60-Hz with battery backup for 60 hours of monitoring service.
   f. The system shall be programmable locally or remotely via touch tone telephone.
   g. Operating Temperature: 20 degrees F to 130 degrees F.
   h. Humidity: 0 to 95 percent noncondensing.
3. Features:
   a. Three-year manufacturer's parts and labor warranty.
   b. Six-digit security code.
   c. Surge protection on power, telephone, and alarm lines.
   d. Direct telephone or cellular communications to FAX machines, answering machines, digital or voice radio pagers, or to computers.
   e. Call progress decoding.
   f. Separate and independent call list for each alarm channel.
   g. Visual indicators for power, fault, run, phone off-hook, line off-hook, incoming call, call in progress, and FAX in progress.
4. Enclosure: NEMA 4X fiberglass.
5. Manufacturers and Products:
   a. Microtel; Series 1000 alarm dialer.
   b. Or approved equal.

R. Y2 Programmable Logic Controller System:

1. General:
   a. Function: Used for process monitoring and control by emulating functions of conventional panel mounted equipment such as relays, timers, counters, current switches, calculation modules, PID controllers, stepping switches, and drum programmers.
   b. Type: Microprocessor based device programmable using ladder logic.
   c. Parts: Central processing unit (CPU), power supply, local and remote input/output modules, local and remote base (chassis/rack) controllers, I/O bases (chassis/rack), data highway, and factory assembled interconnecting cables. Provide components required to make a complete and totally operational system. Reference P&ID Drawings.
   d. All equipment shall be Year 2000 compliant.
2. Environmental:
   a. Temperature: Operating range 32 to 140 degrees F (0 to 60 degrees C); storage range minus 40 to 158 degrees F (0 to 70 degrees C).
   b. Humidity: Operating range 5 to 95 percent noncondensing.
   c. Vibration:
      1) Sinusoidal: IEC 68-2-6, Test Fc; 0.15 mm peak-to-peak, 10- to 57-Hz; 1 g, 57- to 150-Hz.
      2) Random: IEC 68-2-34, Test Fdc; 0.4 g^2/Hz, 80- to 350-Hz, and 3dB/octave rolloff, 80- to 20-Hz and 350- to 2-KHz at 10 min/axis.
   d. Noise: IEC 801, Part 3, Level 3 and Part 4, Level 3; MIL STD-461B.
   e. Isolation: User-side to PLC side 1,500V rms.
   f. Agency Approvals and Standards:
      1) UL listed.
      2) CSA certified.
3. Central Processing Unit (CPU):
   a. Type: Microprocessor, 16-bit minimum.
   b. Scan Time: Less than 1 ms/K words of relay ladder logic.
   c. PLC Communications:
      1) One communication ports, RS-232 or RS-422.
      2) Baud rates supported 1200, 2400, 9600, 19200.
   d. Network Communications: One Allen-Bradley Data Highway Plus port.
   e. Remote I/O Communication Links.

f. Instruction Set:
    1) Timers and counters.
    2) Math: Signed integer and floating-point math including add, subtract, multiply, divide, square root, and compare.
    3) Register Operations: Shift registers, bit shift, bit set, bit clear, data move and data format conversion.
    4) Process Loop Control: User configurable direct or reverse acting PID loop control computation with the capability of both AUTO and MANUAL modes of operation, remote access to controller tuning constants.
    5) Real Time Clock: Date and time set and compare.
    6) Miscellaneous: Jump or skip to a label, one shot, drums, preconfigured analog alarm functions, subroutines.

g. Diagnostics:
    1) Indicators: Battery status, PLC status, PLC operation mode, remote I/O communication status.
    2) Status Word: With failure status for PLC battery, scan overrun, communications, I/O, special functions.
    3) Power Up: PLC checks status of PROMs upon powerup; runs self-diagnostics on power-up; periodically runs self-diagnostics while in RUN mode, halts logic processor and sets outputs to configured state if fatal error is detected.
    4) Diagnostic Tables: Tables, displayable by programming computer, that describe nature and location (address) existing faults and errors.

h. Agency Approvals and Standards:
    1) UL listed.

4. Random Access Memory (RAM):
    a. Memory Size: 32 K words.
    b. Read only memory (ROM) for controller's operating system and diagnostics.
    c. Memory Protection: Switch.
5. Power Supply: One unit for each input/output base assembly:
    a. Voltage: 120/220 volts (user selectable), 60-Hz input; 85 to 132 volts output. Allen-Bradley No. 1746-P2 .
    b. Mounting: External to base.
6. Input/Output: Complete input/output system, including remote I/O with distances up to 10,000 feet maximum up to four remote logical racks.
    a. Discrete Input Modules:
        1) Voltage: 120 volts, 60-Hz.
        2) Operating Power: 2 watts.
        3) Points per Module: 16, maximum.
        4) LED status indicator for each point.
        5) Isolation: Between input point and PLC, 1,500 volts rms.
        6) Manufacturer: Allen-Bradley, Model No. 1746-IA16.

b. Discrete Output Modules:
   1) Voltage: 120 volts, 60-Hz.
   2) Operating Power: 2 watts.
   3) Load Rating: 2 amps continuous.
   4) Isolation: Between PLC and output point, 1,500 volts rms.
   5) Points per Module: 16, maximum.
   6) LED status indicator for each point.
   7) Manufacturer: Allen-Bradley 1746-OA16.

c. Isolated Discrete Output Modules:
   1) Type: Isolated Form A relay.
   2) Voltage: 120 volts, 60-Hz.
   3) Isolated Outputs per Module: 8.
   4) Load Rating: 5 amps continuous.
   5) Operating Power: 2.5 watts.
   6) Points Per Module: 8, maximum.
   7) LED status indicator and fuse for each point.
   8) Isolation: Between PLC and output point, 1,500 volts rms.
   9) Manufacturer: Allen-Bradley, Model No. 1746-0X8.

d. Fast Response DC Input Modules:
   1) Input “Voltage: 24V dc.
   2) Input Current: 8 ma at 24V dc.
   3) Points Per Module: 16, maximum.
   4) Maximum Input Frequency: 1,000 Hz.
   5) Manufacturers and Products: Allen Bradley; Model No. 1746-ITB16 (sink).

e. Analog Input Modules:
   1) Voltage: 24 volts dc.
   2) Power: 3 watts.
   3) Differential Analog Points Per Module: 8 or 4
   4) Isolation: Between PLC and I/O point and between I/O points, 1,500 volts rms.
   5) Analog Input Resolution: 16 bits.
   6) Manufacturer: Allen-Bradley, Model No. 1746-NI8 or 1746-NI4.

f. Analog Output Modules:
   1) Voltage: 24V dc.
   2) Power: 3 watts.
   3) Isolated Analog Points Per Module: 4 maximum.
   4) Isolation Between PLC and I/O Point and Between I/O Points: 1,500 volts rms.
   5) Manufacturer and Product: Allen-Bradley; Model No. 1746-N04I.

7. Remote Adapter Module:
   a. One remote I/O adapter module required for each remote chassis.
   b. Manufacturer and Product: Allen-Bradley; Model No. 1747-ASB.

8. Remote I/O Scanner Module:
    a. Manufacturer: Allen-Bradley Model No. 1747-SN.
9. I/O Chassis:
    a. Each remote I/O panel and SLC 5/04 panel shall be furnished with one I/O chassis.
    b. Each chassis shall have 7, 10, or 13 slots.
    c. Manufacturer and Product: Allen-Bradley; Model Nos. 1746-A7, 1746-A10 and 1746-A13.
10. Fiber Optic Module:
    a. Selectable Wavelengths: 850 nm and 1,300 nm.
    b. Compatible with multimode fiber.
    c. Panel-mounted, 120V ac power supply.
    d. Data highway plus and remote I/O communications.
    e. Fault tolerant.
    f. Interaction diagnostics.
    g. Manufacturer and Product: Phoenix Digital; Model OCM-DPR-13-P-DST-ACV.
11. I/O Placement:
    a. From Left to Right: Analog, DC I/O, AC I/O.
    b. Wired to/from PLC I/O modules or racks to/from control panel terminal blocks in all panels (direct connection of field wiring to I/O module or rack is not acceptable.
12. Identification:
    a. Nameplates installed above/below each PLC component (CPU, I/O rack, power supply, etc.).
    b. Label configured I/O points as they have been configured (addressed) in the system.
13. Programming Software:
    a. Programming software shall be manufactured by Rockwell Automation.
    b. Software shall be suitable for online and offline programming of Allen-Bradley SLC S/04. PLC programming software shall communicate with the PLCs with RS LINX software.
    c. Model Number: RSLOGIX 500 Standard offline/online—disk, latest version.
14. PLC Programming Unit:
    a. The PLC programming unit shall be used to access any PLC for purposes of monitoring the real time operation of the PLC program, and modifying both on and offline the PLC program. The programming unit shall communicate with any PLC by direct connection to the PLC or by connection over the data highway.
    b. Provide all other cabling, cards, memory, software and chips as required to enable the unit to perform its intended functions.
    c. The PLC programming unit shall be a laptop style PC with the following as a minimum requirement:

1) Pentium III processor, 450 mHz.
2) 64 MB RAM.
3) 4 GB hard drive.
4) 32X CD-rom drive.
5) 3-1/4-inch floppy drive (floppy drive and CD-Rom installed internal to PC. Both must be accessible by PC).
6) MS Windows NT (latest version).
7) Microsoft Office Professional Suite (Word, Access, Excel, Power Point).
8) Carrying case.
9) Extra battery pack.
10) Parallel cable for printing.
11) All associated manuals.
12) PCMCIA data highway plus adapter card with cable. Allen-Bradley; Model No. 1784-PCMC1.

NASA – JOHNSON SPACE CENTER

WHITE SANDS TEST FACILITY

TREATMENT SYSTEM FOR

PLUME-FRONT STABILIZATION

WELL VAULT INSTALLATION TECHNICAL SPECIFICATIONS

TABLE OF CONTENTS

I. Scope……1

II. Schedule……...1

III. Earthwork……1

IV. Installation ……..3

V. Certification and Warranty……..4

VI. Submittals……4

LIST OF ATTACHMENTS

Attachment 1 WSTF Groundwater Treatment Facility Project Location

- Dwg # 652-C-01, Project Location
- Dwg # 652-C-02, Well Locations and Piping Layout

Attachment 2 Well Vault Civil Details

Extraction Well PFE-1
- Dwg # 653-C-02, Extraction Well PFE-1 Civil Details

Extraction Well PFE-2
- Dwg # 654-C-02, Extraction Well PFE-2 Civil Details

Extraction Well PFE-3
- Dwg # 655-C-02, Extraction Well PFE-3 Civil Details

Extraction Well PFE-5
- Dwg # 657-C-02, Extraction Well PFE-5 Civil Details

Injection Well PFI-1
- Dwg # 660-C-01, Injection Well PFI-1 Civil Details

Injection Well PFI-2
- Dwg # 661-C-01, Injection Well PFI-2 Civil Details

Injection Well PFI-3
- Dwg # 662-C-01, Injection Well PFI-3 Civil Details

Injection Well PFI-4
- Dwg # 663-C-01, Injection Well PFI-4 Civil Details

I. Scope

This specification defines the requirements for installation of precast concrete well vaults at eight (8) groundwater well locations at the NASA White Sands Test Facility. Maps of WSTF's location and the project location with respect to WSTF's developed areas are presented in Attachment 1. WSTF is located 18 miles northeast of Las Cruces, New Mexico (65 miles north of El Paso, Texas) with access provided through U. S. Highway 70. The project is located in an unimproved area of Sections 4 and 5 of T21S, R3E and Section 32 of T20S, R3E, see Attachment 1. Access to the general project vicinity is provided by a light duty gravel road (the WSTF Well Road).

The contract drawings are presented in Attachment 2. The location of each well vault is shown in Attachment 1. This specification pertains to the installation of four (4) extraction well and four (4) injection well precast concrete vaults, and does not include vault materials.

II. Schedule

A. General Requirements

1. Project Schedule as described below shall be prepared. The scheduling of construction shall be the responsibility of the Contractor. Contractor management personnel shall actively participate in its development. Subcontractors and suppliers working on the project shall also contribute in developing and maintaining an accurate Project Schedule.

2. The proposed Project Schedule shall be approved by the Facilities Engineering Requester and incorporated into an Environmental Department delivery order prior to proceeding with vault installation. The approved Project Schedule shall be used to measure the progress of the work and to aid in evaluating time extensions. The following components shall be considered a minimum appropriate level of detail to be used in the Project Schedule.

B. Activity Durations

Contractor schedule submissions shall utilize reasonable activity durations. Reasonable durations are those that allow the progress of activities to proceed, without excessive float or unreasonably short durations.

C. Government Activities

Anticipated government and other agency activities that could impact progress shall be shown. These activities may include, but are not limited to: approvals, inspections, utility tie-in, Government Furnished Equipment (GFE) and Notice to Proceed for phasing requirements.

D. Responsibility

All activities shall be identified in the project schedule by the party responsible to perform the work. Responsibility includes, but is not limited to, the subcontracting firm, contractor work force, or government agency performing a given task. Activities shall not belong to more than one responsible party.

III. Earthwork

A. Clearing and Grubbing

The proposed vault installation areas have been cleared and grubbed. Minimal to no clearing and/or grubbing is required. Should the Contractor encounter conditions where clearing and grubbing is required, the following shall apply:

1. Clearing shall consist of the felling, trimming, and cutting of trees into sections and the satisfactory disposal of the trees and other vegetation designated for removal, including down timber, snags, brush, and rubbish occurring in the areas to be cleared. Trees, roots, brush, and other vegetation in areas to be cleared shall be cut off flush with or below the original ground surface, except such trees and vegetation as may be indicated or directed to be left standing. Trees and vegetation to be left standing shall be protected from damage incident to clearing, grubbing, and construction operations by the erection of barriers or by such other means as the circumstances require.

2. Grubbing shall consist of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the designated grubbing areas. Material to be grubbed, together with roots and other organic material not suitable for construction purposes, shall be removed to a depth of not less than 12 inches below the original surface level of the ground. Depressions made by grubbing shall be filled with suitable material and compacted to make the surface conform to the original adjacent surface of the ground.

3. Cleared and grubbed materials shall be stockpiled adjacent to the cleared well pad area.

B. Erosion Control

The Contractor shall be responsible for erosion control throughout the duration of the project. Additional work or damage to materials due to the Contractor's fault or neglect shall be repaired or replaced by the Contractor without additional cost to the Government.

C. Excavation

1. Excavation shall be as recommended by the manufacturer of the vault and in accordance with OSHA Regulation 29 CFR Part 1926, Subpart P. In case of no manufacturer recommendations or contradiction between vault manufacturer recommendations and 29 CFR Part 1926, Subpart P, OSHA regulations shall prevail.

2. Excavation shall be sufficient to leave at least 12 inches clear between the outer structure surfaces and the face of the excavation or support members.

3. The bottoms of the excavation shall be accurately graded to provide uniform bearing and support for the bottom section or footer of each vault. Stones of three (3) inches or greater in any dimension shall be removed to avoid point bearing.

4. Loose disintegrated rock and thin strata shall be removed. Removal of unstable material shall be as specified below. When concrete or masonry is to be placed in an excavated area, special care shall be taken not to disturb the bottom of the excavation. Excavation to the final grade level shall not be made until just before the concrete or masonry is to be placed.

5. Where unstable material is encountered, such material shall be removed to the depth directed and replaced to the proper grade with Engineer-approved native backfill. **Note: required excavation areas may coincide with former mud-pit areas (remnant of drilling activities). Allow for this possibility in the schedule and cost estimate.**

6. When removal of unstable material is required due to the Contractor's fault or neglect in performing the work, the resulting material shall be excavated and replaced by the Contractor without additional cost to the Government.

D. Backfill and Compaction

1. Backfilling shall be accomplished after inspection by the Contracting Officer. Backfill shall be placed in such a manner that the structure will not be damaged by the shock of falling earth. The backfill material shall be deposited, compacted and brought up evenly on all sides of the structure to prevent eccentric loading and excessive stress

2. Backfill material shall consist of satisfactory material, select granular material, or initial backfill material as required.

3. Backfill shall be placed in layers not exceeding 12 inches loose thickness for compaction by hand operated machine compactors, and 16 inches loose thickness for other than hand operated machines, unless otherwise specified.

4. Each layer shall be compacted to at least 95 percent maximum density for cohesionless soils and 90 percent maximum density for cohesive soils, unless otherwise specified.

5. The vault excavation shall not be backfilled until all specified tests are performed.

6. Unyielding material removed from the bottom of the excavation shall be replaced with select granular material or initial backfill material.

7. Unstable material removed from the bottom of the excavation shall be replaced with select granular material placed in layers not exceeding 6 inches loose thickness.

8. Testing

   a. Testing shall be the responsibility of the Contractor and shall be performed at no additional cost to the Government.

   b. Tests shall be performed by an approved commercial testing laboratory or may be tested by facilities furnished by the Contractor. No work requiring testing will be permitted until the facilities have been inspected and approved by the Contracting Officer

   c. Testing of Backfill Materials - Classification of backfill materials shall be determined in accordance with ASTM D 2487 and the moisture-density relations of soils shall be determined in accordance with ASTM D 1557. A minimum of one soil classification and one moisture-density relation test shall be performed on each different type of material used for bedding and backfill.

IV. Installation

A. Vendor Qualifications

1. The Contractor shall have successfully completed at least 3 projects of the same scope and size or larger within the last 6 years. Contractor shall demonstrate specific experience in regard to the system installation to be performed.

2. The Contractor shall comply with all applicable OSHA, NASA, JSC and WSTF safety requirements. The Contractor shall provide trained/licensed/certified personnel and safety equipment as required. All Contractor training/certifications and equipment are subject to review, inspection and approval by the Contracting Officer.

3. The Contractor shall comply with all WSTF site security requirements.

B. General Requirements

1. The vaults shall be installed per the contract drawings (Attachment 2) and the vault manufacturer's instructions. After becoming familiar with all details of the work, the Contractor shall verify all dimensions in the field, and shall advise the Contracting Officer of any discrepancy before performing the work.

2. Earthwork shall be performed per Section IV. Temporary closures shall be installed as required to keep the inside of the vault and the vault penetrations clean.

3. The Contractor shall not install any damaged materials. The Contractor shall be responsible for any damage to the vaults in the field. All repairs shall be in accordance with the vault manufacturer's recommendations.

C. Project Area

The project area shall have temporary structures, barricades, project signs, and construction facilities removed. A list of completed clean-up items shall be submitted on the day of final inspection.

V. Certification and Warranty

The minimum design life for installation procured per this PR is thirty (30) years. The certification and warranty shall contain a written certification statement from the installation inspector(s) attesting to the proper installation and testing vaults. The vendor shall provide a warranty that guarantees the installation against defects or failures due to improper installation. At minimum, any defects or failures due to improper installation shall be repaired by the vendor at no cost to WSTF for a (1) one year period. The manufacturer/vendor shall be obligated to replace damaged or defective parts or materials within a two week time frame.

VI. Submittals

Drawings showing final as-built conditions of the project. The final as-built drawings shall consist of one set of electronic drawing files (*.dwg) in AutoCAD V.14 format and one set of the working as-built drawings.

This paragraph covers as-built drawings complete, as a requirement of the contract. The terms "drawings," "contract drawings," "drawing files," "working as-built drawings" and "final as-built drawings" refer to contract drawings that are revised and shall be used as final as-built drawings.

A. Working As-Built and Final As-Built Drawings

The Contractor shall revise two sets of paper drawings by red-line process to show the as-built conditions during the execution of the project. These working as-built marked drawings shall be kept current on a weekly basis and at least one set shall be available on the jobsite at all times. Changes from the design drawings, which might be uncovered in the course of construction, shall be accurately and neatly recorded as they occur by means of details and notes. The working and final as-built drawings shall show, but shall not be limited to, the following information:

1. Correct grade, elevations, cross section, or alignment of roads, earthwork, structures or utilities if any changes were made from contract plans.

2. Changes in details of design or additional information obtained from working drawings specified to be prepared and/or furnished by the Contractor; including but not limited to

fabrication, erection, installation plans and placing details, pipe sizes, insulation material, dimensions of equipment foundations, etc.

3. The topography, invert elevations and grades of drainage installed or affected as part of the project construction.

4. Changes or modifications which result from the final inspection.

5. Where contract drawings or specifications present options, only the option selected for construction shall be shown on the final as-built prints.

6. Systems designed or enhanced by the Contractor, such as vault configuration and installation details.

B. Drawing Preparation

1. The as-built drawings shall be modified as may be necessary to correctly show the features of the project as it has been constructed by bringing the contract set into agreement with approved working as-built prints, and adding such additional drawings as may be necessary. These working as-built marked prints shall be neat, legible and accurate.

2. These drawings are part of the permanent records of this project and shall be returned to the Contracting Officer after approval by the Government. Any drawings damaged or lost by the Contractor shall be satisfactorily replaced by the Contractor at no expense to the Government.

C. Computer Aided Design and Drafting (CADD) Drawings

1. Only personnel proficient in the preparation of CADD drawings shall be employed to modify the contract drawings or prepare additional new drawings.

2. Additions and corrections to the contract drawings shall be equal in quality and detail to that of the originals. Line colors, line weights, lettering, layering conventions, and symbols shall be the same as the original line colors, line weights, lettering, layering conventions, and symbols.

3. If additional drawings are required, they shall be prepared using the specified electronic file format applying the same graphic standards specified for original drawings. The title block and drawing border to be used for any new final as-built drawings shall be identical to that used on the contract drawings.

4. Additions and corrections to the contract drawings shall be accomplished using CADD files. The electronic files will be supplied on 3-1/2 inch high density floppy disks or compact disc.

5. The Contractor shall be responsible for providing all program files and hardware necessary to prepare final as-built drawings. The Contracting Officer will review final as-built drawings for accuracy and the Contractor shall make required corrections, changes, additions, and deletions.

6. CADD colors shall be the "base" colors of red, green, and blue. Color code for changes shall be as follows:

    a. Deletions (red) - Deleted graphic items (lines) shall be colored red with red lettering in notes and leaders.

    b. Additions (Green) - Added items shall be drawn in green with green lettering in notes and leaders.

    c. Special (Blue) - Items requiring special information, coordination, or special detailing or detailing notes shall be in blue.

7. The Contract Drawing files shall be renamed in a manner related to the project name (i.e., Plume-Front Remediation System). Marked-up changes shall be made only to those renamed files. All changes shall be made on the layer/level as the original item. There shall be no deletions of existing lines; existing lines shall be over struck in red. Additions shall be in green with line weights the same as the drawing. Special notes shall be in blue on layer #63.

8. When final revisions have been completed, the cover sheet drawing shall show the wording "RECORD DRAWING AS-BUILT" followed by the name of the Contractor in letters at least 5 mm high. All other contract drawings shall be marked either "As-Built" drawing denoting no revisions on the sheet or "Revised As-Built" denoting one or more revisions. Original contract drawings shall be dated in the revision block.

D. Final As-Built Drawing Submittals

1. Within 14 calendar days after Government approval of all of the working as-built drawings for a phase of work, the Contractor shall prepare the final CADD as-built drawings for that phase of work and submit two sets of blue-lined prints of these drawings for Government review and approval. The Government will promptly return one set of prints annotated with any necessary corrections.

2. Within 7 calendar days the Contractor shall revise the CADD files accordingly at no additional cost and submit one set of final prints for the completed phase of work to the Government.

3. Within 14 calendar days of substantial completion of all phases of work, the Contractor shall submit the final as-built drawing package for the entire project. The submittal shall consist of one set of electronic files on 3-1/2 inch high density floppy disks (for projects with electronic digital files or sets of files less than or equal to 4 diskettes or compact disc, two sets of blue-line prints and one set of the approved working as-built drawings). They shall be complete in all details and identical in form and function to the contract drawing files supplied by the Government. Any transactions or adjustments necessary to accomplish this are the responsibility of the Contractor.

4. The Government reserves the right to reject any drawing files it deems incompatible with the customer's CADD system. Paper prints, drawing files and storage media submitted will become the property of the Government upon final approval. Failure to submit final as-built drawing files and marked prints as specified shall be cause for withholding any payment due the Contractor under this contract. Approval and acceptance of final as-built drawings shall be accomplished before final payment is made to the Contractor.

E. As-Built Record of Equipment and Materials Submittal

1. Installation Instructions - The Contractor shall furnish the manufacturer's installation recommendations or instructions for each material or procedure to be utilized, including materials preparation.

2. Qualifications - A statement certifying that the Contractor has the specified experience.

3. Statement of Satisfactory Installation - The Contractor shall furnish a signed statement certifying that the installation is satisfactory and in accordance with the contract drawings and specifications and the manufacturer's prescribed procedures and techniques, upon completion of the project and before final acceptance.

4. Field Test Reports - The Contractor shall furnish a copy of all field notes and test reports.

F. Final Approved Shop Drawings

The Contractor shall furnish final approved project shop drawings 30 calendar days after transfer of the completed facility.

G. Warranty Management Plan

The Contractor shall submit warranty information for all applicable construction and equipment. This submittal shall include a list for each warranted equipment, item, feature of construction or system indicating:

1. Name of item.
2. Model and serial numbers.
3. Location where installed.
4. Name and phone numbers of manufacturers or suppliers.
5. Names, addresses and telephone numbers of sources of spare parts.
6. Warranties and terms of warranty. This shall include one-year overall warranty of construction. Items that have extended warranties shall be indicated with separate warranty expiration dates.
7. Cross-reference to warranty certificates as applicable.
8. Starting point and duration of warranty period.
9. Summary of maintenance procedures required to continue the warranty in force.
10. Cross-reference to specific pertinent Operation and Maintenance manuals (if applicable).

ATTACHMENT 1

WSTF GROUNDWATER TREATMENT FACILITY

PROJECT LOCATION

ATTACHMENT 2

WSTF GROUNDWATER TREATMENT FACILITY

WELL VAULT DETAILS

NASA – JOHNSON SPACE CENTER

WHITE SANDS TEST FACILITY

GROUND WATER TREATMENT SYSTEM FOR

PLUME-FRONT STABILIZATION

WELL VAULT MATERIAL TECHNICAL SPECIFICATIONS

TABLE OF CONTENTS

I. Scope……..1

II. Material……...1

III. Schedule……..2

IV. Certification and Warranty……..2

V. Submittals……2

LIST OF ATTACHMENTS

Attachment 1 WSTF Groundwater Treatment Facility Project Location

- Dwg # 652-C-01, Project Location
- Dwg # 652-C-02, Well Locations and Piping Layout

Attachment 2 Well Vault Details

Extraction Well PFE-1

- Dwg # 653-C-02, Extraction Well PFE-1 Civil Details

Extraction Well PFE-2

- Dwg # 654-C-02, Extraction Well PFE-2 Civil Details

Extraction Well PFE-3

- Dwg # 655-C-02, Extraction Well PFE-3 Civil Details

Extraction Well PFE-5

- Dwg # 657-C-02, Extraction Well PFE-5 Civil Details

Injection Well PFI-1

- Dwg # 660-C-01, Injection Well PFI-1 Civil Details

Injection Well PFI-2

- Dwg # 661-C-01, Injection Well PFI-2 Civil Details

Injection Well PFI-3

- Dwg # 662-C-01, Injection Well PFI-3 Civil Details

Injection Well PFI-4

- Dwg # 663-C-01, Injection Well PFI-4 Civil Details

I. Scope

This specification defines the requirements for materials of precast concrete well vaults at eight (8) groundwater well locations at the NASA White Sands Test Facility. Maps of WSTF's location and the project location with respect to WSTF's developed areas are presented in Attachment 1. WSTF is located 18 miles northeast of Las Cruces, New Mexico (65 miles north of El Paso, Texas) with access provided through U. S. Highway 70. The project is located in an unimproved area of Sections 4 and 5 of T21S, R3E and Section 32 of T20S, R3E, Attachment 1. Access to the general project vicinity is provided by a light duty gravel road (the WSTF Well Road).

The contract drawings are presented in Attachment 2. The installation location of the well vaults is shown in Attachment 1. This document pertains to the materials of four (4) extraction well and four (4) injection well precast concrete vaults, and does not include the piping system components (pipe, valves, flanges, etc.) located inside the wellhead vaults. This specification does not cover installation of components, and pertains only to construction of eight (8) precast concrete vaults.

II. Material

A. Vendor Qualifications

The manufacturer/vendor of the precast concrete wellhead vaults shall have a minimum of six (6) years of continuous experience. Prior to the award of this procurement, all potential vendors will be required to submit a company profile or Statement of Qualifications that summarizes their capabilities and work experience on similar projects.

B. Well Vaults

1. The location of the wellhead vaults is shown in Attachment 1. Vault details are presented in Attachment 2. The project will include the materials for four (4) extraction well and four (4) injection well precast concrete vaults. The project does not include the materials and installation of piping system components (valves, flanges, and flowmeters) or electrical equipment located inside the well vaults.

2. The vaults and all materials and appurtenances shall be as specified and as shown on the contract drawings, and shall be suitable for the service intended.

3. All materials and appurtenances supplied as part of this contract shall be new and unused except for testing equipment. Components that serve the same function and are the same size shall be identical products of the same manufacturer.

4. The well vaults shall meet all OSHA safety requirements and industry standards. The absence of ladders and other details on the contract drawings does not relieve the Contractor of responsibility for ensuring safe personnel access to the vault.

5. The well vaults, vault penetrations, and vault covers shall be as specified in the contract drawings (Attachment 2), or equivalent.

6. The vaults shall be precast concrete fabricated per ASTM C-857 specifications.

7. The concrete shall have a 28 day compressive strength of 4,500 psi with ASTM A-615 Grade 60 rebar and ASTM A-185 Grade 65 mesh.

8. The vaults and covers shall be designed and fabricated to prevent the ingress of moisture.

C. Material Delivery, Storage, and Handling

1. Proper protection and care of material during fabrication and delivery is the Vendor's responsibility. Any material found to be damaged shall be replaced at the Vendor's expense.

2. Vaults shall be delivered and off-loaded at each well site shown in Attachment 1. In the event weather conditions make the roads to each well site impassable, vaults shall be delivered and off-loaded at the Building 650 location shown in Attachment 1. Vendor shall provide transportation from vendor's facility to the job site. Vendor shall provide suitable means for off-loading the vaults at the job site.

3. Provisions shall be made for the attachment of a fixture or harness to the vaults to facilitate the lifting of the vault by means of a crane. If the fixtures involve the use of a lug or key, the manufacturer will supply with the vault a harness suitable for lifting.

III. Schedule

A fabrication and delivery schedule shall be submitted with the vendor's proposal.

A. Delivery Date

Vendor shall deliver all vaults, materials, and appurtenances to WSTF within 30 calendar days of contract award.

IV. Certification and Warranty

The minimum design life for materials procured per this specification is (30) thirty years. The vendor shall provide a warranty that guarantees the vaults against defects in materials or workmanship. At minimum, any defects in materials or workmanship shall be repaired by the vendor at no cost to WSTF for a one (1) year period. Vendor shall repair or replace damaged or defective parts or materials within two weeks of notification by customer.

V. Submittals

A. Drawings showing final as-built conditions of each well vault. The final as-built drawings shall consist of one set of electronic drawing files (*.dwg) in AutoCAD V.14 format and one set of the working as-built drawings.

B. Installation Instructions - The Contractor shall furnish the manufacturer's installation recommendations or instructions for each material or procedure to be utilized, including materials preparation.

C. Qualifications - A statement certifying that the Contractor has the specified experience.

D. Final Approved Shop Drawings - The Contractor shall furnish NASA with final approved project shop drawings prior to release of a *notice to proceed with fabrication* by NASA.

ATTACHMENT 1

WSTF GROUNDWATER TREATMENT FACILITY

PROJECT LOCATION

ATTACHMENT 2

WSTF GROUNDWATER TREATMENT FACILITY

WELL VAULT DETAILS

ATTACHMENT H

PSD APPLICABILITY DETERMINATION

PSD APPLICABILITY DETERMINATION

Pursuant to Federal 40 CFR 52 Subpart GG and New Mexico 20 NMAC 2, NASA is a synthetic minor and current in all permitting requirements. The historic operations together with the Federally enforceable permitted emissions limits are below the PSD regulatory thresholds for both criteria and hazardous air pollutants. Therefore PSD regulations are not applicable to NASA WSTF.

ATTACHMENT I

APPLICABILITY OF STATE AND FEDERAL REGULATIONS

APPLICABILITY OF STATE AND FEDERAL REGULATIONS

There are no State or Federal air regulations applicable to the pump-and-treat system. NASA WSTF is a synthetic minor, and not regulated under 40 CFR 60, 61, or 63. Emissions from the air strippers do not trigger a NOI pursuant to NMAC 20.2.73, nor do they trigger a construction permit pursuant to NMAC 20.2.72. This NOI is submitted pursuant to NMED Air Quality Bureau request.

ATTACHMENT J

SOURCE EMISSIONS DURING MALFUNCTION, STARTUP, OR SHUTDOWN

SOURCE EMISSIONS DURING MALFUNCTION, STARTUP, OR SHUTDOWN

Since the emissions are from only the air strippers, there is no added source emissions during malfunction, startup, or shutdown.

ATTACHMENT K

AIR QUALITY DISPERSION MODELING

AIR QUALITY DISPERSION MODELING

No air quality dispersion modeling is required for this NOI. The emissions rates for all contaminants of concern are below regulatory threshold limits, or the contaminants are not regulated.

ATTACHMENT L

OTHER RELEVANT INFORMATION

ShallowTray®
low profile air strippers

HIGH FLOW

System Performance Estimate
Client and Proposal Information:

Series chosen:	61200	
Water Flow Rate:	625.0 gpm	142.0 m3/hr
Air Flow Rate:	3600 scfm	6120 m3/hr
Water Temp:	59 °F	15 °C
Air Temp:	9 °F	-13 °C
A/W Ratio:	43	43
Safety Factor:	None	

Contaminant	Untreated Influent / Effluent Target	Model 61211 Effluent lbs/hr ppmv %removal	Model 61221 Effluent lbs/hr ppmv %removal	Model 61231 Effluent lbs/hr ppmv %removal	Model 61241 Effluent lbs/hr ppmv %removal	Model 61251 Effluent lbs/hr ppmv %removal
Trichloroethylene	130.00 ppb	39.85 ppb	12.21 ppb	3.74 ppb	1.15 ppb	0.35 ppb
Solubility 1100 ppm	2.50 ppb	0.03 0.4	0.04 0.5	0.04 0.5	0.04 0.5	0.04 0.5
Mwt 131.5		69.3497%	90.6056%	97.1206%	99.1174%	99.7295%
Tetrachloroethylene	4.20 ppb	1.12 ppb	0.30 ppb	0.08 ppb	0.02 ppb	0.01 ppb
Solubility 150 ppm	2.50 ppb	0.00 0.0	0.00 0.0	0.00 0.0	0.00 0.0	0.00 0.0
Mwt 165.83		73.3148%	92.8790%	98.0997%	99.4929%	99.8647%
Trichlorotrifluoroethane (F11)	860.00 ppb	104.63 ppb	12.73 ppb	1.55 ppb	0.19 ppb	0.02 ppb
Solubility 1,100 ppm	50.00 ppb	0.24 3.0	0.27 3.4	0.27 3.4	0.27 3.4	0.27 3.4
Mwt 137.37		87.8334%	98.5197%	99.8199%	99.9781%	99.9973%
Dichlorofluoromethane (F21)	60.00 ppb	12.38 ppb	2.56 ppb	0.53 ppb	0.11 ppb	0.02 ppb
Solubility 10,000 ppm	10.00 ppb	0.01 0.2	0.02 0.3	0.02 0.3	0.02 0.3	0.02 0.3
Mwt 120.91		79.3642%	95.7417%	99.1213%	99.8187%	99.9626%
1,2-Trichlorotrifluoroethane (F113)	2000.00 ppb	156.45 ppb	12.24 ppb	0.96 ppb	0.07 ppb	0.01 ppb
Solubility 200ppm	600.00 ppb	0.58 5.4	0.62 5.9	0.63 5.9	0.63 5.9	0.63 5.9
Mwt 187		92.1776%	99.3881%	99.9521%	99.9963%	99.9997%
Total ppb	3054.20 ppb	314.43	40.04	6.86	1.54	0.41
Total VOC lbs/hr - ppmv		0.86 9.1	0.95 10.0	0.96 10.1	0.96 10.2	0.96 10.2
Total %removal		89.71%	98.69%	99.78%	99.95%	99.99%

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Report Generated: 8/10/00 Modeler Ev2.2 ppmv

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ShallowTray®
low profile air strippers

System Performance Estimate
Client and Proposal Information:

HIGH FLOW

Series chosen:	61200	
Water Flow Rate:	625.0 gpm	142.0 m3/hr
Air Flow Rate:	3600 scfm	6120 m3/hr
Water Temp:	59 °F	15 °C
Air Temp:	63 °F	17 °C
A/W Ratio:	43	43
Safety Factor:	None	

Contaminant	Untreated Influent / Effluent Target	Model 61211 Effluent lbs/hr ppmv %removal	Model 61221 Effluent lbs/hr ppmv %removal	Model 61231 Effluent lbs/hr ppmv %removal	Model 61241 Effluent lbs/hr ppmv %removal	Model 61251 Effluent lbs/hr ppmv %removal
Trichloroethylene	130.00 ppb	39.45 ppb	11.97 ppb	3.63 ppb	1.10 ppb	0.33 ppb
Solubility 1100 ppm	2.50 ppb	0.03 0.4	0.04 0.5	0.04 0.5	0.04 0.5	0.04 0.5
Mwt 131.5		69.6561%	90.7925%	97.2061%	99.1522%	99.7427%
Tetrachloroethylene	4.20 ppb	1.11 ppb	0.29 ppb	0.08 ppb	0.02 ppb	0.01 ppb
Solubility 150 ppm	2.50 ppb	0.00 0.0	0.00 0.0	0.00 0.0	0.00 0.0	0.00 0.0
Mwt 165.83		73.5862%	93.0231%	98.1571%	99.5132%	99.8714%
Trichlorotrifluoroethane (F11)	860.00 ppb	103.45 ppb	12.44 ppb	1.50 ppb	0.18 ppb	0.02 ppb
Solubility 1,100 ppm	50.00 ppb	0.24 3.0	0.27 3.4	0.27 3.4	0.27 3.4	0.27 3.4
Mwt 137.37		87.9714%	98.5531%	99.8260%	99.9791%	99.9975%
Dichlorofluoromethane (F21)	60.00 ppb	12.25 ppb	2.50 ppb	0.51 ppb	0.10 ppb	0.02 ppb
Solubility 10,000 ppm	10.00 ppb	0.01 0.2	0.02 0.3	0.02 0.3	0.02 0.3	0.02 0.3
Mwt 120.91		79.5889%	95.8339%	99.1496%	99.8264%	99.9646%
1,2-Trichlorotrifluoroethane (F113)	2000.00 ppb	154.67 ppb	11.96 ppb	0.93 ppb	0.07 ppb	0.01 ppb
Solubility 200ppm	600.00 ppb	0.58 5.4	0.62 5.9	0.63 5.9	0.63 5.9	0.63 5.9
Mwt 187		92.2663%	99.4019%	99.9537%	99.9964%	99.9997%

Total	**ppb**	**3054.20 ppb**	**310.92**		**39.17**		**6.64**		**1.48**	**0.39**
Total	**VOC lbs/hr - ppmv**		**0.86**	**9.1**	**0.95**	**10.0**	**0.96**	**10.1**	**0.96 10.2**	**0.96 10.2**
Total	**%removal**		**89.82%**		**98.72%**		**99.78%**		**99.95%**	**99.99%**

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ShallowTray®
low profile air strippers

HIGH FLOW

System Performance Estimate
Client and Proposal Information:

Series chosen:	**61200**	
Water Flow Rate:	**625.0 gpm**	**142.0 m3/hr**
Air Flow Rate:	**3600 scfm**	**6120 m3/hr**
Water Temp:	**59 °F**	**15 °C**
Air Temp:	**111 °F**	**44 °C**
A/W Ratio:	**43**	**43**
Safety Factor:	**None**	

Contaminant	Untreated Influent / Effluent Target	Model 61211 Effluent lbs/hr ppmv %removal	Model 61221 Effluent lbs/hr ppmv %removal	Model 61231 Effluent lbs/hr ppmv %removal	Model 61241 Effluent lbs/hr ppmv %removal	Model 61251 Effluent lbs/hr ppmv %removal
Trichloroethylene	**130.00 ppb**	**39.09 ppb**	**11.76 ppb**	**3.53 ppb**	**1.06 ppb**	**0.32 ppb**
Solubility 1100 ppm	**2.50 ppb**	**0.03 0.4**	**0.04 0.5**	**0.04 0.5**	**0.04 0.5**	**0.04 0.5**
Mwt 131.5		**69.9293%**	**90.9575%**	**97.2809%**	**99.1823%**	**99.7541%**
Tetrachloroethylene	**4.20 ppb**	**1.10 ppb**	**0.29 ppb**	**0.08 ppb**	**0.02 ppb**	**0.01 ppb**
Solubility 150 ppm	**2.50 ppb**	**0.00 0.0**	**0.00 0.0**	**0.00 0.0**	**0.00 0.0**	**0.00 0.0**
Mwt 165.83		**73.8280%**	**93.1503%**	**98.2073%**	**99.5308%**	**99.8772%**
Trichlorotrifluoroethane (F11)	**860.00 ppb**	**102.39 ppb**	**12.19 ppb**	**1.45 ppb**	**0.17 ppb**	**0.02 ppb**
Solubility 1,100 ppm	**50.00 ppb**	**0.24 3.0**	**0.27 3.4**	**0.27 3.4**	**0.27 3.4**	**0.27 3.4**
Mwt 137.37		**88.0942%**	**98.5825%**	**99.8312%**	**99.9799%**	**99.9976%**
Dichlorofluoromethane (F21)	**60.00 ppb**	**12.13 ppb**	**2.45 ppb**	**0.50 ppb**	**0.10 ppb**	**0.02 ppb**
Solubility 10,000 ppm	**10.00 ppb**	**0.02 0.2**	**0.02 0.3**	**0.02 0.3**	**0.02 0.3**	**0.02 0.3**
Mwt 120.91		**79.7890%**	**95.9152%**	**99.1744%**	**99.8331%**	**99.9663%**
1,2-Trichlorotrifluoroethane (F113)	**2000.00 ppb**	**153.09 ppb**	**11.72 ppb**	**0.90 ppb**	**0.07 ppb**	**0.01 ppb**
Solubility 200ppm	**600.00 ppb**	**0.58 5.4**	**0.62 5.9**	**0.63 5.9**	**0.63 5.9**	**0.63 5.9**
Mwt 187		**92.3453%**	**99.4140%**	**99.9551%**	**99.9966%**	**99.9997%**
Total **ppb**	**3054.20 ppb**	**307.80**	**38.40**	**6.45**	**1.42**	**0.37**
Total **VOC lbs/hr - ppmv**		**0.86 9.1**	**0.95 10.0**	**0.96 10.1**	**0.96 10.2**	**0.96 10.2**
Total **%removal**		**89.92%**	**98.74%**	**99.79%**	**99.95%**	**99.99%**

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Report Generated: **8/10/00** **Modeler Ev2.2 ppmv**

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ShallowTray®
low profile air strippers

HIGH FLOW

System Performance Estimate
Client and Proposal Information:

Series chosen:	61200	
Water Flow Rate:	625.0 gpm	142.0 m3/hr
Air Flow Rate:	3600 scfm	6120 m3/hr
Water Temp:	68 °F	20 °C
Air Temp:	9 °F	-13 °C
A/W Ratio:	43	43
Safety Factor:	None	

Contaminant	Untreated Influent Effluent Target	Model 61211 Effluent lbs/hr ppmv %removal	Model 61221 Effluent lbs/hr ppmv %removal	Model 61231 Effluent lbs/hr ppmv %removal	Model 61241 Effluent lbs/hr ppmv %removal	Model 61251 Effluent lbs/hr ppmv %removal
Trichloroethylene	130.00 ppb	34.97 ppb	9.41 ppb	2.53 ppb	0.68 ppb	0.18 ppb
Solubility 1100 ppm	2.50 ppb	0.03 0.4	0.04 0.5	0.04 0.5	0.04 0.5	0.04 0.5
Mwt 131.5		73.0992%	92.7635%	98.0533%	99.4763%	99.8591%
Tetrachloroethylene	4.20 ppb	0.98 ppb	0.23 ppb	0.05 ppb	0.01 ppb	0.00 ppb
Solubility 150 ppm	2.50 ppb	0.00 0.0	0.00 0.0	0.00 0.0	0.00 0.0	0.00 0.0
Mwt 165.83		76.6318%	94.5393%	98.7239%	99.7018%	99.9303%
Trichlorotrifluoroethane (F11)	860.00 ppb	90.23 ppb	9.47 ppb	0.99 ppb	0.10 ppb	0.01 ppb
Solubility 1,100 ppm	50.00 ppb	0.24 3.1	0.27 3.4	0.27 3.4	0.27 3.4	0.27 3.4
Mwt 137.37		89.5081%	98.8992%	99.8845%	99.9879%	99.9987%
Dichlorofluoromethane (F21)	60.00 ppb	10.74 ppb	1.92 ppb	0.34 ppb	0.06 ppb	0.01 ppb
Solubility 10,000 ppm	10.00 ppb	0.02 0.2	0.02 0.3	0.02 0.3	0.02 0.3	0.02 0.3
Mwt 120.91		82.0986%	96.7954%	99.4263%	99.8973%	99.9816%
1,2-Trichlorotrifluoroethane (F113)	2000.00 ppb	134.91 ppb	9.10 ppb	0.61 ppb	0.04 ppb	0.00 ppb
Solubility 200ppm	600.00 ppb	0.59 5.5	0.62 5.9	0.63 5.9	0.63 5.9	0.63 5.9
Mwt 187		93.2543%	99.5450%	99.9693%	99.9979%	99.9999%
Total ppb	3054.20 ppb	271.84	30.13	4.54	0.90	0.21
Total VOC lbs/hr - ppmv		0.87 9.2	0.95 10.0	0.96 10.1	0.96 10.2	0.96 10.2
Total %removal		91.10%	99.01%	99.85%	99.97%	99.99%

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ShallowTray®
low profile air strippers

HIGH FLOW

System Performance Estimate
Client and Proposal Information:

Series chosen:	61200	
Water Flow Rate:	625.0 gpm	142.0 m3/hr
Air Flow Rate:	3600 scfm	6120 m3/hr
Water Temp:	68 °F	20 °C
Air Temp:	63 °F	17 °C
A/W Ratio:	43	43
Safety Factor:	None	

Contaminant	Untreated Influent / Effluent Target	Model 61211 Effluent lbs/hr ppmv %removal	Model 61221 Effluent lbs/hr ppmv %removal	Model 61231 Effluent lbs/hr ppmv %removal	Model 61241 Effluent lbs/hr ppmv %removal	Model 61251 Effluent lbs/hr ppmv %removal
Trichloroethylene	130.00 ppb	34.62 ppb	9.22 ppb	2.46 ppb	0.65 ppb	0.17 ppb
Solubility 1100 ppm	2.50 ppb	0.03 0.4	0.04 0.5	0.04 0.5	0.04 0.5	0.04 0.5
Mwt 131.5		73.3681%	92.9074%	98.1111%	99.4970%	99.8660%
Tetrachloroethylene	4.20 ppb	0.97 ppb	0.22 ppb	0.05 ppb	0.01 ppb	0.00 ppb
Solubility 150 ppm	2.50 ppb	0.00 0.0	0.00 0.0	0.00 0.0	0.00 0.0	0.00 0.0
Mwt 165.83		76.8694%	94.6498%	98.7625%	99.7138%	99.9338%
Trichlorotrifluoroethane (F11)	860.00 ppb	89.21 ppb	9.25 ppb	0.96 ppb	0.10 ppb	0.01 ppb
Solubility 1,100 ppm	50.00 ppb	0.24 3.1	0.27 3.4	0.27 3.4	0.27 3.4	0.27 3.4
Mwt 137.37		89.6271%	98.9240%	99.8884%	99.9884%	99.9988%
Dichlorofluoromethane (F21)	60.00 ppb	10.62 ppb	1.88 ppb	0.33 ppb	0.06 ppb	0.01 ppb
Solubility 10,000 ppm	10.00 ppb	0.02 0.2	0.02 0.3	0.02 0.3	0.02 0.3	0.02 0.3
Mwt 120.91		82.2935%	96.8648%	99.4449%	99.9017%	99.9826%
1,2-Trichlorotrifluoroethane (F113)	2000.00 ppb	133.38 ppb	8.90 ppb	0.59 ppb	0.04 ppb	0.00 ppb
Solubility 200ppm	600.00 ppb	0.59 5.5	0.62 5.9	0.63 5.9	0.63 5.9	0.63 5.9
Mwt 187		93.3308%	99.5552%	99.9703%	99.9980%	99.9999%
Total ppb	3054.20 ppb	268.81	29.48	4.39	0.86	0.20
Total VOC lbs/hr - ppmv		0.87 9.2	0.95 10.1	0.96 10.1	0.96 10.2	0.96 10.2
Total %removal		91.20%	99.03%	99.86%	99.97%	99.99%

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Report Generated: 8/10/00 Modeler Ev2.2 ppmv

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ShallowTray®
low profile air strippers

System Performance Estimate

Client and Proposal Information:

HIGH FLOW

Series chosen:	61200	
Water Flow Rate:	625.0 gpm	142.0 m3/hr
Air Flow Rate:	3600 scfm	6120 m3/hr
Water Temp:	68 °F	20 °C
Air Temp:	111 °F	44 °C
A/W Ratio:	43	43
Safety Factor:	None	

Contaminant	Untreated Influent / Effluent Target	Model 61211 Effluent lbs/hr ppmv %removal	Model 61221 Effluent lbs/hr ppmv %removal	Model 61231 Effluent lbs/hr ppmv %removal	Model 61241 Effluent lbs/hr ppmv %removal	Model 61251 Effluent lbs/hr ppmv %removal
Trichloroethylene	130.00 ppb	34.31 ppb	9.06 ppb	2.39 ppb	0.63 ppb	0.17 ppb
Solubility 1100 ppm	2.50 ppb	0.03 0.4	0.04 0.5	0.04 0.5	0.04 0.5	0.04 0.5
Mwt 131.5		73.6079%	93.0346%	98.1617%	99.5148%	99.8720%
Tetrachloroethylene	4.20 ppb	0.96 ppb	0.22 ppb	0.05 ppb	0.01 ppb	0.00 ppb
Solubility 150 ppm	2.50 ppb	0.00 0.0	0.00 0.0	0.00 0.0	0.00 0.0	0.00 0.0
Mwt 165.83		77.0813%	94.7473%	98.7961%	99.7241%	99.9368%
Trichlorotrifluoroethane (F11)	860.00 ppb	88.30 ppb	9.07 ppb	0.93 ppb	0.10 ppb	0.01 ppb
Solubility 1,100 ppm	50.00 ppb	0.24 3.1	0.27 3.4	0.27 3.4	0.27 3.4	0.27 3.4
Mwt 137.37		89.7330%	98.9459%	99.8918%	99.9889%	99.9989%
Dichlorofluoromethane (F21)	60.00 ppb	10.52 ppb	1.84 ppb	0.32 ppb	0.06 ppb	0.01 ppb
Solubility 10,000 ppm	10.00 ppb	0.02 0.2	0.02 0.3	0.02 0.3	0.02 0.3	0.02 0.3
Mwt 120.91		82.4671%	96.9260%	99.4610%	99.9055%	99.9834%
1,2-Trichlorotrifluoroethane (F113)	2000.00 ppb	132.02 ppb	8.71 ppb	0.58 ppb	0.04 ppb	0.00 ppb
Solubility 200ppm	600.00 ppb	0.59 5.5	0.62 5.9	0.63 5.9	0.63 5.9	0.63 5.9
Mwt 187		93.3989%	99.5643%	99.9712%	99.9981%	99.9999%
Total ppb	3054.20 ppb	266.11	28.90	4.27	0.83	0.19
Total VOC lbs/hr - ppmv		0.87 9.2	0.95 10.1	0.96 10.1	0.96 10.2	0.96 10.2
Total %removal		91.29%	99.05%	99.86%	99.97%	99.99%

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MEMORANDUM

DATE: April 10, 2003

TO: Caryln Tufts,
NASA White Sands Test Facility

FROM: Michael Perry,
CAS

COPY: Janice Jaeger,
CAS

SUBJ.: 1,2-Dichloroethane Contamination

Columbia Analytical Services, Inc. has been detecting low levels of 1,2-Dichloroethane in samples and lab blanks since last fall. The levels have been between 0.2 and 0.4 ppb and have generally not been a problem with the reporting of data. The required reporting limit (PQL) for this project is 1.0 ppb.

Upon realizing there was some concern from NASA/WSTF/Honeywell at the White Sands Facility, we investigated the matter. It was determined that this "contamination" originated when, at the request of the ACOE on a particular project that was initiated last fall, we added a fourth surrogate standard to our normal three compound surrogate standard spiking solution. To simplify methods in the laboratory, we started adding it to all samples, blanks, and standards for all analyses. This fourth surrogate standard added was 1,2-Dichloroethane-d4, the isotope version of 1,2-Dichloroethane. This surrogate standard is routinely purchased pre-prepared and contains 1,2-Dichloroethane as a contaminant in the range stated above. This level of contamination is very close to the statistically calculated MDL of the instruments used for the analysis. This is the reason why it does not consistently show up in all samples and blanks. The MDLs for this compound on the instruments that the NASA/WSTF/Honeywell samples are analyzed on vary in the range of 0.2 – 0.4 ppb. The MDL that is listed on the EDD for submissions prior to R2315812 is the default MDL (the highest water MDL on a GCMS Volatile instrument). The EDD for submissions including and subsequent to R2315812 now reflect the MDLs of the instrument that the samples are analyzed on.

Now that we realize this is an issue we will contact the manufacturer of the standard to see if we can obtain a more pure solution for the surrogate or try alternative sources. Another option is that we would not call any detected 1,2-Dichloroethane below 0.5 ppb and only "J" flag values between 0.5 ppb and the PQL of 1.0 ppb. Presently we are "J" flagging data for 1,2-Dichloroethane on this project between 0.3 and 1.0 ppb.

If further clarification or information is needed on this matter please call Janice or myself at 585-288-5380.

Michael K. Perry, Laboratory Manager
Columbia Analytical Services, Inc

AIR QUALITY NOTICE OF INTENT
AND PERMIT APPLICATION CHECKLIST

This checklist is designed to help applicants to include the required elements under NMAC 2.73 - Notice of Intent and Emission Inventory Requirements, 20.2.72 NMAC - Construction Permits and NMAC 2.74 - Prevention of Significant Deterioration (PSD). Each application submitted shall contain the required items listed below, depending on the regulation under which the application is being submitted, before the Air Quality Bureau will rule the application complete under 20.2.72 NMAC or make a determination that no permit is required under NMAC 2.73. If each applicable item cannot be checked prior to submitting the application, the application will be ruled incomplete. Applications that are ruled incomplete because of missing information will delay any determination or the issuance of the permit. The Department reserves the right to request additional relevant information prior to ruling the application complete in accordance with 20.2.72 NMAC, Section 203.A.11.

Directions for using this checklist: Simply find the symbol to the left of each requirement that applies to your type of application. The symbols that apply to which type of application are given below. Indicate your review of your applicable requirements by checking the appropriate boxes.

applies to applications for a Notice of Intent
+ applies to applications for a construction permit
* applies to applications for a PSD permit

A copy of this checklist shall accompany the application.

*		arrange a pre-application meeting to be held in Santa Fe, which includes the federal land managers, to discuss BACT, modeling, and items of particular interest.
*		submit the BACT analysis for review prior to submittal of the application (no application will be ruled complete until the final determination regarding BACT is made and this determination can ultimately affect information provided in the application).
*		submit a modeling protocol prior to submitting the permit application.
*		submit the monitoring exemption analysis prior to submittal of the application.
*+#	√	the required information made on a form provided by the Department. Additional text, tables, calculations or clarifying information may also be attached to the form.
*+		the $500.00 filing fee as per 20.2.75 NMAC – Construction Permit Fees.
*+		the original and two copies of this entire application package, including copies of the *dispersion modeling summary report* in each application, unless otherwise indicated by the Bureau. Only one complete copy of the dispersion modeling study, including computer disks with all input/output files, should be submitted.
*+#	√	the company name which identifies the particular site.
*+#	√	the date of application.
*+#	√	the four digit Standard Industrialized Code (SIC).

*+# √ the applicant's name, address, and the names and addresses of all other owners or operators of the emission sources.

*+# √ the name, address, and phone number of a person to contact regarding questions about the facility.

*+# √ the current facility status if it already exists.

*+# √ the anticipated maximum production capacity of the entire facility after construction and/or modification or of the applicable emission or process unit. Identify any process bottlenecks that limit production.

*+# √ location information including Section, Range, and Township and UTM or Lat/Long coordinates.

*+# √ the maximum operating schedule for the source after completion of construction or modification in terms of hours per day, days per week, and weeks per year.

*+# √ a list of all regulated equipment.

*+ • a list of all exempted equipment.

*+# √ a list and description of all air pollution control equipment or control method, estimated efficiencies, and estimation method.

*+# √ the types and *potential uncontrolled* amounts of any regulated air contaminants the new source or modification will emit. Complete appropriate sections of the application; attachments can be used to supplement the application, but not replace it.

if the "potential emission rate" for any one criteria pollutant from a new facility is greater than 10 pounds per hour or 25 tons per year a permit is required - complete Section A and B. If as a result of a modification an existing facility's potential emission rate for any one pollutant is greater than 10 pounds per hour or 25 tons per year a permit is required - complete Section A and B. If the emission rate for a toxic pollutant exceeds the thresholds in 20.2.72 NMAC, Sec. 400 a permit is required - complete Section A and B.

"Potential emission rate" under 20.2.72 NMAC means the uncontrolled emission rate at maximum capacity, prior to or in the absence of pollution control equipment, for one hour or one full year (8760 hours per year).

*+# √ the types and controlled amounts of any regulated air contaminants the new source or modification will emit.

if the "potential to emit" for any one criteria pollutant from a new facility exceeds 100 tons per year (major source) for one of the 28 sources listed in Table 1 of NMAC 2.74, or 250 tons per year (major source) for all other sources, a PSD permit is required - complete Section A, B, and C. If the source is an existing PSD major source and a modification occurs which results in an actual increase above the threshold in Table 2 of NMAC 2.74 a PSD permit is required - complete Section A, B, and C.

"potential to emit" under NMAC 2.74 means the controlled emission rate at maximum capacity, after pollution control equipment, for one full year (8760 hours).

*+#	√	the stack and exhaust gas parameters for all existing and proposed emission stacks.
*+#	√	fuel data for each existing and/or proposed piece of fuel burning equipment.
*+#	√	material storage and handling information including composition, characteristics, storage conditions, and tank parameters.
*+	•	a description of emission measurement equipment including CEM and parametric measures.
*+#	√	a notarized statement signed under oath or affirmation by the operator, the owner, or an authorized representative, certifying to the best of his or her knowledge the truth of all information submitted.
*+	•	an attachment containing a process flow sheet, including a material balance, of all components of the facility that would be involved in routine operations and emissions.
*+	•	an attachment containing a plot plan showing emission points, structures, tanks, and fences of property.
*+#	√	an attachment containing all calculations used to estimate *potential controlled and uncontrolled* emissions.
*+#	√	an attachment containing the basis or source for each uncontrolled and controlled emission rate (include the manufacturer's specification sheets when used as the source). This is to include the basis for the estimated control efficiencies and sufficient engineering data for verification of the control equipment operation, including if necessary, design drawings, test reports, and factors that affect the normal operation (e.g. limits to normal operation).
*+#	√	an attachment containing a map, such as a 7.5 minute USGS topographic quadrangle, showing the exact location of the source.

Applications shall include an attachment containing the following public notice announcement documentation in accordance with 20.2.72 NMAC – Construction Permits, Section 203.B;

*+	•	adjacent landowners have been notified of the proposed application,
*+	•	municipalities and counties have been notified,
*+	•	one classified or legal advertisement has been published in a local newspaper,
*+	•	one other advertisement has been published in a local newspaper,
*+	•	notice of the application has been posted in at least four publicly accessible and store, conspicuous places, including the proposed or existing facility entrance. (e.g: post office, library, grocery etc.),
*+	•	submission of a public service announcement has been made to at least one radio or television station that serves the municipality or county in which the source proposes to locate. *The four posting locations should be included in this announcement.*

The public notice shall include the following;

*+ • the applicant's name, address and the names and addresses of all other owners or operators of the emission sources,

*+ • the date of application submittal and the location of the source

*+ • a description of the plant or equipment process for which a permit is sought,

*+ • an estimate of the maximum controlled emission rate for the entire facility in pounds per hour and tons per year for each pollutant, or in the case of a modification to an existing facility, the maximum controlled emission rates for both the modification and the entire facility after the modification,

*+ • the maximum and standard operating schedules expected at the facility after completion of construction (hrs/day, days/wk, wks/yr),

*+ • the current address of the Department to which comments and inquiries may be directed:

New Mexico Environment Department
Air Quality Bureau – Permits Section
2048 Galisteo, Santa Fe, New Mexico 87505 (505) 827-1464

*+# √ an attachment containing a written description of the facility and/or modification including all operations affecting air emissions.

*+ • an attachment containing a PSD applicability determination for the facility.

* • an attachment containing an analysis on the impact on visibility.

* • an attachment containing an analysis on the impact on soils.

* • an attachment containing an analysis on the impact on vegetation, including state and federal threatened and endangered species.

* • an attachment containing documentation that the federal land manager of a Class I area within 100 km of the site has been notified and provided a copy of the application, including the BACT analysis and modeling results.

*+ • an attachment containing a regulatory compliance discussion demonstrating compliance with each applicable regulation (state & federal) and ambient air quality standard, PSD increments (if baseline triggered), and provisions of air toxics, if applicable.

*+ • an attachment containing a preliminary operational plan defining the measures to be taken to mitigate source emissions during malfunction, startup, or shutdown.

*+ • an attachment containing the required air quality modeling analysis.

*+ • an attachment containing a completed Dispersion Modeling Checklist.

State of New Mexico
ENVIRONMENT DEPARTMENT
Air Quality Bureau
2048 Galisteo St.
Santa Fe, NM 87505
Phone (505) 827-1494
Fax (505) 827-1523
www.nmenv.state.nm.us

BILL RICHARDSON
GOVERNOR

RON CURRY
SECRETARY

DERRITH WATCHMAN-MOORE
DEPUTY SECRETARY

October 6, 2003

CERTIFIED MAIL NO. 7001 2510 0000 8015 5021
RETURN RECEIPT REQUESTED

Mr. Michael Zigmond, P.E.
NASA White Sands Test Facility
PO Box 20
Las Cruces, NM 88004-0020

File No. 2904
IDEA No. 124 – PRN20030001
AIRS No. 35-013-0004

Dear Mr. Zigmond:

This letter acknowledges the receipt of your Notice of Intent application dated June 12, 2003 to construct and operate a plume-front pump-and-treat remediation system near Las Cruces, New Mexico. The application was received by the Department on June 20, 2003 and additional material was received by the Department on August 20, 2003.

A review has been completed and the information provided is sufficient to complete an evaluation of your permit application. The results demonstrate that the emissions from the units are too low to trigger 20 NMAC 2.72 - Construction Permits or 2.73 - Notice of Intent and Emissions Inventory Requirements. Therefore this notice of No Permit Required (NPR) authorizes you to operate the facility as stated in the application.

The Department has also determined that the New Source Performance Standards (NSPS) or National Emission Standards for Hazardous Air Pollutants (NESHAPS) do not apply to this facility. Please be advised that this assessment was based upon the application submitted and these sources, when constructed will be subject to inspection.

Sincerely,

Mike Fowler
New Source Review Supervisor
Air Quality Bureau

cc: Daniela Bowman, NMED Hazardous Waste Bureau
Las Cruces NMED District/Field Office

Appendix E - Construction Surveillance Plan

NASA White Sands Test Facility

Plume-Front Remediation System

Installation of Instrumentation and Control (I&C) System

Contract Surveillance Plan

July 7, 2003

I&C Surveillance Plan Revision History

Revision	Date	Description
Basic	July 7, 2003	Original version of document.

1 Contract Identification

AFCEE Contract #	F41624-97-D-8019 Delivery Order DO-0194
Period of Performance	September 10, 2002 to December 31, 2003
Contract Value	$ 1,123,369
Contractor Name Contractor Address	CH2M Hill Inc. 6001 Indian School Road NE Suite 350 Albuquerque, NM 87110-4140
Contractor Project Manager	Amy Halloran
Contractor CAGE Code	0TXD8
AFCEE Contracting Officer (CO)	Gary Macdecy
AFCEE Contracting Officer's Representative (COR)	Dario Beniquez
NASA Project Manager	Michael Zigmond
Date of Plan	June 30, 2003 (initial)

2 Scope

2.1 Introduction

This surveillance plan describes how NASA-JSC White Sands Test Facility (WSTF) will conduct surveillance of the installation of process piping and instrumentation and controls (I&C). This plan is a "living" document; as project details change, this plan will be updated to reflect those changes.

2.2 Relation to Other Projects

The I&C system is an integral part of a larger project, the WSTF Plume-Front Remediation System (PFRS). The PFRS is intended to arrest the movement of a plume of contaminated groundwater, underlying WSTF and lands to the west of WSTF. The plume is approximately 20,000 feet in length, up to 8,000 feet in width (at the plume-front) and 700 feet thick. The PFRS consists of:

- Six groundwater extraction wells
- A dual-wall HDPE pipeline network from the extraction wells to the treatment facility
- A treatment facility (Building 650), containing two sieve-tray air strippers and one UV/oxidation reactor
- A single-wall HDPE pipeline network from the treatment facility to the injection wells
- Four groundwater injection wells
- A leak detection system, in the annulus of the dual-wall HDPE pipeline
- Electric power distribution
- An instrumentation and control (I&C) system (the subject of this surveillance plan)

2.3 Contract Work Breakdown Structure

CH2M Hill's Work Breakdown Structure (WBS) is shown below.

WBS	Description
32.03.01	Preparation of Plans
32.03.01.01	Work Plan
32.03.01.04	Site Health and Safety Plan
32.03.02	Project Management
32.03.02.01	Conduct Project Management
32.03.02.03	Support Subcontracting Activities
32.03.02.03	Administration/Reporting

WBS	Description
32.03.07	Site Work / Temporary Facilities
32.03.07.01	Perform Mobilization / Demobilization
32.03.07.06	Install Electrical
32.03.07.08	Install Mechanical
32.03.07.90	Startup and Training for I&C System
32.03.07.92	RS Power Programming

2.4 Contract Schedule

As part of their proposal, CH2M Hill submitted a project schedule, in the format of a Gantt chart. This project schedule is shown in Figure 1. CH2M Hill plans to work five 8-hour days per week during this project. Any changes to this schedule will be reflected in the Project Schedule, and incorporated into this surveillance plan.

2.5 Contract Description

This contract covers the tasks listed below:

- Procurement of materials
- Installation of process piping, control valves, flow meters, manual valves, and other hardware
- Leak testing the process piping
- Installation of digital and analog sensors and controllers, fiber optic cable, control panels, electric power meters, and other hardware
- Testing the electronic hardware
- Installation of RS View control system software, integration of RS Power software with RS View, followed by testing and verification of the software
- Provision of as-built drawings and O&M manuals
- Training of WSTF personnel

The contract vehicle is a time-and-materials ID/IQ contract between the Air Force Center for Environmental Excellence (AFCEE) and CH2M Hill.

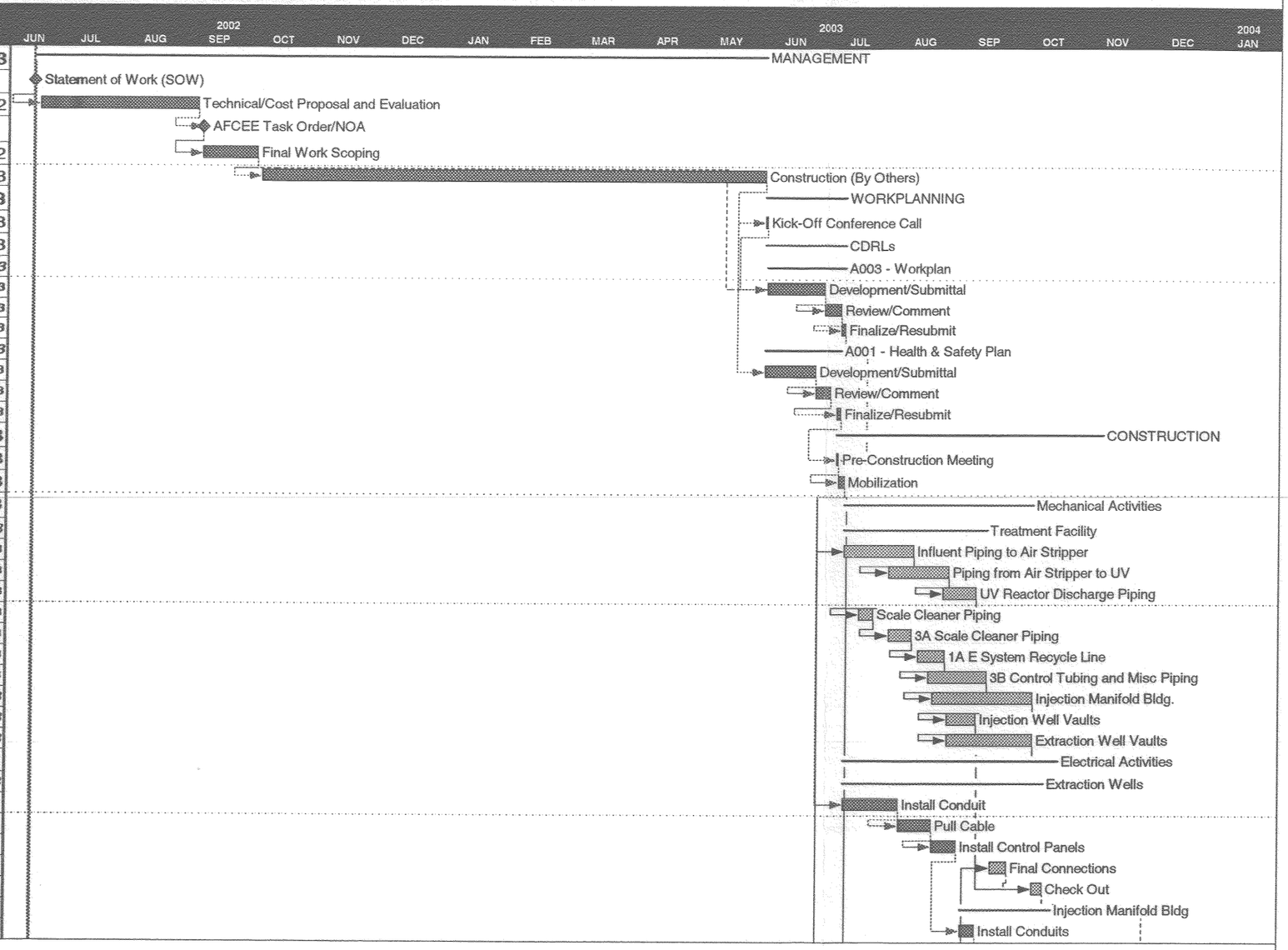
Figure 1 Project Schedule

Air Force Center for Environmental Excellence
Brooks City-Base
F41624-97-D-8019-0194

PROJECT SCHEDULE

NASA - White Sands
Process Piping, Control System and Related Components

Outline Code	Activity ID	Description	Duration	Start	Finish
1	0001	MANAGEMENT	244 *	06/21/02	06/02/03
1.1	0132	Statement of Work (SOW)	0	06/21/02	
1.2	0112	Technical/Cost Proposal and Evaluation	53	06/24/02	09/06/02
1.3	0102	AFCEE Task Order/NOA	0	09/09/02	
1.4	0122	Final Work Scoping	20	09/09/02	10/04/02
1.5	0092	Construction (By Others)	170	10/07/02	06/02/03
2	0002	WORKPLANNING	27 *	06/03/03	07/10/03
2.1	0157	Kick-Off Conference Call	1	06/03/03	06/03/03
2.2	0147	CDRLs	27 *	06/03/03	07/10/03
2.2.1	*0167*	*A003 - Workplan*	*26 **	*06/04/03*	*07/10/03*
2.2.1.1	0207	Development/Submittal	19	06/04/03	06/30/03
2.2.1.2	0217	Review/Comment	5	07/01/03	07/08/03
2.2.1.3	0227	Finalize/Resubmit	2	07/09/03	07/10/03
2.2.2	*0187*	*A001 - Health & Safety Plan*	*25 **	*06/03/03*	*07/08/03*
2.2.2.1	0057	Development/Submittal	18	06/03/03	06/26/03
2.2.2.2	0067	Review/Comment	5	06/27/03	07/03/03
2.2.2.3	0077	Finalize/Resubmit	2	07/07/03	07/08/03
3	0007	CONSTRUCTION	91 *	07/07/03	11/10/03
3.1	0041	Pre-Construction Meeting	1	07/07/03	07/07/03
3.2	0021	Mobilization	3	07/08/03	07/10/03
3.3	0061	Mechanical Activities	64 *	07/11/03	10/08/03
3.3.1	*0071*	*Treatment Facility*	*48 **	*07/11/03*	*09/16/03*
3.3.1.1	0081	Influent Piping to Air Stripper	23	07/11/03	08/12/03
3.3.1.2	0091	Piping from Air Stripper to UV	21	08/01/03	08/29/03
3.3.1.3	0101	UV Reactor Discharge Piping	12	08/27/03	09/11/03
3.3.1.4	0301	Scale Cleaner Piping	5	07/18/03	07/24/03
3.3.1.5	0111	3A Scale Cleaner Piping	7	08/01/03	08/11/03
3.3.1.6	0121	1A E System Recycle Line	9	08/15/03	08/27/03
3.3.1.7	0171	3B Control Tubing and Misc Piping	20	08/20/03	09/16/03
3.3.2	*0361*	*Injection Manifold Bldg.*	*34*	*08/22/03*	*10/08/03*
3.3.3	*0181*	*Injection Well Vaults*	*10*	*08/29/03*	*09/11/03*
3.3.4	*0191*	*Extraction Well Vaults*	*29*	*08/29/03*	*10/08/03*
3.4	0201	Electrical Activities	72 *	07/11/03	10/20/03
3.4.1	*0211*	*Extraction Wells*	*67 **	*07/11/03*	*10/13/03*
3.4.1.1	0221	Install Conduit	18	07/11/03	08/05/03
3.4.1.2	0231	Pull Cable	12	08/06/03	08/21/03
3.4.1.3	0241	Install Control Panels	8	08/22/03	09/02/03
3.4.1.4	0251	Final Connections	6	09/19/03	09/26/03
3.4.1.5	0261	Check Out	3	10/09/03	10/13/03
3.4.2	*0281*	*Injection Manifold Bldg*	*31 **	*09/05/03*	*10/17/03*
3.4.2.1	0291	Install Conduits	5	09/05/03	09/11/03



CH2M HILL, Inc.

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Start milestone point
Finish milestone point

Date	Revision	Checked	Approved
11/01/02	Draft	TEF	TEF
06/30/03	Final Draft	TEF	TEF
07/07/03	Pre-Con Mtg	TEF	TEF

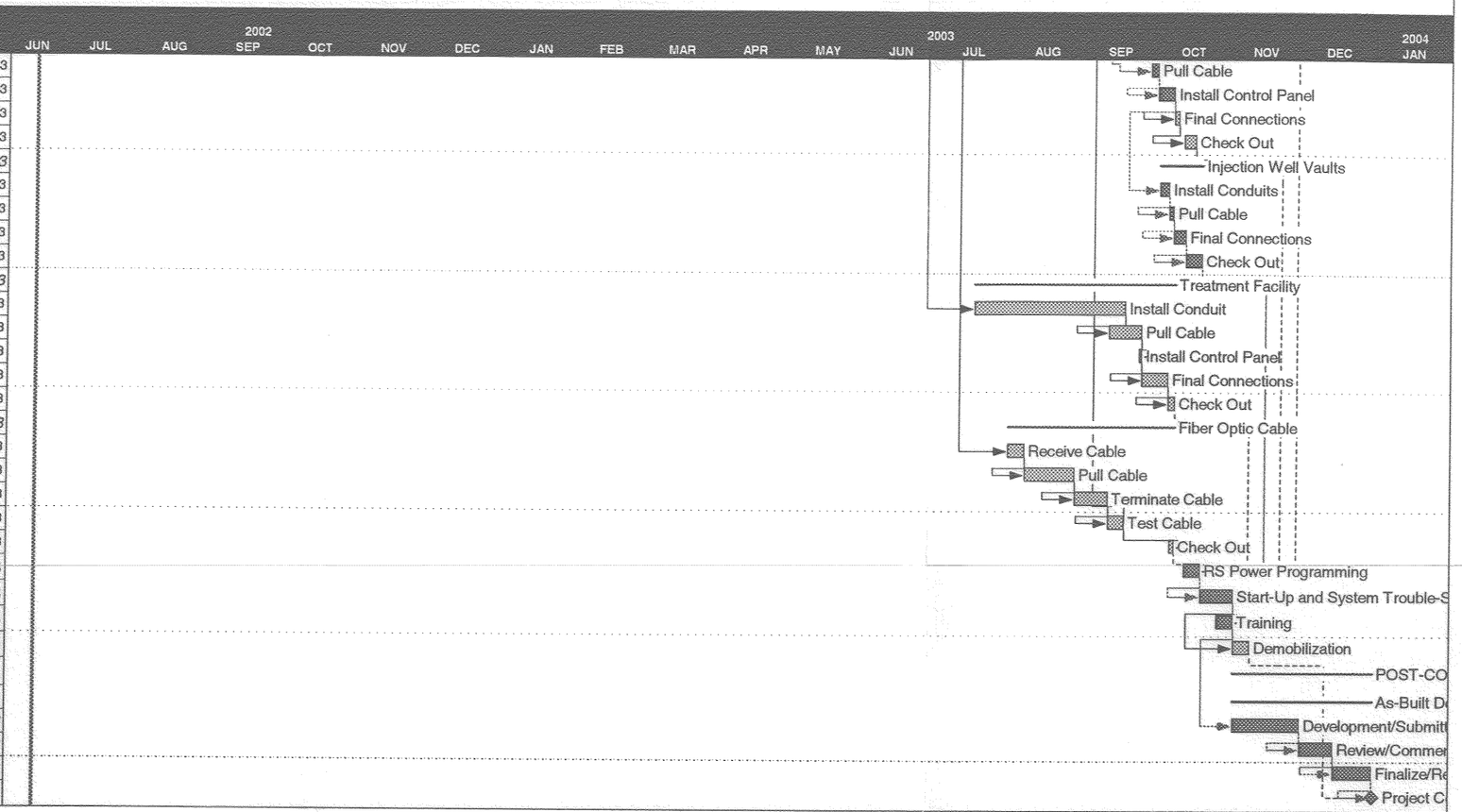
Figure 1 Project Schedule (cont.)

Air Force Center for Environmental Excellence
Brooks City-Base
F41624-97-D-8019-0194

PROJECT SCHEDULE

NASA - White Sands
Process Piping, Control System and Related Components

Outline Code	Activity ID	Description	Duration	Start	Finish
3.4.2.2	0431	Pull Cable	3	09/29/03	10/01/03
3.4.2.3	0441	Install Control Panel	5	10/02/03	10/08/03
3.4.2.4	0311	Final Connections	2	10/09/03	10/10/03
3.4.2.5	0321	Check Out	5	10/13/03	10/17/03
3.4.3	*0331*	*Injection Well Vaults*	*12 **	*10/03/03*	*10/20/03*
3.4.3.1	0341	Install Conduits	2	10/03/03	10/06/03
3.4.3.2	0511	Pull Cable	2	10/07/03	10/08/03
3.4.3.3	0351	Final Connections	3	10/09/03	10/13/03
3.4.3.4	0271	Check Out	5	10/14/03	10/20/03
3.4.4	*0451*	*Treatment Facility*	*60 **	*07/18/03*	*10/09/03*
3.4.4.1	0461	Install Conduit	45	07/18/03	09/18/03
3.4.4.2	0471	Pull Cable	10	09/12/03	09/25/03
3.4.4.3	0481	Install Control Panel	1	09/25/03	09/25/03
3.4.4.4	0491	Final Connections	7	09/26/03	10/06/03
3.4.4.5	0501	Check Out	3	10/07/03	10/09/03
3.4.5	*0421*	*Fiber Optic Cable*	*50 **	*08/01/03*	*10/09/03*
3.4.5.1	0371	Receive Cable	5	08/01/03	08/07/03
3.4.5.2	0381	Pull Cable	15	08/08/03	08/28/03
3.4.5.3	0411	Terminate Cable	10	08/29/03	09/11/03
3.4.5.4	0391	Test Cable	5	09/12/03	09/18/03
3.4.5.5	0401	Check Out	2	10/08/03	10/09/03
3.5	0161	RS Power Programming	5	10/14/03	10/20/03
3.6	0151	Start-Up and System Trouble-Shooting	10	10/21/03	11/03/03
3.7	0141	Training	5	10/28/03	11/03/03
3.8	0131	Demobilization	5	11/04/03	11/10/03
4	**0083**	**POST-CONSTRUCTION**	**42 ***	**11/04/03**	**12/31/03**
4.1	0103	As-Built Documentation	42 *	11/04/03	12/31/03
4.1.1	*0093*	*Development/Submittal*	*20*	*11/04/03*	*12/01/03*
4.1.2	*0113*	*Review/Comment*	*10*	*12/02/03*	*12/15/03*
4.1.3	*0073*	*Finalize/Resubmit*	*12*	*12/16/03*	*12/31/03*
4.2	0063	Project Completion	0		12/31/03



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Date	Revision	Checked	Approved
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06/30/03	Final Draft	TEF	TEF
07/07/03	Pre-Con Mtg	TEF	TEF

2.6 Guidance and Reference Documents

(a) NPG 7120.5A, NASA Program and Project Management Processes and Requirements.
(b) NPG 8820.2C, Facility Project Implementation Handbook.
(c) AFCEE Statement of Work, “Installation Of Mechanical Components And Instrumentation And Controls Of The Groundwater Treatment System At NASA-JSC White Sands Test Facility”, latest revision.
(d) NASA-WSTF, Contract Drawings, latest revision.
(e) AFCEE Surveillance plan (see Appendix A)
(f) NASA-WSTF base support letter (see Appendix B)

3 Risk Assessment

The I&C installation project is vulnerable to the same kinds of risk as any other construction project:

- Actual cost exceeds budget
- Quality does not meet requirements
- Time for completion exceeds requirements

The risk of cost exceeding budget will be managed by closely monitoring CH2M Hill's progress, and comparing their progress against the project schedule. Deviation from the schedule will be discussed with the AFCEE COR, who will give appropriate direction to CH2M Hill to resolve the schedule deviation.

The risk to quality will be addressed in several ways. CH2M Hill's subcontractors are required to provide material submittals to CH2M Hill. CH2M in turn is required to submit material submittals to NASA, prior to the commencement of construction. NASA will either approve, approve with comment, or disapprove these submittals and return them to CH2M Hill. All required submittals must be approved by NASA before construction begins. The kinds of submittals to be provided by the Contractor are:

- Project Workplan and Schedule
- Project Health and Safety Plan
- Manufacturers Qualifications
- Installation Instructions

When construction materials are delivered to the site, NASA will inspect them to ensure they meet the material specifications in the Statement of Work. Non-compliant materials will be rejected, and the Contractor will replace the non-compliant materials at no additional cost to NASA.

Once construction commences, NASA and HTSI/TEAM personnel will inspect the work as it progresses. Work that does not meet the specifications in the Statement of Work will be rejected, and the CH2M Construction Manager will be notified immediately The NASA Project Manager and the CH2M Construction Manager will attempt to resolve the problem; if it cannot be resolved, the issue will be raised to the AFCEE COR and CH2M Project Manager.

The risk to schedule will be addressed by comparing the CH2M's progress reports with the AFCEE-approved Project Schedule. Any deviations between the progress reports and the Project Schedule will be discussed with the AFCEE COR and the CH2M Project Manager, and appropriate adjustments will be made.

4 Surveillance Strategy

NASA procurement guidance describes three kinds of surveillance strategy: oversight, insight, and hybrid. Oversight is defined as "an intrusive process of gathering contractor product or process data through on-site in-series involvement in the process". Insight is defined as "an assurance process that uses product performance requirements and performance metrics to ensure process capability, product quality and end-item effectiveness". A hybrid strategy combines elements of insight and oversight.

The surveillance strategy employed on the pipeline construction project will be oversight. The specifications for installation of the I&C system contain many requirements that are best suited to oversight surveillance. Oversight surveillance will be conducted on:

- Materials procured by the Contractor
- Installation of the hardware and software
- Results of all hardware tests
- Results of the software verification process

The surveillance activities will be managed by the NASA Project Manager. Surveillance activities will be carried out by NASA and HTSI/TEAM technical personnel. Surveillance personnel, and their responsibilities, are described in Section 5 of this document. Surveillance communications during the project will follow the communication flow chart shown in Section 5. Surveillance communications include written reports, verbal reports of non-compliance with the project plans and specifications, submittals, and as-built drawings.

Any WSTF employee may stop work on the project if CH2M Hill or a sub-contractor is about to perform an unsafe act. If work is stopped to prevent an unsafe act, the WSTF employee shall immediately notify the NASA Project Manager and the HTSI/TEAM Safety Department.

If a HTSI/TEAM inspector finds that work does not comply with the project plans or specifications, the HTSI/TEAM inspector is not authorized to give any direction to CH2M Hill or its sub-contractors. If a non-compliance is found, the inspector shall notify the CH2M Superintendent and attempt to resolve the non-compliance. If the issue cannot be resolved by the inspector and Superintendent, the inspector shall document the issue in writing, and notify the NASA Project Manager immediately. The NASA Project Manager and the CH2M Construction Superintendent will attempt to resolve the problem; if it cannot be resolved, the issue will be raised to the AFCEE COR and CH2M Project Manager.

5 Resources

NAME	FUNCTION	RESPONSIBILITIES	LEVEL OF EFFORT
Gary Macdecy	AFCEE Contracting Officer	Resolution of contract issues during the course of the project. Approval of contract modifications.	
Dario Beniquez	AFCEE Contracting Officer's Representative (COR)	Review and approve Contractor invoices, forward invoices to NASA for payment. Verify Contractor compliance with the Davis-Bacon Act.	
Katherine Autry or Michael Lalla	NASA Contracting Officer	Approval of all NASA/DOD purchase requisitions (NDPRs).	As required
Janet Reese	NASA Contract Specialist	Process NASA/DOD purchase requisitions (NDPRs).	As required
Patsy Segura	NASA Accounts Payable Clerk	Process Contractor invoices and payments .	
Michael Zigmond	NASA Project Manager	Overall responsibility to ensure Contractor performs the technical aspects of the project as specified by the project SOW. Coordination of HTSI/TEAM personnel to ensure proper and timely completion of all project requirements. Review and approve Contractor invoices.	As required
Don Minnick (lead), Jack Kirby (alternate), or qualified designee	HTSI/TEAM Construction Inspectors	Inspection of materials and work for compliance with technical specifications and design drawings, and documentation of inspection. Technical review of Contractor submittals.	75% of the duration of the project (2.5 man-days/week)
Qualified designee	HTSI/TEAM Safety Specialists	Review of Contractor Health and Safety Plan. Verification that Contractor field operations are performed in compliance with the applicable OSHA and NASA-WSTF safety directives.	10% of duration of the project (0.5 man-days/week)

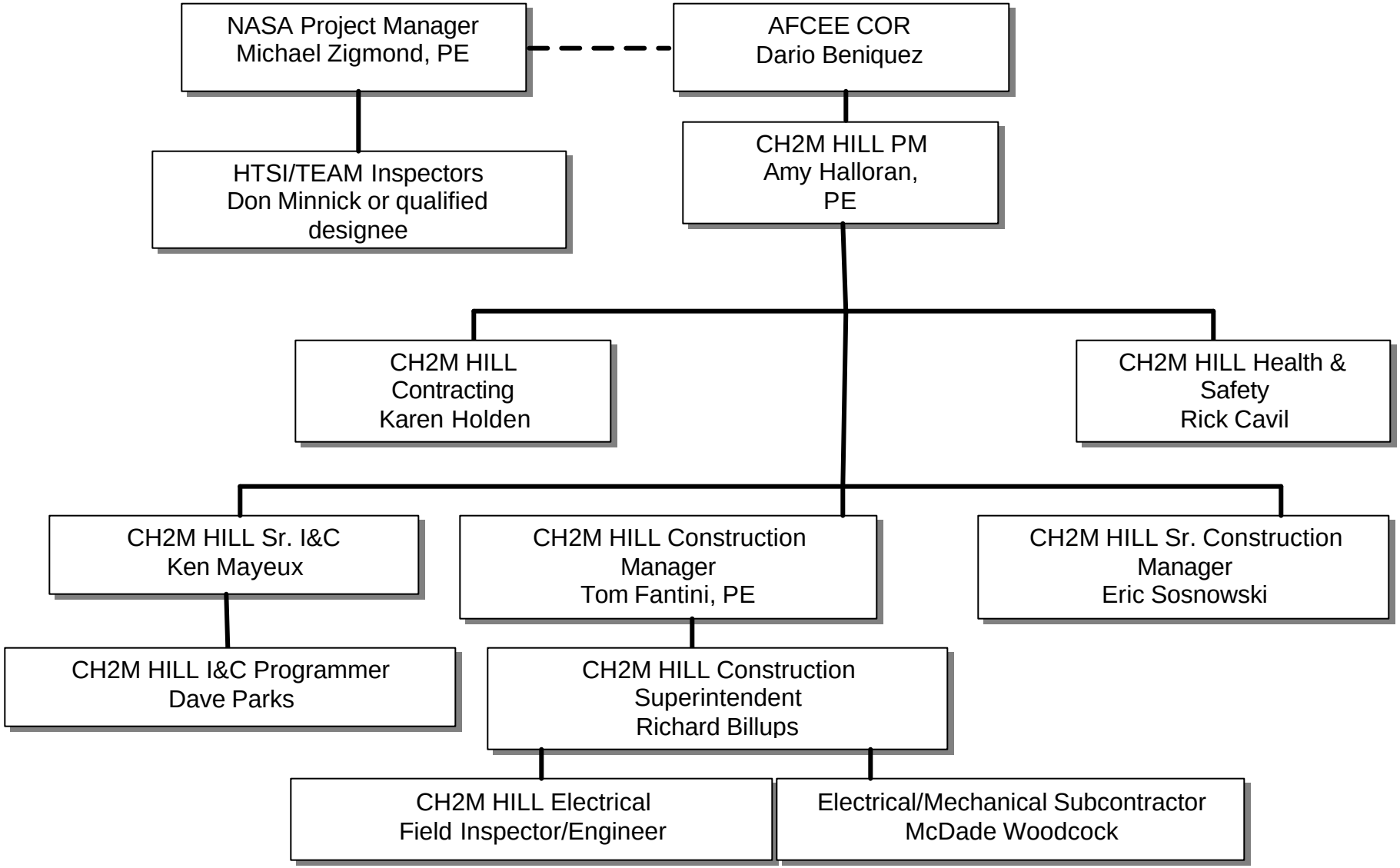


Figure 2 Surveillance Communication Flow Chart

6 Surveillance Methods and Data

Surveillance results will be documented by each inspector, on Air Force Form 1477 (AF 1477, Construction Inspection Record) (shown in Appendix C). An AF 1477 form shall be filled out by each inspector, for each day the inspector visits the job site. Completed AF 1477 forms shall be submitted to the NASA Project Manager on a daily basis. The NASA Project Manager shall submit copies of each AF 1477 form to the AFCEE COR on a weekly basis; if a specification non-compliance arises, the appropriate AF 1477 form(s) shall be submitted to the AFCEE COR immediately.

CH2M Hill is required to prepare a project schedule, and to provide daily reports on the progress of construction. The project schedule, and daily progress reports, will be used to evaluate the performance of the Contractor on an ongoing basis. The daily progress reports and Construction Inspection Records will be used to determine the amount of work completed, and when invoices for progress payments will be approved.

Construction Inspectors shall have the following equipment and materials at all times while in the field:

- Printed copy of the design specifications
- Printed copy of this surveillance plan
- Printed set of design drawings
- Blank copies of AF 1477 forms
- Digital camera
- Measuring tape
- Hardhat, steel-toed boots, eye protection
- Any other PPE appropriate for the type of work being conducted by CH2M Hill
- Any industrial hygiene materials appropriate for the work situation (this could include sunscreen, drinking water, etc.)
- Cellular telephone or 2-way radio
- I&C Surveillance POC list
- WSTF identification badge

Appendix A

AFCEE Surveillance Plan

NASA-JSC WHITE SANDS TEST FACILITY, NEW MEXICO

FIELD OVERSIGHT AND SURVEILLANCE PLAN
F41624-97-D-8019 DO-0194

1. Each government-designated person performing technical oversight surveillance is responsible only for providing technical oversight of contractor field activities, and he/she does not have authority to direct the contractor in any way except when officially designated, in writing by the CO.

2. The COR shall be responsible for reviewing all project notes and meeting minutes and incorporating them into project folder for future reference when certifying contractor invoices and DD250's. Carefully prepared surveillance documentation is a useful tool for cost monitoring.

3. The government POC shall be documented on a Construction Inspection Record AF Form 1477, or other similar method. Entries are to include contractor activities, operations, compliance and noncompliance with contract requirements. Entries shall also be made on instruction given to contractor, problems or potential problems observed, tests performed, materials delivered to job sites, manpower on job sites, special equipment used, and other information requiring documentation.

4. The government surveillance personnel shall document safety violations and immediately report emergency conditions to the remedial program manager and/or base safety office. Government property, either provided by the government or purchased through this contract effort shall be documented when delivered and/or on hand for use. The care, handling, maintenance, and security of government property shall also be documented.

5. Events of non-compliance requiring action shall be reported to the contracting officer (CO) and/or the contracting officer representative (COR) immediately by telephone and/or FAX for appropriate action. A formal written report of noncompliance activities shall be submitted within three working days.

6. Daily visits to the work site shall be made during field activities to ensure contractor compliance with contract requirements.

7. Documents prepared by the contractor as deliverables shall undergo extensive review by the on-site program manager. NASA comments and contractor responses will be maintained in the Administrative Record.

Appendix B

NASA Base Support Letter

RE-

U.S. Air Force Center for Environmental Excellence
Attn: Ms. Lora Gaitwood-Smith
Contract Specialist
Mail Code HSW/PKVBD
3207 Sidney Brooks
Brooks AFB
San Antonio, TX 78235-5344

SUBJECT: WSTF Support Letter for Plume-Front Instrumentation and Control (I&C) System, F41624-97-D-8019 DO-0194, at the NASA-JSC White Sands Test Facility, New Mexico

AFCEE is providing technical and contractual services to the NASA-JSC White Sands Test Facility (WSTF) in support of the above referenced project. As part of these activities, the WSTF will provide support as outlined below. The order follows the items requested by AFCEE.

1. Office space in Building 650 will be made available to the Contractor. NASA will furnish the office with a desk, office chair, table, and file cabinet. Sewer, water, telephone, and electrical utilities are available to the Contractor in Building 650. A desktop computer and printer will be installed in Building 650. Contractor may use Building 650 for equipment and material storage.

2. Keys to the Building 650 yard, Building 650 entrance door, and the pipeline vaults will be issued to the Contractor. If Contractor loses their keys, Contractor shall bear the cost of all applicable re-keying.

3. Contractor shall supply a method of two-way communications (either two-way radio or cellular telephone) when work is required in remote locations. Use of cellular telephones by the Contractor at the job site is not restricted, but use of two-way radio frequencies must be pre-approved by WSTF.

4. Access to engineering plans, drawings, diagrams, maps, files, etc, will be provided by WSTF if available.

5. WSTF shall provide access to “Controlled” or “Secured” areas as needed to support the requirements of the project. Therefore, it shall be mandatory for all Contractor employees working on this project to obtain Base access passes. The acquistion of these passes will be coordinated between the Contractor, Base Point of Contact, and Base Security Police.

6. The Contractor shall ensure minimal disruption of traffic and parking, and disruption of groundwater sampling operations. Contractor may need to coordinate its work schedule with the work of other contractors working on the plume-front remediation system. NASA will facilitate coordination with other contractors as needed.

If you have any questions concerning this letter, please contact the WSTF Point of Contact, Mr. Michael Zigmond, (505) 524-5484 or the AFCEE COR, Mr. Dario Beniquez (210) 536-5284.

Original signed by

Michael Lalla
Contracting Officer

Appendix C

Construction Inspection Record (Air Force Form 1477)

CONSTRUCTION INSPECTION RECORD
(TYPE OR WRITE ALL ENTRIES LEGIBLY IN INK)

INSTALLATION	PROJECT NUMBER
NASA-JSC White Sands Test Facility	
CONTRACT NUMBER	AWARD COST
F41624-97-D-8019, DO-0194	$1,123,369
	FINAL COST

PROJECT TITLE
Installation of Process Piping, Control System, and Related Components

PROJECT DESCRIPTION
Install process piping and instrumentation & controls (I&C) in the plume-front remediation system.

DATE NOTICE TO PROCEED ISSUED (YYYYMMDD)	NUMBER OF CALENDAR DAYS IN CONTRACT
SCHEDULED COMPLETION DATE (YYYYMMDD)	ACTUAL COMPLETION DATE (YYYYMMDD)
PRIME CONTRACTOR	NAME OF AIR FORCE PROJECT ENGINEER
CH2M Hill Inc.	Dario Beniquez (210) 536-5284

SUBCONTRACTORS

McDade-Woodcock Inc.	
Yukon & Associates	
CD Mechanical Inc.	

CERTIFICATION

I CERTIFY THAT I HAVE READ, UNDERSTAND, AND WILL REQUIRE COMPLIANCE WITH THE FOLLOWING ASPECTS AS PERTAIN TO THIS PROJECT: PLANS; TECHNICAL PROVISIONS; FEDERAL SPECIFICATIONS; PROGRESS SCHEDULE; AND FIELD TESTS.

I FURTHER CERTIFY THAT I UNDERSTAND THAT I HAVE NO AUTHORITY TO MAKE CHANGES IN THE PLANS OR SPECIFICATIONS AND THAT MY DUTIES CONSIST PRIMARILY OF SEEING THAT TERMS AND CONDITIONS OF THE CONTRACT ARE CARRIED OUT, TO PROVIDE A PERMANENT RECORD OF THE ACCOMPLISHMENT OF THE PROJECT BY MEANS OF AF FORM 1477, SUPPLEMENTED AS NECESSARY BY ANNOTATED COPIES OF PLANS AND SPECIFICATIONS, AND FURTHER, TO PROVIDE TIMELY RECOMMENDATIONS TO THE BASE CIVIL ENGINEER FOR CHANGES IN THE CONTRACT PLANS AND SPECIFICATIONS, IF REQUIRED.

I WILL MAINTAIN THIS RECORD ON A CURRENT BASIS, IN ACCORDANCE WITH THE REQUIREMENTS OF PERTINENT REGULATIONS AND INSTRUCTIONS GOVERNING THE PREPARATION, MAINTENANCE, AND COMPLETION OF THIS RECORD.

NAME AND GRADE OF INSPECTOR	SIGNATURE	DATE

AIR FORCE CONSTRUCTION MANAGER	PERIOD COVERED (YYYYMMDD)
	FROM 2003-07-07 TO
COMPLETED REPORTS THROUGH	BOOK NO. OF BOOKS

NON-COMPLIANCE ITEMS					
ITEM NO	PLANS OR SPECS	DESCRIPTION	DATE IDENTIFIED	DATE COMPLETED	REMARKS

DAILY INSPECTION RECORD

DATE (YYYYMMDD)	TIME OF INSPECTOR'S VISIT TO SITE							
	ARRIVAL	DEPARTURE	ARRIVAL	DEPARTURE	ARRIVAL	DEPARTURE	ARRIVAL	DEPARTURE

WEATHER CONDITIONS SATISFACTORY FOR WORK ☐ YES ☐ NO *(IF NO, DESCRIBE CONDITIONS)*

WORK FORCE – CONTRACTOR AND SUB-CONTRACTOR

TRADE	NO.	TRADE	NO.	TRADE	NO.	TRADE	NO.

MATERIALS DELIVERED TO JOB SITE

ITEM	QUANTITY	ITEM	QUANTITY

CONTRACTOR EQUIPMENT ON HAND

TYPE	NO.	TYPE	NO.	TYPE	NO.	TYPE	NO.

WORK ACCOMPLISHED OR IN PROGRESS – TESTS PERFORMED

CONTINUE REPORT ON PAGE 4

NOTE: WRITE ALL ENTRIES LEGIBLY IN INK. LINE OUT ALL UNUSED PORTIONS. INSPECTOR SIGNS FIRST NAME, MIDDLE INITIAL, AND LAST NAME ON EACH COMPLETED DAILY INSPECTION RECORD.

REPORT NO.

REMARKS *(Delays; safety; special instructions given or received; reasons for rejecting materials and/or work.)*

SIGNATURE

DATE

RECORD OF SUBMITTAL DATA

SECTION	ITEM DESCRIPTION	TYPE SUBMITTAL	DATE DUE	DATE RECEIVED	DATE APPROVED	REMARKS

GOVERNMENT FURNISHED EQUIPMENT/MATERIALS

DESCRIPTION	DATE ORDERED	DATE RECEIVED	DATE INSPECTED	INSPECTED BY / REMARKS

Sub-Grade High Density Polyethylene (HDPE) Piping and Installation

Contract Surveillance Plan
Revision 2

Contract No. NAS9-01175

September 3, 2002

1 Contract Identification

Solicitation #	RFQ 9-WSRE-W01-1-71Q
Contract #	NAS9-01175
Period of Performance	September 19, 2002 to October 4, 2002
Contract Name	Sub-Grade High Density Polyethylene (HDPE) Piping and Installation
Contract Value	$1,377,214
Contractor Name	URS Group, Inc.
Contractor Address	6501 Americas Parkway NE
	Suite 900
	Albuquerque, NM 87110-5311
Contractor Project Director	Dan Kwiecinski
	(505) 855-7500
	(505) 855-7415 direct
Contractor Project Manager	Jerry May
	(505) 855-7500
	(505) 855-7417 direct
	(505) 280-5402 cellular
Contractor CAGE Code	IN9U6
Contracting Officer Name	Michael Lalla
	(505) 524-5162
Contract Specialist Name	Janet Reese
	(505) 524-5133
COTR Name	Michael Zigmond
	Office (505) 524-5484
	Cell (505) 640-6661
	Pager (505) 524-5085, then enter 5484, then number to be called
Date of Plan	November 14, 2001 (initial) January 10, 2002 (rev. 1) September 3, 2002 (rev. 2)

2 Scope

2.1 Introduction

This surveillance plan describes how NASA-JSC White Sands Test Facility (WSTF) will conduct surveillance over the construction of a high-density polyethylene (HDPE) pipeline network. This plan a "living" document; as project details change, this plan will be updated to reflect those changes.

2.2 Relation to Other Projects

Construction of the HDPE pipeline is an integral part of a larger project, the WSTF Plume-Front Remediation System (PFRS). The PFRS is intended to arrest the movement of a plume of contaminated groundwater, underlying WSTF and lands to the west. The plume is approximately 20,000 feet in length, up to 8,000 feet in width (at the plume-front) and 700 feet thick. The PFRS consists of:

- Six groundwater extraction wells
- A dual-wall HDPE pipeline network from the extraction wells to the treatment facility
- A treatment facility (Building 650), containing two sieve-tray air strippers and one UV/oxidation reactor
- A single-wall HDPE pipeline network from the treatment facility to the injection wells
- Four groundwater injection wells

In the future, NASA plans to install a mid-plume remediation system (MPRS), to extract contaminated groundwater from the mid-plume constriction area (MPCA). Although the MPRS design has not been finalized, NASA has decided to install a dual-wall pipeline from the MPCA to near Building 650.

The construction of the HDPE pipeline networks listed above are the subject of Contract NAS9-01175 and this Surveillance Plan.

2.3 Contract Work Breakdown Structure

As part of their proposal, URS Corp submitted a project schedule, in the format of a Gantt chart. This project schedule is shown in Figure 1.

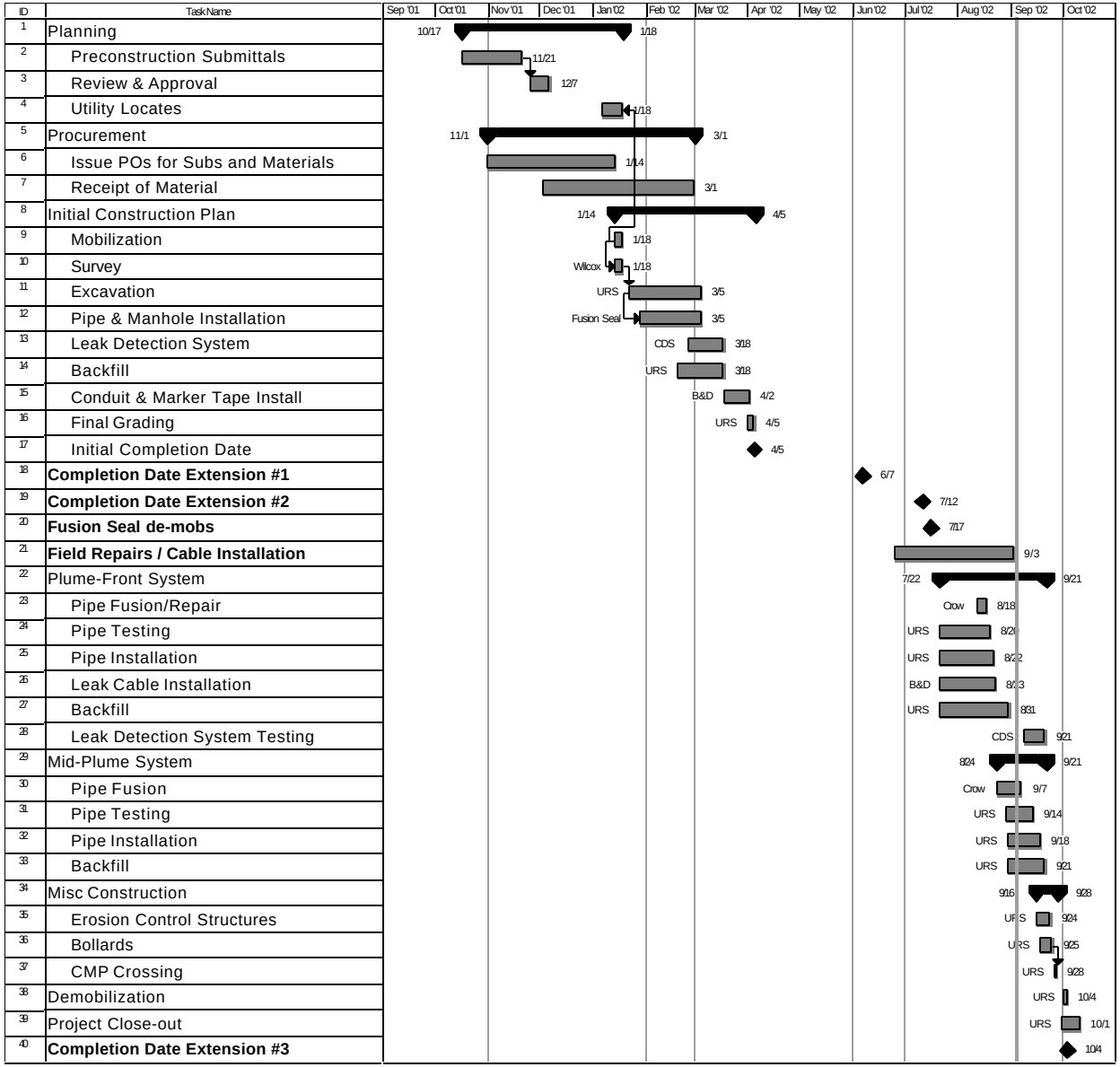


Figure 1 Project Schedule

2.4 Contract Description

This contract covers the construction of a HDPE pipeline. The pipeline connects a network of extraction wells, transports contaminated groundwater to a treatment facility, and transports treated groundwater to a network of injection wells. The construction work includes:

- Procurement of materials
- Earthwork (road grading and trench excavation)
- Assembly of pipe, vaults, leak detection system, and electric conduit
- Leak testing of assembled pipe
- Backfill, compaction, and grading
- Construction of erosion control structures
- Provision of as-built drawings

The contract is firm fixed price (FFP), with a value of $1,377,214.

2.5 Guidance and Reference Documents

(a) NPG 7120.5A, NASA Program and Project Management Processes and Requirements.
(b) NPG 8820.2C, Facility Project Implementation Handbook.
(c) NASA-WSTF, “Subgrade Piping System Statement of Work”, September 6, 2001.
(d) NASA-WSTF, Subgrade Piping System Contract Drawings, latest revision.
(e) NASA-WSTF, Letters responding to URS’ Specification Deviation Requests #2, 3, and 4, August 30, 2002 (shown in Appendix B).

3 Risk Assessment

The plume-front pipeline project is vulnerable to the same kinds of risk as any other construction project:

- Actual cost exceeds budget
- Quality does not meet requirements
- Time for completion exceeds requirements

The risk of cost exceeding budget is minimized by the use of a firm fixed price contract. The cost of construction will increase only if NASA issues a change order that increases the scope of the work.

The risk to quality will be addressed in several ways. The Contractor is required to submit material submittals to NASA, prior to the commencement of construction. NASA will either approve, approve with comment, or disapprove these submittals and return them to the Contractor. All required submittals must be approved by NASA before construction begins. The kinds of submittals to be provided by the Contractor are:

- Manufacturers Qualifications
- Installation Instructions
- Project Schedule
- Piping System Pressure Testing Plan
- Leak Detection System Testing Plan
- Cleaning and Flushing Plan
- Waste Water Disposal
- Materials and Equipment

When construction materials are delivered to the site, NASA will inspect them to ensure they meet the material specifications in the Statement of Work. Non-compliant materials will be rejected, and the Contractor will replace the non-compliant materials at no additional cost to NASA.

Once construction commences, NASA and HTSI/TEAM personnel will inspect the work as it progresses. Work that does not meet the specifications in the Statement of Work will be rejected, and the Contractor will be given the opportunity to correct the non-compliant work.

The risk to schedule will be addressed by comparing the Contractor's progress reports with the NASA-approved Project Schedule. Any deviations between the progress reports and the Project Schedule will be discussed with the Contractor, and appropriate adjustments will be made.

4 Surveillance Strategy

NASA procurement guidance describes three kinds of surveillance strategy: oversight, insight, and hybrid. Oversight is defined as "an intrusive process of gathering contractor product or process data through on-site in-series involvement in the process". Insight is defined as "an assurance process that uses product performance requirements and performance metrics to ensure process capability, product quality and end-item effectiveness". A hybrid strategy combines elements of insight and oversight.

The surveillance strategy employed on the pipeline construction project will be oversight. The specifications for construction of the HDPE pipeline contain many requirements that are best suited to oversight surveillance. Oversight surveillance will be conducted on:

- Materials procured by the Contractor
- Excavation of the pipeline trench
- Installation of the pipe, vaults, and other appurtenances
- Results of leak testing of the pipeline
- Results of testing of the leak detection system
- Backfilling and compaction of the trench

The surveillance activities will be managed by the project COTR. Surveillance activities will be carried out by NASA and HTSI/TEAM technical personnel. Surveillance personnel, and their responsibilities, are described in Section 5 of this document. Surveillance communications during the project will follow the communication flow chart shown in Section 5. Surveillance communications include written reports, verbal reports of non-compliance with the project plans and specifications, submittals, and as-built drawings.

Any WSTF employee may stop work on the project if URS or a URS sub-contractor is about to perform an unsafe act. If work is stopped to prevent an unsafe act, the WSTF employee shall immediately notify the NASA COTR and the HTSI/TEAM Safety Department.

If a HTSI/TEAM inspector finds that work does not comply with the project plans or specifications, the HTSI/TEAM inspector shall not issue a stop work order. If such a non-compliance is found, the inspector shall notify the NASA COTR, CS, or CO immediately.

5 Resources

NAME	FUNCTION	RESPONSIBILITIES	LEVEL OF EFFORT
Michael Lalla	NASA Contracting Officer	Overall responsibility to ensure Contractor complies with the terms of the Contract. Approval of all Contract modifications. Resolution of contract issues during the course of the project.	As required
Janet Reese	NASA Contract Specialist	Process approved Contract modifications. Verify Contractor compliance with the Davis-Bacon Act. Process Contractor invoices and payments .	As required
Michael Zigmond	NASA Project Manager/Contracting Officer Technical Representative	Overall responsibility to ensure the Contractor performs the technical aspects of the project as specified by the Contract. Coordination of Contractor/HTSI/Lynx personnel to ensure proper and timely completion of all project requirements. Ensure overall project safety and resolve technical conflicts.	As required
Jack Kirby or qualified designee	HTSI/TEAM Environmental Department Project Leader or Qualified Environmental Department Designee	Inspection of materials at the time of delivery to ensure that the materials meet the specifications of the Contract and are not damaged or otherwise not suited for service. Inspection and verification that the pipeline, manholes, leak detection equipment, and conduit are installed in accordance with the Contract . Oversight and verification that land clearance, grubbing, and excavation activities are performed by the Contractor in accordance with the Contract. Oversight and verification of backfilling and soil compaction activities to ensure that the Contractor complies with the Contract.	50% of the duration of the project (2.5 man-days/week)
Fred Dishman or qualified designee	HTSI/TEAM Safety Specialists	Verification that Contractor field operations are performed in compliance with the applicable OSHA and NASA-WSTF safety directives.	10% of duration of the project (0.5 man-days/week)

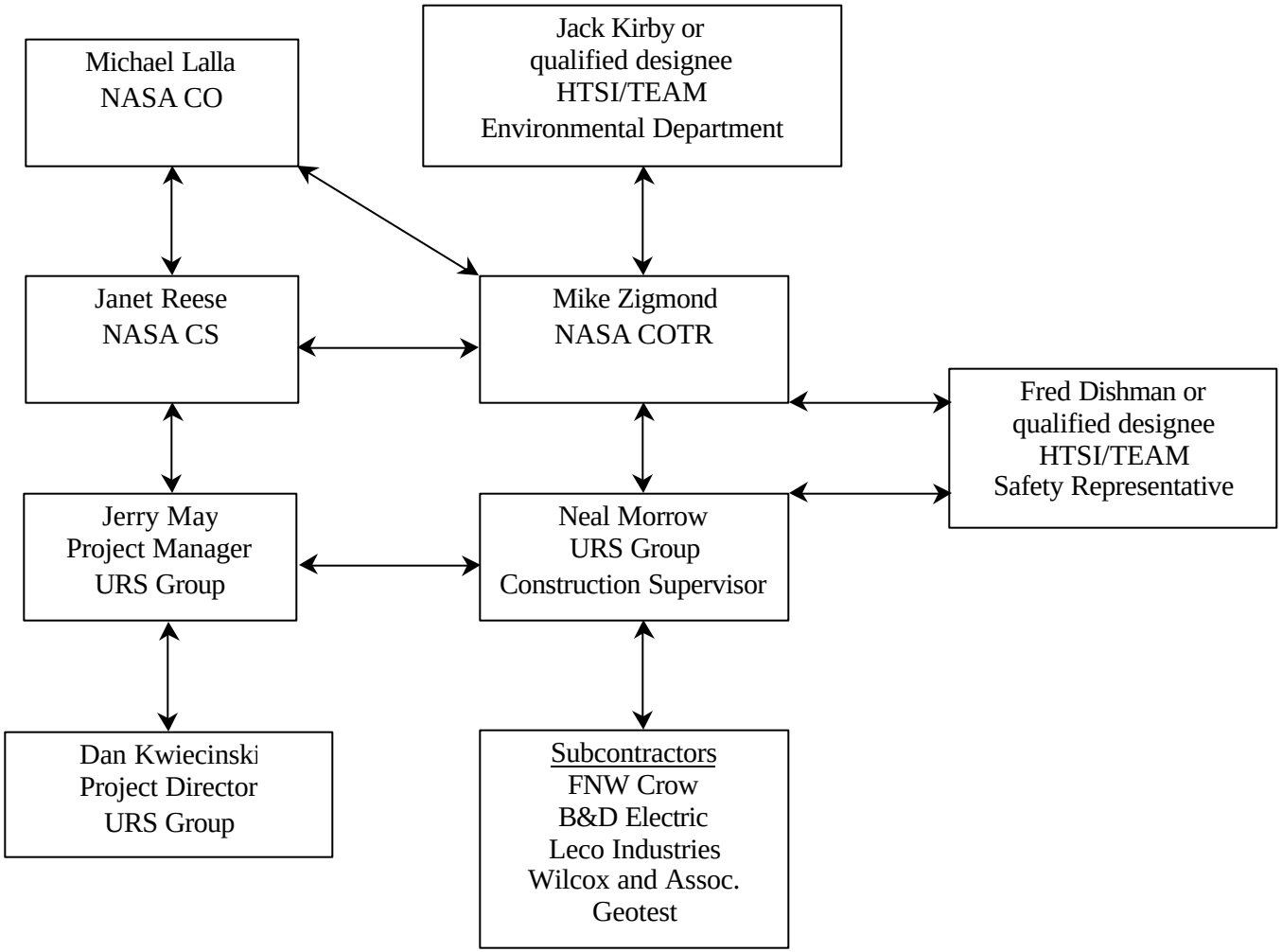


Figure 2 Surveillance Communication Flow Chart

6 Surveillance Methods and Data

Surveillance results will be documented by each inspector, on checklists developed specifically for each kind of work to be performed. The inspection checklists to be used for this Surveillance Plan are shown in Appendix A. The appropriate checklist(s) will be filled out by the lead inspector, and signed by the Contractor's representative and the NASA COTR. Completed inspection checklists will be kept in the NASA project file.

The Contractor is required to prepare a project schedule, using Microsoft Project. In addition, the Contractor is required to provide daily reports on the progress of construction. The project schedule, and daily progress reports, will be used to evaluate the performance of the Contractor on an ongoing basis. The daily progress reports and inspection checklists will be used to determine the amount of work completed, and when invoices for progress payments will be approved.

Appendix A

Construction Inspection Checklists

HDPE Pipeline Construction Inspection Checklist

Date			
Time			
Location (description & station)			
WSTF Inspector(s) Name & Organization			
Contractor Representative(s)			
Material Inspection 1. HDPE Pipe is marked with manufacturer name, size, DR, "PE 3048", and "ASTM F714"? 2. Conduit meets NEMA TC 13, UL 651, and is no less than schedule 40? 3. Valves have attached tag with mfg. name, model no., WSTF component ID? 4. Leak detection cable conductor not less than 20 AWG?		☐ Yes ☐ Yes ☐ Yes ☐ Yes	☐ No ☐ No ☐ No ☐ No
Safety (describe any safety problems observed, and action taken)			
Comments (describe in detail any materials that do not meet spec, and action taken)			
Signature of WSTF Inspector(s)		Signature of Contractor Representative(s)	
Signature of COTR			

Distribution: NASA CO (original), NASA COTR (copy), Contractor (copy)

HDPE Pipeline Construction Inspection Checklist

Date			
Time			
Location (description & station)			
WSTF Inspector(s) Name & Organization			
Contractor Representative(s)			
Excavation Inspection 1. Depth of trench sufficient to provide 3 ft cover over top of pipe? 2. Width of trench not greater than 28" plus pipe OD? 3. Erosion control is in place? 4. Barricades, fencing, and /or caution tape placed around trench where no work is being performed? 5. Excavation for appurtenances has at least 12 inches clearance?		☐ Yes ☐ Yes ☐ Yes ☐ Yes ☐ Yes	☐ No ☐ No ☐ No ☐ No ☐ No
Safety (describe any safety problems observed, and action taken)			
Comments (describe in detail any work that does not meet spec, and action taken)			
Signature of WSTF Inspector(s)		Signature of Contractor Representative(s)	
Signature of COTR			

Distribution: NASA CO (original), NASA COTR (copy), Contractor (copy)

HDPE Pipeline Construction Inspection Checklist

Date		
Time		
Location (description & station)		
WSTF Inspector(s) Name & Organization		
Contractor Representative(s)		
Plume-Front Pipe & Manhole Installation		
1. Correct size of pipe? (diameter and DR)	☐ Yes	☐ No
2. Correct size of conduit?	☐ Yes	☐ No
3. At repair windows, are centralizer notches located between 3 o'clock and 9 o'clock?	☐ Yes	☐ No
4. Vaults & manholes set level?	☐ Yes	☐ No
5. Concrete vault penetrations sealed/grouted?	☐ Yes	☐ No
6. Pipe at vault penetrations is blind flanged after installation?	☐ Yes	☐ No
Safety (describe any safety problems observed, and action taken)		
Comments (describe in detail any work that does not meet spec, and action taken)		
Signature of WSTF Inspector(s) Signature of Contractor Representative(s)		
Signature of COTR		

Distribution: NASA CO (original), NASA COTR (copy), Contractor (copy)

Date	
Time	
Location (description & station)	
WSTF Inspector(s) Name & Organization	
Contractor Representative(s)	

Mid-Plume Pipe & Manhole Installation		
1. Correct size of pipe? (diameter and DR)	☐ Yes	☐ No
2. Pipe centralizer notches aligned at 6 o'clock ± 5°?	☐ Yes	☐ No
3. Correct size of conduit?	☐ Yes	☐ No
4. Vaults & manholes set level?	☐ Yes	☐ No
5. Concrete vault penetrations sealed/grouted?	☐ Yes	☐ No
6. Pipe at vault penetrations is blind flanged after installation?	☐ Yes	☐ No

Safety (describe any safety problems observed, and action taken)

Comments (describe in detail any work that does not meet spec, and action taken)

Signature of WSTF Inspector(s) Signature of Contractor Representative(s)

Signature of COTR

HDPE Pipeline Construction Inspection Checklist

Date	
Time	
Location (description & station)	
WSTF Inspector(s) Name & Organization	
Contractor Representative(s)	

Specification Requirements

	Design Pressure	Test Pressure
SDR 7.3	198 psi	218 psi
SDR 9	156 psi	172 psi
SDR 11	125 psi	138 psi
SDR 17	78 psi	86 psi

Carrier Pipe Leak Test		
Leak test fluid: Water		
1. Actual test pressure _____ psi		
2. Test duration _____ min		
3. Each valve opened & closed several times during hydrostatic test?	☐ Yes	☐ No
4. Pass Test?	☐ Yes	☐ No

Safety (describe any safety problems observed, and action taken)

Comments (describe in detail any work that does not meet spec, and action taken)

Signature of WSTF Inspector(s) Signature of Contractor Representative(s)

Signature of COTR

Distribution: NASA CO (original), NASA COTR (copy), Contractor (copy)

HDPE Pipeline Construction Inspection Checklist

Date	
Time	
Location (description & station)	
WSTF Inspector(s) Name & Organization	
Contractor Representative(s)	

Specification Requirements

	Design Pressure	Test Pressure
SDR 9	156 psi	172 psi
SDR 11	125 psi	138 psi
SDR 17	78 psi	86 psi

Containment Pipe Leak Test		
Leak test fluid: Compressed air		
1. Actual test pressure _____ psi		
2. Test duration _____ min		
3. Pressure relief device provided, and set for 110% of test pressure?	☐ Yes	☐ No
4. Pass Test?	☐ Yes	☐ No
5. Pipe cleaned and flushed, per Contractor plan?	☐ Yes	☐ Yes

Safety (describe any safety problems observed, and action taken)

Comments (describe in detail any work that does not meet spec, and action taken)

Signature of WSTF Inspector(s) Signature of Contractor Representative(s)

Signature of COTR

Distribution: NASA CO (original), NASA COTR (copy), Contractor (copy)

HDPE Pipeline Construction Inspection Checklist

Date			
Time			
Location (description & station)			
WSTF Inspector(s) Name & Organization			
Contractor Representative(s)			
Leak Detection System Test 1. Leak detection mfg. rep. present? 2. Pass/fail criteria for wet/dirty cable is 10 µA? 3. Cable wetted at start, end, and three locations between start and end, per Contractor test plan? 4. Test system for breaks and shorts, per Contractor test plan? 5. Test manhole probe operation, per Contractor test plan? 6. Pass test?		☐ Yes ☐ Yes ☐ Yes ☐ Yes ☐ Yes ☐ Yes	☐ No ☐ No ☐ No ☐ No ☐ No ☐ No
Safety (describe any safety problems observed, and action taken)			
Comments (describe in detail any work that does not meet spec, and action taken)			
Signature of WSTF Inspector(s) Signature of Contractor Representative(s)			
Signature of COTR			

Distribution: NASA CO (original), NASA COTR (copy), Contractor (copy)

HDPE Pipeline Construction Inspection Checklist

Date		
Time		
Location (description & station)		
WSTF Inspector(s) Name & Organization		
Contractor Representative(s)		
Backfill & Compaction Inspection		
1. At least one field density test per lift for every 1000 feet of trench?	☐ Yes	☐ No
2. At least one moisture-density relationship for each 1500 cu yd of backfill?	☐ Yes	☐ No
3. Backfill compacted to 90% of maximum density?	☐ Yes	☐ No
4. Backfill screened to minus 1 inch?	☐ Yes	☐ No
5. Depth of loose backfill lifts no greater than 12 inches for hand operated compactors or 20 inches for self propelled compactor?	☐ Yes	☐ No
6. Metallic locator tape installed (marked "water" and "fiber optic")?	☐ Yes	☐ No
Safety (describe any safety problems observed, and action taken)		
Comments (describe in detail any work that does not meet spec, and action taken)		
Signature of WSTF Inspector(s)	Signature of Contractor Representative(s)	
Signature of COTR		

Distribution: NASA CO (original), NASA COTR (copy), Contractor (copy)

Appendix B

Deviations to Specifications

Appendix F - WSTF Emergency Preparedness Plan

WSTF EMERGENCY PREPAREDNESS PLAN

1. PURPOSE

This WSP establishes procedures and responsibilities for development, maintenance, and exercise of the WSTF Emergency Preparedness Plan (Program). This plan provides direction to mitigate the effects of hazards, preserving life and minimizing damage. This plan directs response during emergencies, and establishes a recovery system in order to return the facility to normal operations after a major incident, such as a natural disaster or a technological accident. In all emergencies, the response precedence shall be:

- Protection of life;
- Prevention and treatment of injuries; and
- Protection of property and the environment

2. REFERENCES

a. NMI 1040.3, "Emergency Preparedness Program"

b. JMI 1040.2, "Emergency Preparedness Program"

c. WSP 01-0005, "Succession to Key Positions"

d. MSM 4.2.1.8, "Emergency Management"

3. ATTACHMENTS

a. Warning

b. Communications

c. Shelter and Mass Care, and Accountability

d. Radiological Protection

e. Evacuation

f. Fire Prevention and Control

g. Security

h. Medical and Occupational Health

i. Emergency Public Information

j. Damage Assessment

k. Plant Engineering and Utilities (includes Annexes K and L)

m. Resource Management

n. EOC/Direction and Control

o. Human Resources

p. Hazard Mitigation

q. HAZMAT/ Hazardous Material/Waste Spill Response

r. Rescue

s. Transportation

t. Training

u. Legal Services

4. DEFINITIONS

a. *Disaster* – A situation resulting from an incident which causes widespread or severe damage, injury, loss of life, property, or resources and for which the recovery capabilities of a jurisdiction are exhausted. Disaster assistance provided by the federal or state government is intended to supplement local government resources to enhance recovery capabilities and achieve a speedy and efficient return to pre-incident conditions.

b. *Emergency Preparedness Planning Board* – A Board appointed by the NASA WSTF Manager with responsibility for maintenance and review of the WSTF Emergency Preparedness Plan, and coordination, implementation and critique of emergency drills.

c. *Emergency Services Section* – The Emergency Services Section are firefighters, auxiliary firefighters, emergency medical technicians, hazardous material/waste response personnel, security personnel, and medical staff personnel.

d. *Executive Group* – The Executive Group (EG) consists of the NASA Manager, the Program Manager, and the NASA Office Chief/Department Managers if requested by

the NASA Manager or Program Manager. Other individuals may be called upon in specific situations.

e. *HAZMAT* – hazardous materials.

f. *Incident Command System (ICS)* – the command system based on a nationally recognized system for managing critical situations, which includes the following characteristics: (1) common organizational structure; (2) common terminology; (3) uniform and consistent procedures; and (4) coordinated communications.

g. *Mitigation* – Activities that eliminate or reduce the probability of a disaster occurring. Included are those long-term activities that lessen the undesirable effects of unavoidable hazards, such as natural disasters.

h. *Preparedness* – Activities performed to develop the response capabilities needed in the event of an emergency. Planning and training are among the activities conducted under this phase.

i. *Recovery* – Operations to restore vital services to the facility and restore the facility to normal operations. Examples of recovery actions are temporary relocation of offices disrupted by structural damage, restoration of non-vital government services, and reconstruction of damaged areas.

j. *Response* – The actual provision of emergency services during a crisis that helps to reduce casualties and damage, and speed recovery. Response activities include warning, evacuation, rescue, and other similar operations.

k. *Shelter in Place* – In the event of an emergency involving an exterior agent such as a chemical spill/release or adverse weather condition (tornado/high winds), site employees will proceed inside any permanent substantial (not sheet metal) structure (building, bunker, tunnel, etc.) immediately to avoid exposure to the harmful agent or condition.

5. ACRONYMS

Administrative Office	AO
Communicating Group	CG
Damage Assessment Team	DAT
Emergency Action Plans	EAP
Emergency Medical Services	EMS
Emergency Operations Center	EOC
Emergency Planning Officer	EPO
Emergency Preparedness Coordinator	EPC
Emergency Preparedness Planning Board	EPPB
Emergency Public Information	EPI

Emergency Response Team	ERT
Emergency Services	ES
Emergency Services Section	ESS
Engineering Office	EO
Executive Group	EG
Facility Safety Officer	FSO
Fire Chief	FC
Fire Department	FD
Government Services Administration	GSA
Health, Safety and Environmental Facility Manager	HSE
Incident Command System	ICS
Incident Commander	IC
Industrial Hygienist	IH
Joint Command System	JCS
Operations Group	OG
Personal Protective Equipment	PPE
Plant Engineering	PE
Public Address	PA
Public Affairs Officer	PAO
Radiation Safety Officer	RSO

6. PROCEDURES

The details of the Emergency Preparedness Plan include an explanation of the situation and assumptions used to develop the plan; concepts of operations, organization, and designation of responsibilities. The attached annexes contain the details of response to given emergencies.

a. Situation and Assumptions

(1) Situation

WSTF is exposed to hazards that could potentially disrupt operations, cause damage, and create casualties. Possible natural hazards include flash floods, drought, tornadoes, fires, storms, and earthquakes. There is also the threat of a war or terrorist-related incident, such as nuclear, biochemical, or conventional attack. Other disaster situations could develop from a hazardous material/waste accident, fire, major transportation accident, or civil disorder. The Hazard/Threat Identification Analysis linked under section 4.2.1.8 of the WSTF Management System Manual lists hazards present and ranking by potential.

Details on how WSTF responds to emergencies at White Sands Space Harbor (WSSH) are not included in this document. Holloman Air Force Base and White Sands Missile Range (WSMR) emergency plans will be implemented at WSSH as needed.

(2) Assumptions

(a) WSTF will continue to be exposed to the hazards previously noted, as well as others that may develop in the future.

(b) WSTF will be prepared to carry out initial disaster response and short-term actions on an independent basis, although outside assistance may be available in some emergencies.

(c) Many disasters and events can occur with little or no warning.

(d) Senior-level management recognizes its responsibility for the safety and well being of employees and the public, and will assume its responsibility in the implementation of this plan.

(e) Proper implementation of this plan will reduce or prevent disaster-related losses.

b. Concept of Operations

(1) General

This plan includes annexes that address specific emergencies, such as hazardous material/waste response, brush fires, and severe weather. Where appropriate, each annex will include mitigation, preparedness, response and recovery elements.

(2) Existing offices will perform emergency activities closely related to those they routinely perform, i.e., security will perform the security function for emergencies, and heavy equipment will provide equipment and operations for use in emergencies.

(3) Building 104 will serve as the Emergency Operations Center (EOC), unless the emergency dictates otherwise. The Incident Commander (IC) and Emergency Preparedness Coordinator (EPC) will establish an alternate location if Building 104 is not functional for the emergency at hand.

(4) The Emergency Services Section (ESS) training area will serve as a conference area for small groups, such as the Executive Group (EG). If a larger area is needed for planning and group actions, accommodations will be set up in the Fire Department (FD) apparatus floor area.

(5) Office Chiefs and Department Managers will retain control over their employees and equipment, unless directed otherwise by the Executive Group.

(6) Line of Succession as related to emergency situations will follow WSP 01-0005, “Succession to Key Positions.”

(7) Each office (major area of site) will prepare and maintain its own detailed procedures to be followed during response operations. These detailed procedures are to be consistent with this plan and annexes.

(8) Site-wide drills and exercises will be conducted at intervals of no less than once annually to ensure proper functioning of this plan. Proper execution of this plan during a legitimate emergency will verify its functionality and will be counted as a drill or exercise, provided it is documented and critiqued following the event.

(9) This plan will be updated as necessary based upon deficiencies identified by drills and exercises, changes in local management structure, and technological changes. Findings or deficiencies identified during the critique will be processed and tracked using the C/PAR system as defined in WSP 14-0001. Changes to an annex will be coordinated through the cognizant NASA office, and approved changes will be incorporated by QARSO-WSTF. Communication of revisions will be distributed to all organizations through document update notifications.

(10) Required reports will be submitted to the appropriate authorities in accordance with individual annexes.

(11) The Emergency Preparedness Planning Board (EPPB) will brief appropriate senior-level management concerning their role in emergency management.

(12) All mutual aid agreements will be entered into by duly authorized officials representing the external organization and will be formalized in writing whenever possible.

(13) Vital records, including legal documents and rights-and-interest documents, such as personnel and payroll records, must be protected to provide normal operations following a disaster. Fire and water are the principal threats to vital records; therefore, they should be protected accordingly.

(14) This plan follows an all-hazard approach and acknowledges that most responsibilities and functions performed during an emergency are not hazard-specific. This plan accounts for activities before, during and after the emergency.

(15) Day-to-day functions that do not contribute directly to the emergency operation may be suspended for the duration of the emergency and re-directed to the accomplishment of emergency tasks.

c. Organization

Every emergency response will be conducted using the Incident Command System (ICS) or a Joint Command System (JCS), with the fire officials being the IC. In a Joint Command situation, the fire official and the designated area representative will share responsibility, while in the ICS the fire official will be the IC and the area representative

will be the Operations Chief. The Executive Group will be called to the Operations Center (Building 104) for briefings and to provide management commitment of resources needed to properly handle the emergency.

d. Responsibilities

(1) The NASA WSTF Manager will

(a) Ensure the development and implementation of a comprehensive emergency management plan, and direct the overall preparedness program

(b) Appoint an EPC

(c) Charter and approve members of the WSTF EPPB

(d) Approve news releases during emergencies

(e) Request outside assistance from local, state, federal, or military services as necessary. Only the NASA Manager or another official duly authorized by the NASA Manager may make the request for assistance.

(f) Chair the Executive Group

(g) Approve mutual aid agreements and understandings

(h) Participate or delegate a representative in the final review of the annual full-scale exercise with EPPB.

(2) NASA Office Chief(s) and contractor Department Manager(s) will

(a) Ensure development and exercising of area-specific chemical response plans (see Annex Q, HAZMAT/ Hazardous Material/Waste Spill Response)

(b) On an as requested basis, serve as a part of the Executive Group in making decisions and establishing support for the IC and EPC during emergency operations

(c) Ensure that each WSTF building has procedures for employee accountability during emergencies.

1 For fire evacuations the Fire Warden will conduct a sweep of the building to ensure everyone has evacuated and will report their actions to the fire department responders. The fire department will conduct a sweep of the building to verify no one is in danger.

2 For chemical emergency/shelter in place events, each Office Chief and Department Manager will account for their employees. It is recommended that each Chief/Manager designate an area of assembly for their employees, i.e. Chief's/Manager's office. Access to the red phone system should be maintained during the emergency.

(3) The executive group will be called to building 104 if the emergency requires their assistance to reallocate resources or support the IC and Emergency Preparedness Coordinator.

(4) The Emergency Preparedness Planning Board (EPPB) will be responsible for

(a) Ensuring maintenance and an annual review of this plan, including annexes

(b) Review of area-specific plans to ensure consistency and integration with the basic emergency preparedness plan

(c) Emergency Preparedness Awareness

(d) Coordination, implementation, and critique of annual emergency drills

(e) Coordination of emergency planning responsibilities and status with the WSTF Executive Group, White Sands Complex, and Air Force tenants

(f) Prepare and maintain Annex A, "Warning"; Annex E, "Evacuation"; Annex N, "EOC/Direction and Control"; and Annex T, "Training."

(5) The Emergency Preparedness Coordinator (EPC) will

(a) Advise the NASA WSTF Manager on emergency matters. The EPC has the primary responsibility for emergency management planning activities for the NASA Manager.

(b) Maintain the EOC in an operating mode at all times or be able to easily convert the EOC area into an operating condition.

(c) Direct and control the EOC during its activation

(d) Advise the Executive Group of emergency status and update as required

(e) Analyze the emergency skills needed by the facility and identify the training necessary to provide those skills

(f) Ensure a resource inventory is prepared and maintained

(g) Serve as day-to-day liaison between WSTF and local emergency management organizations, including organized emergency volunteer groups and private agencies

(h) Inform the NASA WSTF Manager of preparedness status and anticipated needs

(i) Hold a briefing within 60 days after a new NASA Manager is appointed to brief them on this plan

(j) Ensure the WSTF Manager or delegated representative participates in the final review of the annual full-scale exercise with the EPPB.

(6) The Health, Safety and Environmental Facility Managers (HSE) will

(a) Assure emergency action plans (EAP) are developed and implemented that are consistent with this document

(b) Coordinate with supervisors to assure employees are trained in the EAP

(c) Make changes as necessary to the EAP based on lessons learned from the exercises or actual incidents

(7) The Radiation Safety Officer (RSO) will

(a) Establish and maintain a radiation monitoring and reporting network

(b) Secure and ensure initial and refresher training for instructors/monitors

(c) Provide input to the statewide monitoring and reporting system

(d) Under fallout conditions, provide senior management with information on fallout rates, fallout projections, and allowable doses

(e) Coordinate radiation monitoring throughout the facility

(f) Provide monitoring services and advice at the scene of accidents involving radioactive materials

(g) Prepare and maintain Annex D, “Radiological Protection,” to include radiation source accidents

(8) The Emergency Services Section (ESS) will

(a) Chair the EPPB

(b) Identify high-hazard areas and the number of potential evacuees

(c) Evacuate all non-essential personnel from incident areas

(d) Coordinate evacuation planning to include

1 Movement control of evacuees

2 Health, medical, physically challenged or disabled employees

3 Transportation needs

4 Emergency public information materials

5 Shelter and reception

(e) Provide fire prevention and suppression

1 Isolate damage areas and report damage to EOC

2 Coordinate search-and-rescue activities

3 Coordinate triage, first-aid, and emergency medical services

4 Inspect shelters and damaged area for fire hazards

5 Train auxiliary fire fighters for fire and rescue purposes

(f) Oversee the overall hazard mitigation program

(g) Provide 24-hour coverage regarding fire and life safety

1 Maintain equipment and staffing in a continuous state of readiness

2 Mobilize medical, building trades, engineer, heavy equipment, and rescue squad personnel as needed

(h) Prepare and maintain Annex B, “Communications”; Annex C, “Shelter And Mass Care”; Annex F, “Fire Prevention and Control”; Annex P, “Hazard Mitigation”; Annex Q, “HAZMAT/Hazardous Material/Waste Spill Response”; and Annex R, “Rescue.”

(9) The Program Assurance Department Security Officer will

(a) Provide 24-hour coverage for

1 Traffic control

2 Crowd control

3 Site security

(b) Prepare and maintain Annex G, “Security”

(10) QARSO/PAD will provide a safety officer to the IC and will

(a) Be a qualified safety, health, or industrial hygiene professional knowledgeable in emergency preparedness and first responder responsibilities.

(b) Be able to act independent of the safety office in times when emergency conditions require immediate response for life safety.

(c) Be notified of an emergency situation and requested to the scene by ESS

(d) Coordinate safety and health requirements with the on-scene commander, fire chief or the senior member of the response team on site

(e) Coordinate planning efforts of the Dispensary and other health facilities.

(f) The safety officer will advise the IC on safety issues during the emergency.

(g) Coordinate air monitoring for re-occupancy clearance following a hazardous materials release.

(h) Prepare and maintain Annex H, “Industrial Safety and Occupational Health.”

(11) The Environmental Program Manager will

(a) Notify local, state, and federal agencies, as required by law, of appropriate incidents

(b) Ensure proper hazardous spill containment and cleanup

(c) Coordinate environmental concurrence with the emergency response teams

(12) The Public Affairs Officer (PAO) will

(a) Promote ongoing hazard awareness through employee communication programs

(b) Prepare informational releases for the media

1 Arrange for media representatives to receive regular briefings on the facility status during extended emergency situations

2 Handle inquiries from the media and public

3 Coordinate press releases with the NASA WSTF Manager

(c) Acquire printed and photographic documentation of the disaster situation

(d) Handle inquiries from immediate family and relatives whenever there are injuries or fatalities

(e) Establish contacts in the contractor community for hand-off of inquiries on their employees

(f) Prepare and maintain Annex I, “Emergency Public Information”

(13) The Engineering Office (EO) will

(a) Provide a damage assessment team with assessment capabilities and responsibilities

1 Develop systems for reporting and compiling information damage to facilities and private property

2 Compile damage estimates and evaluate damage effects on WSTF facilities for use in long-range recovery planning

3 Condemn unsafe structures

(b) Provide engineering and utilities services

1 Barricade hazardous areas

2 Restore roads in a priority order

3 Remove debris

4 Restore essential services and utilities

5 Identify utility recovery times

(c) Coordinate deployment of equipment, including heavy equipment

(d) Establish and maintain qualified operators, maintenance personnel, parts, and tools

(e) Prepare and maintain Annex J, “Damage Assessment,” and Annexes K and L, “Plant Engineering and Utilities.”

(14) The Administration Office will

(a) Provide fiscal resource management services

1 Coordinate with site management to establish procedures for obtaining and deploying temporary personnel

2 Establish emergency purchasing procedures

3 Maintain records of emergency-related expenses

(b) Provide human resource management services to implement procedures to pay salaries and benefits during emergency operations

(c) Provide transportation services

1 Identify local transportation resources and arrange for their use

2 Coordinate deployment of transportation equipment

3 Maintain records of privately owned transportation equipment used during emergency responses for purposes of reimbursement

(d) Prepare and maintain Annex M, “Resource Management”; Annex O, “Human Resources”; and with the assistance of the EO, prepare Annex S, “Transportation.”

(15) The JSC Chief Legal counsel will be consulted for direction to

(a) Advise WSTF officials on emergency authority and record keeping requirements

(b) Advise WSTF management of responsibilities arising from disaster operations

(c) Maintain Annex U, “Legal Services”; (This is the same as JSC Annex U)

7. RESCISSIONS

This WSP in conjunction with MSM 4.2.1.8, “Emergency Management,” replaces RD-WSTF-0024, “WSTF Emergency Preparedness Plan.”

Original Signed by:
David T. Loyd
Chief, Quality Assurance, Reliability,
and Safety Office

Attachment A Issued: 6/3/03

Attachment A
Annex A - Warning

I. PURPOSE

The purpose of this annex is to provide a plan for disseminating timely warnings to the WSTF community and its employees, including the Air Force Facility and TDRSS stations, and other neighbors who could be affected by an impending hazardous situation.

II. CONCEPT OF OPERATIONS

A. Local Warning Methods

1. Local areas are warned of operations and significant events as follows:

a) 250 and 270 Areas - Warning by PA announcements

b) 300 and 400 Areas

(1) PA announcement of operations taking place

(2) Horn indicating significant event, such as a steam run or engine firing

c) 700 Area - Warning by PA announcements

d) 800 Area - PA announcement of operations taking place

2. Local area warning horns and sirens are used in the 300, 400, 700, and 800 Areas to indicate a hazardous material/waste spill or significant event. In such cases, all employees in these areas are to report to the designated assembly areas.

B. Notification of WSTF Community

1. *Ring-down Phone System* - A ring-down phone system is in operation for notification of all areas. Once the immediate area warning has occurred, that area is to notify other areas of any potential dangers as a result of the incident. If a hazardous material/waste release has occurred and is exceeding local area control, the ring-down phone system should be used in accordance with posted operating instructions. The initial announcement should include the name of the material released, the wind direction and speed (if known),

and areas potentially threatened. The following is a sample announcement for the ring-down phone system:

"<u>OXIDIZER</u> HAS BEEN RELEASED IN THE <u>400</u> AREA AND IS MOVING TOWARDS THE <u>200</u> AREA. INITIATE THE APPROPRIATE EMERGENCY PROCEDURES IMMEDIATELY."

2. *Paging System* - This system has been initiated to warn employees in remote areas of hazardous material/waste spill.

   a. *Emergency Response Team (ERT) Paging* - The following special pager codes will require ERT members to take the action indicated by the code:

      [[[0911]]] Emergency, report to the fire station
      [[[0119]]] Cancel
      [[[5641]]] Information – Call fire department

   b. *Remote Area Paging System* - When the system is activated, the pager shows a Group 4, followed by a code that corresponds to the area in which the spill has occurred. Example: [[[300]]] relates to the 300 area.

      [[[000]]] Test page **or** Cancellation of emergency page
      [[[100]]] Spill in the 100 Area
      [[[200]]] Spill in the 200 Area
      [[[300]]] Spill in the 300 Area
      [[[400]]] Spill in the 400 Area
      [[[500]]] Spill in the 500 Area
      [[[600]]] Spill in the 600 Area
      [[[700]]] Spill in the 700 Area
      [[[800]]] Spill in the 800 Area

      If individuals are in a remote area and their pager shows one of these codes ([[[100]]] through [[[800]]]), they will take the following action:

      1. Depending on the proximity to the area designated on the pager, immediately move to an “upwind” area.

      2 Do not attempt to enter the affected area.

3. Do not call the Emergency Services Control Room. Personnel there will be initiating internal and site emergency procedures.

4. Report his/her location and situation in accordance with the respective office or department internal procedures.

c. If individuals are in a non-remote area and their pager shows one of these codes ([[[100]]] through [[[800]]]), they will follow local area announcements for emergency procedure.

d. Group 4, [[[-000-]]] will be provided to indicate the cancellation of emergency pages when it is safe to do so.

3. *Site Spill Siren(s)* - The site spill sirens in the 100 and 200 areas will warn of a chemical release requiring evacuation to an indoor location (shelter in place concept). The IC will make the call when and if these sirens are to be activated. The decision will be based on wind direction, release, and dangers to exposed areas. Sirens are intended to notify employees in outside areas and are not intended as a means of notification for those inside the buildings.

C. Weather Warnings

1. Management has established a basic distribution list for weather warnings. This distribution list may be modified by written request to the EPC. Notifications are categorized into one of three phases based on conditions with a valid time and date

- Phase One - Possibly Dangerous
- Phase Two - Very Dangerous — Use Extreme Caution
- Phase Three - Life Threatening

2. Emergency weather warnings may be made using the ring-down phone system for “Notification of WSTF Community” and “Notification of WSTF Neighbors” based on the severity of the event and the time available for evacuation and/or sheltering. The Site Manager and/or EPC will determine when and if these notifications are to be initiated.

D. Notification of WSTF Neighbors

If an emergency situation is progressing to a neighboring community and has the potential to present a risk, WSTF neighbors will be notified of the situation by telephone. Phone numbers for the surrounding communities are listed at the end of this attachment. WSTF site management will be responsible for this notification.

E. Task Assignment

The Project Manager, Project Leader, or person who activates the local warning system will notify Emergency Services (ES) at extensions 5111 or 5911 of the emergency condition.

1. Emergency Services (ES)

   a) Notify the EPC at extension 5321 of the emergency condition.

   b) Notify site management of the emergency condition.

2. The EPPB is responsible for assuring the WSTF community is educated regarding the use of the warning systems.

F. Maintenance of Equipment

The owner of each siren/horn system is responsible for maintaining and repairing that equipment. All components of the warning system will be tested at least monthly.

The ring-down phone system will be tested weekly by ES.

Emergency Paging Systems will be tested the first Monday of each month by ES.

The Chemical Spill Sirens will be fully cycle tested the first Monday of January, April, July, and October. They will be bump tested in the evening of the other months to ensure sirens will sound.

III. ANNEX DEVELOPMENT AND MAINTENANCE

The EPPB is responsible for the maintenance and improvement of this annex

Attachment A Issued: 6/3/03

NEIGHBORING COMMUNITIES
POINT OF CONTACT

Las Cruces - Doña Ana County

Office of Emergency Civil Preparedness
1131 Medpark Drive
Director or Deputy Coordinator

Business hours phone 527-8741, 527-8742, or 527-8743

After hours, phone 526-0795 (county dispatch) and ask them to page the Director or Deputy Director of the Office of Emergency Civil Preparedness. Once they have been notified, they will make the other necessary notifications, including those to the state police, sheriff, and county medical and fire departments.

White Sands Missile Range - Air Traffic Control, 678-8000

Holloman Air Force Base - Air Traffic Control, RAPCON 475-1110, Ext. 3421

Attachment A Issued: 6/3/03

HOTLINE OR RING-DOWN PHONE OPERATING INSTRUCTIONS

This phone is a **RECEIVE ONLY** phone. YOU CANNOT ORIGINATE A CALL FROM THIS INSTRUMENT.

IF YOUR RING-DOWN PHONE RINGS:

1. Wait for four (4) rings then pick up and listen.
2. Write down information given (message will be repeated).
3. Acknowledge communications when requested by using the push to talk button.
4. Hang up ***only*** when told to do so.
5. Pass on information via PA system, radio, or conventional phone when appropriate.
6. Initiate Emergency Plans only if your area is threatened.
7. Do No Terminate Emergency Plans until advised to do so by the ***Incident Commander or Fire Department***. (Red Phone Message).
8. Pass on information via PA system, radio, or conventional phone when appropriate

Attachment A Issued: 6/3/03

HOTLINE OR RING-DOWN PHONE OPERATING INSTRUCTIONS

To **Report** an incident or spill that threatens other areas:

1. **Pick up receiver** (phone will automatically ring all ring-down phones).
2. **Wait for four** rings (approximately 5 seconds)
3. Person initiating the call **should**:
   - **State** his/her name
   - **Give** Location (Building, Area, etc.)
   - **Give** the following message:

> (Specific Chemical) has been released in the **(Specify)** Area and is moving towards the **(Specify)** Area(s). Initiate the appropriate emergency procedures immediately.

NOTE:
If possible provide any additional information such as quantity, wind velocity, and recommendations that are appropriate.

4. **Verify** Fire Department Alarm Room is on line
   Verify potentially threatened area(s) is on line
5. **Repeat** the message (keep any discussions **brief**)
6. **Inform** all personnel on ring-down phones to ***hang up at this time.***
7. **Initiate a new announcement to update personnel** as the situation changes. Keep "Chatter" to an absolute minimum.

NOTE: If the ring-down phone at your position is inadvertently activated – **DO NOT HANG UP** – stay on line and inform personnel that there is no emergency.

IF YOUR RING-DOWN PHONE RINGS:

1. Wait for four (4) rings then pick up and listen.
2. Write down information given (message will be repeated).
3. Acknowledge communications when requested by using the push to talk button.
4. Hang up ***only*** when told to do so.
5. Pass on information via PA system, radio, or conventional phone when appropriate.
6. Initiate Emergency Plans only if your area is threatened.
7. Do No Terminate Emergency Plans until advised to do so by the ***Incident Commander or Fire Department***. (Red Phone Message).
8. Pass on information via PA system, radio, or conventional phone when appropriate

Attachment B Issued: 1/30/03

Attachment B:
Annex B – Master Communications Plan

I. PURPOSE

This annex provides information about the communications equipment and capabilities available during emergency operations.

II. SITUATION AND ASSUMPTIONS

A. Situation

Telephones and two-way radios will serve as communications for emergency operations in the EOC.

B. Assumptions

Adequate communications are vital for effective and efficient warning, response, and recovery operations. Precautions will be made to keep two-way radio service in operation during emergencies. Radio service has an uninterruptable power supply backup, and the WSTF Control Room is equipped with an emergency generator.

III. CONCEPT OF OPERATIONS

A. Telephone

1. Emergency Telephones – Two emergency phones are located in the Emergency Center for use with telephone numbers 5911 and 5111, designated for emergency use only. The emergency numbers can be reached from regular phones located throughout the site.

2. Emergency Call List – Shall be located on the WSTF Intranet at s4:\\nt01\sitedbs\FireDept\ecl\call_list.mdb to be used for emergency contact information.

a) Updates shall conform to all guidelines set forth by the data entry procedures.

b) Office Chiefs/Managers will ensure the Emergency Call list assigned to their areas/sections is reviewed monthly and updated as needed.

B. Two-way Radio

1. WSTF utilizes two emergency radio talk groups that are shared with the TDRSS and WSTF Security forces.

   a) Emergency: All WSTF portable trunking system radios will be programmed to position 16 for emergencies.

   b) Fire-1: Dispatching of ire, EMS, and HAZMAT units, Fire Wardens, and general information

2. During emergency operations, facility elements will maintain their existing equipment and procedures for communicating with field operations. They will keep the Incident Commander informed of their operations at all times during the emergency.

3. If needed, the Incident Commander will request EOC activation through the Emergency Coordinator or his designee.

C. Phases of Management

1. **Mitigation** - An adequate communications system is presently installed and in use. Periodic reviews of the system will be made and plans for improvement formulated as necessary.

2. **Preparedness** – Radio equipment is kept under a schedule of testing, maintenance, and repair by the Communications Group (CG). Personnel are trained on the appropriate use of equipment as necessary.

3. **Response** - When emergency operations are initiated, the IC and CG will determine the communications required. Radios from operations may be allocated for the emergency response.

4. **Recovery** - All communications during the emergency phase will continue until they are no longer required.

IV. ORGANIZATION AND ASSIGNMENT OF RESPONSIBILITIES

A. Telephone

The telephone system is controlled by the Administration Department.

B. Two-way Radio

The emergency communications system is controlled by Emergency Services. Warning information received through the Centracom console will be disseminated

to the EPC. The responsibility of ensuring the communications is operational rests with the Emergency Services, the EPC, and the CG. This shall include the development and maintenance of :

1. A communications resource inventory maintained by the CG. These radios are maintained in Building 119. For access to these radios, call Communication Section at extension 5394 or Communication Section Supervisor at extension 5615.

2. WSTF Trunking Radio Fleetmap maintained by WSTF Communication Section's CG Trunking System Manager.

3. Local Area radio fleetmaps will be located in local area emergency procedures and consistent with the WSTF Trunking Radio Fleetmap.

4. A message handling procedure and recall rosters for essential personnel are maintained in Emergency Services.

5. A record of all calls during an emergency is logged by the Centracom Console, however, not recorded.

C. Communication Priorities

Communications will be prioritized on the following basis:

1. **Emergency -** Any communications situation having a life threatening urgency to any person or group of persons.

2. **Priority** - Any important communications, which have a specific time limit; official messages are not covered in the emergency category.

3. **Welfare** - Communications relating to either an inquiry as to the health and welfare of an individual in the disaster area or an advisory that indicates all is well.

4. **Routine** - Most communications in routine situations will bear this designation. In disaster situations, messages labeled "ROUTINE" should be handled last, or not at all, when circuits are busy with higher priority traffic.

V. ANNEX DEVELOPMENT AND MAINTENANCE

Emergency Services and Communication Section will be responsible for the maintenance and improvement of this annex.

Attachment C Issued: 6/3/03

Attachment C

Annex C – SHELTER, MASS CARE AND ACCOUNTABILITY

I. PURPOSE

The purpose of this annex is to define the areas at WSTF that will be used for the shelter and care of personnel in the event of short-duration emergencies.

II. DEFINITIONS

A. Shelter in Place: An action taken upon notification (by way of siren or Public Address (PA) notice) of an emergency situation for such events as a chemical spill or adverse weather potential, where the employee will remain inside a designated solid structure and report to a designated assembly area within that structure for the purpose of reporting into an accountability center.

B. Assembly Area: Locations where employees can gather that will permit accountability or dissemination of emergency information.

III. SITUATION AND ASSUMPTIONS

A. Situation:

Short-duration emergencies, such as severe weather and hazardous material/waste releases, may occur at WSTF.

B. Assumptions:

Only emergency sheltering for short periods is addressed. Hazardous material/waste releases and emergencies such as a tornado watch and/or a tornado warning create short-term sheltering needs. For hazardous material/waste releases, WSTF will shelter in place by securing the building. The fire wardens and HSE facility manager will secure the building to prevent anyone from leaving (exiting into the hazardous condition). Individual departments are responsible for accounting for their personnel. Office Chiefs and Department Managers will assign responsibility for accountability functions. Office Chiefs and Department Managers will designate an Assembly area for their personnel to facilitate initial accountability and dissemination of information concerning the emergency. These designated areas will have access to telephones and the red phones.

Should the threat of nuclear attack increase significantly, shelter provisions will be re-evaluated to accommodate fallout protection.

IV. CONCEPT OF OPERATIONS

A. General: Emergency shelter-in-place locations are provided for local area incidents and defined by local procedures.

B. Alternative: The bunkers and tunnels in the 300 and 400 Areas will support the emergency sheltering of all WSTF personnel. Additional shelter for a limited number of personnel is available in the bunker areas of Building 272.

1. If site personnel are notified of a tornado warning in the WSTF area and it is necessary to seek shelter, the following assignment of shelters is to be followed:

   (a) If time is limited, personnel should attempt to close building doors and take shelter in interior windowless areas.

   (b) If warning is sufficient, and personnel will not be exposed during transit, personnel should report to the bunkers in the 300 and 400 Areas.

   Note: The highest level of protection is provided in bunkers 300, 400, and 272, but employees should not place themselves at risk to reach these shelters.

2. The area HS&E or designee will collect information on who has reported to his/her bunker. An effort will be made to identify individuals who did not report to the bunker, and this information will be communicated to ES. ES will utilize this information to locate the missing individuals once the emergency has passed.

3. The ES will be split assignments between the 300 and 400 Area bunkers to provide any emergency medical services that are required.

4. Nurses will also be split assignments between the 300 and 400 Area bunkers, with one reporting to each of the bunkers.

V. ACCOUNTABILITY

A. The Accountability System is a computer data-based program that will be used to account for personnel in the event of a shelter-in-place situation. This program will have a listing of all site personnel, including visitors.

B. ES will be responsible for updating the system. Changes will be made on a weekly basis or as needed.

C. ITS will be responsible for the regular maintenance and technical support of the program.

D. The Office Chiefs/Department Managers are responsible for assignment and training of personnel who will be using the system. Training will consist of familiarization of the system.

E. Fire Wardens will be trained to serve as back-up personnel for using the system.

F. The accountability stations will be in the assembly areas. Assembly areas will be easily identified for site personnel.

G. Management will report all employees who were not present for the event or drill (vacation, TDY, etc) to ES. A makeup training/drill is required.

H. During an incident, site personnel will check in with the person taking roll. The Check In Attendant will mark the employee as being accounted for. Those employees not on site for various reasons (vacation, TDY, etc) will be marked as accounted for.

I. Testing of this system will be done on the first Monday of the quarter, along with the paging system, Emergency Phones and Sirens.

J. Point of Contact (POC) personnel are responsible for the accountability of visitors and vendors sponsored into the facility.

K. Vendors that report to accountability stations should be referred telephonically to the WSTF Gate at Ext. 5185 or 5186 for accountability.

VI. ANNEX DEVELOPMENT AND MAINTENANCE

ES will be responsible for the maintenance and improvement of this annex.

Attachment C Issued: 6/3/03

Accountability Stations:

Building	Room(s)	Primary Attendant	Telephone Ext.
100 Upstairs	210/211	Denise Mora	5118
100 Upstairs	215/216	Ruby Steele, Georgianna Bernal	5235/5496
100 Downstairs	112	Linda Greene	5770
100	110	Patsy Segura	5131
100 Downstairs	100	Gail Bennett	5277
100	126	Dora Schrishuhn	5530
101 Upstairs	PAD Conf.	Marie Madrid	5589
101 Upstairs	226	Ray Spencer, Tim Davis, Carlyn Tufts	5450/5024 5452
101 Upstairs	212	Melinda Medd	5529
101 Downstairs	110	Geri Vantine	5464
101 Downstairs	108	Florarine Jones	5100
104	Alarm Room	Attendant	5461
110	Rotunda	Chris Wolf	5152
112	Break Room	Cecilia Fischer	5237
113	Machine Shop Offices	Bill Weed	5165
114		Marie Madrid by phone	5589
116		Marie Madrid by phone	5589
120	Offices	Ron Esparza	5782
121		Sonya Veitch	5698
150		Ron Esparza by phone	5782
156		Cecilia Fischer by phone	5237
201	103A	Karen Smith	5279
201	112	Denise Barrett	5681
201	122	Susan Staley	5723
201	117	Denise Barrett	5681
201	107	Susan Staley	5723
203	133	Irene Marrufo	5117
250		Barbara LaRue by phone	5248
255		Barbara LaRue	5248
270 & 272		Denise Barrett by phone	5681
300 BH	Conference	Donna Reffner	5696
310,311,320,362,363, 364		300 Block House Monitor	5171/5173
400 BH	Conference	Delores Puentes, Tracy Gonzales	5192/5062
411,412,460,462,463		400 Block House Monitor	5666
700 Area		Barbara LaRue or Denise Barrett by phone	5248 or 5681
800	Lower Control	Sam Motto, Joe Taylor	5537
801, 802		Sam Motto or Joe Taylor by phone	5537
803	Break Area	Rosemary Robles	5374

Attachment D Issued: 11/18/02

Attachment D
Annex D – Radiological Protection

I. PURPOSE

To purpose of this annex is to provide a plan for identification and control of radiation-producing equipment and radioactive sources during emergency conditions.

II. SITUATION AND ASSUMPTIONS

A. Situation

Localized, low-level radiation emergencies may occur at WSTF.

B. Assumptions

The threat of nuclear attack is considered low. Should there be a nuclear threat, shelter provision will be re-evaluated to accommodate fallout protection in accordance with WSP 25-0009, "WSTF Emergency Preparedness Plan."

III. CONCEPT OF OPERATIONS

A. General

1. A user or operator will immediately report any accident or incident involving radioactive sources or radiation-producing equipment, including equipment malfunctions, to the WSTF RSO.

2. The RSO will promptly investigate any such report and advise the NASA Manager of those findings.

3. The RSO will notify the JSC RSO immediately following an accident or incident.

4. The RSO will provide the JSC RSO with information required for JSC to contact the Nuclear Regulatory Commission.

B. Fire

1. In the event of a fire in areas where radioactive materials are present, the FD and RSO shall be notified immediately.

2. Normal fire fighting procedures call for wearing bunker gear and the self-contained breathing apparatus. The primary objective is to save lives, and then the structure.

3. The Industrial Hygienist (IH) will monitor the building for radioactive contamination following a fire.

C. Off-Site Accidents

WSTF does not have the equipment or technical expertise to assist in off-site accidents involving radioactive material. Holloman Air Force Base Disaster Preparedness, (505) 475-7312, should be contacted for assistance.

V. ANNEX DEVELOPMENT AND MAINTENANCE

The RSO is responsible for the maintenance and improvement of this annex.

Attachment E Issued: 11/18/02

Attachment E
ANNEX E – Evacuation

I. PURPOSE

The purpose of this annex is to provide for the orderly and coordinated evacuation of all or any part of WSTF if it is determined that such action is the most effective means available for protecting employees from the effects of a disaster or hazardous material/waste release.

II. SITUATION AND ASSUMPTIONS

A. Situation

There are a limited number of situations that might require an evacuation of part or all of WSTF. Small-scale, localized evacuations might be needed as a result of a hazardous-materials accident (release) or major fire.

B. Assumptions

1. Most employees will act in their own interest and evacuate dangerous areas when advised to do so by Health, Safety, and Environmental (HSE) Facilities Managers, WSTF management, or ES personnel.

2. While some disaster events are slow-moving, providing ample reaction time, the worst-case assumption is that there will be little or no warning of the need to evacuate.

3. There would not normally be time to obtain support from outside resources.

4. Most evacuees will use private transportation means; however, transportation may need to be provided for some evacuees (car poolers, etc.).

III. CONCEPT OF OPERATION

A. General

The site access road will be the primary route of evacuation. An alternate route is through the JP4 and JP5 area to Holman Road. Personnel will be provided to direct the flow of traffic. Each incident will be evaluated by the Project Manager, Project Leader, Facility Manager, or response team, and a decision will be made on the need for evacuation. This decision will be based on the magnitude, intensity, spread of onset, and duration of the event.

Executive direction and control of the incident and any ensuing evacuation will be conducted from the EOC as outlined in Annex N, "EOC/Direction and Control."

B. Phases of Emergency Management

1. Mitigation

a. Identify areas potentially in need of evacuation (i.e., areas near hazardous material/waste, etc.).

b. Develop an employee information program to increase awareness of reasons for possible evacuation, routes to travel, availability of transportation, and reception locations.

2. Preparedness

a. Identify population groups that may require special assistance during evacuation (disabled employees, etc.).

b. Plan evacuation routes, taking into account traffic capacities and likely road conditions.

c. Educate employees about evacuation procedures.

3. Response

a. Advise employees to evacuate the site when necessary.

b. Arrange to evacuate employees who need assistance.

c. Provide traffic and perimeter control, as needed.

d. Activate shelter operations or contact Facility Managers in assembly areas, as appropriate.

e. Keep employees informed about emergency conditions and other vital information.

4. Recovery

a. Initiate return, where possible.

b. Conduct employee information activities.

C. Hazard-Specific Evacuation

Evacuation information has been developed for certain known hazards and is included in area spill procedures. It describes preplanned traffic and access control points, evacuation routes, evacuation assembly points, and pre-designated mass care facility locations.

IV. ORGANIZATION AND ASSIGNMENT OF RESPONSIBILITIES

A. Organization

The evacuation function is organized around the EPC, the EG, and ES.

B. Task Assignment

1. The Emergency Preparedness Coordinator (EPC) will:
   - a. Decide which areas of the center should be evacuated
   - b. Coordinate evacuation effort with Facility Managers
   - c. Advise employees to evacuate the site, when appropriate
   - d. Direct the relocation of essential resources (personnel, equipment, supplies) to reception areas
   - e. Keep senior management advised of the situation
2. The Emergency Preparedness Planning Board will:
   - a. Identify high-hazard areas and number of potential evacuees
   - b. Coordinate evacuation planning to include:
     - (1) Movement control
     - (2) Health/medical requirements
     - (3) Transportation needs
     - (4) Shelter/reception
3. Emergency Services (ES) and Security will:
   - a. Designate evacuation routes
   - b. Assist in evacuation by providing perimeter and/or traffic control and road blocks as needed
   - c. Coordinate security activities with other emergency services

4. Fire Protection and Control will:

   a. For hazardous material/waste and fire incidents, be responsible for on-scene control and for advising the EPC for evacuation decision

   b. Assist in warning employees

   c. Assist in evacuating disabled and other special population groups

5. Engineering Office will:

   a. Provide traffic control devices

   b. Assist in keeping evacuation routes open

   c. Assist in recovery operations

6. Medical will:

   a. Provide first aid, counseling, and other assistance

   b. Coordinate and monitor evacuation of injured

V. DIRECTION AND CONTROL

A. General

The NASA Manager has the overall authority for evacuation decisions. All activities will be coordinated through the EOC, which will serve as the source of all direction and control.

B. Evacuation Notice

The HSE Department Facility Manager will normally advise employees to evacuate a hazardous area. In situations where rapid evacuation is critical to the continued health and safety of the population, such as hazardous material spills or fire, the HSE Facility Manager may advise employees in the immediate vicinity to evacuate the site.

C. Evacuation Area Definition

The definition of the area to be evacuated will be determined by those officials recommending the evacuation based on the advice of appropriate advisors. In all situations, the hazardous situation will be continually monitored in case changing circumstances, such as a wind shift, require redefinition of the actual potential affected area. The command authority will ensure that the evacuation area is defined in terms clearly understandable by employees.

D. Public Notification

Persons to be evacuated should be given as much warning time as possible.

1. *Pre-Evacuation Warning:*

On slow-moving events, pre-evacuation notice should be given to affected employees if it appears that hazardous conditions may warrant such action. Employees should be advised that they may have to evacuate upon 30 minutes notice or less.

2. *Evacuation Warning:*

All warning modes will be utilized to direct affected employees to evacuate the site. Wherever possible, the warning should be given on a direct basis.

E. Movement

The primary evacuation mode will be in private vehicles.

1. Evacuation routes will be selected by ES and Security personnel at the time of the evacuation decision.

2. If at all possible, two-way traffic will be maintained on evacuation routes to allow continued access for emergency vehicles.

3. Traffic control devices such as signs and barricades will be provided by Facilities and the EO.

F. Access Control

ES and Security personnel will establish a perimeter control to provide security and protection of facilities and property left behind.

G. Re-entry

The re-entry decision and order will be made by the on-scene IC and/or EPC after the threat has passed and the evacuated area has been inspected by FD, Occupational Health, Safety, Security, and PE personnel for safety. Some specific re-entry considerations are

1. Ensure that the threat that caused evacuation is over.

2. Ensure that buildings and offices have been inspected to determine whether they are safe to reoccupy.

3. If offices or buildings have been damaged, determine what alternate office space exists.

4. Inform employees of proper re-entry actions, particularly cautions they should take with regard to utilities (suspicious fumes, odors, etc.). In addition, issue proper cleanup instructions, if necessary.

VI. ANNEX DEVELOPMENT AND MAINTENANCE

The EPC is responsible for the maintenance and improvement of this annex.

Attachment F Issued: 11/18/02

Attachment F
Annex F – Fire Prevention and Control

I. PURPOSE

The purpose of this annex is to provide WSTF with a fire fighting plan to meet the demands of a disaster situation.

II. SITUATION AND ASSUMPTIONS

A. Situation

Fire is a threat to personnel, property, and the mission success of WSTF.

B. Assumptions

Existing fire personnel and equipment will be able to handle most emergency situations. When additional support is required, assistance can be obtained through the use of existing mutual aid agreements or from state and federal agencies. Contact will be made by the EPC or Fire Chief (FC) after consultation with site management.

III. CONCEPT OF OPERATIONS

A. General

The responsibilities of the FD in disaster situations are basically the same as in daily operations. Their primary responsibility is fire control. The FD is also regularly involved with rescue operations and hazardous material/waste incidents.

B. Phases of Management

1. Mitigation

   a) Plan for fire prevention.

   b) Enforce fire code.

   c) Provide employee fire safety information programs.

2. Preparedness

a) Maintain mutual aid agreements at the FD with the phone numbers available at the alarm console.

b) Develop communication procedures.

c) Create, revise, and update pre-fire response plans at regular intervals.

d) Perform exercises and drills to ensure preparedness.

3. Response

a) Contain, control, and extinguish fires.

b) Initiate rescue activities as necessary.

c) Control hazardous material/waste incidents within capability and request assistance as needed.

4. Recovery

a) Perform or assist in decontamination and cleanup.

b) Perform inspection of restored or reconstructed buildings.

IV. ORGANIZATION AND ASSIGNMENT OF RESPONSIBILITIES

The organizational arrangements followed on a day-to-day basis will also be adhered to during an emergency.

1. Fire Chief/Chief Officers – responsible and qualified for coordinating all emergency fire service operations within WSTF.

2. Firefighters – responsible and qualified for medical, fire and hazmat response to emergencies.

3. ERT – WSTF employees responsible and qualified for fire and hazmat response to emergencies.

4. Advisors – WSTF employees that are not emergency responders, with intrinsic site knowledge that is valued during an emergency.

Attachment F Issued: 11/18/02

V. DIRECTION AND CONTROL

Routine operations will be handled by standard procedures. During major emergency or disaster situations that require Command Post activation, the FC will be responsible for coordinating all emergency fire service operations within WSTF. On-scene command post(s) may be established at the site(s) of a disaster situation in conjunction with other responding agencies.

VI. ANNEX DEVELOPMENT AND MAINTENANCE

The EPPB is responsible for the maintenance and improvement of this annex.

Attachment G Issued: 11/18/02

Attachment G
Annex G - Security

I. PURPOSE

This annex provides for proper coordination of security activities to ensure the safety of life and property during emergency situations.

II. SITUATION AND ASSUMPTIONS

A. Situation

During times of emergency, Security and ES personnel will be called upon to expand their operations. The table under resources contains contacts for county, state and federal agencies that can be called upon to provide law enforcement support as needed.

B. Assumptions

Security personnel will generally be able to provide adequate control. When additional law enforcement support is required, the Facility Security Officer (FSO) or designee shall first notify the Doña Ana County Sheriff's Department. For any espionage, terrorist activities, hostage, and damage or larceny of over $5000, the FBI will also be notified.

III. CONCEPT OF OPERATIONS

A. General

Emergency Security operations will be an expansion of normal daily responsibilities. These responsibilities include maintenance of order and discipline, traffic control, and crowd control. Security will have the primary responsibility for routine site security, and support groups will assist in traffic and crowd control.

B. Phases of Management

1. Mitigation

Provide periodic plan review and updating.

2. Preparedness

Provide training of primary and auxiliary personnel.

3. Response

a. Maintain order and discipline.

b. Provide security for key facilities.

c. Patrol evacuated areas.

d. Support other employee safety operations.

e. Provide traffic and crowd control.

4. Recovery

a. Continue response operations.

b. Assist in damage assessment.

IV. ORGANIZATION AND ASSIGNMENT OF RESPONSIBILITIES

A. General

The organizational arrangements followed on a day-to-day basis will also be adhered to during an emergency.

B. Task Assignments

1. FSO and Security will:

a. Coordinate all security activities on the site

b. Maintain order and discipline

c. Provide security for key facilities/resources and the disaster area

d. Provide protection of property in damaged areas

e. Provide traffic control

f. Provide crowd control

g. Assist evacuation

h. Support medical and rescue operations

i. Assist in hazardous material/waste incidents

j. Assist in preparation of appropriate mutual aid agreements

k. Support other employee safety activities

2. Maintenance and Operations Section will position traffic control devices (i.e., barricades, covers, etc.) as per security instructions, and/or EOC.

V. DIRECTION AND CONTROL

During major emergency or disaster situations that require EOC activation, the FSO or designee will be responsible for coordinating all emergency security operations within the site from the EOC.

An on-scene command post may be established along with other responding agencies, such as the FD. The senior security officer established at the disaster site(s), with the help of Security personnel on-scene, will be in charge of security activities and will report to the FSO in the EOC. The FSO or designee will establish and maintain communications with the on-scene command post and direct emergency operations from the EOC in coordination with other responding site representatives at the EOC.

If local capabilities are exceeded, the FSO or designee will request outside assistance from the person in overall charge of the EOC.

VI. ADMINISTRATION AND SUPPORT

A. Communications

The ES Dispatcher operates a multi-channel base station in the EOC Communications Center at all times, including response operations. An internal recall roster of personnel for emergencies will be maintained.

B. Resources

Available supplemental Security resources are listed below.

Doña Ana County Sheriff's Department (First to be notified for law enforcement support)	525-1911 Dispatch # 526-0795
Federal Bureau of Investigation (Espionage, terrorist, hostage, damage or larceny of over $5000)	526-2351
New Mexico State Police (Traffic accidents on the access road and only if the sheriff is unable to respond)	524-6111
U.S. Border Patrol (Illegal aliens)	524-4292
Fort Bliss K-9 Patrol	(915) 568-8561

(Bomb threat)	
WSMR EOD (Actual/suspected bomb discovered)	678-0235
Contractor Facility Security Officer, Martin Reffner Cellular Phone (Any time any of the above are notified)	527-2870 642-1171
Contractor Program Assurance Manager, Bill Blohm (Any time any of the above are notified and Mr. Reffner cannot be reached)	522-5789
NASA Security Officer, Ray Melton (To be notified when FBI assistance is required)	522-5795
Las Cruces Police Department (To be notified only in an extreme need and emergency, such as terrorist attack, riot, or hostage situations)	526-0795
WSMR Military Police (To be notified only in an extreme need and emergency, such as terrorist attack, riot, or hostage situations)	678-2722

VII. ANNEX DEVELOPMENT AND MAINTENANCE

The FSO is responsible for the maintenance and improvement of this annex.

Attachment H Issued: 11/18/02

Attachment H
Annex H – Industrial Safety and Occupational Health

I. PURPOSE

The purpose of this annex is to provide coordinated health and medical services during emergency situations to reduce death and injury, and to assist in damage assessment and restoration of essential health and medical services within WSTF during and immediately following a disaster.

II. SITUATION AND ASSUMPTIONS

A. Situation

1. WSTF employees are vulnerable to disaster occurrences that could result in a need for emergency health or medical support.

2. The Dispensary and Emergency Medical Services are responsible for the day-to-day provision of medical services at WSTF.

3. A mass casualty incident that produces a large number of patients, all needing stabilization at the same time and place, can occur in the absence of similar or related occurrences in surrounding areas.

B. Assumptions

1. Although many health-related problems are associated with disasters, there is an adequate local capability to meet most disaster situations.

2. Employees may require guidance concerning how best to avoid health hazards created by the disaster or arising from conditions existing in the affected area during the recovery and rehabilitation phase.

III. CONCEPT OF OPERATIONS

A. General

Day-to-day functions that do not contribute directly to the emergency operation may be suspended for the duration of the emergency and re-directed to the accomplishment of emergency tasks.

B. Phases of Management

1. Mitigation

a) Immunize employees.

b) Conduct regular physical examinations.

c) Provide specialized training.

d) Maintain employee health-awareness programs.

2. Preparedness

a) Maintain medical supplies.

b) Prepare mutual aid agreements.

3. Response

a) Establish temporary treatment center if number of emergency cases exceeds the dispensary capability.

b) Disease control operations.

c) Collect vital statistics.

d) Execute mutual aid agreements as required.

4. Recovery

a) Continue response activities, as needed.

b) Compile health reports for WSTF, NASA, state, and federal officials.

c) Identify potential or actual continuing hazards affecting employee or public health, and offer appropriate guidance for mitigation of harmful effects.

IV. ORGANIZATION AND ASSIGNMENT OF RESPONSIBILITIES

A. Organization

The site doctor and nurses shall serve as medical advisors to the EOC staff. Response activities will be coordinated from the EOC.

B. Emergency Functions

The site doctor, nurses, and emergency medical technicians are responsible for providing the following services in response to emergency situations.

- Essential medical treatment for injured or ill personnel

- Triage stations, EMS teams, collection centers, and distribution
- Identifying WSTF facilities that could be expanded into emergency treatment centers for disaster victims
- Hazardous material/waste exposure assessment and environmental health assistance to the IC
- Employee health protection for the affected population
- Vital records services

Crisis augmentation of health/medical personnel; e.g., nurses aides, paramedics, Red Cross personnel and other trained volunteers will be planned and incorporated into mutual aid agreements

C. Industrial Hygiene

The IH will assist the IC by providing recommendation on:

1. Environmental health activities in response to hazardous material/waste releases including: exposure, assessment, recommendations on personal protective clothing and equipment, and decontamination for emergency responders, and will provide any other environmental health assistance to the IC

2. Environmental health activities regarding waste disposal, refuse, food, water control, and vector control

D. Mortuary Services

E. The Office of Medical Investigator Phone 526-0795 has responsibility for the collection, identification, storage, and dispatch of deceased victims. Public Affairs Officer (PAO)

The PAO has the primary responsibility for dissemination of employee information. Any release of information concerning the emergency or casualties must go through the PAO and be approved by the site manager.

V. DIRECTION AND CONTROL

A. Damage Assessment

Injuries and Fatalities

Since accurate information concerning casualties is essential in identifying required levels of medical support, information of this type must be forwarded to

the IC as soon as it is available. Army emergency medical airlift services are requested by calling (915) 568-8833.

B. Disaster Area Medical Support

In disaster situations involving significant damage to WSTF medical capabilities or exceeding the site capabilities, assistance will be requested from WSMR at 678-1403 or the Las Cruces Local Emergency Planning Committee at 527-8741.

VI. ADMINISTRATION AND SUPPORT

Medical and health services will participate as required in drills and exercises conducted by the EPC. Additional drills and exercises may be conducted by various agencies and services for the purpose of developing and testing abilities to make effective response to various emergencies.

VII. ANNEX MAINTENANCE

The EPPB is responsible for the maintenance and improvement of this annex.

Attachment I Issued: 11/18/02

Attachment I
Annex I – Emergency Public Information

I. PURPOSE

The purpose of this annex is to provide a plan for the effective collection, control, and dissemination of emergency public information and for the minimization of confusion, misinformation, and rumors during times of emergency.

II. SITUATION AND ASSUMPTIONS

A. Situation

During periods of emergency, the public needs and generally desires detailed information regarding protective action to be taken for minimizing loss of life and property. There are times, however, when disaster strikes without warning, and the public information system cannot react rapidly enough to properly inform the public about the hazard. For this reason, it is important that before the occurrence of an emergency the public be made aware of potential hazards and the protective measures that should be employed.

B. Assumptions

An effective program combining both education and emergency information will significantly reduce disaster-related casualties and property damage. It is recognized, however, that people are generally unconcerned about hazards until they are affected, despite educational programs. Thus, special emphasis must be placed on the effectiveness of the emergency information program.

III. CONCEPT OF OPERATIONS

A. General

Emergency information efforts should focus on specific event-related information. This information will generally be of an instructional nature, focusing on such things as warning, evacuation, and shelter. It is also important to keep the public informed of the general progress of events. A special effort should be made to report positive information regarding emergency response in order to reassure the community that the situation is under control. Rumor control must be a major aspect of the informational program. Education efforts will be directed toward increasing public awareness about potential hazards and how people should deal with them.

B. Phases of Management

1. Mitigation

   a) Conduct hazard awareness programs.

2. Preparedness

   a) Prepare emergency information for release during emergencies.

3. Response

   a) Release public information.

   b) Participate in news conferences.

4. Recovery

   a) Provide public information.

   b) Compile record of events.

   c) Assess effectiveness of information programs.

IV. ORGANIZATION AND ASSIGNMENT OF RESPONSIBILITIES

A. General

The overall responsibility for public information rests with the NASA Manager's Office, which will manage and coordinate all public emergency information-related activities.

B. Tasks

1. The Emergency Preparedness Coordinator (EPC) will:

   Ensure that a public information and awareness program is developed, maintained, and implemented

2. NASA Manager's Office will:

   a) Serve as the sole source for dissemination of Emergency Public Information (EPI)

   b) Notify the JSC Director of any major emergency or related news releases

c) Secure printed and photographic documentation of the emergency situation

d) Compile and prepare emergency information for the public in case of emergency

e) Handle unscheduled inquiries from the media and the public

V. ANNEX DEVELOPMENT AND MAINTENANCE

The NASA Manager's Office is responsible for the development and maintenance of this annex and any related education and information programs.

Attachment J Issued: 11/18/02

Attachment J
Annex J – Damage Assessment

I. PURPOSE

The purpose of this annex is to address the assessment and reporting of damage resulting from a natural disaster, enemy attack, or other major incident.

II. SITUATION AND ASSUMPTIONS

In the event that extensive property damage occurs because of a hazardous event, a planned damage assessment and reporting procedure is essential for reactive response-and-recovery operations. The timely and accurate assessment of property damage will be of vital concern to management following a disaster and will have great bearing upon the manner in which recovery is affected.

III. MANAGEMENT PHASES

A. Mitigation

Compliance with building codes and other regulations can reduce much of the structural damage that would otherwise result from a disaster. Nevertheless, damage will usually occur, and a fast and accurate assessment of conditions is very useful in response operations. In addition, an extensive damage assessment is a necessary part of most recovery programs.

B. Preparedness

The first table within this annex identifies those individuals that would comprise a Damage Assessment Team (DAT). The EO will ensure maps, photos, videos, and other documents, such as a list of critical facilities requiring priority repairs, for damage assessment purposes are maintained.

C. Response

The EPC will notify the EO Chief in the case of an emergency requiring damage assessment assistance. The DAT will be activated by and will coordinate all activities with the EO Chief. DATs will consist of local government and site-support contract employees (See Table 1 for names and phone numbers). When necessary, private sector personnel from the fields of engineering, building trades, property assessment, and other related areas may be used to supplement existing team members. Once surveys of the affected areas have been completed, the results will be compiled by the EO Chief and reported to the EPC.

The checklist in Table 2 will facilitate the execution of damage assessment.

During nuclear attack operations, Radiological Protection personnel will be part of the DAT. When handling an operation such as a hazardous material accident requires specialized assistance, appropriate personnel will be added to the teams.

D. Recovery

Actions for recovery will be determined as necessary to restore services.

IV. ANNEX DEVELOPMENT AND MAINTENANCE

The EO Chief is responsible for the development and maintenance of this annex and its attachments.

Attachment J Issued: 11/18/02

Table 1

DAMAGE ASSESSMENT TEAMS

	Home Phone	Work Phone	Cellular Phone
Team Leaders			
Barry A. Plante	382-5010	524-5539	642-7635
Alan Spencer	915-877-1520	524-5552	642-8802
Team Members			
	NASA		
Tom Condon	523-0236	524-5153	
Holger Fischer	915-584-9378	524-5290	
Clifford Madrid	522-7312	524-5158	
John Villegas	382-0551	524-5189	
Chris Wolf	382-2121	524-5152	
	Contractor		
Bob Christopher	382-8653	524-5765	
Oscar Loera	915-585-1516	524-5101	
Albino Hernandez	541-0511	524-5190	
Hoyt Inman	526-4909	524-5275	
Frank Mathis	522-7056	524-5238	
Jim McCullough	526-4757	524-5287	

Attachment J Issued: 11/18/02

Table 2

DAMAGE ASSESSMENT CHECKLIST

	Completed		
	Yes	No	N/A
Date:_____ Time of incident: _____ Time of notification: _____			
I. In a timely manner, determine general concept of emergency and inform all personnel in the office of the emergency.			
II. Define team assessment capabilities and action responsibilities.			
III. Compile information on damage to facilities and to private property.			
A. Number of deaths resulting from disaster or event._____			
B. Number and classification of injuries resulting form disaster or event._____			
C. Establish extent and magnitude of damage. See attached reports.			
1. Determine extent of damage to buildings and structures (non-test type).			
2. Determine extent of damage to roads and other traffic areas.			
3. Determine extent of damage to utilities systems (water, gas, electricity, etc.)			
4. Determine extent of damage to testing facilities and structures.			
IV. Condemn unsafe structures.			
V. Evaluate effect of damage on WSTF facilities for use in long range recovery planning.			

Attachment K and L Issued: 11/18/02

Attachments K and L
Annexes K and L – Plant Engineering and Utilities

I. PURPOSE

The purpose of this annex is to prompt immediate actions necessary to restore essential services and establish short- and long-term recovery plans.

II. SITUATION AND ASSUMPTIONS

WSTF is subject to disaster circumstances that could occur locally and would create a need for emergency facilities services. All engineering equipment, services, and labor will be utilized in dealing with an emergency. Any assistance from outside organizations will be requested. Facilities include buildings, roads, and all utility systems.

III. MANAGEMENT PHASES

A. Mitigation/Preparedness

Overall responsibility for providing engineering services and utilities during emergencies rests with the EO Chief. Additionally, the EO ensures that facilities' baseline documentation and maintenance program exists, and that a private contractor source list exists for services that may be required following an emergency.

B. Response

1. Assist in search-and-rescue operations, as directed.

2. Repair essential roads, services, utilities and equipment, as necessary.

3. Perform more detailed damage assessment of identified facilities or equipment.

4. Barricade damaged areas and clear debris, as necessary.

5. If shortages or overload conditions appear imminent, coordinate with the EG and initiate curtailment of service(s).

6. Make recommendations to alleviate problems.

7. Secure assistance of private contractors and request aid from other government agencies and the private sector, as needed.

8. Install or restore utility services to outlying locations.

9. Maintain before and after photos and/or video of damaged facilities.

C. Recovery

1. Repair/replace facilities and equipment, as necessary, for returning the site back to normal operations. Evaluate actions taken and produce a "lessons learned" report.

IV. ANNEX DEVELOPMENT AND MAINTENANCE

The EO Chief is responsible for the development and maintenance of this annex.

Attachment M Issued: 12/13/02

Attachment M
Annex M – Resource Management

I. PURPOSE

The purpose of this annex is to provide financial policy and guidance for the accomplishment of WSTF responsibilities in the event of an emergency situation or disaster.

II. PROCEDURE

A. WSTF does not allocate funds in its normal budget to provide for the type of emergencies covered by this plan. The objective of this plan is to provide WSTF with sufficient latitude and resources to permit timely accomplishment of the site's mission and to ensure effective use of resources in the event of an emergency.

B. Available funds will be used initially to support emergencies.

C. Cost records will be established and maintained to support expenditures for each emergency situation or disaster.

D. Issuance of WSTF stock will continue in accordance with current regulations. Latitude will be provided in assigning cost responsibility according to funding constraints versus need for stock. A liberal return policy will be enacted for those stock items issued to support an emergency, with funding reinstated to the requisitioning office.

E. Responsibility for enforcing resource allocation and/or for deviating from current regulations is delegated to the following individuals:

	Home Phone No.	Work Phone No.
Heather Moncrief	373-9440	524-5136
Katherine Autry	527-1147	524-5134

F. Their responsibilities include the preparation and transmittal of supplemental reports, requests for additional funding, dissemination of cost guidance for charging purposes, and assistance to the manager in fund management.

III. ANNEX DEVELOPMENT AND MAINTENANCE

The Administration Office Chief is responsible for the development and maintenance of this annex.

Attachment N Issued: 11/18/02

Attachment N
Annex N - EOC/Direction and Control

I. PURPOSE

The purpose of this annex is to provide a description of the process used by the EOC staff during emergency operations.

II. SITUATION AND ASSUMPTIONS

A. Situation

In order to provide the most effective response to an emergency, all efforts should be coordinated through a central office. The EOC has been designated as the base for all emergency management activities.

B. Assumptions

The response activities presented are applicable to all emergency situations and will provide adequate direction for proper emergency management.

III. CONCEPT OF OPERATIONS

A. General

The IC and the EOC are keys to successful response operations. With decision makers together at one location, staffing and resources can be utilized more effectively. Coordination of activities will ensure that all tasks are accomplished with little duplication of effort.

B. Phases of Management

1. Mitigation

a) Develop the EOC.

b) Provide adequate communications capabilities.

c) Refer to the Emergency Services Section (ESS) Standard Operating Guidelines (SOG34) for initial setup for the EOC. The SOG34 is available in the Alarm Room.

2. Preparedness

a) Instruct officials on EOC operations.

b) Stock adequate administrative supplies.

c) Develop and maintain the "EOC in a Box." The "EOC in a Box" is located in the Alarm Room.

3. Response

a) Activate the EOC as necessary.

b) Initiate response activity.

4. Recovery

a) Continue response operations as needed.

b) Begin recovery activities.

c) Release unnecessary personnel and begin to deactivate the EOC.

C. Execution

1. The IC and EPC will assume responsibility for all emergency operations and actions, and will provide overall direction and control.

2. The EOC will be activated upon direction of the EPC or designated alternate.

3. The IC and EPC will determine the level of staffing required, based upon the situation, and will alert the appropriate personnel.

4. Emergency operations will be conducted by WSTF forces augmented as required by trained auxiliaries, volunteer groups, and forces supplied through mutual aid agreements.

5. If an on-scene command post is established in addition to the activation of the EOC, it will maintain close contact and coordination with the EOC.

6. The EOC will operate on a 24-hour basis during the emergency, and the staff may be required to work 12-hour shifts.

IV. ORGANIZATION AND ASSIGNMENT OF RESPONSIBILITIES

Broad responsibilities are assigned in paragraph 6.d, "Responsibilities," of this plan.

V. DIRECTION AND CONTROL

During emergency operations, the EOC staff is organized into two groups as listed below. The EPC serves as an advisor and liaison between the IC and the EG.

A. Executive Group (EG)

The Executive Group (EG) consists of the NASA Manager, the Program Manager, and the NASA Office Chief /Department Managers if requested by the NASA Manager or Program Manager. Other individuals may be called upon in specific situations. This group is responsible for all major decisions and resources in support of the emergency response.

B. Operations Group (OG)

The OG supports the IC and consists of ES, Project Management, Logistics, Facilities, qualified HAZMAT personnel, and all related technical and support personnel. This group and its field personnel are responsible for conducting response activities as detailed in Annex Q, "HAZMAT/Hazardous Material/Waste Spill Response."

VI. CONTINUITY OF OPERATIONS

During most large-scale emergencies, the EOC will become the focus for all facility control. It will be from here that all major emergency-related decisions will be made.

VII. ADMINISTRATION AND SUPPORT

A. Emergency Action Center

1. Primary EOC

The EOC is located in Building 104, Fire Department Classroom. Should the alternate EOC's, see below, become inaccessible it may become necessary for EOC to relocate into the Fire Department's apparatus bay.

2. Alternate EOC

The alternate EOC is located in Building 101, ITS Classroom (Room 115). Should the primary and secondary EOC become unusable, emergency operations will continue at Building 110 (Rotunda).

3. On-scene Command Post

During emergency operations it may be necessary to set up an on-scene command post to coordinate response activities at the scene. Should such a situation arise, the IC will determine the need for an Operations Section Chief.

B. Reports and Records

Reports and records will be prepared in accordance with mishap/accident investigation guidelines. The use of reports will vary according to the type of emergency being handled.

All requests for assistance and all general messages will be recorded by the Alarm Room Operator.

VIII. ANNEX DEVELOPMENT AND MAINTENANCE

The EPC will be responsible for the maintenance and improvement of this annex.

Attachment O Issued: 12/13/02

Attachment O
Annex O – Human Resources

I. PURPOSE

The purpose of this annex is to provide a plan for the effective use of human resources in an emergency situation or disaster at the White Sands Test Facility.

II. PROCEDURE

Refer to Annex M, "Resource Management," in the event of an emergency that dictates the use of human resources beyond those identified in WSP 25-0009, "WSTF Emergency Preparedness Plan," and attached annexes. In such case, the following individuals are to be contacted:

	Home Phone No.	Work No
Katherine Autry	527-1147	524-5134
William B. Christy	687-1670	524-5233
Larry Schuyler*	523-4526	524-5266

*Alternate For William B. Christy and primary contact for Cafeteria Operations

III. ANNEX DEVELOPMENT AND MAINTENANCE

The Administrative Office has the responsibility for maintaining and improving this annex.

Attachment P Issued: 11/18/02

Attachment P
Annex P – Hazard Mitigation

I. PURPOSE

This annex describes hazard mitigation planning and implementation measures to accomplish the long-term prevention or reduction of the adverse impact of natural and other hazards at WSTF.

II. SITUATION AND ASSUMPTIONS

A. Situation

Several hazardous conditions exist within WSTF that have the potential for causing loss of life, injury, or extensive property damage.

B. Assumptions

The adverse impact of hazards can be reduced by hazard mitigation actions accomplished before an incident occurrence. Effective post-incident mitigation actions can also reduce the risk of a repeat disaster.

Hazard mitigation planning and implementation activities are an ongoing process at WSTF. These activities include System Safety Analysis Teams, Operational Readiness Inspections, Test Readiness Reviews, and Safety Reviews as defined in WSI 04-SW-0001, "Safety and Readiness Reviews," WSI 04-SW-0002, "Hazard Recognition and Control," and WSI 04-SW-0003, "System Safety Analysis."

III. CONCEPT OF OPERATIONS

A. Definitions

Hazard mitigation - Any action taken to eliminate or reduce long-term risk to human life and property from natural and other hazards.

Disaster - A situation resulting from an incident which causes widespread or severe damage, injury, and loss of life, property, or resources, and for which the recovery capabilities of a jurisdiction are exhausted. Disaster assistance provided by the federal or state government is intended to supplement local government resources to enhance recovery capabilities and achieve a speedy and efficient return to pre-incident conditions.

B. General

This annex is not intended to describe in detail all aspects of the mitigation program. Details of required reviews are contained in the previously referenced

WSI's and address facility designs and test readiness. Natural disasters are also addressed in this plan and attached annexes. The following items are considered in assessing hazard potentials:

1. Any previous incidents involving this hazard

2. Number of people killed or injured during previous incidents and number of people potentially at risk from future incidents involving this hazard

3. Probability of future incidents occurring that involve this hazard

4. Damage to homes, businesses, public facilities, crops, and livestock that have been caused by previous incidents or are potentially at risk from future incidents involving this hazard

IV. ANNEX DEVELOPMENT AND MAINTENANCE

The EPC is responsible for the maintenance and improvement of this annex.

Attachment Q Issued: 11/18/02

Attachment Q
Annex Q - HAZMAT/ Hazardous/Waste Spill Response

I. PURPOSE

The purpose of this annex is to provide the policies and procedures for responding to emergency releases of hazardous material/waste.

II. SITUATION AND DEFINITIONS

A. Situation

This annex applies only to procedures for hazardous material/waste releases that go beyond local area resources. Procedures dealing with spills that occur in local areas are covered by WSP 23-0012, "WSTF 100 Area Emergency Response Plan for Hazardous Chemical Releases"; WSI PROP-0055, "Propulsion Test Emergency Procedures Implementation"; WSI LSAFETY-0001, "WSTF 200 and 800 Area Emergency Response Plan for Hazardous Chemical Releases"; WJI LSAFETY-0229, "Hazardous Chemical Spill Procedures"; WJI SVC-FABL-0002, "HWDL Use and Maintenance, and Spill Response for the Chemical Etch Laboratory"; WJI SVC CSS-0037, "Proper Handling and Disposal of Chemicals and Wastes Generated in the Component Services Laboratory"; WJI 800-0053, "Hazardous Materials Release Procedure for the Materials Preparation Laboratory in 803 and the Materials Facility in 804"; and WJI 800HFF-0055, "Area Spill Procedure".

Requests from off-site entities for HAZMAT support must be approved by the NASA Manager.

B. Definitions

Terms used in this annex are defined below.

Emergency release - the release of a hazardous material/waste that occurs outside of WSTF-controlled work areas or, within those areas, goes beyond the scope of the local area emergency procedures, controls, or resources.

Emergency response - a response effort by the WSTF Fire Department to a fire, explosion, unplanned sudden or non-sudden occurrence that results, or is likely to result, in an uncontrolled release of a hazardous material/waste to air, soil, water, or surface water. Responses to incidental releases of hazardous material/waste in which the material/waste can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area, or by maintenance personnel, are not considered to be emergency responses within the

scope of this standard. Responses to releases of hazardous material/waste in which there is no potential safety or health hazard (i.e., fire, explosion, or chemical exposure) are not considered to be emergency responses.

HAZMAT - hazardous materials.
Incident Command System (ICS) - the command system based on a nationally recognized system for managing critical situations, which includes the following characteristics: (1) common organizational structure; (2) common terminology; (3) uniform and consistent procedures; and (4) coordinated communications.

Incidental release - the release of a substance that can be handled within the scope of the local area emergency procedures, controls, and resources.

III. CONCEPT OF OPERATIONS

A. General

Response to the release of a hazardous material/waste at WSTF will be as follows:

1. The local area or worksite will exercise emergency procedures that identify the responsible person in charge.

2. The responsible person in charge will assess the situation and, if it is an incidental release, will perform control and cleanup with appropriately trained personnel equipped with appropriate personnel protective equipment (PPE).

3. If the incident is beyond the control of local personnel and resources, then the HAZMAT response team will be called.

4. A formal handover of command from the local area person in charge to the IC must take place before the ICS is exercised.

5. The local area person in charge becomes an advisor to the IC.

B. Emergency Release or Spill

The following will be implemented in the event of an emergency release or spill of any hazardous material/waste requiring HAZMAT response in the following phases:

1. Phase I, Initial Response: This phase identifies and contains hazardous material/waste releases, and includes the following actions to save lives,

reduce injuries, and protect the environment: evacuation of nonessential personnel; cordoning off the danger area; performing fire and rescue operations; stopping the release if possible; and preventing the spread of the released material into the environment.

2. Phase II, Recovery of Released Hazardous Material/Waste: In this phase, cleanup operations and recovery of the spilled material/waste contaminated by the release are performed.

3. Phase III, Short- and Long-Term Site Restoration (Post-Emergency): In this phase, contaminated soil is removed, the site is restored to permit personnel to resume normal activities, and further contamination of the environment is prevented.

C. HAZMAT Response Team

The HAZMAT Response Team consists of all WSTF FD personnel and selected personnel from the operational areas who are trained to the HAZMAT Technician level. The FD is responsible for HAZMAT Response Team training and equipment, and performs Phase I and Phase II activities. HAZMAT response coverage is provided full-time, 24-hours a day.

Within the WSTF hazardous test areas, supervisors are responsible for writing plans for Phase I emergency response actions to secure the test systems, alert personnel, and evacuate personnel to assembly areas as directed by the cognizant Office Chief or Department Manager. The HAZMAT Response Team will be called when it is determined by the local area person in charge that the condition constitutes an emergency. Incidental spills will be handled and controlled by appropriately trained personnel within the area.

The NASA Environmental Program Manager and the contractor Environmental Section are responsible for approval and oversight of Phase III remediation activities. Operational area personnel will assist in the cleanup operations.

D. Mock Exercises

Guidelines for hazardous material/waste release exercises are found in Table 2. Mock exercises are to be performed annually.

IV. ORGANIZATION AND ASSIGNMENT OF RESPONSIBILITIES

A. The WSTF Site Manager appoints the EPC and provides necessary resources to maintain a competent emergency response capability in accordance with 29 CFR Part 1910.120.

B. NASA Office Chiefs are responsible for: providing appropriate personnel to the HAZMAT Response Team, assuring that personnel under their jurisdiction are appropriately trained in the hazards associated with their operations, and assuring that emergency procedures are established for local area employees to perform emergency shutdown, evacuation, and other initial control functions.

C. NASA Environmental Program Manager assures proper reporting of hazardous material/waste releases, assists the EPC in critique of emergency responses, approves of post-emergency cleanup and decontamination activities, provides oversight of the contractor Environmental Section, and reports releases of hazardous material/waste in compliance with EPA, OSHA, and New Mexico Environmental Department reporting requirements.

D. Contractor Environmental Section provides an advisor to the IC during emergency response incidents, advises warehouse personnel when requested for hazardous material/waste releases in the warehouse, and supervises Phase III operations.

E. NASA Safety Office reviews the results of all HAZMAT responses and mock exercises, acts as an advisor to the IC during emergency incidents, and assists the contractor safety department in determination of PPE and emergency response equipment.

F. The IH acts as a consultant to the EPC for all OSHA-related issues, acts as an advisor to the IC during emergency response activities, assists the NASA WSTF Safety Officer in determination of appropriate PPE and emergency response equipment, and acts as an advisor to the contractor Environmental Section during Phase III operations.

G. Contractor Safety, Security, and the ES Department serve as the central point-of-contact for HAZMAT response at the EOC, maintain the budget for training, equipment, and supplies needed for HAZMAT operations, coordinate and approve training activities, maintain and provide emergency medical and firefighting capability for WSTF, approve, along with the NASA EPC, proper PPE and emergency response equipment, and assist the EPC in determining corrective actions and procedural changes to prevent spill recurrence and improve emergency response.

H. The WSTF Fire Chief serves as one of the IC's during HAZMAT responses, acts as emergency coordinator in the absence of the EPC, is responsible for maintaining emergency response equipment, and acts within the ICS during emergency response events.

I. The WSTF Ordnance Officer serves as an advisor to the IC for any incident involving ordnance.

J. Area Supervisors are responsible for training personnel in local area hazards, emergency procedures, incidental spill cleanup, and completion of spill reports, reviewing area procedures for adequacy in the event of an emergency release, and assisting the IC, where possible, during HAZMAT responses in their areas.

K. Security Guards will assist in traffic control and deny entry of vehicles into evacuation zones, and may also assist in evacuation when requested.

L. The Public Affairs Officer will be the point-of-contact for any off-site news bulletins concerning hazardous releases. The news releases must have the approval of the NASA Manager before release.

M. Fire Wardens are assigned to all occupied buildings at WSTF. During fires and other emergencies, Fire Wardens assist in safely evacuating employees from buildings and directing them to assembly areas as directed by the cognizant department manager or office chief.

N. Auxiliary Firefighters have been trained to support the fire department during major emergencies.

O. Incident Commanders have ultimate authority and command during emergency responses. They are responsible for coordination of activities during emergency responses. This coordination includes ensuring prompt notification is provided to Environmental representatives when potentially reportable quantities of hazardous material/waste are released into the environment. The Incident Commander, in conjunction with the EG, has the authority to commit the necessary site resources, including equipment and manpower, to mitigate the emergency situation.

P. The HAZMAT Response Team is responsible for responding to releases or potential releases of hazardous material/waste in order to favorably change the outcome of the release. They are trained to approach the point-of-release in order to plug, patch, or otherwise stop the release.

V. CONTINUITY OF OPERATIONS

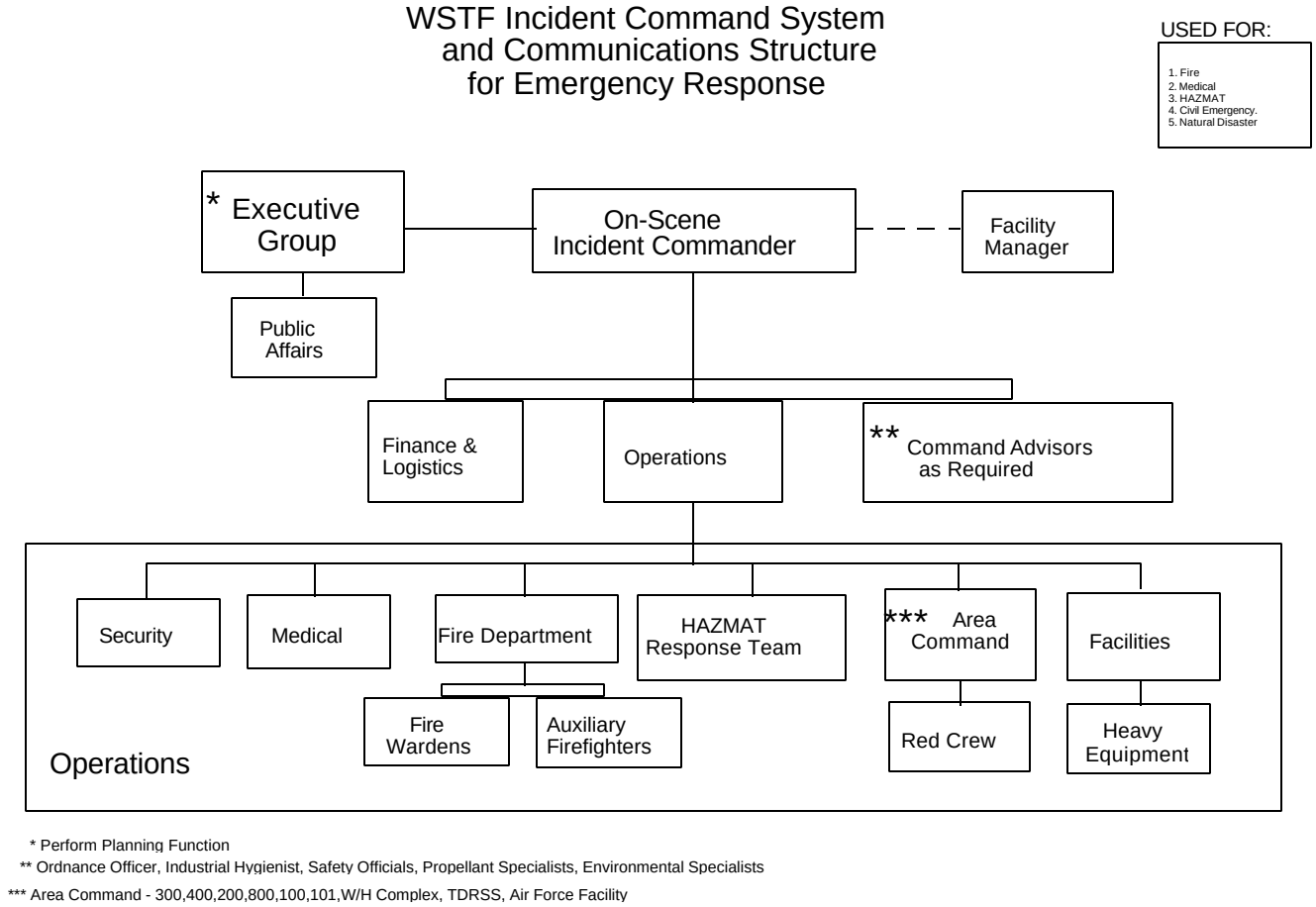
The overall structure of the WSTF ICS is shown in Table 1. The ICS structure is designed so that the IC communicates with as few personnel as practical so as not to become overloaded with information. The EG and the IC work together to respond to and recover from any emergencies affecting the facility.

VI. ANNEX DEVELOPMENT AND MAINTENANCE

The EPC is responsible for the maintenance and improvement of this annex.

Attachment Q Issued: 11/18/02

Table 1



* Perform Planning Function

** Ordnance Officer, Industrial Hygienist, Safety Officials, Propellant Specialists, Environmental Specialists

*** Area Command - 300,400,200,800,100,101,W/H Complex, TDRSS, Air Force Facility

The Emergency Planning Coordinator (EPC) and the Fire Chief will Represent WSTF as the Emergency Coordinators					
Name	Address	Work Number	Home Number	Pager	Cell Phone
Don Hall Primary	12600 NASA Road Las Cruces, NM 88012	505-524-5321	915-821-7283	5321	
Merritt Pratt Alternate	12600 NASA Road Las Cruces, NM 88012	505-524-5217	505-523-0189	5217	505-642-1174

Table 2 Guidelines for Hazardous Material or Waste Release Exercises

The purpose of the exercise is to evaluate existing procedures, communication systems, and staff/management response capabilities. It is to identify where additional procedures, training, and resources are required.

The purpose of this attachment is to establish a standard framework for conducting hazardous material/waste release/spill exercises.

DEFINITIONS

Exercise – An activity designed to promote emergency preparedness; test or evaluate emergency operations; policies, plans, procedures or facilities; train personnel in emergency management duties; and demonstrate operational capability.

Exercise Controller – Is the Emergency Preparedness Coordinator or his designee, and serves as the facilitator of exercise planning.

Simulators – Creates the simulated emergency by providing prescripted messages to the players.

Observers – Will familiarize themselves with emergency procedures for the building, areas to which assigned, the exercise scenario, and the specific assignments made by the Controller(s).

Players – Are onsite WSTF personnel who are scripted to act out a particular exercise/ scenario. They may include scenario area, fire, medical and security personnel.

Participants – Are identified as WSTF employees that are not exempted from the exercise as Controllers, Simulators, or Players.

Non-participants – Persons outside the scope of the exercise assigned to continue performing their normal duties, as though the event was not in progress.

PLANNING THE EXERCISE

Observer, Simulator and Controller(s) must work together as a team for the exercise to go smoothly and achieve exercise objectives. Proper exercise planning/rehearsing/blocking will allow for an easy transition.

Emergency Preparedness Planning Board (EPPB) – Is responsible for developing an annual plan for the sitewide emergency exercise(s). This plan and schedule (Attachment "T", Training) is submitted to the EPC for approval. The plan includes:

- Type and number of exercises
- A schedule for conducting the exercises

EPPB Chair - Prior to the exercise, assembles the "Exercise Design Team" that is composed of EPPB members and others as needed for planning of the site exercise. The EPPB maintains example exercise scenarios, announcements, e-mails sent to management, monitor assignment sheets, and final exercise reports

PREPARATION

Exercise Design Team – Responsible for the following activity:
- Developing a detailed scenario for an exercise.
- Develop scope of realism and depth of simulation.
- Identify critical processes; testing; work being performed during the scheduled exercise that should NOT be stopped.
- Meets with and seeks approval of the NASA and Program Managers for the plan and level of work deviations and notifications prior to the exercise.
- Scheduling the exercise (with approval of the site managers)

Controller(s) – Will provide a copy of the "Master Sequence of Events" to the Simulators, which will map out the exercise.

Simulators – These are usually members of the "Exercise Design Team" and act as control points and maintaining safety during the exercise. Meets with Exercise Controller(s) prior to the exercise for instruction.

Observers – Will meet with the Exercise Controller(s) prior to the exercise to review assignments and to pass out Observer identification.

Players – Will also meet with the Exercise Controller(s) prior to the exercise to review assignment.

Participants and Non-participants – Will be provided employee expectations for the exercise PRIOR to the exercise to include such things as:
- Participant or non-participant designation for the exercise
- Expectation for real or simulated shut down of HVAC and other critical systems
- Continuation of critical processes or tests during the emergency exercise
- Any other activities approved to be simulated or walked-through
- Unacceptability of using uncontrolled copies of procedures, checklists, etc.
- Any special administrative, logistical, or special communications arrangements

CONDUCT OF THE EXERCISE

Code of Conduct – Employee Expectations

1. **Once the exercise has started, each employee will be a participant or non-participant.**
2. **Safety of everyone during the exercise is of the most importance. Your safety and the safety of the players must be ensured. No one is to get hurt or permit property to be damaged.**
3. **There will be ONE Master Controller who will serve as director of the exercise. He may terminate the exercise for any reason.**
4. **In the event of a real emergency, the exercise will immediately cease to support the emergency.**

Announcements – Shall be made notifying employees that an exercise is being conducted. "This is an Exercise" must be included in announcements to personnel. This is to preclude panic by employees.

Controller(s) – There will be one Controller who is to serve as the Director of the Exercise. During the exercise, he monitors flow of the exercise and supervises the input of the messages. The Controller will wear standard identification as "Controller," and will make certain that the exercise is conducted according to objectives, the scenario, and the identified sequence of events.
- Maintains order during the exercise and make sure that the exercise stays on course.

- Act as simulator for unanticipated events or resource requirements.
- May slow down or increase the pace of the exercise as needed.

Simulators – During the exercise, provides inputs to players in accordance to Controller(s). Maintains safety during the exercise, and has the authority to stop individual exercise activities deemed unsafe. Simulators will wear standard identification such as a colored vest.

Observers – They are to record times and key events on paper or on tape. They are wearing vests to distinguish themselves during the exercise and have authority to interrupt the scenario if unsafe conditions are occurring. Observers will wear standard identification such as a colored vest. They are not to analyze actions taken during the exercise.

- Do not use individual names when recording observations. Instead, use specific WSTF locations, the number of individuals, and vehicles observed.
- Indicate whether or not they feel announcements were heard from their respective positions.
- Indicate the time response personnel arrived on scene.
- Wind direction. Have air handlers been shut down, doors closed and sealed? Try to document as much as possible.
- Observers cannot assist, answer questions, or give guidance for personnel during the exercise.

The Exercise Controller will use this information to recreate the sequence of events and facilitate a lessons learned process. Observers will submit a written report of observations within one week to the Exercise Controller(s).

Players - Are expected to follow the script and obtain information through regular established information channels.

AFTER THE EXERCISE

Exercise Controller - An announcement terminating the exercise shall be made at its conclusion and broadcast sitewide.

Exercise Control will request EPPB members consolidate observations from specific areas, and provide a written observation report to him within one week.

EPC shall compile information from observers and perform a post-exercise critique.

The EPC and EPPB Chair will provide a brief to the NASA and Program Managers.

Recommendations for improvements and corrective actions shall be documented using the C/PAR system as defined in WSP 14-0001.

The EPC will classify observations as a deficiency for corrective action if it fails to meet a standard or procedure.

An observation is classified as an improvement if it suggests a means to improve and already adequate situation.

EPPB membership will facilitate answers to questions from the exercise and lessons learned to each respective organization for distribution.

Table 3

EMERGENCY RESPONSE EQUIPMENT		
Equipment	**Description**	**Capabilities**
Fire Extinguishing/Rescue:		**Location: Building 104**
1 Fire Truck/Pumper	2002 E-One Class A Pumper	1250 GPM, 1000 gal. water tank with foam cell, firefighter equipped
1 Fire Truck/Pumper	1990 International 4800 All-wheel drive Class A Pumper	1000 GPM, 750 gal. water tank, firefighter equipped
1 Brush-fire truck	2001 Ford 550 All-wheel drive	90 GPM, 500 gal. water tank w/foam cell, firefighter equipped
1 Ambulance	Type 3	Fully equipped - EMT manned
1 Ambulance	Type 1	Fully equipped - EMT manned
2-Tri-pods/AFFF Foam	Lifting frame	Confined Space Rescue
Rope	Safety/Rescue Rope	Confined Space Rescue
Confined Space Rescue Equip.	Harness, Hardware, Straps	Confined Space Rescue
Foam, 16-5 gal. containers	Chemguard AFFF Alcohol Restraint Foam	Alcohol and Hydrocarbon fire suppression
Foam, 14-5 gal. containers	National Class A Foam	Class A Fire suppression, Environmental friendly foam
Foam, 8-5 gal. containers	Micro-Blaze Class A Foam	Class A Fire suppression, Environmental friendly foam
Spill Control (Spill Response Trailer Unit)		**Location: Building 104**
Spill Response Trailer	Enclosed 20'x 6'10" x 6' tandem-axle	Response equipment transport
1 Generator	7000 Watts, 120/240 Volts, electric start	Illumination during night-time operations
1 Gas Detection Monitor	MSA Green Stick	Monitor O2, H2S, CO, & Combustible Gases
1 Gas Detection Monitor	MSA Passport Personal 4-gas detector	Monitor O2, H2S, CO, & Combustible Gases
1 Gas Detection Monitor	Interscan	Monitor for Hydrazine
1 Gas Detection Monitor	Interscan	Monitor for Oxidizer
4 Portable Lights	Quartz w/wire lens guard	500 Watt illumination
5 Personal Protective Suits	Level "A"	Used for max. protection
4 Personal Protective Suits	Level "B"	Level "A" equal except not gas tight
15 Units	4500 psi	45 min/1 hr air supply
18 SCBA Air Bottles	4500 psi	Extra Bottles for SCBA, 45 min/1 hr air supply

5 Thermal Vests	Pocketed for cold packs	Heat stress protection
Plug/Patch/Repair		
-2 Non-sparking Tool Kit	Hand tools coated w/ non-sparking material	Drum/container patching and contamination containment
-1 Drum Patch Kit	Screws/plugs/stoppers	"
-1 Pipe Patch Kit	Neoprene lined clamps w/wrenches	" (Liners available for compatibility)
-1 Tank Repair Kit	Patches, adjustable chains/straps	"
-1 Box Pipe Wrap	Chemical resistant patching material	"
-9 Boxes Response Stik	Chemical resistant patching material	"
-1 Bung Wrenchs	Non-sparking	Leak/contamination control
-1 Tool Kit	Hand tools, plugs and patching material	Designed for compatibility w/site chemicals
1 Drum Deheader	Forged steel w/steel blade	Contamination containment and removal
3 Bucket	Stainless steel 3 gal.	Chemical compatibility w/site wastes
1 Bucket	Plastic 5 gal.	Chemical compatibility w/site wastes
4 Shovel	Plastic	Flammable waste collection
2 Mop w/4 Mop heads	Chemical sponge	Spill absorption
1 Pink Absorbent Socks	10' long by 8" diameter	Caustics, acids and solvents
12 Pink Absorbent Socks	46" long by 3" diameter	Caustics, acids and solvents
30 Blue Absorbent Socks	46' long by 3" diameter	Caustics, acids and solvents
50 lbs. Clay Absorbent	Clay spill dry	Liquids and petroleum products
200 Blue Paper Towels	12" X 12"	Spill absorption and clean up
2 Pair Binoculars	10 X 50 Power	Remote spill response determination
5 Flashlights	Hazardous atmospheres	Illumination
10 Safety Vests	Fluorescent orange	Response Team ID.
15 Safety Cones	Restricting area labeled	Spill Area ID
2 Signs	Red on white free standing	Spill warning
2 Face Shields	Chemical Resistant	Corrosive and splash protection

2 Aprons	"	Level "C" protection
3 Pair Safety Glasses	"	Level "C" protection
10 Pair Gloves	Plastic	Chemical resistant
20 Pair Boots	Hazmat	Chemical Resistant Steel Toe/Midsole
12 Pair Boots	Tyvek	Chemical resistant
4 Coveralls	Polylaminated Tyvek	Chemical resistant
5 Coveralls	Tyvek	Chemical resistant
Plastic Bags	Assorted sizes	Equipment protection and isolation
1 Drum Truck	Self-standing w/polyolefin wheels	30/55/85 gal drum transport

Spill Control Heavy Equipment		**Location: 150 Yard**
Vacuum Trailer	Gasoline powered - 1000 gal. capacity	Spill containment/transfer
Pickup	4x4 3/4 Ton	Equipped to pull vacuum trailer
Front Loader	4.5 Cu Yd International	Earth movement
Crane	Mobile 35-ton	Equipment and container movement
Crane	Mobile 180-ton	Equipment and container movement
Backhoe	Case w/2 cu. yd. bucket	Diversion, dyking and erosion control
2 Dump Trucks	6 and 12 cu. yd. beds	Earth movement
Semi-Truck	International Diesel	Transfer trailers and equipment
Low-boy Trailer	20 tons	Transfer containers and equipment
Tanker Trailer	Stainless steel 6000 gal.	Spill containment and transfer
Forklifts (all work areas)	Various sizes	Equipment and container transfer
2-Livestock Storage Tanks	1000 gallons	Spill containment
Portable Pump	4" Wheel mounted 100 GPM	Waste transfers
Decon Equipment		**Location: Building 104**
1 Decon Station	3 Station poly-lined boxes w/decon shower	Easily assembled and portable
1 Open Top Container	Poly w/lid	PPE collection for decon
4 Brushes	Long handled/soft	PPE decon
Firehose w/Connections	Length 200' Diameter 2"	Perimeter for decon station
Garden Hose w/Connections	200" Diameter 5/8"	Decon shower water supply
Plastic Sheeting	Polyethylene	Decon station containment
Neutralizing solutions	Clorox/Caustic	Decon Fuel and Ox contamination
Soil, Sand and Gravel	Naturally occurring	Diversion, dyking and erosion control
Additional Emergency Response Equipment/Supplies Available. Located in Warehouse and Related Work Areas		
Hard Hats	Polyethylene	Required in "Level A" suits
Safety Glasses	Assorted	

Goggles	Chemical resistant	Mild acids and caustics protection
Face Shields	Chemical resistant	Corrosive and splash protection
Splash Suits	PVC chemical resistant	Level "B" protection
Totally Encapsulated Suits w/airlines	ILC Dover	Airline - positive pressure, hydrazine/s and oxidizer compatible
SCBA's	MSA	30 min breathing air supply
2 Breathing air trailers	Regulated/manifolded K-bottles	Long term breathing air source
Chemical Cartridges	Assorted	Selected per PPE level and contaminant
Respirators	Airline and 1/2 mask	Selected per PPE level and contaminant
Gloves	Assorted - neoprene, butyl, Silver Shield	For compatibility w/various site known chemicals
Spill Pillows	Assorted	Spill absorption
Clay Absorbent	15-25, 50 lb. bags	Spill absorption
Shovels		
Rakes		
Rope and Line		
Drums	30/55 gal.	Spill containment
Salvage Drums	85 gal.	Overpacking and decon
2 Drum Slings	Cable - proofed to 500 and 1000 lbs.	Drum transfers and overpacking
Hand Pumps	Chemical resistant	Spill transfers

Attachment R Issued: 11/18/02

Attachment R
Annex R - Rescue

I. PURPOSE

This annex is intended to provide a plan by which a trained and equipped emergency rescue force can locate, identify, and remove survivors who have been injured and are in need of medical treatment, or who are marooned in an emergency situation.

II. SITUATION AND ASSUMPTIONS

A. Situation

WSTF buildings are subject to structural damage from severe weather, fire, and explosions that could result in people being trapped in damaged and collapsed structures or lost in remote areas on site.

B. Assumptions

A trained, equipped, organized rescue force will provide the capability to efficiently conduct methodical search-and-rescue operations, suppress and minimize loss of life, shore up and stabilize weakened structures, release trapped persons, and locate the missing and dead.

III. CONCEPT OF OPERATIONS

A. Day-to day rescue operations

The WSTF FD provides 24-hour coverage regarding fire safety and security. The department maintains equipment and staffing in a continuous state of readiness because of their day-to-day operations. In addition, departmental personnel are trained emergency medical technicians and are familiar with extrication techniques.

B. War-related events

The technical competence and ready availability of the rescue force will be augmented during emergencies by mobilizing additional skills in medical, building trades, engineering services, heavy equipment operation, and communications.

C. Natural disaster and technological hazards

The day-to-day rescue capability will be augmented during natural disasters to the extent necessary to eliminate the problem at hand. The operation may require mobilizing medical personnel, building trades, engineering services, heavy equipment operation, the heavy-duty rescue squad, and mutual aid and military support.

IV. ANNEX DEVELOPMENT AND MAINTENANCE

The FC is responsible for the maintenance and improvement of this annex.

Attachment S Issued: 11/18/02

Attachment S
Annex S - Transportation

I. PURPOSE

The purpose of this annex is to provide a plan for the effective allocation of site Government Services Administration (GSA) vehicles in an emergency situation or disaster at WSTF.

II. PROCEDURE

A. In the event of an emergency that requires the use of site GSA vehicles, the following individuals are to be contacted:

	Home Phone No.	Work Phone No.
Johnny J. Bernal	527-2262	524-5140
Jimmy A. Lujan	527-5558	524-5614
Paul S. Goodwin	382-3544	524-5781

These individuals are responsible for obtaining, coordinating and disbursing site vehicles in the event of an emergency situation or disaster:

B. In the event of an emergency that requires the use of site heavy equipment contact:

	Home Phone	Work Phone
David Martinez	523-2387	524-5179
Hoyt Inman	526-4909	524-5275

The following heavy equipment is available for emergency response activities.

Equipment

One 180-ton crane and one 30-ton crane and one boom truck 7.5 tons
Backhoes
Loaders
Graders
Man lift equipment
Forklifts
Bobcat
Tractor for trailers (Hazardous Material Certified)

Dump trucks
Water truck
Air compressors
Generators

III. ANNEX DEVELOPMENT AND MAINTENANCE

The EPC is responsible for the maintenance and improvement of this annex.

Attachment T Issued: 3/13/03

Attachment T
Annex T – Training

I. PURPOSE

The purpose of this annex is to provide a plan for a comprehensive training program in emergency management for all departments and personnel who support the emergency services at WSTF.

II. SITUATION AND ASSUMPTIONS

A. Situation

During an emergency, all WSTF departments may provide services that interface with other departments. Because disaster situations are unusual and infrequent events, it is essential that regular training be conducted to indoctrinate personnel, test plans, and evaluate performance.

B. Assumptions

New employee indoctrination, drills and critique of drills will be the primary training tools used at WSTF.

III. CONCEPT OF OPERATIONS

A. General

The EPC will assist in coordinating an ongoing program of training to include indoctrination, drills, and exercises.

B. Phases of Management

1. Mitigation

a) Development of training curriculum.

b) Identify training aids, resources, and needs.

2. Preparedness

a) Conduct local drills.

b) Schedule personnel to attend training programs.

c) Participate in center-wide and agency drills as appropriate.

d) Review performance during drills against plans.

e) Provide critiques of drills to department heads.

3. Response

Prepare and maintain records of all training activities.

4. Recovery

a) Critique performance and note weaknesses.

b) Develop drills and training materials to strengthen and test shortcomings.

IV. ORGANIZATION AND ASSIGNMENT OF RESPONSIBILITIES

A. Task Assignments

1. Emergency Preparedness Coordinator (EPC)

a) Develop an annual training plan to include instruction, tabletop and full-scale drills.

b) Conduct drills. Arrange for a critique and provide a summary to the appropriate Office Chiefs and Department Managers.

2. All Offices and Departments

a) All Office Chiefs and Department Managers should regularly identify to the EPC those areas involving their local emergency procedures, which should be tested and drilled with other offices and departments.

b) Each Office Chief and Department Manager is responsible for internal departmental training programs that exercise emergency situations (spills) in support of the emergency management program.

3. Specific Support

Upon the initiation of a emergency exercise, the EPC may request Communications Group send a representative to the FCC to monitor and real time trouble shoot Centracom communication problems.

V. DIRECTION AND CONTROL

Training programs and drills involving only a single department may be scheduled and conducted by the department head at any time. Such activities that are supportive of the overall emergency management program should be reported to the EPC.

The EPC should be involved in all drills that involve multiple departments at WSTF.

VI. ANNEX DEVELOPMENT AND MAINTENANCE

The EPC is responsible for maintenance and improvement of this annex.

Attachment T Issued: 3/13/03

Training Schedule

Training Schedule

WSTF/WSC/AF Fire & Emergency Preparedness Program– 2003

Date Originated: 01/05/03	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
WSTF Facility Fire Inspections – Drills												
100 Area & 600 Area & Site Utilities				X								
200 Area			X									
800 Area and 250, 270, and 700 Areas												X
WSSH											X	
300 Area and 500 Cryo Area								X				
400 Area and 500 Propellant Area							X					
WSC / Air Force Pre-plan/ Fire Inspections - Drills*												
WSGT T-1	X											
WSGT T-25, T-20, T-21, T-14, T-16		X										
STGT T-4					X							
Air Force Facility						X						
Fire Program Training/Testing/Audits												
Training for warning, communications		X										
Training for shelter, mass care, evacuation			X									
Fire Warden List Audit	X			X			X			X		
Fire Hydrants Testing	X			X			X			X		
WSTF Sprinkler Stand-pipe Inspection	X			X			X			X		
WSTF Fire Apparatus Pump Test								X				
WSTF Fire Hose Pressure Testing								X				

Attachment T Issued: 03/13/03

Training Schedule

WSTF/WSC/AF Fire & Emergency Preparedness Program– 2003

Date Originated: 01/05/03	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Emergency Preparedness												
WSP 25-0009 Annex Review	N				A,B,Q	C,E,R	F,G,H	J,K,L	D,S,M	I,O,P	T,U	
Local Emergency Plan Review (Area)			200	100	600	400	Fuel	300	Cryo		700	800
Management Tabletop Exercise	X											
Functional or Full-Scale Exercise				X								
Exercise Design											X	
Management Approval of Exercise												X

Attachment U Issued: 11/18/02

Attachment U
Annex U – Legal Services

I. AUTHORITY

See JSCM 1107.1, The JSC Organization.

II. SUPPORT

Legal support shall include in-depth advice on relevant laws and/or regulations (for example: emergency, environmental, privacy, and information release), civil and criminal liability issues, and claims matters.

III. RESPONSIBILITIES

A. Be the legal advisor to activities and groups under the emergency plan(s).

B. Provide legal advice/assistance to management during emergency situations.

C. Provide legal review of SOP's as needed.

D. Review and assist in the development of mutual support agreements as needed.

IV. POINTS OF CONTACT

AL411/Office for General Legal Matters shall be the primary source of legal support. The following members of the Legal Office (General) have been assigned to initially respond to requests for legal advice under this plan and during any emergency:

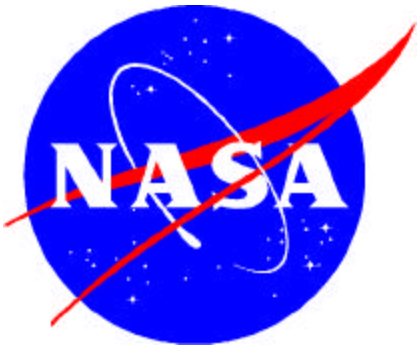
A. Primary - AL4/John Kemp [(281) 483-1005]

B. Alternates - AL4/Herb Chee [(281) 483-1006] and AL4/Dave Samuels [(281) 483-1018]

V. LINES OF SUCCESSION

The Legal Office lines of succession are set out in JSCI 1164.1.

Appendix G - Plume-Front Health Risk Assessment



Johnson Space Center
NASA White Sands Test Facility

Plume-Front Project Plan Health Risk Assessment

November 18, 2003

1.0 Introduction……..……1
1.1 Background…….……....1
1.2 Purpose of the Plume-Front Health Risk Assessment…...1
2.0 Identification of COCs……...……..2
2.1 Guidance for Evaluating COCs……...2
2.2 Data Evaluation……...…2
2.2.1 Scope……..……...2
2.2.2 Identification of Regulatory Limits.…… 8
2.2.3 Comparison of Detection Limits to Regulatory Limits…..…. 8
2.2.4 Calculation of Frequency of Detection…… 8
2.2.5 Comparison of Analyte Maximum Concentration to Regulatory Limits.…… 8
2.3 Justifications for Excluding Analytes from Further Consideration as COCs……9
2.3.1 Five-Year Maximum Concentration Below Regulatory Limit……..…..…….. 9
2.3.2 Absence of Toxicity Data……...…… 9
2.3.3 Laboratory Contaminants……..…..….9
2.3.4 Essential Nutrients……...…… 9
2.3.5 Elimination of Other Analytes…….…… 10
2.3.5.1 Thallium.……..10
2.3.5.2 1,2-Dibromomethane……..10
2.3.5.3 1,4-Dioxane…… 10
2.3.5.4 Bis (2-Ethylhexyl) Phthalate……...10
2.4 Justification for Including Analytes as Potential COCs.…11
2.4.1 Exceedence of ARARs……...……. 10
2.4.2 Historical Use and Previously Defined COCs…….11
2.4.3 EPA Carcinogenic Classification……12
2.4.4 Benzene…… 12
3.0 Toxicity Screen…… 12
3.1 Toxicity Screen for Carcinogens……12
3.1.1 Carcinogenic Analytes Eliminated from Quantitative Health Risk……..…14
3.1.2 Carcinogenic COCs and Toxicity Screen Results……... 14
3.2 Toxicity Screen for Non-Carcinogens……16
3.2.1 Non-Carcinogenic Analytes Eliminated from Quantitative Health Risk…….....16
3.2.2 Non-Carcinogenic COCs and Toxicity Screen Results…….... 16
4.0 COC Assessment……..…….. 18
4.1 Carcinogenic COCs……18
4.1.1 NDMA (CAS. NO. 62-75-9) and DMN (CAS. NO. 4164-28-7)……... 18
4.1.2 TCE (CAS. NO. 79-01-6)……22
4.1.3 PCE (CAS. NO. 127-18-4)……... 23

4.1.4 Contaminants as Consequences of NASA-WSTF Groundwater Monitoring Activities……24
4.1.4.1 Acrylonitrile (CAS. NO. 107-13-1)…… 24
4.1.4.2 Tetrahydrofuran (THF)(CAS. NO. 109-99-9)…… 25
4.1.5 Chloroform (CAS. NO. 67-66-3)……26
4.1.6 Arsenic (CAS. NO. 7440-38-2)……... 27
4.1.7 Lead (CAS. NO. 7439-92-1)……28
4.2 Non-Carcinogenic COCs……29
4.2.1 Freon 11 (CAS. NO. 75-69-4)…… 32
4.2.2 Freon 21 (CAS. NO. 75-43-4)…… 32
4.2.3 Freon 113 (CAS. NO. 76-13-1)……... 33
4.2.4 Freon 123A (CAS. NO. 354-23-4)…….. 34
4.2.5 Bromacil (CAS. NO. 314-40-9)……...34
4.2.6 Cadmium (CAS. NO. 7440-43-9)……35
4.2.7 Chromium III (CAS. NO. 7440-47-3)…… 36
4.2.8 Nickel (CAS. NO. Various)……. ……... 37
4.2.9 Nitrate/Nitrite (Nitrogen) (Nitrate CAS. NO. 14797-55-8; Nitrite CAS. NO. 14797-65-0)…….……... 38
5.0 Plume-Front Health Risk Assessment…… 39
5.1 Exposure Evaluation for Plume-Front Health Risk Assessment……39
5.2 Quantification of Plume-Front Carcinogenic Risk……40
5.2.1 Carcinogenci Risk Calculations……... 40
5.2.2 Estimates of Current Plume-Front Carcinogenic Risk…….42
5.3 Quantification of Non-Carcinogenic Plume-Front HIs……..……42
5.3.1 Non-Carcinogenic HQs and HIs……..…… 42
5.3.2 Estimates of Current Plume-Front Non-Carcinogenic Health Indices…….. 47
5.4 Uncertainty in Health Risk Assessment……47
5.5 Summary……..50
6.0 Plume-Front Project Health Risk Plan……...…51
6.1 Monitor Well Health Risk Evaluation……..……..51
6.2 Treatment Facility Influent and Effluent Piping Health Risk Monitoring……..51
6.3 Extraction Well Health Risk Monitoring……... 51

References……52

Figure 5.1 Contour Map of Carcinogenic Risk at Plume-Front Monitoring Wells……... 45

Table 2.1	Frequency of Detection and Percent Detection Above Regulatory Standards	3
Table 3.1	Toxicity Screen for Carcinogenic Analytes	13
Table 3.2	Toxicity Screen for Non-Carcinogenic Chemicals	17
Table 4.1	Physical and Chemical Properties of Plume-Front Carcinogenic COCs	19
Table 4.2	Toxicity Information for Carcinogenic Plume-Front Chemicals	20
Table 4.3	Toxicity Information for Non-Carcinogenic Effects from Carcinogenic COCs	21
Table 4.4	Physical and Chemical Properties of Plume-Front Non-Carcinogenic COCs	30
Table 4.5	Toxicity Information for Non-Carcinogenic Plume-Front COCs	31
Table 5.1	Chronic Daily Intake (CDI) Assumptions for Age-Adjusted Ingestion of Contaminated Groundwater	41
Table 5.2	Carcinogenic Risk Estimates for Plume-Front Monitoring Wells	43
Table 5.3	Chronic Daily Intake (CDI) Assumptions for Ingestion/ Inhalation Rates of Non-Carcinogens from Contaminated Groundwater	46
Table 5.4	Non-Carcinogenic Hazard Quotients and Indices for Plume-Front Wells	48

Appendix A: Available Information for Analytes Lacking Toxicity Data
Appendix B: Bis (2-Ethylhexyl) Phthalate Discussion
Appendix C: Bromacil Toxicity Evaluation
Appendix D: HSDB and IRIS Toxicity Information for COCs
Appendix E: California EPA Public Health Goal for Lead in Drinking Water
Appendix F: Carcinogenic Risk Calculations
Appendix G: Non-Carcinogenic Hazard Calculations

ARARs	Applicable or Relevant or Appropriate Requirements
BEHP	Bis (2-ethylhexyl) phthalate
BHRA	Baseline Human Health Assessment
Carc.	Carcinogen
CDI	Chronic Daily Intake
Cij	Maximum concentration of chemical "i" in medium "j"
CNS	Central Nervous System
COC(s)	Concentration(s) of Concern
DMN	N-nitrodimethylamine
E	Exclude
EDB	1,2-dibromomethane
EPA	Environmental Protection Agency
FOD	Frequency of Detection
Freon 21	Dichlorofluoromethane
Freon 113	1,1,2-trichloro-1,2,2-trifluoroethane
Freon 123	2,2-dichloro-1,1,1-trifluoroethane
Freon 123A	1,2-dichloro-1,1,2-trifluoroethane
HI(s)	Hazard Index
Hist.	Historical
HSDB	Hazardous Substance Data Bank
HQ	Hazard Quotient
I	Include
IRIS	Integrated Risk Information System
Koc	Normalized Organic Carbon Partition Coefficient
MCL	Maximum Contaminant Level
MF	Modifying Factor
NA	Not Applicable
NASA	National Aeronautics and Space Administration
ND	Not-Detected or Non-Detect analytical results
NDMA	N-nitrosodimethylamine
NIOSH	National Institute for Occupational Safety and Health
NMED	New Mexico Environmental Department
PCE	Tetrachloroethene
PFSWP	Plume-Front Stabilization Work Plan
PRG(s)	Preliminary Remediation Goal(s)
PVC	Polyvinyl Chloride
RAGS	Risk Assessment Guidance for Superfund
RB	Reagent Blank
RBC(s)	Risk-Based Concentration(s)
RCRA	Resource Conservation and Recovery Act
RfC	Chronic Inhalation Exposure
RfDi	Inhalation Reference Dose
RfDo	Oral Reference Dose
Rij	Estimated risk of chemical "i" in medium "j"
SFi	Inhalation Slope Factor

SFo	Oral Slope Factor
TCE	Trichloroethene
THF	Tetrahydrofuran
Tij	Toxicity value of chemical “i” in medium “j”
UF	Uncertainty Factor
WQCC	(New Mexico) Water Quality Control Commission
WSTF	White Sands Test Facility

1.0 Introduction

1.1 Background

A Baseline Human Health Risk Assessment (BHRA), performed for the draft Resource Conservation and Recovery Act (RCRA) Facility Investigation Report in 1996, established the foundation for characterization of health risks resulting from contaminant releases during operations at the National Aeronautics and Space Administration (NASA) White Sands Test Facility (WSTF) (NASA, 1996). Pathways and exposure scenarios were investigated and characterized and the list of contaminants of concern (COCs) was finalized through the processes outlined in the Risk Assessment Guidance for Superfund (RAGS)(Environmental Protection Agency (EPA), 1989).

Releases from hazardous waste management units at WSTF leached through the soil and entered groundwater to form a contaminant plume that has migrated approximately four miles downgradient from the source units. The 1996 BHRA determined that contaminant releases have had a greater impact on groundwater than any other medium (soil or air). Groundwater is therefore considered the medium of primary concern regarding potential exposure and health threat for the purposes of health risk assessment at the plume-front.

Groundwater monitoring analytical data from 1987-1996 were used to assess the character and movement of groundwater contamination. Two exposure scenarios were incorporated into the BHRA screening process. Potential health risks from WSTF groundwater via inhalation, ingestion, and dermal pathways were examined using maximum contaminant values. Two categories of potential receptors were WSTF employees and residents west of the facility. Quantitative evaluation of analytical data and a MODFLOW-SURFACT fate and transport model characterized the potential risk in the period between 1996 and 2026.

The final list of COCs compiled from the 1996 BHRA screening process included carcinogens N-nitrosodimethylamine (NDMA), trichloroethene (TCE), and tetrachloroethene (PCE) and non-carcinogens Freon 11, dichlorofluoromethane (Freon 21) and 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113). N-Nitrodimethylamine (DMN) was added to the list of carcinogenic COCs during preparation of the original Plume-front Stabilization Work Plan (PFSWP)(NASA, 2002). These COCs were carried through the toxicity screen to appropriately evaluate the level of risk of each potential contaminant at WSTF.

1.2 Purpose of the Plume-Front Health Risk Assessment

The WSTF groundwater remediation system is scheduled to become operational in 2004. The purpose of this health risk evaluation is to analyze potential residential risks at the plume front. There are three steps that will be taken to accomplish this goal. The first step will be to reevaluate WSTF analytes and define COCs with potential for adding significant risk to groundwater. The second step will involve calculation of present-day carcinogenic health risk and non-carcinogenic hazard indices (HIs) at the plume-front monitoring wells. The third step will be to outline the plan for monitoring health risk during groundwater remediation activities at the plume-front

2.0 Identification of COCs

Changes in regulatory guidance and groundwater concentrations since 1996 were taken into consideration during the process of this COC reevaluation. A conservative approach was taken during the process of determining the final lists of carcinogenic and non-carcinogenic COCs. Site-wide data from mid-1998 through mid-2003 were used during the COC evaluation.

2.1 Guidance for Evaluating COCs

The procedure for determining the final list of COCs was similar to that followed in the original NASA-WSTF BHRA. The primary guidance was RAGS (EPA, 1989) Volume I Human Health Evaluation Manual Interim Final (Part A). RAGS describes general qualitative criteria which should be considered when evaluating contaminants for either elimination or retention as COCs for a baseline risk assessment.

Supplementary guidance included the EPA Region 8 Superfund Technical Guidance RA-03 (EPA, 1994) Evaluating and Identifying Contaminants of Concern for Human Health and EPA Region III Technical Guidance Manual for Risk Assessment Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening (EPA, 1993). These guidance documents summarized and clarified the RAGS evaluation process for selecting COCs. In doing so, they modified the contaminant selection processes to more efficiently evaluate and reduce preliminary lists of potentially site-related contaminants to define the COCs.

RAGS and the supplementary EPA regional guidance documents discuss the need to focus on the dominant contaminants and routes of exposure at the earliest feasible stage. The list of potentially site-related contaminants at WSTF was lengthy and because overall risk is usually driven by a few contaminants, a selection process was used to further reduce the number of contaminants of potential concern for the groundwater pathway to a reasonable and relevant amount. The process used for eliminating chemicals of potential concern to refine the list of contaminants driving the WSTF human health risk is detailed below.

2.2 Data Evaluation

2.2.1 Scope

Site-wide groundwater analytical results for the last five years (May 1, 1998- June 24, 2003) were evaluated for contaminants of potential concern. All analytes detected in samples from the last five years were considered in the initial assessment. Table 2.1 includes all analytes detected in samples over the last five years.

Table 2.1: Frequency of Detection and Percent Detection Above Regulatory Standards (5/1/98 - 6/24/03).

Analyte Name Inorganic Chemicals	Range of Detection Limits (mg/L)	Number Detects/ Number Samples	Frequency of Detection (Percent)	Maximum Concentration (mg/L)	Regulatory Limit/ Source (mg/L)	Percent Detects Above Reg. Limit	Inclusion/ Exclusion in Toxicity Screen - Justification
Antimony	0.0004 - 0.018	5 / 59	8.48	0.0056	0.006 / EPA[4]	0.0	E- <ARARs
Arsenic	0.0007 - 0.0066	1,068 / 2,565	40.90	1	0.010 / EPA[6]	0.022	I- >ARARs
Barium	0.0004 - 0.00897	2,790 / 2,815	99.11	0.23	1.0 / WQCC[4]	0.0	E- <ARARs
Beryllium	0.0001- 0.00077	9 / 58	15.52	0.0018	0.004 / EPA[4]	0.0	E- <ARARs
Cadmium	0.0002 - 0.0031	75 / 2,498	3.00	0.092	0.005 / EPA[4]	0.08	I- >ARARs
Calcium	0.026 - 0.0842	216 / 216	100.0	103,000	NA	NA	E-Essential Nutrient[3]
Chromium III	0.0003 - 0.01	1,023 / 3,253	31.45	4.69	0.05 / WQCC[4]	4.70	I- >ARARs
Cobalt	0.0003 - 0.00818	17 / 58	29.31	0.00749	0.05 / WQCC[4]	0.0	E- <ARARs
Copper	0.0007- 0.0037	9 / 58	15.52	0.00851	1.3 / EPA[4]	0.0	E- <ARARs
Total Cyanide	0.001 - 0.00539	8 / 58	13.80	0.029	0.2 / WQCC[4]	0.0	E- <ARARs
Fluoride	0.01 - 0.10	211 / 211	100.0	2.7	1.6 / WQCC[4]	3.32	E-Essential Nutrient[3]
Iron	0.0051 - 0.086	78 / 214	36.45	2.6	0.3 / EPA[4]	10.28	E-Essential Nutrient[3]
Lead	0.4 - 2.7	231 / 2,518	9.17	0.0413	0.015 / EPA[4]	0.32	I- >ARARs
Magnesium	0.01 - 0.0531	216 / 216	100.0	82,000	NA	NA	E-Essential Nutrient[3]
Mercury	0.00001 - 0.00013	265 / 2,479	10.69	0.0011	0.002 / WQCC[4]	0.0	E- <ARARs
Nickel	0.0007 - 0.0107	15 / 58	25.86	0.11	0.1 / EPA[4]	1.72	I- >ARARs
Potassium	0.18 - 1.92	212 / 216	98.15	2,850	NA	NA	E-Essential Nutrient[3]
Selenium	0.0008 - 0.0062	873 / 2,491	35.05	0.0298	0.05 / WQCC[4]	0.0	E- <ARARs
Silver	0.0004 - 3.72	190 / 2,486	7.64	0.0099	0.05 / WQCC[4]	0.0	E- <ARARs
Thallium	0.0014 - 0.021	1 / 58	1.72	0.0032	0.002 / EPA[4]	1.72	E-[3]
Tin	0.0015 - 0.068	19 / 58	32.76	15.2	22,000 / RBC[9]	0.0	E- <ARARs
Vanadium	0.0013 - 0.0272	20 / 58	34.48	0.0065	0.02 / HA[4]	0.0	E- <ARARs
Zinc	0.0007 - 0.014	42 / 58	72.41	0.69	5 / EPA[4]	0.0	E- <ARARs
Chloride	0.1 - 0.5	235 / 235	100.0	1,890	250 / WQCC[4]	100.0	E-Essential Nutrient[3]
Total Dissolved Solids	3.8 - 5.4	229 / 229	100.0	8,040	500 / WQCC[4]	100.0	E-NA
Sodium	0.238 - 2.0	216 / 216	100.0	105,000	20 / HA[4]	99.54	E-Essential Nutrient[3]
Total Alkalinity	0.5 - 0.69	208 / 209	99.52	438	NA	NA	E-NA

Table 2.1: Frequency of Detection and Percent Detection above Regulatory Standards (5/1/98 - 6/24/03).

Analyte Name Inorganic Chemicals	Range of Detection Limits (mg/L)	Number Detects/ Number Samples	Frequency of Detection (Percent)	Maximum Concentration (mg/L)	Regulatory Limit/ Source (mg/L)	Percent Detects Above Reg. Limit	Inclusion/ Exclusion in Toxicity Screen - Justification
Nitrogen, as Ammonia	0.005 - 0.29	107 / 209	51.20	1.4	30 / HA[7]	0.0	E- <ARARs
Total Kjeldahl Nitrogen	NA	13 / 19	68.42	0.68	NA	NA	E-NA
Total Sulfide	0.271 - 0.797	1 / 1	100.0	0.4	NA	NA	E-NA
Sulfate	0.1 - 2	215 / 216	99.54	5,380	250 / WQCC[4]	77.6	E-NA
Nitrate/Nitrite Nitrogen	0.002 - 0.021	162 / 226	71.68	660	10 / WQCC[4]	3.2	I- >ARARs
Analyte Name **Organic Chemicals**	**Range of Detection Limits (µg/L)**	**Number Detects/ Number Samples**	**Frequency of Detection (Percent)**	**Maximum Concentration (µg/L)**	**Regulatory Limit/ Source (µg/L)**	**Percent Detects Above Reg. Limit**	**Inclusion/ Exclusion in Toxicity Screen - Justification**
Acetone	0.54 - 7.5	393 / 3,189	12.32	510	610 / RBC[9]	0.0	E- <ARARs
Acrolein	1.9 - 19.0	1 / 3,189	0.03	5.3	0.042 / RBC[9]	0.031	I- >ARARs
Acrylonitrile	1.4 - 13.66	189 / 3,189	5.93	55	0.037 / RBC[9]	5.93	I- >ARARs
Benzene	0.1 - 2.01	68 / 3,189	2.13	4[3]	5 / EPA[4]	0.0	I-Carc.
Bis (2-Ethylhexyl) phthalate	0.441 - 5.31	74 / 155	47.74	86.1	6 / EPA[4]	35.48	E-[3]
Dinonyl phthalate	0.339 - 0.339	2 / 84	2.38	0.62	NA	NA	E-NA
Hexyl 2-ethylhexyl phthalate	0.198 - 0.198	1 / 84	1.19	1	NA	NA	E-NA
Diethyl Phthalate	0.214 - 4.45	8 / 147	5.44	7	29,000 / RBC[9]	0.0	E- <ARARs
Di-N-Butyl Phthalate	0.213 - 4.53	9 / 147	6.12	3	3,600 / PRG[8]	0.0	E- <ARARs
Bromacil	0.005 - 0.234	390 / 794	49.12	54.3	90 / HA[4]	0.0	I-Hist.[3]
Bromodichloromethane (THM)	0.05 - 3.8	14 / 7,220	0.19	0.3	0.17 / RBC[9]	0.13	I- >ARARs
2-Butanone (MEK)	0.6 - 3.7	108 / 3,189	3.39	110	100 / HA	0.031	E-Lab Contaminant[3]
Chloroform	0.056 - 4.2	434 / 7,220	6.01	2.7	100 / WQCC[4]	0.0	I-Carc.
Chloromethane	0.097 - 4.0	55 / 7,220	0.76	9.2	1.5 / PRG[8]	0.19	I- >ARARs
Cyclohexane	NA	7 / 7	100.0	29	35,000 / PRG[8]	0.0	E- <ARARs
1,2-Dibromomethane (EDB)	0.084 - 9.5	1 / 5,772	0.02	1.9	0.05 / EPA[4]	0.017	E-[3]
Dibromochloromethane (THM)	0.05 - 4.6	26 / 7,220	0.36	1.9	0.13 / RBC[9]	0.35	I- >ARARs

Table 2.1: Frequency of Detection and Percent Detection above Regulatory Standards (5/1/98 - 6/24/03).

Analyte Name Organic Chemicals	Range of Detection Limits (µg/L)	Number Detects/ Number Samples	Frequency of Detection (Percent)	Maximum Concentration (µg/L)	Regulatory Limit/ Source (µg/L)	Percent Detects Above Reg. Limit	Inclusion/ Exclusion in Toxicity Screen - Justification
1,1-Dichloroethene	0.073 - 3.6	269 / 7,220	3.73	6.3	5 / WQCC[4]	0.17	I- >ARARs
Dichlorofluoromethane (Freon 21)	0.1 - 7.8	1,432 / 7,220	19.83	60	NA	NA	I-Hist.[1]
1,2-Dichloro-1,1,2-Trifluoroethane (Freon 123A)	0.084 - 8.7	1,743 / 7,220	24.14	78	NA	NA	I-Hist.[1]
2,2-Dichloro-1,1,1-Trifluoroethane (Freon 123)	0.05 - 8.7	57 / 7,220	0.79	4.2	NA	NA	I-Hist.[1]
1,4-Dioxane (p-)	8.0 - 106.04	27 / 3,189	0.85	210	6.1 / RBC[9]	0.85	E-[3]
Methylene chloride	0.093 - 4.6	421 / 7,219	5.83	82[3]	5 / EPA[4]	0.30	E-Lab Contaminant[3]
N-Nitrodimethylamine	0.005 - 0.005	1,012 / 3,556	28.46	25.11	NA	NA	I-Hist.[1]
N-Nitrosodimethylamine	0.005 - 3.71	1,015 / 3,617	28.06	23.8	.0013 / RBC[9]	28.06	I- >ARARs
Naphthalene	0.875 - 3.5	6 / 66	9.10	1.6	6.2 / PRG[8]	0.0	E- <ARARs
Naphthalene, decahydro-,trans	NA	1 / 1	100.0	7	30 / WQCC[4]	0.0	E- <ARARs
Tetrachloroethene	0.1 - 2.05	913 / 7,220	12.65	39	5 / EPA[4]	4.72	I- >ARARs
1,1,2,2-Tetrachloroethane	0.12 - 10.0	25 / 7,220	0.35	0.8	10 / WQCC[4]	0.0	E- <ARARs
Tetrahydrofuran (THF)	0.32 - 2.13	506 / 3,189	15.87	100	1.6 / PRG[8]	14.42	I- >ARARs
Toluene	0.1 - 2.05	115 / 3,189	3.61	30	750 / WQCC[4]	0.0	E- <ARARs
Trichloroethene	0.089 - 2.04	3,035 / 7,220	42.04	2,000	5 / EPA[4]	20.61	I- >ARARs
Trichlorofluoromethane (Freon 11)	0.055 - 1.61	2,816 / 7,220	39.00	1,800	1,300 / RBC[9]	0.06	I- >ARARs
1,1,2-Trichloro-1,2,2-Trifluoroethane (Freon 113)	0.103 - 1.99	3,391 / 7,220	46.97	2,600	59,000 / RBC[9]	0.0	I-Hist.[1]
Vinyl chloride	0.05 - 3.8	133 / 7,220	1.84	2.8	1 / WQCC[4]	0.34	I- >ARARs
1,1,1-Trichloroethane	0.05 - 2.6	18 / 7,220	0.25	0.44	60 / WQCC[4]	0.0	E- <ARARs
1,1,2-Trichloroethane	0.1 - 7.4	13 / 7,220	0.18	1.2	5 / EPA[4]	0.0	E- <ARARs
1,1-Dichloroethane	0.05 - 2.05	12 / 7,220	0.17	0.9	25 / WQCC[4]	0.0	E- <ARARs
1,2,3,4,6,7,8-HpCDD	0.000011-0.0165	1 / 16	6.25	3.768	NA	NA	E-NA
1,2-Dichloroethane	0.092 - 6.0	74 / 7,220	1.03	0.99	5 / EPA[4]	0.0	I-Carc.
1,2-Dichloroethene (total)	0.2 - 4.02	28 / 1,983	1.41	1.2	55 / RBC[9]	0.0	E- <ARARs
1,2-Dichloropropane	0.05 - 6.0	1 / 7,220	0.014	0.14	5 / EPA[4]	0.0	I-Carc.

Table 2.1 : Frequency of Detection and Percent Detection above Regulatory Standards (5/1/98 - 6/24/03).

Analyte Name Organic Chemicals	Range of Detection Limits (µg/L)	Number Detects/ Number Samples	Frequency of Detection (Percent)	Maximum Concentration (µg/L)	Regulatory Limit/ Source (µg/L)	Percent Detects Above Reg. Limit	Inclusion/ Exclusion in Toxicity Screen - Justification
2,4,5-TP (Silvex)	0.01 - 0.32	2 / 58	3.45	0.46	50 / EPA[4]	0.0	E- <ARARs
2,4-D	0.3 - 0.53	1 / 57	1.75	4.7	70 / EPA	0.0	E- <ARARs
2-Hexanone	0.42 - 2.8	2 / 3,189	0.06	9	1,500 / RBC[9]	0.0	E- <ARARs
2-Propanol	5.6 - 30	3 / 3,189	0.09	13	NA	NA	E-NA
4-Methyl-2-Pentanone (MIBK)	0.17 - 3.2	3 / 3,189	0.09	1.2	140 / RBC[9]	0.0	E- <ARARs
Aniline	1.9 - 10.0	2 / 63	3.17	1.4	12 / RBC[9]	0.0	E- <ARARs
Beta-Endosulfan	0.006 - 0.037	3 / 58	5.17	0.037	NA	NA	E-NA
Bromoform (THM)	0.11 - 5.9	32 / 7,220	0.44	3.8	8.5 / RBC[9]	0.0	I-Carc.
Carbon disulfide	0.15 - 2.08	67 / 3,189	2.10	18	1,000 / RBC[9]	0.0	E- <ARARs
Carbon tetrachloride	0.05 - 3.3	20 / 7,220	0.28	2.7	5 / EPA[4]	0.0	I-Carc.
Chlorobenzene	0.05 - 6.8	3 / 7,220	0.04	20	100 / EPA[4]	0.0	E- <ARARs
Chloroethane	0.1 - 5.0	13 / 7,220	0.18	1.6	3.6 / RBC[9]	0.0	E- <ARARs
cis-1,2-Dichloroethene	0.07 - 1.8	48 / 3,821	1.26	2.5	70 / EPA[4]	0.0	E- <ARARs
cis-1,3-Dichloropropene	0.077 - 3.5	4 / 7,220	0.06	0.75	10 / HA[4]	0.0	E- <ARARs
Dalapon (Sodium Salt[5])	0.42 - 0.42	1 / 31	3.23	2.3	200 / EPA[4]	0.0	E- <ARARs
delta-BHC	0.005 - 0.039	1 / 58	1.72	0.24	NA	NA	E-NA
Ethylbenzene	0.1 - 2.0	91 / 3,189	2.85	4	700 / EPA[4]	0.0	E- <ARARs
gamma-BHC (Lindane)	0.003 - 0.044	1 / 58	1.72	0.0088	0.2 / EPA[4]	0.0	I-Carc.
Iodomethane	0.1 - 1.97	1 / 3,189	0.03	0.48	NA	NA	E-NA
MCPP	12 - 12	1 / 31	3.23	300	NA	NA	E-NA
OCDD	0.025 - 30.307	4 / 16	25.00	53.445	NA	NA	E-NA
Propionitrile	2.1 - 8.9	7 / 3,189	0.22	18	NA	NA	E-NA
Styrene	0.2 - 2.01	28 / 1,983	1.41	1.2	100 / EPA[4]	0.0	E- <ARARs
Total Phenolics	0.6 - 1.0	7 / 17	41.17	0.00247	5 / WQCC[4]	0.0	E- <ARARs
Total Phenols	2.8 - 13	2 / 41	4.88	0.004	5 / WQCC[4]	0.0	E- <ARARs
trans 1,2-Dichloroethene	0.05 - 2.5	28 / 5,237	0.53	3.5	100 / EPA[4]	0.0	E- <ARARs
Xylenes (total)	0.3 - 3.8	5 / 3,184	0.16	3.5	620 / WQCC[4]	0.0	E- <ARARs

Table 2.1 : Frequency of Detection and Percent Detection above Regulatory Standards (5/1/98 - 6/24/03), key.

E- < ARARs – Excluded from Toxicity Screen because five year concentrations never exceeded Applicable or Relevant or Appropriate Requirements (ARARs).
E-NA – Excluded from Toxicity Screen because toxicity numbers (slope factor, reference dose) are not available.
E- Lab Contaminant[3] – Excluded from Toxicity Screen as a laboratory contaminant.
E- Essential Nutrient[3] – Excluded from Toxicity Screen. Considered an essential nutrient.
E-[3] – Excluded from Toxicity Screen for reasons described in text. See text for explanation.
I- >ARARs – Included in Toxicity Screen because maximum concentration exceeded ARARs.
I-Hist.[1] – Included in Toxicity Screen regardless of Frequency of Detection (FOD) or concentrations relative to ARARs because of historical use or detection. See BHRA.
I-Hist.[3] – Bromacil is included in Toxicity Screen. See explanation in text and Appendix C.
I-Carc. – Included in Toxicity Screen (regardless of concentration) because chemical is known or reasonably anticipated to be a human carcinogen[10] and classified by EPA in Group A or B[5].

1 – NASA-WSTF Baseline Health Risk Assessment (NASA, 1996)
2 – Pending establishment of background concentration.
3 – Discussion in text.
4 – Table of New Mexico and the U.S. EPA's Groundwater Standards (20.6.2 NMAC) at www.nmenv.state.nm.us/gwb/gwstds.html
5 – 2002 Edition of the Drinking Water Standards and Health Advisories (EPA, 2002a).
6 – National Primary Drinking Water Standards (EPA, 2002b).
7 – Drinking Water Advisory Table or Secondary Drinking Water Regulations in 2002 Edition of the Drinking Water Standards and Health Advisories (EPA, 2002a).
8 – EPA Region 9 Preliminary Remediation Goals (PRGs) for Tap Water (EPA, 2002d).
9 – EPA Region 3 Risk Based Concentrations (RBCs) for Tap Water (EPA, 2002c).
10 – EPA Report on Carcinogens, 10th Edition (EPA, 2002e). Chemical list at http://ehp.niehs.nih.gov/roc/toc10.html

Note: Due to the dynamic nature of the database containing our historical sampling data, the numbers in Table 2.1 reflect the most recent data as of 6/24/03.

2.2.2 Identification of Regulatory Limits

The regulatory limit selected for each individual analyte was the most conservative value of the New Mexico Water Quality Control Commission (WQCC) groundwater standard or the EPA Maximum Contaminant Level (MCL) listed in the Table of New Mexico and the U.S. EPA's Groundwater Standards http://www.nmenv.state.nm.us/gwb/gwstds.html. If no standard existed or the analyte was not included in this table, the most protective value of the EPA Health Advisory, the EPA Region 9 Preliminary Remediation Goal (PRG) (EPA, 2002d) or the EPA Region III Risk Based Concentration (RBC) (EPA, 2002c) was used. Regulatory limits for each analyte were used to compare to method detection limits and maximum analyte concentrations to determine which analytes posed risks warranting their inclusion in the COC determination process. Column 6 of Table 2.1 lists the regulatory limit for each analyte and it's source document. "NA" in Column 6 indicates analytes for which values were not available.

2.2.3 Comparison of Detection Limits to Regulatory Limits

Detection limits and reporting limits were compared to regulatory limits to determine any necessary changes in system quantitation limits in order to detect analytes below the regulatory standard. The ranges of detection limits are listed for each analyte in Table 2.1, Column 2.

2.2.4 Calculation of Frequency of Detection

All positive results were evaluated against the total number of samples analyzed by the appropriate EPA approved method. Those results with J-flag qualifiers were included in the total number of detections due to the certainty of identification. However, according to RAGS guidelines, tentatively identified compounds that were not otherwise detected in sampling results were not included in the totals. Column 3 of Table 2.1 shows the number of detections and the total number of samples for the appropriate method for each analyte.

The Frequency of Detection (FOD) was calculated from the results in Column 3 of Table 2.1. The FOD is the number of positive results divided by the number of total results, including non-detect results (ND), for an individual analyte. Column 4 in Table 2.1 shows the percent FOD for each analyte.

2.2.5 Comparison of Analyte Maximum Concentration to Regulatory Limits

The maximum concentration was determined for each analyte for the 5-year period mentioned above and compared to the regulatory limit. The percent FOD was calculated for the number of results above the regulatory limit. Column 5 in Table 2.1 shows the maximum concentration and Column 7 lists the percentage of detections above the regulatory limit for each analyte. "NA" in Column 7 indicates analytes for which regulatory values were not available.

Once the information for each analyte was synthesized in the Table 2.1, a decision was made whether to carry the analyte further in the COC determination process. For each analyte, Column 8 includes the decision to exclude (E) or include (I) that analyte from further consideration. Also listed in this column is the abbreviation for the justification for that decision.

2.3 Justifications for Excluding Analytes from Further Consideration as COCs

2.3.1 Five-Year Maximum Concentration Below Regulatory Limit

Non-carcinogenic analytes that were never detected above the regulatory limits listed in Table 2.1, Column 6, herein considered the applicable or relevant or appropriate requirements (ARARs), were excluded from further evaluation. Of the 101 analytes listed in the table, 42 were eliminated from further consideration.

2.3.2 Absence of Toxicity Data

Analytes for which regulatory limits or quantitative toxicity values (oral slope factors (SFo) or reference doses) were unavailable were not included in the toxicity screen. SFos (for carcinogens) and reference doses (for non-carcinogens) are necessary for an analyte's inclusion in the toxicity screen and subsequent health risk assessment. For these analytes, "E-NA" appears in Column 8 of Table 2.1. Most of these analytes occurred in <5% of samples or are water quality analytes. Any available information for these analytes is included in Appendix A. Research and evaluation of these analytes will take place as information becomes available in the Integrated Risk Information System (IRIS) (EPA, 2003) or the Hazardous Substance Data Bank (HSDB) (2002). Fifteen of the remaining 59 analytes were eliminated on this basis and included the inorganic water quality analytes sulfate, total dissolved solids, total alkalinity, total Kjeldahl nitrogen, and total sulfide. Organic analytes lacking sufficient information included dinonyl phthalate, hexyl 2-ethylhelxyl phthalate, 1,2,3,4,6,7,8-HpCDD, 2-propanol, beta-endosulfan, delta-BHC, iodomethane, MCPP, OCDD, and propionitrile. Following elimination of these analytes, forty-three analytes remain from the original 101.

2.3.3 Laboratory Contaminants

Acetone, methylene chloride, and 2-butanone are treated as laboratory contaminants in RAGS guidance (EPA, 1989, Section 5.5). Laboratory contaminant detections in blanks are considered positive results only if the sample result is greater than ten-times the blank concentration. Acetone was previously eliminated from the toxicity screen because results never exceeded ARARs. Although methylene chloride and 2-butanone results exceeded ARARs, they were eliminated from further COC evaluation as a significant number of results received reagent blank "RB", equipment blank "EB", and trip blank "TB" flags. With the elimination of these analytes, 41 analytes remained for further evaluation.

2.3.4 Essential Nutrients

Inorganic analytes considered to be essential nutrients and occurring at levels only slightly elevated above regulatory limits or if they are toxic only at very high concentrations can be eliminated from the toxicity screen. Magnesium, potassium, iron, and sodium are listed in RAGS Section 5.9.4 as essential nutrients. Fluoride and chloride were cited as essential nutrients in the EPA Region 8 supplementary guidance and were also eliminated from further consideration. With the elimination of these analytes, 35 analytes remained for further evaluation.

2.3.5 Elimination of Other Analytes

Thallium, 1,2-dibromomethane (EDB), and 1,4-dioxane and all bis (2-ethylhexyl) phthalate (BEHP) were eliminated for reasons unique to those contaminants. Justifications for excluding these analytes from further consideration are discussed in detail below.

2.3.5.1 Thallium

Thallium was detected at 0.0032 mg/L in a single sample (of 58) by RCRA Method 7841. This result is above the 0.002 mg/L EPA MCL for thallium. However, the result was flagged with a J and SP. The J flag, alone would not eliminate thallium from further consideration in the COC evaluation. However, the SP flag indicates that either the spike recovery or the relative percent difference for spike duplicates was outside standard limits. Thallium is therefore eliminated from further consideration in the COC evaluation.

2.3.5.2 1,2-Dibromomethane

EDB was detected once at 1.9 µg/L in well ST-6-575 on 2/8/99. Subsequent sampling of well did not result in repeated detection of EDB. Remediation system sampling analyses will use appropriate quantitation limits for Method 8011 for detection of EDB.

2.3.5.3 1,4-Dioxane

1,4-Dioxane was detected in 27 samples within a limited 4-month period (between 5/13/01 and 9/23/01). All results were flagged with "RB" indicating that the analyte was detected in the reagent blank at or above the reporting limit. All the results were higher than the 6.1 EPA Region III RBC (EPA, 2002c). RAGS (EPA, 1989, Section 5.5) states that for analytes not commonly considered to be laboratory contaminants, site sample results should be considered as positive only if the concentration of the chemical in the site sample exceeds five times the maximum amount detected in any blank. The maximum result for 1,4-dioxane was 210 (less than five times the maximum blank result of 43). Therefore, no results for 1,2-dioxane should be considered positive and 1,4-dioxane was eliminated from further consideration as a COC.

2.3.5.4 Bis (2-ethyl-hexyl) Phthalate

BEHP was eliminated from the Toxicity Screen for reasons described herein. Analyses by EPA Method 8270 inconsistently detected BEHP in WSTF groundwater samples between 1987 and 1999. In 1996, NASA implemented the use of EPA Method 525.2, which is significantly more sensitive to phthalate compounds, for a landfill groundwater monitoring program. Following this implementation analyses by Method 525.2 consistently detected BEHP indicative of contamination in groundwater monitoring wells downgradient of the landfill. Although detections were consistent, the values of analytical results remained inconsistent and an investigation was launched in 1997 to determine the source of the BEHP contamination. The phthalate source was determined to be tape adhesive on non-dedicated Bennett pumps used to purge monitoring wells. NASA subsequently discontinued use of these adhesive tapes. A detailed explanation for the elimination of BEHP from consideration as a contaminant of concern was included in Appendix I of the NASA-WSTF Post Closure Care Annual Report for the year

2000 (NASA, 2000). Appendix B of this document contains the BEHP discussion. NASA has additionally sampled seven wells to verify the absence of BEHP as a groundwater contaminant. These results will be provided to the New Mexico Environment Department (NMED) in the near future.

2.4 Justifications for Including Analytes as Potential COCs

Of the 101 analytes detected in the WSTF-NASA groundwater-monitoring program over the last five years, thirty-one contaminants were included in the toxicity screen. Justifications for including these in the toxicity screen, abbreviated in Column 8 of Table 2.1, are described below. A conservative approach was taken in the decision-making process regarding the analytes retained for the toxicity screen.

2.4.1 Exceedence of ARARs

If the maximum concentration of the analyte exceeded the ARARs, the contaminant was included the toxicity screen. The abbreviation "I- >ARARs" is assigned each of the qualified analytes in Column 8 of Table 2.1. Analytes with available SFos and whose maximum site-wide concentration exceeded ARARs were included in the carcinogenic toxicity screen. Arsenic, lead, acrylonitrile, chloromethane, bromodichloromethane, gamma-BHC (Lindane), NDMA, tetrahydrofuran (THF), TCE, and vinyl chloride were included in the carcinogenic toxicity screen under the condition of exceeding ARARs. Although PCE is still under EPA review for its carcinogenic classification, it is included in the carcinogenic toxicity screen using its California CAL-modified slope factors. Non-carcinogenic analytes exceeding ARARs and included in the toxicity screen were acrolein, cadmium, chromium III, nickel, nitrate/nitrite (nitrogen), 1,1-dichloroethene, and Freon 11.

2.4.2 Historical Use and Previously Defined COCs

The abbreviation "I-Hist." in Column 8 of Table 2.1 was assigned to any analyte reliably associated with site activities based on historical documentation. These analytes were included in the toxicity screen although the maximum concentration did not exceed the applicable ARARs. The analytes falling into this category included bromacil, DMN, Freon 21, Freon 113, 2,2-dichloro-1,1,1-trifluoroethane (Freon 123), and 1,2-dichloro-1,1,2-trifluoroethane (Freon 123A). Appendix C contains a detailed evaluation of bromacil toxicity and documentation of its historical use on site. Historical use of Freons 11, 21, 113, 123, and 123A is documented in the BHRA (NASA, 1996). There are limited toxicological or carcinogenic data available for DMN, therefore, NDMA slope factors and PRGs were applied to DMN for the toxicity screen and subsequent health risk analysis due to the similarity of these two analytes. Although ARARs have not been assigned to Freon 21, the chronic toxicity of this analyte has been compared with that of chloroform (HSDB, 2002). Therefore, chloroform toxicity values were used for Freon 21 in the toxicity screen as subsequent health risk analysis. Freon 123 and Freon 123A also lack published toxicity values. Toxicity values for Freon 11 were applied to Freon 123 and 123A.

2.4.3 EPA Carcinogenic Classification

Contaminants classified as known or reasonably anticipated to be carcinogens, and classified in EPA Groups A or B (EPA, 2003 and EPA, 2002a), were included in the toxicity screen. Column 8 in Table 2.1 lists the abbreviation "I- Carc." for analytes classified as carcinogens where the maximum concentration does not exceed ARARs. Seven analytes fall into this category and include benzene, bromodichloromethane, chloroform, 1,2-dichloroethane, 1,2-dichloropropane, bromoform, and carbon tetrachloride.

2.4.4 Benzene

Benzene was detected in 68 of 3189 samples analyzed over the five-year period. One positive result (12 µg/L) was detected above the 5 µg/L EPA MCL. This sample, taken from well NASA 9 on 5/15/03 was flagged QD and *, indicating that the precision for a field duplicate was outside the standard limits. For EPA Method 8260, benzene was detected in the 1:1 dilution of the sample. The data and sample bottles/labels were checked and verified by the laboratory. This compound was not detected in the 1:5 dilution of the sample, or in a subsequent noncompliant analysis of the sample. Benzene was not detected in any of the other four method 8260 samples collected from NASA 9 on the same day and is not a common laboratory contaminant. The next highest result for benzene is 4 µg/L (below the 5 µg/L EPA MCL) and is included in Table 2.1.

3.0 Toxicity Screen

The toxicity screen is described in RAGS (EPA, 1989, Section 5.9.5) to reduce the number of contaminants carried through the health risk assessment by eliminating contaminants that do not significantly impact health risk. Tables 3.1 and 3.2 are the results from the toxicity screen calculations. The calculation is defined in RAGS (EPA, 1989, Section 5.9.5). The calculation to determine the estimated risk (Rij) of a contaminant at it's maximum concentration (Cij) is: Rij = (Cij)(Tij), where Cij is the maximum concentration of chemical "i" in the medium "j". For the purposes of this health risk analysis, the medium "j" is groundwater. The appropriate toxicity value (Tij) used for carcinogens is the slope factor. For non-carcinogens, the oral reference dose (RfDo) is substituted for Tij.

3.1 Toxicity Screen for Carcinogens

Table 3.1 is the toxicity screen for carcinogens. Analytes are listed in Column 1. The SFo in mg/kg-day for each analyte is listed in Column 2. An analyte's maximum concentration in mg/L from Table 2.1 is listed in Column 3. Column 4 shows the Rij for the analyte at its maximum concentration. Although NDMA, DMN, TCE, and PCE were previously identified as COCs in the baseline health risk analysis, and will be retained as COCs, they were included in the toxicity screen to examine the relative contribution of all potential carcinogens under consideration for plume-front health risk monitoring. Column 5 is the chemical score, which is the ratio of the individual chemical risk to the total site risk at maximum concentrations.

Table 3.1: Toxicity Screen for Carcinogenic Analytes

Analyte	Toxicity Value (SFo)(Tij)	Maximum Concentration (Cij) in (mg/L)	Risk Factor (Rij)	Chemical Score (Rij/Rj)	Chemical Score <0.010	Frequency of Detection <5%	**Justification to include in Health Risk**
Arsenic	**1.5**	**1**	**1.5**	**0.310403088**	No	No	**Chemical Score**
Lead	**0.00568**	**0.0413**	**0.000234584**	**$4.85437x10^{-5}$**	**Yes**	**No**	**FOD**
Acrylonitrile	**0.54**	**0.055**	**0.0297**	**0.006145981**	Yes	No	**FOD**
Benzene	0.055	0.004	0.00022	$4.55258x10^{-5}$	Yes	Yes	NA
Bromodichloromethane	0.062	0.0003	0.0000186	$3.849x10^{-6}$	Yes	Yes	NA
Bromoform	0.0079	0.0038	0.00003002	$6.2122x10^{-6}$	Yes	Yes	NA
Carbon Tetrachloride	0.13	0.0027	0.000351	$7.26343x10^{-5}$	Yes	Yes	NA
Chloroform	**0.031**	**0.0027**	**0.0000837**	**$1.73205x10^{-5}$**	**Yes**	**No**	**FOD**
Chloromethane	0.031	0.0092	0.0001196	$2.47495x10^{-5}$	Yes	Yes	NA
Dibromochloromethane	0.084	0.0019	0.0001596	$3.30269x10^{-5}$	Yes	Yes	NA
1,2-Dichloroethane	0.091	0.00099	0.00009009	$1.86428x10^{-5}$	Yes	Yes	NA
1,2-Dichloropropane	0.068	0.00014	0.00000952	$1.97002x10^{-6}$	Yes	Yes	NA
Gamma-BHC (Lindane)	1.3	0.0000088	0.00001144	$2.36734x10^{-6}$	Yes	Yes	NA
N-Nitrodimethylamine	**51**	**0.02511**	**1.28061**	**0.265003532**	**No**	No	**Chemical Score**
N-Nitrosodimethylamine	**51**	**0.0238**	**1.2138**	**0.251178179**	**No**	No	**Chemical Score**
Tetrachloroethene	**0.052**	**0.039**	**0.002028**	**0.000419665**	**Yes**	**No**	**FOD**
Tetrahydrofuran	**0.0076**	**0.1**	**0.00076**	**0.000157271**	**Yes**	**No**	**FOD**
Trichloroethene	**0.4**	**2**	**0.8**	**0.165548314**	**No**	**No**	**Chemical Score**
Vinyl chloride	1.5	0.0028	0.0042	0.000869129	Yes	Yes	NA
Total of Risk Factors (Rj)			4.832426154				

Toxicity Screen
Rij = (Cij)(Tij)
Where:
Rij = Risk factor for chemical “i” in groundwater;
Cij = Maximum concentration of chemical “i” in groundwater; and
Tij = Toxicity factor for chemical “i” in groundwater (Oral slope factor)
NA = Not Applicable

3.1.1 Carcinogenic Analytes Eliminated from Quantitative Health Risk

This quantitative process eliminated several analytes and defined the list of carcinogenic COCs to be carried through the health risk analysis. Analytes with a chemical score of < 0.01 and < 5% FOD (Table 2.1) were eliminated from consideration as COCs. Thus, benzene, bromodichloromethane, bromoform, carbon tetrachloride, chloromethane, dibromochloromethane, 1,2-dichloroethane, 1,2-dichloropropane, gamma-BHC (Lindane), and vinyl chloride were dropped from the list of potential carcinogenic COCs.

3.1.2 Carcinogenic COCs and Toxicity Screen Results

Analytes with chemical scores > 0.01 and > 5% site wide FOD were retained as COCs. These analytes are arsenic, NDMA, DMN, and TCE. Carcinogenic analytes (classified in EPA groups A or B) with chemical scores < 0.01, but with > 5% site wide FOD, were also retained as COCs (EPA, 2003). Analytes fitting these criteria include lead, acrylonitrile, chloroform, PCE, and THF. This conservative approach will enable these carcinogens to be included in the periodic health risk review. The potential for use of groundwater drinking water down gradient drives the conservative approach to plume-front health risk.

Carcinogenic COCs, previously identified in the BHRA (NASA, 1996) and the PFSWP (NASA, 2002) (DMN, NDMA, TCE and PCE) were retained and five carcinogenic chemicals were added to the COC list for monitoring at the plume-front. The final list of carcinogenic COCs is therefore comprised of DMN, NDMA, PCE, TCE, acrylonitrile, chloroform, THF, arsenic, and lead.

The FOD for NDMA was 28.06% with 1,015 positive detections out of 3,617 analyses. For DMN, the FOD was 28.46% with 1,012 positive detections out of 3,556 analyses. NDMA and DMN are detected by EPA Method 607. Both DMN and NDMA received chemical scores exceeding 0.25 in Table 3.1. These contaminants were included on the original BHRA COC list and are considered the drivers of carcinogenic health risk at WSTF.

The maximum concentration of TCE at WSTF was 2,000 ppb. The site wide 5-year FOD for TCE was 42.04% with 3,035 positive detections out of 7,220 analyses (Table 2.1). TCE is detected by EPA Methods 8010, 8021, 8240, and 8260. TCE, also an original BHRA COC, received a chemical score of 0.16 in Table 3.1. By all attributes, TCE warrants inclusion on the final COC list.

The maximum concentration of PCE at NASA-WSTF was 39 ppb. The PCE FOD was 12.65% with 913 positive detections out of 7,220 analyses. PCE is detected by EPA Methods 8010, 8021, 8240, and 8260. PCE failed to achieve a chemical score > 0.01 (calculated at 0.0004), but its 5-year site wide FOD and its inclusion as an original BHRA COC qualified this analyte for inclusion on the final COC list.

The presence of acrylonitrile and THF are believed to be influenced by the use of Polyvinyl chloride (PVC)-containing well completions for groundwater monitoring. PVC conventional and Westbay® wells are believed to be leaching these contaminants into groundwater

immediately surrounding these wells. The nature and distribution of these analytes is being evaluated in a separate project. Both contaminants had chemical scores of < 0.01, but are present in > 5% of groundwater samples (Table 3.1).

Acrylonitrile has been detected in 189 of 3,189 analyses by EPA Method 8260 since May 1, 1998 for an FOD of 5.93% (Table 2.1). The calculated chemical score for acrylonitrile in Table 3.1 is 0.00614. Rounded to 0.01, this value, in addition to the > 5% FOD for this analyte qualify acrylonitrile to be included as a COC.

THF was positively detected in 506 of 3,189 analyses by EPA Methods 8240 and 8260 resulting in a 15.87% FOD (Table 2.1). The THF chemical score in the toxicity screen was 0.00016 (Table 3.1). However, the high FOD necessitated its inclusion in the carcinogenic COC list.

Chloroform was detected in 434 of 7,220 analyses by EPA Methods 8010, 8021, 8240, and 8260 resulting in 6.01% FOD (Table 2.1). Although concentrations did not exceed ARARs (EPA MCL of 100 µg/L), due to its EPA Group B2 carcinogenic classification, chloroform was included in the Toxicity Screen (Table 3.1). The chemical score for chloroform was < 0.01 when compared to site wide carcinogenic risk estimates. However, chloroform was retained as a COC due to its FOD of > 5%. This conservative approach will assure that chloroform concentrations during plume-front remediation will be monitored for health risks.

Arsenic and lead both occur naturally in groundwater. However, because concentration levels for these analytes exceed MCLs, and due to the absence of background data for the last 5 years with the contamination of background well (300-D-153) their contribution to overall risk is included here. Installation of a replacement background well is pending. Once this well is installed and sampled for an appropriate period of time, background concentrations will be available for comparison to determine if concentrations on site are actually anthropogenic.

The maximum concentration for arsenic over the 5-year review period was 1 mg/l, well above the MCL. Arsenic was detected in 1,068 of 2,565 analyses by EPA Method 7060A, resulting in a site wide 5-year FOD of 40.90% (Table 2.1). Although < 1% of detections were above the MCL, the carcinogenic classification of arsenic and the high site wide FOD indicated the need to monitor arsenic as a COC until such a time that background levels can be established for comparison. Arsenic received a chemical score of 0.31, the highest calculated in the carcinogenic toxicity screen (Table 3.1), qualifying this analyte to be included on the list of carcinogenic COCs.

Lead was detected in 231 of 2,518 analyses for RCRA metals by EPA Method 7421, resulting in a FOD of 9.17% (Table 2.1). Of the positive detections, 0.32% exceeded the EPA MCL of 0.015 µg/L. Although lead received a chemical score of < 0.10 (4.85×10^{-5}), exceedence of ARARs and the sitewide FOD of over 9% warrant its inclusion as a carcinogenic COC until background concentrations are available for comparison.

3.2 Toxicity Screen for Non-Carcinogens

The toxicity screen for non-carcinogenic analytes is shown in Table 3.2. Again, the analytes are listed in Column 1. Column 2 lists the toxicity value (Tij) for each analyte. For non-carcinogens, the toxicity value is 1/RfDo. Column 3 lists the maximum site wide 5-year concentration (Cij) for each analyte. Column 4 is the estimated risk (Rij) of that analyte at its maximum concentration. Column 5 shows the chemical score, the ratio of the Rij of an analyte to the total risk site wide at maximum concentrations.

3.2.1 Non-Carcinogenic Analytes Eliminated from Quantitative Health Risk

Three analytes included in the non-carcinogenic toxicity screen: acrolein, 1,1-dichloroethene and Freon 123, were eliminated from the further consideration as COCs due to chemical scores of < 0.01 and site wide FODs of < 5%.

3.2.2 Non-Carcinogenic COCs and Toxicity Screen Results

The remaining analytes comprise the final list of non-carcinogenic COCs and include cadmium, chromium III, nickel, nitrate/nitrite (nitrogen), bromacil, Freon 11, Freon 21, Freon 113 and Freon 123A. Of these, Freon 11, Freon 21 and Freon 113 were on the original BHRA COC list. The majority of the remaining non-carcinogenic COCs include analytes with documented historical use and high percent FODs, although most chemical scores were < 0.01. These are chromium III, nickel, bromacil, and Freon 123A. Pending further background evaluation, chromium III, nickel and nitrate/nitrite (nitrogen) will be retained on the COC list for inclusion in plume-front health risk reviews. Chromium III has been associated with the breakdown on stainless steel well casing and is retained also on this basis.

Freons, 11, 21, 113 and 123A, detected by EPA Methods 8010, 8021, 8240, and 8260, all received chemical scores of < 0.01, but had high 5-year site wide FODs ranging from 20-47%. Freon 11 was detected in 2,816 of 7,220 analyses resulting in a site wide FOD of 39% for the 5-year review period. Of the positive detections, 0.06% exceeded the RBC. The chemical score in the Toxicity Screen for Freon 11 was 0.0014, < 0.01 cut off value for inclusion in the health risk assessment. However, the previous inclusion of Freon 11 as a BHRA COC, its documented historical site use, and high FOD demand its retention as a COC for plume-front remediation monitoring of health risk.

Freon 21 was detected in 1,432 of 7,220 analyses by, resulting in a site-wide FOD of 19.83%. The chemical score for Freon 21 was 0.0014, < 0.01 cut off value for inclusion in the health risk assessment. However the site wide FOD of > 5% qualified this analyte for subsequent inclusion in the health risk analysis. In addition, the absence of established MCL or WQCC values makes inclusion in the plume-front health risk monitoring prudent.

Table 3.2: Toxicity Screen for Non-Carcinogenic Chemicals

Analyte	Toxicity Value (1/RfDo) (Tij)	Maximum Concentration (Cij) in (mg/L)	Risk Factor (Rij)	Chemical Score (Rij/Rj)	Chemical Score <0.010	Frequency of Detection <5%	**Justification to include in Health Risk**
Acrolein	50	0.0053	0.265	$6.1188x10^{-5}$	Yes	Yes	NA
Cadmium	**2,000**	**0.092**	**184**	**0.042485241**	**No**	**X**	**Chemical Score**
Chromium III	**0.667**	**4.69**	**3.12823**	**0.000722302**	**Yes**	**No**	**FOD**
Nickel	**50**	**0.11**	**5.5**	**0.001269939**	**Yes**	**No**	NA
Nitrate/Nitrite (Nitrogen)	**6.25**	**660**	**4125**	**0.952454454**	**No**	**No**	**Chemical Score**
Bromacil	**10**	**0.0543**	**0.543**	**0.000125378**	**Yes**	**No**	**FOD, Historical**
1,1-Dichloroethene	20	0.0063	0.126	$2.90932x10^{-5}$	Yes	Yes	NA
Freon 11	3.33	1.8	5.994	0.001384003	Yes	No	FOD, Historical
Freon 21	**100**	**0.06**	**6**	**0.001385388**	**Yes**	**No**	**FOD, Historical**
Freon 113	**0.033**	**2.6**	**0.0858**	**$1.98111x10^{-5}$**	**Yes**	**No**	**FOD, Historical**
Freon 123	3.33	0.0042	0.013986	$3.22934x10^{-6}$	Yes	Yes	NA
Freon 123A	**3.33**	**0.078**	**0.25974**	**$5.99735x10^{-5}$**	**Yes**	**No**	**FOD, Historical**
Total of Risk Factors (Rj)			4330.915756				

Toxicity Screen Calculation
Rij = (Cij)(Tij)
Where:
Rij = Risk factor for chemical “i” in groundwater;
Cij = Maximum concentration of chemical “i” in groundwater; and
Tij = Toxicity factor for chemical “i” in groundwater (Oral slope factor)
Historical = Historical use at WSTF
NA = Not Applicable

Freon 113 was detected in 3,391 of 7,220 analyses, resulting in a site-wide FOD of 46.97%. Freon 113 received a Toxicity Screen chemical score of 1.98×10^{-5}. Sitewide concentrations do not approach the risk-based value of 59,000 µg/L (EPA, 2002c), however, due to documented site-historical use, high site-wide FOD, and it's BHRA COC status, Freon 113 will be retained as a non-carcinogenic COC.

Freon 123A was detected in 1,743 of 7,220 analyses, resulting in a site-wide FOD of 24.14%. The Toxicity Screen chemical score for Freon 123A was 6×10^{-5} (applying the Freon 11 RfDo value). The high site-wide FOD and known historical use necessitated the retention of Freon 123A as a non-carcinogenic COC.

The percent FOD for cadmium was 3.00% with 75 positive detections by EPA Methods 6010A and 6010B) out of 2,498 analyses. Cadmium was, therefore, retained as a COC due to its chemical score of 0.0425.

Nitrate/nitrite (nitrogen) had the highest chemical score (0.95) in the Non-Carcinogenic Toxicity Screen and a site wide five-year FOD of 71.68%, with 162 positive detections out of 226 analyses. Nitrate/nitrite was detected by EPA Method 353.2. The low number of analyses and high FOD percent is indicative of the need for increased sampling for this analyte.

The FOD for bromacil was 49.12% with 390 positive detections out of 794 analyses. Bromacil was detected by EPA Methods 607 and 8270. Bromacil received a chemical score well below the 0.01 score required for inclusion of a COC due to the fact that results never exceeded ARARs. However, because historical use of bromacil is documented and the FOD exceeded 49%, this analyte is included on the final list of non-carcinogenic COCs.

Chromium III and nickel, detected by EPA Methods 6010A and 6010B, both received chemical scores of ~0.001. The FOD for chromium III was 31.45% with 1,023 positive detections out of 3,253 analyses. The nickel FOD was 25.86% with 15 positive detections out of 58 analyses.

4.0 COCs Toxicity Assessment

4.1 Carcinogenic COCs

Physical and chemical properties of the plume-front carcinogenic COCs are listed in Table 4.1. Toxicity information is provided for the plume-front carcinogenic COCs in tables 4.2 and 4.3.

4.1.1 NDMA (CAS. NO. 62-75-9) and DMN (CAS. NO. 4164-28-7)

NDMA and DMN groundwater contamination originated from the historical management of unsymmetrical di-methyl hydrazine rocket fuels at WSTF. Toxicological or carcinogenic data is limited for DMN; however, NDMA and DMN have similar chemical structures. Therefore, the most conservative approach for the health risk assessment of DMN is to apply NDMA toxicological values to DMN. The information below was obtained from the HSDB (2002).

TABLE 4.1: PHYSICAL AND CHEMICAL PROPERTIES OF PLUME-FRONT CARCINOGENIC COCS

COMPOUND	MOLECULAR WEIGHT (g/mol)	SPECIFIC GRAVITY	SOLUBILITY (mg/l)	BOILING POINT (°C)	VAPOR PRESSURE (mm Hg)	HENRY'S LAW CONSTANT (atm-m^3/mol)	LOG K_{ow}
NDMA	74.08[a]	1.0059[a] $_{20/4°C}$	Miscible[a]	154[a]	8[a] $_{25°C}$	1.43E-1[a] $_{25°C}$	-0.47[a]
DMN	90.08[b]	---	Miscible[h]	---	1.7[b] $_{20°C}$	---	---
PCE	165.83[a]	1.6227[a] $_{20/4°C}$	150[a] $_{25°C}$	121[a]	19[a] $_{25°C}$	2.685E-2[a] $_{25°C}$	2.53[a]
TCE	131.39[a]	1.4642[a] $_{20/4°C}$	1,100[a] $_{25°C}$	87[a]	77[a] $_{25°C}$	1.17E-2[a] $_{25°C}$	2.53[a]
THF	72.11[c]	0.8892 $_{20/4°C}$	Miscible[c]	65[c]	162 $_{25\,°C}$	7.05E-5[c] $_{25°C}$	.046[c]
Acrylonitrile	53.06[c]	1761.5 kJ/mol[c] $_{25°C}$	74,500 mg/l[c] $_{25°C}$	77.3[c] $_{760\ mm\ Hg}$	109[c] $_{25°C}$	1.38E-4[c] $_{25°C}$	---
Chloroform	119.38[c]	1.4835[c] $_{20°C}$	7,710 mg/l[c] $_{25°C}$	61.2[c]	197[c] $_{25°C}$	3.67E-3[c]	1.97[c]
Arsenic	74.92[c]	5.778[c] $_{25°C}$	Insoluble[c]	---	7.50E-3[c] $_{280°C}$	---	---
Lead	207.2[c]	11.34[c]	---	1740[c]	1.77[c] $_{1000°C}$	N/A	N/A

[a] Handbook of RCRA Ground-Water Monitoring Constituents Chemical and Physical Properties (EPA,1992).
[b] New Jersey Department of Health and Senior Services, Hazardous Substance Fact Sheet, 1998.
[c] Hazardous Substance Data Bank http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?hsdbadv
K_{ow} Octanol-water Partition coefficient

TABLE 4.2: TOXICITY INFORMATION FOR CARCINOGENIC PLUME-FRONT CHEMICALS

Carcinogen	Oral Slope Factor (SF_o) $(mg/kg/day)^{-1}$	Inhalation Slope Factor (SF_i) $(mg/kg/day)^{-1}$	EPA Weight of Evidence Classification	Target Organ(s)	SF Source
NDMA	51	49	B_2	Liver	IRIS
DMN	51[1]	49[1]	Not Assessed	Liver[1]	IRIS[1]
TCE**	0.4	0.4	B_2	Liver[2]	EPA Region 9 PRG Table
PCE**	0.052	0.01	Not Assessed	Liver[2]	EPA Region 9 PRG Table
Acrylonitrile**	0.54	0.24	B_1	Multiple, according to exposure level[3]	EPA Region 9 PRG Table
Chloroform**	0.031	0.019	B_2	Liver, kidney[3]	EPA Region 9 PRG Table[5]
THF**	0.0076	0.0068	Not Assessed	No Data	HSDB
Arsenic**	1.5	15	A_1	Liver, Kidney, Lung, Bladder	EPA Region 9 PRG Table
Lead	0.00568[4]	N/A	B_2	Kidney[2]	IRIS

**Carcinogens with RfD data available are included in the evaluation of non-carcinogens.

1 NDMA values are applied to DMN

2 2002 Edition of EPA Drinking Water Standards and Health Advisories (EPA, 2002a).

3 Hazardous Substance Data Bank (HSDB, 2002).

4 Lead data from: Public Health Goal for Lead in Drinking Water, (California EPA, 1997a).

5 California Modified PRG toxicity values from EPA Region 9 PRG Table (EPA, 2002d).

TABLE 4.3: TOXICITY INFORMATION FOR NON-CARCINOGENIC EFFECTS FROM CARCINOGENIC COCS

Non-Carcinogen	Oral Reference Dose (RfD_o) (mg/kg/day)	Inhalation Reference Dose (RfD_i) (mg/kg/day)	Confidence Level & UF/MF	Health Effect	RfD Source
PCE**	0.01	0.14	Medium 1000/1	Liver	IRIS
TCE**	0.0003	0.01	No data	No data	EPA Region 9 PRG Table
Acrylonitrile**	0.001	0.00057	N/A	Multiple, according to exposure level[2]	EPA Region 9 PRG Table
Chloroform**	0.01	0.00086	1000/1	CNS and cardiac depressant[2]	EPA Region 9 PRG Table
THF**	0.21	0.086	N/A	Skin. Liver, kidney and chronic respiratory diseases	HSDB
Arsenic**	0.0003	N/A	Medium 3/1	Skin, circulatory system damage[1]	EPA Region 9 PRG Table

**Carcinogens with RfD data available are included in the evaluation of non-carcinogens.
MF- Modifying Factor
UF- Uncertainty Factor

1 2002 Edition of EPA Drinking Water Standards and Health Advisories (EPA, 2002a).
2 Hazardous Substance Data Bank (HSDB, 2002).
3 Lead data from: Public Health Goal for Lead in Drinking Water, (California EPA, 1997a).

Toxicity

NDMA is a carcinogen in experimental animals following both oral and inhalation exposure. It is likely to be a human carcinogen as well, based on the high degree of tumor formation in a wide variety of animal species. The EPA classifies NDMA as a Group B2 carcinogen and the American Conference of Governmental Industrial Hygienists has placed NDMA in the A2 category as a suspected human carcinogen. IRIS reports a SFo of 51 $(mg/kg/day)^{-1}$ and an inhalation slop factor (SFi) of 49 $(mg/kg/day)^{-1}$ (EPA, 2003).

NDMA enters the body via breathing or ingesting contaminated media. It can also be absorbed through the skin. Once in the bloodstream, the primary target organs are the liver and respiratory system. Hepatotoxicity is the main effect from both acute and chronic exposure to NDMA. Detailed toxicological profiles are located in Appendix D.

Regulatory Limits

Federal regulatory limits for NDMA have not been established. WQCC regulations consider NDMA a "toxic pollutant" that, in the presence of other listed toxic pollutants, shall not exceed concentrations in groundwater that pose a cancer risk greater than $1x10^{-5}$. EPA Analytical Methods 607 and 8070, the only EPA-approved methods currently available for the detection of NDMA in groundwater, cannot detect NDMA at concentrations below 0.1 ppb.

Environmental Fate and Transport

NDMA may degrade in the environment where exposed to sunlight. When released into the atmosphere, it breaks down by photolysis in minutes. When released to surface soil, NDMA may evaporate into air, break down upon exposure to sunlight, or leach through the soil. It will persist in the absence of sunlight and break down much slower in deep soil and groundwater. No degradation rate is available. It will be transported in groundwater by advection and diffusion and can sorb to the aquifer matrix. NDMA does not appear to be affected by biodegradation as much as by photolysis.

4.1.2 TCE (CAS. NO. 79-01-6)

Information for this analyte was obtained from the HSDB (2002) and IRIS (EPA, 2003). TCE was used as a cleaning solvent for various test article components processed at WSTF. The major exposure routes for TCE are from breathing air and ingestion of contaminated drinking water.

Toxicity

TCE is currently being reassessed under IRIS (EPA, 2003). The EPA classifies TCE as a Group A2 carcinogen. PRG Tables report a SFo of $4.0x10^{-1}$ $(mg/kg/day)^{-1}$, a SFi of 4.0×10^{-1} $(mg/kg/day)^{-1}$, an RfDo of $3x10^{-4}$ (mg/kg/day), and an inhalation reference dose (RfDi) of $1.0x10^{-2}$ (mg/kg/day) (EPA, 2002d).

When inhaled, TCE is absorbed by the lungs, enters the bloodstream, and then distributed throughout the body. Internally, TCE effects the cardiovascular system and the central nervous system (CNS). The target organ is the liver. External exposure is damaging to the skin. Populations at special risk are those with cardiovascular impairment or alcoholics.

TCE mostly effects the CNS. Acute exposure to high levels of TCE can cause death from cardiac or respiratory failure. Inhalation exposure to moderate levels may cause headaches, dizziness, or impaired ability to perform. Chronic exposure effects are uncertain in humans but animals have shown enlarged livers and liver and kidney damage. Detailed toxicological profiles for TCE, including health effects resulting from acute, intermediate, and chronic exposure, are provided in Appendix D.

Environmental Fate and Transport

TCE is relatively short-lived in the atmosphere. Residence times range from five days to three weeks with formation of phosgene, dichloroacetyl chloride, and formyl chloride. It is not subject to direct photolysis. When released to surface soils, TCE is subject to evaporation, biotransformation within soil to 1,1-dichloroethene, cis- and trans-1,2-dichloroethene, and vinyl chloride, and rapid leaching to groundwater with little soil adsorption. TCE decomposes slowly in groundwater. TCE is transported in groundwater by advection and diffusion. The predominant processes affecting TCE in groundwater are volatilization and biotransformation.

Regulatory Limits

Recent changes in toxicity values and EPA cancer risk-based $1x10^{-5}$ concentrations significantly affected the health risk values for NASA-WSTF groundwater. Third only to NDMA and DMN as far as inferred cancer risk values, TCE is a significant driver in health risk calculations.

The present EPA MCL for TCE is 5 µg/L. WQCC groundwater standard is set at 100 µg/L. WSTF's health risk conservative approach recognizes the more protective number of EPA. The Region 9 PRG is 0.028 µg/L and Region III RBC is 0.026 µg/L for tap water.

4.1.3 PCE (CAS. NO. 127-18-4)

Information for this analyte was obtained from the HSDB (2002) and IRIS (EPA, 2003).

Toxicity

PCE may reasonably be anticipated to be a carcinogen. This is based on long term animal studies using high levels of PCE that resulted in liver and kidney cancers. A RfDo of 1×10^{-2} (mg/kg/day) is reported in IRIS with an uncertainty factor of 1000, however, a chronic inhalation exposure (RfC) is not available. No carcinogenicity assessment for lifetime exposure is presently available from IRIS (EPA, 2003). PRG Tables report a SFo of 5.20×10^{-2} $(mg/kg/day)^{-1}$ and a SFi of $1.0x10^{-2}$ $(mg/kg/day)^{-1}$. These values were used for the purposes of this health risk assessment (EPA, 2002d).

The effects of inhalation or ingestion of low levels of PCE are not well known. High levels of PCE in the air may cause dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking, and possible unconsciousness and death. Dermal exposure to PCE causes skin irritation. Chronic exposure effects are uncertain in humans, but animal studies have shown that it can cause liver and kidney damage. Detailed toxicological profiles for PCE, including health effects resulting from acute, intermediate, and chronic exposure, are located in Appendix D.

Environmental Fate and Transport

PCE evaporates easily into air where it takes several months to break down. When released to surface soils, PCE is subject to evaporation to the atmosphere, biodegradation, and decomposition in the soil to TCE, 1,1-dichloroethene, cis- and trans-1,2-dichloroethene, vinyl chloride, and methylene chloride. It is likely that a small amount will adsorb to soils while it leaches to groundwater. PCE decomposes slowly in groundwater. The predominant process effecting it in groundwater is volatilization. Decomposition and biodegradation in groundwater occur slowly. PCE does not appear to bioaccumulate in aquatic organisms.

Regulatory Limits

WQCC regulations list a groundwater standard of 20 µg/L and an EPA MCL of 5 ppb for PCE. NASA-WSTF health risk conservative approach recognizes the more protective number of the EPA. The Region 9 PRG is 0.028 µg/L and Region III RBC is 0.026 µg/L for tap water.

EPA qualitative and quantitative assessments of TCE and PCE are currently underway and are slated for entry into IRIS during the 2003 or 2004 fiscal years (Federal Register, 2003). WSTF health risk reviews will update any changes in the quantitative values for these contaminants as information is made available.

4.1.4 Contaminants as consequences of NASA-WSTF groundwater monitoring activities

4.1.4.1 Acrylonitrile (CAS. NO. 107-13-1)

Information on acrylonitrile has been compiled from IRIS (EPA, 2003) and the HSDB (2002). These and other sources are available through TOXNET, a source for chemical databases at: http://toxnet.nlm.nih.gov/. Acrylonitrile is one component of acrylonitrile-butadiene-styrene plastics, as well as, acrylonitrile resins, acrylamide, nitrile elastomers, polymers, polyols, barrier resins, and carbon fibers may result in its release to the environment through various waste streams. Varying the monomer combinations can produce plastics with a wide range of properties. Acrylonitrile's property contributions to the plastics are rigidity, impact strength, hardness, and chemical and heat resistance.

Toxicity

The EPA has classified acrylonitrile as a probable human carcinogen (Group B1) (EPA, 2003). This classification was based on observations of statistically significant increases in lung cancers in exposed workers and observation of tumors in the brains of rats exposed to acrylonitrile by

various routes including drinking water and inhalation. A reference concentration for RfC of 2E-03 mg/m^3 was established in 1991 and published in IRIS with an uncertainty factor of 1000 with no modifying factor.

A quantitative estimate of carcinogenic risk from oral exposure to acrylonitrile resulted in an estimated SFo of $5.4x10^{-1}$ and drinking water unit risk of $1.5x10^{-5}$ per µg/L. Drinking water concentration at $1x10^{-5}$ cancer risk is $6x10^{-1}$ µg/L and at $1x10^{-6}$ cancer risk is 6E-02. An SFi of $2.4x10^{-1}$ from PRG table is used in calculating health risk of acrylonitrile at the plume-front.

Environmental Fate and Transport

Acrylonitrile is expected to exist solely as a vapor in the ambient atmosphere due to its vapor pressure of 109 mm Hg at 25° C. Vapor-phase acrylonitrile is degraded in the atmosphere by reaction with photochemically produced hydroxyl radicals and ozone with a half-life for reaction with hydroxyl radicals estimated to be four days. Acrylonitrile does not absorb light > 290 nm and is therefore not susceptible to direct photolysis. Acrylonitrile is not expected to adsorb to suspended solids and sediment in an aquatic environment based on an estimated Koc value of 33. Volatilization from surface water is expected based on a Henry's Law constant of $1.38x\ 10^{-4}$ and estimated volatilization half-lives for a model river and model lake are four hours and four days respectively. Environmental biodegradation of acrylonitrile has been demonstrated in wastewater, activated sludge and various microbial cultures (HSDB, 2002).

Regulatory Limits

No EPA MCL or WQCC Groundwater Standard exists for acrylonitrile. One hundred percent of detections of this analyte for the five-year study period were above the 0.037 µg/L RBC (EPA, 2002c).

4.1.4.2 Tetrahydrofuran (THF) (CAS. NO. 109-99-9)

Information on this analyte has been compiled from IRIS (EPA, 2003) and the HSDB (2002) unless otherwise noted. THF is a four-carbon cyclic ether and is widely used as an industrial solvent and a stability agent for other solvents. THF has been identified as a major constituent of PVC primer and adhesive and was found to be leached into water surrounding bonded joints in groundwater wells. The possible leaching of THF from WSTF PVC wells is being investigated.

Toxicity

Data pertaining to the toxicity of THF in humans is limited. THF is currently under investigation as a potential carcinogen in the National Institute for Occupational Safety and Health (NIOSH). The probable oral lethal dose in humans is 50-500 mg/kg. Animal studies indicate that THF is moderately toxic from acute exposure.

Although the EPA has not published an evaluation or classification of THF, it was included in the carcinogenic health risk assessment due to the availability of SFo of $7.6x10^{-3}$ $(mg/kg/day)^{-1}$ and SFi of $6.8x10^{-3}$ $(mg/kg/day)^{-1}$ (EPA, 2002d).

Environmental Fate and Transport

With a Henry's Law constant of $7.10x10^{-5}$ atm-cu m/mole, THF is expected to volatilize from water and possibly moist soil surfaces. THF, which has a vapor pressure of 162 mm Hg at 25° C, will exist solely as a vapor in the ambient atmosphere. Vapor-phase THF is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals (one day) and nitrate (three days) radicals. Butyrolactone and alpha-hydroxytetrahydrofuran were formed as products during the photo-oxidation of THF.

At concentrations of 0.5, 5 and 10 mg/L, THF was detected in distilled water for one to two, six to eight and ten days respectively. In the presence of microbial contamination, degradation took two to three days less. The chemical and biochemical oxidation of THF is accompanied by considerable consumption of dissolved O_2. THF has an estimated Koc value of 18-23 that indicates a very high mobility in soil. A retardation factor of 1.0 was measured for THF in a groundwater system in Indiana and a retardation factor of 2.2 based on plume length, was measured for THF in an aquifer beneath a landfill in Ottawa, Ontario. A column packed with aquifer material was used to measure a retardation factor of 1.2 for THF.

Regulatory Limits

No EPA MCL or WQCC Groundwater Standard are provided for THF. NASA used the EPA Region 9 PRG of 1.6 µg/L for the purpose site concentration comparison.

4.1.5 Chloroform (CAS. NO. 67-66-3)

Information on this analyte has been compiled from IRIS (EPA, 2003) and the HSDB (2002), unless otherwise noted. Chloroform is primarily used at pulp and paper mills, pharmaceutical manufacturing plants, and is a by-product of water chlorination. Human exposure occurs from contaminated air, food and beverages, but also from chlorinated drinking water supplies, pools and spas. Exposure from air is one-tenth that from drinking water but becomes comparable in industrial and urban areas.

Toxicity

Chloroform carcinogenicity data is inadequate in human studies, but sufficient in animal studies. It is classified by the EPA as a B2 (probable human) carcinogen based on increased incidence of several tumor types in rates and three strains of mice.

When ingested, chloroform can be 100% absorbed from the gastrointestinal tract into the bloodstream and distributed to all organs. It is absorbed by the lungs, where it is distributed throughout the body. Internally, the target organs are the liver, kidneys and heart. Externally, chloroform is damaging to the eyes and skin. Populations at special risk are those with liver, kidney, or CNS diseases and/or chronic alcoholics.

Acute effects from chloroform exposure are dizziness, headache, nausea, CNS depression, cardiac arrhythmia, and death. Chronic exposure causes liver and kidney damage. Inhalation studies on humans have shown 400 ppm chloroform can be endured for 30 minutes without

complaint. Dizziness and gastrointestinal upset was noted after a seven-minute exposure of 1,000 ppm. Exposures greater than 1,000 ppm up to 14,000 ppm have caused fatigue, headache, dizziness, salivation, fainting sensation, vomiting, and CNS depression.

During the BHRA process, chloroform was evaluated as a COC using a SFo of $6.1x10^{-3}$ (mg/kg-day) $^{-1}$ and a SFi of $8.05x10^{-2}$ (mg/kg-day) $^{-1}$, EPA values current in 1996. Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS by April 1997 and chloroform underwent reassessment under the IRIS program beginning in December of 1998. In October of 2001, the RfDo and the oral carcinogenicity assessment were updated in IRIS.

Currently, EPA does not assign SFo or SFi values to chloroform. However, the EPA Region 9 PRG Table lists the California EPA SFo of 3.1E-02 (mg/kg-day) $^{-1}$or SFi of 1.9E-02 (mg/kg-day) $^{-1}$ to chloroform (EPA, 2002d). These values were used for chloroform in the Toxicity Screen and the subsequent health risk calculations.

Environmental Fate and Transport

The majority of environmental releases will eventually be conveyed to the atmosphere due to chloroform's high vapor pressure. Once in the atmosphere, it may be transported long distances and will photodegrade with a half-life of a few months. When chloroform is released to surface or near-surface soils, the majority will readily evaporate to the atmosphere. That which does not evaporate leaches through the soil to the groundwater where it is expected to reside for long periods. Chloroform is unlikely to sorb to solid matrix of the aquifer. Data on biodegradation is conflicting. The reduction of chloroform concentrations in groundwater is due mostly likely to volatilization. Chloroform is not expected to bioaccumulate in the food chain.

Regulatory Limits

EPA has promulgated a drinking water MCL for total trihalomethanes (compounds similar to and including chloroform) of 80 µg/L.

4.1.6 Arsenic (CAS. NO.7440-38-2)

Information on this analyte has been compiled from IRIS (EPA, 2003) and the HSDB (2002) unless otherwise noted. Arsenic is a naturally occurring element and is used in manufacturing glass and metallurgy. Human exposure occurs from absorption into the body from industrial exposure, usually by inhalation and ingestion.

Toxicity

The EPA has classified arsenic as a human carcinogen (Group A) based on sufficient evidence from human data. Inhalation exposure has resulted in an increased lung cancer mortality rate in multiple human populations. Increased mortality from liver, kidney, lung and bladder cancers and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic arsenic. A RfDo of $3x10^{-4}$ has been established for arsenic with a medium confidence level and an uncertainty factor of three. No modifying factor was applied.

A quantitative estimate of carcinogenic risk from oral exposure provided an SFo of 1.5 per mg/kg/day and drinking water unit risk of $5x10^{-5}$ per (µg/L). The drinking water concentration is 0.2 µg/L for a $1x10^{-5}$ cancer risk and 0.02 µg/L for $1x10^{-6}$ cancer risk.

Environmental Fate and Transport

Arsenic occurs naturally in soil and minerals. In natural waters, arsenic (as a free element) is rarely encountered. Arsenic can not be destroyed in the environment. Arsenic may enter water sources (lakes, rivers, or underground water) by dissolving in rain or snow or through the discharge from industrial wastes. It can stick to particles in the water or sediment on the bottom of the lakes or river. Ultimately most arsenic ends up in the soil or sediment.

Regulatory Limits

The WQCC groundwater standard for arsenic is .01 mg/L (http://www.nmenv.state.nm.us/gwb/gwstds.html).

4.1.7 Lead (CAS. NO. 7439-92-1)

Toxicity

Data for lead toxicity was taken from the HSDB (2002), IRIS (EPA, 2003) and California EPA Pesticide and Environmental Toxicology Section Office of Environmental Health Hazard Assessment publication Public Health Goal for Lead in Drinking Water (California EPA, 1997a). This document is included in Appendix E. Lead is a known animal carcinogen and has been classified by the U.S. EPA as a B2 (probable human) carcinogen.

Lead has multiple toxic affects on the human body. Among its most serious non-carcinogenic effects are decreased intelligence in children and increased blood pressure in adults.

Environmental Fate and Transport

Lead rarely occurs in the elemental state, but exists in a number of ores. Lead also occurs in various uranium and thorium minerals, arising from radioactive decay. Metallic lead is naturally occurring and is the end product of three natural radioactive elements uranium (206), thorium (208), and actinium (207).

Commercially, lead is the fifth most prevalent naturally occurring metal in the United States. It may enter the environment during its mining, ore processing, smelting, refining, manufacture of lead compounds, use of lead metals, alloys and compounds in products like batteries and paints, recycling, and disposal. A former major source of exposure to lead was from the use of tetraethyl lead as an antiknock agent in gasoline. Lead's initial route of entry is often via the atmosphere. Lead occurs naturally in the earth's crust and may also enter the atmosphere from the weathering of rocks, windblown soil, and volcanoes, but these sources are minor compared with anthropogenic ones.

If released or deposited on soil, most lead will be retained in the upper 2-5 cm of soil, especially in soils with at least 5% organic matter or a pH 5 or above. Leaching is not important under normal conditions. In soil, lead is expected to slowly convert to more insoluble forms such as lead sulfate, lead sulfide, lead oxide, and lead phosphate salts. The uptake of lead from soil into plants is generally not significant.

Lead enters surface water from atmospheric fallout, runoff or wastewater discharges; only a minor amount of lead is transferred from natural minerals or leached from soil. Pb++, the stable ionic species of lead, forms complexes of low solubility with major anions in the natural environment such as the hydroxide, carbonate, sulfide, and sulfate ions, which limit solubility. Organic lead complexes are formed with humic materials, which maintain lead in a bound form even at low pH. Lead is therefore effectively removed from the water column to the sediment by adsorption to organic matter and clay minerals, precipitation as insoluble salt (the carbonate, sulfate, or sulfide), and reaction with hydrous iron, aluminum, and manganese oxides. When released to the atmosphere, lead will generally occur as particulate matter and subject to gravitational settling and be transformed to the oxide and carbonate. A fraction of atmospheric lead, ranging from a few percent to as high as 20% in maritime air may exist as alkyl lead compounds.

The general population is exposed to lead from ambient air, especially in areas near industrial sources. However, the highest lead intake is from food and water. Lead concentrations in food may be elevated due to surface contamination of fresh fruits and vegetables. Elevated lead levels in food may be from lead-soldered cans or leaching from ceramic glazes or lead crystal. Elevated levels of lead in drinking water usually result from corrosion in distribution systems containing lead pipe.

Regulatory Limits

The New Mexico WQCC groundwater standard for lead is 0.05 mg/L. However, the EPA MCL for lead is 0.015 mg/L which is more protective and thus used in this assessment.

The U.S. EPA has adopted a Maximum Contaminant Level Goal of zero for lead in drinking water. The EPA has determined it impractical to quantify toxicity or cancer risk due to the many uncertainties, some of which may be unique to lead. The California EPA has calculated a SFo of 0.00568 mg/kg-day for lead and consequently established a modified PRG of 2 ppb (EPA, 2002d). This California EPA SFo value was used in the Toxicity Screen and is applied to lead in the subsequent health risk calculations. See Appendix E for derivation of this value.

4.2 Non-Carcinogenic COCs

Physical and chemical properties of the plume-front non-carcinogenic COCs are listed in Table 4.4. Toxicity information is provided for the plume-front non-carcinogenic COCs in table 4.5.

TABLE 4.4: PHYSICAL AND CHEMICAL PROPERTIES OF PLUME-FRONT NON-CARCINOGENIC COCs

COMPOUND	MOLECULAR WEIGHT (g/mol)	SPECIFIC GRAVITY	SOLUBILITY (mg/l)	BOILING POINT (? C)	VAPOR PRESSURE (mm Hg)	HENRY'S LAW CONSTANT (atm-m^3/mol)	LOG K_{ow}
Freon 113	187.38[a]	1.5635[a] 20/4? C	170 [a] 25? C	47.7[a]	362.5[c] 25? C	5.26E-1[c] 25? C	3.16[c]
Freon 11	137.38[b]	1.494[b] 17.2/4? C	1,100[b] 25? C	23.7[b]	687[b] 20? C	5.83E-2[b] 25? C	2.53[b]
Freon 21	102.92[a]	1.405[b] 9? C	9,500[a] 25? C	9[a]	1,199[e]	1.04E-2[e]	1.29[d]
Freon 123A	152.93[f]	152[f] 25°C	---	28[f]	620[f] 25°C	9.55E-2[f]	2.17[f]
Bromacil	261.12[f]	1.55[f] 25/25°C	815[f]	--	3.07E-7	5.07E-11	---
Cadmium	112.41[f]	8.65[f] 25°C	Insoluble [f]	765[f]	1 Pa[f] 257°C	N/A	---
Chromium	51.996[f]	7.14[f]	Insoluble [f]	2642[f]	1[f] 1616°C	N/A	N/A

[a] CRC Handbook of Chemistry and Physics, 71st Edition, (Lide, 1990).
[b] Handbook of RCRA Ground-Water Monitoring Constituents Chemical and Physical Properties (EPA, 1992).
[c] Handbook of Environmental Fate and Exposure Data for Organic Chemicals, (Howard, 1990).
[d] EPA Treatability Manual, 1981.
[e] *Journal of Physical Chemistry Reference Data*, Vol. 10, No. 4, 1981.
[f] Hazardous Substance Data Bank http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?hsdbadv
K_{ow} Octanol-water Partition coefficient

TABLE 4.5: TOXICITY INFORMATION FOR NON-CARCINOGENIC PLUME-FRONT COCS

Non-Carcinogen	Oral Reference Dose (RfD_o) (mg/kg/day)	Inhalation Reference Dose (RfD_i) (mg/kg/day)	Confidence Level & UF/MF	Health Effect	RfD Source
Freon 11	0.3	0.2	Medium 1000/1	Psychomotor impairment	IRIS
Freon 21	0.01[3]	.00086[3]	Medium[3] 1000/1	Psychomotor impairment	IRIS[3]
Freon 113	30	8.6	Low 10/1	Psychomotor impairment	IRIS
Freon 123A	0.3[4]	0.2[4]	N/A	N/A	N/A
Bromacil	0.1	N/A	N/A	Irritation to skin, eyes	DWSHA[5]
Cadmium	0.0005	N/A	10/1	Kidney damage[5]	IRIS?
Chromium III	1.5	N/A	Low 100/10	Allergic dermatitis[5]	IRIS
Nickel (Soluble Salts)	0.02	N/A	300/1	Dermatoxicity	IRIS
Nitrate/Nitrite (Nitrogen)	0.16[8]	N/A	1/10	Blue-baby syndrome[5]	IRIS, DWSHA[5]

MF- Modifying Factor
UF- Uncertainty Factor

1 NDMA values are applied to DMN
2 Lead data from: Public Health Goal for Lead in Drinking Water, (California EPA, 1997a)
3 Chloroform RfD applied to Freon 21.
4 Freon 11 RfD applied to Freon 123A.
5 2002 Edition of EPA Drinking Water Standards and Health Advisories (EPA, 2002a)
6 Cadmium data from HSDB (2002)
7 California Modified PRG toxicity values from EPA Region 9 PRG Table (EPA, 2003d)
8 Used more conservative nitrite RfDo

4.2.1 Freon 11 (CAS. NO. 75-69-4)

Information on this analyte has been compiled from IRIS (EPA, 2003) and the HSDB (2002). Freon 11 is an organic solvent principally used in the manufacture of cleaning agents and fire extinguishers and as a refrigerant.

Toxicity

There are no reported human data and inadequate animal evidence to support the carcinogenicity of Freon 11. Human exposure to Freon 11 is predominately via inhalation absorption. Human exposure to Freon 11 vapors at concentrations up to 1,000 ppm have not resulted in adverse health effects. Higher concentrations can result in respiratory, CNS and/or cardiac effects, unconsciousness and death. Intentional inhalation abuse of aerosols containing chlorofluorocarbons has resulted in "sudden sniffing deaths" although no significant findings were noted at autopsy. Dermal exposure to pure Freon 11 liquid can cause frostbite. Freon vapors are heavier than air; they can accumulate in low-lying areas, displacing breathing air and resulting in hazards of inhalation of concentrated vapors and/or asphyxiation. Populations at special risk from Freon exposure are those with skin disorders, cardiovascular disease and/or impaired pulmonary function. Health effects resulting from various types of human exposure to Freon 11 are discussed in Appendix D.

Freon 11 has been assigned an RfDo of $3.0x10^{-1}$ mg/kg-day and an RfDi of $2.0x10^{-1}$ mg/kg-day in the EPA Region 9 PRG Table (EPA, 2002d). The applicable values were used in the Toxicity Screen (Table 3.1) and subsequent hazard quotient (HQ) calculations.

Environmental Fate and Transport

Because Freon 11 is highly volatile, releases are expected to be conveyed to the atmosphere where it remains for long periods of time. When released to surface soil Freon 11 rapidly volatilizes to the atmosphere or leaches through the soil to groundwater. Adsorption in soils is considered negligible. In groundwater, Freon 11 is more soluble that Freon 113 and may persist for longer periods of time. It is mobile in groundwater due to its low capacity for adsorption to sediments and is effected mostly by volatilization. Freon 11 will degrade to Freon 21.

Regulatory Limits

EPA MCL and the WQCC Groundwater Standards have not been assigned to Freon 11. Therefore, for the purposes of this assessment, an EPA Region III RBC of 1,300 µg/L was used.

4.2.2 Freon 21 (CAS. NO. 75-43-4)

Toxicity

Limited toxicological data exists for Freon 21. The NIOSH (1990) lists a threshold limit value of 10 ppm, two orders of magnitude less than the threshold limit values for Freon 11 and Freon 113 (both 1,000 ppm). The HSDB (2002) describes the chronic toxicity of Freon 21 to be similar to that of chloroform.

For purposes of the WSTF health risk assessment, the reference dose for chloroform was used to calculate HQs for Freon 21 concentrations detected in the groundwater plume. The EPA assigns chloroform a RfDo of $1.0x10^{-2}$ mg/kg-day and a RfDi of $8.6x10^{-4}$ mg/kg-day (EPA, 2002d). Toxicity information for plume-front chemicals is summarized in Table 3.2.

Regulatory Limits

No EPA MCL, WQCC Groundwater Standard, or RBC exists for Freon 21. For this purpose and for the purpose of the subsequent health risk assessment, chloroform RfDo ($1.0x10^{-2}$ mg/kg/day) and RfDi ($8.6x10^{-4}$ mg/kg/day) values were applied to Freon 21.

4.2.3 Freon 113 (CAS. NO. 76-13-1)

Toxicity

Information on this analyte has been compiled from the HSDB (2002). There are no reported human data and inadequate evidence of carcinogenicity in animals. Human exposure to Freon 113 is predominantly via inhalation and is rapidly cleared from the body by exhalation with minimal absorption.

Human exposure to vapors at concentrations of 1,500 ppm and below has not resulted in adverse health effects. Exposure to concentrations of 1,500 ppm have resulted in slight impairment of pshychomotor performance with increasing decrement at 4,500 ppm. Higher concentrations of Freon 113 depress the CNS and may cause cardiac arrhythmia. Intentional inhalation abuse of aerosols containing chlorofluorocarbons has resulted in “sudden sniffing deaths” although no significant findings were noted at autopsy. Dermal exposure to pure Freon 113 liquid can cause frostbite. Freon vapors are heavier than air; they can accumulate in low-lying areas, displacing the breathing air resulting in hazards of inhalation of concentrated vapors and/or asphyxiation. Populations at special risk from Freon 113 exposure are those with skin disorders, cardiovascular disease and/or impaired pulmonary function. Detailed toxicological profiles for Freon 113, including health effects resulting from acute, intermediate, and chronic exposure, are located in Appendix D.

The RfDo for Freon 113 is 30 (mg/kg-day), and the RfDi is 8.6 (mg/kg-day) as listed in the EPA Region 9 PRG Table (EPA, 2002d).

Environmental Fate and Transport

Freon 113 is volatile, thus is expected to be released to the atmosphere. When released to surface soil Freon 113 rapidly volatilizes to the atmosphere or leaches through the soil to groundwater. Adsorption in soils is considered negligible. In groundwater, Freon 113 is slightly soluble. It is mobile in groundwater due to its low capacity for adsorption to sediments and is effected mostly by volatilization (EPA-Chemical Fact Sheet EPA 749-F-94-012) at http://www.epa.gov/enviro/html/emci/chemref/.

Regulatory Limits

No EPA MCL or WQCC Groundwater Standards exist for Freon 113. California has the strictest State Drinking Water Standard of 1,200 µg/L. The EPA Region 9 has established a tap water PRG for Freon 113 at 59,000 µg/L.

4.2.4 Freon 123A (CAS. NO. 354-23-4)

Toxicity

Information on this analyte has been compiled from the HSDB (2002). A reduction in ozone concentration will result in increased transmission of solar ultraviolet radiation through the stratosphere. Many significant adverse effects of such an increase in exposure to this radiation have been identified.

The toxicity weight for Freon 123A has yet to be determined.

For the purpose of the toxicology screen and subsequent health risk assessment, Freon 11 RfDo ($3.0x10^{-1}$ mg/kg-day) and RfDi ($2.0x10^{-1}$ mg/kg-day) values listed in the EPA Region 9 PRG Table were applied to Freon 123A (EPA, 2000).

Environmental Fate and Transport

Production and use of Freon 123A may result in its release to the environment through various waste streams. There is no available information regarding current use or production. There is undisputed evidence that the atmospheric concentrations of chlorofluorocarbons deplete ozone in the stratosphere.

If released to air, a vapor pressure of 620 mm Hg at 25 ° C indicates that Freon 123A will exist solely as a vapor in the ambient atmosphere. Vapor-phase Freon 123A will be photochemically degraded in the atmosphere. Freon 123A is fairly soluble in water and may be removed from the air by rain. However, any removed by this process is expected to rapidly revolatilize to the atmosphere. If released to soil, Freon 123A is expected to have moderate mobility based upon and estimated Koc of 154. Volatilization from moist soil surfaces is an important fate process based upon an estimated Henry's Law constant of 0.0955 atm-cu m/mole. If released into water, Freon 123A is expected to adsorb moderately to suspended solids and sediment based upon the estimated Koc. Volatilization from water surfaces is expected to be an important fate process.

Regulatory Limits

No EPA MCL, WQCC Groundwater Standards, or RBC exist for Freon.

4.2.5 Bromacil (CAS. NO. 314-40-9)

Appendix C contains information on bromacil toxicity and characteristics of environmental fate and transport.

Regulatory Limits

The EPA has a drinking water HA of 0.09 ppm (90 µg/L) for bromacil (NMED, 2002).

4.2.6 Cadmium (CAS. NO. 7440-43-9)

Toxicity

Information on this analyte has been compiled from the HSDB (2002) and IRIS (EPA, 2003). When swallowed, cadmium compounds are much less lethal than when inhaled. Although as little as 10-20 mg of soluble cadmium salts have produced severe toxic symptoms when ingested, death probably requires several hundred milligrams by oral route.

Cadmium can potentially cause a variety of effects from acute exposures, which include nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock, and renal failure. Cadmium also has the potential to cause kidney, liver, bone and blood damage from long-term exposure at levels above the MCL.

Cadmium carcinogenicity data is limited in human and animal studies. The EPA classifies cadmium as a B1 (probable human carcinogen) based on limited evidence from occupational epidemiological studies. Also, studies have shown evidence that carcinogenicity develops in rats an mice due to inhalation and intramusclar and subcutaneous injection.

Although cadmium is classified as a B1 probable human carcinogen by inhalation, there is no SFo available for cadmium. In the 2002 Table of Drinking water Standards and Health Advisories, Cadmium is listed in Group D (not classifiable as to human carcinogenicity) (EPA, 2002a). Thus for purposes of the health risk assessment, cadmium non-carcinogenic health effects were calculated from the published RfDo and RfDi (EPA, 2002d).

An RfDo of 5.0×10^{-4} mg/kg/day was established based on an estimated No Observed Adverse Effect Level of 0.005 mg/kg/day for cadmium in drinking water and an uncertainty factor of 10 (HSDB, 2002) and (EPA, 2003).

Environmental Fate and Transport

Cadmium is a relatively rare, naturally occurring element that is widely distributed in the earth's crust. Cadmium occurs in nature as Cd (II). Metallic cadmium does not occur in nature, but may enter the environment during the mining ore processing and smelting of zinc and zinc-lead ores. Cadmium may also be released to the environment during refining, manufacture of cadmium compounds, use of cadmium metals, alloys and compounds, recycling and disposal. Cadmium's initial route of entry is often via the atmosphere. Cadmium metal is expected to be transformed to the oxide and carbonate in the atmosphere. Similarly cadmium is expected to slowly oxidize in both water and soil.

The adsorption of cadmium onto soils and silicon or aluminum oxides is strongly pH-dependent. When the pH is below 6-7, cadmium is desorbed from these materials. Cadmium absorbed to

mineral surfaces or organic materials would be more easily bioaccumulated. Cadmium is not known to form volatile compounds in the aquatic environment.

Regulatory Limits

The EPA MCL for cadmium is 5 µg/L and the WQCC groundwater standard is 10 µg/L.

4.2.7 Chromium III (CAS. NO. 7440-47-3)

The following information was taken from IRIS (EPA, 2003) and the HSDB (2002).

Toxicity

Applying the criteria for evaluating the overall weight of evidence for carcinogenicity to humans outlined in RAGS (EPA, 1986), trivalent chromium is most appropriately designated a Group D (not classified as to its human carcinogenicity). The EPA has established a RfDo for Chromium III of 1.5 mg/kg/day (EPA, 2002d).

Environmental Fate and Transport

Chromium compounds are stable in the trivalent state and occur in nature in this state in ores. Chromium is widely distributed in the earth's crust at an average concentration of 125 mg/kg but is rare in unpolluted waters. The production and use of chromium compounds in stainless steels, alloy cast irons and nonferrous alloys may result in the release to the environment through various waste streams. If released into air, chromium compounds will exist solely in the particulate phase in the ambient atmosphere. Particulate-phase chromium compounds will be removed from the atmosphere by wet and dry deposition. If released into soil, the fate of chromium is greatly dependent upon the speciation of chromium, which is a function of redox potential and the pH of the soil. In most soils, chromium will be present predominantly in the chromium III state. This form has very low solubility and low reactivity resulting in low mobility in the environment. Chromium III predominated under reducing conditions. Chromium III occurs mostly as suspended solids adsorbed onto clay materials, organics, or iron oxide present in water. In natural groundwater, the pH is typically 6 to 8 and Cr (OH)2+ ion will be the dominant species of chromium III. Chromium compounds are expected to exist as non-volatile ions in the environment. Therefore volatilization from moist soil and water surfaces is not expected to be an important fate process.

Most chromium compounds released into water will ultimately be deposited in sediments. Soluble chromium generally accounts for a very small percentage of the total chromium in water.

Regulatory Limits

The EPA MCL for chromium is 0.05 mg/L (http://www.nmenv.state.nm.us/gwb/gwstds.html).

4.2.8 Nickel (CAS. NO. Various)

Toxicity

The following information was taken from the HSDB (2003) and IRIS (EPA, 2002). Nickel can be absorbed in human beings and animals via inhalation or ingestion. Gastrointestinal absorption of nickel is variable and depends on the composition of the diet. Nickel is transported in the blood, principally bound to albumin. Metallic nickel and a very large number of nickel compounds have been tested for carcinogenicity by parenteral routes of administration. With few exceptions they caused local tumors. Only nickel subsulfide has been shown convincingly to cause cancer after inhalation exposure.

Cases of nickel poisoning have been reported in electroplaters who accidentally ingested water contaminated with nickel sulfate and nickel chloride. Chronic effects such as rhinitis, sinusitis, nasal septal perforations, and asthma have been reported in nickel refinery and nickel plating workers. Nickel contact hypersensitivity has been documented extensively in both the general population and in a number of occupations in which workers were exposed to soluble nickel compounds. Transient nephrotoxic effects have been recorded after accidental ingestion of nickel salts. Very high risks of lung and nasal cancer have been reported in nickel refinery workers employed in the high-temperature roasting of sulfide ores, involving substantial exposure to nickel subsulfide, oxide and, perhaps, sulfate.

Nickel refinery dust has been classified as a human carcinogen (Group A), based on sufficient human data, in which exposure to nickel refinery dust caused lung and nasal tumors in sulfide nickel matte refinery workers in several epidemiological studies in different countries (HSDB, 2002).

The overall evaluation on nickel compounds as a group was based on combined results of epidemiological studies, carcinogenicity studies in experimental animals, and several types of other relevant data, supported by the underlying concept that nickel compounds can generate nickel ions at critical sites in their target cells. There is sufficient evidence in humans for the carcinogenicity of nickel sulfate, and of the combinations of nickel sulfides and oxides encountered in the nickel refining industry. There is inadequate evidence in humans for the carcinogenicity of metallic nickel and nickel alloys. There is sufficient evidence in experimental animals for the carcinogenicity of metallic nickel, nickel monoxides, nickel hydroxides and crystalline nickel sulfides. The HSDB (2002) list the source as the International Agency for Research on Cancer monographs where nickel compounds are listed as carcinogenic to humans (Group 1) and metallic nickel as possibly carcinogenic to humans (Group 2B).

In the 2002 Table of Drinking water Standards and Health Advisories, Nickel has not been assigned a carcinogenic group classification. Thus for purposes of the health risk assessment, nickel non-carcinogenic health effects were calculated from the RfDo and RfDi.

While the previous studies on humans with a hypersensitivity to nickel were considered in developing the reference dose, none of them were adequate to serve as the basis for the quantitative risk assessment. The reference dose is believed to be set at a level which would not

cause individuals to become sensitized to nickel; however, those who have already developed a hypersensitivity (e.g., from a dermal exposure) may not be fully protected.

Nickel has been shown to be an essential trace element for several animal species. Rats deprived of nickel exhibit retarded growth and low hemoglobin levels. A requirement for nickel has not been conclusively demonstrated in humans, but nickel is considered to be a normal constituent of the diet. Typical daily intake of nickel ranges from 100-300 µg/day.

An RfDo of 2×10^{-2} mg/kg/day was established for nickel soluble salts (HSDB, 2002 and EPA, 2003).

Environmental Fate and Transport

Nickel's use in the production of steel and various alloys, in electroplating, nickel-cadmium batteries, fuel cells, electronic circuitry and miscellaneous other applications may result in its release to the environment through various waste streams. Approximately 0.009% of the earth's crust is nickel. Estimated worldwide atmospheric emissions (% of total emissions) of nickel from natural sources include windblown dust (9.3%), volcanoes (4.9%) and vegetation (1.6%). Nickel compounds are expected to exist in the particulate phase in the ambient atmosphere. Particulate-phase nickel will be removed from the atmosphere by wet and dry deposition. If released to soil, soluble nickel compounds such as nickel chlorides and nickel nitrate will tend to migrate more than the insoluble compounds such as nickel oxides and nickel sulfides.

If released into water, nickel compounds are expected to adsorb to suspended solids and sediment in water. Due to their low vapor pressure and ionic form, volatilization from water surfaces is not expected to be an important fate process for most nickel compounds.

Regulatory Limits

The EPA MCL for nickel is 0.1 mg/L and the WQCC groundwater standard is 0.2 mg/L.

4.2.9 Nitrate/Nitrate (Nitrogen) (Nitrate CAS. NO. 14797-55-8; Nitrite CAS. NO. 14797-65-0)

Nitrate and nitrite are inorganic compounds that contain nitrogen and oxygen. Nitrates can convert into nitrites and vice versa. The primary use of nitrates is to produce fertilizer. Nitrites are mainly manufactured for use as a food preservative.

Toxicity

Human exposure to nitrate/nitrite is primarily through ingestion. Nitrate is a normal component in the human diet, with an intake level of about 75-mg per day for an adult. Once consumed, the majority of the nitrate is converted into nitrite by the bacteria in saliva and by bacteria inside the alimentary tract. However, if the pH of the gastric fluid is above 5, the nitrate reducing bacteria can grow. Since infants normally have higher gastrointestinal system pH levels, this is a major

concern. Thus, infants who drink water containing an excess of nitrate may become seriously ill. Symptoms include shortness of breath and blueness of skin (http://www.ead.anl.gov/).

Excess exposure to nitrate and nitrite can methemoglobinemia. In the body, nitrate converts to nitrite, nitrite then oxidizes normal hemoglobin creating methomoglobin. Methomoglobin cannot bind oxygen. Although humans have normally low levels of methomoglobin, high levels of methomoglobin can make it difficult to transport oxygen from the lungs to the tissues.

There is limited human data and animal evidence to support the carcinogenicity of nitrate/nitrite. Major studies to determine chemical toxicity values are primarily based on the consumption of nitrate contaminated water. The IRIS lists a RfDo of 1.6 mg/kg-day for nitrate and a RfDo of 0.1 mg/kg-day for nitrite (EPA, 2003).

Environmental Fate and Transport

Nitrates are naturally found in the environment. In the naturally occurring nitrogen cycle, bacteria converts nitrogen to nitrate, which is absorbed by plants. Animals then consume plants and use the nitrates to produce proteins. Nitrate is returned to the environment via animal feces and by degradation of plants and animals after death. This cycle does not produce excess amounts of nitrates or nitrites in the environment. However, livestock and poultry farming produce nitrate-containing manure.

The primary inorganic nitrates that may contaminate drinking water are potassium nitrate and ammonium nitrate, both of which are widely used as fertilizers. Nitrate and nitrate are very soluble in water and very mobile in the environment. Since they are very soluble and do not bind to soils, nitrates have a high potential to contaminate groundwater. Nitrates/nitrites are likely to remain in water until consumed by plants or other organisms because they do not evaporate.

Regulatory Limits

EPA has declared a drinking water MCL for nitrate at 10 ppm and 1 ppm for nitrite.

5.0 Plume-Front Health Risk Assessment

5.1 Exposure Evaluation for Plume-Front Health Risk Assessment

Groundwater is the medium of primary concern for the purposes of health risk assessment at the plume-front. Presently, there are no complete exposure pathways or human or ecological receptors within the plume-front area. Downgradient public and WSTF water supply wells comprise potential future pathways for exposure to groundwater contamination. The focus of the plume-front health risk assessment is the potential for future use of WSTF contaminated groundwater as drinking water. Media of concern, exposure pathways and potential receptors were examined in detail in the BHRA and were not reexamined for purposes of the plume-front health risk assessment (NASA, 1996).

NASA opted to take a conservative approach in calculating cancer risk values and HIs. Mean contaminant concentrations detected in plume-front monitoring wells from the time period August 19, 2001 through August 18, 2003 were used for most analytes. In wells where individual contaminants were not detected, cancer risk and HIs were calculated on one half the most current analytical detection limit. No exposure pathways are complete but future potential exposure of offsite residents and WSTF employees is of primary concern. Therefore the more protective intake assumptions associated with residential exposure via ingestion of contaminated groundwater were used to calculate risk. Use of a residential intake assumption will result in a protective measure of risk to WSTF employees.

The approaches used to determine cancer risk and HIs are based on the assumption that there are no synergistic or antagonistic interactions among the compounds involved, and that all compounds have the same toxic end points and mechanisms of action. The effects of exposure to each of the contaminants have been considered separately, then totaled for a straight-line additive effect, for both carcinogens and non-carcinogens.

5.2 Quantification of Plume-Front Carcinogenic Risk

Calculations for quantifying carcinogenic risk are based on technical guidance from Region 9 PRG tables (EPA, 2002d), Region III RBC tables (EPA, 2002c) and RAGS (EPA, 1989). More conservative applications in risk assessment necessitated two significant changes in risk calculation since the BHRA was completed. First, age-adjusted factors (24 year adult + 6 year child) have been incorporated into calculations for health risk at the plume-front. Secondly, inhalation exposures to volatiles from drinking water have been incorporated into risk calculations with the addition of inhalation and volatilization factors. Both of these changes to carcinogenic risk calculations have resulted in an increase in relative risk associated from potential ingestion WSTF groundwater.

5.2.1 Carcinogenic Risk Calculations

Carcinogenic slope factors (Table 4.3) were used to estimate the potential excess cancer risks from contaminants detected at the WSTF groundwater monitoring wells. The chronic daily intake (CDI) was calculated using the EPA age-adjusted calculations for risk of oral and inhalation exposure to groundwater from the EPA Region III RBC Table: Technical Background Information (EPA, 2002c) and RAGS (EPA, 1989). Variables (acronyms) for the equations are defined in Table 5.1.

1) Calculate Age-Adjusted Ingestion Factor for water (IFWadj):
   a. Step 1:

$$IFWadj = \frac{EDc \times IRWc}{BWc} + \frac{(EDtot - EDc) \times IRWa}{BWa}$$

   b. Step 2:

$$CFWadj = \frac{IFWadj \times EFr}{ATc}$$

2) Calculate the Age-Adjusted Inhalation Factor (InhFadj):
a. Step 1:

$$InhFadj = \frac{EDc \times IRAc}{BWc} + \frac{(EDtot-EDc) \times IRAa}{BWa}$$

b. Step 2:

$$CFAadj = \frac{InhFadj \times EFr}{ATc}$$

3) To calculate age-adjusted Chronic Daily Intake from oral ingestion of drinking water (age adjusted):

$$CDIo = (CW)\ (CFWadj)$$

4) To calculate age-adjusted Chronic Daily Intake from inhalation of volatiles from drinking water:

$$CDIi = (CW)\ (VFw \times InFadj)$$

5) To calculate residential age adjusted Cancer Risk (using oral and inhalation factors) for an individual COC at a given concentration:

$$Risk = (CDIo)(SFo) + (CDIi)(SFi)$$

Table 5.1: Chronic Daily Intake (CDI) Assumptions for Age-Adjusted Ingestion Of Contaminated Groundwater

PARAMETER	DEFAULT EXPOSURE ASSUMPTION
CW (Exposure Point Concentration in Groundwater in mg/L)	Mean concentration detected in each monitoring well for specified time period.
IRWa/IRWc (Ingestion Rate Water)	a) 2 liters/day, adult; c)1 liter/day, child
IRAa/IRAc (Inhalation Rate Air)	a) 20 m^3/day, adult; c) 10 m^3/day, child
EFr (Residential Exposure Frequency) EFo (Occupational Exposure Frequency)	350 days/year 250 days/year
EDa/EDc/EDtot (Exposure Duration)	24 years adult +6 years child = 30 year total
BWa/BWc (Body Weight)	70 kg adult/15 kg child
ATc (Averaging Time-carcinogens) ATn (Averaging Time-non-carcinogens)	70 years x 365 days/year-Carcinogens 30 years x 365 days/year-Non-carcinogens
IFWadj (Age Adj. Ingestion Factor - water)	1.1 L-year/kg-day (NMED)
InhFadj (Age Adj. Inhalation Factor - air)	11 L-year/kg-day (NMED)
CDIoadj (Chronic Daily Intake (mg/kg/d))	(CW) (CFWadj)
CDIiadj (Chronic Daily Intake	(CW) (VFw x InFadj)
CFWadj (Age Adj. Calc. Factor – water)	1.51×10^{-2} (kg/L-day)
CFAadj (Age Adj. Calc. Factor – air)	1.51×10^{-1}
VFw (Volatilization Factor for water)	0.5 L/m^3
SFo (Oral Slope Factor) $(mg/kg\text{-}day)^{-1}$	See Table 3.2
SFi (Inhalation Slope Factor) $(mg/kg\text{-}day)^{-1}$	See Table 3.2

Note: Inhalation slope factors are not available for lead or arsenic. For these COCs:

$$Risk = (CDIo)\ (SFo)$$

The mean concentration for each COC was calculated at each plume front monitoring well and Westbay® sampling zone for a specified time period. One half the most recent detection limit was substituted in the calculation where a result for a particular analyte was ND. Excess cancer risk was then calculated on the highest mean value for individual contaminants at each well, well group, and Westbay® well. Cumulative cancer risk was then estimated by summing risk values for each well grouping. Table 5.2 lists the individual chemical and cumulative carcinogenic risk estimates for the plume-front monitoring wells. Values listed in italics reflect those calculated using one half the most recent analytical detection limit when a contaminant was not detected. Reporting limits were used when detection limits were not available.

5.2.2 Estimates Of Current Plume-front Carcinogenic Risk

Carcinogenic risk from oral and inhalation exposure to contaminated groundwater was calculated for NDMA, DMN, TCE, PCE, acrylonitrile, THF, and chloroform. Risks from oral exposure only were calculated for arsenic and lead.

The time frame used varied with COC due to different sampling frequencies. Mean concentrations available from sampling events for each well for NDMA, DMN, TCE, PCE, acrylonitrile, THF, and chloroform were taken from 8/19/2001 through 8/18/2003. Due to the paucity of sampling events for arsenic and lead, maximum concentrations from all available historical values from 1/1/1988 to 8/18/2003 were used. Mean concentrations for bromacil were taken from dates ranging from 1/1/00 to 8/18/03. See Appendix F for mean concentrations used in the risk calculations. Figure 5.1 is a contour map showing the distribution of orders of magnitude of risk at plume-front monitoring wells.

Carcinogenic risks calculated for one half the method detection limits for NDMA, DMN, TCE, PCE, acrylonitrile and arsenic are also above NMED acceptable carcinogenic risk levels for individual COCs of 1×10^{-6}. Lead is of no significance to cumulative carcinogenic risks in the plume-front monitoring wells.

5.3 Quantification of Non-Carcinogenic Plume-Front HIs

5.3.1 Non-Carcinogenic HQs and HIs

Reference doses were used to compute HQs for the non-carcinogenic effects from exposure to COCs. HQs were calculated for non-carcinogens Freon 11, Freon 21, and Freon 113, Freon 123A, bromacil, cadmium, chromium, nickel, and nitrate/nitrite detected at monitoring wells. In addition, HQs for non-carcinogenic health effects from carcinogenic COCs were calculated. Those carcinogenic COCs with available reference doses included TCE, PCE, acrylonitrile, chloroform, THF and arsenic. HQs for non-carcinogenic effects from lead, NDMA and DMN were not included because applicable reference doses are not available.

TABLE 5.2: CARCINOGENIC RISK ESTIMATES FOR PLUME FRONT MONITORING WELLS.

Well(s)	NDMA	DMN	TCE	PCE	Chloroform	Acrylonitrile	THF	Arsenic	Lead	Cumulative
BLM-2 Group	$4.02x10^{-3}$	$1.88x10^{-3}$	$7.05x10^{-3}$	$1.52x10^{-5}$	*$<4.76x10^{-7}$*	*$<3.00x10^{-5}$*	*$<4.96x10^{-7}$*	$2.49x10^{-6}$	$6.25x10^{-7}$	$1.30x10^{-2}$
BLM-7-509	*$<2.50x10^{-5}$*	*$<1.56x10^{-5}$*	*$<8.34x10^{-6}$*	*$<3.23x10^{-7}$*	*$<3.42x10^{-7}$*	*$<2.76x10^{-5}$*	*$<2.95x10^{-7}$*	*$<3.40x10^{-5}$*	$2.32x10^{-8}$	$1.12x10^{-4}$
BLM-10-517	*$<2.95x10^{-5}$*	*$<1.70x10^{-5}$*	*$<7.61x10^{-6}$*	*$<2.77x10^{-7}$*	*$<3.23x10^{-7}$*	*$<2.36x10^{-5}$*	*$<3.14x10^{-7}$*	*$<3.40x10^{-5}$*	*$<2.23x10^{-7}$*	$1.13x10^{-4}$
BLM-17 Group	$1.14x10^{-2}$	$6.53x10^{-3}$	$5.76x10^{-3}$	$1.26x10^{-5}$	*$<3.61x10^{-7}$*	*$<3.02x10^{-5}$*	*$<2.98x10^{-7}$*	*$<3.40x10^{-5}$*	$2.44x10^{-7}$	$2.38x10^{-2}$
BLM-37	$6.70x10^{-5}$	*$<1.74x10^{-5}$*	*$<1.12x10^{-5}$*	*$<3.54x10^{-7}$*	*$<3.61x10^{-7}$*	*$<3.02x10^{-5}$*	*$<9.49x10^{-7}$*	$6.41x10^{-5}$	$9.18x10^{-8}$	$1.92x10^{-4}$
JP-1-424	*$<2.73x10^{-5}$*	*$<1.65x10^{-5}$*	*$<8.70x10^{-6}$*	*$<3.23x10^{-7}$*	*$<3.42x10^{-7}$*	*$<2.68x10^{-5}$*	*$<1.88x10^{-7}$*	$<3.40x10^{-5}$	$2.57x10^{-7}$	$1.14x10^{-4}$
JP-2-447	*$<2.86x10^{-5}$*	*$<1.70x10^{-5}$*	*$<8.70x10^{-6}$*	*$<3.39x10^{-7}$*	*$<3.61x10^{-7}$*	*$<2.68x10^{-5}$*	*$<3.58x10^{-7}$*	*$<3.40x10^{-5}$*	$7.55x10^{-8}$	$1.16x10^{-4}$
JP-3	*$<2.86x10^{-5}$*	*$<1.74x10^{-5}$*	*$<8.70x10^{-6}$*	*$<3.39x10^{-7}$*	*$<3.61x10^{-7}$*	*$<2.65x10^{-5}$*	*$<4.08x10^{-7}$*	$3.99x10^{-5}$	$5.85x10^{-8}$	$1.22x10^{-4}$
PL-1-486	$1.07x10^{-4}$	$3.13x10^{-5}$	$4.98x10^{-3}$	$5.85x10^{-6}$	*$<3.42x10^{-7}$*	*$<2.84x10^{-5}$*	*$<2.95x10^{-7}$*	*$<3.40x10^{-5}$*	$1.03x10^{-7}$	$5.19x10^{-3}$
PL-2-504	*$<2.73x10^{-5}$*	*$<1.70x10^{-5}$*	$5.22x10^{-3}$	$1.89x10^{-6}$	*$<3.42x10^{-7}$*	*$<2.84x10^{-5}$*	*$<2.95x10^{-7}$*	*$<3.40x10^{-5}$*	$4.72x10^{-8}$	$5.33x10^{-3}$
PL-3-453	*$<2.68x10^{-5}$*	*$<1.61x10^{-5}$*	*$<7.97x10^{-6}$*	*$<3.08x10^{-7}$*	*$<3.42x10^{-7}$*	*$<3.42x10^{-5}$*	*$<2.76x10^{-7}$*	*$<3.40x10^{-5}$*	*$<8.58x10^{-7}$*	*$<1.21x10^{-4}$*
PL-4-464	*$<2.55x10^{-5}$*	*$<1.34x10^{-5}$*	$3.71x10^{-4}$	*$<3.08x10^{-7}$*	$4.95x10^{-7}$	*$<3.10x10^{-5}$*	*$<2.64x10^{-7}$*	*$<5.66x10^{-5}$*	$5.36x10^{-8}$	$4.98x10^{-4}$
PL-5	*$<5.59x10^{-3}$*	$4.92x10^{-4}$	$3.78x10^{-4}$	*$<3.23x10^{-7}$*	*$<3.42x10^{-7}$*	*$<3.05x10^{-5}$*	*$<4.02x10^{-7}$*	$4.37x10^{-5}$	$2.14x10^{-7}$	$6.53x10^{-3}$
PL-6	$4.11x10^{-5}$	*$<1.70x10^{-5}$*	*$<8.34x10^{-6}$*	*$<3.23x10^{-7}$*	*$<3.42x10^{-7}$*	*$<3.34x10^{-5}$*	$1.13x10^{-5}$	$2.79x10^{-4}$	$3.17x10^{-8}$	$3.91x10^{-4}$
PL-7	*$<2.86x10^{-5}$*	*$<1.61x10^{-5}$*	*$<7.97x10^{-6}$*	*$<2.77x10^{-7}$*	*$<3.61x10^{-7}$*	*$<3.34x10^{-5}$*	*$<2.76x10^{-7}$*	*$<5.66x10^{-5}$*	*$<2.14x10^{-7}$*	*$<1.44x10^{-4}$*
PL-8	*$<3.04x10^{-5}$*	*$<1.97x10^{-5}$*	$<7.97X10^{-6}$	*$<3.08x10^{-7}$*	*$<3.42x10^{-7}$*	*$<2.94x10^{-5}$*	$4.52x10^{-7}$	$8.83x10^{-5}$	$5.92x10^{-8}$	$1.77x10^{-4}$
PL-10	*$<3.31x10^{-5}$*	*$<2.15x10^{-5}$*	*$<8.34x10^{-6}$*	*$<3.54x10^{-7}$*	*$<3.42x10^{-7}$*	*$<3.34x10^{-5}$*	*$<1.09x10^{-6}$*	$5.30x10^{-5}$	*$<5.03x10^{-8}$*	$1.51x10^{-4}$

This table presents the individual cancer risks associated with mean contaminant concentrations observed for each well.
Risk was calculated on mean results for the period of 8/19/2001-8/18/2003 for TCE, PCE, THF, Acrylonitrile, Chloroform, and Freons.
Risk was calculated on mean results for the period of (1/1/2001-8/18/2003) for Bromacil
Risk was calculated on mean results for the period of (1/1/1988-2003) for arsenic and lead.
Values listed in italics reflect those calculated on one-half of the most recent analytical detection limit (or reporting limit when a detection limit was not available) when a contaminant was not detected.

TABLE 5.2: CARCINOGENIC RISK ESTIMATES FOR PLUME FRONT MONITORING WELLS.

Well(s)	NDMA	DMN	TCE	PCE	Chloroform	Acrylonitrile	THF	Arsenic	Lead	Cumulative
ST-1 Group	$1.29x10^{-2}$	$6.12x10^{-3}$	$1.29x10^{-2}$	$2.93x10^{-5}$	$5.33x10^{-7}$	*$<3.28x10^{-5}$*	*$<5.97x10^{-7}$*	*$<5.44x10^{-6}$*	$1.89x10^{-7}$	$3.20x10^{-2}$
ST-2-466	*$<3.08x10^{-5}$*	*$<1.61x10^{-5}$*	$1.38x10^{-5}$	*$<2.46x10^{-7}$*	*$<3.04x10^{-7}$*	*$<2.36x10^{-5}$*	*$<3.14x10^{-7}$*	*$<1.59x10^{-6}$*	$2.45x10^{-7}$	$8.70x10^{-5}$
ST-3 Group	$1.05x10^{-2}$	$3.09x10^{-3}$	$9.39x10^{-3}$	$1.90x10^{-5}$	$3.23x10^{-7}$	*$<3.55x10^{-5}$*	*$<1.09x10^{-6}$*	*$<2.27x10^{-6}$*	$3.22x10^{-7}$	$2.30x10^{-2}$
ST-4 Group	$3.80x10^{-5}$	$1.65x10^{-5}$	$5.54x10^{-5}$	*$<2.46x10^{-7}$*	*$<2.85x10^{-7}$*	*$<3.34x10^{-5}$*	*$<3.14x10^{-7}$*	*$<1.81x10^{-6}$*	$2.23x10^{-7}$	$1.46x10^{-4}$
ST-5 Group	$3.13x10^{-5}$	*$<1.61x10^{-5}$*	*$<8.34x10^{-6}$*	*$<3.39x10^{-7}$*	*$<3.61x10^{-7}$*	*$<2.79x10^{-5}$*	*$<5.34x10^{-7}$*	$4.39x10^{-5}$	$3.17x10^{-7}$	$1.29x10^{-4}$
ST-6	*$<2.41x10^{-5}$*	*$<1.56x10^{-5}$*	$1.85x10^{-3}$	$7.39x10^{-7}$	*$<3.23x10^{-7}$*	*$<2.55x10^{-5}$*	*$<7.22x10^{-7}$*	$7.16x10^{-5}$	$7.46x10^{-8}$	$1.99x10^{-3}$
ST-7	*$<2.55x10^{-5}$*	*$<1.92x10^{-5}$*	*$<8.34x10^{-6}$*	*$<3.39x10^{-7}$*	*$<3.61x10^{-7}$*	*$<2.92x10^{-5}$*	*$<2.95x10^{-7}$*	$5.44x10^{-5}$	$4.97x10^{-8}$	$1.38x10^{-4}$
WW-1-452	*$<3.17x10^{-5}$*	*$<1.88x10^{-5}$*	*$<8.34x10^{-6}$*	*$<3.39x10^{-7}$*	*$<3.42x10^{-7}$*	*$<3.34x10^{-5}$*	*$<2.76x10^{-7}$*	*$<3.40x10^{-5}$*	$1.39x10^{-7}$	$1.27x10^{-4}$
WW-2	*$<2.59x10^{-5}$*	*$<1.61x10^{-5}$*	*$<7.97x10^{-6}$*	*$<3.08x10^{-7}$*	*$<3.42x10^{-7}$*	*$<2.94x10^{-5}$*	*$<5.09x10^{-7}$*	$2.82x10^{-4}$	$6.43x10^{-8}$	$3.62x10^{-4}$
WW-3	*$<2.68x10^{-5}$*	*$<1.74x10^{-5}$*	*$<7.97x10^{-6}$*	*$<3.08x10^{-7}$*	*$<3.42x10^{-7}$*	*$<2.92x10^{-5}$*	$4.86x10^{-5}$	$3.85x10^{-5}$	$5.49x10^{-8}$	$1.69x10^{-4}$
WW-4	*$<3.04x10^{-5}$*	$2.68x10^{-5}$	*$<7.97x10^{-6}$*	*$<3.08x10^{-7}$*	*$<3.42x10^{-7}$*	*$<2.76x10^{-5}$*	*$<2.76x10^{-7}$*	$7.27x10^{-5}$	$5.57x10^{-8}$	$1.66x10^{-4}$
WW-5	*$<3.31x10^{-5}$*	*$<2.15x10^{-5}$*	*$<8.34x10^{-6}$*	*$<3.39x10^{-7}$*	*$<3.42x10^{-7}$*	*$<2.84x10^{-5}$*	*$<4.71x10^{-7}$*	$6.39x10^{-5}$	$8.41x10^{-8}$	$1.56x10^{-4}$

This table presents the individual cancer risks associated with mean contaminant concentrations observed for each well.
Risk was calculated on mean results for the period of 8/19/2001-8/18/2003 for TCE, PCE, THF, Acrylonitrile, Chloroform, and Freons.
Risk was calculated on mean results for the period of (1/1/2001-8/18/2003) for Bromacil
Risk was calculated on mean results for the period of (1/1/1988-2003) for arsenic and lead.
Values listed in italics reflect those calculated on one-half of the most recent analytical detection limit (or reporting limit when a detection limit was not available) when a contaminant was not detected.

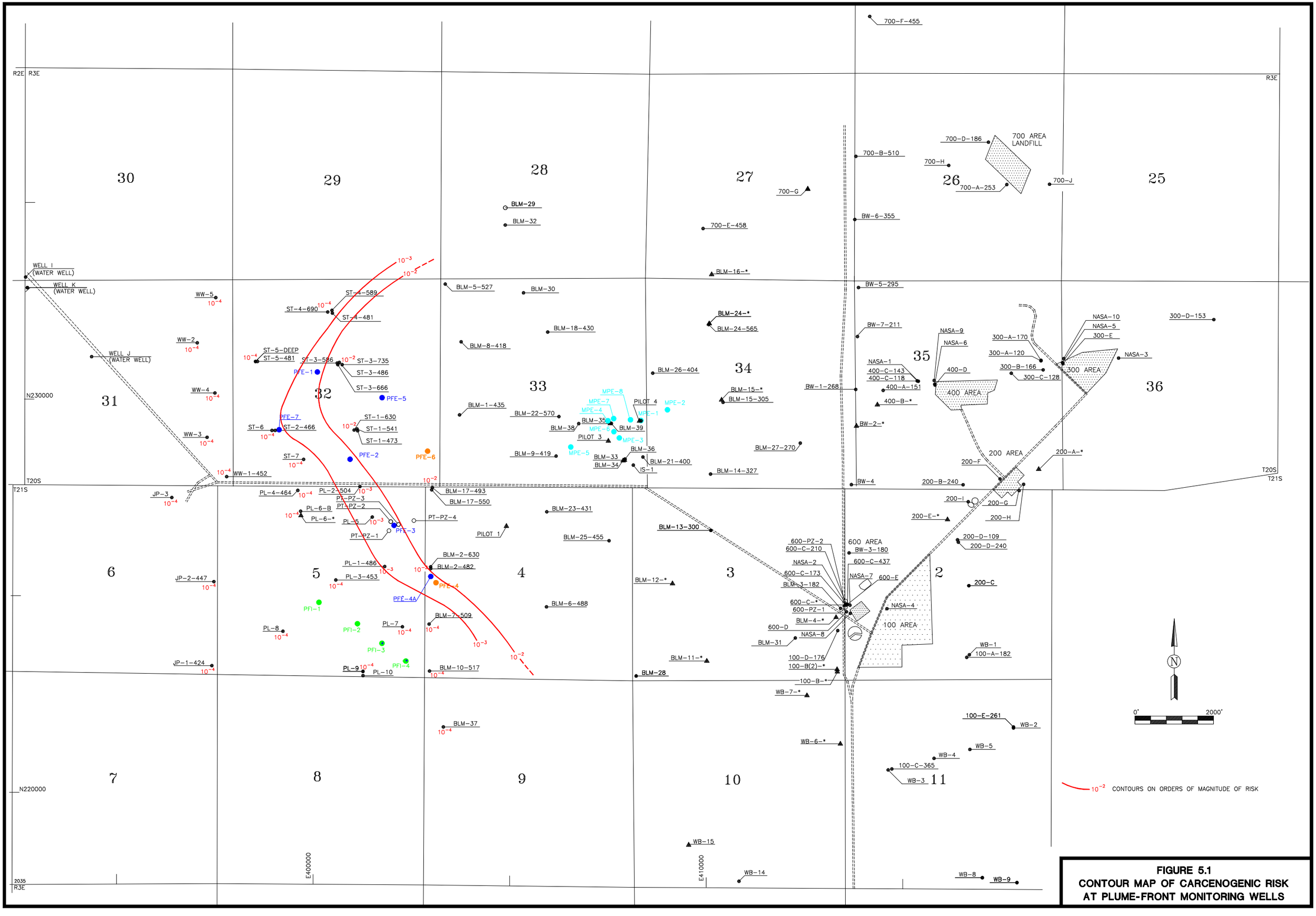


FIGURE 5.1
CONTOUR MAP OF CARCENOGENIC RISK AT PLUME-FRONT MONITORING WELLS

Hazard calculations for non-carcinogenic health effects of plume-front contaminants are based on 30 year adult exposure as suggested in the EPA Region 9 PRG and EPA Region III RBC technical guidelines (EPA, 2000a and EPA 2000b). Hazard calculations include inhalation/volatilization factors only for volatile COCs with Henry's Law Constants of 1.0E-05 atm-m^3/mole or greater and molecular weights of less than 200 g/mole. Variables (acronyms) for the equations are defined in Table 5.3. The following steps were used to calculate HQs for non-carcinogenic effects from ingestion of groundwater:

1) Calculate CDIo (30 year adult):

   a. $CDIo = \frac{CW \times IRWa \times EFr \times EDa}{BWa \times ATn}$;

   b. $CDIo = (CW)\ (2.74E\text{-}02)$

2) Calculate the CDIi (30 year adult):

   a. $CDIi = \frac{CW \times VFw \times IRAa \times EFr \times EDa}{BWa \times Atn}$;

   b. $CDIi = (CW)\ (1.37E\text{-}01)$

3) Calculate the HQ where:

   $HQ = (CDIo/RfDo) + (CDIi/RfDi)$

HQs for chemicals lacking RfDi values, were calculated by (HQ = CDIo/RfDo).

Table 5.3: Chronic Daily Intake (CDI) Assumptions for Ingestion/Inhalation rates of Non-Carcinogens from Contaminated Groundwater

PARAMETER	DEFAULT EXPOSURE ASSUMPTION
CW (Exposure Point Concentration in Groundwater in mg/L)	Mean concentration detected in each monitoring well for specified time period.
IRWa/IRWc (Ingestion Rate Water)	a) 2 liters/day, adult; c)1 liter per day, child
IRAa/IRAc (Inhalation Rate Air)	a) 20 m^3/day, adult; c) 10 m^3/day, child
EFr (Residential Exposure Frequency) EFo (Occupational Exposure Frequency)	350 days/year 250 days/year
EDa (Exposure Duration - Adult)	30 years
BWa (Body Weight)	70 kg adult
ATn (Averaging Time-non-carcinogens)	30 years x 365 days/year-Non-carcinogens
IRWa (Ingestion Rate - water)	2 L/day
IRAa (Inhalation Rate - air)	20 m^3/day
CDIo (Chronic Daily Intake-oral factor)	2.74E-02 L/kg-day
CDIi (Chronic Daily Intake-inhalation factor)	1.37E-01 L/kg-day
VFw (Volatilization Factor for water)	0.5 L/m^3
RfDo (Oral Reference Dose) (mg/kg-day)	See Table 3.2
RfDi (Inhalation Slope Factor) (mg/kg-day)	See Table 3.2

5.3.2 Estimates Of Current Plume-front Non-Carcinogenic Health Indices

Table 5.4 lists the HQs and HIs estimated for the plume-front wells. HQs were calculated for all carcinogenic and non-carcinogenic COCs with the exception of NDMA, DMN and lead. HIs are calculated for each plume-front monitoring well by summing the HQ for non-carcinogenic effects from COCs. For this table, Freon 11, Freon 21, Freon 113 and Freon 123A HQs have been totaled. HQ values for arsenic, cadmium, chromium III, nickel, and nitrate/nitrite (nitrogen) have also been totaled. HQ values for individual analytes are available in Appendix G. Mean contaminant values and time frames used for calculation of non-carcinogenic health effects are identical to those used in the Carcinogenic Risk calculations. HQs and HIs calculated on one half the most current analytical detection or reporting limits are listed in italics. Acceptable individual HQs do not exceed 0.1 and acceptable HI values do not exceed 1.0.

Table 5.4 shows that the highest HQs are associated with TCE and its presence in a monitoring well constitutes the greatest contribution to the well's HI. The contribution to the HI from all the Freon compounds totaled is small in comparison to TCE, and is generally less than 0.1. TCE is the primary chemical of concern that drives the HIs to exceed 1.0.

The HQ for acrylonitrile at all plume-front wells is calculated on one half the most recent analytical detection limit and exceeds the acceptable HQ of 0.10 for an individual COC. With one exception (WW-3), THF HQs are within acceptable values (< 0.10). Chloroform HQs for all plume-front-monitoring wells are <0.10. Bromacil HQs at all wells also fall well below 0.10.

5.4 Uncertainty in Health Risk Assessment

The assumptions and inputs used to assess potential human health risks posed by the WSTF contaminant plume are subject to several areas of uncertainty result in either overestimation or underestimation of risk. Sources of uncertainty applicable to this health risk assessment include sampling and analysis; exposure estimation; toxicological data and dose-response extrapolation; and errors introduced through combining data from the above uncertainty sources.

Uncertainty introduced by sampling and analysis can stem from procedural error, from failure to collect an adequate number of samples to provide areal resolution, human error, or lack of sample heterogeneity. The use of one half the most current applicable detection limits or reference doses (where detection limits were unavailable) for ND analytical results leads to overestimation of calculated risk and HQs for individual chemicals and for cumulative risk and HIs for each plume-front monitoring well.

Exposure estimation inherently introduces uncertainty by the use of default exposure assumptions in health risk calculations. Intake rates, frequency, duration and other exposure assumptions are very conservative (i.e., overestimated to be health protective) and, when calculated over lifetime exposure, may lead to over estimates of chemical intake. In addition, the use of mean concentrations for a specified time-frame rather than the 95% upper confidence limit (UCL) likely leads to overestimate of risk. The degree, to which these factors affect overestimation of risk is unknown, but may be substantial.

TABLE 5.4: NON-CARCINOGENIC HAZARD QUOTIENTS AND INDICES FOR PLUME-FRONT WELLS

Well	TCE	PCE	THF	Acrylonitrile	Bromacil	Chloroform	Freons	Elements	Hazard Index
BLM-2 Group	20.442	0.035	*<0.001*	*<0.305*	0.000016	*<0.040*	0.200	*<0.019*	21.044
BLM-7-509	*<0.024*	*<0.001*	*<0.001*	*<0.281*	NR	*<0.029*	*<0.029*	*<0.275*	*<0.640*
BLM-10-517	*<0.022*	*<0.001*	*<0.001*	*<0.241*	*<0.000001*	*<0.028*	*<0.029*	*<0.275*	0.595
BLM-17 Group	16.700	0.029	*<0.001*	*<0.308*	0.00016	*<0.031*	0.433	0.473	17.975
BLM-37	*<0.033*	*<0.001*	*<0.003*	*<0.308*	*<0.000001*	*<0.031*	*<0.028*	0.277	0.680
JP-1-424	*<0.025*	*<0.001*	*<0.001*	*<0.273*	*<0.000001*	*<0.029*	*<0.028*	*<0.274*	0.631
JP-2-447	*<0.025*	*<0.001*	*<0.001*	*<0.273*	*<0.000001*	*<0.031*	*<0.027*	*<0.274*	*<0.632*
JP-3	*<0.025*	*<0.001*	*<0.001*	*<0.270*	*<0.000001*	*<0.031*	*<0.028*	0.186	0.542
PL-1-486	14.442	0.013	*<0.001*	*<0.289*	0.000003	*<0.029*	0.115	*<0.275*	$<2.95x10^{-7}$
PL-2-504	15.125	0.004	*<0.001*	*<0.289*	NR	*<0.029*	0.140	*<0.276*	15.864
PL-3-453	*<0.023*	*<0.001*	*<0.001*	*<0.348*	*<0.000001*	*<0.029*	*<0.027*	*<0.274*	*<0.703*
PL-4-464	1.074	*<0.001*	*<0.001*	*<0.316*	*<0.000001*	0.042	*<0.036*	0.365	1.835
PL-5	1.095	*<0.001*	*<0.001*	*<0.311*	*<0.000002*	*<0.029*	0.432	*<0.180*	2.049
PL-6	*<0.024*	*<0.001*	0.031	*<0.340*	*<0.000001*	*<0.029*	*<0.029*	1.288	1.742
PL-7	*<0.023*	*<0.001*	*<0.001*	*<0.340*	*<0.000001*	*<0.031*	*<0.028*	*<0.365*	*<0.789*
PL-8	*<0.023*	*<0.001*	*<0.001*	*<0.300*	*<0.000001*	*<0.029*	*<0.026*	*<0.711*	1.092
PL-10	*<0.024*	*<0.001*	*<0.003*	*<0.340*	*<0.000001*	*<0.029*	*<0.027*	0.362	0.787

Hazard quotients were calculated on mean results for the period of 8/19/2001-8/18/2003 for TCE, PCE, THF, Acrylonitrile, Chloroform, and Freons. Hazard quotients were calculated on mean results for the period of (1/1/2000-8/18/2003) for Bromacil Hazard quotients were calculated on mean results for the period of (1/1/1988-8/18/2003) for cadmium, arsenic, lead, and nickel.
Italicized values were calculated on the one-half the most recent analytical detection or reporting limits.
"Freons" column combines risk for Freon 11, Freon 21, Freon 113 and Freon 123A.
"Elements" column combines risk for arsenic, cadmium, chromium III, nickel, and nitrate/nitrite (nitrogen).
NR – No Results

TABLE 5.4: HAZARD QUOTIENTS AND INDICES FOR PLUME-FRONT WELLS

Well	TCE	PCE	THF	Acrylonitrile	Bromacil	Chloroform	Freons	Elements	Hazard Index
ST-1 Group	37.392	0.067	*<0.002*	*<0.335*	0.000022	0.045	0.448	*<0.028*	38.317
ST-2-466	0.040	*<0.001*	*<0.001*	*<0.241*	*NR*	*<0.026*	*<0.029*	*<0.013*	0.350
ST-3 Group	27.204	0.044	*<0.003*	*<0.361*	0.000002	0.028	0.536	*<0.037*	28.213
ST-4 Group	0.161	*<0.001*	*<0.001*	*<0.340*	*<0.000002*	*<0.024*	*<0.027*	*<0.077*	0.631
ST-5 Group	*<0.024*	*<0.001*	*<0.001*	*<0.284*	*<0.000006*	*<0.031*	*<0.028*	*<0.184*	0.553
ST-6	5.357	0.002	*<0.002*	*<0.260*	*<0.000006*	*<0.028*	3.440	0.317	9.405
ST-7	*<0.024*	*<0.001*	*<0.001*	*<0.297*	*<0.000001*	*<0.031*	*<0.028*	0.247	0.629
WW-1-452	*<0.024*	*<0.001*	*<0.001*	*<0.340*	*<0.000001*	*<0.029*	*<0.027*	*<0.247*	0.696
WW-2	*<0.023*	*<0.001*	*<0.001*	*<0.300*	*<0.000001*	*<0.029*	*<0.026*	1.676	2.057
WW-3	*<0.023*	*<0.001*	0.133	*<0.297*	*<0.000002*	*<0.029*	*<0.026*	<0.346	0.856
WW-4	*<0.023*	*<0.001*	*<0.001*	*<0.281*	*<0.000001*	*<0.029*	*<0.026*	0.429	0.790
WW-5	*<0.024*	*<0.001*	*<0.001*	*<0.289*	*<0.000001*	*<0.029*	*<0.028*	*<0.657*	1.030

Hazard quotients were calculated on mean results for the period of 8/19/2001-8/18/2003 for TCE, PCE, THF, Acrylonitrile, Chloroform, and Freons. Hazard quotients were calculated on mean results for the period of (1/1/2000-8/18/2003) for Bromacil Hazard quotients were calculated on mean results for the period of (1/1/1988-8/18/2003) for cadmium, arsenic, lead, and nickel.
Italicized values were calculated on the lowest analytical detection or reporting limits.
"Freons" column combines risk for Freon 11, Freon 21, Freon 113 and Freon 123A.
"Elements" column combines risk for arsenic, cadmium, chromium III, nickel, and nitrate/nitrite (nitrogen).
NR – No Results

Uncertainty is inherent from the use of dose-response extrapolation of toxicological data. Uncertainty factors for COCs' toxicity were taken from the HSDB (2002) and IRIS (EPA, 2003) databases and are included in tables 4.3 and 4.5.

Additional uncertainty is introduced with the quantitative evaluation of COCs in this health risk assessment. Toxicity data are not available for DMN or Freon 21. The RAGS suggests grouping chemicals by class in such situations and applying a known toxicity value from a chemical in that class to characterize risk (EPA, 1989, Section 5.9.2). In order to include COCs with no published SFo/RfDo and SFi/RfDi values in the quantitative evaluation, it was necessary to apply published SFo/RfDo and SFi/RfDi values from similar COCs. Slope factors for NDMA were applied to DMN due to their chemical similarity. This introduces uncertainty in the risk calculations for DMN and in the cumulative cancer risk values for wells where DMN is present.

Non-carcinogenic reference doses for chloroform were applied to Freon 21. This is a conservative approach to the risk posed by Freon 21 given the limited data available. Using the reference doses of chloroform for Freon 21 introduces uncertainty into HQ calculations for Freon 21 and also HIs calculated for each monitoring well.

Freon 11 reference doses were used for Freon 123A due to the similarity in their physical properties. This also introduces uncertainty into HQ calculations for Freon 123A and also HIs calculated for each monitoring well.

Most of the uncertainty introduced into the risk assessment by applications of known toxicological values to chemicals with unknown values is believed to be toward an overestimation of risk.

Overall, it is believed that the combined uncertainty introduced into this risk assessment from various sources described above has led to an overestimation of risk. The degree to which risk has been overestimated is unknown, but may be substantial. Additionally, the conservative approach taken toward the selection of COCs for this health risk assessment added to the overestimation of risk, resulting in a protective assessment of the health risks and hazards of WSTF groundwater.

5.5 Summary

With the design and preparation of the Plume-Front Project Plan, came the opportunity to reevaluate site contaminants and update the WSTF Health Risk assessment for groundwater pending remediation. Groundwater is considered the medium of primary concern for potential exposure to WSTF contaminants for the purposes of the plume-front health risk assessment.

A list of analytes detected at WSTF between mid-1998 and mid-2003 was compiled and evaluated for attributes including maximum concentration, FOD, exceedence of regulatory limits, carcinogenicity, site historical use, and availability of toxicity information. A conservative approach was taken during the process of determining the final lists of carcinogenic and non-carcinogenic COCs.

Nineteen carcinogenic and twelve non-carcinogenic analytes were screened for toxicity. The final list of carcinogenic COCs comprised DMN, NDMA, PCE, TCE, acrylonitrile, chloroform, THF, arsenic, and lead. Non-carcinogenic COCs include cadmium, chromium III, nickel, nitrate/nitrite (nitrogen), bromacil, Freon 11, Freon 21, Freon 113 and Freon 123A.

Present-day COC carcinogenic health risk and non-carcinogenic HIs were calculated for the plume-front monitoring wells. A protective approach to COC definition and additive uncertainty in health risk and hazard calculations resulted in a conservative overestimation of risk.

6.0 Plume-Front Project Health Risk Plan

Health risk evaluations will be performed during Plume-Front Remediation. The purpose of these assessments will be to achieve and maintain quantitative evaluation of the remediation system. Comparisons will be made of monitor well, influent, and effluent health risk values. The goal will be to assure that injected concentrations do not exceed levels specified by the Plume Front Stabilization Work Plan and Discharge Plan DP-1255.

6.1 Monitor Well Health Risk Evaluation

Quarterly sampling events are planned for the plume-front monitor wells. Following data quality assurance analytical data for COCs in individual wells and Westbay® sampling zones will be quantitatively evaluated for health risk. Where analytical results are ND, health risk and hazard calculations will be done on one half the applicable analytical detection limits. Health risk values and HQs for individual analytes will be calculated. Cumulative health risk and HIs will be generated and summarized for each monitoring well on a quarterly basis. Changes in carcinogenic health risk and hazard values for each COC in each well will be monitored as long as the Plume Front Stabilization Work Plan is in effect.

6.2 Treatment Facility Influent and Effluent Piping Health Risk Monitoring

Treatment facility influent and effluent piping samples will be taken twice weekly during the initial start-up and three-month testing period. Following completion of the testing period and through the first 12 months of operation, sampling will take place monthly. After the first year of the treatment facility operation, influent and effluent piping will be sampled quarterly. Health risk and hazard values for COC concentrations or, where applicable, one half of the analytical detection limits will be calculated and summarized on a quarterly basis.

6.3 Extraction Well Health Risk Monitoring

Each extraction well will be sampled twice weekly during the initial start-up and three-month testing period. Monthly sampling events will be performed following completion of the testing period and through the first 12 months of operation. After the first year of the treatment facility operation, influent and effluent piping will be sampled quarterly. Health risk and hazard values for COC concentrations or, where applicable, one half of the analytical detection limits will be calculated and summarized on a quarterly basis. Cumulative health risk and HI values will be generated for each extraction well from values calculated for individual COCs.

California EPA Pesticide and Environmental Toxicology Section Office of Environmental Health Hazard Assessment publication Public Health Goal for LEAD in Drinking Water, December 1997. http://www.calepa.ca.gov/

California EPA Pesticide and Environmental Toxicology Section Office of Environmental Health Hazard Assessment publication Public Health Goal for NITRATE AND NITRITE in Drinking Water, December 1997. http://www.calepa.ca.gov/

Environmental Assessment Division http://www.ead.anl.gov/

Environmental Protection Agency, Chemical Fact Sheet (EPA 749-F-94-012) at http://www.epa.gov/enviro/html/emci/chemref/.

Environmental Protection Agency, Handbook of RCRA Ground-Water Monitoring Constituents: Chemical and Physical Properties (40 CFR Part 264, Appendix IX), EPA Publication Number 530R92022, September 1992.

Environmental Protection Agency, Treatability Manual Volume 1. Treatability Data, Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C., 1981.

Environmental Protection Agency (EPA), Risk Assessment Guidance for Superfund: Volume 1, "Human Health Evaluation Manual, Part A, Interim Final"(EPA/540/I-89/002), Office of Solid Waste and Emergency Response, Washington, D.C., December 1989.

Environmental Protection Agency (EPA), "Integrated Risk Information System (IRIS)", Duluth, MN. Office of Research and Development (ORD), National Center for Environmental Assessment (NCEA), Current, 2003. http://www.epa.gov/iris/subst/index.html

Environmental Protection Agency (EPA), Region 3 Technical Guidance Manual for Risk Assessment, "Selecting Exposure Routes and Contaminants of Concern by Risk-Based Screening" (EPA/903/R-93-001), Philadelphia, Pennsylvania, January 1993.

Environmental Protection Agency (EPA), Region 8 Superfund Technical Guidance RA-03, "Evaluating and Identifying Contaminants of Concern for Human Health", Denver, Colorado, September 1994.

Environmental Protection Agency (EPA), "2002 Edition of the Drinking Water Standards and Health Advisories" (EPA/822/R-02/038), Office of Water, Washington D.C., updated Summer 2002a.

Environmental Protection Agency (EPA), "National Primary Drinking Water Standards" (EPA 816/F-02/013), updated July 2002b.

Environmental Protection Agency (EPA), "Region III Risk-Based Concentration Table", Philadelphia, Pennsylvania, updated October 2002c. Web site: http://www.epa.gov/reg3hwmd/risk/index.htm.

Environmental Protection Agency (EPA), "Region 9 Preliminary Remediation Goals Table", San Francisco, CA, updated October 2002d. Web site: http://www.epa.gov/region09/waste/sfund/prg/index.htm

Environmental Protection Agency (EPA), Report on Carcinogens, Tenth Edition, 2002e.

Federal Register Notice Environmental Protection Agency Integrated Risk Information System Announcement of 2003 Program; Request for Information and Announcement of Workshop, Volume 68 Number 24, Wednesday, February 5, 2003.

Howard, Philip H., Handbook of Environmental Fate and Exposure Data for Organic Chemicals, Lewis Publishers, Chelsea, Michigan, 1990.

Journal of Physical Chemistry Reference Data, Volume 10, Number 4, 1981.

Lide, David R., Ph.D., Editor-in-Chief, CRC Handbook of Chemistry and Physics, 71st Edition, Chemical Rubber Publishing Company, CRC Press, Boston, Massachusetts, 1990.

National Aeronautics and Space Administration, Draft RCRA Facility Investigation Report, NASA WSTF, Las Cruces, NM, March 1996.

National Aeronautics and Space Administration, Revised Plume-Front Stabilization Work Plan, NASA WSTF, Las Cruces, NM, Original Submission January 1999, Revised May 2002.

National Aeronautics and Space Administration White Sands Test Facility Post-Closure Care Report NASA WSTF, Las Cruces, NM, April, 2000.

New Jersey Department of Health and Senior Services, Hazardous Substance Fact Sheet, http://www.state.nj.us/health/eoh/rtkweb/rtkhsfs.htm, 1998.

New Mexico Environment Department, Daniela Bowman, Personal Communication in email to Ray Spencer, Monday, March 3, 2003.

New Mexico Water Quality Control Commission Regulations 20.6.2 NMAC, September 15, 2002.

U.S. National Library of Medicine (NLM), "Hazardous Substance Data Bank", National Institutes of Health-Department of Health & Human Services, Bethesda, MD, (NLM) available through Toxicology Data Network (TOXNET®) web site: http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB updated May, 2002.

Appendix A
Available information for analytes lacking toxicity data.

DINONYL PHTHALATE

CASRN: 84-76-4

For other data, click on the Table of Contents

Human Health Effects:

Probable Routes of Human Exposure:

Occupational exposure to **dinonyl phthalate** may occur through inhalation of aerosols and dermal contact with this compound at workplaces where **dinonyl phthalate** is used in chromatography or as a plasticizer for vinyl resins. (SRC)

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Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** DIOCTYL PHTHALATE ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

```
0.2.1 SUMMARY OF EXPOSURE
 0.2.1.1 ACUTE EXPOSURE
   A.  Dioctyl phthalate is generally considered to be of low
       toxicity via the oral and dermal routes.  Mucous
       membrane and eye irritation may occur.  Central nervous
       system depression may occur.  Dermal irritation is
       seldom seen.  Skin sensitization does not occur in
       humans.  The low vapor pressure usually precludes
       inhalation of any significant amount except perhaps as
       an aerosol adsorbed to airborne particulates.
0.2.4 HEENT
 0.2.4.1 ACUTE EXPOSURE
   A.  Irritation of eyes, nose, and throat may occur.
0.2.6 RESPIRATORY
 0.2.6.1 ACUTE EXPOSURE
   A.  Respiratory irritation is uncommon, but possible.
0.2.7 NEUROLOGIC
 0.2.7.1 ACUTE EXPOSURE
   A.  Central nervous system depression may occur with
       ingestion of large amounts.
0.2.8 GASTROINTESTINAL
```

0.2.8.1 ACUTE EXPOSURE
A. GI tract or esophageal irritation may occur.
0.2.9 HEPATIC
0.2.9.1 ACUTE EXPOSURE
A. Mild hepatotoxicity has been reported in experimental animals.
0.2.14 DERMATOLOGIC
0.2.14.1 ACUTE EXPOSURE
A. Dermal irritation may sometimes develop.
0.2.16 ENDOCRINE
0.2.16.1 ACUTE EXPOSURE
A. Hypoglycemia has been noted in experimental animals.
0.2.20 REPRODUCTIVE HAZARDS
A. At the time of this review, no studies were found on the potential adverse reproductive effects of dioctyl phthalate in humans.
0.2.21 CARCINOGENICITY
0.2.21.1 IARC CATEGORY
A. The IARC has determined that there is sufficient evidence for carcinogenicity in experimental animals; however, there is insufficient data to evaluate the carcinogenic risk in humans (ACGIH, 1991; IARC, 1982).
0.2.22 GENOTOXICITY
A. Results of numerous tests indicate that dioctyl phthalate is not a direct-acting genotoxic agent in vitro.

Laboratory:

A. Monitor liver function tests and blood glucose.

Treatment Overview:

0.4.2 ORAL EXPOSURE
A. INDUCTION OF EMESIS SHOULD BE AVOIDED.
B. GASTRIC LAVAGE: Consider after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation. Control any seizures first.
1. CONTRAINDICATIONS: Loss of airway protective reflexes or decreased level of consciousness in unintubated patients; following ingestion of corrosives; hydrocarbons (high aspiration potential); patients at risk of hemorrhage or gastrointestinal perforation; and trivial or non-toxic ingestion.
C. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.
D. Observe patients with ingestion carefully for the possible development of esophageal or gastrointestinal tract irritation or burns. If signs or symptoms of esophageal irritation or burns are present, consider endoscopy to determine the extent of injury.
E. Carefully observe patients with ingestion exposure for the development of any systemic signs or symptoms and administer symptomatic treatment as necessary.
F. Monitor level of consciousness in patients ingesting large amounts. If central nervous system depression occurs, ensure that adequate respirations and

oxygenation are maintained.
G. If hypoglycemia occurs, administer glucose as needed until corrected.

0.4.3 INHALATION EXPOSURE

A. INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids.

0.4.4 EYE EXPOSURE

A. DECONTAMINATION: Irrigate exposed eyes with copious amounts of room temperature water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility.

0.4.5 DERMAL EXPOSURE

A. DECONTAMINATION: Remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician may need to examine the area if irritation or pain persists.

Range of Toxicity:

A. A probable lethal human oral dose is between 0.5 and 15 grams per kilogram, or between one ounce and one quart in a 70 kg adult.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

For immediate first aid: Ensure that adequate decontamination has been carried out. If victim is not breathing, start artificial respiration, preferably with a demand-valve resuscitator, bag-valve-mask device, or pocket mask as trained. Perform CPR if necessary. Immediately flush contaminated eyes with gently flowing water. Do not induce vomiting. If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain an open airway and prevent aspiration. Keep victim quiet and maintain normal body temperature. Obtain medical attention. /Esters and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 221]**PEER REVIEWED**

For basic treatment: Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Monitor for pulmonary edema and treat if necessary ... . Monitor for shock and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport ... . Do not use emetics. For ingestion, rinse mouth and administer 5 mL/kg up to 200 mL of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal ... . /Esters and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 221]**PEER REVIEWED**

Animal Toxicity Studies:

Non-Human Toxicity Excerpts:

RATS EXPOSED TO SATURATED VAPORS OF **DINONYL PHTHALATE** AT 28 DEG C FOR 6 HR/DAY FOR 12 DAYS SHOWED NO EFFECT. /FROM TABLE/
[Patty, F. (ed.). Industrial Hygiene and Toxicology: Volume II: Toxicology. 2nd ed. New York: Interscience Publishers, 1963. 1907]**PEER REVIEWED**

ACUTE IP LD50 FOR TWELVE PHTHALIC ACID ESTERS, INCLUDING THOSE COMMONLY USED AS PLASTICIZERS, IN MICE RANGED FROM 3.22 TO GREATER THAN 100 G/KG. MOST /CMPD WERE/ 2-4 TIMES MORE TOXIC CHRONICALLY THAN ACUTELY. **DINONYL PHTHALATE** WAS ONE OF THE PHTHALATES.
[LAWRENCE WH ET AL; ENVIRON RES 9 (1): 1-11 (1975)]**PEER REVIEWED**

IN SINGLE DOSE ACUTE ORAL TOXICITY TEST WITH RATS & MICE, **DINONYL PHTHALATE** SHOWED A LOW ORDER OF TOXICITY (LD50 26 G/KG). CHRONIC DOSING OF RATS WITH 5 ML/KG/DAY FOR 7 DAYS CAUSED /CNS/ DEPRESSION. PHTHALATE WAS NONIRRITATING TO SKIN OF RABBITS, BUT CAUSED IRRITATION OF GUINEA PIG SKIN.
[BROWN VK H ET AL; ARCH TOXICOL 26 (1): 84-90 (1970)]**PEER REVIEWED**

DINONYL PHTHALATE ADMIN ORALLY, THROUGH RESP TRACT OR TOPICALLY TO MICE IN ACUTE, SUBACUTE & CHRONIC EXPERIMENTS PRODUCED TOXICITY WITH DEMYELINIZING ACTION. PARALYSIS, DISTURBANCES OF CENTRAL & PERIPHERAL NERVOUS SYSTEMS, & CACHEXIA OBSERVED.
[TIMOFIEVSKAYA LA ET AL; VOPR GIG TR PROFPATOL TOKSIKOL PROIZVOD ISPOLZ FOSFORORG PLASTIF 83-6 (1973)]**PEER REVIEWED**

... At high doses when injected ip, the esters can act as teratogenic agents and possibly as mutagenic agents in rats. These esters also have an effect upon gonads in rats. /Also/ the esters may bring about biochemical and pathological changes in the liver of rats when repeatedly administered orally or by ip. /Phthalic acid esters/
[USEPA; Ambient Water Quality Criteria Doc: Phthalate Esters p.C-56 (1980) EPA 440/5-80-067]**PEER REVIEWED**

Generally, the oral acute toxicity of the phthalates decreases with increasing molecular weight. /Alkyl phthalates/
[Bio-Environmental Sciences Section Battelle's Columbus Lab; Phthalate Atlas Report p.XI-6 (12/80)]**PEER REVIEWED**

Seven phthalate esters of different chain lengths and degrees of branching were evaluated for their ability to induce peroxisomes in the livers of Fischer-344 rats. The esters included di(2-ethylhexyl) phthalate, butyl, benzyl-phthalate, di(n-butyl)phthalate, di(isodecyl)phthalate, di(isononyl)phthalate, di (undecyl)phthalate, di(n-hexyl,n-octyl,undecyl)phthalate, and di(heptyl,nonyl,undecyl)phthalate. ... Each of the compounds was fed to groups of five male and five female rats in the diet at concentrations of 2.5, 1.2, and either 0.6 or 0.3% for a period of 21 days. Cyanide insensitive palmitoyl-CoA oxidation, lauric acid-11-hydroxylase, and lauric acid-12- hydroxylase were assayed in the liver microsomes. Cholesterol and triglyceride concentrations were measured in the serum. The results indicated that none of the esters was more potent than di(2-ethylhexyl)phthalate. The most sensitive parameters were relative liver weight and cyanide insensitive palmitoyl-CoA oxidation. The latter parameter was assumed to be an indicator of peroxisome proliferation and thereby predictive of liver tumorigenesis. Based on these assumptions, the authors conclude that the seven phthalate esters are no more carcinogenic than the weak liver carcinogen di(2-ethylhexyl)phthalate.
[Barber E et al; Toxicology & Industrial Health 3 (2): 7-24 (1987)]**PEER

REVIEWED**

A series of straight and branched chain phthalate monoesters were examined for their effects on hepatocyte intercellular communication in male B6C3F1 mouse hepatocytes. Intercellular communication was determined autoradiographically following the passage and incorporation of 5-(3)H-uridine nucleotides from pre-labelled hepatocytes into nonlabelled hepatocytes. Intercellular communication was evaluated in hepatocytes after 8 hr treatment of straight and branched chain phthalate esters at sublethal concentrations. Straight chain phthalate monoesters (mono(ethyl)phthalate, mono(n-butyl) phthalate, mono(n-hexyl)phthalate, mono(n-octyl)-phthalate, mono(nonyl)phthalate and mono(isononyl)phthalate) had no effect on hepatocyte intercellular communication. Branched chain phthalate monoesters that contained on ethylalkyl moiety (ie mono(2-ethylpropyl) phthalate, mono(2-ethylbutyl)-phthalate, mono(2-ethylphenyl)-phthalate and mono(2-ethylhexyl)phthalate) inhibit intercellular communication in mouse hepatocytes. Based upon previous correlations between inhibition of intercellular communication in hepatocytes and hepatocarcinogenicity, these data suggest that branched chain phthalate esters may be liver carcinogens in male B6C3F1 mice.
[Klaunig JE et al; Cancer Lett 43 (1-2): 65-72 (1988)]**PEER REVIEWED**

The effect of nine different plasticizers on the proliferation of rat hepatic peroxisomes was evaluated statistically by multivariate analysis. The compounds were di(2-ethylhexyl)phthalate (DEHP), butyl,benzyl-phthalate (BBP), di(n-butyl)phthalate (DBP), di(isodecyl)phthalate (DIDP), di(isononyl) phthalate (DINP), di(undecyl)phthalate (DUP), di(n-hexyl,n-ocytl,undecyl)phthalate, di (heptyl,nonyl,undecyl)phthalate, and di(ethylhexyl)adipate. The compounds were fed to rats during a period of 21 days in doses ranging from 0.3 to 2.5 percent of the diet. The following parameters were measured: body weight gains and food intake; serum triglyceride and cholesterol levels; heptic enzyme activity including cyanide insensitive palmitoyl-CoA oxidation; lauric-acid-11- hydroxylase (11H); and lauric-acid-12-hydroylase (12H). By using multivariate analysis, the dosage of each plasticizer needed to protect 99.9 percent of rats against peroxisome proliferation was estimated. The ability of the nine compounds to cause peroxisome proliferation was ranked, in decreasing order, di(2-ethylhexyl) phthalate, di(isodecyl)phthalate, di(isononyl)phthalate di(n-butyl)phthalate, di(ethylhexyl)adipate, di (undecyl)phthalate, butyl,benzyl-phthalate, di(heptyl,nonyl,undecyl)phthalate, and di(n-hexyl,n-ocytl,undecyl)phthalate. The quantitative index for basophilia/eosinophilia was correlated with the peroxisome proliferation index.
[Lin LI-K; Toxicology & Industrial Health 3 (2): 25-48 (1987)]**PEER REVIEWED**

Primary rat hepatocyte cultures were used to compare the effects of some alkylphthalate esters on peroxisomal enzyme activities and morphology. Linear diesters from methyl to n-octyl and their constituent monoesters, and alcohols were compared with the branched chain 2-ethylhexyl derivatives. Studies with diesters indicated that induction of carnitine acetyltransferase required hydrolysis of the diester. The straight chain phthalates had little effect on hepatic peroxisomes compared with the 2-ethylhexyl ester, and hepatocyte cultures provided a rapid means of comparing the peroxisomal effects of different phthalates. /Alkyl phthalate esters/
[Gray TJB et al; Toxicology 28 (1-2): 167-80 (1983)]**PEER REVIEWED**

Estrogens are defined by their ability to induce the proliferation of cells of the female genital tract. The wide chemical diversity of estrogenic compounds precludes an accurate prediction of estrogenic activity on the basis of chemical structure. Rodent bioassays are not suited for the large-scale screening of chemicals before their release into the environment because of their cost, complexity, and ethical concerns. The E-SCREEN assay was developed to assess the estrogenicity of environmental chemicals using the proliferative effect of estrogens on their target cells as an end point. This quantitative assay compares the cell number achieved by similar inocula of MCF-7 cells in the absence of estrogens (negative control) and in the presence of 17 beta-estradiol (positive control) and a range of

concentrations of chemicals suspected to be estrogenic. Among the compounds tested, several "new" estrogens were found; alkylphenols, phthalates, some PCB congeners and hydroxylate PCBs, and the insecticides dieldrin, endosulfan, and toxaphene were estrogenic by the E-SCREEN assay. In addition, these compounds competed with estradiol for binding to the estrogen receptor and increased the levels of progesterone receptor and pS2 in MCF-7 cells, as expected from estrogen mimics. Recombinant human growth factors (bFGF, EGF, IGF-1) and insulin did not increase cell yields. The aims of the work summarized in this paper were a) to validate the E-SCREEN assay; b) to screen a variety of chemicals present in the environment to identify those that may be causing reproductive effects in wildlife and humans; c) to assess whether environmental estrogens may act cumulatively; and finally d) to discuss the reliability of this and other assays to screen chemicals for their estrogenicity before they are released into the environment.
[Soto AM et al; Environmental Health Perspectives 103: 113-122 (1995)]**PEER REVIEWED**

The toxicity to HeLa cells of 29 plasticizers was determined in the MIT (Metabolic Inhibition Test)-24 test system. The 7-day IC50 (median inhibitory concentration) for HeLa cells varied from 260 to 1.5 g/l. Phthalates, adipates, sebacates, azelates and phosphates with long carbon chain alcohols were very non-toxic to the cells, probably due to insolubility in water of the compounds, while the citrates, some phosphates and the 2 polymer plasticizers had a higher toxicity to the cells. A comparison of the HeLa cytotoxicity with the toxicity in vitro to other cells for 7 plasticizers showed a similarity of the cytotoxicity to all cell types. A comparison of the HeLa cytotoxicity for 20 plasticizers with ip lethal dosage in rodents demonstrated a rough similarity of values, suggesting a toxicity in rodents of the compounds by toxic interference of the agents with basal functions and structures of tissues (basal cytotoxicity). Tissue culture studies of the cytotoxic mechanisms of the plasticizers therefore could reveal modes of toxic action in vivo.
[Ekwall B et al; Toxicology 24 (3-4): 199-210 (1982)]**PEER REVIEWED**

The ability of phthalic acid, phthalic acid anhydride, and various phthalate esters to enhance the mutagenicity of many amino acid pyrolysates was observed with the Ames test (Salmonella typhimurium TA98), but not the SOS Chromotest. Phthalate enhancement of the mutagenicity of 4-nitroquinoline-1-oxide, 2-nitrofluorene, and benzo[a]pyrene was not observed with either test. The mutagenicity-enhancing ability may be related to the induction of enzymes such as P450IIB, that metabolize amino acid pyrolysates. By quantitative structure activity relationship (QSAR) analysis, a good correlation was observed between the mutagenicity-enhancing activity of phthalates and their octanol-water partition coefficients.
[Sato T et al; Environ Mol Mutagen 24 (4): 325-31 (1994)]**PEER REVIEWED**

Non-Human Toxicity Values:

LD50 Rat oral 2.00 g/kg /From table/
[USEPA/ECAO; Atlas Document for: Phthalate Esters p.V-3 (1980)]**PEER REVIEWED**

LD50 MOUSE, RAT, & GUINEA PIG ACUTE ORAL VALUE FOR **DINONYL PHTHALATE** WAS 18.0-21.5 G/KG.
[TIMOFIEVSKAYA LA ET AL; GIG TR PROF ZABOL 3: 25-8 (1980)]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

The phthalate diesters are rapidly metabolized to the monoester both in the intestine and following

absorption. The rate of hydrolysis is greater for the lower molecular weight esters. The monoester may undergo further oxidation of the alcohol side chain, but further hydrolysis is minimal. Suggest that the half hydrolysis of diester substrates is due to the anionic charge of the free carbonyl group inhibiting formation of the enzyme-substrate complex. /Phthalate diesters/
[USEPA/ECAO; Atlas Document for: Phthalate Esters p.XI-5 (1980)]**PEER REVIEWED**

Absorption, Distribution & Excretion:

The phthalic acid esters and/or their metabolites are readily absorbed from the intestinal tract, the intraperitoneal cavity, and the lung. There is also evidence indicating that these esters can be absorbed through the skin. The vehicle can play an important role in the absorption, distribution, and elimination of the ester. /Phthalic acid esters/
[USEPA; Ambient Water Quality Criteria Doc: Phthalate Esters p.C-12 (1980) EPA 440/5-80-067]**PEER REVIEWED**

Absorbed esters of phthalic acid esters (or their metabolites) distribute quite rapidly to various organs and tissues both in animals and humans, especially the liver, kidney, and bile. /Phthalic acid esters/
[USEPA/ECAO; Atlas Document for: Phthalate Esters p.IV-3 (1980)]**PEER REVIEWED**

Pharmacokinetic studies have been performed using ingestion, absorption through skin, and injection. Phthalates were readily taken up, distributed, metabolized, and excreted by all three routes of exposure. /Phthalates/
[USEPA/ECAO; Atlas Document for: Phthalate Esters p.XI-4 (1980)]**PEER REVIEWED**

Pharmacology:

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Dinonyl phthalate's production and use as a plasticizer for vinyl resins may result in its release to the environment through various waste streams. If released to air, an estimated vapor pressure of 5.1X10-7 mm Hg at 25 deg C indicates **dinonyl phthalate** is expected to exist in both the vapor and particulate phases in the ambient atmosphere. Vapor-phase **dinonyl phthalate** will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 16 hours. Particulate-phase **dinonyl phthalate** may be physically removed from the atmosphere by wet and dry deposition. If released to soil, an estimated Koc of 3.6X10+6 suggests **dinonyl phthalate** will be essentially immobile. Volatilization from dry soil surfaces is not expected to occur given this compound's estimated vapor pressure. **Dinonyl phthalate** may volatilize from wet soil surfaces based upon an estimated Henry's Law constant of 1.4X10-5 atm-cu m/mole. However, adsorption to organic matter is expected to attenuate this process. Biodegradation is expected to be an important process in both soil and water. A half-life of 6 to 8 days was measured for di (heptyl,nonyl,undecyl)phthalate in river die-away tests. If released into water, **dinonyl phthalate** is expected to adsorb to suspended solids and sediment in the water column based upon the estimated Koc. In sterile microcosms containing lake water and sediment, 80% of di(heptyl,nonyl,undecyl) phthalate partitioned to the sediment. Volatilization from water surfaces is expected to be slow based upon this compound's estimated Henry's Law constant. Estimated volatilization half-lives from a model river and a model lake are 5.6 and 47 days, respectively. Volatilization from water surfaces is expected to be reduced by adsorption to suspended solids and sediment. An estimated BCF of 1.0X10+7 suggests the potential for bioconcentration in aquatic organisms is very high. However, bioconcentration studies on other phthalate esters suggest that bioconcentration may be lower than indicated by the regression-

derived equations due to the ability of aquatic organisms to metabolize phthalate esters. Estimated hydrolysis half-lives of 7.7 years and 280 days at pHs 7 and 8, respectively, suggest hydrolysis is not expected to be an important process. Occupational exposure to **dinonyl phthalate** may occur through inhalation of aerosols and dermal contact with this compound at workplaces where **dinonyl phthalate** is used in chromatography or as a plasticizer for vinyl resins. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

Occupational exposure to **dinonyl phthalate** may occur through inhalation of aerosols and dermal contact with this compound at workplaces where **dinonyl phthalate** is used in chromatography or as a plasticizer for vinyl resins. (SRC)
PEER REVIEWED

Artificial Pollution Sources:

Dinonyl phthalate's production and use as a general purpose, low volatility plasticizer for vinyl resins and the pure form's use as a stationary liquid phase in chromatography(1) may result in its release to the environment through various waste streams(SRC).
[(1) Lewis RJ Jr; Hawley's Condensed Chemical Dictionary 12th ed NY,NY: Van Nostrand Reinhold Co p 424 (1993)]**PEER REVIEWED**

Environmental Fate:

TERRESTRIAL FATE: Based on a recommended classification scheme(1), an estimated Koc value of 3.6X10+6(SRC), determined from an estimated log Kow of 9.5(2,SRC) and a recommended regression-derived equation(3), indicates that **dinonyl phthalate** is expected to be essentially immobile in soil (SRC). Volatilization of **dinonyl phthalate** from moist soil surfaces may be an important fate process (SRC) given an estimated Henry's Law constant of 1.4X10-5 atm-cu m/mole(SRC), using a fragment constant estimation method(4). **Dinonyl phthalate** is not expected to volatilize from dry soil surfaces based on an estimated vapor pressure of 5.1X10-7 mm Hg(SRC), determined from a fragment constant method(5). Biodegradation of **dinonyl phthalate** in soil may be important(SRC), based upon its biodegradation in aqueous screening studies.
[(1) Swann RL et al; Res Rev 85: 23 (1983) (2) Meylan WM, Howard PH; J Pharm Sci 84: 83-92 (1995) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington,DC: Amer Chem Soc pp. 4-9 (1990) (4) Meylan WM, Howard PH; Environ Toxicol Chem 10: 1283-93 (1991) (5) Lyman WJ; p. 31 in Environmental Exposure From Chemicals Vol I, Neely WB, Blau GE(eds), Boca Raton,FL: CRC Press (1985)]**PEER REVIEWED**

AQUATIC FATE: Based on a classification scheme(1), an estimated Koc value of 3.6X10+6(SRC), determined from an estimated log Kow of 9.5(2,SRC) and a regression-derived equation(3), indicates that **dinonyl phthalate** is expected to adsorb to suspended solids and sediment in water(SRC). In sterile microcosms containing lake water and sediment, approximately 80% of di(heptyl,nonyl,undecyl) phthalate partitioned to sediment(4). **Dinonyl phthalate** is expected to volatilize slowly from water surfaces(3,SRC) based on an estimated Henry's Law constant of 1.4X10-5 atm-cu m/mole(SRC), developed using a fragment constant estimation method(5). Estimated volatilization half-lives for a model river and model lake are 5.6 and 47 days, respectively(3,SRC). However, adsorption to suspended solids and sediment is expected to attenuate volatilization(SRC). The volatilization half-life from a pond 2 m deep is estimated to be about 61 days ignoring adsorption(6); when considering maximum adsorption the volatilization half-life increases to 2000 years(6). According to a classification scheme (7), an estimated BCF of 1.0X10+7(3,SRC), from an estimated log Kow(2,SRC), suggests the potential

for bioconcentration in aquatic organisms is very high(SRC). However, bioconcentration studies on other phthalate esters suggest that bioconcentration may be lower than indicated by the regression-derived equations due to the ability of aquatic organisms to metabolize phthalate esters(9,10). **Dinonyl phthalate** is expected to biodegrade in aquatic systems(SRC). Di(heptyl,nonyl,undecyl)phthalate had a half-life of 6 to 8 days in river die-away tests(4). Estimated hydrolysis half-lives of 7.7 years and 280 days at pHs 7 and 8, respectively suggest that hydrolysis is not expected to be an important process(8).
[(1) Swann RL et al; Res Rev 85: 23 (1983) (2) Meylan WM, Howard PH; J Pharm Sci 84: 83-92 (1995) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington,DC: Amer Chem Soc pp. 4-9, 5-4, 5-10, 15-1 to 15-29 (1990) (4) Carson DB et al; Aquat Toxicol Risk Assess: 13th Vol, ASTM STP 1096 pp 48-59 (1990) (5) Meylan WM, Howard PH; Environ Toxicol Chem 10: 1283-93 (1991) (6) USEPA; EXAMS II Computer Simulation (1987) (7) Franke C et al; Chemosphere 29: 1501-14 (1994) (8) Mill T et al; Environmental Fate and Exposure Studies Development of a PC-SAR for Hydrolysis: Esters, Alkyl Halides and Epoxides. EPA Contract No. 68-02-4254. Menlo Park, CA: SRI International (1987) (9) Sasaki S; pp. 283-98 in Aquatic Pollutants: Transformation And Biological Effects. Hutzinger O et al Eds. Oxford: Pergamon Press (1978) (10) Staples CA et al; Chemosphere 35: 667-749 (1997)]**PEER REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), **dinonyl phthalate,** which has an estimated vapor pressure of 5.1X10-7 mm Hg at 25 deg C(2,SRC), will exist in both the vapor and particulate phases in the ambient atmosphere. Vapor-phase **dinonyl phthalate** is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals(SRC); the half-life for this reaction in air is estimated to be about 16 hours(3,SRC). Particulate-phase **dinonyl phthalate** may be physically removed from the air by wet and dry deposition(SRC).
[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Lyman WJ; p 31 in Environmental Exposure From Chemicals Vol I, Neely WB, Blau GE(eds), Boca Raton, FL: CRC Press (1985) (3) Meylan WM, Howard PH; Chemosphere 26: 2293-99 (1993)] **PEER REVIEWED**

Environmental Biodegradation:

Dinonyl phthalate, added to a semi-continuous activated sludge apparatus at 5, 10, and 20 mg added per 24 hr, underwent 52%, 48%, and 54% degradation, respectively, under aerobic conditions(1,2). When **dinonyl phthalate** was incubated with pure cultures of Pseudomonas acidovorans under aerobic conditions, the initial degradation products were phthalic acid and nonyl alcohol(3). Di(heptyl,nonyl,undecyl)phthalate had a half-life of 6 to 8 days in river die-away tests(4). In active microcosms containing lake water and sediment, 40 to 48% of (14)C-di(heptyl,nonyl,undecyl)phthalate radioactivity was evolved as carbon dioxide over a 41 day period; after six weeks no residual (14)C-di(heptyl,nonyl,undecyl)phthalate was found in the water column and only 2 to 6% was associated with sediments(4). In SCAS tests, a primary degradation half-life of <1 day at an addition rate of 5 to 200 mg/l per 24-hour cycle was observed for di(heptyl,nonyl,undecyl)phthalate(4). In shake flask studies using an acclimated bacterial inoculum, an ultimate biodegradation half-life of 5 days was observed for di(heptyl,nonyl,undecyl)phthalate at an initial concentration of 20 mg/l(4). 98% biodegradation of di(heptyl,nonyl,undecyl)phthalate was observed over a period of 28 days in shake flask tests using an acclimated inoculum consisting of soil and sewage microorganisms(5).
[(1) Saeger VW, Tucker ES; Appl Environ Microbiol 31: 29-34 (1976) (2) Saeger VW, Tucker ES; Plastics Eng Aug: 46-49 (1973) (3) Kurane R et al; Agric Biol Chem 41: 2119-23 (1977) (4) Carson DB et al; Aquat Toxicol Risk Assess: 13th Vol, ASTM STP 1096 pp. 48-59 (1990) (5) Sugatt RH et al; Appl Environ Microbiol 47: 601-6 (1984)] **PEER REVIEWED**

ANAEROBIC: **Dinonyl phthalate** was microbially transformed by activated sludge under anaerobic

conditions(1).
[(1) Rogers JE; Anaerobic transformation process: a review of the microbiological literature. Athens, GA: USEPA Res Lab, Report 1986, USEPA/600/3-86/042 (NTIS PB86-230042) pp. 61 (1986)]**PEER REVIEWED**

Environmental Abiotic Degradation:

The rate constant for the vapor-phase reaction of **dinonyl phthalate** with photochemically-produced hydroxyl radicals has been estimated as 2.3X10-11 cu cm/molecule-sec at 25 deg C(SRC) using a structure estimation method(1,SRC). This corresponds to an atmospheric half-life of about 16 hours at an atmospheric concentration of 5X10+5 hydroxyl radicals per cu cm(1,SRC). Phthalate esters hydrolyze in water by acid and base catalyzed reactions(2). A base-catalyzed second order hydrolysis rate constant of 2.9X10-2 L/mol-sec(SRC) was estimated using a structure estimation method(3); this corresponds to half-lives of 280 days and 7.7 years at pH values of 8 and 7, respectively(3,SRC).
[(1) Meylan WM, Howard PH; Chemosphere 26: 2293-99 (1993) (2) Mabey W, Mill T; J Phys Chem Ref Data 7: 383-415 (1978) (3) Mill T et al; Environmental Fate and Exposure Studies Development of a PC-SAR for Hydrolysis: Esters, Alkyl Halides and Epoxides. EPA Contract No. 68-02-4254. Menlo Park, CA: SRI International (1987)] **PEER REVIEWED**

Environmental Bioconcentration:

An estimated BCF of 1.0X10+7 was calculated for **dinonyl phthalate(**SRC), using an estimated log Kow of 9.5(1,SRC) and a regression-derived equation(2). According to a classification scheme(3), this BCF suggests the potential for bioconcentration in aquatic organisms is very high(SRC). However, bioconcentration studies on other phthalate esters suggest that bioconcentration may be lower than indicated by the regression-derived equations due to the ability of aquatic organisms to metabolize phthalate esters(4,5).
[(1) Meylan WM, Howard PH; J Pharm Sci 84: 83-92 (1995) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington,DC: Amer Chem Soc pp. 5-4, 5-10 (1990) (3) Franke C et al; Chemosphere 29: 1501-14 (1994) (4) Sasaki S; pp. 283-98 in Aquatic Pollutants: Transformation And Biological Effects. Hutzinger O et al Eds. Oxford: Pergamon Press (1978) (5) Staples CA et al; Chemosphere 35: 667-749 (1997)]**PEER REVIEWED**

Soil Adsorption/Mobility:

The Koc of **dinonyl phthalate** is estimated as approximately 3.6x10+6(SRC), using an estimated log Kow of 9.5(1,SRC) and a regression-derived equation(2,SRC). According to a classification scheme(3), this estimated Koc value suggests that **dinonyl phthalate** is expected to be essentially immobile in soil (SRC). In sterile microcosms containing lake water and sediment, approximately 80% of di (heptyl,nonyl,undecyl) phthalate partitioned to sediment(4).
[(1) Meylan WM, Howard PH; J Pharm Sci 84: 83-92 (1995) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington,DC: Amer Chem Soc pp. 4-9 (1990) (3) Swann RL et al; Res Rev 85: 23 (1983) (4) Carson DB et al; Aquat Toxicol Risk Assess: 13th Vol, ASTM STP 1096 pp. 48-59 (1990)]**PEER REVIEWED**

Volatilization from Water/Soil:

The Henry's Law constant for **dinonyl phthalate** is estimated as 1.4X10-5 atm-cu m/mole(SRC) using a fragment constant estimation method(1). This value indicates that **dinonyl phthalate** is expected to volatilize slowly from water surfaces(2,SRC). Based on this Henry's Law constant, the estimated volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec) is

estimated as approximately 5.6 days(2,SRC). The estimated volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec) is estimated as approximately 47 days(2,SRC). The volatilization half-life from a pond 2 m deep is estimated to be about 61 days ignoring adsorption (3); when considering maximum adsorption the volatilization half-life increases to 2000 years(3). **Dinonyl phthalate's** Henry's Law constant(1,SRC) indicates that volatilization from moist soil surfaces may occur(SRC). **Dinonyl phthalate** is not expected to volatilize from dry soil surfaces based on an estimated vapor pressure of 5.1X10-7 mm Hg(SRC), determined from a fragment constant method(4).
[(1) Meylan WM, Howard PH; Environ Toxicol Chem 10: 1283-93 (1991) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington,DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (3) USEPA; EXAMS II Computer Simulation (1987) (4) Lyman WJ; p. 31 in Environmental Exposure From Chemicals Vol I, Neely WB, Blau GE(eds), Boca Raton,FL: CRC Press (1985)]**PEER REVIEWED**

Environmental Water Concentrations:

DRINKING WATER: **Dinonyl phthalate** was qualitatively identified in British drinking water derived from lowland river water and groundwater sources, and in a German low land river(1).
[(1) Crathorne B et al; Environ Sci Tech 18: 797-802 (1984)]**PEER REVIEWED**

SURFACE WATER: **Dinonyl phthalate** was detected, but not quantified, in the River Mersey, United Kingdom(1).
[(1) Webster RDJ, Nickless, G; Proc Anal Div Chem Soc 13: 333-5 (1976)]**PEER REVIEWED**

Atmospheric Concentrations:

INDOOR AIR: **Dinonyl phthalate** associated with small particulates was detected inside telephone office buildings in Wichita, KS and Lubbock, TX at a concentration of 15 ng/cu m(1).
[(1) Weschler CJ; Env Sci Tech 18: 648-52 (1984)]**PEER REVIEWED**

Environmental Standards & Regulations:

TSCA Requirements:

Pursuant to section 8(d) of TSCA, EPA promulgated a model Health and Safety Data Reporting Rule. The section 8(d) model rule requires manufacturers, importers, and processors of listed chemical substances and mixtures to submit to EPA copies and lists of unpublished health and safety studies. 1,2-Benzenedicarboxylic acid, dinonyl ester is included on this list.
[40 CFR 716.120 (7/1/96)]**PEER REVIEWED**

Clean Water Act Requirements:

Toxic pollutant designated pursuant to section 307(a)(1) of the Clean Water Act and is subject to effluent limitations. /Phthalate esters/
[40 CFR 401.15 (7/1/88)]**QC REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

C26-H42-O4
[Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van

Nostrand Reinhold, 1984. 1222]**PEER REVIEWED**

Molecular Weight:

418.62
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 2345]**PEER REVIEWED**

Color/Form:

Colorless, oily liquid
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 12th ed. New York, NY: Van Nostrand Rheinhold Co., 1993 424]**PEER REVIEWED**

Boiling Point:

413 DEG C
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 2345]**PEER REVIEWED**

Density/Specific Gravity:

0.972 @ 20 DEG C
[Lefaux, R. Practical Toxicology of Plastics. Cleveland: CRC Press Inc., 1968. 139] **PEER REVIEWED**

Solubilities:

INSOL IN WATER
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 2345]**PEER REVIEWED**

Spectral Properties:

INDEX OF REFRACTION: 1.4871 @ 20 DEG C/D
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 12th ed. New York, NY: Van Nostrand Rheinhold Co., 1993 424]**PEER REVIEWED**

Vapor Pressure:

1 MM HG @ 205 DEG C
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 2345]**PEER REVIEWED**

Viscosity:

112 CP @ 20 DEG C
[Lefaux, R. Practical Toxicology of Plastics. Cleveland: CRC Press Inc., 1968. 139] **PEER REVIEWED**

Other Chemical/Physical Properties:

LOW GELLING POWER
[Lefaux, R. Practical Toxicology of Plastics. Cleveland: CRC Press Inc., 1968. 139] **PEER REVIEWED**

Phthalate esters are soluble to various extents in many common organic solvents and oils, but have a relatively low solubility in water. /Phthalate esters/
[Nat'l Research Council Canada; Phthalate Esters in the Aquatic Environment p.16 (1980) NRCC No. 17583]**PEER REVIEWED**

CONVERSION FACTOR: 17.09 MG/CU M= 1 PPM
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 2345]**PEER REVIEWED**

Suspensions of adsorbents such as kaolin, palygorskite, halloysite and silica were found to readily adsorb di-n-nonylphthalate (DnNP) from solutions of toluene. The phthalate ester formed a monolayer on the adsorbent.
[Nat'l Research Council Canada; Phthalate Esters in the Aquatic Environment p.34 (1980) NRCC No. 17583]**PEER REVIEWED**

Phthalate esters would be expected to have UV maxima in the 230 nm and 270 nm regions. /Phthalate esters/
[Bio-Environmental Sciences Section Battelle's Columbus Lab; Phthalate Atlas Report p.II-5 (12/80)]**PEER REVIEWED**

Most phthalate esters have a relatively high calculated log octanol/water partition coefficient > 2.12 indicating that they are lipophilic. /Phthalate esters/
[Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume II. EPA-440/4-79-029b. Washington, D.C.: U.S. Environmental Protection Agency, December 1979.p. 94-8]**PEER REVIEWED**

Chemical Safety & Handling:

Hazardous Decomposition:

When heated to decomp it emits acrid smoke and irritating fumes.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1388]**PEER REVIEWED**

Protective Equipment & Clothing:

Use ... of garments to protect /workmen/ from irritation due to contact with phthalic anhydride /which is used in the manufacturing process of phthalic acid esters/; the use of gloves to prevent contamination of the hand and lower arm. /Phthalic esters/
[Lefaux, R. Practical Toxicology of Plastics. Cleveland: CRC Press Inc., 1968. 134] **PEER REVIEWED**

SYNTH OF PHTHALATES REQUIRE GOOD VENTILATION IN ORDER TO /MINIMIZE/ CONTAMINATION OF AIR WITH PHTHALIC ANHYDRIDE OR ALCOHOLS. THERE MAY BE ALSO SOME NEED FOR SKIN PROTECTION. HANDLING MINERAL ACIDS USED AS CATALYSTS REQUIRES ORDINARY PRECAUTIONS. /PHTHALATES/

[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 1059]**PEER REVIEWED**

Preventive Measures:

Increased /room/ ventilation and /SRP: decreased/ aspiration of vapors and dusts. /Phthalic esters/
[Lefaux, R. Practical Toxicology of Plastics. Cleveland: CRC Press Inc., 1968. 134] **PEER REVIEWED**

SRP: Contaminated protective clothing should be segregated in such a manner so that there is no direct personal contact by personnel who handle, dispose, or clean the clothing. Quality assurance to ascertain the completeness of the cleaning procedures should be implemented before the decontaminated protective clothing is returned for reuse by the workers. Contaminated clothing should not be taken home at end of shift, but should remain at employee's place of work for cleaning.
PEER REVIEWED

Disposal Methods:

SRP: At the time of review, criteria for land treatment or burial (sanitary landfill) disposal practices are subject to significant revision. Prior to implementing land disposal of waste residue (including waste sludge), consult with environmental regulatory agencies for guidance on acceptable disposal practices.
PEER REVIEWED

Occupational Exposure Standards:

Manufacturing/Use Information:

Major Uses:

It is used for making vinyl mixes which have to withstand heat and resist migration and extraction by detergents; also useful in the technology of plastisols and coating pastes
[Lefaux, R. Practical Toxicology of Plastics. Cleveland: CRC Press Inc., 1968. 139] **PEER REVIEWED**

AS STATIONARY LIQUID PHASE IN CHROMATOGRAPHY (PURE GRADE)
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 12th ed. New York, NY: Van Nostrand Rheinhold Co., 1993 424]**PEER REVIEWED**

Manufacturers:

Sterling Chemicals, Inc., Hq, 1200 Smith Street, Suite 1900, Houston, TX 77002-4312, (713) 650-3700; Production site: Texas City, TX 77590 /Di-(nonyl-heptyl-undecyl)phthalate/
[SRI. 1996 Directory of Chemical Producers-United States of America. Menlo Park, CA: SRI International, 1996. 820]**PEER REVIEWED**

Methods of Manufacturing:

The alcohol (butyl, octyl, etc) esterified with phthalic anhydride in the presence of a catalyst (sulfuric acid or p-toluenesulfonic acid) or non-catalytically at high temp. The esterification is carried out at ordinary pressure or in a vacuum, the water formed during the reaction being eliminated as it is formed by entrainment by a third component (hydrocarbon or usually the alcohol used in the esterification). The

hydrocarbon may be benzene, toluene, or cyclohexane. The reaction can be carried out discontinuously or by a continuous method. /Phthalic esters/
[Lefaux, R. Practical Toxicology of Plastics. Cleveland: CRC Press Inc., 1968. 134]
PEER REVIEWED

Consumption Patterns:

APPROXIMATELY 90% OF ALL PHTHALATE ESTER PLASTICIZERS ARE USED IN POLYVINYL CHLORIDE RESINS; THE REMAINING 10% ARE USED AS PLASTICIZERS IN OTHER RESINS AND AS CARRIERS OR DISPERSING MEDIA FOR OTHER SUBSTANCES, SUCH AS CATALYSTS OR INITIATORS, PESTICIDES, COSMETICS, AND COLORANTS (1975). /PHTHALATE ESTER PLASTICIZERS/
[SRI]**PEER REVIEWED**

U. S. Production:

(1972) PROBABLY GREATER THAN 4.54X10+5 G
[SRI]**PEER REVIEWED**

(1975) PROBABLY GREATER THAN 4.54X10+5 G
[SRI]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

THE KOVATS RETENTION INDEX **DINONYL PHTHALATE** WAS DETERMINED BY GLASS CAPILLARY COLUMN GAS CHROMATOGRAPHY FOR IDENTIFICATION OF THE ESTERS IN BIOLOGICAL FLUIDS. COLUMN PARAMETERS WERE: 0.5% OV-101 COATINGS, 230 DEG C, HELIUM OR NITROGEN AS CARRIER GAS; 0.5% SE-30 COATING, 250 DEG C; A FLAME IONIZATION DETECTOR WAS USED WITH BOTH COLUMNS.
[FRIOCOURT MP ET AL; J CHROMATOGR 172: 261-71 (1979)]**PEER REVIEWED**

Analytic Laboratory Methods:

IN AN ATTEMPT TO DEVELOP A METHOD FOR THE DETERMINATION OF PHTHALATE ESTERS IN WATER BY ADSORPTION CHROMATOGRAPHY, THE HIGH PERFORMANCE LIQUID CHROMATOGRAPHIC BEHAVIOR OF DIONYL PHTHALATE IN WATER USING AN OCTADECYLTRICHLOROSILANE BONDED STATIONARY PHASE WAS EXAMINED. PHTHALATE ESTERS IN WATER WERE COMPLETELY ADSORBED ON OCTADECYLTRICHLOROSILANE BONDED BEADS AND THEIR ELUTION ORDER IN 100% WATER TO 100% METHANOL GRADIENT SYSTEM WAS DIRECTLY RELATED TO THE NUMBER OF ALKYL CARBON ATOMS IN THE ESTER GROUPS OF PHTHALATES. STUDY INDICATED THAT THE SEPARATION MECHANISM MAY BE DUE TO THE INTERACTION OF AFFINITY BETWEEN OCTADECYL GROUPS OF THE BONDED STATIONARY PHASE AND THE LENGTH OF THE ALKYL CHAIN IN THE ESTER GROUP OF EACH PHTHALATE WITH SOLUBILITIES OF EACH PHTHALATE ESTER FOR THE MOBILE PHASE.
[OTSUKI A; J CHROMATOGR 133 (2): 402-7 (1977)]**PEER REVIEWED**

Special References:

Special Reports:

Nat'l Research Council Canada; Phthalate Esters in the Aquatic Environment (1980) NRCC No. 17583

USEPA; Ambient Water Quality Criteria Doc: Phthalate Esters (1980) EPA 440/5-80-067

Woodward KN (ed); Phthalate Esters: Toxicity and Metabolism (1988)

Phthalate Esters; Environ Health Perspect 45: 1-210 (1982)

USEPA/ECAO; Atlas Document for: Phthalate Esters (1980)

Staples CA et al; Environmental Toxicology and Chemistry 16 (5): 875-891 1997. Aquatic toxicity of eighteen phthalate esters.

Lopez-Avila V et al; ASTM Waste Testing and Quality Assurance 3:129-140 1991. Evaluation of sample extract cleanup using solid-phase extraction cartridges.

Pols HB et al; IAWPRC Conf on North Sea Pollution 24 (10): 55-68 1991. The occurrence and the sources of black list substances in two river basins in the Netherlands.

Benenati F; ASTM Plants for Toxicity Assessment 5-13 1990. Plants keystone to risk assessment.

Carson DB et al; ASTM Aquatic Toxicology and Risk Assessment 48-59 1990. Use of microcosms versus conventional biodegradation testing for estimating chemical persistence.

Van Houdt JJ; Atmost Environ Part B Urban Atmos 24 (2): 207-220 1990. Mutagenic activity of airborne particulate matter in indoor and outdoor environments.

Walker JD; ASTM Aquatic Toxicology and Risk Assessment 77-90 1990. Review of chemical fate testing conducted under section 4 of the Toxic Substances Control Act chemical tests and methods.

Dmitriev MT and VD Semyanitsyi; Gig Sanit 0 (8): 55-59 1989. Chromographic methods for the determination of airborne esters for hygienic research.

Lopez-Avila V et al; J Chromatogr Sci 27 (5): 209-220 1989. Cleanup of enivronmental sample extracts using florisil solid-phase extraction cartridges.

Timofievskaya La et al; Gig Tr Prof Zabol 0 (7): 52-55 1988. Regular features of the toxicity and accelerated standardization of o phthalic acid esters.

Thompson TS and FW Karasek; J Chromatogr 388 (2): 351-364 1987. Identification of trace organic contaminants in inorganic water treatment chemicals by gas chromatography mass spectrometry.

Lederer J; Arch Belg Med Soc Hyg Med Trav Med Leg 44 (1-2): 3-44 1986. Problems raised by possible contamination foods by phthalates.

Woodward KN et al; HM Stationeray Office Publications Centre p183 1986. Review of the toxicity of the esters of o-phthalic acid (phthalate esters).

Crathorne B et al; Environ Sci Technol 18 (10): 797-802 1984. Organic compounds in water: Analysis using coupled-column high-performance liquid chromatography and soft-ionization mass spectrometry.

Eder G; Veroeff Inst Meeresforsch Bremerhaven 20 (1): 41-48 1984. Organic pollutants in marine sediments.

Othman MYB et al; J Chromatography 289: 1-16 1984. Total optimization of the separation of C1-C3 chlorohydrocarbons by gas-liquid chromatography.

Weschler CJ; Environ Sci Technol 18 (9): 648-652 1984. Indoor-outdoor relationships for nonpolar organic constituents of aerosol particles.

Takeuchi T and D Ishii; J Chromatogr 218 (0): 199-208 1981. Application of ultra micro high performance liquid chromatography to trace analysis.

Synonyms and Identifiers:

Synonyms:

1,2-BENZENEDICARBOXYLIC ACID, DINONYL ACID
PEER REVIEWED

1,2-Benzenedicarboxylic acid, dinonyl ester
PEER REVIEWED

BISOFLEX DNP
PEER REVIEWED

BISOLFLEX 91
PEER REVIEWED

DINONYL 1,2-BENZENEDICARBOXYLATE
PEER REVIEWED

DI-N-NONYL PHTHALATE
PEER REVIEWED

Di-n-nonylphthalate (DnNP)
PEER REVIEWED

DITRIMETHYLHEXYL PHTHALATE
PEER REVIEWED

NONYL PHTHALATE
PEER REVIEWED

PHTHALIC ACID, DINONYL ESTER
PEER REVIEWED

UNIMOLL DN
PEER REVIEWED

Administrative Information:

Hazardous Substances Databank Number: 365

Last Revision Date: 20020513

Last Review Date: Reviewed by SRP on 1/31/1998

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Complete Update on 11/01/1990, 47 fields added/edited/deleted.
Complete Update on 12/14/1984

Record Length: 58249

ISOPROPANOL

CASRN: 67-63-0

For other data, click on the Table of Contents

Human Health Effects:

Evidence for Carcinogenicity:

Evaluation: There is inadequate evidence for the carcinogenicity of **isopropanol** in humans. There is inadequate evidence for the carcinogenicity of **isopropanol** in experimental animals. Overall evaluation: **Isopropanol** is not classifiable as to its carcinogenicity to humans (Group 3).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 71 1034 (1999)]**QC REVIEWED**

Human Toxicity Excerpts:

... SINCE **ISOPROPYL ALCOHOL** HAS GREATER FAT-SOLVENT EFFECTS THAN ETHYL ALCOHOL, REPEATED USE HAS A DRYING EFFECT ON THE SKIN.
[American Medical Association, AMA Department of Drugs, AMA Drug Evaluations. 3rd ed. Littleton, Massachusetts: PSG Publishing Co., Inc., 1977. 885]**PEER REVIEWED**

SYMPTOMATOLOGY: 1. DIZZINESS, INCOORDINATION, HEADACHE, CONFUSION, STUPOR & COMA. 2. GASTROENTERITIS WITH VOMITING, HEMATEMESIS, & DIARRHEA. 3. HYPOTENSION, WITH OR WITHOUT BRADYCARDIA, & SOMETIMES ... CIRCULATORY COLLAPSE. 4. PERSISTENT COMA WITH HYPOTHERMIA. 5. DEATH BY RESP ARREST. 6. LATE MANIFESTATIONS: ASPIRATION PNEUMONIA; KIDNEY & LIVER DYSFUNCTIONS, WHICH ARE USUALLY MILD & TRANSIENT, BUT THE RENAL IMPAIRMENT MAY BE SERIOUS.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-218]**PEER REVIEWED**

ISOPROPYL ALCOHOL IS NOT A DERMAL IRRITANT ... ALTHOUGH SEVERE CASES /PRIMARY/ OF ALLERGIC CONTACT DERMATITIS HAVE BEEN REPORTED ... .
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 235 (1977)]**PEER REVIEWED**

DAILY ORAL INTAKE OF LOW DOSES (2.6 OR 6.4 MG/KG BODY WEIGHT) OF **ISOPROPYL ALCOHOL** BY GROUPS OF 8 MEN FOR 6 WEEKS HAD NO EFFECT ON BLOOD CELLS, SERUM OR URINE AND PRODUCED NO SUBJECTIVE SYMPTOMS.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 235 (1977)]**PEER REVIEWED**

Blood **isopropyl alcohol** concentrations and clinical findings were evaluated retrospectively in 17 cases of **isopropyl alcohol** ingestion to determine any significant correlations. Admission blood **isopropyl alcohol** ranged from 5-70 mg/dl, while the acetone metabolite levels ranged from undetectable to 220 mg/dl. The most common physical findings were altered consciousness, tachycardia, decreased deep tendon reflexes, dysarthria, ataxia, hypotension, fever and mydriasis. No statistically significant correlations with blood levels were observed.

[Kelner M, Bailey DN; J Toxicol Clin Toxicol 20 (5): 497-507 (1983)]**PEER REVIEWED**

Complete hemolysis or denaturation of human erythrocytes occurred in all aq isopropyl soln after 45 min at 37 deg C. ... A dose of 16 ml has been ingested daily for 3 days without discomfort but acute symptoms have been observed following a dose of 25 ml. ... Transit acute renal failure, hemolysis, and myopathy occurred in a 35 yr old alcoholic, and were attributed to the ingestion of **isopropyl alcohol. ...** A 20 yr old man attempted suicide by the rectal admin of about 500 ml of **isopropyl alcohol.** Stupor was followed, 16 hr after admission to hospital, by peroids of generalized tremors and agitation, progressing to a schizophrenic syndrome. ... An infant developed coma following topical applications of **isopropyl alcohol** for the relief of fever.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 40]**PEER REVIEWED**

ACCORDING TO CLINICAL EXPERIENCE **ISOPROPYL ALCOHOL** IS MORE TOXIC THAN ETHYL ALCOHOL AND LESS TOXIC THAN METHYL ALCOHOL. ... ITS ACUTE POTENCY AS CENTRAL NERVOUS DEPRESSANT IS ABOUT TWICE THAT OF ETHANOL. PROBABLE LETHAL ORAL DOSE FOR ADULT IS 8 OZ (240 ML), BUT AS LITTLE AS 20 ML IN WATER CAN PRODUCE SYMPTOMS.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-271]**PEER REVIEWED**

400 PPM VALUE IS CONSIDERED TO BE LOW ENOUGH NOT TO CAUSE ... /CNS DEPRESSION/ ALTHOUGH SLIGHT IRRITATION MAY OCCUR.
[American Conference of Governmental Industrial Hygienists. TLV's Threshold Limit Values for Chemical Substances and Physical Agents in the Work Environment with Intended Changes for 1983-84. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1983.23]**PEER REVIEWED**

TWO PT WITH ALCOHOL DERMATITIS & HYPERSENSITIVITY TO PRIMARY ALCOHOLS WERE TESTED FOR HYPERSENSITIVITY TO SECONDARY ALCOHOLS. GAS CHROMATOGRAPHICALLY PURE 2-PROPANOL PRODUCED AN INTENSE ECZEMATOUS RESPONSE IN BOTH.
[FREGERT S ET AL; ACTA DERM-VENEROL 51 (4): 271-2 (1971)]**PEER REVIEWED**

REPORT OF A CASE OF OCCUPATIONALLY ACQUIRED SENSITIVITY TO **ISOPROPYL ALCOHOL** IN WHICH, ON TESTING WITH GAS CHROMATOGRAPHICALLY PURIFIED MATERIAL, POSITIVE PATCH TEST REACTIONS WERE FOUND TO 1-PROPANOL, 1-BUTANOL, 2-PROPANOL, 2-BUTANOL.
[LUDWIG E, HAUSEN BM; CONTACT DERMATITIS 3 (5): 240-4 (1977)]**PEER REVIEWED**

An incr incidence of cancer of the paranasal sinuses was observed in workers at factories where **isopropyl alcohol** was manufactured by the strong acid process. The risk for larynegeal cancer may also have been elevated in these workers. It is unclear whether the cancer risk is due to the presence of diisopropyl sulfate, which is an intermediate in the process, to isopropyl oils, which are formed as by-products, or to other factors, such as sulfuric acid. /**Isopropyl alcohol** manufacture/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. S7 229 (1987)]**PEER REVIEWED**

... Mass poisoning involving 372 men who had consumed a soln of 82% methanol and 18% **isopropanol** /was reported/.

[O'Donoghue, J.L. (ed.). Neurotoxicity of Industrial and Commercial Chemicals. Volume II. Boca Raton, FL: CRC Press, Inc., 1985. 82]**PEER REVIEWED**

... /Isopropyl and n-propyl/ alcohols are about twice as toxic as ethanol; the fatal dose by ingestion is 250 ml. ... The principal manifestation of acute isopropyl or n-propyl poison is CNS depression. Symptoms and signs: (From inhalation, ingestion, or skin absorption) ... persistent nausea, vomiting, abdominal pain, hematemesis, refractory ... /CNS depression/, areflexia, depressed respirations, and oliguria followed by diuresis. Deep coma has resulted from sponging with **isopropyl alcohol.** Generalized tenderness, induration, and edema of muscles may occur. ... Prolonged contact with the skin can cause corrosion.
[Dreisbach, R.H. Handbook of Poisoning. 12th ed. Norwalk, CT: Appleton and Lange, 1987. 178]**PEER REVIEWED**

The toxic dose is about 1 ml/kg of a 70% **isopropanol** soln (as commonly seen in rubbing alcohol), but as little as 0.5 ml/kg may cause symptoms. ... Survival has occurred at such levels in an 18 month old child with dialysis and supportive care. Adults have survived 1-liter ingestion.
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 798] **PEER REVIEWED**

Isopropanol intoxication has a rapid onset of action (30-60 min), with peak effects within several hr. ... Severe poisoning presents early with deep coma, resp depression, and hypotension. Central nervous system: Dizziness, poor coordination, headache, and confusion progress to stupor, coma, and loss of deep tendon reflexes in serious cases. Serious nervous system depression often persists for 24 hr. ... Pupils often are miotic, and nystagmus usually is present. Gastrointestinal tract: Gastric irritation appears early, with abdominal pain and vomiting being prominent. Hematemesis may occur. Cardiovascular system: The hypotension associated with large overdoses probably results from peripheral vasodilation. ... Tachycardia was the most common finding ... Organ dysfunction: Cases of acute tubular necrosis, hepatic dysfunction, hemolytic anemia, and myoglobinuria have been reported. ... Mild hypothermia may occur ... .
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 799] **PEER REVIEWED**

ETHANOL & CERTAIN SHORT CHAIN ARYL (BENZYL) & ALIPHATIC (PROPYL, BUTYL) ALCOHOLS PRODUCED UP TO 10 FOLD INCR IN CYCLIC AMP CONCN IN PURIFIED HUMAN PERIPHERAL BLOOD LYMPHOCYTES. ETHANOL CONCN AS LOW AS 80 MG/DL PRODUCED SIGNIFICANT ELEVATIONS IN LYMPHOCYTE CYCLIC AMP.
[ATKINSON JP ET AL; J CLIN INVEST 60 (2): 284-94 (1977)]**PEER REVIEWED**

Human systemic effects by ingestion or inhalation: flushing, pulse rate decr, blood pressure lowering, anesthesia, narcosis, headache, dizziness, mental depression, hallucinations, distorted perceptions, dyspnea, respiratory depression, nausea or vomiting, coma. ... Acts as a local respiratory irritant and in high concn as a narcotic.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1977]**PEER REVIEWED**

It has good warning properties because it causes a mild irritation of the eyes, nose, & throat at a concn level of 400 ppm.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1977]**PEER REVIEWED**

Acute inhalation exposure to **isopropanol** can produce central nervous system depression that may be

prolonged by acetone, a metabolite of **isopropanol**. lethalities have occurred in very young and newborn children. Ingestion of **isopropanol** has been implicated in the deaths of a number of adults, particularly among alcoholics. Pulmonary congestion was the most frequent postmortem finding and is typical, although not diagnostic or specific, of deaths involving drug-induced central nervous system depression.

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V71 1031 (1999)]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Mild irritation of the eyes, nose and throat was induced in human subjects exposed for 3 to 5 min to 400 ppm of **isopropyl alcohol.**
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 2634]**PEER REVIEWED**

It can be an irritant of the eyes, mucous membranes, & respiratory tract.
[Sullivan, J.B. Jr., G.R. Krieger (eds.). Hazardous Materials Toxicology-Clinical Principles of Environmental Health. Baltimore, MD: Williams and Wilkins, 1992. 1107]**PEER REVIEWED**

Medical Surveillance:

A complete history and physical examination should be performed to detect pre existing conditions that might place the employee at increased risk, and to establish a baseline for future health monitoring. Examination of the skin, liver, kidneys, and respiratory system should be stressed. Skin disease: **Isopropyl alcohol** is a defatting agent and can cause dermatitis on prolonged exposure. Persons with pre existing skin disorders may be more susceptible to the effects of this agent. Liver disease: Although **isopropyl alcohol** is not known as a liver toxin in humans, the importance of this organ in the biotransformation and detoxification of foreign substances should be considered before exposing persons with impaired liver function. Kidney disease: Although **isopropyl alcohol** is not known as a kidney toxin in humans, the importance of this organ in the elimination of toxic substances justifies special consideration in those with impaired renal function. Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of **isopropyl alcohol** might cause exacerbation of symptoms due to its irritant properties. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1] **PEER REVIEWED**

The assessment of **isopropyl alcohol** exposure can be accomplished through measurement of either **isopropyl alcohol** or acetone. **Isopropyl alcohol** measurement has not been found to be a good assessment of low level exposure, due to its low sensitivity. However, measurement of acetone has been found to be a good indicator of **isopropyl alcohol** exposure for exposures as low as 70 ppm, and has been found to correlate well with air concentrations. Whole Blood Reference Ranges: Normal - none detected (**isopropyl alcohol);** Exposed - BAT (sampling time is end of exposure or end of shift, measured as the metabolite, acetone), 50 mg/l; Toxic - **Isopropyl alcohol** level associated with serious toxic symptoms is 150 mg/l. Serum or Plasma Reference Ranges: Normal - none detected (**isopropyl alcohol);** Exposed - not established; and Toxic - not established. Urine Reference Ranges: The assessment of **isopropyl alcohol** exposure can be accomplished through measurement of either

isopropyl alcohol or acetone. However only acetone was found to be a useful test, due to its greater sensitivity and good correlation with air exposure levels. Normal - none detected (**isopropyl alcohol);** Exposed - BAT (sampling time is end of exposure or end of shift, measured as the metabolite, acetone), 50 mg/l; Toxic - Not established.
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 782]**PEER REVIEWED**

Renal Function Tests /include/ ... Urine Albumin ... Urinary Beta-2-Microglobulin and/or Retinal Binding Protein (RBP) ... Urinary Alpha and Pi Isoenzymes of Glutathione S-Transferase ... Urinary Enzyme N-Acetylglucosaminidase ... /and/ Routine Urinalysis.
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 783]**PEER REVIEWED**

Populations at Special Risk:

Persons with pre existing skin disorders may be more susceptible to the effects of this agent. ... In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of **isopropyl alcohol** might cause exacerbation of symptoms due to its irritant properties.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1] **PEER REVIEWED**

Probable Routes of Human Exposure:

NIOSH (NOES Survey 1981-1983) has statistically estimated that 4,665,524 workers (2,058,264 of these are female) are potentially exposed to **isopropanol** in the US(1). Occupational exposure to **isopropanol** may occur through inhalation and dermal contact with this compound at workplaces where **isopropanol** is produced or used(SRC). Occupational exposure to **isopropanol** may occur during the mfg of chemicals using **isopropanol**, its use as a solvent in various industrial applications, and its use in medicinal applications(SRC). For example, inhalation exposure of workers to **isopropanol**(sampling location, concn mg/cu m) in various industries are as follows: car painting(personal, avg 7.1); ink production (area, 6.3-32.8); paint manufacture (personal, time-weighted avg range 6-258); hospital operating theater (area, avg 8.8); tractor painting (area, range 33-332); higher aromatic boot spray painting (personal, time-weighted avg-avg 4.7); lower aromatic booth spray painting (personal, time-weighted-avg-avg 10.6); solvent wiping (personal, time-weighted-avg-avg 2.5); paint mixing (time-weighted-avg-avg, 4.2); spraying paint lacquer (personal, time-weighted-avg-avg <2.5); printing (personal, time-weighted-avg-avg 396); printed circuit boards mfg (personal, range 5.8-23); furniture stripping (personal, range 42-160); degreasing metal (personal, range 2.2-10.6); mfg of rubber weather strips (area, range 6.5-140); chemicals packaging (area, range 150-1350); **isopropanol** production (area, avg 165)(2). The inhalation exposure to **isopropanol** varied from 0.4 to 14.8 mg/cu m, with a mean of 5.6 mg/cu m, for hairdressers in Norway(3). Monitoring data indicate that the general population may be exposed to **isopropanol** via inhalation of ambient air, ingestion of food, and dermal contact with this compound directly and from consumer products containing **isopropanol**(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983) (2) WHO; Environmental Health Criteria 103, 2-Propanol. Geneva, Switzerland: WHO International Program on Chemical Safety. pp. 1-77 (1990) (3) Hollund BE, Moen BE; Ann Occup Hyg 42: 277-81 (1998)]**PEER REVIEWED**

Body Burden:

Isopropanol detected in 8 of 12 samples of mother's milk from 4 urban areas in the United States(1).

The avg and range of **isopropanol** concns in human breath due to metabolic processes is 150 ug/cu m and 50-260 ug/cu m (40 subjects in room air), respectively (2).
[(1) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982) (2) Fenske JD, Paulson SE; J Air Waste Manage Assoc 49: 594-598 (1999)]**PEER REVIEWED**

Minimum Fatal Dose Level:

PROBABLE LETHAL ORAL DOSE FOR ADULT IS 8 OZ (240 ML)
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-271]**PEER REVIEWED**

... fatal dose by ingestion is 250 ml. ...
[Dreisbach, R.H. Handbook of Poisoning. 12th ed. Norwalk, CT: Appleton and Lange, 1987. 178]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

EMT Copyright Disclaimer:

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The following Overview, *** **ISOPROPYL ALCOHOL ***,** is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

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0.2.1 SUMMARY OF EXPOSURE
 0.2.1.1 ACUTE EXPOSURE
   A.  Isopropyl alcohol is generally believed to produce
       greater CNS depression than ethanol at comparable blood
       levels.  Isopropyl alcohol is toxic by the oral,
       dermal, parenteral, and inhalation exposure routes.
       Not all rubbing alcohol contains isopropanol; some
       contains ethanol.  Most rubbing alcohol formulations
       contain 70 percent isopropanol.
   B.  Ingestion or inhalation of isopropyl alcohol may result
       in flushing, headache, dizziness, hallucinations,
       distorted perceptions, dyspnea,  nausea, vomiting, CNS
       depression, and coma.  Respiratory depression,
       hypotension, bradycardia, and hypothermia may occur
       with severe overdoses.   Tachycardia is common.
       Ketonemia and ketonuria may be present, generally
       without metabolic acidosis.  Emesis and hemorrhagic
       gastritis may occur  following ingestion.
   C.  Renal insufficiency with anuria followed by oliguria,
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nitrogen retention, and edema may be a complication of poisoning.

0.2.3 VITAL SIGNS

0.2.3.1 ACUTE EXPOSURE

A. Ingestion, dermal absorption, or inhalation commonly cause tachycardia. Hypothermia, bradycardia, and hypotension may occur with severe poisoning.

0.2.4 HEENT

0.2.4.1 ACUTE EXPOSURE

A. Eye discomfort without significant injury occurs with brief vapor or splash exposure (70 percent solution).

B. Temporary changes in the corneal epithelium may develop after prolonged vapor exposure. Moderate irritation has been produced in animal eye tests.

0.2.5 CARDIOVASCULAR

0.2.5.1 ACUTE EXPOSURE

A. Tachycardia is common. Hypotension and bradycardia may occur in severe poisonings.

0.2.6 RESPIRATORY

0.2.6.1 ACUTE EXPOSURE

A. Respiratory depression and failure can occur in cases of severe poisoning from inhalation, ingestion, or parenteral exposure. Tracheobronchitis may occur.

0.2.7 NEUROLOGIC

0.2.7.1 ACUTE EXPOSURE

A. CNS depression is common, ranging from disorientation and lethargy to coma. Dysarthria, ataxia, and nystagmus may develop. Diminished or absent deep tendon reflexes are common. Seizures and increased CSF protein levels are rare effects.

0.2.8 GASTROINTESTINAL

0.2.8.1 ACUTE EXPOSURE

A. Vomiting and gastritis may occur. Hemorrhagic gastritis and associated anemia may be present.

0.2.10 GENITOURINARY

0.2.10.1 ACUTE EXPOSURE

A. Acute renal tubular necrosis has been reported in patients with hypotension or rhabdomyolysis. Myoglobinuria has been reported.

0.2.11 ACID-BASE

0.2.11.1 ACUTE EXPOSURE

A. Ketosis and ketonuria are common. Significant metabolic acidosis is rare.

0.2.13 HEMATOLOGIC

0.2.13.1 ACUTE EXPOSURE

A. Hemolysis may occur after exposure.

0.2.14 DERMATOLOGIC

0.2.14.1 ACUTE EXPOSURE

A. Dermal irritation and burns may develop from chronic use or prolonged contact. Systemic absorption may occur following dermal application, particularly in infants.

0.2.15 MUSCULOSKELETAL

0.2.15.1 ACUTE EXPOSURE

A. Rhabdomyolysis may occur following exposure.

0.2.16 ENDOCRINE

0.2.16.1 ACUTE EXPOSURE

A. Mild hyperglycemia is often reported in adults. Children may be at greater risk for developing

hypoglycemia.
0.2.20 REPRODUCTIVE HAZARDS
A. At the time of this review, no reproductive studies were found for **isopropanol** in humans.
0.2.21 CARCINOGENICITY
0.2.21.1 IARC CATEGORY
A. **Isopropanol** is classified as Group 3 (not classifiable as to its carcinogenicity in humans) by the International Agency for Research on Cancer (IARC, 1999).
B. **Isopropyl alcohol** manufacturing using the strong-acid method has been classified by the IARC in Group 1: carcinogenic to humans (IARC, 1987). The cancer risk is not believed to be due to **isopropyl alcohol,** but possibly results from other chemicals involved in or generated by this manufacturing process.
0.2.21.2 HUMAN OVERVIEW
A. **Isopropanol** is not regarded as a human carcinogen at the present time.
B. Some studies reported an increased incidence of paranasal, laryngeal and pharynx cancers, but this was felt to be related to other chemicals used in the manufacture of **isopropanol** using the strong acid method.
0.2.21.3 ANIMAL OVERVIEW
A. **Isopropyl alcohol** has not been carcinogenic in experimental animals.
0.2.22 GENOTOXICITY
A. **Isopropanol** has not been genotoxic in a variety of short-term tests.

Laboratory:

A. Determine serum **isopropyl alcohol** concentration and blood glucose.
B. Supportive studies -
1. Measure serum and urinary acetone concentrations. Acetone may be present in the serum within 30 min to 1 hour and in the urine by 3 hours after ingestion.
2. In severely symptomatic patients and those in whom the diagnosis may be in doubt, measure serum ethanol levels, electrolytes and arterial blood gases to identify acid-base abnormalities and to rule out ethanol or other alcohol exposure.
C. An increased osmolar gap suggests the possibility of toxic alcohol ingestion, but cannot be reliably used to exclude significant **isopropanol** ingestion.

Treatment Overview:

0.4.2 ORAL EXPOSURE
A. EMESIS - The onset of CNS depression usually occurs within 30 minutes of ingestion; ipecac-induced emesis is NOT recommended.
B. GASTRIC LAVAGE: Consider after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation. Control any seizures first.
1. CONTRAINDICATIONS: Loss of airway protective reflexes or decreased level of consciousness in unintubated

patients; following ingestion of corrosives; hydrocarbons (high aspiration potential); patients at risk of hemorrhage or gastrointestinal perforation; and trivial or non-toxic ingestion.

C. Efficacy of activated charcoal has not been proven in **isopropyl alcohol** ingestions.

D. SYMPTOMATIC AND SUPPORTIVE TREATMENT - is generally all that is needed.

E. MONITOR AND MAINTAIN VITAL SIGNS - Rule out presence of HYPOGLYCEMIA in symptomatic patients.

F. HYPOTENSION: Infuse 10 to 20 mL/kg isotonic fluid. If hypotension persists, administer dopamine (5 to 20 mcg/kg/min) or norepinephrine (ADULT: begin infusion at 0.5 to 1 mcg/min; CHILD: begin infusion at 0.1 mcg/kg/min); titrate to desired response.

G. HEMODIALYSIS - Consider hemodialysis in patients with marked symptomatology (generally hypotension) unresponsive to standard therapy.

0.4.3 INHALATION EXPOSURE

A. INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids.

0.4.4 EYE EXPOSURE

A. DECONTAMINATION: Irrigate exposed eyes with copious amounts of room temperature water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility.

0.4.5 DERMAL EXPOSURE

A. DECONTAMINATION: Remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician may need to examine the area if irritation or pain persists.

Range of Toxicity:

A. Blood **isopropyl alcohol** concentrations of 128 to 200 mg/dL, measured within hours after ingestion, have been associated with deep coma and death.

B. Ingestion of as little as 3 ounces of 70 percent **isopropyl alcohol** may produce blood levels of 100 mg/dL in a 70 kg person if rapidly absorbed.

C. Chronic alcoholics may tolerate very high levels of **isopropyl alcohol** without developing significant CNS depression.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

Basic Treatment: Establish a patent airway. Action if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary. Administer oxygen by nonrebreather mask at 10 to 15

l/min. Monitor for shock and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport ... . Do not use emetics. For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal ... . /Lower alcohols (1-3 Carbons) and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 197]**PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious or in respiratory arrest. Monitor cardiac rhythm and treat arrhythmias if necessary ... . Start an IV with lactated Ringer's to support vital signs. Watch for signs of fluid overload. Monitor for signs of hypoglycemia (decreased LOC, tachycardia, pallor, dilated pupils, diaphoresis, and/or a reading on a dextrose strip or glucometer of less than 50 mg/dl) and administer 50% dextrose if necessary ... . For hypotension with signs of hypovolemia, administer fluid cautiously. Consider vasopressors for hypotension with a normal fluid volume ... . Use proparacaine hydrochloride to assist eye irrigation ... . /Lower alcohols (1-3 Carbons) and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 198]**PEER REVIEWED**

Animal Toxicity Studies:

Evidence for Carcinogenicity:

Evaluation: There is inadequate evidence for the carcinogenicity of **isopropanol** in humans. There is inadequate evidence for the carcinogenicity of **isopropanol** in experimental animals. Overall evaluation: **Isopropanol** is not classifiable as to its carcinogenicity to humans (Group 3).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 71 1034 (1999)]**QC REVIEWED**

Non-Human Toxicity Excerpts:

RATS THAT INGESTED 0.5 TO 10.0 PERCENT **ISOPROPYL ALCOHOL** IN THEIR DRINKING WATER FOR 27 WEEKS SHOWED DECREASED BODY WEIGHT GAIN. NO GROSS OR MICROSCOPIC ABNORMALITIES OF THE BRAIN, PITUITARY, LUNG, HEART, LIVER, SPLEEN, KIDNEYS, OR ADRENALS WERE OBSERVED.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 4564]**PEER REVIEWED**

GROUP OF 30 ROCKLAND MICE WERE TREATED THRICE WEEKLY 1 YR WITH **ISOPROPYL ALCOHOL.** NO SKIN TUMORS WERE DETECTED (NIOSH, 1976) (THE WORKING GROUP NOTED THAT THE SEX, DOSE, AND OBSERVATION PERIOD WERE NOT SPECIFIED).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 231 (1977)]**PEER REVIEWED**

GROUPS OF 3 MO OLD MALE C3H, ABC OR C57BL MICE WERE EXPOSED FOR 3-7 HR/DAY, 5 DAYS/WK FOR 5-8 MO TO A CONCENTRATION OF 7000 MG/CU M **ISOPROPYL ALCOHOL** IN AIR. ANIMALS WERE KILLED @ 8-12 MO OF AGE. INCIDENCE OF LUNG TUMORS WAS NOT INCR, COMPARED WITH THAT IN CONTROLS.

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 232 (1977)]**PEER REVIEWED**

GROUPS OF 3 MO OLD MALE C3H, ABC & C57BL MICE WERE TREATED BY SC INJECTION WITH 0.025 ML ISOPROPYL ALC ONCE WEEKLY FOR 20-40 WK, @ WHICH TIME ANIMALS WERE KILLED. NO INCR IN INCIDENCE OF LUNG TUMORS WERE FOUND.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 232 (1977)]**PEER REVIEWED**

... RATS ... EXPOSED CONTINUOUSLY FOR 86 DAYS TO AIR CONCN OF 8.14 PPM **ISOPROPANOL** (20 MG/CU M) ... SHOWED CHANGES IN REFLEX BEHAVIOR & INCR IN RETENTION OF BROMOSULFOPHTHALEIN. POST MORTEM FINDINGS INCL ENLARGED SPLEEN, SOME EVIDENCE OF LIVER PARENCHYMAL CELL DYSTROPHY & DEGENERATIVE CHANGES IN CEREBRAL MOTOR CORTEX.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 233 (1977)]**PEER REVIEWED**

ISOPROPYL ALC WAS GIVEN CONTINUOUSLY IN DRINKING WATER IN DOSES OF 1.5, 1.4, & 1.3 G/KG BODY WT/DAY TO PARENTS & TO TWO SUCCESSIVE GENERATIONS OF RATS, RESPECTIVELY. NEITHER GROWTH, REPRODUCTIVE FUNCTION NOR EMBRYONIC OR POSTNATAL DEVELOPMENT WERE AFFECTED, EXCEPT FOR SOME RETARDATION OF GROWTH EARLY IN LIFE OF FIRST GENERATION RATS.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 234 (1977)]**PEER REVIEWED**

ACCUMULATION OF LIVER TRIGLYCERIDES WAS OBSERVED IN RATS FOLLOWING SINGLE ORAL DOSE OF 6 G/KG BODY WT.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 233 (1977)]**PEER REVIEWED**

ISOPROPYL ALC CAUSES MILD TRANSITORY INJURY /WHEN APPLIED TO RABBIT EYES/, GRADED 4 ON SCALE OF 1-10 AFTER 24 HR. /MOST SEVERE INJURIES HAVE BEEN RATED 10/. IRRIGATION OF RABBIT EYES FOR 3 MIN WITH 50% **ISOPROPYL ALCOHOL** CAUSED REACTION /WHICH/ GRADED 50 ON SCALE OF 0 TO 100.
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 539]**PEER REVIEWED**

ONE MONKEY WAS GIVEN /ISOPROPYL ALC &/ ... EXAMINER HAD IMPRESSION OF CONGESTION OR HYPEREMIA OF OPTIC NERVEHEADS AFTER FIRST DOSE, THERE APPEARED TO BE NO DISTURBANCE OF THE EYES. IN SAME STUDY SEVERAL RABBITS WERE GIVEN ISOPROPYL ALC BY STOMACH TUBE & RATHER STRANGE OPHTHALMOSCOPIC OBSERVATIONS WERE REPORTED, CONSISTING OF BLURRING OR CUPPING OF OPTIC DISCS IN SOME ANIMALS.
[Grant, W. M. Toxicology of the Eye. 2nd ed. Springfield, Illinois: Charles C. Thomas, 1974. 610]**PEER REVIEWED**

ISOPROPANOL INHIBITED GERMINATION OF LETTUCE FRUITS WITH AN ED50 (MEDIAN EFFECTIVE DOSE) OF 35 MILLIMOLES.

[REYNOLDS I; PLANT SCI LETT 15 (1): 25 (1979)]**PEER REVIEWED**

ISOPROPANOL, 50 MMOL/KG BY GASTRIC TUBE, INDUCED TRIACYLGLYCEROL ACCUMULATION IN LIVER OF FEMALE WISTAR RATS. AFTER ADMIN, LIVER PALMITATE-(14)C UPTAKE INCR WHEREAS HEPATIC PALMITATE OXIDN TO (14)CO2 WAS IMPAIRED & PALMITATE ESTERIFICATION INTO TRIACYLGLYCEROL WAS ENHANCED.
[BEAUGE F ET AL; CHEM-BIOL INTERACT 26 (2): 155 (1979)]**PEER REVIEWED**

ACUTE OR CHRONIC TREATMENT OF RATS WITH **ISOPROPANOL** CAUSED AN INCREASE IN HEPATIC CYTOCHROME P-450 CONTENT & A 2-FOLD INCREASE IN ANILINE HYDROXYLASE & 7-ETHOXYCOUMARIN O-DEETHYLASE ACTIVITIES, BUT NO SIGNIFICANT CHANGE IN ETHYLMORPHINE N-DEMETHYLASE OR BENZO(A)PYRENE HYDROXYLASE ACTIVITY.
[UENG TH ET AL; TOXICOL APPL PHARMACOL 71 (2): 204-14 (1983)]**PEER REVIEWED**

... This compound induced death in 31% of embryos and malformations in 14% of embryos. The substance was given to pregnant rats /at/ 0.018-1008 mg/kg. Behavior abnormalities in progeny of treated females were also found.
[Shepard, T.H. Catalog of Teratogenic Agents. 5th ed. Baltimore, MD: The Johns Hopkins University Press, 1986. 329]**PEER REVIEWED**

A CORRELATION BETWEEN HYPNOTIC POTENCY OF ALIPHATIC ALC & ABILITIES TO DISRUPT STRUCTURE OF NEURONAL MEMBRANE IN VITRO WAS ESTABLISHED. SIGNIFICANT REDN IN ORDER PARAMETER WERE OBSERVED @ NERVE BLOCKING CONCN. THE FOLLOWING ALCOHOLS WERE INVESTIGATED: ETHANOL, PROPANOL, 2-PROPANOL, BUTANOL, 2-BUTANOL, 2-METHYL-1-PROPANOL, 2-METHYL-2-PROPANOL. DISORDERING POTENCY OF EACH ALCOHOL WAS CLOSELY RELATED TO ITS MEMBRANE SOLUBILITY, BASED ON OIL/WATER PARTITION COEFFICIENT.
[LYON RC ET AL; J PHARMACOL EXP THER (3) 218: 669-75 (1981)]**PEER REVIEWED**

IN THE RAT ... THE ORDER OF INCREASING LETHALITY BY SINGLE DOSE ORAL ADMIN IS AS FOLLOWS: ETHYL, ISOPROPYL AND SEC-BUTYL, N-BUTYL, TERT-BUTYL, ISOBUTYL, & AMYL ALCOHOLS.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-12]**PEER REVIEWED**

In an in-vivo study, **isopropanol** did not induce micronuclei in bone marrow of mice. ... Studies conducted in mammalian cells in vitro, it did not induce sister chromatid exchanges or gene mutations. **Isopropanol** did not induce aneuploidy in Neurospora crassa study. ... It as not mutagenic to bacteria.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V71 1032 (1999)]**PEER REVIEWED**

Inhalation of 400 ppm (1000 mg/cu m) **isopropanol** by guinea pigs for 24 hours reduced the ciliary activity in the nasal mucosa, but recovery was complete within two weeks. Higher concentrations produced damage that required longer to repair.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V71 1032 (1999)]**PEER REVIEWED**

Rats continuously inhaling 8 ppm (20 mg cu m) **isopropanol** for 86 days showed increased bromosulfophthalein retention, liver parenchymal dystrophy, enlarged spleen and degenerative changes

in the brain. Groups of rats inhaling **isopropanol** at a concentration of 8000 ppm (20,000 mg/cu m) for 20 weeks showed no change in erythrocyte numbers. There was an increase in serum cholesterol levels throughout the dosing period, which returned to normal values within four weeks in a 12 week recovery period. Serum alanine aminotransferase and aspartate aminotransferase activities were significantly increased during the first 12 weeks of the dosing period, but had returned to normal values by the end of the dosing period. No effect on these parameters was observed at 4000 ppm (10,000 mg/cu m).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V71 1031 (1999)]**PEER REVIEWED**

Groups of 65 male and 65 female Fischer 344 rats, approximately seven weeks old, Were exposed by inhalation to target concentrations of 0 (control), 500, 2500 and 5000 ppm (0, 1225, 6125 and 12250 mg/cu m) **isopropanol** vapor (purity, 99.9%) for 6 hr per day on five days per week for 104 weeks. The mean actual concentrations were 504 + or - 114, 2509 + or - 58 and 5037 + or - 115 ppm, respectively. The highest concentration (5000 ppm) was selected as result of the mortality observed at 10000 ppm in a previous nine day inhalation study and the toxic effects observed at 5000 ppm in a previous 13 week study. Animals were killed immediately after the last exposure and a complete autopsy was carried out on each animal. Almost, all organs, were examined histologically in the high dose and control groups. Histological evaluations of the kidneys, testes and gross lesions were performed for the mid and low dose groups. Survival was poor in male rats but was adequate in females. Increased mortality (100% versus 82% for controls) and decreased mean survival (577 versus 631 days for controls; $p < 0.01$ by life-table analysis) were noted for high dose male rats. No difference in mean survival time was noted for female rats. (The mortality and mean survival time in other groups were indicated only in bar graphs.) Chronic renal disease was attributed as the main cause of death for male and female rats in the high dose groups and was also considered to account for much of the mortality observed in mid dose males. Extensive data were presented on clinical and microscopic renal pathology, but no tumor data were presented. The main cause of death for male controls was mononuclear cell leukemia. Concentration related increases in interstitial cell adenoma of the testes were observed in male rats found dead or moribund during the study (57.5% of control, 72.2% of low-dose, 84.7% of mid-dose and 93.8% of high-dose animals) as well as for all animals in the study (64.9% of control, 77.3% of low-dose, 86.7% of mid-dose and 94.7% of high-dose animals). No increased incidence of neoplastic lesions was observed for female rats from any exposure group but no data were presented.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V71 1029 (1999)]**PEER REVIEWED**

Groups of 55 male and 55 female CD-1 mice, approximately seven weeks old, were exposed by inhalation to target concentrations of 0 (control), 500, 2500 and 5000 ppm (0, 1225, 6125 and 12 250 mg/cu m) **isopropanol** vapor (purity, 99.9%) for 6 hr per day on five days per week for 78 weeks. The mean actual concentrations were 504 + or - 14, 2509 + or - 58 and 5037 + or - 115 ppm, respectively. The highest concentration (5000 ppm) was selected as a result of the mortality observed at 10000 ppm in a previous nine day inhalation study and the toxic effects observed at 5000 ppm in a previous 13 week study. Animals were killed immediately after the last exposure and a complete autopsy was carried out on each animal. No adverse effect on weight gain was observed among treated and control animals. Almost all organs were examined histologically in the high dose and control groups. Histologically evaluations of the kidneys, testes and gross lesions were performed for the mid and low dose groups. No difference in mean survival time was noted for any of the exposure groups. (Mortality and mean survival time were indicated only in bar graphs.) No increased incidence of neoplastic lesions was noted for either sex of mice from any exposure group, but no data were presented.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V71 1029 (1999)]**PEER REVIEWED**

Pregnant female Sprague-Dawley rats were exposed to 0, 3500, 7000, or 10,000 ppm **isopropanol** 7 hr/day during gestation days 1 to 19. The animal showed unsteady gait and narcotization during initial exposures in the mid- and high-dose groups; reduced food consumption and reduced weight gain were also noted in groups.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 2632]**PEER REVIEWED**

... F344 rat and CD-1 mice were exposed to 0, 100, 500, 1500, or 5000 ppm **isopropanol** for 13 weeks. Signs of narcosis were observed in the 5000- ppm **isopropanol** groups only. Increased body weight and/or body weights gain were observed for rats of the 1500- and 5000-ppm groups as well as female mice of the 5000-ppm group compared to control animals. Changes to food and water consumption generally corresponded to changes in body weight. Increased relative liver weights for both sexes of rats and female mice of the 5000-ppm group and increased size and frequency of hyaline droplets within the kidneys of exposed male rats were observed.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 2631]**PEER REVIEWED**

Deaths occurred in 6 of 10 rats following aspiration of 0.2 ml of 100% **isopropanol** and in 1 of 10 rats following aspiration of 70% **isopropanol**.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 2631]**PEER REVIEWED**

In a rat developmental study, female Sprague-Dawley rats were dosed by oral gavage with either 0, 400, 800, or 1200 mk/kg **isopropanol** during gestation days 6 to 15. Mortality was observed in the mid- (4%) and high-dose (8%) animals and reduced maternal gestational weight gain on gestational days 0 to 20 associated with significantly reduced gravid uterine weights were noted in the high-dose animals. Fetal body weights were reduced at 800 and 1200 mg/kg. No adverse maternal or developmental effects at 400 mg/kg. No teratogenic effects were noted at any dose tested.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 2633]**PEER REVIEWED**

Non-Human Toxicity Values:

LD50 Rat oral 5045 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1976]**PEER REVIEWED**

LD50 Rabbit oral 8.0 g/kg
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-176]**PEER REVIEWED**

LD50 Rat ip 2735 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1976]**PEER REVIEWED**

LD50 Rat iv 1099 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1976]**PEER REVIEWED**

LD50 Mouse oral 3600 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1976]**PEER REVIEWED**

LD50 Mouse ip 4477 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1976]**PEER REVIEWED**

LD50 Mouse iv 1509 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1976]**PEER REVIEWED**

LD50 Dog oral 4797 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1976]**PEER REVIEWED**

LD50 Rabbit oral 6410 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1976]**PEER REVIEWED**

LD50 Rabbit skin 12,800 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1976]**PEER REVIEWED**

The acute oral LD50 has been reported as 4.7 g/kg, 5.3 g/kg, 5.3 g/kg, 5.5 g/kg and 5.8 g/kg in rats; 4.5 g/kg in mice; and 5.03 g/kg, 7.8 g/kg, 7.9 g/kg in rabbits. The acute dermal LD50 in rabbits has
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 2630]**PEER REVIEWED**

Ecotoxicity Values:

LD50 Carassius auratus (goldfish) > 5000 mg/l/24 hr modified ASTM D 1345 bioassay
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 776]**PEER REVIEWED**

LD100 Semolitus atromaculatus (creek chub) 1100 mg/l/24 hr in Detroit River water /Conditions of bioassay not specified/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 776]**PEER REVIEWED**

LC50 Poecilia reticulata (guppies) 7060 ppm/7 day /Conditions of bioassay not specified/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 776]**PEER REVIEWED**

LC50 Crangon crangon (brown shrimp) 1400 mg/l/48 hr (Range 900-1950 mg/l) /Conditions of bioassay not specified/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 776]**PEER REVIEWED**

LC50 Crangon crangon (brown shrimp) 1150 mg/l/96 hr (Range 750-1650 mg/l) /Conditions of bioassay not specified/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 776]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnows) 11,830 mg/l/1 hr (static bioassay in Lake Superior water at 18-22 deg C)
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 776]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnows) 11,160 mg/l/24 hr (static bioassay in Lake Superior water at 18-22 deg C)
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 776]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnows) 11,130 mg/l/48 hr, 72 hr, 96 hr, respectively (static bioassay in Lake Superior water at 18-22 deg C)
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 776]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnows) 9.64 g/l/96 hr (95% confidence limit 9.23-10.0 g/l); age 31 days old, water hardness 48.3 mg/l (CaCO3), temp 24.4 deg C, pH 7.79, dissolved oxygen 6.6 mg/l, alkalinity 45.9 mg/l (CaCO3), tank vol: 6.3 l, additions: 3.75 vol/day (flow-through bioassay)
[Brooke, L.T., D.J. Call, D.T. Geiger and C.E. Northcott (eds.). Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales Promelas). Superior, WI: Center for Lake Superior Environmental Studies Univ. of Wisconsin Superior, 1984.70]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnows) 10.4 g/l/96 hr (95% confidence limit 10.2-10.6 g/l); age 29 days old, water hardness 52.5 mg/l (CaCO3), temp 24.6 deg C, pH 7.09, dissolved oxygen 6.7 mg/l, alkalinity 39.5 mg/l (CaCO3), tank vol: 5.5 l, additions: 13.1 vol/day (flow-through bioassay)
[Brooke, L.T., D.J. Call, D.T. Geiger and C.E. Northcott (eds.). Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales Promelas). Superior, WI: Center for Lake Superior Environmental Studies Univ. of Wisconsin Superior, 1984.72]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnows) 6.55 g/l/96 hr (95% confidence limit 5.77-7.45 g/l); age 31 days old, water hardness 44.0 mg/l (CaCO3), temp 24.6 deg C, pH 7.87, dissolved oxygen 6.7 mg/l, alkalinity 42.0 mg/l (CaCO3), tank vol: 1.0 l, additions: 36 (flow-through bioassay)
[Brooke, L.T., D.J. Call, D.T. Geiger and C.E. Northcott (eds.). Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales Promelas). Superior, WI: Center for Lake Superior Environmental Studies Univ. of Wisconsin Superior, 1984.74]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnows) 9.54 g/l/96 hr (95% confidence limit 9.10-10.0 g/l); age 31 days old, water hardness 48.3 mg/l (CaCO3), temp 24.4 deg C, pH 7.79, dissolved oxygen 6.6 mg/l, alkalinity 45.9 mg/l (CaCO3), tank vol: 6.3 l, additions: 3.75 vol/day (flow-through bioassay)
[Brooke, L.T., D.J. Call, D.T. Geiger and C.E. Northcott (eds.). Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales Promelas). Superior, WI: Center for Lake Superior Environmental Studies Univ. of Wisconsin Superior, 1984.70]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnows) 6.12 g/l/96 hr (95% confidence limit 5.58-6.72 g/l); age 31 days old, water hardness 44.0 mg/l (CaCO3), temp 24.6 deg C, pH 7.87, dissolved oxygen 6.7 mg/l, alkalinity 42.0 mg/l (CaCO3), tank vol: 1.0 l, additions: 36 vol/day (flow-through bioassay)
[Brooke, L.T., D.J. Call, D.T. Geiger and C.E. Northcott (eds.). Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales Promelas). Superior, WI: Center for Lake Superior Environmental Studies Univ. of Wisconsin Superior, 1984.74]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnows) 9.49 g/l/96 hr (95% confidence limit 8.91-10.1 g/l); age 29 days old, water hardness 52.5 mg/l (CaCO3), temp 24.4 deg C, pH 7.09, dissolved oxygen 6.7 mg/l, alkalinity 39.5 mg/l (CaCO3), tank vol: 5.5 l, additions: 13.1 vol/day (flow-through bioassay)
[Brooke, L.T., D.J. Call, D.T. Geiger and C.E. Northcott (eds.). Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales Promelas). Superior, WI: Center for Lake Superior Environmental Studies Univ. of Wisconsin Superior, 1984.72]**PEER REVIEWED**

Cell multiplication inhibition test Pseudomonas putida 1050 mg/l
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 776]**PEER REVIEWED**

Cell multiplication test Microcystis aeruginosa (algae) 1000 mg/l
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 776]**PEER REVIEWED**

Cell multiplication test Scenedesmus guadricauda (green algae) 1800 mg/l
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 776]**PEER REVIEWED**

Cell multiplication test Entosiphon sulcatum 4930 mg/l
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 776]**PEER REVIEWED**

Cell multiplication test Uronema parduczi Chatton-Lwoff 3425 mg/l
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 776]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

ISOPROPANOL IS OXIDIZED, MORE SLOWLY THAN ETHANOL OR N-PROPANOL, TO ACETONE, & SOME 10% OF DOSE IS EXCRETED BY RABBITS AS GLUCURONIDE CONJUGATE OF **ISOPROPANOL**.
[Parke, D. V. The Biochemistry of Foreign Compounds. Oxford: Pergamon Press, 1968. 214]**PEER REVIEWED**

METABOLISM OF ETHANOL, PROPANOL, **ISOPROPANOL**, BUTANOL, ISOBUTANOL, SEC-BUTANOL, & TERT-BUTANOL WAS STUDIED AFTER ORAL ADMIN IN RABBITS. BLOOD PH WAS ON THE ACID SIDE WITH PROPANOL, BUTANOL, & ISOBUTANOL, AND ON THE ALKALINE SIDE WITH **ISOPROPANOL** & SEC-BUTANOL, BUT NO CHANGE WAS OBSERVED WITH ETHANOL & TERT-BUTANOL. BUTANOL & ISOBUTANOL HAD THE LOWEST RATE OF URINARY EXCRETION. ACETALDEHYDE AND ACETIC ACID WERE DETECTED AS THE URINARY METABOLITES OF ETHANOL AND PROPANOL, WHEREAS ISOBUTYRALDEHYDE & ISOVALERIC ACID WERE THE METABOLITES OF ISOBUTANOL.
[SAITO M; NICHIDAI IGAKU ZASSHI 34 (8-9): 569-85 (1975)]**PEER REVIEWED**

Alcohol dehydrogenase oxidizes most **isopropanol** to acetone, which the lung or kidney slowly eliminates. Acetone probably is further metabolized to acetate, formate, and finally carbon dioxide.
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 798] **PEER REVIEWED**

Liver alcohol dehydrogonase (ADH) is the major enzyme involved in the oxidation of 2-propanol. ADH oxidizes most 2-propanol to acetone. Acetone then is eliminated from the kidney & expired air. It is estimated that 70-90% of ingested 2-propanol is metabolized to acetone. Acetone is probably further metabolized to acetate, formate & finally carbon dioxide. Conversion of acetone to acetic acid & formic acid may cause acidosis. Metabolism of 2-propanol leads to a shift in NAD/NADH ratio which may cause hypoglycemia.
[Snyder, R. (ed.). Ethel Browning's Toxicity and Metabolism of Industrial Solvents. Second Edition. Volume 3 Alcohols and Esters. New York, NY: Elsevier, 1992. 33] **PEER REVIEWED**

The metabolism of **isopropanol** is via oxidation by aldehyde dehydrogenase (ADH) to acetone. In common with other alpha-substituted (secondary) alcohols, **isopropanol** is a relatively poor substrate for ADH. The primary metabolite, acetone, is eliminated in the expired air and in the urine and also undergoes further oxidation to acetate, formate and ultimately CO2.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V71 1030 (1999)]**PEER REVIEWED**

Absorption, Distribution & Excretion:

DISTRIBUTION OF ISOPROPYL ALC ... IN TISSUES OF DOGS 4 HR AFTER ORAL ADMIN OF 90 ML OF **ISOPROPYL ALCOHOL** WAS DETERMINED ... USING DOGS THAT HAD BEEN GIVEN PROGRESSIVELY INCR AMT OF THE ALCOHOL FOR THE PREVIOUS 59 DAYS. ... CONCENTRATIONS OF **ISOPROPYL ALCOHOL** FOUND IN THE TISSUES AND BODY FLUIDS DECREASED IN THE FOLLOWING ORDER: BRAIN, URINE, HEART, KIDNEY, AND BLOOD.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 4566]**PEER REVIEWED**

Intestinal uptake of **isopropanol** is rapid; 80% of an oral dose is absorbed within 30 min. Complete absorption occurs within 2 hr ... . Skin absorption is probably relatively small but contributes to toxicity with prolonged contact. ... **Isopropanol** distribution in body water with an apparent vol of distribution of 0.6-0.7 l/kg. Two hr are required for complete tissue distribution. ... The kidney excretes 20-50% of an absorbed dose unchanged. Alcohol dehydrogenase oxidizes most **isopropanol** to acetone, which the lung or kidney slowly eliminates. ... Clinically insignificant excretion occurs into the stomach and saliva.
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 798] **PEER REVIEWED**

ABOUT 47% OF ORAL DOSE OF 720 MG ... WAS EXHALED UNCHANGED OVER 3 HR; LESS THAN 3% ... ELIMINATED IN BREATH AS ACETONE ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 235 (1977)]**PEER REVIEWED**

DISAPPEARANCE RATE OF ISOPROPYL ALC IN BLOOD IS HALF THAT OF ETHANOL BUT 5 TIMES THAT OF METHANOL.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 234 (1977)]**PEER REVIEWED**

AFTER INCR ORAL ADMIN OF 4-72 G ... TO 3 DOGS ABOUT 4% OF DOSE WAS EXCRETED UNCHANGED IN URINE & 2% AS ACETONE; LESS THAN 0.1% OF DOSE WAS FOUND IN FECES.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 234 (1977)]**PEER REVIEWED**

... REPORTED THAT 0.34% OF AN ORAL DOSE OF 2 G/KG **ISOPROPYL ALCOHOL** TO RATS WAS EXCRETED IN THE URINE.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 4567]**PEER REVIEWED**

OCCUPATIONAL EXPOSURE TO **ISOPROPANOL** WAS STUDIED IN 12 WORKERS BY TESTING ENVIRONMENTAL AIR, ALVEOLAR AIR, VENOUS BLOOD & URINE DURING THEIR WORK SHIFT. **ISOPROPANOL**, WHICH RANGED IN ENVIRONMENTAL AIR BETWEEN 7 & 645 MG/CU M, WAS DETECTED IN ALVEOLAR AIR, WHERE IT RANGED BETWEEN 4 & 437 MG/CU M, BUT NOT IN BLOOD OR IN URINE. ACETONE, WHICH IS A METABOLITE OF **ISOPROPANOL**, WAS FOUND IN ALVEOLAR AIR, BLOOD & URINE IN CONCN THAT WERE HIGHER DURING EXPOSURE THAN BEFORE. ALVEOLAR & BLOOD ACETONE CONCN WERE HIGHLY CORRELATED WITH ALVEOLAR **ISOPROPANOL** CONCN AT ANY TIME DURING EXPOSURE. ACETONE RANGED BETWEEN 0.76 & 15.6 MG/L IN BLOOD, BETWEEN 4 & 92 UG/L IN ALVEOLAR AIR & BETWEEN 0.85 & 53.7 MG/L IN URINE. ALVEOLAR **ISOPROPANOL** UPTAKE RANGED BETWEEN 0.03 & 6.8 MG/MIN & WAS HIGHLY CORRELATED WITH ENVIRONMENTAL **ISOPROPANOL** CONCN (R= 0.92). DURING EXPOSURE, ACETONE ELIMINATED BY THE LUNG RANGED BETWEEN 20 & 273 MG IN 7 HR & IN URINE BETWEEN 0.3 & 9.6 MG IN 7 HR. ACETONURIA WAS HIGHER THE NEXT MORNING THAN AT THE END OF EXPOSURE.
[BRUGNONE F ET AL; BR J IND MED 40 (2): 160-8 (1983)]**PEER REVIEWED**

Isopropyl alcohol is readily absorbed from the GI tract and persists in the circulation rather longer than ethyl alcohol. There appears to be little absorption through intact skin. ... Unchanged **isopropyl alcohol ...** may be excreted in the urine, esp after large doses.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 40]**PEER REVIEWED**

Urine was analyzed immediately, 1, 2, 8, and 9 hr after drinking (during 2 hr) 3.75 ml/kg of beverages containing orange juice, 15 or 40% ethanol, and 1 g/l of 1-propanol, 2-propanol, 1-butanol, 2-butanol, isobutyl alcohol or a mixture of 1-propanol & isobutyl alcohol. Maximum urine levels /in mg/l/ were found 1 hr after drinking ended: 1-propanol 5.04, 2-propanol 3.36, 1-butanol 0.43, 2-butanol 2.55, isobutyl alcohol ... 1.7-2.03 mg/l. Urine treatment with beta-glucuronidase before analysis indicated that significant amounts of the alcohols were excreted as glucuronides, esp isobutyl alcohol. 2-Propanol and 2-butanol were the slowest to be metabolized. When mixtures of alcohols were given, the concentrations of isobutyl alcohol glucuronides were high with the mixtures containing 5 and 15% ethanol, and decreased at 40% ethanol.
[Bonte W et al; Blutalkohol 18 (6): 412-26 (1981)]**PEER REVIEWED**

2-Propanol is absorbed easily from all segments of the GI tract, most rapidly form the small intestine & least rapidly form the stomach; 80% of an oral dose is absorbed within 30 min & complete absorption occurs within 2 hr. Skin absorption is relatively slow. The kidney excretes about 20-50% of the ingested 2-propanol unchanged. 2-Propanol distributes in body water with an apparent volume of distribution of 0.6-0.7 liters/kg.

[Snyder, R. (ed.). Ethel Browning's Toxicity and Metabolism of Industrial Solvents. Second Edition. Volume 3 Alcohols and Esters. New York, NY: Elsevier, 1992. 33] **PEER REVIEWED**

It has been shown that the elimination of 2-propanol is inhibited by both n-propanol & ethanol. Thus, a competitive substrate inhibition of ADH is suggested.
[Snyder, R. (ed.). Ethel Browning's Toxicity and Metabolism of Industrial Solvents. Second Edition. Volume 3 Alcohols and Esters. New York, NY: Elsevier, 1992. 33] **PEER REVIEWED**

Anesthetized dogs /were given/ 60 ml of 70% aqueous **isopropanol** (approximately 2 ml/kg) and blood levels of **isopropanol** and acetone /were determined/ for up to 6 hours. The peak **isopropanol** level occurred at 3 hours, while acetone concentrations increased throughout the 6 hour experiment.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V71 1031 (1999)]**PEER REVIEWED**

Biological Half-Life:

... 1 G/KG WAS INJECTED IV OR INTRAPERITONEALLY IN DOGS AND RATS & PLASMA LEVELS OF **ISOPROPYL ALCOHOL** & ITS METABOLITE, ACETONE, WERE DETERMINED ... AT INTERVALS. THE MAXIMUM CONCN OF ACETONE WAS 12.4 MMOLES 9 HR AFTER INJECTION ... IN DOGS & 12.0 MMOLES 5 HR AFTER INJECTION IN RATS. ... THE HALF TIME FOR THE ELIMINATION OF **ISOPROPYL ALCOHOL** BY THE DOG & RAT IS 4 & 2 HR, RESPECTIVELY, & OF ACETONE 11 AND 5/HR.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 4567]**PEER REVIEWED**

In two intoxicated chronic alcoholics, **isopropanol** elimination exhibited first order kinetics with a half-life of 2.5-3.2 hr. The elimination half-life of ... acetone was more prolonged.
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 799] **PEER REVIEWED**

/In/ inhalation of 70% **isopropyl alcohol** by a neonate ... the **isopropyl alcohol** elimination half-life was 9.6 hr.
[Ellenhorn, M.J., S. Schonwald, G. Ordog, J. Wasserberger. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. 2nd ed. Baltimore, MD: Williams and Wilkins, 1997. 1148]**PEER REVIEWED**

In adults, the elimination half life ranges from 2.9 to 16.2 hours and this is shorter in alcoholics. Values observed in children poisoned with **isopropanol** fall within this range.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V71 1030 (1999)]**PEER REVIEWED**

Mechanism of Action:

The alcohols apparently produce their effects by denaturing soluble proteins and depressing surface tension. /Alcohols/
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 702]**PEER REVIEWED**

Interactions:

AFTER SINGLE ORAL DOSE OF 2 G/KG BODY WT TO MICE, AUGMENTED HEPATOTOXICITY TO VARIOUS CHLORINATED HYDROCARBONS WAS NOTED.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 233 (1977)]**PEER REVIEWED**

ELIMINATION OF ISOPROPYL ALC IN RATS IS DECR BY SIMULTANEOUS INGESTION OF ETHANOL OR 1-PROPANOL ... .
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 234 (1977)]**PEER REVIEWED**

WORKERS IN AN **ISOPROPYL ALCOHOL** PACKAGING PLANT BECAME ILL AFTER ACCIDENTAL EXPOSURE TO CARBON TETRACHLORIDE. **ISOPROPYL ALCOHOL** POTENTIATION OF CARBON TETRACHLORIDE TOXICITY HAS BEEN SHOWN PREVIOUSLY ONLY IN RATS. ACETONE, A PRODUCT OF **ISOPROPYL ALCOHOL** METABOLISM, IS A MAJOR POTENTIATOR OF CARBON TETRACHLORIDE TOXICITY.
[FOLLAND DS ET AL; J AM MED ASSOC 236 (16): 1853-6 (1976)]**PEER REVIEWED**

PRETREATMENT OF RATS WITH **ISOPROPANOL** ENHANCED BOTH HEPATOTOXICITY & CALCIUM PUMP INHIBITION AFTER CARBON TETRACHLORIDE EXPOSURE IN VIVO OR IN VITRO.
[MOORE L, RAY P; TOXICOL APPL PHARMACOL 71 (1): 54-8 (1983)]**PEER REVIEWED**

Administration of **isopropanol** (2.5 ml/kg, po) or chlordecone (15.2 mg/kg, po) potentiated the release of glutamic oxaloacetic transaminase (GOT) into serum 17 or 7 fold, respectively, in rats exposed subsequently to 30 microliter carbon tetrachloride/kg, po. Hepatocytes isolated from **isopropanol** treated rats, incubated with low concentrations of carbon tetrachloride (0.3 or 0.9 mM), did not have significant increase in the amount of GOT released after 30 min compared to control cells exposed to carbon tetrachloride. However, at 3 hr cells from **isopropanol** treated rats released 10 or 3 fold more GOT when exposed to 0.3 or 0.9 mM carbon tetrachloride, respectively, than control cells exposed to carbon tetrachloride. By hour 5 of incubation this differential of GOT release was not observed. The same dose and time dependent pattern of potentiated GOT release upon exposure of carbon tetrachloride was seen in hepatocytes obtained from chlordecone treated rats. These results indicate that the potentiation by **isopropanol** or chlordecone of carbon tetrachloride induced release of GOT from liver is retained through the procedures of cell isolation.
[Glende EA, Lee PY; Exp Mol Pathol 42 (2): 167-74 (1985)]**PEER REVIEWED**

Previous studies indicate that pretreatment with acetone or **isopropanol**, fasting, and streptozotocin induced diabetes and enhanced hepatic microsomal nitroso-dimethylamine (NDMA) demethylase in rats. This study demonstrates that these same treatments also potentiate the hepatotoxicity of NDMA as indicated by plasma glutamic pyruvate transaminase (GPT) levels and histologic data. Pretreatment with acetone or **isopropanol** (2.5 mg/kg) and 2 days of fasting caused a 2 fold potentiation of NDMA induced plasma GPT elevation, whereas streptozotocin induced diabetes caused a 4.6 fold potentiation. The centrilobular necrosis produced by NDMA was more severe after pretreatment with the inducers. NDMA treatment also decreased hepatic microsomal demethylase activity. These results lend support to the concept that a NDMA demethylase is responsible for the activation of NDMA in vivo to a toxic intermediate, and induction of this enzyme activity potentiates NDMA hepatotoxicity.
[Lorr NA et al; Toxicol Applied Pharmacol 73 (3): 423-31 (1984)]**PEER REVIEWED**

... Ethanol, **isopropanol**, n-butanol, sec-butanol, and tert-butanol ... exert a ... potentiating effect on the acute inhalation toxicity of carbon tetrachloride. ... Interaction between **isopropanol** & carbon tetrachloride was documented in an industrial accident ... where workers exposed to both agents exhibited hepatotoxicity. With ethanol the potentiation seems to be due to the presence of the unmetabolized alcohol; however, with **isopropanol** the effect seems to be caused by the presence of both unmetabolized alcohol and acetone. The results obtained with n-butanol resemble those of ethanol, whereas with 2-butanol they resemble those of **isopropanol** ... .
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 303]**PEER REVIEWED**

ADDING 1 G/L OF PROPAN-1-OL, PROPAN-2-OL, BUTAN-1-OL, BUTAN-2-OL, ISOBUTANOL TO 40% ETHANOL IN ORANGE JUICE LOWERED AND DELAYED BLOOD ETHANOL MAX IN 10 20-30 YR OLD MEN WHO DRANK 3.75 ML/KG OF SYNTHETIC BEVERAGE.
[SPRUNG R ET AL; BLUTALKOHOL 18 (5): 311-4 (1981)]**PEER REVIEWED**

CUTANEOUS REACTIONS TO **ISOPROPANOL** WAS EVALUATED IN A CONTROL GROUP & IN PATIENTS BEFORE & DURING RECEIPT OF DISULFIRAM THERAPY. LOCAL CUTANEOUS ERYTHEMA WAS OBSERVED FROM PATCH TESTS WITH **ISOPROPANOL** IN HYDRATED SKIN. SINCE REACTIONS NOTED FROM TOPICALLY APPLIED ALCOHOLS BEFORE & DURING DISULFIRAM THERAPY WERE NOT STATISTICALLY DIFFERENT, A LOCALIZED DISULFIRAM-ALCOHOL REACTION IS UNLIKELY. ERYTHEMA RESULTING FROM TOPICALLY APPLIED ALCOHOLS OCCURRED IN A DOSE RELATED MANNER & WAS CAUSED BY A DIRECT VASODILATORY EFFECT ON THE CUTANEOUS MICROVASCULATURE.
[HADDOCK NF, WILKIN JK; ARCH DERMATOL 118 (3): 157-9 (1982)]**PEER REVIEWED**

Pharmacology:

Therapeutic Uses:

Anti-Infective Agents, Local; Solvents
[National Library of Medicine's Medical Subject Headings online file (MeSH, 1999)] **PEER REVIEWED**

MEDICATION (VET): ANTISEPTIC, RUBEFACIENT
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 749]**PEER REVIEWED**

ALCOHOLS ARE APPLIED TO REDUCE LOCAL BACTERIAL FLORA PRIOR TO PENETRATION WITH NEEDLES OR OTHER SHARP INSTRUMENTS AND AS A PREOPERATIVE WASH. ... **ISOPROPYL ALCOHOL** HAS SLIGHTLY GREATER BACTERIAL ACTIVITY THAN ETHYL ALCOHOL DUE TO ITS GREATER DEPRESSION OF SURFACE TENSION. IT RAPIDLY KILLS VEGETATIVE FORMS OF MOST BACTERIA WHEN USED FULL STRENGTH OR AS 70% AQ SOLN.
[American Medical Association, Department of Drugs. Drug Evaluations. 6th ed. Chicago, Ill: American Medical Association, 1986. 1523]**PEER REVIEWED**

EXPTL USE: HEPATITIS B VIRUS IN DRIED HUMAN PLASMA WAS EXPOSED FOR 10 MIN AT 20 DEG C TO 70% **ISOPROPANOL**, A CHEMICAL DISINFECTANT HAVING INTERMEDIATE ACTIVITY LEVEL. ONE CHIMPANZEE RECEIVED TREATED MATERIAL IV, & DID NOT SHOW SIGNS OF INFECTION AFTER POST-INOCULATION PERIOD OF 9 MONTHS.

[BOND WW ET AL; J CLIN MICROBIOL 18 (3): 535 (1983)]**PEER REVIEWED**

ANTISEPTIC
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 749]**PEER REVIEWED**

Interactions:

AFTER SINGLE ORAL DOSE OF 2 G/KG BODY WT TO MICE, AUGMENTED HEPATOTOXICITY TO VARIOUS CHLORINATED HYDROCARBONS WAS NOTED.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 233 (1977)]**PEER REVIEWED**

ELIMINATION OF ISOPROPYL ALC IN RATS IS DECR BY SIMULTANEOUS INGESTION OF ETHANOL OR 1-PROPANOL ... .
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 234 (1977)]**PEER REVIEWED**

WORKERS IN AN **ISOPROPYL ALCOHOL** PACKAGING PLANT BECAME ILL AFTER ACCIDENTAL EXPOSURE TO CARBON TETRACHLORIDE. **ISOPROPYL ALCOHOL** POTENTIATION OF CARBON TETRACHLORIDE TOXICITY HAS BEEN SHOWN PREVIOUSLY ONLY IN RATS. ACETONE, A PRODUCT OF **ISOPROPYL ALCOHOL** METABOLISM, IS A MAJOR POTENTIATOR OF CARBON TETRACHLORIDE TOXICITY.
[FOLLAND DS ET AL; J AM MED ASSOC 236 (16): 1853-6 (1976)]**PEER REVIEWED**

PRETREATMENT OF RATS WITH **ISOPROPANOL** ENHANCED BOTH HEPATOTOXICITY & CALCIUM PUMP INHIBITION AFTER CARBON TETRACHLORIDE EXPOSURE IN VIVO OR IN VITRO.
[MOORE L, RAY P; TOXICOL APPL PHARMACOL 71 (1): 54-8 (1983)]**PEER REVIEWED**

Administration of **isopropanol** (2.5 ml/kg, po) or chlordecone (15.2 mg/kg, po) potentiated the release of glutamic oxaloacetic transaminase (GOT) into serum 17 or 7 fold, respectively, in rats exposed subsequently to 30 microliter carbon tetrachloride/kg, po. Hepatocytes isolated from **isopropanol** treated rats, incubated with low concentrations of carbon tetrachloride (0.3 or 0.9 mM), did not have significant increase in the amount of GOT released after 30 min compared to control cells exposed to carbon tetrachloride. However, at 3 hr cells from **isopropanol** treated rats released 10 or 3 fold more GOT when exposed to 0.3 or 0.9 mM carbon tetrachloride, respectively, than control cells exposed to carbon tetrachloride. By hour 5 of incubation this differential of GOT release was not observed. The same dose and time dependent pattern of potentiated GOT release upon exposure of carbon tetrachloride was seen in hepatocytes obtained from chlordecone treated rats. These results indicate that the potentiation by **isopropanol** or chlordecone of carbon tetrachloride induced release of GOT from liver is retained through the procedures of cell isolation.
[Glende EA, Lee PY; Exp Mol Pathol 42 (2): 167-74 (1985)]**PEER REVIEWED**

Previous studies indicate that pretreatment with acetone or **isopropanol**, fasting, and streptozotocin induced diabetes and enhanced hepatic microsomal nitroso-dimethylamine (NDMA) demethylase in rats. This study demonstrates that these same treatments also potentiate the hepatotoxicity of NDMA as indicated by plasma glutamic pyruvate transaminase (GPT) levels and histologic data. Pretreatment with acetone or **isopropanol** (2.5 mg/kg) and 2 days of fasting caused a 2 fold potentiation of NDMA induced plasma GPT elevation, whereas streptozotocin induced diabetes caused a 4.6 fold potentiation.

The centrilobular necrosis produced by NDMA was more severe after pretreatment with the inducers. NDMA treatment also decreased hepatic microsomal demethylase activity. These results lend support to the concept that a NDMA demethylase is responsible for the activation of NDMA in vivo to a toxic intermediate, and induction of this enzyme activity potentiates NDMA hepatotoxicity.
[Lorr NA et al; Toxicol Applied Pharmacol 73 (3): 423-31 (1984)]**PEER REVIEWED**

... Ethanol, **isopropanol**, n-butanol, sec-butanol, and tert-butanol ... exert a ... potentiating effect on the acute inhalation toxicity of carbon tetrachloride. ... Interaction between **isopropanol** & carbon tetrachloride was documented in an industrial accident ... where workers exposed to both agents exhibited hepatotoxicity. With ethanol the potentiation seems to be due to the presence of the unmetabolized alcohol; however, with **isopropanol** the effect seems to be caused by the presence of both unmetabolized alcohol and acetone. The results obtained with n-butanol resemble those of ethanol, whereas with 2-butanol they resemble those of **isopropanol** ... .
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 303]**PEER REVIEWED**

ADDING 1 G/L OF PROPAN-1-OL, PROPAN-2-OL, BUTAN-1-OL, BUTAN-2-OL, ISOBUTANOL TO 40% ETHANOL IN ORANGE JUICE LOWERED AND DELAYED BLOOD ETHANOL MAX IN 10 20-30 YR OLD MEN WHO DRANK 3.75 ML/KG OF SYNTHETIC BEVERAGE.
[SPRUNG R ET AL; BLUTALKOHOL 18 (5): 311-4 (1981)]**PEER REVIEWED**

CUTANEOUS REACTIONS TO **ISOPROPANOL** WAS EVALUATED IN A CONTROL GROUP & IN PATIENTS BEFORE & DURING RECEIPT OF DISULFIRAM THERAPY. LOCAL CUTANEOUS ERYTHEMA WAS OBSERVED FROM PATCH TESTS WITH **ISOPROPANOL** IN HYDRATED SKIN. SINCE REACTIONS NOTED FROM TOPICALLY APPLIED ALCOHOLS BEFORE & DURING DISULFIRAM THERAPY WERE NOT STATISTICALLY DIFFERENT, A LOCALIZED DISULFIRAM-ALCOHOL REACTION IS UNLIKELY. ERYTHEMA RESULTING FROM TOPICALLY APPLIED ALCOHOLS OCCURRED IN A DOSE RELATED MANNER & WAS CAUSED BY A DIRECT VASODILATORY EFFECT ON THE CUTANEOUS MICROVASCULATURE.
[HADDOCK NF, WILKIN JK; ARCH DERMATOL 118 (3): 157-9 (1982)]**PEER REVIEWED**

Minimum Fatal Dose Level:

PROBABLE LETHAL ORAL DOSE FOR ADULT IS 8 OZ (240 ML)
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-271]**PEER REVIEWED**

... fatal dose by ingestion is 250 ml. ...
[Dreisbach, R.H. Handbook of Poisoning. 12th ed. Norwalk, CT: Appleton and Lange, 1987. 178]**PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Isopropanol's production and use in the production of chemicals, as a solvent, and in medicinal applications may result in its release to the environment through various waste streams. **Isopropanol** has been identified as a metabolic product of aerobic microorganisms, anaerobic microorganisms, fungi, and yeast. If released to air, a vapor pressure of 45.4 mm Hg at 25 deg C indicates **isopropanol** will exist solely as a vapor in the ambient atmosphere. Vapor-phase **isopropanol** will be degraded in the

atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 3.2 days. If released to soil, **isopropanol** is expected to have very high mobility based upon an estimated Koc of 25. Volatilization from moist soil surfaces is expected to be an important fate process based upon a Henry's Law constant of 8.10X10-6 atm-cu m/mole. **Isopropanol** may volatilize from dry soil surfaces based upon its vapor pressure. If released into water, **isopropanol** is not expected to adsorb to suspended solids and sediment based upon the estimated Koc. **Isopropanol** is readily degraded in aerobic aqueous systems; the range of half-lives for aerobic degradation using a sewage sludge inocula are <1 day to 48 days. **Isopropanol** has also been shown to be readily degraded under anaerobic aqueous conditions. Volatilization from water surfaces is expected to be an important fate process based upon this compound's Henry's Law constant. Estimated volatilization half-lives for a model river and model lake are 57 hours and 29 days, respectively. An estimated BCF of 3 suggests the potential for bioconcentration in aquatic organisms is low. Hydrolysis is not expected to occur due to the lack of hydrolyzable functional groups. Occupational exposure to **isopropanol** may occur through inhalation and dermal contact with this compound at workplaces where **isopropanol** is produced or used. Monitoring data indicate that the general population may be exposed to **isopropanol** via inhalation of ambient air, ingestion of food and drinking water, and dermal contact with this compound directly and from consumer products containing **isopropanol**. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

NIOSH (NOES Survey 1981-1983) has statistically estimated that 4,665,524 workers (2,058,264 of these are female) are potentially exposed to **isopropanol** in the US(1). Occupational exposure to **isopropanol** may occur through inhalation and dermal contact with this compound at workplaces where **isopropanol** is produced or used(SRC). Occupational exposure to **isopropanol** may occur during the mfg of chemicals using **isopropanol**, its use as a solvent in various industrial applications, and its use in medicinal applications(SRC). For example, inhalation exposure of workers to **isopropanol**(sampling location, concn mg/cu m) in various industries are as follows: car painting(personal, avg 7.1); ink production (area, 6.3-32.8); paint manufacture (personal, time-weighted avg range 6-258); hospital operating theater (area, avg 8.8); tractor painting (area, range 33-332); higher aromatic boot spray painting (personal, time-weighted avg-avg 4.7); lower aromatic booth spray painting (personal, time-weighted-avg-avg 10.6); solvent wiping (personal, time-weighted-avg-avg 2.5); paint mixing (time-weighted-avg-avg, 4.2); spraying paint lacquer (personal, time-weighted-avg-avg <2.5); printing (personal, time-weighted-avg-avg 396); printed circuit boards mfg (personal, range 5.8-23); furniture stripping (personal, range 42-160); degreasing metal (personal, range 2.2-10.6); mfg of rubber weather strips (area, range 6.5-140); chemicals packaging (area, range 150-1350); **isopropanol** production (area, avg 165)(2). The inhalation exposure to **isopropanol** varied from 0.4 to 14.8 mg/cu m, with a mean of 5.6 mg/cu m, for hairdressers in Norway(3). Monitoring data indicate that the general population may be exposed to **isopropanol** via inhalation of ambient air, ingestion of food, and dermal contact with this compound directly and from consumer products containing **isopropanol**(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983) (2) WHO; Environmental Health Criteria 103, 2-Propanol. Geneva, Switzerland: WHO International Program on Chemical Safety. pp. 1-77 (1990) (3) Hollund BE, Moen BE; Ann Occup Hyg 42: 277-81 (1998)]**PEER REVIEWED**

Body Burden:

Isopropanol detected in 8 of 12 samples of mother's milk from 4 urban areas in the United States(1). The avg and range of **isopropanol** concns in human breath due to metabolic processes is 150 ug/cu m and 50-260 ug/cu m (40 subjects in room air), respectively (2).
[(1) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982) (2) Fenske JD, Paulson SE; J Air Waste Manage Assoc 49: 594-598 (1999)]**PEER REVIEWED**

Natural Pollution Sources:

Isopropanol has been identified as a metabolic product of aerobic microorganisms (eg, fish spoilage bacteria, beef spoilage bacteria, potato yuber soft rot bacteria), anaerobic microorganisms, fungi (eg, mushrooms), and yeast(1).
[(1) WHO; Environmental Health Criteria 103, 2-Propanol. Geneva, Switzerland: WHO International Program on Chemical Safety. pp. 1-77 (1990)]**PEER REVIEWED**

Artificial Pollution Sources:

Isopropanol's production and use in the production of chemicals (eg, acetone, methyl isobutyl ketone, etc), as a solvent, and in medicinal applications(1) may result in its release to the environment through various waste streams(SRC).
[(1) Logsdon JE et al; Kirk-Othmer Encycl Chem Technol 4th ed. NY, NY: John Wiley and Sons 20: 236 (1996)]**PEER REVIEWED**

Environmental Fate:

TERRESTRIAL FATE: Based on a classification scheme(1), an estimated Koc value of 25(SRC), determined from a log Kow of 0.05(2) and a regression-derived equation(3), indicates that **isopropanol** is expected to have very high mobility in soil(SRC). Volatilization of **isopropanol** from moist soil surfaces is expected to be an important fate process(SRC) given a Henry's Law constant of 8.10X10-6 atm-cu m/mole(4). The potential for volatilization of **isopropanol** from dry soil surfaces may exist (SRC) based upon a vapor pressure of 45.4 mm Hg(5). **Isopropanol** is readily degraded in aerobic systems(6); the range of half-lives for aerobic degradation using a sewage sludge inoculum are <1 day to 48 days(SRC). **Isopropanol** has also been shown to be readily degraded under anaerobic conditions(6).
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 7 (1995) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9 (1990) (4) Taft RW et al; Nature 313: 384-6 (1985) (5) Daubert TE, Danner RP; Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation. Design Inst Phys Prop Data, Amer Inst Chem Eng NY, NY: Hemisphere Pub Corp 5 Vol (1989) (6) WHO; Environmental Health Criteria 103, 2-Propanol. Geneva, Switzerland: WHO International Program on Chemical Safety. pp. 1-77 (1990)]**PEER REVIEWED**

AQUATIC FATE: Based on a classification scheme(1), an estimated Koc value of 25(SRC), determined from a log Kow of 0.05(2) and a regression-derived equation(3), indicates that **isopropanol** is not expected to adsorb to suspended solids and sediment(SRC). Volatilization from water surfaces is expected(3) based upon a Henry's Law constant of 8.10X10-6 atm-cu m/mole(4). Using this Henry's Law constant and an estimation method(3), volatilization half-lives for a model river and model lake are 57 hours and 29 days, respectively(SRC). According to a classification scheme(5), an estimated BCF of 3(SRC), from a log Kow(2) and a regression-derived equation(6), suggests the potential for bioconcentration in aquatic organisms is low(SRC). **Isopropanol** is readily degraded in aerobic systems (7); the range of half-lives for aerobic degradation using a sewage sludge inoculum are <1 day to 48 days(SRC). **Isopropanol** has also been shown to be readily degraded under anaerobic conditions(7).
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 7 (1995) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9, 15-1 to 15-29 (1990) (4) Taft RW et al; Nature 313: 384-6 (1985) (5) Franke C et al; Chemosphere 29: 1501-14 (1994) (6) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999) (7) WHO; Environmental Health Criteria 103, 2-Propanol. Geneva, Switzerland: WHO International Program on Chemical Safety. pp. 1-77 (1990)]**PEER

REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), **isopropanol**, which has a vapor pressure of 45.4 mm Hg at 25 deg C (2), is expected to exist solely as a vapor in the ambient atmosphere(SRC). Vapor-phase **isopropanol** is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals(SRC); the half-life for this reaction in air is estimated to be 3.2 days(SRC), calculated from its rate constant of 5.07X10-12 cu cm/molecule-sec at 25 deg C(3).
[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Daubert TE, Danner RP; Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation. Design Inst Phys Prop Data, Amer Inst Chem Eng NY, NY: Hemisphere Pub Corp 5 Vol (1989) (3) Kwok ESC, Atkinson R; Estimation of hydroxyl radical reaction rate constants for gas-phase organic compounds using a structure-reactivity relationship: an update. Riverside, CA: Univ CA, Statewide Air Pollut Res Ctr. CMA Contract No. ARC-8.0-OR (1994)]**PEER REVIEWED**

Environmental Biodegradation:

AEROBIC: Degradation of **isopropanol** with municipal waste water for 5 and 20 days resulted in a theoretical oxygen demand (ThOD) of 7% and 70%, respectively(1). Degradation of 3, 7 and 10 mg/l of **isopropanol** with filtered sewage seed in fresh water resulted in a ThOD of 28% in 5 days and 78% in 20 days(2). In 2 other studies, the ThOD for **isopropanol** using domestic waste water was 66% and 74% in 5 days(1). **Isopropanol** was 99% degraded with acclimated activated sludge at 20 deg C (52 mg COD/g-hr rate)(3). Filtered sewage seed resulted in a ThOD of 49% and acclimated sewage seed resulted in a ThOD of 72% after 5 days(4). Degradation of **isopropanol** with sewage at 20 deg C for 5 days resulted in a ThOD of 58% (avg 4 results)(5). In domestic waste water, diluted with salt water, a ThOD of 13% in 5 days and 72% in 20 days was observed(1). Biodegradation of 3, 7, and 10 mg/l of **isopropanol** with filtered sewage seed in salt water resulted in a ThOD of 13% in 5 days and a ThOD of 72% in 20 days(2).
[(1) WHO; Environmental Health Criteria 103, 2-Propanol. Geneva, Switzerland: WHO International Program on Chemical Safety. pp. 1-77 (1990) (2) Price KS et al; J Water Pollut Control Fed 46: 63-77 (1974) (3) Pitter P; Water Res 10: 231-5 (1976) (4) Bridie AL et al; Water Res 13: 627-30 (1979) (5) Heukelekian H, Rand MC; J Water Pollut Control Assoc 29: 1040-53 (1955)]**PEER REVIEWED**

ANAEROBIC: Typical **isopropanol** removal efficiencies for an anaerobic lagoon treatment facility, with a retention time of 15 days, were 50% after loading with dilute waste, and 69 and 74% after loading with concentrated wastes(1). In closed bottle studies, **isopropanol** was completely degraded anaerobically by an acetate-enriched culture, derived from a seed of domestic sludge(1). The culture started to use cross-fed **isopropanol**, after 4 days, at a rate of 200 mg/l/day(1). In a mixed reactor with a 20-day retention time, seeded by the same culture, 56% removal was achieved in the 20 days following 70 days of acclimation to a final concn of 10,000 mg/l(1). The avg percent removal of **isopropanol** in semi-pilot scale anaerobic lagoons was 50% in 7.5-10 days for dilute wastes with 60 ppm **isopropanol** and 69-74% in 20-40 days for concentrated wastes with 175 ppm **isopropanol**(2). **Isopropanol** was readily mineralized to methane and carbon dioxide under methanogenic conditions(3). The degradation rate of **isopropanol** under these conditions in fuel impacted river sediments and industrial/sewage impacted creek sediments was 2.4 +/- 0.3 ppm C/day (82% of expected methane recovery) and 3.0 +/- 0.1 ppm C/day (91% of expected methane recovery), respectively(3). The degradation rate of **isopropanol** in a sediment slurry from a shallow anoxic aquifer under methanogenic conditions was 7.6 +/- 0.3 ppm C/day (112% of theoretical methane recovery)(4).
[(1) WHO; Environmental Health Criteria 103, 2-Propanol. Geneva, Switzerland: WHO International Program on Chemical Safety. pp. 1-77 (1990) (2) Hovious JC et al; Anaerobic Treatment of Synthetic Organic Wastes USEPA-12020 DIS 01/72 p. 41 (1972)

(3) Mormile MR et al; Environ Sci Technol 28: 1727-32 (1994) (4) Suflita JM, Mormile MR; Eniron Sci Technol 27: 976-78 (1993)]**PEER REVIEWED**

Environmental Abiotic Degradation:

The rate constant for the vapor-phase reaction of **isopropanol** with photochemically-produced hydroxyl radicals is 5.07X10-12 cu cm/molecule-sec at 25 deg C(1). This corresponds to an atmospheric half-life of about 3.2 days at an atmospheric concn of 5X10+5 hydroxyl radicals per cu cm(SRC). **Isopropanol** is considered to have low reactivity (class 2 of 5 where class 5 is high) in photochemical smog situations (2-4) having an ozone forming potential 68% that of toluene(3). A 20% decrease in **isopropanol** was observed after 5 hr in a smog chamber at 30 deg C containing 2 ppm **isopropanol** and 1 ppm nitrous oxides at 55% relative humidity(3). **Isopropanol** is not expected to undergo hydrolysis in the environment due to the lack of hydrolyzable functional groups(5) nor to directly photolyze due to the lack of absorption in the environmental UV spectrum (>290 nm).
[(1) Kwok ESC, Atkinson R; Estimation of hydroxyl radical reaction rate constants for gas-phase organic compounds using a structure-reactivity relationship: an update. Riverside, CA: Univ CA, Statewide Air Pollut Res Ctr. CMA Contract No. ARC-8.0-OR (1994) (2) Levy A; Amer Chem Soc Ser 124: 70-94 (1973) (3) Farley FF; Int Conf Photochem Oxidant Pollut Control pp.713-27 USEPA-600/3-77-001b (1977) (4) Lyman WJ et al; Handbook of chemical property estimation methods Environmental behavior of organic compounds NY, NY: McGraw Hill (1982) (5) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 7-4, 7-5 (1990)]**PEER REVIEWED**

Environmental Bioconcentration:

An estimated BCF of 3 was calculated for **isopropanol**(SRC), using a log Kow of 0.05(1) and a regression-derived equation(2). According to a classification scheme(3), this BCF suggests the potential for bioconcentration in aquatic organisms is low(SRC).
[(1) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 7 (1995) (2) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999) (3) Franke C et al; Chemosphere 29: 1501-14 (1994)]**PEER REVIEWED**

Soil Adsorption/Mobility:

The Koc of **isopropanol** is estimated as 25(SRC), using a measured log Kow of 0.05(1) and a regression-derived equation(2). According to a classification scheme(3), this estimated Koc value suggests that **isopropanol** is expected to have very high mobility in soil(SRC).
[(1) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 7 (1995) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9 (1990) (3) Swann RL et al; Res Rev 85: 17-28 (1983)]**PEER REVIEWED**

Volatilization from Water/Soil:

The Henry's Law constant for **isopropanol** is 8.10X10-6 atm-cu m/mole(1). This Henry's Law constant indicates that **isopropanol** is expected to volatilize from water surfaces(2). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec)(2) is estimated as 57 hours(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(2) is estimated as 29 days(SRC). The volatilization of **isopropanol** from a runoff tank of an industrial wastewater treatment facility was measured; the

volatilization rate of **isopropanol** ranged between 0.64-0.69 mg/sq m-min(3). **Isopropanol**'s Henry's Law constant(1) indicates that volatilization from moist soil surfaces may occur(SRC). The evaporation rate of a 1:1 **isopropanol**:water mixture from a shallow pool was 1.5 kg/sq-m per hour at a wind speed of 4.5 m/s and pool temperature of 20 deg C and an ambient air temperature of 22 deg C(4). The potential for volatilization of **isopropanol** from dry soil surfaces may exist(SRC) based upon a vapor pressure of 45.4 mm Hg(5).
[(1) Taft RW et al; Nature 313: 384-6 (1985) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (3) Gholson AR et al; Environ Sci Technol 25: 519-24 (1991) (4) WHO; Environmental Health Criteria 103, 2-Propanol. Geneva, Switzerland: WHO International Program on Chemical Safety. pp. 1-77 (1990) (5) Daubert TE, Danner RP; Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation. Design Inst Phys Prop Data, Amer Inst Chem Eng NY, NY: Hemisphere Pub Corp 5 Vol (1989)]**PEER REVIEWED**

Environmental Water Concentrations:

DRINKING WATER: **Isopropanol** was detected in trace quantities in some drinking water samples from unspecified sources(1).
[(1) IARC; Monograph. Isopropyl Alcohol and Isopropyl Oils 15: 223-43 (1977)]**PEER REVIEWED**

SURFACE WATER: **Isopropanol** was identified but not quantified in the Cuyahoga River, Ohio(1).
[(1) Great Lakes Quality Review Board; An Inventory of Chemical Substance Identified in the Great Lakes Ecosystem Vol 1 - Summary. Windsor Onatrio, Canada (1983)]**PEER REVIEWED**

Effluent Concentrations:

AIR: In view of the physical properties and the use pattern of **isopropanol**, the main pathway of entry of this compound into the environment is through its emission into the atmosphere during production, handling, storage, transport, and use, and following waste disposal(1). In the United States, it was estimated that 50% of the production of **isopropanol** in 1976 was lost into the atmosphere(1). In the Netherlands, an emission factor for the domestic use of **isopropanol** in aerosol sprays was estimated to be 430 mg/person/day(1). **Isopropanol** was identified in the volatile emissions from kitchen waste, building materials with microbial growth, and garden waste(2).
[(1) WHO; Environmental Health Criteria 103, 2-Propanol. Geneva, Switzerland: WHO International Program on Chemical Safety. pp. 1-77 (1990) (2) Wilkins CK, Larsen K; J High Resol Chromatogr 18: 373-7 (1995)]**PEER REVIEWED**

WATER: The concn of **isopropanol** in leachate from 1 of 5 town landfill sites in Connecticut was 3.4 ppm(1). **Isopropanol** was found in 6 of 6 leachate samples from Minnesota landfills with a range of concns from 94-41,000 ug/l(2). **Isopropanol** was also found in groundwater suspected of leachate contamination (based on levels of inorganics) at a range of concns from 8.6-2600 ug/l (6 of 13 samples pos), but not detected in ground water where inorganics levels indicted good or unknown water quality (2). In 1982-83, **isopropanol** concns of up to 8.8 mg/l were measured in 6 of 7 leachate samples obtained from test wells in 1 of 5 landfills in the United Kingdom(3). The concn of **isopropanol** in municipal landfill leachates (complied from 13 sources) was 8.4 mg/l(4).
[(1) Sawhney BL, Kozloski RP; J Environ Qual 13: 349-52 (1984) (2) Sabel GV, Clark TP; pp. 108-25 in Ann Madison Waste Conf Appl Res Pract Munic Ind Waste 6th (1983) (3) WHO; Environmental Health Criteria 103, 2-Propanol. Geneva, Switzerland: WHO International Program on Chemical Safety. pp. 1-77 (1990) (4) Roy WR; p. 411-66 in Contam Groundwaters; Adariana DC et al, eds (1994)]**PEER REVIEWED**

Atmospheric Concentrations:

SOURCE DOMINATED: At an industrial area in Linden, NJ, the **isopropanol** concn was 4-59 ng/cu m (23 ng/cu m avg, 4 of 12 samples pos)(1). Near a polypropylene plant, the concn of **isopropanol** was up to 340 mg/cu m(2). The peak concn of **isopropanol** in Japan resulting from air pollution was 13-24 ppb (3). **Isopropanol** was detected, at level of 95 mg/cu m air, at the outlet of the main chimney of a paint-manufacturing plant in France in the 1980s(4). The compound was not detected at a distance of 10-30 m from this chimney(4). In 1970, avg atmospheric levels of **isopropanol** at distances of 500 and 5000 m from a plant producing **isopropanol** by indirect hydration, were 1.7 and 0.2 mg/cu m air, with maximum of 3 and 0.5 mg/cu m air, respectively(4). **Isopropanol** was detected in the air beneath the surface of 2 of 6 landfill sites sampled in the United Kingdom. At these 2 sites, used for disposal of domestic waste, the **isopropanol** concn were 17 mg/cu m and more than 46 mg/cu m, respectively(4). Analysis of a total of 82 air samples at 5 hazardous waste sites in New Jersey, revealed the presence of **isopropanol** at 4 sites(4). The concn of **isopropanol** upwind and downwind of a furniture factory was 9.3 and 21.2 ppbv, respectively(5).
[(1) Pellizzari ED; Quantification of Chlorinated Hydrocarbons in Previously Collected Air Samples USEPA 450/3-78-112 (1978) (2) IARC; Monograph. Isopropyl Alcohol and Isopropyl Oils 15: 223-43 (1977) (3) Anonymous; Kanagawa-Ken Taiki Osen Chosa Kenkyu Hokoku 20: 86-90 (1978) (4) WHO; Environmental Health Criteria 103, 2-Propanol. Geneva, Switzerland: WHO International Program on Chemical Safety. pp. 1-77 (1990) (5) Kelly TJ et al; Environ Sci Tech 27L 1146-53 (1993)]**PEER REVIEWED**

URBAN/SUBURBAN: The avg concn of **isopropanol** in Stockholm (Sweden) between Aug 1982 to Jun 1983 was 14.3 ppb (56 samples, range 2.8-44.0 ppb) and 5.7 ppb (96 samples, range 0.3-33.3 ppb) on 2 busy streets, respectively(1). At 3 locations with moderate to little traffic, the avg concn of **isopropanol** was 3.1 ppb (56 samples, range 0.3-10.4 ppb), 0.6 ppb (24 samples, range 0.2-1.6 ppb), and 0.30 ppb (56 samples, range 0.05-1.19 ppb), respectively(1). The mean and range of concns of **isopropanol** in Boston, MA was 3.1 ppbv and <1-20 ppbv, respectively(2). In Houston, TX, the mean and range of concn of **isopropanol** was <1 and <1-7.9 ppbv, respectively(2).
[(1) Jonsson A et al; Environ Inter 11: 383-92 (1985) (2) Kelly TJ et al; Environ Sci Tech 27L 1146-53 (1993)]**PEER REVIEWED**

INDOOR AIR: The weighted-average geometric mean concn of **isopropanol** in the indoor air of new buildings (eg, schools, offices, dwellings) was 26 (4 samples), 27 (12 samples), and 900 (46 samples) ug/cu m, respectively(1). The ratio of the weighted-average geometric mean concn of **isopropanol** between new and established is 340(1); which indicates that newer dwellings will have a high indoor air concn of **isopropanol**(1). The concn of **isopropanol** in machine shop and office indoor was 13.7 and 197 ppbv, respectively(2).
[(1) Brown SK et al; Indoor Air 4: 123-34 (1994)]**PEER REVIEWED**

RURAL/REMOTE: **Isopropanol** was identified but not quantified in southern Black Forest (Germany) air in Nov 1984 and Jan 1985(1).
[(1) Juttner F; Chemosphere 15: 985-92 (1986)]**PEER REVIEWED**

Food Survey Values:

When **isopropanol** is used as an extraction or carrier solvent for food constituents, it may be found in the final product(1). **Isopropanol** was detected in 8 of 17 samples of lemonade; these samples were prepared with a natural essence extracted from lemons with **isopropanol**(1). Concn of between 0.2 and 82 mg/l were measured in 7 samples and 325 mg/l in one sample(1). **Isopropanol** was also identified in fish protein concentrate, extracted by **isopropanol**(1). The Scientific Committee for Food of the Commission of the European Communities has published industry-derived residue levels in foodstuffs

following the use of **isopropanol** as an extraction and/or carrier solvent(1). Typical levels are: 250 mg/kg of dry fish protein concentrate, 50 mg/kg of meat product as consumed, 750 mg/kg of meat after use of **isopropanol** as a smoke flavor carrier and before drying, 1200 mg/kg of jam, and 3000 mg/kg of jelly(1). **Isopropanol** has been shown to be used as a flavor volatile in the following foodstuffs: reunion geranium oil, rooibos tea, winged bean (raw/roasted), soybean (raw/roasted), Virginia peanut (raw), peanut (raw/roasted), filbert (roasted), babaco fruit, apple, tomato, lime essence, grapefruit essence, grapefruit aroma oil, mushroom (fresh/edible), kekir culture, yogurt culture, Swiss Gruyere cheese, feta cheese(1). **Isopropanol** has also been detected in the aromas of milk products, apples, and cognac(2,3). Non-alcoholic beverages, candy and baked goods may contain concns of **isopropanol** of 22 ppm, 10-75 ppm, and 75 ppm, respectively(3).
[(1) WHO; Environmental Health Criteria 103, 2-Propanol. Geneva, Switzerland: WHO International Program on Chemical Safety. pp. 1-77 (1990) (2) IARC; Monograph. Isopropyl Alcohol and Isopropyl Oils 15: 223-43 (1977) (3) Furia TE, Bellanca N, eds; Fenaroli's Handbook of Flavor Ingredients. 2nd ed Cleveland, OH: The Chemical Rubber Co 2: 303 (1975)]**PEER REVIEWED**

Milk Concentrations:

Isopropanol was detected in 8 samples of mother's milk from 4 urban areas(1).
[(1) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982)]**PEER REVIEWED**

Environmental Standards & Regulations:

FIFRA Requirements:

Residues of **isopropyl alcohol** are exempted from the requirement of a tolerance when used as a solvent, cosolvent, stabilizer, inhibitor in accordance with good agricultural practice as inert (or occasionally active) ingredients in pesticide formulations applied to growing crops or to raw agricultural commodities after harvest.
[40 CFR 180.1001(c) (7/1/2000)]**PEER REVIEWED**

Isopropyl alcohol is exempted from the requirement of a tolerance when used as a solvent, cosolvent, stabilizer, inhibitor for blended emulsifiers in accordance with good agricultural practice as inert (or occasionally active) ingredients in pesticide formulations applied to growing crops only.
[40 CFR 180.1001(d) (7/1/2000)]**PEER REVIEWED**

Isopropyl alcohol is exempted from the requirement of a tolerance when used as a solvent, cosolvent for blended emulsifiers in accordance with good agricultural practice as inert (or occasionally active) ingredients in pesticide formulations applied to animals.
[40 CFR 180.1001(e) (7/1/2000)]**PEER REVIEWED**

TSCA Requirements:

Pursuant to section 8(d) of TSCA, EPA promulgated a model Health and Safety Data Reporting Rule. The section 8(d) model rule requires manufacturers, importers, and processors of listed chemical substances and mixtures to submit to EPA copies and lists of unpublished health and safety studies. 2-Propanol is included on this list.
[40 CFR 716.120 (7/1/2000)]**PEER REVIEWED**

Atmospheric Standards:

This action promulgates standards of performance for equipment leaks of Volatile Organic Compounds (VOC) in the Synthetic Organic Chemical Manufacturing Industry (SOCMI). The intended effect of these standards is to require all newly constructed, modified, and reconstructed SOCMI process units to use the best demonstrated system of continuous emission reduction for equipment leaks of VOC, considering costs, non air quality health and environmental impact and energy requirements. **Isopropanol** is produced, as an intermediate or a final product, by process units covered under this subpart.
[40 CFR 60.489 (7/1/2000)]**PEER REVIEWED**

State Drinking Water Guidelines:

(CT) CONNECTICUT 2300 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

FDA Requirements:

Isopropanol is a food additive permitted for direct addition to food for human consumption as a synthetic flavoring substance and adjuvant in accordance with the following conditions: a) they are used in the minimum quantity required to produce their intended effect, and otherwise in accordance with all the principles of good manufacturing practice, and 2) they consist of one or more of the following, used alone or in combination with flavoring substances and adjuvants generally recognized as safe in food, prior-sanctioned for such use, or regulated by an appropriate section in this part.
[21 CFR 172.515 (4/1/2000)]**PEER REVIEWED**

Isopropanol is an indirect food additive for use only as a component of adhesives.
[21 CFR 175.105 (4/1/2000)]**PEER REVIEWED**

Isopropyl alcohol (without residue) may be used in inks for marking food supplements in tablet form, gum, and confectionery.
[21 CFR 73.1 (4/1/2000)]**PEER REVIEWED**

Allowable Tolerances:

Residues of **isopropyl alcohol** are exempted from the requirement of a tolerance when used as a solvent, cosolvent, stabilizer, inhibitor in accordance with good agricultural practice as inert (or occasionally active) ingredients in pesticide formulations applied to growing crops or to raw agricultural commodities after harvest.
[40 CFR 180.1001(c) (7/1/2000)]**PEER REVIEWED**

Isopropyl alcohol is exempted from the requirement of a tolerance when used as a solvent, cosolvent, stabilizer, inhibitor for blended emulsifiers in accordance with good agricultural practice as inert (or occasionally active) ingredients in pesticide formulations applied to growing crops only.
[40 CFR 180.1001(d) (7/1/2000)]**PEER REVIEWED**

Isopropyl alcohol is exempted from the requirement of a tolerance when used as a solvent, cosolvent for blended emulsifiers in accordance with good agricultural practice as inert (or occasionally active) ingredients in pesticide formulations applied to animals.
[40 CFR 180.1001(e) (7/1/2000)]**PEER REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

C3-H8-O
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 798]**PEER REVIEWED**

Molecular Weight:

60.10
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 889]**PEER REVIEWED**

Color/Form:

Colorless liquid.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 632]**PEER REVIEWED**

Odor:

Pleasant odor
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 632]**PEER REVIEWED**

SLIGHT ODOR RESEMBLING THAT OF MIXT OF ETHANOL & ACETONE
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 749]**PEER REVIEWED**

Odor of rubbing alcohol.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 94-116. Washington, D.C.: U.S. Government Printing Office, June 1994. 180]**PEER REVIEWED**

Taste:

Slightly bitter taste
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 889]**PEER REVIEWED**

Burning taste
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 798] **PEER REVIEWED**

Boiling Point:

82.5 deg C @ 760 mm Hg
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 889]**PEER REVIEWED**

Melting Point:

-88.5 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 889]**PEER REVIEWED**

Corrosivity:

Isopropyl alcohol will attack some forms of plastics, rubber, and coatings.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2] **PEER REVIEWED**

Critical Temperature & Pressure:

Critical temp: 235 deg C; critical pressure: 47 atm
[Lide, DR (ed.). CRC Handbook of Chemistry and Physics. 81st Edition. CRC Press LLC, Boca Raton: FL 2000,p. 6-52]**PEER REVIEWED**

Density/Specific Gravity:

0.78505 @ 20 deg C/4 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 889]**PEER REVIEWED**

Dissociation Constants:

pKa = 17.10
[Serjeant, E.P., Dempsey B.; Ionisation Constants of Organic Acids in Aqueous Solution. International Union of Pure and Applied Chemistry (IUPAC). IUPAC Chemical Data Series No. 23, 1979. New York, New York: Pergamon Press, Inc.]**PEER REVIEWED**

Heat of Combustion:

7942 cal/g; 7970 cal/g
[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 343]**PEER REVIEWED**

Heat of Vaporization:

45.39 kJ/mol @ 25 deg C
[Lide, DR (ed.). CRC Handbook of Chemistry and Physics. 81st Edition. CRC Press LLC, Boca Raton: FL 2000,p. 6-110]**PEER REVIEWED**

Octanol/Water Partition Coefficient:

log Kow= 0.05
[Hansch, C., Leo, A., D. Hoekman. Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. Washington, DC: American Chemical Society., 1995. 7]**PEER

REVIEWED**

Solubilities:

Miscible with chloroform; insoluble in salt soln
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 889]**PEER REVIEWED**

SOL IN BENZENE
[Weast, R.C. (ed.) Handbook of Chemistry and Physics. 69th ed. Boca Raton, FL: CRC Press Inc., 1988-1989.,p. C-455]**PEER REVIEWED**

MISCIBLE WITH MOST ORGANIC SOLVENTS
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 4562]**PEER REVIEWED**

In water: 1.00X10+6 @ 25 deg C
[Riddick, J.A., W.B. Bunger, Sakano T.K. Techniques of Chemistry 4th ed., Volume II. Organic Solvents. New York, NY: John Wiley and Sons., 1985. 196]**PEER REVIEWED**

> 10% in alcohol
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 798]**PEER REVIEWED**

> 10% in ether
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 798]**PEER REVIEWED**

> 10% in acetone
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 798]**PEER REVIEWED**

Spectral Properties:

Max absorption (liquid): < 200nm
[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 910]**PEER REVIEWED**

Index of refraction: 1.3852 @ 8 deg C/D; 1.3802 @ 15 deg C/D; 1.37723 @ 20 deg C/D; 1.3749 @ 25 deg C/D
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 889]**PEER REVIEWED**

IR: SADG 65 (Sadtler Research Laboratories IR Grating Collection)
[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994.,p. V5 4438]**PEER REVIEWED**

1H NMR: VAR 44 (Varian Associates NMR Spectra Catalogue)
[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994.,p. V5 4438]**PEER REVIEWED**

MS: NIST 18982 (NIST/EPA/MSDC Mass Spectral Database 1990 Version); WILEY 42 (Atlas of Mass Spectral Data, John Wiley & Sons, New York)
[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994.,p. V5 4438]**PEER REVIEWED**

Intense mass spectral peaks: 45 m/z, 60 m/z
[Pfleger, K., H. Maurer and A. Weber. Mass Spectral and GC Data of Drugs, Poisons and their Metabolites. Parts I and II. Mass Spectra Indexes. Weinheim, Federal Republic of Germany. 1985.47]**PEER REVIEWED**

Surface Tension:

22.11 mN/m (dyne/cm) @ 10 deg C; 20.93 mN/m @ 25 deg C; 18.96 mN/m @ 50 deg C; 16.98 mN/m @ 75 deg C
[Lide, DR (ed.). CRC Handbook of Chemistry and Physics. 81st Edition. CRC Press LLC, Boca Raton: FL 2000,p. 6-146]**PEER REVIEWED**

Vapor Density:

2.1 (AIR = 1)
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-63]**PEER REVIEWED**

Vapor Pressure:

45.4 mm Hg @ 25 deg C
[Daubert, T.E., R.P. Danner. Physical and Thermodynamic Properties of Pure Chemicals Data Compilation. Washington, D.C.: Taylor and Francis, 1989.]**PEER REVIEWED**

Relative Evaporation Rate:

21 (ether=1)
[Snyder, R. (ed.). Ethel Browning's Toxicity and Metabolism of Industrial Solvents. Second Edition. Volume 3 Alcohols and Esters. New York, NY: Elsevier, 1992. 32] **PEER REVIEWED**

1.7 (n-butyl acetate=1)
[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 377]**PEER REVIEWED**

Viscosity:

2.1 cP @ 25 deg C
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 632]**PEER REVIEWED**

Other Chemical/Physical Properties:

Freezing point -89.5 deg C; forms azeotrope with water (bp 80.37 deg C, 760 mm Hg, density 0.83361 @ 0 deg C/4 deg C) /**Isopropanol** 87.7% (wt/wt)/
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 889]**QC REVIEWED**

% IN SATURATED AIR: 5.8 (25 DEG C); DENSITY OF SATURATED AIR: 1.06 (AIR= 1); 1 MG/L= 408 PPM & 1 PPM= 2.45 MG/CU M @ 25 DEG C, 760 MM HG
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 4562]**PEER REVIEWED**

Ratio of specific heats of vapor: 1.105; heat of solution: (est) -9 BTU/lb= -5 cal/g= -0.2X10+5 J/kg; heat of fusion 21.37 cal/g; Reid vapor pressure: 1.4 psia
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

BP 80.4 deg C @ 101.3 kPa; surface tension 0.0214 mN/m @ 20 deg C; index of refraction 1.3769 @ 20 deg C and sodium light, vapor pressure 4.5 kPa @ 20 deg C, viscosity 2.1 cp @ 20 deg C, completely soluble in water /91% **isopropanol**/
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 19 (1982) 199]**PEER REVIEWED**

Heat of fusion: 5.41 kJ/mol
[Lide, DR (ed.). CRC Handbook of Chemistry and Physics. 81st Edition. CRC Press LLC, Boca Raton: FL 2000,p. 6-129]**PEER REVIEWED**

Heat capacity (liquid): 2.58 J/g-K @ 25 deg C and constant pressure
[Lide, DR (ed.). CRC Handbook of Chemistry and Physics. 81st Edition. CRC Press LLC, Boca Raton: FL 2000,p. 6-129]**PEER REVIEWED**

Observed and estimated solubility of anthracene in 2-propanol at 20 deg C: 0.0004 mole fraction (observed) 0.0006 (estimated)
[Lyman, W.J., W.F. Reehl, D.H. Rosenblatt. Handbook of Chemical Property Estimation Methods-Environmental Behavior of Organic Compounds. New York, NY: McGraw-Hill Book Company, 1982.,p. 3-22]**PEER REVIEWED**

Dielectric constant: 18.3 debye at 25 deg C; 16.24 debye at 40 deg C; dipole moment: 1.69 debye (gas), 1.66 debye in benzene at 30 deg C
[Dean, J.A. Handbook of Organic Chemistry. New York, NY: McGraw-Hill Book Co., 1987.,p. 4-73]**PEER REVIEWED**

Enthalpies of formation: -75.97 kcal/mole (liquid); -65.11 kcal/mole (gas); Gibbs (free) energies of formation: -43.09 kcal/mole (liquid); -41.44 kcal/mole (gas); Entropies: 43.16 cal/deg-mole (liquid); 74.07 cal/deg-mole (gas); Heat capacities: 36.06 cal/deg-mole (liquid); 21.21 cal/deg-mole (gas)
[Dean, J.A. Handbook of Organic Chemistry. New York, NY: McGraw-Hill Book Co., 1987.,p. 5-35]**PEER REVIEWED**

Heat of melting: 1.293 kcal/mole; heat of sublimation: 10.85 kcal/mole at 298 K; specific heat: 26.78 cal/Kmol at 400 K
[Dean, J.A. Handbook of Organic Chemistry. New York, NY: McGraw-Hill Book Co., 1987.,p. 5-70]**PEER REVIEWED**

Henry's Law constant = 8.10X10-6 atm-cu m/mol @ 25 deg C
[Taft RW et al; Nature 313: 384-6 (1985)]**PEER REVIEWED**

Hydroxyl radical reaction rate constant = 5.07X10-12 cu cm/molecule-sec @ 25 deg C
[Kwok ESC, Atkinson R; Estimation of hydroxyl radical reaction rate constants for gas-phase organic compounds using a structure-reactivity relationship: an update.

Riverside, CA: Univ CA, Statewide Air Pollut Res Ctr. CMA Contract No. ARC-8.0-OR (1994)]**PEER REVIEWED**

Coefficient of expansion: 0.00107 per deg C; density correction: 0.00082 per deg C
[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 380]**PEER REVIEWED**

Forms binary azeotropes with acrylonitrile, benzene, 2-bromobutane, 2-butanone, n-butylamine, butyl isopropyl ether, carbon disulfide, carbon tetrachloride, 1-chlorobutane, 2-chlorobutane, 1-chloro-3-methylbutane, 1,3-cyclohexdiene, cyclohexane, cyclohexene, diethoxymethane, diisobutylene, 2,3-dimethylbutane, 1,3-dimethylcyclohexane, 2,5-dimethylhexane, ethyl acetate, ethyl propyl ether, ethyl sulfide, ethylene dichloride, fluorobenzene, n-heptane, hexane, 1-iodo-2-methylpropane, isobutyl chloride, isopropyl acetate, isopropyl ether, methyl acrylate, methylcyclohexane, methylcyclopentane, methyl ethyl ketone, methyl isobutyrate, methyl propionate, octane, pentane, propyl ether, propyl formate, tetrachloroethylene, thiophene, toluene, trichloroethylene, vinyl acetate, water
[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 346]**PEER REVIEWED**

Forms ternary azeotropes with water, benzene; water, cyclohexane; water, cyclohexene; water, diisobutylene; water, ethyl butyl ether; water, ethylene dichloride; water, isopropyl acetate; water, isopropyl ether; water, nitromethane; water, toluene
[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 346]**PEER REVIEWED**

Liquid heat capacity: 0.605 BTU/lb-F @ 70 deg F; Liquid thermal conductivity: 0.937 BTU-in/hr-sq ft-F at 70 deg F; Saturated vapor density: 0.00717 lb/cu ft @ 70 deg F; Ideal gas heat capacity: 0.352 BTU/lb-F @ 75 deg F
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

6.54 lb/gal @ 20 deg C; acidity (as acetic acid) = 0.002 max wt%; flash point = 13 deg C; fir point 16 deg C
[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 377]**PEER REVIEWED**

Chemical Safety & Handling:

DOT Emergency Guidelines:

Fire or explosion: Highly flammable: Will be easily ignited by heat, sparks or flames. Vapors may form explosive mixtures with air. Vapors may travel to source of ignition and flash back. Most vapors are heavier than air. They will spread along ground and collect in low confined areas (sewers, basements, tanks). Vapor explosion hazard indoors, outdoors or in sewers. Those substances labeled "P" may polymerize explosively when heated or involved in a fire. Runoff to sewer may create fire or explosion hazard. Containers may explode when heated. Many liquids are lighter than water.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-129] **QC REVIEWED**

Health: May cause toxic effects if inhaled or absorbed through skin. Inhalation or contact with material may irritate or burn skin and eyes. Fire will produce irritating, corrosive and/or toxic gases. Vapors may cause dizziness or suffocation. Runoff from fire control or dilution water may cause pollution.

[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-129]
QC REVIEWED

Public safety: Call Emergency Response Telephone Number ... . Isolate spill or leak area immediately for at least 50 to lOO meters (160 to 330 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Keep out of low areas. Ventilate closed spaces before entering.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-129]
QC REVIEWED

Protective clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Structural firefighters' protective clothing will only provide limited protection.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-129]
QC REVIEWED

Evacuation: ... Fire: If tank, rail car or tank truck is involved in a fire, isolate for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-129]
QC REVIEWED

Fire: Caution: All these products have a very low flash point: Use of water spray when fighting fire may be inefficient. Small fires: Dry chemical, CO2, water spray or alcohol-resistant foam. Do not use dry chemical extinguishers to control fires involving nitromethane or nitroethane. Large fires: Water spray, fog or alcohol-resistant foam. Do not use straight streams. Move containers from fire area if you can do it without risk. Fire involving tanks or car/trailer loads: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. Always stay away from tanks engulfed in fire. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-129]
QC REVIEWED

Spill or leak: Eliminate all ignition sources (no smoking, flares, sparks or flames in immediate area). All equipment used when handling the product must be grounded. Do not touch or walk through spilled material. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. A vapor suppressing foam may be used to reduce vapors. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. Use clean non-sparking tools to collect absorbed material. Large spills: Dike far ahead of liquid spill for later disposal. Water spray may reduce vapor; but may not prevent ignition in closed spaces.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-129]
QC REVIEWED

First aid: Move victim to fresh air. Call 911 or emergency medical service. Apply artificial respiration if victim is not breathing. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. Wash skin with soap and water. Keep victim warm and quiet. Effects of exposure (inhalation, ingestion or skin contact) to substance may be delayed. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-129] **QC REVIEWED**

Odor Threshold:

90 mg/cu m
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

... MIN CONCN WITH IDENTIFIABLE ODOR ... IS 200 PPM.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 4571]**PEER REVIEWED**

Odor threshold 7.84 mg/cu m (low) 490 mg/cu m (high).
[Ruth JH; Am Ind Hyg Assoc J 47: A-142-51 (1986)]**PEER REVIEWED**

... Air odor threshold for **isopropanol** has been reported as 22 ppm and 40 ppm.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 2635]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Mild irritation of the eyes, nose and throat was induced in human subjects exposed for 3 to 5 min to 400 ppm of **isopropyl alcohol.**
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 2634]**PEER REVIEWED**

It can be an irritant of the eyes, mucous membranes, & respiratory tract.
[Sullivan, J.B. Jr., G.R. Krieger (eds.). Hazardous Materials Toxicology-Clinical Principles of Environmental Health. Baltimore, MD: Williams and Wilkins, 1992. 1107]**PEER REVIEWED**

Fire Potential:

A very dangerous fire hazard when exposed to heat, flame or oxidizers.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1977]**PEER REVIEWED**

Ignites on contact with dioxygenyl tetrafluoroborate; chromium trioxide; potassium tert-butoxide... .
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1977]**PEER REVIEWED**

NFPA Hazard Classification:

Health: 1. 1= Materials that, on exposure, would cause irritation, but only minor residual injury, including those requiring the use of an approved air-purifying respirator. These materials are only slightly hazardous to health and only breathing protection is needed.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-63]**PEER REVIEWED**

Flammability: 3. 3= This degree includes Class IB and IC flammable liquids and materials that can be easily ignited under almost all normal temperature conditions. Water may be ineffective in controlling or extinguishing fires in such materials.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-63]**PEER REVIEWED**

Reactivity: 0. 0= This degree includes materials that are normally stable, even under fire exposure conditions, and that do not react with water. Normal fire fighting procedures may be used.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-63]**PEER REVIEWED**

Flammable Limits:

LOWER 2.0% & UPPER 12.7% @ 200 deg C (by vol)
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-63]**PEER REVIEWED**

Flash Point:

12 DEG C, 53 DEG F (CLOSED CUP)
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-63]**PEER REVIEWED**

75 deg F (open cup) /91% **isopropanol**/
[Flick, E.W. Industrial Solvents Handbook. 3rd ed. Park Ridge, NJ: Noyes Publications, 1985. 223]**PEER REVIEWED**

Autoignition Temperature:

399 DEG C (750 DEG F)
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-63]**PEER REVIEWED**

Fire Fighting Procedures:

Do not extinguish fire unless flow can be stopped. Use water in flooding quantities as fog. Solid streams of water may be ineffective. Cool all affected containers with flooding quantities of water. Apply water from as far a distance as possible. Use "alcohol" foam, dry chemical or carbon dioxide.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, D.C.: Assoc. of American Railroads, Hazardous Materials Systems (BOE), 1987.398]**PEER REVIEWED**

Firefighting Hazards:

Since vapor is heavier than air flashback along vapor trail may occur.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Explosive Limits & Potential:

MODERATELY EXPLOSIVE WHEN EXPOSED TO HEAT OR FLAME.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-

3. New York, NY: Van Nostrand Reinhold, 1996. 1977]**PEER REVIEWED**

Lower 2.5%, upper 12.0%
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1976]**PEER REVIEWED**

Accumulations of vapor in confined spaces such as buildings or sewers may explode if ignited.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, D.C.: Assoc. of American Railroads, Hazardous Materials Systems (BOE), 1987.398]**PEER REVIEWED**

Forms explosive mixtures with trinitromethane; hydrogen peroxide (similar in power and sensitivity to glyceryl nitrate). Reacts with barium perchlorate to form the highly explosive propyl perchlorate.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1977]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

During distillation of 2-propanol recovered from the reduction of crotonaldehyde with aluminium isopropoxide, a violent explosion occurred. This was attributed either to peroxidized diisopropyl ether (a possible by-product) or to peroxidized crotonaldehyde.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 391]**PEER REVIEWED**

REACTS VIOLENTLY WITH HYDROGEN-PALLADIUM COMBINATION (H2 + Pd); NITROFORM; OLEUM; COCl2; ALUMINUM TRIISOPROPOXIDE; OXIDANTS.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1977]**PEER REVIEWED**

Two explosions occurred during laboratory distillation of **isopropanol**, one with a sample stored for 4 yr. No cause was apparent, but presence of traces of ketone(s) promoting peroxidation is a possibility. Previously, the presence of 0.36 molar peroxide had been reported in a 99.5% pure sample of **isopropanol** stored for several months in a partially full clear glass bottle in strong daylight.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 391]**PEER REVIEWED**

Dissolution of aluminium in 2-propanol to give the isopropoxide is rather exothermic, but often subject to an induction period similar to that in preparation of Grignard reagents.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 30]**PEER REVIEWED**

Addition of a small amount of hydrogen peroxide may reduce sharply the autoignition temp of the alcohol (455 deg C), probably that of the hydroperoxide.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 392]**PEER REVIEWED**

Frozen mixtures of trinitromethane-2-propanol (9:1) exploded during thawing. The former (of positive oxygen balance) dissolve exothermally in the alcohol, the heat effect increasing directly with the concn above 50% wt/wt. Traces of nitric acid may also have been present.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 30]**PEER REVIEWED**

Distillation of mixtures of /barium perchlorate/ with C1-C3 alcohols gives the highly explosive alkyl

perchlorates.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 80]**PEER REVIEWED**

Homogeneous mixtures of concentrated peroxide with alcohols or other peroxide miscible organic liquids are capable of detonation by shock or heat.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 3rd ed. Boston, MA: Butterworths, 1985. 1153]**PEER REVIEWED**

Secondary alcohols are readily autoxidized in contact with oxygen or air, forming ketones and hydrogen peroxide. A partly full bottle of 2-propanol exposed to sunlight for a long period became 0.36 molar in peroxide and potentially explosive.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1395]**PEER REVIEWED**

Contact of 1.5 g portions of the solid /potassium tert-butoxide/ ... with ... vapors of ... /**isopropanol**/ caused ignition after ... 1 min.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 475]**PEER REVIEWED**

Solutions of 90% nitroform in 10% **isopropyl alcohol** in polyethylene bottles exploded.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-128]**PEER REVIEWED**

The reaction between **isopropyl alcohol** and phosgene forms isopropyl chloroformate and hydrogen chloride. In the presence of iron salts thermal decomposition can occur, which in some cases can become explosive.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-105]**PEER REVIEWED**

A very dangerous fire hazard when exposed to heat, flame or oxidizers.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1977]**PEER REVIEWED**

Strong oxidizers, acetaldehyde, chlorine, ethylene oxide, acids, isocyanates.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 180]**PEER REVIEWED**

The presence of 2-butanone incr the reaction rate for peroxide formation.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1977]**PEER REVIEWED**

Vigorous reaction with sodium dichromate + sulfuric acid; aluminum (after a delay).
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1977]**PEER REVIEWED**

Hazardous Decomposition:

When heated to decomposition it emits acrid smoke and fumes.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1977]**PEER REVIEWED**

Prior History of Accidents:

... Mass poisoning involving 372 men who had consumed a soln of 82% methanol and 18% **isopropanol** /was reported/.
[O'Donoghue, J.L. (ed.). Neurotoxicity of Industrial and Commercial Chemicals. Volume II. Boca Raton, FL: CRC Press, Inc., 1985. 82]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

2000 ppm (Based on 10% of the lower explosive limit for safety considerations even though the relevant toxicological data indicated that irreversible health effects or impairment of escape existed only at higher concentrations.)
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 180]**PEER REVIEWED**

Protective Equipment & Clothing:

Wear safety glasses, rubber gloves, a face shield, coveralls ... .
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 290]**PEER REVIEWED**

The following materials are acceptable: neoprene, PVC, paracril/PVC, chlorinated polyethylene, butyl rubber, natural rubber, nitrile, vitron. Unacceptable: PVA. Conditionally acceptable: polyurethane. Note: This ... is ... a guide only. The user is advised to contact the protective clothing manufacturer regarding the specific applicability & limitations of a material under proposed conditions of use.
[Ecology and Environment Inc. Toxic Substance Storage Tank Containment. Park Ridge, NJ: Noyes Publications, 1985. 161]**PEER REVIEWED**

Wear appropriate chemical protective ... boots and goggles.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, D.C.: Assoc. of American Railroads, Hazardous Materials Systems (BOE), 1987.398]**PEER REVIEWED**

Breakthrough times greater than one hour reported by (normally) two or more testers for neoprene and nitrile rubber. Some data (usually from immersion tests) suggesting breakthrough times greater than one hour are not likely for natural rubber. No data for butyl rubber, neoprene/styrene-butadiene rubber, nitrile rubber/polyvinyl chloride, polyethylene, polyvrethane, polyvinyl alcohol, and viton. Some data suggesting breakthrough times of approximated an hour or more for polyvinyl chloride.
[ACGIH; Guidelines Select of Chem Protect Clothing Volume #1 Field Guide p.61 (1983)]**PEER REVIEWED**

Wear appropriate personal protective clothing to prevent skin contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 181]**PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 181]**PEER REVIEWED**

Recommendations for respirator selection. Max concn for use: 2000 ppm. Respirator Class(es): Any supplied-air respirator operated in a continuous flow mode. Eye protection needed. Any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s). Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister. Any powered, air-purifying respirator with organic vapor cartridge(s). Eye protection needed. Any self-contained breathing apparatus with a full facepiece. Any supplied-air respirator with a full facepiece.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 181]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Emergency or planned entry into unknown concn or IDLH conditions: Respirator Class(es): Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode. Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 181]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Escape from suddenly occurring respiratory hazards: Respirator Class(es): Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister. Any appropriate escape-type, self-contained breathing apparatus.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 181]**PEER REVIEWED**

Preventive Measures:

Any clothing which becomes wet with liquid **isopropyl alcohol** should be removed immediately and not reworn until the **isopropyl alcohol** is removed from the clothing. Clothing should then be placed in closed containers for storage until it can be discarded or until provision can be made for the removal of **isopropyl alcohol** from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the **isopropyl alcohol,** the person performing the operation should be informed of **isopropyl alcohol's** hazardous properties.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3] **PEER REVIEWED**

Contact lenses should not be worn when working with this chemical.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 181]**PEER REVIEWED**

SRP: The scientific literature for the use of contact lenses in industry is conflicting. The benefit or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In any event, the usual eye protection equipment should be worn even when contact lenses are in place.
PEER REVIEWED

If material /is/ not on fire and not involved in fire: Keep sparks, flames, and other sources of ignition away. Keep material out of water sources and sewers. Build dikes to contain flow as necessary. Attempt to stop leak if without undue personnel hazard. Use water spray to disperse vapors and dilute standing pools of liquid.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, D.C.: Assoc. of American Railroads, Hazardous Materials Systems (BOE), 1987.398]**PEER REVIEWED**

Avoid breathing vapors. Keep upwind. ... Do not handle broken packages unless wearing appropriate personal protective equipment. Wash away any material which may have contacted the body with copious amounts of water or soap and water.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, D.C.: Assoc. of American Railroads, Hazardous Materials Systems (BOE), 1987.398]**PEER REVIEWED**

Evacuation: If material leaking (not on fire) consider evacuation from downwind area based on amount of material spilled, location and weather conditions.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, D.C.: Assoc. of American Railroads, Hazardous Materials Systems (BOE), 1987.398]**PEER REVIEWED**

SRP: Contaminated protective clothing should be segregated in such a manner so that there is no direct personal contact by personnel who handle, dispose, or clean the clothing. Quality assurance to ascertain the completeness of the cleaning procedures should be implemented before the decontaminated protective clothing is returned for reuse by the workers. Contaminated clothing should not be taken home at end of shift, but should remain at employee's place of work for cleaning.
PEER REVIEWED

Employees who handle liquid isobutyl alcohol should wash their hands before eating or smoking. /Isobutyl alcohol/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]
PEER REVIEWED

The worker should immediately wash the skin when it becomes contaminated.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 181]**PEER REVIEWED**

Work clothing that becomes wet should be immediately removed due to its flammability hazard.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 181]**PEER REVIEWED**

Stability/Shelf Life:

Preserve in tight containers, remove from heat.
[USP Convention. The United States Pharmacopeia 21st Revision/The National Formulary 16th ed. Rockville, MD: United States Pharmacopeial Convention, Inc., Jan. 1, 1985 (plus Supplements 1-6).568]**PEER REVIEWED**

Shipment Methods and Regulations:

No person may /transport,/ offer or accept a hazardous material for transportation in commerce unless that person is registered in conformance ... and the hazardous material is properly classed, described, packaged, marked, labeled, and in condition for shipment as required or authorized by ... /the hazardous materials regulations (49 CFR 171-177)./
[49 CFR 171.2 (7/1/2000)]**PEER REVIEWED**

The International Air Transport Association (IATA) Dangerous Goods Regulations are published by the IATA Dangerous Goods Board pursuant to IATA Resolutions 618 and 619 and constitute a manual of industry carrier regulations to be followed by all IATA Member airlines when transporting hazardous

materials.
[IATA. Dangerous Goods Regulations. 41st Ed.Montreal, Canada and Geneva, Switzerland: International Air Transport Association, Dangerous Goods Regulations, 2000. 175]**PEER REVIEWED**

The International Maritime Dangerous Goods Code lays down basic principles for transporting hazardous chemicals. Detailed recommendations for individual substances and a number of recommendations for good practice are included in the classes dealing with such substances. A general index of technical names has also been compiled. This index should always be consulted when attempting to locate the appropriate procedures to be used when shipping any substance or article.
[IMDG; International Maritime Dangerous Goods Code; International Maritime Organization p.3244 (1998)]**PEER REVIEWED**

Storage Conditions:

Storage temp: ambient
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Cleanup Methods:

If **isopropyl alcohol** is spilled or leaked ... 1. Remove all ignition sources. 2. Ventilate area of spill or leak. 3. For small quantities absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn paper in suitable location away from combustible materials. Large quantities can be collected & atomized in suitable combustion chamber.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.4] **PEER REVIEWED**

Disposal Methods:

SRP: At the time of review, criteria for land treatment or burial (sanitary landfill) disposal practices are subject to significant revision. Prior to implementing land disposal of waste residue (including waste sludge), consult with environmental regulatory agencies for guidance on acceptable disposal practices.
PEER REVIEWED

The following wastewater treatment technology has been investigated for **isopropanol**: Biological treatment.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-3-E-22 (1982)]**PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

Permissible Exposure Limit: Table Z-1 8-hr Time Weighted Avg: 400 ppm (980 mg/cu m).
[29 CFR 1910.1000 (7/1/2000)]**PEER REVIEWED**

Vacated 1989 OSHA PEL TWA 400 ppm (980 mg/cu m); STEL 500 ppm (1225 mg/cu m) is still

enforced in some states.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 366]**PEER REVIEWED**

Threshold Limit Values:

8 hr Time Weighted Avg (TWA) 400 ppm; Short Term Exposure Limit (STEL) 500 ppm
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.37]**QC REVIEWED**

Notice of Intended Change for 2002: These substances, with their corresponding values and notations, comprise those for which a limit has been proposed for the first time or for which a change in the Adopted value is proposed. In each case, the proposed values should be considered trial values for the year following ratification by the ACGIH Board of Directors. If, during the year, no evidence comes to light that questions the appropriateness of these proposals, the value will be reconsidered for adoption as TLVs. Time Weighted Avg (TWA): 200; Short Term Exposure Limit (STEL): 400 ppm; Carcinogenicity, A4.
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.63]**QC REVIEWED**

NIOSH Recommendations:

Recommended Exposure Limit: 10 Hr Time-Weighted Avg: 400 ppm (980 mg/cu m).
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 180]**PEER REVIEWED**

Recommended Exposure Limit: 15 Min Short-Term Exposure Limit: 500 ppm (1225 mg/cu m).
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 180]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

2000 ppm (Based on 10% of the lower explosive limit for safety considerations even though the relevant toxicological data indicated that irreversible health effects or impairment of escape existed only at higher concentrations.)
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 180]**PEER REVIEWED**

Other Occupational Permissible Levels:

In Czechoslovakia a Max allowable concn of about 200 ppm ... Romania (1975) 160 ppm; East Germany (1973) 80 ppm; Japan (1975) and Western European nations, 400 ppm.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.337]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

For **Isopropanol** (USEPA/OPP Pesticide Code: 047501) ACTIVE products with label matches. /SRP: Registered for use in the U.S. but approved pesticide uses may change periodically and so federal, state and local authorities must be consulted for currently approved uses./
[U.S. Environmental Protection Agency/Office of Pesticide Program's Chemical Ingredients Database on Isopropanol (67-63-0). Available from the Database Query page at http://www.cdpr.ca.gov/docs/epa/epamenu.htm as of February 5, 2001.]**PEER REVIEWED**

SYNTHETIC FLAVORING ADJUVANT
[Furia, T.E. (ed.). CRC Handbook of Food Additives. 2nd ed. Cleveland: The Chemical Rubber Co., 1972. 875]**PEER REVIEWED**

USED IN NON-ALCOHOLIC BEVERAGES 25 PPM; CANDY 10-75 PPM; BAKED GOODS 75 PPM.
[Fenaroli's Handbook of Flavor Ingredients. Volume 2. Edited, translated, and revised by T.E. Furia and N. Bellanca. 2nd ed. Cleveland: The Chemical Rubber Co., 1975. 303]**PEER REVIEWED**

Production of isopropyl acetate and herbicidol esters and xanthates
[CONSIDINE. CHEMICAL AND PROCESS TECHNOL ENCYC 1974 p.669]**PEER REVIEWED**

For preserving pathological specimens and for dehydrating tissues; for the preparation of icepacks; solvent in food
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 40]**PEER REVIEWED**

In antifreeze compositions; as solvent for shellac; in quick-drying oils; in quick-drying inks; in denaturing ethyl alcohol; solvent for creosote, in manufacture of glycerol.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 889]**PEER REVIEWED**

Latent solvent for cellulose derivatives, coatings solvent, deicing agent for liquid fuels; lacquers; extraction processes; dehydrating agent; preservative; lotions; denaturant.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 632]**PEER REVIEWED**

Chemical: feedstock in the production of acetone; manufacture of methyl isobutyl ketone, methyl isobutyl carbinol, isopropylamine, and isopropyl acetate.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V20 (1996) 236]**PEER REVIEWED**

Used to prepared hydrogen peroxide by alcohol auto-oxidation process
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V13 (1995) 976]**PEER REVIEWED**

Solvent: oils, gums, waxes, resins, alkaloids, cements, primers, varnishes, paints, printing inks, cosmetics (eg lotions, perfumes, shampoos, skin cleansers, nail polishes, makeup removers, deodorants, body oils, and skin lotions); aerosol formulations (hair sprays, floor detergents, show polishes, insecticides, burn ointments, window cleaners, waxes and polishes, paints, automotive products, insect repellents, flea and tick spray, air refreshers, disinfectants, veterinary wound and pinkeye spray, first-aid spray, foot fungicide, and fabric-wrinkle remover).
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V20 (1996) 236]**PEER REVIEWED**

Medical: anitseptic; disinfectant for home, hospital, and industry; rubbing alcohol; medicinal liniments; tinctures of green soap; scalp tonics; tincture of mercurophen; pharmaceuticals (eg, local abesthetics, tincture of iodine, and bathing solutions for surgical sutures and dressings).
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V20 (1996) 236]**PEER REVIEWED**

Used in gasoline to prevent icing (i.e. depresses the freezing point) of water or surfactants
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V12 (1994) 353]**PEER REVIEWED**

Manufacturers:

Equistar Chemical Company LP, One Houston Center, 1221 McKinney St, Suite 700, Houston TX 77010, (713) 652-7300; Production site: Channelview, TX 77530.
[SRI International. 2000 Directory of Chemical Producers -- United States. SRI Consulting, Menlo Park: CA 2000 694]**PEER REVIEWED**

ExxonMobil Chemical Co, 13501 Katy Freeway, Houston TX 77079, (281) 870-6661; Production site: Baton Rouge, LA 70805.
[SRI International. 2000 Directory of Chemical Producers -- United States. SRI Consulting, Menlo Park: CA 2000 694]**PEER REVIEWED**

Shell Chemical Co, One Shell Plaza, PO Box 2463, Houston TX 77252-2463, (713) 241-6161; Production site: Deer Park, TX 77536.
[SRI International. 2000 Directory of Chemical Producers -- United States. SRI Consulting, Menlo Park: CA 2000 694]**PEER REVIEWED**

Union Carbide Co, 39 Old Ridgebury Rd, Danbury CT 06817-0001, (203) 794-3170; Production site: Texas City, TX 77590.
[SRI International. 2000 Directory of Chemical Producers -- United States. SRI Consulting, Menlo Park: CA 2000 694]**PEER REVIEWED**

Methods of Manufacturing:

Indirect hydration /process/ is based on a two-step reaction of propylene and sulfuric acid; in the first step, mixed sulfate esters, primarily isopropyl hydrogen sulfate, but also diisopropyl sulfate, form; these are then hydrolyzed, forming /**isopropanol**/ and sulfuric acid.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V20 (1996) 223]**PEER REVIEWED**

Acid-catalyzed direct hydration of propylene /has three basic processes of commercial operation which are/: (1) vapor-phase hydration over a fixed-bed catalyst of supported phosphoric acid or silica-supported tungsten oxide with zinc oxide promoter, (2) mixed vapor-liquid-phase hydration at low temperature and high pressure using a strongly acid cation-exchange catalyst, and (3) liquid-phase hydration at high temperature and high pressure in the presence of a soluble tungsten catalyst.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V20 (1996) 227]**PEER REVIEWED**

/Other processes for production of **isopropanol** include:/ liquid phase oxidation of propane; incidentally by the reductive condensation of acetone; fermentation. Large-scale commercial biological production of **isopropanol** from carbohydrate raw materials has also been studied.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V20 (1996) 231]**PEER REVIEWED**

General Manufacturing Information:

Method of purification: rectification.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 632]**PEER REVIEWED**

Formulations/Preparations:

USEPA/OPP Pesticide Code 047501; Trade Names: Arquad DMCB, Component of (with 169108); Vsco 1152, component of (with 107601); **Avantine**; **Isohol**; **Lutosol**; **Petrohol**; Pro.
[U.S. Environmental Protection Agency/Office of Pesticide Program's Chemical Ingredients Database on Isopropanol (67-63-0). Available from the Database Query page at http://www.cdpr.ca.gov/docs/epa/epamenu.htm as of February 5, 2001.]**PEER REVIEWED**

Grades: 91%; 95%; 99%; NF (99%); nanograde.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 632]**PEER REVIEWED**

Grades: Anhydrous (99.8% min **isopropanol**); azeotropic (85% min **isopropanol**); cosmetic (91 vol% and anhydrous) containing perfume; electronic (low conductivity); ACS Reagent; 1990 USP XXII Anhydrous (99.0% **isopropanol**); ASTM D770-85
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V20 (1996) 233]**PEER REVIEWED**

Grades: Technical; semiconductor
[ChemExpo; Chemical Profile: Isopropanol (Dec 28, 1998). Available from database query page at http://www.chemexpo.com/news/profile981228.cfm as of Dec 1, 2000] **PEER REVIEWED**

Isopropyl rubbing alcohol ... contains 68 to 72% v/v of **isopropyl alcohol ... .**
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 40]**PEER REVIEWED**

Avantine ... food grade ... .
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 40]**PEER REVIEWED**

AR, chromAR, SpectrAR
[Kuney, J.H. and J.N. Nullican (eds.) Chemcyclopedia. Washington, DC: American Chemical Society, 1988. 290]**PEER REVIEWED**

Impurities:

Anhydrous: acidity (0.002 wt%); alkalinity (0.0001 meq/l); water (0.1 wt% max).
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V20 (96) 234]**PEER REVIEWED**

Consumption Patterns:

CHEM INTERMED FOR ACETONE, 24%; SOLVENT FOR COATINGS, 15%; SOLVENT FOR INKS & OILS, 11%; PHARMACEUTICAL APPLICATIONS (EG, ANTISEPTIC AND DISINFECTANT, BATHING SOLUTION FOR SUTURES), 11%; COMPONENT OF HOUSEHOLD

PRODUCTS AND COSMETICS, 11%; CHEMICAL PROCESSING SOLVENT, 9%; CHEM INTERMED FOR OTHER CHEMS, 7%; GASOLINE ADDITIVE, 4%; EXPORTS, 8% (1984)
[SRI]**PEER REVIEWED**

CHEMICAL PROFILE: **Isopropanol**. Coating solvent, 18%; processing solvent, 14%; pharmaceuticals, 14%; household and personal products, 14%; acetone, 10%; miscellaneous solvent and chemical intermediate uses, 10%; exports, 20%.
[Kavaler AR; Chemical Marketing Reporter 232 (9): 46 (1987)]**PEER REVIEWED**

CHEMICAL PROFILE: **Isopropanol**. Demand: 1,275 million lb; 1987: 1,325 million lb; 1991 /projected/: 1,400 million lb (Includes exports; in addition, 107 million lb were imported in 1986).
[Kavaler AR; Chemical Marketing Reporter 232 (9): 46 (1987)]**PEER REVIEWED**

Uses in United States (in 1993): chemical intermediates (34%); personal care and household products (24%); coatings and ink solvent (15%); processing solvent (12%); pharmaceuticals (10%); misc (5%).
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V20 (1996) 236]**PEER REVIEWED**

Direct solvent uses(40%); chemical derivatives (27%); acetone(15%); household and personal care products(10%); pharmaceuticals(5%); miscellaneous solvent and chemical intermediate uses(3%).
[ChemExpo; Chemical Profile: Isopropanol (Dec 28, 1998). Available from database query page at http://www.chemexpo.com/news/profile981228.cfm as of Dec 1, 2000]
PEER REVIEWED

U. S. Production:

(1978) 7.85X10+11 G
[SRI]**PEER REVIEWED**

(1982) 6.27X10+11 G
[SRI]**PEER REVIEWED**

(1985) 5.60X10+11 g
[USITC. SYN ORG CHEM-U.S. PROD/SALES 1985 p.266]**PEER REVIEWED**

(1986) 1.27X10+9 lb
[USITC. SYN ORG CHEM-U.S. PROD. PRELIMINARY FEBRUARY 1988 (SERIES C/P-87-5)]**PEER REVIEWED**

(1987) 1.37X10+9 lb
[USITC. SYN ORG CHEM-U.S. PROD/SALES 1987 p.15-5]**PEER REVIEWED**

(1990) 1.38 billion lb
[Chem & Engineering News 70 (15): 17 (4/13/92)]**PEER REVIEWED**

(1991) 1.30 billion lb
[Chem & Engineering News 70 (15): 17 (4/13/92)]**PEER REVIEWED**

Demand: 1.4 billion lbs (in 1997); 1.4 billion lbs (in 1998); 1.45 billion lbs (est in 2002)
[ChemExpo; Chemical Profile: Isopropanol (Dec 28, 1998). Available from database query page at http://www.chemexpo.com/news/profile981228.cfm as of Dec 1, 2000]
PEER REVIEWED

U. S. Imports:

(1978) 1.47X10+10 G
[SRI]**PEER REVIEWED**

(1982) 3.48X10+10 G
[SRI]**PEER REVIEWED**

(1985) 6.18X10+10 g
[BUREAU OF THE CENSUS. US IMPORTS FOR CONSUMPTION AND GENERAL IMPORTS 1985 p.1-581]
PEER REVIEWED

(1986) 1.07X10+8 lb
[BUREAU OF THE CENSUS. US IMPORTS FOR CONSUMPTION AND GENERAL IMPORTS 1986 P.1-527]
PEER REVIEWED

In 1997: 565 million lbs
[ChemExpo; Chemical Profile: Isopropanol (Dec 28, 1998). Available from database query page at http://www.chemexpo.com/news/profile981228.cfm as of Dec 1, 2000]
PEER REVIEWED

U. S. Exports:

(1978) 6.90X10+9 G
[SRI]**PEER REVIEWED**

(1982) 6.40X10+9 G
[SRI]**PEER REVIEWED**

(1985) 8.09X10+10 g
[BUREAU OF THE CENSUS. US EXPORTS, SCHEDULE E, 1985 p.2-74]**PEER REVIEWED**

(1987) 1.44X10+7 lb
[BUREAU OF THE CENSUS. US EXPORTS, SCHEDULE E, DECEMBER 1987, P.2-78]**PEER REVIEWED**

(1988) 3.21X10+7 lb
[BUREAU OF THE CENSUS. US EXPORTS, SCHEDULE E, DECEMBER 1988, P.2-82]**PEER REVIEWED**

In 1996: 115 million lbs
[ChemExpo; Chemical Profile: Isopropanol (Dec 28, 1998). Available from database query page at http://www.chemexpo.com/news/profile981228.cfm as of Dec 1, 2000]
PEER REVIEWED

Laboratory Methods:

Clinical Laboratory Methods:

IDENTIFICATION & QUANTIFICATION OF **ISOPROPANOL** IN BLOOD & URINE BY GAS CHROMATOGRAPHY IS DISCUSSED. SIMPLE MICRO METHOD FOR COLLECTION & STORAGE OF BLOOD FOR ALCOHOL DETERMINATION IS ALSO PRESENTED.
[MANNO BR, MANNO JE; J ANAL TOXICOL 2 (6): 257 (1978)]**PEER REVIEWED**

Biological monitoring of occupational exposure to **isopropanol** vapor by urinalysis for acetone is described. **Isopropanol** and acetone are determined by gas chromatography with FID detector.
[Kawai T et al; Int Arch Occup Environ Health 62: 409-13 (1990)]**PEER REVIEWED**

Analytic Laboratory Methods:

INFRA-RED SPECTROPHOTOMETRY ... USED TO DETERMINE ... ISOPROPYL ALC IN FOODS. (COPPINI D, ALBASINI A; MITT LEBENSMITT HYG (60): 460 (1969)).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 231 (1977)]**PEER REVIEWED**

AOAC Method 942.07. **Isopropanol** in lemon extracts. Titrimetric method. Applicable to lemon extract in absence of acetone.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990 899] **PEER REVIEWED**

A METHOD IS DESCRIBED FOR THE QUANTITATIVE DETERMINATION OF THE RESIDUAL SOLVENT **ISOPROPANOL** IN SOFT DRINKS. THE PROPOSED METHOD IS BASED ON SOLVENT-EXTRACTION TECHNIQUE & QUANTITATIVE DETERMINATION OF THE ALCOHOL BY GAS CHROMATOGRAPHY, USING A GLASS CAPILLARY COLUMN COATED WITH CARBOWAX 20M. THE DETECTION LIMIT FOR **ISOPROPANOL** WAS 0.5 NG WITH 82.5% RECOVERY.
[VAN RILLAER WG, BEERNAERT H; Z LEBENSM-UNTERS -FORSCH 177 (3): 196-9 (1983)]**PEER REVIEWED**

GAS-LIQUID CHROMATOGRAPHIC DETERMINATION OF SOLVENTS IN COMMERCIAL NAIL LACQUER PREPARATION WAS STUDIED.
[STUTSMAN MJ; J ASSOC OFF ANAL CHEM 60 (3): 658-62 (1977)]**PEER REVIEWED**

AOAC Method 935.16. Acetone, other ketones, **isopropanol**, and tertiary butyl alcohol in distilled liquors. Qualitative test.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990 701] **PEER REVIEWED**

AOAC Method 952.07. **Isopropanol** in lemon and orange flavors. Titrimetric method of **isopropanol**. Applicable to lemon and orange flavors in presence of acetone.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990 899] **PEER REVIEWED**

NIOSH Method 1400: Determination of Alcohols by Gas Chromatography, Using a Flame Ionization Detector. Detection limit = 1.000 mg/l.
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

USEPA, Office of Surface Water, Method 8015B: Nonhalogenated Organics Using GC/FID. Detection limit not specified.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

USEPA, Office of Surface Water, Method 8260B: Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique. Detection limit not specified.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

AOAC Method 975.06: Denaturants (Volatile) in Alcoholic Products by Gas Chromatographic Method. Detection limit not specified.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990 232] **PEER REVIEWED**

Sampling Procedures:

NIOSH Method 1400: Determination of Alcohols by Gas Chromatography, Using a Flame Ionization Detector. Calibrate each personal sampling pump with a representative sampler in line. Break the ends of the sampler immediately before sampling and attach the sampler to personal sampling pump with flexible tubing. Sample at a known flow rate between 0.01 and 0.2 l/min for a total sample size of 0.3 to 3 l for **isopropyl alcohol.** Cap the sampler and pack securely for shipment.
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

USEPA, Office of Surface Water, Method 8260B: Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique. Collect water samples in duplicate in 40 ml vials with Teflon lined septum caps. Adjust pH to less than 2 with H2SO4 or HCl. If residual chlorine is present, add 4 drops of 10% sodium thiosulfate solution to 125 ml of sample before transferring to a 40 ml VOA vial.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

Special References:

Synonyms and Identifiers:

Synonyms:

AI3-01636
PEER REVIEWED

ALCOOL ISOPROPILICO (ITALIAN)
PEER REVIEWED

ALCOOL ISOPROPYLIQUE (FRENCH)
PEER REVIEWED

AVANTINE
PEER REVIEWED

Caswell No 507
PEER REVIEWED

(Component of) Hibistat
PEER REVIEWED

DIMETHYLCARBINOL
PEER REVIEWED

Pesticide Code: 047501
PEER REVIEWED

EPA Pesticide Chemical Code 047501
PEER REVIEWED

FEMA NUMBER 2929
PEER REVIEWED

IMSOL A
PEER REVIEWED

IPA
PEER REVIEWED

ISOHOL
PEER REVIEWED

ISOPROPYL ALCOHOL
PEER REVIEWED

ISO-PROPYLALKOHOL (GERMAN)
PEER REVIEWED

LUTOSOL
PEER REVIEWED

PETROHOL
PEER REVIEWED

PRO
PEER REVIEWED

n-Propan-2-ol
PEER REVIEWED

PROPAN-2-OL
PEER REVIEWED

I-PROPANOL (GERMAN)
PEER REVIEWED

i-Propyl alcohol
PEER REVIEWED

SEC-PROPYL ALCOHOL

PEER REVIEWED

I-PROPYLALKOHOL (GERMAN)
PEER REVIEWED

SECONDARY PROPYL ALCOHOL
PEER REVIEWED

Visco 1152
PEER REVIEWED

Formulations/Preparations:

USEPA/OPP Pesticide Code 047501; Trade Names: Arquad DMCB, Component of (with 169108); Vsco 1152, component of (with 107601); **Avantine**; **Isohol**; **Lutosol**; **Petrohol**; Pro.
[U.S. Environmental Protection Agency/Office of Pesticide Program's Chemical Ingredients Database on Isopropanol (67-63-0). Available from the Database Query page at http://www.cdpr.ca.gov/docs/epa/epamenu.htm as of February 5, 2001.]**PEER REVIEWED**

Grades: 91%; 95%; 99%; NF (99%); nanograde.
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Grades: Anhydrous (99.8% min **isopropanol**); azeotropic (85% min **isopropanol**); cosmetic (91 vol% and anhydrous) containing perfume; electronic (low conductivity); ACS Reagent; 1990 USP XXII Anhydrous (99.0% **isopropanol**); ASTM D770-85
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V20 (1996) 233]**PEER REVIEWED**

Grades: Technical; semiconductor
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Isopropyl rubbing alcohol ... contains 68 to 72% v/v of **isopropyl alcohol ... .**
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 40]**PEER REVIEWED**

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AR, chromAR, SpectrAR
[Kuney, J.H. and J.N. Nullican (eds.) Chemcyclopedia. Washington, DC: American Chemical Society, 1988. 290]**PEER REVIEWED**

Shipping Name/ Number DOT/UN/NA/IMO:

UN 1219; **Isopropanol**

UN 1219; **Isopropyl alcohol**

IMO 3.2; **Isopropanol**

Standard Transportation Number:

49 092 05; **Isopropanol**

Administrative Information:

Hazardous Substances Databank Number: 116

Last Revision Date: 20030305

Last Review Date: Reviewed by SRP on 5/10/2001

Update History:

Complete Update on 03/05/2003, 1 field added/edited/deleted.
Field Update on 02/14/2003, 1 field added/edited/deleted.
Complete Update on 10/16/2002, 3 fields added/edited/deleted.
Complete Update on 10/10/2001, 87 fields added/edited/deleted.
Field Update on 08/08/2001, 1 field added/edited/deleted.
Field Update on 05/16/2001, 1 field added/edited/deleted.
Field Update on 05/15/2001, 1 field added/edited/deleted.
Field Update on 02/09/2001, 2 fields added/edited/deleted.
Complete Update on 02/02/2000, 1 field added/edited/deleted.
Complete Update on 01/11/2000, 7 fields added/edited/deleted.
Field Update on 11/16/1999, 1 field added/edited/deleted.
Field Update on 09/21/1999, 1 field added/edited/deleted.
Complete Update on 06/03/1999, 1 field added/edited/deleted.
Complete Update on 01/20/1999, 2 fields added/edited/deleted.
Complete Update on 11/16/1998, 1 field added/edited/deleted.
Complete Update on 11/12/1998, 1 field added/edited/deleted.
Complete Update on 09/11/1998, 1 field added/edited/deleted.
Complete Update on 06/02/1998, 1 field added/edited/deleted.
Complete Update on 02/25/1998, 1 field added/edited/deleted.
Complete Update on 10/17/1997, 1 field added/edited/deleted.
Complete Update on 03/27/1997, 2 fields added/edited/deleted.
Complete Update on 03/11/1997, 3 fields added/edited/deleted.
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Complete Update on 06/03/1996, 1 field added/edited/deleted.
Complete Update on 04/16/1996, 8 fields added/edited/deleted.
Field Update on 01/18/1996, 1 field added/edited/deleted.
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Complete Update on 08/04/1993, 1 field added/edited/deleted.
Field update on 12/11/1992, 1 field added/edited/deleted.
Complete Update on 05/29/1992, 1 field added/edited/deleted.
Complete Update on 04/27/1992, 1 field added/edited/deleted.
Complete Update on 01/23/1992, 1 field added/edited/deleted.
Complete Update on 09/13/1990, 100 fields added/edited/deleted.
Field Update on 05/04/1990, 1 field added/edited/deleted.
Field Update on 01/15/1990, 1 field added/edited/deleted.
Complete Update on 01/11/1990, 98 fields added/edited/deleted.
Complete Update on 01/06/1987

Record Length: 179217

Scorecard

Home
Find Your Community
What's New
Setting Priorities
Pollution Locator
Pollution Rankings
About the Chemicals
Health Effects
Regulatory Controls
Discussion Forums
FAQs
Personalize Scorecard
Glossary
About the Scorecard
Search Scorecard

Go

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SEND TO A FRIEND

Chemical: BETA-ENDOSULFAN
CAS Number: 33213-65-9

Chemical Profile for BETA-ENDOSULFAN (CAS Number: 33213-65-9)

- Human Health Hazards
- Hazard Rankings
- Chemical Use Profile
- Rank Chemicals by Reported Environmental Releases in the United States
- Regulatory Coverage
- Basic Testing to Identify Chemical Hazards
- Information Needed for Safety Assessment
- Links

Human Health Hazards

Health Hazard		Reference(s)
Recognized:	--	
Suspected:	Endocrine Toxicant	IL-EPA

[top]

Hazard Rankings

More hazardous than most chemicals in 2 out of 4 ranking systems.
Ranked as one of the most haza

[top]

Chemical Use Profile

No data on industrial or consumer use in Scorecard.

[top]

- **Rank Chemicals by Reported Environmental Releases in the United States**

No data on environmental releases in Scorecard.

[top]

- **Regulatory Coverage**

On at least 2 federal regulatory lists.

[top]

- **Basic Testing to Identify Chemical Hazards**

Information on whether basic tests to identify chemical hazards have been conducted on this chemical is not available in US EPA's 1998 hazard data availability study.

[top]

- **Information Needed for Safety Assessment**

Lacks at least some of the data required for safety assessment. See risk assessment data for this chemical from U.S. EPA or Scorecard.

[top]

- **Links**

Other web sites specific to this chemical:

- National Toxicology Program Health and Safety Information Sheet

If none of these sources meet your needs, you can try searching some other chemical database Web sites.

[top]

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Health Effects
Regulatory Controls
Discussion Forums
FAQs
Personalize Scorecard
Glossary
About the Scorecard
Search Scorecard
Go
Search Tips
SEND TO A FRIEND

e
ENVIRONMENTAL DEFENSE
finding the ways that work

Endocrine Toxicity Definition

Endocrine toxicity is defined as adverse effects on the structure and /or functioning of the endocrine system that result from exposure to chemical substances. The endocrine system is composed of many organs and glands that secrete hormones directly into the bloodstream, including the pituitary, hypothalamus, thyroid, adrenals, pancreas, thymus, ovaries, and testes. Once synthesized, hormones are conveyed to a target tissue, where they function as chemical messengers that transmit information between cells. Hormone levels and interactions control normal physiological processes, maintaining the bodyÂ's homeostasis. Because the endocrine system is complex, a toxicant may interfere at any of a number of points along a hormoneÂ's pathway of production, regulation, and action. Some chemicals may injure the glands that synthesize and secrete hormones, while others disrupt hormonal actions at the target organ. Compounds that are toxic to the endocrine system may cause diseases such as hypothyroidism, diabetes mellitus, hypoglycemia, reproductive disorders, and cancer.

A wide variety of toxic substances can disrupt the function of the endocrine system. For example, chemicals that resemble the hormone estrogen can bind to estrogen receptors located throughout the body and either mimic the natural hormone or inhibit its actions. Exposure to endocrine-disrupting chemicals such as polychlorinated biphenyls (PCBs) and DDT have caused a host of toxic effects in wildlife, including impaired reproduction and development. Other endocrine toxicants, such as persistent organochlorine pesticides and dioxins, are being studied for their possible role in promoting hormone- induced cancers (such as breast cancer) and in lowering sperm counts and male fertility.

Specific organs and glands in the endocrine system are known to be damaged by chemical toxicants. Several chemicals and drugs can be toxic to the cells of the pancreas that produce insulin. Exposure to the rodenticide Vacor (N-3-pyridylmethyl-NÂ'-p-nitrophenyl urea) can interfere with the secretion and function of pancreatic hormones, resulting in diabetes mellitus and hyperglycemia. Polyhydroxyphenols and the therapeutic drug lithium can disrupt thyroid gland function and cause hypothyroidism and goiter. Endocrine and reproductive dysfunction have been reported in men exposed to inorganic lead. Chronic exposure to lead can cause direct testicular toxicity, followed by hypothalamic or pituitary gland disturbances.

For further general information on chemicals and endocrine toxicity, see the following references:

Barsano, C. P., and J. Thomas. Endocrine Disorders of Occupational and Environmental Origin. *Occupational Medicine*. 7:3 479-502. 1992.

Birnbaum, L. S. Developmental Effects of Dioxins and Related Endocrine

Disrupting Chemicals. *Toxicology Letters*. 82/83: 743-750. 1995.

Colborn, T., and C. Clement, eds. *Chemically-Induced Alterations in Sexual and Functional Development: The Wildlife/Human Connection*. Advances in Modern Environmental Toxicology, vol. 21. Princeton, N.J.: Princeton Scientific Publishing, 1992.

Damstra, T., S. Barlow, A. Bergman, R. Kavlock and G. Van Der Kraak (eds). *Global Assessment of the State-of-the-Science of Endocrine Disruptors*. International Programme On Chemical Safety, 2002. http://ehp.niehs.nih.gov/who/.

Eubanks, M.W. *Hormones and Health*. Environmental Health Perspectives Volume 105, Number 5, May 1997. http://ehpnet1.niehs.nih.gov/qa/105-5focus/focus.html.

National Research Council, Committee on Hormonally Active Agents in the Environment. *Hormonally Active Agents in the Environment* . Washington, DC: National Academy Press, 2000.http://www.nap.edu/books/0309064198/html/.

US Environmental Protection Agency Risk Assessment Forum. *Special Report on Environmental Endocrine Disruption: An Effects Assessment and Analysis*. 1997. http://www.epa.gov/ORD/WebPubs/endocrine/

More

- references used to compile the list of endocrine toxicants
- list of endocrine toxicants

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Home
Find Your Community
What's New
Setting Priorities
Pollution Locator
Pollution Rankings
About the Chemicals
Health Effects
Regulatory Controls
Discussion Forums
FAQs
Personalize Scorecard
Glossary
About the Scorecard
Search Scorecard

Go

Search Tips

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ABOUT THE CHEMICALS|Hazard Rankings

Chemical: BETA-ENDOSULFAN
CAS Number: 33213-65-9

	Least Hazardous / Percentile 25% 50% 75%
Human Health Rankings	
Toxicity and exposure potential	
Worker Exposure Hazard Score (IRCH)	
Ecological Health Rankings	
Toxicity and persistence	
Environmental Hazard Value Score (IRCH)	
Ecological Risk Screening Score (WMPT)	
Integrated Environmental Rankings	
Combined human and ecological scores	
Total Hazard Value Score (IRCH)	

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Scorecard
Home
Find Your Community
What's New
Setting Priorities
Pollution Locator
Pollution Rankings
About the Chemicals
Health Effects
Regulatory Controls
Discussion Forums
FAQs
Personalize Scorecard
Glossary
About the Scorecard
Search Scorecard
Go
Search Tips
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ABOUT THE CHEMICALS|Scorecard Risk Characterization Data

e ENVIRONMENTAL DEFENSE finding the ways that work

Chemical: BETA-ENDOSULFAN
CAS Number: 33213-65-9

Risk Assessment Values or Standards

	Value	Units	Reference
Inhalation cancer risk value (potency)	Not a recognized or suspect carcinogen		
Inhalation noncancer risk value (reference concentration)	Data gap		
National ambient air quality standard	Gap in regulatory coverage		
Ingestion cancer risk value (potency)	Not a recognized or suspect carcinogen		
Ingestion noncancer risk value (reference dose)	Data gap		
National water quality standard	62	ug/L	CWA-AWQC

See the data US EPA possesses for safety assessment.

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Scorecard

Home
Find Your Community
What's New
Setting Priorities
Pollution Locator
Pollution Rankings
About the Chemicals
Health Effects
Regulatory Controls
Discussion Forums
FAQs
Personalize Scorecard
Glossary
About the Scorecard
Search Scorecard

Go

Search Tips

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ABOUT THE CHEMICALS|Regulatory Coverage

Chemical: BETA-ENDOSULFAN
CAS Number: 33213-65-9

Federal Regulatory Program Lists

Hazardous Substances (Superfund)
Priority Pollutants (Clean Water Act)

Environmental Hazard Lists

Persistent, Bioaccumulative, and Toxic Chemicals (U.S. Environmental Protection Agency)

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CONTENTS
1.1 What is endosulfan?
1.2 How might I be exposed to endosulfan?
1.3 How can endosulfan enter and leave my body?
1.4 How can endosulfan affect my health?
1.5 Is there a medical test to determine whether I have been exposed to endosulfan?
1.6 What recommendations has the federal government made to protect human health?
1.7 Where can I get more information?
References

RELATED RESOURCES
ToxFAQ™ 46k
ToxFAQ™ en Español 28k
Public Health Statement 126k
Toxicological Profile 2.6MB

A-Z INDEX
A B C D E
F G H I J K
L M N O P
Q R S T U
V W X Y Z

ATSDR RESOURCES
ToxFAQs™
ToxFAQs™ en Español
Public Health Statements
Toxicological Profiles
Minimum Risk Levels
MMGs
MHMIs
Interaction Profiles
Priority List of Hazardous Substances
Division of Toxicology

April 1993

Public Health Statement for Endosulfan

CAS# 33213-65-9

This Public Health Statement is the summary chapter from the Toxicological Profile for endosulfan. It is one in a series of Public Health Statements about hazardous substances and their health effects. A shorter version, the ToxFAQs™, is also available. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. For more information, call the ATSDR Information Center at 1-888-422-8737.

This Statement was prepared to give you information about endosulfan and to emphasize the human health effects that may result from exposure to it. The Environmental Protection Agency (EPA) has identified 1,177 sites on its National Priorities List (NPL). Endosulfan and/or endosulfan sulfate (a major breakdown product) has been found at 17 of these sites. However, we do not know how many of the 1,177 NPL sites have been evaluated for endosulfan or endosulfan sulfate. As EPA evaluates more sites, the number of sites at which endosulfan or endosulfan sulfate is found may change. The information is important for you, because endosulfan may cause harmful health effects and because these sites are potential or actual sources of human exposure to endosulfan.

When a chemical is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment as a chemical emission. This emission, which is also called a release, does not always lead to exposure. You can be exposed to a chemical only when you come into contact with the chemical. You may be exposed to it in the environment by breathing, eating, or drinking substances containing the chemical or from skin contact with it.

If you are exposed to a hazardous substance such as endosulfan, several factors will determine whether harmful health effects will occur and what the type and severity of those health effects will be. These factors include the dose (how much), the duration (how

long), the route or pathway by which you are exposed (breathing, eating, drinking, or skin contact), the other chemicals to which you are exposed, and your individual characteristics such as age, sex, nutritional status, family traits, life style, and state of health.

1.1 What is endosulfan?

Endosulfan is a man-made insecticide. It is used for control of a number of insects on food crops such as grains, tea, fruits, and vegetables and on nonfood crops such as tobacco and cotton. It is also used as a wood preservative.

Endosulfan is sold as a mixture of two different forms of the same chemical (referred to as alpha- and beta-endosulfan). It is a cream-to-brown-colored solid that may appear crystalline or be in flakes. It has a distinct odor similar to turpentine. Endosulfan does not burn.

Endosulfan enters air, water, and soil when it is manufactured or used as a pesticide. Endosulfan is often applied to crops using sprayers. Some endosulfan in the air may travel long distances before it lands on crops, soil, or water. Endosulfan on crops usually breaks down within a few weeks. Endosulfan released to soil attaches to soil particles. Endosulfan found near hazardous waste sites is usually found in soil. Some endosulfan in soil evaporates into air, and some endosulfan in soil breaks down. However, it may stay in soil for several years before it all breaks down. Rain water can wash endosulfan that is attached to soil particles into surface water. Endosulfan does not dissolve easily in water. Most endosulfan in surface water is attached to soil particles floating in the water or attached to soil at the bottom. The small amounts of endosulfan that dissolve in water break down over time. Depending on the conditions in the water, endosulfan may break down within 1 day or it may take several months. Some endosulfan in surface water evaporates into air and breaks down. Because it does not dissolve easily in water, only very small amounts of endosulfan are found in groundwater (water below the soil surface; for example, well water). Animals that live in endosulfan-contaminated waters can build up endosulfan in their bodies. The amount of endosulfan in their bodies may be several times greater than in the surrounding water.

back to top

1.2 How might I be exposed to endosulfan?

The most likely way for people to be exposed to endosulfan is by eating food contaminated with it. Endosulfan has been found in some food products such as oils and fats and fruit and vegetable products. You can also be exposed to low levels of endosulfan by skin contact with contaminated soil or by smoking cigarettes made from tobacco that has endosulfan residues on it. Well water and public water supplies are not likely sources of exposure to endosulfan. Workers can breathe in the chemical when spraying

the insecticide on crops. Accidental spills and releases to the environment at hazardous waste disposal sites are also possible sources of exposure to endosulfan. The most likely exposure to endosulfan for people living near hazardous waste sites is through contact with soils containing it.

Endosulfan is usually not found in the air, and it is infrequently found in soil and water. When endosulfan is found in soil and water, levels of less than 1 part of endosulfan in 1 billion parts of surface water (ppb) and less than 1 part of endosulfan in 1 million parts of soil (ppm) have been reported.

back to top

1.3 How can endosulfan enter and leave my body?

Endosulfan can enter your body through your lungs when you breathe air containing it, through your stomach and intestines when you eat food or drink water containing it, or through your skin. We have no information on how fast it enters the body tissues when it is breathed in. However, studies in animals show that endosulfan passes slowly through the stomach into the body tissues after it is taken in by mouth. Much of it leaves in the feces without actually entering the body tissues. Studies in animals also show that when endosulfan is applied to the skin it passes slowly through the skin into body tissues. Once endosulfan is in the body, it is broken down in the liver and kidneys and leaves in the urine and feces within a few days or a few weeks.

back to top

1.4 How can endosulfan affect my health?

Symptoms of endosulfan poisoning have been seen in some people who were exposed to very large amounts of this pesticide during its manufacture. Symptoms of endosulfan poisoning have also been seen in people who intentionally or accidentally ate or drank large amounts of endosulfan. Most of these people experienced convulsions or other nervous system effects. Some people who intentionally ate or drank large amounts of endosulfan died. The health effects in people exposed to smaller amounts of endosulfan for longer periods are not known. We have no information on whether it affects the ability of people to have children or whether it causes birth defects in children. We also do not know whether endosulfan has ever affected the ability of people to fight disease or has ever caused cancer in people. The Department of Health and Human Services (National Toxicology Program), the International Agency for Research on Cancer, and EPA have not classified endosulfan as to its carcinogenicity.

Results from animal studies show that exposure to very large amounts of endosulfan for short periods of time can cause adverse nervous system effects (such as hyperexcitability, tremors, and convulsions) and death. Because the brain controls the activity of the lungs and heart, lethal or near lethal exposures in animals have

also resulted in failure of these organs. Other effects seen in animals after short-term, high-level exposures include harmful effects on the stomach, blood, liver, and kidney. After somewhat longer exposures, the ability of animals to fight infection was also impaired. The kidney, testes, and possibly the liver are the only organs in laboratory animals affected by longer-term exposure to low levels of endosulfan. The seriousness of these effects is increased when animals are exposed to higher concentrations of endosulfan.

Studies in animals show no evidence that endosulfan causes cancer in animals. Studies in animals also show no evidence that endosulfan affects the ability of animals to have babies. Some studies show that large amounts of endosulfan damage the testes, but it is unknown whether such large amounts affect the ability of animals to reproduce. Pregnant animals given endosulfan by mouth had some offspring with low birth weight and length and some offspring with skeletal variations. In some cases, the pregnancies were terminated at an early stage. Often, these effects were seen at doses where the pregnant animals showed signs of poisoning by the endosulfan. Because these effects occurred in animals, they might also occur in humans.

back to top

1.5 Is there a medical test to determine whether I have been exposed to endosulfan?

Endosulfan and its breakdown products can be measured in your blood, urine, and body tissues if you have been exposed to a large amount. Tests to measure endosulfan in such bodily tissues or fluids are not usually available at a doctor's office because special equipment is needed for measuring endosulfan and its breakdown products. However, a sample taken in the doctor's office can be properly packed and shipped to a special laboratory if necessary. Because endosulfan leaves the body fairly quickly, these methods are useful only for finding exposures that have occurred within the last few days. At this time, these methods can only be used to prove that a person has been exposed to endosulfan. The test results cannot be used to predict if you will have any adverse health effects. Exposure at the same time to other chemicals at hazardous waste sites could cause some confusion in understanding these results.

back to top

1.6 What recommendations has the federal government made to protect human health?

The federal government has set standards and guidelines to protect people from the possible health effects of endosulfan in drinking water and food. EPA recommends that the amount of endosulfan in lakes, rivers, and streams should not be more than 74 micrograms per liter (µg/L) (74 ppb). This should prevent any harmful health effects from occurring in people who drink the

water or eat fish or seafood that live in the water. The Food and Drug Administration (FDA) allows no more than 24 ppm of endosulfan on dried tea, and EPA allows no more than 0.1–2.0 ppm endosulfan on other raw agricultural products.

The Occupational Safety and Health Administration (OSHA) has set a limit (permissible exposure limit, or PEL) of 0.1 milligrams (mg) endosulfan per cubic meter (m^3) of workroom air to protect workers during an 8-hour shift over a 40-hour work week.

back to top

1.7 Where can I get more information?

If you have any more questions or concerns, please contact your community or state health or environmental quality department or:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop E-29
Atlanta, GA 30333

Information line and technical assistance:

Phone: 888-422-8737
FAX: (404)498-0093

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

To order toxicological profiles, contact:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone: 800-553-6847 or 703-605-6000

back to top

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1993. Toxicological profile for endosulfan. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

back to top

ATSDR Information Center / ATSDRIC@cdc.gov / 1-888-422-8737

This page was updated on Tuesday, September 16, 2003

ATSDR Home | Search | Index | Glossary | Contact Us
About ATSDR | News Archive | ToxFAQs | HazDat | Public Health Assessments
Privacy Policy | External Links Disclaimer | Accessibility
U.S. Department of Health and Human Services

DELTA-HEXACHLOROCYCLOHEXANE

CASRN: 319-86-8

For other data, click on the Table of Contents

Human Health Effects:

Evidence for Carcinogenicity:

CLASSIFICATION: D; not classifiable as to human carcinogenicity. HUMAN CARCINOGENICITY DATA: None.
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on delta-Hexachlorocyclohexane (delta-HCH) (319-86-8) Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000] **PEER REVIEWED**

Human Toxicity Excerpts:

In a cross-sectional study serum hexachlorocyclohexane (HCH) residues were studied in 64 employees of a pesticide manufacturing plant in India. The control group was made up of 14 workers with no occupational exposure to HCH. No quantitative information is provided on exposure levels. Duration of exposure ranged from 0-30 yr. Serum HCH concentrations were estimated by quantifying alpha, beta, gamma, and delta isomers with gas-liquid chromatography (GLC). The range of total HCH residues in the sera studied was 0.143-1.152 ppm. Total HCH residue levels and also the values for the alpha, beta, and gamma isomers in the exposed group were significantly higher than the respective values in the controls ($p<0.01$). Maintenance workers had mean serum levels 3 times higher than controls (0.1436 ppm versus 0.0514 ppm controls). Mean HCH serum levels were 5 times higher than controls in plant operators and supervisors (0.2656 ppm versus 0.0154 ppm controls). The maximum concentration of total serum HCH was obtained in those directly handling and packing the insecticide. The mean serum HCH level (0.6040 ppm) in this group was 12 times that of the controls. "The serum levels of the insecticides were clearly related to the workers' job-related close contact, intensity, frequency, and the duration of their exposure."
[Nigam SK et al; Int Arch Occup Environ Health 57: 315-20 (1986)]**PEER REVIEWED**

alpha-, gamma- and delta-Hexachlorocyclohexane (HCCH), but not the beta-isomer, are shown to be potent stimuli for the production of superoxide anion (O2-) and the release of calcium in human polymorphonuclear leukocytes.
[Kuhns DB et al; Blood 68 (2): 535-40 (1986)]**PEER REVIEWED**

Drug Warnings:

Food and Environmental Agents: Effect on Breast-Feeding: Benzenehexachlorides: None. /from Table 7/
[Report of the American Academy of Pediatrics Committee on Drugs in Pediatrics 93 (1): 142 (1994)]**PEER REVIEWED**

Medical Surveillance:

A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at an increased risk from exposure. Examination of the eyes, central nervous system, blood, liver, and kidneys should be stressed. The skin should be examined for evidence of chronic disorders. Lindane may cause aplastic anemia; a complete blood count should be performed,

including a red cell count, a white cell count, and a differential count of a stained smear, as well as a hemoglobin and hematocrit. The concentration of lindane in the blood is an indication of the extent of absorption. ... Medical examinations should be repeated on an annual basis. /Lindane/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1] **PEER REVIEWED**

SERUM OR PLASMA: The assessment of HCH exposure can be accomplished through measurement of the individual HCH isomer. The level of gamma-HCH is considered only to reflect recent exposure. Limited information was located which demonstrated a correlation between gamma-HCH serum levels and the onset of adverse health effects. Beta-HCH levels, however, have been shown to reflect both intensity and duration of exposure and can be used to assess past or recent exposure. Reference Ranges: Normal - **delta-HCH:** none detected; Exposed - BAT (gamma-HCH) (sampling time is end of exposure or end of shift): 25 ug/l. Levels of beta-HCH have been found to increase approximately 10 ug/l for each year of exposure to beta-HCH air concentrations ranging from 0.001 to 0.38 mg/cu m; Toxic - Not established. /Hexachlorocyclohexane/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1455]**PEER REVIEWED**

URINE: The assessment of HCH exposure can be accomplished through measurement of the phenolic metabolites of gamma-HCH, including pentachlorophenol. However, exposure to chlorobenzene can result in the appearance of some of the same metabolites as those seen with HCH exposure. In addition, detection of pentachlorophenol in the urine may also be an indication of exposure to pentachlorophenol or other compounds that are similar to gamma-HCH. Reference Ranges: Normal - not established; Exposed - not established; Toxic - not established. /Hexachlorocyclohexane/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1455]**PEER REVIEWED**

OTHER TISSUES: The assessment of HCH exposure can be accomplished through measurement of the HCH isomers in adipose tissue. This test may be useful for identification of exposure, but it has not been shown to be useful for predicting adverse health effects. ... /Hexachlorocyclohexane/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1456]**PEER REVIEWED**

Populations at Special Risk:

Preclude from exposure individuals with liver, or kidney /diseases/. /Lindane/
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 302]**PEER REVIEWED**

Formulators, distributors ... and agricultural workers. /Lindane/
[USEPA; Ambient Water Quality Criteria Doc: Hexachlorocyclohexane p.C-36 (1980) EPA 440/5-80-054]**PEER REVIEWED**

Probable Routes of Human Exposure:

Dermal /exposure/ and inhalation. /Hexachlorocyclohexane isomers/
[USEPA; Ambient Water Quality Criteria Doc: Hexachlorocyclohexane p.C-34 (1980) EPA 440/5-80-054]**PEER REVIEWED**

Occupational exposure to delta-hexachlorocyclohexane may occur through inhalation and dermal contact with this compound at workplaces where technical grade BHC is still produced or used(SRC).

delta-Hexachlorocyclohexane was detected at a mean concn of 2.37 ug/l (range: 0-34.09 ug/l) in the blood of occupationally exposed individuals in India who were employed in pesticide spraying operations(1). The general population may be exposed to delta-hexachlorocyclohexane through the ingestion of food that contains this compound(SRC).
[(1) Dua VK et al; Bull Environ Contam Toxicol 56: 50-57 (1996)]**PEER REVIEWED**

Body Burden:

In a 1970 survey of pesticide residues in the adipose tissue of general population of US, mean levels of ... **delta-HCH ...** were 0.01 mg/kg.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 207 (1979)]**PEER REVIEWED**

Gas chromatographic detection of blood levels of organochlorine pesticides in /individuals/ of Southern Nigeria is described. Among the compounds detected and quantified were the HCH-isomers, DDT and its metabolites and dieldrin, the major pollutants being DDT, DDE and the HCH-isomers. **Delta-HCH,** HCB and endrin were also detected in a few samples. Total DDT (DDT + DDE + DDD) ranged from 0.04-7.24 ppm, total HCH (alpha + beta + gamma) 0.08-5.64 ppm, and dieldrin 0.03-0.28 ppm.
[Atuma SS; Toxicol Environ Chem 10 (2): 77-82 (1985)]**PEER REVIEWED**

The residues of BHC isomers were /detected/ in 52 autopsy samples of human adipose tissue collected in the Skierniewice province during 1979. The mean beta-BHC content was 0.35 mg/kg on a lipid weight basis, followed by gamma-BHC 0.024 and alpha-BHC 0.0016. Delta-BHC was absent. The mean total BHC content was 0.37 mg/kg. Beta-, gamma-, alpha-, and delta-BHC were detectable in 100.0, 96.2, 30.8, and 0.0% of the samples analyzed, respectively. A comparison is made with the results of BHC residues detected in human fat /samples/ from other countries.
[Falandysz J et al; Farm Pol 40 (6): 325-8 (1984)]**PEER REVIEWED**

At the Institute of Hygiene of the Federal Dairy Research Center /during/ the years 1981 to 1985 in total of 2,624 samples of human milk were examined for ... residues of organochlorine compounds. The results /indicated/ that the residues did not change considerably in a qualitative /manner/. Concerning quantity, however, a distinct trend downwards could be stated. ...
[Hahne KH et al; Milchwissenschaft 41 (5): 269-72 (1986)]**PEER REVIEWED**

delta-Hexachlorocyclohexane was detected in maternal serum at a mean concn of 0.003 mg/l and infant serum at a concn of 0.001 mg/l in India(1). delta-Hexachlorocyclohexane was detected in human adipose tissue in the general population of the US and northeastern population of the US at avg concns of 0.02 ppm in 1970(2). delta-Hexachlorocyclohexane was detected in human adipose tissue in Italy at an avg concn of 0.007 ppm in 1973-1974 and in Japan at an avg concn of 7.46 ppm in 1974(2). The mean concn of delta-hexachlorocyclohexane in the blood of the general population of India was 0.13 ug/l(3). delta-Hexachlorocyclohexane was detected in human adipose tissue from the general population of Gdansk, Poland at concns of 0.54-2.8 ng/g(4). delta-Hexachlorocyclohexane was detected in human milk from Spain at a mean concn of 92 ug/l(5).
[(1) Nair A et al; Bull Environ Contam Toxicol 56: 58-64 (1996) (2) Kutz FW et al; Rev Environ Contam Toxicol 120: 1-83 (1991) (3) Dua VK et al; Bull Environ Contam Toxicol 60: 238-44 (1998) (4) Tanabe S et al; Environ Pollut 79: 45-49 (1993) (5) Pico Y et al; J Agric Food Chem 43: 1610-15 (1995)]**PEER REVIEWED**

Average Daily Intake:

The AVDI of delta-hexachlorocyclohexane in Osaka, Japan was reported as 0.01 ug from 1977-1985(1).

[(1) Matsumoto H et al; Bull Environ Contam Toxicol 38: 954-58 (1987)]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** LINDANE ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

```
0.2.1 SUMMARY OF EXPOSURE
 0.2.1.1 ACUTE EXPOSURE
   A.  WITH POISONING/EXPOSURE
    1.  The primary target organ is the central nervous
        system.  CNS excitation and seizures may occur.  Other
        effects may include headache, agitation, ataxia,
        nausea, vomiting, dizziness, tremor, diarrhea,
        weakness, cyanosis, dyspnea, circulatory collapse,
        respiratory depression, and coma.  Pulmonary edema has
        been reported.  Blood dyscrasias, primarily aplastic
        anemia, may occur with chronic exposure.
    2.  Poisoning may occur by ingestion, inhalation, or
        percutaneous absorption.  Topical use may cause local
        tissue reactions.  Vapors may irritate eyes, nose and
        throat.
   B.  ANIMAL STUDIES - Liver and kidney damage have occurred
       in experimental animals.
0.2.3 VITAL SIGNS
 0.2.3.1 ACUTE EXPOSURE
   A.  WITH POISONING/EXPOSURE
    1.  Hyperthermia and respiratory depression may occur with
        prolonged seizures.  Hypotension may occur with severe
        poisoning.
0.2.4 HEENT
 0.2.4.1 ACUTE EXPOSURE
   A.  WITH POISONING/EXPOSURE
    1.  Lindane can irritate the eyes, nose, and throat.
0.2.5 CARDIOVASCULAR
 0.2.5.1 ACUTE EXPOSURE
   A.  WITH POISONING/EXPOSURE
    1.  Cardiac dysrhythmias can occur from increased cardiac
        irritability.
0.2.6 RESPIRATORY
 0.2.6.1 ACUTE EXPOSURE
```

A. WITH POISONING/EXPOSURE
1. Aspiration of insecticides containing petroleum distillates may result in chemical pneumonitis. Irritation, reduced gas exchange, cyanosis, dyspnea, chemical pneumonitis, and pulmonary edema may occur.

0.2.7 NEUROLOGIC

0.2.7.1 ACUTE EXPOSURE
A. WITH POISONING/EXPOSURE
1. Central nervous system excitation, agitation, nervousness, tremor, seizures, sensory disturbances, and peripheral neuropathy may occur.

0.2.7.2 CHRONIC EXPOSURE
A. WITH POISONING/EXPOSURE
1. EEG changes have been reported in persons occupationally exposed to lindane.

0.2.8 GASTROINTESTINAL

0.2.8.1 ACUTE EXPOSURE
A. WITH POISONING/EXPOSURE
1. Nausea, vomiting, diarrhea, hypersalivation, and pancreatitis may occur following ingestion.

0.2.9 HEPATIC

0.2.9.1 ACUTE EXPOSURE
A. WITH POISONING/EXPOSURE
1. Hepatic oxidative enzymes are induced by lindane.

0.2.9.2 CHRONIC EXPOSURE
A. WITH POISONING/EXPOSURE
1. Hepatomegaly commonly occurs.
B. ANIMAL STUDIES - Liver cell changes were seen in rats exposed to low levels of lindane.

0.2.10 GENITOURINARY

0.2.10.1 ACUTE EXPOSURE
A. WITH POISONING/EXPOSURE
1. Renal insufficiency and myoglobinuria secondary to rhabdomyolysis associated with prolonged seizures have been described.

0.2.11 ACID-BASE

0.2.11.1 ACUTE EXPOSURE
A. WITH POISONING/EXPOSURE
1. Severe metabolic acidosis may be a consequence of seizures, and an immediate cause of death.

0.2.13 HEMATOLOGIC

0.2.13.1 ACUTE EXPOSURE
A. WITH POISONING/EXPOSURE
1. Lindane has been associated, in several anecdotal reports, with aplastic anemia. All these cases except one have involved concentrations of benzene hexachloride that exceed 1 percent and, in most cases, there is evidence of repeated exposure to these compounds.
2. Mixed porphyria symptoms have been reported following ingestions of hexachlorobenzene.

0.2.13.2 CHRONIC EXPOSURE
A. WITH POISONING/EXPOSURE
1. Aplastic anemia has been reported with repeated exposures to lindane.

0.2.14 DERMATOLOGIC

0.2.14.1 ACUTE EXPOSURE
A. WITH POISONING/EXPOSURE
1. Extensive contact may result in dermatitis,

irritation, and local hypersensitivity.
2. Porphyria cutanea tarda has resulted from acute hexachlorobenzene ingestions.

0.2.15 MUSCULOSKELETAL

0.2.15.1 ACUTE EXPOSURE

A. WITH POISONING/EXPOSURE

1. Tremor and twitching commonly occur with lindane poisoning. Rhabdomyolysis with increased creatine kinase levels may occur.

0.2.16 ENDOCRINE

0.2.16.1 ACUTE EXPOSURE

A. WITH POISONING/EXPOSURE

1. Palpable thyroid enlargement has been observed following hexachlorobenzene ingestions.

0.2.18 PSYCHIATRIC

0.2.18.1 ACUTE EXPOSURE

A. WITH POISONING/EXPOSURE

1. Alterations in mental function occur as a result of the neurotoxicity of chlorinated hydrocarbon insecticides. Hallucinations have been reported.

0.2.18.2 CHRONIC EXPOSURE

A. WITH POISONING/EXPOSURE

1. Anorexia, fatigue, and malaise have occurred with chronic exposure to chlordane.
2. Emotional changes have occurred in persons occupationally exposed to lindane.

0.2.19 IMMUNOLOGIC

0.2.19.2 CHRONIC EXPOSURE

A. ANIMAL STUDIES - Lindane was not immunosuppressive in rabbits.

0.2.20 REPRODUCTIVE HAZARDS

A. Lindane did not have reproductive effects in a 3-generation rat study. It has not been teratogenic in animals. It disturbed the estrus cycle and reduced fertility in female rats. It has been detected in human breast milk. It produced degenerative changes in the testes of rats.

0.2.21 CARCINOGENICITY

0.2.21.1 IARC CATEGORY

A. The IARC classifies hexachlorocyclohexanes including the gamma isomer (Lindane) in Group 2B: Possibly carcinogenic to humans; Sufficient evidence (RTECS, 2000; IARC, 1987).

0.2.21.2 HUMAN OVERVIEW

A. Several cases of acute myeloid leukemia have been reported with lindane exposure. Lindane has been carcinogenic in mice, inducing liver tumors.

0.2.22 GENOTOXICITY

A. Lindane has been inactive in various short-term assays, but may be genotoxic at the chromosomal level. DNA damage was reported in human nasal and gastric mucosal cells after lindane exposure. Mutations have occurred in human lymphocytes.

Laboratory:

A. Blood chlorinated hydrocarbon levels are not clinically useful following acute exposure. For most compounds they reflect cumulative exposure over a period of months or years rather than recent exposure.

Treatment Overview:

0.4.2 ORAL EXPOSURE

A. Emesis is not recommended since seizures may occur suddenly and without warning.

B. GASTRIC LAVAGE: Consider after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation. Control any seizures first.

1. CONTRAINDICATIONS: Loss of airway protective reflexes or decreased level of consciousness in unintubated patients; following ingestion of corrosives; hydrocarbons (high aspiration potential); patients at risk of hemorrhage or gastrointestinal perforation; and trivial or non-toxic ingestion.

C. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.

D. SEIZURES: Administer a benzodiazepine IV; DIAZEPAM (ADULT: 5 to 10 mg, repeat every 10 to 15 min as needed. CHILD: 0.2 to 0.5 mg/kg, repeat every 5 min as needed) or LORAZEPAM (ADULT: 2 to 4 mg; CHILD: 0.05 to 0.1 mg/kg).

1. Consider phenobarbital if seizures recur after diazepam 30 mg (adults) or 10 mg (children > 5 years).
2. Monitor for hypotension, dysrhythmias, respiratory depression, and need for endotracheal intubation. Evaluate for hypoglycemia, electrolyte disturbances, hypoxia.

E. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.

F. Do NOT administer milk, fatty foods, or oils by mouth since these may enhance absorption of lindane.

G. Do NOT administer adrenergic amines, which may potentiate myocardial irritability.

H. DYSTONIC REACTION: ADULT: benztropine 1 to 4 mg IV (max 6 mg/day), or diphenhydramine 25 to 50 mg/dose IV over 2 min (maximum 100 mg/dose, 400 mg/day). CHILD: diphenhydramine 1.25 mg/kg/dose IV over 2 min (maximum 300 mg/day)

0.4.3 INHALATION EXPOSURE

A. INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids.

B. DECONTAMINATION: Remove contaminated clothing and jewelry. Wash the skin, including hair and nails, vigorously; do repeated soap washings. Discard contaminated clothing.

C. First responders should wear protective clothing to prevent secondary contamination. Be prepared to collect any vomitus or excreta in a manner to prevent further

contamination; bag and treat as hazardous waste.

D. SEIZURES: Administer a benzodiazepine IV; DIAZEPAM (ADULT: 5 to 10 mg, repeat every 10 to 15 min as needed. CHILD: 0.2 to 0.5 mg/kg, repeat every 5 min as needed) or LORAZEPAM (ADULT: 2 to 4 mg; CHILD: 0.05 to 0.1 mg/kg).

1. Consider phenobarbital if seizures recur after diazepam 30 mg (adults) or 10 mg (children > 5 years).
2. Monitor for hypotension, dysrhythmias, respiratory depression, and need for endotracheal intubation. Evaluate for hypoglycemia, electrolyte disturbances, hypoxia.

E. REFRACTORY SEIZURES: Consider continuous infusion of midazolam, propofol, and/or pentobarbital. Hyperthermia, lactic acidosis and muscle destruction may necessitate use of neuromuscular blocking agents with continuous EEG monitoring.

F. Do not administer adrenergic amines, which may further increase myocardial irritability and produce refractory ventricular arrhythmias.

G. Dialysis, exchange transfusion, and hemoperfusion are probably ineffective.

H. Treatment should include recommendations listed in the ORAL EXPOSURE section when appropriate.

0.4.4 EYE EXPOSURE

A. DECONTAMINATION: Irrigate exposed eyes with copious amounts of room temperature water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility.

B. DECONTAMINATION: Remove contaminated clothing and jewelry. Wash the skin, including hair and nails, vigorously; do repeated soap washings. Discard contaminated clothing.

C. Carefully observe patient for development of clinical signs and symptoms, and administer treatment as described in DERMAL EXPOSURE where appropriate.

0.4.5 DERMAL EXPOSURE

A. DECONTAMINATION: Remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician may need to examine the area if irritation or pain persists.

B. DECONTAMINATION: Remove contaminated clothing and jewelry. Wash the skin, including hair and nails, vigorously; do repeated soap washings. Discard contaminated clothing.

C. First responders should wear protective clothing to prevent secondary contamination. Be prepared to collect any vomitus or excreta in a manner to prevent further contamination; bag and treat as hazardous waste.

D. SEIZURES: Administer a benzodiazepine IV; DIAZEPAM (ADULT: 5 to 10 mg, repeat every 10 to 15 min as needed. CHILD: 0.2 to 0.5 mg/kg, repeat every 5 min as needed) or LORAZEPAM (ADULT: 2 to 4 mg; CHILD: 0.05 to 0.1 mg/kg).

1. Consider phenobarbital if seizures recur after diazepam 30 mg (adults) or 10 mg (children > 5 years).
2. Monitor for hypotension, dysrhythmias, respiratory depression, and need for endotracheal intubation.

Evaluate for hypoglycemia, electrolyte disturbances, hypoxia.

E. REFRACTORY SEIZURES: Consider continuous infusion of midazolam, propofol, and/or pentobarbital. Hyperthermia, lactic acidosis and muscle destruction may necessitate use of neuromuscular blocking agents with continuous EEG monitoring.

F. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.

G. Do not give oils by mouth.

H. Do not administer adrenergic amines, which may further increase myocardial irritability and produce refractory ventricular arrhythmias.

I. CHOLESTYRAMINE - Oral administration may enhance the excretion of kepone and chlordane which are trapped in the enterohepatic circulation.

J. Dialysis, exchange transfusion, and hemoperfusion are probably ineffective.

Range of Toxicity:

A. The mean fatal dose in humans has been 28 grams. Ingestion of 45 mg has caused seizures in an adult. An adult survived an ingestion of 1035 grams.

B. Ingestion of 90 percent to 100 percent concentrations of lindane is very likely to produce toxicity.

C. Ingestion of as little as 5 mL of 1 percent lindane has caused respiratory depression and/or seizures in children aged 1 to 4 years.

ES

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

Basic treatment: Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Monitor for pulmonary edema and treat if necessary ... . Anticipate seizures and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport ... . Do not use emetics. For ingestion, rinse mouth and administer 5 mL/kg up to 200 mL of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal ... . /Lindane and Related Compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994.,p. 284-5]**PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious or in respiratory arrest. Positive-pressure ventilation techniques with a bag-valve-mask device may be beneficial. Monitor cardiac rhythm and treat arrhythmias if necessary ... . Start an IV with lactated Ringer's to maintain hydration and adequate urine flow. Watch for signs of fluid overload and pulmonary edema. Consider drug therapy for pulmonary edema ... . Treat seizures with diazepam (Valium) ... . Use proparacaine hydrochloride to assist eye irrigation ... . /Lindane and Related compounds/

[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 285]**PEER REVIEWED**

Treatment is symptomatic and supportive. Oils should not be used as either cathartics or dermal cleansing agents, as they increase absorption. Gastric lavage and use of activated charcoal and sodium sulfate are indicated for ingestion. If dermal exposed occurred, contaminated clothes should be removed, and the skin should be thoroughly cleansed with soap and water. Management of seizures in both children and adults is with Valium or phenobarbital. Respiratory depression and even respiratory arrest, especially with concomitant use of Valium and phenobarbital in children, may occur. These drugs preferably should be used only in critical care areas where emergency endotracheal intubation can be performed. /It is recommended/ that epinephrine not be utilized in patients with organochlorine poisoning, as the organochlorines induce myocardial irritability and ventricular arrhythmias may occur. However, dopamine may be necessary in the event of hypotension unresponsive to fluid administration, and epinephrine may be necessary in the event of cardiopulmonary arrest. ... /Organochlorine insecticides/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1084]**PEER REVIEWED**

Seizures, hypoxemia, and resultant acidosis are the immediate life-threatening emergencies. Diazepam is the anticonvulsant of choice. Moderately to severely poisoned patients should have intravenous lines and a cardiac monitor. The usual measures of gut decontamination (ipecac/lavage, charcoal, cathartics) are recommended within the first several hours after exposure. Experimental animal studies suggest that chlorinated hydrocarbon pesticide absorption by charcoal is highly variable. Most organochlorine insecticides contain organic solvents, which are severe aspiration hazards. Skin decontamination (removal of contaminated clothes, washing of area with water and green or mild soap) is necessary to prevent continued dermal absorption. Be careful not to cross-contaminate health personnel. The use of cholestyramine (3-8 g four times a day) increased fecal excretion of chlordecone by seven times and reduced the mean blood half-life from 165 to 80 days. In organochlorine exposures to compounds that have substantial enterohepatic recirculation, activated charcoal also may reduce the half-life and should be considered in serial doses for moderate to severe acute poisonings. Dialysis, diuresis, and hemoperfusion are ineffective because of extensive tissue binding and large volumes of distribution. /Organochlorines/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 1080] **PEER REVIEWED**

Persons exceptionally exposed to organochlorine pesticides by any route should be observed for sensory disturbances, incoordination, speech slurring, mental aberrations, and involuntary motor activity that would warn of imminent convulsions. If convulsions occur, place the victim in the left lateral decubitus position with the head down. Move away furniture or other solid objects that may be a source of injury. If jaw movements are violent, place padded tongue blades between the teeth to protect the tongue. Whenever possible, remove dentures and other removable dental work. Aspirate oral and pharyngeal secretions, and, when possible, insert an oropharyngeal airway to maintain an open passage unobstructed by the tongue. Minimize noise and any manipulation of the patient that may trigger seizure activity. Administer oxygen by mask. Maintain pulmonary gas exchange by mechanically assisted ventilation whenever respiration is depressed. Control convulsions. Drugs that are useful for this purpose are diazepam, lorazepam, barbiturates, and muscle paralyzing agents such as succinylcholine. Benzodiazepine drugs are currently the preferred anticonvulsants. ... Succinycholine (or similar muscle paralyzing drug) may be used if seizures prove intractable. Gain full control of pulmonary ventilation (endotracheal tube or tracheostomy connected to a mechanical ventilator), prepare to monitor blood gases, and secure the services of an anesthesiologist or emergency care physician to induce general anesthesia and administer the neuromuscular depolarizing agent. This procedure predictably controls

seizures, but imposes heavy responsibilities for continuous monitoring of gas exchange and blood pH over several hours. /Solid organochlorine insecticides/
[Morgan DP; Recognition and Management of Pesticide Poisonings. 4th ed. p.21-3 EPA 540/9-88-001. Washington, DC: U.S. Government Printing Office, March 1989]**PEER REVIEWED**

In patients who have been poisoned by organochlorine contamination of skin, clothing, hair and/or eyes, decontamination must proceed concurrently with whatever resuscitative and anticonvulsive measures are necessary to preserve life. Contamination of the eyes should be removed by flushng with copious amounts of clean water. If the pesticide-exposed person remains alert and physically able, a prompt shower and shampoo may be appropriate, provided the patient is carefully observed to insure against sudden appearance of poisoning. If there are any indications of weakness, ataxia, or other neurologic impairment, clothing should be removed and a complete bath and shampoo given while the victim is recumbent, using copious amounts of soap and water. Attendants should wear rubber gloves. Surgical green soap is excellent for this purpose, but ordinary soap is about as good. The possibility of pesticide sequestered under fingernails or in skin folds should not be overlooked. Contaminated clothing should be promptly bagged and not returned until it has been thoroughly laundered. Contaminated leather shoes should be discarded. The possibility that pesticide has contaminated the inside surfaces of gloves, boots, and headgear should be considered. /Solid organochlorine insecticides/
[Morgan DP; Recognition and Management of Pesticide Poisonings. 4th ed. p.23 EPA540/9-88-001. Washington, DC: U.S. Government Printing Office, March 1989]**PEER REVIEWED**

If organochlorine has been ingested in a quantity sufficient to cause poisoning, the stomach and intestine must be emptied, and measures taken to limit toxicant absorption. Because seizure activity may develop rapidly, lavage, with a large bore orogastric tube and with rigorous protection of the airway, is probably preferable to induced emesis in most cases. If the victim is convulsing, it is almost always necessary first to control seizures before attempting gastric intubation. The effectiveness of lavage in removing pesticide from the stomach diminishes rapidly with the passage of time. Particularly in poisoning by large doses of organochlorine, monitor pulmonary ventilation carefully to forestall respiratory failure. Assist pulmonary ventilation mechanically with oxygen whenever respiration is depressed. /Solid organochlorine insecticides/
[Morgan DP; Recognition and Management of Pesticide Poisonings. 4th ed. p.23 EPA 540/9-88-001. Washington, DC: U.S. Government Printing Office, March 1989]**PEER REVIEWED**

In severely poisoned patients, monitor cardiac status by continuous ECG recording to detect arrhythmias. Do not give epinephrine, other adrenergic amines, or atropine because of the enhanced myocardial irritability induced by chlorinated hydrocarbons, which predisposes to ventricular fibrillation. DO NOT GIVE animal or vegetable oils or fats by mouth. They enhance gastrointestinal absorption of the lipophilic organochlorines. To control seizures and myoclonic movements that sometimes persist for several days following acute poisoning by the more slowly excreted organochlorines, phenobarbital orally is likely to be effective. Dosage should be based on manifestations in the individual case and on information contained in the package insert. Cholestyramine resin accelerates the biliary-fecal excretion of the more slowly eliminated organochlorine compounds. It is usually administered in 4 g doses, 4 times a day, before meals and at bedtime. Dose should be mixed with a pulpy fruit or liquid. Prolonged treatment (several weeks or months) may be necessary. During convalescence, enhance carbohydrate, protein, and vitamin intake by diet or parenteral therapy. /Solid organochlorine insecticides/
[Morgan DP; Recognition and Management of Pesticide Poisonings. 4th ed. p.24 EPA540/9-88-001. Washington, DC: U.S. Government Printing Office, March 1989]**PEER REVIEWED**

Animal Toxicity Studies:

Evidence for Carcinogenicity:

CLASSIFICATION: D; not classifiable as to human carcinogenicity. HUMAN CARCINOGENICITY DATA: None.
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on delta-Hexachlorocyclohexane (delta-HCH) (319-86-8) Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000] **PEER REVIEWED**

Non-Human Toxicity Excerpts:

... IT MAINLY ... /DEPRESSES/ NERVOUS SYSTEM. ... FOLLOWING SC INJECTION IN MICE ... ONSET OF EFFECTS IS DELAYED COMPARED WITH THAT OF GAMMA-ISOMER. ... POISONING ... IS CHARACTERIZED BY PROSTRATION, THE ANIMALS REMAINING MOTIONLESS FOR DAYS. IF DEATH OCCURS, IT USUALLY IS DELAYED. FOLLOWING IV INJECTION ... /APPROXIMATING/ 53 MG/KG ... /IT PRODUCED/ HYPEREXCITABILITY LASTING ABOUT 0.5 MIN & FOLLOWED BY A STATE OF NUMBNESS & THEN PROMPT RECOVERY.
[Hayes, Wayland J., Jr. Pesticides Studied in Man. Baltimore/London: Williams and Wilkins, 1982. 218]**PEER REVIEWED**

MALE WISTAR RATS, 5-8 WK OLD, WERE FED DIETS CONTAINING ... 500 OR 1000 MG/KG ... FOR 24 OR 48 WEEKS. /**DELTA-HCH** WAS MORE THAN 99% PURE/. ORIGINAL SIZES OF GROUPS & SURVIVAL RATES WERE NOT REPORTED. ... NO LIVER TUMORS WERE FOUND IN ... 59 RATS FED ... 500 OR 1000 MG/KG DIET FOR 24 OR 48 WEEKS, OR IN 8 CONTROL RATS OBSERVED FOR 72 WEEKS (ITO ET AL, 1975). (THE WORKING GROUP NOTED THE RELATIVELY SHORT DURATION OF STUDY & THE SMALL SIZES OF CONTROL & EXPTL GROUPS).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 214 (1979)]**PEER REVIEWED**

In rats given alpha-, beta-, and delta-hexachlorocyclohexane (I), a reduction of blood and liver glucose (12 and 33% respectively) was observed after 60 days, along with an incr of glucose-6-phosphate after 60 and 90 days, a decr in pyruvate kinase activity in animals treated with alpha-, beta-, delta-hexachlorocyclohexane for 90 days, as well as an incr in glucose-6-phosphate dehydrogenase activity after 60 and 90 days. The liver cytochrome p450 levels showed an incr of 127 and 35% in the animals treated with alpha-, beta-, delta-hexachlorocyclohexane after 60 and 90 days, respectively. Thus a proliferation of smooth endoplasmic reticulum was detected in alpha, beta-, delta-hexachlorocyclohexane treated animals.
[Barros SB de et al; Rev Farm Bioquim Univ Sao Paulo 20 (1): 65-75 (1984)]**PEER REVIEWED**

(35)S-labeled tert-butylcyclophosphorothionate (TBPS) undergoes saturable specific binding to a membrane preparation from housefly thoraces and abdomens with apparent Kd and Bmax values at equilibrium of 0.17 mu M and 2.2 pmol/mg protein, at 20 deg. Lindane is more potent than three other isomers of hexachlorocyclohexane as a toxicant for houseflies and in displacing (35)S-TBPS from this housefly membrane preparation. This correlation of similar stereospecificity for neuroactivity and interaction with the TBPS receptor extends to the Mediterranean fruit fly male attractant trimedlure and its components and analogs. The relative attractancy of tert-butyl-cis-4-chloro-trans-2-

methylcyclohexanecarboxylate and of three less active isomers of this trans-chlorocyclohexanecarboxylate parallel their potency in the (35)S-TBPS binding assay. With both trimedlure and the related cyclohexane attractant siglure, the trans-isomers are more potent than the cis-isomers as attractants and in displacing (35)S-TBPS. Scatchard analyses indicate that lindane binds at the same site as (35)S-TBPS. The hexachlorocyclohexane isomers and the trimedlure components are much more potent inhibitors with membrane preparations from houseflies than from rat brain. The housefly TBPS receptor possibly serves as a model for the primary target sites, thereby suggesting that both the insecticide and the attractant may interact with some component of the putative GABAergic nervous or neuromuscular system.
[Cohen E, Casida JE; Life Sci 36 (19): 1837-42 (1985)]**PEER REVIEWED**

Of several parameters examined spontaneous mitotic activity of rat and mouse thymocytes was the most sensitive indicator of the cytotoxic effects of various compounds. For most of the compounds, the median inhibitory concn values were in the range of concentrations which affected the viability of the cells. The ecto-ATPase inhibition was not correlated with changes of electrophoretic mobility of the thymocytes. **Delta-HCH** and dibutyltin dichloride were the only chemical compounds which changed the electrophoretic mobility of the thymocytes after short-term incubation.
[Hennighausen G et al; Cell Electrophor Proc Int Meet 663-8 (1985)]**PEER REVIEWED**

BHC isomers (10-300 ppm) affected the growth and N-fixation enzyme activity of Spirillum lipoferum, Azotobacter vinelandii, Rhizobium astragali and R japoncium grown on culture media. In S lipoferum, effects on the enzyme activity were delta > alpha > gamma > beta and the effects on growth were delta > gamma > alpha > beta. In A vinelandii, the enzyme activity was decreased by 27% and the microbial count decreased by 61% when treated with 150 ppm technical BHC. In R astragali, a 40% decr in the microbial count was observed when treated with 250 ppm technical BHC. In R japoncium, the enzyme activity was decreased by only 4% when treated with 300 ppm technical BHC. At 250 ppm, technical BHC slightly increased the growth /of the organism/.
[Lu J et al; Huanjing Kexue 5 (3): 35-8 (1984)]**PEER REVIEWED**

The effect of different BHC isomers (alpha, beta, gamma, and delta) on the cell population of a ciliate protozoan, Tetrahymena pyriformis was investigated. At a concn of 5.0 ppm, gamma-BHC reduced the cell number by 89% on the fifth day of treatment. The alpha-isomer reduced the cell number by 88% on the third day of treatment and beta-BHC by 93% on the second day of treatment. The delta-isomer was lethal as all the cells died within 24 hr of treatment. The order of toxicity of different BHC isomers to T pyriformis was delta > beta > alpha > gamma.
[Mathur R et al; Acta Protozool 23 (3): 165-74 (1984)]**PEER REVIEWED**

Non-Human Toxicity Values:

LD50 Rat oral 1000 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 400]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

... /IN RATS/ 2,4,6-TRICHLOROPHENOL IS ... METABOLITE ... OF ... DELTA-HEXACHLOROCYCLOHEXANE. PATHWAY FAVORED ... FOR FORMATION ... /IS/ BY WAY OF HYDROXYLATION OF 1,3,5-TRICHLOROBENZENE, ONE OF PRODUCTS OF

DEHYDROCHLORINATION ... AN ALTERNATIVE PATHWAY /IS PROPOSED/ INVOLVING DIRECT HYDROXYLATION ... TO ALPHA-CHLOROHYDRINS, WHICH, FOLLOWING RAPID, SPONTANEOUS LOSS OF HCL YIELDED ONE OF THE ISOMERS OF PENTACHLOROCYCLOHEXANONE; LOSS THEREFROM OF TWO MOLS OF HCL LED DIRECTLY TO 2,4,6-TRICHLOROPHENOL.
[The Chemical Society. Foreign Compound Metabolism in Mammals. Volume 5: A Review of the Literature Published during 1976 and 1977. London: The Chemical Society, 1979. 463]**PEER REVIEWED**

... 2,4,6-TRICHLOROPHENOL IS ... IN VITRO METABOLITE OF ... **DELTA-HCH** IN RAT-LIVER MICROSOMES ... THE REACTION IS OXIDATIVE & CATALYZED BY CYTOCHROME P450. ... THE RELATIVE ... /RATE/ OF FORMATION ... WAS ... 100 ... PURIFICATION OF ... /GLUTATHIONE-DEPENDENT/ DECHLORINATING ENZYME FROM RAT-LIVER CYTOSOL HAS BEEN ACHIEVED.
[The Chemical Society. Foreign Compound Metabolism in Mammals. Volume 5: A Review of the Literature Published during 1976 and 1977. London: The Chemical Society, 1979. 463]**PEER REVIEWED**

Absorption, Distribution & Excretion:

IN RATS FED 800 MG/KG DIET ... FOR 20 MONTHS ... 0.55 MG/KG ... WAS FOUND IN ADIPOSE TISSUE; LEVELS IN OTHER TISSUES WERE LOWER BY FACTOR OF 5-10. ... UPON CESSATION OF DIETARY EXPOSURE ... IT DISAPPEARED FROM FAT DEPOTS WITHIN 3 WK ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 218 (1979)]**PEER REVIEWED**

Interactions:

... /IT/ COUNTERACTS EFFECTS OF GAMMA-ISOMER SO THAT MORTALITY IS REDUCED WHEN SAME DOSAGE OF LINDANE IS ACCOMPANIED BY EQUAL OR ... GREATER DOSAGE OF ... DELTA ISOMER. ... THE STRONG INHIBITORY ACTION OF GAMMA-ISOMER TOWARD CONVULSIONS CAUSED BY CARDIAZOL IS REDUCED BY SIMULTANEOUS ADMIN OF ... DELTA-ISOMER ...
[Hayes, Wayland J., Jr. Pesticides Studied in Man. Baltimore/London: Williams and Wilkins, 1982. 218]**PEER REVIEWED**

Pharmacology:

Drug Warnings:

Food and Environmental Agents: Effect on Breast-Feeding: Benzenehexachlorides: None. /from Table 7/
[Report of the American Academy of Pediatrics Committee on Drugs in Pediatrics 93 (1): 142 (1994)]**PEER REVIEWED**

Interactions:

... /IT/ COUNTERACTS EFFECTS OF GAMMA-ISOMER SO THAT MORTALITY IS REDUCED WHEN SAME DOSAGE OF LINDANE IS ACCOMPANIED BY EQUAL OR ... GREATER DOSAGE OF ... DELTA ISOMER. ... THE STRONG INHIBITORY ACTION OF GAMMA-ISOMER

TOWARD CONVULSIONS CAUSED BY CARDIAZOL IS REDUCED BY SIMULTANEOUS ADMIN OF ... DELTA-ISOMER ...
[Hayes, Wayland J., Jr. Pesticides Studied in Man. Baltimore/London: Williams and Wilkins, 1982. 218]**PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

delta-Hexachlorocyclohexane's former production and use as a component in the insecticide BHC resulted in its release to the environment through various waste streams. If released to air, a vapor pressure of 3.5X10-5 mm Hg at 25 deg C, indicates that delta-hexachlorocyclohexane is expected to exist in both the vapor and particulate phases in the ambient atmosphere. Vapor-phase delta-hexachlorocyclohexane will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 28 days. Particulate-phase delta-hexachlorocyclohexane will be removed from the atmosphere by wet and dry deposition. If released to soil, delta-hexachlorocyclohexane is expected to have low mobility based upon Koc values of 700-2,700 measured in 2 oil contaminated soils. Volatilization from moist soil surfaces is not expected to be an important fate process based upon an estimated Henry's Law constant of 4.3X10-7 atm-cu m/mole. delta-Hexachlorocyclohexane is not expected to volatilize from dry soil surfaces based upon its vapor pressure. This compound is expected to biodegrade slowly based upon half-lives of 33.9 and 23.4 days on cropped and uncropped soils. If released into water, delta-hexachlorocyclohexane is expected to adsorb to suspended solids and sediment in the water column based upon its measured Koc values. Volatilization from water surfaces is expected to occur slowly based upon this compound's estimated Henry's Law constant. Estimated volatilization half-lives for a model river and model lake are 146 days and 3 years, respectively. An estimated BCF of 800 suggests the potential for bioconcentration in aquatic organisms is high. delta-Hexachlorocyclohexane was completely biodegraded in 140 days with a 60 day lag period under methanogenic conditions by sediment obtained from the Rhine River, Netherlands. Occupational exposure to delta-hexachlorocyclohexane may occur through inhalation and dermal contact with this compound at workplaces where technical grade BHC is still produced or used. The general population may be exposed to delta-hexachlorocyclohexane through the ingestion of food that contains this compound. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

Dermal /exposure/ and inhalation. /Hexachlorocyclohexane isomers/
[USEPA; Ambient Water Quality Criteria Doc: Hexachlorocyclohexane p.C-34 (1980) EPA 440/5-80-054]**PEER REVIEWED**

Occupational exposure to delta-hexachlorocyclohexane may occur through inhalation and dermal contact with this compound at workplaces where technical grade BHC is still produced or used(SRC). delta-Hexachlorocyclohexane was detected at a mean concn of 2.37 ug/l (range: 0-34.09 ug/l) in the blood of occupationally exposed individuals in India who were employed in pesticide spraying operations(1). The general population may be exposed to delta-hexachlorocyclohexane through the ingestion of food that contains this compound(SRC).
[(1) Dua VK et al; Bull Environ Contam Toxicol 56: 50-57 (1996)]**PEER REVIEWED**

Body Burden:

In a 1970 survey of pesticide residues in the adipose tissue of general population of US, mean levels

of ... **delta-HCH ...** were 0.01 mg/kg.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 207 (1979)]**PEER REVIEWED**

Gas chromatographic detection of blood levels of organochlorine pesticides in /individuals/ of Southern Nigeria is described. Among the compounds detected and quantified were the HCH-isomers, DDT and its metabolites and dieldrin, the major pollutants being DDT, DDE and the HCH-isomers. **Delta-HCH,** HCB and endrin were also detected in a few samples. Total DDT (DDT + DDE + DDD) ranged from 0.04-7.24 ppm, total HCH (alpha + beta + gamma) 0.08-5.64 ppm, and dieldrin 0.03-0.28 ppm.
[Atuma SS; Toxicol Environ Chem 10 (2): 77-82 (1985)]**PEER REVIEWED**

The residues of BHC isomers were /detected/ in 52 autopsy samples of human adipose tissue collected in the Skierniewice province during 1979. The mean beta-BHC content was 0.35 mg/kg on a lipid weight basis, followed by gamma-BHC 0.024 and alpha-BHC 0.0016. Delta-BHC was absent. The mean total BHC content was 0.37 mg/kg. Beta-, gamma-, alpha-, and delta-BHC were detectable in 100.0, 96.2, 30.8, and 0.0% of the samples analyzed, respectively. A comparison is made with the results of BHC residues detected in human fat /samples/ from other countries.
[Falandysz J et al; Farm Pol 40 (6): 325-8 (1984)]**PEER REVIEWED**

At the Institute of Hygiene of the Federal Dairy Research Center /during/ the years 1981 to 1985 in total of 2,624 samples of human milk were examined for ... residues of organochlorine compounds. The results /indicated/ that the residues did not change considerably in a qualitative /manner/. Concerning quantity, however, a distinct trend downwards could be stated. ...
[Hahne KH et al; Milchwissenschaft 41 (5): 269-72 (1986)]**PEER REVIEWED**

delta-Hexachlorocyclohexane was detected in maternal serum at a mean concn of 0.003 mg/l and infant serum at a concn of 0.001 mg/l in India(1). delta-Hexachlorocyclohexane was detected in human adipose tissue in the general population of the US and northeastern population of the US at avg concns of 0.02 ppm in 1970(2). delta-Hexachlorocyclohexane was detected in human adipose tissue in Italy at an avg concn of 0.007 ppm in 1973-1974 and in Japan at an avg concn of 7.46 ppm in 1974(2). The mean concn of delta-hexachlorocyclohexane in the blood of the general population of India was 0.13 ug/l(3). delta-Hexachlorocyclohexane was detected in human adipose tissue from the general population of Gdansk, Poland at concns of 0.54-2.8 ng/g(4). delta-Hexachlorocyclohexane was detected in human milk from Spain at a mean concn of 92 ug/l(5).
[(1) Nair A et al; Bull Environ Contam Toxicol 56: 58-64 (1996) (2) Kutz FW et al; Rev Environ Contam Toxicol 120: 1-83 (1991) (3) Dua VK et al; Bull Environ Contam Toxicol 60: 238-44 (1998) (4) Tanabe S et al; Environ Pollut 79: 45-49 (1993) (5) Pico Y et al; J Agric Food Chem 43: 1610-15 (1995)]**PEER REVIEWED**

Average Daily Intake:

The AVDI of delta-hexachlorocyclohexane in Osaka, Japan was reported as 0.01 ug from 1977-1985(1).

[(1) Matsumoto H et al; Bull Environ Contam Toxicol 38: 954-58 (1987)]**PEER REVIEWED**

Artificial Pollution Sources:

delta-Hexachlorocyclohexane's former production and use as a component in the insecticide BHC(1) resulted in its release to the environment through various waste streams(SRC).
[(1) Metcalf RL; Ullmann's Encycl Indust Chem. Elvers B et al Eds. NY,NY: VCH Pub

A14: 820 (1989)]**PEER REVIEWED**

Environmental Fate:

TERRESTRIAL FATE: Based on a classification scheme(1), Koc values of 700-2,700 measured in 2 oil contaminated soils(2), indicates that delta-hexachlorocyclohexane is expected to have low mobility in soil(SRC). Volatilization of delta-hexachlorocyclohexane from moist soil surfaces is not expected to be an important fate process(SRC) given an estimated Henry's Law constant of 4.3X10-7 atm-cu m/mole from its vapor pressure, 3.5X10-5 mm Hg at 25 deg C(3), and water solubility, 31.4 mg/l at 25 deg C(4). delta-Hexachlorocyclohexane is not expected to volatilize from dry soil surfaces(SRC) based upon the vapor pressure of this compound(3). The half-life of delta-hexachlorocyclohexane on cropped and uncropped soils was reported as 33.9 and 23.4 days, respectively(5).
[(1) Swann RL et al; Res Rev 85: 23 (1983) (2) Forst C et al; Chemosphere 26: 1355-64 (1994) (3) Schwabe K, Legler C; Z Elektrochem 64: 902-05 (1960) (4) Shiu WY et al; Rev Environ Contam Toxicol 116: 15-187 (1990) (5) ASTDR; Toxicological Profile For Alpha, Beta, Gamma and Delta Hexachlorocyclohexane. ASTDR/TO-93/09 (1993)] **PEER REVIEWED**

AQUATIC FATE: Based on a classification scheme(1), Koc values of 700-2,700(2), indicate that delta-hexachlorocyclohexane is expected to adsorb to suspended solids and sediment in water(SRC). Volatilization from water surfaces is expected to occur slowly(3) based upon an estimated Henry's Law constant of 4.3X10-7 atm-cu m/mole from its vapor pressure, 3.5X10-5 mm Hg at 25 deg C(4), and water solubility, 31.4 mg/l at 25 deg C(5). Volatilization half-lives for a model river and model lake are 146 days and 3 years, respectively(SRC), using an estimation method(3). According to a classification scheme(6), an estimated BCF of 800(3,SRC), from a log Kow of 4.14(7) suggests the potential for bioconcentration in aquatic organisms is high(SRC). delta-Hexachlorocyclohexane was completely biodegraded in 140 days with a 60 day lag period under methanogenic conditions in sediment obtained from the Rhine River, Netherlands(8). This compound has the potential to undergo hydrolysis(2), but the kinetics of this reaction are unknown(SRC).
[(1) Swann RL et al; Res Rev 85: 23 (1983) (2) Forst C et al; Chemosphere 26: 1355-64 (1994) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington,DC: Amer Chem Soc pp. 4-9, 5-4, 5-10, 15-1 to 15-29 (1990) (4) Schwabe K, Legler C; Z Elektrochem 64: 902-05 (1960) (5) Shiu WY et al; Rev Environ Contam Toxicol 116: 15-187 (1990) (6) Franke C et al; Chemosphere 29: 1501-14 (1994) (7) Hansch C et al; Exploring QSAR Fundamentals and Applications in Chemistry and Biology. Washington,DC: Amer Chem Soc (1995) (8) Middledorp PJM et al; Environ Sci Technol 30: 2345-49 (1996)]**PEER REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), delta-hexachlorocyclohexane, which has a vapor pressure of 3.5X10-5 mm Hg at 25 deg C(2), is expected to exist in both the vapor and particulate phases in the ambient atmosphere. Vapor-phase delta-hexachlorocyclohexane is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals(SRC); the half-life for this reaction in air is estimated to be 28 days(SRC) from its estimated rate constant of 5.7X10-13 cu cm/molecule-sec at 25 deg C(SRC) from a structure estimation method(3). Particulate-phase delta-hexachlorocyclohexane may be removed from the air by wet and dry deposition(SRC).
[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Schwabe K, Legler C; Z Elektrochem 64: 902-05 (1960) (3) Meylan WM, Howard PH; Chemosphere 26: 2293-99 (1993)]**PEER REVIEWED**

Environmental Biodegradation:

delta-Hexachlorocyclohexane was completely biodegraded in 140 days with a 60 day lag period under

methanogenic conditions in sediment obtained from the Rhine River, Netherlands(1). delta-Hexachlorocyclohexane was approximately 90 percent degraded after 570 days in a field test in Japan using agricultural plots(2). A half-life of 126 hours was reported for delta-hexachlorocyclohexane in an acclimated anaerobic sewage sludge obtained from a sewage treatment plant in Switzerland(3). delta-Hexachlorocyclohexane was completely biodegraded within 2 months in flooded agricultural soils in Japan(4). The half-life of delta-hexachlorocyclohexane on cropped and uncropped soils was reported as 33.9 and 23.4 days, respectively(5).
[(1) Middledorp PJM et al; Environ Sci Technol 30: 2345-49 (1996) (2) Suzuki M et al; Bull Environ Contam Toxicol 14: 520-29 (1975) (3) Buser HR, Muller MD; Environ Sci Technol 29: 664-72 (1995) (4) Zhan S et al; Huanjing Kexue 3: 1-3 (1982) (5) ASTDR; Toxicological Profile For Alpha, Beta, Gamma and Delta Hexachlorocyclohexane. ASTDR/TO-93/09 (1993)]**PEER REVIEWED**

Environmental Abiotic Degradation:

... ISOMERIZATION UNDER INFLUENCE OF HEAT HAS BEEN REPORTED. ... HEATING OF DELTA-ISOMER PRODUCED ABOUT EQUAL RECOVERED PORTIONS OF ALPHA, BETA- & DELTA-ISOMERS & SOMEWHAT MORE GAMMA-ISOMER.
[Hayes, Wayland J., Jr. Pesticides Studied in Man. Baltimore/London: Williams and Wilkins, 1982. 216]**PEER REVIEWED**

TRANSFORMATION OF BHC ISOMERS IN AQ SOLN WAS STUDIED AT 25 DEG C +/- 1 DEG C FOR 4 WK USING GLC. RESULTS INDICATED A LOSS & INTERCONVERSION OF ALL ISOMERS WITH TIME. TOXICITY OF THE AQ SOLUTIONS OF ALPHA-, BETA-, & DELTA-ISOMERS SHOWED AN INCREASE.
[DEO PG ET AL; J ENVIRON SCI HEALTH, PART B PESTIC FOOD CONTAM AGRIC WASTES 16 (6): 691-702 (1981)]**PEER REVIEWED**

The rate constant for the vapor-phase reaction of delta-hexachlorocyclohexane with photochemically-produced hydroxyl radicals has been estimated as 5.7X10-13 cu cm/molecule-sec at 25 deg C(SRC) using a structure estimation method(1). This corresponds to an atmospheric half-life of about 28 days at an atmospheric concentration of 5X10+5 hydroxyl radicals per cu cm(1). delta-Hexachlorocyclohexane may undergo hydrolysis(2) but the kinetics of this reaction are unknown(SRC). delt-Hexachlorocyclohexane is not expected to directly photolyze due to the lack of absorption in the environmental UV spectrum.
[(1) Meylan WM, Howard PH; Chemosphere 26: 2293-99 (1993) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington,DC: Amer Chem Soc pp. 7-4, 7-5 (1990)]**PEER REVIEWED**

Environmental Bioconcentration:

An estimated BCF of 800 was calculated for delta-hexachlorocyclohexane(SRC), using a log Kow of 4.14(1) and a regression-derived equation(2). According to a classification scheme(3), this BCF suggests the potential for bioconcentration in aquatic organisms is high(SRC).
[(1) Hansch C et al; Exploring QSAR Fundamentals and Applications in Chemistry and Biology. Washington,DC: Amer Chem Soc (1995) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington,DC: Amer Chem Soc pp. 5-4, 5-10 (1990) (3) Franke C et al; Chemosphere 29: 1501-14 (1994)]**PEER REVIEWED**

Soil Adsorption/Mobility:

Experimentally determined Koc values of 700-2,700 were reported in 2 oil contaminated soils(1). According to a classification scheme(2), these Koc values suggest that delta-hexachlorocyclohexane is

expected to have low mobility in soil(SRC).
[(1) Forst C et al; Chemosphere 26: 1355-64 (1994) (2) Swann RL et al; Res Rev 85: 23 (1983)]**PEER REVIEWED**

Volatilization from Water/Soil:

The Henry's Law constant for delta-hexachlorocyclohexane is estimated as 4.3X10-7 atm-cu m/mole (SRC) from its vapor pressure, 3.5X10-5 mm Hg at 25 deg C(1), and water solubility, 31.4 mg/l at 25 deg C(2). This Henry's Law constant indicates that delta-hexachlorocyclohexane is expected to volatilize slowly from water surfaces(3). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec)(3) is estimated as approximately 146 days(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(3) is estimated as approximately 3 years(SRC). delta-Hexachlorocyclohexane's estimated Henry's Law constant(1,2,SRC) indicates that volatilization from moist soil surfaces may occur slowly (SRC). delta-Hexachlorocyclohexane is not expected to volatilize from dry soil surfaces(SRC) based upon its vapor pressure(1).
[(1) Schwabe K, Legler C; Z Elektrochem 64: 902-05 (1960) (2) Shiu WY et al; Rev Environ Contam Toxicol 116: 15-187 (1990) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington,DC: Amer Chem Soc pp. 15-1 to 15-29 (1990)] **PEER REVIEWED**

Environmental Water Concentrations:

SURFACE WATER: RIVERS IN JAPAN HAVE BEEN FOUND TO CONTAIN LEVELS RANGING FROM ... 0 TO 10 NG/L.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 204 (1979)]**PEER REVIEWED**

GROUNDWATER: delta-Hexachlorocyclohexane was detected in the groundwater at a landfill in Holliday, KS at a concn of 0.66 ug/l(1).
[(1) USEPA; Superfund Record of Decision (EPA Region 7)Doepke Disposal (Holliday), KS. USEPA/ROD/R07-89/032. NTIS PB90-162645 (1989)]**PEER REVIEWED**

DRINKING WATER: delta-Hexachlorocyclohexane was detected in the drinking water of Athens, Greece at a mean concn of 0.001 ug/l(1).
[(1) Tsipi D, Hiskia A; Bull Environ Contam Toxicol 57: 250-57 (1996)]**PEER REVIEWED**

SURFACE WATER: delta-Hexachlorocyclohexane was detected in the Missouri River at concns of less than 0.3 ng/l to 2.2 ng/l(1). delta-Hexachlorocyclohexane was detected in the Ganga River, India near agricultural areas at concns of 0-36.5 ug/l(2). delta-Hexachlorocyclohexane was detected in the Elbe River, Germany at concns of 2-5.7 ng/l(3). delta-Hexachlorocyclohexane was detected in 20 freshwater river samples in Germany at concns of greater than 1 ug/l(4).
[(1) Petty JD et al; Environ Sci Technol 29: 2561-66 (1995) (2) Nayak AK et al; Bull Environ Contam Toxicol 54: 68-75 (1995) (3) Gotz R et al; Chemosphere 36: 2103-18 (1998) (4) Vandenberg R, Vanderlinden TMA; pp. 293-313 in Environ Sci Pollut Control Ser. NY,NY: M Dekker (1994)]**PEER REVIEWED**

Effluent Concentrations:

delta-Hexachlorocyclohexane was detected in the leachate of a landfill in Hamburg, Germany at a concn of 700 ppm(1). delta-Hexachlorocyclohexane was detected in 9 of 628 industrial effluents in the US at

concns of less than 0.007 ug/l(2). delta-Hexachlorocyclohexane was detected in New York City municipal wastewaters at concns of 0.015-0.03 ug/l(3). delta-Hexachlorocyclohexane was detected in the leachate from an industrial waste landfill in Holliday, KS at a concn of 0.7 ug/l(4).
[(1) Gotz R; Chemosphere 15: 1981-84 (1986) (2) Staples CA et al; Environ Toxicol Chem 131-42 (1985) (3) Stubin AI et al; Wat Environ Res 68: 1037-44 (1996) (4) USEPA; Superfund Record of Decision (EPA Region 7) Doepke Disposal (Holliday), KS. USEPA/ROD/R07-89/032. NTIS PB90-162645 (1989)]**PEER REVIEWED**

Sediment/Soil Concentrations:

FIFTEEN YEARS AFTER APPLICATION OF HCH TO SOIL, SAMPLES WERE TAKEN & ANALYZED. ... PERSISTENCE WAS OF ORDER BETA GREATER THAN DELTA WHICH WAS GREATER THAN GAMMA WHICH WAS GREATER THAN ALPHA.
[Menzie, C.M. Metabolism of Pesticides, Update II. U.S. Department of the Interior, Fish Wildlife Service, Special Scientific Report - Wildlife No. 2l2. Washington, DC: U.S. Government Printing Office, 1978.43]**PEER REVIEWED**

delta-Hexachlorocyclohexane was identified in 102 of 822 soil samples at 17 of 49 agricultural facilities in the US at a mean concn of 6 ug/kg(1). delta-Hexachlorocyclohexane was detected in soil surrounding an industrial landfill in Haldensleben, Germany at concns of 0-20 mg/kg in 1971 and 0.5-1 mg/kg in 1980(2). delta-Hexachlorocyclohexane was detected in sediment from the Victorian Harbor in Hong Kong at concns of less than 0.1 to 0.56 ng/g(3). delta-Hexachlorocyclohexane was detected in the soil at an industrial waste landfill in Holliday, KS at a concn of 10 ug/kg(4).
[(1) Krapac IG et al; J Soil Contam 4: 209-26 (1995) (2) Heinisch E et al; Sci Total Environ Supplement 1: 151-59 (1993) (3) Hong H et al; Mar Pollut Bull 31: 229-36 (1995) (4) USEPA; Superfund Record of Decision (EPA Region 7) Doepke Disposal (Holliday), KS. USEPA/ROD/R07-89/032. NTIS PB90-162645 (1989)]**PEER REVIEWED**

Food Survey Values:

delta-Hexachlorocyclohexane was identified in 1 out of 234 ready-to-eat foods in the US at a concn of 0.0030 ug/g(1). delta-Hexachlorocyclohexane was detected in infant formula in Spain at concns of 90-101 ug/l(2). delta-Hexachlorocyclohexane was detected in cheese from Spain at concns of 3-53 ug/kg (3). delta-Hexachlorocyclohexane was detected in potato samples collected from Egypt at concns of less than 0.0005 ppm to 0.53 ppm and a mean concn of 0.006 ppm(4). delta-Hexachlorocyclohexane was detected in 19 of 19,851 agricultural samples in the US at concns of 0.05-0.50 ppm(5).
[(1) Paul TG, Woodson BL; J AOAC Int 78: 614-31 (1995) (2) Pico Y et al; J Agric Food Chem 43: 1610-15 (1995) (3) Bentabol A, Jodral M; Pestic Sci 44: 177-82 (1995) (4) Dogheim SM et al; J AOAC Int 79: 949-52 (1996) (5) Luke MA et al; J Assoc Off Anal Chem 71: 415-20 (1988)]**PEER REVIEWED**

Plant Concentrations:

delta-Hexachlorocyclohexane was identified, not quantified, in pine needles at the French-Spanish border(1). delta-Hexachlorocyclohexane was detected in plants surrounding an industrial landfill in Haldensleben, Germany at concns of 0-1 mg/kg in 1971 and 0-6 mg/kg in 1980(2).
[(1) Kylin H et al; Environ Sci Technol 28: 1320-24 (1994) (2) Heinisch E et al; Sci Total Environ Suppl 1: 151-59 (1993)]**PEER REVIEWED**

Fish/Seafood Concentrations:

delta-Hexachlorocyclohexane was detected at concns of 4.1 and 0.2 ng/g in mussels, 0.1-0.6 ng/g in

clams and 0.01-0.03 ng/g in oysters caught off the coast of Spain(1). Crayfish from a stream in Oak Ridge, TN contained delta-hexachlorocyclohexane at a mean concn of 19.93 ug/kg(2). Flounder caught in Newfoundland, Canada contained delta-hexachlorocyclohexane at a mean concn of 0.05 ng/g(3). delta-Hexachlorocyclohexane was detected in sunfish at concns of 0-187 ppb, sea trout 0-43.6 ppb and flounder 0-9.6 ppb caught off the coast of South Carolina(4).
[(1) Galceran MT et al; Chemosphere 27: 1183-1200 (1993) (2) Rao VR et al; Ecotoxicol Environ Safety 33: 44-55 (1996) (3) Ray S et al; Chemosphere 36: 2201-10 (1998) (4) Mathews TD; Bull Environ Contam Toxicol 53: 412-19 (1994)]**PEER REVIEWED**

Animal Concentrations:

delta-Hexachlorocyclohexane was detected in racoons in Florida at a mean concn of 0.05 ppm and rabbits in Spain at a mean concn of 0.017 ppm(1). Redbreast gulls in Oak Ridge, TN contained delta-hexachlorocyclohexane at a mean concn of 21.85 ug/kg(2). Bats caught in Spain contained delta-hexachlorocyclohexane at concns of 0-0.303 ppm(3). Whales from the Gulf of St. Lawrence contained delta-hexachlorocyclohexane at concns of 0-44 ng/g(4). Herrings from the Baltic Sea contained delta-hexachlorocyclohexane at concns of 0.8-26.1 ng/g(5). delta-Hexachlorocyclohexane was detected in dolphins from the Bay of Bengal, India at concns of 2.8-21 ng/g(6). Bottleneck dolphins from the Gulf of Mexico contained delta-hexachlorocyclohexane at concns of 0-34.6 ng/g with a mean concn of 6.87 ng/g(7).
[(1) Obrien DJ et al; Environ Health Persp 99: 351-68 (1993) (2) Rao VR et al; Ecotoxicol Environ Safety 33: 44-55 (1996) (3) Guillen A et al; Bull Environ Contam Toxicol 52: 231-37 (1994) (4) Gauthier JM et al; Mar Environ Res 44: 201-23 (1997) (5) Roots O; Chemosphere 31: 4085-97 (1995) (6) Tanabe S et al; Mar Pollut Bull 22: 290-97 (1993) (7) Salata GG et al; Environ Pollut 88: 167-75 (1995)]**PEER REVIEWED**

Milk Concentrations:

US domestic 1970-76 4638 samples, 2.0% positive, 0.002 ppm avg(1). In a ten year study of chlorinated hydrocarbons in bovine milk in Illinois, the percent positive samples for all isomers of hexachlorocyclohexane combined between 1972 and 1978 ranged from 68.6-91.8% with average residues of 0.01-0.02 ppm. In 1980 and 1981, only 28.3-31% of samples were positive, with average residues of trace (<0.001 ppm)-0.01 ppm(2).
[(1) Duggan RE et al; Pesticide Residue Levels in Food in the US from July 1, 1969 to June 30, 1976 FDA and AOAC (1983) (2) Steffey KL et al; J Environ Sci Health B 19: 49-65 (1984)]**PEER REVIEWED**

At the Institute of Hygiene of the Federal Dairy Research Center /during/ the years 1981 to 1985 in total of 2,624 samples of human milk were examined for ... residues of organochlorine compounds. The results /indicated/ that the residues did not change considerably in a qualitative /manner/. Concerning quantity, however, a distinct trend downwards could be stated. ...
[Hahne KH et al; Milchwissenschaft 41 (5): 269-72 (1986)]**PEER REVIEWED**

Hexachlorocyclohexane isomers (including delta-hexachlorocyclohexane) were identified in milk fat in Hong Kong at concns of 0.004-0.18 mg/kg (0.03 mg/kg mean) 1993; 0.004-0.6 mg/kg (0.10 mg/kg mean) 1994; 0.004-0.74 mg/kg (0.09 mg/kg mean) 1995(1). delta-Hexachlorocyclohexane was detected in human milk from Spain at a mean concn of 92 ug/l(2).
[(1) Wong SK, Lee WO; J AOAC Int 80: 1332-35 (1997) (2) Pico Y et al; J Agric Food Chem 43: 1610-15 (1995)]**PEER REVIEWED**

Environmental Standards & Regulations:

FIFRA Requirements:

All registered products have been eliminated. In some instances these products were voluntarily cancelled, in others lindane was substituted for BHC non-gamma isomers. These non-gamma isomers may not be sold, manufactured or distributed for use in the US.
[USEPA/OPTS; Suspended, Cancelled and Restricted Pesticides p.2 (1985)]**PEER REVIEWED**

CERCLA Reportable Quantities:

Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 1 lb or 0.454 kg. The toll free telephone number of the NRC is (800) 424-8802; In the Washington metropolitan area (202) 426-2675. The rule for determining when notification is required is stated in 40 CFR 302.6 (section IV. D.3.b).
[51 FR 34534 (9/29/86)]**PEER REVIEWED**

Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 1 lb or 0.454 kg. The toll free number of the NRC is (800) 424-8802; In the Washington D.C. metropolitan area (202) 426-2675. The rule for determining when notification is required is stated in 40 CFR 302.4 (section IV. D.3.b).
[40 CFR 302.4 (7/1/97)]**PEER REVIEWED**

Atmospheric Standards:

Listed as a hazardous air pollutant (HAP) generally known or suspected to cause serious health problems. The Clean Air Act, as amended in 1990, directs EPA to set standards requiring major sources to sharply reduce routine emissions of toxic pollutants. EPA is required to establish and phase in specific performance based standards for all air emission sources that emit one or more of the listed pollutants. Lindane (delta) is included on this list.
[Clean Air Act as amended in 1990, Sect. 112 (b) (1) Public Law 101-549 Nov. 15, 1990]**PEER REVIEWED**

Clean Water Act Requirements:

The ambient water quality criteria for the delta-isomer of hexachlorocyclohexane has not been established because of insufficient data.
[USEPA; Ambient Water Quality Criteria Doc: Hexachlorocyclohexane p.C-39 (1980) EPA 440/5-80-054]**QC REVIEWED**

Toxic pollutant designated pursuant to section 307(a)(1) of the Clean Water Act and is subject to effluent limitations. /Hexachlorocyclohexane/
[40 CFR 401.15 (7/1/85)]**QC REVIEWED**

State Drinking Water Guidelines:

(FL) FLORIDA 0.05 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

C6-H6-Cl6
PEER REVIEWED

Molecular Weight:

290.83
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 76th ed. Boca Raton, FL: CRC Press Inc., 1995-1996.,p. 3-122]**PEER REVIEWED**

Color/Form:

CRYSTALS OR FINE PLATELETS
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 198 (1979)]**PEER REVIEWED**

Boiling Point:

60 deg C AT 0.50 mm Hg
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 76th ed. Boca Raton, FL: CRC Press Inc., 1995-1996.,p. 3-122]**PEER REVIEWED**

Melting Point:

141.5 deg C
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 76th ed. Boca Raton, FL: CRC Press Inc., 1995-1996.,p. 3-122]**PEER REVIEWED**

Octanol/Water Partition Coefficient:

log Kow= 4.14
[Hansch, C., Leo, A., D. Hoekman. Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. Washington, DC: American Chemical Society., 1995. 19]**PEER REVIEWED**

Solubilities:

10 PPM IN WATER; 24.4 G/100 G ETHANOL; 35.4 G/100 G ETHER; 41.1 G/100 G BENZENE
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3741]**PEER REVIEWED**

In water, 31.4 mg/l @ 25 eg C
[Forest C et al; Chemosphere 26: 1355-64 (1994)]**PEER REVIEWED**

Spectral Properties:

INDEX OF REFRACTION: 1.576 TO 1.674 AT 20 DEG C/D

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 198 (1979)]**PEER REVIEWED**

IR: 9696 (Sadtler Research Laboratories Prism Collection)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 480]**PEER REVIEWED**

MASS: 4774 (National Bureau of Standards EPA-NIH Mass Spectra Data Base, NSRDS-NBS-63)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 480]**PEER REVIEWED**

Vapor Pressure:

3.5X10-5 mm Hg @ 25 deg C
[Schwabe K, Legler C; Z Elektrochem 64: 902-05 (1960)]**PEER REVIEWED**

Chemical Safety & Handling:

Hazardous Decomposition:

Decomposition product includes ... carbon monoxide. /Lindane/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2] **PEER REVIEWED**

When heated to decomposition it emits toxic fumes of /hydrogen chloride/.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 400]**PEER REVIEWED**

Protective Equipment & Clothing:

Respiratory protection for lindane is as follows: Particulate concn 5 mg/cu m or less: Any chemical cartridge respirator with an organic vapor cartridge and dust and mist filter, including pesticide respirators which meet the requirements of this class; supplied-air respirator; self-contained breathing apparatus. 25 mg/cu m or less: Chemical cartridge respirator with a full facepiece, organic vapor cartridge and dust and mist filter, including pesticide respirators which meet the requirements of this class; gas mask with a chin-style or a front or back-mounted organic vapor canister and dust and mist filter, including pesticide respirators which meet the requirements of this class; supplied-air respirator with a full facepiece, helmet, or hood; self-contained breathing apparatus with a full facepiece. 500 mg/cu m or less: Powered air-purifying respirator with an organic vapor cartridge and high efficiency particulate filter, including pesticide respirators which meet the requirements of this class; type-C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode. 1000 mg/cu m or less: Type-C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece operated in continuous-flow mode. Greater than 1000 mg/cu m or entry escape from unknown concentrations: Combination respirator which includes a type-C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode. Escape: any gas mask providing protection against organic vapors and particulates, including pesticide respirators which meet the requirements of this class; any escape self-contained breathing apparatus. /Lindane/

[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.4]
PEER REVIEWED

Employees should be provided with and required to use dust and splash-proof safety goggles where lindane or liquids containing lindane may contact the eyes. /Lindane/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]
PEER REVIEWED

Preventive Measures:

Quick drench showers should be provided. /Lindane/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]
PEER REVIEWED

Employees should change from clothing that has become contaminated with lindane or liquids containing lindane into uncontaminated clothing before leaving the work premises. Clothing contaminated with lindane should be placed into closed containers for storage until it can be discarded or until provision is made for the removal of lindane from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the lindane, the person performing the operation, should be informed of lindane's hazardous properties. /Lindane/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]
PEER REVIEWED

Skin that becomes contaminated with solid or liquids containing lindane should be promptly washed or showered with soap or mild detergent and water to remove any lindane. /Lindane/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]
PEER REVIEWED

Eating and smoking should not be permitted in areas where solid lindane is handled, processed, or stored. /Lindane/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]
PEER REVIEWED

Employees who handle lindane or liquids containing lindane should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities. /Lindane/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]
PEER REVIEWED

Cleanup Methods:

Liquids containing lindane should be absorbed in vermiculite, dry sand, earth, or a similar material. /Lindane/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3] **PEER REVIEWED**

For spills and leakage ... dampen spilled material with alcohol to avoid dust, then transfer material to suitable container. Use absorbent paper dampened with alcohol to pick up remaining material. Wash surfaces well with soap & water. Seal all wastes in vapor-tight plastic bags for eventual disposal. /Lindane/
[Keith, L.H., D.B. Walters, (eds.). Compendium of Safety Data Sheets for Research and Industrial Chemicals. Parts I,II,and III. Deerfield Beach, FL: VCH Publishers, 1985. 1061]**PEER REVIEWED**

Disposal Methods:

SRP: At the time of review, criteria for land treatment or burial (sanitary landfill) disposal practices are subject to significant revision. Prior to implementing land disposal of waste residue (including waste sludge), consult with environmental regulatory agencies for guidance on acceptable disposal practices.
PEER REVIEWED

Potential candidate for rotary kiln incineration with a temperature range of 820-1600 deg C with residence times for liquids and gases: seconds; solids, hours. Also, a potential for fluidized bed incineration with a temperature range of 450-980 deg C with residence times for liquids and gases: seconds; solids, longer. /Lindane/
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-13 (1981) EPA 68-03-3025]**PEER REVIEWED**

Occupational Exposure Standards:

Manufacturing/Use Information:

Major Uses:

Formerly used as an insecticide. /Benzene Hexachloride/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-287]**PEER REVIEWED**

Methods of Manufacturing:

In sunlight and in the absence of oxygen and substitution catalysts, chlorine and bromine combine with benzene, forming hexachlorocyclohexanes.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. V3 749]**PEER REVIEWED**

General Manufacturing Information:

Non-gamma isomers may not be sold, manufactured, or distributed for use in the US.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 92]**PEER REVIEWED**

Isomers are separated by fractional crystallization from organic solvents.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. V3 749]**PEER REVIEWED**

Formulations/Preparations:

TECHNICAL BENZENEHEXACHLORIDE ... /CONTAINS/ 2-5% DELTA-BENZENEHEXACHLORIDE ...
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-239]**PEER REVIEWED**

Impurities:

Impurities of delta-hexachlorocyclohexane are the alpha, beta, gamma, eta, theta, epsilon, and iota isomers.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. V3 749]**PEER REVIEWED**

U. S. Production:

(1986) BHC is no longer produced in the US. /BHC/
[Farm Chemicals Handbook 1986. Willoughby, Ohio: Meister Publishing Co., 1986.,p. C-33]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

Determination of organochlorine pesticides in addition to polychlorinated biphenyls in the fat of Elbe River eels.
[Boek K; Lebensmittelchem Gerichtl Chem 38 (5): 117-19 (1984)]**PEER REVIEWED**

Analytic Laboratory Methods:

SEPARATION OF 6 ISOMERS OF HCH BY TLC ALONE: TIELEMANN H, Z CHEM 16: 155 (1976); & IN COMBINATION WITH GC: SZOKOLAY A ET AL, J CHROMATOGR 106: 401 (1975) ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 208 (1979)]**PEER REVIEWED**

DELTA-HCH WAS EXTRACTED FROM SOIL & DETERMINED BY ELECTRON-CAPTURE GAS CHROMATOGRAPHY AT 0.001-0.002 PPM, THE RECOVERY WAS 79-96%.
[WALISZEWSKI S, RZEPCZYNSKI M; FRESENIUS Z ANAL CHEM 301 (1): 32 (1980)]**PEER REVIEWED**

The determination of the delta isomer of benzene hexachloride in pesticide formulations is performed with infra red spectrophotometry. The specific isomer is separated by fractional crytstallization with carbon tetrachloride followed with chloroform. Preparation of purified sample is done with carbon disulfide and the transmittance is read at a wavelength of 13.22 um. Approximate concn are determined using standard and working curves.

[Association of Official Analytical Chemists. Official Methods of Analysis. 10th ed. and supplements. Washington, DC: Association of Official Analytical Chemists, 1965. New editions through 13th ed. plus supplements, 1982.p. 14/107 6.227]**PEER REVIEWED**

EPA Method 608: A gas chromatographic method for the analysis of delta-BHC in municipal and industrial discharges, consists of a glass column, 1.8 m x 4 mm, packed with Supelcoport (100/120 mesh) coated with 1.5% SP-2401, with electron capture detection, and a 5% methane/95% argon mixture as the carrier gas at a flow rate of 60 ml/min, is an EPA approved method. A sample injection volume of 2 to 5 ul is suggested, the column temperature is held isothermal at 200 deg C. This method has a detection limit of 0.009 ug/l and an overall precision of 0.25 times the average recovery + 0.03, over a working range of 0.5 to 30 ug/l.
[40 CFR 136 (7/1/85)]**PEER REVIEWED**

EPA Method 625: A gas chromatographic/mass spectrometry method for the analysis of delta-BHC in municipal and industrial discharges, consists of a glass column, 1.8 m x 2 mm ID, packed with Supelcoport (100/120 mesh) coated with 3% SP-2250, with the detection performed by the mass spectrometer, and helium as the carrier gas at a flow rate of 30 ml/min, is an EPA approved method. A sample injection volume of 2 to 5 ul is suggested, the column temperature is held isothermal at 50 deg C for 4 minutes and then programmed immediately at 8 deg/min to a final temperature of 270 deg C. This method has a detection limit of 3.1 ug/l and an overall precision of 0.93 times the average recovery - 0.17, over a working range of 5 to 1300 ug/l.
[40 CFR 136 (7/1/85)]**PEER REVIEWED**

Method 8081. Determination of Organochlorine Pesticides, Halowaxes, and PCBs as Aroclors by Capillary Column/Gas Chromatography.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September (1994)] **PEER REVIEWED**

Method 8081A. Organochlorine Pesticides in water by Narrow-Bore Capillary Column Gas Chromatography.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September (1994)] **PEER REVIEWED**

Method 8270B. Determination Semivolatile Organic compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September (1994)] **PEER REVIEWED**

Method 8270C. Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September (1994)] **PEER REVIEWED**

Method 3630B. Silica Gel Cleanup Method.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September (1994)] **PEER REVIEWED**

Method 3640A. Gel Permeation Chromatography (GPC) Cleanup Procedure.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September (1994)]
PEER REVIEWED

Method 8080A. Determination of Organochlorine Pesticides and Polychlorinated Biphenyls by Gas Chromatography.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September (1994)]
PEER REVIEWED

Method 8121. Determination of Chlorinated Hydrocarbons by Gas Chromatography: Capillary Column Technique.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September (1994)]
PEER REVIEWED

Method 8250A. Determination of Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September (1994)]
PEER REVIEWED

Special References:

Special Reports:

USEPA/OPTS; Suspended, Cancelled and Restricted Pesticides (1985)

USEPA; Ambient Water Quality Criteria Doc: Hexachlorocyclohexane (1980) EPA 440/5-80-054

DHHS/ATSDR; Toxicological Profile for Alpha-, Beta-, Gamma- and Delta-Hexachlororethane (Update) (1994) ATSDR/TP-93-09

Synonyms and Identifiers:

Related HSDB Records:

1606 [HEXACHLOROCYCLOHEXANES] (Mixture)

Synonyms:

DELTA-(AEEEEE)-1,2,3,4,5,6-HEXACHLOROCYCLOHEXANE
PEER REVIEWED

DELTA-BENZENEHEXACHLORIDE
PEER REVIEWED

DELTA-BHC
PEER REVIEWED

CYCLOHEXANE, DELTA-1,2,3,4,5,6-HEXACHLORO-

PEER REVIEWED

CYCLOHEXANE, 1,2,3,4,5,6-HEXACHLORO-, DELTA-ISOMER
PEER REVIEWED

ENT 9,234
PEER REVIEWED

DELTA-HCH
PEER REVIEWED

1-ALPHA,2-ALPHA,3-ALPHA,4-BETA,5-ALPHA,6-BETA-HEXACHLOROCYCLOHEXANE
PEER REVIEWED

DELTA-1,2,3,4,5,6-HEXACHLOROCYCLOHEXANE
PEER REVIEWED

Formulations/Preparations:

TECHNICAL BENZENEHEXACHLORIDE ... /CONTAINS/ 2-5% DELTA-BENZENEHEXACHLORIDE ...
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-239]**PEER REVIEWED**

Administrative Information:

Hazardous Substances Databank Number: 6184

Last Revision Date: 20021108

Last Review Date: Reviewed by SRP on 1/31/1999

Update History:

Complete Update on 11/08/2002, 1 field added/edited/deleted.
Complete Update on 02/13/2002, 1 field added/edited/deleted.
Complete Update on 01/14/2002, 1 field added/edited/deleted.
Complete Update on 08/09/2001, 1 field added/edited/deleted.
Complete Update on 05/16/2001, 1 field added/edited/deleted.
Complete Update on 05/15/2001, 1 field added/edited/deleted.
Complete Update on 09/12/2000, 1 field added/edited/deleted.
Complete Update on 06/12/2000, 1 field added/edited/deleted.
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Complete Update on 02/08/2000, 1 field added/edited/deleted.
Complete Update on 02/02/2000, 1 field added/edited/deleted.
Complete Update on 09/21/1999, 1 field added/edited/deleted.
Complete Update on 08/27/1999, 1 field added/edited/deleted.
Complete Update on 08/06/1999, 47 fields added/edited/deleted.
Field Update on 03/18/1999, 1 field added/edited/deleted.
Complete Update on 06/03/1998, 1 field added/edited/deleted.

Complete Update on 03/16/1998, 3 fields added/edited/deleted.
Field Update on 03/10/1998, 1 field added/edited/deleted.
Field Update on 11/01/1997, 1 field added/edited/deleted.
Field Update on 05/09/1997, 1 field added/edited/deleted.
Complete Update on 02/03/1997, 1 field added/edited/deleted.
Complete Update on 10/20/1996, 1 field added/edited/deleted.
Complete Update on 07/11/1996, 1 field added/edited/deleted.
Complete Update on 05/14/1996, 1 field added/edited/deleted.
Complete Update on 01/31/1996, 1 field added/edited/deleted.
Complete Update on 08/21/1995, 1 field added/edited/deleted.
Complete Update on 05/26/1995, 1 field added/edited/deleted.
Complete Update on 01/12/1995, 1 field added/edited/deleted.
Complete Update on 11/18/1994, 1 field added/edited/deleted.
Complete Update on 11/14/1994, 1 field added/edited/deleted.
Complete Update on 06/28/1994, 1 field added/edited/deleted.
Complete Update on 05/05/1994, 1 field added/edited/deleted.
Complete Update on 04/04/1994, 1 field added/edited/deleted.
Field update on 01/12/1993, 1 field added/edited/deleted.
Complete Update on 12/10/1992, 1 field added/edited/deleted.
Complete Update on 07/08/1991, 1 field added/edited/deleted.
Complete Update on 10/23/1990, 2 fields added/edited/deleted.
Field Update on 08/23/1990, 1 field added/edited/deleted.
Complete Update on 03/09/1985

Record Length: 96847

METHYL IODIDE

CASRN: 74-88-4

For other data, click on the Table of Contents

Human Health Effects:

Evidence for Carcinogenicity:

Evaluation: No epidemiological data relevant to the carcinogenicity of **methyl iodide** were available. There is limited evidence in experimental animals for the carcinogenicity of **methyl iodide.** Overall evaluation: **Methyl iodide** is not classifiable as to its carcinogenicity to humans (Group 3).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 71 1506 (1999)]**QC REVIEWED**

Human Toxicity Excerpts:

MAY PRODUCE SEVERE ... /SRP: CNS DEPRESSION/; LUNG IRRITATION FROM ACUTE EXPOSURE. PROLONGED CONTACT WITH SKIN CAN CAUSE VESICANT BURNS.
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 872]**PEER REVIEWED**

APPLICATION OF 1 ML ... UNDER GAUZE DRESSING TO SKIN OF VOLUNTEER FOR 1/2 HR PRODUCED ERYTHEMATOUS REACTION WITH VESICLES 19 HR AFTER APPLICATION ... .
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 251 (1977)]**PEER REVIEWED**

A 41 YR OLD CHEMIST DEVELOPED **METHYL IODIDE** INTOXICATION. CHARACTERISTICS OF **METHYL IODIDE** POISONING INCLUDE DELAY BETWEEN EXPOSURE & ONSET OF SYMPTOMS, EARLY SYSTEMIC TOXICITY WITH CONGESTIVE CHANGES IN LUNGS & OLIGURIC RENAL FAILURE, PROMINENT CEREBELLAR & PARKINSONIAN NEUROLOGIC SYMPTOMS AS WELL AS SEIZURES & COMA IN SEVERE CASES, & PSYCHIATRIC DISTURBANCES THAT LAST FROM MONTHS TO YEARS.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 250 (1977)]**PEER REVIEWED**

... FROM INHALATION OF VAPOR ... ONE PATIENT FELT WEAK & DIZZY, WALKING AS THOUGH DRUNK. ... /SRP: DIPLOPIA DEVELOPED HORIZONTALLY & VERTICALLY/ & HE STUMBLED OVER OBSTACLES ... INTERMITTENTLY HE THOUGHT HE COULD NOT SEE. ... 8 DAYS LATER EYES WERE ... FOUND NORMAL, & HE ... HAD NO FURTHER VISUAL TROUBLES.
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 620]**PEER REVIEWED**

/IN FATAL POISONING/ ONLY DESCRIPTION CONCERNING EYES WAS OF NYSTAGMOID MOVEMENTS & SLIGHT RIGHT INTERNAL STRABISMUS ... FUNDI ... SAID TO BE NORMAL. VISION WAS NOT EVALUATED.
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 620]**PEER REVIEWED**

Methyl iodide may cause nausea and vomiting, diarrhea, dizziness, slurred speech, visual disturbances, staggering, shaking, irritability, drowsiness, coma, and death. It may irritate the eyes and lungs. Contact with the liquid may cause irritation and blistering of the skin.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1] **PEER REVIEWED**

THERE ARE INDICATIONS OF LUNG IRRITATION & KIDNEY INVOLVEMENT FROM ACUTE EXPOSURES.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4031]**PEER REVIEWED**

Iodomethane acts as a poison attacking the skin, eyes and the CNS via inhalation, ingestion, eye and skin contact.
[Sittig, M. Handbook of Toxic And Hazardous Chemicals. Park Ridge, NJ: Noyes Data Corporation, 1981. 455]**PEER REVIEWED**

A CNS depressant.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4031]**PEER REVIEWED**

Methyl iodide induced DNA repair synthesis in cultured human lymphoblastoid cells, as measured by caesium chloride-gradient centrifugation.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V41 220 (1986)]**PEER REVIEWED**

/In/ a fatal case of poisoning in a worker exposed to **methyl iodide** fumes during its manufacture: severe neurological symptoms preceded death; all organs showed congestion at autopsy.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V41 221 (1986)]**PEER REVIEWED**

Non-fatal poisonings affecting workers in **methyl iodide** manufacture were characterized by the onset of neurological symptoms (such as vertigo, visual disturbances and weakness); these were followed by psychological disturbances and intellectual impairment, which had not been resolved entirely even after several months or years.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V41 221 (1986)]**PEER REVIEWED**

Massive exposure has led to pulmonary edema; prolonged or repeated exposure may cause CNS effects; prolonged contact may cause skin burns.
[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 957]**PEER REVIEWED**

/Researchers/ reported a fatal case of poisoning from **methyl iodide** in a chemical plant worker. The signs and symptoms included nausea, vomiting, diarrhea and oliguria, vertigo, slurred speech, visual disturbances, ataxia, tremor, irritability, drowsiness, and coma.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II,

III. Cincinnati, OH: ACGIH, 1991.1013]**PEER REVIEWED**

Human Toxicity Values:

LD50 Mouse sc 0.78 mmoles/kg
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1039]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Contact with the liquid may cause irritation ... of the skin.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1] **PEER REVIEWED**

Medical Surveillance:

Physical examination of workers for placement in operations involving possible exposure to these alkylating agents should include consideration of increased personal risk due to cigarette smoking, pregnancy, or treatment with steroids or cytotoxic agents. /Alkylating agents/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 122]**PEER REVIEWED**

IN HUMANS EXPOSED TO **METHYL IODIDE,** SERUM LIPID CONTENT, ESP THE TRIGLYCERIDE CONTENT WAS SHARPLY INCR, WITH NO APPARENT NERVOUS DISORDER. THUS, BLOOD EXAM, ESP SERUM LIPID, & FUNCTIONAL EXAM OF LIVER & KIDNEY, MAY BE USED FOR EARLY DETECTION OF **METHYL IODIDE** POISONING.
[HASEGAWA H ET AL; IND HEALTH 9 (1-2): 36-45 (1971)]**PEER REVIEWED**

Initial Medical Examination: A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the central nervous system should be stressed. The skin should be examined for evidence of chronic disorders. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1] **PEER REVIEWED**

Probable Routes of Human Exposure:

NIOSH (NOES Survey 1981-1983) has statistically estimated that 2182 workers (439 of these are female) are potentially exposed to **methyl iodide** in the US(1). Occupational exposure to **methyl iodide** may occur through inhalation and dermal contact with this compound at workplaces where it is produced or used(SRC). The general population may be exposed to **methyl iodide** via inhalation of ambient air or ingestion of food, primarily marine seafood(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983)]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** **METHYL IODIDE ***,** is relevant for this HSDB record chemical.

Life Support:

o This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE

0.2.1.1 ACUTE EXPOSURE

A. SYSTEMIC EFFECTS - **Methyl Iodide** is a strong narcotic and anesthetic. Massive exposure has led to pulmonary edema. Prolonged or repeated exposure may cause central nervous system effects. The latency period between exposure and onset of symptoms ranges from hours to days.

1. Initial symptoms are lethargy, somnolence, slurred speech, ataxia, dysmetria, and visual disturbances. Neurologic dysfunction may progress to convulsions, coma, and death.
2. If recovery occurs, neurologic findings recede over several weeks and are followed by psychiatric disturbances such as paranoia, delusions, and hallucination.
3. In severe poisoning, the primary target organs were the lungs, liver, kidney, and brain.

B. SKIN - A human skin irritant which may cause burns with repeated exposure.

0.2.3 VITAL SIGNS

0.2.3.1 ACUTE EXPOSURE

A. Dyspnea may occur due to pulmonary irritation.

0.2.4 HEENT

0.2.4.1 ACUTE EXPOSURE

A. Headache may occur after exposure. Diplopia and nystamus have been reported in serious poisonings. Animal exposures have demonstrated eye irritation and lacrimation.

0.2.6 RESPIRATORY

0.2.6.1 ACUTE EXPOSURE

A. Acute exposures may produce lung irritation leading to congestion and pulmonary edema.

0.2.7 NEUROLOGIC

0.2.7.1 ACUTE EXPOSURE

A. Irritability, headache, and syncope have been reported. Cerebellar and parkinsonian neurologic dysfunction may progress to paralysis, convulsions, coma, and death.

B. If recovery occurs, neurologic findings recede over several weeks and may be followed by psychiatric disturbances such as paranoia, delusions, and

hallucination.
0.2.8 GASTROINTESTINAL
0.2.8.1 ACUTE EXPOSURE
A. Nausea, vomiting, and diarrhea have been reported after exposure.
0.2.10 GENITOURINARY
0.2.10.1 ACUTE EXPOSURE
A. Acute exposures may produce oliguric renal failure.
0.2.14 DERMATOLOGIC
0.2.14.1 ACUTE EXPOSURE
A. Exposure to the liquid may produce erythema and blister the skin, especially with prolonged contact. Animal experiments have demonstrated depigmentation.
0.2.17 METABOLISM
0.2.17.1 ACUTE EXPOSURE
A. Human abnormalities not reported.
B. Animal experiments have demonstrated increased insulin, decreased plasma glucose, abnormal responses to glucose tolerance tests, elevated triglycerides and lipids, and changes in ATP, creatinine phosphate, lactate, phosphatidylserine and phosphatidylcholine in rabbit brain tissues.
0.2.20 REPRODUCTIVE HAZARDS
A. At the time of this review, no data were available to assess the teratogenic potential of this agent.
B. At the time of this review, no data were available to assess the potential effects of exposure to this agent during pregnancy or lactation.
0.2.21 CARCINOGENICITY
0.2.21.2 HUMAN OVERVIEW
A. **Methyl iodide** is a suspected carcinogen with experimental neoplastigenic and tumorigenic data. Human mutation data have been reported. The overall IARC evaluation is group 3 (agent is not classifiable as to its human carcinogenicity).
0.2.22 GENOTOXICITY
A. Experimentally, **methyl iodide** has been shown to be mutagenic, causing chromosomal and DNA alternations.

Laboratory:

A. Monitor pulse oximetry and/or ABGs, chest x-ray, and pulmonary function tests in symptomatic patients.
B. This agent may cause nephrotoxicity. Monitor renal function tests and urinalysis in patients with significant exposure.
C. Exposure to **methyl iodide** has increased serum lipids, especially triglycerides. A blood panel, especially of serum lipids, and liver and kidney function testing might be predictive of **methyl iodide** poisoning.
D. If respiratory tract irritation is present, monitor chest x-ray.

Treatment Overview:

0.4.2 ORAL EXPOSURE
A. There is no specific antidote. Care is symptomatic and supportive for CNS depression and skin, eye, pulmonary, and gastrointestinal irritation. Because of its irritant nature, emesis is NOT recommended. Dilution, followed by lavage and activated charcoal may be of some use in significant exposures.

B. DILUTION: Immediately dilute with 4 to 8 ounces (120 to 240 mL) of water (not to exceed 15 mL/kg in a child).
C. Significant esophageal or gastrointestinal tract irritation or burns may occur following ingestion. The possible benefit of early removal of some ingested material by cautious gastric lavage must be weighed against potential complications of bleeding or perforation.
1. GASTRIC LAVAGE: Consider after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation. Control any seizures first.
a. CONTRAINDICATIONS: Loss of airway protective reflexes or decreased level of consciousness in unintubated patients; following ingestion of corrosives; hydrocarbons (high aspiration potential); patients at risk of hemorrhage or gastrointestinal perforation; and trivial or non-toxic ingestion.
D. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.
E. SEIZURES: Administer a benzodiazepine IV; DIAZEPAM (ADULT: 5 to 10 mg, repeat every 10 to 15 min as needed. CHILD: 0.2 to 0.5 mg/kg, repeat every 5 min as needed) or LORAZEPAM (ADULT: 2 to 4 mg; CHILD: 0.05 to 0.1 mg/kg).
1. Consider phenobarbital if seizures recur after diazepam 30 mg (adults) or 10 mg (children > 5 years).
2. Monitor for hypotension, dysrhythmias, respiratory depression, and need for endotracheal intubation. Evaluate for hypoglycemia, electrolyte disturbances, hypoxia.

0.4.3 INHALATION EXPOSURE

A. INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids.
B. INHALATION: Administer oxygen. If respiratory symptoms develop obtain chest x-ray, monitor pulse oximetry and/or blood gases. Treat bronchospasm with inhaled beta agonists. If acute lung injury develops, consider PEEP. Evaluate for esophageal, dermal and eye burns as indicated.
C. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.

0.4.4 EYE EXPOSURE

A. MEDICAL FACILITY: Irrigate with sterile 0.9% saline for at least an hour or until the cul-de-sacs are free of particulate matter and returned to neutrality (confirm with pH paper).
B. EYE ASSESSMENT: The extent of eye injury (degree of

corneal opacification and perilimbal whitening) may not be apparent for 48 to 72 hours after the burn.
C. EYE DAMAGE TREATMENT: If ocular damage is minor, topical mydriatics, antibiotics and systemic analgesics may be sufficient. For grade 3 to 4 injuries one or more of the following may be considered, only with ophthalmologic consultation: acetazolamide, timolol, topical steroids, ascorbate, citrate, tetracycline, or soft contact lenses.

0.4.5 DERMAL EXPOSURE
A. DECONTAMINATION: Remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician may need to examine the area if irritation or pain persists.
B. Treat dermal irritation or burns with standard topical therapy. Patients developing dermal hypersensitivity reactions may require treatment with systemic or topical corticosteroids or antihistamines.

Range of Toxicity:

A. The minimum lethal human dose to this agent has not been delineated.
B. The maximum tolerated human exposure to this agent has not been delineated.
C. The following lethal doses have been reported in animal studies:
1. ORAL - Single oral doses of 70 milligrams per kilogram were lethal to rabbits, but several oral doses of 50 milligrams per kilogram were necessary before they caused death.
2. INHALATION - Inhalation of 54 parts per million (0.31 milligrams per liter) was fatal to mice within 24 hours.
D. The following nontoxic doses have been reported in animal studies:
1. ORAL - Repeated oral doses of 30 to 50 mg/kg of **methyl iodide** were without effect in mice.

SYNDROME

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

Flush eyes thoroughly with water and wash contaminated areas of body with soap and water. Treat skin burns as usual.
[ITII. Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1988. 340]**PEER REVIEWED**

Animal Toxicity Studies:

Evidence for Carcinogenicity:

Evaluation: No epidemiological data relevant to the carcinogenicity of **methyl iodide** were available. There is limited evidence in experimental animals for the carcinogenicity of **methyl iodide.** Overall evaluation: **Methyl iodide** is not classifiable as to its carcinogenicity to humans (Group 3).

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 71 1506 (1999)]**QC REVIEWED**

Non-Human Toxicity Excerpts:

... /AFTER/ 15 MIN EXPOSURE TO 22 MG/L IN AIR (3790 PPM). RATS DIED WITHIN ... 11 DAYS. LUNG IRRITATION & PULMONARY EDEMA /WERE NOTED AT NECROPSY/.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4031]**PEER REVIEWED**

EXPOSURE OF MICE TO ... LETHAL CNCN OF VAPOR (25-85 MG/L OF AIR) ... CAUSED IMMEDIATE IRRITATION OF EYES ... EXPOSURE TO ... 5 MG/L OF AIR FOR 10 MIN CAUSED NO SIGNS OF IRRITATION OF EYES IN MOST ANIMALS, ALTHOUGH ALL DIED WITHIN NEXT DAY.
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 620]**PEER REVIEWED**

... **METHYL IODIDE** IS MUTAGENIC TO SALMONELLA TYPHIMURIUM TA100 WHEN PLATES ARE EXPOSED TO VAPORS ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 250 (1977)]**PEER REVIEWED**

THE EFFECT OF **METHYL IODIDE** ON NERVOUS SYSTEM OF POISONED RABBITS WAS MANIFESTED BY INCREASE SUSCEPTIBILITY TO D-TUBOCURARINE. METABOLIC DISTURBANCES OF ATP, CREATININE PHOSPHATE, LACTATE, PHOSPHATIDYLSERINE & PHOSPHATIDYLCHOLINE WERE OBSERVED IN BRAIN TISSUES. MOST SERIOUS EFFECT ON BLOOD SYSTEM WAS MARKED INCR OF SERUM TRIGLYCERIDE.
[HASEGAWA H ET AL; IND HEALTH 9 (1-2): 36-45 (1971)]**PEER REVIEWED**

/**Iodomethane**/ (57 mg/kg/day) was administered sc to male rabbits on two successive days ... induced a marked hyperlipidemia ... /with an/ 11-fold incr in very low density lipoproteins and a three-fold incr in low-density lipoproteins ... /along with an/ enhancement of triglyceride production ... /and an/ incr insulin resistance, and hyperinsulinemia were also observed ...
[Matsui H et al; Toxicol Appl Pharmacol 65 (2): 245-9 (1982)]**PEER REVIEWED**

/**Iodomethane**/ had little influence on the productivity /of adults of Trogoderma granarium following fumigation of the larvae/.
[Rajendran S; Bull Entomol Res 72 (2): 247-51 (1982)]**PEER REVIEWED**

... **Iodomethane** is generally regarded to be carcinogenic in animals.
[USEPA; Ambient Water Quality Criteria Doc: Halomethanes p.C-59 (1980) EPA 442/5-80-051]**PEER REVIEWED**

The relative toxicity of 7 fumigants to the 4 life cycle stages of Callosobruchus chinensis (a pest of stored cowpeas) was determined in the laboratory. Their relative toxicities to all stages of the insect were phosphine > **methyl iodide** > acrylonitrile > methyl bromide > ethylene dibromide > methyl formate > ethyl formate.
[Adu OO, Muthu M; Insect Sci Appl 6 (1): 75-8 (1985)]**PEER REVIEWED**

A simple rapid determination of glutathione (GSH) and cytoplasmic protein bound SH groups (PBSH),

appropriate to study their relationship in tissues, in rat liver, kidney, and testis was developed. Hepatic glutathione and protein bound SH were measured after treatment with **methyl iodide (**400, 800 mg/kg, after 0.5 hr). ... **Methyl iodide ...** showed a decrease of glutathione and protein bound SH.
[Di Simplicio P et al; Boll Soc Ital Biol Sper 60 (6): 1161-7 (1984)]**PEER REVIEWED**

Blood and liver glutathione levels were measured under the effect of an acute exposure to high doses of glutathione-depleting substances. Among direct-acting glutathione-depleting substances, diethyl maleate (0.3, 0.7, and 1.4 ml/kg) caused a marked reduction of both blood and liver glutathione, whereas **methyl iodide (**320 mg/kg) led to a decrease in liver glutathione stores immediately and in blood stores with a longer latency.
[Di Simplicio P et al; J Appl Toxicol 4 (5): 227-9 (1984)]**PEER REVIEWED**

The monohalomethanes are alkylating agents and thus have generated concern as to their potential for inducing mutations and cancer. All compounds tested were found to be direct acting mutagens in the Ames test. They also demonstrated the ability to produce cancer in mice and rats. ... On the basis of these data, NIOSH recommends that ... **methyl iodide** be considered as a potential occupational carcinogen.
[NIOSH; Monohalomethanes: Methyl Chloride, Methyl Bromide, Methyl Iodide. p.22 (9/27/84)]**PEER REVIEWED**

Depigmentation was produced in mice intradermally injected with nitrogen mustard. The effect in C57 black mice was greater than in CBA brown mice, the females being more sensitive than males. Other alkylating agents which caused depigmentation were ... **methyl iodide (**50 ug). ... Depigmentation was also seen after intradermal injection of known tumor promoters and phenols; however, it was not caused by carcinogens which required metabolic activation even following pretreatment with phenobarbitone or methylcholanthrene to enhance such activation.
[Aw TC, Boyland E; IRCS Med Sci Libr Compend 9 (1): 29-30 (1981)]**PEER REVIEWED**

The quantitation of newly induced trifluorothymidine resistant and 6-thioguanine resistant mutants in TK + or - -3.7.2(C) mouse lymphoma cells was analyzed using conventional soft agar cloning and a newly developed technique that allowed for the sequestering, expression, and selection of mutants in Linbro wells. The conventional method of cloning in semi-soft agar supplemented nutrient medium provided maximum mutant frequencies at 1-3 days posttreatment for trifluorothymidine resistance and 5-8 days for 6-thioguanine resistance. The length of time required to reach maximum expression was mutagen- and dose-dependent. Following complete expression, TK-deficient mutants induced by **iodomethane** declined in frequency.
[Moore MM, Clive D; Environ Mutagen 4 (4): 499-519 (1982)]**PEER REVIEWED**

Chemical mutagens including **iodomethane** have been classified as chromosomal mutagens in a L5178Y/thymidine kinase gene mutation assay. ... /The researchers/ observed mutagen-dependent increases in small thymidine kinase-deficient mutant colonies with detectable damage to the chromosome that carries the thymidine kinase locus. In this study, /the authors/ tested these ... chemicals for the induction of gene mutations at the ouabain-resistance (ouares) locus of 3.7.2(C) L5178Y cells to determine if presumptive chromosomal mutagens would go undetected at a gene locus that is unresponsive to chromosomal damage. A final concentration of 375 micrograms/ml ouabain in soft-agar medium selected against the ouabain-sensitive phenotype without loss of the mutagen-induced ouabain-resistant phenotype. Verification of the mutant phenotype was completed for six individual soft-agar ouares colonies derived from mutagen-treated cultures via growth for 10-11 days in nonselective medium followed by retesting for colony formation in selective soft-agar medium. Dose-related reproducible increases in the frequency of ouabain-resistant mutants were observed for 3.7.2(C) L5178Y cells that had been exposed for 3 hr to 1.9-3.6 ug/ml iodomehtane.

[Amacher DE, Dunn EM; Environ Mutagen 7 (4): 523-33 (1985)]**PEER REVIEWED**

Groups of BD rats (substrain and sex unspecified), about 100 days old, received weekly subcutaneous injections of 10 (16 animals) or 20 mg/kg body weight (eight animals) **methyl iodide (**purity unspecified) in arachis oil for about one year (total dose, 500 or 900 mg/kg body weight), or a single subcutaneous injection of 50 mg/kg body weight (14 animals), and were observed for life. Four and two animals in the first two groups, respectively, died of pneumonia. Subcutaneous sarcomas occurred in 9/12 rats injected with 10 mg/kg body weight, in 6/6 rats injected with 20 mg/kg body weight and in 4/14 rats given a single injection of 50 mg/kg body weight. No subcutaneous tumor was reported to have occurred in control rats ... injected with arachis oil alone. Local tumors occurred more than one year after the first injection; histologically, these were fibrosarcomas and spindle-cell and round-cell sarcomas. In most cases ... pulmonary and lymph-node metastases were observed.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V41 218 (1986)]**PEER REVIEWED**

Groups of 10 male and 10 female A/He mice, six to eight weeks old, were injected intraperitoneally thrice weekly with three dose levels (the highest being the maximum tolerated dose) of **methyl iodide (**> 98% pure) in tricapyrylin for a total of 24 injections (total doses, 8.5, 21.3 and 44.0 mg/kg body weight). A group of 30 untreated mice and a group of 160 tricaprylin-treated mice were used as controls. All survivors were killed 24 weeks after the first injection. Survival was 29/30 and 154/160 in the untreated and vehicle-treated control groups and 19/20 in the low-dose, 20/20 in the mid-dose and 11/20 in the higher dose groups. Proportions of mice with lung tumors were 6/29, 34/154, 4/19, 6/20 and 5/11 in the five groups, respectively (p= 0.048; one sided Cochran-Armitage trend test using vehicle controls only). Average numbers of lung tumors per mouse were 0.21, 0.22, 0.21, 0.30 and 0.55. In positive-control groups receiving a single intraperitoneal injection of 10 or 20 mg urethane, all animals developed lung tumors; the average number of lung tumors per animal was 8.1 in the low-dose and 17.8 in the high-dose group.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 41 218 (1986)]**PEER REVIEWED**

Toxic effects ... observed after exposure to **methyl iodide** include /SRP: CNS depression/, congestion of the lungs, and liver and kidney damage. No death was observed after daily administration of oral doses of 30-50 mg/kg body weight **methyl iodide** to rats on five days per week for a month.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V41 219 (1986)]**PEER REVIEWED**

Oral administration to rats of **methyl iodide** reduced nonprotein thiol concentrations in liver and kidney.

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V41 219 (1986)]**PEER REVIEWED**

Methyl iodide induces DNA damage and is mutagenic to bacteria in the presence or absence of an exogenous metabolic system. It induces mitotic recombination in yeast. It induces transformation in Syrian hamster embryo cells but not in C3H 10T1/2 cells.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V41 222 (1986)]**PEER REVIEWED**

Iodomethane injected sc into rabbits elevated the basal levels of glucagon and insulin, decreased the

response of plasma glucose to injected insulin, and produced abnormal responses in a glucose-tolerance test. With regard to the latter, an iv injection of glucose into the treated animals produced a biphasic increase in plasma glucose, an increase in plasma insulin greater than that of controls, and an increase in glucagon not seen in controls. Thus, **iodomethane** resulted in disturbances in the mechanisms regulating carbohydrate metabolism.
[Matsui H et al; Horm Metab Res 14 (12): 676-7 (1982)]**PEER REVIEWED**

Male rabbits were injected sc with 57 mg/kg of **methyl iodide** for 2 days and their lipid metabolism was examined 48 hr after the last injection. The plasma triglyceride levels increased from the preinjection average of 56.1 mg/dl to 246.0 mg/dl. Analysis of the lipoprotein profile of plasma showed a significant increase of very-low-density lipoproteins. The rate of triglyceride secretion into plasma, measured by Triton WR 1339 injection method, was significantly higher in the animals treated with **methyl iodide** than in the controls. Histological examination of the liver showed diffuse fat deposits in the hepatocytes without any destructive and inflammatory changes. Thus, hyperlipidemia and fatty liver of rabbits induced by **methyl iodide** was related to the elevation of triglyceride synthesis and its secretion in the liver.
[Matsui H et al; Sangyo Igaku 24 (1): 85-9 (1982)]**PEER REVIEWED**

Methyl iodide induces ... mutations in cultured mammalian cells.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V41 222 (1986)]**PEER REVIEWED**

... **Methyl iodide** /is/ about six times as acutely toxic as methyl bromide to mice; the minimal fatal dose with 24 hr exposure being about 75 ppm. ... Ten times as acutely toxic as carbon tetrachloride.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1013]**PEER REVIEWED**

Non-Human Toxicity Values:

LCLO Mouse inhalation 78,693 ppm/10 min.
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 855]**PEER REVIEWED**

LCLO Mouse inhalation 18,109 ppm/30 min
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 855]**PEER REVIEWED**

LD50 RAT ORAL 76 MG/KG.
[JOHNSON MK; BIOCHEM J 98 (1): 38-43 (1966)]**PEER REVIEWED**

LC50 Mouse inhalation 5 mg/l/57 min
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4031]**PEER REVIEWED**

LC50 Rat ihl 1300 mg/cu m/4 hr
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2252]**PEER REVIEWED**

LD50 Rat ip 101 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-

3. New York, NY: Van Nostrand Reinhold, 1996. 2252]**PEER REVIEWED**

LD50 Rat sc 110 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2252]**PEER REVIEWED**

LD50 Mouse ip 172 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2252]**PEER REVIEWED**

LD50 Mouse sc 110 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2252]**PEER REVIEWED**

LD50 Guinea pig ip 51 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2252]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

ORAL DOSES OF **IODOMETHANE** TO RATS WERE RAPIDLY CONVERTED INTO S-METHYLGLUTATHIONE IN LIVER & EXCRETED IN BILE. IT WAS DEGRADED TO S-METHYLCYSTEINE BY KIDNEY HOMOGENATES. ONLY A SMALL PROPORTION OF THE DOSE OF **IODOMETHANE** OR ITS METABOLITE, S-METHYLCYSTEINE, WAS EXCRETED AS A CMPD RELATED TO METHYLMERCAPTURIC ACID.
[JOHNSON MK; BIOCHEM J 98 (1): 38-43 (1966)]**PEER REVIEWED**

Urinary metabolites (2 percent of the total dose) detected after subcutaneous injection of rats with 50 mg/kg body weight **methyl iodide** were S-methylcysteine, N-acetyl-S-methylcysteine, S-methylthio-acetic acid and N-(methylthioacetyl)glycine. ... S-Methylglutathione was isolated from livers of rats treated orally with 90 mg/kg body weight **methyl iodide;** approximately 25% of an oral dose of 50 mg/kg body weight was excreted into the bile as S-methylglutathione. ... Liver and kidney homogenates catalyzed the disappearance of **methyl iodide** in the presence of glutathione ... . S-Methylglutathione was converted to S-methylcysteine by kidney homogenate.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V41 219 (1986)]**PEER REVIEWED**

Methyl iodide reacted in vitro with 4-(para-nitrobenzyl)pyridine and N-7-deoxy- guanosine.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V41 219 (1986)]**PEER REVIEWED**

After inhalation of trace amounts of I-**methyl iodide,** the disappearance of radioactivity from the plasma, uptake in the thyroid and excretion in the urine resembled that of orally administered inorganic iodide.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V41 221 (1986)]**PEER REVIEWED**

Absorption, Distribution & Excretion:

RETENTION OF INHALED (132)I-**METHYL IODIDE** IN 18 VOLUNTEERS RANGED FROM 43-92%, WITH MEAN OF 72% OF AMT INHALED; LEVEL WAS HIGHLY DEPENDENT ON RESP RATE, LOW RATES ... ASSOC WITH HIGH RETENTION & VICE VERSA ... INHALED (132)I-**METHYL IODIDE** WAS RAPIDLY CLEARED FROM LUNGS OF 4 VOLUNTEERS & BROKEN DOWN TO RELEASE IODIDE ION.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 251 (1977)]**PEER REVIEWED**

ORALLY ADMIN **METHYL IODIDE** WAS ... EXCRETED IN BILE OF RAT (22-28% OF 50 MG/KG BODY WT DOSE) ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 250 (1977)]**PEER REVIEWED**

IN POISONED RABBITS **METHYL IODIDE** WAS FOUND IN BRAIN, LIVER & KIDNEYS.
[HASEGAWA H ET AL; IND HEALTH 9 (1-2): 36-45 (1971)]**PEER REVIEWED**

Approximately 1% of an oral dose of 76 mg/kg body weight **methyl iodide** given to rats was expired unchanged within 30 min of administration.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V41 219 (1986)]**PEER REVIEWED**

Mechanism of Action:

Toxicologic and metabolic similarities among the monohalomethanes (chloride, bromide, iodide substituted) suggest a common mechanism of toxic action, probably methylation and disturbance or inactivation of essential proteins (rather than presence of the parent compound or free halide per se).
[USEPA/OTS; Investigation of Selected Potential Environmental Contaminants: Monohalomethanes (1977) EPA 560/2-77-007 as cited in USEPA; Ambient Water Quality Criteria Doc: Halomethanes p.C-30 (1980) EPA 442/5-80-051]**PEER REVIEWED**

Interactions:

... SYNERGIZES TOXICITY OF FENITROTHION ELEVEN FOLD & DICHLOROVOS TWO FOLD /IN MOUSE LIVER/.
[The Chemical Society. Foreign Compound Metabolism in Mammals. Volume 2: A Review of the Literature Published Between 1970 and 1971. London: The Chemical Society, 1972. 390]**PEER REVIEWED**

S-Methyl-N-acetylpenicillamine, S-methylthiol, and S-methylcysteine, as well as **iodomethane** decreased biliary excretion of methylmercury markedly. Excretion of sulfhydryl in bile was not influenced by S-methylcysteine, S-methylthiol, S-methyl-N-acetylpenicillamine or a low dose of **iodomethane** (0.5 mmol/kg). This indicated that coupling of methylmercury to glutathione in the liver before biliary excretion was glutathione S-transferase-dependent reaction and the methylthiols tested, or metabolites of these compounds were likely to be inhibitors of S-transferase. The effect of S-methylcysteine and low doses of **iodomethane** (1 mmol/kg) seem to deplete the liver of reduced glutathione through S-methylation as illustrated by decreased biliary excretion of sulfhydryl.
[Refsvik T; Acta Pharmacol Toxicol 53 (2): 153-8 (1983)]**PEER REVIEWED**

Pharmacology:

Interactions:

... SYNERGIZES TOXICITY OF FENITROTHION ELEVEN FOLD & DICHLOROVOS TWO FOLD /IN MOUSE LIVER/.
[The Chemical Society. Foreign Compound Metabolism in Mammals. Volume 2: A Review of the Literature Published Between 1970 and 1971. London: The Chemical Society, 1972. 390]**PEER REVIEWED**

S-Methyl-N-acetylpenicillamine, S-methylthiol, and S-methylcysteine, as well as **iodomethane** decreased biliary excretion of methylmercury markedly. Excretion of sulfhydryl in bile was not influenced by S-methylcysteine, S-methylthiol, S-methyl-N-acetylpenicillamine or a low dose of **iodomethane** (0.5 mmol/kg). This indicated that coupling of methylmercury to glutathione in the liver before biliary excretion was glutathione S-transferase-dependent reaction and the methylthiols tested, or metabolites of these compounds were likely to be inhibitors of S-transferase. The effect of S-methylcysteine and low doses of **iodomethane** (1 mmol/kg) seem to deplete the liver of reduced glutathione through S-methylation as illustrated by decreased biliary excretion of sulfhydryl.
[Refsvik T; Acta Pharmacol Toxicol 53 (2): 153-8 (1983)]**PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Methyl iodide is produced by marine macroalgae and the ocean is thought to be a major source of **methyl iodide.** Anthropogenic sources of **methyl iodide** resulting from its use as a methylating agent are minor compared with biogenic ones. If released to air, a vapor pressure of 405 mm Hg at 25 deg C indicates **methyl iodide** will exist solely as a vapor in the ambient atmosphere. **Methyl iodide** will degrade in the atmosphere primarily as a result of photolysis. Its photolytic half-life is 2.8 to 5.5 days. By comparison, its half-life as a result of reaction with photochemically-produced hydroxyl radicals is about is about 220 days. If released to soil, **methyl iodide** is expected to have very high mobility based upon an estimated Koc of 14. Volatilization from moist soil surfaces is expected to be an important fate process based upon an estimated Henry's Law constant of 0.00526 atm-cu m/mole. **Methyl iodide** should volatilize from dry soil surfaces based upon its vapor pressure. Ninety-four percent of **methyl iodide** applied 30 cm below the surface of a soil column was lost through volatilization. Abiotic degradation will occur as a result of hydrolysis and reaction with nucleophilic ions such as chloride ions. The half-life of **methyl iodide** in soils that were rich in organic matter was 9-13 days, while in a sandy loam soil it was 42-63 days. If released into water, **methyl iodide** is not expected to adsorb to suspended solids and sediment based upon the estimated Koc. Volatilization from water surfaces is expected to be an important fate process based upon this compound's estimated Henry's Law constant. Estimated volatilization half-lives for a model river and model lake are 1.3 hours and 4.8 days, respectively. **Methyl iodide** hydrolyzes slowly in water with a half-life of 110-251 days at 20-25 deg C in fresh water. In seawater, it reacts with chloride ions and has a half-life of 20 and 58 days at 19.2 and 10.8 deg C, respectively. An estimated BCF of 2.9 suggests that the potential for bioconcentration in aquatic organisms is low. Monitoring data indicate that the general population may be exposed to **methyl iodide** from the ambient air and from ingesting seafood from the ocean. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

NIOSH (NOES Survey 1981-1983) has statistically estimated that 2182 workers (439 of these are female) are potentially exposed to **methyl iodide** in the US(1). Occupational exposure to **methyl iodide** may occur through inhalation and dermal contact with this compound at workplaces where it is

produced or used(SRC). The general population may be exposed to **methyl iodide** via inhalation of ambient air or ingestion of food, primarily marine seafood(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983)]**PEER REVIEWED**

Natural Pollution Sources:

Methyl iodide is formed in the sea as a natural product of marine algae; its estimated annual world production is 4X10+10 kg(1). **Methyl iodide** production rates of varieties of brown (both kelps and nonkelps), red and green marine microalgae have been measured in the laboratory and estimates of oceanic production of **methyl iodide** made from these production rates(3). As with previous extrapolations, **methyl iodide** production rates fail to account for estimated oceanic strengths of the chemical. It is suggested that indirect production of **methyl iodide** via microbial decay of seaweed iodocarbons may fill this gap(3). However, another investigator pointed out that this additional source is much too small(4). Another explanation is that the results of halocarbon production by algae in the laboratory cannot be extended to natural mixed populations. In addition to oceanic emissions, biomass burning has been identified as a minor secondary source of **methyl iodide(**2).
[(1) IARC; Some Fumigants, the Herbicides, 2,4-D and 2,4,5-T, Chlorinated Dibenzodioxins and Miscellaneous Industrial Chemicals; 15: 245-54 (1977) (2) Blake NJ et al; J Geophys Res 102: 28315-31 (1997) (3) Manley SL et al; Limnol Oceanogr 37: 1652-9 (1992) (4) Moore RM, Tokarczyk R; Global Biogeochemical Cycles 7: 195-210 (1993)]**PEER REVIEWED**

Artificial Pollution Sources:

Methyl iodide's production and use as a methylating agent and in organic synthesis(1) may result in its release to the environment through various waste streams. **Methyl iodide** can be formed in the environment of nuclear reactors and vented in exhaust gases(1). Anthropogenic sources have not been identified as major contributors of **methyl iodide** emissions(2). However, **methyl iodide** has been suggested as a replacement for methyl bromide as a soil fumigant(3).
[(1) IARC; Some Fumigants, the Herbicides, 2,4-D and 2,4,5-T, Chlorinated Dibenzodioxins and Miscellaneous Industrial Chemical 15: 245-54 (1977) (2) Moore RM, Tokarczyk R; Global Biogeochemical Cycles 7: 195-210 (1993) (3) Gan J et al; J Environ Qual 26: 1107-15 (1997)]**PEER REVIEWED**

Environmental Fate:

TERRESTRIAL FATE: Based on a classification scheme(1), an estimated Koc value of 14(SRC), determined from a structure estimation method(2), indicates that **methyl iodide** should have very high mobility in soil(SRC). Volatilization of **methyl iodide** from moist soil surfaces is expected to be an important fate process(SRC) given a Henry's Law constant of 0.00526 atm-cu m/mole at 25 deg C(3). The potential for volatilization of **methyl iodide** from dry soil surfaces may exist based upon a vapor pressure of 405 mm Hg(4). Cumulative volatilization losses of **methyl iodide,** applied at 30 cm, from 60-cm soil columns packed with a sandy loam soil ranged from 94% when the soil was untarped to 75% with a high-barrier tarp(5). Volatilization losses were significantly lower, 38% and 53%, from soils high in organic matter and capable of rapidly degrading the chemical. Ten days after **methyl iodide** was applied to field plots (30 cm depth) covered with a polyethylene film, **methyl iodide** was detected at most depths(5). It was concluded that should the water table be shallow and the degradation rate in soil low, **methyl iodide** may leach into ground water(5). **Methyl iodide** abiotically degrades in soil by hydrolysis and reaction with chloride ions, HS- and other nucleophiles(6). The half-life of **methyl iodide** in soils that were rich in organic matter was 9-13 days, while in a sandy loam soil it was 42-63 days. The organic-rich soils were thought to contain more nucleophiles with which **methyl iodide** could react(6).

[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Meylan WM et al; Environ Sci Technol 26: 1560-67 (1992) (3) Hunter-Smith RJ et al; Tellus Ser B B35: 170-6 (1983) (4) Boublik T et al; The Vapour Pressures of Purse Substances. 2nd Rev Ed, Amsterdam: Elsevier p. 51 (1984) (5) Gan J et al; J Environ Qual 26: 1107-15 (1997) (6) Gan J, Yates SR; J Agric Food Chem 44: 4001-8 (1996)]**PEER REVIEWED**

AQUATIC FATE: Based on a classification scheme(1), an estimated Koc value of 14(SRC), determined from an estimation method(2), indicates that **methyl iodide** is not expected to adsorb to suspended solids and sediment in water(SRC). Volatilization from water surfaces is expected(3) based upon a Henry's Law constant of 0.00526 atm-cu m/mole at 25 deg C(4). Using this Henry's Law constant and an estimation method(3), volatilization half-lives for a model river and model lake are 1.3 hours and 4.8 days, respectively(SRC). **Methyl iodide** hydrolyses slowly in water with a half-life of 110-251 days at 20-25 deg C(8,9). It reacts with chloride ions in seawater in which its half-life is 20 and 58 days at 19.2 and 10.8 deg C, respectively(8). According to a classification scheme(5), an estimated BCF of 2.9 (SRC), from its log Kow of 1.51(6) and a regression-derived equation(7), suggests the potential for bioconcentration in aquatic organisms is low.
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Meylan WM et al; Environ Sci Technol 26: 1560-67 (1992) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9, 15-1 to 15-29 (1990) (4) Hunter-Smith RJ et al; Tellus Ser B B35: 170-6 (1983) (5) Franke C et al; Chemosphere 29: 1501-14 (1994) (6) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 3 (1995) (7) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999) (8) Zafiriou OC; J Mar Res 33: 75-81 (1975) (9) Mabey W, Mill T; J Chem Ref Data 7: 383-415 (1978)]**PEER REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), **methyl iodide,** which has a vapor pressure of 405 mm Hg at 25 deg C (2), is expected to exist solely as a vapor in the ambient atmosphere. Vapor-phase **methyl iodide** is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals(SRC); the half-life for this reaction in air is estimated to be 220 days(SRC), from its rate constant of 7.20X10-14 cu cm/molecule-sec at 25 deg C(3). However the major loss process for **methyl iodide** in the atmosphere is direct photolysis. The half-life of this reaction is 2.8-5.5 days(3,4). Physical removal of **methyl iodide** from air may occur via wet deposition since **methyl iodide** is relatively soluble in water (SRC).
[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Boublik T et al; The Vapour Pressures of Purse Substances. 2nd Rev Ed, Amsterdam: Elsevier (1984) (3) Brown AC et al; Atmos Environ 24A: 361-7 (1990) (4) Zafirious OC; J Geophys Res 79: 2730-2 (1974)]**PEER REVIEWED**

Environmental Abiotic Degradation:

Methyl iodide hydrolyses slowly in water yielding methanol(2). The half-life under neutral conditions is 110-251 days at 20-25 deg C(1,2), increasing to 4 yr and 23 yr at 10 and 0 deg C respectively(1). More recent measurements yielded a unimolecular hydrolysis rate constant of 7.1X10-8 1/sec at 25 deg C(6). This is equivalent to a half-life of 110 days(SRC). A base-catalyzed reaction is only important at higher pH's than are observed in the environment(2). However, **methyl iodide** is unstable in seawater, reacting primarily with the chloride ion to form methyl chloride(1). The half-life in seawater of 19.8 parts/thousand chlorinity is 20 and 58 days at 19.2 and 10.8 deg C, respectively(1). More recent studies of the reaction of chloride with **methyl iodide** reports rate constants for both seawater (33.3 parts/thousand chlorinity) and 0.5 M NaCl in distilled water of 1.0X10-6 L/mol-sec(7). The rate in NaCl corresponds to a half-life of 16 days. **Methyl iodide** absorbs UV radiation up to approximately 340 nm and photolyses(3). Photolysis occurs in both the gas phase and in solution. In water photohydrolysis

occurs forming methanol and iodide ions; in air, iodine is formed(8). When irradiated in pure air (relative humidity 50%), **methyl iodide's** half-life was 7 hr(4); with added NO2 its half-life was a little over 3 hr(5). The dissipation half-life of **methyl iodide** from open surface water (30 cm-deep tank) with sunlight irradiation was 26 hours compared with 29 hours indoors. At the end of 6 days, 3.1% of the **methyl iodide** was recovered as I-; no iodine was detected(8). It was concluded that photodegradation was a minor loss mechanism compared with volatilization.
[(1) Zafiriou OC; J Mar Res 33: 75-81 (1975) (2) Mabey W, Mill T; J Chem Ref Data 7: 383-415 (1978) (3) Calvert JG, Pitts JM Jr; Photochemistry. NY, NY: John Wiley and Sons pp. 522-8 (1966) (4) Lillian D et al; Amer Chem Soc Symp Ser 17: 152-8 (1975) (5) Lillian D et al; Environ Sci Technol 9: 1042-8 (1975) (6) Elliott S, Rowland FS; J. Atmos Chem 20: 229-36 (1995) (7) Elliott S, Rowland FS; Geophys Res Let 20: 1043-6 (1993) (8) Gan J, Yates SR; J Agric Food Chem 44: 4001-8 (1996)] **PEER REVIEWED**

The rate constant for the vapor-phase reaction of **methyl iodide** with photochemically-produced hydroxyl radicals is 7.20X10-14 cu cm/molecule-sec at 25 deg C(1,2). This corresponds to an atmospheric half-life of about 220 days at an atmospheric concentration of 5X10+5 hydroxyl radicals per cu cm(1). The major reaction pathway should give rise to CH2I radicals and water(2). A pathway leading to the formation of CH3 radicals and HOI is expected to occur, but to a lesser extent(2). The reaction of **methyl iodide** with hydroxyl radicals is low compared with the photolysis of **methyl iodide,** whose half-life of 2.8-5.5 days(2,3). Therefore reaction with hydroxyl radicals is a minor tropospheric process compared with photolysis. The rate constant for the vapor-phase reaction of **methyl iodide** with nitrate radicals is 1.92X10-17 cu cm/molecule-sec at room temperature(4). This corresponds to an atmospheric half-life of about 4.8 yrs(SRC) at an atmospheric concentration of 2.4X10+8 nitrate radicals per cu cm(5).
[(1) Atkinson R; J Chem Phys Ref Data Monograph 1 (1989) (2) Brown AC et al; Atmos Environ 24A 361-7 (1990) (3) Zafirious OC; J Geophys Res 79: 2730-2 (1974) (4) Carlier P et al; Risol Natl Lab Issrisoe-M-2630. Gasohase Tropospheric NOX Chem-Gasphase multiphase aspects pp.133-41 (1988) (5) Atkinson R; Atmos Environ 24A:1-41 (1990)]**PEER REVIEWED**

Based upon an experimentally determined rate constant of 7.6X10-4/hr, the half-life for the reaction with hydrated electrons (produced by photochemical reaction with dissolved organic matter in water) is about 38 days(2). The hydrolysis rate of **methyl iodide** in water can be increased by the presence of sulfur nucleophiles(3); the increase is dependent on the nucleophile concn(3). Reaction with HS- has been suggested as an important removal pathway of **methyl iodide** from a salt marsh(5). The reaction of **methyl iodide** with dissolved or metal-bound sulfide represents a potential source of environmental dimethyl sulfide(4). Photolysis studies showed that direct photolysis is not as fast in seawater as the SN2 reaction with chloride ion(1); at 29 deg C, the half-life in dark seawater control tubes was 7.8 days while in tubes exposed to Miami sunlight, the half-life was 6.2 days(1); the SN reaction half-life with chloride ion varies dramatically with ocean latitude and depth with half-lives ranging from 6 days in the warmest water to thousands of days in the coldest waters(1). The degradation of **methyl iodide** in soils was not markedly affected by sterilization implying that degradation occurred by chemical mechanisms(5). The fact that degradation was considerably faster in organic matter-rich soils suggests that other reactions, probably with nucleophilic functional groups, are involved. The half-life in soils that were rich in organic matter was 9-13 days, while in a sandy loam soil it was 42-63 days.
[(1) Zika RG et al; p. 18 in Gas Liquid Chemistry of Natural Waters. Newman L ed. Brookhaven Natl Lab, Upton, NY (1984) (2) Zepp RG et al; Environ Sci Technol 21: 485-90 (1987) (3) Haag WR, Mill T; Environ Toxicol Chem 7: 917-24 (1988) (4) Thayer JS et al; Environ Sci Technol 18: 726-9 (1984) (5) Gan J, Yates SR; J Agric Food Chem 44: 4001-8 (1996)]**PEER REVIEWED**

Environmental Bioconcentration:

An estimated BCF of 2.9 was calculated for **methyl iodide(**SRC), using a log Kow of 1.51(1,SRC) and a regression-derived equation(2). According to a classification scheme(3), this BCF suggests the potential for bioconcentration in aquatic organisms is low. While **methyl iodide** has been detected in various fish and shellfish, it is thought that the chemical may have been formed biogenically(4).
[(1) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 3 (1995) (2) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999) (3) Franke C et al; Chemosphere 29: 1501-14 (1994) (4) Dickson AG, Riley JP; Mar Pollut Bull 7: 167-9 (1976)]**PEER REVIEWED**

Soil Adsorption/Mobility:

Using a structure estimation method based on molecular connectivity indices(1), the Koc for **methyl iodide** can be estimated to be 14(SRC). According to a classification scheme(2), this estimated Koc value suggests that **methyl iodide** should have very high mobility in soil. The soil/water distribution coefficient of **methyl iodide** in various soils were (soil, Kd): Greenfield sandy loam, 0.09; Linne clay loam, 0.15; Carsetas loamy sand, 0.16; and potting mix, 0.55(3).
[(1) Meylan WM et al; Environ Sci Technol 26: 1560-67 (1992) (2) Swann RL et al; Res Rev 85: 17-28 (1983) (3) Gan J, Yates SR; J Agric Food Chem 44: 4001-8 (1996) (4) Gan J et al; J Environ Qual 26: 1107-15 (1997)]**PEER REVIEWED**

Volatilization from Water/Soil:

The Henry's Law constant for **methyl iodide** is 0.00526 atm-cu m/mole at 25 deg C(1). This Henry's Law constant indicates that **methyl iodide** should volatilize from water surfaces(2). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec)(2) is estimated as 1.3 hours(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(2) is estimated as 4.8 days(SRC). The Henry's Law constant in seawater of salinity 30.4 g dissolved inorganic matter/kg seawater was 0.00354 atm-cu m/mole at 20 deg C(4) indicating a lower volatization rate for **methyl iodide** in seawater(SRC). Dissipation of **methyl iodide** from open surface water was found to be primarily a result of volatilization(4). Experiments conducted under indoor conditions resulted in a first-order half-life of 29 hours under static conditions and 6.5 hours when stirred at low speed with a magnetic stirrer(5). After 6 days, less that 1% of the **methyl iodide** was detected as iodide ion. **Methyl iodide's** Henry's Law constant(1) indicates that volatilization from moist soil surfaces may occur(SRC). **Methyl iodide** is expected to volatilize from dry soil surfaces(SRC) based upon a vapor pressure of 405 mm Hg at 25 deg C(3).
[(1) Hunter-Smith RJ et al; Tellus Ser B B35: 170-6 (1983) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (3) Boublik T et al; The Vapor Pressures of Pure Substances Amsterdam: Elsevier p. 51 (1984) (4) Moore RM et al; Chemosphere 30: 183- 91 (1995) (5) Gan J, Yates SR; J Agric Food Chem 44: 4001-8 (1996)]**PEER REVIEWED**

Experiments were conducted to assess the volatilization loss of **methyl iodide,** applied at 30 cm, from 60-cm packed soil columns with different soils and under various soil surface conditions(1). In Greenfield sandy loam, the greatest cumulative loss occurred in nontarp applications, 94%, and the least in a high-barrier plastic tarp treatment, 75%. Volatilization losses with a polyethylene film was 90% and therefore this treatment was ineffective at preventing volatilization loss. Volatilization losses using a polyethylene film were significantly lower, 38% and 53%, from two soils high in organic matter and capable of rapidly degrading the chemical.
[(1) Gan J et al; J Environ Qual 26: 1107-15 (1997)]**PEER REVIEWED**

Environmental Water Concentrations:

SURFACE WATER: Point Reyes, CA - nearshore 37 parts/trillion(1). Atlantic Ocean surface water 135 parts/trillion(2). The avg **methyl iodide** concn of seawater sampled in the eastern Pacific Ocean in 1981 was 1.6 ng/l(3). **Methyl iodide** concns were measured in water samples at 58 stations in the northwest Atlantic in April-May 1991(4). Offshore in the upper 50 m, concns ranged from <0.1 ng/l to 1 ng/l. Levels were relatively high near the Greenland coast, 2.2 ng/l but were relatively low off of Labrador. The highest concns (up to 8.7 ng/l) were seen in the shallow waters of the Grand Banks. Concns decreased sharply with depth, frequently with undetectable levels by 500 m.
[(1) Singh HB et al; J Air Pollut Control Assoc 27: 332-6 (1977) (2) Lovelock JE et al; Nature 241: 194-6 (1973) (3) Singh HB et al; J Geophys Res 88: 3884-90 (1983) (4) Moore RM, Tokarczyk R; Global Biogeochemical Cycles 7: 195-210 (1993)]**PEER REVIEWED**

Effluent Concentrations:

Methyl iodide was detected (conc not reported) in air samples collected above a hazardous waste site in NJ(1); its presence is likely the result of volatile emissions from the site(1).
[(1) LaRegina J et al; Environ Prog 5: 18-27 (1986)]**PEER REVIEWED**

Atmospheric Concentrations:

RURAL/REMOTE: US - 286 samples 0-9.2 parts/trillion, 6.7 parts/trillion median(1). Global background 1-3 parts/trillion(2). USEPA Volatile Organics Data Base: Mean concns (parts/trillion): 3 (remote), 7 (rural)(5). Concns of **methyl iodide (**parts/trillion) recorded during cruises (location/date, mean, range of concn): Western Pacific (n=48) - Sept-Oct. 1992, 0.87, 0.05-5.0; Eastern and southeast Asian seas (n=73) - Jan-Mar, 1994, 0.63, 0.24-2.0(6). 1994 winter measurements and 1991 summer measurements of **methyl iodide** were taken over the western Pacific basin. At latitudes >25 deg N, concns were typically between 0.4 and 0.8 parts/trillion(7). By contrast, concns were significantly lower in winter, remaining between 0.2 and 0.4 parts/trillion. Maximum concns in both seasons were below 3 km altitude. URBAN/SUBURBAN: US - 561 samples 3.5 parts/trillion median, 80 part/trillion max(1). USEPA Volatile Organics Data Base: Mean concns (parts/trillion): 7 (suburban), 2 (urban)(5). The following mean (range) concns (parts/trillion) of **methyl iodide** were monitored in the air of various US cities between 1983 and 1985(2): Philadelphia, PA, 3; Staten Island, NY, 5; Houston, TX, 12 (11-48); Downey, CA, 3 (<1-10); Denver, CO, 2 (1-8); San Jose, CA, 3-9 (<1-51)(2,4). Except for some measurements at Houston and under stagnant conditions in San Jose, **methyl iodide** concns were indistinguishable from natural background levels(2). Levels most frequently measurable in close proximity to the ocean were consistent with the suggestion that its origins are in the ocean(3). No significant man-made sources are known to exist(2).
[(1) Brodzinsky R, Singh HB; Volatile Organic Chemicals in the Atmosphere: an assessment of available data; p.85 SRI Intr Contract 68-02-3452 (1982) (2) Singh HB et al; Atmos Environ 26A:2929-46 (1992) (3) Lillian D et al; Amer Chem Soc Symp Ser 17: 152-8 (1979) (4) Fabian P; pp. 23-51 in The Handbook of Environ Chem Vol 4 Part A Berlin: Springer-Verlag, Hutzinger, O ed (1986) (5) Shah JJ, Heyerdahl EK; National Ambient Volatile Organic Compounds (VOC) Data Bas Update. USEPA/600/3-88/010(a) (1988) (6) Yokouchi Y et al; J Geophys Res 102: 8805-9 (1997) (7) Blake NJ et al. J Geophys Res 102: 28315-31 (1997)]**PEER REVIEWED**

Worldwide measurements show that **methyl iodide** is almost uniformly distributed over the oceans, with avg mixing ratios ranging between 0.002 and 0.003 ppb in the planetary boundary layer(1); in regions of high marine biomass production, avgs are roughly between 0.007 and 0.022 ppb(1); mixing ratios over the continents are generally lower than over the ocean(1).
[(1) Fabian P; pp 23-51 in The Handbook of Environ Chem Vol 4 Part A Berlin: Springer-Verlag, Hutzinger, O ed (1986)]**PEER REVIEWED**

Fish/Seafood Concentrations:

Irish Sea - 3 species of mollusks 3-188 ppb methyliodide, 10 ppb median(1). Irish Sea - 5 species of fish 4-166 ppb, 17 ppb median(1).
[(1) Dickson AG, Riley JP; Mar Pollut Bull 7: 167-9 (1976)]**PEER REVIEWED**

Environmental Standards & Regulations:

CERCLA Reportable Quantities:

Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 100 lb or 45.4 kg. The toll free number of the NRC is (800) 424-8802; In the Washington D.C. metropolitan area (202) 426-2675. The rule for determining when notification is required is stated in 40 CFR 302.4 (section IV. D.3.b).
[40 CFR 302.4 (7/1/99)]**PEER REVIEWED**

RCRA Requirements:

U138; As stipulated in 40 CFR 261.33, when **methyl iodide,** as a commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate, becomes a waste, it must be managed according to Federal and/or State hazardous waste regulations. Also defined as a hazardous waste is any residue, contaminated soil, water, or other debris resulting from the cleanup of a spill, into water or on dry land, of this waste. Generators of small quantities of this waste may qualify for partial exclusion from hazardous waste regulations (40 CFR 261.5).
[40 CFR 261.33 (7/1/99)]**PEER REVIEWED**

Atmospheric Standards:

Listed as a hazardous air pollutant (HAP) generally known or suspected to cause serious health problems. The Clean Air Act, as amended in 1990, directs EPA to set standards requiring major sources to sharply reduce routine emissions of toxic pollutants. EPA is required to establish and phase in specific performance based standards for all air emission sources that emit one or more of the listed pollutants. **Methyl iodide** is included on this list.
[Clean Air Act as amended in 1990, Sect. 112 (b) (1) Public Law 101-549 Nov. 15, 1990]**PEER REVIEWED**

Clean Water Act Requirements:

Toxic pollutant designated pursuant to section 307(a)(1) of the Federal Water Pollution Control Act and is subject to effluent limitations. /Halomethanes/
[40 CFR 401.15 (7/1/99)]**QC REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

C-H3-I
PEER REVIEWED

Molecular Weight:

141.94
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1038]**PEER REVIEWED**

Color/Form:

Colorless, transparent liquid (turns brown on exposure to light)
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1039]**PEER REVIEWED**

Odor:

Pungent, ether-like odor.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 210]**PEER REVIEWED**

Boiling Point:

42.5 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1039]**PEER REVIEWED**

Melting Point:

-66.5 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1039]**PEER REVIEWED**

Critical Temperature & Pressure:

Critical temperature: 254.8 deg C; Critical pressure: 72.7 atm
[Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. F-63]**PEER REVIEWED**

Density/Specific Gravity:

2.28 @ 20 deg C/4 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1038]**PEER REVIEWED**

Heat of Combustion:

194.7 kg cal/g mole
[Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. D-275]**QC REVIEWED**

Heat of Vaporization:

27.97 kJ/mol @ 25 deg C
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 6-104]**PEER REVIEWED**

Octanol/Water Partition Coefficient:

log Kow= 1.51
[Hansch, C., Leo, A., D. Hoekman. Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. Washington, DC: American Chemical Society., 1995. 3]**PEER REVIEWED**

Solubilities:

Miscible with alcohol, ether.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1039]**PEER REVIEWED**

Sol in acetone
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-207]**PEER REVIEWED**

SOL IN CARBON TETRACHLORIDE
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 245 (1977)]**PEER REVIEWED**

1.39X10+4 mg/l at 20 deg C in water
[Horvath AL; Halogenated Hydrocarbons: Solubility-Miscibility With Water NY: Marcel Dekker (1982)]**PEER REVIEWED**

Spectral Properties:

Index of refraction: 1.5293 @ 21 deg C/D
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1039]**PEER REVIEWED**

Index of refraction: 1.5380 @ 20 deg C.
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-207]**PEER REVIEWED**

SADTLER REFERENCE NUMBER: 59 (IR, PRISM)
[Weast, R.C. (ed.). Handbook of Chemistry and Physics. 60th ed. Boca Raton, Florida: CRC Press Inc., 1979.,p. C-374]**PEER REVIEWED**

IR: 1310 (Coblentz Society Spectral Collection)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 842]**PEER REVIEWED**

NMR: 7872 (Sadtler Research Laboratories Spectral Collection)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I

and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 842]**PEER REVIEWED**

MASS: 755 (Atlas of Mass Spectral Data, John Wiley & Sons, New York)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 842]**PEER REVIEWED**

Surface Tension:

25.8 dynes/cm at 43.5 deg C in contact with air
[Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. F-34]**PEER REVIEWED**

Vapor Density:

4.9 (AIR= 1)
[Patty, F. (ed.). Industrial Hygiene and Toxicology: Volume II: Toxicology. 2nd ed. New York: Interscience Publishers, 1963. 1255]**PEER REVIEWED**

Vapor Pressure:

4.05X10+2 mm Hg @ 25 deg C
[Boublik, T., Fried, V., and Hala, E., The Vapour Pressures of Pure Substances. Second Revised Edition. Amsterdam: Elsevier, 1984. 51]**PEER REVIEWED**

Viscosity:

0.606 cP at 0 deg C, 0.424 cP at 40 deg C.
[Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. F-40]**PEER REVIEWED**

Other Chemical/Physical Properties:

% IN SATURATED AIR: 53 @ 25 DEG C; CONVERSION FACTORS: 1 MG/L IS EQUIVALENT (EQUIV) TO 172 PPM & 1 PPM IS EQUIV TO 5.8 MG/CU M @ 25 DEG C, 760 TORR
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994.,p. 4030-1]**PEER REVIEWED**

Decomp @ 270 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1079]**PEER REVIEWED**

DENSITY OF SATURATED AIR: 3.04 (AIR= 1)
[Patty, F. (ed.). Industrial Hygiene and Toxicology: Volume II: Toxicology. 2nd ed. New York: Interscience Publishers, 1963. 1255]**PEER REVIEWED**

Henry's constant of 0.00526 atm-cu m/mole at 25 deg C
[Hunter-Smith RJ et al; Tellus Ser B B35: 170-6 (1983)]**PEER REVIEWED**

Hydroxyl radical rate constant = 7.20X10-14 cu cm/molecule-sec at 25 deg C
[Brown AC et al; Atmos Environ 24A: 361-7 (1990)]**PEER REVIEWED**

Chemical Safety & Handling:

DOT Emergency Guidelines:

Health: Highly toxic, may be fatal if inhaled, swallowed or absorbed through skin. Avoid any skin contact. Effects of contact or inhalation may be delayed. Fire may produce irritating, corrosive and/or toxic gases. Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]
QC REVIEWED

Fire or explosion: Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes. Containers may explode when heated. Runoff may pollute waterways.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]
QC REVIEWED

Public safety: CALL Emergency Response Telephone Number. ... Isolate spill or leak area immediately for at least 25 to 50 meters (80 to 160 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Keep out of low areas.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]
QC REVIEWED

Protective clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Wear chemical protective clothing which is specifically recommended by the manufacturer. It may provide little or no thermal protection. Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]
QC REVIEWED

Evacuation: ... Fire: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]
QC REVIEWED

Fire: Small fires: Dry chemical, CO2 or water spray. Large fires: Water spray, fog or regular foam. Move containers from fire area if you can do it without risk. Dike fire control water for later disposal; do not scatter the material. Use water spray or fog; do not use straight streams. Fire involving tanks or car/trailer loads: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Do not get water inside containers. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible withdraw from area and let fire burn.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]
QC REVIEWED

Spill or leak: Do not touch damaged containers or spilled material unless wearing appropriate protective

clothing. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. Cover with plastic sheet to prevent spreading. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. DO NOT GET WATER INSIDE CONTAINERS.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]
QC REVIEWED

First aid: Move victim to fresh air. Call 911 or emergency medical service. Apply artificial respiration if victim is not breathing. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. For minor skin contact, avoid spreading material on unaffected skin. Keep victim warm and quiet. Effects of exposure (inhalation, ingestion or skin contact) to substance may be delayed. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]
QC REVIEWED

Initial Isolation and Protective Action Distances: Small Spills (from a small package or small leak from a large package): First, ISOLATE in all Directions 30 meters (100 feet); then, PROTECT persons Downwind during DAY 0.2 kilometers (0.1 miles) and NIGHT 0.3 kilometers (0.2 miles). LARGE SPILLS (from a large package or from many small packages): First, ISOLATE in all Directions 60 meters (200 feet); then, PROTECT persons Downwind during DAY 0.3 kilometers (0.2 miles) and NIGHT 1.0 kilometers (0.6 miles).
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. TABLE]
QC REVIEWED

Skin, Eye and Respiratory Irritations:

Contact with the liquid may cause irritation ... of the skin.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]
PEER REVIEWED

Fire Potential:

Iodomethane is not flammable.
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 339]**PEER REVIEWED**

Fire Fighting Procedures:

Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive-pressure mode.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.4]
PEER REVIEWED

If material on fire or involved in fire: Extinguish fire using agent suitable for type of surrounding fire. (Material itself dose not burn or burns with difficulty.) Cool all affected containers with flooding quantities of water. Apply water from as far a distance as possible. Keep run-off water out of sewers and water sources.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 709]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

Strong oxidizers [Note: Decomposes at 518 degrees F].
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 210]**PEER REVIEWED**

Attempts to react silver chlorite with methyl or ethyl iodides caused explosions, immediately in the absence of solvents, or delayed in the presence of solvents.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 6]**PEER REVIEWED**

... Turns brown on exposure to light.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2252]**PEER REVIEWED**

Violent reaction with oxygen (at 300 deg C); sodium.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2252]**PEER REVIEWED**

Explosive reaction with trialkylphosphines; silver chlorite.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2252]**PEER REVIEWED**

Hazardous Decomposition:

IODIDE & HYDROGEN IODIDE MAY BE RELEASED WHEN **METHYL IODIDE** UNDERGOES THERMAL DECOMPOSITION (270 DEG C).
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1013]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH considers **methyl iodide** to be a potential occupational carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 210]**PEER REVIEWED**

Protective Equipment & Clothing:

EMPLOYEES SHOULD BE PROVIDED WITH & REQUIRED TO USE IMPERVIOUS CLOTHING, GLOVES, FACE SHIELDS (EIGHT-INCH MIN), & OTHER APPROPRIATE PROTECTIVE CLOTHING NECESSARY TO PREVENT REPEATED OR PROLONGED SKIN CONTACT WITH LIQ ... .
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No.

81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]
PEER REVIEWED

Respiratory protection for **methyl iodide** at 50 ppm or less: Any supplied-air respirator or any self-contained breathing apparatus; At 250 ppm or less: Any supplied-air respirator with a full facepiece, helmet, or hood or any self-contained breathing apparatus with a full facepiece; At 800 ppm or less: A Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode; At greater than 800 ppm or entry and escape from unknown concn: Self-contained breathing apparatus operated in pressure-demand or other positive pressure mode or a combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode; Escape: Any gas mask providing protection against organic vapors, or any escape self-contained breathing apparatus.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.4]
PEER REVIEWED

Employees should be provided with, and required to use splash-proof safety goggles where liquid **methyl iodide** may contact the eyes.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]
PEER REVIEWED

Wear appropriate personal protective clothing to prevent skin contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 211]**PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 211]**PEER REVIEWED**

Eyewash fountains should be provided in areas where there is any possibility that workers could be exposed to the substance; this is irrespective of the recommendation involving the wearing of eye protection.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 211]**PEER REVIEWED**

Facilities for quickly drenching the body should be provided within the immediate work area for emergency use where there is a possibility of exposure. [Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from any body areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.]
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 211]**PEER REVIEWED**

Recommendations for respirator selection. Condition: At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration: Respirator Class(es): Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive pressure mode. Any supplied-air respirator that has a full facepiece and is operated in pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus

operated in pressure-demand or other positive pressure mode.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 211]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Escape from suddenly occurring respiratory hazards: Respirator Class(es): Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister. Any appropriate escape-type, self-contained breathing apparatus.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 211]**PEER REVIEWED**

Preventive Measures:

Contact lenses should not be worn when working with this chemical.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 211]**PEER REVIEWED**

SRP: The scientific literature for the use of contact lenses in industry is conflicting. The benefit or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In any event, the usual eye protection equipment should be worn even when contact lenses are in place.
PEER REVIEWED

Proper ventilation and protective devices /should be used/. Periodic determination of gas concentration in work place /should be made/.
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 339]**PEER REVIEWED**

Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health. In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]
PEER REVIEWED

The following list includes some common operations in which exposure to **methyl iodide** may occur and control methods which may be effective in each case: Operation (1) Use as a methylating agent in organic synthesis; use as a laboratory reagent; use in academic laboratory courses in organic chemistry. Control (1) Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment. Operation (2) Use as an insecticidal fumigant on scale insects and beetles. Control (2) Process enclosure; general dilution ventilation; personal protective equipment. Operation (3) Use in

analytical chemistry laboratories (test for pyridine, evaluating type of sulfur linkage in vulcanized rubber). Control (3) Local exhaust ventilation; general dilution ventilation; personal protective equipment.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]
PEER REVIEWED

Clothing contaminated with **methyl iodide** should be removed immediately.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4031]**PEER REVIEWED**

Skin that becomes wet with liquid **methyl iodide** should be immediately washed or showered with soap or mild detergent and water to remove any **methyl iodide.** Employees who handle liquid **methyl iodide** should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities. Eating and smoking should not be permitted in areas where liquid **methyl iodide** is handled, processed, or stored.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]
PEER REVIEWED

SRP: Contaminated protective clothing should be segregated in such a manner so that there is no direct personal contact by personnel who handle, dispose, or clean the clothing. Quality assurance to ascertain the completeness of the cleaning procedures should be implemented before the decontaminated protective clothing is returned for reuse by the workers. Contaminated clothing should not be taken home at end of shift, but should remain at employee's place of work for cleaning.
PEER REVIEWED

SRP: Local exhaust ventilation should be applied wherever there is an incidence of point source emissions or dispersion of regulated contaminants in the work area. Ventilation control of the contaminant as close to its point of generation is both the most economical and safest method to minimize personnel exposure to airborne contaminants.
PEER REVIEWED

The worker should immediately wash the skin when it becomes contaminated.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 211]**PEER REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed and replaced.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 211]**PEER REVIEWED**

If material not on fire and not involved in fire: Keep material out of water sources and sewers. Build dikes to contain flow as necessary. Attempt to stop leak if without undue personnel hazard.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 709]**PEER REVIEWED**

Personnel protection: Keep upwind. Avoid breathing vapors. ... Avoid bodily contact with the material.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 709]**PEER REVIEWED**

Evacuation: If material leaking (not on fire) consider evacuation from downwind area based on amount of material spilled, location and weather conditions.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 709]**PEER REVIEWED**

Stability/Shelf Life:

COLORLESS LIQUID THAT TURNS YELLOW, RED OR BROWN WHEN EXPOSED TO LIGHT & MOISTURE.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1013]**PEER REVIEWED**

Shipment Methods and Regulations:

No person may /transport,/ offer or accept a hazardous material for transportation in commerce unless that person is registered in conformance ... and the hazardous material is properly classed, described, packaged, marked, labeled, and in condition for shipment as required or authorized by ... /the hazardous materials regulations (49 CFR 171-177)./
[49 CFR 171.2 (7/1/99)]**PEER REVIEWED**

The International Air Transport Association (IATA) Dangerous Goods Regulations are published by the IATA Dangerous Goods Board pursuant to IATA Resolutions 618 and 619 and constitute a manual of industry carrier regulations to be followed by all IATA Member airlines when transporting hazardous materials.
[IATA. Dangerous Goods Regulations. 40th Ed. Montreal, Canada and Geneva, Switzerland: International Air Transport Association, Dangerous Goods Regulations, 1999. 178]**PEER REVIEWED**

The International Maritime Dangerous Goods Code lays down basic principles for transporting hazardous chemicals. Detailed recommendations for individual substances and a number of recommendations for good practice are included in the classes dealing with such substances. A general index of technical names has also been compiled. This index should always be consulted when attempting to locate the appropriate procedures to be used when shipping any substance or article.
[IMDG; International Maritime Dangerous Goods Code; International Maritime Organization p.6197 (1998)]**PEER REVIEWED**

Storage Conditions:

Keep containers closed and store in a dark place.
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 339]**PEER REVIEWED**

... MATERIALS WHICH ARE TOXIC AS STORED OR WHICH CAN DECOMPOSE INTO TOXIC COMPONENTS DUE TO CONTACT WITH HEAT, MOISTURE, ACID, OR ACID FUMES, SHOULD BE STORED IN COOL, WELL-VENTILATED PLACE, OUT OF DIRECT RAYS OF SUN, AWAY FROM AREAS OF HIGH FIRE HAZARD & SHOULD BE PERIODICALLY INSPECTED & MONITORED.
[Sax, N.I. Dangerous Properties of Industrial Materials. 4th ed. New York: Van Nostrand Reinhold, 1975. 926]**PEER REVIEWED**

Cleanup Methods:

1. VENTILATE AREA OF SPILL OR LEAK. 2. COLLECT FOR RECLAMATION OR ABSORB IN VERMICULITE, DRY SAND, EARTH, OR SIMILAR MATERIAL.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3] **PEER REVIEWED**

/In laboratory/ absorb the spills with paper towels, or like materials. Place in hood to evaporate. Dispose by burning the towel.
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 339]**PEER REVIEWED**

Disposal Methods:

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste number U138, must conform with USEPA regulations in storage, transportation, treatment and disposal of waste.
[40 CFR 240-280, 300-306, 702-799 (7/1/91)]**PEER REVIEWED**

A potential candidate for liquid injection incineration at a temperature range of 650 to 1,600 deg C and a residence time of 0.1 to 2 seconds. A potential candidate for rotary kiln incineration at a temperature range of 820 to 1,600 deg C and residence times of seconds for liquids and gases, and hours for solids. A potential candidate for fluidized bed incineration at a temperature range of 450 to 980 deg C and residence times of seconds for liquids and gases, and longer for solids.
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-14 (1981) EPA 68-03-3025]**PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

Permissible Exposure Limit: Table Z-1 8-hr Time-Weighted Avg: 5 ppm (28 mg/cu m). Skin Designation.
[29 CFR 1910.1000 (7/1/99)]**PEER REVIEWED**

Vacated 1989 OSHA PEL TWA 2 ppm (10 mg/cu m), skin designation, is still enforced in some states.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 368]**PEER REVIEWED**

Threshold Limit Values:

8 hr Time Weighted Avg (TWA) 2 ppm, skin
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 49]**QC REVIEWED**

Excursion Limit Recommendation: Excursions in worker exposure levels may exceed three times the TLV-TWA for no more than a total of 30 min during a work day, and under no circumstances should they exceed five times the TLV-TWA, provided that the TLV-TWA is not exceeded.
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 6]**QC REVIEWED**

NIOSH Recommendations:

NIOSH considers **methyl iodide** to be a potential occupational carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 210]**PEER REVIEWED**

NIOSH usually recommends that occupational exposures to carcinogens be limited to the lowest feasible concentration.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 210]**PEER REVIEWED**

Recommended Exposure Limit: 10 Hr Time-Weighted Avg: 2 ppm (10 mg/cu m), skin.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 210]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH considers **methyl iodide** to be a potential occupational carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 210]**PEER REVIEWED**

Other Occupational Permissible Levels:

Emergency Response Planning Guidelines (ERPG): ERPG(1) 25 ppm (no more than mild, transient effects) for up to 1 hr exposure; ERPG(2) 50 ppm (without serious, adverse effects) for up to 1 hr exposure; ERPG(3) 125 ppm (not life threatening) up to 1 hr exposure.
[American Industrial Hygiene Association. The AIHA 1999 Emergency Response Planning Guidelines and Workplace Environmental Exposure Level Guides Handbook. American Industrial Hygiene Association. Fairfax, VA 1999.26]**PEER REVIEWED**

Australia: 2 ppm, Category 3, suspected human carcinogen, skin (1990); Federal Republic of Germany: no numerical limit, Group III A2, unmistakably carcinogenic in animal experimentation only (1992); Sweden: 1 ppm, short-term value 5 ppm, 15 min, skin, carcinogenic (1991); United Kingdom: 5 ppm, 10-min STEL 10 ppm, skin (1991).
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1014]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

Methylating agent; in microscopy because of its high refractive index; as imbedding material for examining diatoms; in testing for pyridine. Light sensitive etching agent for electronic circuits; component in fire extinguishers.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1039]**PEER REVIEWED**

Manufacturers:

Ajay North America, LLC, P.O. 127, 1400 Industry Road, Powder Springs, GA 30127-0127, (770) 943-

6202
[SRI. 1999 Directory of Chemical Producers -United States. Menlo Park, CA. SRI Consulting 1999.. 746]**PEER REVIEWED**

Deepwater Chemicals, Inc., 1210 Airpark Road, Woodward, OK 73801, (508) 256-0500
[SRI. 1999 Directory of Chemical Producers -United States. Menlo Park, CA. SRI Consulting 1999.. 746]**PEER REVIEWED**

Eagle Pitcher Industries, Inc., Eagle Pitcher Technologies, LLC, ChemSyn Laboratories, Hq, 250 East 5th Street, Suite 500, Cincinnati, OH 45202, (513) 721-7010; Production site: Lenexa, KS 66215 /[3H] **Methyl Iodide** and [14C] **Methyl Iodide/**
[SRI. 1999 Directory of Chemical Producers -United States. Menlo Park, CA. SRI Consulting 1999.. 746]**PEER REVIEWED**

R.S.A. Corporation, 39 Old Sherman Turnpike, Danbury CT 06810, (203) 790-8100
[SRI. 1999 Directory of Chemical Producers -United States. Menlo Park, CA. SRI Consulting 1999.. 746]**PEER REVIEWED**

Methods of Manufacturing:

Prepd from methyl alcohol, iodine and red phosphorus; from potassium iodide and methyl sulfate.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1039]**PEER REVIEWED**

From potassium iodide and methyl p-toluenesulfonate; by reaction of dimethyl sulfate with an aqueous iodine slurry containing a reducing agent such as iron or sodium bisulfite; by reaction of methanol and hydrogen iodide; and by reaction of methanol, iodine, and diborane.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V14 728]**PEER REVIEWED**

General Manufacturing Information:

... COMMERCIAL PRODN ... IN USA WAS FIRST REPORTED IN 1943, WHEN ABOUT 1400 KG WERE MANUFACTURED ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 246 (1977)]**PEER REVIEWED**

Methyl iodide has been investigated in India for use as a fumigant to control internal fungi of grain sorghum.
[DHHS/NTP; Fourth Annual Report on Carcinogens p.132 (1985) NTP 85-002]**PEER REVIEWED**

Formulations/Preparations:

... AVAIL IN USA & JAPAN IN GRADE CONTAINING @ LEAST 99% OF PURE CHEM.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 246 (1977)]**PEER REVIEWED**

Impurities:

IODINE MAY BE PRESENT AS AN IMPURITY.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 246 (1977)]**PEER REVIEWED**

U. S. Production:

(1971) 9,000 lb sold
[USITC, 1971]**PEER REVIEWED**

(1972) 18,000 lb
[USITC, 1972]**PEER REVIEWED**

(1977) Iodinated hydrocarbons: 58,000 lb
[USITC, 1977]**PEER REVIEWED**

(1977) AT LEAST 4.99X10+6 G
[SRI]**PEER REVIEWED**

(1982) PROBABLY GREATER THAN 6.81X10+6 G
[SRI]**PEER REVIEWED**

(1978) Iodinated hydrocarbons: 50,000 lb
[USITC, 1978]**PEER REVIEWED**

(1982) 82,000 lb
[USITC, 1982]**PEER REVIEWED**

(1983) 103,000 lb
[USITC, 1983]**PEER REVIEWED**

(1988) NO DATA PROVIDED
[United States International Trade Commission. Synthetic Organic Chemicals- United States Production and Sales, 1988. USITC Publication 1989. Washington, DC: United States International Trade Commission, 1989.p. 15-31]**PEER REVIEWED**

Laboratory Methods:

Analytic Laboratory Methods:

Determination of some iodo-alkanes by molecular emission cavity analysis after gas chromatographic separation.
[Burguera M, Burguera JL; Aval Chim Acta 153: 53-60 (1983)]**PEER REVIEWED**

A selective photometric method is described for determining /**iodomethane**/ traces in gas filling of halide incandescent lamps based on the formation of iodide(-1) as a result of complete degradation of /**iodomethane**/ in an iso-propyl alcohol medium in the presence of alkali. ... The relative error is 5%. The method is suitable for **iodomethane** detection in air, water, and other iodine containing organic media.
[Kochetkova TM; Zavod Lab 47 (8): 19-20 (1981)]**PEER REVIEWED**

Analytical methods for halogenated C1-C2 halo hydrocarbons include gas chromatography, mass

spectrometry, and multiple ion detection.
[Naka K et al; Mie-ken Kankyo Kagaku Senta Kenkyu Hokoku 3: 14-24 (1982)]**PEER REVIEWED**

AIR; ELECTRON CAPTURE GAS CHROMATOGRAPHY.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 248 (1977)]**PEER REVIEWED**

EXHAUST GASES; FLAME IONIZATION GAS CHROMATOGRAPHY.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 248 (1977)]**PEER REVIEWED**

NIOSH Method 1014. **Methyl iodide** by GC/FID. Analyte: **Methyl iodide.** Matrix: Air. Procedure: Gas chromatography flame ionization detection. For **iodomethane** this method has an estimated detection limit of 0.01 mg/sample or 0.200 mg/cu m. The precision/RSD is 0.045 at 0.7 to 2.8 mg/sample. Applicability: The working range of this method is 10 to 100 mg/cu m (1.7 to 17 ppm) for a 50 liter air sample. Interferences: None identified.
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

EPA OSW Method 8240B. Determination of Volatile Organics by Purge and Trap Gas Chromatography/ Mass Spectroscopy. Estimated quatitation limit 5 ug/l.
[USEPA; Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September 1994 (1997)]**PEER REVIEWED**

EPA OSW Method 8260A. Determination of Volatile Organics by Purge and Trap, Capillary Column Gas Chromatography/ Mass Spectroscopy. Detection limit not reported.
[USEPA; Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September 1994 (1997)]**PEER REVIEWED**

EPA EAD Method 1624. Determination of Volatile Toxic Organic Pollutants and Additional Compounds Amenable to Purge and Trap GC/MS. Gas chromatography/mass spectroscopy. Minimum detection level 10 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1 PC# 4082. Rockville, MD: Goverment Institutes (1997)]**PEER REVIEWED**

Sampling Procedures:

On the interaction of **iodomethane** over silver-exchanged molecular sieves /in its removal from radioactive gaseous wastes/.
[Belapurkar AD et al; Surf Technol 21 (3): 263-72 (1984)]**PEER REVIEWED**

(13)C NMR analysis of charcoal adsorbents: reaction of **methyl iodide** /from nuclear reactor waste gases/ with the impregnated tris(ethylene diamine).
[Resing HA et al; Ext Abstr Program-Bienn Conf Carbon 16: 319-20 (1983)]**PEER REVIEWED**

A filter for monitoring radioiodine /including **iodomethane**/ in air.
[Schwarzback R, Hladik O; Kernenergie 27 (1): 25-7 (1984)]**PEER REVIEWED**

NIOSH Method 1014. Analyte: **Methyl iodide.** Matrix: Air. Sampler: solid sorbent tube (coconut shell charcoal, 100 mg/50 mg). Flow Rate: 0.01 to 1 l/min: Sample Size: 50 liters. Shipment: routine. Sample Stability: unknown.
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. 1014-1]**PEER REVIEWED**

Special References:

Special Reports:

USEPA; Ambient Water Quality Criteria Doc: Halomethanes (1980) EPA 442/5-80-051

U.S. Department of Health & Human Services/National Toxicology Program; Tenth Report on Carcinogens. National Institutes of Environmental Health Sciences. The Report on Carcinogens is an informational scientific and public health document that identifies and discusses substances (including agents, mixtures, or exposure circumstances) that may pose a carcinogenic hazard to human health. **Methyl iodide (**74-88-4) was first listed in the Fourth Annual Report on Carcinogens (1985) as reasonably anticipated to be a human carcinogen and delisted in the Fifth Annual Report on Carcinogens (1989).

Synonyms and Identifiers:

Synonyms:

HALON 10001
PEER REVIEWED

IODOMETANO (ITALIAN)
PEER REVIEWED

Iodomethane
PEER REVIEWED

IODURE DE METHYLE (FRENCH)
PEER REVIEWED

JOD-METHAN (GERMAN)
PEER REVIEWED

JOODMETHAAN (DUTCH)
PEER REVIEWED

METHANE, IODO-
PEER REVIEWED

METHYLJODIDE (DUTCH)
PEER REVIEWED

METHYLJODID (GERMAN)

PEER REVIEWED

METYLU JODEK (POLISH)
PEER REVIEWED

MONOIODOMETHANE
PEER REVIEWED

MONOIODURO DI METILE (ITALIAN)
PEER REVIEWED

Formulations/Preparations:

... AVAIL IN USA & JAPAN IN GRADE CONTAINING @ LEAST 99% OF PURE CHEM.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 246 (1977)]**PEER REVIEWED**

Shipping Name/ Number DOT/UN/NA/IMO:

UN 2644; **Methyl iodide**

IMO 6.1; **Methyl iodide**

EPA Hazardous Waste Number:

U138; A toxic waste when a discarded commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or manufacturing chemical intermediate.

Administrative Information:

Hazardous Substances Databank Number: 1336

Last Revision Date: 20030829

Last Review Date: Reviewed by SRP on 1/29/2000

Update History:

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Complete Update on 01/14/2002, 1 field added/edited/deleted.
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Complete Update on 06/08/2000, 1 field added/edited/deleted.
Complete Update on 06/08/2000, 1 field added/edited/deleted.

Complete Update on 06/08/2000, 1 field added/edited/deleted.
Complete Update on 06/08/2000, 1 field added/edited/deleted.
Complete Update on 06/08/2000, 61 fields added/edited/deleted.
Field Update on 02/08/2000, 1 field added/edited/deleted.
Field Update on 02/02/2000, 1 field added/edited/deleted.
Field Update on 11/18/1999, 1 field added/edited/deleted.
Field Update on 09/21/1999, 1 field added/edited/deleted.
Complete Update on 05/11/1999, 1 field added/edited/deleted.
Complete Update on 03/29/1999, 1 field added/edited/deleted.
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Complete Update on 03/31/1998, 3 fields added/edited/deleted.
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Complete Update on 02/28/1997, 1 field added/edited/deleted.
Complete Update on 10/13/1996, 1 field added/edited/deleted.
Complete Update on 06/27/1996, 1 field added/edited/deleted.
Complete Update on 06/06/1996, 2 fields added/edited/deleted.
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Complete Update on 04/09/1996, 10 fields added/edited/deleted.
Field Update on 01/21/1996, 1 field added/edited/deleted.
Field Update on 02/28/1995, 22 fields added/edited/deleted.
Complete Update on 01/23/1995, 71 fields added/edited/deleted.
Field Update on 12/22/1994, 1 field added/edited/deleted.
Field Update on 11/14/1994, 1 field added/edited/deleted.
Field Update on 09/27/1994, 1 field added/edited/deleted.
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Field Update on 03/21/1994, 1 field added/edited/deleted.
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Field update on 12/20/1992, 1 field added/edited/deleted.
Field Update on 12/10/1992, 1 field added/edited/deleted.
Field Update on 04/16/1992, 1 field added/edited/deleted.
Field Update on 04/01/1992, 1 field added/edited/deleted.
Field Update on 01/13/1992, 1 field added/edited/deleted.
Complete Update on 10/15/1990, 6 fields added/edited/deleted.
Field Update on 01/15/1990, 1 field added/edited/deleted.
Complete Update on 01/11/1990, 5 fields added/edited/deleted.
Field Update on 05/05/1989, 1 field added/edited/deleted.
Field Update on 03/01/1989, 1 field added/edited/deleted.
Field Update on 05/12/1988, 1 fields added/edited/deleted.
Complete Update on 03/05/1988, 86 fields added/edited/deleted.
Complete Update on 01/14/1986
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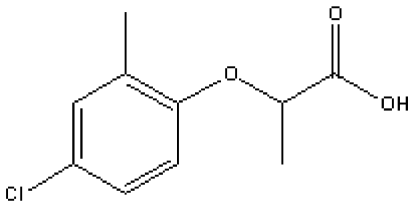
MCPP [93-65-2]
Synonyms: 2-(2-Methyl-4-chlorophenoxy) propionic acid; 2-(2-methyl-4-chlorophenoxy) propionic acid ; 2-(4-Chloro-2-methylphenoxy)propionic acid; 2-(4-Chloro-2-methylphenoxy) propanoic acid; alpha-(4-Chloro-2-methylphenoxy)propionic acid; Astix CMPP; CMPP; Gordon's Mecomec; Lescopex 2.5L; MCPP; mechlorprop; Mecoprop; Methoxone M; RD 4593;



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ADD LINK

Formula	$C_{10}H_{11}ClO_3$	Molecular Weight	214.6481
CAS RN	93-65-2	Melting Point (°C)	93
ACX Number	X1003155-3	Boiling Point (°C)	
Density		Vapor Density	
Refractive Index		Vapor Pressure	
Evaporation Rate		Water Solubility	
Flash Point (°C)		EPA Code	
DOT Number		RTECS	UE9750000
Comments	Solid		

More information about the chemical is available in these categories:

Health Misc Pesticides/Herbicides Physical Properties Regulations

Health (7)

8(e) TRIAGE Chemical Studies Database

ATSDR Internet HazDat Site Contaminant Query

Information about this particular compound

Australian Hazardous Substances Database

Information about this particular compound

International Chemical Safety Cards

Information about this particular compound

International Toxicity Estimates for Risk

Information about this particular compound

RAIS Nonradionuclides Toxicity Values

UMCP Partial list of teratogens

Misc (1)

Protocol Analytical Supplies, Inc. Single-component standards

Pesticides/Herbicides (7)

EXtension TOXicology NETwork

Information about this particular compound

FDA Pestrak files

Florida Agricultural Information Retrieval System

Information about this particular compound

Information about this particular compound

Herbicide Mode-of-Action Summary

The ARS Pesticide Properties Database

Information about this particular compound

US EPA Status of Pesticides in Registration (in PDF format)

Physical Properties (3)

Environmental Science Center database with Experimental Log P coefficients etc.

Information about this particular compound

Pollution Prevention Progress Measurement Method (3P2M) Hazard Ranking

Spectrum Laboratories, Inc.

Information about this particular compound

Regulations (6)

Chemicals Being Added to the EPCRA Section 313 List

Current List of Toxics Release Inventory Chemicals

Guide to NIOSH/OSHA Air Sampling Methods

Information about this particular compound

OSHA Chemical Sampling and Methods

Information about this particular compound

Substances in IRIS (Integrated Risk Information System) (main EPA site)

Information about this particular compound

Title III List of Lists

Enter a Chemical Name, CAS Number, Molecular Formula or Weight.
Use * for partial names (e.g. ben*).
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Home
Find Your Community
What's New
Setting Priorities
Pollution Locator
Pollution Rankings
About the Chemicals
Health Effects
Regulatory Controls
Discussion Forums
FAQs
Personalize Scorecard
Glossary
About the Scorecard
Search Scorecard

Go

Search Tips

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ABOUT THE CHEMICALS|Chemical Profile

Chemical: (+-)-2-(4-CHLORO-2-METHYLPHENOXY)PROPIONIC ACID
CAS Number: 7085-19-0

Chemical Profile for (+-)-2-(4-CHLORO-2-METHYLPHENOXY)PROPIONIC ACID (CAS Number: 7085-19-0)

- Human Health Hazards
- Hazard Rankings
- Chemical Use Profile
- Rank Chemicals by Reported Environmental Releases in the United States
- Regulatory Coverage
- Basic Testing to Identify Chemical Hazards
- Information Needed for Safety Assessment
- Links

Human Health Hazards

Health Hazard	Reference(s)
Recognized:	--
Suspected:	--

[top]

Hazard Rankings

More hazardous than most chemicals in 1 out of 2 ranking systems.

[top]

Chemical Use Profile

No data on industrial use in Scorecard.
Used in pesticide products.

[top]

- **Rank Chemicals by Reported Environmental Releases in the United States**

No data on environmental releases in Scorecard.

[top]

- **Regulatory Coverage**

On at least 1 federal regulatory list.

[top]

- **Basic Testing to Identify Chemical Hazards**

Information on whether basic tests to identify chemical hazards have been conducted on this chemical is not available in US EPA's 1998 hazard data availability study.

[top]

- **Information Needed for Safety Assessment**

Lacks at least some of the data required for safety assessment. See risk assessment data for this chemical from U.S. EPA or Scorecard.

[top]

- **Links**

Other web sites specific to this chemical:

If none of these sources meet your needs, you can try searching some other chemical database Web sites.

[top]

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Scorecard

Home
Find Your Community
What's New
Setting Priorities
Pollution Locator
Pollution Rankings
About the Chemicals
Health Effects
Regulatory Controls
Discussion Forums
FAQs
Personalize Scorecard
Glossary
About the Scorecard
Search Scorecard

Go

Search Tips

SEND TO A FRIEND

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ABOUT THE CHEMICALS|Hazard Rankings

Chemical: (+-)-2-(4-CHLORO-2-METHYLPHENOXY)PROPIONIC ACID
CAS Number: 7085-19-0

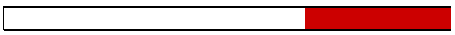
Least Hazardous

Percentile
25% **50%** **75%**

Human Health Rankings

Toxicity and exposure potential

Noncancer Risk Score - Air Releases (EDF)



Noncancer Risk Score - Water Releases (EDF)

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Scorecard
Home
Find Your Community
What's New
Setting Priorities
Pollution Locator
Pollution Rankings
About the Chemicals
Health Effects
Regulatory Controls
Discussion Forums
FAQs
Personalize Scorecard
Glossary
About the Scorecard
Search Scorecard
Go
Search Tips
SEND TO A FRIEND

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ABOUT THE CHEMICALS|Pesticidal Uses

Chemical: (+-)-2-(4-CHLORO-2-METHYLPHENOXY)PROPIONIC ACID
CAS Number: 7085-19-0

List of Brand Name Products which Contain this Chemical	Percentage by Mass
MCPP 98% TECHNICAL ACID HERBICIDE	98%
MCPP 98% TECHNICAL ACID HERBICIDE	98%
MCPP 98% TECHNICAL ACID HERBICIDE	98%
MCPP 98% TECHNICAL ACID	98%
MCPP 98% TECHNICAL ACID HERBICIDE	95%
MCPP TECHNICAL ACID	95%
MCPP ACID TECHNICAL 95%	95%
MCPP TECH	95%
MCPP-TECH	95%
MCPP ACID TECHNICAL 95%	95%
MCPP-TECH	95%
MCPP 98% TECHNICAL ACID HERBICIDE	95%
MCPP ACID TECHNICAL 95%	95%
MCPP-TECH	95%
MCPP-TECH	95%
MCPP-TECH	95%
PRENTOX MCPP-TECH	95%
MCPP TECHNICAL	94%
MCPP TECHNICAL	94%
MCPP (TECHNICAL GRADE)	94%
MCPP TECHNICAL	94%
MCPP IMPORT	94%
MCPP (TECHNICAL GRADE)	94%
MCPP TECHNICAL	94%
MCPP IMPORT	94%
MCPP (TECHNICAL GRADE)	94%
TECHNICAL MCPP	93%
TECHNICAL MCPP ACID	93%

TECHNICAL MCPP	93%
TECHNICAL MECOPROP	93%
MARKS CMPP (MECOPROP) TECHNICAL ACID	93%
MECOPROP AK TECHNICAL ACID	93%
TECHNICAL MECOPROP	93%
BOOTS HERCULES MCPP TECHNICAL GRADE	92%
TECHNICAL MCPP	90.5%
TECHNICAL MCPP	90.5%
CLEARY MCPP -2,4-D	31.5%
WKS-74M SELECTIVE WEED KILLER	25.9%
EH1314 HERBICIDE	22.4%
RIVERDALE TRIPLET MC DRI	20.4%
TRIMEC D.M.B. #2 TURF HERBICIDE	20.4%
RIVERDALE TRI-POWER (R) DRY	20%
LESCO THREE-WAY 53% DG SELECTIVE BROADLEAF HERBICIDE	16.9%
GORDON'S TRIMEC M 936 BROADLEAF HERBICIDE	14.51%
TRIMEC 1144 40% SP	13.75%
ELIMINATE 47% DG SELECTIVE BROADLEAF HERBICIDE.	12.7%
RIVERDALE TRIAMINE II W.S.	8.5%
TRIMEC 1158 BROADLEAF HERBICIDE	6.48%
PROTURF BROAD SPECTRUM WEEDICIDE II	2.78%
TURF BUILDER PLUS 2	1.49%
PRIVATE LABEL WEED AND FEED	1.49%
PRIVATE LABEL FEED AND WEED	1.49%
SCOTTS PROTURF 36-0-0 FERTILIZER PLUS DICOT WEED CONTROL II	1.37%
SCOTTS LAWN PRO LAWN WEED CONTROL PLUS FERTILIZER	1.37%
PROTURF FERTILIZER PLUS DICOT WEED CONTROL IV	1.37%
SCOTTS PROTURF 36-0-0 FERTILIZER PLUS DICOT WEED CONTROL II	1.37%
PROTURF FERTILIZER PLUS DICOT WEED CONTROL IV	1.37%
SCOTT'S LAWN PRO WEED N' FEED	1.37%
TURF BUILDER PLUS 2 W/S FOR GRASS	1.37%
SCOTTS LAWN PRO WEED & FEED WEED CONTROL PLUS LAWN FERTILIZER	1.22%
SCOTTS LAWN PRO WEED AND FEED	1.18%

SCOTTS TURF BUILDER WITH PLUS 2	1.15%
SUPER TURF BUILDER WITH PLUS 2 WEED CONTROL	1.1%
SCOTTS IMPROVED SUPER TURF BUILDER PLUS 2	1.06%
WINTERIZER WITH PLUS 2 WEED CONTROL	1.04%
SUPER WINTERIZER WITH PLUS 2 WEED CONTROL	1.03%
SCOTTS TURF BUILDER PLUS 2 FOR GRASS	.99%
ACE LAWN FOOD WITH WEED CONTROL 22-6-8	.94%
ACE LAWN FOOD WITH WEED CONTROL 22-6-8	.94%
ACE LAWN FOOD WITH WEED CONTROL 22-6-8	.94%
WEED-B-GON PLUS WEED & FEED	.88%
CRABGRASS PREVENTER AND DANDELION CONTROL PLUS FERTILIZER	.76%
SCOTTS TURF BUILDER PLUS 2 FOR IRON DEFICIENT SOILS	.75%
SUPER PLUS 2 WEED CONTROL PLUS LAWN FERTILIZER	.71%
BONUS TYPE B WEED CONTROL PLUS LAWN FERTILIZER	.68%
NEW HALTS PLUS WITH DANDELION CONTROL	.68%
SCOTTS SUPER TURF BUILDER PLUS 2 FOR GRASS	.68%
FERTI LOME WEED KILLER PLUS LAWN FOOD	.64%
TURF BUILDER PLUS 2 (R)	.61%
RIVERDALE GRANULAR LAWN WEED KILLER	.58%
SUPER TURF BUILDER PLUS 2 (R)	.5%
WEED-B-GON JET WEEDER FORMULA II	.37%
RIVERDALE TRI-POWER (R) DRY GRANULAR WEED KILLER	.33%
RIVERDALE SWEET SIXTEEN WEED AND FEED WITH TRIPLET MC DRI	.32%
GOLDEN VIGORO WEED CONTROL PLUS LAWN FERTILIZER 24-4-8	.31%
DEEP GREEN VIGORO 23-3-7 LAWN FERTILIZER & WEED CONTROL	.3%
DEEP GREEN VIGORO 23-3-7 LAWN FERTILIZER & WEED CONTROL	.3%
MORGRO 2-IN-1 WEED & FEED	.3%
PAR EX SLOW RELEASE FERTILIZER	.3%
PAR EX SLOW RELEASE FERTILIZER	.3%
AGRO WEED & FEED 8-2-4 FERTILIZER	.3%
GRO-TONE 18 WEED & FEED	.28%
GRO-TONE 18 WEED & FEED	.28%

FERTILIZER WITH WEED CONTROL	.25%
GRO-TONE 20 WEED & FEED	.25%
GRO-TONE 20 WEED & FEED	.25%
VIGORO WEED CONTROL PLUS LAWN FERTILIZER	.24%
GUARDSMAN SUPREME-D WEED AND FEED 15-3-6	.2%
TRIMEC WEED & FEED 20 FOR NORTHERN TRUFGRASSES	.2%
GORDON'S TRIMEC WEED & FEED 20	.2%
GUARDSMAN SUPREME- D WEED & FEED FERTILIZER	.15%
LILLY'S SUPER RICH FEED & WEED 12-2-3	.15%
GORDON'S TRIMEC WEED AND FEED 27	.14%

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Scorecard

Home
Find Your Community
What's New
Setting Priorities
Pollution Locator
Pollution Rankings
About the Chemicals
Health Effects
Regulatory Controls
Discussion Forums
FAQs
Personalize Scorecard
Glossary
About the Scorecard
Search Scorecard

Go

Search Tips

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ABOUT THE CHEMICALS|Regulatory Coverage

Chemical: (+-)-2-(4-CHLORO-2-METHYLPHENOXY)PROPIONIC ACID
CAS Number: 7085-19-0

Federal Regulatory Program Lists

Registered Pesticides (Federal Insecticide, Fungicide, and Rodenticide Act)

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Scorecard
Home
Find Your Community
What's New
Setting Priorities
Pollution Locator
Pollution Rankings
About the Chemicals
Health Effects
Regulatory Controls
Discussion Forums
FAQs
Personalize Scorecard
Glossary
About the Scorecard
Search Scorecard
Go
Search Tips
SEND TO A FRIEND

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Chemical: (+-)-2-(4-CHLORO-2-METHYLPHENOXY)PROPIONIC ACID
CAS Number: 7085-19-0

The U.S. EPA conducted a comprehensive review of publicly available chemical testing data in 1997 to examine whether the basic information needed to identify chemical hazards is available for high production volume chemicals. EPA searched major chemical databases to determine if the following tests had been conducted on a chemical:

- Acute toxicity
- Chronic toxicity
- Neurotoxicity
- Developmental or reproductive toxicity
- Mutagenicity
- Carcinogenicity
- Ecotoxicity
- Environmental fate

This chemical was not included in EPA's survey of basic testing data.

Track whether this chemical is being voluntarily tested to provide basic hazard data. Copy its CAS number above and check the HPV Chemical Tracker.

More on the importance of basic toxicity testing

Reference

EPA. *Chemical Hazard Data Availability Study: High Production Volume (HPV) Chemicals and SIDS Testing*
Office of Pollution Prevention and Toxics, EPA,Washington, DC. 1998.

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Scorecard

Home
Find Your Community
What's New
Setting Priorities
Pollution Locator
Pollution Rankings
About the Chemicals
Health Effects
Regulatory Controls
Discussion Forums
FAQs
Personalize Scorecard
Glossary
About the Scorecard
Search Scorecard

Go

Search Tips

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ABOUT THE CHEMICALS|Scorecard Risk Characterization Data

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Chemical: (+-)-2-(4-CHLORO-2-METHYLPHENOXY)PROPIONIC ACID
CAS Number: 7085-19-0

Risk Assessment Values or Standards

	Value	Units	Reference
Inhalation cancer risk value (potency)	Not a recognized or suspect carcinogen		
Inhalation noncancer risk value (reference concentration)	Data gap		
National ambient air quality standard	Gap in regulatory coverage		
Ingestion cancer risk value (potency)	Not a recognized or suspect carcinogen		
Ingestion noncancer risk value (reference dose)	0.001	mg/kg-day	OPP-RfD
National water quality standard	Gap in regulatory coverage		

See the data US EPA possesses for safety assessment.

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OCTACHLORODIBENZO-P-DIOXIN

CASRN: 3268-87-9

For other data, click on the Table of Contents

Human Health Effects:

Evidence for Carcinogenicity:

Overall evaluation: Other polychlorinated dibenzo-para-dioxins are not classifiable as to their carcinogenicity to humans (Group 3).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 69 342 (1997)]**QC REVIEWED**

Human Toxicity Excerpts:

To evaluate the association between exposure to pentachlorophenol and the occurrence of chloracne, we studied the medical and personnel records for individuals employed in the manufacturing of pentachlorophenol. Forty seven cases of chloracne were identified among 648 workers (7.0%) assigned to pentachlorophenol production at a single plant between 1953 and 1978. The annual incidence rate varied considerably, ranging from 0 (in 1953) to 1.46 (in 1978). No linear trend in the risk of chloracne was observed with the duration of employment in the pentachlorophenol department. Workers with a documented episode of direct skin contact with pentachlorophenol had a significantly increased risk of chloracne compared with workers who did not have a documented episode of direct skin contact (cumulative incidence ratio = 4.6; 95% confidence interval 2.6-8.1). Results confirm that chloracne is associated with exposure to pentachlorophenol contamined with hexachlorinated, heptachlorinated, and octachlorinated dibenzo-p-dioxins and dibenzofurans.
[O'Malley MA et al; Am J Ind Med 17 (4): 411-22 (1990)]**PEER REVIEWED**

All members of a Spanish family (father, mother and six children) developed chloracne. The causative agent was found to be the family's stock of olive oil, which had become contaminated with dibenzo-p-dioxins, dibenzofurans, pentachlorophenol, and hexachlorobenzene. The more highly chlorinated dibenzo-p-dioxins, in particular octachlorodibenzo-p-dioxin, were the predominant congeners in the oil. Three members of the family exhibited either an overt or a sub-clinical disturbance of kidney function. The father also had a chronic respiratory problem. These changes could not be unequivocally attributed to the dibenzo-p-dioxins. Experimental toxicity of the oil was limited to the development of the oil ceased, contained high levels of the dibenzo-p-dioxins and dibenzofurans. Extrapolation back to ingested dose was used to validate dosage estimates. The use of toxicity equivalence factors provided estimates of cumulative dosage to produce chloracne as 0.13-0.31 ug 2,3,7,8-tetrachlorodibenzo-p-dioxin/kg (using EPA toxicity equivalence factors) or 6.7-16 ug 2,3,7,8-tetrachlorodibenzo-p-dioxin/kg (using Nordic/NATO toxicity equivalence factors). This is the first incident in which human toxicity is related primarily to ingestion of dibenzo-p-dioxins and for which estimates of dosage can be made.
[Rodriguez-pichardo A et al; Hum Exp Toxicol 10 (5): 311-22 (1991)]**PEER REVIEWED**

A case history of chloracne due to exposure to pentachlorophenol treated wood was described. A 32 yr old white male was seen at a university dermatology clinic complaining of an acneform eruption of 6 mo duration. The patient was part owner of a firm that constructed piers for small boat marinas. The lumber used was pretreated with pentachlorophenol. Within about 9 mo after beginning work, he noted a papular acneform eruption that occurred over the entire body. The eruption was characterized by multiple, small yellow/white papules. Areas most involved included the malar regions of the face, post

auricular area, the trunk, buttocks, thighs, and lower legs. Some of the papules were inflamed. A trephine punch biopsy of one of the papules showed a small epithelial lined cystic structure that communicated with the surface. The lining epithelium was composed of atrophic, but normal appearing, epidermis. Contained within the cyst was keratin like material. The condition was diagnosed as chloracne. The patient's condition improved after 6 wk oral treatment with isotretinoin. The patient remained asymptomatic for the ensuing 2 yr of observation. The patient returned to work wearing appropriate protective clothing. A sample of pentachlorophenol used by the firm and samples of treated wood were analyzed for **OCDD**. Samples from the surface of the lumber contained about ten to 40 times the amount of **OCDD** as did the wood itself. The undiluted pentachlorophenol contained 1600 ppm **OCDD**. It was concluded that the patient developed chloracne after exposure to pentachlorophenol treated lumber. The **OCDD** containing surface residue seemed to be the major source of the intoxication.
[Cole GW et al; Contact Dermatitis 15 (3): 164-8 (1986)]**PEER REVIEWED**

Probable Routes of Human Exposure:

The major source of exposure of the general population to polychlorodibenzo-p-dioxins such as octachlorodibenzo-p-dioxin is through consumption of food(1). Exposure also occurs through inhalation of contaminated ambient air and consumption of contaminated drinking water(SRC).
[(1) Vaino H et al; Scand J Work Environ Health 15: 377-82 (1989)]**PEER REVIEWED**

Workers involved in the production of pentachlorophenol are exposed to octachlorodibenzo-p-dioxin and other dioxins and furans which occur as a contaminant in pentachlorophenol(1); a mean octachlorodibenzo-p-dioxin concn of 0.336 ug/cu m was measured in samples of breathing-zone air at a pentachlorophenol production site(1). A study was conducted in two office buildings in Boston to determine background contamination levels of octachlorodibenzo-p-dioxin in buildings with no known previous exposures(2); surface concns of 2.1-130 ng/sq m (mean of 22 ng/sq m) were detected in surface wipe samples(2); airborne concns of 0.0032-0.0076 ng/cu m (mean of 0.0048 ng/cu m) were detected in the office building air which was very similar to outdoor air concns in Boston(2).
[(1) Marlow DA; pp. 161-9 in Hexachlorobenzene: Proceedings of an International Symposium. Morris CR, Cabral JRP (eds), IARC Sci Publ No. 77 Lyon, France: IARC (1986) (2) Kominsky JR, Kwoka CD; Chemosphere 18: 599-608 (1989)]**PEER REVIEWED**

Workers involved in the production of pentachlorophenol may be exposed to one of its contaminants, hexachlorobenzene. Pentachlorophenol is produced commercially in the US by direct chlorination of phenol with chlorine gas in the presence of a catalyst at gradually rising temperatures up to 200 deg C. Other contaminants formed in pentachlorophenol production are isomers of hexa-, hepta- and octachlorodibenzo-para-dioxin and isomers of tetra-, penta-, hexa-, hepta- and octachlorodibenzofuran.
[Marlow DA; IARC Sci Publ 77: 161-9 (1986)]**QC REVIEWED**

Body Burden:

Breast milk from 9 women exposed to a PCB fire in Canada contained a mean octachlorodibenzo-p-dioxin concn of 193.44 ng/kg (fat basis) while the mean concn in milk from 16 control women was 131.70 ng/kg(1). Analysis of 30 human milk samples from Germany found levels of 0.185-1.217 (avg 0.530) ppb(2). Analysis of blood samples from a total of 300 humans in Vietnam, Germany and the US found levels of 0.087-1.655 ppb (lipid)(3). The following concns (ppb lipid) were found in human milk from various countries(3): Vietnam: 0.078-0.292; Cambodia: 0.059; Thailand: 0.068; Germany: 0.185; US: 0.233; Siberia: 0.0502(3). Autopsies of two humans from the US general population detected the following octachlorodibenzo-p-dioxin concns (ppb whole wt basis)(4): adipose tissue: 0.428-0.695; liver: 0.224-0.350; muscle: 0.076- 0.171; and kidney: 0.031-0.039(4). Based upon various monitoring

studies, the background level of octachlorodibenzo-p-dioxin in human adipose tissue ranges from 0.050-1.500 ppb(5). Human adipose tissue obtained during autopsies in 5 Canadian municipalities had an avg concn of 1.0367 ng/g(6).
[(1) Dewailly E et al; Chemosphere 23: 1831-5 (1991) (2) Beck H et al; Chemosphere 16: 1977-82 (1987) (3) Schecter A et al; Chemosphere 23: 1903-12 (1991) (4) Ryan JJ et al; Chemosphere 14: 929-32 (1985) (5) Beck H et al; Chemosphere 18: 507-16 (1989) (6) LeBel GL et al; Chemosphere 21: 1465-75 (1990)]**PEER REVIEWED**

An octachlorodibenzo-p-dioxin concn of 0.690 ppb was detected in the adipose tissue of a person exposed during a PCB transformer fire in Binghamton, NY(1); the concn in the adipose tissue of 4 control people was 0.428-0.695 ppb(1). Analysis of whole blood samples from 10 persons with no declared exposure found octachlorodibenzo-p-dioxin levels of 439-889 ng/kg fat basis(2). Results of the National Human Adipose Tissue Survey (NHATS) for fiscal year 1982 reported an octachlorodibenzo-p-dioxin concn range of 64-1250 ng/kg and a mean concn of 560 ng/kg(3).
[(1) Schecter A et al; Chemosphere 14: 933-7 (1985) (2) Paepke O et al; Chemosphere 19: 941-8 (1989) (3) Stanley JS et al; Chemosphere 15: 1605-12 (1986)]**PEER REVIEWED**

The tissue distribution of 2,3,7,8-chlorine substituted dibenzo-p-dioxins was conducted in 11 patients who died of cancer. The concn of octachlorodibenzo-p-dioxin was the highest in each organ and tissue and heptachlorodibenzo-p-dioxin was also found at relatively high levels, second only to octachlorodibenzo-p-dioxin. The levels of 1,2,3,7,8-pentachlorodibenzo-p-dioxin and 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin in the spleen were the highest, respectively. 2,3,7,8-Tetrachlorodibenzo-p-dioxin was also detected and its concn was the highest in the gonad (0.8-3.2 picogram/g range). From the 2,3,7,8-Tetrachlorodibenzo-p-dioxin toxic equiv calculations, the highest equiv value was obtained from a 54 yr old female who died of cancerous goiter. This individual had the highest concn of 2,3,7,8-substituted penta- and hexachlorodibenzo-p-dioxins among the 11 patients.
[Muto H et al; Life Sci 48 (17): 1645-57 (1991)]**PEER REVIEWED**

Average Daily Intake:

WATER: Based upon monitoring of Canadian drinking water, the avg daily intake of octachlorodibenzo-p-dioxin has been estimated to be 0.0001 ng/adult/day(1). FOOD: The daily intake of all polychlorinated dibenzodioxin isomers has been estimated to be 0.1397 ng/adult/day, the majority of which is octachlorodibenzo-p-dioxin(1); food contribution comes from most food groups with meat, eggs and dairy products the major contributors(1). Based upon a Japanese market basket survey, the average daily intake for octachlorodibenzo-p-dioxin has been estimated to 0.690 ng/adult/day(2).
[(1) Birmingham B et al; Chemosphere 19: 637-42 (1989) (2) Ono M et al; Chemosphere 16: 1823-8 (1987)]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** DIOXINS ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE

0.2.1.1 ACUTE EXPOSURE

A. Exposure to dioxins can cause a burning sensation in the eyes, nose, and throat. Headache, dizziness, blurred vision, muscle and joint pain, impaired muscle coordination, asthenia, nausea, vomiting, emotional disorders, nervousness, irritability, and intolerance to cold may all occur. Chloracne, an acne-like eruption of the skin, commonly occurs. Symptoms (itching, swelling, redness) may occur weeks or months before the eruptions appear and may last a few months or up to 15 years.

B. Dioxin exposure can cause immune system dysfunction, ulcers, peripheral neuropathy, and abnormalities of the liver, pancreas, and circulatory and respiratory systems.

C. CAVEATS - Dioxins occur as contaminants, and nearly all exposures are to mixtures containing very low levels. In such cases there is always a possibility that other components may contribute to the toxicity.

1. In many studies the relative composition of the mixture may not have been known; these studies have uncertainty with respect to QUALITATIVE exposures. Many studies also have uncertainty with respect to QUANTITATIVE exposure, or dose.
2. Some studies, such as a long-term follow-up study of Operation Ranch Hand Vietnam War Veterans, exposed to high levels of dioxins as contaminants in Agent Orange during spraying operations between 1962 and 1971, were done so long after exposure that it is difficult or impossible to determine an accurate exposure assessment based on either historical or analytical data.

D. There are no known cases of human fatalities from acute exposure to dioxins. Most acute exposures to dioxins (tetrachlorodibenzo-p-dioxin, TCDD) occur during runaway chemical reactions. Acute early signs and symptoms include chemical burns of the skin, irritation of the mucous membranes and eyes, nausea, vomiting and severe muscle pains.

1. After a latent period of several weeks, chloracne, porphyria cutanea tarda, hirsutism and/or hyperpigmentation may occur. Polyneuropathies and liver damage are frequently noted. Increased blood lipids are common and may persist.

E. TCDD is characterized by EPA as a human carcinogen. It has been most strongly linked with soft-tissue sarcomas. More limited evidence indicates associations with several other cancers. A US EPA reassessment put the upper limit for overall cancer risk for the general population as high as 1:100 to 1:1,000.

F. Dioxins may be human teratogens, specifically for

ectodermal dysplasia and CNS, cardiac and skeletal defects.

0.2.1.2 CHRONIC EXPOSURE

A. Little is known about potential human health effects (if any) of long-term exposure to low concentrations. The US EPA considers dioxin (TCDD) to be probably carcinogenic to humans (Group B2). IARC classifies TCDD as Group 1 (carcinogenic to humans), but places other dioxins in Group 3 (not classifiable as to their carcinogenicity to humans).

0.2.4 HEENT

0.2.4.1 ACUTE EXPOSURE

A. Conjunctivitis, irritation and burning may be noted.

0.2.5 CARDIOVASCULAR

0.2.5.1 ACUTE EXPOSURE

A. Cardiovascular disorders such as atherosclerosis and myocardial infarction have been suggested but not conclusively shown to be related to TCDD exposure.

0.2.6 RESPIRATORY

0.2.6.1 ACUTE EXPOSURE

A. Dyspnea may be noted.

0.2.7 NEUROLOGIC

0.2.7.1 ACUTE EXPOSURE

A. Peripheral neuropathy, with sensory impairment and lower extremity weakness, central neuropathy, mental status changes, headache and dizziness occur after exposure. Mild exposure may result in asymptomatic EMG alterations.

0.2.8 GASTROINTESTINAL

0.2.8.1 ACUTE EXPOSURE

A. Right-upper-quadrant pain, anorexia, nausea and vomiting may be early symptoms. Pancreatic injury occurred in one case of industrial exposure.

0.2.9 HEPATIC

0.2.9.1 ACUTE EXPOSURE

A. Enzyme induction is prominent with both acute and chronic exposures. Moderate acute exposures may manifest with increased liver function tests, mild fibrosis, fatty liver changes and hepatomegaly.

0.2.10 GENITOURINARY

0.2.10.1 ACUTE EXPOSURE

A. Urinary tract disorders may be a consequence of exposure. Self-limited hemorrhagic cystitis has been reported.

0.2.13 HEMATOLOGIC

0.2.13.1 ACUTE EXPOSURE

A. Prothrombin time prolongation has been noted rarely, in conjunction with liver damage.

0.2.14 DERMATOLOGIC

0.2.14.1 ACUTE EXPOSURE

A. The initial dermal reaction is extensive inflammation of exposed areas with photosensitivity, followed by development of chloracne.

1. Chloracne is considered a sensitive indicator of dioxin exposure; however, some patients seem to be resistant.
2. Chloracne consists of pale yellow cysts mostly on the skin of the face but spreading to other areas as time progresses. Erythema, edema, hirsutism and

photosensitivity may occur.
3. Chloracne clears or persists for several months in mild cases, whereas in severe cases it may persist for 30 years or longer.

B. Porphyria cutanea tarda may occur in moderate or severe exposures. The involvement of TCDD in its development has been disputed.

0.2.15 MUSCULOSKELETAL

0.2.15.1 ACUTE EXPOSURE

A. Myalgia is common in acute occupational exposure.

0.2.16 ENDOCRINE

0.2.16.1 ACUTE EXPOSURE

A. Dioxins affect various hormone systems. Abnormal glucose tolerance tests and diabetes mellitus have been notes after exposure to dioxins.

0.2.16.2 CHRONIC EXPOSURE

A. Changes in glucose tolerance have been seen with chronic occupational TCDD exposure.

0.2.17 METABOLISM

0.2.17.1 ACUTE EXPOSURE

A. TCDD induces cytochrome P450-1A1 and P450-1A2; the degree of toxicity is related to the extent of enzyme induction. The liver is the main site of induction, but other tissues may also be involved.

B. Fat and carbohydrate metabolism are affected by dioxin exposure. Hyperlipidemia and hypercholesterolemia have been described after acute exposure. Porphyria has also been reported, but a direct causal link to dioxin is unlikely.

0.2.18 PSYCHIATRIC

0.2.18.1 ACUTE EXPOSURE

A. Fatigue, emotional disorders, irritability and nervousness have been noted after exposure to dioxins.

0.2.18.2 CHRONIC EXPOSURE

A. Post-traumatic stress disorder was inconclusively associated with Agent Orange exposure in some Vietnam veterans.

0.2.19 IMMUNOLOGIC

0.2.19.1 ACUTE EXPOSURE

A. Dioxins are considered immunotoxic by some sources, although results are conflicting.

0.2.20 REPRODUCTIVE HAZARDS

A. Dioxins have not been proven to produce adverse reproductive effects in humans. However, low birthweights, ectodermal dysplasia, and growth and neurological deficits have been associated with dioxin exposure. Data on spontaneous abortions, decreased sperm quality and feminizing alterations of sex hormones have been mixed. TCDD accumulates in breast milk, and neurological deficits and increases in T4 and TSH have been associated with lactational exposure. TCDD is considered an animal teratogen.

B. The US EPA has been re-evaluating the health effects of dioxins. In its current report version ("Draft Final" of May 2000), it is concluded that TCDD is a likely developmental and reproductive toxin.

0.2.21 CARCINOGENICITY

0.2.21.1 IARC CATEGORY

A. IARC classifies TCDD as Group 1 (carcinogenic to

humans), based on limited evidence in humans and sufficient evidence in experimental animals. However, other dioxins are in Group 3 (not classifiable as to their carcinogenicity to humans), based on limited or inadequate evidence in experimental animals, or evidence suggesting a lack of carcinogenicity (IARC, 1997).

0.2.21.2 HUMAN OVERVIEW

A. Dioxins are probable human carcinogens; TCDD is a known human carcinogen. Results are conflicting regarding increased overall cancer morbidity and mortality, and for an association with soft tissue sarcomas, non-Hodgkin and Hodgkin lymphoma. There is limited evidence of an association with myeloma and pulmonary, prostate, gastric and breast carcinoma. The upper limit for overall risk in the general population may be as high as 1:1,000.

0.2.21.3 ANIMAL OVERVIEW

A. TCDD is the most potent known animal carcinogen and tumor promoter.

0.2.22 GENOTOXICITY

A. TCDD is not directly genotoxic and usually produces negative results in most genotoxicity assays. However, the TCDD-aryl hydrocarbon receptor complex can bind to specific DNA enhancer sequences. This induces a pleiotropic sequence of genetic expression whose products may activate pro-mutagens.

0.2.23 OTHER

0.2.23.1 ACUTE EXPOSURE

A. Cachexia may occur as a result of exposure to TCDD.

Laboratory:

A. It is difficult and expensive to measure dioxins in human tissue specimens. The current analytical techniques involve gas chromatography and mass spectrometry.

B. Liver function tests, CBC, prothrombin time (INR - International Normalized Ratio), serum lipids and uroporphyrins should be obtained in acute exposure. Electrodiagnostic studies such as EMG and nerve conduction velocity may be useful in detecting subclinical neuropathy.

Treatment Overview:

0.4.2 ORAL EXPOSURE

A. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.

Range of Toxicity:

A. Cumulative oral doses of 100 mcg/kg are estimated to be the minimum toxic dose.

B. Dermal exposure to soil concentrations of greater than 100 ppm are likely to produce chloracne.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

For actue 2,4-D or 2,4,5-T exposures, the usual measures of gut and skin decontamination (ipecac/lavage, charcoal, cathartic) are recommended within the first several hours. On the basis of pharmacokinetic data, alkaline diuresis has been suggested in severe overdose as a method to enhance elmination of 2,4-d, but this procedure should be used cautiously in the presence of renal dysfunction. Alkalinization of the urine and generous fluid replacement have the added benefit of treating any myoglobinuria present. Watch for the development of metabolic acidosis, hyperthermia, hyperkalemia, myoglobinuria, and hepatic and/or renal dysfunction. /Chlorophenoxy compounds and dioxin/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 1096] **PEER REVIEWED**

Animal Toxicity Studies:

Evidence for Carcinogenicity:

Overall evaluation: Other polychlorinated dibenzo-para-dioxins are not classifiable as to their carcinogenicity to humans (Group 3).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 69 342 (1997)]**QC REVIEWED**

Non-Human Toxicity Excerpts:

... Groups of 50 male and 50 female B6C3F1 mice were fed diets containing ... 0.25, 0.5 or 1% **OCDD**. ... **OCDD** induced significant mortality within 20 weeks and pathological changes in the lung and liver. ... One animal fed 0.25% **OCDD** showed hyperplasia and metaplasia of the bronchial mucosa and a bronchiolar carcinoma. Hepatotoxic changes were also noted, but no hepatic tumors were reported.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 67 (1977)]**PEER REVIEWED**

Single oral doses of 1-2 g/kg body weight /of/ **OCDD** did not kill female rats, and larger doses of **OCDD** (4 g/kg body weight) were not lethal to mice.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 69 (1977)]**PEER REVIEWED**

In the rabbit ear bioassay for acnegenic activity, solutions of chlorinated dibenzo-para-dioxins were applied to the inside of the ear 5 days per week for 4 weeks. ... Chloroform extracts of 10% suspension of ... **OCDD** ... /were/ inactive.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 71 (1977)]**PEER REVIEWED**

... Groups of 35 male and 35 female Osborne-Mendel rats were fed diets containing ... /0.25, 0.5 or 1%/ **OCDD**. ... /By the 37th week of test there were no survivors in the 0.5% and 1% **OCDD** groups/ No tumors were seen in rats treated for up to 42 weeks (time of reporting). Rats fed **OCDD** had liver changes ranging from early hepatotoxic lesions to cirrhosis.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 67 (1977)]**PEER REVIEWED**

... Groups of 30 male and 30 female Swiss-Webster mice received thrice weekly skin applications of 0.2 ml acetone containing 0.2 mg/kg **OCDD**. ... After 60 weeks, 20 male and 28 female mice ... were still alive. ... None of the treated mice had skin tumors; 1 male and 1 female treated with **OCDD** had sc tumors (type not specified).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 67 (1977)]**PEER REVIEWED**

OCDD administered to pregnant rats at a dose of 500 mg/kg body weight/day from days 6-15 of pregnancy produced sc edema in the fetuses.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 75 (1977)]**PEER REVIEWED**

OCDD was non-mutagenic to Salmonella typhimurium strains G46, TA1530 and TA1531, and doubtful results were obtained with strains TA1532 and TA1534. Metabolic activation systems were not included in ... these microbiological assays.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 75 (1977)]**PEER REVIEWED**

Feeding male Wistar rats (110 g) 0, 0.2, or 1.0 ug octachlorodibenzo-p-dioxin/kg diet for two weeks, resulting in a total intake of 0, 22.7 (+ or - 1.0) or 120.7 (+ or - 2.8) ug octachlorodibenzo-p-dioxins had no effect on body weight gain, feed consumption, or tissue weights (liver, thymus, testes, heart, and kidney). Congestion of the liver occurred in the high-dose group.
[WHO; Environmental Health Criteria 88: Polychlorinated Dibenzo-para-dioxins and Dibenzofurans p.149 (1989)]**PEER REVIEWED**

Daily doses of 100 ug octachlorodibenzo-p-dioxin for 21 days produced no effects on appearance, activity, or eating habits in male Sprague Dawley rats, but slightly increased relative liver weight. A moderate increase in the hepatic smooth endoplasmic reticulum was noted.
[WHO; Environmental Health Criteria 88: Polychlorinated Dibenzo-para-dioxins and Dibenzofurans p.149 (1989)]**PEER REVIEWED**

In vitro exposure of B6C3F1 spleen cells to ... octachlorodibenzo-p-dioxins /was/ without /any/ effect /on the production of anti-sheep red blood cell plaque forming cells/ at concentrations up to 5X10-8 mol/l.
[WHO; Environmental Health Criteria 88: Polychlorinated Dibenzo-para-dioxins and Dibenzofurans p.175 (1989)]**PEER REVIEWED**

Octachlorodibenzo-p-dioxin had no effect /at single oral doses/ of 100 and 500 ug/kg body weight /on suppression of splenic immunoglobulin M response to sheep red blood cells in C57B1/6 mice/.
[WHO; Environmental Health Criteria 88: Polychlorinated Dibenzo-para-dioxins and Dibenzofurans p.177 (1989)]**PEER REVIEWED**

Octachlorodibenzo-p-dioxin was not mutagenic to various strains of Salmonella typhimurium without metabolic activation.
[WHO; Environmental Health Criteria 88: Polychlorinated Dibenzo-para-dioxins and Dibenzofurans p.213 (1989)]**PEER REVIEWED**

Oral doses of octachlorodibenzo-p-dioxin 1 g/kg body weight to five female rats and 4 g/kg body weight to four male mice did not cause any toxic symptoms.
[WHO; Environmental Health Criteria 88: Polychlorinated Dibenzo-para-dioxins and

Dibenzofurans p.140 (1989)]**PEER REVIEWED**

The treatment of 3 day old chicks with ... 2,3,7,8-tetrachlorodibenzo-p-dioxin ... and hexachlorodibenzo-p-dioxins produced chick edema, although birds fed diets containing 0.5% octachlorodibenzo-p-dioxin did not develop edema.
[NRCC; Polychlorinated Dibenzo-p-dioxins: Criteria for Their Effects on Man and His Environment p.88 (1981)]**PEER REVIEWED**

The effects of ... polychlorinated dibenzo-p-dioxins (33% heptachloro- and 66% octachloro-dibenzo-p-dioxins) on the susceptiblilty of ICR/JCL mice to Escherichia coli endotoxin /were reported/. ... A dose-related increase in mortality to the Escherichia coli endotoxin was observed.
[NRCC; Polychlorinated Dibenzo-p-dioxins: Criteria for Their Effects on Man and His Environment p.127 (1981)]**PEER REVIEWED**

Mixtures of polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans were studied in Sprague Dawley rats to evaluate possible additive effects on body wt gain, hepatic enlargement and enzyme induction, thymic atrophy, and vitamin-A retention. Rats in the treatment group were given 2.5 ug tetrachlorodibenzodioxin per kg of body wt with 16 ug/kg pentachlorodibenzodioxin, 53 ug/kg pentachlorodibenzofuran, or 755 ug/kg **OCDD** in corn oil. Control group animals were given vehicle alone. At 4 wk after exposure, the animals were killed, organ weights were determined, and biochemical analyses were performed on liver tissues. Percentage gain in body wt was similar across all groups. Relative thymus weights were slightly decreased in the treatment groups, but not significantly. All congeners caused reduction in hepatic vitamin A of up to 60%, and none caused an additive effect with tetrachlorodibenzodioxin. An additive effect was observed in cytochrome p450 levels in rats treated with TCCD and **OCDD**. Activity of hepatic 7-ethoxyresorufin-O-deethylase was induced up to 15 fold in all except the **OCDD** group.
[Ahlborg UG et al; Chemosphere 18 (1/6): 283-9 (1989)]**PEER REVIEWED**

The effects of subchronic **OCDD** exposure were examined in rats over a 13 wk period. Male Fischer-344 rats were treated with 50 ug per kg (14)C labeled **OCDD** by gavage for 10, 20, 40, or 65 doses (once per day 5 days per wk) and sacrificed 3 days postexposure. Clinical chemistry and hematologic parameters were evaluated in blood samples collected immediately prior to sacrifice. Radioactivity in tissues was determined and hepatic microsomal monooxygenase activity assessed by fluorometric analysis of ethoxyresorufin-O-deethylase activity. **OCDD** accumulated linearly with increasing number of doses; liver was the major depot, followed by adipose tissue. Little **OCDD** was detected in the blood. Hepatic accumulation was associated with alterations of several biochemical parameters. In animals treated 65 times, ethoxyresorufin-O-deethylase activity was elevated 40 fold over controls; total cytochrome p450 content doubled and exhibited a 2 nanometer blue shift in the Soret maximum for the reduced hemoprotein-CO complex. Cytochrome p450c and cytochrome p450d were significantly increased, while cytochrome p450b levels were unaltered. Cytoplasmic fatty vacuolization in the liver occurred concomitant with the biochemical changes. Increases in spleen and liver wt relative to body weight were seen in rats receiving at least 40 doses. Nearly all the dioxin and furan congeners present in liver were represented by **OCDD**, with a slight amount of heptachlorinated dioxin present. It was concluded that subchronic **OCDD** exposure causes toxic effects similar to those observed with other dioxins, but with far less potency than 2,3,7,8-tetrachlorodibenzo-p-dioxin; due to persistent environmental exposure, **OCDD** may pose a potential risk to human health over a lifetime.
[Couture LA et al; Toxicol Appld Pharmacol 93 (1): 31-46 (1988)]**PEER REVIEWED**

The results of both the Salmonella/microsome mutagenicity assay and HPLC analysis were used to evaluate the interactions of binary mixtures of benzo(a)pyrene and several different polychlorinated aromatic hydrocarbons. Binary mixtures of either-nitro-3,7,8-trichlorodibenzo-p-dioxin or pentachlorophenol with benzo(a)pyrene produced synergism, whereas strictly additive effects were

observed with mixtures of octa- or hepta-chlorodibenzo-p-dioxin and benzo(a)pyrene. At a dose of 50 ug/plate, benzo(a)pyrene induced 120 total revertants, whereas the binary mixture of benzo(a)pyrene and pentachlorophenol induced 303 total revertants. The binary mixture of benzo(a)pyrene at 1 ug/plate and 2-nitro-3,7,8-trichlorodibenzo-p-dioxin at 0.5 ug/plate induced 261 net revertants, whereas benzo(a) pyrene alone induced 42 net revertants. HPLC analysis of the mixtures indicated that preincubation of benzo(a)pyrene with 2-nitro-3,7,8-trichlorodibenzo-p-dioxin increased the quantity of benzo(a)pyrene-7,8-dihydrodiol, and 9,10-dihydrodiol metabolites detected. The data suggest that nonmutagenic components of a complex mixture may alter the metabolism of promixate mutagens. Thus, in the present study, 2-nitro-3,7,8-trichlorodibenzo-p-dioxin appears to have inhibited the detoxication of benzo(a) pyrene metabolites.
[Donnelly KC et al; Environ Mol Mutagen 16 (4): 238-45 (1990)]**PEER REVIEWED**

The immunosuppressive effects of dioxins were studied in mice. The effects on selected hepatic microsomal parameters were also investigated. Female B6C3F1 mice were administered 0.1 ug/ml **OCDD** daily for 14 days. **OCDD** had no affinity for the Ah receptor. One day after the last exposure, the animals were killed and weighed, and selected organs were removed, weighed, and examined for histopathological changes. Hepatic microsomal parameters were determined. Animals treated with **OCDD** were evaluated for immunocompetence by determining the antibody response to sheep erythrocytes and dinitrophenyl/Ficoll. **OCDD** showed no immunosuppressive effects.
[Holsapple MP et al; Toxicol Appl Pharmacol 83 (3): 445-55 (1986)]**PEER REVIEWED**

The effect of **OCDD** on aryl hydrocarbon hydroxylase activity in cultured human lymphoblastoid cells was investigated. **OCDD** is considered to be a less toxic isomer of dibenzo-p-dioxin. At a concn of 5 ppb, **OCDD** enhanced the basal aryl hydrocarbon hydroxylase activity by about 30%. In the case of simultaneous treatment of **OCDD** with highly toxic 2,3,7,8-tetrachlorodibenzo-p-dioxin at a concn of 7.5 ppb of each compound, the aryl hydrocarbon hydroxylase activities induced by **OCDD** plus 2,3,7,8-tetrachlorodibenzo-p-dioxin was about 43%, higher than that induced by 2,3,7,8-tetrachlorodibenzo-p-dioxin alone. It has been reported that the aryl hydrocarbon hydroxylase inducibility of dioxins correlates well with their toxic potency. Hence, taking the results of this study into account, the biological and/or health consequences of the mixed contamination of no or less toxic and highly toxic congeners of dioxins by animal experiments and epidemiological studies are clarified.
[Nagayama J et al; Fukuoka Igaku Zasshi 80 (5): 196-200 (1989)]**PEER REVIEWED**

2,3,7,8-Tetrachlorodibenzo-p-dioxin acts as a potent liver tumor promoter in female but not in male rats. As a basis for studying mechanisms of growth control by liver tumor promoters, the effects of tetrachlorodibenzo-p-dioxin, of two congeners and ethinylestradiol have been examined in primary cultures of hepatocytes. The agents alone were relatively ineffective but acted as co-mitogens when DNA synthesis was stimulated by epidermal growth factor. Similar effects were seen with two tetrachlorodibenzo-p-dioxin congeners (1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin and octachlorodibenzo-p-dioxin) in the rank order of their affinity to the Ah receptor. The concn maximum required for their co-mitogenic action was lower than that required for enzyme induction. The results suggest: (i) co-mitogenic actions of tetrachlorodibenzo-p-dioxin and congeners are mediated by the Ah receptor. They are elicited at lower concn than those required for the induction of drug-metabolizing enzymes. (ii) Estrogens enhance the co-mitogenic actions of dioxins.
[Schrenk D et al; Carcinogenesis 13 (3): 453-6 (1992)]**PEER REVIEWED**

Toxicity and biochemical activity of 2,3,7,8-tetrachlorodibenzo-p-dioxin and its congeners were studied. Female Sprague Dawley rats were fed 2,3,7,8-tetrachlorodibenzo-p-dioxin, 1,2,3,4,6,7,8,9-octachlorodibenzo-p-dioxin in corn oil at 40 or 400 ug/kg/day for 3 days. The animals were killed 6 days after the treatment. The low dose of 2,3,7,8-tetrachlorodibenzo-p-dioxin caused a 4.4 fold increase in hepatic lipid peroxidation as determined by hepatic malondialdehyde content. **OCDD** had not

produced noticeable lipid peroxidation. 2,3,7,8-tetrachlorodibenzo-p-dioxin at 40 induced 64% inhibition of selenium dependent glutathione peroxidase (glutathione peroxidase) activity, however, **OCDD** was without an effect. 2,3,7,8-tetrachlorodibenzo-p-dioxin at 40 ug resulted in a 4.2 fold increase in aryl-hydrocarbon-hydroxylase activity. Thymus wt decreased approximately 80% on administration of 40 ug 2,3,7,8-tetrachlorodibenzo-p-dioxin. Animals that received low dose of 2,3,7,8-tetrachlorodibenzo-p-dioxin lost 20% wt. No changes in the kidney malondialdehyde and glutathione peroxidase content were observed. **OCDD** had no effect on hepatic and renal activities.
[Shara MA, Stohs SJ; Arch Environ Contamin Toxicol 16 (5): 599-605 (1987)]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

Metabolic transformation of the dibenzo-p-dioxins in the guppy (Poecilia reticulata) appears to involve hydroxylation, probably mediated by the mixed function oxidase system. /Dibenzo-p-dioxins/
[Frank CG, Schrap SM; Chemosphere 20 (5): 495-512 (1990)]**PEER REVIEWED**

Absorption, Distribution & Excretion:

Male Wistar rats fed 22.7 (+ or -) ug or 120.7 (+ or - 2.9) ug octachlorodibenzo-p-dioxin over a two week period were found to retain about 1-2% of the given dose in the liver. The heart, kidneys, spleen, lung, skeletal muscle, testes, and urine contained no detectable levels of octachlorodibenzo-p-dioxin, but minor amounts were found in the adipose tissue of the high dose group. Feces contained 61% and 37%, respectively, of the low and high doses given. The presence of a large quantity of octachlorodibenzo-p-dioxin in the feces compared to that in the bile 24-72 hr after a single oral dose of 58 ug octachlorodibenzo-p-dioxin to bile-cannulated male Wistar rats (400 g) indicated that the dioxin present in the feces was mainly unabsorbed octachlorodibenzo-p-dioxin.
[WHO; Environmental Health Criteria 88: Polychlorinated Dibenzo-para-dioxins and Dibenzofurans p.106 (1989)]**PEER REVIEWED**

After 21 daily doses of 100 ug octachlorodibenzo-p-dioxin containing 12.6 picograms (35)S-thio-heptachlorodibenzo-p-dioxin to male Sprague Dawley rats, the radioactivity was mainly recovered in the feces and urine, the percentages of the ingested radioactive dose being 93 (+ or - 6) and 5.2 (+ or - 0.8)% respectively. The high fecal excretion suggests poor absorption. Of the radioactive body burden, 50% was contained in the liver. The microsomal fraction contained 96.3 (+ or - 8.2)% of the hepatic radioactivity.
[WHO; Environmental Health Criteria 88: Polychlorinated Dibenzo-para-dioxins andDibenzofurans p.107 (1989)]**PEER REVIEWED**

The polychlorinated dibenzo-p-dioxins and the polychlorinated dibenzofurans are predominantly stored in fat, but they are also excreted in milk and pass the placenta. They also appear in the blood and vital organs at lower concentrations. /Polychlorinated dibenzo-p-dioxins/
[WHO; Environmental Health Criteria 88: Polychlorinated Dibenzo-para-dioxins and Dibenzofurans p.303 (1989)]**PEER REVIEWED**

Octachlorodibenzo-p-dioxin is a widespread environmental contaminant which has been reported to be nontoxic after acute administration. The disposition of (14)C-octachlorodibenzo-p-dioxin was studied in male Fischer 344 rats in order to better assess the significance of chronic environmental exposure to octachlorodibenzo-p-dioxin. Rats were treated with 50 ug octachlorodibenzo-p-dioxin/kg iv, and 50, 500, or 5000 ug/kg orally and held in individual metabolism cages for 3 days. Additional rats treated iv were held up to 56 days to follow elimination of octachlorodibenzo-p-dioxin derived radioactivity and to

determine terminal tissue distribution. Feces was the major route of elimination after both routes of exposure with little radioactivity ever appearing in the urine. GI absorption was nonlinear between 500 and 5000 ug/kg, never exceeding 10% of the administered dose. Liver was the major depot, followed by adipose tissue and skin. No metabolites of octachlorodibenzo-p-dioxin were detected in tissues, bile, or excreta. The whole body half-life for the elimination of octachlorodibenzo-p-dioxin was between 3 and 5 mo. Repeated oral exposure resulted in linear accumulation of octachlorodibenzop-dioxin in the tissues. Thus, octachlorodibenzo-p-dioxin while poorly absorbed, can accumulate upon low-dose, repeated exposure and concentrate in the liver and adipose tissue.
[Birnbaum LS, Couture LA; Toxicol Appl Pharmacol 93 (1): 22-30 (1988)]**PEER REVIEWED**

A study of dibenzo-p-dioxins concn in human milk was conducted. A total of 168 milk samples were obtained from mothers who breast fed their children. Seventy nine samples were obtained from mothers nursing their first child, 74 from mothers nursing their second child, and 15 samples were collected from mothers nursing their third or fourth child. Milk samples were obtained from a single mother 1, 5, 10 to 13, and 52 to 60 wk after delivery and analyzed for dibenzo-p-dioxins. Dibenzo-p-dioxins with 2,3,7,8-chlorine substitution were found in all samples. The mean concn of dibenzo-p-dioxins was 195 parts per trillion for octachlorodibenzo-p-dioxin. The dibenzo-p-dioxin concn in the samples decreased with increasing number of children who were breast fed. The concn of dibenzo-p-dioxins in the breast milk from the single mother decreased to about 30 to 40% of their initial value 52 wk after delivery. The largest decreases generally occurred 1 to 5 wk after delivery. It was concluded that dibenzo-p-dioxins residues in human milk from mothers who nurse their infants decrease from the first to the second child and with time after delivery. Lactation can be regarded as an excretory process for the mother.
[Furst P et al; Chemosphere 18 (1): 439-44 (1989)]**PEER REVIEWED**

A defined mixture of dibenzo-p-dioxins was sc administered to a pregnant marmoset monkey (Callithrix jacchus) 11 wk prior to delivery. Transfer of dibenzo-p-dioxins via placenta and mother's milk was investigated by measurement of concn in a newborn 1 day after birth and in an infant of the same litter after a lactation period of 33 days. Furthermore, comparative measurements were performed in different tissues of the mother at the end of the lactation period, and in addition, in two groups of four adult monkeys each 1 and 6 wk after treatment. Fetal liver is apparently largely unable to accumulate dibenzo-p-dioxins. Concn of octachlorodibenzo-p-dioxin were about three times higher in the newborn than in adult adipose tissue. Transfer of some of the 2,3,7,8-substituted dibenzo-p-dioxins to the offspring via mother's milk was considerable, leading to hepatic concn in the suckled infant at the end of the 33 day nursing period well above corresponding concn in the dam (less than one tenth the concn of octachlorodibenzo-p-dioxin was found in the infant's liver when compared with adult liver). Besides adipose tissue, comparatively high levels were found in thymus and also in lung tissue. The limited data available point to a long persistence of some of the 2,3,7,8-substituted congeners in the thymus. Especially low concn of all the congeners were measured in the brain and testes.
[Hagenmaier H et al; Arch Toxicol 64 (8): 601-15 (1990)]**PEER REVIEWED**

Human adipose tissue samples obtained during autopsies in 5 Canadian municipalities within the Great Lakes basin were analyzed for dibenzodioxins and dibenzofurans using GC high resolution MS. The mean congener values for male and female donors in each municipality are comparable with previously reported data. No significant differences in congener levels between male and female and between municipalities were detected. A positive correlation between congener level and age was observed for several congeners as well as for the total congener concn expressed as its 2,3,7,8-tetrachlorodibenzo-p-dioxin toxic equivalent.
[Lebel GL et al; Chemosphere 21 (12): 1465-76 (1990)]**PEER REVIEWED**

Accumulation of octachlorodibenzo-p-dioxin from water by rainbow trout fry (Salmo gairdneri) and

fathead minnows (Pinephales promelas) was studied using a 5 day uptake and 24 to 48 day depuration period. Average exposure concn ranged from 9 to 415 ng/l for octachlorodibenzo-p-dioxin. Equilibrium bioconcentration factors for total (14)Cin fish, calculated by use of a two-compartment first-order rate model, were 85 and 2226 for octachlorodibenzop-dioxin in trout fry and minnows, respectively. Elimination rates of both isomers were rapid, with half-lives of (14)C ranging from 5 to 13 days for octachlorodibenzo-p-dioxin . The highest concn of radiolabeled octachlorodibenzo-p-dioxin were found in bile. Dietary exposure of rainbow trout resulted in low accumulation factors (0.034 for octachlorodibenzo-p-dioxin) based on toluene-extractable radioactivity.
[Muir D CG et al; Environ Toxicol Chem 5 (3): 261-72 (1986)]**PEER REVIEWED**

The tissue distribution of 2,3,7,8-chlorine substituted dibenzo-p-dioxins was conducted in 11 patients who died of cancer. The concn of octachlorodibenzo-p-dioxin was the highest in each organ and tissue and heptachlorodibenzo-p-dioxin was also found at relatively high levels, second only to octachlorodibenzo-p-dioxin.
[Muto H et al; Life Sci 48 (17): 1645-57 (1991)]**PEER REVIEWED**

A study of tissue concn of dibenzo-p-dioxins in a fatal pentachlorophenol poisoning case was conducted. Periadrenal, adipose, liver and kidney tissue samples were obtained from a 33 yr old male who died from acute pentachlorophenol poisoning. The tissues were analyzed by GC/MS for all dibenzo-p-dioxin congeners /including octachlorodibenzo-p-dioxin / containing four to eight chlorine atoms. The highest concn of dibenzo-p-dioxins on a wet basis were found in the adipose tissue, followed by the liver and kidney in that order. The elevated concn were due primarily to heptachlorinated and octachlorinated congeners that were present in adipose tissue in concn of 10 to 20 and 100 ng/g, respectively. Adipose tissue concn of tetrachlorinated and pentachlorinated isomers were comparable to those found in the general population of North America, at 2.3 to 32 picograms per gram. The estimated body burden of all dibenzo-p-dioxins was around 2 mg, which was approximately 150 times higher than the general background level. It was concluded that the health effects of the dibenzo-p-dioxin tissue burden is unknown, and that the effects of dibenzo-p-dioxin cannot be readily separated from the effects of pentachlorophenol.
[Ryan JJ et al; Chemosphere 16 (8/9): 1989-96 (1987)]**PEER REVIEWED**

A study of changes in adipose tissue dibenzo-p-dioxin concn in a person exposed to PCB contaminated soot was conducted. The subject was a white male in his sixties. In 1981 his blood serum PCB concn were 47 to 60 ppb when expressed as aroclor 1254 and his adipose tissue dibenzo-p-dioxin concn was significantly above the normal mean of1200 parts per trillion. Four serial adipose tissue biopsy samples were taken over a 3.5 yr period and analyzed for dibenzo-p-dioxins. A blood sample was also taken at the time of the last biopsy to determine serum dibenzo-p-dioxin concn. The adipose tissue and serum concn were generally similar except for octachlorodibenzo-p-dioxin . The octachlorodibenzo-p-dioxin concn in adipose tissue and blood samples averaged 1081 and 1853 parts per trillion, respectively. Except for the penta, hexa- and hepta-dibenzofuran concn, which decreased over time, the adipose tissue dibenzo-p-dioxin concn remained relatively constant over the sampling period. It was concluded that the halflives for eliminating penta-, hexa-, and hepta-dibenzofuran from adipose tissue are on the order of 1 or 2 yr.
[Schecter A, Ryan JJ; Chemosphere 18: (1-6): 635-42 (1989)]**PEER REVIEWED**

Biological Half-Life:

The half-lives of 1,2,3,6,7,8-Hexachlorodibenzo-p-dioxin, 1,2,3,4,6,7,8-heptachlorodibenzo-p-dioxin, and octachlorodibenzo-p-dioxin /were calculated/ to be about 3.5, 3.6 and 2 years, respectively. The estimation was based on the analysis of fat tissue biopsies collected with an interval of 28 months from one 14 year old girl who for a period of about 2-3 years had been exposed to technical

pentachlorophenol.
[WHO; Environmental Health Criteria 88: Polychlorinated Dibenzo-para-dioxins and Dibenzofurans p.262 (1989)]**PEER REVIEWED**

Pharmacology:

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Octachlorodibenzo-p-dioxin is released to the environment primarily through emissions from the incineration of municipal and chemical waste. It is also released to the environment in automobile exhaust, emissions from steel mills, and in wastewater effluents from pulp mills and chemical manufacturing. If released to the atmosphere, octachlorodibenzo-p-dioxin will occur primarily in the particulate-phase with small percentages in the gas-phase. In the gas-phase, it will degrade by reaction with photochemically produced hydroxyl radicals (estimated half-life of about 10 days). The particulate-phase is generally stable to atmospheric degradation and can undergo long-range global transport; it will be removed physically from air by dry and wet deposition. If released to water, octachlorodibenzo-p-dioxin will predominantly be associated with sediment and suspended material. Field tests have indicated that sediments are an important environmental sink for octachlorodibenzo-p-dioxin. Dissolved octachlorodibenzo-p-dioxin may undergo some photolysis in sunlight. If released to soil, it is not expected to leach. Octachlorodibenzo-p-dioxin has been shown to be a persistent chemical in water or soil. The major source of exposure of the general population is through consumption of food. Exposure also occurs through inhalation of air and consumption of contaminated drinking water. It is commonly found in human adipose tissue and blood. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

The major source of exposure of the general population to polychlorodibenzo-p-dioxins such as octachlorodibenzo-p-dioxin is through consumption of food(1). Exposure also occurs through inhalation of contaminated ambient air and consumption of contaminated drinking water(SRC).
[(1) Vaino H et al; Scand J Work Environ Health 15: 377-82 (1989)]**PEER REVIEWED**

Workers involved in the production of pentachlorophenol are exposed to octachlorodibenzo-p-dioxin and other dioxins and furans which occur as a contaminant in pentachlorophenol(1); a mean octachlorodibenzo-p-dioxin concn of 0.336 ug/cu m was measured in samples of breathing-zone air at a pentachlorophenol production site(1). A study was conducted in two office buildings in Boston to determine background contamination levels of octachlorodibenzo-p-dioxin in buildings with no known previous exposures(2); surface concns of 2.1-130 ng/sq m (mean of 22 ng/sq m) were detected in surface wipe samples(2); airborne concns of 0.0032-0.0076 ng/cu m (mean of 0.0048 ng/cu m) were detected in the office building air which was very similar to outdoor air concns in Boston(2).
[(1) Marlow DA; pp. 161-9 in Hexachlorobenzene: Proceedings of an International Symposium. Morris CR, Cabral JRP (eds), IARC Sci Publ No. 77 Lyon, France: IARC (1986) (2) Kominsky JR, Kwoka CD; Chemosphere 18: 599-608 (1989)]**PEER REVIEWED**

Workers involved in the production of pentachlorophenol may be exposed to one of its contaminants, hexachlorobenzene. Pentachlorophenol is produced commercially in the US by direct chlorination of phenol with chlorine gas in the presence of a catalyst at gradually rising temperatures up to 200 deg C. Other contaminants formed in pentachlorophenol production are isomers of hexa-, hepta- and octachlorodibenzo-para-dioxin and isomers of tetra-, penta-, hexa-, hepta- and octachlorodibenzofuran.

[Marlow DA; IARC Sci Publ 77: 161-9 (1986)]**QC REVIEWED**

Body Burden:

Breast milk from 9 women exposed to a PCB fire in Canada contained a mean octachlorodibenzo-p-dioxin concn of 193.44 ng/kg (fat basis) while the mean concn in milk from 16 control women was 131.70 ng/kg(1). Analysis of 30 human milk samples from Germany found levels of 0.185-1.217 (avg 0.530) ppb(2). Analysis of blood samples from a total of 300 humans in Vietnam, Germany and the US found levels of 0.087-1.655 ppb (lipid)(3). The following concns (ppb lipid) were found in human milk from various countries(3): Vietnam: 0.078-0.292; Cambodia: 0.059; Thailand: 0.068; Germany: 0.185; US: 0.233; Siberia: 0.0502(3). Autopsies of two humans from the US general population detected the following octachlorodibenzo-p-dioxin concns (ppb whole wt basis)(4): adipose tissue: 0.428-0.695; liver: 0.224-0.350; muscle: 0.076- 0.171; and kidney: 0.031-0.039(4). Based upon various monitoring studies, the background level of octachlorodibenzo-p-dioxin in human adipose tissue ranges from 0.050-1.500 ppb(5). Human adipose tissue obtained during autopsies in 5 Canadian municipalities had an avg concn of 1.0367 ng/g(6).
[(1) Dewailly E et al; Chemosphere 23: 1831-5 (1991) (2) Beck H et al; Chemosphere 16: 1977-82 (1987) (3) Schecter A et al; Chemosphere 23: 1903-12 (1991) (4) Ryan JJ et al; Chemosphere 14: 929-32 (1985) (5) Beck H et al; Chemosphere 18: 507-16 (1989) (6) LeBel GL et al; Chemosphere 21: 1465-75 (1990)]**PEER REVIEWED**

An octachlorodibenzo-p-dioxin concn of 0.690 ppb was detected in the adipose tissue of a person exposed during a PCB transformer fire in Binghamton, NY(1); the concn in the adipose tissue of 4 control people was 0.428-0.695 ppb(1). Analysis of whole blood samples from 10 persons with no declared exposure found octachlorodibenzo-p-dioxin levels of 439-889 ng/kg fat basis(2). Results of the National Human Adipose Tissue Survey (NHATS) for fiscal year 1982 reported an octachlorodibenzo-p-dioxin concn range of 64-1250 ng/kg and a mean concn of 560 ng/kg(3).
[(1) Schecter A et al; Chemosphere 14: 933-7 (1985) (2) Paepke O et al; Chemosphere 19: 941-8 (1989) (3) Stanley JS et al; Chemosphere 15: 1605-12 (1986)]**PEER REVIEWED**

The tissue distribution of 2,3,7,8-chlorine substituted dibenzo-p-dioxins was conducted in 11 patients who died of cancer. The concn of octachlorodibenzo-p-dioxin was the highest in each organ and tissue and heptachlorodibenzo-p-dioxin was also found at relatively high levels, second only to octachlorodibenzo-p-dioxin. The levels of 1,2,3,7,8-pentachlorodibenzo-p-dioxin and 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin in the spleen were the highest, respectively. 2,3,7,8-Tetrachlorodibenzo-p-dioxin was also detected and its concn was the highest in the gonad (0.8-3.2 picogram/g range). From the 2,3,7,8-Tetrachlorodibenzo-p-dioxin toxic equiv calculations, the highest equiv value was obtained from a 54 yr old female who died of cancerous goiter. This individual had the highest concn of 2,3,7,8-substituted penta- and hexachlorodibenzo-p-dioxins among the 11 patients.
[Muto H et al; Life Sci 48 (17): 1645-57 (1991)]**PEER REVIEWED**

Average Daily Intake:

WATER: Based upon monitoring of Canadian drinking water, the avg daily intake of octachlorodibenzo-p-dioxin has been estimated to be 0.0001 ng/adult/day(1). FOOD: The daily intake of all polychlorinated dibenzodioxin isomers has been estimated to be 0.1397 ng/adult/day, the majority of which is octachlorodibenzo-p-dioxin(1); food contribution comes from most food groups with meat, eggs and dairy products the major contributors(1). Based upon a Japanese market basket survey, the average daily intake for octachlorodibenzo-p-dioxin has been estimated to 0.690 ng/adult/day(2).
[(1) Birmingham B et al; Chemosphere 19: 637-42 (1989) (2) Ono M et al; Chemosphere 16: 1823-8 (1987)]**PEER REVIEWED**

Artificial Pollution Sources:

Polychlorodibenzo-p-dioxins, such as octachlorodibenzo-p-dioxin, are emitted into the atmosphere as a result of the incineration of chlorine-containing materials such as waste materials(1). Although the incineration of municipal solid waste is generally regarded as the main source of emission, emissions from automobile exhaust and steel mills are also important(2). An analysis of monitoring data has suggested that incineration of chloro aromatics has been an important source of octachlorodibenzo-p-dioxin emissions to areas of Lake Erie and Siskiwit Lake(3). The similarity of air particulates from urban sources and sediments from remote lakes that can receive only atmospheric inputs suggests that the lakes were contaminated by combustion sources(4); dated sediment cores from the lakes show a strong increase of octachlorodibenzo-p-dioxin since 1940 which indicates that incineration of chlorinated organic compounds is an important source of octachlorodibenzo-p-dioxin to the environment (4).
[(1) Atkinson R; Sci Total Environ 104: 17-33 (1991) (2) Rappe C et al; Chemosphere 18: 1283-90 (1989) (3) Czuczwa JM, Hites RA; Environ Sci Technol 20: 195-200 (1986) (4) Czuczwa JM, Hites RA; Chemosphere 15: 1417-20 (1986)]**PEER REVIEWED**

Octachlorodibenzo-p-dioxin has been detected in effluents from pulp mills(1); the presence of polychlorodibenzo-p-dioxins in pulp mill effluents may result from formation during bleaching processes using chlorine(2). Octachlorodibenzo-p-dioxin emissions have been reported for chemical manufacturing waste incinerators and wastewater effluents from various chemical manufacturing industries(3,4).
[(1) Rappe C et al; Chemosphere 20: 1701-6 (1990) (2) Rappe C et al; Chemosphere 19: 1875-80 (1990) (3) Muto H et al; Environ Res 54: 170-82 (1991) (4) Smith RM et al; Chemosphere 18: 585-92 (1989)]**PEER REVIEWED**

Irradiation of aqueous solutions of chlorinated dibenzo-para-dioxin free sodium pentachlorophenol with ultra-violet light produced small amounts of octachlorodibenzo-p-dioxin.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 59 (1977)]**PEER REVIEWED**

Environmental Fate:

TERRESTRIAL FATE: Based upon Koc values of 50000 to 1X10+7(1-3), octachlorodibenzo-p-dioxin will not leach in soil(SRC). It has been suggested that some leaching could occur in the presence of organic solvents such as methanol(3) which may occur at hazardous waste sites. Although photolysis can occur on soil surfaces(4), photolysis of octachlorodibenzo-p-dioxin adsorbed to fly-ash does not appear to be important(5). There are no known abiotic processes that will degrade octachlorodibenzo-p-dioxin within soil. Although no specific biodegradation data are available, its persistence in sediment cores indicates that it is resistant to degradation. It has been suggested that volatilization from plant leaves may be an important process for transport from the terrestrial environment to air(6).
[(1) Broman D et al; Environ Sci Technol 25: 1850-64 (1991) (2) Srinivasan KR, Fogler HS; pp. 531-9 in Chlorinated Dioxins and Dibenzofurans in Perspective. Rappe C et al (eds) Lewis Publ (1986) (3) Walters RW et al; Assessment of the Potential for Transport of Dioxins and Codisposal Materials to Groundwater. USEPA-600/S6-89/002 Ada, OK: RS Kerr Environ Lab (1989) (4) Miller GC et al; Chemosphere 18: 1265-74 (1989) (5) Koester CJ, Hites RA; Environ Sci Technol 26: 502-7 (1992) (6) Bacci E et al; Bull Environ Contam Toxicol 48: 401-8 (1992)]**PEER REVIEWED**

AQUATIC FATE: Field tests have demonstrated that octachlorodibenzo-p-dioxin partitions rapidly from the water column to sediment and suspended material and remains predominantly in aquatic sediments(1,2); aquatic sediments are probably an important environmental sink for octachlorodibenzo-

p-dioxin(2). Dated sediment cores have detected octachlorodibenzo-p-dioxin from as far back as 1940 (3,4) demonstrating that it can be a very persistent environmental compound. Octachlorodibenzo-p-dioxin is susceptible to direct photolysis in sunlight; near-surface photolysis half-lives (dissolved-phase) of 18-50 days have been estimated for 40 deg N latitudes under full sunlight conditions(5). However, photolysis of octachlorodibenzo-p-dioxin adsorbed to sediments or fly-ash has not been shown to have any environmental importance. Volatilization from water is relatively slow under conditions of zero adsorption (estimated half-lives of 12 and 129 days respectively from a model river and pond); adsorption to sediment will markedly decrease the volatilization rate(SRC).
[(1) Marcheterre L et al; Chemosphere 14: 835-8 (1985) (2) Servos MR et al; Chemosphere 19: 969-72 (1989) (3) Czuczwa JM, Hites RA; Environ Sci Technol 20: 195-200 (1986) (4) Czuczwa JM et al; Chemosphere 14: 1175-9 (1985) (5) Choudhry GC, Webster GRB; Chemosphere 15: 1935-40 (1986)]**PEER REVIEWED**

Based upon an experimental vapor pressure of 8.25X10-13 mm Hg at 25 deg C(1), octachlorodibenzo-p-dioxin will exist primarily in the particulate-phase in the ambient atmosphere(2,SRC); at 25 deg C, approximately 1-10% may exist in the gas-phase(2,SRC). In the gas-phase, it will degrade by reaction with photochemically produced hydroxyl radicals with an estimated half-life of about 10 days(3,SRC). Although direct photolysis will contribute to gas-phase degradation, reaction with OH radicals will probably dominate(3). Based upon laboratory studies, photodegradation of particulate-phase octachlorodibenzo-p-dioxin that is associated with fly-ash will not be an important fate process(4). The atmospheric lifetime of particulate-phase octachlorodibenzo-p-dioxin will be determined predominantly by the rates of dry and wet deposition(3); dry deposition rates are typically on the order of 10 days or greater which permits the occurrence of some long-range global transport(3). In general, physical removal from air by wet deposition (rainfall, etc) is expected to be much less important than dry deposition(3).
[(1) Rordorf BF et al; Chemosphere 18: 783-88 (1989) (2) Bidleman TF; Environ Sci Technol 22: 361-7 (1988) (3) Atkinson R; Sci Total Environ 104: 17-33 (1991) (4) Koester CJ, Hites RA; Environ Sci Technol 26: 502-7 (1992)]**PEER REVIEWED**

Environmental Abiotic Degradation:

The rate constant for the vapor-phase reaction of octachlorodibenzo-p-dioxin with photochemically produced hydroxyl radicals has been estimated to be 1.6X10-12 cu cm/molecule-sec at 25 deg C(1) which corresponds to an atmospheric half-life of about 10 days at an atmospheric concn of 5X10+5 hydroxyl radicals per cu cm(1,SRC); this reaction is expected to dominate the gas-phase, atmospheric degradation of octachlorodibenzo-p-dioxin(1). Octachlorodibenzo-p-dioxin absorbs UV light in the environmental spectra above 290 nm and is susceptible to direct photolysis in sunlight(2-4); Based upon quantum yield measurements and photolysis studies in water/acetonitrile solutions, the following photolysis half-lives (under conditions of midday sun) have been estimated for octachlorodibenzo-p-dioxin in aquatic bodies at a latitude of 40 deg N(2): spring-20.55 days, summer-17.85 days, fall-31.26 days and winter-50.45 days(2). The direct photolysis of octachlorodibenzo-p-dioxin proceeds by a photo-dechlorination process to yield lower chlorinated dibenzo-p-dioxins(5-6).
[(1) Atkinson R; Sci Total Environ 104: 17-33 (1991) (2) Choughry GC, Webster GRB; Chemosphere 15: 1935-40 (1986) (3) Choudhry GC, Webster GRB; Toxicol Environ Chem 14: 43-61 (1987) (4) Choudhry GC, Webster GRB; J Agric Food Chem 37: 254-61 (1989) (5) Miller GC et al; Chemosphere 18: 1265-74 (1989) (6) Hung L, Ingram LL Jr; Bull Environ Contam Toxicol 44: 380-6 (1990)]**PEER REVIEWED**

Photodegradation of octachlorodibenzo-p-dioxin naturally adsorbed to five different fly ashes was examined in the solid-phase using a rotary photoreactor and a mercury vapor lamp to approximate the solar spectrum(1); no statistically significant photodegradation was observed on any of the fly ashes which ranged in color from black to gray to yellow(1); when the fly ashes were spiked with silica gel,

photodegradation did occur (half-life of 270 hr)(1); it was suggested that photodegradation of octachlorodibenzo-p-dioxin bound to atmospheric particles is not an important mechanism for its removal from the environment(1). Similar results were found in another study(2) where octachlorodibenzo-p-dioxin (adsorbed to fly ash) in tetradecane solution photodegraded readily (half-life of 37.3 hr); however, in native solid-phase, octachlorodibenzo-p-dioxin did not degrade under sunlight exposure(2).
[(1) Koester CJ, Hites RA; Environ Sci Technol 26: 502-7 (1992) (2) Tysklind M, Rappe, C; Chemosphere 23: 1365-75 (1991)]**PEER REVIEWED**

Octachlorodibenzo-p-dioxin was applied to two soil surfaces and then exposed to a bank of sunlamps for 20 days(1); at the end of the 20-day exposure period, approximately 34-42% of the octachlorodibenzo-p-dioxin was removed(1); in dark controls, no removal was observed(1). Halogenated aromatics and ethers are generally resistant to aqueous environmental hydrolysis(2); therefore, octachlorodibenzo-p-dioxin is not expected to hydrolyze in water(SRC).
[(1) Miller GC et al; Chemosphere 18: 1265-74 (1989) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods Washington, DC: Amer Chem Soc p. 7-4 (1990)]**PEER REVIEWED**

The chlorinated dibenzo-para-dioxins, when dissolved in methanol, are degraded by exposure to summer sunlight or irradiation with a UV lamp (300 nm). Photolysis of **OCDD** was slower than that of tetrachlorodibenzo-p-dioxin under similar conditions.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 59 (1977)]**PEER REVIEWED**

Environmental Bioconcentration:

Using a continuous flow-through system, octachlorodibenzo-p-dioxin BCFs of 34-136 were measured in rainbow trout and 2226 in fathead minnows(1-2); however, since all of the octachlorodibenzo-p-dioxin present in the system was not in the dissolved-phase ("true-solution"), re-calculation to "true-solution" yields BCFs of 8500 in rainbow trout and 22,300 in fathead minnow(1). Over a 64 day exposure period in an aquarium, the BCF measured for octachlorodibenzo-p-dioxin was 45.5(2); bioaccumulation of the tetrachloro-isomers was an order a magnitude higher than octachlorodibenzo-p-dioxin and the BCF was observed to decrease with an increase of chlorination(2). The BCFs observed for guppies (Poecilia reticulata) were 708 (wet basis) and 7762 (lipid basis)(4); these relatively low BCFs (when compared to the log Kow of 8.2 and measured BCFs for PCBs) were found to result from rapid depuration rates which were attributed to the ability of the guppies to metabolize octachlorodibenzo-p-dioxin(4); the metabolism appeared to involve hydroxylation that was mediated by a mixed function oxidase system (4).
[(1) Muir DCG et al; Chemosphere 14: 829-33 (1985) (2) Muir DCG et al; Environ Toxicol Chem 261-72 (1986) (3) Miyata H et al; Chemosphere 19: 517-20 (1989) (4) Gobas FAPC, Schrap SM; Chemosphere 20: 495-512 (1990)]**PEER REVIEWED**

Soil Adsorption/Mobility:

Based upon monitoring data collected from various regions of the Baltic Sea, the apparent log Koc of octachlorodibenzo-p-dioxin was reported to be 7.9(1). A field study using two outdoor ponds found that applied octachlorodibenzo-p-dioxin disappeared rapidly from the water column and that the pond sediments became an important sink for the octachlorodibenzo-p-dioxin(2). Experiments measuring the sorption of octachlorodibenzo-p-dioxin to clay-humic acid-hydroxy aluminum sorbents in water-tetrahydrofuran (600 ppm) solutions observed Koc values of roughly 50,000 to 350,000(3). Based upon measured sorption isotherms using water-methanol solutions, the log Koc can be extrapolated to

approximately 7 in water-only solution(4). In a field study using lake enclosures in northwestern Ontario, octachlorodibenzo-p-dioxin added to the water column rapidly partitioned to sediment and suspended(5); after 24 days, >98% of the added octachlorodibenzo-p-dioxin was in the sediments(5).
[(1) Broman D et al; Environ Sci Technol 25: 1850-64 (1991) (2) Marcheterre L et al; Chemosphere 14: 835-8 (1985) (3) Srinivasan KR, Fogler HS; pp. 531-9 in Chlorinated Dioxins and Dibenzofurans in Perspective. Rappe C et al (eds) Lewis Publ (1986) (4) Walters RW et al; Assessment of the Potential for Transport of Dioxins and Codisposal Materials to Groundwater. USEPA-600/S6-89/002 Ada, OK: RS Kerr Environ Lab (1989) (5) Servos MR et al; Chemosphere 19: 969-72 (1989)]**PEER REVIEWED**

Volatilization from Water/Soil:

Based upon a vapor pressure of 8.25X10-13 mm Hg at 25 deg C(1) and a water solubility of 7.4X10-8 mg/L at 25 deg C(2), the Henry's Law constant for octachlorodibenzo-p-dioxin can be estimated to be 6.74X10-6 atm-cu m/mole(SRC). This value of Henry's Law constant indicates slow volatilization from water(3). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep flowing 1 m/sec with a wind velocity of 3 m/sec) can be estimated to be about 12 days(3,SRC). The volatilization half-life from a model environmental pond can be estimated to be about 129 days if the effect of adsorption to sediment is ignored(4,SRC); if the maximum effect of adsorption to sediment is included, the estimated volatilization half-life from the pond exceeds ten years(4,SRC).
[(1) Rordorf BF et al; Chemosphere 18: 783-88 (1989) (2) Doucette WJ, Andren AW; Chemosphere 17: 243-52 (1988) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods Washington, DC: Amer Chem Soc pp. 15-15 to 15-29 (1990) (4) USEPA; EXAMS II Computer Simulation (1987)]**PEER REVIEWED**

Environmental Water Concentrations:

DRINKING WATER: A monitoring study of 800 Canadian drinking water samples found octachlorodibenzo-p-dioxin levels of not detected (detection limit not reported) to 0.046 ng/l(1). Tap water from Stockholm, Sweden contained octachlorodibenzo-p-dioxin levels of less than 0.004 ng/kg (2). An analysis of 399 water samples collected from Ontario in 1985-1986 found 36 positive detections of octachlorodibenzo-p-dioxin at levels of 20-175 parts per quadrillion(3). A survey of 20 community water systems in NY between 1986 and 1988 found measurable levels of 1.8-84 parts per quadrillion(4).

[(1) Birmingham B et al; Chemosphere 19: 637-42 (1989) (2) Rappe C et al; Chemosphere 19: 1875-80 (1989) (3) Jobb B et al; Chemosphere 20: 1553-8 (1990) (4) Meyer C et al; Chemosphere 19: 21-6 (1989)]**PEER REVIEWED**

SURFACE WATER: Analysis of surface water samples collected from various coastal and remote regions of the Baltic Sea during Jun-Jul 1988 detected octachlorodibenzo-p-dioxin levels of 0.0041-0.129 ng/cu m in the dissolved water fraction and 0.0518-0.244 ng/cu m in the particle-associated fraction(1).
[(1) Broman D et al; Environ Sci Technol 25: 1850-64 (1991)]**PEER REVIEWED**

RAIN/SNOW: Fog water samples collected at an urban site in Switzerland in Oct 1986 contained octachlorodibenzo-p-dioxin concns of 0.29-2.6 ng/L(1); these levels are generally one to two orders of magnitude higher than levels found in rainwater(1). Rainwater samples collected at two Ontario, Canada sites between 1987 and 1988 contained octachlorodibenzo-p-dioxin levels of 7-180 parts per quadrillion (2).
[(1) Czuczwa J et al; Chemosphere 18: 847-50 (1989) (2) Reid NW et al; Chemosphere 20: 1467-72 (1990)]**PEER REVIEWED**

Effluent Concentrations:

Octachlorodibenzo-p-dioxin concns of 7-350 ng/kg dry pulp and 34-4400 ng/kg sludge were detected in effluents and sludge from Swedish pulp mills(1). Levels of 119-520 ppb have been detected in effluents from municipal waste incinerators in Italy and the Netherlands(2). Analysis of effluents from various paper and pulp mills in Ontario found measurable octachlorodibenzo-p-dioxin concns of 0.000005-0.21 ppb(3); sludges from the mills had concns of 0.12-1.80 ppb(3). Levels of 2-27 ng/g were detected in fly-ash samples collected from an Ontario incinerator during a Sept 1979 monitoring study(4). Ash from wood burning stoves and open fire-places contained octachlorodibenzo-p-dioxin concns of 0.2-10 ppb (5). Stack emissions from a municipal sewage sludge burning incinerator had levels of 0.5-5.0 ng/cu m (6). An octachlorodibenzo-p-dioxin automobile emission rate of 0.42 ng/car/kilometer has been reported (7).
[(1) Rappe C et al; Chemosphere 20: 1701-6 (1990) (2) Czuczwa JM, Hites RA; Environ Sci Technol 20: 195-200 (1986) (3) Clement RE et al; Chemosphere 18: 1189-97 (1989) (4) Clement RE et al; Intern J Environ Anal Chem 17: 257-66 (1984) (5) Clement RE et al; Chemosphere 14: 815-9 (1985) (6) Clement RE et al; Chemosphere 16: 1895-1900 (1987) (7) Bacher R et al; Chemosphere 23: 1151-71 (1991)]**PEER REVIEWED**

A survey of various chemical manufacturing and disposal facilities in Japan found the following effluent levels of octachlorodibenzo-p-dioxin(1): fly ash: 9.4-2770 ng/g; bottom ash: 11.9-3814 ng/g; stack emissions: not detected-571 ng/cu m; discharge water: not detected- 31.5 ng/l(1). A survey of stack emissions from 5 NY municipal solid waste incinerators found octachlorodibenzo-p-dioxin emission levels of 9.53-193 ng/cu m(2).
[(1) Muto H et al; Environ Res 54: 170-82 (1991) (2) Smith RM et al; Chemosphere 18: 585-92 (1989)]**PEER REVIEWED**

Sediment/Soil Concentrations:

Surface sediments collected from Lakes Huron, Michigan, Erie and Ontario and Siskiwit Lake had octachlorodibenzo-p-dioxin concns of 0.56-4.8 ppb dry wt(1); analysis of sediment cores from Lake Erie shows that polychlorodibenzo-p-dioxin levels were very low until 1940, then increased until 1970 and then began declining in mid-1970's(1); it was suggested that the decrease may have resulted from reduced emissions imposed by the Clean Air Act(1). Surficial sediments collected from three lakes in Switzerland had an avg octachlorodibenzo-p-dioxin concn of 1.3 ppb(2); analysis of sediment cores from these lakes indicated that polychlorodibenzo-p-dioxins were absent before 1945(2). Soil samples collected from 5 British cities contained a mean octachlorodibenzo-p-dioxin concn of 9.98 ug/kg(3). Sediment samples collected from estuaries adjacent to an industrial site in Newark, NJ had levels of 3.1-42 ppb(4). Archived soil samples from 1846 to 1986 were analyzed and octachlorodibenzo-p-dioxin levels of 10-13 ng/kg were found in 1864 as compared to 23-25 ng/kg in 1986(5).
[(1) Czuczwa JM, Hites RA; Environ Sci Technol 20: 195-200 (1986) (2) Czuczwa JM et al; Chemosphere 14: 1175-9 (1985) (3) Creaser CS et al; Chemosphere 21: 931-8 (1990) (4) Bopp RF et al; Environ Sci Technol 25: 951-6 (1991) (5) Kjeller LO et al; Environ Sci Technol 25: 1619-27 (1991)]**PEER REVIEWED**

Atmospheric Concentrations:

URBAN/SUBURBAN: Analysis of air particulates collected from 9 urban sites in Sweden during 1985-1986 found octachlorodibenzo-p-dioxin concns of 0.050-1.900 picograms/cu m(1). An avg concn of 0.89 picograms/cu m was detected in ambient air samples from two urban sites in Bloomington in 1986 (2) while samples from a rural area near Bloomington had an avg concn of 0.16 picograms/cu m(2); roughly 80-90% of the octachlorodibenzo-p-dioxin in the samples were in the particulate-phase(2).
[(1) Rappe C et al; Chemosphere 18: 1283-90 (1989) (2) Eitzer BD, Hites RA;

Chemosphere 18: 593-98 (1989)]**PEER REVIEWED**

URBAN/SUBURBAN: An air monitoring study conducted in Japan from Jun to Jul 1988 detected polychlorodibenzo-p-dioxin concns of <0.0001-0.0282 ng/cu m (mean of 0.0054 ng/cu m) of which about 40% was octachlorodibenzo-p-dioxin(1). Octachlorodibenzo-p-dioxin concns of 0.00109-0.00469 ng/cu m were detected in the ambient air at two locations in Dayton, OH in 1988(2); concns of 0.00238-0.00831 ng/cu m were detected in the ambient air near a municipal waste incinerator(2). An ambient air monitoring study conducted in Albany, Binghamton, Utica and Niagara Falls, NY detected octachlorodibenzo-p-dioxin levels of 0.0006-0.0046 ng/cu m(3). During Oct 17-20, 1986, ambient concns of 0.0035-0.0056 ng/cu m were detected in the air of Boston,MA(4).
[(1) Nakano T et al; Atmos Environ 24A: 1361-8 (1990) (2) Tiernan TO et al; Chemosphere 19: 541-6 (1989) (3) Smith RM et al; Environ Sci Technol 24: 1502-6 (1990) (4) Kominsky JR, Kwoka CD; Chemosphere 18: 599-608 (1989)]**PEER REVIEWED**

SOURCE DOMINATED: Monitoring of selected point source ambient air in Germany and Austria found levels of 0.0005-0.0248 ng/cu m(1). An air monitoring study conducted in the North Rhine-Westphalia region of Germany between May 1985 and Mar 1986 found an avg octachlorodibenzo-p-dioxin concn of 0.0001 ng/cu m(2). Results from the first year (Jul 1987-Aug 1988) of an air monitoring network in Southwestern Ontario determined a median octachlorodibenzo-p-dioxin concn of 0.0009 ng/cu m(3). An air monitoring study conducted in Bridgeport, CT in the vicinity of municipal incinerator between Nov 1987 and Jan 1988 found octachlorodibenzo-p-dioxin concns of 0.000174-0.0055 ng/cu m (avg 0.0021 ng/cu m)(4).
[(1) Christmann W et al; Chemosphere 19: 521-6 (1989) (2) Buck M, Kirschmer P; Toxicol Environ Chem 16: 173-202 (1988) (3) Bobet E et al; Chemosphere 20: 1439-45 (1990) (4) Hunt GT, Maisel BE; Chemosphere 20: 1455-62 (1990)]**PEER REVIEWED**

Food Survey Values:

Analysis of food composites from market baskets collected by the Swedish EPA in 1989 found octachlorodibenzo-p-dioxin concns of 1.0-2.1 ng/kg(1); raw and fried Baltic herring had levels of 0.34-7.2 ng/kg(1). Various infant formulas were found to contain levels of 0.021-0.036 ppb octachlorodibenzo-p-dioxin(2). A market basket survey of Japanese foods found the following levels (in ng/kg wet basis)(3): vegetables: <0.3; oil: 4.4; rice & wheat: <1.3, fish: <5.0; beef: <4.5; pork: 11.9; chicken: <4.0; and eggs: <4.0(3). The following concns (in ng/kg) were detected in various foods collected between 1979-1984 as part of US Food and Drug Administration's Total Diet Study(4): bacon: 160; chicken: 29-252; eggs: 80-1610; pork chops: 27-53; beef liver: 133-3830(4).
[(1) DeWit C et al; Chemospshere 20: 1473-80 (1990) (2) Schecter A et al; Chemosphere 19: 913-8 (1989) (3) Ono M et al; Chemosphere 16: 1823-8 (1987) (4) Firestone D et al; pp. 355-65 in Chlorinated Dioxins and Dibenzofurans in Perspective. Rappe C et al (eds) Lewis Publ (1986)]**PEER REVIEWED**

Plant Concentrations:

The following residues of octachlorodibenzo-p-dioxin (in ng/kg fresh wt) were detected in various plants(1): potatoes-3, apples-8, peaches-0.6 and wheat-0.7(1).
[(1) Birmingham B et al; Chemosphere 19: 507-12 (1989)]**PEER REVIEWED**

Fish/Seafood Concentrations:

Analysis of fish from various sources found the following concns (ng/kg) of octachlorodibenzo-p-dioxin (1): bloater from Lake Superior: 2.0; lake trout from Lake Superior: trace-3.0; lake trout from Lake Ontario: 2.0; brook trout from Lake Ontario: 3.0; walleye from Lake Erie: 2.0; common carp from Lake

Erie: 2.0; lake trout from Lake Michigan: 1-2(1). Samples of striped bass, crabs and lobsters collected from the Newark Bay and New York Bight contained octachlorodibenzo-p-dioxin levels of 5.1-94.6 ng/kg wet wt(2). Analysis of various fish species collected from the Rhine and Neckar Rivers in Germany in 1987 and 1988 found levels of <5.0-60 ng/kg fat(3).
[(1) Petty JD et al; Trace Subst Environ Health 17: 96-102 (1983) (2) Rappe C et al; Chemosphere 22: 239-66 (1991) (3) Frommberger R; Chemosphere 22: 29-38 (1991)] **PEER REVIEWED**

Animal Concentrations:

Pigeons collected in Toyko Japan had octachlorodibenzo-p-dioxin concn of 1.2-3.1 ppb in the fat(1). Blubber samples collected from 7 seals in the Arctic at Spitzbergen had levels of 13.0-37.0 ng/kg(2). Analysis of livers of Cormorants and Grey Herons collected in the Netherlands between 1980 and 1982 found measurable octachlorodibenzo-p-dioxin levels of 65-788 ng/kg(3).
[(1) Morita M et al; Chemosphere 16: 1749-52 (1987) (2) Oehme M et al; Chemosphere 17: 1291-300 (1988) (3) Vanden Berg M et al; Arch Environ Contam Toxicol 16: 149-58 (1987)]**PEER REVIEWED**

Milk Concentrations:

Breast milk from 9 women exposed to a PCB fire in Canada contained a mean octachlorodibenzo-p-dioxin concn of 193.44 ng/kg (fat basis) while the mean concn in milk from 16 control women was 131.70 ng/kg(1). Analysis of 30 human milk samples from Germany found levels of 0.185-1.217 (avg 0.530) ppb(2). Analysis of cow's milk from various areas in Germany detected octachlorodibenzo-p-dioxin levels at or below 0.01 ng/kg fat basis(3). The following concns (ppb lipid) were found in human milk from various countries(4): Vietnam: 0.078-0.292; Cambodia: 0.059; Thailand: 0.068; Germany: 0.185; US: 0.233; Siberia: 0.0502(4). Cow's milk from NY had a reported level of 0.015 ppb(5). An analysis of various commercially available cow's milk in Sweden found levels of 1.0-7.8 ng/kg fat(6).
[(1) Dewailly E et al; Chemosphere 23: 1831-5 (1991) (2) Beck H et al; Chemosphere 16: 1977-82 (1987) (3) Beck H et al; Chemosphere 21: 789-98 (1990) (4) Schecter A et al; Chemosphere 23: 1903-12 (1991) (5) Schecter A et al; Chemosphere 19: 913-8 (1989) (6) Rappe C et al; Chemosphere 20: 1649-56 (1990)]**PEER REVIEWED**

Other Environmental Concentrations:

Chicken eggs collected in CA in 1987 and 1988 contained octachlorodibenzo-p-dioxin levels of 57-685 ng/kg fat basis(1). A commercially available liquid soap detergent was found to contain a level of 1.0 ng/l(2). An avg octachlorodibenzo-p-dioxin concn of 130 ppm has been reported as a contaminant in commercial pentachlorophenol(3). Octachlorodibenzo-p-dioxin has been detected in diesel and gasoline motor oil(4). An analysis of cork stoppers used for wine and other purposes found octachlorodibenzo-p-dioxin concns of 3.4-5.0 ng/kg(5). Great Blue Heron eggs taken in British Columbia in 1986-7 had levels of 1-17 ng/kg wet wt(6). A concn of 2 ng/g was detected in soot samples collected from an office building in Binghamton, NY after the occurrence of a PCB transformer fire in 1983(7). An analysis of cigarettes and cigarette smoke found respective concns of 257 ng/kg and 240 ng/cu m(8).
[(1) Chang R et al; Chemospshere 19: 481-6 (1989) (2) Rappe C et al; Chemosphere 21: 43-50 (1990) (3) Czuczwa JM, Hites RA; Environ Sci Technol 20: 195-200 (1986) (4) Ballschmidter K et al; Chemosphere 15: 901-15 (1986) (5) Frommberger R; Chemosphere 23: 133-9 (1991) (6) Elliot JE et al; Environ Pollut 59: 91-114 (1989) (7) Schecter A et al; Chemosphere 14: 933-7 (1985) (8) Muto H, Takizawa Y; Archiv Environ Health 44: 171-4 (1989)]**PEER REVIEWED**

Octachlorodibenzo-p-dioxin levels of 15-2500 ppm have been reported to occur as a contaminant in commercial pentachlorophenol(1).

[(1) Marlow DA; pp 161-9 in Hexachlorobenzene: Proceedings of an International Symposium. Morris CR, Cabral JRP (eds), IARC Sci Publ No. 77 Lyon, France: IARC (1986)]**PEER REVIEWED**

Environmental Standards & Regulations:

Chemical/Physical Properties:

Molecular Formula:

C12-Cl8-O2
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 46 (1977)]**PEER REVIEWED**

Molecular Weight:

459.8
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 46 (1977)]**PEER REVIEWED**

Melting Point:

330 deg C
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 47 (1977)]**PEER REVIEWED**

Octanol/Water Partition Coefficient:

log Kow= 8.78 - 13.37
[WHO; Environmental Health Criteria 88: Polychlorinated Dibenzo-para-dioxins and Dibenzofurans p.29 (1989)]**PEER REVIEWED**

Solubilities:

Solubility (g/l): acetic acid 0.048; anisole 1.730; chloroform 0.562; ortho-dichlorobenzene 1.832; dioxane 0.384; diphenyl oxide 0.841; pyridine 0.400; xylene 3.575.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 48 (1977)]**PEER REVIEWED**

Solubility in water: (0.4 + or -0.1)x10-9 g/l @ 20 deg C
[WHO; Environmental Health Criteria 88: Polychlorinated Dibenzo-para-dioxins andDibenzofurans p.27 (1989)]**PEER REVIEWED**

Spectral Properties:

Max Absorption (Chloroform): 261 nm (E= 285.9, lcm)
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 47 (1977)]**PEER REVIEWED**

Max Absorption (Chloroform): 318 nm (E= 52.2, lcm)
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 47 (1977)]**PEER REVIEWED**

Vapor Pressure:

8.25X10-13 mm Hg @ 25 deg C (experimental).
[Rordorf BF et al; Chemosphere 18: 783-88 (1989)]**PEER REVIEWED**

Other Chemical/Physical Properties:

Henry's Law constant= 6.74X10-6 atm-cu m/mole (est)
[SRC; Rordorf BF et al; Chemosphere 18: 783-88 (1989)]**PEER REVIEWED**

Chemical Safety & Handling:

Stability/Shelf Life:

Extremely stable, even on heating to 700 deg C.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 48 (1977)]**PEER REVIEWED**

Cleanup Methods:

Irradiation experiments (254 nm) were performed to decrease high polychlorinated dibenzo-p-dioxins/furans surface contaminations after a malfunction of a capacitor filled with a technique PCB formulation. Destruction efficiencies > 89% were achieved.
[Borwitzky H, Schramm K-W; Chemosphere 22 (5-6): 485-94 (1991)]**PEER REVIEWED**

Occupational Exposure Standards:

Manufacturing/Use Information:

Methods of Manufacturing:

... By heating pentachlorophenol in the presence of an initiator, such as chlorine, bromine, iodine or 2,3,4,4,5,6-hexachloro-2,5-cyclohexadienone. Hexachlorocyclohexadienone, when heated in an atmosphere of carbon dioxide for 30 minutes, also yields octachlorodibenzo-p-dioxin.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 51 (1977)]**PEER REVIEWED**

General Manufacturing Information:

Chlorodibenzo-p-dioxins are not manufactured commercially but ... are present as impurities in certain herbicide and fungicide formulations, such as 2,4,5-T and the pentachlorophenols. ... Pentachlorophenol may contain 575-2510 mg/kg octachlorodibenzo-p-dioxin.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 49 (1977)]**QC REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

A method for multicomponent determinations of organochlorine contaminants in human milk is described. The lipophilic gel Lipidex 5000 was used for extraction of lipids and organochlorine cmpds. Further purification and separation was achieved by chromatography on partly deactivated aluminum oxide, Lipidex, silica gel, and active basic and acidic aluminum oxide. The concentrations of pesticides and PCBs were determined by electron capture GC. Polychlorinated dibenzo-p-dioxins were determined by selected ion monitoring capillary column GC/MS at a resolution of 8000-9000. Recovery experiments were performed by the addition of pentachlorophenol and certain polychlorinated dibenzo-p-dioxins. The average recovery of 0.5-2.0 ng pentachlorophenol/ml milk was 92%. Ten polychlorinated dibenzo-p-dioxins /including octachlorodibenzo-p-dioxin / reported to occur in milk were added at levels between 0.5 and 50 pg/ml milk. Recoveries of these cmpds were on an average of 79-91%.
[Noren K, Sjoevall J; J Chromatogr 422: 103-15 (1987)]**PEER REVIEWED**

Analytic Laboratory Methods:

EPA Method 1613. Determination of octachlorodibenzo-p-dioxin using a GC method with high resolution MS.
[USEPA/OST; List of Lists: A Catalog of Analytes and Methods p.371 (1991) OST Pub 21W-4005]**PEER REVIEWED**

Commercial chlorophenols were analyzed for chlorodibenzo-para-dioxins by fractionation on an aluminum oxide column, followed by GC with ECD and confirmation by MS. Octachlorodibenzo-p-dioxin was determined, with a detection limit of 20 ug/kg.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 64 (1977)]**PEER REVIEWED**

A method for analyzing samples of unknown origin for chlorodibenzo-para-dioxins involves initial use of an ion-exchange resin column to remove chlorophenoxyphenols before determination of the dioxins by GC and MS using multiple-ion detection. Limit of detection was ... 0.5 mg/kg for octachlorodibenzo-p-dioxin in fats and oils.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 65 (1977)]**PEER REVIEWED**

High-performance, reverse-phase, partition LC has been investigated as a means of determining chlorodibenzo-para-dioxins in pentachlorophenol. The samples were first subjected to an ion-exchange column cleanup to remove phenoxyphenols. Recoveries of 93-104%, with a relative error of + or - 10%, and a detection limit 0.1 mg/kg for octachlorodibenzo-p-dioxin was reported.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V15 66 (1977)]**PEER REVIEWED**

Sampling Procedures:

The data from preliminary investigations of the efficiency of dioxin recovery from fly ash samples during sample exttraction and subsequent column cleanup of sample extracts are discussed. Steps of the extraction and the column cleanup procedures were evaluated by using radiolabeled (14)C dioxins as tracers. Recovery data of spiked (14)C TCDD and (14)C **OCDD** in carbon-free fly ash and fly ash

containing from 0.1 to 10% carbon are discussed. Data indicate that the amt of carbon in the fly ash may affect the recovery of dioxins.
[Finkel JM et al; Chemosphere 19 (1-6): 67-74 (1989)]**PEER REVIEWED**

Special References:

Special Reports:

WHO; Environ Health Criteria 88: Polychlorinated Dibenzo-p-dioxins and Dibenzofurans (1989)

NRCC; Polychlorinated Dibenzo-p-dioxins: Limitations to the Current Analytical Techniques, Publication NRCC No 18576 (1981). A technical review and assessment of the methodology for the analysis of polychlorinated dibenzo-p-dioxins in a variety of substrates. Analytical methodology was evaluated and safety procedures were suggested.

Olson JR et al; Chemosphere 18 (1/6): 371-81 (1989). A review of the toxicological and pharmacokinetic literature on chlorinated dibenzo-p-dioxins and dibenzofurans was presented to evaluate the accuracy and currency of established toxicity equivalence factors.

Synonyms and Identifiers:

Synonyms:

OCDD
QC REVIEWED

1,2,3,4,6,7,8,9-Octachlorodibenzo(b,e)(1,4)dioxin
PEER REVIEWED

Octachloro-para-dibenzodioxin
PEER REVIEWED

1,2,3,4,6,7,8,9-**Octachlorodibenzodioxin**
PEER REVIEWED

Administrative Information:

Hazardous Substances Databank Number: 6480

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Field Update on 03/10/1998, 1 field added/edited/deleted.
Field Update on 11/01/1997, 1 field added/edited/deleted.
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Complete Update on 02/01/1996, 1 field added/edited/deleted.
Complete Update on 08/21/1995, 1 field added/edited/deleted.
Complete Update on 03/20/1995, 1 field added/edited/deleted.
Complete Update on 03/02/1995, 2 fields added/edited/deleted.
Complete Update on 03/13/1994, 52 fields added/edited/deleted.

Record Length: 96941

CONTENTS
1.1 What are CDDs?
1.2 What happens to CDDs when they enter the environment?
1.3 How might I be exposed to CDDs?
1.4 How can CDDs enter and leave my body?
1.5 How can CDDs affect my health?
1.6 How can CDDs affect children?
1.7 How can families reduce the risk of exposure to CDDs?
1.8 Is there a medical test to determine whether I have been exposed to CDDs?
1.9 What recommendations has the federal government made to protect human health?
1.10 Where can I get more information?
References

RELATED RESOURCES
ToxFAQ™ 110k
ToxFAQ™ en Español 28k
Public Health Statement ***128k***
Toxicological Profile *10.2MB*
A-Z INDEX
A B C D E
F G H I J K
L M N O P
Q R S T U
V W X Y Z
ATSDR RESOURCES
ToxFAQs™
ToxFAQs™ en Español
Public Health Statements
Toxicological Profiles
Minimum Risk Levels

December 1998

Public Health Statement for Chlorinated Dibenzo-p-dioxins (CDDs)

This Public Health Statement is the summary chapter from the Toxicological Profile for chlorinated dibenzo-p-dioxins (CDDs). It is one in a series of Public Health Statements about hazardous substances and their health effects. A shorter version, the ToxFAQs™, is also available. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. For more information, call the ATSDR Information Center at 1-888-422-8737.

This public health statement tells you about chlorinated dibenzo-p-dioxins (CDDs) and the effects of exposure.

The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites make up the National Priorities List (NPL) and are the sites targeted for long-term federal clean-up. CDDs (all types) have been found in at least 126 of the 1,467 current or former NPL sites. However, it's unknown how many NPL sites have been evaluated for these substances. As more sites are evaluated, the number of sites with CDDs may increase. This is important because exposure to these substances may harm you and because these sites may be sources of exposure.

When a substance is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. This release does not always lead to exposure. You can be exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance or by skin contact.

If you are exposed to CDDs, many factors determine whether you'll be harmed. These factors include the dose (how much), the duration (how long), and how you come in contact with it. You must also consider the other chemicals you're exposed to and your age, sex, diet, family traits, lifestyle, and state of health.

1.1 What are CDDs?

MMGs
MHMIs
Interaction Profiles
Priority List of Hazardous Substances
Division of Toxicology

CDDs are a family of 75 different compounds commonly referred to as polychlorinated dioxins. These compounds have varying harmful effects. The CDD family is divided into eight groups of chemicals based on the number of chlorine atoms in the compound. The group with one chlorine atom is called the mono-chlorinated dioxin(s). The groups with two through eight chlorine atoms are called di-chlorinated dioxin (DCDD), tri-chlorinated dioxin (TrCDD), tetra-chlorinated dioxin (TCDD), penta-chlorinated dioxin (PeCDD), hexa-chlorinated dioxin (HxCDD), hepta-chlorinated dioxin (HpCDD), and octa-chlorinated dioxin (OCDD). The chlorine atoms can be attached to the dioxin molecule at any one of eight positions. The name of each CDD indicates both the number and the positions of the chlorine atoms. For example, the CDD with four chlorine atoms at positions 2, 3, 7, and 8 on the dioxin molecule is called 2,3,7,8-tetrachlorodibenzo-p-dioxin or 2,3,7,8-TCDD. 2,3,7,8-TCDD is one of the most toxic of the CDDs to mammals and has received the most attention. Thus, 2,3,7,8-TCDD serves as a prototype for the CDDs. CDDs with toxic properties similar to 2,3,7,8-TCDD are called "dioxin-like" compounds.

In the pure form, CDDs are colorless solids or crystals. CDDs enter the environment as mixtures containing a variety of individual components and impurities. In the environment they tend to be associated with ash, soil, or any surface with a high organic content, such as plant leaves. In air and water, a portion of the CDDs may be found in the vapor or dissolved state, depending on the amount of particulate matter, temperature, and other environmental factors. 2,3,7,8-TCDD is odorless. The odors of the other CDDs are not known. CDDs are known to occur naturally, and are also produced by human activities. They are naturally produced from the incomplete combustion of organic material by forest fires or volcanic activity. CDDs are not intentionally manufactured by industry, except in small amounts for research purposes. They are unintentionally produced by industrial, municipal, and domestic incineration and combustion processes. Currently, it is believed that CDD emissions associated with human incineration and combustion activities are the predominant environmental source.

CDDs (mainly 2,3,7,8-TCDD) may be formed during the chlorine bleaching process used by pulp and paper mills. CDDs occur as a contaminant in the manufacturing process of certain chlorinated organic chemicals, such as chlorinated phenols. 2,3,7,8-TCDD is a by-product formed during the manufacture of 2,4,5-trichlorophenol (2,4,5-TCP). 2,4,5-TCP was used to produce hexachlorophene (used to kill bacteria) and the herbicide, 2,4,5-trichlorophenoxyacetic acid (2,4,5-T). Various formulations of 2,4,5-T have been used extensively for weed control on crops and range lands, and along roadways throughout the world. 2,4,5-T was a component of Agent Orange, which was used extensively by

the U.S. military in the Vietnam War. In most industrialized countries the use of products contaminated with CDDs has been greatly reduced. Use of hexachlorophene and the herbicide 2,4,5-T is currently restricted in the United States. Other chlorinated chemicals, like pentachlorophenol (PCP), used to preserve wood, do contain some of the more highly chlorinated CDDs (those with more chlorine atoms), but 2,3,7,8-TCDD is not usually found. The use of PCP has been restricted to certain manufacturing applications.

Currently, CDDs are primarily released to the environment during combustion of fossil fuels (coal, oil, and natural gas) and wood, and during incineration processes (municipal and medical solid waste and hazardous waste incineration). While incineration may be the primary current source of release of CDDs into the environment, the levels of CDDs produced by incineration are extremely low. CDDs are associated with ash generated in combustion and incineration processes. Emissions from incinerator sources vary greatly and depend on management practices and applied technologies. CDDs also have been detected at low concentrations in cigarette smoke, home-heating systems, and exhaust from cars running on leaded gasoline or unleaded gasoline, and diesel fuel. Burning of many materials that may contain chlorine, such as plastics, wood treated with pentachlorophenol (PCP), pesticide-treated wastes, other polychlorinated chemicals (polychlorinated biphenyls or PCBs), and even bleached paper can produce CDDs.

Although this public health statement will focus on CDDs, it is important to note that CDDs are found in the environment together with other structurally related chlorinated chemicals, such as chlorinated dibenzofurans (CDFs) and polychlorinated biphenyls (PCBs). Therefore, people are generally exposed to mixtures of CDDs and other classes of toxicologically and structurally similar compounds. 2,3,7,8-TCDD is one of the most toxic and extensively studied of the CDDs and serves as a prototype for the toxicologically relevant or "dioxin-like CDDs. Based on results from animal studies, scientists have learned that they can express the toxicity of dioxin-like CDDs as a fraction of the toxicity attributed to 2,3,7,8-TCDD. For example, the toxicity of dioxin-like CDDs can be half or one tenth or any fraction of that of 2,3,7,8-TCDD. Scientists call that fraction a Toxic Equivalent Factor (TEF).

back to top

1.2 What happens to CDDs when they enter the environment?

CDDs are released into the air in emissions from municipal solid waste and industrial incinerators. Exhaust from vehicles powered with leaded and unleaded gasoline and diesel fuel also release CDDs to the air. Other sources of CDDs in air include: emissions

from oil- or coal-fired power plants, burning of chlorinated compounds such as PCBs, and cigarette smoke. CDDs formed during combustion processes are associated with small particles in the air, such as ash. The larger particles will be deposited close to the emission source, while very small particles may be transported longer distances. Some of the lower chlorinated CDDs (DCDD, TrCDD, and some of the TCDDs) may vaporize from the particles (and soil or water surfaces) and be transported long distances in the atmosphere, even around the globe. It has been estimated that 20 to 60% of 2,3,7,8-TCDD in the air is in the vapor phase. Sunlight and atmospheric chemicals will break down a very small portion of the CDDs, but most CDDs will be deposited on land or water.

CDDs occur as a contaminant in the manufacture of various chlorinated pesticides and herbicides, and releases to the environment have occurred during the use of these chemicals. Because CDDs remain in the environment for a long time, contamination from past pesticide and herbicide use may still be of concern. In addition, improper storage or disposal of these pesticides and waste generated during their production can lead to CDD contamination of soil and water.

CDDs are released in waste waters from pulp and paper mills that use chlorine or chlorine-containing chemicals in the bleaching process. Some of the CDDs deposited on or near the water surface will be broken down by sunlight. A very small portion of the total CDDs in water will evaporate to air. Because CDDs do not dissolve easily in water, most of the CDDs in water will attach strongly to small particles of soil or organic matter and eventually settle to the bottom. CDDs may also attach to microscopic plants and animals (plankton) which are eaten by larger animals, that are in turn eaten by even larger animals. This is called a food chain. Concentrations of chemicals such as the most toxic, 2,3,7,8-chlorine substituted CDDs, which are difficult for the animals to break down, usually increase at each step in the food chain. This process, called biomagnification, is the reason why undetectable levels of CDDs in water can result in measurable concentrations in aquatic animals. The food chain is the main route by which CDD concentrations build up in larger fish, although some fish may accumulate CDDs by eating particles containing CDDs directly off the bottom.

CDDs deposited on land from combustion sources or from herbicide or pesticide applications bind strongly to the soil, and therefore are not likely to contaminate groundwater by moving deeper into the soil. However, the presence of other chemical pollutants in contaminated soils, such as those found at hazardous waste sites or associated with chemical spills (for example, oil spills), may dissolve CDDs, making it easier for CDDs to move through the soil. The movement of chemical waste containing

CDDs through soil has resulted in contamination of groundwater. Soil erosion and surface runoff can also transport CDDs into surface waters. A very small amount of CDDs at the soil surface will evaporate into air. Certain types of soil bacteria and fungus can break CDDs down, but the process is very slow. In fact, CDDs can exist in soil for many years. Plants take up only very small amounts of CDDs by their roots. Most of the CDDs found on the parts of plants above the ground probably come from air and dust and/or previous use of CDD-containing pesticides or herbicides. Animals (such as cattle) feeding on the plants may accumulate CDDs in their body tissues (meat) and milk.

back to top

1.3 How might I be exposed to CDDs?

CDDs are found at very low levels in the environment. These levels are measured in nanograms and picograms. One nanogram (ng) is one billionth of a gram, and one picogram (pg) is one trillionth of a gram. In some contaminated soils, concentrations of CDDs are reported as parts per billion. One part per billion (ppb) is one part CDD per billion parts of soil. The concentration of CDDs is often reported as parts per trillion, in samples of air, water, or soil. One part per trillion (ppt) is one part CDD per trillion parts of air, water, or soil. In some rural areas where CDD concentrations are very low in air or water, measurements are given in parts per quadrillion (ppq), which means one part CDD per quadrillion parts of air or water.

CDDs are found everywhere in the environment, and most people are exposed to very small background levels of CDDs when they breath air, consume food or milk, or have skin contact with materials contaminated with CDDs. For the general population, more than 90% of the daily intake of CDDs, CDFs, and other dioxin-like compounds comes from food, primarily meat, dairy products, and fish. CDDs may be present at much lower levels in fruits and vegetables. The actual intake of CDDs from food for any one person will depend on the amount and type of food consumed and the level of contamination. Higher levels may be found in foods from areas contaminated with chemicals, such as pesticides or herbicides, containing CDDs as impurities. CDDs have been measured in human milk, cow's milk, and infant formula, so infants are known to be exposed to CDDs.

Most surface water in the United States typically does not contain 2,3,7,8-TCDD and other CDDs at levels that are high enough to be measured (1 ppq or more). Municipal drinking water does not usually contain CDDs because the CDDs do not dissolve in water and primarily stick to particles, which are usually filtered out of treated drinking water. This means that using tap water to wash clothes or to bathe or shower, or swimming in pools or in uncontaminated lakes, rivers, or at ocean beaches will not expose people to significant levels of CDDs. Although CDDs are not

usually found in filtered, treated drinking water, they have, on occasion, been detected in unfiltered groundwater from areas with known CDD contamination.

Exposure to CDDs can also occur through skin contact with chlorinated pesticides and herbicides, contaminated soils, or other materials such as PCP-treated wood and PCB transformer fluids. Background levels of CDDs in soil are higher than background levels in both air and water. Background levels of CDDs detected in uncontaminated soils in the United States are generally very low or not detectable. 2,3,7,8-TCDD is not usually found in rural soil, but is typically found in soil in industrialized areas at levels ranging from 0.001 to 0.01 ppb. However, higher levels of 2,3,7,8-TCDD may be found in areas where CDDs have contaminated the soil. For example, contaminated soil at Times Beach, Missouri, had levels of 2,3,7,8-TCDD ranging from 4.4–317 ppb.

If CDDs are present at all in outdoor air in rural areas, they are generally present at very low levels or at concentrations near the detection limits for testing equipment. In winter, because of the burning of wood and other fuels for home heating, CDD levels may be slightly higher than during other seasons. In general, the background air levels of CDDs in urban areas are higher than in rural areas. Typical levels of CDDs in outdoor air in urban areas and industrial areas averaged 2.3 picograms per meter cubed (pg/m^3). 2,3,7,8-TCDD is not usually found in rural or urban air, but it is found in air near urban waste incinerators and high-traffic areas. The air around people who are smoking cigarettes may also have CDDs at levels above background levels. Although breathing contaminated air is a minor route of exposure for most people, exposure may be greater in areas near these CDD sources.

CDDs have been found in all samples of adipose tissue and blood (serum lipids) from individuals with no known previous exposure. This indicates that all people are exposed to small amounts of CDDs. Levels of 2,3,7,8-TCDD in serum from the general population typically range from 3 to 7 ppt (on a lipid basis), and rarely exceed 10 ppt. Typically, lower levels of CDDs are found in less industrialized countries and in younger people.

The production, use, and disposal of pesticides and phenoxy herbicides, disposal of production waste containing 2,3,7,8-TCDD, industrial accidents involving 2,4,5-trichlorophenol (2,3,5-TCP), and the consumption of CDD-contaminated food, have all led to increased potential for excess exposure of some groups of people. 2,3,7,8-TCDD has been detected at 91 of the 126 hazardous waste sites on the NPL that have been reported to contain CDDs. People living around these sites may be exposed to above-background levels of 2,3,7,8-TCDD and other CDDs. Elevated levels of CDDs have been reported in fish, shellfish, birds, and mammals

collected in areas surrounding various chemical production facilities, various hazardous waste sites, and pulp and paper mills using the chlorine bleaching process. Sometimes these findings have resulted in closure of these areas for the purpose of fishing. People who eat contaminated food from these contaminated areas are at risk of increased exposure to CDDs.

Occupational exposure to CDDs generally occurs through breathing contaminated air, or through skin contact with materials containing CDDs. Workers with the potential to be exposed to above-average levels of CDDs include those involved in the production or handling of certain chlorinated phenols (such as 2,4,5-TCP, PCP) or chlorinated pesticides or herbicides (such as 2,4,5-T, 2,4-D, hexachlorophene, Silvex®), and those involved in application of chlorinated pesticides containing CDDs as impurities. Workers whose jobs involve pressure treatment of wood with PCP and the handling of PCP-treated wood products, chlorination processes at pulp and paper mills, or operation of municipal solid waste or hazardous waste incinerators may have increased exposure to CDDs. Finally, workers involved in hazardous waste clean-up or clean-up of PCB transformer and/or capacitor fires including emergency service personnel like fire fighters and police who respond to such fires are also at additional risk of exposure to CDDs. Most of these occupational exposures have been significantly reduced in recent years.

In general, workers involved in the manufacture of 2,4,5-TCP and subsequent products were exposed to far greater levels of 2,3,7,8-TCDD than those involved in the handling and application of chlorinated pesticides containing CDDs. Current serum lipid levels of 2,3,7,8-TCDD in a small number of U.S. Air Force veterans who were directly involved in the aerial spraying of herbicides (Agent Orange contaminated with 2,3,7,8-TCDD) in Vietnam as part of Operation Ranch Hand, are up to 3 times higher than the general population. However, while studies on blood or fatty tissue 2,3,7,8-TCDD levels in U.S. Army ground combat Vietnam veterans also found some individuals with 2,3,7,8-TCDD levels higher than those of the general population, overall, most Vietnam veterans and Vietnamese living in Vietnam studied to dated have blood and fatty tissue 2,3,7,8-TCDD levels comparable to members of the general U.S. population.

back to top

1.4 How can CDDs enter and leave my body?

CDDs can enter your body when you breathe contaminated air, eat contaminated food, or have skin contact with contaminated soil or other materials. The most common way CDDs can enter your body is by eating food contaminated with CDDs.

If you breathe air that contains CDDs, the CDDs can enter your body through your lungs and pass into the blood stream, but we do

not know how fast or how much of the CDDs will enter the blood stream. If you swallow food or water containing CDDs, most of the CDDs will enter your body and pass from the intestines to the blood stream. Smaller amounts of highly chlorinated CDDs will enter your body compared to the less chlorinated 2,3,7,8-TCDD. If you swallow soil containing CDDs, a small amount of the CDDs will pass through the intestines into the blood stream. If soil contaminated with CDDs comes into contact with your skin, some of the CDDs will enter the body but we do not know how fast they will enter the blood stream.

Once in your body, CDDs can be found in most tissues with the highest amounts found in the liver and body fat (adipose tissue). Body fat and possibly the liver can store CDDs for many years before eliminating them from the body. CDDs with chlorine atoms in the 2, 3, 7, and 8 positions and highly chlorinated dioxins, such as OCDD, are generally found in higher concentrations in the fat than other CDDs.

Little is known about CDDs breakdown in the human body. Studies in animals show that some of the 2,3,7,8-TCDD from food is slowly broken down. There is evidence from animals suggesting that the break-down products are less harmful than the unchanged 2,3,7,8-TCDD.

For people, the average time it takes to remove one-half of the 2,3,7,8-TCDD from the body is highly variable and may take from 7 to 12 years. There is less information on the other CDDs, but what information exists suggests 5 to 15 years. CDDs are eliminated from the body primarily in the stool, and only a small amount leaves the body in the urine. Some CDDs will leave the body in the breast milk of nursing mothers.

Much less is known about how much other CDD compounds will enter the body, how much will be stored in the body and for how long, and how they are removed from the body.

back to top

1.5 How can CDDs affect my health?

Many studies have looked at how CDDs can affect human health. Most of these studies examined workers exposed during the manufacture of chemicals and pesticides contaminated with 2,3,7,8-TCDD. Other studies have looked at American Vietnam veterans and Vietnamese populations exposed to Agent Orange and populations exposed to 2,3,7,8-TCDD as a result of an accident. The workers and Vietnam veterans were most likely exposed to 2,3,7,8-TCDD mainly through breathing and skin contact. People who were accidentally exposed to 2,3,7,8-TCDD in Seveso, Italy, or Times Beach, Missouri, were probably exposed through eating and drinking contaminated food and milk, breathing contaminated particles and dust, and through skin

contact with contaminated soil. Epidemiology is an inexact science and many of the human studies have many shortcomings which make it difficult for scientists to establish an association between 2,3,7,8-TCDD exposure levels and health effects. A common problem with most of the human studies is that the people are exposed to a number of chemicals at the same time. In most human health studies, we do not know how much 2,3,7,8-TCDD people were exposed to or how long the exposure lasted. In other studies, the people were examined many years after they were exposed and some of the effects may have not have been present at the time of examination or the effects observed may not have been caused by 2,3,7,8-TCDD. Some of the more recent studies have measured 2,3,7,8-TCDD levels in the blood or fat tissue of exposed populations. The levels of 2,3,7,8-TCDD in the blood or fat tissue can be used to estimate the extent of past exposures.

A number of effects have been observed in people exposed to 2,3,7,8-TCDD levels which are at least 10 times higher than background levels. The most obvious health effect in people exposed to relatively large amounts of 2,3,7,8-TCDD is chloracne. Chloracne is a severe skin disease characterized by acne-like lesions. Chloracne generally occurs on the face and upper body, but may occur elsewhere on the body. Unlike common acne, severe chloracne is harder to cure and can be more disfiguring. In milder cases, the lesions heal several months after exposure ends. In more severe cases, the lesions may last for many years after exposure. Most of the chloracne cases have been attributed to accidental exposure to high doses of 2,3,7,8-TCDD. Other effects to the skin, such as erythematous or red skin rashes, discoloration, and excessive body hair, have been reported to occur in people following exposure to high concentrations of 2,3,7,8-TCDD. Changes in blood and urine that may indicate liver damage have been observed in people. Alterations in the ability of the liver to metabolize (or breakdown) hemoglobin, lipids, sugar, and protein have been reported in people exposed to relatively high concentrations of 2,3,7,8-TCDD. Most of the effects are considered mild and were reversible. However, in some people these effects may last for many years. Slight increases in the risk of diabetes and abnormal glucose tolerance have been observed in some studies of people exposed to 2,3,7,8-TCDD. We do not have enough information to know if exposure to 2,3,7,8-TCDD will result in reproductive or developmental effects in people, but animal studies suggest that this is a potential health concern. Several studies of workers exposed to high levels (more than 50 times higher than background levels) of 2,3,7,8-TCDD suggest that exposure to 2,3,7,8-TCDD may increase the risk of cancer in people.

The Department of Health and Human Services (DHHS) has determined that it is reasonable to expect that 2,3,7,8-TCDD may

cause cancer. The International Agency for Research on Cancer (IARC) has determined that 2,3,7,8-TCDD can cause cancer in people, but that it is not possible to classify other CDDs as to their carcinogenicity to humans. The EPA has determined that 2,3,7,8-TCDD is a possible human carcinogen when considered alone and a probable human carcinogen when considered in association with phenoxy herbicides and/or chlorophenols. The EPA has determined also that a mixture of CDDs with six chlorine atoms (4 of the 6 chlorine atoms at the 2, 3, 7, and 8 positions) is a probable human carcinogen.

To protect the public from the harmful effects of toxic chemicals and to find ways to treat people who have been harmed, scientists use many tests.

One way to see if a chemical will hurt people is to learn how the chemical is absorbed, used, and released by the body; for some chemicals, animal testing may be necessary. Animal testing may also be used to identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method to get information needed to make wise decisions to protect public health. Scientists have the responsibility to treat research animals with care and compassion. Laws today protect the welfare of research animals, and scientists must comply with strict animal care guidelines.

The health effects of some CDDs have been extensively studied in animals. Some CDDs are much more toxic than others. 2,3,7,8-TCDD and, to a lesser extent, CDDs with five (penta) or six (hexa) chlorine atoms substituted in the 2, 3, 7, and 8 positions, are extremely toxic to animals. Other CDDs, which do not have chlorine atoms substituted in the 2, 3, 7, and 8 positions, are considered relatively less toxic compared to 2,3,7,8-TCDD.

2,3,7,8-TCDD has been the most extensively studied CDD and it has been shown to cause a large number of adverse health effects in animals. There are always going to be some difficulties in using animal data to quantify health risks in people. In general, the doses used in the animal studies result in body burdens that are at least 10 times higher than human background body burdens, often the animal studies use doses that are over 1,000 times higher than human background levels. Some animal species are much more acutely sensitive to 2,3,7,8-TCDD than others. For example, it takes several thousand times more 2,3,7,8-TCDD to kill a hamster than a guinea pig. The reason for the difference in sensitivity among species is currently being investigated. For other effects, such as reproductive toxicity, there is very little difference in sensitivity between hamsters and guinea pigs. Another consideration in using animal data to predict health effects in people exposed to CDDs in the environment is the design of the animal studies. In most of the animal studies, the animals were

exposed to only 2,3,7,8-TCDD, the most toxic CDD. 2,3,7,8-TCDD is rarely the main CDD found in the environment and people are typically exposed to a number of CDDs and compounds with similar toxic actions. Until scientists learn more about possible differences between people and animals, levels recommended to be of little or no risk to human health are based on the more sensitive species and the assumption that effects in animals could occur in people. This approach is further justified on the basis that humans are likely to exhibit a wide range of sensitivities to various health effects and the need to protect the most susceptible individuals.

In certain species, 2,3,7,8-TCDD is especially harmful and can cause death after a single exposure to small amounts. Before death, animals may lose as much as 40% or more of their body weight following a single dose of 2,3,7,8-TCDD. Exposure to non-lethal levels in food can cause a variety of adverse effects in animals, such as weight loss, biochemical and degenerative changes in the liver. Some animals that were exposed to CDDs in food had effects to the skin such as hair loss, swelling of the face, and moderate to severe chloracne. In many species of animals, the immune system appears to be extremely sensitive to 2,3,7,8-TCDD. At relatively low levels (approximately 10 times higher than human background body burdens), 2,3,7,8-TCDD weakens the immune system and causes a decrease in the system's ability to fight foreign substances such as bacteria and viruses.

Exposure to 2,3,7,8-TCDD can cause reproductive damage and birth defects in animals. Decreases in fertility, altered levels of sex hormones, reduced production of sperm, and increased rates of miscarriages were found in animals exposed to 2,3,7,8-TCDD in food. Rats and mice that were exposed to small amounts of 2,3,7,8-TCDD in food for a long time developed cancer of the liver and thyroid, and other types of cancer.

The results of the oral animal studies suggest that the most sensitive effects (effects that will occur at the lowest doses) are immune, endocrine, and developmental effects. It is reasonable to assume that these will also be the most sensitive effects in humans.

We know less about the ability of other CDDs to cause adverse health effects. However, it appears that all CDDs with chlorine in the 2, 3, 7, and 8 positions have similar effects to 2,3,7,8-TCDD but the effects occur at higher doses.

Relatively large amounts of 2,3,7,8-TCDD applied to the skin of some animal species have resulted in deaths. Smaller amounts have resulted in weight loss, acne-like sores on the skin, and biochemical and degenerative changes in the liver. In addition, mice that had 2,3,7,8-TCDD repeatedly applied to their skin developed skin cancer. Although effects in animals following

exposure through the skin have not been as extensively studied as effects following exposure in food, they appear to be quite similar. The ability of other CDDs to cause adverse health effects in animals following exposure to the skin has not been well studied.

back to top

1.6 How can CDDs affect children?

This section discusses potential health effects from exposures during the period from conception to maturity at 18 years of age in humans. Potential effects on children resulting from exposures of the parents are also considered.

Very few studies have looked at how CDDs can affect children's health. Chloracne has been observed in children exposed to much higher than current background levels of 2,3,7,8-TCDD. The children appeared to be more sensitive (effects occurred at a lower body burden) than adults. We do not know why children are more sensitive than adults to this effect. It is likely that children exposed to higher than background levels will have similar effects as adults.

We do not know if exposure to CDDs will result in birth defects or other developmental effects in people. Birth defects have been observed in animals exposed to higher than background levels of 2,3,7,8-TCDD. The developing animal is very sensitive to 2,3,7,8-TCDD. In some studies, effects were observed at body burdens 10 times higher than human background levels. Offspring of animals exposed to 2,3,7,8-TCDD in food during pregnancy often had severe birth defects including bleeding, skeletal deformities, kidney defects, weakened immune responses, impaired development of the reproductive system, and learning and behavioral impairments. Exposure to other CDDs, such as 2,7-DCDD, 1,2,3,7,8-PeCDD, OCDD, and HxCDD, can also result in developmental effects in animals.

We have no information to suggest that there are any differences between children and adults in terms of how much CDDs will enter the body, where CDDs can be found in the body, and how fast CDDs will leave the body. CDDs from the mother can enter her unborn baby through the placenta. It can also be transferred from the mother to infant through breast milk. Because CDDs have been measured in human milk, cows milk, and infant formula, nursing infants are also exposed to CDDs. In most cases the beneficial aspects (biological and psychological) of breast-feeding outweigh any risks from exposure to CDDs from mother's milk.

back to top

1.7 How can families reduce the risk of exposure to CDDs?

If your doctor finds that you have been exposed to significant amounts of CDDs, ask your doctor if children may also be exposed. When necessary your doctor may need to ask your state Department of Public Health to investigate.

Structural material used in building homes such as chemically treated lumber for decking and plastic PVC pipes used in water pipes and other conduits can release CDDs if they are burned as refuse during construction or if there is a structural fire in your home. To avoid exposures from some of these sources, construction refuse should not be burned near your home especially when children are out playing.

Children may be exposed to CDDs from ingestion of contaminated soil or by contact of contaminated soil with their skin. However, skin contact with contaminated soil will result in much less CDDs entering the blood stream than if they ingest contaminated soil. Also, the amount of CDDs that will pass to the blood stream after eating contaminated soil will depend on the type of soil and on how tight the CDDs are bound to the soil. Children should be restricted from playing near any known hazardous waste sites. Some children eat a lot of dirt. Discourage your children from eating dirt or from putting their toys or other foreign objects in their mouths that may be contaminated with soil. Make sure that your children wash their hands frequently, especially before eating. Discourage your children from putting their hands in their mouths or other hand-to-mouth activities.

Older children may be exposed to CDDs if they smoke cigarettes. Younger children and infants may be exposed by inhaling the second-hand smoke from their parents or other adult smokers. Parents should talk to their children about the dangers of smoking cigarettes.

You and your children are likely to be exposed to very low amounts of CDDs in the diet particularly when you consume meat, milk, other dairy products, and fish. This represents the major source of background exposure to CDDs in most people. Children and adults should eat a balanced diet preferably containing low to moderate amounts of animal fats including meat and dairy products, and fish that contain higher amounts of CDDs and eat larger amounts of fruits, vegetables and grains.

You or your children may be exposed to CDDs by eating certain types of fish or wildlife caught in certain locations. A number of states have advisories for CDDs in fish and shellfish species; and one state has a wildlife advisory in effect for wood ducks. Each state, Native American tribe, or U.S. Territory sets its own criteria for issuing fish and wildlife advisories. A fish advisory will specify which waterbodies have restrictions, and a wildlife advisory will specify which hunting areas have restrictions. The

advisory will tell you what types and sizes of fish or game are of concern. The advisory may completely ban eating fish or game or recommend that you limit the number of meals you eat of a certain species. For example, an advisory may tell you to eat a certain type of fish no more than once a month. The advisory may also tell you only to eat certain parts of the fish or game animal and how to prepare or cook the fish or game to decrease your exposure to CDDs. Fish and wildlife advisories are often stricter for pregnant women, nursing mothers, and young children. To reduce your children's exposure to CDDs, obey all fish and wildlife advisories. Information on Fish and Wildlife Advisories in your state is available from your state Public Health Department, or state Natural Resources Department and signs may be posted in certain fishing and hunting areas.

back to top

1.8 Is there a medical test to determine whether I have been exposed to CDDs?

Specific tests exist to measure CDD levels in samples of body fat, blood, and breast milk, but these tests are not routinely available. All people now have some levels of CDDs in their body fat and blood. Levels of 2,3,7,8-TCDD on a lipid basis are generally below 10 pg/g of lipid (ppt) in the blood and fatty tissue of the general population of the United States, and usually range from 3 to 7 ppt. Levels higher than these indicate past exposure to above-normal levels of 2,3,7,8-TCDD. Although CDDs stay in the body fat for a long time (see Section 1.4), tests are not used to determine when exposure occurred, but can be used to estimate dose of the exposure if the time of exposure is known.

Although exposure to 2,3,7,8-TCDD has been associated with adverse health effects in people, no one effect is specifically related to exposure to CDDs. There are laboratory tests which can indicate whether you have been exposed to CDDs, but these are costly and take weeks to perform and they cannot be used to predict whether you will develop harmful health effects.

back to top

1.9 What recommendations has the federal government made to protect human health?

The federal government develops regulations and recommendations to protect public health. Regulations can be enforced by law. Federal agencies that develop regulations for toxic substances include the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA). Recommendations provide valuable guidelines to protect public health but cannot be enforced by law. Federal organizations that develop recommendations for toxic substances include the Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH).

Regulations and recommendations can be expressed in not-to-exceed levels in air, water, soil, or food that are usually based on levels that affect animals, then they are adjusted to help protect people. Sometimes these not-to-exceed levels differ among federal organizations because of different exposure times (an 8-hour workday or a 24-hour day), the use of different animal studies, or other factors.

Recommendations and regulations are also periodically updated as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for CDDs include the following:

The government has developed regulations and guidelines for 2,3,7,8-TCDD. These are designed to protect the public from the potential adverse health effects of the chemical. The Food and Drug Administration (FDA) recommends against consuming fish and shellfish with 2,3,7,8-TCDD levels greater than 50 ppt. Such levels have resulted in the closing of several commercial fishing areas. In addition, EPA has issued guidance to states on how to evaluate health risks to recreational and subsistence fishers, and how to issue fish consumption advisories when concentrations of CDDs in fish and shellfish pose a risk to these populations. Currently, 66 health advisories have been issued by 21 states restricting consumption of fish and wildlife contaminated with CDDs. EPA also has recommended limits on how much 2,3,7,8-TCDD can be present in drinking water. EPA advises that children should not have more than 1 nanogram 2,3,7,8-TCDD per liter of water (ng/L) (ppt) in 1 day, or more than 0.01 ng/L per day for long-term exposure. For long-term exposure in adults, EPA recommends that there should not be more than 0.04 ng/L (ppt) in drinking water.

Human milk can contain higher levels of CDDs than cow's milk. Therefore, breast-fed infants can be exposed to higher levels of CDDs on a body weight basis than adults. The World Health Organization (WHO) has concluded that this risk to infants does not outweigh the positive biological and psychological benefits of breast-feeding at general population levels of dioxins. However, the specific concentration at which CDD levels in human milk would lead to harmful health effects in infants has not yet been determined.

Regulation of many of the sources of CDDs appears to have been successful in reducing the amount of CDDs entering the ecosystem and in decreasing the potential for human exposure. EPA considers 2,3,7,8-TCDD to be a hazardous waste. Many regulations govern its destruction and disposal.

back to top

1.10 Where can I get more information?

If you have any more questions or concerns, please contact your community or state health or environmental quality department or:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop E-29
Atlanta, GA 30333

Information line and technical assistance:

Phone: 888-422-8737
FAX: (404)498-0093

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

To order toxicological profiles, contact:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone: 800-553-6847 or 703-605-6000

back to top

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1998. Toxicological profile for chlorinated dibenzo-p-dioxins (CDDs). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

back to top

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U.S. Department of Health and Human Services

PROPIONITRILE

CASRN: 107-12-0

For other data, click on the Table of Contents

Human Health Effects:

Human Toxicity Excerpts:

SYMPTOMATOLOGY: 1. Massive doses may produce, without warning, sudden loss of consciousness & prompt death from respiratory arrest. With smaller but still lethal doses, the illness may be prolonged for 1 or more hr. 2. Upon ingestion, a bitter, acrid, burning taste is sometimes noted, followed by a feeling of constriction or numbness in the throat. Salivation, nausea & vomiting are not unusual ... 3. Anxiety, confusion, vertigo, giddiness, & often a sensation of stiffness in the lower jaw. 4. Hyperpnea & dyspnea. Respirations become very rapid & then slow & irregular. Inspiration is characteristically short while expiration is greatly prolonged. 5. The odor of bitter almonds may be noted on the breath or vomitus ... 6. In the early phases of poisoning, an incr in vasoconstrictor tone causes a rise in blood pressure & reflex slowing of the heart rate. Thereafter the pulse becomes rapid, weak, & sometimes irregular ... . A bright pink coloration of the skin due to high concn of oxyhemoglobin in the venous return may be confused with that of carbon monoxide poisoning. 7. Unconsciousness, followed promptly by violent convulsions, epileptiform or tonic, sometimes localized but usually generalized. Opisthotonos & trismus may develop. Involuntary micturition & defecation occur. 8. Paralysis follows the convulsive stage. The skin is covered with sweat. The eyeballs protrude, & the pupils are dilated & unreactive. The mouth is covered with foam, which is sometimes bloodstained ... . The skin color may be brick red. Cyanosis is not prominent in spite of weak & irregular gasping. In the unconscious patient, bradycardia & the absence of cyanosis may be key diagnostic signs. 9. Death from respiratory arrest. As long as the heart beat continues, prompt & vigorous treatment offers some promise of survival. /Cyanide/

[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-126]**PEER REVIEWED**

... /IT IS/ AN EXTREMELY HAZARDOUS LIQUID WHICH IS RAPIDLY ABSORBED THROUGH THE SKIN. THE VAPORS ARE ALSO HIGHLY TOXIC. THIS IS ONE OF THE MOST TOXIC ORGANIC CYANIDES KNOWN.

[Deichman, W.B., and H.W. Gerarde. Toxicology of Drugs and Chemicals. 4th ed. New York: Academic Press, 1969. 342]**PEER REVIEWED**

Hydroxocobalamin admin with sodium thiosulfate in experimental poisoning results in excretion of thiocyanate as a primary urinary detoxification product. When hydroxocobalamin is admin alone, the primary elimination product is cyanocobalamin. Although up to 50% of hydroxocobalamin is excreted unchanged in the urine, it may be effective in cyanide detoxification by binding cyanide (forming cyanocobalamin), which is later given up to rhodanese for complexing with sulfone (producing thiocyanate & regenerating hydroxocobalamin).

[Ellenhorn, M.J., S. Schonwald, G. Ordog, J. Wasserberger. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. 2nd ed. Baltimore, MD: Williams and Wilkins, 1997. 1648]**PEER REVIEWED**

Vapor is irritating to eyes, nose & throat. Liquid is irritating to skin & eyes.

[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Vapor is irritating to eyes, nose & throat. Liquid is irritating to skin & eyes.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Populations at Special Risk:

/Protect/ from exposure those individuals with diseases of CNS, heart and lung.
[ITII. Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1988. 445]**PEER REVIEWED**

Probable Routes of Human Exposure:

Occupational exposure to **propionitrile** may occur through inhalation and dermal contact with this compound at workplaces where **propionitrile** is produced or used(SRC). Monitoring data indicate that the general population may be exposed to **propionitrile** via inhalation of ambient air containing **propionitrile**(SRC). **Propionitrile** was detected but not quantified (detection limit was approx 0.5-1.0 ng/ml) in an operating pilot-scale shale oil wastewater treatment plant(1).
[(1) Hawthorne SB, Sievers RE; Environ Sci Technol 18: 483-90 (1984)]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** **PROPIONITRILE** ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE
0.2.1.1 ACUTE EXPOSURE
A. In one reported human case of **propionitrile** poisoning, rapid loss of consciousness and metabolic acidosis were noted.
B. Most of the toxicity of **propionitrile** results from metabolic release of CYANIDE after systemic absorption. Onset of symptoms may therefore be delayed.
1. Expected effects of released CYANIDE include central nervous system and respiratory stimulation followed by depression, giddiness, headache, dyspnea, palpitations, vomiting, bradycardia, hypotension,

coma, seizures, cardiac dysrhythmias, and metabolic acidosis. Cyanosis is generally a late sign, seen only at the stage of circulatory collapse and apnea.

C. **Propionitrile** ingestion causes perforating duodenal ulceration in animals. It is an eye irritant.

0.2.3 VITAL SIGNS

0.2.3.1 ACUTE EXPOSURE

A. Part of the initial presentation of cyanide poisoning may be hyperpnea and tachypnea. Hypoventilation progressing to apnea may be seen in the later phases of cyanide poisoning and is a major cause of death.

B. Tachycardia and hypertension may be seen in the initial phases of cyanide poisoning. Bradycardia and hypotension are seen in the late phases of cyanide poisoning.

C. Tachycardia may occur.

0.2.4 HEENT

0.2.4.1 ACUTE EXPOSURE

A. Eye irritation may be seen.

0.2.5 CARDIOVASCULAR

0.2.5.1 ACUTE EXPOSURE

A. Tachycardia and hypertension are early findings. Bradycardia and hypotension are late findings.

0.2.6 RESPIRATORY

0.2.6.1 ACUTE EXPOSURE

A. Tachypnea, dyspnea, and hyperpnea may occur early.

B. Hypoventilation leading to apnea and cyanosis is seen late in the course.

0.2.7 NEUROLOGIC

0.2.7.1 ACUTE EXPOSURE

A. Agitation, headache, anxiety, coma and convulsions may be seen.

0.2.8 GASTROINTESTINAL

0.2.8.1 ACUTE EXPOSURE

A. Nausea, vomiting and abdominal pain may occur. In rats, duodenal ulceration has been reported.

0.2.11 ACID-BASE

0.2.11.1 ACUTE EXPOSURE

A. Metabolic acidosis may be noted.

0.2.12 FLUID-ELECTROLYTE

0.2.12.1 ACUTE EXPOSURE

A. An elevated anion gap metabolic acidosis is seen in cyanide poisoning, largely from excess production of lactic acid.

0.2.16 ENDOCRINE

0.2.16.1 ACUTE EXPOSURE

A. Insulin resistance was noted in a severely cyanide poisoned patient.

0.2.16.2 CHRONIC EXPOSURE

A. Interference with iodine uptake by the thyroid and subsequent goiter have been seen following chronic occupational exposure to other nitrile compounds, such as acetonitrile.

B. Subclinical derangements of thyroid function and B12 and folate metabolism were noted in a group of chronically exposed cyanide workers.

0.2.20 REPRODUCTIVE HAZARDS

A. Some animal studies showed evidence of teratogenicity and maternal toxicity.

B. Sodium cyanide, acetonitrile, acrylonitrile, **propionitrile**, and laetrile caused resorptions or malformations in the offspring of hamsters.

Laboratory:

A. Monitor arterial blood gases, venous pO2 or measured venous %O2 saturation, serum electrolytes and lactate, and whole blood cyanide levels.

Treatment Overview:

0.4.2 ORAL EXPOSURE

A. In symptomatic patients, skip these steps until other major emergency measures including use of cyanide antidote kit and other life support measures have been instituted.

B. Perform gastric lavage with a large bore tube after endotracheal intubation. DO NOT INDUCE EMESIS - with syrup of ipecac.

1. GASTRIC LAVAGE: Consider after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation. Control any seizures first.

a. CONTRAINDICATIONS: Loss of airway protective reflexes or decreased level of consciousness in unintubated patients; following ingestion of corrosives; hydrocarbons (high aspiration potential); patients at risk of hemorrhage or gastrointestinal perforation; and trivial or non-toxic ingestion.

C. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.

D. ADMINISTER 100% OXYGEN - HYPERBARIC OXYGEN - may be useful in severe cases not responsive to supportive and antidotal therapy.

E. ESTABLISH SECURE LARGE BORE IV -

F. PREPARE THE CYANIDE ANTIDOTE KIT FOR USE IN SYMPTOMATIC PATIENTS - See Main Document under TREATMENT section by appropriate route of exposure for alternate antidotes not available in the USA.

1. AMYL NITRITE AMPULE - Inhale ampule contents for 30 seconds every minute until sodium nitrite is administered. Use a new ampule every 3 minutes.

2. SODIUM NITRITE - Administer IV (ADULT - 10 mL over no less than 5 minutes; CHILD - (with normal hemoglobin concentration) - 0.12 to 0.33 mL/kg up to 10 ml). Repeat one-half of initial sodium nitrite dose 30 minutes later if there is inadequate clinical response.

a. Monitor blood pressure frequently. Reduce nitrite administration rate if hypotension occurs. Monitor methemoglobin levels; do NOT allow to exceed 30%.

3. SODIUM THIOSULFATE - Administer IV immediately following sodium nitrite (ADULT - 50 mL of 25% solution; CHILD - 1.65 mL/kg of 25% solution). Repeat one-half of initial sodium thiosulfate dose 30 minutes later if there is inadequate clinical response.

G. SODIUM BICARBONATE - Administer 1 mEq/kg IV to acidotic patients. Monitor arterial blood gases to guide further

bicarbonate therapy.

H. SEIZURES: Administer a benzodiazepine IV; DIAZEPAM (ADULT: 5 to 10 mg, repeat every 10 to 15 min as needed. CHILD: 0.2 to 0.5 mg/kg, repeat every 5 min as needed) or LORAZEPAM (ADULT: 2 to 4 mg; CHILD: 0.05 to 0.1 mg/kg).

1. Consider phenobarbital if seizures recur after diazepam 30 mg (adults) or 10 mg (children > 5 years).
2. Monitor for hypotension, dysrhythmias, respiratory depression, and need for endotracheal intubation. Evaluate for hypoglycemia, electrolyte disturbances, hypoxia.

I. METHEMOGLOBINEMIA -

1. Rarely, clinically significant excessive methemoglobinemia has occurred following sodium nitrite therapy. Some authors have suggested that methylene blue should not be used in this setting, because it could cause the release of cyanide from the cyanmethemoglobin complex. Such authors have suggested that emergency exchange transfusion is the treatment of choice.
2. Hyperbaric oxygen therapy could be used to support the patient while preparations for exchange transfusion are being made.
3. However, methylene blue has been used successfully in this setting without worsening the clinical course. As long as intensive care monitoring and further antidote doses, if required, are available, methylene blue can most likely be safely administered in this setting.
4. METHEMOGLOBINEMIA: Administer 1 to 2 mg/kg of 1% methylene blue slowly IV in symptomatic patients. Additional doses may be required.

J. HYPOTENSION: Infuse 10 to 20 mL/kg isotonic fluid. If hypotension persists, administer dopamine (5 to 20 mcg/kg/min) or norepinephrine (ADULT: begin infusion at 0.5 to 1 mcg/min; CHILD: begin infusion at 0.1 mcg/kg/min); titrate to desired response.

K. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.

L. HEMODIALYSIS AND HEMOPERFUSION - do not seem to be indicated or efficacious in most cases of cyanide poisoning.

M. Observe patients with ingestion carefully for the possible development of esophageal or gastrointestinal tract irritation or burns. If signs or symptoms of esophageal irritation or burns are present, consider endoscopy to determine the extent of injury.

0.4.3 INHALATION EXPOSURE

A. INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids.

B. Respiratory tract irritation, if severe, can progress to pulmonary edema which may be delayed in onset up to 24

to 72 hours after exposure in some cases.

C. If respiratory tract irritation or respiratory depression is evident, monitor arterial blood gases, chest x-ray, and pulmonary function tests.

D. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.

E. If bronchospasm and wheezing occur, consider treatment with inhaled sympathomimetic agents.

F. All patients with significant inhalation exposure should be carefully observed for signs of SYSTEMIC CYANIDE POISONING. The following recommendations should be followed if significant cyanide poisoning is present.

G. SYSTEMIC CYANIDE POISONING -

1. All patients with significant inhalation exposure should be carefully observed for signs of systemic cyanide poisoning. The following recommendations should be followed if significant cyanide poisoning is present.

H. ADMINISTER 100% OXYGEN - HYPERBARIC OXYGEN - may be useful in severe cases not responsive to supportive and antidotal therapy.

I. ESTABLISH SECURE LARGE BORE IV -

J. PREPARE THE CYANIDE ANTIDOTE KIT FOR USE IN SYMPTOMATIC PATIENTS - See Main Document under TREATMENT section by appropriate route of exposure for alternate antidotes not available in the US.

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   a. Monitor blood pressure frequently. Reduce nitrite administration rate if hypotension occurs. Monitor methemoglobin levels; do NOT allow to exceed 30%.
3. SODIUM THIOSULFATE - Administer IV immediately following sodium nitrite (ADULT - 50 mL of 25% solution; CHILD - 1.65 mL/kg of 25% solution). Repeat one-half of initial sodium thiosulfate dose 30 minutes later if there is inadequate clinical response.

K. SODIUM BICARBONATE - Administer 1 mEq/kg IV to acidotic patients. Monitor arterial blood gases to guide further bicarbonate therapy.

L. SEIZURES: Administer a benzodiazepine IV; DIAZEPAM (ADULT: 5 to 10 mg, repeat every 10 to 15 min as needed. CHILD: 0.2 to 0.5 mg/kg, repeat every 5 min as needed) or LORAZEPAM (ADULT: 2 to 4 mg; CHILD: 0.05 to 0.1 mg/kg).

1. Consider phenobarbital if seizures recur after diazepam 30 mg (adults) or 10 mg (children > 5 years).
2. Monitor for hypotension, dysrhythmias, respiratory depression, and need for endotracheal intubation. Evaluate for hypoglycemia, electrolyte disturbances, hypoxia.

M. METHEMOGLOBINEMIA -

1. Rarely, clinically significant excessive methemoglobinemia has occurred following sodium nitrite therapy. Some authors have suggested that methylene blue should not be used in this setting, because it could cause the release of cyanide from the cyanmethemoglobin complex. Such authors have suggested that emergency exchange transfusion is the treatment of choice.
2. Hyperbaric oxygen therapy could be used to support the patient while preparations for exchange transfusion are being made.
3. However, methylene blue has been used successfully in this setting without worsening the clinical course. As long as intensive care monitoring and further antidote doses, if required, are available, methylene blue can most likely be safely administered in this setting.
4. METHEMOGLOBINEMIA: Administer 1 to 2 mg/kg of 1% methylene blue slowly IV in symptomatic patients. Additional doses may be required.

N. HYPOTENSION: Infuse 10 to 20 mL/kg isotonic fluid. If hypotension persists, administer dopamine (5 to 20 mcg/kg/min) or norepinephrine (ADULT: begin infusion at 0.5 to 1 mcg/min; CHILD: begin infusion at 0.1 mcg/kg/min); titrate to desired response.

O. HEMODIALYSIS AND HEMOPERFUSION - do not seem to be indicated or efficacious in most cases of cyanide poisoning.

0.4.4 EYE EXPOSURE

A. DECONTAMINATION: Irrigate exposed eyes with copious amounts of room temperature water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility.

B. SYSTEMIC CYANIDE POISONING -

1. Treatment should include recommendations listed in the INHALATION EXPOSURE section when appropriate.

0.4.5 DERMAL EXPOSURE

A. DECONTAMINATION: Remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician may need to examine the area if irritation or pain persists.

B. SYSTEMIC CYANIDE POISONING -

1. It is possible that systemic cyanide poisoning may occur following significant dermal exposure. The following recommendations should be followed if significant cyanide poisoning is present.

C. ADMINISTER 100% OXYGEN - HYPERBARIC OXYGEN - may be useful in severe cases not responsive to supportive and antidotal therapy.

D. ESTABLISH SECURE LARGE BORE IV -

E. PREPARE THE CYANIDE ANTIDOTE KIT FOR USE IN SYMPTOMATIC PATIENTS - See Main Document under TREATMENT section by appropriate route of exposure for alternate antidotes not available in the USA.

1. AMYL NITRITE AMPULE - Inhale ampule contents for 30 seconds every minute until sodium nitrite is administered. Use a new ampule every 3 minutes.
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concentration) - 0.12 to 0.33 mL/kg up to 10 ml). Repeat one-half of initial sodium nitrite dose 30 minutes later if there is inadequate clinical response.

a. Monitor blood pressure frequently. Reduce nitrite administration rate if hypotension occurs. Monitor methemoglobin levels; do NOT allow to exceed 30%.

3. SODIUM THIOSULFATE - Administer IV immediately following sodium nitrite (ADULT - 50 mL of 25% solution; CHILD - 1.65 mL/kg of 25% solution). Repeat one-half of initial sodium thiosulfate dose 30 minutes later if there is inadequate clinical response.

F. SODIUM BICARBONATE - Administer 1 mEq/kg IV to acidotic patients. Monitor arterial blood gases to guide further bicarbonate therapy.

G. SEIZURES: Administer a benzodiazepine IV; DIAZEPAM (ADULT: 5 to 10 mg, repeat every 10 to 15 min as needed. CHILD: 0.2 to 0.5 mg/kg, repeat every 5 min as needed) or LORAZEPAM (ADULT: 2 to 4 mg; CHILD: 0.05 to 0.1 mg/kg).

1. Consider phenobarbital if seizures recur after diazepam 30 mg (adults) or 10 mg (children > 5 years).
2. Monitor for hypotension, dysrhythmias, respiratory depression, and need for endotracheal intubation. Evaluate for hypoglycemia, electrolyte disturbances, hypoxia.

H. METHEMOGLOBINEMIA -

1. Rarely, clinically significant excessive methemoglobinemia has occurred following sodium nitrite therapy. Some authors have suggested that methylene blue should not be used in this setting, because it could cause the release of cyanide from the cyanmethemoglobin complex. Such authors have suggested that emergency exchange transfusion is the treatment of choice.
2. Hyperbaric oxygen therapy could be used to support the patient while preparations for exchange transfusion are being made.
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4. METHEMOGLOBINEMIA: Administer 1 to 2 mg/kg of 1% methylene blue slowly IV in symptomatic patients. Additional doses may be required.

I. HYPOTENSION: Infuse 10 to 20 mL/kg isotonic fluid. If hypotension persists, administer dopamine (5 to 20 mcg/kg/min) or norepinephrine (ADULT: begin infusion at 0.5 to 1 mcg/min; CHILD: begin infusion at 0.1 mcg/kg/min); titrate to desired response.

J. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.

K. HEMODIALYSIS AND HEMOPERFUSION - do not seem to be indicated or efficacious in most cases of cyanide poisoning.

L. Treat dermal irritation or burns with standard topical therapy. Patients developing dermal hypersensitivity

reactions may require treatment with systemic or topical corticosteroids or antihistamines.

Range of Toxicity:

A. The maximum tolerated and minimum lethal human exposures for **propionitrile** have not been determined.
DRIN

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

Rapid support of respiration and circulation is essential to successful treatment of cyanide intoxication. Massive cyanide overdoses have survived with only good supportive care. Immediate attention should be directed toward assisted ventilation, administration of 100% oxygen, insertion of intravenous lines, and institution of cardiac monitoring. Obtain an arterial blood gas immediately and correct any severe metabolic acidosis (pH below 7.15). Oxygen (100%) should be used routinely in moderate or severely symptomatic patients even in the presence of a normal pO2, since 100% O2 increases O2 delivery, may reactivate cyanide-inhibited mitochondrial enzymes, and potentiates the effect of thiosulfate. /Cyanides/
[Ellenhorn, M.J., S. Schonwald, G. Ordog, J. Wasserberger. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. 2nd ed. Baltimore, MD: Williams and Wilkins, 1997. 1480]**PEER REVIEWED**

Amyl nitrite perles are designed to produce 3% to 5% methemoglobinemia while an iv line is established for iv sodium nitrite. As a temporizing measure, the patient inhales the vapors until the sodium nitrite is ready. Because of the variability in methemoglobin production and the potential for cardiovascular collapse, this step may be omitted if sodium nitrite is readily available and the patient is not in extremis. Adequate ventilation and oxygenation are more important than administration of amyl nitrite. One perle ... is crushed and inhaled ... until iv nitrite is given. Sodium nitrite is administered iv slowly ... to produce a 20% methemoglobin level in adults. ... Administer sodium nitrite doses to children on the basis of body weight, since fatal methemoglobinemia has occurred in children. /Cyanides/
[Ellenhorn, M.J., S. Schonwald, G. Ordog, J. Wasserberger. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. 2nd ed. Baltimore, MD: Williams and Wilkins, 1997. 1481]**PEER REVIEWED**

Basic treatment: Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilation if necessary. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Administer amyl nitrite ampules as per protocol and physician order ... . Monitor for shock and treat if necessary ... . Monitor for pulmonary edema and treat if necessary ... . Anticipate seizures and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport ... . Do not use emetics. For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool ... . /Cyanide and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 388]**PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious or in respiratory arrest. Positive pressure ventilation techniques with a bag valve mask device may be beneficial. Start an IV with D5W /SRP: "To keep open", minimal flow rate/. Use

lactated Ringer's if signs of hypovolemia are present. Watch for signs of fluid overload. Administer cyanide antidote kit as per protocol and physician order ... . Monitor and treat cardiac arrhythmias if necessary ... . Consider vasopressors to treat hypotension without signs of hypovolemia ... . Consider drug therapy for pulmonary edema ... . Treat seizures with diazepam (Valium) ... . Use proparacaine hydrochloride to assist eye irrigation ... . /Cyanide and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 388]**PEER REVIEWED**

Animal Toxicity Studies:

Non-Human Toxicity Excerpts:

A 2 min inhalation of saturated vapor killed all rats. A 4 hr exposure to 5000 ppm gave a mortality of two out of six rats. Application to the skin & eyes of rabbits did not result in severe damage. ... Exposure of 9500 ppm for 1.5 hr killed all rats.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994.,p. 3144-5]**PEER REVIEWED**

PROPIONITRILE INDUCES ACUTE DUODENAL ULCERS IN RATS. GASTRIC ACID SECRETION WAS INCREASED BY INTRAGASTRIC ADMINISTRATION WHICH APPEARS TO BE REQUIRED FOR ULCER FORMATION.
[LICHTENBERGER LM ET AL; GASTROENTEROLOGY 73 (6): 1305-8 (1977)]**PEER REVIEWED**

INTRAPERITONEAL INJECTIONS OF **PROPIONITRILE** AT 0.54-1.51 MMOLE/KG (30-83 MG/KG) ON DAY 8 OF GESTATION IN THE HAMSTER INDUCED EXENCEPHALY, ENCEPHALOCELES, & RIB FUSIONS & BIFURCATIONS IN THE OFFSPRING. OBSERVATIONS SUGGEST THAT THE TERATOGENIC EFFECTS ARE RELATED TO THE METABOLIC RELEASE OF CYANIDE.
[WILLHITE CC ET AL; TERATOLOGY 23 (3): 317-23 (1981)]**PEER REVIEWED**

The effects of subulcerogenic doses of cysteamine and **propionitrile** on alkali secretion by duodenal surface epithelium and pH at the surface of this mucosa were assessed in the duodenum of anesthetized rats. Alkali secretion was titrated in situ, using segments of duodenum just distal to the Brunner's glands area and devoid of pancreatic carbonite. Surface pH was measured by advancing pH-sensitive microelectrodes from the luminal solution to the epithelial cell surface. ... By delayed (5 hr) actions, both cysteamine and **propionitrile** inhibited the rise in alkali secretion in response to a 5 minute exposure to luminal acid with pH 2.00 in the rat. ... Inhibition of mechanisms mediating this response may contribute to the duodenal ulcerogenic actions of cysteamine and **propionitrile**.
[Briden S et al; Gastroenterology 88 (1): 295-302 (1985)]**PEER REVIEWED**

... Members of this chemical class included several mononitriles (aceto-, propio-, butyro-, and acrylonitrile). ... Broadly defined, retrospective structure-activity relationship analysis suggested that the toxicological profiles of this group of aliphatic nitriles were similar; however, unique differences were observed within each of the toxicity categories and nitrile subclasses as the toxicological focus narrowed.
[Johannsen FR, Levinskas GJ; Fundam Appl Toxicol 7 (4): 690-7 (1986)]**PEER REVIEWED**

Administration of acrylonitrile or **propionitrile** in the pregnant hamster is linked to the production of severe axial skeletal (dysraphic) malformations in the hamster fetus. A histological study of early embryos and term fetuses challenged with a teratogenic dose of either of these nitriles was made.

Inspection of hamster embryos 10 hr after the teratogenic stimulus revealed mesodermal changes including a reduced number of cells, shrinkage of the cell cytoplasm and enlarged extracellular spaces. A reduced number of mitotic figures and focal necrobiosis were also noted. Affected embryos were smaller and were delayed in their development as compared to controls. Analysis of the 14 day old hamster fetuses revealed the basichondrocranium in cranioschisis occulta with encephalocele and cranioschisis aperta with exencephaly to be shorter than control and lordotic to the vertebral axis. These alterations were more accentuated in cranioschisis aperta than in cranioschisis occulta. The ultimate skeletal malformations may be the reflection of a primary paraxial mesodermal insufficiency.
[Willhite CC et al; Teratology 23 (3): 325-34 (1981)]**PEER REVIEWED**

Acetonitrile, adiponitrile, and **propionitrile**, were evaluated for embryotoxic and teratogenic potential in rats. Mated Sprague Dawley rats were administered one of the three nitriles by gavage on gestation days 6-19, inclusive. Daily dosage levels (mg/kg body wt) were: acetonitrile at 0, 125, 190, and 275; adiponitrile at 0, 20, 40, and 80; **propionitrile** at 0, 20, 40, and 80. There was evidence of maternal toxicity in each of the high dose groups treated with acetonitrile, adiponitrile, or **propionitrile**. Some maternal effects also were seen with adiponitrile at the middle dosage. Embryotoxic effects were observed at the highest dosage tested for acetonitrile and middle and high dose levels for **propionitrile**. Slight fetotoxicity was observed at the highest dosage for adiponitrile. No teratogenic effects were observed at any dosage level with acetonitrile, adiponitrile, or **propionitrile**.
[Johannsen FR et al; Fundam Appl Toxicol 7 (1): 33-40 (1986)]**PEER REVIEWED**

Propionitrile rated 4 on rabbit eyes. /Most severe injuries have been rated 10/
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 1054]**PEER REVIEWED**

The factors influencing the ulcerogenic effects of **propionitrile** /were investigated/ in rats. ... Fasting rats showed a decreased frequency of duodenal ulcers compared with those eating ad libitum. Female rats were more susceptible to induction of duodenal ulcers by **propionitrile**, the incidence being 15% for males and 80% for females, suggesting hormonal mediation. Furthermore, the inhibition of alkali secretory function of the GI tissue was suggested as a contributing mechanism of the duodenal ulcerogenic action of **propionitrile**. The induction of ulcers in the duodenum of rats may be due either to **propionitrile** itself, or some metabolite other than cyanide. Neither the nature of the metabolite, nor the site of action, (ie, whether centrally or peripherally mediated) is known.
[Snyder, R. (ed.). Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume II: Nitrogen and Phosphorus Solvents. Amsterdam-New York-Oxford: Elsevier, 1990. 356]**PEER REVIEWED**

Propionitrile is about 3-4 times more toxic than acetonitrile by the respiratory route of administration. The greater toxicity of **propionitrile** is due to its higher lipid-water partition coefficient and lower volatility than acetonitrile. These factors increase its ability to penetrate biological membranes and decrease its elimination in the expired air.
[Snyder, R. (ed.). Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume II: Nitrogen and Phosphorus Solvents. Amsterdam-New York-Oxford: Elsevier, 1990. 355]**PEER REVIEWED**

Non-Human Toxicity Values:

LD50 Rat oral 39 mg/kg
[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1244]**PEER REVIEWED**

LD50 Mouse ip 28 mg/kg

[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-216]**PEER REVIEWED**

LC50 Mice inhalation 163 ppm/60 min
[Willhite CC; Clin Toxicol 18 (8): 991-1003 (1981)]**PEER REVIEWED**

LD50 Rat inhalation 500 ppm/4 hr
[Snyder, R. (ed.). Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume II: Nitrogen and Phosphorus Solvents. Amsterdam-New York-Oxford: Elsevier, 1990. 356]**PEER REVIEWED**

LD50 Rabbit dermal 210 mg/kg
[Snyder, R. (ed.). Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume II: Nitrogen and Phosphorus Solvents. Amsterdam-New York-Oxford: Elsevier, 1990. 356]**PEER REVIEWED**

LD50 Rabbit sc 100 mg/kg
[Snyder, R. (ed.). Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume II: Nitrogen and Phosphorus Solvents. Amsterdam-New York-Oxford: Elsevier, 1990. 356]**PEER REVIEWED**

LD50 Mouse oral 35,797 ug/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2799]**PEER REVIEWED**

LD50 Rabbit iv 50 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2799]**PEER REVIEWED**

Ecotoxicity Values:

LC50 Pimephales promelas (fathead minnow) 1520 mg/l/96 hr (confidence limit 1450 - 1580 mg/l), flow-through bioassay with measured concentrations, 24.4 deg C, dissolved oxygen 7.3 mg/l, hardness 47.0 mg/l calcium carbonate, alkalinity 40.1 mg/l calcium carbonate, and pH 7.6.
[Geiger D.L., D.J. Call, L.T. Brooke. (eds.). Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales- Promelas). Vol. V. Superior WI: University of Wisconsin-Superior, 1990.51]**PEER REVIEWED**

EC50 Pimephales promelas (fathead minnow) 1520 mg/l/96 hr (confidence limit 1450 - 1580 mg/l), flow-through bioassay with measured concentrations, 24.4 deg C, dissolved oxygen 7.3 mg/l, hardness 47.0 mg/l calcium carbonate, alkalinity 40.1 mg/l calcium carbonate, and pH 7.6. Effect: loss of equilibrium.
[Geiger D.L., D.J. Call, L.T. Brooke. (eds.). Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales- Promelas). Vol. V. Superior WI: University of Wisconsin-Superior, 1990.51]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

... /It undergoes/ fairly rapid metabolism to the cyanide ion. The fate of the other portion of the molecule is somewhat uncertain. ... /when admin sc to guinea pigs/ ... 70% of the dose was accounted for as

thiocyanate.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 3145]**PEER REVIEWED**

IN ORDER TO STUDY THE RELATIONSHIP OF STRUCTURE TO METABOLISM OF NITRILES TO CYANIDE IONS, THIOCYANATE WAS MEASURED, AS AN INDEX OF CYANIDE ION RELEASE, IN URINE OF RATS ADMIN EQUIMOLAR DOSES OF NITRILES. AMONG THE SATURATED NITRILES THIOCYANATE EXCRETION WAS MAXIMAL FOR THE C3 & C4 COMPOUNDS, **PROPIONITRILE**, BUTYRONITRILE, & ISOBUTYRONITRILE, AFTER ORAL & IP ADMIN.
[SILVER EH ET AL; DRUG METAB DISPOS 10 (5): 495-8 (1982)]**PEER REVIEWED**

RESULTS FROM THE ADMIN OF ALIPHATIC NITRILES TO RATS SHOWED THAT THE TOXIC ACTIONS OF ALIPHATIC NITRILES DEPENDED ON CYANIDE RELEASE & THE DEGREE OF UNSATURATION. HEPATIC & BLOOD CYANIDE LEVELS 1 HR AFTER TREATMENT WERE HIGHEST FOLLOWING MALONONITRILE & DECREASED IN THE ORDER OF **PROPIONITRILE**, POTASSIUM CYANIDE, BUTYRONITRILE, ACRYLONITRILE, ALLYLCYANIDE; IN THE BRAIN POTASSIUM CYANIDE PRECEDED MALONONITRILE & **PROPIONITRILE**.
[AHMED AE, FAROOQUI M YH; TOXICOL LETT (AMST) 12 (2-3): 157-164 (1982)]**PEER REVIEWED**

Some aliphatic nitriles undergo hepatic biotransformation in mice and rats to release free cyanide ions, but the mechanisms at work in these reactions remain in doubt. N-butyronitrile, **propionitrile**, and their respective alpha-C-hydroxylated homologs, propionaldehyde cyanohydrin and lactonitrile, were used to examine this question in mice. Pretreatment of mice with the hepatic microsomal enzyme inducers, pregnenolone-16-alpha-carbonitrile, troleandomycin, and isosafrole, or with the cytochrome p450-depleting agent, cobaltous chloride, did not influence the mortality of mice given a single dose of nitriles. Repeated injections of aspirin or sodium salicylate in water failed to protect mice against death by the nitriles. ... The cyanohydrins were more acutely toxic than their parent nitriles, produced death more rapidly, and resulted in the same toxic signs, suggesting that they are intermediates in the bioactivation pathway leading to free cyanide ions.
[Kaplita PV, Smith RP; Toxicol Appl Pharamcol 84 (3): 533-40 (1986)]**PEER REVIEWED**

When administered sc to guinea pigs, 70% of the dose was accounted for as thiocyanate.
[Snyder, R. (ed.). Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume II: Nitrogen and Phosphorus Solvents. Amsterdam-New York-Oxford: Elsevier, 1990. 355]**PEER REVIEWED**

Absorption, Distribution & Excretion:

... LIQUID ... IS RAPIDLY ABSORBED THROUGH THE SKIN.
[Deichman, W.B., and H.W. Gerarde. Toxicology of Drugs and Chemicals. 4th ed. New York: Academic Press, 1969. 342]**PEER REVIEWED**

Interactions:

WHEN SODIUM THIOSULFATE WAS GIVEN IN MULTIPLE INJECTIONS, IT PROTECTED MICE AGAINST DEATH BY **PROPIONITRILE**.
[WILLHITE CC, SMITH RP; TOXICOL APPL PHARMACOL 59 (3): 589-602 (1981)]**PEER REVIEWED**

Dose- and time- response studies have been performed with dopamine agonists and antagonists using the cysteamine and **propionitrile** duodenal ulcer models in the rat. The experiments demonstrate that the chemical induced duodenal ulcer is prevented by bromocriptine, lergotrile mesylate and reduced by apomorphine or L-dopa.
[Gallagher G et al; J Pharmacol Exp Ther 240 (3): 883-9 (1987)]**PEER REVIEWED**

Acute toxicity, in vitro metabolism, and structure-toxicity relations of aliphatic mononitriles were examined in mice pretreated with carbon tetrachloride. The LD50 in mice pretreated with carbon tetrachloride was increased in most nitriles compared to that in untreated animals with different degrees among compounds. Microsomal metabolism of nitriles to cyanide was completely inhibited when microsomes were prepared from livers of mice pretreated with carbon tetrachloride. Log(1/LD50-carbon tetrachloride)= -0.371 log p -0.152, and the equation was significant, provided aceto- and 3-hydroxypropionitrile were omitted from the analysis. These two compounds seem to be different from the others in exerting their biological effect.
[Tanii H, Hashimoto K; Toxicol Lett 22 (2): 267-72 (1984)]**PEER REVIEWED**

The effect of ethanol on metabolism of 20 nitriles (including **propionitrile**) was studied in vivo and vitro in mice. The hepatic microsomal metabolizing activity for nitrile was at a maximum 13 hr after ethanol dosing (4.0 g/kg). Using microsomes from mice pretreated with ethanol under the above conditions, enhancement of the in vitro metabolism of nitriles was 1.00-1.83 compared with the glucose-treated control. When mice were orally given nitriles 13 hr after dosing with either ethanol (4.0 g/kg) or glucose (7.0 g/kg), the hepatic metabolizing activity of nitriles for the ethanol-treated group was always higher than that for the glucose group, although no change in the content of hepatic microsomal p450 was observed between the two groups. However, ethanol added to the induction mixture inhibited the in vitro metabolism of most nitriles. The results in the present study suggest that pretreatment with ethanol can enhance the acute toxicity of nitriles.
[Tanii H; Arch Toxicol 58 (3): 171-6 (1986)]**PEER REVIEWED**

Mice were exposed for 60 min to toxic air concentrations of acetonitrile, **propionitrile**, or n-butyronitrile, and were maintained for the following 14 days. The LC50 values for acetonitrile, proprionitrile, and n-butyronitrile were 2693, 163, and 249 ppm respectively. Pre-treatment with sodium thiosulfate or sodium nitrite, two common inorganic cyanide antogonists, provided significant protection against the mortality associated with these exposures. Administration of the thiosulfate consistently provided greater protection than the nitrile. Pre-treatment with a hepatotoxic dose of carbon tetrachloride also provided protection.
[Willhite CC; Clin Toxicol 18 (8): 991-1003 (1981)]**PEER REVIEWED**

The toxic mechanism of nitriles (including **propionitrile**) and the effect of metabolic modifiers in mice were studied in relation to their physicochemical properties. All the test nitriles liberated cyanide both in vivo and in vitro, with the exception of benzonitrile, although the extent of liberation and the effect of carbon tetrachloride pretreatment on the mortality of animals differed among nitriles. From these results, test compounds were tentatively divided into 3 groups. In group 1, acute toxicity was greatly reduced by carbon tetrachloride pretreatment, in group 2, toxicity was not significantly changed or was somewhat enhanced, and in group 3, benzonitrile only, toxicity was clearly enhanced. The amount of cyanide was higher at death in the brains of mice given group 1 compounds, the level being comparable to that found in mice killed by dosing with potassium cyanide. The relation between log (1/LD50) and log p for the compounds in group 1 fitted a parabolic plot, while that for compounds in group 2 was linear. For most nitriles, the in vitro metabolism was inhibited when the incubation mixture contained either SKF-525A, carbon monoxide, or microsomes from mice treated with carbon tetrachloride. When mice were closed with ethyl alcohol, metabolic enhancement of nitriles was seen compared with the control. However, ethyl alcohol, when added to the incubation mixture, inhibited the in vitro metabolism of nitriles.

[Tanii H; Juzen Igakkai Zasshi 94 (4): 664-77 (1985)]**PEER REVIEWED**

Propionitrile-induced structural changes /were reported/ in the cells of the duodenum and stomach. The histamine antagonist metiamide reduced the incidence and intensity of **propionitrile**-induced structural changes. Bilateral vagotomy inhibited the occurrence of duodenal ulcers in rats, while hypophysectomy reduced both the incidence and the severity of duodenal lesions. Methscopolamine and 16,16-dimethylprostaglandin E2 protected rats against the **propionitrile**-induced ulcerogenic effect in a dose-dependent manner, while prednisolone increased the toxicity. Adreno-corticotrophic hormone did not significantly affect the production of **propionitrile**-induced ulcers, although mortality was decreased at the highest dose.
[Snyder, R. (ed.). Ethyl Browning's Toxicity and Metabolism of Industrial Solvents. 2nd ed. Volume II: Nitrogen and Phosphorus Solvents. Amsterdam-New York-Oxford: Elsevier, 1990. 356]**PEER REVIEWED**

Pharmacology:

Interactions:

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Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Propionitrile's production and use as a solvent, dielectric fluid, and chemical intermediate may result in its release to the environment through various waste streams. **Propionitrile** is also present in the product of modern hydrogen cyanide manufacturing facilities and is an organic impurity in acrylonitrile manufacturing which may result in its release to the environment. If released to air, a vapor pressure of 47.4 mm Hg at 25 deg C indicates **propionitrile** will exist solely as a vapor in the ambient atmosphere. Vapor-phase **propionitrile** will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 83 days. If released to soil, **propionitrile** is expected to have very high mobility based upon an estimated Koc of 29. Volatilization from moist soil surfaces is expected to be an important fate process based upon a Henry's Law constant of 3.70X10-5 atm-cu m/mole. **Propionitrile** may volatilize from dry soil surfaces based upon its vapor pressure. If released into water, **propionitrile** is not expected to adsorb to suspended

solids and sediment based upon the estimated Koc. **Propionitrile** is expected to biodegrade in the environment; microorganisms hydrolyze nitriles, such as **propionitrile**, predominately to carboxylic acids plus ammonium ions. For example, a mixed microbial culture, isolated from an environment contaminated with organic cyanides, biodegraded **propionitrile**. Volatilization from water surfaces is expected to be an important fate process based upon this compound's Henry's Law constant. Estimated volatilization half-lives for a model river and model lake are 13 hours and 8 days, respectively. An estimated BCF of 3 suggests the potential for bioconcentration in aquatic organisms is low. Occupational exposure to **propionitrile** may occur through inhalation and dermal contact with this compound at workplaces where **propionitrile** is produced or used. Monitoring data indicate that the general population may be exposed to **propionitrile** via inhalation of ambient air containing **propionitrile**. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

Occupational exposure to **propionitrile** may occur through inhalation and dermal contact with this compound at workplaces where **propionitrile** is produced or used(SRC). Monitoring data indicate that the general population may be exposed to **propionitrile** via inhalation of ambient air containing **propionitrile**(SRC). **Propionitrile** was detected but not quantified (detection limit was approx 0.5-1.0 ng/ml) in an operating pilot-scale shale oil wastewater treatment plant(1).
[(1) Hawthorne SB, Sievers RE; Environ Sci Technol 18: 483-90 (1984)]**PEER REVIEWED**

Artificial Pollution Sources:

An organic impurity in acrylonitrile.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 1 (1978) 414-26]**PEER REVIEWED**

Propionitrile's production and use as a solvent, dielectric fluid, and chemical intermediate(1) may result in its release to the environment through various waste streams(SRC). **Propionitrile** may be released in fugitive or wastewater releases during its by product formation during the electro-reduction of acrylonitrile to form adiponitrile(2). It may also be emitted during shale oil processing(3,4) and from turbine combustion exhaust(5). **Propionitrile** is also present in the product in modern hydrogen cyanide manufacturing facilities as an impurity(6).
[(1) Lewis RJ Sr, ed; Hawley's Condensed Chemical Dictionary. 13th ed. NY, NY: John Wiley and Sons Inc, p. 465 (1997) (2) Jarvis WF et al; Health and Effects Profile on Propionitrile. USEPA Contract 68-03-3228 Task II (1987) (3) Sklarew DS; Hayes DJ; Environ Sci Technol 18: 600-3 (1984) (4)Hawthorne SB, Seivers RE; Environ Sci Technol 18: 483-90 (1984) (5) Graedel TE; Chem Compounds in the Atmosphere. NY, NY: Academic Press (1978) (6) Jenks WR; Kirk-Othmer Encycl Chem Tech. 3rd ed. NY, NY: John Wiley and Sons, 7: 307-19 (1979)]**PEER REVIEWED**

Environmental Fate:

TERRESTRIAL FATE: Based on a classification scheme(1), an estimated Koc value of 29(SRC), determined from an measured log Kow of 0.16(2) and a regression-derived equation(3), indicates that **propionitrile** is expected to have very high mobility in soil(SRC). Volatilization of **propionitrile** from moist soil surfaces is expected to be an important fate process(SRC) given a Henry's Law constant of 3.70X10-5 atm-cu m/mole(4). The potential for volatilization of **propionitrile** from dry soil surfaces may exist(SRC) based upon a vapor pressure of 47.4 mm Hg(5). Microorganisms hydrolyze nitriles predominately to carboxylic acids plus ammonium ions(6,7). A mixed microbial culture, isolated from

an environment contaminated with organic cyanides and PCBs, utilized **propionitrile** as the sole source of carbon and nitrogen(8). Thus **propionitrile** may potentially biodegrade in soil(SRC).
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 6 (1995) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9 (1990) (4) Butler JAV, Ramchandani CN; J Chem Soc pp. 952-5 (1935) (5) Daubert TE, Danner RP; Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation. Design Inst Phys Prop Data, Amer Inst Chem Eng NY, NY: Hemisphere Pub Corp 5 Vol (1989) (6) Meth-Cohn O, Wang MX; J Chem Soc Perkin Trans 1: 1099-1104 (1997) (7) Kobayashi M et al; Biochem Biophys Res Commun 253: 662-666 (1998) (8) Chapatwala KD et al; Environ Toxicol Chem 11: 1145-51 (1992)]**PEER REVIEWED**

AQUATIC FATE: Based on a classification scheme(1), an estimated Koc value of 29(SRC), determined from an measured log Kow of 0.16(2) and a regression-derived equation(3), indicates that **propionitrile** is not expected to adsorb to suspended solids and sediment(SRC). Volatilization from water surfaces is expected(3) based upon a Henry's Law constant of 3.70x10-5 atm-cu m/mole(4). Using this Henry's Law constant and an estimation method(3), volatilization half-lives for a model river and model lake are 13 hrs and 8 days, respectively(SRC). According to a classification scheme(5), an estimated BCF of 3 (SRC), from its log Kow(2) and a regression-derived equation(6), suggests the potential for bioconcentration in aquatic organisms is low(SRC). Microorganisms hydrolyze nitriles predominately to carboxylic acids plus ammonium ions(7,8). A variant of a yeast strain (Candiada famata) isolated from gold mine effluent was able to grow on **propionitrile** as the sole nitrogen source after acclimatization (9). In another study, a mixed microbial culture, isolated from an environment contaminated with organic cyanides and PCBs, utilized **propionitrile** as the sole source of carbon and nitrogen(10). The mixed microbial culture was grown for 48 hrs at pH 7 with 1 g/l of **propionitrile**; the final pH and ammonia concn were determined to be 8.66 and 75.9 umol/ml, respectively(10). **Propionitrile** was rapidly metabolized by activated sewage sludge to the amide(11).
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 6 (1995) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9, 15-1 to 15-29 (1990) (4) Butler JAV, Ramchandani CN; J Chem Soc pp 952-5 (1935) (5) Franke C et al; Chemosphere 29: 1501-14 (1994) (6) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999) (7) Meth-Cohn O, Wang MX; J Chem Soc Perkin Trans 1: 1099-1104 (1997) (8) Kobayashi M et al; Biochem Biophys Res Commun 253: 662-666 (1998) (9) Linardi VR et al; FEMS Microb Lett 144: 67-71 (1996) (10) Chapatwala KD et al; Environ Toxicol Chem 11: 1145-51 (1992) (11) Symons JM et al; J Air Water Pollut 4: 115 (1961)]**PEER REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), **propionitrile**, which has a vapor pressure of 47.4 mm Hg at 25 deg C (2), is expected to exist solely as a vapor in the ambient atmosphere(SRC). Vapor-phase **propionitrile** is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals(SRC); the half-life for this reaction in air is estimated to be 83 days(SRC), calculated from its rate constant of 1.94X10-13 cu cm/molecule-sec at 25 deg C(3).
[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Daubert TE, Danner RP; Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation. Design Inst Phys Prop Data, Amer Inst Chem Eng NY, NY: Hemisphere Pub Corp 5 Vol (1989) (3) Kwok ESC, Atkinson R; Estimation of hydroxyl radical reaction rate constants for gas-phase organic compounds using a structure-reactivity relationship: an update. Riverside, CA: Univ CA, Staewide Air Pollut Res Ctr. CMA Contract No. ARC-8.0-OR (1994)]**PEER REVIEWED**

Environmental Biodegradation:

The fungal strain Nocardia rhodochrous LL100-21 completely hydrolyzed **propionitrile** to propionic acid and ammonia.
[DiGeronemo MT, Antoine AD; Appl Environ Microbiol 31 (6): 900-6 (1976)]**PEER REVIEWED**

Enzyme-catalyzed hydrolysis of nitriles has been shown to proceed by two distinct routes(1,2); a nitrilase transforms the nitriles directly into acids plus ammonium ion, or a nitrile hydratase forms the amide which is hydrolyzed to acid plus ammonium ion by amidase(1,2). A variant of a yeast strain identified as Candiada famata isolated from gold mine effluent was able to grow on **propionitrile** as the sole nitrogen source after acclimatization(3). In another study, a mixed microbial culture, isolated from an environment contaminated with organic cyanides and PCBs, utilized **propionitrile** as the sole source of carbon and nitrogen(4). The mixed microbial culture was grown for 48 hrs at pH 7 with 1 g/l of **propionitrile**; the final pH and ammonia concn were determined to be 8.66 and 76.9 umol/ml, respectively(4). **Propionitrile** was rapidly metabolized by activated sludge to the amide(5).
[(1) Meth-Cohn O, Wang MX; J Chem Soc Perkin Trans 1: 1099-1104 (1997) (2) Kobayashi M et al; Biochem Biophys Res Commun 253: 662-666 (1998) (3) Linardi VR et al; FEMS Microbiology Letters 144: 67-71 (1996) (4) Chapatwala KD et al; Environ Toxicol Chem 11: 1145-51 (1992) (5) Symons JM et al; J Air Water Pollut 4: 115 (1961)]**PEER REVIEWED**

Environmental Abiotic Degradation:

The rate constant for the vapor-phase reaction of **propionitrile** with photochemically-produced hydroxyl radicals is 1.94X10-13 cu cm/molecule-sec at 25 deg C(1). This corresponds to an atmospheric half-life of about 83 days(SRC) at an atmospheric concentration of 5X10+5 hydroxyl radicals per cu cm (2). **Propionitrile** is also not expected to directly photolyze due to the lack of absorption in the environmental UV spectrum (>290 nm)(SRC).
[(1) Kwok ESC, Atkinson R; Estimation of hydroxyl radical reaction rate constants for gas-phase organic compounds using a structure-reactivity relationship: an update. Riverside, CA: Univ CA, Staewide Air Pollut Res Ctr. CMA Contract No. ARC-8.0-OR (1994) (2) Meylan WM, Howard PH; Chemosphere 26: 2293-99 (1993)]**PEER REVIEWED**

Environmental Bioconcentration:

An estimated BCF of 3 was calculated for **propionitrile**(SRC), using log Kow of 0.16(1) and a regression-derived equation(2). According to a classification scheme(3), this BCF suggests the potential for bioconcentration in aquatic organisms is low(SRC).
[(1) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 6 (1995) (2) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999) (3) Franke C et al; Chemosphere 29: 1501-14 (1994)]**PEER REVIEWED**

Soil Adsorption/Mobility:

The Koc of **propionitrile** is estimated as 29(SRC), using a measured log Kow of 0.16(1) and a regression-derived equation(2). According to a classification scheme(3), this estimated Koc value suggests that **propionitrile** is expected to have very high mobility in soil(SRC).
[(1) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 6 (1995) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9 (1990) (3) Swann RL et al; Res Rev 85: 17-28 (1983)]**PEER REVIEWED**

Volatilization from Water/Soil:

The Henry's Law constant for **propionitrile** is 3.70X10-5 atm-cu m/mole(1). This Henry's Law constant indicates that **propionitrile** is expected to volatilize from water surfaces(2). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec)(2) is estimated as 13 hours(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(2) is estimated as 8 days(SRC). **Propionitrile**'s Henry's Law constant(1) indicates that volatilization from moist soil surfaces may occur(SRC). The potential for volatilization of **propionitrile** from dry soil surfaces may exist(SRC) based upon a vapor pressure of 47.4 mm Hg(3).
[(1) Butler JAV, Ramchandani CN; J Chem Soc pp 952-5 (1935) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (3) Daubert TE, Danner RP; Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation. Design Inst Phys Prop Data, Amer Inst Chem Eng NY, NY: Hemisphere Pub Corp 5 Vol (1989)]**PEER REVIEWED**

Environmental Water Concentrations:

DRINKING WATER: **Propionitrile** was detected but not quantified in one sample of groundwater-derived drinking water in a survey of 14 treated drinking waters from different sources(1). **Propionitrile** was not found in a sample from the same supply after distribution(1).
[(1) Fielding M et al; Organic micropollutants in drinking water. Eng Water Res Cent p. 49 TR-159 (1981)]**PEER REVIEWED**

Effluent Concentrations:

The concn of **propionitrile** in the off-gases from oil shale retort at Rio Blanco, Colorado was 16-26 mg/kg(1). The concn of **propionitrile** in condensate retort water from an oil-shale processing facility in Colorado was 8.5 mg/l(2).
[(1) Sklarew DS, Hayes DJ; Environ Sci Technol 18: 600-3 (1984) (2) Leenheer JA et al; Environ Sci Technol 16: 714-23 (1982)]**PEER REVIEWED**

Atmospheric Concentrations:

SOURCE DOMINATED: **Propionitrile** was detected but not quantified (detection limit was approx 0.5-1.0 ng/ml) in the air near a shale oil wastewater facility(1). Not detected in typical urban air or rural air in the oil shale region of western Colorado/Utah(1). URBAN/SUBURBAN: An evaluated database of US air monitoring data for the years 1970-1987 contains the following data for **propionitrile** (concn is reported as daily median concn in selected site types): remote, rural, and suburban sites-648 samples, 0.000 ppb; urban sites-1214 samples, 0.012 ppb; source dominated sites-182 samples, 0.255 ppb(2). From EPA's VOC-AMBI database (1986), the avg concn of **propionitrile** in ambient air from 300 cities in the United States was 0.384 ppb (data points = 2,044)(3).
[(1) Hawthorne SB, Sievers RE; Environ Sci Technol 18: 483-90 (1984) (2) Shah JJ, Heyerdahl; National Ambient Volatile Organic Compounds (VOCs) Database Update. Research Triangle Park, NC: USEPA USEPA/600/3-88-010(a) p. 54 (1988) (3) Shah JJ, Singh HB; Environ Sci Technol 22: 1381-88 (1988)]**PEER REVIEWED**

Other Environmental Concentrations:

Propionitrile levels of 0.055-0.072 ug/g have been detected in machine cutting fluid emulsions(1).
[(1) Yasuhara A et al; Agric Biol Chem 50: 1765-70 (1986)]**PEER REVIEWED**

Environmental Standards & Regulations:

CERCLA Reportable Quantities:

Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 10 lb or 4.54 kg. The toll free number of the NRC is (800) 424-8802; In the Washington D.C. metropolitan area (202) 426-2675. The rule for determining when notification is required is stated in 40 CFR 302.4 (section IV. D.3.b).
[40 CFR 302.4 (7/1/2000)]**PEER REVIEWED**

Releases of CERCLA hazardous substances are subject to the release reporting requirement of CERCLA section 103, codified at 40 CFR part 302, in addition to the requirements of 40 CFR part 355. **Propionitrile** is an extremely hazardous substance (EHS) subject to reporting requirements when stored in amounts in excess of its threshold planning quantity (TPQ) of 500 lbs.
[40 CFR 355 (7/1/2000)]**PEER REVIEWED**

RCRA Requirements:

P101; As stipulated in 40 CFR 261.33, when **propionitrile**, as a commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate, becomes a waste, it must be managed according to federal and/or state hazardous waste regulations. Also defined as a hazardous waste is any container or inner liner used to hold this waste or any residue, contaminated soil, water, or other debris resulting from the cleanup of a spill, into water or on dry land, of this waste. Generators of small quantities of this waste may qualify for partial exclusion from hazardous waste regulations (40 CFR 261.5(e)).
[40 CFR 261.33 (7/1/2000)]**PEER REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

C3-H5-N
PEER REVIEWED

Molecular Weight:

55.08
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1435]**PEER REVIEWED**

Color/Form:

Colorless liquid
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

Odor:

Pleasant, sweetish, ethereal odor.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

Boiling Point:

97.2 deg C @ 760 mm Hg
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1345]**PEER REVIEWED**

Melting Point:

-91.8 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1345]**PEER REVIEWED**

Critical Temperature & Pressure:

Critical temperature = 291.2 deg C; critical pressure 41.3 atm
[Riddick, J.A., W.B. Bunger, Sakano T.K. Techniques of Chemistry 4th ed., Volume II. Organic Solvents. New York, NY: John Wiley and Sons., 1985. 584]**PEER REVIEWED**

Density/Specific Gravity:

SP GR: 0.7818 @ 20 deg C/4 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1345]**PEER REVIEWED**

Dissociation Constants:

pKa = 33.54
[Riddick, J.A., W.B. Bunger, Sakano T.K. Techniques of Chemistry 4th ed., Volume II. Organic Solvents. New York, NY: John Wiley and Sons., 1985. 584]**PEER REVIEWED**

Heat of Combustion:

-1910.62 kJ/mol @ 25 deg C (liquid)
[Riddick, J.A., W.B. Bunger, Sakano T.K. Techniques of Chemistry 4th ed., Volume II. Organic Solvents. New York, NY: John Wiley and Sons., 1985. 584]**PEER REVIEWED**

Heat of Vaporization:

36.03 kJ/mol @ 22.83 deg C
[Riddick, J.A., W.B. Bunger, Sakano T.K. Techniques of Chemistry 4th ed., Volume II. Organic Solvents. New York, NY: John Wiley and Sons., 1985. 584]**PEER REVIEWED**

Octanol/Water Partition Coefficient:

log Kow= 0.16
[Hansch, C., Leo, A., D. Hoekman. Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. Washington, DC: American Chemical Society., 1995. 6]**PEER REVIEWED**

Solubilities:

Miscible with ether, alcohol
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1345]**PEER REVIEWED**

In water, 1.03X10+5 mg/l @ 25 deg C.
[Riddick, J.A., W.B. Bunger, Sakano T.K. Techniques of Chemistry 4th ed., Volume II. Organic Solvents. New York, NY: John Wiley and Sons., 1985. 584]**PEER REVIEWED**

Spectral Properties:

INDEX OF REFRACTION: 1.36812 @ 15 deg C/D; 1.36585 @ 20 deg C/D; 1.36132 @ 30 deg C/D
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1345]**PEER REVIEWED**

IR: SAD 190 (Sadtler Research Laboratories Prism Collection)
[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994.,p. V5 4357]**PEER REVIEWED**

NMR: SAD 1877 (Sadtler Research Laboratories Spectral Collection)
[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994.,p. V5 4357]**PEER REVIEWED**

MS: NIST 49316 (NIST/EPA/MSDC Mass Spectral Database 1990 version)
[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994.,p. V5 4357]**PEER REVIEWED**

Surface Tension:

27.25 dyne/cm @ 20 deg C; 26.19 dyne/cm @ 30 deg C
[Riddick, J.A., W.B. Bunger, Sakano T.K. Techniques of Chemistry 4th ed., Volume II. Organic Solvents. New York, NY: John Wiley and Sons., 1985. 584]**PEER REVIEWED**

Vapor Density:

1.9 (Air= 1)
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 3144]**PEER REVIEWED**

Vapor Pressure:

47.4 mm Hg @ 25 deg C
[Daubert, T.E., R.P. Danner. Physical and Thermodynamic Properties of Pure

Chemicals Data Compilation. Washington, D.C.: Taylor and Francis, 1989.]**PEER REVIEWED**

Viscosity:

0.454 cP @ 15 deg C; 0.389 cP @ 30 deg C
[Riddick, J.A., W.B. Bunger, Sakano T.K. Techniques of Chemistry 4th ed., Volume II. Organic Solvents. New York, NY: John Wiley and Sons., 1985. 584]**PEER REVIEWED**

Other Chemical/Physical Properties:

Density of saturated air: 1.05 @ 22 deg C (air= 1)
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 3144]**PEER REVIEWED**

Vapor pressure: 40 mm Hg @ 22 deg C
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 3144]**PEER REVIEWED**

Henry's Law constant = 3.70X10-5 atm cu m/mole @ 25 deg C
[Butler JAV, Ramchandani CN; J Chem Soc pp. 952-5 (1935)]**PEER REVIEWED**

Hydroxyl radical reaction rate constant = 1.94X10-13 cu cm/molecule-sec @ 25 deg C
[Kwok ESC, Atkinson R; Estimation of hydroxyl radical reaction rate constants for gas-phase organic compounds using a structure-reactivity relationship: an update. Riverside, CA: Univ CA, Statewide Air Pollut Res Ctr. CMA Contract No. ARC-8.0-OR (1994)]**PEER REVIEWED**

Heat of formation: 15.48 kJ/mol @ 25 deg C (liquid), 51.46 kJ/mol @ 25 deg C (gas); aqueous azeotrope = 76% water.
[Riddick, J.A., W.B. Bunger, Sakano T.K. Techniques of Chemistry 4th ed., Volume II. Organic Solvents. New York, NY: John Wiley and Sons., 1985. 584]**PEER REVIEWED**

Chemical Safety & Handling:

DOT Emergency Guidelines:

Health: Toxic; may be fatal if inhaled, ingested or absorbed through skin. Inhalation or contact with some of these materials will irritate or burn skin and eyes. Fire will produce irritating, corrosive and/or toxic gases. Vapors may cause dizziness or suffocation. Runoff from fire control or dilution water may cause pollution.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-131] **QC REVIEWED**

Fire or explosion: Highly flammable: Will be easily ignited by heat, sparks or flames. Vapors may form explosive mixtures with air. Vapors may travel to source of ignition and flash back. Most vapors are heavier than air. They will spread along ground and collect in low or confined areas (sewers, basements, tanks). Vapor explosion and poison hazard indoors, outdoors or in sewers. Those substances designated

with a "P" may polymerize explosively when heated or involved in a fire. Runoff to sewer may create fire or explosion hazard. Containers may explode when heated. Many liquids are lighter than water.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-131]
QC REVIEWED

Public safety: Call Emergency Response Telephone Number ... . Isolate spill or leak area immediately for at least 100 to 200 meters (330 to 660 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Keep out of low areas. Ventilate closed spaces before entering.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-131]
QC REVIEWED

Protective clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Wear chemical protective clothing which is specifically recommended by the manufacturer. It may provide little or no thermal protection. Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-131]
QC REVIEWED

Evacuation: ... Fire: If tank, rail car or tank truck is involved in a fire, isolate for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-131]
QC REVIEWED

Fire: CAUTION: All these products have a very low flash point. Use of water spray when fighting fire may be inefficient. Small fires: Dry chemical, CO2, water spray or alcohol-resistant foam. Large fires: Water spray, fog or alcohol-resistant foam. Move containers from fire area if you can do it without risk. Dike fire control water for later disposal; do not scatter the material. Use water spray or fog; do not use straight streams. Fire involving tanks or car/trailer loads: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. For massive fire use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-131]
QC REVIEWED

Spill or leak: Fully encapsulating, vapor protective clothing should be worn for spills and leaks with no fire. ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). All equipment used when handling the product must be grounded. Do not touch or walk through spilled material. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. A vapor suppressing foam may be used to reduce vapors. Small spills: Absorb with earth, sand or other non-combustible material and transfer to containers for later disposal. Use clean non-sparking tools to collect absorbed material. Large spills: Dike far ahead of liquid spill for later disposal. Water spray may reduce vapor; but may not prevent ignition in closed spaces.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-131]
QC REVIEWED

First aid: Move victim to fresh air. Call 911 or emergency medical service. Apply artificial respiration if

victim is not breathing. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. Wash skin with soap and water. Keep victim warm and quiet. Effects of exposure (inhalation, ingestion or skin contact) to substance may be delayed. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-131] **QC REVIEWED**

Skin, Eye and Respiratory Irritations:

Vapor is irritating to eyes, nose & throat. Liquid is irritating to skin & eyes.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Fire Potential:

DANGEROUS FIRE HAZARD WHEN EXPOSED TO HEAT, FLAME (SPARKS), OXIDIZERS.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2799]**PEER REVIEWED**

NFPA Hazard Classification:

Health: 4. 4= Materials that, on very short exposure, could cause death or major residual injury, including those that are too dangerous to be approached without specialized protective equipment. A few whiffs of the vapor or gas can cause death, or contact with the vapor or liquid may be fatal, if it penetrates the fire fighter's normal protective gear. The normal full protective clothing and breathing apparatus available to the typical fire fighter will not provide adequate protection against inhalation or skin contact with these materials.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-81]**PEER REVIEWED**

Flammability: 3. 3= This degree includes Class IB and IC flammable liquids and materials that can be easily ignited under almost all normal temperature conditions. Water may be ineffective in controlling or extinguishing fires in such materials.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-81]**PEER REVIEWED**

Reactivity: 1. 1= This degree includes materials that are normally stable, but that may become unstable at elevated temperatures and pressures and materials that will react with water with some release of energy, but not violently. Fires involving these materials should be approached with caution.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-81]**PEER REVIEWED**

Flammable Limits:

Lower flammable limit: 3.1% by volume
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-81]**PEER REVIEWED**

Flash Point:

36 deg F (2 deg C) (Closed Cup)
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-81]**PEER REVIEWED**

16 deg C (Open Cup)
[ITII. Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1988. 445]**PEER REVIEWED**

Fire Fighting Procedures:

TO FIGHT FIRE, USE WATER SPRAY, FOAM, MIST, CARBON DIOXIDE, DRY CHEMICAL.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2799]**PEER REVIEWED**

If material on fire or involved in fire: Do not extinguish fire unless flow can be stopped or safely confined. Use water in flooding quantities as fog. Solid streams of water may be ineffective. Use "alcohol" foam, dry chemical or carbon dioxide. Cool all affected containers with flooding quantities of water. Apply water from as far a distance as possible. Keep run-off water out of sewers and water sources.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 917]**PEER REVIEWED**

Toxic Combustion Products:

When heated to decomp it emits toxic fumes of /nitrogen oxides and cyanides/.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2799]**PEER REVIEWED**

Explosive Limits & Potential:

LOWER 3.1%
[Bretherick, L. Handbook of Reactive Chemical Hazards. 3rd ed. Boston, MA: Butterworths, 1985. 1727]**PEER REVIEWED**

Mixture with N-bromosuccinimide may explode when heated.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2799]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

Strong oxidizers & reducing agents, strong acids & bases [Note: Hydrogen cyanide is produced when **propionitrile** is heated to decomposition].
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

Poisonous ... on contact with acids.
[Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984. 2300]**PEER REVIEWED**

After refluxing for 24 hr at 105 deg C, a mixture /with N-bromosuccinimide/ exploded, possibly due to

dehydrohalogenation of the bromonitrile to acrylonitrile, and polymerization of the latter.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 423]**PEER REVIEWED**

Hazardous Decomposition:

When heated to decomp it emits toxic fumes of /nitrogen oxides and cyanides/.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2799]**PEER REVIEWED**

Protective Equipment & Clothing:

Wear long rubber gloves and protective clothing. ... /Wear/ self-contained breathing apparatus.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 752]**PEER REVIEWED**

Wear appropriate personal protective clothing to prevent skin contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

Facilities for quickly drenching the body should be provided within the immediate work area for emergency use where there is a possibility of exposure. [Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from any body areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.]
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

Recommendations for respirator selection. Max concn for use: 60 ppm. Respirator Class(es): Any chemical cartridge respirator with organic vapor cartridge(s). Any supplied-air respirator.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

Recommendations for respirator selection. Max concn for use: 150 ppm. Respirator Class(es): Any supplied-air respirator operated in a continuous flow mode. Any powered, air-purifying respirator with organic vapor cartridge(s).
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

Recommendations for respirator selection. Max concn for use: 300 ppm. Respirator Class(es): Any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s). Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister. Any powered, air-purifying respirator with a tight-fitting facepiece and organic vapor cartridge(s). Any self-contained breathing apparatus with a full facepiece. Any supplied-air respirator with a full facepiece.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

Recommendations for respirator selection. Max concn for use: 1000 ppm. Respirator Class(es): Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Emergency or planned entry into unknown concn or IDLH conditions: Respirator Class(es): Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode. Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Escape from suddenly occurring respiratory hazards: Respirator Class(es): Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister. Any appropriate escape-type, self-contained breathing apparatus.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

Preventive Measures:

Contact lenses should not be worn when working with this chemical.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

SRP: The scientific literature for the use of contact lenses in industry is conflicting. The benefit or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In any event, the usual eye protection equipment should be worn even when contact lenses are in place.
PEER REVIEWED

No eating or smoking in work areas.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 752]**PEER REVIEWED**

SRP: Contaminated protective clothing should be segregated in such a manner so that there is no direct personal contact by personnel who handle, dispose, or clean the clothing. Quality assurance to ascertain the completeness of the cleaning procedures should be implemented before the decontaminated protective clothing is returned for reuse by the workers. Contaminated clothing should not be taken home at end of shift, but should remain at employee's place of work for cleaning.
PEER REVIEWED

Adequate ventilation and protectors. No eating and no smoking in work areas. Apply ear plugs to personnel with split eardrums. Avoid one-man work.
[ITII. Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1988. 445]**PEER REVIEWED**

If material not on fire and not involved in fire: Keep sparks, flames, and other sources of ignition away. Keep material out of water sources and sewers. Build dikes to contain flow as necessary. Attempt to stop leak if without undue personnel hazard.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 917]**PEER REVIEWED**

Personnel protection: Keep upwind. Avoid breathing vapors. ... Do not handle broken packages unless wearing appropriate personal protective equipment.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 917]**PEER REVIEWED**

All nitriles should be handled under carefully controlled conditions and only by personnel having a thorough understanding and knowledge of safe handling techniques. Because of the nature of nitrile cmpd and the lack of complete toxicity data on many nitriles, care should be exercised in handling these cmpd to avoid inhalation of the vapors, ingestion, and contact with the skin. /Nitriles/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1447]**PEER REVIEWED**

The worker should immediately wash the skin when it becomes contaminated.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed or replaced.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

Shipment Methods and Regulations:

No person may /transport,/ offer or accept a hazardous material for transportation in commerce unless that person is registered in conformance ... and the hazardous material is properly classed, described, packaged, marked, labeled, and in condition for shipment as required or authorized by ... /the hazardous materials regulations (49 CFR 171-177)./
[49 CFR 171.2 (7/1/2000)]**PEER REVIEWED**

The International Air Transport Association (IATA) Dangerous Goods Regulations are published by the IATA Dangerous Goods Board pursuant to IATA Resolutions 618 and 619 and constitute a manual of industry carrier regulations to be followed by all IATA Member airlines when transporting hazardous materials.
[IATA. Dangerous Goods Regulations. 41st Ed.Montreal, Canada and Geneva, Switzerland: International Air Transport Association, Dangerous Goods Regulations, 2000. 209]**PEER REVIEWED**

The International Maritime Dangerous Goods Code lays down basic principles for transporting hazardous chemicals. Detailed recommendations for individual substances and a number of recommendations for good practice are included in the classes dealing with such substances. A general index of technical names has also been compiled. This index should always be consulted when attempting to locate the appropriate procedures to be used when shipping any substance or article.
[IMDG; International Maritime Dangerous Goods Code; International Maritime Organization p.3273 (1998)]**PEER REVIEWED**

Disposal Methods:

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste number P101 must conform with USEPA regulations in storage, transportation, treatment and disposal of waste.
[40 CFR 240-280, 300-306, 702-799 (7/1/91)]**PEER REVIEWED**

A good candidate for liquid injection incineration at a temperature range of 650 to 1,600 deg C and a residence time of 0.1 to 2 seconds. Also, a good candidate for rotary kiln incineration at a temperature range of 820 to 1600 deg C and residence times of seconds for liquids and gases, and hours for solids. Also, a good candidate for fluidized bed incineration at a temperature range of 450 to 980 deg C and residence times of seconds for liquids and gases, and longer for solids.
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-10 (1981) EPA 68-03-3025]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for **propionitrile**: Concentration process: Biological treatment.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-35 (1982)]**PEER REVIEWED**

Treatment and Disposal Method: Recommendable: Incineration, alkaline hydrolysis, oxidation, discharge to sewer. Not recommendable: Evaporation. Add by stirring excessive sodium hydroxide. After one hour, evaporate alcohol and add sufficient calcium hypochlorite. After 24 hours, drain into a sewer with abundant water. Peer review: Incinerate in a unit with effluent gas scrubbing. (Peer review conclusions of an IRPTC expert consultation (May 1985))
[United Nations. Treatment and Disposal Methods for Waste Chemicals (IRPTC File). Data Profile Series No. 5. Geneva, Switzerland: United Nations Environmental Programme, Dec. 1985. 272]**PEER REVIEWED**

Occupational Exposure Standards:

NIOSH Recommendations:

Recommended Exposure Limit: 10 Hr Time-Weighted Avg: 6 ppm (14 mg/cu m).
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 266]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

CHEM INT FOR DI-N-PROPYLAMINE
[SRI]**PEER REVIEWED**

Solvent, dielectric fluid, intermediate
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 465]**PEER REVIEWED**

EXPTL APPLICATIONS: ULCEROGEN
[LICHTENBERGER LM ET AL; GASTROENTEROLOGY 73 (6): 1305-8 (1977)]**PEER REVIEWED**

Used as a solvent in petroleum refining, and as a raw material for drug manufacture.

[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2799]**PEER REVIEWED**

Used to manufacture cyanoactetates by oxidation of **propionitrile**.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V15 (95) 938]**PEER REVIEWED**

Manufacturers:

Solutia, Inc. 575 Maryville Centre Drive, P.O. Box 66760, St. Louis, MO 63166-6760; Production site: Decatur, AL 35609
[SRI International. 2000 Directory of Chemical Producers -- United States. SRI Consulting, Menlo Park: CA 2000 858]**PEER REVIEWED**

Methods of Manufacturing:

... Product formation during the electro-reduction of acrylonitrile to form adiponitrile.
[Jarvis WF et al; Health and Effects Profile on Propionitrile. USEPA Contract 68-03-3228 Task II (1987)]**PEER REVIEWED**

May be prepared by dehydration of propionamide (or propionic acid + ammonia) or by distilling ethyl sulfate & concentrated aq potassium cyanide
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1345]**PEER REVIEWED**

Hydrogenation of acrylonitrile is carried out with the use of copper, rhodium, or nickel catalysts.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V1 (91) 356]**PEER REVIEWED**

Heating barium ethyl sulfate and potassium cyanide with subsequent distillation.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 465]**PEER REVIEWED**

By product in the electrohydrodimerization of acrylonitrile to adiponitrile.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V9 (94) 182]**PEER REVIEWED**

U. S. Production:

(1977) AT LEAST 4.63X10+9 G (INCL CAPTIVE)
[SRI]**PEER REVIEWED**

(1982) PROBABLY GREATER THAN 2.27X10+6 G
[SRI]**PEER REVIEWED**

(1977) 10x10+6 to 50x10+6 lb; (1980) 10x10+6 to 50x10+6 lb
[ITC/USEPA; Information Review #252 (Draft) Adiponitrile and Its Process Intermediates and Byproducts p.10 (1981)]**PEER REVIEWED**

(1991) Exceeded 5000 lb or $5000 in value
[SRI. 1992 Directory of Chemical Producers-United States of America. Menlo Park, CA: SRI International, 1992. 917]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

VOLATILE SUBSTANCE CAN BE SEPARATED FROM BIOLOGICAL LIQUIDS AFTER INJECTION ONTO PACKED GAS-CHROMATOGRAPHIC COLUMNS OR IN A CLOSED VESSEL OR BY CONTROLLED TEMP DIFFUSION FROM LIQ PHASE INTO AIR ABOVE SAMPLE (HEAD SPACE). SEPARATED VOLATILE COMPONENT /INCLUDING **PROPIONITRILE**/ MAY BE IDENTIFIED BY GC.
[Sunshine, Irving (ed.) Methodology for Analytical Toxicology. Cleveland: CRC Press, Inc., 1975. 407]**PEER REVIEWED**

Analytic Laboratory Methods:

EPA Method 1624. Isotope Dilution Purge-and-Trap GC/MS. This method is applicable for the determination of volatile organic compounds in municipal and industrial discharges. By adding a known amount of a labeled compound to every sample prior to purging, a correction of recovery of the pollutant can be made. If labeled compounds are not available, an internal standard method is used. Under the prescribed conditions, **propionitrile** the method has an estimated detection limit of 10 ug/kg in solids at high level and 10 ug/l in water with no interferences present as defined by EPA.
[USEPA/OST; List of Lists: A Catolog of Analytes and Methods p.435 (9/1991) OST Pub 21W-4005]**PEER REVIEWED**

OSW Method 8240B-W. Determination of Volatile Organics Compounds by Gas Chromatography/Mass Spectrometry (GC/MS). This method is applicable to various types of samples, regardless of water content, including ground water, aqueous sludge, caustic liquors, acid liquors, waste solvents, and oily waste. Detection limit = 100 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 8240B-S. Determination of Volatile Organics Compounds by Gas Chromatography/Mass Spectrometry (GC/MS). This method is applicable to various types of samples regardless of water content, including ground water, aqueous sludges, caustic liquors, acid liquors, waste solvents, oily waste, mousses, tars, fibrous wastes, polymeric emulsions, filter cakes, spent carbons, spent catalysts, soils, and sediments. Detection limit = 100 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 8015B. Nonhalogenated Organics Using GC/FID. This method is used to determine the concentration of various nonhalogenated volatile and semivolatile organic compounds including total petroleum hydrocarbons (TPH) by gas chromatography. Detection limit unspecified.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 8260A. Determination of Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique. This method is applicable to nearly all types of samples, regardless of water content, including ground water, aqueous sludges, caustic liquors, acid liquors, waste solvents, oily wastes, mousses, tars, fibrous wastes, polymeric emulsions, filter cakes, spent carbons, spent catalysts, soils, and sediments. Detection limit unspecified.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 8260B. Determination of Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique. This method is used to determine volatile organic compounds in a variety of solid waste matrices. It is applicable to nearly all types of samples, regardless of water content, including various air sampling trapping media, ground and surface waters, aqueous sludges, caustic liquors, acid liquors, waste solvents, oily wastes, mousses, tars, fibrous wastes, polymeric emulsions, filter cakes, spent carbons, spent catalysts, soils, and sediments. Detection limit unspecified.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

Sampling Procedures:

EPA Method 8015. For the analysis of solid waste, a representative sample (solid or liquid) is collected in a standard 40-ml glass screw-cap VOA vial equipped with a Teflon-faced silicone septum. Sample agitation, as well as contamination of the sample with air, must be avoided. Two vials are filled per sample location, then placed in separate plastic bags for shipment and storage.
[USEPA/OST; List of Lists: A Catalog of Analytes and Methods p.435 (1991) OST Pub 21W-4005]**PEER REVIEWED**

Special References:

Special Reports:

SZABO S ET AL; ADV PHARMACOL THER, PROC INT CONGR, 8TH, 5: 263-8 (1982). A REVIEW ON THE USEFULNESS OF **PROPIONITRILE**-INDUCED ULCERS IN RATS FOR PHARMACOLOGICAL & PATHOPHYSIOLOGICAL STUDIES, ON ROLE OF DOPAMINE IN PATHOGENESIS & THERAPY OF DUODENAL ULCERS.

Kaplita PV and Smith RP; Toxicol Appl Pharmacol 84 (3): 533-540 (1986). Pathways for the bioactivation of aliphatic nitriles to free cyanide in mice.

Johannsen FR, Levinskas GJ; Fundam Appl Toxicol 7 (4): 690-7 (1986). A retrospective structure-activity relationship comparison was undertaken of several of the toxicological properties (acute and subchronic toxicity, teratogenicity, and biochemical mechanism studies) of a series of structurally similar aliphatic nitriles based on available published data.

Synonyms and Identifiers:

Synonyms:

CYANOETHANE
PEER REVIEWED

ETHER CYANATUS
PEER REVIEWED

ETHYL CYANIDE
PEER REVIEWED

HYDROCYANIC ETHER
PEER REVIEWED

PROPANENITRILE
PEER REVIEWED

PROPIONIC NITRILE
PEER REVIEWED

PROPIONONITRILE
PEER REVIEWED

PROPYLNITRILE
PEER REVIEWED

Shipping Name/ Number DOT/UN/NA/IMO:

UN 2404; **Propionitrile**

IMO 3.2; **Propionitrile**

Standard Transportation Number:

49 235 10; **Propionitrile**

EPA Hazardous Waste Number:

P101; An acute hazardous waste when a discarded commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate.

Administrative Information:

Hazardous Substances Databank Number: 117

Last Revision Date: 20021108

Last Review Date: Reviewed by SRP on 5/10/2001

Update History:

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Complete Update on 11/18/1999, 1 field added/edited/deleted.
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Complete Update on 07/20/1999, 5 fields added/edited/deleted.
Complete Update on 10/07/1998, 1 field added/edited/deleted.

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Complete Update on 10/17/1997, 1 field added/edited/deleted.
Complete Update on 05/08/1997, 1 field added/edited/deleted.
Complete Update on 03/27/1997, 2 fields added/edited/deleted.
Complete Update on 02/26/1997, 1 field added/edited/deleted.
Complete Update on 02/05/1997, 1 field added/edited/deleted.
Complete Update on 01/24/1997, 1 field added/edited/deleted.
Complete Update on 10/12/1996, 1 field added/edited/deleted.
Complete Update on 05/10/1996, 1 field added/edited/deleted.
Complete Update on 04/16/1996, 6 fields added/edited/deleted.
Complete Update on 01/18/1996, 1 field added/edited/deleted.
Complete Update on 04/20/1995, 1 field added/edited/deleted.
Complete Update on 04/20/1995, 1 field added/edited/deleted.
Complete Update on 12/19/1994, 1 field added/edited/deleted.
Complete Update on 04/05/1994, 40 fields added/edited/deleted.
Field Update on 03/21/1994, 1 field added/edited/deleted.
Field update on 12/11/1992, 1 field added/edited/deleted.
Field Update on 12/02/1992, 1 field added/edited/deleted.
Complete Update on 08/17/1992, 30 fields added/edited/deleted.
Complete Update on 11/06/1991, 43 fields added/edited/deleted.
Complete Update on 05/07/1991, 39 fields added/edited/deleted.
Complete Update on 10/22/1990, 5 fields added/edited/deleted.
Field Update on 05/14/1990, 1 field added/edited/deleted.
Field Update on 05/05/1989, 1 field added/edited/deleted.
Complete Update on 08/15/1988, 69 fields added/edited/deleted.
Complete Update on 02/15/1985

Record Length: 112939

Appendix B
Bis (2-ethylhexyl) Phthalate Discussion

Historical Background

Since 1987, phthalates, primarily bis(2-ethylhexyl) phthalate (BEHP), have been detected sporadically in groundwater samples at NASA/WSTF. Initially, phthalates were detected during semi-volatile analyses (EPA Method 8270) associated with Resource Conservation and Recovery Act (RCRA) Appendix IX sampling. The phthalate detections associated with these sampling events were inconsistent and frequently accompanied by data qualifiers indicating contamination of field and laboratory blanks. Table 1 provides the analytical results for EPA Method 8270 analyses.

In 1996, NASA initiated a landfill groundwater monitoring program which required the use of an EPA analytical method that was significantly more sensitive to phthalate compounds (EPA Method 525.2). These analyses, required by the New Mexico Solid Waste Regulations (20NMAC9.1), yielded consistent BEHP detects which indicated apparent contamination in the downgradient landfill monitoring wells. Subsequent sampling events conducted at the landfill continued to report significant BEHP concentrations. Although BEHP was detected regularly, analytical results remained inconsistent, making it difficult to determine the cause of the phthalate concentration. Table 1 provides the analytical results for EPA Method 525.2 analyses.

Phthalate Source Identification

A comprehensive investigation was initiated in late 1997 for wells downgradient of the landfill in an attempt to determine if a phthalate plume existed. Figure 1 provides a map of WSTF which shows the wells selected for this investigation and the applicable analytical results obtained by EPA Methods 525.2, 625 and 8270. These analytical results were evaluated by WSTF groundwater personnel, in conjunction with known historical operations in the vicinity, to determine if any potential releases could have resulted in phthalate contamination. A careful examination revealed no apparent sources or plumes. As indicated by Figure 1, BEHP concentrations appeared randomly located across the sampled area.

NASA personnel determined that actual phthalate contamination caused by releases to the environment was unlikely. As a result of this conclusion, WSTF groundwater personnel devised a deterministic approach to ascertain the source of the phthalate contamination in the groundwater samples. During the development of this strategy, phthalate sampling and analysis was continued at landfill monitoring wells in order to supplement existing data. NASA also expanded its sampling and analytical efforts to include numerous non-landfill monitoring wells. These supplemental samples were analyzed by EPA Method 8061. The results of these analyses are provided in Table 1.

TABLE 1
Analytical Results For Phthalate Analyses

Well Name	Event Date	Purge Device	Sampling Device	EPA Method	Analyte	Result	Units	Reporting Limit	QA Flag
100-A-182	3/3/99	Dedicated Bladder Pump	Dedicated Bladder Pump	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
100-A-182	3/3/99	Dedicated Bladder Pump	Dedicated Bladder Pump	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
300-A-120	3/4/99	Dedicated Bladder Pump	Dedicated Bladder Pump	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
300-A-120	3/4/99	Dedicated Bladder Pump	Dedicated Bladder Pump	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
300-D-153	5/8/96	Dedicated Bladder Pump	Dedicated Bladder Pump	525.2	Bis(2-ethylhexyl) phthalate	ND	ppb	2	
300-D-153	7/2/96	Dedicated Bladder Pump	Dedicated Bladder Pump	525.2	Bis(2-ethylhexyl) phthalate	ND	ppb	2	
300-D-153	8/29/96	Dedicated Bladder Pump	Dedicated Bladder Pump	525.2	Bis(2-ethylhexyl) phthalate	ND	ppb	2	
300-D-153	10/22/96	Dedicated Bladder Pump	Dedicated Bladder Pump	525.2	Bis(2-ethylhexyl) phthalate	ND	ppb	2	
300-D-153	12/3/96	Dedicated Bladder Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	RB
300-D-153	4/3/97	Dedicated Bladder Pump	Dedicated Bladder Pump	525.2	Bis(2-ethylhexyl) phthalate	ND	ppb	2	
300-D-153	9/8/97	Dedicated Bladder Pump	Dedicated Bladder Pump	525.2	Bis(2-ethylhexyl) phthalate	ND	ppb	3	
300-D-153	2/27/98	Dedicated Bladder Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	9.5	
300-D-153	12/8/98	Dedicated Bladder Pump	Dedicated Bladder Pump	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
300-D-153	12/8/98	Dedicated Bladder Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	
300-D-153	1/28/99	Dedicated Bladder Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	0.6	
400-C-118	3/2/99	Dedicated Bladder Pump	Dedicated Bladder Pump	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
BW-5-295	3/24/99	Dedicated Bladder Pump	Dedicated Bladder Pump	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
BW-5-295	3/24/99	Dedicated Bladder Pump	Dedicated Bladder Pump	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
NASA 10	12/16/96	Dedicated Bladder Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	9.4	
NASA 10	3/12/98	Dedicated Bladder Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	1.3	ppb	10	J
NASA 10	12/14/98	Dedicated Bladder Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	
NASA 4	3/3/99	Dedicated Bladder Pump	Dedicated Bladder Pump	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
NASA 5	10/29/97	Dedicated Bladder Pump	Dedicated Bladder Pump	525.2	Bis(2-ethylhexyl) phthalate	ND	ppb	3	
NASA 6	10/29/97	Dedicated Bladder Pump	Dedicated Bladder Pump	525.2	Bis(2-ethylhexyl) phthalate	ND	ppb	3	
NASA 7	12/11/96	Dedicated Bladder Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	24	ppb	10	
NASA 7	10/29/97	Dedicated Bladder Pump	Dedicated Bladder Pump	525.2	Bis(2-ethylhexyl) phthalate	ND	ppb	3	
NASA 7	3/4/98	Dedicated Bladder Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	9.4	
NASA 7	12/9/98	Dedicated Bladder Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	

TABLE 1 (Cont.)
Analytical Results For Phthalate Analyses

Well Name	Event Date	Purge Device	Sampling Device	EPA Method	Analyte	Result	Units	Reporting Limit	QA Flag
NASA 9	12/12/96	Dedicated Bladder Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	
NASA 9	3/16/98	Dedicated Bladder Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	9.4	
NASA 9	3/16/98	Dedicated Bladder Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	9.5	
NASA 9	12/10/98	Dedicated Bladder Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	
200-D-240	12/12/91	Ded. Bladder/Purge Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	
200-D-240	11/3/93	Ded. Bladder/Purge Pump	Dedicated Bladder Pump	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	
200-D-240	11/3/97	Ded. Bladder/Purge Pump	Dedicated Bladder Pump	525.2	Bis(2-ethylhexyl) phthalate	ND	ppb	3	
Supply well	12/21/98	Turbine Pump	Turbine Pump	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
Supply well	12/21/98	Turbine Pump	Turbine Pump	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
200-F-225	12/8/98	NA	In-situ Stainless Steel Bottles	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	
200-G-175	12/14/98	NA	In-situ Stainless Steel Bottles	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	
200-H-225	12/10/98	NA	In-situ Stainless Steel Bottles	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
200-H-225	12/10/98	NA	In-situ Stainless Steel Bottles	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	
300-E-138	11/3/98	NA	In-situ Stainless Steel Bottles	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	
300-E-138	3/10/99	NA	In-situ Stainless Steel Bottles	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
400-D-195	12/16/98	NA	In-situ Stainless Steel Bottles	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
400-D-195	12/16/98	NA	In-situ Stainless Steel Bottles	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	
600-E-280	11/5/98	NA	In-situ Stainless Steel Bottles	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	
600-E-280	3/12/99	NA	In-situ Stainless Steel Bottles	8061	Bis(2-ethylhexyl) phthalate	2.2	ppb	1	
600-E-280	3/12/99	NA	In-situ Stainless Steel Bottles	8061	Bis(2-ethylhexyl) phthalate	2.1	ppb	1	
BLM-30-585	3/16/99	NA	In-situ Stainless Steel Bottles	8061	Bis(2-ethylhexyl) phthalate	1.6	ppb	1	QD
BLM-30-585	3/16/99	NA	In-situ Stainless Steel Bottles	8061	Bis(2-ethylhexyl) phthalate	0.9	ppb	1	J QD
PL-5-495	1/8/99	NA	In-situ Stainless Steel Bottles	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
PL-6-1335	1/5/99	NA	In-situ Stainless Steel Bottles	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
PL-6-545	2/11/99	NA	In-situ Stainless Steel Bottles	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
PL-7-480	2/8/99	NA	In-situ Stainless Steel Bottles	8061	Bis(2-ethylhexyl) phthalate	1.1	ppb	1	
ST-5-485	1/26/99	NA	In-situ Stainless Steel Bottles	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
ST-6-535	2/5/99	NA	In-situ Stainless Steel Bottles	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	
300-B-166	3/2/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	28	ppb	1	

TABLE 1 (Cont.)
Analytical Results For Phthalate Analyses

Well Name	Event Date	Purge Device	Sampling Device	EPA Method	Analyte	Result	Units	Reporting Limit	QA Flag
300-B-166	3/2/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	20.5	ppb	1	
700-A-253	5/8/96	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	15	ppb	2	
700-A-253	7/2/96	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	33	ppb	2	*
700-A-253	8/29/96	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	37	ppb	2	*
700-A-253	10/22/96	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	32	ppb	2	
700-A-253	4/3/97	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	24	ppb	2	
700-A-253	9/9/97	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	10	ppb	10	
700-A-253	10/7/98	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8270	Bis(2-ethylhexyl) phthalate	8	ppb	10	J
700-A-253	1/28/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	MISC	Bis(2-ethylhexyl) phthalate	44	ppb	0.6	G
700-A-253	1/28/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	5.96	ppb	1	
700-B-510	9/9/97	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	6	ppb	3	
700-B-510	1/20/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	27	ppb	1	
700-D-186	4/25/90	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	625	Bis(2-ethylhexyl) phthalate	ND	ppb	10	
700-D-186	5/8/96	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	ND	ppb	2	
700-D-186	7/2/96	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	17	ppb	2	
700-D-186	8/29/96	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	9.6	ppb	2	
700-D-186	10/22/96	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	24	ppb	2	
700-D-186	4/3/97	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	33	ppb	2	
700-D-186	9/8/97	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	3.5	ppb	3	
700-D-186	10/7/98	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8270	Bis(2-ethylhexyl) phthalate	4.4	ppb	10	J
700-D-186	1/8/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	4.8	ppb	1	
700-D-186	1/8/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	4.1	ppb	1	
700-D-186	1/28/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	4.3	ppb	0.6	
700-E-458	2/4/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	29.5	ppb	1	
700-F-455	1/5/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	43	ppb	1	
BLM-10-517	1/27/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	44.7	ppb	1	
BLM-10-517	1/27/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	38.5	ppb	1	

TABLE 1 (Cont.)
Analytical Results For Phthalate Analyses

Well Name	Event Date	Purge Device	Sampling Device	EPA Method	Analyte	Result	Units	Reporting Limit	QA Flag
BLM-13-300	12/28/98	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	9.9	ppb	1	
BLM-14-327	1/21/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	30.6	ppb	1	
BLM-15-305	11/13/97	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	8.5	ppb	3	
BLM-15-305	3/5/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	46.2	ppb	1	
BLM-15-305	3/5/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	43.9	ppb	1	
BLM-17-493	6/7/89	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	625	Bis(2-ethylhexyl) phthalate	ND	ppb	10	FB
BLM-17-550	3/5/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	33.8	ppb	1	
BLM-17-550	3/5/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	17.1	ppb	1	
BLM-18-430	3/22/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	18.3	ppb	1	QD
BLM-18-430	3/22/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	2.5	ppb	1	QD
BLM-21-400	1/14/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	20	ppb	1	
BLM-24-565	3/22/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	86.1	ppb	1	QD
BLM-24-565	3/22/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	47.5	ppb	1	QD
BLM-25-455	11/17/97	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	4.3	ppb	3	
BLM-25-455	3/17/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	50.3	ppb	1	QD
BLM-25-455	3/17/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	35.5	ppb	1	QD
BLM-26-404	3/15/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	26	ppb	1	
BLM-26-404	3/15/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	23.1	ppb	1	
BLM-27-27	3/11/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	32	ppb	1	
BLM-27-27	3/11/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	15.1	ppb	1	
BLM-3-182	1/7/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	14	ppb	1	
BLM-6-488	2/9/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	58.7	ppb	1	
BLM-7-509	12/22/98	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	54.3	ppb	1	QD
BLM-7-509	12/22/98	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	29.2	ppb	1	QD
BLM-9-419	12/16/91	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	RB
BLM-9-419	12/16/91	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	
BLM-9-419	11/13/97	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	76	ppb	30	
BLM-9-419	3/3/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	36.2	ppb	1	
BLM-9-419	3/3/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	34.1	ppb	1	

TABLE 1 (Cont.)
Analytical Results For Phthalate Analyses

Well Name	Event Date	Purge Device	Sampling Device	EPA Method	Analyte	Result	Units	Reporting Limit	QA Flag
BW-1-268	3/19/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	38.2	ppb	1	
BW-1-268	3/19/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	37	ppb	1	
BW-6-355	2/8/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	83.8	ppb	1	
BW-6-355	2/8/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	42.3	ppb	1	QD
BW-6-355	2/8/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	20.6	ppb	1	QD
BW-7-211	6/7/89	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	625	Bis(2-ethylhexyl) phthalate	13	ppb	10	FB
BW-7-211	11/4/97	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	6.6	ppb	3	
JP-1-424	12/18/98	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	85	ppb	1	
JP-2-447	12/21/98	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	29.2	ppb	1	
PL-1-486	12/14/98	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	12.5	ppb	1	
PL-2-504	1/19/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	73	ppb	1	QD
PL-2-504	1/19/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	37	ppb	1	QD
PL-3-453	12/7/98	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	13.7	ppb	1	
PL-4-464	12/9/98	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	33.7	ppb	1	
ST-1-473	3/9/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	24.8	ppb	1	
ST-1-473	3/9/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	16.9	ppb	1	
ST-2-466	12/11/98	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	68.2	ppb	1	
ST-3-486	2/2/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	47.2	ppb	1	
ST-3-586	11/12/92	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	10	
ST-3-586	11/4/97	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	525.2	Bis(2-ethylhexyl) phthalate	ND	ppb	3	
ST-3-586	3/11/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	25.6	ppb	1	
ST-3-586	3/11/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	6.5	ppb	1	
ST-4-481	3/12/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	58.6	ppb	1	
ST-4-481	3/12/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	24.8	ppb	1	
WW-1-452	3/8/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	37.3	ppb	1	
WW-1-452	3/8/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	11.9	ppb	1	
200-D-109	2/16/99	Non-dedicated Bennett Pump	Dedicated Teflon® Bailer	8061	Bis(2-ethylhexyl) phthalate	0.62	ppb	1	J

* - Indicates that the result is an estimated value.
FB - Indicates that the analyte was detected in the field blank at or above the reporting limit.
G - Indicates that the result of the analyte is greater than the calibration limit.
J - Indicates that the result is an estimated value less than the reporting limit, but greater than or equal to the detection limit.
QD - Indicates that the precision for a field duplicate was outside standard limits.
NA - Not Applicable
RB - Indicates that the analyte was detected in the reagent blank at or above the reporting limit.

Groundwater personnel suspected that previous drilling activities may have introduced phthalates to the groundwater through the use of polymeric drilling fluids. All drilling fluids which were available to sampling personnel were sampled and analyzed using phthalate-specific EPA Method 8061. Although a number of the compounds analyzed contained quantifiable levels of several phthalates, the results of drilling fluid analysis wereconsidered of limited use because no connection could be made between the types and amounts of drilling fluids used and the drilling activities for each well at WSTF. Furthermore, not all wells that were known to be drilled using polymeric drilling mud showed positive results for phthalates.

While these analyses were being evaluated, additional analytical data from the supplemental sampling events became available. Upon examination and comparison with existing data, personnel observed a definite correlation between phthalate detections and the use of non-dedicated well purging equipment. It was noted that nearly all phthalate detections were obtained from wells that had been purged with non-dedicated equipment. Table 1 shows each well that was sampled for phthalates, the sampling system in use at the time of sampling, and the subsequent analytical results. These results indicate that phthalate detections are associated with wells that are purged with a non-dedicated reciprocating piston pump (Bennett pump). Based upon these results, a sampling plan was developed that would target all significant aspects of purging with the non-dedicated Bennett pumps.

Bennett Pump Sampling Plan

A Bennett pump is an air-driven reciprocating piston pump. This pump is lowered down a stainless steel conventional monitoring well to just below the static water level and operated with compressed nitrogen. This pump purges the required volume of water from the well prior to sample collection with dedicated Teflon® bailers. The pumphead is suspended in the well by a tubing bundle consisting of three polyethylene tubes. This tubing bundle is bound together by a wrapped layer of plastic adhesive tape, which stops approximately twenty feet above of the Bennett pumphead. Two brands of tape are currently used to secure the tubing bundle; an unknown brand of tape is used to wrap the tubing bundle at the Bennett factory, and Calpico™ tape at WSTF to replace the factory tape as it becomes necessary. Site-specific procedural documentation directs that this layer of tape not be allowed to come in contact with water in the well casing. Before a well is purged with the Bennett pump, the pump and tubing bundle is decontaminated using a steam cleaner. During sampling procedures, personnel wear Nytek gloves to prevent contamination of the samples.

All of the above components and procedures of the sampling system were considered when developing the phthalate sampling plan. Appropriate water samples were collected during each step of the sampling process. First, water was collected directly from the discharge of the steam cleaner to determine if phthalates are present in the tap water or in the steam cleaner. During decontamination procedures while the Bennett pump tubing bundle was being steam cleaned, water was collected as it passed over the tubing bundle. Purified deionized water was then placed in a steam cleaned Teflon® bailer and allowed to stand for five minutes to simulate groundwater sample collection. Samples were collected from the bailer in the same manner as in the field. In addition, Calpico™ tape, the Bennett factory tape, and Nytek gloves were placed in glass beakers of purified deionized water and allowed to stand. The tape resided in the water for

approximately two hours to simulate the possibility of a piece of tape being lost in a monitoring well during purging and sampling operations. The Nytek gloves were kept in the water for approximately 15 minutes to simulate a groundwater sample coming into contact with the gloved hands of sampling personnel. Samples of this water were then collected and shipped to the lab for analysis. Table 2 provides the analytical results for the samples taken during the Bennett pump decontamination, purging, and sampling process.

To supplement these individual samples, a system was constructed to simulate a Bennett pump sampling event. To accomplish this, a twenty-foot joint of stainless steel casing was capped and filled with WSTF groundwater obtained from the drinking water supply well. The Bennett pump and tubing were inserted into this joint of casing and allowed to reside for twenty-four hours, the longest amount of time required to purge any WSTF conventional monitoring well using the Bennett pump. Water samples were collected from the stainless steel casing at intervals of one, two, four, eight, and twenty-four hours. The analytical results of these samples are shown in Table 3.

The results of these tests indicated that the use of non-dedicated Bennett pumps to purge monitoring wells inadvertently introduced phthalate residue to the groundwater. The adhesives used on the tapes (both factory supplied and the Calpico™) contain phthalate based compounds in sufficient quantity to adversely affect the quality of groundwater samples.

TABLE 2
Sampling Equipment Phthalate Investigation 5/4/99

Steam Cleaner

Steam cleaner samples were collected directly from the steam cleaner nozzle after a full Bennett pump decontamination procedure. The steam cleaner burner was still ignited and water was hot at time of sample collection.

Sample #	Analysis	Analyte	Result	Units	Reporting Limit	Detection Limit	QA Flag
9905041332	8061A	Bis(2-ethylhexyl) phthalate	2.4	ppb	1.0	0.4	
9905041332	8061A	Diethyl phthalate	1.0	ppb	1.0	0.4	

Bennett Pump

Bennett pump samples were collected in glass beakers which were cleaned with Alconox, then triple rinsed. Beakers were placed below Bennett pump reel and allowed to fill as the Bennett pump and tubing reel were decontaminated with the steam cleaner.

Sample #	Analysis	Analyte	Result	Units	Reporting Limit	Detection Limit	QA Flag
9905041334	8061A	Bis(2-ethylhexyl) phthalate	5,220	ppb	20	0.4	

Teflon Bailer

Samples were collected from a triple rinsed Teflon bailer that was retrieved from JP-1-424 following installation of dedicated sampling equipment. Purified deionized water was poured directly from the 5-gallon jug into the bailer and allowed to stand for five minutes, then poured directly into the sample container.

Sample #	Analysis	Analyte	Result	Units	Reporting Limit	Detection Limit	QA Flag
9905041340	8061A	Bis(2-ethylhexyl) phthalate	ND	ppb	1.0	0.4	

Blank Samples

Blank samples were collected directly from the 5-gallon jug of purified deionized water.

Sample #	Analysis	Analyte	Result	Units	Reporting Limit	Detection Limit	QA Flag
9905041344	8061A	Bis(2-ethylhexyl) phthalate	ND	ppb	1.0	0.4	

TABLE 2 (Cont.)
Sampling Equipment Phthalate Investigation 5/4/99

Calpico™ Tape

Samples were collected after Calpico™ brand tape had been allowed to reside in 1000-mL glass beakers of purified deionized water for 1.5 to 2 hours. Samples were collected directly from the beakers.

Sample #	Analysis	Analyte	Result	Units	Reporting Limit	Detection Limit	QA Flag
9905041346	8061A	Bis(2-ethylhexyl) phthalate	70	ppb	1.0	0.4	
9905041346	8061A	Bis(4-methyl-2-pentyl) phthalate	3.3	ppb	1.0	0.4	

Tape used at Bennett Pump Factory

Samples were collected after an unknown brand of tape had been allowed to reside in 1000-mL glass beakers of purified deionized water for 1.5 to 2 hours. Samples were collected directly from the beakers

Sample #	Analysis	Analyte	Result	Units	Reporting Limit	Detection Limit	QA Flag
9905051145	8061A	Bis(2-ethylhexyl) phthalate	13	ppb	1.0	0.4	
9905051145	8061A	Diethyl phthalate	0.31	ppb	1.0	0.4	J

Nytek Gloves

Nytek gloves were placed in purified deionized water in clean glass beakers and allowed to stand for 15 minutes. Samples were collected directly from the beakers.

Sample #	Analysis	Analyte	Result	Units	Reporting Limit	Detection Limit	QA Flag
9905051001	8061A	Bis(2-ethylhexyl) phthalate	1.7	ppb	1.0	0.4	

J - Indicates that the result is an estimated value less than the reporting limit, but greater than or equal to the detection limit.

TABLE 3
Simulated Bennett Pump Sampling Event 5/26/99

A Bennett pump and tubing were inserted into a capped twenty foot section of stainless steel casing that was filled with WSTF groundwater obtained from the NASA drinking water supply well to simulate a groundwater sampling event. Water samples were collected directly from the casing at one, two, four, eight, and twenty-four hour intervals. Blank samples were collected directly from the polyethylene drum used to transport water to the sampling site.

Blank Sample

Sample #	Analysis	Analyte	Result	Units	Reporting Limit	Detection Limit	QA Flag
9905260849	8061A	Bis(2-ethylhexyl) phthalate	ND	ppb	1.0	0.4	

1 Hour Sample

Sample #	Analysis	Analyte	Result	Units	Reporting Limit	Detection Limit	QA Flag
9905260847	8061A	Bis(2-ethylhexyl) phthalate	13	ppb	1.0	0.4	
9905260847	8061A	Diethyl phthalate	0.31	ppb	1.0	0.4	J

2 Hour Sample

Sample #	Analysis	Analyte	Result	Units	Reporting Limit	Detection Limit	QA Flag
990526945	8061A	Bis(2-ethylhexyl) phthalate	7.2	ppb	1.0	0.4	

4 Hour Sample

Sample #	Analysis	Analyte	Result	Units	Reporting Limit	Detection Limit	QA Flag
9905261145	8061A	Bis(2-ethylhexyl) phthalate	57	ppb	1.0	0.4	
9905261145	8061A	Di-n-butyl phthalate	2.4	ppb	1.0	0.4	

8 Hour Sample

Sample #	Analysis	Analyte	Result	Units	Reporting Limit	Detection Limit	QA Flag
9905261503	8061A	Bis(2-ethylhexyl) phthalate	6.7	ppb	1.0	0.4	

24 Hour Sample

Sample #	Analysis	Analyte	Result	Units	Reporting Limit	Detection Limit	QA Flag
9905270730	8061A	Bis(2-ethylhexyl) phthalate	3.6	ppb	1.0	0.4	

J - Indicates that the result is an estimated value less than the reporting limit, but greater than or equal to the detection limit.

Landfill Well Sampling Equipment Comparison

Prior to development of the Bennett pump sampling plan, landfill wells 700-A-253 and 700-D-186 were purged and sampled using a Bennett pump and dedicated bailer. Phthalates were regularly detected in both of these wells. Because of the increased concern over phthalate concentrations at the landfill, these wells were equipped with dedicated bladder pump systems in early July 1999. All subsequent phthalate analyses at these wells have been non-detect. Table 4 provides a comparison of the analytical results from these wells using each type of sampling equipment. These results indicate that the use of dedicated bladder pump systems in these wells has eliminated the detection of phthalate compounds in the vicinity of the landfill.

Conclusion

The analytical results of the extended phthalate investigation indicate that previous phthalate detections in the majority of WSTF monitoring wells are the direct result of the use of non-dedicated purge pumps (Bennett pumps). Figure 1 demonstrates the lack of a definable phthalate plume, indicating a source other than actual environmental contamination for the phthalate detections. The results presented in Tables 2 and 3 suggest that phthalates are present in Calpico™ tape and are volatilized by the equipment decontamination procedure of steam cleaning. The phthalate residue is deposited on the Bennett pumphead and exposed polyethylene tubing during steam cleaning and subsequently transferred to the groundwater during well purging operations. This conclusion is further supported by the obvious elimination of phthalate concentrations in landfill wells 700-A-253 and 700-D-186 (shown in Table 4) following the installation of dedicated sampling equipment. In addition, phthalates have not been detected regularly in wells that are equipped with dedicated sampling equipment, such as Teflon® bladder pumps and Westbay multi-port systems.

TABLE 4
Comparison of Landfill Monitoring Well Results

Bennett Pump Landfill Well Results

Sampling events were conducted at the point-of-compliance wells in accordance with Solid Waste Bureau requirements using a Bennett pump for purging and a dedicated bailer to collect samples. The 1996 and 1997 events were conducted to establish background concentrations at the landfill. Subsequent events are required semi-annual detection and assessment monitoring.

Well ID	Sample Event	Analysis	Analyte	Result	Units	Reporting Limit	QA Flag
700-A-253	5/8/96	525.2	Bis(2-ethylhexyl) phthalate	15	ppb	2	
700-A-253	7/2/96	525.2	Bis(2-ethylhexyl) phthalate	33	ppb	2	*
700-A-253	8/29/96	525.2	Bis(2-ethylhexyl) phthalate	37	ppb	2	*
700-A-253	10/22/96	525.2	Bis(2-ethylhexyl) phthalate	32	ppb	2	
700-A-253	4/3/97	525.2	Bis(2-ethylhexyl) phthalate	24	ppb	2	
700-A-253	10/7/98	8270	Bis(2-ethylhexyl) phthalate	8.0	ppb	10	J
700-A-253	1/28/99	525.2	Bis(2-ethylhexyl) phthalate	44	ppb	0.6	G
700-D-186	5/8/96	525.2	Bis(2-ethylhexyl) phthalate	ND	ppb	2	
700-D-186	7/2/96	525.2	Bis(2-ethylhexyl) phthalate	17	ppb	2	
700-D-186	8/29/96	525.2	Bis(2-ethylhexyl) phthalate	9.6	ppb	2	
700-D-186	10/22/96	525.2	Bis(2-ethylhexyl) phthalate	24	ppb	2	
700-D-186	4/3/97	525.2	Bis(2-ethylhexyl) phthalate	33	ppb	2	
700-D-186	10/7/98	8270	Bis(2-ethylhexyl) phthalate	4.4	ppb	10	J
700-D-186	1/28/99	525.2	Bis(2-ethylhexyl) phthalate	4.3	ppb	0.6	

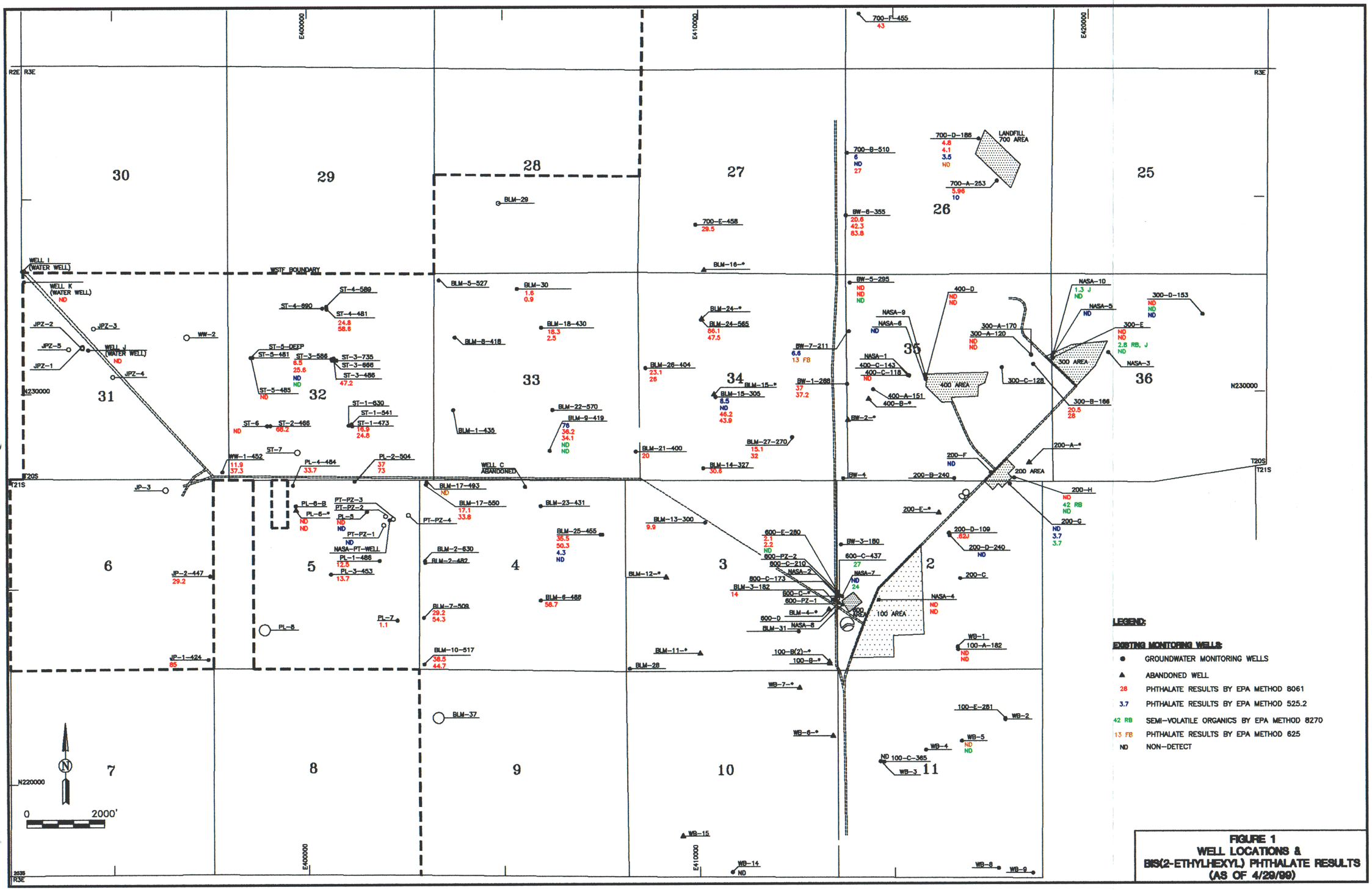
Bladder Pump Landfill Well Results

These sampling events were conducted at the point-of-compliance wells at the landfill after a dedicated bladder pump was installed for sampling.

Well ID	Sample Event	Analysis	Analyte	Result	Units	Reporting Limit	Detection Limit	QA Flag
700-A-253	7/20/99	8061	Bis(2-ethylhexyl) phthalate	ND	ppb	1	0.441	
700-A-253	7/21/99	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	20	2.9	
700-A-253	1/10/00	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	20	2.9	
700-D-186	7/21/99	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	20	2.9	
700-D-186	1/10/00	8270	Bis(2-ethylhexyl) phthalate	ND	ppb	20	2.9	

Corrective Actions/Recommendations

All landfill monitoring wells have been equipped with dedicated bladder pump systems to alleviate future cross-contamination during sampling operations. These systems employ dedicated Teflon® bladder pumps for purging and sample collection. These types of systems have been successfully used in numerous conventional wells that were shown to have corrosion problems at WSTF. They have proven to be very reliable and provide analytical results that are similar the historic results obtained by the Bennett pump/bailer systems previously used in these wells. Additionally, NASA is preparing a modification package for the NMED Hazardous and Radioactive Materials Bureau (HRMB) which will propose dedicated sampling systems (primarily low-flow systems) for all wells that are currently sampled with Bennett pump/bailer systems. By eliminating the use of non-dedicated purging and sampling equipment in WSTF monitoring wells, it is believed that false positive phthalate detections can be minimized significantly. This minimization can be accomplished with dedicated equipment while maintaining the overall high quality of analytical data obtained from these monitoring wells.



LEGEND:

EXISTING MONITORING WELLS:

- ● GROUNDWATER MONITORING WELLS
- ▲ ABANDONED WELL
- 28 PHTHALATE RESULTS BY EPA METHOD 8061
- 3.7 PHTHALATE RESULTS BY EPA METHOD 525.2
- 42 RB SEMI-VOLATILE ORGANICS BY EPA METHOD 8270
- 13 FB PHTHALATE RESULTS BY EPA METHOD 625
- ND NON-DETECT

FIGURE 1
WELL LOCATIONS &
BIS(2-ETHYLHEXYL) PHTHALATE RESULTS
(AS OF 4/29/99)

Appendix C
Bromacil toxicity evaluation

BACKGROUND AND PURPOSE

This memo responds to the request for a toxicity assessment of bromacil. Bromacil has been detected at levels ranging from 0.4 to 51.2 ppb in 19 groundwater monitoring wells at WSTF since the fall of 1997. Depth to groundwater in these wells ranges from approximately 128' to 471.75' below ground surface. Table 1 lists the concentrations of bromacil found in WSTF wells to date.

Bromacil is recommended and predominantly used for non-selective weed and brush control on non-crop lands and is especially effective against perennial grasses. It is primarily absorbed through the roots and apparently acts to inhibit photosynthesis in plants. Bromacil belongs to a group of broad-spectrum compounds called substituted uracils. It is commercially available in granular, liquid, water soluble liquid, granules, soluble concentrate and wettable powder formulations. It is preferably sprayed or spread dry on the soil surface just prior to or during a period of active weed growth.

BROMACIL USE AT WSTF

Historical documents were consulted to discern when and how bromacil was used at WSTF. Documentation is sporadic and although it can be determined when bromacil was first considered for use at WSTF, there is no documentation reflecting the actual period of use at the site. The earliest reference to bromacil was a letter dated 09/18/69, from the NASA-WSTF Technical Manager to the Manager of the Zia Company in which Hyvar X was described as an "approved weed killer". A Department of Agriculture representative was consulted and provided specific guidelines for use of Hyvar X (active ingredient, bromacil) at WSTF. These guidelines stated that Hyvar X would not be used where it could possibly contaminate the WSTF water supply or distribution system. It could not be used adjacent (10 feet from water's edge) to sewage lagoons or holding ponds that contain algae growth. The guidelines also stated that Hyvar X would not be discharged into drains nor sewage system during mixing of chemicals or rinsing of equipment after work was completed. Empty containers were to be buried in the dump area to prevent direct contact with wildlife.

A second letter, dated 09/30/69, to the Technical Manager of the Zia Company from the Chief, Maintenance and Operations Division compared the cost of herbicide application to hand cutting and removal of weeds or cutting and burning by machine. At that time, recommendations were made to apply Hyvar X around buildings in the 100 Area, warehousing areas, along chain link fences, all transformer stations, propellant storage tanks, and weed problem areas at the test sites. Spot use of the chemical was required at cattle guards, sign posts, and marker posts where complete eradication of weeds was desired. The use of herbicide chemicals was to be further evaluated. Potentially, Hyvar X was used on an annual basis following this letter of recommended use. An undated correspondence on a 1974 Federal Working Group on Pest Control Program Report form outlines the use of Hivar-X [sic] at WSTF (see the 1977, 1981 and 1982 guidelines below) and is attached to a note justifying the use of weed killer during the rainy season.

Also listed are materials on hand and materials needed which include 12 lbs. of Hivar-X [sic] and 80 lbs. of Hivar-X [sic] respectively.

Following this correspondence, there is no record of bromacil use at WSTF until 1977. Pest Control Program Report Forms, numbered WSTF-1-77, WSTF-2-77, WSTF-3-77 (all dated 02/15/77); WSTF-1-81 and WSTF-2-81 (dated 02/09/81) and WSTF-1-82 (dated 04/12/82) documented the procedures for use of "Hyvar X Bromacil" for post-emergent control of annual and perennial weeds and grasses at WSTF. Each set of forms was compiled in response to a request by the NASA Occupational Health Office for documentation of the Pest Control Program for that calendar year. Each form called for one application per year of an 80 percent solution (mixed at 8 pounds of water-dispersible powder per 260 gallons of water). Rate of application was 8 pounds per acre, which falls within manufacturer's specifications for control of perennial weeds, grasses and woody species. Application was to be made with an hydraulic sprayer during the months of July-August (rainy season).

Forms WSTF-1-77 and WSTF-1-81 documented the intended use around 25 and 15 buildings, respectively, for a total area of 8 acres. Forms WSTF-2-77, WSTF-3-77, WSTF-1-82 and WSTF-2-81 called for application (15 ft. deep) along the road shoulders (including the access road) for a total area of 38 acres. There is no record of bromacil use at the site after 1982.

It is unclear when the use of "Hyvar X Bromacil" actually ceased at WSTF. An historical document, dated 01/27/92, lists all herbicides and pesticides utilized at WSTF at that time. "Roundup" is the only herbicide listed. According to Tim Dobson, an engineer in the Maintenance, Operations and Construction Division at WSTF, no recorded use of this herbicide has occurred on site since at least 1990. Harold Harrison of the AlliedSignal Environmental Department stated that bromacil was no longer being used when he arrived on site in the summer of 1987. Therefore, the approximate period of bromacil use at WSTF was between 1969 and sometime before mid-1987. Copies of all historical correspondence are attached.

ENVIRONMENTAL FATE OF BROMACIL

Field dissipation studies have shown that phytotoxic residues of bromacil have persisted in both sand and clay soils. It has a half-life of about 60 days (or up to 8 months in certain conditions). It binds or adsorbs only lightly to soil particles and is slightly soluble in water. Soil persistence correlates to organic matter content, cation exchange capacity, total nitrogen and soluble salt concentrations. Bromacil leaches readily through the soil and can contaminate groundwater. The amount of leaching depends upon the amount of rainfall and soil type with the greatest potential for leaching in sandy soils.

Microbial degradation also contributes to the disappearance of bromacil from most treated soils. Tests show that at increased temperatures and long exposures to sunlight, there is very little loss of the herbicide from dry soil. It does not readily volatilize, nor does it photodecompose.

Application of bromacil during the rainy-season months of July-August would have aided in leaching the chemical into the soil at WSTF. These factors may well contribute to fact that following the approximately 17 years since recorded use of this herbicide on site, bromacil was detected in WSTF ground water.

IDENTIFICATION AND INCOMPATABILITY

Chemical formula for bromacil is $C_9H_{13}BrN_2O_2$. The CAS Number is 314-40-9. Chemical Name and synonyms include 2,4(1H,3H)-Pyrimidinedione, 5-Bromo-3-sec-butyl-6-methyluracil and 5-Bromo-6-Methyl-3-(1-Methylpropyl) uracil. Trade names include Hyvar XL, Hyvar X, Borea, Bromax 4G, Bromax 4L, Borocil, Rout, Cynogan, Uragan, Isocil, Urox B, Urox HX, Krovar, Herbicide 976 and others.

Bromacil is an odorless, colorless to white crystalline solid resembling sand. Physical properties are listed below.

Molecular Weight: 261.11

Specific Gravity: 1.55

Water Solubility: 815 mg/L @ 25 ° C

pH: 8.5-9.5

Melting Point: 157.5 °-160 ° C

Vapor Pressure: 0.033 mPa @ 25 ° C

Henry's Law Constant: 5.07E -11 atm$\times$m^3/mole

Bromacil is incompatible with and decomposes slowly in strong acids such as hydrochloric, sulfuric and nitric acids. Bromacil is also incompatible with oxidizing agents such as perchlorates, peroxides, permanganates, chlorates, nitrates, chlorine, bromine and fluorine. It should be stored in tightly closed containers in a cool, well-ventilated area away from heat, sparks and open flames. It is stable at normal temperatures and storage conditions.

REGULATORY STATUS

The U.S. Environmental Protection Agency has classified bromacil as a General Use Herbicide. Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR part 372 requires disclosure of bromacil as a toxic chemical. It is considered to be practically nontoxic in dry form (toxicity class IV) and moderately toxic (toxicity class III) in liquid form. Dry formulations containing bromacil must bear the signal word “CAUTION” and liquid formulations must bear the signal word “WARNING”.

EXPOSURE LIMITS

The EPA has established a Lifetime Health Advisory (LHA) level of 90 µ/L for bromacil in drinking water. In other words, the EPA believes that water containing bromacil at or below this level is acceptable for drinking every day over the course of one's lifetime, and does not pose any health concerns.

Bromacil is not listed in the Integrated Risk Information System (IRIS), the EPA database with RfDs, slope factors and up-to-date regulatory information for numerous chemicals. Nor is it listed in the Risk Based Concentration (RBC) tables or the Health Effects Assessment Summary Tables (HEAST).

Bromacil is cited by the American Conference of Governmental Industrial Hygienists (ACGIH). ACGIH recommends a Threshold Limit Value (TLV) of 1 ppm or 10 mg/m^3 for an 8-hour workday. ACGIH also recommends a Short Term Exposure Limit (STEL) of 2 ppm. The National Institute for Occupational Safety and Health (NIOSH) tests equipment, conducts studies of workplace hazards and proposes standards to the Occupational Safety and Health Administration (OSHA). NIOSH has recommended a Time Weighted Average (TWA) of 1 ppm or 10 mg/m^3 averaged over a 10-hour workday. The U. S. Environmental Protection Agency Office of Drinking Water established an Acceptable Daily Intake (ADI) of 130 µg/kg/day with NOAEL of 12.5 mg/kg/day and 100-fold uncertainty factor (chosen in accordance with EPA guidelines for use with a NOAEL from an animal study). OSHA, which adopts and enforces health and safety standards, has not established a permissible exposure limit (PEL) for bromacil. The New Jersey Department of Environmental Protection has cited bromacil on its Hazardous Substance List.

TOXICITY

Acute Toxicity

Liquid formulations of Bromacil are moderately toxic and dry formulations are relatively non-toxic. Hyvar XL formulation can be harmful or fatal if swallowed. Industrial and agricultural workers are exposed to the wettable powders and aqueous emulsions of bromacil through two primary routes of exposure: inhalation of dusts and sprays, and skin contact with dusts, emulsions and sprays. The herbicide is irritating to the skin, eyes and respiratory tract and can cause coughing or wheezing.

Chronic Toxicity

Chronic consumption of bromacil at high levels well above the established EPA Lifetime Health Advisory level of 90 µg/L per day has been shown to cause damage to the testes, liver and thyroid of laboratory animals. Health effects can occur some time after exposure and can last for months or years.

Although very high inhalation doses result in developmental abnormalities of the musculoskeletal system in embryos or fetuses, no evidence of birth defects in rat offspring followed ingestion of high-doses. Bromacil has not been found to be mutagenic. Testing has not shown bromacil to affect reproduction.

Carcinogenic Effects

Bromacil has not been determined to cause cancer, however, it is considered by the EPA to be a possible human carcinogen and has been classified as a Group C substance. There is some limited evidence that bromacil causes cell mutations resulting in cancer in animals receiving high doses of the chemical over the course of their lifetime. However, there is no human data to corroborate this evidence.

Animal Data

Studies have shown that uracils are absorbed into the gut and excreted primarily in the urine. Small amounts of bromacil were detected in the milk of lactating cows given 5 mg/kg in their food while no trace was found in the urine or feces of those cows.

Oral LD50: 5200 mg/kg (rats) 3040 mg/kg (mice). It is slightly toxic by ingestion.

Skin Absorption LD50: >5000 mg/kg (rabbits). Bromacil is slightly toxic by contact.

Inhalation 4 hr LC50: > 4.8 mg/L (rats). No mortalities occurred at this concentration. Bromacil is considered slightly toxic by inhalation.

CLEAN-UP AND DISPOSAL METHODS

In preliminary tests, photo-oxidation rendered uracil compounds that had been added to industrial waste effluents, non-phytotoxic.

Bromacil should be incinerated in a unit operating at 850 ° C equipped with off-gas scrubbing equipment.

CONCLUSIONS

Since October of 1997, bromacil has been detected in concentrations ranging from 0.4 to 51.2 ppb in groundwater samples from 19 monitoring wells at WSTF. The occurrence of the herbicide is predominantly in wells adjacent to roads or buildings where, according to historical documents, “Hyvar X Bromacil” was applied. The highest concentrations were detected at monitoring well, NASA 4, which is located in the 100 Area, just east of Apollo Blvd. Figure 1 is a map of bromacil results in WSTF wells.

Historical documents indicate that Hyvar X Bromacil was potentially used at WSTF once annually from late 1969 through at least 1982. WSTF employees recall that bromacil was not in use at the site by mid-1987 and certainly since 1990. A 1992 document lists “Roundup” as the only herbicide used at WSTF at that time. Since the use of bromacil

ceased at WSTF, the herbicide has leached through the soil to contaminate the groundwater at depths between approximately 125’ (in the 100 Area) and 488’ (in BLM-6-488).

Using the EPA established Lifetime Health Advisory (LHA) level of 90 µg/L for bromacil in drinking water; the concentrations found at WSTF do not pose a considerable risk to human health.

REFERENCES

Du Pont Agricultural Products. 1990. Material Safety Data Sheet for Bromacil Technical. Du Pont, Registration and Regulatory Affairs, Wilmington, DE.

EXTOXNET. 1993. Extension Toxicology Network. Cooperative Extension Offices of Cornell University, Michigan State University, Oregon State University, and University of California at Davis.

New Jersey Department of Health and Senior Services Hazardous Substance Fact Sheet. 1998. New Jersey Department of Health and Senior Services, Occupational Disease and Injury Services, Trenton, NJ.

National Institute for Occupational Safety and Health (NIOSH). 1994. Registry of toxic effects of chemical substances (RTECS). Cincinnati, OH: NIOSH

NIOSH Pocket Guide to Chemical Hazards. 1997. U.S. Department of Health and Human Services, Public Health Service Centers for Disease Control and Prevention.

TOXNET. 1994. National Library of Medicine's Toxicology Data Network. Hazardous Substances Data Bank (HSDB). Public Health Service. National Institute of Health, U.S. Department of Health and Human Services. Bethesda, MD: NLM.

U. S. Environmental Protection Agency. 1988. Bromacil Health Advisory. Office of Drinking Water.

U. S. Environmental Protection Agency. 1989. Health Advisory Summary: Bromacil. U.S. EPA, Washington, DC.

Appendix D
HSDB and IRIS toxicity information for COCs

ACRYLONITRILE

CASRN: 107-13-1

For other data, click on the Table of Contents

Human Health Effects:

Evidence for Carcinogenicity:

CLASSIFICATION: B1; probable human carcinogen. BASIS FOR CLASSIFICATION: The observation of a statistically statistically significant increase in the incidence of lung cancer in exposed workers and observation of tumors, generally astrocytomas in the brain, in studies in two rat strains exposed by various routes (drinking water, gavage, and inhalation) forms the basis for this classification.

[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Acrylonitrile (107-13-1) from the National Library of Medicine's TOXNET System,March 28, 1994]**PEER REVIEWED**

A3. Confirmed animal carcinogen with unknown relevance to humans.
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.13]**QC REVIEWED**

Evaluation: There is inadequate evidence in humans for the carcinogenicity of **acrylonitrile**. There is sufficient evidence in experimental animals for the carcinogenicity of **acrylonitrile**. Overall evaluation: **Acrylonitrile** is possibly carcinogenic to humans (Group 2B).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V71 ____ (1999)]**QC REVIEWED**

Human Toxicity Excerpts:

SEVERAL CASES OF MILD JAUNDICE ACCOMPANIED BY MILD ANEMIA & LEUKOCYTOSIS HAVE BEEN REPORTED.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 61]**PEER REVIEWED**

WHEN POISONING CASES DO OCCUR, SYMPTOMS DERIVE FROM TISSUE ANOXIA & ARE IN ORDER OF ONSET: LIMB WEAKNESS, DYSPNEA, BURNING SENSATION IN THROAT, DIZZINESS, & IMPAIRED JUDGEMENT, CYANOSIS & NAUSEA, COLLAPSE, IRREGULAR BREATHING, CONVULSIONS & DEATH. IN LATTER STAGES COLLAPSE, IRREGULAR BREATHING OR CONVULSIONS & CARDIAC ARREST MAY OCCUR WITHOUT WARNING. SOME PATIENTS APPEAR HYSTERICAL OR MAY EVEN BE VIOLENT.
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 55]**PEER REVIEWED**

EXAMINATION OF 18 WORKERS WHO HAD BEEN EXPOSED TO **ACRYLONITRILE** FOR AVERAGE OF 15.3 YR & 18 WORKERS WHO HAD NOT BEEN EXPOSED TO **ACRYLONITRILE** SHOWED NO DIFFERENCE IN INCIDENCE OF CHROMOSOME ABERRATIONS.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V19 85 (1979)]**PEER REVIEWED**

IN AN ANALYSIS OF MORTALITY AMONG 327 EMPLOYEES OF RUBBER CHEMICAL

PLANT WHO HAD POTENTIAL EXPOSURE TO **ACRYLONITRILE**, 9 DEATHS FROM LUNG CANCER WERE FOUND IN COMPARISON TO 5.9 EXPECTED BASED ON MORTALITY RATES FOR USA WHITE MALES & 4.7 EXPECTED BASED ON MORTALITY RATES FOR OTHER RUBBER WORKERS FROM THE SAME CITY. THE EXCESS WAS GREATER AMONG MEN WHO WORKED 5 THROUGH 14 YR & WHO DIED 15 OR MORE YR AFTER STARTING WORK IN THE PLANT (4 DEATHS OBSERVED, 0.8 EXPECTED).
[DELZELL E, MONSON RR; J OCCUP MED 24 (10): 767-9 (1982)]**PEER REVIEWED**

Four cases of toxic epidermal necrosis developed 11-21 days after patients were exposed to a fumigant containing 2:1 carbon tetrachloride and **acrylonitrile**. Blisters of the skin and mucous membranes were followed 3-4 weeks later by death from septic shock and gastrointestinal hemorrhage in 3 patients. The fourth, a 10 yr old male, survived with topical and parenteral corticosteroid application.
[Radimer GF et al; Arch Dermatol 110: 103 (1974)]**PEER REVIEWED**

576 Japanese workers exposed to 5-20 ppm over 10 yr showed headache, fatigue, nausea, and weakness with symptoms of anemia, jaundice, conjunctivitis, and abnormal whole blood and serum specific gravity, cholinesterase, urobilinogen, bilirubin, urinary protein, and sugar values, indicative of liver injury and a general toxic effect.
[USEPA; Ambient Water Quality Criteria Doc: Acrylonitrile (Draft) p.C-39 (1980)]**PEER REVIEWED**

Smokers may have incr thiocyanate in blood and urine confusing the possible incr of thiocyanate levels due to **acrylonitrile** exposure.
[USEPA; Ambient Water Quality Criteria Doc: Acrylonitrile (Draft) p.C-102 (1980)]**PEER REVIEWED**

... An occupational epidemiologic study that involved workers exposed to **acrylonitrile** at a DuPont textile fibers plant in Camden, SC was conducted. ... The study cohort was 1,345 male employees "identified as having had potential exposure to **acrylonitrile** at one time between start-up in 1950 and 1966". The cut-off -up through the end of 1976. ... The severity of exposure levels were designated as high, medium, and DuPont representatives agreed that 20 ppm, 10 ppm, and 5 ppm might be used to action of high, medium, and low exposure levels. ... A trend toward increased risks was seen not only with increased follow-up time but also with severity of exposure. In wage roll workers with at least moderate exposure and probable latent period of at least 15 yr, the observed and numbers of cancer cases were 13 and 5.5, respectively. Furthermore, half of this excess cancer was respiratory cancer, 5 /observed/ versus 1.4 /expected/ ($p< 0.05$).
[USEPA; Health Assessment Document: Acrylonitrile p.13-118 (1983) EPA 600/8-82-007F]**PEER REVIEWED**

A cohort mortality study of 1,469 workers from 12 factories located in the Federal Republic of Germany was conducted. ... These 12 factories are part of the BASF Company. ... Not only did an excessive significant risk remain with respect to lung cancer (9 observed versus 4.37 expected based on Federal Republic of Germany rates, $p< 0.05$), but also a significant excess risk of cancer of the lymphatic system was seen (4 observed versus 1.38 expected, $p< 0.05$). These results are questionable. The members of this cohort were apparently exposed to a number of different carcinogens ie, vinyl chloride, distillation residues containing polycyclic hydrocarbons, cadmium, B-napthylamine, dimethylsulfate, and epichlorohydrin. ... /There was an/ incomplete follow-up on foreign workers. Although, there are many limitations to this study, it is possible that exposure to **acrylonitrile** may indeed be related to an excessive risk of lung cancer and cancer of the lymph system.
[USEPA; Health Assessment Document: Acrylonitrile p.13-124 (1983) EPA 600/8-82-007F]**PEER REVIEWED**

A cohort mortality study of 327 white male employees of a rubber manufacturing plant in Akron, Ohio

was conducted ... . The levels of **acrylonitrile** that these workers were exposed to while on the job were not reported. ... The risk of death due to cancer was somewhat elevated, with 22 observed versus 17.9 expected. Most of this excess was due to lung cancer deaths which were nonsignificantly higher, with 9 observed versus 5.9 expected. Only workers employed for 5 to 14 yr and followed for at least 15 yr, had a significantly elevated risk of lung cancer (4 observed versus 0.8 expected p< 0.01). However, if workers who were employed for more than 14 yr and followed for at least 15 yr were added to the latter group, ... the risk of lung cancer was actually reduced but still significant (4 observed versus 1.4 expected, P< 0.05). The excessive risk of lung cancer in this group may not be entirely due to exposure to **acrylonitrile**, but may be partially reflective of exposures to other substances within the same environment.
[USEPA; Health Assessment Document: Acrylonitrile p.13-122 (1983) EPA 600/8-82-007F]**PEER REVIEWED**

A cohort mortality study of 934 men who worked on the polymerization of **acrylonitrile** and spinning of acrylic fiber at six different factories was conducted. ... Two of the six factories were located in Scotland and Northern Ireland; the remainder were located in England and Wales. ... Deaths from cancer of the stomach were statistically significantly elevated over all age groups (5 observed versus 1.9 expected p< 0.05) with deaths to persons in the 55-64 age group contributing the largest portion (3 observed versus 0.7 expected, p< 0.05). On the other hand, a statistically significant elevated risk of cancer of the lung, trachea, and bronchus appeared only in the age group 15-44 (3 observed versus 0.7 expected, p< 0.05) but not in any other age group.
[USEPA; Health Assessment Document: Acrylonitrile p.13-126 (1983) EPA 600/8-82-007F]**PEER REVIEWED**

SYMPTOMATOLOGY: 1. Massive doses may produce, without warning, sudden loss of consciousness & prompt death from respiratory arrest. With smaller but still lethal doses, the illness may be prolonged for 1 or more hours. 2. Upon ingestion, a bitter, acrid, burning taste is sometimes noted, followed by a feeling of constriction or numbness in the throat. Salivation, nausea & vomiting are not unusual ... . 3. Anxiety, confusion, vertigo, giddiness, & often a sensation of stiffness in the lower jaw. 4. Hyperpnea & dyspnea. Respiration become very rapid & then slow & irregular. Inspiration is characteristically short while expiration is greatly prolonged. 5. The odor of bitter almonds may be noted on the breath or vomitus ... . 6. In the early phases of poisoning, an incr in vasoconstrictor tone causes a rise in blood pressure & reflex slowing of the heart rate. Thereafter, the pulse becomes rapid, weak, & sometimes irregular ... . A bright pink coloration of the skin due to high concn of oxyhemoglobin in the venous return may be confused with that of carbon monoxide poisoning. 7. Unconsciousness, followed promptly by violent convulsions, epileptiform or tonic, sometimes localized but usually generalized. Opisthotonos & trismus may develop. Involuntary micturition & defecation occur. 8. Paralysis follows the convulsive stage. The skin is covered with sweat. The eyeballs protrude, & the pupils are dilated & unreactive. The mouth is covered with foam, which is sometimes bloodstained ... . The skin color may be brick red. Cyanosis is not prominent in spite of weak & irregular gasping. In the unconscious patient, bradycardia & the absence of cyanosis may be key diagnostic signs. 9. Death from respiratory arrest. As long as the heart beat continues, prompt & vigorous treatment offers some promise of survival. /Cyanide/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-126]**PEER REVIEWED**

It has long been known to possess a high degree of toxicity & to possess many of the characteristics of poisoning by cyanide ion. ... Level of cyanide ion in blood appears to be correlated with the degree of poisoning ... .
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 3137]**PEER REVIEWED**

A study population composed of 2,671 men who had worked at either of 2 facilities of the American Cyanamid Company was studied for mortality experiences resulting from exposure to **acrylonitrile**. The employment period considered ranged from 1951 for the facility in Fortier, LA & 1957 for the Santa Rose, FL facility & extended through December 31, 1979. Social Security Administration records & the National Death Index were used to determine the vital status of the cohort as of 1983. There were 237 deaths by the end of the study, & 61 men were lost to follow up. Death certificates were used to determine the cause of death; death certificates were not found for 15 men. Industrial hygiene monitoring was begun in 1977 but this was before any major operational changes were made & so the conditions prevailing in 1977 were taken as representative of the conditions back to the beginning of each facility. No statistically significant excess of all cause or cause specific mortality was noted among these workers. No trend was found for respiratory cancer mortality in relation to **acrylonitrile** exposure. Men who had been exposed to high levels of **acrylonitrile** had respiratory cancer rates similar to men who had not been exposed in the workplace to this chemical & similar to the rate in the general US male population. This study does not support the contention that **acrylonitrile** is a carcinogen for humans.
[Collins JJ et al; J of Occup Med 31 (4): 368-71 (1989)]**PEER REVIEWED**

The ability of **acrylonitrile** to induce cytotoxicity, sister chromatid exchanges and DNA single strand breaks was studied in cultured human bronchial epithelial cells. The toxic effect as determined by cloning efficiency was observed at a dose of 600 ug/ml but not at doses of both 150 and 300 ug/ml. The frequency of sister chromatid exchange in untreated cells was 3.7 + or - 1.3 per cell. In contrast, cells treated with **acrylonitrile** at 150 and 300 ug/ml exhibited 6.6 + or - 1.3 and 10.7 + or - 1.7 sister chromatid exchanges per metaphase, respectively. DNA single strand breaks were induced by **acrylonitrile** at dose levels of 200 and 500 ug/ml. The genotoxic effects on human bronchial epithelial cells that were directly exposed to **acrylonitrile** are of interest in relation to evidence for the higher lung cancer incidence of **acrylonitrile** workers in epidemiological studies.
[Chang CM et al; Mutat Res 241 (4): 355-60 (1990)]**PEER REVIEWED**

This study was to determine whether exposure to dimethylformamide & **acrylonitrile** separately or in combination, was assoc with incr cancer incidence. Workers exposed to dimethylformamide &/or **acrylonitrile** were observed from 1956 through 1984 for cancer incidence. The workers exposed to dimethylformamide but not **acrylonitrile** showed significant excesses in incidence for buccal cavity & pharynx cancer & malignant melanoma. A significant excess of prostate cancer incidence was observed among workers exposed to dimethylformamide & **acrylonitrile**. No dose-response relationships were observed between dimethylformamide or **acrylonitrile** exposure & cancer incidence. The significant excesses in cancer incidence among employees exposed to dimethylformamide &/or **acrylonitrile** could be due to statistical chance or other factors, such as tobacco & alcohol consumption.
[Chen JL et al; J Occup Med 30 (10): 813-8 (1988)]**PEER REVIEWED**

Prolonged skin contact with liquid **acrylonitrile** can result in systemic toxicity & the formation of large dermal vesicles after a latent period of several hours. The affected skin area may resemble a second degree, thermal burn.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.31]**PEER REVIEWED**

Acrylonitrile closely resembles hydrocyanic acid in its toxic action. by inhibiting the respiratory enzymes of tissues, it renders the tissue cells incapable of oxygen absorption. Poisoning is acute; there is little evidence of cumulative action on repeated exposure. Exposure to low concn is followed by flushing of the face & incr salivation; further exposure results in irritation of the eyes & nose, photophobia, deepened respiration. If exposure continues, shallow respiration, nausea, vomiting, weakness, an oppressive feeling in the chest, & occasionally headache & diarrhea are other complaints.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes

1-3. New York, NY: Van Nostrand Reinhold, 1996. 61]**PEER REVIEWED**

In humans, breathing **acrylonitrile** at a concn of 16 /ppm/ causes headaches, nausea, & disorientation. This concn is close to that at which **acrylonitrile** can be smelled in air (about 21 ppm). Breathing **acrylonitrile** in air for long periods of time & at high concn can cause death. The actual concn of **acrylonitrile** & breathing times which cause death have not been measured. ... **Acrylonitrile** can be smelled at a concn of 19 ppm when dissolved in water.
[DHHS/ATSDR; Toxicological Profile for Acrylonitrile p.3 TP-90/02 (1990)]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

ACRYLONITRILE SPILLED ON HUMAN SKIN RESULTS IN ERYTHEMA & BLISTERS.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-215]**PEER REVIEWED**

Prolonged skin contact with liquid **acrylonitrile** can result in systemic toxicity & the formation of large dermal vesicles after a latent period of several hours. The affected skin area may resemble a second degree, thermal burn.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.31]**PEER REVIEWED**

Acrylonitrile vapor is ... a potent eye, mucous membrane, and skin irritant ... .
[Sullivan, J.B. Jr., G.R. Krieger (eds.). Hazardous Materials Toxicology-Clinical Principles of Environmental Health. Baltimore, MD: Williams and Wilkins, 1992. 508]**PEER REVIEWED**

Medical Surveillance:

EXAMINATION OF SKIN, CNS, HEPATIC, & RENAL FUNCTION.
[Fuscaldo, A., B. J. Erlick, and B. Hindman. (eds.). Laboratory Safety-Theory and Practice. New York: Academic Press, 1980. 259]**PEER REVIEWED**

Determination of **acrylonitrile** - derived mercapturic acids in urine may prove to be of value for the biological monitoring of exposure.
[WHO; Environ Health Criteria: Acrylonitrile p.11 (1983)]**PEER REVIEWED**

Suggested /monitoring/ tests include determination of cyanide in blood and cyanomethemoglobin in blood.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 44]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Whenever medical surveillance is indicated, in particular when exposure to a carcinogen has occurred, ad hoc decisions should be taken concerning ... /cytogenetic and/or other/ tests that might become useful or mandatory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.23]**PEER REVIEWED**

A nonspecific medical surveillance program should include a preplacement exam & periodic follow-up. a history of fainting spells or convulsive disorders may incr the risk of **acrylonitrile** work. A medical exam with special emphasis on skin, respiratory tract, heart, CNS, kidney, & liver function is recommended. A baseline health status determination will enable the detection of toxic or carcinogenic changes during periodic exams. The periodic exam should be similar to the pre-placement exam.

Symptoms related to the exposure should be included in the medical history. The periodic exam should be done at least every year.
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 950]**PEER REVIEWED**

Populations at Special Risk:

/Protect/ from exposure those individuals with pulmonary and liver diseases.
[ITII. Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1988. 17]**PEER REVIEWED**

Probable Routes of Human Exposure:

INHALATION IS ... MOST IMPORTANT ROUTE OF ABSORPTION IN THE INDUSTRIAL CONTEXT. SKIN ABSORPTION CAN ALSO TAKE PLACE BUT IS SLOWER TO CAUSE EFFECTS. LEATHER GLOVES & FOOTWEAR READILY ABSORB **ACRYLONITRILE** & CAN LEAD TO SKIN ABSORPTION ... .
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 55]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 81,691 workers (27,358 of these are female) are potentially exposed to **acrylonitrile** in the US(1). Occupational exposure to **acrylonitrile** may occur through inhalation and dermal contact with this compound at workplaces where **acrylonitrile** is produced or used(SRC). Monitoring data indicate that the general population may be exposed to **acrylonitrile** via inhalation of ambient air and dermal contact with products containing **acrylonitrile**(SRC). Workplace air at an acrylic fiber plant, where large fraction of workers complained of symptoms of illness, had an **acrylonitrile** concn of 3-20 mg/cu m(2). Air in old thermosetting plastics molding plant where workers had adverse symptoms had an **acrylonitrile** concn of 1.4 mg/ cu m(2). Several steps in production of **acrylonitrile**-butadiene-styrene copolymer have been identified as potential employee exposure sources to **acrylonitrile**(3). Between the years 1980-1983, the range of avg exposures to **acrylonitrile** ranged from 0.01 to 1.85 ppm for workers at 8 **acrylonitrile** production facilities located in Virginia, Ohio, Texas, Louisiana, Florida, and Alabama(4). The general population living within 30 km of an industrial plant which manufactures or uses **acrylonitrile** may be exposed to atmospheric levels as high as 20 ug/cu m(5).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983) (2) USEPA; AWCQ for Acrylonitrile. Washington, DC: USEPA, Off Reg Stand. USEPA 440/5-80-017. p. C-13 (1980) (3) IARC; Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man Geneva, Switzerland: WHO International Agency For Research on Cancer 19: 78 (1979) (4) Stewart PA et al; Scand J Work Environ Health 24: 42-53 (1998) (5) Suta BE; p. 4 in Human Exposure to Atmospheric Concentrations of Selected Chemicals NTIS PB81-193278 (1980)]**PEER REVIEWED**

Average Daily Intake:

Average intake of **acrylonitrile** in the United Kingdom during 1982 was 0.3 ug/person per day.
[United Kingdom Ministry of Agriculture, Fisheries & Food; Survey of Acrylonitrile and Methacrylonitrile in Food Contact Materials and in Food. Paper No. 6 (1982) as cited in WHO; Environ Health Criteria: Acrylonitrile p.32 (1983)]**PEER REVIEWED**

Acrylonitrile

CASRN: 107-13-1
For other data, click on the Table of Contents

Status:

STATUS OF DATA FOR **Acrylonitrile**

File First On-Line 09/30/1987

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	no data	07/01/1993
Inhalation RfC Assessment (I.B.)	on-line	12/01/1991
Carcinogenicity Assessment (II.)	on-line	01/01/1991

Substance Identification:

Substance Name:

Acrylonitrile

CAS Registry Number: 107-13-1

I. Chronic Health Hazard Assessment for Noncarcinogenic Effects:

I.A. Reference Dose for Chronic Oral Exposure (RfD):

Substance Name -- **Acrylonitrile**
CASRN -- 107-13-1

Not available at this time.

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC):

Substance Name -- **Acrylonitrile**
CASRN -- 107-13-1
Last Revised -- 12/01/1991

The inhalation Reference Concentration (RfC) is analogous to the oral RfD and is likewise based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. The inhalation RfC considers toxic effects for both the respiratory system (portal-of-entry) and for effects peripheral to the respiratory system (extrarespiratory effects). It is expressed in units of mg/cu.m. In general, the RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily inhalation exposure of the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Inhalation RfCs were derived according to the Interim Methods for Development of Inhalation Reference Doses (EPA/600/8-88/066F August 1989) and subsequently,

according to Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry (EPA/600/8-90/066F October 1994). RfCs can also be derived for the noncarcinogenic health effects of substances that are carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.B.1. Inhalation RfC Summary:

Critical Effect	Expposures*	UF	MF	RfC
Degeneration and inflammation of nasal respiratory epithelium; hyperplasia of mucous secreting cells Rat 2-Year Inhalation Study Quast et al., 1980	NOAEL: none LOAEL: 43 mg/cu.m (20 ppm) LOAEL (ADJ): 7.7 mg/cu.m LOAEL (HEC): 1.9 mg/cu.m	1000	1	2E-3 mg/cu.m

* Conversion Factors: MW = 53.06. Assuming 25C and 760 mmHg, LOAEL (mg/cu.m) = 20 ppm x 53.06/24.45 = 43. LOAEL(ADJ) = 43 mg/cu.m x 6 hours/24 hours x 5 days/7 days = 7.7 mg/cu.m. The LOAEL(HEC) was calculated for a gas:respiratory effect in the ExtraThoracic region. MVa = 0.33 cu.m/day, MVh = 20 cu.m/day, Sa(ET) = 11.6 sq. cm., Sh(ET) = 177 sq. cm. RGDR(ET) = (MVa/Sa) / (MVh/Sh) = 0.252. LOAEL(HEC) = LOAEL(ADJ) x RGDR = 7.7 mg/cu.m x 0.252 = 1.9 mg/cu.m.

I.B.2. Principal and Supporting Studies (Inhalation RfC):

Quast J.F., D.J. Schwetz, M.F. Balmer, T.S. Gushow, C.N. Park and M.J. McKenna. 1980. A two-year toxicity and oncogenicity study with **acrylonitrile** following inhalation exposure of rats. Dow Chemical Co., Toxicology Research Laboratory, Midland, MI.

Sprague-Dawley rats (100/sex/concentration) were exposed 6 hours/day, 5 days/week for 2 years to concentrations of 0, 20 or 80 ppm **acrylonitrile** (duration-adjusted concentrations of 7.7 and 31 mg/cu.m). The control group was exposed only to air. Additional animals were included for interim sacrifices at 6 months (n=7/sex/dose) and 12 months (n=13/sex/dose). A significant decrease in mean body weight was observed in the rats exposed to 80 ppm **acrylonitrile**. Less significant, but similar weight changes were noted in the 20-ppm females after approximately 1 month. A treatment-related effect on mean body weight was not observed in the 20-ppm males.

A statistically significant increase in mortality ($p<0.05$) was observed within the first year in both male and female rats administered 80 ppm and in the 20-ppm females during the last 10 weeks of the study. The apparent increase in reported mortality for the 20-ppm females was principally due to early sacrifice of rats with large, benign, mammary gland tumors (Quast, 1991). In Sprague-Dawley rats, these tumors occur spontaneously at a high rate, but in this experiment the tumors were observed earlier and more

frequently, and became larger in exposed animals.

Exposure to **acrylonitrile** during the first 6-8 months resulted in a concentration-related increase in water consumption by both males and females. Urine specific gravity, which was repeatedly evaluated during this time interval, was usually decreased among rats exposed to 80 ppm. The authors noted increased pathologic changes to the heart and lungs of male rats of both groups, but indicated that they were identical to effects in the control rats that are usually associated with chronic renal disease. Microscopic analysis of the kidneys indicated a slight, nonstatistically significant increase in the incidence of spontaneously occurring advanced chronic renal disease. However, this slight increase could have been due to increased demand on the kidneys resulting from the increased water consumption seen earlier in the study.

Occasional significant deviation of the packed cell volume (PCV), and in the RBC, hemoglobin, and WBC counts were noted. However, the authors interpreted them as secondary changes associated with decreased growth, tumor formation, and hemorrhaging resulting from exposure to **acrylonitrile**. Urinalysis, hematology, and clinical chemistry were monitored. No other microscopic findings attributable to **acrylonitrile** exposure were observed. No adverse effects were observed on the bone marrow or liver function in rats in either sex exposed to 80 ppm.

Based on gross and histopathologic evaluation of tissues from over 40 different organs (including the respiratory tract and nasal turbinates), the two tissues which exhibited a treatment-related adverse effect due to **acrylonitrile** exposure were the nasal respiratory epithelium (4 transverse sections of the nasal turbinates were cut and examined) and the brain (9 sections through the CNS were cut and examined). Gross pathologic observations revealed significantly increased lung changes suggestive of pneumonia in 20-ppm male rats. Acute suppurative pneumonia was observed in the lungs of 10 male rats in the 80-ppm group between 7 and 12 months; it was occasionally observed in a single rat from the 20-ppm group. There were no indications of pneumonia in female rats of either exposure group. These changes are presumed to have been secondary effects related to the stress associated with the exposure.

A significant increase ($p<0.05$) in focal gliosis and perivascular cuffing was observed in the brains of high-concentration males (1/100 controls; 7/100 exposed) and females (0/100 controls; 8/100 exposed), but not in low- concentration rats. The incidence of glial cell tumors (astocytomas) was significantly increased in the 80-ppm group over controls for both males (15/99 vs. 0/100 in controls) and females (16/100 vs. 0/100 in controls). The incidence of proliferative glial cell lesions suggestive of early tumors was significantly increased in the 80-ppm males (7/100 vs. 0/100 in controls), but not in the females at any level (4/100 at 80 ppm; 4/100 at 20 ppm; 0/100 in controls). Collectively, proliferative changes in the glial cells (i.e., tumors and early proliferation suggestive of tumors), were significantly increased in the 20-ppm (8/100) and 80-ppm (20/100) females over female controls (0/100), and in the 80-ppm males (22/99), but not in the 20-ppm males (4/99) when compared with male controls (0/100). NOAEL(HEC) and LOAEL(HEC) for noncarcinogenic, extrarespiratory effects are 20 ppm (7.7 mg/cu.m) and 80 ppm (31 mg/cu.m), respectively.

There were significant degenerative and inflammatory changes ($p<0.05$; one- sided Fisher's Exact test) in the respiratory epithelium of the nasal turbinates at both exposure concentrations (20 and 80 ppm) which are interpreted to be treatment-related irritation of the nasal mucosa. In the male 20-ppm group, there was a slight but not statistically significant increase in the incidence of respiratory epithelium hyperplasia in the nasal turbinates (0/11 in controls; 4/12 at 20 ppm; 10/10 at 80 ppm) and a statistically significant increase in hyperplasia of the mucous secreting cells (0/11; 7/12; 8/10). In the 20-ppm females there was a slight but not statistically significant increase in focal inflammation in the nasal

turbinates (2/11; 6/10; 7/10) and a statistically significant increase in flattening of the respiratory epithelium of the nasal turbinates (1/11; 7/10; 8/10). In the 80-ppm group, effects were more severe and were characterized by suppurative rhinitis, hyperplasia, focal erosions, and squamous metaplasia of the respiratory epithelium. No treatment-related effects in the olfactory epithelium, trachea, or lower respiratory system were observed in either males or females at either concentration. In this study, 20 ppm (HEC = 1.9 mg/cu.m) is considered a LOAEL for pathological alterations in the respiratory epithelium of the extrathoracic region of the respiratory system.

I.B.3. Uncertainty and Modifying Factors (Inhalation RfC):

UF -- The uncertainty factor of 1000 reflects a factor of 10 to protect unusually sensitive individuals and 3 to adjust from a minimally adverse LOAEL to a NOAEL. An uncertainty factor of 3 for interspecies variability is used because the use of the dosimetric adjustments account for part of this area of uncertainty. An additional factor of 10 is applied due to an incomplete data base, or more specifically, the lack of an inhalation bioassay in a second species, and the lack of reproductive data by the inhalation route with the existence of an oral study showing reproductive effects.

MF -- None

I.B.4. Additional Studies/Comments (Inhalation RfC):

Several epidemiology studies have examined the morbidity and mortality of workers exposed to **acrylonitrile**. Mortality due to noncancer endpoints, including respiratory disease, have been investigated (O'Berg, 1980; Ott et al., 1980; Werner and Carter, 1981; O'Berg et al., 1985; Chen et al., 1987). No significant excess mortality has been noted for any noncarcinogenic endpoint. For further discussion of these cancer assessment studies see Section II.

Workers in a synthetic rubber manufacturing plant exposed to concentrations of 16 to 100 ppm **acrylonitrile** for 20 to 45 minutes experienced mucous membrane irritation, headaches, nausea, feelings of apprehension and nervous irritability. Low grade anemia, leukocytosis, kidney irritation and mild jaundice were also apparent; these effects subsided with exposure cessation (Wilson et al., 1948). Human volunteers exposed acutely (8 hours) to **acrylonitrile** at concentrations of 5.4-10.9 mg/cu.m (2.4-5.0 ppm) exhibited no deleterious effects (Jakubowski et al., 1987).

No statistically significant increases ($p<0.05$) in adverse health effects attributable to **acrylonitrile** were detected by clinical examination in a cross-sectional investigation of Japanese workers (n=102) when compared with matched controls (n=62) employed in 6 different acrylic fiber factories for a minimum of 5 years (Sakurai et al., 1978). Arithmetic mean exposure levels at the different factories (as determined by personal sampling) ranged from 0.1-4.2 ppm. Significantly higher exposure levels (arithmetic mean = 4.2 ppm, geometric mean = 3.7, geometric standard deviation = 1.7) and exposure durations (mean, 12.6 years; stand. dev., 2.1 years) were reported for workers from one factory (n=18). While a slight increase in reddening of conjunctiva and pharynx (3/10 controls; 9/18 exposed) was reported in these workers, it was not statistically significant (Z test with Yates' correction and Fisher's Exact test used). Palpable liver was also elevated in this high exposure group, but was not statistically significant, and blood chemistry evaluations did not indicate liver damage. These study results are inconclusive due to the small size of the cohort, examiner bias (i.e., the medical examiner was not blind to the exposure status of each subject), and shift bias (i.e., the study required shift workers; less fit workers may have transferred to day

work). However, it is worth noting that the HEC value for the only exposure level that appears to show any effects (4.2 ppm), HEC = 4.2 x (53.06/24.45) x (10/20) x (5/7) = 3 mg/cu.m, is consistent with the LOAEL(HEC) calculated from Quast et al. (1980).

The death of a child (age 3) who was sleeping in a room fumigated with **acrylonitrile** has been described by Grunske (1949). Respiratory malfunction, lip cyanosis, and tachycardia were among the symptoms described prior to death. Five adults who spent the night and much of the day in the room complained only of eye irritation or showed no signs of **acrylonitrile** poisoning. The concentration of **acrylonitrile** in the air was not given. Several other instances of death in children with only mild irritation in adults were reported by Grunske (1949), but not described in detail.

In a subchronic inhalation experiment, repeated 4-hour exposures (5 days/week) at various concentrations and durations resulted in moderate toxicity to guinea pigs (265 ppm or 575 mg/cu.m, 8 weeks), rats (100 ppm or 217 mg/cu.m, 8 weeks) and rabbits (100 ppm or 217 mg/cu.m, 8 weeks), and more severe toxicity (including mortality) to cats (153 ppm or 332 mg/cu.m, 8 weeks), dogs (56 ppm or 122 mg/cu.m, 4 weeks) and monkeys (153 ppm or 332 mg/cu.m, 4 weeks) (Dudley et al., 1942). The moderately toxic effects included irritation of the eyes and nose, gastrointestinal disturbances, and weakness of the hind legs. The animals recovered from these effects following exposure cessation. This study is of limited value due to the small number of animals tested, the lack of statistical analyses, and the lack of concurrent controls.

Sprague-Dawley rats (30/sex/concentration) were exposed to 0, 5, 10, 20 and 40 ppm 4 hours/day, 5 days/week for 52 weeks (duration-adjusted concentrations of 0, 1.3, 2.6, 5.2, and 10.4 mg/cu.m, respectively) (Maltoni et al., 1977; Maltoni et al., 1988) and at 60 ppm, 4-7 hours/day, 5 days/week for 104 weeks (Maltoni et al., 1988). Although histopathologic examinations were performed on various organ systems including the lungs, brain, kidney, and liver, no noncarcinogenic effects were reported. The exposures did not have affect on body weight gain. No mortality data were reported.

Beliles et al. (1980) evaluated reproductive capacity in three generations of male (15/generation) and female (30/generation) Charles River rats exposed to mean **acrylonitrile** concentrations of 0, 106 and 522 ppm in drinking water ad libitum. All three generations of parents were exposed for 100 days and throughout a 6 day mating period, gestation and lactation. Parents were examined daily for signs of neurotoxicity. Body weights were obtained every 2 weeks; food consumption was measured weekly; water consumption was measured twice a week. Offspring were examined on days 0, 4 and 21 of lactation. All litters were reduced to 10 pups on day 4 to achieve an equal sex ratio. Body weights were obtained on day 4 (litter) and day 21 (individual). Exposure to 522 ppm **acrylonitrile** in drinking water (70 mg/kg/day) resulted in reduced viability and lactation indices ($p<0.05$) in all generations. Dams of all generations were reported to have decreased water intake through the lactation period. Cross-fostering of pups on untreated dams lessened pup mortality. There were no changes in reproductive capacity at 106 ppm relative to controls.

One developmental study conducted in rats examined both oral and inhalation exposure routes. Rats (30/concentration) were exposed to 0, 40 or 80 ppm **acrylonitrile** vapors 6 hours/day during gestational days 6 to 15. In accordance with current EPA policy, these values are not duration adjusted. The group exposed to 80 ppm exhibited a significant increase ($p=0.06$) in fetal malformations which include short tail, missing vertebrae, short trunk, omphalocele and hemivertebra. Mean number of implantations, live fetuses and resorptions were not significantly altered by exposure to 40 or 80 ppm. Maternal toxicity was reported at both concentration levels tested, as evidenced by decreased weight gain, but no effects on fetal body size were evident (Murray et al., 1978). No evidence of embryotoxicity or teratogenicity was

discerned in rats administered 40 ppm via inhalation. This study identifies a NOAEL(HEC) = 15.5 mg/cu.m and a LOAEL(HEC) = 31 mg/cu.m (with maternal toxicity).

I.B.5. Confidence in the Inhalation RfC:

Study -- Medium
Database -- Medium
RfC -- Medium

The critical study is given medium confidence, because although it was a well-conducted chronic study in an appropriate number of animals (100/sex/concentration), it was performed on only one species, did not identify a NOAEL, was confounded by the early sacrifice of rats with large mammary gland tumors and the target organ (nasal turbinates) was only examined at the end of the study in relatively few animals (10-12/sex/concentration). Confidence in the data base can be considered medium to low due to a lack of chronic or subchronic inhalation data in a second species, the lack of reproductive data by the inhalation route and the existence of an oral study showing reproductive effects. Confidence in the RfC can also be considered medium to low.

I.B.6. EPA Documentation and Review of the Inhalation RfC:

Source Document -- This assessment is not presented in any existing U.S. EPA document.

Other EPA Documentation -- U.S. EPA, 1983

Agency Work Group Review -- 12/19/1990, 08/15/1991

Verification Date -- 08/15/1991

Screening-Level Literature Review Findings -- A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the RfC for **Acrylonitrile** conducted in September 2002 did not identify any critical new studies. IRIS users who know of important new studies may provide that information to the IRIS Hotline at hotline.iris@epa.gov or 301-345-2870.

I.B.7. EPA Contacts (Inhalation RfC):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or hotline.iris@epa.gov (internet address).

II. Carcinogenicity Assessment for Lifetime Exposure:

Substance Name -- **Acrylonitrile**
CASRN -- 107-13-1
Last Revised -- 01/01/1991

Section II provides information on three aspects of the carcinogenic assessment for the substance in

question; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity:

II.A.1. Weight-of-Evidence Characterization:

Classification -- B1; probable human carcinogen

Basis -- The observation of a statistically significant increase in incidence of lung cancer in exposed workers and observation of tumors, generally astrocytomas in the brain, in studies in two rat strains exposed by various routes (drinking water, gavage, and inhalation) forms the basis for this classification.

II.A.2. Human Carcinogenicity Data:

O'Berg (1980) observed 25 cases of cancer, including eight cases of respiratory cancer, in 1345 male textile workers exposed to **acrylonitrile** and followed for 10 or more years. Estimated levels of exposure were 5-20 ppm **acrylonitrile**. All of the cancer cases, except for one nonrespiratory cancer, occurred among 1128 workers with 6 or more months exposure (SIR=126, SMR=113). A trend of increased cancer incidence was seen with increased duration of exposure and increased length of follow-up time. The excess of respiratory cancer was statistically significant and remained so upon evaluation of the contribution of smoking (five observed vs. 1.6 expected).

Three other studies reported a statistically significant increased incidence of lung cancer from exposure to **acrylonitrile**. All suffer from problems with methodology (e.g., exposure to other carcinogens, no smoking history, exposure not quantified). Delzel and Monson (1982) studied 327 male workers at a rubber manufacturing plant and reported a statistically significant increase in lung cancer among workers employed 5 or more years. Thiess et al. (1980) studied 1469 workers employed 6 months or more in **acrylonitrile** processing. A statistically significant increase in lung cancer and cancer of the lymph system was seen. Werner and Carter (1981) studied 934 men employed at least 1 year in polymerization of **acrylonitrile** and spinning of acrylic fiber. A statistically significant increase was seen for stomach cancer in all age groups and for pulmonary cancer in the 15-44 year age group. One other study reported a statistically nonsignificant increase in deaths from cancer from exposure to **acrylonitrile** (Monson, 1978), but workers were also exposed to other carcinogens. Five additional studies reported no evidence of increased risk, but all suffer from deficiencies in design or methodology.

II.A.3. Animal Carcinogenicity Data:

Quast et al. (1980a) administered **acrylonitrile** in drinking water at dose levels of 35, 100, and 300 ppm to 48 Sprague-Dawley rats/sex for 2 years. A statistically significant increase in tumors was observed in the CNS (astrocytomas), Zymbal gland, stomach, tongue, and small intestine for both sexes and in the mammary gland of female rats. In general, the increase was dose-dependent.

Biodynamics (1980a) administered **acrylonitrile** in drinking water at doses of 0, 1, and 100 ppm to 100 Sprague-Dawley rats/sex/group. Interim necropsies were performed at 6, 12, and 18 months (10/sex/group). The study was terminated early because of low survival rates. There was increased incidence of astrocytomas of the brain and spinal cord, carcinomas and adenomas of the Zymbal gland or ear canal, and squamous cell carcinomas and papillomas of the forestomach in high-dose animals.

A second study was conducted by Biodynamics (1980b) wherein **acrylonitrile** was administered in drinking water to 100 Fischer 344 rats/sex/group at dose levels of 1, 3, 10, 30, and 100 ppm and to a control group of 200/sex. Interim necropsies were performed at 6, 12, and 18 months (10/sex/ exposed group and 20/sex/control group). The study was terminated early because of the low survival rate. Increased incidence of tumors (astrocytomas of the brain and spinal cord, and carcinomas of the Zymbal gland) was seen in dose groups of 3 ppm or higher, and the incidence was dose-dependent. An increased incidence of mammary gland tumors was seen in females at the 100 ppm dose level. In a three-generation reproductive study in rats [CRL:COBS CD (SD) BR] were exposed to **acrylonitrile** in drinking water. The second generation showed an increased incidence of cancer (astrocytoma and Zymbal gland) at the 500 ppm exposure level (Beliles, 1980).

Maltoni et al. (1977) administered **acrylonitrile** in olive oil 3 times/week for 52 weeks to Sprague-Dawley rats in doses of 0 ppm to 75 rats/sex and 5 ppm to 40 rats/sex. Increased incidence of tumors of the mammary gland and forestomach was observed in female rats. In another study (Biodynamics, 1980c), **acrylonitrile** was administered at doses of 0, 0.10, and 10.0 mg/kg/day for 5 days to 70 Sprague-Dawley rats/sex/group. The study was terminated at 20 months. Statistically significant increased incidences of brain (astrocytoma) and Zymbal gland tumors were observed in the high-dose group. A statistically significant increased incidence of stomach and intestinal tumors was observed in males and of the mammary gland in females.

In a second study by Quast et al. (1980b), **acrylonitrile** was administered by inhalation at 0, 20, and 80 ppm to 100 male and female Sprague-Dawley rats for 6 hours/day, 5 days/week for 2 years. A statistically significant increase was observed in tumors of the CNS and other sites.

Acrylonitrile was also administered by inhalation at lower doses of 0, 5, 10, 20, and 40 ppm, 4 hours/day, 5 days/week for 12 months to 30 Sprague- Dawley rats/sex/group by Maltoni et al. (1977). This resulted in a statistically significant increase of mammary tumors in males and skin carcinomas in females.

II.A.4. Supporting Data for Carcinogenicity:

Acrylonitrile can cause mutations in both Salmonella typhimurium (Venitt et al., 1977) and Escherichia coli (De Meester et al., 1978). It did not cause chromosomal aberrations in bone marrow cells of rats and mice (Rabello- Gay and Ahmed, 1980; Leonard et al., 1981) or in peripheral blood lymphocytes of

exposed workers (Thiess and Fleig, 1978). **Acrylonitrile** did induce an increase in sister-chromatid-exchange (SCE) in CHO cells (Ved Brat and Williams, 1982), and has also been shown to bind to DNA (Guengerich et al., 1981). A metabolite, 2,3-epoxy-propionitrile, is mutagenic in Salmonella (Kier, 1982). **Acrylonitrile** has been shown to transform Syrian hamster embryo cells and to enhance transformation of these cells infected with an oncogenic virus (Parent and Casto, 1979).

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure:

II.B.1. Summary of Risk Estimates:

Oral Slope Factor -- 5.4E-1 per (mg/kg)/day

Drinking Water Unit Risk -- 1.5E-5 per (ug/L)

Extrapolation Method -- Linearized multistage procedure, extra risk

Drinking Water Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	6E+0 ug/L
E-5 (1 in 100,000)	6E-1 ug/L
E-6 (1in 1,000,000)	6E-2 ug/L

II.B.2. Dose-Response Data (Carcinogenicity, Oral Exposure):

Tumor Type: brain and spinal cord astrocytomas, Zymbal gland carcinomas and stomach papillomas/carcinomas
Test animals: rats (see table)
Route: drinking water
Reference: biodynamics, 1980a,b; Quast et al., 1980a

Administered Dose (ppm)	Administered Dose (mg/kg)/day	Human Equivalent Dose (mg/kg)/day	Tumor Incidence	Reference
Rats/Spartan Sprague-Dawley, males				
0	0.00	0.00	6/100	Biodynamics,
1	0.09	0.02	6/98	1980a
100	7.98	1.36	36/98	
Rats/Fischer 344, males				
0	0.00	0.00	5/200	Biodynamics,
1	0.11	0.02	4/100	1980b
3	0.25	0.04	5/100	
10	0.81	0.14	7/100	
30	2.49	0.43	20/100	
100	8.15	1.39	36/100	
Rats/Sprague-Dawley, males				
0	0.00	0.00	4/80	Quast et al.,
35	3.42	0.58	18/47	1980a
100	8.53	1.46	36/48	
300	21.18	3.62	45/48	

II.B.3. Additional Comments (Carcinogenicity, Oral Exposure):

The quantitative estimate is a geometric mean of these three slope factors: 4.0E-1 (Biodynamics, 1980a), 4.0E-1 (Biodynamics, 1980b) and 9.9E-1 per (mg/kg)/day (Quast et al., 1980a). The overall risk of tumors was determined from the number of animals having tumors that were statistically significant at any site.

The unit risk should not be used if the water concentration exceeds 600 ug/L, since above this concentration the unit risk may not be appropriate.

II.B.4. Discussion of Confidence (Carcinogenicity, Oral Exposure):

Relatively large numbers of animals were treated and observed and a dose- response effect was observed in all studies. The slope factors derived from data on male rats (Quast et al., 1980a; Biodynamics, 1980a,b) were similar [9.9E-1, 4.0E-1, and 4.0E-1 per (mg/kg)/day] and within a factor of 3. The slope factors based on the three female rat studies [9.2E-1, 3.7E-1, and 2.9E- 1 per (mg/kg)/day] were similar to those of the respective male rat studies, as was their geometric mean (4.6E-1 per (mg/kg)/day. In two of the studies (Biodynamics, 1980a,b) the increases reported could vary considerably since interim necropsies were included with the final sacrifice.

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure:

II.C.1. Summary of Risk Estimates:

Inhalation Unit Risk -- 6.8E-5 per (ug/cu.m)

Extrapolation Method -- Average relative risk

Air Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	1E+0 ug/cu.m
E-5 (1 in 100,000)	1E-1 ug/cu.m
E-6 (1 in 1,000,000)	1E-2 ug/cu.m

II.C.2. Dose-Response Data for Carcinogenicity, Inhalation:

Tumor Type: respiratory cancer
Test animals: humans
Route: inhalation
Reference: O'Berg, 1980

The unit risk (BH) was calculated from a relative risk model adjusted for smoking and based on a continuous lifetime equivalent of occupational exposure

BH = PO(R-1)/X

= 1.5E-4/ppb x 0.45 ppb/ug/cu.m

= 6.8E-5 per (ug/cu.m)

where: PO = 0.036 = background lifetime probability of death from respiratory cancer

R = 5.0/1.6 = 3.1 = relative risk of respiratory cancer adjusted for smoking (O'Berg, 1980)

X 500 ppb = continuous equivalent lifetime exposure when 9 years = estimated average exposure duration, and 60 years = estimated maximum possible age at end of observation period.

II.C.3. Additional Comments (Carcinogenicity, Inhalation Exposure):

The excess incidence of respiratory cancer in the O'Berg (1980) study was adjusted for smoking. An exposure of 15 ppm was assumed to be the 8-hour TWA with an average exposure duration of 9 years. The maximum possible age at the end of the observation period was assumed to be 60 years.

The unit risk should not be used if the air concentration exceeds 1E+2 ug/cu.m, as above this concentration the unit risk may not be appropriate.

II.C.4. Discussion of Confidence (Carcinogenicity, Inhalation Exposure):

The cohort was sufficiently large and was followed for an adequate time period. A dose-response relationship was seen for the increased cancer risk. The increased risk remained after adjustment for smoking. Exposure levels were estimated by company representatives. The unit risk based on the Quast et al. (1980b) rat inhalation study was 1.5E-5 per (ug/cu.m).

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment):

II.D.1. EPA Documentation:

Source Document -- U.S. EPA, 1983

The values in the 1983 Health Assessment Document for **Acrylonitrile** have received both Agency and outside review.

II.D.2. EPA Review (Carcinogenicity Assessment):

Agency Work Group Review -- 02/11/1987

Verification Date -- 02/11/1987

Screening-Level Literature Review Findings -- A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the cancer assessment for **Acrylonitrile** conducted in September 2002 identified one or more significant new studies. IRIS users may request the references for those studies from the IRIS Hotline at hotline.iris@epa.gov or 301-345-2870.

II.D.3. EPA Contacts (Carcinogenicity Assessment):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or hotline.iris@epa.gov (internet address).

VI. Bibliography:

VI.A. Oral RfD References:

None

VI.B. Inhalation RfC References:

Beliles, R.P., H.J. Paulin, N.G. Makris and R.J. Weir. 1980. Three- generation reproduction study of rats receiving **acrylonitrile** in drinking water. Chemical Manufacturers Association, Washington, DC, LBI

Project No. 2660, February.

Chen, J.L., J. Walrath, M.T. O'Berg, C.A. Burke and S. Pell. 1987. Cancer incidence and mortality among workers exposed to **acrylonitrile**. Am. J. Ind. Med. 11:157-163.

Dudley, H.C., T.K. Sweeny and J.W. Miller. 1942. Toxicology of **acrylonitrile** (vinly cyanide). II. Studies of effects of daily inhalation. J. Ind. Hyg. Toxicol. 24(9): 255-258.

Grunske, F. 1949. Health care and occupational medicine. Ventox and ventox intoxication. Dtsch. Med. Wochenschr. 74: 1081-1083.

Jakubowski, M., I. Linhart, G. Pielas and J Kopecky. 1987. 2- Cyanoethymercapturic acid (CEMA) in the urine as a possible indicator of exposure to **acrylonitrile**. Br. J. Ind. Med. 44: 834-840.

Maltoni, C., A. Ciliberti, and V. Di Maio. 1977. Carcinogenicity bioassays on rats of **acrylonitrile** administerd by inhalation and by ingestion. Med. Lav. 68(6): 401-411.

Maltoni, C., A. Ciliberti, G. Cotti and G. Perino. 1988. Long-term carcinogenicity biosassays on **acrylonitrile** administered by inhalation and by ingestion to Sprague-Dawley rats. Ann. NY Acad. Sci. 534: 179-202.

Murray, F.J., B.A. Schwetz, K.D. Nitschke, J.A. John, J.M. Norris and P.J. Gehring. 1978. Teratogenicity of **acrylonitrile** given to rats by gavage or by inhalation. Food Cosmet. Toxicol. 16(6): 547-52.

O'Berg, M.T. 1980. Epidemiologic study of workers exposed to **acrylonitrile**. J. Occup. Med. 22(4): 245-252.

O'Berg, M.T., J.L. Chen, C.A. Burke CA, J. Walrath and S. Pell. 1985. Epidemiologic study of workers exposed to **acrylonitrile**: An update. J. Occup. Med. 27(11): 835-840.

Ott, M.G., R.C. Kolesar, H.C. Scharnweber, E.J. Schneider and J.R. Venable. 1980. A mortality survey of employees engaged in the development or manufacture of styrene-based products. J. Occup. Med. 22: 445-460.

Quast, J.F. 1991. DOW Chemical Company, Midland MI. Letter to Dr. Jeffrey Gift, U.S. EPA, Research Triangle Park, NC. Results of the 2-year rat inhalation study on **acrylonitrile** performed by DOW Chemical Company. February 4.

Quast, J.F., D.J. Schuetz, M.F. Balmer, T.S. Gushow, C.N. Park and M.J. McKenna. 1980. A two-year toxicity and oncogenicity study with **acrylonitrile** following inhalation exposure of rats. Dow Chemical Co., Toxicology Research Laboratory, Midland MI.

Sakurai, H., M. Onodera, T. Utsunomiya, H. Minakuchi, H. Iwai and H. Matsumura. 1978. Health effects of **acrylonitrile** in acrylic fibre factories. Br. J. Ind. Med. 35: 219-225.

U.S. EPA. 1983. Health Assessment Document for **Acrylonitrile**. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, NC. October, 1983.

Werner, J.B. and J.T. Carter. 1981. Mortality of United Kingdom **acrylonitrile** polymerisation workers. Br. J. Ind. Med. 38: 247-253.

Wilson, R.H., G.H. Hough and W.E. McCormick. 1948. Medical problems encountered in the manufacture of American-made rubber. Ind. Med. 17(6): 199-207.

VI.C. Carcinogenicity Assessment References:

Beliles, R.P., H.J. Paulin, N.G. Makris and R.J. Weir. 1980. Three-generation reproductive study of rats receiving **acrylonitrile** in drinking water. Prepared by Litton Bionetics, Inc., Kensington, MD, for the Chemical Maufacturers Association, Washington, DC. Available from: CMA, Washington, DC.

Biodynamics, Inc. 1980a. A twenty-four month oral toxicity/carcinogenicity study of **acrylonitrile** administered to Spartan rats in the drinking water, Vol. 1-2. Prepared by Biodynamics Inc., Division of Biology and Safety Evaluation, East Millstone, NJ, for Monsanto Company, St. Louis, MO.

Biodynamics, Inc. 1980b. A twenty-four month oral toxicity/carcinogenicity study of **acrylonitrile** administered in the drinking water to Fischer 344 rats, Vol. 1-4. Prepared by Biodynamics Inc., Division of Biology and Safety Evaluation, East Millstone, NJ, for Monsanto Company, St. Louis, MO.

Biodynamics, Inc. 1980c. A twenty-four month oral toxicity/carcinogenicity study of **acrylonitrile** administered by intubation to Spartan rats, Vol. 1-2. Prepared by Biodynamics Inc., East Millstone, NJ, for Monsanto Company, St. Louis, MO.

Delzell, E. and R.R. Monson. 1982. Mortality among rubber workers. VI. Men with exposure to **acrylonitrile**. J. Occup. Med. 24(10): 767-769.

De Meester, C., F. Poncelet, M. Roberfroid and M. Mercier. 1978. Mutagenicity of acylonitrile. Toxicology. 11: 19-27.

Guengerich, F.P., L.E. Geiger, L.L. Hogy and P.L. Wright. 1981. In vitro metabolism of **acrylonitrile** to 2-cyanoethylene oxide, reaction with glutathione, and irreversible binding to proteins and nucleic acids. Cancer Res. 41: 4925-4933.

Kier, L.D. 1982. Ames/Salmonella mutagenicity assay of **acrylonitrile**. Monsanto Company, St. Louis, Report No: MSL-2063.

Leonard, A., F. Garny, F. Poncelet and M. Mercier. 1981. Mutagenicity of **acrylonitrile** in mouse. Toxicol. Lett. 7: 329-334.

Maltoni, C., A. Ciliberti and V. DiMaio. 1977. Carcinogenicity bioassays on rats of rats of **acrylonitrile** administered by inhalation and by ingestion. Med. Lavoro. 68(6): 401-411.

Monson, R.R. 1978. Mortality and cancer morbidity among chemical workers with potential exposure to **acrylonitrile**. Report to the B.F. Goodrich Company and to the United Rubber Workers. Prepared for submission in the post hearing comment period to the OSHA **Acrylonitrile** Hearing.

O'Berg, M. 1980. Epidemiologic study of workers exposed to **acrylonitrile**. J. Occup. Med. 22: 245-252.

Parent, R.A. and B.C. Casto. 1979. Effect of **acrylonitrile** on primary Syrian golden hamster embryo cells in culture: Transformation and DNA fragmentation. J. Nat. Cancer Inst. 62(4): 1025-29.

Quast, J.F., C.E. Wade, C.G. Humiston, R.M. Carreon, E.A. Hermann, C.N. Park and B.A. Schwetz. 1980a. A two-year toxicity and oncogenicity study with **acrylonitrile** incorporated in the drinking water of rats. Prepared by the Toxicology Research Laboratory, Health and Environmental Sciences, Dow Chemical USA, Midland, MI, for the Chemical Manufacturers Association, Washington, DC. Available from: CMA, Washington DC.

Quast, J.F., D.J. Schuetz, M.F. Balmer, T.S. Gushow, C.N. Park and M.J. McKenna. 1980b. A two-year toxicity and oncogenicity study with **acrylonitrile** following inhalation exposure of rats. Prepared by the Toxicology Research Laboratory, Health and Environmental Sciences, Dow Chemical USA, Midland, MI, for the Chemical Manufacturing Association, Washington, DC.

Rabello-Gay, M.N. and A.E. Ahmed. 1980. **Acrylonitrile**: In vivo cytogenic studies in mice and rats. Mutat. Res. 79: 249-255.

Thiess, A.M. and I. Fleig. 1978. Analysis of chromosomes of workers exposed to **acrylonitrile**. Arch. Toxicol. 41(2): 149-52.

Thiess, A.M., R. Frentzel-Beyme, R. Link and H. Wild. 1980. Mortalitats studie Bei Chemiefacharbeitern Verchiedener Produktionsbetriebe Mit Exposition Auch Gegenuber **Acrylonitrile**. Zentralbl. Arbeitsmed. 30: 359-267.

U.S. EPA. 1983. Health Assessment Document for **Acrylonitrile**. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, NC.

Ved Brat, S. and G.M. Williams. 1982. Hepatocyte-mediated production of sister chromatid exchange in cocultured cells by **acrylonitrile**: Evidence for extra-cellular transport of a stable reactive intermediate. Cancer Letters. 17: 213-216.

Venitt, S., C.T. Bushell and M. Osborne. 1977. Mutagenicity of **acrylonitrile** (cyanoethylene) in Escherichia coli. Mutat. Res. 45(2): 283-88.

Werner, J.B., and J.T. Carter. 1981. Mortality of United Kingdom **acrylonitrile** polymersation workers. Br. J. Ind. Med. 38: 247-253.

VII. Revision History:

Substance Name -- **Acrylonitrile**
CASRN -- 107-13-1

Date	Section	Description
03/01/1988	II.B.4.	Confidence statement revised
02/01/1989	II.D.3.	Secondary contact's phone number corrected
07/01/1989	II.	Citations for Quast et al. clarified
07/01/1989	VI.	Bibliography on-line
06/01/1990	IV.A.1.	Area code for EPA contact corrected
06/01/1990	IV.F.1.	EPA contact changed
01/01/1991	I.B.	Inhalation RfC now under review
01/01/1991	II.	Text edited
01/01/1991	II.C.1.	Inhalation slope factor removed (global change)
11/01/1991	I.B.	Inhalation RfC summary on-line
11/01/1991	VI.B.	Inhalation RfC references added
12/01/1991	I.B.	Text edited
01/01/1992	IV.	Regulatory actions updated
04/01/1992	IV.A.1.	CAA regulatory action withdrawn
08/01/1992	I.A.	Oral RfD now under review
07/01/1993	I.A.	Work group review date added
08/01/1995	I.A.	EPA's RfD/RfC and CRAVE workgroups were discontinued in May, 1995. Chemical substance reviews that were not completed by September 1995 were taken out of IRIS review. The IRIS Pilot Program replaced the workgroup functions beginning in September, 1995.
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program offices for this information.
12/03/2002	I.B.6., II.D.2.	Screening-Level Literature Review Findings message has been added.

ARSENIC COMPOUNDS

CASRN: NO CAS RN

This record contains general information for arsenic ions (+3 and +5) and inorganic and organic arsenic compounds, including statements in the literature referenced to arsenic compounds and arsenic salts. For compound specific information, refer to the appropriate individual records listed in the RELATED HSDB RECORDS field. For information on the metal, refer to the ARSENIC, ELEMENTAL record.

For other data, click on the Table of Contents

Human Health Effects:

Toxicity Summary:

Toxicology: Effects: Vesicants affect both exterior and interior parts of the body. Vesicants cause inflammation, blisters, and general destruction of tissues. Vapors have a greater impact on moist areas of the body. Eyes are especially susceptible to Vesicants. Inhalation of Vesicants can cause lung membranes to swell and become filled with liquid (pulmonary edema). Death may result from lack of oxygen. Arsenical Vesicants are also systemic agents and readily pass through the skin to affect susceptible tissue including blood cells and the liver. Arsenical Vesicants also act as vomiting agents ... and produce violent sneezing and regurgitation. Arsenical Vesicants should be considered carcinogenic. Pathways: Vesicants are hazardous through inhalation, skin and eye exposure, ingestion, and abraded skin (e.g., breaks in the skin or penetration of skin by debris). Liquid agents are much more hazardous than their vapors. /Vesicants - **Arsenic** Based/

[Ellison, D.H., Emergency Action for Chemical and Biological Warfare Agents. CRC Press, Boca Raton, FL 1999. 52]**PEER REVIEWED**

Latency Period: Arsenical vesicants produce pain immediately. Skin impacts begin appearing within minutes of exposure, although it may be up to 18 hours before the full lesion develops. Inhalation of high concentrations may be fatal in as short a time as 10 minutes. Pulmonary edema caused by inhalation of the agent vapor may be delayed for several hours. /Vesicants - **Arsenic** Based/

[Ellison, D.H., Emergency Action for Chemical and Biological Warfare Agents. CRC Press, Boca Raton, FL 1999. 53]**PEER REVIEWED**

Evidence for Carcinogenicity:

Classification of carcinogenicity: 1) evidence in humans: sufficient; 2) evidence in animals: limited. Overall summary evaluation of carcinogenic risk to humans is Group 1: Carcinogenic to humans. NOTE: This evaluation applies to the group of chemicals as a whole and not necessarily to all individual chemicals within the group. /**Arsenic** and **arsenic** compounds/

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. S7 57 (1987)]**PEER REVIEWED**

A1. A1= Confirmed human carcinogen. (1993) /**Arsenic**, elemental and inorganic cmpd (except Arsine), as As/

[American Conference of Governmental Industrial Hygienists. Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs) for 1995-1996. Cincinnati, OH: ACGIH, 1995.13]**PEER REVIEWED**

CLASSIFICATION: A; human carcinogen. BASIS FOR CLASSIFICATION: Based on sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in

populations consuming drinking water high in inorganic **arsenic**. HUMAN CARCINOGENICITY DATA: Sufficient. ANIMAL CARCINOGENICITY DATA: Inadequate. /Inorganic **Arsenic**/
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Arsenic, inorganic (7440-38-2) Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000]**PEER REVIEWED**

Human Toxicity Excerpts:

SYMPTOMATOLOGY (Acute poisoning only): 1. Symptoms usually appear 1/2 to 1 hr after ingestion but may be delayed many hr, esp when **arsenic** is taken with food. 2. Sweetish metallic taste; garlicky odor of breath and feces. 3. Constriction in throat & difficulty in swallowing. Burning & colicky pains in esophagus, stomach & bowel. 4. Vomiting & profuse painful diarrhea. Often excreta resmeble "rice water" stools of cholera; later feces become bloody. 5. Dehydration with intense thirst & muscular cramps. 6. Hematatueia, albuminuria, glycosuria. Elevation of liver enzymes in the plasma. 7. Initial sinus tachycardia and occasionally ventricular arrhythmias, followed by cyanosis, feeble pulse and cold extremities. 8. Vertigo, frontal headache. In some cases ("cerebral type") vertigo, stupor, delirium, & even mania develop without prominent GI signs. 9. Syncope, coma, occasionally convulsions, general paralysis & death. 10. If acute phase is survived, peripheral ... /neuropathy/ with sensory & motor involvement ... 11. Various skin eruptions ... 12. During recovery, weakness & diarrhea may persist for wk, & occasionally syndrome indistinguishable from chronic poisoning evolves ... /**Arsenic** cmpd, ingestion/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-44]**PEER REVIEWED**

The effects of trivalent & pentavalent **arsenic** on the synthesis of DNA, RNA, & protein in cultured human cells were compared. The clastogenicity of these cmpds were also compared. The chromosome-breaking activity in cultured (human) leukocytes was significantly higher for the cmpds with trivalent than with pentavalent **arsenic** The activity in cultured human skin fibroblasts was similar to that in leukocyte cultures. The colony-forming capacity after exposure to **arsenic** cmpd indicated that trivalent cmpd were more toxic than pentavalent cmpd. Both trivalent & pentavalent **arsenic** inhibited DNA & protein synthesis in leukocytes. /Trivalent and pentavalent **arsenic**/
[Nakamuro K, Sayato Y; Mutat Res 88 (1): 73-80 (1981)]**PEER REVIEWED**

Arsenicals may act as contact allergens. Thus, low concn which ordinarily would not result in local irritation caused allergic reactions (eg folliculitis) in sensitized individuals. /Arsenicals/
[Nat'l Research Council Canada; Effects of Arsenic in the Canadian Environment p.258 (1978) NRCC No.15391]**PEER REVIEWED**

The toxicity of arsenical compounds decreases as follows: arsine (-III) > organo-arsine derivatives > arsenites (+III) > arsenoxides > (+III) > arsenates (+V) > pentavalent organic compounds (+V) > arsonium metals (+I) > **metallic arsenic (**0). /Arsenical cmpd/
[Nat'l Research Council Canada; Effects of Arsenic in the Canadian Environment p.20 (1978) NRCC No. 15391]**PEER REVIEWED**

The wrists are common sites of dermatitis, as are the genitalia if personal hygiene is poor. /**Arsenic** and **arsenic** cmpd/
[Sittig, M. Handbook of Toxic And Hazardous Chemicals. Park Ridge, NJ: Noyes Data Corporation, 1981. 59]**PEER REVIEWED**

Chronic arsenical poisoning due to ingestion is rare and generally confined to patients taking prescribed medications. However, it can be a concomitant of inhaled inorganic **arsenic** from swallowed sputum and improper eating habits. /**Arsenic** and **arsenic** cmpd/
[Sittig, M. Handbook of Toxic And Hazardous Chemicals. Park Ridge, NJ: Noyes Data Corporation, 1981. 59]**PEER REVIEWED**

Trivalent **arsenic** compounds are corrosive to the skin. /Inorganic **arsenic** compounds/
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 87]**PEER REVIEWED**

Cases of acute arsenical poisoning due to inhalation are exceedingly rare in industry. ... Resp tract symptoms: cough, chest pain, dyspnea-giddiness, headache, and extreme general weakness precede GI symptoms. The acute toxic symptoms of trivalent arsenicals poisoning are due to severe inflammation of the mucous membranes and greatly incr permeability of the blood capillaries. /Inorganic **arsenic** compounds/
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 88]**PEER REVIEWED**

CHRONIC POISONING CAN RESULT IN EXFOLIATION & PIGMENTATION OF SKIN, HERPES, ... /SRP: POLYNEUROPATHY/ ALTERED HEMATOPOIESIS, DEGENERATION OF LIVER & KIDNEYS. /**ARSENIC**/
[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 126]**PEER REVIEWED**

Arsenical dusts ... encountered in smelting of ores & ... agriculturally, are irritating to upper resp tract & eyes. The conjunctivitis produced ... is characterized by itching, burning, & watering of the eyes, with photophobia & sometimes hyperemia & chemosis. ... In chronic ... poisoning ... rarely ... keratitis ... accompanying conjunctivitis and exfoliative dermatitis. /**Arsenic** & Arsenical dust/
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 115]**PEER REVIEWED**

... PERIPHERAL DISTURBANCES INDICATIVE OF ENDO ANGIITIS--GANGRENE OF EXTREMITIES, ATROPHIC ACRODERMATITIS ... . /**ARSENIC**/
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969. 51]**PEER REVIEWED**

MOST FORMS OF **ARSENIC** ARE HIGHLY TOXIC. /**ARSENIC**/
[The Merck Index: An Encyclopedia of Chemicals and Drugs 8th ed. Rahway, New Jersey: Merck and Co., Inc., 1968. 953]**PEER REVIEWED**

Arsenic-associated lung cancers are usually the poorly differentiated type of epidermoid bronchogenic carcinoma. Worker groups with diagnosed lung cancer were studied in copper smelting communities in Montana. Of 25 smelter workers, 4 had well differentiated epidermoid carcinomas, 10 had poorly differentiated epidermoid carcinomas, 7 had small cell undifferentiated epidermoid carcinomas, and 3 had acinar-type adenocarcinomas. /**Arsenic**/
[USEPA; Health Assessment Document: Inorganic Arsenic p.7-71 (1984) EPA 600/8-83-021]**PEER REVIEWED**

It was suggested that the excess cancer mortality in Butte, /Montana/ might be attributable to community air pollution arising from the sanding material, /containing **arsenic**,/ used on city streets during the winter. /**Arsenic**/
[NIOSH; Criteria Document: Inorganic Arsenic p.50 (1975) DHEW Pub. NIOSH 75-149]**PEER REVIEWED**

Sister chromatid exchanges (SCE) do not seem to be a substantial endpoint for assessing the action of metals on human genetic material, although significantly increased sister chromatid exchange rates have been reported in persons exposed to **arsenic** compounds. /**Arsenic** cmpd/
[Gebhart E; Carcinogen Mut Metal Cmpd 213-25 (1985)]**PEER REVIEWED**

Arsenic is the most common cause of pesticide-induced deaths in children and is the most common

cause of heavy-metal related death, second only to lead. Ant pastes are a major source of exposure. /**Arsenic**/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 101]**PEER REVIEWED**

SMALL DOSES OF INORG **ARSENIC** INDUCE MILD VASODILATION. ... LARGER DOSES EVOKE CAPILLARY DILATATION; INCREASED CAPILLARY PERMEABILITY MAY OCCUR IN ALL CAPILLARY BEDS, BUT IT IS MOST PRONOUNCED IN THE SPLANCHNIC AREA. TRANSUDATION OF PLASMA MAY ALSO OCCUR, AND THE DECR IN INTRAVASCULAR VOLUME MAY BE SIGNIFICANT. MYOCARDIAL DAMAGE AND HYPOTENSION APPEAR LATER. ECG ABNORMALITIES MAY PERSIST FOR MONTHS AFTER RECOVERY FROM ACUTE INTOXICATION. /INORGANIC **ARSENIC** COMPOUNDS/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1660]**PEER REVIEWED**

CHRONIC EXPOSURE TO INORG ... ARSENICALS MAY CAUSE PERIPHERAL ... /NEUROPATHY/ IN SEVERE CASES, SPINAL CORD MAY ALSO BE INVOLVED. AFTER ACUTE INGESTION OF TOXIC DOSES OF INORG **ARSENIC**, APPROX 5% OF THE PATIENTS HAVE CENTRAL DEPRESSION WITHOUT GI SYMPTOMS. /INORGANIC **ARSENIC** COMPOUNDS/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1661]**PEER REVIEWED**

Inorganic arsenicals affects the bone marrow & alter the cellular composition of the blood. Hematological evaluation usually reveals anemia with slight to moderate leukopenia; eosinophilia may also be present. Anisocytosis becomes evident with incr exposure to **arsenic**. The vascularity of bone marrow is incr. Some of the chronic hematological effects may result from impaired absorption of folic acid. /Inorganic **arsenic** compounds/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1661]**PEER REVIEWED**

INORG ARSENICALS ... ARE PARTICULARLY TOXIC TO THE LIVER & PRODUCE FATTY INFILTRATION, CENTRAL NECROSIS, & CIRRHOSIS ... DAMAGE MAY BE MILD OR SO SEVERE THAT ACUTE YELLOW ATROPHY & DEATH ENSUE. THE INJURY IS GENERALLY TO HEPATIC PARENCHYMA. ... /INORGANIC **ARSENIC** COMPOUNDS/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1661]**PEER REVIEWED**

Arsenic causes chromosomal breaks in cultured human leukocytes. ... There is ... epidemiological evidence that chronic ingestion of **arsenic** in drinking water or chronic exposure from the use of inorganic arsenicals in sheep dip or vineyard sprays predisposes to intraepidermal squamous cell and superficial basal cell carcinomas of the skin. Among metal workers, there is a strong correlation between the intensity and duration of exposure to **arsenic** and lung cancer. ... hemangiosarcoma has been found to occur in vineyard workers who are chronically exposed to **arsenic**. /Inorganic **arsenic** compounds/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1661]**PEER REVIEWED**

/ACUTE POISONING EFFECTS:/ BURNING LIPS, CONSTRICTION OF THE THROAT, AND DIFFICULTY IN SWALLOWING MAY BE THE FIRST SYMPTOMS, FOLLOWED BY

EXCRUCIATING GASTRIC PAIN, PROJECTILE VOMITING, AND SEVERE DIARRHEA. OLIGURIA WITH PROTEINURIA AND HEMATURIA IS USUALLY PRESENT; EVENTUALLY ANURIA MAY OCCUR. THE PATIENT OFTEN COMPLAINS OF MARKED SKELETAL MUSCLE CRAMPS AND SEVERE THIRST. AS THE LOSS OF FLUID PROCEEDS, SYMPTOMS OF SHOCK APPEAR. HYPOXIC CONVULSIONS MAY OCCUR TERMINALLY, & COMA & DEATH ENSUE. IN SEVERE POISONING, DEATH CAN OCCUR WITHIN AN HR, BUT THE USUAL INTERVAL IS 24 HR. /INORGANIC **ARSENIC** COMPOUNDS/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1661]**PEER REVIEWED**

The most common early signs of chronic **arsenic** poisoning are muscle weakness & aching, skin pigmentation ... hyperkeratosis, & edema. ... Garlic odor of the breath & perspiration, excessive salivation & sweating, stomatitis, generalized itching, sore throat, coryza, lacrimation, numbness, burning or tingling of the extremities, dermatitis, vitiligo, & alopecia. /Inorganic **arsenic** compounds/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1661]**PEER REVIEWED**

CHRONIC ... POISONING, WHETHER BY INGESTION OR INHALATION, MAY MANIFEST ITSELF IN MANY DIFFERENT WAYS. THERE MAY BE DISTURBANCES OF DIGESTIVE SYSTEM ... CRAMPS, NAUSEA, CONSTIPATION OR DIARRHEA. LIVER DAMAGE MAY OCCUR, RESULTING IN JAUNDICE. /INORGANIC **ARSENIC** COMPOUNDS/
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 275]**PEER REVIEWED**

Acute **arsenic** poisoning, by interfering with cellular respiration, may produce an electrocardiographic picture of mycocardial ischemia and may be associated with focal myocardial hemorrhage, although in pt who recover there are no cardiac symptoms. /Inorganic **Arsenic** compounds/
[Haddad, L.M. and Winchester, J.F. Clinical Management of Poisoning and Drug Overdosage. Philadelphia, PA: W.B. Saunders Co., 1983. 95]**PEER REVIEWED**

Congenital malformations were observed in children whose mothers worked, during pregnancy, at a Swedish copper smelter and were exposed to **arsenic**, other heavy metals and sulfur dioxide. The observed incidence /of malformations/ was 5 times higher than that in children born to other mothers from the same region. /Inorganic **arsenic** compounds/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 66]**PEER REVIEWED**

LIVER HEMANGIOENDOTHELIOMA WAS REPORTED ... /IN CASE WHERE **ARSENIC** WAS FOUND IN DRINKING WATER/. /INORGANIC **ARSENIC** COMPOUNDS/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 103 (1980)]**PEER REVIEWED**

... A PROPORTIONATE MORTALITY OF WORKERS INVOLVED IN MFR OF SHEEP-DIP CONTAINING INORG ARSENICALS ... HAD MEDIAN **ARSENIC** EXPOSURES RANGING FROM 71-696 UG/M3. ... EXCESS OF DEATHS FROM CANCERS OF LUNG & SKIN WAS OBSERVED AMONG HEAVILY-EXPOSED BUT NOT AMONG UNEXPOSED WORKERS IN THE FACTORY. /INORGANIC **ARSENIC** COMPOUNDS/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 105 (1980)]**PEER REVIEWED**

Airborne metallic particulates are associated with fossil-fueled power plants, automobile exhausts, metal mining and metallurgical smelters. The possible toxic effects of metals on the lung are of environmental and occupational concern. In this investigation the effects of in vitro exposure to metallic ions on the following parameters were determined: O2 consumption and membrane integrity of alveolar macrophages and Type II cells, and chemiluminescence of zymosan-stimulated alveolar macrophages. ... Short term in vitro exposure to As(5+) ... had little effect on alveolar macrophages and Type II cells. Although the data suggested that exposure to certain metals may have been harmful to the lung, the pulmonary parameters tested in this investigation displayed differing susceptibility to metal exposure. ... /Inorganic **arsenic** cmpd/
[Castranova V et al; J Toxicol Environ Health 13 (4-6): 845-56 (1984)]**PEER REVIEWED**

CANCERS RESULTING FROM EXPOSURE TO **ARSENIC** USUALLY INVOLVE ... BONE STRUCTURE & LUNG. DESPITE PREDOMINANCE ... IN LUNG & FACE, TUMORS ARE ALSO LIKELY TO OCCUR IN SCROTUM, BUTTOCKS, ABDOMEN, CLAVICLE, & LOWER CHEST. /INORGANIC **ARSENIC** COMPOUNDS/
[Casarett, L.J., and J. Doull. Toxicology: The Basic Science of Poisons. New York: MacMillan Publishing Co., 1975. 219]**PEER REVIEWED**

INGESTION CAUSES IRRITATION OF STOMACH, WEAKNESS, OTHER GI SYMPTOMS. OVERDOSE CAN CAUSE **ARSENIC** POISONING, BUT SYMPTOMS ARE DELAYED. /INORGANIC **ARSENIC** COMPOUNDS/
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

SMALL DOSES OF INORG **ARSENIC** INDUCE MILD VASODILATION. LARGE DOSES EVOKE CAPILLARY DILATATION; INCREASED CAPILLARY PERMEABILITY MAY OCCUR IN ALL CAPILLARY BEDS, BUT IT IS MOST PRONOUNCED IN THE SPLANCHNIC AREA. TRANSUDATION OF PLASMA AND A SHARP DIMINUTION IN BLOOD VOLUME RESULT. ARTERIOLAR AND MYOCARDIAL DAMAGE APPEARS LATER, AND THE BLOOD PRESSURE FALLS PROFOUNDLY. ECG ABNORMALITIES MAY PERSIST FOR MONTHS AFTER RECOVERY FROM ACUTE INTOXICATION. /INORGANIC **ARSENIC**/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1660]**PEER REVIEWED**

INORG ARSENICALS AFFECT BONE MARROW & ALTER CELLULAR COMPOSITION OF BLOOD. VASCULARITY OF BONE MARROW IS INCREASED. MODERATE DOSES ... LOWER ERYTHROCYTE COUNT & LARGE DOSES CAUSE MORPHOLOGICAL CHANGES WITH APPEARANCE OF MEGALOCYTES & MICROCYTES. INORGANIC ARSENICALS ALSO SUPPRESS PRODUCTION OF LEUKOCYTES. SOME OF THE CHRONIC HEMATOLOGICAL EFFECTS MAY RESULT FROM IMPAIRED ABSORPTION OF FOLIC ACID. /INORGANIC ARSENICALS/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1661]**PEER REVIEWED**

INORG ARSENICALS ... ARE PARTICULARLY TOXIC TO LIVER & PRODUCE FATTY INFILTRATION, CENTRAL NECROSIS, & CIRRHOSIS ... DAMAGE MAY BE MILD OR SO SEVERE THAT ACUTE YELLOW ATROPHY & DEATH ENSUE. INJURY IS GENERALLY TO THE HEPATIC PARENCHYMA ... . /INORG ARSENICALS/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York,

NY: McGraw-Hill, 1996. 1661]**PEER REVIEWED**

EPIDEMIOLOGICAL EVIDENCE THAT LONG TERM INGESTION OF **ARSENIC** IN DRINKING WATER ... PREDISPOSES TO INTRAEPIDERMAL SQUAMOUS CELL & SUPERFICIAL BASAL CELL CARCINOMAS OF THE SKIN ... . /**ARSENIC**/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1661]**PEER REVIEWED**

MOST COMMON EARLY SIGNS OF CHRONIC **ARSENIC** POISONING ARE ... GARLIC ODOR OF BREATH & PERSPIRATION, EXCESSIVE SALIVATION & SWEATING, STOMATITIS, GENERALIZED ITCHING, SORE THROAT, CORYZA, LACRIMATION, NUMBNESS, BURNING OR TINGLING OF EXTREMITIES, DERMATITIS, VITILIGO, & ALOPECIA. ... BONE MARROW IS SERIOUSLY INJURED BY **ARSENIC**. WITH SEVERE EXPOSURE, ALL HEMATOLOGICAL ELEMENTS MAY BE AFFECTED. /**ARSENIC**/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1661]**PEER REVIEWED**

In all cases the toxic moiety is presumably trivalent **arsenic**, in the form of inorganic arsenious acid (arsenite) or an organic arsenoxide, rather than the element itself. ... In vivo conversion /of pentavalent arsenicals/ may explain why all chemical forms of **arsenic** eventually produce the same toxic syndrome. /**Arsenic**/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-43]**PEER REVIEWED**

... Studies testing trivalent and pentavalent **arsenic** compounds by oral administration or skin application have not shown potential for either promotion or initiation of carcinogenicity. /Trivalent and pentavalent aresnic cmpds/
[Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 632]**PEER REVIEWED**

IRRITANT & VESICANT ARSENICAL COMPOUNDS, SUCH AS **ARSENIC** TRIOXIDE, **ARSENIC** TRICHLORIDE, & THE ARSENICAL WAR GASES, HAVE BEEN KNOWN TO CAUSE SEVERE DAMAGE TO THE RESPIRATORY SYSTEM UPON INHALATION. SYMPTOMS INCLUDE COUGH, DYSPNEA, & PAIN IN THE CHEST. /**ARSENIC** COMPD/
[Friberg, L., G.R. Nordberg, and V.B. Vouk. Handbook on the Toxicology of Metals. New York: Elsevier North Holland, 1979. 304]**PEER REVIEWED**

/ACUTE POISONING EFFECTS:/ URINE IS SCANTY, ALBUMINOUS, & BLOODY; EVENTUALLY ANURIA MAY OCCUR. ... AS FLUID LOSS PROCEEDS, SYMPTOMS OF SHOCK APPEAR. HYPOXIC CONVULSIONS MAY OCCUR TERMINALLY, & COMA & DEATH ENSUE. IN SEVERE POISONING, DEATH CAN OCCUR WITHIN AN HOUR, BUT THE USUAL INTERVAL IS 24 HR. /**ARSENIC**/
[Gilman, A. G., L. S. Goodman, and A. Gilman. (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 6th ed. New York: Macmillan Publishing Co., Inc. 1980. 1631]**PEER REVIEWED**

If ocular exposure occurs, they cause immediate pain, blepharospasm, and rapid formation of eyelid edema. /Arsenical vesicants/
[Sullivan, J.B. Jr., G.R. Krieger (eds.). Hazardous Materials Toxicology-Clinical Principles of Environmental Health. Baltimore, MD: Williams and Wilkins, 1992. 995]**PEER REVIEWED**

A follow-up study of the population living in the area of Taiwan, where a high prevalence of skin cancer

was associated with **arsenic** contamination in the water supply, also found significantly elevated standard mortality ratios for cancers of the bladder, lung, liver, kidney, and colon. Like skin cancer, the incidence of bladder, liver, and lung cancer cases in this study showed a dose-related increase with **arsenic** exposure. These studies strongly suggest that ingestion of inorganic **arsenic** is associated with cancers in the bladder, kidney, lung, liver, and possibly other sites. /**Arsenic** compounds/
[Chang, L.W. (ed.). Toxicology of Metals. Boca Raton, FL: Lewis Publishers, 1996,p. 222-3]**PEER REVIEWED**

Sublethal **arsenic** poisoning has resulted in renal necrosis and insufficiency. In the contaminated powered milk incident in Mormaga, renal injury was diagnosed by the presence of hematuria, leukocytaria, and glycosuria ... . Proteinuria has also been described secondary to ingestion of ground water contaminated by an **arsenic** plant. /**Arsenic** cmpds/
[Chang, L.W. (ed.). Toxicology of Metals. Boca Raton, FL: Lewis Publishers, 1996,p. 427-8]**PEER REVIEWED**

Liver enlargement was reported in 35.5% of individuals exposed to an average As concentration of 0.64 mg/l in drinking water, whereas people exposed to 0.2 1 mg/l were unaffected ... . Histological examination of livers of individuals chronically exposed to similar levels has revealed a consistent finding of portal tract fibrosis ... leading, in some cases, to portal hypertension and bleeding from esophageal varices. This effect may also occur after acute exposures to higher doses. ... It has been suggested that these hepatic effects are secondary to damage to the hepatic blood vessels. /**Arsenic** compounds/
[Chang, L.W. (ed.). Toxicology of Metals. Boca Raton, FL: Lewis Publishers, 1996 427]**PEER REVIEWED**

Clinical signs of gastrointestinal irritation, including nausea, vomiting, diarrhea, and abdominal pain have been reported in most cases of acute high dose exposure to inorganic **arsenic** ... . Less severe symptoms are also frequently observed in individuals with longer term lower dose exposures via drinking water ... . These effects are usually not detectable at medium term As exposure levels between 0.050 and 0.393 mg/l ... and generally decline within a short time after exposure ceases. /Inorganic **arsenic**/
[Chang, L.W. (ed.). Toxicology of Metals. Boca Raton, FL: Lewis Publishers, 1996 427]**PEER REVIEWED**

Anemia and leukopenia are common effects of **arsenic** poisoning in humans and have been reported following acute, subchronic, and chronic oral exposures. ... **Arsenic** intoxication also causes myelodysplastic syndrome involving dysmyelopoietic changes in all three marrow cell lines. Hematological effects are usually not observed in humans exposed to As levels of 0.07 mg/kg/day or less, although subacute exposure for 2 to 3 weeks to 0.05 mg/kg/day resulted in mild anemia. /**Arsenic** cmpd/
[Chang, L.W. (ed.). Toxicology of Metals. Boca Raton, FL: Lewis Publishers, 1996 428]**PEER REVIEWED**

Cultured human umbilical endothelium was incubated with various concentrations of o-arsenilic acid and ergotamine tartrate for 72 hr. At the end of incubation, medium was removed for the determination of 6-keto-PGF1 alpha concentration ... arsenate (0.1 to 10.0 uM) showed inhibition (17 to 24%) on the PGI2 production. Arsenate in low and high concentrations does not play an important role on prostacyclin synthesis in human umbilical endothelium. /Arsenate/
[Mak OT et al; Cell Biol Int Rep 10 (4): 287-93 (1986)]**PEER REVIEWED**

The strongest evidence that **arsenic** is responsible for the observed lung cancer comes from quantitative dose-response data relating specific **arsenic** exposure levels to lung cancer risk. These data are available for **arsenic**-exposed workers /via inhalation/ at the ASARCO copper smelter in Tacoma, WA ... the

Anaconda copper smelter in MT ... eight other US copper smelters ... and the Ronnskar copper smelter in Sweden ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 44 (2000)]**PEER REVIEWED**

Workers exposed to **arsenic** dusts in air often experience irritation to the mucous membranes of the nose and throat. This may lead to laryngitis, bronchitis, or rhinitis ... and very high exposures (characteristic of workplace exposures in the past) can cause perforation of the nasal septum ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic (Update) p.32 (2000)]**PEER REVIEWED**

A cross-sectional study incl 46 workers in Denmark with varying, unquantified occupational exposure to **arsenic** in different occupations found that systolic blood pressure was significantly incr in the **arsenic** workers (median = 125 mmHg) compared with controls (median = 117 mmHg) ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic (Update) p.34 (2000)]**PEER REVIEWED**

... reported a significant incr in respiratory cancer mortality (standard mortality ratio [SMR] = 189.4) based on 104 observed respiratory cancer deaths and only 54.9 expected over the years 1941-1976 in a cohort of 2,802 male workers employed for at least 1 yr between 1940 and 1964 at the ASARCO smelter. When the cohort was separated into low and high **arsenic** exposure groups, with mean estimated time-weighted avg **arsenic** exposures of 0.054 and 0.157 mg As/m3, respectively ... respiratory cancer mortality was significantly incr in both groups in a concn-related fashion (SMR = 227.7 and 291.4 in the low and high groups, respectively). /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 44 (2000)]**PEER REVIEWED**

Respiratory cancer mortality was significantly incr (SMR = 285) based on 302 observed respiratory deaths between 1938 and 1977 in a cohort of 8,045 white male workers employed for at least 1 yr between 1938 and 1956 at the Anaconda smelter ... . When workers were categorized according to cumulative **arsenic** exposure and date of hire, lung cancer mortality was significantly incr in all groups hired between 1925 and 1947. Workers in the lowest cumulative exposure group (<10 mg-mo/cu m) were reported to have had less than 2 yr exposure at an avg **arsenic** concn of 0.38 mg/cu m. /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 44 (2000)]**PEER REVIEWED**

... studied the mortality experience from 1949 to 1980 of a cohort of 6,078 white males who had worked for 3 yr or more between 1946 and 1976 at one of eight US copper smelters in AZ, UT, TN, and NV. Lung cancer mortality was significantly incr only in the Utah smelter (SMR = 226.7), which had the highest avg **arsenic** exposure concn (0.069 mg/cu m vs 0.007=0.013 mg/cu m in the other smelters) and also contributed the largest number of cohort members (n=2,288 vs 189-965 from the other smelters). /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 45 (2000)]**PEER REVIEWED**

... reported significantly incr lung cancer mortality (SMR = 372, 95% CI = 304-450) based on 106 lung cancer deaths in a cohort of 3,916 male workers employed for at least 3 mo between 1928 and 1967 at the Ronnskar smelter and followed for mortality through 1981. Workers were separated into low, medium, and high **arsenic** exposure groups with mean time-weighted avg exposure estimates of 0.05, 0.2, and 0.4 mg/cu m, respectively. Lung cancer mortality was significantly incr in all three exposure groups in a concn-related fashion (SMR = 201, 353, and 480, respectively). /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 45 (2000)]**PEER REVIEWED**

Two people in a family of eight died from ingestion of water containing about 110 ppm of **arsenic** for a week ... . This corresponded to a dose of about 2 mg As/kg/day. /Inorganic arsenicals/

[DHHS/ATSDR; Toxicological Profile for Arsenic p. 103 (2000)]**PEER REVIEWED**

Five children between the ages of 2 and 7 yr died from late sequelae of chronic **arsenic** poisoning after drinking contaminated water throughout their lives at est avg doses of 0.05-0.1 mg As/kg/day ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 103 (2000)]**PEER REVIEWED**

A 22-yr old man with chronic arsenical dermatosis died from **arsenic**-related effects after lifetime exposure to an est avg dose of 0.014 mg As/kg/day in the drinking water ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 103 (2000)]**PEER REVIEWED**

Serious respiratory effects, incl respiratory distress, hemorrhagic bronchitis, and pulmonary edema, have been reported in some cases of acute oral **arsenic** poisoning at doses of 8 mg As/kg and above ... . These effects may be secondary to injury to the pulmonary vasculature ... . In addition, bronchitis and sequelae ... have been observed at autopsy in some chronic poisoning cases ... . Bronchopneumonia secondary to **arsenic**-induced bronchitis was considered to be the cause of death in one young child who died after several yr of exposure to an avg dose of 0.08 mg As/kg/day ... . In general, however, respiratory effects have not been widely assoc with repeated oral ingestion of low **arsenic** doses. Nevertheless, a few studies have reported minor respiratory symptoms, such as cough, sputum, rhinorrhea, and sore throat, in people with repeated oral exposure to 0.03-0.05 mg As/kg/day ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 104 (2000)]**PEER REVIEWED**

Characteristic effects on the heart from both acute and long-term /oral/ exposure incl altered myocardial depolarization (prolonged Q-T interval, nonspecific S-T segment changes) and cardiac arrhythmias ... . Hypertrophy of the ventricular wall was observed at autopsy after acute exposure to 93 mg As ... . Long-term low-level exposures may also lead to damage to the vascular system. The most dramatic example of this is "Blackfoot disease", a condition that is endemic in an area of Taiwan where avg drinking water levels of **arsenic** range from 0.17 to 0.80 ppm ... corresponding to doses of about 0.014-0.065 mg As/kg/day ... The disease is characterized by a progressive loss of circulation in the hands and feet, leading ultimately to necrosis and gangrene ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 105 (2000)]**PEER REVIEWED**

Clinical signs of GI irritation, incl nausea, vomiting, diarrhea, and abdominal pain, are observed in essentially all cases of acute high-dose /oral/ exposures to inorganic **arsenic** ... . Similar signs are also frequently observed in groups or individuals with longer-term lower-dose exposures ..., but effects are usually not detectable at exposure levels below about 0.01 mg As/kg/day ... . These symptoms generally decline within a short time after exposure ceases. ... More severe symptoms (hematemesis, hemoperitoneum, GI hemorrhage, and necrosis) have been reported in some cases with acute exposure to 8 mg As/kg or more ... and also in some people with long-term ingestion of 0.03-0.05 mg As/kg/day as a medicinal preparation ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 106 (2000)]**PEER REVIEWED**

Anemia and leukopenia are common effects of /oral/ **arsenic** poisoning in humans, and have been reported following acute ... intermediate ... and chronic oral exposure ... at doses of 0.05 mg As/kg/day or more. These effects may be due to both a direct cytotoxic or hemolytic effect on the blood cells ... and a suppression of erythropoiesis ... . However, hematological effects are not observed in all cases of **arsenic** exposure ... or even all acute poisoning cases ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 108 (2000)]**PEER REVIEWED**

A number of studies in humans exposed to inorganic **arsenic** by the oral route have noted signs or symptoms of hepatic injury. Clinical exam often reveals that the liver is swollen and tender ... and analysis of blood sometimes shows elevated levels of heptic enzymes ... . These effects are most often

observed after repeated exposure to doses of 0.01-0.1 mg As/kg/day ... although doses as low as 0.006 mg As/kg/day have been reported to be effective with chronic exposure ... . Hepatic effects have also been reported in acute bolus poisoning cases at doses of 2 mg As/kg/day or more ... although acute exposure to 19 mg As/kg did not cause hepatic effects in an infant ... . Histological exam of the livers of persons chronically exposed to similar doses has revealed a consistent finding of portal tract fibrosis ... leading in some cases to portal hypertension and bleeding from esophageal varices ... . Several researchers consider that these hepatic effects are secondary to damage to the hepatic blood vessels ... but this is not directly established. /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 109 (2000)]**PEER REVIEWED**

One of the most common and characteristic effects of **arsenic** ingestion is a pattern of skin changes that incl generalized hyperkeratosis and formation of hyperkeratotic warts or corns on the palms and soles, along with areas of hyperpigmentation interspersed with small areas of hyperpigmentation on the face, neck, and back. ... In cases of low-level chronic exposure (usually from water), these skin lesions appear to be the most sensitive indication of effect, so this end point is considered to be the most appropriate basis for establishing a chronic oral MRL. This is supported by the finding that other effects (hepatic injury, vascular disease, neurological effects) also appear to have similar thresholds. ... numerous studies in humans have reported dermal effects at chronic dose levels ranging from about 0.01 to 0.1 mg As/kg/day ... .Several epidemiological studies of moderately sized populations (20-200 people) exposed to **arsenic** through drinking water have detected no dermal or other effects at avg chronic doses of 0.0004-0.01 mg As/kg/day ... and one very large study (based on 17,000 people) detected no effects in any person at an avg total daily intake (from water plus food) of 0.0008 mg As/kg/day ... . This value has been used to calculate a chronic oral MRL for inorganic **arsenic** of 0.0003 mg/kg/day ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 112 (2000)]**PEER REVIEWED**

Periorbital swelling was reported in people drinking contaminated well water at an approx dose of 0.2 mg As/kg for 1 wk ... . Facial edema, generally involving the eyelids, was a prominent feature of **arsenic** poisoning among 220 cases assoc with an episode of **arsenic** contamination of soy sauce in Japan ... . Exposure was to an est dose of 0.05 mg/kg/day and lasted for up to 2-3 wk. The edema developed soon after the initial exposure and then subsided. This effects forms the basis (in part) for the provisional acute oral MRL of 0.005 mg/kg/day for inorganic **arsenic** ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 113 (2000)]**PEER REVIEWED**

A large number of epidemiological studies and case reports indicate that ingestion of inorganic **arsenic** can cause injury to the nervous system. Acute, high-dose exposures (2 mg As/kg/day of above) often lead to encephalopathy, with signs and symptoms such as headache, lethargy, mental confusion, hallucination, seizures, and coma ... . Repeated exposures to lower levels (0.03-0.01 mg As/kg/day) are typically characterized by a symmetrical peripheral neuropathy ... . This neuropathy usualy begins as a numbness in the hands and feet, but later may develop into a painful "pins and needles" sensation. Both sensory and motor nerves are affected, and muscle weakness often develops, sometimes leading to wrist-drop or ankle-drop ... . Diminished sensitivity to stimulation and abnormal patellar reflexes have also been reported ... . Histological exam of nerves from affected individuals reveals a dying-back axonopathy with demyelination ... . Some recovery may occur following cessation of exposure, but this is a slow process and recovery is usually incomplete ... . Peripheral neuropathy is also sometimes seen following acute high-dose eposures, with or without the previously described encephalopathy ... . Neurological effects were not generally found in populations chronically exposed to doses of 0.006 mg As/kg/day or less ... although fatigue, headache, dizziness, insomnia, nightmare, and numbness of the extremities were among the symptoms reported at 0.005, but not 0.004 mg As/kg/day in a study of 31,141 inhabitants of 77 villages in Xinjiang, China ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 115 (2000)]**PEER REVIEWED**

A 52-yr old Vietnamese woman ingested an unspecified amt of organic **arsenic** in the form of bird's nest soup, resulting in numbness and tingling of the fingertips, toes, and circumoral region. Discontinuation of exposure resulted in the disappearance of symptoms ... . /Organic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 116 (2000)]**PEER REVIEWED**

There is convincing evidence from a large number of epidemiological studies and case reports that ingestion of inorganic **arsenic** incr the risk of developing skin cancer ... . Lesions commonly observed are multiple squamous cel carcinomas, which appear to develop from some of the hyperkeratotic warts or corns ... . In addition, multiple basal cell carcinomas may occur, typically arising from cells not assoc with hyperkeratinization. In most cases, skin cancer develops only after prolonged exposure, but several studies have reported skin cancer in people exposed for less than 1 yr ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 120 (2000)]**PEER REVIEWED**

... investigated bladder cancer mortality for the years 1986-1991 in the 26 counties of Cordoba, Argentina. Rates for all of Argentina were used as the standard for comparison. Several areas of Argentina have had high exposure to **arsenic** from naturally contaminated drinking water, particularly the eastern region of the province of Cordoba. Bladder cancer SMRs were consistently higher in counties with documented **arsenic** exposure. The clear trends found in this Argentina population with different genetic composition and a high-protein diet support the findings in Taiwan of dose-response relation between ingestion of inorganic **arsenic** from drinking water and bladder cancer. /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 125 (2000)]**PEER REVIEWED**

Dilation of splanchnic vessels causes submucosal vesicle formation. Rupture of these vesicles leads to rice-water stools & bleeding. Subsequently, a protein-losing enteropathy may develop. Despite aggressive management of **arsenic** intoxication & a rapid decr in blood & urine **arsenic** levels, neurologic defects may persist. It appears that distribution into neural tissue is rapid & may be irreversible even with chelation. /**Arsenic**/
[Ellenhorn, M.J., S. Schonwald, G. Ordog, J. Wasserberger. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. 2nd ed. Baltimore, MD: Williams and Wilkins, 1997. 1541]**PEER REVIEWED**

Arsenic exposure has been associated with 3 types of skin cancer: Bowen's disease, basal cell carcinoma, & squamous cell carcinoma. These cancers are frequently multiple in origin & develop primarily from arsenical keratoses. the prevalence of **arsenic**-related skin cancer appears to be related to the total absorbed dose. Excess mortality form **arsenic**-induced skin cancer has been observed in the chemical & wine-producing industries & as a result of consumption of contaminated water. Numerous cases of skin cancer have been attributed to the use of medications containing **arsenic**. /**Arsenic**/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 774]**PEER REVIEWED**

In September 1987, a previously healthy 43-yr old woman & her 45-yr old husband purchased a home in rural upstate NY. Water was supplied from a deep private well, & the water was free of bacterial contamination. In the 3 months that elapsed between the purchase of the home & moving in, the patient would drink 1 or 2 glasses of water on each visit to the property. She noticed the onset of nausea, diarrhea, & abdominal cramps. After she moved into the house, she continued her long-standing habit of drinking 8-10 glasses of water/day. Her GI symptoms worsened, & she also began to experience occasional parenthesis in the lower extremities & the right hand. Diarrhea became continuous & showed traces of blood. A diffuse, erythematous & scaly rash developed. Routine exam of stool for ova, parasites, & common infectious agents was negative. In November 1987, her laboratory testing showed leukopenia (white blood count 900 cells/dl), macrocytic anemia, & elevated liver enzymes. The platelet count was normal. Eventually; heavy metal toxicity was suspected, & a 24 hr urine sample was analyzed

for **arsenic** on December 7, 1987. It showed a urinary **arsenic** concn of 2260 mg/L; the patient had stopped drinking the well water 1 day before the urine collection. On December 10, 1987 the patient was admitted to a hospital for chelation therapy with 2,3-di-mercapto-1-propanol (BAL). Treatment lasted 11 days. The GI & mucous membrane symptoms abated during hospitalization. the skin rash disappeared after a few more weeks. Symptoms suggestive of neuropathy persisted many months. The index patient's husband, previously healthy, had a similar exposure history but consumed less water. His initial findings included GI symptoms, muscle pain in the lower extremities, generalized weakness, & tremor in the fingers. Additionally he experienced intermittent episodes of confusion & disorientation, mental sluggishness, & unusual visual sensations consisting of unformed images in the peripheral fields. He stopped drinking the water at approx. the same time as his wife. He also received chelation therapy with BAL. His symptoms diminished during chelation therapy, but trembling of the extremities persisted for a number of weeks. Results of EKG performed during hospitalization were normal. Environmental assessment consisted of testing the well water at the home for **arsenic**. In eight measurements undertaken between December 1987 & February 1988 inorganic **arsenic** concns ranged from 9000-10,900 mg/L. It was learned that the well drew its water from an abandoned iron-mining operation, & the **arsenic** appeared to have leaked into the water from the tailings from the mine. /**Arsenic**/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 774]**PEER REVIEWED**

Peripheral vascular disease has been observed among persons in Chile & Taiwan whose drinking water contained **arsenic** & also in smelter workers exposed long term to inorganic **arsenic**. Early symptoms include acrocyanosis & Reynaud's phenomenon. Those changes are associated with hyperpigmentation & hyperkeratosis & progress, in severe cases, to endarteritis obliterans, with frank gangrene of the extremities (black foot disease). In Chile, infants & children showed more pronounced vascular symptoms than adults, & myocardial infarction has been reported even in children. The prevalence & severity of peripheral vascular disease appears to be related to **arsenic** concn in water. Pathologic studies indicate that approx 30% of patients with black foot disease had thromboangitis obliterans & 70% showed evidence of atherosclerosis. Undernutrition may contribute to the development of black foot disease. Long-term **arsenic** ingestion appears also to be associated with cardiac disease. Case reports have been published of **arsenic**-associated myocarditis with arrhythmias. Mortality from cardiovascular disease, but not from cerebrovascular disease, is elevated in the **arsenic**-exposed population in Taiwan. /**Arsenic**/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 775]**PEER REVIEWED**

Human Toxicity Values:

Skin impacts from arsenical vesicant vapor occur at concentrations as low as 17 ppm (10 minute exposure). Eye impacts from arsenical vesicant vapor occur at concentrations as low as 3 ppm (10 minute exposure). Permanent eye damage may occur at concentrations as low as 18 ppm (10 minute exposure). LC50s for inhalation of arsenical vesicants are as low as 17 ppm (10 minute exposure). LD50s for skin exposure to liquid arsenical vesicants are as low as 2.8 gm per individual. /Vesicants - **Arsenic** Based/
[Ellison, D.H., Emergency Action for Chemical and Biological Warfare Agents. CRC Press, Boca Raton, FL 1999. 52]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Trivalent **arsenic** compounds are corrosive to the skin. /Trivalent **arsenic** cmpd/
[Sittig, M. Handbook of Toxic And Hazardous Chemicals. Park Ridge, NJ: Noyes Data Corporation, 1981. 58]**PEER REVIEWED**

ARSENICAL DUSTS ... ARE IRRITATING TO UPPER RESP TRACT & EYES. CONJUNCTIVITIS PRODUCED BY ... THESE SUBSTANCES ARE CHARACTERIZED BY ITCHING, BURNING, & WATERING OF EYES. ... /INORGANIC **ARSENIC** DUSTS/
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 115]**PEER REVIEWED**

Drug Warnings:

Vet: Therapeutic dosages of org arsenical cmpd may prove toxic if animal is debilitated or dehydrated. /Org arsenical cmpd/
[Clarke, E.G., and M. L. Clarke. Veterinary Toxicology. Baltimore, Maryland: The Williams and Wilkins Company, 1975. 37]**PEER REVIEWED**

Medical Surveillance:

A periodic sputum cytology examination is recommended for all workers occupationally exposed to inorganic **arsenic**. The frequency of this procedure should be determined by the responsible medical authority. /Inorganic **arsenic**/
[NIOSH; Criteria Document: Inorganic Arsenic p.3 (1975) DHEW Pub. NIOSH 75-149]**PEER REVIEWED**

In employment physical examinations, particular attention should be given to allergic and chronic skin lesions, eye disease, psoriasis, chronic eczematous dermatitis, hyperpigmentation of the skin, keratosis and warts, baseline weight, baseline blood and hemoglobin count, and baseline urinary **arsenic** determinations. Annual examination should include, general health, weight, and dermal checkup, and the worker observed for any evidence of excessive exposure or absorption of **arsenic** should be subjected to a detailed examination. Chest x-ray and lung function should be evaluated; analysis of the urine, hair, or nails for **arsenic** should be made every 60 days as long as exposure continues. /Inorganic **arsenic** cmpd/
[Sittig, M. Handbook of Toxic And Hazardous Chemicals. Park Ridge, NJ: Noyes Data Corporation, 1981. 59]**PEER REVIEWED**

220 Micrograms of total **arsenic**/g creatinine in urine is the recommended maximum permissible value. /**Arsenic** and cmpd/
[Lauwerys RR; Industrial Chemical Exposure: Guidelines for Biological Monitoring, Biomedical Publications, Davis, CA p134 (1983)]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Whenever medical surveillance is indicated, in particular when exposure to a carcinogen has occurred, ad hoc decisions should be taken concerning ... /cytogenetic and/or other/ tests that might become useful or mandatory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.23]**PEER REVIEWED**

Skin, ocular evaluation. Blood counts. Urinary **arsenic** levels. /**Arsenic** cmpd/
[Fuscaldo, A., B. J. Erlick, and B. Hindman. (eds.). Laboratory Safety-Theory and Practice. New York: Academic Press, 1980. 264]**PEER REVIEWED**

The determination of **arsenic** in hair, urine, in some cases blood or stomach contents, is useful for diagnosis if exposure to **arsenic** cannot be readily identified. /**Arsenic** cmpd/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 71]**PEER REVIEWED**

In pre-employment physical examinations, particular attention should be given to allergic and chronic

skin lesions, eye disease, psoriasis, chronic eczematous dermatitis, hyperpigmentation of the skin, keratosis and warts, baseline weight, baseline blood and hemoglobin count, and baseline urinary **arsenic** determinations. In annual examinations, the worker's general health, weight, and skin condition should be checked, and the worker observed for any evidence of excessive exposure or absorption of **arsenic**. Chest X-ray and lung function should be evaluated; analysis of the urine, hair, or nails for **arsenic** should be made every 60 days as long as exposure continues. /**Arsenic** and **arsenic** cmpd/
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 89]**PEER REVIEWED**

The assessment of inorganic & organic **arsenic** exposures can be accomplished through measurement of total **arsenic** ... . Since **arsenic**, both organic & inorganic, is cleared from the blood fairly rapidly, it is difficult to correlate levels with environmental exposure. In addition, when evaluating concns or **arsenic** in blood, interference from organic **arsenic** compounds originating from seafood must be considered. At present, there is no method for individually quantitating the two forms of **arsenic** (inorganic & organic) in blood. If blood levels are elevated, either the person should be questioned about seafood ingestion to rule out organic **arsenic** exposure, or analysis of urinary **arsenic** levels may be needed to quantitate inorganic **arsenic** only. Whole Blood Reference Ranges: Normal- Normal concentration in "unexposed" subjects is in the range of 1-4 ug/l. ...; Exposed- Not established; Toxic- Not established. ... If only a serum or plasma specimen is available, measurement of total **arsenic** can be performed ... . Serum or Plasma Reference Ranges: Normal- Not established, although normal serum levels are probably similar to whole blood levels due to equal distribution of **arsenic** in the blood; Exposed- Not established; Toxic- Not established. The assessment of inorganic **arsenic** exposure can be accomplished through measurement of inorganic **arsenic**, dimethylarsinic acid (DMAA) & methylarsonic acid (MAA). Some laboratories only measure total **arsenic** in the urine, in which both organic & inorganic forms will be measured. Assessment of organic **arsenic** exposure can be determined by direct measurement of arsenobetaine, & when compared to the total **arsenic** level can be used to rule out levels attributable to seafood. Studies have shown that measurement of inorganic **arsenic** is better for low exposure to **arsenic**, while measurements of inorganic **arsenic**, DMAA, & MAA are useful for assessing high level exposures. Urinary levels have been found to be useful for estimating exposure, but no information was found suggesting that urinary levels correlate with the onset of clinical effects. Urine Reference Ranges: Normal- Normal levels are generally below 100 ug/g creatinine; however, arsenobetaine from seafood may raise urinary **arsenic** levels to >100 ug/g creatinine; Exposed- Workers exposed to **arsenic** compounds at an air concn of 0.2 mg/cu m had average urinary **arsenic** levels of 500 ug/l or 220 ug/g creatinine. BEI (Suitable for exposure to **Arsenic** & Soluble Compounds, including Arsine) (sampling time is end of work week, measured as inorganic **arsenic** metabolites): 50 ug/g creatinine (Notice of Intent to Establish or Change: BEI ... 35 ug As/l). **Arsenic** concns in urine that have been found to correlate with workplace air concns are as follows: **Arsenic** Air Levels- 0.01, 0.05, 0.10 (mg/cu m) to Urinary **Arsenic** Levels (sampling time: end of exposure or end of shift) 50, 90, 130 (ug/l), respectively; Toxic- Not established. /Inorganic and organic **arsenic**/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 119]**PEER REVIEWED**

Respiratory Symptom Questionnaires: Questionnaires published by the American Thoracic Society (ATS) & the British Medical Research Council have proven useful for identifying people with chronic bronchitis. Certain pulmonary function tests such as the FEV1 have been found to be better predictors of chronic airflow obstruction. /Inorganic and organic **arsenic**/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 123]**PEER REVIEWED**

Chest Radiography: Chest radiographs are widely used to assess pulmonary disease. They are useful for detecting early lung cancer in asymptomatic people, & especially for detecting peripheral tumors such as

adenocarcinomas. However, even though OSHA mandates this test for exposure to some toxicants such asbestos, experts' views on the risk-to-benefit ratio in detection of pulmonary disease conflict, so routine annual chest x-rays are not recommended for all people. /Inorganic and organic **arsenic**/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 123]**PEER REVIEWED**

Pulmonary Function Tests: The tests that have been found to be practical for population monitoring include: Spirometry & expiratory flow-volume curves; Determination of lung volumes; Diffusing capacity for carbon monoxide; Single-breath nitrogen washout; Inhalation challenge tests; Serial measurements of peak expiratory flow; Exercise testing. /Inorganic and organic **arsenic**/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 123]**PEER REVIEWED**

Urine Albumin: Albuminuria has been shown to be a specific marker of glomerular dysfunction. Tubular damage, however, can also result in increased levels of albumin in the urine. /**Arsenic**/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 121]**PEER REVIEWED**

Urinary Beta-2-Microglobulin and/or Retinal Binding Protein: Measurements for the presence of either of these low molecular weight proteins are useful in detection of early impairment of proximal tubular function. However, beta-2-microglobulin is unstable at urinary pH less than 6, and may degrade in the bladder prior to collection and subsequent neutralization of the urine sample. Measurement of retinal binding protein appears to be a better marker for early tubular dysfunction due to its stability in the urine subsequent to collection and analysis. However, retinal binding protein is produced in the liver and not a constitutive protein of the kidney, so that its presence in the kidney provides only indirect evidence of tubular damage. /**Arsenic**/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 121]**PEER REVIEWED**

Urinary Alpha and Pi Isoenzymes of Glutathione S-Transferase: Radio-immunological and Elisa techniques have been developed for quantitation of /alpha/ and /pi/ isoenzymes of glutathione S-transferase, which are constitutive proteins in the kidney. The /alpha/ isoenzyme is located only in the proximal tubule, while the /pi/ isoenzyme is located in the distal convoluted tubule, the loop of Henle, and the collecting ducts of the kidney. Damage to epithelial cell membranes can result in the increased excretion of these isoenzymes in the urine. This test for assessing renal tubular damage appears to have many advantages over other available tests, such as: (1) the /alpha/ and /pi/ isoenzymes are constitutive proteins in the kidney; (2) these isoenzymes are stable in the urine; (3) the test is simple and reproducible; and (4) due to selective localization of the isoenzymes, differential diagnosis of specific tubular damage is possible. In addition, increased levels of these isoenzymes were seen in patients previously exposed to nephrotoxicants where conventional tests for kidney function were normal, indicating a high degree of sensitivity. /**Arsenic**/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 122]**PEER REVIEWED**

Urinary Enzyme N-Acetylglucosaminidase: This lysosomal enzyme has shown promise in assessment of subclinical nephrotoxic injury. This enzyme is not normally filtered at the glomerulus due to its high molecular weight. In the absence of glomerular injury, this enzyme will be detected in the urine as a result of leakage or exocytosis from damaged, stimulated, or exfoliated renal cells. The sensitivity of measurement for this enzyme has not been thoroughly studied, but it's usefulness has shown some promise. However, this enzyme is unstable at urinary pH >8, which could diminish the sensitivity of the measurement due to enzyme degradation. /**Arsenic**/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 122]**PEER REVIEWED**

Routine Urinalysis: Performing a routine urinalysis including parameters such as specific gravity, glucose, and microscopic examination may be useful for assessing renal toxicity. Cylinduria, or formation of various types of casts from material in the renal tubules, is detected only by microscopic analysis, but is often preceded by albuminuria or increases in white cells, red cells, or epithelial cells in the urine. Workers with potential exposure to nephrotoxins should have baseline, pre-exposure measurements of the parameters that will be selected for assessing early renal damage. Periodic measurement should be compared to the baseline results. The normal progression of chronic renal insufficiency usually takes several years to evolve, however glomerulonephritis can occur as early as several months. /**Arsenic**/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 122]**PEER REVIEWED**

Liver Function Tests: Biochemical tests - Enzymes that reflect cholestasis: alkaline phosphatase (AP), 5'-nucleotidase (5'-NT) & leucine aminopeptidase (LAP); Enzymes that detect direct hepatic damage: aspartate aminotransferase (AST), alanine aminotransferase (ALT) & gammma glutamyl Transpeptidase (GGTP); Clearance tests - indocyanine green, antipyrine test and serum bile acids. /**Arsenic**/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 122]**PEER REVIEWED**

Populations at Special Risk:

Evidence suggests that children may be at special risk for the effects of inorganic **arsenic** under conditions of acute or subacute exposure. /Inorganic **arsenic**/
[USEPA; Health Assessment Document: Inorganic Arsenic p.9-10 (1984) EPA 600/8-83-021]**PEER REVIEWED**

/Protect/ from exposure those individuals with diseases of skin, blood, liver, kidneys, central nervous system. /**Arsenic**/
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 51]**PEER REVIEWED**

Persons with existing diabetes, cardiovascular diseases, allergic or other skin diseases, neurologic, hepatic or renal lesions in **arsenic** work /are at special risk/. /**Arsenic**/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 182]**PEER REVIEWED**

Body Burden:

Normal adults from Glascow, Scotland had avg **arsenic** concns in hair of 0.650 ug/g (range, 0.20-8.17 ug/g; N=1,250)(1). The avg concn of **arsenic** in liver, lung, and spleen from postmortem adults were 0.048 ug/g (range, 0.011-0.152 ug/g), 0.044 ug/g (range, 0.0121-0.125 ug/g), and 0.015 ug/g (range, 0.001-0.063 ug/g), respectively(1). The avg concn of **arsenic** in liver, lung, and spleen from postmortem infants were 0.0099 ug/g (range, 0.0034-0.019 ug/g), 0.007 ug/g (range, 0.0011-0.015 ug/g), and 0.0049 ug/g (range, 0.0011-0.0088 ug/g), respectively(1). Residents from the Palatinate region of Germany had avg concns of **arsenic** in urine (24-hour) and hair of 3.96 ug/g (range, <0.1-18.32 ug/g) and 0.028 ug/g (range, <0.005-0.154 ug/g), respectively(2). Residents from the Saxony region of Germany had avg concns of **arsenic** in urine (24-hour) and hair of 7.58 ug/g (range, 0.29-23.78 ug/g) and 0.069 ug/g (range, 0.013-0.682 ug/g), respectively(2). **Arsenic** was measured in lung tissues from non-occupationally exposed people from Erlangen- Nurenberg, Germany (sampled between Jan 1992-Dec 1993); concns were 5.5 ng/g wet wt (range, <1-13 ng/g wet wt)(3).
[(1) Raie RM; Ecotox Environ Saf 35: 248-252 (1996) (2) Gebel T et al; Anticancer Res 18: 4253-4258 (1998) (3) Kraus T et al; Arch Environ Contam Toxicol 38: 384-389 (2000)]**PEER REVIEWED**

Minimum Fatal Dose Level:

Fatal human dose 70-180 mg. Estimated lethal dose for a 70 kg human as As (III) /**Arsenic** (III)/
[NIH/EPA; OHM/TADS (1985)]**PEER REVIEWED**

PROBABLE ORAL LETHAL DOSE (HUMAN) IS LESS THAN 5 MG/KG, A TASTE (LESS THAN 7 DROPS) FOR 70 KG PERSON (150 LB). /ARSENITES/
[Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976.,p. II-90]**PEER REVIEWED**

Single ingestions ranging from 22 to 108 mg/kg were fatal in human males. /From table/ /As(+3)/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 49 (2000)]**PEER REVIEWED**

Single ingestion of 121 mg/kg was fatal in a human male. /From table/ /As(+5)/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 49 (2000)]**PEER REVIEWED**

Emergency Medical Treatment:

Antidote and Emergency Treatment:

Skin decontamination. Wash arsenical pesticide from skin and hair with copious amounts of soap and water. Flush contaminant from eyes with clean water. If irritation persists, specialized medical treatment should be obtained. /Arsenical pesticides/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare129]**PEER REVIEWED**

Gastrointestinal decontamination. If arsenical pesticide has been ingested within the first hour of treatment, consideration should be given to GI decontamination ... . Because poisoning by ingested **arsenic** almost always results in profuse diarrhea, it is generally not appropriate to administer a cathartic. /Arsenical pesticides/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare129]**PEER REVIEWED**

Intravenous fluids. Administer intravenous fluids to restore adequate hydration, support urine flow, and correct electrolyte imbalances. Monitor intake/output continuously to guard against fluid overload. If acute renal failure occurs, monitor blood electrolytes regularly. Blood transfusions and oxygen by mask may be needed to combat shock. /Arsenical pesticides/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare129]**PEER REVIEWED**

Cardiopulmonary monitoring. Monitor cardiac status by ECG to detect ventricular arrhythmias including prolonged Q-T interval and ventricular tachycardia, and toxic myocardiopathy (T wave inversion, long S-T interval). /Arsenical pesticides/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide

Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare130]**PEER REVIEWED**

Chelation therapy. Administration of Dimercaprol (BAL) is usually indicated in symptomatic **arsenic** poisonings, although DMPS, where available, may prove to be a better antidote. ... Monitor urinary **arsenic** excretion while any chelating agent is being administered. When 24 hour excretion fall below 50 ug per day, it usually is advisable to discontinue the chelation therapy. /Arsenical pesticides/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare130]**PEER REVIEWED**

Oral tretments. After the gastrointestinal tract is reasonably free of **arsenic**, oral administration of d-penicillamine, Succimer (DMSA), or DMPS should probably replace BAL therapy. However, d-penicillamine has demonstrated limited effectiveness for **arsenic** exposure in experimental models. Succimer (DMSA) has been shown to be an effective chelator of **arsenic**, though it is not labeled for this indication. In Europe, DMPS has been used successfully in treatment of **arsenic** poisoning. In light of the lack of effectiveness of d-penicillamine, coupled with the low toxicity and high therapeutic index of DMPS and DMSA, it appears that the latter two agents may be the preferred method for chronic toxicity or when oral chelation is acceptable. /Arsenical pesticides/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcarep. 130-1]**PEER REVIEWED**

Hemodialysis. Extracorporeal hemodialysis, used in combination with BAL therapy, has limited effectiveness in removing **arsenic** from the blood. Hemodialysis is clearly indicated to enhance **arsenic** elimination and maintain extracellular fluid composition if acute renal failure occurs. /Arsenical pesticides/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare131]**PEER REVIEWED**

Renal function. In patients with intact renal function, alkalinization of the urine by sodium bicarbonate to maintain urine pH > 7.5 may help protect renal function in the face of hemolysis occurring as part of the acute poisoning. /Arsenical pesticides/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare131]**PEER REVIEWED**

Treatment of **arsenic** poisoning. After short-term exposure to **arsenic**, routine measures are taken to stabilize the patient and prevent further absorption of the poison. In particular, attention is directed to the status of the intravascular volume, since the effects of **arsenic** on the gastrointestinal tract can result in fatal hypovolemic shock. Hypotension requires fluid replacement and may necessitate pharmacological support of blood pressure with pressor agents such as dopamine. /**Arsenic**/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1661]**PEER REVIEWED**

After long-term exposure to **arsenic**, treatment with dimercaprol & penicillamine may also be used, but

oral penicillamine alone is usually sufficient. The duration of therapy is determined by the clinical condition of the patient, & the decision is aided by periodic determinations of urinary **arsenic** concns. Adverse effects of the chelating agents may limit the usefulness of therapy. Dialysis may become necessary with severe **arsenic**-induced nephropathy; successful removal of **arsenic** by dialysis has been reported. /**Arsenic**/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1662]**PEER REVIEWED**

Exptl Therapy: Meso-dimercaptosuccinic acid (DMSA), 2,3-dimercapto-1-propanesulfonic acid, sodium salt (DMPS), and n-(2,3-dimercaptopropyl)-phthalamidic acid (DMPA) are water soluble analogs of 2,3-dimercapto-1-propanol (BAL). The relative effectiveness or therapeutic index of these dimercapto compounds in protecting mice from the lethal effect of an LD99 of sodium arsenite is DMSA < DMPS < DMPA < BAL in the magnitude of 42:14:4:1, respectively. DMPS, DMPA, or DMSA will mobilize tissue **arsenic**. BAL, however, increases the **arsenic** content of the brain of rabbits injected with sodium arsenite. These results raise the question as to the appropriateness of BAL as the treatment for systemic **arsenic** poisoning. Either DMSA or DMPS, when given SC or orally, will protect rabbits against the lethal systemic effects of SC administered lewisite. DMPS and DMSA have promise as prophylactics for the prevention of the vesicant action of lewisite. The sodium arsenite inhibition of the pyruvate dehydrogenase (PDH) complex can be prevented and reversed in vitro or in vivo by DMPS, DMSA, DMPA, or BAL. Of them all, DMPS is most potent and BAL appears to be the least potent. /Arsenates/arsenites/
[Aposhian HV et al; Fundam Appl Toxicol 4 (2): S58-70 (1984)]**PEER REVIEWED**

... Thioctic acid, alone or combined with BAL, may be beneficial when included in the therapy employed in cattle suffering from acute **arsenic** poisoning. /**Arsenic** poisoning/
[Humphreys, D.J. Veterinary Toxicology. 3rd ed. London, England: Bailliere Tindell, 1988. 23]**PEER REVIEWED**

Traditional supportive measures are employed; evacuation of stomach contents via emesis or lavage ought to be considered if the ingestion has been relatively recent. Activated charcoal is considered beneficial. The use of cathartics, particularly in the face of gastrointestinal symptoms, is of dubious value at best. In contrast, careful assessment of the intravascular volume and adminsitration of appropriate replacement fluids and electrolytes are mandatory and may be life saving in severe cases. Should any bleeding occur, blood replacement ought to be considered. Of course, in acute arsine poisoning, exchange transfusion is of primary importance to overcome the hemolytic response. Baseline complete blood count, urinalysis, and liver and renal function tests should be obtained and followed periodically in cases of significant poisoning. Vital signs and ECG should be closely monitored. Administration of BAL in its oil vehicle intramuscularly (3 to 5 mg/kg initially as a single dose), followed by 3 to 5 mg/kg/dose every 6 to 12 hr for a 24 hr period and thereafter every 12 to 24 hr for 5 to 10 days. Naturally, the course of BAL therapy can be shortened if laboratory determinations refute or modify the initial diagnosis. Some experts advise substituting oral D-penicillamine, 100 mg/kg 24 hr to a maximum of 1 to 2 gm daily divided into four oral doses and administered for 5 to 10 days after the initial 12 to 48 hr of intramuscular BAL therapy. /**Arsenic**/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1026]**PEER REVIEWED**

Basic treatment: Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Monitor for shock and treat if necessary ... . Monitor for pulmonary edema and treat if necessary ... . Treat seizures if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport ... . Do not use emetics. For ingestion, rinse

mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal ... . /**Arsenic** and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994.,p. 332-3]**PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious. Positive pressure ventilation techniques with a bag valve mask device may be beneficial. Monitor cardiac rhythm and treat arrhythmias if necessary ... . Start an IV with D5W /SRP: "To keep open", minimal flow rate/. Use lactated Ringer's if signs of hypovolemia are present. Watch for signs of pulmonary edema. Consider drug therapy for pulmonary edema ... . For hypotension with signs of hypovolemia, administer fluid cautiously. Consider vasopressors for hypotension with a normal fluid volume. Watch for signs of fluid overload ... . Treat seizures with diazepam (Valium) ... . Use proparacaine hydrochloride to assist eye irrigation ... . /**Arsenic** and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 333]**PEER REVIEWED**

First Aid: Signs & Symptoms: Pain and irritation from exposure to either agent liquid or vapor are immediate. Skin impacts may appear in as short a time as 5 minutes although full progression to blisters may not develop for up to 18 hours. Exposure of the eyes to small amounts of vapor produces immediate tearing and pain. Vomiting may occur as a result of exposure to arsenical vesicants. Upper respiratory signs vary with the amount of exposure and include nasal irritation, scratchy throat, laryngitis, and a feeling of shortness of breath. /Vesicants - **Arsenic** Based/
[Ellison, D.H., Emergency Action for Chemical and Biological Warfare Agents. CRC Press, Boca Raton, FL 1999. 55]**PEER REVIEWED**

First Aid: Patient Management: Immediate decontamination of any exposure is essential. Symptomatic management of lesions with administration of antidote for treatment of systemic effects. Asymptomatic individuals suspected of exposure to vesicants should be kept under observation for a least 8 hours. /Vesicants - **Arsenic** Based/
[Ellison, D.H., Emergency Action for Chemical and Biological Warfare Agents. CRC Press, Boca Raton, FL 1999. 56]**PEER REVIEWED**

First Aid: Antidotes: BAL (British-Anti-Lewisite, dimercaprol) will alleviate some effects. BAL is available as a solution in oil for intramuscular administration to counteract systemic effects. BAL skin ointment and BAL ophthalmic ointment are not currently manufactured. /Vesicants - **Arsenic** Based/
[Ellison, D.H., Emergency Action for Chemical and Biological Warfare Agents. CRC Press, Boca Raton, FL 1999. 56]**PEER REVIEWED**

Decontamination: Vapor: Casualties/personnel: Speed in decontamination is absolutely essential. Immediately wash skin and clothes with a bleach solution that is no less than one part household bleach in nine parts water. Rinse with copious amounts of water. To be effective, decontamination must be completed within one minute of exposure. In all cases, clothing should be removed because it may contain "trapped" vapor. Small Areas: Decontaminate with copious amounts of full strength household bleach. Removal of porous material, including painted surfaces, that may have absorbed arsenical vesicant vapor may be required as these materials could continue to re release vapor after exposure has ceased. /Vesicants - **Arsenic** Based/
[Ellison, D.H., Emergency Action for Chemical and Biological Warfare Agents. CRC Press, Boca Raton, FL 1999. 55]**PEER REVIEWED**

Decontamination: Liquid: Casualties/personnel: Speed in decontamination is absolutely essential. Remove contaminated clothing immediately Remove as much of the agent from the skin as fast as possible without spreading the material. Immediately wash skin and clothes with a bleach solution that is no less than one part household bleach in nine parts water. Rinse with copious amounts of water. To be

effective, decontamination must be completed within one minute of exposure. In all cases, clothing should be removed because it may contain "trapped" liquid or vapor. Small Areas: Puddles of liquid must be contained by covering with vermiculite, diatomaceous earth, clay, fine sand, sponges, paper towels, or cloth towels. Remove all material and place in a container. Decontaminate the area with copious amounts of household bleach. Removal of porous material, including painted surfaces, that may have absorbed Vesicant liquid may be required as these materials could continue to re release vapor after exposure has ceased. Surfaces contaminated with vesicants, then only rinsed may still evolve sufficient agent vapor to produce a physiological response. /Vesicants - **Arsenic** Based/
[Ellison, D.H., Emergency Action for Chemical and Biological Warfare Agents. CRC Press, Boca Raton, FL 1999. 55]**PEER REVIEWED**

Animal Toxicity Studies:

Toxicity Summary:

Toxicology: Effects: Vesicants affect both exterior and interior parts of the body. Vesicants cause inflammation, blisters, and general destruction of tissues. Vapors have a greater impact on moist areas of the body. Eyes are especially susceptible to Vesicants. Inhalation of Vesicants can cause lung membranes to swell and become filled with liquid (pulmonary edema). Death may result from lack of oxygen. Arsenical Vesicants are also systemic agents and readily pass through the skin to affect susceptible tissue including blood cells and the liver. Arsenical Vesicants also act as vomiting agents ... and produce violent sneezing and regurgitation. Arsenical Vesicants should be considered carcinogenic. Pathways: Vesicants are hazardous through inhalation, skin and eye exposure, ingestion, and abraded skin (e.g., breaks in the skin or penetration of skin by debris). Liquid agents are much more hazardous than their vapors. /Vesicants - **Arsenic** Based/
[Ellison, D.H., Emergency Action for Chemical and Biological Warfare Agents. CRC Press, Boca Raton, FL 1999. 52]**PEER REVIEWED**

Latency Period: Arsenical vesicants produce pain immediately. Skin impacts begin appearing within minutes of exposure, although it may be up to 18 hours before the full lesion develops. Inhalation of high concentrations may be fatal in as short a time as 10 minutes. Pulmonary edema caused by inhalation of the agent vapor may be delayed for several hours. /Vesicants - **Arsenic** Based/
[Ellison, D.H., Emergency Action for Chemical and Biological Warfare Agents. CRC Press, Boca Raton, FL 1999. 53]**PEER REVIEWED**

Evidence for Carcinogenicity:

Classification of carcinogenicity: 1) evidence in humans: sufficient; 2) evidence in animals: limited. Overall summary evaluation of carcinogenic risk to humans is Group 1: Carcinogenic to humans. NOTE: This evaluation applies to the group of chemicals as a whole and not necessarily to all individual chemicals within the group. /**Arsenic** and **arsenic** compounds/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. S7 57 (1987)]**PEER REVIEWED**

A1. A1= Confirmed human carcinogen. (1993) /**Arsenic**, elemental and inorganic cmpd (except Arsine), as As/
[American Conference of Governmental Industrial Hygienists. Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs) for 1995-1996. Cincinnati, OH: ACGIH, 1995.13]**PEER REVIEWED**

CLASSIFICATION: A; human carcinogen. BASIS FOR CLASSIFICATION: Based on sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human

populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic **arsenic**. HUMAN CARCINOGENICITY DATA: Sufficient. ANIMAL CARCINOGENICITY DATA: Inadequate. /Inorganic **Arsenic**/
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Arsenic, inorganic (7440-38-2) Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000]**PEER REVIEWED**

Non-Human Toxicity Excerpts:

... POISONING IN DOGS BY ORAL ADMIN OF **ARSENIC** IN AQ SOLN ... OVER PERIOD OF 7-8 MO CONFIRM ... THAT **ARSENIC** IS PROTOPLASMIC POISON, WITH PROFOUND EFFECT ... ON FAT METAB. ... FOUND FATTY INFILTRATION OF LIVER & KIDNEYS, SPLEEN, STRIATED MUSCLE, PERIPHERAL NERVES ... BRONCHIAL & INTESTINAL MUCOSA. /**ARSENIC** CMPD/
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969. 44]**PEER REVIEWED**

/CHRONIC POISONING IN DOGS BY ORAL ROUTE/ DEPOSITION OF HEMOSIDERIN IN PARENCHYMATOUS ORGANS DEMONSTRATED TOXIC INFLUENCE OF **ARSENIC** ON HEMATOPOIESIS, & ESPECIALLY UPON EVOLUTION OF ERYTHROCYTES. /INORGANIC **ARSENIC** COMPOUNDS/
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969. 44]**PEER REVIEWED**

ARSENICALS HAVE VESICANT EFFECTS ON THE SKIN, CAUSING NECROSIS & SLOUGHING. /**ARSENIC** CMPD/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1661]**PEER REVIEWED**

Acute toxicity of arsenite and arsenate to hydrobiont, mosquito larvae, and rat was widely different. In a 28-day study, the degree of toxicity of **arsenic** (III) and **arsenic** (V) was nearly equal. The chronic toxicodynamic indicators of both As cmpd were similar. The effective concn of arsenite and arsenate is 0.05 mg/kg, and 0.01 mg/kg is the min ED for these **arsenic** cmpd. Among the gonadotoxic effects examined, both arsenite and arsenate had no effect on acid and osmotic resistance of spermatocytes and size of the gonads. The erythrocyte number in the blood, coproporphyrin excretion in the urine, and activity of aspartate aminotransferase in the blood serum underwent similar changes by arsenite and arsenate. Thus, the valence of **arsenic** has no effect on its toxicity. /Arsenites and arsenates/
[Krasovskii GN, Pozhidaeve NV; Gig Sanit 4: 9-11 (1984)]**PEER REVIEWED**

Inorganic arsenate concn as low as 5 mg/kg injected into pregnant /hamsters/ increased the mortality rate of embryos above control values. The incidence of malformations was significantly increased at an arsenite concn of 20 mg/kg. /Arsenate and arsenite/
[Nat'l Research Council Canada; Effects of Arsenic in the Canadian Environment p.227 (1978) NRCC No.15391]**PEER REVIEWED**

The arsenites (trivalent) are the least stable of the arsenicals and are the most toxic to insects and plants and have been used chiefly as the toxicants in baits. The arsenates (pentavalent), although less insecticidal, are more stable and safer to plants and are favored as general-purpose stomach poisons. /Arsenates and arsenites/
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 13(81) 420]**PEER REVIEWED**

Inorganic **arsenic** (V) was slightly more toxic than **arsenic** (III) to rainbow trout but **arsenic** (III) was nearly twice as toxic to the fathead minnow and Daphnia magna. /**Arsenic** (III) and **arsenic** (V)/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.5 (1984) EPA 440/5-84-033]**PEER REVIEWED**

Arsenic (V) is more toxic than **arsenic** (III) to the amphipod, Ampelisca abdita, whose species mean acute values are 4,610 ug/l for **arsenic**(V) and 8,227 ug/l for **arsenic** (III). /**Arsenic** (III) and **arsenic** (V)/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.7 (1984) EPA 440/5-84-033]**PEER REVIEWED**

Oxidizing enzymes, particularly pyruvate oxidase, D-amino acid oxidase, 2-glutamic acid oxidase, monoamine oxidase, liver choline oxidase, and glucose oxidase are especially vulnerable to arsenite. /Arsenite/
[Webb JL; Enzyme and Metabolic Inhibition, Academic Press 2: 7237 (1966) as cited in USEPA; Ambient Water Quality Criteria Doc: Arsenic p.C-37 (1980) EPA 440/5-80-021]**PEER REVIEWED**

The effects of certain monovalent, divalent, and trivalent metals on a mitochondrial preparation of K+-stimulated-p-nitrophenyl phosphatase from rat brain were studied. Except for salts of nickel (2+), selenium (2+), and lithium (2+), which did not produce 50% inhibition, all of the metals examined were potent inhibitors of the enzyme with I50 value of 550 uM for **arsenic** (3+). The order of their potency was silver (1+), > mercury (2+) > copper (2+) > cadmium (2+) > zinc (2+) > cobalt (2+) > iron (2+) > lead (2+) > iron (3+) > manganese (2+) > **arsenic** (3+) > tin (2+) > aluminum (3+) > nickel (2+) > selenium (2+) > lithium (1+). /**Arsenic** cations/
[Bansal SK et al; Acta Pharmacol Toxicol 53 (4): 333-336 (1983)]**PEER REVIEWED**

Dysfunction of the blood-brain barrier was indicated in rats fed arsenite at a concn of 500 mg/kg diet in a cereal diet for 35 days. /Arsenite/
[Tamura S, Nozaki S; Folia Pharmacol Jpn 68: 800-808 (1972) as cited in WHO; Environ Health Criteria: Arsenic p.105 (1981)]**PEER REVIEWED**

Arsenic (III) increased albinism in channel catfish. /**Arsenic** (III)/
[Westerman A G, Birge W J; Prog Fish-Cult 40: 143 (1978) as cited in USEPA; Ambient Water Quality Criteria Doc: Arsenic p.11 (1984) EPA 440/5-84-033]**PEER REVIEWED**

Cladophora sp (alga), Spirogyra sp (alga), or Zygnema sp (alga) 2,320 ug/l/2 wk, toxic effect: 100% kill. Potomageton sp (submerged plant) 2,320 ug/l/1 mo, toxic effect: 95% kill. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-19 (1980) EPA 440/5-80-021]**PEER REVIEWED**

ARSENICAL DERMATITIS ... IN ANIMALS ... DOES OCCUR FOLLOWING INGESTION OF **ARSENIC**, ESPECIALLY IN PIGS, & HEMORRHAGIC DERMATITIS HAS BEEN DESCRIBED AS CONSTANT SKIN FINDING IN SUBACUTE POISONING IN BUFFALOES ... . /**ARSENIC**/
[Clarke, E.G., and M. L. Clarke. Veterinary Toxicology. Baltimore, Maryland: The Williams and Wilkins Company, 1975. 39]**PEER REVIEWED**

... Inorganic **arsenic** poisoning in cattle is characterized by reddened abomasal or duodenal mucosa and submucosal edema and hemorrhages in the abomasum and duodenum, with resulting sloughing of the duodenal mucosa or perforation of the gut wall. The intestinal contents are fluid, foul smelling, bloody, and may contain shreds of intestinal mucosa. The liver may be soft and yellow. The lung may be edematous and congested. There may be hemorrhages on the heart, peritoneum, kidneys, and liver. In swine, there may be inflamed and edematous fauces. The edema may extend to the larynx and trachea, causing asphyxial signs and lesions. ... /Inorganic **arsenic**/
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th

ed. Ames, Iowa: Iowa State University Press, 1982. 1024]**PEER REVIEWED**

... ORAL INTAKE OF **ARSENIC** HAS BEEN IMPLICATED AS A GOITROGENIC AND THIS POSSIBLE EFFECT HAS BEEN CONFIRMED IN ANIMALS. ... /INORGANIC **ARSENIC** COMPOUNDS/
[Doull, J., C.D. Klaassen, and M. D. Amdur (eds.). Casarett and Doull's Toxicology. 2nd ed. New York: Macmillan Publishing Co., 1980. 437]**PEER REVIEWED**

Cholinesterase inhibition was observed in rats exposed for 3 months to condensation aerosols containing 46 ug/cu m **arsenic**. /Inorganic **arsenic** compounds/
[Rosenshtein IS; Hyg Sanit 35 (1-3): 16 (1970)]**PEER REVIEWED**

CHARACTERISTIC SIGNS /OF CHRONIC POISONING/ ARE ... INDIGESTION, THIRST, WASTING & GENERAL APPEARANCE OF UNTHRIFTINESS, WITH A DRY STARING COAT & BRICK RED COLORATION OF VISIBLE MUCOUS MEMBRANES; THE PULSE IS WEAK & IRREGULAR ... . /**ARSENIC** CMPD/
[Clarke, M. L., D. G. Harvey and D. J. Humphreys. Veterinary Toxicology. 2nd ed. London: Bailliere Tindall, 1981. 32]**PEER REVIEWED**

IN SUBACUTE CASES, ANIMALS MAY LIVE FOR SEVERAL DAYS & THERE MAY BE ... DEPRESSION, LOSS OF APPETITE, STAGGERING GAIT, ... PARALYSIS OF THE HIND QUARTERS, TREMBLING, STUPOR, CONVULSIONS, COLDNESS OF THE EXTREMITIES & SUBNORMAL TEMP, PROTEINURIA & HEMATURIA MAY ALSO OCCUR. /**ARSENIC** CMPD/
[Clarke, M. L., D. G. Harvey and D. J. Humphreys. Veterinary Toxicology. 2nd ed. London: Bailliere Tindall, 1981. 32]**PEER REVIEWED**

PERACUTE ARSENICAL POISONING MAY LEAD TO DEATH SO RAPIDLY THAT ILLNESS IS NEVER OBSERVED. WHEN SYMPTOMS DO MANIFEST THEMSELVES THEY INCL INTENSE ABDOMINAL PAIN, STAGGERING GAIT, COLLAPSE, PARALYSIS & DEATH. IN ACUTE CASES MOST PROMINENT SYMPTOMS ARE SALIVATION, THIRST, VOMITION WHERE POSSIBLE, VIOLENT COLIC, WATERY DIARRHEA SOMETIMES HEMORRHAGIC, EXHAUSTION ... IN SUBACUTE CASES, ANIMALS MAY LIVE FOR SEVERAL DAYS & THERE MAY BE ... DEPRESSION, LOSS OF APPETITE, STAGGERING GAIT ... PARALYSIS OF HIND QUARTERS, TREMBLING, STUPOR, CONVULSIONS, COLDNESS OF EXTREMITIES & SUBNORMAL TEMP, PROTEINURIA & HEMATURIA ... ARSENICAL DERMATITIS ... IN ANIMALS ... DOES OCCUR FOLLOWING INGESTION OF **ARSENIC**, ESPECIALLY IN PIGS, & HEMORRHAGIC DERMATITIS HAS BEEN DESCRIBED AS A CONSTANT FINDING IN SUBACUTE POISONING IN BUFFALOES ... CLINICAL EVIDENCE OF CHRONIC POISONING ... SAID TO INCLUDE INDIGESTION, THIRST, WASTING & GENERAL APPEARANCE OF UNTHRIFTINESS, WITH A DRY STARING COAT & BRICK RED COLORATION OF VISIBLE MUCOUS MEMBRANES; PULSE IS WEAK & IRREGULAR. ... /INORGANIC **ARSENIC** COMPOUNDS/
[Clarke, M. L., D. G. Harvey and D. J. Humphreys. Veterinary Toxicology. 2nd ed. London: Bailliere Tindall, 1981. 32]**PEER REVIEWED**

... THERE IS DIRECT ACTION ON EPITHELIAL CELLS, WHICH SHOW CLOUDY SWELLING AND FATTY DEGENERATION. THESE ... CHANGES ARE ALSO SEEN IN LIVER, KIDNEYS AND HEART, AND THESE ORGANS MAY ALSO SHOW ECCHYMOSES AND SMALL HEMORRHAGES. IN CATTLE, INFLAMMATION OF THE ABOMASUM IS USUALLY PRONOUNCED ... /INORGANIC **ARSENIC** COMPOUNDS/
[Clarke, M. L., D. G. Harvey and D. J. Humphreys. Veterinary Toxicology. 2nd ed. London: Bailliere Tindall, 1981. 32]**PEER REVIEWED**

IN PIGS, INFLAMMATION OF MOUTH & FAUCES WITH EXTRAVASATION OF FLUID MAY

BE SEVERE & EXTEND TO MUCOUS MEMBRANES OF LARYNX & TRACHEA, THUS CAUSING ASPHYXIA. ... IN FOWLS, THE CHARACTERISTIC LESION IS INTENSE INFLAMMATION OF PROVENTRICULARUS & GIZZARD ... THE LIVER IS USUALLY PALE, FRIABLE, & SHOWS FATTY DEGENERATION. /INORGANIC **ARSENIC** COMPOUNDS/
[Clarke, M. L., D. G. Harvey and D. J. Humphreys. Veterinary Toxicology. 2nd ed. London: Bailliere Tindall, 1981. 32]**PEER REVIEWED**

Arsenic causes ... teratogenic effects in hamsters. /Inorganic **arsenic** compounds/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1660]**PEER REVIEWED**

Mutagenicity tests using Salmonella, Escherichia coli system, and Chinese hamster cell line V79 failed to produce point mutations with trivalent or pentavalent inorganic **arsenic**. /Inorganic **arsenic** compounds/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 67]**PEER REVIEWED**

In animals, arsenates (pentavalent) are less toxic than arsenites (trivalent). /Inorganic **arsenic** compounds/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-130]**PEER REVIEWED**

The route of administration was shown to have a significant influence on the teratogenic action of **arsenic** in mice. A much higher oral dose of an aqueous solution of arsenate was needed to induce the same effects as found after intraperitoneal injection. The doses given were 120 and 40 mg arsenate per kg body weight, respectively. /Inorganic **arsenic** compounds/
[Thacker GT et al; Teratology 15: 30-1 (1977) as cited WHO; Environ Health Criteria: Arsenic p.93 (1981)]**PEER REVIEWED**

Arsenate is negative in the Ames assay. /Inorganic **arsenic** compounds/
[Sirover MA; Environ Health Perspect 40: 163-72 (1981)]**PEER REVIEWED**

The effect of phosphates, arsenates and arsenites on the growth of the **arsenic** oxidizing microorganisms Pseudomonas putida and Alcaligenes eutrophus was studied in the presence of yeast extract, glucose, fish peptone agar, sodium citrate, sodium acetate and sodium lactate. The toxic effect of arsenates could be reduced by the addition of phosphates. Phosphates caused the highest inhibitory effect on the growth of arsenite oxidizing bacteria. /Inorganic **arsenic** compounds/
[Abdrashitova SA et al; Izv Akad Nauk Kaz SSR Ser Biol 0 (4): 33-7 (1984)]**PEER REVIEWED**

THE TOXICITY OF **ARSENIC** COMPOUNDS, INCLUDING **ARSENIC** PENTOXIDE, TO STONEFLIES, AMPHIPODS, & TROUT, & THE BIOACCUMULATION OF THESE COMPOUNDS WERE STUDIED DURING A 28 DAY FLOW-THROUGH TEST. DAPHNIA MAGNA WERE EXPOSED FOR 21 DAYS IN STATIC TESTS TO DETERMINE LIFE CYCLE EFFECTS. ALL ANIMALS WERE EXPOSED TO CONCN OF APPROX 100 & 1000 UG/L (AS **ARSENIC**). **ARSENIC** PENTOXIDE DID NOT SIGNIFICANTLY AFFECT THE SURVIVAL OF TEST SPECIES AFTER 28 DAYS OR REDUCED YOUNG PRODUCTION IN DAPHNIA AFTER 14 DAYS OF EXPOSURE. THE CONCN OF ACCUMULATED **ARSENIC** IN STONEFLIES, SNAILS, & DAPHNIA WAS AS MUCH AS 131, 99, & 219 TIMES GREATER THAN THE WATER CONCN, WHEREAS AMPHIPODS & RAINBOW TROUT CONTAINED **ARSENIC** RESIDUES SIMILAR TO THE CONTROLS. RESIDUES IN STONEFLIES, SNAILS, & DAPHNIA EXPOSED TO 1000 UG **ARSENIC**/L, WERE HIGHER THAN THOSE IN ANIMALS EXPOSED TO 100 UG **ARSENIC**/L,

BUT APPEARED TO REACH A STEADY STATE AFTER 14 DAYS. /**ARSENIC** CMPD/
[SPEHAR RL ET AL; ARCH ENVIRON CONTAM TOXICOL 9 (1): 53-63 (1980)]**PEER REVIEWED**

The maximum no-observed effect level for **arsenic** in water is less than 100 ug/l. /Inorganic **arsenic**/
[NAS; Report on Drinking Water and Health (1977)]**PEER REVIEWED**

Many species of bacteria have resistance to specific toxic heavy metals. Cadmium and arsenate resistances are due to reduced net accumulation of these toxic materials. Efficient efflux pumps cause the rapid excretion of cadmuim 2+ and arsenate. /Arsenate/
[Silver S, Misra TK; Basic Life Sci 28: 23-46 (1984)]**PEER REVIEWED**

Yeast cells exposed to 75 ppm arsenate for 30 min exhibited a 60% reduction in phosphate transport and glucose metabolism. Complete inhibition occurred at 375 ppm, while insensitive species could tolerate up to 1600 ppm. /Inorganic **arsenic** compounds/
[Nat'l Research Council Canada; Effects of Arsenic in the Canadian Environment p.21 (1978) NRCC No. 15391]**PEER REVIEWED**

Arsenate resistant clones were obtained with high frequency from colony populations of streptothricin producing strains of Streptomyces noursei by the paper strip method. Whereas in the arsenate resistant strains obtained from both wild type and mutant NG 13 the antibiotic production was reduced to approximately 60% of the parental level, the arsenate-resistant clones isolated from colony populations of mutant UV 12 displayed increased productivity (less than or equal to 150%). However, their improved capacity to produce streptothricins was lost rapidly after repeated cell propagation in submerged cultures, suggesting that unstable genetic elements were involved in enabling streptomyces noursei to grow in the presence of toxic concn of arsenate. /Arsenate/
[Friedrich W et al; Z Alleg Mikrobiol 24 (1): 13-19 (1984)]**PEER REVIEWED**

Arsenate is negative in the Ames assay. /Arsenate/
[Sirover MA; Environ Health Perspect 40: 163-72 (1981)]**PEER REVIEWED**

Cholinesterase inhibition was observed in rats exposed for 3 months to condensation aerosols containing 46 ug/cu m **arsenic**. /Inorganic **arsenic** compounds/
[Rosenshtein IS; Hyg Sanit 35 (1-3): 16 (1970)]**PEER REVIEWED**

Arsenite showed positive mutagenic effects in an Escherichia coli point mutation assay, and in an Escherichia coli DNA repair assay, but negative results in the dominant lethal assay. /Arsenite/
[43 FR 48352 (10/18/78)]**PEER REVIEWED**

Of leghorn chicken embryos injected with arsenate (3 ug/egg) on days 2-4, those treated on day 2 were normal. Of day 3 treated embryos, 21% had abnormalities while 32.5% of day 4 treated embryos had abnormalities. /**Arsenic** compds/
[Puzanova; Sbornik Lekarsky 78: 57 (1976)]**PEER REVIEWED**

... most laboratory animals appear to be substantially less susceptible to **arsenic** than humans. For example, chronic oral exposure of humans to inorganic **arsenic** at doses of 0.05-0.1 mg/kg/day is frequently assoc with neurological ... or hematological signs of **arsenic** toxicity ... but no characteristic neurological or hematological signs of arsenism were detected in monkeys, dogs, or rats chronically exposed to arsenate or arsenite at doses of 0.7-2.8 mg As/kg/day ... . Moreover, while there is good evidence that **arsenic** is carcinogenic in humans by both oral and inhalation routes, evidence of **arsenic**-induced carcinogenicity in animals is mostly negative. For these reasons, quantitative dose-response data from animals are not judged to be reliable for determining levels of significant human exposure ... . /**Arsenic** cmpd/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 18 (2000)]**PEER REVIEWED**

Acute exposure of monkeys to 6 mg As/kg/day resulted in vacuolization of the hepatocytes ... . Studies in dogs or mice have not detected clinically significant hepatic injury following exposure to either arsenite or arsenate ... although enlargement of the common bile duct was noted in rats fed either arsenate or arsenite in the diet for 2 yr ... and lipid vacuolation and fibrosis were seen in the liver or rats exposed to 12 mg As/kg/day as arsenate in the drinking water for 6 wk ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 110 (2000)]**PEER REVIEWED**

... In fowl, there may be an intense inflammation of the proventriculus & gizzard, & the horny lining of the gizzard may be sloughing away because of an underlying gelatinous exudate. The duodenal mucosa may be slightly reddened, & the liver may manifest degenerative changes. /**Arsenic**/
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 1024]**PEER REVIEWED**

... Inorganic **arsenic** poisoning in cattle is characterized by reddened abomasal or duodenal mucosa & submucosal edema & hemorrhages in the abomasum & duodenum, with resulting sloughing of the duodenal mucosa or perforation of the gut wall. The intestinal contents are fluid, foul smelling, bloody, & may contain shreds of intestinal mucosa. The liver may be soft & yellow. The lung may be edematous & congested. There may be hemorrhages on the heart, peritoneum, kidneys, & liver. In swine, there may be inflamed & edematous fauces. The edema may extend to the larynx & trachea, causing asphyxial signs & lesions. ... /Inorganic **arsenic**/
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 1024]**PEER REVIEWED**

The effect of phosphates, arsenates and arsenites on the growth of the As-oxidizing microorganisms Pseudomonas putida and Alcaligenes eutrophus was studied in the presence of yeast extract, glucose, fish peptone agar, sodium citrate, sodium acetate and sodium lactate. The toxic effect of arsenates could be reduced by the addition of phosphates. Phosphates caused the highest inhibitory effect on the growth of arsenite-oxidizing bacteria. /Arsenites and arsenates/
[Abdrashitova SA et al; Izv Akad Nauk Kaz SSR Ser Biol 0 (4): 33-37 (1984)]**PEER REVIEWED**

The effect of the chelating agent dimercaprol (BAL) on the embryotoxic and teratogenic effects of arsenite (As3+) was determined. Dimercaprol (sc,30 mg/kg) was administered to pregnant CD-1 mice, either 8 and 4 hr prior to or 4 and 8 hr after a 12 mg/kg ip dose of arsenite; other females received a single sc injection of 60 mg/kg dimercaprol concurrently with the arsenite. Treatments were given on gestation day 9 or 12 (copulation plug= day 1). Controls received sc corn oil or ip water, with or without arsenite or dimercaprol. Arsenite treatment caused gross and skeletal malformations and prenatal deaths, while controls were unaffected when dimercaprol was given prior to arsenite on Day 9, incidences of prenatal mortality and skeletal malformation were significantly diminished and on day 12, dimercaprol protected against feticidal effects of arsenite when given concurrently with the arsenite. According to these results, dimercaprol is unlikely to have a practical beneficial effect on the arsenite exposed conceptus, because it must be administered prior to the teratogen (or perhaps simultaneously with it) to be effective. /Arsenite/
[Hood RD, Vedel-Macrander GC; Toxicol Appl Pharm 73 (1): 1-7 (1984)]**PEER REVIEWED**

A nested case-control analysis of 102 lung cancer cases and 190 controls from the cohort /at the Ronnskar smelter/ showed that lung cancer incr with incr **arsenic** exposure in nonsmokers, light smokers, and heavy smokers ... . The results demonstrated that **arsenic** is a risk factor for lung cancer in the smelter workers, but also suggested a greater-than-additive interaction between smoking and **arsenic** exposure. /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 45 (2000)]**PEER REVIEWED**

Non-Human Toxicity Values:

LD50 wild Norway rat oral 104 mg/kg. /From table/ /As(+3)/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 49 (2000)]**PEER REVIEWED**

LD50 Sherman female rat oral 44 mg/kg. /From table/ /As(+3)/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 49 (2000)]**PEER REVIEWED**

LD50 Sprague-Dawley male rat oral (in water) 15 mg/kg. /From table/ /As(+3)/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 50 (2000)]**PEER REVIEWED**

LD50 Sprague-Dawley male rat oral (in feed) 145 mg/kg. /From table/ /As(+3)/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 50 (2000)]**PEER REVIEWED**

LD50 Swiss-Webster male mouse oral (in water) 39 mg/kg. /From table/ /As(+3)/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 50 (2000)]**PEER REVIEWED**

LD50 C57H46 male mouse oral (in water) 26 mg/kg. /From table/ /As(+3)/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 50 (2000)]**PEER REVIEWED**

LD50 Dba2 male mouse oral (in water) 32 mg/kg. /From table/ /As(+3)/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 50 (2000)]**PEER REVIEWED**

LD50 C3H male mouse oral (in water) 26 mg/kg. /From table/ /As(+3)/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 50 (2000)]**PEER REVIEWED**

LD50 ddY male mouse oral (in water) 26 mg/kg. /From table/ /As(+3)/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 50 (2000)]**PEER REVIEWED**

LD50 Swiss-Webster male mouse oral (in water) 39 mg/kg. /From table/ /As(+3)/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 50 (2000)]**PEER REVIEWED**

Ecotoxicity Values:

LC50 Penaeus seliferus (white shrimp, juvenile) 24,700 ug/l/96 hr. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-26 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC100 Oncorhynchus gorbuscha (pink salmon) 12,307 ug/l/96 hr; 7,195 ug/l/day. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-26 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 Oncorhynchus keta (chum salmon) 8,330 ug/l/48 hr. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-26 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 Daphnia magna (cladoceran) 2,850 ug/l/3 wk. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-25 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 Daphnia magna 4,340 ug/l/96 hr. /Conditions of bioassay not specified/. /**Arsenic** (III)/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.7 (1984) EPA 440/5-84-033]**PEER REVIEWED**

LT50 Lepomis cyanellus (green sunfish) 60,000 ug/l/678 hr at 10 deg C; 60,000 ug/l/210 hr at 20 deg C; 60,000 ug/l/124 hr at 30 deg C; 30,000 ug/l/527 hr at 20 deg C; 30,000 ug/l/209 hr at 30 deg C. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-25 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LT50 Lepomis cyanellus (green sunfish, juvenile) 40,000 ug/l/39 hr. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-25 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 Nereis diversicolor (polychaete worm) >14,500 ug/l/192 hr. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-25 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 Notropis hudsonicus (spottail shiner) 27,000 ug/l/72 hr. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-24 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnow, juvenile) 10,556 ug/l/336 hr. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-24 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnow) 82,400 ug/l/96 hr. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-24 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 Lepomis macrochirus (bluegill, juvenile) 18,328 ug/l/336 hr. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-24 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 Lepomis macrochirus (bluegill, fingerling) 290 ug/l/48 hr. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-24 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 Gastrophryne carolinensis (toad, embryo-larval) 40 ug/l/7 days. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-23 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 Salmo gairdneri (rainbow trout) 540 ug/l/28 days. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-24 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 Salvelinus tentinalis (brook trout) 10,440 ug/l/262 hr. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-24 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 Bay scallop 3,490 ug/l/96 hr. /Conditions of bioassay not specified/. /Arsenite/

[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-6 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 American oyster 7,500 ug/l/48 hr. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-6 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 Carassius auratus (goldfish, juvenile) 18,618 ug/l/336 hr. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-24 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LC50 Carassius auratus (goldfish, embryo-larval) 490 ug/l/7 days. /Conditions of bioassay not specified/. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.B-24 (1980) EPA 440/5-80-021]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

The toxicity of products formed as a result of bacterial (Pseudomonas putida and Alcaligenes eutrophus) oxidation of arsenites is significantly more than that of the corresponding amounts of mineral arsenates. /Arsenites and arsenates/
[Abdrashitova SA, Abdulline GG; Gig Sanit 10: 86-88 (1984)]**PEER REVIEWED**

... The major metabolite in urine of experimental animals exposed to inorganic **arsenic** is dimethylarsinic acid. The marmoset monkey is the only species to date which has been found to be unable to methylate inorganic **arsenic**. In man the urinary excretion at low levels consists of about 20% inorganic **arsenic**, 20% methylarsonic acid and 60% dimethylarsinic acid. /**Arsenic** cmpd/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 53]**PEER REVIEWED**

The **arsenic** cmpd in which flounder appears to be stable and intact during metabolism since it does not adhere to the erythrocytes of rats as all **arsenic** cmpd were previously expected to do. It was also indicated that when crab meat containing **arsenic** was ingested, the cmpd appeared to be excreted intact. Therefore, it appears that dietary **arsenic**, as that occurring in marine products, is metabolically stable. /**Arsenic** in marine products/
[Siewicki TC; J Nutr 111: 602-9 (1981)]**PEER REVIEWED**

Factors which were discussed influence the methylation of inorganic **arsenic** by rat liver. S-adenosylmethionine alone administered or in association with reduced or oxidized glutathione or acetylcysteine and the increase of hepatic reduced or oxidized glutathione level by butylated hydroxytoluene pretreatment do not stimulate the urinary excretion of the methylated **arsenic** metabolites following a challenge dose of inorganic **arsenic**. Conversely a reduction of the hepatic reduced or oxidized glutathione level by phorone pretreatment greatly modifies the metabolism of inorganic **arsenic** in vivo. A reduction exceeding 90% of the control value leads to a decreased urinary excretion of monomethylarsonic and dimethylarsinic acid and an increased urinary excretion of inorganic **arsenic**. This is also associated with an increased accumulation of inorganic **arsenic** in the liver. A drastic reduction of reduced or oxidized glutathione level in liver not only impairs the methylation of inorganic **arsenic** but also impairs its biliary excretion. When reduced or oxidized glutathione depletion is less severe, the total amount of **arsenic** excreted in urine after a challenge dose

of sodium arsenate is not significantly different from that found in unpretreated animals but the proportion of the three metabolic forms is different: MMA is reduced whereas ASI and DMA tend to increase. These changes resemble those found in patients with liver insufficiency. Long-term pretreatment of rats with carbon tetrachloride slightly reduces the amount of monomethyl arsonic and dimethylarsinic acids excreted in urine following a challenge dose of inorganic **arsenic**. This effect may result from a reduction of reduced or oxidized glutathione transferase activity by carbon tetrachloride. /Inorganic **arsenic**/
[Buchet JP, Lauwreys R; Toxicol Appl Pharmacol 91 (1): 65-74 (1987)]**PEER REVIEWED**

When a 30 yr old man was given wine with 50 ug trivalent and 13 ug pentavalent **arsenic**, the major excreted form in urine, in 61 hours, was dimethylarsinic acid (50%). Tri- and pentavalent each accounted for 8% and methyl **arsenic** acid for 14 percent. /Arsenate and arsenite/
[Crecelius EA; Bull Environ Contam Toxicol 18: 227 (1977) as cited in USEPA; Ambient Water Quality Criteria Doc: Arsenic p.C-25 (1980) EPA 440/5-80-021]**PEER REVIEWED**

LITTLE IS KNOWN ABOUT THE BIOTRANSFORMATIONS OF ARSENICALS IN MAN. SOME PENTAVALENT ARSENICALS ARE PARTLY REDUCED IN VIVO TO THE TRIVALENT FORM. HOWEVER, THE REDOX EQUILIBRIA IN VIVO FAVOR THE OXIDIZED FORM, AND TRIVALENT **ARSENIC** IS SLOWLY OXIDIZED IN THE BODY TO THE PENTAVALENT STATE. THE LOW TOXICITY AND HIGH RECOVERY OF PENTAVALENT ARSENICALS IN URINE AND EXCRETA INDICATE THAT VERY LITTLE REDUCTION TAKES PLACE. IT APPEARS THAT BOTH TRIVALENT AND PENTAVALENT FORMS ARE METHYLATED IN MAN. ... /INORGANIC **ARSENIC** COMPOUNDS/
[Gilman, A.G., L.S.Goodman, and A. Gilman. (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 7th ed. New York: Macmillan Publishing Co., Inc., 1985. 1615]**PEER REVIEWED**

When inorganic **arsenic** was fed to brown trout (Salmo trutta), the **arsenic** was converted to an organic form. /Inorganic **arsenic** compounds/
[Menzie, C.M. Metabolism of Pesticides-Update III. Special Scientific Report-Wildlife No. 232. Washington, DC: U.S.Department of the Interior, Fish and Wildlife Service, 1980. 34]**PEER REVIEWED**

ARSENATE IS METABOLIZED IN BOTH FRESH & SALT WATER BY BACTERIA & FUNGI TO METHYLATED COMPOUNDS, PREDOMINANTLY TO DIMETHYLARSINIC ACID. /INORGANIC **ARSENIC** COMPOUNDS/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 93 (1980)]**PEER REVIEWED**

Various fungi and bacteria growing under aerobic and anaerobic conditions can metabolize arsenate and arsenite to volatile arsinicals, usually to di- or trimethyl arsine. /Inorganic **arsenic** compounds/
[Braman; ACS Symposium Series 7, p.108 (1975)]**PEER REVIEWED**

SOME PENTAVALENT ARSENICALS ARE PARTLY REDUCED IN VIVO TO THE TRIVALENT FORM. HOWEVER, THE REDOX EQUILIBRIA IN VIVO FAVOR OXIDATION, & TRIVALENT **ARSENIC** IS SLOWLY OXIDIZED IN THE BODY TO THE PENTAVALENT STATE. /**ARSENIC** COMPD/
[Gilman, A. G., L. S. Goodman, and A. Gilman. (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 6th ed. New York: Macmillan Publishing Co., Inc. 1980. 1630]**PEER REVIEWED**

... IN VIVO METHYLATION OF INORG **ARSENIC** HAS BEEN DEMONSTRATED BOTH IN ANIMALS & HUMANS /BY TRANSFORMATION OF TRIVALENT TO PENTAVALENT STATE/.

THE MAJOR FORM OF **ARSENIC** IN URINE OF BOTH EXPOSED & UNEXPOSED HUMANS IS DIMETHYLARSINIC ACID. METHYLARSONIC ACID & INORG **ARSENIC** ARE ALSO PRESENT BUT IN LOWER CONCN. /**ARSENIC** COMPD/
[Friberg, L., G.R. Nordberg, and V.B. Vouk. Handbook on the Toxicology of Metals. New York: Elsevier North Holland, 1979. 300]**PEER REVIEWED**

FOLLOWING IV ADMIN OF INORG **ARSENIC**, THE METABOLITE, DIMETHYLARSINIC ACID (DMAA), APPEARED RAPIDLY IN ERYTHROCYTES, THEN PLASMA. WITHIN 6 HR MOST OF THE **ARSENIC** REMAINING WAS DIMETHYLARSINIC ACID. BOTH INORG **ARSENIC** & DIMETHYLARSINIC ACID WERE EXCRETED IN URINE. /INORGANIC **ARSENIC** COMPOUNDS/
[CHARBONNEAU ET AL; TRACE SUBST ENVIRON HEALTH 12: 276 (1978)]**PEER REVIEWED**

These org arsenicals are nonionized ... only slowly broken down in body and ingested portion may be largely excreted unchanged. /Org **arsenic** compd/
[Patty, F. (ed.). Industrial Hygiene and Toxicology: Volume II: Toxicology. 2nd ed. New York: Interscience Publishers, 1963. 872]**PEER REVIEWED**

After exposure to inorganic **arsenic**, the longest retention times are found in the skin, gastrointestinal tract epididymis, thyroid, and skeleton. The highest tissue concentrations in humans have been observed in hair, nails, skin, and lungs ... . Most inorganic **arsenic** is methylated in the body, mainly in the liver, and then excreted into the urine in the form of about 10-20% inorganic **arsenic**, 10-15% monomethylarsonic acid (MMA) and 60-80% dimethylarsinic acid (DMA). With increasing doses, the methylated fraction decreases. About 50-60% of an oral dose of inorganic **arsenic** is excreted within a week About 70 75% of ingested arsenobetaime is excreted into the urine within a week without being metabolized. /Inorganic **arsenic**/
[Chang, L.W. (ed.). Toxicology of Metals. Boca Raton, FL: Lewis Publishers, 1996 98]**PEER REVIEWED**

In studies of smelter workers, a linear relationship between work site air **arsenic** concentrations and the excretion of inorganic **arsenic** and its metabolites in urine has been observed; **arsenic** in urine (ug As/g creatinine)= 29 (ug As/g creatinine) + 2X **arsenic** in air (ug AS/cu m) ... . /**Arsenic** compounds/
[Chang, L.W. (ed.). Toxicology of Metals. Boca Raton, FL: Lewis Publishers, 1996 98]**PEER REVIEWED**

The metabolism of inorganic **arsenic** has been extensively studied in humans and animals. Two processes are involved: (1) reduction/oxidation reactions that interconvert arsenate and arsenite, and (2) methylation reactions, which convert arsenite to MMA and DMA. These processes appear to be similar whether exposure is by the inhalation, oral, or parenteral route. The human body has the ability to change inorganic **arsenic** to less toxic organic forms (i.e., by methylation) that are more readily excreted in urine. In addition, inorganic **arsenic** is also directly excreted in the urine. ... Long-term accommodation to **arsenic** exposure is also possible in which methylation and excretion become more efficient with several months of exposure. This mechanism is thought to have an upper-dose limit which, when overwhelmed, results in a higher incidence of **arsenic** toxicity. /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 139 (2000)]**PEER REVIEWED**

Reduction of arsenate to arsenite can be mediated by glutathione ... . showed that glutathione forms complexes with both arsenate and arsenite in vitro, and that glutathione is oxidized (and arsenate reduced) in the glutathione-arsenate raction. Studies in vitro indicate that the substrate for methylation is As(+3), and that As(+5) is not methylated unless it is first reduced to As(+3) ... . The main site of methylation appears to be the liver, where the methylation process is mediated by enzymes that utilize S-adenosylmethionine as cosubstrate ... . Under normal conditions, the availability of methyl donors (e.g., methionine, choline, cysteine) does not appear to be rate limiting in methylating capacity, either in

humans ... or in animals ... . However, severe dietary restriction of methyl donor intake can result in significant decr in methylating capacity ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 140 (2000)]**PEER REVIEWED**

Organic arsenicals appear to undergo little metabolism. Humans who ingested a dose of MMA converted a small about (about 13%) to DMA ... and several studies in hamsters have noted the formation of low levels of the trimethyl derivative (trimethylarsine oxide, CH3AsO) ... . However, the methylarsenates are not demethlated to inorganic **arsenic** either in humans ... or in animals ... . /Organic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 141 (2000)]**PEER REVIEWED**

Absorption, Distribution & Excretion:

THE PENTAVALENT INORG ARSENICALS ARE BETTER ABSORBED THAN THE TRIVALENT CMPD, PROBABLY BECAUSE THEY REACT LESS WITH INTESTINAL CONTENTS & MUCOSA. /**ARSENIC** CMPD/
[Gilman, A.G., T.W. Rall, A.S. Nies and P. Taylor (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 8th ed. New York, NY. Pergamon Press, 1990. 1603]**PEER REVIEWED**

THE ABSORPTION THROUGH SKIN IS A FUNCTION OF LIPID SOLUBILITY; IN GENERAL, TRIVALENT ARE BETTER ABSORBED THAN PENTAVALENT ARSENICALS. **ARSENIC** CMPD CAN BE ABSORBED THROUGH LUNG. /**ARSENIC** CMPD/
[Gilman, A.G., T.W. Rall, A.S. Nies and P. Taylor (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 8th ed. New York, NY. Pergamon Press, 1990. 1603]**PEER REVIEWED**

The distribution of (74)As-labeled arsenate and arsenite in pregnant mice and a monkey has been studied by autoradiography and gamma counting of isolated tissues, and their in vitro toxicity to a chondrogenic system has been investigated. With both **arsenic** forms, given as single intravenous injections to the mother, the (74)As-**arsenic** appeared to pass the mouse placenta relatively free and approximately to the same extent. The retention time in maternal tissues including the placenta was, however, around three times longer with arsenite than with arsenate. In early gestation, high activity was registered in the embryonic neuroepithelium, which correlates well with reported CNS malformations in rodents. In late gestation, the distribution pattern was more like that in the adults. Accumulation in skin and squamous epithelia of the upper gastrointestinal tract (oral cavity, esophagus and esophageal region of stomach) dominated the distribution picture, especially at a long survival interval. Arsenate, but not arsenite, showed affinity for the calcified areas of the skeleton. A marmoset monkey in late gestation receiving arsenite showed a somewhat lower rate of placental transfer than the mice. Skin and liver had the highest concn (at 8 hr), both in mother and fetuses. This species is known not to methylate **arsenic**, resulting in stronger binding and longer retention times of **arsenic** as compared with other species. The stronger binding in maternal tissues may possibly explain the lower rate of placental transfer. Arsenite was shown to inhibit cartilage formation in a chick limb bud mesenchymal spot culture system (ED50 approximately 5-10 uM), while arsenate seemed to be without effect at concn up to 200 uM (highest tested). Arsenate, however, showed a potentiation of the arsenite toxicity. /Arsenite and arsenate/
[Lindgren A et al; Acta Pharmacol Toxicol (Copenh) 54 (4): 311-320 (1984)]**PEER REVIEWED**

Methylated **arsenic** has been detected in the urine of cows and dogs fed arsenate or arsenite. When the dogs were fed doses of about 1.0 mg As/kg body weight of either valence form for 5 days, approximately equal amounts of inorganic and methylated **arsenic** were excreted in the urine. The cows produced about 3 times as much methylated **arsenic** as inorganic **arsenic** in their urine. /Arsenite and arsenate/
[Lakso JU, Peoples SA; J Agric Food Chem 23: 674-676 (1975) as cited in WHO; Environ Health Criteria: Arsenic p.65 (1981)]**PEER REVIEWED**

In human subjects ingesting arsenite in amounts ranging from 125-1,000 ug/day for 5 days, a steady state was reached within 5 days. During steady state, 60% of daily intake is excreted daily. /Arsenite/
[USEPA; Health Assessment Document: Inorganic Arsenic p.4-25 (1984) EPA-600/8-83-021F]**PEER REVIEWED**

... ORG ARSENICALS ARE EXCRETED VIA FECES & KIDNEYS. /ORG ARSENICALS/
[Kearney, P.C., and D. D. Kaufman (eds.) Herbicides: Chemistry, Degredation and Mode of Action. Volumes 1 and 2. 2nd ed. New York: Marcel Dekker, Inc., 1975. 759]**PEER REVIEWED**

Normal blood **arsenic** values for individuals in the USA and Europe are in the range of 1-5 ug total **arsenic**/l whole blood. ... Cigarette smokers showed mean blood **arsenic** levels approximately 50% higher than nonsmokers. It is reasonable to assume that human background blood levels reflect mainly dietary **arsenic**, much of which would likely be in various organo-arsenical forms that are extensively absorbed and rapidly cleared. /**Arsenic**/
[USEPA; Health Assessment Document: Inorganic Arsenic p.421 (1984) EPA 600/8-83-021]**PEER REVIEWED**

The effects on biotransformation & retention of (76)**arsenic**-labelled arsenite (0.4 mg **arsenic**/kg bw) was studied in rabbits. Fed diets low in methionine, choline, or proteins for 6 wk. All test diets caused a significant decr in urinary excretion of dimethyl (76)**arsenic**-arsinic acid, the main metabolite of inorganic **arsenic** giving rise to an increased retention of **arsenic** in the tissues, especially liver & lung. The test diets also caused an incr in the **arsenic** concn of liver microsomes. Subjects with a poor nutritional status have a lower capacity to methylate & thereby detoxify inorganic **arsenic**. /Arsenite/
[Vahter M, Marafante E; Toxicol Lett 37 (1): 41-6 (1987)]**PEER REVIEWED**

CHEMICAL FORMS OF **ARSENIC** IN URINE AFTER INGESTION OF SEA FOODS WAS STUDIED. MOST **ARSENIC** (GREATER THAN 90%) IN AQUEOUS EXTRACTS OF KONBU, SHRIMPS & FLAT FISH EXISTED IN UNIDENTIFIED BOUND FORMS WITH ORGANIC COMPOUNDS, IE, NOT AS INORGANIC OR METHYLATED **ARSENIC**. A LARGE PORTION IN HIJIKI (MORE THAN 80%) WAS PRESENT AS INORGANIC ARSENATE & ARSENITE (60% & 20%, RESPECTIVELY). EXCRETION PATTERNS OF **ARSENIC** IN URINE AFTER INGESTION OF THESE SEA FOODS WERE: WITH HIJIKI, A LARGE PART OF **ARSENIC** (GREATER THAN 40% OF TOTAL EXCRETED **ARSENIC**) WAS EXCRETED AS DMAA; WITH KONBU, DMAA ACCOUNTED FOR MOST OF THE EXCRETED **ARSENIC**. IN THE CASE OF SHRIMP & FLAT FISH, MORE THAN 50% OF **ARSENIC** WAS EXCRETED AS UNIDENTIFIED BOUND FORMS WITH ORGANIC COMPOUND(S). THE **ARSENIC** IN THESE FOODS, EXCEPT FOR HIJIKI, WAS RAPIDLY EXCRETED IN URINE WITHIN 40 HR AFTER EATING. /**ARSENIC** CMPD/
[FUKUI S ET AL; J FOOD HYG SOC JPN 22 (6): 513-19 (1981)]**PEER REVIEWED**

BOTH HUMAN & ANIMAL DATA INDICATE THAT OVER 80% OF INGESTED DOSE OF DISSOLVED INORG TRIVALENT **ARSENIC** IS ABSORBED FROM GI TRACT. ... IN CASE OF **ARSENIC** TRIOXIDE, WHICH IS ONLY SLIGHTLY SOL IN WATER, GI ABSORPTION WILL BE DEPENDENT ON FACTORS SUCH AS PARTICLE SIZE & PH OF THE GASTRIC JUICES. /AS(+3)/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 51]**PEER REVIEWED**

... PARENTERALLY ADMIN **ARSENIC** COMPOUNDS ARE COMPLETELY ABSORBED WITHIN 24 HR FROM IM & SC INJECTED SITES; 95-99% OF ABSORBED **ARSENIC** IS FOUND 1ST IN RED CELLS & THEN IN LIVER, KIDNEYS, LUNG, WALLS OF GI TRACT & SPLEEN.

AFTER 2 WK, **ARSENIC** IS STORED IN HAIR, SKIN & BONES. /INORGANIC **ARSENIC** COMPOUNDS/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 99 (1980)]**PEER REVIEWED**

THERE IS EVIDENCE THAT ARSENITE & ARSENATE CROSS THE PLACENTA IN MAMMALS. /INORGANIC **ARSENIC** COMPOUNDS/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 113 (1980)]**PEER REVIEWED**

Arsenic tends to accumulate in the liver, from which it is slowly released and becomes distributed to other tissues. After continued admin there is a tendency for it to be stored in the bones, skin and keratinized tissues such as hair and hooves, and to disappear from the soft tissues. **Arsenic** thus stored in the tissues may be found there for a long time, even after it has disappeared from the feces and urine. ... **Arsenic** is excreted in the urine, feces, sweat and milk. /Inorganic **arsenic** compounds/
[Clarke, M. L., D. G. Harvey and D. J. Humphreys. Veterinary Toxicology. 2nd ed. London: Bailliere Tindall, 1981. 30]**PEER REVIEWED**

Absorbed **arsenic** is excreted largely by the kidneys, but feces, skin, and hair sometimes contain appreciable amounts. In three patients, 45% of the absorbed dose of inhaled radio **arsenic** was eliminated in urine within three days, and another 2.5% was excreted in feces. After a single oral dose, excretion is essentially complete within two wk. /Inorganic **arsenic** compounds/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-44]**PEER REVIEWED**

The absorption of poorly water-soluble arsenicals ... greatly depends upon the physical state. ... Experimental evidence has shown a high degree of GI absorption of both trivalent and pentavalent forms of **arsenic**. /Inorganic **Arsenic** compounds/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1660]**PEER REVIEWED**

ARSENIC IS STORED MAINLY IN LIVER, KIDNEY, & LUNG. MUCH SMALLER AMT ARE FOUND IN MUSCLE & NEURAL TISSUE. BECAUSE OF HIGH SULFHYDRYL CONTENT OF KERATIN, HIGH CONCN OF **ARSENIC** ARE FOUND IN HAIR & NAILS. DEPOSITION IN HAIR STARTS WITHIN 2 WK AFTER ADMINISTRATION ... STAYS FIXED AT THIS SITE FOR YEARS. IT IS ALSO DEPOSITED IN BONE AND TEETH AND IS RETAINED THERE FOR LONG PERIODS. ... **ARSENIC** IS ELIMINATED BY MANY ROUTES (FECES, URINE, SWEAT, MILK, HAIR, SKIN, LUNG), ALTHOUGH MOST IS EXCRETED IN URINE IN MAN. /INORGANIC **ARSENIC** COMPOUNDS/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1660]**PEER REVIEWED**

... TENDS TO ACCUMULATE IN LIVER, FROM WHICH IT IS SLOWLY RELEASED AND BECOMES DISTRIBUTED TO OTHER TISSUES. THIS DISTRIBUTION ... IN PIG FOLLOWING ORAL ADMIN OF 104 MG OF **ARSENIC** (AS SODIUM ARSANILATE). STOMACH, SMALL INTESTINE, LARGE INTESTINE ... PANCREAS, HEART, KIDNEY, SPLEEN, BLOOD, BILE, FAT, MUSCLE, BONE, SKIN, FEET, BRISTLES. ... /IN A SEPARATE STUDY,/ AFTER LONG CONTINUED ADMINISTRATION THERE IS A TENDENCY FOR **ARSENIC** TO BE STORED IN BONES, SKIN AND KERATINIZED TISSUES SUCH AS HAIR AND HOOF, AND TO DISAPPEAR FROM THE SOFT TISSUES. **ARSENIC** THUS STORED IN THE TISSUES MAY BE FOUND

THERE FOR A LONG TIME, EVEN AFTER IT HAS DISAPPEARED FROM THE FECES AND URINE. ONCE **ARSENIC** IS DEPOSITED IN THE KERATINIZED CELLS OF HAIR IT IS IRREMOVABLE. /INORGANIC **ARSENIC** CMPD/
[Garner's Veterinary Toxicology. 3rd ed., rev. by E.G.C. Clarke and M.L. Clarke. Baltimore: Williams and Wilkins, 1967. 46]**PEER REVIEWED**

ARSENIC PROBABLY CROSSES THE PLACENTAL BARRIER BUT THE PAUCITY OF CENTRAL NERVOUS SIGNS & LESIONS IN POISONED ANIMALS SUGGESTS THAT **ARSENIC** DOES NOT CROSS BLOOD BRAIN BARRIER VERY WELL. /INORGANIC **ARSENIC** COMPOUNDS/
[Jones, L.M., et al. Veterinary Pharmacology & Therapeutics. 4th ed. Ames: Iowa State University Press, 1977. 1246]**PEER REVIEWED**

THE FRACTION OF A DOSE OF TRIVALENT ARSENICAL ... ABSORBED IS EXCRETED SLOWLY. ... MOST IS EXCRETED IN URINE & FECES. IT MAY TAKE 10 DAYS FOR COMPLETE ELIMINATION OF **ARSENIC** AFTER A SINGLE DOSE & UP TO 70 DAYS AFTER REPEATED ADMIN. THIS SLOW EXCRETION IS BASIS FOR CUMULATIVE TOXIC ACTION ... /INORGANIC **ARSENIC** COMPOUNDS/
[Gilman, A. G., L. S. Goodman, and A. Gilman. (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 6th ed. New York: Macmillan Publishing Co., Inc. 1980. 1630]**PEER REVIEWED**

Microorganisms take up arsenates and arsenites via the phosphate transport system at one-half the rate of phosphate. /Inorganic **arsenic** compounds/
[Button, EPA Rept No R71-8 (1971)]**PEER REVIEWED**

Arsenate ... can be reabsorbed by the proximal tubule in the dog kidney and re-excreted as arsenite. /Inorganic **arsenic** compounds/
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 320]**PEER REVIEWED**

Inorganic **arsenic** is absorbed significantly through the skin; trivalent forms more rapidly than pentavalent. /Inorganic **arsenic** compounds/
[Oehme FW; Clin Toxicol 5 (2): 151 (1972) as cited in Nat'l Research Council Canada; Effects of Arsenic in the Canadian Environment p.74 (1978) NRCC No. 15391]**PEER REVIEWED**

When arsenite administered iv to humans, 99% was excreted in 15 hr, low constant rate for next 155 hr, and remainder at a still slower rate. Arsenite and arsenate recovered, arsenate predominates. /Inorganic **arsenic** compounds/
[Mealey; AMA Arch Neurol Psych 81: 310 (1959)]**PEER REVIEWED**

EXCRETION CAN ALSO TAKE PLACE THROUGH THE SKIN &, IN LACTATING ANIMALS, IN THE MILK. /INORGANIC **ARSENIC** COMPOUNDS/
[Clarke, M. L., D. G. Harvey and D. J. Humphreys. Veterinary Toxicology. 2nd ed. London: Bailliere Tindall, 1981. 6]**PEER REVIEWED**

Skin absorption of **arsenic** in the rat using solutions of arsenate was significant and the uptake rate via the tail was as high as 33.1 ug/sq cm/hr using concn up to 0.2 molar. The corresponding absorption in man, using 700 sq cm as the surface area for both hands, was calculated to be as much as 23.2 mg/hr. /Inorganic **arsenic** compounds/
[Dutkiewicz T; Environ Health Perspect 19: 173 (1977) as cited in USEPA; Ambient Water Quality Criteria Doc: Arsenic p.C-18 (1980) EPA 440/5-80-021]**PEER REVIEWED**

Dogs given a single dose of pentavalent **arsenic** in the form of (74)As-arsenate (about 0.02 ug As/kg

body weight) orally in a gelatin capsule eliminated less than 5% of the dose in the feces during the first week, indicating almost complete absorption from the gastrointestinal tract. /Inorganic **arsenic** compounds/
[Hollins JG et al; Toxicol Lett 4: 7-13 (1979) as cited in WHO; Environ Health Criteria: Arsenic p.53 (1981)]**PEER REVIEWED**

When intramuscular injections of pentavalent **arsenic** (carrier free (74)As arsenate oxidized with nitric acid to the pentavalent state) were given to dogs, rabbits, guinea pigs, chicks, and mice, less than 0.3% of the dose was found in the blood 48 hr after dosing. The corresponding value for cats was 5.6%. Lambs poisoned with **arsenic** acid also showed very low **arsenic** levels in the blood. /Inorganic **arsenic** compounds/
[WHO; Environ Health Criteria: Arsenic p.56 (1981)]**PEER REVIEWED**

WATER SOLUBLE ARSENICALS ARE ABSORBED FROM ALL MUCOUS MEMBRANES & PARENTERAL SITES ... **ARSENIC** CMPD CAN BE ABSORBED THROUGH LUNG. /INORGANIC **ARSENIC** COMPOUNDS/
[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975. 927]**PEER REVIEWED**

INHALED **ARSENIC** CMPD ARE FULLY ABSORBED FROM LUNG & MUCOUS SURFACES OF RESPIRATORY TRACT, & ... ARE ALSO ABSORBED THROUGH THE SKIN; ABSORPTION THROUGH SKIN IS ENHANCED IF **ARSENIC** CMPD IS LIPID SOL OR DISTRIBUTED IN LIPID SOL OINTMENT. /INORGANIC **ARSENIC** COMPOUNDS/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 208]**PEER REVIEWED**

Enzyme sensitivity to **arsenic** toxicity: 12X10-3 M arsenate causes stimulation of adenosine triphosphatase; 1X10-3 M arsenate causes 20% inhibition of glutamate dehydrogenase; < 40X10-3 M arsenate causes stimulation of glyceraldehyde-3-phosphate dehydrogenase and > 80X10-3 M arsenate causes inhibition of glyceraldehyde-3-phosphate dehydrogenase; 1x10-3 M arsenate causes 30% inhibition of beta-hydroxybutyrate dehydrogenase. /Inorganic **arsenic** compounds/
[Nat'l Research Council Canada; Effects of Arsenic in the Canadian Environment p.77 (1978) NRCC No. 15391]**PEER REVIEWED**

FOLLOWING INTRAVENOUS INJECTION OR ABSORPTION INTO THE BLOOD, MOST OF THE INORGANIC **ARSENIC** IS BOUND TO THE GLOBIN OF HEMOGLOBIN IN ERYTHROCYTES; **ARSENIC** IS ALSO BOUND TO SERUM PROTEINS. /**ARSENIC**/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 208]**PEER REVIEWED**

SYSTEMIC TOXIC EFFECTS HAVE RESULTED FROM OCCUPATIONAL ACCIDENTS WHERE **ARSENIC** ACID OR **ARSENIC** TRICHLORIDE ... SPLASHED ON WORKERS, INDICATING THAT THE SKIN IS POSSIBLE ROUTE OF ABSORPTION OF **ARSENIC**. AFTER ABSORPTION BY THE LUNGS OR IN THE GI TRACT, **ARSENIC** IS TRANSPORTED BY THE BLOOD TO OTHER PARTS OF BODY. /**ARSENIC** CMPD/
[Friberg, L., G.R. Nordberg, and V.B. Vouk. Handbook on the Toxicology of Metals. New York: Elsevier North Holland, 1979. 299]**PEER REVIEWED**

IN THE HUMAN FETUS...INCREASING **ARSENIC** LEVELS /WERE REPORTED/ WITH LENGTH OF PREGNANCY. THE **ARSENIC** LEVELS IN BONE, LIVER, SKIN & BRAIN WERE 2-4 TIMES HIGHER IN NEWBORN BABIES COMPARED TO 7-MONTH-OLD FETUSES. /**ARSENIC**/
[Friberg, L., G.R. Nordberg, and V.B. Vouk. Handbook on the Toxicology of Metals. New York: Elsevier North Holland, 1979. 300]**PEER REVIEWED**

THE FRACTION OF A DOSE OF TRIVALENT ARSENICAL THAT IS ABSORBED IS EXCRETED SLOWLY. WHILE **ARSENIC** IS ELIMINATED BY MANY ROUTES (FECES, URINE, SWEAT, MILK, HAIR, SKIN, LUNG), MOST IS EXCRETED IN URINE & FECES. ARSENITE SALTS ARE EXCRETED MAINLY IN THE FECES. /TRIVALENT **ARSENIC**/
[Gilman, A. G., L. S. Goodman, and A. Gilman. (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 6th ed. New York: Macmillan Publishing Co., Inc. 1980. 1630]**PEER REVIEWED**

IT MAY TAKE 10 DAYS FOR COMPLETE ELIMINATION OF ARSENITE AFTER A SINGLE DOSE & UP TO 70 DAYS AFTER REPEATED ADMIN. THIS SLOW EXCRETION IS THE BASIS FOR THE CUMULATIVE TOXIC ACTION OF **ARSENIC**. /ARSENITE/
[Gilman, A. G., L. S. Goodman, and A. Gilman. (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 6th ed. New York: Macmillan Publishing Co., Inc. 1980. 1630]**PEER REVIEWED**

The absorption of orally administered 74-As-labelled trivalent and pentavalent **arsenic** (checked as to valence state at the time of exposure) has been studied in mice. The elimination of **arsenic** with feces during the first 48 hr was 6-9% of the dose (0.4 or 4 mg/kg body weight) for both valence forms. As about the same fecal elimination of **arsenic** was seen after subcutaneous administration, the results indicate almost complete initial absorption from the gastrointestinal tract following oral administration. /Arsenite and arsenate/
[Vahter M, Norin H; Environ Res 21: 446-457 (1980) as cited in WHO; Environ Health Criteria: Arsenic p.53 (1981)]**PEER REVIEWED**

Practically all **arsenic** cmpd which are toxic may be absorbed from ... alimentary tract. The vapors, particularly arsine & ethyl arsine diffuse through the pulmonary sac. /**Arsenic** cmpd/
[Thienes, C., and T.J. Haley. Clinical Toxicology. 5th ed. Philadelphia: Lea and Febiger, 1972. 171]**PEER REVIEWED**

The distribution of **arsenic** depends upon the duration of admin & the particular arsenical involved. **Arsenic** is stored mainly in liver, kidney, & lung. Much smaller amt are found in muscle & neural tissue. Because of high sulfhydryl content of keratin, high concn of **arsenic** are found in hair & nails. Deposition in hair starts within 2 wk after admin, and **arsenic** stary fixed at this site for yr. It is also deposited in bone & teeth ... **Arsenic** is eliminated by many routes (feces, urine, sweat, milk, hair, skin, lung) although most is excreted in urine in man. /**Arsenic** cmpd/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1660]**PEER REVIEWED**

The organic arsenicals are usually excreted more rapidly than are the inorganic forms. /**Arsenic** cmpd/
[Gilman, A.G., T.W. Rall, A.S. Nies and P. Taylor (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 8th ed. New York, NY. Pergamon Press, 1990. 1603]**PEER REVIEWED**

Arsenic compounds can be absorbed through the GI tract, lungs, and skin. After absorption, **arsenic** is transported to other parts of the body and distributed in various organs. The highest concentration of **arsenic** in humans is in hair and nails, followed by skin and lungs. /**Arsenic** compounds/
[Chang, L.W. (ed.). Toxicology of Metals. Boca Raton, FL: Lewis Publishers, 1996 221]**PEER REVIEWED**

Excretion of **arsenic** is mainly through urine. Pentavalent **arsenic** is excreted more rapidly than trivalent, and organic faster than inorganic. The urine **arsenic** concentration is thought to be the best indicator of current or of recent past exposure to **arsenic**. /**Arsenic** compounds/
[Chang, L.W. (ed.). Toxicology of Metals. Boca Raton, FL: Lewis Publishers, 1996 222]**PEER REVIEWED**

Both arsenate and arsenite are well absorbed by both the oral and inhalation routes. Absorption by the dermal route has not been well characterized, but is low compared to the other routes. Inorganic **arsenic** in soil is absorbed to a lesser extent than soln of **arsenic** salts. /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 132 (2000)]**PEER REVIEWED**

Once absorbed, arsenites are partially oxidized to arsenates and arsenates are partially reduced to arsenites, yielding a mixture of As(+3) and As(+5) in the blood. /Arsenates and arsenites/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 132 (2000)]**PEER REVIEWED**

The As(+3) form undergoes enzymic methylation primarily in the liver to form MMA and DMA. The rate and relative proportion of methylation production varies among species ... /and/ may also vary among tissues. /As(+3)/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 133 (2000)]**PEER REVIEWED**

Since **arsenic** exists in air as particulate matter /SRP: except arsine/, absorption across the lung involves two processes: deposition of the particles onto the lung surface, and absorption of **arsenic** from the deposited material. In lung cancer patients exposed to **arsenic** in cigarette smoke, deposition was est to be about 40% and absorption was 75-85% ... . Thus, overall absorption ... was about 30-34%. In workers exposed to **arsenic** trioxide dusts in smelters, the amt of **arsenic** excreted in the urine (the main route of excretion ...) was about 40-60% of the est inhaled dose ... . Absorption of **arsenic** trioxide dusts and fumes ... correlated with time weighted avg **arsenic** air concn from personal breathing zone air samples ... . /**Arsenic** cmpd/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 133 (2000)]**PEER REVIEWED**

Several studies in humans indicate that arsenates and arsenites are well absorbed across the GI tract. The most direct evidence is from measurement of fecal excretion in humans give oral doses of arsenite, where less than 5% was recovered in the feces ... . This indicates absorption was at least 95%. This is supported by studies in which urinary excretion in humans was found to account for 55-80% of daily oral intakes or arsenate or arsenite ... . In contract, ingestion of **arsenic** triselenide ... did not lead to a measurable incr in urinary excretion ... indicated that GI absorption may be much lower if highly insoluble forms of **arsenic** are ingested. There are no data to suggest that absorption of **arsenic** from the gut in children differs from that in adults. /**Arsenic** cmpd/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 134 (2000)]**PEER REVIEWED**

Analysis of tissues taken at autopsy from people who were exposed to background levels of **arsenic** in food and water revealed that **arsenic** is present in all tissues of the body ... . Most tissues had about the same concn level (0.05-0.15 ppm), while levels in hair (0.65 ppm) and nails (0.36 ppm) were somewhat higher. This indicates that there is little tendency for **arsenic** to accumulate preferentially in any internal organs. However, exposure levels may not have been high enough to cause elevated levels in tissues. **Arsenic** exposure may have been low enough that the methylation process in the body resulted in limited accumulation in internal organs. /**Arsenic** cmpd/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 137 (2000)]**PEER REVIEWED**

Arsenic concn were 0.0001-0.0044 ppm in human milk sampled from 88 mothers on the Faroe Islands whose diets were predominantly seafood ... . Exposures to **arsenic** from the seafood diet in this population was mostly likely to organic "fish **arsenic**." /Mainly arsenobetaine and arsenocholine/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 138 (2000)]**PEER REVIEWED**

In a population of Andean women exposed to high concn (about 200 ppb) of inorganic **arsenic** in drinking water, concn of **arsenic** in breast milk ranged from about 0.0008 to 0.008 ppm ... . /Inorganic arsenicals/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 138 (2000)]**PEER REVIEWED**

Biological Half-Life:

The half-life for the urinary excretion of **arsenic** /in man/ is 3 to 5 days. /Inorganic **arsenic** compounds/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1660]**PEER REVIEWED**

Biological half-life for **arsenic** in gut and liver of Lepomis cyanellus (green sunfish) was about seven days. /Inorganic **arsenic** compounds/
[Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume I. EPA-440/4 79-029a. Washington, DC: U.S. Environmental Protection Agency, December 1979.p. 6-9]**PEER REVIEWED**

BIOLOGICAL HALF-LIFE OF **ARSENIC** IN RATS AFTER SINGLE EXPOSURE IS LONG (ABOUT 60 DAYS) DUE TO ACCUMULATION OF **ARSENIC** IN BLOOD. /INORGANIC **ARSENIC** COMPOUNDS/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 55]**PEER REVIEWED**

Mechanism of Action:

Inorganic arsenicals affect the bone marrow & alter the cellular composition of the blood. The vascularity of the bone marrow is incr. Moderate doses of **arsenic** lower the erythrocyte count, & large doses cause morphological changes with the appearance of megalocytes & microcytes. Inorganic arsenicals also suppress production of leukocytes. /**Arsenic** cmpd/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1661]**PEER REVIEWED**

Enzyme sensitivity to arsenite toxicity: 2X10-4 M arsenite causes 100% inhibition of pyruvate dehydrogenase. /Arsenite/
[Nat'l Research Council Canada; Effects of Arsenic in the Canadian Environment p.78 (1978) NRCC No.15391]**PEER REVIEWED**

Enzyme sensitivity to arsenite toxicity: 0.7X10-3 M arsenite causes 48% inhibition of adenylate cyclase. /Arsenite/
[Nat'l Research Council Canada; Effects of Arsenic in the Canadian Environment p.77 (1978) NRCC No.15391]**PEER REVIEWED**

Enzyme sensitivity to **arsenic** toxicity: 12X10-3 M arsenate causes stimulation of adenosine triphosphatase; 1X10-3 M arsenate causes 20% inhibition of glutamate dyhydrogenase; < 40X10-3 M arsenate causes stimulation of glyceraldehyde-3-phosphate dehydrogenase and > 80X10-3 M arsenate causes inhibition of glyceraldehyde-3-phosphate dehydrogenase; 1x10-3 M arsenate causes 30% inhibition of beta-hydroxybutyrate dehydrogenase. /Inorganic **arsenic** compounds/
[Nat'l Research Council Canada; Effects of Arsenic in the Canadian Environment p.77 (1978) NRCC No. 15391]**PEER REVIEWED**

Enzyme sensitivity to arsenate toxicity: 1x10-3 M arsenate causes 30% inhibition of succinic dehydrogenase. /Inorganic **arsenic** compounds/
[Nat'l Research Council Canada; Effects of Arsenic in the Canadian Environment p.78 (1978) NRCC No. 15391]**PEER REVIEWED**

Although various classes of enzymes are sensitive to arsenite, the oxidizing enzyme systems appear to be particularly vulnerable, including: pyruvate oxidase, D-amino acid oxidase, 2-glutamic acid oxidase,

monoamine oxidase, liver choline oxidase, and glucose oxidase. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.C-37 (1980) EPA 440/5-80-021]**PEER REVIEWED**

Arsenite is known to be a potent inhibitor of chicken liver xanthine dehydrogenase and related molybdoflavoproteins and probably interacts with the molybdenum site in these enzymes. /Arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.C-39 (1980) EPA 440/5-80-021]**PEER REVIEWED**

The trivalent form can chemically interfere directly with enzyme action via formation of **arsenic**-sulfur bonds with those thiol groups which participate in either enzyme structure or function. /Trivalent **arsenic**/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.C-37 (1980) EPA 440/5-80-021]**PEER REVIEWED**

ARSONIC ACID HERBICIDES ... ACT THROUGH ENZYME SYSTEMS TO INHIBIT GROWTH. THEY KILL RELATIVELY SLOWLY; FIRST SYMPTOMS ... CHLOROSIS, CESSATION OF GROWTH ... GRADUAL YELLOWING ... BROWNING, ... DEHYDRATION & DEATH. RHIZOMES & TUBERS MAY SHOW BROWNING OF STORAGE TISSUES. EYES OR BUDS FAIL TO SPROUT & ... DECOMP ... WHEN RESPROUTING OF TUBERS OR RHIZOMES ... OCCUR, TREATMENT. REPEATED WHEN SOME OF LEAVES HAVE REACHED FULL SIZE. TREATMENT BEFORE THIS ... WILL NOT RESULT IN TRANSLOCATION BECAUSE MOVEMENT OF ASSIMILATE STREAM INTO UNDERGROUND ORGANS IS NECESSARY TO CARRY TOXICANT TO PROPER SITES OF ACTION. /ARSONIC ACID HERBICIDES/
[Kearney, P.C., and D. D. Kaufman (eds.) Herbicides: Chemistry, Degredation and Mode of Action. Volumes 1 and 2. 2nd ed. New York: Marcel Dekker, Inc., 1975. 763]**PEER REVIEWED**

/INVESTIGATORS/ ... SHOWED THAT PHOSPHATE COULD BE REPLACED BY ARSENATE IN BIOLOGICAL REACTION, BUT ... UNLIKE PHOSPHATE, ARSENATE WAS NOT INCORP INTO ORG FORM. SUBSEQUENTLY, GLYCERALDEHYDE-3-PHOSPHATE DEHYDROGENASE WAS SHOWN TO BE THE SITE OF **ARSENIC** ACTION, & THE IDEA OF AN ARSENOLYTIC REACTION, IE, THE ABILITY OF **ARSENIC** TO PARTICIPATE IN ENZYMIC REACTIONS TO FORM A LABILE **ARSENIC** ANALOG OF THE NORMAL PHOSPHORUS COMPD, BECAME WELL ESTABLISHED. THE SUPPOSITION /IS/ THAT THE **ARSENIC**-CONTAINING REACTION PRODUCT IS RAPIDLY HYDROLYZED TO REGENERATE ARSENATE .... /OTHERS/ ... SUGGESTED THAT THE TOXICITY OF **ARSENIC** MAY RESULT FROM THE BLOCKAGE OR INHIBITION OF ENZYMES NECESSARY TO CATALYZE INTERMEDIARY METABOLIC REACTIONS OR FROM UNCOUPLING OF ATP FORMATION IN THE OXIDATIVE PHOSPHORYLATION PROCESS. /ARSONIC ACID HERBICIDES/
[Kearney, P.C., and D. D. Kaufman (eds.) Herbicides: Chemistry, Degredation and Mode of Action. Volumes 1 and 2. 2nd ed. New York: Marcel Dekker, Inc., 1975. 762]**PEER REVIEWED**

PHOSPHORUS & **ARSENIC** COMPETE ... FOR UPTAKE AT PLANT ROOTS. /ARSENICAL HERBICIDES/
[Kearney, P.C., and D. D. Kaufman (eds.) Herbicides: Chemistry, Degredation and Mode of Action. Volumes 1 and 2. 2nd ed. New York: Marcel Dekker, Inc., 1975. 757]**PEER REVIEWED**

Arsenate (pentavalent) is a well-known uncoupler of mitochondrial oxidative phosphorylation. The mechanism is thought to be related to competitive substitution of arsenate for inorganic phosphate in the formation of adenosine triphosphate, with subsequent formation of an unstable arsenate ester that is rapidly hydrolyzed. This process is termed arsenolysis. Trivalent arsenicals, including inorganic arsenite,

are regarded primarily as sulfhydryl reagents. As such trivalent arsenicals inhibit many enzymes by reacting with biological ligands containing available SH groups. The pyruvate dehydrogenase system is especially sensitive to trivalent arsenicals because of their interaction with two sulfhydryl groups of lipoic acid to form a stable six-membered ring ... . /Pentavalent arsenate/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1660]**PEER REVIEWED**

THE ARSENATES PRODUCE REGURGITATION, TORPOR, & QUIESCENCE IN INSECTS. THE EPITHELIAL CELLS OF THE MID-GUT OF POISONED INSECTS ARE GENERALLY DISINTEGRATED WITH VACUOLIZED CYTOPLASM AND THE CHROMATIN OF THE NUCLEI CLUMPED. THESE ARE ... MANIFESTATIONS OF A MORE FUNDAMENTAL BIOCHEMICAL LESION AS **ARSENIC** POISONING SLOWLY DECREASES THE OXYGEN CONSUMPTION OF THE INSECT. THIS IS ASSOCIATED WITH A REACTION BETWEEN THE TRIVALENT **ARSENIC** AND SULFHYDRYL(-SH) GROUPS OF GLUTATHIONE AND VARIOUS ENZYMES SUCH AS PYRUVATE OXIDASE. /INORGANIC ARSENICAL INSECTICIDES/
[White-Stevens, R. (ed.). Pesticides in the Environment: Volume 1, Part 1, Part 2. New York: Marcel Dekker, Inc., 1971. 68]**PEER REVIEWED**

AT MOLECULAR LEVEL ... TRIVALENT **ARSENIC** ... /ACTS/ BY COMBINING WITH 2 SULFHYDRYL GROUPS OF LIPOIC ... ACID ... INACTIVATING LIPOIC ACID ... INHIBITS FORMATION OF ACETYL, SUCCINYL, & PROPIONYL COENZYMES-A. ... MAJOR CONSEQUENCES ... INHIBITION OR SLOWING OF GLYCOLYSIS & OF CITRATE CYCLE. /INORGANIC **ARSENIC** COMPOUNDS/
[Jones, L.M., et al. Veterinary Pharmacology & Therapeutics. 4th ed. Ames: Iowa State University Press, 1977. 1246]**PEER REVIEWED**

Enzyme activation by arsenicals is also known to occur. This includes activation of cytochrome oxidase of rat brain at an arsenate concn at 1.0 millimolar, catalase, malate dehydrogenase of pig heart at 30 millimolar and, apparently, enzyme systems associated with drug detoxification. /Inorganic **arsenic** compounds/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.C-39 (1980) EPA 440/5-80-021]**PEER REVIEWED**

... Trivalent arsenicals inhibit many enzymes by reacting with biological ligands containing available -SH groups. The pyruvate dehydrogenase system is especially sensitive to trivalent arsenicals because of their interaction with two sulfhydryl groups of lipoic acid to form a stable six-membered ring ... /Inorganic **arsenic** compounds/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1660]**PEER REVIEWED**

Relatively high-dose acute- and intermediate-duration toxicity appears to be the result of **arsenic** cytotoxicity. Reduced inorganic **arsenic** (As(+3)) reacts strongly with sulfhydryl groups in proteins and inactivates many enzymes. A particular target in the cell is the mitochondria, which accumulates **arsenic** ... . **Arsenic** inhibits sucinic dehydrogenase activity and can uncouple oxidative phosphorylation; the resulting fall in ATP levels affects virtually all cellular functions (Na+, K+ balance, protein synthesis, etc.). /**Arsenic** cmpd/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 162 (2000)]**PEER REVIEWED**

Interactions:

A number of researchers have found that **arsenic** cmpd tend to reduce the effects of selenium ... . Likewise, selenium can decr the effects of **arsenic**, incl clastogenicity ... cytotoxicity ... and

teratogenicity ... . The mechanism of this mutual inhibition of effects is not known, but may be related to the formation of a complex that is excreted more rapidly than either **arsenic** or selenium alone ... . /**Arsenic** cmpd/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 199 (2000)]**PEER REVIEWED**

... Simultaneous exposure of rats to ethanol (10% in drinking water) and **arsenic** (dose not stated) for 6 wk produced a significant incr in the concn of **arsenic** in the kidney, a nonsignificant incr in the **arsenic** in the liver and a significant incr in the concn of glutathione in the liver, compared to rats treated with either ethanol or **arsenic** alone ... . Histological damage to the liver, but not the kidneys, was incr in rats treated with both ethanol and **arsenic** compared to those receiving only **arsenic**. /**Arsenic**, NOS/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 199 (2000)]**PEER REVIEWED**

The interactions of tobacco smoking with exposure to occupational chemicals were reviewed. ... A multiplicative interaction was found in one, and an intermediate interaction between additive and multiplicative in two studies of **arsenic** exposure in copper smelters. ... /**Arsenic**/
[Saracci R; Epidemiologic Reviews 9: 175-93 (1987)]**PEER REVIEWED**

Pharmacology:

Therapeutic Uses:

/Former use:/ Organic arsenicals are drugs which were employed in the treatment of syphilis and other diseases since the beginning of this century, and have had toxic side effects upon the eyes in a great many cases. /Organic arsenicals/
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 118]**PEER REVIEWED**

The use of organoarsenic compounds as medicaments like Salvarsan to treat syphilis has become historical since the development of penicillin and other antibiotics. However, for the treatment of certain tropical parasitic diseases some **arsenic** compounds are still indispensable. The possible carcinogenic effect of **arsenic** has led to the abandonment of rebuilding cures for weakened or convalescent patients with the so-called Fowler solution (1% solution of potassium arsenite). Likewise for the treatment of psoriasis vulgaris and anemic disease **arsenic** medicaments are not prescribed anymore. /Organoarsenic cmpd/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 82]**PEER REVIEWED**

MEDICATION (VET): CHEM INT FOR ARSENICALS USED IN VETERINARY MEDICINE /ARSENICALS/
[SRI]**PEER REVIEWED**

Arsenic was used more than 2400 years ago in Greece & Rome as a therapeutic agent & as a poison. The history & folklore of **arsenic** prompted intensive studies by early pharmacologists. Indeed, the foundations of many modern concepts of chemotherapy derive from Ehrlich's early work with organic arsenicals, & such drugs were once a mainstay of chemotherapy. In current therapeutics, arsenicals are important only in the treatment of certain tropical diseases, such as African trypanosomiasis. /Organic arsenicals/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1659]**PEER REVIEWED**

Drug Warnings:

Vet: Therapeutic dosages of org arsenical cmpd may prove toxic if animal is debilitated or dehydrated. /Org arsenical cmpd/
[Clarke, E.G., and M. L. Clarke. Veterinary Toxicology. Baltimore, Maryland: The Williams and Wilkins Company, 1975. 37]**PEER REVIEWED**

Interactions:

A number of researchers have found that **arsenic** cmpd tend to reduce the effects of selenium ... . Likewise, selenium can decr the effects of **arsenic**, incl clastogenicity ... cytotoxicity ... and teratogenicity ... . The mechanism of this mutual inhibition of effects is not known, but may be related to the formation of a complex that is excreted more rapidly than either **arsenic** or selenium alone ... . /**Arsenic** cmpd/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 199 (2000)]**PEER REVIEWED**

... Simultaneous exposure of rats to ethanol (10% in drinking water) and **arsenic** (dose not stated) for 6 wk produced a significant incr in the concn of **arsenic** in the kidney, a nonsignificant incr in the **arsenic** in the liver and a significant incr in the concn of glutathione in the liver, compared to rats treated with either ethanol or **arsenic** alone ... . Histological damage to the liver, but not the kidneys, was incr in rats treated with both ethanol and **arsenic** compared to those receiving only **arsenic**. /**Arsenic**, NOS/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 199 (2000)]**PEER REVIEWED**

The interactions of tobacco smoking with exposure to occupational chemicals were reviewed. ... A multiplicative interaction was found in one, and an intermediate interaction between additive and multiplicative in two studies of **arsenic** exposure in copper smelters. ... /**Arsenic**/
[Saracci R; Epidemiologic Reviews 9: 175-93 (1987)]**PEER REVIEWED**

Minimum Fatal Dose Level:

Fatal human dose 70-180 mg. Estimated lethal dose for a 70 kg human as As (III) /**Arsenic** (III)/
[NIH/EPA; OHM/TADS (1985)]**PEER REVIEWED**

PROBABLE ORAL LETHAL DOSE (HUMAN) IS LESS THAN 5 MG/KG, A TASTE (LESS THAN 7 DROPS) FOR 70 KG PERSON (150 LB). /ARSENITES/
[Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976.,p. II-90]**PEER REVIEWED**

Single ingestions ranging from 22 to 108 mg/kg were fatal in human males. /From table/ /As(+3)/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 49 (2000)]**PEER REVIEWED**

Single ingestion of 121 mg/kg was fatal in a human male. /From table/ /As(+5)/
[DHHS/ATSDR; Toxicological Profile for Arsenic p. 49 (2000)]**PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Arsenic is the 20th most abundant element in the earth's crust. It occurs most often as a compound with sulfide in a variety of complex minerals. Other important natural sources of **arsenic** in the environment are from volcanic eruptions. From the mid-19th century to 1940s, inorganic **arsenic** compounds were the dominant pesticides available to farmers and fruit growers. Around the 1960s, the use of inorganic **arsenic** compounds in agriculture disappeared. However, some **arsenic** pesticides are still used today. The production and use of **arsenic** compounds as wood preservatives (eg, chrome copper arsenate) and

pesticides (eg, cacodylic acid) will result in its direct release to the environment. **Arsenic**'s production and use in nonferrous alloys and in the manufacture of semiconductors may result in its release to the environment through various waste streams. Other important anthropogenic sources of **arsenic** in the environment are metal smelting and coal burning. In air, **arsenic** is present mainly in particulate form as **arsenic** trioxide. **Arsenic** compounds in the particulate phase may be removed from the air by wet and dry deposition. In water, inorganic species of **arsenic** occur mainly as As(V) in oxidizing environments such as surface water and As(III) under reducing conditions in groundwater. Soluble forms of **arsenic** move with water and may be carried long distances. However, **arsenic** strongly sorbs onto sediments. In acidic and neutral waters, As(V) is extensively adsorbed, while As(III) is relatively weakly adsorbed. In waters with a high pH, both oxidation states are relatively weakly adsorbed. Sorbed As(V) in sediments may be remobilized if conditions become sufficiently reduced for As(V) to form As(III). **Arsenic** compounds are methylated by bacteria and fungi to yield dimethyl and trimethylarsines. Methylation is important in the transfer of **arsenic** from the sediment to the water to the atmosphere. In soils, the mobility of **arsenic** in clay soils is low to moderate but much higher for loamy and sandy soils. The max adsorption of As(V) on kaolinite and montmorillonite is pH 5; sorption of As(III) increases beyond this pH and at pH 8 more As(III) is sorbed than As(V). At high pH, both oxidation states of **arsenic** will be more mobile in soil. The potential for volatilization of **arsenic** compounds from moist surfaces varies greatly. Dissociated **arsenic** compounds may be sorbed by soil or may form strong complexes in solution. These **arsenic** compounds are not expected to volatilize from moist soil surfaces. However, **arsenic** compounds in soil may be methylated by microorganisms and subsequently lost by volatilization. Occupational exposure to **arsenic** may occur through inhalation and dermal contact with this compound at workplaces where **arsenic** is produced or used. Monitoring data indicate that the general population may be exposed to **arsenic** via inhalation of ambient air, and ingestion of food and drinking water containing **arsenic**. The avg daily intake of **arsenic** ranges from 0.04 to 46 ug for air, 2 to 92 ug for food, and averages 4.8 ug for drinking water. (SRC)
PEER REVIEWED

Body Burden:

Normal adults from Glascow, Scotland had avg **arsenic** concns in hair of 0.650 ug/g (range, 0.20-8.17 ug/g; N=1,250)(1). The avg concn of **arsenic** in liver, lung, and spleen from postmortem adults were 0.048 ug/g (range, 0.011-0.152 ug/g), 0.044 ug/g (range, 0.0121-0.125 ug/g), and 0.015 ug/g (range, 0.001-0.063 ug/g), respectively(1). The avg concn of **arsenic** in liver, lung, and spleen from postmortem infants were 0.0099 ug/g (range, 0.0034-0.019 ug/g), 0.007 ug/g (range, 0.0011-0.015 ug/g), and 0.0049 ug/g (range, 0.0011-0.0088 ug/g), respectively(1). Residents from the Palatinate region of Germany had avg concns of **arsenic** in urine (24-hour) and hair of 3.96 ug/g (range, <0.1-18.32 ug/g) and 0.028 ug/g (range, <0.005-0.154 ug/g), respectively(2). Residents from the Saxony region of Germany had avg concns of **arsenic** in urine (24-hour) and hair of 7.58 ug/g (range, 0.29-23.78 ug/g) and 0.069 ug/g (range, 0.013-0.682 ug/g), respectively(2). **Arsenic** was measured in lung tissues from non-occupationally exposed people from Erlangen- Nurenberg, Germany (sampled between Jan 1992-Dec 1993); concns were 5.5 ng/g wet wt (range, <1-13 ng/g wet wt)(3).
[(1) Raie RM; Ecotox Environ Saf 35: 248-252 (1996) (2) Gebel T et al; Anticancer Res 18: 4253-4258 (1998) (3) Kraus T et al; Arch Environ Contam Toxicol 38: 384-389 (2000)]**PEER REVIEWED**

Natural Pollution Sources:

Natural sources which are not readily quantifiable are meteoritic and volcanic dustfall, and the decay of vegetation and animals which have accumulated **arsenic**.
[Nat'l Research Council Canada; Effects of Arsenic in the Canadian Environment p.156 (1978) NRCC No.15391]**PEER REVIEWED**

Arsenic is found widely in nature and most abundantly in sulfide ores. Arsenopyrite (FeAsS) is the most abundant one.
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 179]**PEER REVIEWED**

ARSENIC ... ACCOUNTS FOR 5X10-4% OF THE EARTH'S CRUST. MINERALS CONTAINING **ARSENIC** INCLUDE: ... ORPIMENT ... REALGAR ... CLAUDETITE ... COBALTITE ... ENARGITE ... .
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 115]**PEER REVIEWED**

Artificial Pollution Sources:

GALLIUM, INDIUM, PHOSPHORUS, & **ARSENIC** ARE BASE MATERIALS IN SEMICONDUCTOR MFR. WASTE OCCURS AS SLURRY & AS COMPD DISSOLVED IN AQ, ALK, & ACIDIC SOLN. A GAS WASTE SLUDGE RECOVERY & TREATMENT SYSTEM IS DISCUSSED.
[DAMICO FA ET AL; MID ATL IND WASTE CONF (PROC) 11: 157 (1979)]**PEER REVIEWED**

Because **arsenic** cmpd are used for weed control and as desiccants for cotton, dust and gases emitted from cotton gins contain **arsenic**. ... The burning of cotton trash from cotton gins is another source of **arsenic** emissions ... . /**Arsenic** cmpd/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 65 (1980)]**PEER REVIEWED**

ENVIRONMENTAL ACCUMULATION: IT HAS BEEN SUGGESTED THAT FERTILIZER AND DETERGENTS MANUFACTURED FROM PHOSPHATE ROCK CONTAINING **ARSENIC** CONTRIBUTE TO THE INCREASED **ARSENIC** CONTENT OF RIVER WATER. /**ARSENIC** AND **ARSENIC** CMPD/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 56 (1973)]**PEER REVIEWED**

ARSENIC IN TOBACCO SMOKE. **ARSENIC** DERIVED FROM INSECTICIDES AND PRESENT IN SMALL QUANTITIES IN TOBACCO SMOKE. /**ARSENIC** AND **ARSENIC** CMPD/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 68 (1973)]**PEER REVIEWED**

Arsenic's production and use as a wood preservative (as chrome copper arsenate)(1,2) and pesticide (as cacodylic acid, disodium methylarsenite, monosodium methylarsenate, and **arsenic** acid)(3,4) is expected to result in its direct release to the environment(SRC). **Arsenic**'s production and use in nonferrous alloys (as **arsenic** metal)(5) and in the manufacture of semiconductors (as gallium arsenide, **arsenic**, and arsine)(6,7) may result in its release to the environment through various waste streams(SRC). Other important anthropogenic sources of **arsenic** are metal smelting, coal burning, and other industrial activities(8).
[(1) American Wood Preservers Association; FAQ's: Treated Wood Uses. American Wood Preserver's Association. Available from the Database Query page at http://www.awpa.com/faq/faq2.htm as of April 10, 2001. (2) Page BJ, Loar GW; Kirk-Othmer Encycl Chem Technol. 4th ed NY, NY: John Wiley and Sons 6: 297-298 (1993) (3) Farm Chemicals Handbook 2001. Willoughby, Ohio: Meister pp. C 31, C 68, C 160, C 278 (2001) (4) Gianessi LP, Anderson JE; Pesticide Use in US Crop Production. Washington, DC: National Center for Food and Agricultural Policy (1995) (5) USGS; Mineral Commodity Summaries 1999. Arsenic. Available from the Database Query page at

http://minerals.usgs.gov/minerals/pubs/commodity/arsenic as of April 10, 2001. (6) Carapella SC; Kirk-Othmer Encycl Chemical Technol. 4th ed NY, NY: John Wiley and Sons, 3: 624-33 (1992) (7) Sheehy JW, Jones JH; Am Ind Hyg Assoc J 54: 61-69 (1993) (8) Loebenstein JR; The materials flow of arsenic in the United States. Washington, DC: US Dept Int, Bureau Mines, Div Min Commod BUMINES-IC-9382 (1994)]**PEER REVIEWED**

Environmental Fate:

INORGANIC ARSENICALS SUCH AS ... CALCIUM ARSENATE CA3(ASO4)2 HAVE BEEN USED FOR MANY YRS AS SOIL STERILANTS ... THESE CMPD ARE MOST PERSISTENT SOIL STERILANTS & MAY REMAIN EFFECTIVE FOR ... AS LONG AS 5-8 YR ESPECIALLY IN AREAS OF LOW RAINFALL.
[White-Stevens, R. (ed.). Pesticides in the Environment: Volume 1, Part 1, Part 2. New York: Marcel Dekker, Inc., 1971. 34]**PEER REVIEWED**

Aquatic Fate: **Arsenic** as a free element (0-oxidation state) is rarely encountered in natural waters. Soluble inorganic arsenate (+5-oxidation state) predominates under normal conditions since it is thermodynamically more stable in water than arsenite (+3 oxidation state).
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.A-1 (1980) EPA 440/5-80-021]**PEER REVIEWED**

Aquatic: All of the **arsenic** halides are covalent compounds that hydrolyze in the presence of water. /**Arsenic** halides/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.A-3 (1980) EPA 440/5-80-021]**PEER REVIEWED**

Environmental Standards & Regulations:

FIFRA Requirements:

Tolerances for total residues of combined **arsenic** (calculated as As) in food are established as follows: (a) In edible tissues & in eggs of chickens & turkeys: 0.5 ppm in uncooked muscle tissue; 2 ppm in uncooked edible by-products; & 0.5 ppm in eggs. (b) In edible tissues of swine: 2 ppm in uncooked liver & kidney; 0.5 ppm in uncooked muscle tissue & by-products other than liver & kidney. /**Arsenic**/
[21 CFR 556.60 (4/1/2001)]**PEER REVIEWED**

Acceptable Daily Intakes:

WHO= 0.002 mg/kg /Inorganic **arsenic** cmpd, as As; from table/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 843]**PEER REVIEWED**

RCRA Requirements:

D004; A solid waste containing **arsenic** may or may not become characterized as a hazardous waste when subjected to the Toxicity Characteristic Leaching Procedure listed in 40 CFR 261.24, and if so characterized, must be managed as a hazardous waste.
[40 CFR 261.24 (7/1/2001)]**PEER REVIEWED**

Atmospheric Standards:

Inorganic **arsenic** has been designated as a hazardous air pollutant under section 112 of the Clean Air Act. /Inorganic **Arsenic**/

[40 CFR 61.01 (7/1/2001)]**PEER REVIEWED**

(a) The owner or operator of an existing glass melting furnace subject to the provisions of this subpart shall comply with either paragraph (a)(1) or (a)(2) of this section ... (1) Uncontrolled total **arsenic** emissions from the glass melting furnace shall be less than 2.5 Mg (2.7 ton) per year, or ... (2) Total **arsenic** emissions from glass melting furnace shall be conveyed to a control device and reduced by at least 85%. /Total **arsenic**/
[40 CFR 61.162(a) (7/1/2001)]**PEER REVIEWED**

(b) The owner or operator of a new or modified glass melting furnace subject to the provisions of this subpart shall comply with either paragraph (b)(1) or (b)(2) of this section ... (1) Uncontrolled total **arsenic** emissions from the glass melting furnace shall be less than 0.4 Mg (0.44 ton) per year, or ... (2) Total **arsenic** emissions from glass melting furnace shall be conveyed to a control device and reduced by at least 85%. /Total **arsenic**/
[40 CFR 61.162(b) (7/1/2001)]**PEER REVIEWED**

The owner or operator of each copper converter subject to the provisions of this subpart shall reduce inorganic **arsenic** emissions to the atmosphere by meeting the following design, equipment, work practice, and operational requirements: (1) Install, operate, and maintain a secondary hood system on each copper converter. Each secondary hood system shall consist of a hood enclosure, air curtain fan(s), exhaust system fan(s), and ductwork that conveys the captured emission to a control device ... (2) Optimize the capture of secondary inorganic **arsenic** emission by operating the copper converter and secondary hood systems at all times ... . /Inorganic **arsenic**/
[40 CFR 61.172(b) (7/1/2001)]**PEER REVIEWED**

National Emission Standards for Inorganic **Arsenic** Emissions From **Arsenic** Trioxide and **Metallic Arsenic** Production Facilities. (a) Within 30 dyas after the effective date of this subpart, the owner or operator of each source to which this subpart applies shall identify and submit to the Administrator a list of potential sources (equipment and operations) of inorganic arsenic emissions. /Inorganic arsenic/
[40 CFR 61.182(a) (7/1/2001)]**PEER REVIEWED**

National Emission Standards for Inorganic **Arsenic** Emissions From **Arsenic** Trioxide and **Metallic Arsenic** Production Facilities. (b) The owner or operator shall submit a description of an inspection, maintenance, and housekeeping plan for control of inorganic arsenic emissions ... (c) The owner or operator shall implement the plan ... (d) At all times ... the owner or operator ... shall operate and maintain the source incl associated air pollution control equipment in a manner consistent with good air pollution control practice for minimizing emissions of inorganic arsenic to the atmosphere to the maximum extent possible ... . /Inorganic Arsenic/
[40 CFR 61.182(b) (7/1/2001)]**PEER REVIEWED**

Clean Water Act Requirements:

Toxic pollutant designated pursuant to section 307(a)(1) of the Federal Water Pollution Control Act and is subject to effluent limitations. /**Arsenic** & cmpd/
[40 CFR 401.15 (7/1/2001)]**QC REVIEWED**

For the maximum protection of human health from the potential carcinogenic effects due to exposure of **arsenic** through ingestion of contaminated water & contaminated aquatic organisms, the ambient water concn should be zero based on the nonthreshold assumption for this chemical. However, zero level may not be attainable at the present time. Therefore, the levels which may result in incremental increase of cancer risk over the lifetime are estimated at 1X10-5, 1X10-6, & 1X10-7. The corresponding criteria are 22 ng/l, 2.2 ng/l, & .22 ng/l, respectively .... For consumption of aquatic organisms only, excluding

consumption of water, the levels are 175 ng/ml, 17.5 ng/l, & 1.75 ng/l, respectively. /**Arsenic**/
[USEPA; Quality Criteria for Water 1986: Arsenic: Human Health Criteria (May 1, 1986) EPA 440/5-86-001]**QC REVIEWED**

Federal Drinking Water Standards:

10 ug/l /**Arsenic**/
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

FDA Requirements:

No batch of straight color listed in Subpart B, C, or D shall be certified under this part unless: (a) It is free from all impurities (other than those named in paragraph (b) of this section or in the specifications set forth in such paragraph for such color) to the extent that such impurities can be avoided by good manufacturing practice. (b) It conforms to the following specifications: (1) In the case of a straight color listed in subpart B: ... **arsenic** (as As2O3), not more than 0.00014%. ... In the case of straight color listed in subpart C or D: ... **arsenic** (as As2O3), not more than 0.0002%. /**Arsenic** (as As2O3)/
[21 CFR 82.5 (4/1/2001)]**PEER REVIEWED**

Tolerances for total residues of combined **arsenic** (calculated as As) in food are established as follows: (a) In edible tissues & in eggs of chickens & turkeys: 0.5 ppm in uncooked muscle tissue; 2 ppm in uncooked edible by-products; & 0.5 ppm in eggs. (b) In edible tissues of swine: 2 ppm in uncooked liver & kidney; 0.5 ppm in uncooked muscle tissue & by-products other than liver & kidney. /**Arsenic**/
[21 CFR 556.60 (4/1/2001)]**PEER REVIEWED**

Allowable Tolerances:

Tolerances for total residues of combined **arsenic** (calculated as As) in food are established as follows: (a) In edible tissues & in eggs of chickens & turkeys: 0.5 ppm in uncooked muscle tissue; 2 ppm in uncooked edible by-products; & 0.5 ppm in eggs. (b) In edible tissues of swine: 2 ppm in uncooked liver & kidney; 0.5 ppm in uncooked muscle tissue & by-products other than liver & kidney. /**Arsenic**/
[21 CFR 556.60 (4/1/2001)]**PEER REVIEWED**

Chemical/Physical Properties:

Other Chemical/Physical Properties:

The pH of aqueous solutions appears to be the major factor in the relative stability of either valence form. It was found that trivalent **arsenic** in solutions at pH of 7.0 or 9.6 were oxidized to the extent of 70-90% within one week, compared to 25% conversion at pH 4.8. ... Rapid oxidation of As (III) in aqueous solution occurs at room temperature, while storage at 4 deg C showed little conversion. /Inorganic **arsenic**/
[USEPA; Health Assessment Document: Inorganic Arsenic p.4-20 (1984) EPA 600/8-83-021F]**PEER REVIEWED**

Arsenates are oxidizing agents and are reduced by concn hydrochloric acid or sulfur dioxide. /Arsenates/

[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. V3 255 (1978)]**PEER REVIEWED**

ARSENITES OF ALKALI METALS ARE SLOWLY CONVERTED IN SOLN TO ARSENATES BY

ATMOSPHERIC OXYGEN; & DECOMPOSED BY ATMOSPHERIC CARBON DIOXIDE
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 50 (1973)]**PEER REVIEWED**

Chemical Safety & Handling:

DOT Emergency Guidelines:

Health: Highly toxic, may be fatal if inhaled, swallowed or absorbed through skin. Avoid any skin contact. Effects of contact or inhalation may be delayed. Fire may produce irritating, corrosive and/or toxic gases. Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution. /**Arsenic** cmpd/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Fire or explosion: Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes. Containers may explode when heated. Runoff may pollute waterways. /**Arsenic** cmpd/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Public safety: CALL Emergency Response Telephone Number. ... Isolate spill or leak area immediately for at least 25 to 50 meters (80 to 160 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Keep out of low areas. /**Arsenic** cmpd/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Protective clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Wear chemical protective clothing which is specifically recommended by the manufacturer. It may provide little or no thermal protection. Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations. /**Arsenic** cmpd/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Evacuation: ... Fire: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions. /**Arsenic** cmpd/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Fire: Small fires: Dry chemical, CO2 or water spray. Large fires: Water spray, fog or regular foam. Move containers from fire area if you can do it without risk. Dike fire control water for later disposal; do not scatter the material. Use water spray or fog; do not use straight streams. Fire involving tanks or car/trailer loads: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Do not get water inside containers. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible withdraw from area and let fire burn. /**Arsenic** cmpd/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8

Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Spill or leak: Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. Cover with plastic sheet to prevent spreading. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. DO NOT GET WATER INSIDE CONTAINERS. /**Arsenic** cmpd/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

First aid: Move victim to fresh air. Call 911 or emergency medical service. Apply artificial respiration if victim is not breathing. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. For minor skin contact, avoid spreading material on unaffected skin. Keep victim warm and quiet. Effects of exposure (inhalation, ingestion or skin contact) to substance may be delayed. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves. /**Arsenic** cmpd/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Health: Highly toxic, may be fatal if inhaled, swallowed or absorbed through skin. Contact with molten substance may cause severe burns to skin and eyes. Avoid any skin contact. Effects of contact or inhalation may be delayed. Fire may produce irritating, corrosive and/or toxic gases. Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution. /**Arsenic** compound, liquid or solid, nos; Arsenates, liquid or solid, nos/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-152]**QC REVIEWED**

Fire or explosion: Combustible material: may burn but does not ignite readily. Containers may explode when heated. Runoff may pollute waterways. Substance may be transported in a molten form. /**Arsenic** compound, liquid or solid, nos; Arsenates, liquid or solid, nos/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-152]**QC REVIEWED**

Public safety: CALL Emergency Response Telephone Number. ... Isolate spill or leak area immediately for at least 25 to 50 meters (80 to 160 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Keep out of low areas. /**Arsenic** compound, liquid or solid, nos; Arsenates, liquid or solid, nos/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-152]**QC REVIEWED**

Protective clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Wear chemical protective clothing which is specifically recommended by the manufacturer. It may provide little or no thermal protection. Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations. /**Arsenic** compound, liquid or solid, nos; Arsenates, liquid or solid, nos/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-152]**QC

REVIEWED**

Evacuation: ... Fire: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions. /**Arsenic** compound, liquid or solid, nos; Arsenates, liquid or solid, nos/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-152]**QC REVIEWED**

Fire: Small fires: Dry chemical, CO2 or water spray. Large fires: Water spray, fog or regular foam. Move containers from fire area if you can do it without risk. Dike fire control water for later disposal; do not scatter the material. Use water spray; do not use straight streams. Fire involving tanks or car/trailer loads: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Do not get water inside containers. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn. /**Arsenic** compound, liquid or solid, nos; Arsenates, liquid or solid, nos/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-152]**QC REVIEWED**

Spill or leak: Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. Cover with plastic sheet to prevent spreading . Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. DO NOT GET WATER INSIDE CONTAINERS. /**Arsenic** compound, liquid or solid, nos; Arsenates, liquid or solid, nos/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-152]**QC REVIEWED**

First aid: Move victim to fresh air. Call 911 or emergency medical service. Apply artificial respiration if victim is not breathing. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. For minor skin contact, avoid spreading material on unaffected skin. Keep victim warm and quiet. Effects of exposure (inhalation, ingestion or skin contact) to substance may be delayed. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves. /**Arsenic** compound, liquid or solid, nos; Arsenates, liquid or solid, nos/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-152]**QC REVIEWED**

Skin, Eye and Respiratory Irritations:

Trivalent **arsenic** compounds are corrosive to the skin. /Trivalent **arsenic** cmpd/
[Sittig, M. Handbook of Toxic And Hazardous Chemicals. Park Ridge, NJ: Noyes Data Corporation, 1981. 58]**PEER REVIEWED**

ARSENICAL DUSTS ... ARE IRRITATING TO UPPER RESP TRACT & EYES. CONJUNCTIVITIS PRODUCED BY ... THESE SUBSTANCES ARE CHARACTERIZED BY ITCHING, BURNING, & WATERING OF EYES. ... /INORGANIC **ARSENIC** DUSTS/
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 115]**PEER REVIEWED**

Fire Potential:

Fire: Vesicants may be volatilized during a fire or be spread by efforts to extinguish the fire. Combustion of arsenical vesicants will produce volatile, toxic **arsenic** decomposition products. In addition, arsenical vesicants may react with steam or water during a fire to produce toxic, corrosive and/or flammable vapors. Hydrogen produced by the action of the corrosive vapors on metals or other corrodible materials may be present. /Vesicants - **Arsenic** Based/
[Ellison, D.H., Emergency Action for Chemical and Biological Warfare Agents. CRC Press, Boca Raton, FL 1999. 53]**PEER REVIEWED**

Fire Fighting Procedures:

If material involved in fire: Extinguish fire using agent suitable for type of surrounding fire. (Material itself does not burn or burns with difficulty.) Use water in flooding quantities as fog. Use foam, dry chemical, or carbon dioxide. /Arsenical cmpd, liquid, NOS/
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 104]**PEER REVIEWED**

If material involved in fire: Extinguish fire using agent suitable for type of surrounding fire. (Material itself does not burn or burns with difficulty.) Use water in flooding quantities as fog. Use foam, dry chemical, or carbon dioxide. /Arsenical cmpd, solid, NOS/
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 105]**PEER REVIEWED**

Personnel protection: ... Wear positive pressure self-contained breathing apparatus when fighting fires involving this material. /Arsenical cmpd, solid, NOS/
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 105]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

... WHEN WATER SOLN OF ARSENICALS ARE IN CONTACT WITH ACTIVE METALS SUCH AS **ARSENIC**, IRON, ALUMINUM, ZINC, ... HIGHLY TOXIC FUMES OF **ARSENIC** /INCLUDING ARSINE ARE RELEASED/. /**ARSENIC** CMPD/
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 275]**PEER REVIEWED**

Strong oxidizers, bromide azide [Note: Hydrogen gas can react with inorganic **arsenic** to form the highly toxic gas arsine.] /**Arsenic** (inorganic compounds, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

Reactivity: Arsenical vesicant vapors are decomposed rapidly by high humidity. Limited solubility slows the rate of the hydrolysis of liquid agents. /Vesicants - **Arsenic** Based/
[Ellison, D.H., Emergency Action for Chemical and Biological Warfare Agents. CRC Press, Boca Raton, FL 1999. 54]**PEER REVIEWED**

Hazardous Decomposition:

DANGEROUS WHEN HEATED TO DECOMP ... IT EMITS TOXIC FUMES OF **ARSENIC** /SRP: INCLUDING ARSINE/. /**ARSENIC** CMPD/

[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 275]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

5 mg/cu m (as AS); NIOSH considers **arsenic** (inorganic cmpd, as As) to be a potential occupational carcinogen. /**Arsenic** (inorganic cmpd, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

Protective Equipment & Clothing:

Workers should be supplied with suitable protective clothing, protective boots and when there is a risk that the exposure limit for airborne **arsenic** will be exceeded, respiratory protective equipment. /**Arsenic** cmpd/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 182]**PEER REVIEWED**

Where there is occupational exposure to inorganic **arsenic** compounds, protective clothing shall be provided by the employers. This may include underwear, gloves, coveralls, and a hood over the head and neck. /Inorganic **arsenic**/
[NIOSH; Criteria Document: Inorganic Arsenic p.5 (1975) DHEW Pub. NIOSH 75-149]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... dispensers of liq detergent /should be available./ ... Safety pipettes should be used for all pipetting. ... In animal laboratory, personnel should ... wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. ... gowns ... /should be/ of distinctive color, this is a reminder that they are not to be worn outside the laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

Wear mechanical filter respirator with hard rubber frame and surgical sheet wadding over nose and cheeks, ... boots, and long-sleeved coveralls. /**Arsenic**/
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 51]**PEER REVIEWED**

Wear appropriate personal protective clothing to prevent skin contact. /**Arsenic** (inorganic cmpd, as As)/

[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact. /**Arsenic** (inorganic cmpd, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

Recommendations for respirator selection: At concn above the NIOSH REL, or where there is no REL, at any detectable concn. Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive pressure-mode. Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an

auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode. /**Arsenic** (inorganic cmpd, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

Respirators for escape purposes only: Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted acid gas canister having a high-efficiency particulate filter. Any appropriate escape-type, self-contained breathing apparatus. /**Arsenic** (inorganic cmpd, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

Preventive Measures:

WELL VENTILATED & ALL POISONOUS FUME ... CONDENSED & DUST CONTENT REMOVED. ... EXHAUST HOODS ... WORKTABLES ... EQUIPPED WITH DOWN-DRAUGHT ... VENTILATION. /**ARSENIC** CMPD/
[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 117]**PEER REVIEWED**

IN ... /FACTORIES/ WITH **ARSENIC** HAZARD, FLOORS ... SHOULD BE ... IMPERMEABLE ... TO PREVENT ABSORPTION & ... FLUSHED DOWN FREQUENTLY WITH WATER. /**ARSENIC** CMPD/
[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 117]**PEER REVIEWED**

Lockers should be provided with separate compartments for work & personal clothes, & adjacent sanitary facilities of a high standard should be made available. Smoking, eating, & drinking at the workplace should not be allowed. /**Arsenic** & cmpd/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 182]**PEER REVIEWED**

Employees exposed to **arsenic** shall wash their hands and exposed skin before eating or smoking during the work shift. No food shall be permitted in areas where **arsenic** is handled, processed, or stored. Employees shall not smoke in areas where **arsenic** is handled, processed, or stored. /Inorganic **arsenic**/
[NIOSH; Criteria Document: Inorganic Arsenic p.9 (1975) DHEW Pub. NIOSH 75-149]**PEER REVIEWED**

Clean work clothes should be supplied daily and the workers should shower prior to changing to street clothes. /**Arsenic** and **arsenic** cmpd/
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 89]**PEER REVIEWED**

Contact lenses should not be worn when working with this chemical. /**Arsenic** (inorganic cmpd, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

SRP: Contaminated protective clothing should be segregated in such a manner so that there is no direct personal contact by personnel who handle, dispose, or clean the clothing. Quality assurance to ascertain the completeness of the cleaning procedures should be implemented before the decontaminated protective clothing is returned for reuse by the workers. Contaminated clothing should not be taken home at end of shift, but should remain at employee's place of work for cleaning.
PEER REVIEWED

PRECAUTIONS FOR "CARCINOGENS": Smoking, drinking, eating, storage of food or of food & beverage containers or utensils, & the application of cosmetics should be prohibited in any laboratory.

All personnel should remove gloves, if worn, after completion of procedures in which carcinogens have been used. They should ... wash ... hands, preferably using dispensers of liq detergent, & rinse ... thoroughly. Consideration should be given to appropriate methods for cleaning the skin, depending on nature of the contaminant. No standard procedure can be recommended, but the use of organic solvents should be avoided. Safety pipettes should be used for all pipetting. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": In animal laboratory, personnel should remove their outdoor clothes & wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... clothing should be changed daily but ... discarded immediately if obvious contamination occurs ... /also,/ workers should shower immediately. In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. If gowns are of distinctive color, this is a reminder that they should not be worn outside of lab. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... operations connected with synth & purification ... should be carried out under well-ventilated hood. Analytical procedures ... should be carried out with care & vapors evolved during ... procedures should be removed. ... Expert advice should be obtained before existing fume cupboards are used ... & when new fume cupboards are installed. It is desirable that there be means for decreasing the rate of air extraction, so that carcinogenic powders can be handled without ... powder being blown around the hood. Glove boxes should be kept under negative air pressure. Air changes should be adequate, so that concn of vapors of volatile carcinogens will not occur. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Vertical laminar-flow biological safety cabinets may be used for containment of in vitro procedures ... provided that the exhaust air flow is sufficient to provide an inward air flow at the face opening of the cabinet, & contaminated air plenums that are under positive pressure are leak-tight. Horizontal laminar-flow hoods or safety cabinets, where filtered air is blown across the working area towards the operator, should never be used ... Each cabinet or fume cupboard to be used ... should be tested before work is begun (eg, with fume bomb) & label fixed to it, giving date of test & avg air-flow measured. This test should be repeated periodically & after any structural changes. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Principles that apply to chem or biochem lab also apply to microbiological & cell-culture labs ... Special consideration should be given to route of admin. ... Safest method of administering volatile carcinogen is by injection of a soln. Admin by topical application, gavage, or intratracheal instillation should be performed under hood. If chem will be exhaled, animals should be kept under hood during this period. Inhalation exposure requires special equipment. ... unless

specifically required, routes of admin other than in the diet should be used. Mixing of carcinogen in diet should be carried out in sealed mixers under fume hood, from which the exhaust is fitted with an efficient particulate filter. Techniques for cleaning mixer & hood should be devised before expt begun. When mixing diets, special protective clothing &, possibly, respirators may be required. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When ... admin in diet or applied to skin, animals should be kept in cages with solid bottoms & sides & fitted with a filter top. When volatile carcinogens are given, filter tops should not be used. Cages which have been used to house animals that received carcinogens should be decontaminated. Cage-cleaning facilities should be installed in area in which carcinogens are being used, to avoid moving of ... contaminated /cages/. It is difficult to ensure that cages are decontaminated, & monitoring methods are necessary. Situations may exist in which the use of disposable cages should be recommended, depending on type & amt of carcinogen & efficiency with which it can be removed. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": To eliminate risk that ... contamination in lab could build up during conduct of expt, periodic checks should be carried out on lab atmospheres, surfaces, such as walls, floors & benches, & ... interior of fume hoods & airducts. As well as regular monitoring, check must be carried out after cleaning-up of spillage. Sensitive methods are required when testing lab atmospheres. ... Methods ... should ... where possible, be simple & sensitive. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Rooms in which obvious contamination has occurred, such as spillage, should be decontaminated by lab personnel engaged in expt. Design of expt should ... avoid contamination of permanent equipment. ... Procedures should ensure that maintenance workers are not exposed to carcinogens. ... Particular care should be taken to avoid contamination of drains or ventilation ducts. In cleaning labs, procedures should be used which do not produce aerosols or dispersal of dust, ie, wet mop or vacuum cleaner equipped with high-efficiency particulate filter on exhaust, which are avail commercially, should be used. Sweeping, brushing & use of dry dusters or mops should be prohibited. Grossly contaminated cleaning materials should not be re-used ... If gowns or towels are contaminated, they should not be sent to laundry, but ... decontaminated or burnt, to avoid any hazard to laundry personnel. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Doors leading into areas where carcinogens are used ... should be marked distinctively with appropriate labels. Access ... limited to persons involved in expt. ... A prominently displayed notice should give the name of the Scientific Investigator or other person who can advise in an emergency & who can inform others (such as firemen) on the handling of carcinogenic substances. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer,

A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.11]**PEER REVIEWED**

AVOID CONTACT WITH SKIN & EYES, CONTAMINATION OF CLOTHES, & INHALATION OF SPRAY. FOR SKIN PROTECTION, USE **ARSENIC**-RESISTANT CREAM (SILICONE BASED). IF THE CHEMICAL IS SPILLED ON THE SKIN, WASH IMMEDIATELY. ... /ARSENICALS, INORGANIC/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 664]**PEER REVIEWED**

The worker should immediately wash the skin when it becomes contaminated. /**Arsenic** (inorganic cmpd, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

The worker should wash daily at the end of each work shift. /**Arsenic** (inorganic cmpd, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed and replaced. /**Arsenic** (inorganic cmpd, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

Workers whose clothing may have become contaminated should change into uncontaminated clothing before leaving the work premises. /**Arsenic** (inorganic cmpd, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

If material not involved in fire: Keep material out of water sources and sewers. Build dikes to contain flow as necessary. /Arsenical cmpd, liquid, NOS/
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 104]**PEER REVIEWED**

Personnel protection: Avoid breathing vapors. Keep upwind. ... Avoid bodily contact with the material. ... Do not handle broken packages unless wearing appropriate personal protective equipment. Wash away any material which may have contacted the body with copious amounts of water or soap and water. /Arsenical cmpd, liquid, NOS/
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 104]**PEER REVIEWED**

If material not involved in fire: Keep material out of water sources and sewers. /Arsenical cmpd, solid, NOS/
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 105]**PEER REVIEWED**

Personnel protection: Avoid breathing dusts, and fumes from burning material. Keep upwind. Avoid bodily contact with the material. ... Do not handle broken packages unless wearing appropriate personal protective equipment. Wash away any material which may have contacted the body with copious amounts of water or soap and water. /Arsenical cmpd, solid, NOS/
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 105]**PEER REVIEWED**

Eyewash fountains should be provided in areas where there is any possibility that workers could be exposed to the substance; this is irrespective of the recommendation involving the wearing of eye protection. /**Arsenic** (inorganic cmpd, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

Facilities for quickly drenching the body should be provided within the immediate work area for emergency use where there is a possibility of exposure. (Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from any body areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.) /**Arsenic** (inorganic cmpd, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

Stability/Shelf Life:

SLOWLY CONVERTED IN SOLN TO ARSENATES BY ATMOSPHERIC OXYGEN; IN DRY STATE DECOMP BY ATMOSPHERIC CO2. /ARSENITES OF ALKALI METALS/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 50 (1973)]**PEER REVIEWED**

STABLE TO AIR, LIGHT
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 376]**PEER REVIEWED**

The pH of aqueous solutions appears to be a major factor in the relative stability. ... Pentavalent inorganic **arsenic** ... is relatively stable at neutral or alkaline pH but undergoes reduction with decreasing pH. /Pentavalent inorganic **arsenic**/
[Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 631]**PEER REVIEWED**

Shipment Methods and Regulations:

PRECAUTIONS FOR "CARCINOGENS": Procurement ... of unduly large amt ... should be avoided. To avoid spilling, carcinogens should be transported in securely sealed glass bottles or ampoules, which should themselves be placed inside strong screw-cap or snap-top container that will not open when dropped & will resist attack from the carcinogen. Both bottle & the outside container should be appropriately labelled. ... National post offices, railway companies, road haulage companies & airlines have regulations governing transport of hazardous materials. These authorities should be consulted before ... material is shipped. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When no regulations exist, the following procedure must be adopted. The carcinogen should be enclosed in a securely sealed, watertight container (primary container), which should be enclosed in a second, unbreakable, leakproof container that will withstand chem attack from the carcinogen (secondary container). The space between primary & secondary container should be filled with absorbent material, which would withstand chem attack from the

carcinogen & is sufficient to absorb the entire contents of the primary container in the event of breakage or leakage. Each secondary container should then be enclosed in a strong outer box. The space between the secondary container & the outer box should be filled with an appropriate quantity of shock-absorbent material. Sender should use fastest & most secure form of transport & notify recipient of its departure. If parcel is not received when expected, carrier should be informed so that immediate effort can be made to find it. Traffic schedules should be consulted to avoid ... arrival on weekend or holiday ... /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

Storage Conditions:

Protect container against physical damage. Store in well ventilated area away from food or food products and combustible materials. /Inorganic **arsenic** cmpd/
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 51]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Storage site should be as close as practical to lab in which carcinogens are to be used, so that only small quantities required for ... expt need to be carried. Carcinogens should be kept in only one section of cupboard, an explosion-proof refrigerator or freezer (depending on chemicophysical properties ...) that bears appropriate label. An inventory ... should be kept, showing quantity of carcinogen & date it was acquired ... Facilities for dispensing ... should be contiguous to storage area. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

Cleanup Methods:

Both arsenate and arsenite can be removed from the water column by co-precipitation or adsorption onto iron oxides. Arsenate species can also be removed by adsorption onto aluminum hydroxide and clays, while arsenite is readily adsorbed onto metal sulfides. /Arsenate and arsenite/
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.A-2 (1980) EPA 440/5-80-021]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": A high-efficiency particulate arrestor (HEPA) or charcoal filters can be used to minimize amt of carcinogen in exhausted air ventilated safety cabinets, lab hoods, glove boxes or animal rooms ... Filter housing that is designed so that used filters can be transferred into plastic bag without contaminating maintenance staff is avail commercially. Filters should be placed in plastic bags immediately after removal ... The plastic bag should be sealed immediately ... The sealed bag should be labelled properly ... Waste liquids ... should be placed or collected in proper containers for disposal. The lid should be secured & the bottles properly labelled. Once filled, bottles should be placed in plastic bag, so that outer surface ... is not contaminated ... The plastic bag should also be sealed & labelled. ... Broken glassware ... should be decontaminated by solvent extraction, by chemical destruction, or in specially designed incinerators. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

Floors and other accessible surfaces contaminated with inorganic **arsenic** may not be cleaned by the use

of compressed air, and shoveling and brushing may be used only where vacuuming or other relevant methods have been tried and found not to be effective. /Inorganic **arsenic** compounds/
[29 CFR 1910.1000 (7/1/87)]**PEER REVIEWED**

Decontamination: Liquid: Casualties/personnel: Speed in decontamination is absolutely essential. Remove contaminated clothing immediately Remove as much of the agent from the skin as fast as possible without spreading the material. Immediately wash skin and clothes with a bleach solution that is no less than one part household bleach in nine parts water. Rinse with copious amounts of water. To be effective, decontamination must be completed within one minute of exposure. In all cases, clothing should be removed because it may contain "trapped" liquid or vapor. Small Areas: Puddles of liquid must be contained by covering with vermiculite, diatomaceous earth, clay, fine sand, sponges, paper towels, or cloth towels. Remove all material and place in a container. Decontaminate the area with copious amounts of household bleach. Removal of porous material, including painted surfaces, that may have absorbed Vesicant liquid may be required as these materials could continue to re release vapor after exposure has ceased. Surfaces contaminated with vesicants, then only rinsed may still evolve sufficient agent vapor to produce a physiological response. /Vesicants - **Arsenic** Based/
[Ellison, D.H., Emergency Action for Chemical and Biological Warfare Agents. CRC Press, Boca Raton, FL 1999. 55]**PEER REVIEWED**

Disposal Methods:

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste number D004, must conform with USEPA regulations in storage, transportation, treatment and disposal of waste. /**Arsenic**/
[40 CFR 240-280, 300-306, 702-799 (7/1/2000)]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": There is no universal method of disposal that has been proved satisfactory for all carcinogenic compounds & specific methods of chem destruction ... published have not been tested on all kinds of carcinogen-containing waste. ... summary of avail methods & recommendations ... /given/ must be treated as guide only. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.14]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Incineration may be only feasible method for disposal of contaminated laboratory waste from biological expt. However, not all incinerators are suitable for this purpose. The most efficient type ... is probably the gas-fired type, in which a first-stage combustion with a less than stoichiometric air:fuel ratio is followed by a second stage with excess air. Some ... are designed to accept ... aqueous & organic-solvent solutions, otherwise it is necessary ... to absorb soln onto suitable combustible material, such as sawdust. Alternatively, chem destruction may be used, esp when small quantities ... are to be destroyed in laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": HEPA (high-efficiency particulate arrestor) filters ... can be disposed of by incineration. For spent charcoal filters, the adsorbed material can be stripped off at high temp & carcinogenic wastes generated by this treatment conducted to & burned in an incinerator. ... LIQUID WASTE: ... Disposal should be carried out by incineration at temp that ... ensure complete combustion. SOLID WASTE: Carcasses of lab animals, cage litter & misc solid wastes ... should be disposed of by incineration at temp high enough to ensure destruction of chem carcinogens or their

metabolites. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... small quantities of ... some carcinogens can be destroyed using chem reactions ... but no general rules can be given. ... As a general technique ... treatment with sodium dichromate in strong sulfuric acid can be used. The time necessary for destruction ... is seldom known ... but 1-2 days is generally considered sufficient when freshly prepd reagent is used. ... Carcinogens that are easily oxidizable can be destroyed with milder oxidative agents, such as saturated soln of potassium permanganate in acetone, which appears to be a suitable agent for destruction of hydrazines or of compounds containing isolated carbon-carbon double bonds. Concn or 50% aqueous sodium hypochlorite can also be used as an oxidizing agent. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.16]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Carcinogens that are alkylating, arylating or acylating agents per se can be destroyed by reaction with appropriate nucleophiles, such as water, hydroxyl ions, ammonia, thiols & thiosulfate. The reactivity of various alkylating agents varies greatly ... & is also influenced by sol of agent in the reaction medium. To facilitate the complete reaction, it is suggested that the agents be dissolved in ethanol or similar solvents. ... No method should be applied ... until it has been thoroughly tested for its effectiveness & safety on material to be inactivated. For example, in case of destruction of alkylating agents, it is possible to detect residual compounds by reaction with 4(4-nitrobenzyl)-pyridine. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.17]**PEER REVIEWED**

Storage: To convert the gas-cleaning residues obtained during the metallurgical processing of **arsenic**-containing ores into a portable and less water-soluble form, the metals are precipitated as hydroxides by using an excess of lime water and the **arsenic** is precipitated as calcium arsenate and calcium arsenite. This "**arsenic** sludge" is recycled, on the one hand, in order not to lose the valuable metals, and on the other, in order to reduce the problem of **arsenic** sludge disposal. The following storage possibilities are available today for **arsenic** residues that cannot be recycled immediately or at all: special dumps sealed against the penetration of ground water, surface water and rain water; galleries in abandoned salt mines; concrete silos. In any case the sludge must be dewatered beforehand until it is compact. Recommendable methods: Precipitation, solidification, landfill. Not recommendable: Thermal destruction, discharge to sewer. Peer-review: Soluble **arsenic** cmpd should be converted to the insoluble sulfide before solidification. (Peer-review conclusions of an IRPTC expert consultation (May 1985)) /Arsenates and arsenites/
[United Nations. Treatment and Disposal Methods for Waste Chemicals (IRPTC File). Data Profile Series No. 5. Geneva, Switzerland: United Nations Environmental Programme, Dec. 1985. 96]**PEER REVIEWED**

Chemical Treatability of **Arsenic**; Concentration Process: Chemical Precipitation; Chemical Classification: Metal; Scale of Study: Pilot Scale; Type of Wastewater Used: Domestic Wastewater + Pure Compound; Results of Study: 5ppm @ 4gpm @ pH= 7.0. Iron system-90% reduction; low lime system-80% reduction; high lime system-76% reduction; (3 coagulant systems were used; Iron system used 45 ppm as Fe of Fe2(SO4)3 @ pH= 6.0. Low lime system used 20 ppm Fe of Fe2(SO4)3 and 260 ppm of CaO @ pH= 10.0. High lime system used 600 ppm of CaO @ pH= 11.5. Chemical coagulation

was followed by multimedia filtration). /**Arsenic** cmpd/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-68 (1982)]**PEER REVIEWED**

Chemical Treatability of **Arsenic**; Concentration Process: Chemical Precipitation; Chemical Classification: Metal; Scale of Study: Full Scale Continuous Flow; Type of Wastewater Used: Domestic Wastewater; Results of Study: Effluent character (ppb): 2.5, 56% reduction with lime; 3.3, 24% reduction with lime; (lime dose of 350-400 ppm as calcium oxide @ pH= 11.3). /**Arsenic** cmpd/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-68 (1982)]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for **arsenic**: Concentration process: Chemical Precipitation. /**Arsenic**/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-68 (1982)]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for **arsenic**: Concentration process: Activated Carbon. /**Arsenic**/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-162 (1982)]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for **arsenic**: Concentration process: Miscellaneous Sorbents. /**Arsenic**/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-202 (1982)]**PEER REVIEWED**

Dissolve in a minimum amt of concentrated hydrochloric acid. Add to water until the appearance of white precipitate. Add 6M-HCl just to dissolve again. Saturate with hydrogen sulfide. After filtration, wash the precipitate, dry, package and return to suppliers. /**Arsenic**/
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 51]**PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

8 hr Time-Weighted avg: 10 ug/cu m./**Arsenic**, inorganic cmpd (as As)/
[29 CFR 1910.1018 (7/1/2001)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-1 8-Hr Time Weighted Avg: 0.5 mg/cu m. /**Arsenic**, organic cmpd (as As)/
[29 CFR 1910.1000 (7/1/2001)]**PEER REVIEWED**

Threshold Limit Values:

8 hr Time weighted Avg (TWA) 0.01 mg/cu m /**Arsenic** and inorganic cmpd, as As/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2001. Cincinnati, OH. 2001.15]**PEER REVIEWED**

A1: Confirmed human carcinogen. /**Arsenic** and inorganic cmpd, as As/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2001. Cincinnati, OH. 2001.15]**PEER REVIEWED**

BEI (Biological Exposure Index): Determinant: Inorganic **arsenic** plus methylated metabolites in urine;

Sampling Time: end of workweek; BEI: 35 ug As/l. The determinant may be present in biological specimens collected from subjects who have not been occupationally exposed, at a concentration which could affect interpretation of the result. Such background concentrations are incorporated in the BEI value. /**Arsenic**, elemental and soluble inorganic cmpd/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2001. Cincinnati, OH. 2001.86]**PEER REVIEWED**

Excursion Limit Recommendation: Excursions in worker exposure levels may exceed three times the TLV-TWA for no more than a total of 30 min during a work day, and under no circumstances should they exceed five times the TLV-TWA, provided that the TLV-TWA is not exceeded. /**Arsenic** and inorganic compounds, as As/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2001. Cincinnati, OH. 2001.6]**PEER REVIEWED**

NIOSH Recommendations:

5 mg/cu m (as As); NIOSH considers **arsenic** (inorganic cmpd, as As) to be a potential occupational carcinogen. /**Arsenic** (inorganic cmpd, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

Recommended Exposure Limit: 15 Ceiling Limit: (0.002 mg/cu m). /**Arsenic** (inorganic cmpd, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

NIOSH usually recommends that occupational exposures to carcinogens be limited to the lowest feasible concentration. /**Arsenic** (inorganic compounds, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

5 mg/cu m (as AS); NIOSH considers **arsenic** (inorganic cmpd, as As) to be a potential occupational carcinogen. /**Arsenic** (inorganic cmpd, as As)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 20]**PEER REVIEWED**

Other Occupational Permissible Levels:

... The following countries had adopted the ... TLV of 0.5 mg/cu m: Austria, Belgium, Finland, Japan, and Holland. Czechoslavakia, East Germany, Hungary and Poland ... USSR ... 0.3 mg/cu m; Romania and Switzerland, 0.2 mg/cu m; Sweden 0.05 mg/cu m; and Italy 0.25 mg/cu m. /**Arsenic** and sol cmpd/
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.37]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

ARSENICALS ARE STILL EMPLOYED TO A LIMITED EXTENT AS ... DIPS FOR TICKS & OTHER LIVESTOCK PESTS, IN POISON BAITS FOR FLY CONTROL OR FOR CONTROLLING

CUTWORMS, & AS LARVICIDES FOR ANOPHELES MOSQUITOES. /ARSENICALS/
[Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980. 1198]**PEER REVIEWED**

It is used as a ... feed additive. /Phenylarsonic compounds/
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 336]**PEER REVIEWED**

General Manufacturing Information:

... USED AT LOW APPLICATION RATES & HAVE /RELATIVELY LOW MAMMALIAN TOXICITY/ ... BOTH FACTORS CONTRIBUTE TO THEIR BEING AMONG SAFEST ARSENICAL CMPD IN USE AS WEED CONTROL AGENTS. /PENTAVALENT ORGANOARSENICALS/
[Kearney, P.C., and D. D. Kaufman (eds.) Herbicides: Chemistry, Degredation and Mode of Action. Volumes 1 and 2. 2nd ed. New York: Marcel Dekker, Inc., 1975. 743]**PEER REVIEWED**

ARSENICALS HAVE DISADVANTAGES OF BEING HAZARDOUS TO MAN & DOMESTIC ANIMALS & ARE CUMULATIVE POISONS WHEN APPLIED TO SOIL AS SOIL STERILANTS OR AS "RUN-OFF" FROM DUSTS OR SPRAYS. /ARSENATE INSECTICIDES/
[White-Stevens, R. (ed.). Pesticides in the Environment: Volume 1, Part 1, Part 2. New York: Marcel Dekker, Inc., 1971. 68]**PEER REVIEWED**

INSECTICIDAL ACTIVITY OF AN ARSENICAL ... USUALLY DIRECTLY RELATED TO % OF **METALLIC ARSENIC** IT CONTAINS, ALTHOUGH OTHER METALS IN COMBINATION ... MAY ALSO ADD TO TOXICITY. ... THE IDEAL ARSENICAL IS ONE HAVING HIGH ARSENIC CONTENT, NONE OF WHICH IS SOL IN WATER BUT ALL ... READILY SOL IN DIGESTIVE FLUIDS OF INSECT GUT. ... THE ARSENATES (PENTAVALENT), ALTHOUGH LESS INSECTICIDAL /THAN ARSENITES/, ARE MORE STABLE AND SAFER TO PLANTS AND ARE FAVORED AS GENERAL PURPOSE STOMACH POISONS. /ARSENATE INSECTICIDES/
[White-Stevens, R. (ed.). Pesticides in the Environment: Volume 1, Part 1, Part 2. New York: Marcel Dekker, Inc., 1971. 67]**PEER REVIEWED**

The arsenites (trivalent) are the least stable of the arsenicals and are the most toxic to insects and plants and have been used chiefly as the toxicants in baits. The arsenates (pentavalent), although less insecticidal, are more stable and safer to plants and are favored as general purpose /SRP: insecticides/. /Arsenates and arsenites/
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 13(81) 420]**PEER REVIEWED**

Inorganic insecticides are relatively nonspecific, and since they are not too toxic to insects, large quantities (eg, 10-100 lb/acre) are required to control insect pests in the field. Because of these limitations, inorganic insecticides have been gradually replaced by organic, particularly synthetic chemicals. Nevertheless, two groups of inorganic chemicals are used today as insecticieds: arsenicals and fluorides.
[Matsmura F; Toxicol Insect 2nd Ed p.92 (1985)]**PEER REVIEWED**

Formulations/Preparations:

A wood treating cmpd formulation was comprised of creosote 26.6%, pole oil 33.3%, ammonium hydroxide 40.5% (containing 5% **arsenic** salts), and **arsenic** salts 5%. /**Arsenic** salts/
[Krzyzewski J; Can Patent No. 1174004 (9/11/84)]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

EST TRACE AMT OF **ARSENIC** IN BIOL OR INDUSTRIAL MATERIAL ... . TOXICITY OF **ARSENIC** CMPD. ... EST BY RADIOACTIVATION ... /TOTAL **ARSENIC**/
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969. 41]**PEER REVIEWED**

ESTIMATION OF **ARSENIC** IN BIOLOGICAL MATERIALS BY NEUTRON ACTIVATION ANALYSIS. /TOTAL **ARSENIC**/
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969. 41]**PEER REVIEWED**

The qualitative Gutzeit test for **arsenic** in the urine is avail in most hospital lab, & is useful in identifying acute poisonings promptly. Chronic storage of **arsenic** can be detected by analysis of hair or fingernails.
[Morgan, D.P. Recognition and Management of Pesticide Poisonings. EPA 540/9-80-005. Washington, DC: U.S. Government Printing Office, Jan. 1982. 50]**PEER REVIEWED**

Reinsch test: qualitative: Copper strip or copper spiral. Specimen: urine, vomitus, gastric lavage. Results: No deposit on copper strip: rule out **arsenic**. (Units of conventional range): Gray to black deposit: positive for **arsenic**. No deposit on copper strip: rule out **arsenic**. (Units of International recommended range: Gray to black deposit positive for **arsenic**. Remarks: 0.5 ml of potassium cyanide will dissolve a deposit caused by **arsenic** ... . /Total **arsenic**/
[Tietz, N.W. (ed.). Clinical Guide to Laboratory Tests. Philadelphia, PA: W.B. Saunders Co., 1983. 426]**PEER REVIEWED**

NIOSH Method 140. Analyte: **Arsenic**. Specimen: Urine. Procedure: Colorimetric. For **arsenic** this method has a working range from 0.01 to 1.0 mg/l for a 25-ml sample. The precision/RSD is 4-9%. Interferences: Antimony will interfere. /**Arsenic**/
[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing Office, 1977-present.p. V1 140-1]**PEER REVIEWED**

NIOSH Method 192. Analyte: **Arsenic**. Specimen: Blood. Procedure: Anodic stripping voltammetry. For **arsenic** this method has a working range from 0.016 to 0.6 ug/ml for a 1-ml sample. The precision/RSD is 0.08. Interferences: Antimony, bismuth and tin will form resolvable on the cathodic edge of the **arsenic** peak. /**Arsenic**/
[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing Office, 1977-present.p. V1 192-1]**PEER REVIEWED**

Analyte: **Arsenic**; Matrix: Urine; Procedure: Arsine generation, atomic absorption spectroscopy; Range; 0.05 to 2.0 ug/sample; precision 10.7%. /**Arsenic**/
[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing Office, 1977-present.p. 139-1]**PEER REVIEWED**

Analyte: **Arsenic**; Matrix: Urine; Procedure: Arsine generation, colorimetric analysis; Range: 1.0 to 25 mg/sample; Precision 4-9% average deviation. /**Arsenic**/
[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing

Office, 1977-present.p. 140-1]**PEER REVIEWED**

Analyte: **Arsenic**; Matrix: Blood; Procedure: Anodic stripping voltammetry (ASV); Range: 0.016 to 0.6 ug/ml in 1 ml of blood: precision: 0.08 over 0.16 to 0.6 ug/ml. /Total **arsenic**/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.192]**PEER REVIEWED**

Analyte: **Arsenic**; Matrix: Urine; Procedure: Anodic stripping voltammetry; Range 16 to 600 ug/l in 1 ml of urine. Precision: 0.08 over the above range. /Total **arsenic**/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. 196-1]**PEER REVIEWED**

Analyte: Lead; Matrix: blood or tissue; Procedure: Inductively-coupled argon plasma-atomic emission spectroscopy; Wavelength: 220.4 nm; Range: 10 to 10,000 ug/100 g blood, 2 to 2000 ug/g tissue; Est LOD: 1 ug/100 g blood, 0.2 ug/g tissue; Precision: 0.85; Interferences: spectral, minimized by wavelength selection /Total lead/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V1 8005-1]**PEER REVIEWED**

Analyte: Lead in blood and urine; Matrix: blood or urine; Procedure: atomic absorption, air/acetylene; Quality control: commercial controls, pooled urine or blood, urine corrected for creatinine; Extraction media: APDC-MIBK; Range: 5-150 ug/100 g blood, 5 to 150 ug/100 ml urine; Est LOD: 0.05 ug Pb/g blood or /ml urine; Recovery: 0.99; Precision: 0.05; Interferences: Phosphate, EDTA, & oxalate can sequester lead and cause low lead readings. /Total lead/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V1 8003-1]**PEER REVIEWED**

AOAC Method 973.33. **Arsenic** in Meat and Poultry: Molybdenum Blue Method-Final action. Sample is ashed in presence of Magnesium Nitrate at 600: Ash is dissolved in dilute hydrochloric acid; zinc is added to generate phosphine, which is trapped with iodine solution in cell. Heteropoly blue compound is developed and read at 840 nm in same cell. /**Arsenic**/
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990,p. V1 245]**PEER REVIEWED**

The radioactive tracer technique was used for studying the extraction and predicting the best conditions of separation of **arsenic** halides by organic solvents of different natures. Sulfuric acid was found to enhance the extraction of **arsenic** halides. Stomach and liver samples were used. /**Arsenic** halides/
[Alian A et al; J Radioanal Chem 36 (2): 375-88 (1977)]**PEER REVIEWED**

The detn of traces of metals in ... samples is preferably carried out by electrothermal atomic adsorption spectrophotometry (ET-AAS). Each matrix requires a specific analytical program. For example, < or = 12 trace elements can be detd semiautomatically in hairs after HN03 digestion. Not only toxic trace metals are examd, but also other traces which may interfere with these in the biol system. /Total **arsenic**/

[Bertram HP et al; Fresenius' Z Anal Chem 317 (3-4): 462-7 (1984)]**PEER REVIEWED**

A semiquantitative screening method was evaluated for its detection of heavy metals in blood and urine by emission spectroscopy, especially in serious crime cases of attempted murder or murder. The method was originally developed for the detection of As. ... The best results were obtained when samples were stored in polystyrene containers at -10 deg C and analyzed as quickly as possible. /**Arsenic** compd/
[Blacklock EC; Trace Elem Anal Chem Med Biol Proc Int Workshop, 2nd: 893-903, 905 (1983)]**PEER REVIEWED**

An arsine evolution-electrothermal atomic absorption method is described for determination of ng/ml concentrations of total **arsenic** in urine. Organic **arsenic** compounds are decomposed with nitric, sulfuric, and perchloric acids. Sodium borohydride, a redesigned hydride generator, and an electric-heated absorption tube are used for arsine evolution and its conversion to atomic **arsenic**. The method has a detection limit of 6 ng/ml, a sensitivity of 1 ng/ml, & is linear from 0-110 ng/ml **arsenic**. /Organic **Arsenic** Cmpd/
[Cox DH; J Anal Toxicol 4 (4): 207-11 (1980)]**PEER REVIEWED**

A method for determining **arsenic** species in urine samples was described, & tested in subjects exposed & unexposed to **arsenic**. A urine sample spiked with 5 to 40 ug/l sodium arsenite, sodium arsenate, dimethylarsenic acid & monomethylarsonic acid served as the reference. Samples were analyzed by high pressure liquid chromatography atomic absorption; total **arsenic** was also determined. The detection limit was 2 ug/l for arsenite, arsenate, dimethylarsinic acid & monomethylarsonic acid. Analysis of urine of subjects not occupationally exposed to **arsenic** showed little variation in the concn of the four **arsenic** species, while those with recent sea food intake had up to 15 times more total **arsenic**. Total **arsenic** in urine of 12 workers occupationally exposed to **arsenic** was elevated between 65 & 255% over those who had recently consumed sea food. ...
[Chana BS, Smith NJ; Alaytica Chimica Acta 179: 177-86 (1987)]**PEER REVIEWED**

Total **arsenic** content may be determined in blood and urine by means of an AAS method. Separation of inorganic As, monomethylarsonic acid (MMA) and dimethylarsinic acid (DMAA). In a reference population of 148 subjects with only normal environmental exposure to As, total As concentration in the urine averages 17.2 + or - 11.1. Urinary As consists of 10% each of inorganic **arsenic**, monomethylarsonic acid and dimethylarsinic acid, the remaining 70% consisting of other forms of organic As. Blood As concentration averages 5.1 +/- 6.9 ug/l and correlates significantly with the urinary concentration of inorganic **arsenic** and the sum of its metabolites (inorganic **arsenic** + monomethylarsonic acid + dimethylarsinic acid). Inorganic **arsenic** undergoes methylation in the organism. After ingestion of high quantities of **arsenic** trioxide, the time course of excretion of its metabolites indicates that As methylation occurs by a saturable mechanism. /Total **arsenic**/
[Foa V et al; Sci Total Environ 34 (3): 241-59 (1984)]**PEER REVIEWED**

THE CAPABILITY OF INSTRUMENTAL NEUTRON ACTIVATION ANAL WITHOUT RADIOCHEM SEPARATION TO DETERMINE 36 ELEMENTS IN BIOLOGICAL MATERIALS (BOVINE LIVER) WAS DEMONSTRATED. /TOTAL **ARSENIC**/
[MADKARNI RA, MORRISON GH; ANAL CHEM 45 (11): 1957-60 (1973)]**PEER REVIEWED**

ASSESSMENT IN SOFT TISSUE BY FLAMELESS ATOMIC ABSORPTION SPECTROPHOTOMETRY AND GAS-LIQ CHROMATOGRAPHY.
[MUSHAK P ET AL; ENVIRON HEALTH PERSPECT (19): 5-10 (1977)]**PEER REVIEWED**

GC/MASS SPECTROMETRY WAS USED TO DETERMINE DIMETHYLATED **ARSENIC** IN BLOOD, URINE, AND FECES OF RATS. /Dimethylated **arsenic**/
[ODANAKA Y ET AL; J AGRIC FOOD CHEM 26 (2): 505 (1978)]**PEER REVIEWED**

Analysis of biological samples (blood, serum, feces, urine, leaves, and animal organs) and environmental

samples (soils, rocks, dusts, paints, lava) in the presence of 33 other elements. Parr Bomb digestions for non-silacaceous samples used HNO3/HClO4; silicaceous samples required HF/HNO3. The wavelength for **arsenic** was 193.6960 nm. /Total **arsenic**/
[Que Hee, Boyle; Anal Chem 60: 1033-42 (1988)]**PEER REVIEWED**

FRACTIONAL DETERMINATION OF URINARY DIMETHYLARSENIC ACID & OTHER **ARSENIC** COMPD BY REDN VOLATILIZATION & ATOMIC ABSORPTION SPECTROPHOTOMETRY.
[YAMAUCHI H, YAMAMURA Y; SANGYO IGAKU 21 (1): 47-54 (1979)]**PEER REVIEWED**

Analytic Laboratory Methods:

PROCEDURE FOR SEPARATION AND DETERMINATION OF NANOGRAM AMOUNTS OF **ARSENIC** IN INORGANIC **ARSENIC** & METHYLARSENIC COMPOUNDS IS DESCRIBED FOLLOWING THEIR REDUCTION TO ARSINES. ATOMIC **ARSENIC** IS RECORDED BY SCANNING MONOCHROMATOR SYSTEM. LIMIT OF DETECTION FOR **ARSENIC** ARE APPROXIMATELY 1 NG FOR EACH OF THE ARSINES. /TOTAL **ARSENIC**/
[BRAMAN RS ET AL; ANAL CHEM 49 (4): 621 (1977)]**PEER REVIEWED**

TWO AUTOMATED SYSTEMS CONTAINING HIGH-PRESSURE LIQ CHROMATOGRAPHY WITH GRAPHITE FURNACE ATOMIC ABSORPTION SPECTROMETERS WERE DEVELOPED FOR ANALYZING 10-20 PPB **ARSENIC** IN SOIL & DRINKING WATER SAMPLES. /**ARSENIC**/
[BRINCKMAN FE ET AL; J CHROMATOGR 191 (1): 31-46 (1980)]**PEER REVIEWED**

DETERMINATION OF TOTAL **ARSENIC** IN URINE & WATER BY ARSINE EVOLUTION-ELECTROTHERMAL ATOMIC ABSORPTION. THE METHOD HAS A DETECTION LIMIT OF 6 NG/ML, A SENSITIVITY OF 1 NG/ML, & IS LINEAR FROM 0-110 NG/ML **ARSENIC**. /TOTAL **ARSENIC**/
[COX DH; J ANAL TOXICOL 4 (4): 207-11 (1980)]**PEER REVIEWED**

... Enzymatic method has been developed for the determination of As(V) in natural waters. The method uses **arsenic** to catalyze a chemical reaction which produces a fluorescent species. The method has a detection limit of 8 ug/ml. A detailed study of the mechanism and magnitude of interferences has been performed. The results indicate that only Fe(3+) has the capability of causing erroneous results. This problem is avoided by masking with citrate. /Arsenate/
[Goode SR; Govt Reports Announcements & Index (GRA&I) 20 (1983)]**PEER REVIEWED**

AQUEOUS MONOMETHYLARSONATE: DETECTION BY FLAMELESS ATOMIC ABSORPTION. **ARSENIC** RECOVERIES (FULL PROCEDURE) RANGED FROM 97-104% FOR TYPICAL LAKEWATER SAMPLES; OVERALL ANALYTICAL DETECTION LIMIT WAS 10 PPB. /MONOMETHYLARSONATE/
[GRABINSKI AA; ANAL CHEM 53 (7): 966 (1981)]**PEER REVIEWED**

GAS-SAMPLING TECHNIQUE FOR **ARSENIC** DETERMINATION BY ATOMIC ABSORPTION SPECTROPHOTOMETRY. /TOTAL **ARSENIC**/
[HOLAK W; ANAL CHEM 42 (12): 1712-3 (1969)]**PEER REVIEWED**

A COLORIMETRIC METHOD FOR DETERMINATION OF COMPOUNDS (INCLUDING MONOMETHYLARSONIC ACID) IN ... ENVIRONMENTAL SAMPLES. /MONOMETHYLARSONIC ACID/
[LAKSO ET AL; J AGRIC FOOD CHEM 27 (6): 1229 (1979)]**PEER REVIEWED**

A method utilizing pressure decomposition to minimize sample pretreatment was described for the

inductively coupled plasma atomic emission spectrometric (ECP-AES) analysis of red spruce & sugar maple.
[Matusiewicz H, Barnes RM; Anal Chem 57 (2): 406-11 (1985)]**PEER REVIEWED**

A COMBINATION OF GAS CHROMATOGRAPHY WITH MULTIPLE ION DETECTION MASS SPECTROMETRY & HYDRIDE GENERATION-HEPTANE COLD TRAP TECHNIQUE, IS DESCRIBED FOR THE DETECTION OF INORGANIC & METHYLATED **ARSENIC** COMPOUNDS, INCLUDING ARSINE, IN RIVER WATER, & SOIL & PLANT EXTRACTS. THE RELATIVE LIMIT OF DETECTION FOR ARSINES GENERATED BY REDUCTION OF A 50 ML SAMPLE WAS 0.2-0.4 MG **ARSENIC**/ML FOR ARSENATE & **ARSENIC** COMPOUNDS. /TOTAL **ARSENIC**/
[ODANAKA Y ET AL; ANAL CHEM 55 (6): 929-32 (1983)]**PEER REVIEWED**

A GENERAL METHOD IS PRESENTED FOR THE SPECTROPHOTOMETRIC DETERMINATION OF **ARSENIC** AT TRACE LEVELS. THE METHOD IS APPLICABLE TO THE DETERMINATION OF **ARSENIC** IN WATERS AND IN MANY METALS, SALTS, AND ALLOYS. /TOTAL **ARSENIC**/
[PAKALNS P; ANAL CHIM ACTA 47 (2): 225-36 (1969)]**PEER REVIEWED**

STUDIES CONDUCTED FOR THE SELECTION OF AN APPROPRIATE FILTERING MEDIUM & THE EVALUATION OF COMBINED SAMPLING & ANALYSIS METHODS FOR COLLECTION & DETERMINATION OF ORGANOARSENICALS IN AIR ARE DESCRIBED.
[RICCI G ET AL; ACS SYMP SER 149: 383-99 (1981)]**PEER REVIEWED**

FOLLOWING THE DECOMP OF ORG MATTER IN COAL AND INSECTICIDES BY WET COMBUSTION WITH PERCHLORIC ACID PLUS PERIODIC ACID, **ARSENIC** COULD BE DETERMINED BY ATOMIC ABSORPTION SPECTROSCOPY. /TOTAL **ARSENIC**/
[SPIELHOLTZ GI ET AL; MIKROCHIM ACTA 6: 918-23 (1971)]**PEER REVIEWED**

A RAPID AND HIGHLY SENSITIVE SINGLE SWEEP POLAROGRAPHIC METHOD OF ANALYSIS FOR **ARSENIC** (III) IN DRINKING WATER WAS DESCRIBED. /TOTAL **ARSENIC**/
[WHITNACK GC, BROPHY RG; ANAL CHIM ACTA 48 (1): 123-7 (1969)]**PEER REVIEWED**

A METHOD IS DESCRIBED FOR THE SEPARATION & QUANTITATIVE DETERMINATION OF ARSENICAL PESTICIDE RESIDUES & THEIR METABOLITES BY HIGH PRESSURE LIQUID CHROMATOGRAPHY COUPLED WITH GRAPHITE FURNACE ATOMIC ABSORPTION SPECTROMETRY. LIMIT OF DETECTION FOR **ARSENIC** COMPOUNDS WAS ABOUT 5 NG **ARSENIC** INJECTED IN ALIQUOTS OF 20 UL. /**ARSENIC** CMPD/
[WOOLSON EA, AHARONSON N; J ASSOC OFF ANAL CHEM 63 (3): 523-8 (1980)]**PEER REVIEWED**

THE 3 MAIN METHODS FOR ANALYSIS OF **ARSENIC** ARE SPARK SOURCE MASS SPECTROMETRY, NEUTRON ACTIVATION & ATOMIC ABSORPTION ... DETECTION LIMIT FOR FIRST 2 METHODS ... ARE 6X10-11 G & 1X10-10 G RESPECTIVELY. /**ARSENIC**/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 55 (1973)]**PEER REVIEWED**

EST TRACE AMT OF **ARSENIC** IN BIOL OR INDUSTRIAL MATERIAL ... . TOXICITY OF **ARSENIC** COMPD. ... EST BY RADIOACTIVATION ... EST BY NEUTRON ACTIVATION ANALYSIS ... . /TOTAL **ARSENIC**/
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969. 41]**PEER REVIEWED**

Total **arsenic** concn can be determined by reduction of all forms to arsine (AsH3) and collection of the arsine in a pyridine solution of silver diethyldithiocarbamate. /Total **arsenic**/
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. V 24 (1984) 321]**PEER REVIEWED**

PRODUCT ANALYSIS: ... IS BY TITRATION WITH IODINE ... OR BY AOAC METHODS. RESIDUES MAY BE DETERMINED BY THE GUTZEIT METHOD ... OR BY TITRATION WITH BROMATE. ... /TOTAL **ARSENIC**/
[Worthing, C.R. and S.B. Walker (eds.). The Pesticide Manual - A World Compendium. 8th ed. Thornton Heath, UK: The British Crop Protection Council, 1987. 33]**PEER REVIEWED**

PRODUCT ANALYSIS IS BY ACID-BASE TITRATION; TOTAL **ARSENIC** IS DETERMINED BY WET OXIDATION.
[Worthing, C.R. and S.B. Walker (eds.). The Pesticide Manual - A World Compendium. 8th ed. Thornton Heath, UK: The British Crop Protection Council, 1987. 559]**PEER REVIEWED**

Determination of **arsenic** in air by atomic absorption spectrometry. /**Arsenic**/
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 87]**PEER REVIEWED**

PRODUCT ANALYSIS: COLORIMETRIC. ADD SAMPLE TO REAGENT SOLN, HEAT UNTIL COLOR APPEARS & FOR 15 MIN MORE, THEN COOL, DIL WITH MORE REAGENT SOLN & MEASURE ABSORBANCE @ 840 NM AGAINST AS2O3 STD BLANK. STD DEVIATION IS 0.014% FOR **ARSENIC** (STRUDE, R, RESIDUE REVIEW, 24, 79-168, 1968). /TOTAL **ARSENIC**/
[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982. 21]**PEER REVIEWED**

PRODUCT ANALYSIS: MACRO: **ARSENIC** CONTENT: (A) DISSOLVE IN HCL & TITRATE WITH STD NABRO3 SOLN AT 90 DEG C; NOT APPLICABLE IN PRESENCE OF NITRATES (AOAC METHODS, P 58, 1955). (B) DISTILLATION OF ASCL3 FROM HCL-CUCL2 MIXT; TITRATE NEUTRALIZED DISTILLATE WITH STD IODINE SOLN IN PRESENCE OF NAHCO3. (AOAC METHODS, P 47, 1955). /TOTAL **ARSENIC**/
[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982. 77]**PEER REVIEWED**

PRODUCT ANALYSIS: MICRO: (A) OXIDIZE ORG MATTER IN HNO3-H2SO4 & DETERMINE **ARSENIC** CONTENT BY GUTZEIT METHOD (AOAC METHODS, P 396, 1955). (B) RECOVER BY DISTILLATION AS PENTAVALENT BROMIDE & EST COLORIMETRICALLY AS MOLYBDENUM BLUE COMPLEX--SEE BARTLET, JC ET AL, ANAL CHEM, 24, 1821, 1952. /TOTAL **ARSENIC**/
[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982. 77]**PEER REVIEWED**

Solid wastes: the graphite furnace method of evaluating solid wastes uses atomic absorption to analyze samples digested with HNO3/H2O2. The gaseous hydride method of evaluating solid wastes also uses atomic absorption to measure **arsenic** levels in wastes which are digested with HNO3/H2SO4. /Total **arsenic**/
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 9-3]**PEER REVIEWED**

Air: ... Collection of airborne particulate matter on glass fiber filters using the high volume sampling technique and the measurement of **arsenic** in the particulate matter using neutron activation analysis. The limit of detection is approximately 5 mg/cu m, although this will vary with the composition of the glass fiber filters used for sampling.
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 9-1]**PEER REVIEWED**

Arsenic concn between 10 and 1,800 ng/cu m have been measured by X-ray fluorescence.
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 9-1]**PEER REVIEWED**

AOAC Method 920.205. **Arsenic** in Water. Determined by spectrophotometer. Detection limit unspecified.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990 332]**PEER REVIEWED**

AOAC Method 993.14. Trace Elements in Waters and Wastewaters by Inductively Coupled Plasma/Mass Spectrometric Method. Applicable to determination of 20 trace elements in finished drinking water, groundwater, and wastewaters. Detection limit unspecified.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990,p. 5TH SUPP 235]**PEER REVIEWED**

AOAC Method 963.06. **Arsenic** (Total) in Pesticide Formulations. Ion exchange method. /**Arsenic**/
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990,p. V1 149]**PEER REVIEWED**

AOAC Method 924.04. **Arsenic** (Total) in Pesticide Formulations by Iodometric Method. Applicable in presence of sulfides, sulfites, thiosulfates, and large amounts of S or organic matter. Detection limit unspecified.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990 148]**PEER REVIEWED**

NIOSH Method 7300. Elements by ICP. Inductively coupled argon plasma, atomic emission spectroscopy. Air. Range: 2.5 to 1000 ug per sample. Estimated limit of detection: 1 ug per sample. /Total **arsenic**/
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

NIOSH Method 7900. **Arsenic** and compounds as As (except AsH3 and As2O3). Atomic absorption, flame arsine generation. Air. Range: 0.05 to 2.0 ug per sample. Estimated limit of detection: 0.02 ug per sample. /Total particulate **arsenic**/
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

NIOSH Method 5022. Analyte: Anions (ion chromatography); AsH3 (atomic absorption spectrophotometry). Matrix: Air. Procedure: Ion chromatography/hydride atomic absorption. For anions (ion chromatography); AsH3 (atomic absorption spectrophotometry) this method has an estimated

detection limit of 0.2 ug As/sample. The precision/RSD and the recovery is not determined. Applicability: The working range is 0.005 to 10 mg/cu m (as As) for a 100 liter air sample. Interferences: Inorganic **arsenic** (III) co-elutes with dimethylarsenic acid using Eluent A but the two may be separated with Eluent B. /Organoarsenic cmpd/
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

The electrothermal atomic absorption spectrometric method (3113B) is the method of choice in the absence of overwhelming interferences. The hydride generation-atomic absorption method (3114B) is preferred when interferences are present that cannot be overcome by standard electrothermal techniques (e.g., matrix modifiers, background correction). The silver diethyldithiocarbamate method ..., in which arsine is generated by reaction with sodium borohydride in acidic solution, is applicable to the determination total inorganic **arsenic** when interferences are absent and when the sample contains no methylarsenic compounds. This method also provides the advantage of being able to identify and quantify arsenate and arsenite separately by generating arsine at different pHs. The inductively coupled plasma (ICP) emission spectroscopy method (3120) is useful at higher concentrations (greater than 50 ug/l) while the ICP-mass spectrometric method (3125) is applicable at lower concentrations if chloride does not interfere.
[American Public Health Association, American Water Works Association, Warer Environment Federation. M.A.H. Franson (ed.); Standard Methods for the Examination of Water and Wastewater 20th ed., Washington, D.C. 1998.154]**PEER REVIEWED**

APHA Method 3500-AS-C. **Arsenic** in Water by Silver Diethyldithiocarbamate and Spectrophotometry. Detection limit = 1 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 200.1-GFAA. Determination of Acid Soluble Metals in Water by Graphite Furnace Atomic Absorption. This method is applicable to the analysis of As, Cd, Cr, and Cu in ambient waters and aqueous wastes. This method explains how to treat aqueous samples prior to either atomic absorption or atomic emission spectrochemical analysis. Detection limit = 0.9 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 200.1-ICP. Determination of Acid Soluble Metals in Water by Inductively Coupled Plasma and Atomic Emission. This method is applicable to the analysis of As, Cd, Cr, Cu, and Pb in ambient waters and aqueous wastes. This method explains how to treat aqueous samples prior to either atomic absorption or atomic emission spectrochemical analysis. Detection limit = 0.03 mg/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 200.12. Determination of Trace Elements in Marine Waters by Stabilized Temperature Graphite Furnace Atomic Absorption. This method is applicable to marine and estuarine waters, and ocean and brines with salinities up to 35 ppt. Detection limit = 2.6 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 200.15. Determination of Metals and Trace Elements in Water by Ultrasonic Nebulization Inductively Coupled Plasma and Atomic Emission Spectrometry. This method is applicable to dissolved elements in ground and surface waters. This method is also applicable to total recoverable elements in ground, surface, and drinking waters. Detection limit = 3.0 mg/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 200.7-W. Determination of Total Recoverable and Dissolved Elements by Inductively Coupled Plasma and Atomic Emission Spectrometry. The method is for determination of metals and some nonmetals and dissolved elements in water and wastewater. Detection limit = 8.0 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 200.8-W. Determination of Trace Elements in Waters by Inductively Coupled Plasma and Mass Spectrometry. This method is applicable for the determination of dissolved elements in ground, surface, and drinking waters. This method is also applicable for the determination of total recoverable elements in ground, surface, drinking, and wastewater samples. Detection limit = 1.4 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 200.9. Determination of Trace Elements by Stabilized Temperature Graphite Furnace Atomic Absorption Spectrometry. This method is applicable to dissolved and total recoverable elements in ground water, surface water, drinking water, storm runoff, and industrial and domestic wastewater. This method is also applicable to total recoverable elements in sediments, sludges, and soils. Detection limit = 0.5 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 206.2. **Arsenic** by Graphite Furnace Atomic Absorption. Detection limit = 1 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 206.4. **Arsenic** by Spectrophotometric Determination using Silver Diethyldithiocarbamate. This method is applicable to drinking water and most fresh and saline waters in the absence of high concentrations of Cr, Co, Cu, Hg, Mb, Ni, and Ag. This method is applicable to domestic and industrial wastes after sample digestion. Detection limit = 10 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 6010A. Inductively Coupled Plasma-Atomic Emission Spectroscopy. This method is used for the analysis of ground water, aqueous samples, TCLP and EP extracts, industrial and organic wastes, soils, sludges, sediments, and other solid wastes. Detection limit = 53 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA OSW Method 6010B. Inductively Coupled Plasma - Atomic Emission Spectroscopy (ICP-AES). This method is applicable to the analysis of 30 elements by ICP-AES. This method is applicable to the following matrices: ground water, aqueous samples, TCLP and EP extracts, industrial and organic wastes, soils, sludges, sediments, and other solid wastes. Detection limit = 35 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 6020. Inductively Coupled Plasma with Mass Spectrometry. This method is applicable to water and waste samples. Detection limit = 0.4 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 7060A. Determination of **Arsenic** by Atomic Absorption, Furnace Technique. This method is applicable to wastes, mobility procedure extracts, soils, and ground water. Detection limit = 1 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA OSW Method 7061A: **Arsenic** by Gaseous Hydride Atomic Absorption. This method is used to analyze wastes, mobility procedure extracts, soils, and ground waters that do not contain high concentrations of chromium, copper, mercury, nickel, silver, cobalt, or molybdenum. Detection limit = 0.002 mg/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 7062. Determination of Antimony and **Arsenic** by Atomic Absorption and Gaseous Borohydride. This method is applicable to wastes, mobility procedure extracts, soils, and ground water. Detection limit = 1 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 7063. **Arsenic** in Aqueous Samples and Extracts by Anodic Stripping Voltammetry. This method is applicable to the analysis of free soluble **arsenic** in drinking water, surface waters, seawaters, wastewaters, and in soil extracts. Detection limit = 0.1 g/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method OSW-A. Methodology for the Determination of Metals Emissions in Exhaust Gases from Hazardous Waste Incineration and Similar Combustion Processes. This method is applicable to the sampling and analysis of metals in stack emissions from incinerators and combustors by Inductively coupled plasma spectrometry. Detection limit = 53 ng/ml.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 108. Determination of Particulate and Gaseous **Arsenic** Emissions. This method is applicable to the determination of inorganic **arsenic** (As) emissions from stationary sources. Detection limit unspecified.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 206.3. **Arsenic** by Gaseous Hydride Atomic Absorption. This method is applicable to drinking water and most fresh and saline waters. Inorganic **arsenic** must be present at or above 2 ug/L, and high concentrations of Cr, Co, Cu, Hg, Mo, Ni, and Ag must be absent. Detection limit = 2 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

Sampling Procedures:

The dusts and fumes of inorganic **arsenic** compounds in air can be collected on a cellulose membrane filter with a pore size of 5 um or less. /Inorganic **arsenic** compounds/
[NIOSH; Criteria Document: Inorganic Arsenic p.72 (1975) DHEW Pub. NIOSH 75-149]**PEER REVIEWED**

Air: ... Collection of airborne particulate matter on glass fiber filters using the high volume sampling technique. /**Arsenic** and **arsenic** cmpd/
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 9-1]**PEER REVIEWED**

Total **arsenic** concn can be determined by reduction of all forms to arsine (AsH3) and collection of the arsine in a pyridine solution of silver diethyldithiocarbamate. /**Arsenic** and **arsenic** cmpd/
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. V24 (1984) 321]**PEER REVIEWED**

AOAC Method 920.202. Manganese, Iodine, Bromine, **Arsenic**, and Boric Acid in Water for Preparation of Sample.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990 331]**PEER REVIEWED**

OSW Method 3005A. Acid Digestion of Waters for Total Recoverable or Dissolved Metals for Analysis by FLAA or ICP Spectroscopy. This method is applicable to surface waters and ground waters.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 3050A. Acid Digestion of Sediments, Sludges, and Soils. This method is applicable for preparation of sediments, sludges, and soil samples for analysis by flame or furnace atomic absorption spectroscopy or by inductively coupled argon plasma spectroscopy.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA OSW Method 3005B. Acid Digestion of Sediments, Sludges, and Soils for Metals Analysis by FLAA/ICP or GFAA/ICPMS. This method is applicable to the preparation of sediments, sludges, and soils for the analysis of 23 metals by FLAA/ICP or GFAA/ICPMS. Two different preparations are used, one for FLAA and ICP, the other for GFAA and ICPMS.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 3031. Acid Digestion of Oils for Metals Analysis by FLAA or ICP-AES. This method is applicable to the digestion of oils, oil sludges, tars, waxes, paints, paint sludges, and other viscous petroleum products for the analysis of 16 metals by FLAA or ICP-AES.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 3040A. Dissolution Procedure for Oils, Greases, and Waxes. This method is applicable for the preparation of samples containing oils, greases, or waxes. Samples are analyzed by AAS or ICP for 12 metals. This method is a solvent dissolution procedure, not a digestion procedure. This method is suitable for conducting analyses in support of TCLP determinations if the percent solids are below 0.5%.

[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 206.5: Sample Digestion Prior to Total **Arsenic** Analysis by Silver Diethyldithiocarbamate or Hydride Procedures.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

Special References:

Special Reports:

Nat'l Research Council Canada; Effects of **Arsenic** in the Canadian Environment (1978) NRCC No.15391

NIOSH; Criteria Document: **Arsenic** (1975) DHEW Pub. NIOSH 75-149

USEPA; Ambient Water Quality Criteria Doc: **Arsenic** (1980) EPA 440/5-80-021

USEPA; Ambient Water Quality Criteria Doc: **Arsenic** (1984) EPA 440/5-84-033

WHO; Environ Health Criteria: **Arsenic** (1978)

ARSENIC AND **ARSENIC** COMPOUNDS; IARC MONOGR 23: 39-141 (1980). REVIEW: THIS MONOGRAPH ON **ARSENIC** & ITS COMPOUNDS INCL CHEMICAL & PHYSICAL PROPERTIES, PRODN, USE, OCCURRENCE & ANALYSIS OF COMPOUNDS, & TOXICITY.

REVIEW: WHO SWITZ; IARC INTERNATIONAL AGENCY FOR RESEARCH ON CANCER MONOGRAPHS ON EVALUATION OF CARCINOGENIC RISK OF CHEMICALS TO HUMANS, VOL 23: SOME METALS & METALLIC COMPD. INTERNATIONAL AGENCY FOR RESEARCH ON CANCER LYON, FRANCE ISBN 92-832-1223-1; 0(0) 438 (1980) RECD 1981.

NIOSH; Current Intelligence Bulletin Inorganic **Arsenic**-Respiratory Protection #14 (1976)

GIDDING JM & EDDLEMON GK; ARCH ENVIRON CONTAM TOXICOL 6 (4): 491-505 (1977). THE EFFECTS OF MICROCOSM SIZE AND SUBSTRATE TYPE ON AQUATIC MICROCOSM BEHAVIOR AND **ARSENIC** TRANSPORT WERE STUDIED.

LAG J; ACTA AGRIC SCAND 28 (1): 97-100 (1978) **ARSENIC** POLLUTION OF SOILS AT OLD INDUSTRIAL SITES WAS DISCUSSED.

WALSH LM ET AL; ENVIRONMENTAL HEALTH PERSPECT 19: 67-71 (1977). OCCURRENCE AND DISTRIBUTION OF **ARSENIC** IN SOIL AND PLANTS WERE DISCUSSED.

DHHS/ATSDR; Toxicological Profile for **Arsenic** (Update) TP-92/02 (1993)

Los Alamos National Laboratory; A Comparison of Trace Level Concentrations for Silver, **Arsenic**, Barium, Cadmium, and Lead in Drinking Waters Obtained by Inductively Coupled Plasma Mass Spectrometry and Electrothermal Vaporization Atomic Absorption Spectroscopy (1987) LA-11095 MS

Eisler R; **Arsenic** Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review, Report No 12 (1988)

USEPA; Carcinogenic Effects of **Arsenic** Compounds in Drinking Water (1987) EPA 600/1-87/007

USEPA; Health Assessment Document for Inorganic **Arsenic** (1984) EPA 600/8-83- 021F

USEPA; Health Effects Assessment for **Arsenic** (1984) EPA 540/1-86/020

USEPA; The Carcinogen Assessment Group's Final Risk Assessment on **Arsenic** (1981) EPA 600/6-81-002

Cone JE; Occupational Medicine: State of the Art Reviews 2 (2): 273-95 (1977). Aspects of addressing the question of whether or not a case of lung cancer is due to occupational factors are discussed.

Bond GG et al; Am J Ind Med 12 (4): 353-84 (1987). Cause specific mortality was surveyed among 37,682 male employees with three or more days of service between 1940 and 1982 at the Midland or Bay City, Michigan, locations of Dow Chemical USA.

Emmett EA; Occup Med 2 (1): 165-77 (1987). Occupational skin cancer was reviewed and the theory of cutaneous carcinogenesis was summarized.

Fishbein L; Int J Environ Anal Chem 28 91 (2): 21-69 (1987). Trends and methodologies for the determination and speciation of **arsenic**, in human and animal tissues aspects of biological monitoring are stressed due to their potential utility in augmenting diverse epidemiologic and occupational health studies.

A critical literature review of the state of the art for speciation of **arsenic**, chromium, magneses, and nickel in atmospheric samples wa performed. Techniques for disting distinguishing the compound forms and valence states of these metals were critically assessed.
[Riggin RM et al; Gov Rep Announcements Index (12): 1-56 (1984)]

WHO; Environmental Health Criteria 119: Principles and Methods for the Assessment of Nephrotoxicity Associated with Exposure to Chemicals (1991)

DHHS/FDA; Guidance Document for **Arsenic** in Shellfish (1993)

U.S. Department of Health & Human Services/National Toxicology Program; Tenth Report on Carcinogens. National Institutes of Environmental Health Sciences. The Report on Carcinogens is an informational scientific and public health document that identifies and discusses substances (including agents, mixtures, or exposure circumstances) that may pose a carcinogenic hazard to human health. Inorganic **arsenic** compounds was listed in the First Annual Report on Carcinogens (1980) as known to be a human carcinogen. /Inorganic **Arsenic** Compounds/

Synonyms and Identifiers:

Related HSDB Records:

509 [**ARSENIC**; 7440-38-2]

419 [**ARSENIC** TRIOXIDE]

429 [**ARSENIC** PENTOXIDE]

431 [**ARSENIC** ACID]

693 [SODIUM ARSENITE]

1256 [POTASSIUM ARSENITE]

268 [CALCIUM ARSENITE]

1996 [STRONTIUM ARSENITE TETRAHYDRATE]

4071 [COPPER(II) ARSENITE]

1824 [PARIS GREEN]

1675 [SODIUM ARSENATE]

1235 [POTASSIUM ARSENATE]

655 [MAGNESIUM ARSENATE]

1433 [CALCIUM ARSENATE]

457 [FERROUS ARSENATE]

448 [FERRIC ARSENATE]

1648 [LEAD ARSENATE]

4376 [GALLIUM ARSENIDE]

421 [**ARSENIC** TRIFLUORIDE]

422 [**ARSENIC** TRICHLORIDE]

425 [**ARSENIC** TRIBROMIDE]

420 [**ARSENIC** TRIIODIDE]

428 [**ARSENIC** TRISULFIDE]

510 [ARSINE]

6039 [DIETHYLARSINE]

424 [ETHYLDICHLOROARSINE]

6393 [LEWISITE]

6043 [PHENYLDICHLOROARSINE]

845 [METHANEARSONIC ACID]

754 [SODIUM METHANEARSONATE]

1701 [DISODIUM METHANEARSONATE]

360 [DIMETHYLARSENIC ACID]

731 [SODIUM CACODYLATE]

2156 [IRON CACODYLATE]

6381 [BENZENEARSONIC ACID]

4296 [3-NITRO-4-HYDROXYPHENYLARSONIC ACID]

6375 [PHENARSAZINE OXIDE]

432 [ARSANILIC ACID]

5189 [SODIUM ARSANILATE]

6375 [PHENARSAZINE OXIDE]

Associated Chemicals:

Arsenic ion (3+);22541-54-4
Arsenic ion (5+);17428-41-0

Formulations/Preparations:

A wood treating cmpd formulation was comprised of creosote 26.6%, pole oil 33.3%, ammonium hydroxide 40.5% (containing 5% **arsenic** salts), and **arsenic** salts 5%. /**Arsenic** salts/
[Krzyzewski J; Can Patent No. 1174004 (9/11/84)]**PEER REVIEWED**

Shipping Name/ Number DOT/UN/NA/IMO:

UN 1556; **Arsenic** compound, liquid, nos; Arsenates, liquid, nos

UN 1557; **Arsenic** compound, solid, nos; Arsenates, solid, nos

IMO 6.1; **Arsenic** compound, liquid or solid, nos; Arsenates, liquid or solid, nos

EPA Hazardous Waste Number:

D004; A waste containing **arsenic** may or may not be characterized as a hazardous waste following testing by the Toxicity Characteristic Leaching Procedure as prescribed by the Resource Conservation and Recovery Act (RCRA) regulations. /**Arsenic**/

Administrative Information:

Hazardous Substances Databank Number: 6994

Last Revision Date: 20030829

Last Review Date: Reviewed by SRP on 9/15/2001

Update History:

Complete Update on 2003-08-29, 0 fields added/edited/deleted
Complete Update on 01/24/2003, 1 field added/edited/deleted.

Complete Update on 06/11/2002, 2 fields added/edited/deleted.
Complete Update on 05/31/2002, 1 field added/edited/deleted.
Complete Update on 03/26/2002, 87 fields added/edited/deleted.
Created 19901001 by AR

Record Length: 253908.0

ARSENIC, ELEMENTAL

CASRN: 7440-38-2

This record contains information for arsenic in its zero valence state only. For general toxicity and environmental fate of arsenic ions and arsenic compounds, refer to the ARSENIC COMPOUNDS record; for compound specific information, refer to the appropriate individual records, e.g., arsenic trichloride, diethyl arsine, etc.

For other data, click on the Table of Contents

Human Health Effects:

Evidence for Carcinogenicity:

CLASSIFICATION: A; human carcinogen. BASIS FOR CLASSIFICATION: Based on sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic **arsenic**. HUMAN CARCINOGENICITY DATA: Sufficient. ANIMAL CARCINOGENICITY DATA: Inadequate.
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Arsenic, inorganic (7440-38-2) Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000]**PEER REVIEWED**

A1. A1= Confirmed human carcinogen. (1993) /**Arsenic**, elemental and inorganic cmpd (except Arsine), as As/
[American Conference of Governmental Industrial Hygienists. Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs) for 1995-1996. Cincinnati, OH: ACGIH, 1995.13]**PEER REVIEWED**

CLASSIFICATION: A; human carcinogen. BASIS FOR CLASSIFICATION: Based on sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic **arsenic**. HUMAN CARCINOGENICITY DATA: Sufficient. ANIMAL CARCINOGENICITY DATA: Inadequate. /Inorganic **Arsenic**/
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Arsenic, inorganic (7440-38-2) Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000]**PEER REVIEWED**

Human Toxicity Excerpts:

Among smelter workers exposed to a mixture of metals including **arsenic**, the frequency of congenital malformations did not differ from non-exposed populations. However, mean birth wt were reported to be decr in offspring of female employees of the smelter.
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V1 414]**PEER REVIEWED**

The low toxicity of elemental **arsenic** is attributed to its virtual insolubility in water or in body fluids.
[USEPA; Ambient Water Quality Criteria Doc: Arsenic p.A-1 (1980) EPA 440/5-80-021]**PEER REVIEWED**

Medical Surveillance:

The urinary excretion, in mg/L, of elements that are freely eliminated by this route, such as ... **arsenic**, is

at most 2.5-5 times the occupation exposure in mg/cu m of air /SRP: for an 8 hour day/. It is apparent that biological monitoring for **arsenic** by urinalysis would be of limited value in determining whether or not the NIOSH recommended standard ... was being met or exceeded.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.83]**PEER REVIEWED**

Probable Routes of Human Exposure:

Ceramic artists can be exposed to many hazardous materials, generally related to dry clays, glazes and kiln use. Glazes can contain lead, antimony, **arsenic**, barium, beryllium, boron, chromium, cobalt, cadmium, copper, vanadium and other materials. ...
[Hart C; J Environ Health 49 (5): 282-6 (1987)]**PEER REVIEWED**

Heavy metals such as lead, **arsenic**, antimony, cadmium, chromium, cobalt, manganese, and mercury ... used as color pigments in paints can be ingested by contamination of hands, fingernails, food, cups, cigarettes and by holding paint brushes in the mouth.
[Hart C; J Environ Health 49 (5): 282 (1987)]**PEER REVIEWED**

Minimum Fatal Dose Level:

Fatal human dose 70-180 mg depending on weight. Estimated lethal dose for a 70 kg human as As (III).
[NIH/EPA; OHM/TADS (1985)]**PEER REVIEWED**

Arsenic, inorganic

CASRN: 7440-38-2
For other data, click on the Table of Contents

Status:

STATUS OF DATA FOR **Arsenic**, inorganic

File First On-Line 02/10/1988

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on-line	02/01/1993
Inhalation RfC Assessment (I.B.)	no data	
Carcinogenicity Assessment (II.)	on-line	04/10/1998

Substance Identification:

Substance Name:

Arsenic, inorganic

CAS Registry Number: 7440-38-2

I. Chronic Health Hazard Assessment for Noncarcinogenic Effects:

I.A. Reference Dose for Chronic Oral Exposure (RfD):

Substance Name -- **Arsenic**, inorganic
CASRN -- 7440-38-2
Last Revised -- 02/01/1993

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

NOTE: There was not a clear consensus among Agency scientists on the oral RfD. Applying the Agency's RfD methodology, strong scientific arguments can be made for various values within a factor of 2 or 3 of the currently recommended RfD value, i.e., 0.1 to 0.8 ug/kg/day. It should be noted, however, that the RfD methodology, by definition, yields a number with inherent uncertainty spanning perhaps an order of magnitude. New data that possibly impact on the recommended RfD for **arsenic** will be evaluated by the Work Group as it becomes available. Risk managers should recognize the

considerable flexibility afforded them in formulating regulatory decisions when uncertainty and lack of clear consensus are taken into account.

I.A.1. Oral RfD Summary:

Critical Effect	Experimental Doses*	UF	MF	RfD
Hyperpigmentation, keratosis and possible vascular complications Human Chronic oral exposure Tseng, 1977; Tseng et al., 1968	NOAEL: 0.009 mg/L converted to 0.0008 mg/kg-day LOAEL: 0.17 mg/L converted to 0.014 mg/kg-day	3	1	3E-4 mg/kg-day

*Conversion Factors -- NOAEL was based on an arithmetic mean of 0.009 mg/L in a range of **arsenic** concentration of 0.001 to 0.017 mg/L. This NOAEL also included estimation of **arsenic** from food. Since experimental data were missing, **arsenic** concentrations in sweet potatoes and rice were estimated as 0.002 mg/day. Other assumptions included consumption of 4.5 L water/day and 55 kg bw (Abernathy et al., 1989). NOAEL = [(0.009 mg/L x 4.5 L/day) + 0.002 mg/day] / 55 kg = 0.0008 mg/kg-day. The LOAEL dose was estimated using the same assumptions as the NOAEL starting with an arithmetic mean water concentration from Tseng (1977) of 0.17 mg/L. LOAEL = [(0.17 mg/L x 4.5 L/day) + 0.002 mg/day] / 55 kg = 0.014 mg/kg-day.

I.A.2. Principal and Supporting Studies (Oral RfD):

Tseng, W.P. 1977. Effects and dose-response relationships of skin cancer and blackfoot disease with **arsenic**. Environ. Health Perspect. 19: 109-119.

Tseng, W.P., H.M. Chu, S.W. How, J.M. Fong, C.S. Lin and S. Yeh. 1968. Prevalence of skin cancer in an endemic area of chronic arsenicism in Taiwan. J. Natl. Cancer Inst. 40: 453-463.

The data reported in Tseng (1977) show an increased incidence of blackfoot disease that increases with age and dose. Blackfoot disease is a significant adverse effect. The prevalences (males and females combined) at the low dose are 4.6 per 1000 for the 20-39 year group, 10.5 per 1000 for the 40-59 year group, and 20.3 per 1000 for the >60 year group. Moreover, the prevalence of blackfoot disease in each age group increases with increasing dose. However, a recent report indicates that it may not be strictly due to **arsenic** exposure (Lu, 1990). The data in Tseng et al. (1968) also show increased incidences of hyperpigmentation and keratosis with age. The overall prevalences of hyperpigmentation and keratosis in the exposed groups are 184 and 71 per 1000, respectively. The text states that the incidence increases with dose, but data for the individual doses are not shown. These data show that the skin lesions are the more sensitive endpoint. The low dose in the Tseng (1977) study is considered a LOAEL.

The control group described in Tseng et al. (1968; Table 3) shows no evidence of skin lesions and

presumably blackfoot disease, although this latter point is not explicitly stated. This group is considered a NOAEL.

The arithmetic mean of the **arsenic** concentration in the wells used by the individuals in the NOAEL group is 9 ug/L (range: 1-17 ug/L) (Abernathy et al., 1989). The arithmetic mean of the **arsenic** concentration in the wells used by the individuals in the LOAEL group is 170 ug/L (Tseng, 1977; Figure 4). Using estimates provided by Abernathy et al. (1989), the NOAEL and LOAEL doses for both food and water are as follows: LOAEL - [170 ug/L x 4.5 L/day + 2 ug/day (contribution of food)] x (1/55 kg) = 14 ug/kg/day; NOAEL - [9 ug/L x 4.5 L/day + 2 ug/day (contribution of food)] x (1/55 kg) = 0.8 ug/kg/day.

Although the control group contained 2552 individuals, only 957 (approximately 38%) were older than 20, and only 431 (approximately 17%) were older than 40. The incidence of skin lesions increases sharply in individuals above 20; the incidence of blackfoot disease increases sharply in individuals above 40 (Tseng, 1968; Figures 5, 6 and 7). This study is less powerful than it appears at first glance. However, it is certainly the most powerful study available on **arsenic** exposure to people.

This study shows an increase in skin lesions, 22% (64/296) at the high dose vs. 2.2% (7/318) at the low dose. The average **arsenic** concentration in the wells at the high dose is 410 ug/L and at the low dose is 5 ug/L (Cebrian et al., 1983; Figure 2 and Table 1) or 7 ug/L (cited in the abstract). The average water consumption is 3.5 L/day for males and 2.5 L/day for females. There were about an equal number of males and females in the study. For the dose estimates given below we therefore assume an average of 3 L/day. No data are given on the **arsenic** exposure from food or the body weight of the participants (we therefore assume 55 kg). The paper states that exposure times are directly related to chronological age in 75% of the cases. Approximately 35% of the participants in the study are more than 20 years old (Figure 1).

Exposure estimates (water only) are: high dose - 410 ug/L x 3 L/day x (1/55 kg) = 22 ug/kg/day; low dose - 5-7 ug/L x 3 L/day x (1/55 kg) = 0.3-0.4 ug/kg/day.

The high-dose group shows a clear increase in skin lesions and is therefore designated a LOAEL. There is some question whether the low dose is a NOAEL or a LOAEL since there is no way of knowing what the incidence of skin lesions would be in a group where the exposure to **arsenic** is zero. The 2.2% incidence of skin lesions in the low-dose group is higher than that reported in the Tseng et al. (1968) control group, but the dose is lower (0.4 vs. 0.8 ug/kg/day).

The Southwick et al. (1983) study shows a marginally increased incidence of a variety of skin lesions (palmar and plantar keratosis, diffuse palmar or plantar hyperkeratosis, diffuse pigmentation, and arterial insufficiency) in the individuals exposed to **arsenic**. The incidences are 2.9% (3/105) in the control group and 6.3% (9/144) in the exposed group. There is a slight, but not statistically significant increase in the percent of exposed individuals that have abnormal nerve conduction (8/67 vs. 13/83, or 12% vs. 16% (Southwick et al., 1983; Table 8). The investigators excluded all individuals older than 47 from the nerve conduction portion of the study. These are the individuals most likely to have the longest exposure to **arsenic**.

Although neither the increased incidence of skin lesions nor the increase in abnormal nerve conduction is statistically significant, these effects may be biologically significant because the same abnormalities occur at higher doses in other studies. The number of subjects in this study was insufficient to establish statistical significance.

Table 3 (Southwick et al., 1983) shows the annual **arsenic** exposure from drinking water. No data are given on **arsenic** exposure from food or the body weight (assume 70 kg). Exposure times are not clearly defined, but are > 5 years, and dose groups are ranges of exposure.

Exposure estimates (water only) are: dosed group - 152.4 mg/year x 1 year/365 days x (1/70) kg = 6 ug/kg/day; control group - 24.2 mg/year x year/365 days x (1/70) kg = 0.9 ug/kg/day.

Again because there are no data for a group not exposed to **arsenic**, there is some question if the control group is a NOAEL or a LOAEL. The incidence of skin lesions in this group is about the same as in the low-dose group from the Cebrian et al. (1983) study; the incidence of abnormal nerve conduction in the control group is higher than that from the low-dose group in the Hindmarsh et al. (1977) study described below. The control dose is comparable to the dose to the control group in the Tseng et al. (1968) and Hindmarsh et al. (1977) studies. The dosed group may or may not be a LOAEL, since it is does not report statisically significant effects when compared to the control.

This study shows an increased incidence of abnormal clinical findings and abnormal electromyographic findings with increasing dose of **arsenic** (Hindmarsh et al., 1977; Tables III and VI). However, the sample size is extremely small. Percentages of abnormal clinical signs possibly attributed to As were 10, 16, and 40% at the low, mid and high doses, respectively. Abnormal EMG were 0, 17 and 53% in the same three groups.

The exact doses are not given in the Hindmarsh et al. (1977) paper; however, some well data are reported in Table V. The arithmetic mean of the **arsenic** concentration in the high-dose and mid-dose wells is 680 and 70 ug/L, respectively. Figure 1 (Hindmarsh et al., 1977) shows that the average **arsenic** concentration of the low-dose wells is about 25 ug/L. No data are given on **arsenic** exposure from food. We assume daily water consumption of 2 liters and body weight of 70 kg. Exposure times are not clearly stated.

Exposure estimates (water only) are: low - 25 ug/L x 2 L/day x (1/70) kg = 0.7 ug/kg/day; mid - 70 ug/L x 2 L/day x (1/70) kg = 2 ug/kg/day; high - 680 ug/L x 2 L/day x (1/70) kg = 19 ug/kg/day.

The low dose is a no-effect level for abnormal EMG findings. However, because there is no information on the background incidence of abnormal clinical findings in a population with zero exposure to **arsenic**, there is no way of knowing if the low dose is a no-effect level or another marginal effect level for abnormal clinical findings. The low dose is comparable to the dose received by the control group in the Tseng (1977) and Southwick et al. (1983) studies.

The responses at the mid dose do not show a statistically significant increase but are part of a statistically significant trend and are biologically significant. This dose is an equivocal NOAEL/LOAEL. The high dose is a clear LOAEL for both responses.

As discussed previously there is no way of knowing whether the low doses in the Cebrian et al. (1983), Southwick et al. (1983) and Hindmarsh et al. (1977) studies are NOAELs for skin lesions and/or abnormal nerve conduction. However, because the next higher dose in the Southwick and Hindmarsh studies only shows marginal effects at doses 3-7 times higher, the Agency feels comfortable in assigning the low doses in these studies as NOAELs.

The Tseng (1977) and Tseng et al. (1968) studies are therefore considered superior for the purposes of

developing an RfD and show a NOAEL for a sensitive endpoint. Even discounting the people < 20 years of age, the control group consisted of 957 people that had a lengthy exposure to **arsenic** with no evidence of skin lesions.

The following is a summary of the defined doses in mg/kg-day from the principal and supporting studies:

1) Tseng (1977): NOAEL = 8E-4; LOAEL = 1.4E-2

2) Cebrian et al. (1983): NOAEL = 4E-4; LOAEL = 2.2E-2

3) Southwick et al. (1983): NOAEL = 9E-4; LOAEL = none (equivocal effects at 6E-3)

4) Hindmarsh et al., 1977: NOAEL = 7E-4; LOAEL = 1.9E-2 (equivocal effects at 2E-3)

I.A.3. Uncertainty and Modifying Factors (Oral RfD):

UF -- The UF of 3 is to account for both the lack of data to preclude reproductive toxicity as a critical effect and to account for some uncertainty in whether the NOAEL of the critical study accounts for all sensitive individuals.

MF -- None

I.A.4. Additional Studies/Comments (Oral RfD):

Ferm and Carpenter (1968) produced malformations in 15-day hamster fetuses via intravenous injections of sodium arsenate into pregnant dams on day 8 of gestation at dose levels of 15, 17.5, or 20 mg/kg bw. Exencephaly, encephaloceles, skeletal defects and genitourinary systems defects were produced. These and other terata were produced in mice and rats all at levels around 20 mg/kg bw. Minimal effects or no effects on fetal development have been observed in studies on chronic oral exposure of pregnant rats or mice to relatively low levels of **arsenic** via drinking water (Schroeder and Mitchner, 1971). Nadeenko et al. (1978) reported that intubation of rats with **arsenic** solution at a dose level of 25 ug/kg/day for a period of 7 months, including pregnancy, produced no significant embryotoxic effects and only infrequent slight expansion of ventricles of the cerebrum, renal pelves and urinary bladder. Hood et al. (1977) reported that very high single oral doses of arsenate solutions (120 mg/kg) to pregnant mice were necessary to cause prenatal fetal toxicity, while multiple doses of 60 mg/kg on 3 days had little effect.

Extensive human pharmacokinetic, metabolic, enzymic and long-term information is known about **arsenic** and its metabolism. Valentine et al. (1987) established that human blood **arsenic** levels did not increase until daily water ingestion of **arsenic** exceeded approximately 250 ug/day (approximately 120 ug of **arsenic**/L. Methylated species of **arsenic** are successively 1 order of magnitude less toxic and less teratogenic (Marcus and Rispin, 1988). Some evidence suggests that inorganic **arsenic** is an essential nutrient in goats, chicks, minipigs and rats (NRC, 1989). No comparable data are available for humans.

I.A.5. Confidence in the Oral RfD:

Study -- Medium
Database -- Medium
RfD -- Medium

Confidence in the chosen study is considered medium. An extremely large number of people were included in the assessment (> 40,000) but the doses were not well-characterized and other contaminants were present. The supporting human toxicity data base is extensive but somewhat flawed. Problems exist with all of the epidemiological studies. For example, the Tseng studies do not look at potential exposure from food or other source. A similar criticism can be made of the Cebrian et al. (1983) study. The U.S. studies are too small in number to resolve several issues. However, the data base does support the choice of NOAEL. It garners medium confidence. Medium confidence in the RfD follows.

I.A.6. EPA Documentation and Review of the Oral RfD:

Source Document -- This assessment is not presented in any existing U.S. EPA document.

This analysis has been reviewed by EPA's Risk Assessment Council on 11/15/1990. This assessment was discussed by the Risk Assessment Council of EPA on 11/15/1990 and verified through a series of meetings during the 1st, 2nd and 3rd quarters of FY91.

Other EPA Documentation -- U.S. EPA, 1984, 1988

Agency Work Group Review -- 03/24/1988, 05/25/1988, 03/21/1989, 09/19/1989, 08/22/1990, 09/20/1990

Verification Date -- 11/15/1990

Screening-Level Literature Review Findings -- A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the RfD for **Arsenic** (inorganic) conducted in September 2002 identified one or more significant new studies. IRIS users may request the references for those studies from the IRIS Hotline at hotline.iris@epa.gov or 301-345-2870.

I.A.7. EPA Contacts (Oral RfD):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC):

Substance Name -- **Arsenic**, inorganic
CASRN -- 7440-38-2

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure:

Substance Name -- **Arsenic**, inorganic
CASRN -- 7440-38-2
Last Revised -- 04/10/1998

Section II provides information on three aspects of the carcinogenic assessment for the substance in question; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity:

II.A.1. Weight-of-Evidence Characterization:

Classification -- A; human carcinogen

Basis -- based on sufficient evidence from human data. An increased lung cancer mortality was observed in multiple human populations exposed primarily through inhalation. Also, increased mortality from multiple internal organ cancers (liver, kidney, lung, and bladder) and an increased incidence of skin cancer were observed in populations consuming drinking water high in inorganic **arsenic**.

II.A.2. Human Carcinogenicity Data:

Sufficient. Studies of smelter worker populations (Tacoma, WA; Magma, UT; Anaconda, MT; Ronnskar, Sweden; Saganoseki-Machii, Japan) have all found an association between occupational **arsenic** exposure and lung cancer mortality (Enterline and Marsh, 1982; Lee-Feldstein, 1983; Axelson et al., 1978; Tokudome and Kuratsune, 1976; Rencher et al., 1977). Both proportionate mortality and cohort studies of pesticide manufacturing workers have shown an excess of lung cancer deaths among exposed persons (Ott et al., 1974; Mabuchi et al., 1979). One study of a population residing near a pesticide manufacturing plant revealed that these residents were also at an excess risk of lung cancer (Matanoski et al., 1981). Case reports of arsenical pesticide applicators have also corroborated an association between **arsenic** exposure and lung cancer (Roth, 1958).

A cross-sectional study of 40,000 Taiwanese exposed to **arsenic** in drinking water found significant excess skin cancer prevalence by comparison to 7500 residents of Taiwan and Matsu who consumed relatively **arsenic**-free water (Tseng et al., 1968; Tseng, 1977). Although this study demonstrated an association between **arsenic** exposure and development of skin cancer, it has several weaknesses and

uncertainties, including poor nutritional status of the exposed populations, their genetic susceptibility, and their exposure to inorganic **arsenic** from non-water sources, that limit the study's usefulness in risk estimation. Dietary inorganic **arsenic** was not considered nor was the potential confounding by contaminants other than **arsenic** in drinking water. There may have been bias of examiners in the original study since no skin cancer or preneoplastic lesions were seen in 7500 controls; prevalence rates rather than mortality rates are the endpoint; and furthermore there is concern of the applicability of extrapolating data from Taiwanese to the U.S. population because of different background rates of cancer, possibly genetically determined, and differences in diet other than **arsenic** (e.g., low protein and fat and high carbohydrate) (U.S. EPA, 1988).

A prevalence study of skin lesions was conducted in two towns in Mexico, one with 296 persons exposed to drinking water with 0.4 mg/L **arsenic** and a similar group with exposure at 0.005 mg/L. The more exposed group had an increased incidence of palmar keratosis, skin hyperpigmentation and hypopigmentation, and four skin cancers (histologically unconfirmed) (Cebrian et al. (1983). The association between skin cancer and **arsenic** is weak because of the small number of cases, small cohort size, and short duration follow-up; also there was no unexposed group in either town. No excess skin cancer incidence has been observed in U.S. residents consuming relatively high levels of **arsenic** in drinking water but the numbers of exposed persons were low (Morton et al., 1976; Southwick et al., 1981). Therapeutic use of Fowler's solution (potassium arsenite) has also been associated with development of skin cancer and hyperkeratosis (Sommers and McManus, 1953; Fierz, 1965); several case reports implicate exposure to Fowler's solution in skin cancer development (U.S. EPA, 1988).

Several follow-up studies of the Taiwanese population exposed to inorganic **arsenic** in drinking water showed an increase in fatal internal organ cancers as well as an increase in skin cancer. Chen et al. (1985) found that the standard mortality ratios (SMR) and cumulative mortality rates for cancers of the bladder, kidney, skin, lung and liver were significantly greater in the Blackfoot disease endemic area of Taiwan when compared with the age adjusted rates for the general population of Taiwan. Blackfoot disease (BFD, an endemic peripheral artery disease) and these cancers were all associated with high levels of **arsenic** in drinking water. In the endemic area, SMRs were greater in villages that used only artesian well water (high in **arsenic**) compared with villages that partially or completely used surface well water (low in **arsenic**). However, dose-response data were not developed (Chen et al. 1985).

A retrospective case-control study showed a significant association between duration of consuming high-**arsenic** well water and cancers of the liver, lung and bladder (Chen et al., 1986). In this study, cancer deaths in the Blackfoot disease endemic area between January 1980 and December 1982 were chosen for the case group. About 90% of the 86 lung cancers and 95 bladder cancers in the registry were histologically or cytologically confirmed and over 70% of the liver cancers were confirmed by biopsy or à-fetoprotein presence with a positive liver x-ray image. Only confirmed cancer cases were included in the study. A control group of 400 persons living in the same area was frequency-matched with cases by age and sex. Standardized questionnaires of the cases (by proxy) and controls determined the history of artesian well water use, socioeconomic variables, disease history, dietary habits, and lifestyle. For the cancer cases, the age-sex adjusted odds ratios were increased for bladder (3.90), lung (3.39), and liver (2.67) cancer for persons who had used artesian well water for 40 or more years when compared with controls who had never used artesian well water. Similarly, in a 15-year study of a cohort of 789 patients of Blackfoot disease, an increased mortality from cancers of the liver, lung, bladder and kidney was seen among BFD patients when compared with the general population in the endemic area or when compared with the general population of Taiwan. Multiple logistic regression analysis to adjust for other risk factors including cigarette smoking did not markedly affect the exposure-response relationships or odds ratios (Chen et al., 1988).

A significant dose-response relationship was found between **arsenic** levels in artesian well water in 42 villages in the southwestern Taiwan and age- adjusted mortality rates from cancers at all sites, cancers of the bladder, kidney, skin, lung, liver and prostate (Wu et al., 1989). An ecological study of cancer mortality rates and **arsenic** levels in drinking water in 314 townships in Taiwan also corroborated the association between **arsenic** levels and mortality from the internal cancers (Chen and Wang, 1990).

Chen et al.(1992) conducted a recent analysis of cancer mortality data from the **arsenic**-exposed population to compare risk of various internal cancers and compare risk between males and females. The study area and population have been described by Wu et al. (1989). It is limited to 42 southwestern coastal villages where residents have used water high in **arsenic** from deep artesian wells for more than 70 years. **Arsenic** levels in drinking water ranged from 0.010 to 1.752 ppm. The study population had 898,806 person-years of observation and 202 liver cancer, 304 lung cancer, 202 bladder cancer and 64 kidney cancer deaths. The study population was stratified into four groups according to median **arsenic** level in well water (< 0.10 ppm, 0.10- 0.29 ppm, 0.30-0.59 ppm and 60+ ppm), and also stratified into four age groups (< 30 years, 30-49 years, 50-69 years and 70+ years). Mortality rates were found to increase significantly with age for all cancers and significant dose- response relationships were observed between **arsenic** level and mortality from cancer of the liver, lung, bladder and kidney in most age groups of both males and females. The data generated by Chen et al. (1992) provide evidence for an association of the levels of **arsenic** in drinking water and duration of exposure with the rate of mortality from cancers of the liver, lung, bladder, and kidney. Dose-response relationships are clearly shown by the tabulated data (Tables II-V of Chen et al., 1992). Previous studies summarized in U.S. EPA (1988) showed a similar association in the same Taiwanese population with the prevalence of skin cancers (which are often non-fatal). Bates et al. (1992) and Smith et al. (1992) have recently reviewed and evaluated the evidence for **arsenic** ingestion and internal cancers.

II.A.3. Animal Carcinogenicity Data:

Inadequate. There has not been consistent demonstration of carcinogenicity in test animals for various chemical forms of **arsenic** administered by different routes to several species (IARC, 1980). Furst (1983) has cited or reviewed animal carcinogenicity testing studies of nine inorganic **arsenic** compounds in over nine strains of mice, five strains of rats, in dogs, rabbits, swine and chickens. Testing was by the oral, dermal, inhalation, and parenteral routes. All oxidation states of **arsenic** were tested. No study demonstrated that inorganic **arsenic** was carcinogenic in animals. Dimethylarsonic acid (DMA), the end metabolite predominant in humans and animals, has been tested for carcinogenicity in two strains of mice and was not found positive (Innes et al., 1969); however, this was a screening study and no data were provided. The meaning of non-positive data for carcinogenicity of inorganic **arsenic** is uncertain, the mechanism of action in causing human cancer is not known, and rodents may not be a good model for **arsenic** carcinogenicity testing. There are some data to indicate that **arsenic** may produce animal lung tumors if retention time in the lung can be increased (Pershagen et al., 1982, 1984).

II.A.4. Supporting Data for Carcinogenicity:

A retrospective cohort mortality study was conducted on 478 British patients treated between 1945-1969 with Fowler's solution (potassium arsenite). The mean duration of treatment was 8.9 months and the average total oral consumption of **arsenic** was about 1890 mg (daily dose x duration). In 1980, 139 deaths had occurred. No excess deaths from internal cancers were seen after this 20-year follow-up.

Three bladder cancer deaths were observed (1.19 expected, SMR 2.5) (Cuzick et al., 1982). A recent follow-up (Cuzick et al., 1992) indicated no increased mortality from all cancers but a significant excess from bladder cancer (5 cases observed/1.6 expected; SMR of 3.07). A subset of the original cohort (143 persons) had been examined by a dermatologist in 1970 for signs of arsenicism (palmar keratosis). In 1990, there were 80 deaths in the subcohort and 11 deaths from internal cancers. All 11 subjects had skin signs (keratosis-10, hyperpigmentation-5 and skin cancer-3). A case-control study of the prevalence of palmar keratoses in 69 bladder cancer patients, 66 lung cancer patients and 218 hospital controls (Cuzick et al., 1984), indicated an association between skin keratosis (as an indicator of **arsenic** exposure) and lung and bladder cancer. Above the age of 50, 87% of bladder cancer patients and 71% of lung cancer patients but only 36% of controls had one or more keratoses. Several case reports implicate internal cancers with **arsenic** ingestion or specifically with use of Fowler's solution but the associations are tentative (U.S. EPA, 1988).

Sodium arsenate has been shown to transform Syrian hamster embryo cells (Dipaolo and Casto, 1979) and to produce sister chromatid-exchange in DON cells, CHO cells, and human peripheral lymphocytes exposed in vitro (Wan et al., 1982; Ohno et al., 1982; Larramendy et al., 1981; Andersen, 1983; Crossen, 1983). Jacobson-Kram and Montalbano (1985) have reviewed the mutagenicity of inorganic **arsenic** and concluded that inorganic **arsenic** is inactive or very weak for induction of gene mutations in vitro but it is clastogenic with trivalent **arsenic** being an order of magnitude more potent than pentavalent **arsenic**.

Both the pentavalent and trivalent forms of inorganic **arsenic** are found in drinking water. In both animals and humans, arsenate (As+5) is reduced to arsenite (As+3) and the trivalent form is methylated to give the metabolites mononomethylarsinic acid (MMA) and dimethylarsonic acid (DMA) (Vahter and Marafante, 1988). The genotoxicity of arsenate (As+5) and arsenite (As+3) and the two methylated metabolites, MMA and DMA were compared in the thymidine kinase forward mutation assay in mouse lymphoma cells (Harrington-Brock et al. 1993; Moore et al., 1995, in press). Sodium arsenite (+3) and sodium arsenate (+5) were mutagenic at concentration of 1-2 ug/mL and 10-14 ug/mL, respectively, whereas MMA and DMA were significantly less potent, requiring 2.5-5 mg/mL and 10 mg/mL, respectively, to induce a genotoxic response. Based on small colony size the mutations induced were judged chromosomal rather than point mutations. The authors have previously shown that for chemicals having clastogenic activity (i.e., cause chromosomal mutations), the mutated cells grow more slowly than cells with single gene mutations and this results in small colony size. In the mouse lymphoma assay, chromosomal abberations were seen at approximately the same **arsenic** levels as TK forward mutations. Arsenate, arsenite and MMA were considered clastogenic but the abberation response with DMA was insufficient to consider it a clastogen. Since **arsenic** exerts its genotoxicity by causing chromosomal mutations, it has been suggested by the above authors that it may act in a latter stage of carcinogenesis as a progressor, rather than as a classical initiator or promotor (Moore et al., 1994). A finding which supports this process is that arsenate (8-16 uM) and arsenite (3 uM) have been shown to induce 2-10 fold amplification of the dihydrofolate reductase gene in culture in methotrexate resistant 3T6 mouse cells (Lee et al., 1988). Although the mechanism of induction in rodent cells is not known, gene amplification of oncogenes is observed in many human tumors. Inorganic **arsenic** has not been shown to mutate bacterial strains, it produces preferential killing of repair deficient strains (Rossman, 1981). Sodium arsenite (As+3) induces DNA-strand breaks which are associated with DNA-protein crosslinks in cultured human fibroblasts at 3 mM but not 10 mM (Dong and Luo, 1993) and it appears that arsenite inhibits the DNA repair process by inhibiting both excision and ligation (Jha et al., 1992; Lee-Chen et al., 1993).

The inhibitory effect of arsenite on strand-break rejoining during DNA repair was found to be reduced by adding glutathione to cell cultures (Huang et al., 1993). The cytotoxic effects of sodium arsenite in

Chinese hamster ovary cells also has also found to correlate with the intracellular glutathione levels (Lee et al., 1989).

In vivo studies in rodents have shown that oral exposure of rats to arsenate (As+5) for 2-3 weeks resulted in major chromosomal abnormalities in bone marrow (Datta et al., 1986) and exposure of mice to As (+3) in drinking water for 4 weeks (250 mg As/L as **arsenic** trioxide) caused chromosomal aberrations in bone marrow cells but not spermatogonia (Poma et al., 1987); micronuclei in bone marrow cells were also induced by intraperitoneal dosing of mice with arsenate (DeKnudt et al., 1986; Tinwell et al., 1991). Chromosomal aberrations and sister chromatid exchange have been seen in patients exposed to **arsenic** from treatment with Fowler's solution (Burgdorf et al., 1977) and subjects exposed occupationally (Beckman et al., 1977) but no increase in either endpoint was seen in lymphocytes of subjects exposed to **arsenic** in drinking water (Vig et al., 1984).

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure:

II.B.1. Summary of Risk Estimates:

Oral Slope Factor -- 1.5E+0 per (mg/kg)/day

Drinking Water Unit Risk -- 5E-5 per (ug/L)

Extrapolation Method -- Time- and dose-related formulation of the multistage model (U.S. EPA, 1988)

Drinking Water Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	2E+0 ug/L
E-5 (1 in 100,000)	2E-1 ug/L
E-6 (1 in 1,000,000)	2E-2 ug/L

II.B.2. Dose-Response Data (Carcinogenicity, Oral Exposure):

The Risk Assessment Forum has completed a reassessment of the carcinogenicity risk associated with ingestion of inorganic **arsenic** (U.S. EPA, 1988). The data provided in Tseng et al., 1968 and Tseng, 1977 on about 40,000 persons exposed to **arsenic** in drinking water and 7500 relatively unexposed controls were used to develop dose-response data. The number of persons at risk over three dose intervals and four exposure durations, for males and females separately, were estimated from the reported prevalence rates as percentages. It was assumed that the Taiwanese persons had a constant exposure from birth, and that males consumed 3.5 L drinking water/day and females consumed 2.0 L/day. Doses were converted to equivalent doses for U.S. males and females based on differences in body weights and differences in water consumption and it was assumed that skin cancer risk in the U.S. population would be similar to the Taiwanese population. The multistage model with time was used to predict dose-specific and age-specific skin cancer prevalance rates associated with ingestion of inorganic **arsenic**; both linear and quadratic model fitting of the data were conducted. The maximum likelihood estimate (MLE) of skin cancer risk for a 70 kg person drinking 2 L of water per day ranged from 1E-3 to

2E-3 for an **arsenic** intake of 1 ug/kg/day. Expressed as a single value, the cancer unit risk for drinking water is 5E-5 per (ug/L). Details of the assessment are in U.S. EPA (1988).

Dose response data have not been developed for internal cancers for the Taiwanese population. The data of Chen et al. (1992) are considered inadequate at present.

II.B.3. Additional Comments (Carcinogenicity, Oral Exposure):

Eastern Research Group, under contract to EPA, convened an Expert Panel on **Arsenic** Carcinogenicity on May 21 and 22, 1997 (Eastern Research Group, 1997). The Expert Panel believed that, "it is clear from epidemiological studies that **arsenic** is a human carcinogen via the oral and inhalation routes (p. 20)." They also concluded, "that one important mode of action is unlikely to be operative for **arsenic**". The panel agreed that **arsenic** and its metabolites do not appear to directly interact with DNA (pp. 30-31)." In addition, the panel agreed that, "for each of the modes of action regarded as plausible, the dose-response would either show a threshold or would be nonlinear (p. 31)". The panel agreed, however, "that the dose-response for **arsenic** at low doses would likely be truly nonlinear, i.e., with a decreasing slope as the dose decreased. However, at very low doses such a curve might be linear but with a very shallow slope, probably indistinguishable from a threshold (p. 31)."

II.B.4. Discussion of Confidence (Carcinogenicity, Oral Exposure):

This assessment is based on prevalence of skin cancer rather than mortality because the types of skin cancer studied are not normally fatal. However, competing mortality from Blackfoot disease in the endemic area of Taiwan would cause the risk of skin cancer to be underestimated. Other sources of inorganic **arsenic**, in particular those in food sources have not been considered because of lack of reliable information. There is also uncertainty on the amount of water consumed/day by Taiwanese males (3.5 L or 4.5 L) and the temporal variability of **arsenic** concentrations in specific wells was not known. The concentrations of **arsenic** in the wells was measured in the early 1960s and varied between 0.01 and 1.82 ppm. For many villages 2 to 5 analyses were conducted on well water and for other villages only one analysis was performed; ranges of values were not provided. Since tap water was supplied to many areas after 1966, the **arsenic**-containing wells were only used in dry periods. Because of the study design, particular wells used by those developing skin cancer could not be identified and **arsenic** intake could not be assigned except by village. Several uncertainties in exposure measurement reliability existed and subsequent analysis of drinking water found fluorescent substances in water that are possible confounders or caused synergistic effects. Uncertainties have been discussed in detail in U.S. EPA (1988). Uncertainties in exposure measurement can affect the outcome of dose- response estimation.

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure:

II.C.1. Summary of Risk Estimates:

Inhalation Unit Risk -- 4.3E-3 per (ug/cu.m)

Extrapolation Method -- absolute-risk linear model

Air Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	2E-2 ug/cu.m
E-5 (1 in 100,000)	2E-3 ug/cu.m
E-6 (1 in 1,000,000)	2E-4 ug/cu.m

II.C.2. Dose-Response Data for Carcinogenicity, Inhalation:

Tumor Type -- lung cancer
Test animals -- human, male
Route -- inhalation, occupational exposure
Reference -- Brown and Chu, 1983a,b,c; Lee-Feldstein, 1983; Higgins, 1982; Enterline and Marsh, 1982

Ambient Unit Risk Estimates (per µg/cu.m)				
Exposure Source	**Study**	**Unit Risk**	**Geometric Mean Unit Risk**	**Final Estimated Geometric Mean Unit Risk**
Anaconda smelter	Brown and Chu Lee-Feldstein Higgins et al.	1.25E-3 2.80E-3 4.90E-3	2.56E-3	4.29E-3
ASARCO smelter	Enterline & Marsh	6.81E-3 7.60E-3	7.19E-3	4.29E-3

II.C.3. Additional Comments (Carcinogenicity, Inhalation Exposure):

A geometric mean was obtained for data sets obtained with distinct exposed populations (U.S. EPA, 1984). The final estimate is the geometric mean of those two values. It was assumed that the increase in age-specific mortality rate of lung cancer was a function only of cumulative exposures.

The unit risk should not be used if the air concentration exceeds 2 ug/cu.m, since above this concentration the unit risk may not be appropriate.

II.C.4. Discussion of Confidence (Carcinogenicity, Inhalation Exposure):

Overall a large study population was observed. Exposure assessments included air measurements for the Anaconda smelter and both air measurements and urinary **arsenic** for the ASARCO smelter. Observed lung cancer incidence was significantly increased over expected values. The range of the estimates derived from data from two different exposure areas was within a factor of 6.

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment):

II.D.1. EPA Documentation:

U.S. EPA. 1984, 1988, 1993

A draft of the 1984 Health Assessment Document for Inorganic **Arsenic** was independently reviewed in public session by the Environmental Health Committee of the U.S. EPA Science Advisory Board on September 22-23, 1983. A draft of the 1988 Special Report on Ingested Inorganic **Arsenic**; Skin Cancer; Nutritional Essentiality was externally peer reviewed at a two-day workshop of scientific experts on December 2-3, 1986. A draft of the Drinking Water Criteria Document for **Arsenic** was reviewed by the Drinking Water Committee of the U.S. EPA Science Advisory Board on March 10, 1993. The comments from these reviews were evaluated and considered in the revision and finalization of these reports.

II.D.2. EPA Review (Carcinogenicity Assessment):

Agency Work Group Review -- 01/13/1988, 12/07/1989, 02/03/1994

Verification Date -- 02/03/1994

Screening-Level Literature Review Findings -- A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the cancer assessment for **Arsenic** (inorganic) conducted in September 2002 identified one or more significant new studies. IRIS users may request the references for those studies from the IRIS Hotline at hotline.iris@epa.gov or 301-345-2870.

II.D.3. EPA Contacts (Carcinogenicity Assessment):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

VI. Bibliography:

VI.A. Oral RfD References:

Abernathy, C.O., W. Marcus, C. Chen, H. Gibb and P. White. 1989. Office of Drinking Water, Office of Research and Development, U.S. EPA. Memorandum to P. Cook, Office of Drinking Water, U.S. EPA and P. Preuss, Office of Regulatory Support and Scientific Management, U.S. EPA. Report on **Arsenic** (As) Work Group Meetings. February 23.

Cebrian, M.E., A. Albores, M. Aguilar and E. Blakely. 1983. Chronic **arsenic** poisoning in the north of Mexico. Human Toxicol. 2: 121-133.

Ferm, V.H. and S.J. Carpenter. 1968. Malformations induced by sodium arsenate. J. Reprod. Fert. 17: 199-201.

Hindmarsh, J.T., O.R. McLetchie, L.P.M. Heffernan et al. 1977. Electromyographic abnormalities in chronic environmental arsenicalism. J. Analyt. Toxicol. 1: 270-276.

Hood, R.D., G.T. Thacker and B.L. Patterson. 1977. Effects in the mouse and rat of prenatal exposure to **arsenic**. Environ. Health Perspect. 19: 219-222.

Lu, F.J. 1990. Blackfoot disease: **Arsenic** or humic acid? The Lancet. 336: 115-116.

Marcus, W.L. and A.S. Rispin. 1988. Threshold carcinogenicity using **arsenic** as an example. In: Advances in Modern Environmental Toxicology, Vol. XV. Risk Assessment and Risk Management of Industrial and Evironmental Chemicals, C.R. Cothern, M.A. Mehlman and W.L. Marcus, Ed. Princeton Scientific Publishing Company, Princeton, NJ. p. 133-158.

Nadeenko, V.G., V. Lenchenko, S.B. Genkina and T.A. Arkhipenko. 1978. The influence of tungsten, molibdenum, copper and **arsenic** on the intrauterine development of the fetus. TR-79-0353. Farmakologiya i Toksikologiya. 41: 620-623.

NRC (National Research Council). 1989. Recommended Dietary Allowances, 10th ed. Report of the Food and Nutrition Board, National Academy of Sciences, Washington, National Academy Press, Washington, DC. 285 p.

Schroeder, H.A. and M. Mitchner. 1971. Toxic effects of trace elements on the reproduction of mice and rats. Arch. Environ. Health. 23(2): 102-106.

Southwick, J.W., A.E. Western, M.M. Beck, et al. 1983. An epidemiological study of **arsenic** in drinking water in Millard County, Utah. In: **Arsenic**: Industrial, Biomedical, Environmental Perspectives, W.H. Lederer and R.J. Fensterheim, Ed. Van Nostrand Reinhold Co., New York. p. 210-225.

Tseng, W.P. 1977. Effects and dose-response relationships of skin cancer and blackfoot disease with **arsenic**. Environ. Health Perspect. 19: 109-119.

Tseng, W.P., H.M. Chu, S.W. How, J.M. Fong, C.S. Lin and S. Yeh. 1968. Prevalence of skin cancer in an endemic area of chronic arsenicism in Taiwan. J. Natl. Can0cer. Inst. 40(3): 453-463.

Valentine, J.L., L.S. Reisbord, H.K. Kang and M.D Schluchter. 1987. **Arsenic** effects on population health histories. In: Trace Elements in Man and Animals - TEMA 5, C.F. Mills, I. Bremner and J.K. Chesters, eds. Commonwealth Agricultural Bureaux, Aberdeen, Scotland.

U.S. EPA. 1984. Health Assessment Document for Inorganic **Arsenic**. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, NC. EPA 600/8-83-021F.

U.S. EPA. 1988. Quantitative Toxicological Evaluation of Ingested **Arsenic**. Office of Drinking Water, Washington, DC. (Draft)

VI.B. Inhalation RfC References:

None

VI.C. Carcinogenicity Assessment References:

Axelson, O., E. Dahlgren, C.D. Jansson and S.O. Rehnlund. 1978. **Arsenic** exposure and mortality: A case referent study from a Swedish copper smelter. Br. J. Ind. Med. 35: 8-15.

Andersen, O. 1983. Effects of coal combustion products and metal compounds on sister chromatid exchange (SCE) in a macrophage like cell line. Environ. Health Perspect. 47: 239-253.

Bates, M.N., A.H. Smith and C. Hopenhayn-Rich. 1992. **Arsenic** ingestion and internal cancers: A review. Am. J. Epidemiol. 135(5): 462-476.

Beckman, G., L. Beckman and I. Nordenson. 1977. Chromosome aberrations in workers exposed to **arsenic**. Environ. Health Perspect. 19: 145-146.

Brown, C.C. and K.C. Chu. 1983a. Approaches to epidemiologic analysis of prospective and retrospective studies: Example of lung cancer and exposure to **arsenic**. In: Risk Assessment Proc. SIMS Conf. on Environ. Epidemiol. June 28-July 2, 1982, Alta, VT. SIAM Publications.

Brown, C.C. and K.C. Chu. 1983b. Implications of the multistage theory of carcinogenesis applied to occupational **arsenic** exposure. J. Natl. Cancer Inst. 70(3): 455-463.

Brown, C.C. and K.C. Chu. 1983c. A new method for the analysis of cohort studies: Implications of the multistage theory of carcinogenesis appled to occupational **arsenic** exposure. Environ. Health Perspect. 50: 293-308.

Burgdorf, W., K. Kurvink and J. Cervenka. 1977. Elevated sister chromatid exchange rate in lymphocytes of subjects treated with **arsenic**. Hum. Genet. 36(1): 69-72.

Cebrian, M.E., A. Albores, M. Aquilar and E. Blakely. 1983. Chronic **arsenic** poisoning in the north of Mexico. Human Toxicol. 2: 121-133.

Chen, C-J. and C-J. Wang. 1990. Ecological correlation between **arsenic** level in well water and age-adjusted mortality from malignant neoplasms. Cancer Res. 50(17): 5470-5474.

Chen, C-J., Y-C. Chuang, T-M. Lin and H-Y. Wu. 1985. Malignant neoplasms among residents of a Blackfoot disease-endemic area in Taiwan: High-**arsenic** artesian well water and cancers. Cancer Res. 45: 5895-5899.

Chen, C-J., Y-C. Chuang, S-L. You, T-M. Lin and H-Y. Wu. 1986. A retrospective study on malignant neoplasms of bladder, lung, and liver in blackfoot disease endemic area in Taiwan. Br. J. Cancer. 53: 399-405.

Chen, C-J., M-M. Wu, S-S. Lee, J-D. Wang, S-H. Cheng and H-Y. Wu. 1988. Atherogenicity and carcinogenicity of high-**arsenic** artesian well water. Multiple risk factors and related malignant neoplasms of Blackfoot disease. Arteriosclerosis. 8(5): 452-460.

Chen, C-J., CW. Chen, M-M. Wu and T-L. Kuo. 1992. Cancer potential in liver, lung bladder and kidney due to ingested inorganic **arsenic** in drinking water. Br. J. Cancer. 66(5): 888-892.

Crossen, P.E. 1983. **Arsenic** and SCE in human lymphocytes. Mutat. Res. 119: 415-419.

Cuzick, J., S. Evans, M. Gillman and D.A. Price Evans. 1982. Medicinal **arsenic** and internal malignancies. Br. J. Cancer. 45(6): 904-911.

Cuzick, J., R. Harris, P.S. Mortimer. 1984. Palmar keratoses and cancers of the bladder and lung. March 10. The Lancet. 1(8376): 530-533.

Cuzick, J., P. Sasieni and S. Evans. 1992. Ingested **arsenic**, keratoses, and bladder cancer. Am. J. Epidemiol. 136(4): 417-421.

Datta, S., G. Talukder and A. Sharma. 1986. Cytotoxic effects of **arsenic** in dietary oil primed rats. Sci. Culture. 52: 196-198.

DeKnudt, G., A. Leonard, A. Arany, G.D. Buisson and E. Delavignette. 1986. In vivo studies in male mice on the mutagenic effects of inorganic **arsenic**. Mutagenesis. 1(1): 33-34.

DiPaolo, J.A. and B.C. Casto. 1979. Qantitative studies of in vitro morphological transformation of Syrian hamster cells by inorganic metal salts. Cancer Res. 39: 1008-1013.

Dong, J-T., X-M. Luo. 1993. **Arsenic**-induced DNA-strand breaks associated with DNA-protein crosslinks in human fetal lung fibroblasts. Mutat. Res. 302(2): 97-102.

Eastern Research Group. 1997. Report on the expert panel on **arsenic** carcinogenicity: review and workshop. Prepared by Eastern Research Group, Lexington, MA, for the National Center for Environmental Assessment, Washington, DC, under EPA contract no. 68-C6-0041.

Enterline, P.E. and G.M. Marsh. 1982. Cancer among workers exposed to **arsenic** and other substances in a copper smelter. Am. J. Epidemiol. 116(6): 895-911.

Fierz, U. 1965. Catamnestic investigations of the side effects of therapy of skin diseases with inorganic **arsenic**. Dermatologica. 131: 41-58.

Furst, A. 1983. A new look at **arsenic** carcinogenesis. In: **Arsenic**: Industrial, Biomedical, and Environmental Perspectives, W. Lederer and R. Fensterheim, Ed. Van Nostrand Reinhold, New York. p. 151-163.

Harrington-Brock, K., T.W. Smith, C.L. Doerr, and M.M. Moore. 1993. Mutagenicity of the human carcinogen **arsenic** and its methylated metabolites monomethylarsonic and dimethylarsenic acids in L5178Y TK+/- mouse lymphoma cells (abstract). Environ. Mol. Mutagen. 21(Supplement 22): 27.

Higgins, I. 1982. **Arsenic** and respiratory cancer among a sample of Anaconda smelter workers. Report submitted to the Occupatinal Safety and Health Administration in the comments of the Kennecott Minerals Company on the inorganic **arsenic** rulemaking. (Exhibit 203-5)

Higgins, I., K. Welch and C. Burchfield. 1982. Mortality of Anaconda smelter workers in relation to **arsenic** and other exposures. University of Michigan, Dept. Epidemiology, Ann Arbor, MI.

Huang, H., C.F. Huang, D.R. Wu, C.M. Jinn and K.Y. Jan. 1993. Glutathione as a cellular defence against arsenite toxicity in cultured Chinese hamster ovary cells. Toxicology. 79(3): 195-204.

IARC (International Agency for Research on Cancer). 1980. IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man, Vol. 23. Some metals and metallic compounds. World Health Organization, Lyon, France.

Innes, J.R.M., B.M. Ulland, M.G. Valerio, et al. 1969. Bioassay of pesticides and industrial chemicals for tumorigenicity in mice: A preliminary note. JNCI. 42: 1101-1114.

Jacobson-Kram, D. and D. Montalbano. 1985. The reproductive effects assessment group's report on the mutagenicity of inorganic **arsenic**. Environ. Mutagen. 7(5): 787-804.

Jha, A.N., M. Noditi, R. Nilsson and A.T. Natarajan. 1992. Genotoxic effects of sodium arsenite on human cells. Mutat. Res. 284(2): 215-221.

Larramendy, M.L., N.C. Popescu and J.A. DiPaolo. 1981. Induction by inorganic metal salts of sister chromatid exchanges and chromosome aberrations in human and Syrian hamster strains. Environ. Mutagen. 3: 597-606.

Lee, Te-Chang, J. Ko and K.Y. Jan. 1989. Differential cytotoxocity of sodium arsenite in human fibroblasts and chinese hamster ovary cells. Toxicology. 56(3): 289-300.

Lee, Te-Chang, N. Tanaka, P.W. Lamb, T.M. Gilmer and J.C. Barrett. 1988. Induction of gene amplification by **arsenic**. Science. 241(4861): 79-81.

Lee-Chen, S.F., J.R. Gurr, I.B. Lin and K.Y. Jan. 1993. Arsenite enhances DNA double-strand breaks and cell killing of methyl methanesulfonate-treated cells by inhibiting the excision of alkali-labile sites. Mutat. Res. 294(1): 21-28.

Lee-Feldstein, A. 1983. **Arsenic** and respiratory cancer in man: Follow-up of an occupational study. In: **Arsenic**: Industrial, Biomedical, and Environmental Perspectives, W. Lederer and R. Fensterheim, Ed. Van Nostrand Reinhold, New York.

Mabuchi, K., A. Lilienfeld and L. Snell. 1979. Lung cancer among pesticide workers expsoed to inorganic arsenicals. Arch. Environ. Health. 34: 312-319.

Matanoski, G., E. Landau, J. Tonascia, et al. 1981. Cancer mortality in an industrial area of Baltimore. Environ. Res. 25: 8-28.

Moore, M.M., K. Harrington-Brock and C.L. Doerr. 1995. Genotoxicity of **arsenic** and its methylated metabolites. Mutagenesis and Cellular Toxicology Brance, Genetic Toxicology Dividion, Health Effects Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, NC. (In press).

Morton, W., G. Starr, D. Pohl, J. Stoner, S. Wagner, and P. Weswig. 1976. Skin cancer and water **arsenic** in Lane County, Oregon. Cancer. 37: 2523-2532.

Ohno, H., F. Hanaoka and M. Yamada. 1982. Inductibility of sister chromatid exchanges by heavy-metal ions. Mutat. Res. 104(1-3): 141-146.

Ott, M.G., B.B. Holder and H.L. Gordon. 1974. Respiratory cancer and occupational exposure to arsenicals. Arch. Environ. Health. 29: 250-255.

Pershagen, G., B. Lind and N.E. Bjorklund. 1982. Lung retention and toxicity of some inorganic **arsenic** compounds. Environ. Res. 29: 425-434.

Pershagen, G., G. Norberg and N.E. Bjorklund. 1984. Carcinomas of the respiratory tract in hamsters given **arsenic** trioxide and/or benxo(a)pyrene by the pulmonary route. Environ. Res. 34: 227-241.

Poma, K., N. Degraeve and C. Susanne. 1987. Cytogenic effects in mice after chronic exposure to **arsenic** followed by a single dose of ethyl methanesulfonate. Cytologia. 52(3): 445-450.

Rencher, A.C., M.W. Carter and D.W. McKee. 1977. A retrospective epidemiological study of mortality at a large western copper smelter. J. Occup. Med. 19(11): 754-758.

Rossman, T.G. 1981. Enhancement of UV-mutagenesis by low concentrations of arsenite in Escherichia coli. Mutat. Res. 91: 207-211.

Roth, F. 1958. Uber den Bronchialkrebs Arsengeschadigter Winzer. Virchows Arch. 331: 119-137.

Smith, A.H., C. Hopenhayn-Rich, M.N. Bates, et al. 1992. Cancer risks from **arsenic** in drinking water. Environ. Health Perspect. 97: 259-267.

Sommers, S.C. and R.G. McManus. 1953. Multible arsenical cancers of the skin and internal organs. Cancer. 6: 347-359.

Southwick, J., A. Western, M. Beck, et al. 1981. Community health associated with **arsenic** in drinking water in Millard County, Utah. Health Effects Research Laboratory, Cincinnati, OH. EPA-600/1-81-064.

Tinwell, H., S.C. Stephens, J. Ashby. 1991. Arsenite as the probable active species in the human carcinogenicity of **arsenic**: Mouse micronucleus assays on Na and K arsenite, orpiment, and Fowler's solution. Environ. Health Perspec. 95: 205-210.

Tokudome, S. and M. Kuratsune. 1976. A cohort study on mortality from cancer and other causes among workers at a metal refinery. Int. J. Cancer. 17: 310-317.

Tseng W.P., H.M. Chu, S.W. How, J.M. Fong, C.S. Lin, and S. Yen. 1968. Prevalence of skin cancer in an endemic area of chronic arsenicism in Taiwan. J. Natl. Cancer Inst. 40(3): 453-463.

Tseng W.P. 1977. Effects and dose-response relationships of skin cancer and Blackfoot disease with **arsenic**. Environ. Health Perspect. 19: 109-119.

U.S. EPA. 1984. Health Assessment Document for Inorganic **Arsenic**. Prepared by the Office of Research and Development, Environmental Criteria and Assessment Office, Reasearch Triangle Park, NC.

U.S. EPA. 1988. Special Report on Ingested Inorganic **Arsenic**; Skin Cancer; Nutritional Essentiality Risk Assessment Forum. July 1988. EPA/625/3-87/013.

U.S. EPA. 1993. Drinking Water Criteria Document for **Arsenic**. Office of Water, Washington, DC. Draft.

Vahter, M. and E. Marafante. 1988. In vivo methylation and detoxification of **arsenic**. Royal Soc. Chem. 66: 105-119.

Vig, B.K., M.L. Figueroa, M.N. Cornforth, S.H. Jenkins. 1984. Chromosome studies in human subjects chronically exposed to **arsenic** in drinking water. Am. J. Ind. Med. 6(5): 325-338.

Wan, B., R.T. Christian and S.W. Soukup. 1982. Studies of cytogenetic effects of sodium arsenicals on mammalian cells in vitro. Environ. Mutag. 4: 493-498.

Welch, K., I. Higgins, M. Oh and C. Burchfield. 1982. **Arsenic** exposure, smoking, and respiratory cancer in copper smelter workers. Arch. Environ. Health. 37(6): 325-335.

Wu, M-M., T-L. Kuo, Y-H Hwang and C-J. Chen. 1989. Dose-response relation between **arsenic** concentration in well water and mortality from cancers and vascular diseases. Am. J. Epidemiol. 130(6): 1123-1132.

VII. Revision History:

Substance Name -- **Arsenic**, inorganic
CASRN -- 7440-38-2

Date	Section	Description
06/30/1988	II.B.	Revised last paragraph
06/30/1988	II.C.1.	Inhalation slope factor changed
06/30/1988	II.C.3.	Paragraph 2 added
09/07/1988	II.B.	Major text changes
12/01/1988	II.A.2.	Mabuchi et al. citation year corrected
12/01/1988	II.A.3.	Pershagen et al. citation year corrected
09/01/1989	II.C.2.	Citations added to anacondor smelter
09/01/1989	VI.	Bibliography on-line
06/01/1990	II.A.2.	2nd and 3rd paragraph - Text revised
06/01/1990	II.A.4.	Text corrected
06/01/1990	II.C.1.	Inhalation slope factor removed (format change)
06/01/1990	IV.F.1.	EPA contact changed
06/01/1990	VI.C.	References added
12/01/1990	II.B.	Changed slope factor to "unit risk", 2nd para, 1st sen
02/01/1991	II.C.3.	Text edited
09/01/1991	I.A.	Oral RfD summary now on-line
09/01/1991	I.A.	Oral RfD bibliography added
10/01/1991	I.A.1.	Conversion factor text clarified

10/01/1991	IV.B.1.	MCLG noted as pending change
01/01/1992	IV.	Regulatory actions updated
08/01/1992	II.	Note added to indicate text in oral quant. estimate
10/01/1992	VI.C.	Missing reference added to bibliography
02/01/1993	I.A.4.	Citations added to second paragraph
02/01/1993	VI.A.	References added to bibliography
03/01/1993	VI.A.	Corrections to references
03/01/1994	II.D.2.	Work group review date added
06/01/1994	II.	Carcinogen assessment noted as pending change
01/01/1995	II.	Pending change note revised
01/01/1995	II.B.	Dates and document no. added to oral quant. estimate
06/01/1995	II.	Carcinogenicity assessment replaced
06/01/1995	VI.C.	Carcinogenicity references replaced
07/01/1995	II.D.1.	Documentation year corrected; review statement revised
07/01/1995	VI.C.	U.S. EPA, 1994 corrected to 1993
08/01/1995	II.D.2.	EPA's RfD/RfC and CRAVE workgroups were discontinued in May, 1995. Chemical substance reviews that were not completed by September 1995 were taken out of IRIS review. The IRIS Pilot Program replaced the workgroup functions beginning in September, 1995.
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
04/10/1998	II.B.3	Added discussion on expert panel workshop
02/11/2000	II.C.2	Corrected alignment of unit risks in table with corresponding studies
12/03/2002	I.A.6., II.D.2.	Screening-Level Literature Review Findings message has been added.

BROMACIL

CASRN: 314-40-9

For other data, click on the Table of Contents

Human Health Effects:

Human Toxicity Excerpts:

A cohort mortality study was undertaken of foresty workers at a public electrical utility who had worked for six months or more during 1950-82 and who were routinely exposed to herbicides including phenoxy acids. A total of 1222 men with 25,274 years at risk experienced 80 deaths. Ascertainment of vital state at the end of follow up was 95.5%. The male population of the province (Ontario) was used as the reference group. Overall, no excess mortality was found in this cohort relative to the reference population. A statistically significant increase in deaths occurred, however, due to suicide (SMR = 210, 95% confidence interval, 95% CII 105-376) for the cohort as a whole. No deaths were seen due to cancers such as soft tissue sarcoma and non-Hodgkin's lymphoma that have been cited by other authors as being associated with exposure to phenoxy acid herbicides. Although the cohort is not large, the absence of deaths due to these cancers is consistent with findings from other studies with sufficient numbers to allow examination of specific risks. The cohort is still young, however, and at the end of follow up most had not reached an age when increased incidence of cancer would normally be expected.
[Green LM; Br J Ind Med 48 (4): 234-38 (1991)]**PEER REVIEWED**

... **Bromacil** poisoning was characterized by vomiting, gastritis, and tongue numbness.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 3385]**PEER REVIEWED**

The effect of thiocarbamates (S-ethyldipropylthiocarbamate and diallate), substituted ureas (monuron and diuron), and uracils (**bromacil** and terbacil) on lipid metabolism in groundnut (Arachis hypogaea) leaves was investigated under nonphotosynthetic conditions. The uptake of (1-14C)acetate by leaf disks was inhibited by the thiocarbamates and marginally by the substituted ureas, but not by the uracil herbicides. The uptake of (methyl-14C)choline was inhibited to a lesser extent by thiocarbamates, while the other herbicides showed a slight stimulation. The thiocarbamates almost completely inhibited uptake of (32P)orthophosphate at 1.0 mM concentration, while diuron and terbacil showed significant inhibition. (1-14C)Acetate incorporation into lipids was inhibited only by diallate. (Methyl-14C)Choline incorporation into the choline phosphoglycerides was inhibited by diallate, diuron, and **bromacil**. The incorporation of (32P)orthophosphate into phospholipids was substantially inhibited (over 90% at 1.0 mM) by the thiocarbamates, but not by the other herbicides. (35S)Sulfate incorporation into sulfoquinovosyl diglycerides was markedly inhibited only by the thiocarbamate. Fatty acid synthesis by isolated chloroplasts was inhibited 40-85% by thiocarbamates, substituted ureas, and **bromacil**, but not by terbacil. The inhibitory effect of the urea derivatives was reversible, but that of thiocarbamates was irreversible. sn-Glycerol-3-phosphate acyltransferase(s) of the chloroplast and microsomal fractions were profoundly inhibited by thiocarbamates, but not by the other two groups of herbicides. Phosphatidic acid phosphatase was insensitive to all the herbicides tested.
[Rajasekharan R, Sastry PS; Biochem Cell Biol; 68 (2): 567-573 (1990)]**PEER REVIEWED**

Probable Routes of Human Exposure:

NIOSH (NOES Survey 1981-1983 (2) Parmeggiani L; Encyl Occup Health and Safety 3rd ed. Geneva,Switzerland: International Labour Office p. 1616-46 (1983)] NIOSH has statistically estimated

that 4,127 workers are potentially exposed to **bromacil** in the USA(1). The NOES Survey does not include farm workers. Occupational exposure to **bromacil** occurs through dermal contact and inhalation of sprays, especially to workers applying the compound as a herbicide(2).The general population may be exposed to **bromacil** via ingestion of contaminated food and drinking water, particularly from wells near agricultural areas(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983)]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** HERBICIDES: UREA-SUBSTITUTED ***, is relevant for this HSDB record chemical.

Life Support:

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o  This overview assumes that basic life support measures
   have been instituted.
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Clinical Effects:

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0.2.1 SUMMARY OF EXPOSURE
 0.2.1.1 ACUTE EXPOSURE
   A.  On the basis of animal feeding studies these agents
       appear to have low systemic toxicity.  Severity of
       intoxication should be based on clinical findings.
       Methemoglobinemia may be noted in large ingestions.
   B.  If severe symptoms or signs of poisoning are evident,
       other than methemoglobinemia, the operation of an
       alternative or additional toxicant should be suspected.
0.2.4 HEENT
 0.2.4.1 ACUTE EXPOSURE
   A.  Eye exposure may result in ocular irritation.
       Irritation of the respiratory mucous membranes may be
       noted following prolonged heavy contact.
0.2.5 CARDIOVASCULAR
 0.2.5.1 ACUTE EXPOSURE
   A.  CNS depression and hypoxemia may be noted if
       methemoglobinemia is present.
0.2.8 GASTROINTESTINAL
 0.2.8.1 ACUTE EXPOSURE
   A.  Nausea, vomiting, and diarrhea may be noted following
       ingestion.
0.2.10 GENITOURINARY
 0.2.10.1 ACUTE EXPOSURE
   A.  Some metabolites may cause irritation of the urinary
       tract.
0.2.13 HEMATOLOGIC
 0.2.13.1 ACUTE EXPOSURE
   A.  Sulfhemoglobin has been observed in the blood of rats
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and dogs given repeated large doses of diuron, and in one human overdose of monolinuron. Methemoglobinemia may result from effects of metabolites of some urea-based herbicides.

0.2.14 DERMATOLOGIC

0.2.14.1 ACUTE EXPOSURE

A. Cyanosis unresponsive to oxygen therapy may be noted in patients with methemoglobinemia due to absorption of excessive amounts of these agents.

Laboratory:

A. Plasma levels are not clinically useful.
B. Obtain methemoglobin concentrations in all cyanotic patients and patients demonstrating dyspnea or other signs of respiratory difficulty.

Treatment Overview:

0.4.2 ORAL EXPOSURE

A. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.
B. DECONTAMINATION - Remove contaminated clothing and wash affected areas including the hair thoroughly with soap and water.
C. NATIONAL PESTICIDE TELECOMMUNICATIONS NETWORK -
1. The National Pesticide Information Center (NPIC) is a cooperative effort of Oregon State University and the US EPA. NPIC provides consultation to poison centers and other health care professionals for the management of pesticide poisoning. Calls regarding emergency cases requiring immediate medical response will be transferred to the Oregon Poison Center.
a. NPIC contact information: phone: 1-800-858-7378; (outside the U.S. 541-737-6094). FAX: 1-541-737-0761. email: npic@ace.orst.edu Hours: 6:30 AM to 4:30 PM Pacific time 7 days/week excluding holidays.
D. TREATMENT IS PRIMARILY symptomatic and supportive.
E. METHEMOGLOBINEMIA: Administer 1 to 2 mg/kg of 1% methylene blue slowly IV in symptomatic patients. Additional doses may be required.

0.4.3 INHALATION EXPOSURE

A. INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids.

0.4.4 EYE EXPOSURE

A. DECONTAMINATION: Irrigate exposed eyes with copious amounts of room temperature water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility.

0.4.5 DERMAL EXPOSURE

A. DECONTAMINATION: Remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician may need to examine the area if irritation or pain persists.

Range of Toxicity:

A. Insufficient data in the literature to accurately assess the minimal toxic or lethal dose. Severity of intoxication should be based on clinical findings.
B. On the basis of animal studies these agents appear to have a low order of systemic toxicity.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

1. SKIN CONTAMINATION SHOULD BE REMOVED PROMPTLY BY WASHING WITH SOAP AND WATER. CONTAMINATION OF THE EYES SHOULD BE TREATED IMMEDIATELY BY PROLONGED FLUSHING OF THE EYES WITH COPIOUS AMOUNTS OF CLEAN WATER. IF DERMAL OR OCULAR IRRITATION PERSISTS, MEDICAL ATTENTION SHOULD BE OBTAINED WITHOUT DELAY. /OTHER HERBICIDES/
[MORGAN DP; RECOGNITION AND MANAGEMENT OF PESTICIDE POISONINGS. 4TH ED, P.87 EPA 540/9-88-001. WASHINGTON, DC: U.S. GOVERNMENT PRINTING OFFICE, MARCH 1989]**PEER REVIEWED**

2. INGESTIONS OF THESE HERBICIDES ARE LIKELY TO BE FOLLOWED BY VOMITING AND DIARRHEA DUE TO THE IRRITANT PROPERTIES OF MOST OF THE TOXICANTS. ... A. IF LARGE AMOUNTS OF HERBICIDE HAVE BEEN INGESTED, AND IF THE PATIENT IS FULLY ALERT INDUCE EMESIS WITH SYRUP OF IPECAC, FOLLOWED BY SEVERAL GLASSES OF WATER. DOSAGE FOR ADULTS AND CHILDREN OVER 12 YEARS: 30 ML; DOSAGE FOR CHILDREN UNDER 12 YEARS 15 ML. WHEN VOMITING HAS STOPPED, GIVE ACTIVATED CHARCOAL. ADD SORBITOL TO THE CHARCOAL SLURRY UNLESS DIARRHEA HAS ALREADY COMMENCED. IF, FOR SOME REASON, THE PATIENT IS NOT FULLY ALERT, PUT IN PLACE A CUFFED ENDOTRACHEAL TUBE TO PROTECT THE AIRWAY, THEN ASPIRATE AND LAVAGE THE STOMACH WITH A SLURRY OF ACTIVATED CHARCOAL. LEAVE A QUANTITY OF CHARCOAL, WITH SORBITOL, IN THE STOMACH BEFORE WITHDRAWING THE STOMACH TUBE. REPEATED ADMINISTRATION OF CHARCOAL AT HALF OR MORE THE INITIAL DOSAGE EVERY 2-4 HOURS MAY BE BENEFICIAL. /OTHER HERBICIDES/
[MORGAN DP; RECOGNITION AND MANAGEMENT OF PESTICIDE POISONINGS. 4TH ED, P.88 EPA540/9-88-001. WASHINGTON, DC: U.S. GOVERNMENT PRINTING OFFICE, MARCH 1989]**PEER REVIEWED**

2. B. IF THE AMOUNT OF INGESTED HERBICIDES WAS SMALL, IF EFFECTIVE EMESIS HAS ALREADY OCCURRED, OR IF TREATMENT IS DELAYED, ADMINISTER THE ACTIVATED CHARCOAL AND SORBITOL BY MOUTH. C. IF SERIOUS DEHYDRATION AND ELECTROLYTE DEPLETION HAVE OCCURRED AS A RESULT OF VOMITING AND DIARRHEA, MONITOR BLOOD ELECTROLYTES AND AND FLUID BALANCE AND ADMINISTER INTRAVENOUS INFUSIONS OF GLUCOSE, NORMAL SALINE RINGER'S SOLUTION, OR RINGER'S-LACTATE TO RESTORE EXTRACELLULAR FLUID VOLUME AND ELECTROLYTES. FOLLOW THIS WITH ORAL NUTRIENTS AS SOON AS FLUIDS CAN BE RETAINED. FLUIDS SERVE TO SUPPORT EXCRETION OF THE TOXICANTS. D. SUPPORTIVE MEASURES ARE ORDINARILY SUFFICIENT FOR SUCCESSFUL MANAGEMENT OF EXCESSIVE EXPOSURES TO THESE HERBICIDES. /OTHER HERBICIDES/

[MORGAN DP; RECOGNITION AND MANAGEMENT OF PESTICIDE POISONINGS. 4TH ED, P.88 EPA540/9-88-001. WASHINGTON, DC: U.S. GOVERNMENT PRINTING OFFICE, MARCH 1989]**PEER REVIEWED**

Animal Toxicity Studies:

Non-Human Toxicity Excerpts:

SHEEP GIVEN 250 MG/KG ... SHOWED TYMPANY /ABDOMINAL DISTENTION WITH GAS/ & STILTED GAIT WITHIN 4 HR. AFTER ADMINISTRATION ON 4 SUCCESSIVE DAYS THE SHEEP GIVEN **BROMACIL** DIED IN PROSTRATION. PATHOLOGIC FINDINGS INCLUDED GASTROENTERITIS, LIVER ENLARGEMENT & CONGESTION, A FRIABLE APPEARANCE OF THE ADRENALS, HEMORRHAGES IN THE HEART & SWOLLEN & HEMORRHAGIC LYMPH NODES.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-340]**PEER REVIEWED**

... WHEN TESTED ON RABBIT EYES /IT CAUSED/ ONLY SLIGHT TRANSIENT IRRITATION OF THE CONJUNCTIVA WITHOUT INJURY OF THE CORNEA.
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 536]**PEER REVIEWED**

LOW ORDER OF TOXICITY; NO-EFFECT /LEVEL/ FOR **BROMACIL** FED TO MALE & FEMALE RATS FOR 2 YR WAS GREATER THAN 250 PPM BUT LESS THAN 1250 PPM IN THE DIET; FOR MALE & FEMALE DOGS FED FOR 2 YR, 1250 PPM IN THE DIET WAS A NO-EFFECT LEVEL.
[Weed Science Society of America. Herbicide Handbook. 5th ed. Champaign, Illinois: Weed Science Society of America, 1983. 70]**PEER REVIEWED**

WHEN APPLIED DERMALLY TO RABBITS, THE LETHAL DOSE OF **BROMACIL** WAS GREATER THAN 5000 MG/KG, THE MAX FEASIBLE DOSE. NO CLINICAL SIGNS OF TOXICITY & NO GROSS PATHOLOGICAL CHANGES WERE OBSERVED. **BROMACIL** AS A 50% AQ SUSPENSION WAS MILDLY IRRITATING TO THE SKIN OF YOUNG GUINEA PIGS, BUT SLIGHTLY MORE IRRITATING TO THE SKIN OF OLDER ANIMALS; IT WAS NOT A SKIN SENSITIZER.
[Weed Science Society of America. Herbicide Handbook. 5th ed. Champaign, Illinois: Weed Science Society of America, 1983. 70]**PEER REVIEWED**

As little as 100 mg/kg caused vomiting, salivation, muscular weakness, excitability, diarrhea & mydriasis in dogs. One dog survived a single dose of 5 g/kg.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-340]**PEER REVIEWED**

BROMACIL CAUSES EMESIS IN DOGS, ITS ACUTE ORAL TOXICITY HAS NOT BEEN DETERMINED IN THIS SPECIES, BUT ORAL DOSES OF 250 MG/KG PRODUCE TOXICITY (WT LOSS OR ABNORMAL GAIT) IN ... CHICKENS, & CATTLE. TOXIC SYMPTOMS IN POISONED ANIMALS ALSO INCLUDE ANOREXIA, DEPRESSION, TYMPANITES /ABDOMINAL DISTENTION WITH GAS/ (IN CATTLE & SHEEP) & INCR RESP RATE (IN DOGS).
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 540]**PEER REVIEWED**

MALE RATS WERE GIVEN **BROMACIL** (AS A 15% AQ SOLN OF THE 80% AI WETTABLE POWDER) FOR 2 WK (5 DAYS/WK) @ 650, 1035, & 1500 MG/KG. THERE WERE 6 ANIMALS IN

EACH DOSE GROUP; 5 RATS DIED AFTER 5 DOSES @ HIGHEST DOSAGE LEVEL, & 1 DIED AFTER 10 DOSES @ INTERMEDIATE DOSAGE. THERE WERE NO DEATHS IN LOW-DOSAGE GROUP ... . ANIMALS EXHIBITED FOCAL CELL HYPERTROPHY & HYPERPLASIA IN LIVER.
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 540]**PEER REVIEWED**

/IN/ ... SUBCHRONIC STUDY ... 10 MALE & 10 FEMALE RATS WERE FED **BROMACIL** @ 50, 500, 2500, 5000, 6000 & 7500 PPM FOR 90 DAYS, THERE WERE NO SIGNS OF MORTALITY OR TOXICITY; BUT MICROSCOPIC EXAMINATION OF TISSUES FROM THESE ANIMALS REVEALED INCR THYROID ACTIVITY IN RATS FED 5000 PPM /&/ HIGHER. **BROMACIL** (83% AI WETTABLE POWDER) WAS FED TO RATS FOR 2 YR @ 50, 250, & 1250 PPM. ... RATS FROM EACH GROUP WERE SACRIFICED @ END OF 3, 6, & 12 MO OF FEEDING; WT LOSS IN FEMALE RATS FED 1,250 PPM ... HISTOPATHOLOGIC EXAM OF TISSUES ... REVEALED HYPERPLASIA IN LIGHT & FOLLICULAR CELLS OF THYROID, & THERE WAS A FOLLICULAR ADENOMA IN 1 FEMALE FED 1250 PPM.
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 541]**PEER REVIEWED**

BROMACIL WAS FOUND TO BE MUTAGENIC IN HISTIDINE REVERSE MUTATION SYSTEM IN FIVE STRAINS OF SALMONELLA TYPHIMURIUM, MITOTIC RECOMBINATION ASSAY IN DIPLOID STRAIN OF SACCHAROMYCES CEREVISIAE, & RELATIVE TOXICITY ASSAYS IN ESCHERICHIA COLI & BACILLUS SUBTILIS. METABOLIC ACTIVATION WAS USED IN ALL MUTAGENICITY ASSAYS.
[SIMMON VF ET AL; TOXICOL APPL PHARMACOL 37 (1): 109 (1976)]**PEER REVIEWED**

... /**BROMACIL**, LENACIL & TERBACIL/ HAVE BEEN TESTED EXTENSIVELY IN SEVERAL MUTAGEN SCREENING SYSTEMS. NONE WERE MUTAGENIC IN ANY OF THE TESTS. ... SCREENING METHODS CONSISTED OF RECOMBINATION ASSAY (BACILLUS SUBTILIS, 2 STRAINS) & REVERSION ASSAYS WITH & WITHOUT ACTIVATION (ESCHERICHIA COLI, 2 STRAINS; SALMONELLA TYPHIMURIUM, 6 STRAINS).
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 3383]**PEER REVIEWED**

The mutagenicity of 110 herbicides was evaluated in one or more of the four different microbial systems. **Bromacil** was nonmutagenic in eight histidine requiring mutants of Salmonella typhimurium. Mutation frequency (0.11%) in rII mutants of T4 bacteriophage was the same as the spontaneous rate. Amount of **bromacil** used was 50 ug. In reversion assay of bacteriophage AP72 to T4 phenotype, 500 ug of **bromacil** was also nonmutagenic (0.10% compared to 1% for control).
[Andersen KJ et al; J Agric Food Chem 20 (3): 649-56 (1972)]**PEER REVIEWED**

The effects of 2.5, 5.0, and 7.5 kg/ha of **bromacil** on soil microflora were studied in the soil of a plum orchard. A stimulatory effect on the bacterial population and an inhibitory effect on actinomycetes were observed under all the herbicidal treatments up to 60 days from application. Thereafter, the effect leveled off. An inhibitory effect on fungi was noticed with **bromacil**. In general, the herbicide effect lasted up to 60 days and the microbial status of the soil was not significantly disturbed at low and medium concn.
[Bhutani VP et al; Sci Hortic (Amsterdam) 23 (2): 191-4 (1984)]**PEER REVIEWED**

Bromacil fed to pregnant New Zealand white rabbits on days 8-16 of gestation at dietary levels of 0, 50, and 250 ppm was not teratogenic. In a 3 generation 6 litter reproduction study with rats, a dietary level of 250 ppm had no adverse effects upon reproduction and lactation performance; no pathologic changes were observed in weanling pups of the F3b generation.
[Sherman H, Kaplan AM; Toxicol Appl Pharmacol 34 (Nov): 189-96 (1975)]**PEER

REVIEWED**

All rats tolerated a four hr exposure at the equivalent of 4800 mg/cu m (4.8 mg/l) indicating a low order of acute inhalation toxicity.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.64]**PEER REVIEWED**

No significant reproductive effects were observed in a two generation rat study in which indexes of fertility, gestation, viability, and lactation were observed. The dosages for these studies were 50, 250, 1250 ppm, and there were 12 male and 12 female rats in each group. No gross manifestations of teratogenic effects were observed in the fetuses of rabbits fed **bromacil** in the diet at 50, 250, and 1250 ppm.
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 541]**PEER REVIEWED**

Administration of 10 mg of dry 50% powder or 0.1 ml of a 10% suspension in mineral oil to rabbit's eyes resulted in only mild temporary conjunctivitis in both the washed and unwashed eyes of rabbits with no corneal injury.
[Weed Science Society of America. Herbicide Handbook. 5th ed. Champaign, Illinois: Weed Science Society of America, 1983. 70]**PEER REVIEWED**

LC50 values for 30 day old fathead minnows (Pimephales promelas) exposed to **bromacil** were 185, 183, 182, and 167 mg/l at 24, 48, 96, and 168 hr, respectively. In early life-stage exposures, it was not possible to determine a 'no effect' concn for **bromacil**, as growth was reduced at the lowest exposure of 1.0 mg/l. **Bromacil** did not accumulate significantly in fish tissue. Rainbow trout (Salmo gairdneri) injected with radiolabeled **bromacil** eliminated over 90% of the radioactivity within 24 hr.
[Anon; Govt Reports Announcements & Index (GRA&I), Issue 13, 1988]**PEER REVIEWED**

Bromacil was fed to rats at levels of 50, 500, and 7500 ppm for 13 weeks. No effects were seen at 500 ppm and liver, kidney, and thyroid changes accompanied by a lower rate of weight gain were seen in the 7500 ppm treated rats. Extending the feeding period to 2 years at concentrations of 50, 250, and 1250 ppm produced a reduced weight gain (decrease food intake) among females fed 1250 ppm. ... A second 2 year study in rats found decreases in body weight and food consumption at 250 and 2500 ppm (but not at 50 ppm), but no other signs of toxicity.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 3382]**PEER REVIEWED**

Mice fed 100 to 10,000 ppm for 6 weeks showed liver effects at 2500 ppm or greater without any other significant signs of response.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 3382]**PEER REVIEWED**

Mice fed 250, 1250, or 5000 ppm **bromacil** for 18 months showed an increased mortality in females at 5000 ppm. Growth was somewhat reduced in that group as well as in mice fed 1250 ppm. Liver hypertrophy was seen in the two higher feeding levels and an increase in testicular tubule atrophy was seen in all groups.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 3382]**PEER REVIEWED**

Male and female beagle dogs were fed diets containing 50, 250, or 1250 ppm **bromacil** for 2 years and no toxicologic effects were produced. A second study in which dogs were fed 25, 150, and 625 ppm

bromacil for 1 year produced no evidence of chronic toxicity although decreased dietary palatability was seen in females fed 625 ppm.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 3382]**PEER REVIEWED**

No teratogenic effects were seen in rats exposed by inhalation at 38 to 165 mg/cu m **bromacil** for 9 days during gestation. Dose related reductions in fetal weight and caudal ossification were seen and a slightly higher percentage of resorptions occurred at 165 mg/cu m. No fetal changes were seen in rabbits given 30 to 500 mg/kg during gestation although maternal weight loss and decreased food consumption were seen at 300 and 500 mg/kg. Resorptions were increased at these two doses and mean number of viable fetuses was also reduced. No effects were seen in a three generation reproduction study in rats fed diets up to 250 ppm **bromacil** or a two generation rat reproduction study at concentrations up to 2500 ppm.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 3384]**PEER REVIEWED**

Methyluracil Compounds (**bromacil**, terbacil) ... can cause mild toxic signs at levels of 50 mg/kg body wt in sheep, 250 mg/kg in cattle, and 500 mg/kg in poultry when given daily for 8-10 doses. Signs include bloat, in coordination, depression, and anorexia. Application rates of >5 lb/acre (5.6 kg/hectare) can be hazardous, especially for sheep, but no field cases of toxicity have been reported.
[Aiello, S.E. (ed). The Merck Veterinary Manual. 8th ed. Merck & Co., Inc., National Publishing Inc., Philadelphia, PA. 1998. 2060]**PEER REVIEWED**

Bromacil did not cause skin sensitization but was mildly irritating to guinea pigs. Rabbits showed no clinical signs of toxicity as a result of skin application of 5000 mg/kg body weight, the maximum feasible dose under test conditions. Autopsy showed no gross pathologic changes.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.148]**PEER REVIEWED**

In a 90 day feeding study in rats, ten male and ten female ChR CD rats per group were given diets containing 0, 50, 500, or 2500 ppm **bromacil**. Due to the absence of clinical signs of toxicity after 6 weeks, the 2500 ppm level was raised to 5000 ppm; after 10 weeks, the dietary level of five of the rats in this group was further raised to 6000 ppm for 1 week and then to 7500 ppm for 2 weeks. All test animals survived the feeding period; histologic examination of tissue sections from the sacrificed rats in the highest level group showed changes in the thyroid, very slight hyperplasia (suggestive of increased glandular activity), and enlargement of the centrolobular cells in the liver.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.148]**PEER REVIEWED**

The groups of male & female rats fed 1250 ppm **bromacil** in this 2 year feeding study showed very slight hyperplasia of thyroid tissue cells which was considered suggestive of an effect by the test material at this level. However, the authors concluded that the observation of slight histologic changes in the thyroid of rats that received the highest dietary level of **bromacil** (2500-7500 ppm) in the 90 day study & in rats fed 1250 ppm for 2 years, coupled with the absence of a compound induced change in the thyroid of dogs that also were studied in a 2 yr feeding study at 1250 ppm **bromacil**, suggest a very marginal manifestation of cumulative toxicity at these dietary levels. In a follow up study in mice, an incr incidence of hepatocellular adenomas plus carcinomas (combined) was observed in males fed **bromacil** in the diet at a dose level of 871 mg/kg/day for 78 wk.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.148]**PEER REVIEWED**

The effect of thiocarbamates (S-ethyldipropylthiocarbamate and diallate), substituted ureas (monuron and diuron), and uracils (**bromacil** and terbacil) on lipid metabolism in groundnut (Arachis hypogaea) leaves was investigated under nonphotosynthetic conditions. The uptake of (1-14C)acetate by leaf disks was inhibited by the thiocarbamates and marginally by the substituted ureas, but not by the uracil herbicides. The uptake of (methyl-14C)choline was inhibited to a lesser extent by thiocarbamates, while the other herbicides showed a slight stimulation. The thiocarbamates almost completely inhibited uptake of (32P)orthophosphate at 1.0 mM concentration, while diuron and terbacil showed significant inhibition. (1-14C)Acetate incorporation into lipids was inhibited only by diallate. (Methyl-14C)Choline incorporation into the choline phosphoglycerides was inhibited by diallate, diuron, and **bromacil**. The incorporation of (32P)orthophosphate into phospholipids was substantially inhibited (over 90% at 1.0 mM) by the thiocarbamates, but not by the other herbicides. (35S)Sulfate incorporation into sulfoquinovosyl diglycerides was markedly inhibited only by the thiocarbamates. Fatty acid synthesis by isolated chloroplasts was inhibited 40-85% by thiocarbamates, substituted ureas, and **bromacil**, but not by terbacil. The inhibitory effect of the urea derivatives was reversible, but that of thiocarbamates was irreversible.
[Rajasekharan R et al; Biochem Cell Biol 68 (2): 567-3 (1990)]**PEER REVIEWED**

Non-Human Toxicity Values:

LD50 Rat male oral 5200 mg/kg
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.64]**PEER REVIEWED**

LC50 Rat inhalation >4.8 mg/l air/4 hr
[Hartley, D. and H. Kidd (eds.). The Agrochemicals Handbook. 2nd ed. Lechworth, Herts, England: The Royal Society of Chemistry, 1987.,p. A040/Aug 87]**PEER REVIEWED**

LD50 Rabbit percutaneous >5000 mg/kg
[Hartley, D. and H. Kidd (eds.). The Agrochemicals Handbook. 2nd ed. Lechworth, Herts, England: The Royal Society of Chemistry, 1987.,p. A040/Aug 87]**PEER REVIEWED**

LD50 Rat oral 5,200 mg/kg and 641 mg/kg
[Montgomery, J.H.; Agrochemicals Desk Reference 2nd ed. Lewis Publishers, Boca Raton, FL 1997 62]**PEER REVIEWED**

LD50 Rat oral 641 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 504]**PEER REVIEWED**

LD50 Mouse oral 3040 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 504]**PEER REVIEWED**

Ecotoxicity Values:

LC50 BLUEGILL SUNFISH 71 PPM/48 HR /CONDITIONS OF BIOASSAY NOT SPECIFIED/
[Weed Science Society of America. Herbicide Handbook. 5th ed. Champaign, Illinois: Weed Science Society of America, 1983. 70]**PEER REVIEWED**

LC50 Salmo gairdneri (Rainbow trout) 75 ppm/48 hr /conditions of bioassay not specified/
[Weed Science Society of America. Herbicide Handbook. 5th ed. Champaign, Illinois: Weed Science Society of America, 1983. 70]**PEER REVIEWED**

LC50 Cyprinus carpio (CARP) 164 ppm/48 hr /conditions of bioassay not specified/
[Weed Science Society of America. Herbicide Handbook. 5th ed. Champaign, Illinois: Weed Science Society of America, 1983. 70]**PEER REVIEWED**

LC50 Salmo gairdneri (Rainbow trout) 56-60 mg active ingredient (as wp)/l/48 hr /Conditions of bioassay not specified/
[Worthing, C. R. (ed.). Pesticide Manual. 6th ed. Worcestershire, England: British Crop Protection Council, l979. 50]**PEER REVIEWED**

LC50 Coturnix japonica >5,000 ppm (5 day in diet) /Conditions of bioassay not specified/
[Hill, E.F. and Camardese, M.B. Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix. Fish and Wildlife Technical Report 2. Washington, DC: United States Department of Interior Fish and Wildlife Service, 1986.33]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnow) 186 mg/l/96 hr (confidence limit 180-192 mg/l), flow-through bioassay with measured concentrations, 25.0 deg C, dissolved oxygen 8.2 mg/l, hardness 49.4 mg/l calcium carbonate, alkalinity 42.1 mg/l calcium carbonate, and pH 7.4.
[Geiger D.L., Call D.J., Brooke L.T. (eds). Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales Promelas). Vol. IV. Superior Wisconsin: University of Wisconsin-Superior, 1988.201]**PEER REVIEWED**

EC50 Pimephales promelas (fathead minnow) 167 mg/l/96 hr (confidence limit 162-173 mg/l), flow-through bioassay with measured concentrations, 25.0 deg C, dissolved oxygen 8.2 mg/l, hardness 49.4 mg/l calcium carbonate, alkalinity 42.1 mg/l calcium carbonate, and pH 7.4. Stress was characterized by swimming in a spiral motion and by floating vertically in the water.
[Geiger D.L., Call D.J., Brooke L.T. (eds). Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales Promelas). Vol. IV. Superior Wisconsin: University of Wisconsin-Superior, 1988.201]**PEER REVIEWED**

LC50 Bluegill 80 mg active ingredient (as wp)/l/24 hr /Conditions of bioassay not specified/
[Worthing, C. R. (ed.). Pesticide Manual. 6th ed. Worcestershire, England: British Crop Protection Council, l979. 50]**PEER REVIEWED**

LC50 Rainbow trout 75 mg/l/48 hr, bluegill sunfish 71 mg/l/48 hr and carp 164 mg/l/48 hr
[Montgomery, J.H.; Agrochemicals Desk Reference 2nd ed. Lewis Publishers, Boca Raton, FL 1997 62]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

Bromacil ... /is/ metabolized in rodents by side-chain oxidation.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-340]**PEER REVIEWED**

MALE RATS ... MAINTAINED FOR 1 MO ON DIET ... /OF/ 1250 PPM OF **BROMACIL**. URINE WAS COLLECTED ... & ANALYZED. ... METABOLITES ... ISOLATED:
5-BROMO-3-SEC-BUTYL-6-HYDROXYMETHYLURACIL;
5-BROMO-3-(2-HYDROXY-1-METHYL-PROPYL)-6-METHYLURACIL;
5-BROMO-3-(2-HYDROXY-1-METHYLPROPYL)-6-HYDROXYMETHYLURACIL;
3-SEC-BUTYL-6-HYDROXYMETHYLURACIL;
5-BROMO-3-(3-HYDROXY-1-METHYLPROPYL)-6-METHYLURACIL;
3-SEC-BUTYL-6-METHYLURACIL; AND UNIDENTIFIED BROMINE-CONTAINING CMPD OF MOLECULAR WT 339.
[Menzie, C. M. Metabolism of Pesticides, An Update. U.S. Department of the Interior,

Fish, Wild-life Service, Special Scientific Report - Wildlife No. 184, Washington, DC: U.S. Government Printing Office, l974.387]**PEER REVIEWED**

Absorption, Distribution & Excretion:

WHEN HERBICIDE CONCN IN FEED OF COWS WAS 5 & 30 PPM, SECRETION OF INTACT CMPD IN MILK REACHED CONCN OF 0.019 & 0.13 PPM, RESPECTIVELY. **BROMACIL** WAS ABSENT IN URINE & FECES SAMPLES. RAPID UPTAKE VIA THE ROOTS, SLIGHT ABSORPTION VIA THE LEAF CANOPY.
[Menzie, C. M. Metabolism of Pesticides, An Update. U.S. Department of the Interior, Fish, Wild-life Service, Special Scientific Report - Wildlife No. 184, Washington, DC: U.S. Government Printing Office, l974.387]**PEER REVIEWED**

The uptake and translocation of **bromacil** was investigated after root application to maize (Zea mays) and bean (Phaseolus vulgaris). 90-100% was recovered in quant radioassays. Absorption of **bromacil** incr to approx 20% of the applied dose in bean plants after 2 days of exposure, and to approx 11% in maize plants after 4 days. After 4 hr of exposure of the roots approx 1/2 of the absorbed **bromacil** had accum in the shoots, while greater than or equal to 2/3 was translocated to the shoots after 1-4 days. No metabolites of **bromacil** were detected in the 2 plant species.
[Goertz JH, Van Oorschot JLP; Pestic Biochem Physiol 21 (1): 45-52 (1984)]**PEER REVIEWED**

Bromacil is absorbed from the GI tract and appears to be excreted primarily in the urine.
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 540]**PEER REVIEWED**

LC50 values for 30-day old fathead minnows (Pimephales promelas) exposed to **bromacil** were 185, 183, 182, and 167 mg/l at 24, 48, 96, and 168 hr, respectively. In early life-stage exposures, it was not possible to determine a no effect concn for **bromacil**, as growth was reduced at the lowest exposure of 1.0 mg/l. **Bromacil** did not accumulate significantly in fish tissue. Rainbow trout (Salmo gairdneri) injected with radiolabeled **bromacil** eliminated over 90% of the radioactivity within 24 hr.
[Anon; Govt Reports Announcements & Index (GRA&I), Issue 13, 1988]**PEER REVIEWED**

Absorbed mainly through the roots, with slight absorption through the leaves and stems.
[Hartley, D. and H. Kidd (eds.). The Agrochemicals Handbook. 2nd ed. Lechworth, Herts, England: The Royal Society of Chemistry, 1987.,p. A040/Aug 87]**PEER REVIEWED**

Mechanism of Action:

BROMACIL HAS BEEN SHOWN TO BE A POTENT & SPECIFIC INHIBITOR OF PHOTOSYNTHESIS.
[Weed Science Society of America. Herbicide Handbook. 5th ed. Champaign, Illinois: Weed Science Society of America, 1983. 68]**PEER REVIEWED**

Pharmacology:

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Bromacil's use as a herbicide is expected to result in its direct release to the environment. If released to air, a vapor pressure of 3.07X10-7 mm Hg at 25 deg C indicates **bromacil** will exist in both the vapor and particulate phases in the ambient atmosphere. Vapor-phase **bromacil** will be degraded in the

atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 20 hours. Particulate-phase **bromacil** will be removed from the atmosphere by wet and dry deposition. If released to soil, **bromacil** is expected to have very high to moderate mobility based upon Koc values ranging from 2.3 to 289. Volatilization from moist soil surfaces is not expected to be an important fate process based upon an estimated Henry's Law constant of 1.29X10-10 atm-cu m/mole. Hydrolysis and photolysis are not expected to be major fate processes for this compound in soil. Biodegradation occurs slowly under both aerobic and anaerobic conditions in soil and water environments. Dissipation half-lives of 124 and 155 days have been reported in aerobic soil field studies. A biodegradation half-life of 275 days has been reported in soil. In flooded anaerobic soils, half-lives of 144 to 198 days have been measured; degradation proceeds anaerobically via reductive dehalogenation. If released into water, **bromacil** is not expected to adsorb to suspended solids and sediment based upon this compound's Koc range. Volatilization from water surfaces is not expected to be an important fate process based upon this compound's estimated Henry's Law constant. Photolysis in alkaline waters may occur; however in acidic or neutral waters, **bromacil** should not be directly photolyzed. BCF values in fish of 2.8 and 26.5 suggest bioconcentration in aquatic organisms is low. **Bromacil** is widely detected in groundwater, particularly in agricultural areas where this compound has been used. Occupational exposure to **bromacil** may occur through inhalation of sprays and dermal contact with this compound at workplaces where **bromacil** is produced or used. The general population may be exposed to **bromacil** via ingestion of contaminated food and drinking water, particularly from wells near agricultural areas. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

NIOSH (NOES Survey 1981-1983 (2) Parmeggiani L; Encyl Occup Health and Safety 3rd ed. Geneva,Switzerland: International Labour Office p. 1616-46 (1983)] NIOSH has statistically estimated that 4,127 workers are potentially exposed to **bromacil** in the USA(1). The NOES Survey does not include farm workers. Occupational exposure to **bromacil** occurs through dermal contact and inhalation of sprays, especially to workers applying the compound as a herbicide(2).The general population may be exposed to **bromacil** via ingestion of contaminated food and drinking water, particularly from wells near agricultural areas(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983)]**PEER REVIEWED**

Artificial Pollution Sources:

Bromacil's use as a herbicide(1) is expected to result in its direct release to the environment(SRC). During spray application, **bromacil** can be transported to surrounding areas via aerial drift(2,3). After application, **bromacil** can be transported from fields via runoff from rainfall(3). In 1992, 1,194,805 pounds of **bromacil** were applied to citrus crops in the US(4).
[(1) Tomlin CDS, ed; The Pesticide Manual 11th ed.; The British Crop Protection Council; pp. 140-141 (1997) (2) Ferenbaugh RW et al; Bull Environ Contam Toxicol 27: 268-73 (1981) (3) Frank R et al; Arch Environ Contam Toxicol 16: 9-22 (1987) (4) USGS; Pesticide 1992 Annual Use Map on Bromacil. Available from the Database Query page at http://ca.water.usgs.gov./pnsp/use92/brmcil.html as of Oct, 2000.]**PEER REVIEWED**

Environmental Fate:

At 18 mo after spraying 22.4 kg **bromacil**/ha on abandoned field sites overgrown mainly by little bluestem (Andropogon scoparius), poverty grass (Danthonia spicata), timothy (Phleum pratense), quackgrass (Agropyron repens), goldenrod (Solidago) and Kentucky bluegrass (Poa pratensis), the max recovery of detectable **bromacil** residues occurred in the loamy sand, followed by decr amt in the silt

loam, silty clay loam, and light silty clay loam. Org matter content, cation-exchange capacity, total nitrogen and sol salt concn were significantly correlated with residue persistence and incr depth in all 4 soils.
[Shipman RD; Movement and persistence of bromacil in noncultivated soils; Proc Annu Meet Northeast Weed Sci Soc 37: 110-1 (1983)]**PEER REVIEWED**

TERRESTRIAL FATE: **BROMACIL** WAS INCUBATED IN VARIOUS SOILS TO DETERMINE ITS PERSISTENCE. HALF-LIFE IN FLOODED SOIL WAS 155 DAYS; IN FLOODED SOIL PLUS BEAN STRAW, 198 DAYS.
[Menzie, C.M. Metabolism of Pesticides, Update II. U.S. Department of the Interior, Fish Wildlife Service, Special Scientific Report - Wildlife No. 2l2. Washington, DC: U.S. Government Printing Office, 1978.288]**PEER REVIEWED**

TERRESTRIAL FATE: When sterilant rates are applied, activity usually is noted for more than one season. The half-life of 2-(14)C-labeled **bromacil** was determined to be approximately 5 to 6 months when 4 lb/A were applied to the surface of Butlertown silt loam.
[Weed Science Society of America. Herbicide Handbook. 5th ed. Champaign, Illinois: Weed Science Society of America, 1983. 69]**PEER REVIEWED**

TERRESTRIAL FATE: Based on a classification scheme(1), Koc values ranging from 2.3(2) to 289(3), indicate that **bromacil** is expected to have very high to moderate mobility in soil(SRC). In one adsorption study, it was determined that a rainfall of 20-23 cm could displace over 96% of applied **bromacil**(8). Volatilization of **bromacil** from moist soil surfaces is not expected to be an important fate process(6) given a Henry's Law constant of 1.29X10-10 atm-cu m/mole (SRC), estimated from its vapor pressure, 3.07X10-7 mm Hg(4), and water solubility, 815 mg/l(5). **Bromacil** is not expected to volatilize from dry soil surfaces(SRC) based upon its vapor pressure. While losses from soil due to photodecomposition or volatilization are minor(3,7), biodegradation, although slow, is a major degradation pathway for **bromacil** in both aerobic and anaerobic environments. **Bromacil** was biodegraded in aerobic soil with a half-life of 275 days; the major degradate was carbon dioxide(9). Anaerobic half-lives of 144 to 198 days have been reported in flooded soil(10).
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) USDA; ARS Pesticide Properties Database. Available from the Database Query Page at http://wizard.arsuda.gov/rsml/listall.html as of Oct, 2000. (3) Corwin DL, Farmer WJ; Environ Sci Technol 18: 507-18 (1984) (4) Tomlin CDS, ed; The Pesticide Manual World Compendium. 11th ed., Surrey, England: Brit Crop Prot Council p. 140 (1997) (5) Budavari S, ed; The Merck Index. 12th ed. Whitehouse Station, NJ: Merck and Co., Inc., p. 226 (1996) (6) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chm Soc pp. 15-1 to 15-29 (1990)(7) Angermar Y et al; J Environ Qual 13: 321-6 (1984) (8) Reddy KN et al; Bull Environ Contam Toxicol 48: 662-70 (1992) (9) USEPA; Reregistration Eligibility Decisions (REDs) Database on Bromacil. Washington DC: USEPA, Off Prev Pest Toxic Sub USEPA 738-R-96-013 (1996). Available from the Database Query page at http://www.epa.gov/REDs/ as of Oct 17, 2000. (10) Wolf DC, Martin JP; Soil Sci Amer Proc 38: 921-5 (1974)]**PEER REVIEWED**

TERRESTRIAL FATE: **Bromacil** is relatively persistent in soil. The US Dept of Agric's Pesticide Properties Database lists a soil half-life of 60 days for **bromacil**(1). In a laboratory study using a sandy loam soil and saturated soil conditions, **bromacil** had an observed half-life of 144-198 days(2). In an apple orchard study where **bromacil** was applied annually for 6-7 yrs, **bromacil** had an apparent half-life of approximately 8 months(3). In field plots treated with 4 lb **bromacil** per acre, **bromacil** had a half-life of 5 to 6 months(4); identified metabolites included 5-bromo-3-sec-butyl-6-hydroxymethyl uracil, 5-bromo-3-(2-hydroxy-1-methylpropyl)-6-methyluracil, and 5-bromo-3-(3-hydroxy-1-methylpropyl)-6-methyluracil(4). Degradation of 31-65% was observed in six soils after incubation for 6 months under laboratory conditions(5). Laboratory half-lives of 4-5 months were determined for a loam soil at temperatures of 13.2 and 31.2 deg C(6); faster degradation occurred at warmer temperatures(6).

[(1) Wauchope RD et al; Rev Environ Contam Toxicol 123: 1-35 (1991) (2) Wolf DC,Martin JP; Soil Sci Amer, Proc 38: 921-5 (1974) (3) Leistra M et al; Weed Res 15: 243-7 (1975) (4) Gardiner JA et al; J Agric Food Chem 17: 980-6 (1969) (5) Jolliffe VA et al; J Agric Food Chem 15: 174-7 (1967) (6) Zimdahl RL et al; Weed Res 10: 18-26 (1970)]**PEER REVIEWED**

TERRESTRIAL FATE: A single application of **bromacil** at 2 lb ai/acre dissipated with half-lives of 155 days from the upper 10 cm of a bare ground plot of silty clay loam soil in Delaware, and 124 days from the upper 10 cm of a bare ground plot of loam soil located in California(1). **Bromacil** was detected in the upper 10 cm of the Delaware and California plots through 538 and 415 days posttreatment, respectively(1). In general, **bromacil** was not detected below the 40 cm soil depth at both test sites. This may have been due to the amount and timing of rainfall and/or irrigation at these sites(1).
[(1) USEPA; Reregistration Eligibility Decisions (REDs) Database on Bromacil. Washington DC: USEPA, Off Prev Pest Toxic Sub USEPA 738-R-96-013 (1996). Available from the Database Query page at http://www.epa.gov/REDs/ as of Oct 17, 2000.]**PEER REVIEWED**

AQUATIC FATE: Based on a classification scheme(1), Koc values ranging from 2.3(2) to 289(3) indicate that **bromacil** is not expected to adsorb to suspended solids and sediment(SRC). Volatilization from water surfaces is not expected(4) based upon a Henry's Law constant of 1.29X10-10 atm-cu m/mole(SRC), estimated from its vapor pressure, 3.07X10-7 mm Hg(5), and water solubility, 815 mg/l(6). **Bromacil** is stable to hydrolysis(6) and is not susceptible to direct photolysis at pH values of 5 and 7(7). However, in alkaline waters, **bromacil** may be photolyzed based on a study showing a photolysis half-life of 4-7 days at pH 9(7). Biodegradation is expected to be a major fate process for this compound in water. Based on soil studies, **bromacil** is expected to be slowly biodegraded under both aerobic and anaerobic conditions(7). A single sediment/water study reported a half-life of 36 days under anaerobic conditions, following a lag phase of 28 days(7). According to a classification scheme(8), whole fish BCF values of 2.8 and 26.5, measured in bluegill sunfish(7) and fathead minnow(9), respectively, suggest the potential for bioconcentration in aquatic organisms is low.
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) USDA; ARS Pesticide Properties Database. Available from the Database Query Page at http://wizard.arsuda.gov/rsml/listall.html as of Oct, 2000. (3) Corwin DL, Farmer WJ; Environ Sci Technol 18: 507-18 (1984) (4) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9, 15-1 to 15-29 (1990) (5) Tomlin CDS, ed; The Pesticide Manual World Compendium. 11th ed., Surrey, England: Brit Crop Prot Council p. 140 (1997) (6) Budavari S, ed; The Merck Index. 12th ed. Whitehouse Station, NJ: Merck and Co., Inc., p. 226 (1996) (7) USEPA; Reregistration Eligibility Decisions (REDs) Database on Bromacil. Washington DC: USEPA, Off Prev Pest Toxic Sub USEPA 738-R-96-013 (1996). Available from the Database Query page at http://www.epa.gov/REDs/ as of Oct 17, 2000. (8) Franke C et al; Chemosphere 29: 1501-14 (1994) (9) Devillers J et al; Chemosphere 33: 1047-65 (1996)]**PEER REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), **bromacil**, which has a vapor pressure of 3.07X10-7 mm Hg at 25 deg C(2), will exist in both the vapor and particulate phases in the ambient atmosphere. Vapor-phase **bromacil** is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals(SRC); the half-life for this reaction in air is estimated to be 20 hours(SRC), calculated from its rate constant of 1.9X10-11 cu cm/molecule-sec at 25 deg C(SRC), determined using a structure estimation method(3). The rate constant for the vapor-phase reaction of **bromacil** with ozone has been estimated as 0.16X10-17 cu cm/molecule-sec at 25 deg C(SRC) using a structure estimation method(1). This corresponds to an atmospheric half-life of about 7 days at an atmospheric concn of 7X10+11 ozone molecules per cu cm(1). Particulate-phase **bromacil** may be removed from the air by wet and dry deposition(SRC).
[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Tomlin CDS, ed; The

Pesticide Manual World Compendium. 11th ed., Surrey, England: Brit Crop Prot Council p. 140 (1997) (3) Meylan WM, Howard PH; Chemosphere 26: 2293-99 (1993)]**PEER REVIEWED**

Environmental Biodegradation:

OF 55 FUNGAL & 73 BACTERIAL CULTURES ISOLATED FROM SOIL, ONLY 4 FUNGI WERE CAPABLE OF DEGRADING **BROMACIL**. ONE CULTURE WAS IDENTIFIED AS PENICILLIUM PARAHERQUEI ABE.
[Menzie, C.M. Metabolism of Pesticides, Update II. U.S. Department of the Interior, Fish Wildlife Service, Special Scientific Report - Wildlife No. 2l2. Washington, DC: U.S. Government Printing Office, 1978.288]**PEER REVIEWED**

AEROBIC: The microbial degradation of **bromacil** in aerobic soil is slow with a half-life of 275 days in silty clay loam soil incubated for up to 12 months. Carbon dioxide was the major degradate with 5-bromo-6-methyluracil, 5-bromo-3-(alpha-hydroxymethylpropyl)-6-methyluracil, 5-bromo-3-sec-butyl-6-hydroxymethyluracil, 5-bromo-3-(2-hydroxy-1-methylpropyl)-6-methyluracil and 3-sec-butyl-6-methyluracil found as minor metabolites(1). **Bromacil** was degraded within 4 to 6 months when single applications were made to soil; however, when two applications were used, **bromacil** persisted in the top 75 mm of soil for nearly a year(2). The mineralization half-life of (14)C-labeled **bromacil**, incubated in loamy sand and mucky peat soils, was estimated to range from 5,429 to 46,200 days(3).
[(1) USEPA; Reregistration Eligibility Decisions (REDs) Database on Bromacil. Washington DC: USEPA, Off Prev Pest Toxic Sub USEPA 738-R-96-013 (1996). Available from the Database Query page at http://www.epa.gov/REDs/ as of Oct 17, 2000. (2) Sanders P et al; pp. 207-11 in Proc 49th NZ Plant Protection Conf (1996) (3) Madhun YA, Freed VH; Chemosphere 16: 1003-11 (1987)]**PEER REVIEWED**

ANAEROBIC: In a laboratory study using a Greenfield sandy loam soil and saturated soil conditions, (14)C-labeled **bromacil** had an observed half-life of 144 to 198 days; in sterilized soil, virtually no degradation occurred(1). **Bromacil** was debrominated under methanogenic conditions in aquifer slurries; 100% degradation occurred after 160 days of incubation while almost no degradation occurred in sterile controls(2). An anaerobic half-life of 39 days, with an initial 28-day lag phase has been reported for **bromacil** in an anaerobic sediment/water study(3). However, this half-life is based on two measurements, one taken day 28 and a second on day 93 and assumes first-order kinetics(3). 3-sec-Butyl-6-methyluracil was the main metabolite with 80.7% of the initially applied found as this compound by day 304; this compound is most likely formed via reductive dehalogenation(3).
[(1) Wolf DC, Martin JP; Soil Sci Amer Proc 38: 921-5 (1974) (2) Adrian NR, Sulfita JM; Appl Environ Microbiol 56: 292-4 (1990) (3) USEPA; Reregistration Eligibility Decisions (REDs) Database on Bromacil. Washington DC: USEPA, Off Prev Pest Toxic Sub USEPA 738-R-96-013 (1996). Available from the Database Query page at http://www.epa.gov/REDs/ as of Oct 17, 2000.]**PEER REVIEWED**

Environmental Abiotic Degradation:

In a sunlight irradiation study using frozen aqueous solutions of **bromacil** containing photosensitizers (such as methylene blue, rose bengal, and riboflavin), **bromacil** was found to rapidly photodegrade under winter conditions(1); over an 8-hr exposure period, degradation at pHs 6.8, 8.2 and 9.1 was 10-15%, 70-100% and 100%, respectively(1); when the frozen samples were covered by ice blocks, up to 11 cm thick, the amount of incident light was attenuated, but the photodecomposition reaction rates remained high enough to be of practical value(1).
[(1) Acher AJ; Water Res 16: 405-10 (1982)]**PEER REVIEWED**

The rate constant for the vapor-phase reaction of **bromacil** with photochemically-produced hydroxyl

radicals has been estimated as 1.9X10-11 cu cm/molecule-sec at 25 deg C(SRC) using a structure estimation method(1). This corresponds to an atmospheric half-life of about 20 hours at an atmospheric concn of 5X10+5 hydroxyl radicals per cu cm(1). The rate constant for the vapor-phase reaction of **bromacil** with ozone has been estimated as 0.16X10-17 cu cm/molecule-sec at 25 deg C(SRC) using a structure estimation method(1). This corresponds to an atmospheric half-life of about 7 days at an atmospheric concn of 7X10+11 ozone molecules per cu cm(1). Results of photolysis studies indicate that direct photolysis may not be an important environmental fate process for **bromacil**(2); irradiation of aqueous solutions (1-10 ppm) with sunlight or laboratory photoreactors (that simulate sunlight) over a 6-day to 4-month exposure period resulted in only minor loss (<4%) of **bromacil**(2); 5-bromo-6-methyluracil was identified as a photoproduct(2). Studies looking at the effect of pH on the photolysis of **bromacil** noted that while **bromacil** was stable to photoysis in water at pH 5 (half-life of 326 days) and 7(half-life of 102 days), a half-life of 4 to 7 days was reported at pH 9; this was apparently due to a shift in the adsorption spectrum of **bromacil** once it is ionized(7). **Bromacil** is stable to photolysis on soil; the irradiation of **bromacil** on silty clay loam soil for 30 days, 12 hours per day, with a xenon arc lamp resulted in a half-life of 166 days(7). **Bromacil** has been observed to undergo a rapid photosensitized photolysis in sunlight in the presence of photosensitizers such as methylene blue or riboflavin(3-7); the sensitized degradation rate generally increases with an increase in the pH(6); and in one study using riboflavin and methylene blue(6), about 10-15% of initial **bromacil** degraded at pH 7 with 30-min irradiation period(6); at pH 10, 80-90% was degraded(6); no degradation occurred in the absence of the sensitizers(6). **Bromacil** was stable to hydrolysis in sterile aqueous pH 5, 7, and 9 buffer solutions, incubated in the dark, at 25 deg C for 30 days(7).
[(1) Meylan WM, Howard PH; Chemosphere 26: 2293-99 (1993) (2) Moilanen KW, Crosby DG; Arch Environ Contam 2: 3-8 (1974) (3) Watts RJ; Chemosphere 17: 2083-91 (1988) (4) Acher AJ, Dunkelblum E; J Agric Food Chem 27: 1164-7 (1979) (5) Acher AJ; Wat Sci Tech 17: 623-32 (1985) (6) Acher AJ, Saltzman S; J Environ Qual 9: 190-4 (1980) (7) USEPA; Reregistration Eligibility Decisions (REDs) Database on Bromacil. Washington DC: USEPA, Off Prev Pest Toxic Sub USEPA 738-R-96-013 (1996). Available from the Database Query page at http://www.epa.gov/REDs/ as of Oct 17, 2000.]**PEER REVIEWED**

Environmental Bioconcentration:

The bioconcentration of **bromacil** in bluegill sunfish was studied over a 28-day period using flow-through conditions(1). Bluegill sunfish exposed to 10.6 ppm **bromacil** had BCF values for muscle, viscera, carcass, and whole fish of 49, 72, 22, and 26.5, respectively(1). At 1.0 ppm, maximum BCF values were 4.6, 8.3, 2.2, and 2.8 for muscle, viscera, carcass, and whole fish, respectively(1). Depuration was rapid, with >96% of the accumulated residues eliminated from the fish tissues by day 3 of the depuration period. A BCF of 3.2 was measured in fathead minnow(2). According to a classification scheme(3), the whole fish BCF values suggest the potential for bioconcentration in aquatic organisms is low.
[(1) USEPA; Reregistration Eligibility Decisions (REDs) Database on Bromacil. Washington DC: USEPA, Off Prev Pest Toxic Sub USEPA 738-R-96-013 (1996). Available from the Database Query page at http://www.epa.gov/REDs/ as of Oct 17, 2000. (2) Devillers J et al; Chemosphere 33: 1047-65 (1996)(3) Franke C et al; Chemosphere 29: 1501-14 (1994)]**PEER REVIEWED**

Soil Adsorption/Mobility:

Under saturated-flow conditions, **bromacil** was considerably more mobile than buthidazole. Because of their high water solubilities, both herbicides were much more mobile than atrazine, prometon, or diuron.
[Weber JB, Whitacre DM; Weed Sci 30 (6): 579-84 (1982)]**PEER REVIEWED**

Bromacil is very mobile in sand, sandy loam, clay loam and silt loam soils; aged **bromacil** residues are

very mobile in silt loam soils(1). Extensive data exists as evidence that **bromacil** leaches to ground water as a result of normal agricultural use(1). An average Koc value of 23 was determined from experimental values determined in 8 soils and 4 sediments(2). Koc values of 25 to 50 for six Israeli soils(3), 26.3 to 289.1 (avg of 41.1) for eight freshwater sediments(4), 55 to 126(5), 46 to 93 for 7 sandy Florida soils(6), 76 to 129 for a mucky peat and a loamy sand soil incubated at temperatures of 4 and 25 deg C(7), and 12, 33, 2.3, and 14 for 4 different soils have been measured(8). According to a classification scheme(9), these Koc values suggest that **bromacil** is expected to have very high to moderate mobility in soil. In soil column leaching studies, **bromacil** readily leached from loess and sandy soils, but was retained in organic-rich soils(7). As the pH increased from 3 to 12, less adsorption of **bromacil** to Ca-montmorillonite was measured(5). In 7 sandy soils, a rainfall of 20-23 cm displaced over 96% of applied **bromacil**(6). Koc values were slightly higher at lower temperatures(7). Max **bromacil** concns of 1.25 ppm were detected in groundwater (depths of 4.5-6 meters) three months after the herbicide was applied to a surface of Lakeland, FL sandy soil bearing scrub vegetation of small oaks and poor grasses(10).
[(1) USEPA; Reregistration Eligibility Decisions (REDs) Database on Bromacil. Washington DC: USEPA, Off Prev Pest Toxic Sub USEPA 738-R-96-013 (1996). Available from the Database Query page at http://www.epa.gov/REDs/ as of Oct 17, 2000. (2) Gerstl Z, Mingelgrin U; J Environ Sci Health B19: 297-312 (1984) (3) GerstlZ, Yaron B; Soil Sci Soc Amer J 47: 474-8 (1983) (4) Corwin DL, Farmer WJ; Environ Sci Technol 18: 507-18 (1984) (5) Angermar Y et al; J Environ Qual 13: 321-6 (1984) (6) Reddy KN et al; Bull Environ Contam Toxicol 48: 662-70 (1992) (7) Madhun YA et al; Soil Sci Soc Amer J 50: 1467-71 (1986) (8) USDA; ARS Pesticide Properties Database. Available from the Database Query Page at http://wizard.arsuda.gov/rsml/listall.html as of Oct, 2000. (9) Swann RL et al; Res Rev 85: 17-28 (1983) (10) Hebb EA, Wheeler WB; J Environ Qual 7: 598-601 (1978)]**PEER REVIEWED**

Volatilization from Water/Soil:

TESTS @ ELEVATED TEMP & LONG EXPOSURES TO SUNLIGHT INDICATE THAT LOSS FROM SOIL DUE TO VOLATILIZATION ... /IS/ NEGLIGIBLE.
[Weed Science Society of America. Herbicide Handbook. 5th ed. Champaign, Illinois: Weed Science Society of America, 1983. 69]**PEER REVIEWED**

Based upon a vapor pressure of 2.5X10-7 mm Hg(1) and a water solubility of 815 mg/L at 25 deg C(1), the Henry's Law constant for **bromacil** can be estimated to be 5.07X10-11 atm-cu m/mole(SRC). This value of Henry's Law constant indicates that **bromacil** is essentially nonvolatile from water(2). In a volatilization test, **bromacil** was held in an air circulation oven at 120 deg F for 2 weeks(3); losses were less than 0.1% per week(3). Volatilization screening simulations from soil indicate that volatilization from soil (after incorporation to 1-10 cm) is slow(4).
[(1) Worthing CR, Walker SB; The Pesticide Manual 8th ed.; Lavenham Suffolk, England: Lavenham Press Ltd p. 89 (1987) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods Washington,DC: Amer Chem Soc pp. 15-15 to 15-29 (1990) (3) Burnam W et al; Substitute Chemical Program, Initial Scientific & Minieconomic Review of Bromacil. USEPA-540/1-75-006 (NTIS PB-241 801) Kansas City, MO: Mid Res Inst p. 21 (1975) (4) Jury WA et al; J Environ Qual 13: 573-9 (1984)]**PEER REVIEWED**

The Henry's Law constant for **bromacil** is estimated as 1.29X10-10 atm-cu m/mole(SRC) from its vapor pressure, 3.07X10-7 mm Hg(1), and water solubility, 815 mg/l(2). This Henry's Law constant indicates that **bromacil** is expected to be essentially nonvolatile from water surfaces(3). **Bromacil**'s Henry's Law constant(1,2) indicates that volatilization from moist soil surfaces is not expected(SRC). An experiment conducted at elevated temperature and long periods of sunlight exposure indicate that loss of **bromacil** due to volatilization from soil is negligible(4). In a volatilization test, **bromacil** was held in an air-circulation oven at 120 deg F for 2 weeks(5); losses were less than 0.1% per week. Volatilization

screening simulations from soil indicate that volatilization from soil (after incorporation to 1-10 cm) is slow(6). **Bromacil** is not expected to volatilize from dry soil surfaces(SRC) based upon its vapor pressure(1).
[(1) Tomlin CDS, ed; The Pesticide Manual World Compendium. 11th ed., Surrey, England: Brit Crop Prot Council p. 140 (1997) (2) Budavari S, ed; The Merck Index. 12th ed. Whitehouse Station, NJ: Merck and Co., Inc. p. 226 (1996) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (4) Beste CE ed; Herbicide Handbook of the Weed Science Society of America 5th ed; Weed Sci Soc of Amer; p. 69 (1983)(5) Burnam W et al; Substitute Chemical Program, Initial Scientific and Minieconomic Review of Bromacil. USEPA-540/1-75-006 (NTIS PB-241801) Kansas City, MO: Mid Res Inst p. 21 (1975) (6) Jury WA et al; J Environ Qual 13: 573-9 (1984)]**PEER REVIEWED**

Environmental Water Concentrations:

GROUNDWATER: According to an interim report of the USEPA's Groundwater Data Base, **bromacil** has been detected in groundwater samples from NY and CA at a max concn of 22 ppb and a median concn (of positive detections) of 9 ppb(1). Monitoring analyses of 10,929 wells in CA during 1975 to 1989 detected **bromacil** (detection limit and concns not reported) in 4 wells(2). As of June 1984, **bromacil** was not detected (detection limit not reported) in a Wisconsin monitoring study that had analyzed 1508 samples from 358 wells(3). A **bromacil** ground water concn of 300 ppb has been reported for an unnamed FL site(4). As of May 1995, 899 of 2837 wells in Florida's Pesticide Contamination Monitoring System contained **bromacil** at concns less than 90 ppb while 57 wells had concns greater than 90 ppb; 679 of the wells with detections were from the citrus-growing area in the Central Ridge(5). 282 positive detections from 6800 well samples collected from 12 different counties were reported in California(5). The California Department of Pesticide Regulation reported **bromacil** in 90 wells (total wells unreported), samples collected between 1975 and 1991, at a maximum concn of 15 ug/l(6).
[(1) Williams WM et al; Pesticides in Groundwater Data Base: 1988 Interim Report. USEPA 540/09-89-036 (NTIS PB89-164230/AS) (1988) (2) Mackay DM, Smith LA; J Soil Water Conserv 45: 253-5 (1990) (3) Krill RM, Sonzogni; J Amer Water Works Assoc 78: 70-5 (1986) (4) Hallberg GR; Agric Ecosys Environ 26: 299-367(1989) (5) USEPA; Reregistration Eligibility Decisions (REDs) Database on Bromacil. Washington DC: USEPA, Off Prev Pest Toxic Sub USEPA 738-R-96-013 (1996). Available from the Database Query page at http://www.epa.gov/REDs/ as of Oct 17, 2000. (6) Lam RHF et al; pp. 15-44 in Water Contamination and Health. Wang RGM ed. NY, NY: Marcel Dekker (1994)]**PEER REVIEWED**

GROUNDWATER: **Bromacil** concns of 30 to 147 ug/l have been reported for upper ground water samples collected in West Germany(2); concns of <0.1-1.8 ug/l were reported for water samples from bore holes (15-40 m deep) in three provinces in the Netherlands(1). In a 1979-1984 analysis of 7 wells in Ontario, Canada that were in the vicinity of **bromacil** herbicide use, **bromacil** was detected (detection limit 0.1 ug/l) in only one well(2). 95 of 1712 groundwater dominated samples collected from the Federal Republic of Germany between 1986 and 1991 contained **bromacil** at unreported concns(3).
[(1) Leistra M, Boesten JJTI; Agric Ecosys Environ 26: 369-89 (1989) (2) Frank R et al; Arch Environ Contam Toxicol 16: 9-22 (1987) (3) Skark C, Zullei-Seibert N; Intern J Environ Anal Chem 58: 387-96 (1995)]**PEER REVIEWED**

SURFACE WATER: The South Florida Water Management District summarized **bromacil** detections in samples collected every 2 to 3 months from 27 surface water sites within the District from November 1988 through November 1993. 56 of 810 samples contained **bromacil** at concns of 0.002 to 0.25 ppb (maximum of 14 ppb)(1). 3 of 84 surface water samples collected from 6 Louisiana water districts in 1992 contained **bromacil** (detection limit not reported) at concns of 0.4 to 1.73 ppb(1). 12 of 48 surface water samples collected from 8 locations in 5 Louisiana water districts in May-October 1994 contained **bromacil** (detection limit not reported) at concns of 0.13 to 2.63 ppb(1). The National Drinking Water

Contaminant Occurrence Database reports that 144 of 11,438 water samples collected in 47 states/territories, but not necessarily associated with a public drinking water supply, contained **bromacil** at an average concn of 0.0769 ug/l (range of 0 to 3 ug/l)(2). 9 of 1019 surface water samples collected from the Federal Republic of Germany between 1986 and 1991 contained **bromacil** at unreported concns(3).
[(1) USEPA; Reregistration Eligibility Decisions (REDs) Database on Bromacil. Washington DC: USEPA, Off Prev Pest Toxic Sub USEPA 738-R-96-013 (1996). Available from the Database Query page at http://www.epa.gov/REDs/ as of Oct 17, 2000. (2) USEPA; Envirofacts Warehouse. National Drinking Water Contaminant Occurrence Database. Available from the Database Query Page at http://www.epa.gov:9966/ncod/rpt_new_ccl_ambient_pkg.run_report as of Oct 17, 2000. (3) Skark C, Zullei-Seibert N; Intern J Environ Anal Chem 58: 387-96 (1995)]**PEER REVIEWED**

Sediment/Soil Concentrations:

SOIL: **Bromacil** was detected in 29 of 822 soil samples collected in the vicinity of 49 agrichemical facilities in Illinois (4 of these handled **bromacil**) at a mean concn of 168 ug/kg (range=32-15,500 ug/kg) (detection limit range of 18-200 ug/kg)(1).
[(1) Krapac IG et al; J Soil Contam 4: 209-26 (1995)]**PEER REVIEWED**

Food Survey Values:

Bromacil was detected in an unreported number of samples at unspecified concns in the FDA's 1996 Market Basket Survey where a total of 10,374 samples of domestically produced food and imported food from 92 countries were analyzed for pesticide residues(1).
[(1) US FDA; Food and Drug Administration Pesticide Program, Residue Monitoring 1996. Available from the Database Query Page at http://vm.cfsan.fda.gov/~dms/pes96rep.html#program as of Feb 26, 1998.]**PEER REVIEWED**

Plant Concentrations:

Bromacil concn of 30-50 ppm (fresh weight) were detected in tree foliage samples collected 30 to 50 ft away from a Los Alamos, NM roadside where **bromacil** had been sprayed on a 4-ft wide strip to kill vegetation(1).
[(1) Ferenbaugh RW et al; Bull Environ Contam Toxicol 27: 268-73 (1981)]**PEER REVIEWED**

Environmental Standards & Regulations:

FIFRA Requirements:

As the federal pesticide law FIFRA directs, EPA is conducting a comprehensive review of older pesticides to consider their health and environmental effects and make decisions about their future use. Under this pesticide reregistration program, EPA examines health and safety data for pesticide active ingredients initially registered before November 1, 1984, and determines whether they are eligible for reregistration. In addition, all pesticides must meet the new safety standard of the Food Quality Protection Act of 1996. **Bromacil** is found on List A, which contains most food use pesticides and consists of the 194 chemical cases (or 350 individual active ingredients) for which EPA issued registration standards prior to FIFRA, as amended in 1988. Case No: 0041; Pesticide type: herbicide; Registration Standard Date: 09/30/82; Case Status: RED Approved 09/96; OPP has made a decision that some/all uses of the pesticide are eligible for reregistration, as reflected in a Reregistration Eligibility

Decision (RED) document.; Active ingredient (AI): **Bromacil**; Data Call-in (DCI) Date(s): 09/30/91, 03/26/97; AI Status: OPP has completed a Reregistration Eligibility Decision (RED) document for the case/AI.
[USEPA/OPP; Status of Pesticides in Registration, Reregistration and Special Review p.92 (Spring, 1998) EPA 738-R-98-002]**PEER REVIEWED**

A tolerance is established for residues of the herbicide **bromacil** (5-bromo-3-sec-butyl-6-methyluracil) in or on citrus fruits and pineapples.
[40 CFR 180.210 (7/1/2000)]**PEER REVIEWED**

Federal Drinking Water Guidelines:

EPA 90 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

State Drinking Water Guidelines:

(AZ) ARIZONA 80 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(ME) MAINE 25 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

Allowable Tolerances:

A tolerance of 0.1 ppm is established for residues of the herbicide **bromacil** (5-bromo-3-sec-butyl-6-methyluracil) in or on citrus fruits and pineapples.
[40 CFR 180.210 (7/1/2000)]**PEER REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

C9-H13-Br-N2-O2
[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 209]**PEER REVIEWED**

Molecular Weight:

261.12
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 226]**PEER REVIEWED**

Color/Form:

White crystalline solid
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 226]**PEER REVIEWED**

Colorless crystals
[Tomlin, C.D.S. (ed.). The Pesticide Manual - World Compendium, 11 th ed., British Crop Protection Council, Surrey, England 1997 140]**PEER REVIEWED**

Odor:

Odorless.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 32]**PEER REVIEWED**

Melting Point:

157.5-160 DEG C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 226]**PEER REVIEWED**

Corrosivity:

Non-corrosive
[Hartley, D. and H. Kidd (eds.). The Agrochemicals Handbook. 2nd ed. Lechworth, Herts, England: The Royal Society of Chemistry, 1987.,p. A040/Aug 87]**PEER REVIEWED**

Density/Specific Gravity:

1.55 @ 25 deg C/25 deg C
[Ahrens, W.H. Herbicide Handbook of the Weed Science Society of America. 7th ed. Champaign, IL: Weed Science Society of America, 1994. 37]**PEER REVIEWED**

Dissociation Constants:

pKa=9.30 @ 25 deg C
[Weber JB; Advan Chem Ser 111: 55-120 (1972)]**PEER REVIEWED**

Octanol/Water Partition Coefficient:

log Kow= 2.11
[Hansch, C., Leo, A., D. Hoekman. Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. Washington, DC: American Chemical Society., 1995. 61]**PEER REVIEWED**

Solubilities:

SPARINGLY SOL IN HYDROCARBONS
[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982. 51]**PEER REVIEWED**

Sol in ethanol, acetone, acetonitrile, xylene, and 3% aqueous sodium hydroxide at 134, 167, 71, 32, and 88 g/l, respectively, 25 deg C.
[Tomlin, C.D.S. (ed.). The Pesticide Manual - World Compendium, 11 th ed., British Crop Protection Council, Surrey, England 1997,p. 140-141]**PEER REVIEWED**

In water, 815 mg/l @ 25 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and

Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 226]**PEER REVIEWED**

Spectral Properties:

Intense mass spectral peaks: 205 m/z (100%), 207 m/z (98%), 41 m/z (68%), 68 m/z (26%)
[Hites, R.A. Handbook of Mass Spectra of Environmental Contaminants. Boca Raton, FL: CRC Press Inc., 1985. 357]**PEER REVIEWED**

Intense mass spectral peaks: 162 m/z, 188 m/z, 231 m/z, 260 m/z
[Pfleger, K., H. Maurer and A. Weber. Mass Spectral and GC Data of Drugs, Poisons and their Metabolites. Parts I and II. Mass Spectra Indexes. Weinheim, Federal Republic of Germany. 1985.435]**PEER REVIEWED**

Vapor Pressure:

3.07X10-7 mm Hg @ 25 deg C
[Tomlin, C.D.S. (ed.). The Pesticide Manual - World Compendium, 11 th ed., British Crop Protection Council, Surrey, England 1997 140]**PEER REVIEWED**

Other Chemical/Physical Properties:

Decomposes slowly in strong acids
[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982. 51]**PEER REVIEWED**

Sol in water at pH 5, 7, and 9 is 807, 700, and 1287 mg/l, respectively, at 25 deg C.
[Tomlin, C.D.S. (ed.). The Pesticide Manual - World Compendium, 11 th ed., British Crop Protection Council, Surrey, England 1997,p. 140-141]**PEER REVIEWED**

Chemical Safety & Handling:

Fire Potential:

Active ingredient and dry formulations are non-flammable; the liquid formulation (HYVAR-XL) is a combustible mixture which should be kept away from heat and open flame.
[Weed Science Society of America. Herbicide Handbook. 5th ed. Champaign, Illinois: Weed Science Society of America, 1983. 67]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

Strong acids (decomposes slowly), oxidizers, heat, sparks, open flames.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 32]**PEER REVIEWED**

Hazardous Decomposition:

When heated to decomp it emits very toxic fumes of /hydrogen bromide and nitrogen oxides/.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 504]**PEER REVIEWED**

Protective Equipment & Clothing:

Wear appropriate personal protective clothing to prevent skin contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140.

Washington, D.C. U.S. Government Printing Office, 1997. 33]**PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 33]**PEER REVIEWED**

Eyewash fountains should be provided in areas where there is any possibility that workers could be exposed to the substance; this is irrespective of the recommendation involving the wearing of eye protection.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 33]**PEER REVIEWED**

Facilities for quickly drenching the body should be provided within the immediate work area for emergency use where there is a possibility of exposure. [Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from any body areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.]
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 33]**PEER REVIEWED**

Preventive Measures:

DO NOT GET IN EYES. AVOID CONTACT WITH SKIN & CLOTHING. AVOID BREATHING SPRAY MIST; WASH THOROUGHLY AFTER HANDLING. IN CASE OF CONTACT, FLUSH EYES OR SKIN WITH PLENTY OF WATER; FOR EYES, GET MEDICAL ATTENTION. /WATER-SOL LIQ/
[Weed Science Society of America. Herbicide Handbook. 5th ed. Champaign, Illinois: Weed Science Society of America, 1983. 68]**PEER REVIEWED**

Do not reuse containers.
[Weed Science Society of America. Herbicide Handbook. 5th ed. Champaign, Illinois: Weed Science Society of America, 1983. 68]**PEER REVIEWED**

Keep away from heat and open flame.
[Farm Chemicals Handbook 1993. Willoughby, OH: Meister Publishing Co., 1993.,p. C-55]**PEER REVIEWED**

The worker should immediately wash the skin when it becomes contaminated.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 33]**PEER REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed and replaced.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 33]**PEER REVIEWED**

Workers whose clothing may have become contaminated should change into uncontaminated clothing before leaving the work premises.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 33]**PEER REVIEWED**

Contact lenses should not be worn when working with this chemical.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 33]**PEER REVIEWED**

Stability/Shelf Life:

STABLE UP TO MP & SLOWLY SUBLIMES @ TEMP JUST BELOW ITS MP
[Spencer, E. Y. Guide to the Chemicals Used in Crop Protection. 7th ed. Publication 1093. Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1982. 50]**PEER REVIEWED**

Active ingredient is chemically stable under normal storage conditions
[Weed Science Society of America. Herbicide Handbook. 5th ed. Champaign, Illinois: Weed Science Society of America, 1983. 67]**PEER REVIEWED**

Stable in aqueous bases. Slowly decomposed by concentrated acids.
[Hartley, D. and H. Kidd (eds.). The Agrochemicals Handbook. 2nd ed. Lechworth, Herts, England: The Royal Society of Chemistry, 1987.,p. A040/Aug 87]**PEER REVIEWED**

Storage Conditions:

Store in cool, dry place.
[Farm Chemicals Handbook 1993. Willoughby, OH: Meister Publishing Co., 1993.,p. C-55]**PEER REVIEWED**

Exposure of water-soluble formulations to air can cause some loss of water solubility.
[Weed Science Society of America. Herbicide Handbook. 5th ed. Champaign, Illinois: Weed Science Society of America, 1983. 67]**PEER REVIEWED**

Cleanup Methods:

The efficiency of a photo-oxidation procedure for the detoxification of water containing herbicides of the uracil group was tested by bioassay. Treated herbicide soln were checked for their inhibiting effect on germination and photosynthesis in sorghum (Sorghum bicolor). The treated soln and the main photodegradation products of **bromacil** and terbacil did not inhibit significantly either germination or seedling development at concn of up to 200 and 10 mg/l, respectively. Preliminary tests with indust waste effluents containing added uracil cmpd showed that these cmpd were rendered non-phytotoxic by the photo-oxidation procedure.
[Saltzman S et al; Pestic Sci 13 (2): 211-8 (1982)]**PEER REVIEWED**

Disposal Methods:

SRP: At the time of review, criteria for land treatment or burial (sanitary landfill) disposal practices are subject to significant revision. Prior to implementing land disposal of waste residue (including waste sludge), consult with environmental regulatory agencies for guidance on acceptable disposal practices.
PEER REVIEWED

Bromacil should be incinerated in a unit operating at 850 deg C equipped with off gas scrubbing equipment.
[United Nations. Treatment and Disposal Methods for Waste Chemicals (IRPTC File). Data Profile Series No. 5. Geneva, Switzerland: United Nations Environmental Programme, Dec. 1985. 295]**PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

Vacated 1989 OSHA PEL TWA 1 ppm (10 mg/cu m) is still enforced in some states.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 360]**PEER REVIEWED**

Threshold Limit Values:

8 hr Time Weighted Avg (TWA) 10 mg/cu m
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 20]**PEER REVIEWED**

Excursion Limit Recommendation: Excursions in worker exposure levels may exceed more than five times the TLV-TWA for no more than a total of 30 min during a work day, provided that the TLV-TWA is not exceeded.
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 6]**PEER REVIEWED**

A3: Confirmed animal carcinogen with unknown relevance to humans.
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 20]**PEER REVIEWED**

NIOSH Recommendations:

Recommended Exposure Limit: 10 Hr Time-Weighted Avg: 1 ppm (10 mg/cu m).
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 32]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

For **Bromacil** (USEPA/OPP Pesticide Code: 012301) ACTIVE products with label matches. /SRP: Registered for use in the U.S. but approved pesticide uses may change periodically and so federal, state and local authorities must be consulted for currently approved uses./
[U.S. Environmental Protection Agency/Office of Pesticide Program's Chemical Ingredients Database on Bromacil (314-40-9). Available from the Database Query page at http://www.cdpr.ca.gov/docs/epa/epamenu.htm as of Sept 8, 2000.]**PEER REVIEWED**

Bromacil is a non-selective inhibitor of photosynthesis
[Worthing, C.R. and S.B. Walker (eds.). The Pesticide Manual - A World Compendium. 8th ed. Thornton Heath, UK: The British Crop Protection Council, 1987. 89]**PEER REVIEWED**

Herbicide to control weeds and brush
[Farm Chemicals Handbook 2000. Willoughby, Ohio: Meister 2000.,p. C 58]**PEER REVIEWED**

Manufacturers:

DuPont, 1007 Market Street, Wilmington, DE 19898; Dupont Life Sciences Businesses, DuPont Crop Protection, Walker's Mill, Barley Mill Plaza, P.O. Box 80038, Wilmington, DE 19880-0038; Production Site: La Porte, TX 77571.
[SRI International. 2000 Directory of Chemical Producers -- United States. SRI Consulting, Menlo Park: CA 2000 782]**PEER REVIEWED**

Methods of Manufacturing:

BROMINATION OF 3-SEC-BUTYL-6-METHYLURACIL
[SRI]**PEER REVIEWED**

Bromacil is manufactured by the reaction of phosgene and ammonia with sec-butylamine to produce sec-butylurea, which reacts with ethylacetoacetate to produce 3-sec-butyl-6-methyluracil, which is then brominated to produce **bromacil**.
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 537]**PEER REVIEWED**

Production: s-butylamine + sodium cyanate + ethyl acetoacetate + bromine (cyanate addition/condensation/alpha bromination
PEER REVIEWED

General Manufacturing Information:

The water sol formulation is not compatible with ammonium sulfamate and liq formulations of amitrole. Herbicides containing soluble calcium salts form precipitates when used with water-soluble formulations of **bromacil**.
[Tomlin, C.D.S. (ed.). The Pesticide Manual - World Compendium, 11 th ed., British Crop Protection Council, Surrey, England 1997 140]**PEER REVIEWED**

... and recommended for general weed control on non-crop land @ 5-15 kg active ingredient/ha; for subsequent annual maintenance 2-4 kg/ha is enough. It may also be used for annual weed control in established citrus plantations @ 1.6-3.2 kg/ha; for perennial grasses and annual weeds at 3.2-8.0 kg/ha; in pineapple plantations at 1.8-5.5 kg/ha. At higher rates its effect usually persists for more than one season.
[Worthing, C.R. and S.B. Walker (eds.). The Pesticide Manual - A World Compendium. 8th ed. Thornton Heath, UK: The British Crop Protection Council, 1987. 89]**PEER REVIEWED**

Formulations/Preparations:

USEPA/OPP Pesticide Code 012301; Trade Names: **Hyvar X;** Weed-Broom; Cyanogan; Uragan; **Borea**; Borocil 1V; Herbicide 976; **Hyvar X** bromoacil; **Hyvar X** weed killer; **Hyvarex**; Krovar II; **Nalkil**; **Urox B.**
[U.S. Environmental Protection Agency/Office of Pesticide Program's Chemical Ingredients Database on Bromacil (314-40-9). Available from the Database Query page at http://www.cdpr.ca.gov/docs/epa/epamenu.htm as of Sept 8, 2000???.]**PEER REVIEWED**

Granular, liquid, water soluble liquid, and wettable powder
[Farm Chemicals Handbook 2000. Willoughby, Ohio: Meister 2000.,p. C 58]**PEER REVIEWED**

Bromacil + diuron + terbutyrn
[Farm Chemicals Handbook 2000. Willoughby, Ohio: Meister 2000.,p. C 58]**PEER REVIEWED**

Hyvar X Bromacil (wettable powder: 80% ai), **Hyvar X**-WS **Bromacil** (water sol powder: 50% ai), and **Hyvar X**-L **Bromacil** (liq concn: 3 lb ai/gal)
[Spencer, EY; Guide to the Chemicals used in Crop Protection 7th ed Publication 1093; Research Institute; Canada; p. 51 (1982)]**PEER REVIEWED**

Used in mixtures with picloram, diuron, dichlobenil, amitrole plus diuron, sodium chlorate plus sodium metaborate, 2,4-D plus dalapon plus diuron, diuron plus hexazinone, amitrole plus dichlorprop plus diuron.

[Tomlin, C.D.S. (ed.). The Pesticide Manual - World Compendium, 11 th ed., British Crop Protection Council, Surrey, England 1997,p. 140-1]**PEER REVIEWED**

Consumption Patterns:

APPROX 77% FOR INDUSTRIAL/COMMERCIAL USE AS AN HERBICIDE; APPROX 13% FOR AGRICULTURAL USE AS AN HERBICIDE; AND APPROX 10% FOR GOVERNMENT AGENCY USE AS AN HERBICIDE (1972)
[SRI]**PEER REVIEWED**

In 1992, 1,194,805 pounds of **bromacil** were applied to citrus crops in the US.
[USGS; Pesticide 1992 Annual Use Map on Bromacil. Available from the Database Query page at http://ca.water.usgs.gov./pnsp/use92/brmcil.html as of Oct, 2000.]**PEER REVIEWED**

U. S. Production:

(1972) 1.82X10+9 G
[SRI]**PEER REVIEWED**

(1974) 6.4X10+9 G (EST)
[SRI]**PEER REVIEWED**

U. S. Exports:

(1972) APPROX 1.0X10+6 G
[SRI]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

Residues of **bromacil** are extracted from animal tissues with 1% sodium hydroxide solution by using gas chromatographic with microcoulometric detection. Average recoveries ranged from 85 to 115%. Detection limit was 0.04 ppm (25 g sample).
[FDA Pesticide Analytical Manual Vol 2 (Oct) (1989)]**PEER REVIEWED**

Analytic Laboratory Methods:

MACRO: DIFFERENTIAL INFRARED METHOD FOR DETERMINATION IN FORMULATIONS SUCH AS HYVAR **BROMACIL** WEED KILLER.
[Spencer, E.Y. Guide to the Chemicals Used in Crop Protection. 6th ed. Publication 1093, Research Institute, Agriculture Canada, Ottawa, Canada: Information Canada, 1973. 51]**PEER REVIEWED**

A METHOD FOR DETERMINING RESIDUES BY GLC WITH THERMIONIC NITROGEN PHOSPHORUS DETECTOR IS PRESENTED. IT HAS BEEN USED TO RECOVER 0.04 PPM **BROMACIL** ADDED TO CITRUS, PINEAPPLE, SOIL, & WATER, & 0.1 PPM ADDED TO ALFALFA HAY.
[TING KC ET AL; J ASSOC OFF ANAL CHEM 63 (1): 43-6 (1980)]**PEER REVIEWED**

EPA Method 633.GC with nitrogen phosphorus detector for the determination of organonitrogen pesticides in industrial and municipal wastewater. Under the prescribed conditions for **bromacil**, the method detection limit is 2.4 ug/l as determined by EPA Office of Water's Industrial Technology

Division.
[USEPA/SCC; Environmental Monitoring Methods Index p.122 (1992)]**PEER REVIEWED**

Analysis of products is by IR spectrophotometry and by GLC with FID. Analysis of residues is by gas liquid chromatography with microcoulometric detection. In the presence of terbacil, GLC is used.
[Hartley, D. and H. Kidd (eds.). The Agrochemicals Handbook. 2nd ed. Lechworth, Herts, England: The Royal Society of Chemistry, 1987.,p. A040/Aug 87]**PEER REVIEWED**

Residues of **bromacil** are extracted from soil and from plant and animal tissues with 1% sodium hydroxide solution by using gas chromatographic with microcoulometric detection. Recoveries ranged from 47 to 57% for duplicate orange samples fortified at the 0.20 and 0.50 ppm levels and analyzed by using a Micro-Tek 2500R gas chromatograph. Average recoveries ranged from 85 to 115%. Detection limit was 0.04 ppm (25 g sample).
[FDA Pesticide Analytical Manual Vol 2 (Oct) (1989)]**PEER REVIEWED**

FDA Method 211.1. Organochlorine Residues (Nonionic) General Method for Fatty Foods Including Extraction of Fat, Acetonitrile Partition, Florisil Column Cleanup, Partition Chromatography Cleanup, and Supplemental Cleanup. Analysis by GC/ECD.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

FDA Method 212.1. Organochlorine Residues (Nonionic) General Method for Nonfatty Foods Including Acetonitrile Extraction, Water/Acetonitrile Extraction, Aqueous Acetonitrile to Petroleum Ether Transfer, and Florisil Column Cleanup. Analysis by GC.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

FDA Method 231.1. Organophosphorous Residues General Methods for Fatty Foods Including Extraction of Fat, Acetonitrile Partition, and Florisil Column Cleanup. Analysis by GC/FPD.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

FDA Method 242.1. Organonitrogen Residues General Method for Nonfatty Foods Including Acetone Extraction and Isolation in Organic Phase. Analysis by GC/ECD. ALAB (5)S: P: [USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)] EPA-B. Method PMD-BRO. Determination of **Bromacil** by Internal Standard Gas Chromatography. Analysis by GC/FID.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA-B. Method PMD-TLC. Thin-Layer Chromatography Systems for Identification of Pesticides.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 8321A. Determination of Solvent Extractable Non-Volatile Compounds by High Performance Liquid Chromatography/ Thermospray/Mass Spectrometry (HPLC/TSP/MS) or Ultraviolet (UV) Detection.
[USEPA; EMMI. Environmental Monitoring Methods Index Database for Windows. Version 1.1 (1997)]**PEER REVIEWED**

Method EAD 1656. Organo-Halide Pesticides in Municipal and Industrial Wastewater by Gas Chromatography. Method detection limit=70 ng/l. Analysis by capillary GC/ECD.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EMSLC Method 525.2. Determination of Organic Compounds in Drinking Water by Liquid-Solid Extraction and Capillary Column Gas Chromatography and Mass Spectrometry. Revision 1.0. Method detection limit=0.1 ug/l drinking water.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EMSLC Method 507. Determination of Nitrogen- and Phosphorus- Containing Pesticides in Water by Gas Chromatography with a Nitrogen-Phosphorus Detector. Revision 2.0. Estimated detection limit=2.5 ug/l drinking water.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

AOAC Method 991.07. Nitrogen and Phosphorus Containing Pesticides in Finished Drinking Water by Gas Chromatographic Method. Estimated method detection limit=2.5 ug/l drinking water. Analysis by capillary GC with Nitrogen/Phosphorus detection.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990]**PEER REVIEWED**

Special References:

Synonyms and Identifiers:

Synonyms:

BOREA
PEER REVIEWED

BOROCIL
PEER REVIEWED

Bromax
PEER REVIEWED

BROMAZIL
PEER REVIEWED

(5-Bromo-3-sec-butyl-6-methyluracil)
PEER REVIEWED

5-Bromo-6-methyl-3-(1-methylpropyl)-2,4(1H,3H)pyrimidinedione
PEER REVIEWED

5-Bromo-6-methyl-3(1-methylpropyl)uracil
PEER REVIEWED

Cynogan
PEER REVIEWED

DU PONT HERBICIDE 976
PEER REVIEWED

HERBICIDE 976
PEER REVIEWED

HIBOR

PEER REVIEWED

Hyvar
PEER REVIEWED

HYVAR X
PEER REVIEWED

HYVAR X-L
PEER REVIEWED

HYVAR X BROMACIL
PEER REVIEWED

HYVAREX
PEER REVIEWED

HYVAR-X Weed Killer
PEER REVIEWED

HYVAR X-WS
PEER REVIEWED

HYVAR-XL Weed Killer
PEER REVIEWED

Istemul
PEER REVIEWED

KROVAR II Weed Killer
PEER REVIEWED

KROVAR I Weed Killer
PEER REVIEWED

NALKIL
PEER REVIEWED

2,4(1H,3H)-PYRIMIDINEDIONE, 5-BROMO-6-METHYL-3-(1-METHYLPROPYL)-
PEER REVIEWED

ROUT G-8
PEER REVIEWED

URACIL, 5-BROMO-3-SEC-BUTYL-6-METHYL-
PEER REVIEWED

Uragan
PEER REVIEWED

Uragon
PEER REVIEWED

UREABOR
PEER REVIEWED

Urox "B"
PEER REVIEWED

UROX HA
PEER REVIEWED

Urox HX
PEER REVIEWED

Associated Chemicals:

Lithium **bromacil**;53404-19-6
Sodium **bromacil**;69484-12-4

Formulations/Preparations:

USEPA/OPP Pesticide Code 012301; Trade Names: **Hyvar X;** Weed-Broom; Cyanogan; Uragan; **Borea**; Borocil 1V; Herbicide 976; **Hyvar X** bromoacil; **Hyvar X** weed killer; **Hyvarex**; Krovar II; **Nalkil**; **Urox B.**
[U.S. Environmental Protection Agency/Office of Pesticide Program's Chemical Ingredients Database on Bromacil (314-40-9). Available from the Database Query page at http://www.cdpr.ca.gov/docs/epa/epamenu.htm as of Sept 8, 2000???.]**PEER REVIEWED**

Granular, liquid, water soluble liquid, and wettable powder
[Farm Chemicals Handbook 2000. Willoughby, Ohio: Meister 2000.,p. C 58]**PEER REVIEWED**

Bromacil + diuron + terbutyrn
[Farm Chemicals Handbook 2000. Willoughby, Ohio: Meister 2000.,p. C 58]**PEER REVIEWED**

Hyvar X Bromacil (wettable powder: 80% ai), **Hyvar X**-WS **Bromacil** (water sol powder: 50% ai), and **Hyvar X**-L **Bromacil** (liq concn: 3 lb ai/gal)
[Spencer, EY; Guide to the Chemicals used in Crop Protection 7th ed Publication 1093; Research Institute; Canada; p. 51 (1982)]**PEER REVIEWED**

Used in mixtures with picloram, diuron, dichlobenil, amitrole plus diuron, sodium chlorate plus sodium metaborate, 2,4-D plus dalapon plus diuron, diuron plus hexazinone, amitrole plus dichlorprop plus diuron.
[Tomlin, C.D.S. (ed.). The Pesticide Manual - World Compendium, 11 th ed., British Crop Protection Council, Surrey, England 1997,p. 140-1]**PEER REVIEWED**

Administrative Information:

Hazardous Substances Databank Number: 1522

Last Revision Date: 20021108

Last Review Date: Reviewed by SRP on 1/20/2001

Update History:

Complete Update on 11/08/2002, 1 field added/edited/deleted.
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Complete Update on 08/11/1997, 1 field added/edited/deleted.
Complete Update on 04/23/1997, 1 field added/edited/deleted.
Complete Update on 03/27/1997, 1 field added/edited/deleted.
Complete Update on 09/04/1996, 6 fields added/edited/deleted.
Complete Update on 04/15/1996, 1 field added/edited/deleted.
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Complete Update on 01/18/1995, 1 field added/edited/deleted.
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Field Update on 03/21/1994, 1 field added/edited/deleted.
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Field update on 12/20/1992, 1 field added/edited/deleted.
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Complete Update on 05/21/1990, 3 fields added/edited/deleted.
Field Update on 03/06/1990, 1 field added/edited/deleted.
Field Update on 01/15/1990, 1 field added/edited/deleted.
Complete Update on 01/11/1990, 2 fields added/edited/deleted.
Complete Update on 06/19/1989, 2 fields added/edited/deleted.
Complete Update on 01/27/1989, 1 field added/edited/deleted.

Record Length: 108806

CADMIUM COMPOUNDS

CASRN: NONE

This record contains general information for cadmium ions and compounds, including statements in the literature referenced to cadmium compounds, cadmium salts, etc. For compound-specific information, refer to the appropriate individual records as listed in the RELATED HSDB RECORDS field; for information on the metal itself, refer to the CADMIUM, ELEMENTAL record.

For other data, click on the Table of Contents

Human Health Effects:

Evidence for Carcinogenicity:

Evaluation: There is sufficient evidence in humans for the carcinogenicity of **cadmium** and **cadmium** compounds. There is sufficient evidence in experimental animals for the carcinogenicity of **cadmium** compounds. There is limited evidence in experimental animals for the carcinogenicity of **cadmium** metal. In making the overall evaluation, the Working Group took into consideration the evidence that ionic **cadmium** causes genotoxic effects in a variety of types of eukaryotic cells, including human cells. Overall evaluation: **Cadmium** and **cadmium** compounds are carcinogenic to humans (Group 1). /**Cadmium** and **cadmium** compounds/

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 58 210 (1993)]**PEER REVIEWED**

CLASSIFICATION: B1; probable human carcinogen. BASIS FOR CLASSIFICATION: Limited evidence from occupational epidemiologic studies of **cadmium** is consistent across investigators and study populations. There is sufficient evidence of carcinogenicity in rats and mice by inhalation and intramuscular and subcutaneous injection. Seven studies in rats and mice wherein **cadmium** salts (acetate, sulfate, chloride) were administered orally have shown no evidence of carcinogenic response. HUMAN CARCINOGENICITY DATA: Limited.

[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Cadmium (7440-43-9) from the National Library of Medicine's TOXNET System, March 6, 1995]**PEER REVIEWED**

A2. A2= Suspected human carcinogen. /**Cadmium**, elemental and compounds, as Cd/

[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 22]**PEER REVIEWED**

Human Toxicity Excerpts:

CADMIUM AND ITS SALTS ARE HIGHLY TOXIC. INGESTION OF ... SOL CMPD CAUSES INCR SALIVATION, CHOKING, VOMITING, ABDOMINAL PAIN, ANEMIA, RENAL DYSFUNCTION, DIARRHEA, TENESMUS. INHALATION (DUST OR FUMES): THROAT DRYNESS, COUGH, HEADACHE, VOMITING, CHEST PAIN, EXTREME RESTLESSNESS & IRRITABILITY, PNEUMONITIS, POSSIBLY BRONCHOPNEUMONIA. /**CADMIUM** AND ITS SALTS/

[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 223]**PEER REVIEWED**

Acute poisoning may result from inhalation of **cadmium** dusts & fumes ... & from ingestion of **cadmium** salts. When swallowed, **cadmium** compounds are much less lethal than when inhaled, in part because they induce vomiting & ... are not retained. Although as little as 10-20 mg of sol **cadmium** salts

have produced severe toxic symptoms when ingested, death probably requires several hundred milligrams by oral route. /**Cadmium** and **cadmium** salts/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-78]**PEER REVIEWED**

Inhalation of **cadmium** dusts, salts & fume over a number of ... years result in chronic **cadmium** poisoning, a disease characterized by distinctive, nonhypertrophic emphysema with or without renal tubular injury, in which urinary excretion of a protein of molecular wt of 20,000 to 30,000 occurs. ... Further inhalation overexposure results in irreversible renal tubular damage, which may progress into complete Fanconi syndrome with decreased tubular reabsorption of proteins, glucose, amino acids, calcium, phosphorus, & with decreased ability to acidify & concentrate the urine. Other ... toxic effects include anemia, eosinophilia, anosmia, chronic rhinitis, yellow discoloration of teeth, & bone changes. /**Cadmium** and **cadmium** cmpd/
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.87]**PEER REVIEWED**

The consequence of excessive inhalation of **cadmium** fumes and dusts is loss of ventilatory capacity, with a corresponding increase in residual lung volume. Dyspnea is the most frequent complaint of patients with **cadmium** induced lung disease. The pathogenesis of **cadmium**-induced emphysema and pulmonary fibrosis is not well understood; however, **cadmium** specifically inhibits the synthesis of plasma alpha 1-antitrypsin, and there is an association between severe alpha 1-antitrypsin deficiency of genetic origin and emphysema in human beings. /**Cadmium** fumes and dusts/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1663]**PEER REVIEWED**

In chronic **cadmium** poisoning osteomalacia, radiological decreases in bone density, hypercalciuria and renal stones reflect disturbances in calcium metabolism. The alteration in calcium metabolism has often been ascribed to the **cadmium** induced renal tubular injury. /**Cadmium**/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-79]**PEER REVIEWED**

A significantly increased incidence of emphysema and chronic bronchitis is found in **cadmium** workers. A worker developed a progressive pulmonary fibrosis within 4 yr of an acute **cadmium** exposure during welding. A microcytic anemia resistant to iron therapy may also appear. /**Cadmium** and cmpd/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 1019]**PEER REVIEWED**

SYMPTOMATOLOGY: A. Inhalation (an symptomatic period of 4-8 hr may precede the clinical illness). 1. Metallic taste in the mouth and headache. 2. Shortness of breath, chest pain, cough with foamy or bloody sputum. Pulmonary rales and related physical signs. 3. Weakness, leg pains. 4. An asphyxial death from intense pulmonary edema. 5. Gradual resolution of pulmonary edema (over a period of a few days) and development of fever, with persistence of cough, chest pain and dyspnea for one or more weeks. Physical signs of pneumonic consolidation. 6. Late kidney and/or liver damage has followed respiratory exposures in industry. B. Ingestion (an asymptomatic period of 1/2-1 hr may precede the clinical illness). 1. Severe nausea, vomiting, diarrhea and abdominal cramps and salivation. 2. Headache, muscular cramps, vertigo, and perhaps convulsions (rarely). 3. Exhaustion, collapse, shock and death, usually within a period of 24 hr. 4. The gradual evolution of signs and symptoms of liver and kidney damage should be anticipated but are rarely seen in man. /**Cadmium**/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-81]**PEER REVIEWED**

Ingestion of **cadmium** salts has caused severe & sometimes fatal poisoning. /**Cadmium** salts/
[Grant, W. M. Toxicology of the Eye. 2nd ed. Springfield, Illinois: Charles C. Thomas, 1974. 213]**PEER REVIEWED**

Prostate tissues from patients with benign prostatic hypertrophy were separated into epithelial and stromal components and the concentrations of zinc and **cadmium** were determined in these two fractions and in whole tissue by atomic absorption spectrophotometry. The concentrations of testosterone and 5-alpha-dihydrotestosterone (5 alpha-DHT) were determined by radioimmunoassays. The concentration of zinc was found to be significantly greater (P> .001) in epithelial than in stromal preparations: 17.32 + or - 1.15 vs 7.29 + or - 0.53 u mol/g dry weight (SEM, n= 15). The concentrations of **cadmium** in epithelium, 9.55 + or - 1.31 n mol/g dry weight (SEM, n= 15) and in stroma, 6.65 + or - 1.06 n mol/g dry weight (SEM, n= 15), did not differ significantly. The concentrations of zinc and **cadmium** in whole tissues were 13.88 + or - 1.70 u mol/g dry weight and 8.85 + or - 1.53 n mol/g dry weight, respectively (SEM, n= 15). In epithelial preparations, **cadmium** and testosterone were inversely correlated, but no other correlations were noted between metal and androgen concentrations in whole tissue, stroma, or epithelium. The results of the present study indicate that zinc preferably resides in the epithelium of human prostatic tissue and previous findings of high **cadmium** concentrations in hypertrophic and carcinomatous prostatic tissue were not confirmed. /Inorganic **cadmium**/
[Lahtonen R; Prostate 6 (2): 177-83 (1985)]**PEER REVIEWED**

CADMIUM IS APPARENTLY NOT RESPONSIBLE FOR CASES OF PROSTATIC OR OTHER CANCER OBSERVED IN MEN WORKING IN **CADMIUM** DUST. /**CADMIUM**/
[MALCOLM D; ANN OCCUP HYG: 15 (1): 33 (1972)]**PEER REVIEWED**

In-vitro tests showed that potentiation of the anticoagulant response to warfarin as a result of displacement from albumin by heavy metals may be increased in persons occupationally exposed to **cadmium** for long periods. /**Cadmium**/
[Chakrabarti SK; Bichem Pharmacol 27 (24): 2957-9 (1978)]**PEER REVIEWED**

All (aerosols) are hazardous ... particularly fumes. /**Cadmium**/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-78]**PEER REVIEWED**

MANY NONFATAL CASES OF "FOOD POISONING" ... FOLLOWED INGESTION OF ... /ACID/ FOOD KEPT ... FOR BRIEF PERIODS IN /**CADMIUM**/ COATED CONTAINERS, SUCH AS ICE CUBE TRAYS & METAL PITCHERS ... WELDING (OR CUTTING WITH ACETYLENE TORCH) **CADMIUM** PLATED OR **CADMIUM** CONTAINING METAL OBJECTS CONSTITUTE VERY SIGNIFICANT & POTENTIALLY LETHAL HAZARD AFTER ... SHORT EXPOSURES ... SAME ... FOR BRAZING OR SILVER SOLDERING WITH **CADMIUM**-CONTAINING RODS OR WIRES. SOME SILVER SOLDERS CONTAIN MORE THAN 20% **CADMIUM**. IN ... EARLY STAGES THIS SYNDROME MAY BE CONFUSED WITH A MUCH MORE BENIGN ILLNESS CAUSED BY EXPOSURE TO FUMES OF ZINC & SOME OTHER METALS ... /**CADMIUM** AND CD CMPD/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-77]**PEER REVIEWED**

FUMES & DUST OF **CADMIUM** & ITS CMPD ARE VERY TOXIC. /**CADMIUM**, ALLOYS, COMPOUNDS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 233]**PEER REVIEWED**

Two hundred forty male and female workers in a battery factory along with 87 unexposed male controls were studied to determine the excretion of beta(2)-microglobulin. The exposed workers were employed in the department where materials for battery electrodes were made (material plant) or where the

electrodes and batteries were assembled (assembly plant). ... Diagnosis of proteinuria was made in those whose microglobulin excretion was greater than the upper 95% confidence limit of the normal concentration in the urine; ... this was not considered necessarily to be a clinically significant proteinuria. There was an increased incidence of microglobulinuria in the exposed group. In the unexposed controls, 3.4% had microglobulinuria. In the assembly plant, women had a 2.3% incidence of this type of proteinuria and men had a 25% incidence. The men who worked in the material plant had a 52% incidence of microglobulinuria. These incidences in male workers were significantly different from control incidences at ($p< 0.001$); differences in incidences between female workers and controls were not significant. The 2.3% incidence among working women represents one case of microglobulinuria among 41 women. Yet 15 of the women had been exposed for more than 5 years. The lower rate of microglobulinuria among women might in part reflect a lower smoking rate; of the 13 women whose smoking habits were known, 5 were smokers. Nonsmoking **cadmium** exposed workers had a lower prevalence of the defined proteinuria than smoking **cadmium** exposed workers. Nine of the workers were separately treated in the study because they were from Yugoslavia, where tubular proteinuria is endemic (Balkan nephropathy); two of them were found to excrete increased amounts of microglobulin. In the 185 employees that worked continuously with **cadmium**, the prevalence of microglobulinuria increased with exposure time. /**Cadmium**/
[NIOSH; Criteria Document: Cadmium p.23 (1976) DHEW Pub. NIOSH 76-192]**PEER REVIEWED**

Cadmium has been implicated in the increase in prostate cancer incidence in men exposed to high levels. A decrease in zinc and a concomitant increase in **cadmium** levels in the human prostate has been shown. The role and mechanism of **cadmium** action in prostate carcinogenesis is not clear. Selenium, on the other hand, has been shown to inhibit carcinogenesis in several animal systems. Results show that **cadmium** stimulates the growth of human prostatic epithelium in vitro between 10(-9) M and 10(-7) M concentrations. Selenium, at concentrations between 10(-12) M and 10(-7) shows no growth stimulatory or inhibitory effects on these cells. However, when present at 10(-8) M level, selenium inhibits the growth stimulation induced by **cadmium**. /**Cadmium**/
[Webber MM; Biochem Biophys Res Commun 127 (3): 871-7 (1985)]**PEER REVIEWED**

If an acute inhalation is severe there is a latent period of 4-8 hours followed by pulmonary edema which causes severe hypoxia and possible death. If survival occurs a second stage of acute intoxication takes place and consists of cellular proliferation in alveoli and hyperplasia of the lining cells with occasional intra-aveolar hemorrhage. /**Cadmium**/
[Casarett, L.J., and J. Doull. Toxicology: The Basic Science of Poisons. New York: MacMillan Publishing Co., 1975. 469]**PEER REVIEWED**

A case of nonfatal pneumonitis has been reported for a man working for 3 days at air concentrations estimated to be between 0.5 and 2.5 mg/cu m. Relatively mild cases resembling metal fume fever and often with some symptoms and signs of acute gastroenteritis have been attributed to even lower concentrations. /**Cadmium**/
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.191]**PEER REVIEWED**

... Known to be toxic to the yolk sac or chorioallantoic placenta ... /**Cadmium**/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 317]**PEER REVIEWED**

Food and Environmental Agents: Effect on Breast-Feeding: Reported Sign or Symptom in Infant or Effect on Lactation: **Cadmium**: None Reported. /from Table 7/
[Report of the American Academy of Pediatrics Committee on Drugs in Pediatrics 93

(1): 142 (1994)]**PEER REVIEWED**

Medical Surveillance:

Initial medical examination: a complete history and physical examination detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the respiratory system, liver, kidneys, prostate, and blood should be stressed. Since kidney damage has been observed in humans exposed to **cadmium**, a urinalysis should be obtained to include, at minimum: specific gravity, albumin, glucose, and a microscopic /examination of the/ centrifuged sediment. In addition, the urine should be examined for low molecular weight proteins by use of 3% sulfosalicylic acid or other acceptable techniques. A 14 x 17 in roentgenogram should be obtained as **cadmium** causes human lung damage. Surveillance of the lungs is recommended. A profile of liver function should be obtained by utilizing a medically acceptable array of biochemical tests.Since **cadmium** may cause liver damage. FVC and FEV (1 sec): **cadmium** is reported to cause decreased pulmonary function. Therefore periodic surveillance is recommended. Medical examinations should be repeated annually, except that X-ray is considered necessary only when indicated by pulmonary function tests or by symptoms of respiratory disease. Urine protein measurements should be available every four months. /**Cadmium** dust (as **cadmium**)/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... in relation specifically to cancer hazards, there are at present no health monitoring methods that may ensure the early detection of preneoplastic lesions or lesions which may precede them. Whenever medical surveillance is indicated, in particular when exposure to a carcinogen has occurred, ad hoc decisions should be taken concerning additional tests that might become useful or mandatory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.23]**PEER REVIEWED**

Environmental monitoring records shall be maintained for at least 20 years. These records shall include methods of sampling and analysis used, types of respiratory protection used, and TWA and ceiling concentrations found. Each employee shall have made available to them information on their own environmental exposures. Environmental records shall be available to designated representatives of the Secretary of Labor, and the Secretary of /Health and Human Services/. Pertinent medical records shall be retained for 20 years after the last occupational exposure to **cadmium**. Records of environmental exposures applicable to the employee should be included in that employee's medical records. These medical records shall be made available to the designated medical representatives of the Secretary of Labor & of /Health and Human Services/, of the employer, and of the employee or former employee. /**Cadmium** cmpd/
[NIOSH; Criteria Document: Cadmium p.5 (1976) DHEW Pub. NIOSH 76-192]**PEER REVIEWED**

The assessment of **cadmium** exposure can be accomplished through measurement of **cadmium**. Studies assessing correlation of blood levels with occupational exposure found that blood levels correlate with recent exposures, and not well with chronic exposure or assessment of total body burden. Whole Blood Reference ranges: Normal - non-occupational exposure levels range from 0.4 to 1.0 ug/l for nonsmokers and up to 4.5 ug/l for smokers; Exposed - BEI (sampling time is not critical): 5 ug/l; Toxic - levels greater than 10 ug/l have been associated with worker toxicity such as renal dysfunction. Serum or Plasma Reference Ranges: Normal - 0.5 to 2 ug/l; Exposed - not established; Toxic - not established.

Urine Reference ranges: Normal - non-occupational exposure levels range from 0.02 to 4.5 ug/l; Exposed - BEI (sampling time is not critical): 5 ug/g creatinine; Toxic - Several studies have indicated that urinary levels greater than 10 ug/g creatinine or 10 ug/l in workers have been associated with an increased incidence of renal dysfunction. /**Cadmium**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 525]**PEER REVIEWED**

Respiratory Symptom Questionnaires: Questionnaires have been published by the American Thoracic Society (ATS) and the British Medical Research Council. These questionnaires have been found to be useful in identification of people with chronic bronchitis. however certain pulmonary function tests such as FEV1 (see pulmonary function test section) have been found to be better predictors of chronic airflow obstruction. /**Cadmium**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 529]**PEER REVIEWED**

Chest Radiography: This test is widely used for assessing pulmonary disease. Chest radiographs have been found to be useful for detection of early lung cancer in asymptomatic people, especially for detection of peripheral tumors such as adenocarcinomas. However, even though OSHA mandates this test for exposure to some toxicants such as asbestos, there are conflicting views on its efficacy in detection of pulmonary disease. /**Cadmium**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 529]**PEER REVIEWED**

Pulmonary Function Tests: The tests that have been found to be practical for population monitoring include: Spirometry and expiratory flow-volume curves; Determination of lung volumes; Single-breath nitrogen washout; Inhalation challenges tests; Serial measurements of peak expiratory flow; Exercise testing. /**Cadmium**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 529]**PEER REVIEWED**

Populations at Special Risk:

/Populations at special risk include individuals with:/ Renal disease of other etiology, which may add to or magnify the effect of **cadmium** on the kidney; genetic differences in the induction of metallothionein in response to **cadmium** exposure; dietary deficiencies in metal ions and/or protein, which may increase **cadmium** absorption from the gastrointestinal tract; and, neonates or young children possibly having higher gastrointestinal absorption rates than adults. /**Cadmium** and **cadmium** cmpd/
[DHHS/ATSDR; Toxicological Profile for Cadmium (Draft) p.62 (11/87)]**PEER REVIEWED**

Women with low serum ferritin levels have been shown to have twice the normal absorption of **cadmium**. /**Cadmium**/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 700]**PEER REVIEWED**

The low metallothionein levels in vascular tissue may actually predispose a person to the toxic effects of **cadmium**. /**Cadmium**/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 516]**PEER REVIEWED**

Probable Routes of Human Exposure:

OCCUPATIONAL EXPOSURE: EXPOSURE OCCURS PRIMARILY IN SMELTING & REFINING

ZINC, LEAD & COPPER ORES CONTAINING **CADMIUM**, SPRAYING **CADMIUM** CONTAINING PIGMENTS, PROCESSING SCRAP CONTAINING **CADMIUM**, ETC. /**CADMIUM**, ALLOYS, COMPOUNDS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 233]**PEER REVIEWED**

The major route of exposure to **cadmium** for the non-smoking general population is via food ... Tobacco is an important source of **cadmium** uptake in smokers.
[WHO; Environmental Health Criteria 134: Cadmium p.18 (1992)]**PEER REVIEWED**

In locations where health effects from **cadmium** have been reported, water and air contamination from non-ferrous metal mining and production are the predominant sources of general population exposure to **cadmium**(1). All major areas in Japan with elevated **cadmium** levels have been affected by these sources. **Cadmium** intake in children via the ingestion of household dust (hand-mouth route) is about 0.7 ug/day assuming an average cadium concentration in dust of 6.9 mg/kg of dust(1). THerefore ingestion of dust by children is unlikely to be important route of exposure except in the most contaminated localities(1).
[(1) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992)]**PEER REVIEWED**

At the time when the consumption of **cadmium** for coatings and plating started to decline, the **Cadmium** Council, Inc. found that occupational exposures in most **cadmium** plating shops were below 2.5 ug/cu m in air(1). Inhalation of air is the dominant source of occupational exposure to **cadmium**(2). Dust particles cleared from the lungs may be swallowed and dust-contaminated food can be a significant contribution to the ingestion pathway(2). Air **cadmium** concns reported in various workplaces (workplace, air concn in ug/cu m): Two pigment factories, 150-1600 (personal air, respirable fraction), 0.18-3.0 (respirable fraction); Two foundries, 87 (fumes, personal air), 28 (fumes, personal air); alloy processing, 3 (fumes, personal air); Two Ni-Cd battery plants, <20, 7-39; Alkaline batteries, 10-4300 (CdO, total dust)(3).
[(1) US Dept Int; U.S. Geological Survey, Minerals Information - 1997: Cadmium, http://minerals.er.usgs.gov/minerals/pubs/commodity/cadmium (1997) (2) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992) (3) Schaller KH, Angerer J; in IARC Sci Publ 118(Cadmium in the Human Environment): 53-63 (1992)]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 102,665 workers are potentially exposed to some form of **cadmium** in the USA(1).
[(1) NIOSH; National Occupational Exposure Survey (1989)]**PEER REVIEWED**

Body Burden:

To assess the pathophysiologic significance of increased body burdens of **cadmium** (Cd), cross-sectional evaluation of renal function and calcium, phosphorus and vitamin D metabolism was carried out in 38 industrial workers exposed to Cd for 11-37 yr. Average airborne concentrations of Cd ranged from 5 - 229 ug/cu m. Mean kidney Cd burden was 7.4 + or - 4.4 mg in nonsmokers and 12.3 + or - 7.2 mg for smokers. Mean liver Cd in nonsmokers was 4.5 + or -2.6 ug/g and 7.9 + or -4.9 ug/g in smokers. Liver or kidney Cd burden was considered elevated in 31% of the workers. Creatinine clearance was normal in all workers. Maximal urinary concentrating ability was abnormal in a significant fraction (52%) of the men.
[Greenberg A et al; Arch Environ Health 41 (2): 69-76 (1986)]**PEER REVIEWED**

/IN MAN/ ABOUT HALF OF TOTAL BODY BURDEN IS FOUND IN LIVER & KIDNEYS ... **CADMIUM** IN THESE ORGANS IS MAINLY BOUND TO A LOW MOLECULAR WEIGHT

PROTEIN, IN FORM OF A METALLOTHIONEIN ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 90 (1973)]**PEER REVIEWED**

The body burden of **cadmium** in a 50 yr old adult in the US is about 30 mg.
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1662]**PEER REVIEWED**

The mean blood **cadmium** concn found in non-smoking men in the 24 towns and cities included in the British Regional Heart Study ranged from 0.35 ug/l (Guildford) to 1.93 ug/l (Shrewsbury)(1). The arithmetic mean, geometric mean, median, and range for **cadmium** in 210 samples of human milk across Canada were (ng/g): 0.08, 0.063, 0.06, and <0.002-4.05, respectively(2).
[(1) Thornton,I.; Sources and pathways of cadmium in the environment.IARC SCI. PUBL. 118(Cadmium in the Human Environment):149-62.(1992) (2) Dabeka RW et al; Sci Tot Environ 71: 65-6 (1988)]**PEER REVIEWED**

Average Daily Intake:

AIR: (Assume 10 ng/cu m for both indoor and outdoor air(6)) 0.20 ug. In contaminated areas (assuming an air concn of 0.5 ug/cu m(6)) 10 ug. Smoking a pack of cigarettes daily can result in the inhalation of 2-4 ug **cadmium** per day depending on the tobacco smoked(6). WATER: Usually less than 1 ug(6). FOOD: Average daily intakes of **cadmium** from diet estimated for 8 population groups from U.S. FDA's Total Diet Study were(age/sex group, average daily intake in ug/day): 6-11 mo, 4.2; 2 yr, 7.3; 14-16 yr female, 10.6; 14-16 yr male, 15.4; 25-30 yr female, 10.6; 25-30 yr male, 15.0; 60-65 yr female, 9.6; 60-65 yr male, 12.7(5). The 234 representative food items for the survey were obtained in retail markets in 4 broad geographical areas of the US between 1982 and 1984. Results of the FDA's Total Diet Study for 1986-1991 are age/sex group, average daily intake in ug/kg body wt-day): 6-11 mo, 0.36, 2 yr, 0.46; 14-16 yr female, 0.17; 14-16 yr male, 0.22; 25-30 yr female, 0.16; 25-30 yr male, 0.17; 60-65 yr female, 0.14; 60-65 yr male, 0.15(7). For a 25-30-year male, 37 foods, primarily grain, potato, and lettuce contributed 80% of the total daily intake(7). The normal dietary **cadmium** intake in Britain estimated from food acquisitions of more than 7000 households was <0.15 mg/week(1). The intake in the U.S. was 0.23 mg/wk and that in 7 other countries ranged from 0.11 to 0.38 mg/wk. Two studies reporting dietary intakes by children was 0.20 mg/wk and 0.13 mg/wk in Germany and Poland, respectively. According to a Canadian survey of drinking water, the average daily intake of **cadmium** from drinking water is less than or equal to 0.01 ug(2). The mean, median and 95th percentile for dietary exposure to **cadmium** from traditional food among adult indigenous people (Dene/Metis) in the western Northwest Territories, Canada (n=1012) was <0.1 ug/kg; the 99th percentile was 0.1 ug/kg/day(3). The estimated dietary intake of **cadmium** (ug/kg-day) by 0-12 month-old infants fed only (formula/milk, intake): human milk, 0.31; evaporated milk, 0.33; milk-based formula, 0.34; soy-based formula, 0.63(4).
[(1) Thornton I; in IARC Sci Publ 118(Cadmium in the Human Environment): 149-62 (1992) (2) Meranger JC et al; Environ Sci Technol 13: 707-711 (1979) (3) Berti PR et al; Environ Research Section A 76:131-42 (1998) (4) Dabeka RW; Sci Tot Environ 89: 279-89 (1989) (5) Gunderson EL; J Assoc Off Anal Chem 71: 1200-9 (1988) (6) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992) (7) Gunderson EL; J AOAC International 78: 1353-63 (1995)]**PEER REVIEWED**

The **cadmium** intake of dust by children via the hand-to-mouth route (assuming 6.9 mg Cd/kg in dust and 100 mg/day intake) is 0.7 ug(1).
[(1) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992)]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** **CADMIUM** ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE

0.2.1.1 ACUTE EXPOSURE

A. **Cadmium** is a severe lung and gastrointestinal irritant that can be fatal by inhalation and ingestion.

B. The symptoms of acute poisoning after inhalation exposure may be delayed 12 to 36 hours. These include chest pain, cough (with bloody sputum), difficulty breathing, sore throat, 'metal fume fever' (shivering, sweating, body pains, headache) dizziness, irritability, weakness, nausea, vomiting, diarrhea, tracheobronchitis, pneumonitis and pulmonary edema.

C. After acute ingestion, symptoms usually appear in 15 to 30 minutes. These include abdominal pain, burning sensation, nausea, vomiting, salivation, muscle cramps, vertigo, shock, unconsciousness and convulsions.

D. Chronic exposure (by inhalation or ingestion) results in kidney damage, as well as gastrointestinal symptoms, loss of sense of smell, nasal discharge, nose and throat irritation, lack of appetite, weight loss, nausea, tooth discoloration, bone structure defects, liver damage, anemia, pulmonary emphysema, chronic bronchitis, bronchopneumonia and death.

E. Chronic environmental **cadmium** exposure was the etiology of Itai-Itai disease in Japan, and was associated with renal tubular dysfunction, osteomalacia, anemia, and generalized pain.

F. Aaccording to various organizations, **cadmium** and its compounds are considered probably carcinogenic to humans.

0.2.6 RESPIRATORY

0.2.6.1 ACUTE EXPOSURE

A. Acute inhalation of fumes can cause cough, dyspnea and chest tightness which is similar to metal fume fever, but which may progress to pneumonitis, pulmonary edema, and death due to respiratory failure in severe cases. Acute exposure can result in residual emphysema and fibrosis.

B. Bronchitis, emphysema, and fibrosis can result from chronic inhalation of **cadmium** dusts or fumes.

0.2.7 NEUROLOGIC
0.2.7.1 ACUTE EXPOSURE
A. Headaches may occur from chronic occupational exposures.
B. CNS effects of acute exposures have included delayed parkinsonism.
0.2.8 GASTROINTESTINAL
0.2.8.1 ACUTE EXPOSURE
A. INGESTION - Nausea, vomiting, abdominal pain and cramping, diarrhea, salivation, dry mouth, and substernal pain occur.
B. INHALATION - Nausea, vomiting, chills, weakness, diarrhea can occur.
0.2.10 GENITOURINARY
0.2.10.1 ACUTE EXPOSURE
A. Chronic exposure may result in proximal renal tubule damage.
0.2.10.2 CHRONIC EXPOSURE
A. **Cadmium** accumulates in the male reproductive organs with age.
0.2.14 DERMATOLOGIC
0.2.14.1 ACUTE EXPOSURE
A. Skin eruptions and pruritus may occur.
0.2.15 MUSCULOSKELETAL
0.2.15.1 ACUTE EXPOSURE
A. Bone fragility and osteomalacia may be a result of chronic **cadmium** exposure.
0.2.17 METABOLISM
0.2.17.1 ACUTE EXPOSURE
A. **Cadmium** interferes with zinc and calcium metabolism, resulting in bone resorption and osteoporosis.
0.2.20 REPRODUCTIVE HAZARDS
A. Smoking and industrial exposure to **cadmium** has resulted in increased placental levels of **cadmium**.
0.2.21 CARCINOGENICITY
0.2.21.1 IARC CATEGORY
A. **Cadmium** and **cadmium** compounds have been classified by the IARC as Group 1, carcinogenic to humans. Other agencies such as NIOSH and ACGIH have identified **cadmium** and **cadmium** compounds as potential human carcinogens or suspected human carcinogens.
0.2.21.2 HUMAN OVERVIEW
A. Increased incidence of lung, prostate, pancreas and bladder cancers in humans have been reported.
0.2.21.3 ANIMAL OVERVIEW
A. **Cadmium** has produced tumors of the ventral prostate of rats.
0.2.22 GENOTOXICITY
A. Chromosome damage in humans and experimental animals have occurred, although **cadmium** is thought to be a poor mutagen. One study found that **cadmium** (II) inhibited DNA repair enzymes, but low doses stimulated DNA synthesis and cell growth in animals.

Laboratory:

A. Blood **cadmium** levels are a reflection of acute **cadmium** exposure. Urine **cadmium** levels appear to be a better measurement of chronic exposure (Kowal et al, 1979).
B. Urinary metallothionein may be a better indicator of body burden, but is not widely available.

Treatment Overview:

0.4.2 ORAL EXPOSURE
A. Activated charcoal has no proven benefit in **cadmium** poisoning, but may be considered.
1. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.
B. CHELATION - Although not demonstrably efficacious, chelation therapy may be of benefit immediately following acute exposure.
1. Administer CaNa2 EDTA 75 mg/kg/day deep IM or slow IV infusion given in 3 to 6 divided doses for up to 5 days. May be repeated for a second course after a minimum of two days drug holiday; each course should not exceed a total of 500 mg/kg body weight. CAUTION: BAL must not be used with **cadmium** since the complex is nephrotoxic.
0.4.3 INHALATION EXPOSURE
A. INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids.
B. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.
C. Treatment of inhalation toxicity should include recommendations listed in the oral exposure section when appropriate.

Range of Toxicity:

A. Acute ingestion of as little as 10 mg of inorganic **cadmium** has caused severe symptoms. Severe pulmonary toxicity (pulmonary edema) may ensue following inhalation of **cadmium** fumes. Significant dermal absorption seldom occurs.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

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The following Overview, *** METAL FUME FEVER ***, is relevant for this HSDB record chemical.

Life Support:

o This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE

0.2.1.1 ACUTE EXPOSURE

A. Metal fume fever (MFF) is an illness produced by inhaling metal oxides. These oxides are produced by heating various metals including **cadmium**, zinc, magnesium, copper, antimony, nickel, cobalt, manganese, tin, lead, beryllium, silver, chromium, aluminum, selenium, iron, and arsenic.

1. Most common agents involved are zinc and copper. Metal fume fever most often occurs after welding or torch-cutting galvanized (zinc coated) metal, such as air conditioning ducting.

B. MFF is characterized chiefly by fever, chills, malaise, headache, myalgias, fatigue, cough, thirst and abdominal discomfort, with symptom onset about 3 to 10 hrs after exposure. Symptoms usually do not last beyond 24 to 48 hrs.

C. Recovery is usually complete with no chronic impairment from zinc, copper, or brass, and fatalities have not been reported. A type of tolerance builds up during exposures, but is lost after a few days of non-exposure. Symptoms often reappear after a weekend away from the job, thus the name Monday Fever.

D. This condition should NOT be confused with the PNEUMONITIS caused by **CADMIUM** and other more toxic metals. NOTE - This document deals only with metal fume fever. Please see documents for individual metals and/or metal compounds when necessary to obtain information regarding other toxic effects.

0.2.4 HEENT

0.2.4.1 ACUTE EXPOSURE

A. Flushing, dry throat, blurred vision, and stiff neck have been reported. A sweet or metallic taste is common.

0.2.5 CARDIOVASCULAR

0.2.5.1 ACUTE EXPOSURE

A. Myocardial injury was reported in one case.

0.2.6 RESPIRATORY

0.2.6.1 ACUTE EXPOSURE

A. The respiratory tract is the system most likely to be affected in symptomatic MFF. Shortness of breath, chest tightness, rales in the midzone and basal regions, a non-productive cough, dyspnea, expiratory wheeze, and diffuse rales have all been reported. Permanent sequelae and radiographic lung lesions are uncommon.

0.2.7 NEUROLOGIC

0.2.7.1 ACUTE EXPOSURE

A. Headache, myalgias, weakness, and paresthesias in both feet have been reported.

0.2.8 GASTROINTESTINAL

0.2.8.1 ACUTE EXPOSURE

A. Non-specific GI effects may occur including anorexia, constipation or diarrhea, nausea, vomiting, and abdominal pain.

0.2.10 GENITOURINARY

0.2.10.1 ACUTE EXPOSURE

A. There is no evidence that MFF causes kidney damage, even though several of the metals are nephrotoxic on chronic exposure.

0.2.13 HEMATOLOGIC

0.2.13.1 ACUTE EXPOSURE
A. Leukocytosis is almost always present.
0.2.14 DERMATOLOGIC
0.2.14.1 ACUTE EXPOSURE
A. Hives may rarely occur.
0.2.15 MUSCULOSKELETAL
0.2.15.1 ACUTE EXPOSURE
A. Muscle injury may occur.
0.2.19 IMMUNOLOGIC
0.2.19.1 ACUTE EXPOSURE
A. Transient immunologic reactions including tachyphylaxis and anaphylactoid reactions may occur. Increased polymorphonuclear neutrophils and cytokines have been measured in persons exposed to zinc oxide fumes.
0.2.23 OTHER
0.2.23.1 ACUTE EXPOSURE
A. Lactic dehydrogenase is often elevated, especially the pulmonary fraction.
B. Metal fume fever is often confused with other illnesses.

Laboratory:

A. Elevated lactic acid dehydrogenase and elevated zinc levels have been reported after exposure to zinc oxide fumes. The absence of elevated serum zinc levels cannot be used to rule out significant exposure or the presence of metal fume fever. Elevated blood copper levels have also been reported.
B. X-rays are seldom diagnostic; they are usually normal or show only increased bronchovascular markings. Cases have been described in which bilateral diffuse infiltrates are seen on X-ray.
C. HEAVY METAL SCREENING or specific metal assay may be necessary to identify a causal agent with significant acute or chronic toxicity.

Treatment Overview:

0.4.2 ORAL EXPOSURE
A. The primary route of exposure is by inhalation. Although small amounts may reach the gastrointestinal tract, gastrointestinal decontamination is not recommended.
0.4.3 INHALATION EXPOSURE
A. INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids.
B. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.
C. CORTICOSTEROIDS - Have occasionally been recommended to reduce the inflammatory response of patients with serious pulmonary involvement.
D. OXYGEN - Appears to help shortness of breath and dyspnea.
E. ANALGESICS/ANTIPYRETICS - Should be administered as necessary.
F. CHELATION - Although several studies have documented

```
      elevated zinc or copper levels, chelation has not been
      considered unless excessive exposure to a known toxic
      metal is involved.
  0.4.4 EYE EXPOSURE
    A.  No serious ocular toxicity has been reported from metal
        fume fever.
```

Range of Toxicity:

```
  A.  CONCENTRATIONS - 14 mg/m(3) of zinc oxide was well
      tolerated for exposures of 8 hours.  Forty five mg/m(3)
      was tolerated for 20 minutes.  Levels above this are
      poorly tolerated.  Metal fume fever has been reported to
      occur from concentrations below 5 mg/m(3).
```

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

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The following Overview, *** **CADMIUM** OXIDE ***, is relevant for this HSDB record chemical.

Life Support:

```
  o  This overview assumes that basic life support measures
     have been instituted.
```

Clinical Effects:

```
  0.2.1 SUMMARY OF EXPOSURE
   0.2.1.1 ACUTE EXPOSURE
     A.  ACUTE INHALATION EXPOSURE - Even a single exposure to
         cadmium oxide fume can cause (after several hours) dry
         throat, cough, aches and pains, chills, chest pain,
         breathing difficulty, rales, and potentially fatal
         non-cardiogenic pulmonary edema.  Cadmium oxide is
         odorless and POISONING FROM THE FUME CAN OCCUR AT
         CONCENTRATIONS TOO LOW TO CAUSE IRRITATION.
     B.  Kidney or liver damage may occur several days later in
         survivors of acute exposure, and respiratory symptoms
         may persist for months.
     C.  ORAL EXPOSURE - Ingestion can cause severe
         gastrointestinal distress and vomiting.
     D.  CHRONIC EXPOSURES have been associated with severe
         progressive emphysema, kidney damage (renal tubular
         dysfunction with proteinuria), osteomalacia, and
         possible cancer of the respiratory tract and prostate.
  0.2.3 VITAL SIGNS
   0.2.3.1 ACUTE EXPOSURE
     A.  Dyspnea, hypertension, and shock could occur.
         Temperature deregulation has occurred in experimental
         animals exposed to cadmium.
```

0.2.3.2 CHRONIC EXPOSURE
A. Hypertension has been reported in **cadmium** workers.
0.2.4 HEENT
0.2.4.1 ACUTE EXPOSURE
A. A metallic taste in the mouth is a symptom of acute **cadmium** oxide poisoning.
0.2.4.2 CHRONIC EXPOSURE
A. Anosmia and dental discoloration have been seen with chronic exposure to **cadmium**.
0.2.5 CARDIOVASCULAR
0.2.5.1 ACUTE EXPOSURE
A. Shock can occur from ingestion of **cadmium** salts. Hypertension, ECG abnormalities, and dystrophic processes in the myocardium were reported in **cadmium** workers.
0.2.5.2 CHRONIC EXPOSURE
A. Hypertension, ECG abnormalities and dystrophic processes in the myocardium were reported in **cadmium** workers.
0.2.6 RESPIRATORY
0.2.6.1 ACUTE EXPOSURE
A. Inhalation of fresh **cadmium** oxide fume can produce severe and possibly fatal acute **cadmium** poisoning. A severe chemical pneumonitis initially resembling influenza may occur. Pulmonary fibrosis was observed in experimental animals but it has not been reported in humans.
0.2.6.2 CHRONIC EXPOSURE
A. Chronic exposure to **cadmium** oxide has been associated with severe emphysema without chronic bronchitis.
0.2.7 NEUROLOGIC
0.2.7.1 ACUTE EXPOSURE
A. CNS effects of acute exposures in humans have included delayed parkinsonism.
B. Headache, severe pain, muscle cramps, dizziness, and rarely seizures, may occur. **Cadmium**-poisoned experimental animals were hyperactive, had loss of reflexes, spinal ganglion necrosis, sciatic lesions, and showed histological lesions in the central nervous system.
0.2.7.2 CHRONIC EXPOSURE
A. Neurological changes involving reduced optical and dermal stimulability, functional changes in the cerebral cortex and anosmia may be seen in workers chronically exposed to **cadmium** oxide.
0.2.8 GASTROINTESTINAL
0.2.8.1 ACUTE EXPOSURE
A. Nausea, vomiting, chills, weakness, and diarrhea may occur after inhalation.
B. Ingestion of **cadmium** salts may cause severe nausea, vomiting, diarrhea, abdominal cramps, salivation, liver damage, exhaustion, collapse, shock and death generally within 24 hours. Since **cadmium** oxide is one of the more insoluble **cadmium** compounds, its gastrointestinal symptoms may not be as severe as with soluble **cadmium** salts (e.g., **cadmium** acetate).
0.2.8.2 CHRONIC EXPOSURE
A. Chronic exposure to **cadmium** has produced gastrointestinal symptoms.
0.2.9 HEPATIC
0.2.9.1 ACUTE EXPOSURE
A. Hepatotoxicity with hepatic failure may occur.
0.2.9.2 CHRONIC EXPOSURE
A. Hepatotoxicity can occur.

0.2.10 GENITOURINARY

0.2.10.1 ACUTE EXPOSURE

A. Kidney damage is common from acute industrial exposure. Urinary excretion of **cadmium** occurs with exposure to **cadmium** oxide. Renal failure may occur.

0.2.10.2 CHRONIC EXPOSURE

A. Kidney damage is common from chronic industrial exposure. Urinary excretion of **cadmium** occurs with exposure to **cadmium** oxide.

0.2.13 HEMATOLOGIC

0.2.13.1 ACUTE EXPOSURE

A. Chronic exposure to **cadmium** has been associated with anemia and eosinophilia.

0.2.13.2 CHRONIC EXPOSURE

A. Chronic exposure to **cadmium** has been associated with anemia and eosinophilia.

0.2.15 MUSCULOSKELETAL

0.2.15.1 ACUTE EXPOSURE

A. **Cadmium** may act directly on the bone collagen in rats, causing acceleration of collagen catabolism and demineralization. Chronic exposure to **cadmium** has been associated with microfractures, osteomalacia, radiologic decreases in bone density, and disturbances in calcium metabolism.

B. Acute human exposures have resulted in symptoms of arthralgia.

C. In Japan, a painful osteomalacia with skeletal deformities called "itai-itai byo" (ouch-ouch disease) has been linked with ingestion of **cadmium**-contaminated shellfish; occurring primarily in postmenopausal multi-parous women.

0.2.15.2 CHRONIC EXPOSURE

A. Chronic exposure to **cadmium** has been associated with microfractures, osteomalacia, radiologic decreases in bone density and disturbances in calcium metabolism.

0.2.17 METABOLISM

0.2.17.1 ACUTE EXPOSURE

A. **Cadmium** is a general metabolic poison and may inhibit zinc-containing enzymes. **Cadmium** is a potent inhibitor of hepatic microsomal oxidases both in vivo and in vitro. Enzymatic repair was induced in experimental rats exposed to **cadmium** oxide.

0.2.17.2 CHRONIC EXPOSURE

A. **Cadmium** is a general metabolic poison.

0.2.18 PSYCHIATRIC

0.2.18.1 ACUTE EXPOSURE

A. Insomnia and loss of appetite have been reported from exposure to **cadmium** oxide.

0.2.18.2 CHRONIC EXPOSURE

A. Insomnia and loss of appetite have been reported from exposure to **cadmium** oxide.

0.2.20 REPRODUCTIVE HAZARDS

A. Women occupationally exposed to **cadmium** had children with lower birth weights. Children of women exposed to **cadmium** during pregnancy exhibited reduced intellectual/motor skills at 6 years of age. There is some question as to whether these results are the result of lead rather than **cadmium** since lead occurs commonly with **cadmium** and causes similar effects. Teratogenic effects were observed in animal experiments.

0.2.21 CARCINOGENICITY

0.2.21.1 IARC CATEGORY

A. IARC (**cadmium** oxide) (RTECS, 1991)

1. Animal: Sufficient evidence
2. Human: Limited evidence
3. Group 2A

0.2.21.2 HUMAN OVERVIEW

A. **Cadmium** oxide may be an occupational carcinogen and has been linked with prostate and respiratory tract cancer.

0.2.22 GENOTOXICITY

A. Soluble **cadmium** salts have been genotoxic in vitro but **cadmium** oxide is not expected to be strongly genotoxic in vitro since it is insoluble in water (IRPTC, 1984).

0.2.23 OTHER

0.2.23.1 ACUTE EXPOSURE

A. Persons with respiratory or kidney disease may be hypersusceptible to **cadmium** oxide and should be excluded from exposure.

0.2.23.2 CHRONIC EXPOSURE

A. Persons with respiratory or kidney disease may be hypersusceptible to **cadmium** oxide and should be excluded from exposure.

Laboratory:

A. Renal damage can be identified by increased urinary levels of beta2-microglobulin, retinol-binding protein, or other low-molecular- weight proteins. Urinary beta2-microglobulin levels greater than 290 mcg/L may indicate kidney damage.
B. Urinary metallothionein may be a better indicator of body burden.
C. If respiratory tract irritation or respiratory depression is evident, monitor arterial blood gases, chest x-ray, and pulmonary function tests.

Treatment Overview:

0.4.2 ORAL EXPOSURE

A. DILUTION: Immediately dilute with 4 to 8 ounces (120 to 240 mL) of water or milk (not to exceed 4 ounces/120 mL in a child).
B. GASTRIC LAVAGE: Consider after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation. Control any seizures first.

1. CONTRAINDICATIONS: Loss of airway protective reflexes or decreased level of consciousness in unintubated patients; following ingestion of corrosives; hydrocarbons (high aspiration potential); patients at risk of hemorrhage or gastrointestinal perforation; and trivial or non-toxic ingestion.

C. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.
D. Observe patients with ingestion carefully for the possible development of esophageal or gastrointestinal tract irritation or burns. If signs or symptoms of esophageal irritation or burns are present, consider endoscopy to determine the extent of injury.

0.4.3 INHALATION EXPOSURE

A. INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation,

bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids.
B. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.
0.4.4 EYE EXPOSURE
A. DECONTAMINATION: Irrigate exposed eyes with copious amounts of room temperature water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility.
0.4.5 DERMAL EXPOSURE
A. DECONTAMINATION: Remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician may need to examine the area if irritation or pain persists.
B. Treatment should include recommendations listed in the ORAL EXPOSURE section when appropriate.

Range of Toxicity:

A. The lethal inhalation dose of **cadmium** oxide in humans is 2500 mg/m(3) for 1 minute, 40 to 50 mg/m(3) for 1 hour, or 9 mg/m(3) for 5 hours.
DIAMINE

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Animal Toxicity Studies:

Evidence for Carcinogenicity:

Evaluation: There is sufficient evidence in humans for the carcinogenicity of **cadmium** and **cadmium** compounds. There is sufficient evidence in experimental animals for the carcinogenicity of **cadmium** compounds. There is limited evidence in experimental animals for the carcinogenicity of **cadmium** metal. In making the overall evaluation, the Working Group took into consideration the evidence that ionic **cadmium** causes genotoxic effects in a variety of types of eukaryotic cells, including human cells. Overall evaluation: **Cadmium** and **cadmium** compounds are carcinogenic to humans (Group 1).
/**Cadmium** and **cadmium** compounds/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 58 210 (1993)]**PEER REVIEWED**

CLASSIFICATION: B1; probable human carcinogen. BASIS FOR CLASSIFICATION: Limited evidence from occupational epidemiologic studies of **cadmium** is consistent across investigators and study populations. There is sufficient evidence of carcinogenicity in rats and mice by inhalation and intramuscular and subcutaneous injection. Seven studies in rats and mice wherein **cadmium** salts (acetate, sulfate, chloride) were administered orally have shown no evidence of carcinogenic response. HUMAN CARCINOGENICITY DATA: Limited.
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Cadmium (7440-43-9) from the National Library of Medicine's TOXNET System, March 6,

1995]**PEER REVIEWED**

A2. A2= Suspected human carcinogen. /**Cadmium**, elemental and compounds, as Cd/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 22]**PEER REVIEWED**

Non-Human Toxicity Excerpts:

ALTHOUGH PAST ANIMAL STUDIES ... IMPLICATED VARIOUS **CADMIUM** CMPD ... /CHLORIDE, SULFIDE, OXIDE, SULFATE/ & EVEN METAL AS CARCINOGENS, ELICITING RHABDOMYOSARCOMAS & TESTICULAR TUMORS, THERE ARE NO REPORTS THAT **CADMIUM** IS CARCINOGENIC BY INGESTION. /**CADMIUM** SALTS/
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.88]**PEER REVIEWED**

Soluble **cadmium** salts given parenterally to rats, mice or calves induced a temporary castration phenomenon, which progressed with larger doses to irreversible damage to the seminiferous tubules, necrosis of the germinal epithelium and complete loss of fertility. /Soluble **cadmium** salts/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-79]**PEER REVIEWED**

WHEN INJECTED SC, **CADMIUM** SALTS INDUCE INFLAMMATION & COAGULATION NECROSIS AT SITE OF INJECTION. IRRITANT ACTION IS CAUSED BY **CADMIUM** RATHER THAN THE ACID RADICAL ... /**CADMIUM** SALTS/
[Patty, F. (ed.). Industrial Hygiene and Toxicology: Volume II: Toxicology. 2nd ed. New York: Interscience Publishers, 1963. 1013]**PEER REVIEWED**

INGESTION OF **CADMIUM** SALTS INDUCES SALIVATION, CHOKING ATTACKS, PERSISTENT VOMITING, ABDOMINAL PAINS, TENESMUS & DIARRHEA, VERTIGO & LOSS OF CONSCIOUSNESS. CATARRHAL & ULCERATIVE GASTROENTERITIS, CONGESTION, PULMONARY INFARCTS & SUBDURAL HEMORRHAGES ARE FOUND @ NECROPSY. /**CADMIUM** SALTS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1566]**PEER REVIEWED**

SOL **CADMIUM** SALTS GIVEN SC TO RATS INDUCED TEMPORARY CASTRATION PHENOMENON WHICH PROGRESSED WITH LARGER DOSES TO IRREVERSIBLE DAMAGE TO SEMINIFEROUS TUBULES, NECROSIS OF GERMINAL EPITHELIUM & COMPLETE LOSS OF FERTILITY. ... COMPARABLE AMT IN FEMALE RATS PRODUCED NO DETECTABLE LESIONS. /**CADMIUM** SALTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-78]**PEER REVIEWED**

IN RATS, ORAL DOSES OF 40 MG **CADMIUM**/KG BODY WEIGHT PER DAY AS **CADMIUM** CHLORIDE GIVEN ON DAYS 6-19 OF GESTATION INCREASED FETAL RESORPTION AND CAUSED SKELETAL, KIDNEY, AND HEART ABNORMALITIES IN FETUSES, STILLBORN, AND OFFSPRING. THE INCIDENCE AND INTENSITY OF SKELETAL DEFECTS INCREASED WITH **CADMIUM** DOSAGE, BUT THE RENAL AND CARDIAC ABNORMALITIES WERE NOT DOSE-RELATED. /INORGANIC **CADMIUM**/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 83]**PEER REVIEWED**

Cadmium was the most toxic metal tested in respect to the growth rate of the earthworm, Eisenia foetida, followed in decreasing order by nickel, copper, zinc, and lead. The acetate, chloride, nitrate, and sulfate salts of each metal had the same relative toxicity, and the carbonates and oxides were less toxic. Reproduction (Cocoon production) was inhibited by much lower concentrations than growth. The only element earthworms consistently accumulated was **cadmium**. /Inorganic **cadmium**/
[Neuhauser EF et al; Proc Ind Waste Conf 37: 253-8 (1983)]**PEER REVIEWED**

The growth of Chlorella ellipsoidea was enhanced by adding a concn of 0.1 ppm **cadmium** salts to the soln. However, at concentrations greater than 2.5 ppm **cadmium** salts inhibited the growth of Chlorella. /**Cadmium** salts/
[Nagano T et al; Shizuoka-ken Eisei Kenkyusho Hokoku 19: 65-8 (1976)]**PEER REVIEWED**

RATS WERE GIVEN 4 SC INJECTIONS/WK (2.94 MG **CADMIUM**/RAT/WK). AFTER 60 DAYS, CYTOPLASMIC NECROSIS OF HEPATOCYTES, FESTOONING OF NUCLEAR MEMBRANES & ROUND, REGULAR INTRANUCLEAR INCLUSIONS, CONSISTING OF ALTERNATING OPAQUE & TRANSPARENT ZONES WERE OBSERVED. /**CADMIUM**/
[NEIGE G ET AL; ARCH MAL PROF MED TRAV SECUR SOC 35 (7-8): 709 (1974)]**PEER REVIEWED**

Accumulation of **cadmium** (Cd) in a population of the grasshopper, Chorthippus brunneus, from grasslands around a copper refinery complex (0.75 sq km divided into four sites) was monitored, and compared with a control site distant from sources of metal contamination. A sub-control site in an unpolluted stabilized sand dune system where soil copper concentration was deficient was also studied. Each site contained similar mixed grass swards of Agrostis stolonifera L and Festuca rubra L which were the major components of fecal pellets of refinery site grasshoppers. Monthly samples of grasses and adult and nymphal insects were obtained for analysis (n= >100/species/site). Monthly mean Cd concentrations for A stolonifera were: (a) refinery sites, 1.97 ug/g to 3.24 ug/g; (b) 1 km site, 1.19; and (c) control site, 0.63 ug/g. For F rubra, monthly concentrations averaged: (a) refinery sites, 1.95 to 2.60 ug/g; (b) 1 km site, 1.24 ug/g; and (c) control site 0.63 ug/g. For C brunneus concentrations were: (a) refinery sites, 1.63 to 2.44 ug/g; (b) 1 km site, 1.24 ug/g; and (c) control site, 0.19 ug/g. Total body concentration of Cd in grasshoppers showed a linear increase with an increase in dietary contamination levels, which may indicate little metabolic control over uptake of the metal. In control populations of insects the Cd concentrations remained constant in nymphal stages throughout the year. In refinery populations Cd concentrations in corresponding instars increased each month and were significantly higher than those in the controls. /**Cadmium** ion/
[Hunter BA et al; Arch Environ Contam Toxicol 16 (6): 711-6 (1987)]**PEER REVIEWED**

Pregnant Wistar-Porton rats were injected with a solution of **cadmium** (CD) on gestation days (gd) 8-14 (6-8 animals per each gd). **Cadmium** injected ip at doses of 1.25-2.0 mg/kg was fetotoxic and this effect increased with dose. The teratogenic response (hydrocephalus, urogenital malformations, and cleft palate) was maximal at 1.25 mg/kg **cadmium** given iv on gd 10 or ip on gestation day 12. The incidence of skeletal malformations was greater after ip than after iv administration of **cadmium** on gestation day 12. At 1.5 or 2.0 mg/kg doses, **cadmium** was lethal to the mothers when administered by iv route. /**Cadmium**/
[Holt D and Webb M; Arch Toxicol 59: 443-447 (1987)]**PEER REVIEWED**

Oral administration of **cadmium** compounds induced epithelial desquamation and necrosis of the gastric and intestinal mucosa, together with dystrophic changes of the liver, heart, and kidneys. /**Cadmium** compounds/
[WHO; Environmental Health Criteria 134: Cadmium p. 100 (1992)]**PEER REVIEWED**

Glomerulonephritis and renal tubular lesions may follow **cadmium** use. IgG glomerular deposits in the basement membrane, suppression of antibody formation in animals, as well as both impairment and enhancement of growth of animal tumors indicate that **cadmium** can deter certain segments of the immune system but augment others. /**Cadmium**/
[Ellenhorn, M.J., S. Schonwald, G. Ordog, J. Wasserberger. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. 2nd ed. Baltimore, MD: Williams and Wilkins, 1997. 800]**PEER REVIEWED**

... Renal tubular necrosis occurs in non-**cadmium** exposed rats following transplantation of livers from **cadmium** toxic animals. /**Cadmium**/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 701]**PEER REVIEWED**

Structural changes in the renal vessels consisting of diffuse fibrosis of the capillaries have been reported after chronic exposure to **cadmium** in experimental animals. /**Cadmium**/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 524]**PEER REVIEWED**

Cadmium is known to affect male fertility in several species. Acute parenteral administration of **cadmium** to rodents and rabbits and intratesticular administration to dogs result in severe testicular damage, including testicular atrophy and lowered androgen levels. In most strains and species, the dose levels causing testicular damage are below those that cause other signs of toxicity. There is often recovery of androgen production after **cadmium** withdrawal, but germinal epithelium recovery is rare. /**Cadmium**/
[Thomas, J.A., K.S. Korach, J.A. McLachlan. Endocrine Toxicology. New York, NY: Raven Press, Ltd., 1985. 277]**PEER REVIEWED**

Low-level, repeated injections of **cadmium** are less likely to cause testicular damage than a high-dose, single administration despite the higher accumulation of **cadmium** in the testes. ... However, low-level, chronic oral administration of **cadmium** also causes testicular damage in animals. /**Cadmium**/
[Thomas, J.A., K.S. Korach, J.A. McLachlan. Endocrine Toxicology. New York, NY: Raven Press, Ltd., 1985. 291]**PEER REVIEWED**

In vivo administration of **cadmium** causes marked inhibition of choline acetyl transferase activity in spermatozoa, a change known to be associated with impaired sperm function and sterility. In vitro exposure of male and female gametes to **cadmium** decreases sperm motility, the development of two-cell embryos into blastocysts, and the implantation of blastocysts in surrogate dams. /**Cadmium**/
[Thomas, J.A., K.S. Korach, J.A. McLachlan. Endocrine Toxicology. New York, NY: Raven Press, Ltd., 1985. 298]**PEER REVIEWED**

Cadmium is toxic to the growth of the freshwater alga Chlorella pyrenoidosa. /**Cadmium**/
[WHO; Environmental Health Criteria 135: Cadmium - Environmental Aspects p. 60 (1992)]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Absorption, Distribution & Excretion:

CADMIUM ACCUMULATES IN THE LIVER AND KIDNEYS, PERHAPS BECAUSE THESE TWO ORGANS CONTAIN LOW-MOLECULAR-WEIGHT (ABOUT 10,000 DALTONS) PROTEINS CALLED METALLOTHIONEINS. /**CADMIUM** SALTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-78]**PEER REVIEWED**

ABSORPTION OF **CADMIUM** FROM SOILS BY RICE PLANTS INCR WITH INCR SOLUBILITY OF CD CMPD, IN ORDER OF: CDCL2 BEING MORE SOL THAN CD(NO3)2 FOLLOWED BY CDO, CDCO3, METALLIC CD, CD(OH)2, CD3(PO4)2, CDS. CALCIUM SILICATE PLUS PHOSPHATE PREVENTED **CADMIUM** ABSORPTION. /**CADMIUM** & **CADMIUM** CMPD/
[UETA H ET AL; TOTTORI-KEN NOGYO KENKYU HOKOKU 13: 17 (1973)]**PEER REVIEWED**

The absorption of **cadmium** cmpd through skin is negliglible, the main routes of exposure for humans being via respiration and ingestion. Between 10 and 50% of inhaled **cadmium** will be absorbed, the absorption being greater for small particles and fumes than for large particle dust. In humans, about 5% of ingested **cadmium** is absorbed. A low intake of calcium or iron increases absorption. In individuals with iron deficiency, the gastrointestinal absorption rate may be as high as 20%. /**Cadmium** & **cadmium** cmpd/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. VII-130]**PEER REVIEWED**

FOLLOWING INHALATION, PORTION OF RETAINED **CADMIUM** IS FIXED ... TO PULMONARY TISSUE, BUT ... LARGE AMT LEAVE LUNG & ARE DISTRIBUTED TO OTHER ORGANS. IN RABBITS ONLY SMALL QUANTITIES ARE EXCRETED IN URINE & FECAL EXCRETION ... AMT TO /BELOW/ 10% OF SINGLE PARENTERAL DOSE. /**CADMIUM** SALTS/
[Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976.,p. II-12]**PEER REVIEWED**

IN STUDIES IN MICE USING AEROSOLS OF **CADMIUM** COMPOUNDS PARTICLES OF LESS THAN 2 MICRONS WERE FOUND IN THE LUNG. /**CADMIUM** SALTS/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 59 (1976)]**PEER REVIEWED**

IN GOATS, DOGS AND RABBITS GIVEN IV OR SC INJECTIONS, ONLY A SMALL PERCENTAGE OF ABSORBED **CADMIUM** WAS EXCRETED VIA FECES.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 60 (1976)]**PEER REVIEWED**

BLOOD **CADMIUM** EQUILIBRATES WITH ANY GIVEN LEVEL OF EXPOSURE WITHIN A YEAR, WHILE TOTAL AMT IN BODY KEEPS ACCUM OVER A PERIOD OF DECADES. MUCH THE SAME SITUATION HAS BEEN NOTED IN ... URINARY EXCRETION OF **CADMIUM**. /**CADMIUM** SALTS/
[Doull, J., C.D. Klaassen, and M. D. Amdur (eds.). Casarett and Doull's Toxicology. 2nd ed. New York: Macmillan Publishing Co., 1980. 431]**PEER REVIEWED**

WHEN EXPOSURE IS EXCESSIVE ... CONCN OF **CADMIUM** IN LIVER MAY BE UP TO 100 TIMES GREATER THAN NORMAL. IN MANY CASES ... KIDNEY CONCN ARE VERY HIGH, BUT WHEN KIDNEY DAMAGE HAS OCCURRED ... EXCRETION INCR CONSIDERABLY. THIS EXPLAINS FACT THAT IN MOST SEVERELY POISONED WORKERS ... KIDNEY LEVELS, IN CONTRAST TO LIVER ... ARE LOW ... /**CADMIUM**/
[Friberg, L., G.R. Nordberg, and V.B. Vouk. Handbook on the Toxicology of Metals. New York: Elsevier North Holland, 1979. 361]**PEER REVIEWED**

Baseline data on Cd accumulation in organs and tissues, and their variations with age, sex, and habitat in Japanese serows (Capricornus crispus) were determined. The animals were killed during the winter 1981-82 in the Gifu and Nagano Prefectures, Japan. The Cd concentrations were measured by flame

absorption spectrometry. On a wet basis, the mean Cd concentration in muscle, liver, kidneys, and the whole body of fetuses (gestation age 0.3-0.7 yr, N= 13) was <1.0 ng/g; in fawns (age 0.0-0.5 yr, N= 12) was 18, 29, 60, and 22 ng/g, respectively; in yearlings (age 0.5-2.5 yr, N= 6)was 9, 51, 60, and 31 ng/g, respectively; in adults (age 2.5 to 10 yr, N= 42) was 16, 130, 950, and 42 ng/g, respectively; and in adults (age 10 to 17.5 yr, N= 17) was 20, 131, 1080, and 52 ng/g, respectively. The mean Cd concentration in fleece of fawns, yearlings, and adults (age 2.5 to 10 yr) was 55, 37, and 28 ng/g, respectively. The Cd levels in bone samples form two adult serows ranged from 0.4 to 0.8 ug/g. The body burdens of fetuses were low (<1%) compared with those of their mothers. The placental transfer of Cd was negligible; after birth, Cd levels increased each year. There was a significant difference in Cd concentration between collection locations, which was attributed to direct intake of Cd in soil.
[Honda K et al; Arch Environ Contam Toxicol 16: 551-61 (1987)]**PEER REVIEWED**

Cadmium is absorbed poorly from the gastrointestinal tract ... Absorption from the respiratory tract appears to be more complete; cigarette smokers may absorb 10-40% of inhaled **cadmium**. After absorption, **cadmium** is transported in blood, bound mainly to blood cells and albumin. ... After distribution, approx 50% of the total body burden is found in the liver and kidney. /**Cadmium**/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1662]**PEER REVIEWED**

In the blood, a small-molecular weight plasma protein known as metallothionein binds **cadmium**. The elimination half-life of **cadmium** is long (16-33 yr) ... /**Cadmium**/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 1018]**PEER REVIEWED**

IRRESPECTIVE OF MODE OF ADMIN, **CADMIUM** CROSSES PLACENTAL BARRIER IN PREGNANT RATS & HAMSTERS, AS SHOWN BY DETECTABLE AMT IN LIVER, BRAIN & DIGESTIVE TRACT OF NEWBORN. MORE THAN 2.5 TIMES THE AMT WAS FOUND IN LIVERS OF ... TEST ANIMALS ... THAN IN CONTROL ... HOWEVER, THERE IS EFFICIENT PLACENTAL BARRIER AGAINST CD IN GOATS. /**CADMIUM**/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 78]**PEER REVIEWED**

ABOUT 5% OF **CADMIUM** INGESTED BY HUMAN ... IS ABSORBED, BUT CALCIUM AND IRON DEFICIENCY MAY INCR THIS AMOUNT. PORTION OF INHALED **CADMIUM** ABSORBED IS DEPENDENT ON PARTICLE SIZE & SOLUBILITY. ABSORBED **CADMIUM** IS MAINLY STORED IN KIDNEYS & LIVER. EXCRETION IS SLOW, LESS THAN 0.01% OF BODY BURDEN/DAY. /**CADMIUM**/
[Friberg, L., G.R. Nordberg, and V.B. Vouk. Handbook on the Toxicology of Metals. New York: Elsevier North Holland, 1979. 355]**PEER REVIEWED**

WHEN RENAL DAMAGE HAS OCCURRED, **CADMIUM** EXCRETION BY URINE INCR DRAMATICALLY ... /**CADMIUM**/
[Friberg, L., G.R. Nordberg, and V.B. Vouk. Handbook on the Toxicology of Metals. New York: Elsevier North Holland, 1979. 363]**PEER REVIEWED**

IN MANY SPECIES, INCLUDING MICE, RATS, GUINEA PIGS, RABBITS, DOGS & MONKEYS, ABOUT 10-40% OF **CADMIUM** IS RETAINED AFTER INHALATION OF **CADMIUM** CMPD. ... STUDIES IN MICE INDICATE THAT LESS THAN 10% OF ORAL DOSE IS ABSORBED ... /**CADMIUM**/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 87 (1973)]**PEER REVIEWED**

(115)**CADMIUM** WAS FOUND TO ACCUMULATE SELECTIVELY IN RAT KIDNEY CORTEX. (109)**CADMIUM** GIVEN SC TO RATS IMMEDIATELY APPEARED IN BLOOD PLASMA & THEN DISAPPEARED RAPIDLY; AFTER 6 DAYS ONLY 2% OF DOSE WAS EXCRETED IN FECES. /**CADMIUM**/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 87 (1973)]**PEER REVIEWED**

EXCRETION VIA FECES OF NORMAL HUMANS IS ABOUT 30-50 UG/DAY. RETENTION OF INGESTED **CADMIUM** VARIED BETWEEN 4.7-7% IN FIVE ADULT MEN. ONLY VERY SMALL PROPORTION OF DAILY ABSORBED DOSE WILL BE EXCRETED ... NORMAL URINARY EXCRETION IN HUMANS ... 1-2 UG PER DAY. /**CADMIUM**/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 89 (1973)]**PEER REVIEWED**

IN MAMMALS ... **CADMIUM** ... WILL ACCUMULATE ESPECIALLY IN LIVER & KIDNEYS ... STUDIES IN MICE USING AEROSOLS OF **CADMIUM** CMPD SHOWED THAT PARTICLES OF LESS THAN 2 MICRONS WERE FOUND IN LUNGS & WERE ALSO ABSORBED & CONCENTRATED IN KIDNEYS. /**CADMIUM**/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 87 (1973)]**PEER REVIEWED**

CADMIUM (CD) CONCN IN BLOOD & URINE OF EXPOSED & NON-EXPOSED WORKERS WAS MEASURED. SIGNIFICANT POS CORRELATION OBSERVED. CONCN IN BLOOD RELATED TO ENVIRON CD OVER 30 UG/CU M OF EXPOSURE. OVER 6 MO EXPOSURE TO SAME LEVEL SUDDENLY INCR CD-URINE EXCRETION. /**CADMIUM**/
[KONO K ET AL; PROC INT CONGR OCCUP HEALTH 19TH 1 (CHEM HAZARDS): 207 (1980)]**PEER REVIEWED**

Nonradioactive and radioactive metal salts were administered intravenously to Sprague Dawley rats. The highest amount of each metal approached the maximum tolerated dose. Cobalt (Co), silver (Ag), and manganese (Mn) were eliminated rapidly. The elimination of 20 to 50% of the dosage was observed for copper (Cu), thalium (Tl), bismuth (Bi), lead (Pb), cesium (Cs), gold (Au), zinc (Zn), mercury (Hg), selenium (Se), and chromium (Cr). The slowest excretion rate was measured for arsenic (As), **cadmium** (Cd), iron (Fe), methylmecury (MeHg), and tin (Sn). No substantial elimination rate decline was observed for MeHg and Fe, and the decline was small for Tl, Cs, Hg, Sn, Co, Ag, Zn, Cr, and As. Elimination of Ag and Mn via feces was fast, with more than 70% eliminated on the first day. Cu, Tl, Pb, and Zn were excreted at a slower rate, with 30.6 to 38.3% excreted on the first day. The rest of the metals were eliminated slowly by the intestinal route. Co was removed rapidly via urine, while Pb, Sn, Zn, MeHg, Ag, Fe, Mn, and Cd were eliminated slowly. The biliary excretion of Ag, As, and Mn was fast, with 25.5, 30.2 and 16.2% eliminated in two hours. Cu, Se, Cd, Pb, Bi, and Co were eliminated at an intermediate rate via the biliary route. Ag, As, Mn, Cu, Se, Cd, Pb, Bi, and MeHg were highly concentrated in bile relative to plasma. Liver and kidney contained the highest concentrations of most metals. The intestinal route was the major path of elimination for Ag, Mn, Cu, Tl, Pb, Zn, Cd, Fe, and MeHg. Co, Cs, Au, Se, and Cr, were removed predominantly by urine. For Bi, Hg, As, and Sn the two routes were similar. /**Cadmium** salts/
[Gregus Z, Klaassen CO; Toxicol Appl Pharm 85 (1): 24-38 (1986)]**PEER REVIEWED**

Newborn rats absorbed 12% of a dose of **cadmium**, whereas adult rats absorbed only 0.5%. /**Cadmium**/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 97]**PEER

REVIEWED**

Vitamin C reduces ... **cadmium** absorption, probably because of increased absorption of ferrous ion. /**Cadmium**/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 693]**PEER REVIEWED**

... **Cadmium** accumulates with age in horse kidney. /**Cadmium**/
[WHO; Environmental Health Criteria 134: Cadmium p.50 (1992)]**PEER REVIEWED**

The concentrations of mercury (Hg), **cadmium** (Cd) and lead (Pb) in brain (cerebrum) and kidney during fetal (second trimester terminations or abortions, n = 20) and postnatal (infants deceased before three months of age, n = 15) development have been studied. Information on possible sources of exposure was obtained from the mothers of the fetuses, but not from those of the infants. The concentration of Cd in the brain was less than 1 ug/kg in most cases, both in fetuses and infants. The concentration of Cd in the kidneys was significantly higher, with a median of about 2 ug/kg (1-8 ug/kg) in both groups. There was no detectable association between tissue Cd concentrations and the smoking habits of the mothers. In general, the concentrations of Cd and Pb were lower than in previously reported studies.
[Lutz E, et al; J Trace Elem Med Biol 10 (2): 61-7 (1996)]**PEER REVIEWED**

Pregnant Syrian hamsters were given a dose of 3.9 micromoles **cadmium** ion/kg (radiolabelled with 109cadmium) on days 7,8,9, and 11 of gestation. Animals were sacrificed on day 13 of gestation and maternal blood, liver, kidney, placentas, and fetuses collected. No pathology was observed in placentas or fetuses. Maternal liver accounted for 61% of the total **cadmium** injected (15.6 micromoles/kg dam), maternal kidney 4%, and placentas 0.24%. Maternal blood and fetuses contributed negligibly to the total body burden of **cadmium**. Gel filtration experiments indicated two major **cadmium** fractions in maternal liver, maternal kidney, and placental cytosols, one at the excluded volume and another nearly twice the excluded volume. Further purification and characterization of the **cadmium** fraction eluting at twice the excluded volume in the gel filtration experiments showed it to be **cadmium** metallothionein. Ion exchange chromatography on DEAE Sephacel revealed two forms of **cadmium** metallothionein in the cytosols of maternal liver and placentas. Maternal kidney cytosols contained one **cadmium** metallothionein. Amino acid analyses suggest that the thionein components of placental cytosols are synthesized in situ.
[Hanlon DP et al; Reprod Toxicol 3 (1): 51-7 (1989)]**PEER REVIEWED**

Biological Half-Life:

An accumulation of **cadmium** occurs in many tissues and particularly long half-times, 10-30 years, have been reported for muscles, kidneys and liver. /**Cadmium**/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 130]**PEER REVIEWED**

Reported half-times range from several weeks in mice to 22 years in monkeys. /**Cadmium**/
[WHO; Environmental Health Criteria 134: Cadmium p.87 (1992)]**PEER REVIEWED**

Mechanism of Action:

CADMIUM ... IS REPORTED TO BLOCK RENAL SYNTH OF 1,25-DIHYDROXYCHOLECALCIFEROL, THE METABOLICALLY ACTIVE FORM OF VITAMIN D; THIS COULD BE INDIRECTLY RESPONSIBLE FOR SKELETAL ABNORMALITIES FOUND IN **CADMIUM** EMBRYOTOXICITY, IE, LACK OF BONE MINERALIZATION &

OSTEOMALACIA ... /**CADMIUM** COMPOUNDS/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 82]**PEER REVIEWED**

CADMIUM SALTS IN VITRO UNCOUPLE OXIDATIVE PHOSPHORYLATION OF SUCCINATE OR CITRATE BY LIVER MITOCHONDRIA. /**CADMIUM** SALTS/
[Thienes, C., and T.J. Haley. Clinical Toxicology. 5th ed. Philadelphia: Lea and Febiger, 1972. 187]**PEER REVIEWED**

A mouse hepatoma cell line selected for resistance to **cadmium** (Cdr 80 hepa) was compared to the unselected parental hepatoma cell line (Cds hepa) in terms of its sensitivity to a variety of metal ions. The Cdr 80 hepa cells have double minute chromosomes which carry amplified copies of the MT-I and MT-II genes and can accumulate approximately 20 fold more MT mRNA than Cds hepa cells when stimulated with an optimal sode of **cadmium**. The metals zinc, copper, silver, cobalt, mercury, and bismuth also induce higher levels of MT mRNA in the resistant cells than in the unselected cells, yet the Cdr 80 hepa cella only show increased resistance to the toxic effects of zinc, copper, mercury, and bismuth. /**Cadmium** ion/
[Dumam DM, Palmiter RD; Experientia (Suppl) 52: 457-63 (1987)]**PEER REVIEWED**

Interactions:

CONCOMITANT INJECTION OF **CADMIUM** & ZINC SALTS PROTECTED TESTES COMPLETELY. PROTECTION AFFORDED WAS RELATED TO ZINC-**CADMIUM** MOLAR RATIO, AMT OF ZINC 80-200 TIMES THAT OF **CADMIUM** WAS EFFECTIVE /IN RATS, INJECTED SUBCUTANEOUSLY/. /**CADMIUM** SALTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-79]**PEER REVIEWED**

BAL (dimercaprol) increases the liver injury produced by **cadmium** in rabbits.
[Gilman A et al; J Pharmacol Exper Ther 87 (Suppl): 85-101 (1946)]**PEER REVIEWED**

Female Swiss mice were exposed to **cadmium** in the drinking water at concentrations ranging from 0 to 50 ppm for 105 or 280 day time periods. In the 105 day study, the effect of **cadmium** on urethan induced pulmonary adenoma formation was evaluated. Urethan induced sleeping times observed following ip injection of urethan after 3 weeks of **cadmium** exposure were not affected by **cadmium** indicating that chronic **cadmium** exposure did not alter the elimination of urethan. Pulmonary adenoma formation which was evaluated 84 days later was not affected by **cadmium**. The size and number of tumors remained unchanged. Immunosuppressive actions of **cadmium** do not influence urethan induced adenoma formation. In the 280 day study the effects of **cadmium** on the incidence of spontaneous murine lymphocytic leukemia were evaluated. Mice exposed to 10 or 50 ppm **cadmium** experienced 33% more deaths from the virus. The average time till death was unaffected. Immunosuppressive effects of **cadmium** impair immunosurveillance mechanisms that control expression of the murine lymphocytic leukemia virus. /**Cadmium**/
[Blakely BR; Appl Toxicol 6 (6): 425-9 (1986)]**PEER REVIEWED**

Sodium alginate can ... decrease the retention of ... radioactive divalent metallic ions in rats ... with ... /**Cadmium**/ levels being reduced to ... about 50% in three weeks. /**Cadmium**/
[Leung, A.Y., Foster, S. Encyclopedia of Common Natural Ingredients Used in Food, Drugs, and Cosmetics. New York, NY. John Wiley & Sons, Inc. 1996. 17]**PEER REVIEWED**

Selenium may prevent the toxic effects of **cadmium** on rat testicular tissue ... /**Cadmium**/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 720]**PEER

REVIEWED**

Experimental (animal): Rabbits exposed to **cadmium** on a long-term basis and treated with calcium disodium EDTA suffered severe degenerative renal changes as a result of treatment with this chelator. /Inorganic **cadmium**/
[Friberg L; Arch Indust Health 13: 13-23 (1956)]**PEER REVIEWED**

Investigators noted that penicillamine given to **cadmium** poisoned mice resulted in extensive necrosis of the distal portion of the convoluted proximal tubule; most of the nephrons were involved. /Inorganic **cadmium**/
[Klaassen CD et al; Environ Health Perspect 54: 233-242 (1984)]**PEER REVIEWED**

BAL (dimercaprol) increases the liver injury produced by **cadmium** in rabbits. /Inorganic **cadmium**/
[Gilman A et al; J Pharmacol Exper Therap 87 (Suppl): 85-101 (1946)]**PEER REVIEWED**

Pharmacology:

Therapeutic Uses:

/FORMER:/ MEDICATION (VET): **CADMIUM** SALTS ... USED ... AS ANTIHELMINTHICS, ASCARICIDES, NEMATOCIDES ... IN VETERINARY MEDICINE ... ARE OBSOLETE. /**CADMIUM** SALTS/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 76]**PEER REVIEWED**

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[Klaassen CD et al; Environ Health Perspect 54: 233-242 (1984)]**PEER REVIEWED**

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[Gilman A et al; J Pharmacol Exper Therap 87 (Suppl): 85-101 (1946)]**PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Cadmium is a relatively rare, naturally occurring element that is widely distributed in the earth's crust. It may enter the environment during the mining, ore processing and smelting of zinc and zinc-lead ores in which **cadmium** is found and during its recovery, refining, manufacture of **cadmium** compounds, use of **cadmium** metals, alloys and compounds, recycling, and disposal. **Cadmium**'s initial route of entry is often via the atmosphere. Since it occurs naturally in the earth's crust, **cadmium** may also enter the atmosphere from the weathering of rocks, windblown soil, and volcanos. However, these sources are minor compared with anthropogenic ones. In the environment, **cadmium** occurs as Cd(II). If released or deposited on soil, **cadmium** will largely be retained in the surface layers of soil. Adsorption increases with pH and the organic content of the soil. Therefore leaching is more apt to occur under acid conditions in sandy soil. Other studies indicate that **cadmium** adsorption correlates most with the cation exchange capacity of the soil (CEC) especially when the soil is saturated in divalent cations. In soil, **cadmium** is also expected to convert to more insoluble forms such as the carbonate in aerobic environments and the sulfide in anaerobic ones. **Cadmium** enters surface water from atmospheric fallout, runoff or wastewater. In natural waters, **cadmium** can be found in several chemical forms - as the Cd++ or its hydrates, as metal-inorganic complexes, and metal-organic complexes. It may occur in a dissolved, colloidal or particulate form. In freshwater, the most important inorganic complexes are with OH- and HCO3-. In seawater, they are with Cl-. **Cadmium** is removed from the water column by adsorption to organic matter in sediment. It may also precipitate as the carbonate or be adsorbed by or coprecipitate with hydrous iron, aluminum, and manganese oxides. **Cadmium** is taken up by fish through the gills and largely concentrates in the liver and kidneys. When released to the atmosphere, **cadmium** will generally occur as particulate matter and be subject to dry and wet deposition. While anthropogenic releases are as small particles, most **cadmium** appears to be deposited relatively close to its source. **Cadmium** would be expected to be transformed to the oxide and carbonate in the atmosphere. The general population is exposed to **cadmium** from ambient air, especially in areas near industrial

sources. However, the highest **cadmium** intake is from dietary sources. Exposure to **cadmium** in the workplace is generally via inhalation. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

OCCUPATIONAL EXPOSURE: EXPOSURE OCCURS PRIMARILY IN SMELTING & REFINING ZINC, LEAD & COPPER ORES CONTAINING **CADMIUM**, SPRAYING **CADMIUM** CONTAINING PIGMENTS, PROCESSING SCRAP CONTAINING **CADMIUM**, ETC. /**CADMIUM**, ALLOYS, COMPOUNDS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 233]**PEER REVIEWED**

The major route of exposure to **cadmium** for the non-smoking general population is via food ... Tobacco is an important source of **cadmium** uptake in smokers.
[WHO; Environmental Health Criteria 134: Cadmium p.18 (1992)]**PEER REVIEWED**

In locations where health effects from **cadmium** have been reported, water and air contamination from non-ferrous metal mining and production are the predominant sources of general population exposure to **cadmium**(1). All major areas in Japan with elevated **cadmium** levels have been affected by these sources. **Cadmium** intake in children via the ingestion of household dust (hand-mouth route) is about 0.7 ug/day assuming an average cadium concentration in dust of 6.9 mg/kg of dust(1). THerefore ingestion of dust by children is unlikely to be important route of exposure except in the most contaminated localities(1).
[(1) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992)]**PEER REVIEWED**

At the time when the consumption of **cadmium** for coatings and plating started to decline, the **Cadmium** Council, Inc. found that occupational exposures in most **cadmium** plating shops were below 2.5 ug/cu m in air(1). Inhalation of air is the dominant source of occupational exposure to **cadmium**(2). Dust particles cleared from the lungs may be swallowed and dust-contaminated food can be a significant contribution to the ingestion pathway(2). Air **cadmium** concns reported in various workplaces (workplace, air concn in ug/cu m): Two pigment factories, 150-1600 (personal air, respirable fraction), 0.18-3.0 (respirable fraction); Two foundries, 87 (fumes, personal air), 28 (fumes, personal air); alloy processing, 3 (fumes, personal air); Two Ni-Cd battery plants, <20, 7-39; Alkaline batteries, 10-4300 (CdO, total dust)(3).
[(1) US Dept Int; U.S. Geological Survey, Minerals Information - 1997: Cadmium, http://minerals.er.usgs.gov/minerals/pubs/commodity/cadmium (1997) (2) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992) (3) Schaller KH, Angerer J; in IARC Sci Publ 118(Cadmium in the Human Environment): 53-63 (1992)]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 102,665 workers are potentially exposed to some form of **cadmium** in the USA(1).
[(1) NIOSH; National Occupational Exposure Survey (1989)]**PEER REVIEWED**

Body Burden:

To assess the pathophysiologic significance of increased body burdens of **cadmium** (Cd), cross-sectional evaluation of renal function and calcium, phosphorus and vitamin D metabolism was carried out in 38 industrial workers exposed to Cd for 11-37 yr. Average airborne concentrations of Cd ranged from 5 - 229 ug/cu m. Mean kidney Cd burden was 7.4 + or - 4.4 mg in nonsmokers and 12.3 + or - 7.2 mg for smokers. Mean liver Cd in nonsmokers was 4.5 + or -2.6 ug/g and 7.9 + or -4.9 ug/g in smokers. Liver or

kidney Cd burden was considered elevated in 31% of the workers. Creatinine clearance was normal in all workers. Maximal urinary concentrating ability was abnormal in a significant fraction (52%) of the men.
[Greenberg A et al; Arch Environ Health 41 (2): 69-76 (1986)]**PEER REVIEWED**

/IN MAN/ ABOUT HALF OF TOTAL BODY BURDEN IS FOUND IN LIVER & KIDNEYS ... **CADMIUM** IN THESE ORGANS IS MAINLY BOUND TO A LOW MOLECULAR WEIGHT PROTEIN, IN FORM OF A METALLOTHIONEIN ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 90 (1973)]**PEER REVIEWED**

The body burden of **cadmium** in a 50 yr old adult in the US is about 30 mg.
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1662]**PEER REVIEWED**

The mean blood **cadmium** concn found in non-smoking men in the 24 towns and cities included in the British Regional Heart Study ranged from 0.35 ug/l (Guildford) to 1.93 ug/l (Shrewsbury)(1). The arithmetic mean, geometric mean, median, and range for **cadmium** in 210 samples of human milk across Canada were (ng/g): 0.08, 0.063, 0.06, and <0.002-4.05, respectively(2).
[(1) Thornton,I.; Sources and pathways of cadmium in the environment.IARC SCI. PUBL. 118(Cadmium in the Human Environment):149-62.(1992) (2) Dabeka RW et al; Sci Tot Environ 71: 65-6 (1988)]**PEER REVIEWED**

Average Daily Intake:

AIR: (Assume 10 ng/cu m for both indoor and outdoor air(6)) 0.20 ug. In contaminated areas (assuming an air concn of 0.5 ug/cu m(6)) 10 ug. Smoking a pack of cigarettes daily can result in the inhalation of 2-4 ug **cadmium** per day depending on the tobacco smoked(6). WATER: Usually less than 1 ug(6). FOOD: Average daily intakes of **cadmium** from diet estimated for 8 population groups from U.S. FDA's Total Diet Study were(age/sex group, average daily intake in ug/day): 6-11 mo, 4.2; 2 yr, 7.3; 14-16 yr female, 10.6; 14-16 yr male, 15.4; 25-30 yr female, 10.6; 25-30 yr male, 15.0; 60-65 yr female, 9.6; 60-65 yr male, 12.7(5). The 234 representative food items for the survey were obtained in retail markets in 4 broad geographical areas of the US between 1982 and 1984. Results of the FDA's Total Diet Study for 1986-1991 are age/sex group, average daily intake in ug/kg body wt-day): 6-11 mo, 0.36, 2 yr, 0.46; 14-16 yr female, 0.17; 14-16 yr male, 0.22; 25-30 yr female, 0.16; 25-30 yr male, 0.17; 60-65 yr female, 0.14; 60-65 yr male, 0.15(7). For a 25-30-year male, 37 foods, primarily grain, potato, and lettuce contributed 80% of the total daily intake(7). The normal dietary **cadmium** intake in Britain estimated from food acquisitions of more than 7000 households was <0.15 mg/week(1). The intake in the U.S. was 0.23 mg/wk and that in 7 other countries ranged from 0.11 to 0.38 mg/wk. Two studies reporting dietary intakes by children was 0.20 mg/wk and 0.13 mg/wk in Germany and Poland, respectively. According to a Canadian survey of drinking water, the average daily intake of **cadmium** from drinking water is less than or equal to 0.01 ug(2). The mean, median and 95th percentile for dietary exposure to **cadmium** from traditional food among adult indigenous people (Dene/Metis) in the western Northwest Territories, Canada (n=1012) was <0.1 ug/kg; the 99th percentile was 0.1 ug/kg/day(3). The estimated dietary intake of **cadmium** (ug/kg-day) by 0-12 month-old infants fed only (formula/milk, intake): human milk, 0.31; evaporated milk, 0.33; milk-based formula, 0.34; soy-based formula, 0.63(4).
[(1) Thornton I; in IARC Sci Publ 118(Cadmium in the Human Environment): 149-62 (1992) (2) Meranger JC et al; Environ Sci Technol 13: 707-711 (1979) (3) Berti PR et al; Environ Research Section A 76:131-42 (1998) (4) Dabeka RW; Sci Tot Environ 89: 279-89 (1989) (5) Gunderson EL; J Assoc Off Anal Chem 71: 1200-9 (1988) (6) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992) (7) Gunderson EL; J AOAC International 78: 1353-63 (1995)]**PEER REVIEWED**

The **cadmium** intake of dust by children via the hand-to-mouth route (assuming 6.9 mg Cd/kg in dust and 100 mg/day intake) is 0.7 ug(1).
[(1) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992)]**PEER REVIEWED**

Natural Pollution Sources:

Volcanic activity is a major natural source of atmospheric **cadmium** release.
[WHO; Environmental Health Criteria 135: Cadmium - Environmental Aspects p.24 (1992)]**PEER REVIEWED**

Cadmium content /in/: sphalerite: 0.0001-2%; greenockite: 77.8%; hawleyite: 77.8%; chalcopyrite: < 0.4-110 ppm; marcasite: < 0.3-<50 ppm; arsenopyrite: < 5 ppm; galena: < 10-3000 ppm; pyrite: < 0.06-42 ppm; pyrrhotite: trace; tetrahedrite: 80-2000 ppm; magnetite: 0-0.31 ppm; **cadmium** oxide: 87.5%; limonite: < 5-1000 ppm; wad and manganese oxides: < 10-1000 ppm; anglesite: 120->1000 ppm; barite: < 0.2 ppm; anhydrite and gypsum: < 0.2 ppm; calcite: < 1-23 ppm; smithsonite: 0.1-2.35%; otavite: 65.18%; pyromorphite: < 1-8 ppm; scorodite: < 1-5.8 ppm; beudantite: 100-1000 ppm; apatite: 0.14-0.15 ppm; bindheimite: 100-1000 ppm; silicates: 0.03-2.8 ppm.
[Nat'l Research Council Canada; Cadmium p.17 (1979) NRCC No.16743]**PEER REVIEWED**

Volcanic action is considered to be the major natural source of **cadmium**. This is related to the very large quantities of particulate matter emitted, together with high enrichment of **cadmium** in volcanic aerosols. An investigation into trace element emissions from Mount Etna in Sicily estimated that 2.8 x 10-2 tons/day, or about 10 tons/year of **cadmium** was discharged into the atmosphere.
[Baut-Menard P, Arnold M; Geophys Res Lett 5: 245-8 (1978)]**PEER REVIEWED**

Coal and other fossil fuels contain **cadmium**, and their combustion releases the element into the environment.
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1662]**PEER REVIEWED**

/Occurs in/ a greenockite (**cadmium** sulfide) ore containing zinc sulfide; also in lead and copper ores containing zinc. /Found/ in Canada, central and western USA, Peru, Australia, Mexico and Zaire.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 12th ed. New York, NY: Van Nostrand Rheinhold Co., 1993 194]**PEER REVIEWED**

Found in zinc ores; also as CdS, greenockite; CdCO3, otavite.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 265]**PEER REVIEWED**

Cadmium is a naturally occurring element, albeit a relatively rare one, that is widely distributed in the earth's crust with a crustal abundance between 0.1 and 0.5 ppm(1,2). Several minerals of **cadmium** have been identified, the most common of which is greenockite, CdS(2). It is usually found in zinc ores in which the CdS crystals are isomorphic to the zinc mineral sphalerite, ZnS. **Cadmium** is a natural constituent of rock phosphates with some deposits having markedly elevated levels of the metal(1). Weathering of rocks injects a large amount of **cadmium** into the word's rivers and oceans; the annual gross input has been estimated as 15,000 metric tons(1). Volcanic activity is a major natural source of **cadmium** to the atmosphere which is estimated as 100-500 metric tons annually(1). Deep sea volcanism is another source that has yet to be quantified. Mean global atmospheric emissions of **cadmium** from natural sources have been estimated to be 1,000 metric tons per year(3).
[(1) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992) (2) Carr DS; Kirk-Othmer Encycl Chem Tech. 4th. NY,NY: John Wiley

& Sons 4: 748-60 (1992) (3) Nriagu JO, Pacyna JM; Nature 333: 134-9 (1988)]**PEER REVIEWED**

Artificial Pollution Sources:

The mining, ore processing, and smelting of **cadmium**-zinc and **cadmium**-zinc-lead ores, the refining of the metal, the production of **cadmium** alloys and compounds, and the use of **cadmium** metal, alloys and compounds, their recycling, and disposal(1) may result in the release of **cadmium** to the environment through various waste streams(SRC). Sources of **cadmium** emissions to air were primarily ferrous metal production, non-ferrous metal production, oil combustion, coal combustion, and waste incineration(2). Sources of effluents to water were primarily ferrous metal production, non-ferrous metal production, manufacture of pigments, **cadmium** plating, and battery manufacture(2). **Cadmium** disposal in landfills were primarily from ferrous metal production, non-ferrous metal production, cement manufacture, and ashes from combustion(2). A study of **cadmium** deposition at seven sites (3 industrial, 3 residential and 1 commercial) in Detroit between 1982 and 1992 found that the mean dry deposition flux remained relatively constant over the decade (at 0.2 g/sq km-day) suggesting that emissions of **cadmium** to air were unchanged during that time period(3).
[(1) Carr DS; Kirk-Othmer Encycl Chem Tech. 4th. NY, NY: John Wiley and Sons 4: 748-60 (1992) (2) Thornton I; in IARC Sci Publ 118(Cadmium in the Human Environment): 149-62 (1992) (3) Pirrone N et el; Sci Tot Environ 162: 43-61 (1995)]**PEER REVIEWED**

Of the two basic methods of zinc production, thermal smelting and electrolytic refining, only the former releases significant emissions of **cadmium**(1). **Cadmium** emissions at a lead smelter is expected to be elemental **cadmium** and the oxide(3). The two US primary **cadmium** producers both employ electrolytic refining(2). **Cadmium** release from industries that employ thermal process such as iron production, fossil fuel production and cement manufacture result from the presence of small amounts of **cadmium** in the raw material. The large quantities of material processed result in large releases of **cadmium**. In these processes, **cadmium** is volatilized and then condenses in very small particles which are poorly retained by particle control devises(1). In developed countries in western Europe, refuse incineration accounts for about a third of **cadmium** releases to the atmosphere(1). Discharges of **cadmium** to water are primarily associated with non-ferrous metal mining and production where effluents are produced from site drainage and processes such as gas scrubbing(1). Much of the **cadmium** deposited on land result from the landfilling of large volume waste such as ash from fossil fuel combustion, municipal solid waste, and sewage sludge that contain low concentrations of **cadmium**. Of greater environmental significance are the solid wastes arising from non-ferrous metal manufacturing, the manufacture of **cadmium**-containing products, and refuse incineration as these wastes are characterized by elevated **cadmium** levels. The rate of **cadmium** input to agricultural soil from phosphate fertilizers is about 5 g/ha(1). While this represents only about 1% of the surface soil **cadmium**, long-term application of fertilizers have resulted in increased **cadmium** levels in the soil.
[(1) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992) (2) US Dept Int; US Geological Survey, Minerals Information - 1997: Cadmium, http://minerals.er.usgs.gov/minerals/pubs/commodity/cadmium (1997) (3) Struck BD et al; Sci Tot Environ 182: 85-91 (1996)]**PEER REVIEWED**

Corrosion of soldered joints or zinc galvanized plumbing may release **cadmium** into tap water(1). Similarly, acid rain may result in the mobilization of **cadmium** from soil and its entry into surface water as runoff(1).
[(1) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992)]**PEER REVIEWED**

Environmental Fate:

TERRESTRIAL FATE: **Cadmium** is adsorbed to soil but to a much lesser extent than most other heavy metals(1-3). The most important soil properties influencing adsorption is pH and organic content; sorption is strongly correlated with both these properties. Leaching may therefore be expected in acidic, sandy soil.
[(1) Elliott HA et al; J Environ Qual 15: 215-9 (1986) (2) Gerritse RG, van Dreil W; J Environ Qual 13: 197-204 (1984) (3) King LD; J Environ Qual 17: 239-46 (1988)]**PEER REVIEWED**

AQUATIC FATE: Much of the **cadmium** entering surface water from industrial sources is rapidly adsorbed onto particulate matter and settles out. All studies show that **cadmium** concns in bed sediment is at least an order of magnitude higher than in the overlying water(1). **Cadmium** is always found as Cd (II) in water(1). Therefore the redox potential has little effect on the valency of **cadmium**. In natural waters, **cadmium** can be found in several chemical forms - as the Cd++ or its hydrates, as metal-inorganic complexes, and metal-organic complexes(1). It can occur as a colloid or in particulate form. Up to a pH of 9, almost all of the soluble **cadmium** is in the divalent cation form. Above this pH, Cd(OH)2 precipitates out. Under reducing conditions and in the presence of sulfur, insoluble CdS (log Ksp = 5.73) may form(1). In the absence of metal-organic complexes, the most important species in freshwater is predicted from their stability constants to be Cd++, Cd(OH)+, Cd(HCO3)+, and Cd(OH)2. In seawater, the most important species are predicted to be CdCl2, CdCl+, CdCl3-, Cd++, and Cd(OH)2(2,4). Studies of the speciation of **cadmium** in natural waters indicate that humic substances account for most of the complexing, followed in importance by carbonates(1). Hardness and pH had no significant effect on **cadmium**-inorganic interaction but had a pronounced effect on interactions with humic material. Many aquatic plants have the ability to accumulate **cadmium**, primarily in the roots, but also in the stem and leaves(3). Fractionation studies have shown that the dominant fraction of **cadmium** in anaerobic sediment is a nonresidual sulfitic one(5). Due to this association, this **cadmium** is rendered less bioavailable, especially since bottom sediments tend to become more reduced because of the continuous release of electrons to the environment through microorganism respiration processes(5). Remobilization of **cadmium** may occur when anoxic sediment is exposed to an oxidizing environment(5).
[(1) Callahan MA et al; Water-Related Fate of 129 Priority Pollutants Vol I pp. 9-1 to 9-20, USEPA-440/4-79-029A (1979) (2) Long DT, Angino EE; Geochim Cosmochim Acta 412: 1183-91 (1977) (3) McCracken IR; pp. 89-116 in Cadmium in the Aquatic Environment, Nriagu JO and Sprague JB, ed. NY,NY: Wiley (1987) (4) Sadiq M; Environ Technol Letters 10: 1057-70 (1989) (5) Kersten M, Forstner U; pp. 51-88 in Cadmium in the Aquatic Environment, Nriagu JO and Sprague JB, ed. NY,NY: Wiley (1987)]**PEER REVIEWED**

ATMOSPHERIC FATE: **Cadmium** released to the atmosphere will be in particulate matter and be returned to the earth by dry and wet deposition. For both rural and remote areas of the world, the estimated deposition rate for wet deposition of **cadmium** is almost twice that for dry deposition(3). Of the estimated 0.35 ng/sq-cm-yr of **cadmium** deposited in the tropical North Pacific Ocean, approximately 30% is a result of dry deposition and 70% wet deposition(2). **Cadmium** is primarily associated with small particles such as are produced by combustion processes; its mass median diameter is fairly small, 0.84 um (5). As a result of their small size, **cadmium**-containing particles can stay aloft long periods of time and travel long distances. Nevertheless, studies at a lead smelter using bulk deposition collectors indicate that **cadmium** from emission sources is primarily deposited close to (<5 km) the source(3). A study showing that the **cadmium** concn in the upper 2 cm of lakes in the U.S. Arctic is similar to that in the pre-1900 sediment core suggests that there is no enrichment of the surface due to recent anthropogenic activity and that **cadmium** is not transported long distances from smelters and other emission sources to the Arctic(4). Recycled sea spray represents a significant but variable component of the deposition. The average annual scavenging ratio (concn in precipitation (mg/l) to air concn (ug/cu m)) for Cd is 0.44X10+6(1). The mean ratio of wet to dry deposition of **cadmium** in

southern, central and northern Ontario is 3.27, 1.91, and 6.35, respectively(1). For fine particles, this ratio is generally higher away from source areas. Wet and dry atmospheric deposition of **cadmium** measured at biweekly intervals between 9/92 and 9/93 at two sites on Massachusetts Bay averaged 405 ug/sq m-yr(6). Transformations of **cadmium** to the carbonate and oxide may be expected in the atmospheric environment.
[(1) Chan WH et al; Water Air Soil Pollut 29: 373-89 (1986) (2) Arimoto R et al; J Geophys Res 90: 2391-408 (1985) (3) Pilgrim W, Hughes RN; Environ Monit Assess 32: 1-20 (1994 (4) Allen-Gil SM et al.; Environ Toxicol Chem 16: 733-41 (1997) (5) Pirrone N et el; Sci Tot Environ 162: 43-61 (1995) (6) Golomb D et al; Atmos Environ 9: 1349-59 (1997)]**PEER REVIEWED**

Environmental Biodegradation:

No evidence was found that biomethylation of **cadmium** occurs(1).
[(1) Callahan MA et al; Water-Related Fate of 129 Priority Pollutants Vol I pp. 9-1 to 9-20, USEPA-440/4-79-029A (1979)]**PEER REVIEWED**

Environmental Abiotic Degradation:

No evidence was found indicating that photolysis is an important mechanism determining the fate of **cadmium** in the environment(1). Little data are available on the occurrence and speciation of **cadmium** compounds and complexes in nature. The **cadmium** species present in the aquatic environment will be governed by the species present, their solubility products, rates of dissolution, pH, redox potential, and temperature. In rainwater, the solubilities of the probable compounds are much higher that the total **cadmium** concentration suggesting that there are insoluble **cadmium**-containing components in atmospheric particulate matter(2). In aerobic environments, **cadmium** may be expected to precipitate as the carbonate(3). In reducing environments, **cadmium** might be expected to form the sulfide. Such precipitates have not been reported as distinct mineral phases in soil(3). In seawater, the precipitation of the carbonate and phosphate are thought to control **cadmium** concn in seawater(4).
[(1) Callahan MA et al; Water-Related Fate of 129 Priority Pollutants Vol I pp. 9-1 to 9-20, USEPA-440/4-79-029A (1979) (2) Struck BD et al; Sci Tot Environ 182: 85-91 (1996) (3) Evans LJ; Environ Sci Technol 23: 1046-56 (1989) (4) Sadiq M; Environ Technol Letters 10: 1057-70 (1989)]**PEER REVIEWED**

Environmental Bioconcentration:

The uptake of **cadmium** by Daphnia, aquatic insects, mollusks, and crayfish is appreciable(1). After 22 weeks of exposure to 1 ug/l of **cadmium**, the tissue concentration of daphnia reached 17.6 ug/g dry wt, representing a bioconcentration factor of 17,600(1). Exposure to higher levels of **cadmium** resulted in higher tissue concns but a reduction in BCF. Snails exposed to 3.0, 8.3, and 27.5 ug Cd/l for 28 days accumulated 30, 45, and 225 ug Cd/g dry wt and levels were still increasing when the study ended(1). **Cadmium** is taken up in fish both from the water and in their diets. However, studies have shown that water is the primary source of uptake with diet playing a minor role(1). Brook trout exposed to 0.9, 1.7, and 3.4 ug/l of **cadmium** for 84 days had whole body concns of 0.68, 0.65, and 1.26 ug/g dry wt(1). Fathead minnows exposed to 48 ug/l for 46 days had whole-body levels of 10 ug Cd/g dry wt(1). **Cadmium** levels are much higher in the liver than in the whole fish or muscle. In one example, the concn of Cd in the whole body, muscle and liver were 0.36, 0.08, and 3.53 ug/g dry wt, respectively(1). Kidney tissue tend to accumulate more **cadmium** than the liver(1). In the field, several species exposed to **cadmium** ranging from 0.9-4.2 ug Cd/l contained 0.10 to 0.80 ug/g dry wt in their flesh(1). Fish from uncontaminated areas had whole body **cadmium** concentrations of 0.1 to 0.3 ug/g dry wt(1). Bioconcentration factors for **cadmium** in various taxa are (taxa, BCF (wet wt basis)): Marine plants, 1,000; Marine invertebrates, 250,000; Marine fish, 3,000; Freshwater plants, 1,000; Freshwater

invertebrates, 4,000; and Freshwater fish, 3,000(2).
[(1) McCracken IR; pp. 89-116 in Cadmium in the Aquatic Environment, Nriagu JO and Sprague JB, ed. NY,NY: Wiley (1987) (2) Callahan MA et al; Water-Related Fate of 129 Priority Pollutants Vol I pp. 9-1 to 9-20, USEPA-440/4-79-029A (1979)]**PEER REVIEWED**

Soil Adsorption/Mobility:

The most important soil factors influencing plant **cadmium** accumulation are soil pH and **cadmium** concentration. Soil **cadmium** is distributed between a number of pools or fractions, of which only the **cadmium** in soil solution is thought to be directly available for uptake by plants. Soil pH is the principal factor governing the concentration of **cadmium** in the soil solution. **Cadmium** absorption to soil particles is greater in neutral or alkaline soils than in acidic ones and this leads to increased **cadmium** levels in the soil solution. As a consequence, plant uptake of **cadmium** decreases as soil pH increases.
[WHO; Environmental Health Criteria 134: Cadmium p. 48 (1992)]**PEER REVIEWED**

Soil pH is the principal factor affecting the distribution of **cadmium** between soil and water(1). Sorption increases with increasing pH. Increasing the cation exchange capacity and the iron and magnesium hydroxy-oxide, organic, and calcium carbonate content of the soil decreases the adsorption of **cadmium** to soil. For example, highly contaminated soil from Shipham, UK, a non-ferrous mining area, contained 0.04% of soluble **cadmium**, whereas a paddy soil from the Junzu valley in Japan with a hundredth the **cadmium** content of the Shipham soil, contained 4% of soluble **cadmium**(1,2). The Shipham soil had a high pH, 7.5, and high hydrous oxide and calcium carbonate content, while the paddy soil had a low pH, 5.1, and low hydrous oxide and calcium carbide content. In a polluted Japanese River in Japan, the binding of **cadmium** to sediment was primarily determined by the organic carbon content of the sediment and sorption could be represented by a Freundlich equation(3). In unpolluted rivers, association with carbonates (i.e., exchange of **cadmium** for calcium in the lattice structure of carbonate minerals) and adsorption/coprecipitation with hydrous iron, magnesium, and aluminum oxides is more important in controlling solubility(3). Remobilization or desorption is less likely to occur when the **cadmium** is associated with carbonates or hydrous oxides than when adsorbed to clay minerals or organic material. The solid/water distribution constants for **cadmium** vary from a few hundred for the clay mineral kaolinite to nearly 20,000 ml/g for organic matter(4). In 9 river systems where the concentration of **cadmium** in particulate matter and dissolved **cadmium** was determined, the particulate/dissolved distribution constant for **cadmium** varied from 10,000 to 100,000(5).
[(1) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992) (2) Alloway BJ et al; Sci Tot Environ 75: 41-69 (1988) (3) Callahan MA et al; Water-Related Fate of 129 Priority Pollutants Vol I pp. 9-1 to 9-20, USEPA-440/4-79-029A (1979) (4) Bewers JM et al; pp. 1-18 in Cadmium in the Aquatic Environment, Nriagu JO, Sprague JB, ed. NY,NY: Wiley (1987) (5) Yeats PA, Bewers JM; pp. 19-34 in Cadmium in the Aquatic Environment. Nriagu JO, Sprague JB, eds. NY,NY: Wiley (1987)]**PEER REVIEWED**

The most important soil properties affecting **cadmium** adsorption is pH and organic matter content(9-11). Results of a study of the adsorption of Cd on 15 New Jersey soils showed that at a constant pH, adsorption was correlated with organic matter(1). This suggests that surficial adsorption sites are principally composed of organic matter. For the 24-hr equilibrium time employed, diffusion of Cd(II) to the underlying sorptive materials including metal oxides was not important. An empirical relation obtained from batch adsorption studies of low concns of **cadmium** on 38 soils was that the log of the distribution coefficient was proportional to 0.64 times the pH(2). An average of 0.64 moles of protons are released for each mole of **cadmium** adsorbed. The distribution coefficient for the sorption of **cadmium** to a loamy sand and sandy loam soil at pH 6.00 was about 200-250(3). In the pH interval 4-7.7, the sorption capacity increased a factor of 3 for each pH interval. Increasing the calcium concn

from 0.001 M to 0.01 M reduced the sorption capacity of the sandy loam to one third. Sorption of **cadmium** is a rapid process with more than 95% of adsorption occurring within 10 minutes. Sorption was completely reversible from the loam sand but only partially so from the sandy loam(4). Aging of the soil for up to 67 weeks did not change the desorption characteristics. Sorption of **cadmium** to soils was effectively reduced 2-14 times by competition with other heavy metals(5). **Cadmium** distribution coefficients (Kd) for 63 agricultural soils ranged from 15 to 2450 l/kg(6). The observed distribution coefficients correlated very well with the pH and secondarily with the soil organic matter. Kd doubled for each 0.5 increase in pH or 2% increase in organic matter content (weight basis). The sorption of **cadmium** as a function of pH and organic matter content for 17 top soils was described by the Freundlich-like equation(7). Conflicting results on the influence of soil properties on **cadmium** adsorption was obtained in a study involving 22 uncultivated soils(8). These results confirm that the CEC is the soil property that influences **cadmium** adsorption in the 22 soils most, and that Ca++ is the cation in the exchange process that favors the adsorption process the most. The fact that pH was not significantly correlated to adsorption was ascribed to the narrow range of pH values in the soils studied. Other studies indicate that **cadmium** retention in acidic soil is greatly increased when the organic matter content of the soil is increased(9).
[(1) Lee SZ et al; Environ Sci Technol 30: 3418-24 (1996) (2) Anderson PR, Christensen TH; J Soil Sci 39: 15-22 (1988) (3) Christensen TH; Water, Air, Soil Pollut 21: 105-14 (1984) (4) Christensen TH; Water, Air, Soil Pollut 21: 115-25 (1984) (5) Christensen TH; Water, Air, Soil Pollut 34: 293-303 (1987) (6) Christensen TH; Water, Air, Soil Pollut 44: 71-82 (1989) (7) Filius A et al; J Environ Qual 27: 12-8 (1998) (8) Sanchez-Martin MJ, Sanchez-Camazano M; J Environ Qual 22: 737-742 (1993) (9) Elliott HA et al; J Environ Qual 15: 215-9 (1986) (10) Gerritse RG, van Dreil W; J Environ Qual 13: 197-204 (1984) (11) King LD; J Environ Qual 17: 239-46 (1988)]**PEER REVIEWED**

Volatilization from Water/Soil:

Cadmium does not form volatile compounds in the aquatic environment(1) and therefore volatilization from water is not a significant fate process.
[(1) Callahan MA et al; Water-Related Fate of 129 Priority Pollutants Vol I pp. 9-1 to 9-20, USEPA-440/4-79-029A (1979)]**PEER REVIEWED**

Environmental Water Concentrations:

DRINKING WATER: A Canadian national survey (70 municipalities in 10 provinces) to determine the level of **cadmium** in drinking water determined that the median level of **cadmium** in water was less than or equal to 0.01 ug/l(1). The median was the same whether the water was raw, treated or distributed or whether the source was rivers, lakes or wells. The maximum **cadmium** concn in raw, treated, and distributed water was 1.13, 0.26, and 0.27 ug/l, respectively. The concn in samples of raw, treated, and distributed water was not lowered by filtration indicating that **cadmium** was not likely to be associated with particulate matter. A 1982 survey of drinking water in Seattle, WA reported a median **cadmium** level in tap water of 0.01 ug/l and 0.25 ug/l delivered by copper pipes and galvanized pipes, respectively(2). Tap water left to stand in the pipe had **cadmium** levels of 0.06 and 0.63 ug/l, respectively. About 99% of drinking water surveyed in The Netherlands in 1982 had **cadmium** levels less than 0.1 ug/l(2).
[(1) Meranger JC et al; Environ Sci Technol 13: 707-711 (1979) (2) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992)]**PEER REVIEWED**

GROUNDWATER: The **cadmium** content of normal groundwater (n=22) ranged from <0.01 to 1.0 ug/l with a mean of 0.05 ug/l, while groundwaters and mine waters near polymetallic sulfide deposits contained up to 1140 ug Cd/l(1).

[(1) Thornton I; in IARC Sci Pub 118(Cadmium in the Human Environment): 149-62 (1992) (2) Elinder CG; in IARC Sci Pub 118(Cadmium in the Human Environment): 123-32 (1992)]**PEER REVIEWED**

SURFACE WATER: Most unpolluted surface water has **cadmium** concns of <1 ng/g(1). However in the vicinity of **cadmium** bearing minerals, levels may exceed 10 ng/l. **Cadmium** levels in normal stream, river, and lake waters (n=74) ranged from <0.01-5.0 ug/l with a mean of 0.3 ug/l while streams and rivers near **cadmium** deposits (n=10) ranged from <0.01-1000 ug/l(1). The mean total **cadmium** concentration in waters of the St. Lawrence Basin (location, **cadmium** concn in ng/l): Lake Superior, 27, 19; Lake Michigan. 27, 28; Lake Huron, 16; Lake Erie, 98; Lake Ontario, 50; and St. Lawrence River at Quebec City, 110 (dissolved)(3,4). The **cadmium** concn in various rivers (river, concn): Elbe, 150 ng/l particulate, 100-200 ng/l dissolved; Weser. 100 ng/l particulate, 100 ng/l dissolved; Rhine, 1800 ng/l particulate, 400 ng/l dissolved; St. Lawrence, 17 ng/l particulate, 110 ng/l dissolved; Hudson, 70-80 ng/l particulate, 200-300 dissolved(3).
[(1) Thornton I; in IARC Sci Publ 118(Cadmium in the Human Environment): 149-62 (1992) (2) Elinder CG; in IARC Sci Publ 118(Cadmium in the Human Environment): 123-32 (1992) (3) Yeats PA, Bewers JM; pp. 19-34 in Cadmium in the Aquatic Environment. Nriagu JO, Sprague JB, eds. NY,NY: Wiley (1987) (4) Lum KR; pp. 35-50 in Cadmium in the Aquatic Environment. Nriagu JO, Sprague JB, eds. NY,NY: Wiley (1987)]**PEER REVIEWED**

SEAWATER: **Cadmium** concns in seawater ranges between 0.4 and 2900 ng/l(2). Higher values are found in estuarine and coastal waters, especially those affected by point sources. The **cadmium** content of inshore water off the U.K. ranged from 0.14 to 4.20 ug/l which reflects anthropogenic inputs(1). **Cadmium** levels in seawater (n=52) ranged from 0.24-0.48 ug/l with a mean of 0.14 ug/l(1).
[(1) Thornton I; in IARC Sci Publ 118(Cadmium in the Human Environment): 149-62 (1992) (2) Sadiq M; Environ Technol Letters 10: 1057-70 (1989)]**PEER REVIEWED**

RAIN WATER: The **cadmium** content of rainwater and snow in rural areas (n=46) ranged from <0.5-2.0 ug/l with a mean concn of <0.5 ug/l; the high values were from mineralized zones(1). Rainwater and snow from Ottawa, Canada (n=12) contained <0.2-1.0 ug Cd/l with a mean **cadmium** content of 0.3 ug/l(1).
[(1) Thornton I; in IARC SCI. PUBL. 118(Cadmium in the Human Environment): 149-62 (1992) (2) Elinder CG; in IARC Sci Pub 118(Cadmium in the Human Environment): 123-32 (1992)]**PEER REVIEWED**

Effluent Concentrations:

Estimated atmospheric and total **cadmium** inputs into the Great Lakes were estimated to be (Lake, atmospheric input (tons/yr), total input (tons/yr): Superior, 82, 84; Michigan 58, 94; Huron, 60, 62; Erie, 75, 108; Ontario 28, 47(1). The average annual wet flux at two Chesapeake Bay sites from June 1990 to July 1991 was 48 ug/sq m-yr(2). The **cadmium** was derived from non-crustal sources and the maximum flux was during the summer months. **Cadmium** emissions at a lead smelter is expected to be elemental **cadmium** and the oxide(3).
[(1) Lum KR; pp. 35-50 in Cadmium in the Aquatic Environment, Nriagu JO, Sprague JB, ed. NY,NY: Wiley (1987) (2) Scudlark JR et al; Atmos Environ 28: 1487-8 (1994) (3) Struck BD et al; Sci Tot Environ 182: 85-91 (1996)]**PEER REVIEWED**

The median annual estimated anthropogenic input of **cadmium** into the biosphere (terrestrial plus aquatic input minus atmospheric emissions) is 2.15 million metric tons(1). Worldwide atmospheric emissions of **cadmium** for 1983 was estimated to be between 3,900 and 12,000 metric tons per year of which all but 800 tons came from anthropogenic sources(1,2). Its allocation between sources was (source category, emission in metric tons/yr): mining, 0.6-3; zinc and **cadmium** production, 920-4600; copper production, 1700-3400; lead production, 39-196; secondary production, 2.3-3.6; production of

cadmium-containing substances, not determined; iron and steel production, 28-284; coal combustion, 176-882; oil combustion, 41-246; refuse incineration, 56-1400; sewage sludge incineration, 3-36; phosphate fertilizer manufacture, 68-274; cement manufacture, 8.9-534; and wood combustion, 60-180(1). Annual anthropogenic discharges of **cadmium** into the aquatic environment in 1983 was estimated to range from 2.1-17 million kg/yr with a median of 9.4 million kg/yr. The source distribution was (source category, input in millions of kilograms): Domestic wastewater (central), 0.18-1.8; Domestic wastewater (noncentral), 0.3-1.2; Steam electric, 0.01-0.24; base metal mining and dressing, 0-0.3; Non-ferrous metals smelting and refining, 0.01-3.6; Manufacturing processes (metals), 0.5-1.8; Manufacturing processes (chemicals), 0.1-2.5; Atmospheric fallout (assumed to be 30% of atmospheric emissions), 0.9-3.6; Sewage sludge dumping, 0.07-1.3(1). Similarly, annual worldwide anthropogenic discharges of **cadmium** into soil in 1983 was estimated to range from 5.6-38 million kg/yr with a median of 22 million kg/yr. The source distribution was (source category, input in millions of kilograms): Agriculture and food wastes, 0-3.0; Animal wastes, manure, 0.2-1.2; Logging and wood wastes, 0-2.2; Urban refuse, 0.88-7.5; Municipal sewage sludge, 0.02-0.34; Miscellaneous organic wastes including excreta, 0-0.01; Solid wastes, metal manufacturing, 0-0.08; Coal ash, 1.5-13; Fertilizer, 0.03-0.25; Peat (agricultural and fuel usage); Atmospheric fallout (assumed to be 70% of atmospheric emissions), 2.2-8.4(1). The addition of 2.7-4.1 million kg/yr in mine tailings and 1.6-3.2 million kg/yr in smelter slags and waste brings the total annual estimated discharge of **cadmium** on land to 9.9-45 million kg.
[(1) Nriagu JO, Pacyna JM; Nature 333: 134-9 (1988) (2) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992)]**PEER REVIEWED**

Sediment/Soil Concentrations:

Cadmium occurs naturally in soil at concentrations of less than 1 ppm, but soils derived from some marine black shales and rocks containing lead-zinc minerals frequently contain larger amounts(1). In a 1987-1988 study of **cadmium** soil concentrations in 94 gardens and allotments in nine English towns and cities, the geometric mean concn of all soils sampled was 0.53 ug/g and ranged from <0.2-5.9 ug/g(1). The geometric mean for each town and city generally were similar to the 0.6 to 0.9 ug/g found in a study of background concns in agricultural soils. **Cadmium** concns (ug/g dry weight) in soil from the old lead-zinc mining area of Derbyshire, England ranged from 1.40 to 24.5 ug/g with arithmetic and geometric means of 9.30 and 6.60 ug/g(1). A British study has reported that since 1880, atmospheric deposition has been responsible for an increase of 27-55% in soil **cadmium** concn, a rate of 1.2 ug/kg/yr which is equivalent to an increase in plough layer burden of 3.1 g Cd/ha-yr(2). Surficial sediments with elevated **cadmium** concns were (location, concn in mg/kg): North sea, 2; Baltic, 2; West Coast of US, 1-2; New Bedford and Buzzards Bay, 2-50(3). Surficial sediments in Great Lakes contained **cadmium** concns of 0.37 to 5.1 ug/g(4). Experiments in the U.K. have ascribed 27-55% increases in Cd soil levels since 1880 to atmospheric deposition(5).
[(1) Thornton I; in IARC Sci Publ 118(Cadmium in the Human Environment): 149-62 (1992) (2) Jones KC et al; pp. 553-9 in Proc Inter Conf Chem Environ. Lester JN et al, eds. London, England: Selper Ltd (1986) (3) Yeats PA, Bewers JM; pp. 19-34 in Cadmium in the Aquatic Environment. Nriagu JO, Sprague JB, ed., NY,NY: Wiley (1987) (4) Lum KR; pp. 35-50 in Cadmium in the Aquatic Environment. Nriagu JO, Sprague JB, ed., NY,NY: Wiley (1987) (5) Jones KC et al; pp. 553-9 in Proc Inter Conf Chem Environ. Lester JN et al, eds. London, England: Selper Ltd (1986)]**PEER REVIEWED**

Atmospheric Concentrations:

Analysis indicates that retention levels resulting from present and predicted future concentrations of **cadmium** in the ambient air are well below kidney dysfunction level. Compared with 10 ug critical level, average urban air results in a daily **cadmium** retention of less than 0.1 ug. ... Estimates of

maximum anticipated annual average ambient **cadmium** concentrations around the primary sources indicate that very low concentrations should result if the sources, both existing and new, comply with current ambient air standards for particulate matter. These annual average concentrations were estimated to range from a high of about 0.13 ug/cu m, for sewage sludge incinerators, to as little as 0.002 ug/cu m for municipal incinerators.
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 4-1]**PEER REVIEWED**

In the ambient air, **cadmium** concentrations based on long-term sampling periods indicate, in most cases, a range of 0.001-0.015 ug/cu m in rural areas, 0.005-0.05 ug/cu m in urban areas, and up to 0.6 ug/cu m near sources of pollution.
[WHO; Environmental Health Criteria 134: Cadmium p. 197 (1992)]**PEER REVIEWED**

SOURCE AREAS: The annual average **cadmium** concn in England, 1 km from zinc smelter, was 0.533 ug/cu m(1). URBAN/SUBURBAN: The median and maximum **cadmium** concn from weekly mean samples at 15 sites in Birmingham, England in the winter of 1975/6, 1976/7 and 1977/8 ranged from 0.010-0.017 and 0.01-0.610 ug/cu m(1). In the summer of 1976 and 1977, the medians and maximum concns were 0.007-0.014 and 0.01-0.07 ug/cu m(1). Reported urban atmospheric **cadmium** concns were (Site, annual average concn in ug/cu m): 136 U.S. cities, <0.01; Paris, 0.006-0.060; Polish towns, 0.002-0.051; Tokyo, 0.010-0.053; 10 cities in Germany, 0.009-0.056(1). A study of atmospheric **cadmium** concentrations at seven sites (3 industrial, 3 residential and 1 commercial) in Detroit between 1982 and 1992 found that the mean ambient concentration remained the same throughout the decade at about 3.5 ng/cu m(2). RURAL/REMOTE: Reported non-urban atmospheric **cadmium** concns were (Site, annual average concn in ug/cu m): Shetland Isles, 0.008; Non-urban U.K., 0.005; 21 non-urban U.S. sites, 0.004(1).
[(1) Barratt RS; Sci Tot Environ 72: 211-5 (1988) (2) Pirrone N et el; Sci Tot Environ 162: 43-61 (1995)]**PEER REVIEWED**

Food Survey Values:

The average **cadmium** concentration in rice from non-polluted areas /in Japan/ has been reported to be 0.066 mg/kg in polished rice and 0.09 mg/kg in unpolished rice.
[WHO; Environmental Health Criteria 134: Cadmium p. 174 (1992)]**PEER REVIEWED**

The major source of **cadmium** in the traditional food of indigenous people (Dene/Metis) in the western Northwest Territories, Canada was moose liver (900 ng/g) and caribou liver (1200 ng/g) and kidney (3910-9540 ng/g)(1). The **cadmium** concentration in other food items were more than 100-1000 times lower. The mean **cadmium** level in 10 widely-consumed dairy products in Spain ranged from non-detectable to 20 ng/g(2). Increased concns of **cadmium** was found in products packaged in glazed ceramic containers. **Cadmium** levels in infant formulas and milk products in Canada (product, median in ng/g, range in ng/g): evaporated milk, 0.13, 0.017-3.4; milk-based ready-to-use formula, 0.21, 0.032-3.04; soy-based ready-to-use formula, 2.85, 1.87-6.7; concentrated milk-based liquid formula, 0.37, 0.07-6.5; concentrated soy-based liquid formula, 5.54, 3.12-14.8; powdered milk-based formula, 0.80, 0.33-1.41; powdered soy-based formula, 9.8, 2.22-32.7(3).
[(1) Berti PR et al; Environ Research Section A 76: 131-42 (1998) (2) Cabrera C et al; J Agric Food Chem 43: 1605-9 (1995) (3) Dabeka RW; Sci Tot Environ 89: 279-89 (1989)]**PEER REVIEWED**

Five groups of food, each comprising 113 composites and 39 individual foods were analyzed for **cadmium** from food purchased in 5 Canadian cities between 1986 and 1988(1). **Cadmium** levels in individual samples ranged from <0.02 to 167 ng/g with a mean of 9.96 ng/g and a median of 2.37 ng/g. The mean and maximum levels in the various food categories were (category (% contribution to dietary

cadmium intake), mean in ng/g, maximum in ng/g): milk and milk products (2.4%), 1.60, 57.8; meat and poultry (7.9%), 10.05, 167.0; fish (1.2%) 9.38, 57.14, soups (2.7%), 4.86, 15.05; bakery goods and cereals (36.8%), 16.64, 70.68; vegetables (40.3%), 16.53, 129.50; fruits and fruit juice (2.7%), 2.91, 27.43; fats and oils (2.0%), 17.36, 62.22; sugar and candies (0.9%), 3.72, 19.52; beverages (1.9%), 0.34, 1.73; miscellaneous (1.2%), 7.95, 30.63. The highest mean **cadmium** levels were found in organ meat (120 ng/g), followed by potato chips (90 ng/g), wheat and bran cereals (56.5 ng/g), and peanut butter (50 ng/g).
[(1) Dabeka RW, McKenzie AD; J AOAC Inter 78: 897-909 (1995)]**PEER REVIEWED**

Plant Concentrations:

It has been demonstrated that **cadmium** is taken up into plants from soil contaminated with **cadmium** by non-ferrous metal mining or receiving **cadmium** via the application of sewage sludge(2). The other important factor affecting plant uptake of **cadmium** is soil pH. **Cadmium** uptake in plants was greatest where phosphate fertilizer was applied than not and was greater for unlimed than limed soils(4). In a 1987-1988 study of **cadmium** concentrations in vegetables from 94 gardens and allotments in nine English towns and cities, the geometric mean concn of **cadmium** ranged from 0.07 to 1.21 ug/g dry weight with the highest concentration in spinach and lettuce, which are known **cadmium** accumulators(1). The towns having the highest and lowest concns of **cadmium** in vegetables were those with the highest and lowest blood **cadmium** concns in non-smoking men. In an area near a zinc-lead smelting complex, atmospheric deposition was the major source of **cadmium** on the edible part of plants(1). Washing lettuce leaves removed over 50% of the **cadmium**. The **cadmium** concns in ug/g dry weight reported in some vegetables were (vegetable, arithmetic mean, geometric mean, range): broccoli, 0.16, 0.14, 0.05-0.70; cabbage 0.12, 0.11, 0.05-0.28; carrot, 0.25, 0.20, 0.04-1.08; lettuce, 0.66, 0.51, 0.11-3.08; parsnip, 0.10, 0.07, <0.025-0.59; spinach, 1.62, 1.21, 0.18-10.4(1). **Cadmium** concns (ug/g dry weight) in vegetable in the old lead-zinc mining area of Derbyshire, England were (vegetable, arithmetic mean, geometric mean, range): broccoli, 0.92, 0.66, 0.24-2.25; cabbage 0.62, 0.41, 0.20-1.69; carrot, 1.03, 0.73, 0.35-3.20; lettuce, 2.86, 2.36, 0.80-5.40; parsnip, 0.50, 0.43, 0.19-0.85; spinach, 12.8, 7.74, 2.45-19.0(1).In plants grown in gardens in Aspen, CO that had been contaminated with silver mine dump material, the **cadmium** concn was highest in the leaves (0.6-11.9 mg/kg), intermediate in the roots and tubers (0.5-3.6 mg/kg), and lowest in the fruit (<0.5-2.7 mg/kg)(3).
[(1) Thornton I; in IARC Sci Pub 118(Cadmium in the Human Environment): 149-62 (1992) (2) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland. (1992) (3) Boon DY, Soltanpour PN; J Environ Qual 21: 82-6 (1992) (4) Jones KC, Johnston AE; Environ Pollut 57: 199-216 (1989)]**PEER REVIEWED**

Fish/Seafood Concentrations:

Eastern oysters collected from 5 sites in the Mississippi Sound in January 1988 contained levels of **cadmium** ranging from 0.44 ppm to 3.5 ppm (wet wt) (1). The site with the highest mean concn, 2.1 ppm, was St. Louis Bay. In field studies, mollusks taken from the Fox River, IL contained 1.24-3.66 and 2.49-5.89 ug/g dry weight in their shells and bodies, respectively(2). Three species of mollusks from Lake George, NY contained 9-10 ug/g dry wt in their bodies. Several species of fish from contaminated areas contained 0.10 to 0.80 ug Cd/g dry wt in their flesh(2). Fish from uncontaminated areas had whole body **cadmium** concns of 0.1 to 0.3 ug/g dry wt(2).
[(1) Lytle TF, Lytle JS; Bull Environ Contam Toxicol 44: 142-8 (1990) (2) McCracken IR; pp. 89-116 in Cadmium in the Aquatic Environment. Nriagu JO, Sprague JB, ed., NY,NY: Wiley (1987)]**PEER REVIEWED**

Animal Concentrations:

In mammals and birds, **cadmium** accumulates in the livers and kidneys at concns of 0.2-2 mg/kg and 1-10 mg/kg wet weight, respectively(1). The highest kidney **cadmium** concentration in birds and marine mammals is 60 mg/kg wet wt in Adele penguins in Antarctica and 38 mg/kg wet weight for narwhal in Greenland(1).
[(1) Elinder CG; in IARC Sci Pub 118(Cadmium in the Human Environment): 123-32 (1992)]**PEER REVIEWED**

Milk Concentrations:

The arithmetic mean, geometric mean, median, and range for **cadmium** in 210 samples of human milk across Canada were (ng/g): 0.08, 0.063, 0.06, and <0.002-4.05, respectively(1). **Cadmium** levels Canadian evaporated milk ranged from 0.017 to 3.4 ng/g and had a median concn of 0.13 ng/g(2).
[(1) Dabeka RW et al; Sci Tot Environ 71: 65-6 (1988) (2) Dabeka RW; Sci Tot Environ 89: 279-89 (1989)]**PEER REVIEWED**

Other Environmental Concentrations:

It has been reported that one cigarette contains about 1-2 ug **cadmium** and that about 10% of the **cadmium** content is inhaled when the cigarette is smoked.
[WHO; Environmental Health Criteria 134; Cadmium p. 54 (1992)]**PEER REVIEWED**

The concns in various environmental media include: Marine black shales, up to 219 ppm; other shales, 0.22 ppm, mean; sandstone, 0.05 ppm, mean; limestone,0.028 ppm, mean; coal, 0.01-180 ppm in the U.S.(1). The concn of **cadmium** in cigarette tobacco and smoke are (product, tobacco content ug/g, smoke delivery in ug/cigarette): German (1969), 1.5-2.2, 0.007-0.275 (particle phase) and 0.1-0.6 (gas phase); Polish (1983), 1.3-3.8, 0.2 (particle phase) and 0.14 (gas phase); Five countries (1974), 1.2-2.2, 0.07-0.19 (particle phase) and 0.007-0.05 (gas phase); Germany (1983), 0.20-1.94, 0.03-0.1 (particle phase); Italy (1978), 1.3-1.6, 0.04-0.06 (particle phase) and 2-3X10-6 (gas phase)(2). In an extensive survey of metals in household dust in the U.K. (over 4500 samples), the average **cadmium** level in the dust was 6.9 mg/kg(3). In the vicinity of a small lead refinery in the U.K., household dust levels were 193 mg/kg(3).
[(1) Thornton I; in IARC Sci Publ 118(Cadmium in the Human Environment): 149-62 (1992) (2) Jenkins RA; in IARC Sci Publ 71(Environ Carcinog: Sel Methods Anal) 8: 129-41 (1986) (3) World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992)]**PEER REVIEWED**

Environmental Standards & Regulations:

Clean Water Act Requirements:

Toxic pollutant designated pursuant to section 307(a)(1) of the Federal Water Pollution Control Act and is subject to effluent limitations. /**Cadmium** and compounds/
[40 CFR 401.15 (7/1/98)]**QC REVIEWED**

Chemical/Physical Properties:

Chemical Safety & Handling:

DOT Emergency Guidelines:

Health: Highly toxic, may be fatal if inhaled, swallowed or absorbed through skin. Avoid any skin contact. Effects of contact or inhalation may be delayed. Fire may produce irritating, corrosive and/or

toxic gases. Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution. /**Cadmium** compound/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Fire or explosion: Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes. Containers may explode when heated. Runoff may pollute waterways. /**Cadmium** compound/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Public safety: CALL Emergency Response Telephone Number. ... Isolate spill or leak area immediately for at least 25 to 50 meters (80 to 160 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Keep out of low areas. /**Cadmium** compound/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Protective clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Wear chemical protective clothing which is specifically recommended by the manufacturer. It may provide little or no thermal protection. Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations. /**Cadmium** compound/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Evacuation: ... Fire: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions. /**Cadmium** compound/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Fire: Small fires: Dry chemical, CO2 or water spray. Large fires: Water spray, fog or regular foam. Move containers from fire area if you can do it without risk. Dike fire control water for later disposal; do not scatter the material. Use water spray or fog; do not use straight streams. Fire involving tanks or car/trailer loads: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Do not get water inside containers. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible withdraw from area and let fire burn. /**Cadmium** compound/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Spill or leak: Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. Cover with plastic sheet to prevent spreading. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. DO NOT GET WATER INSIDE CONTAINERS. /**Cadmium** compound/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

First aid: Move victim to fresh air. Call 911 or emergency medical service. Apply artificial respiration if victim is not breathing. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. For minor skin contact, avoid spreading material on unaffected skin. Keep victim warm and quiet. Effects of exposure (inhalation, ingestion or skin contact) to substance may be delayed. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves. /**Cadmium** compound/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Fire Fighting Procedures:

If material on fire or involved in fire: Extinguish fire using agent suitable for type of surrounding fire. (Material itself does not burn or burns with difficulty.) Use water in flooding quantities as fog. Use "alcohol" foam, dry chemical or carbon dioxide. /**Cadmium** compounds, NOS/
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 185]**PEER REVIEWED**

Prior History of Accidents:

In Fuchu, Japan, shortly after World War II, a large number of people complained of rheumatic and myalgic pains; the disease was named itai-itai ("ouch-ouch"). It was determined that **cadmium** had washed into the local rice fields from the effluent from a lead-zinc processing plant. /**Cadmium** compounds/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1662]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH considers **cadmium** dust (as Cd) to be a potential occupational carcinogen. /**Cadmium** dust (as Cd)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 44]**PEER REVIEWED**

Protective Equipment & Clothing:

PRECAUTIONS FOR "CARCINOGENS": ... dispensers of liq detergent /should be available./ ... Safety pipettes should be used for all pipetting. ... In animal laboratory, personnel should ... wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. ... Gowns ... /should be/ of distinctive color, this is a reminder that they are not to be worn outside the laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

IN AREAS WITH HAZARDS OF /AIRBORNE/ PARTICLES, CHEM SPLASHES, RADIANT HEAT ... WORKERS SHOULD WEAR APPROPRIATE SAFETY EQUIPMENT SUCH AS EYE, FACE, HAND, & ARM PROTECTION & IMPERMEABLE CLOTHING. /**CADMIUM** & **CADMIUM** CMPD/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 357]**PEER REVIEWED**

... IN CASES SUCH AS WELDING & CUTTING, WHERE ADEQUATE VENTILATION IS NOT ALWAYS POSSIBLE, RESPIRATORS SHOULD BE WORN. /**CADMIUM**, ALLOYS, COMPOUNDS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 234]**PEER REVIEWED**

Preventive Measures:

... PROCESSES OR OPERATIONS WHICH MAY RELEASE **CADMIUM** FUMES OR DUST INTO THE ATMOSPHERE SHOULD BE DESIGNED TO KEEP CONCN LEVELS TO MINIMUM & IF PRACTICABLE BE ENCLOSED & FITTED WITH EXHAUST VENTILATION. /**CADMIUM** & **CADMIUM** CMPD/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 357]**PEER REVIEWED**

ADEQUATE SANITARY FACILITIES SHOULD BE SUPPLIED & WORKERS SHOULD BE ENCOURAGED TO WASH THOROUGHLY & CHANGE THEIR CLOTHES BEFORE LEAVING WORK. SMOKING, EATING & DRINKING IN WORK AREAS SHOULD BE PROHIBITED. /**CADMIUM** & **CADMIUM** CMPD/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 357]**PEER REVIEWED**

SRP: The scientific literature for the use of contact lenses in industry is conflicting. The benefit or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In any event, the usual eye protection equipment should be worn even when contact lenses are in place.
PEER REVIEWED

PRECAUTIONS FOR "CARCINOGENS": Smoking, drinking, eating, storage of food or of food & beverage containers or utensils, & the application of cosmetics should be prohibited in any laboratory. All personnel should remove gloves, if worn, after completion of procedures in which carcinogens have been used. They should ... wash ... hands, preferably using dispensers of liq detergent, & rinse ... thoroughly. Consideration should be given to appropriate methods for cleaning the skin, depending on nature of the contaminant. No standard procedure can be recommended, but the use of organic solvents should be avoided. Safety pipettes should be used for all pipetting. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": In animal laboratory, personnel should remove their outdoor clothes & wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... clothing should be changed daily but ... discarded immediately if obvious contamination occurs ... /also,/ workers should shower immediately. In chemical laboratory,

gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. If gowns are of distinctive color, this is a reminder that they should not be worn outside of lab. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... operations connected with synth & purification ... should be carried out under well-ventilated hood. Analytical procedures ... should be carried out with care & vapors evolved during ... procedures should be removed. ... Expert advice should be obtained before existing fume cupboards are used ... & when new fume cupboards are installed. It is desirable that there be means for decreasing the rate of air extraction, so that carcinogenic powders can be handled without ... powder being blown around the hood. Glove boxes should be kept under negative air pressure. Air changes should be adequate, so that concn of vapors of volatile carcinogens will not occur. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Vertical laminar-flow biological safety cabinets may be used for containment of in vitro procedures ... provided that the exhaust air flow is sufficient to provide an inward air flow at the face opening of the cabinet, & contaminated air plenums that are under positive pressure are leak-tight. Horizontal laminar-flow hoods or safety cabinets, where filtered air is blown across the working area towards the operator, should never be used ... Each cabinet or fume cupboard to be used ... should be tested before work is begun (eg, with fume bomb) & label fixed to it, giving date of test & avg air-flow measured. This test should be repeated periodically & after any structural changes. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Principles that apply to chem or biochem lab also apply to microbiological & cell-culture labs ... Special consideration should be given to route of admin. ... Safest method of administering volatile carcinogen is by injection of a soln. Admin by topical application, gavage, or intratracheal instillation should be performed under hood. If chem will be exhaled, animals should be kept under hood during this period. Inhalation exposure requires special equipment. ... unless specifically required, routes of admin other than in the diet should be used. Mixing of carcinogen in diet should be carried out in sealed mixers under fume hood, from which the exhaust is fitted with an efficient particulate filter. Techniques for cleaning mixer & hood should be devised before expt begun. When mixing diets, special protective clothing &, possibly, respirators may be required. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When ... admin in diet or applied to skin, animals should be kept in cages with solid bottoms & sides & fitted with a filter top. When volatile carcinogens are given, filter tops should not be used. Cages which have been used to house animals that received carcinogens should be decontaminated. Cage-cleaning facilities should be installed in area in which carcinogens are

being used, to avoid moving of ... contaminated /cages/. It is difficult to ensure that cages are decontaminated, & monitoring methods are necessary. Situations may exist in which the use of disposable cages should be recommended, depending on type & amt of carcinogen & efficiency with which it can be removed. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": To eliminate risk that ... contamination in lab could build up during conduct of expt, periodic checks should be carried out on lab atmospheres, surfaces, such as walls, floors & benches, & ... interior of fume hoods & airducts. As well as regular monitoring, check must be carried out after cleaning-up of spillage. Sensitive methods are required when testing lab atmospheres for chem such as nitrosamines. Methods ... should ... where possible, be simple & sensitive. ... /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Rooms in which obvious contamination has occurred, such as spillage, should be decontaminated by lab personnel engaged in expt. Design of expt should ... avoid contamination of permanent equipment. ... Procedures should ensure that maintenance workers are not exposed to carcinogens. ... Particular care should be taken to avoid contamination of drains or ventilation ducts. In cleaning labs, procedures should be used which do not produce aerosols or dispersal of dust, ie, wet mop or vacuum cleaner equipped with high-efficiency particulate filter on exhaust, which are avail commercially, should be used. Sweeping, brushing & use of dry dusters or mops should be prohibited. Grossly contaminated cleaning materials should not be re-used ... If gowns or towels are contaminated, they should not be sent to laundry, but ... decontaminated or burnt, to avoid any hazard to laundry personnel. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Doors leading into areas where carcinogens are used ... should be marked distinctively with appropriate labels. Access ... limited to persons involved in expt. ... A prominently displayed notice should give the name of the Scientific Investigator or other person who can advise in an emergency & who can inform others (such as firemen) on the handling of carcinogenic substances. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.11]**PEER REVIEWED**

VENTILATION CONTROL: PROCESSES OR OPERATIONS WHICH MAY RELEASE **CADMIUM** FUME OR DUST INTO ATMOSPHERE SHOULD BE ... DESIGNED /SO/ THAT CONCN LEVELS ARE KEPT TO A MINIMUM & IF PRACTICABLE /PROCESSES OR OPERATIONS/ SHOULD BE ENCLOSED & FITTED WITH EXHAUST VENTILATION. /**CADMIUM**, ALLOYS, COMPOUNDS/

[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 234]**PEER REVIEWED**

... SMOKING, EATING & DRINKING IN WORK AREA ... PROHIBITED. EXHAUSTED CONTAMINATED AIR ... FILTERED ... /&/ PERSONS ... SERVICING DUST COLLECTORS ...

WEAR RESPIRATORS ... /**CADMIUM** CMPD/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971.]**PEER REVIEWED**

DO NOT BREATHE SPRAY MIST. ... /PROTECT/ EYES /AND/ SKIN. IF SPILLED ON SKIN, WASH OFF IMMEDIATELY WITH LARGE AMOUNTS OF WATER. WASH THOROUGHLY AFTER HANDLING. WASH CONTAMINATED CLOTHING. KEEP CHILDREN & ANIMALS OFF TREATED AREAS UNTIL WASHED INTO SOIL. /**CADMIUM** & CMPD/
[Farm Chemicals Handbook 87. Willoughby, Ohio: Meister Publishing Co., 1987.,p. C-46]**PEER REVIEWED**

The worker should wash daily at the end of each work shift. /**Cadmium** fume (as Cd)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 45]**PEER REVIEWED**

Workers whose clothing may have become contaminated should change into uncontaminated clothing before leaving the work premises. /**Cadmium** fume (as Cd)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 45]**PEER REVIEWED**

AIR IN WORKPLACES /WHERE **CADMIUM** IS SUSPECTED/ SHOULD BE REGULARLY SAMPLED & **CADMIUM** CONCN DETERMINED. /**CADMIUM**, ALLOYS, COMPOUNDS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 234]**PEER REVIEWED**

If material not on fire and not involved in fire: Keep sparks, flames, and other sources of ignition away. Keep material out of water sources and sewers. /**Cadmium** compounds, NOS/
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 185]**PEER REVIEWED**

Personnel protection: Avoid breathing dusts, and fumes from burning material. Keep upwind. ... Avoid bodily contact with the material. ... Do not handle broken packages unless wearing appropriate personal protective equipment. Wash away any material which may have contacted the body with copious amounts of water or soap and water. /**Cadmium** compounds, NOS/
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 186]**PEER REVIEWED**

Shipment Methods and Regulations:

No person may /transport,/ offer or accept a hazardous material for transportation in commerce unless that person is registered in conformance ... and the hazardous material is properly classed, described, packaged, marked, labeled, and in condition for shipment as required or authorized by ... /the hazardous materials regulations (49 CFR 171-177)./
[49 CFR 171.2 (7/1/96)]**PEER REVIEWED**

The International Air Transport Association (IATA) Dangerous Goods Regulations are published by the IATA Dangerous Goods Board pursuant to IATA Resolutions 618 and 619 and constitute a manual of industry carrier regulations to be followed by all IATA Member airlines when transporting hazardous materials.
[IATA. Dangerous Goods Regulations. 38th ed. Montreal, Canada and Geneva, Switzerland: International Air Transport Association, Dangerous Goods Board, January, 1997. 114]**PEER REVIEWED**

The International Maritime Dangerous Goods Code lays down basic principles for transporting

hazardous chemicals. Detailed recommendations for individual substances and a number of recommendations for good practice are included in the classes dealing with such substances. A general index of technical names has also been compiled. This index should always be consulted when attempting to locate the appropriate procedures to be used when shipping any substance or article.
[IMDG; International Maritime Dangerous Goods Code; International Maritime Organization p.6087 (1988)]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Procurement ... of unduly large amt ... should be avoided. To avoid spilling, carcinogens should be transported in securely sealed glass bottles or ampoules, which should themselves be placed inside strong screw-cap or snap-top container that will not open when dropped & will resist attack from the carcinogen. Both bottle & the outside container should be appropriately labelled. ... National post offices, railway companies, road haulage companies & airlines have regulations governing transport of hazardous materials. These authorities should be consulted before ... material is shipped. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When no regulations exist, the following procedure must be adopted. The carcinogen should be enclosed in a securely sealed, watertight container (primary container), which should be enclosed in a second, unbreakable, leakproof container that will withstand chem attack from the carcinogen (secondary container). The space between primary & secondary container should be filled with absorbent material, which would withstand chem attack from the carcinogen & is sufficient to absorb the entire contents of the primary container in the event of breakage or leakage. Each secondary container should then be enclosed in a strong outer box. The space between the secondary container & the outer box should be filled with an appropriate quantity of shock-absorbent material. Sender should use fastest & most secure form of transport & notify recipient of its departure. If parcel is not received when expected, carrier should be informed so that immediate effort can be made to find it. Traffic schedules should be consulted to avoid ... arrival on weekend or holiday ... /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

Storage Conditions:

PRECAUTIONS FOR "CARCINOGENS": Storage site should be as close as practicable to lab in which carcinogens are to be used, so that only small quantities required for ... expt need to be carried. Carcinogens should be kept in only one section of cupboard, an explosion-proof refrigerator or freezer (depending on chemicophysical properties ...) that bears appropriate label. An inventory ... should be kept, showing quantity of carcinogen & date it was acquired ... Facilities for dispensing ... should be contiguous to storage area. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

STORAGE: MATERIALS WHICH ARE TOXIC AS STORED OR ... DECOMP INTO TOXIC COMPONENTS DUE TO CONTACT WITH HEAT, MOISTURE, ACIDS, OR ACID FUMES, SHOULD BE STORED IN COOL, WELL-VENTILATED PLACE, OUT OF ... RAYS OF SUN, AWAY FROM AREAS OF ... FIRE HAZARD ... /**CADMIUM** CMPD/
[Sax, N.I. Dangerous Properties of Industrial Materials. 4th ed. New York: Van

Nostrand Reinhold, 1975. 505]**PEER REVIEWED**

Cleanup Methods:

PEAT IS AN EFFECTIVE & INEXPENSIVE METHOD FOR REMOVING **CADMIUM** FROM PH- & CARBONATE-ADJUSTED INDUSTRIAL WASTEWATERS FREE OF STRONG CHELATING AGENTS. /**CADMIUM**/
[CHANEY RL, HUNDEMANN PT; J WATER POLLUT CONTROL FED 51 (1): 17-21 (1979)]**PEER REVIEWED**

1) REMOVE ALL IGNITION SOURCES. 2) VENTILATE AREA OF RELEASE. 3) COLLECT RELEASED MATERIAL IN THE MOST CONVENIENT AND SAFE MANNER FOR RECLAMATION OR FOR DISPOSAL. ... /**CADMIUM** DUST/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": A high-efficiency particulate arrestor (HEPA) or charcoal filters can be used to minimize amt of carcinogen in exhausted air /from/ ventilated safety cabinets, lab hoods, glove boxes or animal rooms ... Filter housing that is designed so that used filters can be transferred into plastic bag without contaminating maintenance staff is avail commercially. Filters should be placed in plastic bags immediately after removal ... The plastic bag should be sealed immediately ... The sealed bag should be labelled properly ... Waste liquids ... should be placed or collected in proper containers for disposal. The lid should be secured & the bottles properly labelled. Once filled, bottles should be placed in plastic bag, so that outer surface ... is not contaminated ... The plastic bag should also be sealed & labelled. ... Broken glassware ... should be decontaminated by solvent extraction, by chemical destruction, or in specially designed incinerators. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

Disposal Methods:

SRP: At the time of review, criteria for land treatment or burial (sanitary landfill) disposal practices are subject to significant revision. Prior to implementing land disposal of waste residue (including waste sludge), consult with environmental regulatory agencies for guidance on acceptable disposal practices.
PEER REVIEWED

PRECAUTIONS FOR "CARCINOGENS": There is no universal method of disposal that has been proved satisfactory for all carcinogenic compounds & specific methods of chem destruction ... published have not been tested on all kinds of carcinogen-containing waste. ... summary of avail methods & recommendations ... /given/ must be treated as guide only. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.14]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Total destruction ... by incineration may be only feasible method for disposal of contaminated laboratory waste from biological expt. However, not all incinerators are suitable for this purpose.The most efficient type ... is probably the gas-fired type, in which a first-stage combustion with a less than stoichiometric air:fuel ratio is followed by a second stage

with excess air. Some ... are designed to accept ... aqueous & organic-solvent solutions, otherwise it is necessary ... to absorb soln onto suitable combustible material, such as sawdust. Alternatively, chem destruction may be used, esp when small quantities ... are to be destroyed in laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": HEPA (high-efficiency particulate arrestor) filters ... can be disposed of by incineration. For spent charcoal filters, the adsorbed material can be stripped off at high temp & carcinogenic wastes generated by this treatment conducted to & burned in an incinerator. ... LIQUID WASTE: ... Disposal should be carried out by incineration at temp that ... ensure complete combustion. SOLID WASTE: Carcasses of lab animals, cage litter & misc solid wastes ... should be disposed of by incineration at temp high enough to ensure destruction of chem carcinogens or their metabolites. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... small quantities of ... some carcinogens can be destroyed using chem reactions ... but no general rules can be given. ... As a general technique ... treatment with sodium dichromate in strong sulfuric acid can be used. The time necessary for destruction ... is seldom known ... but 1-2 days is generally considered sufficient when freshly prepd reagent is used. ... Carcinogens that are easily oxidizable can be destroyed with milder oxidative agents, such as sat soln of potassium permanganate in acetone, which appears to be a suitable agent for destruction of hydrazines or of compounds containing isolated carbon-carbon double bonds. Concn or 50% aqueous sodium hypochlorite can also be used as an oxidizing agent. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.16]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Carcinogens that are alkylating, arylating or acylating agents per se can be destroyed by reaction with appropriate nucleophiles, such as water, hydroxyl ions, ammonia, thiols & thiosulfate. The reactivity of various alkylating agents varies greatly ... & is also influenced by sol of agent in the reaction medium. To facilitate the complete reaction, it is suggested that the agents be dissolved in ethanol or similar solvents. ... No method should be applied ... until it has been thoroughly tested for its effectiveness & safety on material to be inactivated. For example, in case of destruction of alkylating agents, it is possible to detect residual compounds by reaction with 4(4-nitrobenzyl)-pyridine. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.17]**PEER REVIEWED**

Chemical Treatability of **Cadmium**; Concentration Process: Biological Treatment; Chemical Classification: Metal; Scale of Study: Literature Review; Type of Wastewater Used: Unknown; Results of Study: 1.0 ppb effluent concentration (Activated sludge process). /Soluble **cadmium** cmpd/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-52 (1982)]**PEER REVIEWED**

Chemical Treatability of **Cadmium**; Concentration Process: Biological Treatment; Chemical Classification: Metal; Scale of Study: Full Scale, Continuous Flow; Type of Wastewater Used: Industrial

Wastewater; Results of Study: 27 ppb 16 ppb effluent concentration (Survey of municipal wastewater treatment plants). /**Cadmium** cmpd/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-52 (1982)]**PEER REVIEWED**

Chemical Treatability of **Cadmium**; Concentration Process: Biological Treatment; Chemical Classification: Metal; Scale of Study: Respirometer Study; Type of Wastewater Used: Unknown: Results of Study: 1-10 ppb inhibited oxygen uptake. /Soluble **cadmium** cmpd/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-52 (1982)]**PEER REVIEWED**

Chemical Treatability of **Cadmium**; Concentration Process: Chemical Precipitation; Chemical Classification: Metal; Scale of Study: Pilot Scale; Type of Wastewater Used: Synthetic Wastewater; Results of Study: 45% reduction by ferric chloride: (3 coagulents used; 220 ppm of aluminum @ pH= 6.4, 40 ppm of ferric chloride @ pH= 6.2, 451 ppm of lime @ pH= 11.5. Chemical coagulation was followed by qual media filtration). /**Cadmium** cmpd/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-69 (1982)]**PEER REVIEWED**

Chemical Treatability of **Cadmium**; Concentration Process: Chemical Precipitation; Chemical Classification: Metal; Scale of Study: Pilot Scale; Type of Wastewater Used: Domestic Wastewater; Results of Study: Iron system, 93% reduction; low lime, 95% reduction; high lime 98% reduction (3 coagulent systems were used: iron system used 45 ppm as Fe2(SO4)3 and 260 ppm pf CaO @ pH= 10.0, high lime system used 600 ppm of CaO @ pH= 11.5. Chemical coagulation was followed by multimedia filtration). /**Cadmium** cmpd/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-69 (1982)]**PEER REVIEWED**

Chemical Treatability of **Cadmium**; Concentration Process: Chemical Precipitation; Chemical Classification: Metal; Scale of Study: Full Scale, Continuous Flow; Type of Wastewater Used: Domestic Wastewater; Results of Study: 29 ppb influent character; 29 ppb, 92% reduction with lime; 9 ppb, 68% reduction with lime; (lime dose of 350-400 ppm as calcium oxide @ pH= 11.3). /**Cadmium** cmpd/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-69 (1982)]**PEER REVIEWED**

Chemical Treatability of **Cadmium**; Concentration Process: Reverse Osmosis; Chemical Classification: Metal; Scale of Study: Batch Flow; Type of Wastewater Used: Pure Compound; Results of Study: Influent character (ppm); 0.10, 90% reduction with Ca membrane; 0.96, 99% reduction with Ca membrane; 1.0, 98.7% reduction with Ca membrane (Ca membrane operated at 400 psig and 16-22 deg C). /**Cadmium** cmpd/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-87 (1982)]**PEER REVIEWED**

Chemical Treatability of **Cadmium**; Concentration Process: Activated Carbon; Chemical Classification: Metal; Scale of Study: Pilot Scale, Continuous Flow; Type of Wastewater Used: Pure Compound; Results of Study: With Virgin Filtrasorb 200 average removal was 19%; with exhausted FS 200 average removal was 37%; (Study consisted of 8 tests of about 100 hr duration each). /**Cadmium** cmpd/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-162 (1982)]**PEER REVIEWED**

Precipitate from solution as sulfides, and return to supplier. /**Cadmium** compounds/
[Sittig M; Handbook of Toxic and Hazardous Chemicals p.122 (1981)]**PEER REVIEWED**

The following wastewater treatment technologies have been investigated for **cadmium** compounds:

Concentration process: Biological treatment. /**Cadmium** cmpd/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-3-E-22 (1982)]**PEER REVIEWED**

The following wastewater treatment technologies have been investigated for **cadmium** compounds: Concentration process: Chemical precipitation. /**Cadmium** cmpd/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-3-E-22 (1982)]**PEER REVIEWED**

The following wastewater treatment technologies have been investigated for **cadmium** compounds: Concentration process: Reverse osmosis. /**Cadmium** cmpd/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-3-E-22 (1982)]**PEER REVIEWED**

The following wastewater treatment technologies have been investigated for **cadmium** compounds: Concentration process: Activated carbon. /**Cadmium** cmpd/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-3-E-22 (1982)]**PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

Permissible Exposure Limit: The employer shall assure that no employee is exposed to an airborne concentration of **cadmium** in excess of 5 ug/cu m, calculated as an 8-hr TWA. /**Cadmium**, as Cd/
[29 CFR 1910.1027(c) (7/1/98)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-2 8-hr Time Weighted Avg: 0.1 mg/cu m. This standard applies to any operations or sectors for which the **Cadmium** standard, 1910.1027, is stayed or otherwise not in effect. /**Cadmium** fume/
[29 CFR 1910.1000 (7/1/98)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-2 Acceptable Ceiling Concentration: 0.3 mg/cu m. This standard applies to any operations or sectors for which the **Cadmium** standard, 1910.1027, is stayed or otherwise not in effect. /**Cadmium** fume/
[29 CFR 1910.1000 (7/1/98)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-2 8-hr Time Weighted Avg: 0.2 mg/cu m. This standard applies to any operations or sectors for which the **Cadmium** standard, 1910.1027, is stayed or otherwise not in effect. /**Cadmium** dust/
[29 CFR 1910.1000 (7/1/98)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-2 Acceptable Ceiling Concentration: 0.6 mg/cu m. This standard applies to any operations or sectors for which the **Cadmium** standard, 1910.1027, is stayed or otherwise not in effect. /**Cadmium** dust/
[29 CFR 1910.1000 (7/1/98)]**PEER REVIEWED**

Threshold Limit Values:

8 hr Time Weighted Avg (TWA) 0.01 mg/cu m; 8 hr Time Weighted Avg (TWA) 0.002 mg/cu m respirable fraction. /**Cadmium**, elemental and cmpd, as Cd/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 22]**PEER REVIEWED**

A2. A2= Suspected human carcinogen. /**Cadmium**, elemental and compounds, as Cd/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 22]**PEER REVIEWED**

BEI (Biological Exposure Index): **Cadmium** in urine (timing is not critical) is 5 ug/g creatinine. The determinant is usually present in a significant amt in biological specimens collected from subjects who have not been occupationally exposed. Such background levels are incl in the BEI value. (1993 adoption) /**Cadmium** & inorganic cmpd/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 96]**PEER REVIEWED**

BEI (Biological Exposure Index): **Cadmium** in blood (timing is not critical) is 5 ug/l. The determinant is usually present in a significant amt in biological specimens collected from subjects who have not been occupationally exposed. Such background levels are incl in the BEI value. (1993 adoption) /**Cadmium** & inorganic cmpd/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 96]**PEER REVIEWED**

Excursion Limit Recommendation: Excursions in worker exposure levels may exceed three times the TLV-TWA for no more than a total of 30 min during a work day, and under no circumstances should they exceed five times the TLV-TWA, provided that the TLV-TWA is not exceeded. /**Cadmium**, elemental and cmpd, as Cd/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 6]**PEER REVIEWED**

NIOSH Recommendations:

NIOSH considers **cadmium** dust (as Cd) to be a potential occupational carcinogen. /**Cadmium** dust (as Cd)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 44]**PEER REVIEWED**

NIOSH usually recommends that occupational exposures to carcinogens be limited to the lowest feasible concentration. /**Cadmium** dust (as Cd)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 44]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH considers **cadmium** dust (as Cd) to be a potential occupational carcinogen. /**Cadmium** dust (as Cd)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 44]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

By far the largest use of **cadmium** in 1999 was in batteries (69%), followed by pigments (13%), coatings and plating (8%), stabilizer for plastics (7%), nonferrous alloys (2%), and electro-optical and other uses (1%).

[U.S. Department of Interior; U.S. Geological Survey, Mineral Commodity Survey - 1999: Cadmium. Available from http://minerals.er.usgs.gov/minerals/pubs/commodity/cadmium(1999) as of Sept., 1999]**PEER REVIEWED**

/FORMER:/ MEDICATION (VET): /**CADMIUM** SALTS/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 76]**PEER REVIEWED**

General Manufacturing Information:

Overall environmental concerns have led manufacturers to move away from heavy metal-based stabilizers. There has therefore been a decrease in consumption of **cadmium** compounds in the stabilizer field that began in the late 1970s.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V4 775]**PEER REVIEWED**

Consumption Patterns:

In 1999, the largest use of **cadmium** was in batteries (69%), followed by pigments (13%), coatings and plating (8%), stabilizer for plastics (7%), nonferrous alloys (2%) and electro-optical and other uses (1%).

[US Dept Int; US Geological Survey, Mineral Commodity Survey - 1999 Database on Cadmium Available from the Database Query page at http://minerals.er.usgs.gov/minerals/pubs/commodity/cadmium as of Oct 17, 2000.]**PEER REVIEWED**

Over the last 25 years, the use of **cadmium** in plating has declined markedly because of human health and environmental concerns.
[World Health Organization; Environmental Health Criteria 134. Cadmium. Geneva, Switzerland (1992)]**PEER REVIEWED**

In recent years, the use of **cadmium** in batteries has increased, while other uses have remained stable and even declined, as is the case with pigments.
[US Dept Int; U.S. Geological Survey, Minerals Information - 1997 Database on Cadmium. Available from the Database Query page at http://minerals.er.usgs.gov/minerals/pubs/commodity/cadmium as of Oct 17, 2000.]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

Analysis of blood and urine for **cadmium** by atomic absorption spectrophotometry after extraction by methyl isobutyl ketone of a chelate of **cadmium** and ammonium pyrrolidine dithiocarbamate. Wet ashing of 10 ml of serum or 50 ml of 65% nitric acid, 5 ml of 96% sulfuric acid, and 5 ml of 70% perchloric acid. Residues were dissolved in dilute hydrochloric acid and adjusted to pH 2.5. The chelate was formed by adding 2 ml of 5% aqueous ammonium pyrrolidine dithiocarbamate solution and was extracted into 2 ml methyl isobutyl ketone. The organic phase was then analyzed by atomic absorption spectrophotometry. ... Detection limits of 12 ng Cd/100 ml of urine or 60 ng Cd/100 ml serum, with a precision of 10% and mean recoveries of 96%. /Total **cadmium**/
[Lehnert G et al; Br J Ind Med 26: 156-158 (1969) as cited in NIOSH; Criteria Document: Cadmium p.46 (1976) DHEW Pub. NIOSH 76-192]**PEER REVIEWED**

BLOOD & URINE; ATOMIC ABSORPTION, FLAMELESS; & IN ABSTRACTS OF PAPERS

PRESENTED AT CEE-EPA-WHO INTERNATIONAL SYMPOSIUM ON RECENT ADVANCES IN ASSESSMENT OF HEALTH EFFECTS OF ENVIRONM POLLUTION. /TOTAL **CADMIUM**/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 53 (1976)]**PEER REVIEWED**

PREVIOUSLY PUBLISHED SPECTROFLUOROMETRIC, COLORIMETRIC, POLAROGRAPHIC & ATOMIC ABSORPTION METHODS FOR DETECTION OF **CADMIUM** ARE DESCRIBED. EXCELLENT AGREEMENT OBSERVED WHEN LATTER 2 METHODS WERE USED FOR DETERMINING **CADMIUM** IN ORGANS OF RATS. /TOTAL **CADMIUM**/
[FROMONT B ET AL; BULL SOC PHARM LILLE (2): 77 (1972)]**PEER REVIEWED**

MONITORING METHODS: BLOOD: ANODIC STRIPPING VOLTAMMETRY; RANGE: 0.002 TO 1 UG/ML IN 1 ML OF BLOOD. /TOTAL **CADMIUM**/
[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing Office, 1977-present.p. V1 223-1]**PEER REVIEWED**

MONITORING METHODS: URINE: ANODIC STRIPPING VOLTAMMETRY; RANGE: 1 TO 1000 UG/ML IN 1 ML OF URINE. /TOTAL **CADMIUM**/
[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing Office, 1977-present.p. V1 224-1]**PEER REVIEWED**

IN VIVO DETERMINATION OF **CADMIUM** IN LIVER BY NEUTRON ACTIVATION. /TOTAL **CADMIUM**/
[Friberg, L., G.R. Nordberg, and V.B. Vouk. Handbook on the Toxicology of Metals. New York: Elsevier North Holland, 1979. 356]**PEER REVIEWED**

Analyte: **Cadmium**; Matrix: blood or tissue; Procedure: Inductively-coupled argon plasma-atomic emission spectroscopy; Wavelength: 226.5 nm; Range: 10 to 10,000 ug/100 g blood, 2 to 2000 ug/g tissue; Est LOD: 1 ug/100 g blood, 0.2 ug/g tissue; Precision: 1.1; Interferences: spectral, minimized by wavelength selection. /Total **cadmium**/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V1 8005-1]**PEER REVIEWED**

Analyte: **Cadmium**; Matrix: urine; Procedure: Inductively-coupled argon-plasma, atomic emission spectroscopy; Extraction media: polydithiocarbamate resin; Wavelength: 226.5 nm; Range: 0.25-200 ug/samp; Est LOD: 0.1 ug/samp; Precision: 0.12; Interferences: spectral, minimized by wavelength selection. /Total **cadmium**/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V1 8310-1]**PEER REVIEWED**

Analyte: **Cadmium**; Specimen: Blood or tissue; Vol: 10 ml blood, or 1 g tissue; Preservative: Heparin for blood, none for tissue; Controls: collect 3 blood specimens from unexposed workers; Stability: not established /**Cadmium** and **cadmium** cmpd/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions.

Washington, DC: U.S. Government Printing Office, February 1984.p. V1 8005-1]**PEER REVIEWED**

Analyte: **Cadmium**; Specimen: urine; Vol: 50-200 ml in polyethylene bottle; Preservative: 5 ml conc nitric acid added after collection; Controls: collect at least 3 urine specimens from unexposed workers; Stability: not established /**Cadmium** and **cadmium** cmpd/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V1 8310-1]**PEER REVIEWED**

Analytic Laboratory Methods:

Method 200.7: An Inductively Coupled Plasma - Atomic Emission Spectrophotmetric method for the determination of dissolved, suspended, or total elements in drinking water, surface water, and domestic and industrial wastewaters, is described. **Cadmium** is analyzed at a wavelength of 226.502 nanometers and has an estimated detection limit of 4.0 ug/l.
[40 CFR 136.1 (7/1/85)]**PEER REVIEWED**

EPA (1979) Method 213.1 states that the analysis of **cadmium** in water and wastewaters requires digestion by nitric acid followed by direct aspiration atomic absorption, graphite furnace atomic absorption, voltammetry, or colorimetric determination. This method is also listed as Standard Methods 303, ASTM D3557-84(A) or (B), and USGS I-3135-84.
[51 FR 23693 (6/30/86)]**PEER REVIEWED**

NIOSH Method 7048. Analyte: **Cadmium**; Matrix: air; Procedure: Atomic absorption, flame; Wavelength: 228.8 nm; Range: 2.5-30 ug/samp; Est LOD: 0.05 ug/samp; Precision: 0.05; Interferences: background correction required to control molecular or flame absorption. Detection limit: 0.030 ug/cu m.
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

Analyte: **Cadmium**; Matrix: air; Procedure: X-ray fluorescence; Range: 0.3 - 5.0 mg/cu m; Est LOD: 2 ug each metal/samp; Precision: 0.063; Interferences: Controlled with wavelength dispersive fluorescence, more severe with energy dispersive systems, cobalt in fumes requires different ratio standard element.
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V2 7200-1]**PEER REVIEWED**

NIOSH Method 7300. Analyte: **Cadmium**; Matrix: air; Procedure: inductively coupled argon plasma, atomic emission spectroscopy; Wavelength: 226.5 nm; Range: 2.5-1000 ug/sample; Precision: 0.032 @ 2.5 ug/filter, 0.020 @ 1000 ug/filter; Interferences: spectral, minimized by wavelength selection, interelement and background correction. Detection limit: 0.001 mg/cu m.
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

EPA Method 7130: **Cadmium** (Atomic Absorption, Direct Aspiration) Method 7130 is applicable for the determination of metals in solution by atomic absorption spectrometry. Preliminary treatment of

waste water, ground water, EP extracts, and industrial waste is always necessary because of the complexity and variability of sample matrix. After aspiration and atomization of the sample in a flame, a light beam from a hollow cathod lamp or an electrodeless discharge lamp is directed through the flame into a monochromator and onto a detector that measures the amount of light absorbed. ... The light energy absorbed by the flame is a measure of the concentration of that metal in the sample. The performance characteristics for an aqueous sample free of interferences are: a sensitivity of 0.025 mg/l, and a detection limit of 0.005 mg/l.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW846 Methods (1986)]**PEER REVIEWED**

EPA Method 7131: **Cadmium** (Atomic Absorption, Furnace Technique) Method 7131 is applicable for the determination of metals in solution by atomic absorption spectrometry. For certain samples, lower concentrations may be determined using this technique. To ensure valid data, each matrix must be examined for interference effects and, if detected, treat them accordingly, using either successive dilution, matrix modification, or method of standard additions. If poor recoveries are obtained, a matrix modifier may be necessary. Add 10 ul of phosphoric acid to 1 ml of prepared sample in the furnace sampler cup and mix well. A representative aliquot of a sample is placed in the graphite tube in the furnace, evaporated to dryness, charred, and atomized. ... Radiation from a given excited element is passed through the vapor containing ground-state atoms of that element. ... The metal atoms to be measured are placed in the beam of radiation by increasing the temperature of the furnace, thereby causing the injected specimen to be volatilized. A monochromator isolates the characteristic radiation from the hollow cathode lamp or electrodeless discharge lamp, and a photosensitive device measures the attenuated transmitted radiation. The optimum concentration range is 0.5-10 ug/l with a detection limit of 0.1 ug/l.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW846 Methods (1986)]**PEER REVIEWED**

EPA Method 213.2. **Cadmium**, Atomic Absorption, Graphite Furnace Technique. Water. Detection limit 0.100 ug/l.
[USEPA; Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, Revised March 1983 as cited in USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

Sampling Procedures:

An alternative for determination of particle size frequency over longer time periods is the multiple cyclone sampler. /**Cadmium** and **cadmium** cmpd/
[Lippmann M, Kydonieus A; Am Ind Hyg Assoc J 31: 730-7 (1970) as cited in NIOSH; Criteria Document: Cadmium p.45 (1976) DHEW Pub. NIOSH 76-192]**PEER REVIEWED**

Electrostatic precipitator samples are satisfactory for general air sampling, but inconvenient for breathing zone samples. /**Cadmium** and **cadmium** cmpd/
[NIOSH; Criteria Document: Cadmium p.45 (1976) DHEW Pub. NIOSH 76-192]**PEER REVIEWED**

Analyte: **Cadmium** and cmpd as Cd; Matrix: air; Sampler: Filter (0.8 um cellulose ester membrane); Flow rate: 1-3 l/min; Vol: min: 25 l at 0.1 mg/cu m, max: 1500 l; Stability: stable /**Cadmium** and cmpd as Cd/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V1 7048-1]**PEER REVIEWED**

Analyte: **Cadmium**; Matrix: air; Sampler: filter (0.8 um cellulose ester membrane); Flow rate: 1 l/min; Vol: min: 10 l, max: 400 l; Stability: At least 1 yr at 25 deg C /Welding and brazing fumes/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V2 7200-1]**PEER REVIEWED**

Analyte: **Cadmium**; Matrix: air; Sampler: filter (0.8-um cellulose membrane); Flow rate: 1-4 l/min; Vol: min: 13 l, max: 2000 l; Stability: stable /**Cadmium** and **cadmium** cmpd/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V1 7300-1]**PEER REVIEWED**

Sampling and analyses may be performed by collection of **cadmium** dust on a filter followed by treatment with nitric acid solution in hydrochloric acid. /**Cadmium** and **cadmium** cmpd/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Special References:

Special Reports:

Ragen HA, Mast TJ; **Cadmium** Inhalation and Male Reproductive Toxicity; Rev Environ Contam Toxicol 114: 1-22 (1990)

Nat'l Research Council Canada; **Cadmium** (1979) NRCC No.16743

Health and Welfare Canada; Hazard Assessment Report on **Cadmium** (1983)

EEC; Criteria (Dose/Effect Relationships) for **Cadmium** (1978)

USEPA; Ambient Water Quality Criteria Doc: **Cadmium** (1985) EPA 440/5-84-032

USEPA; Health Assessment Document: **Cadmium** (1981) EPA 600/8-81-023

NIOSH; Criteria Document: **Cadmium** (1976) DHEW Pub. NIOSH 76-192

USEPA/OWRS; Quality Criteria for Water 1986 **Cadmium** (1986) EPA 440/5-86-001.

DHHS/FDA; Guidance Document for **Cadmium** in Shellfish (1993)

DHHS/ATSDR; Toxicological Profile for **Cadmium** (Update) TP-92/06 (1993)

U.S. Department of Health & Human Services/National Toxicology Program; Tenth Report on Carcinogens. National Institutes of Environmental Health Sciences. The Report on Carcinogens is an informational scientific and public health document that identifies and discusses substances (including agents, mixtures, or exposure circumstances) that may pose a carcinogenic hazard to human health. **Cadmium** (7440-43-9) was listed in the First Annual Report on Carcinogens (1980) as reasonably

anticipated to be a human carcinogen and then listed in the Ninth Report on Carcinogens (2000) as a known human carcinogen. /**Cadmium** and **Cadmium** Compounds/
[ ]

Synonyms and Identifiers:

Related HSDB Records:

1613 [**CADMIUM** OXIDE]

282 [**CADMIUM**; 7440-43-9]

278 [**CADMIUM** CHLORIDE]

279 [**CADMIUM** BROMIDE]

276 [**CADMIUM** NITRATE]

274 [**CADMIUM** SULFATE]

1614 [**CADMIUM** SULFIDE]

5827 [**CADMIUM** MERCURY SULFIDE]

1612 [**CADMIUM** CARBONATE]

277 [**CADMIUM** FLUOBORATE]

280 [**CADMIUM** ACETATE]

6140 [**CADMIUM** 2-ETHYLHEXANOATE]

1304 [**CADMIUM** (2+) NTA]

Synonyms:

CADMIUM
PEER REVIEWED

Associated Chemicals:

Cadmium ion (2+);22537-48-0

Shipping Name/ Number DOT/UN/NA/IMO:

UN 2570; **Cadmium** compounds

IMO 6.1; **Cadmium** compounds

Administrative Information:

Hazardous Substances Databank Number: 6922

Last Revision Date: 20030829

Last Review Date: Reviewed by SRP on 9/23/1999

Update History:

Complete Update on 2003-08-29, 0 fields added/edited/deleted
Complete Update on 01/24/2003, 2 fields added/edited/deleted.
Field Update on 11/08/2002, 1 field added/edited/deleted.
Complete Update on 08/06/2002, 1 field added/edited/deleted.
Complete Update on 05/31/2002, 1 field added/edited/deleted.
Complete Update on 05/13/2002, 1 field added/edited/deleted.
Complete Update on 01/14/2002, 1 field added/edited/deleted.
Complete Update on 08/09/2001, 1 field added/edited/deleted.
Complete Update on 05/16/2001, 1 field added/edited/deleted.
Complete Update on 05/15/2001, 1 field added/edited/deleted.
Complete Update on 02/26/2001, 1 field added/edited/deleted.
Complete Update on 10/27/2000, 6 fields added/edited/deleted.
Complete Update on 10/18/2000, 66 fields added/edited/deleted.
Created 19880519 by KFG

Record Length: 181950.0

CADMIUM, ELEMENTAL

CASRN: 7440-43-9

This record contains information for cadmium in its zero valence state only. For general toxicity and environmental fate of cadmium ions and cadmium compounds, refer to the CADMIUM COMPOUNDS record; for compound-specific information, to the appropriate individual record, e.g., cadmium sulfate, cadmium chloride, etc.

For other data, click on the Table of Contents

Human Health Effects:

Evidence for Carcinogenicity:

Evaluation: There is sufficient evidence in humans for the carcinogenicity of **cadmium** and **cadmium** compounds. There is sufficient evidence in experimental animals for the carcinogenicity of **cadmium** compounds. There is limited evidence in experimental animals for the carcinogenicity of **cadmium** metal. In making the overall evaluation, the Working Group took into consideration the evidence that ionic **cadmium** causes genotoxic effects in a variety of types of eukaryotic cells, including human cells. Overall evaluation: **Cadmium** and **cadmium** compounds are carcinogenic to humans (Group 1). /**Cadmium** and **cadmium** compounds/

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 58 210 (1993)]**PEER REVIEWED**

CLASSIFICATION: B1; probable human carcinogen. BASIS FOR CLASSIFICATION: Limited evidence from occupational epidemiologic studies of **cadmium** is consistent across investigators and study populations. There is sufficient evidence of carcinogenicity in rats and mice by inhalation and intramuscular and subcutaneous injection. Seven studies in rats and mice wherein **cadmium** salts (acetate, sulfate, chloride) were administered orally have shown no evidence of carcinogenic response. HUMAN CARCINOGENICITY DATA: Limited.

[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Cadmium (7440-43-9) from the National Library of Medicine's TOXNET System, March 6, 1995]**PEER REVIEWED**

A2. A2= Suspected human carcinogen. /**Cadmium**, elemental and compounds, as Cd/

[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 22]**PEER REVIEWED**

Human Toxicity Excerpts:

In a retrospective study, 311 male workers in an alkaline battery factory were evaluated for **cadmium** exposure. Workers were exposed to > 50 ug/cu m for 1 - 35 years. Hypertension (defined by average blood pressure > 160/95 over a 5 year period) was noted in 23% of workers over 40. The duration of employment correlated with the degree of hypertension among age-matched groups of workers when compared to normotensives. In this study laborers were exposed to levels that exceed 50 ug **cadmium**/cu m, while today's workers are exposed to air levels averaging 10 ug **cadmium**/cu m.

[Engvall J, Perk J; Arch Env Health 40 (3): 185-90 (1985)]**PEER REVIEWED**

The chief chronic pulmonary effects of **cadmium** are ... centrilobular emphysema and bronchitis resulting from several years of occupational exposure to **cadmium** oxide fumes, **cadmium** oxide dust, and **cadmium** pigment dust.

[USEPA; Health Assessment Document: Cadmium p.1-11 (1981) EPA-600/8-81-023]**PEER REVIEWED**

Two hundred forty male and female workers in a battery factory along with 87 unexposed male controls were studied to determine the excretion of beta(2)-microglobulin. The exposed workers were employed in the department where materials for battery electrodes were made (material plant) or where the electrodes and batteries were assembled (assembly plant). ... Diagnosis of proteinuria was made in those whose microglobulin excretion was greater than the upper 95% confidence limit of the normal concentration in the urine; ... this was not considered necessarily to be a clinically significant proteinuria. There was an increased incidence of microglobulinuria in the exposed group. In the unexposed controls, 3.4% had microglobulinuria. In the assembly plant, women had a 2.3% incidence of this type of proteinuria and men had a 25% incidence. The men who worked in the material plant had a 52% incidence of microglobulinuria. These incidences in male workers were significantly different from control incidences at ($p< 0.001$); differences in incidences between female workers and controls were not significant. The 2.3% incidence among working women represents one case of microglobulinuria among 41 women. Yet 15 of the women had been exposed for more than 5 years. The lower rate of microglobulinuria among women might in part reflect a lower smoking rate; of the 13 women whose smoking habits were known, 5 were smokers. Nonsmoking **cadmium** exposed workers had a lower prevalence of the defined proteinuria than smoking **cadmium** exposed workers. Nine of the workers were separately treated in the study because they were from Yugoslavia, where tubular proteinuria is endemic (Balkan nephropathy); two of them were found to excrete increased amounts of microglobulin. In the 185 employees that worked continuously with **cadmium**, the prevalence of microglobulinuria increased with exposure time.
[NIOSH; Criteria Document: Cadmium p.23 (1976) DHEW Pub. NIOSH 76-192]**PEER REVIEWED**

Renal tubular dysfunction was assessed in 102 individuals (36% women, 64% men) with greater than 5 years employment in **cadmium** battery production in an alkaline battery factory. A control group consisted of 53 individuals not involved in **cadmium** battery production, and another 32 individuals working in a cotton factory. Blood **cadmium** (Cd-B), urine **cadmium** (Cd-U), retinol binding protein (RBP), B2-microglobulin (B2-M), and aminoaciduria were determined before the work shift. Wilcoxin's rank sum test was used to assess differences between the control and study groups. Cd-B and Cd-U were higher for subjects working in Cd battery production (Cd-B= 7.5 to 49 ug/l; Cd-U= 5.5 to 36 ug/l) than for those employed at the cotton factory or in work not related to Cd battery production at the alkaline battery factory (Cd-B= 4.8 ug/l; Cd-U= 1.0 ug/l). Urinary excretion of B2-M and RBP was significantly elevated depending on specific work location in the factory) in 20% of workers involved with Cd battery production. A high correlation coefficient (r= 0.85) was obtained for Cd-B and Cd-U values, possibly because Cd-U becomes an indicator of current Cd exposure when Cd exposure is great. Correlation between Cd-U and excretion of B2-M and RBP (r= 0.52 and 0.55, respectively) was also greater than previous reports and possibly indicative of high Cd exposure levels.
[Jakubowski M et al; Int Arch Occup Environ Health 59 (6): 567-77 (1987)]**PEER REVIEWED**

Food and Environmental Agents: Effect on Breast-Feeding: Reported Sign or Symptom in Infant or Effect on Lactation: **Cadmium**: None Reported. /from Table 7/
[Report of the American Academy of Pediatrics Committee on Drugs in Pediatrics 93 (1): 142 (1994)]**PEER REVIEWED**

The consequence of excessive inhalation of **cadmium** fumes and dusts is loss of ventilatory capacity, with a corresponding increase in residual lung volume. Dyspnea is the most frequent complaint of patients with **cadmium** induced lung disease. The pathogenesis of **cadmium**-induced emphysema and pulmonary fibrosis is not well understood; however, **cadmium** specifically inhibits the synthesis of plasma alpha 1-antitrypsin, and there is an association between severe alpha 1-antitrypsin deficiency of genetic origin and emphysema in human beings.
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.).

Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1663]**PEER REVIEWED**

FUMES & DUST OF **CADMIUM** & ITS CMPD ARE VERY TOXIC. /**CADMIUM**, ALLOYS, COMPOUNDS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 233]**PEER REVIEWED**

... EVIDENCE OF GONADAL EFFECTS FROM **CADMIUM**; MICROSCOPIC CHANGES CONSISTING OF DEPRESSION & MATURATION OF SPERMATOCYTES, ASSOC WITH HIGH LEVELS OF **CADMIUM**, WERE FOUND IN TESTES OF MEN EXPOSED TO **CADMIUM** FUME. /**CADMIUM** FUME/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1569]**PEER REVIEWED**

CADMIUM AND ITS SALTS ARE HIGHLY TOXIC. ... INHALATION (DUST OR FUMES): THROAT DRYNESS, COUGH, HEADACHE, VOMITING, CHEST PAIN, EXTREME RESTLESSNESS & IRRITABILITY, PNEUMONITIS, POSSIBLY BRONCHOPNEUMONIA. /**CADMIUM** AND ITS SALTS/
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 223]**PEER REVIEWED**

Acute poisoning may result from inhalation of **cadmium** dusts & fumes ... & from ingestion of **cadmium** salts. When swallowed, **cadmium** compounds are much less lethal than when inhaled, in part because they induce vomiting & ... are not retained. Although as little as 10-20 mg of sol **cadmium** salts have produced severe toxic symptoms when ingested, death probably requires several hundred milligrams by oral route. /**Cadmium** and **cadmium** salts/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-78]**PEER REVIEWED**

Inhalation of **cadmium** dusts, salts & fume over a number of ... years result in chronic **cadmium** poisoning, a disease characterized by distinctive, nonhypertrophic emphysema with or without renal tubular injury, in which urinary excretion of a protein of molecular wt of 20,000 to 30,000 occurs. ... Further inhalation overexposure results in irreversible renal tubular damage, which may progress into complete Fanconi syndrome with decreased tubular reabsorption of proteins, glucose, amino acids, calcium, phosphorus, & with decreased ability to acidify & concentrate the urine. Other ... toxic effects include anemia, eosinophilia, anosmia, chronic rhinitis, yellow discoloration of teeth, & bone changes. /**Cadmium** and **cadmium** cmpd/
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.87]**PEER REVIEWED**

CADMIUM IS APPARENTLY NOT RESPONSIBLE FOR CASES OF PROSTATIC OR OTHER CANCER OBSERVED IN MEN WORKING IN **CADMIUM** DUST.
[MALCOLM D; ANN OCCUP HYG: 15 (1): 33 (1972)]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

It is irritating to the nose and throat ... /From table/
[Sullivan, J.B. Jr., G.R. Krieger (eds.). Hazardous Materials Toxicology-Clinical Principles of Environmental Health. Baltimore, MD: Williams and Wilkins, 1992. 691]**PEER REVIEWED**

Medical Surveillance:

Initial medical examination: a complete history and physical examination detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the respiratory system, liver, kidneys, prostate, and blood should be stressed. Since kidney damage has been observed in humans exposed to **cadmium**, a urinalysis should be obtained to include, at minimum: specific gravity, albumin, glucose, and a microscopic /examination of the/ centrifuged sediment. In addition, the urine should be examined for low molecular weight proteins by use of 3% sulfosalicylic acid or other acceptable techniques. A 14 x 17 in roentgenogram should be obtained as **cadmium** causes human lung damage. Surveillance of the lungs is recommended. A profile of liver function should be obtained by utilizing a medically acceptable array of biochemical tests.Since **cadmium** may cause liver damage. FVC and FEV (1 sec): **cadmium** is reported to cause decreased pulmonary function. Therefore periodic surveillance is recommended. Medical examinations should be repeated annually, except that X-ray is considered necessary only when indicated by pulmonary function tests or by symptoms of respiratory disease. Urine protein measurements should be available every four months. /**Cadmium** dust (as **cadmium**)/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Environmental monitoring records shall be maintained for at least 20 years. These records shall include methods of sampling and analysis used, types of respiratory protection used, and TWA and ceiling concentrations found. Each employee shall have made available to them information on their own environmental exposures. Environmental records shall be available to designated representatives of the Secretary of Labor, and the Secretary of /Health and Human Services/. Pertinent medical records shall be retained for 20 years after the last occupational exposure to **cadmium**. Records of environmental exposures applicable to the employee should be included in that employee's medical records. These medical records shall be made available to the designated medical representatives of the Secretary of Labor & of /Health and Human Services/, of the employer, and of the employee or former employee. /**Cadmium** cmpd/
[NIOSH; Criteria Document: Cadmium p.5 (1976) DHEW Pub. NIOSH 76-192]**PEER REVIEWED**

The assessment of **cadmium** exposure can be accomplished through measurement of **cadmium**. Studies assessing correlation of blood levels with occupational exposure found that blood levels correlate with recent exposures, and not well with chronic exposure or assessment of total body burden. Whole Blood Reference ranges: Normal - non-occupational exposure levels range from 0.4 to 1.0 ug/l for nonsmokers and up to 4.5 ug/l for smokers; Exposed - BEI (sampling time is not critical): 5 ug/l; Toxic - levels greater than 10 ug/l have been associated with worker toxicity such as renal dysfunction. Serum or Plasma Reference Ranges: Normal - 0.5 to 2 ug/l; Exposed - not established; Toxic - not established. Urine Reference ranges: Normal - non-occupational exposure levels range from 0.02 to 4.5 ug/l; Exposed - BEI (sampling time is not critical): 5 ug/g creatinine; Toxic - Several studies have indicated that urinary levels greater than 10 ug/g creatinine or 10 ug/l in workers have been associated with an increased incidence of renal dysfunction. /**Cadmium**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 525]**PEER REVIEWED**

Respiratory Symptom Questionnaires: Questionnaires have been published by the American Thoracic Society (ATS) and the British Medical Research Council. These questionnaires have been found to be useful in identification of people with chronic bronchitis. however certain pulmonary function tests such as FEV1 (see pulmonary function test section) have been found to be better predictors of chronic airflow obstruction. /**Cadmium**/

[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 529]**PEER REVIEWED**

Chest Radiography: This test is widely used for assessing pulmonary disease. Chest radiographs have been found to be useful for detection of early lung cancer in asymptomatic people, especially for detection of peripheral tumors such as adenocarcinomas. However, even though OSHA mandates this test for exposure to some toxicants such as asbestos, there are conflicting views on its efficacy in detection of pulmonary disease. /**Cadmium**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 529]**PEER REVIEWED**

Pulmonary Function Tests: The tests that have been found to be practical for population monitoring include: Spirometry and expiratory flow-volume curves; Determination of lung volumes; Single-breath nitrogen washout; Inhalation challenges tests; Serial measurements of peak expiratory flow; Exercise testing. /**Cadmium**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 529]**PEER REVIEWED**

Probable Routes of Human Exposure:

OCCUPATIONAL EXPOSURE: EXPOSURE OCCURS PRIMARILY IN SMELTING & REFINING ZINC, LEAD & COPPER ORES CONTAINING **CADMIUM**, SPRAYING **CADMIUM** CONTAINING PIGMENTS, PROCESSING SCRAP CONTAINING **CADMIUM**, ETC. /**CADMIUM**, ALLOYS, COMPOUNDS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 233]**PEER REVIEWED**

The major route of exposure to **cadmium** for the non-smoking general population is via food ... Tobacco is an important source of **cadmium** uptake in smokers.
[WHO; Environmental Health Criteria 134: Cadmium p.18 (1992)]**PEER REVIEWED**

Body Burden:

/IN MAN/ ABOUT HALF OF TOTAL BODY BURDEN IS FOUND IN LIVER & KIDNEYS ... **CADMIUM** IN THESE ORGANS IS MAINLY BOUND TO A LOW MOLECULAR WEIGHT PROTEIN, IN FORM OF A METALLOTHIONEIN ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 90 (1973)]**PEER REVIEWED**

The body burden of **cadmium** in a 50 yr old adult in the US is about 30 mg.
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1662]**PEER REVIEWED**

Average Daily Intake:

50 ug
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1662]**PEER REVIEWED**

Average daily intakes from food in most areas not polluted with **cadmium** are between 10-40 ug. In polluted areas it has been found to be several hundred ug/day.
[WHO; Environmental Health Criteria 134: Cadmium p.22 (1992)]**PEER REVIEWED**

Minimum Fatal Dose Level:

Average concentrations responsible for fatal cases have been estimated at 50 mg/cu m and 40 mg/cu m, both for exposures of 1 hr; and 9 mg/cu m for 5 hr.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.191]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** **CADMIUM** ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE
0.2.1.1 ACUTE EXPOSURE

A. **Cadmium** is a severe lung and gastrointestinal irritant that can be fatal by inhalation and ingestion.
B. The symptoms of acute poisoning after inhalation exposure may be delayed 12 to 36 hours. These include chest pain, cough (with bloody sputum), difficulty breathing, sore throat, 'metal fume fever' (shivering, sweating, body pains, headache) dizziness, irritability, weakness, nausea, vomiting, diarrhea, tracheobronchitis, pneumonitis and pulmonary edema.
C. After acute ingestion, symptoms usually appear in 15 to 30 minutes. These include abdominal pain, burning sensation, nausea, vomiting, salivation, muscle cramps, vertigo, shock, unconsciousness and convulsions.
D. Chronic exposure (by inhalation or ingestion) results in kidney damage, as well as gastrointestinal symptoms, loss of sense of smell, nasal discharge, nose and throat irritation, lack of appetite, weight loss, nausea, tooth discoloration, bone structure defects, liver damage, anemia, pulmonary emphysema, chronic bronchitis, bronchopneumonia and death.
E. Chronic environmental **cadmium** exposure was the etiology of Itai-Itai disease in Japan, and was associated with renal tubular dysfunction, osteomalacia, anemia, and generalized pain.
F. Aaccording to various organizations, **cadmium** and its compounds are considered probably carcinogenic to humans.

0.2.6 RESPIRATORY

0.2.6.1 ACUTE EXPOSURE

A. Acute inhalation of fumes can cause cough, dyspnea and chest tightness which is similar to metal fume fever, but which may progress to pneumonitis, pulmonary edema, and death due to respiratory failure in severe cases. Acute exposure can result in residual emphysema and fibrosis.

B. Bronchitis, emphysema, and fibrosis can result from chronic inhalation of **cadmium** dusts or fumes.

0.2.7 NEUROLOGIC

0.2.7.1 ACUTE EXPOSURE

A. Headaches may occur from chronic occupational exposures.

B. CNS effects of acute exposures have included delayed parkinsonism.

0.2.8 GASTROINTESTINAL

0.2.8.1 ACUTE EXPOSURE

A. INGESTION - Nausea, vomiting, abdominal pain and cramping, diarrhea, salivation, dry mouth, and substernal pain occur.

B. INHALATION - Nausea, vomiting, chills, weakness, diarrhea can occur.

0.2.10 GENITOURINARY

0.2.10.1 ACUTE EXPOSURE

A. Chronic exposure may result in proximal renal tubule damage.

0.2.10.2 CHRONIC EXPOSURE

A. **Cadmium** accumulates in the male reproductive organs with age.

0.2.14 DERMATOLOGIC

0.2.14.1 ACUTE EXPOSURE

A. Skin eruptions and pruritus may occur.

0.2.15 MUSCULOSKELETAL

0.2.15.1 ACUTE EXPOSURE

A. Bone fragility and osteomalacia may be a result of chronic **cadmium** exposure.

0.2.17 METABOLISM

0.2.17.1 ACUTE EXPOSURE

A. **Cadmium** interferes with zinc and calcium metabolism, resulting in bone resorption and osteoporosis.

0.2.20 REPRODUCTIVE HAZARDS

A. Smoking and industrial exposure to **cadmium** has resulted in increased placental levels of **cadmium**.

0.2.21 CARCINOGENICITY

0.2.21.1 IARC CATEGORY

A. **Cadmium** and **cadmium** compounds have been classified by the IARC as Group 1, carcinogenic to humans. Other agencies such as NIOSH and ACGIH have identified **cadmium** and **cadmium** compounds as potential human carcinogens or suspected human carcinogens.

0.2.21.2 HUMAN OVERVIEW

A. Increased incidence of lung, prostate, pancreas and bladder cancers in humans have been reported.

0.2.21.3 ANIMAL OVERVIEW

A. **Cadmium** has produced tumors of the ventral prostate of rats.

0.2.22 GENOTOXICITY

A. Chromosome damage in humans and experimental animals have occurred, although **cadmium** is thought to be a poor mutagen. One study found that **cadmium** (II) inhibited DNA repair enzymes, but low doses stimulated DNA synthesis and cell growth in animals.

Laboratory:

A. Blood **cadmium** levels are a reflection of acute **cadmium** exposure. Urine **cadmium** levels appear to be a better measurement of chronic exposure (Kowal et al, 1979).
B. Urinary metallothionein may be a better indicator of body burden, but is not widely available.

Treatment Overview:

0.4.2 ORAL EXPOSURE
A. Activated charcoal has no proven benefit in **cadmium** poisoning, but may be considered.
1. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.
B. CHELATION - Although not demonstrably efficacious, chelation therapy may be of benefit immediately following acute exposure.
1. Administer CaNa2 EDTA 75 mg/kg/day deep IM or slow IV infusion given in 3 to 6 divided doses for up to 5 days. May be repeated for a second course after a minimum of two days drug holiday; each course should not exceed a total of 500 mg/kg body weight. CAUTION: BAL must not be used with **cadmium** since the complex is nephrotoxic.
0.4.3 INHALATION EXPOSURE
A. INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids.
B. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.
C. Treatment of inhalation toxicity should include recommendations listed in the oral exposure section when appropriate.

Range of Toxicity:

A. Acute ingestion of as little as 10 mg of inorganic **cadmium** has caused severe symptoms. Severe pulmonary toxicity (pulmonary edema) may ensue following inhalation of **cadmium** fumes. Significant dermal absorption seldom occurs.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

Exptl Therapy: Quinamic acid, bis-(3-carboxy-5-N-dicarboxymethyl-aminomethyl-6,7-dihydroxy-1,2,-3,4-tetrahydroisoquinolinyl-8)-5,8-dimethyl-6,7-dihydroxyl-1,2,3,4- tetrahydroisoquinoline-3-carboxylic

acid, is a new chelating agent. Quinamic acid iv 500 mg/kg markedly reduced the mortality of acute ip poisoning of zinc sulfate, nickel chloride, **cadmium** chloride, and uranyl nitrate in mice ($p < 0.01$). ... Within two weeks, treated rats showed less toxic reactions and renal damages than the control rats. The activity of urinary catalase in treated rats was significantly lower than in controls.
[Yan X-M et al; Acta Pharmacol Sin 6 (1): 73-6 (1985)]**PEER REVIEWED**

Basic treatment: Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary, Administer oxygen by nonrebreather mask at 10 to 15 L/min. Monitor for pulmonary edema and treat if necessary ... . Anticipate seizures and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport ... . Do not use emetics. For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal ... . /**Cadmium** and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994.,p. 344-5]**PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious or in severe pulmonary edema. Positive-pressure ventilation techniques with a bag-valve-mask device may be beneficial. Monitor cardiac rhythm and treat arrhythmias if necessary ... . Start an IV with D5W TKO /SRP: "To keep open", minimal flow rate/. Use lactated Ringer's if signs of hypovolemia are present. Watch for signs of fluid overload. Consider drug therapy for pulmonary edema ... . Treat seizures with diazepam (Valium) ... . Use proparacaine hydrochloride to assist eye irrigation ... . /**Cadmium** and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 345]**PEER REVIEWED**

Animal Toxicity Studies:

Evidence for Carcinogenicity:

Evaluation: There is sufficient evidence in humans for the carcinogenicity of **cadmium** and **cadmium** compounds. There is sufficient evidence in experimental animals for the carcinogenicity of **cadmium** compounds. There is limited evidence in experimental animals for the carcinogenicity of **cadmium** metal. In making the overall evaluation, the Working Group took into consideration the evidence that ionic **cadmium** causes genotoxic effects in a variety of types of eukaryotic cells, including human cells. Overall evaluation: **Cadmium** and **cadmium** compounds are carcinogenic to humans (Group 1). /**Cadmium** and **cadmium** compounds/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 58 210 (1993)]**PEER REVIEWED**

CLASSIFICATION: B1; probable human carcinogen. BASIS FOR CLASSIFICATION: Limited evidence from occupational epidemiologic studies of **cadmium** is consistent across investigators and study populations. There is sufficient evidence of carcinogenicity in rats and mice by inhalation and intramuscular and subcutaneous injection. Seven studies in rats and mice wherein **cadmium** salts (acetate, sulfate, chloride) were administered orally have shown no evidence of carcinogenic response. HUMAN CARCINOGENICITY DATA: Limited.
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Cadmium (7440-43-9) from the National Library of Medicine's TOXNET System, March 6, 1995]**PEER REVIEWED**

A2. A2= Suspected human carcinogen. /**Cadmium**, elemental and compounds, as Cd/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold

Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 22]**PEER REVIEWED**

Non-Human Toxicity Excerpts:

... MALIGNANT LOCAL TUMORS /OCCURRED/ IN 9/10 & 6/8 FEMALE HOODED RATS GIVEN IM INJECTIONS OF 14 OR 28 MG **CADMIUM** POWDER, RESPECTIVELY, INTO THIGH MUSCLE ... HIGH PROPORTION OF TUMORS WERE RHABDOMYOSARCOMAS ... SOME WERE FIBROSARCOMAS; IN GENERAL, THEY WERE FAIRLY WELL DIFFERENTIATED, BUT MANY METASTASIZED.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 55 (1976)]**PEER REVIEWED**

Cadmium metal implanted experimentally in rabbit eyes has proved very toxic, causing severe purulent intraocular inflammation and cataract.
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 165]**PEER REVIEWED**

ALTHOUGH PAST ANIMAL STUDIES ... IMPLICATED VARIOUS **CADMIUM** CMPD ... /CHLORIDE, SULFIDE, OXIDE, SULFATE/ & EVEN METAL AS CARCINOGENS, ELICITING RHABDOMYOSARCOMAS & TESTICULAR TUMORS, THERE ARE NO REPORTS THAT **CADMIUM** IS CARCINOGENIC BY INGESTION.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.88]**PEER REVIEWED**

Different size groups of mud dwelling crabs, Ilyoplax gangetica, were subjected to various **cadmium** concn to assess the toxicity of the metal. The 96 hr median lethal concn was determined by keeping pH, salinity and dissolved oxygen constant. Smaller crabs are more sensitive to **cadmium**. The bioavailability of **cadmium** can be indirectly influenced by forming hydroxides. The safe values of 25 ppm ammonium hydroxide and 10% standard sewage with different concn of **cadmium** were used to study the size related toxicity to the crabs.
[Borgaonkar SS, Gokhale KS; J Environ Biol 6 (3): 179-83 (1985)]**PEER REVIEWED**

Groups of 10 female hooded rats, two to three months old, received a single intramuscular injection of 14 or 28 mg **cadmium** metal powder ... suspended in 0.4 ml fowl serum into the thigh muscle. The total duration of the study was 84 weeks. ... Two of the rats receiving 28 mg **cadmium** powder were killed within two weeks of injection in order to study acute local reactions. Malignant tumors developed at the site of injection in 9/10 rats given 14 mg and in 6/8 rats given 28 mg **cadmium** powder. Most of the tumors were rhabdomyosarcomas; some fibrosarcomas were seen which metastasized to lymph nodes.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V58 169 (1993)]**PEER REVIEWED**

Non-Human Toxicity Values:

LD50 Rat oral 225 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 613]**PEER REVIEWED**

LC50 Rat ihl 25 mg/cu m/30 mos
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 613]**PEER REVIEWED**

LD50 Mouse oral 890 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 613]**PEER REVIEWED**

LD50 Mouse ip 5700 ug/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 613]**PEER REVIEWED**

TSCA Test Submissions:

The acute inhalation toxicity of **cadmium** (CAS # 7440-43-9) was evaluated in Sprague-Dawley rats (25/sex/group) administered single 125-minute exposures to **cadmium** metal fumes at target concentrations of 0 or 100 mg/cu m (mean analytical concentration based on GCA and 88% **cadmium**/sample, 112 mg/cu m **cadmium**; as measured from filter paper-recovered sample, 72.4 mg/cu m). Two additional rats were treated for retention through Day 30 as potential surrogates for any unanticipated experimental losses. In addition, groups of 5 each male and female rats were necropsied immediately after the exposures, and at 24 and 72 hours, and 7 days post-exposure to provide select tissues to be analyzed for **cadmium** content in pharmacokinetic study. **Cadmium** acetate, dihydrate (10% aqueous solution), vaporized by Laskin nebulizer to an aerosol, was dehumidified and heated to a fume, and then supplied to and diluted in the air of a 760 L glass and stainless steel environmental chamber. All rats were hypoactive but survived the exposures. Subsequently, treated rats showed labored and rapid breathing, excessive dry rales, continuous weight loss, and poor general condition. Of the rats remaining after 24-hour post-exposure necropsy, 25/32 died from Day 2 to Day 6 during observation. Lung and liver discoloration and congestion appeared at Day 2 or later in sequential gross pathology examinations of both the interim sacrifices and decedents, and all rats were gone to either interim sacrifice or spontaneous death by Day 8 of intended 30-day study. The authors reported an acute inhalation LC50 less than 72.4 mg/cu m in rats.
[Shell Oil Co; A Single Exposure Inhalation Study of Cadmium Containing Materials in the Rat; 07/11/80; EPA Document No. 88-920001938; Fiche No. OTS0539392]**QC REVIEWED**

The acute inhalation toxicity and pharmacokinetics of **cadmium** (CAS # 7440-43-9) was evaluated in Sprague-Dawley rats (25/sex/group) administered single 125-minute exposures to **cadmium** metal fumes at target concentrations of 0 or 100 mg/cu m (mean analytical concentration based on GCA and 88% **cadmium**/sample, 112 mg/cu m **cadmium**; as measured from filter paper-recovered sample, 72.4 mg/cu m). Two additional rats were treated for retention through Day 30 as potential surrogates for any unanticipated experimental losses. **Cadmium** acetate, dihydrate (10% aqueous solution), vaporized by Laskin nebulizer to an aerosol, was dehumidified and heated to a fume, and then supplied to and diluted in air of the 760 L glass and stainless steel environmental chamber. Immediately following the exposure and at 24, 48 and 72 hours, and 7 days post-exposure, 5 each male and female treated rats were isolated for collection of urine and feces samples. Another group of 5 each male and female rats, necropsied immediately after the exposures, and at 24 and 72 hours, and 7 days post-exposure, provided select tissues (lung, liver, kidneys, testes, prostate, G.I. wash, heparinized whole blood) to be analyzed for **cadmium** content. Of the rats remaining after 24-hour post-exposure necropsy, 25/32 died from Day 2 to Day 6 during observation. Lung and liver discoloration and congestion appeared at Day 2 or later in sequential gross pathology examinations of both the interim sacrifices and decedents, and all rats were gone to either interim sacrifice or spontaneous death by Day 8 of intended 30-day study. **Cadmium** was found to be largely eliminated in the feces, the greatest average levels (658 and 68 ug for male and female rats, respectively) recovered between 24 and 72 hours post-exposure. Very small amounts (1.97 and 1.17 ug for male and female rats, respectively) appeared in the urine of treated rats during the same time intervals. A specific tissue affinity was also suggested by the greater relative concentrations and periods of residence in lungs, liver, and kidneys of the tissues tested. By the final determinations, the

average levels (ug Cd/g tissue for both male and female rats) of **cadmium** in the lungs (7 ug/g) and liver (2.28 ug/g) were static and those in the kidneys (2.87 ug/g) still increasing at levels significantly higher than those in the control group (0.06 ug/g, 0.0145 ug/g, 0.08 ug/g for lungs, liver, and kidneys, respectively). On comparison, the rate of elimination of **cadmium** in these tissues was much slower than that associated with exposure to either **Cadmium** Red Pigment or **Cadmium** Yellow Pigment.
[Shell Oil Co; A Single Exposure Inhalation Study of Cadmium Containing Materials in the Rat; 07/11/80; EPA Document No. 88-920001938; Fiche No. OTS0539392]**QC REVIEWED**

Metabolism/Pharmacokinetics:

Absorption, Distribution & Excretion:

The relationship between tissue levels of metallothionein and metal concentrations was assessed for zinc, copper, and **cadmium** in ten different organs from human autopsies and rats. Human autopsy specimens were obtained from ten males between the ages of 20 and 50 years within 2 days of sudden death. Tissues assayed included pancreas, liver, kidney, brain, small intestine, stomach, muscle, heart, lung, and spleen. Human metallothionein levels were higher than rat levels for all tissues assayed except brain and small intestine. The highest metallothionein levels were found in human liver and kidney cortex and rat kidney and brain. Zinc levels were highest for human liver, kidney, and muscle; and copper levels were highest for human liver, brain, and heart and rat liver, kidney, and heart. Elevated **cadmium** levels were found in human liver and kidney. All **cadmium** levels were below detectable limits in rats. Significant correlations were established between metallothionein levels and zinc and copper in human liver and between metallothionein and **cadmium** in human kidney cortex.
[Heilmauer HE et al; Toxicol Lett 38 (3): 205-11 (1987)]**PEER REVIEWED**

Mechanism of Action:

RENAL STONES HAVE BEEN FOUND IN SWEDISH **CADMIUM** WORKERS. ... 44% OF WORKERS EXPOSED TO **CADMIUM** DUST FOR MORE THAN 15 YR HAD HISTORY OF RENAL STONES WHICH WERE COMPOSED MAINLY OF CALCIUM & PHOSPHORUS, PROBABLY AS RESULT OF ALTERED CALCIUM & PHOSPHORUS METABOLISM FROM THE **CADMIUM** ...
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1568]**PEER REVIEWED**

A number of studies from experimental animals, as well as tissue culture models, confirm the protective role of metallothionein. ... Toxic cell injury is thought to be caused by unbound **cadmium** or free **cadmium** ion. Administration of metallothionein prepared with different ratios of **cadmium** and zinc to rats has demonstrated that renal tubular necrosis is related to the **cadmium** content, not the amount of metallothionein.
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 595]**PEER REVIEWED**

The ability of a number of metals and organic chemicals to induce metallothionein synthesis in primary cultures of rat hepatocytes was tested to determine whether metallothionein induction in vivo results from a direct effect of the agent on the liver or as a result of an indirect, physiological response to the agent. Hepatocytes were exposed to metals (zinc, **cadmium**, mercury, mangasese, lead, cobalt, nickel, and vanadium) or org cmpd. Ethanol, urethane, L-2-oxothiazolidine-4-carboxylate, or dexamethasone and were assayed for metallothionein by the **cadmium**/mercury radioassay. Cell viability was monitored by protein synthesis activity and cellular potassium ion concn. Increases in metallothionein concn were

noted for zinc (22 fold), mercury (6.4 fold), **cadmium** (4.8 fold), cobalt (2.4 fold), nickel (22 fold), and dexamethasone (4.5 fold). However, even at max tolerated concn, manganese, lead, vanadium, ethanol, urethane, and L-2-oxothiazolidine-4-carboxylate did not increase metallothionein. Thus, zinc, **cadmium**, mercury, cobalt, nickel, and dexamethasone induce metallothionein in vitro and are direct inducers of metallothionein synthesis in hepatic tissue. In contrast, manganese, lead, ethanol, urethane, and L-2-oxothiazolidine-4- carboxylate, which did not increase the metallothionein content of hepatocytes, apparently do so in vivo by an indirect mechanism.
[Bracken WM, Klaassen CD; J Toxicol Environ Health 22 (2): 163-74 (1987)]**PEER REVIEWED**

Pharmacology:

Minimum Fatal Dose Level:

Average concentrations responsible for fatal cases have been estimated at 50 mg/cu m and 40 mg/cu m, both for exposures of 1 hr; and 9 mg/cu m for 5 hr.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.191]**PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Cadmium is a relatively rare, naturally occurring element that is widely distributed in the earth's crust. **Cadmium** occurs in nature as Cd(II). Metallic **cadmium** does not occur in nature. Metallic **cadmium** may enter the environment during the mining, ore processing and smelting of zinc and zinc-lead ores in which **cadmium** is found and during its recovery, refining, manufacture of **cadmium** compounds, use of **cadmium** metals, alloys and compounds, recycling, and disposal. **Cadmium**'s initial route of entry is often via the atmosphere. **Cadmium** metal would be expected to be transformed to the oxide and carbonate in the atmosphere. Similarly **cadmium** would be expected to slowly oxidize in both water and soil. The general population would be primarily exposed to metallic **cadmium** by contact with **cadmium**-containing alloys. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

OCCUPATIONAL EXPOSURE: EXPOSURE OCCURS PRIMARILY IN SMELTING & REFINING ZINC, LEAD & COPPER ORES CONTAINING **CADMIUM**, SPRAYING **CADMIUM** CONTAINING PIGMENTS, PROCESSING SCRAP CONTAINING **CADMIUM**, ETC. /**CADMIUM**, ALLOYS, COMPOUNDS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 233]**PEER REVIEWED**

The major route of exposure to **cadmium** for the non-smoking general population is via food ... Tobacco is an important source of **cadmium** uptake in smokers.
[WHO; Environmental Health Criteria 134: Cadmium p.18 (1992)]**PEER REVIEWED**

Body Burden:

/IN MAN/ ABOUT HALF OF TOTAL BODY BURDEN IS FOUND IN LIVER & KIDNEYS ... **CADMIUM** IN THESE ORGANS IS MAINLY BOUND TO A LOW MOLECULAR WEIGHT

PROTEIN, IN FORM OF A METALLOTHIONEIN ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 90 (1973)]**PEER REVIEWED**

The body burden of **cadmium** in a 50 yr old adult in the US is about 30 mg.
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1662]**PEER REVIEWED**

Average Daily Intake:

50 ug
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1662]**PEER REVIEWED**

Average daily intakes from food in most areas not polluted with **cadmium** are between 10-40 ug. In polluted areas it has been found to be several hundred ug/day.
[WHO; Environmental Health Criteria 134: Cadmium p.22 (1992)]**PEER REVIEWED**

Artificial Pollution Sources:

Liberation during smelting and refining of ores where it is a by-product of zinc, lead and copper bearing ores. Liberation during recovery of metal by processing scrap; during melting and pouring of **cadmium** metal; during casting of alloys for **cadmium**-copper, **cadmium**-lead, **cadmium**-bismuth, **cadmium**-silver, **cadmium**-nickel, **cadmium**-lead-silver, **cadmium**-lead-silver-nickel, **cadmium**-lead-bismuth-tin, and **cadmium**-gold products used for coating telephone cables, trolley wires, welding, electrodes, automatic sprinkling systems, steam boilers, fire alarms, high pressure/temperature bearings, starting switches, aircraft relays, light duty circuit breakers, low temperature solder, and jewlery. Liberation during fabrication of metal, alloys, or plated steel. Liberation during casting and use of solders; during melting of **cadmium** ingots for paint and pigment manufacture used for coloring of plastics and ceramic glazes, electroplating, and in chemical synthesis. Liberation during coating of metals by hot dipping or spraying. Liberation during manufacture of nickel-**cadmium** batteries for use in radio portable telephones, convenience appliances, and vented cells used in airplanes, helicopters, and stand-by power and lighting. /**Cadmium**, **cadmium** oxide/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Fish/Seafood Concentrations:

Marine organisms generally contain higher **cadmium** residues than their freshwater and terrestrial counterparts.
[WHO; Environmental Health Criteria 135: Cadmium - Environmental Aspects p.30 (1992)]**PEER REVIEWED**

Environmental Standards & Regulations:

CERCLA Reportable Quantities:

Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or

greater than its reportable quantity of 10 lb or 4.54 kg. The toll free number of the NRC is (800) 424-8802; In the Washington D.C. metropolitan area (202) 426-2675. The rule for determining when notification is required is stated in 40 CFR 302.4 (section IV. D.3.b).
[40 CFR 302.4 (7/1/98)]**PEER REVIEWED**

RCRA Requirements:

D006; A solid waste containing **cadmium** may or may not become characterized as a hazardous waste when subjected to the Toxicity Characteristic Leaching Procedure listed in 40 CFR 261.24, and if so characterized, must be managed as a hazardous waste.
[40 CFR 261.24 (7/1/98)]**PEER REVIEWED**

Atmospheric Standards:

Listed as a hazardous air pollutant (HAP) generally known or suspected to cause serious health problems. The Clean Air Act, as amended in 1990, directs EPA to set standards requiring major sources to sharply reduce routine emissions of toxic pollutants. EPA is required to establish and phase in specific performance based standards for all air emission sources that emit one or more of the listed pollutants. **Cadmium** is included on this list.
[Clean Air Act as amended in 1990, Sect. 112 (b) (1) Public Law 101-549 Nov. 15, 1990]**PEER REVIEWED**

Clean Water Act Requirements:

Toxic pollutant designated pursuant to section 307(a)(1) of the Clean Water Act and is subject to effluent limitations.
[40 CFR 401.15 (7/1/98)]**QC REVIEWED**

The maximum contaminant level (MCL) set forth in the National Revised Primary Drinking Water Regulations for **cadmium** in community water systems and non-transient, non-community water systems is 0.005 mg/l.
[40 CFR 141.62 (7/1/98)]**QC REVIEWED**

Federal Drinking Water Standards:

EPA 5 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

Federal Drinking Water Guidelines:

EPA 5 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

State Drinking Water Guidelines:

(AZ) ARIZONA 5 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(ME) MAINE 5 ug/l

[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(MN) MINNESOTA 4 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

Cd
PEER REVIEWED

Molecular Weight:

112.41
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 265]**PEER REVIEWED**

Color/Form:

Silver-white, blue-tinged, lustrous metal; distorted hexagonal close-packed structure.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 265]**PEER REVIEWED**

Odor:

Odorless
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Boiling Point:

765 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 265]**PEER REVIEWED**

Melting Point:

321 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 265]**PEER REVIEWED**

Corrosivity:

Highly corrosion resistant
[Sittig, M. Handbook of Toxic And Hazardous Chemicals. Park Ridge, NJ: Noyes Data Corporation, 1981. 119]**PEER REVIEWED**

Density/Specific Gravity:

8.65 g/cu cm @ 25 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 265]**PEER REVIEWED**

Heat of Vaporization:

99.87 kJ/mole at 767 deg C (boiling point)
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 6-101]**PEER REVIEWED**

Solubilities:

Insoluble in water
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 265]**PEER REVIEWED**

Sol in acids & ammonium nitrate solution
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 12th ed. New York, NY: Van Nostrand Rheinhold Co., 1993 194]**PEER REVIEWED**

Spectral Properties:

INDEX OF REFRACTION: 1.8 AT 578 NM & 20 DEG C/D
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 41 (1976)]**PEER REVIEWED**

Vapor Pressure:

1 Pa at 257 deg C
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 6-62]**PEER REVIEWED**

Other Chemical/Physical Properties:

Malleable
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 12th ed. New York, NY: Van Nostrand Rheinhold Co., 1993 194]**PEER REVIEWED**

Heat capacity: 6.22 cal/mole-deg at 25 deg C & constant pressure; readily cut with knife
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 265]**PEER REVIEWED**

Tarnishes in moist air.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 12th ed. New York, NY: Van Nostrand Rheinhold Co., 1993 194]**PEER REVIEWED**

Cadmium becomes brittle at 80 deg C.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 12th ed. New York, NY: Van Nostrand Rheinhold Co., 1993 194]**PEER REVIEWED**

Eight stable isotopes of **cadmium** (Cd) are known in nature with conventional abundances as follows: (106)Cd: 1.21%; (108)Cd: 0.88%; (110)Cd: 12.39%; (111)Cd: 12.75%; (112)Cd: 24.07%, (113)Cd: 12.26%; (114)Cd: 28.86%; (116)Cd: 7.58%.
[Nat'l Research Council Canada; Cadmium p.15 (1979) NRCC No.16743]**PEER REVIEWED**

The electrical conductivity of **cadmium** is less than that of silver or copper, but greater than that of iron.
[Chizhikov DM; Cadmium (1966) as cited in NIOSH; Criteria Document: Cadmium p.7 (1976) DHEW Pub. NIOSH 76-192]**PEER REVIEWED**

Cadmium (Cd) has two radioisotopes: (109)Cd and (115)Cd.
[Mennear JH; Cadmium Toxicity p.1 (1979)]**PEER REVIEWED**

Slowly oxidized by moist air to form CdO. Electrode potential (aq) Cd/Cd2+ 0.4025 V. Reacts readily with dil HNO3; reacts slowly with hot HCl; does not react with alkalies. Other reactions similar to those of zinc. Solns of **cadmium** salts and H2S or Na2S yield a yellow ppt insol in excess Na2S.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 265]**PEER REVIEWED**

Heat of fusion 6.19 kJ/mol
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 6-117]**PEER REVIEWED**

Chemical Safety & Handling:

Hazards Summary:

The major hazards encountered in the use and handling of **cadmium** stem from its toxicologic properties. Toxic primarily by inhalation and ingestion, exposure to **cadmium** (salts, dust, or fumes) may occur from the smelting and refining of ore, and from its use in metal plating and coating, production of batteries, synthesis and use of **cadmium**-containing pigments, soldering, and in plastics, ceramic glazes, alloys, and amalgams. Effects from exposure may include headache, nausea, shortness of breath, chest pain, weakness, fever, kidney damage, liver damage, chronic bronchitis, emphysema, and pulmonary edema (possibly resulting in death). NIOSH has recommended that **cadmium** (dust and fumes) be treated as a potential human carcinogen. The OSHA PEL for **cadmium** fume is 0.1 mg/cu m, and for **cadmium** dust is 0.2 mg Cd/cu m. Neither odor, nor irritation potential serves as an adequate warning of over-exposure. Processes and operations which may release **cadmium** fumes or dust should be enclosed and fitted with exhaust ventilation if practicable. Workers should wear a high efficiency particulate filter respirator or self-contained breathing apparatus in activities where over-exposure is possible. Protective clothing and gloves also should be worn, and these should be removed before leaving work. If contact should occur, immediately wash contaminated skin with large amounts of water. Do not eat, smoke, or drink in work areas. **Cadmium** dust or powder is a moderate firehazard when exposed to heat (autoignition temperature: 250 deg C) or flame, or by chemical reaction with oxidizing agents, metals, hydrogen azide, zinc, selenium, or tellurium. Wear a self-contained breathing apparatus when fighting such fires. **Cadmium** should be stored in closed containers, away from sources of physical damage. Consult the regulatory requirements of the U.S. Department of Transportation before shipping **cadmium**, and with environmental regulatory agencies before implementing land disposal of **cadmium** wastes.
PEER REVIEWED

Skin, Eye and Respiratory Irritations:

It is irritating to the nose and throat ... /From table/

[Sullivan, J.B. Jr., G.R. Krieger (eds.). Hazardous Materials Toxicology-Clinical Principles of Environmental Health. Baltimore, MD: Williams and Wilkins, 1992. 691]**PEER REVIEWED**

Fire Potential:

Powdered **cadmium** is flammable.
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 95]**PEER REVIEWED**

The dust ignites spontaneously in air and is flammable and explosive when exposed to heat, flame, or by chemical reaction with oxidizing agents, metals, ammonia, zinc, selenium, and tellurium.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 613]**PEER REVIEWED**

Autoignition Temperature:

250 deg C, (482 F) layer /**Cadmium** metal dust/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Fire Fighting Procedures:

Fire fighting: /Wear/ self-contained breathing apparatus with a full facepiece operated in pressure-demand, or other positive mode. /**Cadmium** dust (as **cadmium**)/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.6]**PEER REVIEWED**

Toxic Combustion Products:

When heated to a high temperature it emits toxic fumes of **cadmium**.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 613]**PEER REVIEWED**

Explosive Limits & Potential:

The dust ignites spontaneously in air and is flammable and explosive when exposed to heat ... .
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 613]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

REACTS READILY WITH DIL NITRIC ACID; SLOWLY WITH HOT HYDROCHLORIC ACID; DOES NOT REACT WITH ALKALIES
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 223]**PEER REVIEWED**

When nitryl fluoride is passed ... over ... **cadmium** ... /with mild warming/, glowing white incandescence occurs.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1094]**PEER REVIEWED**

A VIOLENT EXPLOSION FOLLOWED IMMERSION OF A **CADMIUM** ROD IN HYDRAZOIC

ACID AFTER ABOUT 30 MIN.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-39]**PEER REVIEWED**

Fused ammonium nitrate with powdered metals is often a violent and sometimes an explosive reaction ... **Cadmium** /is a/ metal that reacted in this way.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-21]**PEER REVIEWED**

Strong oxidizers; elemental sulfur, selenium & tellurium.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 44]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH considers **cadmium** to be a potential occupational carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 44]**PEER REVIEWED**

NIOSH considers **cadmium** dust (as Cd) to be a potential occupational carcinogen. /**Cadmium** dust (as Cd)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 44]**PEER REVIEWED**

Protective Equipment & Clothing:

IN AREAS WITH HAZARDS OF /AIRBORNE/ PARTICLES, CHEM SPLASHES, RADIANT HEAT ... WORKERS SHOULD WEAR APPROPRIATE SAFETY EQUIPMENT SUCH AS EYE, FACE, HAND, & ARM PROTECTION & IMPERMEABLE CLOTHING. /**CADMIUM** & **CADMIUM** CMPD/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 357]**PEER REVIEWED**

Recommendations for respirator selection. Condition: At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration. Respirator Class(es): Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode. Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode. /**Cadmium** fume (as Cd)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 45]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Escape from suddenly occurring respiratory hazards: Respirator Class(es): Any air-purifying, full-facepiece respirator with a high-efficiency particulate filter. Any appropriate escape-type, self-contained breathing apparatus. /**Cadmium** fume (as Cd)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 45]**PEER REVIEWED**

... IN CASES SUCH AS WELDING & CUTTING, WHERE ADEQUATE VENTILATION IS NOT ALWAYS POSSIBLE, RESPIRATORS SHOULD BE WORN. /**CADMIUM**, ALLOYS, COMPOUNDS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 234]**PEER REVIEWED**

Preventive Measures:

SRP: Contaminated protective clothing should be segregated in such a manner so that there is no direct personal contact by personnel who handle, dispose, or clean the clothing. Quality assurance to ascertain the completeness of the cleaning procedures should be implemented before the decontaminated protective clothing is returned for reuse by the workers.
PEER REVIEWED

An eye wash fountain should be provided within the immediate work area where **cadmium** chloride is being used. /**Cadmium** metal dust/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.4]**PEER REVIEWED**

... PROCESSES OR OPERATIONS WHICH MAY RELEASE **CADMIUM** FUMES OR DUST INTO THE ATMOSPHERE SHOULD BE DESIGNED TO KEEP CONCN LEVELS TO MINIMUM & IF PRACTICABLE BE ENCLOSED & FITTED WITH EXHAUST VENTILATION. /**CADMIUM** & **CADMIUM** CMPD/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 357]**PEER REVIEWED**

ADEQUATE SANITARY FACILITIES SHOULD BE SUPPLIED & WORKERS SHOULD BE ENCOURAGED TO WASH THOROUGHLY & CHANGE THEIR CLOTHES BEFORE LEAVING WORK. SMOKING, EATING & DRINKING IN WORK AREAS SHOULD BE PROHIBITED. /**CADMIUM** & **CADMIUM** CMPD/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 357]**PEER REVIEWED**

Contact lenses should not be worn when working with this chemical. /Cadium dust (as Cd)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 45]**PEER REVIEWED**

VENTILATION CONTROL: PROCESSES OR OPERATIONS WHICH MAY RELEASE **CADMIUM** FUME OR DUST INTO ATMOSPHERE SHOULD BE ... DESIGNED /SO/ THAT CONCN LEVELS ARE KEPT TO A MINIMUM & IF PRACTICABLE /PROCESSES OR OPERATIONS/ SHOULD BE ENCLOSED & FITTED WITH EXHAUST VENTILATION. /**CADMIUM**, ALLOYS, COMPOUNDS/

[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 234]**PEER REVIEWED**

The worker should wash daily at the end of each work shift. /**Cadmium** fume (as Cd)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 45]**PEER REVIEWED**

Workers whose clothing may have become contaminated should change into uncontaminated clothing before leaving the work premises. /**Cadmium** fume (as Cd)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 45]**PEER REVIEWED**

AIR IN WORKPLACES /WHERE **CADMIUM** IS SUSPECTED/ SHOULD BE REGULARLY SAMPLED & **CADMIUM** CONCN DETERMINED. /**CADMIUM**, ALLOYS, COMPOUNDS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 234]**PEER REVIEWED**

... SMOKING, EATING & DRINKING IN WORK AREA ... PROHIBITED. EXHAUSTED CONTAMINATED AIR ... FILTERED ... /&/ PERSONS ... SERVICING DUST COLLECTORS ... WEAR RESPIRATORS ... /**CADMIUM** CMPD/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971.]**PEER REVIEWED**

Stability/Shelf Life:

SLOWLY OXIDIZED BY MOIST AIR TO FORM **CADMIUM** OXIDE
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 223]**PEER REVIEWED**

Storage Conditions:

Keep containers closed and protect against physical damage.
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 96]**PEER REVIEWED**

Cleanup Methods:

1) REMOVE ALL IGNITION SOURCES. 2) VENTILATE AREA OF RELEASE. 3) COLLECT RELEASED MATERIAL IN THE MOST CONVENIENT AND SAFE MANNER FOR RECLAMATION OR FOR DISPOSAL. ... /**CADMIUM** DUST/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Disposal Methods:

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste number D006, must conform with USEPA regulations in storage, transportation, treatment and disposal of waste.
[40 CFR 240-280, 300-306, 702-799 (7/1/96)]**PEER REVIEWED**

Recycling: Sort, classify and put in a box properly labeled. Salvage profitably for reuse by local shop or sell as a scrap metal. Recommendable method: /SRP: Hazardous Waste/ Landfill. Not recommendable method: Thermal destruction.
[United Nations. Treatment and Disposal Methods for Waste Chemicals (IRPTC File). Data Profile Series No. 5. Geneva, Switzerland: United Nations Environmental Programme, Dec. 1985. 118]**PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

Permissible Exposure Limit: The employer shall assure that no employee is exposed to an airborne concentration of **cadmium** in excess of 5 ug/cu m, calculated as an 8-hr TWA. /**Cadmium**, as Cd/
[29 CFR 1910.1027(c) (7/1/98)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-2 8-hr Time Weighted Avg: 0.1 mg/cu m. This standard applies to any operations or sectors for which the **Cadmium** standard, 1910.1027, is stayed or otherwise not in effect. /**Cadmium** fume/
[29 CFR 1910.1000 (7/1/98)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-2 Acceptable Ceiling Concentration: 0.3 mg/cu m. This standard applies to any operations or sectors for which the **Cadmium** standard, 1910.1027, is stayed or otherwise not in effect. /**Cadmium** fume/
[29 CFR 1910.1000 (7/1/98)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-2 8-hr Time Weighted Avg: 0.2 mg/cu m. This standard applies to any operations or sectors for which the **Cadmium** standard, 1910.1027, is stayed or otherwise not in effect. /**Cadmium** dust/
[29 CFR 1910.1000 (7/1/98)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-2 Acceptable Ceiling Concentration: 0.6 mg/cu m. This standard applies to any operations or sectors for which the **Cadmium** standard, 1910.1027, is stayed or otherwise not in effect. /**Cadmium** dust/
[29 CFR 1910.1000 (7/1/98)]**PEER REVIEWED**

Threshold Limit Values:

8 hr Time Weighted Avg (TWA) 0.01 mg/cu m; 8 hr Time Weighted Avg (TWA) 0.002 mg/cu m respirable fraction. /**Cadmium**, elemental and cmpd, as Cd/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 22]**PEER REVIEWED**

A2. A2= Suspected human carcinogen. /**Cadmium**, elemental and compounds, as Cd/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 22]**PEER REVIEWED**

BEI (Biological Exposure Index): **Cadmium** in urine (timing is not critical) is 5 ug/g creatinine. The determinant is usually present in a significant amt in biological specimens collected from subjects who have not been occupationally exposed. Such background levels are incl in the BEI value. (1993 adoption) /**Cadmium** & inorganic cmpd/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 96]**PEER REVIEWED**

BEI (Biological Exposure Index): **Cadmium** in blood (timing is not critical) is 5 ug/l. The determinant is usually present in a significant amt in biological specimens collected from subjects who have not been occupationally exposed. Such background levels are incl in the BEI value. (1993 adoption) /**Cadmium** & inorganic cmpd/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 96]**PEER REVIEWED**

Excursion Limit Recommendation: Excursions in worker exposure levels may exceed three times the TLV-TWA for no more than a total of 30 min during a work day, and under no circumstances should they exceed five times the TLV-TWA, provided that the TLV-TWA is not exceeded. /**Cadmium**, elemental and cmpd, as Cd/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 6]**PEER REVIEWED**

NIOSH Recommendations:

NIOSH considers **cadmium** to be a potential occupational carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 44]**PEER REVIEWED**

NIOSH usually recommends that occupational exposures to carcinogens be limited to the lowest feasible concn.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 44]**PEER REVIEWED**

NIOSH considers **cadmium** dust (as Cd) to be a potential occupational carcinogen. /**Cadmium** dust (as Cd)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 44]**PEER REVIEWED**

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[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 44]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

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[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 44]**PEER REVIEWED**

NIOSH considers **cadmium** dust (as Cd) to be a potential occupational carcinogen. /**Cadmium** dust (as Cd)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 44]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

IN ELECTROPLATING OF AUTOMOTIVE, AIRCRAFT & ELECTRONIC PARTS; MARINE EQUIPMENT & INDUSTRIAL MACHINERY; IN PREPN OF **CADMIUM** SULFIDES, **CADMIUM** SELENIDES & MIXT CONTAINING THESE SALTS FOR USE AS PIGMENTS (INCL PHOSPHORS)
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 44 (1976)]**PEER REVIEWED**

In fire protection systems, machinery enamels, baking enamels; Weston standard cell; photography & lithography; mfr fungicide
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 12th ed. New York, NY: Van Nostrand Rheinhold Co., 1993 194]**PEER REVIEWED**

Batteries, including Ni-Cd storage batteries; coating and electroplating steel and cast iron; chemical intermediate for pigments; chemical intermediate for plastic stabilizers; constituent of low melting or easily fusible alloys, e.g., Lichtenberg's, Abel's, Lipowitz', Newton's, and Wood's metal; electronics and optics; soft solder and solder for aluminum; reactor control rods; hardener for copper; catalysts.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 265]**PEER REVIEWED**

Manufacturers:

Big River Zinc Corporation, Sauget, IL
[U.S. Geological Survey - Minerals Information - 1997, http://minerals.usgs.gov/minerals/pubs/commodity/cadmium/index.html]**PEER REVIEWED**

Savage Zinc Inc., Clarksville, TN
[U.S. Geological Survey - Minerals Information - 1997, http://minerals.usgs.gov/minerals/pubs/commodity/cadmium/index.html]**PEER REVIEWED**

Big River Zinc Corporation, Route 3 and Monsanto Avenue, Sauget, IL 62201 (618) 274-5000; Production site: Sauget, IL 62201 /**Cadmium** oxide/
[SRI. 1999 Directory of Chemical Producers -United States. Menlo Park, CA. SRI Consulting 1999.. 503]**PEER REVIEWED**

Methods of Manufacturing:

There are two major classes of process for producing **cadmium**, pyro-hydrometallurgical and electrolytic.
[CONSIDINE. CHEMICAL AND PROCESS TECHNOL ENCYC 1974 p.187]**PEER REVIEWED**

Cadmium was /in 1986/ recovered as a by-product of smelting domestic and imported zinc concentrates.
[BUREAU OF MINES. MINERAL COMMODITY SUMMARIES 1987 p.28]**PEER REVIEWED**

Obtained in vapor form when roasting zinc ores, as sludge from zinc sulfate purification.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 265]**PEER REVIEWED**

Lab prepns from CdSO4: Treadwell, Helv. Chim. Acta 4, 551 (1921).
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 265]**PEER REVIEWED**

The zinc concentrate, obtained after beneficiation of the ores, is first roasted to convert the zinc sulfide to the oxide and a small amount of sulfate. Roasting is normally carried out with an excess of oxygen below 1000 deg C so that little **cadmium** is eliminated from the calcined material. Since the advent of the Imperial Smelting Zinc Furnace, the preliminary roasting processes for zinc and zinc-lead concentrates result in **cadmium** recovery as precipitates from solution or as **cadmium**-lead fume, respectively.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V4 749]**PEER REVIEWED**

General Manufacturing Information:

Cadmium may be alloyed with copper, nickel, gold, silver, bismuth, and aluminum to form easily fusible compounds.
[Sittig, M. Handbook of Toxic And Hazardous Chemicals. Park Ridge, NJ: Noyes Data Corporation, 1981. 119]**PEER REVIEWED**

(109)Cd decays by electron capture to an isomer of the daughter (109)Ag.
[Lederer CM et al; Table of Isotopes p.248 (1967) as cited in Menear JH; Cadmium Toxicity p.4 (1979)]**PEER REVIEWED**

Found ... also as CdS, greenockite; CdCO3, otavite.

[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 265]**PEER REVIEWED**

Cadmium production is dependent on the processing of zinc ores, which often contain 0.2 to 0.4% **cadmium**. U.S demand often exceeds supply and the U.S. is dependent on imports.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V4 754]**PEER REVIEWED**

Cadmium occurs primarily as sulfide minerals in zinc, lead-zinc, and copper-lead-zinc ores. Beneficiation of these minerals, usually by floatation or heavy media separation, yields concentrates which are then processed for the recovery of the metal.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V4 749]**PEER REVIEWED**

Both companies that produce primary **cadmium** in the U.S. use an electrolytic process and recovered the **cadmium** as a byproduct during roasting and leaching of zinc concentrate.
[U.S. Geological Survey - Minerals Information - 1997, http://minerals.usgs.gov/minerals/pubs/commodity/cadmium/index.html]**PEER REVIEWED**

In addition to the two producers of primary **cadmium** in the U.S., a third company in Pennsylvania recovers **cadmium** from spent nickel-**cadmium** batteries.
[U.S. Geological Survey - Minerals Information - 1997, http://minerals.usgs.gov/minerals/pubs/commodity/cadmium/index.html]**PEER REVIEWED**

To date, **cadmium** recycling has been practical only for Ni-Cd batteries, some alloys, and dust from electric arc furnaces which typically contain 0.003% to 0.07% **cadmium**.
[U.S. Geological Survey - Minerals Information - 1997, http://minerals.usgs.gov/minerals/pubs/commodity/cadmium/index.html]**PEER REVIEWED**

Formulations/Preparations:

Grades: technical; powder; pure sticks; ingots; slabs; high purity crystals (10 ppm impurities).
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 12th ed. New York, NY: Van Nostrand Rheinhold Co., 1993 195]**PEER REVIEWED**

CADMIUM SPONGE ... HAS MOISTURE CONTENT OF ABOUT 25% WHEN PACKAGED IN BAGS & 35% WHEN PACKAGED IN DRUMS ... TYPICAL **CADMIUM** CONTENTS ON DRY BASIS ARE 86% IN BAGS & 92% IN DRUMS.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 42 (1976)]**PEER REVIEWED**

/Available in/ 99.5 to 99.999% purity grades
[CHEMCYCLOPEDIA 1987 p.168]**PEER REVIEWED**

Impurities:

PURE FORM OF **CADMIUM** FOR ELECTRONIC USES CONTAINS 0.001% OR LESS OF IMPURITIES.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 42 (1976)]**PEER REVIEWED**

Cadmium Metal Spec for ASTM Spec 3440-66T with 99.90% min Cd contains the following impurities: zinc, 0.035% min; copper, 0.015% max; lead, 0.025% max; tin, 0.01%max; silver, 0.01% max; antimony, 0.001% max; arsenic, 0.003% max; tellurium, 0.003% max
[CONSIDINE. CHEMICAL AND PROCESS TECHNOL ENCYC 1974 p.190]**PEER REVIEWED**

Consumption Patterns:

PLATING & COATING, 51%; BATTERIES, 22%; CHEM INT FOR PIGMENTS, 13%; FOR STABILIZERS, 11%; OTHER USES, 3% (1979)
[SRI]**PEER REVIEWED**

49% IN METAL PLATING, 18% IN PLASTICS STABILIZERS, 14% IN PIGMENTS & 19% IN MISC USES (NICKEL-**CADMIUM** BATTERIES, ALLOYS) (BUREAU OF NATIONAL AFFAIRS, INC, 1975)
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 44 (1976)]**PEER REVIEWED**

Coating and plating, 35%; batteries, 25%; pigments, 20%; plastics and synthetic products, 15%; and alloys and other uses, 5% (1986)
[BUREAU OF MINES. MINERAL COMMODITY SUMMARIES 1987 p.28]**PEER REVIEWED**

Estimated for 1999: Batteries, 69%; pigments, 13%; coatings and plating, 8%; stabilizer for plastics, 7%; nonferrous alloys, 2%; and other, including electrooptics, 1%.
[U.S. Geological Survey - Mineral Commodity Summary - 1999, http://minerals.usgs.gov/minerals/pubs/commodity/cadmium/index.html]**PEER REVIEWED**

... In 1960 /electroplating/ accounted for over half the **cadmium** consumed worldwide, but in 1985 its share was less than 25%. This decline is usually linked to the widespread introduction of progressively stringent effluent limits from plating works and, more recently, to the introduction of general restriction on **cadmium** consumption in certain countries. In contrast, the use of **cadmium** in batteries has shown considerable growth in recent years from only 8% of the total market in 1970 to 37% by 1985. The use of **cadmium** in batteries is particularly important in Japan and represented over 75% of the total consumption in 1985.
[WHO; Environmental Health Criteria 134: Cadmium p. 38 (1992)]**PEER REVIEWED**

U. S. Production:

(1977) 2.00X10+9 G
[SRI]**PEER REVIEWED**

(1982) 1.01X10+9 G
[SRI]**PEER REVIEWED**

WORLD PRODN ... WAS APPROX 16.5 MILLION KG IN 1970 & ... INCR TO 17 MILLION KG BY 1973 ... USA PRODN IN 1973 WAS 3.36 MILLION KG ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 44 (1976)]**PEER REVIEWED**

(1977): 1.6 to 16 million pounds.
[USEPA; Subst Risk Notice, 8(e)HQ-0280-0332 (1983) EPA-560/2-83-001]**PEER REVIEWED**

(1986) 1.30x10+9 g

[BUREAU OF MINES. MINERAL COMMODITY SUMMARIES 1987 p.28]**PEER REVIEWED**

Production of primary and secondary metal in metric tons: 1994: 1010; 1995: 1270; 1996: 1530; 1997: 2060; 1998: 2100 (estimated).
[U.S. Geological Survey - Mineral Commodity Summary - 1999, http://minerals.usgs.gov/minerals/pubs/commodity/cadmium/index.html]**PEER REVIEWED**

U. S. Imports:

(1977) 2.33X10+9 G
[SRI]**PEER REVIEWED**

(1982) 2.30X10+9 G
[SRI]**PEER REVIEWED**

(1977): 1.6 to 16 million pounds.
[USEPA; Subst Risk Notice, 8(e)HQ-0280-0332 (1983) EPA-560/2-83-001]**PEER REVIEWED**

(1986) 3.00x10+9 g /Metal/
[BUREAU OF MINES. MINERAL COMMODITY SUMMARIES 1987 p.28]**PEER REVIEWED**

Imports for consumption, metal, in metric tons: 1994: 1110; 1995: 848; 1996: 843; 1997: 790; 1998: 650.
[U.S. Geological Survey - Mineral Commodity Summary - 1999, http://minerals.usgs.gov/minerals/pubs/commodity/cadmium/index.html]**PEER REVIEWED**

U. S. Exports:

(1978) 3.26X10+8 G
[SRI]**PEER REVIEWED**

(1983) 1.70X10+8 G
[SRI]**PEER REVIEWED**

(1986) 5.00x10+8 g
[BUREAU OF MINES. MINERAL COMMODITY SUMMARIES 1987 p.28]**PEER REVIEWED**

Exports of metal, alloys, and scrap in metric tons of **cadmium**: 1994: 1450; 1995: 1050; 1996: 201; 1997: 554; 1998: 300.
[U.S. Geological Survey - Mineral Commodity Summary - 1999, http://minerals.usgs.gov/minerals/pubs/commodity/cadmium/index.html]**PEER REVIEWED**

Laboratory Methods:

Special References:

Special Reports:

U.S. Department of Health & Human Services/National Toxicology Program; Tenth Report on Carcinogens. National Institutes of Environmental Health Sciences. The Report on Carcinogens is an informational scientific and public health document that identifies and discusses substances (including

agents, mixtures, or exposure circumstances) that may pose a carcinogenic hazard to human health. **Cadmium** (7440-43-9) was listed in the First Annual Report on Carcinogens (1980) as reasonably anticipated to be a human carcinogen and then listed in the Ninth Report on Carcinogens (2000) as a known human carcinogen.
[ ]

Synonyms and Identifiers:

Related HSDB Records:

6922 [**CADMIUM** COMPOUNDS]

Synonyms:

CADMIUM
PEER REVIEWED

C I 77180
PEER REVIEWED

Colloidal cadmium
PEER REVIEWED

KADMIUM (GERMAN)
PEER REVIEWED

Formulations/Preparations:

Grades: technical; powder; pure sticks; ingots; slabs; high purity crystals (10 ppm impurities).
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 12th ed. New York, NY: Van Nostrand Rheinhold Co., 1993 195]**PEER REVIEWED**

CADMIUM SPONGE ... HAS MOISTURE CONTENT OF ABOUT 25% WHEN PACKAGED IN BAGS & 35% WHEN PACKAGED IN DRUMS ... TYPICAL **CADMIUM** CONTENTS ON DRY BASIS ARE 86% IN BAGS & 92% IN DRUMS.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 42 (1976)]**PEER REVIEWED**

/Available in/ 99.5 to 99.999% purity grades
[CHEMCYCLOPEDIA 1987 p.168]**PEER REVIEWED**

EPA Hazardous Waste Number:

D006; A waste containing **cadmium** may or may not be characterized as a hazardous waste following testing by the Toxicity Characteristic Leaching Procedure as prescribed by the Resource Conservation and Recovery Act (RCRA) regulations.

Administrative Information:

Hazardous Substances Databank Number: 282

Last Revision Date: 20030829

Last Review Date: Reviewed by SRP on 9/23/1999

Update History:

Complete Update on 2003-08-29, 1 fields added/edited/deleted
Complete Update on 11/08/2002, 1 field added/edited/deleted.
Complete Update on 05/31/2002, 1 field added/edited/deleted.
Complete Update on 01/14/2002, 1 field added/edited/deleted.
Complete Update on 08/09/2001, 1 field added/edited/deleted.
Complete Update on 05/15/2001, 1 field added/edited/deleted.
Complete Update on 10/18/2000, 80 fields added/edited/deleted.
Field Update on 09/12/2000, 1 field added/edited/deleted.
Field Update on 03/28/2000, 1 field added/edited/deleted.
Field Update on 02/08/2000, 1 field added/edited/deleted.
Field Update on 02/02/2000, 1 field added/edited/deleted.
Field Update on 11/18/1999, 1 field added/edited/deleted.
Field Update on 09/21/1999, 1 field added/edited/deleted.
Field Update on 08/26/1999, 1 field added/edited/deleted.
Field Update on 05/04/1999, 1 field added/edited/deleted.
Field Update on 03/19/1999, 1 field added/edited/deleted.
Complete Update on 02/11/1999, 1 field added/edited/deleted.
Complete Update on 11/24/1998, 1 field added/edited/deleted.
Complete Update on 11/12/1998, 1 field added/edited/deleted.
Complete Update on 09/11/1998, 1 field added/edited/deleted.
Complete Update on 06/02/1998, 1 field added/edited/deleted.
Complete Update on 10/17/1997, 1 field added/edited/deleted.
Complete Update on 03/27/1997, 2 fields added/edited/deleted.
Complete Update on 02/26/1997, 1 field added/edited/deleted.
Complete Update on 01/24/1997, 1 field added/edited/deleted.
Complete Update on 10/12/1996, 1 field added/edited/deleted.
Complete Update on 05/10/1996, 1 field added/edited/deleted.
Complete Update on 05/03/1996, 3 fields added/edited/deleted.
Complete Update on 03/01/1996, 7 fields added/edited/deleted.
Complete Update on 01/18/1996, 1 field added/edited/deleted.
Complete Update on 04/20/1995, 1 field added/edited/deleted.
Complete Update on 04/20/1995, 1 field added/edited/deleted.
Complete Update on 03/07/1995, 1 field added/edited/deleted.
Complete Update on 02/14/1995, 1 field added/edited/deleted.
Complete Update on 01/25/1995, 1 field added/edited/deleted.
Complete Update on 12/19/1994, 1 field added/edited/deleted.
Complete Update on 09/28/1994, 2 fields added/edited/deleted.
Complete Update on 09/26/1994, 1 field added/edited/deleted.
Complete Update on 09/16/1994, 1 field added/edited/deleted.
Complete Update on 08/17/1994, 1 field added/edited/deleted.
Complete Update on 05/05/1994, 1 field added/edited/deleted.
Complete Update on 03/25/1994, 1 field added/edited/deleted.
Complete Update on 02/02/1994, 1 field added/edited/deleted.
Complete Update on 11/05/1993, 1 field added/edited/deleted.

Complete Update on 10/28/1993, 1 field added/edited/deleted.
Complete Update on 08/07/1993, 1 field added/edited/deleted.
Field update on 12/12/1992, 1 field added/edited/deleted.
Complete Update on 04/27/1992, 1 field added/edited/deleted.
Complete Update on 04/01/1992, 1 field added/edited/deleted.
Complete Update on 01/23/1992, 1 field added/edited/deleted.
Complete Update on 08/23/1990, 1 field added/edited/deleted.
Complete Update on 05/29/1990, 9 fields added/edited/deleted.
Field Update on 05/14/1990, 1 field added/edited/deleted.
Field Update on 01/15/1990, 1 field added/edited/deleted.
Complete Update on 01/11/1990, 6 fields added/edited/deleted.
Complete Update on 07/13/1989, 99 fields added/edited/deleted.
Complete Update on 01/27/1986
Created 19830401 by DS

Record Length: 71230.0

Cadmium

CASRN: 7440-43-9
For other data, click on the Table of Contents

Status:

STATUS OF DATA FOR **Cadmium**

File First On-Line 03/31/1987

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on-line	02/01/1994
Inhalation RfC Assessment (I.B.)	no data	
Carcinogenicity Assessment (II.)	on-line	06/01/1992

Substance Identification:

Substance Name:

Cadmium

CAS Registry Number: 7440-43-9

I. Chronic Health Hazard Assessment for Noncarcinogenic Effects:

I.A. Reference Dose for Chronic Oral Exposure (RfD):

Substance Name -- **Cadmium**
CASRN -- 7440-43-9
Last Revised -- 02/01/1994

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.A.1. Oral RfD Summary:

Critical Effect	Experimental Doses*	UF	MF	RfD
Significant proteinuria	NOAEL (water): 0.005 mg/kg/day	10	1	5E-4 mg/kg/day (water)
Human studies involving chronic exposures U.S. EPA, 1985	NOAEL (food): 0.01 mg/kg/day	10	1	1E-3 mg/kg/day (food)

* Conversion Factors: See text for discussion

I.A.2. Principal and Supporting Studies (Oral RfD):

U.S. EPA. 1985. Drinking Water Criteria Document on **Cadmium**. Office of Drinking Water, Washington, DC. (Final draft)

A concentration of 200 ug **cadmium** (Cd)/gm wet human renal cortex is the highest renal level not associated with significant proteinuria (U.S. EPA, 1985). A toxicokinetic model is available to determine the level of chronic human oral exposure (NOAEL) which results in 200 ug Cd/gm wet human renal cortex; the model assumes that 0.01% day of the Cd body burden is eliminated per day (U.S. EPA, 1985). Assuming 2.5% absorption of Cd from food or 5% from water, the toxicokinetic model predicts that the NOAEL for chronic Cd exposure is 0.005 and 0.01 mg Cd/kg/day from water and food, respectively (i.e., levels which would result in 200 ug Cd/gm wet weight human renal cortex). Thus, based on an estimated NOAEL of 0.005 mg Cd/kg/day for Cd in drinking water and ian UF of 10, an RfD of 0.0005 mg Cd/kg/day (water) was calculated; an equivalent RfD for Cd in food is 0.001 mg Cd/kg/day (see Section VI.A. for references).

I.A.3. Uncertainty and Modifying Factors (Oral RfD):

UF -- This uncertainty factor is used to account for intrahuman variability to the toxicity of this chemical in the absence of specific data on sensitive individuals.

MF -- None

I.A.4. Additional Studies/Comments (Oral RfD):

Cd is unusual in relation to most, if not all, of the substances for which an oral RfD has been determined in that a vast quantity of both human and animal toxicity data are available. The RfD is based on the highest level of Cd in the human renal cortex (i.e., the critical level) not associated with significant proteinuria (i.e., the critical effect). A toxicokinetic model has been used to determine the highest level of exposure associated with the lack of a critical effect. Since the fraction of ingested Cd that is absorbed appears to vary with the source (e.g., food vs. drinking water), it is necessary to allow for this difference in absorption when using the toxicokinetic model to determine an RfD.

I.A.5. Confidence in the Oral RfD:

Study -- Not applicable
Database -- High
RfD -- High

The choice of NOAEL does not reflect the information from any single study. Rather, it reflects the data obtained from many studies on the toxicity of **cadmium** in both humans and animals. These data also permit calculation of pharmacokinetic parameters of **cadmium** absorption, distribution, metabolism and elimination. All of this information considered together gives high confidence in the data base. High confidence in either RfD follows as well.

I.A.6. EPA Documentation and Review of the Oral RfD:

Source Document -- U.S. EPA, 1985

Other EPA Documentation -- None

Agency Work Group Review -- 05/15/1986, 08/19/1986, 09/17/1987, 12/15/1987, 01/20/1988, 05/25/1988

Verification Date -- 05/25/1988

I.A.7. EPA Contacts (Oral RfD):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC):

Substance Name -- **Cadmium**
CASRN -- 7440-43-9

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure:

Substance Name -- **Cadmium**
CASRN -- 7440-43-9
Last Revised -- 06/01/1992

Section II provides information on three aspects of the carcinogenic assessment for the substance in question; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose

extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity:

II.A.1. Weight-of-Evidence Characterization:

Classification -- B1; probable human carcinogen

Basis -- Limited evidence from occupational epidemiologic studies of **cadmium** is consistent across investigators and study populations. There is sufficient evidence of carcinogenicity in rats and mice by inhalation and intramuscular and subcutaneous injection. Seven studies in rats and mice wherein **cadmium** salts (acetate, sulfate, chloride) were administered orally have shown no evidence of carcinogenic response.

II.A.2. Human Carcinogenicity Data:

Limited. A 2-fold excess risk of lung cancer was observed in **cadmium** smelter workers. The cohort consisted of 602 white males who had been employed in production work a minimum of 6 months during the years 1940-1969. The population was followed to the end of 1978. Urine **cadmium** data available for 261 workers employed after 1960 suggested a highly exposed population. The authors were able to ascertain that the increased lung cancer risk was probably not due to the presence of arsenic or to smoking (Thun et al., 1985). An evaluation by the Carcinogen Assessment Group of these possible confounding factors has indicated that the assumptions and methods used in accounting for them appear to be valid. As the SMRs observed were low and there is a lack of clear cut evidence of a causal relationship of the **cadmium** exposure only, this study is considered to supply limited evidence of human carcinogenicity.

An excess lung cancer risk was also observed in three other studies which were, however, compromised by the presence of other carcinogens (arsenic, smoking) in the exposure or by a small population (Varner, 1983; Sorahan and Waterhouse, 1983; Armstrong and Kazantzis, 1983).

Four studies of workers exposed to **cadmium** dust or fumes provided evidence of a statistically significant positive association with prostate cancer (Kipling and Waterhouse, 1967; Lemen et al., 1976; Holden, 1980; Sorahan and Waterhouse, 1983), but the total number of cases was small in each study. The Thun et al. (1985) study is an update of an earlier study (Lemen et al., 1976) and does not show excess prostate cancer risk in these workers. Studies of human ingestion of **cadmium** are inadequate to assess carcinogenicity.

II.A.3. Animal Carcinogenicity Data:

Exposure of Wistar rats by inhalation to **cadmium** as **cadmium** chloride at concentrations of 12.5, 25 and 50 ug/cu.m for 18 months, with an additional 13-month observation period, resulted in significant increases in lung tumors (Takenaka et al., 1983). Intratracheal instillation of **cadmium** oxide did not produce lung tumors in Fischer 344 rats but rather mammary tumors in males and tumors at multiple sites in males (Sanders and Mahaffey, 1984). Injection site tumors and distant site tumors (for example, testicular) have been reported by a number of authors as a consequence of intramuscular or subcutaneous administration of **cadmium** metal and chloride, sulfate, oxide and sulfide compounds of **cadmium** to rats and mice (U.S. EPA, 1985). Seven studies in rats and mice where **cadmium** salts (acetate, sulfate, chloride) were administered orally have shown no evidence of a carcinogenic response.

II.A.4. Supporting Data for Carcinogenicity:

Results of mutagenicity tests in bacteria and yeast have been inconclusive. Positive responses have been obtained in mutation assays in Chinese hamster cells (Dom and V79 lines) and in mouse lymphoma cells (Casto, 1976; Ochi and Ohsawa, 1983; 0berly et al., 1982).

Conflicting results have been obtained in assays of chromosomal aberrations in human lymphocytes treated in vitro or obtained from exposed workers. **Cadmium** treatment in vivo or in vitro appears to interfere with spindle formation and to result in aneuploidy in germ cells of mice and hamsters (Shimada et al., 1976; Watanabe et al., 1979; Gilliavod and Leonard, 1975).

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure:

Not available. There are no positive studies of orally ingested **cadmium** suitable for quantitation.

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure:

II.C.1. Summary of Risk Estimates:

Inhalation Unit Risk -- 1.8E-3 per (ug/cu.m)

Extrapolation Method -- Two stage; only first affected by exposure; extra risk

Air Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	6E-2 ug/cu.m
E-5 (1 in 100,000)	6E-3 ug/cu.m
E-6 (1 in 1,000,000)	6E-4 ug/cu.m

II.C.2. Dose-Response Data for Carcinogenicity, Inhalation:

Tumor Type -- lung, trachea, bronchus cancer deaths
Test animals -- human/white male
Route -- inhalation, exposure in the workplace
Reference -- Thun et al., 1985

Cumulative Exposure (mg/day/cu.m)	Median Observation	24 hour/ ug/cu.m Equivalent	No. of Expected Lung, Trachea and Bronchus Cancers Assuming No Cadmium Effect	Observed No. of Deaths (lung, trachea, bronchus cancers)
less than or equal to 584	280	168	3.77	2
585-2920	1210	727	4.61	7
greater than or equal to 2921	4200	2522	2.50	7

The 24-hour equivalent = median observation x lE+3 x 8/24 x 1/365 x 240/365.

II.C.3. Additional Comments (Carcinogenicity, Inhalation Exposure):

The unit risk should not be used if the air concentration exceeds 6 ug/cu.m, since above this concentration the unit risk may not be appropriate.

II.C.4. Discussion of Confidence (Carcinogenicity, Inhalation Exposure):

The data were derived from a relatively large cohort. Effects of arsenic and smoking were accounted for in the quantitative analysis for **cadmium** effects.

An inhalation unit risk for **cadmium** based on the Takenaka et al. (1983) analysis is 9.2E-2 per (ug/cu.m). While this estimate is higher than that derived from human data [1.8E-3 per (ug/cu.m)] and thus more conservative, it was felt that the use of available human data was more reliable because of species variations in response and the type of exposure (**cadmium** salt vs. **cadmium** fume and **cadmium** oxide).

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment):

II.D.1. EPA Documentation:

Source Document -- U.S. EPA, 1985

The Addendum to the **Cadmium** Health Assessment has received both Agency and external review.

II.D.2. EPA Review (Carcinogenicity Assessment):

Agency Work Group Review -- 11/12/1986

Verification Date -- 11/12/1986

II.D.3. EPA Contacts (Carcinogenicity Assessment):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

VI. Bibliography:

VI.A. Oral RfD References:

Foulkes, E.C. 1986. Absorption of **cadmium**. In: Handbook of Experimental Pharmacology, E.C. Foulkes, Ed. Springer Verlag, Berlin. Vol. 80, p. 75-100.

Friberg, L., M. Piscator, G.F. Nordberg and T. Kjellstrom. 1974. **Cadmium** in the environment, 2nd ed. CRC Press, Inc., Boca Raton, FL.

Shaikh, Z.A. and J.C. Smith. 1980. Metabolism of orally ingested **cadmium** in humans. In: Mechanisms of Toxicity and Hazard Evaluation, B. Holmstedt et al., Ed. Elsevier Publishing Co., Amsterdam. p. 569-574.

U.S. EPA. 1985. Drinking Water Criteria Document on **Cadmium**. Office of Drinking Water, Washington, DC. (Final draft)

WHO (World Health Organization). 1972. Evaluation of certain food additives and the contaminants mercury, lead, and **cadmium**. Sixteenth Report of the Joint FAO/WHO Expert Committee on Food Additives. WHO Technical Report Series No. 505, FAO Nutrition Meetings Report Series No. 51. Geneva, Switzerland.

WHO (World Health Organization). 1984. Guidelines for drinking water quality -- recommendations. Vol. 1. Geneva, Switzerland.

VI.B. Inhalation RfC References:

None

VI.C. Carcinogenicity Assessment References:

Armstrong, B.G. and G. Kazantzis. 1983. The mortality of **cadmium** workers. Lancet. June 25, 1983: 1425-1427.

Casto, B. 1976. Letter to Richard Troast, U.S. EPA. Enclosing mutagenicity data on **cadmium** chloride and **cadmium** acetate.

Gilliavod, N. and A. Leonard. 1975. Mutagenicity tests with **cadmium** in the mouse. Toxicology. 5: 43-47.

Holden, H. 1980. Further mortality studies on workers exposed to **cadmium** fumes. Presented at Seminar on Occupational Exposure to **Cadmium**, March 20, 1980, London, England.

Kipling, M.D. and J.A.H. Waterhouse. 1967. **Cadmium** and prostatic carcinoma. Lancet. 1: 730.

Lemen, R.A., J.S. Lee, J.K. Wagoner and H.P. Blejer. 1976. Cancer mortality among **cadmium** production workers. Ann. N.Y. Acad. Sci. 271: 273.

Oberly, T., C.E. Piper and D.S. McDonald. 1982. Mutagenicty of metal salts in the L5178 Y mouse lymphoma assay. J. Toxicol. Environ. Health. 9: 367-376.

Ochi, T. and M. Ohsawa. 1983. Induction of 6-thioguanine-resistant mutants and single-strand scission DNA by **cadmium** chloride in cultured Chinese hamster cells. Mutat. Res. 111: 69-78.

Sanders, C.L. and J.A. Mahaffey. 1984. Carcinogenicity of single and multiple intratracheal instillations of **cadmium** oxide in the rat. Environ. Res. 33: 227-233.

Shimada, T., T. Watanabe and A. Endo. 1976. Potential mutagenicity of **cadmium** in mammalian oocytes. Mutat. Res. 40: 389-396.

Sorahan, T. and J.A.H. Waterhouse. 1983. Mortality study of nickel-**cadmium** battery workers by the method of regression models in life tables. Br. J. Ind. Med. 40: 293-300.

Takenaka, S., H. Oldiges, H. Konig, D. Hochrainer and G. Oberdoerster. 1983. Carcinogenicity of **cadmium** aerosols in Wistar rats. J. Natl. Cancer Inst. 70: 367-373.

Thun, M.J., T.M. Schnorr, A.B. Smith and W.E. Halperin. 1985. Mortality among a cohort of U.S. **cadmium** production workers: An update. J. Natl. Cancer Inst. 74(2): 325-333.

U.S. EPA. 1985. Updated Mutagenicity and Carcinogenicity Assessment of **Cadmium**. Addendum to the Health Assessment Document for **Cadmium** (EPA 600/B- B1-023). EPA 600/B-83-025F.

Varner, M.O. 1983. Updated epidemiologic study of **cadmium** smelter workers. Presented at the Fourth International **Cadmium** Conference. Unpublished.

Watanabe, T., T. Shimada and A. Endo. 1979. Mutagenic effects of **cadmium** on mammalian oocyte chromosomes. Mutat. Res. 67: 349-356.

VII. Revision History:

Substance Name -- **Cadmium**
CASRN -- 7440-43-9

Date	Section	Description
05/21/1987	II.C.	Slope factor corrected
03/01/1988	II.A.1.	Text added
03/01/1988	II.C.3.	Text revised
03/01/1988	II.C.4.	Confidence statement revised
03/01/1988	II.D.3.	Secondary contact changed
01/01/1989	IV.C.1.	Water quality human health criteria added
01/01/1989	IV.C.2.	Corrected marine acute criterion
08/01/1989	VI.	Bibliography on-line
10/01/1989	I.A.	Oral RfD summary on-line
10/01/1989	VI.A.	Oral RfD references added
12/01/1989	I.B.	Inhalation RfC now under review
06/01/1990	IV.A.1.	Area code for EPA contact corrected
06/01/1990	IV.F.1.	EPA contact changed
08/01/1990	II.A.1.	Basis statement revised
08/01/1990	II.A.2.	Text revised, paragraph 1
08/01/1990	II.B.	Text revised
01/01/1991	II.	Text edited
01/01/1991	II.C.1.	Inhalation slope factor removed (global change)
03/01/1991	II.A.1.	Text revised
03/01/1991	II.B.	Text revised
01/01/1992	IV.	Regulatory actions updated
04/01/1992	IV.A.1.	CAA regulatory action withdrawn
05/01/1992	II.C.2.	Number correction in data table
06/01/1992	II.A.2.	Text revised, paragraph 1
06/01/1992	II.A.3.	Text clarified
02/01/1994	I.A.7.	Secondary contact changed
08/01/1995	I.B.	EPA's RfD/RfC and CRAVE workgroups were discontinued in May, 1995. Chemical substance reviews that were not completed by September 1995 were taken out of IRIS review. The IRIS Pilot Program replaced the workgroup functions beginning in September, 1995.
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
01/02/1998	I., II.	This chemical is being reassessed under the IRIS Program.

CHLOROFORM

CASRN: 67-66-3

For other data, click on the Table of Contents

Human Health Effects:

Toxicity Summary:

... The general population is exposed to **chloroform** principally in food, drinking-water and indoor air in approximately equivalent amounts. The estimated intake from outdoor air is considerably less. ... Water use in homes contributes considerably to levels of **chloroform** in indoor air and to total exposure. ... **Chloroform** is well absorbed in animals and humans after oral administrations but the absorption kinetics are dependent upon the vehicle of delivery. ... The primary factors affecting the absorption kinetics of **chloroform** following inhalation are its concentration and species-specific metabolic capacities. It is readily absorbed through the skin of humans and animals and significant dermal absorption of **chloroform** from water while showering has been demonstrated. Hydration of the skin appears to accelerate absorption of **chloroform**. **Chloroform** distributes throughout the whole body. Highest tissue levels are reached in the fat, blood, liver, kidneys, lungs and nervous system. Distribution is dependent on exposure route; extrahepatic tissues receive a higher dose from inhaled or dermally absorbed **chloroform** than from ingested **chloroform**. Placental transfer of **chloroform** has been demonstrated in several animal species and humans. **Chloroform** is eliminated primarily as exhaled carbon dioxide. Unmetabolized **chloroform** is retained longer in fat than in any other tissues. The oxidative biotransformation of **chloroform** is catalyzed by cytochrome P-450 to produce trichloromethanol. Loss of HCl from trichloromethanol produces phosgene as a reactive intermediate. ... The reaction of phosgene with tissue proteins is associated with cell damage and death. ... The liver is the target organ for acute toxicity in rats and several strains of mice. Liver damage is characterized by early fatty infiltration and balloon cells, progressing to centrilobular necrosis and then massive necrosis. The kidney is the target organ in male mice of other more sensitive strains. The kidney damage starts with hydropic degeneration and progresses to necrosis of the proximal tubules. ... In mice the oral LD50 values range from 36 to 1366 mg **chloroform**/kg body weight, whereas for rats, they range from 450 to 2000 mg **chloroform**/kg body weight. ... The carcinogenic effects of **chloroform** on the liver and kidney of rodents appear to be closely related to cytotoxic and cell replicative effects observed in the target organs. ... The weight of the available evidence indicates that **chloroform** has little, if any, capability to induce gene mutation or other types of direct damage to DNA. ... There are some limited data to suggest that **chloroform** is toxic to the fetus but only at doses that are maternally toxic. ... In humans, anesthesia may result in death due to respiratory and cardiac arrhythmias and failure. Renal tubular necrosis and renal dysfunction have also been observed in humans. ... The mean lethal oral dose for an adult is estimated to be about 45 g, but large interindividual differences in susceptibility occur. There is some weight of evidence for an association between exposure to disinfection byproducts in drinking water and colorectal and bladder cancer in some epidemiological studies. ... The evidence for the carcinogenicity of chlorinated drinking water in humans is inadequate. In addition, the disinfection byproducts cannot be attributed to **chloroform** per se. ... However, it is cautioned that where local circumstances require that a choice must be made between meeting microbiological limits or limits for disinfection byproducts such as **chloroform**, the microbiological quality must always take precedence. ... Levels of **chloroform** in surface waters are generally low and would not be expected to present a hazard to aquatic organisms. However, higher levels of **chloroform** in surface water resulting from industrial discharges or spills may be hazardous to the embryo-larval stages of some aquatic species.
[Environmental Health Criteria 163: Chloroform. pp. 13-18 (1994) by the International Programme on Chemical Safety (IPCS) under the joint sponsorship of the

United Nations Environment Programme, the International Labour Organisation and the World Health Organization.]**QC REVIEWED**

Evidence for Carcinogenicity:

CLASSIFICATION: B2; probable human carcinogen. BASIS FOR CLASSIFICATION: Based on increased incidence of several tumor types in rats and three strains of mice. HUMAN CARCINOGENICITY DATA: Inadequate. ANIMAL CARCINOGENICITY DATA: Sufficient.
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Chloroform (67-66-3) Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000]**PEER REVIEWED**

Evaluation: There is inadequate evidence in humans for the carcinogenicity of **chloroform**. There is sufficient evidence in experimental animals for the carcinogenicity of **chloroform**. Overall evaluation: **Chloroform** is possibly carcinogenic to humans (Group 2B).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 73 170 (1999)]**QC REVIEWED**

A3. Confirmed animal carcinogen with unknown relevance to humans.
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 25]**QC REVIEWED**

Human Toxicity Excerpts:

ACUTE ... RESPONSES FROM EXPOSURE AT VARIOUS CONCN OF **CHLOROFORM** IN MAN HAVE BEEN REPORTED TO BE: FAINTING SENSATION & VOMITING FROM 4096 PPM; DIZZINESS & SALIVATION AFTER FEW MIN AT 1475 PPM; INCR INTRACRANIAL PRESSURE & NAUSEA IN 7 MIN; AFTER-EFFECTS, FATIGUE & HEADACHE FOR SEVERAL HR FROM 1024 PPM.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values for Substances in Workroom Air. Third Edition, 1971. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1971. (Plus supplements to 1979)413]**PEER REVIEWED**

RESPONSES ASSOC WITH EXPOSURE TO /**CHLOROFORM**/ CONCN BELOW ANESTHETIC OR PREANESTHETIC LEVEL ARE TYPICALLY INEBRIATION & EXCITATION PASSING INTO ... /CNS DEPRESSION/. VOMITING AND GI UPSETS MAY BE OBSERVED. EXPOSURE INCL RESP DEPRESSION, COMA, RENAL DAMAGE, & LIVER DAMAGE AS MEASURED BY ELEVATED SERUM ENZYME LEVELS.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4054]**PEER REVIEWED**

SPLASH OF LIQ **CHLOROFORM** IN THE EYES CAUSES IMMEDIATE BURNING PAIN, TEARING, & REDDENING OF CONJUNCTIVA. THE CORNEAL EPITHELIUM IS USUALLY INJURED & MAY BE PARTIALLY LOST. HOWEVER, REGENERATION IS PROMPT, AND AS A RULE THE EYE RETURNS TO NORMAL IN 1 TO 3 DAYS.
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 213]**PEER REVIEWED**

CHLOROFORM EXPOSURE HAS REPEATEDLY BEEN FATAL TO MAN. RAPID DEATH WAS ATTRIBUTABLE TO CARDIAC ARREST & DELAYED DEATH TO LIVER & KIDNEY DAMAGE. SYMPTOMS OF **CHLOROFORM** EXPOSURE INCL RESP DEPRESSION, COMA,

RENAL DAMAGE, & LIVER DAMAGE AS MEASURED BY ELEVATED SERUM ENZYME LEVELS.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 415 (1979)]**PEER REVIEWED**

CHLOROFORM WITH METABOLIC ACTIVATION FAILED TO INDUCE CHROMOSOME BREAKAGE OR SISTER-CHROMATID EXCHANGES IN HUMAN LYMPHOCYTES.
[KIRKLAND DJ ET AL; FD COSMET TOXICOL 19: 651 (1981)]**PEER REVIEWED**

... Twenty-five percent of 68 workers handling **chloroform** in a chemical plant had enlarged livers. The lengths of employment were between 1 and 4 yr. Concn of **chloroform** in air ranged from 10-200 ppm.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.290]**PEER REVIEWED**

33-year-old male who habitually inhaled **chloroform** for 12 yr, had psychiatric and neurologic symptoms of depression, loss of appetite, hallucination, ataxia, and dysarthria. Other symptoms from habitual use are moodiness, mental and physical sluggishness, nausea, rheumatic pain, and delirium.
[NIOSH; Criteria for a Recommended Standard Occupational Exposure to Chloroform (1974) DHEW Pub NIOSH 75-114]**PEER REVIEWED**

Signs of **chloroform** poisoning in humans include a characteristic sweetish odor on the breath, dilated pupils, cold and clammy skin, initial excitation alternating with apathy, loss of sensation, abolition of motor functions, prostration, unconsciousness and eventual death.
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 2-1]**PEER REVIEWED**

Worker exposure to concn of **chloroform** of over 112 mg/cu m have been reported to result in depression, ataxia, flatulence, irritability, and liver and kidney damage.
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 2-1]**PEER REVIEWED**

Toxic blood level: 70.0 to 250 mg/l; Lethal blood level: 390.0 mg/l.
[Winek, C.L. Drug and Chemical Blood-Level Data 1985. Pittsburgh, PA: Allied Fischer Scientific, 1985.]**PEER REVIEWED**

An increased incidence of cardiac arrhythmias has been demonstrated during surgery in patients anesthetized with **chloroform** as compared with other anesthetic agents at vapor concn of 22,500 ppm.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

... Produces CNS depression ... Can sensitive the heart to arrhythmias produced by catecholamines. The hepatotoxic potential is highest with **chloroform** ...
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1681]**PEER REVIEWED**

Fatal doses of liquid anesthetic agents by ingestion or inhalation are approx as follows: ... **chloroform**, 10 ml ... .
[Dreisbach, R.H. Handbook of Poisoning. 12th ed. Norwalk, CT: Appleton and Lange, 1987. 314]**PEER REVIEWED**

Concentrations /of **chloroform**/ up to about 400 ppm can be endured for 30 min without complaint;

1000 ppm exposure for 7 min can cause dizziness and GI upset; 14,000 ppm can cause /CNS depression/.
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 748]**PEER REVIEWED**

/**Chloroform** causes/ local irritation (hyperemia, erythema, moisture loss) at the site of skin absorption.
[Malten KE et al; Berufsdermatosen 16: 135 (1968)]**PEER REVIEWED**

Both di- and tri-halogenated methane derivatives have been found to produce increased blood levels of methemoglobin; the greatest increase caused by iodo-, followed by bromo- and chloro- compounds. CNS functional disturbances are reported, including depression of rapid eyemovement sleep, as seen in carbon monoxide exposures. /Di- and tri-halogenated methane derivatives/
[USEPA; Ambient Water Quality Criteria Doc: Halomethanes p.C-40 (1980) EPA 440/5-80-051]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Skin and eye irritant
[Winslow S, Gerstner H; Health Aspects of Chloroform - A Review p.6-9 (1977) ORNL/TIRC-77/4]**PEER REVIEWED**

Threshold of irritation: 20480 mg/cu m
[Ruth JH; Am Ind Hyg Assoc J 47: A-142-51 (1986)]**PEER REVIEWED**

Drug Warnings:

Maternal Medication usually Compatible with Breast-Feeding: **Chloroform**: Reported Sign or Symptom in Infant or Effect on Lactation: None. /from Table 6/
[Report of the American Academy of Pediatrics Committee on Drugs in Pediatrics 93 (1): 140 (1994)]**PEER REVIEWED**

Medical Surveillance:

Initial Medical Examination: A complete history and physical examination ... to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of liver, kidneys, and heart should be stressed. The skin should be examined for evidence of chronic disorders. A profile of liver function should be obtained by using a medically acceptable array of biochemical tests. Since kidney damage has also been observed from exposure /to **chloroform**/, a urinalysis should be obtained to include at a minimum: specific gravity, albumin, glucose, and a microscopic /examination of/ centrifuged sediment. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Whenever medical surveillance is indicated, in particular when exposure to a carcinogen has occurred, ad hoc decisions should be taken concerning ... /cytogenetic and/or other/ tests that might become useful or mandatory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.23]**PEER REVIEWED**

Populations at Special Risk:

... Individuals with diseases of liver, kidneys, and CNS.
[ITII. Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1988. 122]**PEER REVIEWED**

A history of, or physical signs consistent with, chronic alcoholism probably constitutes an increased risk for employees exposed to **chloroform**.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Probable Routes of Human Exposure:

Shell Chem Co, Rocky Mountain Arsenal - mean TWA were 2.6, 0.4 and 0.2 ppm for production operaters, drummers/bottle fillers and maintenance/utility personnel (pesticide plant)(1). Polish pharmaceutical plant 2 - 205 ppm(1); police forensic lab - 8 hr TWA - 15.8 ppm (range 2.6-46.4 ppm)(1); film manufacturing plant using a solvent containing 22% **chloroform** 1968-72 - 7-170 ppm (mean 47 ppm, 79 samples)(1).
[(1) Santodonato J et al; Monograph on Human Exposure to Chemicals in the Workplace: Chloroform. NCI contract N01-CP-26002-03, Syracuse Research Corp. July (1985)]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 95,773 workers (41,397 of these are female) are potentially exposed to **chloroform** in the US(1). Occupational exposure to **chloroform** may occur through inhalation and dermal contact with this compound at workplaces where **chloroform** is produced or used(SRC). The general population may be exposed to **chloroform** via inhalation of ambient air(2,3), ingestion of food(2) and drinking water(2,4).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983) (2) Wallace LA; Crit Rev Environ Sci Technol 27: 113-94 (1997) (3) Sweet CW, Vermette SJ; Environ Sci Technol 26: 165-173 (1992) (4) Dewulf J, Van Langenhove H; Wat Res 31: 1825-38 (1997)]**PEER REVIEWED**

Personal air concns of **chloroform** were studied for 12 hr exposure periods(1). Forty eight people in New Jersey during Feb 1983 had a mean personal exposure of 4.0 ug/cu m during day and nighttime while 40 individuals in Los Angeles, CA during June 1987 had a mean personal exposure of 3.8 ug/cu m during the day and 0.92 ug/cu m during nighttime(1). In Antioch-Pittsburg, CA during June 1984, 68 people had a mean personal exposure to **chloroform** of 0.47 ug/cu m during the day and 0.80 during nighttime(1). Several studies of indoor swimming pools indicate that inhalation can provide substantial amounts of **chloroform**(1). A study of 3 indoor swimming pools and 3 life guards resulted in increases of personal air exposures to **chloroform**(1). Personal air exposures for the 3 lifeguards at the indoor pool were 95, 68, and 46 ug/cu m while at home exposures dropped to 2.2, 2.0 and 5.2 ug/cu m(1). However, outdoor pools showed no difference in personal air exposure to **chloroform**(1). A pilot study carried out in Japan measured the intake of **chloroform** from air, food, and tap water for 7 Japanese housewives on 3 consecutive days in each of two seasons. For all 7 subjects in winter and 6 out of the 7 in summer, food contributed the most to their daily intake, accounting for about half of the daily intake of 37 ug in the summer and 70% of the smaller winter intake of 14 ug(1).
[(1) Wallace LA; Crit Rev Environ Sci Technol 27: 113-94 (1997)]**PEER REVIEWED**

Several experiments indicate that dermal absorption of **chloroform** during a shower is roughly equivalent to inhalation exposure during the shower(1). It has been estimated that about half the exposure from a 10-min shower is due to dermal absorption(1). The major source of exposure to **chloroform** is chlorination of water supplies(1). The results in exposure through ingestion of drinking water, but also through inhalation and skin absorption as a result of the myriad other uses of chlorinated

water in the home: showers, baths, washing clothes and dishes, etc supports this(1). At a typical personal exposure to **chloroform** of about 3 ug/cu m(not including exposure during the shower), this results in an estimated intake of about 24 ug/day for women and 30 ug/day for men(1). A typical **chloroform** level in soft drinks is about 23 ug/l(1). For an avg soft drink intake of 289 ml/day, this corresponds to a **chloroform** intake of about 6 ug/day(1). Limited data on levels of trihalomethanes (including **chloroform**) in food suggest that the additional intake from other foods and dairy products will be small(1). Thus, total intake from food and beverages appears to be approximately 10 ug/day for someone who drinks an avg amount of soft drinks(1).
[(1) Wallace LA; Crit Rev Environ Sci Technol 27: 113-94 (1997)]**PEER REVIEWED**

Body Burden:

Old Love Canal, Niagara Falls, NY - 9 individuals: breath 3.9-95 ug/cu m, 26 ug/cu m median; blood 1.1-3.0 ng/ml, 1.6 ng/ml median; urine 460-1500 ng/l, 860 ng/l median(1). England - 8 individuals: body fat 5-68 ppb; var organs 1-10 ppb(2); US - 4 urban sites: mothers' milk 7 of 8 samples pos, detected, not quantified(3).
[(1) Barkley J et al; Biomed Mass Spectrom 7: 139-47 (1980) (2) McConnell G et al; Endeavour 34: 13-8 (1975) (3) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982)]**PEER REVIEWED**

The largest existing data set on **chloroform** concns in the body has been provided by the TEAM Study measurements of exhaled breath(1). About 800 people provided more than 1250 breath samples with mean concns generally in the range of 0.5-3 ug/cu m with generally lower levels in California compared with other sites (New Jersey, Maryland, North Dakota, and North Carolina)(1). In a study of 163 people at indoor swimming pools, exposed individuals had a mean **chloroform** concn in the higher alveolar of 83 ug/cu m(1). Breath exposures were also studied from a single subject who swam for 30 mins on 3 occasions, rested in the water for the same length of time on one occasion and stayed near the pool but out of the water for 30 mins on the final occasion(1). Pre-exposure breath concns were less than 2 ug/cu m on all occasions, rising to 15 to 25 ug/cu m 2.5 mins after completing the swimming periods, but only to 11 mg/cu m after the poolside exposure period(1). A study of **chloroform** found in blood revealed that out of 979 people sampled between 1988-1992, the mean **chloroform** concn was 0.0444 ng/ml(1). This suggests that a large percentage of the U.S. population is exposed to **chloroform**, but that very large exposures are rare(1). **C**hloroform was also detected in 40 out of 42 breast milk samples at levels ranging from 0.1 to 65 ng/ml from nursing mothers in two New Jersey hospitals and from three other hospitals in Pennsylvania, Louisiana, and West Virginia(1).
[(1) Wallace LA; Crit Rev Environ Sci Technol 27: 113-94 (1997)]**PEER REVIEWED**

Average Daily Intake:

... Although data are scarce, maximum exposure /to **chloroform**/ due to ingestion of food has been estimated at 0.04 mg/day.
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 4-1]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** **CHLOROFORM** ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE

0.2.1.1 ACUTE EXPOSURE

A. **Chloroform** can be a poison by ingestion and inhalation and experimentally is a poison intravenously and is moderately toxic by the intraperitoneal and subcutaneous routes. The main route of absorption after occupational exposure is through inhalation. Percutaneous absorption is possible. Non-occupational exposure occurs mainly through ingestion of drinking water and inhalation of contaminated air. Inhalational abuse occurs.

B. **Chloroform** is an irritant; its main effect is as a central nervous system and cardiac depressant. Delayed renal and hepatic toxicity may also occur.

C. General symptoms of exposure include nausea, vomiting, anorexia, drowsiness, giddiness, disorientation, fatigue, a fainting sensation, headache, chest pain, anesthesia, salivation, a sensation of bodily warmth, and frequent burning urination.

D. Inhalation produces nose and throat irritation, dry mouth, thirst, a dazed feeling, lassitude, hallucinations, perceptual distortions, drunkeness, staggering, delirium, shortness of breath, gastrointesinal effects and pupil dilation with decreased reaction to light.

E. Short exposure to low vapor concentrations results in inebriation, excitation, narcosis, discomfort, dizziness; higher concentrations may also produce hypotension, anoxia, loss of consciousness, cardiorespiratory depression and failure, and death. Inhalational abuse can result in psychotic behavior and brain degeneration.

F. Ingestion of even small amounts (10 mL) can prove fatal. Initially, ingestion causes a burning sensation of the mouth and throat.

G. Demral contact results in irritation, burning pain, reddening, vesiculation and dermatitis via defatting. Prolonged exposure can result in burns. Exposure of the eye to liquid **chloroform** produces a burning pain, tearing, conjunctival redness and reversible injury to the corneal epithelium.

H. Chronic exposure may cause dry mouth, headache, hallucinations, dysarthria, ataxia, loss of reflexes, gastrointestinal distress, hepatotoxicity and psychotic behavior. Hepatotoxicity is not seen with chronic low-level exposure.

I. Heating **chloroform** to decomposition produces the toxic fumes of hydrochloric acid and other chlorinated

compounds.

0.2.3 VITAL SIGNS

0.2.3.1 ACUTE EXPOSURE

A. Hypotension and elevated temperature may be seen.

0.2.4 HEENT

0.2.4.1 ACUTE EXPOSURE

A. Conjunctivitis and blepharospasm may occur from exposure to vapors of **chloroform**.

B. Burning pain, conjunctivitis, and corneal epithelium injury may occur from splashed **chloroform** liquid.

C. Dry mouth and thirst may occur.

0.2.5 CARDIOVASCULAR

0.2.5.1 ACUTE EXPOSURE

A. Cardiac dysrhythmias and cardiac arrest have been reported during **chloroform** anesthesia.

0.2.6 RESPIRATORY

0.2.6.1 ACUTE EXPOSURE

A. Respiratory depression is common, chemical pneumonitis, and pulmonary edema may occur.

0.2.7 NEUROLOGIC

0.2.7.1 ACUTE EXPOSURE

A. Central nervous system depression, headache, and anorexia have been noted.

0.2.7.2 CHRONIC EXPOSURE

A. Headache, altered mental status, dysarthria, ataxia, and loss of reflexes may occur.

0.2.8 GASTROINTESTINAL

0.2.8.1 ACUTE EXPOSURE

A. Nausea, vomiting, and gastrointestinal irritation may occur.

0.2.8.2 CHRONIC EXPOSURE

A. Gastrointestinal distress, nausea, eructation, and loss of appetite have been reported.

0.2.9 HEPATIC

0.2.9.1 ACUTE EXPOSURE

A. Central hepatic necrosis has occurred 10 to 48 hours postingestion.

B. Fatty degeneration and hepatomegaly have been noted.

0.2.9.2 CHRONIC EXPOSURE

A. Fatty degeneration, hepatotoxicity, hepatomegaly, and liver necrosis may occur.

0.2.10 GENITOURINARY

0.2.10.1 ACUTE EXPOSURE

A. Renal damage and frequent urination have been reported.

0.2.10.2 CHRONIC EXPOSURE

A. Kidney epithelial tumors and renal tubular adenomas may occur.

0.2.11 ACID-BASE

0.2.11.1 ACUTE EXPOSURE

A. Metabolic acidosis may occur.

0.2.13 HEMATOLOGIC

0.2.13.1 ACUTE EXPOSURE

A. Hemolysis, leukocytosis and decreased plasma prothrombin levels may be observed.

0.2.14 DERMATOLOGIC

0.2.14.1 ACUTE EXPOSURE

A. Irritation, burns, urticaria, and necrosis may occur.

0.2.18 PSYCHIATRIC

0.2.18.2 CHRONIC EXPOSURE

A. Chronic abuse may produce degenerative brain changes and psychotic behavior.

0.2.20 REPRODUCTIVE HAZARDS

A. **Chloroform** may be embryotoxic and induce changes in sperm morphology.

B. **Chloroform** has been listed by one reviewer as possibly teratogenic in humans (Hoffman et al, 1983), but the basis for this classification is not clear.

0.2.21 CARCINOGENICITY

0.2.21.1 IARC CATEGORY

A. IARC (**chloroform**) (RTECS, 1999)
1. Animals: Sufficient Evidence (1979)
2. Human: Limited Evidence (1979)
3. Group 2B

0.2.21.2 HUMAN OVERVIEW

A. **Chloroform** is listed as a suspected carcinogen.
B. At the time of this review, no human occupational studies were found in which **chloroform** exposure, specifically, was associated with development of cancer.

0.2.21.3 ANIMAL OVERVIEW

A. **Chloroform** is listed as a confirmed animal carcinogen with unknown relevance to humans (ACGIH, 2000).

0.2.22 GENOTOXICITY

A. **Chloroform** may be mutagenic and induce DNA damage, DNA repair, and sister chromatid exchanges.
B. **Chloroform** did not induce unscheduled DNA synthesis in vitro or in vivo in mice (Larson et al, 1994).

0.2.23 OTHER

0.2.23.2 CHRONIC EXPOSURE

A. A high incidence of splenomegaly was reported in chronically-exposed workers.

Laboratory:

A. Urinalysis, liver and renal function tests, chest x-ray, ECG and cardiac monitoring may be useful following exposure to **chloroform**.
B. **Chloroform** is radiopaque and an abdominal radiograph should be obtained if the exposure was oral in order to determine efficacy of decontamination procedures.
C. Gas chromatography with flame-ionization may be used to measure **chloroform** in tissue. Head space gas liquid chromatography and purge-and-trap gas chromatography may be used for environmental monitoring.

Treatment Overview:

0.4.2 ORAL EXPOSURE

A. EMESIS - Since the patient may rapidly become obtunded, ipecac-induced emesis is not recommended.
B. GASTRIC LAVAGE: Consider after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation. Control any seizures first.
1. CONTRAINDICATIONS: Loss of airway protective reflexes or decreased level of consciousness in unintubated patients; following ingestion of corrosives; hydrocarbons (high aspiration potential); patients at risk of hemorrhage or gastrointestinal perforation; and trivial or non-toxic ingestion.
C. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.
D. VENTRICULAR DYSRHYTHMIAS/SUMMARY: Institute continuous cardiac monitoring, obtain an ECG, and administer

oxygen. Evaluate for hypoxia, acidosis, and electrolyte disorders. Lidocaine and amiodarone are generally first line agents for stable monomorphic ventricular tachycardia, particularly in patients with underlying impaired cardiac function. Sotalol is an alternative. Amiodarone and sotalol should be used with caution if a substance that prolongs the QT interval and/or causes torsades de pointes is involved in the overdose. Unstable rhythms require cardioversion.

0.4.3 INHALATION EXPOSURE

A. INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids.

B. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.

C. Treatment is symptomatic and supportive; there is no specific antidote. In substantial exposure, patients should be admitted and observed for several days for possible delayed toxicity. Monitor liver and kidney function. Monitor fluid and electrolyte status.

0.4.4 EYE EXPOSURE

A. DECONTAMINATION: Irrigate exposed eyes with copious amounts of room temperature water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility.

B. Treatment is symptomatic and supportive; there is no specific antidote. In substantial exposure, patients should be admitted and observed for several days for possible delayed toxicity. Monitor liver and kidney function. Monitor fluid and electrolyte status.

0.4.5 DERMAL EXPOSURE

A. DECONTAMINATION: Remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician may need to examine the area if irritation or pain persists.

B. Treatment is symptomatic and supportive; there is no specific antidote. In substantial exposure, patients should be admitted and observed for several days for possible delayed toxicity. Monitor liver and kidney function. Monitor fluid and electrolyte status.

C. **Chloroform** may be absorbed through the skin. Observe patient for delayed toxicity.

Range of Toxicity:

A. As little as 10 mL in an acute ingestion may result in central nervous system depression and death.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

IF INHALATION OCCURS, EPINEPHRINE OR OTHER SYMPATHOMIMETIC AMINES & ADRENERGIC ACTIVATORS SHOULD NOT BE ADMIN SINCE THEY WILL FURTHER SENSITIZE HEART TO DEVELOPMENT OF ARRHYTHMIAS. /FLUOROCARBONS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3101]**PEER REVIEWED**

Basic treatment: Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Monitor for pulmonary edema and treat if necessary ... . Monitor for shock and treat if necessary ... . Anticipate seizures and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport ... . Do not use emetics. For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal ... . Cover skin burns with sterile dressings after decontamination ... . /Halogenated aliphatic hydrocarbons and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 188]**PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the unconscious patient. Positive pre s sure ventilation techniques with a bag valve mask device may be beneficial. Monitor cardiac rhythm and treat arrhythmias as necessary ... . Start an IV with D5W /SRP: "To keep open", minimal flow rate/. Use lactated Ringer's if signs of hypovolemia are present. Consider drug therapy for pulmonary edema ... . For hypotension with signs of hypovolemia, administer fluid cautiously. Consider vasopressors if hypotensive with a normal fluid volume. Watch for signs of cardiac irritability and fluid overload ... . Treat seizures with diazepam (Valium) ... . Use proparacaine hydrochloride to assist eye irrigation ... . /Halogenated aliphatic hydrocarbons and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 188]**PEER REVIEWED**

Animal Toxicity Studies:

Toxicity Summary:

... The general population is exposed to **chloroform** principally in food, drinking-water and indoor air in approximately equivalent amounts. The estimated intake from outdoor air is considerably less. ... Water use in homes contributes considerably to levels of **chloroform** in indoor air and to total exposure. ... **Chloroform** is well absorbed in animals and humans after oral administrations but the absorption kinetics are dependent upon the vehicle of delivery. ... The primary factors affecting the absorption kinetics of **chloroform** following inhalation are its concentration and species-specific metabolic capacities. It is readily absorbed through the skin of humans and animals and significant dermal absorption of **chloroform** from water while showering has been demonstrated. Hydration of the skin appears to accelerate absorption of **chloroform**. **Chloroform** distributes throughout the whole body. Highest tissue levels are reached in the fat, blood, liver, kidneys, lungs and nervous system. Distribution is dependent on exposure route; extrahepatic tissues receive a higher dose from inhaled or dermally absorbed **chloroform** than from ingested **chloroform**. Placental transfer of **chloroform** has been demonstrated in several animal species and humans. **Chloroform** is eliminated primarily as exhaled carbon dioxide. Unmetabolized **chloroform** is retained longer in fat than in any other tissues. The oxidative biotransformation of **chloroform** is catalyzed by cytochrome P-450 to produce trichloromethanol. Loss of HCl from trichloromethanol produces phosgene as a reactive intermediate. ... The reaction of phosgene with tissue proteins is associated with cell damage and death. ... The liver is

the target organ for acute toxicity in rats and several strains of mice. Liver damage is characterized by early fatty infiltration and balloon cells, progressing to centrilobular necrosis and then massive necrosis. The kidney is the target organ in male mice of other more sensitive strains. The kidney damage starts with hydropic degeneration and progresses to necrosis of the proximal tubules. ... In mice the oral LD50 values range from 36 to 1366 mg **chloroform**/kg body weight, whereas for rats, they range from 450 to 2000 mg **chloroform**/kg body weight. ... The carcinogenic effects of **chloroform** on the liver and kidney of rodents appear to be closely related to cytotoxic and cell replicative effects observed in the target organs. ... The weight of the available evidence indicates that **chloroform** has little, if any, capability to induce gene mutation or other types of direct damage to DNA. ... There are some limited data to suggest that **chloroform** is toxic to the fetus but only at doses that are maternally toxic. ... In humans, anesthesia may result in death due to respiratory and cardiac arrhythmias and failure. Renal tubular necrosis and renal dysfunction have also been observed in humans. ... The mean lethal oral dose for an adult is estimated to be about 45 g, but large interindividual differences in susceptibility occur. There is some weight of evidence for an association between exposure to disinfection byproducts in drinking water and colorectal and bladder cancer in some epidemiological studies. ... The evidence for the carcinogenicity of chlorinated drinking water in humans is inadequate. In addition, the disinfection byproducts cannot be attributed to **chloroform** per se. ... However, it is cautioned that where local circumstances require that a choice must be made between meeting microbiological limits or limits for disinfection byproducts such as **chloroform**, the microbiological quality must always take precedence. ... Levels of **chloroform** in surface waters are generally low and would not be expected to present a hazard to aquatic organisms. However, higher levels of **chloroform** in surface water resulting from industrial discharges or spills may be hazardous to the embryo-larval stages of some aquatic species.
[Environmental Health Criteria 163: Chloroform. pp. 13-18 (1994) by the International Programme on Chemical Safety (IPCS) under the joint sponsorship of the United Nations Environment Programme, the International Labour Organisation and the World Health Organization.]**QC REVIEWED**

Evidence for Carcinogenicity:

CLASSIFICATION: B2; probable human carcinogen. BASIS FOR CLASSIFICATION: Based on increased incidence of several tumor types in rats and three strains of mice. HUMAN CARCINOGENICITY DATA: Inadequate. ANIMAL CARCINOGENICITY DATA: Sufficient.
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Chloroform (67-66-3) Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000]**PEER REVIEWED**

Evaluation: There is inadequate evidence in humans for the carcinogenicity of **chloroform**. There is sufficient evidence in experimental animals for the carcinogenicity of **chloroform**. Overall evaluation: **Chloroform** is possibly carcinogenic to humans (Group 2B).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 73 170 (1999)]**QC REVIEWED**

A3. Confirmed animal carcinogen with unknown relevance to humans.
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 25]**QC REVIEWED**

Non-Human Toxicity Excerpts:

MICE EXPOSED TO 8,000 PPM OF **CHLOROFORM** DIED AFTER 3 HR OF EXPOSURE, RABBITS DIED AFTER A 2-HR EXPOSURE TO 12,500 PPM ... DOGS SURVIVED MUCH HIGHER CONCN. ACUTE **CHLOROFORM** EXPOSURE MAY RESULT IN DEATH BY RESP

ARREST. PRIMARY TOXIC RESPONSE AT LOWER LEVELS OF EXPOSURE IS HEPATOTOXICITY LEADING TO FATTY LIVER & CENTRILOBULAR NECROSIS.
[Doull, J., C.D. Klaassen, and M. D. Amdur (eds.). Casarett and Doull's Toxicology. 2nd ed. New York: Macmillan Publishing Co., 1980. 471]**PEER REVIEWED**

... 40% INHIBITION OF MICROSOMAL DRUG-METABOLIZING ENZYME ACTIVITY IN RATS FED 1.05 ML/KG OF **CHLOROFORM** 24 HR PRIOR TO SACRIFICE /IS REPORTED/. THIS MAY BE RELATED TO DEGREE OF HEPATIC NECROSIS PRODUCED BY **CHLOROFORM** OR TO MORE SUBTLE EFFECT ON MICROSOMAL ENZYME SYSTEM.
[Doull, J., C.D. Klaassen, and M. D. Amdur (eds.). Casarett and Doull's Toxicology. 2nd ed. New York: Macmillan Publishing Co., 1980. 471]**PEER REVIEWED**

GROUPS OF 5 STRAIN A MICE OF EACH SEX, 3 MO OLD AT THE BEGINING OF THE EXPERIMENT WERE GIVEN 30 ORAL DOSES OF 0.1, 0.2, 0.4, 0.8 OR 1.6 ML/KG (0.15-2.4 G/KG BODY WT) **CHLOROFORM** IN OLIVE OIL AT 4-DAY INTERVALS. SURVIVORS WERE KILLED 1 MO AFTER LAST TREATMENT. ALL FEMALES AT THE 3 HIGHEST DOSES AND ALL MALES AT THE 3 HIGHEST DOSES DIED EARLY IN THE EXPERIMENT. NONMETASTASIZING HEPATOMAS & CIRRHOSIS WERE FOUND IN ALL SURVIVING FEMALES GIVEN 0.8 OR 0.4 ML/KG BODY WEIGHT PER DOSE. NO HEPATOMAS WERE OBSERVED IN THOSE AT THE TWO LOWEST DOSE LEVELS OR IN THE CONTROLS.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 408 (1979)]**PEER REVIEWED**

GROUPS OF 50 MALE & 50 FEMALE B6C3F1 MICE, 5 WK OF AGE, RECEIVED 2-5% SOLN OF **CHLOROFORM** (USP GRADE) IN CORN OIL BY GAVAGE 5 TIMES/WK FOR 78 WK. THE INITIAL DOSE LEVELS FOR MALES WERE 100 AND 200 MG/KG BODY WT, AND THOSE FOR FEMALES 200 AND 400 MG/KG BODY WT. THESE DOSES WERE INCREASED AFTER 18 WEEKS TO 150 AND 300 MG/KG BODY WT FOR MALES AND 250 AND 500 MG/KG BODY WT FOR FEMALES, SO THAT THE AVERAGE LEVELS WERE 138 AND 277 MG/KG BODY WT FOR MALES AND 238 AND 477 MG/KG BODY WT FOR FEMALES. POOLED CONTROL GROUPS, CONSISTING OF 77 MALE AND 80 FEMALE MICE, AND MATCHED CONTROL GROUPS, CONSISTING OF 20 MALES AND 20 FEMALES, WERE TREATED WITH CORN OIL ONLY. THE EXPERIMENT WAS TERMINATED AT 92-93 WEEKS. THE INCIDENCE OF HEPATOCELLULAR CARCINOMAS IN ALL TREATED GROUPS OF MICE WAS STATISTICALLY SIGNIFICANT ($P < 0.0001$) WHEN COMPARED WITH THAT IN CONTROLS.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 411 (1979)]**PEER REVIEWED**

GROUPS OF 50 MALE & 50 FEMALE OSBORNE-MENDEL RATS, 52 DAYS OLD, RECEIVED A 10% SOLUTION OF **CHLOROFORM** (USP GRADE) IN CORN OIL BY GAVAGE 5 TIMES WEEKLY. MALES WERE GIVEN DOSES OF 90 AND 180 MG/KG BODY WT FOR 78 WEEKS; FEMALE RATS STARTED ON DOSE LEVELS OF 125 AND 250 MG/KG BODY WT, BUT THESE WERE LOWERED TO 90 AND 180 MG/KG BODY WT AFTER 22 WEEKS, GIVING AN AVERAGE LEVEL OF 100 AND 200 MG/KG BODY WT FOR THE STUDY. POOLED CONTROL GROUPS OF 100 MALES AND 100 FEMALES AND MATCHED CONTROL GROUPS OF 20 MALES AND 20 FEMALES WERE TREATED WITH THE VEHICLE ONLY. THE EXPERIMENT WAS TERMINATED AT 111 WEEKS. THE INCIDENCE OF KIDNEY EPITHELIAL TUMOURS IN MALE RATS WAS STATISTICALLY GREATER ($P= 0.0016$) THAN THAT IN CONTROLS.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 411 (1979)]**PEER REVIEWED**

RATS WERE EXPOSED TO SUBANESTHETIC DOSES OF **CHLOROFORM**: 150, 500 & 1500 MG/CU M (30, 100 & 300 PPM), IN AIR BY INHALATION FOR 7 HR/DAY ON DAYS 6-15 OF GESTATION. 100 PPM DOSE CAUSED LOW INCIDENCE OF ACAUDATE FETUSES WITH IMPERFORATED ANUSES. ALL DOSES OF **CHLOROFORM** WERE FETOTOXIC & RETARDED DEVELOPMENT.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 414 (1979)]**PEER REVIEWED**

CLINICAL SIGNS OBSERVED IN RATS FOLLOWING SINGLE ORAL DOSES OF **CHLOROFORM** WERE SEDATION, FLACCID MUSCLE TONE, ATAXIA, PILOERECTION, & PROSTRATION. MALES WERE MORE SUSCEPTIBLE THAN FEMALES.
[CHU I ET AL; TOXICOL APPL PHARMACOL 52 (2): 351-3 (1980)]**PEER REVIEWED**

MALE & FEMALE MICE WERE GAVAGED WITH VEHICLE OR **CHLOROFORM** 31.1 MG/KG/DAY FOR 21 DAYS PRIOR TO MATING, THROUGHOUT MATING & DAMS THROUGHOUT GESTATION & LACTATION. PUPS GAVAGED WITH SAME DOSE DAILY BEGINNING ON DAY 7. NO DIFFERENCES IN CONTROL & TREATED MICE.
[BURKHALTER JE ET AL; NEUROBEHAV TOXICOL 1 (3): 199-205 (1979)]**PEER REVIEWED**

CELLS OF SACCHAROMYCES CEREVISIAE, HARVESTED FROM LOG-PHASE CULTURES, CONTAIN CYTOCHROME P450 & ARE CAPABLE OF METAB PROMUTAGENS TO GENETICALLY ACTIVE PRODUCTS. THE ACTIVITIES OF 7 HALOGENATED ALIPHATIC HYDROCARBONS IN THE YEAST SYSTEM WERE INVESTIGATED. **CHLOROFORM** INDUCED MITOTIC GENE CONVERTANTS & RECOMBINANTS &, TO A LESSER EXTENT, GENE REVERTANTS WHEN INCUBATED WITH LOG-PHASE CELLS OF YEAST STRAIN D7. **CHLOROFORM** CONCN USED RANGED FROM 21 TO 54 MM.
[CALLEN DF ET AL; MUTAT RES 77 (1): 55-63 (1980)]**PEER REVIEWED**

THE TOXIC EFFECTS OF A SINGLE ORAL DOSE OF **CHLOROFORM** WERE EVALUATED IN C57BL, DBA, AND F1 MALE MICE. SOLN OF **CHLOROFORM** IN PEANUT OIL (FINAL VOL= 0.1 ML/10 G BODY WT) WERE ADMIN ONCE BY GAVAGE TO 9-WK-OLD MICE. DBA/2J MALE MICE ARE MORE SENSITIVE TO THE 10-DAY LETHAL EFFECT OF **CHLOROFORM** THAN ARE C57BL/6J MALES, WHEREAS B6D2F1/J ARE INTERMEDIATE. THIS RELATIVE ORDER OF SENSITIVITY IS PRESERVED FOLLOWING SUBLETHAL DOSES IN REGARD TO RADIOLABEL ACCUMULATION INTO SUBCELLULAR BIOCHEMICAL FRACTIONS AND RENAL, BUT NOT HEPATIC, DYSFUNCTION. KIDNEYS FROM MICE OF ALL THREE GENOTYPES ARE ABLE TO REPAIR TUBULAR DAMAGE FROM **CHLOROFORM**.
[CLEMENS TL ET AL; TOXICOL APPL PHARMACOL 48 (1 PART 1): 117-30 (1979)]**PEER REVIEWED**

CHLOROFORM WAS NEGATIVE IN THE SPERM MORPHOLOGY ASSAY WHEN ADMIN TO GROUPS OF 5 (CBAXBALB/C)F1 MALE MICE IP 5 TIMES/DAY @ 5.0 ML/KG/DAY.
[TOPHAM JC; PROGRESS IN MUTATION RESEARCH 1: 718-20 (1981)]**PEER REVIEWED**

EPIDIDYMAL SPERMATOZOA OF (C57BL/C3H)F1 MICE SHOWED SIGNIFICANT INCREASES IN ABNORMALITIES AFTER /28 DAYS OF/ EXPOSURE TO **CHLOROFORM** /NEAR 0.1 MAC AND GREATER CONCN/ 4 HR/DAY FOR 5 DAYS.
[LAND PC ET AL; ANESTHESIOLOGY 54 (1): 53-6 (1981)]**PEER REVIEWED**

MICE WERE GIVEN ACCESS TO DEIONIZED WATER FOR 30 MIN DAILY. WHEN FLUID CONSUMPTION STABILIZED, THEY WERE GIVEN 30 MIN ACCESS TO 0.3% SACCHARIN

FOLLOWED BY ORAL DOSES OF 3, 10 OR 30 MG/KG **CHLOROFORM** OR VEHICLE (EMULPHOR). BEGINNING 24 HR LATER SUBJECTS WERE GIVEN 2-BOTTLE CHOICE TEST SACCHARIN VS WATER FOLLOWED BY ADMIN OF **CHLOROFORM**. 30 MG/KG PRODUCED TASTE AVERSION ON 1ST CHOICE TEST & REDUCTION OF TOTAL FLUID INTAKE. DOSES OF 3 & 10 MG/KG OR VEHICLE DID NOT AFFECT EITHER MEASURE. ALSO IT PRODUCED TASTE AVERSIONS WHEN GIVEN AT RELATIVELY LOW DOSES BY IP ROUTE.
[LANDAUER MR ET AL; NEUROBEHAV TOXICOL TERATOL 4 (3): 305-10 (1982)]**PEER REVIEWED**

NO EVIDENCE OF POTENTIAL MUTAGENICITY WAS OBSERVED WHEN TESTED IN 5 STRAINS OF SALMONELLA TYPHIMURIUM WITH & WITHOUT S-9 MICROSOMAL-ENZYME PREPN. S-9 PREPN WAS DERIVED FROM LIVERS & KIDNEYS OF RATS & MICE PREVIOUSLY EXPOSED TO AROCLOR 1254.
[VAN ABBE NJ ET AL; FOOD CHEM TOXICOL 20 (5): 557-61 (1982)]**PEER REVIEWED**

In mice, immature males, castrated adult males, and estrogen treated males were resistant to **chloroform** renal toxicity, whereas mature males and testosterone treated females were sensitive.
[Vessel ES; Fed Proc 35 (8): 1125-32 (1976)]**PEER REVIEWED**

Rabbits developed slight hyperemia with moderate necrosis and scar tissue formation following one to two, 24 hr dermal applications of **chloroform** on shaven skin.
[Torkelson TR; Amer Ind Hyg Assoc J 37 (12): 697-705 (1976)]**PEER REVIEWED**

Cultured Chinese hamster fibroblasts when exposed to 1-2.5% **chloroform** did not demonstrate mutagenic changes. However, fibroblast multiplication rate was depressed in a dose-dependent pattern.
[Sturrock JE; Anesthesiology 43 (1): 21-30 (1975)]**PEER REVIEWED**

/**Chloroform**/ did not induce sister chromatid exchanges in Chinese hamster ovary cells when tested at 0.71% vol/vol.
[White AE et al; Anesthesiology 50: 426-30 (1979)]**PEER REVIEWED**

Exposure to **chloroform** for 1-5 min caused a gradual browning of the surfaces of Phaseolus vulgaris cotyledons during subsequent incubation for 10-72 hr; this was accompanied by isoflavanoid accumulation in the cotyledons. ... The amts of phytoalexin produced increased with increasing damage, phaseollin, phaseollinisoflavan, and kievitone (< or = to 96 ug/g cotyledon). ... Cotyledons treated with **chloroform** for > 10 min became entirely flaccid and did not become pigmented or produce any of the above compounds. No isoflavanoids were detected in undamaged cotyledons. Hence, accumulation of phytoalexins may be a direct consequence of the death of superficial cells of the bean cotyledons.
[Bailey JA, Berthier M; Phytochemistry 20 (1): 187-8 (1981)]**PEER REVIEWED**

40 and 160 ppm /**chloroform**/ caused no mortality in goldfish after 4 days while at 300 ppm a 30% mortality was observed. 40 ppm caused no mortality in guppies while at 160 and 300 ppm, 30 and 50% mortality, respectively, was observed. At 160 and 300 ppm the fish acquired darker pigmentation, retarded reproduction rate and growth, and caused an equilibrium loss (especially at 300 ppm). 40 ppm caused five-fold incr in leukocytes after a six month exposure.
[Hazdra JJ et al; 9th Proc Int Symp: Adv Comp Leuk Res p.215-7 (1980)]**PEER REVIEWED**

The effects of lifetime exposure to **chloroform** ... were studied in Wistar rats. ... Treatment was initiated with weanlings at 2 ml chlorofrom per liter of water. Concentrations were halved at 72 weeks because of increasing water intake among the test animals. ... Treated rats weighed less than unexposed controls at all ages. At about 15 to 17 weeks, females had a high consumption of water and ... /**chloroform**/ than

males. The incidence of neoplastic nodules was significantly increased in females. ... /Both/ males /and females/ treated with chlorofrom had a high incidence of hepatic adenofibrosis.
[Tumasonis CF et al; Ecotoxicol Environ Safety 9 (2): 233-40 (1985)]**PEER REVIEWED**

Characteristics of **chloroform** (CHCl3) nephrotoxicity and of 2-hexanone potentiation were evaluated in adult male Fischer 344 rats pretreated with vehicle (oil, 10 ml/kg, po) or 2-hexanone (10 mmol/kg, po) 18 hr prior to **chloroform** exposure. ... Little metabolism of (14)C-**chloroform** by renal cortical microsomes from vehicle or 2-hexanone pretreated rats was detected. However, **chloroform** produced a concn-related dysfunction when added to renal cortical slices from Fischer 344 or Sprague-Dawley rats. The degree of **chloroform** toxicity in vitro was not altered when renal cortical slices were preincubated with **chloroform** (8.5 microliter) under an atmosphere of carbon monoxide. In renal cortical slices, deuterated-**chloroform** was less toxic than **chloroform**. Although 2-hexanone pretreatment increased renal slice metabolism of (14)C-**chloroform** twofold, this incr was not associated with an incr in nephrotoxicity after direct exposure of slices to **chloroform** (0 to 10 microliter) in vitro. **Chloroform** (0.5 ml/kg, ip) did not alter renal cortical glutathione concn in vehicle or 2-hexanone pretreated rats. The association of (14)C-**chloroform**-derived radiolabel was incr over control by 2-hexanone pretreatment in protein, lipid, and acid soluble fractions from the renal cortex by approx two-, two-, and five-fold, respectively. In conclusion, renal cytochrome p450 did not appear to mediate **chloroform** metabolism and nephrotoxicity in the rat to the extent observed previously in mice. 2-Hexanone appeared to potentiate nephrotoxicity by a mechanism different than that observed in rat liver.
[Smith JH et al; Toxicol Appl Pharmacol 79 (1): 166-74 (1985)]**PEER REVIEWED**

The genetic damage caused by ... **chloroform** ... was studied in rodents (Rattus norvegicus and Mus musculus). ... Aneuploidy, stages of fuzziness, despiralization and stickiness of the chromosomes were observed. Some metaphases with gaps, breaks and translocations, were also encountered.
[Sharma GP, Anand RK; Proc Natl Acad Sci India Sect B (Biol Sci) 54 (1): 61-7 (1984)]**PEER REVIEWED**

The carcinogenic activity of **chloroform** administered at 0, 200, 400, 900, and 1800 mg/l in drinking water was studied in male Osborne-Mendel rats and female B6C3F1 mice. A second control group was included in the study and was restricted to the water consumption of the high-dose group. Animals were maintained on study for 104 weeks. ... **Chloroform** increased the yield of renal tubular adenomas and adenocarcinomas in male rats in a dose-related manner. For the high-dose group, which corresponded to a time-weighted average dose of 160 mg/kg per day for 104 weeks, there was a 14% incidence of renal tubular adenomas and adenocarcinomas, vs 1% in the control group. This compares to a 24% incidence observed when 180 mg/kg per day of **chloroform** was administered for 78 weeks in earlier studies. In contrast, **chloroform** in the drinking water of mice failed to increase the incidence of hepatocellular carcinomas in female B6C3F1 mice. The highest dose group received a time-weighted average dose of 263 mg/kg per day for 104 weeks, resulting in a 5% combined incidence of hepatocellular adenomas and carcinomas relative to a 6% incidence in the control groups. In a prior National Cancer Institute study an 80% incidence of hepatocellular carcinomas was observed at 270 mg/kg per day for 78 weeks. **Chloroform** administered in drinking water evidently is capable of inducing cancer in the rat kidney. However, the lack of response in the mouse liver when **chloroform** is supplied in the drinking water suggests that earlier reports of **chloroform** hepatocarcinogenesis may be related to some interaction with the mode of administration (corn oil gavage).
[Jorgenson TA et al; Fundam Appl Toxicol 5 (4): 760-9 (1985)]**PEER REVIEWED**

The acute toxicity of **chloroform** in experimental animals is species-, strain-, sex- and age-dependent.
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 2-1]**PEER REVIEWED**

Pregnant C57B1 mice were administered **chloroform**, (14)C-**chloroform**, by inhalation on days 11, 14, and 17 of gestation. In another experiment, six 4-day-old mice received an ip dose of 2 uCi of (14)C-**chloroform** dissolved in maize oil. The pregnant mice and the exposed newborns were killed for autoradiography studies. A high uptake of (14)C-**chloroform** was noted in the pregnant mice after inhalation, especially in the respiratory epithelium, liver, fat, lung, brain, and renal cortex. Metabolites of **chloroform** accumulated in the amniotic fluid. In the newborn mice, a notable accumulation of **chloroform** was noted in the respiratory epithelium, oral/esophageal mucosa, liver, salivary glands, and the conjunctiva of the eye.
[Danielson BRG et al; Biol Res Pregnancy Perinatol 7: 77-83 (1986)]**PEER REVIEWED**

... Male and female B6C3F1 mice were administered **chloroform** at 60, 130, and 270 mg/kg per day for 90 days. At sacrifice, body and organ weights were measured, and blood was recovered to perform the following serum chemistry measurements (in order of priority): glutamate oxalacetate transaminase, lactate dehydrogenase, blood urea nitrogen and triglyceride levels. The liver was sectioned for histopathological examination. **Chloroform** increased glutamate oxalacetate transaminase levels significantly only when administered in corn oil at a dose of 270 mg/kg in both male and female mice. It had no effect on lactate dehydrogenase (LDH) activity. There was a small increase in BUN when **chloroform** was administered in corn oil, but not when adminsitered in 2% Emulphor. When administered in corn oil, **chloroform** significantly decreased serum triglyceride levels but was without effect on this parameter when administered in 2% Emulphor. **Chloroform** decreased body weight and increased liver weight with both vehicles, but the effects were significantly greater when it was administered in corn oil.
[Bull RJ et al; Environ Health Perspect 69: 49-58 (1986)]**PEER REVIEWED**

In C57 male black mice, renal tubular necrosis was produced by ip admin of 300 mg of **chloroform**/kg; an ip injection of 445 mg/kg caused necrosis in the liver and the kidneys.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.289]**PEER REVIEWED**

NCI strain A mice, receiving **chloroform** repeatedly (30 doses by stomach tube at 4-day intervals) developed hepatomas. ... Hepatomas and cirrhosis of the liver were induced only if the dosage was large enough to produce necrosis of the liver (individual doses greater than 300 mg/kg).
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.289]**PEER REVIEWED**

... Negative results of /**chloroform**/ carcinogenicity were obtained in beagle dogs after 7.5 yr, in Sprague-Dawley rats, and in 3 of 4 strains of mice. In the fourth strain (ICI Swiss), renal tumors occurred only in males at the 60 mg/kg/day dose, but not at the 17 mg dose. In the male mouse CBA strain, survival was better than in controls, and fewer liver tumors were seen in the treated than the control mice. The lack of toxicity was attributed to the small doses used in these studies (15 and 30 mg/kg/day, dogs; 60 mg/kg/day in mice and rats). The hepatocellular degeneration and necrosis and the abdominal distention ... were induced by several times higher dosage.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.289]**PEER REVIEWED**

... The hepatotoxic effect of **chloroform** is 20 times greater than the hepatotoxic effect of trichloroethylene and 10 times greater than that of tetrachloroethylene.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.289]**PEER REVIEWED**

Two studies in rats exposed repeatedly to **chloroform** /conclude that/ ... 25-30 ppm, 7 hr/day, 5 days/wk for 6 mo does not produce organ injury; liver and kidney injury start to appear at 50 ppm exposure; and the severity of the injury is concentration dependent. Data ... also indicates that rats are more sensitive to **chloroform** than other species (mice, rabbits, guinea pigs, dogs).
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.289]**PEER REVIEWED**

Chloroform 0.1 to 0.5% was an effective bactericide against small inocula of Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa; against large inocula **chloroform** 0.1% was effective against Pseudomonas aeruginosa, but higher concn were needed against the other organisms. Spores of Bacillus pumilus were not killed.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 745]**PEER REVIEWED**

... Abnormal mitosis has occurred in /plant/ cells exposed to **chloroform** concn of 0.025%. Toxic effects also occur at this level. Concn greater than 0.25% have been shown to be lethal.
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 2-2]**PEER REVIEWED**

... Rabbits, rats, guinea pigs, and dogs /were exposed/ to 25, 50, or 85 ppm **chloroform**, 7 hr/day, 5 days/wk for six months. Histopathological evaluation of animals indicated centrilobular necrosis and cloudy swelling of the kidneys. The effects of the 25 ppm dose were characterized as mild and reversible.
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 748]**PEER REVIEWED**

ANESTHESIA WITH DEUTERATED **CHLOROFORM** AT 0.36% PRODUCED A 35% DECR IN SERUM GLUTAMIC PYRUVIC TRANSAMINASE IN RATS. THUS, DEUTERATION OF VOLATILE ANESTHETICS CHANGES THEIR METABOLISM, IN MOST CASES PRODUCING DECR IN METABOLISM. THIS MAY LESSEN ORGAN TOXICITY.
[MCCARTY LP ET AL; ANESTHESIOLOGY 51 (2): 106-10 (1979)]**PEER REVIEWED**

... Rats pretreated with phenobarbital, but not untreated rats, will produce conjugated dienes during **chloroform** anesthesia; depression of glucose-6-phosphatase activity also occurs after **chloroform** only in phenobarbital-pretreated rats. ... Since **chloroform**-induced liver injury is more severe in phenobarbital-pretreated rats, the possibility exists that the initial lesion induced by **chloroform** in these animals is only aggravated by the appearance of lipid peroxidation. These findings cast doubt on the general applicability of lipid peroxidation as a mechanism for necrogenic haloalkanes.
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 296]**PEER REVIEWED**

STUDIES WERE DONE USING MALE B6C3F1 MICE TO INVESTIGATE POTENTIAL OF **CHLOROFORM** TO INDUCE GENETIC DAMAGE &/OR ORGAN TOXICITY AT SITES WHERE TUMORS HAVE BEEN OBSERVED IN VARIOUS BIOASSAYS. THEY REVEALED THAT CARCINOGENIC DOSES PRODUCED SEVERE NECROSIS AT SITES WHERE TUMORS DEVELOPED. NONCARCINOGENIC DOSES FAILED TO INDUCE THIS RESPONSE. STUDIES OF DNA ALKYLATION & DNA REPAIR IN VIVO FAILED TO GIVE ANY INDICATION THAT IT HAD PRODUCED GENETIC ALTERATIONS ASSOC WITH KNOWN GENOTOXIC CHEMICALS. DATA SUGGEST THAT PRIMARY MECHANISM OF **CHLOROFORM**-INDUCED CARCINOGENESIS IS NONGENETIC.

[REITZ RH ET AL; ENVIRON HEALTH PERSPECT 46: 163-8 (1982)]**PEER REVIEWED**

RELATIONSHIP BETWEEN ACUTE TOXICITY FROM ORAL ADMIN & LONG-TERM TUMORIGENIC POTENTIAL WAS STUDIED IN MALE CFLP OUTBRED SWISS ALBINO MOUSE STRAIN. SINGLE DOSE OF **CHLOROFORM**, APPROX 18 MG/KG HAD NO DETECTABLE ACUTE TOXIC EFFECT ON LIVER OR KIDNEYS & DID NOT STIMULATE REGENERATIVE ACTIVITY. TOXICITY & TISSUE REGENERATION WERE OBSERVED WITH SINGLE 60 MG/KG OR HIGHER DOSE. IN EARLIER LONG-TERM STUDIES IN MICE OF SAME STRAIN, KIDNEY TUMORS OCCURRED IN MALES GIVEN 60 MG/KG/DAY THROUGHOUT LIFE BUT NOT IN MICE GIVEN 17 MG/KG/DAY. FINDINGS ARE CONSISTENT WITH HYPOTHESIS THAT EARLY ACUTE TOXIC CHANGE & SUBSEQUENT REPAIR ARE ESSENTIAL FOR TUMORIGENESIS IN KIDNEY & LIVER.
[MOORE DH ET AL; FOOD CHEM TOXICOL 20 (6): 951-4 (1982)]**PEER REVIEWED**

CHLOROFORM INDUCED DOSE-DEPENDENT INCR OF HEPATIC ORNITHINE DECARBOXYLASE AT 100 MG/KG BODY WT IN FISCHER 344 RATS. FEMALES WERE 2 TO 4 TIMES MORE SUSCEPTIBLE THAN MALES. NUCLEAR RNA POLYMERASE I ACTIVITY WAS ALSO INDUCED. IT REDUCED RENAL ORNITHINE DECARBOXYLASE BY 35% RATHER THAN INCREASING IT. INDUCTION OF HEPATIC ORNITHINE DECARBOXYLASE ACTIVITY MIGHT BE ASSOC WITH REGENERATIVE HYPERPLASIA.
[SAVAGE RE JR ET AL; ENVIRON HEALTH PERSPECT 46: 157-62 (1982)]**PEER REVIEWED**

RATS WERE DOSED 1, 5, OR 10 TIMES WITH **CHLOROFORM** (0.5 TO 50 MG/KG) AND THE LIVER ENZYME ACTIVITIES DETERMINED. **CHLOROFORM** INDUCED CHANGES IN THE 24 ENZYMES INVESTIGATED BUT CAUSED ONLY MINIMAL LIVER ENLARGEMENT. THE MAIN ENZYMATIC CHANGES WERE: STIMULATION OF GLYCOLYSIS & OXIDATIVE PHOSPHORYLATION, INCR BREAKDOWN OF PROTEIN & NUCLEIC ACIDS, REDUCED HEXOSE PHOSPHATE SHUNT ACTIVITY LEADING TO A SHORTAGE OF NADPH IN THE CELL, AND STIMULATION OF ADRENAL MEDULLARY & CORTICAL SECRETION. SOME OF THE CHANGES ARE SIMILAR TO THOSE SEEN WITH LARGER AND ANESTHETIC DOSES.
[GROGER WK ET AL; TOXICOLOGY 14 (1): 23-38 (1979)]**PEER REVIEWED**

Hepatocytes isolated from male Sprague-Dawley rats (Harlan, 200-275 g) were exposed to halogenated hydrocarbons including **chloroform**. Cell suspensions contained 2-3X10+6 cells/ml and were viable for 6 hr as indicated by a < 10% increment in the fractional release of aspartate aminotransferase (AST) activity. The addition of **chloroform** (20 mM) caused a rapid release of AST into the incubation medium. The release peaked within 20 min and approximately 20% (n= 4) of the total activity was found in the medium. Only 3% of the activity was in the medium of control cells. Untreated cells or cells treated with vehicle did not exhibit an increase of AST release with time. The amount of AST release was concentration dependent (tested at 10 and 20 mM) and related to the oil/water partition coefficient. Cellular oxygen consumption was reduced by approximately 50% (n= 8) by 20 mM **chloroform**, and the reduction was dose dependent. The effects of cellular respiration were completely reversible within one hr. A dose-related decrease of DNP stimulated oxygen consumption was observed when **chloroform** was present. Succinate-stimulated oxygen consumption was not abolished by up to 10 mM **chloroform**.
[Berger ML, Sozeri T; Toxicology 45 (3): 319-30 (1987)]**PEER REVIEWED**

... **Chloroform** was administered to rats and mice by inhalation. High doses (300 ppm/6 hr/day for 7 days) caused significant hepatotoxicity and mild renal toxicity. Both hepatotoxicity and renal toxicity were observed in rats. The rats developed a series of nasal lesions involving degeneration of Bowman's glands and osseous hyperplasia.
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 749]**PEER

REVIEWED**

The primary cellular target /of **chloroform**/ is the proximal tubule with no primary damage to the glomerulus or the distal tubule. Proteinuria, glucosuria, and increased blood urea nitrogen levels are all characteristic of **chloroform**-induced nephrotoxicity.
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 432]**PEER REVIEWED**

... Castration of male mice decreased renal cytochrome p450 and **chloroform**-induced nephrotoxicity. Likewise, testosterone pretreatment of female mice increased cytochrome p450 content and rendered female mice susceptible to the nephrotoxic effects of **chloroform**.
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 432]**PEER REVIEWED**

... **Chloroform** ... /administered ip/ produced moderate increases in mouse striatal p-tyramine. /Dose not specified/
[Juorio AV, Yu PH; Biochem Pharmacol 34 (9): 1381-8 (1985)]**PEER REVIEWED**

National Toxicology Program Studies:

The effect of **chloroform** on fertility & reproduction in Swiss CD-l mice was evaluated by use of a Continuous Breeding protocol. **Chloroform** was admin via gavage using corn oil as the vehicle. Based on a 14-day, dose-finding study, 8, 20, & 50 mg/kg bw were chosen to test its effect on fertility & reproduction. Based on the reference analyses of representative aliquots of dosing soln, it was estimated that the actual doses received were 6.6, 16, & 41 mg/kg bw in the low, mid & high dose groups, respectively. Both male & female mice (20 pairs/treatment group, 40 pairs for control animals) were dosed daily for 7 days prior to & during a 98-day cohabitation period. The F1 generation from the control & high dose groups was also evaluated. At the high dose, **chloroform** treatment had no apparent effect on fertility or reproduction in either parental (F0) or F1 generation. F1 generation males in the high dose group showed significantly increased epididymal weights & degeneration of epididymal ductal epithelium. However, epididymal sperm motility, sperm count & sperm morphology were not affected. F1 females in the high dose group showed increased liver weight & there were signs of hepatocellular degeneration. It is concluded that **chloroform** is not a selective reproductive toxicant in Swiss CD-1 mice.
[Department of Health & Human Services/National Institute of Environmental Health Sciences, National Toxicology Program; Chloroform (CAS No. 67-66-3): Reproduction and Fertility Assessment in CD-1 Mice When Administered by Gavage, NTP Study No. RACB87045 (December 1988) available at http://ntp-server.niehs.nih.gov/htdocs/pub-RT0.html as of August 14, 2002]**QC REVIEWED**

Non-Human Toxicity Values:

LD50 Rat intragastric 2000 mg/kg
[Torkelson TR et al; Am Ind Hyg Assoc J 37: 697 (1976)]**PEER REVIEWED**

LD50 White rat oral 2180 mg/kg
[Larson, L.L., Kenaga, E.E., Morgan, R.W. Commercial and Experimental Organic Insecticides. 1985 Revision. College Park, MD: Entomological Society of America, 1985. 25]**PEER REVIEWED**

LD50 Rabbit oral 9827 mg/kg
[Larson, L.L., Kenaga, E.E., Morgan, R.W. Commercial and Experimental Organic

Insecticides. 1985 Revision. College Park, MD: Entomological Society of America, 1985. 25]**PEER REVIEWED**

LD50 Dog oral 2250 mg/kg
[Larson, L.L., Kenaga, E.E., Morgan, R.W. Commercial and Experimental Organic Insecticides. 1985 Revision. College Park, MD: Entomological Society of America, 1985. 25]**PEER REVIEWED**

LD50 RAT MALE ORAL 908 MG/KG
[CHU I ET AL; TOXICOL APPL PHARMACOL 52 (2): 351-3 (1980)]**PEER REVIEWED**

LD50 RAT FEMALE ORAL 1117 MG/KG
[CHU I ET AL; TOXICOL APPL PHARMACOL 52 (2): 351-3 (1980)]**PEER REVIEWED**

LC50 Rat ihl 47,702 mg/cu m/4 hr
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 775]**PEER REVIEWED**

LD50 Mouse oral 36 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 775]**PEER REVIEWED**

LD50 Mouse ip 623 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 775]**PEER REVIEWED**

LD50 Mouse sc 704 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 775]**PEER REVIEWED**

LD50 Dog ip 1000 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 775]**PEER REVIEWED**

Ecotoxicity Values:

LC50 Salmo gairdneri (rainbow trout) 2030 ug/l soft water, 1240 ug/l hard water (40% teratogenesis), 27 day flow-through tests (20 min after fertilization to 8 days after hatching)
[USEPA; Ambient Water Quality Criteria Document: Chloroform p.B-2 (1980) USEPA 440/5-80-033]**PEER REVIEWED**

LC50 Penaeus duorarum (pink shrimp) 81,500 ug/l/96 hr static test
[USEPA; Ambient Water Quality Criteria Document: Chloroform p.B-3 (1980) USEPA 440/5-80-033]**PEER REVIEWED**

LC50 Salmo gairdneri (rainbow trout) 43,800 ug/l/96 hr static test
[USEPA; Ambient Water Quality Criteria Doc: Chloroform p.B-4 (1980) EPA 440/5-80-033]**PEER REVIEWED**

LC50 Lepomis macrochirus (bluegill) 100,000 ug/l/96 hr static test
[USEPA; Ambient Water Quality Criteria Doc: Chloroform p.B-4 (1980) EPA 440/5-80-033]**PEER REVIEWED**

LC50 Micropterus salmoides (largemouth bass) 51 ppm/96 hr /Conditions of bioassay not specified/
[Anderson DR, Lusty EB; Report, ISS PNL-3046, Order No. NUREG/CR-0893 46pp (1980)]**PEER REVIEWED**

LC50 Ictalurus punctatus (channel catfish) 75 ppm/96 hr /Conditions of bioassay not specified/
[Anderson DR, Lusty EB; Report, ISS PNL-3046, Order No. NUREG/CR-0893 46pp

(1980)]**PEER REVIEWED**

LC50 Daphnia magna (cladoceran) 28,900 ug/l/48 hr in a static bioassay
[USEPA; Ambient Water Quality Criteria Doc: Chloroform p.B-4 (1980) EPA 440/5-80-033]**PEER REVIEWED**

LC50 Limanda sp (dab) 28 mg/l/96 hr
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 2-2]**PEER REVIEWED**

TSCA Test Submissions:

The toxicokinetics of **chloroform** (CAS # 67-66-3, CHCl3) was systematically evaluated and interpreted in various species including B6C3F1 mice, Fischer 344 and male Osborne-Mendel rats, and male Syrian Golden hamsters for development and validation of a physiologically-based pharmacokinetic (PB-PK) model of prospective dose-, species- and route-specific disposition of CHCl3. This model assumes total **chloroform** metabolism within target organs, liver and kidney, solely by a mixed function oxidase (MFO) metabolic pathway following Michaelis-Menten kinetics. Metabolic rate constants (Vmax, Km, and V/S), calculated by computer optimization of multispecies enzyme activity and kinetics studies in liver and kidney, allowed extrapolation of results between species. The model facilitates determination of a "delivered dose" (macromolecular binding, MMB) of **chloroform** metabolites to **chloroform**-sensitive internal organs to imply a potential cytotoxicity and tumorigenicity associated with chronic CHCl3 exposure. Toxicologically-significant descending relative rates of **chloroform** sensitivity in mice, rats, and humans were revealed. In chronic inhalation study with B6C3F1 mice, tumorigenicity correlated better with the rate of MMB (and a cellular regenerative response) than with absolute metabolite or MMB levels. Inclusion of historical absorption rates through digestive, respiratory, and circulatory compartments in the mammalian model allowed toxicological simulations based on route of administration. A homologous biochemical response provides a basis for the extrapolation of toxicity associated with the relatively high chronic exposures in studies with laboratory animals to that expected in humans chronically exposed to lower levels of **chloroform** typically encountered in the environment. Phase two studies will attempt to correlate rates of cytotoxicity and cell death to MMB. The authors offered that such a PB-PK model might be used for quantification of the potential biohazard to humans chronically exposed to low level **trichloromethane** found in chlorine-pretreated drinking water.
[Dow Chem Co; Chloroform - A Physiologically-Based Pharmacokinetic Model Including Cytotoxicity as an Endpoint, Part A - Development of the PB-PK Model (Final Report); EPA Document No. 86-890000091; Fiche No. OTS0516654]**QC REVIEWED**

Chloroform (CAS # 67-66-3) bioactivation and toxicity in the kidney and liver was investigated in B6C3F1 mice and in male Osborne-Mendel rats exposed in an environmental chamber to target vapor concentrations of 0, 10 (mice only), 100 (mice only), 400, and 1100 ppm for approximately 6 hours. Groups of 4 mice and 4 rats from each treatment level were sacrificed for quantification of nonprotein sulfhydryl (NPSH, to approximate glutathione) levels in liver and kidney tissues at 0, 2, 4, and 6 hours into the exposures and at 6, 12, 24, 46, and 48 hours following final exposures. In mice, treatment was associated with significant mortality 36 hours following 400 and 1100 ppm exposures, lethargy and perineal staining (400, 1100 ppm), and light anesthesia (1100 ppm). Upon necropsy, livers and kidneys appeared pale as compared to those of sham controls. In rats, light anesthesia upon 1100 ppm exposures alone characterized the clinical toxicity and no gross pathology was identified upon terminal necropsy. Renal NPSH levels were statistically significantly (Winer's paired t-test) depressed for prolonged periods following exposures of 100 ppm and above in mice, while NPSH levels either equalled or slightly exceeded those of sham control animals in rats of exposures below 1100 ppm. Conversely, mouse

hepatic NPSH levels dropped markedly at isolated sampling times only, the NPSH depressions inconsistent and not dose related, but more profound in association with 400 and 1100 ppm than with 10 and 100 ppm exposures. In rats, both renal and liver NPSH levels were statistically significantly (Winer's paired t-test) depressed at 4-hour sampling following 1100 ppm exposures. These studies contributed to derivation of metabolic and bioactivation rate constants in design of a physiologically-based pharmacokinetic (PB-PK) model of **chloroform** toxicity.
[Dow Chem Co; Chloroform - A Physiologically-Based Pharmacokinetic Model Including Cytotoxicity as an Endpoint, Part A - Development of the PB-PK Model (Final Report); EPA Document No. 86-890000091; Fiche No. OTS0516654]**QC REVIEWED**

The metabolic disposition of **chloroform** (CAS # 67-66-3, CHCl3) was evaluated in male B6C3F1 mice (4/group) and Osborne-Mendel rats (3/group) exposed under dynamic flow-through conditions in a Roth-type metabolism chamber to target vapor concentrations of 10 (mice only), 100, 400 and 1100 (rats only) ppm 14CHCl3 for 6 hours. Urine, feces, and CO2 were collected and analyzed for radioactive label both during and after exposure. Likewise, aqueous samples of carcass homogenates (33-50% w/w) and skin, harvested during terminal sacrifice of all test animals 48 hours post exposure, were analyzed to quantify fixed radiolabel. At exposures of 400 ppm, metabolism of 14CHCl3 appeared to become saturating (non-linear) in both mice and rats, with the radioactive body burden recovered as metabolites (mice 92%; rats 80%) diminished relative to that at 100 ppm (98-99%). Additionally, post-exposure metabolism and unmetabolized 14CHCl3 collected following exposures in excess of 100 ppm increased disproportionately. Exhaled 14CO2, urine, and feces, respectively, accounted for approximately 85%, 10%, and 1-1.5% of the total radiolabeled CHCl3 metabolized; the carcass and skin accounted for approximately 3% and 1%, respectively. On comparison, elimination routes and rates were highly consistent in mice and rats, although the total body burden (mg/kg) in mice was 2-4X that in rats. These studies contributed to derivation of metabolic rate constants in design of a physiologically-based pharmacokinetic (PB-PK) model of **chloroform** toxicity.
[Dow Chem Co; Chloroform - A Physiologically-Based Pharmacokinetic Model Including Cytotoxicity as an Endpoint, Part A - Development of the PB-PK Model (Final Report); EPA Document No. 86-890000091; Fiche No. OTS0516654]**QC REVIEWED**

The metabolic disposition of **chloroform** (CAS # 67-66-3, CHCl3) was evaluated in male B6C3F1 mice (4/group) and Osborne-Mendel rats (3/group) exposed under dynamic flow-through conditions in a Roth- type metabolism chamber to target vapor concentrations of 10 (mice only), 100, 400, and 1100 (rats only) ppm 14CHCl3 for 6 hours. All animals were sacrificed at 6 hours post exposure for harvest and assay of liver and kidneys to assess the degree of irreversible macromolecular binding (MMB), or the "delivered dose" (Anderson, 1987) of radiolabel **chloroform** or its metabolites. At low exposure levels (10, 100 ppm), mouse kidney MMB (1.06, 4.01 nmol Eq/mg protein) was 4-10 fold greater than liver MMB (0.10, 1.05 nmol Eq/mg protein), while these values converged at 400 ppm (4.99 and 4.48 nmol Eq/mg protein for liver and kidney, respectively). Conversely, at exposure levels of 100 and 400 ppm, rat liver MMB (0.60, 1.33 nmol Eq/mg protein) and kidney MMB (0.66, 0.89 nmol Eq/mg protein) were roughly equivalent, while these values diverged between 400 and 1100 ppm, such that liver MMB after a 1100 ppm exposure (1.70 nmol Eq/mg protein) was approximately 2X kidney MMB (0.78 nmol Eq/mg protein). Mouse MMB was higher, on comparison, than that in the rat at the same exposure levels, consistent with a higher rate of CHCl3 metabolism. These values became an integral component of a physiologically-based pharmacokinetic (PB-PK) model of **chloroform** toxicity.
[Dow Chem Co; Chloroform - A Physiologically-Based Pharmacokinetic Model Including Cytotoxicity as an Endpoint, Part A - Development of the PB-PK Model (Final Report); EPA Document No. 86-890000091; Fiche No. OTS0516654]**QC REVIEWED**

The rate of **chloroform** (CAS # 67-66-3, CHCl3) metabolism was evaluated in 6-hour in vitro bioassay with microsomal fractions of liver and kidney from B6C3F1 mice, F344 rats, Syrian Golden hamsters, and humans. Microsomal protein preparations of each species were incubated for 30 minutes with

labeled 14CHCl3 in dimethyl formamide, a NADPH regenerating system and a potassium phosphate buffer (pH 7.4). Boiled enzyme preparations containing equivalent amounts of protein served as controls. The reaction terminated at 30 minutes, CO2 generated by the enzymatic reaction was measured and the solution's unreacted substrate (14CHCl3) and water-soluble reaction products separated by solvent extraction (unlabeled CHCl3). Liquid scintillation assay in combined species analysis (mice, rats, hamsters, and humans) documented a rate of 14CHCl3 biotransformation to water-soluble metabolite proportional to time for 10-30 min and proportional to protein concentration up to 1-2 mg protein per incubation. This reaction was wholly inhibited by boiling the enzyme prior to incubation. Reaction rates or MFO (mixed function oxidase) activities (nmoles oxidized/min/mg protein at 0.049-0.058 mM CHCl3) in liver microsomes of mouse, rat, and hamster ranged from 0.0199 (rat) to 0.133 (hamster) nmoles/min/mg protein. Human liver microsomes demonstrated a broad activity range from 0.003 - 0.017 nmoles/min/mg protein (mean +/- s.d. = 0.00816 +/- 0.00448), the slowest rates among tested mammals. Descending rates of CHCl3 metabolism in the kidney were found in mice (0.0102 nmoles/min/mg protein), hamsters (0.00562 nmoles/min/mg protein), and rats (0.000928 nmoles/min/mg protein). Human kidney samples were limited and failed to demonstrate microsomal rates of CHCl3 metabolism above the minimal detection limit (0.0003 nmoles/min/mg protein at 0.06 mM CHCl3). Species-specific metabolic indices were subsequently derived by computer optimization of kinetics study data associated with 1-20 mM 14CHCl3 for development of a physiologically-based pharmacokinetic (PB-PK) model of **chloroform** toxicity.
[Dow Chem Co; Chloroform - A Physiologically-Based Pharmacokinetic Model Including Cytotoxicity as an Endpoint, Part A - Development of the PB-PK Model (Final Report); EPA Document No. 86-890000091; Fiche No. OTS0516654]**QC REVIEWED**

Chloroform (CAS # 67-66-3) was evaluated for developmental toxicity in pregnant Wistar rats (23-25/group) exposed by inhalation at concentrations of 0, 30, 100, and 300 ppm for 7 hours/day during Days 7-16 postconception. Treatment was associated with dose-related depression of maternal food consumption and bodyweight gains, primarily during the first week of treatment; no further signs of maternal toxicity and no gross pathology were observed. Signs of embryotoxicity included dose-dependent early intrauterine loss of primordia with slightly stunted development (slightly reduced crown-rump length) among the remaining live fetuses at all treatment levels. No toxicologically significant incidence of malformations was observed on Day 21 terminal necropsy of treated and control fetuses relative to spontaneous occurrence in experimental controls.
[Halogenated Solvents Industry; Two Genotoxicity Studies on Chloroform and One Embryotoxicity Study on Chloroform; 07/28/88; EPA Document No. FYI-OTS-0988-0635; Fiche No. OTS0000635]**QC REVIEWED**

Chloroform (CAS # 67-66-3) was evaluated for clastogenicity in Chinese Hamsters (5/sex/treatment group) exposed by oral gavage to doses of 0 (solvent control), 40, 120, and 400 mg/kg bw with subsequent harvest, preparation and analysis of metaphase bone marrow cells (100 cells/animal) at 6 (high dose), 24 (all doses), and 48 (high dose) hours post-treatment. Hamsters of 400 mg/kg doses exhibited signs of toxicity including hypoactivity, closed eyes, and arrested food consumption. Slight enhancement of chromosomal aberrations was statistically significant (Mann-Whitney-U-test) 6 and 24 hours after doses of 400 mg/kg, although the rate was still within the range of historical negative controls. Further, outside the range of historical controls, no dose-response relationship was demonstrated. The study authors noted an inference of **chloroform** mutagenicity, however, based on the nature of marked damage (multiple aberrations, chromosomal disintegration, and exchanges) associated with oral **chloroform** at doses of 120 and 400 mg/kg (6-, 24-, and 48-hour assessments). In repeat study, exposing groups of hamsters to doses of 0 (solvent control), 120, and 400 mg/kg bw, 24-hour cytogenetic assay again revealed a slight but statistically significant increase in chromosome aberrations in association with 400 mg/kg doses, failing again to demonstrate a dose-response relationship for rates of damage (chromosome breaks) beyond the range of historical controls. Distinctly heavy damage

(multiple aberrations and exchanges) characterized the **chloroform**-induced aberrations at 400 mg/kg in 6/6000 metaphase bone marrow cells.
[Dow Chem Co; Chloroform - Chromosome Aberrations in Chinese Hamster Bone Marrow Cells; 03/09/88; EPA Document No. 88-920005773; Fiche No. OTS0544556]**QC REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

WHEN (14)C-**CHLOROFORM** WAS ADMIN ORALLY TO MICE, RATS, & MONKEYS, RADIOACTIVITY WAS FOUND IN EXPIRED AIR. MOST OF DOSE WAS EXCRETED UNCHANGED BY MONKEYS, AS (14)CO2 (CARBON DIOXIDE) BY MICE, & AS BOTH BY RATS. THREE METABOLITES WERE DETECTED IN URINE OF RATS & MICE, ONE OF WHICH WAS IDENTIFIED AS UREA.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 414 (1979)]**PEER REVIEWED**

HALOFORMS ARE METABOLIZED TO CARBON MONOXIDE BY HEPATIC MICROSOMAL MIXED FUNCTION OXIDASES & THIS REACTION IS MARKEDLY STIMULATED BY SULFHYDRYL CMPD. MAX STIMULATION OCCURRED AT 0.5 MMOL GLUTATHIONE. A MECHANISM FOR CONVERSION TO CARBON MONOXIDE IS PROPOSED.
[STEVENS JL ET AL; BIOCHEMICAL PHARMACOLOGY 28: 3189 (1979)]**PEER REVIEWED**

TRIHALOMETHANES (HALOFORMS) WERE METAB TO CARBON MONOXIDE BY RAT LIVER MICROSOMAL FRACTION REQUIRING NADPH & MOLECULAR OXYGEN. METABOLISM FOLLOWED HALIDE ORDER; THUS, **CHLOROFORM** YIELDED SMALLEST AMT. RESULTS SUGGEST CYTOCHROME P450 DEPENDENT SYSTEM.
[AHMED AE ET AL; DRUG METABOLISM DISPOSITION 5 (2): 198 (1976)]**PEER REVIEWED**

Deuterium-labeled **chloroform** was less toxic and less readily metabolized than /normal/ **chloroform**, suggesting that the cleavage of the C-H bond is the rate-limiting step in the process resulting in hepatotoxicity.
[Pohl LR; Rev Biochem Toxicol 1: 79 (1979)]**PEER REVIEWED**

Whether **chloroform**-induced nephrotoxicity might be due to its metabolism to phosgene in the kidney was studied. Kidney homogenates from mice in the presence of glutathione metabolize **chloroform** to 2-oxothiazolidine-4-carboxylic acid (OTZ) This product appears to be formed by the initial trapping of COCl2 by 2 molecules of glutathione to form diglutathionyl dithiocarbonate. Kidney gamma-glutamyl transpeptidase can rapidly metabolize diglutathionyl dithiocarbonate to N-(2-oxothiazolidine-4-carbonyl)glycine which is then hydrolyzed, possibly by cysteinyl glycinase to 2-oxothiazolidine-4-carboxylic acid. The finding that deuterium-labeled **chloroform** was less nephrotoxic and depleted less renal glutathione than did **chloroform** suggests that the metabolism of **chloroform** to phosgene also occur in the kidney in vivo and lead to nephrotoxicity.
[Branchflower RV et al; Toxicol Appl Pharmacol 72 (1): 159-68 (1984)]**PEER REVIEWED**

While the liver is the primary site for **chloroform** metabolism, other tissues, including the kidney, can also metabolize **chloroform** to carbon dioxide.
[USEPA; Health Assessment Document: Chloroform (Draft) p.1-3 (1984) EPA-600/8-84-004A]**PEER REVIEWED**

... Relation between metabolism and toxicity of **chloroform** in the kidney of rabbits, a species in which

renal cytochrome p450 is induced by phenobarbital. Pretreatment with phenobarbital enhanced the toxic response of renal cortical slices to **chloroform** in vitro as indicated by decreased p-aminohippurate and tetraethylammonium (+1) accumulation. Phenobarbital pretreatment also potentiated in vitro (14)C-**chloroform** metabolism to (14)carbon dioxide and covalently bound radioactivity in rabbit renal cortical slices and microsomes. Addition of L-cysteine significantly reduced covalent binding in renal microsomes from phenobarbital-treated and control rabbits and was associated with the formation of 2-oxothiazolidine-4-carboxylic acid. Formation of 2-oxothiazolidine-4-carboxylic acid was enhanced in renal microsomes from phenobarbital-treated rabbits. Thus, the kidney metabolizes **chloroform** to phosgene.
[Bailie MB et al; Toxicol Appl Pharmacol 74 (2): 285-92 (1984)]**PEER REVIEWED**

Studies were made with male Wistar rats on the effects of 50% food restriction on the metabolism of ... **chloroform**. ... The activities of liver drug-metabolizing enzymes for this solvent was enhanced almost equally without exception by one-day food restriction, although the restriction produced no significant increase in the microsomal protein and cytochrome p450 contents. Thus, food restriction enhances metabolism of **chloroform** in the liver.
[Koyama Y, Sato A; Jpn J Ind Health 28 (2): 96-100 (1986)]**PEER REVIEWED**

Rats were injected iv or ip with (14)C **chloroform** and the localization and binding of metabolites in the tissues were studied by whole-body and microautoradiography. Based on the the autoradiographic findings various tissues were tested for their capacity to form (14)CO2 and to incorporate (14)C into tissue-macromolecules from the (14)C **chloroform**. Autoradiography in vitro was used to localize the sites of (14)C **chloroform** metabolism under in vitro conditions. The results of the in vitro metabolism studies showed that several tissues had a capacity to metabolize the (14)C **chloroform**. Further, the results showed that there was a correlation between the ability of various tissues to accumulate metabolites in the rats injected with the (14)C **chloroform** and the ability of the same tissues to metabolize the (14)C **chloroform** in vitro. The in vitro autoradiography showed an accumulation of radioactivity at sites corresponding to the ones accumulating metabolites in vivo. It is concluded that many tissues have a capacity to metabolize **chloroform** in vivo and in vitro. The structures identified to have a marked **chloroform**-metabolizing capacity were, besides the liver, the kidney cortex, the mucosa of the bronchial tree, the tracheal mucosa, the olfactory and respiratory nasal mucosa. Bowman's glands in the olfactory lamina propria mucosae, Steno's gland (the lateral nasal gland), the mucosa of the oesophagus, the larynx, the tongue, the gingiva, the cheek, the nasoparyngeal duct, the pharynx and the soft palate (but not the hard palate).
[Lofberg B, Tjalve H; Toxicology 39 (1): 13-36 (1986)]**PEER REVIEWED**

Hepatic lipoperoxidation by highly reactive metabolites produced during biodegradation of **chloroform** is believed to cause delayed hepatic necrosis. Chemilluminescence occurs during interaction of these metabolites with a lipid membrane. We have made continuous in vivo measurements of hepatic light output in the phenobarbital-induced rat breathing either air or **chloroform** vaporized in air. The data permitted direct estimation of the time course of **chloroform**-induced lipoperidoxidation. These potentially toxic events began 15 minutes after initiation of anesthesia and continued for the duration of the study. Chemiluminescence did not occur with inhalation of isoflurane, an anesthetic undergoing minimal biodegradation.
[Cohen PJ, Chance B; Biochim Biophys Acta 884 (3): 517-9 (1986)]**PEER REVIEWED**

IN VITRO ... FINDING OF 2-OXO-THIAZOLIDINE-4-CARBOXYLIC ACID IN INCUBATES WAS STRONG EVIDENCE FOR FORMATION OF PHOSGENE; REACTIVE METABOLITE, PHOSGENE IS FORMED BY MIXED-FUNCTION OXIDATION OF **CHLOROFORM** TO TRICHLOROMETHANOL ... /WHICH UNDERGOES/ DEHYDROCHLORINATION.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man.

Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 414 (1979)]**PEER REVIEWED**

Absorption, Distribution & Excretion:

CHLOROFORM CAN BE ABSORBED THROUGH LUNG, FROM GI TRACT & TO SOME EXTENT THROUGH SKIN. INHALATION ROUTE IS ... PRIMARY SOURCE OF ... ABSORPTION IN MAN.
[Doull, J., C.D. Klaassen, and M. D. Amdur (eds.). Casarett and Doull's Toxicology. 2nd ed. New York: Macmillan Publishing Co., 1980. 47]**PEER REVIEWED**

CHLOROFORM IS RAPIDLY ABSORBED & DISTRIBUTED TO ALL ORGANS, WITH RELATIVELY HIGH CONCN IN NERVOUS TISSUE. AFTER INTRADUODENAL INJECTION OF (14)C-**CHLOROFORM** TO RATS, 70% ... WAS FOUND UNCHANGED IN EXPIRED AIR & 4% AS (14)CO2 (CARBON DIOXIDE) DURING 24 HR. ... LIVER &, TO MUCH LESSER EXTENT, KIDNEY WERE MAIN ORGANS IN WHICH CO2 WAS FORMED.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 414 (1979)]**PEER REVIEWED**

IN MAN, PULMONARY EXCRETIONS OF **CHLOROFORM** & ITS CO2 (CARBON DIOXIDE) METAB ACCOUNT SUBSTANTIALLY FOR SINGLE ORAL DOSE OF 0.5 OR 1.0 G. AMONGST 9 SUBJECTS, UP TO 68% OF DOSE IS EXCRETED UNCHANGED & UP TO 51% OF CO2; NOT MORE THAN 4% OF DOSE IS EXCRETED UNCHANGED AFTER 8 HR.
[The Chemical Society. Foreign Compound Metabolism in Mammals Volume 3. London: The Chemical Society, 1975. 329]**PEER REVIEWED**

... /**CHLOROFORM** CROSSES/ PLACENTA RAPIDLY & ENTERS FETAL CIRCULATION.
[The Chemical Society. Foreign Compound Metabolism in Mammals Volume 3. London: The Chemical Society, 1975. 635]**PEER REVIEWED**

Long-term retention of **chloroform** occurred in body fat, with incr levels occurring in liver during the post-exposure period. Thus, there is redistribution of **chloroform** in body tissues as it slowly builds up in fatty tissues during the post exposure period.
[Cohen EN, Hood N; J Chloroform Anesthesiol 30: 306 (1969)]**PEER REVIEWED**

Chloroform is well absorbed via the respiratory system (94% to 77%). ... Absorption from the gastrointestinal tract approximates 100%.
[USEPA; Ambient Water Quality Criteria Doc: Chloroform p.C-5 (1980) EPA 440/5-80-033]**PEER REVIEWED**

Distribution of radioactivity in pregnant mice was registered at different time intervals (0-24 hr) after a 10 min period of inhalation of (14)C-labeled **chloroform** and methyl **chloroform**. Autoradiographic and liquid scintillation methods were used to make possible the distinction between volatile (non-metabolized), water-soluble and firmly tissue-bound radioactivity. Methyl **chloroform** was retained longer in fat as compared to **chloroform**. Metabolites of **chloroform** were present in a much greater abundancy than those of methyl **chloroform** and they were found preferentially in the respiratory tract (nasal mucosa, trachea and bronchi), liver and excretory organs. Tissue-bound activity after **Chloroform** inhalation or ip injection to newborn mice was found in the respiratory tract and centrilobular areas of the liver. Volatile radioactivity was observed in the placenta and fetuses at short time intervals after inhalation of both **chloroform** and methyl **chloroform** at all stages of gestation. ... Metabolites accumulated in the embryonic neural tissues. Tissue-bound metabolites of **chloroform** were observed in the fetal respiratory epithelium.
[Danielson BRG et al; Biol Res Pregnancy Perinatol 7 (2): 77-83 (1986)]**PEER

REVIEWED**

By using the (14)C-labeled compounds, the absorption, distribution, and excretion of **trichloromethane** ... was determined in rats (100 mg/kg) or in mice (150 mg/kg) after intragastric intubation; most or all the compound was eliminated in both rats and mice by the lung in the expired air. In rats, 40-81% of the compound was expired as (14)C-carbon dioxide and approximately 5-26% as unmetabolized parent. In mice, 4-18% was expired as (14)C-carbon dioxide and approximately 41-67% as parent.
[Mink FL et al; Bull Environ Contam Toxicology 37 (5): 752-8 (1986)]**PEER REVIEWED**

In 6 acute fatalities due to the intentional or forced inhalation of **chloroform**, blood levels of 10-48 mg/l and urine levels of 0-60 mg/l were observed.
[Baselt, R.C. Biological Monitoring Methods for Industrial Chemicals. 2nd ed. Littleton, MA: PSG Publishing Co., Inc. 1988. 81]**PEER REVIEWED**

Mechanism of Action:

Mechanisms of **chloroform** and carbon tetrachloride toxicity to primary cultured male B6C3F1 mouse hepatocytes were investigated. The cytotoxicity of both **chloroform** and carbon tetrachloride was dose and duration dependent. Maximal hepatocyte toxicity, as determined by lactate dehydrogenase leakage into the culture medium, occurred with the highest concentrations of **chloroform** (5 mM) and carbon tetrachloride (2.5 mM) used and with the longest duration of treatment (20 hr). Carbon tetrachloride was approximately 16 times more toxic than **chloroform** to the hepatocytes. The toxicity of these compounds was decreased by adding the mixed function oxidase system inhibitor, SKF-525A (25 microM) to the cultures. The addition of diethyl maleate (0.25 mM), which depletes intracellular glutathione (GSH)-potentiated **chloroform** and carbon tetrachloride toxicity. The toxicity of **chloroform** carbon tetrachloride could also be decreased by adding the antioxidants N,N'-diphenyl-p-phenylenediamine (25 microM), alpha-tocopherol acetate (Vitamin E) (0.1 mM), or superoxide dismutase (100 U/ml) to the cultures. These results suggest that: in mouse hepatocytes, both **chloroform** and carbon tetrachloride are metabolized to toxic components by the mixed function oxidase system; GSH plays a role in detoxifying those metabolites; free radicals are produced during the metabolism of **chloroform** and carbon tetrachloride and free radicals may be important mediators of the toxicity of these two halomethanes.
[Pereira MA, Goldblatt PJ; Environ Health Perspect 69: 301-5 (1986)]**PEER REVIEWED**

The feasibility of an oxygen-independent mechanism of **chloroform** bioactivation was indicated by the covalent binding to lipid and protein occurring in anaerobic incubations of **chloroform** and microsomes in the presence of NADPH. Under these conditions, the loss of cytochrome p450 and the inhibition of related mono-oxygenases were also observed. The **chloroform** anoxic biotransformation was negligible in uninduced microsomes and seemed to be catalyzed mainly by phenobarbital-inducible p450 isozymes. Biotransformation could also be supported by NADH as the source of reducing equivalents. Anaerobic metabolism of **chloroform** led to decreased levels of the main phenobarbital-induced p450 isozymes even at low **chloroform** concentration, and did not affect benzo(a)pyrene hydroxylase activity. These effects were not decreased by thiolic compounds. The oxidation products of **chloroform** caused a general impairment of the monoxygenase system, probably related to the formation of protein aggregates with very high molecular weight. In the presence of physiological concentrations of GSH, the targets of aerobically-produced metabolite were lipids, and, to a smaller extent, p450. At low **chloroform** concentrations and/or in the presence of GSH, the most changes to microsomal structures seemed to be produced by the reductively-formed intermediates.
[Testai E, Vittozi L; Chem-Biol Interact 59 (2): 157-72 (1986)]**PEER REVIEWED**

Interactions:

ONE SERIOUS DRUG INTERACTION INVOLVES SENSITIZATION OF MYOCARDIUM TO CATECHOLAMINES BY ... HALOGENATED HYDROCARBON ANESTHETICS (EG, **CHLOROFORM** ...) IN PRESENCE OF THESE ANESTHETICS, ADMIN OF EPINEPHRINE, ISOPROTERENOL, OR LEVARTERENOL MARKEDLY INCR INCIDENCE OF CARDIAC ARRHYTHMIAS.
[Evaluations of Drug Interactions. 2nd ed. and supplements. Washington, DC: American Pharmaceutical Assn., 1976, 1978. 347]**PEER REVIEWED**

EFFECTS /OF **CHLOROFORM**/ ON LIVER & KIDNEYS ARE EXAGGERATED BY ... INGESTION OF ALCOHOLIC BEVERAGES.
[Thienes, C., and T.J. Haley. Clinical Toxicology. 5th ed. Philadelphia: Lea and Febiger, 1972. 51]**PEER REVIEWED**

... DDT & PHENOBARBITONE POTENTIATED **CHLOROFORM**-INDUCED LIVER DAMAGE IN RATS ...
[The Chemical Society. Foreign Compound Metabolism in Mammals. Volume 2: A Review of the Literature Published Between 1970 and 1971. London: The Chemical Society, 1972. 461]**PEER REVIEWED**

ADMIN OF KEPONE (CHLORDECONE) RESULTED IN MARKED POTENTIATION OF **CHLOROFORM** INDUCED HEPATOTOXICITY WHEREAS PRETREATMENT WITH MIREX HAD NO EFFECT ON LIVER INJURY.
[CINFALONE DJ ET AL; TOXICOL APPL PHARMACOL 53 (1): 140-9 (1980)]**PEER REVIEWED**

Cysteine treatment reduced both covalent binding and hepatotoxicity, while diethyl maleate treatments incr both the hepatotoxicity of **chloroform** and the covalent binding of **chloroform** metabolites to hepatic proteins.
[Stevens JL, Anders MW; Chem Biol Interact 37 (1-2): 207-17 (1981)]**PEER REVIEWED**

Chloroform (CHCl3)-induced liver injury was evaluated in male Sprague-Dawley rats pretreated (15 mmol/kg, po) acetone (Ac), 2-butanone (Bu), 2-pentanone (Pn), 2-hexanone (Hx) or 2-heptanone (Hp). After 18 hr, a challenging dose of **chloroform** (0.50 or 0.75 ml/kg, ip) was given. Liver damage was evaluated 24 hr after **chloroform** admin by determining elevations in plasma GPT and OCT activity. Neither acetone, 2-butanone, 2-pentanone, 2-hexanone, 2-heptanone or the challenging dosages produced marked liver injury when given alone. However, each of the ketones potentiated **chloroform**-induced liver damage. The severity of the potentiated hepatotoxic response was significantly (positively) correlated with the ketone carbon chain length.
[Hewitt WR et al; Toxicol Lett 16 (3-4): 297-304 (1983)]**PEER REVIEWED**

Oral admin of diethyldithiocarbamic acid and carbon disulfide protected mice against **chloroform**-induced kidney injury, as evidenced by normalization of delayed plasma phenolsulfonophthalein clearance, suppression of incr kidney Ca content, and prevention of renal tubular necrosis.
[Masuda Y, Nakayama N; Biochem Pharmacol 32 (21): 3127-35 1983)]**PEER REVIEWED**

Rats were treated with (14)C-**chloroform** (CHCl3) in corn oil or corn oil alone (CO) 8 hr following pretreatment with 2-hexanone in corn oil or corn oil alone. Livers were removed, homogenized 1, 2, and 6 hr post-(14)CHCl3 administration, and glutathione content, irreversible binding of (14)CHCl3-derived radiolabel, and phospholipid composition were determined. The combination of 2-hexanone + CHCl3 reduced glutathione content to 21% of control (CO + CO) /SRP: pretreatment and sham control/ 1 hr after CHCl3 administration. No significant rebound of glutathione was observed 24 hr post-CHCl3

administration. In contrast, glutathione was not altered by administration of CHCl3 to CO-pretreated rats. Although (14)CHCl3-derived radiolabel was irreversibly bound to hepatic macromolecules of both CO- and 2-hexanone pretreated rats, total irreversibly bound (14)C was significantly enhanced in 2-hexanone pretreated rats at all time points. The latter observation was consistent with the decrease in glutathione of 2-hexanone pretreated rats. Total (14)C binding in 2-hexanone pretreated rats reached a plateau 2 hr post-(14)CHCl3 administration and was distributed 52% in protein, 41% in lipid, and 7% in acid soluble fractions 6 hr post-(14)CHCl3 administration. 2-Hexanone enhanced (14)C binding to protein and lipid at each time point. Radiolabel was not detected in neutral lipids of control or 2-hexanone treated animals, but was enhanced 33-fold in phospholipids of 2-hexanone treated animals. Phospholipid fatty acid methyl ester derivatives did not contain (14)C indicating the radiolabel was most likely associated with phospholipid polar head groups. Two dimensional thin layer chromatographic analysis of phospholipid from treated animals demonstrated that 87% of the total radiolabel was associated with a specific phospholipid which had a 1:1 molar ratio of phosphate to (14)C.
[Cowlen MS et al; Toxicol Appl Pharmacol 73 (3): 478-91 (1984)]**PEER REVIEWED**

... When given together, ... /**chloroform** and carbon tetrachloride/ increased the toxic response in rats. ... Histopathological changes were more severe from the combination than from either chemical alone. Although the mechanism of the hepatotoxic interaction between **chloroform** and carbon tetrachloride is unclear, ... there might be a combined effect of phosgene formation and lipid peroxidation initiation.
[USEPA; Health Assessment Document: Chloroform (Draft) p.5-33 (1984) EPA-600/8-84-004A]**PEER REVIEWED**

Exposure to chlordecone (CD, Kepone) is known to increase the hepatotoxicity of **chloroform** in rats. A time-course analysis was conducted relating several indices of biotransformation capacity with the ability of chlordecone to potentiate **chloroform**-induced hepatotoxicity. Male Sprague-Dawley rats were given a single administration of corn oil alone or chlordecone (50 mg/kg, po) dissolved in corn oil. At 2, 4, 8, 16, 20, 24, or 32 days posttreatment, groups of rats were killed and their livers were analyzed for (i) cytochrome p450, NADPH-dependent cytochrome c reductase, cytochrome b5 and glutathione content or (ii) in vitro irreversible binding of (14)CHCl3-derived radiolabel to microsomal protein. Similarly treated rats were challenged (2-32 days posttreatment) with **chloroform** (0.5 ml/kg po); 24 hr later, liver damage was assessed by plasma alanine aminotransferase, plasma ornithine carbamyl transferase, plasma bilirubin, and hepatic glucose-6-phosphatase. Chlordecone potentiation was maximal & persisted up to 20-24 days post-chlordecone treatment.
[Hewitt LA et al; Can J Physiol Pharmacol 64 (4): 477-82 (1986)]**PEER REVIEWED**

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[Smith JH et al; Toxicol Appl Pharmacol 79 (1): 166-74 (1985)]**PEER REVIEWED**

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[Ahmadizadeh M et al; Toxicology 31 (3-4): 343-52 (1984)]**PEER REVIEWED**

... Ethanol ... increased the toxicity of **chloroform** ...
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 755]**PEER REVIEWED**

Pharmacology:

Therapeutic Uses:

MEDICATION (VET): AS INHALATION ANESTHETIC IN HORSES & NOW RARELY IN CATTLE, SHEEP, CATS OR DOGS BECAUSE OF DANGEROUS COMPLICATIONS & SUPERIOR ALTERNATIVES; INTERNALLY, WELL DIL IN INTESTINAL COLIC & FLATULENCE; IN EXPECTORANTS, & LESS COMMONLY AS ANTHELMINTIC (SWINE, DOGS) ... . /FORMER USE/
[Rossoff, I.S. Handbook of Veterinary Drugs. New York: Springer Publishing Company, 1974. 104]**PEER REVIEWED**

MEDICATION (VET): USED/ EXTERNALLY, AS LINIMENT-TYPE COUNTERIRRITANT FOR RELIEF OF DEEP SEATED PAIN, TO EXPEL SCREWWORM LARVAE FROM WOUNDS, AS SKIN CLEANSER (FAT SOLVENT), & AS SKIN COOLANT & LOCAL ANESTHETIC DUE TO ITS EVAPORATION. ... INTERNALLY, IT IS GIVEN IN VARIOUS MIXT WELL DIL TO AVOID GASTRIC IRRITATION ... . /FORMER USE/
[Rossoff, I.S. Handbook of Veterinary Drugs. New York: Springer Publishing Company, 1974. 104]**PEER REVIEWED**

HAS BEEN USED AS AN ANESTHETIC & IN PHARMACEUTICAL PREPARATIONS.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 357]**PEER REVIEWED**

Chloroform was used chiefly as an anesthetic and in pharmaceutical preparation immediately prior to World War II. However, these uses have been banned.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 5(79) 694]**PEER REVIEWED**

Drug Warnings:

Maternal Medication usually Compatible with Breast-Feeding: **Chloroform**: Reported Sign or Symptom in Infant or Effect on Lactation: None. /from Table 6/
[Report of the American Academy of Pediatrics Committee on Drugs in Pediatrics 93 (1): 140 (1994)]**PEER REVIEWED**

Interactions:

ONE SERIOUS DRUG INTERACTION INVOLVES SENSITIZATION OF MYOCARDIUM TO CATECHOLAMINES BY ... HALOGENATED HYDROCARBON ANESTHETICS (EG, **CHLOROFORM** ...) IN PRESENCE OF THESE ANESTHETICS, ADMIN OF EPINEPHRINE, ISOPROTERENOL, OR LEVARTERENOL MARKEDLY INCR INCIDENCE OF CARDIAC ARRHYTHMIAS.
[Evaluations of Drug Interactions. 2nd ed. and supplements. Washington, DC: American Pharmaceutical Assn., 1976, 1978. 347]**PEER REVIEWED**

EFFECTS /OF **CHLOROFORM**/ ON LIVER & KIDNEYS ARE EXAGGERATED BY ... INGESTION OF ALCOHOLIC BEVERAGES.
[Thienes, C., and T.J. Haley. Clinical Toxicology. 5th ed. Philadelphia: Lea and Febiger, 1972. 51]**PEER REVIEWED**

... DDT & PHENOBARBITONE POTENTIATED **CHLOROFORM**-INDUCED LIVER DAMAGE IN RATS ...
[The Chemical Society. Foreign Compound Metabolism in Mammals. Volume 2: A Review of the Literature Published Between 1970 and 1971. London: The Chemical Society, 1972. 461]**PEER REVIEWED**

ADMIN OF KEPONE (CHLORDECONE) RESULTED IN MARKED POTENTIATION OF **CHLOROFORM** INDUCED HEPATOTOXICITY WHEREAS PRETREATMENT WITH MIREX HAD NO EFFECT ON LIVER INJURY.
[CINFALONE DJ ET AL; TOXICOL APPL PHARMACOL 53 (1): 140-9 (1980)]**PEER REVIEWED**

Cysteine treatment reduced both covalent binding and hepatotoxicity, while diethyl maleate treatments incr both the hepatotoxicity of **chloroform** and the covalent binding of **chloroform** metabolites to hepatic proteins.
[Stevens JL, Anders MW; Chem Biol Interact 37 (1-2): 207-17 (1981)]**PEER REVIEWED**

Chloroform (CHCl3)-induced liver injury was evaluated in male Sprague-Dawley rats pretreated (15 mmol/kg, po) acetone (Ac), 2-butanone (Bu), 2-pentanone (Pn), 2-hexanone (Hx) or 2-heptanone (Hp). After 18 hr, a challenging dose of **chloroform** (0.50 or 0.75 ml/kg, ip) was given. Liver damage was evaluated 24 hr after **chloroform** admin by determining elevations in plasma GPT and OCT activity. Neither acetone, 2-butanone, 2-pentanone, 2-hexanone, 2-heptanone or the challenging dosages produced marked liver injury when given alone. However, each of the ketones potentiated **chloroform**-induced liver damage. The severity of the potentiated hepatotoxic response was significantly (positively) correlated with the ketone carbon chain length.
[Hewitt WR et al; Toxicol Lett 16 (3-4): 297-304 (1983)]**PEER REVIEWED**

Oral admin of diethyldithiocarbamic acid and carbon disulfide protected mice against **chloroform**-induced kidney injury, as evidenced by normalization of delayed plasma phenolsulfonophthalein clearance, suppression of incr kidney Ca content, and prevention of renal tubular necrosis.
[Masuda Y, Nakayama N; Biochem Pharmacol 32 (21): 3127-35 1983)]**PEER REVIEWED**

Rats were treated with (14)C-**chloroform** (CHCl3) in corn oil or corn oil alone (CO) 8 hr following pretreatment with 2-hexanone in corn oil or corn oil alone. Livers were removed, homogenized 1, 2, and 6 hr post-(14)CHCl3 administration, and glutathione content, irreversible binding of (14)CHCl3-derived radiolabel, and phospholipid composition were determined. The combination of 2-hexanone + CHCl3 reduced glutathione content to 21% of control (CO + CO) /SRP: pretreatment and sham control/ 1 hr after CHCl3 administration. No significant rebound of glutathione was observed 24 hr post-CHCl3 administration. In contrast, glutathione was not altered by administration of CHCl3 to CO-pretreated rats. Although (14)CHCl3-derived radiolabel was irreversibly bound to hepatic macromolecules of both CO- and 2-hexanone pretreated rats, total irreversibly bound (14)C was significantly enhanced in 2-hexanone pretreated rats at all time points. The latter observation was consistent with the decrease in glutathione of 2-hexanone pretreated rats. Total (14)C binding in 2-hexanone pretreated rats reached a plateau 2 hr post-(14)CHCl3 administration and was distributed 52% in protein, 41% in lipid, and 7% in acid soluble fractions 6 hr post-(14)CHCl3 administration. 2-Hexanone enhanced (14)C binding to protein and lipid at each time point. Radiolabel was not detected in neutral lipids of control or 2-hexanone treated animals, but was enhanced 33-fold in phospholipids of 2-hexanone treated animals. Phospholipid fatty acid methyl ester derivatives did not contain (14)C indicating the radiolabel was most likely associated with phospholipid polar head groups. Two dimensional thin layer chromatographic analysis of phospholipid from treated animals demonstrated that 87% of the total radiolabel was associated with a specific phospholipid which had a 1:1 molar ratio of phosphate to (14)C.
[Cowlen MS et al; Toxicol Appl Pharmacol 73 (3): 478-91 (1984)]**PEER REVIEWED**

... When given together, ... /**chloroform** and carbon tetrachloride/ increased the toxic response in rats. ... Histopathological changes were more severe from the combination than from either chemical alone. Although the mechanism of the hepatotoxic interaction between **chloroform** and carbon tetrachloride is unclear, ... there might be a combined effect of phosgene formation and lipid peroxidation initiation.
[USEPA; Health Assessment Document: Chloroform (Draft) p.5-33 (1984) EPA-600/8-84-004A]**PEER REVIEWED**

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[Ahmadizadeh M et al; Toxicology 31 (3-4): 343-52 (1984)]**PEER REVIEWED**

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[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 755]**PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Chloroform's production and use in the production of hydrochlorofluorocarbon 22 (HCFC-22) may result in its release to the environment through various waste streams. **Chloroform** has been shown to occur naturally in the environment as a plant volatile and in peat bogs. If released to air, a vapor pressure of 197 mm Hg at 25 deg C indicates **chloroform** will exist solely as a vapor in the ambient atmosphere. Vapor-phase **chloroform** will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 151 days. If released to soil, **chloroform** is expected to have moderate mobility based upon a Koc value ranging from 153-196. Volatilization from moist soil surfaces is expected to be an important fate process based upon a Henry's Law constant of 3.67X10-3 atm-cu m/mole. **Chloroform** may volatilize from dry soil surfaces based upon its vapor pressure. Under normal environmental conditions, **chloroform** is not expected to undergo biodegradation in soil. However, several studies have demonstrated that at low concns, **chloroform** can be anaerobically degraded by methanogenic bacteria in the presence of a primary substrate such as acetic acid. If released into water, **chloroform** is not expected to adsorb to sediment and suspended solids in water based upon its Koc values. Biodegradation of **chloroform** in environmental aqueous environments is not well understood. Various reports have both supported and refuted anaerobic biodegradation in water. Volatilization from water surfaces is expected to be an important fate process based upon this compound's Henry's Law constant. Estimated volatilization

half-lives for a model river and model lake are 1.3 hrs and 4.4 days, respectively. BCF values ranging from 2.9-10.35 suggests bioconcentration in aquatic organisms is low. Since **chloroform** has a hydrolysis half-life of 1850 yrs at 25 deg C and pH 7, hydrolysis will not be an environmentally important loss process. Occupational exposure to **chloroform** may occur through inhalation and dermal contact with this compound at workplaces where **chloroform** is produced or used. The general population may be exposed to **chloroform** via inhalation of ambient air, ingestion of food and drinking water. **Chloroform** is widely detected in drinking water where the drinking water is chlorinated. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

Shell Chem Co, Rocky Mountain Arsenal - mean TWA were 2.6, 0.4 and 0.2 ppm for production operaters, drummers/bottle fillers and maintenance/utility personnel (pesticide plant)(1). Polish pharmaceutical plant 2 - 205 ppm(1); police forensic lab - 8 hr TWA - 15.8 ppm (range 2.6-46.4 ppm)(1); film manufacturing plant using a solvent containing 22% **chloroform** 1968-72 - 7-170 ppm (mean 47 ppm, 79 samples)(1).
[(1) Santodonato J et al; Monograph on Human Exposure to Chemicals in the Workplace: Chloroform. NCI contract N01-CP-26002-03, Syracuse Research Corp. July (1985)]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 95,773 workers (41,397 of these are female) are potentially exposed to **chloroform** in the US(1). Occupational exposure to **chloroform** may occur through inhalation and dermal contact with this compound at workplaces where **chloroform** is produced or used(SRC). The general population may be exposed to **chloroform** via inhalation of ambient air(2,3), ingestion of food(2) and drinking water(2,4).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983) (2) Wallace LA; Crit Rev Environ Sci Technol 27: 113-94 (1997) (3) Sweet CW, Vermette SJ; Environ Sci Technol 26: 165-173 (1992) (4) Dewulf J, Van Langenhove H; Wat Res 31: 1825-38 (1997)]**PEER REVIEWED**

Personal air concns of **chloroform** were studied for 12 hr exposure periods(1). Forty eight people in New Jersey during Feb 1983 had a mean personal exposure of 4.0 ug/cu m during day and nighttime while 40 individuals in Los Angeles, CA during June 1987 had a mean personal exposure of 3.8 ug/cu m during the day and 0.92 ug/cu m during nighttime(1). In Antioch-Pittsburg, CA during June 1984, 68 people had a mean personal exposure to **chloroform** of 0.47 ug/cu m during the day and 0.80 during nighttime(1). Several studies of indoor swimming pools indicate that inhalation can provide substantial amounts of **chloroform**(1). A study of 3 indoor swimming pools and 3 life guards resulted in increases of personal air exposures to **chloroform**(1). Personal air exposures for the 3 lifeguards at the indoor pool were 95, 68, and 46 ug/cu m while at home exposures dropped to 2.2, 2.0 and 5.2 ug/cu m(1). However, outdoor pools showed no difference in personal air exposure to **chloroform**(1). A pilot study carried out in Japan measured the intake of **chloroform** from air, food, and tap water for 7 Japanese housewives on 3 consecutive days in each of two seasons. For all 7 subjects in winter and 6 out of the 7 in summer, food contributed the most to their daily intake, accounting for about half of the daily intake of 37 ug in the summer and 70% of the smaller winter intake of 14 ug(1).
[(1) Wallace LA; Crit Rev Environ Sci Technol 27: 113-94 (1997)]**PEER REVIEWED**

Several experiments indicate that dermal absorption of **chloroform** during a shower is roughly equivalent to inhalation exposure during the shower(1). It has been estimated that about half the exposure from a 10-min shower is due to dermal absorption(1). The major source of exposure to **chloroform** is chlorination of water supplies(1). The results in exposure through ingestion of drinking water, but also through inhalation and skin absorption as a result of the myriad other uses of chlorinated water in the home: showers, baths, washing clothes and dishes, etc supports this(1). At a typical personal

exposure to **chloroform** of about 3 ug/cu m(not including exposure during the shower), this results in an estimated intake of about 24 ug/day for women and 30 ug/day for men(1). A typical **chloroform** level in soft drinks is about 23 ug/l(1). For an avg soft drink intake of 289 ml/day, this corresponds to a **chloroform** intake of about 6 ug/day(1). Limited data on levels of trihalomethanes (including **chloroform**) in food suggest that the additional intake from other foods and dairy products will be small(1). Thus, total intake from food and beverages appears to be approximately 10 ug/day for someone who drinks an avg amount of soft drinks(1).
[(1) Wallace LA; Crit Rev Environ Sci Technol 27: 113-94 (1997)]**PEER REVIEWED**

Body Burden:

Old Love Canal, Niagara Falls, NY - 9 individuals: breath 3.9-95 ug/cu m, 26 ug/cu m median; blood 1.1-3.0 ng/ml, 1.6 ng/ml median; urine 460-1500 ng/l, 860 ng/l median(1). England - 8 individuals: body fat 5-68 ppb; var organs 1-10 ppb(2); US - 4 urban sites: mothers' milk 7 of 8 samples pos, detected, not quantified(3).
[(1) Barkley J et al; Biomed Mass Spectrom 7: 139-47 (1980) (2) McConnell G et al; Endeavour 34: 13-8 (1975) (3) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982)]**PEER REVIEWED**

The largest existing data set on **chloroform** concns in the body has been provided by the TEAM Study measurements of exhaled breath(1). About 800 people provided more than 1250 breath samples with mean concns generally in the range of 0.5-3 ug/cu m with generally lower levels in California compared with other sites (New Jersey, Maryland, North Dakota, and North Carolina)(1). In a study of 163 people at indoor swimming pools, exposed individuals had a mean **chloroform** concn in the higher alveolar of 83 ug/cu m(1). Breath exposures were also studied from a single subject who swam for 30 mins on 3 occasions, rested in the water for the same length of time on one occasion and stayed near the pool but out of the water for 30 mins on the final occasion(1). Pre-exposure breath concns were less than 2 ug/cu m on all occasions, rising to 15 to 25 ug/cu m 2.5 mins after completing the swimming periods, but only to 11 mg/cu m after the poolside exposure period(1). A study of **chloroform** found in blood revealed that out of 979 people sampled between 1988-1992, the mean **chloroform** concn was 0.0444 ng/ml(1). This suggests that a large percentage of the U.S. population is exposed to **chloroform**, but that very large exposures are rare(1). **Chloroform** was also detected in 40 out of 42 breast milk samples at levels ranging from 0.1 to 65 ng/ml from nursing mothers in two New Jersey hospitals and from three other hospitals in Pennsylvania, Louisiana, and West Virginia(1).
[(1) Wallace LA; Crit Rev Environ Sci Technol 27: 113-94 (1997)]**PEER REVIEWED**

Average Daily Intake:

... Although data are scarce, maximum exposure /to **chloroform**/ due to ingestion of food has been estimated at 0.04 mg/day.
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 4-1]**PEER REVIEWED**

Natural Pollution Sources:

Chloroform has been shown to occur naturally in the environment. For example, it is produced by the tropical red algae Asparagopsis armata, and by the red seaweed, A. taxiformis(1). It has been estimated that the mass of biogenic **chloroform** exchanged to the atmosphere from tropical oceans is 350X10+3 tons/yr(1). Another source of naturally occurring **chloroform** has been reported in peat bogs(2). Samples taken from a bog located in Lower St. Mary, New Brunswick, Canada in the fall of 1995 contained **chloroform** ranging from 1-2 ppm(2).

[(1) Dewulf J, Van Langenhove H; Wat Res 31: 1825-38 (1997) (2) Silk PJ et al; Chemosphere 35: 2865-880 (1997)]**PEER REVIEWED**

Artificial Pollution Sources:

Emissions from its production and indirect production (in the manufacture of ethylene dichloride); chlorination of drinking water, municipal sewage, cooling water in electric power generating plants; produced during the atmospheric photodegradation of trichloroethylenes; auto exhaust; from its use as an extractant or solvent, chemical intermediate, dry cleaning agent, fumigant ingredient, in fluorocarbon 22 production, synthetic rubber production (1-2).
[(1) USEPA; Health Assessment Document for Chloroform. External Review Draft USEPA-600/8-84-004A p. 3-4 to 3-28 (1984) (2) IARC; Some Halogenated Hydrocarbons 20: 402-5 (1979)]**PEER REVIEWED**

Chloroform's production and use in the synthesis of hydrochlorofluorocarbon 22 (HCFC-22)(1) may result in its release to the environment through various waste streams. **Chloroform** is also released into the environment by the chlorination of drinking or waste-water(2,3). Hypochlorous acid is formed during chlorination which reacts with organic precursors forming **chloroform**(3). Another source of **chloroform** is from the use of household liquid bleach containing sodium hypochlorite(3). Some researchers calculated the total mass of sodium hypochlorite used in bleach in the U.S. in 1984 to be about 150 million lbs(3). Using an emission factor of 0.00168 lb **chloroform** produced per pound of chlorine equivalent, the researchers calculated total emissions of **chloroform** annually in the South Coast basin to be 5.3 tons which would be the equivalent of about 100 tons nationwide(3). **Chloroform** has also been detected as a contaminant in products including stain removers, spot removers, correction fluid, fabric softeners and rodenticides(3). Of 19 building materials and other products used in a new building, four emitted **chloroform**: two insecticides, a rodenticide and a scouring powder(3). Swimming pools have also shown to be important sources of **chloroform** due to their repeated chlorination(3).
[(1) Chemical Marketing Reporter; Chemical Profile Chloroform. December 1, 1997. p. 61 NY,NY: Schnell Pub Co (1997) (2) Dewulf J, Van Langenhove H; Wat Res 31: 1825-38 (1997) (3) Wallace LA; Crit Rev Environ Sci Technol 27: 113-94 (1997)]**PEER REVIEWED**

Environmental Fate:

TERRESTRIAL FATE: Based on a classification scheme(1), a Koc value ranging from 153-196(2,3) indicates that **chloroform** is expected to have moderate mobility in soil(SRC). Volatilization of **chloroform** from moist soil surfaces is expected to be an important fate process(SRC) given a Henry's Law constant of 3.67X10-3 atm-cu m/mole(4). The potential for volatilization of **chloroform** from dry soil surfaces may exist(SRC) based upon a vapor pressure of 197 mm Hg(4). In a study of **chloroform** residence time in soils, **chloroform** was found to have a half-life of 0.3 days when applied 1 cm deep into soil and 1.4 days when applied 10 cm deep(5). It was also classified as a "very short-lived" chemical in soil matrices primarily due to its high volatility(5). Under normal environmental conditions, **chloroform** is not expected to undergo biodegradation in soils. However, several studies have demonstrated that at low concns, **chloroform** can be anaerobically degraded by methanogenic bacteria in the presence of a primary substrate such as acetic acid(6) and even better under sulfate reducing conditions(7).
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Dural NH, Peng D Hazard Ind Wastes 27: 528-37 (1995) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-2 (1990) (4) Gossett JM; Environ Sci Tech 21: 202-6 (1987) (5) Jury WA et al; J Environ Qual 13: 573-79 (1984) (6) Gupta M et al; Wat Res 30: 1377-85 (1996) (7) Gupta M et al; Wat Res 30: 1387-94 (1996)]**PEER REVIEWED**

AQUATIC FATE: Based on a classification scheme(1), a Koc value ranging from 153-196(2,3) indicates that **chloroform** is not expected to adsorb to sediment and suspended solids in water(SRC). Volatilization from water surfaces is expected(3) based upon a Henry's Law constant of 3.67X10-3 atm-cu m/mole(4). Using this Henry's Law constant and an estimation method(3), volatilization half-lives for a model river and model lake are 1.3 hrs and 4.4 days, respectively(SRC). In a field study of **chloroform** volatilization, it was found that the volatilization half-life from the Rhine River was 1.2 days while in a lake located in the Rhine basin the half-life was 31 days(5). In another study, **chloroform** from a municipal treatment plant injected into an estuarine arm of Chesapeake Bay entirely disappeared within 4 km in the spring and within 11 km in winter under ice(6). The decrease in concn could not be entirely due to dilution(6). **Chloroform** was found to have a maximum water-to-air flux from an estuary of 350 tons/year based on its Henry's Law constant and diffusion(7). Based on available experimental data, aquatic degradation and transfer to the biotic mass or into the aquatic sediment are not expected to be major removal mechanisms for **chloroform**(7). The major process to be considered in the study of fate processes for **chloroform** is the diffusive air/water exchange(7). Biodegradation of **chloroform** in environmental aqueous environments is not well understood. Various reports have both supported and refuted anaerobic biodegradation in water(8). According to a classification scheme(9), a BCF ranging from 2.9-10.35(7) suggests the potential for bioconcentration in aquatic organisms is low. Although base catalyzed hydrolysis is expected to occur, the estimated rate constant of 6.4X10-5 L/mol-sec predicts that this will not be an environmentally important degradation process(10).
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Dural NH, Peng D Hazard Ind Wastes 27: 528-37 (1995) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-2, 15-1 to 15-29 (1990) (4) Gossett JM; Environ Sci Tech 21: 202-6 (1987) (5) Zoetman BCJ et al; Chemosphere 9: 231-49 (1980) (6) Helz GR, Hsu RY; Limnol Oceanogr 23: 858-69 (1978) (7) Dewulf J, Van Langenhove H; Wat Res 31: 1825-38 (1997) (8) Prager JC, ed; Environmental Contaminant Reference Databook. NY, NY: Van Nostrand Reinhold 1: 453-57 (1995) (9) Franke C et al; Chemosphere 29: 1501-14 (1994) (10) Mill T et al; Environmental Fate and Exposure Studies Development of a PC-SAR for Hydrolysis: Esters, Alkyl Halides and Epoxides, EPA Contract No. 68-02-4254 (1987)]**PEER REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), **chloroform**, which has a vapor pressure of 197 mm Hg at 25 deg C(2), is expected to exist solely as a vapor in the ambient atmosphere. Vapor-phase **chloroform** is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals(SRC); the half-life for this reaction in air is estimated to be 151 days(SRC), calculated from its rate constant of 1.03X10-13 cu cm/molecule-sec at 25 deg C(3). The tropospheric half-life for **chloroform** has been estimated at 3 yrs(4).
[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Boublik T et al; The Vapor Pressures of Pure Substances, Vol. 17. Amsterdam, Netherlands: Elsevier Sci (1984) (3) Atkinson R; J Phys Chem Ref Data Monograph 1 (1989) (4) Holbrook MT ; Kirk-Othmer Encycl Chem Technol. 4th ed. NY, NY: John Wiley and Sons 5: 1051-62 (1993)]**PEER REVIEWED**

Environmental Biodegradation:

There are conflicting data on the biodegradation of **chloroform**. Slow but substantial biodegradation apparently can occur when the proper microbial populations exist and are acclimated to the chemical(10). Under aerobic conditions, some investigators report little or no degradation in up to 25 wk (1,2,3) while others report considerable degradation: 49% in 7 days, 100% in 28 days; however, a large fraction of this loss was due to volatilization (4); 25% in 14 days(5), and 67% in 24 days(6). Under anaerobic conditions, slow degradation has been reported after acclimation(7) and degradation was reported in river bank (31% in <1 yr) and dune (100% in <3 mo) infiltration(8). However, another investigator reported no degradation in 27 weeks in aquifer material in the laboratory(9).

[(1) Bouwer EJ et al; Environ Sci Technol 15: 569 (1981) (2) Kawasaki M; Ecotox Environ Safety 4: 444-54 (1980) (3) Heukelekian H, Rand MC; J Water Pollut Control Assoc 29: 1040-53 (1955) (4) Tabak HH et al; J Water Pollut Control Fed 53: 1503-18 (1981) (5) Bouwer EJ et al; Water Res 15: 151-9 (1981) (6) Flathman PE, Dahlgran JR; Environ Sci Technol 16:130 (1982) (7) Bouwer EJ, McCarty PL; Appl Environ Microbiol 45: 1286-94 (1983) (8) Zoeteman BCJ et al; Chemosphere 9: 231-49 (1980) (9) Wilson JT et al; Devel Indust Microbiol 24: 225-33 (1983) (10) Prager JC, ed; Environmental Contaminant Reference Databook. Vol 1. NY, NY: Van Nostrand Reinhold (1995)]**PEER REVIEWED**

AEROBIC: No marine biodegradation of CHC (chlorohydrocarbons including **chloroform**) has been reported(1). **Chloroform**, present at 100 mg/l, reached 0% of its theoretical BOD in 2 weeks using an activated sludge inoculum at 30 mg/l and the Japanese MITI test(2). Among the aerobic microorganisms, **chloroform** has been shown to be degradable only by methanotrophic bacteria(3). When it is introduced into an aerobic bioreactor for treatment, it appears in the effluent and is not degraded(3). The disappearance of **chloroform** from a wastewater treatment plant was studied(4). At an air/water flow rate of 0.10 cu cm/cu m min, **chloroform**, at an initial concn of 43.3 ug/l had an avg effluent concn of 3.6 ug/l with 32.5% being air stripped and 59.2% being degraded(4).
[(1) Dewulf J, Van Langenhove H; Wat Res 31: 1825-38 (1997) (2) Chem Inspect Test Inst; Biodegradation and Bioaccumulation Data of Existing Chemicals Based on the CSCL Japan; Published by Japan Chemical Industry Ecology-Toxicology and Information Center. ISBN 4-89074-101-1 pg. 2-8 (1992) (3) Gupta M et al; Wat Res 30: 1377-85 (1996) (4) Parker WJ et al; Wat Environ Res 65: 58-65 (1993)]**PEER REVIEWED**

ANAEROBIC: **Chloroform** can be biodegraded under anaerobic conditions(1). Several studies have demonstrated that at low concns, **chloroform** can be anaerobically degraded by methanogenic bacteria in the presence of a primary substrate such as acetic acid(1). When a batch study was conducted using a mixed methanogenic culture at 35 deg C, **chloroform** underwent complete biodegradation from an initial concn of 0.34 uM soln using acetic acid as the primary substrate(1). It has also been reported that **chloroform** underwent 96% degradation at an initial concn of 0.28 uM in a continuous-flow fixed film methanogenic column which was fed acetic acid as the primary substrate(1). A limiting factor in the anaerobic biodegradation of **chloroform** is the initial concn(1). **Chloroform** has been shown to have an inhibitory effect on degradation at concns as low as 1.67 uM(1). However, under sulfate reducing environments, **chloroform** was found to not have such an inhibitory effect on the microorganisms(2). Even at an initial concn of 22.6 uM, 96% of **chloroform** was reduced by sulfate reducing organisms(2). Rates of transformation by the suflate-reducing culture was found to be much higher than the rates observed for an acetic acid utilizing methanogenic culture(2). The culture degraded **chloroform** primarily by reductive dehalogenation leading to the formation of an equimolar amount of dichloromethane, which was degraded at a very slow rate compared to **chloroform**(2). Additional acclimation of the culture for 1 year did not lead to any appreciable change in the rate of transformation of **chloroform**(2).
[(1) Gupta M et al; Wat Res 30: 1377-85 (1996) (2) Gupta M et al; Wat Res 30: 1387-94 (1996)]**PEER REVIEWED**

Environmental Abiotic Degradation:

The rate constant for the vapor-phase reaction of **chloroform** with photochemically-produced hydroxyl radicals has been estimated as 1.03X10-13 cu cm/molecule-sec at 25 deg C(1). This corresponds to an atmospheric half-life of about 151 days at an atmospheric concn of 5X10+5 hydroxyl radicals per cu cm(1). Some studies have shown that **chloroform** has an atmospheric half-life of 80 days with reaction with hydroxyl radicals which amounts to a 0.9% loss per sunlit day(2,3). **Chloroform** is more reactive in photochemical smog situations (presence of NOx) with an avg degradation rate of 0.8%/hr(4). A base-catalyzed second-order hydrolysis rate constant of 6.5X10-5 L/mole-sec(SRC) was estimated using

a structure estimation method(5); this corresponds to half-lives of 3400 and 340 yrs at pH values of 7 and 8, respectively(5). Based on this estimation, base catalyzed hydrolysis is not expected to be environmentally important degradation process(SRC). Another study has determined a hydrolysis half-life of 1850 yrs at 25 deg C and pH 7(6). Under oxidative degradation, **chloroform** has been shown to produce phosgene, hydrogen chloride, water, carbon dioxide and chlorine(7). **Chloroform** decomposes at ordinary temperature in sunlight in the absence of air, and in the dark in the presence of air(8). Photodegradation does not appear to be a significant loss process in aquatic systems(9).
[(1) Atkinson R; J Phys Chem Ref Data Monograph 1 (1989) (2) Hampson RF; Chemical Kinetics and Photochemical Data Sheets for Atmospheric Reactions. USDOT report FAA-EE-80-17 (1980) (3) Singh HB et al; Atmos Environ 15: 601-12 (1981) (4) Dimitriades B, Joshi SB; Inter Conf on Photochemical Oxidant Pollution and its Control. USEPA-600/3-77-001b pp. 705-11 (1977) (5) Mill T et al; Environmental Fate and Exposure Studies Development of a PC-SAR for Hydrolysis: Esters, Alkyl Halides and Epoxides. EPA Contract No. 68-02-4254. Menlo Park, CA: SRI International (1987) (6) Dewulf J, Van Langenhove H; Wat Res 31: 1825-38 (1997) (7) Holbrook MT; Kirk-Othmer Encycl Cheml Technol. 4th ed. NY, NY: John Wiley and Sons 5: 1051-62 (1993) (8) Prager JC; Environ Contamin Ref Databook. NY, NY: Van Nostrand Reinhold 1: 453 (1995) (9) Jensen S, Rosenberg R; Water Res 9: 659-61 (1975)]**PEER REVIEWED**

Environmental Bioconcentration:

Little or no tendency to bioconcentrate; log bioconcentration factor <1 for 4 species of fish(1,2).
[(1) Barrows ME et al; Dyn Exposure Hazard Assess Toxic Chem Ann Arbor, MI: Ann Arbor Press p 379-92 (1980) (2) Anderson DR, Lusty EB; Acute Toxicity and Bioaccumulation of Chloroform to Four Species of Fresh Water Fish. NUREG/CR-089 Richland, WA: Pacific NW Labs p 8-26 (1980)]**PEER REVIEWED**

The BCF values for **chloroform** range from 2.9-10.35(1). According to a classification scheme(2), these BCF values suggest the potential for bioconcentration in aquatic organisms is low. In another paper, an experimental log BCF of 0.78 was reported further supporting its low potential for bioconcentration(3).
[(1) DeWulf J, Van Lengenhove H; Wat Res 31: 1825-38 (1997) (2) Franke C et al; Chemosphere 29: 1501-14 (1994) (3) Park JH, Lee HJ; Chemosphere 26: 1905-16 (1993)]**PEER REVIEWED**

Soil Adsorption/Mobility:

Chloroform is adsorbed most strongly to peat moss, less strongly to clay, very slightly to dolomite limestone and not at all to sand(1). The Koc values measured for 2 soils was 34; however, 3 other soils with the lowest organic carbon content in the same study gave no appreciable adsorption(3). Field experiments in which **chloroform** was injected into an aquifer and the concentration in a series of observation wells determined, demonstrated that **chloroform** is very poorly retained by aquifer material (retardation factor 2-4), less so than other C1- and C2-halogenated compounds studied(2,3). Laboratory percolation studies with a sandy soil gave similar results (retardation factor <1.5)(4).
[(1) Dilling WL et al; Environ Sci Technol 9: 833-8 (1975) (2) Roberts PV et al; Water Res 16: 1025-35 (1982) (3) Hutzler NJ et al; Amer Chem Soc 186th Mtg Div Environ Chem Preprint 23: 499-502 (1983) (4) Wilson JT et al; J Environ Qual 10: 501-6 (1981)]**PEER REVIEWED**

A soil sorption study was conducted on **chloroform** in three distinctly different soils(1). Soils used were from Missouri (composed of 11.4% sand, 52.7% silt, 33.4% clay, 2.4% organic matter, at pH 6.9), California (composed of 45.1% sand, 35.2% silt, 21.7% clay, organic matter 1.7%, at pH 8.1), and Florida (composed of 91.7% sand, 6.3% silt, 2.0% clay, 1.6% organic matter, at pH 4.7)(1). The ratio of the amount of contaminant adsorbed in micrograms per gram of soil to the equilibrium concn in ppm was used to calculate a Kd value of 2.133 in the Missouri soil, 1.941 in the California soil, and 1.763 in

the Florida soil(1). These values correspond to a Koc value ranging from 153-196 based upon the relationship between Kd and Koc(2).The observed sorption was primarily as a result of adsorption (soil-solute interaction) forces rather than partitioning(1).
[(1) Dural NH, Peng D; Hazard Ind Wastes 27: 528-37 (1995) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-2 (1990)]**PEER REVIEWED**

Volatilization from Water/Soil:

The Henry's Law constant for **chloroform** is 3.67X10-3 atm-cu m/mole(1). This Henry's Law constant indicates that **chloroform** is expected to volatilize rapidly from water surfaces(2). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec)(2) is estimated as 1.3 hrs(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(2) is estimated as 4.4 days(SRC). Three laboratory studies of the evaporation of **chloroform** from water gave half-lives of 3-5.6 hrs with moderate mixing conditions(3-5). **Chloroform**'s Henry's Law constant(1) indicates that volatilization from moist soil surfaces may occur(SRC). The potential for volatilization of **chloroform** from dry soil surfaces may exist(SRC) based upon a vapor pressure of 197 mm Hg(6).
[(1) Gossett JM; Environ Sci Tech 21: 202-6 (1987) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (3) Smith JH et al; Environ Sci Technol 14: 190-6 (1980) (4) Rathbun RE, Tai DY; Water Res 15: 243-50 (1981) (5) Robert PV, Dandliker PG; Environ Sci Technol 17: 484-9 (1983) (6) Boublik T et al; The Vapor Pressures of Pure Substances, Vol. 17; Amsterdam, Netherlands: Elsevier Sci (1984)]**PEER REVIEWED**

Environmental Water Concentrations:

SEAWATER: Pacific Ocean <0.05 parts per trillion (1); Northeast Atlantic Ocean 4-13 parts per trillion , avg 8 parts per trillion (2); Point Reyes (near shore) 2.8 ppb(3). Gulf of Mexico 4-200 ppb(4).
[(1) Singh HB et al; Atmospheric distributions, sources and sinks of selected halocarbons, hydrocarbons, SF6 and NO2 EPA-600/3-79-107 134 p (1979) (2) Murray AJ, Riley JP; Nature 242: 37-8 (1973) (3) Singh HB et al; J Air Pollut Control Assoc 27: 332-6 (1977) (4) Sauer TC Jr; Org Geochem 3: 91-101 (1981)]**PEER REVIEWED**

DRINKING WATER: US Federal Survey of Finished Waters find a 70.3% occurrence in drinking water from groundwater supplies(9); 30 Canadian Treatment Facilities (treated water) 35 ppb avg summer, 21 ppb avg winter (93-97% pos, 110 ppb max - raw water had 2-6 ppb avg concn)(1); US 5 City Survey 1-301 ppb(2); Drinking Water wells in NY and NJ 67-490 ppb(3); Other cities report values between 0-190 ppb(4-7) with the values highest in summer and lowest in winter(4) and increasing on contact with residual chlorine(7). National Organic Reconnaissance Survey (80 US water supplies, 1975) 0-311 ppb, National Organics Monitoring Survey (113 finished water supplies, 1976-1977) 32-68 ppb median of positive supplies, 92-100% pos(8).
[(1) Otson R et al; J Assoc Off Analyt Chem 65: 1370-4 (1982) (2) Coleman WE et al; Analysis and Identification of Organic Substances in Water; L Keith Ed, Ann Arbor, MI: Ann Arbor Press p 305-27 (1976) (3) Burmaster DE; Environ 24: 6-13, 33-6 (1982) (4) Kasso WB, Wells MR; Bull Environ Contam Toxicol 27: 295-302 (1981) (5) Smith VL et al; Environ Sci Technol 14: 190-6 (1980) (6) Williams DT et al; Chemosphere 11: 263-76 (1982) (7) Uden PC, Miller JW; J Amer Water Works Assoc 75: 524-7 (1983) (8) Symon JM et al; J Amer Water Works Assoc (1982) (9) Dyksen JE, Hess AF III; J Amer Water Works Assoc p 394-403 (1982)]**PEER REVIEWED**

DRINKING WATER: **Chloroform** is prevalent in tap water throughout much of the country(1). About 50% of the U.S. population uses chlorinated surface water and another 25% consume chlorinated groundwater(1). In a study of 35 water utility plants(including 10 in California), median **chloroform** levels in distributed water ranged from 9.6-15 ug/l by quarter(1). In another study, **chloroform** concn

was determined in drinking water in Los Angeles from Feb 1987 to July 1987 at 6.8 ug/l and 11 ug/l, respectively(1). The mean concn of **chloroform** in New Jersey drinking water avgd about 50 ug/l, ranging from 17 ug/l in the winter of 1983 to 70 ug/l in the fall of 1981(1). Los Angeles had rather lower levels of 14 and 29 ug/l in the winter and spring of 1984, and even lower levels of 7 and 11 ug/l in winter and summer of 1987(1). Mean values were very low in Devils Lake, ND (1.4 ug/l) because the water supplies were from private wells and were not chlorinated(1). In a similar study, both treatment plant and tap water samples from three community water systems were analyzed for **chloroform** concn(1). **Chloroform** ranged from 11 to 100 ug/l at the plants and from 21 to 160 ug/l at the tap(1).
[(1) Wallace LA; Crit Rev Environ Sci Technol 27: 113-94 (1997)]**PEER REVIEWED**

GROUNDWATER: Contaminated wells in NY and NJ 67-490 ppb(1); Groundwater in the Netherlands 5 ppb(2). Water samples taken from 50 different groundwater sources located within the state of Kansas had an avg **chloroform** concn of 13.5 ug/l (range <0.1-91.2 ug/l)(3). Most of the samples were collected between mar 7 and Apr 11, 1986(3).
[(1) Burmaster DE; Environ 24: 6-13, 33-6 (1982) (2) Zoeteman BCJ et al; Chemosphere 9: 231-49 (1980) (3) Miller RE et al; J Amer Wat Works Assoc 82: 49-62 (1990)]**PEER REVIEWED**

SURFACE WATER: Ohio River Basin (1980-81, 11 stations, 4972 samples) 72% pos, 832 samples 1-10 ppb, 27 samples >10 ppb(1). 14 Heavily Industrialized River Basins in US (204 sites) 1-120 ppb, 79% pos(2). US - 5 industrial cities 9-31 ppb avg, 394 ppb max(3). 11 Water Utilities on Ohio River 0.8 ppb avg, 4.8 ppb max, 68% pos(4); Delaware River and tributaries - 30 sites 93% of samples >1 ppb(5); Ohio River and tributaries 232 samples 0.1-22 ppb, 72% pos(6); Lakes Erie, Michigan and Huron 1-30 ppb, 11 of 13 sites pos(7).
[(1) Ohio R Valley Water Sanit Comm; Assessment of water quality conditions 1980-81. Cincinnati, OH table 13 (1982) (2) Ewing BB et al; Monitoring to detect previously unrecognized pollutants in surface waters. USEPA-560/6-77-015 p. 75 (1977) (3) Pellizzari ED et al; Formulation of preliminary assessment of halogenated organic compounds in man and environmental media. USEPA-560/13-79-006 p. 469 (1979) (4) Ohio R Valley Water Sanit Comm; Water treatment process modifications for trihalomethane control and organic substances in the Ohio River. EPA grant no. R-804615 Cincinnati, OH (1979) (5) DeWalle FB, Chain ESK; Proc Ind Waste Conf 32: 908-19 (1978) (6) Ohio R Valley Water Sanit Comm; Assessment of Water Quality Conditions, Ohio River Mainstream 1978-9, Cincinnati, OH p T-53 (1980) (7) Konasewich D et al; Status report on organic and heavy metal contaminants in the Lakes Erie, Michigan, Huron and Superior basins, Great Lakes Qual Board 373p (1978)]**PEER REVIEWED**

SURFACE WATER: Various estuaries were studied for the concns of several pollutants. From 1987-89, **chloroform** was detected in the Scheldt, Netherlands/Belgium estuary ranging from <10-1640 ng/l whereas in 1993, it was detected at 42.6 ng/l(1). In 1992, **chloroform** was detected in the Humber, Tees, Tyne, Wear, and Tweed estuaries (all located in the U.K.) ranging from <10-16.2, <10-11,500, <10-239, <10-199, and <10 ng/l, respectively(1). In 1990, **chloroform** was detected in the Forth (U.K.) and Rhine (Netherlands) estuaries ranging from <500 and 3-10 ng/l, respectively(1). From 1987-89, **chloroform** was detected in the Mersey(U.K.) estuary ranging from 200-5,200 ng/L(1). In February and May of 1977, **chloroform** was detected in Back River (U.S.A.) ranging from <120-49000 and 120-12500 ng/l, respectively(1). The main factor determining the estuarine VOC concn is the proximity of industrial sites(1). **Chloroform** was also detected in fjord waters at Stenungsundfjorden (Sweden) in 1988 ranging from 5.4-14.8 ng/l and in shelf sea waters off the Belgian Continental Shelf in 1993 ranging from 11.3-17.4 ng/l(1). In August 1972, **chloroform** concns in the North East Atlantic were measured ranging from 4-13 ng/l(1).
[(1) Dewulf J, Van Langenhove H; Wat Res 31: 1825-38 (1997)]**PEER REVIEWED**

RAIN/FOG/SNOW: Detected in rain and snow in Japan(1,2) and 250 parts per trillion rain in West Los Angeles(3). **Chloroform** concns in clouds was investigated from samples collected above the canopy of

a coniferous forest during several days between May and October 1987 and May and July 1988 at Mt. Mitchell State Park, NC(4). The avg concn detected in the cloud water samples was 2.41 ng/ml (range 0-10 ng/ml) while avg air concns were 1.19 ng/l and avg rain concns 241 ng/l(4). The deposition via clouds was estimated to be 1.27X10+6 ng/sq m yr(4).
[(1) Kato T et al; Yokohama Kokuritsu Daigaku Kankyo Kagaku Kenkya Senta Kiyo 6: 11-20 (1980) (2) Morita M et al; Kokyo Toritsu Eisei Kenkyusho Kenkyu Nempo 25: 399-403 (1974) (3) Kawamura K, Kaplan IR; Environ Sci Technol 17: 497-501 (1983) (4) Aneja VP; J Air Waste Manage 43: 1239-44 (1993)]**PEER REVIEWED**

Effluent Concentrations:

Rubber and chemical companies - Louisville, KY 22 ppm max(1). Industries whose wastewater levels of **chloroform** exceed a mean level of 500 ppb are auto and other laundries, aluminum forming, pharmaceuticals, and pulp and paper mills; the pharmaceutical industry contributes the largest amount of **chloroform** with mean and max wastewater concn of 49 and 280 ppb, respectively (2). Auto exhausts typically 27 ug/cu m(1).
[(1) USEPA; Ambient Water Quality Criteria for Chloroform. EPA-440/5-80-033 pp C-1 to C-5 (1980) (2) USEPA; Treatability Manual. EPA-600/2-82-001a pp I.12.3-1 to I.12.3-5]**PEER REVIEWED**

Chloroform was detected at 245 ppm in the gas effluent emitted from a Municipal Landfill Site (MLS) in Palos Verdes, CA(1). A study of compounds found in automobile exhaust revealed that **chloroform** was not present(2). During the chlorite bleaching of kraft pulp, a variety of organic chlorinated compounds can be formed(3). Of these, **chloroform** has been found to be the main volatile organochlorine compound formed(3). The effluent from a kraft pulp mill using chlorite bleaching prior to treatment and the effluent following activated sludge waste water treatment revealed **chloroform** concns at 180 and 34 ug/l, respectively(3). At another mill, concns before and after treatment were 6.2 and 1.6 ug/l while at a third mill concns were 16 ug/l and not detected(3). In 1993, the Toxic Release Inventory (TRI) System reported that 175 facilities had emissions of 13.8 million lb of **chloroform** to air, another 450,000 lb to water, and 70,000 lb to land(4). The facilities with the largest emission (100,000 to 700,000 lb) were pulp and paper plants(4).
[(1) Brosseau J, Heitz M; Atmos Environ 28: 285-93 (1994) (2) Hasanen E et al; Atmos Environ 13: 1217-9 (1979) (3) Juuiti S et al; Chemosphere 33: 2431-2440 (1996) (4) Wallace LA; Crit Rev Environ Sci Technol 27: 113-94 (1997)]**PEER REVIEWED**

Sediment/Soil Concentrations:

Not detected in sediment at an industrial location on US river(1). Not detected in Back River sediment off Baltimore(2).
[(1) Jungclaus GA et al; Environ Sci Technol 12: 88-96 (1978) (2) Helz GR, Hsu RY; Limnol Oceanogr 23: 858-69 (1978)]**PEER REVIEWED**

Atmospheric Concentrations:

URBAN/SUBURBAN: Airborne concns and sources of **chloroform** were evaluated in two urban areas in Illinois: southeast Chicago and East St. Louis between May 1986-April 1990(1). The avg concn of **chloroform** found in 103 air samples from Chicago was 0.3 ug/cu m (max 1.6 ug/cu m) and from 83 air samples from East St. Louis was 0.5 ug/cu m (max 6.6 ug/cu m)(1). The contribution of **chloroform** to Chicago's atmosphere was due to both waste water treatment and chemical plant emissions(1). The Illinois Department of Energy and Natural Resources estimate that Southeast Chicago contributes 12 tons of **chloroform** per year while East St. Louis contributes 9 tons/year(1). Twelve hour avg outdoor concns of **chloroform** in California (from 1984-1987) ranged from 0.2 to 0.6 ug/cu m while outdoor air concns in New Jersey (from 1981-1983) ranged from 0.1 to 1.5 ug/cu m(2). In another study of air from

Los Angeles, CA, 2,251 24-hr air samples had an avg concn of 0.16 ug/cu m between the years 1986-1991(2). Outdoor air measurements made in chemical manufacturing areas sometimes show higher **chloroform** values(2). Studies in the Kanawha Valley from 1986-1988 indicated mean outdoor concns of 11.5 ug/cu m near a major chemical manufacturing facility in Belle, WV(2). Mean values of 3 ug/cu m were observed at two other sites (Institute, WV and South Charleston, WV)(2). Compared to mean personal exposures of indoor air concns, these outdoor values are often lower by factors of 2 to 8(2).
[(1) Sweet CW, Vermette SJ; Environ Sci Technol 26: 165-173 (1992) (2) Wallace LA; Crit Rev Environ Sci Technol 27: 113-94 (1997)]**PEER REVIEWED**

INDOOR: Studies have shown that **chloroform** in indoor air was present at four to five times the outdoor air level, and that levels could be higher still in the shower(1). Subsequent studies verified that inhalation exposure during showers might be comparable to ingestion of 1 to 6 L of drinking water a day(1). Mean indoor air concns of **chloroform** over 12 hr periods during June 1987 in Los Angeles, CA were found to be 1.4 ug/cu m at night in the kitchen, 1.1 ug/cu m during the day in the kitchen and 0.90 during the day in the living room(1). In another study, **chloroform** concns in air from a shower using water from a municipal water supply revealed that **chloroform** concns increased from 2 to 100 ppb (10 to 500 ug/cu m) during the 10 minute shower(1). In a similar study, 19 10-minute showers using water at 40 deg C and **chloroform** concns ranging from 12.9 to 40.0 ug/l resulted in air concns in the shower stall ranging from 69-327 ug/cu m(1). The ultimate source of most of the **chloroform** in indoor air in most homes is evaporation from chlorinated water(1). Major uses of water in the home include showers, baths, clothes washing and dish washing(1). Several studies of indoor swimming pools indicate that inhalation can provide substantial amounts of **chloroform**(1).
[(1) Wallace LA; Crit Rev Environ Sci Technol 27: 113-94 (1997)]**PEER REVIEWED**

US RURAL/REMOTE - 532 samples 40 parts per trillion avg(1); Northern Hemisphere - background 17.1 parts per trillion avg(2) US URBAN/SUBURBAN - 1739 samples, 72 parts per trillion avg(1); US SOURCE DOMINATED AREAS - 306 samples, 820 parts per trillion avg(1). 11 highly industrialized US locations, 0-10.9 ppb(3); 10 US cities 32-703 parts per trillion avg, 5112 parts per trillion max(4-6); 3 areas in NJ, 710 parts per trillion avg, 15% pos avg of pos samples approx 4 ppb(7).
[(1) Brodzinsky R, Singh HB; Volatile organic chemicals in the atmosphere: an assessment of available data. SRI Inter EPA contract 68-02-3452 Menlo Park, CA (1982) (2) Singh HB; Geophys Res Lett 4: 101-4 (1977) (3) Pellizzari ED; Quantification of chlorinated hydrocarbons in previously collected air samples. EPA-450/3-78-112 (1978) (4) Singh HB et al; Atmos Environ 15: 601-12 (1981) (5) Singh HB et al; Atmospheric measurements of selected hazardous organic chemicals. USEPA-600/53-81-032 (1981) (6) Singh HB et al; Environ Sci Technol 16: 372-80 (1982) (7) Bozzelli JW, Kebbekus BB; J Environ Sci Health 17: 693-713 (1982)]**PEER REVIEWED**

RURAL/REMOTE: Rural air samples near Champaign, IL (8 km south of Bondville, IL) were studied from February 1987 to April 1990 for various volatile organic compounds(1). The avg concn of **chloroform** found in 23 air samples was 0.3 ug/cu m (max 0.4 ug/cu m)(1). There were no point sources within 10 km and the site was at least 50 km downwind of urban areas during times of prevailing winds(1).
[(1) Sweet CW, Vermette SJ; Environ Sci Technol 26: 165-173 (1992)]**PEER REVIEWED**

Food Survey Values:

In pilot market basket survey of 4 food groups at 5 sites, the results for **chloroform** were: dairy composite 17 ppb (1 of 5 sites), meat composite - not detected; oil and fat composite - trace (1 of 5 sites); beverage composite 6-32 ppb (4 of 5 sites); high values for individual foods were soft drinks 9-178 ppb; butter 56 ppb; cheese 15-17 ppb; mayonaise 34 ppb(1). England: various samples of food including dairy products, eggs, bread, meat, oils and fats, beverages, fruits and vegetables 0.4-33 ppb,

cheese, butter and tea were high(2). Residues were found in fumigated sorghum, barley and corn but generally disappeared within 60 days when aired at 17 deg C(3).
[(1) Entz RC et al; J Agric Food Chem 30: 846-9 (1982) (2) McConnell G et al; Endeavor 34: 13-8 (1975) (3) IARC; Monograph. Some Halogenated Hydrocarbons 20: 407 (1979)]**PEER REVIEWED**

A pilot study was conducted in 1980 to measure **chloroform** in five "Market Basket" food samples collected from grocery stores in New Jersey, North Carolina, and Washington, D.C.(1). **Chloroform** concns in cola soft drinks avgd 49 ug/l while in non-cola soft drinks 11 ug/l(1). A typical **chloroform** level in soft drinks is about 23 ug/l(1). One of the five dairy composites also contained **chloroform**: milk and cheese avgd 4 ng/g and one butter samples contained 12 ng/g(1). Ice cream and mayonnaise also contained **chloroform** at 12 and 23 ng/g, respectively(1). Another FDA study of VOCs in margarines detected **chloroform** in 5 of 18 samples collected at stores and in 13 of 19 finished products collected at manufacturing plants(1). The levels were much higher at the manufacturing plants than in the stores, with two samples between 100 and 150 ng/g and ten others between 15 and 50 ng/g. It was later determined that VOCs migrated from the packaging glues into the margarine(1). In a study of 18 table-ready food items, ten contained **chloroform** with the highest levels occuring in butter 670 ng/g, Cheddar cheese 80 ng/g, granola 57 ng/g, and peanut butter 29 ng/g(1). Mean values of 14 samples of butter was 364 ng/g; 8 samples of cheese 182 ng/g; 11 samples of cereal 60 ng/g; 7 samples of peanut butter 51.3 ng/g; and 12 samples of highly processed foods 122 ng/g(1). The sources of **chloroform** in food are not clearly understood however migration of **chloroform** from packaging solvents, glues, and inks has been documented(1).
[(1) Wallace LA; Crit Rev Environ Sci Technol 27: 113-94 (1997)]**PEER REVIEWED**

Fish/Seafood Concentrations:

Great Britain: various species of marine fish 5-851 ppb(1,2); marine invertebrates 2-1040 ppb(1,2).
[(1) Dickson AG, Riley JP; Marine Pollut Bull 7: 167-9 (1976) (2) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-32 (1975)]**PEER REVIEWED**

Animal Concentrations:

England: grey seal 7.6-22 ppb (blubber), 0-12 ppb (liver); marine and freshwater birds 0.7-65 ppb(1).
[(1) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-32 (1975)]**PEER REVIEWED**

Milk Concentrations:

US - 4 urban sites: mothers' milk 7 of 8 samples pos detected, not quantified.
[Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982)]**PEER REVIEWED**

A study of human milk and pasteurized and unpasteurized cow's milk from a suburban area of Turku, Finland was conducted to determine possible **chloroform** levels(1). **Chloroform** concns in pasteurized cow's milk ranged from undetectable to 3.1 ug/l while **chloroform** was not detected in either human or unpasteurized cow's milk(1).
[(1) Wallace LA; Crit Rev Environ Sci Technol 27: 113-94 (1997)]**PEER REVIEWED**

Environmental Standards & Regulations:

TSCA Requirements:

Pursuant to section 8(d) of TSCA, EPA promulgated a model Health and Safety Data Reporting Rule. The section 8(d) model rule requires manufacturers, importers, and processors of listed chemical

substances and mixtures to submit to EPA copies and lists of unpublished health and safety studies. **Chloroform** is included on this list.
[40 CFR 716.120 (7/1/99)]**PEER REVIEWED**

CERCLA Reportable Quantities:

Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 10 lb or 4.54 kg. The toll free number of the NRC is (800) 424-8802; In the Washington D.C. metropolitan area (202) 426-2675. The rule for determining when notification is required is stated in 40 CFR 302.4 (section IV. D.3.b).
[40 CFR 302.4 (7/1/99)]**PEER REVIEWED**

Releases of CERCLA hazardous substances are subject to the release reporting requirement of CERCLA section 103, codified at 40 CFR part 302, in addition to the requirements of 40 CFR part 355. **Chloroform** is an extremely hazardous substance (EHS) subject to reporting requirements when stored in amounts in excess of its threshold planning quantity (TPQ) of 10,000 lbs.
[40 CFR 355 (7/1/99)]**PEER REVIEWED**

RCRA Requirements:

U044; As stipulated in 40 CFR 261.33, when **chloroform**, as a commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate, becomes a waste, it must be managed according to Federal and/or State hazardous waste regulations. Also defined as a hazardous waste is any residue, contaminated soil, water, or other debris resulting from the cleanup of a spill, into water or on dry land, of this waste. Generators of small quantities of this waste may qualify for partial exclusion from hazardous waste regulations (40 CFR 261.5).
[40 CFR 261.33 (7/1/99)]**PEER REVIEWED**

D022; A solid waste containing **chloroform** may or may not become characterized as a hazardous waste when subjected to the Toxicity Characteristic Leaching Procedure listed in 40 CFR 261.24, and if so characterized, must be managed as a hazardous waste.
[40 CFR 261.24 (7/1/99)]**PEER REVIEWED**

Atmospheric Standards:

This action promulgates standards of performance for equipment leaks of Volatile Organic Compounds (VOC) in the Synthetic Organic Chemical Manufacturing Industry (SOCMI). The intended effect of these standards is to require all newly constructed, modified, and reconstructed SOCMI process units to use the best demonstrated system of continuous emission reduction for equipment leaks of VOC, considering costs, non air quality health and environmental impact and energy requirements. **Chloroform** is produced, as an intermediate or a final product, by process units covered under this subpart.
[40 CFR 60.489 (7/1/99)]**PEER REVIEWED**

Listed as a hazardous air pollutant (HAP) generally known or suspected to cause serious health problems. The Clean Air Act, as amended in 1990, directs EPA to set standards requiring major sources to sharply reduce routine emissions of toxic pollutants. EPA is required to establish and phase in specific performance based standards for all air emission sources that emit one or more of the listed pollutants. **Chloroform** is included on this list.
[Clean Air Act as amended in 1990, Sect. 112 (b) (1) Public Law 101-549 Nov. 15,

1990]**PEER REVIEWED**

Chloroform has been designated as a hazardous air pollutant under section 112 of the Clean Air Act.
[40 CFR 61.01 (7/1/99)]**PEER REVIEWED**

Clean Water Act Requirements:

Based on the consumption of 2 l of drinking water and consumption of 6.5 g of fish and shellfish, the corresponding cancer risk levels and criteria are 1X10-7: 0.019 ug/l; 1X10-6: 0.19 ug/l; 1X10-5: 1.90 ug/l. Based on consumption of fish and shellfish only, the corresponding cancer risk levels and criteria are 1X10-7: 1.57 ug/l; 1X10-6: 15.7 ug/l; 1X10-5: 157 ug/l.
[USEPA; Ambient Water Quality Criteria Doc: Chloroform E.39 (1980) EPA 440/5-80-033]**QC REVIEWED**

Toxic pollutant designated pursuant to section 307(a)(1) of the Federal Water Pollution Control Act and is subject to effluent limitations.
[40 CFR 401.15 (7/1/99)]**QC REVIEWED**

Chloroform is designated as a hazardous substance under section 311(b)(2)(A) of the Federal Water Pollution Control Act and further regulated by the Clean Water Act Amendments of 1977 and 1978. These regulations apply to discharges of this substance. This designation includes any isomers and hydrates, as well as any solutions and mixtures containing this substance.
[40 CFR 116.4 (7/1/99)]**QC REVIEWED**

The maximum contaminant level (MCL) set forth by the National Primary Drinking Water Regulations for organic chemicals including total trihalomethanes (the sum of the concentrations of bromodichloromethane, dibromochloromethane, tribromomethane (bromoform) and **trichloromethane** (**chloroform**)) is 0.10 mg/l. /Total trihalomethanes/
[40 CFR 141.12 (7/1/99)]**QC REVIEWED**

Federal Drinking Water Standards:

EPA 80 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

State Drinking Water Guidelines:

(AZ) ARIZONA 0.49 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(FL) FLORIDA 6 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(MA) MASSACHUSETTS 5 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(MN) MINNESOTA 60 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee

(FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(NH) NEW HAMPSHIRE 6.0 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(WI) WISCONSIN 6 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

FDA Requirements:

FDA BANNED USE OF **CHLOROFORM** AS INGREDIENT (ACTIVE OR INACTIVE) IN HUMAN DRUG & COSMETIC PRODUCTS AS OF JULY 29, 1976.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 404 (1979)]**PEER REVIEWED**

Chloroform is an indirect food additive for use only as a component of adhesives.
[21 CFR 175.105 (4/1/99)]**PEER REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

C-H-Cl3
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 300]**PEER REVIEWED**

Molecular Weight:

119.38
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 357]**PEER REVIEWED**

Color/Form:

Clear, colorless liquid
[Prager, J.C. Environmental Contaminant Reference Databook Volume 1. New York, NY: Van Nostrand Reinhold, 1995. 453]**PEER REVIEWED**

Colorless, highly refractive, heavy volatile liquid.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 256]**PEER REVIEWED**

Odor:

Pleasant, etheric, nonirritating
[Prager, J.C. Environmental Contaminant Reference Databook Volume 1. New York, NY: Van Nostrand Reinhold, 1995. 453]**PEER REVIEWED**

Pleasant odor.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140.

Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

Odor threshold: 205-307 ppm
[Weiss, G.; Hazardous Chemicals Handbook. 1986, Noyes Data Corporation, Park Ridge, NJ 1986. 261]**PEER REVIEWED**

Taste:

Sweet taste
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 256]**PEER REVIEWED**

Boiling Point:

61.2 deg C
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 256]**PEER REVIEWED**

Melting Point:

-63.2 deg C
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V5 (93) 1052]**PEER REVIEWED**

Corrosivity:

Liquid **chloroform** will attack some forms of plastics, rubber, and coatings.
[Prager, J.C. Environmental Contaminant Reference Databook Volume 1. New York, NY: Van Nostrand Reinhold, 1995. 453]**PEER REVIEWED**

Critical Temperature & Pressure:

Critical temperature: 506 deg F= 263.2 deg C= 536.4 K; Critical pressure: 790 psia= 54 atm= 5.5 Mn/sq m
[Weiss, G.; Hazardous Chemicals Handbook. 1986, Noyes Data Corporation, Park Ridge, NJ 1986. 261]**PEER REVIEWED**

Density/Specific Gravity:

Specific gravity: 1.4835 @ 20 deg C/20 deg C
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 256]**PEER REVIEWED**

Heat of Combustion:

Not pertinent
[Weiss, G.; Hazardous Chemicals Handbook. 1986, Noyes Data Corporation, Park Ridge, NJ 1986. 261]**PEER REVIEWED**

Heat of Vaporization:

106.7 BTU/lb= 59.3 cal/g= 2.483X10+5 J/kg
[Weiss, G.; Hazardous Chemicals Handbook. 1986, Noyes Data Corporation, Park Ridge, NJ 1986. 261]**PEER REVIEWED**

Octanol/Water Partition Coefficient:

log Kow= 1.97
[Hansch, C., Leo, A., D. Hoekman. Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. Washington, DC: American Chemical Society., 1995. 3]**PEER REVIEWED**

Solubilities:

Sol in carbon disulfide
[Prager, J.C. Environmental Contaminant Reference Databook Volume 1. New York, NY: Van Nostrand Reinhold, 1995. 453]**PEER REVIEWED**

Water solubility = 7,710 mg/l at 25 deg C
[Dewulf J, VanLangenhove H; Wat Res 31: 1825-38 (1997)]**PEER REVIEWED**

Miscible with alcohol, ether, benzene, carbon tetrachloride, fixed and volatile oils.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 356]**PEER REVIEWED**

In water, 3.81 g/kg @ 25 deg C
[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed.Vol A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present.,p. VA6 (86) 238]**PEER REVIEWED**

Spectral Properties:

[Lillian D et al; Environ Sci Technol 9: 1042-8 1975) as cited in USEPA; Water-Related Environ Fate of 129 Priority Pollutants p.40-2 (1979) USEPA 440/4-79-0296] Absorbs UV maximally at 175 nm
[Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume I. EPA-440/4 79-029a. Washington, DC: U.S. Environmental Protection Agency, December 1979.]**PEER REVIEWED**

SADTLER REF NUMBER: 2224 (IR, PRISM)
[Weast, R.C. (ed.). Handbook of Chemistry and Physics. 60th ed. Boca Raton, Florida: CRC Press Inc., 1979.,p. C-375]**PEER REVIEWED**

Index of refraction: 1.4422 @ 25 deg C/D
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 256]**PEER REVIEWED**

IR: 305 (Sadtler Research Laboratories IR Grating Collection)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 842]**PEER REVIEWED**

NMR: 10513 (Sadtler Research Laboratories Spectral Collection)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 842]**PEER REVIEWED**

MASS: 445 (Atlas of Mass Spectral Data, John Wiley & Sons, New York)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 842]**PEER REVIEWED**

Intense mass spectral peaks: 83 m/z, 118 m/z
[Pfleger, K., H. Maurer and A. Weber. Mass Spectral and GC Data of Drugs, Poisons and their Metabolites. Parts I and II. Mass Spectra Indexes. Weinheim, Federal Republic of Germany. 1985.147]**PEER REVIEWED**

Surface Tension:

27.1 dynes/cm= 0.0271 N/M @ 20 deg C
[Weiss, G.; Hazardous Chemicals Handbook. 1986, Noyes Data Corporation, Park Ridge, NJ 1986. 261]**PEER REVIEWED**

Vapor Density:

4.12 (Air= 1)
[Weiss, G.; Hazardous Chemicals Handbook. 1986, Noyes Data Corporation, Park Ridge, NJ 1986. 261]**PEER REVIEWED**

Vapor Pressure:

197 mm Hg at 25 deg C
[Boublik, T., Fried, V., and Hala, E., The Vapour Pressures of Pure Substances. Second Revised Edition. Amsterdam: Elsevier, 1984.]**PEER REVIEWED**

Relative Evaporation Rate:

11.6 (butyl acetate= 1)
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Viscosity:

5.63 millipoises at 20 deg C; 5.10 millipoises at 30 deg C
[Prager, J.C. Environmental Contaminant Reference Databook Volume 1. New York, NY: Van Nostrand Reinhold, 1995. 453]**PEER REVIEWED**

Other Chemical/Physical Properties:

Liquid-Water Interfacial Tension: 32.8 dynes/cm= 0.0328 N/m at 20 deg C
[Prager, J.C. Environmental Contaminant Reference Databook Volume 1. New York, NY: Van Nostrand Reinhold, 1995. 453]**PEER REVIEWED**

Ratio of specific heats of vapor: 1.146
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Weight per gallon at 25 deg C: 12.29 lb
[Weiss, G.; Hazardous Chemicals Handbook. 1986, Noyes Data Corporation, Park Ridge, NJ 1986. 261]**PEER REVIEWED**

Partition coefficients at 25 deg C for **chloroform** into blood= 8.4; into oil= 394.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V2 (92) 781]**PEER REVIEWED**

Ionization potential: 11.42 eV
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

Heat of fusion: 17.62 cal/g
[Weast, R.C. (ed.) Handbook of Chemistry and Physics. 69th ed. Boca Raton, FL: CRC Press Inc., 1988-1989.,p. C-666]**PEER REVIEWED**

Heat capacity @ 20 deg C: 0.979 kJ/kg.K; critical density: 500 kg/cu m; critical vol: 0.002 cu m/kg; thermal conductivity @ 20 deg C: 0.130 W/m.K; coefficient of cubical expansion: 0.001399; dielectric constant @ 20 deg C: 4.9; dipole moment: 3.84X10-30 C.m; heat of formation @ 25 deg C: -89.66 MJ/kg.mole (gas), -120.9 MJ/kg.mole (liq); latent heat of evaporation @ bp: 247 kJ/kg
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V5 (93) 10525(79) 695]**PEER REVIEWED**

The azeotrope with water boils @ 56.1 deg C and contains 97.2% **chloroform**. The ternary azeotrope with ethanol and water boils @ 55.5 deg C and contains 4 mol% alcohol and 3.5 mol% water. At 25 deg C, **chloroform** dissolves 3.59 times its volume of carbon dioxide.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V5 (93) 1053]**PEER REVIEWED**

Chloroform forms azeotropes with acetone, 2-bromopropane, 2-butanone, ethanol, ethyl formate, formic acid, n-hexane, isopropanol, methanol, methyl acetate, and water.
[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed.Vol A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present.,p. VA6 (86) 238]**PEER REVIEWED**

Mobile liquid
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V1 61 (1979)]**PEER REVIEWED**

Vapor pressure= 100 mm Hg @ 10.4 deg C
[Prager, J.C. Environmental Contaminant Reference Databook Volume 1. New York, NY: Van Nostrand Reinhold, 1995. 453]**PEER REVIEWED**

Henry's Law constant = 3.67X10-3 atm-cu m/mol at 24 deg C
[Gossett JM; Environ Sci Tech 21: 202-6 (1987)]**PEER REVIEWED**

Hydroxyl radical rate constant= 1.03X10-13 cu cm/molecule-sec @ 25 deg C
[Atkinson R; J Phys Chem Ref Data Monograph No. 1 (1989)]**PEER REVIEWED**

Chemical Safety & Handling:

Hazards Summary:

The major hazards encountered in the use and handling of **chloroform** stem from its toxicologic properties. Toxic effects may be exerted from all routes of exposure (ie, ingestion, dermal, or inhalation). Aside from possible contact burns or irritation to the skin and eyes, the range of acute effects from exposure to **chloroform** include dizziness, headache, nausea, CNS depression, cardiac arrhythmia, and death. Chronic exposure may result in damage (sometimes fatal) to the liver and kidneys. OSHA has set the PEL at 50 ppm, while the ACGIH recommends a TLV of 10 ppm. These levels notwithstanding, contact with **chloroform** also should be protected against by wearing impervious clothing (PVC and rubber are not suitable), and a full facepiece self-contained breathing apparatus operated in positive pressure mode. Non-impervious clothing which becomes wet with **chloroform** should be promptly removed and any contaminated skin washed with soap and water. Only authorized personnel should be permitted in areas where **chloroform** exposure may occur. **Chloroform** will not ignite easily, but it may burn with the emission of highly toxic (eg, phosgene) and irritating gases. If **chloroform** is involved in a fire, extinguish the fire using an agent suitable for the type surrounding material. Wear protective equipment as stated above. Fire-control water should be diked, as necessary, to prevent **chloroform** from entering water sources and sewers. **Chloroform** reacts explosively with chemically-reactive metals (eg, aluminum or magnesium powder, sodium, and lithium), strong oxidizers, and strong caustics (eg,

alkalis), and decomposes in sunlight. Therefore, **chloroform** should be stored away from such materials and in a dark, cool, dry, well-ventilated areas. While **chloroform** has a pleasant, etheric odor, this clear, colorless liquid also has the ability to cause olfactory fatigue and, therefore, warning of its presence is not assured. For this reason, and because its decomposition by prolonged exposure to air can result in accumulation of phosgene, **chloroform** should be kept in tightly closed containers affixed with the label, "Poison". Containers may be transported by air, rail, road, or water. Small spills of **chloroform** should be absorbed with vermiculite, dry sand, or earth and collected for disposal. Large land spills should be diked (eg, with soil or sand bags) and the bulk liquid absorbed (eg, with fly ash or cement powder), or contained in an excavated pit, pond, or other holding area that has been sealed with an impermeable flexible membrane liner. Spills of **chloroform** in bodies of water may first need to be trapped at the bottom with sand bag barriers and treated with activated carbon. Trapped material is then removed by suction hose, mechanical lifts, or dredges. Collected **chloroform** is a candidate for liquid injection, rotary kiln, or fluidized bed incineration. Before implementing any plans for permanent land disposal, consult with environmental regulatory agencies.
PEER REVIEWED

DOT Emergency Guidelines:

Health: Highly toxic, may be fatal if inhaled, swallowed or absorbed through skin. Avoid any skin contact. Effects of contact or inhalation may be delayed. Fire may produce irritating, corrosive and/or toxic gases. Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution.

[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Fire or explosion: Non-combustible, substance itself does not burn but may decompose upon heating to produce corrosive and/or toxic fumes. Containers may explode when heated. Runoff may pollute waterways.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Public safety: CALL Emergency Response Telephone Number. ... Isolate spill or leak area immediately for at least 25 to 50 meters (80 to 160 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Keep out of low areas.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Protective clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Wear chemical protective clothing which is specifically recommended by the manufacturer. It may provide little or no thermal protection. Structural firefighters' protective clothing provides limited protection in fire situations ONLY; it is not effective in spill situations.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Evacuation: ... Fire: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Fire: Small fires: Dry chemical, CO2 or water spray. Large fires: Water spray, fog or regular foam. Move containers from fire area if you can do it without risk. Dike fire control water for later disposal; do not scatter the material. Use water spray or fog; do not use straight streams. Fire involving tanks or car/trailer loads: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Do not get water inside containers. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible withdraw from area and let fire burn.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Spill or leak: Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. Cover with plastic sheet to prevent spreading. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. DO NOT GET WATER INSIDE CONTAINERS.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

First aid: Move victim to fresh air. Call 911 or emergency medical service. Apply artificial respiration if victim is not breathing. Do not use mouth-to-mouth method if victim ingested or inhaled the substance; induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory medical device. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. For minor skin contact, avoid spreading material on unaffected skin. Keep victim warm and quiet. Effects of exposure (inhalation, ingestion or skin contact) to substance may be delayed. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-151]**QC REVIEWED**

Odor Threshold:

3.30 mg/l (Detection in air; purity not specified)
[Fazzalari, F.A. (ed.). Compilation of Odor and Taste Threshold Values Data. ASTM Data Series DS 48A (Committee E-18). Philadelphia, PA: American Society for Testing and Materials, 1978. 36]**PEER REVIEWED**

Odor thresholds: low= 250 mg/cu m; high= 1000 mg/cu m. /From table/
[Ruth JH; Am Ind Hyg Assoc J 47: A-142-51 (1986)]**PEER REVIEWED**

Odor thresholds of 85 ppm and 2.4 ppm have been reported for **chloroform** in air and water, respectively.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.289]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Skin and eye irritant
[Winslow S, Gerstner H; Health Aspects of Chloroform - A Review p.6-9 (1977) ORNL/TIRC-77/4]**PEER REVIEWED**

Threshold of irritation: 20480 mg/cu m
[Ruth JH; Am Ind Hyg Assoc J 47: A-142-51 (1986)]**PEER REVIEWED**

Fire Fighting Procedures:

If material involved in fire: Extinguish fire using agent suitable for type of surrounding fire. (Material itself does not burn or burns with difficulty.)
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 243]**PEER REVIEWED**

Toxic Combustion Products:

Liberates phosgene when heated or involved in fire.
[ITII. Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1988. 121]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

Mixtures with dinitrogen tetraoxide are explosive when subjected to shock of 25 g TNT equiv or less.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1352]**PEER REVIEWED**

Chloroform and acetone interact vigorously & exothermally in presence of solid potassium hydroxide or calcium hydroxide to form 1,1,1-trichloro-2-hydroxy-2-methylpropane. A laboratory incident involving the bursting of a solvent residues bottle was attributed to this reaction.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 132]**PEER REVIEWED**

A **chloroform**-methanol mixture was put into a drum contaminated with sodium hydroxide. A vigorous reaction set in, and the drum exploded. **Chloroform** normally reacts slowly with sodium hydroxide owing to the insolubility of the latter. The presence of methanol (or other solubilizer) increases the rate of reaction by increasing the degree of contact between **chloroform** and alkali.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 133]**PEER REVIEWED**

OXIDIZED BY STRONG OXIDIZING AGENTS SUCH AS CHROMIC ACID, WITH FORMATION OF PHOSGENE & CHLORINE GAS
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 402 (1979)]**PEER REVIEWED**

Heating aluminum powder with carbon tetrachloride-**chloroform** mixtures in closed systems to 152 deg C may cause an explosion, particularly if traces of aluminum chloride are present.
[Bretherick L; Hdbk Reac Chem Hazard p.161 (1975)]**PEER REVIEWED**

Contact of 1.5 g portions of the solid potassium tert-butoxide with drops of liquid **chloroform** caused ignition after 0 min, and with vapors of **chloroform** caused ignition after 2 min.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 475]**PEER REVIEWED**

Triisopropylphosphine reacts, when undiluted, rather vigorously with **chloroform**.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 794]**PEER REVIEWED**

Disilane ... reacts vigorously with incandescence in contact with **chloroform**.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-78]**PEER REVIEWED**

Chloroform with various alkali metals is impact-sensitive as follows: weak explosion with lithium; fairly strong with sodium; strong with potassium; and violent with sodium-potassium.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-108]**PEER REVIEWED**

A violent explosion occurs if a soln of perchloric acid in **chloroform** is poured on phosphorus pentoxide.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-150]**PEER REVIEWED**

When 1 g of sodium hydroxide was added to a mixture of 1 ml methanol and 1 ml **chloroform**, an exothermic reaction occurred. Potassium hydroxide and other alkalies may replace sodium hydroxide as a reactant.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-179]**PEER REVIEWED**

Incompatible with dinitrogen tetraoxide, fluorine, metals, or triisopropylphosphine.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 775]**PEER REVIEWED**

CHLOROFORM ... EXPLODES WHEN IN CONTACT WITH ALUMINUM POWDER OR MAGNESIUM POWDER.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-14]**PEER REVIEWED**

Strong caustics; chemically-active metals such as aluminum or magnesium powder, sodium & potassium; strong oxidizers [Note: When heated to decomposition forms phosgene gas].
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

Explosive reaction with sodium + methanol or sodium methoxide + methanol. Mixtures with sodium or potassium are impact sensitive explosives.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 775]**PEER REVIEWED**

Hazardous Decomposition:

The products of oxidative breakdown include phosgene, hydrogen chloride, chlorine, carbon dioxide, and water.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 5(79) 694]**PEER REVIEWED**

On prolonged heating with water @ 225 deg C, decomp to formic acid, carbon monoxide, and hydrogen chloride occurs.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 5(79) 694]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH recommends that **chloroform** be regulated as a potential human carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

Protective Equipment & Clothing:

When handling /**chloroform**/, use safety glasses, self-contained breathing apparatus, protective clothing. Note: Polyvinyl chloride and rubber are unsuitable materials for protective clothing.
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 7-1]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Dispensers of liq detergent /should be available./ ... Safety pipettes should be used for all pipetting. ... In animal laboratory, personnel should ... wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. ... Gowns ... /should be/ of distinctive color, this is a reminder that they are not to be worn outside the laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

Personnel protection: ... Wear appropriate chemical protective gloves, boots and goggles.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 243]**PEER REVIEWED**

For **chloroform** some data (usually from emmession tests) suggesting breakthrough times greater than one hour are not likely for butyl rubber.
[ACGIH; Guidelines Select of Chem Protect Clothing Volume #1 Field Guide p.48 (1983)]**PEER REVIEWED**

For **chloroform** breakthrough times (usually significantly less) than one hour reported by (normally) two or more tests for natural rubber, neoprene, neoprene/ natural rubber, nitrile rubber (nitrile) polyethylene (PE), chlorinated polyethylene (CPE) polyvinyl chloride (PVC).
[ACGIH; Guidelines Select of Chem Protect Clothing Volume #1 Field Guide p.48 (1983)]**PEER REVIEWED**

For **chloroform** breakthrough times greater than one hour reported by (normally) two or more tests for polyvinyl alcohol (PVA) and viton.
[ACGIH; Guidelines Select of Chem Protect Clothing Volume #1 Field Guide p.48 (1983)]**PEER REVIEWED**

Wear appropriate personal protective clothing to prevent skin contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

Eyewash fountains should be provided in areas where there is any possibility that workers could be exposed to the substance; this is irrespective of the recommendation involving the wearing of eye protection.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

Facilities for quickly drenching the body should be provided within the immediate work area for emergency use where there is a possibility of exposure. [Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from any body areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.]
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

Recommendations for respirator selection. Condition: At concentrations above the NIOSH REL, or where there is no REL at any detectable concentration. Respirator Class(es): Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode. Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Escape from suddenly occurring respiratory hazards: Respirator Class(es): Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister. Any appropriate escape-type, self-contained breathing apparatus.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

Preventive Measures:

Local exhaust as required to control TLV in air.
[DLA/DOD; Hazardous Materials Info System #6810-00-222-2639 (1982)]**PEER REVIEWED**

Wash thoroughly after handling, avoid breathing vapor, and avoid contact with eyes.
[DLA/DOD; Hazardous Materials Info System #6810-00-222-2639 (1982)]**PEER REVIEWED**

Eating and smoking should not be permitted in areas where liquid **chloroform** is handled, processed, or stored.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Skin that becomes wet with liquid **chloroform** should be promptly washed or showered with soap or mild detergent and water to remove any **chloroform**. Employees who handle **chloroform** should wash their hands thoroughly with soap and mild detergent and water before eating, or smoking.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Where there is any possibility that employees' eyes may be exposed to **chloroform**, an eye-wash fountain should be provided within the immediate work area for emergency use.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Areas in which exposure to **chloroform** may occur should be identified by signs or other appropriate

means, and access to these areas should be limited to authorized persons.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Clothing wet with liquid **chloroform** should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of **chloroform** from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the **chloroform**, the person performing the operation should be informed of **chloroform**'s hazardous properties.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Contact lenses should not be worn when working with this chemical.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

SRP: The scientific literature for the use of contact lenses in industry is conflicting. The benefit or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In any event, the usual eye protection equipment should be worn even when contact lenses are in place.
PEER REVIEWED

PRECAUTIONS FOR "CARCINOGENS": Smoking, drinking, eating, storage of food or of food & beverage containers or utensils, & the application of cosmetics should be prohibited in any laboratory. All personnel should remove gloves, if worn, after completion of procedures in which carcinogens have been used. They should ... wash ... hands, preferably using dispensers of liq detergent, & rinse ... thoroughly. Consideration should be given to appropriate methods for cleaning the skin, depending on nature of the contaminant. No standard procedure can be recommended, but the use of organic solvents should be avoided. Safety pipettes should be used for all pipetting. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": In animal laboratory, personnel should remove their outdoor clothes & wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists),

gloves, hair covering & overshoes. ... clothing should be changed daily but ... discarded immediately if obvious contamination occurs ... /also,/ workers should shower immediately. In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. If gowns are of distinctive color, this is a reminder that they should not be worn outside of lab. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Operations connected with synth & purification ... should be carried out under well-ventilated hood. Analytical procedures ... should be carried out with care & vapors evolved during ... procedures should be removed. ... Expert advice should be obtained before existing fume cupboards are used ... & when new fume cupboards are installed. It is desirable that there be means for decreasing the rate of air extraction, so that carcinogenic powders can be handled without ... powder being blown around the hood. Glove boxes should be kept under negative air pressure. Air changes should be adequate, so that concn of vapors of volatile carcinogens will not occur. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Vertical laminar-flow biological safety cabinets may be used for containment of in vitro procedures ... provided that the exhaust air flow is sufficient to provide an inward air flow at the face opening of the cabinet, & contaminated air plenums that are under positive pressure are leak-tight. Horizontal laminar-flow hoods or safety cabinets, where filtered air is blown across the working area towards the operator, should never be used ... Each cabinet or fume cupboard to be used ... should be tested before work is begun (eg, with fume bomb) & label fixed to it, giving date of test & avg air-flow measured. This test should be repeated periodically & after any structural changes. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Principles that apply to chem or biochem lab also apply to microbiological & cell-culture labs ... Special consideration should be given to route of admin. ... Safest method of administering volatile carcinogen is by injection of a soln. Admin by topical application, gavage, or intratracheal instillation should be performed under hood. If chem will be exhaled, animals should be kept under hood during this period. Inhalation exposure requires special equipment. ... Unless specifically required, routes of admin other than in the diet should be used. Mixing of carcinogen in diet should be carried out in sealed mixers under fume hood, from which the exhaust is fitted with an efficient particulate filter. Techniques for cleaning mixer & hood should be devised before expt begun. When mixing diets, special protective clothing &, possibly, respirators may be required. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When ... admin in diet or applied to skin, animals should be kept in cages with solid bottoms & sides & fitted with a filter top. When volatile carcinogens are given,

filter tops should not be used. Cages which have been used to house animals that received carcinogens should be decontaminated. Cage-cleaning facilities should be installed in area in which carcinogens are being used, to avoid moving of ... contaminated /cages/. It is difficult to ensure that cages are decontaminated, & monitoring methods are necessary. Situations may exist in which the use of disposable cages should be recommended, depending on type & amt of carcinogen & efficiency with which it can be removed. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": To eliminate risk that ... contamination in lab could build up during conduct of expt, periodic checks should be carried out on lab atmospheres, surfaces, such as walls, floors & benches, & ... interior of fume hoods & airducts. As well as regular monitoring, check must be carried out after cleaning-up of spillage. Sensitive methods are required when testing lab atmospheres. ... Methods ... should ... where possible, be simple & sensitive. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Rooms in which obvious contamination has occurred, such as spillage, should be decontaminated by lab personnel engaged in expt. Design of expt should ... avoid contamination of permanent equipment. ... Procedures should ensure that maintenance workers are not exposed to carcinogens. ... Particular care should be taken to avoid contamination of drains or ventilation ducts. In cleaning labs, procedures should be used which do not produce aerosols or dispersal of dust, ie, wet mop or vacuum cleaner equipped with high-efficiency particulate filter on exhaust, which are avail commercially, should be used. Sweeping, brushing & use of dry dusters or mops should be prohibited. Grossly contaminated cleaning materials should not be re-used ... If gowns or towels are contaminated, they should not be sent to laundry, but ... decontaminated or burnt, to avoid any hazard to laundry personnel. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Doors leading into areas where carcinogens are used ... should be marked distinctively with appropriate labels. Access ... limited to persons involved in expt. ... A prominently displayed notice should give the name of the Scientific Investigator or other person who can advise in an emergency & who can inform others (such as firemen) on the handling of carcinogenic substances. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.11]**PEER REVIEWED**

Non-impervious clothing which becomes wet with liquid **chloroform** should be removed promptly and not worn until the **chloroform** is removed ... .
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

If material not involved in fire: Keep material out of water sources and sewers. Build dikes to contain flow as necessary.

[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 243]**PEER REVIEWED**

The worker should immediately wash the skin when it becomes contaminated.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed or replaced.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

Personnel protection: Keep upwind. ... Avoid breathing vapors or dusts. Wash away any material which may have contacted the body with copious amounts of water or soap and water.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 243]**PEER REVIEWED**

Stability/Shelf Life:

Decomposes at ordinary temp in sunlight in the absence of air, and in the dark in the presence of air.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 5(79) 693]**PEER REVIEWED**

... The following shelf lives were recommended: **chloroform** soln and non-sedimented mixtures could be stored in well-closed well-filled containers for 2 mo at ambient temp; when stored in partially-filled containers periodically opened the shelf-life should not exceed 2 wk; sedimented mixtures could be stored for 2 mo in well-closed well-filled containers, but because loss of **chloroform** could be expected in containers periodically opened such mixtures should be prepared as required or packed in their final containers; for **chloroform**-containing mixtures in the home a shelf-life of 2 wk was suggested.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 745]**PEER REVIEWED**

Shipment Methods and Regulations:

No person may /transport,/ offer or accept a hazardous material for transportation in commerce unless that person is registered in conformance ... and the hazardous material is properly classed, described, packaged, marked, labeled, and in condition for shipment as required or authorized by ... /the hazardous materials regulations (49 CFR 171-177)./
[49 CFR 171.2 (7/1/99)]**PEER REVIEWED**

The International Air Transport Association (IATA) Dangerous Goods Regulations are published by the IATA Dangerous Goods Board pursuant to IATA Resolutions 618 and 619 and constitute a manual of industry carrier regulations to be followed by all IATA Member airlines when transporting hazardous materials.
[IATA. Dangerous Goods Regulations. 40th Ed. Montreal, Canada and Geneva, Switzerland: International Air Transport Association, Dangerous Goods Regulations, 1999. 129]**PEER REVIEWED**

The International Maritime Dangerous Goods Code lays down basic principles for transporting hazardous chemicals. Detailed recommendations for individual substances and a number of recommendations for good practice are included in the classes dealing with such substances. A general index of technical names has also been compiled. This index should always be consulted when attempting to locate the appropriate procedures to be used when shipping any substance or article.
[IMDG; International Maritime Dangerous Goods Code; International Maritime Organization p.6103 (1998)]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Procurement ... of unduly large amt ... should be avoided. To avoid spilling, carcinogens should be transported in securely sealed glass bottles or ampoules, which should themselves be placed inside strong screw-cap or snap-top container that will not open when dropped & will resist attack from the carcinogen. Both bottle & the outside container should be appropriately labelled. ... National post offices, railway companies, road haulage companies & airlines have regulations governing transport of hazardous materials. These authorities should be consulted before ... material is shipped. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When no regulations exist, the following procedure must be adopted. The carcinogen should be enclosed in a securely sealed, watertight container (primary container), which should be enclosed in a second, unbreakable, leakproof container that will withstand chem attack from the carcinogen (secondary container). The space between primary & secondary container should be filled with absorbent material, which would withstand chem attack from the carcinogen & is sufficient to absorb the entire contents of the primary container in the event of breakage or leakage. Each secondary container should then be enclosed in a strong outer box. The space between the secondary container & the outer box should be filled with an appropriate quantity of shock-absorbent material. Sender should use fastest & most secure form of transport & notify recipient of its departure. If parcel is not received when expected, carrier should be informed so that immediate effort can be made to find it. Traffic schedules should be consulted to avoid ... arrival on weekend or holiday ... /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

Storage Conditions:

Keep in tightly closed containers; storage code: LI
[DLA/DOD; Hazardous Materials Info System #6810-00-222-2639 (1982)]**PEER REVIEWED**

STORE IN COOL, DRY, WELL-VENTILATED LOCATION. SEPARATE FROM STRONG ALKALIS AND STRONG MINERAL ACIDS.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-39]**QC REVIEWED**

Glass containers should be dark green or amber. Technical-grade **chloroform** can be stored in lead-lined or mild steel containers of all-welded construction. When storage vessels are made of unlined steel, precautions are needed to prevent the entry of moisture.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 5(79) 700]**PEER REVIEWED**

PVC bottles should not be used for storing or dispensing **chloroform** and morphine tincture, aqueous mixtures containing more than 5% thereof, mixtures or dispersions in which **chloroform** was present in excess of its aqueous solubility, aqueous mixtures containing **chloroform** and high concn of electrolytes, or **chloroform** water or mixtures containing it if the period of use would exceed six wk.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 745]**PEER REVIEWED**

Preserve ... at a temp not exceeding 30 deg C.
[USP Convention. The United States Pharmacopeia XXII/National Formulary XVII.

Rockville, MD: United States Pharmacopeial Convention, Inc., 1990. 1920]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Storage site should be as close as practicable to lab in which carcinogens are to be used, so that only small quantities required for ... expt need to be carried. Carcinogens should be kept in only one section of cupboard, an explosion-proof refrigerator or freezer (depending on chemicophysical properties ...) that bears appropriate label. An inventory ... should be kept, showing quantity of carcinogen & date it was acquired ... Facilities for dispensing ... should be contiguous to storage area. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

Cleanup Methods:

1. VENTILATE AREA OF SPILL OR LEAK. 2. COLLECT FOR RECLAMATION OR ABSORB IN VERMICULITE, DRY SAND, EARTH, OR A SIMILAR MATERIAL.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.4]**PEER REVIEWED**

Flush spill area with water.
[DOD; HMIS (1984)]**PEER REVIEWED**

Do not touch spilled material. Use water spray to reduce vapors. For small spills, take up with absorbent material then flush area with water. For large spills, dike far ahead.
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 8-1]**PEER REVIEWED**

/SRP: In laboratory setting only:/ Absorb on paper and evaporate on a glass dish in hood. Burn the paper. Purify /liquids/ by distillation, then return to supplier.
[ITII. Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1988. 122]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": A high-efficiency particulate arrestor (HEPA) or charcoal filters can be used to minimize amt of carcinogen in exhausted air ventilated safety cabinets, lab hoods, glove boxes or animal rooms ... Filter housing that is designed so that used filters can be transferred into plastic bag without contaminating maintenance staff is avail commercially. Filters should be placed in plastic bags immediately after removal. ... The plastic bag should be sealed immediately. ... The sealed bag should be labelled properly ... Waste liquids ... should be placed or collected in proper containers for disposal. The lid should be secured & the bottles properly labelled. Once filled, bottles should be placed in plastic bag, so that outer surface ... is not contaminated. ... The plastic bag should also be sealed & labelled. ... Broken glassware ... should be decontaminated by solvent extraction, by chemical destruction, or in specially designed incinerators. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

Environmental considerations - Land spill: Dig a pit, pond, lagoon, holding area to contain liquid or solid material. /SRP: If time permits, pits, ponds, lagoons, soak holes, or holding areas should be sealed with an impermeable flexible membrane liner./ Dike surface flow using soil, sand bags, foamed polyurethane, or foamed concrete. Absorb bulk liquid with fly ash or cement powder. Apply "universal"

gelling agent to immobilize spill.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 243]**PEER REVIEWED**

Environmental considerations - Water spill: Use natural deep water pockets, excavated lagoons, or sand bag barriers to trap material at bottom. Remove trapped material with suction hoses. If dissolved, in region of 10 ppm or greater concentration, apply activated carbon at ten times the spilled amount. Use mechanical dredges or lifts to remove immobilized masses of pollutants and precipitates.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 243]**PEER REVIEWED**

Disposal Methods:

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste number U044, must conform with USEPA regulations in storage, transportation, treatment and disposal of waste.
[40 CFR 240-280, 300-306, 702-799 (7/1/89)]**PEER REVIEWED**

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste number D022, must conform with USEPA regulations in storage, transportation, treatment and disposal of waste.
[40 CFR 240-280, 300-306, 702-799 (7/1/96)]**PEER REVIEWED**

Group I Containers: Combustible containers from organic or metallo-organic pesticides (except organic mercury, lead, cadmium, or arsenic compounds) should be disposed of in pesticide incinerators or in specified landfill sites. /Organic or metallo-organic pesticides/ product, or to a drum reconditioner for reuse with the same type of pesticide product, if such reuse is legal under Department of Transportation regulations (eg 49 CFR 173.28). Containers that are not to be reused should be punctured ... and transported to a scrap metal facility for recycling, disposal or burial in a designated landfill. /Organic or metallo-organic pesticides/
[40 CFR 165 (7/1/86)]**PEER REVIEWED**

Group II Containers: Non-combustible containers from organic or metallo-organic pesticides (except organic mercury, lead, cadmium, or arsenic compounds) must first be triple-rinsed. Containers that are in good condition may be returned to the manufacturer or formulator of the pesticide product, or to a drum reconditioner for reuse with the same type of pesticide product, if such reuse is legal under Department of Transportation regulations (eg 49 CFR 173.28). Containers that are not to be reused should be punctured ... and transported to a scrap metal facility for recycling, disposal or burial in a designated landfill. /Organic or metallo-organic pesticides/
[40 CFR 165 (7/1/86)]**PEER REVIEWED**

Chloroform is a waste chemical stream constituent which may be subjected to ultimate disposal by controlled incineration, preferably after mixing with another combustible fuel; care must be exercised to assure complete combustion to prevent the formation of phosgene; an acid scrubber is necessary to remove the halo acids produced.
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.2-5 (1981) EPA 68-03-3025]**PEER REVIEWED**

Potential candidate for liquid injection incineration, with a temperature range of 650 to 1600 deg C and a residence time of 0.1 to 2 seconds; for rotary kiln incineration with a temperature of 820 to 1600 deg C and a residence time of seconds for liquids and gases, hours for solids; and for fluidized bed incineration, with a temperature range of 450 to 980 deg C and a residence time of seconds for liquids

and gases, longer for solids.
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-11 (1981) EPA 68-03-3025]**PEER REVIEWED**

Peer-review: Small amt: Evaporate. (Peer-review conclusions of an IRPTC expert consultation (May 1985))
[United Nations. Treatment and Disposal Methods for Waste Chemicals (IRPTC File). Data Profile Series No. 5. Geneva, Switzerland: United Nations Environmental Programme, Dec. 1985. 134]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": There is no universal method of disposal that has been proved satisfactory for all carcinogenic compounds & specific methods of chem destruction ... published have not been tested on all kinds of carcinogen-containing waste. ... Summary of avail methods & recommendations ... /given/ must be treated as guide only. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.14]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Incineration may be only feasible method for disposal of contaminated laboratory waste from biological expt. However, not all incinerators are suitable for this purpose. The most efficient type ... is probably the gas-fired type, in which a first-stage combustion with a less than stoichiometric air:fuel ratio is followed by a second stage with excess air. Some ... are designed to accept ... aqueous & organic-solvent solutions, otherwise it is necessary ... to absorb soln onto suitable combustible material, such as sawdust. Alternatively, chem destruction may be used, esp when small quantities ... are to be destroyed in laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": HEPA (high-efficiency particulate arrestor) filters ... can be disposed of by incineration. For spent charcoal filters, the adsorbed material can be stripped off at high temp & carcinogenic wastes generated by this treatment conducted to & burned in an incinerator. ... LIQUID WASTE: ... Disposal should be carried out by incineration at temp that ... ensure complete combustion. SOLID WASTE: Carcasses of lab animals, cage litter & misc solid wastes ... should be disposed of by incineration at temp high enough to ensure destruction of chem carcinogens or their metabolites. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Small quantities of ... some carcinogens can be destroyed using chem reactions ... but no general rules can be given. ... As a general technique ... treatment with sodium dichromate in strong sulfuric acid can be used. The time necessary for destruction ... is seldom known ... but 1-2 days is generally considered sufficient when freshly prepd reagent is used. ... Carcinogens that are easily oxidizable can be destroyed with milder oxidative agents, such as saturated soln of potassium permanganate in acetone, which appears to be a suitable agent for destruction of hydrazines or of compounds containing isolated carbon-carbon double bonds. Concn or 50% aqueous sodium hypochlorite can also be used as an oxidizing agent. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.16]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Carcinogens that are alkylating, arylating or acylating agents per se can be destroyed by reaction with appropriate nucleophiles, such as water, hydroxyl ions, ammonia, thiols & thiosulfate. The reactivity of various alkylating agents varies greatly ... & is also influenced by sol of agent in the reaction medium. To facilitate the complete reaction, it is suggested that the agents be dissolved in ethanol or similar solvents. ... No method should be applied ... until it has been thoroughly tested for its effectiveness & safety on material to be inactivated. For example, in case of destruction of alkylating agents, it is possible to detect residual compounds by reaction with 4(4-nitrobenzyl)-pyridine. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.17]**PEER REVIEWED**

The following wastewater treatment technologies have been investigated for **Chloroform**: Concentration process: Biological treatment.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-50 (1982)]**PEER REVIEWED**

The following wastewater treatment technologies have been investigated for **Chloroform**: Concentration process: stripping.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-98-E-99 (1982)]**PEER REVIEWED**

The following wastewater treatment technologies have been investigated for **Chloroform**: Concentration process: activated carbon.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-154 (1982)]**PEER REVIEWED**

The following wastewater treatment technologies have been investigated for **Chloroform**: Concentration process: resin adsorption.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-191 (1982)]**PEER REVIEWED**

SRP: At the time of review, criteria for land treatment or burial (sanitary landfill) disposal practices are subject to significant revision. Prior to implementing land disposal of waste residue (including waste sludge), consult with environmental regulatory agencies for guidance on acceptable disposal practices.
PEER REVIEWED

Occupational Exposure Standards:

OSHA Standards:

Permissible Exposure Limit: Table Z-1 Ceiling value: 50 ppm (240 mg/cu m).
[29 CFR 1910.1000 (7/1/99)]**PEER REVIEWED**

Vacated 1989 OSHA PEL TWA 2 ppm (9.78 mg/cu m) is still enforced in some states.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 361]**PEER REVIEWED**

Threshold Limit Values:

8 hr Time Weighted Avg (TWA) 10 ppm
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 25]**QC REVIEWED**

A3. A3= Confirmed animal carcinogen with unknown relevance to humans.
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 25]**QC REVIEWED**

Excursion Limit Recommendation: Excursions in worker exposure levels may exceed three times the TLV-TWA for no more than a total of 30 min during a work day, and under no circumstances should they exceed five times the TLV-TWA, provided that the TLV-TWA is not exceeded.
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 6]**QC REVIEWED**

NIOSH Recommendations:

NIOSH recommends that **chloroform** be regulated as a potential human carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

NIOSH usually recommends that occupational exposures to carcinogens be limited to the lowest feasible concn.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

Recommended Exposure Limit: 60 Min Short-Term Exposure Limit: 2 ppm (9.78 mg/cu m).
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH recommends that **chloroform** be regulated as a potential human carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 64]**PEER REVIEWED**

Other Occupational Permissible Levels:

Emergency Response Planning Guidelines (ERPG): ERPG(1) Not appropriate; ERPG(2) 50 ppm (without serious, adverse effects) for up to 1 hr exposure; ERPG(3) 5000 ppm (not life threatening) up to 1 hr exposure.
[American Industrial Hygiene Association. The AIHA 1999 Emergency Response Planning Guidelines and Workplace Environmental Exposure Level Guides Handbook. American Industrial Hygiene Association. Fairfax, VA 1999.25]**PEER REVIEWED**

Australia: 10 ppm, Category 3 carcinogen, substances suspected of having carcinogenic potential, substance under review (1990); Federal Republic of Germany: 10 ppm, short-term level 20 ppm, 30 min, 4 times per shift, Group B Carcinogen, justifiably suspected of having carcinogenic potential, Pregnancy Group B, risk of damage to the developing embryo or fetus must be considered to be probable (1990); Sweden: 2 ppm, short-term value 5 ppm, 15 min, carcinogen (1984); United Kingdom: 10 ppm, 10-min STEL 50 ppm, substance under review (1991).
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.291]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

For **Chloroform** (USEPA/OPP Pesticide Code: 020701) there are 0 labels match. /SRP: Not registered for current use in the U.S., but approved pesticide uses may change periodically and so federal, state and local authorities must be consulted for currently approved uses./
[U.S. Environmental Protection Agency/Office of Pesticide Program's Chemical Ingredients Database on Chloroform (67-66-3). Available from the Database Query page at http://www.cdpr.ca.gov/docs/epa/epamenu.htm as of October 24, 2002.]**QC REVIEWED**

Chloroform is now used primarily in the manufacture of HCFC-22, monochlorodifluoromethane, a refrigerant and as a raw material for polytetrafluoroethylene plastics.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V5 (93) 1051]**PEER REVIEWED**

As a solvent for fats, oils, rubber, alkaloids, waxes, gutta-percha, resins; as cleansing agent; in fire extinguishers to lower the freezing temp of carbon tetrachloride; in the rubber industry.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 357]**PEER REVIEWED**

REGISTERED FOR USE IN USA AS INSECTICIDAL FUMIGANT ON STORED BARLEY, CORN, OATS, POPCORN, RICE, RYE, SORGHUM & WHEAT /SRP: FORMERLY REGISTERED/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 405 (1979)]**PEER REVIEWED**

CHEM INT FOR FLUOROCARBON 22 (CHLORODIFLUOROMETHANE)
[SRI]**PEER REVIEWED**

EXTRACTION & PURIFICATION SOLVENT - EG, FOR PENICILLIN
[SRI]**PEER REVIEWED**

MILDEWCIDE FOR TOBACCO SEEDLINGS
[SRI]**PEER REVIEWED**

DRY CLEANING AGENT
[SRI]**PEER REVIEWED**

CHEM INT FOR DYES & PESTICIDES
[SRI]**PEER REVIEWED**

POLYMER CHAIN TRANSFER AGENT
[SRI]**PEER REVIEWED**

CHEM INT FOR TRIBROMOMETHANE
[SRI]**PEER REVIEWED**

MEDICATION (VET):
PEER REVIEWED

Has been used as an anesthetic and in pharmaceutical preparations.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 357]**PEER REVIEWED**

COMPONENT OF COUGH SYRUPS, TOOTHPASTES (FORMER USE)
[SRI]**PEER REVIEWED**

COMPONENT OF LINAMENTS & TOOTHACHE CMPD (FORMER USE)
[SRI]**PEER REVIEWED**

As a solvent for coating compositions of urea or melamine resins and for preparations of lubricant additives and plasticizers; surface-active agents; lubricant additives, rubber chemicals, flotation agents, antifoam agent; flavoring agent; reaction medium for hydrogen pyroxide production; defoamer.
[Prager, J.C. Environmental Contaminant Reference Databook Volume 2. New York, NY: Van Nostrand Reinhold, 1996. 453]**PEER REVIEWED**

Manufacturers:

Dow Chemical USA, Hq,Dow Center, Midland, MI 48674, (517) 636-1000; Production site: Freeport, TX 77541; Production site: Plaquemine, LA 70765
[SRI. 1999 Directory of Chemical Producers -United States. Menlo Park, CA. SRI Consulting 1999.. 523]**PEER REVIEWED**

Vulcan Materials Company, Vulcan Chemicals Group, P.O. Box 530390, Birmingham, AL 35253-0390, (205)877-3000. Chloralkali Business Unit; Production sites: Giesmar LA 70734; Wichita, KS 67277
[SRI. 1999 Directory of Chemical Producers -United States. Menlo Park, CA. SRI Consulting 1999.. 523]**PEER REVIEWED**

Methods of Manufacturing:

Made from acetone and bleaching powder by addn of sulfuric acid. May also be prepared by carefully controlled chlorination of methane.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 357]**PEER REVIEWED**

Today, **trichloromethane** (**chloroform**) is prepared exclusively and on a massive scale by the chlorination of methane and/or monochloromethane.
[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed.Vol A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present.,p. VA6 *86) 236]**PEER REVIEWED**

Reaction of chlorinated lime with acetone, acetaldehyde, or ethanol. By-product from the chlorination of methane.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 256]**PEER REVIEWED**

Hypochlorite reacts with aldehyde to produce **chloroform**.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 1(78) 103]**PEER REVIEWED**

General Manufacturing Information:

Method of purification: extraction with concentrated sulfuric acid and rectification.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 256]**PEER REVIEWED**

HCFC-22 (produced using **chloroform**) has an ODP(ozone depletion potential) that is about 1/10 that of CFC-11 and CFC-12, but it and other HCFCs are considered interim products along the way to non-chlorine-containing HFCs. HCFC-22 use is expected to be curtailed by 2010 in the US, although environmentalists are pushing for an earlier phaseout date and proposals in other countries are calling for restrictions on the material's uses. Under the Montreal Protocol, HCFC-22 is scheduled to be phased out globally by the year 2030.

[Chemical Marketing Reporter; Chemical Profile Chloroform. December 1, 1997. p. 61 NY, NY: Schnell Pub Co (1997)]**PEER REVIEWED**

Small quantities of ethyl alcohol stablilize **chloroform** during storage.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 5(79) 696]**PEER REVIEWED**

Noncommercial processes include limited reduction of carbon tetrachloride to **chloroform**, effected by reaction with hydrogen, methane, zinc dust, or ethyl alcohol; decomposition of pentachloroethane with aluminum chloride; electrolysis of alkali-metal or alkaline-earth metal chlorides in aqueous alcohol solution; or monoxide and hydrogen chloride under pressure at about 40 deg C in the presence of catalytic oxides
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984. 262]**PEER REVIEWED**

Formulations/Preparations:

Grade: Technical, CP, ACS, NF, reagent
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 256]**PEER REVIEWED**

Very high purity grades; AR, NANOGRADE, ChromAR, SpectrAR, HPLC grades
[Kuney, J.H. (ed.). CHEMCYCLOPEDIA 90. Washington, DC: American Chemical Society, 1990. 288]**PEER REVIEWED**

At least one grain fumigant mixture contains **chloroform** (73.2%) with carbon disulfide (26.8%).
[Farm Chemicals Handbook 1989. Willoughby, OH: Meister Publishing Co., 1989.,p. C-69]**PEER REVIEWED**

Chloroform emulsion: **chloroform** 5 ml, quillaia liquid extract 0.1 ml, tragacanth mucilage 5 ml, water to 100 ml
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 745]**PEER REVIEWED**

Chloroform spirit: **chloroform** 5% vol/vol in alcohol (90%)
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 745]**PEER REVIEWED**

Chloroform water: **chloroform** 0.25% vol/vol in freshly boiled and cooled water
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 745]**PEER REVIEWED**

Concentrated **chloroform** water: **chloroform** 10 ml, alcohol (90%) 60 ml, water to 100 ml
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 745]**PEER REVIEWED**

Double-strength **chloroform** water: **chloroform** 0.5% vol/vol in freshly boiled and cooled water
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 745]**PEER REVIEWED**

Chloroform and morphine tincture: **chloroform** 12.5 ml, morphine hydrochloride 229 mg, alcohol (90%) 12.5 ml, liquorice liquid extract 12.5 ml, treacle of commerce 12.5 ml, water 5 ml, anesthetic ether 3 ml, peppermint oil 0.1 ml, syrup to 100 ml.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 745]**PEER REVIEWED**

Chloroform contains not less than 99.0% and not more than 99.5% **chloroform**, the remainder consisting of alcohol.

[USP Convention. The United States Pharmacopeia XXII/National Formulary XVII. Rockville, MD: United States Pharmacopeial Convention, Inc., 1990. 1920]**PEER REVIEWED**

Impurities:

Reagent grade **chloroform** of several brands was reported to contain detectable amounts of methylene chloride and other chloromethanes.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V1 61 (1972)]**PEER REVIEWED**

Typical specifications for National Formulary grade **chloroform** ... acidity, as hydrogen chloride, 0.0002% max; residue on evaporation, 0.0013% max; and stabilizer, 0.5 to 1.0% ethanol by volume. Technical grade **chloroform** ... acidity, as hydrogen chloride, 0.002% max; residue on evaporation, 0.0007% max; moisture, 0.0150% max; and stabilizer, 0.5 to 1.0% ethanol by volume.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 402 (1979)]**PEER REVIEWED**

The following impurities have been detected in **chloroform**: bromochloromethane, bromodichloroethane, bromodichloromethane, carbon tetrachloride, dibromodichloroethane, dibromodichloromethane, 1,1-dichloroethane, 1,2-dichloroethane, vinylidene chloride, cis-1,2-dichloroethene, trans-1,2-dichloroethylene, dichloromethane, diethyl carbonate, ethyl benzene, 2-methoxy ethanol, nitromethane, pyridine, 1,1,2,2-tetrachloroethane, trichloroethylene, meta-xylene, ortho-xylene, and para-xylene.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 403 (1979)]**PEER REVIEWED**

n-Nitrosomorpholine was found in 4/10 batches of analytical grade **chloroform**, at levels of 2-376 ug/l.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 403 (1979)]**PEER REVIEWED**

A representative technical quality **chloroform** contains the following amounts of the indicated substances (maximums): Water (50 ppm), acid as HCL (10 ppm), methylene chloride (200 ppm), bromochloromethane (300 ppm), carbon tetrachloride (250 ppm), 1,2-dichloroethylene (100 ppm), vinylidene chloride (100 ppm), residue on evaporation at 110 deg C (10 ppm), and dissolved chlorine (not detectable).
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V5 (93) 1058]**PEER REVIEWED**

Consumption Patterns:

CHEM INT FOR FLUOROCARBON 22, 96%; OTHER, 4% (1981)
[SRI]**PEER REVIEWED**

Fluorocarbon 22, 93% (refrigerants, 70%; fluoropolymers, 30%); miscellaneous, 4%; export, 3% (1986)
[CHEMICAL PROFILE: Chloroform, 1986]**PEER REVIEWED**

CHEMICAL PROFILE: **Chloroform**. Fluorocarbon 22, 90% (refrigerants, 70%; fluoropolymers, 30%); export, 8%; other, 2%
[Kavaler AR; Chemical Marketing Reporter 235 (9): 56 (1989)]**PEER REVIEWED**

CHEMICAL PROFILE: **Chloroform**. Demand: 1988: 500 million lb; 1989: 525 million lb; 1993

/projected/: 650 million lb (Includes exports, but not imports, which totaled 24 million lb last year).
[Kavaler AR; Chemical Marketing Reporter 235 (9): 56 (1989)]**PEER REVIEWED**

Hydrochlorofluorocarbon 22 (HCFC-22), 98% (refrigerants 70%; fluoropolymers 30%); miscellaneous, including laboratory reagents and extraction solvents for pharmaceuticals, 2%.
[Chemical Marketing Reporter; Chemical Profile Chloroform. December 1, 1997. p. 61 NY, NY: Schnell Pub Co (1997)]**PEER REVIEWED**

U. S. Production:

(1981) 1.82X10+11 G
[US INTERNATIONAL TRADE COMMISSION, WASH, DC 20436; SOC SERIES C/P-82-1]**PEER REVIEWED**

(1982) 402 million lb
[Kavaler; Chem Market Reporter (1982)]**PEER REVIEWED**

(1978) 1.58X10+11 G
[SRI]**PEER REVIEWED**

(1983) 1.68X10+11 G
[SRI]**PEER REVIEWED**

(1977): 93 million to 350 million lb (includes importation)
[USEPA; Subst Risk Notice, 8EHQ-0180-0324 (1980)]**PEER REVIEWED**

(1985) 1.25X10+11 g
[USITC. SYN ORG CHEM-U.S. PROD/SALES 1985 p.268]**PEER REVIEWED**

(1986) 4.21X10+8 lb
[USITC. SYN ORG CHEM-U.S. PROD. PRELIMINARY MARCH 1987 (SERIES C/P-87-1)]**PEER REVIEWED**

(1988) 5.23X10+8 lb
[USITC. SYN ORG CHEM-U.S. PROD/SALES 1988 p.15-7]**PEER REVIEWED**

(1987) 4.61X10+8 lb
[USITC. SYN ORG CHEM-U.S. PROD/SALES 1987 p.15-7]**PEER REVIEWED**

(1989) 266.53X10+3 tons
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V5 (93) 1058]**PEER REVIEWED**

(1990) 219,687,000 kg
[USITC; Synthetic Organic Chemicals--United States Production and Sales, 1990. USITC. Washington, DC: United States Trade Commission p. 15-8 (1991)]**PEER REVIEWED**

(1991) 228,901,000 kg
[USITC; Synthetic Organic Chemicals--United States Production and Sales, 1991. USITC. Washington, DC: United States Trade Commission p. 15-9 (1993)]**PEER REVIEWED**

(1993) 215,932,000 kg
[USITC; Synthetic Organic Chemicals--United States Production and Sales, 1993. USITC. Washington, DC: United States Trade Commission p. 3-17 (1994)]**PEER REVIEWED**

U. S. Imports:

(1985) 1.52X10+10 g
[BUREAU OF THE CENSUS. U.S. IMPORTS FOR CONSUMPTION AND GENERAL IMPORTS 1985 p.1-583]**PEER REVIEWED**

U. S. Exports:

(1985) 1.99X10+10 g
[BUREAU OF THE CENSUS. U.S. EXPORTS, SCHEDULE E, 1985 p.2-73]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

Headspace analysis of **chloroform** in blood uses gas chromatography and flame ionization detection. Retention time is 2.0 min. This method has a sensitivity of 0.1 mg/l. Normal plasma components do not interfere with the assay, but many other volatile organic cmpd are detected with this technique and may interfere.
[Baselt, R.C. Biological Monitoring Methods for Industrial Chemicals. 2nd ed. Littleton, MA: PSG Publishing Co., Inc. 1988. 37]**PEER REVIEWED**

FISH SAMPLES WERE ANALYZED FOR **CHLOROFORM** BY GAS CHROMATOGRAPHY. DETECTION LIMIT IS IN 0.1-1.0 PPB RANGE.
[OFSTAD EB ET AL; THE SCIENCE OF THE TOTAL ENVIRONMENT 20: 205-16 (1981)]**PEER REVIEWED**

Analytic Laboratory Methods:

EPA Method 624: Purgeables. A purge-and-trap gas chromatography/mass spectrometry method for the analysis of **Chloroform** in municipal and industrial discharges, consists of a glass column, 6 ft x 0.1 in, packed with Carbopack B (60/80 mesh) coated with 1% SP-1000, with the detection performed by the mass spectrometer, and helium as the carrier gas at a flow rate of 30 ml/min. A sample injection volume of 2 to 5 ul is suggested, the column temperature is held isothermal at 45 deg C for 3 min and then programmed at 8 deg C/min to a final temperature of 220 deg C. This method has a detection limit of 1.6 ug/l and an overall precision of 0.18 times the average recovery + 0.16, over a working range of 5 to 600 ug/l.
[40 CFR 136 (7/1/88)]**PEER REVIEWED**

Chloroform, as a volatile fumigant in wheat and corn grain, is analyzed using gas chromatography equipped with source-heated electron capture detection. Retention time for **chloroform** is 3 min.
[Association of Official Analytic Chemists. Official Methods of Analysis of the AOAC. 14th ed. Arlington, VA: Association of Official Analytic Chemists, Inc., 1984.,p. 547 29.071]**PEER REVIEWED**

Chloroform in drugs using titrimetric method. The sample is acidified with nitric acid and mixed with silver nitrate. Iron ammonium sulfate is added as an indicator, and excess silver nitrate is titrated using 0.05 N ammonium or potassium thiocyanate. Each ml 0.1N silver nitrate = 0.00398 g **chloroform**.
[Association of Official Analytical Chemists. Official Methods of Analysis. 10th ed. and supplements. Washington, DC: Association of Official Analytical Chemists, 1965. New editions through 13th ed. plus supplements, 1982.p. 11/680 36.013]**PEER REVIEWED**

Chloroform in drugs using infrared spectrophotometry and standard curves determined after extracting sample with carbon disulfide. Peak infrared absorption is at 8.25 um with a baseline of 7.70 to 8.70 um.

[Association of Official Analytic Chemists. Official Methods of Analysis of the AOAC. 14th ed. Arlington, VA: Association of Official Analytic Chemists, Inc., 1984.,p. 669 36.018]**PEER REVIEWED**

AOAC Method 977.18. Volatile Fumigants in Grain by Gas Chromatographic Method.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990]**PEER REVIEWED**

EPA Method 601: Purgeable Halocarbons. A purge-and-trap gas chromatography method for the analysis of **chloroform** in municipal and industrial discharges, consists of a stainless steel column, 8 ft x 0.1 in ID, packed with Carbopack B (60/80 mesh) coated with SP-1000, with electrolytic conductivity detection, and helium as the carrier gas at a flow rate of 40 ml/min. A sample injection volume of 2 to 5 ul is suggested, the column temperature is held isothermal at 45 deg C for 3 min then programmed at 8 deg C/min to final temperature of 220 deg C. This method has a detection limit of 0.05 ug/l and an overall precision of 0.19 times the average recovery - 0.02, over a working range of 8.0 to 500 ug/l.
[40 CFR 136 (7/1/88)]**PEER REVIEWED**

The most widely used method of analysis for **chloroform** is gas chromatography. The detector of choice is a flame ionization detector. **Chloroform** may be estimated quantitatively by determining the amount of copper oxide produced when it is warmed with Fehling's solution, which is potassium cupritartrate. An alternative procedure consists of heating the **chloroform** with concentrated alcoholic potassium hydroxide in a sealed tube at 100 deg C and determining the amount of potassium chloride produced.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V5 (93) 1058]**PEER REVIEWED**

AOB Method VA-004-1. Halogenated Volatile Organic Compounds (VOCs) in Air by direct Gas Chromatography with an Electron Capture Detector.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

AOB Method VA-006-1. Volatile Organic Compounds (VOCs) in Ambient Air by Direct Portable GC/PID.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

NIOSH Method 1003. Determination of Halogenated Hydrocarbons by Gas Chromatography with Flame Ionization Detection.
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

EPA Method EMSLC 551. Determination of Chlorination Disinfection Byproducts and Chlorinated Solvents in Drinking Water by Liquid-Liquid Extraction and Gas Chromatography with Electron-Capture Detection.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

Sampling Procedures:

NIOSH 1003: Analyte: **Chloroform**; Matrix: Air; Sampler: Solid sorbent tube (coconut shell charcoal, 100 mg/50 mg); Flow rate: 0.01-0.2 l/min; Vol: min 1 l @ 50 ppm, max 50 l; Stability: not determined /Hydrocarbons, halogenated/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual

of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V2 1003-1]**PEER REVIEWED**

Special References:

Special Reports:

REUBER MD; CARCINOGENICITY OF **CHLOROFORM**; ENVIRON HEALTH PERSPECT 31: 171-82 (1979). A REVIEW ARTICLE ON CARCINOGENICITY OF **CHLOROFORM**.

USEPA; Locating and Estimating Air Emissions from Sources of **Chloroform** (1984) EPA 450/4-84-007c

USEPA; Ambient Water Quality Criteria Doc: **Chloroform** (1980) EPA 440/5-80-033

USEPA; Health Assessment Document: **Chloroform** (Draft) (1984) EPA-600/8-84-004A

DHHS/ATSDR; Toxicological Profile for **Chloroform** (Update) TP-92/07 (1993)

USEPA; Health and Environmental Effects Profile for **Chloroform** (Carbon Trichloromethone); No 47 (1980)

WHO; Environmental Health Criteria 119: Principles and Methods for the Assessment of Nephrotoxicity Associated with Exposure to Chemicals (1991)

U.S. Department of Health & Human Services/National Toxicology Program; Tenth Report on Carcinogens. National Institutes of Environmental Health Sciences. The Report on Carcinogens is an informational scientific and public health document that identifies and discusses substances (including agents, mixtures, or exposure circumstances) that may pose a carcinogenic hazard to human health. **Chloroform** (67-66-3) was first listed in the Second Annual Report on Carcinogens (1981) as reasonably anticipated to be a human carcinogen.
[ ]

Synonyms and Identifiers:

Synonyms:

R 20
PEER REVIEWED

CHLOROFORME (FRENCH)
PEER REVIEWED

CLOROFORMIO (ITALIAN)
PEER REVIEWED

Pesticide Code: 020701
QC REVIEWED

FORMYL TRICHLORIDE
PEER REVIEWED

Freon 20
PEER REVIEWED

METHANE TRICHLORIDE
PEER REVIEWED

METHANE, TRICHLORO-
PEER REVIEWED

METHENYL CHLORIDE
PEER REVIEWED

METHENYL TRICHLORIDE
PEER REVIEWED

METHYL TRICHLORIDE
PEER REVIEWED

NCI-C02686
PEER REVIEWED

R 20 (REFRIGERANT)
PEER REVIEWED

TCM
PEER REVIEWED

TRICHLOORMETHAAN (DUTCH)
PEER REVIEWED

TRICHLORMETHAN (CZECH)
PEER REVIEWED

TRICHLOROFORM
PEER REVIEWED

TRICHLOROMETHANE
PEER REVIEWED

TRICLOROMETANO (ITALIAN)
PEER REVIEWED

Formulations/Preparations:

Grade: Technical, CP, ACS, NF, reagent
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 256]**PEER REVIEWED**

Very high purity grades; AR, NANOGRADE, ChromAR, SpectrAR, HPLC grades
[Kuney, J.H. (ed.). CHEMCYCLOPEDIA 90. Washington, DC: American Chemical Society, 1990. 288]**PEER REVIEWED**

At least one grain fumigant mixture contains **chloroform** (73.2%) with carbon disulfide (26.8%).
[Farm Chemicals Handbook 1989. Willoughby, OH: Meister Publishing Co., 1989.,p. C-69]**PEER REVIEWED**

Chloroform emulsion: **chloroform** 5 ml, quillaia liquid extract 0.1 ml, tragacanth mucilage 5 ml, water

to 100 ml
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 745]**PEER REVIEWED**

Chloroform spirit: **chloroform** 5% vol/vol in alcohol (90%)
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 745]**PEER REVIEWED**

Chloroform water: **chloroform** 0.25% vol/vol in freshly boiled and cooled water
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 745]**PEER REVIEWED**

Concentrated **chloroform** water: **chloroform** 10 ml, alcohol (90%) 60 ml, water to 100 ml
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 745]**PEER REVIEWED**

Double-strength **chloroform** water: **chloroform** 0.5% vol/vol in freshly boiled and cooled water
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 745]**PEER REVIEWED**

Chloroform and morphine tincture: **chloroform** 12.5 ml, morphine hydrochloride 229 mg, alcohol (90%) 12.5 ml, liquorice liquid extract 12.5 ml, treacle of commerce 12.5 ml, water 5 ml, anesthetic ether 3 ml, peppermint oil 0.1 ml, syrup to 100 ml.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 745]**PEER REVIEWED**

Chloroform contains not less than 99.0% and not more than 99.5% **chloroform**, the remainder consisting of alcohol.
[USP Convention. The United States Pharmacopeia XXII/National Formulary XVII. Rockville, MD: United States Pharmacopeial Convention, Inc., 1990. 1920]**PEER REVIEWED**

Shipping Name/ Number DOT/UN/NA/IMO:

UN 1888; **Chloroform**

IMO 6.1; **Chloroform**

Standard Transportation Number:

49 403 10; **Chloroform** (not elsewhere classified, other than technical grade)

49 403 11; **Chloroform** (not elsewhere classified, technical grade)

EPA Hazardous Waste Number:

U044; A toxic waste when a discarded commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or manufacturing chemical intermediate.

Administrative Information:

Hazardous Substances Databank Number: 56

Last Revision Date: 20030829

Last Review Date: Reviewed by SRP on 1/29/2000

Update History:

Complete Update on 2003-08-29, 1 fields added/edited/deleted
Complete Update on 03/05/2003, 5 fields added/edited/deleted.
Field Update on 02/14/2003, 1 field added/edited/deleted.
Field Update on 11/08/2002, 1 field added/edited/deleted.
Field Update on 10/31/2002, 1 field added/edited/deleted.
Complete Update on 05/31/2002, 1 field added/edited/deleted.
Complete Update on 05/13/2002, 1 field added/edited/deleted.
Complete Update on 01/18/2002, 2 fields added/edited/deleted.
Field Update on 01/14/2002, 1 field added/edited/deleted.
Complete Update on 08/09/2001, 1 field added/edited/deleted.
Complete Update on 05/16/2001, 1 field added/edited/deleted.
Complete Update on 02/20/2001, 2 fields added/edited/deleted.
Complete Update on 01/30/2001, 1 field added/edited/deleted.
Complete Update on 11/08/2000, 1 field added/edited/deleted.
Complete Update on 06/08/2000, 81 fields added/edited/deleted.
Field Update on 02/02/2000, 1 field added/edited/deleted.
Field Update on 11/29/1999, 1 field added/edited/deleted.
Field Update on 09/21/1999, 1 field added/edited/deleted.
Field Update on 08/26/1999, 1 field added/edited/deleted.
Complete Update on 05/04/1999, 1 field added/edited/deleted.
Complete Update on 03/29/1999, 3 fields added/edited/deleted.
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Complete Update on 02/24/1997, 1 field added/edited/deleted.
Complete Update on 07/22/1996, 4 fields added/edited/deleted.
Complete Update on 05/03/1996, 2 fields added/edited/deleted.
Complete Update on 04/16/1996, 9 fields added/edited/deleted.
Field Update on 01/18/1996, 1 field added/edited/deleted.
Complete Update on 11/10/1995, 1 field added/edited/deleted.
Complete Update on 02/13/1995, 1 field added/edited/deleted.
Complete Update on 01/18/1995, 1 field added/edited/deleted.
Complete Update on 12/19/1994, 1 field added/edited/deleted.
Complete Update on 09/26/1994, 1 field added/edited/deleted.
Complete Update on 08/31/1994, 2 fields added/edited/deleted.

Complete Update on 08/23/1994, 1 field added/edited/deleted.
Complete Update on 07/20/1994, 1 field added/edited/deleted.
Complete Update on 05/05/1994, 1 field added/edited/deleted.
Complete Update on 03/25/1994, 1 field added/edited/deleted.
Complete Update on 02/02/1994, 1 field added/edited/deleted.
Complete Update on 11/05/1993, 1 field added/edited/deleted.
Complete Update on 08/07/1993, 1 field added/edited/deleted.
Complete Update on 08/04/1993, 1 field added/edited/deleted.
Field update on 12/10/1992, 1 field added/edited/deleted.
Complete Update on 04/01/1992, 1 field added/edited/deleted.
Complete Update on 01/23/1992, 1 field added/edited/deleted.
Complete Update on 05/08/1991, 1 field added/edited/deleted.
Complete Update on 05/07/1991, 1 field added/edited/deleted.
Complete Update on 02/13/1991, 72 fields added/edited/deleted.
Field Update on 08/23/1990, 1 field added/edited/deleted.
Field Update on 05/04/1990, 1 field added/edited/deleted.
Complete Update on 01/11/1990, 62 fields added/edited/deleted.
Field Update on 05/05/1989, 1 field added/edited/deleted.
Field Update on 03/01/1989, 1 field added/edited/deleted.
Field Update on 05/12/1988, 1 fields added/edited/deleted.
Complete Update on 03/04/1988, 115 fields added/edited/deleted.
Complete Update on 05/02/1985
Created 19830315 by DS

Record Length: 226247.0

Chloroform

CASRN: 67-66-3
For other data, click on the Table of Contents

Status:

STATUS OF DATA FOR **Chloroform**

File First On-Line 01/31/1987

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on-line	10/19/01
Inhalation RfC Assessment (I.B.)	not available	
Carcinogenicity Assessment (II.)	on-line	10/19/01

Substance Identification:

Substance Name:

Chloroform

CAS Registry Number: 67-66-3

I. Chronic Health Hazard Assessment for Noncarcinogenic Effects:

I.A. Reference Dose for Chronic Oral Exposure (RfD):

Chloroform
CASRN -- 67-66-3
Last Revised -- 10/19/01

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg/day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.A.1. Oral RfD Summary:

Traditional Approach

For comparison purposes, an RfD was developed using the traditional NOAEL/LOAEL approach. The

results of this method are provided below. This is the same approach and RfD result reported on IRIS (01/13/87).

Critical Effect	Experimental Doses*	UF	MF	RfD
Moderate/marked fatty cyst formation in the liver and elevated SGPT Dog, chronic oral bioassay Heywood et al., 1979	NOAEL: none LOAEL: 15 mg/kg/day (converted to 12.9 mg/kg/day)	1,000	1	0.01 (mg/kg/day)

*Conversion Factors and Assumptions -- 15 mg/kg/day × 6 days/7 days = 12.9 mg/kg/day.

I.A.2. Principal and Supporting Studies (Oral RfD):

Heywood, R; Sortwell, RJ; Noel, PRB; et al. (1979) Safety evaluation of toothpaste containing **chloroform**: III. Long-term study in beagle dogs. J Environ Pathol Toxicol 2:835-851.

Heywood et al. (1979) exposed groups of eight male and eight female beagle dogs to doses of 15 or 30 mg **chloroform**/kg/day. The chemical was given orally in a toothpaste base in gelatin capsules, 6 days/week for 7.5 years. This was followed by a 20- to 24-week recovery period. Eight dogs of each sex served as an untreated group and a final group of 16 dogs (8/sex) received an alternative nonchloroform toothpaste (vehicle control). Four male dogs (one each from the low- and high-dose **chloroform** groups, the vehicle control group, and the untreated control group) and seven female dogs (four from the vehicle control group and three from the untreated control group) died during the study. In the low-dose group, levels of serum glutamate-pyruvate transaminase (SGPT, also known as alanine aminotransferase) were increased by an average of about 40% compared with control, with the effects being statistically significant from week 130 through week 364. In the high-dose group, SGPT levels tended to average about twice those in the control group, and the differences were statistically significant from week 6 throughout treatment. After 14 weeks of recovery, SGPT levels remained significantly increased in the high-dose group, but not in the low-dose group, when compared with the controls. After 19 weeks of recovery, SGPT levels were not significantly increased in either treated group when compared with the controls. The authors concluded that the increases in SGPT levels were likely the result of minimal liver damage. Serum alkaline phosphatase (SAP) and SGPT levels were also moderately increased (not statistically significant) in the treated dogs at the end of the treatment period when compared with the controls. Microscopic examinations were conducted on the major organs. The most prominent microscopic effect observed in the liver was the presence of "fatty cysts," which were described as aggregations of vacuolated histiocytes. The fatty cysts were observed in the control and treated dogs, but were larger and more numerous (i.e., higher incidence of cysts rated as "moderate or marked," as opposed to "occasional or minimal") in the treated dogs than in the control dogs at both doses. The prevalence of moderate or marked fatty cysts was 1/27 in control animals, 9/15 in low dose animals, and 13/15 in high dose animals. Nodules of altered hepatocytes were observed in both treated and control animals, and therefore were not considered related to treatment. No other treatment-related nonneoplastic or neoplastic lesions were reported for the liver, gall bladder, cardiovascular system, reproductive system, or urinary system. A NOAEL was not identified in this study. However, a LOAEL of 15 mg/kg/day was identified, based on elevated SGPT levels and increased incidence and severity of

fatty cysts (U.S. EPA, 1998a).

Benchmark Dose (BMD) Approach

Selection of Data Sets for Modeling

The following data sets were selected for BMD modeling:

- Incidence of fatty cysts in liver and SGPT levels of dogs (Heywood et al., 1979)
- Histological evidence of renal cytotoxicity in male rats exposed via drinking water (Hard et al., 2000)
- Increased labeling index in kidney of female mice exposed via drinking water (Larson et al., 1994b)
- Increased labeling index in liver of female rats exposed via gavage in corn oil (Larson et al., 1995b)

  These studies were chosen because they all provide quantitative dose-response data for sensitive indicators of **chloroform** toxicity.

BMD Modeling of Selected Data Sets

The detailed results of the BMD model fitting are presented in Appendix B of the Toxicological Review of **Chloroform**. Within a data set, the preferred model was selected based on the quality of the model fit to the data.

As seen, the kidney LI data set from Larson et al. (1994b) could not be adequately described by any of the continuous models. This is because even though the response was statistically significant, the magnitude of the response was small in comparison to normal variability, and the data did not form a smooth dose-response relationship (tending to first increase and then decrease as dose increased). The liver and kidney LI data sets from Larson et al. (1995b) were reasonably well fit by the Hill equation, with BMD values of 64-75 mg/kg/day. However, the software was not able to estimate a benchmark dose limit (BMDL) value in either case. The data sets from the studies by Hard et al. (2000) and by Heywood et al. (1979) were adequately fit by one or more of the dichotomous models, with the best fit being given by the log-logistic and the quantal-linear models, respectively. The preferred BMD of 70 mg/kg/day based on the renal cytotoxicity data of Hard et al. (2000) is similar to the BMD values derived for the LI data from Larson et al (1995b), but is significantly higher than the preferred BMD based on the incidence of fatty cysts in dogs (1.7 mg/kg/day) reported by Heywood et al. (1979). The basis for this marked difference in BMD between studies is not known, but the data suggest that liver toxicity in the dog is a more sensitive endpoint of **chloroform** toxicity than renal or liver cytotoxicity in rodents.

Calculation of the BMD-Based RfD

Critical Effect	Experimental Doses*	UF	MF	RfD
Moderate/marked fatty cyst formation in the liver and elevated SGPT Dog, chronic oral bioassay Heywood et al., 1979	$BMDL_{10}$: 1.2 mg/kg/day (converted to 1.0 mg/kg/day)	100	1	0.01 (mg/kg/day)

The $BMDL_{10}$ provided in the table represents the 95% confidence lower bound on the dose associated with a 10% extra risk based on the prevalence of animals with moderate to marked fatty cysts in liver and elevated SGPT. The value of the $BMDL_{10}$ was calculated from the data of Heywood et al. (1979) using EPA's BMDS software Version 1.2. The value derived from the BMD modeling (1.2 mg/kg/day) was adjusted by a factor of 6/7 to account for exposure 6 days per week.

I.A.3. Uncertainty and Modifying Factors (Oral RfD):

UF = 100

In the benchmark dose approach, an uncertainty factor (UF) of 10 was used to account for interspecies extrapolation, and a UF of 10 was used to protect sensitive subpopulations. In the NOAEL/LOAEL approach, an additional factor of 10 was used to account for extrapolation from a LOAEL to a NOAEL (total UF = 1,000). No additional factors were required to account for extrapolation from short term to long term (the study duration was 7.5 years) or to account for limitations in the database.

MF = 1

No additional modifying factors (MFs) were considered necessary because there are no substantial concerns or limitations in the derivation of the RfD that are not accounted for in the UFs described above.

I.A.4. Additional Studies/Comments (Oral RfD):

In general, the NOAEL/LOAEL approach for derivation of an RfD is subject to a number of limitations, most of which are addressed by use of the BMD approach (U.S. EPA, 1995). Thus, the RfD based on the BMD approach is generally preferred, unless there are insufficient dose-response data to support derivation of a reliable BMD.

In this case, the dose-response data set from the critical study (Heywood et al., 1979) is composed of only two doses plus a control group. This is considered to be a limitation, as the shape of the dose-response curve is difficult to define with only three values, especially when the lowest dose yields a response that is well above the benchmark response. Nevertheless, the data do yield curve fits of adequate quality, so the results of the BMD approach are considered preferable to the NOAEL/LOAEL approach.

Note that, in this particular case, the two approaches (NOAEL/LOAEL and benchmark) yield equal RfD values. This is consistent, albeit coincidental, with the results from the default LOAEL/NOAEL method.

Many other studies in animals support the conclusion that the liver and/or the kidney are the key target organs for **chloroform**-induced toxicity. Most of these studies have been performed in rats and mice, and most yield LOAEL values that are substantially higher than those observed in dogs.

In a study conducted by Palmer et al. (1979), in which rats were administered daily oral doses of 60 mg **chloroform**/kg/day in a toothpaste vehicle, treatment-related effects included a decrease in plasma but not erythrocyte, cholinesterase in females, a decrease in liver weight in females, and a marginal but consistent and progressive retardation in weight gain in both sexes. The authors stated that although minor histological changes in the liver were noted, there was no evidence of severe fatty infiltration, fibrosis, or bile duct abnormalities in the livers of treated animals. The authors concluded that there was no evidence of treatment-related toxic effects in the liver. However, the "minor histopathological" changes in the liver were not described and the presence of any fatty infiltration that would be designated as less than severe was not reported. Therefore, these results could not be compared to those reported in the dog study. The LOAEL for this study was 60 mg/kg/day.

A slight (2%–3% vs. 7%–8%) increase in moderate to severe fatty degeneration of the liver was seen in ICI mice given 60 mg but not 17 mg **chloroform**/kg/day in a toothpaste vehicle for 80 weeks (Roe et al., 1979). However, no effects were evident when the incidences of fatty and nonfatty liver degeneration were combined in the ICI or three other mice strains. No other noncancer effects attributable to **chloroform** were noted. A NOAEL of 17 mg/kg/day and a LOAEL of 60 mg/kg/day were identified from this study.

No treatment-related noncancer effects were noted in rats administered **chloroform** in drinking water for 23 months at time-weighted average doses up to 160 mg/kg/day (Jorgenson et al., 1982, 1985). However, subsequent review of the histopathology slides from this study revealed evidence that **chloroform** produced a moderate to low level of renal proximal tubule injury associated with cell turnover indicative of cytotoxicity (Hard et al., 2000). These changes were noted in the high-dose (160 mg/kg) group males as early as 12 months but were increased in grade by 18 months. Similar changes were found in the mid-dose males (81 mg/kg), although at a lower grade, in the 18-month and 2-year dose groups. These changes were not seen in controls or the low-dose group. Therefore, the identified NOAEL for noncancer effects for this study is 38 mg **chloroform**/kg/day, with the LOAEL at 81 mg/kg/day.

In mice exposed to **chloroform** in drinking water, mortality within the first 3 weeks was significantly increased in the two highest dose groups, 130 and 263 mg/kg/day, but was comparable with controls after that time (Jorgenson et al., 1982). Early mortality and behavioral effects (e.g., lassitude, lack of vigor) were apparently related to reduced water consumption among some treated mice in the two highest dose groups. A significant increase in liver fat in mice was noted at doses of 65 mg/kg/day and higher at 3 months, but only at doses of 130 and 263 mg/kg/day by 6 months. Liver fat content was not reported for any later time points or at terminal sacrifice; therefore, the relevance of this observation as an adverse effect rather than an adaptive response could not be assessed. No increased incidence of liver tumors was reported, and the presence or absence of nonneoplastic histopathological alterations was not described. These data indicate that doses of 130 to 263 mg/kg/day may produce adverse effects in mice; however, these effects may be secondary to decreased water consumption.

Reproductive/developmental toxicity studies were also considered in the selection of the critical study/effect for the reference dose in the event the fetus represented a more sensitive population. These included studies in rats (Thompson et al., 1974), in rabbits (Thompson et al., 1974), and in mice (NTP, 1988). In the developmental studies in rabbits and rats, no treatment-related effects were noted when **chloroform** was administered by gavage in corn oil during gestation at doses of 50 mg/kg/day or less (Thompson et al., 1974). In the rabbit study, a clear dose-response was absent and the effects noted in offspring of dams administered **chloroform** at doses up to 50 mg/kg/day (the highest dose tested) on days 6 to 18 of gestation were not considered to be treatment-related (Thompson et al., 1974). In rats, the only effect noted was a significant reduction in fetal weight found only in offspring of dams given **chloroform** at the highest dose tested, 126 mg/kg/day, on days 6 to 15 of gestation (Thompson et al., 1974). No fetal effects attributed to **chloroform** treatment were noted in this rat study for the lower dose groups (up to 50 mg/kg/day during gestation). A NOAEL of 50 mg/kg/day was identified for both studies.

In a two-generation reproductive study in mice, no significant effects were seen in any reproductive parameter assessed in either the parental or the F_1 generations at doses up to 41 mg/kg/day administered by gavage in corn oil (NTP, 1988). Systemic toxicity was not evaluated in the parental generation. However, increased liver weights and liver lesions, described as mild to moderate degeneration of centrilobular hepatocytes accompanied by single-cell necrosis, were noted in F_1 females, but not males, exposed both in utero and postnatally at a dose of 41 mg/kg/day. Postnatal exposure in the F_1 generation began at postnatal day 22 and continued until the birth of the F_2 generation (mice were mated at 64 to 84 days of age). The F_1 offspring in the two lower dose groups, 6.6 and 16 mg/kg/day, were not evaluated histopathologically; therefore, no NOAEL or LOAEL could be definitively established for this study. A dose of 41 mg/kg/day may represent the LOAEL; however, the amount of in utero exposure was not estimated, nor was the contribution of in utero exposure to liver toxicity assessed. Because quantitative data were available only for the control and high-dose groups, the study was not selected for benchmark modeling.

In the reproductive/developmental studies, both maternal toxicity and effects on the fetus or offspring occurred at doses higher than those that produced evidence of liver toxicity in the dog study. Therefore, these were not used as the critical study for derivation of the RfD. ***For more detail on Susceptible Populations, exit to the toxicological review, Section 4.7 (PDF)***.

I.A.5. Confidence in the Oral RfD:

Study -- Medium
Database -- Medium
RfD -- Medium

The overall confidence in this RfD assessment is medium. The database on noncancer effects in animals is extensive, and data are adequate to derive reliable dose-response curves for key endpoints. Confidence is not rated higher because data in humans are limited, and extrapolation from animals to humans (with an attendant uncertainty factor of 10) is required.

For more detail on Characterization of Hazard and Dose Response, exit to the toxicological review,

***Section 6* (PDF)**.

I.A.6. EPA Documentation and Review of the Oral RfD:

Source Document -- U.S. EPA, 2001

This assessment was peer reviewed by external scientists. Their comments have been evaluated carefully and incorporated in finalization of this IRIS summary. A record of these comments is included as an appendix to U.S. EPA (2001). ***To review this appendix, exit to the toxicological review, Appendix A, External Peer Review -- Summary of Comments and Disposition (PDF)***.

Other EPA Documentation -- U.S. EPA, 1994, 1997, 1998a-c, 2001

Agency Consensus Date -- 7/27/2001

I.A.7. EPA Contacts (Oral RfD):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC):

(Not available. To be developed)

II. Carcinogenicity Assessment for Lifetime Exposure:

Chloroform
CASRN -- 67-66-3
Last Revised -- 10/19/01

Section II provides information on three aspects of the carcinogenic assessment for the substance in question; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per µg/L drinking water or risk per µg/cu.m air breathed. The third form in which risk is presented is a concentration of the chemical in drinking water or air associated with cancer risks of 1 in 10,000, 1 in 100,000, or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity:

II.A.1. Weight-of-Evidence Characterization:

Under the 1986 U.S. EPA Guidelines for Carcinogen Risk Assessment, **chloroform** has been classified as Group B2, *probable human carcinogen*, based on "sufficient evidence" of carcinogenicity in animals (U.S. EPA, 1998a).

Under the Proposed Guidelines for Carcinogen Risk Assessment (U.S. EPA, 1996; U.S. EPA, 1999), **chloroform** is *likely to be carcinogenic to humans by all routes of exposure* under high-exposure conditions that lead to cytotoxicity and regenerative hyperplasia in susceptible tissues (U.S. EPA, 1998a,b). **Chloroform** is *not likely to be carcinogenic to humans by any route of exposure* under exposure conditions that do not cause cytotoxicity and cell regeneration. This weight-of-evidence conclusion is based on: 1) observations in animals exposed by both oral and inhalation pathways which indicate that sustained or repeated cytotoxicity with secondary regenerative hyperplasia precedes, and is probably required for, hepatic and renal neoplasia; 2) there are no epidemiological data specific to **chloroform** and, at most, equivocal epidemiological data related to drinking water exposures that cannot necessarily be attributed to **chloroform** amongst multiple other disinfection byproducts; and 3) genotoxicity data on **chloroform** are essentially negative, although there are some scattered positive results that generally have limitations such as excessively high dose or with confounding factors. Thus, the weight-of-evidence of the genotoxicity data on **chloroform** supports a conclusion that **chloroform** is not strongly mutagenic, and that genotoxicity is not likely to be the predominant mode of action underlying the carcinogenic potential of **chloroform**. Although no cancer data exist for exposures via the dermal pathway, the weight-of-evidence conclusion is considered to be applicable to this pathway as well, because **chloroform** absorbed through the skin and into the blood is expected to be metabolized and to cause toxicity in much the same way as **chloroform** absorbed by other exposure routes.

For more detail on Characterization of Hazard and Dose Response, exit to the toxicological review, Section 6 (PDF).

For more detail on Susceptible Populations, exit to the toxicological review, Section 4.7 (PDF).

II.A.2. Human Carcinogenicity Data:

Inadequate. There are no epidemiological data attributing cancer to exposure to **chloroform** *per se*. Although there are some equivocal epidemiological data relating a weak association of drinking water exposures to bladder, rectal and colon cancer (Morris et al. 1992 ; McGeehin et al., 1993; Vena et al. 1993; Morris, 1995; King and Marrett, 1996; Doyle et al., 1997; Freedman et al., 1997; Cantor et al, 1998; Hildesheim et al., 1998), these studies can not attribute to **chloroform** among multiple other disinfection byproducts (DBPs) (SAB, 2000, ATSDR, 1997; IPCS, 2000). Morris et al. (1992) did a meta-analysis that pooled the relative risks from ten cancer epidemiology studies in which there was a presumed exposure to chlorinated water and its byproducts and estimated that approximately 10,000 cases of rectal and bladder cancer cases per year could be associated with exposure to DBPs in chlorinated water in the United States. Later, Poole (1997) reviewed the studies available to Morris et al. (1992) plus three additional studies (McGeehin et al., 1993; Vena et al., 1993; and King and Marrett, 1996). Poole (1997) observed that there was considerable heterogeneity among the data and that there

was evidence of publication bias within the body of literature. In addition, Poole found that the aggregate estimates reported by Morris et al. were sensitive to small changes in the analysis (e.g., addition or deletion of a single study). Based on the observations, Poole recommended that the cancer epidemiology data considered in the Morris evaluation should not be combined into a single summary estimate and that the data had limited utility for risk assessment purposes. Based on the available cancer epidemiology database, bladder cancer studies provide the strongest evidence for an association between exposure to chlorinated water and cancer. Based on the studies of Cantor et al. (1985), McGeehin et al. (1993), King and Marrett (1996), Freedman et al. (1997), and Cantor et al. (1998), EPA calculated that the population attributable risk (the fraction of a disease that could be eliminated if the exposure of concern were eliminated) for bladder cancer ranged from 2% to 17% (U.S. EPA, 1998c). However, these calculations are based on a number of assumptions, including the assumption that there is a cause-effect relationship between exposure to chlorinated drinking water and increased risk of bladder cancer. This assumption is subject to considerable uncertainty, especially because findings are not consistent within or between studies. Evaluation of these studies by application of standard criteria for establishing causality from epidemiological observations (strength of association, consistency of findings, specificity of association, temporal sequence, dose-response relation, biological plausibility) has led EPA to conclude that the current data are insufficient to establish a causal relationship between exposure to **chloroform** and increased risk of cancer (U.S. EPA, 1998a). Moreover, if, in the future, the weight-of-evidence does reach a point where a causal link is established between exposure to chlorinated water and increased risk of bladder or other types of cancer, it could not be concluded from epidemiological studies of this type that **chloroform** per se is carcinogenic in humans, as chlorinated water contains numerous disinfection byproducts besides **chloroform** that are potentially carcinogenic (U.S. EPA, 1998a).

II.A.3. Animal Carcinogenicity Data:

Adequate. At high doses, **chloroform** has been reported to be carcinogenic in several chronic animal bioassays, with significant increases in the incidence of liver tumors in male and female mice and significant increases in the incidence of kidney tumors in male rats and mice (U.S. EPA, 1994, 1998c). When examining the biology of the tumor production, the occurrence of tumors is demonstrably species-, strain-, and gender-specific, and has only been observed under dose conditions that caused cytotoxicity and regenerative cell proliferation in the target organ.

In a gavage bioassay (NCI, 1976), Osborne-Mendel rats and B6C3F1 mice were treated with **chloroform** in corn oil 5 times/week for 78 weeks (50 animals per sex per dose group). Male rats received 90 or 125 mg/kg/day; females initially were treated with 125 or 250 mg/kg/day for 22 weeks and 90 or 180 mg/kg/day thereafter. A decrease in survival rate and weight gain was evident for all treated rats. A significant increase in kidney epithelial tumors was observed in male rats (0% in controls, 8% in the low dose and 24% in the high dose groups). Male mice received 100 or 200 mg/kg/day, raised to 150 or 300 mg/kg/day at 18 weeks; females were dosed with 200 or 400 mg/kg/day, raised to 250 or 500 mg/kg/day. Survival rates and weight gains were comparable for all groups except high dose female mice which had a decreased survival. In mice, highly significant increases in hepatocellular carcinomas were observed in both sexes (98% and 95% for males and females at the high dose; 36% and 80% for males and females at the low dose as compared with 6% of both matched and colony control males , 0% in matched control females and 1% in colony control females). Nodular hyperplasia of the liver was observed in many low dose male mice that had not developed hepatocellular carcinoma. Hepatomas have also developed in female strain A mice and NLC mice gavaged with **chloroform** (Eschenbrenner and Miller, 1945; Rudali, 1967).

Jorgenson et al. (1985) administered **chloroform** (pesticide quality and distilled) in drinking water to male Osborne-Mendel rats and female B6C3F1 mice at concentrations of 200, 400, 900, and 1,800 mg/L for 104 weeks. These concentrations were reported by the author to correspond to 19, 38, 81, and 160 mg/kg/day for rats and 34, 65, 130, and 263 mg/kg/day for mice. The combined benign and malignant renal tumor incidence in male rats was 2%, 2%, 2%, 5%, 6% and 14% for the control, matched control, 19, 38, 81, and 160 mg/kg/day groups, respectively. A significant increase in renal tumors (14%) in rats was observed in the highest dose group (160 mg/kg/day). A reevaluation of the histopathology of the slides (Hard et al., 2000), found evidence of persistent cytotoxicity and regenerative hyperplasia in all rats of the highest dose group. Similar changes were also observed in rats at 81 mg/kg/day, but at a much lower incidence and grade. Thus, the histopathology reexamination provides evidence supporting chronic renal tubule injury as the mode of action underlying the renal tumor response. The liver tumor incidence in female mice was not significantly increased.

Chloroform administered in toothpaste was not carcinogenic to male C57B1, CBA, CF-1, or female ICI mice or to beagle dogs. Male ICI mice administered 60 mg/kg/day were found to have an increased incidence of kidney epithelial tumors (Roe et al., 1979; Heywood et al., 1979). A pulmonary tumor bioassay in strain A/St mice was negative, as was one in which newborn C57X DBA2/F1 mice were treated s.c. on days 1 to 8 of life (Theiss et al., 1977; Roe et al., 1968).

Matsushima (1994) exposed F344 rats (50/sex/group) and BDF1 mice (50/sex/group) to **chloroform** vapor 6 hours/day, 5 days/week for 104 weeks. Rats were exposed to concentrations of 0, 10, 30, or 90 ppm, and mice were exposed to 0, 5, 30, or 90 ppm. In order to avoid short- term lethality, mice in the two highest groups (30 and 90 ppm) were initially exposed to a lower levels for 2-6 weeks before the long-term exposure. The time-weighted average (TWA) for the 30 ppm group was 29.1 ppm and for the 90 ppm group was 85.7 ppm (U.S. EPA, 1998a). Statistically significant increases in the incidence of overall renal cell adenoma and renal cell carcinoma were observed in male mice in the 30 (7/50) and 90 (12/48) ppm groups, when compared to controls (0/50). The overall incidence rates of renal cell carcinoma were statistically significantly increased in males in the 90-ppm group (11/48) when compared to controls (0/50). There were no statistically significant findings reported for female mice in any exposure groups.

II.A.4. Supporting Data for Carcinogenicity:

Mutagenicity

Many studies have investigated the mutagenic potential of **chloroform**. However, there are several reasons these studies must be reviewed carefully and interpreted cautiously. For example, **chloroform** is relatively volatile, so test systems not designed to prevent **chloroform** escape to the air may yield unreliable results. Earlier studies in which appropriate P450-based metabolic activation systems were absent are also likely to be unreliable. Further, some older studies that used ethanol as a solvent or preservative for **chloroform** may be confounded by formation of ethyl or diethyl carbonate, which are potent alkylating agents. Another important issue is that studies that focused on clastogenicity endpoints using excessively high doses may be confounded by severe cytotoxicity, causing lysosomal or other releases (Brusick, 1986).

In Vitro Studies

Two investigators reported DNA binding in studies with calf thymus DNA in the presence of exogenous

activation (DiRenzo et al., 1982; Colacci et al., 1991). The study by DiRenzo et al. (1982) used ethanol as a solvent, suggesting that ethyl carbonate formation might be a problem. In the study by Colacci et al. (1991), addition of SKF-525A inhibited DNA binding, suggesting that binding was mediated by a cytochrome P-450 mediated pathway, as would be expected for **chloroform**. In interpreting these studies, it is important to remember that cell-free systems may not always be a good model for intact cellular processes.

Gene mutation studies in *Salmonella typhimurium* and *E. coli* (Ames assay), including tests done under conditions designed to reduce evaporation, are mostly negative, with or without activation with microsomes from liver or kidney of rats or mice (Rapson et al., 1980; San Agustin and Lim-Sylianco, 1978; Van Abbe et al., 1982; Uehleke et al., 1977; Gocke et al., 1981; Roland-Arjona et al., 1991; Le Curieux et al., 1995; Kirkland et al., 1981; Simmon et al., 1977). However, four studies have showed positive results in bacteria. Varma et al. (1988) reported that **chloroform** caused mutagenicity in five strains of *S. typhimurium*, but the response was noted only at the lowest dose tested, and all higher doses were not different from control. This unusual pattern casts some doubt on these results. San Agustin and Lim-Sylianco (1997) reported that **chloroform** caused DNA damage in *Bacillus subtilis*, and Wecher and Scher (1982) reported that **chloroform** caused mutations in *Photobacterium phosphoreum*. However, neither study reported the exposure concentrations that caused these effects, so the relevance of these reports is uncertain. In addition, the studies by Varma et al. (1988) and Wecher and Scher (1982) each used ethanol as a diluent, raising the possibility that the positive effect might be related to ethyl carbonate formation rather than to **chloroform**. The majority of results reported for *S. typhimurium* and *E. coli* exposed to the vapor phase were also negative (Van Abbe et al., 1982; Pegram et al., 1997; Simmon, 1977; Sasaki et al., 1998). Pegram et al. (1997) reported that **chloroform** was weakly positive at vapor concentrations greater than 19,200 ppm (about 770 mg/L in the aqueous phase). Employing physiologically based pharmacokinetic models, the authors estimated the oral doses needed to produce the effect would exceed 2,000 mg/kg (approximately twice the LD50).

Tests of genotoxicity are also mainly negative in fungi (Gualandi, 1984; Mehta and von Borstel, 1981; Kassinova et al., 1981; Jagannath et al., 1981). However, **chloroform** was shown to induce intrachromosomal recombination in *Saccharomyces cerevisiae* at concentrations of 6,400 mg/L (Callen et al., 1980) or 750 mg/L (Brennan and Schiestl, 1998). In the Brennan and Schiestl study, addition of *N*-acetylcysteine reduced **chloroform**-induced toxicity and recombination, suggesting a free radical may have been involved. Chromosome malsegregation was also reported in *Aspergillus nidulans* (Crebelli et al., 1988), but only at concentrations above 1,600 mg/L. In all three of these positive studies, doses that caused positive results also caused cell death, indicating that exposures were directly toxic to the test cells.

Studies in intact mammalian cells are mainly negative (Larson et al., 1994a; Perocco and Prodi, 1981; Butterworth et al., 1989; Kirkland et al., 1981; White et al., 1979; Sturrock, 1977), although positive results have been reported in a few systems. Increased sister chromatid exchange was reported in human lymphocytes at a concentration of about 1,200 mg/L without exogenous activation (Morimoto and Koizumi, 1983), and at a lower concentration (12 mg/L) with exogenous activation (Sobti, 1984). In the study by Sobti, the increase was quite small (less than 50%), and there was an increase in the number of cells that did not exclude dye. This suggests that the exposure levels that caused the mutagenic effect may have been directly toxic to the cells. In addition, ethanol was used as a dose vehicle. Mitchell et al. (1988) did not detect an increase in mutation in mouse lymphoma cells at an exposure level of 2,100 mg/L in the absence of exogenous activation, but did detect an effect at a concentration of 59 mg/L with exogenous activation.

In Vivo Studies

A number of different endpoints of **chloroform** genotoxicity have been measured in intact animals exposed to **chloroform** either orally or by inhalation. In studies of DNA binding in liver and kidney of mice and rats, negative results have been reported at doses of 742 mg/kg, 119 mg/kg, and 48 mg/kg (Diaz-Gomez and Castro, 1980; Reitz et al., 1982; Pereira et al., 1982). However, positive results have been reported at doses as low as 2.9 mg/kg (Colacci et al., 1991). But, in the study by Colacci et al. (1991), no significant difference in binding was noted between multiple tissues (liver, kidney, lung, and stomach), and there was no increase in binding with phenobarital pretreatment. This suggests the binding may not have been related to **chloroform** metabolism.

Studies based on signs of DNA damage or repair have been uniformly negative (Larson et al., 1994a; Potter et al., 1996; Reitz et al., 1982; Mirsalis et al., 1982). However, studies based on various signs of chromosomal abnormalities have been mixed, with some studies reporting negative findings at doses of 371 mg/kg and 800 mg/kg (Shelby and Witt, 1995; Topham, 1980), while other studies report positive results at doses as low as 1.2 mg/kg (Fujie et al., 1990). However, the positive result at low dose in the study by Fujie et al. (1990) was observed following intraperitoneal exposure, and positive results following oral exposure were not observed until a dose level of 119 mg/kg. Morimoto and Koizumi (1983) observed an increase in the frequency of sister chromatid exchange in bone marrow cells at a dose of 50 mg/kg/day, but at 200 mg/kg/day, all of the mice died. As discussed before, mutagenicity results observed following highly toxic doses may have been confounded by cytotoxic responses and should be viewed as being of uncertain relevance.

Several studies have reported negative findings for the micronucleus test in rats and mice (Gocke et al., 1981; Salamone et al., 1981; Le Curieux, 1995), but several other studies have detected positive results, mainly at exposure levels of 400-600 mg/kg (San Agustin and Lim-Sylianco, 1982; Robbiano et al., 1998; Sasaki et al., 1998; Shelby and Witt, 1995). This suggests that **chloroform** may be clastogenic, but it is important to note that these doses are well above the level that causes cytotoxicity in liver and kidney in most oral exposure studies in rodents.

Butterworth et al. (1998) did not detect an increase in mutation frequency in male mice exposed by inhalation at an exposure level of 90 ppm, even though this exposure did cause an increase in tumors in the study by Nagano et al. (1998). Increased incidence of sperm head abnormalities was reported in mice exposed at 400 ppm (Land et al., 1981), but was not observed in mice exposed to 371 mg/kg intraperitoneally (Topham, 1980).

In *Drosophila melanogaster* larvae exposed to **chloroform** vapor, gene mutation (Gocke et al., 1981) and mitotic recombination tests (Vogel and Nivard, 1993) were both negative. Grasshopper embryos (*Melanoplus sanguinipes*) did not display mitotic arrest at vapor concentrations of 30,000 ppm, but an effect was seen at 150,000 ppm (Liang et al., 1983). San Agustin and Lim-Syllianco (1981) reported a single positive and negative result for host- mediated mutagenicity in *Salmonella typhimurium*, but exposure levels were not reported in either case.

On the basis of the in vitro and in vivo studies reviewed above, even though a role of mutagenicity cannot be completely ruled out, the majority of available studies are negative, and many of the positive studies have limitations (excessive doses or other confounding factors). Thus, the weight-of-evidence supports the conclusion that **chloroform** is not strongly mutagenic, and that genotoxicity is not likely to be the predominant mode of action underlying the carcinogenic potential of **chloroform**. This conclusion is supported by a number of other groups who have reviewed and evaluated the available data

on **chloroform** genotoxicity, including the International Commission for Protection against Environmental Mutagens and Carcinogens (Lohman et al., 1992), ILSI (1997), Health Canada (2000), and WHO (1998).

Mode of Action

1. Summary of Postulated Mode of Action

Studies in animals reveal that **chloroform** can cause an increased incidence of kidney tumors in male rats and an increased incidence of liver tumors in male and female mice. Available data suggest that tumors are produced only at dose levels that result in cytotoxicity. These induced tumor responses are postulated to be secondary to sustained or repeated cytotoxicity and secondary regenerative hyperplasia. **Chloroform**'s carcinogenic effects in rodent liver and kidney are attributed to oxidative metabolism-mediated cytotoxicity in the target organs. Although **chloroform** undergoes both oxidative and reductive cytochrome P450-mediated metabolism, it is the oxidative (CYP2E1) metabolic pathway that predominates at low **chloroform** exposures. This oxidative pathway produces highly tissue-reactive metabolites (in particular phosgene) that lead to tissue injury and cell death. It is likely that the electrophilic metabolite phosgene causes cellular toxicity by reaction with tissue proteins and cellular macromolecules as well as phospholipids, glutathione, free cysteine, histidine, methionine, and tyrosine. The liver and kidney tumors induced by **chloroform** depend on persistent cytotoxic and regenerative cell proliferation responses. The persistent cell proliferation presumably would lead to higher probabilities of cell mutation and subsequent cancer. The weight of the evidence indicates that a mutagenic mode of action via DNA reactivity is not a significant component of the **chloroform** carcinogenic process.

2. Identification of key events

There are essentially three key steps in the sequence of events that lead to **chloroform**-induced tumorigenesis in the liver and kidneys of rodents. The first step is oxidative metabolism of **chloroform** in the target organs, kidney and liver. Numerous binding and metabolism studies (as described in ILSI, 1997, and U.S. EPA, 1998a) provide support that **chloroform** is metabolized by the oxidative cytochrome P450 (CYP2E1) pathway. This conclusion is supported by the study of Constan et al. (1999) in Sv/129 wild type, Sv/129 CYP2E1 null, and B6C3F1 mice. In the wild type of each strain, exposure to 90 ppm **chloroform** for 6 hours per day for 4 consecutive days resulted in severe hepatic and renal lesions along with increased cell proliferation. With the same exposure, neither the cytotoxicity nor cell proliferation occurred in the CYP2E1 null mouse or in the wild type of either strains treated with the P450 inhibitor ABT.

Available evidence indicates that metabolism by CYP2E1 predominates at low exposures and is rate-limiting to **chloroform**'s carcinogenic potential. Reductive metabolism, if it occurs, can lead to free radicals and tissue damage, but this pathway is absent or minor under normal physiological conditions. The next key step is the resultant cytotoxicity and cell death caused by the oxidative metabolites (with phosgene as the significant toxic intermediate). Regenerative cell proliferation follows the hepatotoxicity and nephrotoxicity as measured by labeling index in mouse kidney and liver and rat kidney from **chloroform**-treated animals. This increase in cell division is responsible for the increased probability of cancer.

3. Strength, consistency, specificity of association

There are numerous cases where exposure to **chloroform** causes an increase in cytotoxicity (as

evidenced by histopathological evaluation and/or increased labeling index) without any observable increase in cancer incidence. These data indicate that **chloroform** exposures that are adequate to cause cytotoxicity and regenerative cell proliferation do not always lead to cancer. However, there are no cases where a tumorogenic response has been observed in which evidence of cell regeneration is not also observed at the same or lower dose as that which caused an increase in tumors. This consistency of evidence (i.e., cell regeneration is detected in all cases of tumorigenicity) is strong evidence supporting the conclusion that cell regeneration is a mandatory precursor for tumorigenicity.

Evidence for a link between sustained cytotoxicity/regenerative hyperplasia and cancer is strongest in the kidney. In male Osborne-Mendel rats exposed to **chloroform** in water for 2 years (Jorgenson et al., 1985), a statistically significant increase in renal tumors was observed at a concentration of 1,800 ppm (160 mg/kg/day). A re-analysis of the histopathological slides from this study (Hard et al., 2000) revealed evidence for sustained cytotoxicity and cell proliferation in the kidney at exposures of 900 ppm (81 mg/kg/day) or higher. Likewise, in BDF_1 mice exposed to **chloroform** by inhalation at 5, 30, or 90 ppm for 6 hours/day, 5 days/week (Nagano et al., 1998), increased incidence of renal tumors was observed in male mice at the two higher doses, whereas females showed no significant tumor response. Templin et al. (1998) duplicated this exposure regimen in order to study whether the treatment caused cytotoxicity and regenerative hyperplasia. These authors observed cytotoxicity and hyperplasia in the kidneys of male mice exposed to 30 or 90 ppm throughout a 90-day exposure period, but not in females. This observation is consistent with the hypothesis that sustained cytotoxicity and regenerative hyperplasia are key events in the neoplastic response of the kidney to **chloroform**.

Available data also indicate that cytotoxicity and regenerative hyperplasia are required for liver cancer, although the strength of this conclusion is somewhat limited because most of the observations are based on short-term rather than long-term histological or labeling index measurements. For example, in the B6C3F1 mouse, corn oil gavage (bolus dosing) at the same doses that resulted in liver tumors in the study by NCI (1976) also caused hepatic cytolethality and a cell proliferative response at both 4 days and 3 weeks (Larson et al., 1994b,c). Similarly, exposure of female B6C3F1 mice to **chloroform** in drinking water at levels that did not induce liver tumors (Jorgenson et al., 1985) also did not induce hepatic cytolethality or cell proliferation at 4 days or 3 weeks (Larson et al., 1994b). This consistency of the data (i.e., evidence of cytolethality and/or regenerative hyperplasia is always observed in cases of increased liver tumors) supports the conclusion that this liver cancer also occurs via a mode of action involving regenerative hyperplasia.

4. Dose-response relationship

Chloroform-induced liver tumors in mice are only seen after bolus corn oil dosing. Mouse liver tumors are not found following administration by other routes (drinking water and inhalation). Rat liver tumors are not induced by **chloroform** following either drinking water or corn oil gavage administration. Kidney tumors are found in mice exposed to **chloroform** via inhalation or toothpaste preparations, and in rats when exposed via drinking water or corn oil gavage. Kidney and liver tumors develop only at doses that cause persistent cytotoxicity and regenerative proliferation, regardless of route of exposure or dosing regime. The overall dose-response for the cytotoxicity and cell proliferation responses is nonlinear. All key events and tumor effects depend on the dose-rate as shown by the difference in oil gavage versus drinking water administration (ILSI, 1997; U.S. EPA, 1998a).

5. Temporal relationship

As noted above, there is very strong evidence from short-term and long-term histological and labeling

index studies in mice and rats that cytotoxicity and cell proliferation always precede the occurrence of increased kidney or liver tumor effects in long-term bioassays. For example, a re-evaluation of serial sacrifice data from the **chloroform** 2-year drinking water bioassay in Osborne-Mendel rats revealed a linkage between toxicity in the renal tubules and tumor development and showed that renal toxicity preceded tumor development (Hard and Wolf, 1999; Hard et al., 2000).

6. Biological plausibility and coherence

The theory that sustained cell proliferation to replace cells killed by toxicity, viral, or other insults such as physical abrasion of tissues can be a significant risk factor for cancer is plausible and generally accepted (Correa, 1996). It is logical to deduce that sustained cytotoxicity and regenerative cell proliferation may result in a greater likelihood of mutations being perpetuated with the possibility of more of these resulting in uncontrolled growth. It may also be that continuous stimulus of proliferation by growth factors involved in inflammatory responses increases the probability that damaged cells may slip through cell cycle check points carrying DNA alterations that would otherwise be repaired. Current views of cancer processes support both these possibilities. There are no data on **chloroform** that allow the events that occur during cell proliferation to be directly observed. A high proliferation rate alone is not assumed to cause cancer; tissues with naturally high rates of turnover do not necessarily have high rates of cancer and tissue toxicity in animal studies does not invariably lead to cancer. Nevertheless, regenerative proliferation associated with persistent cytotoxicity appears to be a risk factor of consequence.

7. Role of genotoxicity

As noted above, the question whether **chloroform** or a metabolite is mutagenic has been tested extensively across different phylogenetic orders (i.e., bacterial, eukaryotic, and mammalian systems). Predominately negative results are reported in all test systems, with no pattern of mutagenicity seen in any one system considered to be a competent predictor. Positive results appear sporadically in the database, but they generally have problems with high dose or other confounding issues. ILSI (1997) considered results from 40 tests by the quantitative weight-of-evidence method for heterogeneous genetic toxicology databases from the International Commission for Protection against Environmental Mutagens and Carcinogens (ICEMC) (Lohman et al., 1992). This method scores relative DNA reactivity, with a maximum positive score being +100 and maximum negative -100. The maximum positive score obtained among 100 chemical databases has been +49.7 (triazaquone) and the maximum negative has been -27.7. The score for **chloroform** was -14.3.

Testing of **chloroform** in the p53 heterozygous knockout mouse shows no tumor effect (Gollapudi et al., 1999). Heterozygous p53 males were dosed up to 140 mg/kg and females up to 240 mg/kg via corn oil gavage for 13 weeks. This model is known to respond most effectively to mutagenic carcinogens.

Products of oxidative and reductive metabolism of **chloroform** are highly reactive. Such species are unstable and will likely react with cytoplasmic molecules before reaching nuclear DNA. Such reactive species (e.g., phosgene) have not been evaluated separately for genetic toxicity, and because of reactivity, would not be amenable to study and would not likely be able to transport from the cellular site of production to the nucleus.

Comparative examination of both oxidative and reductive metabolism for structural analogues and **chloroform** has revealed that carbon tetrachloride, which is largely metabolized to a free radical via the reductive pathway, results in cell toxicity, not mutagenicity. Moreover, **chloroform** and carbon

tetrachloride show very different patterns of liver toxicity (i.e., carbon tetrachloride's toxicity is more consistent with free radical production and **chloroform**'s is not). For methylene chloride, glutathione conjugation results in mutagenic metabolites. When rat glutathione transferase gene copies are introduced into *Salmonella*, bromodichloromethane produces mutagenic metabolites; the fact that **chloroform** in this system did so only marginally and only at high toxic doses (Pegram et al., 1997) supports a conclusion that the reductive pathway does not contribute to **chloroform**'s toxicity or carcinogenicity.

In initiation-promotion studies, **chloroform** at the highest test dose of the drinking water bioassay does not promote development of hepatic lesions in rats or two strains of mice, nor does it initiate or act as a cocarcinogen. Administered in oil, **chloroform** was a promoter in the rat liver in initiation-promotion protocols. These results are more consistent with the postulated mode of action than with any mutagenic potential.

8. Effects on children

The central questions asked in a mode of action analysis are, 1) whether the standard assumption that a mode of action observed in animals is relevant to humans holds true in a particular case, and 2) what the nature of the mode of action implies about the shape of the dose response relationship. In the case of **chloroform** the conclusions have been that the rodent mode of action can be assumed to be relevant to humans and that a nonlinear approach is most appropriate. The next question is whether the data lead one to anticipate similarities or differences in response by sex or age.

Ideally, one would have adequate data to compare each of the key events of **chloroform** toxicity and subsequent carcinogenicity in tissues of adults with those of the developing fetus and young. This kind of information is currently not to be found. In the absence of data on the fetus and young specific to **chloroform**, an evaluation is made as to whether a cogent biological rationale exists for determining that the postulated mode of action is applicable to children (EPA, 1999). There is no suggestion from available studies of **chloroform** to indicate that children or fetuses would be qualitatively more sensitive to its effects than adults. The developing organism would not be expected to be particularly sensitive to cytotoxic agents at minimally toxic levels because cell division is proceeding rapidly and repair capacity at the molecular and cellular level is high. This is reflected by the relatively low incidence of spontaneous tumors in developing and young organisms. Moreover, the reproductive and developmental studies available, while they have limitations, show that fetal effects are seen only at doses at which maternal toxicity is evident. Research would be needed to further explore whether there are circumstances in which this relationship does not hold. Research would also be needed to discover whether there is some other mode of action, not seen in rodents, that might be possible. Presently, there are no clues from in vivo or in vitro studies as to what alternative mode of action might be considered. In keeping with traditional toxicologic evaluations, **chloroform** has been tested in lifetime studies with high level doses to provide maximal opportunities for toxicologic effects to manifest themselves in multiple tissues and organs through multiple mechanisms. In the absence of data to the contrary, this approach is considered to provide evidence for lack of potential for significant response, other than those noted, even for sensitive individuals and life stages.

The mode of action analyzed as well as all other potential modes of action identified required that **chloroform** be metabolized by cytochrome P450 (CYP2E1) (SAB (2000), p.2). When this is considered along with the comparison of this enzyme activity between adults and the young there is confidence in assuming similarity in response among life stages. Further research on the processes of cell injury, death and regeneration would increase this confidence by addressing any uncertainty about potential

quantitative similarity. The literature does not reveal any such quantitative data at present.

Given the above, it is reasonable to assume that: 1) The reactive metabolite inside the cell should have similar effects by reacting with and disrupting macromolecules in the cells of fetuses, children and adults, 2) Cell necrosis and reparative replication are not likely to be qualitatively different in various stages in life, 3) Cancer risk to the fetus or children would be a function of cytotoxic injury, like in adults, and protecting these life stages from sufficient cytotoxicity to elicit this response should protect against cancer risks. Further research would be needed to assess whether there are significant quantitative differences between life stages which have not yet been elucidated.

It can be noted that if data indicated that it were appropriate to apply a linear approach to part of a lifetime, such as the first 3 years of life, the resulting risk would be represented by a small increment of the total dose per body weight over a lifetime since most of a 70 year life is at an adult body weight. When this total is divided by 70 years to derive the lifetime average daily dose, the small increment of early dose does not significantly increase risk.

9. Conclusion regarding cancer mode of action

The weight of the evidence supports the conclusion that **chloroform**-induced tumors in liver and kidney are produced only at dose levels that result in repeated or sustained cytotoxicity and regenerative cell proliferation. A wide range of evidence across different species, sexes, and routes of exposure implicates oxidative CYP2E1 metabolism leading to persistent cytotoxicity and regenerative cell proliferation as events that precede and are associated with tumor formation. The cytochrome P450 oxidative metabolism that leads to oxidative damage and ensuing cell growth, involving basic tissue responses to cellular toxicity and death, is common to humans and rodents. No data exist indicating that the mode of action observed in rodents is not also likely to apply to humans.

Available data on the mutagenic potential of **chloroform** are mixed, but the majority of tests are negative, and some of the positive results are observed only at extreme exposure conditions. Thus, the weight of the evidence indicates that **chloroform** is not a strong mutagen and that neither **chloroform** nor its metabolites readily bind to DNA. On the basis of these results and the results of studies that evaluated other endpoints of mutagenicity, it seems likely that even though a role for mutagenicity cannot be excluded with certainty, **chloroform** does not produce carcinogenic effects primarily by a specific genotoxic mechanism.

The proposed dose-response relationship for **chloroform** tumorigenesis by the cytotoxicity-regenerative hyperplasia mode of action will be nonlinear, as it is dependent on biochemical and histopathological events that are nonlinear. The dose-response assessment would ideally be based on use of phosgene dosimetry because it marks the rate-limiting step of oxidative metabolism. The toxicokinetic modeling to support this phosgene approach is not currently available, so the dose-response assessment is based on the tumor precursor event of cytotoxicity to project a level of exposure that will be protective against the key event of regenerative hyperplasia.

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure:

In accord with proposed EPA guidelines for cancer risk assessment (U.S. EPA, 1996), the method used to characterize and quantify cancer risk from a chemical depends on what is known about the mode of action of carcinogenicity and the shape of the cancer dose-response curve for that chemical. A default

assumption of linearity is appropriate when evidence supports a mode of action of gene mutation due to DNA reactivity, or another mode of action that is anticipated to be linear. The linear approach is used as a matter of policy if the mode of action of carcinogenicity is not understood. Alternatively, an assumption of nonlinearity is appropriate when there is no evidence for linearity and sufficient evidence to support an assumption of nonlinearity. In this case, the carcinogenicity may be a secondary effect of toxicity that itself is a threshold phenomenon (U.S. EPA, 1996).

In the case of **chloroform**, the mode of action of carcinogenicity is reasonably well understood. Available data indicate that **chloroform** is not strongly mutagenic and **chloroform** is not expected to produce rodent tumors via a mutagenic mode of action (ILSI, 1997). Rather, there is good evidence that carcinogenic responses observed in animals are associated with regenerative hyperplasia that occurs in response to cytolethality (ILSI, 1997; U.S. EPA, 1998a,b). Because cytolethality occurs only at exposure levels above some critical dose level, a nonlinear approach is considered the most appropriate method for characterizing the cancer risk from **chloroform**.

The Proposed Guidelines for Carcinogenic Risk Assessment (U.S. EPA, 1996) state that when the mode-of-action analysis based on available data indicates that "the carcinogenic response is secondary to another toxicity that has a threshold, the margin-of-exposure analysis performed for toxicity is the same as is done for a noncancer endpoint, and an RfD for that toxicity may be considered in the cancer assessment." For **chloroform**, available evidence indicates that **chloroform**-induced carcinogenicity is secondary to cytotoxicity and regenerative hyperplasia; hence, the Agency relies on a nonlinear dose-response approach and the use of a margin-of-exposure analysis for cancer risk. The Agency has also chosen not to rely on a mathematical model to estimate a point of departure for cancer risk estimate, because the mode of action indicates that cytotoxicity is the critical effect and the reference dose value is considered protective for this effect.

RfD and Margin of Exposure

For more discussion of margin of exposure (MOE), see the Toxicological Review for **Chloroform**. Based on the kidney tumor of the drinking water study (Jorgenson et al., 1985), a point of departure (Pdp or LED_{10}) of 23 mg/kg/day can be calculated using quantitative modeling of tumor dose-response data. Comparing the Pdp to the RfD of 0.01 mg/kg/day leads to a MOE of 2,000, which is considered large. Thus, in this case, the RfD for noncancer effect is also considered adequately protective of public health for cancer effects by the oral route, on the basis of the nonlinear dose response for **chloroform** and the mode of action for both cancer and noncancer effects having a common link through cytotoxicity.

As discussed above, the RfD for noncancer effects is derived from the most sensitive endpoint in the most sensitive species. The RfD is based on fatty cysts formation (fat accumulation) in the liver and elevation of SGPT in dogs (Heywood et al., 1979). Hepatic fat accumulation and elevated SGPT are considered early signs of impaired liver function resulting from **chloroform**-induced cytotoxicity. This effect occurs at doses at or below those that cause increased labeling index, morphological changes, or cellular necrosis, so protection against this effect is believed to protect against cytolethality and regenerative hyperplasia. Accordingly, the RfD of 0.01 mg/kg/day presented in Section I.A.1 can be considered protective against increased risk of cancer.

II.B.1. Summary of Risk Estimates:

A dose of 0.01 mg/kg/day (equal to the RfD) can be considered protective against cancer risk

II.B.1.1.Oral Slope Factor:

Not applicable (see text).

II.B.1.2. Drinking Water Unit Risk:

Not applicable (see text).

II.B.2. Dose-Response Data (Carcinogenicity, Oral Exposure):

Dose-response data used to derive the RfD for **chloroform** are presented in Section I.A.2.

II.B.3. Additional Comments (Carcinogenicity, Oral Exposure):

Because **chloroform** is a volatile chemical, exposure to **chloroform** in drinking water may occur not only via direct ingestion, but also by inhalation of **chloroform** released from household uses of water (showering, cooking, washing, etc.) into indoor air. Therefore, assessments of cancer and noncancer health effects from **chloroform** in water should account for exposures by all pathways, including oral, inhalation, and dermal.

II.B.4. Discussion of Confidence (Carcinogenicity, Oral Exposure):

Confidence in the cancer assessment for **chloroform** is rated as medium. This is based on a strong database in animals that supports the conclusion that cancer does not occur without antecedent cytotoxicity and regenerative hyperplasia, leading in turn to the conclusion that cancer risk is negligible at doses that do not result in cytotoxicity. Confidence in this conclusion is tempered by absence of direct studies in humans and by the finding that there are some positive results in studies on the mutagenicity of **chloroform**, even though the weight-of-evidence indicates that **chloroform** is not a strong mutagen and that a mutagenic mode of action is not likely to account for the cancer responses observed in animals.

EPA is currently revising its guidelines for cancer risk assessment. Among other issues, EPA is looking closely at how to assess whether a postulated mode of action in adults is applicable to children. When the guidelines are final, EPA will consider their impact on existing health assessments on IRIS.

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure:

NOTE: The following evaluation of cancer risk from chloroform inhalation was developed in 1987 and does not incorporate newer data or the 1996 or 1999 draft cancer assessment guidelines. EPA is currently working to revise the assessment for inhalation exposure.

II.C.1. Summary of Risk Estimates:

II.C.1.1. Inhalation Unit Risk:

2.3E-5 per (ug/m3).

II.C.1.2. Extrapolation method:

Linearized multistage procedure, extra risk.

Air Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	4E+0 µg/m3
E-5 (1 in 100,000)	4E-1 µg/m3
E-6 (1 in 1,000,000)	4E-2 µg/m3

II.C.2. Dose-Response Data for Carcinogenicity, Inhalation:

Tumor Type -- hepatocellular carcinoma
Test Animals -- mouse, B6C3F1, female
Route -- oral, gavage
Reference -- NCI, 1976

---------- Dose ----------		
Administered (mg/kg/day)	**Human Equivalent (mg/kg/day)**	**Tumor Incidence**
Female		
0	0	0/20
238	9.9	36/45
477	19.9	39/41
Male		
0	0	1/18
138	6.2	18/50
277	12.5	44/45

II.C.3. Additional Comments (Carcinogenicity, Inhalation Exposure):

This inhalation quantitative risk estimate is based on data from a gavage study. Above doses are TWA;

body weights at the end of the assay were 35 g for males and 28 g for females. Vehicle control animals were run concurrently and housed with test animals. All treated animals experienced decreased body weight gain. Survival was reduced in high-dose males and in all treated females. Experimental data for this compound support complete absorption of orally administered **chloroform** under conditions of this assay. There are no apparent species differences in this regard. Extrapolation of metabolism-dependent carcinogenic responses from mice to humans on the basis of body surface area is supported by experimental data. The incidence data for both male and female mice were used to derive slope factors of 3.3E-2 and 2.0E-1 per (mg/kg)/day, respectively. The unit risk was prepared by taking a geometric mean of the slope factor and assuming 100% for low doses of **chloroform** in air. The unit risk should not be used if the air concentration exceeds 400 µg/m^3, because above this concentration the unit risk may not be appropriate.

II.C.4. Discussion of Confidence (Carcinogenicity, Inhalation Exposure):

Adequate numbers of animals were treated and observed. Risk estimates derived from male rat kidney tumor data (2.4E-2) (NCI, 1976) and studies by Roe et al. (1979) (1.0E-1) are generally supportive of the risk estimate.

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment):

II.D.1. EPA Documentation:

Source Document -- U.S. EPA, 2001 (oral carcinogenicity assessment); U.S. EPA, 1985, 1987 (inhalation carcinogenicity assessment)

This assessment was peer reviewed by external scientists. Their comments have been evaluated carefully and incorporated in finalization of this IRIS summary. A record of comments on the oral carcinogenicity assessment is included in an appendix to U.S. EPA (2001). ***To review this appendix, exit to the toxicological review, Appendix A, External Peer Review -- Summary of Comments and Disposition (PDF)***.

II.D.2. EPA Review (Carcinogenicity Assessment):

Agency Consensus Date (oral carcinogenicity assessment) -- 7/27/2001
Verification Date (inhalation carcinogenicity assessment) – 8/26/1987

II.D.3. EPA Contacts (Carcinogenicity Assessment):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

VI. Bibliography:

VI.A. Oral RfD References:

Golden, RJ; Holm, SE; Robinson, DE; et al. (1997) **Chloroform** mode of action: implications for cancer risk assessment. Reg Toxicol Pharmacol 26:142-155.

Hard, GC; Boorman, GA; Wolf, DC. (2000) Re-evaluation of the 2-year **chloroform** drinking water carcinogenicity bioassay in Osborne-Mendel rats supports chronic renal tubule injury as the mode of action underlying renal tumor response. Toxicol Sci 53:237-244.

Heywood, R; Sortwell, RJ; Noel, PRB; et al. (1979) Safety evaluation of toothpaste containing **chloroform**: III. Long-term study in beagle dogs. J Environ Pathol Toxicol 2:835-851.

Jorgenson, TA; Meierhenry, EF; Rushbrook, CJ; et al. (1985) Carcinogenicity of **chloroform** in drinking water to male Osborne-Mendel rats and female B6C3F1 mice. Fundam Appl Toxicol 5:760-769.

Jorgenson, TA; Rushbrook, CJ; Jones DCL. (1982) Dose-response study of **chloroform** carcinogenesis in the mouse and rat: Status report. Environ Health Perspect 46:141-149.

Larson, JL; Sprankle, CS; Butterworth, BE. (1994a) Lack of **chloroform**-induced DNA repair in vitro and in vivo in hepatocytes of female B6C3F1 mice. Environ Mol Mutagen 23:132-136.

Larson, JL; Wolf, DC; Butterworth, BE. (1994b) Induced cytotoxicity and cell proliferation in the hepatocarcinogenicity of **chloroform** in female B6C3F1 mice. Comparison of administration by gavage in corn oil vs. *ad libitum* in drinking water. Fundam Appl Toxicol 22:90-102.

Nagano, K; Nishizawa, T; Yamamoto, S; et al. (1998) Inhalation carcinogenesis studies of six halogenated hydrocarbons in rats and mice. In: Advances in the prevention of occupational respiratory diseases. Chiyotani, K; Hosoda, Y; Aizawa, Y, eds. Elsevier Science B.V.

National Toxicology Program (NTP). (1988) **Chloroform** reproduction and fertility assessment in CD-1 mice when administered by gavage. Report by Environmental Health Research and Testing, Inc., Lexington, KY to National Toxicology Program, NTP- 89-018. NTIS PB89-148639.

Palmer, AK; Street, AE; Roe, FJC; et al. (1979) Safety evaluation of toothpaste containing **chloroform**: II. Long-term studies in rats. J Environ Pathol Toxicol 2:821-833.

Pereira, MA; Lin, LC; Lippitt, JM; et al. (1982) Trihalomethanes as initiators and promoters of carcinogenesis. Environ Health Perspect 46:151-156.

Reitz, RH; Fox, TR; Quast, JF. (1982) Mechanistic considerations for carcinogenic risk estimation: **Chloroform**. Environ Health Perspect 45:163-168.

Roe, FJ; Palmer, AK; Worden, AN; et al. (1979) Safety evaluation of toothpaste containing **chloroform**: I. Long-term studies in mice. J Environ Pathol Toxicol 2:799-819.

Salamone, MF; Heddle, JA; Katz, M. (1981) Mutagenic activity of 41 compounds in the in vivo micronucleus assay. In: Evaluation of short-term tests for carcinogens: Report of the international collaborative program. Prog Mutat Res 1:686-697.

Templin, MV; Constan, AA; Wolf, DC; et al. (1998) Patterns of **chloroform**-induced regenerative cell proliferation in BDF1 mice correlate with organ specificity and dose-response of tumor formation. Carcinogenesis 19(1):187-193.

Thompson, DJ; Warner, SD; Robinson, VB. (1974) Teratology studies on orally administered **chloroform** in the rat and rabbit. Toxicol Appl Pharmacol 29:348-357.

Tsuchimoto, T; Matter, BE. (1981) Activity of coded compounds in the micronucleus test. In: evaluation of short-term test for carcinogens: report of the international collaborative program. Arch Toxicol 46:89-98.

U.S. Environmental Protection Agency (U.S. EPA). (1994) Final draft for the drinking water criteria document on trihalomethanes. Prepared for Health and Ecological Criteria Division, Office of Science and Technology, Washington, DC. Under EPA Contract No. 68-C2-0139 by Clement International Corporation. April 8, 1994.

U.S. EPA. (1995) Use of the benchmark dose approach in health risk assessment. EPA/630/R-94/007.

U.S. EPA. (1997) Summary of new data on trihalomethanes (THMS) for the notice of availability. Draft.

U.S. EPA. (1998a) Benchmark modeling of studies related to RfDs for trihalomethanes: **Chloroform**, bromodichloromethane, dibromochloromethane, and bromoform. Draft. Prepared by ICF Kaiser International. Washington, DC: Office of Water, Health Effects Criteria Division. June, 1998.

U.S. EPA. (1998b) National primary drinking water regulations: disinfectants and disinfection byproducts. Notice of data availability; proposed rule. 40 CFR Parts 141-142:15674.

U.S. EPA. (1998c) Health risk assessment/characterization of the drinking water disinfection byproduct **chloroform**. Prepared for Health and Ecological Criteria Division, Office of Science and Technology, Washington, DC. Prepared by Toxicology Excellence for Risk Assessment, Cincinnati, OH, under Purchase Order No. 8W-0767-NTLX. November 4, 1998.

U.S. EPA. (2001) Toxicological review of **chloroform** in support of summary information on IRIS. Available online at www.epa.gov/IRIS.

VI.B. Inhalation RfC References:

(Not applicable.)

VI.C. Carcinogenicity Assessment References:

ATSDR 1997. Toxicological Profile for **Chloroform** (Update). Agency for Toxic Substances and Disease Registry. Atlanta, GA.

Brennan, RJ; Schiestl, RH. (1998) **Chloroform** and carbon tetrachloride induce intrachromosomal recombination and oxidative free radicals in Saccharomyces cerevisiae. Mutat Res 397:271-278.

Butterworth, BE; Templin, MV; Constan, AA; et al. (1998) Long-term mutagenicity studies with **chloroform** and dimethylnitrosamine in female *lacI* transgenic B6C3F1 mice. Environ Mol Mutagen 31:248-256.

Butterworth, B; Smith-Oliver, T; Earle, L; et al. (1989) Use of primary cultures of human hepatocytes in toxicology studies. Cancer Res 49:1075-108.

Callen, DF; Wolf, CR; Philpot, RM. (1980) Cytochrome P-450 mediated genetic activity and cytotoxicity of seven halogenated aliphatic hydrocarbons in *Saccharomyces cerevisiae*. Mutat Res 77:55-63.

Cantor, KP; Hoover, R; Hartge, RP; et al. (1985) Drinking water source and bladder cancer: case-control study. In: Water chlorination chemistry, environmental impact and health effects. Vol. 5. Jolley, RL; Bull, RJ; Davis, WP; et al., eds. Chelsea MI: Lewis Publishers, Inc., pp. 145-152.

Cantor, KP; Lunch, CF; Hildesheim, M; et al. (1998) Drinking water source and chlorination byproducts. I. Risk of bladder cancer. Epidemiology 9:21-28.

Colacci, A; Bartolie, S; Bonora, B; et al. (1991) **Chloroform** bioactivation leading to nucleic acids binding. Tumori 77:285-290.

Constan, AA; Sprankle, CS; Peters, JM; et al. (1999) Metabolism of **chloroform** by cytochrome P450 2E1 is required for induction of toxicity in the liver, kidney, and nose of male mice. Toxicol Appl Pharmacol 160:120-126.

Correa, P. (1996) Morphology and natural history of cancer precursors. In: Cancer epidemiology and prevention. Schottenfield, D; Fraumeni, JF, eds. New York: Oxford University Press.

Crebelli, R; Benigni, R; Franekic, J; et al. (1988) Induction of chromosomes malsegregation by halogenated organic solvents in Aspergillus nidulans: unspecific or specific mechanism? Mutat Res 101:401-411.

Diaz-Gomez, MI; Castro, JA. (1980) Covalent binding of **chloroform** metabolites to nuclear proteins: No evidence for binding to nucleic acids. Cancer Lett 9:213-218.

DiRenzo, AB; Gandolfi, AJ; Sipes, IG. (1982) Microsomal bioactivation and covalent binding of aliphatic halides to DNA. Tox Lett 11:243-252.

Doyle, TJ; Sheng, W; Cerhan, JR; et al. (1997) The association of drinking water source and chlorination by-products with cancer incidence among postmenopausal women in Iowa: a prospective cohort study. Am J Public Health 87:7.

Eschenbrenner, AB; Miller, E. (1945) Induction of hepatomas in mice by repeated oral administration of **chloroform**, with observations on sex differences. J Natl Cancer Inst 5:251-255.

Freedman, M; Cantor, KP; Lee, NL; et al. (1997) Bladder cancer and drinking water: a population-based case-control study in Washington County, Maryland (United States). Cancer Causes Control 8:738-744.

Fujie, K; Aoki, T; Wada, M. (1990) Acute and subacute cytogenetic effects of the trihalomethanes on rat bone marrow cells *in vivo*. Mutat Res 242:111-119.

Gocke, E; King, MT; Eckhardt, K; et al. (1981) Mutagenicity of cosmetics ingredients licensed by the European communities. Mutat Res 90:91-109.

Gollapudi, BB; Yano, BL; Day, SJ; et al. (1999) Response of the transgenic P53+/- mouse 26-week carcinogenicity assay to **chloroform**. SOT, 1999 Annual Meeting, The Toxicologists, Abstract #1740, p. 369.

Gualandi, G. (1984) Genotoxicity of the free-radical producers CCl4 and lipoperoxidation in Aspergillus nidulans. Mutat Res 136:109-114.

Hard, GC; Wolf, DC. (1999) Re-evaluation of the **chloroform** 2-year drinking water bioassay in Osborne Mendel rats indicates that sustained renal tubule injury is associated with renal tumor development. Toxicol Sci 48 (1-S): Abstr 140, 30.

Heywood, R; Sortwell, RJ; Noel, PRB; et al. (1979) Safety evaluation of toothpaste containing **chloroform**: III. Long-term study in beagle dogs. J Environ Pathol Toxicol 2:835-851.

Hildesheim, ME; Cantor, KP; Lynch, CF; Dosemeci, M; Lubin, J; Alavanja, M; Craun, GF. (1998) Drinking water sources and chlorination byproducts: risk of colon and rectal cancers. Epidemiology 9(1):29-35.

International Life Sciences Institute (ILSI). (1997) An evaluation of EPA's proposed guidelines for carcinogen risk assessment using **chloroform** and dichloroacetate as case studies: report of an expert panel. Washington, DC: ILSI Health and Environmental Sciences Institute. November, 1997.

IPCS. (2000) International Programme on Chemical Safety. Environmental Health Criteria 216. Disinfectants and Disinfectant Byproducts. Geneva: WHO.

Jagannath, DR; Vultaggio, DM; Brusick, DJ. (1981) Genetic activity of forty-two coded compounds in the mitotic gene conversion assay using saccharomyces cerevisiae strain D4. In: Evaluation of short-term tests for carcinogens; Report of the International Collaborative Program.

Jorgenson, TA; Meierhenry, EF; Rushbrook, CJ; et al. (1985) Carcinogenicity of **chloroform** in drinking water to male Osborne-Mendel rats and female B6C3F1 mice. Fundam Appl Toxicol 5:760-769.

Kassinova, GV; Kovaltsova, SV; Marfin, SV; et al. (1981) Activity of 40 coded compounds in differential inhibition and mitotic crossing-over assays in yeast. Environmental Health Criteria 163.

King, WD; Marrett, LD. (1996) Case control study of water sources and bladder cancer. Cancer Causes Control 7:596-604.

Kirkland, DJ; Smith, KL; Van Abbe, NJ. (1981) Failure of **chloroform** to induce chromosome damage or sister chromatid exchanges in cultured human lymphocytes and failure to induce reversion in Escherichia coli. Food Cosmet Toxicol 19:651-656.

Land, PC; Owen, EL; Linde, HW. (1981) Morphologic changes in mouse spermatozoa after exposure to

inhalational anesthetics during early spermatogenesis. Anesthesiology 54:53-56.

Larson, JL; Sprankle, CS; Butterworth, BE. (1994a) Lack of **chloroform**-induced DNA repair in vitro and in vivo in hepatocytes of female B6C3F1 mice. Environ Mol Mutagen 23:132-136.

Larson, JL; Wolf, DC; Butterworth, BE. (1994b) Induced cytotoxicity and cell proliferation in the hepatocarcinogenicity of **chloroform** in female B6C3F1 mice. Comparison of administration by gavage in corn oil vs. *ad libitum* in drinking water. Fundam Appl Toxicol 22:90-102.

Larson, JL; Wolf, DC; Butterworth, BE. (1994c) Induced cytolethality and regenerative cell proliferation in the livers and kidneys of male B6C3F1 mice given **chloroform** by gavage. Fundam Appl Toxicol 23:537-543.

LeCurieux, F; Gauthier, L; Erb, F; et al. (1995) Use of the SOS chromotest, the Ames-fluctuation test and the newt micronucleus test to study the genotoxicity of four trihalomethanes. Mutagenesis 10:333-341 (as cited in U.S. EPA, 1998a).

Liang, JC; Hsu, TC; Henry, JE. (1983) Cytogenetic assays for mitotic poisoning: The grasshopper embryo system for volatile liquids. Mutat Res 113:467-479 (as cited in U.S. EPA, 1994).

Lohman, PHM; Mendelsohn, ML; Moore, DH II; et al. (1992) A method for comparing and combining short-term genotoxicity test data: the basic system. Mutat Res 266:7-25.

Matsushima, T. (1994) Inhalation carcinogenesis study of **chloroform**. Letter summary from T. Matsushima (Japan Bioassay Laboratory) to A. Chiu (U.S. EPA), August 1994.

McGeehin, MA; et al. (1993) Case-control study of bladder cancer and water disinfection methods in Colorado. Am J Epidemiol 138:492-501.

Mehta, RD; Von Borstel, RC. (1981) Mutagenic activity of forty two encoded compounds in the haploid yeast reversion assay, strain XV18514C. In: Evaluation of short-term tests for carcinogens: Report of the International Collaborative Program. Prog Mutat Res 1:414-423.

Mirsalis, J; Tyson, K; Butterworth, B. (1982) Detection of genotoxic carcinogens in the vivo-in vitro hepatocyte DNA repair assay. Environ Mutagen 4:553-562.

Mitchell, A; Myhr, B; Rudd, C; et al. (1988) Evaluation of the L5178Y mouse lymphoma cell mutagenesis assay: Intra-laboratory results for sixty-three coded chemicals tested at SRI International. Environ Mol Mutagen 12(Suppl 13):37-101.

Morimoto, K; Koizumi, A. (1983) Trihalomethanes induce sister chromatid exchanges in human lymphocytes *in vitro* and mouse bone marrow cells *in vivo*. Environ Res 32:72-79.

Morris, RD; Audet, AM; et al. (1992). "Chlorination, chlorination byproducts, and cancer: a meta-analysis". Am J Public Health 82:955-63.

National Academy of Sciences (NAS). (1987) Drinking water and health. Washington, DC: National Academy of Sciences.

National Cancer Institute (NCI). (1976) Report on carcinogenesis bioassay of **chloroform**. Bethesda, MD: National Cancer Institute.

Pegram, RA; Andersen, ME; Warren, SH; et al. (1997) Glutathione S-transferase mediated mutagenicity of trihalomethanes in *Salmonella typhimurium*: contrasting results with bromodichloromethane and **chloroform**. Toxicol Appl Pharmacol 144:183-188.

Periera, MA; Lin, LC; Lippitt, JM; et al. (1982) Trihalomethanes as initiators and promoters of carcinogenesis. Environ Health Perspect 46:151-156.

Perocco, P; Prodi, G. (1981) DNA damage by haloalkanes in human lymphocytes cultured in vitro. Cancer Lett 13:213-218.

Poole, C (1997). Analytical meta analysis of epidemiological studies of chlorinated drinking water and cancer. Quantitative review of re-analysis of the work published by Morris et al., Am J Public Health 1992. 82:955-963. National Center for Environmental Assessment, Office of Research and Development, EPA, September 30, 1997.

Potter, CL; Chang, LW; DeAngelo, AB; et al. (1996) Effects of four trihalomethanes on DNA strand breaks, renal hyaline droplet formation and serum testosterone in male F-344 rats. Cancer Lett 106:235-242 (as cited in U.S. EPA, 1998b).

Rapson, WH; Nazar, MA; Butsky, W. (1980) Mutagenicity produced by aqueous chlorination of organic compounds. Bull Environ Contam Toxicol 24:590-596 (as cited in U.S. EPA, 1994).

Reitz, RH; Fox, TR; Quast, JF. (1982) Mechanistic considerations for carcinogenic risk estimation: **Chloroform**. Environ Health Perspect 45:163-168.

Ries, LAG; Smith, MA; Gurney, JG; Linet, M; Tamara, T; Young, JL; Bunin, GR, eds. (1999) Cancer incidence and survival among children and adolescents: United States SEER Program 1975-1995. National Cancer Institute, SEER Program, NIH Pub. 99-4649. Bethesda, MD.Ref. VI.C. References.

Robbiano, L; Meretoe, E; Migliazza Morando, A; et al. (1998) Increased frequency of micronucleated kidney cells in rats exposed to halogenated anaesthetics. Mutat Res 413:1-6.

Roe, FJC; Carter, RL; Mitchley, BCV. (1968) Test of **chloroform** and AS-hydroxyquinoline for carcinogenicity using newborn mice. Br Emp Campgn 46:13.

Roe, FJC; Palmer, AK; Worden, AN; et al. (1979) Safety evaluation of toothpaste containing **chloroform**: I. Long-term studies in mice. J Environ Pathol Toxicol 2:799-819.

Roldlan-Arjona, T; Garcia-Pedrajas, MD; Luque-Romero, FL; et al. (1991) An association between mutagenicity of the ARA test of Salmonella typhimurium and carcinogenicity in rodents for 16 halogenated aliphatic hydrocarbons. Mutagen 6(3):199-205

Rudali, G. (1967) A propos de l'activate oncogene de quelques hydrocarbures halogens utilises en therapeutique. Springer Verlag 7:138-143.

SAB, 2000. Science Advisory Board Review Report. See http://www.epa.gov/sab/fiscal00.htm.

Salamone, MF; Heddle, JA; Katz, M. (1981) Mutagenic activity of 41 compounds in the in vivo micronucleus assay, in: Evaluation of short-term tests for carcinogens: report of the International Collaborative Program. Prog Mutat Res 1:686-697.

San Agustin, J; Lim-Sylianco, CY. (1978) Mutagenic and clastogenic effects of **chloroform**. Bull Phil Biochem Soc 1:17-23.

Sasaki, TM; Suzuki, K; Noda, T; et al. (1998) Mutagenicity study of carbon tetrachloride and **chloroform** with microbial mutagenicity test and rat liver micronucleus test. Abstract. P-018. J Toxicol Sci 23 (suppl. II):305.

Shelby, MD; Witt, KL. (1995) Comparison of results from mouse bone marrow chromosome aberration and micronucleus tests. Environ Mol Mutagen 25:302-313 (as cited in U.S. EPA, 1998a).

Simmon, VF; Kauhanen, K; Tardiff, RG. (1977) Mutagenic activity of chemicals identified in drinking water. In: Progress in genetic toxicology. Scott, D; Bridges, DA; Sobels, eds. Elsevier/North Holland: Biomedical Press, pp. 249-258.

Sobti, RC. (1984) Sister chromatid exchange induction potential of the halogenated hydrocarbons produced during water chlorination. Chromo Info Serv 37:17-19.

Sturrock, J. (1977) Lack of mutagenic effects of halothene or **chloroform** on cultured cells using the azaguanine test system. Br J Anaesth 49:207-210.

Templin, MV; Constan, AA; Wolf, DC; et al. (1998) Patterns of **chloroform**-induced regenerative cell proliferation in BDF1 mice correlate with organ specificity and dose-response of tumor formation. Carcinogenesis 19(1):187-193.

Theiss, JC; Stoner, GD; Shimkin, MB. (1977) Test for carcinogenicity of organic contaminants of United States drinking waters by pulmonary tumor response in strain A mice. Cancer Res 37:2717-2720.

Topham, JC. (1980) Do induced sperm-head abnormalities in mice specifically identify mammalian mutagens rather than carcinogens? Mutat Res 74:379-387.

Uehleke, H; Werner, T; Greim, H; et al. (1977) Metabolic activation of haloalkanes and tests in vitro for mutagenicity. Xenobiotica 7:393-400.

U.S. EPA. (U.S. Environmental Protection Agency). (1994) Final draft for the drinking water criteria document on trihalomethanes. Prepared for Health and Ecological Criteria Division, Office of Science and Technology, Washington, DC. Under EPA Contract No. 68-C2-0139 by Clement International Corporation. April 8, 1994.

U.S. EPA. (1996) Proposed guidelines for carcinogen risk assessment. Federal Register 61(79):17960-18011.

U.S. EPA. (1998a) Health risk assessment/characterization of the drinking water disinfection byproduct **chloroform**. Prepared for Health and Ecological Criteria Division, Office of Science and Technology, Washington, DC, by Toxicology Excellence for Risk Assessment, Cincinnati, OH, under Purchase Order

No. 8W-0767-NTLX. November 4, 1998.

U.S. EPA. (1998b) National primary drinking water regulations: disinfectants and disinfection byproducts. Notice of data availability; proposed rule. 40 CFR Parts 141-142:15674.

U.S. EPA. (1998c) National primary drinking water regulations: disinfectants and disinfection byproducts. Final Rule. Federal Register 63(241):69406-69407. Wed. Dec. 16, 1998.

U.S. EPA. (1999) Guidelines for Carcinogenic Risk Assessment. Review Draft. July 1999. US Environmental Protection Agency, Risk Assessment Forum.

U.S. EPA. (2001) Toxicological review of **chloroform** in support of summary information on IRIS. Available online at http://www.epa.gov/IRIS.

Van Abbe, NJ; Green, TJ; Richold, M. (1982) Bacterial mutagenicity studies on **chloroform** in vitro. Food Chem Toxicol 20:557-561.

Varma, MM; Ampy, FR; Verma, K; et al. (1988) In vitro mutagenicity of water contaminants in complex mixtures. J Appl Toxicol 8:243-248.

Vena, JE; Graham, S; Freudenheim, JO; et al. (1993). Drinking water, fluid intake, and bladder cancer in Western New York. Archives of Environmental Health. 48:(3).

Vogel, EW; Nivard, MJM. (1993) Performance of 181 chemicals in a Drosophila assay predominantly monitoring interchromosomal mitotic recombination. Mutagenesis 8:57-81.

Wecher, RA; Scher, S. (1982) Bioassay procedures for identifying genotoxic agents using light- emitting bacteria as indicator organisms. In: Luminescent assays: perspectives in endocrinology and clinical chemistry. Seno M, Pazzagli M, eds. New York: Raven Press, pp. 109-113.

White, AE; Takehisa, S; Eger, EI; et al. (1979) Sister chromatid exchanges induced by inhaled anesthetics. Anesthesiology 50:426-430 (as cited in U.S. EPA, 1994).

World Health Organization (WHO). (1998) Guidelines for drinking-water quality. Second edition. Addendum to Volume 2. Health criteria and other supporting information. **Chloroform**. Geneva: World Health Organization, pp. 255-275.

VII. Revision History:

Chloroform
CASRN -- 67-66-3

Date	Section	Description
03/01/1988	I.A.1.	Dose conversion clarified
03/01/1988	I.A.2.	LOAEL and RfD in text corrected
03/01/1988	I.A.4.	Text revised
03/01/1988	I.A.5.	Text revised
06/30/1988	II.	Carcinogen summary on-line
06/30/1988	I.A.7.	Primary contact changed
10/01/1989	I.B.	Inhalation RfD now under review
06/01/1990	IV.A.1.	Area code for EPA contact corrected
06/01/1990	IV.F.1.	EPA contact changed
01/01/1991	II.	Text edited
01/01/1991	II.C.1.	Inhalation slope factor removed (global change)
02/01/1991	II.C.3.	Information on extrapolation process included
02/01/1991	II.C.4.	Text edited
03/01/1991	II.D.3.	Primary contact changed
01/01/1992	IV.	Regulatory actions updated
04/01/1992	IV.A.1.	CAA regulatory action withdrawn
07/01/1992	I.A.	Clarify Schwetz citation
07/01/1992	VI.C.	Oral RfD references on-line
07/01/1992	VI.C.	Carcinogenicity assessment references on-line
09/01/1992	I.A.7.	Primary contact changed
08/01/1995	I.B.	EPA's RfD/RfC and CRAVE workgroups were discontinued in May, 1995. Chemical substance reviews that were not completed by September 1995 were taken out of IRIS review. The IRIS Pilot Program replaced the workgroup functions beginning in September, 1995.
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
12/10/1998	I.B.	This chemical is being reassessed under the IRIS Program.
10/19/2001	I.A.,VI	Oral RfD and references updated
10/19/2001	II.B.,VI	Oral carcinogenicty assessment and references updated
01/08/2002	II.C.1.	Corrected typographical error in units in inhalation unit risk.
03/26/2002	Tox. Review	Corrected list of external peer reviewers.

CHROMIUM COMPOUNDS

CASRN: NO CAS RN

This record contains general information for chromium ions and inorganic and organic chromium compounds, including statements in the literature referenced to chromium compounds and chromium salts. For compound specific information, refer to the appropriate individual records listed in the RELATED HSDB RECORDS field. For information on the metal, refer to the Chromium, ELEMENTAL record.

For other data, click on the Table of Contents

Human Health Effects:

Evidence for Carcinogenicity:

WEIGHT OF EVIDENCE CHARACTERIZATION: Applying the criteria for evaluating the overall weight of evidence for carcinogenicity to humans outlined in EPA's guidelines for risk assessment (1986), trivalent chromium is most appropriately designated a Group D -- Not classified as to its human carcinogenicity. Using the Proposed Guidelines for Carcinogen Risk Assessment (1996), there are inadequate data to determine the potential carcinogenicity of trivalent chromium ... However, the classification of hexavalent chromium as a known human carcinogen raises a concern for the carcinogenic potential of trivalent chromium. HUMAN CARCINOGENICITY DATA: Occupational exposure to trivalent chromium and other chromium compounds by inhalation has been studied in the chromate manufacturing and ferrochromium industries; however, exposures all include mixed exposures to both Cr(III) and Cr(VI). Cr(VI) species is the likely etiological agent in reports of excess cancer risk in chromium workers. Data addressing exposures to Cr(III) alone are not available and data are inadequate for an evaluation of human carcinogenic potential. ... ANIMAL CARCINOGENICITY DATA: The data from oral and inhalation exposures of animals to trivalent chromium do not support documentation of the carcinogenicity of trivalent chromium. IARC concluded that animal data are inadequate for the evaluation of the carcinogenicity of Cr(III) compounds. Furthermore, although there is sufficient evidence of respiratory carcinogenicity associated with exposure to chromium, the relative contribution of Cr(III), Cr(VI), metallic chromium, or soluble versus insoluble chromium to carcinogenicity cannot be elucidated... /**Chromium (III),** insoluble salts/
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) for Chromium (III), insoluble salts (16065-83-1) Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000]**PEER REVIEWED**

WEIGHT OF EVIDENCE CHARACTERIZATION: Under the current guidelines (1986), Cr(VI) is classified as Group A - known human carcinogen by the inhalation route of exposure. Carcinogenicity by the oral route of exposure cannot be determined and is classified as Group D. Under the proposed guidelines (1996), Cr(VI) would be characterized as a known human carcinogen by the inhalation route of exposure on the following basis. Hexavalent chromium is known to be carcinogenic in humans by the inhalation route of exposure. Results of occupational epidemiological studies of chromium-exposed workers are consistent across investigators and study populations. Dose-response relationships have been established for chromium exposure and lung cancer. Chromium-exposed workers are exposed to both Cr(III) and Cr(VI) compounds. Because only Cr(VI) has been found to be carcinogenic in animal studies, however, it was concluded that only Cr(VI) should be classified as a human carcinogen. Animal data are consistent with the human carcinogenicity data on hexavalent chromium. Hexavalent chromium compounds are carcinogenic in animal bioassays, producing the following tumor types: intramuscular injection site tumors in rats and mice, intrapleural implant site tumors for various Cr(VI) compounds in rats, intrabronchial implantation site tumors for various Cr(VI) compounds in rats and subcutaneous injection site sarcomas in rats. In vitro data are suggestive of a potential mode of action for hexavalent

chromium carcinogenesis. Hexavalent chromium carcinogenesis may result from the formation of mutagenic oxidatitive DNA lesions following intracellular reduction to the trivalent form. Cr(VI) readily passes through cell membranes and is rapidly reduced intracellularly to generate reactive Cr(V) and Cr(IV) intermediates and reactive oxygen species. A number of potentially mutagenic DNA lesions are formed during the reduction of Cr(VI). Hexavalent chromium is mutagenic in bacterial assays, yeasts and V79 cells, and Cr(VI) compounds decrease the fidelity of DNA synthesis in vitro and produce unscheduled DNA synthesis as a consequence of DNA damage. Chromate has been shown to transform both primary cells and cell lines. HUMAN CARCINOGENICITY DATA: Occupational exposure to chromium compounds has been studied in the chromate production, chromeplating and chrome pigment, ferrochromium production, gold mining, leather tanning and chrome alloy production industries. Workers in the chromate industry are exposed to both trivalent and hexavalent compounds of chromium. Epidemiological studies of chromate production plants in Japan, Great Britain, West Germany, and the United States have revealed a correlation between occupational exposure to chromium and lung cancer, but the specific form of chromium responsible for the induction of cancer was not identified ... Studies of chrome pigment workers have consistently demonstrated an association between occupational chromium exposure (primarily Cr(VI)) and lung cancer. Several studies of the chromeplating industry have demonstrated a positive relationship between cancer and exposure to chromium compounds. ANIMAL CARCINOGENICITY DATA: Animal data are consistent with the findings of human epidemiological studies of hexavalent chromium ... /Chromium (VI)/
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) for Chromium (VI) (18540-29-9) Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000]**PEER REVIEWED**

CLASSIFICATION: A; human carcinogen. BASIS FOR CLASSIFICATION: Results of occupational epidemiologic studies of chromium-exposed workers are consistent across investigators and study populations. Dose-response relationships have been established for chromium exposure and lung cancer. Chromium-exposed workers are exposed to both cromium III and chromium VI compounds. Because only chromium VI has been found to be carcinogenic in animal studies, however, it was concluded that only chromium VI be classified as a human carcinogen. HUMAN CARCINOGENICITY DATA: Sufficient. /Chromium VI/
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Chromium VI (18540-29-9 Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000]**PEER REVIEWED**

A4; Not classifiable as a human carcinogen. /Metal and Cr(III) compounds, as Cr/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.23]**PEER REVIEWED**

A1; Confirmed human carcinogen. /Water soluble Cr(VI) compounds, as Cr/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.23]**PEER REVIEWED**

A1; Confirmed human carcinogen. /Insoluble Cr(VI) compounds, as Cr/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.23]**PEER REVIEWED**

Evaluation: There is sufficient evidence in humans for the carcinogenicity of chromium(VI) compounds as encountered in the chromate production, chromate pigment production and chromium plating industries. There is sufficient evidence in experimental animals for the carcinogenicity of calcium chromate, zinc chromates, strontium chromate and lead chromates. There is limited evidence in experimental animals for the carcinogenicity of chromium trioxide (chromic acid) and sodium

dichromate. Overall evaluation: Chromium(VI) is carcinogenic to humans (Group 1). The Working Group made the overall evaluation on chromium(VI) compounds on the basis of the combined results of epidemiological studies, carcinogenicity studies in experimental animals, and several types of other relevant data which support the underlying concept that chromium(VI) ions generated at critical sites in the target cells are responsible for the carcinogenic action observed. /Chromium(VI) compounds/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V49 213 (1990)]**PEER REVIEWED**

Evaluation: There is inadequate evidence in humans for the carcinogenicity of metallic chromium and of **chromium(III)** compounds. There is inadequate evidence in experimental animals for the carcinogenicity of metallic chromium, barium chromate and **chromium(III)** compounds. Overall evaluation: Metallic chromium and **chromium(III)** compounds are not classifiable as to their carcinogenicity to humans (Group 3). /Metallic chromium and **chromium(III)** compounds/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V49 213 (1990)]**PEER REVIEWED**

Human Toxicity Excerpts:

THERE IS EXCESSIVE RISK OF LUNG CANCER AMONG WORKERS IN CHROMATE-PRODUCING INDUSTRY. IT IS LIKELY THAT EXPOSURE TO 1 OR MORE CHROMIUM CMPD IS RESPONSIBLE, BUT IDENTITY OF THIS OR THESE IS NOT KNOWN. THERE IS NO EVIDENCE THAT NON-OCCUPATIONAL EXPOSURE TO CHROMIUM CONSTITUTES CANCER HAZARD. /CHROMIUM & CHROMIUM CMPD/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 120 (1973)]**PEER REVIEWED**

Chromium(III), the naturally occurring form, has low toxicity due to poor membrane permeability and noncorrosivity, while Cr(VI), from industrial emissions, is highly toxic due to strong oxidation characteristics and ready membrane permeability. /Cr(III) and Cr(VI)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.15 (1976) NRCC No.15017]**PEER REVIEWED**

Studies of patients who received surgical implantations of chromium alloy prostheses have given conflicting results regarding mobilization of chromium from these devices. The discrepancies in results may have been due not only to differences among alloys and coating of the prostheses, but also to analytical "inaccuracies," including metal contamination during specimen collection. In their own study of serum and urine from 44 patients from day 1 through 2.5 yr after implantation of cobalt chromium and/or titanium aluminum vanadium alloy prostheses, elevated levels of chromium were detected only in the urine of three patients at day 1-2 after surgery. These increased urinary chromium concentrations were thought to be due to the trauma of surgery rather than to mobilization from the prosthesis. /Chromium and chromium cmpd/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.47 (10/87)]**PEER REVIEWED**

... PULMONARY DISEASE IN WORKERS EXPOSED TO FERROCHROME ALLOYS WITH CHROMIUM LEVELS IN AIR OF 0.27 MG/CU M REPORTED. OTHER DUSTS & FUMES WERE PRESENT, HOWEVER, IN THIS PLANT. /TOTAL CHROMIUM/
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.139]**PEER REVIEWED**

Symptoms /of exposure/: histologic fibrosis of lung /Chromium metal and insoluble salts (as Cr)/
[NIOSH. Pocket Guide to Chemical Hazards. 5th Printing/Revision. DHHS (NIOSH) Publ. No. 85-114. Washington, D.C.: U.S. Dept. of Health and Human Services, NIOSH/Supt. of Documents, GPO, Sept. 1985.83]**PEER REVIEWED**

The organ which is affected by exposure to chromium metal & insol salts (as Cr) is resp system. /Chromium metal and insoluble salts (as Cr)/
[NIOSH. Pocket Guide to Chemical Hazards. 5th Printing/Revision. DHHS (NIOSH) Publ. No. 85-114. Washington, D.C.: U.S. Dept. of Health and Human Services, NIOSH/Supt. of Documents, GPO, Sept. 1985.83]**PEER REVIEWED**

Potential symptoms as a result of exposure /to chromium, chromic, chromous salts (as Cr)/: sensitive dermatitis. /Chromium, chromic, chromous salts (as Cr)/
[NIOSH. Pocket Guide to Chemical Hazards. 5th Printing/Revision. DHHS (NIOSH) Publ. No. 85-114. Washington, D.C.: U.S. Dept. of Health and Human Services, NIOSH/Supt. of Documents, GPO, Sept. 1985.85]**PEER REVIEWED**

CORROSIVE BECAUSE OF ... OXIDIZING POTENCY. ... IF INGESTED, VIOLENT GASTROENTERITIS, SEVERE CIRCULATORY COLLAPSE AND TOXIC NEPHRITIS MAY ENSUE. /CHROMATE SALTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-109]**PEER REVIEWED**

THE PHYSIOLOGICAL RESPONSES TO CHROMIUM & ITS CMPD ARE WIDE & VARIED, BECAUSE ASSOC WITH EACH OF THE 3 CHROMIUM VALENCIES, 2+, 3+, & 6+, ARE DIFFERENT TOXICOLOGIC POTENTIALS. FURTHER, WITHIN EACH VALENCY GROUP, TOXICITY VARIES ACCORDING TO SOLUBILITY. /CHROMIUM & CHROMIUM CMPD/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1593]**PEER REVIEWED**

The inhalation of insoluble chromium compounds has led to pneumoconiosis with impairment of pulmonary function; exposure to the chromite ore roasting process is suspected to have carcinogenic potential. /Insoluble chromium cmpd/
[Baselt RC; Biological Monitoring Methods for Industrial Chemicals p.81 (1980)]**PEER REVIEWED**

... HIGH RELATIVE FREQUENCY OF DEATH FROM RESP CANCER AMONG WORKERS IN CHROMATE PRODUCING INDUSTRY /REPORTED/. AMONG 193 DEATHS FROM ALL CAUSES AT 6 CHROMATE-PRODUCING PLANTS IN USA, 21.8% RESULTED FROM RESP CANCER, AS COMPARED TO AN EXPECTED FREQUENCY OF 1.4% IN CONTROL GROUP FROM OTHER INDUSTRIES. ... IN ADDITION, CLINICAL OBSERVATIONS FROM GERMANY HAVE SUGGESTED POSSIBLE RELATION OF LUNG CANCER TO CHROME PIGMENT INDUSTRY ... /CHROMATES/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 118 (1973)]**PEER REVIEWED**

PRINCIPAL TOXIC EFFECTS OF CHROMIUM FROM INDUSTRIAL POINT OF VIEW ARE EXERTED ON SKIN, NASAL MUCOUS MEMBRANES & LUNG. SYSTEMIC EFFECTS HAVE BEEN RARELY DESCRIBED IN INDUST WORKERS BUT LESIONS OF KIDNEYS ... OCCURRED IN NON-INDUST POPULATION FOLLOWING INGESTION OR EXTERNAL APPLICATION OF CHROMIUM CMPD. ... LARGE DOSES OF CHROMATES ARE FOLLOWED BY ALBUMINURIA WITH DESQUAMATED CELLS, & KIDNEYS SHOW HYPEREMIA, FATTY DEGENERATION & NECROSIS ... /CHROMATES/
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York:

Appleton-Century-Crofts, 1969. 121]**PEER REVIEWED**

WHEN ... HEXAVALENT CHROMIUM COMPOUNDS ARE DEPOSITED ON THE BROKEN SKIN, A DEEPLY PENETRATING ROUND HOLE MAY DEVELOP. ... FAVORED SITES FOR ULCER DEVELOPMENT ARE THE NAILROOT AREAS, OVER THE KNUCKLES & FINGERWEBS, ON THE BACK OF THE HANDS, & ON THE FOREARM. SOMETIMES THESE ULCERS ARE DESCRIBED AS PAINFUL, BUT MOST OF THEM ARE PAINLESS. SEVERE ULCERATIVE CHANGES PENETRATING TO JOINTS HAVE BEEN DESCRIBED. THE ULCER HEALS SLOWLY & MAY PERSIST FOR MONTHS. THE ULCER DOES NOT SEEM TO BEAR ANY RELATIONSHIP TO THE DEVELOPMENT OF ALLERGIC SENSITIZATION TO CHROMIUM COMPOUNDS. /HEXAVALENT CHROMIUM COMPOUNDS/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 195]**PEER REVIEWED**

EXPOSURE TO CHROMATE PIGMENTS MAY BE RELATED TO INCR INCIDENCE OF BRONCHIAL CANCER (3 YR MIN EXPOSURE). POSSIBILITY OF CONTRIBUTING EFFECT OF TOBACCO SMOKING. /CHROMATE PIGMENT/
[LANGARD S, NORSETH T; BR J IND MED 32 (1): 62 (1975)]**PEER REVIEWED**

ALTHOUGH THE AVAILABLE EPIDEMIOLOGICAL EVIDENCE DOES NOT PERMIT A CLEAR DISTINCTION BETWEEN THE RELATIVE CARCINOGENICITY OF CHROMIUM COMPOUNDS OF DIFFERENT OXIDATION STATES OR SOLUBILITIES, IT APPEARS THAT EXPOSURE TO A MIXTURE OF CHROMIUM (VI) COMPOUNDS OF DIFFERENT SOLUBILITIES (AS FOUND IN THE CHROMATE PRODUCTION INDUSTRY) CARRIES THE GREATEST RISK TO HUMANS. /CHROMIUM & CHROMIUM CMPD/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 303 (1980)]**PEER REVIEWED**

There are few acute toxicity studies of oral chromium exposure. The oral dose which will cause death in humans has been estimated to be 1-3 g of chromium(VI). ... Oral chromium toxicity is probably a result of GI bleeding rather than systemic poisoning. /Chromium (VI)/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 247]**PEER REVIEWED**

PRINCIPAL MANIFESTATION OF CHROMIUM POISONING IS IRRITATION OR CORROSION. ACUTE POISONING: (FROM INGESTION.) DIZZINESS, INTENSE THIRST, ABDOMINAL PAIN, VOMITING, SHOCK, & OLIGURIA OR ANURIA. DEATH IS FROM UREMIA. /CHROMIUM(VI)/
[Dreisbach, R.H. Handbook of Poisoning. 11th ed. Los Altos, CA: Lange Medical Publications. 1983. 251]**PEER REVIEWED**

CHRONIC POISONING: (FROM INHALATION OR SKIN CONTACT.) REPEATED SKIN CONTACT LEADS TO INCAPACITATING ECZEMATOUS DERMATITIS WITH EDEMA, & ULCERATION WHICH HEALS SLOWLY. BREATHING ... FUMES OVER LONG PERIODS CAUSES PAINLESS ULCERATION, BLEEDING, & PERFORATION OF NASAL SEPTUM ACCOMPANIED BY FOUL NASAL DISCHARGE. /CHROMIUM(VI)/
[Dreisbach, R.H. Handbook of Poisoning. 11th ed. Los Altos, CA: Lange Medical Publications. 1983. 251]**PEER REVIEWED**

CHRONIC POISONING: ... CONJUNCTIVITIS, LACRIMATION, & ACUTE HEPATITIS WITH JAUNDICE ... ALSO ... OBSERVED. FINDINGS IN ACUTE HEPATITIS INCL NAUSEA, VOMITING, LOSS OF APPETITE, & ENLARGED, TENDER LIVER. /CHROMIUM(VI)/
[Dreisbach, R.H. Handbook of Poisoning. 11th ed. Los Altos, CA: Lange Medical Publications. 1983. 251]**PEER REVIEWED**

CHRONIC POISONING: ... INCIDENCE OF LUNG CANCER IS INCR UP TO 15 TIMES NORMAL IN WORKERS EXPOSED TO DUST OF CHROMITE, CHROMIC OXIDE, & CHROMIUM ORES. /CHROMIUM(VI)/
[Dreisbach, R.H. Handbook of Poisoning. 11th ed. Los Altos, CA: Lange Medical Publications. 1983. 251]**PEER REVIEWED**

LARGE DOSES OF CHROMATES ARE FOLLOWED BY ALBUMINURIA WITH DESQUAMATED CELLS, & KIDNEYS SHOW HYPEREMIA, FATTY DEGENERATION & NECROSIS ... /CHROMIUM/
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969. 121]**PEER REVIEWED**

THE (6+) COMPOUNDS OF CHROMIUM CAUSE BOTH PRIMARY SKIN IRRITATION AND SENSITIZATION. ...GENERALIZED BRONCHOSPASM /OCCURS WITH DUST OR MIST INHALATION/... IN A FEW CASES, SENSITIZATION OCCURS RESULTING IN TYPICAL ASTHMATIC ATTACKS, WHICH RECUR ON SUBSEQUENT EXPOSURE. /CHROMIUM (6+) COMPOUNDS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 471]**PEER REVIEWED**

Effects on the upper respiratory tract have been observed in workers in chromium-related industries. The major effects of chromium on this system include ulceration of the nasal septum, with subsequent perforation, and chronic rhinitis and pharangitis. ... Approximately one-half to four-fifths of the workers in chromate plants had perforated nasal septa, at levels of exposure that approached 1 mg/cu m. ... Chromic acid levels exceeding 0.1 mg/cu m also caused perforated septums in some workers. /Chromates/
[USEPA; Health Assessment Document: Chromium p.2-8 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

Allergic contact dermatitis may arise from exposure to either trivalent or hexavalent chromium, although hexavalent chromium is responsible for most of the reported cases. Cr(VI) penetrates undamaged skin, & subsequently reduces to Cr(III) which combines with proteins or other skin components to form a whole skin allergen. /Hexavalent chromium/
[USEPA; Health Assessment Document: Chromium p.2-8 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

Acute chromic acid ingestion causes an acute gastroenteritis, hepatic necrosis, bleeding, and acute tubular necrosis with renal failure. An intravenous chromic acid exposure resulted in nausea, vomiting, dark red urine, loose reddish stool, and renal failure which required temporary hemodialysis. Chromic acid burns can result in systemic toxicity. External burns of 10% of the total body surface caused by chromic acid were fatal in one case, whereas 20% burns produced hepatic damage, acute renal failure, and a normochromic and normocytic anemia in another. /Chromic acid/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 1020]**PEER REVIEWED**

The strong oxidizing potential of chromium(VI) compounds explain much of their irritating and toxic properties. /Chromium(VI) compounds/
[USEPA; Health Assessment Document: Chromium p.2-7 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

... Researchers reported severe nephritis & death of a patient after cauterization of a wound with chromium(VI) oxide. It should be noted that these cases involved damaged rather than intact skin. /Hexavalent chromium/

[Major RH; Johns Hopkins Hosp Bull 33: 56-61 (1922) as cited in DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.52 (10/87)]**PEER REVIEWED**

A wide range of other respiratory effects have also been reported in workers exposed to chromium compounds. German investigators have reported that prolonged inhalation of chromate(VI) dust resulted in chronic irritation of the respiratory tract, & congestion & hyperemia, chronic rhinitis, congestion of the larynx, polyps of the upper respiratory tract, chronic inflammation of the lung, emphysema, tracheitis, chronic bronchitis, chronic pharyngitis, & perivascular lung markings, X-ray observations included enlargement of the hilar region & lymph nodes, incr in peribronchial & perivascular lung markings, & adhesions of the diaphragm. /Hexavalent chromium/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.55 (10/87)]**PEER REVIEWED**

The frequency of sister chromatid exchange were examined in lymphocytes of 24 chromium platers and 24 office workers matched in terms of sex, age, and smoking habits. The chromium platers had worked for an average of 11.6 + or - 7.5 years. The results indicated no significant differences in sister chromatid exchange frequencies between the two groups. Urinary chromium levels of chromium platers averaged 13.1 ug/l; chromium was not detected in the urine of controls. A correlation between urinary chromium concentrations and sister chromatid exchange frequency in chromium platers was not observed. /Chromium compounds/
[Nagaya T; Mutat Res 170 (3): 129-32 (1986) as cited in DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.63 (10/87)]**PEER REVIEWED**

Three periods of nausea were noted in a volunteer who drank a 10 ppm soln of chromium(VI) as his only fluid for 15 days. A total of 235 mg chromium(VI) was ingested. The study was continued for 14 more days at chromium(VI) concns of 2.5-5 ppm. Mild nausea occurred when the subject drank a 5 ppm soln on an empty stomach; this did not occur at 2.5-3.5 ppm. /Hexavalent chromium/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.60 (10/87)]**PEER REVIEWED**

Chromate manufacture workers showed perforated nasal septums from 0.005-0.17 mg/cu m Cr(VI) exposure 8 hr/day: 39.3% of those exposed 0.5-3 yr, 55.4% of those exposed 3-10 yr, 69.6% of those exposed over 10 yr. Also, 10 confirmed cases of pulmonary cancer resulted from 0.03-1.1 mg/cu m for 4-24 yr. Death from respiratory cancer was increased 29 times for exposed individuals of all ages versus non-exposed, increased 40 times for ages 15-44, 30 times for ages 45-55 & 20 times for ages 55-74. /Cr(VI)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.107,109 (1976) NRCC No.15017]**PEER REVIEWED**

A family drank water containing 1-25 ppm chromium(VI) for three years with no deleterious effects, although drinking water containing 5 ppm or more of Cr(VI) has been known to cause nausea when consumed on an empty stomach. /Cr(VI)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.18 (1976) NRCC No.15017]**PEER REVIEWED**

Hexavalent chromium irritates mucous membranes causing sneezing, rhinorrhea, irritation, redness of throat, & generalized bronchiospasm. Sensitization may develop resulting in asthmatic attacks even at low exposure levels. /Hexavalent chromium/
[NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.59 (1974)]**PEER REVIEWED**

In a study of British chromate producing facilities, 724 workers exposed to 0.4-17,000 ug Cr(VI)/cu m, 3.6 times as many workers died of lung cancer as expected in general population of England & Wales. /Cr(VI)/

[NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.51 (1974)]**PEER REVIEWED**

Prolonged inhalation of chromate dust produces chronic respiratory irritation with hyperemia, chronic catarrh, congestion of larynx, polyps of upper resp tract, chronic inflammation of lung, emphysema, tracheitis, chronic bronchitis, chronic pharyngitis, and bronchopneumonia. /Chromate dust/
[NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.59 (1974)]**PEER REVIEWED**

Oral ingestion of chromium(VI) may cause intense gastrointestinal irritation, violent epigastric pain, nausea, vomiting, severe diarrhea, hemorrhage, circulatory collapse, unconsciousness, and death. /Cr(VI)/
[Kaufman DB et al; Am J Dis Child 119: 74-176 (1970) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.113 (1976) NRCC No.15017]**PEER REVIEWED**

The lethal oral dose of chromium(VI) (single dose basis) for a 14 yr old boy was estimated to be 10 mg/kg body weight. /Cr(VI)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.18 (1976) NRCC No.15017]**PEER REVIEWED**

... A case of hepatic injury /was reported/ in a woman who had been employed for 5 years at a chromium-plating factory. She was hospitalized with jaundice and was found to be excreting large amounts of chromium. A liver biopsy revealed microscopic changes. Examination of eight coworkers revealed that four were excreting significant amounts of chromium. Liver biopsies and hepatic function tests of three workers who had been exposed to chromic acid mists for 1-4 years revealed mild to moderate abnormalities. /Chromium and chromium cmpd/
[Pascale LR et al; J Amer Med Assoc 149: 1385-9 (1952) as cited in DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.59 (10/87)]**PEER REVIEWED**

Soluble salts of hexavalent chromium are corrosive & have produced skin ulceration, dermatitis, perforation of the nasal septum, respiratory sensitization & lung cancer. Acute poisoning with soluble salts usually results in local tissue necrosis & severe kidney damage. Electroplaters & paint pigment workers who expressed symptoms of cough, indigestion & dermal itching were found to have urine chromium concns of 91-1116 ug/l. /Soluble salts of hexavalent chromium/
[Baselt RC; Biological Monitoring Methods for Industrial Chemicals p.81 (1980)]**PEER REVIEWED**

... PULMONARY DISEASE IN WORKERS EXPOSED TO FERROCHROME ALLOYS WITH CHROMIUM LEVELS IN AIR OF 0.27 MG/CU M REPORTED. OTHER DUSTS & FUMES WERE PRESENT, HOWEVER, IN THIS PLANT. /TOTAL CHROMIUM/
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.139]**PEER REVIEWED**

The chromium concentration in 261 samples of breast milk randomly collected from 45 American women had a mean concentration of 0.30 ng/l with a range of 0.06 to 1.56 ng/l. The mean concentration of chromium in human hair from randomly selected people in the United States was 0.23 mg/kg. /Total chromium/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.84 (10/87)]**PEER REVIEWED**

Of 85 chrome factory workers exposed to 4.5-9.2 mg/cu m **chromium(III),** 18.8% developed chronic bronchitis after 5 yr exposure, and 5.9% developed pneumoconiosis after 9 yr exposure. /Cr(III)/
[Mikov MI; Arch Hig Rada Toksikol (Yugoslavia) 18: 25 (1967) as cited in Nat'l

Research Council Canada; Effects of Chromium in the Canadian Envir p.108 (1976) NRCC No.15017]**PEER REVIEWED**

A CYTOGENETIC EXAMINATION OF WORKERS EXPOSED TO CHROMIUM(VI) COMPOUNDS BY INHALATION OF AEROSOLS REVEALED THAT EXPOSURE CAUSED AN INCREASE IN CHROMOSOMAL ABERRATIONS IN PERIPHERAL BLOOD LYMPHOCYTES (3.6-9.4% CELLS WITH ABERRATIONS COMPARED WITH 1.9% IN UNEXPOSED CONTROLS). ... AN INCREASE IN CHROMOSOMAL ABERRATIONS /ALSO OCCURRED/ IN PERIPHERAL BLOOD LEUKOCYTES OF WORKERS HANDLING DIFFERENT CHROMIUM COMPOUNDS. /CHROMIUM(VI) COMPOUNDS/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 286 (1980)]**PEER REVIEWED**

THERE IS EXCESSIVE RISK OF LUNG CANCER AMONG WORKERS IN CHROMATE-PRODUCING INDUSTRY. IT IS LIKELY THAT EXPOSURE TO 1 OR MORE CHROMIUM CMPD IS RESPONSIBLE, BUT IDENTITY OF THIS OR THESE IS NOT KNOWN. THERE IS NO EVIDENCE THAT NON-OCCUPATIONAL EXPOSURE TO CHROMIUM CONSTITUTES CANCER HAZARD. /CHROMIUM & CHROMIUM CMPD/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 120 (1973)]**PEER REVIEWED**

THE PHYSIOLOGICAL RESPONSES TO CHROMIUM & ITS CMPD ARE WIDE & VARIED, BECAUSE ASSOC WITH EACH OF THE 3 CHROMIUM VALENCIES, 2+, 3+, & 6+, ARE DIFFERENT TOXICOLOGIC POTENTIALS. FURTHER, WITHIN EACH VALENCY GROUP, TOXICITY VARIES ACCORDING TO SOLUBILITY. /CHROMIUM & CHROMIUM CMPD/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1593]**PEER REVIEWED**

The dusts of chromium metal & its insoluble salts, chiefly the chromites, are usually reported to be relatively nontoxic; this is debatable, since exposures associated with toxic effects are usually mixed exposures involving several hexavalent chromium compounds. /Chromium metal and insoluble chromium salts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Trivalent chromium cmpds are considerably less toxic than the hexavalent cmpds & are neither irritating nor corrosive. Nevertheless, nearly all workers in industries are exposed to both forms of chromium cmpds, & at present, there is no information as to whether there is a gradient of risk from predominant exposure to hexavalent or insoluble forms of chromium to exposure to soluble trivalent forms. /Trivalent chromium/
[Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 639]**PEER REVIEWED**

... Respiratory symptoms, lung function, & changes in the nasal septum /were examined/ in chrome plating workers in Sweden, exposed almost exclusively to chromic(VI) acid. Exposure durations ranged from 0.2-23.6 yr (median= 2.5 yr). The reference group was a group of 119 auto mechanics & 19 office employees. Exposure measurements were made with stationary & personal samplers. The personal samplers were used on a total of 84 subjects on 13 different days. Data were collected with the use of interviews, based on a standardized questionaire for the assessment of respiratory symptoms, an inspection of the nose, forced expiratory studies with a spirometer, & single breath nitrogen washouts. ...

The results of interviews indicated that at mean air chromium(VI) concns of >2 ug/cu m about half of the workers complained of "constantly running nose" or "stuffy nose." At mean chromium (VI) exposures of < or = 2 ug/cu m, 4/19 complained of nasal symptoms, while at <1 ug/cu m 0/9 complained of symptoms. The exams revealed a clear dose-response relationship, especially with highest exposure value rather than mean value of exposure. The number of workers with a smeary & crusty septal nasal mucosa in workers exposed to mean chromium(VI) concns of <2 ug/cu m were significantly higher than controls (11/19 exposed versus 5/19 controls; $p<0.05$). Workers experiencing ulceration &/or perforation were all exposed to mean chromium(VI) concns of > or = 2 ug/cu m ($p<0.01$), with the highest exposure values > or = 20 mg/cu m. The period of exposure for individuals experiencing ulceration varied from 5 mo to >10 yr. /Hexavalent chromium/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.53 (10/87)]**PEER REVIEWED**

Dermatitis has been reported in workers handling trivalent chromium cmpd. /Trivalent chromium cmpd/
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values, 4th ed., 1980. Cincinnati, Ohio: American Conference of Governmmental Industrial Hygienists, Inc., 1980.99]**PEER REVIEWED**

... chromium in the +3 oxidation state is considerably less hazardous /than the +6 oxidation state/. /Chromium, alloys and cmpd/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 470]**PEER REVIEWED**

... Cmpd of chromium in the trivalent state have no established toxicity. When taken by mouth, they do not give rise to local or systemic effects and are poorly absorbed. No specific effects are known to result from inhalation. ... Trivalent chromium ... provokes allergic skin responses in chromium-sensitive subjects. /Trivalent chromium salts/
[National Research Council. Drinking Water and Health. Volume 3. Washington, DC: National Academy Press, 1980. 367]**PEER REVIEWED**

/Signs/ ... of exposure: Respiratory irritations; nasal septum irritations; leukocytosis, leukopenia, monocytosis, eosinophilia; eye injury, conjunctivitis; skin ulcers, sensitization dermatitis; lung cancer. /Chromic acid & chromates (as CrO3)/
[NIOSH. Pocket Guide to Chemical Hazards. 2nd Printing. DHHS (NIOSH) Publ. No. 85-114. Washington, D.C.: U.S. Dept. of Health and Human Services, NIOSH/Supt. of Documents, GPO, February 1987.83]**PEER REVIEWED**

Principal manifestation of chromium poisoning is irritation or corrosion. A. Acute poisoning: (form ingestion.) dizziness, intense thirst, abdominal pain, vomiting, shock, and oliguria or anuria. Death is from uremia. /Chromium/
[Dreisbach, R. H. Handbook of Poisoning. 9th ed. Los Altos, California: Lange Medical Publications, 1977. 218]**PEER REVIEWED**

CHRONIC POISONING: (FROM INHALATION OR SKIN CONTACT.) REPEATED SKIN CONTACT LEADS TO INCAPACITATING ECZEMATOUS DERMATITIS WITH EDEMA, & ULCERATION WHICH HEALS SLOWLY. BREATHING ... FUMES OVER LONG PERIODS CAUSES PAINLESS ULCERATION, BLEEDING, & PERFORATION OF NASAL SEPTUM ACCOMPANIED BY FOUL NASAL DISCHARGE. /CHROMIUM/
[Dreisbach, R. H. Handbook of Poisoning. 9th ed. Los Altos, California: Lange Medical Publications, 1977. 218]**PEER REVIEWED**

CHRONIC POISONING: ... CONJUNCTIVITIS, LACRIMATION, & ACUTE HEPATITIS WITH JAUNDICE ... ALSO ... OBSERVED. FINDINGS IN ACUTE HEPATITIS INCL NAUSEA, VOMITING, LOSS OF APPETITE, & ENLARGED, TENDER LIVER. /CHROMIUM/
[Dreisbach, R. H. Handbook of Poisoning. 9th ed. Los Altos, California: Lange

Medical Publications, 1977. 218]**PEER REVIEWED**

Chromic acid & its salts have a corrosive action on the skin & mucous membranes. The lesions are confined to the exposed parts, affecting chiefly the skin of the hands & forearms & the mucous membranes of the nasal septum. The characteristic lesion is a deep, penetrating ulcer, which, for the most part, does not tend to suppurate, & which is slow in healing. Small ulcers, about the size of a match head, may be found, chiefly around the base of the nails, on the knuckles, dorsum of the hands & forearms. These ulcers tend to be clean & progress slowly. They are frequently painless, even though quite deep. They heal slowly & leave scars. On the mucous membranes of the nasal septum, the ulcers are usually accompanied by purulent discharge & crusting. If exposure continues, perforation of the nasal septum may result but produces no deformity of the nose. /Chromic acid and salts/
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 854]**PEER REVIEWED**

Other acute responses to hexavalent chromium intoxication include gastric distress, olfactory sense impairment, & yellowing of the teeth & tongue. /Hexavalent chromium/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 800]**PEER REVIEWED**

The seriously detrimental effects of hexavalent chromium are primarily the result of chronic low-level exposure. Increased incidence of gingivitis & periodontitis are common, as is ocular damage, including eye lesions, conjunctivitis, & keratitis. /Hexavalent chromium/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 800]**PEER REVIEWED**

Major health problems can arise form long-term inhalation of chromium particles or solubilized chromium in mists or dusts. Apart from the carcinogenic potential, prolonged exposure can result in chronic bronchitis, rhinitis, or sinusitis or the formation of nasal mucosal polyps. In addition to being immunosuppressive, chromium cmpds can also induce acute chemical pneumonitis. Besides the lungs & intestinal tract, the liver & kidney are often target organs of chromate toxicity. Interestingly, the kidneys appear to be as sensitive or more so, overall, to the toxic effect from trivalent chromium. By far the major health hazard due of long-term chromium exposure is the increased risk of lung & GI tract (esophageal, stomach, intestinal, & pancreatic) cancers. Extensive reviews of chromium carcinogenicity have been published by several government & international organizations, as well as by individual laboratories. These & other studies provided epidemiologic evidence for the carcinogenicity of chromium & demonstrated in animal models that there was a direct association between hexavalent chromium exposure & cancers at various sites in the respiratory & GI tracts. These studies also demonstrate the relevance of oxidation state, chromium solubility, & route of exposure as critical parameters in assessing carcinogenic potentials for chromium cmpds. /Chromium compounds/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 800]**PEER REVIEWED**

A study using only questionnaires, which were completed by 997 chrome platers and 1117 controls, found a statistically significant incr in the incidence of chronic rhinitis, rhinitis with bronchitis, and nasal ulcers and perforations in workers exposed to chromium(VI) in the chrome plating industry in 54 plants compared to the control population ... . The workers had been exposed to chromium(VI) in air and in dust. The air levels were generally <0.03 mg chromium(VI)/m3, and dust levels were generally between 0.3 and 97 mg chromium(VI)/g. /Chromium(VI), NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 33 (2000)]**PEER REVIEWED**

In a ... /evaluation/ of an electroplating facility in the United States, 5 of 11 workers reported symptoms of stomach pain, two of duodenal ulcer, one of gastritis, one of stomach cramps, and one of frequent indigestion. The workers were employed for an avg of 7.5 yr and were exposed to mean concn of 0.004

mg chromium(VI)/m3 ... . These workers were not compared to a control group. /Chromium (VI), NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 41 (2000)]**PEER REVIEWED**

An otolaryngological exam of 77 employees of 8 chromium electroplating facilities in Czechoslovakia, where the mean level in the breathing zone above the plating baths was 0.414 mg chromium(VI)/m3, revealed 12 cases of chronic tonsillitis, 5 cases of chronic pharyngitis, and 32 cases of atrophy of the left larynx ... . /Chromium(VI), NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 41 (2000)]**PEER REVIEWED**

Workers exposed /via inhalation/ to chromium(VI) compounds in a chromate production plant were found to have higher levels of a brush border protein antigen and retinol binding protein in the urine compared with controls ... . /Chromium(VI), NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 45 (2000)]**PEER REVIEWED**

A positive dose-repsonse for elevated urinary levels of beta2-microglobulin was found in chrome platers who were exposed /via inhalation/ to 0.004 mg chromium(VI)/m3, measured by personal air samplers, for a mean of 5.3 yr. However, since no incr in beta2-microglobulin levels was found in ex-chrome platers who had worked for at least one yr in an old chrome plating plant from 1940 to 1968, this effect may be reversible ... .similarly found significantly higher urinary beta2-microglobulin and N-acetyl-beta-glucosaminidase levels in hard-chrome electroplaters exposed to 0.0042 mg chromium/m3 for a mean of 5.8 yr, as compared to aluminum anode-oxidation workers. The prevalence of elevated levels (higher than reference values) was significantly incr for N-acetyl-beta-glucosaminidase, but not for beta2-microglobulin. /Chromium(VI) and chromium, NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 46 (2000)]**PEER REVIEWED**

In another study, comparison of results of renal function tests between chrome platers and construction workers revealed that the chrome platers had significantly ... incr levels of urinary chromium and incr clearance of chromium, but decr ... levels of retinol binding protein. However, no differences were found for blood urea nitrogen, serum and urinary beta2-microglobulin, serum immunoglobulin, total protein in the urine, urinary albumin, N-acetyl-beta-D-glucosamidase, beta-galactosidase, or lysozyme ... . /Chromium, NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 46 (2000)]**PEER REVIEWED**

The first epidemiology study of chromate production workers in the US that demonstrated an assoc with lung cancer was conducted with 1445 workers in seven plants engaged in the extraction of chromates from ore from 1930 to 1947. The mortality rates and causes of deaths for 193 chromate production workers were compared with 733 deaths in industrial workers not exposed to chromates. A total of 42 deaths from cancer of the respiratory system was found in the exposed group, which represented 21.8% of all deaths and 63.6% of all deaths from cancer. In the control group, 10 deaths from cancer of the respiratory system were found representing 1.4% of all deaths and 8.7% of deaths from all cancers ... . /Chromium cmpds/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 56 (2000)]**PEER REVIEWED**

In a cohort of 2101 employees who had worked for at least 90 days during the years 1945-1959 in ... production plant in Baltimore, MD, and followed until 1977, there were 59 deaths from lung cancer compared with 29.16 expected based on the mortality rates for Baltimore. The SMR of 202 was significant ($p<0.01$). Long-term (> or = 3 yr) employees had a higher risk than short-term (90 days to 2 yr) employees ... . In a separate analysis ... concurrent exposure data for the Baltimore plant in this study were determined from monitoring records for the yr of the study (1945-1959), and the usual concn was est to be 0.413 mg chromium(VI)/m3 for the yr 1945-1949. Too few data were available for later yr to estimate usual exposures. However, cumulative exposures were estimated to be 0.670 mg chromium(VI)/m3-yr for short-term employees and 3.647 mg chromium(VI)/m3-yr for long-term

employees ... . /Chromium(VI), NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 57 (2000)]**PEER REVIEWED**

A cohort of 3408 workers from four former facilities that produced chromium cmpds from chromite ore in northern NJ was assembled in 1990-1991 using social security records ... . The subjects were known to have worked in the four facilities sometime between 1937 and 1971, when the last facility closed. Exposure durations ranged from <1 yr to >20 yr. the overall risk of lung cancer derived from proportionate cancer mortality ratios (PCMR) was 1.51 for white males and 1.34 for black males. The risk incr with duration of employment and latency since time of first employment. The cancer mortality ratio for >20 yr of workplace exposure and >20 yr since first exposure was 194 and 308 for white and black males, respectively. This study also showed significantly incr risk for nasal cavity/sinus cancer indicated by a PCMR of 518 which has not been observed in previous studies in the US. A cluster of bladder cancer was seen at one facility among black workers with a PCMR of 330. /Chromium cmpds, NOS from chromite ore/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 59 (2000)]**PEER REVIEWED**

Among 4 cases of nasal carcinoma in men who worked for 19 and 32 yr in a Japanese chromate factory, 1 patient was diagnosed with squamous cell carcinoma of the left nasal cavity 11 yr after retirement ... . the other three patients underwent lobectomy for lung cancer, and 6-15 yr later, all three contracted nasal cancer, two in the nasal cavity and one in the nasopharynx. The period for the appearance of nasal cancer was about 39 yr after first being exposed to chromium. No mention was made of the possibility of metastasis of lung cancer to the nasal region. /Chromium, NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 61 (2000)]**PEER REVIEWED**

In an analysis of the cause of death among 172 white male and 49 white female employees engaged for at least 10 yr in die-casting and electroplating at an automobile hardware manufacturing plant in the US, statistically significant SMRs were found for all cancers in men (O/E=53/39.39), SMR=135, $p<0.05$), for respiratory system cancers in men (O/E=30/15.37, SMR=195, $p<0.001$) and women (O/E=10/2.80, SMR=357, $p<0.001$), and for lung cancer specifically in men (O/E=28/14.68, SMR=191, $p<0.001$) and women (O/E=10/2.70, SMR=370, $p<0.001$). The SMR for lung cancer was significant in men with at least 15 years service, but not for men with <15 yr service. When the lung cancer deaths were matched to a study population of referents of the same sex and race who died of cardiovascular disease, an assoc was found between lung cancer and work in certain departments where there were mixed exposures to die-casting emissions and plating mists ... . /Chromium cmpds/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 66 (2000)]**PEER REVIEWED**

... another mortality study of a cohort of 2689 (1288 men, 1401 women) chrome platers employed for at least 6 mo in a different plant in the UK between 1946 and 975 found excess risks for several types of cancer, compared with the mortality rates for England and Wales. Statistically significant excesses among male workers were as follows: stomach cancer (O/E=21/11.3, SMR=186, $p<0.05$); primary liver cancer (O/E=4/0.6, SMR=667, $p<0.01$); nose and nasal cavity cancer (O/E=2/0.2, SMR=1000, $p<0.05$); cancer of the lungs and bronchi (O/E=63/40.0, SMR=158, P,0.001), and all cancers (O/E=142/96.9, SMR=147, $p<0.001$). No excesses were found for women alone. Most of the excesses in men were attributed to working in the chrome bath works, where exposures were mainly to chromium(VI) as chromic acid. The correlation with duration of chrome bath work was positive only for cancers of the lung and bronchus. Exact exposure concn were not known, but the contribution of nickel exposure to the effects was found to be unimportant. /Chromium cmpds and chromic acid/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 67 (2000)]**PEER REVIEWED**

In addition to lung, nasal, and possibly stomach cancer, exposure to chromium(VI) in the electroplating industry may also be assoc with oral cavity cancer. In 77 employees of chromium electroplating factories in Czechoslovakia, 16 growths in the oral cavity were found in 14 individuals. Histological exam of

three of the growths led to the diagnosis of papilloma, which was considered to be a precancerous lesion. All of the papillomas were found to contain chromium (mean 9.25 mg %), and were believed to be due to chromium exposure via mouth breathing. Analysis of the breathing zone of the electroplaters showed that the avg air level above the plating baths was 0.414 mg chromium(VI)/cu m ... . /Chromium(VI), NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 68 (2000)]**PEER REVIEWED**

An excess of lung cancer was found in a study of 325 male workers employed for >1 yr in a ferrochromium producing factory in Norway between 1928 and 1977, and whose employment began before 1960. The rates of cancer deaths in the ferrochromium workers were compared with national and local rates. Seven cases of lung cancer were found in the ferrochromium workers compared with 3.1 expected using the national rate (SMR=226, p=0.08) and 1.8 expected using the local rate (SMR=389, p=0.06). When the internal reference group /recruited from the same local population as the ferrochromium group/ of ferrosilicon workers was used, the SMR was 850 (p=0.026). ... Workroom monitoring in 1975 indicated that the ferrochromium furnace operators worked in an atmosphere with 0.04-0.29 mg total chromium/m3, with 11-33% of the total chromium as chromium(VI) ... . /Ferrochromium, total chromium, and chromium(VI)/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 70 (2000)]**PEER REVIEWED**

In a cross sectional study conducted in 1965 of 155 villagers whose well water contained 20 mg chromium(VI)/l as a result of pollution from an alloy plant in the People's Republic of China, assoc were found between drinking the contaminated water and oral ulcer, diarrhea, abdominal pain, indigestion, and vomiting. The alloy plant began chromium smelting in 1961 and began regular production in 1965. ... The 20 mg chromium(VI)/l concn is equivalent to a dose of 0.57 mg chromium(VI)/kg/day, using a default reference water consumption rate and body weight value of 2 l/day and 70 kg, respectively (note that these values may not be appropriate for the Chinese study population). /Chromium(VI), NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 93 (2000)]**PEER REVIEWED**

In a cross sectional study conducted in 1965 of 155 villagers whose well water contained 20 mg chromium(VI)/l as a result of pollution from an alloy plant in the People's Republic of China, assoc were found between drinking the contaminated water and leukocytosis and immature neutrophils. The alloy plant began chromium smelting in 1961 and began regular production in 1965. ... The 20 mg chromium(VI)/l concn is equivalent to a dose of 0.57 mg chromium(VI)/kg/day. /Chromium(VI), NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 94 (2000)]**PEER REVIEWED**

A retrospective mortality study conducted on a population who resided in a polluted area near an alloy plant that smelted chromium in the People's Republic of China found incr incidences of lung and stomach cancer. The alloy plant began smelting chromium in 1961 and began regular production in 1965, at which time sewage containing chromium(VI) dramatically incr. The population was followed from 1970 to 1978. The size of the population was not reported. The adjusted mortality rates of the exposed population ranged from 71.89 to 92.66 per 100,000, compared with 65.4 per 100,000 in the general population of the district. The adjusted mortality rates for lung cancer ranged from 13.17 to 21.39 per 100,000 compared with 11.21 per 100,000 in the general population. The adjusted mortality rates for stomach cancer ranged from 27.67 to 55.17 per 100,000, which were reported to be higher than avg rate for the whole district (control rates not reported). The higher cancer rates were found for those who liver closer to the dump site ... .it was not possible to estimate exposure levels ... . The exposed population was probably exposed by all environmentally relevant routes .. . /Chromium(VI), NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 107 (2000)]**PEER REVIEWED**

Some chromium(VI) cmpds, such as chromium trioxide (chromic acid), potassium dichromate, potassium chromate, sodium dichromate, and sodium chromate, are very caustic and can cause burns upon dermal contact. These burns can facilitate the absorption of the cmpd and lead to systemic toxicity.

/Chromium(VI) cmpds/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 108 (2000)]**PEER REVIEWED**

In an extensive survey to determine the health status of chromate workers in seven US chromate production plants, 50% of the chromate workers had skin ulcers or scars. In addition, inflammation of oral structures, keratosis of the lips, gingiva, and palate, gingivitis, and periodontis due to exposure of these mucocutaneous tissues to airborne chromium were observed in higher incidence in the chromate workers than in controls. Various manufacturing processes in the plants resuled in exposure of workers to chromite ore (mean time-weighted concn of 0-0.89 mg **chromium(III)/**m3 air); water-soluble chromium(VI) cmpd (0.005-0.17 mg chromium(VI)/m3); and acid-soluble/water-insoluble chromium cmpds (incl basic chromium sulfate), which may or may not entirely represent **chromium(III) (**0-0.47 mg chromium/m3 air) ... . /Chromite ore, water-soluble chromium(VI) cmpd, and acid-soluble/water-insoluble chromium cmpd/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 117 (2000)]**PEER REVIEWED**

An early report of cases of chrome ulcers in leather tanners noted that the only workmen in tanneries who suffered chrome holes were those who handled dichromate salts. In one of these cases, the penetration extended into the joint, requiring amputation of the finger ... . /Dichromate salts/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 118 (2000)]**PEER REVIEWED**

In an extensive study of chromate workers in seven US chromate production plants, eyes were examined because accidental splashes of chromium cmpd into the eye had been observed in these plants. congestion of the conjunctiva was found in 38.7% of the 897 workers, discharge in 3.2%, corneal scaring in 2.3%, any abnormal finding in 40.8%, and burning in 17.0%, compared with respective frequencies of 25.8, 1.3, 2.6, 29.0, and 22.6% in 155 nonchromate workers. Only the incidences of congestion of the conjunctiva and any abnormal findings were significantly higher in the exposed workers than in the controls ... . /Chromium cmpd, NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 119 (2000)]**PEER REVIEWED**

Studies conducted on chromium(VI) sensitive printers and lithographers indicate that chromium(VI) cmpds elicit /allergic/ reactions more frequently than do **chromium(III)** cmpds ... . /Chromium(VI) and (III) cmpds/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 120 (2000)]**PEER REVIEWED**

THERE IS AN EXCESSIVE RISK OF LUNG CANCER AMONG WORKERS IN CHROMATE PRODUCING INDUSTRY. IT IS LIKELY THAT EXPOSURE TO 1 OR MORE CHROMIUM CMPD IS RESPONSIBLE, BUT IDENTITY OF THIS OR THESE IS NOT KNOWN. /CR CMPD/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 120 (1973)]**PEER REVIEWED**

Occupational exposure to chromium(VI) cmpd in a number of industries has been assoc with incr risk of respiratory system cancers, primarily bronchogenic and nasal. Among the industries investigated in retrospective mortality studies are chromate production, chromate pigment production and use, chrome plating, stainless steel welding, ferrochromium alloy production, and leather tanning. Studies of chromate production workers, who are exposed to a variety of chromium cmpd both hexavalent and trivalent, and chromate pigment industries, where exposure is mainly to chromium(VI), have consistently demonstrated an assoc with respiratory system cancer. Studies in chrome platers, who are exposed to chromium(VI) and other agents, incl nickel, generally support the conclusion that certain chromium(VI) cmpd are carcinogenic. Studies in stainless steel welders exposed to chromium(VI) and other chemicals, and in ferrochromium alloy workers, who are exposed mainly to chromium(0) and **chromium(III),** but also to some chromium(VI), were inconclusive. Studies in leather tanners, who are exposed to **chromium(III),** were consistently negative. /Chromium cmpd/

[DHHS/ATSDR; Toxicological Profile for Chromium p. 56 (2000)]**PEER REVIEWED**

The effects of chromium compounds on the skin are caused primarily by direct contact. Most of the effects have occurred in occupational settings, and as expected, with more men than women reporting these effects. /Chromium compounds/
[USEPA; Health Assessment Document: Chromium p.2-8 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

There is sufficient evidence for increased incidence of lung cancer among workers in the chromate producing industry and possibly also among chromium platers and chromium alloy workers. /Chromate/
[DHHS/NTP; Fourth Annual Report On Carcinogens p.58 (1985) NTP 85-002]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Chromic acid mist & chromate dusts may cause severe irritation of the nose, throat, bronchial tubes, and lung. /Chromic acid mist & chromate dusts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Short-term exposure: ... Chromate dusts may cause severe irritation of the nose, throat, bronchii, and lung. /Chromate dusts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Chromic acid & its salts have a corrosive action on the skin & mucous membranes. /Chromic acid/
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 854]**PEER REVIEWED**

Eczematous dermatitis due to trivalent chromium compounds has been reported. /Trivalent chromium compounds/
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 854]**PEER REVIEWED**

Medical Surveillance:

Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to chromium metal or insoluble chromium salts. /Chromium metal or insoluble chromium salts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

1) Initial Medical Examination: a) A complete history and physical examination: The purpose is to detect existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the respiratory system should be stressed. b) 14" x 17" chest roentgenogram: Chromium and its insoluble salts may cause human lung damage. Surveillance of the lung is indicated. c) FVC and FEV (1 sec): Insoluble chromium salts are reported to cause decreased pulmonary function. Periodic surveillance is indicated. 2) Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis. /Chromium metal or insoluble chromium salts/

[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Preemployment physical exam should incl: a work history to determine past exposure to chromic acid and hexavalent Cr cmpd, exposure to other carcinogens, smoking history, history of skin or pulmonary sensitization to Cr, history or presence of dermatitis, skin ulcers, or lesions of the nasal mucosa and/or perforation of the septum, and a chest x-ray. On periodic exam an evaluation should be made of skin and respiratory complaints, esp in workers who demonstrate allergic reactions. Chest x-ray should be taken yearly for workers over 40, and every five years for younger workers. Blood, liver, and kidney function should be evaluated periodically. /Chromium & cmpd/
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 246]**PEER REVIEWED**

Initial Medical Examination: 1) A complete history and physical examination: The purpose is to detect existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. ... Exam of the respiratory system, blood, liver, and kidneys should be stressed. The skin should be examined for evidence of chronic disorders. 2) A complete blood count: Chromates have been shown to cause blood changes in humans. A complete blood count should be performed, including a red cell count, a white cell count, a differential count of a stained smear, as well as hemoglobin and hematocrit. 3) 14" x 17" chest roentgenogram: Chromates may cause human lung damage and are associated with a high incidence of lung cancer. Surveillance of the lung is indicated. 4) FVC and FEV (1 sec): Chromates are reported to cause decreased pulmonary function. Periodic surveillance is indicated. 5) Urinalysis: Since chromates may cause kidney damage, a urinalysis should be obtained, including, at a minimum specific gravity, albumin, glucose, & a microscopic ... /examination of/ centrifuged sediment. 6) Liver function tests: Chromates may cause liver damage. A profile of liver function should be obtained by utilizing a medically acceptable array of biochemical tests. 7) Skin disease: Chromates are defatting agents and can cause dermatitis on prolonged exposure. Persons with existing skin disorders may be more susceptible to the effects of these agents. Periodic Medical Examination: The aforementioned medical examination should be repeated on annual basis. Emphasis should be placed on observation for changes in the mucous membranes of the upper respiratory tract, ulceration of the skin, and surveillance for malignancy of the respiratory tract and lung. /Chromic acid and chromates/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

The assessment of chromium exposure can be accomplished through measurement of chromium. Measurement of chromium in whole blood can be used for assessing exposure, but is not as useful as the other monitoring tests in plasma, urine or erythrocytes, which have been more extensively studied and determined to be better indicators of chromium exposure. Whole Blood References Ranges: Normal - less than 0.37 mg/l. Exposed - Chromium (alkali chromates, Cr(IV)) concentrations in erythrocytes that have been found to correlate with workplace air concentrations are as follows: (CrO3 air levels in mg/cu m; Chromium levels, ug/l whole blood (not applicable for exposure to welding fumes), sampling time - long-term exposure, after several shifts: 0.03 mg/cu m CrO3, 9 ug/l; 0.05 mg/cu m CrO3, 17 ug/l; 0.08 mg/cu m CrO3, 25 ug/l; 0.10 mg/cu m CrO3, 35 ug/l; Toxic - Not established. /Chromium/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 370]**PEER REVIEWED**

The assessment of chromium exposure can be accomplished through measurement of chromium. Levels of chromium determined in plasma or serum are indicative of exposure against chromium of all

valences. ... Serum or Plasma Reference Ranges: Normal - .018 to 1.04 mg/l for people not occupationally exposed to chromium; Exposed - An average plasma level of 9 mg/l corresponds to an external Cr(VI) concentration of approximately 100 mg/cu m; Toxic - Not established. /Chromium/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 371]**PEER REVIEWED**

The assessmentof chromium exposure can be accomplished through measurement of chromium. Levels of chromium determined in urine are indicative of exposure against chromium of all valences. ... The optimal time to collect urine for Cr(VI) assessment isat the end of the work week. Urine Reference Ranges: Normal - Average 0.18 to 1.60 mg/l for "unexposed" people; Exposed - BEI (sampling time: increase during shift, measured as total chromium): 10 mg/g creatinine. BEI (sampling time at end of shift at end of workweek, measured as total chromium: 30 mg/g creatinine. Chromium (alkali chromates, Cr(IV)) concentrations in urine that have been found to correlate with workplace air concentrations are as follows: (CrO3 air levels in mg/cu m; Urine chromium levels, ug/l (also applicable for exposure to welding fumes), sampling time - end of exposure or end of shift: 0.03 mg/cu m CrO3, 12 ug/l; 0.05 mg/cu m CrO3, 20 ug/l; 0.08 mg/cu m CrO3, 30 ug/l; 0.10 mg/cu m CrO3, 40 ug/l. Toxic - Not established. /Chromium/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 371]**PEER REVIEWED**

Measurement of methemoglobin may be useful for assessing exposure. However, methemoglobin levels may be artificially low if not analyzed within a few hours after drawing the blood. Methemoglobin levels have been found to correlate with clinical symptoms in most cases. The following table lists methemoglobin levels with corresponding clinical symptoms: less than 1%, none (normal level); 15-20%, clinical cyanosis and chocolate-brown blood evident, patient usually asymptomatic; 20-45%, headache, lethargy, dizziness, fatigue, syncope, dyspnea; 45-55%, increasing CNS depression; 55-70%, coma, convulsions, arrhythmias, shock; greater than 70%, high incidence of mortality, if untreated. /Chromium/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 372]**PEER REVIEWED**

Renal Function Tests /include/ ... Urine Albumin ... Urinary Beta-2-Microglobulin and/or Retinal Binding Protein (RBP) ... Urinary Alpha and Pi Isoenzymes of Glutathione S-Transferase ... Urinary Enzyme N-Acetylglucosaminidase ... /and/ Routine Urinalysis. /Chromium/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 372]**PEER REVIEWED**

Respiratory Symptom Questionnaires: Questionnaires published by the American Thoracic Society (ATS) and the British Medical Research Council have proven useful for identifying people with chronic bronchitis. Certain pulmonary function tests such as the FEV1 have been found to be better predictors of chronic airflow obstruction. /Chromium/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 374]**PEER REVIEWED**

Chest Radiography: Chest radiographs are widely used to assess pulmonary diesase. They are useful for detecting early lung early lung cancer in asymptomatic people, and especially for detecting of peripheral tumors such as adenocarcinomas. However, even though OSHA mandates this test for exposure to some toxicants such as asbestos, experts' views on the risk-to-benefit ratio in detection of pulmonary disease conflict, so routine annual chest x-rays are not recommended for all people. /Chromium/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 374]**PEER REVIEWED**

Pulmonary Function Tests: The tests that have been found to be practical for population monitoring include: Spirometry and expiratory flow-volume curves; Determination of lung volumes; Diffusing

capacity for carbon monoxide; Single-breath nitrogen washout; Inhalation challenge tests; Serial measurements of peak expiratory flow; Exercise testing. /Chromium/
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 374]**PEER REVIEWED**

Populations at Special Risk:

Persons with a history of asthma, allergies, or known sensitizations to chromic acid or chromates would be expected to be at increased risk from exposure. /Chromic acid or chromates/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Probable Routes of Human Exposure:

EFFECTS OF CHROMIUM ENCOUNTERED IN OCCUPATIONS WHERE CHROMIUM CMPD ARE MFR & USED ARE DUE TO CHROMIUM(6+) & INVOLVE MAINLY SKIN & RESP SYSTEM. /CHROMIUM CMPD/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 470]**PEER REVIEWED**

Common operations in which exposure to chromium metal or insoluble chromium salts may occur includes the following: 1) use in fabrication of alloys; 2) use in preparation of alloy steels to enhance corrosion and heat resistance; 3) use in fabrication of plated products for decoration or increased wear resistance; 4) use in production of non ferrous alloys to impart special qualities to the alloys; 5) use in production and processing of insoluble salts; 6) use as chemical intermediates; use in textile industry in dyeing, silk treating, printing, and moth proofing wool; 7) use in leather industry in tanning; use in photographic fixing baths; 8) use as catalysts for halogenation, alkylation, and catalytic cracking of hydrocarbons; and 9) use as fuel additives and propellant additives; in photographic fixing baths and in ceramics. /Chromium metal and insoluble chromium salts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Common operations in which exposure to soluble chromic and chromous salts may occur include the following: 1) use in textile treatment in dyeing, printing, moth proofing, and water proofing; use in tanning of leather in gloves, garments, and shoe uppers; 2) use in manufacture of pigments of green varnishes, inks, paints, and glazes; 3) use in metal treatment and polishing; 4) use in photographic fixing baths for hardening of emulsions; use as catalysts and in manufacture of catalysts; and 5) use in chemical synthesis; use as corrosion inhibitors. /Sol chromic & chromous salts (as Cr)/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

THE CHIEF EXPOSURE TO HAZARDOUS CHROMIUM SUBSTANCES IN AMERICAN INDUSTRY IS BELIEVED TO BE AN ACID SOLUBLE, WATER INSOLUBLE CHROMATE-CHROMITE MIXTURE PRODUCED IN PREPARATION OF CHROMATE. /WATER INSOL CHROMATE-CHROMITE MIXTURE/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1591]**PEER REVIEWED**

CHIEF EXPOSURE TO HAZARDOUS CR SUBSTANCES IN AMERICAN INDUSTRY IS BELIEVED TO BE TO ACID-SOL, WATER-INSOL CHROMATE-CHROMITE MIXT PRODUCED IN PREPN OF CHROMATE. /CHROMIUM CMPD/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1017]**PEER REVIEWED**

OCCUPATIONAL EXPOSURE: CHROMIUM & ITS CMPD ARE FOUND IN 3 MAIN TYPES OF INDUST ACTIVITY: (I) MOST CR DERIV ARE USED IN METALLURGICAL INDUST ... (II) CHROMIUM CMPD ARE ... COMPONENT OF REFRACTORY MATERIALS ... & (III) MANY OF HIGHLY COLORED CHROMATE SALTS ... ARE USED IN PIGMENT, PAINT, TANNING & DYEING INDUSTRIES. /CHROMIUM COMPOUNDS/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 243 (1980)]**PEER REVIEWED**

Exposure to the metal and its insoluble salts is generally via inhalation of dusts or fumes; the current threshold limit values for these compounds range from 0.05-0.5 mg/cu m /Chromium metal and its salts/

[Baselt RC; Biological Monitoring Methods for Industrial Chemicals p. 81 (1980)]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 304,829 workers are potentially exposed to chromium(VI) in the US(1). Monitoring data indicate that the general population may be exposed to chromium compounds via inhalation of ambient air, and ingestion of food and drinking water containing chromium compounds(SRC). Typical concns of chromium in ambient air and water are <0.01 to 0.3 ug/cu m(2) and < 2 ug/l(3), respectively. The typical daily food intake of chromium ranges from 25-224 ug with an avg of 76 ug(4).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983) (2) Fishbein L; Int J Environ Anal Chem 17: 113-70 (1984) (3) Greathouse DG, Craun GF; pp. 31-39 in Trace substances in environmental health. Vol. XII. , Hemphil DD, ed. Columbia, MO: Univ Missouri (1978) (4) Kumpulainen J; pp. 253-277 in Techniques and instrumentation in analytical chemistry Vol 4. Vercruysse A, ed. Amsterdam, The Netherlands: Elsevier Sci Pub (1984)]**PEER REVIEWED**

Workers in industries that use chromium can be exposed to concns of chromium two orders of magnitude higher than exposure to the general population(1). Occupational exposure to chromium occurs mainly from chromate production, stainless steel production and welding, chromium plating, ferrochrome alloys and chrome pigment production, and working in tanning industries(2). For most occupations, exposure is due to both **chromium(III)** and chromium(VI) present as soluble and insoluble fractions(3). However, exceptions include: the tanning industry, where exposure is mostly from soluble **chromium(III)** and the plating industry, where exposure is due to soluble chromium(VI)(3). The typical concn ranges of airborne chromium(VI) to which workers in these industries were exposed during an avg of 5-20 years of employment were: chromate production, 100-500 ug/cu m; stainless steel welding, 50-400 ug/cu m; chromium plating, 5-25 ug/cu m; ferrochrome alloys, 10-140 ug/cu m; and chrome pigment, 60-600 ug/cu m(3).
[(1) Hemminki K, Vainio H; Human exposure to potentially carcinogenic compounds 59: 37-45 (1984) (2) IARC; IARC monographs on the evaluation of carcinogenic risks to humans 49: 49-256 (1990) (3) Stern RM; pp. 5-47 in Biological and environmental aspects of chromium. Langard S, ed NY, NY: Elsevier Biomed Press (1982) (4) Angerer J et al; Int Arch Occup Environ Health 59: 503-12 (1987) (5) Kuo H-W et al; Am Ind Hyg Assoc J 58: 29-32 (1997) (6) Gianello G et al; Ind Health 36: 74-77 (1998) (7) NIOSH; National Occupation Exposure Survey. Cincinnati, OH: USDHH, PHS, CDC, NIOSH (1989)]**PEER REVIEWED**

In the tanning industry, except for 2 bath processes, the typical exposure range due to **chromium(III)**

was 10-50 ug/cu m(1). A more recent study of chromium oxide levels in the working environment of stainless steel welders in Germany reported a max value of 80 ug/cu m, with a median value ranging from 4 to 10 ug/cu m(2). Because of better emission control measures, occupational airborne chromium concns have declined significantly since the 1970s(1). In a recent study conducted in Taiwan to estimate worker exposure to chromium in electroplating factories, the chromium concns were 0.5-6.0 ug/cu m near the electroplating tanks and 0.3 ug/cu m in the manufacturing area(3). In an occupational exposure study of chromium in an aircraft construction factory, airborne samples were collected over a 4-hour period; urinary samples were collected at the beginning (Monday), end (Friday), and after the work shift in order to analyze the absorption of chromium during working hours(4). The air sampling results were 0.02-1.5 mg/cu m, and the urine sampling results were 0.16-7.74 ug/g creatinine(4). Compared to the ACGIH and BEI-ACGIH Hygiene Standard of 50 ug/cu m, both sets of results indicated a very low risk of exposure(4).
[(1) Stern RM; pp. 5-47 in Biological and environmental aspects of chromium. Langard S, ed. NY, NY: Elsevier Biomed Press (1982) (2) Angerer J et al; Int Arch Occup Environ Health 59: 503-12 (1987) (3) Kuo H-W et al; Am Ind Hyg Assoc J 58: 29-32 (1997) (4) Gianello G et al; Ind Health 36: 74-7 (1998)]**PEER REVIEWED**

In a survey of workers in pigment factories in England that produced strontium and lead chromate, the concns of chromium in the whole blood in exposed workers ranged from 3 to 216 ug/l, compared to a level of <1 ug/l for the nonoccupationally exposed population(1). The corresponding concns in the urine of exposed workers and the unexposed population were 1.8-575 ug chromium/g creatinine and <0.5 ug chromium/g creatinine, respectively(1). Other investigators have found a higher lung burden for chromium in occupational groups than in unexposed groups(2). The median concn of chromium in the lungs of deceased smelter workers in Sweden was 450 ug/kg (wet weight), compared to a value of 110 ug/kg (wet weight) for rural controls and 199 ug/kg (wet weight) for urban controls(2).
[(1) McAughey JJ et al; Sci Total Environ 71: 317-22 (1988) (2) Gerhardsson L et al; Sci Total Environ 74: 97-110 (1988)]**PEER REVIEWED**

Body Burden:

In spite of the refined methods of analysis available, a reliable range of normal blood chromium concentrations cannot be given with confidence. When using modern methods for analysis, the whole blood concentration may be suggested to be within the range of 0.5 to 3 ppb, while the serum level is probably below 0.2 ppb. /Total chromium/
[USEPA; Health Assessment Document: Chromium p.2-6 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

Human soft tissues contain 0.03 ppm chromium. /Total chromium/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.14 (1976) NRCC No.15017]**PEER REVIEWED**

Human fetus (heart, liver, and spleen) showed an accumulation factor of 10 when compared to adult tissues with levels decreasing upon aging. /Total chromium/
[Nat'l Research Council Canada; Effects of Chromium in Canadian Envir p. 50 (1976) NRCC No.15017]**PEER REVIEWED**

Total body burden of 2-6 mg chromium may represent a marginally deficient state. /Total chromium/
[USEPA; Ambient Water Quality Criteria Doc: Chromium p.C-11 (1980) EPA 440/5-80-035]**PEER REVIEWED**

In persons without excess exposure, blood chromium concn is between 20 and 30 ug/l and is evenly distributed between erythrocytes and plasma. With occupational exposure, incr in blood chromium is related in incr in chromium in red blood cells. Urinary excretion is generally less than 10 ug/day in the absence of excess exposure. /Total chromium/

[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 598]**PEER REVIEWED**

... In hair, values from 200 to 2000 ug/kg ... 700 ug/kg of chromium in the lung for persons in the New York/Chicago area; ... liver 270 ug/kg and kidney 90 ug/kg. ... Denver area ... 140 ug/kg for the lung, 30 ug/kg for the liver, and 40 ug/kg for the kidney. ... 300 ug/kg for the lung, 40 ug/kg for the liver, and about 15 ug/kg or the kidney ... from Japan. ... At present the concn of chromium (normal levels) in plasma ... 0.14 ug/l, and in urine 0.32-0.41 ug/l. /Total chromium/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 193]**PEER REVIEWED**

Occupationally exposed workers had chromium concn in lung that were 300 fold higher than nonexposed controls, and concn in liver, kidney, and adrenal glands that were 2 to 4 fold, 10 fold, and 10 to 50 fold higher, respectively. /Total chromium/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 243]**PEER REVIEWED**

Concentrations of chromium cmpd, calculated as Cr, in body tissues of persons without and with known exposure to Cr: Normal tissues (ug/kg wet tissue): lung 0-330, tracheobronchial lymph node 0-10, kidney 0-96, liver 10-110, spleen 0-980, abdominal lymph node 10, stomach 0-50, intestine 100, muscle 0-80, pancreas 210, thyroid 430, adrenal 0-410, brain 0-40, bone 50; Tissues from chromate workers (ug/kg wet tissue): lung 1300-98,870, lung tumor 0-16,580, metastatic tumor 20-1000, tracheobronchial lymph node 120-75,900, bronchus 950-3860, trachea 0-320, nasal septum 2870, larynx 210, kidney 0-2110, liver 0-1590, spleen 0-910, abdominal lymph node 40-800, stomach 40-110, intestine 40-50, bladder 30-2260, heart 0-200, muscle 0-190, pancreas 80-360, thyroid 240-530, adrenal 50-760, brain 0-50, bone 0-2920, cartilage 60, bile 10, hair 310, skin 50, aorta 30. /From table/ /Total chromium/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 249 (1980)]**PEER REVIEWED**

Serum chromium concentrations average about 0.16 ug/l (range 0.04-0.35) in healthy subjects. Literature published prior to 1978 refers to normal serum chromium values ranging from 0.7 to 150 ug/l due to methodological difficulties in trace analysis of chromium. /Chromium/
[Baselt RC; Biological Monitoring Methods for Industrial Chemicals p. 81 (1980)]**PEER REVIEWED**

A recent East German autopsy study of people with no occupational exposure to chromium found that chromium levels in lung and kidney were not correlated with age. /Chromium and chromium cmpd/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.46 (10/87)]**PEER REVIEWED**

The chromium content in tissues and body fluids of the general population are as follows: serum, 0.006 ug/l (range, 0.01-0.17 ug/l)(1); urine, 0.4 ug/l (range, 0.24-1.8 ug/l)(2); lung, 201 ug/kg(wet wt; range, 28-898 ug/kg)(3); breast milk, 0.30 ug/l (range, 0.06-1.56 ug/l)(4); hair, 0.234 mg/kg(5); and nail, 0.52 mg/kg(5). The concn of chromium in human liver (from Spanish population) was 2.49 +/- 0.89 ppm(6).
[(1) Sunderman FW et al; J Orthop Res 7: 307-15 (1989) (2) Iyengar V, Woittiez ; Clin Chem 34: 474-81 (1988) (3) Raithel HJ et al; Am J Ind Med 12: 55-70 (1987) (4) Casey CE, Hambidge KM; Br J Nutr 52: 73-7 (1984) (5) Takagi Y et al; Bull Environ Contam Toxicol 36: 793-800 (1986) (6) Bona MA et al; Human Exp Toxicol 11: 311-4 (1992)]**PEER REVIEWED**

Average Daily Intake:

Estimated safe and adequate daily dietary intakes of chromium: infants: 0-0.5 yr: 0.01-0.04 mg; 0.5-1 yr:

0.02-0.06 mg; children and adolescents: 1-3 yr: 0.02-0.08 mg; 4-6 yr: 0.03-0.12 mg; 7-10 yr: 0.05-0.2 mg; 11+ yr: 0.05-0.2 mg; adults: 0.05-0.2 mg /From table/ /Total chromium/
[Gilman, A.G., L.S.Goodman, and A. Gilman. (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 7th ed. New York: Macmillan Publishing Co., Inc., 1985. 1548]**PEER REVIEWED**

AIR INTAKE: Assume <0.01 to 0.3 ug/cu m(1), 0.2 to 0.6 ug(SRC). WATER INTAKE: Assume < 2 ug/l(2), <4 ug(SRC). FOOD INTAKE: 25 to 224 ug with an avg of 76 ug(3).
[(1) Fishbein L; Int J Environ Anal Chem 17: 113-70 (1984) (2) Greathouse DG, Craun GF; pp. 31-9 in Trace substances in environmental health. Vol. XII., Hemphil DD, ed. Columbia, MO: Univ Missouri (1978) (3) Kumpulainen J; pp. 253- 77 in Techniques and instrumentation in analytical chemistry Vol 4. Vercruysse A, ed. Amsterdam, The Netherlands: Elsevier Sci Pub (1984)]**PEER REVIEWED**

FOOD INTAKE: The dietary intake estimates of chromium in foods from France are as follows: vegetables, 7.3 ug/day; fruits, 4.4 ug/day, beverages, 20 ug/day; cereals, 17 ug/day; fish-crustaceans, 4.5 ug/day; meat-poultry-eggs, 23 ug/day; milk-dairy-products, 17 ug/day; condiments-sugar-oils, 1.2 ug/day; canned foods, 3.8 ug/day(1). Dietary intake estimates of chromium from France, Denmark, Spain, Belgium, and US are 98 ug/day, 50 ug/day, 99 ug/day, 240 ug/day, and 50-200 ug/day, respectively(1).
[(1) Biego GH et al; Sci Total Environ 217: 27-36 (1998)]**PEER REVIEWED**

Emergency Medical Treatment:

Antidote and Emergency Treatment:

TREATMENT: B. CHRONIC POISONING: 1. TREAT WEEPING DERMATITIS WITH 1 % ALUMINUM ACETATE WET DRESSINGS. AVOID FURTHER EXPOSURE TO CHROMATE. 2. TREAT LIVER DAMAGE BY GIVING HIGH-CARBOHYDRATE, HIGH-PROTEIN, HIGH VITAMIN DIET ... /CHROMIUM/
[Dreisbach, R. H. Handbook of Poisoning. 9th ed. Los Altos, California: Lange Medical Publications, 1977. 219]**PEER REVIEWED**

TREAT LOCAL INJURIES LIKE ACID BURNS; ALSO EXTERNAL LESIONS MAY BE SCRUBBED WITH DIL SODIUM HYPOSULFITE SOLN (2%) OR TREATED WITH CALCIUM DISODIUM EDETATE OINTMENT. ... TREAT PERIPHERAL VASCULAR SHOCK VIGOROUSLY. /CHROMATE SALTS/
[Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976.,p. II-75]**PEER REVIEWED**

... MILK OR OTHER EMULGATIONS HAVE BEEN ADVISED IN ... CHROMIC ACID INGESTION. ACUTE ASTHMATIC ATTACKS CAUSED BY CHROMATES SHOULD BE TREATED LIKE OTHER ASTHMATIC ATTACKS. ... WOUNDS ON HANDS & ARMS ... CLEANED & COVERED ... /CHROMIUM CMPD/
[Friberg, L., G.R. Nordberg, and V.B. Vouk. Handbook on the Toxicology of Metals. New York: Elsevier North Holland, 1979. 394]**PEER REVIEWED**

Exptl therapy: Uremia caused by tubular necrosis is the most frequent outcome of transdermal absorption of hexavalent chromium. This study confirms earlier observations that uremia can be prevented by immediate application of ascorbic acid. Serum & plasma samples spontaneously reduced concn of chromium(VI) cmpd by about 2 ppm. Addition of ascorbic acid in doses of 50 to 1000 ppm led to a rapid & dose dependent reduction of Cr(VI). For example, in the presence of 1000 ppm ascorbic acid, a concn of 5 ppm Cr(VI) declines to 0.7 ppm within 20 min & to undetectable concn after 40 min.

Cr(VI) concn is reduced by ascorbic acid & the resulting Cr(III) protein complexes are non toxic & can be excreted with the urine. Early & repeated high iv doses of ascorbic acid are recommended as the therapy of choice for Cr(VI) poisoning. /Hexavalent chromium/
[Korallus U et al; Int Arch Occup Environ Health 53 (3): 247-56 (1984)]**PEER REVIEWED**

Acute chromium poisoning from chromium trioxide or chromate salts, if ingested, is characterized by fulminant gastroenteritis, thrombocytopenia, shock, & toxic nephritis. Treatment of acute toxicity involves gastric lavage, alkaline diuresis, chelatin therapy with calcium disodium edetate or BAL, hemodialysis in the event of renal failure, & supportive therapy. /Chromium salts or chromium trioxide/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1030]**PEER REVIEWED**

TREATMENT OF CHROMIUM ULCERS HAS NOT BEEN VERY SUCCESSFUL. ... OINTMENT CONTAINING 10% SODIUM CALCIUM EDTA, OR 10% SOLN FRESH ASCORBIC ACID, SEEMS TO GIVE SOME PROTECTION TO SKIN. /CHROMIUM COMPD/
[Friberg, L., G.R. Nordberg, and V.B. Vouk. Handbook on the Toxicology of Metals. New York: Elsevier North Holland, 1979. 395]**PEER REVIEWED**

TREATMENT: A. ACUTE POISONING: 1. EMERGENCY MEASURES--REMOVE SWALLOWED CHROMATE BY GASTRIC LAVAGE ... 2. USE OF DIMERCAPROL ... SUGGESTED ON BASIS OF FINDINGS IN ANIMALS ... 3. GENERAL MEASURES--IF OLIGURIA OR ANURIA PRESENT, MAINTAIN CAREFUL FLUID & ELECTROLYTE BALANCE ... /CHROMIUM/
[Dreisbach, R. H. Handbook of Poisoning. 9th ed. Los Altos, California: Lange Medical Publications, 1977. 219]**PEER REVIEWED**

PROGNOSIS: IN ACUTE POISONING, RAPID PROGRESSION TO ANURIA INDICATES POOR OUTCOME. DERMATITIS & LIVER DAMAGE WILL RESPOND TO REMOVAL FROM FURTHER EXPOSURE. /CHROMIUM/
[Dreisbach, R. H. Handbook of Poisoning. 9th ed. Los Altos, California: Lange Medical Publications, 1977. 219]**PEER REVIEWED**

TREAT LOCAL INJURIES LIKE ACID BURNS; ALSO EXTERNAL LESIONS MAY BE SCRUBBED WITH DIL SODIUM HYPOSULFITE SOLN (2%) OR TREATED WITH CALCIUM DISODIUM EDETATE OINTMENT. ... TREAT PERIPHERAL VASCULAR SHOCK VIGOROUSLY. /CHROMATE SALTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-109]**PEER REVIEWED**

Emesis should generally not be induced, due to the potential corrosive effects of the chromium compound & the potential for rapid deterioration of the patient. Ascorbic acid should generally be admin orally or nasogastrically, if the patient is seen while the chromium compound is still in the stomach. Ascorbic acid has been shown to ameliorate the effects of topical human exposure to chromates, & to reduce toxicity following ingestion in rats if given within 2 hrs of exposure. Ascorbic acid functions to chemically reduce /hexavalent chromium/ to /trivalent chromium/, the form less toxic to the gastric & intestinal mucosa. ... Dilution of the ingested agent is appropriate, particularly if its pH is quit low or quite high. Dilution may be accomplished with water or with fluids which also serves as demulcents, such as milk. The use of demulcent cmpds (such as antacids, corn starch, or milk) in addition to those used for dilution has been recommended and seems reasonable but has not been formally studied. Gastric lavage to reduce the dose ingested should be utilized if chromium is still present in the stomach. A soft tube is preferable due to the possibility of injury to gastric mucosa already having occurred. Lavage using antacids such as magnesium hydroxide has been suggested, but no studies have been carried out to demonstrate its relative efficacy to the use of water. ... Elimination enhancement . Exchange transfusion was effective in reducing blood chromium levels 67% in one case, using 10.9

liters of blood. Existing evidence does not allow the conclusion that exchange transfusion should generally be employed, however. Hemodialysis & chemical hemoperfusion do no substantially enhance chromium removal from the body if renal function remains normal. However, if renal failure ensues, hemodialysis may be necessary for management of the renal failure itself. Treatment. Fluid balance must be maintained carefully. The patient should be monitored carefully for evidence of GI bleeding, methemoglobinemia, hemolysis, coagulopathy, seizures, or pulmonary dysfunction, & appropriate supportive measures should be employed as indicated. If hemolysis develops, gentle alkaline diuresis may be indicated to reduce the possibility of further renal injury. If methemoglobinemia exceeding 30% is observed, treatment with methylene blue should be employed. Chelation with calcium disodium EDTA & BAL does not seem to confer clinical benefit. N-Acetylcysteine (NAC) increased chromium clearance & reversed oliguria in rats poisoned with potassium dichromate, but there is no human published experience using NAC. /Chromium and compounds/
[Sullivan, J.B. Jr., G.R. Krieger (eds.). Hazardous Materials Toxicology-Clinical Principles of Environmental Health. Baltimore, MD: Williams and Wilkins, 1992. 893]**PEER REVIEWED**

Animal Toxicity Studies:

Evidence for Carcinogenicity:

WEIGHT OF EVIDENCE CHARACTERIZATION: Applying the criteria for evaluating the overall weight of evidence for carcinogenicity to humans outlined in EPA's guidelines for risk assessment (1986), trivalent chromium is most appropriately designated a Group D -- Not classified as to its human carcinogenicity. Using the Proposed Guidelines for Carcinogen Risk Assessment (1996), there are inadequate data to determine the potential carcinogenicity of trivalent chromium ... However, the classification of hexavalent chromium as a known human carcinogen raises a concern for the carcinogenic potential of trivalent chromium. HUMAN CARCINOGENICITY DATA: Occupational exposure to trivalent chromium and other chromium compounds by inhalation has been studied in the chromate manufacturing and ferrochromium industries; however, exposures all include mixed exposures to both Cr(III) and Cr(VI). Cr(VI) species is the likely etiological agent in reports of excess cancer risk in chromium workers. Data addressing exposures to Cr(III) alone are not available and data are inadequate for an evaluation of human carcinogenic potential. ... ANIMAL CARCINOGENICITY DATA: The data from oral and inhalation exposures of animals to trivalent chromium do not support documentation of the carcinogenicity of trivalent chromium. IARC concluded that animal data are inadequate for the evaluation of the carcinogenicity of Cr(III) compounds. Furthermore, although there is sufficient evidence of respiratory carcinogenicity associated with exposure to chromium, the relative contribution of Cr(III), Cr(VI), metallic chromium, or soluble versus insoluble chromium to carcinogenicity cannot be elucidated... /**Chromium (III),** insoluble salts/
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) for Chromium (III), insoluble salts (16065-83-1) Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000]**PEER REVIEWED**

WEIGHT OF EVIDENCE CHARACTERIZATION: Under the current guidelines (1986), Cr(VI) is classified as Group A - known human carcinogen by the inhalation route of exposure. Carcinogenicity by the oral route of exposure cannot be determined and is classified as Group D. Under the proposed guidelines (1996), Cr(VI) would be characterized as a known human carcinogen by the inhalation route of exposure on the following basis. Hexavalent chromium is known to be carcinogenic in humans by the inhalation route of exposure. Results of occupational epidemiological studies of chromium-exposed workers are consistent across investigators and study populations. Dose-response relationships have been established for chromium exposure and lung cancer. Chromium-exposed workers are exposed to both

Cr(III) and Cr(VI) compounds. Because only Cr(VI) has been found to be carcinogenic in animal studies, however, it was concluded that only Cr(VI) should be classified as a human carcinogen. Animal data are consistent with the human carcinogenicity data on hexavalent chromium. Hexavalent chromium compounds are carcinogenic in animal bioassays, producing the following tumor types: intramuscular injection site tumors in rats and mice, intrapleural implant site tumors for various Cr(VI) compounds in rats, intrabronchial implantation site tumors for various Cr(VI) compounds in rats and subcutaneous injection site sarcomas in rats. In vitro data are suggestive of a potential mode of action for hexavalent chromium carcinogenesis. Hexavalent chromium carcinogenesis may result from the formation of mutagenic oxidatitive DNA lesions following intracellular reduction to the trivalent form. Cr(VI) readily passes through cell membranes and is rapidly reduced intracellularly to generate reactive Cr(V) and Cr(IV) intermediates and reactive oxygen species. A number of potentially mutagenic DNA lesions are formed during the reduction of Cr(VI). Hexavalent chromium is mutagenic in bacterial assays, yeasts and V79 cells, and Cr(VI) compounds decrease the fidelity of DNA synthesis in vitro and produce unscheduled DNA synthesis as a consequence of DNA damage. Chromate has been shown to transform both primary cells and cell lines. HUMAN CARCINOGENICITY DATA: Occupational exposure to chromium compounds has been studied in the chromate production, chromeplating and chrome pigment, ferrochromium production, gold mining, leather tanning and chrome alloy production industries. Workers in the chromate industry are exposed to both trivalent and hexavalent compounds of chromium. Epidemiological studies of chromate production plants in Japan, Great Britain, West Germany, and the United States have revealed a correlation between occupational exposure to chromium and lung cancer, but the specific form of chromium responsible for the induction of cancer was not identified ... Studies of chrome pigment workers have consistently demonstrated an association between occupational chromium exposure (primarily Cr(VI)) and lung cancer. Several studies of the chromeplating industry have demonstrated a positive relationship between cancer and exposure to chromium compounds. ANIMAL CARCINOGENICITY DATA: Animal data are consistent with the findings of human epidemiological studies of hexavalent chromium ... /Chromium (VI)/
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) for Chromium (VI) (18540-29-9) Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000]**PEER REVIEWED**

CLASSIFICATION: A; human carcinogen. BASIS FOR CLASSIFICATION: Results of occupational epidemiologic studies of chromium-exposed workers are consistent across investigators and study populations. Dose-response relationships have been established for chromium exposure and lung cancer. Chromium-exposed workers are exposed to both cromium III and chromium VI compounds. Because only chromium VI has been found to be carcinogenic in animal studies, however, it was concluded that only chromium VI be classified as a human carcinogen. HUMAN CARCINOGENICITY DATA: Sufficient. /Chromium VI/
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Chromium VI (18540-29-9 Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000]**PEER REVIEWED**

A4; Not classifiable as a human carcinogen. /Metal and Cr(III) compounds, as Cr/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.23]**PEER REVIEWED**

A1; Confirmed human carcinogen. /Water soluble Cr(VI) compounds, as Cr/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.23]**PEER REVIEWED**

A1; Confirmed human carcinogen. /Insoluble Cr(VI) compounds, as Cr/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure

Indices for 2002. Cincinnati, OH. 2002.23]**PEER REVIEWED**

Evaluation: There is sufficient evidence in humans for the carcinogenicity of chromium(VI) compounds as encountered in the chromate production, chromate pigment production and chromium plating industries. There is sufficient evidence in experimental animals for the carcinogenicity of calcium chromate, zinc chromates, strontium chromate and lead chromates. There is limited evidence in experimental animals for the carcinogenicity of chromium trioxide (chromic acid) and sodium dichromate. Overall evaluation: Chromium(VI) is carcinogenic to humans (Group 1). The Working Group made the overall evaluation on chromium(VI) compounds on the basis of the combined results of epidemiological studies, carcinogenicity studies in experimental animals, and several types of other relevant data which support the underlying concept that chromium(VI) ions generated at critical sites in the target cells are responsible for the carcinogenic action observed. /Chromium(VI) compounds/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V49 213 (1990)]**PEER REVIEWED**

Evaluation: There is inadequate evidence in humans for the carcinogenicity of metallic chromium and of **chromium(III)** compounds. There is inadequate evidence in experimental animals for the carcinogenicity of metallic chromium, barium chromate and **chromium(III)** compounds. Overall evaluation: Metallic chromium and **chromium(III)** compounds are not classifiable as to their carcinogenicity to humans (Group 3). /Metallic chromium and **chromium(III)** compounds/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V49 213 (1990)]**PEER REVIEWED**

Non-Human Toxicity Excerpts:

The presence of > 100 ppm Chromium may adversely affect the biodegradation of sewage sludge. /Total chromium/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.91 (1976) NRCC No.15017]**PEER REVIEWED**

Low doses of chromium produce a relatively specific necrosis of the proximal convoluted tubule. Functionally, this leads to pronounced glucosuria. After low doses of chromium the surface of the kidney shows marked signs of ischemia and tissue damage. ... when the dose of the chromium is incr, toxicity is seen throughout the proximal tubule. /Chromium/
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 319]**PEER REVIEWED**

EXPERIMENTS IN MICE, RATS, HAMSTERS, GUINEA-PIGS AND RABBITS TO INVESTIGATE THE CARCINOGENICITY OF CHROMIC (III) ACETATE, CHROMIC (III) OXIDE ... CHROMIUM (VI) TRIOXIDE, CHROMIUM METAL ... SODIUM CHROMATE (VI) ... SODIUM DICHROMATE (VI) ... **CHROMIUM (III)** SULFATE ... WERE INADEQUATE TO EVALUATE THE CARCINOGENICITY OF THESE CHROMIUM COMPOUNDS. /CHROMIUM COMPOUNDS/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 302 (1980)]**PEER REVIEWED**

THE RECENTLY DEVELOPED STRAIN TA102, PARTICULARLY SUITED FOR THE DETECTION OF OXIDATIVE MUTAGENS, WAS THE MOST SENSITIVE OF TA100, TA97, TA92, TA1978, TA98, TA1537 & TA1538 STRAINS OF SALMONELLA TYPHIMURIUM HIS- IN REVEALING THE MUTAGENICITY OF HEXAVALENT CHROMIUM CMPD. STRAIN TA1535 WAS THE ONLY INSENSITIVE STRAIN TESTED. TRIVALENT CHROMIUM CMPD WAS TOTALLY INACTIVE WITH ALL STRAINS. /HEXAVALENT & TRIVALENT CHROMIUM/

[BENNICELLI C ET AL; MUTAT RES 122 (1): 1-6 (1983)]**PEER REVIEWED**

SEVEN DIFFERENT TEST SYSTEMS WERE UTILIZED TO INVESTIGATE THE GENETIC ACTIVITY OF CHROMIUM CMPD: INFIDELITY OF DNA REPLICATION IN VITRO BY DNA POLYMERASE ALPHA FROM CALF THYMUS, DAMAGE OF DNA DETECTED BY ALKALINE ELUTION IN TREATED MAMMALIAN CELLS OR IN DNA PURIFIED & TREATED IN VITRO, DNA REPAIR SYNTHESIS IN MAMMALIAN CELLS IN VITRO, GENE MUTATIONS IN THE SALMONELLA TYPHIMURIUM AMES TEST, GENE MUTATIONS IN CULTURED HAMSTER CELLS, SISTER-CHROMATID EXCHANGES IN DIFFERENT RODENT CELL CULTURES, & TRANSFORMATION TO ANCHORAGE-INDEPENDENT GROWTH OF HAMSTER CELLS IN VITRO. HEXAVALENT CHROMIUM CMPD WAS ACTIVE IN ALL THE TESTED SYSTEMS, EXCEPT IN THE INDUCTION OF DNA DAMAGE & DNA REPAIR SYNTHESIS IN CULTURED CELLS. TRIVALENT CHROMIUM CMPD WERE ABSOLUTELY INACTIVE UNLESS A DIRECT INTERACTION WITH PURIFIED DNA WAS PERMITTED BY THE TEST CONDITIONS. /HEXAVALENT & TRIVALENT CHROMIUM/
[BIANCHI V ET AL; MUTAT RES 117 (3-4): 279-300 (1983)]**PEER REVIEWED**

THE INHIBITION OF CELL GROWTH, THE REDUCTION OF CELL SURVIVAL & THE INDUCTION OF CHROMOSOME ABERRATIONS & OF SISTER CHROMATID EXCHANGE WERE DETERMINED IN CULTURED HAMSTER CELL LINES (FIBROBLAST BHK & OVARY CHO) TREATED WITH 11 WATER SOL CMPD OF HEXAVALENT (CR(6+)) & TRIVALENT CHROMIUM (CR(3+)). ALL CR(6+) COMPOUNDS INHIBIT GROWTH OF BHK CELLS & REDUCE SURVIVAL OF CHO CELLS TO LEVELS COMPARABLE TO THOSE OBTAINED ONLY AFTER EXPOSURE TO 100-1000 TIMES HIGHER CR(3+) CONCN. BOTH CR(6+) & CR(3+) CMPD ARE ABLE TO INDUCE CHROMOSOME ABERRATIONS, WHEREAS CR(3+) IS ABSOLUTELY INCAPABLE OF INDUCING SISTERCHROMATID EXCHANGE, ONLY CR(6+) BEING ACTIVE. /HEXAVALENT & TRIVALENT CHROMIUM/
[LEVIS AG, MAJONE F; BR J CANCER 40 (4): 523-33 (1979)]**PEER REVIEWED**

HEXAVALENT CHROMIUM INTERACTS WITH BACTERIAL DNA BY CAUSING FRAMESHIFT MUTATIONS & BASEPAIR SUBSTITUTIONS. AVERAGE OF 1 UMOL HEXAVALENT CHROMIUM YIELDED APPROX 500 REVERTANTS OF TA100 STRAIN. TRIVALENT CMPD WERE NEITHER TOXIC NOR MUTAGENIC FOR BACTERIAL STRAINS. /HEXAVALENT & TRIVALENT CHROMIUM/
[PETRILLI FL ET AL; APPL ENVIRON MICROBIOL 33 (4): 805-9 (1977)]**PEER REVIEWED**

Low doses of chromium produce a relatively specific necrosis of the proximal convoluted tubule. Functionally, this leads to pronounced glucosuria. After low doses of chromium the surface of the kidney shows marked signs of ischemia and tissue damage. ... when the dose of the chromium is incr, toxicity is seen throughout the proximal tubule. /Chromium/
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 319]**PEER REVIEWED**

In general, soluble chromium(VI) compounds are less active in the presence of metabolic activating systems. The reduction of Cr(VI) to Cr(III) by cellular agents in metabolic activation systems, in part, explains the reduced mutagenic activity of Cr(VI) in the presence of such activating systems. ... Some recent evidence implicating both Cr(VI) and Cr(III) in induced mutagenesis has been reported in DNA interaction and DNA polymerase infidelity assays, and several tests with apparently pure Cr(III) samples have found chromosomal aberrations. However, with the exception of hexacoordinate Cr(III) compounds, and Cr(III) compounds contaminated with Cr(VI), trivalent chromium is generally considered to be a relatively inactive genotoxic agent, owing to its inability to cross cell membranes. /Trivalent chromium/

[USEPA; Health Assessment Document: Chromium p.2-9 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

Limited work has been reported on the reproductive effects of chromium. Cr(VI) and Cr(III) have been found to cross the placental barrier in animals (hamsters and mice) and enter the fetus during mid to late gestation. Fetal uptake of Cr(VI), however, was much greater than that of Cr(III). Developmental effects attributed to both Cr(VI) and Cr(III) differed between hamsters and mice, and included such external abnormalities as cleft palate and skeletal defects, and (in one study of a Cr(III) compound) neural tube defects. It was concluded that Cr(VI) was present at sufficiently high fetal concentrations to cause direct effects on embryonic structures, but also questioned whether all of the teratogenicity and fetal toxicity associated with exposure to Cr(III) might be attributed to extra-embryonic effects, for example, those on placental tissues. /Trivalent and hexavalent chromium/
[USEPA; Health Assessment Document: Chromium p.2-8 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

The main toxic action of chromium takes place in the roots of soybeans. More than 0.1 ppm Cr(6+) in a solution culture interfered with the uptake and translocation of essential elements by the roots of soybeans. In solution culture, 1-5 ppm of either Cr(3+) or Cr(6+) was the toxic threshold for a number of plant species. When compost was used for the growth medium, the toxic threshold was increased to 500 ppm for Cr(6+) and 5000 ppm for Cr(3+). In contrast, the use of sand as the growth medium did not change the toxic thresholds much from those for the solution cultures. This increase in the toxic threshold was related to the greater ion exchange capacity of compost over that of sand. Thus, the greatest risk of chromium toxicity to plants is in acidic, sandy soil having low organic content. /Chromium/
[Nat'l Research Council Canada; Executive Reports: Effects of Chromium, Alkali Halides, Arsenic, Asbestos, Mercury, Cadmium in the Canadian Evironment p.13 (1980) NRCC No 17585]**PEER REVIEWED**

Several hexavalent chromium compounds have been shown to be carcinogenic in cancer bioassay studies. Only calcium chromate has consistently produced lung tumors in rats by several routes of administration. Other chromium compounds: strontium chromate, zinc chromate, sodium dichromate, lead chromate, lead chromate oxide, and sintered chromium trioxide have produced local sarcomas or lung tumors in rats at the site of intrabronchial, intratracheal, intramuscular, subcutaneous and intraperitoneal application. Hexavalent chromium compounds have not induced lung tumors by inhalation; however, studies have not been reported in detail. ... Animal cancer bioassay studies suggest that hexavalent chromium compounds (particularly ... sparingly soluble compounds) are probably the etiologic agent in chromium related human cancer. Under the IARC criteria, the animal bioassay studies would constitute sufficient evidence of the carcinogenicity of hexavalent chromium compounds. /Hexavalent chromium/
[USEPA; Health Assessment Document: Chromium p.2-10 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

The dietary toxic threshold for Cr(6+) in experimental animals is higher than in man. In dogs, fatal exposure was 0.1 g Cr(6+)/day in food for 2-3 months; 11.2 ppm in drinking water for 4 years caused significant tissue accumulation of chromium, but no obvious pathological effects; 6 ppm was the threshold for accumulation in the tissues. In rats, 134 ppm Cr(6+) in drinking water for 2-3 months caused kidney and liver lesions, while the toxic threshold for Cr(6+) in the food of young rats was 0.1% (1000 ppm). Hence Cr(6+), when blended with food, is much less available than Cr(6+) in drinking water. /Hexavalent chromium/
[Nat'l Research Council Canada; Executive Reports: Effects of Chromium, Alkali Halides, Arsenic, Asbestos, Mercury, Cadmium in the Canadian Environment p.14 (1980) NRCC No. 17585]**PEER REVIEWED**

The toxicity of chromium(VI) to fish, shrimp, crab, and clam increased as salinity decreased. The change was usually less than a factor of two, except when salinity was about 1 g/kg. /Hexavalent chromium/
[USEPA; Ambient Water Quality Criteria Doc: Chromium p.7 (1984) EPA 440/5-84-029]**PEER REVIEWED**

METAL COMPOUNDS WERE TESTED FOR THEIR ABILITY TO INDUCE CHROMOSOMAL ABERRATIONS IN CULTURED MAMMALIAN (C3H MOUSE MAMMARY CARCINOMA FM3A) CELLS. AMONG 6 VALENT CHROMIUM COMPOUNDS, POTASSIUM DICHROMATE & CHROMIUM TRIOXIDE INDUCED HIGH LEVELS OF ABERRATIONS, AT RATES WHICH WERE SIMILAR FOR CHROMIUM EQUIVALENT DOSES.
[UMEDA M, NISHIMURA M; MUTAT RES 67 (3): 221-30 (1979)]**PEER REVIEWED**

IN DOGS, DIALYZER CHROMATE CLEARANCE WAS SIMILAR TO THEIR RENAL CLEARANCE & CHROMATE CLEARANCE WAS NOT SIGNIFICANTLY DIFFERENT BEFORE & AFTER DIMERCAPROL ADMINISTRATION. /CHROMATE/
[ELLIS EN ET AL; J TOXICOL CLIN TOXICOL 19 (3): 249-58 (1982)]**PEER REVIEWED**

EXTRA-CORPOREAL HEMODIALYSIS INSTITUTED FOR UREMIA APPEARED IN SEVERAL CASES TO LOWER BLOOD CR LEVELS. PERHAPS DIALYSIS SHOULD BE TRIED EARLIER IN COURSE OF INTOXICATION. IN ANIMAL EXPT DIMERCAPROL WAS AT LEAST AS EFFECTIVE AGAINST CHROMATE AS AGAINST MERCURY. /DICHROMATE SALTS (SOLUBLE)/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-109]**PEER REVIEWED**

Records of acute toxicities of hexavalent and trivalent chromium salts to representative species of aquatic life (Table 4) make it clear that Cr(6+) is the more toxic to freshwater biota in comparatively soft and acidic waters, that younger life stages are more sensitive than older organisms, and that 96 hours is insufficient to attain stable mortality patterns. There are at least five ionic species of hexavalent Cr, of which two (the hydrochromate ion and the chromate ion) are the predominant species and probably the agents that are toxic to freshwater life. However, water pH dramatically affects the concentration of each: as pH decreased from 7.8 to 6.5, the hydrochromate ion increased by a factor of about 3, and the chromate ion decreased by a factor of about 6.8. More research is needed to fully elucidate chromium's mode of action. The organisms most sensitive to Cr(6+), as judged by 96 hour LC50 values, were freshwater crustaceans and rotifers, and marine crustaceans, for which LC50 values were 445 to 3,100 ppb. /Chromium(6+)/
[US Dept of the Interior: Chromium Hazards to Fish, Wildlife, and Invertebrates: A synoptic Review p.19 Rpt# 85(1.6) (1986)]**PEER REVIEWED**

Levels of Chromium(VI) above 0.125% in feed impaired reproductive function and caused sterility in rats. Stunted growth and roughness of fur were also noted in young rats. /Cr(VI)/
[Gross WG, Heller VG; J Ind Hyg Toxicol 28: 52-56 (1946) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.99 (1976) NRCC No.15017]**PEER REVIEWED**

Rats injected with 10-20 mg/kg chromium(VI) showed swelling/loss of microvilli, formation of intracellular vacuoles, mitochondrial swelling, loss of cells lining the nephron surface, and nephron damage. /Cr(VI)/
[Evan AP, Dail WG; Lab Invest 30: 704-715 (1974) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.101 (1976) NRCC No.15017]**PEER REVIEWED**

50 ppm chromium(VI) applied to plant leaves produced visible necrosis 24-48 hr after application, but was not appreciably translocated to other parts of the plant. /Cr(VI)/

[Levi E et al; Plant Soil 381: 683-6 (1973) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.93 (1976) NRCC No.15017]**PEER REVIEWED**

0.1 ppm chromium(VI) interfered with uptake and translocation by the roots in soybeans. /Cr(VI)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.16 (1976) NRCC No.15017]**PEER REVIEWED**

0.5 ppm **chromium(III)** interfered with microbial metabolism and 1-10 ppm irreversibly inactivated T1 phage and Escherichia coli, while 0.1 ppb Cr(VI) was toxic to certain yeasts and microbes. /Cr(III) & Cr(VI)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.15 (1976) NRCC No.15017]**PEER REVIEWED**

Biological oxidation by sewage sludge microbes was adversely affected by 50 ppm **chromium(III)** or 5 ppm Cr(VI) in raw sewage. /Cr(III) and Cr(VI)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.15 (1976) NRCC No.15017]**PEER REVIEWED**

Repeated exposure to solutions containing 1,000-3,000 ppm **chromium(III)** or Cr(VI) salts induced contact dermal allergic response to as little as 10 ug in guinea pigs. /Cr(III) or Cr(VI) salts/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.17 (1976) NRCC No.15017]**PEER REVIEWED**

Water hardness, temperature and dissolved oxygen may modify Cr effects to fish and aquatic life. **Chromium(III)** appears more acutely toxic to fish than Cr(VI), while Cr(VI) is more chronically toxic than Cr(III). /Cr(III) and Cr(VI)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.83 (1976) NRCC No.15017]**PEER REVIEWED**

Inhibition of DNA synthesis by chromium compounds was studied in mouse L cells, both intact and permeabilized. 1X10-5 cells were plated in 35 mm dishes and treated with concentrations of chromium(VI) at 0.1-1000 uM and of Cr(III) at 0.1-3300 uM. A 2 hr treatment with 10 uM Cr(VI) inhibited DNA synthesis to 50% of the control value. Complete inhibition occurred at 100 uM and higher. Cr(III) showed no effect at 3.3 uM. In permeabilized cells Cr(III) and Cr(VI) inhibited 50% DNA synthesis at 330 uM. Cr(III) was as active as Cr(VI) in inhibiting DNA synthesis in permeabilized cells but was much less effective on intact cells, probably due to its inability to cross the cell membrane. /Cr(III) and Cr(VI)/
[Nishio A, Vyeki E; J Tox Env Health 15: 237-44 (1985)]**PEER REVIEWED**

Toxicity threshold Diatoms, 0.03 ppm /Cr(VI)/
[Bui HT et al; Terres et Eaux 661: 13-17 (1971) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.89 (1976) NRCC No.15017]**PEER REVIEWED**

0.03-64 ppm hexavalent chromium inhibits growth of algae. /Hexavalent chromium/
[Shepherd CM; NRL Report 7215 p.1-18 (1971) as cited in NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.83 (1974)]**PEER REVIEWED**

The presence of > 100 ppm Chromium may adversely affect the biodegradation of sewage sludge. /Total chromium/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.91 (1976) NRCC No.15017]**PEER REVIEWED**

ADMIN OF 2 OR 5% IN FEED FOR 90 DAYS PRODUCED NO TOXIC EFFECTS & NO DETECTABLE DIFFERENCES FROM CONTROLS. FERTILITY WAS NORMAL & YOUNG

SHOWED NO MALFORMATIONS. FEEDING OF 1, 2 OR 5% FOR 2 YR WAS WELL TOLERATED. NO CARCINOGENIC ACTION WAS NOTED IN THE RATS. /CHROMIUM/
[IVANKOVIC S, PREUSSMANN R; FOOD COSMET TOXICOL 13 (3): 347 (1975)]**PEER REVIEWED**

HEAVY METALS AS NUTRIENT MARKERS. 3 GENERATIONS OF MICE FED 0, 1, 10, 100 & 1000 TIMES USE AMT (0.02 PPM). AMT USED WAS 1/5 OF CONCN REQUIRED FOR ACTIVATION ANAL. MORTALITY NEGLIGIBLE. REPRODUCTION, SURVIVAL, HEMATOLOGY, MATURATION & LACTATION PERFORMANCE WERE COMPARABLE TO CONTROLS. /CHROMIUM/
[HUTCHESON ET AL; J NUTR 105: 670 (1975)]**PEER REVIEWED**

The carcinogenic effects of chromium compounds (chromic chromate, chromic(III) oxide, chromic(VI) trioxide, calcium chromate(VI), and process residue) /were studied/ by implanting cholesterol pellets containing the compounds in bronchia of rats. After implantation, the rats were observed for up to 136 weeks. The only compound resulting in a carcinogenic effect was calcium chromate; six squamous cell carcinomas and two adenocarcinomas developed in 100 rats, and no tumors developed in 24 controls.
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.70 (10/87)]**PEER REVIEWED**

EIGHT RABBITS WERE EXPOSED BY INHALATION FOR 4-5 HOURS/DAY ON 4 DAYS/WEEK FOR UP TO 50 MONTHS TO A COMBINATION OF MIXED CHROMATES IN DUST /MIXTURE CONTAINED APPROXIMATELY 12% CHROMIUM, WHICH CONSISTED OF WATER SOLUBLE HEXAVALENT SODIUM CHROMATE, WATER INSOLUBLE BUT ACID SOLUBLE CHROMIUM CHEMICALS WHICH WERE PARTLY TRIVALENT, AND PARTLY HEXAVALENT AND SOME UNCHANGED CHROMITE(III) ORE/, AND AEROSOLS OF POTASSIUM DICHROMATE (VI) AND SODIUM CHROMATE (VI) AND "PULVERIZED RESIDUE DUST" (ROAST MATERIAL FROM WHICH SOLUBLE CHROMATES HAD BEEN LEACHED), ACCORDING TO A COMPLEX DOSAGE SCHEDULE ... THESE /CARCINOGENICITY/ STUDIES ALL GAVE NEGATIVE RESULTS (STEFFEE & BAETJER, 1965). /CHROMIUM AND CHROMIUM CMPDS AS DUSTS/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 257 (1980)]**PEER REVIEWED**

IN GENERAL, HEXAVALENT CHROMIUM IS CONVINCINGLY MUTAGENIC IN AT LEAST THREE DIFFERENT BACTERIAL MUTATION SYSTEMS. ... HEXAVALENT CHROMIUM IS VERY MUCH MORE EFFECTIVE THAN TRIVALENT CHROMIUM IN TESTS WHERE THE INDUCTION OF DNA DAMAGE IS INFERRED FROM DIFFERENCES IN SURVIVAL AFTER TREATMENT OF DNA REPAIR PROFICIENT AND DNA REPAIR DEFICIENT STRAINS OF BACTERIA. .... MUTAGENICITY OF CHROMIUM(VI) IS DECR OR ABOLISHED BY CHEMICAL & BIOLOGICAL REDUCING AGENTS (SUCH AS MICROSOMAL FRACTION FROM RAT LIVER, ERYTHROCYTE LYSATE ... BUT NOT THE MICROSOMAL FRACTIONS FROM RAT LUNG OR MUSCLE). /CHROMIUM (VI) CMPD/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 279 (1980)]**PEER REVIEWED**

Hexavalent chromium induced dominant lethal mutations, chromsomal aberrations and micronuclei in rodents treated in vivo. In human cells in vitro, it caused chromosomal aberrations, sister chromatid exchanges and DNA damage. In cultured rodent cells, it induced transformation, chromosomal aberrations, sister chromatid exchanges, mutation and DNA damage. It induced aneuploidy in drosophila and mitotic recombination in yeast. It was mutagenic and caused DNA damage in bacteria. /Hexavalent chromium/

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. S7 167 (1987)]**PEER REVIEWED**

Hexavalent anionic chromium is topically corrosive, and oral ingestion is toxic. In rabbits, large doses of chromate cause albuminuria with desquamated cells and renal hyperemia, fatty generatin, the necrosis. Nephritis, anuria and extensive lesions in the kidey, and gastrointestinal ulceratin are noticed in humans suffering from chromium(VI) toxicity. Chromate contact dermatitis extends from a dry erythematous condition to eczema on the hands and oter exposed parts. Inhalatin of chromium(VI) causes inflammation and ulceration of the nasal mucosa. Pulmonary carcinoma in humans 3-4 years after initial inhalation exposure is linked to chromium(VI); experimental evidence in animals is lacking. Intramuscular implantation of chromium trioxide or calcium chromate in rats, however, causes a high percentage of malignant tumors. /Hexavalent anionic chromium/
[Luckey, T.D. and B. Venugopal. Metal Toxicity in Mammals, 1. New York: Plenum Press, 1977. 183]**PEER REVIEWED**

Hexavalent chromium is topically corrosive, and oral ingestion of chromium(VI) is toxic despite the organism's ability to reduce chromium(VI) to the less toxic **chromium(III).** Life-term studies with mice given 5 ppm chromium(VI) in their drinking water showed a slight growth retardation and formation of malignant tumors ... . Laboratory animals can tolerte about 0.1% chromium(VI) in their diet. In rabbits large doses of chromates were followed by albuminuria with desquamated cells; the kidneys showed hyperemia, fatty degeneration, and necrosis. In the past, treatment of warts by local application of chromic acid caused chromium(VI) poisoning in humans, leading to nephritis, anuria, and extensive lesions in the kidneys. ... /Hexavalent chromium/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 251]**PEER REVIEWED**

OF GUINEA PIGS EXPOSED BY INHALATION TO A COMBINATION OF MIXED CHROMATE DUST, AEROSOLS OF POTASSIUM DICHROMATE (VI) AND SODIUM CHROMATE (VI) AND "PULVERIZED RESIDUE DUST" (ROAST MATERIAL FROM WHICH SOLUBLE CHROMATES HAD BEEN LEACHED) FOR 4-5 HR/DAY ON 4 DAYS/WK FOR LIFESPAN (AVG DOSE, 3-4 MG/CU M CHROMIC (III) OXIDE), 3/50 DEVELOPED PULMONARY ADENOMAS. ... NO PULMONARY CARCINOMAS DEVELOPED IN ANY EXPERIMENTAL GROUP. NO PULMONARY ADENOMAS OCCURRED IN 44 CONTROLS ... (STEFFEE & BAETJER, 1965) /CHROMIUM AND CHROMIUM CMPDS AS DUSTS/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 257 (1980)]**PEER REVIEWED**

High dose of chromates given sc to rabbits and guinea pigs damage the kidneys with the production of albumin and casts ... /Chromates/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1594]**PEER REVIEWED**

TOXIC ACTION OF WATER POLLUTANT ON DAPHNIA MAGNA STRAUS REVEALED THE MEAN EFFECTIVE CONCN (EC50) FOR THE ANION, CHROMATE, WAS LESS THAN 1 MG/L. /CHROMATE/
[BRINSMANN G; Z WASSER ABWASSER FORSCH 15 (1): 1-6 (1982)]**PEER REVIEWED**

Selected ranked Species Mean Acute Values for freshwater species are as follows: Neophasganophora capitata (stonefly) 1,870,000 ug/l, Lepomis macrochirus (bluegill) 132,900 ug/l, Carassius auratus (goldfish) 119,500 ug/l, Salmo gairdneri (rainbow trout) 69,000 ug/l, Pimephales promelas (fathead minnow) 41,050 ug/l, Poecilia reticulata (guppy) 30,000 ug/l, and Daphnia magna (cladoceran) 23.07

ug/l. A freshwater Final Acute Value of 31.49 ug/l was calculated from the Genus Mean Acute Values using the procedure described in the guidelines. /Hexavalent chromium/
[USEPA; Ambient Water Quality Criteria Doc: Chromium p.7, 43-5 (1984) EPA 440/5-84-029]**PEER REVIEWED**

The toxicities of dichromate and chromate were compared to the bluegill in soft water. The 96 hr LC50s were 110,000 ug/l for dichromate and 170,000 ug/l for chromate. They concluded that acidic dichromate was more toxic than basic chromate because the greatest part of the chromium(VI) was in the form of the hydrochromate ion at the lower pH of the dichromate solutions, whereas at the higher pH of the chromate solutions most of the chromium(VI) was in the form of the chromate ion. /Hexavalent chromium/
[Trama FB, Benoit RJ; J Water Pollut Control Fed 32: 868 (1960) as cited in USEPA; Ambient Water Quality Criteria Doc: Chromium p.6 (1984) EPA 440/5-84-029]**PEER REVIEWED**

Treatment of rat kidney slices with chromate or dichromate ion interfered with the transport of organic cmpd and the maintenance of normal electrolytic gradients. In rabbit kidney slices, dichromate was more effective than chromate at inhibiting transport. /Chromate or dichromate ion/
[Berndt WO: Toxicol Environ Health 1: 449-59 (1976) as cited in DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.59 (10/87)]**PEER REVIEWED**

Chronic toxicity from total recoverable trivalent chromium occurs at concn as low as 44 ug/l for freshwater aquatic life, while the acute toxicity from total recoverable trivalent chromium occurs at concn as low as 10,300 ug/l for saltwater aquatic life. /Total recoverable trivalent chromium/
[USEPA; Ambient Water Quality Criteria Doc: Chromium p.vi (1980) EPA 440/5-80-035]**PEER REVIEWED**

Rats that inhaled finely powdered chromite dust for 18 months showed elevated chromium levels in blood. /Chromium/
[Heuper WC, Proc 7th Saranac Sym on Pneumo coniosis, 1952 as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Environment p.98 (1976) NRCC No. 15017]**PEER REVIEWED**

Chromium metal tested by implantation in rabbit eyes was well tolerated while under observation for one year.
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 234]**PEER REVIEWED**

Significantly incr incidences of pulmonary lesions (lung abscesses, bronchopneumonia, giant cells, and granulomata) were found in rats exposed chronically to a finely ground, mixed chromium roast material that resulted in airborne concn of 1.6-2.1 mg chromium(VI)/m3 compared with controls. In the same study, guinea pigs exposed chronically to the chromium roast material along with mists of potassium dichromate or sodium chromate soln that also resulted in 1.6-2.1 mg chromium(VI)/m3 had significantly incr incidences of alveolar and interstitial inflammation, alveolar hyperplasia, and interstitial fibrosis, compared with controls. Simiarly, rabbits were also exposed and also had pulmonary lesions similar to those seen int he rats and guinea pigs, but the number of rabbits was too small for meaningful statistical analysis ... . /Chromium roast material, potassium dichromate, and/or sodium chromate soln/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 39 (2000)]**PEER REVIEWED**

Rats treated by gavage with 13.5 mg chromium(VI)/kg/day for 20 days had incr accumulation of lipids and accumulated triglycerides and phospholipids in different regions of the kidney than controls ... . Similar treatment of rats also resulted in inhibition of membrane enzymes (alkaline phosphatase, acid phosphatase, glucose-6-phosphatase, and lipase) in the kidneys ... . /Chromium(VI), NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 97 (2000)]**PEER REVIEWED**

Ecotoxicity Values:

The acute toxicity of chromium(VI) to 23 saltwater vertebrate and invertebrate species ranged from 2,000 ug/l for a polychaete worm and a mysid to 105,000 ug/l for the mud snail. The chronic values for a polychaete ranged from < 13 to 36.74 ug/l, whereas that for a mysid was 132 ug/l. The acute-chronic ratios ranged from 15.38 to > 238.5. Toxicity to macroalgae was reported at 1,000 and 5,000 ug/l. /Chromium VI/
[USEPA; Ambient Water Quality Criteria Doc: Chromium p.18 (1984) EPA 440/5-84-029]**PEER REVIEWED**

The chronic value for both rainbow trout and brook trout is 264.6 ug/l which is much lower than the chronic value of 1,987 ug/l for the fathead minnow. The acute chronic ratios for these three fishes range from 18.55 to 260.8. In all three chronic tests a temporary reduction in growth occurred at low concentrations. Six chronic tests with five species of daphnids gave chronic values that range from < 2.5 to 40 ug/l and the acute chronic ratios range from 1.130 to > 9.680. Growth of chinook salmon was reduced at a measured concentration of 16 ug/l. The acute toxicity of chromium(VI) to 23 saltwater vertebrate and invertebrate species ranges from 2,000 ug/l for a polychaete worm and a mysid to 105,000 ug/l for the mud snail. The chronic values for a polychaete range from < 13 to 36.74 ug/l whereas that for a mysid is 132 ug/l. The acute chronic ratios range from 15.38 to > 238.5. Toxicity to macroalgae was reported at 1,000 and 5,000 ug/l. /Chromium(VI)/
[USEPA/OWRS; Quality Criteria for Water 1986 Chromium (VI) (1986) EPA 440/5-86-001]**PEER REVIEWED**

Toxic threshold, Daphnia magna 0.016-0.7 ppm /Cr(VI)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.15 (1976) NRCC No.15017]**PEER REVIEWED**

Toxicity threshold Diatoms, 0.03 ppm /Cr(VI)/
[Bui HT et al; Terres et Eaux 661: 13-17 (1971) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.89 (1976) NRCC No.15017]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnow) 3 ppm (softwater) to 72 ppm (hardwater), 96 hr /Conditions of bioassay not specified/ /Cr(VI)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.16 (1976) NRCC No.15017]**PEER REVIEWED**

LC50 Rotifers 3.1 ppm (25 mg/l hardness) to 15.0 ppm (81 mg/l hardness), 96 hr /Conditions of bioassay not specified/ /Cr(VI)/
[Buikema AL et al; Water Resour Bull 10: 648-661 (1974) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.78 (1976) NRCC No.15017]**PEER REVIEWED**

LC50 Goldfish 18 ppm (softwater) to 133 ppm (hardwater), 96 hr /Conditions of bioassay not specified/ /Cr(VI)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.16 (1976) NRCC No.15017]**PEER REVIEWED**

Inhibited growth of Selenastrum capricornutum (green alga) 62 ug/l as Cr(VI). /Cr (VI)/
[USEPA; Ambient Water Quality Criteria Doc: Chromium p.51 (1984) EPA 440/5-84-029]**PEER REVIEWED**

50% Inhibition of growth in 4 days Selenastrum capricornutum 183 ug/l as Cr(VI) with a water hardness of 53 mg/l as calcium carbonate. /Cr (VI)/
[USEPA; Ambient Water Quality Criteria Doc: Chromium p.51 (1984) EPA 440/5-84-029]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

In vitro studies indicate that chromium(VI) is readily reduced to **chromium(III).** Evidence is provided that a chromium(V) intermediate was formed during in vitro reduction of chromium(VI) to **chromium(III)** in rat liver microsomes & suggested that the intermediate may be the form of chromium that interacts with cellular macromolecules. Human RBC were incubated with an excess of chromium(VI) (sodium chromate) (10 mM) & found that the glutathione content of the cells was depleted to 10% of the original amount. Chromium(VI) incubated alone with glutathione was reduced to **chromium(III).** The reaction required 3 glutathione molecules to reduce 1 molecule of chromate & was faster at pH values <5. The reaction was accelerated when glutathione was present in excess of 100-1000 fold, conditions similar to those in the liver & RBC. /Hexavalent & trivalent chromium/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.48 (10/87)]**PEER REVIEWED**

Microsomal reduction of chromium(VI) was found to be reduced nicotinamide adenine dinucleotide dependent in studies using a large number of cell preparations from various species. Most of the reducing activity was detected in the cytosol & was ascribed to enzyme catalyzed mechanisms. Minor activity was attributed to reduced glutathione. /Hexavalent chromium/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.48 (10/87)]**PEER REVIEWED**

Hexavalent chromium injected intravenously in rats was rapidly reduced to the trivalent form. /Hexavalent chromium/
[NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.23 (1974)]**PEER REVIEWED**

Chromium(VI) is reduced to Cr(III) within the skin by methionine, cystine, & cysteine. Several researchers concluded that allergy to Cr(VI) unequivically implies allergy to Cr(III) ... . The reduced trivalent Cr may form haptene-protein complexes initiating sensitization. /Chromium and cmpd/
[NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.68-72 (1974)]**PEER REVIEWED**

Aquatic Fate: Little is known about the relation between concns of total Chromium in a given environment & biological effects on the organisms living there. Depending on the physical & chemical state of the Cr, the same elemental concn has a wide variety of of mobilities & reactivities & thus has different effects. Chromium toxicity to aquatic biota is significantly influenced by abiotic variables such as hardness, temperature, pH, & salinity of water; & biological factors such as species, life stage, & potential differences in sensitivities of local populations. /Total chromium/
[US Dept of the Interior: Chromium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review; p.3 Rpt# 85(1.6) (1985)]**PEER REVIEWED**

Metabolism of chromium(VI) involves cellular reduction of chromium(VI) by small molecules & enzyme systems, a process which generates reactive intermediates & **chromium(III).** The metabolites ultimately bind to cellular constituents & may result in impairment of their normal function in the cell. In vitro, ascorbic acid (vitamin C) & the thiols, glutathione, cysteine, cysteamine, lipoic acid, coenzyme A, & coenzyme M reduce chrominum(VI) at a significant rate under physiological conditions. ... /Chromium (VI)/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 243]**PEER REVIEWED**

The biologically active **chromium(III)** molecule often referred to as GTF appears to be a dinicotinato-**chromium(III)** glutathione-like complex. The molecule has not been fully characterized ... . This biologically active molecule functions by facilitating interaction of insulin with its receptor site, thus influencing glucose, protein, and lipid metabolism. Inorganic chromium cmpds do not appear to have insulin-potentiating activity. However, humans and animals are capable of converting inactive chromium cmpds to biologically active forms ... . /**Chromium(III)** cmpds/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 141 (2000)]**PEER REVIEWED**

In vivo and in vitro experiments in rats indicated that, in the lungs, chromium(VI) can be reduced to **chromium(III)** by ascorbate. The reduction of chromium(VI) by ascorbate results in a shorter residence time of chromium in the lungs and constitutes the first defense against oxidizing reagents in the lungs. When ascorbate is depleted from the lungs, chromium(VI) can also be reduced by glutathione. The reduction of chromium(VI) by glutathione is slower and results in greater residence time of chromium in the lungs, compared to reduction by ascorbate ... . Other studies reported the reduction of chromium(VI) to **chromium(III)** by epithelial lining fluid (ELF) obtained from the lungs of 15 individuals by bronchial lavage. The avg reduction accounted for 0.6 ug chromium(VI)/mg of ELF protein. In addition, cell extracts made from pulmonary alveolar macrophages derived from five healthy male volunteers were able to reduce an avg of 4.8 ug chromium(VI)/10+6 cells or 14.4 ug chromium(VI)/mg protein. Metabolism of the chromium(VI) to **chromium(III)** by these cell fractions significantly reduced the mutagenic potency of the chromium when tested in the Ames reversion assay. /Chromium(VI) and (III) cmpds/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 142 (2000)]**PEER REVIEWED**

For humans, the overall chromium(VI)-reducing/sequestering capacities were est to be 0.7-2.1 mg/day for saliva, 8.3-12.5 mg/day for gastric juice, 11-24 mg for intestinal bacteria eliminated daily with feces, 3,300 mg/hr for liver, 234 mg/hr for males and 187 mg/hr for females for whole blood, 128 mg/hr for males and 93 mg/hr for females for red blood cells, 0.1-1.8 mg/hr for ELF, 136 mg/hr for pulmonary alveolar macrophages, and 260 mg/hr for peripheral lung parenchyma. Although these ex vivo data provide important info in the conversion of chromium(VI) to reduced states, the values may over or under estimate the in vivo reducing capabilities ... . /Chromium cmpds/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 143 (2000)]**PEER REVIEWED**

Reduction of chromium(VI) in the red blood cell occurs by the action of glutathione. Since the red blood cell membrane is permeable to chromium(VI) but not **chromium(III),** the **chromium(III)** formed by reduction of chromium(VI) by glutathione is essentially trapped within the red blood cell. Eventually the diffusion of chromium(VI), the reduction to **chromium(III),** and complexing to nucleic acids and proteins within the cell will cause the concn equilibrium to change so that more chromium(VI) is diffused through the membrane. Thus, ther is a physiological drag so that incr diffusion results in greater chromium concn in the cell ... . /Chromium cmpds/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 143 (2000)]**PEER REVIEWED**

In addition to the reduction of chromium(VI) by ascorbate or glutathione, in vitro studies have demonstrated reduction of chromium(VI) by microsomal enzymes. Hepatic microsomal proteins from male Sprague-Dawley rats pretreated with chromium(VI) reduced chromium(VI) to **chromium(III).** The rate of reduction vaired both with the concn of microsomal protein and the concn of nicotinamide adenine dinucleotide phosphate (NADPH). In the absence of NADPH, microsomes did not reduce significant amt of Cr(VI) over the 24-hr observation period. Therefore, the reduction of chromium(VI) in rat hepatic microsomes is NADPH-dependent ... . /Chromium cmpds/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 144 (2000)]**PEER REVIEWED**

Absorption, Distribution & Excretion:

HEPATIC CONCN OF CHROMIUM IS HIGH IN CHILDHOOD & DECLINES TO VERY LOW LEVELS AFTER AGE OF 20 YR. /CHROMIUM & INORGANIC CR CMPD/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 118 (1973)]**PEER REVIEWED**

CHROMIUM IS EXCRETED IN URINE & FECES WITH THE URINARY PATHWAY ACCOUNTING FOR 80%. NEARLY ALL CR IN URINE IS PRESENT IN FORM OF LOW MOLECULAR WEIGHT COMPLEXES: VERY LITTLE PROTEIN BOUND CR IS EXCRETED. ... MEAN 24 HR URINARY CR EXCRETION OF 20 YOUNG ADULTS WAS 8.4 UG WITH AN AVG RANGE OF 1.6-21 UG ... /CHROMIUM/
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 243]**PEER REVIEWED**

Chromium levels in the lung were 10 times higher in rats exposed to a pyrolyzed chromium oxide mixture (Cr5O12, 3:2 chromium(VI)/**chromium(III))** aerosol at 100 ug/cu m chromium for 18 months, followed by 12 months of observation, compared to rats exposed to sodium dichromate at 100 ug/cu m chromium. /Chromium and chromium cmpd/
[Glaser U et al; Toxicology 42 (3): 219-32 (1986) as cited in DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.46 (10/87)]**PEER REVIEWED**

CHROMATES(VI) ARE ABSORBED FROM THE GI TRACT AT A RATE OF ABOUT 2%. WHEN (51)CR(VI) WAS ADMINISTERED INTRADUODENALLY, APPROXIMATELY HALF OF THE ADMINISTERED RADIOACTIVITY APPEARED TO BE ABSORBED, ON THE BASIS OF FE CAL EXCRETION, WHILE 10% APPEARED IN THE URINE DURING THE FIRST 24 HOURS. /CHROMATES(VI)/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 286 (1980)]**PEER REVIEWED**

DISTRIBUTION OF CHROMIUM IN RATS FED CR(6+) IN DRINKING WATER @ VARIOUS LOW LEVELS (0.45-11 PPM) FOR 1 YR SHOWED HIGHEST AMT IN SPLEEN, THEN BONE, KIDNEY, & LIVER. /CHROMIUM(VI)/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1597]**PEER REVIEWED**

In 6+ state, chromium cmpd are ... absorbed by ingestion, through skin and by inhalation. /Chromium(VI) cmpd/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 470]**PEER REVIEWED**

IT HAS BEEN SHOWN THAT CHROMIUM(6+) PENETRATES SKIN THROUGH SWEAT GLANDS & IS REDUCED TO CHROMIUM(3+) IN CORIUM. /CHROMIUM(VI) CMPD/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 471]**PEER REVIEWED**

EXPERIMENTS WITH RATS INHALING ZINC CHROMATE DUST HAVE SHOWN THAT WATER SOLUBLE CHROMATES MAY BE TAKEN UP IN THE LUNG IN THE HEXAVALENT STATE & TRANSFERRED INTO THE RED BLOOD CELLS BEFORE REDUCTION TO THE TRIVALENT STATE TAKES PLACE. /HEXAVALENT CHROMIUM/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 191]**PEER REVIEWED**

ANIMAL EXPT INDICATE THAT TRIVALENT CHROMIUM IS POORLY ABSORBED FROM GI

TRACT, VALUES <1% OF AN ORAL DOSE HAVING BEEN REPORTED. CHROMATES ARE ABSORBED AT 3-6% IN RATS, & ABOUT 2% IN MAN. THERE IS EVIDENCE THAT NOT ONLY VALENCE STATE OF CHROMIUM IN DIET BUT ALSO FUNCTIONAL STATE OF INTESTINES HAS BEARING ON ABSORPTION ... /TRIVALENT & HEXAVALENT CHROMIUM/

[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 191]**PEER REVIEWED**

Organs which specifically retained chromium in experiments with dose levels of 60-250 ug/animal were the reticuloendothelial system, the liver, the spleen, & the bone marrow. ... The testes, & in the epididymis after injection of the trivalent form to the rat. ... After admin of chromium as the glucose tolerance factors distribution proved to be different; the highest concn ... in the liver, followed by the uterus & the kidney. Cr is found in the newborn & in the fetus. ... Once absorbed & bound in biological tissue, Cr cmpd are found in the trivalent form. ... When the reducing capacity of liver cells is reduced ... the hexavalent form may be excreted in the bile. /Chromium/

[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 191]**PEER REVIEWED**

BILIARY EXCRETION OF CHROMIUM HAS BEEN DEMONSTRATED IN THE RAT; LESS THAN 1% OF AN IV INJECTED DOSE OF THE TRIVALENT FORM WAS EXCRETED IN 5 HR, 6-8% OF CORRESPONDING DOSES OF THE HEXAVALENT FORM WAS FOUND. FECAL CONTENT OF CHROMIUM MAY VARY CONSIDERABLY & IS MAINLY CONSEQUENCE OF INGESTED UNABSORBED CHROMIUM CMPD. /TRIVALENT & HEXAVALENT CHROMIUM/

[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 192]**PEER REVIEWED**

In the airways & in the GI tract, soluble chromium(VI) compounds are apparently taken up by epithelial cells, by simple diffusion, through the plasma membrane. After entry, Cr(VI) reduction occurs from the action of enzymatically mobilized electrons, which are available from reduced glutathione, reduced nicotinamide adenine dinucleotide, & nicotinamide adenine dinucleotide. The reducing capacity inside the cell is limited, so that Cr(VI) & Cr(III) exist simultaneously inside the cytoplasm; Cr(VI) is then released from the cell by simple diffusion into the bloodstream & taken up by blood cells. /Hexavalent chromium/

[USEPA; Health Assessment Document: Chromium p.2-6 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

The acute and subacute toxicities of several Cr(III) and Cr(VI) compounds (chromium(3+) chloride, chromium(3+) nitrate, chromium(3+) sulfate, chromium trioxide, potassium dichromate) were determined in NZC and (CxO) mice injected ip. The distal median lethal doses (> 10 days after treatment) averaged (17.9 + or - 1.8) X 10(-6) g chromium/g body wt regardless of the oxidation state of the Cr compound injected (chromium(3+) sulfate may be an exception), but acute toxicity (3 days) was much greater with Cr(VI) compounds. Acid digests of entire male mice that were administered ip 1/6 of the distal LD50, either once or repeatedly at weekly intervals, were analyzed to determine the whole body persistence and clearance kinetics of Cr. Mice dosed once with Cr(III) retained 6.5 times more chromium at 21 days than mice treated with Cr(VI). When Cr(III) was given at weekly intervals mice accumulated 6 times more Cr by 8 wk than Cr(VI)-treated mice, though only the latter showed symptoms of chromic toxicity. Whole body Cr concentrations continued to rise with further Cr(III) treatments, but slowly declined with Cr(VI). Analyses of fecal and urinary excretion confirmed that most of the urinary Cr excretion from Cr(VI)-treated animals was much faster in both urine and feces than from mice given Cr(III). The differential storage and clearance kinetics of Cr(III) and Cr(VI) compounds

may be significant in experimental Cr carcinogenesis studies and in the toxicology of Cr in workers exposed industrially to potentially carcinogenic chromium-containing dusts or aerosols. /Potassium dichromate/
[Bryson WG, Goodall CM; Carcinogenesis 4 (12): 1535-40 (1983)]**PEER REVIEWED**

Of an absorbed dose of chromium, at least 80% is excreted in the urine & a lesser amount in the feces. Hexavalent chromium, which is generally more soluble & more toxic than the trivalent form, tends to be reduced to trivalent chromium in vivo. Chromium does not appear to accumulate in bone or most soft tissues as a result of age, occupation or smoking history. The lung however, usually contains the highest concn of any organ in deposition of insoluble chromium compounds present in air. Normal urinary chromium concns average 4-5 ug/l & range up to 15 ug/l, the daily urinary output of chromium ranges from 1.6-21 ug in healthy young adults. /Chromium/
[Baselt RC; Biological Monitoring Methods for Industrial Chemicals p.81 (1980)]**PEER REVIEWED**

Urinary chromium concentrations in exposed workers have been found to correlate well with air chromium concentrations and are a good indicator of short-term exposure. A chromium level of 40-50 ug/l or 30 ug/g creatinine, in a urine specimen collected at the end of the working day is consistent with exposure to chromium at the TLV of 0.05 mg/cu m. The renal clearance of chromium may be a better indicator of chromium body burden and nephrotoxicity than urine concentrations of the metal. /Chromium/
[Baselt RC; Biological Monitoring Methods for Industrial Chemicals p. 82 (1980)]**PEER REVIEWED**

Gastrointestinal absorption of chromium from chromic chloride in rats was approximately 1.4%, with absorption of chromium from sodium chromate at approximately 2.4%. Absorption of chromium from both salts increased to 11% when rats were fasted for 48 hr. (51)Chromium from (51)chromic choride was absorbed from the gastrointestinal tract of 2 day old rats at levels 10 times higher than in adults. Absorption of (51)Cr by adult rats was < 0.5% of the administered dose. /Chromium cmpd/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.45 (10/87)]**PEER REVIEWED**

Rats received 25 mg/l **chromium(III)** or concn of Cr(VI) up to 25 mg/l in drinking water for one yr. Cr(VI) dosed animals showed 9 times more Cr in tissues than Cr(III) dosed rats reflecting the fact that ... Cr(VI) is more readily absorbed from the intestines. /Cr(III) and Cr(VI)/
[MacKenzie RD et al; AMA Arch Ind Health 18: 232 (1958) as cited in USEPA; Ambient Water Quality Criteria Doc: Chromium p.C-18 (1980) EPA 440/5-80-035]**PEER REVIEWED**

Inorganic **chromium(III)** and Cr(VI) are poorly absorbed by the gastrointestinal tract as determined by urinalysis. (0.5% of chromic chloride given orally is absorbed by man, 2-3% by rats, 2.1% of oral dosed chromate Cr(VI) is absorbed by man, and 3-6% by rats). /Inorganic Cr(III) and Cr(VI)/
[Mertz W; Physiol Rev 49: 165-239 (1969) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.99 (1976) NRCC No.15017]**PEER REVIEWED**

Leaves of bean plants grown in (51)chromium(VI) soln were fed to rats. Less than 0.5% of the (51)Cr fed to the rats in the leaves was retained after 48 hours. /Cr(VI)/
[Huffman EWD, Allaway WH; J Agric Food Chem 21: 982-6 (1973) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.99 (1976) NRCC No.15017]**PEER REVIEWED**

Chromium(VI) penetrates red blood cells to form a stable complex with hemoglobin. /Cr(VI)/
[Gray SJ, Sterling K; J Clin Invest 29: 1604-13 (1950) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.69 (1976) NRCC

No.15017]**PEER REVIEWED**

Chromium(VI) is reduced to Cr(III) in the skin, clearing at a slow rate causing skin reactions years after original exposure. /Cr(VI)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.18 (1976) NRCC No.15017]**PEER REVIEWED**

Chromium(VI) uptake in rat and rabbit renal slices was examined. The results indicated that chromium ion was accumulated by the slices by mechanisms other than simple, passive binding. /Chromate or dichromate ion/
[Berndt WO: Toxicol Environ Health 1: 449-59 (1976) as cited in DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.59 (10/87)]**PEER REVIEWED**

In experimental studies with animals, chromum(VI) is taken up much more readily than **chromium(III).** Following oral administration, approximtely 10% of the dose of chromium(VI) is absorbed, whereas less than 0.5% of the **chromium(III)** dose is absorbed. Chromium(VI) can be reduced to **chromium(III)** by the GI tract, thereby reducing uptake. Following intratracheal or intravenous exposure, both **chromium(III)** and (VI) are distributed thorughout the body, with the highest concentrations in liver, kidneys, and lungs, which are the target organs for toxicity. /Chromium (VI)/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 243]**PEER REVIEWED**

In spite of the refined methods of analysis available, a reliable range of normal blood chromium concentrations cannot be given with confidence. When using modern methods for analysis, the whole blood concentration is suggested to be within the range of 0.5 to 3 ppb, while the serum level is probably below 0.2 ppb. /Chromium/
[USEPA; Health Assessment Document: Chromium p.2-6 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

THIRTY DAYS AFTER INJECTION, 30% OF THE TRIVALENT CHROMIUM BUT ONLY 2.4% OF THE HEXAVALENT CHROMIUM WAS STILL PRESENT IN THE LUNG TISSUE. /TRIVALENT & HEXAVALENT CHROMIUM/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 277 (1980)]**PEER REVIEWED**

CHROMIUM IS EXCRETED IN URINE & FECES WITH THE URINARY PATHWAY ACCOUNTING FOR 80%. NEARLY ALL CR IN URINE IS PRESENT IN FORM OF LOW MOLECULAR WEIGHT COMPLEXES: VERY LITTLE PROTEIN BOUND CR IS EXCRETED. ... MEAN 24 HR URINARY CR EXCRETION OF 20 YOUNG ADULTS WAS 8.4 UG WITH AN AVG RANGE OF 1.6-21 UG ... /CHROMIUM/
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 243]**PEER REVIEWED**

/Chromium in the +3 oxidation state/ ... is not readily absorbed from the digestive system and combines with proteins in the superficial layers of skin to form stable complexes. /Chromium, alloys and cmpd/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 470]**PEER REVIEWED**

Whole body distribution studies indicate that the liver, spleen, kidney, & testes accumulate the majority of chromium after exposure. Other organs such as the heart, pancreas, lung, & brain take up & retain substantially less. The subcellular distribution of chromium in the liver & kidneys results in 45-50% of the total cell burden location to the nuclear fraction, with lesser amounts retained by cytoplasmic, mitochondrial, & microsomal fractions, respectively. /Chromium compounds/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA:

Little, Brown and Company, 1992. 800]**PEER REVIEWED**

While trivalent chromium ions are rapidly cleared from the blood, hexavalent ions are retained much longer owing to internalization by red & white cells. Besides the blood, the various target organs also display different rates of clearance for each metal species. Therefore, no true equilibrium between tissue stores & circulating chromium levels can accurately be established. This makes the monitoring of chromium exposure by monitoring blood burdens less valuable or reliable as an indicator than originally surmised. Following clearance form the blood, chromium is excreted principally in the urine. Secondary excretion of small amounts of ingested metal & expectorated particles occurs via bile & feces. A minor route of excretion is through the skin & via sweat. Because the chromium found in urine is likely to have been derived from the dialyzable fraction of serum, reabsorption along the renal tubules following glomerular filtration presents another route by which circulating levels of chromium might remain elevated following acute exposure. /Chromium compounds/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 801]**PEER REVIEWED**

Absorption of chromium(VI) cmpds is higher than that of **chromium(III)** cmpds. this is because the chromate anion (CrO4)2- can enter cells via facilitated diffusion through non-specific anion channels ... . Absorption of **chromium(III)** cmpds is via passive diffusion and phagocytosis. /Chromium(VI) and (III) cmpds/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 122 (2000)]**PEER REVIEWED**

Absorption of inhaled chromium cmpds takes place in the lung via transfer across cell membranes and in the GI tract from particles cleared from the lungs. Absorption after oral exposure in humans varies from essentially none for the highly insoluble **chromium(III)** cmpd chromic oxide, to 0.5-2.0% for **chromium(III)** cmpds in the diet, to approx 2-10% for chromium(VI) as potassium chromate. Dermal absorption depends on the physical and chemical properties of the cmpd, the vehicle, and the integrity of the skin. Concentrated soln of chromium(VI) cmpds such as potassium chromate can cause chemical burns and facilitate absorption. /Chromium cmpds/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 123 (2000)]**PEER REVIEWED**

Once in the blood, chromium cmpds are distributed to all organs of the body. Particles containing chromium can be retained in the lung for years after occuaptional exposure. Chromium(VI) is unstable in the body and is reduced to chromium(VI), chromium(IV), and ultimately to **chromium(III)** by many substances incl ascorbate and glutathione. It is believed that the toxicity of chromium(VI) cmpds results from damage to cellular components during this process (e.g., generation of free radicals). There is also evidence in in vitro experiments that **chromium(III)** can be reduced to chromium(II) and exert toxic effects. Absorbed chromium is excreted primarily in urine, the half-time for excretion of chromium admin as potassium chromate is estimated to be 35-40 hr in humans. Hair and nails are minor pathways of excretion. /Chromium cmpds/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 123 (2000)]**PEER REVIEWED**

Exam of tissues from Japanese chrome platers and chromate refining workers at autopsy revealed higher chromium levels in the hilar lymph node, lung, spleen, liver, kidney, and heart, compared to normal healthy males ... . /Chromium, NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 132 (2000)]**PEER REVIEWED**

Analysis of the chromium concn in organs and tissues at autopsy of a man who died of lung cancer 10 yr after his retirement from working in a chromate producing plant for 30 yr revealed measurable levels in the brain, pharyngeal wall, lung, liver, aorta, kidney, abdominal rectal muscle, suprarenal gland, sternal bone marrow, and abdominal skin. The levels were significantly higher than in five controls with no occupational exposure to chromium. The man had been exposed mainly to chromium(VI), with lesser

exposure to **chromium(III)** as the chromite ore ... . /Chromium(VI), NOS and chromite ore/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 132 (2000)]**PEER REVIEWED**

Autopsy studies in the US indicate that chromium concn in the body are highest in kidney, liver, lung, aorta, heart, pancreas, and spleen at birth and tend to decr with age. The levels in liver and kidney declined after the second decade of life. The aorta, heart, and spleen levels declined rapidly between the first 45 days of life and 10 yr, with low levels persisting throughout life. The level in the lung declined early, but increased again from mid life to old age ... . /Chromium, NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 134 (2000)]**PEER REVIEWED**

Chromium may be transferred to infants via breast milk as indicated by breast milk levels of chromium in women exposed occupationally ... or via normal levels in the diet ... . It has been demonstrated that in healthy women, the levels of chromium measured in breast milk are independent of serum chromium levels, urinary chromium excretion, or dietary intake of chromium ... but other ... have disputed this observation. /Chromium, NOS/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 134 (2000)]**PEER REVIEWED**

An in vitro study in human blood showed that chromium(VI) was rapidly cleared from the plasma ... . The reduction capacity appears to be concn dependent and is overwhelmed at spike concn between 2,000 and 10,000 ug/l. High chromium(VI) concn (10,000 ug/l spike concn) resulted in an accumulation of chromium(VI) in the erythrocytes and a lower plasma:erythrocyte ratio of total chromium. This study also found that the plasma reduction capacity was enhanced by a recent meal. /Chromium cmpds/
[DHHS/ATSDR; Toxicological Profile for Chromium, p. 138 (2000)]**PEER REVIEWED**

Biological Half-Life:

The elimination curve for chromium as measured by whole-body counting has an exponential form. In rats, 3 different components of the curve have been identified with the half-times of 0.5, 5.9, and 83.4 days, respectively. /Chromium/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 193]**PEER REVIEWED**

Half-time for elimination of chromium from rats is 0.5, 5.9, and 83.4 days, according to a three compartment model. /Chromium/
[Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 639]**PEER REVIEWED**

Mechanism of Action:

Contact hypersensitivity due to chromium compounds ... is caused by a direct effect of a hapten on the skin, where chromium is conjugated with autologous proteins. Chromium(VI) is reduced to Cr(III) in the skin, chiefly by sulfhydryl groups of amino acids; only Cr(III) is then able to conjugate with proteins. Cr(III) is therefore probably bound to proteins to build the full antigen. /Chromium cmpd/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 285 (1980)]**PEER REVIEWED**

In vitro studies using isolated rat liver or ox heart mitochondria have shown that low levels of chromium(VI) can powerfully inhibit respiratory chain activity. At 1.56 ppm Cr(VI) completely inhibited within 2-3 min the respiration of glutamate & alpha-oxoglutarate; inhibition of the enzymes alpha-oxoglutarate dehydrogenase & glutamate dehydrogenase. At 21 ppm Cr(VI) completely inhibited respiration of beta-hydroxybutyrate, malate & pyruvate, possibly through inhibition of nicotinamide adenine dinucleotide dehydrogenase. At 156 ppm Cr(VI) completely inhibited succinate dehydrogenase.

/Cr(VI)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.69 (1976) NRCC No.15017]**PEER REVIEWED**

Chromium(VI) at 10+3 ppm mutates bacterial DNA, by modifying DNA bases so that base pair errors arise at subsequent cell divisions. G-C base pairs are attacked causing G-C to A-T transitions. /Cr(VI)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.70 (1976) NRCC No.15017]**PEER REVIEWED**

Reduction of /inhaled/ chromium(VI) to Cr(III) is accompanied by alveolar scarring, which may be related to long retention time of Cr in lung tissue & may be a preliminary step in carcinogenesis. /Cr(VI)/

[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.96 (1976) NRCC No.15017]**PEER REVIEWED**

Chromium(III) is an essential nutrient required for normal energy metabolism. The biologically active form is an unidentified organic complex of **chromium(III)** often refereed to as GTF. Chromium is poorly taken up by cells in any valence state, but **chromium(III)** is absorbed less efficiently than chromium(VI). This is believed to be due to the tetrahedral configuration of the chromate anion, which allows it to enter the cells via facilitated diffusion and through non-specific anion channels. In contrast, **chromium(III)** is absorbed via passive diffusion and phagocytosis, resulting in much lower total uptake into cells. Once absorbed, chromium(VI) is reduced to **chromium(III),** with chromium(V) and chromium(IV) as intermediates in the process. Chromium(V) and chromium(IV) are believed to be able to react with intracellular constituents, resulting in either the formation of free radicals or direct binding to macromolecules. Most of the effects of **chromium(III)** are mediated by direct binding to macromolecules, although there is a slight possibility that it may also contribute to free radical formation. The radical intermediates and the direct binding to macromolecules, can then result in DNA-protein crosslinks, DNA-DNA crosslinks, DNA strand breaks, lipid peroxidation, and alterations in cellular signaling pathways. All of these may contribute to toxicity and carcinogenicity of chromium cmpds. /Chromium cmpds/
[DHHS/ATSDR; Toxicological Profile for Chromium p. 163 (2000)]**PEER REVIEWED**

Interactions:

Chromium(VI) poisoning of the kidneys leads to decr in ascorbic acid content. 0.2-0.5 mg/kg produces marked necrosis of the kidneys. Ascorbic acid may protect the tissues from oxidative action of Cr(VI) and its depletion increases susceptibility to toxicity. /Cr(VI)/
[Simavoryan PS; Trans Erevan Med Inst 15: 219-233 (1971) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.101 (1976) NRCC No.15017]**PEER REVIEWED**

Drinking water supplemented with 10 ppm chromium significantly reduced serum copper levels and ceruloplasmin activity /in male rats/; zinc or manganese supplementations reversed this trend. /Total chromium/
[O'Flaherty EJ et al; Fed Proc 33: 68 (1974) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.68 (1976) NRCC No.15017]**PEER REVIEWED**

Chromium (III) is considered an essential trace nutrient serving as a component of the "glucose tolerance factor". If H is a cofactor for insulin action and has a role in the peripheral activities of this hormone by forming a ternary complex with insulin receptors, facilitating the attachment of insulin to these sites. /Trivalent chromium/
[Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 638]**PEER REVIEWED**

Some studies have found that administration of chromium supplements to a chromium deficient patient may improve glucose tolerance; this could decrease insulin requirement; careful monitoring of blood glucose may be necessary with chromium therapy to avoid hypoglycemia. /Chromium supplements/
[MICROMEDEX Thomson Health Care. USPDI - Drug Information for the Health Care Professional 21 st ed. Volume 1. MICROMEDEX Thomson Health Care, Englewood, CO. 2001. Content Reviewed and Approved by the U.S. Pharmacopeial Convention, Inc.875]**PEER REVIEWED**

Pharmacology:

Therapeutic Uses:

Trivalent chromium has been used successfully to treat some cases of impaired glucose tolerance in adult diabetic humans and undernourished children. /Trivalent chromium salts/
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 645]**PEER REVIEWED**

Some disorders caused by lack of manganese can be treated with chromium (Cr).
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.68 (1976) NRCC No.15017]**PEER REVIEWED**

Chromium (Cr) supplemented animal diets reduced incidence of atherosclerosis.
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.94 (1976) NRCC No.15017]**PEER REVIEWED**

Protein-calorie malnutrition & the syndrome of kwashiorkor & marasmus improve when children are fed one dose of 250 ug Cr.
[NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.33 (1974)]**PEER REVIEWED**

... A chromium supplements such as Brewer's yeast extract can have beneficial effects in some cases, particularly with the elderly, malnourished children, & diabetics.
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 245]**PEER REVIEWED**

The trace mineral chromium is being marketed as a safe replacement for anabolic steroids. The proposed anabolic mechanism involves increased insulin activity which in turn stimulates intracellular uptake of amino acids. Chromium is most often sold as chromium picolinate through nutrition stores. Human performance data are limited to a few poorly-controlled studies involving small study populations. Although most people in the United States do not get enough chromium in their diet, taking chromium picolinate supplements in excess of the usual dose of 200 ug could potentially lead to anemia.
[Young, L.Y., M.A. Koda-Kimble (eds.). Applied Therapeutics. The Clinical Use of Drugs. 6th ed. Vancouver, WA., Applied Therapeutics, Inc. 1995.,p. 87-5]**PEER REVIEWED**

Chromium supplements are indicated in the prevention and treatment of chromium deficiency, which may result from inadequate nutrition, protein malnutrition, or intestinal malabsorption but does not occur in healthy individuals receiving an adequate balanced diet. For prophylaxis of chromium deficiency, dietary improvement, rather than supplementation, is advisable. for treatment of chromium deficiency, supplementation is preferred. /Chromium supplements; Included in US product labeling/
[MICROMEDEX Thomson Health Care. USPDI - Drug Information for the Health Care Professional 21 st ed. Volume 1. MICROMEDEX Thomson Health Care, Englewood, CO. 2001. Content Reviewed and Approved by the U.S. Pharmacopeial Convention, Inc.875]**PEER REVIEWED**

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[Simavoryan PS; Trans Erevan Med Inst 15: 219-233 (1971) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.101 (1976) NRCC No.15017]**PEER REVIEWED**

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[O'Flaherty EJ et al; Fed Proc 33: 68 (1974) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.68 (1976) NRCC No.15017]**PEER REVIEWED**

Chromium (III) is considered an essential trace nutrient serving as a component of the "glucose tolerance factor". If H is a cofactor for insulin action and has a role in the peripheral activities of this hormone by forming a ternary complex with insulin receptors, facilitating the attachment of insulin to these sites. /Trivalent chromium/
[Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 638]**PEER REVIEWED**

Some studies have found that administration of chromium supplements to a chromium deficient patient may improve glucose tolerance; this could decrease insulin requirement; careful monitoring of blood glucose may be necessary with chromium therapy to avoid hypoglycemia. /Chromium supplements/
[MICROMEDEX Thomson Health Care. USPDI - Drug Information for the Health Care Professional 21 st ed. Volume 1. MICROMEDEX Thomson Health Care, Englewood, CO. 2001. Content Reviewed and Approved by the U.S. Pharmacopeial Convention, Inc.875]**PEER REVIEWED**

Bionecessity:

Chromium (Cr) is an essential element for fungi and vertebrates. /Trivalent chromium/
[Altman PL, Dittmer DS, eds; Biology Data Book 2nd ed (1974) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.20 (1976) NRCC No.15017]**PEER REVIEWED**

Trivalent chromium is considered essential for the maintenance of normal glucose tolerance in animals and man, and the factor or the group of factors containing trivalent chromium, called GTF (glucose tolerance factor) has been suggested to be responsible for this favorable action of chromium. The chromium status in diabetic subjects appears to be abnormal, and chromium is capable of potentiating insulin, but so far the exact structure(s) of the biologically active chromium complex(es) has (have) not been identified. /Trivalent chromium/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 194]**PEER REVIEWED**

Chromium(III) may stabilize biological proteins in their proper configurations. /Cr(III)/
[Mertz W; Physiol Rev 49: 165-239 (1969) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.67 (1976) NRCC No.15017]**PEER REVIEWED**

Trivalent chromium is essential in mammals. Adequate trivalent chromium nutrition improves growth and longevity and, along with insulin, helps to maintain correct glucose, lipid, and protein metabolism. /Trivalent chromium/

[Nat'l Research Council Canada; Effects of Chromium in the Canadian Environment p.94 (1976) NRCC No 15017]**PEER REVIEWED**

Chromium, usually supplied by glucose tolerance factor (Cr(III) complexed with amino acids and nicotinic acid) assists in binding insulin to fat cell membranes stimulating them to absorb glucose. /Chromium ion/
[Mertz W et al; Fed Proc 33: 2275-80 (1974) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.66 (1976) NRCC No.15017]**PEER REVIEWED**

Trypsin contains chromium as an integral part. Cr removal, by dialysis, results in loss of enzyme activity, while the addition of Cr restores activity. /Chromium ion/
[Langenbeck W; Hoppe Seyler Z Physiol Chem 324: 54-7 (1961) as cited in NAS; Medical and Biological Effects of Environmenal Pollutants: Chromium p.25 (1974)]**PEER REVIEWED**

Deficiency of chromium in the diet of animals causes a syndrome simulating diabetes. /Chromium ion/
[Waldbott GL; Health Effects of Envir Poll p.201 (1973)]**PEER REVIEWED**

A lack of chromium has been associated with atherosclerotic heart disease, elevated cholesterol levels in the blood, and high fat content of the aorta. /Chromium ion/
[Waldbott GL; Health Effects of Envir Poll p.201 (1973)]**PEER REVIEWED**

Chromium is essential for sugar and fat metabolism. /Chromium ion/
[Britt DL & Hushon JM; Bio Effects Criteria & Stds for Hazardous Pollutants p.6-21 (1976)]**PEER REVIEWED**

... Defect in chromium deficiency ... in young animal, growth rate may be reduced. Corneal lesions have been observed in rats deficient in both chromium and protein; no lesions have been seen with either single deficiency. /Chromium ion/
[Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980. 975]**PEER REVIEWED**

Deficiency has been reported in a few pt receiving total parenteral nutrition for 5 mo to three yr. These pt had peripheral neuropathy and/or encephalopathy that was alleviated by admin of chromium 150 ug daily. Symptoms incl a diabetes like condition with impaired utilization of glucose. Other pt with similar symptoms of glucose intolerance also had protein calorie malnutrition. /Chromium ion/
[American Medical Association, Department of Drugs. Drug Evaluations. 6th ed. Chicago, Ill: American Medical Association, 1986. 856]**PEER REVIEWED**

Impairment of glucose tolerance is the first response of animals to a mild chromium deficiency. A more severe deficiency can be produced by raising animals in an environment that allows strict control of airborne contamination or by subjecting them to additional stress, such as low-protein diets, hemorrhage or strenuous exercise. Chromium deficiency in rats resulted in significantly increased concentrations of circulating cholesterol and incidences of aortic plaques. Fasting hyperglycemia and glycosuria were observed in rats raised under maximal exclusion of chromium contamination. More than half of the 185 chromium deficient rats showed a positive test for urine sugar. The combination of chromium deficiency and protein deficiency produced by feeding rats a diet containing 10% isolated soy protein, resulted in the degeneration of the cornea, manifested by vascular infiltration and opacities. The mortality of male mice raised in an environment allowing maximal exclusion of trace contamination was decreased if chromium was added to their drinking water at 5 mg/l. In rats, early mortality was not significantly affected, but chromium supplementation increased the lifespan of survivors. The mean age of last surviving 10% was increased from 1,141 to 1,249 days. Most mice and rats grew significantly better with chromium supplementation than their deficient controls. Chromium supplemented rats had a significantly lower incidence of aortic plaques than chromium deficient controls. 9 out of 87 chromium

supplemented controls had positive tests for urine sugar. /Chromium ion/
[NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.31 (1974)]**PEER REVIEWED**

Chromium is an essential nutrient for man, being required for the maintenance of normal glucose tolerance. The human diet supplies from 5-115 ug/day of the element, of which only 1-25% is absorbed from the gastrointestinal tract. /Chromium/
[Baselt RC; Biological Monitoring Methods for Industrial Chemicals p. 81 (1980)]**PEER REVIEWED**

Chromium(III) may stabilize biological proteins in their proper configurations. /Cr(III)/
[Mertz W; Physiol Rev 49: 165-239 (1969) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.67 (1976) NRCC No.15017]**PEER REVIEWED**

Estimated safe & adequate daily dietary intakes of ... chromium (ug): Infants (Age 0-0.5) 10-40; Infants (Age 0.5-1) 20-60; Children (Age 1-3) 20-80; Children (Age 4-6) 30-120; Children (Age 7-10) 50-200; Adolescents (Age 11+) 50-200; Adults 50-200. /From table/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1550]**PEER REVIEWED**

Deficiency of chromium may lead to glucose intolerance and peripheral or central neuropathy. /Chromium supplements/
[MICROMEDEX Thomson Health Care. USPDI - Drug Information for the Health Care Professional 21 st ed. Volume 1. MICROMEDEX Thomson Health Care, Englewood, CO. 2001. Content Reviewed and Approved by the U.S. Pharmacopeial Convention, Inc.875]**PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Chromium is a metallic element with oxidation states ranging from chromium(-2) to chromium(+6). The important valence states of **chromium are III** and VI. Chromium compounds are stable in the trivalent state and occur in nature in this state in ores, such as ferrochromite(FeCr2O4). The hexavalent (VI or chromate) is the second most stable state. However, hexavalent chromium rarely occurs naturally, but is produced from anthropogenic sources. Chromium is widely distributed in the earth's crust at an avg concn of 125 mg/kg but is rare in unpolluted waters. The production and use of chromium compounds in stainless steels, alloy cast irons, and nonferrous alloys, as linings for high temperature industrial furnaces (eg, chromite and chrome-magnesite, magnesite-chrome bricks) and pigments (eg, Cr(III) and Cr(VI) compounds), for metal finishing (eg, Cr(VI)), leather tanning (eg, Cr(III)), and wood preservation (eg, Cr(VI)) may result in their release to the environment through various waste streams. Chromium compounds are released into the atmosphere mainly by anthropogenetic stationary point sources, including industrial, commercial, and residential fuel combustion, via the combustion of natural gas, oil, and coal. If released to air, chromium compounds will exist solely in the particulate phase in the ambient atmosphere. Particulate-phase chromium compounds will be removed from the atmosphere by wet and dry deposition. If released to soil, the fate of chromium is greatly dependent upon the speciation of chromium, which is a function of redox potential and the pH of the soil. In most soils, chromium will be present predominantly in the **chromium(III)** state. This form has very low solubility and low reactivity resulting in low mobility in the environment. Under oxidizing conditions chromium(VI) may be present in soil as chromate and HCrO4- ion. In this form, chromium is relatively soluble and mobile. In contrast to Cr(III), the adsorption of Cr(VI) decreases as pH increases. If released into water, most chromium

compounds will ultimately be deposited in sediments. The adsorption of Cr(III) and Cr(VI) on suspended solids and sediment is complicated by redox changes that can occur. Chromium(VI) predominates under highly oxidizing conditions; whereas **chromium(III)** predominates under reducing conditions. **Chromium(III)** occurs mostly as suspended solids adsorbed onto clay materials, organics, or iron oxide (eg, Fe2O3) present in water. In natural groundwater, the pH is typically 6 to 8, and chromate (eg, CrO4-2) is the predominant species of Cr(VI), while Cr(OH)2+ ion will be the dominant species of Cr(III). Chromium compounds are expected to exist as ions in the environment and therefore volatilization from moist soil and water surfaces is not expected to be an important fate process because ions are not expected to volatilize. According to a classification scheme, a BCF for chromium(VI) in rainbow trout of one, suggests the potential for bioconcentration in aquatic organisms is low. There is no indication of biomagnification of chromium along the terrestrial food chain (soil-plant-animal). Occupational exposure to chromium compounds may occur through inhalation of dust and dermal contact with this compound at workplaces where these compounds are produced or used. Monitoring data indicate that the general population may be exposed to chromium compounds via inhalation of ambient air, and ingestion of food and drinking water containing chromium compounds. Typical concns of chromium in ambient air and water are <0.01 to 0.3 ug/cu m and <2 ug/l, respectively. The typical daily food intake of chromium ranges from 25-224 ug with an avg of 76 ug. In humans and animals, **chromium(III)** is an essential nutrient. Chromium picolinate, Cr(III) complexed with picolinic acid, is used as a dietary supplement. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

EFFECTS OF CHROMIUM ENCOUNTERED IN OCCUPATIONS WHERE CHROMIUM CMPD ARE MFR & USED ARE DUE TO CHROMIUM(6+) & INVOLVE MAINLY SKIN & RESP SYSTEM. /CHROMIUM CMPD/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 470]**PEER REVIEWED**

Common operations in which exposure to chromium metal or insoluble chromium salts may occur includes the following: 1) use in fabrication of alloys; 2) use in preparation of alloy steels to enhance corrosion and heat resistance; 3) use in fabrication of plated products for decoration or increased wear resistance; 4) use in production of non ferrous alloys to impart special qualities to the alloys; 5) use in production and processing of insoluble salts; 6) use as chemical intermediates; use in textile industry in dyeing, silk treating, printing, and moth proofing wool; 7) use in leather industry in tanning; use in photographic fixing baths; 8) use as catalysts for halogenation, alkylation, and catalytic cracking of hydrocarbons; and 9) use as fuel additives and propellant additives; in photographic fixing baths and in ceramics. /Chromium metal and insoluble chromium salts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Common operations in which exposure to soluble chromic and chromous salts may occur include the following: 1) use in textile treatment in dyeing, printing, moth proofing, and water proofing; use in tanning of leather in gloves, garments, and shoe uppers; 2) use in manufacture of pigments of green varnishes, inks, paints, and glazes; 3) use in metal treatment and polishing; 4) use in photographic fixing baths for hardening of emulsions; use as catalysts and in manufacture of catalysts; and 5) use in chemical synthesis; use as corrosion inhibitors. /Sol chromic & chromous salts (as Cr)/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

THE CHIEF EXPOSURE TO HAZARDOUS CHROMIUM SUBSTANCES IN AMERICAN INDUSTRY IS BELIEVED TO BE AN ACID SOLUBLE, WATER INSOLUBLE CHROMATE-CHROMITE MIXTURE PRODUCED IN PREPARATION OF CHROMATE. /WATER INSOL CHROMATE-CHROMITE MIXTURE/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1591]**PEER REVIEWED**

CHIEF EXPOSURE TO HAZARDOUS CR SUBSTANCES IN AMERICAN INDUSTRY IS BELIEVED TO BE TO ACID-SOL, WATER-INSOL CHROMATE-CHROMITE MIXT PRODUCED IN PREPN OF CHROMATE. /CHROMIUM CMPD/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1017]**PEER REVIEWED**

OCCUPATIONAL EXPOSURE: CHROMIUM & ITS CMPD ARE FOUND IN 3 MAIN TYPES OF INDUST ACTIVITY: (I) MOST CR DERIV ARE USED IN METALLURGICAL INDUST ... (II) CHROMIUM CMPD ARE ... COMPONENT OF REFRACTORY MATERIALS ... & (III) MANY OF HIGHLY COLORED CHROMATE SALTS ... ARE USED IN PIGMENT, PAINT, TANNING & DYEING INDUSTRIES. /CHROMIUM COMPOUNDS/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 243 (1980)]**PEER REVIEWED**

Exposure to the metal and its insoluble salts is generally via inhalation of dusts or fumes; the current threshold limit values for these compounds range from 0.05-0.5 mg/cu m /Chromium metal and its salts/

[Baselt RC; Biological Monitoring Methods for Industrial Chemicals p. 81 (1980)]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 304,829 workers are potentially exposed to chromium(VI) in the US(1). Monitoring data indicate that the general population may be exposed to chromium compounds via inhalation of ambient air, and ingestion of food and drinking water containing chromium compounds(SRC). Typical concns of chromium in ambient air and water are <0.01 to 0.3 ug/cu m(2) and < 2 ug/l(3), respectively. The typical daily food intake of chromium ranges from 25-224 ug with an avg of 76 ug(4).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983) (2) Fishbein L; Int J Environ Anal Chem 17: 113-70 (1984) (3) Greathouse DG, Craun GF; pp. 31-39 in Trace substances in environmental health. Vol. XII. , Hemphil DD, ed. Columbia, MO: Univ Missouri (1978) (4) Kumpulainen J; pp. 253-277 in Techniques and instrumentation in analytical chemistry Vol 4. Vercruysse A, ed. Amsterdam, The Netherlands: Elsevier Sci Pub (1984)]**PEER REVIEWED**

Workers in industries that use chromium can be exposed to concns of chromium two orders of magnitude higher than exposure to the general population(1). Occupational exposure to chromium occurs mainly from chromate production, stainless steel production and welding, chromium plating, ferrochrome alloys and chrome pigment production, and working in tanning industries(2). For most occupations, exposure is due to both **chromium(III)** and chromium(VI) present as soluble and insoluble fractions(3). However, exceptions include: the tanning industry, where exposure is mostly from soluble **chromium(III)** and the plating industry, where exposure is due to soluble chromium(VI)(3). The typical concn ranges of airborne chromium(VI) to which workers in these industries were exposed during an avg of 5-20 years of employment were: chromate production, 100-500 ug/cu m; stainless steel welding, 50-400 ug/cu m; chromium plating, 5-25 ug/cu m; ferrochrome alloys, 10-140 ug/cu m; and chrome pigment, 60-600 ug/cu m(3).

[(1) Hemminki K, Vainio H; Human exposure to potentially carcinogenic compounds 59: 37-45 (1984) (2) IARC; IARC monographs on the evaluation of carcinogenic risks to humans 49: 49-256 (1990) (3) Stern RM; pp. 5-47 in Biological and environmental aspects of chromium. Langard S, ed NY, NY: Elsevier Biomed Press (1982) (4) Angerer J et al; Int Arch Occup Environ Health 59: 503-12 (1987) (5) Kuo H-W et al; Am Ind Hyg Assoc J 58: 29-32 (1997) (6) Gianello G et al; Ind Health 36: 74-77 (1998) (7) NIOSH; National Occupation Exposure Survey. Cincinnati, OH: USDHH, PHS, CDC, NIOSH (1989)]**PEER REVIEWED**

In the tanning industry, except for 2 bath processes, the typical exposure range due to **chromium(III)** was 10-50 ug/cu m(1). A more recent study of chromium oxide levels in the working environment of stainless steel welders in Germany reported a max value of 80 ug/cu m, with a median value ranging from 4 to 10 ug/cu m(2). Because of better emission control measures, occupational airborne chromium concns have declined significantly since the 1970s(1). In a recent study conducted in Taiwan to estimate worker exposure to chromium in electroplating factories, the chromium concns were 0.5-6.0 ug/cu m near the electroplating tanks and 0.3 ug/cu m in the manufacturing area(3). In an occupational exposure study of chromium in an aircraft construction factory, airborne samples were collected over a 4-hour period; urinary samples were collected at the beginning (Monday), end (Friday), and after the work shift in order to analyze the absorption of chromium during working hours(4). The air sampling results were 0.02-1.5 mg/cu m, and the urine sampling results were 0.16-7.74 ug/g creatinine(4). Compared to the ACGIH and BEI-ACGIH Hygiene Standard of 50 ug/cu m, both sets of results indicated a very low risk of exposure(4).
[(1) Stern RM; pp. 5-47 in Biological and environmental aspects of chromium. Langard S, ed. NY, NY: Elsevier Biomed Press (1982) (2) Angerer J et al; Int Arch Occup Environ Health 59: 503-12 (1987) (3) Kuo H-W et al; Am Ind Hyg Assoc J 58: 29-32 (1997) (4) Gianello G et al; Ind Health 36: 74-7 (1998)]**PEER REVIEWED**

In a survey of workers in pigment factories in England that produced strontium and lead chromate, the concns of chromium in the whole blood in exposed workers ranged from 3 to 216 ug/l, compared to a level of <1 ug/l for the nonoccupationally exposed population(1). The corresponding concns in the urine of exposed workers and the unexposed population were 1.8-575 ug chromium/g creatinine and <0.5 ug chromium/g creatinine, respectively(1). Other investigators have found a higher lung burden for chromium in occupational groups than in unexposed groups(2). The median concn of chromium in the lungs of deceased smelter workers in Sweden was 450 ug/kg (wet weight), compared to a value of 110 ug/kg (wet weight) for rural controls and 199 ug/kg (wet weight) for urban controls(2).
[(1) McAughey JJ et al; Sci Total Environ 71: 317-22 (1988) (2) Gerhardsson L et al; Sci Total Environ 74: 97-110 (1988)]**PEER REVIEWED**

Body Burden:

In spite of the refined methods of analysis available, a reliable range of normal blood chromium concentrations cannot be given with confidence. When using modern methods for analysis, the whole blood concentration may be suggested to be within the range of 0.5 to 3 ppb, while the serum level is probably below 0.2 ppb. /Total chromium/
[USEPA; Health Assessment Document: Chromium p.2-6 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

Human soft tissues contain 0.03 ppm chromium. /Total chromium/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.14 (1976) NRCC No.15017]**PEER REVIEWED**

Human fetus (heart, liver, and spleen) showed an accumulation factor of 10 when compared to adult tissues with levels decreasing upon aging. /Total chromium/
[Nat'l Research Council Canada; Effects of Chromium in Canadian Envir p. 50 (1976) NRCC No.15017]**PEER REVIEWED**

Total body burden of 2-6 mg chromium may represent a marginally deficient state. /Total chromium/
[USEPA; Ambient Water Quality Criteria Doc: Chromium p.C-11 (1980) EPA 440/5-80-035]**PEER REVIEWED**

In persons without excess exposure, blood chromium concn is between 20 and 30 ug/l and is evenly distributed between erythrocytes and plasma. With occupational exposure, incr in blood chromium is related in incr in chromium in red blood cells. Urinary excretion is generally less than 10 ug/day in the absence of excess exposure. /Total chromium/
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 598]**PEER REVIEWED**

... In hair, values from 200 to 2000 ug/kg ... 700 ug/kg of chromium in the lung for persons in the New York/Chicago area; ... liver 270 ug/kg and kidney 90 ug/kg. ... Denver area ... 140 ug/kg for the lung, 30 ug/kg for the liver, and 40 ug/kg for the kidney. ... 300 ug/kg for the lung, 40 ug/kg for the liver, and about 15 ug/kg or the kidney ... from Japan. ... At present the concn of chromium (normal levels) in plasma ... 0.14 ug/l, and in urine 0.32-0.41 ug/l. /Total chromium/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 193]**PEER REVIEWED**

Occupationally exposed workers had chromium concn in lung that were 300 fold higher than nonexposed controls, and concn in liver, kidney, and adrenal glands that were 2 to 4 fold, 10 fold, and 10 to 50 fold higher, respectively. /Total chromium/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 243]**PEER REVIEWED**

Concentrations of chromium cmpd, calculated as Cr, in body tissues of persons without and with known exposure to Cr: Normal tissues (ug/kg wet tissue): lung 0-330, tracheobronchial lymph node 0-10, kidney 0-96, liver 10-110, spleen 0-980, abdominal lymph node 10, stomach 0-50, intestine 100, muscle 0-80, pancreas 210, thyroid 430, adrenal 0-410, brain 0-40, bone 50; Tissues from chromate workers (ug/kg wet tissue): lung 1300-98,870, lung tumor 0-16,580, metastatic tumor 20-1000, tracheobronchial lymph node 120-75,900, bronchus 950-3860, trachea 0-320, nasal septum 2870, larynx 210, kidney 0-2110, liver 0-1590, spleen 0-910, abdominal lymph node 40-800, stomach 40-110, intestine 40-50, bladder 30-2260, heart 0-200, muscle 0-190, pancreas 80-360, thyroid 240-530, adrenal 50-760, brain 0-50, bone 0-2920, cartilage 60, bile 10, hair 310, skin 50, aorta 30. /From table/ /Total chromium/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 249 (1980)]**PEER REVIEWED**

Serum chromium concentrations average about 0.16 ug/l (range 0.04-0.35) in healthy subjects. Literature published prior to 1978 refers to normal serum chromium values ranging from 0.7 to 150 ug/l due to methodological difficulties in trace analysis of chromium. /Chromium/
[Baselt RC; Biological Monitoring Methods for Industrial Chemicals p. 81 (1980)]**PEER REVIEWED**

A recent East German autopsy study of people with no occupational exposure to chromium found that chromium levels in lung and kidney were not correlated with age. /Chromium and chromium cmpd/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.46 (10/87)]**PEER REVIEWED**

The chromium content in tissues and body fluids of the general population are as follows: serum, 0.006 ug/l (range, 0.01-0.17 ug/l)(1); urine, 0.4 ug/l (range, 0.24-1.8 ug/l)(2); lung, 201 ug/kg(wet wt; range, 28-898 ug/kg)(3); breast milk, 0.30 ug/l (range, 0.06-1.56 ug/l)(4); hair, 0.234 mg/kg(5); and nail, 0.52 mg/kg(5). The concn of chromium in human liver (from Spanish population) was 2.49 +/- 0.89 ppm(6).

[(1) Sunderman FW et al; J Orthop Res 7: 307-15 (1989) (2) Iyengar V, Woittiez ; Clin Chem 34: 474-81 (1988) (3) Raithel HJ et al; Am J Ind Med 12: 55-70 (1987) (4) Casey CE, Hambidge KM; Br J Nutr 52: 73-7 (1984) (5) Takagi Y et al; Bull Environ Contam Toxicol 36: 793-800 (1986) (6) Bona MA et al; Human Exp Toxicol 11: 311-4 (1992)]**PEER REVIEWED**

Average Daily Intake:

Estimated safe and adequate daily dietary intakes of chromium: infants: 0-0.5 yr: 0.01-0.04 mg; 0.5-1 yr: 0.02-0.06 mg; children and adolescents: 1-3 yr: 0.02-0.08 mg; 4-6 yr: 0.03-0.12 mg; 7-10 yr: 0.05-0.2 mg; 11+ yr: 0.05-0.2 mg; adults: 0.05-0.2 mg /From table/ /Total chromium/
[Gilman, A.G., L.S.Goodman, and A. Gilman. (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 7th ed. New York: Macmillan Publishing Co., Inc., 1985. 1548]**PEER REVIEWED**

AIR INTAKE: Assume <0.01 to 0.3 ug/cu m(1), 0.2 to 0.6 ug(SRC). WATER INTAKE: Assume < 2 ug/l(2), <4 ug(SRC). FOOD INTAKE: 25 to 224 ug with an avg of 76 ug(3).
[(1) Fishbein L; Int J Environ Anal Chem 17: 113-70 (1984) (2) Greathouse DG, Craun GF; pp. 31-9 in Trace substances in environmental health. Vol. XII., Hemphil DD, ed. Columbia, MO: Univ Missouri (1978) (3) Kumpulainen J; pp. 253- 77 in Techniques and instrumentation in analytical chemistry Vol 4. Vercruysse A, ed. Amsterdam, The Netherlands: Elsevier Sci Pub (1984)]**PEER REVIEWED**

FOOD INTAKE: The dietary intake estimates of chromium in foods from France are as follows: vegetables, 7.3 ug/day; fruits, 4.4 ug/day, beverages, 20 ug/day; cereals, 17 ug/day; fish-crustaceans, 4.5 ug/day; meat-poultry-eggs, 23 ug/day; milk-dairy-products, 17 ug/day; condiments-sugar-oils, 1.2 ug/day; canned foods, 3.8 ug/day(1). Dietary intake estimates of chromium from France, Denmark, Spain, Belgium, and US are 98 ug/day, 50 ug/day, 99 ug/day, 240 ug/day, and 50-200 ug/day, respectively(1).
[(1) Biego GH et al; Sci Total Environ 217: 27-36 (1998)]**PEER REVIEWED**

Natural Pollution Sources:

CHROMIUM OCCURS IN NATURE MOSTLY AS CHROME IRON ORE (FEO.CR2O3). CHROMIUM IS PRESENT IN SMALL QUANTITIES IN ALL SOILS & PLANTS, @ 1-2.5 PPB IN SEA WATER, & @ ABOUT 200 PPM IN THE EARTH'S CRUST. THE NORMAL HUMAN ADULT BODY CONTAINS ABOUT 6 MG CR, WITH TISSUE CONCN OF 0.02-0.04 PPM CR ON DRY WT BASIS.
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 248]**PEER REVIEWED**

The most common meteorites, ie chondrites, contain 3,000 ug/g (ppm) chromium. /Total chromium/
[NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.2 (1974)]**PEER REVIEWED**

PRESENT IN ALL SOILS & PLANTS & ... CONSIDERED AGRICULTURALLY AS A DELETERIOUS ELEMENT. CERTAIN SOILS WITH A RELATIVELY HIGH CONTENT (0.2-0.4%) ARE SAID TO BE INFERTILE; CITRUS TREES GROWN ON THEM SHOW YELLOWING OF FOLIAGE ... .
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969. 119]**PEER REVIEWED**

Chromium occurs naturally in the Earth's crust(1). Chromium is widely distributed(2); avg concn is 125 mg/kg in the continental crust (range, 80-200 mg/kg)(2), but rare in natural waters(2). The abundance of chromium in various materials is as follows: 1,000-3,400 ppm in ultramafic igneous rocks, 1,800 ppm avg(3); 40-600 ppm in basaltic igneous rocks, 220 ppm avg(3); 2-90 ppm in granitic igneous rocks, 20

ppm avg(3); 30-590 ppm in shales and clays, 120 ppm avg(3); and 10-1,000 ppm in coals, 20 ppm avg(3). Chromium occurs in minor amounts in many minerals where Cr(III) replaces Fe(III) or Al(III), such as crocoite, chromium tourmalines, garnets, micas, chlorites, and true emeralds(3). Generally, Cr(III) bearing minerals are associated with ultrabasic rocks away from farm lands and urban centers(4). Cr(III) bearing minerals include chromite, copiapite, halotrichite, kammerite, magnesiochromite, muscovite, serpentine, stichtite, and livarovite(4). Chromium is derived mainly from chromite (FeO-Cr2O3) which is found in considerable quantities in Rhodesia, Russia, South Africa, New Caledonia and The Philippines(5); chromite contains 40-50% chromium(5). Continental dust is the main source of exposure to natural chromium present in the atmosphere(1); volcanic dust and gas flux are minor natural sources of chromium in the atmosphere(1). Chromium in air associated with large particles (>5 um diameter) originates from wind blown soil and soil forming processes(4).
[(1) Fishbein L; Environ Health Perspect 40: 43-64 (1981) (2) USEPA; Ambient Water Quality Criteria Doc: Chromium. USEPA 440/5-80-035 p.C-4 (1980) (3) NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.3, 9 (1974) (4) Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir. NRCC No.15017 p.26, 117 (1976) (5) IARC; Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva, Switzerland: WHO 2: 108 (1973)]**PEER REVIEWED**

Artificial Pollution Sources:

The occurrence of excess chromium in drinking water is relatively infrequent. Contamination of water sources results from the use of chromates as corrosion inhibitors. /Chromium/
[48 FR 45512 (10/5/88)]**PEER REVIEWED**

Air emissions containing chromium result from the following major industries: paper mills, organic & inorganic petr-chemicals, fertilizers, steel and metal foundries, motor vehicles, glass, cement, asbestos manufacture, textile mills and steam generation power plants.
[Dean JG et al; Envir Sci Technol 6: 518-22 (1972) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Environment p.92 (1976) NRCC No. 15017]**PEER REVIEWED**

Particles emitted from coal fired power plants contained 2.3-31 ppm, chromium emitted gases contained 0.22-2.2 mg/cu m. Concn were reduced by fly ash collection to 0.19-6.6 ppm and 0.018-0.5 mg/cu m, respectively. /Total chromium/
[Sullivan RJ; Preliminary Air Poll Survey of Chromium and its Compounds p.1-75 (1969) NAPCA Pub. APTD 69-34 as cited in NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.15 (1974)]**PEER REVIEWED**

The burning of wood in fireplaces, campfires, leaf burning, and rubbish incineration contribute chromium to the air. /Total chromium/
[Schroeder HA; API Air Quality Monograph #70-15: Chromium p.1-28 (1970) as cited in NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.15 (1974)]**PEER REVIEWED**

Wastewater treatment sludge from the production of chrome yellow, orange, and green pigments, chrome oxide green pigments, molybdate orange, zinc yellow, and iron blue pigments, and oven residue from chrome oxide green pigments contain toxic metals including hexavalent chromium. An est 4300 metric tons of sludge are generated per yr (50-60% of this in 1980 or 2100-2600 lb). These wastes are frequently disposed of in unlined lagoons and landfills or dumped in the open creating a potential for toxic environmental contamination. /Total chromium/
[USEPA; Background Document, Resource Conservation and Recovery Act Subtittle C: Identification and Listing of Hazardous Waste p.188, 202 (1980)]**PEER REVIEWED**

The production and use of chromium compounds in stainless steels, alloy cast irons, and nonferrous alloys(1), as linings for high temperature industrial furnaces (e.g., chromite and chrome-magnesite,

magnesite-chrome bricks)(1) and pigments (eg, Cr(III) and Cr(VI) compounds)(2), for metal finishing (e.g., Cr(VI))(3), leather tanning (e.g., Cr(III))(2), and wood preservation (e.g., Cr(VI))(3), may result in chromium release to the environment through various waste streams(SRC). Smaller amounts are used in drilling muds, chemical manufacturing, textiles, toners for copying machines, magnetic tapes, and as catalysts(4,5). In the past, chromium was also used in cooling towers as a rust and corrosion inhibitor(4,5). Chromium alloys are also used in metal joint prostheses(6). Chromium picolinate, a trivalent form of chromium complexed with picolinic acid, is used as a dietary supplement(7).
[(1) Ashford RD; Ashford's Dictionary of Industrial Chemicals. London, England: Wavelength Publ Ltd, p. 219 (1994) (2) Lewis RJ Sr, ed; Hawley's Condensed Chemical Dictionary. 13th ed. NY, NY: John Wiley and Sons Inc, pp. 267-9, 916 (1997) (3) Mackison FW et al, eds; NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. Washington, DC: USGPO, DHHS (NIOSH) Pub No 81-123 p. 4 (1981) (4) USEPA; Health assessment document for chromium. Research Triangle Park, NC: Environ Assess Criteria Off, USEPA 600/8-83-014F (1984) (5) IARC; IARC monographs on the evaluation of carcinogenic risks to humans. Chromium, nickel and welding. 49: 49-256 (1990) (6) Sunderman FW et al; J Orthop Res 7: 307-15 (1989) (7) Broadhurst CL et al; J Inorg Biochem 66: 119-130 (1997)]**PEER REVIEWED**

Chromium compounds are released into the atmosphere mainly by anthropogenetic stationary point sources, including industrial, commercial, and residential fuel combustion, via the combustion of natural gas, oil, and coal(1). Other important anthropogenetic stationary point sources of chromium emission to the atmosphere are metal industries(2). Older estimates indicated that emissions from the metal industry ranged from 35% to 86% of the total, and emission from fuel combustion ranged from 11% to 65% of the total(3).
[(1) ATSDR; Toxicological Profile for Chromium. Atlanta, GA: USHHS (2000) (2) USEPA; Health assessment document for chromium. Research Triangle Park, NC: USEPA 600/8-83-014F (1984) (3) USEPA; Reviews of the environmental effects of pollutants: III. Chromium. Cincinnati, OH: USEPA-600/1-78-023 (1978)]**PEER REVIEWED**

Although some piping materials contain significant levels of chromium (corrosion resistant steel, 8-14%; cement, 5-120 ppm chromium), little is leached into drinking water(1). New York City emits 4.4X10+8 g/yr Cr. 43% of the daily Cr in New York City sewer burden and 24% of chromium emission from New York City to vapor are from electroplating wastes, while residential waste and rain water runoff contribute 28% and 9%, respectively(1). A moderate sized cooling tower system operating at a residual chromate level of 30-35 ppm, discharges more than 7 tons of Cr(VI) in water annually(1). A tannery processing 2500 hides/day produces 820 kg Cr(III)/day in effluent(1).
[(1) Nat'l Research Council Canada; Effects of Chromium in the Canadian Environment. NRCC No 15017 p.36, 56, 58 (1976)]**PEER REVIEWED**

Direct sources of chromium include chemical and refractory plants; indirect sources include fossil fuel combustion, waste incineration, and cement plant emissions(1). Some source categories are likely to emit both Cr(III) and Cr(VI)(1). These are steel, refractory, and chemicals manufacturing, as well as sewage sludge, and municipal incineration(1). Cooling towers and chrome plating facilities emit Cr(VI), and chromium ore refining, ferro-chromium production, cement production, and coal and oil combustion are likely to be sources of Cr(III)(1). Maximum annual avg ambient (total) chromium levels within 20 km of these sources range from approx 0.01-13.50 ug/cu m(1).
[(1) USEPA; Health Assessment Document: Chromium. USEPA 600/8-83-014F pp. 36, 56, 58 (1976)]**PEER REVIEWED**

Environmental Fate:

The processes that control the environmental chemistry of chromium include redox transformation, precipitation/dissolution, and adsorption/desorption reactions. Commonly occurring reductants, such as ferrous iron and organic material, can transform chromium(VI) to **chromium(III),** but manganese

oxides are the only inorganic oxidants found in the environment that cause the rapid oxidation of **chromium(III)** to chromium(VI). In the trivalent state, chromium readily forms compounds such as Cr(OH)3 and (Cr,Fe)(OH)3. These solids show amphoteric solubility behavior, with hydroxo complexes being the dominant aqueous species of **chromium(III).** The relatively low solubilities of Cr(OH)3 and (Cr,Fe)(OH)3 limit **chromium(III)** concentrations to less than the drinking water limit over much of the pH range of environmental interest. In the hexavalent state, the formation of the Ba(S,Cr)O4 solid solution controls the dissolved chromium concentrations in environments that contain barium sulfate. In the absence of solubility controlling chromium(VI) solids, chromium(VI) concentrations in acidic to slightly alkaline conditions are expected to be limited by adsorption. Iron oxides are the most important absorbents for aqueous chromium(VI) species in most soil environments. Although these processes are complex and interrelated, each must be considered to predict the aqueous concentrations, mobility, and toxicity of chromium in the environment.
[Rai D et al; Sci Total Environ 86 (1-2): 15-23 (1989)]**PEER REVIEWED**

AQUATIC FATE: Chromium(VI) occurs in higher conc near ocean surfaces than in deeper water, the reverse is true for Cr(III). Cr(VI) run off is reduced to Cr(III) which settles into deeper waters. /Cr(III) and Cr(VI)/
[NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.10 (1974)]**PEER REVIEWED**

AQUATIC FATE: Below pH 5, **chromium(III)** forms a stable complex with water. Above pH 9, soluble negatively charged hydroxides are formed. /Cr(III)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.22 (1976) NRCC No.15017]**PEER REVIEWED**

AQUATIC FATE: In natural waters dichromate oxion (low pH) concn is low, hydrochromate ions predominate under acid conditions and chromate ions predominate in alkaline conditions. /Chromates/
[Trama FB, Benoit RJ; J Water Pollut Control Fed 32: 868 (1960) as cited in USEPA; Ambient Water Quality Criteria Doc: Chromium p.A-1 (1980) EPA 440/5/80-045]**PEER REVIEWED**

TERRESTRIAL FATE: The fate of chromium in soil is greatly dependent upon the speciation of chromium, which is a function of redox potential and the pH of the soil(SRC). In most soils, chromium will be present predominantly in the **chromium(III)** state(1). This form has very low solubility and low reactivity resulting in low mobility in the environment(2). The amounts of Cr(III) adsorbed correspond to adsorption of the hydrolyzed Cr(III) species on cation exchange sites(3). Under oxidizing conditions chromium(VI) may be present in soil as chromate and HCrO4- ion(4). In this form, chromium is relatively soluble and mobile(4). In contrast to Cr(III), the adsorption of Cr(VI) decreases as pH increases(5). In deeper soil where anaerobic conditions exist, chromium(VI) will be reduced to **chromium(III)** by sulfide and Fe(II) present in soil(6). The reduction of chromium(VI) to **chromium(III)** is possible in aerobic soils that contain appropriate organic energy sources to carry out the redox reaction(1). The reduction of chromium(VI) to **chromium(III)** is facilitated by low pH (eg, 4 to 6). From thermodynamic considerations, chromium(VI) may exist in the aerobic zone of some natural soil(1). The oxidation of **chromium(III)** to chromium(VI) in soil is facilitated by the presence of low oxidizable organic substances, oxygen, manganese dioxide, and moisture(1,8). Oxidation is also enhanced at elevated temperatures in surface soil that result from brush fires(6,9). Organic forms of **chromium(III) (**eg, humic acid complexes) are more easily oxidized than insoluble oxides(8). Formation of soluble organic complexes reduces the degree of adsorption(5). Soluble **chromium(III)** in soil can be partly oxidized to chromium(VI) by manganese dioxide in soil, and the process is enhanced by pH higher than six(10). Because most **chromium(III)** in soil is immobilized due to adsorption and complexation with soil materials, the barrier to this oxidation process is the lack of availability of mobile **chromium(III)** to immobile manganese dioxide in soil surfaces(4,10). Due to this lack of availability of

mobile **chromium(III)** to manganese dioxide surfaces, a large portion of chromium in soil will not be oxidized to chromium(VI), even in the presence of manganese dioxide and favorable pH conditions(4,10).
[(1) Kimbrough DE et al; Crit Rev Env Sci Technol 29: 1-46 (1999) (2) Barnhart J; J Soil Contam 6: 561-568 (1997) (3) Schmidt JA, Andren AW; Adv Environ Sci Technol 14: 81-103 (1984) (4) James BR et al; J Soil Contam 6: 569-80 (1997) (5) Bodek I et al, eds; Environmental Inorganic Chemistry. Properties, Processes, and Estimation Methods. NY, NY: Pergamon Press, p. 7.6-1 to 7.6-12 (1988) (6) Cary EE; pp. 49-64 in Topics in Environmental Health 5. Langard S, ed. NY, NY: Elsevier Biomed Press (1982) (7) USEPA; Noncarcinogenic effects of chromium: Update to health assessment document. Research Triangle Park, NC: Environ Crit Assess Off, Off Health Environ Assess. USEPA 600/8-87/048F (1990) (8) Saleh FY et al; Sci Total Environ 86: 25-41 (1989) (9) Calder LM; Adv Env Sci Technol 20: 215-29 (1988) (10) Bartlett R; Environ Health Perspect 92: 17- 24 (1991)]**PEER REVIEWED**

AQUATIC FATE: Most chromium compounds released into water will ultimately be deposited in sediments(1). The adsorption of Cr(III) and Cr(VI) on suspended solids and sediment is complicated by redox changes that can occur(2). Chromium(VI) predominates under highly oxidizing conditions; whereas **chromium(III)** predominates under reducing conditions(3). The reduction of chromium(VI) by sulfide or Fe(II) ions is fast under anaerobic conditions; the reduction half-life ranges from instantaneous to a few days(4). However, the reduction of chromium(VI) by organic sediments is much slower and depends on the type and amount of organic material and on the redox condition of the water(4). The reduction half-life of chromium(VI) in water with sediment ranged from 4 to 140 days(4). Dissolved oxygen by itself in natural waters does not cause any measurable oxidation of **chromium(III)** to chromium(VI) in 128 days(4). Therefore, oxidation of Cr(III) will not be significant in most natural waters(4). In contrast to Cr(VI), the adsorption of Cr(III) on suspended solids and sediment increases as pH increases(2). In a laboratory study of adsorption of chromium onto clay minerals, it was found that 30 to 300 times more Cr(III) was adsorbed than Cr(VI)(2). A very small percentage of chromium can be present in water in both soluble and insoluble forms(1). Soluble chromium generally accounts for a very small percentage of the total chromium in water(1). Most of the soluble chromium is present as chromium(VI) and soluble **chromium(III)** complexes(1). **Chromium(III)** occurs mostly as suspended solids adsorbed onto clay materials, organics, or iron oxide (eg, Fe2O3) present in water(1). In natural groundwater, the pH is typically 6 to 8, and chromate (eg, CrO4-2) is the predominant species of Cr(VI), while Cr(OH)2+ ion will be the dominant species of Cr(III)(5). This species and other **chromium(III)** species will predominate in more acidic pH; **chromium(III)** hydroxide and Cr(OH)4- ion predominate in more alkaline waters(5). Chromium compounds are expected to exist as ions in the environment and therefore volatilization from water surfaces is not expected to be an important fate process because ions are not expected to volatilize(SRC). According to a classification scheme(6), a BCF for chromium(VI) in rainbow trout of one(7- 10), suggests the potential for bioconcentration in aquatic organisms is low(SRC).
[(1) Cary EE; pp. 49-64 in Topics in Environmental Health 5. Langard S, ed. NY, NY: Elsevier Biomed Press (1982) (2) Bodek I et al, eds; Environmental Inorganic Chemistry. NY, NY: Pergamon Press, p. 7.6-1 to 7.6-12 (1988) (3) Fukai R; Nature 213: 901 (1967) (4) Saleh FY et al; Sci Total Environ 86: 25-41 (1989) (5) Calder LM; Adv Env Sci Technol 20: 215-229 (1988) (6) Franke C et al; Chemosphere 29: 1501-14 (1994) (7) USEPA; 1980. Ambient water quality criteria for chromium. Washington, DC: USEPA-440/5-80-035 (1980) (8) USEPA; Health assessment document for chromium. Research Triangle Park, NC: USEPA 600/8-83-014F (1984) (9) Fishbein L; Environ Health Perspect 40: 43-64 (1981) (10) Schmidt JA, Andren AW; Adv Environ Sci Technol 14: 81-103 (1984)]**PEER REVIEWED**

ATMOSPHERIC FATE: Chromium is present in the atmosphere primarily in particulate form(1). Naturally occurring gaseous forms of chromium are rare(1). In the atmosphere, chromium(VI) may be reduced to **chromium(III)** at a significant rate by vanadium (eg, V(II), V(III), and VO2+ ions), Fe(II) ion, bisulfite (eg, HSO3-), and As(III) ion(2). Conversely, **chromium(III),** if present as a salt other than

chromium(III) oxide, eg Cr2O3, may be oxidized to chromium(VI) in the atmosphere in the presence of at least 1% manganese oxide(3). However, this reaction is unlikely under most environmental conditions(SRC). The estimated atmospheric half-life for chromium(VI) reduction to **chromium(III)** was reported in the range of 16 hours to about 5 days(4). Particulate chromium in the atmosphere is deposited on land and water via wet and dry deposition(SRC). Chromium particles of aerodynamic diameter <20 um may remain airborne for longer periods of time and be transported for greater distances than larger particles(SRC). There are no data in the reviewed literature indicating that chromium particles are transported from the troposphere to the stratosphere(5). By analogy with the residence time of general particles with mass median diameters similar to that of chromium, the residence time of atmospheric chromium is expected to be <10 days(6). Based on a troposphere to stratosphere turnover time of 30 years(7), atmospheric particles with a residence time of <10 days are not expected to transport from the troposphere to the stratosphere(SRC).
[(1) Cary EE; pp. 49-64 in Topics in Environmental Health 5. Langard S, ed. NY, NY: Elsevier Biomed Press (1982) (2) USEPA; Quality criteria for water 1986. Washington, DC: Off Water Reg Stand, USEPA 440/5-86-001 (1987) (3) USEPA; Noncarcinogenic effects of chromium: Update to health assessment document. Research Triangle Park, NC: Environ Crit Assess Off, Off Health Environ Assess, USEPA 600/8-87/048F (1990) (4) Kimbrough DE et al; Crit Rev Env Sci Technol 29: 1-46 (1999) (5) Pacyna JM, Ottar B; Atmos Environ 19: 2109-20 (1985) (6) Nriagu JO; pp. 43-75 in Copper environment. Nriagu JO, ed. NY, NY: John Wiley and Sons (1979) (7) USEPA; Water-related environmental fate of 129 priority pollutants: Vol. I. Washington, DC: Off Water Plan Stand, Off Water Waste Manag, USEPA 440/5-79-029a pp. 40-43 (1979)]**PEER REVIEWED**

Environmental Biodegradation:

Factors affecting the microbial reduction of chromium(VI) to **chromium(III)** include biomass concn, initial chromium(VI) concn, temperature, pH, carbon source, oxidation-reduction potential and the presence of both oxyanions and metal cations(1). Although high levels of chromium(VI) are toxic to most microbes, several resistant bacterial species have been identified which could ultimately be employed in remediation strategies(1).
[(1) Chen JM, Hao OJ; Crit Rev Environ Sci 28: 219-51 (1998)]**PEER REVIEWED**

Environmental Abiotic Degradation:

In the atmosphere, chromium(VI) may be reduced to **chromium(III)** at a significant rate by vanadium (eg, V(II), V(III), and VO2+ ions), Fe(II) ion, bisulfite (eg, HSO3-), and As(III) ion(1). Conversely, **chromium(III),** if present as a salt other than **chromium(III)** oxide, eg Cr2O3, may be oxidized to chromium(VI) in the atmosphere in the presence of at least 1% manganese oxide(2). However, this reaction is unlikely under most environmental conditions(SRC). The estimated atmospheric half-life for chromium(VI) reduction to **chromium(III)** was reported in the range of 16 hours to about 5 days(3).
[(1) USEPA; Quality criteria for water 1986. Washington, DC: Off Water Reg Stand, USEPA 440/5-86-001 (1987) (2) USEPA; Noncarcinogenic effects of chromium: Update to health assessment document. Research Triangle Park, NC: Environ Crit Assess Off, Off Health Environ Assess, USEPA 600/8-87/048F (1990) (3) Kimbrough DE et al; Crit Rev Env Sci Technol 29: 1-46 (1999)]**PEER REVIEWED**

The reduction of chromium(VI) and the oxidation of **chromium(III)** in water has been investigated(1). The reduction of chromium(VI) by sulfide or Fe(II) ions under anaerobic conditions was fast, and the reduction half-life ranged from instantaneous to a few days(1). However, the reduction of chromium(VI) by organic sediments and soils was much slower and depended on the type and amount of organic material and on the redox condition of the water(1). The reaction was generally faster under anaerobic than aerobic conditions(1). The reduction half-life of chromium(VI) in water with soil and sediment ranged from 4 to 140 days(1). Dissolved oxygen by itself in natural waters did not cause any measurable

oxidation of **chromium(III)** to chromium(VI) in 128 days(1). When **chromium(III)** was added to lake water, a slow oxidation of **chromium(III)** to chromium(VI) occurred, corresponding to an oxidation half-life of nine years(1). Addition of 50 mg/l manganese oxide accelerated the process, decreasing the oxidation half-life to 2 years(1). Therefore, this oxidation process would not be significant in most natural waters(1). The oxidation of **chromium(III)** to chromium(VI) during chlorination of water was highest in the pH range of 5.5 to 6.0(1). However, the process would rarely occur during chlorination of drinking water because of the low concns of **chromium(III)** in these waters, and the presence of naturally occurring organics that may protect **chromium(III)** from oxidation, either by forming strong complexes with **chromium(III)** or by acting as a reducing agent to free available chlorine(2). In **chromium(III)**-contaminated waste waters having pH ranges of 5 to 7, chlorination may convert **chromium(III)** to chromium(VI) in the absence of **chromium(III)**-complexing and free chlorine reducing agents(2).
[(1) Saleh FY et al; Sci Total Environ 86: 25-41 (1989) (2) USEPA; Fate of chromium(III) in chlorinated water. Cincinnati, OH: Off Res Devel, NTIS PB88-130992 (1988)]**PEER REVIEWED**

Chromium speciation in groundwater depends on the redox potential and pH conditions in the aquifer(1). Chromium(VI) predominates under highly oxidizing conditions; whereas **chromium(III)** predominates under reducing conditions(1). Oxidizing conditions are generally found in shallow aquifers, and reducing conditions generally exist in deeper groundwaters(1). In sea water, chromium(VI) is generally stable(1). In natural groundwater, the pH is typically 6 to 8, and chromate is the predominant species of chromium in the hexavalent oxidation state, while Cr(OH)2+ ion will be the dominant species in the trivalent oxidation state(2). This species and other **chromium(III)** species will predominate in more acidic pH; **chromium(III)** hydroxide and Cr(OH)4- ion predominate in more alkaline waters(2).
[(1) Fukai R; Nature 213: 901 (1967) (2) Calder LM; Adv Env Sci Technol 20: 215-29 (1988)]**PEER REVIEWED**

In most soils, chromium will be present predominantly in the **chromium(III)** state(1). Under oxidizing conditions chromium(VI) may be present in soil as chromate and HCrO4- ion(2). In deeper soil where anaerobic conditions exist, chromium(VI) will be reduced to **chromium(III)** by sulfide and Fe(II) present in soil(3). The reduction of chromium(VI) to **chromium(III)** is possible in aerobic soils that contain appropriate organic energy sources to carry out the redox reaction(1). The reduction of chromium(VI) to **chromium(III)** is facilitated by low pH(e.g., 4 to 6). From thermodynamic considerations, chromium(VI) may exist in the aerobic zone of some natural soil(1). The oxidation of **chromium(III)** to chromium(VI) in soil is facilitated by the presence of low oxidizable organic substances, oxygen, manganese dioxide, and moisture(1,5). Oxidation is also enhanced at elevated temperatures in surface soil that result from brush fires(3,6). Organic forms of **chromium(III) (**eg, humic acid complexes) are more easily oxidized than insoluble oxides(5). However, oxidation of **chromium(III)** to chromium(VI) was not observed in soil under conditions of max aeration and a max pH of 7.3(7). Soluble **chromium(III)** in soil can be partly oxidized to chromium(VI) by manganese dioxide in soil, and the process is enhanced by pH higher than six(8). Because most **chromium(III)** in soil is immobilized due to adsorption and complexation with soil materials, the barrier to this oxidation process is the lack of availability of mobile **chromium(III)** to immobile manganese dioxide in soil surfaces(2,8). Due to this lack of availability of mobile **chromium(III)** to manganese dioxide surfaces, a large portion of chromium in soil will not be oxidized to chromium(VI), even in the presence of manganese dioxide and favorable pH conditions(2,8).
[(1) Kimbrough DE et al; Crit Rev Env Sci Technol 29: 1-46 (1999) (2) James BR et al; J Soil Contam 6: 569-80 (1997) (3) Cary EE; pp. 49-64 in Topics in Environmental Health 5. Langard S, ed. NY, NY: Elsevier Biomed Press (1982) (4) USEPA; Noncarcinogenic effects of chromium: Update to health assessment document. Research Triangle Park, NC: Environ Crit Assess Off, Off Health Environ Assess, USEPA 600/8-87/048F (1990) (5) Saleh FY et al; Sci Total Environ 86: 25-41 (1989) (6)

Calder LM; Adv Env Sci Technol 20: 215-29 (1988) (7) Bartlett RJ, Kimble JM; J Environ Qual 5: 379-86 (1976) (8) Bartlett R; Environ Health Perspect 92: 17-24 (1991)]**PEER REVIEWED**

Environmental Bioconcentration:

Effects of humic acid on the bioaccumulation of Cr(VI) and other trace metals was evluated in the freshwater cladoceran, Daphnia magna. Results showed the humic acid (0.5, 5, and 50 mg/l) had only minor influence on the bioaccumulation of Cr(VI) by D. magna. The mean background level of Cr in the daphnids was 4.0 ug/g dry wt. At time points 1 through 72 hr, Cr content increased steadily to 64.2 ug/g and humic acid did significantly decrease the bioaccumulation of Cr(VI) (to 52.1 ug/g vs 65.8 ug/g in the control), while the remaining concentrations continued to have no influence on the bioaccumulation. /Hexavalent chromium/
[Stackhouse RA, Benson WH; Environ Toxicol Chem 8 (7): 639-44 (1989)]**PEER REVIEWED**

Oysters accumulated enough Chromium from the sea water (10 ppb) over 2 yr to suffer toxic & lethal effects during the summer metabolic peak period. /Total chromium/
[Nat'l Research Council Canada; Effects of Chromium in Canadian Envir p. 16 (1976) NRCC No.15017]**PEER REVIEWED**

Generally, it can be stated that there is little tendency for chromium to accumulate along food chains in the trivalent inorganic form. /Trivalent chromium/
[Nat'l Research Council Canada; Effects of Chromium in Canadian Environment p. 49 (1976) NRCC No.15017]**PEER REVIEWED**

The BCF for chromium(VI) in rainbow trout is one(1-4). The highest reported BCF for rainbow trout was about 3(5), and organ-specific BCFs approaching 10 have been reported(6). However, bioconcentration factors seldom exceed 10 for chromium(7). High BCFs were reported for bottom-dwelling fish(5). In the most extreme example, brown bullhead concentrated chromium in liver and muscle tissue 1,822 to 2,622 times the river water concn, but below the sediment concn(5). In bottom feeder bivalves, such as oyster, blue mussel, and soft shell clam, the BCF values for **chromium(III)** and chromium(VI) may range from 86 to 192(1-4). The bioavailability of **chromium(III)** to freshwater invertebrates decreased with the addition of humic acid(8). This decrease in bioavailability was attributed to lower availability of the free form of the metal due to its complexation with humic acid(8). Based on this information, chromium is not expected to biomagnify in the aquatic food chain(SRC). Although higher concns of chromium have been reported in plants growing in high chromium-containing soils (eg, soil near ore deposits or chromium-emitting industries and soil fertilized by sewage sludge) compared with plants growing in normal soils, most of the increased uptake in plants is retained in roots, and only a fraction is translocated in the above ground part of the edible plants(9,10). Therefore, bioaccumulation of chromium from soil to above-ground parts is unlikely(11). There is no indication of biomagnification of chromium along the terrestrial food chain (soil-plant-animal)(9).
[(1) USEPA; 1980. Ambient water quality criteria for chromium. Washington, DC: USEPA-440/5-80-035 (1980) (2) USEPA; Health assessment document for chromium. Research Triangle Park, NC: USEPA 600/8-83-014F (1984) (3) Fishbein L; Environ Health Perspect 40: 43-64 (1981) (4) Schmidt JA, Andren AW; Adv Environ Sci Technol 14: 81-103 (1984) (5) Calimari D et al; Chemosphere 11: 59-70 (1982) (6) Kimbrough DE et al; Crit Rev Env Sci Technol 29: 1-46 (1999) (7) Camusso M et al; Ecotocol Environ Saf 31: 133-41 (1995) (8) Ramelow GJ et al; Arch Environ Contam Toxicol 18: 804-18 (1989) (9) Cary EE; pp. 49-64 in Topics in Environmental Health 5. Langard S, ed. NY, NY: Elsevier Biomed Press (1982) (10) Grubinger VP et al; Chemosphere 28: 717-20 (1994) (11) Petruzzelli G et al; Water Air Soil Pollut 32: 389-95 (1987)]**PEER REVIEWED**

No bioconcentration factor has been measured for Cr(III) in freshwater organisms(1). Bioconcentration factors for Cr(III) in saltwater organisms range from 86 to 153, which are comparable to the BCFs for Cr(VI) in saltwater species(1). In fish muscle, the BCF for Cr(VI) was <1; BCFs were 125 and 192 in oyster and blue oyster, respectively(2). For Cr(III), BCFs of 116, 153, 86 were reported for oyster, soft shell clam, and blue mussel, respectively(2). Weighted avg BCF for Cr(III) and Cr(VI) in the edible portion of fish/seafood was 16(2). Oysters were found after 84 days to have a BCF of 125 in their soft parts for Cr(VI), while blue mussels showed a BCF of 192(2). BCFs for Cr(VI) range from 125 to 236 for bivalve molluscs and polychaetes(3). BCFs for total chromium of 440 in mollusks, 100 in crustacean muscle, and 70 in fish muscle, have been reported(4). Snails showed a BCF of 10+6(5). BCFs for total chromium of 1600 in benthic algae, 2300 in phytoplankton, 1900 in zooplankton, have been reported(4). A shrub (Leptospermum scoparum) showed an accumulation factor of 10+3 compared to normal plants(5). Seaweed showed an accumulation factor of 10+2(5).
[(1) USEPA; Ambient Water Quality Criteria Doc: Chromium. USEPA 440/5-84-029 p.19 (1984) (2) USEPA; Ambient Water Quality Criteria Doc: Chromium. USEPA 440/5-80-035 p. C-7,8 (1980) (3) USEPA/OWRS; Quality Criteria for Water 1986 Chromium(VI). USEPA 440/5-86-001 (1986) (4) NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.86 (1974) (5) Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir. NRCC No.15017 p.16, 50 (1976)]**PEER REVIEWED**

Soil Adsorption/Mobility:

The adsorption of Cr(III) and Cr(VI) is complicated by redox changes that can occur in soil environments(1). Organic matter in soils can bring about the spontaneous reduction of Cr(VI) to Cr(III), even under alkaline conditions(2). Manganese oxides in soil oxidize Cr(III) to Cr(VI)(3). Chromate and dichromate ions form many soluble salts and thus represent the mobile and potentially toxic forms in soils(4). Under anaerobic conditions, these species are rapidly reduced to Cr(III) and precipitated as hydroxides and oxides(1). As soil conditions approach neutrality, the formation of dichromates is minimized(5). Cr(VI) is not sorbed to any significant degree by clays or hydrous metal oxides(1); however, it is strongly sorbed by activated carbon and therefore may have some affinity for organic matter in the environment(4). Adsorption of Cr(VI) by hydrous metal oxides and soil(4) decreases as pH increases(1). Some adsorption occurs on manganese and iron oxides(1). The presence of other anions (e.g., sulfate and phosphate) significantly affects the extent of adsorption by competing for adsorption sites(1). Formation of ion pairs, such as dissolved calcium chromate, can also reduce the extent of adsorption(1).
[(1) Bodek I et al, eds; Environmental Inorganic Chemistry. NY, NY: Pergamon Press, p. 7.6-1 to 7.6-12 (1988) (2) Callahan MA et al; Water-Related Environmental Fate of 129 Priority Pollutants. Vol I. Washington, DC: USEPA- 440/4 79-029a (1979) (3) Bartlett R, James B; J Environ Qual 8: 31-5 (1979) (4) Bartlett R, Kimble JM; J Environ Qual 5: 383-5 (1976) (5) Schroeder DC, Lee GF; Water Air Soil Pollut 4: 355-65 (1975)]**PEER REVIEWED**

In contrast to Cr(VI), the adsorption of Cr(III) increases as pH increases(1). In a laboratory study of adsorption of chromium onto clay minerals, under fixed conditions, it was found that 30 to 300 times more Cr(III) was adsorbed than Cr(VI)(1); e.g., Cr(III) on montmorillonite (sorption constant, umol/g) at pHs 2.45 (345), 3.0 (632,649), and 4.0 (2622, 2689); while Cr(VI) on montmorillonite (sorption constant, umol/g) at pHs 3.0 (3.64, 12.8), 4.0 (2.50, 10.3), 5.0 (2.22, 8.03), and 7.0 (0.98, 8.03)(1). The amounts of Cr(III) adsorbed correspond to adsorption of the hydrolyzed Cr(III) species on cation exchange sites(2). Sorption of Cr(III) onto bed sediments is an important removal mechanism(1,3). At low concn and low pH, where solubility of Cr(III) is higher, strong specific adsorption on iron and manganese oxides occurs(1). Formation of soluble organic complexes reduces the degree of adsorption(1). Organic material may also be an important absorbent in soil(1). Slight enrichment occurs in the humic acid fraction of sediments; the enrichment factor (defined as the ratio of metal concn in the humic acid fraction to its total concn in the associated sediments) is 0.83-1.9(4).

[(1) Bodek I et al, eds; Environmental Inorganic Chemistry. Properties, Processes, and Estimation Methods. NY, NY: Pergamon Press, p. 7.6-1 to 7.6-12 (1988) (2) Schmidt JA, Andren AW; Adv Environ Sci Technol 14: 81-103 (1984) (3) Callahan MA et al; Water-Related Environmental Fate of 129 Priority Pollutants. Vol I. Washington, DC: USEPA-440/4 79-029a (1979) (4) Nriagu JO, Coker RD; Environ Sci Technol 14: 443-6 (1980)]**PEER REVIEWED**

Chromium in soil is present mainly as an insoluble Cr(III) oxide, Cr2O3nH2O(1), and is not very mobile in soil(SRC). A leachability study was conducted to study the mobility of chromium in soil(2). Due to different pH values, a complicated adsorption process was observed and chromium moved only slightly in soil(2). Chromium was not found in the leachate from soil, possibly because it formed complexes with organic matter(2). These results support previous data finding that chromium is not very mobile in soil(2). These results are supported by leachability investigation in which chromium mobility was studied for a period of 4 years in a sandy loam(3). The vertical migration pattern of chromium in this soil indicated that after an initial period of mobility, chromium forms insoluble complexes and little leaching is observed(3). Flooding of soils and the subsequent anaerobic decomposition of plant detritus matters may increase the mobilization of **chromium(III)** in soils due to formation of soluble complexes(4). This complexation may be facilitated by a lower soil pH(4). A smaller percentage of total chromium in soil exists as soluble chromium(VI) and **chromium(III),** which are more mobile in soil(4). The sorption of chromium to soil depends primarily on the clay content of the soil and, to a lesser extent, on iron oxide (eg, Fe2O3) and the organic content of soil(5). Chromium that is irreversibly sorbed onto soil will not be bioavailable to plants and animals(5). Chromium in soil may be transported to the atmosphere as an aerosol(SRC). Surface runoff from soil can transport both soluble and bulk precipitate of chromium to surface water(6). Soluble and unadsorbed chromium(VI) and **chromium(III)** complexes in soil may leach into groundwater(6). The leachability of chromium(VI) in the soil increases as the pH of the soil increases(6). On the other hand, lower pH present in acid rain may facilitate leaching of acid-soluble **chromium(III)** and chromium(VI) compounds in soil(6).
[(1) USEPA; Health assessment document for chromium. Research Triangle Park, NC: USEPA 600/8-83-014F (1984) (2) Lin KY et al; Proc Natl Sci Counc Repub China B 20: 19-25 (1996) (3) Sheppard MI, Thibault DH; J Environ Qual 20: 101- 14 (1991) (4) Stackhouse RA, Benson WH; Ecotoxicol Environ Safety 17: 105-111 (1989) (5) King LD; J Environ Qual 17: 239-246 (1988) (6) Cary EE; pp. 49-64 in Topics in Environmental Health 5. Langard S, ed. NY, NY: Elsevier Biomed Press (1982)]**PEER REVIEWED**

Volatilization from Water/Soil:

Chromium compounds are expected to exist as ions in the environment and therefore volatilization from water surfaces is not expected to be an important fate process. Chromium compounds are not expected to volatilize from dry soil surfaces based upon their ionic character and low vapor pressures. (SRC)
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Environmental Water Concentrations:

Freshwater contains 0.0001-0.08 ppm chromium. /Soluble chromium salts/
[Bowen HJM, ed; Trace Elements in Biochem (1966) as cited in NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.9 (1974)]**PEER REVIEWED**

Ottawa River, at 7 sites: dissolved chromium ranged from 0.24 to 1.31 ppb. The fraction of Cr in particulate matter was 0-100%. /Soluble chromium salts/
[Merritt WF; Can J Earth Sci (1974) as cited in Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.25 (1976) NRCC No.15017]**PEER REVIEWED**

/Chromium/ in analysis of red water and in finished water in the Columbus, Ohio Distribution system:

0.001 mg/l (red water); 0.001 mg/l (domestic faucet); 0.0003 or < 0.0005 mg/l (finished water) /From table/ /Soluble chromium salts/
[National Research Council. Drinking Water & Health, Volume 4. Washington, DC: National Academy Press, 1981. 95]**PEER REVIEWED**

GROUNDWATER: The concns of total chromium in groundwater at the Idaho National Engineering Laboratory, where chromate is used as a corrosion inhibitor, ranged from <1 to 280 ug/l(1). The water from a village well situated near a waste pond receiving chromate waste in Douglas, MI, contained 10,800 ug/l chromium(VI)(1). Similarly, water from a private well adjacent to an aircraft plant in Nassau County, NY, contained 25,000 ug/l chromium(VI), while water from a public well adjacent to another aircraft plant in Bethpage, NY, contained 1,400 ug/l chromium(VI)(2). In a later study, water from an uncontaminated well in Nassau County, NY, contained an undetectable level of chromium(VI), whereas a contaminated well in the vicinity of a plating plant contained 6,000 ug/l chromium(VI)(3). A high chromium concn (120 ug/l) was detected in private drinking water wells adjacent to a NPL site in Galena, KS(4). 2,327 of 6,393 of the groundwater sources in the National Contaminant Occurrence Database (NCOD) contained dissolved chromium; the mean dissolved chromium concn was 19.13 +/- 481.20 ug/l(5); 162 of 416 of the groundwater sources in the NCOD contained Cr(VI); the mean Cr(VI) concn was 20.99 +/- 52.43 ug/l(5). Natural Chromium levels in ground waters of the Netherlands range from < 0.5-2 ppb(6).
[(1) USGS; 1989. Concns of nine trace metals in ground water at the Idaho National Engineering Laboratory, Idaho. Idaho Falls, Idaho: USGS, USDOE NTIS DE88015177 (1989) (2) Davids HW, Lieber M; Water Sewage Works 98: 528-34 (1951) (3) Lieber M et al; J Am Water Works Assoc 56: 739-47 (1964) (4) ATSDR; Health assessment for Cherokee County-Galena subsite National Priorities List (NPL) site, Galena, Cherokee County, Kansas, Region 7. Atlanta, GA: ATSDR CERCLIS No. KSD980741862. NTIS PB90-112053 (1990) (5) USEPA; National Contaminant Occurrence Database (NCOD) for Chromium. Available from the Database Query page at http://oaspub.epa.gov/ncod/rpt_options_ambient_pkg.national_state_selection as of Aug 8, 2001. (6) Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir. NRCC No.15017 p.36 (1976)]**PEER REVIEWED**

SURFACE WATER: Chromium concns in US river water usually range from <1 to 30 ug/l(1-3), with a median value of 10 ug/l(4,5). Chromium concns in lake water generally do not exceed 5 ug/l(6,7). The higher levels of chromium can be related to source(s) of anthropogenic pollution(6,7). Dissolved chromium concns of 0.57-1.30 ug/l were reported in the Delaware River near Marcus Hook and Fieldsboro, PA in January 1992, with **chromium(III)** composing 67% of the total(8). In March 1992 these concns decreased to 0.03-0.23 ug/l(8). The mean chromium concn in ocean water is 0.3 ug/l, with a range of 0.2-50 ug/l(7). In general, the concn of chromium in ocean water is much lower than that in lakes and rivers(SRC). All 4 of the estuary sources in the National Contaminant Occurrence Database (NCOD) contained dissolved chromium; the mean concn was 7.49 +/- 23.39 ug/l(9). The mean concn of dissolved chromium was 1.52 +/- 3.04 ug/l(9) from 69 of 224 of the lake/reservoir sources in the NCOD(9). 663 of 2,395 other surface water sources in the NCOD contained dissolved chromium; the mean concn was 15.17 +/- 50.29 ug/l(9). The mean concn of Cr(VI) was 1.69 +/- 0.83 ug/l from 18 of 58 other surface water sources in the NCOD(9). The avg concn of total dissolved chromium in surface waters of Lakes Superior, Erie, and Ontario were 69 ng/l, 136 ng/l, and 351 ng/l, respectively(10). Cr(VI) made up 75-85% of total dissolved chromium(10). The avg concn in Lake Ontario is about 2.5 times higher than in Lake Erie and about 4.5 times higher than in Lake Superior(10).
[(1) USEPA; Health assessment document for chromium. Research Triangle Park, NC: Environ Assess Crit Off, USUSEPA 600/8-83-014F (1984) (2) Malm O et al; Sci Total Environ 75: 201-9 (1988) (3) Ramelow GJ et al; Environ Pollut 43: 247-63 (1987) (4) Eckel WP, Jacob TA; Proc 196th meet Amer Chem Soc Div Environ Chem 28: 371-372 (1988) (5) Smith, RA et al; Science 235: 1607-15 (1987) (6) Borg H; Water Res 21: 65-72 (1987) (7) Cary EE; pp. 49-64 in Topics in Environmental Health 5. Langard S, ed. NY, NY: Elsevier Biomed Press (1982) (8) Riedel GF, Sanders JG; Estuaries 21: 78-90 (1998) (9) USEPA; National Contaminant Occurrence Database (NCOD) for

Chromium. Available from the Database Query page at http://oaspub.epa.gov/ncod/rpt_options_ambient_pkg.national_state_selection as of Aug 8, 2001. (10) Beaubien S et al; Environ Sci Technol 28: 730-6 (1994)]**PEER REVIEWED**

SURFACE WATER: Fifteen rivers in US rivers were found to contain > 0.7 ug/l (Sacramento River) to 84 ug/l (Mississippi River); the avg ranged from 1-10 ug/l chromium, depending on size and soil composition(1). Seawater chromium concns are usually below 1 ug/l(1). Seawater samples taken near the coast of Japan contained 0.04-0.07 ppb chromium; near England, 0.13-0.25 ppb; in the Ligurian Sea, 0.2-0.4 ppb; and in the Irish Sea, 0.46 ppb(1).
[(1) NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.10 (1974)]**PEER REVIEWED**

SURFACE WATER: Frequency of dissolved chromium levels in Canadian streams and rivers was as follows: < 10 ppb, 4163 samples (95.9%)(1); 10-14 ppb, 92 samples (2.12%)(1); 15-24 ppb, 62 samples (1.43%)(1); 25-49 ppb, 19 samples (0.44%)(1); 50-99 ppb, 4 samples (0.092%)(1); and 100-500 ppb, 2 samples (0.046%)(1). In the Ottawa River (Canada) at 7 sites, the dissolved chromium ranged from 0.24 to 1.31 ppb(1).
[(1) Nat'l Research Council Canada; Effects of Chromium in the Canadian Environment. NRCC No 15017 p.25, 35 (1976)]**PEER REVIEWED**

DRINKING WATER: The chromium levels detected in drinking water in an earlier study (1962-1967 survey) may be erroneous due to questionable sampling and analytical methods(1). A survey conducted from 1974 to 1975 that had a detection limit of 0.1 ug/l and surveyed 3,834 US tap waters probably provides better estimates of chromium concns in US drinking water(2). The survey reported chromium concns in drinking water that ranged from 0.4 to 8.0 ug/l, with a mean value of 1.8 ug/l(2). These values may be higher than the actual values, due to inadequate flushing of tap water before sample collection(1). The concn of chromium in household tap water may be higher than supply water due to corrosion of chromium-containing pipes(1). At a point of max contribution from corrosion of the plumbing system, the peak chromium in tap water in Boston, Massachusetts, was 15 ug/l(3). A survey that targeted drinking waters from 115 Canadian municipalities during 1976-1977 reported the median and the range of chromium concns to be <2.0 ug/l (at detection limit) and <2.0-8.0 ug/l, respectively(4). In the National Contaminant Occurrence Database (NCOD), chromium was detected in 106 of 349 public water systems in the US in which the source was derived from surface water(5); the mean concn of chromium in these systems was 282.2 +/- 690.1 ug/l(5). In the NCOD, chromium was detected in 544 of 2,007 public water systems in the US in which the source was derived from groundwater(5); the mean concn of chromium in these systems was 146.7 ug/l +/- 634.0 ug/l(5).
[(1) USEPA; Health assessment document for chromium. Research Triangle Park, NC: Environ Assess Crit Off, USEPA 600/8-83-014F (1984) (2) Greathouse DG, Craun GF; pp. 31-9 in Trace substances in environmental health. Vol. XII. Hemphil DD, ed. Columbia, MO: Univ Missouri (1978) (3) Ohanian EV; Trace Substances and Environmental Health 20: 122-38 (1986) (4) Meranger JC et al; Environ Sci Technol 13: 707-11 (1979) (5) USEPA; National Contaminant Occurrence Database (NCOD) for Chromium. Available from the Database Query page at http://oaspub.epa.gov/ncod/rpt_options_pws_pkg.national_state_selection as of Aug 8, 2001.]**PEER REVIEWED**

DRINKING WATER: Median chromium concentrations in tap water from Dallas, TX was 4.0 ug/l (range, 1.0-20 ug/l)(1). In 1962, the median concn of chromium was 0.4 ug/l (range, 0.2-35 ug/l) in the 100 largest US cities(1). 380 finished waters in US between 1962-1967 had a median concn of 7.5 ug/l (range, 1.0-29 ug/l)(1). 3,834 tap waters in US between 1974-1975 had a median concn of Cr of 1.8 ug/l (range, 0.4-8 ug/l)(1). 83 Midwestern cities in US had chromium concns that ranged from <5.0-17.0 ug/l(1). In Canada, background levels in water averaged 1 ppb while municipal drinking water contain 0.1-35 ppb(2). 115 Canadian municipalities between 1975-1977 had chromium concns < 2.0 ug/l (range,

< 2.0-4.1 ug/l)(1).
[(1) USEPA; Health Assessment Document: Chromium. USEPA 600/8-83-014F p.3-27 (1984) (2) Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir. NRCC No.15017 p.14 (1976)]**PEER REVIEWED**

RAIN/SNOW: The mean concn of chromium in rainwater is 0.14-0.9 ug/l(1,2). Natural chromium levels (total dissolved & undissolved chromium) in rainwater range from 2.0 to 3.6 ng/cu m(3). The median concn of chromium in rainwater samples collected during the summer 1994 in eight arctic catchments in Northern Europe ranged from <0.2-0.47 ug/l(4). The highest concns were observed near metal smelters located in the region(4). The concn of chromium in rainwater from Riyadh, Saudi Arabia ranged from not detected-5.8 ug/l in 1994(5). The concn of chromium in the particulate portion of melted snow collected from two urban areas (Toronto and Montreal) of Canada ranged from 100 to 3,500 mg/kg(6).
[(1) Barrie LA et al; Atmos Environ 21: 1133-5 (1987) (2) Dasch JM, Wolff GT; Water Air Soil Pollut 43: 401-12 (1989) (3) Nat'l Research Council Canada; Effects of Chromium in the Canadian Environment. NRCC No 15017 p.35 (1976) (4) Reimann C et al; Atmos Environ 31: 159-70 (1997) (5) Alabdula'aly AI, Khan MA; Arch Environ Contam Toxicol 39: 66-73 (2000) (6) Landsberger S et al; Int J Environ Anal Chem 16: 95-130 (1983)]**PEER REVIEWED**

Effluent Concentrations:

Untreated effluents may contain as much as 5x10+7 ppb chromium. Cr(III) is adsorbed on particulate matter & Cr(VI) remains in soln reducing to Cr(III) when reacting with animal or vegetable material. /Cr(III) and Cr(VI)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.14 (1976) NRCC No.15017]**PEER REVIEWED**

Screening of three chrome pigment plants showed 55-310 ppm chromium(VI) in raw waste streams, and, at one facility, 130 ppm in treated waste effluent. /Cr(VI)/
[USEPA; Background Document Resource Conser and Recovery Act Subtitle C: Identification and Listing of Hazardous Waste p.202 (1980)]**PEER REVIEWED**

Chromium is released into the atmosphere mainly by anthropogenic stationary point sources, including industrial, commercial, and residential fuel combustion, via the combustion of natural gas, oil, and coal(1). Other important anthropogenic stationary point sources of chromium emission to the atmosphere are metal industries(1). It has been estimated that ca 16,000 metric tons of chromium were emitted into the atmosphere from US anthropogenic sources in 1970(1). These older estimates indicated that emissions from the metal industry ranged from 35% to 86% of the total, and emissions from fuel combustion ranged from 11% to 65% of the total(2). More recent estimates of atmospheric chromium emission in 1976 and 1980 in the Los Angeles, California, and Houston, Texas, areas indicate that emissions from stationary fuel combustion are ca 46-47% of the total, and emissions from the metal industry range from 26 to 45% of the total(3). The primary stationary nonpoint source of chromium emission into the atmosphere is fugitive emissions from road dusts(4). Other potentially small sources of atmospheric chromium emission are cement-producing plants (cement contains chromium), the wearing down of asbestos brake linings that contain chromium, incineration of municipal refuse and sewage sludge, and emission from chromium-based automotive catalytic converters(4). Emissions from cooling towers that previously used chromate chemicals as rust inhibitors are also atmospheric sources of chromium(4,5).
[(1) USEPA; Health assessment document for chromium. Research Triangle Park, NC: Environ AssessCrit Off, USEPA 600/8-83-014F (1984) (2) USEPA; Reviews of the environmental effects of pollutants: III. Chromium. Cincinnati, OH: Off Res Devel, USEPA-600/1-78-023 (1978) (3) Cass GR, McRae GJ; pp. 145-71 in Toxic metals in the atmosphere. Nriagu JO, Davidson CI eds. NY, NY: John Wiley and Sons Inc (1986) (4) USEPA; Locating and estimating air emissions from sources of chromium. Research Triangle Park, NC: Off Air Qual Plan Stand, NTIS PB85-106474 (1984) (5) Fishbein L;

Environ Health Perspect 40: 43-64 (1981)]**PEER REVIEWED**

The estimates of US atmospheric chromium emissions (and %Cr(VI) emissions) from anthropogenic sources (numbers are estimated) are as follows(1): combustion of coal and oil, 1,723 metric tons/yr (many sources; 0.2% Cr(VI)); chromium chemical manufacturing, 18 metric tons/yr (2 sources; 67% Cr(VI)); chemical manufacturing cooling towers, 43 metric tons/yr (2,039 sources; 100% Cr(VI)); petroleum refining cooling towers, 32 metric tons/yr (475 sources; 100% Cr(VI)); specialty/steel production, 103 metric tons/yr (18 sources; 2.2% Cr(VI); primary metal cooling towers, 8 metric tons/yr (224 sources; 100% Cr(VI)); chrome plating, 700 metric tons/yr (4,000 sources; ca 100% Cr(VI)); comfort cooling towers, 7.2- 206 metric tons/yr (38,000 sources; 100% Cr(VI)); textile manufacturing cooling tower, 0.1 metric tons/yr (51 sources; 100% Cr(VI)); refractory production, 24 metric tons/yr (10 sources; 1.3% Cr(VI)); ferrochromium production, 16 metric tons/yr (2 sources; 5.4% Cr(VI)); sewage sludge incineration, 13 metric tons/yr (133 sources; <0.1% Cr(VI)); tobacco cooling towers, 0.2 metric tons/yr (16 sources; 100% Cr(VI)); utility industry cooling towers, 1.0 metric tons/yr (6 sources; 100% Cr(VI)); chrome ore refining, 4.8 metric tons/yr (6 sources; <0.1% Cr(VI)); tire and rubber cooling tower, 0.2 metric tons/yr (40 sources; 100% Cr(VI)); glass manufacturing cooling towers, 0.01 metric tons/yr (3 sources; 100% Cr(VI)); cement production, 3 metric tons/yr (145 sources, 0.2% Cr(VI)); municipal refuse incineration, 2.5 metric tons/yr (95 sources, 0.3% Cr(VI)). The total estimate of US atmospheric chromium emissions from anthropogenic sources is 2,700 to 2,900 metric tons/yr(1).
[(1) USEPA; Noncarcinogenic effects of chromium: Update to health assessment document. Research Triangle Park, NC: Environ Crit Assess Off, Off Health Environ Assess, USEPA 600/8-87/048F (1990)]**PEER REVIEWED**

Cement-producing plants are a potential source of atmospheric chromium(1). Portland cement contains 41.2 mg/kg chromium (range, 27.5-60 mg/kg)(1). Soluble chromium accounts for 4.1 mg/kg (range, 1.6-8.8 mg/kg) of which 2.9 mg/kg (range, 0.03-7.8 mg/kg) is chromium(VI)(1). The wearing down of vehicular brake linings that contain asbestos represents another source of atmospheric chromium(1). Asbestos may contain ca 1,500 mg/kg of chromium(1). The introduction of catalytic converters on US automobiles in 1975 in the United States represented an additional source of atmospheric chromium(1). Catalysts, such as copper chromite, emit <10+6 metal-containing condensation nuclei per cubic centimeter in vehicular exhaust, under various operating conditions(1).
[(1) Fishbein L; Environ Health Perspect 40: 43-64 (1981)]**PEER REVIEWED**

The most significant anthropogenic point sources of chromium in surface waters and groundwaters are the waste waters from electroplating operations, leather tanning industries, and textile manufacturing(1). In addition, deposition of airborne chromium is also a significant non-point source of chromium in surface water(1). In a 1972 survey, the contribution of different sources to chromium load in the influent waste water of a treatment plant in New York City was estimated to be as follows: electro-plating industry, 43%; residential waste water, 28%; other industries, 9%; runoff, 9%; and unknown, 11%(2). On a worldwide basis, the major chromium source in aquatic ecosystems is domestic waste water effluents (32.2% of the total)(3). The other major sources are metal manufacturing (25.6%), ocean dumping of sewage (13.2%), chemical manufacturing (9.3%), smelting and refining of nonferrous metals (8.1%), and atmospheric fallout (6.4%)(3). Annual anthropogenic input of chromium into water has been estimated to exceed anthropogenic input into the atmosphere(3). The mass loading of chromium by direct discharges to the Newark Bay Estuary from municipal treatment systems, industry direct discharge, combined sewer overflows, stormwater runoff, and tributary flow were 34.98, 0.58, 39.0, 33.9, and 10.9 kg/day, respectively(4). Indirect discharges to Newark Bay from the Passaic Valley Sewer Commission and Middlesex County Sewer Authority were 138.9 and 5.25 kg/day, respectively(4).
[(1) Fishbein L; Environ Health Perspect 40: 43-64 (1981) (2) Klein LA et al; J Water Pollut Control Fed 46: 2653-62 (1974) (3) Nriagu JO, Pacyna JM; Nature 333: 134-9 (1988) (4) Crawford DW et al; Ecotoxicol Environ Saf 30: 85-100 (1995)]**PEER REVIEWED**

On a worldwide basis, the disposal of commercial products that contain chromium may be the largest contributor, accounting for ca 51% of the total chromium released to soil(1). Other significant sources of chromium release into soil include the disposal of coal fly ash and bottom fly ash from electric utilities and other industries (33.1%), agricultural and food wastes (5.3%), animal wastes (3.9%), and atmospheric fallout (2.4%)(1). Solid wastes from metal manufacturing constituted <0.2% to the overall chromium release in soil(1).
[(1) Nriagu JO, Pacyna JM; Nature 333: 134-9 (1988)]**PEER REVIEWED**

Sediment/Soil Concentrations:

SOILS: The chromium level in soils varies greatly and depends on the composition of the parent rock from which the soils were formed(SRC). Basalt and serpentine soils, ultramafic rocks, and phosphorites may contain chromium as high as a few thousand mg/kg(1) whereas soils derived from granite or sandstone will have lower concns of chromium(2). The concn range of chromium in 1,319 samples of soils and other surficial materials collected in the conterminous US was 1-2,000 mg/kg, with a geometric mean of 37 mg/kg(3). Chromium concns in Canadian soils ranged from 5 to 1,500 mg/kg, with a mean of 43 mg/kg(4). The mean concn of chromium in sandy soils from around the world was 47 mg/kg (dry wt)(5). The geometric mean concn of chromium in Florida soils was 3.7 mg/kg (dry wt)(5). In a study with different kinds of soils from 20 diverse sites including old chromite mining sites in MD, PA, and VA, the chromium concn ranged from 4.9 to 71 mg/kg(6). A polynuclear aromatic hydrocarbon (PAH) soil study was conducted to determine the metal levels in soil at the edge of a busy road that runs through the Aplerbecker Forest in Germany(7). Chromium(VI) concns of 64 mg/kg were measured, and these concns were 2- to 4-fold higher along the road than in the natural forest(7). The soil beneath decks treated with chrominated copper arsenate (CCA), a wood preservative, had an avg chromium content of 43 mg/kg(8). Chromium has been detected at a high concn (43,000 mg/kg) in soil at the Butterworth Landfill site in Grand Rapid City, MI, which was a site listed on the NPL(9).
[(1) Merian E; Toxicol Environ Chem 8: 9-38 (1984) (2) Swaine DJ, Mitchell RL; J Soil Sci 11: 347-68 (1960) (3) USGS; Element concentrations in soils and other surficial materials of the conterminous United States. USGS Professional Paper 1270. Washington, DC: USGS (1984) (4) Cary EE; pp. 49-64 in Topics in Environmental Health 5. Langard S, ed. NY, NY: Elsevier Biomed Press (1982) (5) Ma LQ et al; J Environ Qual 26: 769-75 (1997) (6) Beyer WN, Cromartie EJ; Environ Monit Assess 8: 27-36 (1987) (7) Munch D; Sci Total Environ 138: 47-55 (1993) (8) Stillwell DE, Gorny KD; Bull Environ Contam Toxicol 58: 22-9 (1997) (9) ATSDR; Health assessment for Butterworth Landfill, Kent County, Michigan, Region 5. Atlanta, GA: ATSDR CERCLIS No. MIDO62222997. NTIS PB90-106899 (1990)]**PEER REVIEWED**

SEDIMENTS: Chromium was detected in sediment obtained from the coastal waters of the eastern US seashore at concns of 3.8-130.9 ug/g in 1994 and 0.8-98.1 ug/g in 1995(1). In the suspended materials and sediment of water bodies, chromium levels ranged from 1 to 500 mg/kg(2-5). Trace-element concns in 541 streambed- sediment samples collected from 20 study areas across the conterminous US were examined as part of the National Water-Quality Assessment Program of USGS (1992-1996); the median and range of concn(s) of chromium was 64 ug/g (dry wt) and <1.0-700 ug/g (dry wt), respectively(6). Mean chromium levels in Great Lakes and in river mouth sediments of the Great Lakes were as follows (as dry weight): Lake Superior, 8.6 ppm (range, trace-27.2ppm); Lake Michigan, 84.6 ppm (range, trace-2,085 ppm); Georgian Bay, 10.6 ppm (range, 0.9-37.8 ppm); Lake Huron, 3.8 ppm (range, trace-10.5 ppm); Detroit River-St. Claire, 20.5 ppm (range, 5.0-89.4 ppm); Lake Erie, 29.5 ppm (range, 3.4-156.8 ppm); Lake Ontario, 18.3 ppm (range 4.5-51.8 ppm)(7). The mean concn of chromium in river sediments from the heavily polluted West Branch of the Grand Calumet River (IN-IL) was 288 +/- 298 ppm (grab sample)(8).
[(1) Hyland JL et al; Environ Monitor Assess 51: 331-43 (1998) (2) Byrne CJ, DeLeon IR; Bull Environ Contam Toxicol 37: 151-8 (1986) (3) USEPA; Health assessment

document for chromium. Research Triangle Park, NC: Environ Assess Crit Off, USEPA 600/8-83-014F (1984) (4) Mudroch A et al; J Great Lakes Res 14: 241-51 (1988) (5) Ramelow GJ et al; Environ Pollut 43: 247-63 (1987) (6) Rice KC; Environ Sci Technol 33: 2499-2504 (1999) (7) Nat'l Research Council Canada; Effects of Chromium in the Canadian Environment. NRCC No 15017 p.39 (1976) (8) Cahill RA, Unger MT; Wat Sci Tech 28: 53-8 (1993)]**PEER REVIEWED**

Atmospheric Concentrations:

The concns of chromium range from 0.0012-0.0026 ug/cu m in the Norwegian arctic & 0.00006-0.00041 ug/cu m in the Canadian arctic. /Total chromium/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.83 (10/87)]**PEER REVIEWED**

Annual mean concn for ambient chromium, over the time period from 1962 to 1969, in 20 of the larger (or more industrialized) cities in the country, revealed values ranging from 0.01 to 0.03 ug/cu m, in urban areas, and values seldom reaching 0.01 ug/cu m, in rural areas. /Total chromium/
[NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.13-14 (1974)]**PEER REVIEWED**

URBAN/SUBURBAN: The atmospheric total chromium concn in the United States is typically 10-30 ng/cu m in urban areas(1). Levels of total chromium in the ambient air in US urban and nonurban areas during 1977-1984 are reported in USEPA's National Aerometric Data Bank(2,3). According to this databank, the arithmetic mean total chromium concns from a total of 2,106 monitoring stations ranged from 5 to 525 ng/cu m(2). The two locations that showed the highest total arithmetic mean chromium concns were in Steubenville, OH, in 1977 (525 ng/cu m) and in Baltimore, MD, in 1980 (226 ng/cu m)(2). Arithmetic mean total chromium concns in only 8 of 173 sites monitored in 1984 were >100 ng/cu m(2). By comparing the levels of atmospheric chromium at 59 sites in US cities during 1968-1971 with data from EPA's National Aerometric Data Bank file for 1975-1983, it may be concluded that atmospheric chromium levels may have declined in the early 1980s from the levels detected in the 1960s and 1970s(4). During the summer of 1994, the avg concn of Cr(VI) was 0.65 +/- 0.38 ng/cu m in outdoor air near 33 homes located in Hamilton, Ontario, Canada(5).
[(1) Fishbein L; Int J Environ Anal Chem 17: 113-70 (1984) (2) USEPA; Noncarcinogenic effects of chromium: Update to health assessment document. Research Triangle Park, NC: Environ Crit Assess Off, Off Health Environ Assess, USEPA 600/8-87/048F (1990) (3) Wiersema JM et al; p. 2-15 in Human exposure to potentially toxic elements through ambient air in Texas. Austin, TX: Proc 77th mtg Air Poll Control Assoc (1984) (4) Saltzman BE et al; Environ Sci Technol 19: 328-33 (1985) (5) Bell RW, Hipfner JC; Air Waste Manage Assoc 47: 905-10 (1997)]**PEER REVIEWED**

URBAN/SUBURBAN: In urban areas values range 10-60 ng/cu m(1). Levels of chromium in air exceeding 0.01 ug/cu m have been reported from 59 of 186 urban areas(2).
[(1) Nat'l Res Council of Canada; Effects of Chromium in the Canadian Environ. NRCC No.15017 p.14 (1976) (2) USEPA; Ambient Water Quality Criteria Doc: Chromium. USEPA 440-5-80-035 p. C-5 (1980)]**PEER REVIEWED**

RURAL/REMOTE: The atmospheric total chromium concn in the US is typically <10 ng/cu m in rural areas(1). The concns of atmospheric chromium in remote areas range from 0.005 to 2.6 ng/cu m(2-6). Remote sampling data from a number of investigators point to a world background chromium concn in lower atmosphere aerosols ranging from 0.3-2 ng/cu m, with an avg near 1 ng/cu m(7).
[(1) Fishbein L; Int J Environ Anal Chem 17: 113-70 (1984) (2) Barrie LA, Hoff RM; Atmos Environ 19: 1995-2010 (1985) (3) Cary EE; pp. 49-64 in Topics in Environmental Health 5. Langard S, ed. NY, NY: Elsevier Biomedical Press (1982) (4) Schroeder WH et al; J Air Pollut Control Assoc 37: 1267-85 (1987) (5) Sheridan PJ, Zoller WH; J Atmospher Chem 9: 363-81 (1989) (6) USEPA; Health Assessment Document: Chromium USEPA 600/8-83-014F p. 2-3 (1984) (7) Nat'l Research Council Canada; Effects of Chromium in the Canadian Environment. NRCC No 15017 p. 33 (1976)]**PEER REVIEWED**

INDOOR AIR: An indoor/outdoor air study was conducted in southwestern Ontario to measure levels of chromium(VI) and the size fraction of chromium(VI)(1). Indoor and outdoor samples were taken from 57 homes during the summer months of 1993(1). The concns were 0.1-0.6 ng/cu m indoors (geometric mean 0.2 ng/cu m) and were 0.10-1.6 ng/cu m outdoors (geometric mean 0.55 ng/cu m)(1). The indoor concns were less than 1/2 of the outdoor concns(1). Analysis of airborne chromium(VI) particles showed that they are inhalable in size(1). The concns of chromium(VI) in the indoor air of residences in Hudson County, New Jersey, in 1990, ranged from 0.38 to 3,000 ng/cu m, with a mean of 1.2 ng/cu m(2). In a field study to assess inhalation exposure to chromium during showering and bathing activities, the avg chromium(VI) concn in airborne aerosols ranged from 87 to 324 ng/cu m when water concns of 0.89-11.5 mg/l of chromium(VI) were used in a standard house shower(3). During the summer of 1994, the avg concn of Cr(VI) was 0.23 +/- 0.13 ng/cu m in the indoor air of 33 homes located in Hamilton, Ontario, Canada(4).
[(1) Bell RW, Hipfner JC; J Air Waste Manage Assoc 47: 905-10 (1997) (2) Falerios M et al; J Air Waste Manage Assoc 42: 40-8 (1992) (3) Finley BL et al; J Expo Anal Environ Epidemiol 6: 229-45 (1996) (4) Bell RW, Hipfner JC; Air Waste Manage Assoc 47: 905-10 (1997)]**PEER REVIEWED**

SOURCE DOMINATED: During the period 1978-1982, the max level of total chromium in ambient air samples in Corpus Christi, Texas, a site of chromate manufacture, was 5,500 ng/cu m(1). The annual avg concn of chromium in Corpus Christi ambient air was 400 ng/cu m during the same period (1). The EPA monitored two locations in Corpus Christi in 1981 and reported an arithmetic mean chromium concn of 100 ng/cu m(2). An indoor/outdoor study was conducted at 25 industrial sites in Hudson County, New Jersey to analyze soils containing chromite ore processing residues(3). The industrial sites include industrial, manufacturing, trucking, and warehouse facilities(3). The study found industrial indoor chromium(VI) and total chromium concns to be 0.23-11 ng/cu m and 4.1-130 ng/cu m and industrial outdoor chromium(VI) and total chromium concns to be 0.013-15.3 ng/cu m and 1.9-84.5 ng/cu m(3). The results of this study found that higher levels of chromium(VI) in soil do not result in higher levels of chromium(VI) in air(3). The mean concn of total chromium at the same sites was 7.1 ng/cu m, with a concn range of 3.7-12 ng/cu m(3). Recent monitoring data in Hudson County, NJ has shown a background chromium(VI) concn of 0.2 to 3.8 ng/cu m with a mean concn of 1.2 ng/cu(4). The airborne total chromium concn range was 1.5-10 ng/cu m with a mean concn of 4.5 ng/cu m(4). The mean airborne chromium(VI) and total chromium concns in the indoor air of industrial sites in Hudson County, New Jersey, contaminated by chromite ore-processing residue were 3 ng/cu m (range, 0.23-11 ng/cu m) and 23 ng/cu m (range, 4.11-130 ng/cu m), respectively(5). The mean airborne chromium(VI) and total chromium concns in outdoor air for the same sites were 9.9 ng/m 3 (range, 0.13-110 ng/cu m) and 37 ng/cu m (range, 1.9-250 ng/cu m), respectively(5). An air dispersion model was recently developed which accurately estimated chromium(VI) concns at two of these industrial sites in Hudson County, NJ(6). The background corrected airborne concns for seven sampling dates are reported as measured (estimated): 0.0 (0.41) ng/cu m; 6.2 (7.7) ng/cu m; 0.9 (1.7) ng/cu m; 2.8 (2.7) ng/cu m; 0.0 (0.08) ng/cu m; 0.3 (0.1) ng/cu m; and 1.2 (0.12) ng/cu m(6). Fly ash from a coal-fired power plant contained 1.4-6.1 mg/kg chromium(VI)(7).
[(1) Wiersema JM et al; p. 2-15 in Human exposure to potentially toxic elements through ambient air in Texas. Austin, TX: Proc 77th mtg Air Poll Control Assoc (1984) (2) USEPA; Noncarcinogenic effects of chromium: Update to Health Assessment Document. Research Triangle Park, NC: Environ Crit Assess Off, Off Health Environ Assess, USEPA 600/8-87/048F (1990) (3) Finley B et al; Appl Occup Environ Hyg 8: 191-200 (1993) (4) Scott PK et al; J Air Waste Manage Assoc 47: 592-600 (1997) (5) Falerios M et al; J Air Waste Manage Assoc 42: 40-8 (1992) (6) Scott PK et al; J Air Waste Manage Assoc 47: 753-65 (1997) (7) Stern RM et al; Toxicol Environ Chem 8: 95-108 (1984)]**PEER REVIEWED**

Food Survey Values:

Total chromium levels in most fresh foods are extremely low (vegetables (20-50 ug/kg), fruits (20 ug/kg), and grains and cereals (40 ug/kg))(1). In a study to find the concns of chromium in edible vegetables in Tarragon Province, Spain, the highest levels of chromium were found in radish root and spinach, with a non-significant difference between the samples collected in two areas (northern industrial and southern agricultural)(2). The samples ranged in concn from 0.01 ug/g to 0.21 ug/g (industrial) and from 0.01 ug/g to 0.22 ug/g (agricultural)(2). Acidic foods that come into contact with stainless steel surfaces during harvesting, processing, or preparation for market are sometimes higher in chromium content because of leaching conditions(3,4). Processing, however, removes a large percentage of chromium from foods (eg, whole-grain bread contains 1,750 ug/kg chromium, but processed white bread contains only 140 ug/kg; and molasses contains 260 ug/kg chromium, but refined sugar contains only 20 ug/kg chromium)(3,4).
[(1) Fishbein L; Int J Environ Anal Chem 17: 113-70 (1984) (2) Schuhmacher M et al; Bull Environ Contam Toxicol 50: 514-21 (1993) (3) Anderson RA; Sci Total Environ 17: 13-29 (1981) (4) USEPA; Health Assessment Document for Chromium. Research Triangle Park, NC: Environ Assess Crit Off, USEPA 600/8-83-014F (1984)]**PEER REVIEWED**

The mean chromium concn in various US foods are as follows: fresh vegetables, 20-140 ug/kg(1); frozen vegetables, 230 ug/kg(1); canned vegetables, 230 ug/kg(1); fresh fruits, 90-190 ug/kg(1); fruits, 20 ug/kg(1); canned fruits, 510 ug/kg(1); dairy products, 100 ug/kg(1); chicken eggs, 160-520 ug/kg(2); whole fish, 50-80 ug/kg(1); edible portion of fresh fin fish, <100-160 ug/kg(3); meat and fish, 110-230 ug/kg(1); seafoods, 120-470 ug/kg(1); grains and cereals, 40-220 ug/kg(1); refined sugar, <20 ug/kg(4).
[(1) USEPA; Health Assessment Document for Chromium. Research Triangle Park, NC: Environ Assess Crit Off, USEPA 600/8-83-014F (1984) (2) Kirkpatrick DC, Coffin DE; J Food Sci Agric 26: 99-103 (1975) (3) Eisenberg M, Topping JJ; J Environ Sci Health 21: 87-102 (1986) (4) WHO; Environmental health criteria 61: Chromium. Geneva, Switzerland: WHO pp. 197 (1988)]**PEER REVIEWED**

Chromium content of various foodstuffs (ug/g fresh weight): milk and dairy products, 0.05-0.23; meat, fish, and poultry, 0.06-0.23; cereals, 0.06-0.22; potatoes, 0.04-0.26; leafy vegetables, 0.09-0.11; legumes, 0.04-0.16; root vegetables, 0.06-0.15; garden fruits, 0.05-0.23; fruits, 0.05-0.09; oils and fats, 0.03-0.18; sugars and candy, 0.17-0.34; drinks, 0.03-0.07; and condiments, 0.33(1). The relative amt of chromium extracted from 1 g fresh weight of selected food were as follows: brewer's yeast, 44.88 ug, black pepper, 10.21 ug; calves liver, 4.52 ug; wheat germ, 4.05 ug; margarine, 2.48 ug; mushrooms, 1.92 ug; beer, 1.77 ug; egg white, 1.77 ug(1).
[(1) Nat'l Research Council Canada; Effects of Chromium in the Canadian Environment. NRCC No 15017 p. 44-5 (1976)]**PEER REVIEWED**

Chromium content of various foodstuffs (ug/g fresh weight): milk and dairy products, 0.05-0.23; meat, fish, and poultry, 0.06-0.23; cereals, 0.06-0.22; potatoes, 0.04-0.26; leafy vegetables, 0.09-0.11; legumes, 0.04-0.16; root vegetables, 0.06-0.15; garden fruits, 0.05-0.23; fruits, 0.05-0.09; oils and fats, 0.03-0.18; sugars and candy, 0.17-0.34; drinks, 0.03-0.07; and condiments, 0.33. /Total chromium/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Environment p.44 (1976) NRCC No 15017]**PEER REVIEWED**

Plant Concentrations:

Chromium concns in potatoes & hay were 80 and 590 ppb, respectively. Cr content in hay incr sharply at the time of seed ripening. /Total chromium/
[NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.11 (1974)]**PEER REVIEWED**

Higher plants - conifers, deciduous trees, and shrubs take up less chromium (18-73 ppm) than lower plants - lichens, mosses, ferns, and grasses (100-650 ppm) on ultrabasic soils (2,000-6,000 ppm). Also,

lichens and mosses take up 39-48 ppm Cr from silica soils (140 ppm Cr) where other plants take up only 4.9-7.6 ppm. /Total chromium/
[NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.12-13 (1974)]**PEER REVIEWED**

Higher concns of chromium have been reported in plants growing in high chromium-containing soil (eg, soil near ore deposits or chromium-emitting industries and soil fertilized by sewage sludge) compared with plants growing in normal soils(1). However, most of the increased uptake of chromium results in accumulation in the roots, and only a small fraction of the total chromium is translocated to the above-ground part of edible plants(2). Leaves usually contain higher chromium concns than grains(3).
[(1) Grubinger W et al; Chemosphere 28: 77-20 (1994) (2) Cary EE; pp. 49-64 in Topics in Environmental Health 5. NY, NY: Elsevier Biomedical Press (1982) (3) Smith S et al; Toxicol Environ Chem 24: 241-51 (1989)]**PEER REVIEWED**

Fish/Seafood Concentrations:

Edible tissues of commercially important North American molluscs contained 0.1 to 0.6 mg chromium/kg fresh weight. Although this concentration is in general agreement with molluscan data from other geographic areas in edible portions as high as 3.4 in oysters (Crassostrea virginica), 5.8 in hardshell clams (Mercenaria mercenaria), and 5.0 in softshell clams (Mya arenaria). The ability of marine molluscs to accumulate Cr far in excess of that in ambient seawater was documented by Papadopoulou (1973), who found that the Cr concentration in 5 species of bivalves from Greek waters exceeded that in seawater by 16,000 times (Pinna nobilis) to 260,000 times (Astralium rogosum). /Total chromium/
[US Dept of the Interior: Chromium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review p.33 Rpt# 85(1.6) (1986)]**PEER REVIEWED**

Marine animals contain 0.2-1.0 ppm chromium. /Total chromium/
[NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.9 (1974)]**PEER REVIEWED**

Fish contains 0.01-0.02 ug/g chromium (wet wt), while seafood contains 0-0.44 ug/g. /Total chromium/
[Schroeder HA; API Air Quality Monograph #70-15: Chromium p.1-28 (1970)]**PEER REVIEWED**

The major portion of chromium in fish from great Lakes waters appears to be associated with the portions of the fish not consumed as food, such as skin, bones and organs. /Total chromium/
[Nat'l Research Council Canada; Effects of Chromium in Canadian Environment p. 43 (1976) NRCC No.15017]**PEER REVIEWED**

Chromium levels in oysters, mussels, clams, and mollusks vary from <0.1 to 6.8 mg/kg (dry weight)(1,2). Fish and shellfish collected from ocean dump sites off New York City, Delaware Bay, and New Haven, CT, contained <0.3-2.7 mg/kg chromium (wet wt)(3). The chromium concn in fish sampled from 167 lakes in the northeastern US was 0.03-1.46 ug/g with a mean concn of 0.19 ug/g(4). The concn of chromium in the hepatopancreatic tissue (fat) and tail meat of Atchafalaya River (LA) Basin and pond crayfish ranged from <0.40-1.16 mg/kg (wet wt) between the years 1986-87(5). The concn of chromium in muscle tissue from fish collected near a cliff-face sewage outfall near Sydney, Australia are as follows (mg/kg wet wt): Kapala stingray, 0.14 +/- 0.08; eagle ray, 0.18 +/- 0.10; red gurnard, 0.09 +/- 0.06; cocky gurnard, 0.10 +/- 0.03; marbled flathead, 0.24 +/- 0.28; longspined flathead, 0.16 +/- 0.12; tarwine, 0.08 +/- 0.04; snapper, 0.11 +/-0.02; small tooth flounder, 0.11 +/- 0.03; yellowfin leatherjacket, 0.10 +/- 0.04; chinaman leatherjacket, 0.11 +/- 0.03; boxfish, 0.11 +/- 0.07; Port Jackson shark, 0.09 +/- 0.19; shovelnose ray, 0.09 +/- 0.04; silver trevally, 0.08-0.42 (range); yellowfin bream, 0.07-0.13 (range)(6). Avg chromium content of 3 species of Great Lakes fish was 1 ppm (fresh weight)(7).
[(1) Byrne CJ, DeLeon IR; Bull Environ Contam Toxicol 37: 151-8 (1986) (2) Ramelow

GJ et al; Arch Environ Contam Toxicol 18: 804-18 (1989) (3) Greig RA, Jones J; Arch Environ Contam Toxicol 4: 420-34 (1976) (4) Yeardley RB et al; Environ Toxicol Chem 17: 1875-84 (1988) (5) Madden JD et al; J Food Safety 12: 1-15 (1991) (6) Gibbs PJ, Miskiewicz; Mar Pollut Bull 30: 667-74 (1995) (7) Nat'l Research Council Canada; Effects of Chromium in the Canadian Envirn. NRCC No.15017 p.43 (1976)]**PEER REVIEWED**

Animal Concentrations:

The newborn animal has large stores of chromium that decline with age. /Total chromium/
[Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980. 975]**PEER REVIEWED**

Chromium is an essential element in animals(1). The concn of chromium in field populations of mammalian wildlife were as follows (ug/g dry wt): pronghorn antelope (ID), 1.1-640 (hair); pronghorn antelope (WY), 0.3-130 (hair); short-tailed shrew, 21 (whole sample; from polluted area); coyote (WY), 0.6-12 (hair); elk (ID), 1.9-570 (hair); porcupine (WY), 0.9 (hair); porcupine (WY), 0.8 (quills); chipmunk (WY), 29 (hair); meadow vole (England), 0.1-1.1 (brain, liver, kidney, and bone); meadow vole (England), 3-4 (remaining carcass); mountain vole (WY), 9.9-180 (hair); meadow vole (Northeastern US), 6.9 (whole; from polluted area); Richardson's vole (WY), 10 (hair); house mouse (Northeastern US), 11-18 (whole); house mouse (Northeastern US), 11 (whole; from polluted area); mule deer (ID), 13-630 (hair); white-tailed deer (IL), 2.7 +/- 0.1 (liver); mountain goat (ID), 4.0-5.5 (hair); bighorn sheep (ID), <0.1 (hair); bighorn sheep (WY), <0.1 (hair); white-footed mouse (Northeastern US), 7.1 (whole; polluted area)(2). The concn of chromium in field populations of avian wildlife were as follows (ug/g dry wt): Atlantic flyway(Nova Scotia, Canada to VA), 0.64 +/- 0.07 (eggs); white-fronted goose (Canada), 0.05 (feathers); lesser scaup duck (Canada), 0.05 (feathers); crow (TN), 1.0 (whole); Atlantic puffin (Newfoundland, Canada), 4.35 +/- 0.72 (liver); Atlantic puffin (Quebec, Canada), 1.53 +/- 0.57 (liver); herring gull (Atlantic, Canada), <1.2 (liver); lesser black-backed gull (Norway), 1 (muscle, kidney, liver); swamp sparrow (NJ), 12 (whole; polluted area); black-crowned night heron (Northeastern US), <0.05-0.29 (liver); black-crowned night heron (Northeastern US), <0.05-0.51 (liver; polluted area); house sparrow (TN), 1.0 (whole)(2).
[(1) Kimbrough DE et al; Crit Rev Env Sci Technol 29: 1-46 (1999) (2) Outridge PM, Scheuhammer AM; Rev Environ Contam Toxicol 130: 31-77 (1993)]**PEER REVIEWED**

Milk Concentrations:

Milk powder contains 18 ug/l chromium. /Total chromium/
[NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.11 (1974)]**PEER REVIEWED**

The concn of chromium in breast milk was 0.30 ug/l (range, 0.06-1.56 ug/l)(1). Milk and dairy products contain 0.05-0.23 ug/g fresh weight(2).
[(1) Casey CE, Hambidge KM; Br J Nutr 52: 73-7 (1984) (2) Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir NRCC No. 15017 p.44 (1976)]**PEER REVIEWED**

Other Environmental Concentrations:

Cigarette tobacco reportedly contains 0.24-14.6 mg/kg chromium, but no estimates were available regarding the chromium levels in inhaled cigarette smoke(1). Cigarette tobacco grown in the US contains <6.3 mg/kg chromium(2).
[(1) Langard S, Norseth T; pp. 185-210 in Handbook on the toxicology of metals. Vol II: Specific metals. 2nd ed. Friberg L et al, eds. Amsterdam, Netherlands: Elsevier Science Publishers BV (1986) (2) IARC; IARC monographs on the evaluation of the carcinogenic risk of chemicals to man. 23: 205-323 (1980)]**PEER REVIEWED**

The range concns of chromium in agricultural fertilizers are as follows (mg/kg dry wt): sewage sludge, 20-40,600; phosphate fertilizers, 66-245; limestones 10-15; nitrogen fertilizers, 3.2-19; manure, 5.2-55(1).
[(1) Breckenridge RP, Crockett AB; Determination of Background Concentration of Inorganics in Soils and Sediments at Hazardous Waste Sites. Washington DC: Technol Innovat Off, Off Solid Waste Emer Resp, USEPA/540/S-96/500 (1995)]**PEER REVIEWED**

Environmental Standards & Regulations:

Acceptable Daily Intakes:

Estimated Adequate and Safe Intake (EASI) levels for chromium: Infants: 1) age 0.0-0.5 yr: 0.01-0.04 mg/day, 2) age 0.5-1.0 yr: 0.02-0.06 mg/day; Children: 1) age 1-3 yr: 0.02-0.08 mg/day, 2) age 4-6 yr: 0.03-0.12 mg/day, 3) age 7-10 yr: 0.05-0.20 mg/day, & 4) age > or = to 11 yr: 0.05-0.20 mg/day; & Adults: 0.05-0.20 mg/day. /Chromium, from table/
[USEPA; Health Assessment Document: Chromium p.6-2 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

Acceptable daily intake (ADI) value of 0.175 mg/day/man for chromium(VI). /Hexavalent chromium/
[USEPA; Health Assessment Document: Chromium p.7-161 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

Acceptable daily intake (ADI) value of 125 mg/day/man for **chromium(III). /**Trivalent chromium/
[USEPA; Health Assessment Document: Chromium p.7-161 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

RCRA Requirements:

D007; A solid waste containing chromium may or may not become characterized as a hazardous waste when subjected to the Toxicity Characteristic Leaching Procedure listed in 40 CFR 261.24, and if so characterized, must be managed as a hazardous waste. /Chromium/
[40 CFR 261.24 (7/1/2001]**PEER REVIEWED**

Atmospheric Standards:

Chromium has been designated as a hazardous air pollutant under section 112 of the Clean Air Act. /Total chromium/
[40 CFR 61.01 (7/1/88)]**PEER REVIEWED**

Clean Water Act Requirements:

Toxic pollutant designated pursuant to section 307(a)(1) of the Federal Water Pollution Control Act and is subject to effluent limitations. /Chromium and compounds/
[40 CFR 401.15 (7/1/2001)]**QC REVIEWED**

Chemical/Physical Properties:

Corrosivity:

CORROSIVE BECAUSE OF ... OXIDIZING POTENCY /CHROMATE SALTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-109]**PEER REVIEWED**

Other Chemical/Physical Properties:

Chromium forms a number of cmpd in various oxidation states. Those of 2+ (chromous), 3+ (chromic) and 6+ (chromates) are the most important /Chromium, alloys and cmpd/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 468]**PEER REVIEWED**

Hexavalent chromium is acidic. /Hexavalent chromium/
[USEPA; Health Assessment Document: Chromium p.2-2 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

Chromium(VI) as chromate is potentially an oxidizing agent that may react with reducing (organic) matter to form **chromium(III). /**Hexavalent chromium/
[NIOSH; Criteria Document: Chromium (VI) p.33 (1976) DHEW Pub. NIOSH 76-129]**PEER REVIEWED**

Chromium(VI) anions are hydrochromate, chromate or dichromate depending upon pH. /Cr(VI) anions/
[USEPA; Ambient Water Quality Criteria Doc: Chromium p.A-1 (1980) EPA 440/5-80-035]**PEER REVIEWED**

... The +3 state is amphoteric. /**Chromium (III)/**
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 468]**PEER REVIEWED**

Chromium(III) compounds are reduced to Cr(II) compounds by hypophosphites, electrolysis, or reducing metals, such as zinc, magnesium, & aluminum in acid soln (although it should be noted that Cr(II) compounds are stable only in the absence of air). In basic solution, Cr(III) is readily oxidized to chromium oxide (CrO4(-2)) by hypochlorite, hypobromite, peroxide, & oxygen under pressure at high temperature. In acid solution, Cr(III) is difficult to oxidize & needs strong oxidizing agents, such as concentrated perchloric acid, sodium bismuthate, & permanganate. /Trivalent chromium/
[USEPA; Health Assessment Document: Chromium p.3-17 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

CR(III) IS MOST STABLE OXIDATION STATE OF CHROMIUM & IS ALWAYS PRESENT AS A COORDINATION COMPLEX /TRIVALENT CHROMIUM/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 274]**PEER REVIEWED**

Slightly soluble in water. /Trivalent chromium/
[48 FR 45512 (10/5/83)]**PEER REVIEWED**

Hexavalent chromium is linked to oxygen and is a powerful oxidizer, but it does not form coordination compounds, and is easily reduced to chromium trioxide. /Hexavalent chromium/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978.,p. 249]**PEER REVIEWED**

Divalent chromium is chemically basic. /Divalent chromium/
[USEPA; Health Assessment Document: Chromium p.2-2 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

Chromium(+2) compounds closely resemble iron(+2) compounds /Divalent chromium compounds/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1593]**PEER REVIEWED**

Chemical Safety & Handling:

Skin, Eye and Respiratory Irritations:

Chromic acid mist & chromate dusts may cause severe irritation of the nose, throat, bronchial tubes, and lung. /Chromic acid mist & chromate dusts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Short-term exposure: ... Chromate dusts may cause severe irritation of the nose, throat, bronchii, and lung. /Chromate dusts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Chromic acid & its salts have a corrosive action on the skin & mucous membranes. /Chromic acid/
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 854]**PEER REVIEWED**

Eczematous dermatitis due to trivalent chromium compounds has been reported. /Trivalent chromium compounds/
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 854]**PEER REVIEWED**

Fire Fighting Procedures:

Respiratory protection from chromium metal and insoluble chromium salts while fighting fires: self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. /Chromium metal and insoluble chromium salts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.6]**PEER REVIEWED**

Respiratory protection from soluble chromic and chromous salts while fighting fires: self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. /Sol chromic & chromous salts (as Cr)/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.5]**PEER REVIEWED**

/When fire fighting wear/ self-contained breathing apparatus, with a full facepiece, operated in pressure-demand or other positive pressure mode. /Chromic acid & chromates/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.7]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

Potentially hazardous incompatibility with strong oxidizers. /Chromium metal and insoluble salts (as Cr)/
[NIOSH. Pocket Guide to Chemical Hazards. 5th Printing/Revision. DHHS (NIOSH) Publ. No. 85-114. Washington, D.C.: U.S. Dept. of Health and Human Services, NIOSH/Supt.

of Documents, GPO, Sept. 1985.82]**PEER REVIEWED**

Combustible, organic, or other readily oxidizable materials: paper, wood, sulfur, aluminum, plastics, etc; corrosive to metals. /Chromic acid and chromates (as Cr)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 70]**PEER REVIEWED**

Incompatibilities: Combustible, organic, or other readily oxidizable materials: paper, wood, sulfur, aluminum, plastics, etc. /Chromic acid & chromates (as CrO3)/
[NIOSH. Pocket Guide to Chemical Hazards. 2nd Printing. DHHS (NIOSH) Publ. No. 85-114. Washington, D.C.: U.S. Dept. of Health and Human Services, NIOSH/Supt. of Documents, GPO, February 1987.82]**PEER REVIEWED**

Hydrazine is decomposed explosively by chromates and chromic anhydride. /Chromates
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-61]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH considers chromic acid and chromates to be potential occupational carcinogens. /Chromic acid and chromates/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 70]**PEER REVIEWED**

15 mg/cu m as Cr(VI). /Chromic acid and chromates/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 70]**PEER REVIEWED**

250 mg/cu m as Cr(II). /Chromium(II)compounds (as Cr)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 70]**PEER REVIEWED**

25 mg/cu m as Cr(III). /**Chromium(III)**compounds (as Cr)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 70]**PEER REVIEWED**

Protective Equipment & Clothing:

[ACGIH; Guidelines Select of Chem Protect Clothing Volume #1 Field Guide p.65 (1983)] Some data suggests breakthrough times /for nitrile rubber/ of approximately an hour or more. Breakthrough times /for polyvinyl chloride/ are greater than one hour reported by (normally) two or more testers. /Chromic acid/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.4]**PEER REVIEWED**

Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch min), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with solids or liquids containing insol chromium salts. ... Employees should be provided with and required to use dust and splashproof safety goggles where solids or liquids containing insol chromium salts may contact the eyes. /Chromium metal and insol chromium salts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Admin ... or by the National Institute for Occupational Safety and Health. /Chromium metal and insol chromium salts (as Chromium)/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.]**PEER REVIEWED**

Respirator selection: Upper limit respirator devices permitted: 0.25 mg/cu m: any supplied air respirator or any self-contained breathing apparatus or any dust and mist respirator except single-use and quarter-mask respirators; 0.625 mg/cu m: any powered air-purifying respirator with a high-efficiency particulate filter or any supplied-air respirator operated in a continuous flow mode; 1.25 mg/cu m: any air-purifying full facepiece respirator with a high-efficiency particulate filter or any powered air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter or any self-contained breathing apparatus with a full facepiece or any supplied-air respirator with a full facepiece; 25 mg/cu m: any supplied-air respirator with a half-mask and operated in a pressure-demand or other positive pressure mode; 50 mg/cu m: any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode; Emergency or planned entry in unknown concn or IDLH conditions: any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode or any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode; escape: any air-purifying full facepiece respirator with a high-efficiency particulate filter or any self-contained breathing apparatus with a full facepiece. /Chromium metal and insoluble salts (as Cr), noncarcinogenic Cr (VI)/
[NIOSH. Pocket Guide to Chemical Hazards. 5th Printing/Revision. DHHS (NIOSH) Publ. No. 85-114. Washington, D.C.: U.S. Dept. of Health and Human Services, NIOSH/Supt. of Documents, GPO, Sept. 1985.83]**PEER REVIEWED**

Impervious gloves, aprons, and footwear shall be worn at operations where solutions of chromium (VI) may contact the skin. Protective gloves shall be worn at operations where dry compounds of chromium (VI) are handled and may contact the skin. /Cr(VI)/
[NIOSH; Criteria Document: Chromium (VI) p.8 (1976) DHEW Pub. NIOSH 76-129]**PEER REVIEWED**

Protective clothing: Coveralls or other full-body protective clothing shall be worn in areas where there is occupational exposure to chromium (VI). Protective clothing shall be changed at least daily at the end of the shift and more frequently if it should become grossly contaminated. /Cr(VI)/
[NIOSH; Criteria Document: Chromium (VI) p.8 (1976) DHEW Pub. NIOSH 76-129]**PEER REVIEWED**

RESPIRATORS OF APPROVED TYPE ... MUST BE WORN ... WHERE ATMOSPHERIC SAMPLING HAS SHOWN CONCN ABOVE RECOMMENDED LEVEL ... PROVIDE AIR SUPPLIED RESP PROTECTIVE EQUIPMENT FOR CERTAIN JOBS ... IT IS NECESSARY ... TO PROVIDE OVERALLS WHICH ARE LAUNDERED DAILY, HAND PROTECTION & EYE PROTECTION ... . /CR CMPD/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 472]**PEER REVIEWED**

/NIOSH APPROVED BREATHING APPARATUS/ ... MUST BE WORN IN SITUATIONS WHERE ATMOSPHERIC SAMPLING HAS SHOWN CONCN ABOVE RECOMMENDED LEVEL & IT

MAY BE NECESSARY TO PROVIDE AIR-SUPPLIED RESP PROTECTIVE EQUIP FOR CERTAIN JOBS ... IT IS NECESSARY ALSO TO PROVIDE OVERALLS WHICH ARE LAUNDERED DAILY, HAND PROTECTION & EYE PROTECTION ... /CHROMIUM, ALLOYS & CMPD/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 472]**PEER REVIEWED**

WORKERS ... SHOULD WEAR PERSONAL PROTECTIVE EQUIPMENT (ACID-PROOF PROTECTIVE CLOTHING, FOOTWEAR, GLOVES AND GOGGLES). /OXIDIZING SUBSTANCES/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1576]**PEER REVIEWED**

HANDLE IN EFFECTIVE FUME REMOVAL DEVICE FROM BEHIND EXPLOSION-RESISTANT BARRIER. USE FACE SHIELD. /OXIDIZERS/
[Association of Official Analytical Chemists. Official Methods of Analysis. 10th ed. and supplements. Washington, DC: Association of Official Analytical Chemists, 1965. New editions through 13th ed. plus supplements, 1982.p. 13/883 51.069]**PEER REVIEWED**

Rubber gloves, face shield or goggles ... /Zinc dichromate trihydrate/
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

WORKERS ... SHOULD WEAR PERSONAL PROTECTIVE EQUIPMENT (ACID-PROOF PROTECTIVE CLOTHING, FOOTWEAR, GLOVES AND GOGGLES). /OXIDIZING SUBSTANCES/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1576]**PEER REVIEWED**

Recommendations for respirator selection. Condition: At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration: Respirator Class(es): Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive pressure-mode. Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode. /Chromic acid and cromates/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Escape from suddenly occurring respiratory hazards: Respirator Class(es): Respirators for escape purposes only: Any air-purifying, full-facepiece respirator with a high-efficiency particulate filter. Any appropriate escape-type, self-contained breathing apparatus. /Chromic acid and chromates /
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Recommendations for respirator selection. Max. concn for use: 2.5 mg/cu m; Any dust and mist respirator. Substance reported to cause eye irritation or damage, may require eye protection. /Chromium(II) compounds, as Cr/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Recommendations for respirator selection. Max. concn for use: 5 mg/cu m; Any dust and mist respirator except single-use and quarter-mask respirators. Substance reported to cause eye irritation or damage, may require eye protection.; Any supplied-air respirator. Substance reported to cause eye irritation or damage, may require eye protection. /Chromium(II) compounds, as Cr/

[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Recommendations for respirator selection. Max. concn for use: 12.5 mg/cu m; Any supplied-air respirator operated in a continuous-flow mode. Substance reported to cause eye irritation or damage, may require eye protection.; Any powered, air-purifying respirator with a dust and mist filter. Substance reported to cause eye irritation or damage, may require eye protection. /Chromium(II) compounds, as Cr/

[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Recommendations for respirator selection. Max. concn for use: 25 mg/cu m; Any air-purifying, full-facepiece respirator with a high-efficiency particulate filter.; Any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter. Substance reported to cause eye irritation or damage, may require eye protection.; Any self-contained breathing apparatus with a full facepiece.; Any supplied-air respirator with a full facepiece. /Chromium(II) compounds, as Cr/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Recommendations for respirator selection. Max. concn for use: 250 mg/cu m; Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode. /Chromium(II) compounds, as Cr/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Recommendations for respirator selection. Condition: At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration: Respirator Class(es): Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive pressure-mode. Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode. /Chromium(II) compounds, as Cr/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Escape from suddenly occurring respiratory hazards: Respirator Class(es): Respirators for escape purposes only: Any air-purifying, full-facepiece respirator with a high-efficiency particulate filter. Any appropriate escape-type, self-contained breathing apparatus. /Chromium(II) compounds, as Cr/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Recommendations for respirator selection. Max. concn for use: 2.5 mg/cu m; Any dust and mist respirator. Substance reported to cause eye irritation or damage, may require eye protection. /**Chromium(III)** compounds, as Cr/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Recommendations for respirator selection. Max. concn for use: 5 mg/cu m; Any dust and mist respirator except single-use and quarter-mask respirators. Substance reported to cause eye irritation or damage, may require eye protection.; Any supplied-air respirator. Substance reported to cause eye irritation or damage, may require eye protection. /**Chromium(III)** compounds, as Cr/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

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respirator operated in a continuous-flow mode. Substance reported to cause eye irritation or damage, may require eye protection.; Any powered, air-purifying respirator with a dust and mist filter. Substance reported to cause eye irritation or damage, may require eye protection. /**Chromium(III)** compounds, as Cr/
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Recommendations for respirator selection. Max. concn for use: 25 mg/cu m; Any air-purifying, full-facepiece respirator with a high-efficiency particulate filter.; Any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter. Substance reported to cause eye irritation or damage, may require eye protection.; Any self-contained breathing apparatus with a full facepiece.; Any supplied-air respirator with a full facepiece. /**Chromium(III)** compounds, as Cr/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Recommendations for respirator selection. Condition: At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration: Respirator Class(es): Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive pressure-mode. Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode. /**Chromium(III)** compounds, as Cr/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Escape from suddenly occurring respiratory hazards: Respirator Class(es): Respirators for escape purposes only: Any air-purifying, full-facepiece respirator with a high-efficiency particulate filter. Any appropriate escape-type, self-contained breathing apparatus. /**Chromium(III)** compounds, as Cr/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Preventive Measures:

Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. ... In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training /sessions/, maintenance, inspection, cleaning, and evaluation /of the equipment/. /Chromium metal and insoluble chromium salts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Control methods which may be effective include local exhaust ventilation, general dilution ventilation, & personal protective equipment. /Chromium metal and insol chromium salts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Persons not wearing protective equipment and clothing should be restricted from areas of spills until cleanup has been completed. /Chromium metal and insoluble chromium salts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.4]**PEER

REVIEWED**

Eating and smoking should not be permitted in areas where solids or liquids containing insoluble chromium salts are handled, processed, or stored. /Chromium metal and insoluble chromium salts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Clothing contaminated with insol chromium salts should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of insol chromium salts from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the insol chromium salts, the person performing the operation should be informed of insol chromium salt's hazardous properties. Non-impervious clothing which becomes contaminated with insol chromium salts should be removed promptly and not reworn until the insol chromium salts are removed from the clothing. ... Skin that becomes contaminated with insol chromium salts should be promptly washed or showered with soap and mild detergent and water to remove any insol chromium salts. Eating and smoking should not be permitted in areas where solids or liquids containing insol chromium salts are handled, processed, or stored. Employees who handle solids or liquids containing insol chromium salts should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities. /Insol chromium salts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Promptly remove non-impervious clothing that becomes contaminated. /Chromium metal and insoluble salts (as Cr)/
[NIOSH. Pocket Guide to Chemical Hazards. 5th Printing/Revision. DHHS (NIOSH) Publ. No. 85-114. Washington, D.C.: U.S. Dept. of Health and Human Services, NIOSH/Supt. of Documents, GPO, Sept. 1985.83]**PEER REVIEWED**

Contact lenses should not be worn when working with this chemical. /Chromium metal and insoluble salts (as Cr)/
[NIOSH. Pocket Guide to Chemical Hazards. 5th Printing/Revision. DHHS (NIOSH) Publ. No. 85-114. Washington, D.C.: U.S. Dept. of Health and Human Services, NIOSH/Supt. of Documents, GPO, Sept. 1985.83]**PEER REVIEWED**

Daily washing of the inside of the nose combined with covering the nasal septum with zinc or barium ointment should be sufficient to avoid ulcerations and perforation of the septum. /Chromic acid and dichromates/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 205]**PEER REVIEWED**

Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. ... In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training /sessions/, maintenance, inspection, cleaning, and evaluation /of the equipment/. /Chromium metal and insoluble chromium salts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Wear appropriate personal protective clothing to prevent skin contact. /Chromic acid and cromates/

[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact. /Chromic acid and cromates/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

The worker should immediately wash the skin when it becomes contaminated. /Chromic acid and cromates/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed and replaced. /Chromic acid and cromates/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Workers whose clothing may have become contaminated should change into uncontaminated clothing before leaving the work premises. /Chromic acid and cromates/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Eyewash fountains should be provided in areas where there is any possibility that workers could be exposed to the substance; this is irrespective of the recommendation involving the wearing of eye protection. /Chromic acid and cromates/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Facilities for quickly drenching the body should be provided within the immediate work area for emergency use where there is a possibility of exposure. (Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from any body areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.) /Chromic acid and cromates/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Wear appropriate personal protective clothing to prevent skin contact. /Chromium(II) compounds, as Cr/

[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact. /Chromium(II) compounds, as Cr/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

The worker should immediately wash the skin when it becomes contaminated. /Chromium(II) compounds, as Cr/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed and replaced. /Chromium(II) compounds, as Cr/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Wear appropriate personal protective clothing to prevent skin contact. /**Chromium(III)** compounds, as Cr/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact. /**Chromium(III)** compounds, as Cr/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

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[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

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[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 71]**PEER REVIEWED**

Stability/Shelf Life:

Trivalent chromium is the most stable oxidation state and hexavalent chromium is the second most stable state. /Trivalent and hexavalent chromium/
[USEPA; Health Assessment Document: Chromium p.2-2 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

STABLE IN DRY AIR BUT OXIDIZES RAPIDLY IF MOIST
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 319]**PEER REVIEWED**

Hygroscopic; above 38 deg C changes to isomeric green modification; loses 1 H2O, forming trihydrate at 51 deg C; absorbs O2 even when dry, forming greenish-black oxychloride; on standing in solution it is oxidized by water with liberation of hydrogen. /Tetrahydrate/
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 319]**PEER REVIEWED**

Storage Conditions:

... MATERIALS WHICH ARE TOXIC AS STORED OR WHICH CAN DECOMP INTO TOXIC COMPONENTS ... SHOULD BE STORED IN A COOL, WELL-VENTILATED PLACE, OUT OF DIRECT RAYS OF THE SUN, AWAY FROM AREAS OF HIGH FIRE HAZARD, & SHOULD BE PERIODICALLY INSPECTED ... INCOMPATIBLE MATERIALS SHOULD BE ISOLATED FROM EACH OTHER. /CHROMIUM CMPD/
[Sax, N.I. Dangerous Properties of Industrial Materials. 4th ed. New York: Van Nostrand Reinhold, 1975. 558]**PEER REVIEWED**

Cleanup Methods:

If chromium metal or insoluble chromium salts are spilled, the following steps should be taken: 1. Remove all ignition sources where metallic chromium has been spilled. 2. Ventilate area of spill. 3) Collect spilled material in the most convenient and safe manner and deposit in sealed containers for reclamation or for disposal in a secured sanitary landfill. Liquid containing chromium metal or insoluble chromium salts should be absorbed in vermiculite, dry sand, earth, or a similar material. /Chromium metal and insoluble chromium salts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA -

Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.4]**PEER REVIEWED**

WHERE POSSIBLE, WET METHODS OF CLEANING SHOULD BE USED; AT OTHER SITES, THE ONLY ACCEPTABLE ALTERNATIVE IS BY VACUUM CLEANING. SPILLS OF LIQ OR SOLID MUST BE REMOVED IMMEDIATELY TO PREVENT DISPERSION AS AIRBORNE DUST. /CHROMIUM CMPD/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 472]**PEER REVIEWED**

CR(VI) CMPD IN WASTE SLUDGE ARE COMPLETELY REMOVED BY REDN BY CARBON AT 600 DEG C. /CHROMIUM VI/
[JAROSINSKI A ET AL; STUDY ON THE POSSIBILITY OF ELIMINATING CHROMIUM(VI) CMPD IN WASTE SLUDGE FROM CHROMATE PRODUCTION; ZESZ NAUK POLITECH KRAKOW, CHEM 8: 55 (1977)]**PEER REVIEWED**

Persons not wearing protective equipment and clothing should be restricted from areas of spills until cleanup has been completed. If chromic acid or chromates are spilled, the following steps should be taken: 1. Ventilate area of spill. 2. Collect spilled material in the most convenient and safe manner and deposit in sealed containers for reclamation or for disposal in a secured sanitary landfill. Liquid containing chromic acid or chromates should be absorbed in vermiculite, dry sand, earth, or a similar material. /Chromic acid and chromates/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.5]**PEER REVIEWED**

Trivalent chromium can be effectively removed from drinking water by conventional coagulation techniques, but these techniques are inadequate when chromium is in the hexavalent form. Reverse osmosis is effective for removal of both forms of chromium. /Chromium/
[48 FR 45512 (10/5/83)]**PEER REVIEWED**

Disposal Methods:

Removal of hexavalent chromium from waste streams has been accomplished by reduction and precipitation, ion exchange, and evaporative recovery /Hexavalent chromium/
[Patterson JW; Industrial Wastewater Treatment Technolgy 2nd Edition p.70 (1985)]**PEER REVIEWED**

The following wastewater treatment technologies have been investigated for chromium(+6): Concentration process: Chemical precipitation, activated carbon, and biological treatment. /Chromium(+6)/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-3-E-22 (1982)]**PEER REVIEWED**

Oven residue from the production of chrome oxide green pigments is a poor candidate for incineration. /Chrome green oxide pigments/
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-5 (1981) EPA 68-03-3025]**PEER REVIEWED**

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste number D007, must conform with USEPA regulations in storage, transportation, treatment and disposal of waste. /Chromium/
[40 CFR 240-280, 300-306, 702-799 (7/1/90)]**PEER REVIEWED**

Waste disposal method: Chromium metal or insoluble chromium salts may be disposed of in sealed containers in a secured sanitary landfill. /Chromium metal and insoluble chromium salts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.4]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for chromium: Concentration process: Biological Treatment. /Chromium/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-52 (1982)]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for chromium: Concentration process: Chemical Precipitation. /Chromium/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-70 (1982)]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for chromium: Concentration process: Reverse Osmosis. /Chromium/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-87 (1982)]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for chromium: Concentration process: Activated Carbon. /Chromium/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-162 (1982)]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for chromium: Concentration process: Miscellaneous Sorbents. /Chromium/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-202 (1982)]**PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

Permissible Exposure Limit: Table Z-1 8-hr Time Weighted Avg: 1 mg/cu m. /Chromium metal and insoluble salts, as Cr/
[29 CFR 1910.1000 (7/1/2001)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-1 8-hr Time Weighted Avg: 0.5 mg/cu m. /Chromium(II) compounds, as Cr/
[29 CFR 1910.1000 (7/1/2001)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-1 8-hr Time Weighted Avg: 0.5 mg/cu m. /**Chromium(III)** compounds, as Cr/
[29 CFR 1910.1000 (7/1/2001)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-2 Acceptable Ceiling Concentration: 1 mg/10 cu m. /Chromic acid and chromates/
[29 CFR 1910.1000 (7/1/2001)]**PEER REVIEWED**

Threshold Limit Values:

8 hr Time Weighted Avg (TWA) 0.5 mg/cu m, as Cr /Metal and Cr(III) compounds, as Cr/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold

limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.23]**PEER REVIEWED**

A4; Not classifiable as a human carcinogen. /Metal and Cr(III) compounds, as Cr/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.23]**PEER REVIEWED**

Excursion Limit Recommendation: Excursions in worker exposure levels may exceed three times the TLV-TWA for no more than a total of 30 min during a work day and under no circumstances should they exceed five times the TLV-TWA, provided that the TLV-TWA is not exceeded. /Metal and Cr(III) compounds, as Cr/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.6]**PEER REVIEWED**

8 Hr Time Weighted Avg (TWA) 0.05 mg/cu m. /Water soluble Cr(VI) compounds, as Cr/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.23]**PEER REVIEWED**

A1; Confirmed human carcinogen. /Water soluble Cr(VI) compounds, as Cr/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.23]**PEER REVIEWED**

Biological Exposure Index (BEI): Determinant: total chromium in urine; Sampling Time: increase during shift; BEI: 10 ug/g cretinine. The determinant may be present in biological specimens collected from subjects who have not been occupationally exposed, at a concentration which could affect interpretation of the result. Such background concentrations are incorporated in the BEI value. /Chromium(VI), water soluble fume/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.89]**PEER REVIEWED**

Biological Exposure Index (BEI): Determinant: total chromium in urine; Sampling Time: end of shift at end of workweek; BEI: 30 ug/g cretinine. The determinant may be present in biological specimens collected from subjects who have not been occupationally exposed, at a concentration which could affect interpretation of the result. Such background concentrations are incorporated in the BEI value. /Chromium(VI), water soluble fume/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.89]**PEER REVIEWED**

Excursion Limit Recommendation: Excursions in worker exposure levels may exceed three times the TLV-TWA for no more than a total of 30 min during a work day and under no circumstances should they exceed five times the TLV-TWA, provided that the TLV-TWA is not exceeded. /Water soluble Cr(VI) compounds, as Cr/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.6]**PEER REVIEWED**

8 hr Time Weighted Avg (TWA) 0.01 mg/cu m, as Cr /Insoluble Cr(VI) compounds, as Cr/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.23]**PEER REVIEWED**

A1; Confirmed human carcinogen. /Insoluble Cr(VI) compounds, as Cr/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.23]**PEER REVIEWED**

Excursion Limit Recommendation: Excursions in worker exposure levels may exceed three times the TLV-TWA for no more than a total of 30 min during a work day and under no circumstances should they exceed five times the TLV-TWA, provided that the TLV-TWA is not exceeded. /Insoluble Cr(VI) compounds, as Cr/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.6]**PEER REVIEWED**

NIOSH Recommendations:

NIOSH considers chromic acid and chromates to be a potential occupational carcinogen. /Chromic acid and chromates/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 70]**PEER REVIEWED**

NIOSH usually recommends that occupational exposures to carcinogens be limited to the lowest feasible concentration. /Chromic acid and chromates/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 70]**PEER REVIEWED**

Recommended Exposure Limit: 10 Hr Time-Weighted Avg: 0.001 mg/cu m. /Chromic acid and chromates/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 70]**PEER REVIEWED**

The NIOSH Recommended Exposure Limit (10-hour TWA) is 0.001 mg Cr(VI)/cu m for all hexavalent chromium (Cr(VI)) compounds.NIOSH considers all Cr(VI) compounds (including chromic acid, tert-butyl chromate, zinc chromate, and chromyl chloride) to be potential occupational carcinogens. The NIOSH Recommended Exposure Limit (8-hour TWA) is 0.5 mg Cr/cu m for chromium metal and chromium(II) and **chromium(III)** compounds.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 351]**PEER REVIEWED**

Recommended Exposure Limit: 10-hour Time-Weighted Avg: 0.5 mg/cu m. /Chromium(II)compounds (as Cr)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 70]**PEER REVIEWED**

Recommended Exposure Limit: 10-hour Time-Weighted Avg: 0.5 mg/cu m. /**Chromium(III)**compounds (as Cr)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 70]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH considers chromic acid and chromates to be potential occupational carcinogens. /Chromic acid and chromates/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 70]**PEER REVIEWED**

15 mg/cu m as Cr(VI). /Chromic acid and chromates/

[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 70]**PEER REVIEWED**

250 mg/cu m as Cr(II). /Chromium(II)compounds (as Cr)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 70]**PEER REVIEWED**

25 mg/cu m as Cr(III). /**Chromium(III)**compounds (as Cr)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 70]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

Pigments for floor covering products, paper, cement, and asphalt roofing. /Total chromium/
[USEPA; Background Document, Resource Conservation and Recovery Act Subtitle C: Identification and Listing of Hazardous Waste p.189 (1980)]**PEER REVIEWED**

1) Use in fabrication of alloys; 2) use in preparation of alloy steels to enhance corrosion and heat resistance; 3) use in fabrication of plated products for decoration or increased wear resistance; 4) use in production of non-ferrous alloys to impart special qualities to the alloys; 5) use in production and processing of insoluble salts; 6) use as chemical intermediates; use in textile industry in dyeing, silk treating, printing, and moth proofing wool; 7) use in leather industry in tanning; use in photographic fixing baths; 8) use as catalysts for halogenation, alkylation, and catalytic cracking of hydrocarbons; and 9) use as fuel additives and propellant additives; in ceramics. /Chromium metal and insoluble chromium salts/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Chromium and its compounds are used in metal alloys such as stainless steel; protective coatings on metal; magnetic tapes; and pigments for paints, cement, paper, rubber, composition floor covering and other materials. Other uses include organic chemical synthesis, photochemical processing and industrial water treatment. In medicine, chromium compounds are used in astringents and antiseptics. /Chromium and its compounds/
[DHHS/NTP; Fourth Annual Report On Carcinogens p.58 (1985) NTP 85-002]**PEER REVIEWED**

Chromium encounters many industrial applications, including its uses in steel and nonferrous alloys, metal-plating, refractory materials, chromate pigments and chromate preservatives. /Chromium/
[Baselt RC; Biological Monitoring Methods for Industrial Chemicals p.81 (1980)]**PEER REVIEWED**

CONSTITUENT OF INORG PIGMENTS. /TOTAL CHROMIUM/
[Sax, N.I. and R.J. Lewis, Sr. (eds.). Hawley's Condensed Chemical Dictionary. 11th ed. New York: Van Nostrand Reinhold Co., 1987. 280]**PEER REVIEWED**

SENSITIZER IN PHOTOGRAPHIC INDUSTRY; PREPARATION OF CHROMATES. /TOTAL CHROMIUM/
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969. 120]**PEER REVIEWED**

(51)Chromium is used as a radioisotopic tracer. /(51)Chromium isotope/
[NAS; Medical and Biological Effects of Environmental Pollutants: Chromium p.3

(1974)]**PEER REVIEWED**

Chromium salts are used extensively in the metal finishing industry as electroplating cleaning agents, and as mordants in the textile industry. They also are used in cooling waters, and in the leather tanning industry, in catalytic manufacture, and in fungicides and wood preservatives. /Chromium salts/
[USEPA; Ambient Water Quality Criteria Doc: Chromium p.A-2 (1980) EPA 440/5-80-035]**PEER REVIEWED**

1) Use in textile treatment in dyeing, printing, moth proofing, and water proofing; use in tanning of leather in gloves, garments, and shoe uppers; 2) use in manufacture of pigments of green varnishes, inks, paints, and glazes; 3) use in metal treatment and polishing; 4) use in photographic fixing baths for hardening of emulsions; use as catalysts and in manufacture of catalysts; and 5) use in chemical synthesis; use as corrosion inhibitors. /Soluble chromic and chromous salts (as Cr)/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

AQUATIC FATE: Chormium(VI) is mobile in ground water and sometimes used as a tracer to follow ground water flows. /Cr VI/
[Todorovic L, Filip A; in Proc Symp Isotope Radiation Techniques in Soil Physics Irriga Studies, Istanbul (1967) as cited in Nat'l research Council Canada; Effects of Chromium in the Canadian Envir p. 28 (1976) NRCC No.15017]**PEER REVIEWED**

Manufacturers:

Elementis Chromium LP, Buddy Lawrence Dr., P.O. Box 9912, Corpus Christi, TX 78469, (800) 531-3188; Production site: Corpus Christi, TX 78469 /Chromium chemicals/
[USGS; Minerals Yearbook (Chromium). Available from Database Query page at http://minerals.usgs.gov/minerals/pubs/commodity/chromium/180499.pdf as of August 2, 2001.]**PEER REVIEWED**

Methods of Manufacturing:

Mixtures of basic chromic sulfates (containing mainly **chromium(III)** hydroxy sulfate (Cr(OH)SO4)) with sodium sulfate are produced commercially by the organic reduction (with such substances as molasses) of a solution of sodium dichromate in the presence of sulfuric acid or by reduction of dichromate solutions with sulfur dioxide. /Basic chromic sulfates/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 228 (1980)]**PEER REVIEWED**

General Manufacturing Information:

Eleven plants manufacture chrome pigments, individually producing 9-79 metric tons/day. Industry wide production= 64,500 metric tons, 60% from two plants in NE United States. /Chrome pigments/
[USEPA; Background Document, Resource Conservation and Recovery Act Subtitle C: Identification and Listing of Hazardous Waste p.189 (1980)]**PEER REVIEWED**

Formulations/Preparations:

Basic chromic sulfate is available from one company in the USA in 3 grades containing 24%, 24.5% & 25% Cr (calculated as chromic oxide), respectively. All grades dissolve readily to give clear solutions substantially free from iron, vanadium & silica. Similar grades are available in Japan. /Basic chromic sulfates/

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 216 (1980)]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

Sample matrix: body fluids (milk, urine, etc); Sample preparation: dried sample ashed by oxygen plasma, hydrogen peroxide addition, drying, and dilution in normal hydrochloric acid. /Total chromium/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.92 (10/87)]**PEER REVIEWED**

Sample matrix: blood, serum, orchard leaves; Sample preparation: sample after wet digestion converted to a volatile chelate usually with fluorinated acetyl-acetone. /Total chromium/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.92 (10/87)]**PEER REVIEWED**

Sample matrix: plasma; Sample preparation: wet washing with nitric acid/hydrochlorous acid/sulfuric acid; residue complexed with APDC and extracted with MIBK; evaporated residue dissolved in nitric acid/hydrochloric acid, and soln deposited on a polycarbonate foil. /Total chromium/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.90 (10/87)]**PEER REVIEWED**

It can be shown that polarography is most effectually suitable to the determination of chromium(VI) compounds. Chromium(VI) is electrochemically active over the entire pH range, so that medium pH can be selected for measuring, thus protecting samples most effectively from undergoing redox reactions during the analytical procedure. In some cases sample pre-treatment can be employed to eliminate reductants prior to final measurement. Very few methods are available to selectively measure **chromium(III).**
[Harzdorf AC; Int J Environ Anal Chem 29 (4): 249-61 (1987)]**PEER REVIEWED**

SPARK SOURCE MASS SPECTROSCOPY OF BIOLOGICAL MATERIALS; EVANS JR CA & MORRISON GH, TRACE ELEMENT SURVEY ANALYSIS OF BIOLOGICAL MATERIALS BY SPARK SOURCE MASS SPECTROMETRY, ANALYT CHEM 40: 869 (1968). /TOTAL CHROMIUM/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 107 (1973)]**PEER REVIEWED**

Whole human blood; X-ray fluorescence with sensitivity of 0.15 mg/l: Paradellis T; Eur J Nucl Med 2: 277-279 (1977); Blood serum; Atomic Absorption Spectroscopy with sensitivity of 0.02 mg/l: Arpadzhyan S, Kachov I; Zentralbl Pharm 117: 237-240 (1978) & Long-path photometry; Yarbro S, Flaschka HA; Microchem J 21: 415-423 (1976); Urine; Gas Chromatography with sensitivity of 0.1 pg: Ryan TR, Vogt CRH; J Chromatogr 130: 346-350 (1977). /Total chromium/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 253 (1980)]**PEER REVIEWED**

The traditional colorimetric method employing the violet complex of 1,5-diphenylcarbazide is still a valuable method for analyzing chromium in urine. The detection limit is 3.5 ng but method is subject to interference by ... ions. Flame photometry, X-ray emission spectrography & polarography are less sensitive than diphenylcarbazide method. Polarographic methods with detection limit as low as 1 ng have been described, but ... are subject to interference by ... ions: Beyermann K; Z Anal Chem 190: 4-33

& 346-369 (1962). Neutron activation ... has been used for determination of chromium in urine: Cornelis R et al; Anal Chim Acta 78: 317-327 (1975). /Total chromium/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 187]**PEER REVIEWED**

NIOSH Method 8005-B. Determination of Elements in Blood or Tissue Samples by Inductively Coupled Argon Plasma - Atomic Emission Spectroscopy (ICP-AES). This method is for monitoring the blood of workers exposed to several metals simultaneously. Detection limit = 0.010 ug/g. /Total chromium/
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

NIOSH Method 8005-T. Determination of Elements in Blood or Tissue Samples by Inductively Coupled Argon Plasma - Atomic Emission Spectroscopy (ICP-AES). This method is for monitoring the tissue of workers exposed to several metals simultaneously. Detection limit = 0.20 ug/g. /Total chromium/
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

NIOSH Method 8310. Metals in Urine by ICP-AES. Detection limit = 0.001 ug/ml. /Total chromium/
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

ANALYTE: CHROMIUM, MATRIX: WHOLE HUMAN BLOOD, PROCEDURE: X-RAY FLUORESCENCE, SENSITIVITY: 0.15 MG/L. /TOTAL CHROMIUM/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 251]**PEER REVIEWED**

Urine is diluted with water and analyzed directly by graphite-furnace atomic absorption spectrometry, using tungsten-halogen background correction. Reagents: stock soln; 1 mg/ml chromium ion (Fisher reference std); Aqueous standards: 5, 10, 20, 40, and 80 ug/l (All soln should be stored in Polyethylene containers which have been washed in 50% nitric acid); Instrumental conditions: Atomic absorption spectrometer with graphite furnace, optical temperature sensor, and tungsten-halogen background corrector, Chromium hollow cathode lamp, Argon purge gas in interrupt mode. (40 ml/min); Procedure: dilute 0.5 ml of the urine specimen or Aqueous standards to 2.5 ml with deionized water, inject 20 ul ... into graphite furnace, measure absorption at 357.9 nm; Evaluation: sensitivity, 0.1 ug/l; linearity, 5-40 ug/l with dilution: CV, not established; Relative recovery, not established; Interferences: none are known. /Total chromium/
[Baselt RC; Biological Monitoring Methods for Industrial Chemicals p. 82-83 (1980)]**PEER REVIEWED**

CELLULAR ANALYSIS FOR CHROMIUM ACCOMPLISHED BY ION MICROSCOPE OR LASER MICROPROBE TECHNIQUES. /TOTAL CHROMIUM/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 107 (1973)]**PEER REVIEWED**

Analysis by emission spectroscopy of unashed, dried biological samples using a DCARC excitation source with photoplate detection has a detection limit of 0.5 ppm and > or = to 15% precision. /Total chromium/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.129

(1976) NRCC No.15017]**PEER REVIEWED**

50% of chromium detected in blood samples originated from distilled water reagent or glass surfaces of equipment. /Total chromium/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.127 (1976) NRCC No.15017]**PEER REVIEWED**

Analyte: chromium; matrix: hair; Procedure: AAS; conventional reference range: 0.21 + or - 0.14 ug/g (mean + or - 1 SD); international recommended reference range: 4.0 + or - 2.7 nmol/g (mean + or - 1 SD). /Total chromium/
[Tietz, N.W. (ed.). Clinical Guide to Laboratory Tests. Philadelphia, PA: W.B. Saunders Co., 1983. 120]**PEER REVIEWED**

Several methods are available for measuring elemental chromium in ... biological samples. These include atomic absorption spectroscopy, instrumental neutron activation analysis, X-ray fluorescence, and particle-induced X-ray emissions (PIXE). While these methods are sensitive to the ppb level, problems in sample collection, preparation and interferences are shared by all. In biological samples, neutron activation analysis data tend to be lower than atomic absorption and X-ray fluorescence data. ... Generally, a comparison of the results indicates that modified atomic absorption spectroscopy provides relatively reliable analyses. Another problem in chromium determination is the lack of adequate reference materials. Ideally, reference materials should match the samples to be analyzed with respect to chromium levels and each reference composition. Because the materials are not yet standardized, inter-laboratory comparisons are difficult. /Total chromium/
[USEPA; Health Assessment Document: Chromium p.2-4 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

Gas chromatography can be used for analyzing biological fluids preceded by solvent extraction of the **chromium(III)**-trifluoroacetyl-acetone complex, detection limit= 10 ppb. /Cr(III)/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.127 (1976) NRCC No.15017]**PEER REVIEWED**

Analysis by emission spectroscopy of unashed, dried biological samples using a DCARC excitation source with photoplate detection has a detection limit of 0.5 ppm and > or = to 15% precision. /Total chromium/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.129 (1976) NRCC No.15017]**PEER REVIEWED**

Analytic Laboratory Methods:

It can be shown that polarography is most effectually suitable to the determination of chromium(VI) compounds. Chromium(VI) is electrochemically active over the entire pH range, so that medium pH can be selected for measuring, thus protecting samples most effectively from undergoing redox reactions during the analytical procedure. In some cases sample pre-treatment can be employed to eliminate reductants prior to final measurement. Very few methods are available to selectively measure **chromium(III).**
[Harzdorf AC; Int J Environ Anal Chem 29 (4): 249-61 (1987)]**PEER REVIEWED**

Sample matrix: plasma; Sample preparation: wet washing with nitric acid/hydrochlorous acid/sulfuric acid; residue complexed with APDC and extracted with MIBK; evaporated residue dissolved in nitric acid/hydrochloric acid, and soln deposited on a polycarbonate foil. /Total chromium/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.90 (10/87)]**PEER REVIEWED**

Sample matrix: air; Sample preparation: air particulate matter collected on filter & irradiated with x-ray

photons. /Total chromium/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.90 (10/87)]**PEER REVIEWED**

Sample matrix: wet atmospheric deposition (snow), determination in soluble ... part; Sample preparation: melted snow filtered through Nucleophore filter, the filtrate acidified with nitric acid & dried by freeze drier, residue dissolved in nitric acid, this preconcentrated soln placed in plastic tubes, both plastic tube & Nucleophore filter irradiated with protons. /Total chromium/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.90 (10/87)]**PEER REVIEWED**

Sample matrix: wastewater; Sample preparation: sample mixed with a masking agent & acetyltrimethylammonium bromide soln at pH 4.7-6.6, heated in water bath at 50 deg C for 10 min. /Total chromium/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.91 (10/87)]**PEER REVIEWED**

Sample matrix: simultaneous determination of **chromium(III)** & chromium(VI) in water extract from metal fumes; Sample preparation: sample soln at pH 5 reacted with disodium ethylenediamine tetraacetic acid at 50 deg C for 1 hr. /Total **chromium(III)** and chromium(VI)/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.91 (10/87)]**PEER REVIEWED**

Sample matrix: wastewater and industrial effluent; Sample preparation: buffered sample mixed with aluminum chloride and the precipitate separated by centrifugation or filtration. /Total chromium(VI)/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.91 (10/87)]**PEER REVIEWED**

Sample matrix: simultaneous determination of **chromium(III)** and chromium(VI) in water extract from metal fumes; Sample preparation: sample soln at pH 5 reacted with disodium ethylenediamine tetraacetic acid at 50 deg C for 1 hour. /Total **chromium(III)** and chromium(VI)/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.91 (10/87)]**PEER REVIEWED**

Sample matrix: welding fumes (total chromium(VI)); Sample preparation: air particulate collected on PVC filter is extracted with hot 3% sodium carbonate, 2% sodium hydroxide in the presence of magnesium chloride, extract acidified with sulfuric acid, and complexed with diphenylcarbazide. /Total chromium(VI)/
[DHHS/ATSDR; Toxicological Profile for Chromium (Draft) p.91 (10/87)]**PEER REVIEWED**

MATRIX: WASTE WATER; PROCEDURE: PULSE POLAROGRAPHY; SESITIVITY: 0.01 MG/L (HEXAVALENT); HEIGL, A; POLAROGRAPHIC DETERMINATION OF CHROMIUM IN WASTE WATER (GER); CHIMIA, 32: 339 (1978). /TOTAL CHROMIUM/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 251 (1980)]**PEER REVIEWED**

MATRIX: SEAWATER; PROCEDURE: ISOTOPE DILUTION MASS SPECTROMETRY; SENSITIVITY: 0.001 UG/L; OSAKI S ET AL; DETERMINATION OF HEXAVALENT AND TOTAL CHROMIUM IN SEA WATER BY ISOTOPE DILUTION MASS SPECTROMETRY (JPN); BUNSEKI KAGAKU, 25: 358 (1976). /TOTAL CHROMIUM/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 252 (1980)]**PEER REVIEWED**

MATRIX: RIVER WATER; PROCEDURE: X-RAY EMISSION ANALYSIS; LI MC ET AL; DETERMINATION OF TRACE ELEMENTS IN ENVIRONMENTAL SAMPLES BY PROTON-INDUCED X-RAY EMISSION ANALYSIS (CHIN); K'O HSUEH TUNG PAO, 24: 19 (1979). /TOTAL CHROMIUM/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 252 (1980)]**PEER REVIEWED**

SPARK SOURCE MASS SPECTROSCOPY. EVANS JR CA & MORRISON GH, TRACE ELEMENT SURVEY ANALYSIS OF BIOLOGICAL MATERIALS BY SPARK SOURCE MASS SPECTROMETRY, ANALYT CHEM 40: 869 (1968). /TOTAL CHROMIUM/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 107]**PEER REVIEWED**

GAS CHROMATOGRAPHY. TAYLOR ML; GAS LIQUID CHROMATOGRAPHY OF TRACE METALS. IN: MERTZ W & COMATZER WE, EDS, NEWER TRACE ELEMENTS, NEW YORK, MARCEL DEKKER, P 363 (1971). /TOTAL CHROMIUM/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 107]**PEER REVIEWED**

Trivalent chromium in tanning liquors; Iodometric titration: Makarov-Zemlyanskii YY et al; Kozho Obuvn Prom-st 20: 43-45 (1978). /Trivalent chromium cmpd/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 251 (1980)]**PEER REVIEWED**

Hexavalent & trivalent chromium in seawater; Flameless atomic absorption spectrometry with detection limit of 0.01 ug/l (hexavalent) & 0.03 ug/l (trivalent): de Jong GJ, Brinkman UAT; Anal Chim Acta 98: 243-250 (1978). Sediments; Neutron Activation Analysis with detection limits of 1.5 mg/kg: Ackermann F; Dtsch Gewaesserkd Mitt 21: 53-60 (1977). /Total chromium, hexavalent and trivalent/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 252 (1980)]**PEER REVIEWED**

Filtering materials contain chromium which can be transferred to the sample, ie, Delbag= 0.19 ppm Cr, Millipore= 17.6 ppm Cr, Millipore= 17.6 ppm Cr, Nucleopore= 0.57 ppm Cr. /Total chromium/
[National Research Council Canada; Effects of Chromium in the Canadian Envir p.118 (1986) NRCC No.15017]**PEER REVIEWED**

Low temp, oxygen plasma ashing should be used over high temp drying ashing to minimize Cr loss by volatilization. /Total chromium/
[National Research Council Canada; Effects of Chromium in the Canadian Envir p.120 (1976) NRCC No.15017]**PEER REVIEWED**

Gravimetric determination of chromium involves dissolution of the sample, isolation by separation, precipitation of hydrous Cr oxide and ignition to chromic oxide; detection limit= 5 ppm. /Total chromium/
[National Research Council Canada; Effects of Chromim in the Canadian Envir p. 126 (1976) NRCC No.15017]**PEER REVIEWED**

Electron microprobe analysis, where a sample is bombarded with high energy electrons causing emission of characteristic x-rays has a detection limit of 100-2,000 ppm. Proton bombardment and proton microprobe analysis has a detection limit of 0.1 ppm chromium in a sample area 1 um in diam. Laser (high energy pulse of coherent light) and ion (inert gas or oxygen ions accelerated to high energies)

microprobe methods have a detection limit of 1 ppm. /Total chromium/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.134 (1976) NRCC No.15017]**PEER REVIEWED**

Electron spectroscopy for chemical analysis (ESCA) uses bombardment of sample with photons (x-rays) causing elements to project electrons. Elemental analysis and determination of oxidation states is possible, with a detection limit of 1,000 ppm. /Total chromium/
[Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir p.136 (1976) NRCC No.15017]**PEER REVIEWED**

Analysis of soil samples for metals content is normally done using an air dried sample ground with a porcelain mortar and pestle to pass a 2 mm sieve and digested using concentrated nitric acid or hydrofluoric acid in an acid digestion bomb. Extracts can be analyzed for ... chromium ... . /Total chromium/
[Brown, K.W., G. B. Evans, Jr., B.D. Frentrup (eds.). Hazardous Waste Land Treatment. Boston, MA: Butterworth Publishers, 1983. 105]**PEER REVIEWED**

CHROMIUM WAS DETERMINED IN ENVIRONMENTAL MATERIALS BY NEUTRON ACTIVATION ANALYSIS, ATOMIC ABSORPTION & GAS CHROMATOGRAPHY IN 3 LABORATORIES. /TOTAL CHROMIUM/
[PIERCE JO ET AL; MEAS, DETECT CONTROL ENVIRON POLLUT, PROC INT SYMP: 357-68 (1976)]**PEER REVIEWED**

Techniques for monitoring hexavalent chromium are subject to considerable error. For example, although the OSHA colorimetric method is the most commonly used analytical tool, particularly in occupational settings, low sample recoveries have been reported in chromium levels of less than 10 ug. /Total hexavalent chromium/
[USEPA; Health Assessment Document: Chromium p.2-4 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

For expressing aquatic life criteria for chromium ... acid-soluble **chromium(III) (**operationally defined as the **chromium(III)** that passes through a 0.45 um membrane filter after the sample is acidified to pH = 1.5 to 2.0 with nitric acid) and acid-soluble chromium(VI) are probably the best measurements at the present. /Chromium/
[USEPA; Ambient Water Quality Criteria Doc: Chromium p.1 (1984) EPA 440/5-84-029]**PEER REVIEWED**

Several methods are available for measuring elemental chromium in ... environmental ... samples. These include atomic absorption spectroscopy, instrumental neutron activation analysis, X-ray fluorescence, and particle-induced X-ray emissions (PIXE). While these methods are sensitive to the ppb level, problems in sample collection, preparation and interferences are shared by all. ... In environmental samples, neutron activation analysis data are higher. Generally, a comparison of the results indicates that modified atomic absorption spectroscopy provides relatively reliable analyses. Another problem in chromium determination is the lack of adequate reference materials. Ideally, reference materials should match the samples to be analyzed with respect to chromium levels and each reference composition. Because the materials are not yet standardized, inter-laboratory comparisons are difficult. /Chromium/
[USEPA; Health Assessment Document: Chromium p.2-4 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

The determination of various chromium species in welding fume normally involves digestion in a hot alkaline solution. This work confirms that **chromium(III)** can be oxidized to chromium(VI) during this digestion. However, only dissolved forms of **chromium(III),** such as the hydroxochromate(III) ion (Cr(OH)4) are susceptible to oxidation under these conditions. The air oxidation of **chromium(III)** can be prevented by hydrolytic destabilization of the hydroxochromate(III) complex by the presence of

magnesium hydroxide precipitate. The procedure has been used successfully in the determination of insoluble chromium(VI) in welding fumes. Excellent reproducibility is documented for soluble and insoluble chromium(VI) fractions.
[Zatha VJ; Am Ind Hyg Assoc J 46 (6): 327-31 (1985)]**PEER REVIEWED**

Acidic solutions readily dissolve chromium(II) oxides or inorganic salts with the exception of dichromium trioxide in corundum structure. Aqueous solutions of any pH value readily dissolve chromium((VI) oxides or salts except lead chromate and zinc chromate. Chromium(VI) was reduced at an appreciable rate in acidic solutions. The soluble chromium in the fumes must therefore have been hexavalent since the amount of chromium dissolved in the acidic solution was less than those dissolved in the neutral or alkaline solutions. The amount of chromium(VI) which dissolves in the tris buffer solution was regarded as the amount of chromium trioxide in the fumes. Metallic chromium was not detectable in the fumes. After 6 hours of leaching with heated dilute sulfuric acid, 75% of the chromium was dissolved. The fine green particles which remained undissolved were dichromium trioxide with a corundum structure. The dissolved part was mixed oxide of chromium(II) and chromium(VI) dissolving slowly in hydrochloric acid solution.
[Sawatari K, Serita F; Ind Health 24 (1): 51-61 (1986)]**PEER REVIEWED**

NIOSH Method 7024. Chromium and compounds as Cr. Determination of Chromium by Flame Atomic Absorption Spectroscopy. This method is applicable to air samples. Detection limit = 0.06 ug/cu m. /Chromium and chromium cmpd/
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

NIOSH Method 7300. Elements by ICP. Determination of Elements by Inductively Coupled Argon Plasma - Atomic Emission Spectroscopy (ICP-AES). This method is applicable to air samples. Detection limit = 0.001 mg/cu m. /Chromium and chromium cmpd/
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

EPA Method 29. Determination of Metals Emissions from Stationary Sources (Proposed). This method is applicable to the determination of Cr emissions from stationary sources. This method may also be used to determine particulate emissions if the prescribed procedures are followed. Detection limit unspecified. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 306. Determination of Chromium Emissions from Decorative and Hard Chromium Electroplating and Anodizing Operations. This method applies to decorative and hard chromium electroplating and anodizing operations. It is used for determining total chromium emissions. Detection limit unspecified. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method OSW-A. Methodology for the Determination of Metals Emissions in Exhaust Gases from Hazardous Waste Incineration and Similar Combustion Processes. This method is applicable to the sampling and analysis of metals in stack emissions from incinerators and combustors. Detection limit = 7 ng/ml. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 0060. Determination of Metals in Stack Emissions. This method is applicable to the determination of metals in stack emissions from hazardous waste incinerators. Detection limit unspecified. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method ITM-001. Determination of Metals Emissions from Stationary Combustion Sources. This method is used to determine emissions of total chromium from sewage sludge incinerators. Detection limit unspecified. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method CTM-006. Determination of Chromium Emissions from Chromium Electroplaters. This method is used to determine the concn of chromium emissions from chromium electroplaters and anodizing operations using a chromic acid bath. Detection limit unspecified. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 306A. Determination of Chromium Emissions from Decorative and Hard Chromium Electroplating and Anodizing Operations. This method applies to decorative chromium electroplating and anodizing operations that use a chromic acid bath. It is used for determining total chromium emissions. This method is less expensive and less complex than Method 306, and is applicable under ambient moisture, air, and temperature conditions. Detection limit unspecified. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

AOAC Method 974.27. Chromium in Water by Atomic Absorption Spectrophotometric Method. Metals in solution are detected directly by AA spectrophotometry, suspended metals are separated by membrane filtration, or suspension is dissolved and analyzed. Applicable to surface and saline waters, and domestic and industrial wastes. Detection limit = 1 mg/l. /Chromium and chromium cmpd/
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990 324]**PEER REVIEWED**

AOAC Method 993.14. Trace Elements in Waters and Wastewaters by Inductively Coupled Plasma/Mass Spectrometric Method. Applicable to determination of trace elements in finished drinking water, groundwater, and wastewaters. Detection limit unspecified. /Chromium and chromium cmpd/
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990,p. S5 235]**PEER REVIEWED**

APHA Method 3111-B. Metals by Direct Air-Acetylene Flame Atomic Absorption Spectrometry. This method is applicable to the determination of metals by direct air-acetylene FAAS. Detection limit unspecified. /Chromium and chromium cmpd/
[American Public Health Association, American Water Works Association, Warer Environment Federation. M.A.H. Franson (ed.); Standard Methods for the Examination of Water and Wastewater 20th ed., Washington, D.C. 1998.p. 3-17]**PEER REVIEWED**

APHA Method 3111-C. Metals by Chelation and Extraction and Air-Acetylene Flame Atomic Absorption Spectrometry. This method is applicable to the determination of low concns of chromium. Detection limit unspecified. /Chromium and chromium cmpd/
[American Public Health Association, American Water Works Association, Warer Environment Federation. M.A.H. Franson (ed.); Standard Methods for the Examination of Water and Wastewater 20th ed., Washington, D.C. 1998.p. 3-19]**PEER REVIEWED**

APHA Method 3113-B. Metals in Water by Electrothermal Atomic Absorption Spectrometry. Electrothermal atomic absorption permits determination of most metallic elements in water with sensitivity and detection limits from 20 to 1000 times better than those of flame techniques. Detection limit unspecified. /Chromium and chromium cmpd/
[American Public Health Association, American Water Works Association, Warer Environment Federation. M.A.H. Franson (ed.); Standard Methods for the Examination of Water and Wastewater 20th ed., Washington, D.C. 1998.p. 3-19]**PEER REVIEWED**

APHA Method 3120. Metals in Water by Plasma Emission Spectroscopy. Detection limit = 7 ug/l. /Chromium and chromium cmpd/
[American Public Health Association, American Water Works Association, Warer Environment Federation. M.A.H. Franson (ed.); Standard Methods for the Examination of Water and Wastewater 20th ed., Washington, D.C. 1998.p. 3-38]**PEER REVIEWED**

APHA Method 3500-CR-B. Chromium in Water by Colorimetry. This method is applicable to the analysis of only Cr(VI). Detection limit unspecified. /Chromium and chromium cmpd/
[American Public Health Association, American Water Works Association, Warer Environment Federation. M.A.H. Franson (ed.); Standard Methods for the Examination of Water and Wastewater 20th ed., Washington, D.C. 1998.p. 3-66]**PEER REVIEWED**

APHA Method 3500-CR-C. Chromium in Water by Ion Chromatography. This method is applicable to the determination of dissolved Cr(VI) in industrial wastewater effluents, groundwater, and drinking water. Detection limit unspecified. /Chromium and chromium cmpd/
[American Public Health Association, American Water Works Association, Warer Environment Federation. M.A.H. Franson (ed.); Standard Methods for the Examination of Water and Wastewater 20th ed., Washington, D.C. 1998.p. 3-68]**PEER REVIEWED**

EPA Method 200.10_M. Inductively Coupled Plasma - Mass Spectrometry. This method is applicable to low concn waters. This method describes a multi-element determination using inductively coupled plasma with mass spectrometry. Detection limit unspecified. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 6020_M. Inductively Coupled Plasma - Mass Spectrometry Technique. This technique is applicable to a large number of elements in water and wastes after appropriate sample preparation steps are taken. This method describes a multi-element determination procedure using inductively coupled plasma with a mass spectrometer. Detection limit = 0.020 ug/l. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method ICP-AES. Inductively Coupled Plasma Atomic Emission Spectrometric Method. This method is applicable to trace elements in solution. Detection limit unspecified. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EMSLC Method 200.0. Metals (Atomic Absorption Methods). This method is applicable to a large number of metals in drinking, surface, and saline waters. This method is also applicable to metals in domestic and industrial wastes. Detection limit unspecified. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EMSLC Method 200.0. Metals (Atomic Absorption Methods). This method is applicable to a large number of metals in drinking, surface, and saline waters. This method is also applicable to metals in domestic and industrial wastes. Detection limit unspecified. /Chromium and chromium cmpd/

[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 200.1-FLAA: Determination of Acid Soluble Metals in Water by Flame Atomic Absorption. This method is applicable to the analysis of Cr in ambient waters and aqueous wastes. This method explains how to treat aqueous samples prior to either atomic absorption or atomic emission spectrochemical analysis. Detection limit = 0.05 mg/l. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 200.1-GFAA: Determination of Acid Soluble Metals in Water by Graphite Furnace Atomic Absorption. This method is applicable to the analysis of Cr in ambient waters and aqueous wastes. This method explains how to treat aqueous samples prior to either atomic absorption or atomic emission spectrochemical analysis. Detection limit = 0.2 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EMSLC Method 200.1-ICP. Determination of Acid Soluble Metals in Water by Inductively Coupled Plasma and Atomic Emission. This method is applicable to the analysis of As, Cd, Cr, Cu, and Pb in ambient waters and aqueous wastes. This method explains how to treat aqueous samples prior to either atomic absorption or atomic emission spectrochemical analysis. Detection limit = 0.007 mg/l. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EMSLC Method 200.12. Determination of Trace Elements in Marine Waters by Stabilized Temperature Graphite Furnace Atomic Absorption. This method is applicable to marine and estuarine waters, and ocean and brines with salinities up to 35 ppt. For determination of total recoverable analytes in marine waters, a digestion/extraction is required prior to analysis. Detection limit unspecified. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EMSLC Method 200.15. Determination of Metals and Trace Elements in Water by Ultrasonic Nebulization Inductively Coupled Plasma and Atomic Emission Spectrometry. This method is applicable to dissolved elements in ground and surface waters. This method is also applicable to total recoverable elements in ground, surface, and drinking waters. Detection limit = 0.900 mg/l. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EMSLC Method 200.7-W. Determination of Total Recoverable and Dissolved Elements by Inductively Coupled Plasma and Atomic Emission Spectrometry. The method is for determination of metals and some nonmetals and dissolved elements in water and wastewater. Detection limit = 4 ug/l. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EMSLC Method 200.8-W. Determination of Trace Elements in Waters by Inductively Coupled Plasma and Mass Spectrometry. This method is applicable for the determination of dissolved elements in ground, surface, and drinking waters. This method is also applicable for the determination of total recoverable elements in ground, surface, drinking, and wastewater samples. Detection limit = 0.90 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 200.9: Determination of Trace Elements by Stabilized Temperature Graphite Furnace Atomic Absorption Spectrometry. This method is applicable to dissolved and total recoverable elements in ground water, surface water, drinking water, storm runoff, and industrial and domestic wastewater. This method is also applicable to total recoverable elements in sediments, sludges, and soils. Detection limit = 0.10 ug/l. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EMSLC Method 218.1. Chromium by Direct Aspiration Atomic Absorption. Detection limit = 0.05 mg/l. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 218.2: Chromium by Graphite Furnace Atomic Absorption. Detection limit = 1.0 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EMSLC Method 218.3. Chromium by Chelation-Extraction and Flame Atomic Absorption Spectrophotometry. This method is applicable to drinking, surface, and saline waters. This method is also applicable to domestic and industrial wastes which do not contain high concns of other reactive metals. Detection limit = 1.0 ug/l. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EMSLC Method 200.11. Determination of Metals in Fish Tissue by Inductively Coupled Plasma and Atomic Emission Spectrometry. This method is applicable to the edible tissue portion (fillet) of a fresh fish. Detection limit = 0.050 ug/g. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 7190. Chromium by Direct Aspiration Atomic Absorption. Detection limit = 0.05 mg/l. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 7191. Chromium by Graphite Furnace Atomic Absorption. Detection limit = 1.0 ug/l. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 1639. Trace Elements in Ambient Waters by Stabilized Temperature Graphite Furnace Atomic Absorption. This method is applicable to the determination of trace Cr(III) in ambient waters. This method is not suited for the analysis of industrial discharges with higher levels of metals present. Detection limit = 0.10 ug/l. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 6010A. Inductively Coupled Plasma-Atomic Emission Spectroscopy. Estimated instrument detection level = 70 ug/l. /Chromium/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 6010B. Inductively Coupled Plasma - Atomic Emission Spectroscopy (ICP-AES). Detection Limit = 4.7 ug/l. /Chromium/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

NIOSH Method 7600. Chromium, hexavalent. Determination of Hexavalent Chromium by Visible Absorption Spectrophotometry. This method is applicable to air samples. Detection limit unspecified. /Hexavalent chromium/
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

NIOSH Method 7604. Chromium, hexavalent. Determination of Hexavalent Chromium by Ion Chromatography. This method is applicable to air samples. Detection limit = 0.004 mg/cu m. /Hexavalent chromium/
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

OSW Method 0061. Determination of Hexavalent Chromium Emissions from Stationary Sources. This method is applicable to the determination of Cr(VI) in stack emissions from hazardous waste incinerators, municipal waste combustors, and sewage sludge incinerators. Detection limit = 16 ng/cu m. /Hexavalent chromium/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method OSW-B. Determination of Hexavalent Chromium Emissions from Stationary Sources. This method is applicable to determination of chromium in stack emissions from incinerators and combustors. Cr(VI) present in stack emissions is absorbed in an alkali impinger solution. Cr(VI) is preconcentrated on solid absorbent and eluted onto an ion chromatography column. Detection limit = 16 ng/cu m. /Hexavalent chromium/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

AOAC Method 993.23. Dissolved Cr(VI) In Drinking Water, Groundwater, and Industrial Wastewater Effluents by Ion Chromatographic Method. Applicable to determination of Cr(VI) in drinking water, groundwater, and industrial wastewaters. Detection limit unspecified.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990,p. S5 244]**PEER REVIEWED**

EPA Method 218.4. Hexavalent Chromium by Chelation-Extraction Atomic Absorption. This method is applicable to drinking, surface, and saline waters. This method is also applicable to domestic and industrial wastes which have been filtered and does not contain high concns of other reactive metals. Detection limit = 10 ug/l. /Hexavalent chromium/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 218.5. Dissolved Hexavalent Chromium by Graphite Furnace Atomic Absorption. This method is applicable to drinking and surface waters. This method may also be applied to filtered domestic and industrial wastes provided that potential interferents are accounted for. Detection limit = 5 ug/l. /Hexavalent chromium/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 218.6. Determination of Dissolved Hexavalent Chromium in Drinking Water, Groundwater, and Industrial Wastewater Effluents by Ion Chromatography. This method is applicable to drinking water, groundwater, and industrial wastewater effluents. Detection limit = 0.30 ug/l.

/Hexavalent chromium/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 7195. Dissolved Hexavalent Chromium by Coprecipitation and Atomic Absorption Spectroscopy. This method is used to determine the concn of Cr(VI) in Extraction Procedure (EP) toxicity characteristic extracts and ground waters. This method may also be applicable to certain domestic and industrial wastes. Detection limit = 5.0 ug/l. /Hexavalent chromium/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 7196A. Hexavalent Chromium by Colorimetry. This method is used for the analysis of EP/TCLP extracts, ground waters, and domestic and industrial wastes with no interfering substances. Detection limit = 0.5 mg/l. /Hexavalent chromium/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 7197. Dissolved Hexavalent Chromium by Chelation/ Extraction and Flame Atomic Absorption Spectroscopy. This method is use to determine the concn of dissolved Cr(VI) in Extraction Procedure (EP) toxicity characteristic extracts and ground waters. It may also be applicable to certain domestic and industrial wastes. Detection limit = 1 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 7198. Hexavalent Chromium Differential Pulse Polarography. This method is used to determine the concn of Cr(VI) in natural waters, waste waters, and in EP extracts. Detection limit = 10 ug/l. /Hexavalent chromium/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 7199. Determination of Hexavalent Chromium in Drinking Water, Groundwater, and Industrial Effluents by Ion Chromatography. This method is applicable to the analysis of Cr(VI) in aqueous samples by ion chromatography. Detection limit unspecified. /Hexavalent chromium/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

Sampling Procedures:

Measurements to determine employee exposure are best taken so that the average eight hour exposure is based on a single eight hour sample or on two four hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). /Chromium metal, insoluble chromium salts, sol chromic and chromous salts (as Cr)/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of chromium metal or insoluble chromium salts. Each measurement should consist of a fifteen minute sample or series of consecutive samples totalling fifteen minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three measurements should be taken on one work shift with the highest level of all measurements taken as an estimate of the employee's exposure. /Chromium metal, insoluble chromium salts, chromic acid and chromates/

[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Direct preconcentration of chromium in natural waters using a cationic ion exchange resin is likely to occlude much of the Cr. /Chromium and chromium cmpd/
[National Research Council Canada; Effects of Chromium in the Canadian Envir p. 118 (1976) NRCC No.15017]**PEER REVIEWED**

For expressing aquatic life criteria for chromium ... acid soluble **chromium(III) (**operationally defined as the **chromium(III)** that passes through a 0.45 um membrane filter after the sample is acidified to pH= 1.5 to 2.0 with nitric acid) and acid soluble chromium(VI) are probably the best measurements at the present. /**Chromium(III)** and (VI)/
[USEPA; Ambient Water Quality Criteria Doc: Chromium p.1 (1984) EPA 440/5-84-029]**PEER REVIEWED**

Techniques for monitoring hexavalent chromium are subject to considerable error. For example, although the OSHA colorimetric method is the most commonly used analytical tool, particularly in occupational settings, low sample recoveries have been reported in chromium levels of less than 10 ug. /Hexavalent chromium/
[USEPA; Health Assessment Document: Chromium p.2-4 (1984) EPA 600/8-83-014F]**PEER REVIEWED**

Particulate filter collection; acid work-up; atomic absorbtion spectrometry analysis. /Chromium metal and insoluble salts/
[NIOSH; Pocket Guide to Chemical Hazards p.70 (1981) DHEW (NIOSH) Pub No. 78-210]**PEER REVIEWED**

OSW Method 7191. Chromium (Atomic Absorption, Furnace Technique) Method 7191 is applicable for the determination of metals in solution by atomic absorption spectrometry. For certain samples, lower concentrations may be determined using this technique. To ensure valid data, each matrix must be examined for interference effects and, if detected, treat them accordingly, using either successive dilution, matrix modification, or method of standard additions. If poor recoveries are obtained, a matrix modifier may be necessary. A representative aliquot of a sample is placed in the graphite tube in the furnace, evaporated to dryness, charred, and atomized. ... Radiation from a given excited element is passed through the vapor containing ground-state atoms of that element. ... The metal atoms to be measured are placed in the beam of radiation by increasing the temperature of the furnace, thereby causing the injected specimen to be volatilized. A monochromator isolates the characteristic radiation from the hollow cathode lamp or electrodeless discharge lamp, and a photosensitive device measures the attenuated transmitted radiation. The optimum concentration range is 5-100 ug/l with a detection limit of 1 ug/l. /Chromium and chromium cmpd/
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

NIOSH Method 7024. Analyte: Chromium; Matrix: air; Sampler: filter (0.8 um cellulose ester membrane); Flow rate: 1-3 l/min; Vol: min: 10 l @ 0.5 mg/cu m, max: 1000 l; Stability: stable. /Chromium and chromium cmpd/
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

NIOSH Method 7200. Analyte: Chromium; Matrix: air; Sampler: filter (0.8 um cellulose ester membrane); Flow rate: 1 l/min; Vol: min: 10 l, max: 400 l; Stability: At least 1 yr at 25 deg C.

/Chromium and chromium cmpd/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.]**PEER REVIEWED**

NIOSH Method 7300. Analyte: Chromium; Matrix: air; Sampler: filter (0.8 um cellulose membrane); Flow rate: 1-4 l/min; Vol: min: 5 l, max: 1000 l; Stability: stable /Chromium and chromium cmpd/
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

NIOSH Method 8005. Analyte: Chromium; Specimen: Blood or tissue; Vol: 10 ml blood, or 1 g tissue; Preservative: Heparin for blood, none for tissue; Controls: collect 3 blood specimens from unexposed workers; Stability: not established. /Chromium and chromium cmpd/
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

NIOSH Method 8310. Analyte: Chromium; Specimen: urine; Vol: 50-200 ml in polyethylene bottle; Preservative: 5 ml concn nitric acid added after collection; Controls: collect at least 3 urine specimens from unexposed workers; Stability: not established. /Chromium and chromium cmpd/
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

Special References:

Special Reports:

Riggin RM et al; Gov Rep Announcements Index (12): 1-56 (1984). A critical literature review of the state of the art for speciation of arsenic, chromium, manganese, and nickel in atmospheric samples was performed. Techniques for distinguishing the compound forms and valence states of these metals were critically assessed.

Eisler R; Gov Rep Announcements Index (8): 1-70 (1986). Ecological and toxicological aspects of chromium in the environment are reviewed, with special reference to North American natural resources. Subtopics include chemical properties and background concentrations in biological and abiotic samples, persistence, beneficial and protective properties, toxic and sublethal effects, results of field investigations, and current recommendations for the protection of sensitive species of fish and wildlife.

Nat'l Research Council Canada; Effects of Chromium in the Canadian Environment (1976) NRCC No 15017

Nat'l Research Council Canada; Executive Reports: Effects of Chromium, Alkali Halides, Arsenic, Asbestos, Mercury, Cadmium in the Canadian Environment (1980) NRCC No 17585

USEPA; Ambient Water Quality Criteria Doc: Chromium (1984) EPA 440/5-84-029

USEPA; Health Assessment Document: Chromium (1984) EPA 600/8-83-014F

CPSC; Chemical Hazard Assessment Profile: Chromium (1980)

USEPA; Air Quality Data for Metals 1968 and 1969 APDT

USEPA; Drinking Water Criteria Document: Chromium (Draft) (1981) EPA Contract No 68-02-3651

NORSETH T; THE CARCINOGENICITY OF CHROMIUM; ENVIRON HEALTH PERSPECT 40: 121 (1981). THE CARCINOGENICITY OF CHROMIUM COMPOUNDS IS REVIEWED WITH SPECIFIC ATTENTION TO THE GAPS IN KNOWLEDGE FOR RISK ESTIMATION & RESEARCH NEEDS.

NAS; Medical and Biological Effects of Environmental Pollutants: Chromium (1974)

USEPA; Background Document, Resource Conservation and Recovery Act Subtitle C: Identification and Listing of Hazardous Waste (1980)

US Dept of Interior: Chromium Hazards to Fish, Wildlife, and Invertebrates: A Synoptic Review: Rpt# 85(1.6) (1986).

DHHS/ATSDR; Toxicological Profile for Chromium (Update) TP-92/08 (2000)

WHO; Environmental Health Criteria 119: Principles and Methods for the Assessment of Nephrotoxicity Associated with Exposure to Chemicals (1991)

DHHS/FDA; Guidance Document for Chromium in Shellfish (1993)

U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) for **Chromium (III),** insoluble salts (16065-83-1) Toxicological Review in Adobe PDF. Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of Sept 3, 1998.

U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) for Chromium (VI)(18540-29-9) Toxicological Review in Adobe PDF. Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of Sept 3, 1998.

NIOSH; Criteria Document: Chromium (VI) (1976) DHEW Pub NIOSH 76-129

Korallus U; Toxicol Environ Chemistry 12 (1/2): 47-59 (1986). /A study of the carcinogenic properties of chromium compounds/.

U.S. Department of Health & Human Services/National Toxicology Program; Tenth Report on Carcinogens. National Institutes of Environmental Health Sciences. The Report on Carcinogens is an informational scientific and public health document that identifies and discusses substances (including agents, mixtures, or exposure circumstances) that may pose a carcinogenic hazard to human health. Chromium hexavalent compounds was listed in the First Annual Report on Carcinogens (1980) as known to be a human carcinogen. /Chromium Hexavalent Compounds/

Synonyms and Identifiers:

Related HSDB Records:

910 [CHROMIUM; 7440-47-3]

1620 [CHROMIUM DIOXIDE]

518 [CHROMIC TRIOXIDE]

1619 [CHROMIC OXIDE]

5796 [CHROMIUM TRIHYDROXIDE]

6769 [CHROMIC ACID]

2960 [CHROMIUM CHROMATE]

2961 [CHROMIC ACID, CHROMIUM(3+) SALT]

2963 [CHROMITE]

988 [CHROMIUM (II) CHLORIDE]

990 [CHROMYL CHLORIDE]

6341 [CHROMIC CHLORIDE]

2543 [**CHROMIUM (III)** SULFATE]

989 [CHROMIUM (II) OXALATE]

985 [**CHROMIUM(III)** ACETATE]

2962 [SODIUM CHROMATE]

737 [SODIUM DICHROMATE]

482 [AMMONIUM CHROMATE]

481 [AMMONIUM DICHROMATE]

1249 [POTASSIUM CHROMATE]

1238 [POTASSIUM DICHROMATE]

650 [LITHIUM CHROMATE]

248 [CALCIUM CHROMATE]

6190 [BARIUM CHROMATE]

2546 [STRONTIUM CHROMATE]

6188 [ZINC CHROMATE]

1060 [ZINC POTASSIUM CHROMATE]

6189 [ZINC CHROMATE HYDROXIDE]

1045 [ZINC DICHROMATE]

1650 [LEAD CHROMATE]

6185 [LEAD CHROMATE OXIDE]

4205 [ACID BLACK 52]

5825 [C.I. PIGMENT YELLOW 34]

Formulations/Preparations:

Basic chromic sulfate is available from one company in the USA in 3 grades containing 24%, 24.5% & 25% Cr (calculated as chromic oxide), respectively. All grades dissolve readily to give clear solutions substantially free from iron, vanadium & silica. Similar grades are available in Japan. /Basic chromic sulfates/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 216 (1980)]**PEER REVIEWED**

EPA Hazardous Waste Number:

D007; A waste containing chromium may or may not be characterized as a hazardous waste following testing by the Toxicity Characteristic Leaching Procedure as prescribed by the Resource Conservation and Recovery Act (RCRA) regulations. /Chromium/

Administrative Information:

Hazardous Substances Databank Number: 6999

Last Revision Date: 20030829

Last Review Date: Reviewed by SRP on 1/26/2002

Update History:

Complete Update on 2003-08-29, 0 fields added/edited/deleted
Complete Update on 09/16/2002, 76 fields added/edited/deleted.
Created 20010809 by KC

Record Length: 342975.0

Chromium(III), insoluble salts

CASRN: 16065-83-1

For other data, click on the Table of Contents

Best Sections

I.A.4. Additional Studies/Comments (Oral RfD) :

This RfD is limited to metallic **chromium (III)** of insoluble salts. Examples of insoluble salts include chromic III oxide (Cr_2O_3) and **chromium (III)** sulfate ($Cr_2[SO_4]_3$).

Trivalent chromium is an essential element that potentiates insulin action in peripheral tissue and is essential for lipid, protein, and fat metabolism in animals and human beings. Chromium deficiency causes changes in the metabolism of glucose and lipids and may be associated with maturity-onset diabetes, cardiovascular diseases, and nervous system disorders (Anderson, 1993, 1995). The National Research Council has identified an estimated safe and adequate daily dietary intake (ESADDI) for chromium of 50-200 µg/d (NRC, 1989), corresponding to 0.71-2.9 µg/kg/d for a 70 kg adult. FDA has selected a Reference Daily Intake for chromium of 120 µg/d (DHHS, 1995).

Very limited data suggest that Cr(III) may have respiratory effects on humans (see Section I.B). No data on chronic or subchronic effects of inhaled Cr(III) in animals can be found. Adequate developmental toxicity data do not exist, and there are inadequate data on reproductive effects.

Elbetieha and Al-Hamood (1997) reported impacts on fertility following high doses (2,000-5,000 ppm in the drinking water) of chromium chloride in mice; however, many of the observed effects did not occur in a clear dose-dependent fashion. The authors did not indicate the amount of water ingested by the animals, and only stated that water ingestion was reduced in the treatment groups relative to the controls. Zahid et al. (1990) fed mice trivalent chromium at concentrations of 100, 200, and 400 ppm for 35 days in food and reported ambiguous levels of degeneration in the outermost cellular layers of the seminiferous tubules, reduced spermatogonia per tubule, reduced sperm count, and increased percentage of morphologically abnormal sperms at all dose levels. Serious questions have been raised regarding the design and conduct of this study (Finley et al., 1993; NTP, 1996a,b, 1997). The methods utilized by Zahid et al. were considered to be insufficient to identify spermatogonia, likely generated nonreproducible counts of epididymal sperm, and resulted in the biologically implausible conclusion of reduction in spermatogonia numbers concurrent with unchanged spermatocyte and spermatid numbers. Additional questions have been raised with regard to the groupings of animals used and the statistical analysis of the data. The uncertainties preclude the use of the Elbetieha and Al-Hamood (1997) and Zahid et al. (1990) studies in the risk assessment for trivalent chromium.

The 1998 IRIS assessment updates the previous RfD of 1E+0 mg/kg-day.

For more details on other Hazard Identification Issues, exit to the toxicological review, Section 4.7 (PDF).

Substance Name :

Chromium(III), insoluble salts

Status :

STATUS OF DATA FOR **Chromium(III),** insoluble salts

File First On-Line 01/31/1987

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on-line	09/03/1998
Inhalation RfC Assessment (I.B.)	on-line	09/03/1998
Carcinogenicity Assessment (II.)	on-line	09/03/1998

:

Substance Name -- **Chromium(III),** insoluble salts
CASRN -- 16065-83-1
Last Revised -- 09/03/1998

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.A.6. EPA Documentation and Review of the Oral RfD :

Source Document -- U.S. EPA, 1998

This assessment was peer reviewed by external scientists. Their comments have been evaluated carefully and incorporated in finalization of this IRIS summary. A record of these comments is included as an appendix to the Toxicological Review of Trivalent Chromium in support of Summary Information on the Integrated Risk Information System (IRIS) (U.S. EPA, 1998). ***To review this appendix, exit to the toxicological review, Appendix A, Summary of and Response to External Peer Review Comments (PDF)***.

Other EPA Documentation -- U.S. EPA, 1984

Agency Consensus Date -- 4/28/98

Screening-Level Literature Review Findings -- A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the RfD for **Chromium(III),** insoluble salts, conducted in November 2001 did not identify any critical new studies. IRIS users who know of important new studies may provide that information to the IRIS Hotline at hotline.iris@epa.gov or 301-345-2870.

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Chromium(III), insoluble salts
CASRN -- 16065-83-1
Last Revised -- 09/03/1998

The inhalation Reference Concentration (RfC) is analogous to the oral RfD and is likewise based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. The inhalation RfC considers toxic effects for both the respiratory system (portal-of-entry) and for effects peripheral to the respiratory system (extrarespiratory effects). It is generally expressed in units of mg/m^3. In general, the RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily inhalation exposure of the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Inhalation RfCs were derived according to the Interim Methods for Development of Inhalation Reference Doses (U.S. EPA, 1989) and subsequently, according to Methods for Derivation of Inhalation Reference Concentrations and Application of Inhalation Dosimetry (U.S. EPA, 1994). RfCs can also be derived for the noncarcinogenic health effects of substances that are carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.B.6. EPA Documentation and Review of the Inhalation RfC :

Source Document -- U.S. EPA, 1998

This assessment was peer reviewed by external scientists. Their comments have been evaluated carefully and incorporated in finalization of this IRIS summary. A record of these comments is included as an appendix to the Toxicological Review of Trivalent Chromium in support of Summary Information on the Integrated Risk Information System (IRIS) (U.S. EPA, 1998). ***To review this appendix, exit to the toxicological review, Appendix A, Summary of and Response to External Peer Review Comments (PDF)***.

Screening-Level Literature Review Findings -- A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the RfC for **Chromium(III),** insoluble salts, conducted in November 2001 did not identify any critical new studies. IRIS users who know of important new studies may provide that information to the IRIS Hotline at hotline.iris@epa.gov or 301-345-2870.

:

Chromium(III), insoluble salts
CASRN -- 16065-83-1
Last Revised -- 09/03/1998

Section II provides information on three aspects of the carcinogenic assessment for the substance in question, the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk

estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per mg/kg-day. The unit risk is the quantitative estimate in terms of either risk per µg/L drinking water or risk per µg/m^3 air breathed. The third form in which risk is presented is a concentration of the chemical in drinking water or air associated with cancer risks of 1 in 10,000, 1 in 100,000, or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are deSRCibed in the Risk Assessment Guidelines of 1986 (U.S. EPA, 1986) and in the IRIS Background Document. IRIS Summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (U.S. EPA, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.D.2. EPA Review (Carcinogenicity Assessment) :

Not available.

Screening-Level Literature Review Findings -- A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the cancer assessment for **Chromium(III),** insoluble salts, conducted in November 2001 did not identify any critical new studies. IRIS users who know of important new studies may provide that information to the IRIS Hotline at hotline.iris@epa.gov or 301-345-2870.

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Chromium(III), insoluble salts
CASRN -- 16065-83-1

Date	Section	Description
03/01/1988	I.A.1.	Critical effect added
03/01/1988	III.A.	Health Advisory added
08/01/1989	VI.	Bibliography on-line
08/01/1990	IV.F.1.	EPA contact changed
10/01/1990	I.B.	Inhalation RfC now under review
11/01/1990	III.A.	Full Health Advisory summary added
01/01/1992	I.A.7.	Secondary contact changed
01/01/1992	IV.	Regulatory actions updated
05/01/1992	II.	Carcinogenicity assessment now under review
09/01/1994	File	File name changed to include "insoluble salts"
08/01/1995	I.B., II.	EPA's RfD/RfC and CRAVE workgroups were discontinued in May, 1995. Chemical substance reviews that were not completed by September 1995 were taken out of IRIS review. The IRIS Pilot Program replaced the workgroup functions beginning in September, 1995.
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
09/03/1998	I., II., VI.	Revised RfD, RfC, carcinogenicity sections, refs.
12/03/2002	I.A.6., I.B.6., II.D.2.	Screening-Level Literature Review Findings message has been added.

TRICHLOROFLUOROMETHANE

CASRN: 75-69-4

For other data, click on the Table of Contents

Human Health Effects:

Human Toxicity Excerpts:

BY INHALATION, LARGE, ACUTE DOSES HAVE RESULTED IN CARDIAC SENSITIZATION (ARRHYTHMIA) OR BRONCHIAL CONSTRICTION LEADING TO DEATH ... .
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 782]**PEER REVIEWED**

... HUMAN EXPOSURE TO 1000 PPM, 8 HR/DAY, 5 DAYS/WK FOR A TOTAL OF 18 EXPOSURES HAD NO UNTOWARD SUBJECTIVE EFFECTS, & THERE WERE NO CHANGES IN THE ELECTROCARDIOGRAM OR PULMONARY FUNCTION TESTS. THE VENOUS BLOOD LEVELS OF FC11 AFTER 8 HR WERE AS HIGH AS 4.69 UG/ML. THE GRADUAL ATTAINMENT OF THIS LEVEL REPRESENTS A LOW UPTAKE OF THE GAS.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1201]**PEER REVIEWED**

... BRADYCARDIA IS THE USUAL RESPONSE IN HUMAN SUBJECTS INHALING 10% OF CFC 11. ... IT IS REASONABLE TO SUGGEST THAT BRADYCARDIA IN MAN ORIGINATES FROM IRRITATION OF THE UPPER RESPIRATORY TRACT, & THAT CARDIAC EFFECTS CAN BE INITIATED PRIOR TO ABSORPTION OF CFC 11 IN THE LUNGS.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1182]**PEER REVIEWED**

GAS OF LOW TOXICITY BUT NOT ENTIRELY INERT.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-160]**PEER REVIEWED**

MAY BE /CENTRAL NERVOUS SYSTEM DEPRESSANT/ ... IN HIGH CONCN.
[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1517]**PEER REVIEWED**

A SPECIAL CLASS OF CHEMICALS SUBJECT TO ABUSE BY INHALATION ARE THE FLUOROHYDROCARBONS, SUCH AS ... **TRICHLOROFLUOROMETHANE** ... THE "SNIFFING" OF SUCH AEROSOL SPRAYS IS HAZARDOUS PRACTICE. ... 110 "SUDDEN SNIFFING DEATHS" /HAVE BEEN IDENTIFIED/ ... IN EACH CASE THE VICTIM SPRAYED THE AEROSOL INTO A PLASTIC BAG, INHALED THE CONTENTS, BECAME EXCITED, RAN 90 M OR SO, COLLAPSED, & DIED. NECROPSY FINDINGS WERE LARGELY NEGATIVE.
[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975. 910]**PEER REVIEWED**

... TWO CASES OF PHOSGENE POISONING FROM DISINTEGRATION OF FC 11 PROPELLANT AT AN OPEN FLAME IN AN ENCLOSURE /REPORTED/.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3075]**PEER REVIEWED**

Workers ... /involved in a spill of/ large volume of CFC-11 were exposed to high concentrations and

developed /CNS depressant/ effects. In one case, unconsciousness occurred, and in another, potentiation of the endogenous adrenaline effect and tachycardia.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.93 (1990)]**PEER REVIEWED**

Three volunteers were exposed to a CFC-11 concentration of 3750 mg/cu m (657 ppm). The average value of pulmonary retention was 18.9%. CFC-11 levels in alveolar air and blood were 3066 mg/cu m (537 ppm) and 2.8 ug/ml, respectively.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.57 (1990)]**PEER REVIEWED**

/UV-B Radiation is likely to incr by ozone depletion caused by atmospheric concentrations of chlorofluorocarbons/. Indications are increasing that UV-B radiation ... plays a role in the induction and growth of cutaneous melanomas, a ... dangerous type of skin cancer. ... There are indications that ... suppression of the immune response by UV-B radiation may occur in humans. The antigen presenting Langerhans cells in the skin are damaged and allergic responses are depressed. ... There are indications that UV-B radiation increases cataract formation, an important cause of blindness especially in areas with limited medical facilities. /Chlorofluorocarbons/
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.101 (1990)]**PEER REVIEWED**

Many gases emitted as a result of industrial and agricultural activities can accumulate in the earth's atmosphere and ultimately contribute to alterations in the vertical distribution and concentrations of stratospheric ozone. Among the most important are those trace gases that have long residence times in the atmosphere. This allows accumulation in the troposphere and a gradual upward migration of the gases into the stratosphere where they contribute to depletion of stratospheric ozone layer. The atmospheric and chemical processes involved are extremely complex. Trace gases of particular concern include certain long lived chlorofluorocarbons, such as CFC-11, CFC-12, and CFC-113. Since the transport of these gases to the stratosphere is slow, their residence times there are long, and the removal processes are slow, any effect on stratospheric ozone already seen is probably the result of anthropogenic emissions of these gases several decades ago. Those gases already in the atmosphere will continue to exert stratospheric ozone depletion effects well into the next century. /Chlorofluorocarbons/
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.47 (1990)]**PEER REVIEWED**

Increased UV-B radiation would be expected to increase photochemical smog, and this would aggravate the related health problems in urban and industrialized areas. /UV-B Radiation/
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.21 (1990)]**PEER REVIEWED**

/In a patient/ gastric perforation ... occurred one-half hour after accidental ingestion of refrigerated **Freon 11;** transient jaundice and liver enzyme elevation postoperatively was /also/ reported in this patient.
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1281]**PEER REVIEWED**

Deaths resulting from cardiovascular collapse after arrhythmias have been reported after inhalation of Freons 11 and 12.
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 528]**PEER REVIEWED**

Trichlorofluoromethane ... a liquid used mainly as a refrigerant, has no known systemic toxic effect on the eye.
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas

Publisher, 1986. 941]**PEER REVIEWED**

Ten subjects /were exposed/ to CFC-11, CFC-12, CFC-114, two mixtures of CFC-11 and CFC-12, and a mixture of CFC-12 and CFC-114 (breathing concentrations between 16 and 150 g/cu m) for 15, 45, or 60 seconds, and found significant acute reduction of ventilatory lung capacity (FEV50, FEF25) on exposure to each chlorofluorocarbon, as well as bradycardia and increased variability in heart rate in seven subjects, negative T-waves in two subjects (one was exposed to CFC-11 and CFC-12), and atrioventricular block in 1 subject (CFC-114). Mixtures exerted stronger respiratory effects than individual chlorofluorocarbon at the same level of exposure.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.90 (1990)]**PEER REVIEWED**

Allergic contact eczema /was reported/ in patch tests performed on three patients that had a prior history of skin reactions to deodorant sprays. All three patients showed strong positive reactions to 11 deodorant sprays and mild to strong reactions to CFC-11. One patient showed a mild reaction to CFC-12. Fifteen controls (without prior history of allergy to deodorants) showed no response to either CFC-11 or CFC-12. These results suggest that individuals may become sensitized to certain chlorofluorocarbons applied repeatedly to the skin surface.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.91 (1990)]**PEER REVIEWED**

Effects of chlorofluorocarbons on bronchiolar tone in asthmatic children /were studied/. Forced expiratory volume, a measure of bronchial tone, was measured in 18 children with a history of asthma, before and after inhaling aerosols of the B2-receptor agonist, fenoterol, or a mixture of CFC-11, CFC-12, and CFC-114, and in the absence of treatment. The levels of exposure were not reported. Exposure to the chlorofluorocarbon mixture significantly reduced forced expiratory volume for 2 hr, relative to no treatment, and for 8 hr relative to exposure to fenoterol (containing CFC-11 and CFC-12). The results suggest that chlorofluorcarbons can decrease bronchial tone in asthmatic patients, but that this effect is transient and of a sufficiently small magnitude to be superseded by the dilating effects of fenoterol when both fenoterol and chlorofluorcarbon propellants are inhaled together.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.91 (1990)]**PEER REVIEWED**

Eighty nine workers were examined during their work with refrigerant equipment. The refrigerants used were mainly CFC-12 (in 56% of the cases) and HCFC-22 (32%), the rest being CFC-11, CFC-500 (a mixture of CFC-12 and HCFC 152a), CFC-502 (a mixture of CFC-115 and HCFC 22). The mean exposure time was 10 min. Chlorofluorocarbon concentrations in the breathing zone were measured for each person individually. The levels exceeded 750 ppm at least once (as one min mean values) for 60 of the 89 individuals. Cardiac arrhythmias were registered before, during, and after the exposure by means of a portable ECG instrument connected to a tape recorder. No statistically significant difference was found between exposed and nonexposed period, nor was there any dose related trend for different individuals when grouped into different exposure groups. In this study, possible effects on the central nervous system were also studied by means of simple reaction time measurements before and after the exposure. No impairment was seen.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.93 (1990)]**PEER REVIEWED**

Trichlorofluoromethane can affect the body if it is inhaled or if it comes in contact with the eye or skin. It can also affect the body if it is swallowed.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Propellant /fluorocarbon/ gases were generated from commercial aerosol units and applied to the from distance of 50 cm for periods of 15 to 60 sec. At a measured concn of 95,000 mg/cu m (1700 ppm), there was a biphasic change in ventilation capacity, the first reduction occurring within a few minutes after exposure, and second delayed until 13 to 30 min after exposure, and second delayed until 13 to 30 min after exposure. Most subjects developed bradycardia, and inversion of the T-wave. /Propellant gases/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1201]**PEER REVIEWED**

Freon 11, inhaled at 5% concentration, sensitizes the myocardium to epinephrine. A 6% concentration results in apnea and areflexia. A 10% concentration produces cardiac arrhythmias. Deaths resulting from cardiovascular collapse after arrhythmias have been reported after inhalation of /**Freon 11/ ... .**
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 528]**PEER REVIEWED**

EXCESSIVE SKIN CONTACT WITH LIQ FLUOROCARBONS SHOULD BE MINIMIZED TO PREVENT DEFATTING OF SKIN ... /FLUOROCARBONS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 897]**PEER REVIEWED**

Fluorocarbon vapors are 4 to 5 times heavier than air. Thus high concn tend to accumulate in low-lying areas, resulting in hazard of inhalation of concentrated vapors, which may be fatal. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Under certain condition, fluorocarbon vapors may decompose on contact with flames or hot surfaces, creating potential hazard of inhalation of toxic decomposition products. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

EARLY ... HUMAN EXPERIENCE INDICATED THAT HIGH VAPOR CONCN (EG, 20%) MAY CAUSE CONFUSION, PULMONARY IRRITATION, TREMORS & RARELY COMA, BUT THAT THESE EFFECTS WERE GENERALLY TRANSIENT & WITHOUT LATE SEQUELAE. ... CAUSE OF DEATH /FROM ABUSE OF FLUOROCARBONS/ IS IN CONSIDERABLE DOUBT. FREEZING OF AIRWAY SOFT TISSUES CAN PROBABLY BE ELIMINATED AS A CAUSE OF DEATH EXCEPT IN CASES WHERE THE PRODUCT WAS SPRAYED DIRECTLY INTO THE MOUTH FROM ITS CONTAINER OR FROM A BALLOON CONTAINING SOME LIQUID. LARYNGEAL SPASM OR EDEMA, OXYGEN DISPLACEMENT, OR SENSITIZATION OF MYOCARDIUM TO ENDOGENOUS CATECHOLAMINES WITH SUBSEQUENT VENTRICULAR FIBRILLATION APPEAR TO BE REASONABLE POSSIBILITIES. /FLUOROCARBON REFRIGERANTS & PROPELLANTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-159]**PEER REVIEWED**

A SPECIAL CLASS OF CHEMICALS SUBJECT TO ABUSE BY INHALATION ARE THE FLUOROHYDROCARBONS ... THE "SNIFFING" OF SUCH AEROSOL SPRAYS IS HAZARDOUS PRACTICE. ... 110 "SUDDEN SNIFFING DEATHS" /HAVE BEEN IDENTIFIED/ ... IN EACH CASE THE VICTIM SPRAYED THE AEROSOL INTO A PLASTIC BAG, INHALED THE CONTENTS, BECAME EXCITED, RAN 90 M OR SO, COLLAPSED, & DIED. NECROPSY FINDINGS WERE LARGELY NEGATIVE ... ALTHOUGH AMOUNT OF PROPELLANT ABSORBED INTO BLOOD FROM USE OF HAIRSPRAY, COSMETIC, HOUSEHOLD, &

MEDICATED AEROSOLS MUST VARY WITH CIRCUMSTANCES, PHYSICIAN IS ADVISED TO COUNSEL ... PATIENT ON POTENTIAL DANGERS, PARTICULARLY FROM THEIR USE IN POORLY VENTILATED CONFINED AREAS. IT IS POSSIBLE THAT PATIENTS WITH CARDIAC OR RESPIRATORY DISORDERS MAY PROVE ESPECIALLY SUSCEPTIBLE. /FLUOROHYDROCARBONS/
[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975. 910]**PEER REVIEWED**

In a cross-sectional study the neurological effects of fluorocarbons were evaluated in 27 refrigeration repair workers. Fourteen age matched reference subjects were selected from a local union of plumbers, pipe-fitters, and insulation workers. A case of peripheral neuropathy in a commercial refrigeration repairman prompted the investigation. Personal air samples from 2 worker-participants over the course of a typical workshift showed 1.4 ppm chlorodifluoromethane and 2.2 ppm chloropenta-fluoroethane. There were no cases of peripheral neuropathy in the study subjects. There was no significant difference in mean nerve conduction velocities (ulnar, median, peroneal, sural, tibial) between study and reference subjects. Lightheadedness and palpitations were reported significantly more often by refrigeration repair workers ($p<0.05$). /Fluorocarbons/
[Campell DD et al; Br J Ind Med 43:107-11 (1986)]**PEER REVIEWED**

Fluorocarbons were initially believed to be compounds low in toxicity. In the late 1960s there were early reports of deaths caused by intentional inhalation abuse of various aerosols. Victims frequently discharged the aerosol contents into a plastic bag and then inhaled the gaseous contents. Suffocation was initially considered to be the cause of death. In 1970, 110 cases of "sudden sniffing death" /were reviewed/ without finding evidence of suffocation. The majority of those deaths (59) involved fluorocarbon propellants. He noted that in several cases sudden death followed a burst of emotional stress or exercise. No significant findings were noted at autopsy. /Fluorocarbons/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1281]**PEER REVIEWED**

Fluorocarbon propellants are anesthetic and cardiotoxic. ... Aerosol propellants produce hallucinogenic effects, and, rarely, contact dermatitis. /Fluorocarbon propellants/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 528]**PEER REVIEWED**

Fluorocarbon propellants, benzene, 1,1,1-trichloroethane, gasoline, toluene, and hydrocarbons have been implicated in 110 sudden deaths after inhalant abuse in which no obvious cardiac or pulmonary pathology existed. Heavy exercise or stress was associated with 18 of those deaths, /it was/ proposed that these inhalants act to sensitize the myocardium to endogenous catecholamines. Hypoxia, hypercarbia, and acidosis may exacerbate these effects. /Fluorocarbon propellants/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 841]**PEER REVIEWED**

Chlorinated hydrocarbons may cause systemic toxicity through percutaneous absorption. Systemic toxicity includes convulsion, delirium, and central nervous system depression /From table/. /Chlorinated hydrocarbons/
[Zenz, C. Occupational Medicine-Principles and Practical Applications. 2nd ed. St. Louis, MO: Mosby-Yearbook, Inc, 1988. 160]**PEER REVIEWED**

There is ... evidence that the atmospheric concns of chlorofluorocarbons deplete ozone in the stratosphere. A reduction in ozone concn will result in increased transmission of solar UV radiation through the stratosphere. Many significant adverse effects of such an incr in exposure to this radiation have been identified. ... One of the most well-defined human health effects resulting from stratospheric

ozone depletion is an incr in the frequency of skin cancer expected as a result of even small increases in UV-B radiation (280-320 nm) reaching the earths's surface. /Chlorofluorocarbons/
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.95 (1990)]**PEER REVIEWED**

Freons are toxic to humans by several mechanisms. Inhaled fluorocarbons sensitized the myocardium to catecholamines, frequently resulting in lethal ventricular arrhythmias. Because they are gases heavier than air, fluorocarbons can displace atmospheric oxygen, thus resulting in asphyxiation. These compounds also have a central nervous system (CNS) anesthetic effect analogous to a structurally similar general anesthetic, halothane. Pressurized refrigerant or liquid fluorocarbons with a low boiling point have a cyrogenic effect on exposed tissues, causing frostbite, laryngeal or pulmonary edema, and gastrointestinal perforation. Certain fluorocarbons degrade at high temperatures into toxic products of chlorine, hydrofluoric acid, or phosgene gases. /Freons/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1281]**PEER REVIEWED**

... HIGH VAPOR CONCN (EG, 20%) MAY CAUSE CONFUSION, PULMONARY IRRITATION, TREMORS & RARELY COMA ... BUT ... THESE EFFECTS WERE GENERALLY TRANSIENT & WITHOUT LATE SEQUELAE. /FLUOROCARBON REFRIGERANTS & PROPELLANTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-159]**PEER REVIEWED**

Non-occupational exposure and accidental or abusive inhalation of aerosols /due to Fluorocarbon propellants/ have also been documented, the main symptoms being CNS depression and cardiovascular reactions. Cardiac arrhythmia, possibly aggravated by elevated levels of catecholamines due to stress or by moderate hypercapnia, is suggested as the cause of these adverse response, which may lead to death. /Aerosols/
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.20 (1990)]**PEER REVIEWED**

... CAUSE OF DEATH /FROM ABUSE OF FLUOROCARBONS/ IS IN ... DOUBT. FREEZING OF AIRWAY SOFT TISSUES CAN PROBABLY BE ELIMINATED ... EXCEPT IN CASES WHERE PRODUCT WAS SPRAYED DIRECTLY INTO MOUTH FROM CONTAINER OR BALLOON CONTAINING SOME LIQ. /FLUOROCARBON REFRIGERANTS & PROPELLANTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-159]**PEER REVIEWED**

... CAUSE OF DEATH /FROM ABUSE OF FLUOROCARBONS/ ... IN ... DOUBT. ... LARYNGEAL SPASM OR EDEMA, OXYGEN DISPLACEMENT, OF SENSITIZATION OF MYOCARDIUM TO ENDOGENOUS CATECHOLAMINES WITH ... VENTRICULAR FIBRILLATION APPEAR TO BE ... POSSIBILITIES. /FLUOROCARBON REFRIGERANTS & PROPELLANTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-159]**PEER REVIEWED**

There are isolated reports of poisoning from exposure to refrigerants and solvents, and some studies showing a higher incidence of coronary heart disease among hospital personnel are required to establish causal relationship between fluorine containing organic compounds, and cardiovascular and bronchopulmonary diseases among exposed workers. The high incidence of cancer among hospital personnel repeatedly exposed to fluorine-containing general anesthetics raises a fundamental need to examine other chlorofluorocarbon-exposed workers for similar effects. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1209]**PEER REVIEWED**

Clinical pathologists exposed to fluorocarbons in the preparation of frozen tissue sections have been seen to develop coronary heart disease. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1209]**PEER REVIEWED**

Manufacturing processes use hydrofluoric acid from fluorospar in the production of most fluorine containing organic compounds. Some processes use carbon tetrachloride from carbon disulfide or as a co product of perchloroethylene and chlorination of propylene, or chloroform from chlorination of methanol. The major hazards relate primarily to the inadvertent release of hydrofluoric acid or carbon tetrachloride, rather than to the manufactured final product. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1194]**PEER REVIEWED**

The toxicity of Chlorofluorocarbons (CFCs) had been considered to be low; it is absorbed via the lungs and undergoes little subsequent biotransformation. In the United States when sudden unexplained deaths of aerosol "sniffers" were reported they were considered to be possibly due to cardiac arrhythmias induced by the CFC propellants. /CFCs/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 1299]**PEER REVIEWED**

Aerosol sprays containing fluorocarbon propellants are another source of solvent intoxication. Prolonged exposure or daily use may result in damage to several organ systems. Clinical problems include cardiac arrhythmias, bone marrow depression, cerebral degeneration, and damage to liver, kidney, & peripheral nerves. Death occasionally has been attributed to inhalant abuse, probably via the mechanism of cardiac arrhythmias, especially accompanying exercise or upper airway obstruction. /fluorocarbon propellants/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 575]**PEER REVIEWED**

High concentrations cause narcosis and anesthesia in humans. Human systemic effects by inhalation: conjunctiva irritation, fibrosing alveolitis and liver changes.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 3236]**PEER REVIEWED**

... Workers who spilled a large volume of CFC-11 were exposed to high concentrations & developed signs of narcosis. One of the workers became unconscious, & another experienced tachycardia.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1621]**PEER REVIEWED**

... Normal household exposure to CFC-11 aerosols produced no changes in respiratory parameters, biochemical parameters, or hematologic indices in 20 women followed for 1 month.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1621]**PEER REVIEWED**

In a controlled study, volunteers were exposed to CFC-11 at concentrations of 250, 500, or 1000 ppm for periods of 1 min to 8 hr. Volunteers were also exposed for 8 hr/day, 5 days/week for 2 to 4 weeks to CFC-11 at a concentration of 1000 ppm. The acute exposures did not produce any untoward physiological effects as determined by a number of biological endpoints, including clinical hematology & chemistry, EKG, EEG, neurological parameters, pulmonary function, & cognitive tests. The repetitive exposure at 1000 ppm was without measurable untoward physiological effect except for a minor decrement in several cognitive tests. The authors considered these decrements spurious because similar

changes could not be detected in volunteers acutely exposed for 8 hr at 1000 ppm.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1620]**PEER REVIEWED**

Intentional inhalation of aerosols containing extremely high concentrations of mixtures of CFC-11 & CFC-12 has caused instantaneous death. The /Intentions Program on Chemical Safety/ considered the deaths associated with these exposures to be caused by cardiac arrhythmia, aggravated by elevated levels of catecholamines due to stress or by moderate hypercapnia.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1621]**PEER REVIEWED**

Medical Surveillance:

Employees should be screened for history of certain medical conditions ... which might place the employee at increased risk from dichlorodifluoromethane exposure. Cardiovascular disease: In persons with impaired cardiovascular function, especially those with a history of cardiac arrhythmias, the inhalation of dichlorodifluoromethane might cause exacerbation of disorders of the conduction mechanism due to its sensitizing effects on the myocardium. ... Any employee developing the above-listed conditions should be referred for further medical examination.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Populations at Special Risk:

Employees /with cardiovascular disease are/ at increased risk.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.]**PEER REVIEWED**

IT IS POSSIBLE THAT PT WITH CARDIAC OR RESP DISORDERS MAY PROVE ESP SUSCEPTIBLE. /FLUOROCARBONS/
[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975. 910]**PEER REVIEWED**

Probable Routes of Human Exposure:

GREATEST OCCUPATIONAL EXPOSURE BY VOLUME USE OF REFRIGERANTS IS IN SERVICING (NOT INCLUDING RECHARGING), INITIAL CHARGING, & MANUFACTURING & INSTALLATION. /FLUOROCARBONS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3102]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 267,742 workers (95,886 of these are female) are potentially exposed to **trichlorofluoromethane** in the US(1). Occupational exposure to **trichlorofluoromethane** may occur through inhalation and dermal contact with this compound at workplaces where **trichlorofluoromethane** is produced or used(SRC). Monitoring data indicate that the general population may be exposed to **trichlorofluoromethane** via inhalation of ambient air, ingestion of drinking water, and dermal contact with this compound and other consumer products containing **trichlorofluoromethane**(SRC).

[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983)]**PEER REVIEWED**

Body Burden:

7 of 8 samples of mother's milk from 4 urban sites in US positive for trichlorfluoromethane(1). It was detected in 4 of 8 samples of respired air at a range of 0.007 to 0.041 ug/hr, positive subjects having been previously occupationally exposed (laboratory technicians)(2).
[(1) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982) (2) Conkle JP; Arch Environ Health 30: 290-5 (1975)]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** FLUORINATED HYDROCARBONS ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

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0.2.1 SUMMARY OF EXPOSURE
 0.2.1.1 ACUTE EXPOSURE
   A.  LOW CONCENTRATION - Inhalations such as those caused by
       leaking air conditioners or refrigerators may result in
       transient eye, nose, and throat irritation.
       Palpitations, light-headedness, and headaches are also
       seen.
   B.  HIGH CONCENTRATION - Inhalation associated with
       deliberate abuse, spills or industrial use occurring in
       poorly ventilated areas has been associated with
       ventricular dysrhythmias, pulmonary edema and sudden
       death.
0.2.4 HEENT
 0.2.4.1 ACUTE EXPOSURE
   A.  EYES - Eye irritation occurs with ambient exposure.
       Frostbite of the lids may be severe.  Ocular
       instillation results in corneal burns in rabbits.
   B.  NOSE - Nasal irritation occurs with ambient exposure.
   C.  THROAT - Irritation occurs.  Frostbite of the lips,
       tongue, buccal mucosa and hard palate developed in a
       man after deliberate inhalation.
0.2.5 CARDIOVASCULAR
 0.2.5.1 ACUTE EXPOSURE
   A.  Inhalation of high concentrations is associated with
       the development of refractory ventricular dysrhythmias
       and sudden death, believed to be secondary, primarily,
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to hypoxia or myocardial sensitization to endogenous catecholamines. Some individuals may be susceptible to arrhythmogenic effects at lower concentrations.

0.2.6 RESPIRATORY

0.2.6.1 ACUTE EXPOSURE

A. Pulmonary irritation, bronchial constriction, cough, dyspnea, and chest tightness may develop after inhalation. Chronic pulmonary hyperreactivity may occur. Adult respiratory distress syndrome has been reported following acute inhalational exposures. Pulmonary edema is an autopsy finding in fatal cases.

0.2.7 NEUROLOGIC

0.2.7.1 ACUTE EXPOSURE

A. Headache, dizziness, and disorientation are common. Cerebral edema may be found on autopsy. A syndrome of impaired psychomotor speed, impaired memory and learning, and emotional lability has been described in workers with chronic occupational exposure to fluorinated hydrocarbons.

0.2.8 GASTROINTESTINAL

0.2.8.1 ACUTE EXPOSURE

A. Nausea may develop. Ingestion of a small amount of **trichlorofluoromethane** resulted in necrosis and perforation of the stomach in one patient.

0.2.9 HEPATIC

0.2.9.1 ACUTE EXPOSURE

A. Jaundice and mild elevations in transaminases may develop after inhalational exposure or ingestion. Hepatocellular coagulative necrosis has been observed on liver biopsy.

0.2.14 DERMATOLOGIC

0.2.14.1 ACUTE EXPOSURE

A. Dermal contact may result in defatting, irritation or contact dermatitis. Severe frostbite has been reported as an effect of freon exposure. Injection causes transient pain, erythema and edema.

0.2.15 MUSCULOSKELETAL

0.2.15.1 ACUTE EXPOSURE

A. Rhabdomyolysis has been reported in a worker susceptible to malignant hyperthermia after exposure to fluorinated hydrocarbons and also following intentional freon inhalation. Compartment syndrome is a rare complication of severe exposure.

0.2.20 REPRODUCTIVE HAZARDS

A. Dichlorodifluoromethane was not teratogenic in rats and rabbits.

B. The reproductive effects of 1,1,1,2-tetrafluoroethane were studied in rats. No adverse effects on reproductive performance was noted or on the development, maturation or reproductive performance of up to two successive generations.

0.2.22 GENOTOXICITY

A. The hydrochlorofluorocarbons, HCFC-225ca and HCFC-225cb, were not mutagenic in the Ames reverse mutation assay, or clastogenic in the chromosomal aberration assay with Chinese hamster lung cells. Neither induced unscheduled DNA synthesis in liver cells. Both of these agents were clastogenic in the chromosomal aberration assay with human lymphocytes.

Laboratory:

A. Fluorinated hydrocarbons plasma levels are not clinically useful.

B. No specific lab work (CBC, electrolyte, urinalysis) is needed unless otherwise indicated.
C. Obtain baseline pulse oximetry or arterial blood gas analysis.

Treatment Overview:

0.4.2 ORAL EXPOSURE
A. These substances may cause frostbite to the upper airway and gastrointestinal tract after ingestion. Administer oxygen and manage airway as clinically indicated. Emesis, activated charcoal, and gastric lavage are not recommended.
0.4.3 INHALATION EXPOSURE
A. MONITOR ECG and VITAL SIGNS carefully. Cardiopulmonary resuscitation may be necessary. Caution is advised with the administration of CATECHOLAMINE drugs.
B. PROVIDE A QUIET CALM ATMOSPHERE to prevent adrenaline surge if the patient is seen before the onset of cardiac arrhythmias. Minimize physical exertion.
C. MONITOR pulse oximetry or arterial blood gases.
D. Provide symptomatic and supportive care.
E. These substances may cause frostbite of the upper airway with the potential for severe edema. Administer oxygen and manage airway early in patients with evidence of upper airway injury.
F. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.
0.4.4 EYE EXPOSURE
A. DECONTAMINATION: Irrigate exposed eyes with copious amounts of room temperature water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility.
B. Ophthalmologic consultation should be considered in symptomatic patients.
0.4.5 DERMAL EXPOSURE
A. DECONTAMINATION: Remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician may need to examine the area if irritation or pain persists.
B. If frostbite has occurred, refer to dermal treatment in the main body of this document for rewarming.

Range of Toxicity:

A. Freons are very toxic when inhaled in high concentrations and/or for extended periods. At lower concentrations or brief exposure, freons may cause transient eye, nose, and throat irritation.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

Emergency treatment is supportive & includes decontamination, oxygen, & any specific therapy required

in a particular case such as antiarrhythmics or anticonvulsants. A few patients may require intermittent positive-pressure ventilation, dialysis, or treatment for hepatic failure. /Solvent abuse/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1259]**PEER REVIEWED**

... In persons who are intoxicated with fluorocarbons, steps can be taken to lessen the risk of arrhythmias. ... Before evaluation at the hospital, patients should be advised to avoid strenuous exercise. In the hospital, patients can be placed in a quiet, nonthreatening environment and sedated if necessary. If hypoxic, oxygen should be administered and metabolic abnormalities corrected. Sympathomimetic drugs should be avoided. Ventricular arrhythmias are best treated with beta-blocking agents. /Fluorocarbons/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 81]**PEER REVIEWED**

Patients with fluorohydrocarbon poisoning should not be given epinephrine (Adrenalin) or similar drugs because of the tendency of fluorohydrocarbon to induce cardiac arrhythmia, including ventricular fibrillation. /Fluorohydrocarbons/
[Zenz, C. Occupational Medicine-Principles and Practical Applications. 2nd ed. St. Louis, MO: Mosby-Yearbook, Inc, 1988. 543]**PEER REVIEWED**

Victims of freon inhalation require management for hypoxic, CNS anesthetic, & cardiac symptoms. Patients must be removed from the exposure environment, & high flow supplemental oxygen should be utilized. The respiratory system should be evaluated for injury, aspiration, or pulmonary edema & treated appropriately. CNS findings should be treated supportively. A calm environment with no physical exertion is imperative to avoid increasing endogenous adrenegic levels. Exogenous adrenergic drugs must not be used to avoid inducing sensitized myocardial dysrhythmias. Atropine is ineffective in treating bradyarrhythmias. For ventricular dysrhythmias, diphenylhydantoin & countershock may be effective. Cryogenic dermal injuries should be treated by water bath rewarming at 40-42 deg C until vasodilatory flush has returned. Elevation of the limb & standard frostbite management with late surgical debridement should be utilized. Ocular exposure requires irrigation & slit lamp evaluation for injury. /Freons/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1282]**PEER REVIEWED**

... If inhalation occurs, epinephrine or other sympathomimetic amines and adrenergic activators should not be admin since they will further sensitize heart to development of arrhythmias. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1201]**PEER REVIEWED**

Basic treatment: Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations as needed. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Minimize physical activity and provide a quiet atmosphere. Monitor for pulmonary edema and treat if necessary ... . Anticipate seizures and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport ... . Do not use emetics. Rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal ... . Treat frostbite with rapid rewarming techniques ... . /Chlorinated fluorocarbons (CFCs) and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 192]**PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious or in respiratory arrest. Positive pressure ventilation techniques with a bag valve mask device may be beneficial. Monitor cardiac rhythm and treat arrhythmias if necessary ... . Start an IV with D5W /SRP: "To keep open", minimal flow rate/. Use lactated Ringer's if signs of hypovolemia

are present. Watch for signs of fluid overload. Consider drug therapy for pulmonary edema ... . Treat seizures with diazepam ... . Use proparacaine hydrochloride to assist eye irrigation ... . /Chlorinated fluorocarbons (CFCs) and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 192]**PEER REVIEWED**

Animal Toxicity Studies:

Non-Human Toxicity Excerpts:

... IT HAS HIGHEST DEGREE OF CARDIOTOXICITY IN MONKEYS.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-160]**PEER REVIEWED**

... MICE GIVEN 0.1 ML OF 10% SOLN /BY GAVAGE/ AT 1 & 7 DAYS OF AGE & 0.2 ML AT 14 & 21 DAYS OF AGE WERE OBSERVED FOR 1 YR. NO EVIDENCE OF CARCINOGENIC EFFECT OF **FREON 11** WAS FOUND.
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 782]**PEER REVIEWED**

... NO HARMFUL EFFECTS ON RABBIT EYES WHEN 9 APPLICATIONS OF 0.1 ML WERE MADE DURING 11-DAY PERIOD. ALSO, EXPOSING EYES OF RABBITS TO 5-SECOND BURSTS OF PROPELLANT FROM DISTANCE OF 20 CM FROM CORNEA 5 DAYS/WK FOR A MONTH IS SAID TO HAVE PRODUCED NOTHING MORE THAN HYPEREMIA OF EYE LASTING SEVERAL HR ... MILD INFLAMMATION OF EYELIDS.
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 941]**PEER REVIEWED**

... INHALATION @ 20,000 PPM OF 9:1 MIXT OF FREON 12 & **FREON 11** BY RATS ON DAYS 4-16 OF GESTATION & RABBITS ON DAYS 5-20 OF GESTATION DID NOT INDUCE ANY EMBRYOTOXIC OR TERATOGENIC EFFECTS.
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 782]**PEER REVIEWED**

MICE THAT INHALED 10% DEVELOPED CARDIAC ARRHYTHMIA ... DOGS THAT INHALED 2.5% HAD DECR MYOCARDIAL FUNCTION, INCL CARDIAC OUTPUT ... & MONKEYS THAT INHALED 5% DEVELOPED TACHYCARDIA & HYPOTENSION ...
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 782]**PEER REVIEWED**

FREON 11 IN CORN OIL WAS ADMINISTERED BY GAVAGE FOR 78 WK TO 50 MALE & 50 FEMALE OSBORNE-MENDEL RATS & B6C3F1 MICE, 5 DAYS/WK. THE TIME WEIGHTED AVERAGE HIGH & LOW DOSAGES WERE, RESPECTIVELY, 977 & 488 MG/KG/DAY FOR MALE RATS, 1077 & 538 MG/KG/DAY FOR FEMALE RATS, & 3925 & 1962 MG/KG/DAY FOR MICE OF BOTH SEXES. A HIGH RATE OF EARLY DEATH OCCURRED AMONG MALE & FEMALE RATS. NO GROUPS OF MALE OR FEMALE MICE DOSED WITH **FREON 11** HAD SIGNIFICANTLY INCREASED TUMOR INCIDENCES RELATIVE TO THEIR RESPECTIVE CONTROL GROUPS.
[CARCINOG TEST PROGRAM, BETHESDA, MD; REPORT; ISS DHEW/PUB/NIH/78-1356, NCI-CG-TR-106; ORDER NUMBER PB-286187, 93 PAGES (1978)]**PEER REVIEWED**

A 4-week series of 3.5 hr exposures at 12,500 or 25,000 ppm, a 6-week study with 7 hr exposures at 4000 ppm & another 6-week study with 8 hr exposures at 10,250 ppm showed no adverse effects attributable to inhaled CFC-11 in various species. Monkeys, dogs, rats, & guinea pigs exposed

continuously at 1000 ppm for 90 days showed no specific abnormalities that the investigators attributed to CFC-11.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1620]**PEER REVIEWED**

RATS & RABBITS EXPOSED TO 50,000 PPM FOR ONE HR TWICE DAILY FOR 15 DAYS SHOWED INCREASED BLOOD GLUCOSE & LACTIC ACID, DECREASED OXYGEN UPTAKE, & OTHER BIOCHEMICAL CHANGES CONSISTENT WITH SLOWING OF CELLULAR OXIDATION. COMPARABLE EXPOSURE AT 25,000 PPM DID NOT CAUSE THESE CHANGES.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1620]**PEER REVIEWED**

Twelve guinea pigs divided into 4 groups of 3 each were exposed for 5 min, 30 min, 1 hr, & 2 hr, respectively. Exposure of 2.5% for 30 min caused occasional tremors & the rate of respiration became irregular. Exposure to 10% for 1 hr resulted in coma. The guinea pigs exposed to this concn for 2 hr were sacrificed 8 days later. Whereas their lungs were found to contain mottled areas of congestion, other organs showed no pathological changes. ... Exposure to a concn of 20% for 1 hr was lethal.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1180]**PEER REVIEWED**

/Rats exposed/ ... to CFC 11 in concentrations ranging from 5 to 50% for 30 min. Whereas a concentration of 5% produced no symptoms of intoxication, concentrations of 6 and 7% caused a loss of postural reflex, 8% a loss of righting reflex, and 9% complete unconsciousness. The following concentrations and times were lethal: 10% inhaled for 20 to 30 min: 15% for 8 min; 20 to 30% for 4 min; and 50%, for 1 min.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1180]**PEER REVIEWED**

... Inhalation of 10 percent CFC I I for 1 hr was lethal to the /cats/. In an atmosphere containing 15 percent CFC 11, mice succumbed in a few minutes.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1180]**PEER REVIEWED**

THE DOSE THAT CAUSES A SIGNIFICANT REDUCTION IN RESP MINUTE VOLUME /IN MONKEYS/ IS 5% ... RESP EFFECT IS BROUGHT ABOUT BY A COMBINATION OF REDUCED RESP RATE & TIDAL VOLUME. THE RESP THRESHOLD DOSES FOR DOGS ARE LOWER THAN THOSE FOR THE MONKEY. ... THE MINIMAL DOSE THAT DEPRESSES RESP MINUTE VOLUME IS 2.5% ... WITH ADMIN OF INCREASING CONCN OF FC 11, A 40% DEPRESSION OF RESP MINUTE VOLUME OCCURRED /IN RATS/ AT 10% CONCN ... /IN MICE/ ... 2.5% CONCN CAUSED A 65% DEPRESSION OF RESP MINUTE VOLUME, WHICH WAS SUPPORTED BY A REDUCTION IN RATE & TIDAL VOLUME.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1181]**PEER REVIEWED**

Trichlorofluoromethane was tested for mutagenicity in the Salmonella microsome preincubation assay using a protocol approved by the National Toxicology Program. **Trichlorofluoromethane** was tested at doses of 0, 100, 333, 1000, 3333, and 10,000 ug/plate in four Salmonella typhimurium strains (TA98, TA100, TA1535, and TA1537) in the presence and absence of Aroclor-induced rat and/or hamster liver S9. **Trichlorofluoromethane** was negative in these tests and the highest ineffective dose level tested in

any Salmonella tester strain was 10,000 ug/plate.
[Zeiger E et al; Environ Mutagen 9: 1-110 (1987)]**PEER REVIEWED**

In dogs, **trichloromonofluoromethane** (**Freon 11,** F11, Fluorocarbon 11) at concns between 15% & 21% causes sinus bradycardia terminating in asystole. These concns are exceeded (ie, 35% to 40%) when plastic bags are filled with Freon propellants, similar to the manner in which other inhalation products are abused.
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 884]**PEER REVIEWED**

The induction of pentobarbital anesthesia reduced the incidence of arrhythmia and increased the threshold concentration to 10%. CFC 11 Rats that developed cardiac necrosis elicited by isoproterenol injections showed a reduction in threshold concentration to 5%. Likewise, those that developed pulmonary arterial thrombosis showed a similar increase in the proarrhythmic activity of CFC 11. The induction of pulmonary emphysema did not increase cardiac sensitivity. Adrenalectomy or injection of drugs that block cardiac adrenergic receptors protected the heart from CFC 11 induced arrhythmia.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1181]**PEER REVIEWED**

MICE UNDER PENTOBARBITAL ANESTHESIA DID NOT SHOW ANY CARDIAC ARRHYTHMIA FOLLOWING INHALATION OF 2 OR 5% FC 11. HOWEVER, INHALATION OF 10% FC 11 PRODUCED SECOND-DEGREE ATRIOVENTRICULAR BLOCK, & INHALATION OF 5% ... CAUSED THE APPEARANCE OF ATRIOVENTRICULAR BLOCK, FOLLOWING A CONCURRENT IV INJECTION OF EPINEPHRINE.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1181]**PEER REVIEWED**

... INSEMINATED WISTAR ALBINO RATS & ALBINO RABBITS ... /WERE/ ADMIN MIXT OF 90% FREON 12 ... & 10% **FREON 11** BY INHALATION FOR 2 HR/DAY. RATS WERE EXPOSED ON DAYS 4 TO 16 OF GESTATION & RABBITS ON DAYS 5 TO 20. MIXT WAS ADMIN IN 20% CONCN (200,000 PPM). NO INDICATIONS OF ANY EMBRYOTOXIC, FETOTOXIC OR TERATOGENIC CHANGES WERE FOUND WHEN DAMS WERE SACRIFICED & FETUSES REMOVED ON DAY 20 OF GESTATION (RATS) OR DAY 30 OF GESTATION (RABBITS).
[National Research Council. Drinking Water and Health. Volume 3. Washington, DC: National Academy Press, 1980. 103]**PEER REVIEWED**

CFC-11, CFC-12, CFC-114, and mixtures of CFC-11 and CFC-12 and of CFC-11 and CFC-22 /were applied/ to the skin, tongue, soft palate and auditory canal of rats, 1-2 times/day, 5 days/week, for 5-6 weeks. The same compounds were applied once a day, 5 days/week for 1 month to the eye of rabbits. Slight irritation was noted only in the skin of the rats and in the eye of the rabbits. The healing rate of experimental burns on the skin of rabbits, however, was noticeably retarded by all of the compounds.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.74 (1990)]**PEER REVIEWED**

Experimental evidence suggests that increased UV-B irradiation at the earth's surface, resulting from ozone depletion /caused by the atmospheric chlorofluorocarbons/, would have deleterious effects on both terrestrial and aquatic biota. Despite uncertainities resulting from the complexities of field experiments, the data currently available suggest that crop yields and forest productivity are vulnerable to increased levels of solar UV-B radiation. Existing data also suggest that increased UV-B radiation will notify the distribution and abundance of plants, and change ecosystem structure. /UV-B Radiation/
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.18

(1990)]**PEER REVIEWED**

Various studies of marine ecosystems have demonstrated that UV-B radiation causes damage to fish larvae and juveniles, shrimp larvae, crab larvae, copepods, and plants essential to the marine food web. These damaging effects include decreased fecundity, growth, and survival. Experimental evidence suggests that even small increases in ambient UV-B exposure could result in significant ecosystem changes. /UV-B Radiation/
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.18 (1990)]**PEER REVIEWED**

Short-term inhalation studies have been reported for CFC-11, CFC-12, CFC-112, CFC-113, CFC-114, and CFC-115. The results showed low toxicity, and the effects observed were related mainly to the CNS, respiratory tract, and the liver. Oral toxicity studies have confirmed the low toxicity.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.18 (1990)]**PEER REVIEWED**

CFC-11, CFC-12, CFC-113, and CFC-114 at 40% in sesame oil were sprayed onto shaved rabbit skin for 12 exposures with no effect.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.73 (1990)]**PEER REVIEWED**

Trichlorofluoromethane ... /was/ tested by inhalation on Sprague-Dawley rats and Swiss mice. The animals were exposed for 4 hr a day, 5 days a week; rats were exposed for 104 weeks, and mice were exposed for 78 weeks. Animals were observed until spontaneous death. **Trichlorofluoromethane** exposure to rats caused no carcinogenic effects. **Trichlorofluoromethane** exposure to mice caused increased numbers of total tumors in females which was dose related, mammary tumors in females at 5000 ppm, lung adenomas and leukemias in females, both dose related.
[Maltoni C et al; Annals of the New York Academy of Sciences 534: 261-82 (1988)]**PEER REVIEWED**

Negative results were also obtained for CFC-11, CFC-12, and CFC-115 in a cell transformation assay and for CFC-11 and CFC-12 in a mammalian cell mutagenicity test.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.79 (1990)]**PEER REVIEWED**

When administered to groups of 90 male & 90 female /Sprague-Dawley/ rats & 60 male & 60 female /Swiss/ mice at concns of 1000 or 5000 ppm (57 or 285 g CFC-11/cu m; 49 or 247 g CFC-12/cu m), 4 hr/day, 5 days/wk, neither cmpd was found to have induced statistically significant differences in the incidence of total benign or malignant tumors when compared with groups of unexposed rats or mice. The incidence of all tumors & of some particularly frequently occurring spontaneous tumors in mice showed a tendency to incr in animals exposed to CFC-11 & CFC-12 & that the increased incidence was usually observed in one sex & was not always dose related, possibly due to a longer survival of the treated mice compared with controls.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.82 (1990)]**PEER REVIEWED**

THE MOUSE & RAT REQUIRE A FC 11 CONCN OF 2.5 TO 5.0% IN ORDER TO AFFECT THE CIRCULATORY SYSTEM. WHEN ANESTHETIZED, THESE TWO SPECIES RESPOND WITH BRADYCARDIA. THE IMPORTANCE OF PARASYMPATHETIC NERVOUS SYSTEM HAS BEEN DEMONSTRATED BY THE USE OF ATROPINE, WHICH BLOCKS THE RESPONSE.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1182]**PEER REVIEWED**

EARLY ANIMAL ... WORK INDICATED THAT HIGH VAPOR CONCN (EG, 20%) MAY CAUSE

CONFUSION, PULMONARY IRRITATION, TREMORS & RARELY COMA, BUT THAT THESE EFFECTS WERE GENERALLY TRANSIENT & WITHOUT LATE SEQUELAE. /FLUOROCARBON REFRIGERANTS & PROPELLANTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-159]**PEER REVIEWED**

... THE MECHANISM OF FC 11 CARDIOTOXICITY ... /ORIGINATES/ FROM IRRITATION OF THE RESPIRATORY TRACT WHICH IN TURN REFLEXLY INFLUENCES THE HEART RATE EVEN PRIOR TO ABSORPTION OF THE FLUOROCARBON, FOLLOWED BY DIRECT DEPRESSION OF THE HEART AFTER ABSORPTION. ... FC 11 CAUSES ONLY DEPRESSION OF RESPIRATORY MINUTE VOLUME THAT IS NOT PRECEDED BY STIMULATION OF BREATHING. THERE IS ULTIMATE CESSATION OF RESPIRATION, WHICH IS A MANIFESTATION OF GENERALIZED DEPRESSION OF THE CNS BY FC 11.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1183]**PEER REVIEWED**

The immume system of experimental animals is suppressed in specific ways by UV-B radiation. This results in a decreased resistance to implanted UV-B induced tumors and an increased growth of such tumors in mice, in the suppression of sensitization by contact allergens, and the response to allergens in sensitized animals. /Chlorofluorocarbons/
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.101 (1990)]**PEER REVIEWED**

Three propellant chlorofluorocarbons (FC-11, FC-12 /dichlorodifluoromethane/, FC-22) administered by inhalation at concentrations of 5000 and 1000 ppm for 4 hours daily, 5 days weekly for 78 to 104 weeks to rats and mice had no carcinogenic effects.
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 1300]**PEER REVIEWED**

... Chlorofluorocarbons could sensitize the canine myocardium to adrenaline, resulting in serious cardiac arrhythmias. /CFCs/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 1300]**PEER REVIEWED**

Fluorocarbon inhalation in dogs resulted in dysrhythmias that were enhanced by anoxia, injected epinephrine, & noise stress. Fatal responses resulted from inhaled concns of 0.35-0.61% of **Freon 11** & of 5% of Freon 12 & 114.
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1281]**PEER REVIEWED**

National Toxicology Program Studies:

... The bioassay of technical grade **trichlorofluoromethane** for possible carcinogenicity was conducted using Osborne-Mendel rats and B6C3F1 mice. /The cmpd/ in corn oil was admin by gavage, at either of two dosages, to groups of 50 male and 50 female animals of each species, 5 days/wk, over a period of 78 wk. The time weighted avg high and low dosages of **trichlorofluoromethane** in the chronic bioassay were, respectively 977 and 488 mg/kg for male rats, 1,077 and 538 mg/kg/day for female rats, and 3,925 and 1,962 mg/kg/day for mice of both sexes. After a 78 wk dosing period, rats were observed for an additional period of up to 33 wk and mice were observed for an additional period of up to 13 wk, For each species, 20 animals of each sex were placed on test as vehicle controls. These animals were gavaged with corn oil at the same time dosed animals were gavaged /with the cmpd/. Twenty animals of each sex were placed on test as untreated controls for each species. These animals were not gavaged. A high rate of early deaths occurred among male and female rats in this bioassay. An insufficient number

of rats of either sex survived long enough to be at risk from late developing tumors. Survival of mice was adequate for meaningful statistical analysis of late developing tumors. ... The results of the bioassay of **trichlorofluoromethane** in Osborne-Mendel rats for possible carcinogenicity are not conclusive because of inadequate numbers of rats survived sufficiently long enough to be at risk from late developing tumors. Under the conditions of this bioassay, **trichlorofluoromethane** was not carcinogenic to male or female B6C3F1 mice. Levels of Evidence of Carcinogenicity: Male Rats: Inadequate study; Female Rats: Inadequate study; Male Mice: Negative; Female Mice: Negative.
[Bioassay of Trichlorofluoromethane for Possible Carcinogenicity (1978) Technical Rpt Series No. 106 DHEW Pub No. (NIH) 78-1356 U.S. Department of Health Education and Welfare, National Cancer Institute, Bethesda, MD 20014]**QC REVIEWED**

Non-Human Toxicity Values:

LD50 Guinea pig inhalation 250,000 ppm/30 min
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 677]**PEER REVIEWED**

LD50 Rat inhalation 100,000 ppm/30 min
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 677]**PEER REVIEWED**

LD50 Rabbit inhalation 250,000 ppm/30 min
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 677]**PEER REVIEWED**

LD50 Mouse intraperitoneal 1743 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 3236]**PEER REVIEWED**

LD50 Rat oral 3725 mg/kg
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1619]**PEER REVIEWED**

LC50 Mouse inhalant 10,000 ppm/ 30 minutes
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 3236]**PEER REVIEWED**

LC50 Hamster inhalation 571 g/cu m/4 hr
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.64 (1990)]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

WHEN **TRICHLOROFLUOROMETHANE** WAS INHALED BY HUMANS, RECOVERY OF INTACT CMPD IN EXHALED AIR WAS 79-99% & IN URINE, 0.07-0.09%, & METABOLITES AMT TO 0.2% OR LESS ... .
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 781]**PEER REVIEWED**

RAT-LIVER MICROSOMES DECHLORINATE **TRICHLOROFLUOROMETHANE** TO DICHLOROFLUOROMETHANE. THIS REACTION ... IS MEDIATED VIA THE HEPATIC MICROSOMAL P450 ENZYME SYSTEM. ... **TRICHLOROFLUOROMETHANE** & DICHLOROFLUOROMETHANE ADMIN AS HIGH ACUTE INHALATION DOSAGES WERE

EXPIRED UNCHANGED BY BOTH DOGS & RABBITS.
[The Chemical Society. Foreign Compound Metabolism in Mammals. Volume 4: A Review of the Literature Published during 1974 and 1975. London: The Chemical Society, 1977. 241]**PEER REVIEWED**

THEORETICAL METABOLITES OF **TRICHLOROFLUOROMETHANE** ARE DICHLOROFLUOROMETHANE & TETRACHLORODIFLUOROETHANE. NO EVIDENCE OF FREE-RADICAL FORMATION IN RATS OR MICE HAS BEEN SHOWN; NOR IS THERE EVIDENCE OF SIGNIFICANT METABOLISM OF **TRICHLOROFLUOROMETHANE** ...
[National Research Council. Drinking Water and Health. Volume 3. Washington, DC: National Academy Press, 1980. 166]**PEER REVIEWED**

Absorption, Distribution & Excretion:

PULMONARY UPTAKE OF INHALED CFC-11 BY RABBITS & DOGS IS PROMPT. PEAK CIRCULATING CONCENTRATIONS AFTER EXPOSURE AT 4500 TO 5000 PPM WERE ACHIEVED IN 15 SECONDS WITH STEADY-STATE REACHED AT 20 MIN. ELIMINATION IS RELATIVELY RAPID. DOGS EXHALED WITHIN 1 HR ESSENTIALLY ALL THE CFC-11 INHALED DURING A 6 TO 20 MIN EXPOSURE AT 5,000 PPM. INHALED CFC-11 WAS PROMPTLY DETECTED IN BLOOD, CEREBROSPINAL FLUID, BILE & URINE OF ANESTHETIZED RABBITS & DOGS ... . UNANESTHETIZED DOGS EXPOSED TO 1,000-10,000 PPM FOR 10 MIN SHOWED A RAPID RISE IN BLOOD CONC OF CFC-11 DURING THE FIRST 5 MIN, WHICH WAS FOLLOWED BY A RAPID & THEN MORE GRADUAL DECLINE AFTER EXPOSURE.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1620]**PEER REVIEWED**

A free compartment open model was proposed for disposition of iv **trichlorofluoromethane** in dogs with average half-lives of 3.2, 16 and 93 min for 3 disposition phases. Tissue compartment distribution following a single dose showed that about 2 hr were required to achieve pseudo distribution equilibrium, following which more than 90% of the drug remaining in the body was retained in tissue compartments.The volume of distribution was approximately 6 times the body weight in terms of blood concn and about 30% of the propellant was cleaned from blood passing through the lungs in each cycle. Disposition of propellant followed dose independent kinetics after multiple dosing, and accumulation in tissues continued for a much longer period, resulting in high tissue compartment levels.
[Niazi S, Chiou WL; J Pharm Sci 64 763-9 May (1975)]**PEER REVIEWED**

A 15-year old boy found dead with a plastic bag and a 9 oz aerosol can of a spray on coating for frying pans lying adjacent to him. ... CFC 11 ... used as propellants were detected in the tissues removed at the autopsy: CFC (ul/100g): blood 0.86, kidney 1.65, brain 1.33, liver 0.83, stomach contents 5.78. ... Death of a teenager due to inhalation of fluorocarbon CFC-containing aerosols ... /noted/ distribution of fluorocarbons: CFC 11 (mg/100 g): blood 3.2, brain 6.1, liver 4.5, lung 3.2, kidney 2.5, trachea 2.1, and bile 0.6.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994.,p. 1202-3]**PEER REVIEWED**

/After/ ... human exposure to 1000 ppm 8 hr/day, 5 days/week ... venous blood levels of CFC 11 ... were as high as 419 ug/ml. The gradual attainment of this level represents a low uptake of the gas. ... There was no significant CFC 11 accumulation in the body following 8 hr exposures to 1000 ppm, repeated every 24 hr.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons

Inc., 1993-1994. 1201]**PEER REVIEWED**

(38)Chlorine-labeled CFC was poorly absorbed in the lung, with much of the inhaled vapor exhaled. After 30 min, the amount retained in the lungs was about 23 percent of the total unexpired CFC 11. Presumably, the compound remained in the lung tissue; after 5 min only a small fraction of the retained material was present in the blood. Using fluorine 18-labeled CFC 11, ... the same partition coefficient derived (olive oil/air partition = 27) ... The fall in pulmonary concentration was consistent with rapid uptake into the tissues followed by slow elimination into expired air.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1201]**PEER REVIEWED**

/In a group of asthmatic patients inhaling bronchodilator aerosols/ CFC 11 level in arterial blood /following/ two actuations 30 sec apart: 0.53-3.1 ug/ml; one actuation: 0.26-2.0 ug/ml. /Table/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1202]**PEER REVIEWED**

A PHARMACOKINETIC MODEL BASED ON ANALYSIS IN DOGS & HUMANS GAVE AN ESTIMATE OF 77% ABSORPTION OF THE INHALED FC-11 FROM AN 8 HR EXPOSURE TO 1000 PPM. THIS ABSORPTION WOULD RESULT IN ABOUT 1/4 THE BLOOD LEVEL REQUIRED TO SENSITIZE DOGS RECEIVING THE ADDITIONAL STRESS OF IV EPINEPHRINE.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1620]**PEER REVIEWED**

Human & animal studies indicate rapid excretion of inhaled FC-114. In a study with radiolabeled FC-114, 30 min retention of the dose inhaled in a single breath was 12% versus 23%, 10%, & 20% for comparable doses of FC-11, FC-12, and FC-113, respectively.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.444]**PEER REVIEWED**

Average pulmonary retention at an apparent steady state after 1 hr of exposure was 18.2%. Similarly, the ... pulmonary retention of 19% for CFC-11 and 18% for CFC-12 in workers during occupational exposure.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.61 (1990)]**PEER REVIEWED**

CFC-11 has been shown to bind in vitro to liver microsomal protein and lipid.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.62 (1990)]**PEER REVIEWED**

... MAIN FACTOR AFFECTING FATE OF FLUOROCARBONS IS BODY FAT, WHERE THEY ARE CONCENTRATED & SLOWLY RELEASED INTO BLOOD @ CONCN THAT SHOULD NOT CAUSE ANY RISK OF CARDIAC SENSITIZATION. /FLUOROCARBONS/
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 781]**PEER REVIEWED**

There is a significant accumulation of propellant in the brain, liver and lung compared to blood levels, signifying a tissue distribution of propellant similar to that of chloroform. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1203]**PEER REVIEWED**

Absorption of fluorocarbons is much lower after oral ingestion (35-48 times) than after inhalation. ...

The lung generally has the highest fluorocarbon concentrations on autopsy. /Fluorocarbons/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 884]**PEER REVIEWED**

Although fluorocarbons cause cardiac sensitization in certain animal species, rapid elimination prevents the development of cardiotoxic concentrations from aerosol bronchodilator use except at exceedingly high doses (12 to 24 doses in 2 minutes). /Fluorocarbons/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 884]**PEER REVIEWED**

FLUOROCARBON COMPOUNDS ARE LIPID-SOLUBLE AND THUS ARE GENERALLY WELL ABSORBED THROUGH LUNG. ABSORPTION AFTER INGESTION IS 35 TO 48 TIMES LOWER THAN AFTER INHALATION. ... FLUOROCARBONS ARE ELIMINATED BY WAY OF LUNG. /FLUOROCARBON COMPOUNDS/
[National Research Council. Drinking Water and Health. Volume 3. Washington, DC: National Academy Press, 1980. 101]**PEER REVIEWED**

Three volunteers were exposed to a CFC-11 concentration of 3750 mg/cu m (657 ppm). The average value of pulmonary retention was 18.9%. CFC-11 levels in alveolar air and blood were 3066 mg/cu m (537 ppm) and 2.8 ug/ml, respectively.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.57 (1990)]**PEER REVIEWED**

Regardless of the route of entry, chlorofluorocarbons appear to be eliminated almost exclusively through the respiratory tract. Little, if any, chlorofluorocarbon or metabolite has ever been reported in urine or feces. /Chlorofluorocarbons/
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.60 (1990)]**PEER REVIEWED**

Biological Half-Life:

The distribution half-life of the common fluorocarbons (**Freon 11,** Freon 12) averages 13 to 14 seconds; the elimination half-life is longer (1.5 hours) because of slower release from fat stores.
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 884]**PEER REVIEWED**

Volunteers exposed to CFC-11 at 3751 mg/cu m (657 ppm) for 150-210 min showed half-lives for the initial and second phases of elimination from venous blood of 11 min and 1 hr respectively. Half-lives for the initial and second phases of CFC-11 elimination in alveolar air were 7 min and 1.8 hr, respectively.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.60 (1990)]**PEER REVIEWED**

Interactions:

CARDIAC SENSITIZATION STUDIES WITH CONSCIOUS DOGS EXPOSED TO 5,000 PPM FC-11 PLUS IV EPINEPHRINE YIELDED 1 OF 12 DOGS WITH ... SERIOUS ARRHYTHMIA, INDICATING THAT FC 11 IS ONE OF THE MORE POTENT CARDIAC SENSITIZERS AMONG HOMOLOGOUS COMPD. THIS SENSITIZATION IS VERY BRIEF, AS DEMONSTRATED IN A SIMILAR EXPT WHERE 2 OF 4 DOGS WERE SENSITIZED AT 12,500 PPM BUT FOLLOW-UP INJECTIONS OF EPINEPHRINE 10 MINUTES AFTER END OF EXPOSURE YIELDED NO ARRHYTHMIA. DOGS THAT HAD RECOVERED FROM EXPTL-INDUCED MYOCARDIAL

INFARCTIONS & WERE THEN EXPOSED TO FC 11 PLUS IV EPINEPHRINE SHOWED NO CHANGE IN THE THRESHOLD FOR CARDIAC SENSITIZATION; BOTH THESE & NORMAL DOGS SHOWED 0 OF 12 RESPONSES AT 1,000 PPM.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.598]**PEER REVIEWED**

The minimal concn that elicited cardiac arrhythmia in the anesthetized monkey was 5% CFC 11 inhaled for less than 5 min. In a group of seven monkeys, two developed ventricular premature beats and atrioventricular block. The sensitivity of the heart to arrhythmia was increased by infusion of epinephrine.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1181]**PEER REVIEWED**

... FOCAL MYOCARDIAL NECROSIS /OBSERVED/ IN DOGS EXPOSED FOR 2 CONSECUTIVE DAYS TO AEROSOLS CONTAINING FC 11 AS PROPELLANT, & ISOPROTERENOL AS THE BRONCHODILATOR DRUG.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1182]**PEER REVIEWED**

The minimal conc that increases /airway/ resistance in anesthetized mouse is 1%, which is blocked by pretreatment with atropine.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1184]**PEER REVIEWED**

Trichlorofluoromethane, one of the most toxic fluorocarbons, sensitized dogs to epinephrine at a concn of 0.3%, and such an effect has also occurred in humans.
[Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 442]**PEER REVIEWED**

/IN HUMANS/ A 10 TO 90% MIXTURE OF FC 11 & FC 12, RESPECTIVELY, CAUSED MORE SEVERE RESPIRATORY EFFECTS THAN EITHER FLUOROCARBON INHALED SINGLY.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3081]**PEER REVIEWED**

If inhalation occurs, epinephrine or other sympathomimetic amine and adrenergic activators should not be admin since they will further sensitize heart to development of arrhythmias. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1201]**PEER REVIEWED**

... The combination of CFC with a sympathomimetic bronchodilator is potentially dangerous for the treatment of bronchial asthma. For the same reason, sympathomimetic drugs are contraindicated in cardiac resuscitation of patients suffering from CFC poisoning. /Fluorocarbon poisoning/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1183]**PEER REVIEWED**

Patients with fluorohydrocarbon poisoning should not be given epinephrine (Adrenalin) or similar drugs because of the tendency of fluorohydrocarbon to induce cardiac arrhythmia, including ventricular fibrillation. /Fluorohydrocarbons/
[Zenz, C. Occupational Medicine-Principles and Practical Applications. 2nd ed. St.

Louis, MO: Mosby-Yearbook, Inc, 1988. 543]**PEER REVIEWED**

Pharmacology:

Interactions:

CARDIAC SENSITIZATION STUDIES WITH CONSCIOUS DOGS EXPOSED TO 5,000 PPM FC-11 PLUS IV EPINEPHRINE YIELDED 1 OF 12 DOGS WITH ... SERIOUS ARRHYTHMIA, INDICATING THAT FC 11 IS ONE OF THE MORE POTENT CARDIAC SENSITIZERS AMONG HOMOLOGOUS COMPD. THIS SENSITIZATION IS VERY BRIEF, AS DEMONSTRATED IN A SIMILAR EXPT WHERE 2 OF 4 DOGS WERE SENSITIZED AT 12,500 PPM BUT FOLLOW-UP INJECTIONS OF EPINEPHRINE 10 MINUTES AFTER END OF EXPOSURE YIELDED NO ARRHYTHMIA. DOGS THAT HAD RECOVERED FROM EXPTL-INDUCED MYOCARDIAL INFARCTIONS & WERE THEN EXPOSED TO FC 11 PLUS IV EPINEPHRINE SHOWED NO CHANGE IN THE THRESHOLD FOR CARDIAC SENSITIZATION; BOTH THESE & NORMAL DOGS SHOWED 0 OF 12 RESPONSES AT 1,000 PPM.
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/IN HUMANS/ A 10 TO 90% MIXTURE OF FC 11 & FC 12, RESPECTIVELY, CAUSED MORE SEVERE RESPIRATORY EFFECTS THAN EITHER FLUOROCARBON INHALED SINGLY.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3081]**PEER REVIEWED**

If inhalation occurs, epinephrine or other sympathomimetic amine and adrenergic activators should not be admin since they will further sensitize heart to development of arrhythmias. /Fluorocarbons/

[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1201]**PEER REVIEWED**

... The combination of CFC with a sympathomimetic bronchodilator is potentially dangerous for the treatment of bronchial asthma. For the same reason, sympathomimetic drugs are contraindicated in cardiac resuscitation of patients suffering from CFC poisoning. /Fluorocarbon poisoning/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1183]**PEER REVIEWED**

Patients with fluorohydrocarbon poisoning should not be given epinephrine (Adrenalin) or similar drugs because of the tendency of fluorohydrocarbon to induce cardiac arrhythmia, including ventricular fibrillation. /Fluorohydrocarbons/
[Zenz, C. Occupational Medicine-Principles and Practical Applications. 2nd ed. St. Louis, MO: Mosby-Yearbook, Inc, 1988. 543]**PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Trichlorofluoromethane's former production & use as a refrigerant, in fire extinguishers, chemical intermediate, & blowing agent resulted in its direct release to the environment through various waste streams. Aerosol propellant use was banned in the US on December 15, 1978. **Trichlorofluoromethane** has been identified in emissions from volcanoes. If released to air, a vapor pressure of 803 mm Hg at 25 deg C indicates **trichlorofluoromethane** will exist solely as a gas in the ambient atmosphere. **Trichlorofluoromethane** is very stable in the troposphere having a half-life of 52-207 yr. As a result of its stability, **trichlorofluoromethane** is transported long distances & its concn is fairly uniform around the globe away from known sources. The only major sink for **trichlorofluoromethane** is its slow diffusion into the stratosphere where photolysis occurs & subsequent reactions which destroy ozone. If released to soil, **trichlorofluoromethane** is expected to have moderate mobility based upon an estimated Koc of 97. Volatilization from moist soil surfaces is expected to be an important fate process based upon a Henry's Law constant of 9.7X10-2 atm-cu m/mole. **Trichlorofluoromethane** may volatilize from dry soil surfaces based upon its vapor pressure. If released into water, **trichlorofluoromethane** is not expected to adsorb to suspended solids & sediment based upon the estimated Koc. Biodegradation in water & soils proceeds slowly under anaerobic conditions. Volatilization from water surfaces is expected to be an important fate process based upon this cmpd's Henry's Law constant. Estimated volatilization half-lives for a model river & model lake are 3 hrs & 5 days, respectively. Concn profiles in oceans show that **trichlorofluoromethane** is primarily in surface layers, suggesting that the oceans are not a sink for this chemical. An estimated BCF of 49 suggests the potential for bioconcentration in aquatic organisms is moderate. Hydrolysis is not expected to occur due to the lack of hydrolyzable functional groups. Occupational exposure to **trichlorofluoromethane** may occur through inhalation & dermal contact with this cmpd at workplaces where **trichlorofluoromethane** is produced or used. Monitoring data indicate that the general population may be exposed to **trichlorofluoromethane** via inhalation of ambient air, ingestion of drinking water, & dermal contact with this cmpd & other consumer products containing **trichlorofluoromethane**. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

GREATEST OCCUPATIONAL EXPOSURE BY VOLUME USE OF REFRIGERANTS IS IN SERVICING (NOT INCLUDING RECHARGING), INITIAL CHARGING, & MANUFACTURING &

INSTALLATION. /FLUOROCARBONS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3102]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 267,742 workers (95,886 of these are female) are potentially exposed to **trichlorofluoromethane** in the US(1). Occupational exposure to **trichlorofluoromethane** may occur through inhalation and dermal contact with this compound at workplaces where **trichlorofluoromethane** is produced or used(SRC). Monitoring data indicate that the general population may be exposed to **trichlorofluoromethane** via inhalation of ambient air, ingestion of drinking water, and dermal contact with this compound and other consumer products containing **trichlorofluoromethane**(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983)]**PEER REVIEWED**

Body Burden:

7 of 8 samples of mother's milk from 4 urban sites in US positive for trichlorfluoromethane(1). It was detected in 4 of 8 samples of respired air at a range of 0.007 to 0.041 ug/hr, positive subjects having been previously occupationally exposed (laboratory technicians)(2).
[(1) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982) (2) Conkle JP; Arch Environ Health 30: 290-5 (1975)]**PEER REVIEWED**

Natural Pollution Sources:

Trichlorofluoromethane has been identified in emissions from volcanoes(1).
[(1) Graedel TE; Chemical Compounds in the Atmosphere. NY, NY: Academic Press pp. 440 (1978)]**PEER REVIEWED**

Artificial Pollution Sources:

Trichlorofluoromethane was released as emissions or in wastewater during its production, storage, transport and use as a foaming agent for polyurethane foams, degreaser and solvent, especially in the aerospace and electronics industries, and as a fire extinguishing agent(1-3). In the early 1970's the largest release of **trichlorofluoromethane** was from aerosols (75%) with refrigerants and foaming agent use coming next by contributing 14 and 21%, respectively(3). Because its release into the atmosphere was believed to cause depletion of the ozone layer, production was curtailed, from a maximum of 1.58X10+5 metric tons in 1974(3), and declining through 1982(3-8). Production of **trichlorofluoromethane**-containing propellants was banned after Dec 15, 1978 in the USA(3).
[(1) Graedel TE; Chemical Compounds in the Atmosphere. NY, NY: Academic Press pp. 440 (1978) (2) Verschuren K; Handbook of Environmental Data on Organic Chemicals 3rd ed. NY, NY: Van Nostrand Reinhold p. 1016 (1996) (3) Astrologes G; Kirk-Othmer Encycl Chem Technol 3rd NY, NY: Wiley 10: 856-74 (1980) (4) Inter Trade Comm; Synthetic Organic Chemicals. United States Production and Sales 1978 USITC Publ 1001 (1979) (5) Inter Trade Comm; Synthetic Organic Chemicals. United States Production and Sales 1979 USITC Publ 1099 (1980) (6) Inter Trade Comm; Synthetic Organic Chemicals. United States Production and Sales 1980 USITC Publ 1183 (1981) (7) Inter Trade Comm; Synthetic Organic Chemicals. United States Production and Sales 1981 USITC Publ 1292 (1982) (8) Inter Trade Comm; Synthetic Organic Chemicals. United States Production and Sales 1982 USITC Publ 1422 (1983)]**PEER REVIEWED**

Trichlorofluoromethane's former production and use as a refrigerant(1), solvent, in fire extinguishers, chemical intermediate, and blowing agent(2), may have resulted in its release to the environment through various waste streams(SRC).
[(1) Budavari S, ed; The Merck Index. 12th ed Whitehouse Station, NJ: Merck and Co., Inc. p. 1643 (1996) (2) Lewis RJ Sr, ed; Hawley's Condensed Chemical Dictionary.

13th ed. NY, NY: John Wiley & Sons, Inc p. 1125 (1997)]**PEER REVIEWED**

Environmental Fate:

TERRESTRIAL FATE: Based on a classification scheme(1), an estimated Koc value of 97(SRC), determined from a measured water solubility of 1,100(2) and a regression-derived equation(3), indicates that **trichlorofluoromethane** is expected to have high mobility in soil(SRC). Volatilization of **trichlorofluoromethane** from moist soil surfaces is expected to be an important fate process(SRC) given a Henry's Law constant of 9.7X10-2 atm-cu m/mole(4). The potential for volatilization of **trichlorofluoromethane** from dry soil surfaces may exist(SRC) based upon a vapor pressure of 803 mm Hg(5).
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Yalkowsky SH, Dannenfelser RM; The AQUASOL dATAbASE of Aqueous Solubility. Ver 5. Tucson, AZ: Univ AZ, College of Pharmacy (1992) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-5 (1990) (4) Warner MJ, Weiss RF; Deep Sea Res A 32: 1485-97 (1985) (5) Daubert TE, Danner RP; Physical and thermodynamic properties of pure chemicals: data compilation. Design Inst Phys Prop Data, Amer Inst Chem Eng. NY, NY: Hemisphere Pub. Corp 4 Vol (1989)]**PEER REVIEWED**

AQUATIC FATE: Based on a classification scheme(1), an estimated Koc value of 97(SRC), determined from a measured water solubility of 1,100(2) and a regression-derived equation(3), indicates that **trichlorofluoromethane** is not expected to adsorb to suspended solids and sediment(SRC). Volatilization from water surfaces is expected(3) based upon a Henry's Law constant of 9.7X10-2 atm-cu m/mole(4). Using this Henry's Law constant and an estimation method(3), volatilization half-lives for a model river and model lake are 3 hrs and 5 days, respectively(SRC). According to a classification scheme(5), an estimated BCF of 49(SRC), from its log Kow of 2.53(6) and a regression-derived equation(7), suggests the potential for bioconcentration in aquatic organisms is moderate.
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Yalkowsky SH, Dannenfelser RM; The AQUASOL dATAbASE of Aqueous Solubility. Ver 5. Tucson, AZ: Univ AZ, College of Pharmacy (1992) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-5, 15-1 to 15-29 (1990) (4) Warner MJ, Weiss RF; Deep Sea Res A 32: 1485-97 (1985) (5) Franke C et al; Chemosphere 29: 1501-14 (1994) (6) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 3 (1995) (7) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999)]**PEER REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), **trichlorofluoromethane**, which has a estimated vapor pressure of 803 mm Hg at 25 deg C(2), is expected to exist solely as a gas in the ambient atmosphere. **Trichlorofluoromethane** is very stable in the troposphere having a half-life of 52-207 years(3,4). The dominant atmospheric sink of **trichlorofluoromethane** is UV in the stratosphere(5). In the stratosphere this compound will slowly photolyze to release chlorine atoms which in turn participates in the catalytic removal of stratospheric ozone(6); the ozone depletion potential for trichloroflouromethane is 1.0(7).
[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Daubert TE, Danner RP; Physical and thermodynamic properties of pure chemicals: data compilation. Design Inst Phys Prop Data, Amer Inst Chem Eng. NY, NY: Hemisphere Pub. Corp 4 Vol (1989) (3) Brice KA et al; Atmos Environ 16: 2543-54 (1982) (4) Penkett SA et al; Nature 286: 793-5 (1980) (5) Wolff GT; Kirk Othmer Encycl Chem Technol 4th. NY, NY: Wiley 1: 715 (1991) (6) Makide T et al; Chem Lett 4: 355-8 (1979) (7) Verschueren K; Handbook of Environmental Data on Organic Chemicals. 3rd ed. NY, NY: Van Nostrand Reinhold Co. p. 1016 (1996)]**PEER REVIEWED**

Environmental Biodegradation:

No significant biodegradation was observed when incubated with a sewage seed for 7 days followed by three weekly subcultures(1). Losses reported during biological treatment are probably the result of evaporative losses or adsorption to charcoal(2). No information could be found concerning the biodegradation of **trichlorofluoromethane** under aerobic conditions.
[(1) Tabak HH et al; J Water Pollut Control Fed 53: 1503-18 (1981) (2) Patterson JW, Kodukala PS; Chem Eng Prog 77: 48-55 (1981)]**PEER REVIEWED**

ANAEROBIC: **Trichlorofluoromethane**, present at 8 mg/cu m, degraded to approximately 0.7 mg/cu m in 100 days using a lab-scale anaerobic digester and municipal solid waste inoculum from Hamburg, Germany(1). Trace amounts were still detected at 340 days(1). Samples of anaerobic peat soil from a conifer swamp and a temperate bog in New York were shown to have the capacity to serve as a sink for atmospheric trichlorfluoromethane(2). Headspace concns decreased by 34% in 7 days, and by 70% in 10 days in swamp peat and bog peat, respectively(2). Samples from the subsurface anoxic zones of the Black Sea and from Saanich Inlet, British Columbia, Canada showed a depletion of dissolved **trichlorofluoromethane**, with the removal rate ranging from 0.26-0.48/yr(3).
[(1) Deipser A, Stegmann R; Waste Manag Res 12: 129-39 (1994) (2) Bauer MR, Yavitt JB; Chemosphere 32: 759-68 (1996) (3) Bullister JL, Lee BS; Geophys Res Lewtt 22: 1893-96 (1995)]**PEER REVIEWED**

Environmental Abiotic Degradation:

... PHOTODISSOCIATION OF FLUOROCARBONS IN STRATOSPHERE PRODUCES SIGNIFICANT AMT OF CHLORINE ATOMS & LEADS TO DESTRUCTION OF ATMOSPHERIC OZONE. /FLUOROCARBONS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3090]**PEER REVIEWED**

Trichlorofluoromethane does not absorb UV radiation >290 nm(1) nor does it react appreciably with reactive atmospheric species such as hydroxyl radicals or singlet oxygen atoms(2); nor does it degrade under photochemical smog conditions(3). Estimates of tropospheric half-lives based on time series concentration measurements, etc. range from 52-207 yrs(4,5). The only sink is diffusion to the stratosphere where photolysis by short wavelength UV radiation occurs(6,9). In the stratosphere this compound will slowly photolyze to release chlorine atoms which in turn participates in the catalytic removal of stratospheric ozone(10); the ozone depletion potential for trichloroflouromethane is 1.0(11). Heterogeneous photolysis occurs when **trichlorofluoromethane** is adsorbed on silica gel with 23% degradation occurring in 170 hr when exposed to sunlight(6), however it is difficult to assess the effect this has on the lifetime. **Trichlorofluoromethane** is not expected to undergo hydrolysis in the environment due to the lack of hydrolyzable functional groups(7), however the rate is greatly affected by the presence of metals such as steel which act as catalysts(8).
[(1) Hubrich C, Stuhl F; J Photochem 12: 93-107 (1980) (2) Hampson RF; Chemical Kinetic and Photochemical Data Sheets for Atmospheric Reactions. FAA-EE-80-17 (1980) (3) Japar S et al; Univ Calif Riverside CA Personal Comm (1974) (4) Brice KA et al; Atmos Environ 16: 2543-54 (1982) (5) Penkett SA et al; Nature 286: 793-5 (1980) (6) Gaeb S et al; Angew Chem 90: 398-9 (1978) (7) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 7-4, 7-5 (1990) (8) DuPont de Nemours Co; Freon Products Information B-2. A98825 12/80 (1980) (9) Wolff GT; Kirk Othmer Encycl Chem Technol 4th. NY, NY: Wiley 1: 715 (1991) (10) Makide T et al; Chem Lett 4: 355-8 (1979) (11) Verschueren K; Handbook of Environmental Data on Organic Chemicals. 3rd ed. NY, NY: Van Nostrand Reinhold Co. p. 1016 (1996)]**PEER REVIEWED**

Environmental Bioconcentration:

An estimated BCF of 49 was calculated for **trichlorofluoromethane**(SRC), using a log Kow of 2.53(1)

and a regression-derived equation(2). According to a classification scheme(3), this BCF suggests the potential for bioconcentration in aquatic organisms is moderate. The levels of **trichlorofluoromethane** in three species of mollusks and five species of fish are only slightly enriched (usually 2-25 times on a dry weight basis) over the seawater levels(4). The usual order of enrichment was found to be brain > liver > gill > muscle(4).
[(1) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 3 (1995) (2) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999) (3) Franke C et al; Chemosphere 29: 1501-14 (1994) (4) Dickson AG, Riley JP; Mar Pollut Bull 7: 167-9 (1976)]**PEER REVIEWED**

Soil Adsorption/Mobility:

The Koc of **trichlorofluoromethane** is estimated as 97(SRC), using a water solubility of 1,100 mg/l at 20 deg C(1) and a regression-derived equation(2). According to a classification scheme(3), this estimated Koc value suggests that **trichlorofluoromethane** is expected to have high mobility in soil. **Trichlorofluoromethane** has negligible adsorption to soil and modeling studies which predict distributions between environmental compartments indicate that none of the chemical will reside in the soil or sediment(4,5).
[(1) Yalkowsky SH, Dannenfelser RM; The AQUASOL dATAbASE of Aqueous Solubility. Ver 5. Tucson, AZ: Univ AZ, College of Pharmacy (1992) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9 (1990) (3) Swann RL et al; Res Rev 85: 17-28 (1983) (4) Kloepffer W et al; Ecotox Environ Safety 6: 294-301 (1982) (5) Neeley WB; Environ Toxicol Contam 1: 259-66 (1982)]**PEER REVIEWED**

Volatilization from Water/Soil:

The Henry's Law constant for **trichlorofluoromethane** is 9.70X10-2 atm-cu m/mole(1). This Henry's Law constant indicates that **trichlorofluoromethane** is expected to volatilize rapidly from water surfaces(2). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec)(2) is estimated as 3 hours(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(2) is estimated as 5 days(SRC). **Trichlorofluoromethane**'s Henry's Law constant(1) indicates that volatilization from moist soil surfaces may occur(SRC). The potential for volatilization of **trichlorofluoromethane** from dry soil surfaces may exist(SRC) based upon a vapor pressure of 803 mm Hg(3).
[(1) Warner MJ, Weiss RF; Deep Sea Res A 32: 1485-97 (1985) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (3) Daubert TE, Danner RP; Physical and thermodynamic properties of pure chemicals: data compilation. Design Inst Phys Prop Data, Amer Inst Chem Eng. NY, NY: Hemisphere Pub. Corp 4 Vol (1989) (4) Kloepffer W et al; Ecotox Environ Safety 6: 294-301 (1982) (5) Neeley WB; Environ Toxicol Contam 1: 259-66 (1982)]**PEER REVIEWED**

Environmental Water Concentrations:

GROUNDWATER: **Trichlorofluoromethane** concns in cluster wells at manufacturing research facility in the Northeastern US were as follows: glacial shallow wells 80 ppb mean, median not detectable; glacial deep wells 5 ppb mean, 4 ppb median; bedrock wells 650 ppb mean, 23 ppb median(1). The atmosphere may be a source of the trichlorfluoromethane detected in 72 shallow groundwater samples from Gluocester County, NJ sampled in December, 1996 and 6 wells sampled in November 1997(2). Groundwater samples from the Danube River Basin in Hungary contained trichlorofluormethane concns ranging from 0.0 to 14.61 pmol/l(3). Concn in the Pannonian deep well in the same region was 0.07 pmol/l(3).

[(1) Rich CA; Stud Environ Sci 17 (Qual Groundwater): 309-14 (1981) (2) Baehr AL et al; Water Res Res 35: 127-36 (1999) (3) Bohlke JK et al; Environ Sci Technol 31: 3293-9 (1997)]**PEER REVIEWED**

DRINKING WATER: **Trichlorofluoromethane** was detected, not quantified in drinking water samples worldwide(1). Water supply wells in the Danube River Basin Hungary contained trichlorofluormethane concns ranging from 0.0 to 2.75 pmol/l, sampled in the spring, 1993, the highest concns being within 2 km from Danube River(2).
[(1) Kool HJ et al; Crit Rev Environ Control 12: 307-57 (1982) (2) Bohlke JK et al; Environ Sci Technol 31: 3293-9 (1997)]**PEER REVIEWED**

SURFACE WATER: **Trichlorofluoromethane** was detected in the Ohio River Basin (11 stations, 4972 samples) in 5.3% of samples at 0.1 ppb; 46 samples between 1 and 10 ppb, and 3 samples >10 ppb(1). 14 Heavily industrialized river basins in US (204 sites) - 11 sites positive all in the Chicago area and Illinois River Basin 3-20 ppb(2). Lake Erie central and eastern basins - 34 and 46 parts/trillion average in 1977 and 1978, respectively, with concentration uniform throughout the basin(3). Delaware River Basin (30 sites, depth integrating samples) - 3% of sites had values > 1 ppb(4). Lake Michigan (9 sites) - 5 sites positive, 1-20 ppb(5). Levels in two Danube River samples, Hungary were 7.82 and 7.74 pmol/l, May, 1993(6).
[(1) Ohio R Valley Water Sanit Comm; Assessment of Water Quality Conditions. Ohio River Mainstream 1980-81 Cincinnati OH (1982) (2) Ewing BB et al; Monitoring to Detect Previously Unrecognized Pollutants in Surface Waters USEPA-560/6-77-015 (1977) (3) Kaiser KLE, Valdamis I; J Great Lakes Res 5: 160-9 (1979) (4) Dewalle FB, Chian ESK; Proc Ind Waste Conf 32: 908-19 (1978) (5) Konasewich D et al; Status Report on Organic and Heavy Metal Contaminants in the Lake Erie, Michigan, Huron and Superior Basins. Great Lakes Qual Rev Board (1978) (6) Bohlke JK et al; Environ Sci Technol 31: 3293-9 (1997)]**PEER REVIEWED**

SEAWATER: Pacific Ocean 0.13 parts/trillion average at surface. 0.06 parts/trillion average at 300 m depth(1) Point Reyes, CA nearshore 43 parts/trillion(2). **Trichlorofluoromethane** is most abundant in the surface layers of the sea as opposed to the depths as was demonstrated in concn profiles of the Greenland(3) and Norwegian Seas(3,4).
[(1) Singh HB et al; Atmospheric Distributions, Sources and Sinks of Selected Halocarbons, Hydrocarbons, SF6 and N2O pp. 134 USEPA-600/3-79-107 (1979) (2) Singh HB et al; J Air Pollut Control Assoc 27: 332-6 (1977) (3) Bullister JL, Weiss RF; Science 221: 265-8 (1983) (4) Hahne A et al; Pure Appl Geoph 116: 575-82 (1978)]**PEER REVIEWED**

Effluent Concentrations:

Industries whose raw or treated wastewater exceed an average of 10 ug/l **trichlorofluoromethane** include: auto and other laundries, electrical components, nonferrous metal manufacturing, coal mining, photographic equipment/supplies and textile mills(1). Maximum levels at or above 100 ppb occurred in textile mills (2100 ppb) auto and other laundries (120 ppb), and nonferrous metal manufacturing (100 ppb)(1). Of 343 industrial effluents sites representing all STORET stations, 0.6% were positive for **trichlorofluoromethane**, with a median of <5 ppb(2). National Urban Runoff Program (nineteen cities including 11 of the 18 river basins in the contiguous USA - 86 samples) reports a 6% frequency of detection, 0.6-27 ppb(3). The concn of trichloroflouromethane in a Los Angeles municipal wastewater was below the detection limit of 0.3 ppb(4).
[(1) USEPA; Treatability Manual pp. 1-12 to 22-1 to 1-12 to 22-4 USEPA-600/2-82-001a (1981) (2) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985) (3) Cole RH et al; J Water Pollut Control Fed 56: 898-908 (1984) (4) Young DR et al; pp. 871-84 in Water Chlorination: Environ Impact Health Effects Book 2 Vol. 4 (1983)]**PEER REVIEWED**

Sediment/Soil Concentrations:

SEDIMENT: Bottom sediment from the submarine outfall of Los Angeles sewage treatment plant contained < 0.5 ppb **trichlorofluoromethane**(1).
[(1) Young DR et al; pp. 87-84 in Water Chlorination: Environ Impact Health Effects Book 2 Vol 4 (1983)]**PEER REVIEWED**

Atmospheric Concentrations:

URBAN/SUBURBAN: In the USA, 903 samples contained 100-4900 parts/trillion **trichlorofluoromethane** with a median concn of 380 parts/trillion(1). Mean concns in the US were as follows (ppb, location, date): 0.025, Seagirt, NJ, 6/74; 1.44, New York, NY, 6/74; 0.28, Sandy Hook, NJ 7/74; 0.13, Delaware City, DE, 7/74; 0.24, Baltimore, MD, 7/74; 0.14, Wilmington, OH, 7/74; and 1.34, Bayonne, NJ, 3/73-12/73(2). In Tubingen and Leipzig in Germany, median levels were elevated by approximately 50% compared to background levels; a max concn of 100 ug/cu m was detected in Tubingen(3). Using national and United Nations statistics for 1986, it was determined that almost 75% of the total CFC emissions come from developed countries(4). Monitoring evidence suggests that **trichlorofluoromethane** emissions in Europe have declined to about one third of the 1987 levels to the end of 1990(5).
[(1) Brodzinsky R, Singh HB; Volatile Organic Chemicals in the Atmosphere: An Assessment of Available Data SRI International p. 198 Contract 68-02-3452 1982) (2) Lillian D et al; Environ Sci Technol 9: 1042-8 (1975) (3) Frank W et al; Chemosphere 23: 609-626 (1991) (4) McCulloch A et al; Atmos Environ 28: 2567-82 (1998) (5) Simmonds PG et al; Atmos Environ 27A: 1397-407 (1993)]**PEER REVIEWED**

INDOOR AIR: **Trichlorofluoromethane** levels of 1.7X10-3 to 2.9 mg/cu m have been reported in homes. A concn of 0.28 mg/cu m was reported in a beauty shop where fluorocarbon aerosol cosmetic sprays were likely to be used(1).
[(1) USEPA; Ambient Water Quality Criteria for Halomethanes pp. C-18 PB81-117624 Oct (1980)]**PEER REVIEWED**

RURAL/REMOTE: US (1977-1980, 431 samples) 120 parts/trillion median, 230 parts/trillion maximum(1). South Pole (1975-1980) 90-166 parts/trillion, average annual concn increase 8-12%(2). US Pacific NW (1975-1980) 125-188 parts/trillion, average annual concn increase 8-12%(2). Harwell England (1/78-6/81) 207-272 parts/trillion monthly average, annual rate of increase between 1975-1981 10-11 parts/trillion rate of increase slowing down(3). Southern Hemisphere Background: 182 parts/trillion average in 1981 with an annual growth 11.5 parts/trillion for 1979-1981 as measured at Cape Point, South Africa(4) and 130 parts/trillion in June 1977 with an increase of nearly 20% in the previous 12 months as measured at Cape Grim, Australia(5). Point Barrows, Alaska 192.3-202.6 parts/trillion with the highest concentration during the winter(6). The source of the **trichlorofluoromethane** is anthropogenic in the mid-latitudes(6). Concn measurements as a function of latitude show that the concn decreases with altitude in the troposphere followed by a sharper decrease through the tropopause and into the stratosphere(7). Mean concn in troposphere over Southern France, June-Sept 1977, 130 parts/trillion(8). Three altitudes over Pacific Ocean, Hawaii to Alaska, Oct-Nov 1974, 6 locations (km altitude, range parts/trillion) - 15.2, 65-106; 18.3, 29-96; 21.3, 5.5-86(9). Northern stratosphere, April 1974 - Nov 1976, 49-90 parts/trillion, 65.3 avg; upper troposphere, May-Nov 1976, 115-126 parts/trillion, 122 avg(10). Tropospheric concn range of 127-149 parts/trillion, May 1975 - April 1977, from 4 samples sites between California and Alaska(11).
[(1) Brodzinsky R, Singh HB; Volatile Organic Chemicals in the Atmosphere: An Assessment of Available Data SRI International p. 198 Contract 68-02-3452 (1982) (2) Rasmussen RA et al; Science 211: 285-7 (1981) (3) Brice KA et al; Atmos Environ 16: 2543-54 (1982) (4) Brunke EG, Halliday EC; Atmos Environ 17: 823-6 (1983) (5) Wainwright L; Clean Air 13: 5-10 (1979) (6) Khalil MAK, Rasmussen RA; Environ Sci Technol 17: 157-64 (1983) (7) Schmeltekopf PD et al; Geophys Res Lett 2: 393-6 (1975) (8) Fabian P et al; J Geophys Res 84: 3149-54 (1979) (9) Vedder JF et al;

Geophys Res Lett 5: 33-6 (1978) (10) Leifer R et al; J Geophys Res 85: 1096-72 (1980) (11) Saunder WD et al; Water Air Pollut 10: 421-39 (1978)]**PEER REVIEWED**

RURAL/REMOTE: **Trichlorofluoromethane** was detected, not quantified at Point Barrow, Alaska, showing seasonal variations that parallel that of Arctic haze(1). Samples from ground-level atmosphere in Antartica contained average concns of 254 and 269 parts/trillion volume, sampled during Austral summer 1989/90 and 1990/91, respectively(2). **Trichlorofluoromethane** levels at Caparica, Portugal on the Atlantic coast are approximately 20% lower than at 3 remote forest areas in Germany, Berchtesgaden, Erzgeirge, and Freudenstadt(3). The mean concn at Whiteface Mountain, New York was 0.13 ppb, sampled from Sept 16 through Sept 19, 1974(4).
[(1) Barrie LA; Atmos Environ 20: 643-63 (1986) (2) Bruner F et al; Intern J Environ Anal Chem 55: 311-8 (1994) (3) Frank W et al; Chemosphere 23: 609-626 (1991) (4) Lillian D et al; Environ Sci Technol 9: 1042-8 (1975)]**PEER REVIEWED**

SOURCE DOMINATED: **Trichlorofluoromethane** was dectected at one unspecified USA site at a concn of 260 parts/trillion(1). It was identified in landfill gas from seven municipal waste disposal facilities in the UK at concns of <0.5-74, <0.1, <0.1, <0.1, <01.-28, <0.5, and <0.5(2). The concn range of **trichlorofluoromethane** in six municipal landfills in Hamburg, Germany was from not detected to 10.79 mg/kg(3).
[(1) Brodzinsky R, Singh HB; Volatile Organic Chemicals in the Atmosphere: An Assessment of Available Data. SRI Inter p. 198 Contract 68-02-3452 (1982) (2) Allen MR et al; Environ Sci Technol 31: 1054-61 (1997) (3) Deipser A, Stegmann R; Waste Manag Res 12: 129-39 (1994)]**PEER REVIEWED**

Fish/Seafood Concentrations:

Samples from the Isle of Man - Irish Sea contained trichlorofluormethane concns as follows: 3 species of mollusks 0.2-1.4 ppb dry weight; 5 species of fish 0.1-5.0 ppb dry weight(1).
[(1) Dickson AG, Riley JP; Mar Pollut Bull 7: 167-9 (1976)]**PEER REVIEWED**

Milk Concentrations:

In mother's milk from 4 urban sites in US - 7 of 8 samples positive for **trichlorofluoromethane**(1).
[(1) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982)]**PEER REVIEWED**

Environmental Standards & Regulations:

FIFRA Requirements:

Residues of **trichlorofluoromethane** are exempted from the requirement of a tolerance when used as a propellant in accordance with good agricultural practices as inert (or occasionally active) ingredients in pesticide formulations applied to growing crops or to raw agricultural commodities after harvest.
[40 CFR 180.1001(c) (7/1/91)]**PEER REVIEWED**

Trichlorofluoromethane is exempted from the requirement of a tolerance when used as a propellant in accordance with good agricultural practice as inert (or occasionally active) ingredients in pesticide formulations applied to animals.
[40 CFR 180.1001(e) (7/1/91)]**PEER REVIEWED**

As the federal pesticide law FIFRA directs, EPA is conducting a comprehensive review of older pesticides to consider their health and environmental effects and make decisions about their future use. Under this pesticide reregistration program, EPA examines health and safety data for pesticide active ingredients initially registered before November 1, 1984, and determines whether they are eligible for

reregistration. In addition, all pesticides must meet the new safety standard of the Food Quality Protection Act of 1996. Pesticides for which EPA had not issued Registration Standards prior to the effective date of FIFRA, as amended in 1988, were divided into three lists based upon their potential for human exposure and other factors, with List B containing pesticides of greater concern and List D pesticides of less concern. **Trichloromonofluoromethane** is found on List D. Case No: 4042; Pesticide type: insecticide; Case Status: No products containing the pesticide are actively registered ... The case /is characterized/ as "cancelled." Under FIFRA, pesticide producers may voluntarily cancel their registered products. EPA also may cancel pesticide registrations if registrants fail to pay required fees or make/meet certain reregistration commitments, or if EPA reaches findings of unreasonable adverse effects.; Active ingredient (AI): **Trichloromonofluoromethane**; AI Status: The active ingredient is no longer contained in any registered pesticide products ... "cancelled."
[USEPA/OPP; Status of Pesticides in Registration, Reregistration and Special Review p.312 (Spring, 1998) EPA 738-R-98-002]**PEER REVIEWED**

Ninety days after publication of this notice the ingredients /incl **trichloromonofluoromethane**/ ... will be removed from Reregistration List D, and all associated registrations will be cancelled ... .
[56 FR 50425 (10/4/91)]**PEER REVIEWED**

TSCA Requirements:

(a) After October 15, 1978, no person may manufacture, except to import, any fully halogenated chlorofluoroalkane for any aerosol propellant use except ... for use in an article which is a food, food additive, drug, cosmetic, or device exempted under 15 U.S.C. 2602 (21 CFR 2.125) ... for those essential uses listed in 40 CFR 762.58 ... for exempted uses listed in 40 CFR 762.59; (b) After December 15, 1978, no person may import into the customs territory of the United States any fully halogenated chlorofluoroalkane, whether as a chemical substance or as a component of a mixture or article, for any aerosol propellant use except ... for use in an article which is a food, food additive, drug, cosmetic, or device exempted under 15 U.S.C. 2602 (21 CFR 2.125) ... for those essential uses listed in 40 CFR 762.58 ... for exempted uses listed in 40 CFR 762.59; (c) Every person manufacturing fully halogenated chlorofluoroalkanes for aerosol propellant uses after October 15, 1978 must obtain a signed statement ... for aerosol propellant uses permitted under 40 CFR Part 762 or 21 CFR 2.125, or ... for other uses. /Fully halogenated chlorofluoroalkanes/
[40 CFR 762.45 (7/1/91)]**PEER REVIEWED**

(a) After December 15, 1978, no person may process any fully halogenated chlorofluoroalkane into any aerosol propellant article except ... for use in an article which is a food, food additive, drug, cosmetic, or device exempted under 15 U.S.C. 2602 (21 CFR 2.125) ... for those essential uses listed in 40 CFR 762.58 ... for exempted uses listed in 40 CFR 762.59; (b) After December 15, 1978 no person may process any fully halogenated chlorofluoroalkane into any aerosol propellant article intended for export except ... for use in an article which is a food, food additive, drug, cosmetic, or device exempted under 15 U.S.C. 2602 (21 CFR 2.125) ... for those essential uses listed in 40 CFR 762.58 ... for exempted uses listed in 40 CFR 762.59. /Fully halogenated chlorofluoroalkanes/
[40 CFR 762.50 (7/1/91)]**PEER REVIEWED**

After December 15, 1978, no person may distribute in commerce any fully halogenated chlorofluoroalkane for processing into any aerosol propellant article except ... for use in an article which is a food, food additive, drug, cosmetic, or device exempted under 15 U.S.C. 2602 (21 CFR 2.125) ... for those essential uses listed in 40 CFR 762.58 ... for exempted uses listed in 40 CFR 762.59. /Fully halogenated chlorofluoroalkanes/
[40 CFR 762.55 (7/1/91)]**PEER REVIEWED**

The following aerosol propellant uses of fully halogenated chlorofluoroalkanes are essential and exempt

from 40 CFR 762.45, 40 CFR 762.50 and 40 CFR 762.55: (a) Mercaptan stench warning devices; (b) Release agents for molds used in the production of plastic and elastomeric materials; (c) Flying insect pesticides ... for use in nonresidential food handling areas ... for space spraying of aircraft; (d) Diamond-grit spray; (e) Nonconsumer articles used as cleaner-solvents, lubricants, or coatings for electrical or electronic equipment; (f) Articles necessary for safe maintenance and operation of aircraft; (g) Uses essential to the military preparedness of the United States as determined by the Administrator and the Secretary of Defense; (h) Pharmaceutical rotary tablet press punch lubricants; (i) Automatic timed-release insecticide dispensing system for facilities in which tobacco is stored for three or more years for use from May 18, 1981 to December 31, 1981. /Fully halogenated chlorofluoroalkanes/
[40 CFR 762.58 (7/1/91)]**PEER REVIEWED**

Special exemptions: (a) Inkless fingerprinting systems until August 1, 1981; (b) ... For producers of pyrethrin pesticide formulations; ... (c) Effective June 1, 1982, Virginia Chemicals Inc. (VCI) may process chlorofluorocarbons (CFCs) for incorporation into its automatic timed-release insecticide dispensing A-System customers for use before December 31, 1982 ... . /Fully halogenated chlorofluorocarbons/
[40 CFR 762.59 (7/1/91)]**PEER REVIEWED**

CERCLA Reportable Quantities:

Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 5000 lb or 2270 kg. The toll free number of the NRC is (800) 424-8802; In the Washington D.C. metropolitan area (202) 426-2675. The rule for determining when notification is required is stated in 40 CFR 302.4 (section IV. D.3.b).
[40 CFR 302.4 (7/1/2000)]**PEER REVIEWED**

RCRA Requirements:

U121; As stipulated in 40 CFR 261.33, when **trichloromonofluoromethane** as a commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate, becomes a waste, it must be managed according to Federal and/or State hazardous waste regulations. Also defined as a hazardous waste is any residue, contaminated soil, water, or other debris resulting from the cleanup of a spill, into water or on dry land, of this waste. Generators of small quantities of this waste may qualify for partial exclusion from hazardous waste regulations (40 CFR 261.5).
[40 CFR 261.33 (7/1/2000)]**PEER REVIEWED**

F002; When **trichlorofluoromethane** is a spent halogenated solvent, it is classified as a hazardous waste from a nonspecific source (F002), as stated in 40 CFR 261.31, and must be managed according to state and/or federal hazardous waste regulations.
[40 CFR 261.31 (7/1/2000)]**PEER REVIEWED**

Atmospheric Standards:

This action promulgates standards of performance for equipment leaks of Volatile Organic Compounds (VOC) in the Synthetic Organic Chemical Manufacturing Industry (SOCMI). The intended effect of these standards is to require all newly constructed, modified, and reconstructed SOCMI process units to use the best demonstrated system of continuous emission reduction for equipment leaks of VOC, considering costs, non air quality health and environmental impact and energy requirements. **Trichlorofluoromethane** is produced, as an intermediate or a final product, by process units covered under this subpart.

[40 CFR 60.489 (7/1/2000)]**PEER REVIEWED**

Federal Drinking Water Guidelines:

EPA 2000 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

State Drinking Water Standards:

(CA) CALIFORNIA 150 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

State Drinking Water Guidelines:

(AZ) ARIZONA 2100 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(FL) FLORIDA 2,100 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(ME) MAINE 2300 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(MN) MINNESOTA 2000 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(WI) WISCONSIN 3500 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(WA) WASHINGTON 1,300 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

Allowable Tolerances:

Residues of **trichlorofluoromethane** are exempted from the requirement of a tolerance when used as a propellant in accordance with good agricultural practices as inert (or occasionally active) ingredients in pesticide formulations applied to growing crops or to raw agricultural commodities after harvest.
[40 CFR 180.1001(c) (7/1/91)]**PEER REVIEWED**

Trichlorofluoromethane is exempted from the requirement of a tolerance when used as a propellant in accordance with good agricultural practice as inert (or occasionally active) ingredients in pesticide formulations applied to animals.

[40 CFR 180.1001(e) (7/1/91)]**PEER REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

C-Cl3-F
PEER REVIEWED

Molecular Weight:

137.37
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

Color/Form:

Liquid @ temp below 23.7 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

Colorless liquid
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1125]**PEER REVIEWED**

Colorless to water-white ... liquid or gas (above 75 degrees F).
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 146]**PEER REVIEWED**

Odor:

In concn of less than 20% (by volume in air), **trichlorofluoromethane** is odorless, in higher concn, its odor is mild and somewhat ethereal.
[Matheson Gas Products; Matheson Gas Data Book 6th Ed p.670 (1980)]**PEER REVIEWED**

... Nearly odorless ...
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 146]**PEER REVIEWED**

Characteristic; quality: sweet, pleasant to unpleasant
[Verschueren, K. Handbook of Environmental Data on Organic Chemicals. 3rd ed. New York, NY: Van Nostrand Reinhold Co., 1996. 1016]**PEER REVIEWED**

Boiling Point:

23.7 deg C @ 760 mm Hg
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

Melting Point:

-111 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and

Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

Corrosivity:

Liquid **fluorotrichloromethane** will attack some forms of plastics, rubber, and coatings.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Critical Temperature & Pressure:

Critical temperature: 198 deg C; critical pressure: 43.2 atm (635 lb/sq in, absolute)
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

Density/Specific Gravity:

1.494 @ 17.2 deg C/4 deg C /liquid/
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

Heat of Vaporization:

25.1 kJ/mol @ 23.7 deg C
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 6-103]**PEER REVIEWED**

Octanol/Water Partition Coefficient:

log Kow= 2.53
[Hansch, C., Leo, A., D. Hoekman. Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. Washington, DC: American Chemical Society., 1995. 3]**PEER REVIEWED**

Solubilities:

Sol in alc, ether, other org solvents
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

1 G SOL IN 1 L WATER @ 25 DEG C
[National Research Council. Drinking Water and Health. Volume 3. Washington, DC: National Academy Press, 1980. 167]**PEER REVIEWED**

In water, 1,100 mg/l @ 25 deg C.
[DuPont de Nemours Co; Freon Products Information B-2. A98825. December (1980)]**PEER REVIEWED**

Solubility in water: 0.0036 g/100 g @ 0 deg C; 0.013 g/100 g @ 30 deg C
[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed.Vol A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present.,p. VA11 (88) 356]**PEER REVIEWED**

In water, 1,100 mg/l @ 20 deg C
[Yalkowsky SH, Dannenfelser RM; The AQUASOL dATAbASE of Aqueous Solubility. Ver 5. Tucson, AZ: Univ AZ, College of Pharmacy (1992)]**PEER REVIEWED**

Spectral Properties:

Index of refraction: 1.3865 @ 18.5 deg C/D
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

Index of Refraction (liquid): 1.374 @ 25 deg C
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V11 (94) 505]**PEER REVIEWED**

IR: 1113 (Sadtler Research Laboratories Prism Collection)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 841]**PEER REVIEWED**

Surface Tension:

18 dyn/cm @ 25 deg C
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V11 (94) 512]**PEER REVIEWED**

Vapor Density:

5.04 @ 25 deg C (Air= 1)
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

Vapor Pressure:

803 mm Hg @ 25 deg C
[Daubert, T.E., R.P. Danner. Physical and Thermodynamic Properties of Pure Chemicals Data Compilation. Washington, D.C.: Taylor and Francis, 1989.]**PEER REVIEWED**

Relative Evaporation Rate:

63 (butyl acetate= 1)
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Specific enthalpy of evaporation at standard BP: 182 kJ/kg
[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed.Vol A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present.,p. B3 (88) 19-8]**PEER REVIEWED**

Viscosity:

Gas: 0.0105 mPa.s @ 24 deg C; liquid: 0.43 mPa.s @ 20 deg C
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V11 (94) 512]**PEER REVIEWED**

Other Chemical/Physical Properties:

Dipole moment: 0.45 debye
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 15-18]**PEER REVIEWED**

Specific heat of liquid: 0.89 J/g K @ 25 deg C and 1 atm
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 15-18]**PEER REVIEWED**

Global warming potential: 1.0; ozone depletion potential: 1.0
[Verschueren, K. Handbook of Environmental Data on Organic Chemicals. 3rd ed. New York, NY: Van Nostrand Reinhold Co., 1996. 1016]**PEER REVIEWED**

1.476 g/ml @ 25 deg C /Liquid density/
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V11 (94) 505]**PEER REVIEWED**

Critical volume: 2476 cu cm /mol
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 6-48]**PEER REVIEWED**

Critical density: 0.548 g/cu m
[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed.Vol A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present.,p. VA11 (88) 356]**PEER REVIEWED**

Specific heat of vapor at 38 deg C and 1 atm: 0.142 cal/g
[Lide, D.R. (ed). CRC Handbook of Chemistry and Physics. 72nd ed. Boca Raton, FL: CRC Press, 1991-1992.,p. 6-171]**PEER REVIEWED**

Liquid heat capacity @ 80 deg F= 0.213 Btu/lb-deg F; ideal gas heat capacity @ 70 deg F= 0.127 Btu/lb-deg F.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Volatile liquid
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1125]**PEER REVIEWED**

Ozone depletion potential: 1.0. (Ozone depletion potential relative to R11= 1.0. Scientific assessment of ozone: 1989.) /From table/
[Baxter V, Fairchild P; Oak Ridge National Laboratory Review No. 3 (1990)]**PEER REVIEWED**

Henry's Law constant = 9.70X10-2 atm-cu cm/mol @ 25 deg C
[Warner MJ, Weiss RF; Deep Sea Res A 32: 1485-97 (1985)]**PEER REVIEWED**

Hydroxyl radical rate constant < 5X10-16 cu cm/molecule-sec @ 25 deg C
[Atkinson R; J Phys Chem Ref Data Monograph No. 2 (1994)]**PEER REVIEWED**

Viscosity: 0.439 cP @ 70 deg F
[Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980. 1616]**PEER REVIEWED**

Greenhouse efficiency: 17,500, relative to CO2 on a volume basis
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V1 (91) 739]**PEER REVIEWED**

Chemical Safety & Handling:

Odor Threshold:

Low: 28.0 mg/cu m; High: 1170.4 mg/cu m
[Ruth JH; Am Ind Hyg Assoc J 47: A-142-51 (1986)]**PEER REVIEWED**

Flammable Limits:

Non-flammable
[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1517]**PEER REVIEWED**

Fire Fighting Procedures:

If material involved in fire: Extinguish fire using agent suitable for type of surrounding fire. (Material itself does not burn or burns with difficulty). Keep runoff water out of sewers and water sources.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 1074]**PEER REVIEWED**

Toxic Combustion Products:

WHEN HEATED TO DECOMP, IT EMITS HIGHLY TOXIC FUMES OF FLUORIDE & CHLORIDE IONS.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 3236]**PEER REVIEWED**

ALL FLUOROCARBONS WILL UNDERGO THERMAL DECOMPOSITION WHEN EXPOSED TO FLAME OR RED-HOT METAL. DECOMPOSITION PRODUCTS OF THE CHLOROFLUOROCARBONS WILL INCLUDE HYDROFLUORIC & HYDROCHLORIC ACID ALONG WITH SMALLER AMOUNTS OF PHOSGENE & CARBONYL FLUORIDE. THE LAST COMPOUND IS VERY UNSTABLE TO HYDROLYSIS & QUICKLY CHANGES TO HYDROFLUORIC ACID & CARBON DIOXIDE IN THE PRESENCE OF MOISTURE. /FLUOROCARBONS/
[International Labour Office. Encyclopaedia of Occupational Health and Safety. 4th edition, Volumes 1-4 1998. Geneva, Switzerland: International Labour Office, 1998.,p. 104.185]**PEER REVIEWED**

IN CONTACT WITH OPEN FLAME OR VERY HOT SURFACE FLUOROCARBONS MAY DECOMP INTO HIGHLY IRRITANT & TOXIC GASES: CHLORINE, HYDROGEN FLUORIDE OR CHLORIDE, & EVEN PHOSGENE. /FLUOROCARBON REFRIGERANT & PROPELLANTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-159]**PEER REVIEWED**

Under certain conditions, fluorocarbon vapors may decompose on contact with flames or hot surfaces, creating the potential hazard of inhalation of toxic decomposition products. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

Chemically active metals such as sodium, potassium, calcium, powdered aluminum, zinc, magnesium &

lithium shavings; granular barium.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 146]**PEER REVIEWED**

Granular barium in contact with **fluorotrichloromethane** ... is susceptible to detonation.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 78]**PEER REVIEWED**

Mixtures of lithium shavings and several halocarbon derivatives /including **fluorotrichloromethane**/ are impact-sensitive and will explode, sometimes violently.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1315]**PEER REVIEWED**

Dangerous ... on contact with acid or acid fumes, they emit highly toxic fumes. /Fluorides/
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1660]**PEER REVIEWED**

DANGEROUS ... ON CONTACT WITH ACIDS OR ACID FUMES THEY EVOLVE HIGHLY TOXIC CHLORIDE FUMES. /CHLORIDES/
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 715]**PEER REVIEWED**

Hazardous Decomposition:

UNDER CERTAIN CONDITIONS, FLUOROCARBON VAPORS MAY DECOMPOSE ON CONTACT WITH FLAMES OR HOT SURFACES, CREATING THE POTENTIAL HAZARD OF INHALATION OF TOXIC DECOMPOSITION PRODUCTS. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

When heated to decomposition it emits highly toxic fumes of /hydrogen fluorides/ and /hydrogen chlorides/.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 3236]**PEER REVIEWED**

APPEARANCE OF TOXIC DECOMP PRODUCTS SERVES AS WARNING OF OCCURRENCE OF THERMAL DECOMP & DETECTION OF SHARP ACRID ODOR WARNS OF PRESENCE ... HALIDE LAMPS OR ELECTRONIC LEAK DETECTORS MAY ALSO BE USED. ADEQUATE VENTILATION ALSO AVOIDS PROBLEM OF TOXIC DECOMPOSITION PRODUCTS. /FLUOROCARBONS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3101]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

2000 ppm
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 146]**QC REVIEWED**

Protective Equipment & Clothing:

AIR LINE RESPIRATOR; RUBBER GLOVES; MONOGOGGLES.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Employees should be provided with and required to use impervious clothing, gloves, face-shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged of skin contact with liquid **fluorotrichloromethane**. Employees should be provided with and required to use splash-proof goggles where liquid **fluorotrichloromethane** may contact the eyes.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Wear appropriate personal protective clothing to prevent skin contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 147]**PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 147]**PEER REVIEWED**

Eyewash fountains should be provided in areas where there is any possbility that workers could be exposed to the substance; this is irrespective of the recommendation involving the wearing of eye protection.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 147]**PEER REVIEWED**

Facilities for quickly drenching the body should be provided within the immediate work area for emergency use where there is a possibility of exposure. [Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from any body areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.]
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 147]**PEER REVIEWED**

Recommendations for respirator selection. Max concn for use: 2000 ppm: Respirator Classes: Any supplied-air respirator. Any self-contained breathing apparatus with a full facepiece.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 147]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Emergency or planned entry into unknown concn or IDLH conditions: Respirator Classes: Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode. Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 147]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Escape from suddenly occurring respiratory hazards: Respirator Classes: Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister. Any appropriate escape-type, self-contained breathing apparatus.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 147]**PEER REVIEWED**

Many of the fluorocarbons are good solvents of skin oil, so protective ointment should be used. /Fluorocarbons/

[Zenz, C. Occupational Medicine-Principles and Practical Applications. 2nd ed. St. Louis, MO: Mosby-Yearbook, Inc, 1988. 544]**PEER REVIEWED**

Neoprene gloves, protective clothing, and eye protection minimize risk of topical contact. The degreasing effect on the skin can be treated with lanolin ointment. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1198]**PEER REVIEWED**

Forced air ventilation and level of vapor concentration together with the use of individual breathing devices with independent air supply will minimize risk of inhalation. Lifelines should be worn when entering tanks or other confined spaces. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Preventive Measures:

Contact lenses should not be worn when working with this chemical.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 147]**PEER REVIEWED**

Persons not wearing protective equipment and clothing should be restricted from areas of spills until cleanup has been completed.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Non-impervious clothing which becomes contaminated with liquid **fluorotrichloromethane** should be removed immediately and not reworn until the **fluorotrichloromethane** has evaporated.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Inhalation of fluorocarbon vapors should be avoided. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Forced air ventilation at the level of vapor concentration together with the use of individual breathing devices with independent air supply will minimize the risk of inhalation. Lifelines should be worn when entering tanks or other confined spaces. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Enclosure of process materials and isolation of reaction vessels and proper design and operation of filling heads for packaging and shipping /are administrative controls that may be instituted to limit

occupational exposure to fluorocarbons during manufacture, packaging, and use/. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Filling areas should be monitored to ensure that the ambient concn of fluorocarbons does not exceed 1000 ppm ... Inhalation of fluorocarbon vapors should be avoided ... . If inhalation occurs, epinephrine or other sympathomimetic amines and adrenergic activators should not be admin since they will further sensitize heart to development of arrhythmias. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Personnel protection: Keep upwind. Avoid breathing vapors. ... Do not handle broken packages unless wearing appropriate personal protective equipment.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 1074]**PEER REVIEWED**

If material not on fire or involved in fire: Keep material out of water sources and sewers. Build dikes to contain flow as necessary. Attempt to stop leak if without undue personnel hazard.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 1074]**PEER REVIEWED**

APPEARANCE OF TOXIC DECOMP PRODUCTS SERVES AS WARNING OF OCCURRENCE OF THERMAL DECOMP & DETECTION OF SHARP ACRID ODOR WARNS OF PRESENCE ... HALIDE LAMPS OR ELECTRONIC LEAK DETECTORS MAY ALSO BE USED. ADEQUATE VENTILATION ALSO AVOIDS PROBLEM OF TOXIC DECOMPOSITION PRODUCTS. /FLUOROCARBONS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3101]**PEER REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed and replaced.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 147]**PEER REVIEWED**

SRP: Local exhaust ventilation should be applied wherever there is an incidence of point source emissions or dispersion of regulated contaminants in the work area. Ventilation control of the contaminant as close to its point of generation is both the most economical and safest method to minimize personnel exposure to airborne contaminants.
PEER REVIEWED

SRP: Contaminated protective clothing should be segregated in such a manner so that there is no direct personal contact by personnel who handle, dispose, or clean the clothing. Quality assurance to ascertain the completeness of the cleaning procedures should be implemented before the decontaminated protective clothing is returned for reuse by the workers. Contaminated clothing should not be taken home at end of shift, but should remain at employee's place of work for cleaning.
PEER REVIEWED

Storage Conditions:

Storage temp: ambient; venting: safety relief
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER

REVIEWED**

Cleanup Methods:

If **fluorotrichloromethane** is spilled or leaked, the following steps should be taken: 1) Ventilate area of spill or leak. 2) If gas is leaking, stop the flow of gas. 3) If in liquid form, allow to vaporize.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Disposal Methods:

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste numbers U121; F002 must conform with USEPA regulations in storage, transportation, treatment and disposal of waste.
[40 CFR 240-280, 300-306, 702-799 (7/1/2000)]**PEER REVIEWED**

A potential candidate for rotary kiln incineration at a temperature range of 820 to 1,600 deg C and residence times of seconds for liquids and gases, and hours for solids. A potential candidate for fluidized bed incineration at a temperature range of 450 to 980 deg C and residence times of seconds for liquids and gases, and longer for solids.
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-13 (1981) EPA 68-03-3025]**PEER REVIEWED**

Trichlorofluoromethane is a waste chemical stream constituent which may be subjected to ultimate disposal by controlled incineration. Incineration, preferably after mixing with another combustible fuel. Care must be exercised to assure complete combustion to prevent the formation of phosgene. An acid scrubber is necessary to remove the halo acids produced.
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.2-10 (1981) EPA 68-03-3025]**PEER REVIEWED**

This compound should be susceptible to removal from waste water by air stripping.
[USEPA/ORD; Innovative and Alternative Technology Assessment Manual pp.3-5, 3-11,12 (1980) EPA 430/9-78-009]**PEER REVIEWED**

Because of recent discovery of potential ozone decomposition in the stratosphere by **fluorotrichloromethane**, this material should be released to the environment only as a last resort. Waste material should be /recovered and/ returned to the vendor, or to licensed waste disposal company.
[United Nations. Treatment and Disposal Methods for Waste Chemicals (IRPTC File). Data Profile Series No. 5. Geneva, Switzerland: United Nations Environmental Programme, Dec. 1985. 207]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for **trichlorofluoromethane**: Concentration process: Solvent extraction.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-118 (1982)]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for **trichlorofluoromethane**: Concentration process: Activated carbon.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-161 (1982)]**PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

Permissible Exposure Limit: Table Z-1 8-hr Time Weighted Avg: 1000 ppm (5600 mg/cu m).
[29 CFR 1910.1000 (7/1/2000)]**PEER REVIEWED**

Vacated 1989 OSHA PEL Ceiling limit 1000 ppm (5600 mg/cu m) is still enforced in some states.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 364]**PEER REVIEWED**

Threshold Limit Values:

Ceiling Limit 1,000 ppm
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 68]**PEER REVIEWED**

A4: Not classifiable as a human carcinogen.
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 68]**PEER REVIEWED**

NIOSH Recommendations:

Recommended Exposure Limit: Ceiling Value: 1,000 ppm (5,600 mg/cu m).
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 146]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

2000 ppm
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 146]**QC REVIEWED**

Manufacturing/Use Information:

Major Uses:

For **Trichlorofluoromethane** (USEPA/OPP Pesticide Code: 000013) there are 0 labels match. /SRP: Not registered for current use in the U.S., but approved pesticide uses may change periodically and so federal, state and local authorities must be consulted for currently approved uses./
[U.S. Environmental Protection Agency/Office of Pesticide Program's Chemical Ingredients Database on Trichlorofluoromethane (75-69-4). Available from the Database Query page at http://www.cdpr.ca.gov/docs/epa/epamenu.htm as of Sept 8, 2000.]**PEER REVIEWED**

Fully halogenated chlorofluorocarbons (CFCs) such as **trichlorofluoromethane** were scheduled for production phase-out in 1987 by the Montreal Protocol. Although originally scheduled for 50% production phase-out by the year 2000 in developed countries, the worsening ozone depletion has forced acceleration of the CFC phase-out.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V21 (1997) 132]**PEER REVIEWED**

USED IN MFR OF CLEANING CMPD AND IN FIRE EXTINGUISHERS /FORMER/
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 781]**PEER REVIEWED**

Solvent, fire extinguishers, chemical intermediate, blowing agent /Former/
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1125]**PEER REVIEWED**

BLOWING AGENT IN PRODN OF POLYURETHANE FOAMS; REFRIGERANT; DEGREASING AGENT
[SRI]**PEER REVIEWED**

Freon 11 is used in electric insulation since it has high electric strength, inhibits partial discharges, and tends to extinguish power arcs.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. V13 556 (1980)]**PEER REVIEWED**

Propellant in aerosols for insecticides, floor waxes, paint, cosmetics, and perfumes /former use/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

In production of polymeric resins.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Dielectric fluid in bubble chambers and in wind tunnels.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Sulfonation solvent in chemical synthesis.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

USED TO PROPEL BRONCHODILATOR SYMPATHOMIMETIC DRUGS OR CORTICOSTERIODS FOR THE TREATMENT OF BRONCHIAL ASTHMA ... /FORMERLY/ IN COSMETIC AEROSOL PRODUCTS.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3074]**PEER REVIEWED**

In refrigeration machinery requiring a refrigerant effective at negative pressures. As aerosol propellant /former use/.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

MECHANICAL VAPOR COMPRESSION SYSTEMS USE FLUOROCARBONS FOR REFRIGERATION & AIR CONDITIONING & ACCOUNT FOR ... MAJORITY OF REFRIGERATION CAPABILITY IN US. ... FLUOROCARBONS ARE USED AS REFRIGERANTS IN HOME APPLIANCES, MOBILE AIR CONDITIONING UNITS, RETAIL FOOD REFRIGERATION SYSTEMS & ... CHILLERS. /FLUOROCARBONS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3102]**PEER REVIEWED**

Blowing agent (polyurethane foams); dry cleaning solvent; aerosol propellant; heat-transfer fluid; refrigerant/air conditioning gas /Former/
[Ashford, R.D. Ashford's Dictionary of Industrial Chemicals. London, England: Wavelength Publications Ltd., 1994. 906]**PEER REVIEWED**

Laboratory use
[Verschueren, K. Handbook of Environmental Data on Organic Chemicals. 3rd ed. New York, NY: Van Nostrand Reinhold Co., 1996. 1016]**PEER REVIEWED**

Reactive ion etching of integrated circuits. ... being replaced by fluorine-based ... chlorine-based ..., and bromine-based gases.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V14 (95) 690]**PEER REVIEWED**

Hydrologic tracer and age-dating tool in shallow groundwaters
[Busenberg E, Plummer LN; Water Res Res 28: 2257-83 (1992)]**PEER REVIEWED**

GENETRON AEROSOL PROPELLANTS; GENETRON 11= **TRICHLOROMONOFLUOROMETHANE** /DISCONTINUED BY ALLIED CHEM CORP, SPECIALTY CHEM DIVISION/
[Farm Chemicals Handbook 1991. Willoughby, OH: Meister, 1991.,p. C-152]**PEER REVIEWED**

Methods of Manufacturing:

CARBON TETRACHLORIDE IS REACTED WITH ANTIMONY TRIFLUORIDE IN THE PRESENCE OF A SMALL QUANTITY OF ANTIMONY PENTACHLORIDE.
[Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980. 1266]**PEER REVIEWED**

From carbon tetrachloride and hafnium, in the presence of fluorinating agents such as antimony tri- and penta-fluoride.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1125]**PEER REVIEWED**

Prepn: Henne, Organic Reactions 2, 64 (1944).
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

Carbon tetrachloride + hydrogen fluoride (Halogen exchange; coproduced with dichlorodifluormethane)
[Ashford, R.D. Ashford's Dictionary of Industrial Chemicals. London, England: Wavelength Publications Ltd., 1994. 906]**PEER REVIEWED**

Natural gas + chlorine + hydrogen fluoride (Montedison single- step process; coproduced with dichlorodifluoromethane)
[Ashford, R.D. Ashford's Dictionary of Industrial Chemicals. London, England: Wavelength Publications Ltd., 1994. 906]**PEER REVIEWED**

General Manufacturing Information:

GENETRON AEROSOL PROPELLANTS; GENETRON 11= **TRICHLOROMONOFLUOROMETHANE** /DISCONTINUED BY ALLIED CHEM CORP, SPECIALTY CHEM DIVISION/
[Farm Chemicals Handbook 1991. Willoughby, OH: Meister, 1991.,p. C-152]**PEER REVIEWED**

... /The use of chlorofluorocarbons for aerosol sprays/ was prohibited in 1979 except for a few specialized items, because of their depleting effect on stratospheric ozone. /Chlorofluorocarbons/
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 256]**PEER REVIEWED**

Formulations/Preparations:

USEPA/OPP Pesticide Code 000013; Trade Names: **Freon 11;** Propellent 11; Frigen 11; Halon 11; FC 11; Khaladon 11; Kaltron 11; Isotron 11; Eskimon 11; and Genetron 11. /Former trade names/
[U.S. Environmental Protection Agency/Office of Pesticide Program's Chemical Ingredients Database on Trichlorofluoromethane (75-69-4). Available from the Database Query page at http://www.cdpr.ca.gov/docs/epa/epamenu.htm as of Sept 8, 2000.]**PEER REVIEWED**

Technical, 99.9% min
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1125]**PEER REVIEWED**

Consumption Patterns:

Refrigeration/air conditioning, 43%; foam blowing agents, 20%; polymer precursors, 13%; solvent cleaning, 12% aerosol propellants, 2%; medical equipment sterilization, 3%; other, 7%. (1991). /Estimates are for CFC-11,-12,-113,-114,-115 and HCFC-22 only/
[Chemical Profile: Fluorocarbons (1992)]**PEER REVIEWED**

REFRIGERANTS, 39%; FOAM BLOWING AGENTS, 17%; SOLVENTS, 14%; FLUOROPOLYMERS, 14%; STERILANT GAS, 2%; AEROSOL PROPELLANTS, 2%; FOOD FREEZANT, 1%; OTHER, 8%; EXPORTS, 3% (1985) /FLUOROCARBONS/
[CHEMICAL PROFILE: FLUOROCARBONS (1986)]**PEER REVIEWED**

U. S. Production:

(1978) 8.80X10+10 G
[SRI]**PEER REVIEWED**

(1982) 6.40X10+10 G
[SRI]**PEER REVIEWED**

(1988) 249,012,000 lb
[United States International Trade Commission. Synthetic Organic Chemicals- United States Production and Sales, 1988. USITC Publication 1989. Washington, DC: United States International Trade Commission, 1989.p. 15-7]**PEER REVIEWED**

(1989) 87,335,000 lb
[United States International Trade Commission. Synthetic Organic Chemicals-United States Production and Sales, 1989. USITC Publication 2338, 1990. Washington, DC: United States International Trade Commission, 1990.p. 15-8]**PEER REVIEWED**

(1984) 1.36X10+11 g (est) /CFC-13, -113, -114, -115, FLUORINATED MONOMERS AND SPECIALITIES/
[CHEMICAL PRODUCTS SYNOPSIS: FLUOROCARBONS (1984)]**PEER REVIEWED**

(1991) 7x10+8 lb (est) /Estimates are for CFC-11,-12,-113,-114,-115 and HCFC-22 only/
[Chemical Profile: Fluorocarbons (1992)]**PEER REVIEWED**

(1992) 6.1x10+8 lb (est) /Estimates are for CFC-11,-12,-113,-114,-115 and HCFC-22 only/
[Chemical Profile: Fluorocarbons (1992)]**PEER REVIEWED**

(1996) 3.75x10+8 lb (est) /Estimates are for CFC-11,-12,-113,-114,-115 and HCFC-22 only/
[Chemical Profile: Fluorocarbons (1992)]**PEER REVIEWED**

U. S. Imports:

(1978) 2.40X10+9 G (INCLUDES FLUOROCARBON 12)
[SRI]**PEER REVIEWED**

(1982) 1.30X10+9 G (INCLUDES FLUOROCARBON 12)
[SRI]**PEER REVIEWED**

(1985) 9.68X10+9 g
[BUREAU OF THE CENSUS, US IMPORTS FOR CONSUMPTION AND GENERAL IMPORTS 1985 p.1-584]**PEER REVIEWED**

(1984) 3.95X10+9 g /COMBINATION OF **TRICHLOROFLUOROMETHANE** & DICHLORODIFLUOROMETHANE/
[BUREAU OF THE CENSUS US IMPORTS FOR CONSUMPTION AND GENERAL IMPORTS (1984) p.1-363]**PEER REVIEWED**

(1984) GREATER THAN 4.54X10+9 g (est) /UNCLASSIFIED FLUOROCARBONS/
[CHEMICAL PRODUCTS SYNOPSIS: FLUOROCARBONS (1984)]**PEER REVIEWED**

U. S. Exports:

(1984) RANGE FROM 1.82X10+10 g TO 2.27X10+10 g (est) /UNCLASSIFIED FLUOROCARBONS/

[CHEMICAL PRODUCTS SYNOPSIS: FLUOROCARBONS (1984)]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

HEXANE EXTRACTION PROCEDURE FOR THE DETERMINATION OF COMMON FLUOROCARBON PROPELLANTS IN BLOOD WAS EVALUATED. AN ANALYSIS OF SAMPLE HEADSPACE WAS ALSO EVALUATED FOR DETERMINING CHLOROPENTAFLUOROETHANE IN BLOOD. BOTH PROCEDURES INVOLVED ANALYSIS BY GAS CHROMATOGRAPHY USING ELECTRON CAPTURE DETECTION. THE WIDELY USED HEXANE EXTRACTION PROCEDURE FOR DETERMINING PPM LEVELS OF VOLATILE HALOCARBONS IN TISSUE WAS EVALUATED BY A COMBINATION OF RADIOCHEMICAL AND GAS CHROMATOGRAPHIC TECHNIQUES. THE DATA SUGGEST THAT HEXANE EXTRACTION GIVES SIGNIFICANTLY LOW RESULTS. /FLUOROCARBONS/
[TERRILL JB; AMER IND HYG ASSOC J 33 (11): 736-44 (1972)]**PEER REVIEWED**

Analysis of fluorinated hydrocarbon propellants in blood using head-space gas chromatography.
[Chio WL, Niazi S; Chem Pathol Pharm 6: 481-98 (1973)]**PEER REVIEWED**

Analytic Laboratory Methods:

EPA Method IP-1A. High resolution capillary gas chromatography/mass spectrometry method coupled to one or more detectors (eg flame ionization detector, electron capture detector, photoionization detector) for the determination of volatile organic compounds in indoor air using stainless steel canisters. During analysis, water vapor is reduced in the gas stream by a Nafion(R) dryer and the temperature of

the trap is raised. Under the prescribed conditions, the method detection limit are not given as defined by EPA.
[USEPA/SCC; Environmental Monitoring Methods Index p.94 (1992)]**PEER REVIEWED**

EPA Method 5030. Purge and Trap extraction procedure for the analysis of volatile organics. Such cmpds include low-molecular weight halogenated hydrocarbons, aromatics, ketones, nitriles, acetates, acrylates, ethers and sulfides. An inert gas is bubbled through the solution at ambient temperature, and the volatile components are efficiently transferred from the aqueous phase to the vapor phase. After purging is complete, the sorbent column is heated and backflushed with inert gas to desorb the components onto a GC column. Water samples can be analyzed directly, while preparation is necessary for water-miscible liquids, solids, wastes and soil/sediments.
[USEPA; Test Methods for Evaluating Solid Waste SW-846 (1986)]**PEER REVIEWED**

EPA Method 5040. Protocol for Analysis of Sorbent Cartridges from Volatile Organic Sampling Train. This method covers the determination of volatile principal organic hazardous constituents collected on Tenax and Tenax/charcoal sorbent cartridges using a volatile organic sampling train, from wet stack gas effluents from hazardous waste incinerators. The contents of the sorbent cartidges are thermally desorbed, bubbled, and trapped on an analytical adsorbent trap. The desired target detection limit of the analytical method is 0.1 ng/l. Interferences include phthalate esters, detectable levels of volatile principal hazardous constituents in blanks, and soap residue on the glassware.
[USEPA; Test Methods for Evaluating Solid Waste SW-846 (1986)]**PEER REVIEWED**

EPA Method 3580. Waste Dilution. One gram of sample is weighed into a capped tube and the sample is diluted with an appropriate solvent. This method is designed for wastes that may contain organic chemicals at a level greater than 20,000 mg/kg. It is recommended that an aliquot of the diluted sample be cleaned up with an applicable technique.
[USEPA; Test Methods for Evaluating Solid Waste SW-846 (1986)]**PEER REVIEWED**

NIOSH Method 1006. Determination of **Fluorotrichloromethane** by Gas Chromatography with Flame Ionization Detection. Detection limit= 1.0 mg/cu m.
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

EPA Method OSW 8010B. Determination of Halogenated Volatile Organics by Gas Chromatography.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September (1994)]**PEER REVIEWED**

EPA Method OSW 8240B. Determination of Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS).
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September (1994)]**PEER REVIEWED**

EMSLC Method 601. Purgeable Halocarbons in Wastewater by Gas Chromatography with Electrolytic Conductivity Detection.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EMSLC Method 624. Protocol for the Analysis of Purgeable Organic Priority Pollutants in Industrial and Municipal Wastewater.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method OSW 8010B. Determination of Halogenated Volatile Organics by Gas Chromatography.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September (1994)]**PEER REVIEWED**

EPA OSW Method 8240. Determination of Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS).
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September (1994)]**PEER REVIEWED**

EPA Method 502.1. Volatile Halogenated Organic Compounds in Water by Purge and Trap Gas Chromatography. Revision 2.0.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 502.2. Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series. Revision 2.0.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 524.1. Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography and Mass Spectrometry. Revision 3.0.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 524.2. Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry. Revision 4.0.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method OSW 8260B. Determination of Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September (1994)]**PEER REVIEWED**

EPA Method 1624. Volatile Organic Compounds by Isotope Dilution GCMS. Minimum level= 10 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method OSW 8021A. Analysis of Halogenated and Aromatic Volatiles By Gas Chromatography using Electrolytic Conductivity and Photoionization Detectors in Series: Capillary Column Technique.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/ Chemical Methods, SW-846, 3rd Edition, Final Update II, September (1994)]**PEER REVIEWED**

EPA Method 6230B. Volatile Halocarbons in Water by Purge and Trap Packed-Column Gas Chromatography.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

Sampling Procedures:

Measurements to determine employee exposure are best taken so that the average eight-hr exposure is based on a single eight-hr sample or two four-hr samples. Several short time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the

employee's breathing zone (air that would most nearly represent that inhaled by the employee).
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

NIOSH Method 1006. Analyte: **Freon 11.** Matrix: Air. Sampler: Solid sorbent tube (coconut shell, charcoal, 400 mg/200 mg). Flow Rate: 0.01 to 0.05 l/min. Sample Size: 4 l. Shipment: Refrigerate. Sample Stability: Quantitative recovery after 8 days @ 25 deg C.
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

EPA Method 8010. For the analysis of solid waste, a representative sample (solid or liquid) is collected in a standard 40 ml glass screw-cap VOA vial equipped with a Teflon-faced silicone septum. Sample agitation, as well as contamination of the sample with air, must be avoided. Two vials are filled per sample location, then placed in separate plastic bags for shipment and storage.
[USEPA; Test Methods for Evaluating Solid Waste SW-846 (1986)]**PEER REVIEWED**

EPA Method 8240. Gas Chromatography/Mass Spectrometry for the determination of volatile Organics. This method can be used to quantify most volatile organic compounds including trchlorofluoromethane that have boiling points below 200 deg C and are insoluble or slightly soluble in water. The detection limit is not given. Precision and method accuracy were found to be directly related to the concentration of the analyte and essentially independent of the sample matrix.
[USEPA; Test Methods for Evaluating Solid Waste SW-846 (1986)]**PEER REVIEWED**

Special References:

Special Reports:

Barlow SM, Sullivan FM; Fluorocarbons; Reproductive Hazards of Industrial Chemicals pp.326-33 (1982.).

Edling C, Soderkvist P; Criteria Document for Threshold Limit Values: Fluorocarbons; Arbetarskyddsstyrelsen 171 (84) 38p (1982). A literature survey of the health hazards of fluorocarbons (Freons 11, 12, 22, and 113).

WHO; Environmental Health Criteria 113 Fully Halogenated Chlorofluorocarbons (1990)

Aviado DM; Toxicity of Propellants; Progress Research 18: 365-97 (1974). Available information concerning toxicity of 15 propellants used in aerosols was reviewed.

Zakhari S, Aviado DM; Cardiovascular Toxicology of Aerosol Propellants, Refrigerants and Related Solvents; Target Organ Toxicology Series: Cardiovascular Toxicology, XII+ 388 pages; Raven Press: New York, NY 281-326 (1982). Review of the toxicology of aerosol propellants, refrigerants and related solvents on the cardiovascular system of humans.

Bioassay of **Trichlorofluoromethane** for Possible Carcinogenicity (1978) Technical Rpt Series No. 106 DHEW Pub No. (NIH) 78-1356 U.S. Department of Health Education and Welfare, National Cancer Institute, Bethesda, MD 20014

Synonyms and Identifiers:

Synonyms:

F-11
PEER REVIEWED

F 11B
PEER REVIEWED

R 11
PEER REVIEWED

ALGOFRENE TYPE 1
PEER REVIEWED

ARCTON 9
PEER REVIEWED

Arcton 11
PEER REVIEWED

Caswell No. 878
PEER REVIEWED

CFC 11
PEER REVIEWED

ELECTRO-CF 11
PEER REVIEWED

EPA Pesticide Chemical Code 000013
PEER REVIEWED

ESKIMON 11
PEER REVIEWED

FC-11
PEER REVIEWED

FC 11 (HALOCARBON)
PEER REVIEWED

FKW 11
PEER REVIEWED

FLUOROCARBON-11
PEER REVIEWED

FLUOROCARBON NO. 11
PEER REVIEWED

FLUOROCHLOROFORM
PEER REVIEWED

FLUOROTRICHLOROMETHANE
PEER REVIEWED

FLUOROTROJCHLOROMETAN (POLISH)
PEER REVIEWED

FREON 11
PEER REVIEWED

FREON HE
PEER REVIEWED

FREON MF
PEER REVIEWED

FRIGEN 11
PEER REVIEWED

HALON 11
PEER REVIEWED

ISCEON 131
PEER REVIEWED

ISOTRON 11
PEER REVIEWED

KALTRON 11
PEER REVIEWED

KHLADON 11
PEER REVIEWED

LEDON 11
PEER REVIEWED

METHANE, FLUOROTRICHLORO-
PEER REVIEWED

METHANE, TRICHLOROFLUORO-
PEER REVIEWED

MONOFLUOROTRICHLOROMETHANE
PEER REVIEWED

NCI-C04637
PEER REVIEWED

PROPELLANT 11
PEER REVIEWED

R 11 (REFRIGERANT)
PEER REVIEWED

Refrigerant 11
PEER REVIEWED

TRICHLOROMONOFLUOROMETHANE
PEER REVIEWED

UCON REFRIGERANT 11
PEER REVIEWED

Formulations/Preparations:

USEPA/OPP Pesticide Code 000013; Trade Names: **Freon 11;** Propellent 11; Frigen 11; Halon 11; FC 11; Khaladon 11; Kaltron 11; Isotron 11; Eskimon 11; and Genetron 11. /Former trade names/
[U.S. Environmental Protection Agency/Office of Pesticide Program's Chemical Ingredients Database on Trichlorofluoromethane (75-69-4). Available from the Database Query page at http://www.cdpr.ca.gov/docs/epa/epamenu.htm as of Sept 8, 2000.]**PEER REVIEWED**

Technical, 99.9% min
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1125]**PEER REVIEWED**

EPA Hazardous Waste Number:

U121; A toxic waste when a discarded commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or manufacturing chemical intermediate.

F002; A hazardous waste from nonspecific sources when a spent solvent.

Administrative Information:

Hazardous Substances Databank Number: 138

Last Revision Date: 20030214

Last Review Date: Reviewed by SRP on 1/20/2001

Update History:

Complete Update on 02/14/2003, 1 field added/edited/deleted.
Complete Update on 11/08/2002, 1 field added/edited/deleted.
Complete Update on 08/09/2001, 1 field added/edited/deleted.
Complete Update on 05/23/2001, 67 fields added/edited/deleted.
Field Update on 05/16/2001, 1 field added/edited/deleted.
Complete Update on 06/12/2000, 1 field added/edited/deleted.
Complete Update on 03/28/2000, 1 field added/edited/deleted.
Complete Update on 03/13/2000, 2 fields added/edited/deleted.
Complete Update on 02/02/2000, 1 field added/edited/deleted.
Complete Update on 11/04/1999, 1 field added/edited/deleted.
Complete Update on 09/21/1999, 1 field added/edited/deleted.
Complete Update on 08/26/1999, 1 field added/edited/deleted.
Complete Update on 07/20/1999, 8 fields added/edited/deleted.
Complete Update on 03/17/1999, 1 field added/edited/deleted.
Complete Update on 01/20/1999, 3 fields added/edited/deleted.
Field Update on 12/18/1998, 1 field added/edited/deleted.
Complete Update on 11/16/1998, 1 field added/edited/deleted.

Complete Update on 11/12/1998, 1 field added/edited/deleted.
Complete Update on 06/02/1998, 1 field added/edited/deleted.
Complete Update on 10/17/1997, 1 field added/edited/deleted.
Complete Update on 03/27/1997, 1 field added/edited/deleted.
Complete Update on 02/26/1997, 1 field added/edited/deleted.
Complete Update on 01/09/1997, 1 field added/edited/deleted.
Complete Update on 11/26/1996, 2 fields added/edited/deleted.
Complete Update on 06/11/1996, 1 field added/edited/deleted.
Complete Update on 04/16/1996, 7 fields added/edited/deleted.
Complete Update on 01/18/1996, 1 field added/edited/deleted.
Complete Update on 11/10/1995, 1 field added/edited/deleted.
Complete Update on 09/29/1995, 1 field added/edited/deleted.
Complete Update on 08/14/1995, 1 field added/edited/deleted.
Complete Update on 05/26/1995, 1 field added/edited/deleted.
Complete Update on 01/24/1995, 1 field added/edited/deleted.
Complete Update on 12/19/1994, 1 field added/edited/deleted.
Complete Update on 08/04/1994, 1 field added/edited/deleted.
Complete Update on 03/25/1994, 1 field added/edited/deleted.
Complete Update on 09/15/1993, 1 field added/edited/deleted.
Complete Update on 08/07/1993, 1 field added/edited/deleted.
Complete Update on 08/04/1993, 1 field added/edited/deleted.
Complete Update on 06/03/1993, 60 fields added/edited/deleted.
Field Update on 04/27/1993, 1 field added/edited/deleted.
Field Update on 02/05/1993, 1 field added/edited/deleted.
Field update on 12/11/1992, 1 field added/edited/deleted.
Field Update on 11/23/1992, 1 field added/edited/deleted.
Field Update on 11/04/1992, 1 field added/edited/deleted.
Complete Update on 09/03/1992, 1 field added/edited/deleted.
Complete Update on 07/02/1992, 56 fields added/edited/deleted.
Field Update on 04/16/1992, 1 field added/edited/deleted.
Field Update on 01/13/1992, 1 field added/edited/deleted.
Complete Update on 09/26/1991, 1 field added/edited/deleted.
Complete Update on 10/15/1990, 5 fields added/edited/deleted.
Field Update on 05/14/1990, 1 field added/edited/deleted.
Field Update on 04/02/1990, 1 field added/edited/deleted.
Field Update on 01/15/1990, 1 field added/edited/deleted.
Complete Update on 01/11/1990, 3 fields added/edited/deleted.
Complete Update on 01/27/1989, 1 field added/edited/deleted.
Complete Update on 12/09/1988, 2 fields added/edited/deleted.
Complete Update on 09/23/1988, 1 field added/edited/deleted.
Complete Update on 06/22/1988, 63 fields added/edited/deleted.

Record Length: 188017

Trichlorofluoromethane

CASRN: 75-69-4
For other data, click on the Table of Contents

Status:

STATUS OF DATA FOR **Trichlorofluoromethane**

File First On-Line 01/31/1987

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on-line	08/01/1992
Inhalation RfC Assessment (I.B.)	no data	
Carcinogenicity Assessment (II.)	no data	

Substance Identification:

Substance Name:

Trichlorofluoromethane

CAS Registry Number: 75-69-4

I. Chronic Health Hazard Assessment for Noncarcinogenic Effects:

I.A. Reference Dose for Chronic Oral Exposure (RfD):

Substance Name -- **Trichlorofluoromethane**
CASRN -- 75-69-4
Last Revised -- 08/01/1992

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.A.1. Oral RfD Summary:

Critical Effect	Experimental Doses*	UF	MF	RfD
Survival and histopathology Cancer Bioassay Studies in Rats and Mice NCI, 1978	NOAEL: none LOAEL: 488 mg/kg/day converted to 349 mg/kg/day	1000	1	3E-1 mg/kg/day

*Conversion Factors: 5 days/7 days; thus, 488 mg/kg/day x 5 days/7 days = 349 mg/kg/day

I.A.2. Principal and Supporting Studies (Oral RfD):

NCI (National Cancer Institute). 1978. Bioassay of **trichlorofluoromethane** for possible carcinogenicity. Report. No. 106, PHS/NIH, DHEW Publ. No. 78- 1356.

The NCI bioassay was performed on rats and mice exposed to various doses of **trichloromonofluoromethane** by gavage over a period of 78 weeks (50 animals/species/sex/dose for each of two doses with 20 animals/species/sex for each of two control groups). A statistically significant positive association between increased dosage and accelerated mortality by the Tarone test in male and female rats and female mice were observed. In treated rats of both sexes there were also elevated incidences of pleuritis and pericarditis not seen in controls. Inhalation studies which employed multispecies exposures to higher levels of the compound than used by NCI (Leuschner et al., 1983) reported no adverse clinical/pathologic signs of toxicity due to subchronic or short-term exposures.

The LOAEL of 488 mg/kg/day (based on mortality in rats) was converted to 349 mg/kg/day on a 7-day exposure basis.

I.A.3. Uncertainty and Modifying Factors (Oral RfD):

UF -- An uncertainty factory of 1000 (10 for LOAEL, 10 for species conversion, and 10 for sensitive human population), results in an RfD of 0.3 mg/kg/day.

MF -- None

I.A.4. Additional Studies/Comments (Oral RfD):

None.

I.A.5. Confidence in the Oral RfD:

Study -- Medium
Database -- Medium

RfD -- Medium

The chosen study is given a medium confidence rating because large numbers of animals/sex were tested in two doses for chronic exposures, but the study did not establish a NOEL. The data base is given a medium confidence rating because of the support of chronic data, but the lack of reproductive data. Medium confidence in the RfD follows.

I.A.6. EPA Documentation and Review of the Oral RfD:

Source Document -- This assessment is not presented in any existing U.S. EPA document.

Other EPA Documentation -- None

Agency Work Group Review -- 05/20/1985, 05/31/1985

Verification Date -- 05/31/1985

Screening-Level Literature Review Findings -- A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the RfD for **Trichlorofluoromethane** conducted in September 2002 did not identify any critical new studies. IRIS users who know of important new studies may provide that information to the IRIS Hotline at hotline.iris@epa.gov or 301-345-2870.

I.A.7. EPA Contacts (Oral RfD):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC):

Substance Name -- **Trichlorofluoromethane**
CASRN -- 75-69-4

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure:

Substance Name -- **Trichlorofluoromethane**
CASRN -- 75-69-4

This substance/agent has not undergone a complete evaluation and determination under US EPA's IRIS program for evidence of human carcinogenic potential.

VI. Bibliography:

VI.A. Oral RfD References:

Leuschener, F., B.W. Neumann and F. Hubscher. 1983. Report on the subacute toxicological studies with several fluorocarbons in rats and dogs by inhalation. Arzneim-Forsch. 33(10): 1475-1476.

NCI (National Cancer Institute). 1978. Bioassay of **trichlorofluoromethane** for possible carcinogenicity. Report No. 106, PHS/NIH, DWEH, Publ. No. 78- 1356.

VI.B. Inhalation RfC References:

None

VI.C. Carcinogenicity Assessment References:

None

VII. Revision History:

Substance Name -- **Trichlorofluoromethane**
CASRN -- 75-69-4

Date	Section	Description
03/31/1987	I.A.6.	Documentation corrected
03/01/1988	I.A.5.	Confidence levels revised
08/01/1990	I.A.	Text edited
08/01/1990	IV.F.1.	EPA contact changed
01/01/1992	I.A.7.	Primary contact changed
01/01/1992	IV.	Regulatory actions updated
07/01/1992	I.A.2.	Citations removed
07/01/1992	VI.A.	Oral RfD references on-line
08/01/1992	I.A.3.	Minor text change
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
12/03/2002	I.A.6.	Screening-Level Literature Review Findings message has been added.

1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE

CASRN: 76-13-1

For other data, click on the Table of Contents

Human Health Effects:

Human Toxicity Excerpts:

HUMAN ... EXPOSURES LIMITED TO 2.75 HOURS AT CONCENTRATIONS FROM 1500 TO 4500 PPM /**TRICHLOROTRIFLUOROETHANE**/ ... RESULTED IN NO SIGNIFICANT DETERIORATION OF PSYCHOMOTOR PERFORMANCE AT 1500 PPM, SLIGHT DETERIORATION AT 2500 PPM, AND INCREASING DECREMENT AT 4500 PPM.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values for Substances in Workroom Air. Third Edition, 1971. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1971. (Plus supplements to 1979)267]**PEER REVIEWED**

EXPOSURE OF HUMAN VOLUNTEERS INDICATE THAT THE THRESHOLD CONCENTRATION FOR IMPAIRMENT OF PSYCHOMOTOR PERFORMANCE (LOSS OF ABILITY TO CONCENTRATE, MILD LETHARGY) IS ABOUT 2500 PPM. DAILY SIX-HR EXPOSURES AT 500 OR 1000 PPM, 5 DAYS A WK FOR 2 WEEKS, YIELDED NO COMPLAINTS OF ANY ADVERSE EFFECTS EXCEPT MILD THROAT IRRITATION ONLY ON THE FIRST DAY. NO ADVERSE CHANGES WERE SEEN IN PERFORMANCE OF COMPLEX MENTAL TASKS, CLINICAL STATUS OR RESULTS OF BIOCHEMICAL TESTS.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1603]**PEER REVIEWED**

... CARDIOTOXIC EFFECTS, MANIFESTED IN ARRHYTHMIAS ... ARE ASSOCIATED WITH PULMONARY EXPOSURE TO FLUOROCARBONS, ESPECIALLY ... FLUOROCARBON 113 ... .
[Hamilton, A., and H. L. Hardy. Industrial Toxicology. 3rd ed. Acton, Mass.: Publishing Sciences Group, Inc., 1974. 293]**PEER REVIEWED**

TEN WOMEN & THREE MEN WERE OCCUPATIONALLY EXPOSED TO 1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE. EVALUATION OF CLINICAL CHEM PARAMETERS SHOWED NO INDICATION OF SOLVENT-CAUSED ADVERSE EFFECTS.
[TRIEBIG G, BURKHARDT K; INT ARCH OCCUP ENVIRON HEALTH 42 (2): 129-36 (1978)]**PEER REVIEWED**

... There is no evidence indicating that human health effects are likely to occur at ambient mixing ratios (18 parts-per-trillion) found or expected in the general environment or even at higher levels (<4,160 parts-per-trillion). ... Available experimental data do not indicate that any adverse health effects are directly induced in humans at TLV of /500/ ppm due to exposure to CFC-113.
[USEPA; Health Assessment Document for 1,1,2-Trichloro-1,2,2-Trifluoroethane p.1 (1983) EPA-600/58-82-002F]**PEER REVIEWED**

... A single case /was reported/ of sensorimotor neuropathy in a woman who had worked as a laundress with **trichlorotrifluoroethane** (**Freon 113)** for several years. Weakness, pain, and paresthesias were most severe distally in the legs. Electrodiagnostic testing was consistent with axonal damage. Removal from exposure to **trichlorotrifluoroethane** resulted in gradual recovery.
[O'Donoghue, J.L. (ed.). Neurotoxicity of Industrial and Commercial Chemicals. Volume II. Boca Raton, FL: CRC Press, Inc., 1985. 110]**PEER REVIEWED**

A patient who ingested 1 liter of **Freon 113** experienced transient cyanosis and suffered rectal irritation

and diarrhea. /No other effects were noted/.
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1282]**PEER REVIEWED**

Propellant /fluorocarbon/ gases were generated from commercial aerosol units and applied to the from distance of 50 cm for periods of 15 to 60 sec. At a measured concn of 95,000 mg/cu m (1700 ppm), there was a biphasic change in ventilation capacity, the first reduction occurring within a few minutes after exposure, and second delayed until 13 to 30 min after exposure, and second delayed until 13 to 30 min after exposure. Most subjects developed bradycardia, and inversion of the T-wave. /Propellant gases/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1201]**PEER REVIEWED**

... The combination of CFC with a sympathomimetic bronchodilator is potentially dangerous for the treatment of bronchial asthma. For the same reason, sympathomimetic drugs are contraindicated in cardiac resuscitation of patients suffering from CFC poisoning. /Fluorocarbon poisoning/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1183]**PEER REVIEWED**

Fluorocarbon vapors are 4 to 5 times heavier than air. Thus high concn tend to accumulate in low-lying areas, resulting in hazard of inhalation of concentrated vapors, which may be fatal. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Under certain condition, fluorocarbon vapors may decompose on contact with flames or hot surfaces, creating potential hazard of inhalation of toxic decomposition products. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Freons are toxic to humans by several mechanisms. Inhaled fluorocarbons sensitize the myocardium to catecholamines, frequently resulting in lethal ventricular arrhythmias. Because they are gases heavier than air, fluorocarbons can displace atmospheric oxygen, thus resulting in asphyxiation. These compounds also have a central nervous system anesthetic effect analogous to a structurally similar general anesthetic, halothane. Pressurized refrigerant or liquid fluorocarbons with a low boiling point have a cryogenic effect on exposed tissues, causing frostbite, laryngeal or pulmonary edema, and gastrointestinal perforation. /Freons/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1281]**PEER REVIEWED**

Fluorocarbons were initially believed to be compounds low in toxicity. In the late 1960s there were early reports of deaths caused by intentional inhalation abuse of various aerosols. Victims frequently discharged the aerosol contents into a plastic bag and then inhaled the gaseous contents. Suffocation was initially considered to be the cause of death. In 1970, 110 cases of "sudden sniffing death" /were reviewed/ without finding evidence of suffocation. The majority of those deaths (59) involved fluorocarbon propellants. He noted that in several cases sudden death followed a burst of emotional stress or exercise. No significant findings were noted at autopsy. /Fluorocarbons/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1281]**PEER REVIEWED**

A worker died while assisting three workers who were cleaning out a **Freon 113** vapor degreaser at a chemical fuel plant. During this procedure solvent was drained off and the residue on the bottom of the degreaser was cleaned out. The company had written instruction for cleaning out the degreasing tank. All

but about 1 gallon of the solvent had been drained off. After taking a break for lunch, the three men returned, picking up the fourth worker who was experienced in the cleaning operation. Using removable wooden stairs two men, including the experienced worker, climbed into the tank. Shortly thereafter both men had trouble breathing and exited the tank. the experienced worker collapsed to the floor and died shortly. The other worker experienced no ill effects. The men were using air purifying respirators designed for limited use with organic solvents. The cause of death had not been determined.
[NIOSH; FACE Report: Worker Dies While Cleaning Freon 13 Degreasing Tank in Virginia, November 21, 1986 Report No. FACE-87-17, 6pp (1986)]**PEER REVIEWED**

There are isolated reports of poisoning from exposure to refrigerants and solvents, and some studies showing a higher incidence of coronary heart disease among hospital personnel are required to establish causal relationship between fluorine containing organic compounds, and cardiovascular and bronchopulmonary diseases among exposed workers. The high incidence of cancer among hospital personnel repeatedly exposed to fluorine-containing general anesthetics raises a fundamental need to examine other chlorofluorocarbon-exposed workers for similar effects. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1209]**PEER REVIEWED**

Clinical pathologists exposed to fluorocarbons in the preparation of frozen tissue sections have been seen to develop coronary heart disease. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1209]**PEER REVIEWED**

The toxicity of Chlorofluorocarbons (CFCs) had been considered to be low; it is absorbed via the lungs and undergoes little subsequent biotransformation. In the United States when sudden unexplained deaths of aerosol "sniffers" were reported they were considered to be possibly due to cardiac arrhythmias induced by the CFC propellants. /CFCs/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 1299]**PEER REVIEWED**

... Working with high conc of CFC-113 or other chlorofluorocarbons in confined spaces has the potential to cause death by cardiac arrhythmia, asphyxiation, or both. ... 4 reports of 12 fatalities resulting from occupational exposure to CFC-113 under conditions typical of situations in which CFC-113 can cause death. In most of the reports, the conc of CFC-113 was not specified. However, in one of the deaths from cardiac arrhythmia, the exposure was for 1 min & the CFC-113 concn measured 24 hr after exposure was 7600 ppm. In a death from asphyxiation, the CFC-113 conc was estimated to be 300,000 ppm, but the duration of exposure was not stated; however from the description of the incident, the exposure was relatively brief.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1633]**PEER REVIEWED**

Psychomotor performance was evaluated using CFC-113 at concentrations of 0.15% (12 g/cu m), 0.25% (19 g/cu m), 0.35% (27 g/cu m) or 0.45% (35 g/cu m) for 165 min. There was no effect at the lowest concentration, but there was difficulty in mental concentration and some decrease in test scores beginning at 0.35% (27 g/cu m).
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.19 (1990)]**PEER REVIEWED**

Human Toxicity Values:

TCLO HUMAN INHALATION 4500 PPM; TOXIC EFFECT: CNS EFFECTS

[Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984. 1458]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

... May cause irritation of eyes & throat. ... 1,1,2-Trichloro-1,2,2-trifluoroethane on prolonged or repeated contact with skin may cause skin irritation.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Medical Surveillance:

Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from ... exposure. ... 1,1,2-Trichloro-1,2,2-trifluoroethane is a defatting agent and can cause dermatitis on prolonged exposure. Persons with existing skin disorders may be more susceptible to the effects of this agent. ... In persons with impaired cardiovascular function, especially those with a history of cardiac arrhythmias, the breathing of 1,1,2-trichloro-1,2,2-trifluoroethane might cause exacerbation of symptoms due to its sensitizing properties. ... Any employee developing the above-listed conditions should be referred for further medical examination.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Populations at Special Risk:

Persons with existing skin disorders may be more susceptible to the effects of this agent. ... In persons with impaired cardiovascular function, especially those with history of cardiac arrhythmias, the breathing of 1,1,2-trichloro-1,2,2-trifluoroethane might cause exacerbation of symptoms due to its sensitizing properties.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.]**PEER REVIEWED**

Probable Routes of Human Exposure:

Routes of entry inhalation, ingestion, skin & eye contact.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 889]**PEER REVIEWED**

... 50 workers at the Kennedy Space Center exposed to levels ranging from 46 to 4700 ppm for an overall average duration of 2.77 yr /were examined/. There were no signs or symptoms of adverse effects.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3092]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 250,773 workers (79,790 of these are female) are potentially exposed to 1,1,2-trichloro-1,2,2-trifluoroethane in the US(1). Occupational exposure to 1,1,2-trichloro-1,2,2-trifluoroethane may occur through inhalation and dermal contact with this compound at workplaces where it is produced or used. Due to its long atmospheric residence time, the general population is exposed to 1,1,2-trichloro-1,2,2-trifluoroethane through inhalation of ambient

air. Monitoring data indicate that the general population may also be exposed to 1,1,2-trichloro-1,2,2-trifluoroethane via ingestion of contaminated water, and via inhalation and dermal contact with this compound and other consumer products containing this compound(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983)]**PEER REVIEWED**

Average Daily Intake:

The average daily in take of 1,1,2-trichloro-1,2,2-trifluoroethane in air, (assume 13-31 parts/trillion(1,2)) is 2.0-4.8 ug/day(SRC).
[(1) Fabian P et al; J Geophys Res 90: 13091-3 (1985) (2) Brodzinsky R, Singh HB; pp. 23-184 in Volatile Organic Chemicals in the Atmosphere: An Assessment of Available Data Menlo Park, CA: SRI International (1982)]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** FLUORINATED HYDROCARBONS ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

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0.2.1 SUMMARY OF EXPOSURE
 0.2.1.1 ACUTE EXPOSURE
   A.  LOW CONCENTRATION - Inhalations such as those caused by
       leaking air conditioners or refrigerators may result in
       transient eye, nose, and throat irritation.
       Palpitations, light-headedness, and headaches are also
       seen.
   B.  HIGH CONCENTRATION - Inhalation associated with
       deliberate abuse, spills or industrial use occurring in
       poorly ventilated areas has been associated with
       ventricular dysrhythmias, pulmonary edema and sudden
       death.
0.2.4 HEENT
 0.2.4.1 ACUTE EXPOSURE
   A.  EYES - Eye irritation occurs with ambient exposure.
       Frostbite of the lids may be severe.  Ocular
       instillation results in corneal burns in rabbits.
   B.  NOSE - Nasal irritation occurs with ambient exposure.
   C.  THROAT - Irritation occurs.  Frostbite of the lips,
       tongue, buccal mucosa and hard palate developed in a
       man after deliberate inhalation.
0.2.5 CARDIOVASCULAR
 0.2.5.1 ACUTE EXPOSURE
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A. Inhalation of high concentrations is associated with the development of refractory ventricular dysrhythmias and sudden death, believed to be secondary, primarily, to hypoxia or myocardial sensitization to endogenous catecholamines. Some individuals may be susceptible to arrhythmogenic effects at lower concentrations.

0.2.6 RESPIRATORY

0.2.6.1 ACUTE EXPOSURE

A. Pulmonary irritation, bronchial constriction, cough, dyspnea, and chest tightness may develop after inhalation. Chronic pulmonary hyperreactivity may occur. Adult respiratory distress syndrome has been reported following acute inhalational exposures. Pulmonary edema is an autopsy finding in fatal cases.

0.2.7 NEUROLOGIC

0.2.7.1 ACUTE EXPOSURE

A. Headache, dizziness, and disorientation are common. Cerebral edema may be found on autopsy. A syndrome of impaired psychomotor speed, impaired memory and learning, and emotional lability has been described in workers with chronic occupational exposure to fluorinated hydrocarbons.

0.2.8 GASTROINTESTINAL

0.2.8.1 ACUTE EXPOSURE

A. Nausea may develop. Ingestion of a small amount of trichlorofluoromethane resulted in necrosis and perforation of the stomach in one patient.

0.2.9 HEPATIC

0.2.9.1 ACUTE EXPOSURE

A. Jaundice and mild elevations in transaminases may develop after inhalational exposure or ingestion. Hepatocellular coagulative necrosis has been observed on liver biopsy.

0.2.14 DERMATOLOGIC

0.2.14.1 ACUTE EXPOSURE

A. Dermal contact may result in defatting, irritation or contact dermatitis. Severe frostbite has been reported as an effect of freon exposure. Injection causes transient pain, erythema and edema.

0.2.15 MUSCULOSKELETAL

0.2.15.1 ACUTE EXPOSURE

A. Rhabdomyolysis has been reported in a worker susceptible to malignant hyperthermia after exposure to fluorinated hydrocarbons and also following intentional freon inhalation. Compartment syndrome is a rare complication of severe exposure.

0.2.20 REPRODUCTIVE HAZARDS

A. Dichlorodifluoromethane was not teratogenic in rats and rabbits.

B. The reproductive effects of 1,1,1,2-tetrafluoroethane were studied in rats. No adverse effects on reproductive performance was noted or on the development, maturation or reproductive performance of up to two successive generations.

0.2.22 GENOTOXICITY

A. The hydrochlorofluorocarbons, HCFC-225ca and HCFC-225cb, were not mutagenic in the Ames reverse mutation assay, or clastogenic in the chromosomal aberration assay with Chinese hamster lung cells. Neither induced unscheduled DNA synthesis in liver cells. Both of these agents were clastogenic in the chromosomal aberration assay with human lymphocytes.

Laboratory:

A. Fluorinated hydrocarbons plasma levels are not clinically useful.
B. No specific lab work (CBC, electrolyte, urinalysis) is needed unless otherwise indicated.
C. Obtain baseline pulse oximetry or arterial blood gas analysis.

Treatment Overview:

0.4.2 ORAL EXPOSURE
A. These substances may cause frostbite to the upper airway and gastrointestinal tract after ingestion. Administer oxygen and manage airway as clinically indicated. Emesis, activated charcoal, and gastric lavage are not recommended.
0.4.3 INHALATION EXPOSURE
A. MONITOR ECG and VITAL SIGNS carefully. Cardiopulmonary resuscitation may be necessary. Caution is advised with the administration of CATECHOLAMINE drugs.
B. PROVIDE A QUIET CALM ATMOSPHERE to prevent adrenaline surge if the patient is seen before the onset of cardiac arrhythmias. Minimize physical exertion.
C. MONITOR pulse oximetry or arterial blood gases.
D. Provide symptomatic and supportive care.
E. These substances may cause frostbite of the upper airway with the potential for severe edema. Administer oxygen and manage airway early in patients with evidence of upper airway injury.
F. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.
0.4.4 EYE EXPOSURE
A. DECONTAMINATION: Irrigate exposed eyes with copious amounts of room temperature water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility.
B. Ophthalmologic consultation should be considered in symptomatic patients.
0.4.5 DERMAL EXPOSURE
A. DECONTAMINATION: Remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician may need to examine the area if irritation or pain persists.
B. If frostbite has occurred, refer to dermal treatment in the main body of this document for rewarming.

Range of Toxicity:

A. Freons are very toxic when inhaled in high concentrations and/or for extended periods. At lower concentrations or brief exposure, freons may cause transient eye, nose, and throat irritation.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

... IF INHALATION OCCURS, EPINEPHRINE OR OTHER SYMPATHOMIMETIC AMINES & ADRENERGIC ACTIVATORS SHOULD NOT BE ADMIN SINCE THEY WILL FURTHER SENSITIZE HEART TO DEVELOPMENT OF ARRHYTHMIAS.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1201]**PEER REVIEWED**

... In persons who are intoxicated with fluorocarbons, steps can be taken to lessen the risk of arrhythmias. ... Before evaluation at the hospital, patients should be advised to avoid strenuous exercise. In the hospital, patients can be placed in a quiet, nonthreatening environment and sedated if necessary. If hypoxic, oxygen should be administered and metabolic abnormalities corrected. Sympathomimetic drugs should be avoided. Ventricular arrhythmias are best treated with beta-blocking agents. /Fluorocarbons/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 81]**PEER REVIEWED**

Basic treatment: Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations as needed. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Minimize physical activity and provide a quiet atmosphere. Monitor for pulmonary edema and treat if necessary ... . Anticipate seizures and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport ... . Do not use emetics. Rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal ... . Treat frostbite with rapid rewarming techniques ... . /Chlorinated fluorocarbons (CFCs) and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 192]**PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious or in respiratory arrest. Positive pressure ventilation techniques with a bag valve mask device may be beneficial. Monitor cardiac rhythm and treat arrhythmias if necessary ... . Start an IV with D5W /SRP: "To keep open", minimal flow rate/. Use lactated Ringer's if signs of hypovolemia are present. Watch for signs of fluid overload. Consider drug therapy for pulmonary edema ... . Treat seizures with diazepam ... . Use proparacaine hydrochloride to assist eye irrigation ... . /Chlorinated fluorocarbons (CFCs) and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 192]**PEER REVIEWED**

Animal Toxicity Studies:

Non-Human Toxicity Excerpts:

THE CHIEF EFFECTS OF EXPOSURE TO ... /**TRICHLOROTRIFLUOROETHANE**/ ARE DEPRESSION OF THE CENTRAL NERVOUS SYSTEM AND IRRITATION OF THE RESPIRATORY TRACT. SUCH EFFECTS OCCUR IN ANIMALS AT CONCENTRATIONS ABOVE 12000 PPM. MILD LIVER CHANGES HAVE BEEN NOTICED AT LEVELS SOMEWHAT BELOW THIS.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values for Substances in Workroom Air. Third Edition, 1971. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1971. (Plus supplements to 1979)267]**PEER REVIEWED**

GUINEA PIGS EXPOSED ... FOR PERIODS OF 5 MINUTES TO 2 HOURS SHOWED INCREASING SIGNS OF IRRITATION AND /CNS DEPRESSION/; NASAL IRRITATION WAS

APPARENT IN 5 MINUTES AT 25000 PPM, AND LOSS OF COORDINATION AT 50000 PPM AFTER 30 MINUTES; DEATHS OCCURRED AFTER 1 HOUR AT THIS LEVEL.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values for Substances in Workroom Air. Third Edition, 1971. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1971. (Plus supplements to 1979)267]**PEER REVIEWED**

SUBACUTE EXPOSURES OF RATS FOR 30 DAYS DURATION, SEVEN HOURS DAILY, FIVE DAYS EACH WEEK AT 2520 PPM SHOWED NO MORTALITY OR OTHER EFFECTS OF EXPOSURE. A SIMILAR STUDY ... AT 5000 PPM, ALTHOUGH SHOWING NO MORTALITY, INDICATED SOME EFFECTS ON THE LIVER.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values for Substances in Workroom Air. Third Edition, 1971. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1971. (Plus supplements to 1979)267]**PEER REVIEWED**

/**TRICHLOROTRIFLUOROETHANE**/ ... PRODUCED NO IRRITATION ON THE ABRADED OR INTACT SKIN OF GUINEA PIGS, AND NO CORNEAL INJURY OR IRRITATION DURING A SUBSEQUENT 72-HOUR PERIOD.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values for Substances in Workroom Air. Third Edition, 1971. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1971. (Plus supplements to 1979)267]**PEER REVIEWED**

... ACUTE INHALATION STUDIES OF RATS TO THE VAPOR FOR 6 HOURS SHOWED PULMONARY CHANGES AROUND LEVELS OF 30000 PPM, BUT NO MORTALITY UNTIL LEVELS AROUND 87000 PPM.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values for Substances in Workroom Air. Third Edition, 1971. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1971. (Plus supplements to 1979)267]**PEER REVIEWED**

IN EXPERIMENTAL ANIMALS VARIABLE DEGREES OF TACHYCARDIA, MYOCARDIAL DEPRESSION, AND HYPOTENSION HAVE BEEN DESCRIBED.
[Hamilton, A., and H. L. Hardy. Industrial Toxicology. 3rd ed. Acton, Mass.: Publishing Sciences Group, Inc., 1974. 293]**PEER REVIEWED**

INHALATION OF 0.5% **FREON 113** BY UNANESTHETIZED BEAGLE DOGS WAS REQUIRED FOR CARDIAC SENSITIZATION. ARTERIAL BLOOD LEVEL ASSOC WITH EFFECT WAS 12.5 UG/L & VENOUS LEVEL WAS 4.9 UG/L.
[TROCHIMOWICZ HJ ET AL; J AM IND HYG ASSOC 35 (10): 632-9 (1974)]**PEER REVIEWED**

FREON 113 WAS INVESTIGATED FOR ITS ACTION ON PULMONARY SURFACTANT IN RATS. IN VITRO VENTILATION OF RAT LUNG WITH VAPORS PRODUCED ALVEOLAR INSTABILITY & ATELECTASIS. IT CAN DISSOLVE & DISPLACE LIPID PORTION OF ALVEOLAR SURFACTANT CAUSING ALVEOLAR INSTABILITY.
[ALARIE Y ET AL; TOXICOL APPL PHARMACOL 31 (2): 233-42 (1975)]**PEER REVIEWED**

TRICHLOROTRIFLUOROETHANE CAUSED TACHYCARDIA, HYPOTENSION IN ANESTHETIZED RHESUS MONKEYS WHEN INHALED @ 2.5-5%.
[AVIADO DM, SMITH DG; TOXICOL 3 (2): 241-52 (1975)]**PEER REVIEWED**

TRICHLOROTRIFLUOROETHANE @ 2.5 & 5% DEPRESSED VENTRICULAR FUNCTION IN HEART-LUNG PREPN FROM DOG.
[AVIADO DM, BELEJ M; TOXICOLOGY 3 (1): 78-86 (1975)]**PEER REVIEWED**

RABBITS WERE USED TO STUDY IRRITANT POWERS OF PRINCIPAL ALIPHATIC SOLVENTS ON SKIN & OCULAR MUCOSA. SOLVENTS TESTED WERE FOUND TO BE PRIMARY IRRITANTS WITH EXCEPTION OF TRICHLOROTRIFLUORO-1,1,2-ETHANE BUT THEIR EFFECTS ON SKIN & OCULAR MUCOSA DIFFER.
[DUPRAT ET AL; EUR J TOXICOL ENVIRON HYG 9 (3): 171-7 (1976)]**PEER REVIEWED**

Animal studies indicate low acute toxicity when FC-113 is inhaled. The LC50 for 4 hr exposure of rats range from 52000 to 68000 ppm, while 2 hr lethal concn for rats, guinea pigs, mice, and rabbits ranged from 50000 to 120000 ppm. FC 113 act like a weak ... /CNS depressant/ and has relatively strong sensitization potential compared to homologous fluorocarbons. ... In another study, rotobar-trained rats exposed at 11000-13000 ppm for 6 hr showed no decrement in performance; dogs showed vomiting, lethargy, nervousness, and tremors, all reversible within 15 min after exposure.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1631]**PEER REVIEWED**

When studied at doses below those causing maternal toxicity, FC 113 caused no changes in the offspring from pregnant rabbits exposed either by the oral or by nine daily two hr exposures at levels as high as 20000 ppm.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1632]**PEER REVIEWED**

Studies of 4 to 6-weeks duration, conducted at concn <25,000 ppm, reported variable findings. After 19 seven-hr exposures at 5000 ppm, some rats developed slight, diffuse, degenerative fatty infiltration; no such changes or other pathological findings were observed in three subsequent similar studies. No clinical, biochemical, or pathologic changes developed after twenty 3.5 hr daily exposures of rats & guinea pigs, or rats & dogs after 20 six-hr exposures at 5100 ppm or in rats after 30 seven-hr exposures at 2520 ppm; however, after inhaling 5000 ppm, 7 hr/day for 30 days, body-weight gain was depressed in the rat. After 14 days of continuous exposure of monkeys, dogs, mice, and rats at 2000 ppm, no adverse effects could be detected. The only morphologic & biochemical changes noted in male Wistar rats inhaling 1000 or 2000 ppm CFC-113, 6 hr/day, 5 days/week were proliferation of hepatic smooth endoplasmic reticulum & induction of hepatic microsomal enzymes.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1632]**PEER REVIEWED**

Instillation of undiluted CFC-113 produced no significant irritation in the rabbit eye. Topical application of 11,000 mg/kg was required to kill rabbits, but it was not irritating to the skin.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1631]**PEER REVIEWED**

CFC-113 is of low acute oral toxicity; it was necessary to give multiple doses in order to determine an LD50 value of 43 g/kg in male rats. Pulmonary hemorrhage & mottled livers were noted in rats that died; death occurred with in 5 to 24 hr. ... Rabbits appeared more susceptible; two of eight died after three doses of 1 g/kg/day, half the group died after one or four doses.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1631]**PEER REVIEWED**

An Ames bacterial mutagen test was negative.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.603]**PEER

REVIEWED**

Various animal studies (non-human primates and dogs) have indicated that acute exposure to high concn of CFC-113 (as low as 2,000 ppm or 15,400 mg/cu m in a 6 hr exposure period) followed by a large injected dose of epinephrine resulted in cardiac arrhythmias.
[USEPA; Health Assessment Document for 1,1,2-Trichloro-1,2,2-Trifluoroethane p.2 (1983) EPA-600/58-82-002F]**PEER REVIEWED**

Preliminary data from ... a two yr chronic inhalation study in rats indicate no hepatotoxic effects attributable to CFC-113.
[USEPA; Health Assessment Document for 1,1,2-Trichloro-1,2,2-Trifluoroethane p.2 (1983) EPA-600/58-82-002F]**PEER REVIEWED**

... Chlorofluorocarbons could sensitize the canine myocardium to adrenaline, resulting in serious cardiac arrhythmias. /CFCs/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 1300]**PEER REVIEWED**

In most inhalation toxicity studies, CFC-113 caused no adverse effects, even after a 90 day exposure of rats to 155 g/cu m (20,000 ppm) and dogs to 40 g/cu m (5,000 ppm). However, effects in rats after 30 exposures (each of 7 hours) to 40 g/cu m (5,000 ppm) /were reported/.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.66 (1990)]**PEER REVIEWED**

A pad saturated with CFC-113 was applied to an area corresponding to 10% of the body surface for 5 min, twice daily, for 10, 20, or 40 days. No changes occurred in the group exposed to 10 days. Increased vacuolization of liver endoplasmic reticulum was seen after 20 days exposure, which was less pronounced after 40 days, whereas swollen mitrochondria were only found after 20 days exposure.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.73 (1990)]**PEER REVIEWED**

CFC-113 applied to rabbit skin at 5 g/kg per day for 5 days caused gross and histological damage to the skin as well as slight changes in the liver.
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.73 (1990)]**PEER REVIEWED**

Non-Human Toxicity Values:

LD50 Rat oral 43 g/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1698]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Absorption, Distribution & Excretion:

Arterial and venous concn of 3 C2 fluorocarbons were obtained in unanesthetized beagle dogs during and after 10 min of exposures. Blood concn increased rapidly during the 1st 5 min of exposure and more slowly or not at all thereafter. At termination of exposure, fluorocarbon blood concn decreased rapidly at 1st, followed by a more prolonged decline. An arterial-venous difference, observed during and after exposure, suggested a tissue uptake of fluorocarbon. Although a wide range of inspired concn 0.5% fluorocarbon 113, 2.5% fluorocarbon 114, and 15.0% fluorocarbon 115, is needed to produce cardiac sensitization, arterial or venous fluorocarbon concn associated with these sensitizing levels differ only slightly among the cmpds tested: 12.5, 13.8, and 5.8 ug/ml arterial and 4.9, 7.2 and 3.9 ug/ml venous

respectively. Sensitizing blood levels from 25-35 ug/ml arterial and from 18-23 ug/ml venous were reported for C1 fluorocarbons 11 and 12.
[Trochimowicz et al; J Am Ind Hyg Assocc 35 (10): 632-9 (1974)]**PEER REVIEWED**

Human exposure to CFC 113 is predominantly by inhalation and most of it is rapidly cleared from the body by exhalation.
[USEPA; Health Assessment Document for 1,1,2-Trichloro-1,2,2-Trifluoroethane p.2 (1983) EPA-600/58-82-002F]**PEER REVIEWED**

Animal exposure studies indicate that CFC 113 partitions preferentially into lipid-rich tissues and is poorly metabolized. Loss of CFC 113 from all tissues is rapid during post-exposure periods with virtually 100% clearance within 24 hr after cessation of acute exposure.
[USEPA; Health Assessment Document for 1,1,2-Trichloro-1,2,2-Trifluoroethane p.2 (1983) EPA-600/58-82-002F]**PEER REVIEWED**

Human & animal studies indicate rapid excretion of inhaled FC-114. In a study with radiolabeled FC-114, 30 min retention of the dose inhaled in a single breath was 12% versus 23%, 10%, & 20% for comparable doses of FC-11, FC-12, and FC-113, respectively.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.444]**PEER REVIEWED**

... MAIN FACTOR AFFECTING FATE OF FLUOROCARBONS IS BODY FAT, WHERE THEY ARE CONCENTRATED & SLOWLY RELEASED INTO BLOOD @ CONCN THAT SHOULD NOT CAUSE ANY RISK OF CARDIAC SENSITIZATION. /FLUOROCARBONS/
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 781]**PEER REVIEWED**

There is a significant accumulation of fluorocarbons in brain, liver and lung compared to blood levels, signifying a tissue distribution of fluorocarbons similar to that of chloroform.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1203]**PEER REVIEWED**

Abosrption of fluorocarbons is much lower after oral ingestion (35-48 times) than after inhalation. ... The lung generally have the highest fluorocarbon concentrations on autopsy. /Fluorocarbons/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 884]**PEER REVIEWED**

Although fluorocarbons cause cardiac sensitization in certain animal species, rapid elimination prevents the development of cardiotoxic concentrations from aerosol bronchodilator use except at exceedingly high doses (12 to 24 doses in 2 minutes). /Fluorocarbons/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 884]**PEER REVIEWED**

FLUOROCARBON COMPOUNDS ARE LIPID-SOLUBLE AND THUS ARE GENERALLY WELL ABSORBED THROUGH LUNG. ABSORPTION AFTER INGESTION IS 35 TO 48 TIMES LOWER THAN AFTER INHALATION. ... FLUOROCARBONS ARE ELIMINATED BY WAY OF LUNG. /FLUOROCARBON COMPOUNDS/
[National Research Council. Drinking Water and Health. Volume 3. Washington, DC: National Academy Press, 1980. 101]**PEER REVIEWED**

The retention and elimination of 1,1,2-trichloro-1,2,2-trifluoroethane was examined in seven human volunteers by measuring FC 113 in blood and breath during and after a 4 hour inhalation exposure

period. In a pilot study a single volunteer was exposed to a target concentration of 7600 mg/cu m. In the main study two groups of three subjects were exposed to 1900 and 3800 mg/cu m. Low blood/breath ratios were noted which were consistent with the low solubility of FC 113 in the blood. While pulmonary retention during the exposure period was 14%, only 2.6 to 4.3% of the dose was recovered unchanged in breath after the exposure period, suggesting that FC 113 could be metabolized following inhalation. It was suggested that the measurement of end tidal breath concentrations of FC 113 could serve as the basis of a biological monitoring method. If results are normalized to the body fat content of individual workers, as estimated from height and weight measurements, the predictive value of such a measurement would be improved.
[Woollen BH et al; Internat Arch Occupat Environ Health 62 (1): 73-8 (1990)]**PEER REVIEWED**

... >50% of an inspired 7 mg of CFC-113 inhaled as a single dose was exhaled immediately; 19.8% was retained after 30 min. When four men inhaled 500 ppm CFC-113, 6 hr/day for 5 days, only 4 of 20 morning breath samples contained >1 ppm. When these same volunteers inhaled 1000 ppm under the same protocol the following week, 14 of 20 morning samples of exhaled air showed concn >1 ppm. No trend indicative of CFC-113 accumulation in the body could be discerned, & at 2 days after cessation of exposure, only one sample of expired air contained measurable quantities of the compound. Breath-holding trials of inspired CFC-113 found that total excretion in expired air after 1 hr was 63% of the inhaled compound, a value corresponding to an elimination half-time of 17 min. Urinary excretion accounted for <0.01%/ min. Even after exposure at 10,000 ppm, the compound was eliminated entirely within 3 months.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1633]**PEER REVIEWED**

Interactions:

The interaction of **Freon 113** and hypoxia on the heart conduction system was investigated by using the isolated perfused hearts from Wistar rats. The mean preexposure heart rate was 214.8 beats per minute and the mean preexposure atrioventricular conduction time (PQ interval was 42.9 milliseconds. **Freon 113** alone elicited significant change to control levels in heart rate which was enhanced by the coadministration of hypoxia. An enhanced delayed PQ interval was noted following coadministration of **Freon 113** and hypoxia, although significant PQ interval changes were noted with **Freon 113** alone or with hypoxia alone. In the coadministration group, a 2:1 atrioventricular block was elicited in two of four hearts. It was suggested that in occupational deaths among **Freon 113** workers, there may be complex interactions between hypoxia, enhanced cardiac sensitivity to circulating epinephrine, and direct alterations of cardiac muscle cell membrane potentials which result in arrhythmias following **Freon 113** exposures.
[Kawakami T et al; Toxicol Indust Health 6 (3/4): 493-8 (1990)]**PEER REVIEWED**

Pharmacology:

Interactions:

The interaction of **Freon 113** and hypoxia on the heart conduction system was investigated by using the isolated perfused hearts from Wistar rats. The mean preexposure heart rate was 214.8 beats per minute and the mean preexposure atrioventricular conduction time (PQ interval was 42.9 milliseconds. **Freon 113** alone elicited significant change to control levels in heart rate which was enhanced by the coadministration of hypoxia. An enhanced delayed PQ interval was noted following coadministration of **Freon 113** and hypoxia, although significant PQ interval changes were noted with **Freon 113** alone or

with hypoxia alone. In the coadministration group, a 2:1 atrioventricular block was elicited in two of four hearts. It was suggested that in occupational deaths among **Freon 113** workers, there may be complex interactions between hypoxia, enhanced cardiac sensitivity to circulating epinephrine, and direct alterations of cardiac muscle cell membrane potentials which result in arrhythmias following **Freon 113** exposures.
[Kawakami T et al; Toxicol Indust Health 6 (3/4): 493-8 (1990)]**PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

1,1,2-Trichloro-1,2,2-trifluoroethane's former production and use as solvent may have resulted in its release to the environment through various waste streams. Fully halogenated chlorofluorocarbons (CFCs), such as 1,1,2-trichloro-1,2,2-trifluoroethane, were scheduled for production phase-out in 1987 by the Montreal Protocol. Although originally scheduled for 50% production phase-out by the year 2000 in developed countries, the worsening ozone depletion has forced acceleration of the CFC phase-out. If released to air, a vapor pressure of 363 mm Hg at 25 deg C indicates 1,1,2-trichloro-1,2,2-trifluoroethane will exist solely as a vapor in the ambient atmosphere. This compound does not react with photochemically produced hydroxyl radicals, ozone molecules or nitrate radicals in the troposphere. This compound will gradually diffuse into the stratosphere above the ozone layer where it will slowly degrade due to direct photolysis from UV-C radiation and contribute to the catalytic removal of stratospheric ozone. If released to soil, 1,1,2-trichloro-1,2,2-trifluoroethane is expected to have moderate mobility based upon an estimated Koc of 316. Volatilization from moist soil surfaces is expected to be an important fate process based upon a Henry's Law constant of 5.3X10-1 atm-cu m/mole. 1,1,2-Trichloro-1,2,2-trifluoroethane may volatilize from dry soil surfaces based upon its vapor pressure. If released into water, 1,1,2-trichloro-1,2,2-trifluoroethane is expected to adsorb slightly to suspended solids and sediment based upon the estimated Koc. Biodegradation in water is not an important environmental fate process; however, some loss was noted under anoxic groundwater conditions. Volatilization from water surfaces is expected to be an important fate process based upon this compound's Henry's Law constant. Estimated volatilization half-lives for a model river and model lake are 4 hrs and 5 days, respectively. Hydrolysis is not expected to occur due to the lack of hydrolyzable functional groups. A BCF range of 11 to 86 suggests bioconcentration in aquatic organisms is low to moderate. Occupational exposure to 1,1,2-trichloro-1,2,2-trifluoroethane may occur through inhalation and dermal contact with this compound at workplaces where 1,1,2-trichloro-1,2,2-trifluoroethane is produced or used. Due to its long atmospheric residence time, the general population is exposed to 1,1,2-trichloro-1,2,2-trifluoroethane through inhalation of ambient air. Monitoring data indicate that the general population may also be exposed to 1,1,2-trichloro-1,2,2-trifluoroethane via ingestion of contaminated water, and via inhalation and dermal contact with this compound and other consumer products containing 1,1,2-trichloro-1,2,2-trifluoroethane. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

Routes of entry inhalation, ingestion, skin & eye contact.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 889]**PEER REVIEWED**

... 50 workers at the Kennedy Space Center exposed to levels ranging from 46 to 4700 ppm for an overall average duration of 2.77 yr /were examined/. There were no signs or symptoms of adverse effects.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology:

Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3092]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 250,773 workers (79,790 of these are female) are potentially exposed to 1,1,2-trichloro-1,2,2-trifluoroethane in the US(1). Occupational exposure to 1,1,2-trichloro-1,2,2-trifluoroethane may occur through inhalation and dermal contact with this compound at workplaces where it is produced or used. Due to its long atmospheric residence time, the general population is exposed to 1,1,2-trichloro-1,2,2-trifluoroethane through inhalation of ambient air. Monitoring data indicate that the general population may also be exposed to 1,1,2-trichloro-1,2,2-trifluoroethane via ingestion of contaminated water, and via inhalation and dermal contact with this compound and other consumer products containing this compound(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983)]**PEER REVIEWED**

Average Daily Intake:

The average daily in take of 1,1,2-trichloro-1,2,2-trifluoroethane in air, (assume 13-31 parts/trillion(1,2)) is 2.0-4.8 ug/day(SRC).
[(1) Fabian P et al; J Geophys Res 90: 13091-3 (1985) (2) Brodzinsky R, Singh HB; pp. 23-184 in Volatile Organic Chemicals in the Atmosphere: An Assessment of Available Data Menlo Park, CA: SRI International (1982)]**PEER REVIEWED**

Artificial Pollution Sources:

... Common operations in which exposure to 1,1,2-trichloro-1,2,2-trifluoroethane may occur ...: use as selective solvent in degreasing electrical equipment, photographic films, magnetic tapes, precision instruments, plastics, glass, elastomers, or metal components; as dry cleaning solvent for all fabrics, leather, & suedes; use as refrigerant in commercial/industrial air conditioning and industrial process cooling; use as chemical intermediate for dechloronization of chemicals in the mfg of polymers, and copolymers in prodn of high-temp lubricants; use as a foaming or blowing agent in mfg of polymers for flame retardancy; use as a solvent in textile industry; and as a solvent in special lab usage.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

In cleaning and drying operations, two types of solvent losses occur: (1) escape in vapor form and (2) in liquid form when tanks are emptied for cleaning.
[USEPA; Health Assessment Document for 1,1,2-Trichloro-1,2,2-Trifluoroethane p.2 (1983) EPA-600/58-82-002F]**PEER REVIEWED**

1,1,2-Trichloro-1,2,2-trifluoroethane may be released to the environment as emissions from production, storage, transport; from turbine engine exhaust; from use as a foaming agent, refrigerant, and solvent, or use in the manufacture of fluoropolymers(1,2,SRC). 1,1,2-Trichloro-1,2,2-trifluoroethane together with Freon 114, Freon 115, and Freon 13 contain about 3% of the organically bound chlorine present in the atmosphere(2). The global release rate of **Freon 113** is estimated to be 9.1X10+4 tons per year, which corresponds with a 15% annual increase in the abundance of **Freon 113** in the atmosphere(2). This compound may be released to soil from the disposal of products containing this compound(SRC). These products include mobile air conditioners, retail food refrigeration units, and centrifugal and reciprocating chillers(3).
[(1) Graedel TE; Chemical Compounds in the Atmosphere NY: Academic Press p. 327 (1978) (2) Fabian P; pp. 23-51 in The Handbook of Environmetal of Environmental Chemistry, Vol 4/Part A; Hutzinger O ed NY, NY: Springer-Veralg (1986) (3) Clayton GD, Clayton FE eds; pp. 3102-3 in Patty's Industrial Hygiene and Toxicology Vol IIb 3rd ed NY, NY: Wiley and Sons (1981)]**PEER REVIEWED**

1,1,2-Trichloro-1,2,2-trifluoroethane's production and use as a solvent in dry cleaning(1) and circuit board production(2) may result in its release to the environment through various waste streams(SRC). Fully halogenated chlorofluorocarbons (CFCs) such as 1,1,2-trichloro-1,2,2-trifluoroethane were scheduled for production phase-out in 1987 by the Montreal Protocol(3). Although originally scheduled for 50% production phase-out by the year 2000 in developed countries, the worsening ozone depletion has forced acceleration of the CFC phase-out(3).
[(1) Lewis RJ Sr, ed; Hawley's Condensed Chemical Dictionary. 13th ed. NY, NY: John Wiley and Sons, Inc. p. 1127 (1997) (2) Daigle S et al; Ullmann's Encycl Indust Chem. 5th ed. Deerfield Beach, FL: VCH Pub, A9: 290 (1987) (3) Sibley HW; Kirk-Othmer Encycl Chem Technol 4th. NY, NY: Wiley Interscience 21: 128-149 (1997)]**PEER REVIEWED**

Environmental Fate:

Because CFC 113 has very limited solubility in water and is highly volatile, all releases of CFC 113 can be expected to be eventually conveyed to the atmosphere.
[USEPA; Health Assessment Document for 1,1,2-Trichloro-1,2,2-Trifluoroethane p.2 (1983) EPA-600/58-82-002F]**PEER REVIEWED**

ATMOSPHERIC: Because it is essentially inert in the troposphere, CFC 113 is transported slowly to the stratosphere. While CFC 113 has some potential to perturb stratospheric ozone, there is presently no evidence demonstrating that any indirect effects of CFC 113 on human health has or is likely to occur as a result of ozone perturbation.
[USEPA; Health Assessment Document for 1,1,2-Trichloro-1,2,2-Trifluoroethane p.2 (1983) EPA-600/58-82-002F]**PEER REVIEWED**

TERRESTRIAL FATE: Based on a classification scheme(1), an estimated Koc value of an 316(2) indicates that 1,1,2-trichloro-1,2,2-trifluoroethane is expected to have moderate mobility in soil(SRC). Volatilization of 1,1,2-trichloro-1,2,2-trifluoroethane from moist soil surfaces is expected to be an important fate process(SRC) given an estimated Henry's Law constant of 5.26X10-1 atm-cu m/mole(SRC), based upon its vapor pressure, 363 mm Hg(3), and water solubility, 170 mg/l(4). The potential for volatilization of 1,1,2-trichloro-1,2,2-trifluoroethane from dry soil surfaces may exist(SRC) based upon its vapor pressure(3). 1,1,2-Trichloro-1,2,2-trifluoroethane was degraded under anaerobic landfill conditions using an anoxic landfill leachate microcosm(2), suggesting this compound may biodegrade in soils under anaerobic conditions(SRC).
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Jackson RE et al; pp. 511-26 in Environ Sci Pollut Control Ser 4(Groundwater Contam Anal Haz Waste Sites). Lesage S, Jackson RE, eds. NY, NY: M Dekker (1992) (3) Boublik T et al; The Vapour Pressures of Pure Substances. 2nd Rev Ed, Amsterdam: Elsevier p. 74 (1984) (4) Horvath AL et al; J Phys Chem Ref Data 28: 395-507 (1999)]**PEER REVIEWED**

AQUATIC FATE: Based on a classification scheme(1), an estimated Koc value of 316(2) indicates that 1,1,2-trichloro-1,2,2-trifluoroethane is not expected to adsorb to suspended solids and sediment(SRC). Volatilization from water surfaces is expected(4) based upon an estimated Henry's Law constant of 5.26X10-1 atm-cu m/mole(SRC), based upon its vapor pressure, 363 mm Hg(3), and water solubility, 170 mg/l(5). Using this Henry's Law constant and an estimation method(5), volatilization half-lives for a model river and model lake are 4 hrs and 5 days, respectively(SRC). According to a classification scheme(6), BCFs of 11-86(7) suggest the potential for bioconcentration in aquatic organisms is low to moderate. The compound is non-biodegradable under aerobic conditions(7), however biodegradation was observed in anoxic groundwater studies(8).
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Jackson RE et al; pp. 511-26 in Environ Sci Pollut Control Ser 4(Groundwater Contam Anal Haz Waste Sites). Lesage S, Jackson RE, eds. NY, NY: M Dekker (1992) (3) Boublik T et al; The Vapour Pressures of Pure Substances. 2nd Rev Ed, Amsterdam: Elsevier p. 74 (1984) (4) Horvath AL et al; J Phys Chem Ref Data 28: 395-507 (1999) (5) Lyman WJ et al; Handbook of Chemical

Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9, 15-1 to 15-29 (1990) (6) Franke C et al; Chemosphere 29: 1501-14 (1994) (7) Chemicals Inspection and Testing Institute; Biodegradation and bioaccumulation data of existing chemicals based on the CSCL Japan. Japan Chemical Industry Ecology - Toxicology and Information Center. ISBN 4-89074-101-1 p. 2-22 (1992) (8) Semprini L et al; Environ Sci Technol 26: 2454-61 (1992)]**PEER REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), 1,1,2-trichloro-1,2,2-trifluoroethane, which has a vapor pressure of 363 mm Hg at 25 deg C(2), is expected to exist solely as a vapor in the ambient atmosphere. The moderate water solubility of 170 mg/l suggests that some loss by wet deposition occurs, but any loss by this mechanism is probably returned to the atmosphere by volatilization.
1,1,2-Trichloro-1,2,2-trifluoroethane will not degrade in the troposphere, thus diffusion from the troposphere to the stratosphere would be the sole removal mechanism (half-life 20 years(4)). This compound will gradually diffuse into the stratosphere above the ozone layer where it will slowly degrade due to direct photolysis from UV-C radiation and contribute to the catalytic removal of stratospheric ozone. The stratospheric lifetime of this compound ranges between 63 and 122 years(5). As a result of this persistence in the atmosphere(5), this vapor-phase compound can be transported long distances and therefore, its concn should be fairly uniform throughout the globe away from known sources(SRC).
[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Boublik T et al; The Vapour Pressures of Pure Substances. 2nd Rev Ed, Amsterdam: Elsevier p. 74 (1984) (3) Horvath AL et al; J Phys Chem Ref Data 28: 395-507 (1999) (4) Dilling WL; pp. 154-97 in Environmental Risk Analysis for Chemicals. Conway RA, ed. NY, NY: Van Nostrand Reinhold Co (1982) (5) Chou CC et al; J Phys Chem 82: 1-7 (1978)]**PEER REVIEWED**

Environmental Biodegradation:

AEROBIC: 1,1,2-Trichloro-1,2,2-trifluoroethane, present at 100 mg/l, reached 0-5% of its theoretical BOD in 4 weeks using an activated sludge inoculum at 30 mg/l and the Japanese MITI test(1). Therefore this compound is not expected to biodegrade rapidly.
[(1) Chemicals Inspection and Testing Institute; Biodegradation and bioaccumulation data of existing chemicals based on the CSCL Japan. Japan Chemical Industry Ecology - Toxicology and Information Center. ISBN 4-89074-101-1 p. 2-22 (1992)]**PEER REVIEWED**

ANAEROBIC: Using a 1,1,1-trichloroethane, CFC-11, and 1,1,2-trichloro-1,2,2-trifluoroethane contaminated shallow sand and gravel aquifer at the Moffett Field Naval Air Station in Mountain View, CA, an average 1,1,2-trichloro-1,2,2-trifluoroethane concn of 0.0062 mg/l was 8, 20 , and 18% transformed along 3 well sampling sites for the period between 1450 and 1550 hrs after commencing biostimulation through the addition of acetate(1). This compound appears to be persistent in groundwater but biotransforms to a very toxic vinyl chloride analogue(2). The half-life of 1,1,2-trichloro-1,2,2-trifluoroethane in an anoxic landfill leachate microcosm study was 5.3 days at 21 deg C(2).
[(1) Semprini L et al; Environ Sci Technol 26: 2454-61 (1992) (2) Jackson RE et al; pp. 511-26 in Environ Sci Pollut Control Ser 4(Groundwater Contam Anal Haz Waste Sites). Lesage S, Jackson RE, eds. NY, NY: M Dekker (1992)]**PEER REVIEWED**

Environmental Abiotic Degradation:

1,1,2-Trichloro-1,2,2-trifluoroethane is not expected to undergo hydrolysis in the environment due to the lack of hydrolyzable functional groups(1,2). 1,1,2-Trichloro-1,2,2-trifluoroethane is essentially inert to reaction with photochemically generated radicals and ozone molecules(3,4). This compound will not undergo direct photolysis in the troposphere(5). The stratospheric lifetime of 1,1,2-trichloro-1,2,2-trifluoroethane has been estimated to range from 63 and 122 years with direct

photolysis being the dominant removal mechanism and reaction with singlet oxygen being the secondary removal mechanism(6). In the stratosphere this compound will slowly photolyze to release chlorine atoms which in turn participates in the catalytic removal of stratospheric ozone(5). The infrared intensity for 1,1,2-trichloro-1,2,2-trifluoroethane is 4,905 sq cm/atm, which, in combination with its long atmospheric lifetime(6), contribute to its greenhouse potential(7). 1,1,2-Trichloro-1,2,2-trifluoroethane has a GWP (greenhouse warming potential) of 1.24(8).
[(1) Du Pont de Nemours Co; Freon Products Information B-2; A98825 12/80 (1980) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 7- 4, 7-5 (1990) (3) Atkinson R; Chem Rev 85: 69-201 (1985) (4) GEMS; Graphical Exposure Modeling System. FAP Fate of Atmos Pollut (1986) (5) Makide T et al; Chem Lett 4: 355-8 (1979) (6) Chou CC et al; J Phys Chem 82: 1-7 (1978) (7) Rogers JD, Stephens RD; J Geophys Res 93: 2423-8 (1988) (8) Montague DC, Perrine RL; Atmos Environ 24A: 1331-9 (1990)]**PEER REVIEWED**

Environmental Bioconcentration:

BCFs of 11-33 and 14-86 were measured for 1,1,2-trichloro-1,2,2-trifluoroethane at concns of 0.198 and 0.0198 mg/l, respectively(1). According to a classification scheme(2), these BCF values suggest the potential for bioconcentration in aquatic organisms is low to moderate.
[(1) Chemicals Inspection and Testing Institute; Biodegradation and bioaccumulation data of existing chemicals based on the CSCL Japan. Japan Chemical Industry Ecology - Toxicology and Information Center. ISBN 4-89074-101-1 p. 2-22 (1992) (2) Franke C et al; Chemosphere 29: 1501-14 (1994)]**PEER REVIEWED**

Soil Adsorption/Mobility:

The Koc of 1,1,2-trichloro-1,2,2-trifluoroethane has been estimated as 316(1). According to a classification scheme(2), this estimated Koc value suggests that 1,1,2-trichloro-1,2,2-trifluoroethane is expected to have moderate mobility in soil. Because of its density in both the liquid and vapor phases, 1.565 and 4.46 respectively, 1,1,2-trichloro-1,2,2-trifluoroethane sinks rapidly through soils to the water table(1).
[(1) Jackson RE et al; pp. 511-26 in Environ Sci Pollut Control Ser 4(Groundwater Contam Anal Haz Waste Sites). Lesage S, Jackson RE, eds. NY, NY: M Dekker (1992) (2) Swann RL et al; Res Rev 85: 17-28 (1983)]**PEER REVIEWED**

Volatilization from Water/Soil:

The Henry's Law constant for 1,1,2-trichloro-1,2,2-trifluoroethane is estimated as 5.3X10-1 atm-cu m/mole(SRC) based upon its vapor pressure, 363 mm Hg(1), and water solubility, 170 mg/l(2). This Henry's Law constant indicates that 1,1,2-trichloro-1,2,2-trifluoroethane is expected to volatilize rapidly from water surfaces(3). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec)(3) is estimated as 4 hours(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(3) is estimated as 5 days(SRC). Half-lives in ponds, lakes, and rivers were estimated at 10.3-4.9, 11.4-3.8, and 11.4-0.1 days, respectively, using an estimated transfer rate of 12.2 cm/h(4).
1,1,2-Trichloro-1,2,2-trifluoroethane's Henry's Law constant(1,2) indicates that volatilization from moist soil surfaces may occur(SRC). The potential for volatilization of 1,1,2-trichloro-1,2,2-trifluoroethane from dry soil surfaces may exist(SRC) based upon its vapor pressure(1).
[(1) Boublik T et al; The Vapour Pressures of Pure Substances. 2nd Rev Ed, Amsterdam: Elsevier p. 74 (1984) (2) Horvath AL et al; J Phys Chem Ref Data 28: 395-507 (1999) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (4) Okouchi S; Environ Inter 18: 389-96 (1992)]**PEER REVIEWED**

Environmental Water Concentrations:

GROUNDWATER: Because of its density in both the liquid and vapor phases, 1,1,2-trichloro-1,2,2-trifluoroethane rapidly sinks through soils, penetrates the water table, and pools on low permeability units(3). 1,1,2-Trichloro-1,2,2-trifluoroethane was detected in a small percentage of 2948 groundwater samples collected from the continuous United States between 1985 and 1995 at a concn ranging from 0.4 to 10 ug/l, median 0.5 ug.l in 3.1% of 406 wells in urban areas, and at a median concn of 0.2 ug.l in 0.1% of 2,542 wells in rural areas(1). Trace amounts were detected in 6.3% of 320 groundwater samples in Kanagawa Prefecture, Japan, concns ranging from 0.0001-0.19 mg/l(2). 1,1,2-Trichloro-1,2,2-trifluoroethane was detected in samples from two monitoring wells in the Gloucester landfill in Ottawa, Ontario, Canada at concns of 2725 and 200 ug/l, and 903 and 234 ug/l in 1988 and 1989, respectively(3).
[(1) Squillace PJ et al; Environ Sci Technol 33: 4176-87 (1999) (2) Itoh S et al; Kanagawa-ken Eisei Kenkyusho Kenkyu Hokoku (19): 44-6 (1989) (3) Jackson RE et al; pp. 511-26 in Environ Sci Pollut Control Ser 4(Groundwater Contam Anal Haz Waste Sites). Lesage S, Jackson RE, eds. NY, NY: M Dekker (1992)]**PEER REVIEWED**

SURFACE WATER: 1,1,2-Trichloro-1,2,2-trifluoroethane was detected in water samples taken from the Niagara River and Cayuhoga River(1); it was not detected in water samples taken from Lake Ontario(1). 1,1,2-Trichloro-1,2,2-trifluoroethane was detected, not quantified in Antarctic surface seawater samples collected from October to mid-December, 1987(2). The concns of dissolved 1,1,2-trichloro-1,2,2-trifluoroethane in seawater from the northeast Atlantic Ocean, above the Porcupine Abyssal Plain, on February 5, 1991 were 2.8 pMol/l at 0 db pressure, 1.5 pMol/l at 100 db, and 0.2 pMol/l at 1500 db(3).
[(1) Great Lakes Water Quality Board; in An Inventory of Chemical Substances Identified in the Great Lakes Ecosystem Vol.1-Summary Windsor, Ontario: Great Lakes Quality Board (1983) (2) Reifenhauser W, Heumann KG; Chemospere 24: 1293-300 (1992) (3) Haine TWN et al; J Geophys Res 100: 10,745-53 (1995)]**PEER REVIEWED**

Effluent Concentrations:

The annual emissions of 1,1,2-trichloro-1,2,2-trifluoroethane were estimated at 100 million kg/yr, increasing exponentially at 5% per year from 1981 through 1988(1). Of the total evaporative losses of 1,1,2-trichloro-1,2,2-trifluoroethane from cleaning and electronic maintenance operations at the Newark AFB, Ohio, 73% was from spraying/flushing booths, 21% was from ultrasonic cleaners, 4.3% from degreasers, and 1.7% from brushing/wiping and miscellaneous(2). 1,1,2-Trichloro-1,2,2-trifluoroethane concns in samples from six municipal solid waste landfills in Hamburg, Germany ranged from not detected to 0.01 mg/kg(3). The range in landfill gas from seven U.K. municipal waste disposal sites was <0.5 to 74 mg/cu m(4).
[(1) Khalil MAK, Rasmussen RA; Chem Geol 70: 99 (1988) (2) Brewer PJ et al; Solvent chemical inventory of the Newark AFB Building 4 facility. Mountain View, CA: Acurex Corp. AFESC/ESL-TR-90-31, NTIS AD-A242320 pp. 44 (1990) (3) Deipser A, Stegmann R; Waste Manage Res 12: 129-39 (1994) (4) Allen MR et al; Environ Sci Technol 31: 1054-61 (1997)]**PEER REVIEWED**

Atmospheric Concentrations:

The World Meteorological Organization ... reported a current global annual emissions rate of about 91,000 metric tons.
[USEPA; Health Assessment Document for 1,1,2-Trichloro-1,2,2-Trifluoroethane p.2 (1983) EPA-600/58-82-002F]**PEER REVIEWED**

The World Meteorological Organization reported that ambient air levels are in the range of 12 to 25 parts/trillion in the northern hemisphere and 11 to 22 parts/trillion in the southern hemisphere. Based on measurements made in the USA, CFC-113 background levels are generally less than 20 parts/trillion.

[USEPA; Health Assessment Document for 1,1,2-Trichloro-1,2,2-Trifluoroethane p.2 (1983) EPA-600/58-82-002F]**PEER REVIEWED**

The global growth rate of 1,1,2-trichloro-1,2,2-trifluoroethane is estimated to have averaged 3.1 parts/trillion/year from 1991 through 1993(1).
[(1) Reifenhauser W, Heumann KG; Chemospere 24: 1293-300 (1992)]**PEER REVIEWED**

URBAN/SUBURBAN: 1,1,2-Trichloro-1,2,2-trifluoroethane was detected in air samples collected throughout the U.S. between 1973 and 1980: rural/remote locations, 284 data points, median concn 31 parts/trillion, mean concn 28 parts/trillion; urban/suburban areas, 851 data points, median concn 170 parts/trillion, mean concn 220 parts/trillion(1). It was detected in "clean air" samples collected in central California May 1975, avg concn 19.9 parts/trillion(2), and in air samples collected in the San Francisco area during winter 1975, 274 samples, 100% pos., avg concn 16.9 parts/trillion(3). Samples from Downey, CA (February 1984), Houston, TX (March 1984), Denver, CO (March 1984), San Jose, CA (April 1985, August 1985, and Decemeber 1985) contained mean concns of 118, 58, 41, 1256, 616, and 1211 parts per trillion, respectively(6). In a study conducted in the Aichi prefecture, Japan, it was concluded that chlorofluorocarbon concns were generally higher in urban areas with more precision machine or metalworking industries than in rural areas(4). Air concns of 1,1,2-trichloro-1,2,2-trifluoroethane in samples from Teipei, Taiwan were uniform and close to background levels 90 and 85 parts/trillion volume, respectively, suggesting emissions were of little importance(5).
[(1) Brodzinsky R, Singh HB; p. 23, 184 in Volatile Organic Chemicals in the Atmosphere: An Assessment of Available Data Menlo Park, CA: SRI International (1982) (2) Singh HB et al; Atmos Environ 11: 819-28 (1977) (3) Singh HB et al; J Air Pollut Control Assoc 27: 332-6 (1977) (4) Otsuka H et al; Aichi-ken Kogai Chosa Senta Shoho 19: 10-7 (1991) (5) Wang JL et al; Chemosphere 36: 2391-400 (1998) (6) Singh HB et al; Atmos Environ 26A: 2929-46 (1992)]**PEER REVIEWED**

RURAL/REMOTE: During 1978, the average concn of 1,1,2-trichloro-1,2,2-trifluoroethane in ambient air in the Northern and Southern hemispheres was 13 and 12 parts per trillion, respectively(1). Samples from the Aichi Prefecture, Japan sampled monthly from October 1990 to March 1991 had a mean concn of 0.14 ppb. This is 5 times greater than the tropospheric background concn for the northern hemisphere(2). 1,1,2-Trichloro-1,2,2-trifluoroethane surface level atmospheric concns in the mid-lattitude northern hemisphere in Hokkaido, Japan for the period of 1979-1991 has slowly risen from 100 parts per trillion volume in 1979 to 150 parts per trillion volume in 1991(3). Concns in Anarctica during the same time period, while lower, showed the same linear increase(3). The average global tropospheric concn of 1,1,2-trichloro-1,2,2-trifluoroethane was estimated at 70 parts per trillion volume in 1990(3). Mean concn from July 1984 to June 1989 at Cape Meares, OR; Ragged Point, Barbados; Cape Matatulaa, Samoa; Cape Grim, Tasmania; and archived air, Cape Grin were 53.1; 48.8; 46.2; 44.2; and 44.2 parts per trillion, respectively(4). Mean concns from July 1989 to June 1994 at Mace Head, Ireland; Ragged Point, Barbados; Cape Grim, Tasmania; and archived air, Cape Grim were 80.3; 78.5; 72.8; and 72.9 parts per trillion, respectively(4). 1,1,2-Trichloro-1,2,2-trifluoroethane was detected, not quantified in Antarctic marine air samples collected from October to mid-December, 1987(5). The compound was detected, not quantified in air samples from the forest at Eggegebirge in North Rhine-Westfalia, Germany(6). Atmospheric concns were 0 and 0.07 ppb volume in 1960 and 1990, respectively(7). Stratospheric air sample analysis showed an average 1882 through 1984 midlatitude concn of 23 parts per trillion volume at the tropopause to 1 part per trillion at 32 km(8).
[(1) Fabian P et al; J Geophys Res 90: 13091-3 (1985) (2) Otsuka H et al; Aichi-ken Kogai Chosa Senta Shoho 19: 10-7 (1991) (3) Tominaga T; Pure Appl Chem 64: 529-536 (1992) (4) Fraser P et al; J Geophys Res 101: 12585-99 (1996) (5) Reifenhauser W, Heumann KG; Chemospere 24: 1293-300 (1992) (6) Helmig D et al; Chemopshere 19: 1399-412 (1989) (7) McCarty PL, Reinhard M; pp. 839-52 in The biogeochemistry of global change: radiative trace gases. Oremland RS, ed. NY, NY: Chapman Hall (1993) (8) Borchers R et al; Planet Space Sci 35: 657-63 (1987)]**PEER REVIEWED**

SOURCE DOMINATED: 1,1,2-Trichloro-1,2,2-trifluoroethane was detected between 1978 to 1982 in factory samples collected from various industries in Germany at a 1.5% detection frequency(1).
[(1) Lehmann E et al; pp. 31-41 in Safety Health Aspects Org Solvents. Riihimake V, Ulfvarson U, eds. NY, NY: Alan R Liss, Inc (1986)]**PEER REVIEWED**

Other Environmental Concentrations:

Average 1,1,2-trichloro-1,2,2-trifluoroethane concns are as follows (%hit, concn % w/w, class): 1.8, 0.1, automotive products; 1.8, 49.7, household cleaners; 1.9, 2.4, paint-related products; 4.4, 1.7, fabric and leather treatments; 20.3, 57.3 cleaners for electronic equipment; 5.4, 1.0, oils, greases, and lubricants; 2.6, 0.2, adhesive-related products; 7.0, 79.5, miscellaneous products(1).
[(1) Sack TM et al; Atmos Environ 26A: 1063-70 (1992)]**PEER REVIEWED**

Environmental Standards & Regulations:

TSCA Requirements:

Pursuant to section 8(d) of TSCA, EPA promulgated a model Health and Safety Data Reporting Rule. The section 8(d) model rule requires manufacturers, importers, and processors of listed chemical substances and mixtures to submit to EPA copies and lists of unpublished health and safety studies. 1,1,2-Trichloro-1,2,2-trifluoroethane is included on this list.
[40 CFR 716.120 (7/1/2000)]**PEER REVIEWED**

CERCLA Reportable Quantities:

Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 5000 lb or 2270 kg. The toll free number of the NRC is (800) 424-8802; In the Washington D.C. metropolitan area (202) 426-2675. The rule for determining when notification is required is stated in 40 CFR 302.4 (section IV. D.3.b).
[40 CFR 302.4 (7/1/2000)]**PEER REVIEWED**

RCRA Requirements:

F002; When 1,1,2-trichloro-1,2,2-trifluoroethane is a spent halogenated solvent, it is classified as a hazardous waste from a nonspecific source (F002), as stated in 40 CFR 261.31, and must be managed according to state and/or federal hazardous waste regulations.
[40 CFR 261.31 (7/1/2000)]**PEER REVIEWED**

Atmospheric Standards:

This action promulgates standards of performance for equipment leaks of Volatile Organic Compounds (VOC) in the Synthetic Organic Chemical Manufacturing Industry (SOCMI). The intended effect of these standards is to require all newly constructed, modified, and reconstructed SOCMI process units to use the best demonstrated system of continuous emission reduction for equipment leaks of VOC, considering costs, non air quality health and environmental impact and energy requirements. 1,1,2-Trichloro-1,2,2,-trifluoroethane is produced, as an intermediate or a final product, by process units covered under this subpart.
[40 CFR 60.489 (7/1/2000)]**PEER REVIEWED**

State Drinking Water Standards:

(CA) CALIFORNIA 1200 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

State Drinking Water Guidelines:

(FL) FLORIDA 500,000 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(MA) MASSACHUSETTS 210000 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(MI) MICHIGAN 190,000 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(MN) MINNESOTA 200000 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

C2-Cl3-F3
PEER REVIEWED

Molecular Weight:

187.38
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-157]**PEER REVIEWED**

Color/Form:

Colorless gas
[Sax, N.I. Dangerous Properties of Industrial Materials. Vol 1-3 7th ed. New York, NY: Van Nostrand Reinhold, 1989. 1775]**PEER REVIEWED**

Volatile liquid
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1127]**PEER REVIEWED**

Colorless to water-white liquid ... [Note: A gas above 118 degrees F].
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 316]**PEER REVIEWED**

Clear, dense, colorless liquid
[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed.Vol

A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present.,p. VA9 (87) 290]**PEER REVIEWED**

Odor:

Nearly odorless
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1127]**PEER REVIEWED**

Odor like carbon tetrachloride at high concentrations
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 888]**PEER REVIEWED**

Faint solvent odor
[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed.Vol A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present.,p. VA9 (87) 290]**PEER REVIEWED**

Boiling Point:

47.7 deg C
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-157]**PEER REVIEWED**

Melting Point:

-35 deg C
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-157]**PEER REVIEWED**

Corrosivity:

... 1,1,2-Trichloro-1,2,2-trifluoroethane will attack some forms of plastics, rubber, & coatings.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Critical Temperature & Pressure:

Critical temperature: 214.3 deg C; critical pressure: 3.42 MPa
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 6-49]**PEER REVIEWED**

Density/Specific Gravity:

1.5635 @ 25 deg C/4 deg C
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-157]**PEER REVIEWED**

Heat of Vaporization:

28.4 kJ/mol @ 25 deg C
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 6-104]**PEER REVIEWED**

Octanol/Water Partition Coefficient:

log Kow= 3.16
[Hansch, C., Leo, A., D. Hoekman. Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. Washington, DC: American Chemical Society., 1995. 3]**PEER REVIEWED**

Solubilities:

Soluble in ethanol. Miscible in ethyl ether and benzene.
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-157]**PEER REVIEWED**

In water, 170 mg/l @ 25 deg C
[Horvath AL et al; J Phys Chem Ref Data 28: 395-507 (1999)]**PEER REVIEWED**

Spectral Properties:

Index of refraction: 1.3557 @ 25 deg C/D
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-157]**PEER REVIEWED**

SADTLER REF NUMBER: 23717 (IR, PRISM); 10998 (IR, GRATING)
[Weast, R.C. (ed.). Handbook of Chemistry and Physics. 60th ed. Boca Raton, Florida: CRC Press Inc., 1979.,p. C-294]**PEER REVIEWED**

UV absorbance, maxima: 1.00 at 231 nm; 0.20 at 240 nm; 0.01 at 260-400 nm. /Photrex reagent, 1.00 cm path vs distilled water/
[JT Baker Chemical Co; Reagents and Laboratory Products Catalog 860C p.143 (1986)]**PEER REVIEWED**

IR: 1925 (Coblentz Society Spectral Collection)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 607]**PEER REVIEWED**

MASS: 1277 (Atlas of Mass Spectral Data, John Wiley & Sons, New York)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 607]**PEER REVIEWED**

Surface Tension:

0.0196 N/m @ 20 deg C
[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed.Vol A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present.,p. VA9 (87) 51]**PEER REVIEWED**

Vapor Density:

6.5 (Air= 1)
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Vapor Pressure:

363 mm Hg @ 25 deg C
[Boublik, T., Fried, V., and Hala, E., The Vapour Pressures of Pure Substances.

Second Revised Edition. Amsterdam: Elsevier, 1984. 74]**PEER REVIEWED**

Relative Evaporation Rate:

>1 (Butyl acetate= 1)
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

1.3 (Ether= 1)
[Flick, E.W. Industrial Solvents Handbook. 3rd ed. Park Ridge, NJ: Noyes Publications, 1985. 87]**PEER REVIEWED**

170 (CCl4= 100)
[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed.Vol A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present.,p. VA9 (87) 51]**PEER REVIEWED**

Viscosity:

0.497 mPa.s @ 48.9 deg C (liq); 0.0108 mPa.s @ 49 deg C (gas)
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V11 (94) 512]**PEER REVIEWED**

Other Chemical/Physical Properties:

Dielectric constant at 60 Hz= 2.41
[Flick, E.W. Industrial Solvents Handbook. 3rd ed. Park Ridge, NJ: Noyes Publications, 1985. 87]**PEER REVIEWED**

Volume resistivity= 1x10+16 ohm/cm
[Flick, E.W. Industrial Solvents Handbook. 3rd ed. Park Ridge, NJ: Noyes Publications, 1985. 87]**PEER REVIEWED**

Critical volume= 325 cu cm/mol; critical density= 0.576 g/cu m; density of saturated vapor at boiling point= 7.38 g/l: solubility of water in **freon 113 @** 25 deg C= 0.011 (wt%)
[Lide, D.R. (ed). CRC Handbook of Chemistry and Physics. 72nd ed. Boca Raton, FL: CRC Press, 1991-1992.,p. 6-172]**PEER REVIEWED**

Ozone Depleting Potential: 0.8
[Environmental Defense Fund; Environmental Defense Scorecard on 1,1,2-trichloro-1,2,2-trifluoroethane (76-13-1). Available from the Database Query page at http://www.scorecard.org/chemical-profiles/ as of July 27, 2000.]**PEER REVIEWED**

GWP (greenhouse warming potential) = 1.24
[Montague DC, Perrine RL; Atmos Environ 24A: 1331-9 (1990)]**PEER REVIEWED**

Chemical Safety & Handling:

Odor Threshold:

Odor detection in air: 4.5x10+1 ppm; odor recognition in air: 6.8x10+1 ppm /Purities not specified/
[Fazzalari, F.A. (ed.). Compilation of Odor and Taste Threshold Values Data. ASTM Data Series DS 48A (Committee E-18). Philadelphia, PA: American Society for Testing and Materials, 1978. 159]**PEER REVIEWED**

Low: 342 mg/cu m; High: 1026 mg/cu m /From table/
[Ruth JH; Am Ind Hyg Assoc J 47: A-142-51 (1986)]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

... May cause irritation of eyes & throat. ... 1,1,2-Trichloro-1,2,2-trifluoroethane on prolonged or repeated contact with skin may cause skin irritation.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Fire Potential:

Not combustible.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

COMBUSTIBLE WHEN EXPOSED TO HEAT OR FLAME.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 1698]**PEER REVIEWED**

Fire Fighting Procedures:

/During fire fighting wear/ self-contained breathing apparatus with full facepiece operated in pressure-demand or other positive pressure mode.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.4]**PEER REVIEWED**

Toxic Combustion Products:

ALL FLUOROCARBONS WILL UNDERGO THERMAL DECOMPOSITION WHEN EXPOSED TO FLAME OR RED-HOT METAL. DECOMPOSITION PRODUCTS OF THE CHLOROFLUOROCARBONS WILL INCLUDE HYDROFLUORIC & HYDROCHLORIC ACID ALONG WITH SMALLER AMOUNTS OF PHOSGENE & CARBONYL FLUORIDE. THE LAST COMPOUND IS VERY UNSTABLE TO HYDROLYSIS & QUICKLY CHANGES TO HYDROFLUORIC ACID & CARBON DIOXIDE IN THE PRESENCE OF MOISTURE. /FLUOROCARBONS/
[International Labour Office. Encyclopaedia of Occupational Health and Safety. 4th edition, Volumes 1-4 1998. Geneva, Switzerland: International Labour Office, 1998.,p. 104.185]**PEER REVIEWED**

IN CONTACT WITH OPEN FLAME OR VERY HOT SURFACE FLUOROCARBONS MAY DECOMP INTO HIGHLY IRRITANT & TOXIC GASES: CHLORINE, HYDROGEN FLUORIDE OR CHLORIDE, & EVEN PHOSGENE. /FLUOROCARBON REFRIGERANT & PROPELLANTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-159]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

Reacts with chemically active metals such as calcium, powdered aluminum, zinc, magnesium, & beryllium. Contact with magnesium alloys containing more than 2% magnesium may cause

decomposition.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Mixtures /of aluminum/ with fluorotrichloroethane and with **trichlorotrifluoroethane** will flash or spark on heavy impact.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 25]**PEER REVIEWED**

Finely divided barium, slurried with **trichlorotrifluoroethane**, exploded during transfer owing to frictional initiation. Granular barium in contact with ... 1,1,2-**trichlorotrifluoroethane** ... is susceptible to detonation.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 78]**PEER REVIEWED**

Mixtures of lithium shavings and several halocarbons are impact sensitive and will explode, sometimes violently. Such materials include: ... 1,1,2-**trichlorotrifluoroethane**. ...
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1315]**PEER REVIEWED**

Mixture of powdered titanium and trichloroethylene or 1,1,2-**trichlorotrifluoroethane** flash or spark under heavy impact.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1464]**PEER REVIEWED**

When two drops of **trichlorotrifluoroethane** were added to a sodium-potassium alloy (NaK), there was a violent explosion.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-184]**PEER REVIEWED**

DANGEROUS ... ON CONTACT WITH ACIDS OR ACID FUMES THEY EVOLVE HIGHLY TOXIC CHLORIDE FUMES. /CHLORIDES/
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 715]**PEER REVIEWED**

Chemically-active metals such as calcium, powdered aluminum, zinc, magnesium & beryllium [Note: Decomposes if in contact with alloys containing >2% magnesium].
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 316]**PEER REVIEWED**

Hazardous Decomposition:

... WHEN DECOMP, EMITS HIGHLY TOXIC FUMES OF FLUORIDES AND CHLORIDES.
[Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984. 1034]**PEER REVIEWED**

Toxic gases & vapors (such as hydrogen chloride, hydrogen fluoride, phosgene, carbon monoxide) may be released when 1,1,2-trichloro-1,1,2-trifluoroethane decomposes.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

APPEARANCE OF TOXIC DECOMP PRODUCTS SERVES AS WARNING OF OCCURRENCE OF THERMAL DECOMP & DETECTION OF SHARP ACRID ODOR WARNS OF PRESENCE ... .

[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3101]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

2000 ppm
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

Protective Equipment & Clothing:

Employees should be provided with and required to use impervious clothing, gloves, face-shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact. Employees should be provided with and required to use splash-proof goggles where there is any possibility of liquid 1,1,2-trichloro-1,2,2-trifluoroethane contacting the eyes.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Wear appropriate personal protective clothing to prevent skin contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

Recommendations for respirator selection. Max concn for use: 2000 ppm. Respirator Class(es): Any supplied-air respirator. Any self-contained breathing apparatus with a full facepiece.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Emergency or planned entry into unknown concn or IDLH conditions: Respirator Class(es): Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode. Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Escape from suddenly occurring respiratory hazards: Respirator Class(es): Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister. Any appropriate escape-type, self-contained breathing apparatus.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

Preventive Measures:

Workers should wash immediately when skin becomes contaminated.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health. In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Non-impervious clothing which becomes contaminated with liquid 1,1,2-trichloro-1,2,2-trifluoroethane should be removed immediately and not reworn until it is removed from the clothing.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Skin that becomes contaminated with liquid 1,1,2-trichloro-1,2,2-trifluoroethane should be immediately washed or showered with soap or mild detergent and water.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

APPEARANCE OF TOXIC DECOMP PRODUCTS SERVES AS WARNING OF OCCURRENCE OF THERMAL DECOMP & DETECTION OF SHARP ACRID ODOR WARNS OF PRESENCE ... . ADEQUATE VENTILATION ALSO AVOIDS PROBLEM OF TOXIC DECOMPOSITION PRODUCTS.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3101]**PEER REVIEWED**

Contact lenses should not be worn when working with this chemical.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

SRP: The scientific literature for the use of contact lenses in industry is conflicting. The benefit or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In any event, the usual eye protection equipment should be worn even when contact lenses are in place.
PEER REVIEWED

SRP: Contaminated protective clothing should be segregated in such a manner so that there is no direct personal contact by personnel who handle, dispose, or clean the clothing. Quality assurance to ascertain the completeness of the cleaning procedures should be implemented before the decontaminated protective clothing is returned for reuse by the workers. Contaminated clothing should not be taken home at end of shift, but should remain at employee's place of work for cleaning.
PEER REVIEWED

Enclosure of process materials and isolation of reaction vessels and proper design and operation of filling heads for packaging and shipping /are administrative controls that may be instituted to limit occupational exposure to fluorocarbons during manufacture, packaging, and use/. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology.

Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

SUFFICIENT EXHAUST & GENERAL VENTILATION SHOULD BE PROVIDED TO KEEP VAPOR CONCN BELOW RECOMMENDED LEVELS. /FLUOROCARBONS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 897]**PEER REVIEWED**

Inhalation of fluorocarbon vapors should be avoided. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Many of the fluorocarbons are good solvents of skin oil, so protective ointment should be used. /Fluorocarbons/
[Zenz, C. Occupational Medicine-Principles and Practical Applications. 2nd ed. St. Louis, MO: Mosby-Yearbook, Inc, 1988. 544]**PEER REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed and replaced.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

Cleanup Methods:

If ... spilled or leaked, the following steps should be taken: 1. Ventilate area of spill or leak. 2. Collect for reclamation or absorb in vermiculite, dry sand, earth, or similar material.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Disposal Methods:

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste number F002, must conform with USEPA regulations in storage, transportation, treatment and disposal of waste.
[40 CFR 240-280, 300-306, 702-799 (7/1/2000)]**PEER REVIEWED**

A potential candidate for liquid injection incineration at a temperature range of 650 to 1,600 deg C and a residence time of 0.1 to 2 seconds. A potential candidate for rotary kiln incineration at a temperature range of 820 to 1,600 deg C and residence times of seconds for liquids and gases, and hours for solids. A potential candidate for fluidized bed incineration at a temperature range of 450 to 980 deg C and residence times of seconds for liquids and gases, and longer for solids.
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-4 (1981) EPA 68-03-3025]**PEER REVIEWED**

Incineration, preferably after mixing with ... combustible fuel. Care must be exercised to assure complete combustion to prevent the formation of phosgene. An acid scrubber is necessary to remove the halo acids produced.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 889]**PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

Permissible Exposure Limit: Table Z-1 8-hr Time Weighted Avg: 1000 ppm (7600 mg/cu m).
[29 CFR 1910.1000 (7/1/2000)]**PEER REVIEWED**

Threshold Limit Values:

8 hr Time Weighted Avg (TWA) 1,000 ppm; Short Term Exposure Limit (STEL) 1,250 ppm
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 69]**PEER REVIEWED**

A4: Not classifiable as a human carcinogen.
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 69]**PEER REVIEWED**

NIOSH Recommendations:

Recommended Exposure Limit: 10 Hr Time-Weighted Avg: 1,000 ppm (7,600 mg/cu m).
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 316]**PEER REVIEWED**

Recommended Exposure Limit: 15 Min Short-Term Exposure Limit: 1,250 ppm (9,500 mg/cu m).
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 316]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

2000 ppm
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

CHEM INT FOR POLYCHLOROTRIFLUOROETHYLENE RESINS & POLYCHLOROTRIFLUOROETHYLENE-VINYLIDENE FLUORIDE.
[SRI]**PEER REVIEWED**

Fully halogenated chlorofluorocarbons (CFCs) such as 1,1,2-trichloro-1,2,2-trifluoroethane were scheduled for production phase-out in 1987 by the Montreal Protocol. Although originally scheduled for 50% production phase-out by the year 2000 in developed countries, the worsening ozone depletion has forced acceleration of the CFC phase-out.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V21 (97) 132]**PEER REVIEWED**

Dry-cleaning solvent, fire extinguishers, to make chlorotrifluoroethylene, blowing agent, polymer intermediate, solvent drying, drying electronic parts and precision equipment.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1127]**PEER REVIEWED**

CFC-113 IS USED IN CENTRIFUGAL COMPRESSOR SYSTEMS FOR WATER OR BRINE CHILLING.
[CHEMICAL PRODUCTS SYNOPSIS: FLUOROCARBONS (1984)]**PEER REVIEWED**

INTERMEDIATE IN THE PRODUCTION OF CHLOROTRIFLUOROETHYLENE MONOMER BY

REACTION WITH ZINC.
[SITTIG. HDBK TOX & HAZARD CHEM & CARCINOGENS 2ND ED (1985) p.888]**PEER REVIEWED**

It is not used in aerosol formulations as a propellant component, but is used as a solvent or active ingredient in certain aerosol formulations.
[USEPA; Health Assessment Document for 1,1,2-Trichloro-1,2,2-Trifluoroethane p.2 (1983) EPA-600/58-82-002F]**PEER REVIEWED**

... Selective solvent in degreasing electrical equipment, photographic films, magnetic tapes, precision instruments, plastics, glass, elastomers, or metal components. Dry cleaning solvent for all fabrics, leather, and suede. ... Solvent in textile industry, and ... in special laboratory usage.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.]**PEER REVIEWED**

... Refrigerant in commerical/industrial air conditioning and industrial process cooling.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.]**PEER REVIEWED**

... Chem intermediate for dechloronization of chemicals in the manufacture of polymers and copolymers in the production of high-temp lubricants.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.]**PEER REVIEWED**

... Foaming or blowing agent in the manufacture of polymers for flame retardancy.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.]**PEER REVIEWED**

Clean /semiconductor/ wafers; remove grease from printed circuit boards; in defluxing operations to remove solder flux after components are attached /to printed circuit boards/.
[Desktop Analysis Tool for Common Data Base, Report to the National Science Foundation by Chemical Abstract Services and American Chemical Society, 1968.,p. VA9 (87) 290]**PEER REVIEWED**

Major dry cleaning solvent
[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed.Vol A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present.,p. VA9 (87) 49]**PEER REVIEWED**

Manufacturers:

AlliedSignal Inc., 101 Columbia Rd., P.O. Box 1057, Morristown, NJ 07962-1057, (973) 455-2000. AlliedSignal Specialty Chemicals; Production site: Baton Rouge, LA 70805
[SRI. 1999 Directory of Chemical Producers -United States. Menlo Park, CA. SRI Consulting 1999.. 648]**PEER REVIEWED**

DuPont, 1007 Market St., Wilmington, DE 19898, (302) 774-1000. DuPont Specialty Chemicals, DuPont Fluoroproducts ; Production site: Corpus Christi, TX 78400
[SRI. 1999 Directory of Chemical Producers -United States. Menlo Park, CA. SRI Consulting 1999.. 648]**PEER REVIEWED**

Methods of Manufacturing:

REACTION OF PERCHLOROETHYLENE WITH A MIXTURE OF HYDROGEN FLUORIDE AND CHLORINE IN THE PRESENCE OF A ZIRCONIUM FLUORIDE CATALYST
[SRI]**PEER REVIEWED**

From perchloroethylene and hafnium.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1127]**PEER REVIEWED**

... Catalytic fluorination of perhalo-olefins or alkanes with hydrogen fluoride.
[Matheson Gas Products; Matheson Gas Data Book 6th Ed p.678 (1980)]**PEER REVIEWED**

... By electrolysis of bromotrichloroethylene, lithium fluoride, and calcium fluoride in liquid hydrogen fluoride.
[Matheson Gas Products; Matheson Gas Data Book 6th Ed p.678 (1980)]**PEER REVIEWED**

Formulations/Preparations:

GRADES: TECHNICAL; SPECTROPHOTOMETRIC.
[Hawley, G.G. The Condensed Chemical Dictionary. 10th ed. New York: Van Nostrand Reinhold Co., 1981. 1043]**PEER REVIEWED**

Impurities:

Maximum limits of impurities: Residue after evaporation: 0.0005%; Water (by Karl Fischer titrn): 0.05%. /'Photrex' reagent/
[JT Baker Chemical Co; Reagents and Laboratory Products Catalog 860C p.143 (1986)]**PEER REVIEWED**

Consumption Patterns:

MOST CFC 113 ... IS USED AS A SOLVENT /ALTHOUGH/ IT ALSO HAS REFRIGERANT APPLICATIONS (1984).
[CHEMICAL PRODUCTS SYNOPSIS: FLUOROCARBONS (1984)]**PEER REVIEWED**

REFRIGERANTS, 39%; FOAM BLOWING AGENTS, 17%; SOLVENTS, 14%; FLUOROPOLYMERS, 14%; STERILANT GAS, 2%; AEROSOL PROPELLANTS, 2%; FOOD FREEZANT, 1%; OTHER, 8%; EXPORTS, 3% (1985) /FLUOROCARBONS/
[CHEMICAL PROFILE: FLUOROCARBONS (1986)]**PEER REVIEWED**

Approximately 160-170 million lb/yr ... is consumed in the United States, particularly by the electronics industry.
[Jackson RE et al; pp. 511-26 in Environ Sci Pollut Control Ser 4(Groundwater Contam Anal Haz Waste Sites). Lesage S, Jackson RE, eds. NY, NY: M Dekker (1992)]**PEER REVIEWED**

U. S. Production:

(1974) 2.9X10+10 GRAMS
[SRI]**PEER REVIEWED**

(1975) GREATER THAN 4.54X10+5 GRAMS
[SRI]**PEER REVIEWED**

>35 million lbs annual capacity

[SRI. 1999 Directory of Chemical Producers -United States. Menlo Park, CA. SRI Consulting 1999.. 648]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

SERUM FROM WORKERS EXPOSED TO 1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE CAN BE ANALYZED BY GAS CHROMATOGRAPHY.
[TRIEBIG G, BURKHARDT K; INT ARCH OCCUP ENVIRON HEALTH 42 (2): 129-36 (1979)]**PEER REVIEWED**

GAS CHROMATOGRAPHIC METHOD FOR DETERMINING FLUOROCARBONS IS DESCRIBED. CONCN IN BODY FLUIDS ARE DETERMINED BY MEANS OF HEAD SPACE ANALYSIS. /FLUOROCARBONS/
[RAUWS ET AL; J PHARM PHARMACOL 25 (9): 718-22 (1973)]**PEER REVIEWED**

HEXANE EXTRACTION PROCEDURE FOR THE DETERMINATION OF COMMON FLUOROCARBON PROPELLANTS IN BLOOD WAS EVALUATED. AN ANALYSIS OF SAMPLE HEADSPACE WAS ALSO EVALUATED FOR DETERMINING CHLOROPENTAFLUOROETHANE IN BLOOD. BOTH PROCEDURES INVOLVED ANALYSIS BY GAS CHROMATOGRAPHY USING ELECTRON CAPTURE DETECTION. THE WIDELY USED HEXANE EXTRACTION PROCEDURE FOR DETERMINING PPM LEVELS OF VOLATILE HALOCARBONS IN TISSUE WAS EVALUATED BY A COMBINATION OF RADIOCHEMICAL AND GAS CHROMATOGRAPHIC TECHNIQUES. THE DATA SUGGEST THAT HEXANE EXTRACTION GIVES SIGNIFICANTLY LOW RESULTS. /FLUOROCARBONS/
[TERRILL JB; AMER IND HYG ASSOC J 33 (11): 736-44 (1972)]**PEER REVIEWED**

Analytic Laboratory Methods:

NIOSH Method 1020. Determination of 1,1,2-Trichloro-1,2,2-Trifluoroethane by Gas Chromatography with Flame Ionization Detection. Detection limit= 1 mg/cu m.
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

NIOSH Method 2549. Volatile Organic Compounds (Screening). Thermal desorption, gas chromatography, mass spectrometry.
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

AREAL Method IP-1A. Determination of Volatile Organic Compounds (VOCs) in Indoor Air Using Stainless Steel Canisters. Capillary gas chromatography with low resolution mass spectrometry.
[USEPA/Atmospheric Research and Exposure Assessment Laboratory; Compendium of Methods for the Determination of Air Pollutants in Indoor Air, Draft, September 1989, Frank McElroy, U.S. Environmental Protection Agency, Atmospheric Research and Exposure Assessment Laboratory (MD-77), Research Triangle Park, NC 27711 as cited in USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC #4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

AREAL Method TO-14. Determination of Volatile Organic Compounds (VOCs) in Ambient Air using SUMMA Passivated Canister Sampling and Gas Chromatographic Analysis.
[USEPA/Atmospheric Research and Exposure Assessment Laboratory; Compendium of

Methods for the Determination of Air Pollutants in Indoor Air, Draft, September 1989, Frank McElroy, U.S. Environmental Protection Agency, Atmospheric Research and Exposure Assessment Laboratory (MD-77), Research Triangle Park, NC 27711 as cited in USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC #4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method OAQPS CTM-011. Determination of Halogenated Organics from Stationary Sources.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW Method 0040. Sampling of Principal Organic Hazardous Constituents from Combustion Sources Using Tedlar Bags.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

... Detector tubes certified by NIOSH under 42 CFR part 84 or other direct-reading devices calibrated to measure 1,1,2-trichloro-1,2,2-trifluoroethane may be used.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Sampling Procedures:

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or two four-hour samples. Several short time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

NIOSH Method 1020. Analyte: **Freon TF.** Matrix: Air. Sampler: Solid sorbent tube (coconut shell charcoal, 100 mg/50 mg). Flow Rate: 0.01 to 0.05 l/min. Sample Size: 1.5 liter. Shipment: Refrigerated. Sample Stability: Not determined.
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. 1020-1]**PEER REVIEWED**

Special References:

Special Reports:

USEPA; Health Assessment Document: 1,1,2-Trichloro-1,2,2-trifluoroethane (1983) EPA-600/58-5-82-002F

Zakhari S, Aviado DM; Cardiovascular Toxicology of Aerosol Propellants, Refrigerants and Related Solvents; Target Organ Toxicology Series: Cardiovascular Toxicology, XII+ 388 pages; Raven Press: New York, NY 281-326 (1982). Review of the toxicology of aerosol propellants, refrigerants and related solvents on the cardiovascular system of humans.

Barlow SM, Sullivan FM; Fluorocarbons; Reproductive Hazards of Industrial Chemicals pp.326-33 (1982.).

Synonyms and Identifiers:

Related HSDB Records:

144 [FREON 112]

146 [FREON 114]

1092 [1,1,1,2-TETRACHLORO-2,2-DIFLUOROETHANE]

Synonyms:

F 113
PEER REVIEWED

R 113
PEER REVIEWED

ARCTON 63
PEER REVIEWED

ARKLONE P
PEER REVIEWED

CFC-113
PEER REVIEWED

Daiflon S 3
PEER REVIEWED

ETHANE, 1,1,2-TRICHLORO-1,2,2-TRIFLUORO-
PEER REVIEWED

FC 113
PEER REVIEWED

Flugene 113
PEER REVIEWED

FORANE 113
PEER REVIEWED

FREON R 113
PEER REVIEWED

FREON 113
PEER REVIEWED

FREON TF
PEER REVIEWED

FREON 113 TR-T
PEER REVIEWED

FRIGEN 113TR-N

PEER REVIEWED

FRIGEN 113TR-T
PEER REVIEWED

FRIGEN 113
PEER REVIEWED

FRIGEN 113A
PEER REVIEWED

FRIGEN 113TR
PEER REVIEWED

Genesolv D
PEER REVIEWED

GENETRON 113
PEER REVIEWED

HALOCARBON 113
PEER REVIEWED

Kaltron 113MDR
PEER REVIEWED

Khladon 113
PEER REVIEWED

TCTFE
PEER REVIEWED

Trichlorotrifluoroethane
PEER REVIEWED

1,2,2-**TRICHLOROTRIFLUOROETHANE**
PEER REVIEWED

TTE
PEER REVIEWED

UCON FLUOROCARBON 113
PEER REVIEWED

Formulations/Preparations:

GRADES: TECHNICAL; SPECTROPHOTOMETRIC.
[Hawley, G.G. The Condensed Chemical Dictionary. 10th ed. New York: Van Nostrand Reinhold Co., 1981. 1043]**PEER REVIEWED**

EPA Hazardous Waste Number:

F002; A hazardous waste from nonspecific sources when a spent solvent.

Administrative Information:

Hazardous Substances Databank Number: 145

Last Revision Date: 20030214

Last Review Date: Reviewed by SRP on 1/20/2001

Update History:

Complete Update on 02/14/2003, 1 field added/edited/deleted.
Complete Update on 11/08/2002, 1 field added/edited/deleted.
Complete Update on 08/09/2001, 1 field added/edited/deleted.
Complete Update on 05/23/2001, 61 fields added/edited/deleted.
Field Update on 05/16/2001, 1 field added/edited/deleted.
Complete Update on 06/12/2000, 1 field added/edited/deleted.
Complete Update on 03/28/2000, 1 field added/edited/deleted.
Complete Update on 02/02/2000, 1 field added/edited/deleted.
Complete Update on 09/21/1999, 1 field added/edited/deleted.
Complete Update on 08/26/1999, 1 field added/edited/deleted.
Complete Update on 07/20/1999, 7 fields added/edited/deleted.
Complete Update on 03/25/1999, 1 field added/edited/deleted.
Complete Update on 02/24/1999, 1 field added/edited/deleted.
Complete Update on 01/20/1999, 1 field added/edited/deleted.
Complete Update on 11/27/1998, 1 field added/edited/deleted.
Complete Update on 11/12/1998, 1 field added/edited/deleted.
Complete Update on 06/02/1998, 1 field added/edited/deleted.
Complete Update on 10/17/1997, 1 field added/edited/deleted.
Complete Update on 02/26/1997, 1 field added/edited/deleted.
Complete Update on 01/09/1997, 1 field added/edited/deleted.
Complete Update on 06/11/1996, 1 field added/edited/deleted.
Complete Update on 04/16/1996, 7 fields added/edited/deleted.
Complete Update on 01/18/1996, 1 field added/edited/deleted.
Complete Update on 11/10/1995, 1 field added/edited/deleted.
Complete Update on 05/26/1995, 1 field added/edited/deleted.
Complete Update on 05/17/1995, 2 fields added/edited/deleted.
Complete Update on 01/24/1995, 1 field added/edited/deleted.
Complete Update on 12/19/1994, 1 field added/edited/deleted.
Complete Update on 08/04/1994, 1 field added/edited/deleted.
Complete Update on 03/25/1994, 1 field added/edited/deleted.
Complete Update on 08/07/1993, 1 field added/edited/deleted.
Complete Update on 08/04/1993, 1 field added/edited/deleted.
Complete Update on 02/12/1993, 57 fields added/edited/deleted.
Field Update on 02/05/1993, 1 field added/edited/deleted.
Field update on 12/11/1992, 1 field added/edited/deleted.
Field Update on 10/27/1992, 1 field added/edited/deleted.
Complete Update on 08/17/1992, 51 fields added/edited/deleted.
Field Update on 04/16/1992, 1 field added/edited/deleted.
Field Update on 01/13/1992, 1 field added/edited/deleted.
Field Update on 01/10/1992, 1 field added/edited/deleted.
Complete Update on 10/23/1990, 1 field added/edited/deleted.
Field update on 05/18/1990, 1 field added/edited/deleted.

Complete Update on 04/16/1990, 1 field added/edited/deleted.
Field update on 12/29/1989, 1 field added/edited/deleted.
Complete Update on 12/19/1989, 1 field added/edited/deleted.
Complete Update on 03/29/1989, 1 field added/edited/deleted.
Complete Update on 01/27/1989, 1 field added/edited/deleted.
Complete Update on 12/09/1988, 2 fields added/edited/deleted.
Complete Update on 10/20/1988, 69 fields added/edited/deleted.

Record Length: 126470

1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113)

CASRN: 76-13-1
For other data, click on the Table of Contents

Status:

STATUS OF DATA FOR CFC-113

File First On-Line 01/31/1987

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on line	02/01/1996
Inhalation RfC Assessment (I.B.)	no data	
Carcinogenicity Assessment (II.)	no data	

Substance Identification:

Substance Name:

1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113)

CAS Registry Number: 76-13-1

I. Chronic Health Hazard Assessment for Noncarcinogenic Effects:

I.A. Reference Dose for Chronic Oral Exposure (RfD):

Substance Name -- 1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113)
CASRN -- **76-13-1**
Last Revised -- 02/01/1996

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

NOTE: The Oral RfD for 1,1,2-trichloro-1,2,2-trifluoroethane may change in the near future pending the outcome of a further review now being conducted by the Oral RfD Work Group.

I.A.1. Oral RfD Summary:

Critical Effect	Experimental Doses*	UF	MF	RfD
Psychomotor impairment Epidemiologic Study: Human Occupational Exposure Imbus and Adkins, 1972	NOAEL: 5358 mg/cu.m converted to 273 mg/kg/day	10	1	3E+1 mg/kg/day

*Conversion Factors: 10 cu.m/day (8-hour human breathing volume), 5 days/7 days, 0.5 absorption factor, 70 kg bw; thus, 5358 mg/cu.m x 10 cu.m/day x 5 days/7 days x 0.5/70 kg = 273 mg/kg/day

I.A.2. Principal and Supporting Studies (Oral RfD):

Imbus, H.R. and C. Adkins. 1972. Physical examination of workers exposed to trichlorotrifluoroethane. Arch. Environ. Health. 24(4): 257-261.

Several animal inhalation studies reported negative results in dogs, rabbits, and rats chronically exposed to very high concentrations of trichlorotrifluoroethane (U.S. EPA, 1983). No apparent adverse effects have been reported in humans occupationally exposed to trichlorotrifluoroethane at either 500 mg/cu.m levels for 11 years or 5358 mg/cu.m levels for 2.77 years (Imbus and Adkins, 1972).

Slight impairment of psychomotor performance was reported in male volunteers exposed to trichlorotrifluoroethane concentrations of 19,161 mg/cu.m for 2.75 hours (Stopps and McLaughlin, 1967). This exposure period was too brief to consider a NOAEL for chronic exposure. Therefore, the RfD of 30 mg/kg/day is considered protective.

I.A.3. Uncertainty and Modifying Factors (Oral RfD):

UF -- The uncertainty factor of 10 accounts for the expected interhuman variability to the toxicity of this chemical in lieu of specific data.

MF -- None

I.A.4. Additional Studies/Comments (Oral RfD):

None.

I.A.5. Confidence in the Oral RfD:

Study -- Low
Database -- Low
RfD -- Low

Confidence in the chosen study, data base, and RfD are all considered low. Despite the fact that the chosen study describes human data and the fact that several chronic studies in animals are supportive, uncertainties in both the exposure levels and route extrapolation preclude higher confidence ratings.

I.A.6. EPA Documentation and Review of the Oral RfD:

Source Docuemnt -- U.S. EPA, 1983

Other EPA Documentation -- None

Agency Work Group Review -- 06/24/1985, 07/08/1985

Verification Date -- 07/08/1985

Screening-Level Literature Review Findings -- A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the RfD for 1,1,2-Trichloro-1,2,2-trifluoroethane conducted in September 2002 did not identify any critical new studies. IRIS users who know of important new studies may provide that information to the IRIS Hotline at hotline.iris@epa.gov or 301-345-2870.

I.A.7. EPA Contacts (Oral RfD):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC):

Substance Name -- 1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113)
CASRN -- **76-13-1**

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure:

Substance Name -- 1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113)
CASRN -- **76-13-1**

Not available at this time.

VI. Bibliography:

VI.A. Oral RfD References:

Imbus, H.R. and C. Adkins. 1972. Physical examination of workers exposed to trichlorotrifluoroethane.

Arch. Environ. Health. 24(4): 257-261.

Stopps, G.J. and M. McLaughlin. 1967. Psychophysiological testing of human subjects exposed to solvent vapors. Amer. Ind. Hyg. Assoc. J. 28: 43-50.

U.S. EPA. 1983. Health Assessment Document for 1,1,2-trichloro-1,2,2- trifluoroethane (chlorofluorocarbon CFC 113). Office of Air Quality Planning and Standards, Research Triangle Park, NC. EPA-600/8-82-002F. NTIS PB84- 118843. (Final Report)

VI.B. Inhalation RfC References:

None

VI.C. Carcinogenicity Assessment References:

None

VII. Revision History:

Substance Name -- 1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113)
CASRN -- **76-13-1**

Date	**Section**	**Description**
04/06/1987	I.A.1.	RfD corrected
03/01/1988	I.A.1.	Dose conversion factor corrected
12/01/1988	I.A.	RfD noted as pending change
01/01/1990	I.A.6.	Added U.S. EPA citation
01/01/1990	VI.	Bibliography on-line
06/01/1990	IV.A.1.	Area code for EPA contact corrected
01/01/1992	I.A.7.	Primary contact changed
01/01/1992	IV.	Regulatory actions updated
04/01/1992	IV.A.1.	CAA regulatory action withdrawn
08/01/1995	I.A.	EPA's RfD/RfC and CRAVE workgroups were discontinued in May, 1995. Chemical substance reviews that were not completed by September 1995 were taken out of IRIS review. The IRIS Pilot Program replaced the workgroup functions beginning in September, 1995.
02/01/1996	I.A.7.	Contact changed
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
12/03/2002	I.A.6.	Screening-Level Literature Review Findings message has been added.

1,2-DICHLORO-1,1,2-TRIFLUOROETHANE

CASRN: 354-23-4

For other data, click on the Table of Contents

Human Health Effects:

Human Toxicity Excerpts:

PROPELLANT /FLUOROCARBON/ GASES WERE GENERATED ... FROM A DISTANCE OF 50 CM FOR PERIODS OF 15 TO 60 SECONDS. AT A MEASURED CONCN OF 95,000 MG/CU M (1700 PPM), THERE WAS BIPHASIC CHANGE IN VENTILATORY CAPACITY, THE FIRST REDUCTION OCCURRING WITHIN FEW MIN AFTER EXPOSURE, & SECOND DELAYED UNTIL 13 TO 30 MIN AFTER EXPOSURE. MOST SUBJECTS DEVELOPED BRADYCARDIA, & INVERSION OF THE T-WAVE. /PROPELLANT GASES/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

EXCESSIVE SKIN CONTACT WITH LIQ FLUOROCARBONS SHOULD BE MINIMIZED TO PREVENT DEFATTING OF SKIN ... /FLUOROCARBONS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 897]**PEER REVIEWED**

FLUOROCARBON VAPORS ARE 4 TO 5 TIMES HEAVIER THAN AIR. THUS HIGH CONCN TEND TO ACCUMULATE IN LOW-LYING AREAS, RESULTING IN HAZARD OF INHALATION OF CONCENTRATED VAPORS, WHICH MAY BE FATAL. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

UNDER CERTAIN CONDITIONS, FLUOROCARBON VAPORS MAY DECOMPOSE ON CONTACT WITH FLAMES OR HOT SURFACES, CREATING POTENTIAL HAZARD OF INHALATION OF TOXIC DECOMPOSITION PRODUCTS. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

SNIFFING OF **FREON** PROPELLANTS (FLUOROCARBONS) FOR THEIR INTOXICATING EFFECTS FROM PRODUCTS SUCH AS DRY HAIR SHAMPOOS OR **FREON** REFRIGERANTS, AS COCKTAIL GLASS CHILLERS, HAS PRODUCED OVER ONE HUNDRED DOCUMENTED DEATHS (PERHAPS OTHERS NOT REPORTED). /**FREON** PROPELLANTS/
[Arena, J.M. and Drew, R.H. (eds.) Poisoning-Toxicology, Symptoms, Treatments. 5th ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 831]**PEER REVIEWED**

EARLY ... HUMAN EXPERIENCE INDICATED THAT HIGH VAPOR CONCN (EG, 20%) MAY CAUSE CONFUSION, PULMONARY IRRITATION, TREMORS & RARELY COMA, BUT THAT THESE EFFECTS WERE GENERALLY TRANSIENT & WITHOUT LATE SEQUELAE. ... CAUSE OF DEATH /FROM ABUSE OF FLUOROCARBONS/ IS IN CONSIDERABLE DOUBT. FREEZING OF AIRWAY SOFT TISSUES CAN PROBABLY BE ELIMINATED AS A CAUSE OF DEATH EXCEPT IN CASES WHERE THE PRODUCT WAS SPRAYED DIRECTLY INTO THE MOUTH FROM ITS CONTAINER OR FROM A BALLOON CONTAINING SOME LIQUID. LARYNGEAL SPASM OR EDEMA, OXYGEN DISPLACEMENT, OR SENSITIZATION OF MYOCARDIUM TO ENDOGENOUS CATECHOLAMINES WITH SUBSEQUENT VENTRICULAR FIBRILLATION

APPEAR TO BE REASONABLE POSSIBILITIES. /FLUOROCARBON REFRIGERANTS & PROPELLANTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-159]**PEER REVIEWED**

A SPECIAL CLASS OF CHEMICALS SUBJECT TO ABUSE BY INHALATION ARE THE FLUOROHYDROCARBONS ... THE "SNIFFING" OF SUCH AEROSOL SPRAYS IS HAZARDOUS PRACTICE. ... 110 "SUDDEN SNIFFING DEATHS" /HAVE BEEN IDENTIFIED/ ... IN EACH CASE THE VICTIM SPRAYED THE AEROSOL INTO A PLASTIC BAG, INHALED THE CONTENTS, BECAME EXCITED, RAN 90 M OR SO, COLLAPSED, & DIED. NECROPSY FINDINGS WERE LARGELY NEGATIVE ... ALTHOUGH AMOUNT OF PROPELLANT ABSORBED INTO BLOOD FROM USE OF HAIRSPRAY, COSMETIC, HOUSEHOLD, & MEDICATED AEROSOLS MUST VARY WITH CIRCUMSTANCES, PHYSICIAN IS ADVISED TO COUNSEL ... PATIENT ON POTENTIAL DANGERS, PARTICULARLY FROM THEIR USE IN POORLY VENTILATED CONFINED AREAS. IT IS POSSIBLE THAT PATIENTS WITH CARDIAC OR RESPIRATORY DISORDERS MAY PROVE ESPECIALLY SUSCEPTIBLE. /FLUOROHYDROCARBONS/
[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975. 910]**PEER REVIEWED**

In a cross-sectional study the neurological effects of fluorocarbons were evaluated in 27 refrigeration repair workers. Fourteen age matched reference subjects were selected from a local union of plumbers, pipe-fitters, and insulation workers. A case of peripheral neuropathy in a commercial refrigeration repairman prompted the investigation. Personal air samples from 2 worker-participants over the course of a typical workshift showed 1.4 ppm chlorodifluoromethane and 2.2 ppm chloropenta-fluoroethane. There were no cases of peripheral neuropathy in the study subjects. There was no significant difference in mean nerve conduction velocities (ulnar, median, peroneal, sural, tibial) between study and reference subjects. Lightheadedness and palpitations were reported significantly more often by refrigeration repair workers ($p<0.05$). /Fluorocarbons/
[Campell DD et al; Br J Ind Med 43:107-11 (1986)]**PEER REVIEWED**

Fluorocarbons were initially believed to be compounds low in toxicity. In the late 1960s there were early reports of deaths caused by intentional inhalation abuse of various aerosols. Victims frequently discharged the aerosol contents into a plastic bag and then inhaled the gaseous contents. Suffocation was initially considered to be the cause of death. In 1970, 110 cases of "sudden sniffing death" /were reviewed/ without finding evidence of suffocation. The majority of those deaths (59) involved fluorocarbon propellants. He noted that in several cases sudden death followed a burst of emotional stress or exercise. No significant findings were noted at autopsy. /Fluorocarbons/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1281]**PEER REVIEWED**

Fluorocarbon propellants are anesthetic and cardiotoxic. ... Aerosol propellants produce hallucinogenic effects, and, rarely, contact dermatitis. /Fluorocarbon propellants/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 528]**PEER REVIEWED**

Fluorocarbon propellants, benzene, 1,1,1-trichloroethane, gasoline, toluene, and hydrocarbons have been implicated in 110 sudden deaths after inhalant abuse in which no obvious cardiac or pulmonary pathology existed. Heavy exercise or stress was associated with 18 of those deaths, /it was/ proposed that these inhalants act to sensitize the myocardium to endogenous catecholamines. Hypoxia, hypercarbia, and acidosis may exacerbate these effects. /Fluorocarbon propellants/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of

Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 841]**PEER REVIEWED**

THERE ARE ISOLATED REPORTS OF POISONING FROM EXPOSURE TO FLUOROCARBON PROPELLANTS & SOME STUDIES SHOWING A HIGHER INCIDENCE OF CORONARY HEART DISEASE AMONG HOSPITAL PERSONNEL & REFRIGERANT MECHANICS EXPOSED TO FLUOROCARBONS. ADDITIONAL INVESTIGATION IS REQUIRED TO ESTABLISH CAUSAL RELATIONSHIP BETWEEN FLUOROCARBONS & CARDIOVASCULAR & BRONCHOPULMONARY DISEASES AMONG EXPOSED WORKERS. THE HIGH INCIDENCE OF CANCER AMONG HOSPITAL PERSONNEL REPEATEDLY EXPOSED TO FLUORINE-CONTAINING GENERAL ANESTHETICS RAISES A FUNDAMENTAL NEED TO EXAMINE OTHER FLUOROCARBON-EXPOSED WORKERS FOR SIMILAR EFFECTS. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1209]**PEER REVIEWED**

CLINICAL PATHOLOGISTS EXPOSED TO FLUOROCARBONS IN THE PREPN OF FROZEN TISSUE SECTIONS HAVE BEEN SEEN TO DEVELOP CORONARY HEART DISEASE. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1209]**PEER REVIEWED**

There is undisputed evidence that the atmospheric concentrations of chlorofluorocarbons deplete ozone in the stratosphere. A reduction in ozone concentration will result in increased transmission of solar ultraviolet radiation through the stratosphere. Many significant adverse effects of such an increase in exposure to this radiation have been identified. ... One of the most well-defined human health effects resulting from stratospheric ozone depletion is an increase in the frequency of skin cancer expected as a result of even small increases in UV-B radiation (280-320 nm) reaching the earths's surface. /Chlorofluorocarbons/
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.95 (1990)]**PEER REVIEWED**

Freons are toxic to humans by several mechanisms. Inhaled fluorocarbons sensitized the myocardium to catecholamines, frequently resulting in lethal ventricular arrhythmias. Because they are gases heavier than air, fluorocarbons can displace atmospheric oxygen, thus resulting in asphyxiation. These compounds also have a central nervous system (CNS) anesthetic effect analogous to a structurally similar general anesthetic, halothane. Pressurized refrigerant or liquid fluorocarbons with a low boiling point have a cryogenic effect on exposed tissues, causing frostbite, laryngeal or pulmonary edema, and gastrointestinal perforation. Certain fluorocarbons degrade at high temperatures into toxic products of chlorine, hydrofluoric acid, or phosgene gases. /Freons/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1281]**PEER REVIEWED**

... HIGH VAPOR CONCN (EG, 20%) MAY CAUSE CONFUSION, PULMONARY IRRITATION, TREMORS & RARELY COMA ... BUT ... THESE EFFECTS WERE GENERALLY TRANSIENT & WITHOUT LATE SEQUELAE. /FLUOROCARBON REFRIGERANTS & PROPELLANTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-159]**PEER REVIEWED**

Non-occupational exposure and accidental or abusive inhalation of aerosols /due to Fluorocarbon propellants/ have also been documented, the main symptoms being CNS depression and cardiovascular reactions. Cardiac arrhythmia, possibly aggravated by elevated levels of catecholamines due to stress or

by moderate hypercapnia, is suggested as the cause of these adverse response, which may lead to death. /Aerosols/
[WHO; Environmental Health Criteria 113: Fully Halogenated Chlorofluorocarbons p.20 (1990)]**PEER REVIEWED**

MANUFACTURING PROCESSES USE HYDROFLUORIC ACID FROM FLUOROSPAR IN PRODUCTION OF ALL FLUOROCARBONS. SOME PROCESSES USE CARBON TETRACHLORIDE FROM CARBON DISULFIDE, OR AS CO-PRODUCT OF PERCHLOROETHYLENE & CHLORINATION OF PROPYLENE, OR CHLOROFORM FROM CHLORINATION OF METHANOL. THE MAJOR HAZARDS RELATE PRIMARILY TO THE INADVERTENT RELEASE OF HYDROFLUORIC ACID OR CARBON TETRACHLORIDE, RATHER THAN TO THE MANUFACTURED FLUOROCARBONS. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1194]**PEER REVIEWED**

... CAUSE OF DEATH /FROM ABUSE OF FLUOROCARBONS/ IS IN ... DOUBT. FREEZING OF AIRWAY SOFT TISSUES CAN PROBABLY BE ELIMINATED ... EXCEPT IN CASES WHERE PRODUCT WAS SPRAYED DIRECTLY INTO MOUTH FROM CONTAINER OR BALLOON CONTAINING SOME LIQ. /FLUOROCARBON REFRIGERANTS & PROPELLANTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-159]**PEER REVIEWED**

... CAUSE OF DEATH /FROM ABUSE OF FLUOROCARBONS/ ... IN ... DOUBT. ... LARYNGEAL SPASM OR EDEMA, OXYGEN DISPLACEMENT, OF SENSITIZATION OF MYOCARDIUM TO ENDOGENOUS CATECHOLAMINES WITH ... VENTRICULAR FIBRILLATION APPEAR TO BE ... POSSIBILITIES. /FLUOROCARBON REFRIGERANTS & PROPELLANTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-159]**PEER REVIEWED**

Populations at Special Risk:

IT IS POSSIBLE THAT PATIENT WITH CARDIAC OR RESP DISORDERS MAY PROVE ESP SUSCEPTIBLE. /FLUOROCARBONS/
[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975. 910]**PEER REVIEWED**

Probable Routes of Human Exposure:

Occupational exposure to 1,2-dichloro-1,1,2-trifluoroethane may occur through inhalation and dermal contact with this compound at workplaces where it is produced or used. (SRC)
PEER REVIEWED

Emergency Medical Treatment:

Antidote and Emergency Treatment:

Emergency treatment is supportive and includes decontamination, oxygen, and any specific therapy required in a particular case such as antiarrhythmics or anticonvulsants. A few patients may require intermittent positive-pressure ventilation, dialysis, or treatment for hepatic failure. /Solvent abuse/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1259]**PEER REVIEWED**

... In persons who are intoxicated with fluorocarbons, steps can be taken to lessen the risk of

arrhythmias. ... Before evaluation at the hospital, patients should be advised to avoid strenuous exercise. In the hospital, patients can be placed in a quiet, nonthreatening environment and sedated if necessary. If hypoxic, oxygen should be administered and metabolic abnormalities corrected. Sympathomimetic drugs should be avoided. Ventricular arrhythmias are best treated with beta-blocking agents. /Fluorocarbons/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 81]**PEER REVIEWED**

Patients with fluorohydrocarbon poisoning should not be given epinephrine (Adrenalin) or similar drugs because of the tendency of fluorohydrocarbon to induce cardiac arrhythmia, including ventricular fibrillation. /Fluorohydrocarbons/
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 498]**PEER REVIEWED**

Victims of **Freon** inhalation require management for hypoxic, CNS anesthetic, and cardiac symptoms. Patients must be removed from the exposure environment, and high-flow supplemental oxygen should be utilized. The respiratory system should be evaluated for injury, aspiration, or pulmonary edema and treated appropriately. CNS findings should be treated supportively. a calm environment with no physical exertion is imperative to avoid increasing endogenous adrenergic levels. Exogenous adrenergic drugs must not be used to avoid inducing sensitized myocardial dysrhythmias. Atropine is ineffective in treating bradyarrhythmias. For ventricular dysrhythmias, diphenylhydantoin and countershock may be effective. Cryogenic dermal injuries should be treated by water bath rewarming at 40 to 42 deg C until vasodilatory flush has returned. Elevation of the limb and standard frostbite management with late surgical debridement should be utilized. Ocular exposure requires irrigation and slit-lamp evaluation for injury. /Freons/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1282]**PEER REVIEWED**

... IF INHALATION OCCURS, EPINEPHRINE OR OTHER SYMPATHOMIMETIC AMINES & ADRENERGIC ACTIVATORS SHOULD NOT BE ADMIN SINCE THEY WILL FURTHER SENSITIZE HEART TO DEVELOPMENT OF ARRHYTHMIAS. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Animal Toxicity Studies:

Non-Human Toxicity Excerpts:

EARLY ANIMAL ... WORK INDICATED THAT HIGH VAPOR CONCN (EG, 20%) MAY CAUSE CONFUSION, PULMONARY IRRITATION, TREMORS & RARELY COMA, BUT THAT THESE EFFECTS WERE GENERALLY TRANSIENT & WITHOUT LATE SEQUELAE. /FLUOROCARBON REFRIGERANTS & PROPELLANTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-159]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

1,2-Dichloro-1,1,2-trifluoroethane (HCFC-**123a**) is a potential alternative to replace ozone-depleting chlorofluorocarbons. The metab of HCFC-**123a** was studied in microsomes of rats, mice, & humans as well as in rats & mice in vivo. Rat, mouse, & human liver microsomes metabolized HCFC-**123a** to

inorganic fluoride & chlorodifluoroacetic acid. Fluoride formation was dependent on time & NADPH, HCFC-**123a**, & protein concn. Microsomes from untreated rats oxidized HCFC123a at low rates (0.49 nmol fluoride/20 min x mg protein). Pretreatment of rats with pyridine & ethanol, inducers of P450 2E1, increased the rates of fluoride release. In mouse liver microsomes, the rates of HCFC-**123a** oxidation to release fluoride were significantly higher (1.68 nmol fluoride/20 min x mg) than in rat liver microsomes. Incubation of HCFC-**123a** with microsomes & diethyldithiocarbamate (100 gm), an inhibitor of P450 2E1, reduced fluoride formation by more than 60%. In different samples of human liver microsomes, rates of fluoride formation were between two- & fourfold higher than those observed in liver microsomes from untreated rats. In rats & mice exposed to concns of HCFC-**123a** up to 5000 ppm in a closed recirculating exposure system, chlorodifluoroacetic acid, & inorganic fluoride were identified as urinary metabolites. The biotransformation of HCFC123a in rats was saturated after exposure to more than 2000 ppm HCFC-**123a** for 6 hr, whereas no saturation was evident in mice exposed to concns of up to 5000 ppm. The obtained results suggest a major role of P450 2E1 in the oxidation of HCFC-**123a** & in the different capacities for oxidative biotransformation of HCFC-**123a** in rodents. Mice may thus be more sensitive to toxic effects of HCFC-**123a** depending on biotransformation after admin of high doses.

[Dekant W, et al; Toxicol Appl Pharm 135 (2): 200-7 (1995)]**PEER REVIEWED**

Absorption, Distribution & Excretion:

... MAIN FACTOR AFFECTING FATE OF FLUOROCARBONS IS BODY FAT, WHERE THEY ARE CONCENTRATED & SLOWLY RELEASED INTO BLOOD @ CONCN THAT SHOULD NOT CAUSE ANY RISK OF CARDIAC SENSITIZATION. /FLUOROCARBONS/
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 781]**PEER REVIEWED**

THERE IS A SIGNIFICANT ACCUMULATION OF FLUOROCARBONS IN BRAIN, LIVER & LUNG COMPARED TO BLOOD LEVELS, SIGNIFYING A TISSUE DISTRIBUTION OF FLUOROCARBONS SIMILAR TO THAT OF CHLOROFORM. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1203]**PEER REVIEWED**

Abosrption of fluorocarbons is much lower after oral ingestion (35-48 times) than after inhalation. ... The lung generally has the highest fluorocarbon concentrations on autopsy. /Fluorocarbons/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 884]**PEER REVIEWED**

Although fluorocarbons cause cardiac sensitization in certain animal species, rapid elimination prevents the development of cardiotoxic concentrations from aerosol bronchodilator use except at exceedingly high doses (12 to 24 doses in 2 minutes). /Fluorocarbons/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 884]**PEER REVIEWED**

FLUOROCARBON COMPOUNDS ARE LIPID-SOLUBLE AND THUS ARE GENERALLY WELL ABSORBED THROUGH LUNG. ABSORPTION AFTER INGESTION IS 35 TO 48 TIMES LOWER THAN AFTER INHALATION. ... FLUOROCARBONS ARE ELIMINATED BY WAY OF LUNG. /FLUOROCARBON COMPOUNDS/
[National Research Council. Drinking Water and Health. Volume 3. Washington, DC: National Academy Press, 1980. 101]**PEER REVIEWED**

Interactions:

IF INHALATION OCCURS, EPINEPHRINE OR OTHER SYMPATHOMIMETIC AMINES & ADRENERGIC ACTIVATORS SHOULD NOT BE ADMIN SINCE THEY WILL FURTHER SENSITIZE HEART TO DEVELOPMENT OF ARRHYTHMIAS. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

... THE COMBINATION OF FLUOROCARBON WITH A SYMPATHOMIMETIC BRONCHODILATOR IS POTENTIALLY DANGEROUS FOR THE TREATMENT OF BRONCHIAL ASTHMA. FOR THE SAME REASON, SYMPATHOMIMETIC DRUGS ARE CONTRAINDICATED IN CARDIAC RESUSCITATION OF PATIENTS SUFFERING FROM FLUOROCARBON POISONING. /FLUOROCARBON POISONING/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1183]**PEER REVIEWED**

Pharmacology:

Interactions:

IF INHALATION OCCURS, EPINEPHRINE OR OTHER SYMPATHOMIMETIC AMINES & ADRENERGIC ACTIVATORS SHOULD NOT BE ADMIN SINCE THEY WILL FURTHER SENSITIZE HEART TO DEVELOPMENT OF ARRHYTHMIAS. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

... THE COMBINATION OF FLUOROCARBON WITH A SYMPATHOMIMETIC BRONCHODILATOR IS POTENTIALLY DANGEROUS FOR THE TREATMENT OF BRONCHIAL ASTHMA. FOR THE SAME REASON, SYMPATHOMIMETIC DRUGS ARE CONTRAINDICATED IN CARDIAC RESUSCITATION OF PATIENTS SUFFERING FROM FLUOROCARBON POISONING. /FLUOROCARBON POISONING/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1183]**PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

1,2-Dichloro-1,1,2-trifluoroethane's production and use may result in its release to the environment through various waste streams. However, no information was found as to whether 1,2-dichloro-1,1,2-trifluoroethane is presently manufactured or used. If released to air, a vapor pressure of 620 mm Hg at 25 deg C indicates 1,2-dichloro-1,1,2-trifluoroethane will exist solely as a vapor in the ambient atmosphere. Vapor-phase 1,2-dichloro-1,1,2-trifluoroethane will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is about 3.6 years. 1,2-Dichloro-1,1,2-trifluoroethane is fairly soluble in water and may be removed from the air by rain; however, any removed by this process is expected to rapidly revolatilize to the atmosphere. If released to soil,1,2-dichloro-1,1,2-trifluoroethane is expected to have moderate mobility based upon an estimated Koc of 154. Volatilization from moist soil surfaces is an important fate process based upon an estimated Henry's Law constant of 0.0955 atm-cu m/mole. 1,2-Dichloro-1,1,2-trifluoroethane may volatilize from dry soil surfaces based upon its vapor pressure.

Its biodegradability and hydrolyzability in soil and water are not known. If released into water, 1,2-dichloro-1,1,2-trifluoroethane is expected to adsorb moderately to suspended solids and sediment based upon the estimated Koc. Volatilization from water surfaces is expected to be an important fate process based upon this compound's estimated Henry's Law constant. Estimated volatilization half-lives for a model river and model lake are 1.3 hours and 4.9 days, respectively. An estimated BCF of 9 indicates that its potential for bioconcentration in aquatic organisms is low. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

Occupational exposure to 1,2-dichloro-1,1,2-trifluoroethane may occur through inhalation and dermal contact with this compound at workplaces where it is produced or used. (SRC)
PEER REVIEWED

Environmental Fate:

TERRESTRIAL FATE: Based on a classification scheme(1), an estimated Koc value of 154(SRC), determined from a structure estimation method(2), indicates that 1,2-dichloro-1,1,2-trifluoroethane is expected to have moderate mobility in soil(SRC). Volatilization of 1,2-dichloro-1,1,2-trifluoroethane from moist soil surfaces is expected to be an important fate process(SRC) given an estimated Henry's Law constant of 9.55X10-2 atm-cu m/mole(SRC), using a fragment constant estimation method(3). The potential for volatilization of 1,2-dichloro-1,1,2-trifluoroethane from dry soil surfaces may exist based upon a vapor pressure of 620 mm Hg(4).
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Meylan WM et al; Environ Sci Technol 26: 1560-67 (1992) (3) Meylan WM, Howard PH; Environ Toxicol Chem 10: 1283-93 (1991) (4) Kubota H et al; Inter J Therm 10: 629-637 (1989)]**PEER REVIEWED**

AQUATIC FATE: Based on a classification scheme(1), an estimated Koc value of 154(SRC), determined from a structure estimation method(2), indicates that 1,2-dichloro-1,1,2-trifluoroethane is expected to adsorb moderately to suspended solids and sediment(SRC). Volatilization from water surfaces is expected(3), based upon an estimated Henry's Law constant of 9.55X10-2 atm-cu m/mole(SRC), developed using a fragment constant estimation method(4). It's hydrolyzability in water is not known(SRC). According to a classification scheme(5), a an estimated BCF of 9(SRC), from an estimated log Kow of 2.17(6) and a regression-derived equation(7), suggests the potential for bioconcentration in aquatic organisms is low.
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Meylan WM et al; Environ Sci Technol 26: 1560-67 (1992) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9, 15-1 to 15-29 (1990) (4) Meylan WM, Howard PH; Environ Toxicol Chem 10: 1283-93 (1991) (5) Franke C et al; Chemosphere 29: 1501-14 (1994) (6) Meylan WM, Howard PH; J Pharm Sci 84: 83-92 (1995) (7) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999)]**PEER REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), 1,2-dichloro-1,1,2-trifluoroethane, which has a vapor pressure of 620 mm Hg at 25 deg C(2), is expected to exist solely as a vapor in the ambient atmosphere. Vapor-phase 1,2-dichloro-1,1,2-trifluoroethane is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals(SRC); the half-life for this reaction in air is about 3.6 years(SRC), calculated from its rate constant of 1.23X10-14 cu cm/molecule-sec at 25 deg C(3). The estimated water solubility of 1,2-dichloro-1,1,2-trifluoroethane of 232 mg/l at 25 deg C(4), indicates that it may undergo atmospheric removal by wet deposition processes; however, any removed by this process is expected to rapidly revolatilize to the atmosphere(SRC).
[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Kubota H et al; Inter J Therm 10: 629-637 (1989) (3) Orkin VL, Khamaganov VG; J Atmos Chem 16: 157-67 (1993)

(4) Meylan WM et al; Environ Toxicol Chem 15: 1000-6 (1995)]**PEER REVIEWED**

Environmental Abiotic Degradation:

The rate constant for the vapor-phase reaction of 1,2-dichloro-1,1,2-trifluoroethane with photochemically-produced hydroxyl radicals is 1.23X10-14 cu cm/molecule-sec at 25 deg C(1). This corresponds to an atmospheric half-life of about 3.6 years at an atmospheric concentration of 5X10+5 hydroxyl radicals per cu cm(SRC). 1,2-Dichloro-1,1,2-trifluoroethane has groups that may hydrolyze(2); however no hydrolysis rates were found in the available literature. 1,2-Dichloro-1,1,2-trifluoroethane is not expected to undergo direct photolysis due to the lack of absorption in the environmental UV spectrum (>290 nm)(3).
[(1) Orkin VL, Khamaganov VG; J Atmos Chem 16: 157-67 (1993) (2) Mill T et al; Environmental Fate and Exposure Studies Development of a PC-SAR for Hydrolysis: Esters, Alkyl Halides and Epoxides. EPA Contract No. 68-02-4254. Menlo Park, CA: SRI International (1987) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc p. 8-13 (1990)]**PEER REVIEWED**

Environmental Bioconcentration:

An estimated BCF of 9.4 was calculated for 1,2-dichloro-1,1,2-trifluoroethane(SRC), using an estimated log Kow of 2.17(1) and a regression-derived equation(2). According to a classification scheme(3), this BCF suggests the potential for bioconcentration in aquatic organisms is low.
[(1) Meylan WM, Howard PH; J Pharm Sci 84: 83-92 (1995) (2) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999) (3) Franke C et al; Chemosphere 29: 1501-14 (1994)]**PEER REVIEWED**

Soil Adsorption/Mobility:

Using a structure estimation method based on molecular connectivity indices(1), the Koc for 1,2-dichloro-1,1,2-trifluoroethane can be estimated to be 154(SRC). According to a classification scheme(2), this estimated Koc value suggests that 1,2-dichloro-1,1,2-trifluoroethane is expected to have moderate mobility in soil.
[(1) Meylan WM et al; Environ Sci Technol 26: 1560-67 (1992) (2) Swann RL et al; Res Rev 85: 17-28 (1983)]**PEER REVIEWED**

Volatilization from Water/Soil:

The Henry's Law constant for 1,2-dichloro-1,1,2-trifluoroethane is estimated as 9.55X10-2 atm-cu m/mole(SRC) using a fragment constant estimation method(1). This Henry's Law constant indicates that 1,2-dichloro-1,1,2-trifluoroethane is expected to volatilize rapidly from water surfaces(2). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec)(2) is estimated as 1.3 hours(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(2) is estimated as 4.9 days(SRC). 1,2-Dichloro-1,1,2-trifluoroethane's Henry's Law constant(1) indicates that volatilization from moist soil surfaces may occur(SRC). 1,2-Dichloro-1,1,2-trifluoroethane would be expected to volatilize from dry soil surfaces(SRC) based upon a vapor pressure of 620 mm Hg(4).
[(1) Meylan WM, Howard PH; Environ Toxicol Chem 10: 1283-93 (1991) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (3) Lyman WJ; p. 31 in Environmental Exposure From Chemicals Vol I, Neely WB, Blau GE, eds, Boca Raton, FL: CRC Press (1985) (4) Kubota H et al; Inter J Therm 10: 629-637 (1989)]**PEER REVIEWED**

Environmental Standards & Regulations:

Chemical/Physical Properties:

Molecular Formula:

C2-H-Cl2-F3
PEER REVIEWED

Molecular Weight:

152.93
[Lide DR, ed; CRC Handbook of Chemistry and Physics. 81st ed. 2000-2001. Boca Raton, FL: CRC Press Inc. p. 3-154 (2000)]**PEER REVIEWED**

Boiling Point:

28 deg C
[Lide DR, ed; CRC Handbook of Chemistry and Physics. 81st ed. 2000-2001. Boca Raton, FL: CRC Press Inc. p. 3-154 (2000)]**PEER REVIEWED**

Melting Point:

-78 deg C
[Lide DR, ed; CRC Handbook of Chemistry and Physics. 81st ed. 2000-2001. Boca Raton, FL: CRC Press Inc. p. 3-154 (2000)]**PEER REVIEWED**

Density/Specific Gravity:

152 g/cu cm at 25 deg C
[Lide DR, ed; CRC Handbook of Chemistry and Physics. 81st ed. 2000-2001. Boca Raton, FL: CRC Press Inc. p. 3-154 (2000)]**PEER REVIEWED**

Spectral Properties:

Index of refraction: 1.327 @ 20 deg C
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V11 (94) 506]**PEER REVIEWED**

Vapor Pressure:

102.0 kPa @ 303.15 K (620 mm Hg @ 25 deg C)
[Kubota H et al; Intern J Thermophysics 10: 629-7 (1989)]**PEER REVIEWED**

Other Chemical/Physical Properties:

Hydroxyl radical rate constant= 1.23X10-14 cu cm/molecule-sec @ 25 deg C
[Orkin VL, Khamaganov VG; J Atmos Chem 16: 157-67 (1993)]**PEER REVIEWED**

Ozone depletion potential=0.06 (CFC11=1)
[Environment Canada; Canadian Environmental Protection Act. Regulations Respecting the Manufacture, Use, Sale, Offer for Sale, Import and Export of Certain Ozone-Depleting Substances and Amending the List of Toxic Substances in Schedule I to the Canadian Environmental Protection Act. JUS-95-510-02. (SOR/DORS) Available at http://www.pyr.ec.gc.ca/ep/ozone/95-0510.html as of Jan 23, 2001.]**PEER REVIEWED**

Chemical Safety & Handling:

Toxic Combustion Products:

ALL FLUOROCARBONS WILL UNDERGO THERMAL DECOMPOSITION WHEN EXPOSED TO FLAME OR RED-HOT METAL. DECOMPOSITION PRODUCTS OF THE CHLOROFLUOROCARBONS WILL INCLUDE HYDROFLUORIC & HYDROCHLORIC ACID ALONG WITH SMALLER AMOUNTS OF PHOSGENE & CARBONYL FLUORIDE. THE LAST COMPOUND IS VERY UNSTABLE TO HYDROLYSIS & QUICKLY CHANGES TO HYDROFLUORIC ACID & CARBON DIOXIDE IN THE PRESENCE OF MOISTURE. /FLUOROCARBONS/
[International Labour Office. Encyclopaedia of Occupational Health and Safety. 4th edition, Volumes 1-4 1998. Geneva, Switzerland: International Labour Office, 1998.,p. 104.185]**PEER REVIEWED**

IN CONTACT WITH OPEN FLAME OR VERY HOT SURFACE FLUOROCARBONS MAY DECOMP INTO HIGHLY IRRITANT & TOXIC GASES: CHLORINE, HYDROGEN FLUORIDE OR CHLORIDE, & EVEN PHOSGENE. /FLUOROCARBON REFRIGERANT & PROPELLANTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-159]**PEER REVIEWED**

UNDER CERTAIN CONDITIONS, FLUOROCARBON VAPORS MAY DECOMPOSE ON CONTACT WITH FLAMES OR HOT SURFACES, CREATING THE POTENTIAL HAZARD OF INHALATION OF TOXIC DECOMPOSITION PRODUCTS. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

Dangerous ... on contact with acid or acid fumes, they emit highly toxic fumes. /Fluorides/
[Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984. 541]**PEER REVIEWED**

DANGEROUS ... ON CONTACT WITH ACIDS OR ACID FUMES THEY EVOLVE HIGHLY TOXIC CHLORIDE FUMES. /CHLORIDES/
[Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984. 966]**PEER REVIEWED**

Hazardous Decomposition:

UNDER CERTAIN CONDITIONS, FLUOROCARBON VAPORS MAY DECOMPOSE ON CONTACT WITH FLAMES OR HOT SURFACES, CREATING THE POTENTIAL HAZARD OF INHALATION OF TOXIC DECOMPOSITION PRODUCTS. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Dangerous; When heated to decomp ... they evolve highly toxic fumes of /hydrogen chloride and hydrogen fluoride/.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 832]**PEER REVIEWED**

APPEARANCE OF TOXIC DECOMP PRODUCTS SERVES AS WARNING OF OCCURRENCE OF THERMAL DECOMP & DETECTION OF SHARP ACRID ODOR WARNS OF PRESENCE ... . /FLUOROCARBONS/

[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3101]**PEER REVIEWED**

Protective Equipment & Clothing:

Many of the fluorocarbons are good solvents of skin oil, so protective ointment should be used. /Fluorocarbons/
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 499]**PEER REVIEWED**

NEOPRENE GLOVES, PROTECTIVE CLOTHING, & EYE PROTECTION MINIMIZE RISK OF TOPICAL CONTACT. DEGREASING EFFECT ON SKIN CAN BE TREATED WITH LANOLIN OINTMENT. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

FORCED AIR VENTILATION @ LEVEL OF VAPOR CONCN TOGETHER WITH USE OF INDIVIDUAL BREATHING DEVICES WITH INDEPENDENT AIR SUPPLY WILL MINIMIZE RISK OF INHALATION. LIFELINES SHOULD BE WORN WHEN ENTERING TANKS OR OTHER CONFINED SPACES. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Preventive Measures:

SUFFICIENT EXHAUST & GENERAL VENTILATION SHOULD BE PROVIDED TO KEEP VAPOR CONCN BELOW RECOMMENDED LEVELS. /FLUOROCARBONS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 897]**PEER REVIEWED**

INHALATION OF FLUOROCARBON VAPORS SHOULD BE AVOIDED. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Forced air ventilation at the level of vapor concentration together with the use of individual breathing devices with independent air supply will minimize the risk of inhalation. Lifelines should be worn when entering tanks or other confined spaces. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

Enclosure of process materials and isolation of reaction vessels and proper design and operation of filling heads for packaging and shipping /are administrative controls that may be instituted to limit occupational exposure to fluorocarbons during manufacture, packaging, and use/. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

FILLING AREAS SHOULD BE MONITORED TO ENSURE ... AMBIENT CONCN OF FLUOROCARBONS DOES NOT EXCEED 1000 PPM ... INHALATION OF FLUOROCARBON VAPORS SHOULD BE AVOIDED ... IF INHALATION OCCURS, EPINEPHRINE OR OTHER SYMPATHOMIMETIC AMINES & ADRENERGIC ACTIVATORS SHOULD NOT BE ADMIN

SINCE THEY WILL FURTHER SENSITIZE HEART TO DEVELOPMENT OF ARRHYTHMIAS. /FLUOROCARBONS/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

APPEARANCE OF TOXIC DECOMP PRODUCTS SERVES AS WARNING OF OCCURRENCE OF THERMAL DECOMP & DETECTION OF SHARP ACRID ODOR WARNS OF PRESENCE ... HALIDE LAMPS OR ELECTRONIC LEAK DETECTORS MAY ALSO BE USED. ADEQUATE VENTILATION ALSO AVOIDS PROBLEM OF TOXIC DECOMPOSITION PRODUCTS. /FLUOROCARBONS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3101]**PEER REVIEWED**

Eye washer and instant shower facilities should be located near the work areas where spills and splash hazards exist. /Fluorocarbons/
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 499]**PEER REVIEWED**

Disposal Methods:

SRP: At the time of review, criteria for land treatment or burial (sanitary landfill) disposal practices are subject to significant revision. Prior to implementing land disposal of waste residue (including waste sludge), consult with environmental regulatory agencies for guidance on acceptable disposal practices.
PEER REVIEWED

Occupational Exposure Standards:

Manufacturing/Use Information:

Major Uses:

The HCFCs are used as alternatives to CFCs in application such as refrigerants, blowing agents, cleaning agents, and fire extinguishants /HCFCs/
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V11 (94) 511]**PEER REVIEWED**

Manufacturers:

Halocarbon Products Corporation, Hq, 887 Kinderkamack Road, P.O. Box 661, River Edge, NJ 07661, (201) 262-8899; Production site: North Augusta, SC 29841 /Fluorocarbons, 1,1-dichloro-2,2,2-trifluoroethane, CFC alternates/
[SRI. 1994 Directory of Chemical Producers -United States of America. Menlo Park, CA: SRI International, 1994.. 179]**PEER REVIEWED**

Methods of Manufacturing:

The most important commercial method for manufacturing /chlorofluoro carbons/ is the successive replacement of chlorine by fluorine using hydrogen fluoride ... the traditional, liquid-phase process uses antimony pentafluoride or a mixture of antimony trifluoride and chlorine as catalysts ... continuous vapor-phase processes that employ gaseous hydrogen fluoride in the presence of heterogenous chromium, iron or fluorinated alumina catalysts are also widely used ... the direct chlorination of

hydroflurocarbons and fluoroolefins has also been used commercially /CFCs and HCFCs/
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V11 (94) 507]**PEER REVIEWED**

Impurities:

Chlorofluoroalkanes produced on an industrial scale are subject to stringent standards ... impurities must not exceed the following limits (vol%): acids, 0; moisture, <0.001; higher-boiling fractions, <0.05; other gases, 2 /Chlorofluoroalkanes/
[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed.Vol A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present.,p. VA11 (88) 358]**PEER REVIEWED**

Consumption Patterns:

Refrigeration/air conditioning, 43%; foam blowing agents, 20%; polymer percursors, 13%; solvent cleaning, 12%; aerosol propellants, 2%; medical equipment sterilization, 3%; other, 7% /Fluorocarbons/
[Chemical Marketing Reporter; Chemical Profile: Fluorocarbons, Mar 16, 1992]**PEER REVIEWED**

Refrigeration/air conditioning, 46%; fluoropolymer precursors, 28%, foam blowing agents, 20%; solvent cleaning, 3%; Miscellaneous, including aerosol propellants, medical equipment sterilization, food freezing and halon manufacture 3% /Fluorocarbons/
[Chemical Marketing Reporter; ChemExpo Chemical Profile Database on Fluorocarbons, October 11, 1999. Available from the database query page at http://www.chemexpo.com/news/newsframe.cfm?framebody=/news/profile.cfm as of Sept 19, 2000]**PEER REVIEWED**

Laboratory Methods:

Analytic Laboratory Methods:

AREAL Method IP-1A. Determination of Volatile Organic Compounds (VOCs) in Indoor Air Using Stainless Steel Canisters; Capillary GC/MS; detection limit = ppb (quantity not specified).
[USEPA/Atmospheric Research & Exposure Assessment Laboratory (AREAL); Compendium of Methods for the Determination of Air Pollutants in Indoor Air, Engineering Science, One Harrison Park, Suite 305, 401 Harrison Oaks Blvd, Cary, NC 27513 as cited in USEPA; EMMI. Environmental Monitoring Index Database Version 1.02 (1992) EPA/871-B-92-001 (NTIS Document No. PB92-503093)]**PEER REVIEWED**

Special References:

Synonyms and Identifiers:

Related HSDB Records:

6876 [DICHLORO-1,1,2-TRIFLUOROETHANE] (Mixture)

6752 [2,2-DICHLORO-1,1,1-TRIFLUOROETHANE] (Isomer)

6874 [DICHLOROTRIFLUOROETHANE] (Mixture)

6873 [HCFC-123b] (Isomer)

Synonyms:

HCFC-**123a**
PEER REVIEWED

Administrative Information:

Hazardous Substances Databank Number: 6871

Last Revision Date: 20010524

Last Review Date: Reviewed by SRP on 1/20/2001

Update History:

Complete Update on 05/24/2001, 38 fields added/edited/deleted.
Complete Update on 09/10/1996, 1 field added/edited/deleted.
Complete Update on 06/07/1996, 1 field added/edited/deleted.
Complete Update on 08/14/1995, 1 field added/edited/deleted.
Complete Update on 06/08/1995, 39 fields added/edited/deleted.

Record Length: 47868

DICHLOROFLUOROMETHANE

CASRN: 75-43-4

For other data, click on the Table of Contents

Human Health Effects:

Human Toxicity Excerpts:

IN HIGH CONCN, IT MAY CAUSE CENTRAL NERVOUS DEPRESSION.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-159]**PEER REVIEWED**

EARLY ... HUMAN EXPERIENCE INDICATED THAT HIGH VAPOR CONCN (EG, 20%) MAY CAUSE CONFUSION, PULMONARY IRRITATION, TREMORS & RARELY COMA, BUT THAT THESE EFFECTS WERE GENERALLY TRANSIENT & WITHOUT LATE SEQUELAE. ... CAUSE OF DEATH /FROM ABUSE OF FLUOROCARBONS/ IS IN CONSIDERABLE DOUBT. FREEZING OF AIRWAY SOFT TISSUES CAN PROBABLY BE ELIMINATED AS A CAUSE OF DEATH EXCEPT IN CASES WHERE THE PRODUCT WAS SPRAYED DIRECTLY INTO THE MOUTH FROM ITS CONTAINER OR FROM A BALLOON CONTAINING SOME LIQUID. LARYNGEAL SPASM OR EDEMA, OXYGEN DISPLACEMENT, OR SENSITIZATION OF MYOCARDIUM TO ENDOGENOUS CATECHOLAMINES WITH SUBSEQUENT VENTRICULAR FIBRILLATION APPEAR TO BE REASONABLE POSSIBILITIES. /FLUOROCARBON REFRIGERANTS & PROPELLANTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-159]**PEER REVIEWED**

Although toxicity due to acute inhalation is low, CFC-21 is appreciably more toxic than related difluorinated methanes such as dichlorodifluoromethane or chlorodifluoromethane. The chronic toxicity of CFC-21 is markedly different from these compounds, and appears to be more similar to chloroform.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.434]**PEER REVIEWED**

Manufacturing processes use hydrofluoric acid from fluorospar in the production of most fluorine containing organic compounds. Some processes use carbon tetrachloride from carbon disulfide or as a co-product of perchloroethylene and chlorination of propylene, or chloroform from chlorination of methanol. At the outset, it is important to emphasize that most fluorine containing compounds (CFC, HCFC, and HFC) are less toxic than any of the process materials used in their manufacture. The major hazards relate primarily to the inadvertent release of hydrofluoric acid or carbon tetrachloride, rather than to the manufactured final product. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1194]**PEER REVIEWED**

A SPECIAL CLASS OF CHEMICALS SUBJECT TO ABUSE BY INHALATION ARE THE FLUOROHYDROCARBONS, SUCH AS ... **DICHLOROFLUOROMETHANE** ... THE "SNIFFING" OF SUCH AEROSOL SPRAYS IS HAZARDOUS PRACTICE. ... 110 "SUDDEN SNIFFING DEATHS" /HAVE BEEN IDENTIFIED/ ... IN EACH CASE THE VICTIM SPRAYED THE AEROSOL INTO A PLASTIC BAG, INHALED THE CONTENTS, BECAME EXCITED, RAN 90 M OR SO, COLLAPSED, & DIED. NECROPSY FINDINGS WERE LARGELY NEGATIVE ... ALTHOUGH AMOUNT OF PROPELLANT ABSORBED INTO BLOOD FROM USE OF HAIRSPRAY, COSMETIC, HOUSEHOLD, & MEDICATED AEROSOLS MUST VARY WITH

CIRCUMSTANCES, PHYSICIAN IS ADVISED TO COUNSEL ... PATIENT ON POTENTIAL DANGERS, PARTICULARLY FROM THEIR USE IN POORLY VENTILATED CONFINED AREAS. /FLUOROHYDROCARBONS/
[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975. 910]**PEER REVIEWED**

EXCESSIVE SKIN CONTACT WITH LIQUID FLUOROCARBONS SHOULD BE MINIMIZED TO PREVENT DEFATTING OF SKIN ... /FLUOROCARBONS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 897]**PEER REVIEWED**

... LOWER IN TOXICITY THAN CORRESPONDING CHLORINATED OR BROMINATED HYDROCARBONS. ... ASSOC WITH GREATER STABILITY OF C-F BOND; & PERHAPS ALSO WITH LOWER LIPID SOLUBILITY ... TOXIC EFFECTS FROM REPEATED EXPOSURE, SUCH AS LIVER OR KIDNEY DAMAGE, HAVE NOT BEEN PRODUCED BY FLUOROMETHANES ... /FLUOROCARBONS/
[International Labour Office. Encyclopaedia of Occupational Health and Safety. 4th edition, Volumes 1-4 1998. Geneva, Switzerland: International Labour Office, 1998.,p. 104.184]**PEER REVIEWED**

... ATTENTION /HAS BEEN DRAWN/ TO PROMINENT CARDIOTOXIC EFFECTS, MANIFESTED IN ARRHYTHMIAS, THAT ARE ASSOC WITH PULMONARY EXPOSURE TO ... FLUOROCARBON 21 ... TACHYCARDIA, MYOCARDIAL DEPRESSION, & HYPOTENSION HAVE BEEN DESCRIBED.
[Hamilton, A., and H. L. Hardy. Industrial Toxicology. 3rd ed. Acton, Mass.: Publishing Sciences Group, Inc., 1974. 293]**PEER REVIEWED**

Inhalation of vapors should be avoided. Forced air ventilation at the level of vapor concentration together with the use of individual breathing devices with independent air supply will minimize the risk of inhalation.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

The toxicity of Chlorofluorocarbons (CFCs) had been considered to be low; it is absorbed via the lungs and undergoes little subsequent biotransformation. In the United States when sudden unexplained deaths of aerosol "sniffers" were reported they were considered to be possibly due to cardiac arrhythmias induced by the CFC propellants. /CFCs/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 1299]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Refrigerant 21 vapor is respiratory irritant ...
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

On contact with liquid /**dichlorofluoromethane**/: frostbite
[International Labour Office. Encyclopaedia of Occupational Health and Safety. 4th edition, Volumes 1-4 1998. Geneva, Switzerland: International Labour Office, 1998.,p. 104.188]**PEER REVIEWED**

Medical Surveillance:

Consider the points of attack /respiratory system, lung, cardiovascular system/ in preplacement and periodic physical examinations.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 325]**PEER REVIEWED**

Populations at Special Risk:

IT IS POSSIBLE THAT PT WITH CARDIAC OR RESP DISORDERS MAY PROVE ESP SUSCEPTIBLE. /FLUOROCARBONS/
[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975. 910]**PEER REVIEWED**

Probable Routes of Human Exposure:

Inhalation, ingestion, eye and skin contact.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 325]**PEER REVIEWED**

Occupational exposure to manufactured fluorocarbons occurs in the manufacture, use, servicing, and disposal of refrigeration units, solvent applications, and plastic foam blowing. Cylinder packers and shippers; occassional high exposure to tank truck and tank car fillers; maintenance operators; lab analysts. /Fluorocarbons/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 1195]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 12,182 workers (1,640 of these are female) are potentially exposed to **dichlorofluoromethane** in the US(1). Occupational exposure to **dichlorofluoromethane** may occur through inhalation of this compound at workplaces where **dichlorofluoromethane** is produced or used(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983)]**PEER REVIEWED**

Personal air samples were collected from firefighters in Buffalo, NY while responding to 3 wood-frame building structure fires and one car fire; the range of **dichlorofluoromethane** detected in the breathing space varied from 0.67 to 12.1 ppm(1).
[(1) Brandt-Rauf PW et al; Br J Ind Med 45: 606-12 (1988)]**PEER REVIEWED**

Body Burden:

Dichlorofluoromethane was found in the expired air of 2 of 8 male volunteers; the amounts exhaled in these two subjects were 0.14 and 0.062 fg/hr(1). **Dichlorofluoromethane** was detected, but not quantified, in the expired air of a nonsmoking population of 62 males and females, suburban and urban residents(2). The percentage of subjects whose breath contained **dichlorofluoromethane** was not reported.
[(1) Conkle JP et al; Arch Environ Health 30: 290-5 (1975) (2) Krotoszynski BK, O'Neill HJ; J Environ Sci Health A17: 855-83 (1982)]**PEER REVIEWED**

LEAD COMPOUNDS

CASRN: NO CAS RN

This record contains general information for lead ions and compounds, including statements in the literature referenced to lead compounds, lead salts, etc. For compound-specific information, refer to the appropriate individual records as listed in the RELATED HSDB RECORDS field; for information on the metal itself, refer to the LEAD, ELEMENTAL record.

For other data, click on the Table of Contents

Human Health Effects:

Toxicity Summary:

Lead toxicity causes hematological, gastrointestinal, and neurological dysfunction in adults and children. Symptoms are usually noted with blood **lead** greater than 1.93 umol/L. Severe or prolonged exposure may also cause chronic nephropathy, hypertension, and reproductive impairment. **Lead** inhibits enzymes; alters cellular calcium metabolism; stimulates synthesis of binding proteins in kidney, brain, and bone; and slows nerve conduction. Less severe exposure to **lead**, designated by blood **lead** levels of 0.48-0.96 umol/L, has been implicated in poor pregnancy outcomes, impaired neurobehavioral development, reduced stature in young children, and higher blood pressure in adults. ... Dust, water and paint chips are still major sources of **lead** but **lead** from folk remedies, cosmetics, food supplements, food preparation utensils, and improperly prepared infant formula has caused epidemic and sporadic severe **lead** toxicity. Screening for pediatric low level **lead** requires measurement of blood **lead**. /Inorganic **lead** compounds/

[G. Lockitch. Clin Biochem 26: 371-381 (1993)]**PEER REVIEWED**

Evidence for Carcinogenicity:

Classification of carcinogenicity: 1) evidence in humans: inadequate; 2) evidence in animals: sufficient. Overall summary evaluation of carcinogenic risk to humans is Group 2B: The agent is possibly carcinogenic to humans. /**Lead** and inorganic **lead** cmpds, from table/

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. S7 65 (1987)]**PEER REVIEWED**

CLASSIFICATION: B2; probable human carcinogen. BASIS FOR CLASSIFICATION: Sufficient animal evidence. Ten rat bioassays and one mouse assay have shown statisticlly significant increases in renal tumors with dietary and subcutaneous exposure to several soluble **lead** salts. Animal assays provide reproducible results in several laboratories, in multiple rat strains with some evidence of multiple tumor sites. Short term studies show that **lead** affects gene expression. Human evidence is inadequate. HUMAN CARCINOGENICITY DATA: Inadequate. ANIMAL CARCINOGENICITY DATA: Sufficient.

[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Lead and compounds (inorganic) (7439-92-1) Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000]**PEER REVIEWED**

A3; Confirmed animal carcinogen with unknown relevance to humans. /**Lead**, elemental, and inorganic compounds, as Pb/

[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.38]**QC REVIEWED**

Human Toxicity Excerpts:

LEAD IS POISONOUS IN ALL FORMS. IT IS ONE OF THE MOST HAZARDOUS OF THE TOXIC METALS BECAUSE THE POISON IS CUMULATIVE & THE TOXIC EFFECTS ARE MANY & SEVERE. /**LEAD** CMPD/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-226]**PEER REVIEWED**

Acute **lead** poisoning is relatively infrequent and occurs from ingestion of acid soluble **lead** compounds or inhalation of **lead** vapors. Local actions in the mouth produce marked astringency, thirst, and a metallic taste. Nausea, abdominal pain, and vomiting ensue. The vomitus may be milky from the presence of **lead** chloride. Although the abdominal pain is severe, it is unlike that of chronic poisoning. Stools may be black from **lead** sulfide, and there may be diarrhea or constipation. If large amounts of **lead** are absorbed rapidly, a shock syndrome may develop as the result of massive gastrointestinal loss of fluid. Acute symptoms of the central nervous system incl paresthesia, pain, and muscle weakness. An acute hemolytic crisis sometimes occurs and causes severe anemia and hemoglobinuria. The kidneys are damaged, and oliguria and urinary changes are evident. Death may occur in 1 or 2 days. If the patient survives the acute episode, characteristic signs & symptoms of chronic **lead** poisoning are likely to appear. /Inorganic **lead** compounds/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1651]**PEER REVIEWED**

Signs & symptoms of chronic **lead** poisoning (plumbism) can be divided into 6 categories: gastrointestinal, neuromuscular, CNS, hematological, renal, & other. They may occur separately or in combination. The neuromuscular & CNS syndromes usually result from intense exposure, while the abdominal syndrome is a more common manifestation of a very slowly & insidiously developing intoxication. The CNS syndrome is usually more common among children, while the GI syndrome is more prevalant in adults. /Inorganic **lead** compounds/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1651]**PEER REVIEWED**

... /IN CHRONIC **LEAD** POISONING/ THE ABDOMINAL SYNDROME OFTEN BEGINS WITH VAGUE SYMPTOMS, SUCH AS ANOREXIA, MUSCLE DISCOMFORT, MALAISE, AND HEADACHE. CONSTIPATION IS USUALLY AN EARLY SIGN, ESP IN ADULTS, BUT DIARRHEA OCCASIONALLY OCCURS. A PERSISTENT METALLIC TASTE APPEARS EARLY IN THE COURSE OF THE SYNDROME. AS INTOXICATION ADVANCES, ANOREXIA AND CONSTIPATION BECOME MORE MARKED. INTESTINAL SPASM, WHICH CAUSES SEVERE ABDOMINAL PAIN, OR **LEAD** COLIC, IS THE MOST DISTRESSING FEATURE OF THE ADVANCED ABDOMINAL SYNDROME. THE ATTACKS ARE PAROXYSMAL AND GENERALLY EXCRUCIATING. THE ABDOMINAL MUSCLES BECOME RIGID, & TENDERNESS IS ESP MANIFESTED IN THE REGION OF THE UMBILICUS. /INORGANIC **LEAD** COMPOUNDS/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1651]**PEER REVIEWED**

THE NEUROMUSCULAR SYNDROME OR **LEAD** PALSY NOW IS RARE IN THE UNITED STATES. IT IS A MANIFESTATION OF ADVANCED SUBACUTE POISONING. MUSCLE WEAKNESS & EASY FATIGUE OCCUR LONG BEFORE ACTUAL PARALYSIS AND MAY BE THE ONLY SYMPTOMS. WEAKNESS OR PALSY MAY NOT BECOME EVIDENT UNTIL AFTER EXTENDED MUSCLE ACTIVITY. THE MUSCLE GROUPS INVOLVED USUALLY ARE

THE MOST ACTIVE ONES (EXTENSORS OF THE FOREARM, WRIST, & FINGERS & EXTRAOCULAR MUSCLES). WRIST DROP &, TO A LESSER EXTENT, FOOT DROP WITH APPROPRIATE HISTORY OF EXPOSURE HAVE BEEN CONSIDERED ALMOST PATHOGNOMONIC FOR **LEAD** POISONING. THERE IS USUALLY NO SENSORY INVOLVEMENT. DEGENERATIVE CHANGES IN MOTONEURONS & THEIR AXONS HAVE BEEN DESCRIBED. /INORGANIC **LEAD** COMPOUNDS/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1651]**PEER REVIEWED**

THE CNS SYNDROME HAS BEEN TERMED **LEAD** ENCEPHALOPATHY. IT IS THE MOST SERIOUS MANIFESTATION OF **LEAD** POISONING, AND IS MUCH MORE COMMON IN CHILDREN THAN IN ADULTS. THE EARLY SIGNS OF THE SYNDROME MAY BE CLUMSINESS, VERTIGO, ATAXIA, FALLING, HEADACHE, INSOMNIA, RESTLESSNESS, AND IRRITABILITY. AS THE ENCEPHALOPATHY DEVELOPS, THE PATIENT MAY FIRST BECOME EXCITED AND CONFUSED; DELIRIUM WITH REPETITIVE TONIC-CLONIC CONVULSIONS OR LETHARGY & COMA FOLLOW. VOMITING, A COMMON SIGN, IS USUALLY PROJECTILE. VISUAL DISTURBANCES ARE ALSO PRESENT. ... TREATMENT FOR CEREBRAL EDEMA MAY BECOME NECESSARY. THERE MAY BE APROLIFERATIVE MENINGITIS, INTENSE EDEMA, PUNCTATE HEMORRHAGES, GLIOSIS AND AREAS OF FOCAL NECROSIS. ... THE MORTALITY RATE AMONG PATIENTS WHO DEVELOP CEREBRAL INVOLVEMENT IS ABOUT 25%. WHEN CHELATION THERAPY IS BEGUN AFTER THE SYMPTOMS OF ACUTE ENCEPHALOPATHY APPEAR, APPROXIMATELY 40% OF SURVIVORS HAVE NEUROLOGICAL SEQUELAE, SUCH AS MENTAL RETARDATION, EEG ABNORMALITIES OR ... SEIZURES, CEREBRAL PALSY, OPTIC ATROPHY, OR DYSTONIA MUSCULORUM DEFORMANS. /INORGANIC **LEAD** COMPOUNDS/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1651]**PEER REVIEWED**

EXPOSURE TO **LEAD** OCCASIONALLY PRODUCES ... PROGRESSIVE MENTAL DETERIORATION IN CHILDREN. THE HISTORY OF THESE CHILDREN INDICATES NORMAL DEVELOPMENT DURING THE FIRST 12-18 MONTHS OF LIFE OR LONGER, FOLLOWED BY A STEADY LOSS OF MOTOR SKILLS & SPEECH. THEY MAY HAVE SEVERE HYPERKINETIC AND AGGRESSIVE BEHAVIOR DISORDERS & A POORLY CONTROLLED CONVULSIVE DISORDER. THE LACK OF SENSORY PERCEPTION SEVERELY IMPAIRS LEARNING. CONCN OF **LEAD** IN BLOOD EXCEED 60 UG/DL OF WHOLE BLOOD, & X-RAY MAY SHOW HEAVY, MULTIPLE BANDS OF INCR DENSITY IN THE GROWING LONG BONES. ... AN INCREASED INCIDENCE OF HYPERKINETIC BEHAVIOR & A STATISTICALLY SIGNIFICANT, ALTHOUGH MODEST, DECREASE IN IQ HAVE BEEN SHOWN IN CHILDREN WITH BLOOD **LEAD** CONCN OF 30-50 UG/DL. /INORGANIC **LEAD** COMPOUNDS/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1652]**PEER REVIEWED**

When the blood **lead** concn is near 80 ug/dl or greater, basophilic stippling (the aggregation of ribonucleic acid) occurs in erythrocytes. This is thought to result from the inhibitory effect of **lead** on the enzyme, pyrimidine-5'-nucleotidase. Basophilic stippling is not ... pathognomonic of **lead** poisoning. A more common hematological result of chronic **lead** intoxication is a hypochromic microcytic anemia, which is more frequently observed in children and is morphologically similar to that which results from iron deficiency. The anemia is thought to result from two factors: a decreased life span of the erythrocytes & an inhibition of heme synthesis. Very low concn of **lead** influence the synthesis of heme.

... **Lead** clearly inhibits heme formation at several ... /enzymatic steps/. /Inorganic **lead** compounds/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1652]**PEER REVIEWED**

Renal toxicity occurs in two forms: a reversible renal tubular disorder (usually seen after acute exposure of children to **lead**) and an irreversible interstitial nephropathy (more commonly observed in chronic industrial **lead** exposure). Clinically, a Fanconi-like syndrome is seen with proteinuria, hematuria, and casts in the urine. Hyperuricemia with gout occurs more frequently in the presence of chronic **lead** nephropathy than in any other type of chronic renal disease. Histologically, **lead** nephropathy is revealed by a characteristic nuclear inclusion body, composed of a **lead**-protein complex; this appears early & resolves after chelation therapy. Such inclusion bodies have been reported in the urine of workers exposed to **lead** in an industrial setting. /Inorganic **lead** compounds/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1652]**PEER REVIEWED**

OTHER SIGNS & SYMPTOMS OF PLUMBISM ARE ASHEN COLOR OF THE FACE & PALLOR OF LIPS; RETINAL STIPPLING; APPEARANCE OF "PREMATURE AGING," WITH STOOPED POSTURE, POOR MUSCLE TONE, & EMACIATION; & BLACK, GRAYISH, OR BLUE-BLACK SO-CALLED **LEAD** LINE ALONG THE GINGIVAL MARGIN. ... THE HUMAN CARCINOGENICITY IS NOT WELL ESTABLISHED, BUT IT HAS BEEN SUGGESTED, & SEVERAL CASE REPORTS OF RENAL ADENOCARCINOMA IN **LEAD** WORKERS HAVE BEEN PUBLISHED. /INORGANIC **LEAD** COMPOUNDS/
[Hardman, J.G., L.E. Limbird, P.B. Molinoff, R.W. Ruddon, A.G. Goodman (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 9th ed. New York, NY: McGraw-Hill, 1996. 1652]**PEER REVIEWED**

THERE IS NO EVIDENCE TO SUGGEST THAT EXPOSURE TO **LEAD** SALTS CAUSES CANCER OF ANY SITE IN MAN. HOWEVER, ONLY ONE EPIDEMIOLOGICAL STUDY OF THE RELATIONSHIPS BETWEEN EXPOSURE TO **LEAD** & THE OCCURRENCE OF CANCER HAS BEEN REPORTED. ... THE LEVEL OF HUMAN EXPOSURE EQUIVALENT TO THE LEVEL OF **LEAD** ACETATE PRODUCING RENAL TUMORS IN RATS IS 810 MG/DAY (550 MG PB). THIS LEVEL APPEARS TO EXCEED BY FAR THE MAX TOLERATED DOSE FOR MAN. /INORGANIC **LEAD** COMPOUNDS/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V1 48 (1972)]**PEER REVIEWED**

A few clinical studies have found increased chromosomal defects in workers with blood **lead** levels above 60 ug/dl. /Inorganic **lead** compounds/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 708]**PEER REVIEWED**

RESIDUAL NEUROLOGICAL SEQUELAE MAY AFFECT AS HIGH AS 82% OF SURVIVORS. /INORGANIC **LEAD** COMPOUNDS/
[PERLSTEIN; CLINICAL PED 5: 292 (1966)]**PEER REVIEWED**

IN MANY CASES THERE IS NO MACROSCOPIC OR MICROSCOPIC EVIDENCE OF BRAIN EDEMA. EDEMA IS RARELY THE CAUSE OF DEATH. /INORGANIC **LEAD** COMPOUNDS/
[KRIGMAN ET AL; EXP CLIN NEUROTOXICOLOGY, WILLIAMS & WILLIAMS (1980)]**PEER REVIEWED**

MICROCYTOSIS & ANEMIA EVIDENTLY OCCUR MUCH LESS COMMONLY THAN

PREVIOUSLY REPORTED IN CHILDHOOD **LEAD** POISONING UNCOMPLICATED BY OTHER HEMATOLOGIC DISORDERS. /INORGANIC **LEAD** COMPOUNDS/
[COHEN AR ET AL; PEDIATRICS 67 (6): 904-6 (1981)]**PEER REVIEWED**

... The incidence of premature fetal membrane rupture in term and preterm infants is much higher (17%) 30 to 50 miles west of a **lead** mining area of Missouri than in a Missouri urban area remote from **lead** mining activities (0.41%). Maternal and fetal blood **lead** levels (PbB) at birth also differed significantly for normal births vs births with premature membrane rupture. Maternal and fetal blood **lead** levels for the normal deliveries were about 14 and 4 ug/dl respectively, whereas they were about 26 and 13 ug per dl for mothers and infants with membrane rupture. /Inorganic **lead** compounds/
[USEPA; Ambient Water Quality Criteria Doc: Lead p.C-67 (1980) EPA 440/5-80-057]**PEER REVIEWED**

INCREASED SERUM ARGINASE ACTIVITY MAY INDICATE LIVER DAMAGE, WHILE DECR KALLIKREIN ACTIVITY MAY INDICATE KIDNEY DAMAGE IN WORKERS EXPOSED TO **LEAD**. /INORGANIC **LEAD** COMPOUNDS/
[CHMIELNICKA J ET AL; BR J IND MED 38 (2): 175-8 (1981)]**PEER REVIEWED**

Blood **lead** values in children ranging from 40 to 80 ug/100 ml seem to be associated with adverse neuropsychological effects. Landrigan and coworkers ... compared a group of 70 children, aged 3 to 15 years (mean blood **lead** 48 ug/100 ml). They found that higher **lead** levels were associated with decreased intelligence and slowing in a finger wrist tapping test. /Inorganic **lead** compounds/
[NIOSH; Criteria Document: Inorganic Lead p.XI-56 (1978) DHEW Pub. NIOSH 78-158]**PEER REVIEWED**

The reproductive ability of men was ... shown to be adversely affected by moderate absorption of **lead**. Concn of **lead** in blood greater than 52 ug/100 ml were associated with a high frequency of altered spermatogenesis. Disorders of sexual dynamics were evident with blood **lead** values greater than 41 ug/100 ml. Among the workers with the highest concn of **lead** in blood (mean 74.50 + or - 26 ug/100 ml), 75% were judged to be hypofertile, 50% being even infertile. It was not possible, however, to demonstrate a reliable association between **lead** absorption in these men and the number of normal pregnancies per couple, or the frequency of miscarriages, ectopic pregnancies, or premature births. Nevertheless, these results were interpreted to indicate that **lead** clearly has a direct toxic action on the male gonads at relatively low levels of absorption. /Inorganic **lead** compounds/
[NIOSH; Criteria Document: Inorganic Lead p.XI-52 (1978) DHEW Pub. NIOSH 78-158]**PEER REVIEWED**

... WHEN AN EXCESSIVE AMT OF **LEAD** HAS BEEN DEPOSITED IN BONE, EITHER FROM INGESTION OR FROM INDUSTRIAL EXPOSURE, & HAS REMAINED IMMOBILIZED FOR YEARS, INTERCURRENT FACTORS CAUSING MOBILIZATION MAY CAUSE A SUDDEN OUTBREAK OF CLINICAL SYMPTOMS OF **LEAD** POISONING. /INORGANIC **LEAD** COMPOUNDS/
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969. 174]**PEER REVIEWED**

... In rural Scotland, four people developed clinical **lead** poisoning and others showed biochemical evidence of grossly elevated **lead** exposure. Pb concn in the domestic water supply was 2-3 mg/l. In this case the reason for the extreme contamination was that the water was stored in **lead** tanks. /Inorganic **lead**/
[WHO; Environ Health Criteria: Lead p.49 (1977)]**PEER REVIEWED**

... In humans, **lead** decreased glucose-6-phosphate dehydrogenase activity and thus decreased the gluthathione level in red blood cells. /**Lead** cmpd/

[Nat'l Research Council Canada; Effects of Lead in the Canadian Envir p.572 (1978) NRCC No 16736]**PEER REVIEWED**

ON BASIS OF CLINICAL OBSERVATION ... DISTURBANCES /OCCUR IN/ VISUAL CORTEX & SUPRAGENICULATE PATHWAY; OPTIC NERVE ... RETROBULBAR & BULBAR; RETINA; INTRAOCULAR MUSCLE; LENS; & EXTRAOCULAR MUSCLE. INDIVIDUAL PORTION OF VISUAL SYSTEM MAY BE AFFECTED ... MORE /OFTEN/ SEVERAL PORTIONS. ... /**LEAD** CMPD/
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 551]**PEER REVIEWED**

... **Lead** levels were elevated in the liver of individuals having liver siderosis or other diseases involving altered iron metabolism. ... Hemosiderin induced by high levels of iron, may act as a binding agent not only for iron but for Pb as well. Thus these diseases may incr Pb retention in the body and especially in the liver. The Pb(+2) may later be released by being replaced with Fe(+3). /Inorganic **lead**/
[Nat'l Research Council Canada; Effects of Lead in the Canadian Envir p.572 (1978) NRCC No.16736]**PEER REVIEWED**

Lead containing particles in ambient air have an aerodynamic diameter of approx 0.1-1.0 um, & the predicted deposition in the airway is about 35%. This is questionable for smaller particles (< 0.1 um) which are mainly deposited by diffusion. Actual measurements of deposition in human volunteers gave results that differed considerably depending on the physical & chemical properties of the inhaled aerosol. ... A deposition of approx 25% /was observed/ after exposure to particles with a mass median aerodynamic diameter of 0.25 um. ... A deposition in the resp tract of about 60% /was observed/ in persons close to a motorway, where particles were about 0.03 um in diameter. This figure is consistent with lab expt carried out by the same authors, in which subjects inhaled radioactively labeled particles of about the same size. When volunteers inhaled **lead** particles near urban roads where the particle size was larger (0.2-2.0 um), deposition was about 50%. Based on available data, it seems reasonable to conclude that the rate of deposition of airborne **lead** in the general population is approx 30-50%, depending on particle size & ventilation rates. /Inorganic **lead** compounds/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 311]**PEER REVIEWED**

Recent research work on the clinical effects of **lead** has focused on the subtle neuropsychiatric, reproductive, & renal effects of chronic low dose **lead** exposure. Children are particularly susceptible to **lead** induced impairment of neuropsychological development because of their reduced ability to excrete **lead** & their enhanced absorption of **lead** compared to adults. Death in children from undetected **lead** poisoning may be greater than heretofore suspected. /Inorganic **lead**/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 1030]**PEER REVIEWED**

Lead systemic poisoning can cause a wide variety of visual & ocular disturbances according to many case reports during the past 3.5 centuries. Much of what ... /is known/ of the clinical aspects of ocular effects comes from early literature which has been condensed in several reviews. ... Of 172 eye cases surveyed by Lewin & Guillery /& reported in 1913/, 79 had colic, 52 had headache, 47 had convulsions, delirium, stupor, or coma, & 27 had paralysis of extensor muscles. In general ocular disturbances appeared most commonly after many months or years of chronic poisoning, & at least after several weeks of poisoning. As a rule, ocular involvement was not among the early symptoms in adults, although it could be one of the first symptoms, esp in children. On the basis of clinical & exptl observations, it has been possible to recognize disturbances of the following sites: visual cortex & supragenicular pathways; optic nerve, both retrobulbar & bulbar; retina; intraocular muscles; &

extraocular muscles. Unfortunately many reports describing visual symptoms provide insufficient information for determination of site or mechanism. /Inorganic **lead**/
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 550]**PEER REVIEWED**

... Studies correlating elevated blood **lead** levels to hypotension are conflicting. Concern exists over possibility that soft acid water increases the solubility of **lead** & that elevated levels account for the increased incidence of hypertension & cardiovascular mortality in areas with soft-water supplies. The contribution of increased **lead** absorption to gout, hypertension, nephropathy, & neurotoxicity remains to be determined. /Inorganic **lead**/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 1030]**PEER REVIEWED**

Although per day children ingest less **lead** in their diets and inhale less Pb than do adults, on a dose per body weight basis children may have 2-3 times the exposure. Furthermore children because of their poor oral hygiene are more likely than adults to absorb Pb from extraneous sources: ingestion of foreign objects, dust, paint chips, inhalation of resuspended settled dusts. Preliminary data indicate that children absorb 50% of ingested Pb, ie at a rate 5 times greater than adults. Animal studies support the hypothesis that the young retain more of a Pb dose than do adults and that this is reflected in soft tissue Pb levels. The portions of the Pb body burden found in soft tissues of children and adults are 27.5% and 5% respectively. Hence, a higher fraction of a child's body burden of Pb is available to produce toxic effects in soft tissues. /Inorganic **lead**/
[USEPA; Ambient Water Quality Criteria Doc: Lead p.C1-9 (1984) EPA 440/5-84-027]**PEER REVIEWED**

SYMPTOMATOLOGY: A. Acute poisoning by ingestion only. 1) An astringent and metallic taste in the mouth, dry throat, thirst. 2) Burning abdominal pain, nausea, and vomiting. The vomitus may appear milky due to the presence of **lead** chloride. The abdominal pain may become colicky and severe. 3) Sometimes diarrhea, less often constipation. The stools may be bloody, or black due to the presence of **lead** sulfide. 4) Peripheral circulatory collapse. 5) Neuromuscular symptoms include muscular weakness, pain, and cramps, especially in the legs. 6) Central nervous system manifestations include headache, insomnia, paresthesias, depression, coma, and death. 7) Though usually of secondary concern, kidney damage may result in oliguria, albuminuria, and cylindruria. The renal lesion may be due to the mildly nephrotoxic action of **lead**, to disturbances in kidney circulation, or to the products of intravascular hemolysis. Renal lesions may assume increased importance if edetate calcium disodium therapy is instituted. 8) An acute hemolytic crisis sometimes develops and results in anemia and hemoglobinuria. 9) Death may occur within 1 or 2 days, but recovery is the rule. Convalescence is slow and may be interrupted by episodes like those seen in typical chronic poisoning. /**Lead** cmpd/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-232]**PEER REVIEWED**

SYMPTOMATOLOGY: B. **Lead** encephalopathy in chronic **lead** poisoning. 1) Headache and insomnia. 2) Persistent vomiting, which is sometimes projectile. A typical **lead** colic may or may not be present. 3) Visual disturbances, choked optic disks. 4) Irritability, restlessness, delirium, hallucinations. 5) Convulsions and coma. 6) The intracranial pressure is characteristically high. The cerebrospinal fluid is generally unremarkable except for and elevation of total protein. 7) Death from exhaustion and respiratory failure. The mortality rate is high; Recovery is slow and frequently incomplete. /**Lead** cmpd/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-233]**PEER REVIEWED**

Blood **lead** level was determined in forty-five traffic controllers working on Alexandria road intersections. Central nervous system dysfunction in the subjects /was studied/ by means of performance

tests. Biochemical indicators related to **lead** exposure such as delta-aminolevulinic acid dehydratase and hemoglobin in their blood were also determined. Results indicated that most of the subjects studied have a comparably high blood **lead** level. They also showed significantly poorer performance scores than that obtained in a previous study with a group of textile workers of the same age and educational levels. The mean of the blood **lead** level in the traffic controllers was found to be 68.28 + or - 13.22 ug/dl. This is a very high level compared to an acceptable level of 30.00 ug/dl. All neurobehavioral symptoms demonstrated in the traffic controllers could be attributed to a high level of **lead** exposure. /Inorganic **lead**/
[Ahmed NS et al; Arch Environ Health 42 (2): 92 (1987)]**PEER REVIEWED**

Three epidemiological studies of workers exposed to **lead** & **lead** compounds were reviewed previously. ... A study on battery workers in the UK is now avail, & studies of a USA **lead** smelter & of a Swedish copper smelter have also been reported. ... The excess of resp cancer in these studies were relatively small, showed no clear-cut trend with length or degree of exposure, & could have been confounded by factors such as smoking or exposure to arsenic. ... /**Lead** and **lead** compounds/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. S7 230 (1987)]**PEER REVIEWED**

Short-term (acute): Exposure to inorganic **lead** can cause decreased appetite, insomnia, headache, muscle and joint pain, colic, and constipation. /Inorganic **lead**/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.]**PEER REVIEWED**

Long-term (chronic): Exposure to inorganic **lead** can cause weakness, weight loss, nausea, vomiting, constipation, blue or blue-black dot-like pigmentation on the gums (**lead** line), severe headache and abdominal cramps, delirium, convulsions, and coma. /Inorganic **lead**/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.]**PEER REVIEWED**

Health effects from **lead**, inorganic fumes and dusts (as Pb) /are/ cumulative blood and neurologic effects/reproductive hazard. /**Lead**, inorganic fumes and dusts (as Pb); from table/
[Cralley, L.J., L.V. Cralley (eds.). Patty's Industrial Hygiene and Toxicology. Volume III: Theory and Rationale of Industrial Hygiene Practice. 2nd ed., 3A: The Work Environment. New York, NY: John Wiley Sons, 1985.p. V3A 172]**PEER REVIEWED**

Following ingestion of a large amount of any soluble **lead** salt ... the initial signs and symptoms are due largely to local irritation of the alimentary tract, ... pain, leg cramps, muscle weakness, paresthesias, ... coma, and death may follow within 1 or 2 days. /**Lead**/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-138]**PEER REVIEWED**

Intoxication from multiple exposures ... represents a response to the accumulative retention of **lead** from repeated small intakes. Chronic plumbism expresses itself in many diverse ways, but three major clinical syndromes are recognized. The alimentary type ... the neuromuscular type ... /and/ ... the cerebral type ... In any type of chronic plumbism, the patient may show facial pallor, a gingival **lead** line, mild jaundice, anemia, basophilic stippling of the red blood cells, albuminuria, cylindruria, porphyrinuria, and excessive urinary and blood concentrations of **lead**. /**Lead**/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-138]**PEER REVIEWED**

One of the characteristic cellular metabolic reactions in **lead** intoxication is the formation of intranuclear inclusion bodies, a discrete, dense-staining mass found in the liver parenchyma and in the tubular lining cells of the kidney in man and animal. Consisting of a dense, central core and outer fibrillary zone, they can be identified and distinguished from those from bismuth intoxication or from those of viral origin by special stains (mercury bromophenol blue and basic fuchsin). **Lead** has been identified by direct chemical analysis to be in the form of a **lead**-protein complex to the extent of about 50 ug **lead**/mg protein. The included **lead** is 60 to 100 times more concentrated than whole kidney **lead**. /**Lead**/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 2073]**PEER REVIEWED**

Lead toxicity in adults results primarily from workplace exposure via inhalation. **Lead** exposure can occur by ingestion as a result of the lack of proper hygiene in **lead** contaminated environments (eg, eating or smoking in areas of **lead** work). /**Lead**/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 1030]**PEER REVIEWED**

IN THE **LEAD** OXIDE EXPOSED WORKERS IN THE STATE OF NUEVO LENO, MEXICO, SIGNIFICANT INCR IN CHROMOSOME DAMAGE, BLOOD **LEAD** LEVELS AND URINARY DELTA-AMINOLEVULINIC ACID LEVELS WERE SEEN IN COMPARISON TO CONTROLS. AS FOR GENETIC MARKER FREQUENCIES, SIGNIFICANT DIFFERENCES BETWEEN THE WORKERS & CONTROLS WERE SEEN ONLY IN THE RH BLOOD GROUP. NO SIGNIFICANT ASSOCIATION WAS FOUND BETWEEN GENETIC MARKERS & CHROMOSOME DAMAGE. /**LEAD** OXIDE/
[GARZA-CHAPA R ET AL; ARCH INVEST MED 11 (4): 547 (1980)]**PEER REVIEWED**

Colic is seen in children and US EPA concluded that the lowest-observed-adverse-effect level was in the range of 2.88-4.80 umol/L (60-100 ug/dl). /Inorganic **Lead**/
[WHO; Environ Health Criteria #165: Inorganic Lead p.203 (1995)]**PEER REVIEWED**

Reproductive effects /of men/ from occupational exposure to **lead** include asthenospermia, hypospermia, teratospermia and hypogonadism. In men, effects on sperm or the testes may result from chronic exposure to **lead** at blood levels of the order of 1.92-2.4 umol/liter (40-50 ug/dl). /Inorganic **lead**/
[WHO; Environ Health Criteria #165: Inorganic Lead p.205 (1995)]**PEER REVIEWED**

... The mortality was examined for the total 34 yr period 1947-1980. Elevated standardized mortality ratios for malignant neoplasms have been found in both battery and production workers, the excess deaths being predominantly from gastrointestinal tract cancer and lung cancer. In the battery workers, there were 34 deaths from stomach cancer with 20.2 expected and 109 deaths from lung cancer with 87.8 expected, both standardized mortality ratios being significantly raise. /**Lead**/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V1 373]**PEER REVIEWED**

... It has been possible to develop dose-effect relationships for **lead** exposure and anemia. However, since so many other factors may influence the degree of anemia, it has been more common to define a level of hemoglobin concentration and then to develop a dose-response relationship for the percent of the population with that or a lower concentration of hemoglobin. /**Lead** cmpd/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V1 152]**PEER REVIEWED**

Suggestive evidence of a **lead**-related decrease in hearing acuity in children has been reported. Hearing

thresholds at 2000 Hertz increased linearly with maximum blood **lead** levels, indicating that **lead** adversely affects auditory function. The blood **lead** levels in 75 asymptomatic black children, 3-7 years old, ranged from 6 to 59 ug/dL (mean = 26.7 ug/dL). The children were healthy and did not have middle ear infections at the time of testing. /**Lead** compound/
[Robinson GS et al; World Health Organization Regional Office for Europe, 177-82 (1985) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.46 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

The most extensive was a series of a large number of workers at 6 domestic **lead** production plants (smelters and recycling plants) and 10 battery plants. Increased incidences of total malignant neoplasms were observed for both categories of **lead** workers, but the increase was statistically significant only for **lead** production workers. The increase in total malignancies appeared to be due to small, statistically nonsignificant increases in digestive and respiratory tract tumors (evident in both the **lead** production and battery workers) and urinary tract tumors (in production workers). /**Lead** cmpd/
[Cooper WC; Ann NY Acad Sci 271:250-59 (1976) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.56 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

/It was/ reported that **lead** had no cancer-inducing properties, although standard mortality ratios of 125-149% for total malignant neoplasms, 172% for respiratory cancer, and 229% for cancers of other sites were reported in battery workers. In a recent evaluation of a more select subset from the original study, ... increased standard mortality ratios for total malignancies in both groups of workers (statistically significant only in the battery workers) attributed to digestive and respiratory cancers were reported. These small excesses of cancer death could not be correlated with onset, duration, or level of exposure. /**Lead** compound/
[Cooper WC; New York, NY: Academic Press, 111-43 (1981) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.56 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

In a study of **lead** workers, 15 who were identified had no other risk factors for renal disease and who had previously unsuspected **lead** nephropathy (detected as reduced glomerular filtration rates). Only 3 of the 15 men had experienced symptoms of **lead** poisoning. Blood **lead** levels were as follows: >80 ug/dL in 1 subject, 40-80 ug/dL in 11 subjects, and <40 ug/dL in 3 subjects. Examination of renal biopsies from 12 of these men revealed focal interstitial nephritis in 6, in addition to nonspecific changes, including deformed mitochondria, in proximal tubules. /**Lead** compound/
[Wedeen RP et al; Arch Intern Med 139: 53-7 (1979) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.29 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

Significantly increased central and peripheral nervous system and gastrointestinal symptoms were reported among 25 **lead** workers with maximum blood **lead** levels of 50-69 ug/dL and significantly increased central nervous system symptoms among 20 **lead** workers with maximum blood **lead** levels <50 ug/dL. /**Lead** compound/
[Haenninen H et al Neurotoxicology 1: 333-47 (1979) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.37 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

288 **lead** exposed workers (current or historical blood **lead** level of >35 ug/dL) at three battery plants with 181 unexposed workers (current blood **lead** level of less than or equal to 35 ug/dL) at a truck frame plant reported a few differences in neurobehavioral or psychosocial indices. Because the **lead** exposed workers were younger, less educated, employed for fewer years, and earned less income than the unexposed workers, the analysis adjusted for age , education, and income. Exposed workers had mean current, time weighted average and peak blood **lead** levels of 40.0, 48.8, and 78.8 ug/dL, respectively.

/**Lead** compound/
[Parkinson DK et al; Am J Epidemiol 123: 261-9 (1986) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.37-8 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

Twenty unexposed men (mean blood **lead** level = 20.4 ug/dL; range = 11.1-27.1 ug/dL), 20 men exposed to low **lead** levels (mean blood **lead** level = 31.7 ug/dL; range = 26-35 ug/dL), and 20 men exposed to high **lead** levels (mean blood **lead** level = 52.5 ug/dL; range = 45-60 ug/dL) at an electric storage battery plant were studied. Significant dose-response trends were observed in symptoms such as loss of appetite, paresthesia in lower limbs, weakness of upper limbs, and dropping of objects, with the most marked increases in neurological symptoms in the high-**lead** group. The high-**lead** workers performed significantly less well on neurobehavioral tests, with general performance on cognitive and visual motor coordination tasks and verbal reasoning ability most markedly impaired. /**Lead** compound/
[Campara et al; Int Arch Occup Environ Health 53: 233-46 (1984) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.38 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

Blood **lead** levels were reported on school children residing near a battery plant in Shanghai, China. A significant dose-effect relationship was found between children's blood **lead** levels and their neuropsychological performance without any obvious signs of **lead** poisoning. The blood levels in these children (6-14 years old) ranged from 10 to >30 ug/dL; IQ decreased as blood **lead** level increased. This dose-response existed after confounding variables were controlled. However, no non-**lead**-exposed group was used. The study estimated that an increase of 10 ug/dL of blood would result in a lowering of verbal IQ of 8 points, performance IQ of 7 points, and full-scale IQ of 9 points. /**Lead** compound/
[Wang L et al; Biomed Environ Sci 2: 325-30 (1989) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.44-5 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

In a cross-sectional study of 236 mothers and their infants in Glasgow, Scotland, reductions were demonstrated in gestational age with increasing cord or maternal blood **lead** levels. In the 11 cases of premature birth (gestational age <38 weeks), maternal blood **lead** levels averaged approximately 21 ug/dL, and cord blood **lead** levels averaged approximately 17 ug/dL at delivery. The overall geometric mean blood **lead** levels at delivery were 14 ug/dL (maternal) and 12 ug/dL (cord). Statistical analyses showed significant negative coefficients for length of gestation against log-transformed maternal or cord blood levels. Birth weight was not associated with blood **lead** levels. /**Lead** compound/
[Moore MR et al; Scott Med J 27: 113-22 (1982) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.48 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

Eighteen separate measures were made on a total of 201 boys and girls aged 5.5 years to assess a variety of cognitive, performance, neuropsychological, and behavioral end points. The children were randomly selected from birth records from inner city area of Birmingham, United Kingdom. The selection criteria were quite stringent to control for confounding factors in neuropsychological development. There were no significant correlations between blood **lead** and any of the three IQ measures. Birth order and mother's IQ were good predictors of IQ. The Factual Performance Test time decreased with increasing blood levels (an improvement in performance), but results of the star copying test were poorer as **lead** levels increased. /It was/ concluded that the effects of **lead** found in this inner urban area (mean blood **lead** = 13.05 ug/dL) in the United Kingdom are small and generally not significant. /**Lead** compound/
[Harvey PG et al; Br J Dev Psychol 6: 145:56 (1988) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.45 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

One hundred and four children of lower socioeconomic status were evaluated on the Bayley Mental Development Index (MDI) or Stanford-Binet IQ Scale at ages 10 months to 6.5 years by Schroeder.

Hierarchical backward stepwise regression analyses indicated that blood **lead** levels (range: 6-59 ug/dL) were a significant source of the variance in IQ and MDI scores after controlling for socioeconomic status and other factors. Fifty of the children were examined again 5 years later at which time blood **lead** levels were less than or equal to 30 ug/dL. The 5 years follow-up IQ scores were inversely correlated with contemporary and initial blood **lead** levels, but the effect of **lead** was not significant after covariates, especially socioeconomic status, were including in the analysis. /**Lead** compound/
[Schroeder SR et al; Environ Res 38: 144-154 (1985) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.44 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

Neurobehavioral function was measured in 59 **lead** workers and 59 controls matched for age, type of job, time on the job, education level, smoking history and alcohol assumption. Statistically significant decreases in the **lead**-exposed workers were seen for critical flicker fusion reaction, simple reaction time , tracking speeds, hand steadiness tests, and sensory store memory. Sensory store memory speed showed a low but statistically significant correlation with blood **lead** concentrations. Measurement of neurobehavioral function seemed well chosen, and repeated measures with associated appropriate statistics were used. The performance of the **lead**-exposed workers was significantly impaired. /**Lead** compound/
[Williamson AM, RKC Teo; Br J Ind Med 43:374-380 (1986) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.39 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

Autopsies of occupational workers showed that the **lead** content in lungs was elevated compared to control levels. Autopsies of nonoccupational subjects revealed that males had a higher **lead** content in tissues compared to females; however, sex differences in **lead** levels were not observed in tissues of children. In most soft tissues (including brain), **lead** does not appear to accumulate as a function of age in humans over 20 years old, but these data are based on limited sample size. /**Lead** compound/
[Barry PSI; Br J Ind Med 32: 119-39 (1975) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.103 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

Dose-response information on a pediatric population relating blood **lead** levels with the occurrence of acute encephalopathy and death was compiled ... The range of blood levels associated with encephalopathy was approximately 90-800 ug/dL (mean ~330 ug/dL), and the range associated with death was approximately 125-750 ug/dL (mean = 327 ug/dL). All but 1 of the 98 cases of fatal encephalopathy had blood levels 150 ug/dL. /**Lead** compound/
[Chisolm JJ Jr; J Pediatr 60: 1-17 (1962) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.20 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

High levels of **lead** have been suggested as a causative agent in Sudden Infant Death Syndrome (SIDS). Blood **lead** levels in 41 victims of Sudden Infant Death Syndrome (3.9 + or - 1.8 ug/dL) were compared to those of 77 living control babies (3.5 + or - 1.2 ug/dL) and 5 babies of the same ages who died from traumatic causes (3.5 + or - 2.1 ug/dL). The authors controlled for several factors that may influence blood **lead** levels, including post-mortem shifts in blood water, age, sex, social class, nutrition, fever prior to death or sampling, birth weight, complications at birth, premature birth, and pregnancy history of the mothers. None of these factors differed significantly between the Sudden Infant Death Syndrome babies and the control babies. The post-mortem shift in blood water was accounted for by calculation of the **lead** concentration in blood dry weight. ... a significantly greater number of the highest **lead** concentrations in dry blood were found in the Sudden Infant Death Syndrome group than in the control babies ($p < 0.01$) as determined by chi-square analysis. Based on these results, there may be an association between higher body burdens of **lead** and Sudden Infant Death Syndrome, but the mechanism behind this association cannot be determined at this time. Possibilities include an effect of

lead on prenatal and/or postnatal neurological development. /**Lead** compound/
[Drasch et al; Eur J Pediatr 147: 79-84 (1988) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.20 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

Construction workers (race not specified) using oxyacetylene torches to cut a metal bridge that had been painted with **lead**-based paint were reported to exhibit increases in heart rate and blood pressure after 4 wk of exposure. Steep increases in blood **lead** levels were observed only 2 wk after work began. Peak blood **lead** levels ranged from 48-120 ug/dL. Personal breathing zone exposure to airborne **lead** ranged from 600-4,000 ug/cu m. /**Lead** compound/
[Marino et al; Arch Environ Health 44: 140-145 (1989) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.21 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

An increased risk of death due to cerebrovascular disease was observed in a cohort of 1,261 white male newspaper printers (typesetters). /**Lead** compound/
[Michaels D et al; Int J Epidemiol 20: 970-983 (1991) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.21 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

In adults, a study of 75 autopsies of persons who had resided in a soft-water, leached soil region of North Carolina found a positive correlation between **lead** level in the aorta and death from heart-related disease. The association persisted after adjustment for the effect of age. /**Lead** compound/
[Voors AW et al; Arch Environ Health 37: 98-102 (1982) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.25 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

In a study of 102 cases of occupational **lead** poisoning, 17 cases of clinically verified chronic nephropathy were found. Endogenous creatinine clearance was <80 ug/dL. The mean blood **lead** level for the entire study population was 80 ug/dL (range = 42-141 ug/dL). Nephropathy was more common among those exposed to **lead** for more than 10 years than among those exposed for less than 10 years. /**Lead** compound/
[Lilis R et al; Br J Ind Med 25: 196-202 (1968) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.29 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

Excessive **lead** exposure has been implicated as a causative agent in kidney disease associated with gout. A correlation was found between the amount of mobilizable **lead** and the degree of renal impairment in 44 veterans with gout. The 44 gout patients were similar with respect to age, duration of gout, hypertension, history of **lead** exposure, serum uric acid concentration, blood **lead** and kidney function was assessed by measuring serum creatinine concentration, creatinine clearance, and 24-hr urinary protein excretion. The results of the 3-day EDTA **lead** mobilization test were significantly different for the gout patients with renal impairment than for the gout patients without renal impairment. The gout patients with renal impairment excreted 806 + or - 90 ug **lead** over the 3 days compared to 470 + or - 52 ug **lead** per three days in patients with gout but no renal impairment. The upper limit of normal in this test is 600 ug **lead** excreted over 3 days. To rule out the possibility that the renal impairment itself was the cause of excessive mobilizable **lead** in patients with gout, 10 patients with renal disease but no gout were used as controls for the EDTA **lead** mobilization test. These controls excreted approximately the same amount of **lead** over the 3 days as the gout patient 424 + or - 72 ug **lead**). In addition, the severity of renal impairment (as determined by the serum creatinine concentration) was directly correlated with the amount of mobilizable **lead** measured in the EDTA test. It is important to note that the gout patients with high mobilizable **lead** and renal impairment had blood **lead** levels and ZPP concentrations that were no different from the rest of the group, indicating that there was no indication of **lead** overexposure in these individuals until the EDTA **lead** mobilization test was administered. Based on these results, it

may be concluded that excessive **lead** absorption may somehow be involved in the renal impairment associated with some forms of gout. /**Lead** compound/
[Batuman V et al; N Engl J Med 304: 520-23 (1981) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.31 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

... The Fanconi syndrome is estimated to occur in approximately one out of three children with encephalopathy and blood **lead** levels of approximately 150 ug/dL. /**Lead** compound/
[National Academy of Sciences; Lead: Airborne lead in perspective: Biologic effects of atmospheric pollutants. 71-177, 281-313 (1972) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.32 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

In a preliminary report of a cohort study of Danish children of homogeneous social/ethnic background joining the first grade in 1982-1983, tooth **lead** was significantly associated with height after controlling for other variables (e.g., child's medical history, dietary history, behavior, tobacco smoking of parent, and sociodemographic factors). Exposed children had tooth **lead** levels of greater than 18.7 ug/g, while controls had tooth **lead** levels less than 5 ug/g. The average blood **lead** level in the exposed cohort was <60 ug/dL. The investigators concluded that early **lead** absorption was a risk factor for impaired growth in children. /**Lead** compound/
[Lyngbye T et al; International Conference on Heavy Metals in the Environment: The influence of environmental factors on physical growth in school age: A study of low level lead exposure p.210-12 (1987) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.35 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

Disturbances in reaction time, visual motor performance, hand dexterity, IQ test and cognitive performance, nervousness, mood or coping ability were observed in **lead** workers with blood **lead** levels of 50-80 ug/dL. /**Lead** compound/
[Arnvig E et al; Toxicol Lett 5: 399-404 (1980) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.38 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

... Observed hyperactivity and a decrement of approximately 16 IQ points on the McCarthy General Cognitive Index (GCI) among children who had previously had encephalopathy and whose average maximum blood **lead** levels at the time of encephalopathy were 88 ug/dL (average blood **lead** level = 59-64 ug/dL). Asymptomatic children with long-term **lead** exposures and average maximum blood **lead** levels of 68 ug/dL (average blood **lead** level = 51-56 ug/dL vs. 21 ug/dL in controls) had an average decrement of 5 IQ points on the McCarthy GCI. ... Children with short-term exposure and average maximum blood **lead** levels of 61 ug/dL (average blood **lead** level = 46-50 ug/dL) did not differ from controls. /**Lead** compound/
[Rummo JH et al; Arch Environ Health 34: 120-5 (1979) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.42 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

In comparison with children having low dentin **lead** levels (<10 ppm), children having high dentin **lead** levels (>20 ppm) had significantly lower full-scale WISC-Revised scores; IQ deficits of approximately 4 points; and significantly poorer scores on tests of auditory and verbal processing, on a test of attentional performance as measured by reaction time under conditions of varying delay, and on a teachers' behavioral rating. The frequency of non-adaptive classroom behavior as rated by teachers increased in a dose-related fashion to dentin **lead** levels. /**Lead** compound/
[Needleman HL et al; N Engl J Med 300: 689-95 (1979) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.42 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

... A cohort of children studied as primary school students was reexamined as young adults (mean age = 18.4 yr). Neurobehavioral functioning had been found to be inversely related to dentin **lead** levels at the earlier examination. When the 132 were reexamined 11 yr. later, impairment of neurobehavioral function was still found to be related to the **lead** content of teeth shed at the ages of 6 and 7 years. In this study, higher **lead** levels in childhood were significantly associated with lower class standing in high school, increased absenteeism, lower grammatical-reasoning scores, lower vocabulary, poorer hand-eye coordination, longer reaction times, and slower finger tapping. /**Lead** compound/
[Needleman HL et al; N Engl J Med 322: 83-8 (1990) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.43 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

Maternal and infant hair **lead** levels, determined from hair samples taken at birth, were found to be correlated inversely with results on neurobehavioral tests (McCarthy Scales of Children's Abilities) when the children were tested at 6 yr of age. /**Lead** compound/
[Bonithon-Kopp C et al; Neurobehav Toxicol Teratol 8: 307-310 (1986) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.52 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

A group of 150 workmen with long-term **lead** exposure were categorized by clinical and toxicological data into four groups: **lead**-poisoned (mean blood **lead** level = 74.5 ug/dL), and moderately (mean = 52.8 ug/dL), slightly (mean = 41 ug/dL), or physiologically (mean = 23 ug/dL) exposed to **lead**. The **lead**-poisoned group and moderately exposed group had decreases in fertility, as measured by asthenospermia, hypospermia, and teratospermia. The effect of **lead** was thought to be directly on the testes because tests for changes in gonadotropin secretion were negative. /**Lead** compound/
[Lancranjan I et al; Arch Environ Health 30: 396-401 (1975) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.54 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

Food and Environmental Agents: Effect on Breast-Feeding: Reported Sign or Symptom in Infant or Effect on Lactation: **Lead**: Possible neurotoxicity. /From Table 7/
[Report of the American Academy of Pediatrics Committee on Drugs in Pediatrics 93 (1): 142 (1994)]**PEER REVIEWED**

Bone may be affected adversely by **lead** but also serves as the body's major storage site. /Inorganic **lead**/
[WHO; Environ Health Criteria: Lead p.110 (1995)]**PEER REVIEWED**

One of the characteristic cellular metabolic reaction in **lead** intoxication is the formation of intranuclear inclusion bodies, a descrete, dense-staining mass found in the liver parenchyma and in the tubular lining cells of the kidney in man and animal. /**Lead**/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1711]**PEER REVIEWED**

Inorganic **lead** causes contraction of the peripheral vascular system and affects the blood and blood forming tissues (bone marrow). The "normal" cases of **lead** poisoning in industry always include hemopoietic effects; These occur very early, before the appearance of /other/ symptoms or signs and, therefore, are important for diagnosis. **Lead** shortens the life of erythrocytes and impairs hemoglobin synthesis. /**Lead** cmpd/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1201]**PEER REVIEWED**

Chronic exposure to **lead** has been found to produce infertility, germinal epithelium damage, oligospermia and testicular degeneration, decreased sperm motility, and prostatic hyperplasia. /**Lead**/
[Thomas, J.A., K.S. Korach, J.A. McLachlan. Endocrine Toxicology. New York, NY: Raven Press, Ltd., 1985. 167]**PEER REVIEWED**

There is convincing evidence that **lead** is transferred to neonates via maternal milk. It appears that maternal milk might be a source of **lead** for the neonates, particularly when metal levels are elevated in the mother. /**Lead**/
[Thomas, J.A., K.S. Korach, J.A. McLachlan. Endocrine Toxicology. New York, NY: Raven Press, Ltd., 1985. 168]**PEER REVIEWED**

Arthralgia, often associated with muscle aches and pain, is a frequent symptom in **lead** poisoning. Although generally thought to appear mainly in chronic poisoning, joint pain is often reported even by persons exposed briefly (weeks) who have relatively low blood **lead** concentrations. It is a symptom that ... frequently indicates that the blood **lead** concentration is on the rise. /**Lead**/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 744]**PEER REVIEWED**

The earliest subjective symptoms /of **lead** poisoning in working adults/ are diffuse and include weariness at the end of the day. The patient is moody and irritable and may fall asleep watching television. Often he loses his interest in leisure-time activities. Such mild symptoms frequently occur with blood-**lead** levels below 80 ug/100 ml. /**Lead** and compounds/
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 518]**PEER REVIEWED**

... /Researchers/ found impaired performances on tests of verbal concept formation, perceptual performance, and memory in a **lead**-exposed group with present **lead** concentrations between 40 and 60 ug/100 ml. /**Lead**/
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 782]**PEER REVIEWED**

A study of 260 infants prospectively followed from birth suggests that the expected stature of a child born to a mother with a prenatal blood **lead** concentration over 7.7 ug/dL is about 2 cm shorter at 15 mos of age if, potentially, the infant also incurred a 10 ug/dL blood level increase during the 3- to 15-month interval of life. /**Lead**/
[Ellenhorn, M.J., S. Schonwald, G. Ordog, J. Wasserberger. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. 2nd ed. Baltimore, MD: Williams and Wilkins, 1997. 1565]**PEER REVIEWED**

Moderate effects on follicle stimulating hormone and luteinizing hormone have been correlated with **lead** levels over about 50 ug/dL. /**Lead**/
[Ellenhorn, M.J., S. Schonwald, G. Ordog, J. Wasserberger. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. 2nd ed. Baltimore, MD: Williams and Wilkins, 1997. 1565]**PEER REVIEWED**

The relative risk of preterm delivery at exposure levels of 14 ug/dL or greater was 8.7 times the risk at levels of up to 8 ug/dL in one prospective study. A Cincinnati study noted a half-week's reduction in gestation for every 10 ug/dL increment in blood **lead**. /**Lead**/
[Ellenhorn, M.J., S. Schonwald, G. Ordog, J. Wasserberger. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. 2nd ed. Baltimore, MD: Williams and Wilkins, 1997. 1565]**PEER REVIEWED**

Lead has an adverse effect on fetuses, particularly in the later stages of development. Distribution of **lead** in fetal tissues was examined in a case in which a woman was exposed during pregnancy. The female worker was exposed to **lead** dust for 8 hr daily when conception occurred. ... Measurements of **lead** content were started after the end of the exposure and continued for 6 months until normal values were obtained. Because of half-life of nearly 20 days for **lead** elimination from blood, the estimated body burden at the end of exposure was about 1200 ppb. The fetal tissue samples contained between 0.4 (brain) and 7.9 (liver) ug Pb/g dry weight. The fetal **lead** was stored mainly in bone, blood, and liver.

/**Lead**/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 2073]**PEER REVIEWED**

Small increases in blood pressure have been related to adults with PbB levels down to 7 ug/dl. /**Lead**/
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.849]**PEER REVIEWED**

... PbB concentrations in excess of 60 ug/100 g ... have been associated with peripheral neuropathy, gastrointestinal disturbances and anemia. ... Nerve conduction velocities ... /decreases/ in workers with maximal blood leads between 50 and 70 ug/100 g. /**Lead**/
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.849]**PEER REVIEWED**

Medical Surveillance:

... Unacceptable absorption of **lead** posing a risk of **lead** poisoning is demonstrated at levels equal to or greater than 0.060 mg Pb/100 g whole blood. All workers subject to exposure to inorganic **lead** shall be offered biologic monitoring at least every 6 months. ... A medical examination for possible **lead** poisoning shall be made available to workers with unacceptable blood **lead** levels. Medical examination: Medical examinations shall be made available prior to employee placement and annually thereafter, unless a different frequency is indicated by professional medical judgement, based on such factors as emergencies, variations in work periods, and the existing health status of the individual worker. These examinations should focus on the blood forming elements, the kidneys, and the nervous and reproductive systems. They should include a physical examination, complete blood counts, blood **lead** determinations, routine urinalysis (specific gravity, sugar and protein determinations, and microscopic examination), and should record any signs or symptoms of plumbism present. ... Each employee who absorbs unacceptable amounts of **lead**, as indicated by biologic monitoring, shall be examined as soon as practical after such absorption is demonstrated and confirmed, and at least every three months thereafter until blood levels have returned to below the acceptable limit ... . If clinical evidence of plumbism is obtained from the medical examinations, the worker shall be kept under a physician's care until completely recovered, or maximal improvement has occurred. Medical records shall include information on all biologic determinations and on all required medical examinations. ... These records shall be kept for at least 30 years after the last occupational exposure to inorganic **lead**. /Inorganic **lead** compounds/
[NIOSH; Criteria Document: Inorganic Lead p.I-2 (1978) DHEW Pub. NIOSH 78-158]**PEER REVIEWED**

If environmental sampling and analysis show that environmental levels are at or greater than the recommended environmental levels, ... blood analysis shall be conducted quarterly ... until blood levels have returned to below the acceptable limit. If a blood level of 0.060 mg Pb/100 g or greater is found and confirmed by a second sample to be taken within two weeks, steps to reduce absorption of **lead** shall be taken as soon as the high levels are confirmed and a medical examination for possible **lead** poisoning shall be made available to workers with unacceptable blood **lead** levels. /Inorganic **lead** compounds/
[NIOSH; Criteria Document: Inorganic Lead p.I-2 (1978) DHEW Pub. NIOSH 78-158]**PEER REVIEWED**

In addition to the recommended methods for blood analysis, zinc protoporphyrin (ZPP) shows promise of being a very useful, more direct measure of **lead** activity. This additional blood test may be considered as an adjunct to the biologic monitoring program. /Inorganic **lead** compounds/
[NIOSH; Criteria Document: Inorganic Lead p.I-2 (1978) DHEW Pub. NIOSH 78-158]**PEER REVIEWED**

Medical records shall include information on all biologic determinations and on all required medical examinations. These records shall be available to the medical representatives of the employer, the Secretary of Labor, the Secretary of Health, Education, and Welfare and at the employee's request, to the employee's physician. These records shall be kept for at least 30 years after the last occupational exposure to inorganic **lead**. /Inorganic **lead** compounds/
[NIOSH; Criteria Document: Inorganic Lead p.I-2 (1978) DHEW Pub. NIOSH 78-158]**PEER REVIEWED**

... Comparative advantages of /the biological indicator/ delta-aminolevulinic acid dehydratase (ALAD) in typical (variable) occupational exposure conditions included: the highest sensitivity at low and relatively high **lead** exposure levels; better reflection of biologically active Pb as opposed to blood **lead** (PbB) (particularly compared to delta-aminolevulinic acid (ALAU) and coproporphyrin (CPU)); higher specificity compared to other indicators of Pb effect; and generally higher reliability with regard to biologically and methodologically induced variations. ... /**Lead**/
[Telisman S et al; Int Arch Occup Environ Health 50 (4): 397-412 (1982)]**PEER REVIEWED**

Medical examination: Medical examinations shall be made available prior to employee placement and annually thereafter, unless a different frequency is indicated by professional medical judgement, based on such factors as emergencies, variations in work periods, and the existing health status of the individual worker. These examinations should focus on the blood-forming elements, the kidneys, and the nervous and reproductive systems. They should include a physical examination, complete blood counts, blood **lead** determinations, routine urinalysis (specific gravity, sugar and protein determinations, and microscopic examination), and should record any signs or symptoms of plumbism present. If clinical evidence of plumbism is obtained from the medical examinations, the worker shall be kept under a physician's care until the worker has completely recovered, or maximal improvement has occurred. /Inorganic **lead**/
[NIOSH; Criteria Document: Inorganic Lead p.I-2 (1978) DHEW Pub. NIOSH 78-158]**PEER REVIEWED**

Periodic medical examination should involve measurement of health risk (PbB), and of health effects (ZPP, Hb, physical examination). Preemployment examination should include measurement of PbB, ZPP, Hb. /**Lead** alloys and inorganic cmpd/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1204]**PEER REVIEWED**

The assessment of **lead** exposure can be accomplished through measurement of **lead**, which has been found to be indicative of recent exposure or exposure over a period of up to 3 to 5 weeks. In addition, zinc proptoporphyrin levels can be measured, which is indicative of **lead** exposure from greater than a month prior. Blood Reference Ranges: Normal - Children (0-6 yr old): Less than 10 ug/dl; Adults: Less than 10 ug/dl; Exposed - Children (0-6 yr old): Greater than or equal to 10 ug/dl; Action level for occupational exposure: 40 ug/dl; BEI (sampling time not critical): 30 ug/dl whole blood; BAT (sampling time is not fixed): 700 ug/dl; (women < 45 yr): 300 ug/l; Toxic - Children (0-6 yr): Greater than 70 ug/dl; Adults: Greater than 80 ug/dl. ... /**Lead**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1517]**PEER REVIEWED**

Evaluation of Peripheral Neuropathy: Nerve conduction study; Electromyography; Quantitative sensory testing; Thermography. /**Lead**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1521]**PEER REVIEWED**

Evaluation of Central Nervous System Effects: Evaluation of CNS effects can be performed through

neuropsychological assessment, which consists of a clinical interview and administration of standardized personality and neuropsychological tests. The areas that the neuropsychology test batteries focus on include the domains of memory and attention; visuoperceptual, visual scanning, visuospatial, and visual memory; and motor speed and reaction time. There is limited data on which components of the test batteries are best indicators of early CNS effects. /**Lead**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1521]**PEER REVIEWED**

Evaluation of Cranial Neuropathies: Evaluation of cranial nerve damage, as evidenced by symptoms such as loss of balance, visual function, smell, taste, or sensation on the face, can be accomplished through a physical examination focusing on tests such as: Smell Assessment ... Vision Assessment ... Facial and Trigeminal Nerve Assessment ... Vestibular Assessment ... Hearing Assessment. /**Lead**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1522]**PEER REVIEWED**

Populations at Special Risk:

Population subgroups expected to have a more than average susceptibility to **lead** induced neuropathy are: Individuals with one kidney removed; Persons genetically predisposed to renal tubular dysfunction; Individuals who excrete a lower percentage of absorbed Pb than normal. /Inorganic **lead** compounds/
[Nat'l Research Council Canada; Effects of Lead in the Canadian Environment p.67 (1978) NRCC No.16736]**PEER REVIEWED**

Children with pica for paint chips or for soil may experience an elevation in blood **lead** ranging from marginal to sufficiently high levels to cause clinical illness. ... Women in workplace are more likely to experience adverse effects from **lead** exposure than men due to the fact that their hematopoietic system is more **lead** sensitive than men's. /Inorganic **lead** compounds/
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 543]**PEER REVIEWED**

Children with sickle-cell anemia are at greater risk of developing nervous system effects due to **lead** absorption ... /because the disease results in/ an increased erythrocyte turnover, ... altered renal functioning ... and a zinc deficiency. ... /**Lead** cmpd/
[Nat'l Research Council Canada; Effects of lead in the Canadian Envir p.571 (1978) NRCC No.16736]**PEER REVIEWED**

Pregnant women undergoing lithium (Li) psychotherapy were considered ... especially susceptible to **lead** (Pb) exposure ... /since/ both Li and Pb cross the placental barrier and could interact to harm the fetus. /**Lead**/
[Nat'l Research Council Canada; Effects of Lead in the Canadian Envir p.563 (1978) NRCC No.16736]**PEER REVIEWED**

Exposure to **lead** is dangerous for the fetus, because of its great sensitivity during development, and for young children, because they ingest more **lead** through normal mouthing activity, absorb more of the **lead** that they ingest, and are more sensitive to its effects. /**Lead** cmpd/
[Agency for Toxic Substance and Disease Registry; Toxicological Profile for Lead: 3 (1988)]**PEER REVIEWED**

Exposure of a mother to **lead** results in the transfer of **lead** to the fetus and may cause preterm birth, reduced birth weight, and decreased intelligence quotient (IQ) in the infant. /Inorganic **lead**/
[Agency for Toxic Substance and Disease Registry; Toxicological Profile for Lead: 3 (1988)]**PEER REVIEWED**

Individuals with sickle-cell anemia may be at greater risk than normal individuals of developing nervous system effects from **lead** exposure because the disease results in increased erythrocyte turnover, altered

kidney function and zinc deficiency. Individuals with S or C thalassemia have increased susceptibility to the effects of Pb on red blood cell synthesis. Individuals having genetically caused glucose-6-phosphate dehydrogenase deficiency are at higher risk of Pb induced hemolysis than normal individuals. Various iron storage diseases may incr Pb in the human liver. /Inorganic **lead**/
[Nat'l Research Council Canada; Effects of Lead in the Canadian Envir p.67 (1978) NRCC No.16736]**PEER REVIEWED**

Children from disadvantaged backgrounds had higher mean **lead** levels than those from more advantaged backgrounds, and this difference persisted when other social environmental factors (such as the effects of housing, proximity to main roads, and childhood pica) were taken into account. /Inorganic **Lead**/
[WHO; Environ Health Criteria #165: Inorganic Lead p.157 (1995)]**PEER REVIEWED**

... If a pregnant woman is exposed to **lead**, it can be carried to the unborn child and cause premature birth, low birth weight, or even abortion. /**Lead** cmpd/
[DHHS/ATSDR; Toxicological Profile for Lead p. 2 (1990) TP-88/17]**PEER REVIEWED**

Young children are at risk because they swallow **lead** when they put toys or objects soild with **lead** containing dirt in their mouths. For infants and young children, **lead** exposure has been shown to decrease intelligence (IQ) scores, slow their growth, and cause hearing problems. /**Lead** cmpd/
[DHHS/ATSDR; Toxicological Profile for Lead p.2-3 (1990) TP-88/17]**PEER REVIEWED**

Probable Routes of Human Exposure:

The principal route of exposure ... is food, and sources that produce excess exposure and toxic effects are usually environmental and presumably controllable. These sources include ... **lead** in air from combustion of **lead** containing industrial emissions, **lead** based paint, hand to mouth activities of young children living in polluted environments, **lead**-glazed pottery &, less commonly, **lead** dust brought home by industrial workers on their clothes & shoes.
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 704]**PEER REVIEWED**

Lead is dissolved out of **lead** water supply pipes to enter the diet through the drinking water. ... The disposal of metallic **lead** & demolition debris in landfills therefore poses a potential hazard if the leachate is allowed to pass into ground water feeding a water supply system.
[Sax, N.I. Dangerous Properties of Industrial Materials. 5th ed. New York: Van Nostrand Rheinhold, 1979. 221]**PEER REVIEWED**

Eating of **lead** paint by children and drinking of **lead** contaminated, distilled (moonshine) whiskey are important sources of nonindustrial poisoning. ... Exposure to burning battery castings, drinking of liquids from improperly fired, **lead** glazed containers, and high levels of airborne **lead**.
[NIOSH; Criteria Document: Inorganic Lead p.III-3 (1978) DHEW Pub. NIOSH 78-158]**PEER REVIEWED**

... Man absorbs **lead** in small amounts, which normally does not cause poisoning, from food, water, and air.
[NIOSH; Criteria Document: Inorganic Lead p.III-3 (1978) DHEW Pub. NIOSH 78-158]**PEER REVIEWED**

Poor work hygiene, smoking during work (pollution of tobacco; polluted fingers while smoking), poor personal hygiene may considerably increase total exposure mainly by the oral route.
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1201]**PEER REVIEWED**

Ingestion of dust, inhalation of dust or fume, skin and eye contact. /Inorganic **lead** compounds/
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 544]**PEER REVIEWED**

Exposures to **lead** dust may occur during mining, smelting, and refining and to fume, during high temp (above 500 deg C) operations such as welding or spray coating of metals with molten **lead**. There are numerous applications for **lead** compounds, some of the more common being in the plates of electric batteries & accumulators, as compounding agents in rubber mfr, as ingredients in paints, glazes, glass, pigments, & in the chemical industry. It is est that approximately 783,000 industrial workers are potentially exposed to **lead** products. ... The level of exposure resulting from contact is highly variable. Children with pica for paint chips or for soil may experience elevation in blood **lead** ranging from marginal to sufficiently great to cause clinical illness. Certain adults may also be exposed to hazardous concn of **lead** in the workplace, notably in **lead** smelters and storage battery manufacturing plants. Again the range of exposure is highly variable. /Inorganic **lead**/
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 543]**PEER REVIEWED**

LEAD ALMOST ALWAYS ENTERS THE BODY THROUGH THE MOUTH, ALTHOUGH THE INHALATION OF **LEAD** LADEN DUST CAUSED BY MECHANICAL REMOVAL OF PAINT CAN CAUSE POISONING. /**LEAD**/
[Clarke, M. L., D. G. Harvey and D. J. Humphreys. Veterinary Toxicology. 2nd ed. London: Bailliere Tindall, 1981. 56]**PEER REVIEWED**

Traces of **lead** occur in many rocks in addition to those that qualify as ores. It thus finds its way into soil & water & hence into food & into human & animal tissues even in remote places where there is no use of the metal or its compounds. /**Lead**/
[Hayes, Wayland J., Jr. Pesticides Studied in Man. Baltimore/London: Williams and Wilkins, 1982. 29]**PEER REVIEWED**

The exposure of humans ... to **lead** contamination in the environment, & the ingestion of **lead** from cooking & eating utensils causes **lead** poisoning. Acidic food, fruit juices, & wines stored in **lead**-lined bronze utensils cause high **lead** toxicity among the Romans. ... Improperly glazed pots have caused **lead** poisoning in recent times. /**Lead**/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 185]**PEER REVIEWED**

... SEVERE MANIFESTATIONS, ESPECIALLY ENCEPHALOPATHY, ARE PRACTICALLY NEVER ENCOUNTERED IN INDUSTRY ... OCCUPATIONS IN WHICH **LEAD** POISONING IS INVOLVED INCLUDE "THE USE OR HANDLING OF OR EXPOSURE TO FUME, DUST OR VAPOR OF **LEAD** OR CMPD OF **LEAD**, OR SUBSTANCE CONTAINING **LEAD**"... /Inorganic **lead**/
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969. 177]**PEER REVIEWED**

Sources of **lead** in a child's environment include house dust (new inner-city homes, 2 to 24 ug/sq ft floor surface; contaminated sources: old inner-city homes, 33 to 486 ug/sq ft floor surface, mean 11,000 ug/g; homes of **lead** smelter workers, mean 2,687 ug/g; homes within 1.6 km of smelter, mean 22,191 ug/g; & homes located 1.7 to 3.2 km from smelter, mean 2,124 ug/g). /Inorganic **lead**; from table/
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 1031]**PEER REVIEWED**

Increased blood pressure is associated with blood **lead** concentrations possibly as low as 7 ug/dL. It appears that this relationship is particularly significant for middle-aged white males (aged 40-59). /**Lead**/

[USEPA; Air Quality Criteria for Lead (1986) EPA 600/8-83-028F as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.201 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

People living in the vicinity of **lead** mining operations, processing, and use operations may be exposed to **lead** principally by ingesting soil, although the form of **lead** ingested is not usually known. **Lead** may be released from contaminated soil in the stomach after which it may be absorbed in moderate quantities. In a recent study, it was found that over 50% of the total **lead** was released from contaminated soil from a Pb mining and processing site within the first 10 minutes of exposure to simulated gastric conditions; release rates at 297 K and pH 1 were 53 and 31 mg of Pb/min during this period but subsequently declined(4). However geochemical factors that control Pb availability in mining waste combine to decrease the potential bioavailability of Pb when compared to urban or smelter-derived soil(5). The general population is exposed to **lead** in the air which arises from the use of leaded gasoline and industrial sources. This **lead** is primarily in airborne particulate matter that settles out on plants and in water and may subsequently be ingested. **Lead** in drinking water most frequently arises in soft water areas where the water distribution system contains **lead** pipe(1), however the water supply itself may contain **lead** from natural sources, fallout or runoff. **Lead** may also leak into tap water from PVC as well as leaded pipes since **lead** stearate is used as a stabilizer in PVC pipe(3). **Lead** concentrations in canned food vary widely but they average about ten times greater than fresh food(1). Another source of dietary **lead** is from the use of inadequately glazed earthenware vessels for food storage and cooking(1). Exposure may arise from contact with clothing from occupationally exposed people, drinking whiskey made in home-made stills containing **lead** and contact with **lead** storage batteries(2). Children are exposed to **lead** from ingesting **lead** paint, colored newsprint or playing in the dirt especially near busy highways(2).
[(1) USEPA; Air Quality Criteria for Lead; p. 7-1 to 7-17 USEPA-600/8-77-017 (1977) (2) IARC; Monograph Some Metals and Metallic Compounds 23: 325-415 (1977) (3) USEPA; Ambient Water Quality Criteria for Lead; p. B-1 to B-38, C-1 to C-5 USEPA-440/5-80-057 (1980) (4) Gasser UG et al; Environ Sci Technol 30: 761-9 (1996) (5) Davis A et al; Environ Sci Technol 26: 461-8 (1992)]**PEER REVIEWED**

Depending on water quality, new cast brass faucets could contribute in excess of 10 ug/l of **lead** to drinking water. In a laboratory study designed to assess the leaching of **lead** from faucets, it was found that 60 to 75% of the leached **lead** appear in the first 125 ml of water drawn and that after 200-250 ml has flowed, 95% of the **lead** has been flushed(1). Nonmetallic faucets or faucets with small amounts of brass did not present a problem even when the water was very aggressive. Air concns in three primary **lead** smelters, 80-2900 ug/cu m, mean(2); electric storage battery manufacture, 50-5400 ug/cu m, mean; welding and shipbuilding, 180-2700 ug/cu m; printing, 30-360 ug/cu m, tetraalkyl **lead** manufacture, 120-179 ug/cu m(2). Geometric mean air Pb levels in areas of an acid-**lead** battery factory were: 92.01 ug/cu m in the casting and pasting areas; 85.73 ug/cu m in the assembly line area; 36.31 ug/cu m in the battery charging and sales area; and 4.2 ug/cu m in the administration area(3).
[(1) Gardels MC, Sorg TJ; J Amer Water Works Assoc 81: 101-13 (1989) (2) World Health Organization; Envrionmental Health Criteria 3. Lead. Geneva, Switzerland: World Health Organization (1977) (3) Ibiebele DD; Sci Total Environ 152: 269-73 (1994)]**PEER REVIEWED**

Electric arc welding produced an average concn of 5.63 mg/cu m and oxy-acetylene welding produced 1.96 mg/cu m of **lead**. /**Lead** fume/
[NIOSH; Criteria Document: Inorganic Lead p.IV-3 (1978) DHEW Pub. NIOSH 78-158]**PEER REVIEWED**

Body Burden:

In human subjects with low level exposure, about 90% of the total body burden is found in bone. ... /It was/ found that in the United Kingdom the **lead** concentration in bones of men & women over 16 yr of age ranged from 9 to 34 mg/kg wet wt. The concn in liver was about 1 mg/kg; & in the kidney, 0.8 mg/kg in the cortex & 0.5 mg/kg in the medulla. Studies in the United States & Japan revealed similar concentrations & distribution patterns. A comparatively high concentration (2.5 mg/kg wet wt) was found in the aorta with atheroma. Also, /it is/ reported that the mean **lead** concentration in the brain cortex of 50 adult males did not exceed 0.1 mg/kg wet wt with a range of individual values from 0.02 to 0.8 mg/kg; in the basal ganglia the range was 0.04 to 0.2 mg/kg. According to the review ... /of/ literature of accumulation & distribution of **lead** in human tissues, there are no marked trends of either increase or decrease of avg **lead** body burden in human adults. /Inorganic **lead** compounds/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 313]**PEER REVIEWED**

... In human milk in concentrations ... up to 12 ug/l. /Inorganic **lead**/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 314]**PEER REVIEWED**

Lead has a strong tendency to localize and accumulate in bone. /Inorganic **lead**/
[WHO; Environ Health Criteria: Lead p.80 (1977)]**PEER REVIEWED**

... THERE IS FAIRLY GOOD CORRELATION BETWEEN DEGREE OF **LEAD** INTOXICATION & BODY BURDEN OF **LEAD**, MAIN EXCEPTION BEING WHERE THERE HAS BEEN HIGH EXPOSURE OVER SHORT PERIOD. /INORGANIC **LEAD** COMPOUNDS/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V1 47 (1972)]**PEER REVIEWED**

Body burden of **lead** increases from birth to old age. /Inorganic **lead**/
[Barry PSI; Brit J Ind Med 32: 119-39 (1975) as cited in WHO; Environ Health Criteria: Lead p.81 (1977)]**PEER REVIEWED**

The body burden of the average adult in the USA is reported to be not less than 100 mg and not more than 300 mg. Ninety five percent of the total body burden is stored in bone. /**Lead**/
[Committee on Biological Effects of Atmospheric Pollutants, Lead, National Academy of Sciences, Washington, DC (1972)]**PEER REVIEWED**

The half-life of **lead** in human blood is 28 to 36 days (Griffin et al, 1975, Rabinowitz et al, 1976); thus, levels of **lead** in blood reflect relatively recent exposure compared with levels of **lead** in teeth, which continue to accumulate **lead** over time. /Inorganic **lead**/
[Agency for Toxic Substance and Disease Registry; Toxicological Profile for Lead: 25 (1988)]**PEER REVIEWED**

A cross-sectional study of blood **lead** levels in 100 inner city residents of Stockholm for the period of 1980-1984 was conducted to investigate whether recent measures undertaken in Sweden to decrease environmental exposure to **lead** have had any effect. Measures include replacement of **lead** soldered food cans and a decrease in allowable gasoline levels from 1.9 to 0.7 mmol **lead**/l gasoline. The average blood **lead** levels of all the subjects examined were 0.37, 0.26, and 0.25 umol/l for 1980, 1983, and 1984, respectively. The mean change in individual levels between 1980 and 1984 was 0.12 umol/l, which corresponds to an average individual decrease in blood **lead** of 34%. The decrease occurred mainly during the period 1980-1983 (0.11 umol/l) and was statistically significant for this period ($p<0.01$). Age, sex, and change of residence during the observation period did not influence the results.
[Elinder CG et al; Scand J Work Environ Health 12: 114-20 (1986)]**PEER REVIEWED**

Seventy-five workers in 27 radiator repair shops were interviewed and tested for blood Pb and free erythrocyte protoporphyrin levels. Fifty-six of the workers were actual radiator mechanics (repairing and soldering radiators) and 19 workers performed other jobs, such as trucking and delivery. No totally unexposed controls were tested. The mean blood Pb level found in the radiator mechanics was 37.1 +/- 13.8 ug/dl (range 16-73 ug/dl), (39% had blood Pb levels >40 ug/dl and 16% had levels >50 ug/dl). The mean blood Pb level for the other workers was 21.6 +/- 11.2 ug/dl (range 7-51 ug/dl). Multiple regression analysis showed that the most significant variable contributing to an increase in the blood Pb level was the number of radiator repair stations within the shop. Mean zinc protoporphyrin levels (used as a screen for **lead** intoxication) was 40.6 ug/dl for the radiator mechanics and 15.6 ug/dl for the other workers. One 32 yr-old radiator mechanic whose Pb level was 72 ug/dl, reported with symptoms of fatigue, headache, dizziness, nausea, and abdominal and back pains.
[Goldman RH et al; N E J Med 317 (4): 214-8 (1987)]**PEER REVIEWED**

A group of 109 male workers occupationally exposed to both antimony (as Sb2O3) and **lead** in the glass-producing industry were examined for levels of these metals in whole blood and urine. The workers were divided into four groups based on specific work activities: melter (n= 32), batch mixer (n= 45), craftsman (n= 8), and glass washer (n= 24). Blood and urine samples were collected at the end of a shift. Concentrations of **lead** in the blood ranged from 70 to 680 ug/l. Median values for melters, batch mixers, craftsmen, and glass washers were 220, 340, 275, and 170 ug/l, respectively. A significant difference ($p< 0.05$) was found only between the batch mixers and glass washers. The urinary **lead** values ranged from 7 to 110 ug/l with median values for melters, batch mixers, craftsmen, and glass washers of 35, 43, 24, and 42 ug/l, respectively. A significant difference was found between only the batch mixers and craftsmen ($p< 0.05$). Exposure rates for **lead** were not given.
[Ludersdorf R et al; Int Arch Occupat Environ Health 59 (5): 469-74 (1987)]**PEER REVIEWED**

Total **lead** content in 60-70 year old men may reach more than 200 mg with about 95% residing in the bone(1). The mean **lead** level in the milk of occupationally unexposed women in Malaysia was 43.5 ug/l(5). Human milk 12 ug/l and <5 ug/l in 2 studies(1). Blood **lead** 100-250 ug/l in occupationally unexposed rural and urban populations in the majority of studies(1). Blood levels of German children 0-1 yr 33 ug/l, 6-8 yr 115 ug/l. Children aged 1-5 in rural U.S. counties 228 ug/l avg(1). Urban children may display blood **lead** levels >590 ug/l(1). Blood levels in children in a Texas city with smelter >400 ug/l(1). Human tissue from an industrial city and rural area in northwest Germany 4.53 ppm avg and 2.74 ppm avg respectively(2). Average blood levels in the EPA sponsored NHANES II survey from Feb 1976 to Feb 1980 fell from 158 to 98 ug/l, during which time the semiannual use of **lead** in gasoline dropped from 105 to 48 thousand tons(3). Mean **lead** levels in whole blood and urine of subgroups of low income rural black and urban Hispanics of Mexican-American ancestry ranged from 39.2-138.8 ug/l and 1.9-8,5 ug/l(4). Levels were highest for male rural blacks and lowest from urban female Hispanics.
[(1) IARC; Monograph Some Metals and Metallic Compounds 23: 325-415 (1977) (2) International Register of Potentially Toxic Chemicals; p. 171-77 United Nations Environment Program Geneva Switzerland (1979) (3) Schwartz J et al; Cost and Benefits of Reducing Lead in Gasoline USEPA-230-03-84-005 (1984) (4) Prevost RJ et al; Measurement of Cadmium, Lead. Zinc, and Calcium in selected populations in the United States USEPA-600/S1-84-021 (1985) (5) Ong CN et al; Arch Disease Childhood 60: 756-9 (1985)]**PEER REVIEWED**

A survey of **lead** in hair among suburban University communities in England and West Germany found mean (standard deviation) levels of 10.2 (8.4) and 8.2 (6.4) ug/g respectively(1). The results also showed that the average smoker has hair levels that are on the average 2.25 ug/g above those of nonsmokers and that females have hair **lead** levels averaging 2.8 ug/g higher than those of males. The geometric mean (range) blood **lead** level in the U.S. Population as determined in he National Health and Nutrition

Survey (NHANES III, 1988-1991) was 2.8 (2.7-3.0) ug/dl (n = 13,201)(3). A group of 31 subjects that consumed fish from the Great Lakes had geometric mean whole blood **lead** levels of 4.0 ug/dl (range 0.9-13.0)(2). The mean blood **lead** levels of 60 inhabitants of a Polish village 900 m from a copper smelter dropped from 0.52 to 0.31 ug/ml in five years(4). In that time, the emission of **lead** in dust dropped from 1729 to 30 tons/yr. The mean (standard deviation) blood **lead** levels of 42 non-exposed, non-smoking Finnish females was 0.28 (0.12) umol/l(6). While the mean (standard deviation) dietary intake of the subjects were 14.5 (3.1) ug/day, it was concluded that blood **lead** levels were not a good indicator of **lead** exposure. Thirty-one children exposed to **lead** had whole blood Pb concns of 99-920 ug/l, 370 ug/l median versus 39-120 ug/l, 66 ug/l median for 13 considerably less exposed (unexposed) children(7). Corresponding plasma Pb concns were 0.46-18.4, median 2.4 ug/l and 0.14 to 0.38, median 0.21 ug/l, respectively. The relationship between blood **lead** and plasma **lead** was non-linear with increases in blood Pb being relatively less than plasma **lead**. The **lead** levels in deciduous teeth of children living near a **lead** smelter decreased with distance from the smelter(5). The mean tooth **lead** levels were (concn in ug/g (distance from smelter)): 34.6 (150-180 m); 19.3 (1200-3400 m); 19.5 (4200-6500 m); 7.4 (7 km).
[(1) Ahmed AFM, Elmubarak AH; Bull Environ Contam Toxicol 45: 139-48 (1990) (2) Anderson HA et al; Environ Health Perspectives 106: 279-89 (1998) (3) Brody DL et al; JAMA 272: 277-83 (1994) (4) Andrzejak R et al; Sci Tot Environ, Suppl 1993: 233-6 (1993) (5) Blanusa M et al; Bull Environ Contam Toxicol 45: 478-85 (1990) (6) Louekari K et al; Sci Tot Environ 105: 87-99 (1991) (7) Bergdahl IA et al; Environ Research A80: 25-33 (1999)]**PEER REVIEWED**

Blood, sweat, and urine levels in 19 battery factory workers were 13-36 ug/dl, 72-256 ug/l, and 28-288 ug/g creatinine compared with 9-12.2 ug/dl, 9-30 ug/l, and 9-19.6 ug/g creatinine for 8 controls(1). Breast milk of 35 women living with a 200 m radius of 3 smelters in Mexico City contained 0.92-35.10 ug Pb/dl, mean 6.18 ug Pb/dl(2). **Lead** levels in shed teeth (dentin) of 2187 children from Boston averaged 3.4 ug/g with a standard deviation of 2.4 ug/g(3).
[(1) Omokhodion FO, Howard JM; Sci Tot Environ 103: 123-8 (1991) (2) Namihira D et al; J Toxicol Environ Health 38: 225-32 (1993) (3) Rabinowitz MB e tal; Bull Environ Contam Toxicol 47: 602-8 (1991)]**PEER REVIEWED**

Average Daily Intake:

An average daily intake of 231 ug **lead** for Finnish adult males and 178 ug Pb for adult females was reported. This is consistent with a British study reporting 274 ug Pb/day for young adults and with a Japanese study reporting 299 ug Pb/day for adult males doing medium work. The first two studies described the duplicate portions technique, whereas the third used the composites approach. Another study reported an average intake of 218 ug Pb/day for sedentary men.
[USEPA; Ambient Water Quality Criteria Doc: Lead p.C-6 (1980) EPA 440/5-80-057]**PEER REVIEWED**

AIR INTAKE: (Assume 1 ug/cu m) 20 ug, 40 ug adult(4), 6 ug child(4); WATER INTAKE: (Assume 15 ug/l) 30 ug, 12 ug adult(4), 13 ug child(4); FOOD INTAKE: (Assume 100-500 ug/day) 100-500 ug, 180 ug adult which includes 60 ug from surface contamination(4), 170 ug child which includes 40 ug from surface contamination and 48 ug from dirt on hands(4). It has been estimated that adult Americans absorb 29 ug of Pb daily from atmospheric and dietary sources with approximately 9% of one's Pb intake being absorbed(3). Results of a study of **lead** in two low income groups, rural black and urban Hispanics of Mexican-American ancestry showed that Pb ingestion by these groups (means of subgroups 16.4-82.1 ug/day) were no greater than and is probably less than that of the general population(3). The average dietary intake in the U.K. is about 30 ug(2). Fruits and vegetables exposed to source emissions of **lead** may be appreciably contaminated. One researcher determined that the daily ingestion of **lead** in the food of peasants living near a smelter was 670-2640 ug(1). Dietary exposure to **lead** ranges from 100-500

ug/day(5), however, people living near a smelter have intakes of 670-2640 ug/day(5).
[(1) World Health Organization; Envrionmental Health Criteria 3. Lead. Geneva, Switzerland: World Health Organization (1977) (2) Sherlock JC; Environ Geochem Health 9: 43-7 (1987) (3) Prevost RJ et al; Measurement of Cadmium, Lead. Zinc, and Calcium in selected polulations in the United States USEPA-600/S1-84-021 (1985) (4) Bennett BG; IARC 71: 115-28 (1986) (5) IARC; Monograph Some Metals and Metallic Compounds 23: 325-415 (1980)]**PEER REVIEWED**

Average daily inputs from diet estimated for 8 population groups from U.S. FDA's Total Diet Study were(age/sex group, average daily intake in ug/day): 6-11 mo, 16.7; 2 yr, 23.0; 14-16 yr female, 28.7; 14-16 yr male, 41.3; 25-30 yr female, 29.6; 25-30 yr male, 40.9; 60-65 yr female, 30.4; 60-65 yr male, 37.6(1). The 234 representative food items for the survey were obtained in retail markets in 4 broad geographical areas of the US between 1982 and 1984. Average daily inputs from diet estimated for 10 population groups by Health and Welfare Canada were (age/sex group, average daily intake in ug/day): 1-4 yr, 15; 5-11 yr, 20; 12-19 yr female, 21; 12-19 yr male, 26; 20-39 yr female, 24; 20-39 yr male, 33; 40-65 yr female, 23; 40-65 yr male, 30; 65+ yr female, 20; 65+ yr male, 24(2). The average dietary **lead** intake for all ages male and female was 24 ug/day(3). The food items for the survey was purchased in 5 Canadian cities between 1984 and 1986. The estimated dietary intake of **lead** by 0-12 month-old infants in Canada fed milk or formula was (milk or formula, Pb intake in ug/kg-day): human milk, 1.13; ready-to-use formula, 1.19; concentrated liquid formula, 1.64; powdered formula, 1.96; evaporated milk (**lead**-free), 1.60; evaporated milk (**lead**-soldered), 6.04(3). Average daily dietary exposures to Pb were estimated by combining data on annual diet, as measured by a food frequency questionnaire, with contaminant residue data for table-ready food collected as part of the FDA Total Diet Study(4). Estimated mean, geometric mean (standard deviation), minimum and maximum levels for 78,882 adult females and 38,075 males in 1990 were 14.9, 13.6 (1.51), 2.07, 163.5 and 14.8, 13.4 (1.54), 0.59, 160.3 ug/day, respectively.
[(1) Gunderson EL; J Assoc Off Anal Chem 71: 1200-9 (1988) (2) Dabeka RW, McKenzie AD; J AOAC International 78: 897-909 (1995) (3) Dabeka RW; Sci Total Environ 89: 279-89 (1989) (4) MacIntosh DL et al; Environ Health Perspectives 104: 202-9 (1996)]**PEER REVIEWED**

LEAD, ELEMENTAL

CASRN: 7439-92-1

This record contains information for lead in its zero valence state only. For general toxicity and environmental fate of lead ions and lead compounds, refer to the LEAD COMPOUNDS record; for compound-specific information, to the appropriate individual record, e.g., lead iodide, lead phosphate, etc.

For other data, click on the Table of Contents

Human Health Effects:

Evidence for Carcinogenicity:

CLASSIFICATION: B2; probable human carcinogen. BASIS FOR CLASSIFICATION: Sufficient animal evidence. Ten rat bioassays and one mouse assay have shown statisticlly significant increases in renal tumors with dietary and subcutaneous exposure to several soluble **lead** salts. Animal assays provide reproducible results in several laboratories, in multiple rat strains with some evidence of multiple tumor sites. Short term studies show that **lead** affects gene expression. Human evidence is inadequate. HUMAN CARCINOGENICITY DATA: Inadequate. ANIMAL CARCINOGENICITY DATA: Sufficient. /**Lead** and compounds/

[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Lead and compounds (inorganic) (7439-92-1) Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000]**PEER REVIEWED**

A3; Confirmed animal carcinogen with unknown relevance to humans. /**Lead**, elemental, and inorganic compounds, as Pb/

[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.38]**QC REVIEWED**

Human Toxicity Excerpts:

TOXIC BY INGESTION & INHALATION OF DUST OR FUME.

[Sax, N.I. and R.J. Lewis, Sr. (eds.). Hawley's Condensed Chemical Dictionary. 11th ed. New York: Van Nostrand Reinhold Co., 1987. 687]**PEER REVIEWED**

SEVERE POISONING IS PRODUCED THROUGH EXPOSURE TO FUMES FROM **LEAD** FURNACES IF FUMES ARE ALLOWED TO ESCAPE & FROM DUST FROM DROSSING.

[Hamilton, A., and H. L. Hardy. Industrial Toxicology. 3rd ed. Acton, Mass.: Publishing Sciences Group, Inc., 1974. 88]**PEER REVIEWED**

MOST ... **LEAD** EXPOSURE STUDIES INVOLVE **LEAD** OXIDE DUST OR THE FUME OF METALLIC **LEAD**. SOME REPORTS HAVE INDICATED THAT THE DUSTS OF CERTAIN INSOLUBLE **LEAD** COMPOUNDS, SUCH AS THE SULFIDE & CHROMATE, WERE LESS HAZARDOUS THAN MORE SOLUBLE FORMS OF **LEAD**.

[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.848]**PEER REVIEWED**

ONE OF 2 /EPIDEMIOLOGICAL/ STUDIES ON METALLIC **LEAD** WORKERS SHOWED NO EXCESS OF CANCER DEATHS. THE OTHER SHOWED A SLIGHT (ALTHOUGH SIGNIFICANT) EXCESS OF DEATHS DUE TO CANCERS OF DIGESTIVE SYSTEM & RESP SYSTEM AMONG SMELTER WORKERS BUT NOT AMONG WORKERS IN **LEAD**-ACID BATTERY FACTORY. AS 60% OF MEMBERS OF SMELTER WORKERS COHORT WERE HIRED AFTER 1950, FURTHER

FOLLOW-UP OF THIS COHORT IS WARRANTED, IN ORDER TO DETERMINE MORE RELIABLY IF THERE IS AN EXCESS RISK.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 387 (1980)]**PEER REVIEWED**

Cases of **lead** poisoning due to retained bullets are reported only rarely but represent potentially life-threatening reactions. ... Almost all cases in USA have involved the dissolution of a single bullet over several mo to more than 20 yr. ... Bullets in joint spaces are ... more likely to cause toxic complications than are bullets lodged in soft tissues.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. III-227]**PEER REVIEWED**

LEAD METAL FOREIGN BODIES IN EYE OR ... ORBIT IN HUMANS ... HAVE BEEN CONSIDERED TO CAUSE LITTLE REACTION & RARELY ANY TOXIC EFFECT. CLINICAL EXPERIENCES WITH VARIOUS INTRAOCULAR FOREIGN BODIES PRESENTED IN DETAIL WITH HISTOLOGIC STUDIES ... INDICATED THAT **LEAD** METALLIC FOREIGN BODIES CAUSED MINIMAL INFLAMMATORY REACTION, MAINLY MECHANICAL INJURY. ... /IN ANOTHER REPORT IT WAS/ CONCLUDED THAT **LEAD** FRAGMENTS IN PATIENTS WERE WELL TOLERATED IN THE EYE & IN THE ORBIT & THAT THEY SHOULD NOT BE REMOVED UNLESS THEY WERE IN THE ANTERIOR CHAMBER. ... /A/ CASE /IS DESCRIBED/ IN WHICH ... A SMALL **LEAD** SHOT WAS ALLOWED TO REMAIN IN THE VITREOUS, THE VISION RETURNED TO NORMAL AS BLOOD IN THE VITREOUS ABSORBED OR SETTLED IN THE COURSE OF A YEAR. ... IN ONE CASE, WHICH APPEARS TO HAVE BEEN QUITE EXCEPTIONAL ... A PATIENT WITH A **LEAD** SHOT BEHIND ONE GLOBE HAD IMPAIRED VISION IN THAT EYE. THIS WAS ASSUMED TO BE DUE TO A TOXIC EFFECT OF **LEAD**. WHETHER THIS INTERPRETATION WAS CORRECT OR NOT, A SIGNIFICANT IMPROVEMENT OF VISION WAS REPORTED WHEN SYSTEMIC & TOPICAL TREATMENT WITH 2,3-DIMERCAPTOPROPANSULFONATE SODIUM WAS STARTED 5 YEARS AFTER THE INJURY.
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 548]**PEER REVIEWED**

In a cross-sectional study, the neurobehavioral effects of low-level **lead** exposure were evaluated in a group of 59 **lead** workers compared with 59 matched controls. The groups were not significantly different in age, education level, sleep pattern, or use of alcohol. The mean blood **lead** level in the exposed group was 2.37 umol/l (50 ug/100 ml) which was similar to the previous three years (2.36, 2.36, and 2.32 umol/l, respectively). The mean duration of exposure was 8109 hrs. Visual sensory function was affected, and perhaps as a consequence sustained attention and psychomotor tasks were performed more slowly by the **lead** exposed group. Cognitive functions were also impaired, with sensory store and short term memories, and learning abilities all showing deficits in **lead** workers. Multiple linear regression analysis relating to **lead** workers test performance and their **lead** exposure showed that performance on the sensory store memory test alone was significantly related to exposure.
[Williamson AM, Teo RKC; Br J Ind Med 43: 374-80 (1986)]**PEER REVIEWED**

The activities of erythrocyte (rbc) arginase, pyrimidine 5'- nucleotidase (P5N), and deoxypyrimidine 5'-nucleotidase (dP5N) were compared in 16 **lead** workers and 14 age-matched controls as correlates of blood **lead** (PbB) and unextracted zinc protoporphyrin (EP). Subjects with blood **lead** of 0.9-2.5 uM (19-52 ug/dl) had 6.5 + or - 0.6 IU of pyrimidine 5'-nucleotidase activity with uridine monophosphate (UMP) as substrate, significantly less ($p < 0.001$) than the 12.0 + or - 0.7 IU activity of controls with blood **lead** 0.3-0.6 uM (6-12 ug/dl). Erythrocyte pyrimidine 5'-nucleotidase was significantly correlated with blood **lead** ($r = 0.75$). There were no significant differences in erythrocyte arginase or

deoxypyrimidine 5'-nucleotidase activity.
[Cook LR et al; Br J Ind Med 43: 387-90 (1986)]**PEER REVIEWED**

In a cross-sectional study of 20 gun-metal foundry workers (mean age 47 yr) the subclinical neurophysiological effects of exposure to **lead**, zinc, copper, and tin were evaluated by "short-latency" somatosensory evoked potential (SSEP). Controls were age and height-matched males without occupational exposure to **lead**. Range of employment was 1-16 yr (mean 10 yr). In exposed workers, mean blood **lead** was 42 ug/dl, mean zinc plasma 95 ug/dl, mean copper plasma 105 ug/dl, and mean urinary tin 28 ug/l. In workers, the interpeak latency of SSEP in the cervico-spino-bulbar region (N9(Erb)-N13 latency) was significantly prolonged ($p < 0.05$), and the MCV and SCV in the forearm were significantly slowed ($0.01 < p < 0.05$) when compared with controls. The yield of urinary **lead** following challenge with Ca-EDTA was positively related to SSEP latency in the cervico-spino-bulbar region and inversely related to hematocrit ($p < 0.05$). The interpeak latency in the upper central nervous system (N13-20 latency) was inversely related to zinc concentration in erythrocytes. Latency up to the Erbs point was inversely related to urinary zinc. MCV and SCV in the palm were positively related to erythrocyte zinc concentration and plasma copper concentration, respectively ($p < 0.05$). It appears that zinc antagonizes the central and peripheral neurophysiologic dysfunction caused by **lead**, and similarly copper antagonizes the peripheral sensory nerve dysfunction.
[Araki S et al; Am J Ind Med 10: 163-75 (1986)]**PEER REVIEWED**

Battery workers (N= 18), who were exposed to high airborne **lead** levels, /were compared/ with cement workers (N= 18), who were exposed to ambient **lead** levels. Blood **lead** urinary **lead**, semen **lead**, and zinc protoporphyrin concentrations were markedly elevated ($p < 0.001$) in battery workers. Battery workers had a significantly shifted ($p < 0.025$) frequency distribution of sperm count (median count, 45 vs 73x10x6 cells/cc, respectively). ... These results suggest a direct toxic effect of increased **lead** absorption on sperm production or transport in man.
[Assennato G et al; Arch Environ Health 42 (2): 124 (1987)]**PEER REVIEWED**

Lead containing particles in ambient air have an aerodynamic diameter of approx 0.1-1.0 um, & the predicted deposition in the airway is about 35%. This is questionable for smaller particles (< 0.1 um) which are mainly deposited by diffusion. Actual measurements of deposition in human volunteers gave results that differed considerably depending on the physical & chemical properties of the inhaled aerosol. ... A deposition of approx 25% /was observed/ after exposure to particles with a mass median aerodynamic diameter of 0.25 um. ... A deposition in the resp tract of about 60% /was observed/ in persons close to a motorway, where particles were about 0.03 um in diameter. This figure is consistent with lab expt carried out by the same authors, in which subjects inhaled radioactively labeled particles of about the same size. When volunteers inhaled **lead** particles near urban roads where the particle size was larger (0.2-2.0 um), deposition was about 50%. Based on available data, it seems reasonable to conclude that the rate of deposition of airborne **lead** in the general population is approx 30-50%, depending on particle size & ventilation rates.
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 311]**PEER REVIEWED**

There is no evidence that inhaled **lead** /as a trace substance in the environment/ has local effects on the respiratory system in man ... .
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 324]**PEER REVIEWED**

Dissolution of **lead** from **lead** soldered joints in water pipes frequently occurs where water is soft or acidic. /SRP: Thereby contributing to long term chronic exposure to the general population./
[Evans RD, Rigler FH; Water Air Soil Pollution 24: 141-51 (1985)]**PEER REVIEWED**

Most **lead** poisoning in children occurs between ages 1 and 5 years. There is a higher incidence of child-related **lead** poisoning during the warmer months.
[Gossel, T.A., J.D. Bricker. Principles of Clinical Toxicology. 3rd ed. New York, NY: Raven Press, Ltd., 1994. 192]**PEER REVIEWED**

Chronic exposure to **lead** has been found to produce infertility, germinal epithelium damage, oligospermia and testicular degeneration, decreased sperm motility, and prostatic hyperplasia.
[Thomas, J.A., K.S. Korach, J.A. McLachlan. Endocrine Toxicology. New York, NY: Raven Press, Ltd., 1985. 167]**PEER REVIEWED**

There is convincing evidence that **lead** is transferred to neonates via maternal milk. It appears that maternal milk might be a source of **lead** for the neonates, particularly when metal levels are elevated in the mother.
[Thomas, J.A., K.S. Korach, J.A. McLachlan. Endocrine Toxicology. New York, NY: Raven Press, Ltd., 1985. 168]**PEER REVIEWED**

Arthralgia, often associated with muscle aches and pain, is a frequent symptom in **lead** poisoning. Although generally thought to appear mainly in chronic poisoning, joint pain is often reported even by persons exposed briefly (weeks) who have relatively low blood **lead** concentrations. It is a symptom that ... frequently indicates that the blood **lead** concentration is on the rise.
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 744]**PEER REVIEWED**

... The EPA concluded that blood levels in the range of 50-70 ug/dl are associated with a 5-point reduction in IQ, even among asymptomatic children and after controlling for potential confounding factors.
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 1233]**PEER REVIEWED**

/Researchers/ reported on a cohort of 132 young adults whose levels of dentine **lead** were measured in primary school. Young people whose childhood dentine levels were greater than 20 ppm were found to be at a markedly higher risk of dropping out of high school and having reading disabilities, than the low-**lead** exposure group, whose dentine **lead** levels had been less than 10 ppm. Other measures of performance affected included vocabulary and grammatical reasoning, absenteeism, hand-eye coordination (poorer) and reaction time (slowed).
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 1234]**PEER REVIEWED**

The earliest subjective symptoms /of **lead** poisoningin working adults/ are diffuse and include weariness at the end of the day. The patient is moody and irritable and may fall asleep watching television. Often he loses his interest in leisure-time activities. Such mild symptoms frequently occur with blood-**lead** levels below 80 ug/100 ml.
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 518]**PEER REVIEWED**

... 49 long-term **lead**-exposed workers were compared to 27 low-exposed workers through a number of psychologic tests. After controlling for age, the exposed group performed worse on tests measuring memory, learning, and reaction time, while impaired performance was not detected in reasoning, perceptual speed, and psychomotor ability.
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 782]**PEER REVIEWED**

... /Researchers/ found impaired performances on tests of verbal concept formation, perceptual performance, and memory in a **lead**-exposed group with present **lead** concentrations between 40 and 60

ug/100 ml.
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 782]**PEER REVIEWED**

A study of 260 infants prospectively followed from birth suggests that the expected stature of a child born to a mother with a prenatal blood **lead** concentration over 7.7 ug/dL is about 2 cm shorter at 15 mos of age if, potentially, the infant also incurred a 10 ug/dL blood level increase during the 3- to 15-month interval of life.
[Ellenhorn, M.J., S. Schonwald, G. Ordog, J. Wasserberger. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. 2nd ed. Baltimore, MD: Williams and Wilkins, 1997. 1565]**PEER REVIEWED**

Moderate effects on follicle stimulating hormone and luteinizing hormone have been correlated with **lead** levels over about 50 ug/dL.
[Ellenhorn, M.J., S. Schonwald, G. Ordog, J. Wasserberger. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. 2nd ed. Baltimore, MD: Williams and Wilkins, 1997. 1565]**PEER REVIEWED**

The relative risk of preterm delivery at exposure levels of 14 ug/dL or greater was 8.7 times the risk at levels of up to 8 ug/dL in one prospective study. A Cincinnati study noted a half-week's reduction in gestation for every 10 ug/dL increment in blood **lead**.
[Ellenhorn, M.J., S. Schonwald, G. Ordog, J. Wasserberger. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. 2nd ed. Baltimore, MD: Williams and Wilkins, 1997. 1565]**PEER REVIEWED**

Lead has an adverse effect on fetuses, particularly in the later stages of development. Distribution of **lead** in fetal tissues was examined in a case in which a woman was exposed during pregnancy. The female worker was exposed to **lead** dust for 8 hr daily when conception occurred. ... Measurements of **lead** content were started after the end of the exposure and continued for 6 months until normal values were obtained. Because of half-life of nearly 20 days for **lead** elimination from blood, the estimated body burden at the end of exposure was about 1200 ppb. The fetal tissue samples contained between 0.4 (brain) and 7.9 (liver) ug Pb/g dry weight. The fetal **lead** was stored mainly in bone, blood, and liver.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 2073]**PEER REVIEWED**

Goyer found inclusion bodies in renal biopsies of two **lead** industry workers who had excess **lead** exposure, but only subclinical signs of **lead** toxicity in the form of weakness, nausea, some abdominal colic, and blood **lead** values of about 100 ug/dl.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 2073]**PEER REVIEWED**

Finnish men were biologically monitored for **lead** exposure. The cases (213 spontaneous abortions) and controls (300 births) were identified from medical registers in Finland. The results did not show a statistically significant relationship between spontaneous abortion and paternal **lead** exposure among all the study subjects. However, a significant increase in the risk of those women whose husbands had been monitored (blood **lead** equal to or greater than 1.5 umol/l) during or close to the time of spermatogenesis was observed.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 2081]**PEER REVIEWED**

Small increases in blood pressure have been related to adults with PbB levels down to 7 ug/dl.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II,

III. Cincinnati, OH: ACGIH, 1991.849]**PEER REVIEWED**

... PbB concentrations in excess of 60 ug/100 g ... have been associated with peripheral neuropathy, gastrointestinal disturbances and anemia. ... Nerve conduction velocities ... /decreases/ in workers with maximal blood leads between 50 and 70 ug/100 g.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.849]**PEER REVIEWED**

Food and Environmental Agents: Effect on Breast-Feeding: Reported Sign or Symptom in Infant or Effect on Lactation: **Lead**: Possible neurotoxicity. /From Table 7/
[Report of the American Academy of Pediatrics Committee on Drugs in Pediatrics 93 (1): 142 (1994)]**PEER REVIEWED**

Medical Surveillance:

... Comparative advantages of /the biological indicator/ delta-aminolevulinic acid dehydratase in typical (variable) occupational exposure conditions included: the highest sensitivity at low and relatively high **lead** (Pb) exposure levels; better reflection of biologically active Pb as opposed to blood **lead** (particularly compared to delta-aminolevulinic acid and coproporphyrin); higher specificity compared to other indicators of Pb effect; and generally higher reliability with regard to biologically and methodologically induced variations. ...
[Telisman S et al; Int Arch Occup Environ Health 50 (4): 397-412 (1982)]**PEER REVIEWED**

Populations at Special Risk:

SRP: Law enforcement officers are subject to potential intoxication while firing weapons in an indoor firing range.
PEER REVIEWED

Lead toxicity is of special concern to workers, such as miners and smelters, automobile finishers, foundry and storage battery workers, typesetters, sheet metal workers, and spray painters. **Lead** ... may also be a contaminant in moonshine whiskey.
[Gossel, T.A., J.D. Bricker. Principles of Clinical Toxicology. 3rd ed. New York, NY: Raven Press, Ltd., 1994. 191]**PEER REVIEWED**

Probable Routes of Human Exposure:

... MOST SEVERE HAZARD OCCURS IN SPRAYING OF MOLTEN **LEAD** ... GRINDING OR POWER SANDING ... SOLDER & POURING OF LEADED IRON & STEEL ... MIXING & WEIGHING OF **LEAD** POWDERS.
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969. 173]**PEER REVIEWED**

PRINCIPAL TYPES OF PRIMARY INDUSTRIES WITH OCCUPATIONAL EXPOSURE ... ARE **LEAD** SMELTING & REFINING, STORAGE BATTERY MANUFACTURE, WELDING & STEEL CUTTING & PRINTING. HIGHEST EXPOSURES ... OCCUR IN SMELTING & REFINING OF **LEAD**. MOLTEN **LEAD** & **LEAD** ALLOYS ARE BROUGHT TO HIGH TEMP, RESULTING IN VAPORIZATION OF **LEAD**.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 345 (1980)]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** **LEAD** ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE

0.2.1.1 ACUTE EXPOSURE

A. **Lead** poisoning can affect almost every organ system. Organ systems primarily affected include the central and peripheral nervous systems, cardiovascular, gastrointestinal, renal, endocrine, and hematologic systems. **Lead** can also adversely impact reproductive functioning and the developing fetus and child. The signs or symptoms may be varied and non-specific, and the clinician needs to consider the constellation of complaints and findings that may suggest **lead** poisoning as the diagnosis. Symptoms may be absent despite significant poisoning.

1. ACUTE TOXICITY - Common in young children with a history of pica. Symptoms can include: anorexia, vomiting, malaise, and convulsions; may cause permanent brain damage and reversible renal injury.

a. The ingestion of rapidly absorbed salts causes an acute syndrome of hepatic injury, hemolysis, anorexia, vomiting, malaise, and seizures due to increased intracranial pressure, as well as, chronic exposure effects.

2. CHRONIC TOXICITY - Children show weight loss, weakness, and anemia. The first signs in children may be subtle neurobehavioral deficits adversely affecting classroom behavior and social interaction. Adults manifest vague gastrointestinal and CNS complaints; wrist drop and colic rarely occur.

0.2.1.2 CHRONIC EXPOSURE

A. The hazard of exposure to **lead** is particularly serious in small companies or operations, often employing no more than three or four workers, engaged in radiator repair, leaded or stained glass production, laboratories, or ceramics.

B. **Lead** poisoning in adults is usually occupational or hobbies related due to inhalation of **lead** containing dust, fumes or vapors. Upon inhalation, absorption takes place easily from the respiratory tract and symptoms develop relatively quickly as compared to oral ingestion.

C. Subtle neurological/neurophysiological effects have been demonstrated in workers with blood **lead** levels below 60 microgram per 100 milliliter of blood.
D. The onset of symptoms of chronic **lead** poisoning often is gradual. The major organ systems affected are the nervous system, red blood cells, and kidneys.
E. Signs and symptoms include:
Abdominal tenderness
Anemia
Anxiety
Disturbance of the gastrointestinal tract (includes constipation, anorexia, and rarely excruciating colic)
Facial pallor
Forgetfulness and/or poor concentration
Glomerular sclerosis
Hypotension
Insomnia
Interstitial fibrosis
Irreversible vascular sclerosis
Lassitude
Motor weakness (which may **lead** to paralysis of the extensor muscles of the wrist and ankles)
Pallor of the eye grounds
Tubular cell atrophy
Weight loss and/or malnutrition
F. **Lead** poisoning diagnosis is supported when **lead** content of blood is greater than 50 mcg/dL, and if urine is greater than 80 mcg/dL.
G. **Lead** poisoning has been misdiagnosed as chronic fatigue syndrome in some patients, due to the presenting signs and symptoms.
H. PEDIATRIC - Children have been considered a risk group for **lead** toxicity, mainly due to the neurophysiological or neuro-cognitive deficits that may result.
I. Signs and symptoms for children include weight loss, weakness, and anemia. Encephalopathy occurs frequently in children who have ingested inorganic **lead** compounds.

0.2.3 VITAL SIGNS
0.2.3.1 ACUTE EXPOSURE
A. Chronic **lead** exposure may cause hypertension and gout.

0.2.7 NEUROLOGIC
0.2.7.1 ACUTE EXPOSURE
A. In young children, developmental defects, including learning disabilities and behavioral abnormalities, can occur without symptoms at blood **lead** levels at or even below 10 micrograms/deciliter.
B. At higher levels of exposure headache, fatigue, irritability and malaise may occur. At high levels, generally above 100 mcg/dL, encephalopathy, seizures and focal neurologic findings with imminent risk of death, permanent mental retardation, and motor deficits may occur.
0.2.7.2 CHRONIC EXPOSURE
A. During chronic exposure to **lead**, the concentration in the brain is relatively low comparing to other soft tissues such as aorta, liver, and kidneys. However, inorganic **lead** does pass the blood brain barrier.
B. Low levels of **lead** impair neurotransmission. **Lead** exposure has been shown to be associated with lowered IQ in children, cephalopathy, and peripheral nervous paralysis.

0.2.8 GASTROINTESTINAL
0.2.8.1 ACUTE EXPOSURE

A. CHRONIC **LEAD** EXPOSURE: Abdominal pain, nausea, anorexia, vomiting, constipation, diarrhea, and a metallic taste in the mouth have been reported with chronic toxicity. Severe and paroxysmal colic characterized by a rigid and retracted abdomen may occur.

0.2.8.2 CHRONIC EXPOSURE

A. Gastrointestinal problems are the most commonly reported effects of **lead**. When there is no obvious history of **lead** exposure, the severe symptoms in the gastrointestinal system may aid in the diagnosis of **lead** poisoning. Even gunshot wounds have been reported to display gastrointestinal symptoms.

B. Gastrointestinal absorption of **lead** varies widely and depends on other substances present in the diet.

0.2.9 HEPATIC

0.2.9.1 ACUTE EXPOSURE

A. Hepatic injury has been associated with acute **lead** poisoning, but is uncommon in chronic poisoning.

0.2.10 GENITOURINARY

0.2.10.1 ACUTE EXPOSURE

A. In acutely ill patients, proteinuria, glucosuria, and aminoaciduria may occur, and reversible kidney damage has been reported. In individuals chronically exposed to **lead**, signs and symptoms can include tubular damage, azotemia, and gout. Decreased sperm count in males has also been described.

0.2.10.2 CHRONIC EXPOSURE

A. Chronic exposure can result in kidney disease with few symptoms appearing until extensive and permanent damage has occurred.

0.2.13 HEMATOLOGIC

0.2.13.1 ACUTE EXPOSURE

A. **Lead** interrupts several steps in heme synthesis resulting in anemia. With some **lead** salts, hemolysis is possible. RBCs occasionally show endoplasmic clumping known as stippling. Iron deficiency is common in **lead** poisoned children.

0.2.13.2 CHRONIC EXPOSURE

A. Anemia is an early indication of chronic exposure to **lead**.

0.2.14 DERMATOLOGIC

0.2.14.2 CHRONIC EXPOSURE

A. Cutaneous absorption of **lead** is limited.

0.2.15 MUSCULOSKELETAL

0.2.15.1 ACUTE EXPOSURE

A. CHRONIC **LEAD** EXPOSURE: Muscle and joint pain are common complaints with chronic **lead** poisoning. Radiographic **lead** lines may be seen in the metaphyses in chronically poisoned children. Most of the body burden of **lead** is stored in bone.

0.2.16 ENDOCRINE

0.2.16.1 ACUTE EXPOSURE

A. **Lead** exposure has been associated with decreased stature, decreased growth hormone secretion, decreased levels of 1,25 dihydroxy vitamin D, and increased catecholamine levels.

0.2.17 METABOLISM

0.2.17.1 ACUTE EXPOSURE

A. CHRONIC **LEAD** EXPOSURE - Hyperuricemia may be seen after chronic **lead** poisoning.

0.2.19 IMMUNOLOGIC

0.2.19.2 CHRONIC EXPOSURE

A. Low levels of **lead** can impair immune system function.

0.2.20 REPRODUCTIVE HAZARDS

A. **Lead** is transferred across the placenta. It can affect reproduction in males and females, and affects neurodevelopmental milestones in children with both prenatal and postnatal exposure.

0.2.21 CARCINOGENICITY

0.2.21.1 IARC CATEGORY

A. **Lead** and inorganic compounds are classified in Group 2B, possibly carcinogenic in humans (limited evidence of carcinogenicity in humans and less than sufficient evidence of carcinogenicity in experimental animals). Organic **lead** compounds are classified in Group 3, not classifiable as to their carcinogenicity to humans.

B. EPA CLASSIFICATION - B2, possibly human carcinogen, based on a combination of sufficient evidence in animals and inadequate data in humans.

0.2.22 GENOTOXICITY

A. Exposure to **lead** has been reported to cause chromosome aberrations in humans, rats, and monkeys, but mixed exposures were involved in the human study.

B. Varying results of genotoxicity tests with **lead** and its compounds may be due to differing solubilities, different specificities of the tests, or possible indirect genotoxic mechanisms. The potential genotoxicity of **lead** remains unclear.

Laboratory:

A. Elevation of blood **lead** level is essential to the diagnosis of childhood and industrial cases. Children with a blood **lead** level of 45 mcg/dL or greater require medical intervention and chelation.

B. Children with venous BLLs of 20 mcg/dL or greater or with venous BLLs of 15-19 mcg/dL that persist for at least 3 months should receive medical evaluation and treatment. Chelation therapy should be instituted in all children with a blood **lead** level of 45 mcg/dL or greater using venous blood **lead** measurement.

C. Obtain a CBC to assess for anemia and perform a peripheral smear. Hypochromia and basophilic stippling suggest **lead** intoxication, but they are non-specific and their absence does not rule out the diagnosis.

D. Employees whose blood **lead** level is equal to or greater than 50 mcg/100 g shall be temporarily removed from exposure until their blood **lead** level is at or below 40 mcg/dl.

Treatment Overview:

0.4.2 ORAL EXPOSURE

A. ACUTE EXPOSURE -

1. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.
2. Consider gastric lavage in patients with recent ingestion of liquid or powdered products.
3. GASTRIC LAVAGE: Consider after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal

intubation. Control any seizures first.
a. CONTRAINDICATIONS: Loss of airway protective reflexes or decreased level of consciousness in unintubated patients; following ingestion of corrosives; hydrocarbons (high aspiration potential); patients at risk of hemorrhage or gastrointestinal perforation; and trivial or non-toxic ingestion.
4. WHOLE BOWEL IRRIGATION - Perform whole bowel irrigation if there is evidence of radiopaque material on abdominal radiographs. Administer a polyethylene glycol balanced electrolyte solution orally. Adults: 2 liters initially followed by 1 liter/hour. Repeat the x-ray to determine if radiopaque material has been removed (N.B. **lead** may remain in the GI tract even though rectal effluent has been clear for several hours or even days). Children: 500 ml initially followed by 500 mL/hour until rectal effluent is clear and radiopaque material is removed.
5. Obtain a blood **lead** level; repeat in 48 hours and as needed thereafter.
6. Chelation should be considered in patients with large ingestions or highly elevated blood **lead** levels.

B. ACUTE OR CHRONIC EXPOSURE -
1. OBTAIN BLOOD **LEAD** LEVEL - Hospitalize any child with a BLL of 45-69 micrograms/deciliter (mcg/dL) and symptoms (significant CNS or protracted gastrointestinal symptoms), or with BLL of greater than or equal to 70 mcg/dL, with or without symptoms (CDC, 1997).
a. Chelation therapy should be instituted in all patients with a blood **lead** level of 45 micrograms/deciliter (2.2 micromoles/liter) or greater using venous blood **lead** measurement. The child should be in a **lead**-safe environment before beginning chelation therapy (CDC, 1997).
2. CALCIUM EDTA PROVOCATION TEST - May be useful in determining necessity for therapeutic chelation in children with blood **lead** levels of 25 to 44 mcg/dL. This may be performed as an outpatient if the patient remains in the clinic. Because of the difficulties in administering the test and the uncertainties in interpreting results it is not as widely used as in the past.
3. CHELATION THERAPY -
a. Chelation therapy should be instituted in all patients with a blood **lead** level of 45 micrograms/deciliter (2.2 micromoles/liter) or greater using venous blood **lead** measurement. If a capillary sample is used and BLL is elevated, a second BLL by venipuncture should be performed before starting chelation therapy. The child should be in a **lead**-safe environment before beginning chelation therapy. Returning the individual to a contaminated environment may result in re-accumulation of the metal (CDC, 1997). Symptoms and signs, along with the EP and blood **lead** level, determine the route, dose, and agent to be used for chelation.
b. BAL (dimercaprol) - 3 to 5 mg/kg/dose deep IM every 4 hours for 2 days; then every 4 to 6 hours for 2 more days; then every 4 to 12 hours up to an additional 7 days.
c. CALCIUM EDTA - 50 to 75 mg/kg/day deep IM in 3 to 6 divided doses for up to 5 days. EDTA should only be administered after BAL in patients with encephalopathy or children with levels >69 mcg/dL.

d. D-PENICILLAMINE - 250 mg 4 times a day PO for up to 5 days. Do not exceed 40 mg/kg/day. OSHA prohibits prophylactic chelation therapy in workers occupationally exposed to **lead**.
e. DMSA - Initial pediatric dose is 10 mg/kg or 350 mg/m(2) orally every 8 hours for 5 days; reduced to every 12 hours for an additional 2 weeks. OSHA prohibits prophylactic chelation therapy in workers occupationally exposed to **lead**.

4. ESTABLISH ADEQUATE FLUID BALANCE with a urine flow of 1 to 2 mL/kg/hour, unless encephalopathy present or suspected, or increased intracranial pressure noted on CT. Do not force fluids if neuro compromise possible.
5. PERFORM A NEUROLOGICAL EXAM with particular reference to the presence of encephalopathy; particularly after starting EDTA, mental status may worsen; observe carefully.
6. CEREBRAL EDEMA - May be managed by ventilation and the administration of 1.5 g/kg of 20% mannitol IV over 20 minutes. Dexamethasone: up to 1 to 2 mg/kg/day IV in divided doses. Spinal tap may be dangerous in the presence of increased intracranial pressure.
7. SEIZURES: Administer a benzodiazepine IV; DIAZEPAM (ADULT: 5 to 10 mg, repeat every 10 to 15 min as needed. CHILD: 0.2 to 0.5 mg/kg, repeat every 5 min as needed) or LORAZEPAM (ADULT: 2 to 4 mg; CHILD: 0.05 to 0.1 mg/kg).
   a. Consider phenobarbital if seizures recur after diazepam 30 mg (adults) or 10 mg (children > 5 years).
   b. Monitor for hypotension, dysrhythmias, respiratory depression, and need for endotracheal intubation. Evaluate for hypoglycemia, electrolyte disturbances, hypoxia.
8. FOR ENCEPHALOPATHY, institute BAL followed 4 hours later by EDTA in the maximum dose. Administer EDTA as a continuous infusion over 24 hours.
9. Although chelation therapy is associated with significant decrease in BLL, surgery may be considered to remove **lead** foreign bodies.

Range of Toxicity:

A. A preterm infant with severe congenital **lead** poisoning (cord blood **lead** 7.6 mcmol/L or 157.5 mcg/dL; BLL of 11.8 mcmol/L) recovered following chelation therapy.
B. A man with a history of schizophrenia developed severe **lead** poisoning (BLL 391 mcg/dL) after ingesting 206 22-caliber **lead** bullets. He recovered following aggressive GI decontamination and chelation therapy.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

Basic treatment: Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Monitor for shock and treat if necessary ... . Anticipate seizures and treat if necessary ... . For eye

contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport ... . Do not use emetics. For ingestion, rinse mouth and administer 5 mL/kg up to 200 mL of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal ... . /**Lead** and related cmpds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 356]**PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious. Use hyperventilation to help control increased intracranial pressure. Start an IV with lactated Ringer's to support vital signs. For hypotension with signs of hypovolemia, administer fluid cautiously. Watch for signs of fluid overload ... . Treat seizures with diazepam (Valium) ... . Use proparacaine hydrochloride to assist eye irrigation ... . /**Lead** and related cmpds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 357]**PEER REVIEWED**

The treatment of **lead** poisoning is based on the prompt termination of exposure and on the use of chelating agents. The first requirement is categoric. The second is determined by the severity of poisoning; at present, the greatest issue is whether a symptomatic patients should be treated or not. The most commonly used therapeutic chelating agents are CaEDTA, BAL, and D-penicillamine can be given ... . /SRP: DMSA should also be considered./ It is not easy to judge which method is superior. ... /**Lead**/
[Zenz, C. Occupational Medicine-Principles and Practical Applications. 2nd ed. St. Louis, MO: Mosby-Yearbook, Inc, 1988. 563]**PEER REVIEWED**

Animal Toxicity Studies:

Evidence for Carcinogenicity:

CLASSIFICATION: B2; probable human carcinogen. BASIS FOR CLASSIFICATION: Sufficient animal evidence. Ten rat bioassays and one mouse assay have shown statisticlly significant increases in renal tumors with dietary and subcutaneous exposure to several soluble **lead** salts. Animal assays provide reproducible results in several laboratories, in multiple rat strains with some evidence of multiple tumor sites. Short term studies show that **lead** affects gene expression. Human evidence is inadequate. HUMAN CARCINOGENICITY DATA: Inadequate. ANIMAL CARCINOGENICITY DATA: Sufficient. /**Lead** and compounds/
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Lead and compounds (inorganic) (7439-92-1) Available from: http://www.epa.gov/ngispgm3/iris on the Substance File List as of March 15, 2000]**PEER REVIEWED**

A3; Confirmed animal carcinogen with unknown relevance to humans. /**Lead**, elemental, and inorganic compounds, as Pb/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.38]**QC REVIEWED**

Non-Human Toxicity Excerpts:

Lead particles have been well tolerated in the eyes of dogs & rats. ... **Lead** particles in the anterior chamber in rabbits became coated with purulent exudate & sometimes were extruded through the cornea at the limbus. In the vitreous humor in rabbits a similar purulent reaction was observed, causing the vitreous to shrink & the retina to separate.
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 549]**PEER REVIEWED**

LEAD POWDER SUSPENDED IN CORN OIL WAS ADMIN TO MALE & FEMALE FISCHER 344 RATS BY STOMACH TUBE (10 MG TWICE/MO FOR 12 MO). CONTROL RATS WERE GIVEN 0.5 ML OF CORN OIL BY STOMACH TUBE ACCORDING TO SAME SCHEDULE. ONE LYMPHOMA & 4 LEUKEMIAS WERE FOUND IN 5/47 **LEAD**-TREATED RATS; THIS DID NOT DIFFER SIGNIFICANTLY FROM THE INCIDENCE OF 3 LYMPHOMAS IN 29 CONTROLS. NO OTHER NEOPLASMS WERE REPORTED IN TREATED OR CONTROL RATS.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 362 (1980)]**PEER REVIEWED**

LEAD POWDER SUSPENDED IN TRIOCTANOIN WAS ADMIN IM TO 25 MALE & 25 FEMALE FISCHER RATS AS 9 MONTHLY INJECTIONS OF 10 MG, THEN 3 MONTHLY INJECTIONS OF 5 MG. EQUAL NUMBER OF VEHICLE CONTROLS WERE USED. 1 TREATED FEMALE DEVELOPED FIBROSARCOMA AT SITE OF IMPLANTATION ... THE LYMPHOMA RATE WAS SAME IN TREATED AS IN CONTROL ANIMALS.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 364 (1980)]**PEER REVIEWED**

TWELVE SHEEP WERE EXPOSED TO FINELY POWDERED METALLIC **LEAD** IN THEIR DIET (DOSES, 0.5 TO 16 MG/KG BODY WT) DURING ENTIRE ... PREGNANCY; BLOOD LEVELS WERE ABOUT 0.4 MG/L, WITHOUT RESULTING IN DEATH. NINE ANIMALS SERVED AS CONTROLS. RATE OF LAMBING WAS 18% IN EXPOSED (27% ABORTIONS) & 100% IN UNEXPOSED SHEEP (NO ABORTIONS). NO MALFORMATIONS WERE REPORTED. ... /IT WAS CONCLUDED THAT/ CHRONIC **LEAD** POISONING IN SHEEP CAUSED ABORTION, MISCARRIAGE & TRANSITORY STERILITY.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 368 (1980)]**PEER REVIEWED**

THERE WAS NO SIGNIFICANT EXCESS OF CHROMOSOME DAMAGE IN CULTURED LEUKOCYTES OBTAINED FROM 9 COWS ACCIDENTALLY INTOXICATED WITH MIXTURE OF HEAVY METALS & SHOWN TO HAVE TOXIC LEVELS OF **LEAD** IN LIVER & KIDNEYS.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 376 (1980)]**PEER REVIEWED**

Waterfowl can become poisoned by ingesting 6-8 buckshot from frequently hunted shorelines. Natural sources of **lead** such as galena or soils are not particularly toxic but can add to the total body burden.
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 1005]**PEER REVIEWED**

In waterfowl, **lead** shot ingestion causes anorexia, loss of wt, weakness, lethargy, diarrhea, coma, & quiet death. ... Progressive tachycardia /has been observed/ in geese as the birds became more & more ill. Some geese developed ECG abnormalities.
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 1008]**PEER REVIEWED**

In geese chronically poisoned with **lead** shot, microscopic degenerative lesions appear in the myocardium before any ECG abnormalities are manifested. Lesions include upper GI impaction with plant materials, emaciation, distended gallbladder, flabby hemorrhagic heart, discolored friable liver, & enteritis. Lesions in mallard ducks given **lead** shot include destruction of proventricular epithelium, bone medullary osteocytes, & pectoral muscle cells. Renal proximal tubules contain intranuclear inclusions. Mallard ducks also may develop encephalopathy & peripheral neuropathy.
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th

ed. Ames, Iowa: Iowa State University Press, 1982. 1009]**PEER REVIEWED**

Metallic **lead** in the form of weights or foil can cause poisoning, as also can shot; duck frequently dredge up shot from the mud at the bottom of ponds. **Lead** shot in muscle is usually encapsulated, & systemic poisoning from it is unlikely. Nevertheless, **lead** shot dropped by anglers on river banks is a serious cause of poisoning in swans. ... Vegetation in the neighborhood of a smelter engaged in melting down old battery plates had a **lead** content of up to 3200 ppm. ... Vegetation near a busy highway may contain 500 ppm of **lead** due to contamination by exhaust fumes. It should be noted that in these cases the **lead** is only a surface contaminant; significant quantities of the element cannot be taken up by vegetation from **lead**-bearing soil, although the latter has itself caused poisoning in small animals.
[Clarke, M. L., D. G. Harvey and D. J. Humphreys. Veterinary Toxicology. 2nd ed. London: Bailliere Tindall, 1981. 55]**PEER REVIEWED**

Birds (fowls, ducks, geese & pigeons) are all susceptible to **lead** poisoning. They show anorexia & ataxia, followed by excitement & loss of condition. Egg production, fertility, & hatchability decrease; & mortality may be high.
[Clarke, M. L., D. G. Harvey and D. J. Humphreys. Veterinary Toxicology. 2nd ed. London: Bailliere Tindall, 1981. 57]**PEER REVIEWED**

It is doubtful whether the term "toxic dose" has any real meaning when it is applied to a substance such as /elemental/ **lead** /in its ionic form/, as it is affected by so many different factors. Among these are environment, nutrition, disease & age, the last of these being considerably more important, as young animals are considerably more sensitive than old ones. There is also a seasonal variation. Over half the cases of **lead** poisoning in cattle in Scotland occur in the spring. Similar effects have been noted for dogs. ... Even more important is the fact that **lead** is both cumulative & ubiquitous. All living creatures are continually absorbing it, & the "toxic" dose is only the amount necessary to bridge the gap between this normal intake & a potentially dangerous level. ... Three or four **lead** shots will kill a duck, 10 a goose.
[Clarke, M. L., D. G. Harvey and D. J. Humphreys. Veterinary Toxicology. 2nd ed. London: Bailliere Tindall, 1981. 56]**PEER REVIEWED**

The acute oral lethal single dose of **lead** in ... calves /is/ 50-600 mg/kg as **lead** or **lead** salts. ... Solid **lead** is not as toxic as /the/ more soluble salts, which are more readily absorbed.
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 1005]**PEER REVIEWED**

Eleven pregnant squirrel monkeys were perorally exposed to **lead** during the latter two-thirds of pregnancy (mean blood **lead** 0.54 ug/ml (2.61 umol/l), range 0.39-0.82 ug/ml (1.88-3.96 umol/l), at a dosing regime producing no maternal toxic symptoms. Lesions similar to **lead** encephalopathy and growth retardation of the fetal cerebrum were seen in some of the offspring, as well as neurological and behavioral symptoms at adult age. Cerebral **lead** levels in offspring (an abortion, stillborns, a sacrificed full-term fetus, and a neonatal death) were between 0.1-0.7 ug/g. Pre- and perinatal mortality, and prematurity, was increased, and the size of the offspring at birth was reduced. The head circumference tended to be reduced postnatally.
[Logdberg MD et al; Scand J Work Environ Health 13: 135-45 (1987)]**PEER REVIEWED**

... Animal studies indicate that relatively high levels of **lead** exposure interfere with resistance to infectious disease.
[USEPA; Ambient Water Quality Criteria Doc: Lead p.C-71 (1980) EPA 440/5-80-057]**PEER REVIEWED**

ORAL ADMIN OF **LEAD** TO RATS INHIBITED ACTIVITY OF DELTA-AMINOLEVULINIC ACID DEHYDRATASE. EDTA TREATMENT OF RATS GIVEN **LEAD** CAUSED

REACTIVATION OF LIVER DELTA-AMINOLEVULINIC ACID DEHYDRATASE.
[HAMMOND PB; TOXICOL APPL PHARMACOL 26 (3): 466 (1973)]**PEER REVIEWED**

Studies have been conducted with nestling kestrels in which oral intubations were administered daily for the first 10 days post-hatching. A high mortality from metallic **lead** was observed with 525 mg/kg, reduced growth was observed with 125 mg/kg, and altered physiology was observed with 25 mg/kg. /From table/
[Hoffman, D.J., B.A. Rattner, G.A. Burton Jr, J. Cairns Jr. Handbook of Ecotoxicology. Boca Raton, FL: CRC Press, Inc., 1995. 55]**PEER REVIEWED**

Ecotoxicity Values:

LC50 Japanese quail (Coturnix japonica), males or females, 14 days old, oral (5-day ad libitum in diet) >5,000 ppm; at 1000, 2236 & 5000 onset of toxic signs began at 7, 7 & 7 days and remissed at 11, 11 & 12 days, respectively, no mortality was observed; control references were dieldrin & dicrotophos; corn oil diluent was added to diet at ratio of 2:98 by wt; (extreme concentrations: 1,000-5,000 ppm) /**Lead** metal, 100%/
[Hill, E.F. and Camardese, M.B. Lethal Dietary Toxicities of Environmental Contaminants and Pesticides to Coturnix. Fish and Wildlife Technical Report 2. Washington, DC: United States Department of Interior Fish and Wildlife Service, 1986.86]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Absorption, Distribution & Excretion:

Only 1 to 2% of ingested **lead** is absorbed from the GI tract because it can form rather insoluble compounds, even within the gut. Acid conditions favor dissolution of **lead** & its compounds.
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 1005]**PEER REVIEWED**

... Metallic **lead** shot or bullets lodged in tissues do not dissolve readily because tissue pH is not low enough.
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 1006]**PEER REVIEWED**

The absorption rate of deposited **lead** depends on various factors, particularly on the physiochemical form of **lead** in particles. There is ... no evidence of **lead** accumulation in the lung, & any **lead** compound once deposited is eventually absorbed or transferred to the gastrointestinal tract.
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 312]**PEER REVIEWED**

Only a very minor fraction of particles over 0.5 um in mean maximal external diameter are retained in the lung but are then cleared from the respiratory tract & swallowed. ... The percentage of particles less than 0.5 um retained in the lung increases with reduction in particle size. About 90% of **lead** particles in ambient air that are deposited in lung are small enough to be retained. Absorption of retained **lead** through alveoli is relatively efficient & complete.
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 704]**PEER REVIEWED**

A group of 109 male workers occupationally exposed to both antimony (as Sb2O3) and **lead** in the glass-producing industry were examined for levels of these metals in whole blood and urine. The

workers were divided into four groups based on specific work activities: melter (n= 32), batch mixer (n= 45), craftsman (n= 8), and glass washer (n= 24). Blood and urine samples were collected at the end of a shift. Concentrations of **lead** in the blood ranged from 70 to 680 ug/l. Median values for melters, batch mixers, craftsmen, and glass washers were 220, 340, 275, and 170 ug/l, respectively. A significant difference ($p< 0.05$) was found only between the batch mixers and glass washers. The urinary **lead** values ranged from 7 to 110 ug/l with median values for melters, batch mixers, craftsmen, and glass washers of 35, 43, 24, and 42 ug/l, respectively. A significant difference was found between only the batch mixers and craftsmen ($p< 0.05$). Exposure rates for **lead** were not given.
[Ludersdorf R et al; Int Arch Occupat Environ Health 59 (5): 469-74 (1987)]**PEER REVIEWED**

... Two human volunteers were given 212Pb intravenously. There was no **lead** in the feces during the first 24 hr, whereas the urine contained 4.42% of the dose. The figures for the second 24 hours, however, were 1.5% and 1.42%, respectively, which indicates that the fecal route may contribute as much as the urinary one to total excretion.
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 514]**PEER REVIEWED**

Other possible routes for **lead** excretion include sweat, milk, hair, nails, desquamating epithelia, and teeth.
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 514]**PEER REVIEWED**

As much as 90% of ingested **lead** is not absorbed and is excreted in the feces. The urine is the primary vehicle for excretion of absorbed **lead**, but a smaller proportion may be excreted in the bile.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 2074]**PEER REVIEWED**

An inverse relationship was found between diets containing metallic **lead** of particle sizes </= 250 um and absorption in rats.
[Barltrop D, Meek F; Arch Environ Health 34: 280-5 (1979) as cited in U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for Lead (Update) p.99 (1993) ATSDR/TP-92/12]**PEER REVIEWED**

Biological Half-Life:

The first half-time of **lead** in blood after the cessation of exposure is 35-40 days, while for the **lead** in long bones, the half-time is around 20 yr.
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 144]**PEER REVIEWED**

Mechanism of Action:

The ability of a number of metals and organic chemicals to induce metallothionein synthesis in primary cultures of rat hepatocytes was tested to determine whether metallothionein induction in vivo results from a direct effect of the agent on the liver or as a result of an indirect, physiological response to the agent. Hepatocytes were exposed to metals (zinc, cadmium, mercury, manganese, **lead**, cobalt, nickel, and vanadium) or org cmpd. Ethanol, urethane, L-2-oxothiazolidine-4-carboxylate, or dexamethasone and were assayed for metallothionein by the cadmium/mercury radioassay. Cell viability was monitored by protein synthesis activity and cellular potassium ion concn. Increases in metallothionein concn were noted for zinc (22 fold), mercury (6.4 fold), cadmium (4.8 fold), cobalt (2.4 fold), nickel (22 fold), and dexamethasone (4.5 fold). However, even at max tolerated concn, manganese, **lead**, vanadium, ethanol, urethane, and L-2-oxothiazolidine-4-carboxylate did not increase metallothionein. Thus, zinc, cadmium,

mercury, cobalt, nickel, and dexamethasone induce metallothionein in vitro and are direct inducers of metallothionein synthesis in hepatic tissue. In contrast, manganese, **lead**, ethanol, urethane, and L-2-oxothiazolidine-4-carboxylate, which did not increase the metallothionein content of hepatocytes, apparently do so in vivo by an indirect mechanism.
[Bracken WM, Klaassen CD; J Toxicol Environ Health 22 (2): 163-74 (1987)]**PEER REVIEWED**

Interactions:

Female Swiss mice were exposed to **lead** in the drinking water at concentrations ranging from 0 to 1000 ppm for 105 or 280 day periods of time. The effect of **lead** on urethane induced pulmonary adenoma formation was evaluated in the 105 day study. Urethane induced sleeping times observed following ip injection of urethane (1.5 mg/g) after 3 weeks of **lead** exposure were not altered by **lead** indicating that **lead** did not affect the rate of urethane elimination. Pulmonary adenoma formation was evaluated 84 days later. **Lead** exposure did not affect the number of tumors produced, nor did it alter the mean tumor diameter in the **lead** treatment groups. Immunosuppressive activity of **lead** did not enhance urethane induced adenoma formation. In the 280 day study, leukemia was observed in all treatment groups. Mortality was greater in the **lead** exposed mice. Mice exposed to 50 or 1000 ppm **lead** had 41.6% and 58.3% more deaths associated with the virus. The median survival time was also reduced in the **lead** exposed mice. Immunosuppressive effects of **lead** increased expression of the murine lymphocytic leukemia virus.
[Blakley BR; J Appl Toxicol 7 (3): 167-72 (1987)]**PEER REVIEWED**

Cultured C6 rat glioma cells were exposed to **lead** acetate (0, 1, 10, or 100 uM) for 3-4 days. Cells were analyzed for changes in viability and intracellular **lead**, iron, and copper concentrations after **lead** treatment was discontinued. **Lead** uptake did not affect intracellular iron or copper concentrations. Unlike C6 cells, however, astroglia showed elevations of intracellular iron or copper after **lead** treatment. C6 cells appear to be an adequate model for selected events in glial toxicosis, such as **lead** stimulated protein synthesis in oligodendroglia and **lead** uptake in astroglia, but not **lead** induced alterations of intracellular copper and iron in astroglia.
[Bratton GR; J Toxicol Environ Health 23 (2): 267-80 (1988)]**PEER REVIEWED**

The distribution of iv admin **lead** (50 nmol/kg) was studied by means of autoradiography and impulse counting in pregnant C57BL mice (day 18 of gestation) treated orally with dithiocarbamates. Diethyldithiocarbamate, disulfiram or thiram (2X1 mmol/kg) or vehicle (gelatin) alone, was given by gavage 2 hr before & immediately after injection of **lead**. All the dithiocarbamates changed the distribution pattern of **lead**. Disulfiram had the greatest effect at 24 hr after **lead**. The pattern of changes in **lead** distribution is consistent with the formation in the body of lipid sol. **Lead**-dithiocarbamate complexes that pass biological barriers more easily than inorganic **lead** (to brain, fetus, melanocytes, etc), probably are followed by a dissociation of the complexes in the tissues.
[Danielsson BR G et al; Arch Toxicol 55 (1): 27-33 (1984)]**PEER REVIEWED**

Chelating agents, zinc salts, and selenium preparations have been utilized with some success in attempts to reduce absorption and/or increase the excretion of absorbed **lead**. ... Both selenium and vitamin E have been shown to be involved in decreasing the toxic effect of **lead** in rats.
[Thomas, J.A., K.S. Korach, J.A. McLachlan. Endocrine Toxicology. New York, NY: Raven Press, Ltd., 1985. 170]**PEER REVIEWED**

Pharmacology:

Interactions:

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[Thomas, J.A., K.S. Korach, J.A. McLachlan. Endocrine Toxicology. New York, NY: Raven Press, Ltd., 1985. 170]**PEER REVIEWED**

Environmental Fate & Exposure:

Probable Routes of Human Exposure:

... MOST SEVERE HAZARD OCCURS IN SPRAYING OF MOLTEN **LEAD** ... GRINDING OR POWER SANDING ... SOLDER & POURING OF LEADED IRON & STEEL ... MIXING & WEIGHING OF **LEAD** POWDERS.
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969. 173]**PEER REVIEWED**

PRINCIPAL TYPES OF PRIMARY INDUSTRIES WITH OCCUPATIONAL EXPOSURE ... ARE

LEAD SMELTING & REFINING, STORAGE BATTERY MANUFACTURE, WELDING & STEEL CUTTING & PRINTING. HIGHEST EXPOSURES ... OCCUR IN SMELTING & REFINING OF **LEAD**. MOLTEN **LEAD** & **LEAD** ALLOYS ARE BROUGHT TO HIGH TEMP, RESULTING IN VAPORIZATION OF **LEAD**.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V23 345 (1980)]**PEER REVIEWED**

Natural Pollution Sources:

LEAD RARELY OCCURS IN THE ELEMENTAL STATE, BUT EXISTS ... IN A NUMBER OF ORES ... ALSO OCCURS IN VARIOUS URANIUM & THORIUM MINERALS, ARISING FROM RADIOACTIVE DECAY.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1687]**PEER REVIEWED**

Pb derived from the decay of radon. /Inorganic **lead**/
[WHO; Environ Health Criteria: Lead p.32 (1977)]**PEER REVIEWED**

Metallic **lead** is naturally occurring and is the end product of three natural radioactive elements uranium (206), thorium (208), and actinium (207)(1).
[(1) Hawley GG; Condensed Chem Dictionary 10th ed pp.604-5 Von Nostrand Reinhold NY (1981)]**PEER REVIEWED**

Milk Concentrations:

Other possible routes for **lead** excretion include ... milk....
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 514]**PEER REVIEWED**

Environmental Standards & Regulations:

Acceptable Daily Intakes:

Tolerable intake of **lead** for preschool children should be less than the 3 mg/wk recommended provisionally for adults. ... /Inorganic **lead**/
[WHO; Environ Health Criteria: Lead p.127 (1977)]**PEER REVIEWED**

0.007 mg/kg (WHO) /**Lead**; from table/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 843]**PEER REVIEWED**

CERCLA Reportable Quantities:

Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 10 lb or 4.54 kg. The toll free number of the NRC is (800) 424-8802; In the Washington D.C. metropolitan area (202) 426-2675. The rule for determining when notification is required is stated in 40 CFR 302.4 (section IV. D.3.b).
[40 CFR 302.4 (7/1/97)]**PEER REVIEWED**

RCRA Requirements:

D008; A solid waste containing **lead** may or may not become characterized as a hazardous waste when subjected to the Toxicity Characteristic Leaching Procedure listed in 40 CFR 261.24, and if so characterized, must be managed as a hazardous waste.
[40 CFR 261.24 (7/1/97)]**PEER REVIEWED**

Atmospheric Standards:

National primary and secondary ambient air quality standard for **lead** and its compounds, measured as elemental **lead** is: 1.5 ug/cu m, maximum arithmetic mean averaged over a calendar quarter. /**Lead** and its compounds, as Pb/
[40 CFR 50.12 (7/1/97)]**PEER REVIEWED**

Listed as a hazardous air pollutant (HAP) generally known or suspected to cause serious health problems. The Clean Air Act, as amended in 1990, directs EPA to set standards requiring major sources to sharply reduce routine emissions of toxic pollutants. EPA is required to establish and phase in specific performance based standards for all air emission sources that emit one or more of the listed pollutants. **Lead** compounds are included on this list. /**Lead** compounds/
[Clean Air Act as amended in 1990, Sect. 112 (b) (1) Public Law 101-549 Nov. 15, 1990]**PEER REVIEWED**

Clean Water Act Requirements:

Toxic pollutant designated pursuant to section 307(a)(1) of the Clean Water Act and is subject to effluent limitations. /**Lead** and inorganic and organic **lead** compounds/
[40 CFR 401.15 (7/1/87)]**QC REVIEWED**

Designated as a hazardous substance under section 311(b)(2)(A) of the Federal Water Pollution Control Act and further regulated by the Clean Water Act Amendments of 1977 and 1978. These regulations apply to discharges of this substance.
[40 CFR 116.4 (7/1/87)]**QC REVIEWED**

Federal Drinking Water Standards:

EPA 15 ug/l (Action Level)
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

State Drinking Water Guidelines:

(AZ) ARIZONA 20 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(ME) MAINE 20 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

FDA Requirements:

The FDA action level of **lead** is 7.0 ug/ml of leaching soln for pottery (ceramics) flatware (avg of 6 units); 5.0 ug/ml of leaching soln for small hollowware (any one of 6 units); 2.5 ug/ml of leaching soln for large hollowware (any one of 6 units); 7.0 ug/ml of leaching soln if product intended for use by

adults for silver-plated hollowware (avg of 6 units); and 0.5 ug/ml of leaching soln if product intended for use by infants and children for silver-plated hollowware (one or more of 6 units). /Inorganic **lead**/
[FDA; Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed p.9 (1982)]**PEER REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

Pb
PEER REVIEWED

Molecular Weight:

207.2
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 922]**PEER REVIEWED**

Color/Form:

Bluish-white, silvery, gray metal. Highly lustrous when freshly cut, tarnishes upon exposure to air. Cubic crystal structure.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 922]**PEER REVIEWED**

Boiling Point:

1740 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 922]**PEER REVIEWED**

Melting Point:

327.4 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 922]**PEER REVIEWED**

Density/Specific Gravity:

11.34 @ 20 deg C/4 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 922]**PEER REVIEWED**

Heat of Vaporization:

206 cal/g @ 1740 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 922]**PEER REVIEWED**

Vapor Pressure:

1.77 mm Hg @ 1000 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 922]**PEER REVIEWED**

Viscosity:

Viscosity of molten **lead** (327.4 deg C) 3.2 centipoises, (400 deg C) 2.32 cP, (600 deg C) 1.54 cP, (800 deg C) 1.23 cP.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 922]**PEER REVIEWED**

Other Chemical/Physical Properties:

VAPOR PRESSURE: 10 MM HG AT 1162 DEG C; 100 MM HG AT 1421 DEG C; 400 MM HG AT 1630 DEG C
[Sunshine, I. (ed.). CRC Handbook of Analytical Toxicology. Cleveland: The Chemical Rubber Co., 1969. 706]**PEER REVIEWED**

Very soft and malleable, easily melted, cast, rolled, and extruded. Density (at mp) 10.65 g/cu cm. Heat capacity (20 deg C): 0.031 cal/g/deg C. Resistivity (microohm-cm) at 20 deg C: 20.65; at 100 deg C: 27.02; at 320 deg C: 54.76; at 330 deg: 96.74. Standard electromotive force (aq) Pb/Pb2+ +0.126 v. Coefficient of linear expansion (0-100 deg C) 29X10-6, (20-300 deg C) 31.3X10-6, (-183 deg C to +14 deg C) 27X10-6; thermal conductivity varies from 0.083 at 50 deg C to 0.077 at 225 deg C. Hardness 1 on Mohs' scale; Brinell hardness (high purity Pb) 4.0.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 922]**PEER REVIEWED**

Reacts with hot concd nitric acid, with boiling concd hydrochloric or sulfuric acid. Attacked by pure water, weak organic acids in the presence of oxygen. Resistant to tap water, hydrofluoric acid, brine, solvents.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 922]**PEER REVIEWED**

Chemical Safety & Handling:

Fire Potential:

Flammable in the form of dust when exposed to heat or flame.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2028]**PEER REVIEWED**

Toxic Combustion Products:

When heated ... it emits highly toxic fumes of **lead**.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2028]**PEER REVIEWED**

Explosive Limits & Potential:

Moderately explosive in the form of dust when exposed to heat or flame.

[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2028]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

CAN REACT VIGOROUSLY WITH OXIDIZING MATERIALS.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2028]**PEER REVIEWED**

Ground mixtures of sodium carbide and ... **lead** ... can react vigorously.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-118]**PEER REVIEWED**

... Trituration in a mortar of disodium acetylide with finely divided **lead** may be violent, carbon being liberated.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 327]**PEER REVIEWED**

... Reaction with chlorine trifluoride at ambient or slightly elevated temp is violent, ignition often occurring.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 944]**PEER REVIEWED**

Mixtures of trioxane with 60% hydrogen peroxide solution are detonable by heat or shock, or spontaneously after contact with metallic **lead**. The latter may be ... /due/ to the heat of oxidation of **lead**.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1209]**PEER REVIEWED**

... Reacts violently or explosively with fused ammonium nitrate below 200 deg C.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1250]**PEER REVIEWED**

... **Lead** containing dry-box gloves may ignite in nitric acid environment.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1167]**PEER REVIEWED**

Finely divided **lead** produced by reduction of the oxide with furfural vapor at 290 deg C is pyrophoric and chemically reactive.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1442]**PEER REVIEWED**

A solution of sodium azide in copper pipe with **lead** joints formed copper azide and **lead** azide, both detonating compounds.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-176]**PEER REVIEWED**

REACTS WITH HOT CONCN NITRIC ACID, BOILING CONCN HYDROCHLORIC & SULFURIC ACIDS
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 776]**PEER REVIEWED**

Strong oxidizers, hydrogen peroxide, acids.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 94-116. Washington, D.C.: U.S. Government Printing Office, June 1994. 184]**PEER REVIEWED**

Incompatible with NaN3; Zirconium ...
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes

1-3. New York, NY: Van Nostrand Reinhold, 1996. 2028]**PEER REVIEWED**

Hazardous Decomposition:

When heated to decomposition it emits highly toxic fumes of **lead**.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2028]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

100 mg/cu m
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 184]**PEER REVIEWED**

Protective Equipment & Clothing:

Wear appropriate personal protective clothing to prevent skin contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 184]**PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 184]**PEER REVIEWED**

Recommendations for respirator selection. Max concn for use: 0.5 mg/cu m. Respirator Class(es): Any air-purifying respirator with a high-efficiency particulate filter. Any supplied-air respirator.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 185]**PEER REVIEWED**

Recommendations for respirator selection. Max concn for use: 1.25 mg/cu m. Respirator Class(es): Any supplied-air respirator operated in a continuous flow mode. Any powered, air-purifying respirator with a high-efficiency particulate filter.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 185]**PEER REVIEWED**

Recommendations for respirator selection. Max concn for use: 2.5 mg/cu m. Respirator Class(es): Any air-purifying, full-facepiece respirator with a high-efficiency particulate filter. Any supplied-air respirator that has a tight-fitting facepiece and is operated in a continuous-flow mode. Any powered, air-purifying respirator with a tight-fitting facepiece and a high-efficiency particulate filter. Any self-contained breathing apparatus with a full facepiece. Any supplied-air respirator with a full facepiece.

[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 185]**PEER REVIEWED**

Recommendations for respirator selection. Max concn for use: 50 mg/cu m. Respirator Class(es): Any supplied-air respirator operated in a pressure-demand or other positive-pressure mode.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 185]**PEER REVIEWED**

Recommendations for respirator selection. Max concn for use: 100 mg/cu m. Respirator Class(es): Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 185]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Emergency or planned entry into unknown concn

or IDLH conditions: Respirator Class(es): Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode. Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 185]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Escape from suddenly occurring respiratory hazards: Respirator Class(es): Any air-purifying, full-facepiece respirator with a high-efficiency particulate filter. Any appropriate escape-type, self-contained breathing apparatus.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 185]**PEER REVIEWED**

Preventive Measures:

Control of exposure to toxic materials in ceramics is important because of the large variety of toxic materials /including **lead** tetroxide/. Dust control is of paramount importance. This is accomplished by good local exhaust ventilation, careful handling and storage of materials and proper clean-up techniques. The area should have general dilution ventilation, but also local exhaust systems for dry clay and glaze mixing, liquid glaze spraying and for the kiln emissions. All dry clays and glazes should be stored in sealed containers (not in ripped open paper bags). Plastic garbage cans with lids, on wheels, or similar containers can be used. All materials should be handled in a manner that prevents the creation of dusts. Premixed liquid glazes should be used and work done with materials in the wet form as much as possible. Good housekeeping is essential to keep the dust level down. There must be no dry sweeping or vacuuming in the studio, as this will resuspend settled dust that can be inhaled by the artists. Wet mopping, wet wiping and wet vacuuming or high efficiency particulate air (HEPA) filtered vacuuming is recommended. Protective equipment such as respirators, heat resistant gloves, eye protection, emergency showers and fire extinguishers are recommended around kilns. Proper studio design is important to insure that adequate ventilation, proper storage areas, handwashing sinks, safety equipment and other facilities are provided and safety hazards are avoided. Personal hygiene is also important. Artists should not eat, drink or smoke in the studio. Clothes should be washed daily. Hands and particularly nails should be washed frequently throughout the day, especially before eating, drinking, smoking or leaving the studio for the day.
[Hart C; J Environ Health 49 (5): 285-86 (1987)]**PEER REVIEWED**

Cloakroom accommodation should be provided for personal protective equipment with separate accommodation for clothing taken off during working hours. Washing accommodation, including bathing accommodation with warm water, should be provided and used. Time should be allowed for washing before eating. Arrangements should be made to prohibit eating and smoking in the vicinity of **lead** processes and suitable messrooms should be provided.
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1204]**PEER REVIEWED**

SRP: Local exhaust ventilation should be applied wherever there is an incidence of point source emissions or dispersion of regulated contaminants in the work area. Ventilation control of the contaminant as close to its point of generation is both the most economical and safest method to minimize personnel exposure to airborne contaminants.
PEER REVIEWED

SRP: Contaminated protective clothing should be segregated in such a manner so that there is no direct personal contact by personnel who handle, dispose, or clean the clothing. Quality assurance to ascertain

the completeness of the cleaning procedures should be implemented before the decontaminated protective clothing is returned for reuse by the workers. All contaminated clothing should not be taken home at end of shift, but should remain at employee's place of work for cleaning.
PEER REVIEWED

The worker should wash daily at the end of each work shift.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 184]**PEER REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed or replaced.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 184]**PEER REVIEWED**

Workers whose clothing may have become contaminated should change into uncontaminated clothing before leaving the work premises.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 184]**PEER REVIEWED**

Stability/Shelf Life:

TARNISHES ON EXPOSURE TO AIR; ATTACKED BY PURE WATER, WEAK ORG ACIDS IN PRESENCE OF OXYGEN; RESISTANT TO TAP WATER, HYDROFLUORIC ACID, BRINE, SOLVENTS
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 776]**PEER REVIEWED**

Cleanup Methods:

Environmental considerations: Water spill: Neutralize with agricultural lime (CaO), crushed limestone (CaCO3), or sodium bicarbonate (NaHCO3). Adjust pH to neutral (pH= 7). Use mechanical dredges of lifts to remove immobilized masses of pollutants & precipitates.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, D.C.: Assoc. of American Railroads, Hazardous Materials Systems (BOE), 1987.407]**PEER REVIEWED**

Environmental considerations: Land spill: Dig a pit, pond, lagoon, or holding area to contain liquid or solid material. /SRP: If time permits, pits, ponds, lagoons, soak holes, or holding areas should be contained with a flexible impermeable membrane liner./ Cover solids with a plastic sheet to prevent dissolving in rain or fire fighting water.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, D.C.: Assoc. of American Railroads, Hazardous Materials Systems (BOE), 1987.407]**PEER REVIEWED**

... Described treatment of wastewater from a tetraethyl **lead** manufacturing process. Two major categories of waste were inorganic **lead** wastewaters and organic **lead** wastewaters. After sedimentation in a holding basin to recover solid **lead** and **lead** oxide, the inorganic **lead** waste fraction (66.1 mg/l) was effectively treated by coagulation with ferric and ferrous sulfate. /Inorganic **lead**/
[Patterson JW; Industrial Wastewater Treatment Technolgy 2nd Edition p.75 (1985)]**PEER REVIEWED**

Disposal Methods:

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste number D008, must conform with USEPA regulations in storage, transportation, treatment and disposal of waste.

[40 CFR 240-280, 300-306, 702-799 (7/1/97)]**PEER REVIEWED**

Precipitation is the preferred treatment process for removing toxic heavy metals from electroplating waters. Precipitation processes include hydroxide, lime and/or sulfide treatment. Chemical reduction is used to treat complex metals such as nickel, copper, hexavalent chromium waste, soluble **lead**, silver, metal containing cyanide, and mercury. Adsorption has shown potential for treating and polishing aqueous metal bearing wastes. Activated carbon, activated alumina, and iron filings are all applicable adsorbents. Alkaline chlorination and incineration are effective cyanide destruction treatments. Evaporation, ion-exchange, reverse osmosis, electrodialysis, and electrolytic recovery are waste reduction and recovery techniques applicable to metal bearing hazardous streams.
[Grosse DW; 12th Annual Research Symposium on Land Disposal, Remedial Action, Incineration, and Treatment of Hazardous Wastes (1986)]**PEER REVIEWED**

The following wastewater treatment technologies have been investigated for **lead**: Concentration process: Biological treatment. /**Lead**/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-53 (1982)]**PEER REVIEWED**

The following wastewater treatment technologies have been investigated for **lead**: Concentration process: Chemical precipitation. /**Lead**/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-71-72 (1982)]**PEER REVIEWED**

The following wastewater treatment technologies have been investigated for **lead**: Concentration process: Reverse osmosis. /**Lead**/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-88 (1982)]**PEER REVIEWED**

The following wastewater treatment technologies have been investigated for **lead**: Concentration process: Activated carbon. /**Lead**/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-164 (1982)]**PEER REVIEWED**

The following wastewater treatment technologies have been investigated for **lead**: Concentration process: Miscellaneous sorbents. /**Lead**/
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-202 (1982)]**PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

The employer shall assure that no employee is exposed to **lead** at concentrations greater than 50 ug/cu m averaged over an 8-hr period. If an employee is exposed to **lead** for more than 8 hr in any work day, the permissible exposure limit, as a TWA for that day, shall be reduced according to the following formula: Maximum permissible limit (in ug/cu m)= 400 divided by the number of hours worked in the day. /**Lead**, inorganic, as Pb/
[29 CFR 1910.1025(c) (7/1/98)]**PEER REVIEWED**

Threshold Limit Values:

8 hr Time Weighted Avg (TWA): 0.05 mg/cu m. /**Lead**, elemental, and inorganic compounds, as Pb/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.38]**QC REVIEWED**

Excursion Limit Recommendation: Excursions in worker exposure levels may exceed three times the TLV-TWA for no more than a total of 30 min during a work day, and under no circumstances should they exceed five times the TLV-TWA, provided that the TLV-TWA is not exceeded. /**Lead**, elemental, and inorganic compounds, as Pb/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.6]**QC REVIEWED**

A3; Confirmed animal carcinogen with unknown relevance to humans. /**Lead**, elemental, and inorganic compounds, as Pb/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.38]**QC REVIEWED**

Biological Exposure Index (BEI): Determinant: **lead** in blood; Sampling Time: not critical; BEI: 30 ug/100 ml. [Note: Women of child bearing potential, whose blood Pb exceeds 10 ug/dl, are at risk of delivering a child with a blood Pb over the current Centers for Disease Control guideline of 10 ug/dl. If the blood Pb of such children remains elevated, they may be at increased risk of cognitive deficits. The blood Pb of these children should be closely monitored and appropriate steps should be taken to minimize the child's exposure to environmental **lead**.] /**Lead**, elemental/
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.91]**QC REVIEWED**

NIOSH Recommendations:

Recommended Exposure Limit: 10 hr Time-Weighted avg: 0.1 mg/cu m.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 184]**PEER REVIEWED**

Air concentrations should be maintained so that worker blood **lead** remains less than 0.06 mg PB/100 g of whole blood.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 184]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

100 mg/cu m
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 184]**PEER REVIEWED**

Other Occupational Permissible Levels:

Australia: 0.15 mg/cu m (as Pb) (1990); Federal Republic of Germany: 0.1 mg/cu m total dust (as Pb), short-term level 1 mg/cu m, 30 min, once per shift, Pregnancy group B, a risk of damage to the developing embryo or fetus must be considered to be probable, to minimize the potential risk, a BAT value of 30 ug/dl blood has been evaluated specifically for women under 45 years old (1991); Sweden: 0.1 mg/cu m, total dust, 0.05 mg/cu m, respirable dust (1989); United Kingdom: 0.15 mg/cu m (1991).
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.851]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

Main uses are in the manufacture of storage batteries, ammunition, nuclear and x-ray shielding devices, cable covering, ceramic glazes, noise control materials, bearing, brass and bronze, casting metals, solders, pipes, traps, and bends.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V15 111]**PEER REVIEWED**

Construction material for tank linings, piping, and other equipment handling corrosive gases and liqs used in the manuf of sulfuric acid, petr refining, halogenation, sulfonation, extraction, condensation; for x-ray and atomic radiation protection; manuf of tetraethyllead, pigments for paints, and other organic and inorganic **lead** compds; bearing metal and alloys; storage batteries; in ceramics, plastics, and electronic devices; in building construction; in solder and other **lead** alloys; in the metallurgy of steel and other metals.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 922]**PEER REVIEWED**

Lead and **lead** compounds was used in solder applied to water distribution pipes and to seams of cans used for food, in some traditional remedies, in bottle closures for alcoholic beverages and in ceramic glazes and crystal tableware.
[WHO; Environ Health Criteria: Lead p. 26 (1995)]**PEER REVIEWED**

Manufacturers:

ASARCO, Incorporated, Hq, 180 Maiden Lane, New York, NY 10038 (212) 510-2000. Production sites: Glover, MO 63646; Denver CO 80216
[SRI. 1998 Directory of Chemical Producers -United States of America. SRI International, Menlo Park, CA. 1998.. 43]**PEER REVIEWED**

The Doe Run Co., hq, 1801 Park 270 Drive, Suite 300, St. Louis, MO 63146 (314) 453-7100. Production site: Boss, MO 65440
[SRI. 1998 Directory of Chemical Producers -United States of America. SRI International, Menlo Park, CA. 1998.. 120]**PEER REVIEWED**

Cominco Alaska Incorporated, (wholely owned subsidiary of Cominco Ltd.,Toronto, Canada)
[U.S. Geological Survey; Minerals Information-1997: Lead. http://minerals.er.usgs.gov/minerals/pubs/commodity/lead/]**PEER REVIEWED**

Hecla Mining Company, Coeur d'Alene, ID
[U.S. Geological Survey; Minerals Information-1997: Lead. http://minerals.er.usgs.gov/minerals/pubs/commodity/lead/]**PEER REVIEWED**

Pegasus Gold, Inc., Spokane, WA.
[U.S. Geological Survey; Minerals Information-1997: Lead. http://minerals.er.usgs.gov/minerals/pubs/commodity/lead/]**PEER REVIEWED**

Methods of Manufacturing:

The **lead** mineral in most crude ores is separated from the gangue and other valuable minerals. Occasionally, the ores are sufficently rich in **lead** and low in impurities to be smelted directly. The primary operation of ore dressing are crushing, grinding, and concentration (beneficiation). The first step is a size reduction of the mined ore to liberate the desired minerals from interlocking gangue. Primary (gyratory or jaw) and secondary (gyratory or roll) crushers are employed. Wire-mesh screens bypass the finer material & return the oversize for recrushing. Further comminution is accomplished by wet

grinding in horizontal, cylindrical mills containing steel balls, rods, or flint pebbles. Autogenous grinding is employed occasionally. Classifiers that depend on differences in settling rates in air or water are used in closed circuit with grinding mills to recirculate oversize for regrinding.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 14 (81) 102]**PEER REVIEWED**

Gravity concentration ... /such as/ the separation of ore from gangue using jigs, heavy-medium separation, or tables, is applicable to **lead** ores. These techniques are often combined with the more widely used flotation process. Flotation ... makes it possible to selectively separate ... the gangue ... /&/ other valuable minerals from the **lead** ore, such as sphalerite (zinc sulfide). For flotation the ore is ground to a size sufficiently fine that the surface forces of adhesion to the bubbles, supplied for buoyancy, overcome the force of gravity. ... The ground & sized ore is discharged from classifiers to a conditioning tank in which the slurry is mixed with the required chemicals, & then passed to the flotation cells in which air is forced up through the slurry, forming bubbles to which the galena adheres. The floated galena is trapped in the top froth & eventually skimmed. ... The **lead** concentrate skimmed from the cell is dewatered & thickened to a moisture content of 50%. Vacuum filtering further decreases the moisture to 15% ... .
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 14(81) 102]**PEER REVIEWED**

... /The/ series of processes ... /used to/ produce commercial grade of **lead** /from **lead** concentrate include/ blast-furnace smelting (sintering ... /&/ smelting) ... drossing (soda process ... /&/ continuous drossing) ... refining (pyrometallurgical methods ... /&/ electrolytic refining) ... /& the/ imperial smelting process (none in the USA).
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 14(81) 104-29]**PEER REVIEWED**

General Manufacturing Information:

The Bureau of Mines is investigating a leach-electrolysis technique to produce **lead** from galena concentrates without sulfur emissions. The concentrate is leached with a hot FeCl3-NaCl solution to obtain a filtrate containing more than 99% of the **lead** & a residue of elemental sulfur & gangue material. Pure PbCl2 crystallizes out of the leach solution on cooling & is electrolyzed in a relatively low temp fused-salt cell to yield **lead** metal & chlorine gas. New developments in the refining of **lead** in general have focused on improvements & adaptions of the traditional pyrometallurgical & electrorefining processes, & esp on the conversion of batch processes into continuous processes. Completely continuous refining operations are the goal of these efforts.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 14(81) 130-1]**PEER REVIEWED**

The recovery of **lead** from scrap is an important source for the **lead** demands of the USA & rest of the world. In the USA, 50% of the **lead** requirements are satisfied by recycled **lead** products. The ratio of secondary to primary **lead** increases with increasing **lead** consumption for batteries. The well-organized collecting channels forecast a stable & growing future for **lead**. ... The principal types of scrap are battery plates, drosses, skimmings, & industrial scrap such as solders, babbitts, cable sheathing, etc. Some of this material is reclaimed by kettle melting & refining. ... Most scrap is a combination of metallic **lead** & its alloying constituents mixed with compounds of these metals, usually oxides & sulfates. ... Most recycled **lead** derives from scrap **lead** batteries since >50% of the **lead** consumed in the USA is in the form of **lead** batteries. About 90% is reclaimed; hence, the bulk of the recycling industry is centered on the processing of **lead** battery scrap.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 14(81) 131]**PEER REVIEWED**

At present, battery scrap is converted to impure **lead** or **lead** alloys by pyrometallurgical processes employing blast, reverberatory, or rotary furnaces. In many plants, a furnace combination is used. ... The overall recovery of the metallic components of scrap in plants having both reverberatory & blast furnaces is over 95%. ... The decisions being made by the operators of secondary smelters as to which procedures will be designed into new plants or installed in updating old plants are strongly influenced by the introduction of new grid alloys, such as calcium alloys, low-antimony alloys (2-3%), & strontium alloys, to replace the traditional 5-7% antimonial alloys, & by air pollution standard requirements.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 14(81) 132-3]**PEER REVIEWED**

The projected world and USA demand for **lead** in the year 2000, including that supplied from recycled **lead**, is est at approx 9X10+6 and 2.2X10+6 tonnage/yr, respectively. This is an annual growth rate of about 3% for the world & 1.5% for the USA. The demand in the developing nations is expected to grow at a faster rate than in the industrialized nations. If these estimates are correct, the **lead** industry in the USA would have to increase by 50 to 60%. The cumulative demand for primary **lead** in the world from 1973 to 2000 has been est at 140X10+6 tons. The est world reserves of 150X10+6 tons are sufficient to supply this demand.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 14(81) 133]**PEER REVIEWED**

The economics of USA **lead** prodn, both primary & recycled, are markedly influenced by government regulations concerning **lead** concn in air. Compliance with those standards has been costly, and if more limiting standards are imposed, can result in a reduction of present smelter capacity & set limits on future expansion.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 14(81) 135]**PEER REVIEWED**

Stricter regulations concerning **lead** emissions and ambient air **lead** levels, as well as the need to reduce capital and operating costs have **lead** to the development of alternative **lead** smelting processes to replace the sinter-blast furnace combination. Four processes have reached the stage of being promoted for commercial use, namely: Kivcet, QSL, Isamelt, and Boliden Kaldo. These processes have the potential advantages of meeting proposed in-plant hygiene requirements, utilizing the heat of combustion and thereby reducing energy costs, reduction in capital and operating costs through the use of high intensity vessels, and the production of low volumes of process gas of high SO2 content through the use of large amounts of oxygen.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V15 79-87]**PEER REVIEWED**

1997 Production by state: Missouri, 412,000 metric tons; Montana, 9,230 metric tons; and Colorado, Idaho, Illinois, New York, and Tennessee (combined), 26,600 metric tons.
[U.S. Geological Survey; Minerals Information-1997: Lead. http://minerals.er.usgs.gov/minerals/pubs/commodity/lead/]**PEER REVIEWED**

1997: **Lead** recovered from new scrap, 63,700 metric tons; old scrap, 1,040,000 metric tons, of which 991,000 metric tons comes from batteries.
[U.S. Geological Survey; Minerals Information-1997: Lead. http://minerals.er.usgs.gov/minerals/pubs/commodity/lead/]**PEER REVIEWED**

The princpal U.S. **lead** producers, ASARCO, Inc. and The Doe Run Co., account for 75% of domestic mine production and 100% of primary **lead** production. Both companies employ sintering/blast furnace operations at their smelters and pyrometallurigical methods in their refineries.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V15 105]**PEER REVIEWED**

The most important ore mineral is galena, PbS (87% Pb), followed by anglesite, PbSO4 (68% Pb), and cerussite, PbCO3 (77.5% Pb). The latter two minerals result from the natural weathering of galena.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V15 70]**PEER REVIEWED**

Although **lead** is a relatively rare element, the occurrence of concentrated and easily accessible **lead** ore deposits is unexpectedly high.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V15 70]**PEER REVIEWED**

Formulations/Preparations:

Grade: high purity (less than 10 ppm impurity); pure (99.9+); powdered (99% pure); pig **lead**; paste. Forms available: ingots, sheet, pipe, shot, buckles or straps, grids, rod, wire, etc; paste; powder; single crystals.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 12th ed. New York, NY: Van Nostrand Rheinhold Co., 1993 686]**PEER REVIEWED**

Low bismuth, low silver, pure **lead**. 99.995% **lead** (ASTM B29-92) (for chemical applications requiring low bismuth and silver contents). Specifications (max allowable metal, wt%: Sb, As, Sn, 0.0005 each; Cu, 0.0010; Ag, 0.0010; Bi, 0.0015; Zn, 0.0005; Te, 0.0001; Ni, 0.0002; Fe, 0.0002.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V15 110]**PEER REVIEWED**

Refined pure **lead**. 99.97% **lead** (ASTM B29-92) (for **lead** battery applications). Specifications (max allowable metal, wt%: Sb, As, Sn, 0.0005 each; Cu, 0.0010; Ag, 0.0025; Bi, 0.025; Zn, 0.0005; Te, 0.0001; Ni, 0.0002; Fe, 0.001.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V15 110]**PEER REVIEWED**

Pure **lead**. 99.94% **lead** (ASTM B29-92). Specifications (max allowable metal, wt%: Sb, As, Sn, 0.001 each, 0.002 total; Cu, 0.0015; Ag, 0.005; Bi, 0.05; Zn, 0.001; Ni, 0.001; Fe, 0.001.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V15 110]**PEER REVIEWED**

Chemical copper-**lead**. 99.90% **lead** (ASTM B29-92) (for applications requiring corrosion protection and formability). Specifications (max allowable metal unless range is given, wt%: Sb, As, Sn, 0.001 each, 0.002 total; Cu, 0.040-0.080; Ag, 0.020; Bi, 0.025; Zn, 0.001; Ni, 0.002; Fe, 0.002.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V15 110]**PEER REVIEWED**

Impurities:

ASTM requires pig **lead** to be 99.85 to 99.90% pure; impurities consist of silver, copper, arsenic, antimony, tin, zinc, iron, and/or bismuth.
[ASTM; Annual Book of ASTM Standards Section 3 E-37-36 (1984)]**PEER REVIEWED**

After softening /**lead** bullion/, the impurities that may still remain in the **lead** are silver (about 0.2%), gold (about 0.006%), copper, tellurium, platinum metals, & bismuth (up to 0.1%). Although these concentrations may be tolerable for some **lead** applications, their market value encourages separation & recovery.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 14(81) 117]**PEER REVIEWED**

Consumption Patterns:

Transportation-automotive batteries, gasoline additives, 70%; construction, ammunition, electrical uses, TV glass, and paint, 25%; ceramics, type metal, ballast or weights, and tubes or containers, 5% (1986)
[BUREAU OF MINES. MINERAL COMMODITY SUMMARIES 1987 p.88]**PEER REVIEWED**

COMPONENT OF **LEAD** OXIDE BATTERIES, 36.5%; COMPONENT OF ANTIMONIAL **LEAD** BATTERIES, 29.1%; CHEM INT FOR **LEAD** ALKYLS, 11.1%; CHEM INT FOR PIGMENTS, 5.7%; AMMUNITION, 4.1%; SOLDER, 2.6%; SHEET **LEAD**, 1.4%; CABLE COVERING, 1.4%; OTHER METAL PRODUCTS, 6.3%; OTHER, 1.8% (1982)
[SRI]**PEER REVIEWED**

Lead consumption in the USA by product in approx metric tons for 1979: ammunition, 52,884; bearing metal, 12,230; brass & bronze, 15,569; cable covering, 15,623; caulking **lead**, 4,055; casting metals, 9,365; pipes, traps, bends, 2,942; sheet **lead**, 6,545; solders, 40,429; storage battery grids, posts, etc, 309,838; storage battery oxides, 337,412; terne metal, 4,722; pigments, 82,788; antiknock additives, 186,947.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 14(81) 135]**PEER REVIEWED**

Lead consumption in the USA by product in approx metric tons for 1978: ammunition, 55,776; bearing metal, 9,510; brass & bronze, 16,502; cable covering, 13,851; caulking **lead**, 9,909; casting metals, 3,611; pipes, traps, bends, 10,479; sheet **lead**, 12,626; solders, 68,391; storage battery grids, posts, etc, 412,568; storage battery oxides, 466,714; terne metal, 3,778; pigments, 91,643; antiknock additives, 178,333.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 14(81) 135]**PEER REVIEWED**

Lead consumption in the USA by product in approx metric tons for 1977: ammunition, 61,961; bearing metal, 10,873; brass & bronze, 15,148; cable covering, 13,705; caulking **lead**, 8,725; casting metals, 5,428; pipes, traps, bends, 10,555; sheet **lead**, 15,205; solders, 58,320; storage battery grids, posts, etc, 416,709; storage battery oxides, 441,387; terne metal, 1,491; pigments, 90,703; antiknock additives, 211,295; annealing, weights, galvanizing ballast, 21,478; other uses, 35,812.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 14(81) 135]**PEER REVIEWED**

Lead consumption in the USA by product in approx metric tons for 1976: ammunition, 66,659; bearing metal, 11,851; brass & bronze, 14,207; cable covering, 14,452; caulking **lead**, 11,317; casting metals, 6,085; pipes, traps, bends, 12,509; sheet **lead**, 22,170; solders, 57,447; storage battery grids, posts, etc, 348,221; storage battery oxides, 397,859; terne metal, 1,447; pigments, 95,792; antiknock additives, 217,507; annealing, weights, galvanizing ballast, 24,401; other uses, 29,351.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 14(81) 135]**PEER REVIEWED**

By class of products, 1997: Metal products, 7.8%; Storage Batteries, 86.9%; Miscellaneous, including other oxides, 5.3%.
[U.S. Geological Survey; Minerals Information-1997: Lead.
http://minerals.er.usgs.gov/minerals/pubs/commodity/lead/]**PEER REVIEWED**

By product, 1997: Ammunition, shot and bullets, 3.46%; Bearing metals, 0.16%; Brass and bronze, billets and ingots, 0.28%; Cable covering, power and communication, 0.31%; Caulking **lead**, building construction, 0.087%; Casting metals 1.14%; Pipes, traps and extruded products, 0.12%; Sheet **lead**, 1.19%; Solder, 0.60%; Storage batteries, 86.9%; Other metal products, 0.47%; Other oxides, 4.18%; Miscellaneous uses, 0.53%.
[U.S. Geological Survey; Minerals Information-1997: Lead.

http://minerals.er.usgs.gov/minerals/pubs/commodity/lead/]**PEER REVIEWED**

U. S. Production:

Between 1960 & 1978, mine prodn in the USA ... increased from 232,00 to 541,000 tonnage. The large increase occurred from 1968 to 1970 with the coming on stream of mines & smelters in the newly developed Missouri **lead** belt. Domestic mine prodn in 1978 accounted for 70% of the USA primary **lead** prodn.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 14(81) 133]**PEER REVIEWED**

(1977) 1.31X10+12 G
[SRI]**PEER REVIEWED**

(1978) 541,000 metric tons (mine production); 776,000 metric tons (refined production with some secondary **lead** included)
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 14(81) 134]**PEER REVIEWED**

(1982) 1.09X10+12 G
[SRI]**PEER REVIEWED**

(1986) 1.26x10+12 g
[BUREAU OF MINES. MINERAL COMMODITY SUMMARIES 1987 p.88]**PEER REVIEWED**

1997: Recoverable **lead** from mines (after smelting and refining), 448,000 metric tons; Primary **lead** (refined; domestic ores and base bullion), 343,000 metric tons; Secondary **lead** (**lead** content), 1,110,000 metric tons.
[U.S. Geological Survey; Minerals Information-1997: Lead.
http://minerals.er.usgs.gov/minerals/pubs/commodity/lead/]**PEER REVIEWED**

U. S. Imports:

(1977) 2.30X10+11 G
[SRI]**PEER REVIEWED**

(1982) 9.50X10+10 G
[SRI]**PEER REVIEWED**

(1986) 1.20X10+10 g
[BUREAU OF MINES. MINERAL COMMODITY SUMMARIES 1987 p.88]**PEER REVIEWED**

1997: **Lead** in ore and concentrates, 17,800 metric tons; **Lead** in base bullion, 25 metric tons; **lead** in pigs, bars, and reclaimed scrap, 265,000 metric tons. (**lead** content)
[U.S. Geological Survey; Minerals Information-1997: Lead.
http://minerals.er.usgs.gov/minerals/pubs/commodity/lead/]**PEER REVIEWED**

U. S. Exports:

(1977) 8.90X10+9 G
[SRI]**PEER REVIEWED**

(1982) 5.56X10+10 G
[SRI]**PEER REVIEWED**

(1986) 1.40X10+10 g

[BUREAU OF MINES. MINERAL COMMODITY SUMMARIES 1987 p.88]**PEER REVIEWED**

1997: **Lead** ore and concentrates, 42,200 metric tons; **Lead** materials, excluding scrap, 104,000 metric tons. (**lead** content)
[U.S. Geological Survey; Minerals Information-1997: Lead.
http://minerals.er.usgs.gov/minerals/pubs/commodity/lead/]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

MICRODETERMINATION OF **LEAD** IN BLOOD & URINE BY ANODIC STRIPPING VOLTAMMETRY EQUIPPED WITH MERCURY ELECTRODE. NO INTERFERENCE WAS FOUND WITH COEXISTING IONS FOUND IN URINE. /TOTAL **LEAD**/
[KARAI I ET AL; OSAKA CITY MED J 26 (1): 39-46 (1981)]**PEER REVIEWED**

High performance liquid chromatography assay of RBC UMPase activity is a sensitive and rapid assay that appears to meet criteria for a reliable clinical laboratory index of blood **lead** concentrations. /Total **lead**/
[Cook LR et al; Br J Ind Med 43: 387-90 (1986)]**PEER REVIEWED**

Lead concentrations (ug/g wet weight) in human bone (tibia) were measured noninvasively in vivo employing an x-ray fluoresence technique. Forty-five workers who had been chronically exposed to **lead** (mean duration of employment 20.9 yr) were found to have a mean bone **lead** content of 52.9 ug/g wet weight (range 0-198 ug/g). Blood **lead**, urinary **lead** excretion after EDTA chelation, zinc protoporphyrin, and unstimulated urinary **lead** excretion were also evaluated. The correlation coefficients (r) between bone **lead** measurements (as assayed by x-ray fluoresence) and blood **lead**, zinc protoporphyrin, or unstimulated urinary **lead** were 0.44 (p=0.004), 0.39 (p=0.015), and 0.40 (p=0.01) respectively. The correlation coefficient between x-ray fluoresence (XRF) findings and **lead** excretion following Ca-EDTA administration was 0.69 (p<0.001). /Total **lead**/
[Wielopolski L et al; Am J Ind Med 9: 221-26 (1986)]**PEER REVIEWED**

Biological indicator of exposure to **lead** or **lead** compounds. Analyte: **Lead**. Matrix: blood or tissue. Method: Inductively-coupled argon plasma-atomic emission spectroscopy. Wavelength: 220.4 nm. Precision: 0.85. This method is useful for monitoring the blood of workers exposed to several metals simultaneously. This is a simultanous multielemental analysis, but is not compound-specific. /Total **lead**/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V1 8005-1]**PEER REVIEWED**

Biological indicator of exposure to **lead** & **lead** compounds. Analyte: **Lead**(II)-APDC (ammonium pyrrolidine dithiocarbamate) complex. Matrix: blood or urine. Technique: atomic absorption, air/acetylene. Quality control: commercial controls, pooled urine or blood, urine corrected for creatinine. Extraction: APDC-MIBK (methyl isobutyl ketone). Range: 5 to 150 ug/100 g blood; 5 to 150 ug/100 ml urine. Precision: 0.05. This procedure quantitates Pb(2+) in blood or urine to assess body burden, injury to the hematopoietic system, & to comply with Federal regulations. Blood **lead** is the preferred biological indicator of **lead** absorption. The optimum working range is 0.1 to 1.5 ug Pb/g or per ml urine. Interferences: Phosphate, EDTA, & oxalate can sequester **lead** and cause low **lead** readings. /Total **lead**/
[U.S. Department of Health and Human Services, Public Health Service. Centers for

Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V1 8003-1]**PEER REVIEWED**

Sampling Procedures:

Airborne particulate **lead** is sampled with a high-volume air sampler (as high as 2 cu m/min) for a period of 24 hr and analyzed by atomic absorption spectrometry. Gross particulate loading is determined by weighing the filter before and after sample collection. Additional supplemental samplers include the following: 1) dichotomous sampler - to fractionate samples into two size ranges, since there are distinct differences in the effects of small and large particles on humans; 2) tape sampler - to monitor airborne particulates for shorter time intervals (for source and transport studies).
[USEPA; Air Quality Criteria for Lead p.4-3 (1977) USEPA 600/8-77-017]**PEER REVIEWED**

Analyte: **Lead**. Matrix: Air. Sampler: Filter (0.8-um cellulose ester membrane). Flow rate: 1 to 4 l/min. Vol: min, 200 l at 0.05 mg/cu m; max, 1200 l. Stability: stable. Shipment is routine. Range studied: 0.13 to 0.4 mg/cu m; 0.15 to 1.7 mg/cu m (fume). Overall precision: 0.072; 0.068 (fume). The working range is 0.25 to 0.5 mg/cu m for a 400 l air sample. The method is applicable to elemental **lead**, including **lead** fume, & all other aerosols containing **lead**. This is an elemental analysis, not compound specific.
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V2 7082-1]**PEER REVIEWED**

Special References:

Special Reports:

CHISOLM JJ JR, D BARLTROP; RECOGNITION & MANAGEMENT OF CHILDREN WITH INCR **LEAD** ABSORPTION; ARCHIVES OF DISEASES IN CHILDHOOD 54: 249-62 (1979). REVIEW WITH DISCUSSION ON MANAGEMENT & RECOGNITION OF INCREASED **LEAD** ABSORPTION IN CHILDREN

USEPA; Ambient Water Quality Criteria Doc: **Lead** (1980) EPA 440/5-80-057

USEPA; Air Quality Criteria for **Lead** (1977) EPA 600/8-77-017

USEPA; Intermedia Priority Pollutants Guidance Document **Lead** (1982)

Nat'l Research Council Canada; Effects of Chromium in the Canadian Envir (1976) NRCC No.15017

WHO; Environ Health Criteria: **Lead** (1977)

USEPA; Air Quality Criteria for **Lead** I-IV (1986) EPA-600/8-83/028aF

McInnes G; Airborn **Lead** Concentrations and the Effect of Reductions in the **Lead** Content of Petrol (1986)

National Academy of Sciences; **Lead** in the Human Environment (1980)

USEPA; Health Effects Assessment for **Lead** (1984) PB86-134665

DHHS/ATSDR; The Nature and Extent of **Lead** Poisoning in Children in the United States: A Report to Congress (7/88)

WHO; Environmental Health Criteria 119: Principles and Methods for the Assessment of Nephrotoxicity Associated with Exposure to Chemicals (1991)

DHHS/FDA; Guidance Document for **Lead** in Shellfish (1993)

U.S. Dept Health & Human Services/Agency for Toxic Substances & Disease Registry; Toxicological Profile for **Lead** (Update) (1993) ATSDR/TP-92/12

Synonyms and Identifiers:

Related HSDB Records:

6923 [**LEAD** COMPOUNDS]

Synonyms:

CI pigment metal 4
PEER REVIEWED

CI 77575
PEER REVIEWED

KS-4
PEER REVIEWED

LEAD
PEER REVIEWED

Lead flake
PEER REVIEWED

Lead metal
PEER REVIEWED

Lead S2
PEER REVIEWED

Olow (Polish)
PEER REVIEWED

Pb-S 100
PEER REVIEWED

PLUMBUM
PEER REVIEWED

Formulations/Preparations:

Grade: high purity (less than 10 ppm impurity); pure (99.9+); powdered (99% pure); pig **lead**; paste. Forms available: ingots, sheet, pipe, shot, buckles or straps, grids, rod, wire, etc; paste; powder; single crystals.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 12th ed. New York, NY: Van Nostrand Rheinhold Co., 1993 686]**PEER REVIEWED**

Low bismuth, low silver, pure **lead**. 99.995% **lead** (ASTM B29-92) (for chemical applications requiring low bismuth and silver contents). Specifications (max allowable metal, wt%: Sb, As, Sn, 0.0005 each; Cu, 0.0010; Ag, 0.0010; Bi, 0.0015; Zn, 0.0005; Te, 0.0001; Ni, 0.0002; Fe, 0.0002.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V15 110]**PEER REVIEWED**

Refined pure **lead**. 99.97% **lead** (ASTM B29-92) (for **lead** battery applications). Specifications (max allowable metal, wt%: Sb, As, Sn, 0.0005 each; Cu, 0.0010; Ag, 0.0025; Bi, 0.025; Zn, 0.0005; Te, 0.0001; Ni, 0.0002; Fe, 0.001.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V15 110]**PEER REVIEWED**

Pure **lead**. 99.94% **lead** (ASTM B29-92). Specifications (max allowable metal, wt%: Sb, As, Sn, 0.001 each, 0.002 total; Cu, 0.0015; Ag, 0.005; Bi, 0.05; Zn, 0.001; Ni, 0.001; Fe, 0.001.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V15 110]**PEER REVIEWED**

Chemical copper-**lead**. 99.90% **lead** (ASTM B29-92) (for applications requiring corrosion protection and formability). Specifications (max allowable metal unless range is given, wt%: Sb, As, Sn, 0.001 each, 0.002 total; Cu, 0.040-0.080; Ag, 0.020; Bi, 0.025; Zn, 0.001; Ni, 0.002; Fe, 0.002.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V15 110]**PEER REVIEWED**

EPA Hazardous Waste Number:

D008; A waste containing **lead** may (or may not) be characterized a hazardous waste following testing by the Toxicant Extraction Procedure as prescribed by the Resource Conservation and Recovery Act (RCRA) regulations. /**Lead**/

Administrative Information:

Hazardous Substances Databank Number: 231

Last Revision Date: 20030214

Last Review Date: Reviewed by SRP on 5/20/1999

Update History:

Complete Update on 02/14/2003, 1 field added/edited/deleted.
Complete Update on 11/08/2002, 1 field added/edited/deleted.
Complete Update on 07/22/2002, 2 fields added/edited/deleted.
Complete Update on 01/14/2002, 1 field added/edited/deleted.
Complete Update on 08/09/2001, 1 field added/edited/deleted.
Complete Update on 05/16/2001, 1 field added/edited/deleted.
Complete Update on 09/12/2000, 1 field added/edited/deleted.

Complete Update on 06/12/2000, 1 field added/edited/deleted.
Complete Update on 06/01/2000, 87 fields added/edited/deleted.
Field Update on 02/02/2000, 1 field added/edited/deleted.
Field Update on 09/21/1999, 1 field added/edited/deleted.
Field Update on 08/26/1999, 1 field added/edited/deleted.
Field Update on 05/04/1999, 1 field added/edited/deleted.
Field Update on 02/11/1999, 1 field added/edited/deleted.
Field Update on 11/20/1998, 1 field added/edited/deleted.
Field Update on 11/17/1998, 1 field added/edited/deleted.
Complete Update on 06/02/1998, 1 field added/edited/deleted.
Complete Update on 10/17/1997, 1 field added/edited/deleted.
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Complete Update on 05/08/1997, 1 field added/edited/deleted.
Complete Update on 03/27/1997, 1 field added/edited/deleted.
Complete Update on 02/18/1997, 1 field added/edited/deleted.
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Complete Update on 02/02/1994, 1 field added/edited/deleted.
Complete Update on 01/17/1994, 1 field added/edited/deleted.
Complete Update on 11/05/1993, 1 field added/edited/deleted.
Complete Update on 10/28/1993, 1 field added/edited/deleted.
Complete Update on 08/17/1993, 4 fields added/edited/deleted.
Field Update on 08/03/1993, 1 field added/edited/deleted.
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Field Update on 01/20/1993, 1 field added/edited/deleted.
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Complete Update on 12/10/1992, 1 field added/edited/deleted.
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Complete Update on 01/07/1991, 7 fields added/edited/deleted.
Field update on 11/09/1990, 1 field added/edited/deleted.
Field update on 05/18/1990, 1 field added/edited/deleted.

Field Update on 01/15/1990, 1 field added/edited/deleted.
Complete Update on 01/11/1990, 6 fields added/edited/deleted.
Field update on 12/29/1989, 1 field added/edited/deleted.
Complete Update on 07/12/1989, 89 fields added/edited/deleted.
Complete Update on 02/24/1988, 11 fields added/edited/deleted.
Complete Update on 04/17/1987

Record Length: 129630

Lead and compounds (inorganic)

CASRN: 7439-92-1
For other data, click on the Table of Contents

Status:

STATUS OF DATA FOR **Lead** and compounds (inorganic)

File First On-Line 03/01/1988

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	message	02/01/1991
Inhalation RfC Assessment (I.B.)	no data	
Carcinogenicity Assessment (II.)	on-line	11/01/1993

Substance Identification:

Substance Name:

Lead and compounds (inorganic)

CAS Registry Number: 7439-92-1

I. Chronic Health Hazard Assessment for Noncarcinogenic Effects:

I.A. Reference Dose for Chronic Oral Exposure (RfD):

Substance Name -- **Lead** and compounds (inorganic)
CASRN -- 7439-92-1

A great deal of information on the health effects of **lead** has been obtained through decades of medical observation and scientific research. This information has been assessed in the development of air and water quality criteria by the Agency's Office of Health and Environmental Assessment (OHEA) in support of regulatory decision-making by the Office of Air Quality Planning and Standards (OAQPS) and by the Office of Drinking Water (ODW). By comparison to most other environmental toxicants, the degree of uncertainty about the health effects of **lead** is quite low. It appears that some of these effects, particularly changes in the levels of certain blood enzymes and in aspects of children's neurobehavioral development, may occur at blood **lead** levels so low as to be essentially without a threshold. The Agency's RfD Work Group discussed inorganic **lead** (and **lead** compounds) at two meetings (07/08/1985 and 07/22/1985) and considered it inappropriate to develop an RfD for inorganic **lead**. For additional information, interested parties are referred to the 1986 Air Quality Criteria for **Lead** (EPA-600/8-83/028a-dF) and its 1990 Supplement (EPA/600/8-89/049F).

Screening-Level Literature Review Findings -- A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the RfD for **Lead** and compounds (inorganic) conducted in September 2002 identified one or more significant new studies. IRIS users may request the references for those studies from the IRIS Hotline at hotline.iris@epa.gov or 301-345-2870.

EPA Contacts:

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC):

Substance Name -- **Lead** and compounds (inorganic)
CASRN -- 7439-92-1

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure:

Substance Name -- **Lead** and compounds (inorganic)
CASRN -- 7439-92-1
Last Revised -- 11/01/1993

Section II provides information on three aspects of the carcinogenic assessment for the substance in question; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity:

II.A.1. Weight-of-Evidence Characterization:

Classification -- B2; probable human carcinogen

Basis -- Sufficient animal evidence. Ten rat bioassays and one mouse assay have shown statistically significant increases in renal tumors with dietary and subcutaneous exposure to several soluble **lead** salts. Animal assays provide reproducible results in several laboratories, in multiple rat strains with some evidence of multiple tumor sites. Short term studies show that **lead** affects gene expression. Human evidence is inadequate.

II.A.2. Human Carcinogenicity Data:

Inadequate. There are four epidemiologic studies of occupational cohorts exposed to **lead** and **lead** compounds. Two studies (Dingwall-Fordyce and Lane, 1963; Nelson et al., 1982) did not find any association between exposure and cancer mortality. Selevan et al. (1985), in their retrospective cohort mortality study of primary **lead** smelter workers, found a slight decrease in the total cancer mortality (SMR=95). Apparent excesses were observed for respiratory cancer (SMR=111, obs=41, p>0.05) and kidney cancer (SMR=204, obs=6, p>0.05). Cooper and Gaffey (1975) and Cooper (1985 update) performed a cohort mortality study of battery plant workers and **lead** smelter workers. They found statistically significant excesses for total cancer mortality (SMR=113, obs=344), stomach cancer (SMR=168, obs=34), and lung cancer (SMR=124, obs=109) in the battery plant workers. Although similar excesses were observed in the smelter workers, they were not statistically significant. Cooper and Gaffey (1975) felt it was possible that individual subjects were monitored primarily on the basis of obvious signs of **lead** exposure, while others who showed no symptoms of **lead** poisoning were not monitored.

All of the available studies lacked quantitative exposure information, as well as information on the possible contribution from smoking. All studies also included exposures to other metals such as arsenic, cadmium, and zinc for which no adjustment was done. The cancer excesses observed in the lung and stomach were relatively small (<200). There was no consistency of site among the various studies, and no study showed any dose-response relationship. Thus, the available human evidence is considered to be inadequate to refute or demonstrate any potential carcinogenicity for humans from **lead** exposure.

II.A.3. Animal Carcinogenicity Data:

Sufficient. The carcinogenic potential of **lead** salts (primarily phosphates and acetates) administered via the oral route or by injection has been demonstrated in rats and mice by more than 10 investigators. The most characteristic cancer response is bilateral renal carcinoma. Rats given **lead** acetate or subacetate orally have developed gliomas, and **lead** subacetate also produced lung adenomas in mice after i.p. adminstration. Most of these investigations found a carcinogenic response only at the highest dose. The **lead** compounds tested in animals are almost all soluble salts. Metallic **lead**, **lead** oxide and **lead** tetralkyls have not been tested adequately. Studies of inhalation exposure have not been located in the literature.

Azar et al. (1973) administerd 10, 50, 100, and 500 ppm **lead** as **lead** acetate in dietary concentrations to 50 rats/sex/group for 2 years. Control rats (100/sex) received the basal laboratory diet. In a second 2-year feeding study, 20 rats/group were given diets containing 0, 1000, and 2000 ppm **lead** as **lead** acetate. No renal tumors were reported in the control groups or in treated animals of either sex receiving 10 to 100 ppm. Male rats fed 500, 1000, and 2000 ppm **lead** acetate had an increased renal tumor incidence of 5/50, 10/20, and 16/20, while 7/20 females in the 2000-ppm group developed renal tumors.

The Azar et al. (1973) study is limited by the lack of experimental detail. The possibility of environmental contamination from **lead** in the air or drinking water was not mentioned. The strains of rats used were not specified in the study, but the Health Effects Assessment for **Lead** (U.S. EPA, 1984) indicates the rats were Wistar strain. The weight gain at 1000 and 2000 ppm was reported to be depressed, but details were not given.

Kasprzak et al. (1985), in investigating the interaction of dietary calcium on **lead** carcinogenicity, fed 1% **lead** subacetate (8500 ppm Pb) to male Sprague-Dawley rats in the diet for 79 weeks. Of the rats surviving (29/30) in this treatment group beyond 58 weeks, 44.8% had renal tumors. Four rats had adenocarcinomas; the remainaing nine had adenomas. Bilateral tumors were noted. No renal tumors were noted among the controls.

As part of a study to determine interactions between sodium nitrite, ethyl urea and **lead**, male Sprague-Dawley rats were given **lead** acetate in their drinking water for 76 weeks (Koller et al., 1986). The concentration of **lead** was 2600 ppm. No kidney tumors were detected among the 10 control rats. Thirteen of 16 (81%) **lead**-treated rats had renal tubular carcinoma; three tumors were detected at 72 weeks and the remainder detected at the termination of the study.

Van Esch and Kroes (1969) fed basic **lead** acetate at 0, 0.1%, and 1.0% in the diet to 25 Swiss mice/sex/group for 2 years. No renal tumors developed in the control group, but 6/25 male mice of 0.1% basic **lead** acetate group had renal tumors (adenomas and carcinomas combined). In the 1.0% group, one female had a renal tumor. The authors thought that the low incidence in the 1.0% group was due to early mortality.

Hamsters given **lead** subacetate at 0.5% and 1% in the diet had no significant renal tumor response (Van Esch and Kroes, 1969).

II.A.4. Supporting Data for Carcinogenicity:

Lead acetate induces cell transformation in Syrian hamster embryo cells (DiPaolo et al., 1978) and also enhances the incidence of simian adenovirus induction. **Lead** oxide showed similar enhanced adenovirus induction (Casto et al., 1979).

Under certain conditions **lead** compounds are capable of inducing chromosomal aberrations in vivo and in tissue cultures. Grandjean et al. (1983) showed a relationship between SCE and **lead** exposure in exposed workers. **Lead** has been shown, in a number of DNA structure and function assays, to affect the molecular processes associated with the regulation of gene expression (U.S. EPA, 1986).

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure:

Not available.

Quantifying **lead**'s cancer risk involves many uncertainties, some of which may be unique to **lead**. Age, health, nutritional state, body burden, and exposure duration influence the absorption, release, and excretion of **lead**. In addition, current knowledge of **lead** pharmacokinetics indicates that an estimate derived by standard procedures would not truly describe the potential risk. Thus, the Carcinogen Assessment Group recommends that a numerical estimate not be used.

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure:

Not available.

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment):

II.D.1. EPA Documentation:

Source Document -- U.S. EPA, 1984, 1986, 1989

U.S. EPA, 1989 has received OHEA and SAB review.

The 1986 Air Quality Criteria Document for **Lead** has received Agency and External Review.

II.D.2. EPA Review (Carcinogenicity Assessment):

Agency Work Group Review -- 05/04/1988

Verification Date -- 05/04/1988

Screening-Level Literature Review Findings -- A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the cancer assessment for **Lead** and compounds (inorganic) conducted in September 2002 did not identify any critical new studies. IRIS users who know of important new studies may provide that information to the IRIS Hotline at hotline.iris@epa.gov or 301-345-2870.

II.D.3. EPA Contacts (Carcinogenicity Assessment):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

VI. Bibliography:

VI.A. Oral RfD References:

None

VI.B. Inhalation RfC References:

None

VI.C. Carcinogenicity Assessment References:

Anderson, E.L., and CAG (Carcinogenic Assessment Group). 1983. Quantitative approaches in use to assess cancer risk. Risk Analysis. 3: 277-295.

Azar, A., H.J. Trochimowicz and M.E. Maxfield. 1973. Review of **lead** studies in animals carried out at Haskell Laboratory - Two year feeding study and response to hemorrhage study. In: Barth D., A. Berlin, R. Engel, P. Recht and J. Smeets, Ed. Environmental health aspects of **lead**: Proceedings International Symposium; October 1972; Amsterdam, The Netherlands. Commission of the European Communities, Luxemberg. p. 199-208.

Casto, B.C., J. Meyers and J.A. DiPaolo. 1979. Enhancement of viral transformation for evaluation of the carcinogenic or mutagenic potential of inorganic metal salts. Cancer Res. 39: 193-198.

Cooper, W.C. 1985. Mortality among employees of **lead** battery plants and **lead** producing plants, 1947-1980. Scand. J. Work Environ. Health. 11: 331-345.

Cooper, W.C. and W.R. Gaffey. 1975. Mortality of **lead** workers. In: Proceedings of the 1974 Conference on Standards of Occupational **Lead** Exposure, J.F. Cole, Ed., February, 1974. Washington, DC. J. Occup. Med. 17: 100-107.

Dingwall-Fordyce, I. and R.E. Lane. 1963. A follow-up study of **lead** workers. Br. J. Ind. Med. 20: 313-315.

DiPaolo, J.A., R.L. Nelson and B.C. Casto. 1978. In vitro neoplastic transformation of Syrian hamster cells by **lead** acetate and its relevance to environmental carcinogenesis. Br. J. Cancer. 38: 452-455.

Grandjean, P., H.C. Wulf and E. Niebuhr. 1983. Sister chromatid exchange in response to variations in occupational **lead** exposure. Environ. Res. 32: 199-204.

Kasprzak, K.S., K.L. Hoover and L.A. Poirier. 1985. Effects of dietary calcium acetate on **lead** subacetate carcinogenicity in kidneys of male Sprague- Dawley rats. Carcinogenesis. 6(2): 279-282.

Koller, L.D., N.I. Kerkvliet and J.H. Exon. 1986. Neoplasia induced in male rats fed **lead** acetate, ethyl urea and sodium nitrate. Toxicol. Pathol. 13: 50-57.

Nelson, D.J., L. Kiremidjian-Schumacher and G. Stotzky. 1982. Effects of cadmium, **lead**, and zinc on macrophage-mediated cytotoxicity toward tumor cells. Environ. Res. 28: 154-163.

Selevan, S.G., P.J. Landrigan, F.B. Stern and J.H. Jones. 1985. Mortality of **lead** smelter workers. Am. J. Epidemiol. 122: 673-683.

U.S. EPA. 1984. Health Effects Assessment for **Lead**. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH, for the Office of Emergency and Remedial Response, Washington, DC. EPA/540/1-86/055. NTIS PB85-163996/AS.

U.S. EPA. 1986. Air Quality Criteria Document for **Lead**. Volumes III, IV. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, NC, for the Office of Air Quality Planning and Standards. EPA-600/8-83/028dF.

U.S. EPA. 1989. Evaluation of the potential carcinogenicity of **lead** and **lead** compounds: In support of reportable quantity adjustments pursuant to CERCLA Section 102. Prepared by the Office of Health and Environmental Assessment, Washington, DC. EPA/600/8-89/045A. (External Review Draft).

Van Esch, G.J. and R. Kroes. 1969. The induction of renal tumors by feeding of basic **lead** acetate to mice and hamsters. Br. J. Cancer. 23: 265-271.

VII. Revision History:

Substance Name -- **Lead** and compounds (inorganic)
CASRN -- 7439-92-1

Date	Section	Description
09/26/1988	II.	Carcinogen summary on-line
02/01/1989	IV.B.1.	Effect level corrected in discussion
06/01/1989	II.D.3.	Primary contact changed
06/01/1989	IV.A.1.	Reference corrected - changed number for part in CFR
12/01/1989	II.A.3.	Last paragraph - Correct Van Esch 1969 citation
12/01/1989	VI.	Bibliography on-line
07/01/1990	I.A.	Changed contact J. Cohen's office and telephone number
07/01/1990	IV.F.1.	EPA contact changed
02/01/1991	I.A.	Message revised to include new EPA document
02/01/1991	I.A.	EPA contacts changed
05/01/1991	II.A.	Text edited
01/01/1992	IV.	Regulatory actions updated
06/01/1992	IV.B.2.	MCL monitoring reqs. and BAT corrected
07/01/1993	II.D.3.	Secondary contact's phone number changed
07/01/1993	VI.C.	References alphabetized correctly
11/01/1993	II.D.1.	U.S. EPA 1987 replaced with 1989; rev. state. revised
11/01/1993	VI.C.	U.S. EPA 1987 deleted; U.S. EPA 1989 added
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
12/03/2002	I.A., II.D.2.	Screening-Level Literature Review Findings message has been added.

N-NITROSODIMETHYLAMINE

CASRN: 62-75-9

For other data, click on the Table of Contents

Human Health Effects:

Evidence for Carcinogenicity:

No data are available in humans. Sufficient evidence of carcinogenicity in animals. OVERALL EVALUATION: Group 2A: The agent is probably carcinogenic to humans.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. S7 67 (1987)]**PEER REVIEWED**

... Identified as an occupational carcinogen without establishing a PEL.
[29 CFR 1910.1016 (7/1/91)]**PEER REVIEWED**

CLASSIFICATION: B2; probable human carcinogen. BASIS FOR CLASSIFICATION: Induction of tumors at multiple sites in both rodents and nonrodent mammals exposed by various routes.
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on N-Nitrosodimethylamine (62-75-9) from the National Library of Medicine's TOXNET System, November 1, 1994]**PEER REVIEWED**

A3; Confirmed animal carcinogen with unknown relevance to humans. Skin notation.
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.45]**QC REVIEWED**

Human Toxicity Excerpts:

IN 4 MEN, LAB EXPOSURE TO ... /**NDMA**/ GAVE RISE TO ACUTE LIVER NECROSIS WHICH LATER DEVELOPED INTO CIRRHOSIS; IN 1 CASE, THE ACUTE LIVER INJURY PROVED TO BE FATAL.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V17 151 (1978)]**PEER REVIEWED**

... TWO CASES OF POISONING FROM **DIMETHYLNITROSAMINE** ... IN SURVEY OF LARGE AUTOMOBILE FACTORY. APPARENTLY, THE ACTION OF THE POISON WAS ON THE LIVER, PRODUCING CIRRHOSIS WITH JAUNDICE & ASCITES.
[Hamilton, A., and H. L. Hardy. Industrial Toxicology. 3rd ed. Acton, Mass.: Publishing Sciences Group, Inc., 1974. 311]**PEER REVIEWED**

IN 8 HR PERIOD, FIVE MEMBERS OF TWO KINDRED FAMILIES SUDDENLY BECAME ILL WITH NAUSEA, VOMITING & MALAISE. THIS WAS FOLLOWED BY ACUTE LIVER DISEASE, GENERALIZED BLEEDING, & LOW PLATELET COUNT. 2 OF THE PATIENTS DIED FOUR AND FIVE DAYS AFTER ONSET. **DMNA** HAD BEEN ADDED TO BEVERAGES.
[COOPER SW, KIMBROUGH RD; J FORENSIC SCI 25 (4): 874-82 (1980)]**PEER REVIEWED**

UNSCHEDULED DNA SYNTH ... OBSERVED ... IN HUMAN FIBROBLASTS IN CULTURE IN PRESENCE OF **NDMA** & MOUSE LIVER MICROSOMAL FRACTION.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V17 150 (1978)]**PEER REVIEWED**

Systemic effects are characterized by onset in a few hr of nausea and vomiting, abdominal cramps and diarrhea. ... Headache, fever, weakness ... may occur.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 669]**PEER REVIEWED**

DIMETHYLNITROSAMINE (**NDMA**) WAS DETECTED AT LEVELS OF ABOUT 32 UG/L IN DIALYZATE FROM 5 OF 16 DIALYSIS UNITS SURVEYED /SRP: **NDMA** ENTERED DIALYSIS UNITS VIA PLASTIC COMPONENTS OF THE DIALYZER/. BLOOD DRAWN FROM PATIENTS AT 1 OF THESE UNITS IN WHICH **NDMA** WAS RAISED IN THE DIALYZATE SHOWED A SIGNIFICANT INCREASE IN THE AMOUNT OF **NDMA** IN THE PATIENT'S BLOOD WHEN PREDIALYSIS LEVELS WERE COMPARED WITH 15 MIN INTRADIALYSIS LEVELS.
[SIMENHOFF ML ET AL; J AM MED ASSOC 250 (15): 2020-4 (1983)]**PEER REVIEWED**

... Although it is acknowledged that endogenous formation of N-nitroso compounds has been associated with increased risk of certain cancers, eg, stomach and esophagus, it was concluded that "no convincing epidemiological evidence has been presented concerning the etiological role of these compounds in human cancer." Likewise, in spite of several epidemiological studies "consistent with the hypothesis that exposure of humans to high levels of nitrate and/or nitrite may be associated with an increased incidence of cancers of the stomach and esophagus," the overall "epidemiological evidence suggesting that nitrate, nitrite, and N-nitroso compounds play a role in the development of cancer in humans is largely circumstantial." /N-Nitroso Cmpd/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 513]**PEER REVIEWED**

In persons with acute poisoning due to systemic exposure, headaches, a feeling of generalized malaise, fever, and weakness often occur. Gastrointestinal effects are frequent and include abdominal cramping and nausea. Vomiting and diarrhea occur within hours of absorption. Liver enlargement and jaundice may follow.
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1277]**PEER REVIEWED**

... Health hazards ... related to the consumption of water containing large concentrations of nitrate (or nitrite) ... /include/ potential formation of carcinogenic nitrosamines. /Nitrosamines/
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 416]**PEER REVIEWED**

Caution: Potential symptoms of overexposure are nausea, vomiting, diarrhea and abdominal cramps; headache; fever; enlarged liver, jaundice; reduced function of liver, kidneys and lungs.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1140]**PEER REVIEWED**

Has caused fatal liver disease in humans. Symptoms include headache, fever, weakness, nausea, vomiting, dizziness, diarrhea, GI hemorrhage, hepatomegaly, jaundice, and ascites.
[Prager, J.C. Environmental Contaminant Reference Databook Volume 1. New York, NY: Van Nostrand Reinhold, 1995. 611]**PEER REVIEWED**

DNA, ISOLATED FROM 2 SAMPLES OF HUMAN LIVER OBTAINED FROM SUSPECTED **DIMETHYLNITROSAMINE** POISONING, CONTAINED 1363-1373 UMOL OF 7-METHYLGUANINE/MOLE OF GUANINE & 273-317 UMOLE OF O6-METHYLGUANINE/MOLE OF GUANINE. FROM DNA METHYLATION LEVELS, IT IS EST THAT VICTIM OF **DIMETHYLNITROSAMINE**-POISONING WAS EXPOSED TO DOSE OF 20 MG OR MORE/KG OF BODY WT.
[HERRON DC, SHANK RC; CANCER RES 40 (9): 3116-17 (1980)]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

The liquid and vapor /may be/ irritating to the skin or eyes. ...
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 669]**PEER REVIEWED**

Medical Surveillance:

PRECAUTIONS FOR "CARCINOGENS": Whenever medical surveillance is indicated, in particular when exposure to a carcinogen has occurred, ad hoc decisions should be taken concerning ... /cytogenetic and/or other/ tests that might become useful or mandatory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.23]**PEER REVIEWED**

Workers with potential exposures to chemical hazards should be monitored in a systematic program of medical surveillance intended to prevent or control occupational injury and disease. The program should include education of employers and workers about work-related hazards, placement of workers in jobs that do not jeopardize their safety and health, earliest possible detection of adverse health effects, and referral of workers for diagnostic confirmation and treatment. ... A medical surveillance program should include systematic collection and epidemiologic analysis of relevant environmental and biologic monitoring, medical screening, morbidity, and mortality data. ... Prior to placing a worker in a job with a potential for exposure to N-nitrosodimethyl- amine, the physician should evaluate and document the worker's baseline health status ... /concentrating/ on the function and integrity of the liver, kidneys and respiratory system. ... Occupational health interviews and physical examinations should be performed at regular intervals. ... The medical, environmental, and occupational history interviews, the physical examination and selected physiologic and laboratory tests which were conducted at the time of placement should be repeated at the time of job transfer or termination. ... Because occupational exposure to N-**nitrosodimethylamine** may cause diseases of prolonged induction-latency, the need for medical surveillance may extend well beyond termination of employment.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Populations at Special Risk:

Protect from exposure those individuals with diseases of liver.
[ITII. Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1988. 379]**PEER REVIEWED**

Probable Routes of Human Exposure:

Inhalation of vapor and possibly percutaneous absorption.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 669]**PEER REVIEWED**

N-**nitrosodimethylamine** was identified as an air pollutant near /a factory/ using the amine as a raw material. ... Typical daily human exposures were calculated to be 39 ug on site, 10 ug in the adjacent residential neighborhood, and 0.3 ug two miles away.
[Fine, DH et al; Human Exposure to N-nitroso Compounds in the Environment, Origins of Human Cancer (1977a) as cited in USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.C-12 (1980) EPA-440/5-80-064]**PEER REVIEWED**

Air, diet, and smoking all play a roughly equivalent role in direct human exposure to preformed N-nitrosamine contributing a few micrograms per day, with direct intake from drinking water probably much less than 1 ug/day. /Nitrosamines/
[USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.C-14 (1980) EPA 440/5-80-064]**PEER REVIEWED**

The extent of exposure to the general population of N-Nitrosamines and N-Nitrosamides is unknown. ... exposures, resulting from anthropogenic sources, are probably restricted to limited industrial areas. /N-Nitrosamines and N-Nitrosamides/
[USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.A-2 (1980) EPA-440/5-80-064]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 747 workers are potentially exposed to N-**nitrosodimethylamine** in the US(1). N-**Nitrosodimethylamine** air concentrations at occupational settings were: less than or equal to 47 ug/cu m at a leather tannery(2), 0.1 ug/cu m at a foundry(3), 29 to 212 ppt in the compression molding department at Rubbermaid, Inc, Wooster, OH(4); 0.5 ug/cu m at a tire chemical factory(5), 0.14 ug/cu m at an industrial rubber products factory(5), 160 ng/cu m at an amine plant area in Belle, WV(6), 91 ng/cu m at a DuPont plant in Belle, WV(6), 4.4 ug/cu m at a hot process area tire manufacturing plant(7), 0.16 to 0.49 ug/cu m (time weighted avg breathing - zone concentration) at a tire manufacturing plant(7), 1.02 ug/c u m at Firestone Tire and Rubber Co, Akron, OH(7), and 11,600 ng/cu m (avg) at a chemical factory in Baltimore(8). Other N-**nitrosodimethylamine** air concentrations and the associated industry were, ug/cu m: 0.01 to 0.06 (0.03 avg) fish processing, <0.03 to 0.01 (0.03 avg) dye, <0.05 to 47 (3.4 avg) leather, 0.02 to 5.5 (0.6 avg) rubber, and 0.03 to 0.8(0.2 avg) surfactant(9). All 28 personal breathing zone samples collected at a rubber vehicle sealing plant contained detectable levels of N-**nitrosodimethylamine** at concentrations ranging from 0.47 to 11.44 ug/cu m(10). Airborne levels of N-**nitrosodimethylamine** in factories using metal-working fluids ranged from not detected to 0.102 ug/cu m(11). Personal breathing zone samples collected in a tire manufacturing plant contained N-**nitrosodimethylamine** at the following average concentrations, ug/cu m: 0.1 to 0.3 in the feed mill and calendar and 0.1 to 0.4 in the warm-up mills(12). The general population may be exposed to N-**nitrosodimethylamine** via inhalation of ambient air and cigarette smoke and ingestion of contaminated food and drinking water(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983) (2) Rounbehler DP et al; Food Cosmet Toxicol 17: 487-91 (1979) (3) IARC; N-nitroso Compd: Occurrence Biol Eff 41: 223-9 (1982) (4) Albrecht WN; Gov Rep Announce Index 83: 757 (1983) (5) Fajen JM et al; Sci 205: 1262-4 (1979) (6) Fine DH et al; Spec Conf Toxic Subst Air Environ (Proc) Meet Date 1976 p 168-81 (1977) (7) McGlothlin JD et al; ACS Symp Ser 149: 283-99 (1981) (8) Fine DH et al; Environ Sci Technol 11: 581-4 (1977) (9) Fajen JM et al; IARC Sci Publ 41: 223-9 (1982) (10) Reh BD, Fajen JM; Amer Indust Hyg Assoc J 57: 918-23 (1996) (11) Fadlallah S et al; Bull Environ Contam Toxicol 57: 867-74 (1996) (12) McGlothlin JD et al; ACS Symp Ser 169: 283-99 (1981)]**PEER REVIEWED**

Body Burden:

More N-**nitrosodimethylamine** was detected in human blood immediately after ingestion of a meal containing spinach, bacon, tomato, bread and beer than was present before(1).
[(1) IARC; IARC Monographs on the Evaluation of Carcinogenic Risks to Humans 17: 125-76 (1978)]**PEER REVIEWED**

Average Daily Intake:

WATER: (assume 3 to 6 ng N-**nitrosodimethylamine**/l)(1) 6 to 12 ng; direct intake from drinking water is probably much less than 1 ug/day(2). AIR: (estimates of 400,000 people in the USA are exposed to 0.1 ng N-**nitrosodimethylamine**/cu m)(3) 2 ng. FOOD: (assume <0.1 to 84 ug/kg)(4) <0.16 to 134 ug.

[(1) Kimoto WI et al; Water Res 15: 1099-1106 (1981) (2) USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.C-14 (1980) EPA 440/5-80-064 (3) Anderson JE; Human Exposure to Atmospheric Concentrations of Selected Chemicals Vol 1 Off Air Qual Planning and Standards USEPA 230 p (1983) (4) IARC; IARC Monographs on the Evaluation of Carcinogenic Risks to Humans 17: 125-76 (1978)]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** **DIMETHYLNITROSAMINE** ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE

0.2.1.1 ACUTE EXPOSURE

A. **Dimethylnitrosamine** (**DMNA**) is an hepatotoxin and a probable human carcinogen. There are few reports of acute overexposure in humans.

B. Fever, headache, malaise, vomiting, conjunctivitis, photophobia, periorbital ecchymosis, coagulopathy, subarachnoid hemorrhage, pulmonary edema, seizures, cerebral edema, hepatitis, hepatomegaly, ascites, hepatic necrosis, and thrombocytopenia have been reported following acute exposure.

C. Inhalation may produce immediate effects of skin, nose, and eye irritation.

0.2.1.2 CHRONIC EXPOSURE

A. Dietary intake has been associated with gastric cancer.

0.2.4 HEENT

0.2.4.1 ACUTE EXPOSURE

A. Ingestion has caused conjunctival injection, periorbital ecchymosis, and conjunctival hemorrhages. Scleral jaundice may occur following oral or inhalational exposure. Corneal damage and uveitis may occur after a latent period.

0.2.5 CARDIOVASCULAR

0.2.5.1 ACUTE EXPOSURE

A. Myocardial hemorrhages have occurred following oral exposure.

0.2.6 RESPIRATORY

0.2.6.1 ACUTE EXPOSURE

A. Pulmonary edema, congestion, and hemorrhagic areas have been reported.

0.2.7 NEUROLOGIC

0.2.7.1 ACUTE EXPOSURE

A. Seizures, cerebral edema, headache, and malaise have been reported.

0.2.8 GASTROINTESTINAL

0.2.8.1 ACUTE EXPOSURE

A. Vomiting, gastrointestinal hemorrhage, and peritonitis have occurred.

0.2.9 HEPATIC

0.2.9.1 ACUTE EXPOSURE

A. The liver is the primary target organ. Centrilobular liver necrosis, hepatomegaly, jaundice, ascites, and hepatitis have been reported after ingestion and inhalational exposures. Diffuse hemorrhages around central veins of the liver may occur.

0.2.10 GENITOURINARY

0.2.10.1 ACUTE EXPOSURE

A. Red blood cells have been seen in the kidney tubules following ingestion.

0.2.13 HEMATOLOGIC

0.2.13.1 ACUTE EXPOSURE

A. Thrombocytopenia, coagulopathy and hemorrhage have developed after exposures.

0.2.19 IMMUNOLOGIC

0.2.19.1 ACUTE EXPOSURE

A. Lymph node fibrosis has been reported following inhalation.

B. Humoral and cellular immunity can be suppressed in experimental animals. Toxicity may involve autoimmunity.

0.2.20 REPRODUCTIVE HAZARDS

A. Fetal death, fetotoxicity, and other teratogenic effects were observed in rat and mouse studies. Pre- and post-implantation mortality and abortion were observed in rats. Abnormal changes in sperm morphology were detected in mice.

0.2.21 CARCINOGENICITY

0.2.21.1 IARC CATEGORY

A. Category 2A (The agent is probably carcinogenic to humans, based upon positive cancer findings in experimental animal studies) (Clayton & Clayton, 1994).

0.2.21.2 HUMAN OVERVIEW

A. Dietary **dimethylnitrosamine** intake has been associated with a higher risk of gastric cancer.

0.2.21.3 ANIMAL OVERVIEW

A. **Dimethylnitrosamine** is a potent animal carcinogen; it has been positive in all species tested. It is active transplacentally.

B. **Dimethylnitrosamine** is in Group B2, potency group 2 and "medium" ranking, based on the US EPA's guidelines, for carcinogenicity.

Laboratory:

A. No toxic serum levels have been established. Monitor liver enzymes, platelet count, INR or prothrombin time and bleeding time, and blood glucose levels.

B. Specific OSHA requirements have been promulgated for the medical surveillance of employees exposed to **DMNA**.

Treatment Overview:

0.4.2 ORAL EXPOSURE

A. EMESIS/NOT RECOMMENDED -

1. EMESIS: Ipecac-induced emesis is not recommended because of the potential for CNS depression and

seizures.
B. ACTIVATED CHARCOAL -
1. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.
C. GASTRIC LAVAGE -
1. GASTRIC LAVAGE: Consider after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation. Control any seizures first.
a. CONTRAINDICATIONS: Loss of airway protective reflexes or decreased level of consciousness in unintubated patients; following ingestion of corrosives; hydrocarbons (high aspiration potential); patients at risk of hemorrhage or gastrointestinal perforation; and trivial or non-toxic ingestion.
D. ACUTE LUNG INJURY
1. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.
E. SEIZURES -
1. SEIZURES: Administer a benzodiazepine IV; DIAZEPAM (ADULT: 5 to 10 mg, repeat every 10 to 15 min as needed. CHILD: 0.2 to 0.5 mg/kg, repeat every 5 min as needed) or LORAZEPAM (ADULT: 2 to 4 mg; CHILD: 0.05 to 0.1 mg/kg).
a. Consider phenobarbital if seizures recur after diazepam 30 mg (adults) or 10 mg (children > 5 years).
b. Monitor for hypotension, dysrhythmias, respiratory depression, and need for endotracheal intubation. Evaluate for hypoglycemia, electrolyte disturbances, hypoxia.
F. HEMORRHAGE -
1. Transfusions of packed red blood cells, fresh frozen plasma or platelets may be necessary if bleeding is extensive or platelet count is below 20,000/mm(3).
G. MONITORING PARAMETERS -
1. Obtain baseline liver studies. It may be advisable to monitor for several months following the exposure.
H. SYMPTOMATIC/SUPPORTIVE TREATMENT -
1. Appropriate supportive measures should be considered.

0.4.3 INHALATION EXPOSURE

A. INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids.

0.4.4 EYE EXPOSURE

A. DECONTAMINATION: Irrigate exposed eyes with copious amounts of room temperature water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility.

0.4.5 DERMAL EXPOSURE

A. DECONTAMINATION: Remove contaminated clothing and jewelry. Wash the skin, including hair and nails, vigorously; do repeated soap washings. Discard

contaminated clothing.

Range of Toxicity:

A. A potentially lethal dose (extrapolated from animal data) is 1.8 gm for an average adult or 0.3 gm for a 10 kg child.

AMATE

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

Irrigate eyes with water. Wash contaminated areas of body with soap and water.
[ITII. Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1988. 379]**PEER REVIEWED**

The worker should be removed from the area of exposure. The eyes should be irrigated with water if there has been a potential exposure of the conjunctival membranes. Contaminated parts of body are washed with soap and water. It is necessary to evaluate liver size and function by monitoring serum albumin, prothrombin time, conjugated bilirubin, or other indices of hepatic function. It is also necessary to monitor changes in the patient's chest x-ray and renal function parameters. The patient should be followed for other possible malignant changes as dictated by the family history or other factors, ie, breast cancer screening in female patients or sputum cytology in an employee who smokes or has a family history of lung cancer.
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 1277]**PEER REVIEWED**

Basic treatment: Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist respirations if needed. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Monitor for pulmonary edema and treat if necessary ... . Monitor for shock and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuosly with normal saline during transport ... . Do not use emetics. Activate charcoal is not effective . For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Do not attempt to neutralize because of exothermic reaction. Cover skin burns with dry, sterile dressings after decontamination ... .
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 149]**PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious, has severe pulmonary edema, or is in respiratory arrest. Early intubation at the first signs of upper airway obstruction, may be necessary. Positive-pressure ventilation techniques with a bag-valve-mask device may be beneficial. Monitor cardiac rhythm and treat arrhythmias as necessary ... . Start an IV with D5W TKO. Watch for signs of fluid overload. Consider drug therapy for pulmonary edema ... . For hypotension with signs of hypovolemia, administer fluid cautiously. Consider vasopressors if patient is hypotensive with a normal fluid volume . Watch for signs of fluid overload ... . Use proparacaine hydrochloride to assist eye irrigation ... .
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 149]**PEER REVIEWED**

Animal Toxicity Studies:

Evidence for Carcinogenicity:

No data are available in humans. Sufficient evidence of carcinogenicity in animals. OVERALL EVALUATION: Group 2A: The agent is probably carcinogenic to humans.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. S7 67 (1987)]**PEER REVIEWED**

... Identified as an occupational carcinogen without establishing a PEL.
[29 CFR 1910.1016 (7/1/91)]**PEER REVIEWED**

CLASSIFICATION: B2; probable human carcinogen. BASIS FOR CLASSIFICATION: Induction of tumors at multiple sites in both rodents and nonrodent mammals exposed by various routes.
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on N-Nitrosodimethylamine (62-75-9) from the National Library of Medicine's TOXNET System, November 1, 1994]**PEER REVIEWED**

A3; Confirmed animal carcinogen with unknown relevance to humans. Skin notation.
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.45]**QC REVIEWED**

Non-Human Toxicity Excerpts:

ADMIN BY STOMACH TUBE OF 1.6, 1.0 & 1.0 MG/ANIMAL OVER 5 WK, OR OF 1 DOSE OF 1.6 MG/ANIMAL, TO SYRIAN GOLDEN HAMSTERS INDUCED CHOLANGIOADENOMA, CHOLANGIOCARCINOMAS & HEMANGIOSARCOMAS AS WELL AS HEMANGIOENDOTHELIOMAS OF LIVER.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V17 137 (1978)]**PEER REVIEWED**

WEEKLY SC INJECTIONS OF 0.5-1.0 MG **NDMA** FOR 6-20 WK ... CAUSED ... ESTHESIONEUROEPITHELIOMAS OF NASAL CAVITY IN SYRIAN GOLDEN HAMSTERS.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V17 139 (1978)]**PEER REVIEWED**

MALE GUINEA PIGS GIVEN 1-2 MG/KG BODY WT ORALLY FOR 40-55 WK DEVELOPED PAPILLARY CHOLANGIOMAS & LIVER-CELL CARCINOMAS. ... DOSES OF 25 PPM & 50 PPM GIVEN TO RABBITS IN DIET FOR 17-51 WK RESULTED IN HEPATOCELLULAR CARCINOMA WITH LUNG METASTASES & BENIGN PAPILLARY CHOLANGIOMAS. DOSES OF 300 PPM, 1200 PPM, 4800 PPM & 19200 PPM GIVEN IN DIET FOR MORE THAN 6 MO INDUCED ADENOMAS & ADENOCARCINOMAS OF LIVER /IN RAINBOW TROUT/.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V1 99 (1972)]**PEER REVIEWED**

MASTOMYS (RATS): TWICE-WEEKLY SC INJECTIONS OF 0.1 MG **NDMA** PER ANIMAL FOR 10 TO 44 WEEKS INDUCED LIVER TUMORS IN 6/36 MALES: 2 CHOLANGIOMAS, 2 CHOLANGIOCARCINOMAS, 1 HEMANGIOENDOTHELIOMA AND 1 HEPATIC CELL CARCINOMA; NONE WERE SEEN IN FEMALES. IN CONTROLS, 4/82 LIVER TUMORS WERE SEEN IN FEMALES AND NONE IN MALES.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer,

1972-PRESENT. (Multivolume work).p. V17 140 (1978)]**PEER REVIEWED**

RAT: SINGLE OR REPEATED INHALATION EXPOSURES ... RESULTED IN TUMORS OF NASAL CAVITIES & KIDNEYS. ... RATS GIVEN A SINGLE INJECTION OF 18 MG/KG BODY WT EITHER IM, RETROPERITONEALLY OR DIRECTLY INTO THE KIDNEY, DEVELOPED RENAL TUMORS.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V1 100 (1972)]**PEER REVIEWED**

... VAPOR CAUSED LIVER DAMAGE, ASCITES, & DISRUPTION OF BLOOD COAGULATION WITH BLEEDING IN DOGS, RATS, & MICE. CONCENTRATION: DOG, 16-144 PPM/4 HR INHALATION; RATS, 51-151 PPM/4 HR INHALATION; MICE, 39-60 PPM/4 HR INHALATION.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 2788]**PEER REVIEWED**

IN MICE, SINGLE OR REPEATED INJECTIONS OF 12.5-75 MG/KG BODY WT **NDMA** DURING LAST DAYS OF PREGNANCY RESULTED IN LUNG ADENOMAS & HEPATOMAS IN OFFSPRING. **NDMA** INDUCED A LOW FREQUENCY OF KIDNEY TUMORS IN OFFSPRING OF PREGNANT RATS TREATED DURING LAST WEEK OR DURING THE WHOLE PREGNANCY (TOTAL DOSE, 11 MG) .
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V17 142 (1978)]**PEER REVIEWED**

DIMETHYLNITROSAMINE REQUIRES MAMMALIAN METABOLIC ACTIVATION BEFORE SHOWING MUTAGENIC ACTIVITY. USING A COMPLEMENT-RESISTANT ESCHERICHIA COLI STRAIN INJECTED INTO MICE GIVEN A SINGLE DOSE OF DMN, A LINEAR RESPONSE CURVE WAS ESTABLISHED USING AMPICILLIN & NALIDIXIC ACID AS 2 FORWARD MUTATION MARKERS.
[NEALE S, SOLT AK; CHEM-BIOL INTERACT 31 (2): 221-26 (1980)]**PEER REVIEWED**

AN IN VIVO INTRASANGUINE HOST-MEDIATED ASSAY REVEALED THAT MUTATIONS OCCURRED @ SIGNIFICANT RATE IN SALMONELLA TYPHIMURIUM G-46 EMPLOYED AS INDICATOR ORGANISMS RECOVERED FROM LIVER, LUNG, KIDNEY AND SPLEEN OF **NDMA**-TREATED MICE, COMPARED TO NEGATIVE CONTROL ANIMALS.
[BAKSHI K, BRUSICK D; MUTAT RES 72 (1): 79-89 (1980)]**PEER REVIEWED**

SHORT-TERM MAMMALIAN CARCINOGENICITY TEST IS PRESENTED IN WHICH AN IN VIVO ADMIN TO RATS IS FOLLOWED AFTER 2 WK BY IN VITRO CULTURE OF PERITONEAL CELLS. THE INCIDENCE OF RATS SHOWING TRANSFORMED COLONIES IN CULTURES AFTER SINGLE **NDMA** DOSE OF 20 MG/KG WAS NEARLY DOUBLE THAT REPORTED FOR RATS DEVELOPING TUMORS AFTER A HIGHER SINGLE DOSE OF 30 MG/KG.
[NASHED N, CHANDRA P; CANCER LETT 10 (2): 95-108 (1980)]**PEER REVIEWED**

DIMETHYLNITROSAMINE WAS ACTIVATED TO MUTAGEN ON INCUBATION WITH DROSOPHILA MELANOGASTER MICROSOMES. MUTAGENICITY WAS OBSERVED IN CHINESE HAMSTER OVARY CELLS, ESCHERICHIA COLI STRAINS 343/113/R-9 AND 343/113/UVRB, AND SALMONELLA TYPHIMURIUM TA 1538. DROSOPHILA MICROSOMES APPEARED TO BE AT LEAST AS ACTIVE AS RAT LIVER MICROSOMES WHEN COMPARED IN THIS TYPE OF MUTAGENICITY TESTING.
[BAARS AJ ET AL; MUTAT RES 72 (2): 257-64 (1980)]**PEER REVIEWED**

COMBINED INTRASANGUINEOUS & URINARY MUTAGENIC ASSAY IN VIVO WAS TESTED WITH **DIMETHYLNITROSAMINE**, USING SCHIZOSACCHAROMYCES POMBE. DOSE OF 0, 250 AND 405 MG/KG CYCLOPHOSPHAMIDE OR 5, 10, OR 100 MG/KG **DIMETHYLNITROSAMINE** WERE GIVEN TO MICE AND RATS IMMEDIATELY AFTER THEY WERE INJECTED WITH THE YEAST CELLS. TESTED; LUNG AND KIDNEYS WERE MORE ACTIVE THAN SPLEEN & TESTES. **DMNA** WAS INACTIVE IN URINE.
[BAUER C ET AL; MUTAT RES 74 (4): 291-302 (1980)]**PEER REVIEWED**

MALE RATS RECEIVED A SINGLE INJECTION OF **DIMETHYLNITROSAMINE** (**NDMA**). SIGNIFICANT INCREASES IN FREQUENCIES OF SISTER CHROMATID EXCHANGES (SCE) IN LYMPHOCYTES & INCIDENCE OF MICRONUCLEATED HEPATOCYTE WERE OBSERVED. **NDMA**-INDUCED PRECLASTOGENIC DAMAGE IN HEPATOCYTES WAS LOST BETWEEN 28 & 56 DAYS AFTER INJECTION.
[TATES AD ET AL; MUTAT RES 107 (1): 131-51 (1983)]**PEER REVIEWED**

WHOLE CELL PREPARATIONS DERIVED FROM COLLAGENASE-TREATED RAT LIVER WERE COCULTIVATED OVERNIGHT WITH STATIONARY CULTURES OF L 5178 Y/TK+/- CELLS IN N-**NITROSODIMETHYLAMINE**. SUBSTANTIAL DOSE-DEPENDENT INCREASES IN TRIFLUOROTHYMIDINE-RESISTANT VARIANTS WERE OBSERVED AFTER 20 HR TOTAL EXPOSURE TIME.
[AMACHER DE, PAILLET SC; MUTAT RES 113 (1): 77-88 (1983)]**PEER REVIEWED**

MUTAGENESIS STUDIES ON DROSOPHILA OOGONIAL CELLS WITH **DIMETHYLNITROSAMINE** REVEALED HIGH RATES OF SEX-LINKED RECESSIVE LETHALS.
[ABRAHAMSON S ET AL; ENVIRON MUTAGEN 5 (6): 891-905 (1983)]**PEER REVIEWED**

CELL-MEDIATED ASSAYS WERE USED TO STUDY ORGAN (LIVER, LUNG, KIDNEY, & BLADDER) & SPECIES (RAT & HAMSTER) SPECIFICITY OF **NITROSODIMETHYLAMINE** (**NDMA**) & OTHER CHEMICALS. **NDMA** WAS HIGHLY ACTIVE IN LIVER CELL-MEDIATED SYSTEM. WITH REGARD TO SPECIES SPECIFICITY, HAMSTER HEPATOCYTES WERE 3-4 TIMES AS ACTIVE AT METABOLIZING **NDMA** TO MUTAGENIC INTERMEDIATES AS WERE RAT HEPATOCYTES.
[LANGENBACH R, NESNOW S; USEPA, RES DEV, (REP) EPA (EPA-600/9-83-008, ORGAN SPECIES SPECIF CHEM CARCINOG; PB83-220137): 377-90 (1983)]**PEER REVIEWED**

DNA REPAIR WAS ELICITED BY **DIMETHYLNITROSAMINE** IN HEPATOCYTES FROM B6C3F1 MICE & SYRIAN HAMSTERS.
[MCQUEEN CA ET AL; ENVIRON MUTAGEN 5 (1): 1-8 (1983)]**PEER REVIEWED**

ALTERATIONS IN GENE EXPRESSION BY **DIMETHYLNITROSAMINE** (**NDMA**) WERE ANALYZED ON 3 UNSTABLE ALLELES OF THE WHITE (W+) LOCUS OF DROSOPHILA MELANOGASTER: WHITE-CREAM (WC); WHITE-IVORY 16 (WI16); & WHITE-UNSTABLE 11 (WU11). THE CMPD APPLIED TOPICALLY DURING THE EARLY LARVAL STAGES INFLUENCED THE DIFFERENT UNSTABLE W ALLELES. THE GENETIC EFFECTS ASSAYED WERE THE ALTERATIONS IN EYE COLOR EITHER WILD-TYPE (W+) OR TO OTHER W MUTANTS, INITIATED BOTH SOMATICALLY & GERMINALLY, AS WELL AS THE SIMULTANEOUSLY INDUCED X-CHROMOSOME RECESSIVE MUTATIONS.
[FAHMY MJ, FAHMY OG; CANCER RES 43 (2): 801-7 (1983)]**PEER REVIEWED**

SPONGIOSIS HEPATITIS WAS OBSERVED IN RATS AFTER THE ADMIN OF RELATIVELY LOW DOSES OF **DIMETHYLNITROSAMINE**. SPONGIOSIS IS A PERSISTING LESION DUE

TO SPECIFIC CHANGES OF LIVER CELLS BY HEPATOTROPIC CARCINOGENS.
[ZERBAN H, BANNASCH P; CANCER LETT 19 (3): 247-52 (1983)]**PEER REVIEWED**

LIVERS OF GERM-FREE RATS WERE MORE SUSCEPTIBLE TO THE ACUTE TOXIC EFFECTS OF **DIMETHYLNITROSAMINE** (**NDMA**) AS WELL AS **NDMA** + SODIUM NITRITE ADMIN THAN WERE LIVERS OF CONVENTIONAL RATS.
[SUMI Y, MIYAKAWA M; CANCER RES 43 (6): 2942-6 (1983)]**PEER REVIEWED**

INDUCTION OF SINGLE-STRAND BREAKS IN THE DNA OF 3 ORGANS OF BD-VI RATS & SYRIAN GOLDEN HAMSTERS WAS EXAM 4 HR AFTER DOSAGE. RATS RECEIVED 40 TO 80 MG/KG IP DOSE OF N-**NITROSODIMETHYLAMINE** (**NDMA**) AND HAMSTERS RECEIVED 30 MG/KG **NDMA**. DNA DAMAGE OCCURRED IN THE LIVER & KIDNEY OF RATS & IN THE LIVER & LUNGS OF HAMSTERS. DAMAGE WAS MONITORED IN VIVO BY ALKALINE ELUTION METHOD, FLUOROMETRICALLY.
[BARBIN A ET AL; CARCINOGENESIS (LONDON) 4 (5): 541-5 (1983)]**PEER REVIEWED**

NO EVIDENCE OF LIVER NECROSIS WAS OBSERVED AT 24, 48, OR 72 HR AFTER IP INJECTION OF 70 MG/KG INTO PIGEONS. RESISTANCE OF PIGEON LIVER IS RELATED TO ITS LACK TO ACTIVATE **NDMA** METABOLICALLY.
[DIAZ GOMEZ MI ET AL; CANCER LETT 18 (2): 157 (1983)]**PEER REVIEWED**

HOLTZMAN RATS WERE ADMIN SINGLE ORAL DOSES OF N-**NITROSODIMETHYLAMINE** (**NDMA**) ON DIFFERENT DAYS OF PREGNANCY. **NDMA** WAS NOT LETHAL TO PREGNANT RATS UP TO DAY 16 OF PREGNANCY, BUT SINGLE ORAL DOSE OF 15 & 20 MG/KG KILLED 9.4% & 35.3%, RESPECTIVELY, OF RATS TREATED ON DAY 18 OF PREGNANCY. THE ACUTE TOXIC EFFECT OF **NDMA** WAS GREATER IN PREGNANT THAN IN NONPREGNANT RATS, ESPECIALLY NEAR THE END OF PREGNANCY.
[NISHIE K; FOOD CHEM TOXICOL 21 (4): 453-62 (1983)]**PEER REVIEWED**

NAGASE ANALBUMINEMIC RATS (NA) AND NORMAL MALE SPRAGUE-DAWLEY RATS (SD). ANALBUMINEMIC RATS /SRP: A MUTANT STRAIN OF SPRAGUE-DAWLEY RAT/ WERE HIGHLY SUSCEPTIBLE TO INDUCTION OF RENAL TUMORS. AT 6 WEEKS OF AGE, NA-RATS AND SD-RATS RECEIVED A SINGLE INTRAPERITONEAL INJECTION OF DMN AT 50 MG/KG. THIRTY-NINE WEEKS AFTER N-**DIMETHYLNITROSAMINE** ADMIN, THE INCIDENCE OF RENAL TUMORS & AVG WT OF KIDNEYS (INCLUDING TUMORS) WERE 76% & 10.8 G IN ANALBUMINEMIC RATS, RESPECTIVELY, WHEREAS THEY WERE 37.1% & 3.5 G, RESPECTIVELY, IN NORMAL MALE SPRAGUE-DAWLEY RATS.
[NAGASE S ET AL; GANN 74 (3): 317-8 (1983)]**PEER REVIEWED**

RATS WERE GIVEN A SINGLE DOSE OF 200 MG/KG N-NITROSODIETHYLAMINE (DEN) AND 2 WK LATER WERE TREATED WITH VARIOUS TEST COMPOUNDS FOR 6 OR 10 WK. IN TESTS ON DOSE-DEPENDENT EFFECTS OF PROMOTING AGENTS, **DIMETHYLNITROSAMINE** (**NDMA**) WAS GIVEN AT DIFFERENT CONCENTRATIONS FOR 6 WK AFTER N-NITROSODIETHYLAMINE TREATMENT. CLEAR DOSE-DEPENDENT EFFECTS OF **NDMA** WERE SEEN IN INDUCTION OF GAMMA-GLUTAMYL TRANSPEPTIDASE POSITIVE FOCI IN THE SHORT-TERM EXPERIMENT & NEOPLASTIC LESIONS IN THE LONG-TERM ONE.
[ITO N ET AL; ENVIRON HEALTH PERSPECT 50: 131-8 (1983)]**PEER REVIEWED**

N-**NITROSODIMETHYLAMINE** AT 50PPM INDUCED HEPATOMAS IN BRACHYDANIO RERIO (FISH) EXPOSED FOR 22-23 WK.
[AYDIN NE, BULAY OM; DOGA SERI C 7 (1): 1-7 (1983)]**PEER REVIEWED**

TOXIC EFFECTS OF N-**NITROSODIMETHYLAMINE** (**NDMA**) WERE STUDIED BY LIGHT & ELECTRON MICROSCOPY AFTER INJECTION INTO THE FOOT OF MUSSELS. ONE INJECTION OF **NDMA** AT 0.1, 0.2, 0.4, & 0.8 MG/MUSSEL PRODUCED, WITHIN 15 DAYS EXTENSIVE INFLAMMATORY REACTIONS IN THE SUPPORTING LEYDIG CELL TISSUE IN THE DIGESTIVE DIVERTICULA, NECROSIS OF THE EPITHELIUM LINING, THE DIGESTIVE TUBULES, & NECROSIS OF GERMINAL EPITHELIUM LINING THE GENITAL FOLLICLES. 8 WEEKLY INJECTIONS OF 0.2 MG, EXAM FOR 3O WK PRODUCED EXTENSIVE COLLAGENOUS SCAR TISSUE FORMATION BETWEEN THE TUBULES OF THE DIGESTIVE DIVERTICULA, PRESENCE OF NUMEROUS GRANULOCYTOMAS, & NECROSIS OF THE GERMINAL EPITHELIUM OF THE GENITAL FOLLICLES.
[RASMUSSEN LP D ET AL; AQUAT TOXICOL 3 (4): 285-99 (1983)]**PEER REVIEWED**

Shasta strain of rainbow trout were fed N-**nitrosodimethylamine** in the diet for 52 weeks. After this time the fish were placed on a control diet for an additional 26 weeks. No hepatocellular carcinomas were detected at 26 weeks after feeding of the nitrosamine began. At 52 weeks, however, a direct dose-related response of hepatocellular carcinoma occurred in trout fed 200, 400, and 800 mg **dimethylnitrosamine**/kg. A greater incidence of carcinomas was observed at 78 weeks, even though feeding was discontinued after 52 weeks.
[USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.1127 (1980) EPA-440/5-80-064]**PEER REVIEWED**

Of the 107 N-nitroso compounds (including 83 N-nitrosamines) listed, 87 (including 67 N-nitrosamines) are reported as having carcinogenic activity. Since that time more compounds have been tested and, to date, approximately 100 N-nitroso compounds are known to be carcinogenic in one or more species of experimental animals. /N-Nitrosamines/
[USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.C-26 (1980) EPA-440/5-80-064]**PEER REVIEWED**

Single doses of **DMNA** (**dimethylnitrosamine**) from 8 to 15 mg/kg body weight were given to 37 foxes. The course and intensity of the disease was not influenced by the application route, but was directly related to the amount of **DMNA** given per kg body weight, causing hemorrhagic centrolobular liver necrosis and acute vessel changes. ... The LD50 determined after 4 wk was 10 mg **DMNA**/kg body weight In a longer experiment 18 foxes in 3 groups were given 2 weekly doses of **DMNA** in food. They were treated with daily estimated doses of 1.0, 0.2 and 0.1 mg **DMNA**/kg body weight, respectively. The foxes in groups 1 and 2 developed ascites, jaundice, and liver failure after intake of 45-70 mg **DMNA**/kg body weight. The foxes treated with 1 mg **DMNA**/kg body weight showed centrolobular hemorrhagic liver necrosis and productive vessel changes in the hepatic vein system. The second group given 0.2 mg **DMNA**/kg body weight developed hemorrhagic centrolobular necrosis which healed with fibrosis leading to cirrhosis and chronic occlusion in many hepatic veins. Noduli of chondroid lamellae and foci of hematopoietic tissue and early stages of hemagiomatous liver tumors were found in the liver. The group exposed to 0.1 mg of **DMNA**/kg body weight/day developed thickening in the walls of the hepatic veins. After more than 3.5 yr of exposure, multiple hemangiosarcomas grew out from the changed vessel walls. In a shorter experiment with daily **DMNA** doses in the feed below 0.165 mg/kg body weight, all the foxes were completely healthy and only some showed beginning changes in the hepatic vein walls. Hematomas were often seen in foxes dying after a single **DMNA** dose. One fox treated with 0.1 mg **DMNA**/kg body weight died of brain bleeding after 220 days of treatment. Chronic vessel changes were found in the heart and kidneys of the **DMNA** treated foxes. **DMNA** produces vessel changes of a more general nature.
[Koppang N et al; Acta Vet Scand 22 (3-4): 501-16 (1982)]**PEER REVIEWED**

... In vitro RNA synthesis and methylation were proportional to time and nuclear concentration and

dependent on exogenous nucleoside triphosphates and S-adenosylmethionine. Of the in vitro synthesis, 60-70% was inhibited by 1 ug/ml alpha-amanitin. Total liver nuclear RNA systhesis was increased after **dimethylnitrosamine** exposure but, unlike RNA synthesis in nuclei after partial hepatectomy, alpha-amanitin sensitive and resistant synthesis were increased. Differences were found between **dimethylnitrosamine**-treated liver and kidney nuclear RNA synthesis which was sensitive to inhibition by 1-10 ug/ml alpha-amanitin, presumably a product of RNA polymerase III. Nuclear RNA methylation with S-adenosylmethionine, which was dependent on new RNA synthesis, differed between **dimethylnitrosamine**-treated rat liver and kidney nuclei. The endogenous RNA methyl substituents labeled in vitro showed differences in levels of methylation of bases, the 2'-O position of ribose and caps in comparisons between control and **dimethylnitrosamine**-treated nuclei from liver and kidney. Significant differences were obtained in nuclear RNA transcription and methylation in vitro between the 2 tissues in response to pretreatment of the rat in vitro with **dimethylnitrosamine**.
[Winicov I; Biochim Biophys Acta 654 (1): 31-41 (1981)]**PEER REVIEWED**

Although N-nitrosamines are rapidly and fairly evenly distributed throughout the bodies of rats after injection, the acute toxic damage they produce is more severe in the liver than elsewhere, and tumors following chronic exposure are confined mainly to the liver and kidney. /N-Nitrosamines/
[USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.C-41 (1980) EPA-440/5-80-064]**PEER REVIEWED**

Many N-nitrosamines are teratogenic, mutagenic, and carcinogenic. Evidence from experimental animals suggests that, as carcinogens, they are /effective by all routes of administration/. However, some are capable of inducing tumors after a single dose, and they are also capable of inducing tumors in certain organs and tissues regardless of the route of administration, ie, they are systemic carcinogens. /N-Nitrosamines/
[USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.C-42 (1980) EPA-440/5-80-064]**PEER REVIEWED**

All animal species are susceptible to carcinogenesis induced by N-nitroso compounds, including nitrosamines. /Nitrosamines and other N-nitroso carcinogens/
[Haddad, L.M., Clinical Management of Poisoning and Drug Overdose. 2nd ed. Philadelphia, PA: W.B. Saunders Co., 1990. 513]**PEER REVIEWED**

Dimethylnitrosamine given on the last day of pregnancy produced only a few uncharacteristic tumors. **Dimethylnitrosamine** was not teratogenic in rats when 30 mg was given orally in single days during gestation.
[Shepard, T.H. Catalog of Teratogenic Agents. 5th ed. Baltimore, MD: The Johns Hopkins University Press, 1986. 199]**PEER REVIEWED**

Deuterated and non-deuterated N-**nitrosodimethylamine**, epichlorohydrin and dimethyl sulfate were evaluated for the ability to induce DNA single-strand breaks in rat hepatocytes as measured by alkaline elution. Non-deuterated **nitrosodimethylamine** induced twice the amount of DNA-strand breaks as the deuterated form. No evidence of a deuterium isotope effect was seen for the direct-acting alkylating agents epichlorohydrin and dimethyl sulfate.
[Sargent EV et al; Mutation Res 263 (1): 9-12 (1991)]**PEER REVIEWED**

IN ALKALINE CONDITIONS (PH 12.5), THE REDUCED VISCOSITY OF KIDNEY & LUNG DNA FROM CONTROL RATS INCR SLOWLY WITH TIME REACHING MAX AFTER 9-12 HR. CARCINOGENS, BY INDUCING DNA STRAND BREAKS EITHER CHEMICALLY OR INDIRECTLY BY EXCISION REPAIR OR DURING INCUBATION IN ALKALI, CAUSE A REDN OF DNA SUPERCOILING WHICH CAN BE SENSITIVELY MEASURED BY MONITORING CHANGES IN VISCOSITY. COMPUTERIZED ANALYSES OF TIME-VISCOSITY CURVES SHOWED 95% OF ITS MAX VALUE (T-95) WAS INDUCED BY IP DOSES OF

N-**NITROSODIMETHYLAMINE**: KIDNEY 0.07 MG/KG, LUNG 0.28 MG/KG. THE DECREASE IN T-95 WAS DOSE-RELATED.
[CARLO P ET AL; CARCINOGENESIS 4 (2): 137-40 (1983)]**PEER REVIEWED**

VISCOMETRIC ASSAY OF DNA DAMAGE IN RAT LIVER AFTER SINGLE IP DOSES OF N-**NITROSODIMETHYLAMINE** (0.07 MG/KG) REVEALED THE TIME REQUIRED FOR DNA REDUCED VISCOSITY TO REACH ITS MAXIMUM VALUE WAS SIGNIFICANTLY REDUCED.
[BRAMBILLA G ET AL; CANCER RES 43 (1): 202-9 (1983)]**PEER REVIEWED**

THE INDIRECT-ACTING ALKYLATING AGENT, **DIMETHYLNITROSAMINE** INDUCED DNA DAMAGE ONLY WHEN NADPH GENERATING SYSTEM WAS INCLUDED IN THE INCUBATION MIXTURE.
[COHEN AM, PRABHAKAR H; CANCER LETT 18 (2): 163-7 (1983)]**PEER REVIEWED**

STRUCTURAL ANALYSES BY CHROMATOGRAPHY ON BENZOYLATED-DEAE-CELLULOSE WAS MADE OF HEPATIC DNA FROM RATS TREATED IP DAILY (1 MG/KG) FOR UP TO 21 WK WITH **DIMETHYLNITROSAMINE** (**NDMA**). THE PROPORTION OF DNA RETAINED INCREASED. IN THE COURSE OF CHRONIC ADMIN INCREASING TIME IS REQUIRED TO COMPLETE DNA REPAIR PROCESSES OPERATIVE IN RAT LIVER.
[KOSIC J, STEWART BW; CANCER LETT 20 (1): 5-12 (1983)]**PEER REVIEWED**

A SINGLE ADMIN OF 50 MG N-**NITROSODIMETHYLAMINE**/KG REDUCED THE TOTAL PROTEIN CONTENT IN THE HEPATIC MICROSOMES OF RATS. IT REDUCED PROTEIN SYNTHESIS, PARTICULARLY AT THE TRANSLATIONAL LEVEL, & THIRDLY ITS INTERACTION WITH CELL MEMBRANE LIPID COMPONENTS RESULTED IN THE DISINTEGRATION & CONFORMATIONAL CHARGES IN MEMBRANE-BOUND PROTEINS.
[TUTELYAN VA, LASHNEVA NV; FARMAKOL TOKSIKOL (MOSCOW) 46 (2): 111-4 (1983)]**PEER REVIEWED**

The product(s) of metabolism of N-nitrosamines are thought to be responsible for the mutagenicity and/or carcinogenicity of many of these compounds. One hypothesis is that these active intermediates alkylate DNA at specific sites. Although the liver appears to be the major site of decomposition, other organs, such as kidney and lung, possess varying capacity to metabolize nitrosamines. The relative metabolic activity of different organs toward the same compound varies among species. /Nitrosamines/
[USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.C-23 (1980) EPA-440/5-80-064]**PEER REVIEWED**

Non-Human Toxicity Values:

LC50 Rat inhalation 78 ppm/4 hr
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1128]**PEER REVIEWED**

LC50 Mouse inhalation 57 ppm/4 hr
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1128]**PEER REVIEWED**

Ip LD50 rat = 34 mg/kg
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1140]**PEER REVIEWED**

LD50 Rat oral 27-41 mg/kg
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of

the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1128]**PEER REVIEWED**

Ecotoxicity Values:

LD50 Salmo gairdneri (Rainbow trout) ip 1770 mg/kg/10 day
[Verschueren, K. Handbook of Environmental Data on Organic Chemicals. 3rd ed. New York, NY: Van Nostrand Reinhold Co., 1996. 830]**PEER REVIEWED**

LD50 Austropotamobius pallipes, Crayfish male (adult) 2250 mg/kg
[Alibaud R et al; Xenobiotica 15 (12): 1103-10 (1985)]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

FORMATION OF N-**NITROSODIMETHYLAMINE** (**NDMA**) IN THE STOMACHS OF RATS & MICE AFTER SIMULTANEOUS ORAL ADMIN OF (14)C-LABELED DIMETHYLAMINE & POTASSIUM NITRITE WAS DETERMINED BY MEASURING THE METHYLATION OF LIVER DNA. SIMULTANEOUS ADMIN OF 50 MG ASCORBATE/KG INHIBITED THE NITROSATION BY APPROX 80%. 50 MG ALPHA-TOCOPHEROL ACETATE/KG REDUCED THE NITROSATION BY APPROX 50%.
[MEIER-BRATSCHI A ET AL; FOOD CHEM TOXICOL 21 (3): 285-9 (1983)]**PEER REVIEWED**

A METHOD FOR QUANTITATIVE ESTIMATION OF THE FORMATION OF N-**NITROSODIMETHYLAMINE** (**NDMA**) IN MICE WAS DEVELOPED. WHEN 0.25 UMOLE OF AMINOPYRINE & 0.25-2.0 UMOLE OF SODIUM NITRITE WERE SIMULTANEOUSLY ADMIN ORALLY TO MICE, THE AMT OF **NDMA** FORMED IN 20 MIN WAS 8.2-60.3 NMOL. THESE VALUES ARE EQUAL TO APPROX 30-200 UG/KG OF BODY WT WHICH ARE NEARLY DAILY DOSES EXPECTED TO CAUSE CARCINOGENIC EFFECT IN MICE OR RATS.
[KAWANISHI T ET AL; ARCH TOXICOL 54 (4): 323-30 (1983)]**PEER REVIEWED**

AVAIL EVIDENCE SUGGESTS THAT **NDMA** REQUIRES METABOLIC ACTIVATION TO EXERT ITS TOXIC & CARCINOGENIC EFFECTS. RATE OF METAB ... IN VIVO HAS BEEN EXAM BY MEASURING RATE OF LOSS OF **NDMA** FROM BLOOD & EXHALATION OF (14)CO2 FOLLOWING ADMIN OF (14)C-**NDMA**. IN RATS ... 30 MG/KG ADMIN BY IP INJECTION IS METABOLIZED WITHIN 6 HR. RATE OF METAB OF **NDMA** IN VITRO ... MEASURED BY USE OF SLICES OF LIVER & OTHER ORGANS ... FROM RATS, HAMSTERS, MONKEYS, TROUT, GOLDFISH & VARIOUS AMPHIBIANS. ... OXIDATIVE N-DEMETHYLATION TO FORM FORMALDEHYDE HAS BEEN DEMONSTRATED WITH LIVER MICROSOMES FROM RATS, MICE & HAMSTERS. MICROSOMAL OXIDN HAS BEEN SUGGESTED TO RESULT IN UNSTABLE N-NITROSO-N-METHYL-N-HYDROXYMETHYLAMINE, WHICH DECOMP TO YIELD METHYLATING SPECIES & FORMALDEHYDE ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V17 146 (1978)]**PEER REVIEWED**

... IN THE METABOLISM ... ONE OF THE INTERMEDIARY PRODUCTS IS DIAZOMETHANE.
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 621]**PEER REVIEWED**

NITROSODIMETHYLAMINE (**NDMA**) & 2 OF ITS METABOLITES, METHYLHYDRAZINE &

1,1-DIMETHYLHYDRAZINE, WERE METABOLIZED TO CARBON DIOXIDE BY LIVER SLICES OBTAINED FROM RATS. RAT LIVER MICROSOMES OR 9,000XG SUPERNATANTS TRANSFORMED **NDMA** TO FORMALDEHYDE. **NDMA** LED TO COVALENT BINDING TO PROTEINS IN INCUBATION MIXTURES CONTAINING MICROSOMES OR 9,000XG SUPERNATANTS. IN THE CASE OF **NDMA**, THE PROCESS WAS ENZYMIC & REQUIRED NADPH IN BOTH CELLULAR FRACTIONS.
[GODOY HM ET AL; J NATL CANCER INST 71 (5): 1047-51 (1983)]**PEER REVIEWED**

MAXIMAL RATES OF METABOLIC OXIDATION OF N-**NITROSODIMETHYLAMINE** (**NDMA**) & **NDMA**-D6 IN VIVO WERE MEASURED BY FOLLOWING (14)CO2 EXHALATION IN RATS AFTER IP INJECTION OF 2 (14)C-LABELED CARCINOGENS AT DOSES OF 20 OR 40 MG/KG. COMPLETE DEUTERATION OF **NDMA** REDUCED ONLY SLIGHTLY THE MAXIMAL RATE OF METABOLISM WHEN THE 2 SUBSTRATES WERE ADMIN SEPARATELY. HOWEVER, MUCH LARGER DEUTERIUM ISOTOPE EFFECTS WERE OBSERVED WHEN MIXTURES OF **NDMA** WITH **NDMA**-D6 WERE INJECTED. THESE RESULTS ARE TENTATIVELY INTERPRETED AS EVIDENCE THAT C-H BOND CLEAVAGE IS NOT A RATE-LIMITING FEATURE OF OVERALL METABOLISM, BUT THAT THE COMPLEX BETWEEN **NDMA** & THE PRINCIPAL ENZYME(S) METABOLIZING IT IN VIVO FREELY EQUILIBRATES WITH UNBOUND SUBSTRATE.
[SWANN PF ET AL; CARCINOGENESIS (LONDON) 4 (7): 821-5 (1983)]**PEER REVIEWED**

Highly purified NADPH-cytochrome p450 reductase and the other major forms of cytochrome p450 induced by phenobarbital and beta-naphthoflavone were used in reconsitituted systems to study the demethylation and activation of **dimethylnitrosamine** to mutagenic intermediates. Both forms of cytrochrome p450 were active in the demethylation of **dimethylnitrosamine**, but cytochrome p450 from phenobarbital treated rats was more active and produced nearly twice as much formaldehyde per mole of hemoprotein.
[Masson HA et al; Toxicol Lett 17 (1-2): 131-5 (1983)]**PEER REVIEWED**

THE DEMETHYLATION OF **NDMA** BY RAT HEPATIC MICROSOMES WAS NOT CHANGED BY PRETREATMENT WITH PHENOBARBITAL & METHYLCHOLANTHRENE.
[KAWANISHI T ET AL; CANCER LETT (SHANNON, IREL) 20 (2): 157-64 (1983)]**PEER REVIEWED**

FASTING FOR 1-3 DAYS CAUSES A 2- OR 3-FOLD ENHANCEMENT OF THE REDUCED NADP-DEPENDENT **NITROSODIMETHYLAMINE** DEMETHYLASE (NDMAD) ACTIVITY. THE CYTOCHROME P450 (P450) CONTENT & ACTIVITIES OF REDUCED NADP P450 REDUCTASE & BENZPHETAMINE DEMETHYLASE, HOWEVER, ARE ONLY MODESTLY INCREASED. ELECTROPHORETIC ANALYSIS REVEALED THE INDUCTION OF A 50,000-DALTON PROTEIN BAND DURING FASTING.
[TU YY, YANG CS; CANCER RES 43 (2): 623-9 (1983)]**PEER REVIEWED**

DNA BREAKS INDUCED BY **DIMETHYLNITROSAMINE** IN CULTURED LIVER CELLS WERE MORE DETECTABLE FROM RAT TREATED WITH PHENOBARBITAL. TREATMENT FOR 24 HR WITH 60 & 13.5 UMOLAR **DIMETHYLNITROSAMINE** (**NDMA**) OF HEPATOCYTES FROM UNTREATED & PHENOBARBITAL TREATED RATS, RESPECTIVELY, DECREASED THE MOLECULAR WT OF DNA BY 50%. IT IS MORE GENOTOXIC FOR HEPATOCYTES FROM PHENOBARBITAL-TREATED RATS, PROBABLY DUE TO AUGUMENTED METABOLISM OF **NDMA** BY THESE CULTURES.
[MENDOZA-FIGUEROA T ET AL; TOXICOL 27 (1): 55-69 (1983)]**PEER REVIEWED**

Metabolites identified inexcreta /from Austropotamobius pallipes, crayfish/ include

monomethylnitrosamine from **dimethylnitrosamine**, and (hydroxyethyl)ethyl, bis(hydroxyethyl), and (carboxyethyl)ethylnitrosamine from diethylnitrosamine.
[Alibaud R et al; Xenobiotica 15 (12): 1103-10 (1985)]**PEER REVIEWED**

... Reduction of nitrate to nitrite /in the gastrointestinal tract/ permits the formation of highly carcinogenic nitrosamines by reaction with secondary amines from the diet. /Nitrosamines/
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 33]**PEER REVIEWED**

The metabolism of N-**nitrosodimethylamine** by liver microsomes from acetone-induced rats as well as by a reconstituted system containing purified cytochrome p450IIE1 was examined. The products consisted of methylamine, formaldehyde, methanol, methylphosphate and formic acid from N-**nitrosodimethylamine**. Compared to liver microsomes from untreated rats, the metabolic activity of acetone induced microsomes was approximately 4 times higher for N-**nitrosodimethylamine**. Using the reconstituted system, the enzyme activities (nmol substrate metabolized/nmol p450/min) N-**nitrosodimethylamine** was 9.47. Incubations carried out in the presence of a monoclonal antibody to cytochrome p450IIE1 resulted in a 85-90% inhibition in this system. The results indicate that N-**nitrosodimethylamine** is metabolized by the same form of rat liver cytochrome p450. The stoichiometry of N-**nitrosodimethylamine** products formed in these reactions indicates that denitrosation, a presumed detoxication process, and alpha-hydroxylation, an activation reaction, are also catalyzed by the same cytochrome p450 isozyme.
[Sohn OS et al; Carcinogenesis 12 (1): 127-31 (1991)]**PEER REVIEWED**

A study was conducted on the mechanism by which hepatic N-**nitrosodimethylamine** demethylase, also known as cytochrome p450-IIE1, is induced by acetone treatment in the rat. Acetone was fed at a concentration of 5% volume/volume in drinking water to male Sprague-Dawley rats for at least 10 days before experiments. Tritiated leucine was given to some animals, which were killed 3, 8 or 15 minutes later to measure the rate of synthesis of N-**nitrosodimethylamine** demethylase. Another group of animals received (14)C labeled acetate and were killed at 21, 24, 48 and 72 hours later for determination of the rate of degradation of N-**nitrosodimethylamine** demethylase. N-**nitrosodimethylamine** demethylase was purified from solubilized liver microsomal protein by an immunoaffinity column coupled to mouse monocolonal antibody raised against N-nitrosodimetylamine demethylase. Acetone treatment did not alter the rate of synthesis of N-**nitrosodimethylamine** demethylase. In control rats, the degradation of N-**nitrosodimethylamine** demethylase was biphasic, with the fast and slow phases having half-lives of approximately 7 and 37 hours, respectively. In rats given acetone, the degradation curve for labeled N-**nitrosodimethylamine** demethylase showed only one phase, corresponding to the slower one in control rats. The mechanism for the acetone induction of N-**nitrosodimethylamine** demethylase is that acetone stabilizes the N-**nitrosodimethylamine** demethylase protein, thereby slowing its degradation.
[Song BJ et al; J Biological Chem 264 (6): 3568-72 (1989)]**PEER REVIEWED**

The metabolism of N-**nitrosodimethylamine** was investigated in incubations with human liver microsomes from alcoholics and control patients who suffered from other diseases, but had a histological normal liver. All of the microsomal samples studied were able to metabolize N-**nitrosodimethylamine** at various concentrations to both formaldehyde and nitrite. Analysis of the liver microsomes from alcoholics revealed that both enzymatic activities, formaldyhyde and nitrite formation, were enhanced several times as compared to the control patients. Alcoholics metabolize N-**nitrosodimethylamine** at a higher rate probably due to the induction of one or more ethanol-inducible human liver cytochromes p450.
[Amelizad S et al; Cancer Letters 46 (1): 43-9 (1989)]**PEER REVIEWED**

The metabolic activation of N-**nitrosodimethylamine** to an active metabolite is important in its

carcinogenic effect. The lung and liver were compared for their responses to the induction of N-**nitrosodimethylamine** demethylation by 10% ethanol in the drinking water and by repeated bolus injections. Ethanol in the drinking water increased **NDMA** metabolism several-fold in both the liver and the lung. Repeated ip injections with 0.6 and 3.0 ml ethanol/kg for 7 days also enhanced this activity in a dose-dependent fashion. These results suggest that in the lung, as in the liver, ethanol may influence the metabolic activation of this nitrosamine.
[Carlson GP; Cancer Letters 54 (3): 153-6 (1990)]**PEER REVIEWED**

The product(s) of metabolism of N-nitrosamines are thought to be responsible for the mutagenicity and/or carcinogenicity of many of these compounds. One hypothesis is that these active intermediates alkylate DNA at specific sites. Although the liver appears to be the major site of decomposition, other organs, such as kidney and lung, possess varying capacity to metabolize nitrosamines. The relative metabolic activity of different organs toward the same compound varies among species. /Nitrosamines/
[USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.C-23 (1980) EPA-440/5-80-064]**PEER REVIEWED**

Absorption, Distribution & Excretion:

IT IS ABSORBED FROM GASTROINTESTINAL TRACT & LUNG ... SKIN ABSORPTION IS SLOW. WHEN ADMINISTERED TO RATS, MICE, & RABBITS, IT IS DISTRIBUTED UNIFORMLY IN TISSUE ... ALTHOUGH THE LIVER IS MAIN ORGAN CONCERNED WITH ITS METABOLISM & IS SITE OF SELECTIVE TOXICITY, **DIMETHYLNITROSAMINE** DOES NOT CONCENTRATE THERE. ONLY A SMALL PERCENTAGE IS EXCRETED UNCHANGED IN RAT URINE AFTER ORAL & IV DOSES OF 50 TO 100 MG/KG. A LARGE PROPORTION ... APPEARS IN THE EXPIRED AIR AS ... CARBON DIOXIDE (APPROX 60% IN 24 HR).
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 2787]**PEER REVIEWED**

N-**NITROSODIMETHYLAMINE** (**NDMA**) REACHED EQUAL MAX CONCN IN THE MATERNAL & FETAL BLOOD & TISSUES WITHIN 5-15 MIN & 30-60 MIN, RESPECTIVELY, AFTER AN IV INJECTION OF 50 MG/KG INTO MICE & RATS ON DAYS 21-23 OF PREGNANCY. THE SUBSEQUENT EXPONENTIAL DECR IN **NDMA** WAS MORE RAPID IN MICE THAN IN RATS. INCREASING THE **NDMA** LEVEL IN MATERNAL BLOOD BY INCREASED DOSES, LINEARLY INCREASED THE FETAL BLOOD **NDMA** TO A PEAK OF 120 MUG/ML IN MICE & 220 UG/ML IN RATS, WHEREAS THE LEVEL OF **NDMA** IN MATERNAL BLOOD CONTINUED TO INCREASE AS DOSES WERE INCREASED TO 300 MG/KG.
[SHENDRIKOVA IA ET AL; FARMAKOL TOKSIKOL (MOSCOW) 46 (6): 53-7 (1983)]**PEER REVIEWED**

N-**Nitrosodimethylamine** (DMN) was shown to be assimilated by the roots and translocated to the tops of lettuce and spinach plants.
[Dean-Raymond D, Alexander M; Nature 262: 394-6 (1976)]**PEER REVIEWED**

The acute toxicities of **dimethylnitrosamine** and diethylnitrosamine were evaluated in adult male crayfish. Toxicokinetic studies of (14)C **dimethylnitrosamine** and (14)C diethylnitrosamine in Austropotamobius pallipes (crayfish), administered by iv injection, show high concns of (14)C in abdominal muscle and hepatopancreas. Excretion is greater with **dimethylnitrosamine**, and retention in tissues, especially the hepatopancreas, is greater with diethylnitrosamine.
[Alibaud R et al; Xenobiotica 15 (12): 1103-10 (1985)]**PEER REVIEWED**

Biological Half-Life:

WHEN ADMINISTERED TO RATS, MICE & RABBITS, IT IS ... METABOLIZED RAPIDLY, WITH A HALF-LIFE OF APPROX 4 HR.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 2787]**PEER REVIEWED**

Mechanism of Action:

NDMA IS METABOLIZED BY MICROSOMAL ENZYME SYSTEM THAT REQUIRES NADPH & OXYGEN. THIS METABOLISM LEADS TO UNSTABLE PRODUCTS WHICH DECOMP TO YIELD REACTIVE ALKYLATING SPECIES. ALKYLATION OF CELLULAR COMPONENTS, PARTICULARLY DNA, IS THE CRITICAL EVENT IN INITIATION OF TUMORS. WHEN SMALL DOSES ARE GIVEN, THE CAPACITY OF LIVER TO METAB THE CARCINOGEN IS SUFFICIENT THAT NITROSAMINE IS EFFECTIVELY CLEARED IN 'FIRST-PASS' EFFECT, LEAVING VERY LITTLE TO INTERACT WITH OTHER ORGANS. THIS HAS 2 CONSEQUENCES: 1. LEVELS OF **NDMA** FOUND IN PERIPHERAL BLOOD MAY BE SIGNIFICANTLY LOWER THAN THOSE EXPECTED BECAUSE OF RAPID METAB & EFFECTIVE CLEARANCE OF CARCINOGEN BY LIVER; 2. PHYSIOLOGICAL FACTORS LEADING TO REDN OF METAB ACTIVATION IN LIVER MAY RESULT IN MORE OF CARCINOGEN BEING METABOLIZED IN OTHER TISSUES & INCR THE RISK OF CANCER DEVELOPING IN THOSE TISSUES.
[PEGG AE; IARC SCI PUBL (27): 3-22 (1980)]**PEER REVIEWED**

CYTOGENETIC CHANGES WERE INVESTIGATED DURING THE EARLY STAGES OF HEPATIC ADENOCARCINOMA DEVELOPMENT IN CHINESE HAMSTERS INJECTED WITH SINGLE DOSE OF N-**NITROSODIMETHYLAMINE** (**NDMA**). ANEUPLOIDY, TETRAPLOIDY, & CHROMOSOME ABERRATIONS INCREASED SIGNIFICANTLY IN THE HEPATIC CELLS OF **NDMA**-TREATED ANIMALS IN VIVO, WITH NO SIGNIFICANT CHANGE OVER THE 7- TO 35-WK PERIOD. THE IMPORTANCE OF INCREASED ANEUPLOIDY IN EARLY CARCINOGENESIS & THE DIFFERENCES BETWEEN THE IN VIVO & IN VITRO RESULTS ARE DISCUSSED.
[SWINDELL JA, OCKEY CH; CANCER GENET CYTOGENET 10 (1): 23-36 (1983)]**PEER REVIEWED**

EFFECT OF **DIMETHYLNITROSAMINE** (**NDMA**) ON FUNCTIONAL ACTIVITIES OF LIVER CHROMATIN WAS STUDIED IN MICE AFTER A SINGLE IV INJECTION (25 MG/KG, 45 MIN BEFORE SACRIFICE). ISOLATED LIVER NUCLEI WERE INCUBATED WITH MICROCOCCAL NUCLEASE TO AN ACID SOLUBILITY OF 2.5% OF TOTAL DNA & CHROMATIN WAS FRACTIONATED (1200 G PELLET P1, 102,000 G PELLET P2, & SUPERNATANT FRACTION S2). CHROMATIN-BOUND RNA POLYMERASE I PLUS III ACTIVITY DECR 15% IN P1 & 25% IN P2 FRACTION. NO CHANGES IN ACTIVITY WERE OBSERVED IN S2 FRACTION. CHROMATIN-BOUND RNA POLYMERASE II ACTIVITY DECR 19% IN P1, 49% IN P2, & 32% IN S2 FRACTION. FORMATION OF INITIATION IN NUCLEAR LYSATES WITH RNA POLYMERASE FROM ESCHERICHIA COLI INCR AFTER ADMIN OF **NDMA** SUGGESTING AN INCR IN THE NUMBER OF SITES AVAILABLE FOR START OF RNA CHAIN. LIMITED DIGESTION OF NUCLEI WITH ENDONUCLEASE CLEAVES CHROMATIN REGIONS WHICH ARE MORE AFFECTED BY **NDMA** THAN THE TOTAL CHROMATIN SUGGESTING A NONRANDOM EFFECT ON CHROMATIN. MODIFICATIONS OF DNA TEMPLATE BY **NDMA** IS INDICATED BY THE CHANGE IN NUMBER OF INITIATION COMPLEXES.
[KLAUDE M, VON DER DECKEN A; ARCH TOXICOL 54 (3): 215-25 (1983)]**PEER REVIEWED**

A CARCINOGEN-DNA ADDUCT WAS FOUND IN THE LIVERS OF RATS GIVEN

N-**NITROSODIMETHYLAMINE**. THIS ADDUCT, WHICH ACCOUNTED FOR 55% OF TOTAL METHYL RESIDUES IN DNA AT 72 HR AFTER CARCINOGEN TREATMENT, WAS IDENTICAL TO A SYNTHETIC PURINE RING-OPENED DERIVATIVE OF 7-METHYLGUANINE.
[BERANEK DT ET AL; BIOCHEM BIOPHYS RES COMMUN 110 (2): 625-31 (1983)]**PEER REVIEWED**

... Hamsters are more susceptible than rats to liver cancer by **dimethylnitrosamine** because of its deficiency in repair of O6-alkylation of guanine in DNA. In rats a single large dose of **dimethylnitrosamine** induces kidney, but not liver, cancer because of the capability of liver repair enzymes to remove alkylated forms of DNA from the liver.
[Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 148]**PEER REVIEWED**

Dimethylnitrosamine probably ... /affects protein synthesis/ by causing a loss of messenger RNA.
[Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 340]**PEER REVIEWED**

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[Benemanskii VV et al; vopr Onkol 36 (3): 327-31 (1990)]**PEER REVIEWED**

... The effect of ethanol on nitrosamine metabolism and carcinogenicity is reviewed, together with new work on pharmacokinetics. This work shows that small quantities of ethanol alter the distribution and metabolism of small oral doses of N-**nitrosodimethylamine** and N-nitrosodiethylamine in rats, to increase by several fold the alkylation of DNA in organs that are particularly susceptible to their carcinogenic effect. It is shown that in the case of N-**nitrosodimethylamine** this is the result of prevention of first-pass clearance of the nitrosamine as it travels in the blood draining the gut through the liver before entering the general circulation. ...
[Swann PF; IARC Sci Publ 57: 501-12 (1984)]**PEER REVIEWED**

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In chronic experiments, albino noninbred rats were fed 20.0, 2.0 or 0.2 mg/l **nitrosodimethylamine** and 1000 or 100 mg/l ascorbic acid (average daily dose 100 or 10 mg/kg body weight). There was a modifying effect of ascorbic acid on **nitrosodimethylamine** induced carcinogenesis. A decrease in tumor incidence was observed, particularly, at high level of the carcinogen. High dose ascorbic acid did not affect tumor incidence in intact animals; however, time to detection of the first tumor and mean duration of tumor development proved longer.
[Benemanskii VV et al; vopr Onkol 36 (3): 327-31 (1990)]**PEER REVIEWED**

... The effect of ethanol on nitrosamine metabolism and carcinogenicity is reviewed, together with new work on pharmacokinetics. This work shows that small quantities of ethanol alter the distribution and metabolism of small oral doses of N-**nitrosodimethylamine** and N-nitrosodiethylamine in rats, to increase by several fold the alkylation of DNA in organs that are particularly susceptible to their carcinogenic effect. It is shown that in the case of N-**nitrosodimethylamine** this is the result of prevention of first-pass clearance of the nitrosamine as it travels in the blood draining the gut through the liver before entering the general circulation. ...

[Swann PF; IARC Sci Publ 57: 501-12 (1984)]**PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

No evidence was found that N-**nitrosodimethylamine** is currently used, except for research purposes and may be released to the environment with laboratory waste. N-**Nitrosodimethylamine**'s former production and use in the production of rocket fuels; antioxidant; additive for lubricants; and as a softener of copolymers may have resulted in its release to the environment through various waste streams. If released to air, a measured vapor pressure of 2.7 mm Hg at 20 deg C indicates N-**nitrosodimethylamine** is expected to exist solely as a vapor in the ambient atmosphere. Vapor-phase N-**nitrosodimethylamine** will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals with an estimated half-life of 6.3 days. N-**Nitrosodimethylamine** absorbs light in the environmental spectrum indicating a potential for direct photolysis. If released to soil, an estimated Koc of 12 indicates this compound is expected to have very high mobility. Volatilization from wet soil surfaces may be an important fate process based upon a measured Henry's Law constant of 1.82X10-6 atm-cu m/mole at 37 deg C. Under laboratory conditions, greater than 70% of N-**nitrosodimethylamine** applied to the surface of a moist, warm soil (12% moisture content, 22 deg C) volatilized in 10 hours. N-**Nitrosodimethylamine** may potentially volatilize from dry soil surfaces based upon its measured vapor pressure. A half-life of about three weeks was reported for N-**nitrosodimethylamine** in aerobic soil under laboratory conditions; the primary removal processes were volatilization and biodegradation. If released into water, N-**nitrosodimethylamine** is not expected to adsorb to suspended solids and sediment in the water column based upon its estimated Koc. The potential for bioconcentration in aquatic organisms is low based upon an estimated BCF of 0.22. This compound's measured Henry's Law constant indicates that volatilization from water surfaces is expected to occur. Estimated volatilization half-lives from a model river and a model lake are 17 and 130 days, respectively. Hydrolysis is not expected to be an important process. A photodegradation half-life of 79 hours was measured in distilled water exposed to fluorescent light through a pyrex filter (wavelength >280 nm). No biodegradation of N-**nitrosodimethylamine** was observed in lake water samples during an observation period of 3.5 months. Occupational exposure to N-**nitrosodimethylamine** may occur through inhalation of air at workplaces involved in rubber processing or tire manufacturing or where metal-working fluids are used. The general population may be exposed to N-**nitrosodimethylamine** via inhalation of ambient air and cigarette smoke and ingestion of contaminated food and drinking water. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

Inhalation of vapor and possibly percutaneous absorption.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 669]**PEER REVIEWED**

N-**nitrosodimethylamine** was identified as an air pollutant near /a factory/ using the amine as a raw material. ... Typical daily human exposures were calculated to be 39 ug on site, 10 ug in the adjacent residential neighborhood, and 0.3 ug two miles away.
[Fine, DH et al; Human Exposure to N-nitroso Compounds in the Environment, Origins of Human Cancer (1977a) as cited in USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.C-12 (1980) EPA-440/5-80-064]**PEER REVIEWED**

Air, diet, and smoking all play a roughly equivalent role in direct human exposure to preformed

N-nitrosamine contributing a few micrograms per day, with direct intake from drinking water probably much less than 1 ug/day. /Nitrosamines/
[USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.C-14 (1980) EPA 440/5-80-064]**PEER REVIEWED**

The extent of exposure to the general population of N-Nitrosamines and N-Nitrosamides is unknown. ... exposures, resulting from anthropogenic sources, are probably restricted to limited industrial areas. /N-Nitrosamines and N-Nitrosamides/
[USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.A-2 (1980) EPA-440/5-80-064]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 747 workers are potentially exposed to N-**nitrosodimethylamine** in the US(1). N-**Nitrosodimethylamine** air concentrations at occupational settings were: less than or equal to 47 ug/cu m at a leather tannery(2), 0.1 ug/cu m at a foundry(3), 29 to 212 ppt in the compression molding department at Rubbermaid, Inc, Wooster, OH(4); 0.5 ug/cu m at a tire chemical factory(5), 0.14 ug/cu m at an industrial rubber products factory(5), 160 ng/cu m at an amine plant area in Belle, WV(6), 91 ng/cu m at a DuPont plant in Belle, WV(6), 4.4 ug/cu m at a hot process area tire manufacturing plant(7), 0.16 to 0.49 ug/cu m (time weighted avg breathing - zone concentration) at a tire manufacturing plant(7), 1.02 ug/c u m at Firestone Tire and Rubber Co, Akron, OH(7), and 11,600 ng/cu m (avg) at a chemical factory in Baltimore(8). Other N-**nitrosodimethylamine** air concentrations and the associated industry were, ug/cu m: 0.01 to 0.06 (0.03 avg) fish processing, <0.03 to 0.01 (0.03 avg) dye, <0.05 to 47 (3.4 avg) leather, 0.02 to 5.5 (0.6 avg) rubber, and 0.03 to 0.8(0.2 avg) surfactant(9). All 28 personal breathing zone samples collected at a rubber vehicle sealing plant contained detectable levels of N-**nitrosodimethylamine** at concentrations ranging from 0.47 to 11.44 ug/cu m(10). Airborne levels of N-**nitrosodimethylamine** in factories using metal-working fluids ranged from not detected to 0.102 ug/cu m(11). Personal breathing zone samples collected in a tire manufacturing plant contained N-**nitrosodimethylamine** at the following average concentrations, ug/cu m: 0.1 to 0.3 in the feed mill and calendar and 0.1 to 0.4 in the warm-up mills(12). The general population may be exposed to N-**nitrosodimethylamine** via inhalation of ambient air and cigarette smoke and ingestion of contaminated food and drinking water(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983) (2) Rounbehler DP et al; Food Cosmet Toxicol 17: 487-91 (1979) (3) IARC; N-nitroso Compd: Occurrence Biol Eff 41: 223-9 (1982) (4) Albrecht WN; Gov Rep Announce Index 83: 757 (1983) (5) Fajen JM et al; Sci 205: 1262-4 (1979) (6) Fine DH et al; Spec Conf Toxic Subst Air Environ (Proc) Meet Date 1976 p 168-81 (1977) (7) McGlothlin JD et al; ACS Symp Ser 149: 283-99 (1981) (8) Fine DH et al; Environ Sci Technol 11: 581-4 (1977) (9) Fajen JM et al; IARC Sci Publ 41: 223-9 (1982) (10) Reh BD, Fajen JM; Amer Indust Hyg Assoc J 57: 918-23 (1996) (11) Fadlallah S et al; Bull Environ Contam Toxicol 57: 867-74 (1996) (12) McGlothlin JD et al; ACS Symp Ser 169: 283-99 (1981)]**PEER REVIEWED**

Body Burden:

More N-**nitrosodimethylamine** was detected in human blood immediately after ingestion of a meal containing spinach, bacon, tomato, bread and beer than was present before(1).
[(1) IARC; IARC Monographs on the Evaluation of Carcinogenic Risks to Humans 17: 125-76 (1978)]**PEER REVIEWED**

Average Daily Intake:

WATER: (assume 3 to 6 ng N-**nitrosodimethylamine**/l)(1) 6 to 12 ng; direct intake from drinking water is probably much less than 1 ug/day(2). AIR: (estimates of 400,000 people in the USA are exposed to 0.1 ng N-**nitrosodimethylamine**/cu m)(3) 2 ng. FOOD: (assume <0.1 to 84 ug/kg)(4) <0.16 to 134 ug.
[(1) Kimoto WI et al; Water Res 15: 1099-1106 (1981) (2) USEPA; Ambient Water

Quality Criteria Doc: Nitrosamines p.C-14 (1980) EPA 440/5-80-064 (3) Anderson JE; Human Exposure to Atmospheric Concentrations of Selected Chemicals Vol 1 Off Air Qual Planning and Standards USEPA 230 p (1983) (4) IARC; IARC Monographs on the Evaluation of Carcinogenic Risks to Humans 17: 125-76 (1978)]**PEER REVIEWED**

Natural Pollution Sources:

Formation of DMN ... can occur by reaction of nitrites with dimethylamine produced by intestinal bacteria.
[Haddad, L.M. and Winchester, J.F. Clinical Management of Poisoning and Drug Overdosage. Philadelphia, PA: W.B. Saunders Co., 1983. 227]**PEER REVIEWED**

Formed by the interaction of nitrite with dimethylamine and by the action of nitrate-reducing bacteria(1). One group that found N-**nitrosodimethylamine** in tap water (3 to 6 ng/l) concluded that the N-**nitrosodimethylamine** may have formed from the reaction of low concentrations of nitrite, an oxidizing agent (possibly chlorine), and secondary amines(2). Another researcher concluded that extensive nitrosamine formation in natural waters is not likely because of low nitrite concentrations, low levels of nitrosatable amines, and expected third order kinetics(3).
[(1) Budavari S; The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. 12th ed. Whitehouse Station, NJ: Merck and Co Inc p. 1140 (1996) (2) Kimoto WI et al; Water Res 15: 1099-1106 (1981) (3) Oliver JE; Agric Symp Ser 174: 349-62 (1981)]**PEER REVIEWED**

Artificial Pollution Sources:

The mainstream smoke from an 85 mm US blended cigarette without a filter-tip has been found to contain 0.084 ug N-**nitrosodimethylamine**.
[USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.C-12 (1980) EPA-440/5-80-064]**PEER REVIEWED**

Emitted during the compounding, forming & curing operations of elastomeric parts by reaction of accelerators/stabilizers used such as tetramethylthiuram disulfide, tetramethylthiuram monosulfide & tetraethylthiuram disulfide.
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 558]**PEER REVIEWED**

THERE IS SOME EVIDENCE THAT DMN MIGHT BE FORMED DURING THE BURNING OF DIMETHYLHYDRAZINE AS A ROCKET FUEL.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V1 97 (1972)]**PEER REVIEWED**

N-**Nitrosodimethylamine**'s former production and use in the production of rocket fuels; antioxidant; additive for lubricants; and as a softener of copolymers(1) may have resulted in its release to the environment through various waste streams(SRC). No evidence was found that N-**nitrosodimethylamine** is currently used, except for research purposes(2). Two studies have demonstrated N-**nitrosodimethylamine** formation in both sterile and non-sterile soils to which nitrite and dimethylamine were added(3,4). Another study demonstrated N-**nitrosodimethylamine** formation when sewage, dimethylamine and nitrite were continuously percolated through a soil(3). It was also demonstrated that N-**nitrosodimethylamine** may form from fertilized and polluted areas when dimethylamine was added(5). There is some evidence that N-**nitrosodimethylamine** might be formed during the burning of dimethylhydrazine as a rocket fuel(6).
[(1) Budavari S; The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. 12th ed. Whitehouse Station,NJ: Merck and Co Inc p. 1140 (1996) (2) IARC; IARC Monographs on the Evaluation of Carcinogenic Risks to Humans 17: 125-76

(1978) (3) Pancholy SK; Soil Biol Biochem 10: 27-32 (1978) (4) Mills AL, Alexander M; J Environ Qual 5: 437-40 (1976) (5) Greene S et al; J Environ Qual 10: 416-21 (1981) (6) IARC; IARC Monographs on the Evaluation of Carcinogenic Risks to Humans 1: 97 (1972)]**PEER REVIEWED**

Environmental Fate:

TERRESTRIAL FATE: Based on a recommended classification scheme(1), an estimated Koc value of 12(SRC), determined from a measured log Kow of -0.57(2) and a recommended regression-derived equation(3), indicates that N-**nitrosodimethylamine** is expected to have very high mobility in soil(SRC). Volatilization of N-**nitrosodimethylamine** from moist soil surfaces may be an important fate process(SRC) given an estimated Henry's Law constant of 1.2X10-6 atm-cu m/mole(4,SRC). Under laboratory conditions, greater than 70% of N-**nitrosodimethylamine** applied to the surface of a moist, warm soil (12% moisture content, 22 deg C) volatilized in 10 hours(5). The potential for volatilization of N-**nitrosodimethylamine** from dry soil surfaces may exist(SRC) based on a measured vapor pressure of 2.7 mm Hg(6). A half-life of about three weeks was reported for N-**nitrosodimethylamine** in aerobic soil under laboratory conditions; the primary removal processes were volatilization and biodegradation(6). 17% of the added N-**nitrosodimethylamine** (132 ug/g soil) was lost from sandy loam soil after 10 days incubation at 30 deg C; no further loss was noted during the next 30 days incubation(7). However, when the organic matter content was increased from 2.16% to 17.5%, over 60% of the added N-**nitrosodimethylamine** was lost by day 15 of the incubation period(7).
[(1) Swann RL et al; Res Rev 85: 23 (1983) (2) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR (consult ed) Washington,DC: Amer Chem Soc p 5 (1995) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington,DC: Amer Chem Soc pp. 4-9 (1990) (4) Meylan WM, Howard PH; Environ Toxicol Chem 10: 1283-93 (1991) (5) Klein RG; Toxicology 23: 135-47 (1982) (6) Oliver JE et al; J Agric Food Chem 27: 887-91 (1979) (7) Malik MAB, Tesfai K; Bull Environ Contam Toxicol 27: 115-21 (1981)]**PEER REVIEWED**

AQUATIC FATE: Based on a recommended classification scheme(1), an estimated Koc value of 12(SRC), determined from a measured log Kow of -0.57(2) and a recommended regression-derived equation(3), indicates that N-**nitrosodimethylamine** is not expected to adsorb to suspended solids and sediment in water(SRC). N-**Nitrosodimethylamine** is expected to volatilize from water surfaces(3,SRC) based on an estimated Henry's Law constant of 1.2X10-6 atm-cu m/mole(4,SRC). Estimated volatilization half-lives for a model river and model lake are 26 and 190 days, respectively(3,SRC). According to a classification scheme(5), an estimated BCF of 0.22(3,SRC), from a measured log Kow(2), suggests that bioconcentration in aquatic organisms is low(SRC). A photodegradation half-life of 79 hours was measured in distilled water following exposure to fluorescent light through a Pyrex filter(6). Hydrolysis is probably not an important removal process since the N-**nitrosodimethylamine** concn in lake water essentially did not change after 3.5 months incubation at 30 deg C in the dark(7). No biodegradation of N-**nitrosodimethylamine** was observed in lake water samples during an observation period of 3.5 months(8). Static and continuous biodegradation tests on N-**nitrosodimethylamine** using seed from an activated sludge plant and feed that contained a nutrient solution based on yeast extract resulted in 47 to 72% degradation of the N-**nitrosodimethylamine** in 7 days(9).
N-**Nitrosodimethylamine** disappeared rapidly from aqueous solution due to evaporation and photolysis, with acidic solutions giving a somewhat higher removal than basic solutions or water, half-life of 0.8 hours versus 0.9 and 1.6 hours, respectively(10).
[(1) Swann RL et al; Res Rev 85: 23 (1983) (2) Hansch C et al.; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR (consult ed) Washington,DC: Amer Chem Soc p 5 (1995) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington,DC: Amer Chem Soc pp. 4-9, 5-4, 5-10, 15-1 to 15-29 (1990) (4) Meylan WM, Howard PH; Environ Toxicol Chem 10: 1283-93 (1991) (5) Franke C et al; Chemosphere 29: 1501-14 (1994) (6) Polo J, Chow YL; J Natl Cancer Inst 56: 997-1001 (1976) (7) Tate RL, Alexander M; J Natl Cancer Inst 54:

327-30 (1975) (8) Callahan MA et al; Water-Rel Environ Fate Priority Pollut Vol 1 (1979) (9) Fochtman EG, Eisenberg W; Treatability of Carcinogenic and Other Hazardous Organic Compounds USEPA-600/2-79-097 (1979) (10) MacNaughton MC, Stauffer TB; Air Force Civil Eng Cen Environ Dir. (AFCEC-TR-75-9) (1975)]**PEER REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), N-**nitrosodimethylamine**, which has a measured vapor pressure of 2.7 mm Hg at 20 deg C(2), is expected to exist solely as a vapor in the ambient atmosphere. Vapor-phase N-**nitrosodimethylamine** is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals(SRC); the half-life for this reaction in air is estimated to be about 6.3 days(3,SRC).
[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Klein RG; Toxicology 23: 135-47 (1982) (3) Atkinson R; Journal of Physical and Chemical Reference Data. Monograph 1 (1989)]**PEER REVIEWED**

Environmental Biodegradation:

No biodegradation of **dimethylnitrosamine** was observed in lake water samples during an observation period of 3.5 months, and a lag of nearly 30 days occurred before its slow disappearance from soil. The nitrosamine appeared to be degraded very slowly in sewage, but it was not affected by the anaerobic organisms /found in collected bog sediments/.
[Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume I. EPA-440/4 79-029a. Washington, DC: U.S. Environmental Protection Agency, December 1979.p. 99-4]**PEER REVIEWED**

Type of biological degradation: P statzeri, P fragi, B mycoides, B cereus, B subtilis, C suboxydans, C Pasteurianum, A picolinophilus, A suboxydans and 4 unclassified strains of arthrobacter were incubated for 72 hr with N-**nitrosodimethylamine**. No evidence of degradation.
[Castegnaro, M., G. Eisenbrand, G. Ellen, L. Keefer, D. Klein, E.B. Sansone, D. Spincer, G. Telling, K. Webb, and W. Davis (eds.). Laboratory Decontamination and Destruction of Carcinogens in Laboratory Wastes: Some N-Nitrosamines. IARC Publications No. 43. Lyon, France: International Agency for Research on Cancer, 1982.53]**PEER REVIEWED**

Degradation by Rhizopus orizae, Streptococcus cremoris, and Saccharomyces rouxii was found.
[Castegnaro, M., G. Eisenbrand, G. Ellen, L. Keefer, D. Klein, E.B. Sansone, D. Spincer, G. Telling, K. Webb, and W. Davis (eds.). Laboratory Decontamination and Destruction of Carcinogens in Laboratory Wastes: Some N-Nitrosamines. IARC Publications No. 43. Lyon, France: International Agency for Research on Cancer, 1982.53]**PEER REVIEWED**

Enrichment cultures were inoculated with soil and sewage but failed to produce any organisms capable of metabolizing N-**nitrosodimethylamine**(1). The lack of N-**nitrosodimethylamine** biodegradation did not appear to be due to its toxicity but may have been due to the inability of the microorganisms to cleave the N-N bond(1). Another group, however, found a number of bacterial strains were unable to metabolize N-**nitrosodimethylamine** at concentrations of 25 or 150 ppm nitroso incubated for 72 hours(1). Static and continuous biodegradation tests on N-**nitrosodimethylamine** using seed from an activated sludge plant and feed that contained a nutrient solution based on yeast extract resulted in 47 to 72% degradation of the N-**nitrosodimethylamine** in 7 days(2). In a continuous biological reactor, N-**nitrosodimethylamine** at an initial concentration of 1.93 mg/l was reduced to <0.01 mg/l in the effluent from the reactor (based on a 24 hour composite sample)(2). In an activated sludge treatment plant, >95% of the approximately 2000 ug N-**nitrosodimethylamine**/l in the influent was removed(3). N-**nitrosodimethylamine** was biodegraded by a fungus, bacterium, and yeast(4). The rate of disappearance in raw sewage at pH 6.0 was nearly the same as that in sterile samples, indicating nonbiological factors were largely or entirely responsible for the N-**nitrosodimethylamine** disappearance(5).

[(1) Tate RL III, Alexander M; J Environ Qual 5: 131-3 (1976) (2) Fochtman EG, Eisenberg W; Treatability of Carcinogenic and Other Hazardous Organic Compounds USEPA-600/2-79-097 (1979) (3) Patterson JW, Kodukala PS; Chem Eng Prog 77: 48-55 (1981) (4) Harada K, Yamada K; Nippon Suisan Gakki Aishi 45: 925-8 (1979) (5) Tate RL, Alexander M; J Natl Cancer Inst 54: 327-30 (1975)]**PEER REVIEWED**

ANAEROBIC: A photosynthetic bacterium was able to metabolize 100 mg N-**nitrosodimethylamine**/l under anaerobic conditions(1). An inoculum of activated sludge, anaerobic sludge digest, and garden soil was used to study the biodegradation of N-**nitrosodimethylamine** in lake water; it was found that the rate of mineralization and total mineralization increased with decreasing initial N-**nitrosodimethylamine** concns(2). After 114 days incubation at room temperature with basal salts added, 16.4% of N-**nitrosodimethylamine** at an initial concn of 15 mg/l was mineralized while on the other hand, 78.6% was mineralized when the initial concn was 0.162 ug/l; formaldehyde and methylamine were identified as biodegradation intermediates(2).
[(1) Kobayashi M, Tchan YT; Water Res 12: 199-201 (1978) (2) Kaplan DL, Kaplan AM; App Environ Microbiol 50: 1077-86 (1985)]**PEER REVIEWED**

Environmental Abiotic Degradation:

Exposure in the vapor phase to direct sunlight for about 30 min (50% efficiency) yielded nitric oxide, carbon monoxide, and formaldehyde and unidentified compounds.
[Castegnaro, M., G. Eisenbrand, G. Ellen, L. Keefer, D. Klein, E.B. Sansone, D. Spincer, G. Telling, K. Webb, and W. Davis (eds.). Laboratory Decontamination and Destruction of Carcinogens in Laboratory Wastes: Some N-Nitrosamines. IARC Publications No. 43. Lyon, France: International Agency for Research on Cancer, 1982.56]**PEER REVIEWED**

The rate constant for the vapor-phase reaction of N-**nitrosodimethylamine** with photochemically-produced hydroxyl radicals has been measured as 2.5X10-12 cu cm/molecule-sec at 25 deg C(1). This corresponds to an atmospheric half-life of about 6.3 days at an atmospheric concn of 5X10+5 hydroxyl radicals per cu cm(1,SRC). N-**Nitrosodimethylamine** disappears rapidly from aqueous solution due to evaporation and photolysis, with acidic solutions giving a somewhat higher removal than basic solutions or water, half-life of 0.8 hours versus 0.9 and 1.6 hours, respectively(2). N-**Nitrosodimethylamine** at an initial concn of 74 mg/l photodegraded with a half-life of 79 hours in distilled water exposed to fluorescent light through a Pyrex filter (wavelength >280 nm)(3). In alcohol, N-**nitrosodimethylamine** absorbs light in the environmental spectrum(4) indicating a potential for direct photolysis(SRC). Hydrolysis of N-**nitrosodimethylamine** is probably not important since its concn in lake water did not essentially change after 3.5 months incubation in the dark at 30 deg C(5).
[(1) Atkinson R; Journal of Physical and Chemical Reference Data. Monograph 1 (1989) (2) MacNaughton MC, Stauffer TB; Air Force Civil Eng Cen Environ Dir. (AFCEC-TR-75-9) (1975) (3) Polo J, Chow YL; J Natl Cancer Inst 56: 997-1001 (1976) (4) Radding SB et al; Review of the Environmental Fate of Chemicals, NTIS 68-01-2681 (1977) (5) Tate RL, Alexander M; J Natl Cancer Inst 54: 327-30 (1975)]**PEER REVIEWED**

Environmental Bioconcentration:

An estimated BCF of 0.22 was calculated for N-**nitrosodimethylamine**(SRC), using a measured log Kow of -0.57(1) and a recommended regression-derived equation(2). According to a classification scheme(3), this BCF suggests that bioconcentration in aquatic organisms is low(SRC).
[(1) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR (consult ed) Washington, DC: Amer Chem Soc p. 5 (1995) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington DC: Amer Chem Soc pp. 5-4, 5-10 (1990) (3) Franke C et al; Chemosphere 29: 1501-14 (1994)]**PEER REVIEWED**

N-**Nitrosodimethylamine** applied to sandy soil at 10 and 100 ppm exhibited 3.20 and 3.25% uptake by lettuce plants after 2 days exposure(1). 1.56, 0.21, and 0.02% uptake was observed following application of 100 ppm after 4, 9, and 15 days, respectively(1). 10 and 100 ppm added to spinach plants in water resulted in 0.38 and 0.27% uptake after 2 days, respectively(1).
[(1) Dean-Raymond D, Alexander M; Nature 262: 394-6 (1976)]**PEER REVIEWED**

Soil Adsorption/Mobility:

The Koc of N-**nitrosodimethylamine** is estimated as approximately 12(SRC), using a measured log Kow of -0.57(1) and a regression-derived equation(2,SRC). According to a recommended classification scheme(3), this estimated Koc value suggests that N-**nitrosodimethylamine** is expected to have very high mobility in soil(SRC). N-**Nitrosodimethylamine** was found to leach through 4 different soils as readily as chloride ion(4). Another study also found that N-**nitrosodimethylamine** readily leached through soils(5).
[(1) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR (consult ed) Washington,DC: Amer Chem Soc p 5 (1995) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington,DC: Amer Chem Soc pp. 4-9 (1990) (3) Swann RL et al; Res Rev 85: 23 (1983) (4) Dean-Raymond D, Alexander M; Nature 262: 394-6 (1976) (5) Greene S et al; J Environ Qual 10: 416-21 (1981)]**PEER REVIEWED**

Volatilization from Water/Soil:

A half-life of 3 to 6 hours, with respect to volatilization from distilled water in a petri dish, at an initial concentration of 200 mg/l, was reported. The results with Cayuga Lake water indicated that volatilization, if it occurred, was very slow in comparison to the 3.5 month period of observation. The water samples were well stirred and maintained at 30 deg C during this time. It should be noted that the concentration of **dimethylnitrosamine** never fell below 20 mg/l even though the water-depth in the petri dish did not exceed one centimeter. The rate of volatilization from water or highly solvated molecules becomes very slow compared to the rate of volatilization of the water itself at very dilute concentrations of the solute molecule.
[Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume I. EPA-440/4 79-029a. Washington, DC: U.S. Environmental Protection Agency, December 1979.p. 99-3]**PEER REVIEWED**

The measured Henry's Law constant for N-**nitrosodimethylamine** is 1.82X10-6 atm-cu m/mole(1). This value indicates that N-**nitrosodimethylamine** is expected to volatilize slowly from water surfaces(2,SRC). Based on this Henry's Law constant, the estimated volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec) is approximately 17 days(2,SRC). The estimated volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec) is estimated as approximately 130 days(2,SRC). N-**Nitrosodimethylamine**'s Henry's Law constant(1) indicates that volatilization from moist soil surfaces may occur(SRC). The potential for volatilization of N-**nitrosodimethylamine** from dry soil surfaces may exist(SRC) based on a measured vapor pressure of 2.7 mm Hg(3). Under laboratory conditions, greater than 70% of N-**nitrosodimethylamine** applied to the surface of a moist, warm soil (12% moisture content, 22 deg C) volatilized in 10 hours(4).
[(1) Mirvish SS et al; J Natl Cancer Inst 56: 1125-9 (1976) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington,DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (3) Klein RG; Toxicology 23: 135-47 (1982) (4) Oliver JE; J Environ Qual 8: 596-601 (1979)]**PEER REVIEWED**

Environmental Water Concentrations:

NDMA WAS PRESENT IN SEA-WATER ADJACENT TO 1,1-DIMETHYLHYDRAZINE CHEM FACTORY IN BALTIMORE WHICH WAS EMITTING **NDMA** INTO THE AIR; LEVELS VARIED FROM 0.08-0.25 UG/L.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V17 128 (1978)]**PEER REVIEWED**

DRINKING WATER: N-**Nitrosodimethylamine**'s concentration in Philadelphia tap water was 3 to 6 ng/l(1), 0.03 to 0.34 ppb in water exposed to deionizing resins(2), and 0.06 ug/l in deionized, distilled laboratory water(3).
[(1) Kimoto WI et al; Water Res 15: 1099-106 (1981) (2) Fiddler W et al; Food Cosmet Toxicol 15: 441-4 (1977) (3) Gough TA et al; Food Cosmet Toxicol 15: 437-40 (1977)]**PEER REVIEWED**

SURFACE WATER: N-**Nitrosodimethylamine** was reported in a preliminary aqueous sample collected from the Potomac River, Quantico, VA, at a concentration of <6 ug/l(1).
[(1) Hall LW Jr; Aquat Toxicol 10: 73-99 (1987)]**PEER REVIEWED**

SEAWATER: N-**Nitrosodimethylamine** was present in seawater adjacent to a 1,1-dimethylhydrazine chemical factory in Baltimore which was emitting N-**nitrosodimethylamine** into the air; levels varied from 0.08 to 0.25 ug/l(1). N-**Nitrosodimethylamine** concentrations in Curtis Bay and Stonehouse Cove (Baltimore) were 35 to 940 ng/l and in Newark Bay (Elizabeth, NJ) the N-**nitrosodimethylamine** concentration was 0.22 ng/ml(2,3).
[(1) IARC; IARC Monographs on the Evaluation of Carcinogenic Risks to Humans 17: 125-76 (1978) (2) Fine DH et al; Environ Sci Technol 11: 581-4 (1977) (3) Fine DH et al; Spec Conf Toxic Subst Air Environ (Proc) Meet Date 1976 p 168-81 (1977)]**PEER REVIEWED**

Effluent Concentrations:

N-**Nitrosodimethylamine**'s concentration in a chemical plant effluent released to a river was 9040 ng/l(1); it was detected but not quantified in the effluent from an Addison, IL wastewater treatment plant(2). Other N-**nitrosodimethylamine** concentrations in wastewater and wastewater related samples were: 2 ng/ml in an aerobic lagoon in Belle, WV(3), 2700 ng/l in a sewer sample in Baltimore(4), 0.2 to 0.3 ug/l in wastewater(5), 0.374 ug/g in a municipal sewage sludge sample(6), 53 ppb in dried sludge from a Syracuse, NY treatment plant(7), 0.2 ng/l in the influent to a wastewater treatment plant in Belle, WV(3), and 0.5 ng/ml in lagoon seepage at Belle, WV(3). Heavy duty diesel engines emitted from 4.4 to 136.0 g N-**nitrosodimethylamine**/hour; the maximum N-**nitrosodimethylamine** concentration in the diesel crankcase emissions was 17.2 ug/cu m(8). N-**Nitrosodimethylamine** has also been detected in the exhaust from catalyst equipped cars(9).
[(1) Hartmetz G, Slemrova J; Bull Environ Contam Toxicol 25: 106-12 (1980) (2) Ellis DD et al; Arch Environ Contam Toxicol 11: 373-82 (1982) (3) Fine DH et al; Spec Conf Toxic Subst Air Environ (Proc) Meet Date 1976 p. 168-81 (1977) (4) Fine DH et al; Environ Sci Technol 11: 581-4 (1977) (5) IARC; N-Nitroso Compd: Anal Form Occurrence 31: 377-87 (1980) (6) Brewer et al; Environ Pollut Ser B Chem Phys 1: 37-44 (1980) (7) Mumma RO et al; Arch Environ Contam Toxicol 13: 75-83 (1984) (8) Goff EU et al; Anal Chem 52: 1833-6 (1980) (9) Smith LR; Characterization of Emissions from Motor Vehicles Designed for Low Nitrogen Oxide (NOx)Emissions USEPA-600/2-80-276 (1980)]**PEER REVIEWED**

Sediment/Soil Concentrations:

N-**nitrosodimethylamine** has been found in a number of soil samples at the 1 to 8 ug/kg (dry basis) level.
[Fine, DH et al; Determination of Dimethylnitrosamine in Air, Water and Soil by

Thermal Energy analysis (1977c) as cited in USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.C-5 (1980) EPA-440/5-80-064]**PEER REVIEWED**

SOIL: Soil samples taken from several locations near industrial plants in New Jersey contained N-**nitrosodimethylamine** at concentrations ranging from 0 to 15.1 ng/g(1). Soil samples from West Virginia, near Belle and Charleston contained 0.2 to 5.4 ng/g; in New York City soil samples contained 0 to 0.32 ng/g N-**nitrosodimethylamine**(1).
[(1) IARC; IARC Monographs on the Evaluation of Carcinogenic Risks to Humans 17: 125-76 (1978)]**PEER REVIEWED**

Atmospheric Concentrations:

N-**nitrosodimethylamine** was identified as an air pollutant near two chemical plants, one using the amine as a raw material and the other discharging it as an unwanted by-product. Typical levels at the first factory were 6 to 36 ug/cu m on site, 1 ug/cu m in the residential neighborhood adjacent to the factory, and 0.1 ug/cu m two miles away. ... Typical levels adjacent to the second site were 0.001 to 0.04 ug/cu m.
[Fine DH et al; Origins of Human Cancer (1977) as cited in USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.C-12 (1980) EPA-440/5-80-064]**PEER REVIEWED**

N-**Nitrosodimethylamine** concentrations in ambient air were: 32,000 ng/cu m in East Brooklyn area of Baltimore(1); 56 ng/cu m at Union Carbide, South Charleston, WV(1); 980 ng/cu m at DuPont, Belle, WV(1); 1070 ng/cu m (avg) in a community near a chemical plant in Baltimore that manufactured unsymmetrical dimethylhydrazine(2); 30 to 100 ng/cu m in downtown Baltimore(2); 0.07 to 0.83 ug/cu m (0.29 ug/cu m avg) in the front passenger area of new 1979 automobiles(3); 0.3 ug/cu m (avg) in the interior of new 1979 automobiles(4); 0.02 to 0.05 ng/l in smoke-filled rooms(5); 15.6 ng/cu m on I-95 through New York City, NY(6); 0.01 to 0.2 ug/cu m in Paris(7); and 0.03 to 0.15 ug/cu m in Hidazubo City, Japan(8). Average daily ambient air concentrations for N-**nitrosodimethylamine** were 0.58 ppbv in the U.S. between 1980 and 1987; median N-**nitrosodimethylamine** concentrations were 0.003, 0.013, 0.014, and 0.016 ppbv for rural, suburban, urban and source dominated sites, respectively(9).
[(1) Pellizzari ED; The Measurement of Carcinogenic Vapors in Ambient Atmospheres USEPA-600/7-77-055 (1977) (2) Fine DH et al; Environ Sci Technol 11: 581-4 (1977) (3) Rounbehler DP et al; Food Cosmet Toxicol 18: 147-52 (1980) (4) Fine DH et al; IARC Sci Publ 31: 541-54 (1980) (5) Stehlik G et al; Ecotoxicol Environ Safety 6: 495-500 (1982) (6) Fine DH et al; Spec Conf Toxic Subst Air Environ (Proc) Meet Date 1976: 168-81 (1977) (7) Chuong BT et al; Stud Environ Sci 1: 73-6 (1978) (8) Aihara K, Shinozaki M; Kanagawa-Ken Kogai Senta Nempo 11: 38 (1980) (9) Shah JJ, Heyerdahl EK; National Ambient Volatile Organic Compounds (VOCs) Database Update, EPA/600/3-88/010 (1988)]**PEER REVIEWED**

Food Survey Values:

N-**nitrosodimethylamine** has been found to be present in a variety of foods (included smoked, dried or salted fish, ... salami, frankfurters, and cured meats) in the 1 to 100 ug/kg range, but more usually in the 1 to 10 ug/kg range.
[Montesano, R and Bartsch, H; Mutagenic and Carcinogenic N-nitroso Compounds, Mutation Research V32 (1976) as cited in USEPA; Ambient Water Quality Criteria Doc: Nitrosamines p.179 (1980) EPA-440/5-80-064]**PEER REVIEWED**

N-**Nitrosodimethylamine** concns in foods were: 0.02 ppb in sukiyaki broth(1); not detected to 7.7 ppb in beer(2); 2.7 ppb (avg) and 68 ppb (max) in draft and bottle beers(3); 7.7 ppb (avg) in lager beer(4); 5 ppb in ale(4); 2.8 ppb (avg) in malt lager(4); 150 ug/kg in barley malt(5); 22 to 118 ppb in commercially malted barley(6); 2.7 ppb (avg) in fried bacon(7); 2.6 ppb in cooked bacon(7); 0.26 to 0.93 ppb in edible oils(8); 0.3 ppb in margarine(9); traces in cheeses(10); 1.2 ppb in whole wheat biscuits(11); 0.8 ppb in flour(11); 0.8 ppb in dried peas(11); 0.4 ppb in malt vinegar(11); and 1.0 ug/kg in infant formula(5).

N-**Nitrosodimethylamine** was detected in samples of smoked and unsmoked bacon at concns ranging from <2.0 to 8.0 ug/kg(12). N-**Nitrosodimethylamine** was detected in the following canned luncheon meats produced in Italy at the following median concns, ppb: beef with jelly, 0.35; ground beef and pork, 8.7; and turkey, 0.94(13). It was detected in the following cured meats produced in Italy at median concns of, ppb: prosciutto, 0.54; bologna, 4.76; salami, 5.35; rolled bacon, 0.59; coppa, 3.29 to 6.23; and bresaola, 24.70(13). Concns of N-**nitrosodimethylamine** in Italian beer were not detected to 0.71 ppb in light beer and not detected to 0.42 ppb in dark beer; imported light and dark beer contained 0.07 to 0.19 ppb and 0.15 and 0.36 ppb N-**nitrosodimethylamine**, respectively(13). N-**Nitrosodimethylamine** has been detected in the following Italian cheeses, ug/kg: grana padano, 0.35; gorgonzola, 0.84; processed cheese, 0.40; processed cheese with added polyphosphates, 0.38; edam, 0.73; and gouda, 0.39(14).
[(1) Shibamoto T et al; J Agric Food Chem 29: 57-63 (1981) (2) Andrzejewski D et al; J Assoc Off Anal Chem 64: 1457-61 (1981) (3) Spiegelhalder B et al; Food Cosmet Toxicol 17: 29-32 (1979) (4) Scanlan RA et al; Food Cosmet Toxicol 18: 27-30 (1980) (5) Lawrence FJ, Weber DF; J Agric Food Chem 32: 749-7 (1984) (6) Hotchkiss JH et al; J Agric Food Chem 28: 678-80 (1980) (7) IARC; N-nitroso Compd: Anal Form Occurrence 31: 403-17 (1980) (8) Fiddler W et al; J Food Sci 46: 603-5 (1981) (9) Sen NP, Seaman S; J Agric Food Chem 29: 787-9 (1981) (10) Alliston TG et al; Analyst 97: 915-20 (1972) (11) Weston RJ; J Sci Food Agric 35: 782-6 (1984) (12) Massey RC et al; Food Addit Contam 8: 585-98 (1991) (13) Gavinelli M et al; Bull Environ Contam Toxicol 40: 41-56 (1988) (14) Dellisanti A et al; Bull Environ Contam Toxicol 57: 16-21 (1996)]**PEER REVIEWED**

Examination of over 100 apple brandies has shown that N-**nitrosodimethylamine** was present in the majority of samples at an average concentration of 0.5 ug/kg; maximum concentration 10 ug/kg(1). It was also found in a number of ciders, cognacs, Armagnac, rums, and whiskeys; average levels ranged from 0.1 to 0.4 ug/kg with a maximum concentration of 1.6 ug/kg(1).
[(1) IARC; IARC Monographs on the Evaluation of Carcinogenic Risks to Humans 17: 125-76 (1978)]**PEER REVIEWED**

Fish/Seafood Concentrations:

N-**Nitrosodimethylamine** concentrations in fish and seafood were: 200 to 1400 ng/kg in fried salted yellow croaker(1), 0.2 (avg) in frozen cod and sole fillet(2), 0.6 ppb (avg) in miscellaneous smoked fish(2), 0.26 ng/g in a crab from the Raritan River, NJ(3) and a trace in uncooked, fresh cod(4). N-**Nitrosodimethylamine** is often present in fish meal(5).
[(1) Huang DP et al; Food Cosmet Toxicol 19: 167-72 (1981) (2) Sen NP et al; J Agric Food Chem 33: 264-8 (1985) (3) Fine DH et al; Spec Conf Toxic Subst Air Environ (Proc) Meet Date 1976: 168-81 (1977) (4) Alliston TG et al; Analyst 97: 915-20 (1972) (5) Lewis RJ Jr; Hawley's Condensed Chemical Dictionary 12th ed NY, NY: Van Nostrand Reinhold Co p. 831 (1993)]**PEER REVIEWED**

Milk Concentrations:

N-**Nitrosodimethylamine** concentrations in milk were: 3.559 ppb (avg) in nonfat dry milk(1), 0.10 ppb (avg) in whole milk(2), 0.09 ppb (avg) in low fat milk(2), 0.10 ppb (avg) in skim milk(2), 0.32 ppb avg in evaporated milk(2), 0.58 ppb (avg) in sweetened condensed milk(2), 1.69 ppb (avg) and 4.5 ppb in nonfat dried milk(2,3), 1.8 ppb in dried buttermilk(3), and 0.3 ug/kg skim milk powder(4).
[(1) Sen NP et al; J Agric Food Chem 33: 264-8 (1985) (2) Lakritz L, Pensabene JW; J Dairy Sci 64: 371-4 (1981) (3) Libbey LM et al; Food Cosmet Toxicol 18: 459-62 (1980) (4) Lawrence FJ, Weber DF; J Agric Food Chem 32: 749-7 (1984)]**PEER REVIEWED**

Other Environmental Concentrations:

In relatively high concentrations (in the order of 100 mg/cu m), secondary amines and nitrogen dioxide

can react rapidly to form nitrosamines; this reaction apparently occurs in tobacco smoke. /Nitrosamines/
[USEPA; Ambient Water Qualitu Criteria Doc: Nitrosamines p.A-2 (1980) EPA-440/5-80-064]**PEER REVIEWED**

N-**Nitrosodimethylamine** concentrations in cigarette smoke were 5 to 180 ng/cigarette(1) and 460 to 1880 ng/cigarette(2). N-**Nitrosodimethylamine** was detected in 5 brands of snuff from the U.S. and 5 Swedish brands of snuff at 2 to 215 ug/kg and 2 to 60 ug/kg, respectively(3). Sidestream and mainstream cigarette smoke from commercial U.S. cigarettes contained N-**nitrosodimethylamine** at concentrations ranging from 680 to 1040 ug/cigarette in sidestream smoke and 6 to 65 ug/cigarette in mainstream smoke(3). N-**Nitrosodimethylamine** was detected in sidestream and mainstream smoke from small cigars at 1,770 and 43 ug/cigarette, respectively(3). N-**Nitrosodimethylamine** was detected in a sample of a pacifier nipple at concentrations of 14.1 to 21.9 ng/g(4). It was detected in baby bottle rubber nipples at concentrations ranging from 2.1 to 24.6 ppb(5). N-**Nitrosodimethylamine** concentrations in cigarette tobacco ranged from 0.4 to 1.7 ng/cigarette and 0.5 to 5.0 ng/cigarette for filter and non-filter cigarettes, respectively(6).
[(1) McCormick A et al; Nature 244: 237-8 (1973) (2) Brunnenmann KD et al; J Agric Food Chem 31: 1221-4 (1983) (3) Preussman R; Occurrence and Exposure to N-nitroso Compounds and Precursors, IARC Sci Publ 57: 3-15 (1984) (4) Thompson HC Jr et al; J Toxicol Environ Health 13: 615-32 (1984) (5) Gray JI, Stachiw MA; J Assoc Off Anal Chem 70: 64-8 (1987) (6) Tricker AR, Preussmann R; Clin Invest 70: 283-9 (1992)]**PEER REVIEWED**

Environmental Standards & Regulations:

CERCLA Reportable Quantities:

Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 10 lb or 4.54 kg. The toll free number of the NRC is (800) 424-8802; In the Washington D.C. metropolitan area (202) 426-2675. The rule for determining when notification is required is stated in 40 CFR 302.4 (section IV. D.3.b).
[40 CFR 302.4 (7/1/96)]**PEER REVIEWED**

Releases of CERCLA hazardous substances are subject to the release reporting requirement of CERCLA section 103, codified at 40 CFR part 302, in addition to the requirements of 40 CFR part 355. **Nitrosodimethylamine** is an extremely hazardous substance (EHS) subject to reporting requirements when stored in amounts in excess of its threshold planning quantity (TPQ) of 1,000 lbs.
[40 CFR 355 (7/1/97)]**QC REVIEWED**

RCRA Requirements:

P082; As stipulated in 40 CFR 261.33, when N-**nitrosodimethylamine**, as a commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate, becomes a waste, it must be managed according to federal and/or state hazardous waste regulations. Also defined as a hazardous waste is any container or inner liner used to hold this waste or any residue, contaminated soil, water, or other debris resulting from the cleanup of a spill, into water or on dry land, of this waste. Generators of small quantities of this waste may qualify for partial exclusion from hazardous waste regulations (40 CFR 261.5(e)).
[40 CFR 261.33 (7/1/96)]**PEER REVIEWED**

Atmospheric Standards:

Listed as a hazardous air pollutant (HAP) generally known or suspected to cause serious health

problems. The Clean Air Act, as amended in 1990, directs EPA to set standards requiring major sources to sharply reduce routine emissions of toxic pollutants. EPA is required to establish and phase in specific performance based standards for all air emission sources that emit one or more of the listed pollutants. N-**Nitrosodimethylamine** is included on this list.
[Clean Air Act as amended in 1990, Sect. 112 (b) (1) Public Law 101-549 Nov. 15, 1990]**QC REVIEWED**

Clean Water Act Requirements:

Toxic pollutant designated pursuant to section 307(a)(1) of the Clean Water Act and is subject to effluent limitations. /Nitrosamines/
[40 CFR 401.15 (7/1/91)]**QC REVIEWED**

The levels for N-**nitrosodimethylamine** through ingestion of contaminated water and contaminated aquatic organisms ... which may result in incremental increase of cancer risk over the lifetime are estimated at 1X10-5, 1X10-6, and 1X10-7. The corresponding criteria are 14 ng/l, 1.4 ng/l, and 0.14 ng/l, respectively. For consumption of aquatic organisms only, excluding consumption of water, the levels are 160,000 ng/l, 16,000 ng/l, and 1,600 ng/l, respectively. /Nitrosamines/
[USEPA; Quality Criteria for Water 1986: Nitrosamines (May 1, 1986) EPA 440/5-86-001]**QC REVIEWED**

State Drinking Water Guidelines:

(FL) FLORIDA 7.5 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

C2-H6-N2-O
[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1049]**PEER REVIEWED**

Molecular Weight:

74.08
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1139]**PEER REVIEWED**

Color/Form:

Yellow, oily liquid.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 94-116. Washington, D.C.: U.S. Government Printing Office, June 1994. 232]**PEER REVIEWED**

Odor:

Faint, characteristic odor.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 94-116. Washington, D.C.: U.S. Government Printing Office, June 1994. 232]**PEER REVIEWED**

Boiling Point:

151-153 DEG C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1140]**PEER REVIEWED**

Density/Specific Gravity:

1.0048 AT 20 DEG C/4 DEG C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1140]**PEER REVIEWED**

Octanol/Water Partition Coefficient:

log Kow= -0.57
[Hansch, C., Leo, A., D. Hoekman. Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. Washington, DC: American Chemical Society., 1995. 5]**PEER REVIEWED**

Solubilities:

SOL IN ALL COMMON ORGANIC SOLVENTS & IN LIPIDS
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V1 95 (1972)]**PEER REVIEWED**

VERY SOL IN WATER, ALCOHOL, ETHER
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1140]**PEER REVIEWED**

MISCIBLE WITH METHYLENE CHLORIDE, VEGETABLE OILS
[Hamilton, A., and H. L. Hardy. Industrial Toxicology. 3rd ed. Acton, Mass.: Publishing Sciences Group, Inc., 1974. 311]**PEER REVIEWED**

Soluble in ethanol, ethyl ether, and chloroform; soluble in water.
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 76th ed. Boca Raton, FL: CRC Press Inc., 1995-1996.,p. 3-205]**PEER REVIEWED**

Spectral Properties:

INDEX OF REFRACTION: 1.4368 AT 20 DEG C/D
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1140]**PEER REVIEWED**

MAX ABSORPTION (WATER): 230 NM (LOG E= 3.86); 332 NM (LOG E= 1.98)
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V1 95 (1972)]**PEER REVIEWED**

Ultraviolet absorption maxima values; Solvent: Light Petroleum (232 nm, 351 nm, 374 nm), Ethanol (231 nm, 346 nm), Water (230 nm, 332 nm)
[Castegnaro, M., G. Eisenbrand, G. Ellen, L. Keefer, D. Klein, E.B. Sansone, D. Spincer, G. Telling, K. Webb, and W. Davis (eds.). Laboratory Decontamination and Destruction of Carcinogens in Laboratory Wastes: Some N-Nitrosamines. IARC

Publications No. 43. Lyon, France: International Agency for Research on Cancer, 1982.51]**PEER REVIEWED**

IR: 4837 (Coblentz Society Spectral Collection)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 562]**PEER REVIEWED**

UV: 6-5 (Organic Electronic Spectral Data, Phillips et al, John Wiley & Sons, New York)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 562]**PEER REVIEWED**

NMR: 375 (Varian Associates NMR Spectra Catalogue)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 562]**PEER REVIEWED**

MASS: 13 (Aldermaston, Eight Peak Index of Mass Spectra, UK)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 562]**PEER REVIEWED**

Vapor Density:

2.56
[Verschueren, K. Handbook of Environmental Data on Organic Chemicals. 3rd ed. New York, NY: Van Nostrand Reinhold Co., 1996. 829]**PEER REVIEWED**

Vapor Pressure:

2.7 mm Hg at 20 deg C.
[Klein RG; Toxicology 23: 135-48 (1982)]**PEER REVIEWED**

Viscosity:

LOW
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V1 95 (1972)]**PEER REVIEWED**

Other Chemical/Physical Properties:

OXIDIZED TO NITRAMINE OR REDUCED TO THE HYDRAZINE &/OR AMINE; RELATIVELY RESISTANT TO HYDROLYSIS; PHOTOCHEMICALLY REACTIVE
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V1 96 (1972)]**PEER REVIEWED**

1 MG/L= 330 PPM; 1 PPM= 3.03 MG/CU M
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 2787]**PEER REVIEWED**

Chemical Safety & Handling:

Skin, Eye and Respiratory Irritations:

The liquid and vapor /may be/ irritating to the skin or eyes. ...
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 669]**PEER REVIEWED**

Fire Potential:

Combustible
[Sax, N.I. and R.J. Lewis, Sr. (eds.). Hawley's Condensed Chemical Dictionary. 11th ed. New York: Van Nostrand Reinhold Co., 1987. 832]**PEER REVIEWED**

Fire Fighting Procedures:

/Fire fighters should wear/ any self-contained breathing apparatus with a full facepiece and operated in a pressure demand or other positive pressure mode.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.6]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

Strong oxidizers. (Note: Should be stored in dark bottles.)
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 232]**QC REVIEWED**

Incompatibilities: ultraviolet light
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Hazardous Decomposition:

When heated to decomp it emits toxic fumes of ... /nitrogen oxides/.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2469]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH considers N-**nitrosodimethylamine** to be a potential occupational carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 232]**QC REVIEWED**

Protective Equipment & Clothing:

... Appropriate type fullface supplied air respirators of continuous flow or pressure demand type. ... Use all purpose canister mask.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 669]**PEER REVIEWED**

Wear butyl rubber gloves, face shield and working clothes.
[ITII. Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1988. 378]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Dispensers of liq detergent /should be available./ ... Safety pipettes should be used for all pipetting. ... In animal laboratory, personnel should ... wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when

working with particulates or gases, & disposable plastic aprons might provide addnl protection. ... gowns ... /should be/ of distinctive color, this is a reminder that they are not to be worn outside the laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

Wear appropriate personal protective clothing to prevent skin contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 233]**QC REVIEWED**

Wear appropriate eye protection to prevent eye contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 233]**QC REVIEWED**

Facilities for quickly drenching the body should be provided within the immediate work area for emergency use where there is a possibility of exposure. [Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from any body areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.]
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 233]**QC REVIEWED**

Eyewash fountains should be provided in areas where there is any possibility that workers could be exposed to the substance; this is irrespective of the recommendation involving the wearing of eye protection.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 233]**QC REVIEWED**

Recommendations for respirator selection. Condition: At concentrations above the NIOSH REL, or where there is no REL at any detectable concentration: Respirator Class(es): Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive pressure mode. Any supplied-air respirator that has a full facepiece and is operated in pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 233]**QC REVIEWED**

Recommendations for respirator selection. Condition: Escape from suddenly occurring respiratory hazards: Respirator Class(es): Any air-purifying, full-facepiece respirator with a high-efficiency particulate filter. Any appropriate escape-type, self-contained breathing apparatus.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 233]**QC REVIEWED**

Wear nitrile rubber gloves, protective laboratory coat, self-contained breathing apparatus, eye protection and protective shoes. /Nitrosamines/
[Armour, M.A. Hazardous Laboratory Chemicals Disposal Guide. Boca Raton, FL: CRC Press Inc., 1991. 256]**PEER REVIEWED**

Preventive Measures:

Contact lenses should not be worn when working with this chemical.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 233]**QC REVIEWED**

The worker should immediately wash the skin when it becomes contaminated.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 233]**QC REVIEWED**

The worker should wash daily at the end of each work shift.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 233]**QC REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed and replaced.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 233]**QC REVIEWED**

Workers whose clothing may have become contaminated should change into uncontaminated clothing before leaving the work premises.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 233]**QC REVIEWED**

... Engineering controls ... prevent all contact with the skin, eyes, or resp tract. On exit from a regulated area, employees should be required to shower before changing into street clothes, leaving their protective clothing and equipment at the point of exit, to be placed in impervious containers at the end of the work shift for decontamination or disposal.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 669]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Smoking, drinking, eating, storage of food or of food & beverage containers or utensils, & the application of cosmetics should be prohibited in any laboratory. All personnel should remove gloves, if worn, after completion of procedures in which carcinogens have been used. They should ... wash ... hands, preferably using dispensers of liq detergent, & rinse ... thoroughly. Consideration should be given to appropriate methods for cleaning the skin, depending on nature of the contaminant. No standard procedure can be recommended, but the use of organic solvents should be avoided. Safety pipettes should be used for all pipetting. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": In animal laboratory, personnel should remove their outdoor clothes & wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... clothing should be changed daily but ... discarded immediately if obvious contamination occurs ... /also,/ workers should shower immediately. In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide additional protection. If gowns are of distinctive color, this is a reminder that they should not be worn outside of lab. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Operations connected with synthesis & purification ... should be carried out under well-ventilated hood. Analytical procedures ... should be carried out with care & vapors evolved during ... procedures should be removed. ... Expert advice should be obtained before existing fume cupboards are used ... & when new fume cupboards are installed. It is desirable that there be means for decreasing the rate of air extraction, so that carcinogenic powders can be handled

without ... powder being blown around the hood. Glove boxes should be kept under negative air pressure. Air changes should be adequate, so that concn of vapors of volatile carcinogens will not occur. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Vertical laminar-flow biological safety cabinets may be used for containment of in vitro procedures ... provided that the exhaust air flow is sufficient to provide an inward air flow at the face opening of the cabinet, & contaminated air plenums that are under positive pressure are leak-tight. Horizontal laminar-flow hoods or safety cabinets, where filtered air is blown across the working area towards the operator, should never be used. ... Each cabinet or fume cupboard to be used ... should be tested before work is begun (eg, with fume bomb) & label fixed to it, giving date of test & avg air-flow measured. This test should be repeated periodically & after any structural changes. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Principles that apply to chem or biochem lab also apply to microbiological & cell-culture labs ... Special consideration should be given to route of admin. ... Safest method of admin volatile carcinogen is by injection of a soln. Admin by topical application, gavage, or intratracheal instillation should be performed under hood. If chem will be exhaled, animals should be kept under hood during this period. Inhalation exposure requires special equipment. ... Unless specifically required, routes of admin other than in the diet should be used. Mixing of carcinogen in diet should be carried out in sealed mixers under fume hood, from which the exhaust is fitted with an efficient particulate filter. Techniques for cleaning mixer & hood should be devised before expt is begun. When mixing diets, special protective clothing &, possibly, respirators may be required. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When ... admin in diet or applied to skin, animals should be kept in cages with solid bottoms & sides & fitted with a filter top. When volatile carcinogens are given, filter tops should not be used. Cages which have been used to house animals that received carcinogens should be decontaminated. Cage-cleaning facilities should be installed in area in which carcinogens are being used, to avoid moving of ... contaminated /cages/. It is difficult to ensure that cages are decontaminated, & monitoring methods are necessary. Situations may exist in which the use of disposable cages should be recommended, depending on type & amt of carcinogen & efficiency with which it can be removed. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": To eliminate risk that ... contamination in lab could build up during conduct of expt, periodic checks should be carried out on lab atmospheres, surfaces, such as walls, floors & benches, & ... interior of fume hoods & airducts. As well as regular monitoring, check must be carried out after cleaning-up of spillage. Sensitive methods are required when testing lab atmospheres for chem such as nitrosamines. Methods ... should ... where possible, be simple & sensitive.

... /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Rooms in which obvious contamination has occurred, such as spillage, should be decontaminated by lab personnel engaged in expt. Design of expt should ... avoid contamination of permanent equipment. ... Procedures should ensure that maintenance workers are not exposed. ... Particular care should be taken to avoid contamination of drains or ventilation ducts. In cleaning labs, procedures should be used which do not produce aerosols or dispersal of dust, ie, wet mop or vacuum cleaner equipped with high-efficiency particulate filter on exhaust, which are avail commercially, should be used. Sweeping, brushing & use of dry dusters or mops should be prohibited. ... Contaminated cleaning materials should not be re-used. ... If gowns or towels are contaminated, they should not be sent to laundry, but ... decontaminated or burnt, to avoid any hazard to laundry personnel. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Doors leading into areas where carcinogens are used ... should be marked distinctively with appropriate labels. Access should be ... limited to persons involved in expt. ... A prominently displayed notice should give the name of the Scientific Investigator or other person who can advise in an emergency & who can inform others (such as firemen) on the handling of carcinogenic substances. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.11]**PEER REVIEWED**

SRP: The scientific literature for the use of contact lenses in industry is conflicting. The benefit or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In any event, the usual eye protection equipment should be worn even when contact lenses are in place.
PEER REVIEWED

Stability/Shelf Life:

STABLE @ ROOM TEMP MORE THAN 14 DAYS IN NEUTRAL & ALKALINE SOLN IN DARK; SLIGHTLY LESS STABLE IN ACIDIC SOLN; SENSITIVE TO UV LIGHT.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V17 126 (1978)]**PEER REVIEWED**

Shipment Methods and Regulations:

PRECAUTIONS FOR "CARCINOGENS": Procurement ... of unduly large amt ... should be avoided. To avoid spilling, carcinogens should be transported in securely sealed glass bottles or ampoules, which should themselves be placed inside strong screw-cap or snap-top container that will not open when dropped & will resist attack from the carcinogen. Both bottle & the outside container should be

appropriately labelled. ... National post offices, railway companies, road haulage companies & airlines have regulations governing transport of hazardous materials. These authorities should be consulted before ... material is shipped. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When no regulations exist, the following procedure must be adopted. The carcinogen should be enclosed in a securely sealed, watertight container (primary container), which should be enclosed in a second, unbreakable, leakproof container that will withstand chem attack from the carcinogen (secondary container). The space between primary & secondary container should be filled with absorbent material, which would withstand chem attack from the carcinogen & is sufficient to absorb the entire contents of the primary container in the event of breakage or leakage. Each secondary container should then be enclosed in a strong outer box. The space between the secondary container & the outer box should be filled with an appropriate quantity of shock-absorbent material. Sender should use fastest & most secure form of transport & notify recipient of its departure. If parcel is not received when expected, carrier should be informed so that immediate effort can be made to find it. Traffic schedules should be consulted to avoid ... arrival on weekend or holiday ... /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

Storage Conditions:

SHOULD BE STORED IN DARK BOTTLES.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V1 95 (1972)]**PEER REVIEWED**

ALL BOTTLES OF N-NITROSODIETHYLAMINE SHOULD BE STORED & TRANSPORTED WITHIN UNBREAKABLE OUTER CONTAINER; STORAGE SHOULD BE IN VENTILATED STORAGE CABINET (OR IN HOOD). /N-NITROSODIETHYLAMINE, ALSO APPLICABLE TO OTHER DIALKYLNITROSAMINES/
[National Research Council. Prudent Practices for Handling Hazardous Chemicals in Laboratories. Washington, DC: National Academy Press, 1981. 55]**PEER REVIEWED**

Cleanup Methods:

SPILLS OF N-NITROSODIETHYLAMINE CAN BE ABSORBED BY CELITE OR COMMERCIAL SPILL ABSORBANT. AFTER ABSORBANT CONTAINING MAJOR SHARE OF NITROSAMINE HAS BEEN PICKED UP (AVOID DUSTS; DO NOT SWEEP), SURFACE SHOULD BE THOROUGHLY CLEANED WITH STRONG DETERGENT SOLN. IF MAJOR SPILL OCCURS OUTSIDE OF VENTILATED AREA, ROOM SHOULD BE EVACUATED & CLEANUP OPERATION SHOULD BE CARRIED OUT BY PERSONS EQUIPPED WITH SELF-CONTAINED RESPIRATORS. THOSE INVOLVED IN THIS OPERATION SHOULD WEAR RUBBER GLOVES, LAB COATS, & PLASTIC APRONS OR EQUIVALENT PROTECTIVE APPAREL. /N-NITROSODIETHYLAMINE, ALSO APPLICABLE TO OTHER DIALKYLNITROSAMINES/
[National Research Council. Prudent Practices for Handling Hazardous Chemicals in Laboratories. Washington, DC: National Academy Press, 1981. 55]**PEER REVIEWED**

Nitrosamine residues generated in laboratory research or accidental spills in research laboratories and

diluted to concn of 10 mg/l or less are rapidly reduced to innocuous amines, ammonia, or alcohols by aluminum-nickel alloy powder and aqueous alkali. The method is applicable to a variety of media (water, mineral oil, olive oil, dimethylsulfoxide, soln of agar gel) but is not recommended for use with nitrosamines in acetone or dichloromethane because reactions are slow and incomplete. After the reduced reaction mixture is filtered, the liquid is disposed of by pouring it over sufficient absorbent material to convert it to a solid waste for incineration. /Nitrosamines/
[Lunn G et al; Carcinogenesis 4 (3): 315-19 (1983)]**PEER REVIEWED**

After covering the spills with soda ash, mix and spray with water. Scoop into a bucket of water and /let/ it stand for two hr. Neutralize with 6M hydrochloric acid and flush with sufficient water.
[ITII. Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1988. 379]**PEER REVIEWED**

Decontamination of lab wastes using triethyloxonium salts /was described/. This method specifies a procedure for the decontamination of lab wastes either dissolved in or extractable by dichloromethane. This method has been ... studied using triethyloxonium tetrafluoroborate for the treatment of solutions of N-**nitrosodimethylamine** ... in dichloromethane ... .
[Castegnaro, M., G. Eisenbrand, G. Ellen, L. Keefer, D. Klein, E.B. Sansone, D. Spincer, G. Telling, K. Webb, and W. Davis (eds.). Laboratory Decontamination and Destruction of Carcinogens in Laboratory Wastes: Some N-Nitrosamines. IARC Publications No. 43. Lyon, France: International Agency for Research on Cancer, 1982.31]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": A high-efficiency particulate arrestor (HEPA) or charcoal filters can be used to minimize amt of carcinogen in exhausted air ventilated safety cabinets, lab hoods, glove boxes or animal rooms. ... Filter housing that is designed so that used filters can be transferred into plastic bag without contaminating maintenance staff is avail commercially. Filters should be placed in plastic bags immediately after removal. ... The plastic bag should be sealed immediately. ... The sealed bag should be labelled properly. ... Waste liquids ... should be placed or collected in proper containers for disposal. The lid should be secured & the bottles properly labelled. Once filled, bottles should be placed in plastic bag, so that outer surface ... is not contaminated. ... The plastic bag should also be sealed & labelled. ... Broken glassware ... should be decontaminated by solvent extraction, by chemical destruction, or in specially designed incinerators. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

If N-**nitrosodimethylamine** is spilled or leaked, the following steps should be taken: 1. Ventilate area of spill or leak. 2. For small quantities /of/ liquids containing N-nitrosodimethyl-amine, absorb on paper towels and place in an appropriate container. 3. Large quantities of liquids containing N-nitrosodi-methylamine may be absorbed in vermiculite, dry sand, earth, or a similar material and placed in an appropriate container. 4. Liquids containing N-**nitrosodimethylamine** may be collected by vacuuming with an appropriate system.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.4]**PEER REVIEWED**

Cover spill with a 1:1:1 mixture by weight of sodium carbonate or calcium carbonate, clay cat litter (bentonite) and sand. Scoop the mixture into an appropriately labeled container for disposal by burning. ... Dissolve the compound in a flammable solvent and spray into furnace with afterburner and scrubber.
[Armour, M.A. Hazardous Laboratory Chemicals Disposal Guide. Boca Raton, FL: CRC Press Inc., 1991. 258]**PEER REVIEWED**

Disposal Methods:

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste number P082, must conform with USEPA regulations in storage, transportation, treatment and disposal of waste.
[40 CFR 240-280, 300-306, 702-799 (7/1/91)]**PEER REVIEWED**

A potential candidate for rotary kiln incineration at a temperature range of 820 to 1,600 deg C and residence times of seconds for liquids and gases, and hours for solids. A potential candidate for fluidized bed incineration at a temperature range of 450 to 980 deg C and residence times of seconds for liquids and gases, and longer for solids.
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-9 (1981) EPA 68-03-3025]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for **dimethylnitrosamine**: Concentration process: Activated carbon.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-139 (1982)]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": There is no universal method of disposal that has been proved satisfactory for all carcinogenic compounds & specific methods of chem destruction ... published have not been tested on all kinds of carcinogen-containing waste. ... Summary of avail methods & recommendations ... /given/ must be treated as guide only. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.14]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Total destruction ... by incineration may be only feasable method for disposal of contaminated laboratory waste from biological expt. However, not all incinerators are suitable. ... Most efficient type ... is probably the gas-fired type, in which a first-stage combustion with a less than stoichiometric air:fuel ratio is followed by a second stage with excess air. Some ... are designed to accept ... aqueous & organic-solvent solutions, otherwise it is necessary ... to absorb soln onto suitable combustible material, such as sawdust. Alternatively, chem destruction may be used, esp when small quantities ... are to be destroyed in laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": HEPA (high-efficiency particulate arrestor) filters ... can be disposed of by incineration. For spent charcoal filters, the adsorbed material can be stripped off at high temp & carcinogenic wastes generated by this treatment conducted to & burned in an incinerator. ... LIQUID WASTE: ... Disposal should be carried out by incineration at temp that ... ensure complete combustion. SOLID WASTE: Carcasses of lab animals, cage litter & misc solid wastes ... should be disposed of by incineration at temp high enough to ensure destruction of chem carcinogens or their metabolites. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Small quantities of ... some carcinogens can be destroyed using chem reactions ... but no general rules can be given. ... As a general technique ... treatment with sodium dichromate in strong sulfuric acid can be used. The time necessary for destruction ... is seldom

known ... but 1-2 days is generally considered sufficient when freshly prepd reagent is used. ... Carcinogens that are easily oxidizable can be destroyed with milder oxidative agents, such as saturated soln of potassium permanganate in acetone, which appears to be a suitable agent for destruction of hydrazines or of compounds containing isolated carbon-carbon double bonds. Concn of 50% aqueous sodium hypochlorite can also be used as an oxidizing agent. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.16]**PEER REVIEWED**

N-**nitrosodimethylamine** can be destroyed by dichromate-sulfuric acid; it may also be reduced ... by zinc powder and acetic acid or by caustic soda and aluminum to the carcinogen, dimethylhydrazine, which in turn has to be oxidized ... using a permanganate solution. Nitrosamines can also be split into nitrites and amines by ... acetic acid; and their efficient degradation by photolysis has been described ... . Effective destruction of N-nitrosamines at levels below 500 ppm by hydrochloric acid ... have been described.
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.17]**PEER REVIEWED**

Pour or sift onto a thick layer of sand and soda ash mixture (90-10). Mix and shovel into a heavy paper box with much paper packing. Burn in an incinerator. Fire may be augmented by adding excelsior and scrap wood. Waste may be dissolved in flammable solvent and sprayed into fire box of an incinerator with afterburner and scrubber. Recommendable methods: Incineration, chemical treatment ... .
(Peer-review conclusions of an IRPTC expert consultation (May 1985))
[United Nations. Treatment and Disposal Methods for Waste Chemicals (IRPTC File). Data Profile Series No. 5. Geneva, Switzerland: United Nations Environmental Programme, Dec. 1985. 164]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Carcinogens that are alkylating, arylating or acylating agents per se can be destroyed by reaction with appropriate nucleophiles, such as water, hydroxyl ions, ammonia, thiols & thiosulfate. The reactivity of various alkylating agents varies greatly ... & is also influenced by sol of agent in the reaction medium. To facilitate the complete reaction, it is suggested that the agents be dissolved in ethanol or similar solvents. ... No method should be applied ... until it has been thoroughly tested for its effectiveness & safety on material to be inactivated. For example, in case of destruction of alkylating agents, it is possible to detect residual compounds by reaction with 4(4-nitrobenzyl)-pyridine. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.17]**PEER REVIEWED**

(1) Add the contaminated amine to a layer of sodium bisulfate in a large evaporating dish. Spray with water. (2) Dissolve in a flammable solvent. Burn in an open pit by means of an excelsior train. Stay on upwind side. (3) The solution of no. 2 may be sprayed into the fire box of an incinerator with afterburner and scrubber.
[Prager, J.C. Environmental Contaminant Reference Databook Volume 1. New York, NY: Van Nostrand Reinhold, 1995. 611]**PEER REVIEWED**

(1) Nitrosamines may be reduced to the corresponding amine by using nickel-aluminum (Ni-Al) alloy in dilute base. The nitrosamines ere completely degraded (99.9%) and only the amines (RR'NH) were found in the final reaction mixtures. No traces (generally <0.1%) of the corresponding, possibly carcinogenic, hydrazines (RR'NNH2) were found in the final reaction mixtures. (2) Nitrosamines may be

oxidized by potassium permanganate in 3 M sulfuric acid (KMnO4 in H2SO4). The nitrosamines were completely destroyed (>99.5%). The products of this reaction have not been determined. (3) Nitrosamines may be destroyed by using hydrogen bromide (HBr) in glacial acetic acid. The nitrosamines were completely destroyed (>99%) and the products were presumably the corresponding amines. All of these procedures were validated by an international collaborative study. /Nitrosamines/
[Lunn, G., E.B. Sansone. Destruction of Hazardous Chemicals in the Laboratory. New York, NY: John Wiley & Sons, Inc. 1994. 293]**PEER REVIEWED**

Occupational Exposure Standards:

Threshold Limit Values:

A3; Confirmed animal carcinogen with unknown relevance to humans. Skin notation.
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.45]**QC REVIEWED**

Exposure by all routes should be carefully controlled to levels as low as possible.
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.45]**QC REVIEWED**

NIOSH Recommendations:

NIOSH considers N-**nitrosodimethylamine** to be a potential occupational carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 232]**QC REVIEWED**

NIOSH usually recommends that occupational exposures to carcinogens be limited to the lowest feasible concentration.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 232]**QC REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH considers N-**nitrosodimethylamine** to be a potential occupational carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 232]**QC REVIEWED**

Manufacturing/Use Information:

Major Uses:

INDUSTRIAL SOLVENT, ANTIOXIDANT; SOLVENT IN FIBER & PLASTICS INDUSTRY; IN LUBRICANTS, CONDENSERS TO INCR DIELECTRIC CONSTANT; HAS BEEN USED AS NEMATOCIDE; SOFTENER FOR COPOLYMERS. /FORMER USES/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V1 96 (1972)]**PEER REVIEWED**

RESEARCH CHEMICAL; CHEM INT FOR 1,1-DIMETHYLHYDRAZINE (FORMER USE)
[SRI]**PEER REVIEWED**

... Solvent, Rubber accelerator
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 12th ed. New York,

NY: Van Nostrand Rheinhold Co., 1993 831]**PEER REVIEWED**

Inhibition of nitrification in soil, used as plasticizer for acrylonitrile polymers, used in active metal anode-electrolyte systems (high-energy batteries), in the preparation of thiocarbonyl fluoride polymers, in the plasticization of rubber.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 668]**PEER REVIEWED**

No evidence was found that **NDMA** is used at present, except for research purposes.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V17 126 (1978)]**PEER REVIEWED**

Formerly in the production of rocket fuels; antioxidant; additive for lubricants; softener of copolymers.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1140]**PEER REVIEWED**

Methods of Manufacturing:

REACTION OF NITROUS ACID WITH DIMETHYLAMINE
[SRI]**PEER REVIEWED**

IT CAN BE PREPARED BY ADDITION OF ACETIC ACID & SODIUM NITRITE TO DIMETHYLAMINE.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 2786]**PEER REVIEWED**

Industrial prepn: Brit pat 772,331 (1957 to Olin Mathieson), C.A, 51, 14783a (1957); Ioffe, Zh Obshch (1959); Campbell, U.S. pat 2,981,752 (1961 to C.S.C); Datin, Elliott, U.S. patent3,136,821 (1964 to Allied Chem).
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1140]**PEER REVIEWED**

General Manufacturing Information:

N-Nitrosamines are products formed from the nitrosation of secondary amines, but are occasionally also derived from the nitrosation of some primary and tertiary amines or quaternary ammonium compounds. /N-nitrosamines/
[Castegnaro, M., G. Eisenbrand, G. Ellen, L. Keefer, D. Klein, E.B. Sansone, D. Spincer, G. Telling, K. Webb, and W. Davis (eds.). Laboratory Decontamination and Destruction of Carcinogens in Laboratory Wastes: Some N-Nitrosamines. IARC Publications No. 43. Lyon, France: International Agency for Research on Cancer, 1982.3]**PEER REVIEWED**

Formed by the interaction of nitrite with dimethylamine and by the action of nitrate-reducing bacteria.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1140]**PEER REVIEWED**

U. S. Production:

(1977) NOT PRODUCED COMMERCIALLY IN USA
[SRI]**PEER REVIEWED**

(1982) NOT PRODUCED COMMERCIALLY IN USA
[SRI]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

N-**NITROSODIMETHYLAMINE** WAS DETECTED BY CHEMILUMINESCENCE & MASS SPECTROMETRY AFTER SEPARATION FROM HUMAN BLOOD. IT WAS DETECTED AT CONCENTRATIONS FROM THE DETECTION LIMIT (0.1 UG/L) TO 1.4 UG/L WITH MEAN CONCN OF 0.5 UG/L.
[GOUGH TA ET AL; FOOD CHEM TOXICOL 21 (2): 151-6 (1983)]**PEER REVIEWED**

METHOD FOR ANALYZING NITROSAMINES IN AQ SOLN & IN BIOLOGICAL FLUIDS (BLOOD PLASMA & RAT LIVER MICROSOMAL PREPN) IS PRESENTED. SCHEME IS A 3 MODULAR COMPONENT SYSTEM. FLUOROMETRIC ANALYSIS IMPROVED SENSITIVITY TO 4 NG/ML.
[MUSSON DG, STERNSON LA; J PHARM SCI 68 (9): 1159-62 (1979)]**PEER REVIEWED**

A gas chromatographic method coupled with a thermal energy analyzer was developed for the quantitative analysis of nitrosamines in the urine of workers & bottle-fed babies.
[Airoldi L et al; J Chromatogr 276 (2): 402-7 (1983)]**PEER REVIEWED**

Gas chromatography/high resolution mass spectrometry methods were developed for quantifying **nitrosodimethylamine** (**NDMA**) in human urine. The limits of quantitation of these methods, which utilize stable isotope analogs of **nitrosodimethylamine** as internal standards, were 5 pg/ml for **nitrosodimethylamine**.
[Garland WA et al; Cancer Res 46 (10): 5392-400 (1986)]**PEER REVIEWED**

N-**NITROSODIMETHYLAMINE** WAS DETERMINED IN SALIVA TEST SOLUTIONS WHICH HAD CONTACTED NURSING-BOTTLE NIPPLES & PACIFIERS BY GAS CHROMATOGRAPHIC TECHNIQUE.
[SPIEGELHALDER B; IARC SCI PUBL 45 (ENVIRON CARCINOG: SEL METHODS ANAL, V6): 265-73 (1983)]**PEER REVIEWED**

A rapid, sensitive, specific, and cost effective method for the detection of N-**nitrosodimethylamine** in rodent tissue and body fluids /is described/. The method involves isolation of N-**nitrosodimethylamine** from the samples with subsequent detection and quantitation of observed N-**nitrosodimethylamine** against a mass labeled N-(15)N-nitrosodimethyl-(15)N-amine internal standard by capillary gas chromatography/mass spectrometry with selected ion monitoring. Validation of the method includes linearity studies of N-**nitrosodimethylamine** response, calculation of the relative response factor (RRF) for n-**nitrosodimethylamine** vs (15)N-nitrosodimethyl-(15)N-amine, and absoulte recovery studies. Estimates of percision, detection limit, and minimum quantifiable limit are also reported.
[Timmons L et al; J Anal Toxicol 12 (3): 117-21 (1988)]**PEER REVIEWED**

Analytic Laboratory Methods:

N-NITROSAMINES ARE COLLECTED FROM CIGARETTE SMOKE. THE EXTRACT IS CONCENTRATED & ANALYZED FOR N-**NITROSODIMETHYLAMINE** ON A GAS CHROMATOGRAPH WITH A THERMAL ENERGY ANALYZER.
[MATSUSHITA H ET AL; TAIKI OSEN GAKKAISHI 18 (4): 339-45 (1983)]**PEER REVIEWED**

N-**Nitrosodimethylamine** in non-fat dry milk is analyzed by gas chromatography detector with a

thermal energy analyzer. The sample is mixed with Celite, ammonium sulfamate, and dil sulfuric acid and packed in a column containing anhydrous sodium sulfate.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990,p. 15/835 984.16]**PEER REVIEWED**

N-**Nitrosodimethylamine** in beer is analyzed by gas chromatography with either electrolytic conductivity or thermal energy analyzer. **NDMA** is isolated by either adsorption on Celite or by distillation.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990,p. 15/719 982.11]**PEER REVIEWED**

N-**Nitrosodimethylamine** in beer is analyzed by gas chromatography with a thermal energy analyzer. The sample is treated with sulfamic acid and hydrochloric acid, and is separated by distillation. Ave recovery at 0.14-5 ppb is 101% with a precision of 0.03-0.7.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990,p. 15/720 982.22]**PEER REVIEWED**

N-Nitrosamines in fried bacon are determined using gas chromatography with a thermal energy analyzer. The samples must be ground and extracted with mineral vacuum distillation and concentrated with a Kuderna-Danish apparatus. N-**Nitrosodimethylamine** has an ave recovery of 89.6% at 3-18 ppb and a precision of 0.5-2.6.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990,p. 15/938 982.22]**PEER REVIEWED**

Volatile N-nitrosamines were confirmed in foods at concentrations of less than 10 ug/kg by full scan low resolution mass spectrometry. Concn from 1 ug/kg in foods to 2-5 ug/kg in fried commercial bacon were detected.
[Hotchkiss JH et al; J Assoc Off Anal Chem 63 (1): 74-9 (1980)]**PEER REVIEWED**

Levels of N-**nitrosodimethylamine** (**NDMA**) were determined in 112 samples of 2,4-dichlorophenoxyacetic acid, (2,4-D), formulated as the dimethylamine salt, collected over a 2 year period from products on the Canadian market. Nitrosamine levels are determined using a gas chromatograph interfaced with a thermal energy analyzer. Recovery of N-**nitrosodimethylamine** spiked into samples were 103 + or - 16.
[Hindle RW et al; J Assoc Off Anal Chem 70 (1): 49-51 (1987)]**PEER REVIEWED**

A rapid and sensitive procedure was described for determining 4 N-nitrosodialkylamines including the dimethyl morpholine in animal feed. The volatile N-nitrosamines were isolated by using a modified high temperature purge and trap apparatus designed for multiple sample cleanup. The feed sample was mixed with mineral oil and a nitrosation inhibitor, the N-nitrosamines were purged onto a ThermoSorb/N cartridge, eluted with acetone-dichloromethane (1 + 1) and determined by gas chromatography, using a thermal energy analyzer.
[Billedeau SM et al; J Assoc Off Anal Chem 67 (3): 557-62 (1984)]**PEER REVIEWED**

Volatile N-Nitrosamines are extracted from cut-up rubber nipples with dichloromethane by gas chromatography and analyzed with a thermal energy analyser.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990,p. 15/1182 987.05]**PEER REVIEWED**

EPA Method 8250. Packed Column Gas Chromatography/Mass Spectrometry Technique for the

determination of semivolatile organic compounds in extracts prepared from all types of solid waste matrices, soil, and groundwater. This method is applicable to quantify most neutral, acidic, and basic organic compounds that are soluble in methylene chloride and capable of being eluted with derivatization as sharp peaks from a gas chromatographic packed column. Under the prescribed conditions, N-**nitrosodimethylamine** has no detection limit given. Precision and method accuracy were found to be directly related to the concentration of the analyte and essentially independent of the sample matrix.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW846 Methods (1986)]**PEER REVIEWED**

EPA Method 607. Gas Chromatography with nitrogen/phosphorus detector for the analysis of nitrosamines including N-**nitrosodimethylamine** municipal and industrial discharges. Under the prescribed conditions, for N-**nitrosodimethylamine** method has a detection limit of 0.15 ug/l. Precision and method accuracy were found to be directly related to the concentration of the parameter and essentially independent of the sample matrix.
[40 CFR 136 97/1/90)]**PEER REVIEWED**

EPA Method 1625. Isotope Dilution Capillary Column Gas Chromatography/Mass Spectrometry for the determination of semivolatile organic compounds in municipal and industrial discharges. By adding a known amount of an isotopically labeled compound to every sample prior to purging, a correction of recovery of the pollutant can be made. If isotopically labeled compounds are not available, an internal standard method is used. Under the prescribed conditions for both the isotopically labeled and unlabeled N-nitrosodimetylamine, the method has a minimum detection level of 50 ug/l.
[40 CFR 136, App. A (7/1/91)]**PEER REVIEWED**

EPA Method 8270. Capillary Column Gas Chromatography/Mass Spectrophotometry. This method is used for the determination of semivolatile organic compounds in extracts prepared from all types of solid waste matrices, soils, and groundwater. This method is applicable to quantify most acidic, basic, and neutral organic compounds that are soluble in methylene chloride and are capable of being eluted without derivatization as sharp peaks from a capillary column (DB-5 or equivalent). The Practical Quantitation Limit for N-**nitrosodimethylamine** is not given in ground water and in low soil/sediment. The precision and a method accuracy were found to be directly related to the concentration of the analyte and essentially independent of the sample matrix.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW846 Methods (1986)]**PEER REVIEWED**

EPA Method 625. Gas Chromatography/Mass Spectrometry for the analysis of base/neutral extractables including N-**nitrosodimethylamine** in municipal and industrial discharges. Under the prescribed conditions for N-nitrosodimethylame the method detection limit is not determined. Precision and method accuracy were found to be directly related to the concentration of the parameter and essentially independent of the sample matrix. Interferences: PCBs.
[USEPA/OST; List of Lists: A Catalog of Analytes and Methods p.164 (1991) OST Pub 21W-4005]**PEER REVIEWED**

Method MTO-7. Gas chromatography/mass spectrometry method for the determination of N-**nitrosodimethylamine** in ambient air using a carbowax 20M capillary column. N-**nitrosodimethylamine** is quantified from m/e 74 molecular ion using an external standard calibration method. Under the prescribed conditions, N-**nitrosodimethylamine** has a detection limit of 1.0 ug/l as defined by USEPA Atmospheric Research & Exposure Laboratory.
[USEPA/SCC; Environmental Monitoring Methods Index p.164 (1992)]**PEER REVIEWED**

Method 8070. Gas chromatography with nitrogen-phosphorus detector or thermal energy analyzer and the reductive hall detector for the determination of nitrosamines. A measured volume of 1 liter aqueous

sample is solvent extracted with methylene chloride using a separately funnel. The sample is washed with dilute hydrochloric acid, dried, and concentrated to 10 ml or less. Under the prescribed conditions, N-**nitrosodimethylamine** has a detection limit of 0.15 ug/l.
[USEPA/SCC; Environmental Monitoring Methods Index p.164 (1992)]**PEER REVIEWED**

Method O-3118. Gas chromatography with a flame ionization detector or mass spectrometric analysis for the determination of extractable organic base/neutral compounds in water or water-suspended-sediment mixtures with methylene chloride. Under the prescribed conditions, N-**nitrosodimethylamine** has an estimated detection limit of 5.0 ug/l as used by US Geological Survey Methods.
[USEPA/SCC; Environmental Monitoring Methods Index p.164 (1992)]**PEER REVIEWED**

EPA Method 3540. Soxhlet Extraction. A solid sample is mixed with anhydrous sodium sulfate and extracted using an appropriate solvent in a Soxhlet extractor. The sample is then dried and concentrated using a Kuderna-Danish apparatus. This is a procedure for extracting nonvolatile and semivolatile organic compounds from solids such as soils, sludges, and waste.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW846 Methods (1986)]**PEER REVIEWED**

EPA Method 3550. Sonication Extraction. A 2- to 3-g solid sample is mixed with anhydrous sodium sulfate to form a free-flowing powder, then solvent extracted using a horn-type sonicator, followed by vacuum filtration or centrifugation for organic components of equal or less than 20 mg/kg. This method is applicable to the extraction of nonvolatile and semivolatile organic compounds from solids such as soils, sludges, and waste. Interferences include chlorofluorocarbons and methylene chloride.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW846 Methods (1986)]**PEER REVIEWED**

NIOSH Method: 2522. Analyte: N-**nitrosodimethylamine**. Matrix: Air. Procedure: Gas chromatography, thermal energy analyzer. For N-**nitrosodimethylamine** this method has an estimated detection limit of 0.05 ug/sample. The precision/RSD is 0.014 @ 0.05 to 0.4 ug/sample and the recovery is not determined. Applicability: The working range is 0.003 to 10 mg/cu m for a 50 liter air sample. Interferences: When the thermal energy analyzer (TEA) is operated in the nitrosamine mode, it is highly specific, for N-nitroso compounds. There is little or no interference from other cmpds.
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. 2522-1]**PEER REVIEWED**

Rapid gas chromatographic method using nitrogen-phosphorus detection for detection of N-**nitrosodimethylamine** in 2,4-D and MCPA herbicide formulations.
[Scharfe RR, McLenaghan CC; J Assoc Off Anal Chem 72 (3): 508-12 (1989)]**PEER REVIEWED**

Separation and assay of N-nitroso compounds by high-performance liquid chromatography and assay of N-nitroso compounds by high-performance liquid chromatography with chemiluminescence detection.
[Pinche C et al; J Chromatogr 463 (1): 201-6 (1989)]**PEER REVIEWED**

Determination of N-nitroso compounds by high-performance liquid chromatography with postcolumn reaction and a thermal energy analyzer. /N-Nitroso cmpd/
[Havery DC; J Anal Toxicol 14 (3): 181-5 (1990)]**PEER REVIEWED**

Rapid and simple method for isolation and gas chromatographic determination of N-**nitrosodimethylamine** in dimethyldithiocarbamate formulations.
[Wigfield YY, McLenaghan CC; J Assoc Off Anal Chem 72 (4): 663-6 (1989)]**PEER

REVIEWED**

Sampling Procedures:

The ThermoSorb/N air sampling cartridge containing a mixture of magnesium silicate & an amine-trapping agent effectively collects airborne nitrosamines without in-situ artifact formation.
[Rounbehler DP et al; ASTM Spec Tech Publ 721 (Sampling Anal Toxic Org Atmos): 80-91 (1980)]**PEER REVIEWED**

NIOSH Method 2522. Analyte: N-**Nitrosodimethylamine**. Matrix: Air. Sampler: Solid sorbent tube (Thermosorb/N air sample). Flow Rate: 0.2 to 2 l/min. Sample Size: 50 liters. Shipment: Routine. Sample Stability: At least 6 weeks @ 20 deg C.
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. 2522-1]**PEER REVIEWED**

Special References:

Special Reports:

TSCA CHIPs present a preliminary assessment of N-**nitrosodimethylamine**'s potential for injury to human health & the environment (available at EPA's TSCA Assistance Office: (202) 554-1404

Eisenbrand G et al; Some recent results on the Chemistry, Formation and Biological Activity of N-nitroso Compounds. Gann Monograph 133-143: (1975)

Longnecker DS; Carcinogenesis in the Pancreas. Archives of Pathology and Lab Medicine 107 (2): 54-8 (1983)

USEPA; Ambient Water Quality Criteria Doc: Nitrosamines (1980) EPA-440/5-80-064

WHO; Environ Health Criteria 5: Nitrates, Nitrites, and N-Nitroso Compounds (1978)

USEPA; Environmental Assessment of Atmospheric Nitrosamines, MTR-7512, Contract No 68-02-1495 (1976)

DHHS/ATSDR; Toxicological Profile for N-**Nitrosodimethylamine** (1989) ATSDR/TP-89/17

Haggert HG, Holsapple MP; Role of Metabolism in **Dimethylnitrosamine** Induced Immunosuppresion: A review. Toxicology 63 (1): 1-23 (1990). This review discussed the metabolism of **dimethylnitrosamine** to an intermediate capable of suppressing the humoral immune response which may be qualitatively and/or quantitatively different from that which mediates hepatotoxicity and genotoxicity.

Castergnaro M et al; International Agency for Research on Cancer: 73 (1982). Details are presented of 5 methods for the laboratory degradation of N-**nitrosodimethylamine**, N-nitrosodiethylamine, N-nitrosodipropylamine, N-nitrosodibutylamine, N-nitrosopiperidine, N-nitrosopyrrolidine, N-nitrosomorpholine, and N,N'-dinitrosopiperazine, prior to disposal of otherwise carcinogenic waste.

U.S. Department of Health & Human Services/National Toxicology Program; Tenth Report on

Carcinogens. National Institutes of Environmental Health Sciences. The Report on Carcinogens is an informational scientific and public health document that identifies and discusses substances (including agents, mixtures, or exposure circumstances) that may pose a carcinogenic hazard to human health. N-**Nitrosodimethylamine** (62-75-9) was first listed in the Second Annual Report on Carcinogens (1981) as reasonably anticipated to be a human carcinogen.
[ ]

Synonyms and Identifiers:

Synonyms:

DIMETHYLAMINE, N-NITROSO-
PEER REVIEWED

DIMETHYLNITROSAMINE
PEER REVIEWED

N-Dimethyl-nitrosamine
PEER REVIEWED

N,N-**DIMETHYLNITROSAMINE**
PEER REVIEWED

DIMETHYLNITROSAMIN (GERMAN)
PEER REVIEWED

DIMETHYLNITROSOAMINE
PEER REVIEWED

DMN
PEER REVIEWED

DMNA
PEER REVIEWED

METHANAMINE, N-METHYL-N-NITROSO-
PEER REVIEWED

N-METHYL-N-NITROSOMETHANAMINE
PEER REVIEWED

NDMA
PEER REVIEWED

NITROSODIMETHYLAMINE
PEER REVIEWED

N-NITROSO-N,N-DIMETHYLAMINE
PEER REVIEWED

Nitrous Dimethylamide
PEER REVIEWED

EPA Hazardous Waste Number:

P082; An acute hazardous waste when a discarded commercial chemical product or manufacturing

chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate.

Administrative Information:

Hazardous Substances Databank Number: 1667

Last Revision Date: 20030829

Last Review Date: Reviewed by SRP on 1/31/1998

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Complete Update on 03/29/1999, 2 fields added/edited/deleted.
Field Update on 03/22/1999, 1 field added/edited/deleted.
Complete Update on 11/12/1998, 1 field added/edited/deleted.
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Field Update on 06/02/1998, 1 field added/edited/deleted.
Field Update on 02/27/1998, 1 field added/edited/deleted.
Field Update on 08/12/1997, 5 fields added/edited/deleted.
Field Update on 05/08/1997, 1 field added/edited/deleted.
Field Update on 05/01/1997, 2 fields added/edited/deleted.
Complete Update on 10/13/1996, 1 field added/edited/deleted.
Complete Update on 07/11/1996, 1 field added/edited/deleted.
Complete Update on 06/06/1996, 2 fields added/edited/deleted.
Complete Update on 05/10/1996, 1 field added/edited/deleted.
Complete Update on 04/09/1996, 10 fields added/edited/deleted.
Field Update on 01/21/1996, 1 field added/edited/deleted.
Complete Update on 01/24/1995, 1 field added/edited/deleted.
Complete Update on 12/28/1994, 1 field added/edited/deleted.
Complete Update on 11/04/1994, 1 field added/edited/deleted.

Complete Update on 09/26/1994, 1 field added/edited/deleted.
Complete Update on 08/02/1994, 1 field added/edited/deleted.
Complete Update on 05/05/1994, 1 field added/edited/deleted.
Complete Update on 03/25/1994, 1 field added/edited/deleted.
Complete Update on 12/17/1993, 69 fields added/edited/deleted.
Field Update on 05/28/1993, 1 field added/edited/deleted.
Field update on 12/21/1992, 1 field added/edited/deleted.
Field Update on 04/16/1992, 1 field added/edited/deleted.
Field Update on 04/01/1992, 1 field added/edited/deleted.
Field Update on 01/13/1992, 1 field added/edited/deleted.
Complete Update on 07/08/1991, 2 fields added/edited/deleted.
Complete Update on 10/23/1990, 6 fields added/edited/deleted.
Field Update on 08/23/1990, 1 field added/edited/deleted.
Field Update on 05/14/1990, 1 field added/edited/deleted.
Field Update on 01/15/1990, 1 field added/edited/deleted.
Complete Update on 01/11/1990, 4 fields added/edited/deleted.
Field Update on 05/05/1989, 1 field added/edited/deleted.
Field Update on 03/01/1989, 1 field added/edited/deleted.
Complete Update on 12/09/1988, 2 fields added/edited/deleted.
Complete Update on 09/21/1988, 86 fields added/edited/deleted.
Complete Update on 02/23/1985
Created 19830315 by GCF

Record Length: 163138.0

N-Nitrosodimethylamine

CASRN: 62-75-9
For other data, click on the Table of Contents

Status:

STATUS OF DATA FOR N-**Nitrosodimethylamine**

File First On-Line 01/31/1987

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	no data	
Inhalation RfC Assessment (I.B.)	no data	09/01/1992
Carcinogenicity Assessment (II.)	on-line	07/01/1993

Substance Identification:

Substance Name:

N-**Nitrosodimethylamine**

CAS Registry Number: 62-75-9

I. Chronic Health Hazard Assessment for Noncarcinogenic Effects:

I.A. Reference Dose for Chronic Oral Exposure (RfD):

Substance Name -- N-**Nitrosodimethylamine**
CASRN -- 62-75-9
Primary Synonym -- **Dimethylnitrosamine**

Not available at this time.

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC):

Substance Name -- N-**Nitrosodimethylamine**
CASRN -- 62-75-9
Primary Synonym -- **Dimethylnitrosamine**

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure:

Substance Name -- N-**Nitrosodimethylamine**
CASRN -- 62-75-9

Primary Synonym -- **Dimethylnitrosamine**
Last Revised -- 07/01/1993

Section II provides information on three aspects of the carcinogenic assessment for the substance in question; the weight-of-evidence judgment of the likelihood that the substance is a human carcinogen, and quantitative estimates of risk from oral exposure and from inhalation exposure. The quantitative risk estimates are presented in three ways. The slope factor is the result of application of a low-dose extrapolation procedure and is presented as the risk per (mg/kg)/day. The unit risk is the quantitative estimate in terms of either risk per ug/L drinking water or risk per ug/cu.m air breathed. The third form in which risk is presented is a drinking water or air concentration providing cancer risks of 1 in 10,000, 1 in 100,000 or 1 in 1,000,000. The rationale and methods used to develop the carcinogenicity information in IRIS are described in The Risk Assessment Guidelines of 1986 (EPA/600/8-87/045) and in the IRIS Background Document. IRIS summaries developed since the publication of EPA's more recent Proposed Guidelines for Carcinogen Risk Assessment also utilize those Guidelines where indicated (Federal Register 61(79):17960-18011, April 23, 1996). Users are referred to Section I of this IRIS file for information on long-term toxic effects other than carcinogenicity.

II.A. Evidence for Human Carcinogenicity:

II.A.1. Weight-of-Evidence Characterization:

Classification -- B2; probable human carcinogen

Basis -- Induction of tumors at multiple sites in both rodents and nonrodent mammals exposed by various routes

II.A.2. Human Carcinogenicity Data:

Human exposure to nitrosamines results from contact with mixtures containing these compounds (e.g., cutting oils, tobacco products). Because of potential confounding by the other substances in these mixtures, data from human exposure is of limited use in the evaluation of carcinogenicity of individual nitrosamines.

II.A.3. Animal Carcinogenicity Data:

There is a large data base on the carcinogenicity of nitrosamines, most of which pertains to structure-activity relationships rather than to dose- response. N-**Nitrosodimethylamine** produced liver tumors in BD rats when administered in drinking water (Druckrey et al., 1967) and in female Porton rats when administered in the diet (Terracini et al., 1967). Magee et al. (1976) state that **dimethylnitrosamine** produced many hemangiomatous tumors and some parenchymal cell tumors in the livers of rats after oral administration.

N-**Nitrosodimethylamine** acts as a transplacental carcinogen when administered to pregnant rats, mice, and Syrian golden hamsters by several routes (Tomatis, 1973). Increases in lung, liver, and kidney tumors were observed in both Wistar rats and Balb/C mice exposed by inhalation. Mink are very

sensitive to the effects of **dimethylnitrosamine**, developing tumors when fed 0.05 mg/kg 2 days/week (NAS, 1978).

Peto et al. (1984) exposed groups of Colworth rats (36/sex/dose) to 15 concentrations of N-**nitrosodimethylamine** in drinking water (0.033-16.896 ppm). Daily water consumption was 41 mL/kg for males and 72 mL/kg for females. Tumors were generally of hepatic origin, and these tumors constituted the only cause of mortality considered treatment-related. Tumor incidences for each treatment group were not reported, but pooled data indicated possible positive trends for lung, skin, seminal vesicle, lymphatic/hematopoetic system, and liver tumors.

II.A.4. Supporting Data for Carcinogenicity:

N-**Nitrosodimethylamine** is mutagenic for Escherichia coli, Salmonella typhimurium and Neurospora crassa, produces mitotic recombination in Sacharoyus cerevesiae, recessive lethal mutations in Drosophilla melanogaster, and chromosomal aberrations in mammalian cells. Positive responses in bacterial cells are dependent upon the addition of a mammalian metabolism system (Montesano and Bartsch, 1976). **Dimethylnitrosamine** is structurally related to known carcinogens.

II.B. Quantitative Estimate of Carcinogenic Risk from Oral Exposure:

II.B.1. Summary of Risk Estimates:

Oral Slope Factor -- 5.1E+1 per (mg/kg)/day

Drinking Water Unit Risk -- 1.4E-3 per (ug/L)

Extrapolation Method -- Weibull, extra risk

Drinking Water Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	7E-2 ug/L
E-5 (1 in 100,000)	7E-3 ug/L
E-6 (1 in 1,000,000)	7E-4 ug/L

II.B.2. Dose-Response Data (Carcinogenicity, Oral Exposure):

Tumor Type -- liver
Test Animals -- rat/Colworth, female
Route -- drinking water
Reference -- Peto et al., 1984

Specific tumor incidences were not published. Data from Peto et al. (1984) on incidence of liver tumors of all types in female rats were shown to follow this relationship:

CI = 51.45 (d + 0.1) **6 x t**7

where: CI =cumulative incidence
d =dose (mg/kg/day)
t = time in years

Using procedures described in U.S. EPA (1980) to correct for background response, the increased risk of 1 ug/kg/day for 3 years = 7.8E-3 or a slope factor for rats of 7.8 per (mg/kg)/day. The slope factor was thus calculated to be 51 per (mg/kg)/day by using the cube root of the ratio of the assumed human body weight (70 kg) to the reported rat body weight of (250 g).

II.B.3. Additional Comments (Carcinogenicity, Oral Exposure):

The unit risk should not be used if the water concentration exceeds 7 ug/L, since above this concentration the unit risk may not be appropriate.

II.B.4. Discussion of Confidence (Carcinogenicity, Oral Exposure):

Although specific tumor incidence data was not reported, it appears that large numbers of animals were treated over a wide dose range. Both tumor incidence and latency were shown to be dose-dependent. The study was designed specifically for analysis using the Weibull model. A slope factor based on data by Druckrey et al. (1972) was determined by use of a one-hit model to be 26 per (mg/kg)/day.

II.C. Quantitative Estimate of Carcinogenic Risk from Inhalation Exposure:

II.C.1. Summary of Risk Estimates:

Inhalation Unit Risk -- 1.4E-2 per (ug/cu.m)

Extrapolation Method -- Weibull, extra risk

Air Concentrations at Specified Risk Levels:

Risk Level	Concentration
E-4 (1 in 10,000)	7E-3 ug/cu.m
E-5 (1 in 100,000)	7E-4 ug/cu.m
E-6 (1 in 1,000,000)	7E-5 ug/cu.m

II.C.2. Dose-Response Data for Carcinogenicity, Inhalation:

Calculated from data in Section II.B.2.

II.C.3. Additional Comments (Carcinogenicity, Inhalation Exposure):

The above unit risk should not be used if the air concentration exceeds 0.7 ug/cu.m, since above this concentration the unit risk may not be appropriate.

II.C.4. Discussion of Confidence (Carcinogenicity, Inhalation Exposure):

See II.B.4.

II.D. EPA Documentation, Review, and Contacts (Carcinogenicity Assessment):

II.D.1. EPA Documentation:

Source Document -- U.S. EPA, 1980, 1986

The values in the Health and Environmental Effects Profile for Nitrosamines (U.S. EPA, 1986) received Agency review.

II.D.2. EPA Review (Carcinogenicity Assessment):

Agency Work Group Review -- 06/26/1986, 08/13/1986, 10/29/1986

Verification Date -- 10/29/1986

Screening-Level Literature Review Findings -- A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the cancer assessment for N-**Nitrosodimethylamine** conducted in September 2002 identified one or more significant new studies. IRIS users may request the references for those studies from the IRIS Hotline at hotline.iris@epa.gov or 301-345-2870.

II.D.3. EPA Contacts (Carcinogenicity Assessment):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

VI. Bibliography:

VI.A. Oral RfD References:

None

VI.B. Inhalation RfC References:

None

VI.C. Carcinogenicity Assessment References:

Druckrey, H., R. Preussmann, S. Ivankovic and D. Schmaehl. 1967. Organotropism and c carcinogenic effects of 65 different N-nitroso compounds in BD-rats. Z. Kerbsforsch. 69(2): 103-201.

Druckrey, H., S. Ivankovic, R. Preussmann, K.J. Zulch and H.D. Mennel. 1972. Selective induction of malignant tumors of the nervous system by resorptive carcinogens. In: Experimental Biology of Brain Tumors. p. 85-112.

Magee, P.N., R. Montesano and R. Preussmann. 1976. N-nitroso compounds and related carcinogens. ACS Monograph. 173: 491-625.

Montesano, R. and H. Bartsch. 1976. Mutagenic and carcinogenic N-nitroso compounds: Possible environmental Hazards. Mutat. Res. 32: 179-228.

NAS (National Academy of Sciences). 1978. Nitrates: An environmental assessment. A report prepared by the panel on nitrates of the Coordinating Comm. Sci. Tech. Assess. Environ. Pollut., Washington, DC.

Peto, R., R. Gray, P. Brantom and P. Grasso. 1984. Nitrosamine carcinogenesis in 5120 rodents: Chronic administration of sixteen different concentrations of NDEA, NDMA, NPYR and NPIP in the water of 4440 inbred rats, with parallel studies on NDEA alone of the effect of age of starting (3, 6 or 20 weeks) and of species (rats, mice, hamsters). IARC Sci. Publ. 57: 627-665.

Terracini, B., P.N. Magee and J.M. Barnes. 1967. Hepatic pathology in rats on low dietary levels of **dimethylnitrosamine**. Br. J. Cancer. 21: 559-565.

Tomatis, L. 1973. Transplacental carcinogenesis. In: Modern Trends in Oncology. Part I, R.W. Raven, Ed. Butterworths, London.

U.S. EPA 1980. Ambient Water Quality Criteria for Nitrosamines. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Water Regulations and Standards, Washington, DC. EPA 440/5-80-064. NTIS PB 81-117756.

U.S. EPA. 1986. Health and Environmental Effects Profile for Nitrosamines. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Solid Waste and Emergency Response, Washington, DC.

VII. Revision History:

Substance Name -- N-**Nitrosodimethylamine**

CASRN -- 62-75-9
Primary Synonym -- **Dimethylnitrosamine**

Date	Section	Description
03/31/1987	IV.	RQ added
09/30/1987	IV.	Regulatory Action section on-line
03/01/1988	II.A.1.	Text clarified
03/01/1988	II.B.1.	Number rounded off
03/01/1988	II.B.3.	Text revised
03/01/1988	II.B.4.	Confidence statement revised
03/01/1988	II.C.1.	Number rounded off
03/01/1988	II.C.4.	Confidence statement revised
03/01/1988	II.D.3.	Secondary contact changed
02/01/1990	VI.	Bibliography on-line
03/01/1990	VI.C.	Druckrey & Peto references clarified
01/01/1991	II.	Text edited
01/01/1991	II.C.1.	Inhalation slope factor removed (global change)
01/01/1992	IV.	Regulatory actions updated
09/01/1992	I.B.	Inhalation RfC now under review
07/01/1993	II.D.3.	Secondary contact's phone number changed
08/01/1995	I.B.	EPA's RfD/RfC and CRAVE workgroups were discontinued in May, 1995. Chemical substance reviews that were not completed by September 1995 were taken out of IRIS review. The IRIS Pilot Program replaced the workgroup functions beginning in September, 1995.
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
12/03/2002	II.D.2.	Screening-Level Literature Review Findings message has been added.

NICKEL COMPOUNDS

CASRN: NO CAS RN

This record contains general information for nickel ions and compounds, including statements in the literature referenced to nickel compounds, nickel salts, etc. For compound-specific information, refer to the appropriate individual records as listed in the RELATED HSDB RECORDS field; for information on the metal itself, refer to the NICKEL, ELEMENTAL record.

For other data, click on the Table of Contents

Human Health Effects:

Toxicity Summary:

Nickel can be absorbed in human beings and animals via inhalation or ingestion, or percutaneously. Respiratory absorption with secondary gastrointestinal absorption of **nickel** (insoluble and soluble) is the major route of entry during occupational exposure. A significant quantity of inhaled material is swallowed following mucociliary clearance from the respiratory tract. ... Percutaneous absorption is negligible, quantitatively, but is important in the pathogenesis of contact hypersensitivity. Absorption is related to the solubility of the compound, following the general relationships **nickel** carbonyl> soluble **nickel** compounds > insoluble **nickel** compounds. ... **Nickel** is transported in the blood, principally bound to albumin. Gastrointestinal absorption of **nickel** is variable and depends on the composition of the diet. ... All body secretions are potential routes of excretion including urine, bile, sweat, tears, milk, and mucociliary fluid. Non-absorbed **nickel** is eliminated in the feces. ... Following parenteral administration of **nickel** salts, the highest **nickel** accumulation occurs in the kidney, endocrine glands, lung and liver: high concentrations are also observed in the brain following administration of **nickel** carbonyl. ... **Nickel** is essential for the catalytic activity of some plant and bacterial enzymes. Slow weight gain, anemia, and decreased viability of offspring have been described in some animal species after dietary deprivation of **nickel**. The most acutely toxic **nickel** compound is **nickel** carbonyl, the lung being the target organ; pulmonary edema may occur within 4 hr following exposure. ... contact allergy to **nickel** is very common in human beings ... Metallic **nickel** and a very large number of **nickel** compounds have been tested for carcinogenicity by parenteral routes of administration; with few exceptions, they caused local tumors. Only **nickel** subsulfide has been shown convincingly to cause cancer after inhalation exposure. ... In terms of human health, **nickel** carbonyl is the most acutely toxic **nickel** compound. ... Cases of **nickel** poisoning have also been reported in patients dialysed with **nickel**-contaminated dialysate and in electroplaters who accidently ingested water contaminated with **nickel** sulfate and **nickel** chloride. Chronic effects such as rhinitis, sinusitis, nasal septal perforations and asthma have been reported in **nickel** refinery and **nickel** plating workers. ... **Nickel** contact hypersensitivity has been documented extensively in both the general population and in a number of occupations in which workers were exposed to soluble **nickel** compounds. ... Nephrotoxic effects, such as renal edema with hyperemia and parenchymatous degeneration, have been reported in cases of accidental industrial exposure to **nickel** carbonyl. Transient nephrotoxic effects have been recorded after accidental ingestion of **nickel** salts. Very high risks of lung and nasal cancer have been reported in **nickel** refinery workers employed in the high-temperature roasting of sulfide ores, involving substantial exposure to **nickel** subsulfide, oxide and, perhaps, sulfate.

[Environmental Health Criteria 108: Nickel. pp. 17-22 (1991) by the International Programme on Chemical Safety (IPCS) under the joint sponsorship of the United Nations Environment Programme, the International Labour Organisation and the World Health Organization.]**PEER REVIEWED**

Evidence for Carcinogenicity:

Evaluation: There is sufficient evidence in humans for the carcinogenicity of **nickel** sulfate, and of the combinations of **nickel** sulfides and oxides encountered in the **nickel** refining industry. There is inadequate evidence in humans for the carcinogenicity of metallic **nickel** and **nickel** alloys. There is sufficient evidence in experimental animals for the carcinogenicity of metallic **nickel**, **nickel** monoxides, **nickel** hydroxides and crystalline **nickel** sulfides. There is limited evidence in experimental animals for the carcinogenicity of **nickel** alloys, nickelocene, **nickel** carbonyl, **nickel** salts, **nickel** arsenides, **nickel** antimonide, **nickel** selenides and **nickel** telluride. There is inadequate evidence in experimental animals for the carcinogenicity of **nickel** trioxide, amorphous **nickel** sulfide and **nickel** titanate. The Working Group made the overall evaluation on **nickel** compounds as a group on the basis of the combined results of epidemiological studies, carcinogenicity studies in experimental animals, and several types of other relevant data, supported by the underlying concept that **nickel** compounds can generate **nickel** ions at critical sites in their target cells. Overall evaluation: **Nickel** compounds are carcinogenic to humans (Group 1). Metallic **nickel** is possibly carcinogenic to humans (Group 2B).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V49 410 (1990)]**PEER REVIEWED**

A1. A1= Confirmed human carcinogen. /**Nickel**, insoluble compounds, as Ni/
[American Conference of Governmental Industrial Hygienists. Guide to Occupational Exposure Values - 1999. Cincinnati, OH: 1999. 51]**PEER REVIEWED**

Human Toxicity Excerpts:

... **Nickel** ... has been known to cause both irritation and bronchial asthma. /**Nickel**/
[Chang, L.W. (ed.). Toxicology of Metals. Boca Raton, FL: Lewis Publishers, 1996 461]**PEER REVIEWED**

Nickel and its salts are among the commonest causes of metal allergic contact dermatitis and ... the most common of all causes of human skin sensitization. /**Nickel**/
[Chang, L.W. (ed.). Toxicology of Metals. Boca Raton, FL: Lewis Publishers, 1996 827]**PEER REVIEWED**

... immunoallergological studies on some ... revealed humoral and cell-mediated immunity to ... **nickel**. /**Nickel**/
[Chang, L.W. (ed.). Toxicology of Metals. Boca Raton, FL: Lewis Publishers, 1996 452]**PEER REVIEWED**

EXPOSURE TO INDUSTRIAL **NICKEL** DUST CAUSES **NICKEL** DERMATITIS. SENSITIVITY TO **NICKEL** MAY BE EXHIBITED FROM SKIN CONTACT ... DIVALENT **NICKEL** IONS CAN PENETRATE SKIN AT SWEAT-DUCT & HAIR FOLLICLE OSTIA, & BIND WITH KERATIN. CONTACT DERMATITIS THUS RESULTS FROM PERMEABILITY OF ... DERMIS & EPIDERMIS TO **NICKEL**. /**NICKEL** DUST & SALTS/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 292]**PEER REVIEWED**

"**NICKEL** ITCH", WHICH IS VARIABLE IN NATURE, USUALLY BEGINS WITH SENSATION OF BURNING & ITCHING IN HAND, FOLLOWED BY ERYTHEMA & NODULAR ERUPTION ON WEB OF FINGERS, WRISTS & FOREARMS. NODULES MAY BECOME PUSTULES OR MAY ULCERATE. /**NICKEL** SALTS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1829]**PEER REVIEWED**

PARTLY BECAUSE OF LOCAL ASTRINGENT & IRRITANT ACTIONS, **NICKEL** SALTS ACT

AS EMETICS WHEN SWALLOWED (BUT ALSO BY OTHER ROUTES). AS WITH OTHER IRRITANT- EMETICS, THE ORAL LETHAL DOSE IS PRESUMED TO VARY WIDELY. ABSORPTION FROM BOWEL IS POOR & SYSTEMIC POISONING IS RARE. SYSTEMIC EFFECTS INCL CAPILLARY DAMAGE (ESPECIALLY IN BRAIN & ADRENALS), RENAL INJURY, MYOCARDIAL WEAKNESS, & CENTRAL NERVOUS DEPRESSION. /**NICKEL** SALTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-145]**PEER REVIEWED**

A **nickel** plated water heater in a dialysis unit was believed to be responsible for contaminating dialysis fluid, which resulted in mild signs of intoxication in 23 pt. At plasma **nickel** levels of 3 mg/l, nausea, vomiting, weakness, headache and palpitations occurred; they regressed over 3 to 13 hr. /**Nickel** salts/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-145]**PEER REVIEWED**

An incr incidence of lung and nasal cavity cancers has been noted among workmen in **nickel** smelters and refineries. /**Nickel** dust and compounds/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-145]**PEER REVIEWED**

It has been estimated that 5% of all eczema can be linked to contact with **nickel** containing cmpd. /**Nickel** & **nickel** compounds/
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 266]**PEER REVIEWED**

... Incr in lung cancer among **nickel** workers has been reported from several different countries incl suggestions of incr risks to laryngeal cancer in **nickel** refinery workers in Norway and gastric carcinoma and soft tissue sarcoma from the Soviet Union. Six cases of renal cancer have been reported among Canadian and Norwegian workers employed in electrolytic refining of **nickel**. /The investigator/ ... has been able to detect early cytologic changes in sputum of exposed workers prior to chest X-ray or clinical indicators of resp tract cancers. /**Nickel** and **nickel** cmpd/
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 610]**PEER REVIEWED**

The organs which are affected by exposure to **nickel**, metal & sol cmpd (as Ni) are nasal cavities, lung, skin. /**Nickel**, metal & sol compounds (as Ni)/
[NIOSH. Pocket Guide to Chemical Hazards. 5th Printing/Revision. DHHS (NIOSH) Publ. No. 85-114. Washington, D.C.: U.S. Dept. of Health and Human Services, NIOSH/Supt. of Documents, GPO, Sept. 1985.173]**PEER REVIEWED**

IN **NICKEL** PLATING INDUSTRY, EXPOSURE TO **NICKEL**-CONTAINING VAPORS HAS BEEN REPORTED TO BE ASSOC WITH ASTHMA. SYMPTOMS WERE ATTRIBUTED TO HYPERSENSITIVITY TO **NICKEL** OF NON-OCCUPATIONAL ORIGIN. PNEUMOCONIOSIS HAS BEEN REPORTED AMONG WORKERS EXPOSED TO **NICKEL** DUST ... EFFECTS ON NASAL MEMBRANE WERE NOTED IN WORKERS EXPOSED TO **NICKEL** AEROSOLS IN AN ELECTROLYSIS SHOP. /**NICKEL** VAPORS & DUST/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 473]**PEER REVIEWED**

WORKERS EMPLOYED IN **NICKEL** PLATING HAVE DEVELOPED CONJUNCTIVITIS & EPIPHORA WHEN VENTILATION WAS POOR. /**NICKEL** PLATING CMPD/
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 661]**PEER REVIEWED**

The avg latency period for the induction of ... /lung and nasal passage/ cancers appears to be about 25 yr (range 4 to 51 yr). /**Nickel** and sol cmpd/
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 640]**PEER REVIEWED**

NICKEL AS INDUSTRIAL INHALANT WAS FIRST SUSPECTED AS CARCINOGEN IN BRONCHI IN 1933, ESTABLISHED BOTH EPIDEMIOLOGICALLY & EXPERIMENTALLY; FIRST AS CARCINOGEN IN NASAL CAVITY IN 1933, ESTABLISHED EPIDEMIOLOGICALLY BUT NEGATIVE RESULTS EXPERIMENTALLY. /FROM TABLE, **NICKEL**/
[Searle, C. E. (ed.). Chemical Carcinogens. ACS Monograph 173. Washington, DC: American Chemical Society, 1976. 327]**PEER REVIEWED**

THE TOXICITY /TO HUMANS/ OF **NICKEL** OR **NICKEL** SALTS THROUGH ORAL INTAKE IS LOW ... **NICKEL** SALTS EXERT THEIR ACTION MAINLY BY GASTROINTESTINAL IRRITATION. /**NICKEL** OR **NICKEL** SALTS/
[National Research Council. Drinking Water and Health. Volume 3. Washington, DC: National Academy Press, 1980. 348]**PEER REVIEWED**

LOW ABSORPTION FROM GI TRACT CAUSES **NICKEL** CMPD TO BE ESSENTIALLY NONTOXIC AFTER INGESTION. AFTER INHALATION CERTAIN **NICKEL** CMPD ARE EXTREMELY POTENT CARCINOGENS.
[LEONARD A ET AL; MUTAT RES 87 (1): 1 (1981)]**PEER REVIEWED**

Based on data concerning the death of a patient given human serum albumin which was suspected of being contaminated with **nickel**, it is recommended that the maximum permissible level of Ni be 5 ug/l for common iv solutions containing albumins or amino acids. Also, it is recommended that the maximum permissible amount of Ni administered to infants, children, and adults as a contaminant in iv fluids should not exceed 0.5 ug/kg/day. /Soluble **nickel** cmpd/
[Sunderman FW Jr; Ann Clin Lab Sci 13 (1): 1-4 (1983)]**PEER REVIEWED**

In a cross-sectional study, 38 production workers exposed to **nickel** (Ni) and 35 exposed to cobalt (Co) were examined for the content of Ni and cobalt in hair, serum concentration levels of immunoglobulins, and serum proteins. Age matched healthy males without exposure to Ni or cobalt were selected as controls. No information was provided on dose or duration of exposure. The respective geometric mean values of Ni and cobalt in the hair of Ni exposed workers were 216.75 and 3.31 ug/g and in cobalt exposed workers were 34.5 and 96.8 ug/g, respectively. these values were significantly higher than respective control values (Ni: 3.31 ug/g, cobalt: 0.38 ug/g). Tests for serum immunoglobulins revealed that **nickel** workers differed from controls by exhibiting significantly elevated IgG ($p<0.005$), IgA ($p<0.01$), and IgM ($p<0.005$) levels and that cobalt workers differed from controls by a significant elevation of IgA level ($p<0.05$). Both workers exposed to Ni or to cobalt exhibited a significant drop in IgE level ($0.001<p<0.05$). There was a significant elevation (p,0.001, $p<0.005$) in the concentration of the serum proteins, alpha-one-antitrypsin, alpha-two-macroglobulin, ceruloplasmin, and lysozyme, in exposed workers when compared to controls. /Soluble **nickel** cmpd/
[Bencko V et al; Environ Res 40: 399-410 (1986)]**PEER REVIEWED**

BLACK PATIENT READILY ACQUIRE ALLERGIC CONTACT DERMATITIS FROM **NICKEL**. SUCH DERMATITIS IS OFTEN COMPLICATED BY HYPERPIGMENTATION AND LICHENIFICATION UNLESS TREATED EARLY AND VIGOROUSLY WITH SYSTEMIC CORTICOSTEROIDS. /**NICKEL**/
[FISHER AA; CUTIS 20 (3): 303 (1977)]**PEER REVIEWED**

EPIDEMIOLOGICAL STUDIES CONCLUSIVELY DEMONSTRATE AN EXCESS RISK OF CANCER OF THE NASAL CAVITY & LUNG IN WORKERS IN **NICKEL** REFINERIES. IT IS

LIKELY THAT **NICKEL** IN SOME FORM(S) IS CARCINOGENIC TO MAN. /**NICKEL** AND **NICKEL** CMPD/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 104 (1976)]**PEER REVIEWED**

Nickel dermatitis, "**nickel** itch," consititutes the most common affliction among **nickel** platers. It has two components, a simple dermatitis localized to the area of contact and a chronic eczema or a neurodermatitis without apparent connection to such contact. /**Nickel** salts/
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 2159]**PEER REVIEWED**

Pregnancy complications, ... increased occurence of birth defects (primarily cardiovascular and musculoskeletal) have been reported ...
[Chang, L.W. (ed.). Toxicology of Metals. Boca Raton, FL: Lewis Publishers, 1996 994]**PEER REVIEWED**

Sensitization is only known to occur after dermal exposure to **nickel**, whereas provocation can take place after exposure of the skin and after ingestion of **nickel**. The clinical manifestations of **nickel** associated allergic contact dermatitis comprise both primary and secondary eruptions. The primary eruptions usually appear at the site of sensitization, and the secondary eruptions will frequently be more or less generalized, often symmetrical, maculopapular vesicules of the pompholyx type eczema, which affects the flexures of the elbows, the sides of the neck, the axillae, the eyelids, and the genital area. A vesicular hand eczema can also develop. /**Nickel**/
[WHO; Environ Health Criteria 108: Nickel p.263 (1991)]**PEER REVIEWED**

... Adverse health effects from occupational exposure to **nickel** have been reported. Increased risk of cancer of the lung ... /and/ Nasal sinus ... Increased risk of laryngeal ... /and/ gastric cancer ... Increased risk of sarcoma ... Chronic irritation of the upper respiratory tract ... Pulmonary irritation and ... fibrosis ... Pneumoconiosis ... Bronchial asthma ... Increased susceptibility of respiratory infections ... Allergic contact dermatitis ... Acute toxic effects from exposure to **nickel** carbonyl ... /Reported health effects from occupational exposure to **nickel** and **nickel** compounds/
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 563]**PEER REVIEWED**

Many are human carcinogens by inhalation. **Nickel** and many of its compounds are poisons and carcinogens. ... Ingestion of large doses ... of **nickel** compounds has been shown to cause intestinal disorders, convulsions, and asphyxia. ... The most common effect resulting from exposure to **nickel** compounds is the development of "**nickel** itch." /**Nickel** and cmpd/
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 2402]**PEER REVIEWED**

Allergic reaction as well as urticarial and eczematous dermatitis in **nickel**-sensitive persons can be produced by implanted prostheses and other surgical devices made from **nickel**-containing alloys ... **Nickel** sensitivity /was found/ in 11 out of 85 patients following hip prosthesis implantation. Three of the patients had had previous implants ... described 4 patients with a history of metal intolerance, who developed dermatitis following surgical wound closure with disposable skin clips (**nickel** content about 10%). Two positive reactions were reported ... in 85 patch-tested patients, who had undergone hip arthroplasty. /**Nickel**-containing alloys/
[WHO; Environ Health Criteria 108: Nickel p.263 (1991)]**PEER REVIEWED**

It has been estimated that 5% of all eczema can be linked to contact with **nickel** containing cmpd. /**Nickel**/

[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 266]**PEER REVIEWED**

Nickel-induced toxicity depends on the route of exposure and the solubility of the **nickel** compound. The major route of toxic **nickel** exposure is via pulmonary absorption. Gastrointestinal and dermal absorption of **nickel** compounds is significantly less important, although dermal exposure can lead to **nickel** sensitivity and contact sensitivity. ... Kidney and lung are the primary organs for the accumulation of **nickel**. Absorbed **nickel** can also be measured in the blood, where it is mostly protein bound.
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 808]**PEER REVIEWED**

Nickel has both embryotoxic and teratogenic effects in animals. It can directly affect the developing embryo or fetus and indirectly alters the maternal hormone balance by inducing hyperglycemia. Maternal exposure can result in decreased implantation frequency, increased early and late resorption and increased frequency of stillborn fetuses. Exposure to **nickel** during organogenesis can also result in a variety of teratogenic effects, such as exoencephaly, eye malformations, and skeletal abnormalities.
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 808]**PEER REVIEWED**

The chronic effects of exposures to Ni compounds primarily affect the immune system and the respiratory tract.
[Sullivan, J.B. Jr., G.R. Krieger (eds.). Hazardous Materials Toxicology-Clinical Principles of Environmental Health. Baltimore, MD: Williams and Wilkins, 1992. 870]**PEER REVIEWED**

50 patients with chronic fatigue syndrome and 73 controls were patch tested with 8 metal allergens. We found an overrepresentation of allergies among the chronic fatigue syndrome patients, which was not significant. However, allergy to **nickel** occurred in 36% of patients in the chronic fatigue syndrome group and in 19% of subjects in the control group ($p<0.05$). The high frequency of **nickel** allergy was more noteworthy in females in the chronic fatigue syndrome group than among female controls (52% and 24%, respectively, $p<0.05$).
[Marcusson JA et al; Contact Dermatitis 40 (5): 269-72 (1999)]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

EYE IRRITATION IN WORKERS EXPOSED TO AEROSOLS FROM **NICKEL** ELECTROLYSIS TANKS HAS BEEN REPORTED. /**NICKEL** AND COMPOUNDS/
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.422]**PEER REVIEWED**

Medical Surveillance:

... NIOSH RECOMMENDS THAT WORKERS EXPOSED TO **NICKEL** & INORG **NICKEL** COMPOUNDS SHOULD HAVE INITIAL MEDICAL EXAM, INCL (A) COMPREHENSIVE MEDICAL & WORK HISTORIES WITH EMPHASIS ON SKIN CONDITIONS, ALLERGIES, UPPER & LOWER RESP TRACT ILLNESSES, & SMOKING; (B) COMPLETE PHYS EXAM WITH PARTICULAR ATTENTION TO UPPER RESP TRACT & SKIN; (C) SPECIFIC CLINICAL TESTS SUCH AS CHEST X-RAY, PULMONARY FUNCTION TESTS, &, IF INDICATED, SPUTUM CYTOLOGY & URINE **NICKEL** ANALYSIS; & (D) JUDGEMENT OF EMPLOYEE'S ABILITY TO USE POS OR NEG PRESSURE RESPIRATORS ...(E) PERIODIC MEDICAL EXAM ... PERFORMED AT LEAST ANNUALLY, INCL SAME PHYS EXAM & CLINICAL TESTS; (F) EMPLOYEES WITH MED CONDITIONS SUCH AS DERMATITIS ... MUST BE COUNSELED ON

POTENTIAL HEALTH RISK; (G) APPROPRIATE MEDICAL SERVICES ... AVAIL TO EMPLOYEES SUFFERING ADVERSE HEALTH EFFECTS FROM ... EXPOSURE TO **NICKEL**; (I) MEDICAL RECORDS ... MAINTAINED FOR AT LEAST 40 YR AFTER LAST OCCUPATIONAL EXPOSURE TO **NICKEL**. /**NICKEL** AND **NICKEL** COMPOUNDS/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1439]**PEER REVIEWED**

Employment physical examinations should evaluate any history of skin allergies or asthma, other exposures to **nickel** or other suspect carcinogens, smoking history, and the respiratory tract. Lung function should be studied and chest x-rays periodically evaluated. Special attention should be given to the nasal sinuses and skin. Note also that measurement of urinary **nickel** levels for several days after acute exposures may be helpful. /**Nickel** and soluble compounds/
[Sittig M; Handbook of Toxic and Hazardous Chemicals p.482 (1981)]**PEER REVIEWED**

Complete Blood Count: **Nickel** has been shown to cause hematological changes, which can be assessed by performing a complete blood count. /**Nickel**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1786]**PEER REVIEWED**

The assessment of **nickel** exposure can be accomplished through measurement of **nickel**. ... Blood Reference Ranges: Normal - less than 2 ug/l; Exposed - not established; Toxic - not established. ... Serum or Plasma Reference Ranges: Normal - less than 4 ug/l; Exposed - levels of 3 to 11 ug/l have been seen in refinery workers without overt clinical effects; Toxic - not established. ... Urine Reference Ranges: Normal - average approx 2.0 ug/l; Exposed - **Nickel** (**nickel** metal, **nickel** oxide, **nickel** carbonate, **nickel** sulfide, and sulfitic ores) concentrations in urine that have been found to corelate with workplace air concentrations are as follows: ... Urinary levels of 30-50 ug/l have been found to correlate with an air level of 0.5 mg/cu m. Urinary levels of approx 12 ug/l have been found to ccorrelate with an air level of 0.05 mg/cu m.; Toxic - greater than 400 ug/l. /**Nickel**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1785]**PEER REVIEWED**

Respiratory Symptom Questionnaires: Questionnaires have been published by the American Thoracic Society and the British Medical Research Council. These questionnaires have been found to be useful in identification of people with chronic bronchitis, however certain pulmonary function tests such as FEV1 have been found to be better predictors of chronic airflow obstruction. /**Nickel**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1787]**PEER REVIEWED**

Chest Radiography: This test is widely used for assessing pulmonary disease. Chest radiographs have been found to be useful for detection of early lung cancer in asymptomatic people, especially for detection of peripheral tumors such as adenocarcinomas. However, even though OSHA mandates this test for exposure to some toxicants such as asbestos, there are conflicting views on its efficacy in detection of pulmonary disease. /**Nickel**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1787]**PEER REVIEWED**

Pulmonary Function Tests: The tests that have been found to be practical for population monitoring include: Spirometry and expiratory flow-volume curves; Determination of lung volumes; Diffusing capacity for carbon monoxide; Single-breath nitrogen washout; Inhalation challenge tests; Serial measurements of peak expiratory flow; Exercise testing. /**Nickel**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1787]**PEER REVIEWED**

Sputum Cytology: Sputum cytology along with chest radiographs have been the standard procedures for

detecting early lung cancer in asymptomatic patients. Sputum cytology has been found to be useful for detection of central tumors, especially squamous carcinomas. /**Nickel**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1787]**PEER REVIEWED**

Evaluation of Peripheral Neuropathy: Nerve conduction study; Electromyography; Quantitative sensory testing; Thermography. /**Nickel**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1788]**PEER REVIEWED**

Evaluation of Central Nervous System Effects: Evaluation of CNS effects can be performed through neuropsychological assessment, which consists of a clinical interview and administration of standardized personality and neuropsychological tests. The areas that the neuropsychology test batteries focus on include the domains of memory and attention; visuoperceptual, visual scanning, visuospatial, and visual memory; and motor speed and reaction time. There is limited data on which components of the test batteries are best indicators of early CNS effects. /**Nickel**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1788]**PEER REVIEWED**

Evaluation of Cranial Neuropathies: Evaluation of cranial nerve damage, as evidenced by symptoms such as loss of balance, visual function, smell, taste, or sensation on the face, can be accomplished through a physical examination focusing on tests such as: Smell Assessment ... Visual Assessment ... Facial and Trigeminal Nerve Assessment ... Vestibular Assessment ... Hearing Assessment. /**Nickel**/
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 1788]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Whenever medical surveillance is indicated, in particular when exposure to a carcinogen has occurred, ad hoc decisions should be taken concerning ... /cytogenetic and/or other/ tests that might become useful or mandatory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.23]**PEER REVIEWED**

Populations at Special Risk:

... OF INTEREST TO EMERGING ROLE OF WOMEN IN INDUSTRY, **NICKEL** CAN APPARENTLY CROSS ... PLACENTA, FOR **NICKEL** HAS BEEN FOUND IN HUMAN FETAL TISSUE & IN CORD SERUM WHERE AVG CONCN FROM 12 NEWBORNS WAS 0.3 TO 12 UG/DL (RANGE 0.17 TO 0.49), & WAS IDENTICAL WITH THAT IN MOTHER'S SERUM IMMEDIATELY AFTER DELIVERY. /**NICKEL** SALTS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1834]**PEER REVIEWED**

Probable Routes of Human Exposure:

HIGHEST RISK OF MORTALITY FROM CANCER OF RESP TRACT IS FOUND AMONG **NICKEL** MINE WORKERS INVOLVED IN ROASTING, SMELTING, & ELECTROLYSIS.
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 296]**PEER REVIEWED**

EPIDEMIOLOGICAL STUDIES CONCLUSIVELY DEMONSTRATE AN EXCESS OF CANCER OF THE NASAL CAVITY & LUNG IN WORKERS IN **NICKEL** REFINERIES. IT IS LIKELY THAT **NICKEL** IN SOME FORM IS CARCINOGENIC TO MAN. /**NICKEL**/

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 104 (1976)]**PEER REVIEWED**

THE INDUSTRIAL MOND PROCESS WAS DEVELOPED IN WALES FOR PRODUCTION OF PURE **NICKEL** & REQUIRED MIXTURE OF **NICKEL** OXIDE & CARBON MONOXIDE TO MAKE **NICKEL** CARBONYL. IT IS THIS PROCESS WHICH HAS BEEN THE GREATEST CAUSE OF INDUSTRIAL ILLNESS ASSOCIATED WITH **NICKEL** EXPOSURE.
[Hamilton, A., and H. L. Hardy. Industrial Toxicology. 3rd ed. Acton, Mass.: Publishing Sciences Group, Inc., 1974. 151]**PEER REVIEWED**

The toxicologically important routes of entry for **nickel**, metal & sol compounds (as Ni) are inhalation, skin absorption, ingestion, and skin and/or eye contact. /**Nickel** and **nickel** cmpd/
[NIOSH. Pocket Guide to Chemical Hazards. 5th Printing/Revision. DHHS (NIOSH) Publ. No. 85-114. Washington, D.C.: U.S. Dept. of Health and Human Services, NIOSH/Supt. of Documents, GPO, Sept. 1985.173]**PEER REVIEWED**

The route by which most people in the general population receive the largest portion of daily **nickel** intake is through food. /**Nickel** and **nickel** cmpd/
[USEPA; Ambient Water Quality Criteria Document: Nickel p.C-130 (1980) EPA 400/5-80-060]**PEER REVIEWED**

Metallic **nickel** or soluble **nickel** compounds can affect the body if they are inhaled or if they come in contact with eyes or skin. They also can affect the body if they are swallowed. /**Nickel** and **nickel** compounds/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

SOL **NICKEL** SALTS ... PRESENT EXPOSURE POTENTIAL FROM THEIR USE IN ELECTROPLATING BATHS & IN PREPN OF **NICKEL** CATALYSTS. **NICKEL** DERMATITIS, "**NICKEL** ITCH", CONSTITUTES MOST COMMON AFFECTION AMONG **NICKEL** PLATERS. ... HEAT AROUND **NICKEL** PLATING BATHS IS CONSIDERED TO BE A PREDISPOSING FACTOR. /**NICKEL** SALTS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1822]**PEER REVIEWED**

Occupational exposures to **nickel** and its cmpd occur in (1) mining and comminution of **nickel** containing ores; (2) **nickel** refining and smelting; (3) **nickel** electroplating; (4) producing and using **nickel** catalysts; (5) fabricating parts and structures by welding, flame spraying, cutting, grinding, and polishing of **nickel** containing alloys; (6) manufacturing **nickel** cadmium batteries; (7) constructing **nickel** molds in glass bottle factories; (8) spraying **nickel** containing paints (eg, yellow **nickel** titanate pigment); and (9) recycling or disposal of **nickel** containing products. /**Nickel** & compounds/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 455]**PEER REVIEWED**

IN **NICKEL** PLATING INDUSTRY, EXPOSURE TO **NICKEL**-CONTAINING MISTS HAS BEEN REPORTED TO BE ASSOC WITH ASTHMA. SYMPTOMS WERE ATTRIBUTED TO HYPERSENSITIVITY TO **NICKEL**. ... EFFECTS ON NASAL MEMBRANE WERE NOTED IN WORKERS EXPOSED TO **NICKEL** AEROSOLS IN AN ELECTROLYSIS SHOP. /**NICKEL** SALTS/
[Friberg, L., G.R. Nordberg, and V.B. Vouk. Handbook on the Toxicology of Metals. New York: Elsevier North Holland, 1979. 549]**PEER REVIEWED**

Occupational groups such as **nickel** workers and other workers handling **nickel** comprise the individuals at the highest risk. Women, particularly housewives, are at special risk to **nickel** induced skin disorders because of the greater than average contact with **nickel** containing materials. Approximately 47 million individuals, comprising the smoking population of the United States, are potentially at risk for possible co-factor effects of **nickel** in adverse effects on the respiratory track. /**Nickel** and **nickel** cmpd/
[USEPA; Ambient Water Quality Criteria Doc: Nickel p.C-130 (1980) EPA 400/5-80-060]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 507,681 workers (19,673 of these are female) are potentially exposed to **nickel** and **nickel** compounds in the US(1). Occupational exposure to **nickel** and **nickel** compounds may occur through inhalation of dust particles and fumes and dermal contact with this compound at workplaces where **nickel** and **nickel** compounds are produced or used(SRC). Exposure to **nickel** and **nickel** compounds is common for workers in industrial operations that involve **nickel** or **nickel** compounds, such as mining, smelting, welding, casting, spray painting and grinding(2). The general population may be exposed to **nickel** and **nickel** compounds via inhalation of ambient air, ingestion of food and drinking water, and dermal contact with this compound and other products containing **nickel** and **nickel** compounds(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983) (2) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment; Merian E, ed. NY, NY: Weinheim (1991)]**PEER REVIEWED**

Body Burden:

... Mean serum levels of 2.6 ... and 3.1 ug/l ... in persons living in Connecticut ... In newborns, the serum concn of **nickel** were similar to those of mothers, ie an avg of 3 ug/l ... In whole blood, a level of 4.8 ug/l has been reported. ... Avg **nickel** concn /was/ ... 0.22 ug/l in hair. ... Hair values were 0.6 and 1 ug/g in men and women ... /**Nickel** and **nickel** cmpd/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 470]**PEER REVIEWED**

Nickel concn in specimens from healthy, nonexposed adults: Whole blood: 0.34 + or - 0.28 ug/l; Serum: 0.28 + or - 0.24 ug/l; Urine (spot collection): 2.0 + or - 1.5 ug/l; Urine (24 hr collection): 2.2 + or - 1.2 ug/l; Feces (3 day collection): 14.2 + or - 2.7 ug/g dry wt /From table/ /**Nickel** and **nickel** cmpd/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 463]**PEER REVIEWED**

Usually, Ni is found at low levels (< 0.1 mg/kg, wet weight) in most human tissues and body fluids. The average population has 3-7 ug Ni/l of whole blood, 1-5 ug Ni/l in blood serum, and 1-5 ug Ni/l in urine. Perspiration contains 52 + or - 36 ug Ni/l. /**Nickel** and **nickel** cmpd/
[Nat'l Research Council Canada; Effects of Nickel in the Canadian Environment p.29 (1981) NRCC 18568]**PEER REVIEWED**

In 24 hr urine: reference range (conventional): 2.6 ug + or - 1.3 (1 SD) (male); 2.2 + or - 0.8 ug/dl (female); 8-800 ug/l (refinery workers); reference range (international recommended): 44.2 + or - 22.1 nmol/d (1 SD) (male); 37.4 + or - 13.6 (female); 136-13,600 nmol/l (refinery workers); In feces: reference range (conventional): 260 + or - 120 ug/d (1 SD) (adult); reference range (international recommended): 4.4 + or - 2.1 umol/d (1 SD) (adult) /**Nickel** and **nickel** cmpd/
[Tietz, N.W. (ed.). Clinical Guide to Laboratory Tests. Philadelphia, PA: W.B. Saunders Co., 1983. 358]**PEER REVIEWED**

In 24 hr urine: reference range (conventional): 100-2500 ug/l; reference range (international recommended): 1700-42500 nmol/l.
[Tietz, N.W. (ed.). Clinical Guide to Laboratory Tests. Philadelphia, PA: W.B.

Saunders Co., 1983. 358]**PEER REVIEWED**

In hair: reference range (conventional): 0.24 ug + or - 0.09 ug/kg and 0.19 + or - 0.04 ug/kg (adult); reference range (international recommended): 4.1 + or - 1.5 ug/kg and 3.2 + or - 0.7 ug/kg (adult) /**Nickel** and **nickel** cmpd/
[Tietz, N.W. (ed.). Clinical Guide to Laboratory Tests. Philadelphia, PA: W.B. Saunders Co., 1983. 358]**PEER REVIEWED**

... Serum **nickel** was found to be 2.6 + or - 0.9 ug/l (range: 0.8 to 5.2) and mean excretion of **nickel** in urine of 2.6 + or - 1.4 ug/day (range: 0.5 to 6.4). ... Serum **nickel** measured in persons living in Sudbury, Ontario, which is in the vicinity of a large **nickel** mine, showed concn of 4.6 + or - 1.4 ug/l (range: 2.0 to 3.7) and urinary concn were 7.9 + or - 3.7 ug/day (range: 2.3 to 15.7). Generally, fetal **nickel** is about 100 times urine **nickel** concn. /**Nickel** and **nickel** cmpd/
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 610]**PEER REVIEWED**

Normal level of **nickel** in human blood: 0.011 mg%, 0.11 ug/ml. /**Nickel**/
[Winek CL; Drug & Chemical Blood-Level Data Nickel (1985)]**PEER REVIEWED**

NICKEL HAS BEEN FOUND IN HUMAN FETAL TISSUE & IN CORD SERUM WHERE AVG CONCN FROM 12 NEWBORNS WAS 0.3 TO 12 UG/DL (RANGE 0.17 TO 0.49), & WAS IDENTICAL WITH THAT IN MOTHER'S SERUM IMMEDIATELY AFTER DELIVERY. /**NICKEL** SALTS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1834]**PEER REVIEWED**

The avg body burden of **nickel** in healthy adults is 7.3 ug/kg body weight(1). The range and avg **nickel** concns in whole blood, serum, urine (24-hour collection) and feces (72-hour collection) of non-exposed, healthy adults are: <0.05-1.05 ug/l, 0.34 ug/l; <0.05-1.08 ug/l, 0.28 ug/l; 0.7-5.2 ug/l, 2.2 ug/l, and 10.8-18.6 ug/g, 14.2 ug/g (dry weight)(1). The following mean, median, and ranges of **nickel** concns in various body tissues were found in non-occupationally exposed individuals (wet weight; number of observations indicated in parentheses): lung - 18, 12, 7-46 (9); thyroid - 20,24, 7-32 (8); adrenal - 26, 24, 13-56 (10); kidney - 9, 7, 3-25 (10); heart - 8, 6, 1-14 (9); liver - 10, 8, 2-21 (10); brain - 8, 8, 5-11 (7); spleen - 7, 4, 1-15 (10); pancreas - 8, 6, 9-19 (10)(2).
[(1) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment. Merian E, ed. NY, NY: Weinheim (1991) (2) ATSDR; Toxicological Profile for Nickel. ATSDR/TP-88/19 pp. 1-70 (1988)]**PEER REVIEWED**

Average Daily Intake:

The average daily oral intake of **nickel** has been reported to be 300 to 600 ug/day. /**Nickel** and **nickel** cmpd/
[48 FR 45502 (10/05/83)]**PEER REVIEWED**

The highest level of **nickel** observed in water was 75 ug/l. Average drinking water levels are about 5 ug/l. A typical consumption of 2 liters daily would yield an additional intake of 10 ug of **nickel**, of which 1 ug would be expected to be absorbed. /**Nickel** and **nickel** cmpd/
[USEPA; Ambient Water Quality Criteria Doc: Nickel p.C-130 (1980) USEPA 400/5-80-060]**PEER REVIEWED**

Average daily **nickel** intake from food in institutionalized children 9-12 years of age from 28 US cities was 451 ug/l. /**Nickel** and **nickel** cmpd/
[Murthy GD et al; Envir Sci Tech 7: 1042 (1973)]**PEER REVIEWED**

Nickel content of nine institutional diets in the US would result in an avg Ni intake of 165 ug/day. /**Nickel** and **nickel** cmpd/
[Myron DR et al; Am J Clin Nutr 31: 527 (1978)]**PEER REVIEWED**

Nickel may be inhaled by urban residents at a rate of about 2-14 ug/day. /**Nickel** and **nickel** cmpd/
[NAS; Report of the Committee on Med and Envir Poll; Nickel (1975) as cited in NTP; Chem Selection Profile: Nickel Chloride p.2 (1979)]**PEER REVIEWED**

In a ... study of **nickel** content of diets prepared in university or hospital kitchens in the US, ... /the investigators/ found **nickel** intake to avg 165 (SD +/- 11) ug/day or 75 +/- 10 ug/1000 cal.
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 610]**PEER REVIEWED**

Average **nickel** intake for American adults is 300-600 ug/day. /**Nickel** and **nickel** cmpd/
[Schroeder HA et al; J Chronic Dis 15: 51-65 (1962)]**PEER REVIEWED**

/Daily intake/ in seafood /ranges from/ 0.3-1.7 ug/g. /**Nickel** and **nickel** cmpd/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 465]**PEER REVIEWED**

Estimates of the avg daily intake of **nickel** range from 0.14 to 0.6 mg/day(1). Diet is the source of approximately 83-94% of the body burden of **nickel**(2). The inhalation of **nickel** in urban areas is reported to range between 0.2 to 1.0 ug/day, with an avg rate of 0.4 ug/day; in rural areas the range is 0.1-0.4 ug/day with an avg of 0.2 ug/day(1). Smoking cigarettes can increase the intake of **nickel** by 4 ug/day per pack of cigarettes smoked(1).
[(1) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment; Merian E, ed. NY, NY: Weinheim (1991) (2) ATSDR; Toxicological Profile for Nickel. ATSDR/TP-88/19. pp. 1-70 (1988)]**PEER REVIEWED**

Emergency Medical Treatment:

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The following Overview, *** **NICKEL** ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE
0.2.1.1 ACUTE EXPOSURE
A. Adverse effects can result from ingestion, skin contact, inhalation or parenteral routes of exposure; **nickel** may be absorbed from the gastrointestinal and

respiratory tracts as well as percutaneously.

B. Inhalation of **nickel** alloys or dust has been linked to pulmonary irritation, asthma, pneumoconiosis, pulmonary fibrosis and pulmonary edema. Gingivitis, stomatitis, metallic taste, nasal irritation, nasal mucosa damage, nasal septum perforation, hyposmia/anosmia, cough and shortness of breath are sometimes reported. Exposure to **nickel** fumes may result in 'metal fume fever'. Death from adult respiratory distress syndrome has occurred.

1. However, inhalation exposures are usually to **nickel** carbonyl. Exposure to **nickel** carbonyl produces severe acute systemic effects not found with exposure to **nickel** metal, salts or alloys.

a. **Nickel** carbonyl inhalation toxicity is divided into early and late phases. Initially, exposure results in headache, discomfort, fatigue, weakness, nausea and vomiting, and 'flu-like' symptoms. Then, 12 to 36 hours later, shortness of breath, pallor, chest pain and dyspnea occur. Pneumonitis, convulsions and death are possible consequences.

C. Contact dermatitis or hypersensitivity, possibly severe, occurs in sensitized individuals (2 to 5% of the general population). **Nickel** is the most common cause of allergic contact sensitization (10% of all positive patch tests).

1. Exposure can result in localized pruritis ('**nickel** itch'), erythema, papules, eczema and possibly vesicles after 1 to 2 days of continuous contact, and may also be linked to conjunctivitis, asthma and allergic rhinitis. Mucosal contact hypersensitivity (with piercings) has been reported.

2. Costume jewelry was found to be one of the main causes of **nickel** dermatitis, especially in children 10 to 19 years of age, mainly female.

D. Parenteral exposures may occur from implanted metal prostheses, stainless steel needles or contaminated dialysate solutions. Inflammatory reactions have occurred around **nickel**-containing prostheses and medical implants. '**Nickel** intoxication' from dialysis exposure includes nausea, vomiting, headache, weakness and palpitations.

E. Elemental **nickel** is present in some foods and water, but dietary exposures are generally not significant. Ingestion of soluble **nickel** salts can cause nausea, vomiting and diarrhea.

F. Some work environments (such as **nickel** refinery work) and forms of **nickel** are associated with human malignancies, mainly nasal and respiratory cancers. Other forms of **nickel** are anticipated to be carcinogenic or have not been fully evaluated in humans.

0.2.3 VITAL SIGNS

0.2.3.1 ACUTE EXPOSURE

A. Acute intoxication by **nickel** carbonyl has two stages: immediate and delayed. An exposed individual may develop a delayed fever, but it will seldom rise above 101 degrees.

0.2.4 HEENT

0.2.4.1 ACUTE EXPOSURE

A. Acute toxicity from **nickel** inhalation includes sore throat and hoarseness.

B. There is speculation that conjunctivitis and epiphora

have occurred in **nickel** plating work environments due to poor ventilation.

C. Occasional exposure to **nickel** aerosol and other contaminants has caused nasal irritation, loss of sense of smell, damage to the nasal mucosa, and perforation of the nasal septum.

D. In rare cases, **nickel** workers have complained of a bitter metallic taste.

0.2.6 RESPIRATORY

0.2.6.1 ACUTE EXPOSURE

A. Inhalation: Phase I of an acute **nickel** carbonyl exposure involves nonproductive cough, and rapid, panting breathing. The second phase involves tightness in the chest, cough, dyspnea, retrosternal pain and shortness of breath. Late changes involve pulmonary edema and interstitial fibrosis.

B. ANIMAL - Animals exposed to **nickel** carbonyl by inhalation for 5 days, 12 hours/day had signs of dyspnea, fever, vomiting, diarrhea, apathy, anorexia, tachypnea, cyanosis and occasionally hind-limb paralysis with generalized convulsions followed by death.

0.2.7 NEUROLOGIC

0.2.7.1 ACUTE EXPOSURE

A. Early symptoms after inhalation are dizziness, giddiness, and weakness.

0.2.7.2 CHRONIC EXPOSURE

A. EEG abnormalities have been reported in **nickel** carbonyl workers.

0.2.8 GASTROINTESTINAL

0.2.8.1 ACUTE EXPOSURE

A. Large doses taken orally or by inhalation may cause nausea, vomiting, and diarrhea.

0.2.9 HEPATIC

0.2.9.1 ACUTE EXPOSURE

A. Hyperbilirubinemia and elevated SGPT have been reported.

0.2.10 GENITOURINARY

0.2.10.1 ACUTE EXPOSURE

A. Changes found in the kidneys of one case included vacuolization of the proximal convoluted tubules, but no tubular necrosis.

0.2.13 HEMATOLOGIC

0.2.13.1 ACUTE EXPOSURE

A. Leukocytosis, reticulocytosis, and erthrocytosis have been reported.

0.2.14 DERMATOLOGIC

0.2.14.1 ACUTE EXPOSURE

A. Contact dermatitis is the most common reaction to **nickel**. It is estimated that 5 percent of all eczemas are **nickel** reactions. "**Nickel** itch" may begin with a burning and itching sensation, followed by erythema and nodular eruptions. Once acquired, **nickel** sensitivity usually persists.

B. **Nickel** and its inorganic compounds can be absorbed through the skin but not in amounts sufficient to cause intoxication.

C. Dermal reactions to **nickel** carbonyl are rare.

D. A single case of eczematous dermatitis was reported as a result of a chronic **nickel** carbonyl inhalation exposure.

0.2.19 IMMUNOLOGIC

0.2.19.1 ACUTE EXPOSURE

A. **Nickel** is a sensitizer.

0.2.20 REPRODUCTIVE HAZARDS

A. **Nickel** salts are reported to be animal teratogens. Increased incidence of stillbirth and neonatal mortality of rat offspring were associated with maternal consumption of **nickel** chloride solutions prior to mating and during gestation. **Nickel** has been found in breast milk. Oral administration of **nickel** sulfate to rats caused decreased testicular, prostate, and seminal vesicle size as well as abnormalities of sperm and decreased sperm count.

0.2.21 CARCINOGENICITY

0.2.21.1 IARC CATEGORY

A. **Nickel** compounds are in IARC Group 1 (carcinogenic to humans, sufficient evidence of carcinogenicity) and metallic **nickel** is in IARC Group 2B (possibly carcinogenic to humans, limited evidence in humans in the absence of sufficient evidence in experimental animals) (IARC, 2000; HSDB, 2000).

0.2.21.2 HUMAN OVERVIEW

A. **Nickel** and many **nickel** compounds are considered human carcinogens or probable human carcinogens.

B. ACGIH rates **nickel** as an A5, not suspected as a human carcinogen.

C. **Nickel**-induced respiratory cancer has a latency period. Lung cancer may develop 13 to 14 years from the time of the first employment exposure. Nasal cancer may occur 15 or more years later.

D. Roasting **nickel** subsulfide is associated with an increased risk for respiratory cancer.

0.2.22 GENOTOXICITY

A. Some **nickel** compounds concentrate in the nuclei of animal cells. **Nickel** chloride did not cause DNA strand breaks or inhibit DNA repair in Chinese hamster ovarian cells by treatment with methyl methanesulfonate, but did inhibit DNA repair of cells exposed to UV light.

B. Sister chromatid exchanges have been observed in human lymphocytes. Chromosomal aberrations in lymphocytes of some workers have also been reported. A larger number of chromosomal aberrations than expected have been identified in some study controls.

C. Morphological transformation in animal cells have also been reported. Insoluble **nickel** compounds (**nickel** sulfide, **nickel** subsulfide, **nickel** oxides) produced mutations in G12 and G10 transgenic Chinese hamster cells. Some soluble **nickel** compounds were weakly mutagenic in AS52 cells.

Laboratory:

A. BLOOD

A healthy individual has **nickel** concentrations in the plasma ranging from 1.4 to 3.4 mcg/L (averages 2.1 mcg/L).

1. Whole blood concentrations are usually twice the level of plasma or serum.

B. URINE

1. A healthy individual has **nickel** concentrations in the urine ranging from 0.5 to 6.5 mcg/L.

Treatment Overview:

0.4.2 ORAL EXPOSURE

A. Oral toxicity of elemental **nickel** is low. Treatment of illness caused by ingestion of **nickel** salts is usually

limited to fluid replacement in cases of severe vomiting and diarrhea. Decisions to institute gastric lavage or administer activated charcoal are at the discretion of the treating clinician.

1. GASTRIC LAVAGE: Consider after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation. Control any seizures first.
   a. CONTRAINDICATIONS: Loss of airway protective reflexes or decreased level of consciousness in unintubated patients; following ingestion of corrosives; hydrocarbons (high aspiration potential); patients at risk of hemorrhage or gastrointestinal perforation; and trivial or non-toxic ingestion.
2. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.

B. Parenteral: It is unusual for **nickel** to be injected, so elevated blood levels are usually from chronic exposures to implanted devices.

C. Other treatments are symptomatic and supportive.

0.4.3 INHALATION EXPOSURE

A. Move the patient to fresh air. The first phase of **nickel** carbonyl inhalation is deceptive in its lack of severe symptoms.

B. CHELATING AGENTS - Although penicillamine has an effect, diethyldithiocarbamate (DDC) is the preferred chelating agent in the literature.

1. Collect an 8 hour sample immediately after exposure. Levels of:
   a. Less than 10 mcg/dL: delayed symptoms are not expected. DDC is unnecessary.
   b. 10 to 50 mcg/dL: DDC should be administered orally (50 mg/kg/day on day 1, then 400 mg every 8 hours until the patient is symptom free and urine **nickel** is under 10 mcg/dL.
   c. Greater than 50 mcg/dL: the dose of DDC parenterally is 25 mg/kg. Severe cases may use 100 mg/kg for the first 24 hours.
2. If there is doubt as to the severity of the exposure, give a course of 2 g of DDC orally until a urine **nickel** can be obtained.

C. DDC is an "orphan" drug in the United States, but the company has not been assigned. Dr F Wm Sunderman Sr of the Hahnemann Medical College and Hospital, Philadelphia, PA has the IND.

D. DISULFIRAM is metabolized to 2 molecules of DDC. If DDC is not available, disulfiram may prove of some use, although studies using disulfiram are limited to dermatitis.

0.4.5 DERMAL EXPOSURE

A. Disulfiram (Antabuse(R)) is metabolized to 2 molecules of diethyldithiocarbamate (DDC). It has been shown effective in clearing cases of **nickel** dermatitis. 50 to 100 mg/day were used in the treatment. Many other topical and oral drugs are being investigated.

Range of Toxicity:

A. Oral toxicity is low and unusual.

B. Maximum Tolerated Dose - It has been recommended that a

plasma level of 10 mcg/L be set as a biomonitoring limit for **nickel** refinery workers.
C. A normal serum **nickel** level in humans is approximately 0.011 mg% or 0.11 micrograms/milliliter.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

DIETHYLDITHIOCARBAMATE TRIHYDRATE (DITHIOCARB), A METAL BINDING AGENT, HAS BEEN USED SUCCESSFULLY TO TREAT ACUTE POISONING. /**NICKEL**/
[Casarett, L.J., and J. Doull. Toxicology: The Basic Science of Poisons. New York: MacMillan Publishing Co., 1975. 488]**PEER REVIEWED**

/BAL/ is ... useful for treatment of poisoning by compounds of ...**nickel**. /**Nickel** compounds/
[Hayes, W.J., Jr., E.R. Laws Jr., (eds.). Handbook of Pesticide Toxicology Volume 1. General Principles. New York, NY: Academic Press, Inc., 1991. 396]**PEER REVIEWED**

A number of chelating agents have been assessed for their ability to prevent the systemic toxicity associated with **nickel** exposure, including diethyldithiocarbamate (DDC, a metabolite of disulfiram or Antabuse). /**Nickel**/
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA: Little, Brown and Company, 1992. 808]**PEER REVIEWED**

Basic treatment: Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilation if necessary. Administer oxygen by nonrebreather mask at 10 t0 15 L/min. Monitor for shock and treat if necessary ... . Monitor for pulmonary edema and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport ... . Do not use emetics. For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool ... . /**Nickel** and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994.,p. 371-2]**PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious. Positive pressure ventilation techniques with a bag valve mask device may be beneficial. Monitor cardiac rhythm and treat arrhythmias if necessary ... . Consider drug therapy for pulmonary edema ... . Start an IV with D5W /SRP: "To keep open", minimal flow rate/. Use lactated Ringer's if signs of hypovolemia are present. For hypotension with signs of hypovolemia, administer fluid cautiously. Consider vasopressors for hypotension with a normal fluid volume. Watch for signs of fluid overload ... . Use proparacaine hydrochloride to assist eye irrigation ... . /**Nickel** and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 372]**PEER REVIEWED**

Animal Toxicity Studies:

Toxicity Summary:

Nickel can be absorbed in human beings and animals via inhalation or ingestion, or percutaneously.

Respiratory absorption with secondary gastrointestinal absorption of **nickel** (insoluble and soluble) is the major route of entry during occupational exposure. A significant quantity of inhaled material is swallowed following mucociliary clearance from the respiratory tract. ... Percutaneous absorption is negligible, quantitatively, but is important in the pathogenesis of contact hypersensitivity. Absorption is related to the solubility of the compound, following the general relationships **nickel** carbonyl> soluble **nickel** compounds > insoluble **nickel** compounds. ... **Nickel** is transported in the blood, principally bound to albumin. Gastrointestinal absorption of **nickel** is variable and depends on the composition of the diet. ... All body secretions are potential routes of excretion including urine, bile, sweat, tears, milk, and mucociliary fluid. Non-absorbed **nickel** is eliminated in the feces. ... Following parenteral administration of **nickel** salts, the highest **nickel** accumulation occurs in the kidney, endocrine glands, lung and liver: high concentrations are also observed in the brain following administration of **nickel** carbonyl. ... **Nickel** is essential for the catalytic activity of some plant and bacterial enzymes. Slow weight gain, anemia, and decreased viability of offspring have been described in some animal species after dietary deprivation of **nickel**. The most acutely toxic **nickel** compound is **nickel** carbonyl, the lung being the target organ; pulmonary edema may occur within 4 hr following exposure. ... contact allergy to **nickel** is very common in human beings ... Metallic **nickel** and a very large number of **nickel** compounds have been tested for carcinogenicity by parenteral routes of administration; with few exceptions, they caused local tumors. Only **nickel** subsulfide has been shown convincingly to cause cancer after inhalation exposure. ... In terms of human health, **nickel** carbonyl is the most acutely toxic **nickel** compound. ... Cases of **nickel** poisoning have also been reported in patients dialysed with **nickel**-contaminated dialysate and in electroplaters who accidently ingested water contaminated with **nickel** sulfate and **nickel** chloride. Chronic effects such as rhinitis, sinusitis, nasal septal perforations and asthma have been reported in **nickel** refinery and **nickel** plating workers. ... **Nickel** contact hypersensitivity has been documented extensively in both the general population and in a number of occupations in which workers were exposed to soluble **nickel** compounds. ... Nephrotoxic effects, such as renal edema with hyperemia and parenchymatous degeneration, have been reported in cases of accidental industrial exposure to **nickel** carbonyl. Transient nephrotoxic effects have been recorded after accidental ingestion of **nickel** salts. Very high risks of lung and nasal cancer have been reported in **nickel** refinery workers employed in the high-temperature roasting of sulfide ores, involving substantial exposure to **nickel** subsulfide, oxide and, perhaps, sulfate.
[Environmental Health Criteria 108: Nickel. pp. 17-22 (1991) by the International Programme on Chemical Safety (IPCS) under the joint sponsorship of the United Nations Environment Programme, the International Labour Organisation and the World Health Organization.]**PEER REVIEWED**

Evidence for Carcinogenicity:

Evaluation: There is sufficient evidence in humans for the carcinogenicity of **nickel** sulfate, and of the combinations of **nickel** sulfides and oxides encountered in the **nickel** refining industry. There is inadequate evidence in humans for the carcinogenicity of metallic **nickel** and **nickel** alloys. There is sufficient evidence in experimental animals for the carcinogenicity of metallic **nickel**, **nickel** monoxides, **nickel** hydroxides and crystalline **nickel** sulfides. There is limited evidence in experimental animals for the carcinogenicity of **nickel** alloys, nickelocene, **nickel** carbonyl, **nickel** salts, **nickel** arsenides, **nickel** antimonide, **nickel** selenides and **nickel** telluride. There is inadequate evidence in experimental animals for the carcinogenicity of **nickel** trioxide, amorphous **nickel** sulfide and **nickel** titanate. The Working Group made the overall evaluation on **nickel** compounds as a group on the basis of the combined results of epidemiological studies, carcinogenicity studies in experimental animals, and several types of other relevant data, supported by the underlying concept that **nickel** compounds can generate **nickel** ions at critical sites in their target cells. Overall evaluation: **Nickel** compounds are carcinogenic to humans (Group 1). Metallic **nickel** is possibly carcinogenic to humans (Group 2B).

[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V49 410 (1990)]**PEER REVIEWED**

A1. A1= Confirmed human carcinogen. /**Nickel**, insoluble compounds, as Ni/
[American Conference of Governmental Industrial Hygienists. Guide to Occupational Exposure Values - 1999. Cincinnati, OH: 1999. 51]**PEER REVIEWED**

Non-Human Toxicity Excerpts:

... **NICKEL** SALTS CAUSE INJURY OR DESTRUCTION OF ALPHA CELLS OF PANCREAS, & ... TO A LESS EXTENT, DAMAGE TO BETA CELLS. /**NICKEL** SALTS/
[Thienes, C., and T.J. Haley. Clinical Toxicology. 5th ed. Philadelphia: Lea and Febiger, 1972. 203]**PEER REVIEWED**

BY ORAL ADMIN LARGE DOSES OF **NICKEL** SALTS CAUSE ACUTE GASTRO-INTESTINAL IRRITATION, WITH VOMITING & DIARRHEA. LETHAL DOSE VARIES WITH THE SPECIES. ... IN ... INVESTIGATIONS, 6-12 MG OF **NICKEL** PER KG BODY WT DAILY FOR 100-200 DAYS OF CHLORIDE & SULFATE IN THE FORM OF THE ACETATE, CAUSED NO SIGNIFICANT INJURY. BY SUBCUTANEOUS OR INTRAVENOUS INJECTION ... NERVOUS SYMPTOMS ... OCCUR: TREMOR, CHOREA-LIKE MOVEMENTS & FINALLY PARALYSIS; CONVULSIONS ARE RARE IN DOGS & DEATH IS DUE TO HEART FAILURE. /**NICKEL** SALTS/
[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969. 252]**PEER REVIEWED**

TOXICITY STUDIES HAVE DEMONSTRATED THAT ... **NICKEL** SALTS HAVE RELATIVELY LOW TOXICITY IN VARIOUS SPECIES OF ANIMALS WHEN ADMIN ORALLY. ... PARENTERAL INJECTIONS OF **NICKEL** SALTS ARE MUCH MORE TOXIC. MAJOR SIGNS OF ACUTE **NICKEL** TOXICITY CONSIST OF HYPERGLYCEMIA & GI & CNS EFFECTS. /**NICKEL** SALTS/
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 287]**PEER REVIEWED**

NICKEL SALTS ARE HIGHLY TOXIC WHEN ADMIN IV OR SC. GASTROENTERITIS, TREMORS, & PARALYSIS OCCUR IN DOGS & GUINEA PIGS IMMEDIATELY FOLLOWING IV ADMIN OF SUBLETHAL DOSES; HYPERGLYCEMIA DEVELOPS, BUT CAN BE PREVENTED BY ADMIN OF INSULIN. LOCALIZATION OF INJECTED **NICKEL** SALTS IN PITUITARY GLAND & SUBSEQUENT DECREASED SERUM LEVEL OF PROLACTIN SUGGEST THAT DIVALENT **NICKEL** EXERTS A DIRECT SPECIFIC INHIBITORY ACTION ON PROLACTIN-SECRETING CELLS IN ANTERIOR PITUITARY. /**NICKEL** SALTS/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 295]**PEER REVIEWED**

There is evidence in lab animals that **nickel** exposure results in altered resistance to virus and bacteria. A direct effect on macrophage function has also been attributed to **nickel**. /**Nickel** compounds/
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 276]**PEER REVIEWED**

IN LABORATORY ANIMALS, INHALATION OF **NICKEL** CMPD WITH LOW SOLUBILITY CAUSES INFLAMMATORY REACTIONS IN NASAL MUCOSA & IN LUNG. /**NICKEL** SALTS/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 462]**PEER REVIEWED**

... RATS /WERE GIVEN/ **NICKEL** SALT IN DRINKING WATER (5 MG NI/LITER) FOR 3

GENERATIONS & NOTED AN INCR MORTALITY AMONG NEWBORNS IN ALL 3 GENERATIONS & AN INCR NUMBER OF RUNTS. IN THIRD GENERATION MORE FEMALES THAN MALES WERE BORN. /**NICKEL** SALTS/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 475]**PEER REVIEWED**

... **Nickel** in drinking water to rats for 7 mo before pregnancy and during pregnancy and some incr of preimplantation mortality was found. Some cases of malformed fetuses were noted. /**Nickel** salts/
[Shepard, T.H. Catalog of Teratogenic Agents. 5th ed. Baltimore, MD: The Johns Hopkins University Press, 1986. 409]**PEER REVIEWED**

DNA LESIONS OBSERVED IN KIDNEY NUCLEI ISOLATED FROM RATS 20 HR AFTER IP INJECTION. DOSE-DEPENDENT, **NICKEL**-INDUCED DNA CROSSLINKS & DNA SINGLE STRAND BREAKS WERE DETECTED USING ALKALINE ELUTION TECHNIQUE. DNA DAMAGE IS DISCUSSED RELATIVE TO CARCINOGENICITY OF **NICKEL** CMPD.
[CICCARELLI RB ET AL; CANCER LETT 12 (4): 349 (1981)]**PEER REVIEWED**

Although water soluble **nickel** salts have not been shown to initiate carcinogenesis in rodents, the soluble **nickel** salts are evidently effective as cancer promotors following initiation of tumorigenesis by aromatic hydrocarbons and nitrosoamines. Growing evidence suggest that the **nickel**(III)/**nickel**(II) redox couple facilitates oxygen free radical reactions, which may represent one of the molecular mechanisms for genotoxicity and carcinogenicity of **nickel** cmpds. /Soluble **nickel** cmpd/
[Sunderman FW; Sangyo Ika Daegaku Zasshi 9 (suppl): 84-94 (1987)]**PEER REVIEWED**

Coliphage T1 was more sensitive than its host bacterium, Escherichia coli B, to **nickel**. A five hr exposure to 100 ppm Ni in nutrient broth did not adversely affect T1, whereas 10 and 20 ppm Ni extended the lag phase of growth of E coli B, and no growth occurred with 40 or more ppm Ni. Ni (5 ppm) enhanced the survival (after 4 wk) of T1 in sea or simulated estuarine water but was toxic (ie reduced viral infectivity) in lake water; 50 ppm Ni was not toxic to T1 in sea water, was moderately toxic in estuarine water, but was highly toxic in lake water; and 100 ppm Ni was toxic in all systems, with the sequence of loss in viral infectivity being lake > estuarine > sea water. Ni (100 ppm) was not toxic to T1 in nutrient broth, even after 3 weeks of exposure, probably because of the protective effect of the organic compounds in the broth. /Soluble **nickel** cmpd/
[Babich H et al; Curr Microbiol 8 (2): 101-5 (1983)]**PEER REVIEWED**

The survival of some eubacteria, an actinomycete, and yeasts after acute and chronic exposure to **nickel** in lake, simulated estuarine and sea waters; and the influence of environmental factors on Ni toxicity were determined. Ni toxicity to microbes in marine systems was reduced by increasing the salinity, decreasing the temperature, and incorporation of simulated sediment. The toxicity of Ni to microbes in fresh water was reduced by increasing the pH, increasing the hardness, and incorporation of suspended particulates. Chronic toxicity studies indicated that fresh waters were more sensitive than marine waters to Ni pollution, as microbial survival was greater in marine waters stressed with equivalent concentrations of Ni. /Soluble **nickel** cmpd/
[Babich H, Stotzky G; Aquat Toxicol 3 (3): 195-208 (1983)]**PEER REVIEWED**

Plasma and pancreatic cation alterations were investigated in rats subjected to chronic oral **nickel** ingestion. Decreases in sodium and potassium, significant in the former, were observed in plasma, while calcium and magnesium were unchanged. Calcium and zinc levels in total pancreatic tissue were higher than in the controls. /Soluble **nickel** cmpd/
[Sanchez Reus MI et al; An Real Acad Farm 50 (1): 125-32 (1984)]**PEER REVIEWED**

Eggs, alevins, swim up fry, and 8 month old Atlantic salmon (Salmo salar) were exposed to

concentrations of ... **nickel** in soft water. ... The maximum acceptable toxicant concentration (MATC) was approximately ... 50 ug Ni/l. ... Ni affected the hatching process, delayed hatching, and increased mortality of embryos. /Soluble **nickel** cmpd/
[Grande M, Andersen S; Vatten 39 (4): 405-16 (1983)]**PEER REVIEWED**

... IN PROPER CONCN ... /**NICKEL**/ CAN ACTIVATE PANCREATIC RIBONUCLEASE & DESOXYRIBONUCLEASE I & CAN REPLACE ZINC IN CARBOXYPEPTIDASE & CARBONIC ANHYDRASE ... INHIBITION OF RNA POLYMERASE & ATPASE ARE OF PARTICULAR SIGNIFICANCE ... /SOLUBLE **NICKEL** CMPD/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1836]**PEER REVIEWED**

Phytotoxicity causes visible symptoms (interveinal chlorosis of young leaves) at about 50-100 mg/kg dry leaves. These levels are phytotoxic for grasses, legumes, and leafy vegetables. ... No health effect or **nickel** bioaccumulation in voles fed sludge fertilized soybeans containing 30 ppm **nickel**; this is the Ni level in soybean grain when yield is significantly reduced. /Soluble **nickel** cmpd/
[Parr, J.F., P.B. Marsh, and J.M. Kla (eds.). Land Treatment of Hazardous Wastes. Park Ridge, New Jersey: Noyes Data Corporation, 1983. 185]**PEER REVIEWED**

Maximum acceptable **nickel** concn from partial and complete life cycle toxicity test with fathead minnow is 380-730 ug/l, from embryo larval and early juvenile 380-730 ug/l. /From table/ /Soluble **nickel** cmpd/
[Murty, A.S. Toxicity of Pesticides to Fish. Volumes I, II. Boca Raton, FL: CRC Press Inc., 1986.,p. V2 6]**PEER REVIEWED**

Aquatic plants can extract **nickel** from water and concentrate it to a high degree (1x10+3-1x10+4 mg/kg dry weight). Laboratory experiments showed that planktonic algae and aquatic macrophytes had 50% reductions in growth rates when exposed to aqueous **nickel** in the range 0.5-2.0 mg/l. /Soluble **nickel** cmpd/
[Nat'l Research Council Canada; Effects of Nickel in the Canadian Environment p.28 (1981) NRCC No. 18568]**PEER REVIEWED**

The effect of **nickel**(2+) on the release of amylase from rat parotids, insulin from mouse pancreatic islets, and growth hormone from bovine pituitary slices were investigated. In all these secretory systems, Ni(2+) inhibited release evoked by a variety of stimuli both physiological and pharmacological. ... Results suggest that this inhibitory action of Ni(2+) does not arise through an effect on energy metabolism or cyclic AMP metabolism. /Soluble **nickel** cmpd/
[Dormer RL et al; Biochem J 140: 135 (1973)]**PEER REVIEWED**

A study involving three experiments was done to ascertain whether the beneficial effect of **nickel** on hematopoiesis in moderately iron deficient rats was due to physiologic and/or pharmacologic mechanisms. Female Sprague-Dawley rats were fed **nickel** supplements ranging from 0 to 100 micrograms/g in iron low (15 micrograms iron(3+)/g), iron adequate (65 micrograms iron(3+)/g), or iron luxuriant (100 micrograms iron(3+)/g) diets. The basal diet contained from 2 ng (experiment 3) to 36 ng (experiment 1) of **nickel**/g. At 10 weeks, both **nickel** deficiency and toxicity (100 micrograms/g diet) tended to depress hematopoiesis and markedly altered femur and liver trace element content in marginally iron deficient rats. The alterations included elevated copper, iron and **nickel**, and depressed calcium and manganese in femurs. The pharmacologic action of **nickel** was indicated by the finding that high dietary **nickel** (5, 10, 20, or 50 micrograms/g) apparently stimulated hematopoiesis in marginally iron deprived rats to a greater extent than dietary levels of **nickel** (0.1, 0.5, or 1.0 micrograms/g) considered adequate for nutritional needs. High dietary **nickel** also elevated the iron content in liver of marginally iron adequate rats. The findings indicate that **nickel** influences iron metabolism at

physiologic, pharmacologic, and toxic levels of intake. They also indicate that many previously reported signs of **nickel** deprivation, including effects on hematopoiesis, may have been misinterpreted and might be manifestations of pharmacologic actions of **nickel**. /Soluble **nickel** cmpd/
[Nielsen FH et al; J Nutr 114 (7): 1280-8 (1984)]**PEER REVIEWED**

The DNA damaging effect of ionic **nickel** was studied in Chinese hamster ovary cells using several chromatin isolation methods in combination with SDS-polyacrylamide gel electrophoresis. DNA from **nickel** treated cells consistently had more (35S)-methionine radioactivity than did DNA from untreated cells. This radioactivity was resistant to ribonuclease but sensitive to protease. Differential extraction using denaturing agents and high ionic strength followed by SDS-polyacrylamide gel electrophoresis revealed that most of the tightly bound proteins were nonhistone chromosomal proteins, and possibly histone 1. The enhancement of DNA protein binding from **nickel** treated cells was disrupted by SDS, suggesting that **nickel** ions do not function as classical bifunctional crosslinking agents. /Soluble **nickel** cmpd/
[Patiemo SR, Costa M; Cancer Biochem Biophys 9 (2): 113-26 (1987)]**PEER REVIEWED**

Nickel treatment of a liver epithelial cell line (T51B) in vitro selectively induced cytokeratin filament accumulation in a juxtanuclear location as the cells rounded up. After removal of **nickel**, vimentin filaments remained attached to the cell periphery as the cells spread out again, but the cytokeratin filaments remained aggregated in a perinuclear position without reestablishing all peripheral connections. /Soluble **nickel** cmpd/
[Katsuma Y et al; J Hepatol 5 (3): 344-54 (19870]**PEER REVIEWED**

The Potential of ammonium chloride, sodium butyrate, sodium propionate, and the heavy metals **nickel**, zinc, and copper to interfere with methanogenesis of Methanospirillum hungatei, Methanosarcina barkeri, Methanobacterium thermoautotrophicum, and Methanobacterium formicicum at pH 6.5 was studied. All strains were sensitive to copper (1-5 mg/l) and zinc (1-10 mg/l) but resistant to **nickel**. /Soluble **nickel** cmpd/
[Jarrell KF et al; Can J Microbiol 33 (6): 551-6 (1987)]**PEER REVIEWED**

Nickel dusts and several specific cmpd are carcinogenic in animals after inhalation or parenteral admin, but not by ingestion or skin contact. /**Nickel** dust and compounds/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-145]**PEER REVIEWED**

... **Nickel** also affects the hypothalamus of animals. **Nickel** salts specifically inhibited the release of prolactin in vivo (in the rat) and in vitro from bovine pituitary. /**Nickel** salts/
[WHO; Environ Health Criteria 108: Nickel p.190 (1991)]**PEER REVIEWED**

Ecotoxicity Values:

LC50 Channa punctatus 306.9 mg/l/96-hr /Conditions of bioassay not specified/ /**Nickel** ion/
[Saxena OP; J Environ Biol 4 (2): 91 (1983)]**PEER REVIEWED**

LC50 Daphnia magna 0.13 mg/l/3 weeks /Conditions of bioassay not specified/ /**Nickel** ion/
[Nat'l Research Council Canada; Effects of Nickel in the Canadian Environment p.28 (1981) NRCC 18568]**PEER REVIEWED**

LC50 Acroneuria lycoria 4 mg/l/96 hr /Conditions of bioassay not specified/ /**Nickel** ion/
[Nat'l Research Council Canada; Effects of Nickel in the Canadian Environment p.28 (1981) NRCC 18568]**PEER REVIEWED**

LC50 Artemia salina 163.0 mg/l/48 hr /Conditions of bioassay not specified/ /**Nickel** ion/
[Kissa E et al; Arch Hydrobiol 102 (2): 255-64 (1984)]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Absorption, Distribution & Excretion:

... RETAINED ESP BY LUNG, 38% OF ITS UPTAKE BEING PRESENT AFTER 72 HR, WHILE THE BRAIN, WITH 16.7%, ALSO RETAINED LARGER AMT THAN OTHER TISSUES. /**NICKEL**/

[Browning, E. Toxicity of Industrial Metals. 2nd ed. New York: Appleton-Century-Crofts, 1969. 252]**PEER REVIEWED**

INGESTED **NICKEL** IS EXCRETED PRIMARILY IN FECES, WHEREAS PARENTERALLY ADMIN **NICKEL** IS EXCRETED MOSTLY IN URINE.
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 288]**PEER REVIEWED**

APPROX 50% OF INHALED **NICKEL** DUST IS DEPOSITED ON BRONCHIAL MUCOSA & SWEPT UPWARD IN MUCUS TO BE SWALLOWED, ABOUT 25% IS EXHALED, & REST IS DEPOSITED IN THE PULMONARY PARENCHYMA. ... IV INJECTED **NICKEL** SALTS DISAPPEAR QUICKLY FROM BLOOD, INDICATING WIDESPREAD DISTRIBUTION IN TISSUES. IN SPITE OF FIRMLY CHELATED **NICKEL** IN HUMAN TISSUES, RETENTION OF NEWLY ACQUIRED **NICKEL** IN TISSUES IS TRANSIENT & POOR. ... UNDER CERTAIN PATHOLOGICAL CONDITIONS ... INCR AMT OF **NICKEL** ARE FOUND IN BLOOD ... EXCRETION OF INGESTED **NICKEL** CMPD IS MAINLY FECAL, WITH ONLY ABOUT 10% IN URINE; THIS ... IS NOTED ... IN DOGS & HUMANS. EXCRETION OF ABSORBED **NICKEL** & IV ADMIN **NICKEL** CMPD IS PRIMARILY URINARY (ABOUT 60%) & REST FECAL, PRESUMABLY FROM BILE, WHICH INDICATES AN ENTEROHEPATIC TRANSFER. /**NICKEL** CMPD/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 291]**PEER REVIEWED**

... OF INTEREST TO EMERGING ROLE OF WOMEN IN INDUSTRY, **NICKEL** CAN APPARENTLY CROSS ... PLACENTA, FOR **NICKEL** HAS BEEN FOUND IN HUMAN FETAL TISSUE & IN CORD SERUM WHERE AVG CONCN FROM 12 NEWBORNS WAS 0.3 TO 12 UG/DL (RANGE 0.17 TO 0.49), & WAS IDENTICAL WITH THAT IN MOTHER'S SERUM IMMEDIATELY AFTER DELIVERY. /**NICKEL** SALTS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1834]**PEER REVIEWED**

ABSORPTION FROM BOWEL IS POOR ... /**NICKEL** SALTS/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-145]**PEER REVIEWED**

Therapeutic or normal level of **nickel** in human blood was determined: 0.011 mg%, 0.11 ug/ml. /**Nickel**/

[Winek, C.L. Drug and Chemical Blood-Level Data 1985. Pittsburgh, PA: Allied Fischer Scientific, 1985.]**PEER REVIEWED**

Nickel is only sparsely absorbed from the GI tract. It is transported in the plasma bound to serum albumin and multiple small organic ligands, amino acids, or polypeptides. /Soluble **nickel** cmpd/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 713]**PEER REVIEWED**

Nickel admin parenterally to animals is rapidly distributed to kidney, pituitary, lung, skin, adrenal, and ovary and testis. /**Nickel** salts/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 713]**PEER REVIEWED**

IN ANIMAL EXPT ABOUT 90% OF INGESTED **NICKEL** WAS RECOVERED IN FECES, MEANING THAT ABOUT 10% MIGHT HAVE BEEN ABSORBED. ... 10 PERSONS WITH AVG FECAL ELIMINATION OF ... 258 UG/DAY HAD A CORRESPONDING URINARY EXCRETION OF 2.6 UG/DAY. ... THESE DATA INDICATE THAT ABSORPTION IS LESS THAN 10% IN HUMAN ... /**NICKEL** SALTS/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 467]**PEER REVIEWED**

WHEN SINGLE OR REPEATED IV INJECTIONS OF SOL **NICKEL** SALTS WERE GIVEN TO RABBITS, HIGHEST CONCN WAS FOUND IN KIDNEY. PITUITARY GLAND, LIVER & LUNG ALSO CONTAINED RELATIVELY LARGE AMT OF **NICKEL**. IN RATS GIVEN INTRATRACHEAL INJECTIONS OF SOL **NICKEL** SALTS, CONCN PATTERN WAS SIMILAR, WITH EXCEPTION THAT PITUITARY GLAND WAS NOT AS RICH ... /SOL **NICKEL** SALTS/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 468]**PEER REVIEWED**

Following parenteral admin of **nickel** salts in experimental animals, **nickel** is cleared rapidly from plasma and excreted predominantly in the urine. ... Only a few percent of an injected dose is excreted via the GI tract in the rat. Experiments on rabbits indicate that biliary excretion is the principal excretion mechanism for the GI tract. ... In human beings **nickel** is excreted via urine, saliva and sweat ... /**Nickel** salts/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 469]**PEER REVIEWED**

BOTH SERUM **NICKEL** & URINARY **NICKEL** SEEM TO BE GOOD INDICATORS OF ... EXPOSURE. ... PERSONS LIVING IN VICINITY OF LARGE **NICKEL** MINE HAD AVG SERUM CONCN OF 4.6 UG/L & EXCRETED 7.9 UG/DAY. THE CORRESPONDING VALUES IN NON-EXPOSED POPULATION WERE 2.6 UG/L & 2.6 UG/L. IN WORKERS IN **NICKEL** REFINERY A SIGNIFICANT CORRELATION WAS FOUND BETWEEN LEVELS OF **NICKEL** IN URINE & PLASMA. IN 3 GROUPS OF WORKERS WITH AVG PLASMA LEVELS OF 6.4, 7.2 & 11.9 UG/L, RESPECTIVELY, THE CORRESPONDING MEAN URINARY CONCN OF **NICKEL** WERE 44.6, 65.0 & 129.2 UG/L.
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 470]**PEER REVIEWED**

ABSORPTION OF **NICKEL** IS SMALL FROM ORDINARY DIETS. EXCRETION IS PRIMARILY THROUGH FECES; HOWEVER SIGNIFICANT AMT CAN BE LOST IN SWEAT. /**NICKEL**/
[Osol, A. and J.E. Hoover, et al. (eds.). Remington's Pharmaceutical Sciences. 15th ed. Easton, Pennsylvania: Mack Publishing Co., 1975. 969]**PEER REVIEWED**

NICKEL IS PRESENT IN LUNG, LIVER, KIDNEY, & INTESTINE OF MOST STILLBORN INFANTS. CONCN IN LUNG INCR WITH AGE. IN RATS BONES ACCUMULATE A MAJOR PORTION OF INCR INTAKE. ... **NICKEL** HAS BEEN FOUND IN BILE. /**NICKEL**/
[Casarett, L.J., and J. Doull. Toxicology: The Basic Science of Poisons. New York:

MacMillan Publishing Co., 1975. 488]**PEER REVIEWED**

Tissue distribution of **nickel** (II) after parenteral administration generally leads to highest accumulation in kidneys, endocrine glands, lung, and liver, with only slight uptake into bone, and little retention in soft or mineral tissue. /Divalent **nickel** salts/
[NAS; Report of the Committee on Med and Envir Poll: Nickel (1975)]**PEER REVIEWED**

Nickel concn were determined in roots and green parts of Cannabis sativa, Phleum pratense, Lyninus luteus, Zea mays, Cucumis sativus, and Avena sativa at Ni concn in soil of 2.5-50 ppm. Avena sativa and Lyninus luteus were most sensitive (> or = 5 ppm) and Cannabis sativa and Zea mays were least sensitive to Ni. Ni concn in roots are usually several fold higher than in green parts. Monocotyledons accumulated less Ni than dicotyledons. Zea mays had the highest ratio of root to leaf concns of Ni. Apparently, corn has a very efficient barrier against heavy metals between root and leaf. /Soluble **nickel** cmpd/
[Boratynski J, Fabiszewski J; Bioindyk Skazen Przem Roln, Mater Pokonf p.285-96 (1983)]**PEER REVIEWED**

AFTER ACUTE OR CHRONIC EXPOSURE OF RATS ... BY INHALATION, INCR IN **NICKEL** OCCUR PREDOMINANTLY IN MICROSOMAL & SUPERNATANT FRACTIONS OF LUNG & LIVER. AFTER CHRONIC EXPOSURE, INCR AMT OF NI ARE ALSO OBSERVED IN NUCLEAR & MITOCHONDRIAL FRACTION OF THE LUNG. /**NICKEL** AND **NICKEL** CMPD/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 100 (1976)]**PEER REVIEWED**

SIGNIFICANT UPTAKE & ACCUM OCCURRED IN 20, 40, & 80 MG **NICKEL**/L IN 96 HR EXPT. MUSSELS SECRETED BYSSAL THREADS IN CONCN OF 20 MG NI/L, BUT NOT IN HIGHER CONCN. /**NICKEL** AND **NICKEL** CMPD/
[FRIEDRICH AR ET AL; BULL ENVIRON CONTAM TOXICOL 16 (6): 750 (1976)]**PEER REVIEWED**

Metallic **nickel** oxide and nonsoluable salts are only very slowly (within tens of years) cleared from the mucous membranes of the respiratory tract. Soluable **nickel** salts are rapidly cleared and excreted in the urine. /**Nickel**/
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 145]**PEER REVIEWED**

An important factor for retention in the lung is the solubility of the **nickel** compounds. Insoluble forms, such as **nickel** oxide and metallic **nickel**, seem to be retained in the lung for a longer time, whereas the more soluble **nickel** salts are absorbed. They are also solubilized in the fluids and mucus cleared from the lung by the mucociliary mechanisms into the alimentary tract.
[WHO; Environ Health Criteria 108: Nickel p.107 (1991)]**PEER REVIEWED**

Nickel is poorly absorbed from ordinary diets and is eliminated mainly in the feces. This has been shown in a **nickel** balance study on dogs ... in which the **nickel** intake in the food was equal to the output in the urine and feces. The results also indicated than an avg of 90% ... of the amt of **nickel** ingested ... was eliminated in the feces. In rats, even at very high intakes of **nickel** (approx 14.5 mg) from different sources, over periods of 4, 8, 12, and 16 days, **nickel** was absorbed poorly (0.15 mg, i.e., 1%) and was eliminated mainly in the feces (13.9 mg = 96%). Levels of retained **nickel** avg 0.5 mg (range: 0.29-0.8 mg), i.e., 3.5% ... . /**Nickel**/
[WHO; Environ Health Criteria 108: Nickel p.110 (1991)]**PEER REVIEWED**

Biological Half-Life:

For the first 50 hr after exposure, the biological half-life of **nickel** in rat plasma was 6.3 hr, and in rabbit plasma it was 7.5 hr. /**Nickel** salts/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 469]**PEER REVIEWED**

On the basis of **nickel** values in air, plasma and urine in four **nickel** platers during one working week ... /the investigators/, assuming a one-compartment model, computed the biological half-life for **nickel** in plasma to range from 20 to 34 hr and in urine from 17 to 39 hr. /**Nickel**/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 469]**PEER REVIEWED**

The kinetics of sol Ni2+ cmpd admin to rats and rabbits by parenteral routes confirm to a two-compartment model; the biological half-life for injected (63)Ni2+ in rats is approx 10 hr. /**Nickel**(2+) sol compounds/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 458]**PEER REVIEWED**

Mechanism of Action:

... **NICKEL** SALTS CAUSE INJURY OR DESTRUCTION OF ALPHA CELLS OF PANCREAS, & ... TO A LESS EXTENT, DAMAGE TO BETA CELLS. /**NICKEL** SALTS/
[Thienes, C., and T.J. Haley. Clinical Toxicology. 5th ed. Philadelphia: Lea and Febiger, 1972. 203]**PEER REVIEWED**

... HAS INDIRECT EFFECTS ON MANY BODY ENZYME SYSTEMS, & ON PIGMENTATION. /**NICKEL**/
[Rossoff, I.S. Handbook of Veterinary Drugs. New York: Springer Publishing Company, 1974. 383]**PEER REVIEWED**

DIVALENT **NICKEL** IONS CAN PENETRATE SKIN AT SWEAT-DUCT & HAIR FOLLICLE OSTIA, & BIND WITH KERATIN. CONTACT DERMATITIS THUS RESULTS FROM PERMEABILITY OF ... DERMIS & EPIDERMIS TO **NICKEL**. /**NICKEL** SALTS/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 292]**PEER REVIEWED**

LOCALIZATION OF INJECTED **NICKEL** SALTS IN PITUITARY GLAND & SUBSEQUENT DECREASED SERUM LEVEL OF PROLACTIN SUGGEST THAT DIVALENT **NICKEL** EXERTS A DIRECT SPECIFIC INHIBITORY ACTION ON PROLACTIN-SECRETING CELLS IN ANTERIOR PITUITARY. /**NICKEL** SALTS/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 295]**PEER REVIEWED**

... **NICKEL** CMPD FORM COMPLEXES WITH SERUM PROTEINS OR ULTRAFILTRABLE MOLECULES ... THESE ... COMPLEXES ADSORB TO SURFACE OF CELL & ENTER ... BY ENDOCYTOSIS. WITHIN CELL, LYSOSOMAL PROTEINASES HYDROLYZE CARRIER PROTEIN TO RELEASE ELECTROPHILIC METAL ION. **NICKEL** IONS THEN BIND WITH NUCLEIC ACIDS & ... CELLULAR CONSTITUENTS.
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 296]**PEER REVIEWED**

... /**NICKEL**/ CAN ACTIVATE PANCREATIC RIBONUCLEASE & DESOXYRIBONUCLEASE I & CAN REPLACE ZINC IN CARBOXYPEPTIDASE & CARBONIC ANHYDRASE ... INHIBITION OF RNA POLYMERASE & ATPASE ARE OF PARTICULAR SIGNIFICANCE ... /**NICKEL**/

[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1836]**PEER REVIEWED**

The intracellular distribution and binding of **nickel** is not well understood. Ultrafiltrable ligands seem to be of major importance in transport in serum and bile and urinary excretion as well as intracellular binding. The ligands are not well characterized, but ... /the investigator/ suggests that cysteine, histidine, and aspartic acid form **nickel** complexes either singly or as **nickel**-ligand species. In vivo binding with metallothionein has been demonstrated, but **nickel** at best induces metallothionein synthesis in liver or kidney only slightly. /Soluble **nickel** cmpd/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 713]**PEER REVIEWED**

The mechanisms of **nickel** toxicity are not well understood, but studies ... suggest that acute Ni2+ toxicity in rats is assoc with lipid peroxidation in target organs. The chemical reactions whereby Ni2+ induces lipid peroxidation in vivo have not yet been explained, however, ... proposed the following four possible mechanisms: i.) An indirect mechanism owing to Ni2+ displacement of iron and copper from intracellular binding sites; ii) An indirect mechanism, by which Ni2+ inhibits cellular defences against peroxidative damage, mediated by catalase, superoxide dismutase, glutathione peroxidase, aldehyde dehydrogenase, or other enzymes that protect against free-radical injury or that metabolize products of lipid peroxidation; iii) Generation of oxygen-free radicals by the redox couple ... iv) Ni2+ may accelerate the degradation of lipid hydroperoxides to form lipid-oxygen radicals, propagating autocatalytic peroxidation of polyenoic fatty acids /**Nickel**/
[WHO; Environ Health Criteria 108: Nickel p.182 (1991)]**PEER REVIEWED**

... In the presence of certain peptides, the Ni3+/Ni2+ redox couple can participate in dioxygen radical reactions in vitro. As chemical promoters of cancer appear to have the capacity to stimulate phagocytic cells to produce dioxygen radicals, which may damage DNA, proteins and lipids, and as metal ions catalyze processes involving molecular oxygen, this observed effect of **nickel** may have implications for **nickel** carcinogenesis. /**Nickel** ions/
[WHO; Environ Health Criteria 108: Nickel p.255 (1991)]**PEER REVIEWED**

The activity of the DNA repair protein O6-alkylguanine-DNA-alkyltransferase was found to be strongly inhibited by a number of metal ions. However, other metals or metallic compounds which are known to be carcinogenic (such as compounds containing arsenic, lead, **nickel**, or chromium) did not interfere with DNA repair by this protein.
[Scicchitano DA, Pegg AE; Mutat Res 192 (3): 207-10 (1987)]**PEER REVIEWED**

The parent wild strain Neurospora crassa Em 529a and 3 **nickel**(2) resistant Neurospora crassa mutants excreted pyruvic acid into the culture medium in **nickel**(2) ... toxicities. The excretion is progressive with growth inhibition and is abolished by magnanese(2) in all strains and by iron(3) partially in the Em strain but not in Neurospora crassa NiR1. Pyruvate, citric acid, and malic acid supplementation reverse growth inhibition caused by excess **nickel** (2), but with concomitant suppression of **nickel**(2) accumulation. Apparently, one of the features of **nickel**(2) toxicity in Neurospora crassa is a derangement in carbohydrate metabolism at step(s) beyond pyruvate.
[Mohan PM, Sastry KS; J Biosci 6 (3): 283-8 (1984)]**PEER REVIEWED**

In vitro studies have shown **nickel** to be an activator of several enzymes. **Nickel** stabilizes RNA and DNA against thermal denaturation and may have a role in membrane structure or metabolism.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 15(81) 598]**PEER REVIEWED**

Nickel readily crosses the cell membrane via Ca2+ channels and competes with Ca2+ for specific

receptors.
[Ellenhorn, M.J., S. Schonwald, G. Ordog, J. Wasserberger. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. 2nd ed. Baltimore, MD: Williams and Wilkins, 1997. 1604]**PEER REVIEWED**

Interactions:

... SOL **NICKEL** SALTS IN DRINKING WATER PRODUCED ADVERSE EFFECTS ON RAT REPRODUCTION WHEN CHROMIUM WAS ADDED TO DIET IN TRACE AMT. /**NICKEL** SALTS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1829]**PEER REVIEWED**

An interaction of **nickel** with copper and zinc is suspected since anemia-induced **nickel** deficiency is only partially corrected with **nickel** supplementation in rats receiving low dietary copper and zinc. /**Nickel**/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 713]**PEER REVIEWED**

Certain oral medications (eg, disulfiram (tetraethylthiuram disulfide) used for aversion therapy of alcoholism) can cause incr **nickel** concn in blood and urine by enhancing its gastrointestinal uptake. /**Nickel**/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 457]**PEER REVIEWED**

Co-administration of high doses of vitamin C to ... weanling rats offset the effects of oral **nickel** exposure on growth rate, and the activity of certain enzymes, such as liver and kidney succinic dehydrogenase and liver glutamic-oxaloacetic transaminase. /Soluble **nickel** cmpd/
[USEPA; Health Assessment Document: Nickel p.93 (1983) EPA-600/8-83-012]**PEER REVIEWED**

Divalent **nickel** appears to antagonize the digoxin induced arrhythmias in the rat, rabbit, and guinea pig in both intact, as well as, isolated hearts, ... by either binding competitively with calcium ion at cell membranes or provoking an increase in malic and oxaloacetic acid activity. /Soluble **nickel** cmpd/
[USEPA; Health Assessment Document: Nickel p.93 (1983) EPA 600/8-83-012]**PEER REVIEWED**

Chlorine-**nickel** (Cl-Ni) temperature interactions were studied in rainbow trout (Salmo gairdneri). Mortality in chlorine-**nickel** test groups was significantly greater than predicted by an additive interaction. chlorine-**nickel** treatment groups with high chlorine concn, regardless of the level of Ni, had higher mortality rates than chlorine-**nickel** treatment groups with low chlorine concn. Chlorine-**nickel** treatment groups with low chlorine concn, regardless of Ni concn, showed greater percentage mortality than treatment groups with either Ni or chlorine alone. When chlorine and Ni were combined, the chlorine concn was the key factor in determining mortality, even at sublethal levels of chlorine for the concn tested. Temperature did not influence toxicity as strongly as either chlorine or Ni concn. The presence of 0.018 ppm total residual chlorine significantly increased Ni accumulation in tissues from fish exposed to chlorine and Ni, when compared with tissue samples from fish under similar exposure conditions in the absence of chlorine. The increased Ni concn may be attributed to an increase in the permeability of the gill to Ni during chlorine exposures. /Soluble **nickel** cmpd/
[Anderson DR; Environ Impact Health Eff 4 (2): 811-26 (1983)]**PEER REVIEWED**

Suggested that iron might affect **nickel** absorption. Using isolated intestinal segments of rats in an in

vitro test system, they found that **nickel** ions had their own transport system located in the proximal part of the intestine, thus making it likely that iron nutrition could affect **nickel** absorption ... Found that the transfer of **nickel** from the mucosal to the serosal side was elevated in iron-deficient intestinal segments.

[WHO; Environ Health Criteria 108: Nickel p.113 (1991)]**PEER REVIEWED**

Pharmacology:

Interactions:

... SOL **NICKEL** SALTS IN DRINKING WATER PRODUCED ADVERSE EFFECTS ON RAT REPRODUCTION WHEN CHROMIUM WAS ADDED TO DIET IN TRACE AMT. /**NICKEL** SALTS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1829]**PEER REVIEWED**

An interaction of **nickel** with copper and zinc is suspected since anemia-induced **nickel** deficiency is only partially corrected with **nickel** supplementation in rats receiving low dietary copper and zinc. /**Nickel**/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 713]**PEER REVIEWED**

Certain oral medications (eg, disulfiram (tetraethylthiuram disulfide) used for aversion therapy of alcoholism) can cause incr **nickel** concn in blood and urine by enhancing its gastrointestinal uptake. /**Nickel**/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 457]**PEER REVIEWED**

Co-administration of high doses of vitamin C to ... weanling rats offset the effects of oral **nickel** exposure on growth rate, and the activity of certain enzymes, such as liver and kidney succinic dehydrogenase and liver glutamic-oxaloacetic transaminase. /Soluble **nickel** cmpd/
[USEPA; Health Assessment Document: Nickel p.93 (1983) EPA-600/8-83-012]**PEER REVIEWED**

Divalent **nickel** appears to antagonize the digoxin induced arrhythmias in the rat, rabbit, and guinea pig in both intact, as well as, isolated hearts, ... by either binding competitively with calcium ion at cell membranes or provoking an increase in malic and oxaloacetic acid activity. /Soluble **nickel** cmpd/
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permeability of the gill to Ni during chlorine exposures. /Soluble **nickel** cmpd/
[Anderson DR; Environ Impact Health Eff 4 (2): 811-26 (1983)]**PEER REVIEWED**

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[WHO; Environ Health Criteria 108: Nickel p.113 (1991)]**PEER REVIEWED**

Bionecessity:

Nickel deficiency has been reported in ... birds; deficiency is unlikely in humans taking a conventional diet; the margin between required & toxic concn is wide. /**Nickel**/
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 47]**PEER REVIEWED**

Pathological signs of **nickel** deficiency have been produced in chickens, rats and swine. Retarded growth, anemia and decr enzyme activities are among the signs seen in rat. /**Nickel**/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 471]**PEER REVIEWED**

In vitro studies have shown **nickel** to be an activator of several enzymes. **Nickel** stabilizes RNA and DNA against thermal denaturation and may have a role in membrane structure or metabolism. /**Nickel**/
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 15(81) 598]**PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Nickel's use in the production of steel and various alloys, in electroplating, **nickel**-cadmium batteries, fuel cells, electronic circuitry and miscellaneous other applications, may result in its release to the environment through various waste streams. Approximately 0.009% of the earth's crust is **nickel**. Estimated worldwide atmospheric emissions of **nickel** from natural sources include (% of total emissions) windblown dust: 9.3%; volcanoes: 4.9% and vegetation: 1.6%. **Nickel** compounds are expected to exist in the particulate phase in the ambient atmosphere. An exception is **nickel** carbonyl which is expected to exist entirely in the vapor phase. Particulate-phase **nickel** will be removed from the atmosphere by wet and dry deposition. If released to soil, soluble **nickel** compounds such as **nickel** chlorides and **nickel** nitrate, will tend to migrate more than the insoluble compounds such as **nickel** oxides and **nickel** sulfides. Volatilization from moist and dry soil surfaces is not expected to be an important fate process based upon the low vapor pressures for most **nickel** compounds. An exception is **nickel** carbonyl which is expected to volatilize from moist and dry soil surfaces. If released into water, **nickel** compounds are expected to adsorb to suspended solids and sediment in water. Due to their low vapor pressure and ionic form, volatilization from water surfaces is not expected to be an important fate process for most **nickel** compounds. An exception is **nickel** carbonyl which is expected to volatilize from water surfaces. BCFs ranging from 40-100 suggest that the potential for bioconcentration in aquatic organisms is low to moderate. Occupational exposure to **nickel** and **nickel** compounds may occur through inhalation of dust particles and fumes and dermal contact with this compound at workplaces where **nickel** is produced or used. Cigarette smoking increases exposure to **nickel**. The general population may be exposed to **nickel** and **nickel** compounds via inhalation of ambient air, ingestion of

food and drinking water, and dermal contact with this compound and other products containing **nickel** and **nickel** compounds. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

HIGHEST RISK OF MORTALITY FROM CANCER OF RESP TRACT IS FOUND AMONG **NICKEL** MINE WORKERS INVOLVED IN ROASTING, SMELTING, & ELECTROLYSIS.
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 296]**PEER REVIEWED**

EPIDEMIOLOGICAL STUDIES CONCLUSIVELY DEMONSTRATE AN EXCESS OF CANCER OF THE NASAL CAVITY & LUNG IN WORKERS IN **NICKEL** REFINERIES. IT IS LIKELY THAT **NICKEL** IN SOME FORM IS CARCINOGENIC TO MAN. /**NICKEL**/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 104 (1976)]**PEER REVIEWED**

THE INDUSTRIAL MOND PROCESS WAS DEVELOPED IN WALES FOR PRODUCTION OF PURE **NICKEL** & REQUIRED MIXTURE OF **NICKEL** OXIDE & CARBON MONOXIDE TO MAKE **NICKEL** CARBONYL. IT IS THIS PROCESS WHICH HAS BEEN THE GREATEST CAUSE OF INDUSTRIAL ILLNESS ASSOCIATED WITH **NICKEL** EXPOSURE.
[Hamilton, A., and H. L. Hardy. Industrial Toxicology. 3rd ed. Acton, Mass.: Publishing Sciences Group, Inc., 1974. 151]**PEER REVIEWED**

The toxicologically important routes of entry for **nickel**, metal & sol compounds (as Ni) are inhalation, skin absorption, ingestion, and skin and/or eye contact. /**Nickel** and **nickel** cmpd/
[NIOSH. Pocket Guide to Chemical Hazards. 5th Printing/Revision. DHHS (NIOSH) Publ. No. 85-114. Washington, D.C.: U.S. Dept. of Health and Human Services, NIOSH/Supt. of Documents, GPO, Sept. 1985.173]**PEER REVIEWED**

The route by which most people in the general population receive the largest portion of daily **nickel** intake is through food. /**Nickel** and **nickel** cmpd/
[USEPA; Ambient Water Quality Criteria Document: Nickel p.C-130 (1980) EPA 400/5-80-060]**PEER REVIEWED**

Metallic **nickel** or soluble **nickel** compounds can affect the body if they are inhaled or if they come in contact with eyes or skin. They also can affect the body if they are swallowed. /**Nickel** and **nickel** compounds/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

SOL **NICKEL** SALTS ... PRESENT EXPOSURE POTENTIAL FROM THEIR USE IN ELECTROPLATING BATHS & IN PREPN OF **NICKEL** CATALYSTS. **NICKEL** DERMATITIS, "**NICKEL** ITCH", CONSTITUTES MOST COMMON AFFECTION AMONG **NICKEL** PLATERS. ... HEAT AROUND **NICKEL** PLATING BATHS IS CONSIDERED TO BE A PREDISPOSING FACTOR. /**NICKEL** SALTS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1822]**PEER REVIEWED**

Occupational exposures to **nickel** and its cmpd occur in (1) mining and comminution of **nickel** containing ores; (2) **nickel** refining and smelting; (3) **nickel** electroplating; (4) producing and using

nickel catalysts; (5) fabricating parts and structures by welding, flame spraying, cutting, grinding, and polishing of **nickel** containing alloys; (6) manufacturing **nickel** cadmium batteries; (7) constructing **nickel** molds in glass bottle factories; (8) spraying **nickel** containing paints (eg, yellow **nickel** titanate pigment); and (9) recycling or disposal of **nickel** containing products. /**Nickel** & compounds/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 455]**PEER REVIEWED**

IN **NICKEL** PLATING INDUSTRY, EXPOSURE TO **NICKEL**-CONTAINING MISTS HAS BEEN REPORTED TO BE ASSOC WITH ASTHMA. SYMPTOMS WERE ATTRIBUTED TO HYPERSENSITIVITY TO **NICKEL**. ... EFFECTS ON NASAL MEMBRANE WERE NOTED IN WORKERS EXPOSED TO **NICKEL** AEROSOLS IN AN ELECTROLYSIS SHOP. /**NICKEL** SALTS/
[Friberg, L., G.R. Nordberg, and V.B. Vouk. Handbook on the Toxicology of Metals. New York: Elsevier North Holland, 1979. 549]**PEER REVIEWED**

Occupational groups such as **nickel** workers and other workers handling **nickel** comprise the individuals at the highest risk. Women, particularly housewives, are at special risk to **nickel** induced skin disorders because of the greater than average contact with **nickel** containing materials. Approximately 47 million individuals, comprising the smoking population of the United States, are potentially at risk for possible co-factor effects of **nickel** in adverse effects on the respiratory track. /**Nickel** and **nickel** cmpd/
[USEPA; Ambient Water Quality Criteria Doc: Nickel p.C-130 (1980) EPA 400/5-80-060]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 507,681 workers (19,673 of these are female) are potentially exposed to **nickel** and **nickel** compounds in the US(1). Occupational exposure to **nickel** and **nickel** compounds may occur through inhalation of dust particles and fumes and dermal contact with this compound at workplaces where **nickel** and **nickel** compounds are produced or used(SRC). Exposure to **nickel** and **nickel** compounds is common for workers in industrial operations that involve **nickel** or **nickel** compounds, such as mining, smelting, welding, casting, spray painting and grinding(2). The general population may be exposed to **nickel** and **nickel** compounds via inhalation of ambient air, ingestion of food and drinking water, and dermal contact with this compound and other products containing **nickel** and **nickel** compounds(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983) (2) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment; Merian E, ed. NY, NY: Weinheim (1991)]**PEER REVIEWED**

Body Burden:

... Mean serum levels of 2.6 ... and 3.1 ug/l ... in persons living in Connecticut ... In newborns, the serum concn of **nickel** were similar to those of mothers, ie an avg of 3 ug/l ... In whole blood, a level of 4.8 ug/l has been reported. ... Avg **nickel** concn /was/ ... 0.22 ug/l in hair. ... Hair values were 0.6 and 1 ug/g in men and women ... /**Nickel** and **nickel** cmpd/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 470]**PEER REVIEWED**

Nickel concn in specimens from healthy, nonexposed adults: Whole blood: 0.34 + or - 0.28 ug/l; Serum: 0.28 + or - 0.24 ug/l; Urine (spot collection): 2.0 + or - 1.5 ug/l; Urine (24 hr collection): 2.2 + or - 1.2 ug/l; Feces (3 day collection): 14.2 + or - 2.7 ug/g dry wt /From table/ /**Nickel** and **nickel** cmpd/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 463]**PEER REVIEWED**

Usually, Ni is found at low levels (< 0.1 mg/kg, wet weight) in most human tissues and body fluids. The average population has 3-7 ug Ni/l of whole blood, 1-5 ug Ni/l in blood serum, and 1-5 ug Ni/l in urine.

Perspiration contains 52 + or - 36 ug Ni/l. /**Nickel** and **nickel** cmpd/
[Nat'l Research Council Canada; Effects of Nickel in the Canadian Environment p.29 (1981) NRCC 18568]**PEER REVIEWED**

In 24 hr urine: reference range (conventional): 2.6 ug + or - 1.3 (1 SD) (male); 2.2 + or - 0.8 ug/dl (female); 8-800 ug/l (refinery workers); reference range (international recommended): 44.2 + or - 22.1 nmol/d (1 SD) (male); 37.4 + or - 13.6 (female); 136-13,600 nmol/l (refinery workers); In feces: reference range (conventional): 260 + or - 120 ug/d (1 SD) (adult); reference range (international recommended): 4.4 + or - 2.1 umol/d (1 SD) (adult) /**Nickel** and **nickel** cmpd/
[Tietz, N.W. (ed.). Clinical Guide to Laboratory Tests. Philadelphia, PA: W.B. Saunders Co., 1983. 358]**PEER REVIEWED**

In 24 hr urine: reference range (conventional): 100-2500 ug/l; reference range (international recommended): 1700-42500 nmol/l.
[Tietz, N.W. (ed.). Clinical Guide to Laboratory Tests. Philadelphia, PA: W.B. Saunders Co., 1983. 358]**PEER REVIEWED**

In hair: reference range (conventional): 0.24 ug + or - 0.09 ug/kg and 0.19 + or - 0.04 ug/kg (adult); reference range (international recommended): 4.1 + or - 1.5 ug/kg and 3.2 + or - 0.7 ug/kg (adult) /**Nickel** and **nickel** cmpd/
[Tietz, N.W. (ed.). Clinical Guide to Laboratory Tests. Philadelphia, PA: W.B. Saunders Co., 1983. 358]**PEER REVIEWED**

... Serum **nickel** was found to be 2.6 + or - 0.9 ug/l (range: 0.8 to 5.2) and mean excretion of **nickel** in urine of 2.6 + or - 1.4 ug/day (range: 0.5 to 6.4). ... Serum **nickel** measured in persons living in Sudbury, Ontario, which is in the vicinity of a large **nickel** mine, showed concn of 4.6 + or - 1.4 ug/l (range: 2.0 to 3.7) and urinary concn were 7.9 + or - 3.7 ug/day (range: 2.3 to 15.7). Generally, fetal **nickel** is about 100 times urine **nickel** concn. /**Nickel** and **nickel** cmpd/
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 610]**PEER REVIEWED**

Normal level of **nickel** in human blood: 0.011 mg%, 0.11 ug/ml. /**Nickel**/
[Winek CL; Drug & Chemical Blood-Level Data Nickel (1985)]**PEER REVIEWED**

NICKEL HAS BEEN FOUND IN HUMAN FETAL TISSUE & IN CORD SERUM WHERE AVG CONCN FROM 12 NEWBORNS WAS 0.3 TO 12 UG/DL (RANGE 0.17 TO 0.49), & WAS IDENTICAL WITH THAT IN MOTHER'S SERUM IMMEDIATELY AFTER DELIVERY. /**NICKEL** SALTS/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1834]**PEER REVIEWED**

The avg body burden of **nickel** in healthy adults is 7.3 ug/kg body weight(1). The range and avg **nickel** concns in whole blood, serum, urine (24-hour collection) and feces (72-hour collection) of non-exposed, healthy adults are: <0.05-1.05 ug/l, 0.34 ug/l; <0.05-1.08 ug/l, 0.28 ug/l; 0.7-5.2 ug/l, 2.2 ug/l, and 10.8-18.6 ug/g, 14.2 ug/g (dry weight)(1). The following mean, median, and ranges of **nickel** concns in various body tissues were found in non-occupationally exposed individuals (wet weight; number of observations indicated in parentheses): lung - 18, 12, 7-46 (9); thyroid - 20,24, 7-32 (8); adrenal - 26, 24, 13-56 (10); kidney - 9, 7, 3-25 (10); heart - 8, 6, 1-14 (9); liver - 10, 8, 2-21 (10); brain - 8, 8, 5-11 (7); spleen - 7, 4, 1-15 (10); pancreas - 8, 6, 9-19 (10)(2).
[(1) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment. Merian E, ed. NY, NY: Weinheim (1991) (2) ATSDR; Toxicological Profile for Nickel. ATSDR/TP-88/19 pp. 1-70 (1988)]**PEER REVIEWED**

Average Daily Intake:

The average daily oral intake of **nickel** has been reported to be 300 to 600 ug/day. /**Nickel** and **nickel** cmpd/
[48 FR 45502 (10/05/83)]**PEER REVIEWED**

The highest level of **nickel** observed in water was 75 ug/l. Average drinking water levels are about 5 ug/l. A typical consumption of 2 liters daily would yield an additional intake of 10 ug of **nickel**, of which 1 ug would be expected to be absorbed. /**Nickel** and **nickel** cmpd/
[USEPA; Ambient Water Quality Criteria Doc: Nickel p.C-130 (1980) USEPA 400/5-80-060]**PEER REVIEWED**

Average daily **nickel** intake from food in institutionalized children 9-12 years of age from 28 US cities was 451 ug/l. /**Nickel** and **nickel** cmpd/
[Murthy GD et al; Envir Sci Tech 7: 1042 (1973)]**PEER REVIEWED**

Nickel content of nine institutional diets in the US would result in an avg Ni intake of 165 ug/day. /**Nickel** and **nickel** cmpd/
[Myron DR et al; Am J Clin Nutr 31: 527 (1978)]**PEER REVIEWED**

Nickel may be inhaled by urban residents at a rate of about 2-14 ug/day. /**Nickel** and **nickel** cmpd/
[NAS; Report of the Committee on Med and Envir Poll; Nickel (1975) as cited in NTP; Chem Selection Profile: Nickel Chloride p.2 (1979)]**PEER REVIEWED**

In a ... study of **nickel** content of diets prepared in university or hospital kitchens in the US, ... /the investigators/ found **nickel** intake to avg 165 (SD +/- 11) ug/day or 75 +/- 10 ug/1000 cal.
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 610]**PEER REVIEWED**

Average **nickel** intake for American adults is 300-600 ug/day. /**Nickel** and **nickel** cmpd/
[Schroeder HA et al; J Chronic Dis 15: 51-65 (1962)]**PEER REVIEWED**

/Daily intake/ in seafood /ranges from/ 0.3-1.7 ug/g. /**Nickel** and **nickel** cmpd/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 465]**PEER REVIEWED**

Estimates of the avg daily intake of **nickel** range from 0.14 to 0.6 mg/day(1). Diet is the source of approximately 83-94% of the body burden of **nickel**(2). The inhalation of **nickel** in urban areas is reported to range between 0.2 to 1.0 ug/day, with an avg rate of 0.4 ug/day; in rural areas the range is 0.1-0.4 ug/day with an avg of 0.2 ug/day(1). Smoking cigarettes can increase the intake of **nickel** by 4 ug/day per pack of cigarettes smoked(1).
[(1) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment; Merian E, ed. NY, NY: Weinheim (1991) (2) ATSDR; Toxicological Profile for Nickel. ATSDR/TP-88/19. pp. 1-70 (1988)]**PEER REVIEWED**

Natural Pollution Sources:

Found in many ores as sulfides, arsenides, antimonides and oxides or silicates; chief sources incl chalcopyrite ... pyrrhotite, pentlandite ((Fe,Ni)S8) and garnierite (3(Mg,Ni)O.-2SiO2.2H2O); other ores incl niccolite ... and millerite (NiS).
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1116]**PEER REVIEWED**

NICKEL ... IS IN SEAWATER AT 2-5 PPB. ... **NICKEL** OCCURS IN VERY MINOR QUANTITIES IN ALL TYPES OF COAL ...

[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 289]**PEER REVIEWED**

NICKEL CONSTITUTES 0.03% OF THE PARTICULATE MATTER SUSPENDED IN ATMOSPHERE.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 131 (1973)]**PEER REVIEWED**

Natural sources of airborne particles that contain **nickel** include soil, sea, volcanoes, forest fires, and vegetation. /**Nickel** and **nickel** cmpd/
[Davies CN; Atmos Envir 8: 1069-79 (1974) as cited in Nat'l Research Council Canada; Effects of Nickel in the Canadian Environ p.60 (1981) NRCC No.18568]**PEER REVIEWED**

Average concn of **nickel** in the earth's crust is 60-90 mg/kg. /**Nickel** and **nickel** cmpd/
[Nat'l Research Council Canada; Effects of Nickel in the Canadian Environ p.27 (1981) NRCC No.18568]**PEER REVIEWED**

Approximately 0.009% of the earth's crust is **nickel**(1). The largest economic reserves are located in Canada, Cuba and Russia(2). An estimated 8X10+08 tons of **nickel** are present in seabed nodules, which contain approximately 1% **nickel**(2). As of 1992, approximately 50% of **nickel** comes from sulfide deposits mined in Canada, Russia and Finland(2). The other economically-significant source of **nickel** is found in lateritic ores, in the form of oxides and silicates, which are found in regions that are, or which were once tropical or subtropical for extended periods(2). Ni(II) is the most common oxidation state(3). Estimated worldwide atmospheric emissions of **nickel** from natural sources include (% of total emissions) windblown dust: 9.3%; volcanoes: 4.9% and vegetation: 1.6%(1).
[(1) ATSDR; Toxicological Profile for Nickel. ATSDR/TP-88/19 pp. 1-70 (1988) (2) Tunderman JH et al; Kirk-Othmer Encycl Chem Technol 4th ed NY, NY: John Wiley and Sons 17: 3-4 (1992) (3) Antonsen DH; Kirk-Othmer Encycl Chem Technol 4th ed NY, NY: John Wiley and Sons 17: 18-36 (1992)]**PEER REVIEWED**

Artificial Pollution Sources:

Cigarette smoking can contribute significantly to man's daily **nickel** intake by inhalation and **nickel** from this source probably exceeds the amount absorbed by breathing ambient air. /**Nickel** and cmpd/
[USEPA; Ambient Water Quality Criteria Document : Nickel p.C-18 (1980) EPA 400/5-80-060]**PEER REVIEWED**

Regular gasoline contains 0.001-0.07 mg/kg Ni; Premium gasoline contains 0.003-1.5 mg/kg Ni; Low-lead contains 0.03-2.0 mg/kg Ni. /**Nickel** and cmpd/
[Jungers RH et al; Environ Health Perspect 10: 143-150 (1975) as cited in Nat'l Research Council Canada; Effects of Nickel in the Canadian Environ p.59 (1981) NRCC No.18568]**PEER REVIEWED**

Crude oil (Canadian): 0.4-35 mg/kg of Ni; Crude oil (Venezuelan): 2-45 mg/kg of Ni; Heavy fuel oil (Canadian): 3-72 mg/kg of Ni; Light fuel oil: <0.05-0.09 mg/kg of Ni; Diesel oil: <0.05-0.06 mg/kg of Ni. /**Nickel** and cmpd/
[Petroleum Assoc for Conservation of the Canadian Envir; Determination of Trace Elements in Canadian Petroleum Feedstocks and Prod. Report No 77-5 80pp. (1977) as cited in Nat'l Research Council Canada; Effects of Nickel in the Canadian Environ p.59 (1981) NRCC No.18568]**PEER REVIEWED**

NICKEL SALTS ARE CONSIDERED AN INDUSTRIAL HEALTH HAZARD BECAUSE MANY **NICKEL** COMPOUNDS ARE RELEASED INTO THE ATMOSPHERE DURING MINING, SMELTING, & REFINING OPERATIONS. /**NICKEL** SALTS/

[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 290]**PEER REVIEWED**

The extraction, processing and use of **nickel** compounds may result in their release to the environment through various waste streams(SRC). There are over 237,000 **nickel** compounds(1). Estimated worldwide atmospheric emissions of **nickel** from artificial sources include (% of total emissions) residual and fuel oil combustion: 52%, **nickel** mining and refining: 14%; incineration: 10%; steel production: 2.3%; gasoline and diesel fuel combustion: 1.8%; **nickel** alloy production: 1.4%; coal combustion: 1.3%(1).
[(1) Antonsen DH; Kirk-Othmer Encycl Chem Technol 4th ed NY, NY: John Wiley and Sons 17: 18-36 (1992)]**PEER REVIEWED**

Environmental Fate:

AQUATIC FATE: The mobility of **nickel** in the aquatic environment is controlled largely by the capability of various sorbents to scavenge it from solution. Although data are limited, it appears that in pristine environments, hydrous oxides of iron and manganese control **nickel**'s mobility via co-precipitation and sorption. In polluted environments, the more prevalent organic material will keep **nickel** soluble. In reducing environments, insoluble **nickel** sulfide may be formed. Although **nickel** is bioaccumulated, the concn factors are such as to suggest that partitioning into the biota is not a dominant fate process. **Nickel** is one of the most mobile of the heavy metals in the aquatic environment. /**Nickel** and **nickel** cmpd/
[Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume I. EPA-440/4 79-029a. Washington, DC: U.S. Environmental Protection Agency, December 1979.p. 15-6]**PEER REVIEWED**

ATMOSPHERIC FATE: The atmosphere is a major conduit for **nickel** as particulate matter. Contributions to atmospheric loading come from both natural sources and anthropogenic activity, with input from both stationary and mobile sources. Various dry and wet precipitation processes remove particulate matter as wash out or fallout from the atmosphere with transfer to soils and waters. Soil borne **nickel** may enter waters by surface runoff or by percolation into ground water. Once **nickel** is in surface and ground water systems, physical and chemical interactions (complexation, precipitation/dissolution, adsorption/desorption, and oxidation/reduction) occur that will determine its fate and that of its constituents. /**Nickel** and cmpd/
[USEPA; Health Assessment Document: Nickel p.20 (1983) EPA 600/8-83-012]**PEER REVIEWED**

TERRESTRIAL FATE: In general, the mobility of **nickel** compounds that are soluble in water, such as **nickel** chlorides and **nickel** nitrate, will tend to be greater than the mobility of insoluble compounds such as **nickel** oxides and **nickel** sulfides(1,SRC). At pH values less than 6.5 the soluble **nickel** compounds predominate(2), increasing the mobility of **nickel**. Organic substances and sulphate ion can increase the mobility of **nickel** through the formation of complexes(3). In polluted environments, the presence of EDTA, a common substitute for polyphosphates, will tend to increase the mobility of **nickel** and **nickel** compounds through the formation of complexes(4). The majority of **nickel** compounds are not expected to volatilize from moist or dry soil surfaces, based on their low vapor pressures(5). One notable exception is **nickel** carbonyl which is expected to volatilize from moist and dry soil surfaces based on its estimated Henry's Law constant(SRC) and vapor pressure(5). However **nickel** carbonyl is unstable under normal atmospheric conditions(2).
[(1) Dean JA ed; Lange's Handbook of Chemistry 13th ed pp. 4-81, 4-82 (1985) (2) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment. Merian E, ed. NY, NY: Weinheim (1991) (3) Anderson PR, Christensen TH; J Soil Sci 39: 15-22 (1988) (4) Thomas RAP et al; Appl Environ Microbiol 64: 1319-1322 (1998) (5) Ohe S; Computer Aided Data Book of Vapor Pressure pp. 588,

1902, 1978 (1976)]**PEER REVIEWED**

AQUATIC FATE: **Nickel** compounds that are soluble in water such as **nickel** chlorides and **nickel** nitrate, are generally more mobile than insoluble **nickel** compounds such as **nickel** oxides and **nickel** sulfides(SRC). At pH levels less than 6.5 the soluble compounds predominate(1). Approximately half of the **nickel** in river water is in the ionic form while the other half forms complexes with organic material(1). In polluted environments the presence of EDTA, a common substitute for polyphosphates, will tend to increase the mobility of **nickel** and **nickel** compounds through the formation of complexes(2). The majority of **nickel** compounds are not expected to volatilize from water surfaces based on their low vapor pressures(3). One notable exception is **nickel** carbonyl which is expected to volatilize from water surfaces based on its estimated Henry's Law constant(SRC). However, **nickel** carbonyl is unstable under normal atmospheric conditions(1). If released into water, **nickel** compounds are expected to adsorb to sediment and suspended solids in water(4,5).
[(1) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment. Merian E, ed. NY, NY: Weinheim (1991) (2) Thomas RAP et al; Appl Environ Microbiol 64: 1319-1322 (1998) (3) Ohe S; Computer Aided Data Book of Vapor Pressure pp. 588, 1902, 1978 (1976) (4) Anderson PR, Christensen TH; J Soil Sci 39: 15-22 (1988) (65 Gao S et al; Water Air Soil Pollut 93: 331-345 (1997)]**PEER REVIEWED**

ATMOSPHERIC FATE: **Nickel** compounds, which generally have low vapor pressures(1), are expected to exist in the particulate phase in the ambient atmosphere. One exception is **nickel** carbonyl which is expected to exist entirely in the vapor phase(1). However, **nickel** carbonyl is unstable under normal atmospheric conditions(2). **Nickel** compounds in the particulate-phase may be removed from the air by wet and dry deposition(SRC).
[(1) Ohe S; Computer Aided Data Book of Vapor Pressure pp. 588, 1902, 1978 (1976) (2) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment; Merian E, ed. NY, NY: Weinheim (1991)]**PEER REVIEWED**

Environmental Bioconcentration:

Six strains of algae and one Euglena sp were tested for their ability to bioaccumulate (63)Ni. The cyanobacteria tested were more sensitive to Ni toxicity than the green algae or the Euglena sp. The concentration factor for Ni was determined under a variety of conditions and in the range 0-3.0x10+3. The effect of environmental variables on Ni uptake was examined, and a striking pH effect for bioaccumulation was observed, with most of the algae strains accumulating Ni optimally at approximate pH= 8.0. /**Nickel** and **nickel** cmpd/
[Wang HK, Wood JM; Environ Sci Technol 18 (2): 106-9 (1984)]**PEER REVIEWED**

Fish can accumulate Ni from food and water. Levels up to 13 mg/kg were measured in pike and pickerel. /**Nickel** and **nickel** cmpd/
[Nat'l Research Council Canada; Effects of Nickel in the Canadian Environment p.28 (1981) NRCC 18568]**PEER REVIEWED**

Although aquatic organisms may accumulate Ni from their surroundings, there is little evidence for significant biomagnification of Ni levels along food chains. /**Nickel** and **nickel** cmpd/
[Nat'l Research Council Canada; Effects of Nickel in the Canadian Environment p.28 (1981) NRCC 18568]**PEER REVIEWED**

Aquatic plants can extract **nickel** from water and concentrate it to ... (10+3 to 10+4 mg/kg dry weight). /**Nickel** and **nickel** cmpd/
[Nat'l Research Council Canada; Effects of Nickel in the Canadian Environment p.28 (1981) NRCC 18568]**PEER REVIEWED**

... No ... **nickel** bioaccumulation in voles fed sludge-fertilized soybeans containing 30 ppm **nickel** ...

/**Nickel** and **nickel** cmpd/
[Parr, J.F., P.B. Marsh, and J.M. Kla (eds.). Land Treatment of Hazardous Wastes. Park Ridge, New Jersey: Noyes Data Corporation, 1983. 185]**PEER REVIEWED**

Water-soluble **nickel** compounds, such as the chloride and sulfate compounds, are poorly absorbed by most living organisms(1). The uptake of **nickel** by plants depends upon the extractable **nickel** content of a soil which is a function of physical, chemical and biological factors of the soil environment(1). High **nickel** concns have been found in jack beans and soybeans, Seberetia acuminata (tree native to New Caledonia), oatmeal, wheat bran, dried beans, and soya products(1). Reported BCFs for **nickel** range from 100 for fresh water plants, 550-2000 for seaweeds, <20-8000 for marine phytopklankton and 2,000-40,000 for algae(2) suggests the potential for bioconcentration ranges from moderate to very high(SRC).
[(1) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment; Merian E, ed. NY, NY: Weinheim (1991) (2) ATSDR; Toxicological Profile for Nickel. ATSDR/TP-88/19 pp. 1-70 (1988)]**PEER REVIEWED**

Higher **nickel** concns have been observed in shellfish and crustacea than in fish(1). Reported BCFs for **nickel** range from 40 for fresh water fish, 50 for skipjack tuna and 100 for marine fish(2). The bioconcentration of **nickel** in a mussel (L. marginalis) and fish (C. carpio) was found to be concentration-dependent(3). Higher concns of **nickel** in fish that are bottom feeders has been observed(4).
[(1) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment; Merian E, ed. NY, NY: Weinheim (1991) (2) ATSDR; Toxicological Profile for Nickel. ATSDR/TP-88/19 pp. 1-70 (1988) (3) Sreedevi P et al; Chemosphere 24: 29-36 (1992) (4) Campbell KR; Arch Environ Contam Toxicol 27: 352-356 (1994)]**PEER REVIEWED**

Soil Adsorption/Mobility:

In general, water-soluble **nickel** compounds, such as **nickel** chlorides and **nickel** nitrate, may travel more easily through soil than the insoluble **nickel** compounds such as **nickel** oxides and **nickel** sulfides(1,SRC). Adsorption experiments conducted on a mixture of low concns of **nickel**, cadmium, cobalt and zinc, in soils with varying pH's, clay content and organic carbon content, indicated **nickel** was more mobile than cadmium, less mobile than cobalt and had approximately the same mobility as zinc(2). The mobility of **nickel** in acid soils relative to other heavy metals was reported to be as follows (in decreasing mobility): cadmium> **nickel** > zinc > manganese > copper > lead > mercury(2). Another study found the following relationship among the mobility, based on measured distribution coefficients, for heavy metals in nine soils at two pH levels (increasing mobility); pH = 4.5: lead, copper, zinc, **nickel**, cadmium/chromium; pH = 6.5: lead, copper/zinc, cadmium, **nickel**, chromium(3). Organic substances and sulphate can increase the mobility of **nickel** through the formation of complexes(2). Conversely, acid-volatile sulfide can decrease the mobility of **nickel** through the formation of insoluble sulfide complexes(4). The presence of dissolved organic carbon has been shown to increase the mobility of **nickel** in groundwater environments(5). Very high mobility for **nickel** was observed in 5 sandy sediments with low organic carbon content(4).
[(1) Dean JA ed; Lange's Handbook of Chemistry 13th ed p.4-81-82 (1985) (2) Anderson PR, Christensen TH; J Soil Sci 39: 15-22 (1988) (3) Gao S et al; Water Air Soil Pollut 93: 331-345 (1997) (4) Hassan SM et al; Environ Toxicol Chem 15: 2198-2208 (1996) (5) Christensen JB et al; Wat Res 30: 3037-3049 (1996)]**PEER REVIEWED**

Volatilization from Water/Soil:

No evidence was found to suggest that volatilization of **nickel** compounds occurs from the aquatic environment.

[Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume I. EPA-440/4 79-029a. Washington, DC: U.S. Environmental Protection Agency, December 1979.p. 15-2]**PEER REVIEWED**

In general, **nickel** compounds are not expected to volatilize from water surfaces based on their low vapor pressures(1). One notable exception is **nickel** carbonyl(1) which is expected to volatilize based on an estimated Henry's Law constant. However, **nickel** carbonyl is unstable under normal atmospheric conditions, persisting forapproximately 60 seconds at 23 degress C(2).
[(1) Ohe S; Computer Aided Data Book of Vapor Pressure pp.588, 1902, 1978 (1976) (2) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment; Merian E, ed. NY, NY: Weinheim (1991)]**PEER REVIEWED**

Environmental Water Concentrations:

Municipal tap water Hartford, Connecticut 1.1 ug/l **nickel**; tap water Sudbury, Ontario 200 ug/l. /**Nickel** and soluble cmpd/
[McNeely MD et al; Clin Chem 18: 992-5 (1972) as cited in NIOSH; Criteria Document: Inorganic Nickel p.193 (1977) DHEW Pub. NIOSH 77-164]**PEER REVIEWED**

GROUNDWATER: **Nickel** was detected in groundwater samples collected from an aquifer contaminated by leachate from a municipal landfill near North Bay, Ontario at 0.060-0.10 mg/l(1).
[(1) Barker JF et al; J Contam Hydrol 1: 171-89 (1986)]**PEER REVIEWED**

DRINKING WATER: Typical concns of **nickel** found in drinking water are less than 20 ug/l although higher concns may be found due to the presence of **nickel** in pipe materials and fixtures(1). The range and mean (std error) of 59 potable water samples collected from 32 primary schools in Riyadh, Saudi Arabia was 0.42 - 129.09 and 11.79 (21.70)(2).
[(1) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment; Merian E, ed. NY, NY: Weinheim (1991) (2) Al-Saleh IA; Sci Total Environ 181: 215-21 (1996)]**PEER REVIEWED**

SURFACE WATER: Typical concns of **nickel** in seawater range from 0.1-0.5 ug/l, mainly as Ni 2+ and as chloro- and carbonato-complexes; concns increase with depth(1).
[(1) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment; Merian E, ed. NY, NY: Weinheim (1991)]**PEER REVIEWED**

SURFACE WATER: **Nickel** concns in fresh water typically avg 15-20 ug/l(1). Mean **nickel** concns measured in water samples collected on 25 Nov 1986 in 11 locations from a lake in Illinois that received industrial and municipal wastewater discharges and agricultural runoff range from below detection (detection limit = 0.007 mg/l) to 0.010 mg/l(2). Dissolved **nickel** concn measured in samples collected between 1980-84 from a polluted estuary of the UK (Mersey) ranged from 1 to 16 ug/l(3). **Nickel** concns in suspended solids collected from a heavily polluted harbor of Lake Ontario between April and September 1986 ranged from 12-102 ug/g(4).
[(1) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment; Merian E, ed. NY, NY: Weinheim (1991) (2) Kohler CC et al; Levels of PCBs and Trace Elements in Crab Orchard Lake Sediment, Benthos, Zooplanton and Fish. NTIS PB 90-195652 p. 54 (1990) (3) Campbell JA et al; Sci Total Environ 71: 141-55 (1988) (4) Mayer T, Manning PG; J Great Lakes Res 16: 299-318 (1990)]**PEER REVIEWED**

RAIN/SNOW/FOG: **Nickel** concn in arctic snow varies from 20-300 uk/kg(1). Mean **nickel** concns measured in precipitation collected from southwest Ontario, Sudbury Ontario (mining/smelting area), Delaware, northwest Ontario and Bermuda were 0.9, 0.5-17, 0.79, 0.7 and 0.17 ug/l respectively; the latter two sites were considered remote areas(2).
[(1) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment; Merian E, ed. NY, NY: Weinheim (1991) (2) Barrie LA et al; Atmos

Environ 21: 1133-5 (1987)]**PEER REVIEWED**

Effluent Concentrations:

Nickel (unfiltered, total) was detected in 103 of 322 samples of raw wastewater samples (20 of 37 plants) collected from 37 Ontario municipal wastewater treatment plants between January 1987 and July 1987 at concns ranging from 20-1469.9 ug/l and a geometric mean concn of 38.8; the detection limit was 10 ug/l(1). In the same survey, **nickel** (unfiltered, total) was detected in 10 of 48 samples of primary effluent(4 of 7 plants) at concns ranging from below the detection limit (10 ug/l) to 140 ug/l at a geometric mean concn of 8.7 ug/l, and in secondary effluent in 171 of 267 samples (24 of 28 plants) ranging from below the detection limit (10 ug/l) to 900 ug/l at a geometric mean concn of 22.1 ug/l(1).
[(1) Canviro Consultants; Thirty Seven Municipal Water Pollution Control Plants Pilot Monitoring Study V1 Interim Report (1988)]**PEER REVIEWED**

Sediment/Soil Concentrations:

Commercial fertilizers add little Ni to soil, but sewage-derived fertilizer from industrial areas may contain 1000 mg/kg (dry weight) or more. /**Nickel** and **nickel** cmpd/
[Nat'l Research Council Canada; Effects of Nickel in the Canadian Environment p.28 (1981) NRCC 18568]**PEER REVIEWED**

Aerial fallout from a **nickel** smelter at Port Colborne, Ontario, Canada, resulted in accumulation of **nickel** ranging from 600 to 6455 mg/kg in the organic soil of a farm. /**Nickel** and **nickel** cmpd/
[USEPA; Health Assessment Document: Nickel p.29 (1983) USEPA 600/8-83-012]**PEER REVIEWED**

Uncontaminated agricultural soils in Canada generally contain less than 30 mg Ni/kg. Soils derived from serpentine rock may contain up to 25,000 mg Ni/kg, although a more typical value is 1000 mg/kg. Accumulations of Ni in soil exceeding 1000 mg/kg occur within 1-2 km of large **Nickel** smelters. /**Nickel** and **nickel** cmpd/
[Nat Research Council Canada; Effects of Nickel in the Canadian Envir p.28 (1981) NRCC No. 18568]**PEER REVIEWED**

The use of irrigation water that contains the upper limit of the acceptable concn of **nickel** as recommended by NAS and NAE (1972) is equivalent to an accumulation of 100 ppm of Ni in the upper 15 cm of soil. ... the phytotoxic level of Ni in soil ranges from 50 to 200 ppm. /**Nickel** and **nickel** cmpd/
[Brown, K.W., G. B. Evans, Jr., B.D. Frentrup (eds.). Hazardous Waste Land Treatment. Boston, MA: Butterworth Publishers, 1983. 286]**PEER REVIEWED**

SOIL: **Nickel** was detected in soil samples collected from four areas of the Chukotka arctic region at mean concns (std errors; number of observations) ranging from 2.3 (0.3; 12) to 209 (42; 36) ppm(1). Typical concns of **nickel** in US soils range from <5-150 mg/kg (dry weight)(2). **Nickel** was detected in soil samples collected from three areas in Sudbury, Ontario that were contaminated by **nickel** and copper mining and smelting operations at concns ranging from 23-2,149 mg/kg with mean concns ranging from 210-580 mg/kg (dry weight)(3). **Nickel** was detected in soil samples collected from four sites in the US, adjacent to heavily traveled roadways, at concns ranging from 3-47 mg/kg(4).
[(1) Alexeeva-Popova NV et al; Sci Total Environ 106/161: 643-652 (1995) (2) Breckenridge RP, Crockett AB; Determination of Background concns of Inorganics in Soil and Sediments at Hazardous Waste Sites. USEPA/540/S-96/500 pp.8-10 (1995) (3) Adamo P et al; Environ Poll 91: 11-19 (1996) (4) Amrhein C et al; Environ Sci Technol 26: 703-709 (1992)]**PEER REVIEWED**

SEDIMENT: Mean **nickel** concns measured in sediment samples collected on 4 December 1986 from 11 locations in an Illinois lake that received industrial and municipal wastewater discharges and agricultural

runoff ranged from below detection (detection limit = 6.80 mg/kg) to 28.3 mg/kg (dry weight)(1). The mean **nickel** concn (std error) measured in sediment samples collected between 11-16 February 1990 from 13 locations in an industrialized harbor of Ireland ranged from 11.50 mg/kg (0.75) to 15.77 mg/kg (0.47)(2). **Nickel** concns in samples of suspended solids collected from a heavily polluted harbor of Lake Ontario between April and September 1986 ranged from 12-102 ug/g(3). **Nickel** was detected in non-polluted sediments of the Great Lakes, Puget Sound and Yaquina Bay at <20, 13 and 14.5 mg/kg, respectively(4). **Nickel** was detected in three sediment samples collected from each of 10 lakes located at various distances from the Sudbury copper and smelting area of Ontario as follows (distance(km) - mean(ug/g dry weight) - std error): 10-4490-230, 10-4390-115, 10-2500-150, 30-444-25, 35-495-75, 35-1080-25, 35-205-25, 40-255-30, 40-300-25, 180-17.5-5.3(5).
[(1) Kohler CC et al; Levels of PCBs and Trace Elements in Crab Orchard Lake Sediment, Benthos, Zooplanton and Fish p.54 (1990) PB 90-195652 (2) Berrow SD; Mar Pollut Bull 22: 467-9 (1991) (3) Mayer T, Manning PG; J Great Lakes Res 16: 299-318 (1990) (4) Breckenridge RP, Crockett AB; Determination of Background concns of Inorganics in Soil and Sediments at Hazardous Waste Sites. pp.8-10 USEPA/540/S-96/500 (1995) (5) Bradley RW, Morros JR; Water Air Soil Pollution 27: 341-354 (1986)]**PEER REVIEWED**

Atmospheric Concentrations:

Typical average levels of airborne **nickel** are: 0.00001-0.003 ug/cu m in remote areas; 0.003-0.03 ug/cu m in urban areas having no metallurgical industry; 0.07-0.77 ug/cu m in **nickel** processing areas. /**Nickel** and cmpd/
[Nat'l Research Council Canada; Effects of Nickel in the Canadian Envir p.27 (1981) NRCC No. 18568]**PEER REVIEWED**

URBAN/SUBURBAN: Avg **nickel** concns in non-urban areas is 6 ng/cu m; in urban areas the avg **nickel** concn is 17 ng/cu m in the summer and 25 ng/cu m in the winter(1).
[(1) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment; Merian E, ed. NY, NY: Weinheim (1991)]**PEER REVIEWED**

RURAL/REMOTE: Avg annual **nickel** concns of arctic air samples collected between 1979 and 1984 from three locations in Canada ranged from 0.14-0.45 ng/cu m(1).
[(1) Barrie LA, Hoff RM; Atmos Environ 19: 1995-2010 (1985)]**PEER REVIEWED**

SOURCE DOMINATED: Concns of **nickel** as high as 120-170 ng/cu m have been found in some urban areas(1). Avg **nickel** concn was 1.2 ug/cu m near a **nickel** refinery in West Virginia(1).
[(1) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment; Merian E, ed. NY, NY: Weinheim (1991)]**PEER REVIEWED**

Food Survey Values:

The **nickel** content, in ppm wet weight, was determined for various classes of food in the US diet. Grains/grain products: wheat flour, all purpose (0.54); corn, fresh frozen (0.70); rice, polished American (0.47). Fruits: apples (0.08); bananas (0.34); pears (0.20). Vegetables: potatoes, raw (0.56); tomatoes, fresh (0.02); celery, fresh (0.37). Meats: pork, chops (0.02); lamb, chops (not detected); beef, round (not detected). /**Nickel** and **nickel** cmpd/
[USEPA; Health Assessment Document: Nickel p.27 (1983) USEPA 600/8-83-012]**PEER REVIEWED**

Nickel content was determined for the edible parts of crops grown on the soil of a farm located one kilometer from a **nickel** smelter and in direct line with the prevailing winds. **Nickel** (mg/kg dry weight) ranged from 80 to 280 in beet roots, 76 to 400 in cabbage heads, 15 to 395 in celery tops, 22 to 130 in lettuce tops, and 24 to 140 in radish roots. /**Nickel** and **nickel** cmpd/

[USEPA; Health Assessment Document: Nickel p.29 (1983) USEPA 600/8-83-012]**PEER REVIEWED**

A 2,300 calorie diet with 100 g fat, 100 g protein, and 250 g carbohydrate could have a **nickel** content varying from 3-10 to 700-900 ug. /**Nickel** and **nickel** cmpd/
[Schroeder HA et al; J Chronic Dis 15: 51-65 (1962) as cited in NIOSH; Criteria Document: Inorganic Nickel p.192 (1977) DHEW Pub. NIOSH 77-164]**PEER REVIEWED**

Concentrations of **nickel** in various foods include: up to 6.5 ug/g in cereal foodstuffs, up to 2.6 ug/g in vegetables, and up to 7.6 ug/g in tea. /**Nickel** and **nickel** cmpd/
[NAS; Report of the Committe on Med and Envir Poll: Nickel (1975) as cited in NTP; Chem Selection Profile: Nickel Chloride p.2 (1979)]**PEER REVIEWED**

The avg concn (mg/kg) of **nickel** in various foods were reported as follows: wheat - 0.19-0.34, rye - 0.12, potatoes - 0.05-0.26, fruit - 0.08, cocoa - 15.1, tea - 5.25, and coffee - 0.77(1); oat, precooked - 2.35, rice, American, polished - 0.47, spinach - 2.4-4.6, peas - 2.25, clams, fresh - 0.58, shrimp, fresh-frozen - 0.03; haddock - 0.05, pork chop - 0.02, whole egg - 0.03, orange pekoe tea - 7.6, beer - 0.01, salt - 0.35, sugar - 0.03 and cinnamon - 0.74(2).
[(1) Weigert P; pp.449-468 in Metals and Their Compounds in the Environment. Merian E, ed. NY, NY: Weinheim (1991) (2) ATSDR; Toxicological Profile for Nickel. ATSDR/TP-88/19 pp. 77 (1988)]**PEER REVIEWED**

Nickel concns measured in vegetables, fruits and herbs grown in a remote location of the UK were reported as follows (all ug/g, fresh weight): vegetables - ranged from 0.01-0.14, maximum concns detected in carrots and onions; fruits - 0.008 ug/g; cereals - 0.02-0.04; herbs - 0.04-0.08(1). **Nickel** concns measured in vegetables, fruits and herbs grown approximately 30 m from a roadway (London Orbital Motorway) with daily traffic volume of 120,000 vehicles/day were reported as follows(all ug/g, fresh weight): vegetables - <detection-0.0.09; strawberry - 0.003 ug/g; herbs - 0.06-0.105(1). Avg concns of **nickel** found in Japanese shellfish ranged from 0.5-2.2 mg/kg; 1-13 ppb typically is found in bovine meat(2).
[(1) Ward NI, Savage JM; Sci Tot Environ 147: 309-319 (1994) (2) Sunderman FW Jr, Oskarsson A; pp. 1101-1126 in Metals and Their Compounds in the Environment; Merian E, ed. NY, NY: Weinheim (1991)]**PEER REVIEWED**

Plant Concentrations:

Concentrations of ... Ni ... in leaf and root tissue of Typha latifolia grown in a series of solution cultures containing 10-150 ug g/l Ni ... were correlated with concentrations of the same metals in the growth medium. In contrast to plants growing in contaminated wetlands near Sudbury, Ontario (Canada), plants grown in solution culture were unable to minimize entry of ... Ni into leaf tissue. Leaves of Typha latifolia accumulated 467 + or - 50 ug g/l Ni and did not show toxic symptoms ... Thus, T latifolia would appear to have internal ... Ni tolerance mechanisms. /**Nickel** and **nickel** cmpd/
[Taylor GJ, Crowder AA; Can J Bot 61 (7): 1825-30 (1983)]**PEER REVIEWED**

Concn of **nickel** in plant leaves: range: 0.1-1.0 ppm dry wt; toxic: > 50-200 ppm dry wt (From table) /**Nickel** and **nickel** cmpd/
[Brown, K.W., G. B. Evans, Jr., B.D. Frentrup (eds.). Hazardous Waste Land Treatment. Boston, MA: Butterworth Publishers, 1983. 312]**PEER REVIEWED**

In grains, fresh-weight values ranged from 0-6.45 ug/g, in vegetables and fruits from 0-2.59 ug/g. /**Nickel** and **nickel** cmpd/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 465]**PEER REVIEWED**

Nickel has been found in plants grown in lateritic soils at concns up to 100 ppm(1). **Nickel** concns measured in 26 mushroom species collected from remote areas of Latin American forests between 1967-81 ranged from 1.36 - 38.10 ppm with a mean of 7.95 ppm (dry weight)(2).
[(1) Antonsen DH; Kirk-Othmer Encycl Chem Technol 4th ed NY, NY: John Wiley and Sons 17: 35 (1992) (2) Michelot F et al; Arch Environ Contam Toxicol 36: 256-63 (1999)]**PEER REVIEWED**

Fish/Seafood Concentrations:

/Daily intake/ in seafood /ranges from/ 0.3-1.7 ug/g. /**Nickel** and **nickel** cmpd/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 465]**PEER REVIEWED**

Up to 1.7 ug/g of **nickel** found in fish. /**Nickel** and **nickel** cmpd/
[NAS; Report of the Committee on Med and Envir Poll: Nickel (1975) as cited in NTP; Chem Selection Profile: Nickel Chloride p.2 (1979)]**PEER REVIEWED**

The **nickel** content, in ppm wet weight, was determined for seafood in US diet. Oysters, fresh (1.50); Clams, fresh (0.58); shrimp (0.03); Crabmeat, canned (0.03); Swordfish, frozen (0.02); Salmon (1.70).
[USEPA; Health Assessment Document: Nickel p.27 (1983) EPA 600/8-83-012]**PEER REVIEWED**

Mean **nickel** concns in samples of 6 species of fish collected between 24 September and 4 November 1996 from an Illinois lake that received industrial and municipal wastewater discharges and agricultural runoff, ranged from non-detectable to approximately 1.70 mg/kg (n=26-27 for each species)(1). The mean **nickel** concn (std error) measured in mussels (Mytilus edulis L.) collected between 11-16 February 1990 from 13 locations in an industrialized harbor of Ireland ranged from 6.17 mg/kg (0.93) to 11.67 mg/kg (0.44)(2). The mean **nickel** concn measured in samples of American oysters (Crassostrea virginica) collected between August 1984 and June 1985 from the San Andres Lagoon in Mexico, which is reportedly not impacted by industrial pollution, ranged from 2.0-4.5 ppm; the maximum concn found was 12.0 ppm(3). **Nickel** was detected in muscle tissue of lake trout and grayling collected from four arctic lakes in Alaska at geometric mean concns ranging from 0.07-0.45 and 0.12-0.33 ug/g (dry weight), respectively(4).
[(1) Kohler CC et al; Levels of PCBs and Trace Elements in Crab Orchard Lake Sediment, Benthos, Zooplanton and Fish, NTIS PB 90-195652 p. 54 (1990) (2) Berrow SD; Mar Pollut Bull 22: 467-9 (1991) (3) Vazquez F et al; Bull Environ Contam Toxicol 45: 907-914 (1990) (4) Allen-Gil SM et al; Environ Toxicol Chem 16: 733-41 (1997)]**PEER REVIEWED**

Other Environmental Concentrations:

In cigarettes ... an average **nickel** content of 2.2 and 2.3 ug/cigarette /was found/. /**Nickel** and **nickel** cmpd/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 465]**PEER REVIEWED**

Environmental Standards & Regulations:

Clean Water Act Requirements:

Toxic pollutant designated pursuant to section 307(a)(1) of the Clean Water Act and is subject to effluent limitations. /**Nickel** and compounds/
[40 CFR 401.15 (7/1/99)]**QC REVIEWED**

Chemical/Physical Properties:

Chemical Safety & Handling:

Skin, Eye and Respiratory Irritations:

EYE IRRITATION IN WORKERS EXPOSED TO AEROSOLS FROM **NICKEL** ELECTROLYSIS TANKS HAS BEEN REPORTED. /**NICKEL** AND COMPOUNDS/
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.422]**PEER REVIEWED**

Toxic Combustion Products:

Toxic gases and vapors (such as **nickel** carbonyl) may be released in a fire involving **nickel** ... /**Nickel** & sol **nickel** cmpd/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

Incompatibilities: Strong acids /**Nickel**, metal & sol compounds (as Ni)/
[NIOSH. Pocket Guide to Chemical Hazards. 5th Printing/Revision. DHHS (NIOSH) Publ. No. 85-114. Washington, D.C.: U.S. Dept. of Health and Human Services, NIOSH/Supt. of Documents, GPO, Sept. 1985.172]**PEER REVIEWED**

Reacts vigorously or explosively with aniline, hydrogen sulfide , flammable solvents, hydrazine, and metal powders (especially zinc, aluminum, and magnesium). /**Nickel**/
[William S ed; Official Methods of Analysis of the Association of official Analytical Chemist 14th ed p.449 (1984)]**PEER REVIEWED**

Hazardous Decomposition:

Toxic gases and vapors (such as **nickel** carbonyl) may be released ... in the decomp of **nickel** cmpd. /**Nickel** & sol **nickel** cmpd/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH considers **nickel** to be a potential occupational carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 224]**PEER REVIEWED**

Protective Equipment & Clothing:

Respirator selection: Upper limit devices recommended by NIOSH: > at any detectable concn: any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode or any supplied-air respirator with a full facepiece and operated in a

pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode; escape: any air-purifying full facepiece respirator with a high-efficiency particulate filter; any appropriate escape-type self-contained breathing apparatus /**Nickel**, metal & sol compounds (as Ni)/
[NIOSH. Pocket Guide to Chemical Hazards. 5th Printing/Revision. DHHS (NIOSH) Publ. No. 85-114. Washington, D.C.: U.S. Dept. of Health and Human Services, NIOSH/Supt. of Documents, GPO, Sept. 1985.173]**PEER REVIEWED**

Respiratory protection for dust, mist, or fume of **nickel** metal and soluble compounds is as follows: 10 mg/cu m or less: any fume respirator, high efficiency particulate respirator, supplied air respirator, or any self-contained breathing apparatus; 50 mg/cu m or less: a high efficiency particulate filter respirator with a full facepiece, any supplied-air respirator with a full facepiece, helmet or hood or any self-contained breathing apparatus with a full facepiece; 1000 mg/cu m or less: a powered air-purifying respirator with a high efficiency filter or a type-C supplied-air respirator operated in pressure-demand, positive pressure or continous flow mode; 2000 mg/cu m or less: a type-C supplied-air respirator with a full facepiece operated in a pressure-demand or other positive pressure mode or with full facepiece, helmet, or hood operated in a continuous-flow mode; > 2000 mg/cu m or entry and escape from unknown concn: a self-contained breathing apparatus with a full facepiece operated in pressure demand or other positive pressure mode or a combination respirator which includes a type-C supplied-air respirator. /**Nickel** metal and soluble compounds, dust, mist, or fume/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.7]**PEER REVIEWED**

If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health. ... Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with powdered **nickel** or solid or liquids containing sol **nickel** cmpd. /**Nickel** metal and sol **nickel** cmpd/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Use goggles, barrier shields, and other devices as necessary for personal protection; use polyvinyl chloride, not rubber, for gloves. /**Nickel**/
[Williams S ed; Official Methods of Analysis of the Association of Official Analytical Chemist 14th ed p.449 (1984)]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Dispensers of liq detergent /should be available./ ... Safety pipettes should be used for all pipetting. ... In animal laboratory, personnel should ... wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. ... Gowns ... /should be/ of distinctive color, this is a reminder that they are not to be worn outside the laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

Preventive Measures:

Stringent requirements for warning labels and signs ... employee instruction, work practices, sanitation, environmental monitoring, and record keeping are recommended ... where employees are exposed to **nickel** cmpd. /**Nickel** & compounds/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1439]**PEER REVIEWED**

Skin that becomes contaminated with metallic **nickel** or sol **nickel** cmpd should be promptly washed or showered with soap or mild detergent and water to remove any metallic **nickel** or sol **nickel** cmpd. Eating and smoking should not be permitted in areas where solids or liquids containing sol **nickel** cmpd are handled, processed, or stored. Employees who handle powdered metallic **nickel** or solids or liquids containing sol **nickel** cmpd should wash their hands thoroughly with soap or mild detergent before eating, smoking, or using toilet facilities. Areas in which exposure to **nickel** metal and sol **nickel** cmpd may occur should be identified by signs or appropriate means, and access to these areas should be limited to authorized persons. /**Nickel** or sol **nickel** cmpd/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. ... If employees' clothing becomes contaminated with powdered metallic **nickel** or solid sol **nickel** cmpd, employees should change into uncontaminated clothing before leaving the work premises. Clothing contaminated with metallic or sol **nickel** cmpd should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of metallic **nickel** or sol **nickel** cmpd from the clothing. If the clothing is to be laundered or otherwise cleaned to remove metallic **nickel** or sol **nickel** cmpd, the person performing the operation should be informed of these substances's hazardous properties. Non-pervious clothing which becomes contaminated with metallic or sol **nickel** cmpd should be removed promptly and not reworn until the **nickel** or sol **nickel** cmpd are removed from the clothing. /**Nickel** or sol **nickel** cmpd/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

WORKERS WHO DEVELOP **NICKEL** DERMATITIS SHOULD BE REMOVED FROM CONTACT & SHOULD NOT BE ALLOWED TO RESUME WORK UNTIL CONDITION HAS DISAPPEARED. EVEN THEN, WORKER SHOULD RECEIVE CLOSE MEDICAL SUPERVISION TO DETECT EARLIEST SIGN OF RECURRENCE. /**NICKEL** & **NICKEL** CMPD/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 932]**PEER REVIEWED**

Full body protective clothing is advisable, as is the use of barrier creams to prevent skin sensitization and dermatitis. Employees should wash promptly when skin is wet or contaminated. Work clothing should be changed daily if it is possible that clothing is contaminated. Remove nonimpervious clothing promptly if wet or contaminated. /**Nickel** and soluble compounds/
[Sittig M; Handbook of Toxic and Hazardous Chemicals p.483 (1981)]**PEER REVIEWED**

PERSONS ... REQUIRED TO WORK WITH ... **NICKEL** SALTS SHOULD BE PROVIDED WITH ADEQUATE WASHING FACILITIES & INSTRUCTED CONCERNING NECESSITY OF

AVOIDING CONTACT WITH MATERIALS IN QUESTION. ... /**NICKEL**/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1439]**PEER REVIEWED**

SRP: Local exhaust ventilation should be applied wherever there is an incidence of point source emissions or dispersion of regulated contaminants in the work area. Ventilation control of the contaminant as close to its point of generation is both the most economical and safest method to minimize personnel exposure to airborne contaminants.
PEER REVIEWED

SRP: Contaminated protective clothing should be segregated in such a manner so that there is no direct personal contact by personnel who handle, dispose, or clean the clothing. Quality assurance to ascertain the completeness of the cleaning procedures should be implemented before the decontaminated protective clothing is returned for reuse by the workers. Contaminated clothing should not be taken home at end of shift, but should remain at employee's place of work for cleaning.
PEER REVIEWED

SRP: The scientific literature for the use of contact lenses in industry is conflicting. The benefit or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In any event, the usual eye protection equipment should be worn even when contact lenses are in place.
PEER REVIEWED

The worker should immediately wash the skin when it becomes contaminated. /**Nickel** metal and other compounds, as Ni/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 225]**PEER REVIEWED**

The worker should wash daily at the end of each work shift. /**Nickel** metal and other compounds, as Ni/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 225]**PEER REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed and replaced. /**Nickel** metal and other compounds, as Ni/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 225]**PEER REVIEWED**

Workers whose clothing may have become contaminated should change into uncontaminated clothing before leaving the work premises. /**Nickel** metal and other compounds, as Ni/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 225]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Smoking, drinking, eating, storage of food or of food & beverage containers or utensils, & the application of cosmetics should be prohibited in any laboratory. All personnel should remove gloves, if worn, after completion of procedures in which carcinogens have been used. They should ... wash ... hands, preferably using dispensers of liq detergent, & rinse ... thoroughly. Consideration should be given to appropriate methods for cleaning the skin, depending on nature of the contaminant. No standard procedure can be recommended, but the use of organic solvents should be avoided. Safety pipettes should be used for all pipetting. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France:

International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": In animal laboratory, personnel should remove their outdoor clothes & wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... Clothing should be changed daily but ... discarded immediately if obvious contamination occurs ... /also,/ workers should shower immediately. In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. If gowns are of distinctive color, this is a reminder that they should not be worn outside of lab. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Operations connected with synth & purification ... should be carried out under well-ventilated hood. Analytical procedures ... should be carried out with care & vapors evolved during ... procedures should be removed. ... Expert advice should be obtained before existing fume cupboards are used ... & when new fume cupboards are installed. It is desirable that there be means for decreasing the rate of air extraction, so that carcinogenic powders can be handled without ... powder being blown around the hood. Glove boxes should be kept under negative air pressure. Air changes should be adequate, so that concn of vapors of volatile carcinogens will not occur. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Vertical laminar-flow biological safety cabinets may be used for containment of in vitro procedures ... provided that the exhaust air flow is sufficient to provide an inward air flow at the face opening of the cabinet, & contaminated air plenums that are under positive pressure are leak-tight. Horizontal laminar-flow hoods or safety cabinets, where filtered air is blown across the working area towards the operator, should never be used ... Each cabinet or fume cupboard to be used ... should be tested before work is begun (eg, with fume bomb) & label fixed to it, giving date of test & avg air-flow measured. This test should be repeated periodically & after any structural changes. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Principles that apply to chem or biochem lab also apply to microbiological & cell-culture labs ... Special consideration should be given to route of admin. ... Safest method of administering volatile carcinogen is by injection of a soln. Admin by topical application, gavage, or intratracheal instillation should be performed under hood. If chem will be exhaled, animals should be kept under hood during this period. Inhalation exposure requires special equipment. ... Unless specifically required, routes of admin other than in the diet should be used. Mixing of carcinogen in diet should be carried out in sealed mixers under fume hood, from which the exhaust is fitted with an efficient particulate filter. Techniques for cleaning mixer & hood should be devised before expt begun. When mixing diets, special protective clothing &, possibly, respirators may be required. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France:

International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When ... admin in diet or applied to skin, animals should be kept in cages with solid bottoms & sides & fitted with a filter top. When volatile carcinogens are given, filter tops should not be used. Cages which have been used to house animals that received carcinogens should be decontaminated. Cage-cleaning facilities should be installed in area in which carcinogens are being used, to avoid moving of ... contaminated /cages/. It is difficult to ensure that cages are decontaminated, & monitoring methods are necessary. Situations may exist in which the use of disposable cages should be recommended, depending on type & amt of carcinogen & efficiency with which it can be removed. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": To eliminate risk that ... contamination in lab could build up during conduct of expt, periodic checks should be carried out on lab atmospheres, surfaces, such as walls, floors & benches, & ... interior of fume hoods & airducts. As well as regular monitoring, check must be carried out after cleaning-up of spillage. Sensitive methods are required when testing lab atmospheres. ... Methods ... should ... where possible, be simple & sensitive. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Rooms in which obvious contamination has occurred, such as spillage, should be decontaminated by lab personnel engaged in expt. Design of expt should ... avoid contamination of permanent equipment. ... Procedures should ensure that maintenance workers are not exposed to carcinogens. ... Particular care should be taken to avoid contamination of drains or ventilation ducts. In cleaning labs, procedures should be used which do not produce aerosols or dispersal of dust, ie, wet mop or vacuum cleaner equipped with high-efficiency particulate filter on exhaust, which are avail commercially, should be used. Sweeping, brushing & use of dry dusters or mops should be prohibited. Grossly contaminated cleaning materials should not be re-used ... If gowns or towels are contaminated, they should not be sent to laundry, but ... decontaminated or burnt, to avoid any hazard to laundry personnel. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Doors leading into areas where carcinogens are used ... should be marked distinctively with appropriate labels. Access ... limited to persons involved in expt. ... A prominently displayed notice should give the name of the Scientific Investigator or other person who can advise in an emergency & who can inform others (such as firemen) on the handling of carcinogenic substances. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.11]**PEER REVIEWED**

Shipment Methods and Regulations:

PRECAUTIONS FOR "CARCINOGENS": Procurement ... of unduly large amt ... should be avoided. To avoid spilling, carcinogens should be transported in securely sealed glass bottles or ampoules, which

should themselves be placed inside strong screw-cap or snap-top container that will not open when dropped & will resist attack from the carcinogen. Both bottle & the outside container should be appropriately labelled. ... National post offices, railway companies, road haulage companies & airlines have regulations governing transport of hazardous materials. These authorities should be consulted before ... material is shipped. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When no regulations exist, the following procedure must be adopted. The carcinogen should be enclosed in a securely sealed, watertight container (primary container), which should be enclosed in a second, unbreakable, leakproof container that will withstand chem attack from the carcinogen (secondary container). The space between primary & secondary container should be filled with absorbent material, which would withstand chem attack from the carcinogen & is sufficient to absorb the entire contents of the primary container in the event of breakage or leakage. Each secondary container should then be enclosed in a strong outer box. The space between the secondary container & the outer box should be filled with an appropriate quantity of shock-absorbent material. Sender should use fastest & most secure form of transport & notify recipient of its departure. If parcel is not received when expected, carrier should be informed so that immediate effort can be made to find it. Traffic schedules should be consulted to avoid ... arrival on weekend or holiday ... /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

Storage Conditions:

PRECAUTIONS FOR "CARCINOGENS": Storage site should be as close as practical to lab in which carcinogens are to be used, so that only small quantities required for ... expt need to be carried. Carcinogens should be kept in only one section of cupboard, an explosion-proof refrigerator or freezer (depending on chemicophysical properties ...) that bears appropriate label. An inventory ... should be kept, showing quantity of carcinogen & date it was acquired ... Facilities for dispensing ... should be contiguous to storage area. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

Cleanup Methods:

1. VENTILATE AREA OF SPILL. 2. COLLECT SPILLED MATERIAL IN THE MOST CONVENIENT & SAFE MANNER FOR RECLAMATION. LIQ CONTAINING **NICKEL** SHOULD BE ABSORBED IN VERMICULITE, DRY SAND, EARTH, OR A SIMILAR MATERIAL. /**NICKEL** & SOL **NICKEL** COMPOUNDS/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.4]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": A high-efficiency particulate arrestor (HEPA) or charcoal filters can be used to minimize amt of carcinogen in exhausted air ventilated safety cabinets, lab hoods, glove boxes or animal rooms ... Filter housing that is designed so that used filters can be transferred into

plastic bag without contaminating maintenance staff is avail commercially. Filters should be placed in plastic bags immediately after removal ... The plastic bag should be sealed immediately ... The sealed bag should be labelled properly ... Waste liquids ... should be placed or collected in proper containers for disposal. The lid should be secured & the bottles properly labelled. Once filled, bottles should be placed in plastic bag, so that outer surface ... is not contaminated ... The plastic bag should also be sealed & labelled. ... Broken glassware ... should be decontaminated by solvent extraction, by chemical destruction, or in specially designed incinerators. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

Disposal Methods:

SRP: At the time of review, criteria for land treatment or burial (sanitary landfill) disposal practices are subject to significant revision. Prior to implementing land disposal of waste residue (including waste sludge), consult with environmental regulatory agencies for guidance on acceptable disposal practices.
PEER REVIEWED

Chemical Treatability of **Nickel**; Concentration Process: Biological Treatment; Chemical Classification: Metal; Scale of Study: Full Scale; Type of Wastewater Used: Domestic Wastewater; Results of Study: 0-33% reduction achieved; (Survey of municipal wastewater treatment plant).
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-53 (1982)]**PEER REVIEWED**

Chemical Treatability of **Nickel**; Concentration Process: Biological Treatment; Chemical Classification: Metal; Scale of Study: Continuous Flow, Pilot Scale; Type of Wastewater Used: Domestic Wastewater; Results of Study: 28-42% reduction; (Activated sludge process).
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-53 (1982)]**PEER REVIEWED**

Chemical Treatability of **Nickel**; Concentration Process: Biological Treatment; Chemical Classification: Metal; Scale of Study: Continuous Flow, Full Scale; Type of Wastewater Used: Domestic Wastewater; Results of Study: 30% reduction; (Activated sludge process).
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-54 (1982)]**PEER REVIEWED**

Chemical Treatability of **Nickel**; Concentration Process: Biological Treatment; Chemical Classification: Metal; Scale of Study: Pilot Scale; Type of Wastewater Used: Domestic Wastewater; Results of Study: 28% reduction; (Activated sludge process).
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-54 (1982)]**PEER REVIEWED**

Chemical Treatability of **Nickel**; Concentration Process: Chemical Precipitation; Chemical Classification: Metal; Scale of Study: Pilot Scale; Type of Wastewater Used: Synthetic Wastewater; Results of Study: 25% reduction with aluminum; (3 coagulants used: 220 ppm of aluminum @ pH= 6.4. 40 ppm of ferric chloride @ pH= 6.2, 415 ppm of lime @ pH= 11.5. Chemical coagulation was followed by dual media filtration).
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-73 (1982)]**PEER REVIEWED**

Chemical Treatability of **Nickel**; Concentration Process: Chemical Precipitation; Chemical Classification: Metal; Scale of Study: Laboratory Scale, Continuous Flow; Type of Wastewater Used: Synthetic Wastewater; Results of Study: 100% reduction with lime; (lime dose of 50 ppm added).
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-73

(1982)]**PEER REVIEWED**

Chemical Treatability of **Nickel**; Concentration Process: Chemical Precipitation; Chemical Classification: Metal; Scale of Study: Pilot Scale; Type of Wastewater Used: Domestic Wastewater + Pure Compound; Results of Study: 5ppm @ 4 gpm @ pH= 7.0. Iron system-10% reduction; low lime system-94% reduction; high lime system-97% reduction; (3 coagulant systems were used: Iron system used 45 ppm as Fe of Fe2(SO4)3 @ pH= 6.0. Low lime system used 20 ppm as Fe of Fe2(SO4)3 and 260 ppm of CaO @ pH= 10.0. High lime system used 600 ppm of CaO @ pH= 11.5. Chemical coagulation was followed by multimedia filtration).
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-73 (1982)]**PEER REVIEWED**

Chemical Treatability of **Nickel**; Concentration Process: Reverse Osmosis; Chemical Classification: Metal; Scale of Study: Batch Flow; Type of Wastewater Used: Pure Compound; Results of Study: Each with C-PEI membrane and effluent character of 12.5 ppm; 92.8% reduction @ pH= 8.0, 97.6% reduction @ pH= 11.0. (C-PEI) membrane operated @ 600 psig and room temperature).
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-88 (1982)]**PEER REVIEWED**

Chemical Treatability of **Nickel**; Concentration Process: Activated Carbon; Chemical Classification: Metal; Scale of Study: Laboratory Scale, Isotherm Test; Type of Wastewater Used: Pure Compound; Results of Study: 0 ppm carbon dose, 0 % removal; 500 ppm carbon dose, 4% removal; 1000 ppm carbon dose, 5% removal; 5000 ppm carbon dose, 10.5% removal; 10,000 ppm carbon dose, 52% removal; (24 hr contact time, test chemical used was NiCl2).
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-165 (1982)]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": There is no universal method of disposal that has been proved satisfactory for all carcinogenic compounds & specific methods of chem destruction ... published have not been tested on all kinds of carcinogen-containing waste. ... summary of avail methods & recommendations ... /given/ must be treated as guide only. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.14]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Incineration may be only feasible method for disposal of contaminated laboratory waste from biological expt. However, not all incinerators are suitable for this purpose. The most efficient type ... is probably the gas-fired type, in which a first-stage combustion with a less than stoichiometric air:fuel ratio is followed by a second stage with excess air. Some ... are designed to accept ... aqueous & organic-solvent solutions, otherwise it is necessary ... to absorb soln onto suitable combustible material, such as sawdust. Alternatively, chem destruction may be used, esp when small quantities ... are to be destroyed in laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": HEPA (high-efficiency particulate arrestor) filters ... can be disposed of by incineration. For spent charcoal filters, the adsorbed material can be stripped off at high temp & carcinogenic wastes generated by this treatment conducted to & burned in an incinerator. ... LIQUID WASTE: ... Disposal should be carried out by incineration at temp that ... ensure complete combustion. SOLID WASTE: Carcasses of lab animals, cage litter & misc solid wastes ... should be disposed of by incineration at temp high enough to ensure destruction of chem carcinogens or their

metabolites. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Small quantities of ... some carcinogens can be destroyed using chem reactions ... but no general rules can be given. ... As a general technique ... treatment with sodium dichromate in strong sulfuric acid can be used. The time necessary for destruction ... is seldom known ... but 1-2 days is generally considered sufficient when freshly prepd reagent is used. ... Carcinogens that are easily oxidizable can be destroyed with milder oxidative agents, such as saturated soln of potassium permanganate in acetone, which appears to be a suitable agent for destruction of hydrazines or of compounds containing isolated carbon-carbon double bonds. Concn or 50% aqueous sodium hypochlorite can also be used as an oxidizing agent. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.16]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Carcinogens that are alkylating, arylating or acylating agents per se can be destroyed by reaction with appropriate nucleophiles, such as water, hydroxyl ions, ammonia, thiols & thiosulfate. The reactivity of various alkylating agents varies greatly ... & is also influenced by sol of agent in the reaction medium. To facilitate the complete reaction, it is suggested that the agents be dissolved in ethanol or similar solvents. ... No method should be applied ... until it has been thoroughly tested for its effectiveness & safety on material to be inactivated. For example, in case of destruction of alkylating agents, it is possible to detect residual compounds by reaction with 4(4-nitrobenzyl)-pyridine. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.17]**PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

Permissible Exposure Limit: Table Z-1 8-hr Time Weighted Avg: 1 mg/cu m. /**Nickel**, soluble cmpd, as Ni/
[29 CFR 1910.1000 (7/1/99)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-1 8-hr Time Weighted Avg: 1 mg/cu m. /**Nickel**, metal and insoluble cmpd, as Ni/
[29 CFR 1910.1000 (7/1/99)]**PEER REVIEWED**

Threshold Limit Values:

8 hr Time Weighted Avg (TWA) 0.1 mg/cu m, inhalable fraction. A4. A4= Not classifiable as a human carcinogen. /**Nickel**, soluble compounds, as Ni/
[American Conference of Governmental Industrial Hygienists. Guide to Occupational Exposure Values - 1999. Cincinnati, OH: 1999. 51]**PEER REVIEWED**

8 hr Time Weighted Avg (TWA) 0.2 mg/cu m, inhalable fraction. A1. A1= Confirmed human carcinogen. /**Nickel**, insoluble compounds, as Ni/
[American Conference of Governmental Industrial Hygienists. Guide to Occupational Exposure Values - 1999. Cincinnati, OH: 1999. 51]**PEER REVIEWED**

Excursion Limit Recommendation: Excursions in worker exposure levels may exceed three times the TLV-TWA for no more than a total of 30 min during a work day, and under no circumstances should they exceed five times the TLV-TWA, provided that the TLV-TWA is not exceeded.
[American Conference of Governmental Industrial Hygienists. Guide to Occupational Exposure Values - 1999. Cincinnati, OH: 1999. 6]**PEER REVIEWED**

NIOSH Recommendations:

NIOSH considers **nickel** metal and other compounds (as Ni) to be a potential occupational carcinogen. /**Nickel** metal and other compounds (as Ni)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 224]**PEER REVIEWED**

NIOSH usually recommends that occupational exposures to carcinogens be limited to the lowest feasible concentration. /**Nickel** metal and other compounds (as Ni)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 224]**PEER REVIEWED**

Recommended Exposure Limit: 10 Hr TWA 0.015 mg/cu m. /**Nickel** metal and other compounds (as Ni)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 224]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH considers **nickel** to be a potential occupational carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 224]**PEER REVIEWED**

Other Occupational Permissible Levels:

Max allowable concn (MAC) USSR 0.5 mg/cu m /**Nickel**, **nickel** oxide and **nickel** sulfides as dust/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1438]**PEER REVIEWED**

Max allowable concn (MAX) USSR 0.005 mg/cu m as Ni /**Nickel** salts & aerosols/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1438]**PEER REVIEWED**

Other recommendations: 0.05 ppm, Australia (1978), Belgium (1978), and the Netherlands (1978); 0.001 ppm, Finland (1975), Italy (1978), Japan (1978), Poland (1976), Sweden (1978), and Yugoslavia (1971); 0.002 ppm, Romania (1975); and 0.00007 ppm, USSR (1977). Italy and Sweden retained the carcinogenic designation.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.424]**PEER REVIEWED**

1 ug **nickel**/deciliter blood and 70 ug/g creatine urine are suggested as the maximum permissable values. ... /**Nickel** and **nickel** cmpd/
[Lauwerys Rh; Industrial Chemicals Exposure: Guidelines for Biological Monitoring, Biomedical Publications, Davis, CA p.135 (1983)]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

The primary uses for **nickel** compounds, aside from **nickel** refining and electroplating, are in steel making, catalysts, storage batteries, specialty chemicals, and specialty ceramics.
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V17 (92) 18]**PEER REVIEWED**

The major uses of **nickel** include the production of steel and various alloys and electroplating; it is also used in **nickel**-cadmium batteries, fuel cells, specialty ceramics, magnets, specialty chemicals, electronic circuitry, filters for gases, preparation of colored glass, as a hydrogenation catalyst in industrial and laboratory processes, in various pigments and for color stabilization of color copy paper. **Nickel** plating is used for car bumpers and trim and other consumer products.
[ATSDR; Toxicological Profile for Nickel. ATSDR/TP-88/19 pp. 67-70 (1988)]**PEER REVIEWED**

Consumption Patterns:

TOTAL USA CONSUMPTION IN 1973 OF **NICKEL** SULFATE & OTHER **NICKEL** SALTS WAS REPORTED TO BE 3.3 MILLION KG.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 84 (1976)]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

NANOGRAM QUANTITIES OF **NICKEL** IN URINE & BLOOD CAN BE DETERMINED BY PULSE POLAROGRAPHY. /TOTAL **NICKEL**/
[NIEBOER E ET AL; ANN CLIN LAB SCI 8 (6): 497 (1978)]**PEER REVIEWED**

FLAMELESS ATOMIC ABSORPTION HAS BEEN USED FOR ANALYSIS OF **NICKEL** IN SMALL TISSUE (61 TO 662 MG WET WT) SAMPLES WHERE **NICKEL** CONCN WERE OF ... 4 TO 30 UG/100 G TISSUE: TORJUSSEN W ET AL, CLIN CHEM 23: 1018 (1977). /TOTAL **NICKEL**/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1824]**PEER REVIEWED**

AN IMPROVED CHELATION EXTRACTION METHOD USING FURILDOXIME FOR **NICKEL** ANALYSIS IN SERUM & URINE BY ELECTROTHERMAL ATOMIC ABSORPTION HAS BEEN REPORTED ... MIKAC-DEVIC D ET AL, CLIN CHEM 23: 948 (1977). /TOTAL **NICKEL**/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1824]**PEER REVIEWED**

Analyte: **Nickel**; Matrix: blood or tissue; Procedure: Inductively-coupled argon plasma-atomic emission spectroscopy; Wavelength: 231.6 nm; Range: 10 to 10,000 ug/100 g blood, 2 to 2000 ug/g tissue; Est LOD: 1 ug/100 g blood, 0.2 ug/g tissue; Precision: 16; Interferences: spectral, minimized by wavelength selection /Total **nickel**/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V1 8005-1]**PEER REVIEWED**

Analyte: **Nickel**; Matrix: urine; Procedure: Inductively-coupled argon-plasma, atomic emission spectroscopy; Extraction media: polydithiocarbamate resin; Wavelength: 231.6 nm; Range: 0.25-200 ug/samp; Est LOD: 0.1 ug/samp; Precision: 0.42; Interferences: spectral, minimized by wavelength selection /Total **nickel**/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V1 8310-1]**PEER REVIEWED**

Analyte: **nickel**; matrix: urine; range: <5 ug/g creatinine (normal value), 70 ug/g creatinine (tentative max permissible value) /Total **nickel**/
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 909]**PEER REVIEWED**

Analyte: **nickel**; matrix: plasma; range: <1 ug/100 ml (normal value), 1 ug/100 ml (tentative max permissible value) /Total **nickel**/
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 909]**PEER REVIEWED**

FLAMELESS ATOMIC ABSORPTION HAS BEEN USED FOR ANALYSIS OF **NICKEL** IN SMALL TISSUE (61 TO 662 MG WET WT) SAMPLES WHERE **NICKEL** CONCN WERE OF ... 4 TO 30 UG/100 G TISSUE. /**NICKEL**/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1824]**PEER REVIEWED**

AN IMPROVED CHELATION EXTRACTION METHOD USING FURILDOXIME FOR **NICKEL** ANALYSIS IN SERUM & URINE BY ELECTROTHERMAL ATOMIC ABSORPTION HAS BEEN REPORTED ... . /**NICKEL**/
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 1824]**PEER REVIEWED**

NIOSH Method: 8005. Analyte: **Nickel**. Matrix: Blood or tissue. Procedure: Inductively coupled argon plasma, atomic emission spectroscopy. For **nickel** this method has an estimated detection limit of 1 ug/100 g blood; 0.2 ug/g tissue. The precision/RSD is 16 and the recovery is 86%. The working range is 10 to 10,000 ug/100 g blood; 2 to 2,000 ug/g tissue for a 10 ml (blood) or 1 g (tissue) sample. Applicability: This method is useful for monitoring the blood of workers exposed to several metals simultaneously. Interferences: No specific interferences. /**Nickel**/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. 8005-1]**PEER REVIEWED**

NIOSH Method 8310. Analyte: **Nickel**. Specimen: Urine. Procedure: Inductively coupled argon plasma, atomic emission spectroscopy. For **nickel** this method has an estimated detection limit of 0.1 ug/sample. The precision/RSD is 0.42 and the recovery is 80%. The working range is 0.25 to 200 ug/sample. Applicability: This method measures urine concentrations of metals. Interferences: Spectral interferences. /**Nickel**/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. 8310-1]**PEER

REVIEWED**

TYPE C PROCEDURE (C= ELEGANT & PRECISE, USING REQUIRED EQUIPMENT) FOR SERUM, URINE, WHOLE BLOOD & TISSUES; SPECTROMETER, ATOMIC ABSORPTION. CADMIUM & GOLD SALTS CAN CAUSE SLIGHT INHIBITION OF ATOMIC ABSORPTION OF **NICKEL** WHEN THEIR CONCN EXCEED 10 & 25 UG/100 ML, RESPECTIVELY. /**NICKEL**/
[Sunshine, Irving (ed.) Methodology for Analytical Toxicology. Cleveland: CRC Press, Inc., 1975. 275]**PEER REVIEWED**

Electrothermal atomic absorption spectrophotometry with Zeeman background correction provides an accurate, sensitive, and practical routine mehtod for analysis of **nickel** concentrations in body fluids and tissues of human subjects to monitor environmetal, occupational, or iatrogenic exposures to **nickel** compounds. /Total **nickel**/
[Sunderman FW; Govt Reports Announcements & Index 5 (1988)]**PEER REVIEWED**

Analytic Laboratory Methods:

ATOMIC ABSORPTION SPECTROPHOTOMETRY ... FOR **NICKEL** IN BOTH AIR & WATER: SACHDEV SL, WEST PW; ENVIRON SCI TECHNOL 4: 749 (1970). DIMETHYLGLYOXIME METHOD FOR COLORIMETRIC DETERMINATION OF TRACES OF **NICKEL** ... SANDELL EB; COLORIMETRIC DETERMINATION OF TRACES OF METALS, 3RD ED, 665 (1959), INTERSCIENCE, NY. /TOTAL **NICKEL**/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 86 (1976)]**PEER REVIEWED**

DUST FILTER SAMPLE WAS PLACED ON A FLAT POLISHED QUARTZ GLASS & IRRADIATED WITH PRIMARY X-RAY BEAM TO ANALYZE THE DUST. **NICKEL** & OTHER METALS WERE DETERMINED. /TOTAL **NICKEL**/
[FREITAG K ET AL; GES KERNENERGIEVERWERT SCHIFFBAU SCHIFFAHRT (BER), ISS GUSS 79/E/9 (1979)]**PEER REVIEWED**

Analyte: **nickel**; matrix: air; procedure: AAS; range: 0.447-2.075 mg/cu m; precision (coefficient of variation): 0.057 /Total **nickel**/
[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing Office, 1977-present.p. V3 S206-1]**PEER REVIEWED**

Analyte: trace metals (incl **nickel**); matrix: air; procedure: AAS; range: 0.5-5.0 ug/ml; 21-210 ug/cu m; precision: 3% RSD (analytical) /Trace metals/
[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing Office, 1977-present.p. V5 173-1]**PEER REVIEWED**

MATRIX: AIR: ATOMIC ABSORPTION WITH HEATED GRAPHITE ATOMIZING ROD, TUBE OR FURNACE; RANGE: 0.005-0.030 MG/CU M (METHOD IS PROPOSED). /TOTAL **NICKEL**/
[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing Office, 1977-present.p. V5 298-1]**PEER REVIEWED**

Analyte: **nickel**; matrix: air; procedure: AAS; range: 0.57-30.7 ug/cu m; precision: 0.075 /Total **nickel**/
[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing

Office, 1977-present.p. V7 298-1]**PEER REVIEWED**

Analyte: **Nickel**; Matrix: air; Procedure: X-ray fluorescence; Range: 0.02 - 0.14 mg/cu m; Est LOD: 2 ug each metal/samp; Precision: 0.071; Interferences: Controlled with wavelength dispersive fluorescence, more severe with energy dispersive systems, cobalt in fumes requires different ratio standard element /Total **nickel**/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V2 7200-1]**PEER REVIEWED**

NIOSH Method 7300. Analyte: **Nickel**; Matrix: air; Procedure: inductively coupled argon plasma, atomic emission spectroscopy; Wavelength: 231.6 nm; Range: 2.5-1000 ug/sample; Precision: at 2.5 ug/filter: 0.027, at 1000 ug/filter: 0.020; Interferences: spectral, minimized by wavelength selection, interelement and background correction /Total **nickel**/
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

NIOSH 8005. Determination of Elements in Blood or Tissue Samples by Inductively Coupled Argon Plasma - Atomic Emission Spectroscopy (ICP-AES). This method is for monitoring the tissue of workers exposed to several metals simultaneously. This is a simultaneous multielemental analysis, but is not compound specific. The reported detection limit is 0.2 ug/g.
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

NICKEL ANALYSIS DEVICE IS COMPRISED OF A FIRST AUTOMATIC MEASURING SYSTEM, A SECOND AUTOMATIC MEASURING SYSTEM, AND A COLORIMETRIC MEASUREMENT SYSTEM. /TOTAL **NICKEL**/
[YEE TB; GOVT REPORTS ANNOUNCEMENTS & INDEX (GRA&I) (3) (1981)]**PEER REVIEWED**

METHOD HAS BEEN APPLIED TO DETERMINE **NICKEL** @ PERCENTAGE LEVEL IN ALLOY & @ TRACE LEVELS IN TEA & FAT SAMPLES. /TOTAL **NICKEL**/
[BARRATT RS ET AL; ANALYTICA CHIMICA ACTA (59): 59 (1972)]**PEER REVIEWED**

A RAPID ELECTROTHERMAL ATOMIC ABSORPTION PROCEDURE FOR ANALYSIS OF METAL CONTENT OF SEWAGE SLUDGE IS PRESENTED. /TOTAL **NICKEL**/
[CARRONDO MJ T ET AL; ANAL CHIM ACTA 106 (2): 309 (1979)]**PEER REVIEWED**

The Parr bomb technique is found to be the preferred acid digestion method for multi-elemental analysis by simultaneous inductively coupled plasma atomic emission spectroscopy when compared with microwave and hot plate methods for many environmental and biological specimens, but especially for the latter. One digestion alone often did not produce quantitative results compared with a sequential digestion scheme. The digestions were then refined to be as similar as possible for the various substrates studied. The use of modified k values was demonstrated to provide accuracy and had to be used for inductively coupled plasma atomic emission spectroscopy spectrometers where background corrections were performed first for fixed channels. /Total **nickel**/
[Que Hee SS, Boyle Jr; Anal Chem 60 (10): 1033-42 (1988)]**PEER REVIEWED**

EPA Method 7520: **Nickel** (Atomic Absorption, Direct Aspiration) Method 7520 is applicable for the determination of metals in solution by atomic absorption spectrometry. Preliminary treatment of waste

water, ground water, EP extracts, and industrial waste is always necessary because of the complexity and variability of sample matrix. After aspiration and atomization of the sample in a flame, a light beam from a hollow cathode lamp or an electrodeless discharge lamp is directed through the flame into a monochromator and onto a detector that measures the amount of absorbed light. ... The light energy absorbed by the flame is a measure of the concentration of that metal in the sample. The performance characteristics for an aqueous sample free of interferences are: optimum concentration range of 0.3-5 mg/l with a wavelength of 232.0 nm, a sensitivity of 0.15 mg/l, and a detection limit of 0.04 mg/l. /Total **nickel**/
[USEPA; Test Methods for Evaluating Solid Waste SW-846 (1986)]**PEER REVIEWED**

Direct Aspiration Atomic Absorption Spectrometry is used for the determination of **nickel**. Using air-acetylene as the flame gas at a wavelength of 232.0 nm, the detection limit is 0.02 mg/l, with a sensitivity of 0.15 mg/l, at an optimum concentration range of 0.3-10 mg/l. /Total **nickel**/
[Franson MA (Ed); Standard Methods for the Examination of Water and Wastewater p. 154 (1985)]**PEER REVIEWED**

Method 3114 C. Electrothermal Atomization Atomic Absorption Spectrometry for the determination of micro quantities of selected elements including **nickel** in water and wastewater samples. Using an electrically heated atomizer or graphite furnace, at a wavelength of 232.0 nm, the estimated detection limit for **nickel** is 1 ug/l at an optimum concentration range of 5 to 100 ug/l. These values may vary with the chemical form of the **nickel** being determined, sample composition, or instrumental conditions. Pyrolytically coated tubes are used to minimize the chemical interaction with **nickel** to form the refractory carbide at high atomization temperatures. Elements that form carbides are barium, molybdenum. **nickel**, titanium, vanadium, and silicon. /Total **nickel**/
[Franson MA, ed; Standard Methods for the Examination of Water and Wastewater, 17th ed p.3-32 (1989)]**PEER REVIEWED**

Method 3120. Emission Spectroscopy for the determination of **nickel** in water and wastewater samples using an inductively coupled plasma source. The exact choice of emission line is related to sample matrix and instrumentation. A typically used emission line for **nickel** in water is a wavelength of 231.60 nm, with an estimated detection limit of 15 ug/l. /Total **nickel**/
[Franson MA, ed; Standard Methods for the Examination of Water and Wastewater, 17th ed p.3-53 (1989)]**PEER REVIEWED**

EPA Method 200.7: An Inductively Coupled Plasma - Atomic Emission Spectrophotmetric method for the determination of dissolved, suspended, or total elements in drinking water, surface water, and domestic and industrial waste waters, is described. **Nickel** is analyzed at a wavelength of 231.604 nm and has an estimated detection limit of 15 ug/l. /Total **nickel**/
[40 CFR 136 (7/1/87)]**PEER REVIEWED**

DETERMINATION OF **NICKEL** IN RAT LUNG BY ATOMIC ABSORPTION SPECTROPHOTOMETRY. /TOTAL **NICKEL**/
[KAPLAN P ET AL; ARCH ENVIRON HEALTH 27 (6): 387 (1973)]**PEER REVIEWED**

A method capable of speciation of metallic **nickel**, **nickel**(+2) and **nickel** oxides in atmospheric monitoring is described.
[Wu TG, Wong JL; Anal Chim Acta 235: 457-60 (1990)]**PEER REVIEWED**

DOE MS410. Determination of **Nickel** (Ni2+) in Aqueous Samples using the Indicator Strip Based Colorimetric Test. This field screening method is applicable to waste water samples containing **nickel**. The reported detection limit is 5 ug/ml.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW 6020. Inductively Coupled Plasma with Mass Spectrometry. This method is applicable to water and waste samples. Prior to analysis for total values, samples must be digested using appropriate sample preparation methods (such as OSW Methods 3005A, 3010A, 3015, 3020A, 3040, or 3050A). The reported detection limit is 0.03 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW 7000A. Atomic Absorption By FLAA. This method is used for the analysis of drinking water, surface water, saline waters, and domestic and industrial wastes. Drinking water free of particulates may be analyzed directly. Ground water, other aqueous samples, EP extracts, industrial wastes, soils, sludges, sediments and other solid wastes require digestion by Methods 3005-3050 prior to analysis for both total and acid leachable metals. When analyzing for dissolved metals, acid digestion is not necessary for samples that have been filtered and preserved. The reported detection limit is 0.04 mg/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

SFSAS_14. Analysis of Fish for Metals. This method is applicable to the determination of metals in fish tissue. For sample preparation refer to method SFSAS_FT-PREP. Group I: Samples are digested by a dry ashing process. For samples being tested for Be, Cd, Cr, Cu, Pb, Ni, Ag, Tl, and Zn. The detection limit is not provided.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

OSW 3031. Acid Digestion of Oils for Metals Analysis by FLAA or ICP-AES. This method is applicable to the digestion of oils, oil sludges, tars, waxes, paints, paint sludges, and other viscous petroleum products for the analysis of 16 metals by FLAA or ICP-AES. The detection limit is not provided.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

Sampling Procedures:

Analyte: **nickel**; matrix: air; procedure: filter collection, acid digestion, graphite furnace /**Nickel** and **nickel** cmpd/
[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing Office, 1977-present.p. V7 298-1]**PEER REVIEWED**

Measurements to determine employee exposure are best taken so that the avg 8-hr exposure is based on a single 8-hr sample or on two 4-hr samples. Several short-time interval samples (up to 30 min) may also be used to determine the avg exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). /**Nickel** metal and sol **nickel** compounds/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Sampling and analyses may be performed by collection on a cellulose membrane filter followed by treatment with nitric and perchloric acids, solution in nitric acid ... /**Nickel** metal and soluble **nickel** compound/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER

REVIEWED**

Analyte: **Nickel**; Matrix: air; Sampler: filter (0.8-um cellulose membrane); Flow rate: 1-4 l/min; Vol: min: 5 l, max: 1000 l; Stability: stable /**Nickel** and **nickel** cmpd/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V1 7300-1]**PEER REVIEWED**

Analyte: **Nickel**; Specimen: Blood or tissue; Vol: 10 ml blood, or 1 g tissue; Preservative: Heparin for blood, none for tissue; Controls: collect 3 blood specimens from unexposed workers; Stability: not established /**Nickel** and **nickel** cmpd/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V1 8005-1]**PEER REVIEWED**

Analyte: **Nickel**; Specimen: urine; Vol: 50-200 ml in polyethylene bottle; Preservative: 5 ml conc HNO3 added after collection; Controls: collect at least 3 urine specimens from unexposed workers; Stability: not established /**Nickel** and **nickel** cmpd/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V1 8310-1]**PEER REVIEWED**

Analyte: **Nickel**; Matrix: air; Sampler: filter (0.8 um cellulose ester membrane); Flow rate: 1 l/min; Vol: min: 10 l, max: 400 l; Stability: At least 1 yr at 25 deg C /Welding and brazing fumes/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. V2 7200-1]**PEER REVIEWED**

NIOSH Method 7200. Analyte: **Nickel**. Matrix: Air. Sampler: Filter (0.8 um cellulose ester membrane). Flow Rate: 1 l/min. Sample Size: 100 liters. Shipment: Routine. Sample Stability: Stable at least 1 year @ 25 deg C. /**Nickel**/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. 7200-1]**PEER REVIEWED**

NIOSH Method 8005. Analyte: **Nickel**. Specimen: Blood or tissue. Volume: 10 ml (blood) or 1 g (tissue). Preservative: Heparin (blood); none for tissue. Shipment: Frozen for blood and "wet" tissue; routine for "dry" tissue. Sample Stability: Not established. /**Nickel**/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. 8005-1]**PEER REVIEWED**

NIOSH Method 8310. Analyte: **Nickel**. Specimen: Urine. Volume: 50 to 200 ml in polyethylene bottle. Preservative: 5.0 ml conc nitric acid added after collection. Shipment: Frozen in dry ice. Sample Stability: Not established. /**Nickel**/
[U.S. Department of Health and Human Services, Public Health Service. Centers for

Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. 8310-1]**PEER REVIEWED**

NIOSH Method 7300. Analyte: **Nickel**. Matrix: Air. Sampler: Filter (0.8 um, cellulose ester membrane). Flow Rate: 1 to 4 l/min. Sample Size: 500 liters. Shipment: Routine. Sample Stability: Stable. /**Nickel**/
[U.S. Department of Health and Human Services, Public Health Service. Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods, 3rd ed. Volumes 1 and 2 with 1985 supplement, and revisions. Washington, DC: U.S. Government Printing Office, February 1984.p. 7300-1]**PEER REVIEWED**

NIOSH Method 173. Analyte: **Nickel**. Matrix: Air. Procedure: Filter collection, acid digestion. Flow Rate: 1.5 l/min. Sample Size: 10 ml. /**Nickel**/
[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing Office, 1977-present.p. V5 173-1]**PEER REVIEWED**

NIOSH Method S206. Analyte: **Nickel**. Matrix: Air. Procedure: Filter collection, acid digestion. Flow Rate: 1.5 l/min. Sample Size: 90 liters. /**Nickel**/
[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing Office, 1977-present.p. V3 S206-1]**PEER REVIEWED**

NIOSH Method 298. Analyte: **Nickel**. Matrix: Air. Procedure: Filter collection, acid digestion. Flow Rate: 1.5 to 2.5 l/min. Sample Size: 400 liters. /**Nickel**/
[U.S. Department of Health, Education Welfare, Public Health Service. Center for Disease Control, National Institute for Occupational Safety Health. NIOSH Manual of Analytical Methods. 2nd ed. Volumes 1-7. Washington, DC: U.S. Government Printing Office, 1977-present.p. V7 298-1]**PEER REVIEWED**

Special References:

Special Reports:

NIOSH; Criteria Document: Inorganic **Nickel** (1977) DHEW Pub NIOSH 77-164

Nat'l Research Council Canada; **Nickel** (1981) NRCC No. 18568

DHHS/ATSDR; Toxicological Profile for **Nickel** (Draft) (10/87)

NAS; Report of the Committee on Med and Envir Poll: **Nickel** (1975)

NTP; Chem Selection Profile: **Nickel** Chloride (1979)

USEPA; Ambient Water Quality Criteria Doc: **Nickel** (1980) EPA 400/5-80-060

USEPA; Health Assessment Document: **Nickel** (1983) EPA 600/8-83-012

Longstaff E et al; IARC Sci Pub 53: 235-43 (1984). Epidemiological studies of workers exposed to **nickel** ores free of sulfur and workers exposed to metallic **nickel** and its alloys in the steel industry and in an aircraft engine manufacturing facility have not shown any connection between exposure and deaths

from cancer. In experiments in which rodents were exposed to metallic **nickel** dust, **nickel** carbonyl, **nickel** subsulfide, and **nickel** oxide, only **nickel** subsulfide has been found to be definitely carcinogenic. **Nickel** cmpds do not all have the same biological potential. **Nickel** and **nickel** oxide should not be considered carcinogenic for risk assessment purposes.

Santodonato J et al; Monograph on Human Exposure to Chemicals in the Workplace: **Nickel** Report No SRC-TR-84-673 (1985). This report summarizes and evaluates toxicologic information relevant to an occupational hazard assessment of **nickel**, including chemical and physical properties, production and use of **nickel** metal and **nickel** compounds, pharmacokinetics (absorption, distribution, metabolism, excretion), animal carcinogenicity and mutagenicity, and epidemiological studies.

Synonyms and Identifiers:

Related HSDB Records:

1096 [**NICKEL**, ELEMENTAL; 7440-02-0]

1664 [**NICKEL** OXIDE]

1827 [**NICKEL** HYDROXIDE]

1662 [**NICKEL** CARBONATE]

6154 [BASIC **NICKEL**(II) CARBONATE]

1826 [**NICKEL** FLUORIDE]

860 [**NICKEL** CHLORIDE]

1828 [**NICKEL** IODIDE]

1829 [**NICKEL** NITRATE]

1190 [**NICKEL** PERCHLORATE]

1114 [**NICKEL** SULFATE]

1241 [**NICKEL** AMMONIUM SULFATE]

2965 [TRINICKEL DISULFIDE]

1663 [**NICKEL** CARBONYL]

1191 [**NICKEL** FORMATE]

1029 [**NICKEL** ACETATE]

1309 [**NICKEL** (2+) NTA]

2950 [**NICKEL**, BIS(DIBUTYLDITHIOCARBAMATO)-]

1185 [**NICKEL** CYANIDE]

Associated Chemicals:

Nickel ion (2+);14701-22-5

Administrative Information:

Hazardous Substances Databank Number: 6933

Last Revision Date: 20030214

Last Review Date: Reviewed by SRP on 5/6/2000

Update History:

Complete Update on 02/14/2003, 1 field added/edited/deleted.
Complete Update on 05/13/2002, 1 field added/edited/deleted.
Complete Update on 01/14/2002, 1 field added/edited/deleted.
Complete Update on 05/16/2001, 1 field added/edited/deleted.
Complete Update on 05/15/2001, 1 field added/edited/deleted.
Complete Update on 02/26/2001, 1 field added/edited/deleted.
Complete Update on 09/08/2000, 64 fields added/edited/deleted.

Record Length: 215559

NICKEL, ELEMENTAL

CASRN: 7440-02-0

This record contains information for nickel in its zero valence state only. For general toxicology and environmental fate of nickel ion and nickel compounds, refer to the NICKEL COMPOUNDS record; for compound-specific information, refer to the appropriate individual records, e.g., nickel sulfate, nickel chloride, etc.

For other data, click on the Table of Contents

Human Health Effects:

Toxicity Summary:

Nickel is a ubiquitous trace metal and occurs in soil, water, air and the biosphere. **Nickel** ore deposits are accumulations of **nickel** sulfide minerals (mostly pentlandite) and laterites. Most **nickel** is used for production of stainless steel and other **nickel** alloys with high corrosion and temperature resistance. **Nickel** levels in terrestrial and aquatic organisms can vary over several orders of magnitude. Dermal exposure in the general environment is important for the induction and maintenance of contact hypersensitivity caused by daily contact with **nickel** plated objects or **nickel** containing alloys (e.g. jewellery, coins or clips). Iatrogenic exposure to **nickel** results from implants and prostheses made from **nickel** containing alloys, from iv or dialysis fluids and from radiographic contrast media. In the working environment, airborne **nickel** concentrations can vary from a few microgram/cu m to a few mg/cu m, depending upon the process involved and the **nickel** content of the material being handled. Workers are exposed to **nickel** containing dusts and fumes during welding, plating, grinding, mining, **nickel** refining, and in steel plants. Dermal exposure to **nickel** may occur in a wide range of jobs, either by direct exposure, dissolved **nickel** in refining, electroplating and electroforming industries or by handling **nickel** containing materials. **Nickel** can be absorbed in human beings and animals via inhalation or ingestion or percutaneously. Respiratory absorption with secondary gastrointestinal absorption (insoluble and soluble) is a major route of entry during occupational exposure. Percutaneous absorption is negligible, quantatively, but is important in the pathogenesis of contact hypersensitivity. **Nickel** is transported in the blood, principally bound to albumin. Gastrointestinal absorption of **nickel** is variable and depends on the composition of the diet. All body secretions are potential routes of excretion including the urine, bile, sweat, tears, milk and mucociliary fluid. Non-absorbed nicke is eliminated in the feces. Data on **nickel** excretion suggest a two compartment model. **Nickel** concentration in the serum and urine of healthy non-occupationally exposed adults are 0.2 ug/l (range: 0.05-1.1 ug/l) and 1.5 ug creatinine (range: 0.5-4.0 mg/g creatinine, respectively. The body burden of **nickel** in non-exposed 70 kg adult is 0.5 ug. **Nickel** is essential for the catalytic activity of some plant and bacterial enzymes. Slow weight gain, anemia and decreased viability has been described in some animal species after dietary deprivation of **nickel**. Contact allergy to **nickel** is very common in human beings; experimental sensitization in animals is only successful under special conditions. Longterm inhalation exposure to metallic **nickel** caused mucosal damage and inflammatory reaction, sometimes accompanied by slight fibrosis, was observed in rabbits after high level exposure to **nickel** graphite dust. Metallic **nickel** induced local mesenchymal tumors in a variety of experimental animals after im, sc, intraosseous, intrarenal, intra-articular, pleural, intraocular, intratesticular or intra-adipose administrtation. Metallic **nickel** has been tested for carcinogenicity by parenteral routes of administration, local tumors were noted. In studies using repeated intratracheal instillation, **nickel** powder caused respiratory tumors. Chronic effects such as rhinitis, sinusitis, nasal septal perforations and asthma have been reported in **nickel** refinery and **nickel** plating workers. Some researchers reported pulmonary changes with fibrosis in workers handling **nickel** dust. Orsal **nickel** intake may aggravate vesicular hand eczema. Prostheses or other surgical implants make with **nickel** containing alloys have been reported to cause **nickel** sensitization. Cancer rates have

generally been close to normal in stainless steel welding and **nickel** using industries, with the exception of those involving exposure to chromium, particularly electroplating. **Nickel**/cadmium battery workers exposed to high levels of both **nickel** and cadmium may have resulted in a slightly increased risk of lung cancer. Excesses of various cancers other than lung and nasal cancers such as renal, gastric or prostatic have occasionally been reported in **nickel** workers, but none have been found consistently. No increased cancer risk has been demonstrated in workers exposed exclusively to metallic **nickel**. The combined data on **nickel** alloy workers and gasseous diffusion workers, all of whom were exposed to average concentrations of the order of 0.5 mg **nickel**/cu m show no excess risk, though the total number of lung cancers in these cohorts was to small to exclude a small increase in risk at this level.
[World Health Organization/International Programme on Chemical Safety. Environmental Health Criteria 108 Nickel p.13 (1991)]**QC REVIEWED**

Evidence for Carcinogenicity:

CLASSIFICATION: A; human carcinogen. BASIS FOR CLASSIFICATION: Human data in which exposure to **nickel** refinery dust caused lung and nasal tumors in sulfide **nickel** matte refinery workers in several epidemiologic studies in different countries and on animal data in which carcinomas were produced in rats by inhalation and injection. HUMAN CARCINOGENICITY DATA: Sufficient.
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Nickel refinery dust (NO CAS RN) from the National Library of Medicine's TOXNET System, March 1, 1995]**PEER REVIEWED**

Evaluation: There is sufficient evidence in humans for the carcinogenicity of **nickel** sulfate, and of the combinations of **nickel** sulfides and oxides encountered in the **nickel** refining industry. There is inadequate evidence in humans for the carcinogenicity of metallic **nickel** and **nickel** alloys. There is sufficient evidence in experimental animals for the carcinogenicity of metallic **nickel**, **nickel** monoxides, **nickel** hydroxides and crystalline **nickel** sulfides. There is limited evidence in experimental animals for the carcinogenicity of **nickel** alloys, nickelocene, **nickel** carbonyl, **nickel** salts, **nickel** arsenides, **nickel** antimonide, **nickel** selenides and **nickel** telluride. There is inadequate evidence in experimental animals for the carcinogenicity of **nickel** trioxide, amorphous **nickel** sulfide and **nickel** titanate. The Working Group made the overall evaluation on **nickel** compounds as a group on the basis of the combined results of epidemiological studies, carcinogenicity studies in experimental animals, and several types of other relevant data, supported by the underlying concept that **nickel** compounds can generate **nickel** ions at critical sites in their target cells. Overall evaluation: **Nickel** compounds are carcinogenic to humans (Group 1). Metallic **nickel** is possibly carcinogenic to humans (Group 2B). /**Nickel** compounds/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V49 410 (1990)]**PEER REVIEWED**

A1. A1= Confirmed human carcinogen. /**Nickel**, insoluble compounds, as Ni/
[American Conference of Governmental Industrial Hygienists. Guide to Occupational Exposure Values - 1999. Cincinnati, OH: 1999. 51]**PEER REVIEWED**

Human Toxicity Excerpts:

NICKEL METAL IS WELL KNOWN CAUSE OF CONTACT DERMATITIS IN SENSITIZED INDIVIDUALS. INSTANCES OF DERMATITIS IN REGION OF EYES HAS RESULTED FROM CONTACT WITH **NICKEL** SPECTACLE FRAMES, BUT EYE ITSELF HAS NOT BEEN INVOLVED.
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 661]**PEER REVIEWED**

HISTOLOGICAL CHANGES IN NASAL MUCOSA OF **NICKEL** WORKERS WERE STUDIED.

[REITH A ET AL; ANN CLIN LAB SCI 8 (6): 503 (1978)]**PEER REVIEWED**

EPIDEMIOLOGICAL STUDIES CONCLUSIVELY DEMONSTRATE EXCESS RISK OF CANCER OF NASAL CAVITY & LUNG IN WORKERS IN **NICKEL** REFINERIES. IT IS LIKELY THAT **NICKEL** IN SOME FORM(S) IS CARCINOGENIC TO MAN.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 104 (1976)]**PEER REVIEWED**

In **nickel** refinery workers, an excess risk of nasal and lung cancers has been demonstrated.
[USEPA; Ambient Water Quality Criteria Document: Nickel p.C-105 (1980) EPA 400/5-80-060]**PEER REVIEWED**

Nickel, **nickel** subsulfide, and **nickel** oxide are generated in relatively large particle sizes during the production & miniing of **nickel** & are, thus, associated with damage to the nasal mucosa.
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 352]**PEER REVIEWED**

/The investigators/ found no chromosomal aberrations after human lymphocytes were treated in vitro with **nickel** oxide and **nickel** powder. No doses or toxicity levels were given, and it is not clear whether the cells had a significant exposure to these insol cmpd.
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V1 342]**PEER REVIEWED**

IN **NICKEL** PLATING INDUSTRY, EXPOSURE TO **NICKEL** CONTAINING VAPORS HAS BEEN REPORTED TO BE ASSOC WITH ASTHMA. SYMPTOMS WERE ATTRIBUTED TO HYPERSENSITIVITY TO **NICKEL** OF NON-OCCUPATIONAL ORIGIN. PNEUMOCONIOSIS HAS BEEN REPORTED AMONG WORKERS EXPOSED TO **NICKEL** DUST ... EFFECTS ON NASAL MEMBRANE WERE NOTED IN WORKERS EXPOSED TO **NICKEL** AEROSOLS IN AN ELECTROLYSIS SHOP. /**NICKEL** VAPORS & DUST/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 473]**PEER REVIEWED**

WORKERS EMPLOYED IN **NICKEL** PLATING HAVE DEVELOPED CONJUNCTIVITIS & EPIPHORA WHEN VENTILATION WAS POOR.
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 661]**PEER REVIEWED**

NICKEL AS INDUSTRIAL INHALANT WAS FIRST SUSPECTED AS CARCINOGEN IN BRONCHI IN 1933, ESTABLISHED BOTH EPIDEMIOLOGICALLY & EXPERIMENTALLY; FIRST AS CARCINOGEN IN NASAL CAVITY IN 1933, ESTABLISHED EPIDEMIOLOGICALLY BUT NEGATIVE RESULTS EXPERIMENTALLY. /FROM TABLE/
[Searle, C. E. (ed.). Chemical Carcinogens. ACS Monograph 173. Washington, DC: American Chemical Society, 1976. 327]**PEER REVIEWED**

... TOXIC AS DUST OR POWDER.
[Sax, N.I. and R.J. Lewis, Sr. (eds.). Hawley's Condensed Chemical Dictionary. 11th ed. New York: Van Nostrand Reinhold Co., 1987. 818]**PEER REVIEWED**

The mortality of a cohort of 2689 **nickel**/chromium platers between 1946 and 1983 was investigated. All members of the study cohort had some /exposure to chrome during their/ employment. Overall, /when/ compared with the general population of England and Wales, statistically significant differences relating to cancer were found for cancer of the stomach (E= 16.2, 0= 25), primary cancer of the liver (E= 0.8, 0= 4), cancer of the nose and nasal cavities (E= 0.3, 0= 3), cancers of the lung and bronchus (E= 48.1, 0=

72), and all cancers (E= 164.2, 0= 213). Exposure to **nickel** was shown not to be an important confounding effect.
[Sorahan T et al; Br J Ind Med 44 (4): 250-8 (1987)]**PEER REVIEWED**

Nickel sensitivity was detected in 176 cases out of 2400 patients at eight patch test clinics in five eastern European countries. Each clinic tested 300 consecutive patients. Of the positive responses obtained, 89.2 percent occured in females; only 2.1 percent of tested men were **nickel** sensitive. **Nickel** dermatitis appeared to be a disorder primarily of schoolgirls and women younger than 25 yr. Exposure to **nickel** in 49 percent of the cases was for 1 yr or less. Occupational contact was not significant in 75 percent of the cases. Jewelry was the cause in 31.8 percent of the patients, wrist watches and their straps in 23.3 percent, and clothing buckles in 6.3 percent. Buttons on jeans were also a common cause. Occupational causes were cited in 44 cases, with the main source of exposure being scissors, medical instruments, kitchen articles, and plating solution. A secondary role was played by coins. Hands and wrists were predominant sites for dermatitis.
[Schubert H et al; Contact Dermatitis 16 (3): 122-8 (1987)]**PEER REVIEWED**

Employees of the heat seal department at COSCO Inc (SIC-2519), Columbus, Indiana, complained of eye, nose, and throat irritation plus skin rashes and a burning sensation on the lips. Breathing zone monitoring of welders indicated that one was exposed to excessive levels (37 micrograms/cu m) of airborne **nickel**.
[Hartle RW, Albrect W; Govt Reports Announcements & Index (GRA & I) 23 (1987)]**PEER REVIEWED**

Of 557 patients with occupational dermatoses seen at the Middle Road Hospital, Singapore, 55.7% were irritant contact dermatitis, 38.6% were allergic contact dermatitis, and 5.7% were non-contact dermatitis. More than half of the patients were below 30 years old and most were from the construction (29.5%), metal/engineering (20.6%), electrical/electronic (16.4%), transport (5.5%), and food catering (3.8%) industries. Resins including epoxy, acrylate and paratertiary butyl phenol resins and other metals (**nickel** and cobalt) were occupational allergens.
[Goh CL; Ann Acad Med Singapore 16 (2): 303-5 (1987)]**PEER REVIEWED**

A worker who coated pipes with synthetic rubber showed no reaction to rubber or rubber chemicals in patch tests, but showed strong positive reactions to **nickel** and chromium. Investigation indicated that he worked near 2 metal spraying areas where airborne **nickel** levels were 4 times higher and chromium up to 18 times higher than the UK Health and Safety Executive recommended maximum time weighted averages.
[Handfield Jones S et al; Contact Dermatitis 16 (1): 44 (1987)]**PEER REVIEWED**

A mortality study and an incidence study for laryngeal cancer, was conducted on 361 men (minimum employment, one year) in the Italian soap production industries. Employment in this industry includes some exposure to sulfuric acid vapors and **nickel** dusts. Mortality from all causes was lower than expected; lung cancer and laryngeal cancer deaths showed nonsignificant increases. Five new laryngeal cancer cases were detected during the study period. All the men with respiratory cancer had been working for several years, and the latency time was greater than 10 years.
[Forastiere F et al; Scand J Work Environ Health 13 (3): 258-60 (1987)]**PEER REVIEWED**

Occupational cancers of the respiratory tract were reviewed, and the historical development of lung cancer as an occupational disease was summarized. A variety of etiologic agents in occupational lung cancer were discussed including arsenic, asbestos, beryllium, chloromethyl ethers, chromium compounds, polycyclic aromatic hydrocarbons, mustard gas, **nickel**, ionizing radiation, and a variety of suspected carcinogens including vinyl chloride, fibrous mineral materials, chloroprene, and vegetable

dusts.
[Frank AL et al; Occup Med: State of the Art Rev 2 (1): 71-83 (1987)]**PEER REVIEWED**

The contributions of sulfur dioxide and arsenic to lung cancer were assessed in copper smelter workers with regard to the confounding variable of cigarette smoking. The study included a total of 6,078 white male workers who worked for a least 3 years in a USA copper smelter between the dates of January 1, 1946, and December 31, 1976. Worker exposure to arsenic, sulfur dioxide (SO2), dust, **nickel**, lead, and cadmium was categorized by job and year. The percentage of the cohort alive at the end of the study period was 73.9, and the standard mortality ratios relative to three reference populations were comparable. Standard mortality ratios revealed a dose response relationship between arsenic, sulfur dioxide exposure and development of lung cancer. A nested case control analysis showed cigarette smoking and arsenic exposure, but not sulfur dioxide exposure, to be significant factors in the etiology of lung cancer in smelter employees.
[Enterline PE et al; J Occup Med 29 (10): 831-8 (1987)]**PEER REVIEWED**

Galvanizer's eczema, a skin condition encountered among 40 workers engaged in the electric coating of metals with other metals, particularly **nickel** coating, is discussed. An ointment is described for the treatment of the condition, although prevention is essential. In addition to some protective cream, mandatory preventive measures should be imposed for all galvanizing operations. The physician's role is briefly outlined.
[Blaschko A; Deutsche Medizinische Wochenschrift 15: 925-7 (1989)]**PEER REVIEWED**

Nickel, **nickel** subsulfide, and **nickel** oxide are generated in relatively large sizes during the production & mining of **nickel** & are, thus, associated with damage to the nasal mucosa.
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 352]**PEER REVIEWED**

Nasal mucosal biopsy specimens from five normal individuals and 15 cases of pathological epithelia were obtained from **nickel** workers. The immunohistochemical detection of keratins was carried out using monoclonal antibodies AE1 and AE3. The antibody AE1 stained only the basal cells of normal mucociliary epithelium. All layers of the surface epithelium of regular metaplasias were stained with AE3. The dysplastic and neoplastic lesions exhibited an extraordinary increase in the staining patterns with AE3 and to a lesser extent with AE1. Involucrin, which was absent from the normal pseudostratified epithelium, appeared in all metaplastic dysplastic lesions and in keratinized areas of carcinomas. The combined detection of keratins and involucrin proved useful in detecting the degree of maturity and differentiation of preneoplastic and neoplastic lesions of the nasal mucosa.
[Klein Szanto AJ et al; Arch Pathol Lab Med 3 (2): 1057-61 (1987)]**PEER REVIEWED**

Seventy three **nickel** sensitive patients were patch tested with tin plated discs for 48 hr, to identify metal alloys which are safe with respect to **nickel** allergy. Copper discs were produced and a coating of pure tin was plated onto the discs. A six week corrosion test using synthetic sweat at 30 deg C was conducted; **nickel** release was measured after 1, 3, and 6 weeks by atomic absorption spectrometry. Six patients had a positive allergic reaction; four had equivocal positive reactions, and 63 patients were negative. All patients had at least two other positive tests at the same time. Retesting, done on the upper arm of one positive patient after three months, confirmed the earlier observation.
[Menne T et al; Contact Dermatitis 16 (1): 9-10 (1987)]**PEER REVIEWED**

Delayed type hypersensitivity to **nickel** is one of the most common allergies. About 4.5% of the general population in Europe and 5.8% in the United States are allergic to this metal. Patch test clinics throughout the world have a high prevalence of **nickel** sensitivity, in the range of 10% with a significantly rising prevalence in some European countries approaching 20% to 30%. This is

undoubtedly related to ear piercing.
[Marks, J.G. Jr., DeLeo V.A., Contact and Occupational Dermatology. St. Louis, MO: Mosby Year Book 1992. 83]**PEER REVIEWED**

A recent study by Fischer et al. in Sweden showed that all metal pins used for ear piercing released **nickel** in varying amounts, thus allowing exposure to the antigen. Not only are women and schoolgirls affected, but also men, now that ear piercing has become fashionable among them. Among schoolgirls with pierced ears, 13% were allergic to **nickel**. In contrast, only 1% without pierced ears exhibited **nickel** sensitivity. There is conflicting evidence as to how good a history is at predicting **nickel** sensitivity. Some studies have found a high correlation between a positive **nickel** patch test response and a history of jewelry sensitivity. In one study, 10 of 12 subjects developed dermatitis on the ears either shortly after ear piercing or after wearing low quality pierced earrings.
[Marks, J.G. Jr., DeLeo V.A., Contact and Occupational Dermatology. St. Louis, MO: Mosby Year Book 1992. 83]**PEER REVIEWED**

Nickel is the most frequent metal which induces allergic contact sensitization and accounts for approximately 10% of all positive patch tests in North America.
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 106]**PEER REVIEWED**

Nickel hypersensitivity dermatitis may be initiated by contact with **nickel** on the skin. Disulfiram metabolizes to dithiocarbamate and is an effective **nickel** chelator in patients with **nickel** hypersensitivity dermatitis. **Nickel** dermatitis may develop at previously affected sites during initiation of disulfiram therapy for alcohol use.
[Ellenhorn, M.J., S. Schonwald, G. Ordog, J. Wasserberger. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. 2nd ed. Baltimore, MD: Williams and Wilkins, 1997. 1358]**PEER REVIEWED**

Asthma, urticaria, erythema multiforme, contact dermatitis, and hand eczema may follow use of objects made with **nickel**.
[Ellenhorn, M.J., S. Schonwald, G. Ordog, J. Wasserberger. Ellenhorn's Medical Toxicology: Diagnosis and Treatment of Human Poisoning. 2nd ed. Baltimore, MD: Williams and Wilkins, 1997. 1604]**PEER REVIEWED**

Nickel poisoning was reported in a group of 23 dialyzed patients, when leaching from a **nickel**-plated stainless steel water heater tank contaminated the dialysate. Symptoms occurred during, and after, dialysis, at plasma-**nickel** concentrations of approximately 3 mg/litre. Symptoms included nausea (37 out of 37), vomiting (31 out of 37), weakness (29 out of 37), headache (22 out of 37), and palpitation (2 out of 37). Recovery occurred spontaneously, generally 3-13 hr after cessation of dialysis ... .
[WHO; Environ Health Criteria 108: Nickel p.??? (1991)]**PEER REVIEWED**

EXPOSURE TO INDUSTRIAL **NICKEL** DUST CAUSES **NICKEL** DERMATITIS. SENSITIVITY TO **NICKEL** MAY BE EXHIBITED FROM SKIN CONTACT ... DIVALENT **NICKEL** IONS CAN PENETRATE SKIN AT SWEAT-DUCT & HAIR FOLLICLE OSTIA, & BIND WITH KERATIN. CONTACT DERMATITIS THUS RESULTS FROM PERMEABILITY OF ... DERMIS & EPIDERMIS TO **NICKEL**. /**NICKEL** DUST & SALTS/
[Venugopal, B. and T.D. Luckey. Metal Toxicity in Mammals, 2. New York: Plenum Press, 1978. 292]**PEER REVIEWED**

An incr incidence of lung and nasal cavity cancers has been noted among workmen in **nickel** smelters and refineries. /**Nickel** dust and compounds/
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-145]**PEER REVIEWED**

Medical Surveillance:

PRECAUTIONS FOR "CARCINOGENS": ... In relation specifically to cancer hazards, there are at present no health monitoring methods that may ensure the early detection of preneoplastic lesions or lesions which may preclude them. Whenever medical surveillance is indicated, in particular when exposure to a carcinogen has occurred, ad hoc decisions should be taken concerning additional tests that might become useful or mandatory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.23]**PEER REVIEWED**

Probable Routes of Human Exposure:

Occupational exposures to **nickel** and its cmpd occur in (1) mining and comminution of **nickel** containing ores; (2) **nickel** refining and smelting; (3) **nickel** electroplating; (4) producing and using **nickel** catalysts; (5) fabricating parts and structures by welding, flame spraying, cutting, grinding, and polishing of **nickel** containing alloys; (6) manufacturing **nickel** cadmium batteries; (7) constructing **nickel** molds in glass bottle factories; (8) spraying **nickel** containing paints (eg, yellow **nickel** titanate pigment); and (9) recycling or disposal of **nickel** containing products. /**Nickel** and **nickel** cmpd/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 455]**PEER REVIEWED**

IN **NICKEL** PLATING INDUSTRY, EXPOSURE TO **NICKEL** CONTAINING VAPORS HAS BEEN REPORTED TO BE ASSOC WITH ASTHMA. SYMPTOMS WERE ATTRIBUTED TO HYPERSENSITIVITY TO **NICKEL** OF NON-OCCUPATIONAL ORIGIN. PNEUMOCONIOSIS HAS BEEN REPORTED AMONG WORKERS EXPOSED TO **NICKEL** DUST ... EFFECTS ON NASAL MEMBRANE WERE NOTED IN WORKERS EXPOSED TO **NICKEL** AEROSOLS IN AN ELECTROLYSIS SHOP. /**NICKEL** VAPORS & DUST/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 473]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** **NICKEL** ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE

0.2.1.1 ACUTE EXPOSURE

A. Adverse effects can result from ingestion, skin contact, inhalation or parenteral routes of exposure; **nickel** may be absorbed from the gastrointestinal and respiratory tracts as well as percutaneously.

B. Inhalation of **nickel** alloys or dust has been linked to pulmonary irritation, asthma, pneumoconiosis, pulmonary fibrosis and pulmonary edema. Gingivitis, stomatitis, metallic taste, nasal irritation, nasal mucosa damage, nasal septum perforation, hyposmia/anosmia, cough and shortness of breath are sometimes reported. Exposure to **nickel** fumes may result in 'metal fume fever'. Death from adult respiratory distress syndrome has occurred.

1. However, inhalation exposures are usually to **nickel** carbonyl. Exposure to **nickel** carbonyl produces severe acute systemic effects not found with exposure to **nickel** metal, salts or alloys.

a. **Nickel** carbonyl inhalation toxicity is divided into early and late phases. Initially, exposure results in headache, discomfort, fatigue, weakness, nausea and vomiting, and 'flu-like' symptoms. Then, 12 to 36 hours later, shortness of breath, pallor, chest pain and dyspnea occur. Pneumonitis, convulsions and death are possible consequences.

C. Contact dermatitis or hypersensitivity, possibly severe, occurs in sensitized individuals (2 to 5% of the general population). **Nickel** is the most common cause of allergic contact sensitization (10% of all positive patch tests).

1. Exposure can result in localized pruritis ('**nickel** itch'), erythema, papules, eczema and possibly vesicles after 1 to 2 days of continuous contact, and may also be linked to conjunctivitis, asthma and allergic rhinitis. Mucosal contact hypersensitivity (with piercings) has been reported.

2. Costume jewelry was found to be one of the main causes of **nickel** dermatitis, especially in children 10 to 19 years of age, mainly female.

D. Parenteral exposures may occur from implanted metal prostheses, stainless steel needles or contaminated dialysate solutions. Inflammatory reactions have occurred around **nickel**-containing prostheses and medical implants. '**Nickel** intoxication' from dialysis exposure includes nausea, vomiting, headache, weakness and palpitations.

E. Elemental **nickel** is present in some foods and water, but dietary exposures are generally not significant. Ingestion of soluble **nickel** salts can cause nausea, vomiting and diarrhea.

F. Some work environments (such as **nickel** refinery work) and forms of **nickel** are associated with human malignancies, mainly nasal and respiratory cancers. Other forms of **nickel** are anticipated to be carcinogenic or have not been fully evaluated in humans.

0.2.3 VITAL SIGNS

0.2.3.1 ACUTE EXPOSURE

A. Acute intoxication by **nickel** carbonyl has two stages: immediate and delayed. An exposed individual may develop a delayed fever, but it will seldom rise above 101 degrees.

0.2.4 HEENT

0.2.4.1 ACUTE EXPOSURE
A. Acute toxicity from **nickel** inhalation includes sore throat and hoarseness.
B. There is speculation that conjunctivitis and epiphora have occurred in **nickel** plating work environments due to poor ventilation.
C. Occasional exposure to **nickel** aerosol and other contaminants has caused nasal irritation, loss of sense of smell, damage to the nasal mucosa, and perforation of the nasal septum.
D. In rare cases, **nickel** workers have complained of a bitter metallic taste.

0.2.6 RESPIRATORY
0.2.6.1 ACUTE EXPOSURE
A. Inhalation: Phase I of an acute **nickel** carbonyl exposure involves nonproductive cough, and rapid, panting breathing. The second phase involves tightness in the chest, cough, dyspnea, retrosternal pain and shortness of breath. Late changes involve pulmonary edema and interstitial fibrosis.
B. ANIMAL - Animals exposed to **nickel** carbonyl by inhalation for 5 days, 12 hours/day had signs of dyspnea, fever, vomiting, diarrhea, apathy, anorexia, tachypnea, cyanosis and occasionally hind-limb paralysis with generalized convulsions followed by death.

0.2.7 NEUROLOGIC
0.2.7.1 ACUTE EXPOSURE
A. Early symptoms after inhalation are dizziness, giddiness, and weakness.
0.2.7.2 CHRONIC EXPOSURE
A. EEG abnormalities have been reported in **nickel** carbonyl workers.

0.2.8 GASTROINTESTINAL
0.2.8.1 ACUTE EXPOSURE
A. Large doses taken orally or by inhalation may cause nausea, vomiting, and diarrhea.

0.2.9 HEPATIC
0.2.9.1 ACUTE EXPOSURE
A. Hyperbilirubinemia and elevated SGPT have been reported.

0.2.10 GENITOURINARY
0.2.10.1 ACUTE EXPOSURE
A. Changes found in the kidneys of one case included vacuolization of the proximal convoluted tubules, but no tubular necrosis.

0.2.13 HEMATOLOGIC
0.2.13.1 ACUTE EXPOSURE
A. Leukocytosis, reticulocytosis, and erthrocytosis have been reported.

0.2.14 DERMATOLOGIC
0.2.14.1 ACUTE EXPOSURE
A. Contact dermatitis is the most common reaction to **nickel**. It is estimated that 5 percent of all eczemas are **nickel** reactions. "**Nickel** itch" may begin with a burning and itching sensation, followed by erythema and nodular eruptions. Once acquired, **nickel** sensitivity usually persists.
B. **Nickel** and its inorganic compounds can be absorbed through the skin but not in amounts sufficient to cause intoxication.
C. Dermal reactions to **nickel** carbonyl are rare.
D. A single case of eczematous dermatitis was reported as a result of a chronic **nickel** carbonyl inhalation

exposure.

0.2.19 IMMUNOLOGIC

0.2.19.1 ACUTE EXPOSURE

A. **Nickel** is a sensitizer.

0.2.20 REPRODUCTIVE HAZARDS

A. **Nickel** salts are reported to be animal teratogens. Increased incidence of stillbirth and neonatal mortality of rat offspring were associated with maternal consumption of **nickel** chloride solutions prior to mating and during gestation. **Nickel** has been found in breast milk. Oral administration of **nickel** sulfate to rats caused decreased testicular, prostate, and seminal vesicle size as well as abnormalities of sperm and decreased sperm count.

0.2.21 CARCINOGENICITY

0.2.21.1 IARC CATEGORY

A. **Nickel** compounds are in IARC Group 1 (carcinogenic to humans, sufficient evidence of carcinogenicity) and metallic **nickel** is in IARC Group 2B (possibly carcinogenic to humans, limited evidence in humans in the absence of sufficient evidence in experimental animals) (IARC, 2000; HSDB, 2000).

0.2.21.2 HUMAN OVERVIEW

A. **Nickel** and many **nickel** compounds are considered human carcinogens or probable human carcinogens.

B. ACGIH rates **nickel** as an A5, not suspected as a human carcinogen.

C. **Nickel**-induced respiratory cancer has a latency period. Lung cancer may develop 13 to 14 years from the time of the first employment exposure. Nasal cancer may occur 15 or more years later.

D. Roasting **nickel** subsulfide is associated with an increased risk for respiratory cancer.

0.2.22 GENOTOXICITY

A. Some **nickel** compounds concentrate in the nuclei of animal cells. **Nickel** chloride did not cause DNA strand breaks or inhibit DNA repair in Chinese hamster ovarian cells by treatment with methyl methanesulfonate, but did inhibit DNA repair of cells exposed to UV light.

B. Sister chromatid exchanges have been observed in human lymphocytes. Chromosomal aberrations in lymphocytes of some workers have also been reported. A larger number of chromosomal aberrations than expected have been identified in some study controls.

C. Morphological transformation in animal cells have also been reported. Insoluble **nickel** compounds (**nickel** sulfide, **nickel** subsulfide, **nickel** oxides) produced mutations in G12 and G10 transgenic Chinese hamster cells. Some soluble **nickel** compounds were weakly mutagenic in AS52 cells.

Laboratory:

A. BLOOD

A healthy individual has **nickel** concentrations in the plasma ranging from 1.4 to 3.4 mcg/L (averages 2.1 mcg/L).

1. Whole blood concentrations are usually twice the level of plasma or serum.

B. URINE

1. A healthy individual has **nickel** concentrations in the urine ranging from 0.5 to 6.5 mcg/L.

Treatment Overview:

0.4.2 ORAL EXPOSURE

A. Oral toxicity of elemental **nickel** is low. Treatment of illness caused by ingestion of **nickel** salts is usually limited to fluid replacement in cases of severe vomiting and diarrhea. Decisions to institute gastric lavage or administer activated charcoal are at the discretion of the treating clinician.

1. GASTRIC LAVAGE: Consider after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation. Control any seizures first.

a. CONTRAINDICATIONS: Loss of airway protective reflexes or decreased level of consciousness in unintubated patients; following ingestion of corrosives; hydrocarbons (high aspiration potential); patients at risk of hemorrhage or gastrointestinal perforation; and trivial or non-toxic ingestion.

2. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.

B. Parenteral: It is unusual for **nickel** to be injected, so elevated blood levels are usually from chronic exposures to implanted devices.

C. Other treatments are symptomatic and supportive.

0.4.3 INHALATION EXPOSURE

A. Move the patient to fresh air. The first phase of **nickel** carbonyl inhalation is deceptive in its lack of severe symptoms.

B. CHELATING AGENTS - Although penicillamine has an effect, diethyldithiocarbamate (DDC) is the preferred chelating agent in the literature.

1. Collect an 8 hour sample immediately after exposure. Levels of:

a. Less than 10 mcg/dL: delayed symptoms are not expected. DDC is unnecessary.

b. 10 to 50 mcg/dL: DDC should be administered orally (50 mg/kg/day on day 1, then 400 mg every 8 hours until the patient is symptom free and urine **nickel** is under 10 mcg/dL.

c. Greater than 50 mcg/dL: the dose of DDC parenterally is 25 mg/kg. Severe cases may use 100 mg/kg for the first 24 hours.

2. If there is doubt as to the severity of the exposure, give a course of 2 g of DDC orally until a urine **nickel** can be obtained.

C. DDC is an "orphan" drug in the United States, but the company has not been assigned. Dr F Wm Sunderman Sr of the Hahnemann Medical College and Hospital, Philadelphia, PA has the IND.

D. DISULFIRAM is metabolized to 2 molecules of DDC. If DDC is not available, disulfiram may prove of some use, although studies using disulfiram are limited to dermatitis.

0.4.5 DERMAL EXPOSURE

A. Disulfiram (Antabuse(R)) is metabolized to 2 molecules of diethyldithiocarbamate (DDC). It has been shown effective in clearing cases of **nickel** dermatitis. 50 to 100 mg/day were used in the treatment. Many other topical and oral drugs are being investigated.

Range of Toxicity:

A. Oral toxicity is low and unusual.
B. Maximum Tolerated Dose - It has been recommended that a plasma level of 10 mcg/L be set as a biomonitoring limit for **nickel** refinery workers.
C. A normal serum **nickel** level in humans is approximately 0.011 mg% or 0.11 micrograms/milliliter.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

Basic treatment: Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilation if necessary. Administer oxygen by nonrebreather mask at 10 t0 15 L/min. Monitor for shock and treat if necessary ... . Monitor for pulmonary edema and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport ... . Do not use emetics. For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool ... . /**Nickel** and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994.,p. 371-2]**PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious. Positive pressure ventilation techniques with a bag valve mask device may be beneficial. Monitor cardiac rhythm and treat arrhythmias if necessary ... . Consider drug therapy for pulmonary edema ... . Start an IV with D5W /SRP: "To keep open", minimal flow rate/. Use lactated Ringer's if signs of hypovolemia are present. For hypotension with signs of hypovolemia, administer fluid cautiously. Consider vasopressors for hypotension with a normal fluid volume. Watch for signs of fluid overload ... . Use proparacaine hydrochloride to assist eye irrigation ... . /**Nickel** and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 372]**PEER REVIEWED**

Animal Toxicity Studies:

Toxicity Summary:

Nickel is a ubiquitous trace metal and occurs in soil, water, air and the biosphere. **Nickel** ore deposits are accumulations of **nickel** sulfide minerals (mostly pentlandite) and laterites. Most **nickel** is used for production of stainless steel and other **nickel** alloys with high corrosion and temperature resistance. **Nickel** levels in terrestrial and aquatic organisms can vary over several orders of magnitude. Dermal exposure in the general environment is important for the induction and maintenance of contact hypersensitivity caused by daily contact with **nickel** plated objects or **nickel** containing alloys (e.g. jewellery, coins or clips). Iatrogenic exposure to **nickel** results from implants and prostheses made from **nickel** containing alloys, from iv or dialysis fluids and from radiographic contrast media. In the working environment, airborne **nickel** concentrations can vary from a few microgram/cu m to a few mg/cu m, depending upon the process involved and the **nickel** content of the material being handled. Workers are exposed to **nickel** containing dusts and fumes during welding, plating, grinding, mining, **nickel** refining,

and in steel plants. Dermal exposure to **nickel** may occur in a wide range of jobs, either by direct exposure, dissolved **nickel** in refining, electroplating and electroforming industries or by handling **nickel** containing materials. **Nickel** can be absorbed in human beings and animals via inhalation or ingestion or percutaneously. Respiratory absorption with secondary gastrointestinal absorption (insoluble and soluble) is a major route of entry during occupational exposure. Percutaneous absorption is negligible, quantatively, but is important in the pathogenesis of contact hypersensitivity. **Nickel** is transported in the blood, principally bound to albumin. Gastrointestinal absorption of **nickel** is variable and depends on the composition of the diet. All body secretions are potential routes of excretion including the urine, bile, sweat, tears, milk and mucociliary fluid. Non-absorbed nicke is eliminated in the feces. Data on **nickel** excretion suggest a two compartment model. **Nickel** concentration in the serum and urine of healthy non-occupationally exposed adults are 0.2 ug/l (range: 0.05-1.1 ug/l) and 1.5 ug creatinine (range: 0.5-4.0 mg/g creatinine, respectively. The body burden of **nickel** in non-exposed 70 kg adult is 0.5 ug. **Nickel** is essential for the catalytic activity of some plant and bacterial enzymes. Slow weight gain, anemia and decreased viability has been described in some animal species after dietary deprivation of **nickel**. Contact allergy to **nickel** is very common in human beings; experimental sensitization in animals is only successful under special conditions. Longterm inhalation exposure to metallic **nickel** caused mucosal damage and inflammatory reaction, sometimes accompanied by slight fibrosis, was observed in rabbits after high level exposure to **nickel** graphite dust. Metallic **nickel** induced local mesenchymal tumors in a variety of experimental animals after im, sc, intraosseous, intrarenal, intra-articular, pleural, intraocular, intratesticular or intra-adipose administrtation. Metallic **nickel** has been tested for carcinogenicity by parenteral routes of administration, local tumors were noted. In studies using repeated intratracheal instillation, **nickel** powder caused respiratory tumors. Chronic effects such as rhinitis, sinusitis, nasal septal perforations and asthma have been reported in **nickel** refinery and **nickel** plating workers. Some researchers reported pulmonary changes with fibrosis in workers handling **nickel** dust. Orsal **nickel** intake may aggravate vesicular hand eczema. Prostheses or other surgical implants make with **nickel** containing alloys have been reported to cause **nickel** sensitization. Cancer rates have generally been close to normal in stainless steel welding and **nickel** using industries, with the exception of those involving exposure to chromium, particularly electroplating. **Nickel**/cadmium battery workers exposed to high levels of both **nickel** and cadmium may have resulted in a slightly increased risk of lung cancer. Excesses of various cancers other than lung and nasal cancers such as renal, gastric or prostatic have occasionally been reported in **nickel** workers, but none have been found consistently. No increased cancer risk has been demonstrated in workers exposed exclusively to metallic **nickel**. The combined data on **nickel** alloy workers and gasseous diffusion workers, all of whom were exposed to average concentrations of the order of 0.5 mg **nickel**/cu m show no excess risk, though the total number of lung cancers in these cohorts was to small to exclude a small increase in risk at this level.
[World Health Organization/International Programme on Chemical Safety. Environmental Health Criteria 108 Nickel p.13 (1991)]**QC REVIEWED**

Evidence for Carcinogenicity:

CLASSIFICATION: A; human carcinogen. BASIS FOR CLASSIFICATION: Human data in which exposure to **nickel** refinery dust caused lung and nasal tumors in sulfide **nickel** matte refinery workers in several epidemiologic studies in different countries and on animal data in which carcinomas were produced in rats by inhalation and injection. HUMAN CARCINOGENICITY DATA: Sufficient.
[U.S. Environmental Protection Agency's Integrated Risk Information System (IRIS) on Nickel refinery dust (NO CAS RN) from the National Library of Medicine's TOXNET System, March 1, 1995]**PEER REVIEWED**

Evaluation: There is sufficient evidence in humans for the carcinogenicity of **nickel** sulfate, and of the combinations of **nickel** sulfides and oxides encountered in the **nickel** refining industry. There is

inadequate evidence in humans for the carcinogenicity of metallic **nickel** and **nickel** alloys. There is sufficient evidence in experimental animals for the carcinogenicity of metallic **nickel**, **nickel** monoxides, **nickel** hydroxides and crystalline **nickel** sulfides. There is limited evidence in experimental animals for the carcinogenicity of **nickel** alloys, nickelocene, **nickel** carbonyl, **nickel** salts, **nickel** arsenides, **nickel** antimonide, **nickel** selenides and **nickel** telluride. There is inadequate evidence in experimental animals for the carcinogenicity of **nickel** trioxide, amorphous **nickel** sulfide and **nickel** titanate. The Working Group made the overall evaluation on **nickel** compounds as a group on the basis of the combined results of epidemiological studies, carcinogenicity studies in experimental animals, and several types of other relevant data, supported by the underlying concept that **nickel** compounds can generate **nickel** ions at critical sites in their target cells. Overall evaluation: **Nickel** compounds are carcinogenic to humans (Group 1). Metallic **nickel** is possibly carcinogenic to humans (Group 2B). /**Nickel** compounds/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V49 410 (1990)]**PEER REVIEWED**

A1. A1= Confirmed human carcinogen. /**Nickel**, insoluble compounds, as Ni/
[American Conference of Governmental Industrial Hygienists. Guide to Occupational Exposure Values - 1999. Cincinnati, OH: 1999. 51]**PEER REVIEWED**

Non-Human Toxicity Excerpts:

... INGESTION OF **NICKEL** ... RELATIVELY LOW DEGREE OF TOXICITY. DOGS ARE ABLE TO TOLERATE DOSES OF METALLIC **NICKEL** ... AS HIGH AS 3 G/KG BODY WT.
[International Labour Office. Encyclopedia of Occupational Health and Safety. Volumes I and II. New York: McGraw-Hill Book Co., 1971. 932]**PEER REVIEWED**

... NO ABNORMALITIES OF BRONCHIAL MUCOSA IN 20 FEMALE C57BL MICE EXPOSED TO ATMOSPHERE CONTAINING 15 MG/CU M OF GREATER THAN 99% PURE **NICKEL** POWDER (MAJORITY OF PARTICLES 4 UM OR LESS DIAMETER) FOR 6 HR/DAY ON 4-5 DAYS/WK FOR UP TO 21 MO. TWO LYMPHOSARCOMAS WERE OBSERVED; THERE WAS NO UNEXPOSED CONTROL GROUP ... /BECAUSE OF THE LARGE SIZE OF THE PARTICLES IN THIS STUDY, NEGATIVE RESULTS MAY ONLY REFLECT THE LOW BIOAVAILABILITY OF SUCH LARGE PARTICLES/ (HUEPER, 1958).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 87 (1976)]**PEER REVIEWED**

IN 15 OF TOTAL OF 50 RATS OF BOTH STRAINS ... STUDIED /WISTAR & NIH BLACK, EXPOSED TO ATMOSPHERE CONTAINING 15 MG/CU M OF GREATER THAN 99% PURE **NICKEL** POWDER, 6 HR/DAY, 4-5 DAYS/WK FOR UP TO 21 MO/ ... LUNG SHOWED 'ABNORMAL MULTICENTRIC ADENOMATOID FORMATION AFFECTING ALVEOLAR STRUCTURES & ATYPICAL PROLIFERATIONS OF EPITHELIAL LINING OF TERMINAL BRONCHIOLI'. IN SOME ... RATS, 'SUBCHRONIC INFLAMMATORY REACTIONS' WERE ASSOC WITH ADENOMATOID FORMATIONS; INFLAMMATORY CHANGES & MUCOSAL ULCERS ... FOUND IN PARANASAL SINUSES. AUTHOR REGARDED THE ADENOMATOID LUNG LESIONS AS BENIGN NEOPLASMS; THERE WAS NO EXCESS OF NEOPLASMS IN OTHER ORGANS. NO COMPARABLE UNEXPOSED CONTROL GROUPS ... WERE INCLUDED ... (HUEPER, 1958).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 87 (1976)]**PEER REVIEWED**

SARCOMA INDUCTION AFTER IM INJECTION IN FISCHER RATS: CMPD: **NICKEL** DUST;

DOSE: 3.6 MG/RAT, 60 UM-ATOM OF METAL/RAT; LOCAL SARCOMA INCIDENCE BY 2 YR: 0/10; SECOND DOSE 14.4 MG/RAT; 240 UM-ATOM OF METAL/RAT; LOCAL SARCOMA INCIDENCE BY 2 YR: 2/10. (SUNDERMAN & MAENZA, 1976) /FROM TABLE/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 95 (1976)]**PEER REVIEWED**

... NO NEOPLASMS /WERE FOUND/ IN RESPONSE TO 2 IV INJECTIONS OF 0.05 ML OF 0.005% SUSPENSION OF **NICKEL** POWDER IN 2.5% GELATIN INTO TAIL VEIN OF 25 C57BL MALE MICE, 19 OF WHICH LIVED FOR MORE THAN 1 YR & 6 OF WHICH LIVED FOR MORE THAN 15 MO. NO CONTROLS WERE USED (HUEPER, 1955).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 96 (1976)]**PEER REVIEWED**

... 6 WEEKLY INJECTIONS OF 0.5 ML/KG ... OF 0.5% SUSPENSION OF **NICKEL** POWDER IN PHYSIOLOGICAL SALINE IN SAPHENOUS VEIN OF 25 WISTAR RATS. ONLY NEOPLASMS THAT COULD BE ATTRIBUTED TO TREATMENT AROSE 7-8 MO AFTER FIRST INJECTION IN 7 RATS NEAR SITE OF INJECTION (REGION OF GROIN) WHERE SEEPAGE OF INJECTED MATERIAL HAD OCCURRED. ... NO CONTROLS WERE USED (HUEPER, 1955).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 96 (1976)]**PEER REVIEWED**

... NO NEOPLASMS IN 10 RABBITS GIVEN 6 WEEKLY /IV/ INJECTIONS OF 0.5 ML/KG BODY WT OF 1% SUSPENSION OF **NICKEL** POWDER IN 25% AQ GELATIN SOLN. ONLY 4 OF RABBITS SURVIVED FOR MORE THAN 2 YR. NO EFFECTS ... SEEN IN CONTROLS ... OBSERVED UP TO 40 MO (HUEPER, 1955).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 96 (1976)]**PEER REVIEWED**

... FINE **NICKEL** POWDER (0.02 ML OF SUSPENSION OF 0.2 G NI/ML OF 10% GELATIN) /WAS INTRODUCED/ DIRECTLY INTO LUNG OF 34 NIH BLACK RATS BY THORACOTOMY. ALL SURVIVORS WERE SIMILARLY TREATED 12 MO LATER. OF 14 ... THAT LIVED FOR 18 OR MORE MO AFTER FIRST TREATMENT, 1 DEVELOPED SARCOMA @ SITE OF INJECTION. ... NO CONTROLS WERE USED (HUEPER & PAYNE, 1962).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 96 (1976)]**PEER REVIEWED**

/INVESTIGATORS/ ... REPORTED FORMATION OF ROUND-CELL & SPINDLE-CELL TUMORS @ SITE OF INJECTION IN 4/12 FEMALE OSBORNE MENDEL RATS THAT DIED BETWEEN 7 & 16 MO AFTER 5 MO /INTRAPLEURAL/ INJECTIONS OF 0.05 ML OF 12.5% (BY VOL) SUSPENSION OF **NICKEL** POWDER IN LANOLIN (HUEPER, 1952).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 97 (1976)]**PEER REVIEWED**

... 5 MONTHLY /INTRAPLEURAL/ INJECTIONS OF 5 MG **NICKEL** POWDER IN 0.2 ML SALINE TO 5 MALE & 5 FEMALE FISCHER RATS. 20 CONTROL RATS ... WERE GIVEN 5 MONTHLY INJECTIONS OF SALINE SOLN. PLEURAL MESOTHELIOMAS DEVELOPED IN 2/10 OF **NICKEL** TREATED RATS & IN 0/20 CONTROLS (FURST ET AL, 1973).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 97 (1976)]**PEER REVIEWED**

... SQUAMOUS CELL CARCINOMA OF FISTULOUS DUCT & 3 OSTEOSARCOMAS @ SITE OF INJECTION IN 4/17 FEMALE OSBORNE-MENDEL RATS SURVIVING 7 MO AFTER /INTRAMEDULLARY INJECTION INTO FEMUR/ ... OF 0.05 ML OF 12.5% (BY VOL) SUSPENSION OF **NICKEL** POWDER IN LANOLIN (HUEPER, 1952). THIS FINDING WAS NOT CONFIRMED IN SUBSEQUENT STUDY IN WHICH 27/100 WISTAR RATS ... DEVELOPED NEOPLASMS AT OR NEAR SITE OF INJECTION OF 0.1 ML OF 5% SUSPENSION OF **NICKEL** POWDER IN 20% GELATIN-SALINE. SOME ... RECEIVED A SECOND INJECTION AFTER 18 MO. ... 16 OF THE TUMORS WERE FIBROSARCOMAS; 4 ... RHABDOMYOSARCOMAS; 5 ... THOUGHT TO BE NEUROGENIC IN ORIGIN; 1 ... ANGIOSARCOMA; & 1, A RETICULUM-CELL SARCOMA (HUEPER, 1955).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 97 (1976)]**PEER REVIEWED**

... 1/6 RABBITS GIVEN 2 INJECTIONS, 27 MO APART, OF 0.25 ML **NICKEL** POWDER IN LANOLIN (12.5% **NICKEL** BY VOL) DEVELOPED METASTASIZING ENDOSTEAL FIBROSARCOMA OF FEMUR. TWO RABBITS GIVEN INJECTIONS OF LANOLIN ALONE DID NOT DEVELOP LOCAL TUMORS (HUEPER, 1955).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 98 (1976)]**PEER REVIEWED**

... 4 **NICKEL** PELLETS (2 MM DIAMETER) /IMPLANTED/ SUBDERMALLY IN EACH OF 5 MALE & 5 FEMALE WISTAR RATS. WITHIN 104 WK AFTER IMPLANTATION OF **NICKEL** PELLETS, 3 MALES & 2 FEMALES HAD DEVELOPED SARCOMAS AROUND 1 PELLET (MITCHELL ET AL, 1960).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 98 (1976)]**PEER REVIEWED**

LUNG OF RABBITS EXPOSED TO METALLIC **NICKEL** DUST (2 MG/CU M, OF WHICH ABOUT 1/2 WAS RESPIRABLE) FOR 4 WK WERE LAVAGED & MACROPHAGES COLLECTED. THERE WAS SIGNIFICANT INCR IN WT & DENSITY OF LUNG, SIZE VARIATION OF LUNG CELLS, PHAGOCYTOSIS OF SILVER COATED PARTICLES & METABOLIC ACTIVITY.
[JARSTRAND C ET AL; TOXICOLOGY 11 (4): 353 (1978)]**PEER REVIEWED**

LONG TERM INHALATION STUDIES ... PERFORMED ON GUINEA PIGS, RATS & MICE, RATS, & HAMSTERS. EXPOSURE LASTED MORE THAN 1.5 YR IN ALL ... STUDIES. ... METALLIC **NICKEL** POWDER /WAS 1 OF THE COMPOUNDS TESTED (15 MG/CU M)/ ... IN THE STUDY ... NASAL SINUS INFLAMMATIONS & ULCERS ... NOTED IN RATS, & SIGNS OF LUNG IRRITATION ... IN GUINEA PIGS & RATS. ... IN MICE SIGNS OF LUNG IRRITATION WERE SEEN, BUT NOT TO THE EXTENT SEEN IN GUINEA PIGS & RATS.
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 471]**PEER REVIEWED**

Acute toxicity tests were conducted to establish the response of Selenastrum capricornutum to sublethal concentrations of ... **nickel** (Ni) ... at a broad range of pH levels. Cultures were incubated for a period of 7 days at pH 4 in standard algal assay media containing sublethal concentrations of metal. At this low pH, growth was depressed. The adjustment of pH to higher levels resulted in increased growth when cultures were treated with ... Ni and incubated for an additional 7 days. Toxicity was least at the optimum pH range for growth of alga.

[Michnowicz CJ, Weaks TE; Hydrobiologia 118 (3): 299-305 (1984)]**PEER REVIEWED**

Low Ni concentrations (2.5-20 ppm) stimulated the growth of some soil fungi (eg Spicaria violacea, Aspergillus ornatus, Penicillium chrysogenum, and Penicillium canescens). The lowest tolerance to Ni was observed with Rhizopus arrhizus, the highest tolerance with Trychoderma polysporum. Most of the fungi were inhibited by Ni at all concentrations (2.5-100 ppm: P canescens, P rubrum, Penicillium strain no 38, R arrhizus, and T polysporum). Ni accumulation in the fungi was highest in R arrhizus and lowest in T polysporum. Thus, the soil fungi can be used as indicators of soil pollution by heavy metals. The fungi with relatively high resistance to the metals can be used for the reclamation of heavily polluted soils.
[Zabawski J; Bioindyk Skazen Przem Roln Mater Pokonf p.303-15 (1983)]**PEER REVIEWED**

... **Nickel** /was given/ in drinking water to rats for 7 mo before pregnancy and during pregnancy and some incr of preimplantation mortality was found. Some cases of malformed fetuses was noted.
[Shepard, T.H. Catalog of Teratogenic Agents. 5th ed. Baltimore, MD: The Johns Hopkins University Press, 1986. 408]**PEER REVIEWED**

There is evidence in lab animals that **nickel** exposure results in altered resistance to virus and bacteria. A direct effect on macrophage function has also been attributed to **nickel**.
[Doull, J., C.D.Klassen, and M.D. Amdur (eds.). Casarett and Doull's Toxicology. 3rd ed., New York: Macmillan Co., Inc., 1986. 276]**PEER REVIEWED**

Prenatal effects of **nickel** result from direct insults to the mammalian embryo as well as from indirect ones through maternal damage. **Nickel** may upset the hormonal balance of the mother and can impair the development of the preimplantation embryo. The metal can cross the feto-maternal barrier and enter the fetus. In addition to an increase in prenatal and neonatal mortality, **nickel** can produce different types of malformations in the surviving embryos but its teratogenic action seems to be delayed, probably as a result of retarded transfer via the placenta. No definite conclusions can be reached, at the present time, as to whether the embryotoxicity and fetal toxicity of **nickel** is eventually related to its mutagenic properties. **Nickel** alters macromolecular synthesis but no convincing evidence has been provided of its ability to produce gene mutations or structural chromosome aberrations in mammalian cells.
[Leonard A, Jacquet P; IARC Sci Publ 53: 277-91 (1984)]**PEER REVIEWED**

... NO LUNG TUMORS IN 100 MALE HAMSTERS, 66 OF WHICH SURVIVED FOR MORE THAN 18 MO, AFTER SIMULTANEOUS EXPOSURE TO 98.95% PURE **NICKEL** POWDER (LEVEL UNSPECIFIED), 20-35 PPM (MG/KG) SULFUR DIOXIDE (ACTING AS LUNG IRRITANT), & POWDERED LIMESTONE (1 PART FOR 3-4 PARTS OF NI, TO PREVENT **NICKEL** PARTICLES FROM ... /CONGLOMERATING/).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 89 (1976)]**PEER REVIEWED**

The regulation of the heme biosynthetic pathway in the kidney by various metals has been reviewed. Acute treatment of rats with **nickel**, platinum, tin, antimony, bismuth, and cobalt rsults in induction of heme oxygenase, followed by decreased microsomal heme content and ALAS stimulation in the kidney.
[Oskarsson A, Fowler BA; Ann NY Acad Sci 514: 268-77 (1987)]**PEER REVIEWED**

The carcinogenicity of 50 dusts in rats following intraperitoneal injection or intratracheal instillation was examined. **Nickel** powder, **nickel** oxide, **nickel** subsulfide, and cadmium sulfide were carcinogenic in the two tests.
[Pott F et al; Exp Pathol 32 (3): 129-52 (1987)]**PEER REVIEWED**

Exposure of Nostoc muscorum to different concentrations of **nickel** and silver brought about reduction

in growth, carbon fixation, heterocyst production, and nitrogenase activity and increase in the loss of ions (K+, Na+). In an attempt to ameliorate the toxicity of test metals by ascorbic acid, glutathione, and sulfur containing amino acids (L-cysteine and L-methionine), it was found that the level of protection by ascorbic acid and glutathione was more for silver than **nickel**. However, metal induced inhibition of growth and carbon fixation was equally ameliorated by methionine. But the level of protection by cysteine was quite different, ie, 27% for **nickel** and 22% for silver.
[Rai LC, Raizada M; Ecot Environ Safe 14 (1): 12-21 (1987)]**PEER REVIEWED**

A 2 yr study of carcinogenesis in male Wistar (Cr1:(WI)BR) rats administered cadmium chloride (CdCl2), 6 revealed many cases of persistent tumor like masses at the site of the metal identification tags in the ears of the animal. (Study I) A total of 14 tumors (mostly compound ostersarcomas) was diagnosed in 168 rats. Almost 90% of rats showed some significant lesion at the tag site including various degrees of chronic inflammation, chondrous hyperplasia, and osseous metaplasia of the pinnal cartilage. In contrast, only two tumors were detected in 193 animals in a second study (Study II) in the same strain of rats, and only 56% of the rats had lesions at the tag site. A high incidence (greater than 25%) of clinically severe inflammation at the tag site was seen early in Study I and persisted during the first 6 mo of the study, while the incidence of such reactions in Study II was never more than 1%. Elemental analysis of the tags provided no explanation for the differences between the two studies; tags used in both studies were of the same composition, predominantly **nickel** and copper.
[Wallkes MP et al; Cancer Res 47 (9): 2445-50 (1987)]**PEER REVIEWED**

Acute treatment with **nickel**, platinum, tin, antimony, bismuth, and cobalt induced heme oxygenase, followed by decreased microsomal heme content and aminolevulinic acid synthetase stimulation in kidney.
[Oskarsson A, Fowler BA; Ann NY Acad Sci 514: 268-77 (1987)]**PEER REVIEWED**

Metabolism/Pharmacokinetics:

Absorption, Distribution & Excretion:

THIRTY-FIVE LUNG PAIRS OBTAINED DURING AUTOPSY FROM RANDOMLY SELECTED PATIENTS WERE INVESTIGATED BY PARTICLE INDUCED X-RAY EMISSION FOR OVERALL & REGIONAL ELEMENTAL CONTENT DETERMINATION. **NICKEL** DISTRIBUTION SEEMS TO BE RELATED TO AIR POLLUTION PECULIAR TO /BELGIUM/.
[BARTSCH P ET AL; ARCH ENVIRON HEATLH 37 (2): 111-7 (1982)]**PEER REVIEWED**

Biological Half-Life:

On the basis of **nickel** values in air, plasma and urine in four **nickel** platers during one working week ... /the investigators/, assuming a one-compartment model, computed the biological half-life for **nickel** in plasma to range from 20 to 34 hr and in urine from 17 to 39 hr.
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 469]**PEER REVIEWED**

Mechanism of Action:

Nickel is hepatotoxic in animals and has been shown to effect renal function in man. It binds to the anionic glycosaminoglycan sites of the glomerular basement membrane. Ionic blocking of these sites leads to the loss of selectivity in the filtration of albumin and may explain the proteinuria associated with **nickel** exposure.
[Rom, W.N. (ed.). Environmental and Occupational Medicine. 2nd ed. Boston, MA:

Little, Brown and Company, 1992. 809]**PEER REVIEWED**

Pharmacology:

Environmental Fate & Exposure:

Probable Routes of Human Exposure:

Occupational exposures to **nickel** and its cmpd occur in (1) mining and comminution of **nickel** containing ores; (2) **nickel** refining and smelting; (3) **nickel** electroplating; (4) producing and using **nickel** catalysts; (5) fabricating parts and structures by welding, flame spraying, cutting, grinding, and polishing of **nickel** containing alloys; (6) manufacturing **nickel** cadmium batteries; (7) constructing **nickel** molds in glass bottle factories; (8) spraying **nickel** containing paints (eg, yellow **nickel** titanate pigment); and (9) recycling or disposal of **nickel** containing products. /**Nickel** and **nickel** cmpd/
[Seiler, H.G., H. Sigel and A. Sigel (eds.). Handbook on the Toxicity of Inorganic Compounds. New York, NY: Marcel Dekker, Inc. 1988. 455]**PEER REVIEWED**

IN **NICKEL** PLATING INDUSTRY, EXPOSURE TO **NICKEL** CONTAINING VAPORS HAS BEEN REPORTED TO BE ASSOC WITH ASTHMA. SYMPTOMS WERE ATTRIBUTED TO HYPERSENSITIVITY TO **NICKEL** OF NON-OCCUPATIONAL ORIGIN. PNEUMOCONIOSIS HAS BEEN REPORTED AMONG WORKERS EXPOSED TO **NICKEL** DUST ... EFFECTS ON NASAL MEMBRANE WERE NOTED IN WORKERS EXPOSED TO **NICKEL** AEROSOLS IN AN ELECTROLYSIS SHOP. /**NICKEL** VAPORS & DUST/
[Friberg, L., Nordberg, G.F., Kessler, E. and Vouk, V.B. (eds). Handbook of the Toxicology of Metals. 2nd ed. Vols I, II.: Amsterdam: Elsevier Science Publishers B.V., 1986.,p. V2 473]**PEER REVIEWED**

Natural Pollution Sources:

Abundance in earth's crust 0.018%. ... occurs free in meteorites.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1116]**PEER REVIEWED**

... THERE IS EVIDENCE THAT PURE **NICKEL** POWDERS ... OF LESS THAN 1 U IN SIZE ARE DEPOSITED AS METEORITIC DUST FROM STRATOSPHERE. /**NICKEL** AND **NICKEL** CMPD/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V2 131 (1973)]**PEER REVIEWED**

Artificial Pollution Sources:

Food processing methods apparently add to the **nickel** levels already present in foodstuffs via (1) leaching from **nickel** containing alloys in food processing equipment made from stainless steel, (2) the milling of flour, and (3) catalytic hydrogenation of fats and oils by use of **nickel** catalysts.
[USEPA; Ambient Water Quality Criteria Document : Nickel p.C-7 (1980) EPA 400/5-80-060]**PEER REVIEWED**

Environmental Biodegradation:

No data was found to suggest that **nickel** is involved in any biological transformation in the aquatic environment.
[Callahan, M.A., M.W. Slimak, N.W. Gabel, et al. Water-Related Environmental Fate of 129 Priority Pollutants. Volume I. EPA-440/4 79-029a. Washington, DC: U.S.

Environmental Protection Agency, December 1979.p. 15-6]**PEER REVIEWED**

Environmental Bioconcentration:

... no ... **nickel** bioaccumulation in voles fed sludge-fertilized soybeans containing 30 ppm **nickel** ...
[Parr, J.F., P.B. Marsh, and J.M. Kla (eds.). Land Treatment of Hazardous Wastes. Park Ridge, New Jersey: Noyes Data Corporation, 1983. 185]**PEER REVIEWED**

Environmental Standards & Regulations:

CERCLA Reportable Quantities:

Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 100 lb or 45.5 kg. The toll free number of the NRC is (800) 424-8802; In the Washington D.C. metropolitan area (202) 426-2675. The rule for determining when notification is required is stated in 40 CFR 302.4 (section IV. D.3.b).
[40 CFR 302.4 (7/1/99)]**PEER REVIEWED**

Atmospheric Standards:

Listed as a hazardous air pollutant (HAP) generally known or suspected to cause serious health problems. The Clean Air Act, as amended in 1990, directs EPA to set standards requiring major sources to sharply reduce routine emissions of toxic pollutants. EPA is required to establish and phase in specific performance based standards for all air emission sources that emit one or more of the listed pollutants. **Nickel** is included on this list.
[Clean Air Act as amended in 1990, Sect. 112 (b) (1) Public Law 101-549 Nov. 15, 1990]**PEER REVIEWED**

Clean Water Act Requirements:

Toxic pollutant designated pursuant to section 307(a)(1) of the Clean Water Act and is subject to effluent limitations. /**Nickel** and compounds/
[40 CFR 401.15 (7/1/99)]**QC REVIEWED**

Federal Drinking Water Guidelines:

EPA 100 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

State Drinking Water Guidelines:

(AZ) ARIZONA 150 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(MA) MASSACHUSETTS 100 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(ME) MAINE 150 ug/l

[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(MN) MINNESOTA 100 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

FDA Requirements:

Substance added directly to human food affirmed as generally recognized as safe (GRAS).
[21 CFR 184.1537 (4/1/99)]**PEER REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

Ni
PEER REVIEWED

Molecular Weight:

58.6934
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1116]**PEER REVIEWED**

Color/Form:

SILVERY METAL
[Weast, R.C. (ed.) Handbook of Chemistry and Physics, 68th ed. Boca Raton, Florida: CRC Press Inc., 1987-1988.,p. B-110]**PEER REVIEWED**

Metal: Lustrous, silvery solid.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 224]**PEER REVIEWED**

Lustrous, white, hard, ferromagnetic metal; face centered cubic crystals
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1116]**PEER REVIEWED**

Silvery, malleable, magnetic metal
[Ashford, R.D. Ashford's Dictionary of Industrial Chemicals. London, England: Wavelength Publications Ltd., 1994. 628]**PEER REVIEWED**

Odor:

Odorless
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 224]**PEER REVIEWED**

Boiling Point:

2730 deg C
[Weast, R.C. (ed.) Handbook of Chemistry and Physics, 68th ed. Boca Raton, Florida:

CRC Press Inc., 1987-1988.,p. B-110]**PEER REVIEWED**

Melting Point:

1455 deg C
[Weast, R.C. (ed.) Handbook of Chemistry and Physics, 68th ed. Boca Raton, Florida: CRC Press Inc., 1987-1988.,p. B-110]**PEER REVIEWED**

Corrosivity:

Excellent resistance to corrosion
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 785]**PEER REVIEWED**

Density/Specific Gravity:

8.908
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 785]**PEER REVIEWED**

Solubilities:

INSOL IN WATER, AMMONIA; SOL IN DIL NITRIC ACID; SLIGHTLY SOL IN HYDROCHLORIC ACID, SULFURIC ACID
[Weast, R.C. (ed.) Handbook of Chemistry and Physics, 68th ed. Boca Raton, Florida: CRC Press Inc., 1987-1988.,p. B-110]**PEER REVIEWED**

Vapor Pressure:

1 MM HG @ 1810 DEG C
[Weast, R.C. (ed.) Handbook of Chemistry and Physics, 68th ed. Boca Raton, Florida: CRC Press Inc., 1987-1988.,p. D-194]**PEER REVIEWED**

Other Chemical/Physical Properties:

Heat capacity @ 25 deg C: 6.23 cal/g-atom/deg C; Mohs' hardness 3.8; latent heat of fusion 73 cal/g; electrical resistivity @ 20 deg C: 6.844 microohms/cm; burns in oxygen, forming **nickel** oxide; decomp steam @ a red heat; slowly attacked by dil hydrochloric or sulfuric acid; readily attacked by nitric acid; five naturally occurring isotopes: 58 (67.76%); 60 (26.16%); 61 (1.25%); 62 (3.66%); 64 (1.16%); artificial isotopes: 56; 57; 59; 63; 65-67
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1116]**PEER REVIEWED**

Not attacked by fused alkali hydroxides
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1116]**PEER REVIEWED**

Readily fabricated by hot and cold working; takes high polish
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 785]**PEER REVIEWED**

Atomic number 28; valence 2; seldom 1,3,4
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1116]**PEER

REVIEWED**

Dark gray powder or crystal; Pyrophoric
[Sax, N.I. and R.J. Lewis, Sr. (eds.). Hawley's Condensed Chemical Dictionary. 11th ed. New York: Van Nostrand Reinhold Co., 1987. 818]**PEER REVIEWED**

Crystallizes as metallic cubes
[Sax, N.I. Dangerous Properties of Industrial Materials. Vol 1-3 7th ed. New York, NY: Van Nostrand Reinhold, 1989. 2477]**PEER REVIEWED**

Chemical Safety & Handling:

DOT Emergency Guidelines:

Fire or explosion: Flammable/combustible material. May ignite on contact with moist air or moisture. May burn rapidly with flare-burning effect. Some react vigorously or explosively on contact with water. Some may decompose explosively when heated or involved in a fire. May re-ignite after fire is extinguished. Runoff may create fire or explosion hazard. /**Nickel** catalyst, dry/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-135]**QC REVIEWED**

Health: Fire will produce irritating, corrosive and/or toxic gases. Inhalation of decomposition products may cause severe injury or death. Contact with substance may cause severe burns to skin and eyes. Runoff from fire control may cause pollution. /**Nickel** catalyst, dry/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-135]**QC REVIEWED**

Public safety: CALL Emergency Response Telephone Number. ... Isolate spill or leak area immediately for at least 100 to 150 meters (330 to 490 feet) in all directions. Stay upwind. Keep unauthorized personnel away. Keep out of low areas. /**Nickel** catalyst, dry/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-135]**QC REVIEWED**

Protective clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Wear chemical protective clothing which is specifically recommended by the manufacturer. It may provide little or no thermal protection. Structural firefighters' protective clothing will only provide limited protection. /**Nickel** catalyst, dry/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-135]**QC REVIEWED**

Evacuation: ... Fire: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions. /**Nickel** catalyst, dry/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-135]**QC REVIEWED**

Fire: DO NOT USE WATER, CO2 OR FOAM ON MATERIAL ITSELF. Some of these materials may react violently with water. EXCEPTION: For Dithionite (Hydrosulfite/Hydrosulphite) UN1384, UN1923 and UN1929, USE FLOODING AMOUNTS OF WATER for SMALL AND LARGE fires to stop the reaction. Smothering will not work for these materials. They do not need air to burn. Small fires: Dry

chemical, soda ash, lime or dry sand. EXCEPT for UN1384, UN1923, UN1929. Large fires: DRY sand, dry chemical, soda ash or lime, EXCEPT for UN1384, UN1923, UN1929, or withdraw from area and let fire burn. Move containers from fire area if you can do it without risk. Fire involving tanks or car/trailer loads: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Do not get water inside containers or in contact with substance. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. /**Nickel** catalyst, dry/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-135]**QC REVIEWED**

Spill or leak: Fully encapsulating, vapor protective clothing should be worn for spills and leak with no fire. ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). Do not touch or walk through spilled material. Stop leak if you can do it without risk. Small spills: EXCEPTION: For Dithionite (Hydrosulfite/Hydrosulphite) spills, UN1384, UN1923 and UN1929, dissolve with 5 parts water and collect for proper disposal. Cover with DRY earth, DRY sand, or other non-combustible material followed with plastic sheet to minimize spreading or contact with rain. Use clean non-sparking tools to collect material and place it into loosely covered plastic containers for later disposal. Prevent entry into waterways, sewers, basements or confined areas. /**Nickel** catalyst, dry/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-135]**QC REVIEWED**

First aid: Move victim to fresh air. Call 911 or emergency medical service. Apply artificial respiration if victim is not breathing. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. Keep victim warm and quiet. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves. /**Nickel** catalyst, dry/
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-135]**QC REVIEWED**

Flammable Limits:

Flammable ... as dust or fume.
[Sax, N.I. and R.J. Lewis, Sr. (eds.). Hawley's Condensed Chemical Dictionary. 11th ed. New York: Van Nostrand Reinhold Co., 1987. 818]**PEER REVIEWED**

Fire Fighting Procedures:

Flood with water. Use dry chemical, graphite, or dry earth. /**Nickel** catalyst, wet/
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, D.C.: Assoc. of American Railroads, Hazardous Materials Systems (BOE), 1987.483]**PEER REVIEWED**

Toxic Combustion Products:

Toxic gases and vapors (such as **nickel** carbonyl) may be released in a fire involving **nickel** ... /**Nickel** & sol **nickel** cmpd/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

MIXTURES CONTAINING POTASSIUM PERCHLORATE WITH **NICKEL** & TITANIUM POWDERS & INFUSORIAL EARTH GAVE SEVERE EXPLOSIONS DURING A FRICTION TEST.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-122]**QC REVIEWED**

SPARKS--LESS THAN THOSE AVAILABLE FROM STATIC ELECTRICITY ON THE HUMAN BODY--CAN IGNITE THE MIXTURE /CONTAINING POTASSIUM PERCHLORATE WITH **NICKEL** & TITANIUM POWDERS & INFUSORIAL EARTH/.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-122]**QC REVIEWED**

Upon heating, a mixture of powdered **nickel** and sulfur or selenium will react incandescently.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1333]**PEER REVIEWED**

If **nickel** powder comes into contact with bromine pentafluoride at ambient or slightly elevated temperatures, ignition will probably occur.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 93]**PEER REVIEWED**

Adding 2-3 drops of approximately 90% peroxyformic acid to powdered **nickel** will result in an explosion.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 152]**PEER REVIEWED**

A mixture of **nickel** and nitryl fluoride will become incandescent if slightly warmed.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1094]**PEER REVIEWED**

Powdered **nickel** reacts explosively upon contact with fused ammonium nitrate at temperatures below 200 deg C.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1250]**PEER REVIEWED**

Strong acids, sulfur, selenium, wood & other combustibles, **nickel** nitrate.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 224]**PEER REVIEWED**

Incompatibilities: Aluminum, aluminum trichloride, ethylene, p-dioxan, hydrogen, methanol, non-metals, oxidants, sulfur cmpd.
[Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984. 1991]**PEER REVIEWED**

Reacts vigorously or explosively with aniline, hydrogen sulfide , flammable solvents, hydrazine, and metal powders (especially zinc, aluminum, and magnesium). /**Nickel**/
[William S ed; Official Methods of Analysis of the Association of official Analytical Chemist 14th ed p.449 (1984)]**PEER REVIEWED**

Hazardous Decomposition:

Toxic gases and vapors (such as **nickel** carbonyl) may be released ... in the decomp of **nickel** cmpd. /**Nickel** & sol **nickel** cmpd/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH considers **nickel** metal and other compounds (as Ni) to be a potential occupational carcinogen. /**Nickel** metal and other compounds (as Ni)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 224]**PEER REVIEWED**

Protective Equipment & Clothing:

ENGINEERING CONTROLS & PROTECTIVE CLOTHING ARE NEEDED TO ENSURE SAFE WORKING CONDITIONS.
[Hamilton, A., and H. L. Hardy. Industrial Toxicology. 3rd ed. Acton, Mass.: Publishing Sciences Group, Inc., 1974. 154]**PEER REVIEWED**

Use goggles, barrier shields, and other devices as necessary for personal protection; use polyvinyl chloride, not rubber, for gloves.
[Williams S ed; Official Methods of Analysis of the Association of Official Analytical Chemists 14th ed p.449 (1984)]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... dispensers of liq detergent /should be available./ ... Safety pipettes should be used for all pipetting. ... In animal laboratory, personnel should ... wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. ... gowns ... /should be/ of distinctive color, this is a reminder that they are not to be worn outside the laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

Wear appropriate personal protective clothing to prevent skin contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 225]**PEER REVIEWED**

Recommendations for respirator selection: Condition: At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration: Respirator Class(es): Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive pressure-mode. Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 225]**PEER REVIEWED**

Recommendations for respirator selection: Condition: Escape from suddenly occurring respiratory hazards: Respirator Class(es): Any air-purifying, full-facepiece respirator with a high-efficiency particulate filter. Any appropriate escape-type, self-contained breathing apparatus.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 225]**PEER REVIEWED**

Respirator selection: Upper limit devices recommended by NIOSH: > at any detectable concn: any self-contained breathing apparatus with a full facepiece and operated in a pressure-demand or other positive pressure mode or any supplied-air respirator with a full facepiece and operated in a

pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode; escape: any air-purifying full facepiece respirator with a high-efficiency particulate filter; any appropriate escape-type self-contained breathing apparatus /**Nickel**, metal & sol compounds (as Ni)/
[NIOSH. Pocket Guide to Chemical Hazards. 5th Printing/Revision. DHHS (NIOSH) Publ. No. 85-114. Washington, D.C.: U.S. Dept. of Health and Human Services, NIOSH/Supt. of Documents, GPO, Sept. 1985.173]**PEER REVIEWED**

Respiratory protection for dust, mist, or fume of **nickel** metal and soluble compounds is as follows: 10 mg/cu m or less: any fume respirator, high efficiency particulate respirator, supplied air respirator, or any self-contained breathing apparatus; 50 mg/cu m or less: a high efficiency particulate filter respirator with a full facepiece, any supplied-air respirator with a full facepiece, helmet or hood or any self-contained breathing apparatus with a full facepiece; 1000 mg/cu m or less: a powered air-purifying respirator with a high efficiency filter or a type-C supplied-air respirator operated in pressure-demand, positive pressure or continous flow mode; 2000 mg/cu m or less: a type-C supplied-air respirator with a full facepiece operated in a pressure-demand or other positive pressure mode or with full facepiece, helmet, or hood operated in a continuous-flow mode; > 2000 mg/cu m or entry and escape from unknown concn: a self-contained breathing apparatus with a full facepiece operated in pressure demand or other positive pressure mode or a combination respirator which includes a type-C supplied-air respirator. /**Nickel** metal and soluble compounds, dust, mist, or fume/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.7]**PEER REVIEWED**

If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health. ... Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent repeated or prolonged skin contact with powdered **nickel** or solid or liquids containing sol **nickel** cmpd. /**Nickel** metal and sol **nickel** cmpd/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Preventive Measures:

SRP: Local exhaust ventilation should be applied wherever there is an incidence of point source emissions or dispersion of regulated contaminants in the work area. Ventilation control of the contaminant as close to its point of generation is both the most economical and safest method to minimize personnel exposure to airborne contaminants.
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 359]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Smoking, drinking, eating, storage of food or of food & beverage containers or utensils, & the application of cosmetics should be prohibited in any laboratory. All personnel should remove gloves, if worn, after completion of procedures in which carcinogens have been used. They should ... wash ... hands, preferably using dispensers of liq detergent, & rinse ... thoroughly. Consideration should be given to appropriate methods for cleaning the skin, depending on nature of the contaminant. No standard procedure can be recommended, but the use of organic solvents should be avoided. Safety pipettes should be used for all pipetting. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the

Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": In animal laboratory, personnel should remove their outdoor clothes & wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... clothing should be changed daily but ... discarded immediately if obvious contamination occurs ... /also,/ workers should shower immediately. In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. If gowns are of distinctive color, this is a reminder that they should not be worn outside of lab. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... operations connected with synth & purification ... should be carried out under well-ventilated hood. Analytical procedures ... should be carried out with care & vapors evolved during ... procedures should be removed. ... Expert advice should be obtained before existing fume cupboards are used ... & when new fume cupboards are installed. It is desirable that there be means for decreasing the rate of air extraction, so that carcinogenic powders can be handled without ... powder being blown around the hood. Glove boxes should be kept under negative air pressure. Air changes should be adequate, so that concn of vapors of volatile carcinogens will not occur. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Vertical laminar-flow biological safety cabinets may be used for containment of in vitro procedures ... provided that the exhaust air flow is sufficient to provide an inward air flow at the face opening of the cabinet, & contaminated air plenums that are under positive pressure are leak-tight. Horizontal laminar-flow hoods or safety cabinets, where filtered air is blown across the working area towards the operator, should never be used ... Each cabinet or fume cupboard to be used ... should be tested before work is begun (eg, with fume bomb) & label fixed to it, giving date of test & avg air-flow measured. This test should be repeated periodically & after any structural changes. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Principles that apply to chem or biochem lab also apply to microbiological & cell-culture labs ... Special consideration should be given to route of admin. ... Safest method of administering volatile carcinogen is by injection of a soln. Admin by topical application, gavage, or intratracheal instillation should be performed under hood. If chem will be exhaled, animals should be kept under hood during this period. Inhalation exposure requires special equipment. ... unless specifically required, routes of admin other than in the diet should be used. Mixing of carcinogen in diet should be carried out in sealed mixers under fume hood, from which the exhaust is fitted with an efficient particulate filter. Techniques for cleaning mixer & hood should be devised before expt begun. When mixing diets, special protective clothing &, possibly, respirators may be required. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the

Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When ... admin in diet or applied to skin, animals should be kept in cages with solid bottoms & sides & fitted with a filter top. When volatile carcinogens are given, filter tops should not be used. Cages which have been used to house animals that received carcinogens should be decontaminated. Cage-cleaning facilities should be installed in area in which carcinogens are being used, to avoid moving of ... contaminated /cages/. It is difficult to ensure that cages are decontaminated, & monitoring methods are necessary. Situations may exist in which the use of disposable cages should be recommended, depending on type & amt of carcinogen & efficiency with which it can be removed. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": To eliminate risk that ... contamination in lab could build up during conduct of expt, periodic checks should be carried out on lab atmospheres, surfaces, such as walls, floors & benches, & ... interior of fume hoods & airducts. As well as regular monitoring, check must be carried out after cleaning-up of spillage. Sensitive methods are required when testing lab atmospheres for chem such as nitrosamines. Methods ... should ... where possible, be simple & sensitive. ... /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Rooms in which obvious contamination has occurred, such as spillage, should be decontaminated by lab personnel engaged in expt. Design of expt should ... avoid contamination of permanent equipment. ... Procedures should ensure that maintenance workers are not exposed to carcinogens. ... Particular care should be taken to avoid contamination of drains or ventilation ducts. In cleaning labs, procedures should be used which do not produce aerosols or dispersal of dust, ie, wet mop or vacuum cleaner equipped with high-efficiency particulate filter on exhaust, which are avail commercially, should be used. Sweeping, brushing & use of dry dusters or mops should be prohibited. Grossly contaminated cleaning materials should not be re-used ... If gowns or towels are contaminated, they should not be sent to laundry, but ... decontaminated or burnt, to avoid any hazard to laundry personnel. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Doors leading into areas where carcinogens are used ... should be marked distinctively with appropriate labels. Access ... limited to persons involved in expt. ... A prominently displayed notice should give the name of the Scientific Investigator or other person who can advise in an emergency & who can inform others (such as firemen) on the handling of carcinogenic substances. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.11]**PEER REVIEWED**

SRP: Contaminated protective clothing should be segregated in such a manner so that there is no direct personal contact by personnel who handle, dispose, or clean the clothing. Quality assurance to ascertain the completeness of the cleaning procedures should be implemented before the decontaminated

protective clothing is returned for reuse by the workers. Contaminated clothing should not be taken home at end of shift, but should remain at employee's place of work for cleaning.
PEER REVIEWED

The worker should immediately wash the skin when it becomes contaminated.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 225]**PEER REVIEWED**

The worker should wash daily at the end of each work shift.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 225]**PEER REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed and replaced.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 225]**PEER REVIEWED**

Stability/Shelf Life:

STABLE IN AIR @ ORDINARY TEMP; NOT AFFECTED BY WATER
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 932]**PEER REVIEWED**

Heat /contributes to instability/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Shipment Methods and Regulations:

No person may /transport,/ offer or accept a hazardous material for transportation in commerce unless that person is registered in conformance ... and the hazardous material is properly classed, described, packaged, marked, labeled, and in condition for shipment as required or authorized by ... /the hazardous materials regulations (49 CFR 171-177)./
[49 CFR 171.2 (7/1/99)]**PEER REVIEWED**

The International Air Transport Association (IATA) Dangerous Goods Regulations are published by the IATA Dangerous Goods Board pursuant to IATA Resolutions 618 and 619 and constitute a manual of industry carrier regulations to be followed by all IATA Member airlines when transporting hazardous materials.
[IATA. Dangerous Goods Regulations. 40th Ed. Montreal, Canada and Geneva, Switzerland: International Air Transport Association, Dangerous Goods Regulations, 1999. 175]**PEER REVIEWED**

The International Maritime Dangerous Goods Code lays down basic principles for transporting hazardous chemicals. Detailed recommendations for individual substances and a number of recommendations for good practice are included in the classes dealing with such substances. A general index of technical names has also been compiled. This index should always be consulted when attempting to locate the appropriate procedures to be used when shipping any substance or article.
[IMDG; International Maritime Dangerous Goods Code; International Maritime Organization p.4245, 4246 (1998)]**PEER REVIEWED**

Storage Conditions:

PRECAUTIONS FOR "CARCINOGENS": Storage site should be as close as practicable to lab in which carcinogens are to be used, so that only small quantities required for ... expt need to be carried.

Carcinogens should be kept in only one section of cupboard, an explosion proof refrigerator or freezer (depending on chemicophysical properties ...) that bears appropriate label. An inventory ... should be kept, showing quantity of carcinogen & date it was acquired ... Facilities for dispensing ... should be contiguous to storage area. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

Cleanup Methods:

PRECAUTIONS FOR "CARCINOGENS": A high efficiency particulate arrestor (HEPA) or charcoal filters can be used to minimize amt of carcinogen in exhausted air ventilated safety cabinets, lab hoods, glove boxes or animal rooms. ... Filter housing that is designed so that used filters can be transferred into plastic bag without contaminating maintenance staff is avail commercially. Filters should be placed in plastic bags immediately after removal. ... The plastic bag should be sealed immediately. ... The sealed bag should be labelled properly. ... Waste liquids ... should be placed or collected in proper containers for disposal. The lid should be secured & the bottles properly labelled. Once filled, bottles should be placed in plastic bag, so that outer surface ... is not contaminated. ... The plastic bag should also be sealed & labelled. ... Broken glassware ... should be decontaminated by solvent extraction, by chemical destruction, or in specially designed incinerators. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

Disposal Methods:

SRP: At the time of review, criteria for land treatment or burial (sanitary landfill) disposal practices are subject to significant revision. Prior to implementing land disposal of waste residue (including waste sludge), consult with environmental regulatory agencies for guidance on acceptable disposal practices.
PEER REVIEWED

PRECAUTIONS FOR "CARCINOGENS": There is no universal method of disposal that has been proved satisfactory for all carcinogenic compounds & specific methods of chem destruction ... published have not been tested on all kinds of carcinogen-containing waste. ... Summary of avail methods & recommendations ... /given/ must be treated as guide only. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.14]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Incineration may be only feasible method for disposal of contaminated laboratory waste from biological expt. However, not all incinerators are suitable for this purpose.The most efficient type ... is probably the gas fired type, in which a first-stage combustion with a less than stoichiometric air:fuel ratio is followed by a second stage with excess air. Some ... are designed to accept ... aqueous & organic solvent solutions, otherwise it is necessary ... to absorb soln onto suitable combustible material, such as sawdust. Alternatively, chem destruction may be used, esp when small quantities ... are to be destroyed in laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": HEPA (high efficiency particulate arrestor) filters ... can be disposed of by incineration. For spent charcoal filters, the adsorbed material can be stripped off at high temp & carcinogenic wastes generated by this treatment conducted to & burned in an incinerator. ... LIQUID WASTE: ... Disposal should be carried out by incineration at temp that ... ensure complete combustion. SOLID WASTE: Carcasses of lab animals, cage litter & misc solid wastes ... should be disposed of by incineration at temp high enough to ensure destruction of chem carcinogens or their metabolites. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Small quantities of ... some carcinogens can be destroyed using chem reactions ... but no general rules can be given. ... As a general technique ... treatment with sodium dichromate in strong sulfuric acid can be used. The time necessary for destruction ... is seldom known ... but 1-2 days is generally considered sufficient when freshly prepd reagent is used. ... Carcinogens that are easily oxidizable can be destroyed with milder oxidative agents, such as sat soln of potassium permanganate in acetone, which appears to be a suitable agent for destruction of hydrazines or of compounds containing isolated carbon-carbon double bonds. Concn or 50% aqueous sodium hypochlorite can also be used as an oxidizing agent. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.16]**PEER REVIEWED**

Precipitation is the preferred treatment process for removing toxic heavy metals from electroplating waters. Precipitation processes include hydroxide, lime and/or sulfide treatment. Chemical reduction is used to treat complex metals such as **nickel**, copper, hexavalent chromium waste, soluble lead, silver, metal containing cyanide, and mercury. Adsorption has shown potential for treating and polishing aqueous metal bearing wastes. Activated carbon, activated alumina, and iron filings are all applicable adsorbents. Alkaline chlorination and incineration are effective cyanide destruction treatments. Evaporation, ion-exchange, reverse osmosis, electrodialysis, and electrolytic recovery are waste reduction and recovery techniques applicable to metal bearing hazardous streams.
[Grosse DW; 12th Annual Research Symposium on Land Disposal, Remedial Action, Incineration, and Treatment of Hazardous Wastes (1986)]**PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

Permissible Exposure Limit: Table Z-1 8-hr Time Weighted Avg: 1 mg/cu m. /**Nickel**, soluble cmpd, as Ni/
[29 CFR 1910.1000 (7/1/99)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-1 8-hr Time Weighted Avg: 1 mg/cu m. /**Nickel**, metal and insoluble cmpd, as Ni/
[29 CFR 1910.1000 (7/1/99)]**PEER REVIEWED**

Threshold Limit Values:

8 hr Time Weighted Avg (TWA) 1.5 mg/cu m, inhalable fraction /**Nickel**, elemental, metal/
[American Conference of Governmental Industrial Hygienists. Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents Biological Exposure Indices for 1999. Cincinnati, OH: ACGIH, 1999. 51]**PEER REVIEWED**

A5. A5=Not suspected as a human carcinogen. /**Nickel**, elemental, metal/
[American Conference of Governmental Industrial Hygienists. Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents Biological Exposure Indices for 1999. Cincinnati, OH: ACGIH, 1999. 51]**PEER REVIEWED**

Excursion Limit Recommendation: Excursions in worker exposure levels may exceed three times the TLV-TWA for no more than a total of 30 min during a work day, and under no circumstances should they exceed five times the TLV-TWA, provided that the TLV-TWA is not exceeded. /**Nickel**, elemental, metal/
[American Conference of Governmental Industrial Hygienists. Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents Biological Exposure Indices for 1999. Cincinnati, OH: ACGIH, 1999. 6]**PEER REVIEWED**

8 hr Time Weighted Avg (TWA) 0.2 mg/cu m, inhalable fraction. A1. A1= Confirmed human carcinogen. /**Nickel**, insoluble compounds, as Ni/
[American Conference of Governmental Industrial Hygienists. Guide to Occupational Exposure Values - 1999. Cincinnati, OH: 1999. 51]**PEER REVIEWED**

Excursion Limit Recommendation: Excursions in worker exposure levels may exceed three times the TLV-TWA for no more than a total of 30 min during a work day, and under no circumstances should they exceed five times the TLV-TWA, provided that the TLV-TWA is not exceeded.
[American Conference of Governmental Industrial Hygienists. Guide to Occupational Exposure Values - 1999. Cincinnati, OH: 1999. 6]**PEER REVIEWED**

NIOSH Recommendations:

NIOSH considers **nickel** metal and other compounds (as Ni) to be a potential occupational carcinogen. /**Nickel** metal and other compounds (as Ni)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 224]**PEER REVIEWED**

NIOSH usually recommends that occupational exposures to carcinogens be limited to the lowest feasible concentration. /**Nickel** metal and other compounds (as Ni)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 224]**PEER REVIEWED**

Recommended Exposure Limit: 10 Hr TWA 0.015 mg/cu m. /**Nickel** metal and other compounds (as Ni)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 224]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH considers **nickel** metal and other compounds (as Ni) to be a potential occupational carcinogen. /**Nickel** metal and other compounds (as Ni)/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 224]**PEER REVIEWED**

Other Occupational Permissible Levels:

Max allowable concn (MAC) USSR 0.5 mg/cu m /**Nickel**, **nickel** oxide and **nickel** sulfides as dust/
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1438]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

Nickel plating; for various alloys such as new silver, Chinese silver, German silver; for coins, electrotypes, lightning rod tips, electrical contacts and electrodes, spark plugs, machinery parts; catalyst for hydrogenation of org substances; in mfr of monel metal, stainless steels, and **nickel** chrome resistance wire; in alloys for electronic and space applications
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1116]**PEER REVIEWED**

IT IS EXTENSIVELY USED FOR MAKING STAINLESS STEEL & OTHER CORROSION RESISTANT ALLOYS ... TUBING MADE OF COPPER **NICKEL** ALLOY ... USED IN MAKING DESALINATION PLANTS ... IN MAKING **NICKEL** STEEL ARMOR PLATE & BURGLAR PROOF VAULTS ... **NICKEL** ADDED TO GLASS GIVES GREEN COLOR.
[Weast, R.C. (ed.) Handbook of Chemistry and Physics, 68th ed. Boca Raton, Florida: CRC Press Inc., 1987-1988.,p. B-26]**PEER REVIEWED**

COMPONENT OF FERROUS ALLOYS
[SRI]**PEER REVIEWED**

COMPONENT OF NONFERROUS ALLOYS
[SRI]**PEER REVIEWED**

COMPONENT OF PERMANENT MAGNETS
[SRI]**PEER REVIEWED**

/**Nickel** is/ used as a catalyst ... Used in the hydrogenation of fats and oils ... .
[21 CFR 184.1537 (4/1/86)]**PEER REVIEWED**

COMPONENT OF CERAMICS
[SRI]**PEER REVIEWED**

COMPONENT OF BATTERIES & FUEL CELLS
[SRI]**PEER REVIEWED**

CHEM INT FOR **NICKEL** COMPOUNDS
[SRI]**PEER REVIEWED**

IN SURGICAL & DENTAL PROSTHESES
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 1438]**PEER REVIEWED**

As antistatic coating
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 3(78) 169]**PEER REVIEWED**

Use in cooling towers as anodic inhibitor
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 21(83) 73]**PEER REVIEWED**

Alloys (stainless steel, copper and brass, permanent magnets, electrical resistance alloys), electroplated protective coatings, electro-formed coatings, alkaline storage battery, fuel cell electrodes, catalyst for methanation of fuel gases and hydrogenation of vegetable oils.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 785]**PEER REVIEWED**

Nickel's greatest value is as an alloying agent with other metallic elements, adding strength and corrosion resistance over a wide range of temperatures.
[Bureau of Mines. Minerals Yearbook. 1992. Washington, DC: U.S. Government Printing Office, 1992. 863]**PEER REVIEWED**

Manufacturers:

Norilsk **Nickel** Combine, Russia
[Bureau of Mines. Minerals Yearbook. 1992. Washington, DC: U.S. Government Printing Office, 1992. 864]**PEER REVIEWED**

Inco Ltd., Canada
[Bureau of Mines. Minerals Yearbook. 1992. Washington, DC: U.S. Government Printing Office, 1992. 864]**PEER REVIEWED**

Falconbridge Ltd., Canada
[Bureau of Mines. Minerals Yearbook. 1992. Washington, DC: U.S. Government Printing Office, 1992. 864]**PEER REVIEWED**

Glenbrook **Nickel** Co., Riddle, OR, ... closed in 1997.
[USGS; Minerals Information - 1997. Nickel. Available from: http://minerals.usgs.gov/minerals/pubs/commodity/nickel/500497.pdf as of Jan., 2000]**PEER REVIEWED**

Methods of Manufacturing:

... high purity **nickel**: Wise, Schaefer, Metals Alloys 16, 424 (1924); from **nickel** oxide and hydrogen gas: Glemser in Handbook of Preparative Inorganic Chemistry Vol 2, G Brauer, ed (Academic Press, NY, 2nd ed, 1965) pp 1543-1544; by electrolysis: Vu Quang Kinh, Nardin Compt Rend Ser c266, 307 (1968).
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 932]**PEER REVIEWED**

RECOVERY FROM **NICKEL** SULFIDE ORES BY CRUSHING & CONCENTRATING BY FLOTATION & MAGNETIC SEPN, THEN ROASTING & SMELTING, & FINALLY PROCESSING OF THE **NICKEL**-COPPER MATTE BY PYROMETALLURGY (ROASTING TO OXIDE & REDUCTION TO METAL) OR HYDROMETALLURGY (FORMATION OF SALT SOLN & REDN TO METAL)
[SRI]**PEER REVIEWED**

REACTION OF **NICKEL** OR **NICKEL** ORE WITH CARBON MONOXIDE TO FORM **NICKEL** CARBONYL GAS, WHICH IS DECOMPOSED BY HEAT TO OBTAIN PURE, FINELY DIVIDED **NICKEL** (MOND PROCESS)
[SRI]**PEER REVIEWED**

Recovery of **nickel** can be accomplished by ion exchange. ... In exchange treatment requires waste stream segregation, particularly in the presence of cyanide, in order that the **nickel** regenerant can be recovered by precipitation. ... Cation-anion exchange has been used to treat **nickel** sulfate plating bath ... complete **nickel** removal was reported ... .
[Patterson JW; Industrial Wastewater Treatment Technolgy 2nd Edition p.226 (1985)]**PEER REVIEWED**

General Manufacturing Information:

(1992) World mine production: the former U.S.S.R. (27%), Canada (21%), New Caledonia (10%),

Indonesia (7%), Australia (7%), and Cuba (4%).
[Bureau of Mines. Minerals Yearbook. 1992. Washington, DC: U.S. Government Printing Office, 1992. 864]**PEER REVIEWED**

World mine production (1998): Russia, 265,000 metric tons; Canada, 225,000 metric tons; New Caledonia, 137,000 metric tons; Australia, 145,000 metric tons; Indonesia, 76,400 metric tons; Cuba, 66,000 metric tons.
[USGS; Minerals Commodity Summary - 1999. Nickel. Available from: http://minerals.usgs.gov/minerals/pubs/commodity/nickel/500399.pdf as of January, 2000]**PEER REVIEWED**

The only **nickel** smelter in the United States closed April 1998 because of low **nickel** prices. ... The adjoining mine on **Nickel** Mountain has been idle since 1996.
[USGS; Minerals Commodity Summary - 1999. Nickel. Available from: http://minerals.usgs.gov/minerals/pubs/commodity/nickel/500399.pdf as of January, 2000]**PEER REVIEWED**

About 66,000 tons of **nickel** was recovered from purchased scrap in 1998. This represented about 35% of reported consumption for the year.
[USGS; Minerals Commodity Summary - 1999. Nickel. Available from: http://minerals.usgs.gov/minerals/pubs/commodity/nickel/500399.pdf as of January, 2000]**PEER REVIEWED**

Formulations/Preparations:

Grades: electrolytic; ingot; pellets; shot; sponge; powder; high purity strip; single crystals (wire 2x0.05-0.005 in)
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 785]**PEER REVIEWED**

Ferronickel has a **nickel** content of 24-48%. Also available are electrolytic cathode sheets and pellets produced by the decomposition of **nickel** carbonyl.
[CONSIDINE. CHEMICAL AND PROCESS TECHNOL ENCYC 1974 p.766]**PEER REVIEWED**

Pellets (99.99%), spherical powder, spray powder, **nickel** flour; high density grade for electronics; **nickel** flour for shielding coatings, HP pellets for vacuum and chemical work, spherical powder for spray work.
[Newman A, ed; Chemcyclopedia 2000. Washington, DC: Amer Chem Soc p. 302 (1999)]**PEER REVIEWED**

Commercial **nickel** metal is more than 99.5% pure and may be in the form of square plates, powder, briquets, pellets, ingots, disks, or shot.
[Bureau of Mines. Minerals Yearbook. 1992. Washington, DC: U.S. Government Printing Office, 1992. 863]**PEER REVIEWED**

Consumption Patterns:

FERROUS ALLOYS, 44%; OTHER ALLOYS, 32%; ELECTROPLATING, 20%; OTHER, 4% (1982)
[SRI]**PEER REVIEWED**

Transportation, 25%, chemical industry, 15%; electrical equipment, 9%; construction, 9%; fabricated metal products, 9%; petroleum, 8%; household appliances, 7%; machinery, 7%; and other, 11% (1986)
[BUREAU OF MINES. MINERAL COMMODITY SUMMARIES 1987 p.108]**PEER REVIEWED**

Stainless steel producers accounted for 40% of primary **nickel** demand in the United States and more than 60% of primary demand in the world.

[USGS; Minerals Information - 1997. Nickel. Available from: http://minerals.usgs.gov/minerals/pubs/commodity/nickel/500497.pdf as of January, 2000]**PEER REVIEWED**

Approximately 44% of the primary **nickel** consumed went into stainless and alloy production, 38% into nonferrous alloys and super alloys, 14% into electroplating, and 4% into other uses.
[USGS; Minerals Commodity Summary - 1999. Nickel. Available from: http://minerals.usgs.gov/minerals/pubs/commodity/nickel/500399.pdf as of January, 2000]**PEER REVIEWED**

Ultimate end uses were as follows: transportation, 31%; chemical industry, 14%; electrical equipment, 11%; construction, 8%; fabricated metal products, 8%; petroleum, 7%; machinery, 7%; household appliances, 6%; and other 8%.
[USGS; Minerals Commodity Summary - 1999. Nickel. Available from: http://minerals.usgs.gov/minerals/pubs/commodity/nickel/500399.pdf as of January, 2000]**PEER REVIEWED**

(1997) 122,000 metric tons (Reported, primary); 68,800 metric tons (Reported, secondary)
[USGS; Minerals Commodity Summary - 1999. Nickel. Available from: http://minerals.usgs.gov/minerals/pubs/commodity/nickel/500399.pdf as of January, 2000]**PEER REVIEWED**

Automotive manufacturers in the European Union, Japan, and the United States have begun producing electric vehicles powered by **nickel**-metal hydride, **nickel**-cadmium, or sodium metal-**nickel** batteries. ... **Nickel** metal powder production facilities in the United Kingdom are being expanded to meet growing demand from battery manufacturers.
[USGS; Minerals Commodity Summary - 1999. Nickel. Available from: http://minerals.usgs.gov/minerals/pubs/commodity/nickel/500399.pdf as of January, 2000]**PEER REVIEWED**

U. S. Production:

(1978) 3.39X10+10 G
[SRI]**PEER REVIEWED**

(1982) 4.08X10+10 G
[SRI]**PEER REVIEWED**

(1986) 3.84X10+10 g
[BUREAU OF MINES. MINERAL COMMODITY SUMMARIES 1987 p.108]**PEER REVIEWED**

(1992) 1.27X10+6 metric tons
[Bureau of Mines. Minerals Yearbook. 1992. Washington, DC: U.S. Government Printing Office, 1992. 863]**PEER REVIEWED**

(1997) 16,000 tons
[USGS; Minerals Information - 1997. Nickel. Available from: http://minerals.usgs.gov/minerals/pubs/commodity/nickel/500497.pdf as of January, 2000]**PEER REVIEWED**

U. S. Imports:

(1978) 2.13X10+11 G
[SRI]**PEER REVIEWED**

(1982) 1.18X10+11 G
[SRI]**PEER REVIEWED**

(1986) 1.27X10+11 g
[BUREAU OF MINES. MINERAL COMMODITY SUMMARIES 1987 p.108]**PEER REVIEWED**

(1998, estimated): 1,420 metric tons (ore); 155,000 metric tons (primary); 9,780 metric tons (secondary)
[USGS; Minerals Commodity Summary - 1999. Nickel. Available from: http://minerals.usgs.gov/minerals/pubs/commodity/nickel/500399.pdf as of January, 2000]**PEER REVIEWED**

Import sources (1994-97): Canada, 37%; Norway, 15%; Russia, 14%; Australia, 10%; and other, 24%.
[USGS; Minerals Commodity Summary - 1999. Nickel. Available from: http://minerals.usgs.gov/minerals/pubs/commodity/nickel/500399.pdf as of January, 2000]**PEER REVIEWED**

U. S. Exports:

(1978) 3.30X10+10 G
[SRI]**PEER REVIEWED**

(1982) 5.18X10+10 G
[SRI]**PEER REVIEWED**

(1986) 2.72X10+9 g
[BUREAU OF MINES. MINERAL COMMODITY SUMMARIES 1987 p.108]**PEER REVIEWED**

(1997) 17,600 tons metric (ore); 147,000 metric tons (primary); 11,000 metric tons (secondary).
[USGS; Minerals Commodity Summary - 1999. Nickel. Available from: http://minerals.usgs.gov/minerals/pubs/commodity/nickel/500399.pdf as of January, 2000]**PEER REVIEWED**

Laboratory Methods:

Special References:

Special Reports:

U.S. Department of Health & Human Services/National Toxicology Program; Tenth Report on Carcinogens. National Institutes of Environmental Health Sciences. The Report on Carcinogens is an informational scientific and public health document that identifies and discusses substances (including agents, mixtures, or exposure circumstances) that may pose a carcinogenic hazard to human health. **Nickel**, metallic (7440-02-0) was listed in the First Annual Report on Carcinogens (1980) as reasonably anticipated to be a human carcinogen and listed in the Tenth Report on Carciongens (2002) as reasonably anticipated to be a human carcinogen. /**Nickel**, metallic (7440-02-0)/

Synonyms and Identifiers:

Related HSDB Records:

6933 [**NICKEL** COMPOUNDS]

Synonyms:

CI 77775
PEER REVIEWED

NI 0901-S
PEER REVIEWED

NI 270
PEER REVIEWED

NI-4303T
PEER REVIEWED

NICHEL (ITALIAN)
PEER REVIEWED

NICKEL
PEER REVIEWED

Nickel 200
PEER REVIEWED

Nickel 201
PEER REVIEWED

Nickel 205
PEER REVIEWED

Nickel 207
PEER REVIEWED

NICKEL 270
PEER REVIEWED

NICKEL SPONGE
PEER REVIEWED

NI 0901-S (HARSHAW)
PEER REVIEWED

NP-2
PEER REVIEWED

RANEY ALLOY
PEER REVIEWED

RANEY NICKEL
PEER REVIEWED

RCH 55/5
PEER REVIEWED

Formulations/Preparations:

Grades: electrolytic; ingot; pellets; shot; sponge; powder; high purity strip; single crystals (wire 2x0.05-0.005 in)
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 785]**PEER REVIEWED**

Ferronickel has a **nickel** content of 24-48%. Also available are electrolytic cathode sheets and pellets produced by the decomposition of **nickel** carbonyl.
[CONSIDINE. CHEMICAL AND PROCESS TECHNOL ENCYC 1974 p.766]**PEER REVIEWED**

Pellets (99.99%), spherical powder, spray powder, **nickel** flour; high density grade for electronics; **nickel** flour for shielding coatings, HP pellets for vacuum and chemical work, spherical powder for spray work.
[Newman A, ed; Chemcyclopedia 2000. Washington, DC: Amer Chem Soc p. 302 (1999)]**PEER REVIEWED**

Commercial **nickel** metal is more than 99.5% pure and may be in the form of square plates, powder, briquets, pellets, ingots, disks, or shot.
[Bureau of Mines. Minerals Yearbook. 1992. Washington, DC: U.S. Government Printing Office, 1992. 863]**PEER REVIEWED**

Standard Transportation Number:

49 162 25; **Nickel** catalyst, not spent

49 162 26; **Nickel** catalyst, spent

Administrative Information:

Hazardous Substances Databank Number: 1096

Last Revision Date: 20030829

Last Review Date: Reviewed by SRP on 5/6/2000

Update History:

Complete Update on 2003-08-29, 0 fields added/edited/deleted
Complete Update on 02/14/2003, 1 field added/edited/deleted.
Complete Update on 10/16/2002, 1 field added/edited/deleted.
Complete Update on 05/13/2002, 1 field added/edited/deleted.
Complete Update on 03/06/2002, 1 field added/edited/deleted.
Complete Update on 01/18/2002, 2 fields added/edited/deleted.
Field Update on 01/14/2002, 1 field added/edited/deleted.
Complete Update on 05/16/2001, 1 field added/edited/deleted.
Complete Update on 05/15/2001, 1 field added/edited/deleted.
Complete Update on 09/08/2000, 63 fields added/edited/deleted.
Field Update on 02/02/2000, 1 field added/edited/deleted.
Complete Update on 09/21/1999, 1 field added/edited/deleted.
Complete Update on 08/26/1999, 1 field added/edited/deleted.
Complete Update on 07/27/1999, 7 fields added/edited/deleted.
Complete Update on 06/03/1999, 1 field added/edited/deleted.
Complete Update on 04/02/1999, 1 field added/edited/deleted.
Complete Update on 01/27/1999, 1 field added/edited/deleted.
Complete Update on 11/27/1998, 1 field added/edited/deleted.
Complete Update on 11/12/1998, 2 fields added/edited/deleted.
Complete Update on 06/02/1998, 1 field added/edited/deleted.
Complete Update on 03/18/1998, 3 fields added/edited/deleted.
Field Update on 02/27/1998, 1 field added/edited/deleted.
Field Update on 10/20/1997, 1 field added/edited/deleted.

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Field Update on 01/15/1990, 1 field added/edited/deleted.
Complete Update on 01/11/1990, 2 fields added/edited/deleted.
Complete Update on 07/25/1989, 90 fields added/edited/deleted.
Complete Update on 04/25/1986
Created 19830401 by DS

Record Length: 95745.0

Nickel, soluble salts

CASRN: Various
For other data, click on the Table of Contents

Status:

STATUS OF DATA FOR **Nickel**, soluble salts

File First On-Line 09/30/1987

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on-line	12/01/1996
Inhalation RfC Assessment (I.B.)	no data	
Carcinogenicity Assessment (II.)	message	08/01/1994

Substance Identification:

Substance Name:

Nickel, soluble salts

CAS Registry Number: Various

I. Chronic Health Hazard Assessment for Noncarcinogenic Effects:

I.A. Reference Dose for Chronic Oral Exposure (RfD):

Substance Name -- **Nickel**, soluble salts
CASRN -- Various
Last Revised -- 12/01/1996

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.A.1. Oral RfD Summary:

Critical Effect	Experimental Doses*	UF	MF	RfD
Decreased body and organ weights	NOAEL: 100 ppm diet (5 mg/kg/day)	300	1	2E-2 mg/kg/day
Rat Chronic Oral Study	LOAEL: 1000 ppm diet (50 mg/kg/day)			
Ambrose et al., 1976				

*Conversion Factors -- 1 ppm = 0.05 mg/kg/day (assumed rat consumption)

I.A.2. Principal and Supporting Studies (Oral RfD):

Ambrose, A.M., D.S. Larson, J.R. Borzelleca and G.R. Hennigar, Jr. 1976. Long-term toxicologic assessment of **nickel** in rats and dogs. J. Food Sci. Technol. 13: 181-187.

Ambrose et al. (1976) reported the results of a 2-year feeding study using rats given 0, 100, 1000 or 2500 ppm **nickel** (estimated as 0, 5, 50 and 125 mg Ni/kg bw) in the diet. Body weights in the high-dose male and female rats were significantly decreased compared with controls. Body weight was also reduced at 1000 ppm. This reduction was significant for females at week 6 and from weeks 26 through 104, whereas males showed body weight reduction only at 52 weeks. Groups of female rats on the 1000 or 2500 ppm **nickel** diets (50 and 125 mg Ni/kg bw) had significantly higher heart-to-body weight ratios and lower liver-to-body weight ratios than controls. No significant effects were reported at 100 ppm (5 mg Ni/kg bw). The dose of 1000 ppm (50 mg Ni/kg bw) represents a LOAEL for this study, while the dose of 100 ppm (5 mg Ni/kg bw) is a NOAEL. In this study, 2-year survival was poor, particularly in control rats of both sexes (death: 44/50), raising some concern about the interpretation of the results of this study. A subchronic study conducted by American Biogenics Corp. (ABC, 1986) also found 5 mg/kg/day to be a NOAEL, which supports the Ambrose et al. (1976) chronic NOAEL of 5 mg/kg/day.

Dietary exposure of dogs to 2500 ppm Ni (about 63 mg/kg/day) resulted in depressed body weight gain; no effects were seen at either 100 ppm (about 2.5 mg/kg/day) or 1000 ppm Ni (about 25 mg/kg/day) in the diet (Ambrose et al., 1976). This study demonstrates that rats are the more sensitive of the two species.

ABC (1986) conducted the 90-day study with **nickel** chloride in water (0, 5, 35 and 100 mg/kg/day) administered by gavage to both male and female CD rats (30 animals/sex/group). The data generated in this study included clinical pathology, ophthalmological evaluations, serum biochemistry, body and organ weight changes and histopathological evaluations of selected organs (heart, kidney, liver).

The body weight and food consumption values were consistently lower than those of controls for the 35 and 100 mg/kg/day dosed males. Female rats in both high-dose groups had lower body weights than controls, but food consumption was unaffected by the test article. Clinical signs of toxicity, such as lethargy, ataxia, irregular breathing, cool body temperature, salivation and discolored extremities, were seen primarily in the 100 mg/kg/day group; these signs were less severe in the 35 mg/kg/day group. The 5 mg/kg/day group did not show any significant clinical signs of toxicity. There was 100% mortality in the high-dose group; 6/30 males and 8/30 females died in the mid-dose group (35 mg/kg/day). Histopathologic evaluation indicated that deaths of 3/6 males and 5/8 females in the mid-dose group

were due to gavage errors. At sacrifice, kidney, liver and spleen weights for 35 mg/kg/day treated males and right kidney weights for 35 mg/kg/day treated females were significantly lower than controls. Based on the results obtained in this study, the 5 mg/kg/day **nickel** dose was a NOAEL, whereas 35 mg/kg/day was a LOAEL for decreased body and organ weights.

I.A.3. Uncertainty and Modifying Factors (Oral RfD):

UF -- An uncertainty factor of 10 is used for interspecies extrapolation and 10 to protect sensitive populations. An additional uncertainty factor of 3 is used to account for inadequacies in the reproductive studies (RTI, 1987; Ambrose et al., 1976; Smith et al., 1990) (see Additional Comments section). During the gestation and postnatal development of F1b litters in the RTI (1987) study, temperatures were about 10 degrees F higher than normal at certain times, which makes evaluation of this part of the reproductive study impossible. In the Ambrose et al. (1976) study, statistical design limitations included small sample size and use of pups rather than litters as the unit for comparison. There were also problems with the statistical analysis of the Smith et al. (1990) study.

The Ni dietary study by Ambrose et al. (1976) identifying a NOAEL of 100 ppm (5 mg/kg/day) is supported by the subchronic gavage study in water (ABC, 1986), which indicated the same NOAEL (5 mg/kg/day).

MF -- None

I.A.4. Additional Studies/Comments (Oral RfD):

In addition to the effects on organ weights described in the critical study, two other sensitive endpoints exist: neonatal mortality and dermatotoxicity. While no reproductive effects have been associated with **nickel** exposure to humans, several studies in laboratory animals have demonstrated fetotoxicity. These studies are described below.

Following the reproductive studies is a discussion of **nickel**-induced dermatotoxicity in hypersensitive humans. While **nickel** has long been recognized as a contact irritant, many studies have also demonstrated dermal effects in sensitive humans resulting from ingested **nickel**. The weight-of-evidence from these studies indicates that ingested **nickel** may invoke an eruption or worsening of eczema; however, a dose-response relationship is difficult to establish. A few representative studies and review articles are cited below.

While the systemic toxicity data (as manifested in organ weight changes) was used as the critical study for the RfD determination, the reproductive/fetotoxicity and the dermatotoxicity were both considered as possible endpoints upon which to base the quantitative risk assessment of **nickel**. The data for effects on the latter two endpoints do not demonstrate consistent dose-response relationships, and in both cases the available studies are sufficiently flawed so as to prevent their selection as the basis for the oral RfD. It is noted, however, that the RfD based on the Ambrose et al. (1976) study is considered to be protective of all endpoints with the possible exception of hypersensitive individuals as described below.

In addition to the 2-year feeding study used as the basis for the RfD, Ambrose et al. (1976) also reported reproductive toxicity of **nickel**. The study had some statistical design limitations including small sample size and use of pups rather than litters as the unit for comparison. Furthermore, the results were

equivocal and did not clearly define a NOAEL or LOAEL. Because **nickel** was administered in a laboratory chow diet rather than drinking water, quantifying analogous **nickel** exposure via drinking water was problematic.

In a 2-generation study (RTI, 1987) **nickel** chloride was administered in drinking water to male and female CD rats (30/sex/dose) at dose levels of 0, 50, 250 and 500 ppm (0, 7.3, 30.8 and 51.6 mg/kg/day, estimated) for 90 days before breeding (10 rats/sex/group comprised a satellite subchronic nonbreeder group). At the 500 ppm dose level there was a significant decrease in the Po maternal body weight, along with absolute and relative liver weights. Thus, 250 ppm (30.8 mg/kg/day) was a NOAEL for Po breeders. Histopathology was performed for liver, kidney, lungs, heart, pituitary, adrenals and reproductive organs to make this assessment. This NOAEL is higher than the NOAEL derived from the chronic Ambrose et al. (1976) and subchronic gavage (ABC, 1986) assays.

In the RTI (1987) F1a generation (postnatal days 1-4) at the 500 ppm dose level the number of live pups/litter was significantly decreased, pup mortality was significantly increased, and average pup body weight was significantly decreased in comparison with controls. Similar effects were seen with F1b litters of Po dams exposed to 500 ppm **nickel**. In the 50 and 250 ppm dose groups increased pup mortality and decreased live litter size was observed in the F1b litters. However, these effects seen with F1b litters are questionable because the room temperature tended to be 10 degrees F higher than normal at certain times (gestation-postnatal days) along with much lower levels of humidity. As evidenced in the literature, temperatures that are 10 degrees F above normal during fetal development cause adverse effects (Edwards, 1986). Therefore, the above results seen at 50 and 250 ppm cannot be considered to be genuine adverse effects.

F1b males and females of the RTI (1987) study were randomly mated on postnatal day 70 and their offspring (F2a and F2b) were evaluated through postnatal day 21. This phase included teratological evaluations of F2b fetuses. Evaluation of the data indicated that the 500 ppm dose caused significant body weight depression of both mothers and pups, and increased neonatal mortality during the postnatal development period. The intermediate dose, 250 ppm **nickel**, produced transient depression of maternal weight gain and water intake during gestation of the F2b litters. The 50 ppm **nickel** exposure caused a significant increase in short ribs (11%). However, since this effect was not seen in both the higher dose groups, the reported incidence of short ribs in the 50 ppm group is not considered to be biologically significant.

Schroeder and Mitchener (1971) conducted a 3-generation study in which 5 mating pairs of rats were provided drinking water containing 5 mg Ni/L (estimated as 0.43 mg/kg bw). Results of this study indicated significant increases in neonatal mortality and in the number of runts born to exposed rats compared with controls. The major weakness of this study, however, is that the end result is based on a total of five matings. The matings were not randomized and the males were not rotated. The Schroeder and Mitchener (1971) study was conducted in an environmentally controlled facility where rats had access to food and water containing minimal levels of essential trace metals. Because of the interactions of **nickel** with other trace metals, the restricted exposure to trace metals (chromium was estimated as inadequate) may have contributed to the toxicity of **nickel**.

Smith et al. (1990) also studied the reproductive and fetotoxic effects of **nickel**. Four groups of 34 female Long-Evans rats were given drinking water containing **nickel** chloride in the following concentrations of **nickel**: 0, 10, 50 or 250 ppm (0, 1.3, 6.8 or 31.6 mg/kg/day) for 11 weeks prior to mating and during two successive gestation periods (G1, G2) and lactation periods (L1, L2). Maternal body weight gain was reduced during G1 in mid- and high-dose females. The reproductive performance

of the exposed rats was not affected. Pup birth weight was unaltered by treatment, and weight gain was reduced only in male pups exposed to 50 ppm **nickel** during L1. The most significant toxicological finding was the increased incidence of perinatal mortality. The proportion of dead pups per litter was elevated at the high dose in L1 and at 10 and 250 ppm in L2. While the perinatal mortality reported in this study is consistent with other reproductive studies on **nickel**, it is hard to define a NOAEL and LOAEL because of the absence of a clear dose-response trend at the lower doses.

Many studies have been published regarding **nickel** sensitivity in humans. Of the general population, approximately 8-10% of women and 1-2% of men demonstrate a sensitivity to **nickel** as determined by a patch test (North American Contact Dermatitis Group, 1973; Prystowsky et al., 1979). Initial sensitization to **nickel** is believed to result from dermal contact, but recurring flares of eczema, particularly of the hands, may be triggered by ingestion.

The human studies described below are difficult to interpret for several reasons: very small numbers of subjects (mostly women already determined to be sensitive to **nickel** by a patch test) were used in the studies; many investigators reported a placebo effect; many studies were not conducted in a double-blind manner, thereby introducing investigator bias; and it was often not specified whether subjects had been fasted overnight or whether there were other dietary restrictions. It is important to note that the way in which **nickel** is consumed may greatly affect its bioavailability. Sunderman et al. (1989) demonstrated that 27+/-17% of the **nickel** in drinking water was absorbed by healthy humans whereas only 0.7+/-0.4% of the same dose of **nickel** ingested in food was absorbed (a 40-fold difference). One final point to bear in mind in interpreting these studies is that the subjects were generally given a bolus dose of **nickel**. The absorption and biokinetics following such an exposure may be quite different from an exposure which is given incrementally throughout the day.

Following an overnight fast, groups of 5 **nickel**-sensitive women were given 100 mL of water along with one oral dose of **nickel** sulfate containing 0.6, 1.25 or 2.5 mg **nickel** (Cronin et al., 1980). The clinical response was observed for the next 24 hours. Worsening of hand eczema was reported in 2/5 female subjects that received 0.6 mg, 3/5 at 1.25 mg and 5/5 at 2.5 mg. Erythema was observed in 1/5 (0.6 mg), 4/5 (1.25 mg) and 4/5 (2.5 mg) women. While there appears to be a good dose-response relationship, this study did not report controls. The response observed at the lowest dose may well be within background levels.

Numerous other studies have been conducted to attempt to establish the relationships between **nickel** exposure and dermal irritation. Kaaber et al. (1978, 1979) reported worsening of eczema following an oral challenge with 2.5 mg **nickel**. In the 1978 study, 17/28 subjects experienced aggravation of dermatitis following **nickel** ingestion. Nine of the 17 that experienced adverse effects from the **nickel** found that their condition improved when they adopted a low **nickel** diet. In the 1979 study 9/14 subjects responded negatively to **nickel** treatment.

Studies conducted by Gawrodger et al. (1986), Burrows et al. (1981) and Jordan and King (1979) offer different results. Jordan and King's double blind, placebo controlled investigation suggested that 0.5 mg supplement to a normal diet was safe with the possible exception of extremely sensitive individuals. Gawrodger et al. (1986) reported that 5/10 women responded to both the 0.4 and 2.5 mg doses of **nickel**, but 10/26 also reacted to a placebo. They determined the LOAEL of their experiment to be 5.6 mg of **nickel**, a dose at which 100% of the women responded. Burrows et al. (1981) administered 0.5 mg **nickel** twice a day on two consecutive days to 22 patients, each of whom served as her own control. There was no significant difference between the number of individuals responding to a placebo as compared to **nickel**. However, the placebo response was high (12/22). The authors concluded that there

is probably no connection between **nickel** in an ordinary diet and exacerbation of dermatitis but that a higher level may aggravate dermatitis in some individuals.

Nielsen (1989) describes a study in which 12 **nickel**-sensitive women were challenged for a 4-day period with a diet providing 490 ug Ni/day. No changes were observed before the start of the **nickel** challenge to day 0 (start of challenge). On day 4, the eczema of 6 patients was considered to be worse according to both the patients' impressions and a dermatologist's evaluation. The delayed reaction in this study may be attributed to the fact that the dose of **nickel** was ingested in the diet throughout the day as opposed to studies which employed a bolus dose. This difference may greatly affect the pharmacokinetics of ingested **nickel**.

While the previous studies on humans with a hypersensitivity to **nickel** were considered in developing the RfD, none of them were adequate to serve as the basis for the quantitative risk assessment. The RfD is believed to be set at a level which would not cause individuals to become sensitized to **nickel**; however, those who have already developed a hypersensitivity (e.g., from a dermal exposure) may not be fully protected.

One final point to bear in mind in establishing an RfD for **nickel** is that **nickel** has been shown to be an essential trace element for several animal species. Rats deprived of **nickel** exhibit retarded growth and low hemoglobin levels (Schnegg and Kirchgessner, 1977). A requirement for **nickel** has not been conclusively demonstrated in humans, but **nickel** is considered to be a normal constituent of the diet. Typical daily intake of **nickel** ranges from 100-300 ug/day.

I.A.5. Confidence in the Oral RfD:

Study -- Low
Database -- Medium
RfD -- Medium

The chronic study (Ambrose et al., 1976) was properly designed and provided adequate toxicological endpoints; however, high mortality occurred in the controls (44/50). Therefore, a low confidence is recommended for the study. The data base provided adequate supporting subchronic studies, one by gavage and the other in drinking water (Po animals of the RTI subchronic study, 1986). A medium confidence level in the data base is recommended since there are inadequacies in the remaining reproduction data.

I.A.6. EPA Documentation and Review of the Oral RfD:

Source Document -- U.S. EPA, 1986, 1991

The information contained in the Quantification of Toxicologic Effects for **Nickel** was reviewed by the Science Advisory Board in August 1990.

Other EPA Documentation -- None

Agency Work Group Review -- 04/16/1987, 05/20/1987, 07/16/1987, 05/17/1990, 08/14/1991

Verification Date -- 07/16/1987

I.A.7. EPA Contacts (Oral RfD):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC):

Substance Name -- **Nickel**, soluble salts
CASRN -- Various

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure:

Substance Name -- **Nickel**, soluble salts
CASRN -- Various

The U.S. EPA has not evaluated soluble salts of **nickel**, as a class of compounds, for potential human carcinogenicity. However, **nickel** refinery dust and specific **nickel** compounds - **nickel** carbonyl and **nickel** subsulfide - have been evaluated. Summaries of these evaluations are on IRIS.

VI. Bibliography:

VI.A. Oral RfD References:

Ambrose, A.M., P.S. Larson, J.R. Borzelleca and G.R. Hennigar, Jr. 1976. Long-term toxicologic assessment of **nickel** in rats and dogs. J. Food Sci. Technol. 13: 181-187.

ABC (American Biogenics Corp.). 1986. Ninety-day gavage study in albino rats using **nickel**. Draft Final Report submitted to Research Triangle Institute, P.O. Box 12194, Research Triangle Park, NC 27709.

Burrows, D., S. Creswell and J.D. Merrett. 1981. **Nickel**, hands and hip prostheses. Br. J. Dermatol. 105: 437-444.

Cronin, E., A. Di Michiel and S.S. Brown. 1980. Oral **nickel** challenge in **nickel**-sensitive women with hand eczema. In: **Nickel** Toxicology, S.S. Brown and F.W. Sunderman Jr., Ed. Academic Press, New York. p. 149-152.

Edwards, M.J. 1986. Hyperthermia as a teratogen: A review of experimental studies and their clinical significance. Terat. Carcin. Mutagen. 6: 563-582.

Gawkrodger, D.J., S.W. Cook, G.S. Fell and J.A.A. Hunter. 1986. **Nickel** dermatitis: The reaction to oral **nickel** challenge. Br. J. Dermatol. 115: 33-38.

Jordan, W.P. and S.E. King. 1979. **Nickel** feeding in **nickel**-sensitive patients with hand eczema. J. Am. Acad. Dermatol. 1(6): 506-508.

Kaaber, K., N.K. Veien and J.C. Tjell. 1978. Low **nickel** diet in the treatment of patients with chronic **nickel** dermatitis. Br. J. Derm. 98: 197-201.

Kaaber, K., T. Menne, J.C. Tjell and N. Veien. 1979. Antabuse treatment of **nickel** dermatitis. Chelation - a new principle in the treatment of **nickel** dermatitis. Contact Derm. 5: 221-228.

Nielsen, G.D. 1989. Oral challenge of **nickel**-allergic patients with hand eczema. In: **Nickel** and Human Health: Current Perspectives. Advances in Environmental Science and Technology, E. Nieboer and A. Aitio, Ed. John Wiley and Sons, Inc., New York, NY. Chapter 16: 1.

North American Contact Dermatitis Group. 1973. Epidemiology of contact dermatitis in North America: 1972. Arch. Dermatol. 108: 537-540.

Prystowsky, S.D., A.M. Allen, R.W. Smith, J.H. Nonomura, R.B. Odom and W.A. Akers. 1979. Allergic contact hypersensitivity to **nickel**, neomycin, ethylenediamine and benzocaine. Relationships between age, sex, history, exposure and reactivity to standard patch tests and use tests in a general population. Arch. Dermatol. 115(8): 959-962.

RTI (Research Triangle Institute). 1987. Two generation reproduction and fertility study of **nickel** chloride administered to CD rats in drinking water: Fertility and reproductive performance of the Po generation (Part II of III) and F1 generation (Part III of III). Final study report. Report submitted to Office of Solid Waste Management, U.S. EPA, Washington, DC.

Schnegg, A. and M. Kirchgessner. 1977. Ni deficiency and its effect on metabolism. In: Trace Element Metabolism in Man and Animals, Vol. 3, M. Kirchgessner, Ed. Freising-Weihenstephan: Tech. Univ. Munich West Germany. p. 236-243.

Schroeder, H.A. and M. Mitchener. 1971. Toxic effects of trace elements on the reproduction of mice and rats. Arch. Environ. Health. 23: 102-106.

Schroeder, H.A., J.J. Balassa and I.H. Tipton. 1962. Abnormal trace elements in man - **nickel**. J. Chronic Dis. 15: 51.

Smith, M.K., J.A. George, H.F. Stober and G.L. Kimmel. 1990. Perinatal toxicity associated with **nickel** chloride exposure. Fund. Appl. Toxicol. Preliminary unpublished draft.

Sunderman Jr., F.W., S.M. Hopfer, K.R. Sweeney, A.H. Marcus, B.M. Most and J. Creason. 1989. **Nickel** absorption and kinetics in human volunteers. Proc. Soc. Exp. Biol. Med. 191: 5-11.

U.S. EPA. 1986. Health Assessment Document for **Nickel**. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, NC. (Final Report). EPA/600/8- 83/012FF.

U.S. EPA. 1991. Quantification of Toxicologic Effects for **Nickel**. Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Cincinnati, OH for the Office of Water, Office of Science and Technology, Washington, DC.

VI.B. Inhalation RfC References:

None

VI.C. Carcinogenicity Assessment References:

None

VII. Revision History:

Substance Name -- **Nickel**, soluble salts
CASRN -- Various

Date	Section	Description
03/01/1988	I.A.2.	Text clarified paragraph 1
12/01/1989	I.B.	Inhalation RfD now under review
04/01/1990	I.A.	ABC, 1986 corrected to U.S. EPA, 1986
04/01/1990	VI.	Bibliography on-line
06/01/1990	I.A.	Oral RfD summary noted as pending change
06/01/1990	IV.F.1.	EPA contact changed
09/01/1991	I.A.	Oral RfD no longer pending change; no changes made
12/01/1991	I.A.3.	Text revised; additional study added
12/01/1991	I.A.4.	Text significantly revised; additional studies added
12/01/1991	VI.A.	Oral RfD references revised to reflect new text
01/01/1992	I.A.4.	Citation year corrected for Schnegg and Kirchgessner
01/01/1992	IV.	Regulatory actions updated
01/01/1992	VI.A.	Citation year corrected for Schnegg and Kirchgessner
03/01/1994	II.	Carcinogenicity assessment now under review
08/01/1994	II.	Message added
08/01/1994	II.	Work group review date added
05/01/1995	All	CAS Registry Number changed to Various
08/01/1995	I.B., II.	EPA's RfD/RfC and CRAVE workgroups were discontinued in May, 1995. Chemical substance reviews that were not completed by September 1995 were taken out of IRIS review. The IRIS Pilot Program replaced the workgroup functions beginning in September, 1995.
12/01/1996	I.A.7.	Primary contact removed
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and

		Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
12/10/1998	I., II.	This chemical is being reassessed under the IRIS Program.

Nitrate

CASRN: 14797-55-8
For other data, click on the Table of Contents

Status:

STATUS OF DATA FOR **Nitrate**

File First On-Line 01/31/1987

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on-line	10/01/1991
Inhalation RfC Assessment (I.B.)	no data	
Carcinogenicity Assessment (II.)	no data	

Substance Identification:

Substance Name:

Nitrate

CAS Registry Number: 14797-55-8

I. Chronic Health Hazard Assessment for Noncarcinogenic Effects:

I.A. Reference Dose for Chronic Oral Exposure (RfD):

Substance Name -- **Nitrate**
CASRN --14797-55-8
Last Revised -- 10/01/1991

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.A.1. Oral RfD Summary:

Critical Effect	Experimental Doses*	UF	MF	RfD
Early clinical signs of methemoglobinemia in excess of 10% (0-3 months old infants formula) Human Epidemiological Surveys Bosch et al., 1950; Walton, 1951	NOAEL: 10 mg **nitrate**-nitrogen/L (1.6 mg/kg/day) LOAEL: 11-20 mg **nitrate**-nitrogen/L (1.8-3.2 mg/kg/day)	1	1	1.6E+0 mg/kg/day

*Conversion Factor: Expressed as the amount of nitrogen within the nitrite molecule commonly shown as mg **nitrate**-nitrogen/L (1 mg **nitrate**-nitrogen = 4.4 mg **nitrate**). Doses based on ingestion of drinking water used to prepare infants' formula: 0.64 L/day by a 4 kg infant (0.16 L/kg/day) (Davidson et al., 1975). 10 mg/L x 0.64 L/day divided by 4 kg = 1.6 mg/kg/day.

I.A.2. Principal and Supporting Studies (Oral RfD):

Bosch, H.M., A.B. Rosefield, R. Huston, H.R. Shipman and F.L. Woodward. 1950. Methemoglobinemia and Minnesota well supplies. J. Am. Water Works Assoc. 42: 161-170.

Walton, G. 1951. Survey of literature relating to infant methemoglobinemia due to **nitrate**-contaminated water. Am. J. Public Health. 41: 986-996.

Most cases of infant methemoglobinemia are associated with exposure to **nitrate** in drinking water used to prepare infants' formula at levels >20 mg/L of **nitrate**-nitrogen (Bosch et al., 1950; Walton, 1951; Sattelmacher, 1962; Simon et al., 1964; ECETOC, 1988). Cases reported at levels of 11-20 mg/L **nitrate**- nitrogen are usually associated with concomitant exposure to bacteriologically contaminated water or excess intake of **nitrate** from other sources.

Bosch et al. (1950) evaluated 139 cases of cyanosis due to methemoglobinemia reported by physicians in Minnesota. All of the cases were in young children (ages 8 days to 5 months), with 90% occurring in infants <2 months of age. A study of the **nitrate** concentration of the wells (a total of 129) used to supply water to the children with methemoglobinemia was performed. None of the wells contained <10 mg/L **nitrate**-nitrogen. Two wells (1.5%) contained 10- 20 mg/L, although the diagnosis of methemoglobinemia was considered questionable in both these cases. There were 25 wells (19%) that contained 21-50 mg/L, 53 (41%) that contained 51-100 mg/L, and 49 (38%) that contained >100 mg/L **nitrate**-nitrogen. Nearly all the wells were shallow with inadequate protection from surface contamination. Coliform organisms were detected in 45 of 51 samples (88%) tested for bacterial contamination.

Walton (1951) described a survey performed by the American Public Health Association to identify clinical cases of infantile methemoglobinemia that were associated with ingestion of **nitrate**-contaminated water. A total of 278 cases of methemoglobinemia were reported. Of 214 cases for which data were available on **nitrate** levels in water, none occurred in infants consuming water

containing <10 mg **nitrate**-nitrogen/L (1.6 mg **nitrate**-nitrogen/kg/day). There were 5 cases (2%) in infants exposed to 11-20 mg **nitrate**-nitrogen/L (1.8-3.2 mg/kg/day), 36 cases (17%) in infants exposed to 21-50 mg/L (3.4-8.0 mg/kg/day), and 173 (81%) in infants exposed to >50 mg/L (>8 mg/kg/day). Data on the ages of the infants were not provided.

Cornblath and Hartmann (1948) supplied **nitrate**-containing water to eight healthy infants (ages 2 days to 11 months) at doses of 50 or 100 mg NO3/kg/day (11 or 23 mg **nitrate**-nitrogen/kg/day). Assuming average consumption of about 0.16 L/kg/day, this corresponds to concentrations of 70 or 140 mg **nitrate**- nitrogen/L. No cyanosis was evident in any infant, and the highest concentration of methemoglobin was 7.5%. These authors also administered doses of 100 mg/kg of **nitrate** to four healthy infants (age 2 days to 6 months) and to two infants (age 6 and 7 weeks) who had been admitted to the hospital for cyanosis. No cyanosis was produced in the healthy infants, but cyanosis did occur in the individuals with a prior history of cyanosis. Examination of the saliva, gastric juice and stools of these infants revealed the presence of bacteria that readily reduced **nitrate** to nitrite. The gastric pH of these infants was >4 in both cases.

Donahoe (1949) reported five cases of moderate to severe cyanosis in infants (age 1-7 weeks) in South Dakota. In four of the five cases, the water used to feed the infants was from shallow wells and was shown to be heavily contaminated with bacteria. **Nitrate** levels were measured in two cases, with values of 50 and 177 mg/L (12 and 41 mg **nitrate**-nitrogen/L), respectively. This corresponds to doses of 8 and 28 mg **nitrate**-nitrogen/kg/day.

Simon et al. (1964) measured methemoglobin levels in 89 healthy infants who received **nitrate**-free water, 38 infants who received water containing 11-23 mg **nitrate**-nitrogen/L (1.8-3.7 mg **nitrate**-nitrogen/kg/day), and 25 infants receiving water containing >23 mg **nitrate**-nitrogen/L (>3.7 mg **nitrate**- nitrogen/kg/day). For infants age 1-3 months, mean methemoglobin levels in these three groups were 1.0, 1.3 and 2.9%, respectively. For infants age 3-6 months, values were 0.8, 0.8 and 0.7%, respectively. No clinical signs of methemoglobinemia were detected in any of the infants.

Toussaint and Selenka (1970) supplied 34 healthy infants (age 1-3 months) with formula prepared with water containing 150 mg **nitrate**/L (34.5 mg **nitrate**- nitrogen/L, corresponding to 5.5 mg **nitrate**-nitrogen/kg/day). Average methemoglobin levels rose from about 1% to about 2-3% within 1-2 days, and then tended to stay steady for up to 10 days. No clinical signs of methemoglobinemia were reported.

I.A.3. Uncertainty and Modifying Factors (Oral RfD):

UF -- An uncertainty factor of 1 was employed because available data define the no-observed-adverse-effect level for the critical toxic effect in the most sensitive human subpopulation.

MF -- None

I.A.4. Additional Studies/Comments (Oral RfD):

Nitrate toxicity is due primarily to its conversion to nitrite, which oxidizes the Fe(+2) form of iron in hemoglobin to the Fe(+3) state. This compound (methemoglobin) does not bind oxygen, resulting in reduced oxygen transport from lungs to tissues. Low levels of methemoglobin occur in normal

individuals, with typical values usually ranging from 0.5 to 2.0% (NAS, 1981). However, due to the large excess capacity of blood to carry oxygen, levels of methemoglobin up to around 10% are not associated with any significant clinical signs (Walton, 1951; ECETOC, 1988). Concentrations above 10% may cause a bluish color to skin and lips (cyanosis), while values above 25% lead to weakness, rapid pulse and tachypnea (Jones et al., 1973). Death may occur if methemoglobin values exceed 50-60%.

Conversion of **nitrate** to nitrite is mostly mediated by bacteria in the gastrointestinal system. Consequently, the risk of methemoglobinemia from ingestion of **nitrate** depends not only on the dose of **nitrate**, but also on the number and type of enteric bacteria. In healthy adults, available data suggest about 5% of a dose of **nitrate** is reduced to nitrite by bacteria in the mouth (NAS, 1981). Conversion of **nitrate** to nitrite may also occur in the stomach if the pH of the gastric fluid is sufficiently high (above pH 5) to permit bacterial growth. This is of concern in adults with diseases such as achlorhydria or atrophic gastritis. It is also of concern in infants, since the infant gastrointestinal system normally has a high pH that favors the growth of **nitrate**-reducing bacteria. For this reason, infants (especially age 0-3 months) are generally recognized as being the subpopulation most susceptible to **nitrate**-induced methemoglobinemia. Risk is especially high in infants who are exposed to water that is contaminated with bacteria, since this tends to promote high concentrations of bacteria in the stomach and intestines.

Nitrate is a normal component of the human diet. A typical daily intake by an adult in the United States is about 75 mg/day (about 0.2-0.3 mg **nitrate**- nitrogen/kg/day) (NAS, 1981). Of this, over 85% comes from the natural **nitrate** content of vegetables such as beets, celery, lettuce and spinach. Daily intakes of **nitrate** by vegetarians may exceed 250 mg/day (0.8 mg **nitrate**- nitrogen/kg/day) (NAS, 1981). The contribution from drinking water is usually quite small (about 2-3% of the total) (NAS 1981), but could reach 85 mg/day (0.29 mg **nitrate**-nitrogen/kg/day) if water containing 10 mg **nitrate**-nitrogen/L was consumed. Thus, some adults consuming high levels of vegetables along with water containing high levels of **nitrate** (up to 10 mg **nitrate**-nitrogen/L) could receive total doses of **nitrate** approaching the RfD of 1.6 mg **nitrate**- nitrogen/kg/day.

Two epidemiological studies have been performed on the adverse effects of **nitrate** exposure, but the results are internally inconsistent or inconclusive. Dorsch et al. (1984) found a statistically significant increase in risk of birth defects in children of women consuming groundwater (which contained 5-15 mg/L of **nitrate**) compared with women consuming rainwater (which contained <5 mg/L **nitrate**). These authors emphasized that their results are limited by a number of factors, and stated that "it would be premature to interpret our case-control findings exclusively in terms of water **nitrate** exposure." Arbuckle et al. (1988) reported nonstatistically significant increase in the odds ratio for birth defects in children of women exposed to well-water (26 mg/L **nitrate**, equivalent to 0.2 mg **nitrate**-nitrogen/kg/day) compared with rain water (0.1 mg/L **nitrate**, equivalent to 0.0008 mg **nitrate**-nitrogen/kg/day). However, decreased odds ratios (also not statistically significant) were noted for exposure to **nitrate** in spring water (17 mg/L, equivalent to 0.13 mg **nitrate**-nitrogen/kg/day) or public water (26 mg/L).

Craun et al. (1981) conducted an epidemiologic study of 102 children aged 1-8 years in Washington County, Illinois. Sixty-four children were selected from families consuming high-**nitrate** water (22-111 mg/L **nitrate**-nitrogen) and 38 children (controls) were from families consuming water containing <10 mg/L **nitrate**-nitrogen. Ingestion of high-**nitrate** water was not found to result in above-normal methemoglobin levels in exposed children. Assuming ingestion of 0.1 L/kg/day by older children, these concentrations correspond to doses of 2.2-11 mg **nitrate**-nitrogen/kg/day. This study indicates that older children are much less susceptible to **nitrate**-induced methemoglobinemia than are infants.

The Food and Drug Administration sponsored extensive tests of the reproductive and developmental effects of NaNO3 and KNO3 in mice, rats, hamsters and rabbits (FDA, 1972a,b). Groups of 20-26 mice, rats or hamsters and 10-13 rabbits were treated by gavage on days 6-15 (mice, rats), days 6-10 (hamster) or days 6-18 (rabbits) of gestation. Fetuses were delivered by Cesarean section and examined for visceral and skeletal malformations. Dose levels (expressed as mg **nitrate**-nitrogen) ranged from 0.6-66 mg/kg/day for mice, from 0.3-41 mg/kg/day for rats, from 0.4-66 mg/kg/day for hamsters and from 0.3-41 mg/kg/day for rabbits. No significant effects were detected regarding maternal reproductive parameters (percent pregnant, abortion frequency, number of litters), fetotoxicity (percent fetal resportions, live fetuses per dam, average fetal weight) or fetal malformations up to the maximum doses administered to each species. These studies identify a reproductive/developmental NOAEL of 66 mg **nitrate**-nitrogen/kg/day for mice and hamsters and 41 mg **nitrate**-nitrogen/kg/day for rats and rabbits.

Sleight and Atallah (1968) studied the effects of **nitrate** on reproduction and development in guinea pigs. Groups of 3-6 females were exposed to drinking water containing 0, 300, 2500, 10,000 or 30,000 ppm KNO3 for 143-204 days. This resulted in average doses of 0, 12, 102, 507 or 1130 mg **nitrate**-nitrogen/kg/day. Normal conception occurred at all dose levels. No significant effect on reproductive performance was detected except in the high-dose group, where there was a decrease in number of live births. The authors attributed the fetotoxic effects to hypoxia due to maternal methemoglobinemia, although data on this were not provided. No fetal malformations were observed at any dose. This study identifies a reproductive NOAEL of 507 and a LOAEL of 1130 mg **nitrate**-nitrogen/kg/day.

No multi-generation studies were located on the reproductive effects of **nitrate**. In the absence of such data, observations from animals exposed to nitrite may be used as a conservative estimate of **nitrate** toxicity.

Hugot et al. (1980) performed a three-generation study in rats. Female animals were administered sodium nitrite in the diet at doses of 90 or 160 mg nitrite-nitrogen/kg/day. There were no effects on a number of reproductive parameters. Some pups showed small decreases in birth weight and growth rate during lactation, and changes in organ weights at weaning. This study identifies a LOAEL of 90 mg nitrite-nitrogen/kg/day. Assuming that a maximum of 10% of a dose of **nitrate** is converted to nitrite by an adult human, this would correspond to a LOAEL of 900 mg **nitrate**-nitrogen/kg/day.

Druckrey et al. (1963) supplied rats with NaNO2 in drinking water for three generations at a dose level of 100 mg/kg/day (20 mg nitrite-nitrogen/kg/day). No teratogenic effects or adverse effects on reproduction were detected in any generation. Assuming that a maximum of 10% of a dose of **nitrate** is converted to nitrite by an adult human, this would correspond to a NOAEL of 200 mg **nitrate**-nitrogen/kg/day.

No studies were located on systemic effects of **nitrate** in humans or animals. In the absence of such data, observations from animals exposed to nitrite may be used as a conservative estimate of **nitrate** toxicity. Druckrey et al. (1963) exposed rats for their lifetime to NaNO2 in drinking water at a dose of 100 mg/kg/day (20 mg nitrite-nitrogen/kg/day). No treatment-related histologic or hematologic effects were noted except for elevated methemoglobin levels in the treated animals.

Til et al. (1988) supplied rats with drinking water containing up to 3000 mg/L of KNO2 (500 mg nitrite-nitrogen/L, equivalent to 50 mg nitrite- nitrogen/kg/day) for 13 weeks. No histological effects were detected except for a very slight to slight hypertrophy of the zona glomerulosa. This was probably due to reduced water intake, and is not judged to constitute an adverse health effect. This study identifies

a NOAEL of 17 and a LOAEL of 50 mg nitrite-nitrogen/kg/day (based on methemoglobin levels). Assuming that a maximum of 10% of a dose of **nitrate** is converted to nitrite by an adult human, this would correspond to a NOAEL of 170 and a LOAEL of 500 mg **nitrate**- nitrogen/kg/day.

Shuval and Gruener (1972) exposed rats for 24 months to water containing 0, 100, 1000, 2000 or 3000 ppm of sodium nitrite (0, 2, 20, 40 or 60 mg nitrite- nitrogen/kg/day). Histological examination of the lungs revealed dilated bronchi, fibrosis and emphysema at 1000 ppm or above. Histological examination of the heart revealed an increased percentage of coronary arteries that were characterized as "thin and dilated." This effect appears to be at least partly due to the absence of coronary artery thickening and narrowing that normally occurs in aged rats, so it is not certain that these changes are inherently adverse. Based on effects on the lung, this study identifies a NOAEL of 2 and a LOAEL of 20 mg nitrite-nitrogen/kg/day. Assuming that a maximum of 10% of a dose of **nitrate** is converted to nitrite by an adult human, this would correspond to a NOAEL of 20 and a LOAEL of 200 mg **nitrate**-nitrogen/kg/day.

I.A.5. Confidence in the Oral RfD:

Study -- High
Database -- High
RfD -- High

The studies of Bosch et al. (1950) and Walton (1951) provide convincing evidence that infantile methemoglobinemia does not occur at drinking water levels of 10 mg **nitrate**-nitrogen/L or less. This is supported by a large number of additional epidemiological and case studies in humans (e.g., Cornblath and Hartmann, 1948; Simon et al., 1964; Toussaint and Selenka, 1970; Craun et al., 1981; see U.S. EPA, 1990 for descriptions of additional studies).

I.A.6. EPA Documentation and Review of the Oral RfD:

Source Document -- This assessment is not presented in any existing U.S. EPA document.

Other EPA Documentation -- U.S. EPA, 1990

Agency Work Group Review -- 11/21/1985, 02/05/1986, 02/26/1986, 06/20/1990, 07/25/1990, 08/22/1990

Verification Date -- 08/22/1990

Screening-Level Literature Review Findings -- A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the RfD for **Nitrate** conducted in September 2002 identified one or more significant new studies. IRIS users may request the references for those studies from the IRIS Hotline at hotline.iris@epa.gov or 301-345-2870.

I.A.7. EPA Contacts (Oral RfD):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at

(301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC):

Substance Name -- **Nitrate**
CASRN --14797-55-8

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure:

Substance Name -- **Nitrate**
CASRN --14797-55-8

Not available at this time.

VI. Bibliography:

VI.A. Oral RfD References:

Arbuckle, T.E., G.J. Sherman, P.N. Corey, D. Walters and B. Lo. 1988. Water **nitrates** and CNS birth defects: A population-based case-control study. Arch. Environ. Health. 43(2): 162-167.

Bosch, H.M., A.B. Rosefield, R. Huston, H.R. Shipman and F.L. Woodward. 1950. Methemoglobinemia and Minnesota well supplies. J. Am. Water Works Assoc. 42: 161-170.

Cornblath, M. and A.F. Hartmann. 1948. Methemoglobinemia in young infants. J. Pediatr. 33: 421-425.

Craun, G.F., D.G. Greathouse and D.H. Gunderson. 1981. Methaemoglobin levels in young children consuming high **nitrate** well water in the United States. Int. J. Epidemiol. 10(4): 309-317.

Davidson, S., R. Passmore, J.F. Brock and A.S. Truswell. 1975. Human Nutrition and Dietetics, 6th ed. Churchill Livingstone, New York. p. 644- 645.

Donahoe, W.E. 1949. Cyanosis in infants with **nitrates** in drinking water as cause. Pediatrics. 3: 308-311.

Dorsch, M.M., R.K.R. Scragg, A.J. McMichael, P.A. Baghurst and K.F. Dyer. 1984. Congenital malformations and maternal drinking water supply in rural South Australia: A case-control study. J. Epidemiol. 119(4): 473-486.

Druckrey, H., D. Steinhoff, H. Beuthner, H. Schneider and P. Klarner. 1963. Screening of nitrite for chronic toxicity in rats. Arzneim. Forsch. 13: 320- 323. (Ger. with Eng. summary)

ECETOC (European Chemical Industry Ecology and Toxicology Center). 1988. **Nitrate** and drinking

water. Technical Report No. 27, **Nitrate** and Drinking Water. Brussels, Belgium.

FDA (Food and Drug Administration). 1972a. Teratologic evaluation of FDA 71- 7 (sodium **nitrate**). Food and Drug Administration, Washington, DC. PB 221775.

FDA (Food and Drug Administration). 1972b. Teratologic evaluation of FDA 71-8 (potassium **nitrate**). Food and Drug Administration, Washington, DC. PB 221774.

Hugot, D., J. Causeret and C. Richir. 1980. The influence of large amounts of sodium nitrite on the reproductive performances in female rats. Ann. Nutr. Alim. 34: 1115-1124.

Jones, J.H., H.T. Sethney, G.W. Schoenhals, R.N. Grantham and H.D. Riley, Jr. 1973. Grandmother's poisoned well: Report of a case of methemoglobinemia in an infant in Oklahoma. Okla. State Med. Assoc. J. 66: 60-66.

NAS (National Academy of Sciences). 1981. The health effects of **nitrate**, nitrite and N-nitroso compounds. National Academy Press, Washington, DC.

Sattelmacher, P.G. 1962. Methamoglobinamie durch **Nitrate** im Trinkwasser. Schriftenreie Verein Wasser Boden Lufthyg. Berlin-Dahlem, no. 20. Gustav Fischer Verlag, Stuttgart. (Ger.)

Shuval, H.I. and N. Gruener. 1972. Epidemiological and toxicological aspects of **nitrates** and nitrites in the environment. Am. J. Public Health. 62(8): 1045-1052.

Simon, C., H. Manzke, H. Kay and G. Mrowetz. 1964. Occurrence, pathogenesis, and possible prophylaxis of nitrite induced methemoglobinemia. Zeitschr. Kinderheilk. 91: 124-138. (Ger.)

Sleight, S.D. and O.A. Atallah. 1968. Reproduction in the guinea pig as affected by chronic administration of potassium **nitrate** and potassium nitrite. Toxicol. Appl. Pharmacol. 12: 179-185.

Til, H.P., H.E. Falke, C.F. Kuper and M.I. Willems. 1988. Evaluation of the oral toxicity of potassium nitrite in a 13-week drinking-water study in rats. Food Chem. Toxicol. 26(10): 851-859.

Toussaint, W. and F. Selenka. 1970. Methemoglobin formation in infants. A contribution to drinking water hygiene in Rhine-Hesse. Mschr. Kinderheilk. June: 282-284.

U.S. EPA. 1990. Criteria Document for **Nitrate**/Nitrite. Office of Drinking Water, Washington, DC.

Walton, G. 1951. Survey of literature relating to infant methemoglobinemia due to **nitrate**-contaminated water. Am. J. Public Health. 41: 986-996.

VI.B. Inhalation RfC References:

None

VI.C. Carcinogenicity Assessment References:

None

VII. Revision History:

Substance Name -- **Nitrate**
CASRN --14797-55-8

Date	Section	Description
03/31/1987	I.A.6.	Documentation corrected
09/30/1987	IV.	Regulatory Action section on-line
03/01/1988	III.A.	Health Advisory added
07/01/1990	I.A.	Oral RfD summary noted as pending change
09/01/1990	I.A.	Withdrawn; new Oral RfD verified (in preparation)
05/01/1991	I.A.	Oral RfD summary replaced (RfD changed)
05/01/1991	VI.	Bibliography on-line
06/01/1991	III.A.	Health Advisory noted as being revised
10/01/1991	I.A.	Uncertainty factor text clarified
01/01/1992	IV.	Regulatory actions updated
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
12/03/2002	I.A.6.	Screening-Level Literature Review Findings message has been added.

Nitrite

CASRN: 14797-65-0
For other data, click on the Table of Contents

Status:

STATUS OF DATA FOR **Nitrite**

File First On-Line 01/31/1987

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on-line	09/01/1997
Inhalation RfC Assessment (I.B.)	no data	
Carcinogenicity Assessment (II.)	no data	

Substance Identification:

Substance Name:

Nitrite

CAS Registry Number: 14797-65-0

I. Chronic Health Hazard Assessment for Noncarcinogenic Effects:

I.A. Reference Dose for Chronic Oral Exposure (RfD):

Substance Name -- **Nitrite**
CASRN -- 14797-65-0
Last Revised -- 09/01/1997

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

NOTE: The oral RfD for **nitrite** may change in the near future pending the outcome of a further review now being conducted by the RfD/RfC Work Group.

I.A.1. Oral RfD Summary:

Critical Effect	Experimental Doses*	UF	MF	RfD
Methemoglobinemia Infant Chronic Exposure to Drinking Water Walton, 1951	NOEL: 10 ppm of drinking water or 10 mg/L converted to 1.0 mg/kg/day LOAEL: 11-20 ppm	1	10	1E-1 mg/kg/day

*Conversion Factor: 1 L drinking water/day 10 kg child; thus, 10 mg/L x 1 L/day / 10 kg = 1.0 mg/kg/day

I.A.2. Principal and Supporting Studies (Oral RfD):

Walton, G. 1951. Survey of literature relating to infant methemoglobinemia due to nitrate-contaminated water. Am. J. Public Health. 41: 986-996.

This is an epidemiologic study on the incidence of methemoglobinemia in infants routinely fed formula prepared from nitrate-contaminated water. This study analyzed all known cases of infant methemoglobinemia occurring in 37 U.S. states irrespective of date or type of water supply. Nitrate (nitrogen) content ranged from 10 ppm to over 100 ppm. No incidences of methemoglobinemia were found to occur in drinking water containing less than or equal to 10 ppm (10 mg/L) nitrate (nitrogen). A NOEL of 10 mg/L was derived from these studies.

Exposure of hemoglobin to **nitrite** results in the oxidation of the hemoglobin to methemoglobin. Animals do not provide a good model for methemoglobin formation because many species lack nitrate-reducing bacteria. Infants are, however, particularly susceptible due to their high gut content of nitrate- reducing bacteria, their lower enzymatic capacity to reduce methemoglobin to hemoglobin, and to the the presence of hemoglobin F, which is more susceptible to oxidation.

Several more recent studies support Walton's (1951) 10 mg/L NOAEL for infant methemoglobinemia (NAS, 1977; Winton, 1971; Calabrese, 1978).

Using the NOAEL from the Walton study and a modifying factor of 10, the RfD for **nitrite** was calculated (U.S. EPA, 1985) for a 10-kg child drinking 1 L of water/day as 0.1 mg/kg/day or 1 mg/day.

I.A.3. Uncertainty and Modifying Factors (Oral RfD):

UF -- No uncertainty factor was used in the derivation of the RfD because the NOEL was of the critical toxic effect (i.e., methemoglobinemia) in the sensitive human population (i.e., infants). The length of exposure encompassed both the critical effect and the sensitive population.

MF -- A modifying factor of 10 was applied because of the direct toxicity of **nitrite**.

I.A.4. Additional Studies/Comments (Oral RfD):

An RfD of 0.2 mg/kg/day could be calculated from the Walton (1951) study using the body weight of 4 kg and fluid consumption of 0.64 L/day for infants. The lower value of 0.1 mg/kg/day is maintained, however, because of the uncertainties in the changing fluid consumption and body weight as a neonate (4 kg) ages to a 2-year-old child (10 kg). While there are some data to the contrary, it is most likely that older children do not respond with increased methemoglobin to nitrate in drinking water. For example, Craun et al. (1981) reported that 64 children aged 1-8, consuming water with nitrate nitrogen concentrations of 22 to 111 mg/L, had an average methemoglobin concentration of 1.13%. This is not considered to be elevated and was in fact no different from the level (0.98%) observed in 38 children who drank water contaminated with less than 10 mg nitrate/L.

I.A.5. Confidence in the Oral RfD:

Study -- High
Database -- High
RfD -- High

Confidence in the study is high because the NOEL is determined in the known sensitive human population. The data base contains several recent supporting epidemiologic studies for the critical effect in the sensitive population (infants); therefore, a high confidence rating is given to the data base. High confidence in the RfD follows.

I.A.6. EPA Documentation and Review of the Oral RfD:

Source Document -- This assessment is not presented in any existing U.S. EPA document.

Other EPA Documentation -- U.S. EPA, 1985

Agency Work Group Review -- 11/21/1985, 02/05/1986, 02/26/1986, 06/24/1992

Verification Date -- 02/26/1986

Screening-Level Literature Review Findings -- A screening-level review conducted by an EPA contractor of the more recent toxicology literature pertinent to the RfD for **Nitrite** conducted in September 2002 did not identify any critical new studies. IRIS users who know of important new studies may provide that information to the IRIS Hotline at hotline.iris@epa.gov or 301-345-2870.

I.A.7. EPA Contacts (Oral RfD):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC):

Substance Name -- **Nitrite**

CASRN -- 14797-65-0

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure:

Substance Name -- **Nitrite**
CASRN -- 14797-65-0

Not available at this time.

VI. Bibliography:

VI.A. Oral RfD References:

Calabrese, E.J. 1978. Drinking Water Standards. In: Methodological Approaches to Deriving Environmental and Occupational Health Standards. John Wiley and Sons, Inc., New York, NY. p. 165-169.

Craun, G.F., D.G. Greathouse and D.H. Gunderson. 1981. Methemoglobin levels in young children consuming high nitrate well water in the United States. Int. J. Epidemiol. 10: 309-317.

NAS (National Academy of Sciences). 1977. Drinking Water and Health. Washington, DC.

U.S. EPA. 1985. Drinking Water Criteria Document for Nitrates/Nitrites. Office of Drinking Water, Washington, DC.

Walton, G. 1951. Survey of literature relating to infant methemoglobinemia due to nitrate-contaminated water. Am. J. Public Health. 41: 986-996.

Winton, E.F., R.G. Tardiff and L.J. McCabe. 1971. Nitrate in drinking water. J. Am. Water Works Assoc. 63: 95-98.

VI.B. Inhalation RfC References:

None

VI.C. Carcinogenicity Assessment References:

None

VII. Revision History:

Substance Name -- **Nitrite**

CASRN -- 14797-65-0

Date	Section	Description
03/31/1987	I.A.6.	Documentation corrected
09/30/1987	IV.	Regulatory Action section on-line
03/01/1988	I.A.2.	Text added
03/01/1988	III.A.	Health Advisory added
08/01/1991	I.A.	Oral RfD summary noted as pending change
08/01/1991	VI.	Bibliography on-line
01/01/1992	IV.	Regulatory actions updated
08/01/1992	I.A.6.	Work group review date added
08/01/1995	I.A., I.A.6.	EPA's RfD/RfC and CRAVE workgroups were discontinued in May, 1995. Chemical substance reviews that were not completed by September 1995 were taken out of IRIS review. The IRIS Pilot Program replaced the workgroup functions beginning in September, 1995.
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
09/01/1997	I.A.2.	Concentration corrected to "less than or equal to"
12/03/2002	I.A.6.	Screening-Level Literature Review Findings message has been added.

TETRACHLOROETHYLENE

CASRN: 127-18-4

For other data, click on the Table of Contents

Human Health Effects:

Evidence for Carcinogenicity:

Evaluation: There is limited evidence in humans for the carcinogenicity of **tetrachloroethylene**. There is sufficient evidence in experimental animals for the carcinogenicity of **tetrachloroethylene**. Overall evaluation: **Tetrachloroethylene** is probably carcinogenic to humans (Group 2A). In making the overall evaluation, the working group considered the following evidence: (1) Although **tetrachloroethylene** is known to induce peroxisome proliferation in mouse liver, a poor quantitative correlation was seen between peroxisome proliferation and tumor formation in the liver after administration of **tetrachloroethylene** by inhalation. The spectrum of mutations in proto-oncogenes in liver tumors from mice treated with **tetrachloroethylene** is different from that in liver tumors from mice treated with trichloroethylene. (2) The cmpd induced leukemia in rats. (3) Several epidemiological studies showed elevated risks for esophageal cancer, non-Hodgkin's lymphoma and cervical cancer.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 63 204 (1995)]**PEER REVIEWED**

A3. A3= Animal carcinogen.
[American Conference of Governmental Industrial Hygienists. Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs) for 1995-1996. Cincinnati, OH: ACGIH, 1995.28]**PEER REVIEWED**

Human Toxicity Excerpts:

... acute hepatic necrosis and oliguric uremia have followed human exposure.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-165]**PEER REVIEWED**

/CNS depressant/ ... in high concentrations. Defatting action on skin can lead to dermatitis.
[The Merck Index. 10th ed. Rahway, New Jersey: Merck Co., Inc., 1983. 1315]**PEER REVIEWED**

Excessive exposure ... has resulted in effects on the central nervous system, mucous membranes, eyes, & skin, & to a lesser extent the lungs, liver, kidneys. The effects most frequently noted have been on the nervous system. Unconsciousness, dizziness, headache, vertigo or light ... /CNS depression/ have occurred in many instances after occupational exposures.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.464]**PEER REVIEWED**

Perchloroethylene has been reported to produce effects on the liver in humans. The concn ... generally appeared to be in excess of 100 ppm.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values, 4th ed., 1980. Cincinnati, Ohio: American Conference of Governmmental Industrial Hygienists, Inc., 1980.325]**PEER REVIEWED**

Several studies of the effects of prolonged exposure to **perchloroethylene** vapors on human volunteers are avail. ... Prolonged exposure to 200 ppm results in early signs of CNS depression, while there was no

response in men or women repeatedly exposed to 100 ppm for 7 hr/day. Clinical chemical studies indicate no liver or kidney effects at these levels but massive exposure to concentrations causing unconsciousness have resulted in proteinuria & hematuria.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.464]**PEER REVIEWED**

A CASE OF CNS DEPRESSION & 2 CASES OF ACUTE OLIGURIC UREMIA AFTER INHALATION OF **PERCHLORETHYLENE** VAPORS FROM NEWLY CLEANED CLOTHES IN A SELF-SERVICE DRY-CLEANING MACHINE ARE REPORTED.
[LARSEN NA ET AL; UGESKR LAEG 139 (5): 270-5 (1977)]**PEER REVIEWED**

A PT IS REPORTED WHO HAD A CONNECTIVE TISSUE TYPE OF DISEASE CLINICALLY SIMILAR TO VINYL CHLORIDE DISEASE, POSSIBLY CAUSED BY ABNORMAL SENSITIVITY TO **PERCHLORETHYLENE** TO WHICH HE WAS EXPOSED IN HIS OCCUPATION.
[SPARROW GP; CLIN EXP DERMATOL 2 (1): 17-22 (1977)]**PEER REVIEWED**

CHANGES IN NEUROLOGICAL NATURE OF WORKERS EXPOSED TO **TETRACHLOROETHYLENE** AT GREATER THAN MAC (MAXIMUM PERMISSIBLE CONCENTRATION) WERE RELATED TO DEFECTIVE ACTION OF LIVER & SUPRARENAL GLAND CORTEX. INCR IN AMINOTRANSFERASE IN BLOOD SERUM & SLIGHT SHIFTS IN PROTEINOGRAMS OBSERVED.
[CHMIELEWSKI J ET AL; BULL INST MARIT TROP MED GDYNIA 27 (2): 197-205 (1976)]**PEER REVIEWED**

SIX WK OLD BREAST-FED INFANT HAD OBSTRUCTIVE JAUNDICE & HEPATOMEGALY. **TETRACHLOROETHYLENE** WAS DETECTED IN MILK & BLOOD. AFTER DISCONTINUANCE OF BREAST-FEEDING RAPID CLINICAL & BIOCHEM IMPROVEMENT WERE NOTED.
[BAGNELL PC, ELLENBERGER HA; CAN MED ASSOC J 117 (9): 1047-8 (1977)]**PEER REVIEWED**

LYMPHOCYTES FROM 10 FACTORY WORKERS EXPOSED TO **TETRACHLOROETHYLENE** FOR 3 MO TO 18 YR SHOWED NO SIGNIFICANT DOSE-RELATED CHANGES IN CHROMOSOME ABERRATIONS, SISTER CHROMATID EXCHANGE RATE, PROPORTION OF M2+M3 METAPHASES OR MITOTIC INDEX, COMPARED WITH CONTROLS.
[IKEDA M ET AL; TOXICOLOGY LETTERS 5: 251 (1980)]**PEER REVIEWED**

A new form of substance abuse in adolescents is the inhalation of fumes from typewriter correction fluids (Liquid Paper, Wite-Out, Snopake, etc), which are composed of various chlorinated solvents, /including **tetrachloroethylene**/, to induce euphoria. Medical complications of such abuse and medical management of acute toxic episodes are discussed herein, along with suggestions for controlling this substance abuse.
[Greer JE; South Med J 77 (3): 297-8 (1984)]**PEER REVIEWED**

After ingestion of 12-16 g **tetrachloroethylene**, a 6 year old boy was admitted to the clinic in coma. In view of the high initial **tetrachloroethylene** blood level, hyperventilation therapy was performed. Under this therapeutic regimen, the clinical condition of the patient improved considerably. The **tetrachloroethylene** blood level profile which was determined under hyperventilation therapy could be computer fitted to a two compartment model. Elimination of **tetrachloroethylene** from the blood compartment occurred via a rapid and a slow process with half-lives of 30 min and 35 hours, respectively. These values compared favorably with the half-lives of 160 min and 33 hours under normal respiratory conditions. During hyperventilation therapy, the relative contribution to the fast elimination

process increased from 70% for physiological minute volume to 99.9%. A minor fraction of the ingested dose was excreted with the urine (integral of 1% during the first 3 days). In contrast to previous results, trace amounts of unchanged **tetrachloroethylene** were detected in the urine besides trichloroacetic acid and trichloroethanol.
[K'oppel C et al; J Toxicol Clin Toxicol 23 (2-3): 103-15 (1985)]**PEER REVIEWED**

Pulmonary edema occurred in a laundry worker who was found unconscious after exposure to **tetrachloroethylene** vapor. ... Multiple premature ventricular contractions in otherwise healthy workers have been reported in occupational **tetrachloroethylene** exposures, but no direct link with sudden death has been made. Chronic exposure has not produced cardiovascular toxicity.
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988.,p. 986-7]**PEER REVIEWED**

A 68 year old launderette worker was anesthetised & suffered erythema & 30% superficial burns after spilling a container of **tetrachloroethylene** over his clothes. The defatting property of **tetrachloroethylene** would lead to cracking of damaged skin.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 107]**PEER REVIEWED**

A 21 year old man who had been exposed to fumes of **tetrachloroethylene** developed acute pulmonary edema & became comatose. He received isoprenaline 800 ug in 1 l of dextrose injection iv, furosemide 40 mg, aminophylline 250 mg, & dexamethasone 10 mg iv. Oxygen was admin. After 6 hr, improvement was noted. No evidence of liver or kidney damage was seen.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 107]**PEER REVIEWED**

... Residual organ damage is not commonly observed in humans who have been exposed to large quantities of the compound. **Tetrachloroethylene** was formerly used widely as an intestinal anthelminthic. ... Oral doses of 2.8 to 4.0 ml given for this purpose were quite effective & safe. Inebriation was the only troublesome side effect that was noted in 46,000 treated patients. Inhalation of **tetrachloroethylene** sufficient to produce inebriation & unconsciousness has failed to elicit hepatic, renal, or hematological abnormalities in some individuals. However, in other cases, mild to severe hepatotoxicity has been diagnosed. In most such instances, liver injury was not manifest until several days after exposure. Recovery was uneventful, but sometimes prolonged, particularly in the more severe cases. **Tetrachloroethylene** was quite slowly eliminated, in that approx 1 ppm **tetrachloroethylene** was measured in the breath of victims as long as 11 to 12 days after exposure. Little evidence of kidney injury or damage of any other organ was noted in any of the aforementioned cases. ...
[National Research Council. Drinking Water and Health. Volume 3. Washington, DC: National Academy Press, 1980. 136]**PEER REVIEWED**

Acute exposure to **tetrachloroethylene** by inhalation results in central nervous system depression. Liver & kidney toxicity have been reported as effects of acute exposures to very high doses. In dry cleaners chronically exposed to **tetrachloroethylene**, incr levels of markers of early renal damage &/or dysfunction were attributed to the exposure.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 191 (1995)]**PEER REVIEWED**

To evaluate the risk of cancer & other diseases among workers engaged in aircraft manufacturing & potentially exposed to cmpds containing chromate, trichloroethylene (TCE), **perchloroethylene** (**PCE**), & mixed solvents. A retrospective cohort mortality study was conducted of workers employed for at least 1 year at a large aircraft manufacturing facility in California on or after 1 January 1960. The mortality experience of these workers was determined by exam of national, state, & company records to

the end of 1996. Standardised mortality ratios (SMRs) were evaluated comparing the observed numbers of deaths among workers with those expected in the general population adjusting for age, sex, race, & calendar year. The SMRs for 40 cause of death categories were computed for the total cohort & for subgroups defined by sex, race, position in the factory, work duration, yr of first employment, latency, and broad occupational groups. Factory job titles were classified as to likely use of chemicals, & internal Poisson regression analyses were used to compute mortality risk ratios for categories of yr of exposure to chromate, TCE, **PCE**, & mixed solvents, with unexposed factory workers serving as referents. RESULTS: The study cohort comprised 77,965 workers who accrued nearly 1.9 million person-years of follow up (mean 24.2 yr). Mortality follow up, estimated as 99% complete, showed that 20,236 workers had died by 31 December 1996, with cause of death obtained for 98%. Workers experienced low overall mortality (all causes of death SMR 0.83) & low cancer mortality (SMR 0.90). No significant increases in risk were found for any of the 40 specific cause of death categories, whereas for several causes the numbers of deaths were significantly below expectation. Analyses by occupational group & specific job titles showed no remarkable mortality patterns. Factory workers estimated to have been routinely exposed to chromate were not at increased risk of total cancer (SMR 0.93) or of lung cancer (SMR 1.02). Workers routinely exposed to TCE, **PCE**, or a mixture of solvents also were not at increased risk of total cancer (SMRs 0.86, 1.07, & 0.89, respectively), & the numbers of deaths for specific cancer sites were close to expected values. Slight to moderately increased rates of non-Hodgkin's lymphoma were found among workers exposed to TCE or **PCE**, but none was significant. A significant incr in testicular cancer was found among those with exposure to mixed solvents, but the excess was based on only six deaths & could not be linked to any particular solvent or job activity. Internal cohort analyses showed no significant trends of increased risk for any cancer with increasing years of exposure to chromate or solvents. The results from this large scale cohort study of workers followed up for over 3 decades provide no clear evidence that occupational exposures at the aircraft manufacturing factory resulted in increases in the risk of death from cancer or other diseases. Our findings support previous studies of aircraft workers in which cancer risks were generally at or below expected levels.
[Boice JD Jr et al; Occup Environ Med 56 (9): 581-597 (1999)]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Eye exposure can lead to conjunctivitis; Skin exposure can lead to inflamation; Inhalation can lead to respiratory tract irritation.
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 507]**PEER REVIEWED**

Tetrachloroethylene vapor is a mucous membrane & upper resp irritant at levels above 75 to 100 ppm.
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 986]**PEER REVIEWED**

Drug Warnings:

VET: AT ONE TIME IT WAS USED FAIRLY EXTENSIVELY AGAINST GI PARASITES OF RUMINANTS. ITS DISADVANTAGE IN RUMINANTS IS NECESSITY OF STIMULATING CLOSURE OF ESOPHAGEAL GROOVE SO THAT MEDICATION IS DELIVERED DIRECTLY TO ABOMASUM RATHER THAN PASSING INTO RUMEN WHICH ... REDUCES EFFECTIVENESS OF DRUG. ... NO FOOD OR WATER SHOULD BE ALLOWED FOR 12-18 HR BEFORE & FOR 4 HR AFTER DOSING. ... /IT/ IS CONTRAINDICATED IN TAPEWORM-INFECTED ANIMALS SINCE IRRITATION OF THESE WORMS MAY RESULT IN THEIR BALLING UP & OCCLUDING DIGESTIVE PASSAGE. IT IS ... CONTRAINDICATED IN ANIMALS WITH DISTEMPER ... & SHOULD NOT BE ADMIN TO NURSING ANIMALS OR THOSE WEIGHING LESS THAN 2 LB

(APPROX 1 KG).
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 839]**PEER REVIEWED**

VET: RESTRICT DIETARY FAT WITHIN 2 DAYS BEFORE AND AFTER USE TO AVOID ENHANCED ABSORPTION OF THIS FAT SOL LIVER TOXICANT. CONTRAINDICATED IN FEBRILE DISEASES OR IN DEBILITATED ANIMALS. STRONG MUCOSAL IRRITANT. BREAKING CAPSULES IN MOUTH HAS PRODUCED ATAXIA, CONVULSIONS, AND ANESTHESIA.
[Rossoff, I.S. Handbook of Veterinary Drugs. New York: Springer Publishing Company, 1974. 587]**PEER REVIEWED**

Food and Environmental Agents: Effect on Breast-Feeding: **Tetrachloroethylene**-cleaning fluid (**perchloroethylene**): Obstructive jaundice, dark urine. /from Table 7/
[Report of the American Academy of Pediatrics Committee on Drugs in Pediatrics 93 (1): 142 (1994)]**PEER REVIEWED**

Medical Surveillance:

Periodical exam of the liver and kidneys.
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 508]**PEER REVIEWED**

Exhaled air was analyzed for **tetrachloroethene** in teachers and 4-5 year old pupils of a kindergarten situated near a factory, and in residents of an old folks home situated near a former chemical waste dump. The **tetrachloroethene** concentrations were higher in the exhaled air of children living near the factory (mean 24 ug/cu m, n= 6) than in control children (mean 2.8 ug/cu m, n= 11). In the old folks home, the **tetrachloroethene** concentrations in the exhaled air of people living on the first floor were higher (mean 7.8 ug/cu m, n= 10) than in the exhaled air of the people living on the second floor and higher (mean 1.8 ug/cu m, n= 19). From the results of this study, it is clear that in environmental exposure to **tetrachloroethene**, biological monitoring of exhaled air is a simple, efficient, effective, and convenient method of assessing total ambient exposure of both young and aged subjects.
[Monster AC, Smolders JF; Int Arch Occup Environ Health 53 (4): 331-6 (1984)]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... in relation specifically to cancer hazards, there are at present no health monitoring methods that may ensure the early detection of preneoplastic lesions or lesions which may precede them. Whenever medical surveillance is indicated, in particular when exposure to a carcinogen has occurred, ad hoc decisions should be taken concerning additional tests that might become useful or mandatory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.23]**PEER REVIEWED**

Populations at Special Risk:

... individuals with diseases of the heart, liver, kidneys, and lung.
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 508]**PEER REVIEWED**

Probable Routes of Human Exposure:

Currently at risk of exposure are more than 500,000 workers, primarily in the dry cleaning & textile industries, which use more than 2/3 of the domestically produced **tetrachloroethylene**.

[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 986]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 536,688 workers (139,308 of these are female) are potentially exposed to **tetrachloroethylene** in the US(1). Occupational exposure to **tetrachloroethylene** may occur through inhalation and dermal contact with this compound at workplaces where **tetrachloroethylene** is produced or used(SRC). The mean concn of **tetrachloroethylene** in alveolar air in 18 workers at 12 dry cleaning stores was 73 mg/cu m(2). The general population may be exposed to **tetrachloroethylene** via inhalation of ambient air, ingestion of food and drinking water(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983) (2) Verberk MM, Scheffers TML; Environ Res 21: 432-7 (1980)]**PEER REVIEWED**

Body Burden:

Tetrachloroethylene was detected in 7 of 8 samples in mother's milk from 4 urban areas in the US(1). One hour after a visit to a dry cleaning plant, one sample of mother's milk contained 10 ppm **tetrachloroethylene**. This decreased to 3 ppm after 24 hr(2). **Tetrachloroethylene** was detected in expired breath and blood from 9 individuals living in Love Canal, NY at 600-4,500 ng/cu m and 0.35-260 ng/ml, respectively(3). **Tetrachloroethylene** was detected in human body fat (8 subjects) 0.4-29.2 ppb and various human organs less than 6 ng/g(4). The mean concn of **tetrachloroethylene** in alveolar air in 136 residents living near 12 dry-cleaning stores were: living equal to or <5 floors above the stores 5 mg/cu m, adjacent houses 1 mg/cu m, one house away 0.2 mg/cu m, across street <.1 mg/cu m, whereas the mean concn in 18 workers from these stores was 73 mg/cu m(5).
[(1) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982) (2) Jensen AA; Res Rev 89: 1-128 (1983) (3) Barkley J et al; Biomed Mass Spectrom 7: 139-47 (1980) (4) McConnell G et al; Endeavour 34: 13-8 (1975) (5) Verberk MM, Scheffers TML; Environ Res 21: 432-7 (1980)]**PEER REVIEWED**

Whole blood, USA survey of 250 (121 males, 129 females), 0.7-23 ppb, 2.4 ppb avg(1). Breath samples (ug/cu m, weighted statistics), Elizabeth and Bayonne, NJ, 1981, 295-339 samples, 93% pos, 280 max, 13.0 avg, 6.8 median(2). Alveolar air in children and teachers in school situated near factory were 24 ug/cu m avg for children and 11 and 47 ug/cu m for the teachers(3). The mean concentration of **tetrachloroethylene** in the classroom was 13 ug/cu m(3). Alveolar air of residents of a nursing home situated near a former chemical waste dump averaged 7.8 ug/cu m first floor and 1.8 ug/cu m on the second floor, where ambient concentrations averaged 8.2 and 1.6 ug/cu m, respectively(3). USA FY82 National Human Adipose Tissue Survey specimens, 46 composites, 61% pos (>3 ppb, wet tissue concn), 94 ppb max(4).
[(1) Antoine SR et al; Bull Environ Contam Toxicol 36: 364-71 (1986) (2) Wallace L et al; J Occup Med 28: 603-7 (1986) (3) Monster AC, Smolders JFJ; Int Arch Environ Health 53: 331-6 (1984) (4) Stanley JS; Broad Scan Analysis of the FY82 National Human Adipose Tissue Survey Specimens Vol. I Executive Summary p. 5 USEPA-560/5-86-035 (1986)]**PEER REVIEWED**

Average Daily Intake:

The AVDI of **tetrachloroethylene** measured in 8 urban areas of Japan was reported as 21 ug (inhalation) and 0.84 ug (ingestion)(1).
[(1) Yoshida K; Chemosphere 27: 621-30 (1993)]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** **TETRACHLOROETHYLENE** ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE

0.2.1.1 ACUTE EXPOSURE

A. **Tetrachloroethylene** is irritating to the eyes, skin and mucous membranes. Signs and symptoms of exposure may include CNS depression, malaise, dizziness, headache, lightheadedness, disorientation, seizures, respiratory tract irritation, non-cardiogenic pulmonary edema, nausea, vomiting and diarrhea.

B. Eye contact may cause pain, lacrimation and burning. Dermal exposure can cause dermatitis, erythema, burns and vesiculation.

C. Long-term exposure may cause liver, kidney and heart damage.

0.2.1.2 CHRONIC EXPOSURE

A. Chronic exposure may affect the liver and kidneys and may cause dysrhythmias, reduced color perception, contact dermatitis and defatting dermatitis, impaired memory; numbness of the extremities, peripheral neuropathy and impaired vision.

B. Chronic inhalation exposure has been associated with the development of peripheral neuropathies.

C. Chronic occupational exposure has resulted in hepatitis, confusion, disorientation, muscle cramps, fatigue and agitation.

0.2.4 HEENT

0.2.4.1 ACUTE EXPOSURE

A. Eye, nose and throat irritation may occur.

0.2.5 CARDIOVASCULAR

0.2.5.1 ACUTE EXPOSURE

A. Cardiac dysrhythmias may develop with high exposures.

0.2.6 RESPIRATORY

0.2.6.1 ACUTE EXPOSURE

A. Upper respiratory tract irritation and non-cardiogenic pulmonary edema may occur.

0.2.7 NEUROLOGIC

0.2.7.1 ACUTE EXPOSURE

A. CNS depression, coma and peripheral neuropathies may develop. Optic neuritis has been reported.

0.2.8 GASTROINTESTINAL

0.2.8.1 ACUTE EXPOSURE

A. Nausea, vomiting and anorexia may be noted acutely.

Diarrhea and bloody stools may result from ingestion. Long-term exposure has been associated with abdominal pain and constipation.

0.2.9 HEPATIC

0.2.9.1 ACUTE EXPOSURE

A. Hepatotoxicity with increased enzyme levels may be seen.

0.2.10 GENITOURINARY

0.2.10.1 ACUTE EXPOSURE

A. Proteinuria, hematuria and oliguric renal failure have occurred.

0.2.14 DERMATOLOGIC

0.2.14.1 ACUTE EXPOSURE

A. Dermatitis, a burning sensation and erythema may be seen after dermal exposure. Toxic epidermal necrolysis has occurred after ingestion.

0.2.18 PSYCHIATRIC

0.2.18.1 ACUTE EXPOSURE

A. Psychosis, hallucinations and distorted perceptions have been reported with inhalation exposure to **tetrachloroethylene**. Drug dependence may occur.

0.2.20 REPRODUCTIVE HAZARDS

A. Fetotoxicity and developmental abnormalities have been described in experimental animals only.

0.2.21 CARCINOGENICITY

0.2.21.1 IARC CATEGORY

A. IARC has classified **tetrachloroethylene** as Group 2A (probably carcinogenic to humans), based on limited evidence in humans and sufficient evidence in animals (IARC, 2001).

0.2.21.2 HUMAN OVERVIEW

A. Epidemiologic data suggest a possible increased incidence of liver, esophageal and urinary tract tumors and leukemia in humans, but data are inadequate.

0.2.21.3 ANIMAL OVERVIEW

A. **Tetrachloroethylene** is carcinogenic in experimental animals.

0.2.22 GENOTOXICITY

A. Chromosome abnormalities were seen in lymphocytes from exposed workers.

Laboratory:

A. Monitor liver and renal function tests and urinalysis in patients with significant exposure.

B. **Tetrachloroethylene** is radiopaque, abdominal radiographs may be useful to assess decontamination following ingestion.

C. Expired air **tetrachloroethylene** or urinary metabolite measurements may be useful for monitoring chronically exposed workers.

Treatment Overview:

0.4.2 ORAL EXPOSURE

A. EMESIS: Ipecac-induced emesis is not recommended because of the potential for CNS depression.

B. GASTRIC LAVAGE: Consider after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation. Control any seizures first.

1. CONTRAINDICATIONS: Loss of airway protective reflexes

or decreased level of consciousness in unintubated patients; following ingestion of corrosives; hydrocarbons (high aspiration potential); patients at risk of hemorrhage or gastrointestinal perforation; and trivial or non-toxic ingestion.

C. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.

D. Monitor level of consciousness, EKG, adequacy of respirations and oxygenation, and liver and renal function tests.

1. Endotracheal intubation and ventilatory assistance with supplemental oxygen may be required if CNS and respiratory depression are present.

E. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.

F. Some halogenated hydrocarbons sensitize the myocardium to catecholamines, but this effect has not been substantiated for **tetrachloroethylene**. Epinephrine or other beta-adrenergic agents should be used only with caution and only when clearly indicated. Careful EKG monitoring for the possible induction of arrhythmias should be done, and resuscitation medications and equipment should be readily available. Beginning therapy with the lowest effective doses of these agents is advisable.

G. Koppel et al (1985) have demonstrated that controlled hyperventilation enhanced pulmonary elimination of **tetrachloroethylene** in a child who had ingested 8 to 10 mL.

1. While there is little clinical experience with this treatment modality, it is physiologically attractive and most likely safe in patients requiring endotracheal intubation and mechanical ventilation for CNS and respiratory depression. Monitor arterial blood gases and avoid pH> 7.55.

0.4.3 INHALATION EXPOSURE

A. INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids.

B. Monitor level of consciousness, EKG, adequacy of respirations and oxygenation, and liver and renal function tests.

1. Endotracheal intubation and ventilatory assistance with supplemental oxygen may be required if CNS and respiratory depression are present.

C. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.

D. Some halogenated hydrocarbons sensitize the myocardium to catecholamines, but this effect has not been substantiated for **tetrachloroethylene**. Epinephrine or other beta-adrenergic agents should be used only with caution and only when clearly indicated. Careful EKG monitoring for the possible induction of dysrhythmias should be done, and resuscitation medications and

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      equipment should be readily available.  Beginning
      therapy with the lowest  effective doses of these agents
      is advisable.
   E. Treatment should include recommendations listed in the
      ORAL EXPOSURE section when appropriate.
0.4.4 EYE EXPOSURE
   A. DECONTAMINATION:  Irrigate exposed eyes with copious
      amounts of room temperature water for at least 15
      minutes.  If irritation, pain, swelling, lacrimation, or
      photophobia persist, the patient should be seen in a
      health care facility.
0.4.5 DERMAL EXPOSURE
   A. DECONTAMINATION:  Remove contaminated clothing and wash
      exposed  area thoroughly with soap and water.  A
      physician may need to  examine the area if irritation or
      pain persists.
   B. Treat dermal irritation or burns with standard topical
      therapy.  Patients developing dermal hypersensitivity
      reactions may require treatment with systemic or topical
      corticosteroids or antihistamines.
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Range of Toxicity:

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A. Exposure to tetrachloroethylene, between 200 and 1500 ppm,
   can cause irritant and CNS depressant effects.  Chronic
   exposure of 60 to 450 ppm has caused CNS effects in
   workers.  Ingestion of as much as 500 mg/kg has been
   survived.
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[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

Basic treatment: .Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Monitor for pulmonary edema and treat if necessary ... . Monitor for shock and treat if necessary ... . Anticipate seizures and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport ... . Do not use emetics. For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal ... . Cover skin burns with sterile dressings after decontamination ... . /Carbon tetrachloride and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994.,p. 194-5]**PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious. Positive pressure ventilation techniques with a bag valve mask device may be beneficial. Monitor cardiac rhythm and treat arrhythmias if necessary ... . Start an IV with D5W /SRP: "To keep open", minimal flow rate/. Use lactated Ringer's if signs of hypovolemia are present. Watch for signs of fluid overload. Consider drug therapy for pulmonary edema ... . For hypotension with signs of hypovolemia, administer fluid cautiously. Consider vasopressors if patient is hypotensive with a normal fluid volume. Watch for signs of myocardial irritability and fluid overload ... . Treat seizures with diazepam (Valium) ... . Use proparacaine hydrochloride to assist eye irrigation ... . /Carbon tetrachloride and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure.

2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 195]**PEER REVIEWED**

Animal Toxicity Studies:

Evidence for Carcinogenicity:

Evaluation: There is limited evidence in humans for the carcinogenicity of **tetrachloroethylene**. There is sufficient evidence in experimental animals for the carcinogenicity of **tetrachloroethylene**. Overall evaluation: **Tetrachloroethylene** is probably carcinogenic to humans (Group 2A). In making the overall evaluation, the working group considered the following evidence: (1) Although **tetrachloroethylene** is known to induce peroxisome proliferation in mouse liver, a poor quantitative correlation was seen between peroxisome proliferation and tumor formation in the liver after administration of **tetrachloroethylene** by inhalation. The spectrum of mutations in proto-oncogenes in liver tumors from mice treated with **tetrachloroethylene** is different from that in liver tumors from mice treated with trichloroethylene. (2) The cmpd induced leukemia in rats. (3) Several epidemiological studies showed elevated risks for esophageal cancer, non-Hodgkin's lymphoma and cervical cancer.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 63 204 (1995)]**PEER REVIEWED**

A3. A3= Animal carcinogen.
[American Conference of Governmental Industrial Hygienists. Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs) for 1995-1996. Cincinnati, OH: ACGIH, 1995.28]**PEER REVIEWED**

Non-Human Toxicity Excerpts:

UNCONSCIOUSNESS WAS OBSERVED IN RATS WITHIN FEW MIN @ CONCN OF 6000 PPM OR MORE & AFTER SERVERAL HOURS AT 3000 PPM, BUT UNCONSCIOUSNESS WAS NOT OBSERVED AT 2000 PPM. AT THESE HIGH-LEVEL SINGLE EXPOSURES, THE PREDOMINANT RESPONSE WAS ... DEPRESSION OF NERVOUS SYSTEM. THERE WERE SLIGHT CHANGES IN LIVER, CHARACTERIZED BY SLIGHT INCR IN WT, SLIGHT INCR IN TOTAL LIPID, AND SLIGHT CLOUDY SWELLING.
[Clayton, G. D. and F. E. Clayton (eds.). Patty's Industrial Hygiene and Toxicology: Volume 2A, 2B, 2C: Toxicology. 3rd ed. New York: John Wiley Sons, 1981-1982. 3562]**PEER REVIEWED**

EXCESSIVE ABSORPTION OF DRUG WILL RESULT IN DIZZINESS AND INCOORDINATION ... AND EVEN DEATH.
[Jones, L.M., et al. Veterinary Pharmacology & Therapeutics. 4th ed. Ames: Iowa State University Press, 1977. 1034]**PEER REVIEWED**

IN HOST MEDIATED ASSAY IN MICE, USING SALMONELLA TYPHIMURIUM TA1950, TA1951 AND TA1952, THERE WAS A SIGNIFICANT INCR IN NUMBER OF REVERTANTS WITH DOSES EQUIV TO LD50 & HALF THE LD50, BUT THIS WAS NOT DOSE RELATED. ... THERE WAS NO INDUCTION OF CHROMOSOMAL ABERRATIONS IN BONE MARROW CELLS OF MICE THAT HAD RECEIVED EITHER SINGLE (HALF LD50) OR 5 DAILY IP INJECTIONS (1/6 LD50) OF ... /**TETRACHLOROETHYLENE**/.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 503 (1979)]**PEER REVIEWED**

... pregnant mice and rats /were exposed/ to concn of 300 ppm. Both species were exposed for /periods of/ 7 hours daily, on days 6 through 15 of gestation. No fetal toxicity or teratogenicity was detected.

[Shepard, T.H. Catalog of Teratogenic Agents. 5th ed. Baltimore, MD: The Johns Hopkins University Press, 1986. 547]**PEER REVIEWED**

... behavioral tests /were performed/ on the offspring of rats exposed to 100 ppm for 7 hr daily on days 14-20 of gestation ... no changes ... /were observed in/ the control pups. At exposure levels of 900 ppm the maternal animals gained less weight and the offspring performed less well on neuromotor tests and had lower levels of brain acetylcholine and dopamine. Pair fed controls were not used.
[Shepard, T.H. Catalog of Teratogenic Agents. 5th ed. Baltimore, MD: The Johns Hopkins University Press, 1986. 547]**PEER REVIEWED**

GROUPS OF 50 MALE & 50 FEMALE B6C3F1 MICE, APPROX 5 WK OLD ... WERE ADMIN **TETRACHLOROETHYLENE** IN CORN OIL BY GAVAGE ON 5 CONSECUTIVE DAYS/WK FOR 78 WK. ... TIME-WEIGHTED AVG DOSES WERE 536 AND 1072 MG/KG BODY WT/DAY IN MALES & 386 AND 772 MG/KG BODY WT/DAY IN FEMALES. GROUPS OF 20 MALE AND 20 FEMALE MICE WERE EITHER UNTREATED OR RECEIVED CORN OIL ALONE. ... THE SHORTER LIFESPAN IN TREATED ANIMALS WAS DUE TO EARLY TOXICITY & HIGH INCIDENCES OF HEPATOCELLULAR CARCINOMAS IN ANIMALS OF BOTH SEXES ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 497 (1979)]**PEER REVIEWED**

... ONLY A NEARLY LETHAL /ORAL/ DOSE (4 G/KG BODY WT) CAUSED SWELLING OF THE CONVOLUTED /KIDNEY/ TUBULES AND HYDROPIC DEGENERATION IN MALE MICE ... IP DOSES OF 1.6-2.3 G/KG BODY WT ... CAUSED SLIGHT CALCIFICATION OF THE TUBULES OF THE KIDNEY IN DOGS ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 502 (1979)]**PEER REVIEWED**

MALE RATS WERE EXPOSED FOR 4 HR TO VARIOUS CONCN OF **TETRACHLOROETHYLENE**. THE ENZYMES SGOT, SGPT, AND OCT WERE MARKEDLY ELEVATED AS A RESULT OF EXPOSURE.
[DREW RT ET AL; TOXICOL APPL PHARMACOL 45 (3): 809-20 (1978)]**PEER REVIEWED**

Rats inhalation: No pathological effects @ 70 ppm, 8 hr/day, 5 days/wk, 7 mo; Some pathological changes in liver and kidneys @ 230 ppm, 8 hr/day, 5 days/wk, 7 mo.
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1080]**PEER REVIEWED**

/**Tetrachloroethylene** was not/ mutagenic ... in 2 strains of Salmonella typhimurium in the presence of a postmitochondrial mouse liver supernatant, following exposure to vapors ...
[Bartsch H et al; Arch Toxicol 41 (4): 249-78 (1979)]**PEER REVIEWED**

The cardiac effects of **tetrachloroethylene** ... were studied in several species. To standardize the dosimetry, **tetrachloroethylene** was prepared for iv injection in soln of Tween 80, which had no demonstratable cardiotoxicity. In rabbits under urethane anesthesia and in cats and dogs under pentobarbital anesthesia, **tetrachloroethylene** increased the vulnerability of the ventricles to epinephrine induced extrasystoles, bigeminal rhythms, and tachycardia. The mean threshold doses of **tetrachloroethylene** were 10 mg/kg in rabbits, 24 mg/kg in cats, and 13 mg/kg in dogs. In rabbits this threshold dose for cardiac arrhythmias corresponded to blood levels between 2.2 and 3.6 ug/ml. Animals demonstrating a reflex bradycardia to vasopressor doses of epinephrine were relatively resistant to the arrhythmogenic action of **tetrachloroethylene**. Ventricular arrhythmias occurred in less than 30% of the animals after **tetrachloroethylene** alone. In cats higher doses of **tetrachloroethylene** (40 mg/kg) produced acute pulmonary edema. **Tetrachloroethylene** (30-40 mg/kg) decreased left intraventricular

dP/dt (max) in dogs, without significantly increasing left intraventricular end diastolic pressure, although there was a transient decrease in arterial blood pressure that accompanied the early phase of myocardial depression.
[Kobayashi S et al; J Toxicol Environ Health 10: 23-30 (1982)]**PEER REVIEWED**

A study was designed to determine the effects of **tetrachloroethylene** on the phyto- and zooplankton community at initial concentrations of 1.2 and 0.44 mg/l in separated compartments of an experimental pond. Measurements in the surrounding water were made simultaneously to detect possible effects of compartmentalization. Residues as low as 0.1 mg/l could be analyzed 5 days (low dose) and 38 days (high dose) post-application. In all applied biotopes, a lethal effect on the Daphnia population was detected. The phytoplankton community showed an increase of relative abundance and a decrease in species diversity. Studies of the frequency distribution of 6 selected phytoplankton species. (Spirogyra species, Microcystis flos-aquae, Stichococcus bacillaris, Nitzschia acicularis, Chilomonas parameium, Actinophrys species) demonstrated the total elimination of at least 4 species from the treated compartments. In spite of different dosing, only weak differences were found in toxic effects between the low and high dosed compartments. No significant chemically induced effect was observed on the physicochemical properties of the treated water.
[Lay JP et al; Arch Environ Contam Toxicol 13 (2): 135-42 (1984)]**PEER REVIEWED**

Exptl momentary spraying of rabbits eyes with **tetrachloroethylene** from a pressurized fire extinguisher from a distance of 1 foot caused immediate pain & blepharospasm. The corneal epithelium became granular & optically irregular, & patches of epithelium were lost, but the eyes recovered completely within 2 days.
[Grant, W.M. Toxicology of the Eye. 3rd ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 888]**PEER REVIEWED**

Results of the mutagenicity test using L5178Y mouse lymphoma cells were positive for **tetrachlorethylene**.
[NTP; Fiscal Year 1987 Annual Plan p.82 (1987) NTP-87-001]**PEER REVIEWED**

Oxidative DNA damage is emerging as an biomarker of effect in studies assessing the health risks of occupational chemicals. Trichloroethylene (TCE) & **perchloroethylene** (PERC) are used in the dry cleaning industry & their metab can produce reactive oxygen cmpds. The present study examined the potential for TCE & PERC to induce oxidative DNA damage in rats that was detectable as increased urinary excretion of 8-hydroxydeoxyguanosine (8OHdG). Thiobarbaturic acid reactive substances (TBARS) & 8-epiprostaglandin F2alpha (8epiPGF) were also measured as biomarkers of increased oxidative stress. Male Fischer rats were admin a single i.p. injection of 0, 100, 500, or 1000 mg/kg of PERC or TCE. Control rats received only vehicle (1:4 v/v of Alkamuls/water). A positive control group received 100 mg/kg 2-nitropropane (2NP). Rats were sacrificed 24 hr after dosing. In rats receiving 2NP or TCE but not PERC, TBARS & the 8OHdG/dG ratios were significantly elevated in liver. Lymphocyte 8OHdG/dG was not affected significantly by 2NP, TCE or PERC. In rats receiving 2NP, urinary excretion of 8OHdG & 8epiPGF2 were significantly increased. In rats receiving TCE or PERC, significant increases in 8epiPGF2 or 8OHdG were not evident. Results indicate that a single high dose of TCE, but not PERC, can induce an increase in oxidative DNA damage in rat liver. However, the usefulness of 8OHdG as a biomarker of TCE-induced oxidative DNA damage is questionable.
[Toraason M et al; Toxicology 138 (1): 43-53 (1999)]**PEER REVIEWED**

Rats, rabbits, and monkeys withstood 7 hr exposures to 400 ppm **tetrachloroethylene** vapor 5 days/week for 6 months without apparent adverse effects on mortality, growth, body and organ weights, and periodic clinical chemistry determinations. However, guinea pigs could tolerate repeated 7 hr exposures at concentrations no higher than 100 ppm.
[Hayes, W.J., Jr., E.R. Laws, Jr., (eds.). Handbook of Pesticide Toxicology. Volume

2. Classes of Pesticides. New York, NY: Academic Press, Inc., 1991. 697]**PEER REVIEWED**

Rats died within a few minutes of inhaling a vapor concentration of 30,000 ppm **tetrachloroethylene** and in about 30 min at 19,000 ppm. Death was narcotic in nature. A series of essentially straight lines was obtained when log concentration was plotted against log time for exposures to **tetrachloroethylene** that were just sufficient to cause lethality in rats, just small enough to be survived by all rats, and just small enough to cause no organic injury. A concentration of 2000 ppm was tolerated for up to 14 hr, and 3000 ppm was tolerated for 4 hr with no deaths. Unconsciousness was produced in rats within a few minutes at concentrations of 6000 ppm or greater and after several hr at 3000 ppm was tolerated for 4 hr with no deaths. Unconsciousness was produced in rats within a few minutes at concentrations of 6000 ppm or greater and after several hours at 3000 ppm, but unconsciousness was not observed at 2000 ppm.

[Hayes, W.J., Jr., E.R. Laws, Jr., (eds.). Handbook of Pesticide Toxicology. Volume 2. Classes of Pesticides. New York, NY: Academic Press, Inc., 1991. 697]**PEER REVIEWED**

National Toxicology Program Studies:

The bioassay of USP grade **tetrachloroethylene** for possible carcinogenicity was conducted using Osborne-Mendel rats and B6C3F1 mice. **Tetrachloroethylene** in corn oil was admin by gavage at either of two dosages to groups of 50 male and 50 female animals of each species, 5 days/wk, over a period of 78 wk followed by an observation period of 32 wk for rats and 12 wk for mice. Initial dosage levels for the chronic bioassay were selected on the basis of a preliminary subchronic toxicity test. Subsequent dosage adjustments were made during the course of the chronic bioassay. The high and low time weighted avg dosages of **tetrachloroethylene** in the chronic study were 941 and 471 mg/kg/day for the male rats, 949 and 474 mg/kg/day for the female rats, 1072 and 536 mg/kg/day for the male mice, and 772 and 386 mg/kg/day for the female mice. For each species, 20 animals of each sex were placed on test as vehicle controls. These animals were gavaged with corn oil at the same time that dosed animals were gavaged with **tetrachloroethylene** mixtures. Twenty animals of each sex were placed on test as untreated controls for each species. These animals received no gavage treatments. No significant incr incidence of neoplastic lesions was observed in treated rats. ... In both male and female mice, admin of **tetrachloroethylene** was associated with a significantly incr incidence of hepatocellular carcinoma. Hepatocellular carcinomas were observed in 2/17 (12%) untreated control males, 2/20 (10%) untreated control females, 0/20 vehicle control females, 19/48 (40%) low dose females, and 19/48 (40%) high dose females. Hepatocellular carcinomas metastasized to the kidney in one untreated control male and to the lung in three low dose males, one low dose female, and one high dose female. ... The results of the bioassay of **tetrachloroethylene** in Osborne-Mendel rats do not allow an evaluation of the carcinogenicity of this cmpd due to the high rate of early death among the treated animals. However, under the condition of this study, **tetrachloroethylene** was a liver carcinogen in B6C3F1 mice of both sexes. Levels of Evidence of Carcinogenicity: Male Rats: Inadequate study; Female Rats: Inadequate study; Male Mice: Positive; Female Mice: Positive.
[DHEW/NCI; Bioassay of Tetrachloroethylene for Possible Carcinogenicity (1977) Technical Rpt Series No. 13 DHEW Pub No. (NIH) 77-813]**PEER REVIEWED**

Toxicology and carcinogenesis studies of **tetrachloroethylene** (99.9%) pure were conducted by inhalation exposure of groups of 50 male and 50 female F344/N rats and B6C3F1 mice 6 hr/day 5 days/wk for 103 wk. The exposure concn used (0, 200 or 400 ppm for rats and 0, 100 or 200 ppm for mice) were selected on the basis of results from a 13 wk inhalation study. ... During the 2 yr studies, exposure to **tetrachloroethylene** did not consistently affect body wt gains in either rats or mice. ... Both concns of **tetrachloroethylene** were associated with incr incidences of mononuclear cell leukemia in

male rats (28/50; 37/50; 37/50). In female rats, **tetrachloroethylene** incr the incidence of leukemia (18/50; 30/50; 29/50) and decr the time to occurrence of the disease. **Tetrachloroethylene** produced renal tubular cell karyomegaly in male and female rats, renal tubular cell hyperplasia in male rats, and renal tubular cell adenomas and adenocarcinomas (combined) in male rats (1/49; 3/49; 4/50). The incidence of renal tubular cell tumors was statistically significant; these uncommon tumors have been consistently found at low incidences in male rats in other 2 yr studies of chlorinated ethanes and ethylenes. One low dose male rat had a kidney lipoma, and another had a nephroblastoma. Four high dose male and two high dose female rats had gliomas of the brain, whereas one control male and one control female had this tumor. In male and female mice, **tetrachloroethylene** caused dose related incr in the incidences of hepatocellular neoplasms. In males, **tetrachloroethylene** at 200 ppm incr the incidence of hepatocellular adenomas (11/49; 8/49; 18/50) and at both concn incr the incidence of hepatocellular carcinomas (7/49; 25/49; 26/50). In female mice, **tetrachloroethylene** at both concn incr the incidences of hepatocellular carcinoma (1/48; 13/50; 36/50). **Tetrachloroethylene** also produced renal cell karomegaly in both sexes of mice, and one low dose male mouse had a tubular cell adenocarcinoma. In these inhalation studies, there was no neoplastic changes in the respiratory tracts of either species, but there was an incr in the incidence of squamous metaplasia in the nasal cavities in dosed male rats (0/50; 5/50; 5/50). ... Under the conditions of these 2 yr inhalation bioassays, there was clear evidence of the carcinogenicity of **tetrachloroethylene** for male F344/N rats as shown by incr incidence of mononuclear cell leukemia and uncommon renal tubular cell neoplasms. There was some evidence of carcinogenicity of **tetrachloroethylene** for female F344/N rats as shown by incr incidences of mononuclear cell leukemia. There was clear evidence of carcinogenicity for B6C3F1 mice as shown by incr incidences of both hepatocellular adenomas and carcinomas in males and of hepatocellular carcinomas in females.
[DHHS/NTP; Toxicology & Carcinogenesis Studies of Tetrachloroethylene in F344/N Rats and B6C3F1 Mice (Inhalation Studies) Technical Report Series No. 311 (1986) NIH Publication No. 86-2567]**PEER REVIEWED**

Non-Human Toxicity Values:

LD50 Oral Mouse 6000-8571 mg/kg body weight LD50 Oral Rat 2400-13000 mg/kg bw
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 191 (1995)]**PEER REVIEWED**

LC50 Rat inhalation 4100 ppm/6 hr LC50 Rat inhalation 5000 ppm/8 hr LC50 Mouse inhalation 5200 ppm/4 hr LC50 Mouse inhalation 2978 ppm/6 hr
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 191 (1995)]**PEER REVIEWED**

Ecotoxicity Values:

LC50 Poecilia reticulata (guppy) 18 ppm/7 days /Conditions of bioassay not specified/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1080]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnow) 18.4 mg/l/96 hr (flow-through bioassay)
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1080]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnow) 21.4 mg/l/96 hr (static bioassay)
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1080]**PEER REVIEWED**

LC50 LEPOMIS MACROCHIRUS (BLUEGILL SUNFISH) 46 MG/L/24 HR AT 21-23 DEG C (95%

CONFIDENCE LIMIT 11-15 MG/L) /CONDITIONS OF BIOASSAY NOT SPECIFIED/
[BUCCAFUSCO RJ ET AL; BULL ENVIRONM CONTAM TOXICOL 26: 446 (1981)]**PEER REVIEWED**

LC50 LEPOMIS MACROCHIRUS (BLUEGILL SUNFISH) 13 MG/L/96 HR AT 21-23 DEG C (95% CONFIDENCE LIMIT 11-15 MG/L) /CONDITIONS OF BIOASSAY NOT SPECIFIED/
[BUCCAFUSCO RJ ET AL; BULL ENVIRONM CONTAM TOXICOL 26: 446 (1981)]**PEER REVIEWED**

LC50 Daphnia magna (water flea) 18 mg/l/48 hr, static bioassay, at 22 deg C
[Le Blanc GA; Bull Environ Contam Toxicol 24: 684-91 (1980) as cited in WHO; Environ Health Criteria: Tetrachloroethylene p.15 (1984)]**PEER REVIEWED**

LC50 Salmo gairdneri (rainbow trout) 5 mg/l/96 hr, static bioassay at 12 deg C
[Shubat PJ et al; Bull Environ Contam Toxicol 28: 7-10 (1982) as cited in WHO; Environ Health Criteria: Tetrachloroethylene p.24 (1984)]**PEER REVIEWED**

LC50 Limanda limanda (dab) 5 mg/l/96 hr, flow-through bioassay
[Pearson CR, McConnell G; Proc R Soc Land B 189: 305-32 (1975) as cited in WHO; Environ Health Criteria: Tetrachloroethylene p.24 (1984)]**PEER REVIEWED**

LC50 Tanytarsus dissimilis (midge) 30, 840 ug/l/48 hr, static bioassay
[USEPA; Task 11, Contract No 68-01-3887 (1980) as cited in USEPA; Ambient Water Quality Criteria Doc: Tetrachloroethylene p.B-1 (1980) EPA 440/5-80-073]**PEER REVIEWED**

LC50 Lepomis macrochirus (bluegill sunfish) 12,900 ug/l/96 hr, static bioassay
[USEPA; Contract No 68-01-4646 (1978) as cited in USEPA; Ambient Water Quality Criteria Doc: Tetrachloroethylene p.B-2 (1980) EPA 440/5-80-073]**PEER REVIEWED**

TSCA Test Submissions:

The ability of **tetrachloroethylene** to induce morphological transformation in the BALB/3T3 mouse cell line (Cell Transformation assay) was evaluated. Based on preliminary toxicity test determinations (exposure time=3 days), **tetrachloroethylene** was tested at 0, 2, 10, 50 and 250 ug/ml, with cell survival ranging from 100% to 51% relative to untreated controls. None of the tested concentrations produced significantly greater transformation frequencies relative to untreated controls.
[Arthur D. Little, Inc.; Cell Transformation Assays of 11 Chlorinated Hydrocarbon Analogs. (1983), EPA Document No. 40-8324457, Fiche No. OTS0509392]**QC REVIEWED**

The mutagenicity of **tetrachloroethylene** was evaluated in Salmonella tester strains TA98, TA100, TA1535 and TA1537 (Ames Test), both in the presence and absence of added metabolic activation by Aroclor-induced rat liver S9 fraction. **Tetrachloroethylene** did not cause a positive response in any of the tester strains with or without added metabolic activation. **Tetrachloroethylene** was evaluated using a protocol in which the test article was usually tested over a minimum of 6 dose levels, the highest nontoxic dose level being 10 mg/plate unless solubility, mutagenicity or toxicity dictated a lower upper limit.
[SRI International; Investigations of the Species Sensitivity and Mechanism of Carcinogenicity of Halogenated Hydrocarbons. (1984), EPA Document No. 40-8424225, Fiche No. OTS0509408]**QC REVIEWED**

The ability of **tetrachloroethylene** to induce DNA repair in the hepatocyte primary culture (HPC) system was evaluated using hepatocytes from male B6C3F1 mice and Osborne-Mendel rats. In both the mouse and rat HPC/DNA repair assays, **tetrachloroethylene** was cytotoxic from 0.01% to 0.1% and was not genotoxic from 0.001% to 0.00001%.
[Naylor Dana Institute; DNA Repair Tests of 11 Chlorinated Hydrocarbon Analogs, Final Report. (1983), EPA Document No. 40-8324292, Fiche No. OTS0509403]**QC REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

METABOLITES: TRICHLOROACETIC ACID; TRICHLOROETHANOL; INORG CHLORIDE; TRANS-1,2-DICHLOROETHYLENE IN EXPIRED AIR. /FROM TABLE/
[Sunshine, I. (ed.). CRC Handbook of Analytical Toxicology. Cleveland: The Chemical Rubber Co., 1969. 381]**PEER REVIEWED**

IN **TETRACHLOROETHYLENE** EXPOSURE, URINARY METABOLITE LEVELS OF TRICHLOROETHANOL, TOTAL TRICHLORO COMPOUNDS, AND TRICHLOROACETIC ACID INCREASED UNTIL THE ATMOSPHERIC CONCN OF THE SOLVENT REACHED 50 TO 100 PPM; LITTLE INCR IN THESE METABOLITES OCCURRED AT HIGHER SOLVENT CONCN.
[IKEDA M ET AL; BRIT J IND MED 29 (3): 328-33 (1972)]**PEER REVIEWED**

The relationship among dose, metabolism and hepatotoxicity in mice which resulted from subchronic exposure to the chlorinated solvents trihloroethylene and **perchloroethylene** were examined. Male Swiss-Cox mice received either trichloroethylene (0 to 3200 mg/kg/day) or perchlorothylene (0 to 2000 mg/kg/day) in corn oil by gavage for 6 weeks. Urinary metabolites from individual mice were quantified to estimate the extent to which each compound was metabolized. Four parameters of hepatotoxicity were assessed: liver weight, triglycerides, glucose-6-phophatase activity, and serum glutamic-pyruvic transaminase (SGPT) activity. Trichloroethylene sigificantly affected liver weight and glucose-6-phosphatase activity; **perchloroethylene** affected all four parameters. The metabolism of trichloroethylene was linearly related to dose through 1600 mg/kg, but then became saturated. The metabolism of **perchloroethylene** was saturable. The dose-effect curves of the affected hepatotoxicity parameters of both compounds were nonlinear and resembled the dose-metabolism graph of the corresponding solvent. Plots of the hepatotoxicity data of each compound against total urinary metabolites were linear in all cases, suggesting that the hepatotoxicity of both **perchloroethylene** and trichloroethylene in mice is directly related to the extent of their metabolism. This pattern is consistent with formation of the toxic intermediate in the primary metabolic pathway of each compound.
[Buben JA, O'Flaherty EJ; Toxicol Appl Pharmacol 78 (1): 105-22 (1985)]**PEER REVIEWED**

Toxicokinetic modeling of the uptake & elimination of **tetrachloroethylene** showed that human metabolic parameters could be predicted by scaling rat metabolic parameters for **tetrachloroethylene** as a function of body weight. Trichloroacetic acid & trichloroethanol have been reported as urinary metabolites of **tetrachloroethylene** in both humans & experimental animals.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 190 (1995)]**PEER REVIEWED**

Absorption, Distribution & Excretion:

... READILY ABSORBED THROUGH THE LUNG AND TO A MUCH SMALLER DEGREE THROUGH SKIN OR MUCOUS MEMBRANES OR FOLLOWING INGESTION.
[Arena, J.M. and Drew, R.H. (eds.) Poisoning-Toxicology, Symptoms, Treatments. 5th ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 257]**PEER REVIEWED**

METABOLISM ... IS RELATIVELY SLOW WITH ONLY FEW PERCENT OF DOSE BEING EXCRETED AS METABOLITES, MAJOR ONE BEING TRICHLOROACETIC ACID ...
[Doull, J., C.D. Klaassen, and M. D. Amdur (eds.). Casarett and Doull's Toxicology. 2nd ed. New York: Macmillan Publishing Co., 1980. 476]**PEER REVIEWED**

(36)CL-**TETRACHLOROETHYLENE** FED TO RATS IS EXCRETED LARGELY UNCHANGED IN EXPIRED AIR (98% OF DOSE IN 2 DAYS), AND IS METABOLIZED, TO ONLY SLIGHT EXTENT, INTO TRICHLOROACETIC ACID (2%) WHICH IS EXCRETED IN URINE.
[Parke, D. V. The Biochemistry of Foreign Compounds. Oxford: Pergamon Press, 1968. 213]**PEER REVIEWED**

Concn curves of **perchloroethylene** in blood and exhaled air after exposure showed that it was eliminated from the body at three different rates with corresponding half-life.
[Monster AC, Houtkooper JM; Int Arch Occup Env Health 42: 319 (1979)]**PEER REVIEWED**

Personal monitoring of exposure to **tetrachloroethylene** ... and analyses of urine for total trichloro-compounds were carried out in two groups of workers ... one group (20 males and 19 females) in dry-cleaning workshops and the other (16 males and 6 females) engaged in the removal of glue from silk cloth. Comparison of the urinary trichloro-compounds levels with **tetrachloroethylene** in the environment revealed that, while the metabolite levels increased essentially linear to **tetrachloroethylene** concn up to 100 ppm, leveling off was apparent in the metabolite excretion when the exposure to **tetrachloroethylene** was more intense (eg more than 100 ppm), indicating that the capacity of humans to metabolize **tetrachloroethylene** is rather limited. A tentative calculation ... indicated that, at the end of an 8 hr shift with exposure to **tetrachloroethylene** at 50 ppm (TWA), 38% of the **tetrachloroethylene** absorbed through the lung would be exhaled unchanged and less than 2% would be metabolized to be excreted into the urine, while the rest would remain in the body to be eliminated later.
[Ohtsuki T et al; Int Arch Occup Environ Health 51: 381-90 (1983)]**PEER REVIEWED**

Tetrachloroethylene was still detectable in the breath of rats 16 hr after a single exposure to levels of 339-3390 mg/cu m for 1-40 hr.
[WHO; Environ Health Criteria: Tetrachloroethylene p.21 (1984)]**PEER REVIEWED**

Male Sprague-Dawley rats exposed to (14)C-**tetrachloroethylene** by either gavage (1.0 mg/kg) or inhalation (10 ppm, 10.4 mg/kg) excreted 70% of the dose unchanged in expired air. Approximately 3% was excreted as carbon dioxide, and approximately 23% was excreted in the urine and feces as nonvolatile metabolites.
[NTP; Toxicology and Carcinogenesis Studies of Tetrachloroethylene p.19 Report #311 (1986) NIH Pub# 86-2567]**PEER REVIEWED**

Once in the bloodstream, **tetrachloroethylene** tends to distribute to body fat. In human tissue at autopsy, ratios of fat to liver concentrations are greater than 6:1
[McConnell G et al; Endeavor 34: 13-8 (1975) as cited in USEPA; Health Advisories for 25 Organics: Tetrachloroethylene p.307 (1987) PB 87-235578]**PEER REVIEWED**

An autopsy after a fatal **tetrachloroethylene** exposure revealed an 8 times greater concn in brain compared with blood ...
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 986]**PEER REVIEWED**

Tetrachloroethylene (**PCE**) is eliminated primarily via the lung. The respiratory half-life for **PCE** elimination has been estimated at 65 to 70 hours.
[Stewart RD et al; Arch Environ Health 20: 224-9 (1970) as cited in USEPA; Health Advisories for 25 Organics: Tetrachloroethylene p.307 (1987) PB 87-235578]**PEER REVIEWED**

Tetrachloroethylene reached near steady-state levels in blood of human volunteers with two hours of

continuous exposure.
[Stewart RD et al; Arch Environ Health 2: 516 (1961) as cited in USEPA; Ambient Water Quality Criteria Doc: Tetrachloroethylene p.C-3 (1980) EPA 440/5-80-073]**PEER REVIEWED**

Absorption of **tetrachloroethylene** (**PCE**) through the skin by immersing the thumbs of volunteers in **PCE** for 40 minutes and measuring the **PCE** in the exhaled air. High concentrations of **PCE** in exhaled breath (160 to 260 ug/cu m) were measurable five hours after exposure.
[Stewart RD and Dodd HC; Am Ind Hug Assoc Jour 25: 439 (1964) as cited in USEPA; Ambient Water Quality Criteria Doc: Tetrachloroethylene p.C-4 (1980) EPA 440/5-80-073]**PEER REVIEWED**

Tetrachloroethylene excretion in breast milk has been associated with obstructive jaundice in newborn infants.
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 986]**PEER REVIEWED**

Nine unrelated groups (659 males) working in plastic boat, chemical, plastic button, paint, and shoe factories were studied. Urine samples were collected at the beginning of the workshift and at the end of the first half of the shift. A close relationship (correlation coefficient always above 0.85) between the average environmental solvent concentration (mg/cu m) measured in the breathing zone and the urinary concentration of unchanged solvent (ug/L) was observed. The authors recommended a biological equivalent exposure limit of 101 ug/L. biological exposure data for urine collected over 4 hr during random sampling for at least 1 yr could be used to evaluate long-term exposure and probability of non-compliance for individual or groups of workers.
[Ghittori S et al; Am Ind Hyg Assoc J 48 (9): 786-90 (1987)]**PEER REVIEWED**

Objective: The present study was initiated to examine a quantitative relationship between **tetrachloroethene** (TETRA) in blood & urine with TETRA in air, & to compare TETRA in blood or urine with trichloroacetic acid (TCA) in urine as exposure markers. Methods: In total, 44 workers (exposed to TETRA during automated, continuous cloth-degreasing operations), & ten non-exposed subjects volunteered to participate in the study. The exposure to vapor was monitored by diffusive sampling. The amounts of TETRA & TCA in end-of-shift blood & urine samples were measured by either head-space gas chromatography (HS-GC) or automated methylation followed by HS-GC. The correlation was examined by regression analysis. Results: The maximum time-weighted average (TWA) concn for TETRA-exposure was 46 ppm. Regression analysis for correlation of TETRA in blood, TETRA in urine & TCA in urine, with TETRA in air, showed that the coefficient was largest for the correlation between TETRA in air & TETRA in blood. The TETRA in blood, in urine & in air correlated mutually, whereas TCA in urine correlated more closely with TETRA in blood than with TETRA in urine. ... The biological marker levels at a hypothetical exposure of 25 ppm TETRA were substantially higher in the present study than were the levels reported in the literature. ... Conclusions: Blood TETRA is the best marker of occupational exposure to TETRA, being superior to the traditional marker, urinary TCA.
[FURUKI K et al; INTERNATIONAL ARCHIVES OF OCCUPATIONAL AND ENVIRONMENTAL HEALTH 73 (4): 221-227 (2000)]**PEER REVIEWED**

In vitro dermal absorption was measured for 3 volatile organic cmpds in dilute aqueous soln through freshly prepared & previously frozen human skin. The permeability coefficients at 26 deg C for chloroform (0.14 cm/h) & trichloroethylene (0.12 cm/h) were similar but much larger than that for **tetrachloroethylene** (0.018 cm/h). Storage of the skin at -20 deg C did not significantly affect the penetration of these chemicals. The dermal absorption of chloroform through freshly prepared human skin was not changed significantly by pretreatment of the skin with commonly used consumer products

(moisturizer, baby oil, insect repellent, sunscreen); however, the permeability coefficient was found to incr from 0.071 cm/h at 11 deg C to 0.19 cm/h at 50 deg C. These data suggest that exposure estimates for chloroform & other contaminants in water should consider the appropriate exposure scenario to properly assess the dermal dose.
[Nakai JS et al; J Toxicol Environ Health 58 (3): 157-170 (1999)]**PEER REVIEWED**

During hyperventilation therapy, the relative contribution to the fast elimination process increased from 70% for physiological minute volume to 99.9%. A minor fraction of the ingested dose was excreted with the urine (integral of 1% during the first 3 days). In contrast to previous results, trace amounts of unchanged **tetrachloroethylene** were detected in the urine besides trichloroacetic acid and trichloroethanol.
[K'oppel C et al; J Toxicol Clin Toxicol 23 (2-3): 103-15 (1985)]**PEER REVIEWED**

Biological Half-Life:

The elimination of **tetrachloroethylene** in expired air ranged from 50 to 150 ppm (339 to 1,017 mg/cu m) for up to 8 hr. Biological half-life for fat stores was 71.5 hr.
[Gruberan E, Fernandez J; Brit J Ind Med 31: 159 (1974)]**PEER REVIEWED**

The biological half-life of **tetrachloroethylene** metabolites (as measured as total trichloro-compounds) is 144 hours.
[Ikeda M and Imamura T; Int Arch Arbeitsmed 31: 209 (1973) as cited in USEPA; Ambient Water Quality Criteria Doc: Tetrachloroethylene p.C-4 (1980) EPA 440/5-80-073]**PEER REVIEWED**

Elimination is slow (biological half-life of 65 hours for exhaled **perchloroethylene**) because of continuing release of **perchloroethylene** from fat stores.
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 986]**PEER REVIEWED**

Mechanism of Action:

... /**TETRACHLOROETHYLENE** HAS BEEN/ SHOWN ... TO RELEASE LYSOSOMAL ENZYMES FROM GRANULAR FRACTIONS PREPARED FROM NEMATODES. SINCE GUT OF NEMATODES SEEMS TO BE SPECIALIZED FOR LYSOSOMAL INTRACELLULAR DIGESTION OF NUTRIENTS, INTERFERENCE WITH THIS PROCESS MAY WELL EXPLAIN ACTION OF **TETRACHLOROETHYLENE** ... IT HAS BEEN ASSUMED THAT AFFECTED WORMS ARE PARALYZED SUFFICIENTLY TO RELEASE THEIR ATTACHMENT TO INTESTINAL WALL ...
[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975. 1031]**PEER REVIEWED**

Interactions:

/When formerly used/ ... alcohol must be avoided before and for 24 hours after use of **tetrachloroethylene**. ... No laxative should be given, since this increases the toxic effects and decreases the effectiveness of the drug.
[American Medical Association, Department of Drugs. Drug Evaluations. 6th ed. Chicago, Ill: American Medical Association, 1986. 1612]**PEER REVIEWED**

Intubation of rats with mixtures of benzene and **tetrachloroethylene** yielded a combined toxicity which was only slightly less than additive. Mixtures of toluene with **tetrachloroethylene** resulted in LD50 values of less than than predicted for simple additivity, indicating synergistic effects.
[USEPA; Ambient Water Quality Criteria Doc: Tetrachloroethylene p.C-17 (1980) EPA

440/5-80-073]**PEER REVIEWED**

Pharmacology:

Therapeutic Uses:

MEDICATION (VET): After the advent of phenothiazine ... little use has been made of the chlorinated hydrocarbons ... /as a ruminant anthelmintic/. **Tetrachloroethylene** has continued to be used in small animals over the years but has been largely replaced by drugs that are less toxic & easier to admin.
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 839]**PEER REVIEWED**

... /IT/ IS USEFUL ONLY AGAINST HOOKWORM INFESTATIONS IN MAN. TREATMENT WITH THIS AGENT IS MORE EFFECTIVE AGAINST NECATOR AMERICANUS THAN AGAINST ANCYLOSTOMA DUODENALE ... /FORMER USE/
[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975. 1032]**PEER REVIEWED**

... SINGLE DOSE /ORAL/ OF 0.12 ML/KG ... MAX OF 5 ML. ... DIET BEFORE ADMIN ... SHOULD BE LOW IN FAT & PT SHOULD EAT ONLY LIGHT MEAL PREVIOUS EVENING. NEXT MORNING ... /DRUG/ INGESTED ON EMPTY STOMACH ... SINGLE TREATMENT ... GENERALLY REMOVE ... WORMS, BUT TWO OR MORE TREATMENTS @ 4-DAY INTERVALS ... TO CLEAR INFESTATION. /FORMER USE/
[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975. 1031]**PEER REVIEWED**

TETRACHLOROETHYLENE, USP ... AVAILABLE IN SOFT GELATIN CAPSULES CONTAINING 0.2, 1.0, OR 2.5 ML OF DRUG. IT MAY BE DIFFICULT TO OBTAIN DRUG IN CAPSULE FORM FOR HUMAN USE. /FORMER USE/
[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975. 1031]**PEER REVIEWED**

Drug Warnings:

VET: AT ONE TIME IT WAS USED FAIRLY EXTENSIVELY AGAINST GI PARASITES OF RUMINANTS. ITS DISADVANTAGE IN RUMINANTS IS NECESSITY OF STIMULATING CLOSURE OF ESOPHAGEAL GROOVE SO THAT MEDICATION IS DELIVERED DIRECTLY TO ABOMASUM RATHER THAN PASSING INTO RUMEN WHICH ... REDUCES EFFECTIVENESS OF DRUG. ... NO FOOD OR WATER SHOULD BE ALLOWED FOR 12-18 HR BEFORE & FOR 4 HR AFTER DOSING. ... /IT/ IS CONTRAINDICATED IN TAPEWORM-INFECTED ANIMALS SINCE IRRITATION OF THESE WORMS MAY RESULT IN THEIR BALLING UP & OCCLUDING DIGESTIVE PASSAGE. IT IS ... CONTRAINDICATED IN ANIMALS WITH DISTEMPER ... & SHOULD NOT BE ADMIN TO NURSING ANIMALS OR THOSE WEIGHING LESS THAN 2 LB (APPROX 1 KG).
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 839]**PEER REVIEWED**

VET: RESTRICT DIETARY FAT WITHIN 2 DAYS BEFORE AND AFTER USE TO AVOID ENHANCED ABSORPTION OF THIS FAT SOL LIVER TOXICANT. CONTRAINDICATED IN FEBRILE DISEASES OR IN DEBILITATED ANIMALS. STRONG MUCOSAL IRRITANT. BREAKING CAPSULES IN MOUTH HAS PRODUCED ATAXIA, CONVULSIONS, AND ANESTHESIA.
[Rossoff, I.S. Handbook of Veterinary Drugs. New York: Springer Publishing Company,

1974. 587]**PEER REVIEWED**

Food and Environmental Agents: Effect on Breast-Feeding: **Tetrachloroethylene**-cleaning fluid (**perchloroethylene**): Obstructive jaundice, dark urine. /from Table 7/
[Report of the American Academy of Pediatrics Committee on Drugs in Pediatrics 93 (1): 142 (1994)]**PEER REVIEWED**

Interactions:

/When formerly used/ ... alcohol must be avoided before and for 24 hours after use of **tetrachloroethylene**. ... No laxative should be given, since this increases the toxic effects and decreases the effectiveness of the drug.
[American Medical Association, Department of Drugs. Drug Evaluations. 6th ed. Chicago, Ill: American Medical Association, 1986. 1612]**PEER REVIEWED**

Intubation of rats with mixtures of benzene and **tetrachloroethylene** yielded a combined toxicity which was only slightly less than additive. Mixtures of toluene with **tetrachloroethylene** resulted in LD50 values of less than than predicted for simple additivity, indicating synergistic effects.
[USEPA; Ambient Water Quality Criteria Doc: Tetrachloroethylene p.C-17 (1980) EPA 440/5-80-073]**PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Tetrachloroethylene's production and use as a dry cleaning agent, degreasing agent and as a chemical intermediate in the production of fluorocarbons will result in its release to the environment through various waste streams. If released to air, a vapor pressure of 18.5 mm Hg at 25 deg C indicates **tetrachloroethylene** will exist solely as a vapor in the ambient atmosphere. Vapor-phase **tetrachloroethylene** will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 96 days. Direct photolysis is not expected to be an important environmental fate process since this compound only absorbs light weakly in the environmental UV spectrum. If released to soil, **tetrachloroethylene** is expected to have moderate mobility based upon Koc values in the range of 200-237 and **tetrachloroethylene** has often been detected in groundwater. Volatilization from moist soil surfaces is expected to be an important fate process based upon a Henry's Law constant of 0.0177 atm-cu m/mole. **Tetrachloroethylene** may volatilize from dry soil surfaces based upon its vapor pressure. Volatilization half-lives in the range of 1.2-5.4 hrs were measured for **tetrachloroethylene** from a sandy loam soil surface and volatilization half-lives of 1.9-5.2 hrs were measured from an organic topsoil. Biodegradation is expected to occur slowly in soils under both aerobic and anaerobic conditions. If released into water, **tetrachloroethylene** is not expected to adsorb to suspended solids and sediment in water based upon the Koc data. The biodegradation half-lives of **tetrachloroethylene** in aerobic and anaerobic waters were reported as 180 and 98 days, respectively. Volatilization from water surfaces is expected to be an important fate process based upon this compound's Henry's Law constant. Estimated volatilization half-lives for a model river and model lake are 1 hour and 5 days, respectively. Measured BCF values of 26-77 in fish suggest bioconcentration in aquatic organisms is low to moderate. Hydrolysis is not expected to be an important environmental fate process based on a hydrolysis half-life of 9 months. **Tetrachloroethylene** may undergo indirect photolysis in natural waters when photosensitizers such as humic material are present. Occupational exposure to **tetrachloroethylene** may occur through inhalation and dermal contact with this compound at workplaces where **tetrachloroethylene** is produced or used. The general population may be exposed to **tetrachloroethylene** via inhalation of ambient air, ingestion of food and drinking

water. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

Currently at risk of exposure are more than 500,000 workers, primarily in the dry cleaning & textile industries, which use more than 2/3 of the domestically produced **tetrachloroethylene**.
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 986]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 536,688 workers (139,308 of these are female) are potentially exposed to **tetrachloroethylene** in the US(1). Occupational exposure to **tetrachloroethylene** may occur through inhalation and dermal contact with this compound at workplaces where **tetrachloroethylene** is produced or used(SRC). The mean concn of **tetrachloroethylene** in alveolar air in 18 workers at 12 dry cleaning stores was 73 mg/cu m(2). The general population may be exposed to **tetrachloroethylene** via inhalation of ambient air, ingestion of food and drinking water(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983) (2) Verberk MM, Scheffers TML; Environ Res 21: 432-7 (1980)]**PEER REVIEWED**

Body Burden:

Tetrachloroethylene was detected in 7 of 8 samples in mother's milk from 4 urban areas in the US(1). One hour after a visit to a dry cleaning plant, one sample of mother's milk contained 10 ppm **tetrachloroethylene**. This decreased to 3 ppm after 24 hr(2). **Tetrachloroethylene** was detected in expired breath and blood from 9 individuals living in Love Canal, NY at 600-4,500 ng/cu m and 0.35-260 ng/ml, respectively(3). **Tetrachloroethylene** was detected in human body fat (8 subjects) 0.4-29.2 ppb and various human organs less than 6 ng/g(4). The mean concn of **tetrachloroethylene** in alveolar air in 136 residents living near 12 dry-cleaning stores were: living equal to or <5 floors above the stores 5 mg/cu m, adjacent houses 1 mg/cu m, one house away 0.2 mg/cu m, across street <.1 mg/cu m, whereas the mean concn in 18 workers from these stores was 73 mg/cu m(5).
[(1) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982) (2) Jensen AA; Res Rev 89: 1-128 (1983) (3) Barkley J et al; Biomed Mass Spectrom 7: 139-47 (1980) (4) McConnell G et al; Endeavour 34: 13-8 (1975) (5) Verberk MM, Scheffers TML; Environ Res 21: 432-7 (1980)]**PEER REVIEWED**

Whole blood, USA survey of 250 (121 males, 129 females), 0.7-23 ppb, 2.4 ppb avg(1). Breath samples (ug/cu m, weighted statistics), Elizabeth and Bayonne, NJ, 1981, 295-339 samples, 93% pos, 280 max, 13.0 avg, 6.8 median(2). Alveolar air in children and teachers in school situated near factory were 24 ug/cu m avg for children and 11 and 47 ug/cu m for the teachers(3). The mean concentration of **tetrachloroethylene** in the classroom was 13 ug/cu m(3). Alveolar air of residents of a nursing home situated near a former chemical waste dump averaged 7.8 ug/cu m first floor and 1.8 ug/cu m on the second floor, where ambient concentrations averaged 8.2 and 1.6 ug/cu m, respectively(3). USA FY82 National Human Adipose Tissue Survey specimens, 46 composites, 61% pos (>3 ppb, wet tissue concn), 94 ppb max(4).
[(1) Antoine SR et al; Bull Environ Contam Toxicol 36: 364-71 (1986) (2) Wallace L et al; J Occup Med 28: 603-7 (1986) (3) Monster AC, Smolders JFJ; Int Arch Environ Health 53: 331-6 (1984) (4) Stanley JS; Broad Scan Analysis of the FY82 National Human Adipose Tissue Survey Specimens Vol. I Executive Summary p. 5 USEPA-560/5-86-035 (1986)]**PEER REVIEWED**

Average Daily Intake:

The AVDI of **tetrachloroethylene** measured in 8 urban areas of Japan was reported as 21 ug (inhalation) and 0.84 ug (ingestion)(1).
[(1) Yoshida K; Chemosphere 27: 621-30 (1993)]**PEER REVIEWED**

Artificial Pollution Sources:

Water pollution by **tetrachloroethylene** leaching from vinyl liners in asbestos-cement water pipelines for water distribution.
[Yuskus LR; J Am Water Works Assoc 76 (2): 76-81 (1984)]**PEER REVIEWED**

During chlorination water treatment, it can be formed in small quantities.
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 769]**PEER REVIEWED**

Tetrachloroethylene's production and use as a dry cleaning agent, degreasing agent and as a chemical intermediate in the production of fluorocarbons(1) may result in its release to the environment through various waste streams(SRC). **Tetrachloroethylene** is released through vaporization losses from dry cleaning and industrial metal cleaning(2), and in wastewater, particularly from metal finishing, laundries, aluminum forming, organic chemical/plastics manufacturing and municipal treatment plants(3).
[(1) Lewis RJ Sr; Hawley's Condensed Chemical Dictionary. 13th ed. NY, NY: VanNostrand Reinhold Co., p. 850 (1997) (2) Chemical Marketing Reporter; Chemical Profile Tetrachloroethylene. December 15, 1997. NY, NY: Schnell Pub Co (1997) (3) US EPA; Treatability Manual. p. I.12.26-1 to I.12.26-5 USEPA-600/2-82-001A (1981)]**PEER REVIEWED**

Environmental Fate:

TERRESTRIAL FATE: Based on a classification scheme(1), Koc values in the range of 200-237(2-4), indicates that **tetrachloroethylene** is expected to have moderate mobility in soil(SRC). Volatilization of **tetrachloroethylene** from moist soil surfaces is expected to be an important fate process(SRC) given a Henry's Law constant of 0.0177 atm-cu m/mole(5). **Tetrachloroethylene** may volatilize from dry soil surfaces based on a vapor pressure of 18.5 mm Hg at 25 deg C(6). Volatilization half-lives in the range of 1.2-5.4 hrs were measured for **tetrachloroethylene** from a sandy loam soil surface and volatilization half-lives of 1.9-5.2 hrs were measured from an organic topsoil(7). **Tetrachloroethylene**, reached 11% of its theoretical BOD in 4 weeks using an activated sludge inoculum in the Japanese MITI test(8), suggesting biodegradation will be slow under aerobic conditions(SRC). Biodegradation under anaerobic conditions occurs slowly with acclimated microorganisms(9,10).
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Choiu CT et al; Science 206: 831-2 (1979) (3) Wilson JT et al; Environ Qual 10: 501-506 (1981) (4) Friesel P et al; Fresenius Z Anal Chem 319: 160-64(1984) (5) Gossett JM; Environ Sci Technol 21: 202-206 (1987) (6) Riddick JA et al; Organic Solvents: Physical Properties and Methods of Purification 4th ed NY, NY: Wiley Interscience (1986) (7) Zytner RG et al; pp. 101-8 in 43rd Purdue Indust Waste Conf (1989) (8) Chemicals Inspection and Testing Institute. Japan Chemical Industry Ecology - Toxicology and Information Center.ISBN 4-89074-101-1 (1992) (9) Bouwer EJ, McCarty PL; Appl Environ Micribiol 45: 1286-94 (1983) (10) Wilson JT et al; Devel Indust Microbiol 24: 225-33 (1983)]**PEER REVIEWED**

AQUATIC FATE: Based on a classification scheme(1), Koc values in the range of 200-237(2-4) indicate that **tetrachloroethylene** is not expected to adsorb to suspended solids and sediment in water(SRC). Volatilization from water surfaces is expected(5) based upon a Henry's Law constant of 0.0177 atm-cu m/mole(6). Using this Henry's Law constant and an estimation method(5), volatilization half-lives for a model river and model lake are 1 hour and 5 days, respectively(SRC). According to a classification scheme(7), BCF values in the range of 26-77 measured in fish(8-10), suggests bioconcentration in aquatic organisms is low to moderate(SRC). The biodegradation half-lives of **tetrachloroethylene** in

aerobic and anaerobic waters were reported as 180 and 98 days, respectively(11). Hydrolysis is not expected to be an important environmental fate process for **tetrachloroethylene** based on a hydrolysis half-life of 9 months in purified, de-ionized water(12). **Tetrachloroethylene** may undergo indirect photolysis in natural waters when photosensitizers such as humic acids are present(13). This process is only expected to be important in sunlit surface waters containing humic material.
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Choiu CT et al; Science 206:831-2 (1979) (3) Wilson JT et al; Environ Qual 10: 501-506 (1981) (4) Friesel P et al; Fresenius Z Anal Chem 319: 160-64(1984) (5) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9, 15-1 to 15-29 (1990) (6) Gossett JM; Environ Sci Technol 21: 202-206 (1987) (7) Franke C et al; Chemosphere 29: 1501-14 (1994) (8) Neely WB et al; Environ Sci Technol 8: 1113-15 (1974) (9) Barrows ME et al; Dyn Exposure Hazzard Assess Toxic Chem Ann Arbor, MI: Ann Arbor Sci p. 379-92 (1980) (10) Chemicals Inspection and Testing Institute. Japan Chemical Industry Ecology - Toxicology and Information Center. ISBN 4-89074-101-1 (1992) (11) Capel PD, Larson SJ; Chemosphere 30: 1097-1106 (1995) (12) Dilling WL et al; Environ Sci Technol 9: 833-88 (1975) (13) Mill T; Chemosphere 38: 1379-90 (1999)]**PEER REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), **tetrachloroethylene**, which has a vapor pressure of 18.5 mm Hg at 25 deg C(2), is expected to exist solely as a vapor in the ambient atmosphere. Vapor-phase **tetrachloroethylene** is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals(SRC); the half-life for this reaction in air is estimated to be 96 days(SRC), calculated from its rate constant of 1.67X10-13 cu cm/molecule-sec at 25 deg C(3). **Tetrachloroethylene** may also be degraded in the atmosphere by reaction with ozone, but the rate of this reaction is too slow to be environmentally important(4). Direct photolysis is not expected to be an important environmental fate process since this compound only absorbs light weakly in the environmental UV spectrum(5).
[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Riddick JA et al; Organic Solvents: Physical Properties and Methods of Purification 4th ed NY, NY: Wiley Interscience (1986) (3) Atkinson R; J Phys Chem Ref Data Monograph 1 (1989) (4) Atkinson R, Carter WPL; Chem Rev 84: 437-70 (1984) (5) Crutzen PJ et al; J Geophys Res 83: 345-63 (1978)]**PEER REVIEWED**

Environmental Biodegradation:

No degradation occurred in 21 days in 3 biodegradability tests with acclimated or unacclimated inocula or in a river die-away test(4). Microbial degradation did not contribute to the removal of **tetrachloroethylene** (**PCE**) in a mesocosm experiment which simulated Narraganset Bay, RI(5). Under aerobic conditions there was no degradation in 25 weeks in a batch experiment with a sewage inoculum(1) or when low concentrations of **PCE** (16 ug/l) were circulated through an acclimated aerobic biofilm column over a period of 1 year(2). While only 3.75% of the **PCE** treated by conventional, extended and 2-stage activated-sludge pilot plants appeared in the effluent, most of the **PCE** was discharged to the air from the extended aeration(3).
[(1) Bouwer EJ et al; Environ Sci Technol 15: 596-9 (1981) (2) Bouwer EJ, McCarty PL; Environ Sci Technol 16: 836-43 (1982) (3) Watanabe H; Gesuido Kyokaiski 20: 29-37 (1983) (4) Mudder TI; Amer Chem Soc Div Env Chem Conf p. 52-3 (1982) (5) Wakeham SG; Environ Sci Technol 17: 611-7 (1983)]**PEER REVIEWED**

ANAEROBIC: There is evidence that slow biodegradation of **tetrachloroethylene** (**PCE**) occurs under anaerobic conditions when the microorganisms have been acclimated, yielding trichloroethylene (TCE) as a product(1,2). An experiment in a continuous-flow laboratory methanogenic column using well acclimated mixed culture and a 2-day detention time had an average **PCE** removal rate of 76%(3). In a continuous-flow mixed-film methanogenic column with a liquid detention time of 4 days, mineralization of 24% of the **PCE** present occurred; TCE was the major intermediate formed (72%), but traces of dichloroethylene isomers and vinyl chloride were also found(4). In other column studies under a

different set of methanogenic conditions, nearly quantitative conversion of **PCE** to VC was found in 10 days(4). Removal of 86% **PCE** occurred in a methanogenic biofilm column (8 weeks of activation followed by 9-12 weeks of acclimation(5)).
[(1) Bouwer EJ, McCarty PL; Appl Environ Micribiol 45: 1286-94 (1983) (2) Wilson JT et al; Devel Indust Microbiol 24: 225-33 (1983) (3) Bouwer EJ, McCarty PL; Ground Water 22: 433-40 (1984) (4) Vogel TM, McCarty PL; Appl Environ Microbiol 49: 1080-3 (1985) (5) Bouwer EJ, Wright JP; Am Chem Soc Div Environ Chem. 191st Natl Meet 26: 42-5 (1986)]**PEER REVIEWED**

A large reduction of **tetrachloroethylene** which had been recirculated through a soil column for 14 days was attributed to adsorption and volatilization(2). In a microcosm containing muck from an aquifer recharge basin, 72.8% loss was observed in 21 days against 12-17% in controls, and the metabolites trichloroethylene, cis- and trans-1,2-dichloroethylene, dichloromethane, and chloroethene were identified(3). However, when subsurface samples were aseptically removed from above and below the water table and incubated in the laboratory, no degradation occurred in 16 weeks(4). In one field groundwater recharge project, degradation was observed in the 50 day recharge period(1).
[(1) Bouwer EJ et al; Environ Sci Technol 15: 596-99 (1981) (2) Bouwer EJ et al; Water Res 15: 151-59 (1981) (3) Parsons F et al; J Amer Wat Works Assoc 76: 56-9 (1984) (4) Wilson JT et al; Ground Water 21: 134-42 (1983)]**PEER REVIEWED**

Tetrachloroethylene, present at 30 mg/l, reached 11% of its theoretical BOD in 4 weeks using an activated sludge inoculum at 100 mg/l and the Japanese MITI test(1), suggesting biodegradation will be slow under aerobic conditions(SRC). The biodegradation half-life of **tetrachloroethylene** in aerobic and anaerobic waters was reported as 180 and 98 days, respectively(2). The first-order anaerobic biodegradation rate constant of **tetrachloroethylene** was reported in the range of 0.00042-0.0071 day-1(3), corresponding to half-lives of 98-1,650 days(SRC). **Tetrachloroethylene** was degraded to trichloroethene, 1,2-dichloroethene and ultimately vinyl chloride during a 6 day incubation period using a groundwater and sediment microcosm obtained from a contaminated site in Toronto, Canada(4).
[(1) Chemicals Inspection and Testing Institute. Japan Chemical Industry Ecology - Toxicology and Information Center.ISBN 4-89074-101-1 (1992) (2) Capel PD, Larson SJ; Chemosphere 30: 1097-1106 (1995) (3) Rathbun RE; US Geol Surv Prof Pap 1589: 1-151 (1998) (4) Hunkeler D et al; Environ Sci Technol 33: 2733-38 (1999)]**PEER REVIEWED**

Environmental Abiotic Degradation:

The rate constant for the vapor-phase reaction of **tetrachloroethylene** with photochemically-produced hydroxyl radicals is 1.67X10-13 cu cm/molecule-sec at 25 deg C(1). This corresponds to an atmospheric half-life of about 96 days at an atmospheric concn of 5X10+5 hydroxyl radicals per cu cm(1). **Tetrachloroethylene** may also be degraded in the atmosphere by reaction with ozone, but the rate of this reaction is too slow to be environmentally important(2). Direct photolysis is not expected to be an important environmental fate process since this compound only absorbs light weakly in the environmental UV spectrum(3). **Tetrachloroethylene** may undergo indirect photolysis in natural waters when photosensitizers such as humic material are present(4). When **tetrachloroethylene** in aqueous solution was irradiated with light greater than 290 nm in wavelength, 75% degradation was observed over the course of one year, while 59-65% degradation was observed for dark controls(5). Hydrolysis is not expected to be an important environmental fate process for **tetrachloroethylene** based on a hydrolysis half-life of 9 months in purified, de-ionized water(5).
[(1) Atkinson R; J Phys Chem Ref Data Monograph 1 (1989) (2) Atkinson R, Carter WPL; Chem Rev 84: 437-70 (1984) (3) Crutzen PJ et al; J Geophys Res 83: 345-63 (1978) (4) Mill T; Chemosphere 38: 1379-90 (1999) (5) Dilling WL et al; Environ Sci Technol 9: 833-88 (1975)]**PEER REVIEWED**

Photodegradation in the stratosphere is rapid(1). When **PCE** adsorbed to silica gel is irradiated through a

pyrex filter, 50-90% is lost in 6 days(2).
[(1) Mueller JPH Korte F; Chemosphere 3: 195-8 (1977) (2) Gaeb S et al; Nature 270: 331-3 (1977)]**PEER REVIEWED**

Environmental Bioconcentration:

The BCF value of **tetrachloroethylene** in fathead minnows was 39(1) and the BCF value for bluegill sunfish was 49(2). BCF values of 26-77 were observed for carp exposed to 0.1 mg/l of **tetrachloroethylene** and values of 28-76 were observed for carp exposed to 0.01 mg/l over an 8 week incubation period(3). According to a classification scheme(4), these BCF data suggest that bioconcentration in aquatic organisms is low to moderate(SRC).
[(1) Neely WB et al; Environ Sci Technol 8: 1113-15 (1974) (2) Barrows ME et al; Dyn Exposure Hazzard Assess Toxic Chem Ann Arbor, MI: Ann Arbor Sci pp. 379-92 (1980) (3) Chemicals Inspection and Testing Institute. Japan Chemical Industry Ecology - Toxicology and Information Center.ISBN 4-89074-101-1 (1992) (4) Franke C et al; Chemosphere 29: 1501-14 (1994)]**PEER REVIEWED**

Soil Adsorption/Mobility:

The Koc value of **tetrachloroethylene** in a silt loam was measured as 210(1) and the Koc in a Lincoln fine sandy soil was 200(2). An average Koc of 237 was calculated for **tetrachloroethylene** in 6 soils (acid peat, acid humic, calcareous humic, iron-oxide rich subsurface soil, clay subsurface soil, and sandy subsurface soil)(3). According to a classification scheme(4) these Koc data suggest that **tetrachloroethylene** is expected to have moderate mobility in soil(SRC).
[(1) Choiu CT et al; Science 206: 831-2 (1979) (2) Wilson JT et al; Environ Qual 10: 501-506 (1981) (3) Friesel P et al; Fresenius Z Anal Chem 319: 160-64 (1984) (4) Swann RL et al; Res Rev 85: 17-28 (1983)]**PEER REVIEWED**

Volatilization from Water/Soil:

The Henry's Law constant for **tetrachloroethylene** is 0.0177 atm-cu m/mole(1). This Henry's Law constant indicates that **tetrachloroethylene** expected to volatilize rapidly from water surfaces(2). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec)(2) is estimated as 1 hour(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(2) is estimated as 5 days(SRC). The volatilization half-life of **tetrachloroethylene** was reported as 3.2 minutes in laboratory experiments using distilled water(3). **Tetrachloroethylene**'s Henry's Law constant(1) indicates that volatilization from moist soil surfaces may occur(SRC). **Tetrachloroethylene** is expected to volatilize from dry soil surfaces based on a vapor pressure of 18.5 mm Hg at 25 deg C(4). Volatilization half-lives in the range of 1.2-5.4 hrs were measured for **tetrachloroethylene** from a sandy loam soil surface and volatilization half-lives of 1.9-5.2 hrs were measured from an organic topsoil(5).
[(1) Gossett JM; Environ Sci Technol 21: 202-206 (1987) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (3) Chiou CT et al; Environ Int 3: 231-4 (1980) (4) Riddick JA et al; Organic Solvents: Physical Properties and Methods of Purification 4th ed NY, NY: Wiley Interscience (1986) (5) Zytner RG et al; pp. 101-8 in 43rd Purdue Indust Waste Conf (1989)]**PEER REVIEWED**

Environmental Water Concentrations:

Samples for analysis of volatile organic compounds were collected from 315 wells in the Potomac-Raritan-Magothy aquifer system in southwestern New Jersey and a small adjacent area in Pennsylvania (USA) during 1980-1982. Volatile organic compounds were detected in all 3 aquifer units of the Potomac-Raritan-Magothy aquifer system. Most of the contamination appeared to be confined to

the outcrop area. Low levels of contamination were found away from the outcrop area in the upper and middle aquifer. Trichloroethylene, **tetrachloroethylene** and benzene were the most frequently detected compounds. Differences in the distributions of light chlorinated hydrocarbons, /(including **tetrachloroethylene**)/, trichloroethylene, and aromatic hydrocarbons, ie, benzene, were noted and were probably due to differences in the uses of the compounds and the distribution patterns of potential contamination sources. The distribution patterns of volatile organic compounds differed greatly among the 3 aquifer units. The upper aquifer, which cropped out mostly in less-developed areas, had the lowest percentage of wells with volatile organic compounds detected (10% of wells sampled). The concentrations in most wells in the upper aquifer which had detectable levels were <10 ug/l. In the middle aquifer, which cropped out beneath much of the urban and industrial area adjacent to the Delaware River, detectable levels of volatile organic compounds were found in 22% of wells sampled, and several wells contained concentrations >100 ug/l. The lower aquifer, which was confined beneath much of the outcrop area of the aquifer system, had the highest percentage of wells (28%) with detectable levels. This was probably due to vertical leakage of contamination from the middle aquifer and the high percentage of wells tapping the lower aquifer in the most heavily developed areas of the outcrop.
[Fusillo TV et al; Ground Water 23 (3): 354-60 (1985)]**PEER REVIEWED**

The National Health Department (Italy) had promoted and supported a preliminary survey on the presence of some chlorinated organic compounds in the drinking water. The drinking water of some cities of northern Italy was analyzed for the presence of trichloroethylene, **tetrachloroethylene**, methylchloroform, carbon tetrachloride, trihalomethanes, polychlorinated biphenyls, and the most common chlorinated pesticides. From March, 1981 to June, 1982, 8 controls were done for 11 sampling points. All water underwent different treatments with carbon. In the raw water, trichloroethylene (47/48) and **tetrachloroethylene** (34/48) showed the highest frequency of positivity. One well had the highest concentrations of these compounds (trichloroethylene 81-158 ug/l; **tetrachloroethylene** 15-32 ug/l). In the finished waters, carbon trichloride the most abundant trihalomethane formed during chlorination, was detected in 80% of the 39 samples, against 31% in the 48 raw water samples. No polychlorinated biphenyls and chlorinated pesticides were found at the chosen detection limit (0.05 ug/l).
[Ziglio G et al; Ig Mod 82 (3): 419-35 (1984)]**PEER REVIEWED**

DRINKING WATER: In a survey of 180 US cities with finished surface water, the median concn of **tetrachloroethylene** in drinking water was reported as 0.3 ppb with a max concn of 21 ppb(1). In survey of 36 US cities with finished groundwater, the median concn of **tetrachloroethylene** was 3 ppb(1). **Tetrachloroethylene** was detected at a max conc of 1.5 ppm in contaminated drinking wells in the US(2,3). The avg concn of **tetrachloroethylene** from 30 Canadian potable water facilities was reported as 1 ppb(4). A survey of drinking water sources in the Netherlands showed that 64 sources had **tetrachloroethylene** concns greater than 10 ppb, 12 sources had concns greater than 100 ppb, 4 sources had concns greater than 1 ppm and 2 sources had concns greater than 100 ppm(5). Drinking water obtained from the Rhine River, Netherlands had a max concn of 50 parts per trillion **tetrachloroethylene**(6). Drinking water in Niagra Falls, NY had **tetrachloroethylene** concns of 0.35-2.9 ppb(7). A survey of drinking water for individual states in the US reported that 220 of 1,569 samples contained **tetrachloroethylene** at concns of trace to 3,000 ppb(8). **Tetrachloroethylene** was detected in 264 drinking water wells in California at a max concn of 166 ug/l(9).
[(1) Coniglio WA et al; Occurrence of Volatile Organics in Drinking Water. p. 7 Unpublished EPA report (1980) (2) Burmaster DE; Environ 24: 6-13, 33-6 (1982) (3) Giger W, Molnar-Kubica E; Bull Environ Contam Toxicol 19: 475-80 (1978) (4) Otson R et al; J Assoc Off Anal Chem 65: 1370-4 (1982) (5) Trouwborst T; Sci Total Environ 21: 41-6 (1981) (6) Piet GJ, Morra CF; pp. 31-42 in Artificial Groundwater recharge; Huismon L, Olsthorn TN, eds, Pitman Pub (1983) (7) Barkley J et al; Biomed Mass Spectrum 7: 139-47 (1980) (8) Cotruvo JA et al; pp. 511-30 in Organic Carcinogens in Drinking Water (1986) (9) Lam RHF et al; pp. 15-44 in Water Contamination and

Health. Wang RGM, ed, NY, NY: Marcel Dekker, Inc (1994)]**PEER REVIEWED**

GROUNDWATER: The median concn of **tetrachloroethylene** in groundwater from 27 US cities was 0.6 ppb(1). The max concn of **tetrachloroethylene** in groundwater wells from San Fernando Valley, CA was 130 ppb(2). Groundwater from Britain contained less than 2 ppb of **tetrachloroethylene** in 8 out of 10 samples analyzed(3). Groundwater underlying 2 rapid infiltration sites in the US contained **tetrachloroethylene** at concns of 0.07 and 0.63 ppb(4). Shallow groundwater wells in Japan contained **tetrachloroethylene** at concns of 0.2-23,000 ppb and deep wells contained 0.2-150 ppb(5). **Tetrachloroethylene** was identified, not quantified in 27% of groundwater samples obtained from shallow wells in southern New Jersey(6).
[(1) Coniglio WA et al; Occurrence of Volatile Organics in Drinking Water. p. 7 Unpublished EPA report (1980) (2) Chemical Engineering 90: 35 (1983) (3) Fielding M et al; Environ Technol Lett 2: 545-50 (1981) (4) Hutchins SR et al; Environ Toxicol Chem 2: 195-216 (1983) (5) Magara Y, Furuichi T; pp. 231-43 in New Concepts and Development in Toxicol. Chambers PL et al, eds. Elsevier Sci Publ (1986) (6) Baehr L et al; Water Resour Res 35: 127-36 (1999)]**PEER REVIEWED**

SURFACE WATER: The median concn of **tetrachloroethylene** in surface water from 154 US cities was 2 ppb(1). **Tetrachloroethylene** was identified, not quantified, in 2,346 out of 4,972 samples of water from the Ohio River(2). The avg concn of **tetrachloroethylene** in Lake Ontario water was reported as 0.009 ppb(3). The concn of **tetrachloroethylene** in the Rhine River, Netherlands was reported as 0.12-0.62 ppb from 1976-1982(4). The concn of **tetrachloroethylene** in Lake Zurich, Switzerland was reported as 0.025-0.14 ppb(5,6). The STORET Database of US surface water reported that **tetrachloroethylene** was identified in 3,543 out of 9,323 surface water samples(7). **Tetrachloroethylene** was detected in the Elbe River near Hamburg Germany at concns of 16-163 ng/l from 1992-1993(8).
[(1) Coniglio WA et al; Occurrence of Volatile Organics in Drinking Water. p. 7 Unpublished EPA report (1980) (2) Ewing BB et al; Monitoring to Detect Previously Unrecognized Pollutants in Surface Water. USEPA-560/6-77-015 and USEPA-560/6-77-015A (1977) (3) Kaiser KLE et al; J Great Lakes Res 9: 212-23 (1983) (4) Malle KG; Z Wasser Abwasser Forsch 17: 75-81 (1984) (5) Grob K, Grob G; J Chrom 90: 303-13 (1974) (6) Schwarzenbach RP et al; Environ Sci Technol 13: 1367-73 (1979) (7) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985) (8) Gotz R et al; Chemosphere 36: 2085-2101 (1998)]**PEER REVIEWED**

SEAWATER: **Tetrachloroethylene** has been detected in seawater at concns of 0.1 to 0.8 parts per trillion(1,2). **Tetrachloroethylene** was detected in the Gulf of Mexico at concns of 0-40 parts per trillion(3). Surface water from the Eastern Pacific Ocean contained **tetrachloroethylene** at concns of 0.1-2.8 parts per trillion(4).
[(1) Murray AJ, Riley JP; Nature 242: 37-8 (1973) (2) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-32 (1975) (3)Sauer TC Jr; Org Geochem 3: 91-101 (1981) (4) Singh HB et al; J Geophys Res 88: 3675-83 (1983)]**PEER REVIEWED**

RAIN/SNOW: Tetrachloroetheylene was detected in rain from an industrial city in England at 150 parts per trillion(1). West Los Angeles (3/26/82) **tetrachloroethylene** was detected in rain at a concn of 21 parts per trillion(2). **Tetrachloroethylene** was detected in rain from La Jolla, California at 5.7 parts per trillion(3) and central and southern California at 1.4 and 2.3 parts per trillion, respectively(3).
[(1) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-32 (1975) (2) Kawamura K, Kaplan IR; Environ Sci Technol 17: 497-501 (1983) (3) Su C, Goldberg ED; Mar Poll Transfer 1976: 353-74 (1976)]**PEER REVIEWED**

Effluent Concentrations:

Tetrachloroethylene was detected in industrial effluent at concns of 1-20 ppb and in the effluent of municipal treatment plants at concns of 1-10 ppb(1). **Tetrachloroethylene** was released from the

Baltimore Municipal Treatment Plant at concns of 8-129 ppb(2). Maximum concns of **tetrachloroethylene** were reported in wastewater from the following industries: auto and laundry facilities, 93 ppm; aluminum forming facilities, 4 ppm; metal finishing plants; 110 ppm; organic chemical/plastic manufacturing plants, 5.1 ppm (mean value); paint and ink plants, 4.9 ppm(3). **Tetrachloroethylene** was detected in landfill gas from 7 waste sites in the United Kingdom at concns of 0.1-255 ng/cu m(4). **Tetrachloroethylene** was detected in the effluent of a municipal waste incinerator in Germany at 0.16 ug/cu m(5). **Tetrachloroethylene** was identified, not quantified, in water samples at 279 hazardous waste sites in the US(6).
[(1) STORET Data Base (2) Helz GR, Hsu RY; Limnol Oceanogr 23: 858-69 (1978) (3) US EPA; Treatability Manual. p.I.12.26-1 to I.12.26-5 USEPA-600/2-82-001A (1981) (4) Allen MR Environ Sci Technol 31: 1054-61 (1997) (5) Jay K, Stieglitz L; Chemosphere 30: 1249-60 (1995) (6) Johnson BL; Chemosphere 31: 2415-28 (1995)]**PEER REVIEWED**

Sediment/Soil Concentrations:

SOIL: **Tetrachloroethylene** was detected in soil samples from rural areas of the Netherlands at concns of 0.2-1.0 ug/kg(1). **Tetrachloroethylene** was identified, not quantified, in soil samples from a photocopier refurbishing plant in NY(2). **Tetrachloroethylene** was detected in soil from an industrial waste disposal site in Denmark at a concn of 19 mg/kg(3).
[(1) Hoekstra EJ et al; Chemosphere 38: 2875-83 (1999) (2) Pavlostathis SG, Zhuang P; Chemosphere 27: 586-96 (1993) (3) Broholm K et al; Environ Technol 12: 279-89 (1991)]**PEER REVIEWED**

SEDIMENT: **Tetrachloroethylene** was detected in sediment from 172 stations in Liverpool Bay, England at an avg concn of 4.8 parts per trillion(1). **Tetrachloroethylene** was detected in 25 of 359 sediment samples from the US at a median concn of less than 0.050 ppb(2). **Tetrachloroethylene** was detected in sediment from Ijmeer, Netherlands at concns of 0.02 and 0.07 mg/kg(3).
[(1) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-32 (1975) (2) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985) (3) Heida H; Contam Soil Int Conf 909-912 (1986)]**PEER REVIEWED**

Atmospheric Concentrations:

URBAN/SUBURBAN: The concentration of **tetrachloroethylene** at various US cities ranged from less than 0.2 to 9.75 ppb(1). **Tetrachloroethylene** mean concentrations from seven U.S. cities (1980-1981) ranged from 0.290-0.590 ppb with a max concn of 7.60 ppb(2).
[(1) Lillian D et al; Amer Chem Soc Symp Ser 17: 152-8 (1975) (2) Andelman JB; Environ Health Persp 62: 313-8 (1985)]**PEER REVIEWED**

INDOOR: The median concn of **tetrachloroethylene** inside 9 homes near Old Love Canal, Niagara, NY was reported as 71 parts per trillion(1). **Tetrachloroethylene** was detected in a classroom near a dry cleaning facility in the Netherlands at 1.9 ppb,(2) and a nursing home situated near a former chemical waste dump at 1.2 and 0.2 ppb on first and second floors, respectively(3).
[(1) Barkley J et al; Biomed Mass Spectron 7: 139-47 (1980) (2) Monster AC, Smolders JFJ; Int Arch Occup Environ Health 53: 331-6 (1984) (3) Herbert P et al; Chem Ind 24: 861-9 (1986)]**PEER REVIEWED**

RURAL/REMOTE: **Tetrachloroethylene** was detected in White Face Mountains, NY at concns of less than 0.02 to 0.19 ppb from September 16-19 1974(1). **Tetrachloroethylene** was detected in Barrows, Alaska at concns of 56-128 parts per trillion(2). The average concn of **tetrachloroethylene** in the northern hemisphere was reported as 40 parts per trillion(3).
[(1) Lillian D et al; Amer Chem Soc Symp Ser 17: 152-8 (1975) (2) Khalil MAK, Rasmussen RA; Environ Sci Technol 17: 157-64 (1983) (3) Singh HB et al; Atmospheric Distrbutions, Sources and Sinks of Selected Halocarbons, Hydrocarbons, SF6 and N20. USEPA-600/3-79-107 p. 88,117-8 (1979)]**PEER REVIEWED**

SOURCE DOMINATED: Typical concns of **tetrachloroethylene** in source dominated and industrial areas have been reported in the range of 0.3-1.5 ppb, with max concns of 10 ppb(1-5). **Tetrachloroethylene** was detected in Old Love Canal, Niagara, NY at a median concn of 109 parts per trillion(6). **Tetrachloroethylene** was detected around a playground near a dry cleaning facility in the Netherlands at 0.15 ppb(7). **Tetrachloroethylene** was detected in industrialized regions of Tsubame, Japan (0.019-0.23 ppb), Tokamachi, Japan (0.20-2.8 ppb) and Kubiki, Japan (0.024-0.63 ppb)(8).
[(1) Lillian D et al; Amer Chem Soc Symp Ser 17: 152-8 (1975) (2) Pellizzari ED; Quantation of Chlorinated Hydrocarbons in Previously Collected Air Samples. USEPA-450/3-78-112 (1978) (3) Singh HB et al; Environ Sci Technol 16: 872-80 (1982) (4) Su C, Goldberg ED; Mar Pollut Transfer pp. 353-74 (1976) (5) Leoy PJ et al; Atmos Environ 17: 2321-30 (1983) (6) Barkley J et al; Biomed Mass Spectron 7: 139-47 (1980) (7) Monster AC, Smolders JFJ; Int Arch Occup Environ Health 53: 331-6 (1984) (8) Kawata K et al; Bull Environ Contam Toxicol 57: 1-7 (1996)]**PEER REVIEWED**

Food Survey Values:

Tetrachloroethylene concentrations in foods ranged from non-detectable amounts (<0.01 ug/kg) in orange juice to 13 ug/kg in English butter.
[McConnell G et al; Endeavour 34: 13 as cited in USEPA; Ambient Water Quality Criteria Doc: Tetrachloroethylene p.C-1 (1980) EPA 440/5-80-073]**PEER REVIEWED**

Tetrachloroethylene was detected in Chinese style sauce (2 ppb), quince jelly (2.2 ppb), crab apple jelly (2.5 ppb), grape jelly (1.6 ppb) and chocolate sauce (3.6 ppb)(1). **Tetrachloroethylene** was detected in various food from England at concns of 0.01-0.13 ppb(2). **Tetrachloroethylene** was detected in 2 of 10 wheat samples at 1.8 and 2.1 ppb and 2 corn samples at 0.45 and 0.54 ppb(3). **Tetrachloroethylene** was detected in butter and margarine at concns of 0.7-18 ug/kg and peanut butter at concns of 0.6-9.7 ug/kg(4).
[(1) Entz RC, Hollifield HC; J Agric Food Chem 30: 84-88 (1982) (2) McConnell G et al; Endeavour 34: 13-18 (1975) (3) Heikes DL, Hopper ML; J Assoc Anal Chem 69: 990-98 (1986) (4) Page BD, Lacroix GM; J AOAC Int 78: 1416-28 (1995)]**PEER REVIEWED**

Plant Concentrations:

Tetrachloroethylene was detected in marine algae at concns of 13-23 ppb(1).
[(1) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-22 (1975)]**PEER REVIEWED**

Fish/Seafood Concentrations:

Tetrachloroethylene was detected at concns of 0.3-43 ppb in marine fish, 0.5-176 ppb in marine invertebrates in England(1), 250 ppb in American eel (Delaware River), 1,050 ppb in American eel (Newark Bay), 77 ppb in carp (Delaware River), 108 ppb in striped bass (Raritan River), 88 ppb in spot fish (Houston Ship Channel)(2). **Tetrachloroethylene** was detected in fish from the Rhine River and Lake Constance Germany at concns of 25-100 ppb(3). **Tetrachloroethylene** was detected in clams from the Ariho River, Japan at 0.6 ug/kg(4).
[(1) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-32 (1975) (2) Dickson AG, Riley JP; Mar Pollut Bull 7: 167-9 (1976) (3) Binnemann PH et al; A Lebensm - Unters Forsch 176: 253-61 (1983) (4) Gotoh M et al; Bull Environ Contam Toxicol 60: 74-80 (1998)]**PEER REVIEWED**

Animal Concentrations:

Tetrachloroethylene was detected at concns of 0.6-19 ppb in grey seal blubber (NE Coast of England)

and at concns of 1.4-39 ppb in marine and freshwater birds (coast of England)(1).
[(1) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-32 (1975)]**PEER REVIEWED**

Milk Concentrations:

Tetrachloroethylene was detected in 7 of 8 samples in mother's milk from 4 urban areas in the US(1). One hour after a visit to a dry cleaning plant, one sample of mother's milk contained 10 ppm **tetrachloroethylene**. This decreased to 3 ppm after 24 hr(2).
[(1) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982) (2) Jensen AA; Res Rev 89: 1-128 (1983)]**PEER REVIEWED**

Environmental Standards & Regulations:

Acceptable Daily Intakes:

Suggested No-Adverse-Response Level (SNARL): In light of the lack of definitive information regarding the quantitiy of **tetrachloroethylene** that must be ingested to depress psychophysiological function, it seems appropriate that calculations for a SNARL be based upon quantities of the chemical that are required to produce tissue injury. ... the 0.3 ml/kg (0.49 g/kg) dose appears to be a reasonable "minimum toxic dose" from which to calculate a 24-hr SNARL for contamination of drinking water, assuming that the sole source of **tetrachloroethylene** during this period will be from 2 l/day of drinking water consumed by a 70 kg human. A safety factor of 100 is applied: 490 mg/kg times 70 kg/100 times 2 l= 172 mg/l. The above considerations ignore the possibility that **tetrachloroethylene** may be carcinogenic. ... a 7-day standard for drinking water contamination, which was obtained by dividing the 24-hr standard by 7 (172 mg/l/7 days= 24.5 mg/l), should protect against adverse effects by the chemical.

[National Research Council. Drinking Water and Health. Volume 3. Washington, DC: National Academy Press, 1980. 140]**PEER REVIEWED**

TSCA Requirements:

Pursuant to section 8(d) of TSCA, EPA promulgated a model Health and Safety Data Reporting Rule. The section 8(d) model rule requires manufacturers, importers, and processors of listed chemical substances and mixtures to submit to EPA copies and lists of unpublished health and safety studies. **Tetrachloroethylene** is included on this list.
[40 CFR 716.120 (7/1/2000)]**PEER REVIEWED**

RCRA Requirements:

D039; A solid waste containing **tetrachloroethylene** may or may not become characterized as a hazardous waste when subjected to the Toxicity Characteristic Leaching Procedure listed in 40 CFR 261.24, and if so characterized, must be managed as a hazardous waste.
[40 CFR 261.24 (7/1/2000)]**PEER REVIEWED**

F002; When **tetrachloroethylene** is a spent halogenated solvent, it is classified as a hazardous waste from a nonspecific source (F002), as stated in 40 CFR 261.31, and must be managed according to state and/or federal hazardous waste regulations.
[40 CFR 261.31 (7/1/2000)]**PEER REVIEWED**

Atmospheric Standards:

Listed as a hazardous air pollutant (HAP) generally known or suspected to cause serious health problems. The Clean Air Act, as amended in 1990, directs EPA to set standards requiring major sources to sharply reduce routine emissions of toxic pollutants. EPA is required to establish and phase in specific performance based standards for all air emission sources that emit one or more of the listed pollutants. **Tetrachloroethylene** is included on this list.
[Clean Air Act as amended in 1990, Sect. 112 (b) (1) Public Law 101-549 Nov. 15, 1990]**PEER REVIEWED**

Clean Water Act Requirements:

Toxic pollutant designated pursuant to section 307(a)(1) of the Federal Water Pollution Control Act and is subject to effluent limitations.
[40 CFR 401.15 (7/1/2000)]**QC REVIEWED**

Federal Drinking Water Standards:

EPA 5 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

State Drinking Water Standards:

(FL) FLORIDA 3 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(NJ) NEW JERSEY 1 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

State Drinking Water Guidelines:

(AZ) ARIZONA 0.67 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(CT) CONNECTICUT 5 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(ME) MAINE 3 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(MN) MINNESOTA 7 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(WA) WASHINGTON 4 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee

(FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

C2-Cl4
PEER REVIEWED

Molecular Weight:

165.83
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-164]**PEER REVIEWED**

Color/Form:

Colorless liquid.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

Odor:

Ether-like odor
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 850]**PEER REVIEWED**

Mildly sweet, chloroform-like odor
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Chlorinated solvent odor
[Ruth JH; Am Ind Hyg Assoc J 47: A-142-51 (1986)]**PEER REVIEWED**

Boiling Point:

121.3 deg C
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-164]**PEER REVIEWED**

Melting Point:

-22.3 deg C
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-164]**PEER REVIEWED**

Corrosivity:

Corrosion of aluminum, iron, and zinc, which is negligible unless water is present, can be inhibited by the addition of stabilizers
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V6 (93) 52]**PEER REVIEWED**

Critical Temperature & Pressure:

347.1 deg C; 9.74 MPa (to convert MPa to atm, divide by 0.101)
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V6 (93) 52]**PEER REVIEWED**

Density/Specific Gravity:

1.6227 @ 20 deg C/4 deg C
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-164]**PEER REVIEWED**

Heat of Combustion:

679.9 kJ/mol (constant pressure with formation of aq hydrochloric acid; 831.8 kJ/mol (constant volume at 18.7 deg C) (to convert J to cal, divide by 4.184)
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V6 (93) 51]**PEER REVIEWED**

Heat of Vaporization:

90.2 BTU/lb= 50.1 cal/g= 2.10X10+5 J/kg
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Octanol/Water Partition Coefficient:

log Kow= 3.40
[Hansch, C., Leo, A., D. Hoekman. Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. Washington, DC: American Chemical Society., 1995. 3]**PEER REVIEWED**

Solubilities:

Miscible with alcohol, ether, chloroform, benzene
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1571]**PEER REVIEWED**

Miscible with solvent hexane; dissolves in most of the fixed and volatile oils
[Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980. 1184]**PEER REVIEWED**

0.015 G/100 ML WATER AT 25 DEG C
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 492 (1979)]**PEER REVIEWED**

Spectral Properties:

SADTLER REF NUMBER: 237 (IR, PRISM); 79 (IR, GRATING)
[Weast, R.C. (ed.). Handbook of Chemistry and Physics. 60th ed. Boca Raton, Florida: CRC Press Inc., 1979.,p. C-298]**PEER REVIEWED**

Index of Refraction: 1.5053 at 20 deg C/D
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-164]**PEER REVIEWED**

IR: 4786 (Coblentz Society Spectral Collection)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 627]**PEER REVIEWED**

MASS: 1053 (Atlas of Mass Spectral Data, John Wiley & Sons, New York)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 627]**PEER REVIEWED**

Surface Tension:

31.74 dynes/cm at 20 deg C in contact with vapor
[Weast, R.C. (ed.) Handbook of Chemistry and Physics, 68th ed. Boca Raton, Florida: CRC Press Inc., 1987-1988.,p. F-37]**PEER REVIEWED**

Vapor Density:

5.7 (AIR= 1)
[Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965. 213]**PEER REVIEWED**

Vapor Pressure:

18.5 mm Hg @ 25 deg C
[Riddick, J.A., W.B. Bunger, Sakano T.K. Techniques of Chemistry 4th ed., Volume II. Organic Solvents. New York, NY: John Wiley and Sons., 1985.]**PEER REVIEWED**

Relative Evaporation Rate:

EVAPORATION RATE SLOWER THAN THAT FOR TRICHLOROETHYLENE, ABOUT 3-1.
[Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965. 213]**PEER REVIEWED**

Viscosity:

Liquid: 0.932, 0.839, 0.657 & 0.534 CP at 15, 25, 50 & 75 deg C, respectively; Vapor: 9900 CP at 60 deg C
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V6 (93) 51]**PEER REVIEWED**

Other Chemical/Physical Properties:

Liquid-water interfacial tension: 44.4 dynes/cm= 0.0444 N/m at 25 deg C
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Conversion factors: 1 mg/l equals 147.4 ppm and 1 ppm equals 6.78 mg/cu m at 25 deg C, 760 mm Hg
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4208]**PEER REVIEWED**

Partition coefficients at 37 deg C for **tetrachloroethylene** into blood= 13.1; into oil= 1,920
[Sato A, Nakajima T; Scand J Work Environ Health 13: 81-93 (1987)]**PEER REVIEWED**

Sat concn in air: 126 g/cu m at 20 deg C, 210 g/cu m at 30 deg C
[Verschueren, K. Handbook of Environmental Data on Organic Chemicals. 3rd ed. New

York, NY: Van Nostrand Reinhold Co., 1996. 1674]**PEER REVIEWED**

DECOMP SLOWLY IN WATER TO YIELD TRICHLOROACETIC AND HYDROCHLORIC ACIDS; OXIDIZED BY STRONG OXIDIZING AGENTS
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 492 (1979)]**PEER REVIEWED**

Henry's law constant = 0.0177 atm-cu m/mole @ 25 deg C
[Gossett JM; Environ Sci Technol 21: 202-6 (1987)]**PEER REVIEWED**

Hydroxyl radical rate constant = 1.67X10-13 cu cm/molecule-sec @ 25 deg C
[Atkinson R; J Phys Chem Ref Data Monograph No. 2 (1994)]**PEER REVIEWED**

Chemical Safety & Handling:

Hazards Summary:

The major hazards encountered in the use and handling of **tetrachloroethylene** stem from its toxicologic properties. Exposure to this colorless liquid may occur from its use as a solvent and as an intermediate in chemical syntheses. In addition to eye and skin inflammation from contacting liquid **tetrachloroethylene**, inhalation of its vapor can cause central nervous system depression, liver necrosis, and effects on the lung, heart, and kidney. The ACGIH recommends a workplace limit (TLV) of 50 ppm as an 8 hr time-weighted average (TWA) with a note to prevent skin contact. **Tetrachloroethylene**'s sweet chloroform-like odor may warn of its presence at a sub-TLV level of 4.68 ppm; however, to assure against exposure, it is recommended that self-contained breathing apparatus and full protective clothing be worn, especially in fire or spill situations. Although considered nonflammable, containers of **tetrachloroethylene** may explode in the heat of a fire and its vapor will decompose in contact with open flames or red-heated materials to yield the poisonous gas, phosgene. For small fires involving **tetrachloroethylene**, extinguish with dry chemical or CO2, and for large fires, use water spray, fog, or foam. Cool containers with water. If the fire involves a tank car or truck, isolate the area for 1/2 mile in all directions. **Tetrachloroethylene** should be stored in a cool, dry, well-ventilated location, away from strong oxidizers, potential fire hazards, caustic soda, potash, and chemically active metals such as barium, lithium, and beryllium. For small spills of **tetrachloroethylene**, ventilate the area then take up with vermiculite, dry sand, or earth. Large spills should be diked for later disposal. Prior to implementing land disposal of waste residues (including waste sludge), consult environmental regulatory agencies for guidance.
PEER REVIEWED

DOT Emergency Guidelines:

Health: Vapors may cause dizziness or suffocation. Exposure in an enclosed area may be very harmful. Contact may irritate or burn skin and eyes. Fire may produce irritating and/or toxic gases. Runoff from fire control or dilution water may cause pollution.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

Fire or explosion: Some of these materials may burn, but none ignite readily. Most vapors are heavier than air. Air/vapor mixtures may explode when ignited. Container may explode in heat of fire.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

Public safety: CALL Emergency Response Telephone Number ... . Isolate spill or leak area immediately for at least 25 to 50 meters (80 to 160 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Many gases are heavier than air and will spread along ground and collect in low or confined areas (sewers, basements, tanks). Keep out of low areas. Ventilate closed spaces before entering.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

Protective clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Structural firefighters' protective clothing will only provide limited protection.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

Evacuation: ... Fire: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

Fire: Small fires: Dry chemical, CO2 or water spray. Large fires: Dry chemical, CO2, alcohol-resistant foam or water spray. Move containers from fire area if you can do it without risk. Dike fire control water for later disposal; do not scatter the material. Fire involving tanks or car/trailer loads: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

Spill or leak: Eliminate all ignition sources (no smoking, flares, sparks or flames in immediate area). Stop leak if you can do it without risk. Small liquid spills: Take up with sand, earth or other noncombustible absorbent material. Large spills: Dike far ahead of liquid spill for later disposal. Prevent entry into waterways, sewers, basements or confined areas.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

First aid: Move victim to fresh air. Call 911 or emergency medical service. Apply artificial respiration if victim is not breathing. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. For minor skin contact, avoid spreading material on unaffected skin. Wash skin with soap and water. Keep victim warm and quiet. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

Odor Threshold:

The distinctive odor of **tetrachloroethylene** does not necessarily provide adequate warning. Because **tetrachloroethylene** quickly desensitizes olfactory responses, persons can suffer exposure to vapor concentrations in excess of TLV limits without smelling it.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 5(79) 761]**PEER REVIEWED**

Recognition in air: 4.68 ppm (chemically pure)
[Fazzalari, F.A. (ed.). Compilation of Odor and Taste Threshold Values Data. ASTM Data Series DS 48A (Committee E-18). Philadelphia, PA: American Society for Testing and Materials, 1978. 155]**PEER REVIEWED**

Perchloroethylene has a not unpleasant etheral or aromatic odor. ... 50 ppm, odor threshold (very faint) to unacclimated; no physiological effects (8 hr). 100 ppm, odor (faint) definitely apparent to unacclimated; very faint to not perceptible during exposure; no physiological effects (8 hr). 200 ppm, odor (definite) moderate to faint upon exposure; faint to moderate eye irritation; minimal light-headedness; (eye irritation threshold 100-200 ppm). 400 ppm, odor (strong) unpleasant; definite eye irritation, slight nasal irritation; definite incoordination (2 hr). 600 ppm, odor (strong) very unpleasant but tolerable; definite eye & nasal irritation; dizziness, loss of inhibitions (10 min). 1000 ppm, odor (very strong) intense, irritating; markedly irritating to eyes & resp tract; considerable dizziness (2 min). 1500 ppm, odor (almost intolerable) "gagging"; irritation almost intolerable to eyes & nose; complete incoordination within minutes to unconsciousness within 30 min.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4240]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Eye exposure can lead to conjunctivitis; Skin exposure can lead to inflamation; Inhalation can lead to respiratory tract irritation.
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 507]**PEER REVIEWED**

Tetrachloroethylene vapor is a mucous membrane & upper resp irritant at levels above 75 to 100 ppm.
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 986]**PEER REVIEWED**

Flash Point:

No flash point in conventional closed tester.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-125]**PEER REVIEWED**

Fire Fighting Procedures:

Approach from upwind to avoid hazardous vapors and toxic decomposition products. Use water spray to keep fire-exposed containers cool. Use flooding quantities of water as fog or spray. Extinguish fire using agent suitable for surrounding fire.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-125]**PEER REVIEWED**

Toxic Combustion Products:

Combustion by-products may include hydrogen chloride and phosgene.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-125]**PEER REVIEWED**

Explosive Limits & Potential:

Mixtures with lithium shavings ... are impact-sensitive and will explode, sometimes violently.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA:

Butterworth-Heinemann Ltd., 1990 1315]**PEER REVIEWED**

The presence of 0.5% of trichloroethylene as impurity in **tetrachloroethylene** during unheated drying over solid sodium hydroxide caused the generation of dichloroacetylene. After subsequent fractional distillation, the volatile fore-run exploded.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 211]**PEER REVIEWED**

Mixtures of /dinitrogen/ tetraoxide with ... **tetrachloroethylene** are explosive when subjected to shock of 25 g TNT equivalent or less.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1352]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

Granular barium in contact with ... **tetrachloroethylene** ... is susceptible to detonation.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 78]**PEER REVIEWED**

Reacts with metals to form explosive mixtures; Sodium hydroxide, possible explosion.
[ITII. Toxic and Hazarous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1982. 696]**PEER REVIEWED**

Several cases of violent reaction between aluminum and ... **tetrachloroethylene** in vapor degreasers have been noted.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 26]**PEER REVIEWED**

Strong oxidizers; chemically-active metals such as lithium, beryllium, and barium; caustic soda; sodium hydroxide; potash.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

Strong oxidizers; chemically active metals such as lithium, beryllium & barium; caustic soda; sodium hydroxide; potash.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

Hazardous Decomposition:

When in contact with activated charcoal decomposes to form hexachloroethane and hexachlorobenzene at 700 deg C.
[Gonikberg MG et al; Bul Acad Sci USSR Dir Chem Sci p.739 (1956)]**PEER REVIEWED**

... decomposes slowly in contact with moisture to yield trichloroacetic acid and hydrochloric acid
[WHO; Environ Health Criteria: Tetrachloroethylene p.9 (1984)]**PEER REVIEWED**

It affords various decomp products depending on conditions, but mostly hydrogen chloride & phosgene.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 5(79) 754]**PEER REVIEWED**

... If involved in a fire decomposes to produce hydrogen chloride and phosgene.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-125]**PEER REVIEWED**

Prior History of Accidents:

On September 28, 1982, an Illinois Gulf Railroad freight train derailed 43 cars in Livingston, Louisiana. Thirty-six cars were tank cars, of which 27 contained various regulated hazardous or toxic chemical commodities, 2 contained nonregulated hazardous materials, and 5 contained flammable petroleum products. Fires resulted and toxic gases were released into the atmosphere. Residents within a 5 mile radius of the derailment were evacuated for up to two weeks. More than 200,000 gal of toxic chemical products were spilled and absorbed into the ground. Extensive excavation of the contaminated soil and its transportation to a distant dump site were required. Property damage was estimated to be greater than 14 million dollars and long-term closure of the railroad line and adjacent highway resulted. ... Evacuation of the residents was accomplished successfully although no contingency plan had been developed. The effort to contain and remove chemical pollution resulting from the derailment was directed effectively by the Louisiana Department of Natural Resources. The principal problem was **tetrachloroethylene**... .
[Nat Transp Safety Board; Railroad Accident Report: Derailment of Illinois Central Gulf Railroad Freight Train Extra 9629 East and Release of Hazardous Materials at Livingston, LA on September 28, 1982 80 pp. (1983) NTSB/RAR-83105]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH has recommended that **tetrachloroethylene** be treated as a potential human carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

Protective Equipment & Clothing:

FOR HIGH VAPOR CONCN USE APPROVED CANISTER OR AIR-SUPPLIED MASK; CHEMICAL GOGGLES OR FACE SHIELD; PLASTIC GLOVES.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... dispensers of liq detergent /should be available./ ... Safety pipettes should be used for all pipetting. ... In animal laboratory, personnel should ... wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. ... gowns ... /should be/ of distinctive color, this is a reminder that they are not to be worn outside the laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

Wear appropriate personal protective clothing to prevent skin contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

Eyewash fountains should be provided in areas where there is any possbility that workers could be exposed to the substance; this is irrespective of the recommendation involving the wearing of eye protection.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140.

Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

Facilities for quickly drenching the body should be provided within the immediate work area for emergency use where there is a possibility of exposure. [Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from any body areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.]
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

Recommendations for respirator selection. Condition: At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration. Respirator Class(es): Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive pressure mode. Any supplied-air respirator that has a full face piece and is operated in pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Escape from suddenly occurring respiratory hazards: Respirator Class(es): Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister. Any appropriate escape-type, self-contained breathing apparatus.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

Preventive Measures:

Contact lenses should not be worn when working with this chemical.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

SRP: The scientific literature for the use of contact lenses in industry is conflicting. The benefit or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In any event, the usual eye protection equipment should be worn even when contact lenses are in place.
PEER REVIEWED

The worker should immediately wash the skin when it becomes contaminated.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 301]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Smoking, drinking, eating, storage of food or of food & beverage containers or utensils, & the application of cosmetics should be prohibited in any laboratory. All personnel should remove gloves, if worn, after completion of procedures in which carcinogens have been used. They should ... wash ... hands, preferably using dispensers of liq detergent, & rinse ... thoroughly. Consideration should be given to appropriate methods for cleaning the skin, depending on nature of the contaminant. No standard procedure can be recommended, but the use of organic solvents should be avoided. Safety pipettes should be used for all pipetting. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer,

A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": In animal laboratory, personnel should remove their outdoor clothes & wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... clothing should be changed daily but ... discarded immediately if obvious contamination occurs ... /also,/ workers should shower immediately. In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. If gowns are of distinctive color, this is a reminder that they should not be worn outside of lab. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... operations connected with synth & purification ... should be carried out under well-ventilated hood. Analytical procedures ... should be carried out with care & vapors evolved during ... procedures should be removed. ... Expert advice should be obtained before existing fume cupboards are used ... & when new fume cupboards are installed. It is desirable that there be means for decreasing the rate of air extraction, so that carcinogenic powders can be handled without ... powder being blown around the hood. Glove boxes should be kept under negative air pressure. Air changes should be adequate, so that concn of vapors of volatile carcinogens will not occur. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Vertical laminar-flow biological safety cabinets may be used for containment of in vitro procedures ... provided that the exhaust air flow is sufficient to provide an inward air flow at the face opening of the cabinet, & contaminated air plenums that are under positive pressure are leak-tight. Horizontal laminar-flow hoods or safety cabinets, where filtered air is blown across the working area towards the operator, should never be used ... Each cabinet or fume cupboard to be used ... should be tested before work is begun (eg, with fume bomb) & label fixed to it, giving date of test & avg air-flow measured. This test should be repeated periodically & after any structural changes. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Principles that apply to chem or biochem lab also apply to microbiological & cell-culture labs ... Special consideration should be given to route of admin. ... Safest method of administering volatile carcinogen is by injection of a soln. Admin by topical application, gavage, or intratracheal instillation should be performed under hood. If chem will be exhaled, animals should be kept under hood during this period. Inhalation exposure requires special equipment. ... unless specifically required, routes of admin other than in the diet should be used. Mixing of carcinogen in diet should be carried out in sealed mixers under fume hood, from which the exhaust is fitted with an efficient particulate filter. Techniques for cleaning mixer & hood should be devised before expt begun. When mixing diets, special protective clothing &, possibly, respirators may be required. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer,

A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When ... admin in diet or applied to skin, animals should be kept in cages with solid bottoms & sides & fitted with a filter top. When volatile carcinogens are given, filter tops should not be used. Cages which have been used to house animals that received carcinogens should be decontaminated. Cage-cleaning facilities should be installed in area in which carcinogens are being used, to avoid moving of ... contaminated /cages/. It is difficult to ensure that cages are decontaminated, & monitoring methods are necessary. Situations may exist in which the use of disposable cages should be recommended, depending on type & amt of carcinogen & efficiency with which it can be removed. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": To eliminate risk that ... contamination in lab could build up during conduct of expt, periodic checks should be carried out on lab atmospheres, surfaces, such as walls, floors & benches, & ... interior of fume hoods & airducts. As well as regular monitoring, check must be carried out after cleaning-up of spillage. Sensitive methods are required when testing lab atmospheres for chem such as nitrosamines. Methods ... should ... where possible, be simple & sensitive. ... /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Rooms in which obvious contamination has occurred, such as spillage, should be decontaminated by lab personnel engaged in expt. Design of expt should ... avoid contamination of permanent equipment. ... Procedures should ensure that maintenance workers are not exposed to carcinogens. ... Particular care should be taken to avoid contamination of drains or ventilation ducts. In cleaning labs, procedures should be used which do not produce aerosols or dispersal of dust, ie, wet mop or vacuum cleaner equipped with high-efficiency particulate filter on exhaust, which are avail commercially, should be used. Sweeping, brushing & use of dry dusters or mops should be prohibited. Grossly contaminated cleaning materials should not be re-used ... If gowns or towels are contaminated, they should not be sent to laundry, but ... decontaminated or burnt, to avoid any hazard to laundry personnel. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Doors leading into areas where carcinogens are used ... should be marked distinctively with appropriate labels. Access ... limited to persons involved in expt. ... A prominently displayed notice should give the name of the Scientific Investigator or other person who can advise in an emergency & who can inform others (such as firemen) on the handling of carcinogenic substances. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.11]**PEER REVIEWED**

The worker should immediately wash the skin when it becomes contaminated.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140.

Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed or replaced.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

Stability/Shelf Life:

RAPIDLY DETERIORATES IN WARM CLIMATES
[Goodman, L.S., and A. Gilman. (eds.) The Pharmacological Basis of Therapeutics. 5th ed. New York: Macmillan Publishing Co., Inc., 1975. 1031]**PEER REVIEWED**

Tetrachloroethylene is stable up to 500 deg C in the absence of catalysts, moisture, and oxygen.
[WHO; Environ Health Criteria: Tetrachloroethylene p.9 (1984)]**PEER REVIEWED**

THE MATERIAL IS EXTREMELY STABLE & RESISTS HYDROLYSIS
[Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984. 2518]**PEER REVIEWED**

PURE CMPD IS SLOWLY DECOMP BY VARIOUS METALS IN PRESENCE OF MOISTURE
[Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980. 1177]**PEER REVIEWED**

The physical stability of emulsions of **tetrachloroethylene** can be enhanced by diluting the **tetrachloroethylene** with arachis oil before emulsification. This practice may be harmful because the oil increases the absorption, & thus the toxicity, of the drug.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 107]**PEER REVIEWED**

Shipment Methods and Regulations:

PRECAUTIONS FOR "CARCINOGENS": Procurement ... of unduly large amt ... should be avoided. To avoid spilling, carcinogens should be transported in securely sealed glass bottles or ampoules, which should themselves be placed inside strong screw-cap or snap-top container that will not open when dropped & will resist attack from the carcinogen. Both bottle & the outside container should be appropriately labelled. ... National post offices, railway companies, road haulage companies & airlines have regulations governing transport of hazardous materials. These authorities should be consulted before ... material is shipped. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When no regulations exist, the following procedure must be adopted. The carcinogen should be enclosed in a securely sealed, watertight container (primary container), which should be enclosed in a second, unbreakable, leakproof container that will withstand chem attack from the carcinogen (secondary container). The space between primary & secondary container should be filled with absorbent material, which would withstand chem attack from the carcinogen & is sufficient to absorb the entire contents of the primary container in the event of breakage or leakage. Each secondary container should then be enclosed in a strong outer box. The space between the secondary container & the outer box should be filled with an appropriate quantity of shock-absorbent material. Sender should use fastest & most secure form of transport & notify recipient of its departure. If parcel is not received when expected, carrier should be informed so that immediate effort can be made to find it. Traffic schedules should be consulted to avoid ... arrival on weekend or holiday ... /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

No person may /transport,/ offer or accept a hazardous material for transportation in commerce unless that person is registered in conformance ... and the hazardous material is properly classed, described, packaged, marked, labeled, and in condition for shipment as required or authorized by ... /the hazardous materials regulations (49 CFR 171-177)./
[49 CFR 171.2 (7/1/2000)]**PEER REVIEWED**

The International Air Transport Association (IATA) Dangerous Goods Regulations are published by the IATA Dangerous Goods Board pursuant to IATA Resolutions 618 and 619 and constitute a manual of industry carrier regulations to be followed by all IATA Member airlines when transporting hazardous materials.
[IATA. Dangerous Goods Regulations. 41st Ed.Montreal, Canada and Geneva, Switzerland: International Air Transport Association, Dangerous Goods Regulations, 2000. 224]**PEER REVIEWED**

The International Maritime Dangerous Goods Code lays down basic principles for transporting hazardous chemicals. Detailed recommendations for individual substances and a number of recommendations for good practice are included in the classes dealing with such substances. A general index of technical names has also been compiled. This index should always be consulted when attempting to locate the appropriate procedures to be used when shipping any substance or article.
[IMDG; International Maritime Dangerous Goods Code; International Maritime Organization p.6264 (1998)]**PEER REVIEWED**

Storage Conditions:

STORE IN COOL, DRY, WELL-VENTILATED LOCATION. SEPARATE FROM ACTIVE METALS. ISOLATE FROM OPEN FLAMES, AND COMBUSTIBLES.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-125]**PEER REVIEWED**

It is stored in mild steel tanks equipped with breathing vents & chemical driers. It can be transferred through seamless black iron pipes, with gasketing materials of compressed asbestos, asbestos reinforced with metal, or asbestos impregnated with Teflon or Viton, employing centrifugal or positive displacement pumps of cast iron or steel construction. Small quantities ... may be stored safely in green or amber glass containers.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. 5(79) 759]**PEER REVIEWED**

TEMPERATURE: AMBIENT. VENTING: PRESSURE-VACUUM.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Storage site should be as close as practicable to lab in which carcinogens are to be used, so that only small quantities required for ... expt need to be carried. Carcinogens should be kept in only one section of cupboard, an explosion-proof refrigerator or freezer (depending on chemicophysical properties ...) that bears appropriate label. An inventory ... should be kept, showing quantity of carcinogen & date it was acquired ... Facilities for dispensing ... should be contiguous to storage area. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France:

International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

Cleanup Methods:

1. VENTILATE AREA OF SPILL OR LEAK. 2. COLLECT FOR RECLAMATION OR ABSORB IN VERMICULITE, DRY SAND, EARTH, OR A SIMILAR MATERIAL.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.4]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": A high-efficiency particulate arrestor (HEPA) or charcoal filters can be used to minimize amt of carcinogen in exhausted air ventilated safety cabinets, lab hoods, glove boxes or animal rooms ... Filter housing that is designed so that used filters can be transferred into plastic bag without contaminating maintenance staff is avail commercially. Filters should be placed in plastic bags immediately after removal ... The plastic bag should be sealed immediately ... The sealed bag should be labelled properly ... Waste liquids ... should be placed or collected in proper containers for disposal. The lid should be secured & the bottles properly labelled. Once filled, bottles should be placed in plastic bag, so that outer surface ... is not contaminated ... The plastic bag should also be sealed & labelled. ... Broken glassware ... should be decontaminated by solvent extraction, by chemical destruction, or in specially designed incinerators. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

Approach release from upwind. Stop or control the leak, if this can be done without undue risk. Control runoff and isolate discharged material for proper disposal.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-125]**PEER REVIEWED**

Disposal Methods:

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste number F002; U210, must conform with USEPA regulations in storage, transportation, treatment and disposal of waste.
[40 CFR 240-280, 300-306, 702-799 (7/1/2000)]**PEER REVIEWED**

TETRACHLOROETHYLENE MAY BE DISPOSED OF BY ABSORBING IT IN VERMICULITE, DRY SAND, EARTH OR SIMILAR MATERIAL & DISPOSING IN A SECURED SANITARY LANDFILL /SRP: MORE DESIRABLE METHODS OF DISPOSAL ARE AVAILABLE/
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.5]**PEER REVIEWED**

... Tower aeration is the most cost-effective technique for removing volatile organic chlorine chemicals from drinking water. /Volatile organic chlorine chemicals/
[Clark RM et al; J Environ Eng 110 (6): 1146-62 (1984)]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": There is no universal method of disposal that has been proved satisfactory for all carcinogenic compounds & specific methods of chem destruction ... published have not been tested on all kinds of carcinogen-containing waste. ... summary of avail methods & recommendations ... /given/ must be treated as guide only. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer,

A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.14]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Total destruction ... by incineration may be only feasible method for disposal of contaminated laboratory waste from biological expt. However, not all incinerators are suitable for this purpose.The most efficient type ... is probably the gas-fired type, in which a first-stage combustion with a less than stoichiometric air:fuel ratio is followed by a second stage with excess air. Some ... are designed to accept ... aqueous & organic-solvent solutions, otherwise it is necessary ... to absorb soln onto suitable combustible material, such as sawdust. Alternatively, chem destruction may be used, esp when small quantities ... are to be destroyed in laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": HEPA (high-efficiency particulate arrestor) filters ... can be disposed of by incineration. For spent charcoal filters, the adsorbed material can be stripped off at high temp & carcinogenic wastes generated by this treatment conducted to & burned in an incinerator. ... LIQUID WASTE: ... Disposal should be carried out by incineration at temp that ... ensure complete combustion. SOLID WASTE: Carcasses of lab animals, cage litter & misc solid wastes ... should be disposed of by incineration at temp high enough to ensure destruction of chem carcinogens or their metabolites. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... small quantities of ... some carcinogens can be destroyed using chem reactions ... but no general rules can be given. ... As a general technique ... treatment with sodium dichromate in strong sulfuric acid can be used. The time necessary for destruction ... is seldom known ... but 1-2 days is generally considered sufficient when freshly prepd reagent is used. ... Carcinogens that are easily oxidizable can be destroyed with milder oxidative agents, such as sat soln of potassium permanganate in acetone, which appears to be a suitable agent for destruction of hydrazines or of compounds containing isolated carbon-carbon double bonds. Concn or 50% aqueous sodium hypochlorite can also be used as an oxidizing agent. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.16]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Carcinogens that are alkylating, arylating, or acylating agents per se can be destroyed by reaction with appropriate nucleophiles, such as water, hydroxyl ions, ammonia, thiols, & thiosulfate. The reactivity of various alkylating agents varies greatly ... & is also influenced by sol of agent in the reaction medium. To facilitate the complete reaction, it is suggested that the agents be dissolved in ethanol or similar solvents. ... No method should be applied ... until it has been thoroughly tested for its effectiveness & safety on material to be inactivated. For example, in case of destruction of alkylating agents, it is possible to detect residual compounds by reaction with 4(4-nitrobenzyl)-pyridine. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.17]**PEER REVIEWED**

Chemical Treatability of **Tetrachloroethylene**; Concentration Process: Activated carbon; Chemical Classification: Halocarbon; Scale of Study: Laboratory scale; Type of Wastewater Used: Well water; Results of Study: Performance for treatment of water containing several halogens. Virgin: 5100 BV to 33 ppb compound leakage; 13.3 days; gal treated/cu ft sorbent, 38,250. Regenerated: 4000 BV to 33 ppb compound leakage; 10.4 days; gal treated/cu ft sorbent, 30.0; (column studies 14 mm diameter glass tubes, height 4 in (15 cu cm absorbent) Flow-2 gpm/cu ft (16 BV/hr) regenerated at 37 lb steam/cu ft @ 5 psig).
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-159 (1982)]**PEER REVIEWED**

Chemical Treatability of **Tetrachloroethylene**; Concentration Process: Resin Adsorption; Chemical Classification: Halocarbon; Scale of Study: Laboratory Scale; Type of Wastewater Used: Well Water; Comments: Column studies: 14 mm diameter glass tubes, height 4 in (15 cu cm adsorbent) Flow-2 gpm/cu ft (16 BV/hr) regenerated at 37 lb steam/cu ft @ 5 psig.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-192 (1982)]**PEER REVIEWED**

A potential candidate for liquid injection incineration at a temperature range of 650 to 1,600 deg C and a residence time of 0.1 to 2 seconds. A potential candidate for rotary kiln incineration at a temperature range of 820 to 1,600 deg C and residence times of seconds for liquids and gases, and hours for solids. A potential candidate for fluidized bed incineration at a temperature range of 450 to 980 deg C and residence times of seconds for liquids and gases, and longer for solids.
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-15 (1981) EPA 68-03-3025]**PEER REVIEWED**

Incineration, preferably after mixing with another combustible fuel. Care must be exercised to assure complete combustion to prevent the formation of phosgene. An acid scrubber is necessary to remove the halo acids produced. Alternatively, it may be recovered from waste gases and reused. Recommendable method: Incineration.
[United Nations. Treatment and Disposal Methods for Waste Chemicals (IRPTC File). Data Profile Series No. 5. Geneva, Switzerland: United Nations Environmental Programme, Dec. 1985. 180]**PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

Permissible Exposure Limit: Table Z-2 8-hr Time Weighted Avg: 100 ppm.
[29 CFR 1910.1000 (7/1/2000)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-2 Acceptable Ceiling Concentration: 200 ppm.
[29 CFR 1910.1000 (7/1/2000)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-2 Acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift. Concentration: 300 ppm. Maximum Duration: 5 minutes in any 3 hours.
[29 CFR 1910.1000 (7/1/2000)]**PEER REVIEWED**

Vacated 1989 OSHA PEL TWA 25 ppm (170 mg/cu m) is still enforced in some states.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 372]**PEER REVIEWED**

Threshold Limit Values:

8 hr Time Weighted Avg (TWA) 25 ppm; Short Term Exposure Limit (STEL) 100 ppm
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 55]**PEER REVIEWED**

BEI (Biological Exposure Index) for **Perchloroethylene**: **Perchloroethylene** in end-exhaled air prior to the last shift of workweek is 5 ppm. (1997 adoption)
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 101]**PEER REVIEWED**

BEI (Biological Exposure Index) for **Perchloroethylene**: **Perchloroethylene** in blood prior to the last shift of workweek is 0.5 mg/l. (1997 adoption)
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 101]**PEER REVIEWED**

BEI (Biological Exposure Index) for **Perchloroethylene**: Trichloroacetic acid in urine at end of shift at end of workweek is 3.5 mg/l. The determinant is nonspecific, since it is observed after exposure to other chemicals. The biological determinant is an indicator of exposure to the chemical, but the quantitative interpretation of the measurement is ambiguous. These determinants should be used as a screening test if a quantitative test is not practical or as a confirmatory test if the quantitative test is not specific and the origin of the determinant is in question. (1997 Adoption)
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 101]**PEER REVIEWED**

A3: Confirmed animal carcinogen with unknown relevance to humans.
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 55]**PEER REVIEWED**

NIOSH Recommendations:

NIOSH recommends that **tetrachloroethylene** be regulated as a potential human carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

NIOSH usually recommends that occupational exposures to carcinogens be limited to the lowest feasible concn.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

Minimize workplace exposure concentrations; limit number of workers exposed.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH has recommended that **tetrachloroethylene** be treated as a potential human carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 300]**PEER REVIEWED**

Other Occupational Permissible Levels:

Maximum allowable concentrations range from 10 mg/cu m (1.5 ppm, ceiling value) in the USSR, 140 mg/cu m (20 ppm, TWA) in Sweden, and 250 mg/cu m (37 ppm) in Czechoslovakia to 340 mg/cu m (50

ppm) in the Federal Republic of Germany, Japan. Short-term exposure limits range from 340 mg/cu m (50 ppm) in Sweden to 1250 mg/cu m (183 ppm) in Czechoslovakia and 1340 mg/cu m (200 ppm) in the USA. The acceptable limit in Brazil is 525 mg/cu m (78 ppm) for 48 hr per week.
[WHO; Environ Health Criteria: Tetrachloroethylene p.35 (1984)]**PEER REVIEWED**

Maximum allowable concentrations are 1.0 mg/cu m average per day or 4.0 mg/cu m average per 0.5 hr in Czechoslovakia and 0.06 mg/cu m average per day in the USSR.
[WHO; Environ Health Criteria: Tetrachloroethylene p.35 (1984)]**PEER REVIEWED**

Emergency Response Planning Guidelines (ERPG): ERPG(1) 100 ppm (no more than mild, transient effects) for up to 1 hr exposure; ERPG(2) 200 ppm (without serious, adverse effects) for up to 1 hr exposure; ERPG(3) 1000 ppm (not life threatening) up to 1 hr exposure.
[American Industrial Hygiene Association. The AIHA 2000 Emergency Response Planning Guidelines and Workplace Environmental Exposure Level Guides Handbook. AIHA Press, Fairfax, VA. 2000. 27]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

For **Tetrachloroethylene** (USEPA/OPP Pesticide Code: 078501) there are 0 labels match. /SRP: Not registered for current use in the U.S., but approved pesticide uses may change periodically and so federal, state and local authorities must be consulted for currently approved uses./
[U.S. Environmental Protection Agency/Office of Pesticide Program's Chemical Ingredients Database on Tetrachloroethylene (127-18-4). Available from the Database Query page at http://www.cdpr.ca.gov/docs/epa/epamenu.htm as of Sept 8, 2000.]**PEER REVIEWED**

Used in the textile industry for dry-cleaning & for processing & finishing; used in both cold cleaning & vapor degreasing of metals; it is used as a chem intermediate in the synthesis of fluorocarbon 113, 114, 115, & 116; it is used as a heat-exchange fluid
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 494 (197)]**PEER REVIEWED**

SCOURING, SIZING & DESIZING AGENT IN TEXTILE MANUFACTURE
[SRI]**PEER REVIEWED**

COMPONENT OF AEROSOL LAUNDRY-TREATMENT PRODUCTS
[SRI]**PEER REVIEWED**

SOLVENT, EG, FOR SILICONES
[SRI]**PEER REVIEWED**

Insulating fluid and cooling gas in electric transformers
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1571]**PEER REVIEWED**

In typewriter correction fluids (eg, Liquid Paper, Wite-Out, Snopake, etc)
[Greer JE; South Med J 77 (3): 297-8 (1984)]**PEER REVIEWED**

Formerly used, but no longer approved, in mixtures with grain protectants and certain liquid grain fumigants
[Farm Chemicals Handbook 87. Willoughby, Ohio: Meister Publishing Co., 1987.,p. C-248]**PEER REVIEWED**

MEDICATION (VET): After the advent of phenothiazine ... little use has been made of the chlorinated hydrocarbons ... /as a ruminant anthelmintic/. **Tetrachloroethylene** has continued to be used in small animals over the years but has been largely replaced by drugs that are less toxic & easier to admin.
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 839]**PEER REVIEWED**

Manufacturers:

Dow Chemical USA, Hq 2030 Dow Center, Midland, MI 48674, (517) 636-1000; Production site: Plaquemine, LA 70764
[SRI. 1999 Directory of Chemical Producers -United States. Menlo Park, CA. SRI Consulting 1999.. 780]**PEER REVIEWED**

PPG Industries, Inc, Hq One PPG Place, Pittsburgh, PA 15272, (412) 434-3131; Production site: Chemicals Group, Lake Charles, LA 70601
[SRI. 1999 Directory of Chemical Producers -United States. Menlo Park, CA. SRI Consulting 1999.. 780]**PEER REVIEWED**

Vulcan Materials Company, Metal Division, Hq, PO Box 530930, Birmingham, AL 35253, (205) 877-3000; Vulcan Chemicals, division, PO Box 7689, Birmingham, AL 35253; Production site: Geismar, LA 70734
[SRI. 1999 Directory of Chemical Producers -United States. Menlo Park, CA. SRI Consulting 1999.. 780]**PEER REVIEWED**

Methods of Manufacturing:

Manufactured by catalytic oxidn of 1,1,2,2-tetrachloroethane: Ellsworth, vancamp, US patent 2,951,103 (1960 to Columbia-Southern Chem); Feathers, Rogerson, US patent 3,040,109 (1962 to Pittsburgh Plate Glass) ... by catalytic chlorination of acetylene: Thermet, Parvi, US patent 2,938,931 (1960 to Societe d'electrochimie, d'electrometallurgie et des acieries electriques d'Ugine).
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1571]**PEER REVIEWED**

Prepared primarily by two processes: (1) The Huels method whereby direct chlorination of ethylene yields 70% **perchloroethylene**, 20% carbon tetrachloride, and 10% other chlorinated products; (2) Hydrocarbons such as methane, ethane, or propane are simultaneously chlorinated and pyrolyzed to yield over 95% **perchloroethylene** plus carbon tetrachloride and hydrochloric acid.
[Fishbein L; Potential Indust Carcin & Mutagens p.148 (1977) USEPA 560/5-77-005]**PEER REVIEWED**

Tetrachloroethylene is produced mainly by oxyhydrochlorination, perchlorination, and/or dehydrochlorination of hydrocarbons or chlorinated hydrocarbons such as 1,2 dichloroethane, propylene, propylene dichloride, and 1,1,2-trichloroethane.
[WHO; Environ Health Criteria: Tetrachloroethylene p.15 (1984)]**PEER REVIEWED**

General Manufacturing Information:

Method of purification: distillation
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 850]**PEER REVIEWED**

Formulations/Preparations:

Available in the United States ... in veterinary preparations (eg, Nema Worm Capsules (Parke-Davis)). These capsules contain pure **tetrachloroethylene**. Avail sizes are 0.2, 0.5, 1.0, 2.5 & 5 ml.
[American Medical Association, Department of Drugs. Drug Evaluations. 6th ed. Chicago, Ill: American Medical Association, 1986. 1612]**PEER REVIEWED**

Tetrachloroethylene is avail in the USA in the following grades: purified, technical, USP, spectrophotometric, & dry-cleaning. The technical & dry-cleaning grades both meet specifications for technical grade & differ only in the amount of stabilizer added to prevent decomposition. Stabilizers ... incl amines or mixtures of epoxides & esters. Typical analysis of the commercial grade is ... nonvolatile residue, 0.0003%; free chlorine, none; moisture, no cloud at -5 deg C ... USP grade contains not less than 99.0% & no more than 99.5% **tetrachloroethylene**, the remainder consisting of ethanol. ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 492 (1979)]**PEER REVIEWED**

Food Grade
[Kuney, J.H. and J.N. Nullican (eds.) Chemcyclopedia. Washington, DC: American Chemical Society, 1988. 116]**PEER REVIEWED**

/**Tetrachloroethylene** (BP) may/ ... contain thymol 0.01% wt/wt as a preservative.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 106]**PEER REVIEWED**

Tetrachloroethylene Capsules (USP, BP, 1973)
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 107]**PEER REVIEWED**

Tetrachloroethylene Draught (BNF, 1966): **tetrachloroethylene** 2.5 ml, acacia 2 g, peppermint emulsion 0.3 ml, chloroform water to 50 ml.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 107]**PEER REVIEWED**

Perklone (ICI Mond, UK): a brand of **tetrachloroethylene** for dry-cleaning purposes.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 107]**PEER REVIEWED**

Consumption Patterns:

The consumption pattern in the USA in 1974 is est to have been as follows: Textile and dry cleaning industries, 69%; Metal cleaning, 16%; Chemical intermediate (eg, prepn of trichloroacetic acid in some fluorocarbons), 12%; Miscellaneous uses, 3%.
[Fishbein L; Potential Indust Carcins & Mutagens p.148 (1977) EPA-560/5-77-005]**PEER REVIEWED**

Demand: (1982), 545 million lb; (1983), 679 million lb; (1987), 625 million lb
[Kavaler. Chem Market Reporter 1983]**PEER REVIEWED**

(1974) Dry cleaning & textile processing, 59%; Industrial metal cleaning, 21%; Exports, 11%; Chemical intermed (mostly fluorocarbons), 6%; Other, 3%.
[Kavaler. Chem Market Reporter 1983]**PEER REVIEWED**

SOLVENT IN DRY CLEANING, 46%; DEGREASING SOLVENT, 21%; CHEM INTERMED FOR FLUOROCARBONS, 12%; AGENT IN TEXTILE MFR, 7%; COMPONENT OF AEROSOL PRODUCTS, 2%; OTHER, 12% (1980, EST)
[SRI]**PEER REVIEWED**

CHEMICAL PROFILE: **Perchloroethylene**. Demand: 1988: 495 million lb; 1989: 495 million lb; 1993 /projected/: 495 million lb. (Includes exports, but not imports, which totaled 121 million lb last yr).
[Kavaler AR; Chemical Marketing Reporter 235 (6): 46 (1989)]**PEER REVIEWED**

CHEMICAL PROFILE: **Perchloroethylene**. Dry cleaning and textile processing, 50%; chemical intermediate (mostly fluorocarbon F-113), 28%; industrial metal cleaning, 9%; exports, 10%; other, 3%.
[Kavaler AR; Chemical Marketing Reporter 235 (6): 46 (1989)]**PEER REVIEWED**

Demand: (1996) 280 million pounds; (1997) 290 million pounds; (2001, projected) 335 million pounds
[Chemical Marketing Reporter; Chemical Profile Tetrachloroethylene. December 15, 1997. NY, NY: Schnell Pub Co (1997)]**PEER REVIEWED**

(1998) 312 million pounds; (1999) 318 million pounds; (2003) /projected/ 340 million pounds
[ChemExpo; Chemical Profile Database on Perchloroethylene (127-18-4). 10/30/00. Available from the Database Query page at http://www.chemexpo.com/news/newsframe.cfm?framebody=/news/profile.cfm as of Nov 6, 2000.]**PEER REVIEWED**

Chemical precursor, 50 percent; dry cleaning, 21 percent; metal cleaning and vapor degreasing, 18 percent; other, 11 percent.
[ChemExpo; Chemical Profile Database on Perchloroethylene (127-18-4). 10/30/00. Available from the Database Query page at http://www.chemexpo.com/news/newsframe.cfm?framebody=/news/profile.cfm as of Nov 6, 2000.]**PEER REVIEWED**

U. S. Production:

(1981) 3.16X10+11 GRAMS
[US INT'L TRADE COMM. SOC SERIES C/P-82-1]**PEER REVIEWED**

(1976) 121x10+6 lb
[Fishbein L; Potential Indust Carcins & Mutagens p.35 (1977) USEPA 560/ 5-77-005]**PEER REVIEWED**

(1978) 3.34X10+11 G
[SRI]**PEER REVIEWED**

(1983) 2.40X10+11 G
[SRI]**PEER REVIEWED**

(1985) 3.08X10+11 g
[USITC. SYN ORG CHEM-U.S. PROD/SALES 1985 p.268]**PEER REVIEWED**

(1986) 4.05X10+8 LB
[USITC. SYN ORG CHEM-U.S. PROD/SALES. PRELIMINARY 1988 SERIES C/P-87-5]**PEER REVIEWED**

(1987) 4.70X10+8 LB
[USITC. SYN ORG CHEM-U.S. PROD/SALES. PRELIMINARY 1988 SERIES C/P-87-5]**PEER REVIEWED**

(1982) 550 million lb
[USITC; USITC Publications 1422 (1983) as cited in USEPA; Health Advisories for 25 Organics: Tetrachloroethylene p.306 (1987) PB 87-235578]**PEER REVIEWED**

(1974) 333,100 tons; (1976) 303,400 tons; (1978) 333,400 tons; (1980) 347,100 tons; (1982) 265,300 tons; (1984) 260,000 tons; (1986) 187,800 tons; (1988) 225,800 tons; (1989) 218,300 tons; (1990) 132,300 tons.

[Chemical Marketing Reporter; Chemical Profile Tetrachloroethylene. December 15, 1997. NY, NY: Schnell Pub Co (1997)]**PEER REVIEWED**

U. S. Imports:

(1977) 5.98X10+10 G
[SRI]**PEER REVIEWED**

(1982) 1.70X10+10 G
[SRI]**PEER REVIEWED**

(1985) 6.36X10+10 g
[BUREAU OF THE CENSUS. U.S. IMPORTS FOR CONSUMPTION AND GENERAL IMPORTS 1985 p.1-584]**PEER REVIEWED**

(1986) 1.83X10+5 LB
[BUREAU OF THE CENSUS. US IMPORTS FOR CONSUMPTION AND GENERAL IMPORTS 1986 P.1-530]**PEER REVIEWED**

61 million pounds in 1996.
[Chemical Marketing Reporter; Chemical Profile Tetrachloroethylene. December 15, 1997. NY, NY: Schnell Pub Co (1997)]**PEER REVIEWED**

U. S. Exports:

(1978) 2.90X10+10 G
[SRI]**PEER REVIEWED**

(1983) 2.47X10+10 G
[SRI]**PEER REVIEWED**

(1985) 9.84X10+9 g
[BUREAU OF THE CENSUS. U.S. EXPORTS, SCHEDULE E, 1985 p.2-69]**PEER REVIEWED**

48 million pounds in 1996.
[Chemical Marketing Reporter; Chemical Profile Tetrachloroethylene. December 15, 1997. NY, NY: Schnell Pub Co (1997)]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

DETERMINATION OF **TETRACHLOROETHYLENE** IN FISH BY GAS CHROMATOGRAPHY; DETECTION LIMITS IN 0.1-1.0 PPB RANGE.
[OFSTAD EB ET AL; THE SCIENCE OF THE TOTAL ENVIRONMENT 20: 205-16 (1981)]**PEER REVIEWED**

The expired breath of subjects, exposed for periods of approx 90 min to atmospheres artificially contaminated with low levels ... **tetrachloroethylene** (approx 50 ppm), was monitored during and after the exposure period using an atm pressure ionization mass spectrometer (API/MS), fitted with a direct breath analysis system. The retention of solvent by the subjects estimated from steady state levels in the expired breath, averaged 87%. The elimination of unchanged solvent via respiration during the post exposure period followed first order kinetics a with mean half-life value of 79 min.
[Benoit FM et al; Int Arch Occup Health 55 (2): 113-20 (1985)]**PEER REVIEWED**

NIOSH Method 3704. **Perchloroethylene** in exhaled breath and air. Portable GC/PID.

[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

Analytic Laboratory Methods:

A freeze-out concn method is used to determine trace levels of **tetrachloroethylene** in the presence of other cmpd. Detection limit is 0.2 ppt (1.36X10-6 mg/cu m) for 500 ml aliquots of ambient air samples. Samples are measured by gas chromatography coupled with electron capture configuration. When freeze-out is completed, **tetrachloroethylene** remains behind; While oxygen and nitrogen gasses are passed through as the freeze-out loop is heated. Carrier gas sweeps the contents onto the column.
[Rasmussen RA et al; J Air Poll Cont Assoc 27: 579 (1977)]**PEER REVIEWED**

DETERMINATION OF TRACE AMT OF 136 C1-C13 ORG CMPD (INCL **TETRACHLOROETHYLENE**) IN AIR SAMPLES COLLECTED FROM THE ATMOSPHERE OF STREETS BY GC IS DISCUSSED.
[IOFFE BV ET AL; J CHROMATOGR 142: 787-95 (1977)]**PEER REVIEWED**

TETRACHLOROETHYLENE IN DRINKING WATER IS ANALYZED DIRECTLY WITH GAS CHROMATOGRAPHY EQUIPPED WITH ELECTRON CAPTURE DETECTION. THE LIMIT OF DETECTION IS 0.5 UG/L (NICHOLSON AA ET AL; ANAL CHEM 49: 814-9 (1977)).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 498 (1979)]**PEER REVIEWED**

TETRACHLOROETHYLENE WAS DETERMINED IN WASTE-CONTAMINATED SOIL AND CHEMICAL STILL BOTTOM EXTRACTS BY GAS CHROMATOGRAPHY.
[GURKA DF, BETOWSKI LD; ANAL CHEM 54: 1819 (1982)]**PEER REVIEWED**

DETERMINATION OF **TETRACHLOROETHYLENE** IN FISH BY GAS CHROMATOGRAPHY; DETECTION LIMITS IN 0.1-1.0 PPB RANGE.
[OFSTAD EB ET AL; THE SCIENCE OF THE TOTAL ENVIRONMENT 20: 205-16 (1981)]**PEER REVIEWED**

NIOSH Method 1003. Analyte: **Tetrachloroethylene**; Matrix: air; Procedure: Gas chromatography, flame ionization detector; Desorption: 1 ml CS2, stand 30 min; Range: 0.4 to 12 mg/sample; Precision: 0.052; Est LOD: 0.01 mg/sample; Interferences: none
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

EPA Method 8010: Halogenated Volatile Organics. For the analysis of solid waste ... Under the prescribed conditions, **tetrachloroethylene** has a detection limit of 0.03 ug/l, an average recovery range of four measurements of 8.1-29.6 ug/l, and a limit for the standard deviation of 5.4 ug/l.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW846 Methods (1986)]**PEER REVIEWED**

EPA Method 8240B: Gas Chromatography/Mass Spectrometry for Volatile Organics Method 8240 can be used to quantify most volatile organic commpounds that have boiling points below 200 deg C and that are insoluble or slightly soluble in water, including the title compound. ... Under the prescribed conditions, **tetrachloroethylene** has an average recovery range for four samples of 17.0-26.6 ug/l with a limit for the standard deviation of 5.0 ug/l and a retention time of 22.2 min.
[USEPA/Office of Solid Waste (OSW); Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW846 Methods (1986)]**PEER REVIEWED**

EPA Method 601 A purge and trap gas chromatography method for the analysis of **tetrachloroethylene** in municipal and industrial discharges, consists of a stainless steel column, 8 ft x 0.1 in ID, packed with Carbopack B (60/80 mesh) coated with SP-1000, with electrolytic conductivity detection, and helium as the carrier gas at a flow rate of 40 ml/min. A sample injection volume of 2 to 5 ul is suggested, the column temperature is held isothermal at 45 deg C for 3 minutes then programmed at 8 deg/min to final temperature of 220 deg C. This method has a detection limit of 0.03 ug/l and an overall precision of 0.18 times the average recovery +2.21, over a working range of 8.0 to 500 ug/l.
[40 CFR 136 (7/1/87)]**PEER REVIEWED**

EPA Method 624: A purge and trap gas chromatography/mass spectrometry method for the analysis of **tetrachloroethylene** in municipal and industrial discharges, consists of a glass column, 6 ft x 0.1 in, packed with Carbopack B (60/80 mesh) coated with 1% SP-1000, with the detection performed by the mass spectrometer, and helium as the carrier gas at a flow rate of 30 ml/min. A sample injection volume of 2 to 5 ul is suggested, the column temperature is held isothermal at 45 deg C for 3 minutes and then programmed at 8 deg/min to a final temperature of 220 deg C. This method has a detection limit of 4.1 ug/l and an overall precision of 0.16 times the average recovery - 0.45, over a working range of 5 to 600 ug/l.
[40 CFR 136 (7/1/87)]**PEER REVIEWED**

EPA Method 1624: An isotope dilution gas chromatography/ mass spectrometry method for the determination of volatile organic compounds in municipal and industrial discharges is described. This method is designed to meet the survey requirements of Effluent Guidelines Division (EGD) and the National Pollution Discharge Elimination System (NPDES). Under the prescribed conditions, unlabeled **tetrachloroethylene** has a minimum level of 10 ug/l and a mean retention time of 1528 sec. The labeled compound has a characteristic primary m/z of 166/172. This method has an initial precision of 6.6 ug/l, an accuracy of 15.1-28.5 ug/l, and a labeled compound recovery of 31-181%.
[40 CFR 136 (7/1/87)]**PEER REVIEWED**

AOB Method VA-005-1. Volatile Organic Compounds (VOCs) in Ambient Air by Purge and Trap Gas Chromatography. No detection limit.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

AOB Method VA-006-1. Volatile Organic Compounds (VOCs) in Ambient Air by Direct Portable GC/PID. No detection limit.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

AOB Method VA-008-1. Volatile Organic Compounds (VOCs) in Ambient Air by Portable GC/PID with Direct Sampling via Pump and Sample Loop. No detection limit.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

APHA Method 6210-D. Volatile Organics in Water by Gas Chromatographic/ Mass Spectrometric Purge and Trap Capillary-Column Technique. No detection limit
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

APHA Method 6220-C. Volatile Aromatic Organics in Water by Purge and Trap Gas Chromatography. Detection limit = 0.05 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

APHA Method 6230-C. Volatile Aromatic Organics in Water by Purge and Trap Gas Chromatography. Detection limit = 0.03 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

AOB Method VS-001-1. Volatile Organic Compounds (VOCs) in Soil by Purge and Trap GC/PID/ELCD. Detection limit = 10 ug/kg.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

AOB Method VS-001-1. Volatile Organic Compounds (VOCs) in Soil and Sediment by Automated Headspace GC/PID/ELCD. Detection limit = 100 ug/kg.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

Sampling Procedures:

Volatile organic compounds pose a challenge to ground-water sampling protocols, since they can be lost as a water sample degasses or lost due to sorption on tubing or pump materials. Laboratory sorption experiments were conducted with 5 common flexible tubing materials to determine the impact of sorptive bias for chloroform, trichloroethylene, trichloroethane and **tetrachloroethylene**. Tubes made of Teflon, polyethylene, polypropylene, polyvinyl chloride and silicone rubber were all found to sorb the test compounds in short exposure periods. Virgin tubing materials introduce substantial amounts of leachable organic matter in similar exposures. Tubing made of Teflon showed the least absorption and leaching problems and should be the tubing material of choice for detailed organic sampling purposes. Absorption into the polymer matrix is the likely mechanism for the errors.
[Barcelona MJ et al; Anal Chem 27 (2): 460-4 (1985)]**PEER REVIEWED**

Analyte: **Tetrachloroethylene**; Matrix: Air; Sampler: Solid sorbent tube (coconut shell charcoal, 100 mg/50 mg); Flow rate: 0.01-0.2 l/min; Vol: min: 0.2 @ 100 ppm, max: 40; Stability: not determined
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.p. V2 1003-1]**PEER REVIEWED**

Special References:

Special Reports:

IKEDA M; IGAKU NO AYUMI 102 (6-7): 453-9 (1977). REVIEW OF INDUCTION OF LIVER ANGIOSARCOMA, HEPATOCELLULAR CARCINOMA, NEPHROBLASTOMA, PULMONARY TUMOR, KIDNEY ADENOCARCINOMA, & MAMMARY CARCINOMA BY CHLORINATED ETHYLENES IN RATS & MICE INCL CORRELATION OF EFFECTS TO DOSE, AGE & SEX.

UTZINGER R, SCHLATTER C; CHEMOSPHERE 6 (9): 517-24 (1977). A REVIEW ON THE TOXICITY OF TRACE AMT OF **TETRACHLOROETHYLENE** IN WATER WITH EMPHASIS ON MUTAGENICITY, CARCINOGENICITY & MIXED FUNCTION OXIDASE.

HAKE CL, STEWART RD; ENVIRON HEALTH PERSPECT 21: 231-8 (1977). REVIEW OF ACCIDENTAL & CONTROLLED EXPOSURE OF HUMANS TO **TETRACHLOROETHYLENE**.

WALTER P ET AL; CHLORINATED HYDROCARBON TOXICITY (1,1,1-TRICHLOROETHANE, TRICHLOROETHYLENE, & **TETRACHLOROETHYLENE**): A MONOGRAPH. US NTIS, PB

REP; ISS PB-257185, 178 PP (1976). REVIEW WITH 91 REFERENCES. RESULTS OF A STUDY OF THE 1920-1975 LITERATURE ON TOXICITY OF **TETRACHLOROETHYLENE**.

DHHS/ATSDR; Toxicological Profile for **Tetrachloroethylene** (Update) TP-92/18 (1993)

NIOSH Current Intelligence Bulletin No 20 for **Tetrachloroethylene** (1978)

WHO; Environmental Health Criteria for **Tetrachloroethylene** No 31 (1984)

USEPA Ambient Water Quality Criteria for **Tetrachloroethylene** (1980) EPA 440/5-80-073

SRI; Assessment of Human Exposures to Atmospheric **Perchloroethylene** Contract No 68-02-2835 (1979)

USEPA; Health Effects Assessment for **Tetrachloroethylene** EPA/540/1-86/009 (1984)

USEPA; Health Advisories for 25 Organics: **Tetrachloroethylene** (1987) PB 87-235578

DHEW/NCI; Bioassay of **Tetrachloroethylene** for Possible Carcinogenicity (1977) Technical Rpt Series No. 13 DHEW Pub No. (NIH) 77-813

DHHS/NTP; Toxicology & Carcinogenesis Studies of **Tetrachloroethylene** in F344/N Rats and B6C3F1 Mice (Inhalation Studies) Technical Report Series No. 311 (1986) NIH Publication No. 86-2567

U.S. Department of Health & Human Services/National Toxicology Program; Tenth Report on Carcinogens. National Institutes of Environmental Health Sciences. The Report on Carcinogens is an informational scientific and public health document that identifies and discusses substances (including agents, mixtures, or exposure circumstances) that may pose a carcinogenic hazard to human health. **Tetrachloroethylene** (127-18-4) was first listed in the Fifth Annual Report on Carcinogens (1989) as reasonably anticipated to be a human carcinogen.
[ ]

Synonyms and Identifiers:

Synonyms:

AI3-01860
PEER REVIEWED

Ankilostin
PEER REVIEWED

Antisal 1
PEER REVIEWED

Antisol 1
PEER REVIEWED

Caswell no 827
PEER REVIEWED

CZTEROCHLOROETYLEN (POLISH)
PEER REVIEWED

Didakene
PEER REVIEWED

Dow-Per
PEER REVIEWED

ENT 1,860
PEER REVIEWED

EPA pesticide chemical code 078501
PEER REVIEWED

ETHENE, TETRACHLORO-
PEER REVIEWED

ETHYLENE TETRACHLORIDE
PEER REVIEWED

Ethylene, tetrachloro-
PEER REVIEWED

Fedal-Un
PEER REVIEWED

NCI-C04580
PEER REVIEWED

Nema
PEER REVIEWED

PCE
PEER REVIEWED

Per
PEER REVIEWED

Perawin
PEER REVIEWED

Perc
PEER REVIEWED

PERCHLOORETHYLEEN, PER (DUTCH)
PEER REVIEWED

Perchlor
PEER REVIEWED

PERCHLORAETHYLEN, PER (GERMAN)
PEER REVIEWED

PERCHLORETHYLENE
PEER REVIEWED

PERCHLORETHYLENE, PER (FRENCH)

PEER REVIEWED

PERCHLOROETHYLENE
PEER REVIEWED

Perclene
PEER REVIEWED

PERCLOROETILENE (ITALIAN)
PEER REVIEWED

Percosolv
PEER REVIEWED

Perk
PEER REVIEWED

Perklone
PEER REVIEWED

Persec
PEER REVIEWED

Tetlen
PEER REVIEWED

Tetracap
PEER REVIEWED

TETRACHLOORETHEEN (DUTCH)
PEER REVIEWED

TETRACHLORAETHEN (GERMAN)
PEER REVIEWED

TETRACHLORETHYLENE
PEER REVIEWED

TETRACHLOROETHENE
PEER REVIEWED

1,1,2,2-**TETRACHLOROETHYLENE**
PEER REVIEWED

TETRACLOROETENE (ITALIAN)
PEER REVIEWED

Tetraguer
PEER REVIEWED

Tetraleno
PEER REVIEWED

Tetralex
PEER REVIEWED

Tetravec
PEER REVIEWED

Tetroguer
PEER REVIEWED

Tetropil
PEER REVIEWED

Formulations/Preparations:

Available in the United States ... in veterinary preparations (eg, Nema Worm Capsules (Parke-Davis)). These capsules contain pure **tetrachloroethylene**. Avail sizes are 0.2, 0.5, 1.0, 2.5 & 5 ml.
[American Medical Association, Department of Drugs. Drug Evaluations. 6th ed. Chicago, Ill: American Medical Association, 1986. 1612]**PEER REVIEWED**

Tetrachloroethylene is avail in the USA in the following grades: purified, technical, USP, spectrophotometric, & dry-cleaning. The technical & dry-cleaning grades both meet specifications for technical grade & differ only in the amount of stabilizer added to prevent decomposition. Stabilizers ... incl amines or mixtures of epoxides & esters. Typical analysis of the commercial grade is ... nonvolatile residue, 0.0003%; free chlorine, none; moisture, no cloud at -5 deg C ... USP grade contains not less than 99.0% & no more than 99.5% **tetrachloroethylene**, the remainder consisting of ethanol. ...
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 492 (1979)]**PEER REVIEWED**

Food Grade
[Kuney, J.H. and J.N. Nullican (eds.) Chemcyclopedia. Washington, DC: American Chemical Society, 1988. 116]**PEER REVIEWED**

/**Tetrachloroethylene** (BP) may/ ... contain thymol 0.01% wt/wt as a preservative.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 106]**PEER REVIEWED**

Tetrachloroethylene Capsules (USP, BP, 1973)
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 107]**PEER REVIEWED**

Tetrachloroethylene Draught (BNF, 1966): **tetrachloroethylene** 2.5 ml, acacia 2 g, peppermint emulsion 0.3 ml, chloroform water to 50 ml.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 107]**PEER REVIEWED**

Perklone (ICI Mond, UK): a brand of **tetrachloroethylene** for dry-cleaning purposes.
[Reynolds, J.E.F., Prasad, A.B. (eds.) Martindale-The Extra Pharmacopoeia. 28th ed. London: The Pharmaceutical Press, 1982. 107]**PEER REVIEWED**

Shipping Name/ Number DOT/UN/NA/IMO:

UN 1897; **Tetrachloroethylene**; **Perchloroethylene**

IMO 6.1; **Tetrachloroethylene**

Standard Transportation Number:

49 403 55; **Tetrachloroethylene**

EPA Hazardous Waste Number:

U210; A toxic waste when a discarded commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate.

F002; A hazardous waste from nonspecific sources when a spent halogenated solvent.

Administrative Information:

Hazardous Substances Databank Number: 124

Last Revision Date: 20030829

Last Review Date: Reviewed by SRP on 1/20/2001

Update History:

Complete Update on 2003-08-29, 1 fields added/edited/deleted
Complete Update on 02/14/2003, 1 field added/edited/deleted.
Complete Update on 11/08/2002, 1 field added/edited/deleted.
Complete Update on 10/16/2002, 1 field added/edited/deleted.
Complete Update on 05/31/2002, 1 field added/edited/deleted.
Complete Update on 05/13/2002, 1 field added/edited/deleted.
Complete Update on 02/13/2002, 1 field added/edited/deleted.
Complete Update on 01/14/2002, 1 field added/edited/deleted.
Complete Update on 08/09/2001, 1 field added/edited/deleted.
Complete Update on 05/23/2001, 85 fields added/edited/deleted.
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Complete Update on 02/02/2000, 1 field added/edited/deleted.
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Complete Update on 01/11/1990, 5 fields added/edited/deleted.
Complete Update on 07/28/1989, 108 fields added/edited/deleted.
Complete Update on 09/03/1987
Created 19830315 by DS

Record Length: 176523.0

Tetrachloroethylene

CASRN: 127-18-4
For other data, click on the Table of Contents

Status:

STATUS OF DATA FOR **Tetrachloroethylene**

File First On-Line 01/31/1987

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	on-line	03/01/1988
Inhalation RfC Assessment (I.B.)	no data	
Carcinogenicity Assessment (II.)	no data	

Substance Identification:

Substance Name:

Tetrachloroethylene

CAS Registry Number: 127-18-4

I. Chronic Health Hazard Assessment for Noncarcinogenic Effects:

I.A. Reference Dose for Chronic Oral Exposure (RfD):

Substance Name -- **Tetrachloroethylene**
CASRN -- 127-18-4
Last Revised -- 03/01/1988

The oral Reference Dose (RfD) is based on the assumption that thresholds exist for certain toxic effects such as cellular necrosis. It is expressed in units of mg/kg-day. In general, the RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. Please refer to the Background Document for an elaboration of these concepts. RfDs can also be derived for the noncarcinogenic health effects of substances that are also carcinogens. Therefore, it is essential to refer to other sources of information concerning the carcinogenicity of this substance. If the U.S. EPA has evaluated this substance for potential human carcinogenicity, a summary of that evaluation will be contained in Section II of this file.

I.A.1. Oral RfD Summary:

Critical Effect	Experimental Doses*	UF	MF	RfD
Hepatotoxicity in mice, weight gain in rats 6-Week Mouse Gavage Study Buben and O'Flaherty, 1985	NOAEL: 20 mg/kg/day (converted to 14 mg/kg/day) LOAEL: 100 mg/kg/day (converted to 71 mg/kg/day)	1000	1	1E-2 mg/kg/day

*Conversion Factors: Doses have been adjusted for treatment schedule (5 days/week)

I.A.2. Principal and Supporting Studies (Oral RfD):

Buben, J.A. and E.J. O'Flaherty. 1985. Delineation of the role of metabolism in the hepatotoxicity of trichloroethylene and **perchloroethylene**: a dose- effect study. Toxicol. Appl. Pharmacol. 78: 105-122.

Buben and O'Flaherty (1985) exposed Swiss-Cox mice to **tetrachloroethylene** in corn oil by gavage at doses of 0, 20, 100, 200, 500, 1500, and 2000 mg/kg, 5 days/ week for 6 weeks. Liver toxicity was evaluated by several parameters including liver weight/body weight ratio, hepatic triglyceride concentration, DNA content, histopathological evaluation, and serum enzyme levels. Increased liver triglycerides were first observed in mice treated with 100 mg/kg. Liver weight/body weight ratios were significantly higher than controls for animals treated with 100 mg/kg. At higher doses, hepatotoxic effects included decreased DNA content, increased SGPT, decreased levels of G6P and hepatocellular necrosis, degeneration and polyploidy.

A NOEL of 14 mg/kg/day was established in a second study, as well (Hayes et al., 1986). Groups of 20 Sprague-Dawley rats of both sexes were administered doses of 14, 400, or 1400 mg/kg/day in drinking water. Males in the high-dose group and females in the two highest groups exhibited depressed body weights. Equivocal evidence of hepatotoxicity (increased liver and kidney weight/body weight ratios) were also observed at the higher doses.

I.A.3. Uncertainty and Modifying Factors (Oral RfD):

UF -- The uncertainty factor of 1000 results from multiplying factors of 10 to account for intraspecies variability, interspecies variability and extrapolation of a subchronic effect level to its chronic equivalent.

MF -- None

I.A.4. Additional Studies/Comments (Oral RfD):

Other data support the findings of the principal studies. Exposure of mice and rats to **tetrachloroethylene** by gavage for 11 days caused hepatotoxicity (centrilobular swelling) at doses as

low as 100 mg/kg/day in mice (Schumann et al., 1980). Mice were more sensitive to the effects of **tetrachloroethylene** exposure than rats. Increased liver weight was observed in mice at 250 mg/kg, while rats did not exhibit these effects until doses of 1000 mg/kg/day were reached. Relative sensitivity to man cannot be readily established but the RfD of 1E-2 mg/kg/day is protective of the most mild effects observed in humans [diminished odor perception/modified Romberg test scores in volunteers exposed to 100 ppm for 7 hours; roughly equivalent to 20 mg/kg/day (Stewart et al., 1961)].

The principal studies are of short duration. Inhalation studies have been performed which indicate that the uncertainty factor of 10 is sufficient for extrapolation of the subchronic effect to its chronic equivalent. Liver enlargement and vacuolation of hepatocytes were found to be reversible lesions for mice exposed to low concentrations of **tetrachloroethylene** (Kjellstrand et al., 1984). In addition, elevated liver weight/body weight ratios observed in animals exposed to **tetrachloroethylene** for 30 days were similar to those in animals exposed for 120 days. Several chronic inhalation studies have also been performed (Carpenter, 1937; NTP, 1985; Rowe et al., 1952). None are inconsistent with a NOAEL of 14 mg/kg/day for **tetrachloroethylene** observed by Buben and O'Flaherty (1985) and Hayes et al. (1986).

I.A.5. Confidence in the Oral RfD:

Study -- Low
Database -- Medium
RfD -- Medium

No one study combines the features desired for deriving an RfD: oral exposure, large number of animals, multiple dose groups, testing in both sexes and chronic exposure. Confidence in the principal studies is low mainly because of the lack of complete histopathological examination at the NOAEL in the mouse study. The data base is relatively complete but lacks studies of reproductive and teratology endpoints subsequent to oral exposure; thus, it receives a medium confidence rating. Medium confidence in the RfD follows.

I.A.6. EPA Documentation and Review of the Oral RfD:

U.S. EPA. 1985. Health Assessment Document for **Tetrachloroethylene** (**Perchloroethylene**). Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, NC for the Office of Air Quality Planning and Standards, Research Triangle Park, NC. EPA 600/8-82/005F.

U.S. EPA. 1987. Quantification of Toxicological Effects for **Tetrachloroethylene**. Prepared from the Health Assessment Document for **Tetrachloroethylene** (**Perchloroethylene**). Office of Drinking Water, Washington, DC.

Agency Work Group Review -- 05/20/1985, 08/05/1986, 09/17/1987

Verification Date -- 09/17/1987

I.A.7. EPA Contacts (Oral RfD):

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov(internet address).

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC):

Substance Name -- **Tetrachloroethylene**
CASRN -- 127-18-4

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure:

Substance Name -- **Tetrachloroethylene**
CASRN -- 127-18-4

Not available at this time.

VI. Bibliography:

VI.A. Oral RfD References:

Buben, J.A. and E.J. O'Flaherty. 1985. Delineation of the role of metabolism in the hepatotoxicity of trichloroethylene and **perchloroethylene**: A dose- effect study. Toxicol. Appl. Pharmacol. 78: 105-122.

Carpenter, C.P. 1937. The chronic toxicity of **tetrachloroethylene**. J. Ind. Hyg. Toxicol. 19(7): 323-336.

Hayes, J.R., L.W. Condie, Jr. and J.F. Borzelleca. 1986. The subchronic toxicity of **tetrachloroethylene** (**perchloroethylene**) administered in the drinking water of rats. Fund. Appl. Toxicol. 7: 119-125.

Kjellstrand, P., B. Holmquist, M. Kanje, et al. 1984. **Perchloroethylene**: Effects on body and organ weights and plasma butyrylcholinesterase activity in mice. Acta Pharmacol. Toxicol. 54(5): 414-424.

NTP (National Toxicology Program). 1985. NTP Technical Report on the Toxicology and Carcinogenesis Studies of **Tetrachloroethylene** (**perchloroethylene**). U.S. Dept. Health and Human Services, NIH Publ. No. 85- 2567.

Rowe, V.K., D.D. McCollister, H.C. Spencer, E.M. Adams and D.D. Irish. 1952. Vapor toxicity of **tetrachloroethylene** for laboratory animals and human subjects. Arch. Ind. Hyg. Occup. Med. 5: 566-579.

Schumann, A.M., J.F. Quast and P.G. Watanabe. 1980. The pharmacokinetics and macromolecular interaction of **perchloroethylene** in mice and rats as related to oncogenicity. Toxicol. Appl. Pharmacol. 55: 207-219.

Stewart, R.D., H.H. Gay, D.S. Erley, C.L. Hake and A.W. Schaffer. 1961. Human exposure to **tetrachloroethylene** vapor. Arch. Environ. Health. 2: 40-46.

U.S. EPA. 1985. Health Assessment Document for **Tetrachloroethylene** (**perchloroethylene**). Prepared by the Office of Health and Environmental Assessment, Environmental Criteria and Assessment Office, Research Triangle Park, NC for the Office of Air Quality Planning and Standards, Research Triangle Park, NC. EPA 600/8-82-005F. Office of Drinking Water, Washington, DC.

U.S. EPA. 1987. Quantification of Toxicological Effects for **Tetrachloroethylene**. Prepared from the Health Assessment Document for **Tetrachloroethylene** (**perchloroethylene**). Office of Drinking Water, Washington, DC.

VI.B. Inhalation RfC References:

None

VI.C. Carcinogenicity Assessment References:

None

VII. Revision History:

Substance Name -- **Tetrachloroethylene**
CASRN -- 127-18-4

Date	Section	Description
12/23/1987	I.A.	RfD withdrawn pending further review
03/01/1988	I.A.	Revised Oral RfD sumary added - RfD changed
03/01/1988	III.A.	Health Advisory added
07/01/1989	VI.	Bibliography on-line
05/01/1990	II.	Carcinogen assessment now under review
06/01/1990	IV.A.1.	Area code for EPA contact corrected
06/01/1990	IV.F.1.	EPA contact changed
01/01/1992	IV.	Regulatory actions updated
04/01/1992	IV.	Regulatory action section withdrawn
08/01/1995	II.	EPA's RfD/RfC and CRAVE workgroups were discontinued in May, 1995. Chemical substance reviews that were not completed by September 1995 were taken out of IRIS review. The IRIS Pilot Program replaced the workgroup functions beginning in September, 1995.
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
01/02/1998	I., II.	This chemical is being reassessed under the IRIS Program.

TRICHLOROETHYLENE

CASRN: 79-01-6

For other data, click on the Table of Contents

Human Health Effects:

Evidence for Carcinogenicity:

There is limited evidence in humans for the carcinogenicity of **trichloroethylene**. There is sufficient evidence in experimental animals for the carcinogenicity of **trichloroethylene**. OVERALL EVALUATION: **Trichloroethylene** is probably carcinogenic to humans Group 2A. In making the overall evaluation, the working group considered the following evidence: (1) Although the hypothesis linking the formation of mouse liver tumors with peroxisome proliferation is plausible, **trichloroethylene** also induced tumors at other sites in mice and rats.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 63 136 (1995)]**PEER REVIEWED**

A5. A5= Not suspected as a human carcinogen. (1993) ... The substance has been demonstrated by well-controlled epidemiological studies not to be associated with any increased risk of cancer in exposed humans.
[American Conference of Governmental Industrial Hygienists. Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs) for 1995-1996. Cincinnati, OH: ACGIH, 1995.34]**PEER REVIEWED**

Human Toxicity Excerpts:

IN ACUTE INHALATION EXPOSURES RAPID COMA MAY ENSUE WITH EVENTUAL DEATH FROM HEPATIC OR RENAL FAILURE. AN OCCASIONAL SUDDEN DEATH SUGGESTS VENTRICULAR FIBRILLATION. SEQUELAE, WHICH MAY BE MORE COMMON AFTER INHALATION THAN AFTER INGESTION, INCLUDE LIVER AND KIDNEY LESIONS, REVERSIBLE TRIGEMINAL (OR OTHER NERVE) DEGENERATION AND PSYCHIC DISTURBANCES.
[Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976.,p. II-112]**PEER REVIEWED**

... Workers exposed @ concn avg about 10 ppm ... complained of headache, dizziness and sleepiness. ... An epidemiology study on the hepatic tumor incidence in subjects working with **trichloroethylene** ... failed to show a correlation between liver /cancer/ and occupational exposure. ... Another ... study looked at the mortality of 2117 workers exposed to **trichloroethylene** ... found no correlation between cancer and occupational exposure.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.596]**PEER REVIEWED**

Trichloroethylene is only mildly irritating to the skin if allowed to evaporate. From continued use of the material in contact with the skin, defatting can take place.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4196]**PEER REVIEWED**

Fatal hepatic failure has been observed following the use of **trichloroethylene** as an anesthetic. This

effect has occurred in patients with complicating conditions such as malnutrition, toxemias, burns, or those who have received transfusions.
[Dafalque RJ; Clin Pharm Ther 2: 665 (1961) as cited in USEPA; Ambient Water Quality Criteria Document: Trichloroethylene p.C-17 (1980) EPA-440/5/80-007]**PEER REVIEWED**

Prolonged occupational exposure to **trichloroethylene** has been associated with impairment of peripheral nervous system function, persistent neuritis and temporary loss of tactile sense and paralysis of the fingers after direct contact with the solvent.
[Bardodej Z, Vyskocil J; AMA Arch Ind Health 13: 581 (1956) as cited in USEPA; Ambient Water Quality Criteria Document: Trichloroethylene p.C-17 (1980) EPA 440/5/80-007]**PEER REVIEWED**

A case of severe liver necrosis following a prolonged (4-1/2 hour) use of **trichloroethylene** as an anesthetic has been reported.
[Herdman KN; Br Med J (3): 689-90 (1945) as cited in Health and Safety Executive Monograph: Trichloroethylene #6 p.14 (1982)]**PEER REVIEWED**

Following chronic and acute overexposure to **trichloroethylene** during operation of a dry cleaning unit, symptoms included symmetrical bilateral VIIIth cranial nerve deafness as well as cerebral cortical dysrhythmia and alterations in the electroencephalogram. The patient recovered after the exposure stopped.
[Tomasini M, Sartorelli E; Med Lav 62: 277-80 (1971) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.5-2 (1983) EPA-600/8-82-006B]**PEER REVIEWED**

Acute overexposure to **trichloroethylene** resulted in chronic involvement of the bulbar cranial nerves and esophageal and pharyngeal motility impairment.
[Lawrence WH, Partyka EK; Ann Int Med 95 (6): 710 (1981) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.5-2 (1983) EPA-600/8-82-006B]**PEER REVIEWED**

Autopsy findings in a 16 yr old boy who died while sniffing plastic cement containing **TCE** indicated severe heart failure. ... Liver failure is not the usual cause of death among solvent sniffers, but liver biopsies often reveal toxic centrilobular necrosis.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-165]**PEER REVIEWED**

The behavioral effects of exposure to **trichloroethylene** /indicate that/ laboratory /and work-place/ exposure to 540 or 1080 mg/cu m for 70 min, has no effect on reaction time or short-term memory.
[Gamberale F et al; Scand J Work Environ Health 4: 220-4 (1976) as cited in WHO; Environ Health Criteria 50: Trichloroethylene p.83 (1985)]**PEER REVIEWED**

Chromosome analyses of cultured lymphocytes from 28 workers aged 23-67 who had been employed on degreasing unit using **trichloroethylene** for 1-21 years showed high rates of hypodiploid cells (9 of 28).
[Konietzko H et al; Arch Toxicol 40 (3): 201-6 (1978)]**PEER REVIEWED**

Evoked trigeminal potentials were studied in 104 subjects occupationally exposed to **trichloroethylene**. Subjects had an average exposure time of 8.23 yr and an average daily exposure of 7 hr (exposure levels were not given). Controls were 52 healthy nonexposed subjects. Symptoms suffered by 49 of the exposed subjects included dizziness, headache, asthenia, insommnia, mood perturbation, and sexual problems. Eighteen subjects had trigeminal nerve symptoms. These subjects were significantly older ($p < 0.001$) than asymptomatic subjects. Forty subjects had a pathological trigeminal somatosensory evoked potential. Of these, 28 had a normal trigeminal examination and 12 an abnormal one. For those with trigeminal symptoms, an abnormal trigeminal somatosensory evoked potential was observed in subjects

who had the longest and most intense exposure periods.
[Barret L et al; Arch Environ Health 42 (5): 297-302 (1987)]**PEER REVIEWED**

Estimated human lifetime carcinogenic risk: 3.77X10-7 for male and 6.84X10-8 for female /From table, assuming a daily consumption of 1 liter of water containing **trichloroethylene** in a concn of 1 ug/l/
[National Research Council. Drinking Water & Health. Volume 5. Washington, D.C.: National Academy Press, 1983. 84]**PEER REVIEWED**

... Eye irritation: 160 ppm; supportable during 30 min: 379-372 ppm; full /SRP: CNS depression/: 2,500-6,000 ppm; severe toxic effects: 2,000 ppm= 10,940 mg/cu m, 60 min; symptoms of illness: 800 ppm= 4,376 mg/cu m; unsatisfactory /exposure level/: > 400 ppm= 2,188 mg/cu m
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

... The estimated fatal oral dose in humans is 3-5 ml/kg. The lowest concn produce unconsciousness in adult humans is 16 mg/l (3,000 ppm); the equivalent oral dose is 40-150 ml.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-165]**PEER REVIEWED**

77 of 104 **trichloroethylene** workers showed abnormal electrocardiographic tracings, which may precede permanent heart damage.
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 721]**PEER REVIEWED**

Adverse psychological and behavioral abnormalities have been reported in industrial overexposures and include symptoms of headache, fatigue, lightheadedness, depression, insomnia, irritability, and confusion. Cranial and peripheral neuropathies have been associated with industrial and medical use. Selective trigeminal neuralgia has been diagnosed in one study in 20% of **trichloroethylene** workers by demonstrating electrophysiological abnormalities.
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 992]**PEER REVIEWED**

Skin: defatting action /of **trichloroethylene**/ can cause dermatitis.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

In anesthetic concn, **trichloroethylene** causes little or no irritation to the respiratory tract. **Trichloroethylene** causes increased respiratory rate (tachypnea) but decreased alveolar ventilatory amplitude, which is associated with decreased blood oxygen tension and increased carbon dioxide tension.
[Dobkin A, Byles P; Clin Anesth 1: 44-65 (1963) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.5-11 (1983) EPA-600/8-82-006B]**PEER REVIEWED**

... In almost all cases where a xenobiotic /incl **trichloroethylene**/ has a terminal carbon with two halides attached, side-chain oxidation mediated by cytochrome p450 will produce a toxic, reactive intermediate.
[Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 121]**PEER REVIEWED**

Eight men inhaled **trichloroethylene** at concentrations of 0, 100, 300, and 1000 ppm for 2 hr. Each man received the different concentrations in random order. Five tests of visualmotor performance were administered to each volunteer three times during each 2 hr session, and one additional test was administered immediately before and immediately after exposure. At a concentration of 1000 ppm, the compound adversely affected performance in tests of depth perception, steadiness, and manual skill but

had no statistically significant effect on performance in three other standard tests. The small increase in errors associated with 100 and 300 ppm were not statistically significant.
[Hayes, W.J., Jr., E.R. Laws, Jr., (eds.). Handbook of Pesticide Toxicology. Volume 2. Classes of Pesticides. New York, NY: Academic Press, Inc., 1991. 694]**PEER REVIEWED**

Six naive volunteers were exposed to **trichloroethylene** aerosol and vapor for 8 hr in one day (two 4 hr exposures separated by a 1.5 hr interval); the concentration varied from 90 to 130 ppm. A slight sense of dizziness and transient eye irritation occurred during maximal fractuations in concentration. Although there was no objective disturbance of motor function, coordination, equilibrium, or behavior, there was a statistically significant decrement in performance of standard tests of perception, memory, complex reaction time, and manual dexterity. Similar results were obtained when the study was repeated with six workers who were accustomed to the odor of the compound.
[Hayes, W.J., Jr., E.R. Laws, Jr., (eds.). Handbook of Pesticide Toxicology. Volume 2. Classes of Pesticides. New York, NY: Academic Press, Inc., 1991. 694]**PEER REVIEWED**

Three volunteers each placed one thumb in **trichloroethylene** for 30 min. They experienced a burning sensation on the dorsum of their thumbs within 3-18 min, and this burning became moderately severe within 5 min after onset in two persons but remained mild in one. The pain became more intense for several minutes just after the thumbs were removed from the solvent, and tingling persisted for 30 min. Erythema subsided within 2 hr. The compound was measurable in the breath of some volunteers within 10 min after exposure started and in all within 20 min. The mean peak breath concentration was 0.5 ppm.
[Hayes, W.J., Jr., E.R. Laws, Jr., (eds.). Handbook of Pesticide Toxicology. Volume 2. Classes of Pesticides. New York, NY: Academic Press, Inc., 1991. 694]**PEER REVIEWED**

Vapors of **trichloroethylene** are only slightly irritating to the respiratory tract. Premedication with atropine or scopolamine hydrobromide is recommended to eliminate possible mucus secretions. The anesthetic typically accelerates respiratory rate. As the tachypnea progresses, respiratory activity becomes more rapid and shallower. Sudden bursts of tachypnea are sometimes associated directly with surgical stimulation.
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 195]**PEER REVIEWED**

A retrospective cohort study of 14,457 workers at an aircraft maintenance facility was undertaken to evaluate mortality associated with exposures in their workplace. The purpose was to determine whether working with solvents, particularly **trichloroethylene**, posed any excess risk of mortality. The study group consisted of all civilian employees who worked for at least one year at Hill Air Force Base, Utah, between 1 January 1952 and 31 December 1956. Work histories were obtained from /official records/ ... and the cohort was followed up for ascertainment of vital state until 31 December 1982. Observed deaths among white people were compared with the expected numbers of deaths, based on the Utah white population, and adjusted for age, sex and calendar period. Significant deficits occurred for mortality from all causes (SMR 92, 95% CI 90-95), all malignant neoplasms (SMR 90, CI 83-97), ischemic heart disease (SMR 93, 95% CI 88-98), nonmalignant respiratory disease (SMR 87, 95% CI 76-98) and accidents (SMR 61, 95% CI 52-70). Mortality was raised for multiple myeloma in white women (SMR 236, 95% CI 87-514), non-Hodgkin's lymphoma in white women (SMR 212, 95% CI 102-390), and cancer of the biliary passages and liver of white men dying after 1980 (SMR 358, 95% CI 116-836). Detailed analysis of 6929 employees occupationally exposed to **trichloroethylene**, the most widely used solvent at the base during the 1950s and 1960s, did not show any significant or persuasive association between several measures of exposure to **trichloroethylene** and any excess of cancer. Women employed in departments in which fabric cleaning and parachute repair operations were performed had more deaths

than expected from multiple myeloma and non-Hodgkin's lymphoma. The inconsistent mortality patterns by sex, multiple and overlapping exposures, and small numbers made it difficult to ascribe these excesses to any particular substance. ...
[Spirtas R et al; Br J Ind Med 48 (8): 515-30 (1991)]**PEER REVIEWED**

Human subjects with high repeated, but non-occupational, exposure may exhibit toxic effects on the liver (e.g., elevated aspartate & alanine aminotransferase), renal insufficiency, & abnormal EEG patterns.
[WHO; Environ Health Criteria 50: Trichloroethylene p.82 (1985)]**PEER REVIEWED**

Acute effects on the CNS are characterized by two sequential phases (i.e., excitation & depression), & are usually reversible. ... In the early phase of excitation, euphoria & inebriation are present. The subsequent phase of CNS depression is characterized by various degrees of narcosis culminating in coma. Muscular hypotomy, muscular spasms, reduced tendon reflexes, & loss of coordination may occur.
[WHO; Environ Health Criteria 50: Trichloroethylene p.82 (1985)]**PEER REVIEWED**

Childhood leukemia in a community in Massachusetts, USA, where water from two wells was contaminated with **trichloroethylene** /was studied/. Measurements made in 1979 showed a concentration of 267 ppb (ug/l) **trichloroethylene** in the well water. Twenty cases of childhood leukemia were diagnosed in the community in 1964-83, and these were associated with a significantly higher estimated cumulative exposure to water from the two contaminated wells than a random sample of children from the community (observed cumulative exposure, 21.1; expected cumulative exposure, 10.6; p= 0.03).
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 103 (1995)]**PEER REVIEWED**

A study conducted in New Jersey, USA, during 1979-87 included 75 towns, of which 27 were included in a /previous/ study. **Trichloroethylene** concentrations were measured during 1984-85, and an average level was assigned to each town. The highest level assigned was 67 ug/l. The water supply of six towns contained > 5 ug/l **trichloroethylene** (average, 23.4 ug/l). Women in these towns had a significantly higher total incidence of leukemia than the inhabitants of towns were the concentration of **trichloroethylene** in drinking water was < 0.1 ug/l (relative risk, 1.4; 95% CI, 1.1-1.9); no such effect was seen for men (1.1, 0.84-1.4). The risk among women was particularly elevated for acute lymphocytic leukemia, chronic lymphocytic leukemia in childhood was also significantly increased, in girls but not in boys. Increased risks for non-Hodgkin's lymphoma were apparent in towns in the highest category of **trichloroethylene** contamination (0.2; 0.94-1.5 for men and 1.4; 1.1-1.7 for women) and was particularly elevated for high-grade lymphomas.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 104 1995]**PEER REVIEWED**

Trichloroethylene (Tri) caused modest cytotoxicity in freshly isolated human proximal tubular (hPT) cells, as assessed by significant decreases in lactate dehydrogenase (LDH) activity after 1 hr of exposure to 500 muM Tri. Oxidative metabolism of Tri by cytochrome p450 to form chloral hydrate (CH) was only detectable in kidney microsomes from one patient out of four tested & was not detected in hPT cells. In contrast, GSH conjugation of Tri was detected in cells from every patient tested. The kinetics of Tri metab to its GSH conjugate S-(1,2-dichlorovinyl)glutathione (DCVG) followed biphasic kinetics, with apparent Km & Vmax values of 0.51 & 24.9 mM & 0.10 & 1.0 nmol/min/mg protein, respectively. S-(1,2-dichlorovinyl)-L-cysteine (DCVC), the cysteine conjugate metabolite of Tri that is considered the penultimate nephrotoxic species, caused both time- & concn-dependent increases in LDH release in freshly isolated hPT cells. Preincubation of hPT cells with 0.1 mM aminooxyacetic acid did not protect

hPT cells from DCVC-induced cellular injury, suggesting that another enzyme besides the cysteine conjugate beta-lyase may be important in DCVC bioactivation. ... These data indicate that the pathway involved in the cytotoxicity & metab of Tri in hPT cells is the GSH conjugation pathway & that the cytochrome p450-dependent pathway has little direct role in renal Tri metabolism in humans.
[Cummings; Lash LH; Toxicological Sciences 53 (2): 458-466 (2000)]**PEER REVIEWED**

Trichloroethylene (**TCE**) is both acutely toxic & carcinogenic to the mouse lung following exposure by inhalation. In contrast, it is not carcinogenic in the rat lung & is markedly less toxic following acute exposure. Toxicity to the mouse lung is confined almost exclusively to the nonciliated Clara cell & is characterized by vacuolation & incr in cell replication. Chloral, a metabolite of **TCE** that accumulates in Clara cells and has been shown to be the cause of the toxicity, also causes aneuploidy in some test systems. Cytotoxicity, increased cell division, & aneuploidy are known risk factors in the development of cancer & provide a plausible mode of action for **TCE** as a mouse lung carcinogen. All acute & chronic effects of **TCE** on the mouse lung are believed to be a direct consequence of high cytochrome P450 activity & impaired metab of chloral in Clara cells. Comparisons between species suggest that the ability of the human lung to metabolize **TCE** is approx 600-fold < that in the mouse. In addtn, the human lung differs markedly from the mouse lung in the number & morphology of its Clara cells. Thus, the large quantitative differences between the metabolic capacity of the mouse lung & the human lung, together with the species differences in the number & morphology of lung Clara cells, suggest that the risks to humans are minimal & that other tumor sites should take precedent over the lung when assessing the potential risks to humans exposed to **TCE**.
[Green T; Environ Health Perspect 108 (2): 261-264 (2000)]**PEER REVIEWED**

An ecological epidemiological study was conducted with data obtained from an environmental dose-reconstruction study & the Arizona Birth Information Tapes. Before 1981, a portion of the city of Tucson water-distribution system was contaminated with **trichloroethylene** (i.e., <5 ug/l of water to 107 ug/l of water). Target & comparison populations were selected with a Geographic Information System. Logistical-regression analysis revealed an association between maternal exposure to **trichloroethylene** via drinking water & very-low-birth-weight babies (i.e., < 1,501 grams) (odds ratio = 3.3; 95% confidence interval = 0.5, 20.6; & Wald chi-square p value = 0.2). No association was found between maternal exposure to **trichloroethylene** via drinking water & low birth weight or full-term low-birth-weight infants (gestational period > 35 wk & <46 wk).
[Rodenbeck SE et al; Arch Environ Health 55 (3): 188-194 (2000)]**PEER REVIEWED**

... Changes in EKG waves have been observed among persons with exposure to **trichloroethylene**.
[International Labour Office. Encyclopaedia of Occupational Health and Safety. 4th edition, Volumes 1-4 1998. Geneva, Switzerland: International Labour Office, 1998.,p. 7.22]**PEER REVIEWED**

Human Toxicity Values:

Estimated fatal oral dose 3 to 5 mg/kg
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 990]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Exposure to **trichloroethylene** vapor may cause irritation of the eyes, nose, and throat.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 884]**PEER REVIEWED**

Liquid: irritating to skin and eyes.

[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Drug Warnings:

TRICHLOROETHYLENE HAS BEEN REPORTED TO CAUSE CONVULSIONS IN CHILDREN; THEREFORE, IT SHOULD NOT BE USED IN PATIENTS WITH CONVULSIVE DISORDERS.
[Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980. 986]**PEER REVIEWED**

Patients exposed to **trichloroethylene** should be warned of the potential adverse effects of ethanol ingestion.
[Hansten, P.D. Drug Interactions. 4th ed. Philadelphia: Lea and Febiger, 1979. 219]**PEER REVIEWED**

Isopropanol and acetone ... cause enhanced hepatotoxicity with ... **trichloroethylene**.
[Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 348]**PEER REVIEWED**

...Its anesthetic action is weak. Its low volatility appears in part to be responsible for this effect. ... Apparatus that employs bubbling oxygen assists in accelarating the volatility of the anesthetic to increase its potency. Because of its inherent weakness as an anesthetic, induction of anesthesia is slow. Cardiac arrhythmias produced by the anesthetic are unfavorable. **Trichloroethylene** cannot be used in a closed circuit with soda lime because of formation of a toxic product.
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 195]**PEER REVIEWED**

Relaxation of abdominal musculature is poor during **trichloroethylene** anesthesia.This effect is similar to other agents (eg, ketamine, alpha-chloralose) that do not induce Stage III anesthesia. **Trichloroethylene** is considered unsatisfactory for this type of surgery unless it is used in conjunction with a skeletal muscle relaxant. It has very little if any effect upon uterine function. It readly crosses the placenta to reach the fetal circulation of sheep, goats, and probably other species.
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 195]**PEER REVIEWED**

Medical Surveillance:

Preplacement and periodic exam should incl the skin, resp, cardiac, central, and peripheral nervous systems, as well as liver and kidney function. Alcohol intake should be evaluated.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 884]**PEER REVIEWED**

Effective medical supervision requires an adequate assessment of the level of exposure. This should be achieved by environmental monitoring ... as well as by biological monitoring.
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 2216]**PEER REVIEWED**

/Protect/ from exposure those individuals with diseases of central nervous system, lung, liver, and kidneys.
[ITII. Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1988. 537]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Whenever medical surveillance is indicated, in particular when exposure to a carcinogen has occurred, ad hoc decisions should be taken concerning ... /cytogenetic and/or other/ tests that might become useful or mandatory. /Chemical Carcinogens/

[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.23]**PEER REVIEWED**

... Changes in EKG waves have been observed among persons with exposure to **trichloroethylene**.
[International Labour Office. Encyclopaedia of Occupational Health and Safety. 4th edition, Volumes 1-4 1998. Geneva, Switzerland: International Labour Office, 1998.,p. 7.22]**PEER REVIEWED**

The assessment of **trichloroethylene** exposure can be accomplished through measurement of either **trichloroethylene** or the metabolite, trichloroethanol. The most reliable biological monitoring test appears to be measurement of trichloroethanol, which has been found to correlate with exposure levels. ... Whole Blood Reference Ranges: Normal - none detected (**trichloroethylene**, trichloroethanol); Exposed - BEI (sampling time is end of shift at end of workweek, measured as free trichloroethanol) 4.0 mg/l, BAT (sampling time is end of exposure or end of shift, or for long-term exposure sampling time is after several shifts: both measured as the metabolite, trichloroethanol) 5 mg/l; Toxic - levels greater than 1500 ug/l have been associated with onset of coma.
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 2209]**PEER REVIEWED**

The assessment of **trichloroethylene** exposure can be accomplished through measurement of either trichloroacetic acid or trichloroethanol. These levels have been found to correlate well with exposure levels. ... Urine Reference Ranges: Normal - none detected (trichloroacetic acid or trichloroethanol); Exposed - BEI (sampling time is end of workweek, measured as the metabolite, trichloroacetic acid) 100 mg/g creatinine, BEI (sampling time is end of workweek, measured as the metabolites trichloroacetic acid and trichloroethanol) 300 mg/g creatinine, BAT (sampling time is end of exposure or end of shift, or for long-term exposures sampling time is after several shifts: both measured as the metabolite, trichloroacetic acid) 100 mg/l; Toxic - not established.
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 2209]**PEER REVIEWED**

Liver Function Tests: ... Biochemical tests - Enzymes that reflect cholestasis: alkaline phosphatase (AP), 5'-nucleotidase (5'-NT) /and/ leucine aminopeptidase (LAP); ... Enzymes that detect direct hepatic damage: aspartate aminotransferase (AST) /and/ alanine aminotransferase (ALT). ... Clearance tests - indocyanine green ... antipyrine test ... /and/ serum bile acids.
[Ryan, R.P., C.E. Terry (eds.). Toxicology Desk Reference 4th ed. Volumes 1-3. Taylor & Francis, washington, D.C. 1997. 2211]**PEER REVIEWED**

Probable Routes of Human Exposure:

TRICHLOROETHYLENE WHEN PRESENT IN AIR NEAR OPEN ARC WELDING MAY BE DECOMP TO LEVELS OF PHOSGENE DANGEROUS TO HEALTH, WHEREAS THE HCL AND CL2 FORMED SIMULTANEOUSLY MAY NOT ALWAYS PROVIDE AN ADEQUATE WARNING AGAINST THE PRESENCE OF PHOSGENE.
[RINZEMA LC; INT ARCH ARBEITSMED 28 (2): 151 (1971)]**PEER REVIEWED**

Many industrial workers, operating room personnel and dentists are regularly exposed to **TCE**, some to large doses. The general public encounters **trichloroethylene** in cleaning fluids, some decaffeinated coffees and spice extracts.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-165]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 392,805 workers (169,851 of these are female) are potentially exposed to **trichloroethylene** in the US(1). Occupational exposure to

trichloroethylene may occur through inhalation and dermal contact with this compound at workplaces where **trichloroethylene** is produced or used(SRC). Extensive monitoring data indicate that the general population may be exposed to **trichloroethylene** via inhalation of ambient air, ingestion of food and drinking water, and dermal contact with this compound and other products containing **trichloroethylene**(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983)]**PEER REVIEWED**

An open-top and an enclosed conveyor-loaded production **trichloroethylene** vapor degreasers had average emission factors of 2.6 g **TCE**/min and 0.67 g **TCE**/min, respectively(1). Waste gases from aluminum plasma-etching processes (using chlorine containing etchants) during semiconductor production contained **trichloroethylene** at an average concn of 315.70 ng /l(2). The number of US workers exposed to **TCE** is estimated to be 283,000(3). Operating room levels range from 0.3-103 ppm, with an estimated 5000 medical, dental and hospital personnel being routinely exposed(1). Air levels at a dial assembly workshop in Japan measured 25-100 ppm; degreasing room levels, 150-250 ppm(3). **Trichloroethylene** was detected in 6% of 7705 solvent air samples reported from different industries in Norway and stored in the EXPO occupational exposure database(4).
[(1) Wadden RA et al; Am Ind Hyg Asssoc J 50: 496-500 (1989) (2) Bauer S and Wolff I; in Mat Res Soc Symp Proc 447: 35-41 (1997) (3) IARC; Cadmium, Nickel, Some Epoxides, Miscellaneous Industrial Chemicals and General Consideration on Volatile Anaesthetics 11: 263 (1976) (4) Fjeldstad PE, Woldbaek T; A National Exposure Database Special Publ. - Royal Soc Chem (Natl Inst Occup Hlth, Oslo, Norway) 108(Clean Air Work): 303-10 (1992)]**PEER REVIEWED**

23-41% of **trichloroethylene** in feed water to showers was lost with a water temperature of 23 to 40 deg C(1). **Trichloroethylene** was detected in chlorinated swimming pool water from a pool in Gdansk, Poland at concns of not detected (detection limit, on average, 0.01 ug/cu dm) to 13.3 ug/cu dm for 4 different dates in 1991(2).
[(1) Tancrede M et al; Atmos Environ 26A: 1103-11 (1992) (2) Biziuk M et al; Intern J Environ Anal Chem 50: 109-15 (1993)]**PEER REVIEWED**

Body Burden:

Therapeutic or normal blood level 0.1-9 mg%
[Winek, C.L. Drug and Chemical Blood-Level Data 1985. Pittsburgh, PA: Allied Fischer Scientific, 1985.]**PEER REVIEWED**

PERSONAL AIR: The exhaled breath of 73% of 26 smokers and 81% of 43 nonsmokers contained **trichloroethylene** at unreported concns(1). Breath of 12.5% of 50 individuals living in the Los Angeles area contained **trichloroethylene**(2). 51.2% of personal air samples collected from these 50 individuals contained **trichloroethylene**(2). Increased personal air exposures were reported following solvent use, household cleaning, furniture stripping, visiting a dry cleaning shop, photo developing and using paint remover of up to 220 ug/cu m from a baseline of <2 ug/cu m(3). Personal air samples of Los Angeles and Contra Costa residents contained **trichloroethylene** at concns of 7.8 (n=110, Los Angeles residents, February 1984), 6.4(n=50, Los Angeles residents, May 1984) and 3.8 (n=67, Contra Costa residents, June 1984)(4).
[(1) Gordon SM; J Chrom 511: 291-302 (1990) (2) Hartwell TD et al; Atmos Environ 26A: 1519-27 (1992) (3) Wallace LA et al; pp. 2-181 to 2-185 in 4th Int Conf on Indoor Air Quality and Climate. Germany (1987) (4) Wallace LA et al; Atmos Environ 22: 2141-63 (1988)]**PEER REVIEWED**

Blood samples from 179 of 277 people from the general population contained **trichloroethylene** at a mean concn of 458 ng/l; a mean blood concn of 763 ng/l was reported from 63 of 113 urban workers as compared to 180 ng/l from 82 of 127 workers(1). Blood samples collected from workers exposed to **trichloroethylene** in 4 dry-cleaning shops (air concns ranged from 25-40 ppm) contained this compound

(median=3.39 umol /l after work (range=0.46-12.71), 0.38 umol /l before work (range=0.15-3.58)(2). Urine samples from the same workers contained the **trichloroethylene** metabolite, trichloroethanol (median=54.89 umol/mol creatinine, range=5.30-177.67 after work; median=9.70 umol/mol creatinine, range=0.38-35.65 before work)(2). Kidney (n=9), lung (n=13), and muscle (n=16) tissues collected from humans in Turku, Finland in 1987 contained **trichloroethylene** at 0.7, 0.02, and 0.2 ug/kg, respectively(3). 20% of composite adipose tissue samples collected in FY82 (n=46 composite samples) contained **trichloroethylene**(4). Breathing air samples from 30 residents of Tokyo, Japan had a mean concn of 2.0 ug/cu m **trichloroethylene** with a calculated daily intake due to breathing ambient air of 40 ug/person (men 24.9 ug/person; women 51.5 ug/person)(5). Breath samples of Los Angeles and Contra Costa residents contained **trichloroethylene** at concns of 1.6 (n=110, Los Angeles residents, February 1984), 1.0 (n=50, Los Angeles residents, May 1984) and 0.6 (n=67, Contra Costa residents, June 1984)(6).
[(1) Brugnone F et al; Med Lav 85: 370-89 (1994) (2) Kender LJ et al; Arch Environ Hlth 46: 174-78 (1991) (3) Kroneld R; Bull Environ Contam Toxicol 42: 873-77 (1989) (4) Onstot JD, Stanley JS; Identification of SARA Compounds in Adipose Tissue. Washington DC: US EPS, Office of Toxic Substances, USEPA-560/5-89-003 (1989) (5) Nakahama T et al; Jpn J Toxicol Environ Hlth; 43: 280-84 (1997) (6) Wallace LA et al; Atmos Environ 22: 2141-63 (1988)]**PEER REVIEWED**

Trichloroethylene was detected in mother's milk samples from 4 US urban areas, with 8 of 8 samples testing pos(1). Concns in post-mortem wet tissue samples were 1-32 ppb(2). Breath samples Love Canal residents, Niagara Falls, NY contained a trace of **trichloroethylene** with 4 of 9 samples pos; blood - 0.09.50 ppb, 6 of 9 samples pos; and urine - 40-550 parts/trillion, 9 of 9 samples pos(3). Concns in whole blood specimens from 250 subjects ranged from not detected to 1.5 ppb, with a 0.4 ppb avg(4).
[(1) Pellizzari ED et al; Bull Contam Toxicol 28: 322-8 (1982) (2) IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man 11: 263-76 (1976) (3) Barkley J et al; Biomed Mass Spectrom 7: 139-47 (1980) (4) Antoine SR et al; Bull Environ Toxicol 36: 364-71 (1986)]**PEER REVIEWED**

Trichloroethylene was detected in the blood of 13 of 677 samples taken from non-occupationally exposed Americans (detection limit= 0.010 ppb(1). **Trichloroethylene** was measured in blood samples collected from 79 humans at concns ranging from <0.015 to 0.090 ug/l(2). Exhaled breath from humans following both inhalation and dermal exposures during showering or dermal exposure following bathing using normal tap water contained **trichloroethylene** at concns up to 0.32 ug/cu m/ug/l(3).
[(1) Ashley DL et al; Clin Chem 40: 1401-4 (1994) (2) Skender L et al; Arch Environ Hlth 49: 445-51 (1994) (3) Weisel CP, Jo W-K; Environ Hlth Perspect 104: 48-51 (1996)]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** **TRICHLOROETHYLENE** ***, is relevant for this HSDB record chemical.

Life Support:

- This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE

0.2.1.1 ACUTE EXPOSURE

A. GENERAL - **Trichloroethylene** (**TCE**) is toxic by ingestion, inhalation or dermal exposure. Inhalation of **TCE** can cause euphoria, hallucinations and distorted perceptions; inhalational abuse, with addiction, has been reported. **TCE** vapor may be irritating to the nose and throat.

B. INHALATION - Narcosis and anesthesia occur after inhalation. Adverse effects from inhalation exposure include bronchial irritation, dyspnea, pulmonary edema, respiratory depression, euphoria, dizziness, restlessness, irritability, incoordination, central nervous system depression, impaired concentration, confusion, drowsiness, loss of consciousness, seizures, renal and hepatic damage, as well as fatal cardiac dysrhythmias.

C. INGESTION - Effects from ingestion include nausea, vomiting, diarrhea, abdominal pain, dysphagia, jaundice, somnolence, headache, dizziness, incoordination, hallucinations or distorted perceptions, paresthesia, partial paralysis, dysrhythmias and circulatory collapse. The main systemic response is CNS depression.

D. OCULAR - Direct contact with the eye may result in pain and injury to the corneal epithelium; recovery usually occurs within a few days. Double vision, blurred vision, optic neuritis and blindness can occur after exposure.

E. DERMAL - **TCE** is a skin irritant and may cause defatting dermatitis of the skin. Scleroderma has been linked with **TCE** exposure. Dermal absorption is not likely to be significant if dermatitis is prevented. Vasodilation and malaise ('degreasers flush') recur in workers who drink ethanol after exposure to **TCE**.

F. CHRONIC - Long-term occupational exposure may result in hearing loss, memory loss, fatigue, flushing, ECG changes, vomiting, renal and hepatic damage, CNS depression, irritability, encephalopathy, dementia, neuropathy, paresthesias and possibly systemic sclerosis. Visual disturbances, oculomotor paralysis and trigeminal palsies have been reported after occupational exposure.

0.2.1.2 CHRONIC EXPOSURE

A. Chronic inhalational exposures may result in renal and hepatic damage as well as CNS depressant effects.

0.2.4 HEENT

0.2.4.1 ACUTE EXPOSURE

A. Optic neuritis and blindness has been reported after exposure. Direct contact with the eye may result in injury to the corneal epithelium; recovery usually occurs within a few days and permanent injury is unlikely.

B. Hearing deficiency and bilateral, symmetrical sixth cranial nerve deafness have been reported.

C. Cranial nerve palsies have developed as a result of **TCE** exposure.

0.2.5 CARDIOVASCULAR
0.2.5.1 ACUTE EXPOSURE
A. Cardiac dysrhythmias (ventricular and atrial fibrillation), hypotension, conduction defects and myocardial injury have been noted.
0.2.6 RESPIRATORY
0.2.6.1 ACUTE EXPOSURE
A. Respiratory depression, cyanosis, pulmonary hemorrhages and edema have been reported after exposure to **TCE**.
0.2.7 NEUROLOGIC
0.2.7.1 ACUTE EXPOSURE
A. CNS depression, lightheadedness, dizziness and euphoria, particularly after inhalation, have been noted. Trigeminal nerve impairment has been reported in individuals chronically and acutely poisoned by **TCE**.
B. CNS depression, tremor and motor restless may occur after ingestion.
C. Multiple nerve palsies and peripheral neuropathy have been reported after intoxication.
0.2.8 GASTROINTESTINAL
0.2.8.1 ACUTE EXPOSURE
A. Nausea, vomiting, salivation, loss of taste, anorexia, abdominal pain, diarrhea and dysphagia have all been linked with exposure to **TCE**.
0.2.9 HEPATIC
0.2.9.1 ACUTE EXPOSURE
A. Liver injury has been reported.
0.2.10 GENITOURINARY
0.2.10.1 ACUTE EXPOSURE
A. Renal failure may occur after oral or inhalation exposure to **TCE**.
0.2.14 DERMATOLOGIC
0.2.14.1 ACUTE EXPOSURE
A. **TCE** is mildly irritating to the skin. Defatting dermatitis can occur after contact with the liquid. Higher concentrations, including vapor exposure, may result in chemical burns. Chronic exposure may produce rash, dry skin and scleroderma.
0.2.15 MUSCULOSKELETAL
0.2.15.1 ACUTE EXPOSURE
A. Diffuse fasciitis with eosinophilia has been reported after chronic ingestion.
B. Systemic sclerosis has been described after occupational exposures.
0.2.16 ENDOCRINE
0.2.16.1 ACUTE EXPOSURE
A. Menstrual irregularities and possible anovulation were reported after occupational exposure to **TCE** vapor.
0.2.18 PSYCHIATRIC
0.2.18.1 ACUTE EXPOSURE
A. Organic dementia has been reported after occupational exposure to **TCE**.
0.2.19 IMMUNOLOGIC
0.2.19.1 ACUTE EXPOSURE
A. Symptoms of systemic lupus erythematosus have been reported after chronic exposures.
B. Eosinophilia has been reported after acute exposures.
0.2.20 REPRODUCTIVE HAZARDS
A. Although some studies have found birth defects and spontaneous abortions related to exposure to **TCE**, most involved concomitant confounding exposure to other chemicals. It does cross the placenta. Abnormal sperm morphology has occurred after exposure.
B. Many laboratory animal studies have shown that **TCE** does

not adversely affect fertility or embryo implantation and survival, and does not cause teratogenic effects. **TCE** has, however, been shown to produce some developmental abnormalities. Reversible suppression of male copulation was shown in a few studies.

0.2.21 CARCINOGENICITY

0.2.21.1 IARC CATEGORY

A. **TCE** is classified as Group 2A (probably carcinogenic to humans) by IARC, based on limited evidence for carcinogenicity in humans and sufficient evidence for carcinogenicity in laboratory animals (IARC, 1997).

0.2.21.2 HUMAN OVERVIEW

A. Conflicting results have been obtained regarding the carcinogenicity of **TCE** in humans. Some cohort studies have indicated a link with hepatic and renal cancers and non-Hodgkin lymphoma.

0.2.21.3 ANIMAL OVERVIEW

A. **TCE** has been shown to be carcinogenic in laboratory animals in some studies, particularly for hepatic cancer in rats and renal and pulmonary cancer in mice. However, the study results were weakened by possible presence of confounding contaminants.

0.2.22 GENOTOXICITY

A. **TCE** has produced mixed genotoxic results in humans, laboratory animals and cultured cells. The presence or absence of contaminants seems to affect its genotoxicity.

Laboratory:

A. **Trichloroethylene** plasma levels after overdose are not clinically useful.
B. Monitor renal and liver function tests if kidney or liver injury is suspected.
C. Monitor ECG after substantial exposures.

Treatment Overview:

0.4.2 ORAL EXPOSURE

A. EMESIS: Ipecac-induced emesis is not recommended because of the potential for cardiovascular instability and CNS depression.
B. GASTRIC LAVAGE: Consider after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation. Control any seizures first.
1. CONTRAINDICATIONS: Loss of airway protective reflexes or decreased level of consciousness in unintubated patients; following ingestion of corrosives; hydrocarbons (high aspiration potential); patients at risk of hemorrhage or gastrointestinal perforation; and trivial or non-toxic ingestion.
C. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.
D. Monitor ECG and vital signs frequently in symptomatic patients.
E. AVOID EPINEPHRINE - and other catecholamines (especially beta agonists) which may increase the risk of dysrhythmias.
F. Pulmonary edema, renal failure and liver injury should

be managed symptomatically.
G. DEGREASERS FLUSH - May respond to propranolol (40 to 80 mg PO).
H. VENTRICULAR DYSRHYTHMIAS/SUMMARY: Institute continuous cardiac monitoring, obtain an ECG, and administer oxygen. Evaluate for hypoxia, acidosis, and electrolyte disorders. Lidocaine and amiodarone are generally first line agents for stable monomorphic ventricular tachycardia, particularly in patients with underlying impaired cardiac function. Sotalol is an alternative. Amiodarone and sotalol should be used with caution if a substance that prolongs the QT interval and/or causes torsades de pointes is involved in the overdose. Unstable rhythms require cardioversion.
2. Ventricular dysrhythmias may also respond to beta blockers. A short acting titratable agent such as esmolol is preferred.
I. HYPOTENSION: Infuse 10 to 20 mL/kg isotonic fluid. If hypotension persists, administer dopamine (5 to 20 mcg/kg/min) or norepinephrine (ADULT: begin infusion at 0.5 to 1 mcg/min; CHILD: begin infusion at 0.1 mcg/kg/min); titrate to desired response.

0.4.3 INHALATION EXPOSURE
A. INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids.
B. ACUTE LUNG INJURY: Maintain ventilation and oxygenation and evaluate with frequent arterial blood gas or pulse oximetry monitoring. Early use of PEEP and mechanical ventilation may be needed.

0.4.4 EYE EXPOSURE
A. DECONTAMINATION: Irrigate exposed eyes with copious amounts of room temperature water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility.

0.4.5 DERMAL EXPOSURE
A. DECONTAMINATION: Remove contaminated clothing and wash exposed area thoroughly with soap and water. A physician may need to examine the area if irritation or pain persists.

Range of Toxicity:

A. The estimated fatal ingested dose in humans is reported to be 3 to 5 milliliters/kilogram.
B. Dysrhythmia and severe CNS depression are generally associated with **TCE** blood concentrations >1.5 mg/L.
C. The TLV is 50 ppm.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

Most mild exposures respond to removal from the source and supportive care. Serious toxicity most

often results from hypoxemia or cardiac dysrhythmias so that oxygen, intubation, intravenous lines, and cardiac monitoring should be started initially as the clinical situation dictates. ... Syrup of ipecac should be given to the alert patient who ingests more than a minor amount (eg, more than several swallows in a 2-year-old) and presents within 2 hours of ingestion. Activated charcoal and cathartics may be given, although their efficacy has not been studied.
[Ellenhorn, M.J. and D.G. Barceloux. Medical Toxicology - Diagnosis and Treatment of Human Poisoning. New York, NY: Elsevier Science Publishing Co., Inc. 1988. 992]**PEER REVIEWED**

Basic treatment: .Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Monitor for pulmonary edema and treat if necessary ... . Monitor for shock and treat if necessary ... . Anticipate seizures and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport ... . Do not use emetics. For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Administer activated charcoal ... . Cover skin burns with sterile dressings after decontamination ... . /Carbon tetrachloride and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994.,p. 194-5]**PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious. Positive pressure ventilation techniques with a bag valve mask device may be beneficial. Monitor cardiac rhythm and treat arrhythmias if necessary ... . Start an IV with D5W /SRP: "To keep open", minimal flow rate/. Use lactated Ringer's if signs of hypovolemia are present. Watch for signs of fluid overload. Consider drug therapy for pulmonary edema ... . For hypotension with signs of hypovolemia, administer fluid cautiously. Consider vasopressors if patient is hypotensive with a normal fluid volume. Watch for signs of myocardial irritability and fluid overload ... . Treat seizures with diazepam (Valium) ... . Use proparacaine hydrochloride to assist eye irrigation ... . /Carbon tetrachloride and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 195]**PEER REVIEWED**

Skin decontamination. Flush contaminating fumigants from the skin and eyes with copious amounts of water or saline for at least 15 minutes. Some fumigants are corrosive to the cornea and may cause blindness. Specialized medical treatment should be obtained promptly following decontamination. Skin contamination may cause blistering and deep chemical burns. Absorption of some fumigants across the skin may be sufficient to cause systemic poisoning in the absence of fumigant inhalation. For all these reasons, decontamination of eyes and skin must be immediate and thorough. /Fumigants/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare162]**PEER REVIEWED**

Physical placement. Remove victims of fumigant inhalation to fresh air immediately. Even thought initial symptoms and signs are mild, keep the victim quiet, in a semi-reclining position. Minimum physical activity limits the likelihood of pulmonary edema. /Fumigants/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare162]**PEER REVIEWED**

Respiration. If victim is not breathing, clear the airway of secretions and resuscitate with positive

pressure oxygen apparatus. If this is not available, use chest compression to sustain respiration. If victim is pulseless, employ cardiac resuscitation. /Fumigants/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare163]**PEER REVIEWED**

Pulmonary edema. If pulmonary edema is evident, there are several measures available to sustain life. Medical judgment must be relied upon, however, in the management of each case. The following procedures are generally recommended: Put the victim in a sitting position with a backrest. Use intermittent and/or continuous positive pressure oxygen to relieve hypoxemia. (Do not give oxygen at greater concentrations or longer periods than necessary, because it may exaggerate the fumigant injury to long tissue. Monitor arterial pO2.) slowly administer furosemide ... to reduce venous load by inducing diuresis. Consult package insert for additional directions and warnings. Some patients may benefit from careful administration of anxiolytic drugs. Whenever possible, such patients should be managed by intensivists in an intensive care center. Limit victim's physical activity for at least 4 weeks. Severe physical weakness usually indicates persistent pulmonary injury. Serial pulmonary function testing may be useful in assessing recovery. /Fumigants/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare163]**PEER REVIEWED**

Shock. Combat shock by placing victim in the Trendelenburg position and administering plasma, whole blood, and/or electrolyte and glucose solutions intravenously, with great care, to avoid pulmonary edema. Central venous pressure should be monitored continuously. Vasopressor amines must be given with great caution, because of the irritability of the myocardium. /Fumigants/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare163]**PEER REVIEWED**

Control convulsions. Seizures are most likely to occur in poisonings by methyl bromide, hydrogen cyanide, acrylonitrile, phosphine, and carbon disulfide. /Lorazepam is increasingly being recognized as the drug of choice for status epilepticus, although there are few reports of its use with certain pesticides. One must be prepared to assist ventilation with lorazepam and any other medication used to control seizures. ... Phenobarbital is an additional treatment for seizure control. ... For seizure management, most patients respond well to usual management consisting of benzodiazepines, or phenytoin and phenobarbital./ /Fumigants/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare163]**PEER REVIEWED**

Gastrointestinal decontamination. If a fumigant liquid or solid has been ingested less than an hour prior to treatment, consider gastric emptying, followed by activated charcoal, ... /Fumigants/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare163]**PEER REVIEWED**

Fluid balance should be monitored, and urine sediment should be checked regularly for indications of tubular injury. Measure serum alkaline phosphatase, LDH, ALT, AST, and bilirubin to assess liver injury. /Fumigants/
[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare163]**PEER REVIEWED**

Extracorporeal hemodialysis may be needed to regulate extracellular fluid composition if renal failure supervenes. It is probably not very effective in removing lipophilic fumigant compounds from blood, but it is, of course, effective in controlling extracellular fluid composition if renal failure occurs. /Fumigants/

[U.S. Environmental Protection Agency/Office of Prevention, Pesticides, and Toxic Substances. Reigart, J.R., Roberts, J.R. Recognition and Management of Pesticide Poisonings. 5th ed. 1999. EPA Document No. EPA 735-R-98-003, and available in electronic format at: http://www.epa.gov/pesticides/safety/healthcare164]**PEER REVIEWED**

Animal Toxicity Studies:

Evidence for Carcinogenicity:

There is limited evidence in humans for the carcinogenicity of **trichloroethylene**. There is sufficient evidence in experimental animals for the carcinogenicity of **trichloroethylene**. OVERALL EVALUATION: **Trichloroethylene** is probably carcinogenic to humans Group 2A. In making the overall evaluation, the working group considered the following evidence: (1) Although the hypothesis linking the formation of mouse liver tumors with peroxisome proliferation is plausible, **trichloroethylene** also induced tumors at other sites in mice and rats.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. 63 136 (1995)]**PEER REVIEWED**

A5. A5= Not suspected as a human carcinogen. (1993) ... The substance has been demonstrated by well-controlled epidemiological studies not to be associated with any increased risk of cancer in exposed humans.
[American Conference of Governmental Industrial Hygienists. Threshold Limit Values (TLVs) for Chemical Substances and Physical Agents and Biological Exposure Indices (BEIs) for 1995-1996. Cincinnati, OH: ACGIH, 1995.34]**PEER REVIEWED**

Non-Human Toxicity Excerpts:

MUTAGENICITY: MUTATION RESEARCH 86: 355 (1981). MOUSE IN VIVO SOMATIC MUTATION ASSAY (SPOT TEST) - COAT COLOR MUTANTS: POSITIVE.
[GENE-TOX Program: Current Status of Bioassay in Genetic Toxicology. U.S. Environmental Protection Agency, Washington, DC. Office of Toxic Substances and Pesticides. (For program information, contact Environmental Mutagen Information Center, Oak Ridge National Laboratory, Post Office Box Y, Oak Ridge, Tennessee 37830. Telephone (615) 574-7871)]**PEER REVIEWED**

... REPORTED SYMPTOMS OF CHRONIC INTOXICATION IN DOGS IN 3-8 WEEKS AFTER INHALATION OF 500 TO 750 PPM FOR 4-8 HOURS DAILY, 5-6 DAYS PER WEEK. THE SYMPTOMS CONSISTED OF LETHARGY, ANOREXIA, NAUSEA, VOMITING AND LOSS OF WEIGHT. LIVER DYSFUNCTION WAS ALSO SHOWN IN THESE DOGS.
[American Conference of Governmental Industrial Hygienists. Documentation of the

Threshold Limit Values for Substances in Workroom Air. Third Edition, 1971. Cincinnati, Ohio: American Conference of Governmental Industrial Hygienists, 1971. (Plus supplements to 1979)263]**PEER REVIEWED**

... REPEATED EXPOSURE TO 3000 PPM (27 EXPOSURES DURING 36 DAYS) ... CAUSED DISTURBANCES OF EQUILIBRIUM AND COORDINATION ... AFTER ... 1ST WEEK SALIVATION, RESTLESSNESS AND HYPEREXCITABILITY, THEY RECOVERED ... ONLY HISTOLOGICAL ABNORMALITY ... FAT VACUOLES IN ... LIVER OF FEMALE RATS.
[Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965. 197]**PEER REVIEWED**

WHEN SOYA-BEAN MEAL IS EXTRACTED WITH **TRICHLOROETHYLENE** IT WAS TOXIC TO CATTLE ... THE SYNDROME IN CATTLE IS KNOWN VARIOUSLY AS STOCKMAN DISEASE, DUREN DISEASE AND BARBANT DISEASE.
[Clarke, E.G., and M. L. Clarke. Veterinary Toxicology. Baltimore, Maryland: The Williams and Wilkins Company, 1975. 262]**PEER REVIEWED**

CATS AND GUINEA PIGS EXPOSED TO 1000 PPM DAILY FOR 1 1/2 HR ... FROM 10 DAYS TO 10 MONTHS ... IN THOSE WHICH SURVIVED SEVERAL MONTHS, CIRRHOSIS AND BILIARY HYPERPLASIA ... LATTER PROGRESSING IN SOME ANIMALS TO PROLIFERATIVE 'BILIARY ADENOMATOSIS'.
[Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965. 198]**PEER REVIEWED**

GASTRIC INTUBATION OF 2.4 OR 1.2 G/KG BODY WT **TRICHLOROETHYLENE** 5 TIMES WEEKLY IN MALE B6C3F1 MICE (AGE NOT SPECIFIED) & OF 1.8 OR 0.9 G/KG BODY WT IN FEMALES INDUCED HEPATOCELLULAR CARCINOMAS IN 30/98 MICE GIVEN LOW DOSE & IN 41/95 (43.2%) MICE GIVEN HIGHER DOSE. HEPATOCELLULAR CARCINOMAS ... IN 1/40 (2.5%) CONTROL MICE.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V11 268 (1976)]**PEER REVIEWED**

FEMALE RATS EXPOSED TO VAPORS OF 200 TO 1800 PPM FOR 2 WK SHOWED NO EFFECTS INDICATIVE OF TREATMENT-RELATED MATERNAL TOXICITY, EMBRYOTOXICITY, ... TERATOGENICITY OR BEHAVIORAL DEFECTS. ... /SRP: EVIDENCE OF DEVELOPMENTAL DELAY WAS SEEN/.
[DORFMUELLER MA ET AL; TOXICOLOGY 14 (2): 153-66 (1979)]**PEER REVIEWED**

PURE **TRICHLOROETHYLENE** STABILIZED BY AMINE BASE, ADMIN BY INHALATION @ 0, 100 & 500 PPM FOR 6 HR/DAY, 5 DAY/WK FOR 18 MO TO /NMRI/ MICE, RATS & SYRIAN HAMSTERS. ONLY FEMALE MICE SHOWED INCR IN MALIGNANT LYMPHOMAS.
[HENSCHLER D ET AL; ARCH TOXICOL 43 (4): 237-48 (1980)]**PEER REVIEWED**

EXPOSURE OF MALE MICE TO **TRICHLOROETHYLENE** VAPORS DURING 24 HR @ LEVELS OF 50, 202 & 450 PPM DID NOT REVEAL MUTAGENIC EFFECTS IN DOMINANT LETHAL ASSAY.
[SLACIK-ERBEN R ET AL; ARCH TOXICOL 45 (1): 37-44 (1980)]**PEER REVIEWED**

TRICHLOROETHYLENE WAS AMONG HALOGENATED HYDROCARBONS TESTED FOR CARCINOGENICITY BY CHRONIC ADMIN BY 1 OR MORE ROUTES IN HA:ICR SWISS MICE. **TCE** INACTIVE BY CRITERIA USED.
[VAN DUUREN BL ET AL; J NATL CANCER INST 63 (6): 1433-40 (1979)]**PEER REVIEWED**

... 50 MALE & 50 FEMALE B6C3F1 HYBRID MICE, 5 WK OLD, WERE ADMIN 99% PURE

TRICHLOROETHYLENE, CONTAINING 0.19% 1,2-EPOXYBUTANE & 0.09% EPICHLOROHYDRIN IN CORN OIL BY GAVAGE ON 5 DAYS A WK FOR 78 WK. HIGH DOSE MALES RECEIVED 2000-2400 MG/KG BODY WT/DAY, & FEMALE 1400-1800 MG/KG BODY WT/DAY; LOW DOSE MALE & FEMALES RECEIVED 1000-1200 MG/KG BODY WT/DAY & 700-900 MG/KG BODY WT. ALL SURVIVING ANIMALS WERE OBSERVED UNTIL ... 95 WK OF AGE. ... HEPATOCELLULAR CARCINOMA OCCURRED IN 1/20 CONTROL MALES AND 0/20 CONTROL FEMALES, IN 26/50 LOW DOSE MALES & 4/50 LOW DOSE FEMALES, & IN 31/48 HIGH DOSE MALES, 11/47 HIGH DOSE FEMALES. METASTASES OF THE LIVER CELL TUMORS TO THE LUNG WAS FOUND IN 7/98 TREATED MALES & IN 1 CONTROL MALE. LUNG TUMORS OCCURRED IN TREATED ANIMALS OF BOTH SEXES ... ONLY ONE LUNG ADENOMA IN FEMALE.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 555 (1979)]**PEER REVIEWED**

A single 1000 mg/kg body wt dose ... in corn oil was admin by gavage to 50 mice of each sex, and doses of 1000 and 500 mg/kg body wt were given in the same manner to 50 rats of each sex 5 days/wk for 2 yr. For each group of test animals there were corresponding groups of controls composed of 50 animals of each sex. The **trichloroethylene** was stabilized with an amine antioxidant (diisopropylamine) and contained no detectable traces of 1,2-epoxybutane or epichlorohydrin. ... The results observed in the mice support the previous NCI (1976) findings that **trichloroethylene** significantly incr the incidence of hepatocellular carcinomas in B6C3F1 mice of both sexes.
[National Research Council. Drinking Water & Health. Volume 5. Washington, D.C.: National Academy Press, 1983. 82]**PEER REVIEWED**

IN VIVO AND IN VITRO METHODOLOGIES THAT HAVE EMPLOYED THE YEAST SCHIZOSACCHAROMYCES POMBE AS GENETIC INDICATOR HAVE BEEN UTILIZED TO INVESTIGATE THE MUTAGENICITY OF TWO **TRICHLOROETHYLENE** (**TCE**) SAMPLES OF PURE AND TECHNICAL GRADE. BOTH **TCE** SAMPLES GAVE NEGATIVE RESULTS FOR IN VIVO AND IN VITRO ASSAYS, WHEREAS THE 2 CONTAMINANTS WERE FOUND MUTAGENIC ONLY IN VITRO.
[ROSSI AM ET AL; TERATOGENESIS CARCINOG MUTAGEN 3 (1): 75 (1983)]**PEER REVIEWED**

No liver lesions or hepatomas were found in NLC mice which had received oral doses of 0.1 ml of a 40% solution of **trichloroethylene** in oil twice weekly for an unspecified period.
[Fishbein L; Potential Indust Carcins & Mutagens p.147 (1977) USEPA 560/ 5-77-005]**PEER REVIEWED**

Trichloroethylene (3.3 mM) in the presence of a metabolic activating microsomal system induced reverse mutations in Escherichia coli strain K12. It has also been shown to induce frame-shift as well as base substitution mutations in Saccharomyces cerevisiae strain XV185-14C in the presence of mouse liver homogenate.
[Fishbein L; Potential Indust Carcins & Mutagens p.147 (1977) USEPA 560/ 5-77-005]**PEER REVIEWED**

In rabbits, blood levels of greater than 30 mg/l (following continuous iv infusion of 1-5 mg/kg/min, **trichloroethylene**) induced positional nystagmus /SRP: rapid movement of the eyeball when the head is held in various positions/.
[Tham R et al; Acta Pharmacol Toxicol 44: 336-42 (1979) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.5-6 (1983) EPA-600/8-82-006B]**PEER REVIEWED**

ACS purity **trichloroethylene** induced both point mutation and gene conversion at the ilv and trp loci of the D7 strains of Saccharomyces cerevisiae in the presence of a mouse liver 10,000 g supernatant

metabolizing system. A dose response was observed in both instances over the range of 10-40 mM.
[Bronzetti G et al; J Envir Pathol Toxicol 1: 411-18 (1978) as cited in Health and Safety Executive Monograph: Trichloroethylene #6 p.8 (1982)]**PEER REVIEWED**

Application of 0.1 ml of **trichloroethylene** directly applied to the eye of a rabbit produced a mild-moderate conjunctivitis with some epithelial abrasions being noted on examination with fluorescein. Microscopic examination on day 7 indicated epithelial keratosis in the process of healing. The eye returned to normal in two weeks.
[Duprat P et al; Eur J Toxicol 3: 171-77 (1976) as cited in Health and Safety Executive Monograph: Trichloroethylene #6 p.6 (1982)]**PEER REVIEWED**

Concentration of 1 mM **trichloroethylene** induced transformation of rat embryo cells (Fischer rat embryo cell system F1706) in vitro which appeared as a progressively growing foci of cells lacking contact inhibition and by the growth of macroscopic foci when inoculated in semi-solid agar. The transformed cells grew as undifferentiated fibrosarcomas at the site of inoculation in 100% of newborn Fischer rats between 27 and 68 days post-inoculation.
[Price PJ et al; In Vitro 14: 290 (1978) as cited in USEPA; Ambient Water Quality Criteria Document: Trichloroethylene p.C-23 (1980) EPA-440/5/80-007]**PEER REVIEWED**

Chronic administration /by gavage/ of 2400 mg/kg per day of **trichloroethylene** to male B6C3F1 mice, induced localized cell necrosis, enhanced DNA synthesis, and centrilobular hepatocellular swelling. Prolonged exposure (3 weeks), the primary response was dose-related centrilobular hepatocellular swelling and the occurrence of mineralized (calcified) cells.
[Stott WT et al; Toxicol Appl Pharm 62: 137-51 (1982) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.4-35 (1983) EPA-600/8-82-006B]**PEER REVIEWED**

Trichloroethylene was non-mutagenic in the Ames Salmonella assay when tested with TA100 in a 10 liter desicator. Exposure levels were as high as 20% in air (v/v) for up to 16 hr. The assay was performed in the presence and absence of a phenobarbital-induced liver S9 fraction from male mice. Chloral hydrate, a metabolite of **trichloroethylene**, was found to be mutagenic in strain TA100 in the Salmonella standard plate incorporation assay in doses ranging from 0.5 to 10.0 mg/plate. The mutagenic activity was enhanced in the presence of rat liver S9 mix.
[National Research Council. Drinking Water & Health. Volume 5. Washington, D.C.: National Academy Press, 1983. 81]**PEER REVIEWED**

Sperm exam from mice exposed to 0.3% for 4 hr daily for 5 days revealed incr abnormalities after 28 days.
[Shepard, T.H. Catalog of Teratogenic Agents. 5th ed. Baltimore, MD: The Johns Hopkins University Press, 1986. 572]**PEER REVIEWED**

Rats exposed to 37,000, 42,000, and 56,000 mg/cu m of **trichloroethylene** vapor for two hours exhibited elevated activities of serum glutamic pyruvic transaminase, glutamic oxaloacetic transaminase, and isocitrate dehydrogenase. Hepatotoxicity (indicated by the increased levels of these hepatic enzymes in the serum) was greatly enhanced by pretreatment with 3-methylcholanthrene.
[Carlson GP; Res Comm Chem Pathol Pharmacol 7: 637 (1974) as cited in USEPA; Ambient Water Quality Document: Trichloroethylene p.C-19 (1980) EPA-440/5/80-007]**PEER REVIEWED**

Trichloroethylene was neither embryotoxic nor teratogenic in Sprague-Dawley rats and Swiss Webster mice inhaling **trichloroethylene**. These results have been confirmed in two other studies in female rats exposed in one case to 500 ppm and in other to 1800 ppm. **Trichloroethylene** was found to be weakly mutagenic in Escherichia coli in the presence of a metabolizing system ... or in extensive studies in Drosophila. Positive effects in some studies may be due to epoxy stabilizers sometimes present in

trichloroethylene.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.596]**PEER REVIEWED**

Female Sprague-Dawley rats were given **trichloroethylene** (**TCE**) in distilled drinking water at concentrations of 312, 625, and 1250 mg/l. Dams received **TCE** from 14 days prior to breeding, throughout gestation, and until the pups were weaned at 21 days of age. Control dams received untreated distilled water. Male offspring of experimental and control dams were used to study exploratory behavior either 28, 60, or 90 days of age. Wheel-running, feeding, and drinking behavior tests in rat pups were conducted for 24 hr/day from 55-60 days of age. At 28 days of age, no difference in exploratory activity was seen among treatment groups. At 60 and 90 days of age, rat pups exposed to /SRP: even the lowest concentrations/ of **TCE** exibited increased levels of exploration. Rats exposed to 1250 mg/l **TCE** were more active on the wheel than controls or those exposed to 625 mg/l **TCE**. No significant differences were detected among treatment groups for the levels or timing of feeding or drinking activities.
[Taylor DH et al; Sci Total Environ 47: 415-20 (1985)]**PEER REVIEWED**

Trichloroethylene was evaluated for mutagenicity in the Salmonella/microsome preincubation assay using the standard protocol approved by the National Toxicology Program. **Trichloroethylene** was tested doses at doses of 0.01, 0.033, 0.10, 0.333, and 1.0 mg/plate in as many as 5 Salmonella typhimurium strains (TA1535, TA1537, TA97, TA98, and TA100) in the presence and absence of rat or hamster liver S-9. **Trichloroethylene** was negative in these tests and the highest ineffective dose tested in any S typhimurium strain was 1.0 mg/plate. Slight clearing of the background bacterial lawn occurred in all cultures at the high dose.
[Mortelmans K et al; Environ Mutagen 8: 1-119 (1986)]**PEER REVIEWED**

Affected fathead minnows, 31 days old, in toxicant concentrations ranging from 8.43-77.3 mg/l, lost schooling behavior, swam in a corkscrew/spiral pattern near the surface, were hyperactive & hemorrhaging. Equilibrium loss was not observed prior to death. No effect data were recorded. Individual lengths & weights were not recorded; however, the measured mean weight was 0.109 g. Spike recovery data were not available, but the mean recovery was likely >90%.
[Geiger D.L., Poirier S.H., Brooke L.T., Call D.J., (eds). Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales Promelas). Vol. II. Superior, Wisconsin: University of Wisconsin-Superior, 1985.33]**PEER REVIEWED**

Trichloroethylene /0.5 ml/ (purity 99.5%) applied to the shaved non-abraded skin of rabbits for 24 hours under an occlusive dressing, produced severe skin irritation.
[Duprat P et al; Eur J Toxicol 9(3): 171-7 (1976) as cited in WHO; Environ Health Criteria 50: Trichloroethylene p.50 (1985)]**PEER REVIEWED**

Trichloroethylene (1.0 ml) /purity not specified/ was applied, occluded in a skin depot, to the clipped skin of a guinea pig. Histological examinations performed at 15 minutes, 1, 4, and 16 hour /indicated/ degenerative changes (pyknotic nuclei) were observed in the epidermis after 15 minutes, and were progressive (pyknosis, karyolysis, junctional separation of the epidermis) up to the end of the study.
[Kronevi T et al; Int J Tiss React 111(1): 21-30 (1981) as cited in WHO; Environ Health Criteria 50: Trichloroethylene p.50 (1985)]**PEER REVIEWED**

Groups of 49-50 female ICR mice 4 weeks of age ... exposed by inhalation to **trichloroethylene** (purity = 99.8%, with 0.128% carbon tetrachloride, 0.019% benzene, 0.019% epichlorohydrin, and 0.01% 1,1,2-trichlorethane) at 0.270, 810, or 2430 mg/cu m 7 hr/day for 5 days/wk, for 104 weeks. The surviving animals were /sacrificed/ 107 weeks after the start of the study. Mortality was similar in control and treated groups. Lung adenomas were found in 5, 2, 5, and 4 mice in the control, low-dose,

mid-dose and high-dose groups, respectively. Adenocarcinomas occurred in 1/49, 3/50, 8/50, and 7/46 mice in the control, low-dose, mid-dose and high-dose groups, respectively; increased incidences in the mid- and high-dose groups were statistically significant compared with controls.
[Fukuda K et al; Ind Health 21: 243-5 (1983) as cited in WHO; Environ Health Criteria 50: Trichloroethylene p.65 (1985)]**PEER REVIEWED**

A pure sample of **trichloroethylene**, stabilized with thymol /concentration not specified/ did not induce forward mutations at the HGPRT locus of a Chinese hamster V-79 cell line treated in vitro, with or without S9 mix metabolic activation.
[Loprieno N, Abbondandolo A; Comparative Mutagenic Evaluation of Some Industrial Compounds. Proc Symp Short-Term Test Syst Defect Carcinogenesis pp. 333-56 (1980) as cited in WHO; Environ Health Criteria 50: Trichloroethylene p.71 (1985)]**PEER REVIEWED**

Gelatinsorbitol microcapsules containing 44.1% **trichloroethylene** (**TCE**) were prepared and mixed in NIH-07 rodent meal diet and provided at microcapsule concentrations of 0 (untreated control group), 1.25, 2.5, 5.0, or 10% (equivalent to 0, 0.55, 1.10, 2.21, or 4.41% **TCE** in the diet, respectively) to groups of 10 male F344 rats for 14 days. An additional control group received diets containing 5% empty capsules. For comparisions, **TCE** dissolved in corn oil was administered by gavage to different groups of 10 male rats for 14 consecutive days at dose levels adjusted to correspond to those in the feed study. Treatment-related deaths occurred only in the highest dose group of the gavage study. Body weight gain and feed consumption were reduced in high-dose groups of both the feed and gavage studies. ... Dose-related increases in organ (liver and kidney) weight/body weight ratios, individual cell necrosis in the liver, and hepatic microsomal NADPH cytochrome-c reductase and peroxisomal palmitoyl-CoA oxidase and catalase activities were found in both the dosed-feed and gavage groups. Induction of cytochrome p450 occurred only in the dosed-feed study.
[Melnick RL et al; Fundam Appl Toxicol 8 (4): 432-42 (1987)]**PEER REVIEWED**

... MAJOR CONSIDERATION MUST BE GIVEN TO CUMULATIVE EFFECTS OF THIS COMPOUND. ... IN LONG-TERM FEEDING STUDIES CARRIED OUT BY THE NATIONAL CANCER INSTITUTE (1976b), ... MICE (BOTH SEXES, AT BOTH LOW AND HIGH DOSE LEVELS) EXPERIENCED A HIGHLY SIGNIFICANT INCREASE IN HEPATOCELLULAR CARCINOMAS. ... MIKISKOVA AND MIKISKA (1966) DEMONSTRATED THAT TRICHLOROETHANOL HAD A PRONOUNCED DEPRESSANT EFFECT ON THE CENTRAL NERVOUS SYSTEM.
[Doull, J., C.D. Klaassen, and M. D. Amdur (eds.). Casarett and Doull's Toxicology. 2nd ed. New York: Macmillan Publishing Co., 1980. 475]**PEER REVIEWED**

When fed in drinking water to mice for 4 to 6 months at concentrations of 0, 0.1, 1.0, and 2.5, and 5.0 mg/ml of water, "There was a decreased body weight gain at the highest dose, which could be attributed to a decrease in fluid consumption. The most significant effects attributable to **TCE** were an increase in liver weight in both sexes accompanied by increased nonprotein sulfhydryl levels in the males, and an increase in kidney weight in both sexes accompanied by increases in protein and ketones in the urine. ... The 6 months average daily doses were 0, 144, 217, 393, and 660 mg/kg body weight for the male mice. Female mice averaged 0, 18, 193, 437, and 793 mg/kg/day.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4197]**PEER REVIEWED**

... Several species of animals /were exposed/ 7 hr/day, 5 days/week for approximately 6 months. At 3000 ppm by volume in air, rats and rabbits both showed an increase in liver and kidney weight. At 400 ppm rats showed an increase in liver and kidney weights and the male rats also showed significantly less growth. Guinea pigs had increased liver weights and the growth of the exposed males was less than the

controls. Rabbits showed a slight increase in liver weight. An exposed monkey showed no response at 400 ppm. At 200 ppm, the only effect was depressed growth in guinea pigs. Rats, rabbits, and monkeys showed no response. At a concentration of 100 ppm, none of the species showed any significant response. The maximum concentrations tolerated without adverse effect for the 6 month period were as follows: monkeys, 400 ppm; rats and rabbits, 200 ppm; and guinea pigs, 100 ppm.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4197]**PEER REVIEWED**

... Rats, guinea pigs, dogs, rabbits, and monkeys /were exposed/ 24 hr/day for 90 days to 35 ppm with no effect except slight growth depression. Repeated 8 hr daily exposures to 700 ppm for 90 days were also without effect.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4197]**PEER REVIEWED**

Pregnant /rats and mice and their offsprings/ were exposed for 7 hr to 300 ppm on days 6 to 15 of pregnancy with no evidence of adverse effect on the dams, on reproduction, or on the offspring by any of the usual criteria of a teratogenic study.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4198]**PEER REVIEWED**

In a teratology reproduction study, the NTP fed microencapsulated **trichloroethylene** to rats and mice at doses as high as 300 mg/kg/day to rats and 750 mg/kg/day to mice with little effect. Sperm motility was reduced 45% in F0, males and 18% in F1, male mice. There is no ready explanation for less response in the F1-generation male mice.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4198]**PEER REVIEWED**

When fed to B6D2F1 mice by gavage on days 1 to 5, 6 to 10, or 10 to 15 (day 1, vaginal plug) **trichloroethylene** in corn oil cause no reproductive, maternal, or foal effects. Daily dosages were 0, 1/10, or 1/100 of the oral LD50 (2402 mg/kg used as LD50 value). Weanlings were kept for 21 days or 42 days. **Trichloroethylene** also had no effect on in vitro fertilization.
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4198]**PEER REVIEWED**

Apart from two reports in which **trichloroethylene** weakly induced mutation in Salmonella typhimurium TA1535, purified **trichloroethylene** did not induce gene mutation in various strains of Salmonella in the absence of metabolic activation; however, **trichloroethylene** containing directly mutagenic epoxide stabilizers did.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 131 (1995)]**PEER REVIEWED**

Previous epidemiological studies with humans & laboratory studies with chickens & rats linked **trichloroethylene** (**TCE**) exposure to cardiac defects. Although the cardiac defects in humans & laboratory animals produced by **TCE** are diverse, a majority of them involves valvular & septal structures. Progenitors of the valves & septa are formed by an epithelial-mesenchymal cell transformation of endothelial cells in the atrioventricular (AV) canal & outflow tract areas of the heart. Based on these studies, we hypothesized that **TCE** might cause cardiac valve & septa defects by specifically perturbing epithelial-mesenchymal cell transformation. We tested this hypothesis using an in vitro chick-AV canal culture model. This study shows that **TCE** affected several elements of

epithelial-mesenchymal cell transformation. In particular, **TCE** blocked the endothelial cell-cell separation process that is associated with endothelial activation. Moreover, **TCE** inhibited mesenchymal cell formation throughout the concn range tested (50-250 ppm). In contrast, **TCE** had no effect on the cell migration rate of the fully formed mesenchymal cells. Finally, the expression of 3 proteins (selected as molecular markers of epithelial-mesenchymal cell transformation) was analyzed in untreated & **TCE**-treated cultures. **TCE** inhibited the expression of the transcription factor Mox-1 & extracellular matrix (ECM) protein fibrillin 2. In contrast, **TCE** had no effect on the expression of alpha-smooth muscle actin. These data suggest that **TCE** may cause cardiac valvular & septal malformations by inhibiting endothelial separation & early events of mesenchymal cell formation in the heart.
[Boyer AS et al; Toxicological Sciences 53 (1): 109-117 (2000)]**PEER REVIEWED**

Strategies are needed for assessing the risks of exposures to airborne toxicants that vary over concns & durations. The goal of this project was to describe the relationship between the concn & duration of exposure to inhaled **trichloroethylene** (**TCE**), a representative volatile organic chemical, tissue dose as predicted by a physiologically based pharmacokinetic model, & neurotoxicity. Three measures of neurotoxicity were studied: hearing loss, signal detection behavior, & visual function. The null hypothesis was that exposure scenarios having an equivalent product of concn & duration would produce equal toxic effects, according to the classic linear form of Haber's Rule ... . All experiments used adult male, Long-Evans rats. Acute & repeated exposure to **TCE** increased hearing thresholds, & acute exposure to **TCE** impaired signal detection behavior & visual function. Examination of all three measures of neurotoxicity showed that if Haber's Rule were used to predict outcomes across exposure durations, the risk would be overestimated when extrapolating from shorter to longer duration exposures, & underestimated when extrapolating from longer to shorter duration exposures. For the acute effects of **TCE** on behavior & visual function, the estimated concn of **TCE** in blood at the time of testing correlated well with outcomes, whereas cumulative exposure, measured as the area under the blood **TCE** concn curve, did not. ... Models incorporating dosimetry can account for differing exposure scenarios & will therefore improve risk assessments over models considering only parameters of external exposure.
[Boyes WK et al; Environ Health Perspect 108 (2): 317-322 (2000)]**PEER REVIEWED**

Trichloroethylene (**TCE**) induces liver cancer in mice but not in rats. Three metabolites of **TCE** may contribute chloral hydrate (CH), dichloroacetate (DCA), & trichloroacetate (TCA). CH & TCA appear capable of only inducing liver tumors in mice, but DCA is active in rats as well. The concns of TCA in blood required to induce liver cancer approach the mM range. Concns of DCA in blood associated with carcinogenesis are in the sub-muM range. The carcinogenic activity of CH is largely dependent on its conversion to TCA &/or DCA. TCA is a peroxisome proliferator in the same dose range that induces liver cancer. Mice with targeted disruptions of the peroxisome proliferator-activated receptor alpha (PPARalpha) are insensitive to the liver cancer-inducing properties of other peroxisome proliferators. Human cells do not display the responses associated with PPARalpha that are observed in rodents. This may be attributed to lower levels of expressed PPARalpha in human liver. DCA treatment produces liver tumors with a different phenotype than TCA. Its tumorigenic effects are closely associated with differential effects on cell replication rates in tumors, normal hepatocytes, & suppression of apoptosis. Growth of DCA-induced tumors has been shown to arrest after cessation of treatment. The DCA & TCA adequately account for the hepatocarcinogenic responses to **TCE**. Low-level exposure to **TCE** is not likely to induce liver cancer in humans. Higher exposures to **TCE** could affect sensitive populations. Sensitivity could be based on different metabolic capacities for **TCE** or its metabolites or result from certain chronic diseases that have a genetic basis.
[Bull RJ; Environmental Health Perspectives 108 (2): 241-259 (2000)]**PEER REVIEWED**

The possibility that the acute neurotoxic effects of organic solvents change with repeated exposure will

affect risk assessment of these pollutants. ... Rats inhaling **trichloroethylene** (**TCE**) showed a progressive attenuation of impairment of signal detection behavior across several wk of intermittent exposure, suggesting the development of tolerance. Here, we explored the development of tolerance to **TCE** during 2 wk of daily exposures, & the degree to which learned behavioral modifications ("behavioral tolerance") could account for the effect. Adult Long-Evans rats were trained to perform a visual signal detection task (SDT) in which a press on one lever yielded food if a visual stimulus (a "signal") had occurred on that trial, & a press on a second lever produced food if no signal had been presented. In two experiments, with 2000 & 2400 ppm of **TCE** res pectively, trained rats were divided into two groups (n = 8/group) with equivalent accuracy & then exposed to **TCE** in two-phase studies. In Phase 1, one group of rats received daily SDT tests paired with 70-min **TCE** exposures, followed by 70-min exposures to clean air after testing. The other group received daily SDT tests in clean air, followed by 70-min exposures to **TCE** (unpaired exposure & testing). All rats thus received the same number & daily sequence of exposures to **TCE** that differed only in the pairing with SDT testing. Both concns of **TCE** disrupted performance of the paired groups & this disruption abated over the 9 days of exposure. In Phase 2, the pairing of exposure & test conditions were reversed for the two groups. The groups that were shifted from unpaired to paired exposures (Unpaired-Paired groups) showed qualitatively similar patterns of deficit & recovery as did the rats whose tests were initially paired with **TCE** (Paired-Unpaired groups), indicating that task-specific learning was involved in the development of tolerance. Quantitative differences in the magnitude & duration of the effects of **TCE** in the two groups indicated that other factors, not specific to the SDT, also contributed to the development tolerance to **TCE**.
[Bushnell PJ et al; Neurotoxicology and Teratology 22 (2): 221-229 (2000)]**PEER REVIEWED**

Exposure of rats to **trichloroethylene** induces a sustained excretion of large amounts of formic acid in urine. Both of the major metabolites, trichloroethanol & trichloroacetic acid, were found to induce this response, but not the minor metabolite S-(1, 2-dichlorovinyl) cysteine. Other polychlorinated solvents, including carbon tetrachloride & chloroform, also increased urinary formate excretion. Addition of folic acid either to diet or drinking water modulated the response indicating that these rats were folate deficient. Two markers of vitamin B(12) deficiency, methylmalonic acid & 5-methyltetrahydrofolate, were also markedly incr in urine & plasma respectively. The incr in 5-methyltetrahydrofolate is consistent with a folate deficiency caused by an inhibition of the vitamin B(12) dependent methionine salvage pathway. Since both vitamin B(12) & chemicals containing polychlorinated carbon atoms readily form free radicals, it is suggested that trichloroacetic acid & trichloroethanol interact with vitamin B(12) through a free radical mechanism inducing a B(12) deficiency &, as a consequence, a folate deficiency. As a result of the folate deficiency, excess formic acid, which is normally utilised through this pathway, is excreted in urine.
[Dow JL; Green T; Toxicology 146 (2-3): 123-136 (2000)]**PEER REVIEWED**

... There is increasing evidence relating exposure to **trichloroethylene** /(1,1,2-**trichloroethene**)/ with autoimmunity. To investigate potential mechanisms, we treated the autoimmune-prone MRL + / + mice with **trichloroethylene** in the drinking water at 0, 2.5 or 5.0 mg/ml ... . As early as 4 wk of treatment. Western blot analysis showed a dose-dependent incr in the level of **trichloroethylene**-modified proteins, indicating that a reactive metabolite of **trichloroethylene** was formed. Significant increases in antinuclear antibodies (ANA) & total serum immunoglobulins were found following 4-8 wk of **trichloroethylene** treatment, indicating that **trichloroethylene** was accelerating an autoimmune response. Investigation into possible mechanisms of this autoimmune response revealed that **trichloroethylene** tre atment dramatically increased the expression of the activation marker CD44 on splenic CD4+ T cells at 4 wk. In addtn, splenic T cells from mice treated for 4 wk with **trichloroethylene** secreted more IFN-gamma & less IL-4 than control T cells, consistent of a T-helper

type 1 (Th1) type immune or inflammatory response. A specific immune response directed against dichloroacetylated proteins was found at 22 wk of **trichloroethylene** treatment. ... The results suggest that **trichloroethylene** treatment accelerated an autoimmune response characteristic of MRL + / + mice in association with nonspecific activation of Th1 cells. In addtn, long-term treatment with **trichloroethylene** led to the initiation of a **trichloroethylene**-specific immune response.
[Griffin JM et al; Iimmunopharmacology 46 (2): 123-137 (2000)]**PEER REVIEWED**

The mechanism of **trichloroethylene**-induced liver peroxisome proliferation & the sex difference in response was investigated using wild-type Sv/129 & peroxisome proliferator-activated receptor alpha (PPARalpha)-null mice. **Trichloroethylene** treatment (0.75 g/kg for 2 wk by gavage) resulted in liver peroxisome proliferation in wild-type mice, but not in PPARalpha-null mice, suggesting that **trichloroethylene**-induced peroxisome proliferation is primarily mediated by PPARalpha. No remarkable sex difference was observed in induction of peroxisome proliferation, as measured morphologically, but a markedly higher induction of several enzymes & PPARalpha protein & mRNA was found in males. On the other hand, **trichloroethylene** induced liver cytochrome P450 2E1, the principal enzyme responsible for metabolizing **trichloroethylene** to chloral hydrate, only in males, which resulted in similar expression levels in both sexes after the treatment. **Trichloroethylene** influenced neither the level of catalase, an enzyme involved in the reduction of oxidative stress, nor aldehyde dehydrogenase, the main enzyme catalyzing the conversion to trichloroacetic acid. These results suggest that **trichloroethylene** treatment causes a male-specific PPARalpha-dependent increase in cellular oxidative stress.
[Nakajima T et al; CCarcinogenesis 21 (4): 677-682 (2000)]**PEER REVIEWED**

Trichloroethylene (**TCE**), dichloroacetic acid (DCA), & trichloroacetic acid (TCA) are environmental contaminants that are carcinogenic in mouse liver. 5-Methylcytosine (5-MeC) in DNA is a mechanism that controls the transcription of mRNA, including the protooncogenes, c-jun & c-myc. ... **TCE** decreased methylation of the c-jun & c-myc genes & increased the level of their mRNAs. Decreased methylation of the protooncogenes could be a result of a deficiency in S-adenosylmethionine (SAM), so that methionine, by increasing the level of SAM, would prevent hypomethylation of the genes. For 5 days, female B6C3F1 mice were admin, daily by oral gavage, either 1000 mg/kg bw of **TCE** or 500 mg/kg DCA or TCA. At 30 min after each dose of carcinogen, the mice received, by ip injection, 0, 30, 100, or 450 mg/kg methionine. Mice were euthanized at 100 min after the last dose of DCA, TCA, or **TCE**. Decreased methylation in the promoter regions of the c-jun & c-myc genes & increased levels of their mRNA & proteins were found in livers of mice exposed to **TCE**, DCA, & TCA. Methionine prevented both the decreased methylation & the increased levels of the mRNA & proteins of the two protooncogenes. The prevention by methionine of DCA- TCA-, & **TCE**-induced DNA hypomethylation supports the hypothesis that these carcinogenes act by depleting the availability of SAM. Hence, methionine would prevent DNA hypomethylation by maintaining the level of SAM. Furthermore, the results suggest that the dose of DCA, TCA, or **TCE** must be sufficient to decrease the level of SAM in order for these carcinogens to be active.
[Tao L et al; Toxicological Sciences 54 (2): 399-407 (2000)]**PEER REVIEWED**

National Toxicology Program Studies:

Toxicology and carcinogenesis studies of **trichloroethylene** (more than 99% pure, stabilized with 8 ppm diisopropylamine) were conducted by administering the chemical in corn oil by gavage at doses of 0, 500, or 1000 mg/kg/day 5 days/wk for 103 wk to groups of 50 male and 50 female ACI, August, Marshall, and Osborne-Mendel rats. ... Under the conditions of these two yr gavage studies of **trichloroethylene** in male and female ACI, August, Marshall, and Osborne-Mendel rats, **trichloroethylene** administration caused renal tubular cytomegaly and toxic nephropathy in both sexes

of the four strains. However, these are considered to be inadequate studies of carcinogenic activity because of chemically induced toxicity, reduced survival, and deficiencies in the conduct of these studies. Despite these limitations, tubular cell neoplasms of the kidney were observed in rats exposed to **trichloroethylene** and interstitial cell neoplasms of the testis were observed in Marshall rats exposed to **trichloroethylene**. /**Trichloroethylene** stabilized with 8 ppm diisopropylamine/
[DHHS/NTP; Toxicology and Carcinogenesis Studies of Trichloroethylene in Four Strains of Rats (Gavage Studies) p.5 (1988) Technical Rpt Series No. 273 NIH Pub No. 88-2529]**PEER REVIEWED**

Carcinogenesis studies of epichlorohydrin-free **trichloroethylene** (**TCE**) was conducted by administering the test chemical in corn oil by gavage to groups of 50 male and 50 female F344/N rats and B6C3F1 mice. Dosage levels were 500 and 1,000 mg/kg for rats and 1,000 mg/kg for mice. **Trichloroethylene** was administered five times per week for 103 weeks, and surviving animals were killed between weeks 103 and 107. Groups of 50 rats and 50 mice of each sex received corn oil by gavage on the same schedule and served as vehicle controls. Groups of 50 male and 50 female rats were used as untreated controls. Epichlorohydrin-free **trichloroethylene** caused renal tubular-cell neoplasms in male F344/N rats, produced toxic nephrosis in both sexes, and shortened the survival time of males. This experiment in male F344/N rats was considered to be inadequate to evaluate the presence or absence of a carcinogenic response to **trichloroethylene**. For female F344/N rats receiving **trichloroethylene**, containing no epichlorohydrin, there was no evidence of carcinogenicity. **Trichloroethylene** (without epichlorohydrin) was carcinogenic for B6C3F1 mice, causing increased incidences of hepatocellular carcinomas in males and females and of hepatocellular adenomas in females.
[DHHS/NTP; Toxicology and Carcinogenesis Studies of trichloroethylene (without epichlorohydrin) (CAS #79-01-6) in F344/N Rats and B6C3F1 Mice (Gavage Studies) p.7 (1990) Technical Rpt Series No. 243 NIH Pub No. 90-1779]**PEER REVIEWED**

Trichloroethylene (**TCE**), a common industrial solvent & dry cleaning agent, was tested for its effects on reproduction & fertility in Fisher 344 rats using the RACB protocol. **TCE** was microencapsulated in a gelatin/sorbitol shell, & added to the diet. Data from a 2 wk dose-range-finding study (Task 1) were used to set exposure concns for the Task 2 continuous cohabitation study at 0.15, 0.30, & 0.60% w/w. Based on the results of the analysis of feed formulations & measures of feed consumption, the daily **TCE** dosages were nearly equal to 76, 156, & 289 mg/kg/day. In the F0 animals, there were no clinical signs of toxicity, & no animals died during the Task 2 phase. Dam postpartum body weights were reduced at all dose levels during Task 2: from 4-6% at the low dose to nearly equal to 8% at the high dose. There was a monotonic trend to fewer litters/pair (from 3.5 in controls to 2.9 in the high dose group), & the middle & high dose groups had 9% & 16% fewer pups/litter than the controls. Pup weight & viability were unchanged at any dose level. The last litter was reared by the dam. During this 21 day nursing period, viability was not affected by **TCE** exposure, but body weights were depressed for pups from all treated groups. The decr was not dose-related, & ranged from 9%-20% compared to controls. At 21 & 45 days post-partum, the F1 rats from all groups were tested for behavioral alterations in an open-field test. At 21 days there were no differences across groups, while at 45 days, mice at the high dose crossed the field fewer times, each trip was quicker than controls, & there were fewer rearing episodes, & more time spent grooming. The changes in fertility & pup number seen in Task 2 prompted the conduct of a Task 3 crossover to determine the affected sex using the control & top dose groups. While 100% of the control x control pairs mated, only 75% of the groups containing a treated animal did. There were no differences across groups in terms of the number of pups/litter, or the viability or weight of those pups. An affected sex could not be determined for this compound. After the delivery & assessment of the Task 3 litters, the control & high dose F0 adults were killed & necropsied. The body weight of high-dose treated males was reduced by nearly equal to 4%, while relative liver weight & kidney weight was increased by nearly equal to 24% & 12%, respectively, compared to controls. There

were no changes in sperm indices. For females, body weight was reduced by nearly equal to 10%, while relative liver weight was increased by nearly equal to 19% & kidney weight was increased by nearly equal to 7%. The fertility of the second generation was evaluated for all dose groups. There was no treatment-related effect on the proportion of pairs mating or delivering litters, nor were there any differences between the groups in terms of number of pups/litter, or pup viability or weight. After delivery & evaluation of the F2 pups, the F1 adults were killed & necropsied. Male body weights were reduced by 5%, 7%, & 9% (low to high dose groups, respectively). Absolute testis weight was also reduced, by 6-8% in all dosed groups. Adjusted liver weights were increased by 6%, 9%, & 16%, respectively. Seminal vesicle weight was increased by nearly equal to 18% at the middle dose only. Treated female body weights were reduced by 4%, 3%, & 11%, respectively, from low to high dose groups, while adjusted liver weight was increased by 10% at both the middle & high dose levels. Abnormal sperm forms were more numerous at the low dose, approx doubled from 0.54% to 1.13%. No other sperm changes were noted. No vaginal cyclicity data were collected. In sum, these data indicate that **TCE** produced some general toxicity (reduced body weight gain, increased relative liver & kidney weights) at all doses, while reducing reproductive indices only in the F1 rats at the middle & high dose levels. Thus, **TCE** was not found to be a selective reproductive toxicant in rats.
[Department of Health & Human Services/National Institute of Environmental Health Sciences, National Toxicology Program; Trichloroethylene (CAS # 79-01-6): Reproduction and Fertility Assessment in F344 Rats When Administered in Feed, NTP Study No. RACB84112 (January 1986) available at http://ntp-server.niehs.nih.gov/htdocs/pub-RT0.html as of August 14, 2002]**QC REVIEWED**

Trichloroethylene (**TCE**), a common industrial solvent & dry cleaning agent, was tested for its effects on reproduction & fertility in Swiss CD-1 mice using the RACB protocol. **TCE** was microencapsulated in a gelatin/sorbitol shell, & added to the diet. Data from a 2 wk dose-range-finding study (Task 1) were used to set exposure concns for the Task 2 continuous cohabitation study at 0.15, 0.30, & 0.60% w/w. Based on the results of the analysis of feed formulations & an avg daily feed consumption of nearly equal to 5.0g, the daily **TCE** dosages were nearly equal to 100, 300, & 700 mg/kg/day. **TCE** exposure was associated with no adverse clinical signs, & post-partum dam weights during the Task 2 cohabitation phase were not reduced by **TCE**. The only adverse reproductive change noted during Task 2 was a 4% reduction in pup weight adjusted for litter size at the high dose. The last litter from the control & high dose groups was reared to weaning, for subsequent evaluation of second generation fertility. Maternal **TCE** exposure during lactation was associated with a significant incr in perinatal mortality: the 28% mortality rate in control litters is significantly less than the 61% mortality rats in the high dose **TCE** group. After weaning, mortality rates were comparable between the two groups. After the F1 pups were weaned, the F0 control & high dose mice were killed & necropsied. Male body weight was not changed, while absolute testis weight was reduced by 4%, adjusted liver weight was increased by nearly equal to 34%, & adjusted prostate weight was reduced by nearly equal to 16%. Sperm motility was reduced by nearly equal to 45% in the high dose **TCE** treated animals; no other sperm or reproductive changes were noted. In females, body weight was unchanged while adjusted liver weight was increased by nearly equal to 30%. No histologically-visible changes in vaginal epithelium were noted. Treated mice had a greater incidence of centrilobular hypertrophy, & renal tubular degeneration & corticomedullary epithelial karyomegaly. Males were generally more affected than females. The second generation mice from the control & high dose groups were cohabited at nearly equal to /postnatal day/ 74. No reproductive endpoint was altered by **TCE** exposure. After evaluation of the F2 pups, the F1 adults were killed & necropsied. Male body weight was unchanged, but adjusted liver weight was increased by nearly equal to 60%, adjusted kidney weight was increased by nearly equal to 9%, & adjusted epididymis weight increased by nearly equal to 9%. The % motile sperm was reduced by nearly equal to 20%, while the proportion of abnormal sperm was increased from a control value of 8%, to 10% in the treated mice. **TCE**-treated female body weights were not different from controls, while adjusted

liver weight & kidney weight were increased by nearly equal to 30% & 16%, respectively. Hepatic & renal microscopic lesions were similar to those noted for the F0 mice. Histologic evaluation of the vaginal epithelium indicated cycling in both groups, but cycles were not assessed in vivo. In summary, **TCE** exposure to mice via the diet produced significant hepatic & renal toxicity (increased weights & microscopic lesions), reduced sperm motility in both generations, & produced greater lactational mortality in the high dose group. These data suggest that the hepatic/renal/lactational toxicities were more severe than the relatively moderate reductions in sperm motility.
[Department of Health & Human Services/National Institute of Environmental Health Sciences, National Toxicology Program; Trichloroethylene (CAS # 79-01-6): Reproduction and Fertility Assessment in CD-1 Mice When Administered in Feed, NTP Study No. RACB84113 (November 1985) available at http://ntp-server.niehs.nih.gov/htdocs/pub-RT0.html as of August 14, 2002]**QC REVIEWED**

... The purpose of this time course study was to determine the potential effects of **trichloroethylene** to induce autoimmunity in the Brown Norway Rat model and to determine the time of maximum effect. The studies were conducted in female Brown Norway Rat. The animals were administered **trichloroethylene** (500 mg/kg) five days a week for an 8-week period by oral gavage. **Trichloroethylene** was prepared weekly in a 10% Alkamus-deionized water solution. Additional groups of vehicle- and **trichloroethylene**-exposed animals also received mercuric chloride (1 mg/kg) three times per week by subcutaneous injection for 2 additional weeks. Various parameters of autoimmunity were evaluated weekly, at the time of sacrifice following **trichloroethylene** treatment, and at time of sacrifice following challenge with mercuric chloride. ... The results of the time course study demonstrate that female Brown Norway rats have a strong aversion to being exposed to **trichloroethylene** by oral gavage. Furthermore, during the study 3 deaths directly related to chemical exposure were observed in the **trichloroethylene** exposure group which consisted of 15 animals. Animals exposed to **trichloroethylene** had decreased body weights compared to the vehicle control animals during the first two weeks of the study and a decrease in body weight gain over the course of the study period. While no effect was observed on spleen, lungs, thymus or adrenal weights, increases were observed in relative kidney (8%) and liver (14%) weights compared to the vehicle controls. When parameters indicative of autoimmune responses were evaluated, no effect was observed on serum IgE levels evaluated weekly, at the time of sacrifice or following challenge with mercuric chloride. No effect was observed on total serum IgG levels at the time of sacrifice; however, a decreased total IgG response was observed in the **trichloroethylene**-exposed animals following challenge with mercuric chloride. No effect was observed on serum IgG antibody titers to dinitrophenol-human serum albumin (DNP-HSA) evaluated weekly or at the time of sacrifice. Decreased serum IgG antibody titers to DNP-HSA response were observed in the **trichloroethylene**-exposed animals following challenge with mercuric chloride. While no effect was observed on serum IgG antibody titers to sheep erythrocytes at the time of sacrifice, a decrease in serum IgG antibody titers to sheep erythrocytes was observed in the **trichloroethylene**-exposed animals following challenge with mercuric chloride. When parameters related to autoimmune disease were evaluated, no effects were observed in blood urea nitrogen (BUN) levels at the time of sacrifice or following challenge with mercuric chloride. No effect was observed on urinalysis parameters which included glucose, protein, pH, and blood in the urine as measured using Hema-Combistix. No effect was observed on serum IgG antibody titers to laminin evaluated weekly or at the time of sacrifice. A decrease in serum IgG antibody titers to laminin was observed in the **trichloroethylene**-exposed animals following challenge with mercuric chloride; however, the decrease did not reach the level of statistical significance. No effects were observed in serum IgG antibody titers to double stranded DNA (dsDNA) at the time of sacrifice or following challenge with mercuric chloride. In conclusion, this time course study demonstrates that exposure to **trichloroethylene** at a dose level of 500 mg/kg for eight weeks results in significant changes in parameters of autoimmunity and that the time of maximum effect on IgG responses occurred 6 weeks after initiation of **trichloroethylene** exposure. Although no effects were

observed on IgE responses, significant changes were observed in IgG antibody-mediated parameters following mercuric chloride challenge. **Trichloroethylene**, at a dose level of 500 mg/kg, produced no significant effect on any of the indicators of autoimmune disease. Due to the exposure-related loss of animals at the 500 mg/kg dose level, future studies using the Brown Norway rat should be conducted at lower doses.
[Department of Health & Human Services/National Institute of Environmental Health Sciences, National Toxicology Program; Time Course Autoimmunity Study of Trichloroethylene (CAS No. 79-01-6) in Female Brown Norway Rats, NTP Study No. IMM96007 (January 1997) available at http://ntp-server.niehs.nih.gov/htdocs/pub-IT0.html as of August 21, 2002]**QC REVIEWED**

... **Trichloroethylene** ... had previously been shown to suppress immune function. **Trichloroethylene** was selected for study with the intent of performing an interaction study with ethanol with the immune system being the target system. Previous studies were performed by the investigators showing that **trichloroethylene**, administered in the drinking water to CD-mice for 120 days, suppressed selected parameters of the immune system. The purpose of this range-finding study was to select doses for use in the interaction study. In order for the study to be performed within the confines of an interaction study, the period of exposure was set at 14 days and higher doses than were previously reported were used. The route of administration was by gavage. Corn oil was selected as the vehicle ... . Toxicological parameters assessed were body weight, selected organ weights and selected hematological indicators. The two immunological assays used to assess immune status were the IgM spleen antibody-forming cell (AFC) response to sheep erythrocytes (sRBC) and the cytotoxic T lymphocyte (CTL) response. Tricloroethylene, in doses between and including 50 and 800 mg/kg administered for 14 days, did not alter body weight or body weight gain or change the hematological parameters examined. Trichlorethylene, in doses including and between 100 and 800 mg/kg, caused a dose-related increase in liver weight but no changes in kidney, spleen or thymus weight. Tricloroethylene, in doses between and including 50 and 800 mg/kg administered for 14 days, did not affect the spleen IgM antibody-forming cell response to sheep erythrocytes. Trichlorethylene, in doses including and between 100 and 800 mg/kg, did not affect the cytotoxic T lymphocyte response. ...
[Department of Health & Human Services/National Institute of Environmental Health Sciences, National Toxicology Program; The Immunotoxicity of Trichloroethylene (corn oil) (CAS No. 79-01-6) Dose Range-Finding Study in Female B6C3F1 Mice, NTP Study No. IMM98010 available at http://ntp-server.niehs.nih.gov/htdocs/pub-IT0.html as of August 21, 2002]**QC REVIEWED**

Non-Human Toxicity Values:

LC50 Rat inhalation 26,000 ppm/1 hr.
[Vernot EH; Toxicol Appl Pharmacol 42 (2): 417-24 (1977)]**PEER REVIEWED**

LC50 Rat inhalation 12,000 ppm/4 hr.
[Siegel J; Toxicol Appl Pharmacol 18 (1): 168-74 (1971)]**PEER REVIEWED**

LC50 Mouse inhalation 8450 ppm/4 hr.
[Friberg L; Acta Pharmacol Toxicol 9 (4): 303-12 (1953)]**PEER REVIEWED**

LD50 Rabbit percutaneous 29 g/kg.
[Smyth HF; Am Ind Hyg Assoc J 23 (2): 95-107 (1962)]**PEER REVIEWED**

LD10 Female CD-1 Mouse gavage 1161 mg/kg; male CD-1 mouse gavage 1347 mg/kg.
[Tucker AN et al; Toxicol Appl Pharmacol 62 (3): 351-7 (1982)]**PEER REVIEWED**

LD50 Female CD-1 Mouse gavage 2443 mg/kg; male CD-1 mouse gavage 2402 mg/kg
[Tucker AN et al; Toxicol Appl Pharmacol 62 (3): 351-7 (1982)]**PEER REVIEWED**

LD90 Female CD-1 Mouse gavage 2443 mg/kg; male CD-1 mouse gavage 4253 mg/kg.
[Tucker AN et al; Toxicol Appl Pharmacol 62 (3): 351-7 (1982)]**PEER REVIEWED**

LD100 Female CD-1 Mouse gavage 5500 mg/kg; male CD-1 mouse gavage 6000 mg/kg.
[Tucker AN et al; Toxicol Appl Pharmacol 62(3): 351-357 (1982)]**PEER REVIEWED**

LD50 Mouse inhalation 49,000 ppm/30 min
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

Rat inhalation 100 ppm/8 hr, no effect.
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

Rabbit inhalation 1,200 ppm/473 hr, no effect.
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

Rabbit, ape, rat, guinea pig inhalation 730 ppm/8 hr/day, 6 weeks, no effects.
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

LD50 Mouse inhalation 5,500 ppm/10 hr
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

LD50 Dog oral 5680 mg/kg
[WHO; Environmental Health Criteria 50; Trichloroethylene p.55 (1985)]**PEER REVIEWED**

LD50 Dog ip 2,800 mg/kg
[WHO; Environmental Health Criteria 50; Trichloroethylene p.55 (1985)]**PEER REVIEWED**

LD50 Rabbit dermal 20 ml/kg
[WHO; Environmental Health Criteria 50; Trichloroethylene p.55 (1985)]**PEER REVIEWED**

LD50 Rat oral 4920 mg/kg
[Hayes, W.J., Jr., E.R. Laws, Jr., (eds.). Handbook of Pesticide Toxicology. Volume 2. Classes of Pesticides. New York, NY: Academic Press, Inc., 1991. 690]**PEER REVIEWED**

LD50 Mouse (female) oral 2443 mg/kg
[Hayes, W.J., Jr., E.R. Laws, Jr., (eds.). Handbook of Pesticide Toxicology. Volume 2. Classes of Pesticides. New York, NY: Academic Press, Inc., 1991. 690]**PEER REVIEWED**

LD50 Mice (male) oral 2402 mg/kg
[Hayes, W.J., Jr., E.R. Laws, Jr., (eds.). Handbook of Pesticide Toxicology. Volume 2. Classes of Pesticides. New York, NY: Academic Press, Inc., 1991. 690]**PEER REVIEWED**

LD50 Mouse ip 3222 mg/kg
[Hayes, W.J., Jr., E.R. Laws, Jr., (eds.). Handbook of Pesticide Toxicology. Volume 2. Classes of Pesticides. New York, NY: Academic Press, Inc., 1991. 690]**PEER REVIEWED**

LD50 Dog ip 2783 mg/kg

[Hayes, W.J., Jr., E.R. Laws, Jr., (eds.). Handbook of Pesticide Toxicology. Volume 2. Classes of Pesticides. New York, NY: Academic Press, Inc., 1991. 690]**PEER REVIEWED**

Ecotoxicity Values:

LC50 Sheepshead minnow 20 mg/l/96 hr. /Conditions of bioassay not specified/
[Borthwick PW; Results of Toxicity Tests with Fish and Macroinvertebrates. USEPA Environmental Research Laboratory (1977)]**PEER REVIEWED**

LC50 Bluegill sunfish 44,700 ug/l/96 hr. /Static bioassay/
[USEPA; In-Depth Studies on Health and Envir Impacts of Selected Water Poll. Contract No. 68-01-4646 (1978) as cited in Ambient Water Quality Document: Trichloroethylene p.B-2 (1980) EPA-440/5/80-007]**PEER REVIEWED**

LC50 Grass shrimp 2 mg/l/96 hr. /Conditions of bioassay not specified/
[Borthwick PW; Results of Toxicity Tests with Fishes and Macroinvertebrates. USEPA, Envir Research Lab (1977)]**PEER REVIEWED**

Toxicity Threshold (Cell Multiplication Inhibition Test) Entosiphon sulcatum (protozoa) 1200 mg/l /Time not specified, conditions of bioassay not specified/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

Toxicity Threshold (Cell Multiplication Inhibition Test) Uronema parduczi Chatton-Lwoff (protozoa) >960 mg/l /Time not specified, conditions of bioassay not specified/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

Toxicity Threshold (Cell Multiplication Inhibition Test) Scenedesmus quadricauda(green algae) >1000 mg/l /Time not specified, conditions of bioassay not specified/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

Toxicity Threshold (Cell Multiplication Inhibition Test) Microcystis aeruginosa (algae) 63 mg/l /Time not specified, conditions of bioassay not specified/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1134]**PEER REVIEWED**

LC50 Mexican axolotl (3-4 wk after hatching) 48 mg/l/48 hr /Conditions of bioassay not specified/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

LC50 Clawed toad (3-4 wk after hatching) 45 mg/l/48 hr /Conditions of bioassay not specified/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnow) 40.7 mg/l/96 hr (95% confidence limits 31.4-71.8 mg/l) /Flow-through test/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

LC50 Pimephales promelas (fathead minnow) 66.8 mg/l/96 hr (95% confidence limits 59.6-74.7 mg/l) /Static test/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

EC10 Pimephales promelas (fathead minnow) 15.2 mg/l/24 hr; 16.9 mg/l/48 hr; 15.5 mg/l/72 hr; 13.7

mg/l/96 hr; Toxic effect for all concentrations specified: loss of equilibrium. /Flow-through bioassay/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

EC50 Pimephales promelas (fathead minnow) 23.0 mg/l/24 hr; 22.7 mg/l/48 hr; 22.2 mg/l/72 hr; 21.9 mg/l/96 hr; Toxic effect for all concentrations specified: loss of equilibrium. /Flow-through bioassay/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

EC90 Pimephales promelas (fathead minnow) 36.2 mg/l/24 hr; 30.6 mg/l/48 hr; 31.8 mg/l/72 hr; 34.9 mg/l/96 hr; Toxic effect for all concentrations specified: loss of equilibrium. /Flow-through bioassay/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1135]**PEER REVIEWED**

Toxicity Threshold (Cell Multiplication Inhibition Test) Pseudomonas putida (bacteria) 65 mg/l
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1134]**PEER REVIEWED**

TSCA Test Submissions:

The ability of **trichloroethylene** to induce morphological transformation in the BALB/3T3 mouse cell line (Cell Transformation Assay) was evaluated. Based on preliminary toxicity determinations (exposure time=1 day), **trichloroethylene** was tested at 0, 4, 20, 100 and 250 ug/ml, with cell survival ranging from 125% to 96% relative to untreated controls. The test compound did not produce significantly greater transformation frequencies than untreated controls.
[Arthur D. Little, Inc.; Cell Transformation Assays of 11 Chlorinated Hydrocarbon Analogs. (1983), EPA Document No. 40-8324457, Fiche No. OTS0509392]**QC REVIEWED**

The effects of **trichloroethylene** were examined in the mouse hepatocyte primary culture DNA repair assay. Based on preliminary toxicity tests, **trichloroethylene** was tested at concentrations of 1, 0.1, 0.01, 0.001, 1x10(-4), 1x10(-5) and 1x10(-6)% in DMSO solvent vehicle. The highest two concentrations were too cytotoxic to evaluate in the assay. The lower levels were not cytotoxic but the 0.01 and 0.001% levels caused a significant increase in the unscheduled DNA synthesis over the solvent control (DMSO).
[Naylor Dana Institute; DNA Repair Tests of 11 Chlorinated Hydrocarbon Analogs. (1983), EPA Document No. 40-8324292, Fiche No. OTS0509403]**QC REVIEWED**

The effects of **trichloroethylene** were examined in the rat hepatocyte primary culture DNA repair assay. Based on preliminary toxicity tests, **trichloroethylene** was tested at concentrations of 1, 0.1, 0.01, 0.001, 1x10(-4) and 1x10(-5)% in DMSO solvent vehicle. The higher two levels were too cytotoxic to be evaluated in the assay. The concentrations at 0.01% or lower were not cytotoxic and did not cause a significant increase in the unscheduled DNA synthesis over the solvent control.
[Naylor Dana Institute; DNA Repair Tests of 11 Chlorinated Hydrocarbon Analogs. (1983), EPA Document No. 40-8324292, Fiche No. OTS0509403]**QC REVIEWED**

The mutagenicity of trichloroethane was evaluated in Salmonella tester strains TA98, TA100, TA1535 and TA1537 (Ames Test), both in the presence and absence of added metabolic activation by Aroclor-induced rat liver S9 fraction. **Trichloroethylene** caused a positive response in strains TA100 and TA1535, both with and without added metabolic activation. **Trichloroethylene** did not cause a positive response in strains TA98 or TA1537 in any of the test. **Trichloroethylene** was evaluated using a protocol in which the test article was usually tested over a minimum of 6 dose levels, the highest nontoxic dose level being 10 mg/plate unless solubility, mutagenicity or toxicity dictated a lower limit.
[SRI International; Investigation of the Species Sensitivity and Mechanism of Carcinogenicity of Halogenated Hydrocarbons. (1984), EPA Document No. 40-8424225, Fiche No. OTS0509408]**QC REVIEWED**

The pharmacokinetics of 1,1,2-**trichloroethylene** (TRI) was evaluated in male B6C3F1 mice (4/exposure) and male Osborne-Mendel rats (4/exposure) receiving nominal concentrations of 14C-TRI at 10ppm or 600ppm for 6 hours in a dynamic airflow chamber. Mice and rats were placed in Roth-type metabolism cages for collection of feces, urine and expired air for 50 hours post exposure. Within 50 hours, 98-99% of the total radioactivity observed in all exposed male mice was metabolized. The primary route of elimination (approximately, 75% of total body burden) for all mice was via the urine. Approximately 9% of 14C-TRI body burden in mice was biotransformed to the 14C-carbon dioxide. No indication of saturation of 14C-TRI metabolites in the high dose mice was observed. In contrast, rats metabolism of 14C-TRI appeared to show characteristics of saturation at the high dose level. Total metabolism of 14C-TRI in rats at the high dose level (79% of absorbed dose) was decreased relative to the low dose rats (98% of the absorbed dose). Also, exhalation of 14C-TRI increased 10-fold with increased exposure in rats. The primary route of elimination of 14C-TRI in the rat was via the urine which accounted for approximately 62% and 55% of the 14C-TRI body burden in low and high doses, respectively. Mice metabolized 2.2 fold and 3.6 fold more TRI on a per kg body weight basis than rats at 10ppm and 600ppm, respectively.
[Dow Toxicology Research Laboratory; The Pharmacokinetics and Macromolecular Interactions of Trichloroethylene in Mice and Rats, Final Report, (1981), EPA Document No. FYI-AX-0781-0120, Fiche No. OTS0000120-0]**QC REVIEWED**

The ability of 1,1,2-**trichloroethylene** to alkylate hepatic DNA was evaluated in four male B6C3F1 mice receiving a carcinogenic dose (1200mg/kg) of 14C-TRI orally by gavage. Mice were sacrificed 5 hours post exposure, and liver were excised. 1,1,2-**Trichloroethylene** alkylated hepatic DNA in mice to a very small degree, with the maximum estimate average DNA alkylation of 0.62 (+/-0.42) alkylations/10(6) nucleotides for three mice and no 14C-associated bases were detected in the fourth mouse.
[Dow Toxicology Research Laboratory; The Pharmacokinetics and Macromolecular interactions of Trichloroethylene in Mice and Rats as Related to Oncogenicity, Final Report, (1981), EPA Document No. FYI-AX-0781-0120, Fiche No. OTS0000120-0]**QC REVIEWED**

The ability of **trichloroethylene** (**TCE**) to cause unscheduled DNA synthesis was evaluated in 3 sets of male B6C3F1 mice (10-12/group) exposed by gavage using 3 regimes: Set 1, 0 or 2400 mg/kg/day for 3 days; Set 2, 0 or 2400 mg/kg/day for 5 days/week for 3 weeks; and Set 3, 0 , 250, 500, 1200 or 2400 mg/kg/day for 5 days/week for 3 weeks. Mice were injected subcutaneously with radiolabelled thymidine, Set 1 daily, and Sets 2 and 3 on the last 5 and 4 days of **TCE** treatment, respectively. The animals were sacrificed upon termination of treatment and the kidneys (Set 1 only) and livers examined. There were statistically significant differences noted between treated and control mice in the following: Sets 1 and 2 ($p < 0.01$, Dunnett's or Student's t-test), increased liver/body weight ratio and hepatic DNA synthesis, and decreased ug DNA/g tissue; Set 3, dose-related increase in liver/body weight ratio (500 mg/kg/day and above, $p < 0.01$), and a dose-related decrease in hepatic DNA synthesis (500 mg/kg/day and above, $p < 0.01$). No significant differences were observed between the kidneys of treated and control mice of Set 2. Histopathological changes in hepatic tissue were observed in all treated animals (dose-related in Set 3 animals). Five mice treated with 1200 mg radiolabelled **TCE**/kg by gavage and sacrificed 3 hrs later indicated that **TCE** alkylated hepatic DNA only to a small degree.
[Dow Chemical USA; The Pharmacokinetics and Macromolecular Interactions of Trichloroethylene in Mice and Rats as Related to Oncogenicity. (1981), EPA Document No. FYI-AX-0781-0120, Fiche No. OTS0000120-0]**QC REVIEWED**

The ability of **trichloroethylene** (**TCE**) to cause unscheduled DNA synthesis was evaluated in 2 sets of male Osborne-Mendel rats (4/group) exposed by gavage using 2 regimes: Set 1, 0 or 1100 mg/kg/day for 3 days, and Set 2, 0 or 1100 mg/kg/day for 5 days/week for 3 weeks. The rats were injected subcutaneously with radiolabelled thymidine, Set 1 daily, and Set 2 on the last 5 days of **TCE** treatment.

The animals were sacrificed upon termination of treatment and the kidneys (Set 1 only) and livers examined. There were statistically significant differences noted between treated and control rats in the following: Set 2 ($p < 0.01$, Dunnett's or Student's t-test), increased liver/body weight ratio and hepatic DNA synthesis. No significant differences were observed between the kidneys of treated and control rats of Set 2 or the livers of treated and control rats of Set 1. No significant histopathological changes in hepatic tissue were observed in any of the groups of animals.
[Dow Chemical USA; The Pharmacokinetics and Macromolecular Interactions of Trichloroethylene in Mice and Rats as Related to Oncogenicity. (1981), EPA Document No. FYI-AX-0781-0120, Fiche No. OTS0000120-0]**QC REVIEWED**

The macromolecular binding of 1,1,2-**trichloroethylene** (TRI) was evaluated in male B6C3F1 mice (12/exposure) and male Osborne-Mendel rats (12/exposure) receiving nominal concentrations of 14C-TRI at 10ppm or 600ppm for 6 hours in a dynamic air flow chamber. Four rats and four mice were sacrificed at 0, 6 and 24 hours post exposure, and liver and kidneys were excised. Additional mice and rats were sacrificed at 50 hour post exposure from a previous study under the same conditions. The mice had greater binding of radiolabel from TRI than the rat after exposure to 10 or 600ppm of 14C-TRI. Macromolecular binding as measured by pmole Eq C14-TRI per ug protein was three to four times greater in both hepatic and renal tissue in mice following 600ppm exposure than rats. Only a modest increase was observed in hepatic tissue of the mouse following 10ppm exposure relative to the rat. Maximum binding in the liver for both species was observed immediately following exposure (3 hours for the kidneys) and decreased steadily over the next 48 hours.
[Dow Toxicology Research Laboratory; The Pharmacokinetics and Macromolecular Interactions of Trichloroethylene in Mice and Rats, Final Report, (1981), EPA Document No. FYI-AX-0781-0120, Fiche No. OTS0000120-0]**QC REVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

RATS EXCRETE 5-7 TIMES MORE TRICHLOROETHANOL THAN TRICHLOROACETIC ACID AFTER EXPOSURE TO **TRICHLOROETHYLENE**.
[National Research Council. Drinking Water & Health Volume 1. Washington, DC: National Academy Press, 1977. 777]**PEER REVIEWED**

EXCRETION OF METABOLITES HAS BEEN STATED TO AMT TO 56% OF **TRICHLOROETHYLENE** INHALED-7-27% TRICHLOROACETIC ACID, 22.2-22.5% TRICHLOROETHANOL, FREE OR CONJUGATED, 22.5-45.5% UROCHLORALIC ACID AND SMALL AMT ... OF MONOCHLOROACETIC ACID AND CHLOROFORM. ...
[Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965. 194]**PEER REVIEWED**

METAB OF **TCE** PROCEEDED THROUGH FORMATION OF A COMPLEX WITH OXYGENATED CYTOCHROME P450 WHICH, BY REARRANGEMENT, CAN LEAD TO: (A) SUICIDAL HEME DESTRUCTION; (B) FORMATION OF CHLORAL, WHICH COULD BE REDUCED TO TRICHLOROETHANOL AND CONJUGATED TO FORM A GLUCURONIDE OR OXIDIZED TO TRICHLOROACETIC ACID; (C) FORMATION OF **TCE** OXIDE, WHICH DECOMP TO CO AND GLYOXYLIC ACID; AND (D) METABOLITES WHICH BIND IRREVERSIBLY TO PROTEIN, DNA, AND RNA.
[MILLER RE, GUENGERICH FP; CANCER RES 43 (3): 1145-52 (1983)]**PEER REVIEWED**

Hepatic microsomes from rats fed for 3 weeks on an isocaloric diet deficient in carbohydrate (sucrose) had an increased capacity (2-1/2-fold) to metabolize **trichloroethylene**.
[Nakajima T et al; Biochem Pharmacol 31: 1005-11 (1982) as cited in USPEA; Health

Assessment Document: Trichloroethylene (Draft) p.4-39 (1983)
EPA-600/8-82-006B]**PEER REVIEWED**

IN VITRO ADDITION OF **TCE** TO INCUBATION MIXTURE DECR METAB OF ETHYLMORPHINE & HEXOBARBITAL BY HEPATIC MICROSOMES IN RATS. INHIBITION OF HEXOBARBITAL METAB WAS COMPETITIVE. REPEATED ADMIN TO RATS DECR MICROSOMAL CYTOCHROME P450; INCR LIVER/BODY WT RATIO, MICROSOMAL PROTEINS, NADPH-CYTOCHROME C REDUCTASE ACTIVITY, ANILINE HYDROXYLASE ACTIVITY.
[PESSAYRE D ET AL; TOXICOL APPL PHARMACOL 49 (2): 355-64 (1979)]**PEER REVIEWED**

The metabolism of **TCE** in rats involves oxidation by the liver /SRP: post-mitochondrial supernatant/ mixed function oxidase system to an epoxide intermediate, which binds covalantly to proteins and causes centrilobular damage in the liver. ...
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-165]**PEER REVIEWED**

Rats and mice metabolize **trichloroethylene** in a qualitatively similar fashion; however, the greater rate of metabolism in mice resulted in (a) a 4-fold greater burden of metabolized **trichloroethylene** per kilogram of body weight (600 ppm/hr and 2000 mg/kg oral dose) and (b) 4- and 7-fold higher blood concentrations of trichloroethanol and trichloroacetic acid in mice versus rats (1000 mg/kg oral dose), respectively. Humans metabolize **trichloroethylene** to trichloroethanol and trichloroacetic acid, but more slowly than either mice or rats, which is thought to have important implications with respect to the greater sensitivity of the mouse to toxic effects of **trichloroethylene**. **Trichloroethylene** is metabolized by the cytochrome p450 mixed-function oxidase system to chloral (trichloroacetaldehyde), which is subsequently oxidized to trichloroacetic acid or reduced to trichloroethanol (free and conjugated).
[Hayes, W.J., Jr., E.R. Laws, Jr., (eds.). Handbook of Pesticide Toxicology. Volume 2. Classes of Pesticides. New York, NY: Academic Press, Inc., 1991. 691]**PEER REVIEWED**

Trichloroethylene is converted to trichloroethanol, free and conjugated with glucuronic acid. The initial conversion of the solvent is to chloral hydrate. Trichloroacetic and the monochloroacetic acid and trichloroethanol are found in the urine. Urinary metabolites can be used for assessment of exposure.
[Zenz, C., O.B. Dickerson, E.P. Horvath. Occupational Medicine. 3rd ed. St. Louis, MO., 1994 721]**PEER REVIEWED**

The toxicity & metab of **trichloroethylene** (TRI) were studied in renal proximal tubular (PT) & distal tubular (DT) cells from male Fischer 344 rats. TRI was slightly toxic to both PT and DT cells, & inhibition of cytochrome P450 (P450; substrate, reduced-flavoprotein:oxygen oxidoreductase (RH-hydroxylating or -epoxidizing); EC 1.14.14.1) increased TRI toxicity only in DT cells. In untreated cells, glutathione (GSH) conjugation of TRI to form S-(1,2-dichlorovinyl)glutathione (DCVG) was detected only in PT cells. Inhibition of P450 transiently increased DCVG formation in PT cells & resulted in detection of DCVG formation in DT cells. Formation of DCVG in PT cells was described by a two-component model (apparent Vmax values of 0.65 & 0.47 nmol/min per mg protein & Km values of 2.91 & 0.46 mM). Cytosol isolated from rat renal cortical, PT, & DT cells expressed high levels of GSH S-transferase (GST; RX:glutathione R-transferase; EC 2.5.1.18) alpha (GSTalpha) but not GSTpi. Low levels of GSTmu were detected in cortical & DT cells. Purified rat GSTalpha2-2 exhibited markedly higher affinity for TRI than did GSTalpha1-1 or GSTalpha1-2, but each isoform exhibited similar Vmax values. Triethyltinbromide (TETB) (9 muM) inhibited DCVG formation by purified GSTalpha1-1 & GSTalpha2-2, but not GSTalpha1-2. Bromosulfophthalein (BSP) (4 muM) only inhibited DCVG formation by GSTalpha2-2. TETB & BSP inhibited approximately 90% of DCVG formation in PT cytosol but had no effect in DT cytosol. This suggests that GSTalpha1-1 is the primary isoform in rat renal PT cells responsible for GSH conjugation of TRI. These data ... describe the metab

of TRI by individual GST isoforms & suggest that DCVG feedback inhibits TRI metab by GSTs.
[Cummings BS et al; Biochemical Pharmacology 59 (5): 531-543 (2000)]**PEER REVIEWED**

A major focus in the study of metab & disposition of **trichloroethylene** (**TCE**) is to identify metabolites that can be used reliably to assess flux through the various pathways of **TCE** metab & to identify those metabolites that are causally associated with toxic responses. ... Sex- & species-dependent differences in biotransformation pathways ... can play an important role in the utility of laboratory animal data for understanding the pharmacokinetics & pharmacodynamics of **TCE** in humans. Sex-, species-, & strain-dependent differences in absorption & distribution of **TCE** may play some role in explaining differences in metab & susceptibility to toxicity from **TCE** exposure. The majority of differences in susceptibility, however, are likely due to sex-, species-, & strain-dependent differences in activities of the various enzymes that can metabolize **TCE** & its subsequent metabolites. An addtl factor that plays a role in human health risk assessment for **TCE** is the high degree of variability in the activity of certain enzymes. **TCE** undergoes metab by two major pathways, cytochrome P450 (P450)-dependent oxidation & conjugation with glutathione (GSH). Key P450-derived metabolites of **TCE** that have been associated with specific target organs, such as the liver & lungs, include chloral hydrate, trichloroacetate, & dichloroacetate. Metabolites derived from the GSH conjugate of **TCE**, in contrast, have been associated with the kidney as a target organ. Specifically, metab of the cysteine conjugate of **TCE** by the cysteine conjugate beta-lyase generates a reactive metabolite that is nephrotoxic & may be nephrocarcinogenic. Although the P450 pathway is a higher activity & higher affinity pathway than the GSH conjugation pathway, one should not automatically conclude that the latter pathway is only important at very high doses.
[Lash LH et al; Environmental Health Perspectives 108 (2): 177-200 (2000)]**PEER REVIEWED**

Metabolites of toluene (hippuric acid) & **trichloroethylene** (total trichloro cmpds) have been estimated in labotratory rats after microsomal induction by phenobarbital. Phenobarbital pretreatment accelerated the removal of total trichloro cmpds, however, excretion of hippuric acid was moderately diminished. Results on cytochrome P450 suggest that microsomal induction by phenobarbital was higher in **trichloroethylene** treated rats than toluene treated rats. It is concluded that in addition to distinct substrate specificity of CYP450 isozymes several other factors like Vmax/Km & QH determine the metab of organic solvents.
[RANA S VS; GUPTA S; JOURNAL OF ENVIRONMENTAL BIOLOGY 21 (2): 105-109 (2000)]**PEER REVIEWED**

A ... study investigated the possible differences in metabolism and pharmacokinetics between mice and rats exposed to **trichloroethylene**. A comparison of metabolized **trichloroethylene** on a wt basis indicates that the mouse metabolizes 2.2 times more than the rat at 10 ppm and 3.6 times at 600 ppm. Hepatic macromolecular binding was greater in the mouse than in the rat. The binding data suggest that tumor formation in the mouse exposed to **trichloroethylene** occurred via a nongenetic mechanism and tumors are not expected if liver injury does not occur.
[American Conference of Governmental Industrial Hygienists. Documentation of the Threshold Limit Values and Biological Exposure Indices. 5th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, 1986.596]**PEER REVIEWED**

Absorption, Distribution & Excretion:

... It can penetrate intact human skin.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-165]**PEER REVIEWED**

PLACENTAL TRANSMISSION DATA: TIME TO APPEAR IN FETUS--2 MIN; TIME TO FETAL/MATERNAL CONCN EQUILIBRIUM--6 MIN; FETAL/MATERNAL CONCENTRATION RATIO--1.0 /FROM TABLE/
[LaDu, B.N., H.G. Mandel, and E.L. Way. Fundamentals of Drug Metabolism and Disposition. Baltimore: Williams and Wilkins, 1971. 100]**PEER REVIEWED**

... A DAILY EXPOSURE LEVEL OF APPROXIMATELY 100 PPM, ONLY ONE-THIRD OF THE RETAINED **TRICHLOROETHYLENE** (CALCULATED) IS EXCRETED AS METABOLITES IN THE URINE DURING THE WORK DAY.
[Doull, J., C.D. Klaassen, and M. D. Amdur (eds.). Casarett and Doull's Toxicology. 2nd ed. New York: Macmillan Publishing Co., 1980. 475]**PEER REVIEWED**

BINDING OF **TCE** TO LIVER MICROSOMAL PROTEINS OF MALE B6C3 HYBRID MICE WAS 46% HIGHER THAN /BINDING OF/ (14)C-**TCE** TO MICROSOMAL PROTEINS FROM MALE OSBORNE-MENDEL RATS.
[BANERJEE S ET AL; CANCER RES 38 (3): 776-80 (1978)]**PEER REVIEWED**

10 VOLUNTEER STUDENTS WERE EXPOSED TO 250-380 PPM OF **TRICHLOROETHYLENE** FOR 160 MIN. RETENTION AMOUNTED TO 36%. 16% OF THE RETAINED AMT WAS ELIMINATED THROUGH RESPIRATION AFTER EXPOSURE. TRICHLOROACETIC ACID EXCRETION IN FEMALES WAS 2-3 TIMES MORE THAN THAT IN MALES FOR THE 1ST 24 HR AFTER EXPOSURE. TWICE AS MUCH TRICHLOROETHANOL WAS EXCRETED IN MALES THAN IN FEMALES FOR THE 1ST 12 HR. THESE FINDINGS SUGGEST A SEX DIFFERENCE IN HUMAN METABOLISM OF **TRICHLOROETHYLENE**.
[NOMIYAMA K, NOMIYAMA H; INT ARCH ARBEITSMED 28 (1): 37-48 (1971)]**PEER REVIEWED**

The blood concn of **trichloroethylene** during inhalation and elimination /in humans/ closely parallels alveolar gas concn. **Trichloroethylene** most rapidly attains equilibrium by passive diffusion into the vessel rich group of tissues (VRG) (brain, heart, kidneys, liver, endocrine and digestive systems), more slowly with lean mass (MG) (muscle and skin) and lastly with adipose tissue (FG). As determined from elimination kinetics following exposure, **trichloroethylene** distributes from blood into these 3 major compartments at approx rate constants of VRG: 17 hr(-1) (half-life, 2.4 min), MG: 1.7 hr(-1) (t/2, 25 min) and FG: 0.2 hr(-1) (half-life, 3.5 hr). While MG is 50% of the body vol versus 20% for FG, saturation and desaturation proceeds more rapidly from the MG compartment than the FG compartment because of the considerably greater solubility of **trichloroethylene** in lipids. Thus, variations in **trichloroethylene** uptake between individuals is influenced first by lean body mass and second by adipose tissue mass.
[USEPA; Health Assessment Document: Trichloroethylene (Draft) p.4-5 (1983) EPA-600/8-82-006B]**PEER REVIEWED**

Careful balance studies using GC methodology show, that after single or repeated daily exposures to **trichloroethylene** concentrations between 50 and 380 ppm, an average of 11% of /absorbed/ **trichloroethylene** is eliminated unchanged by the lung (half-life= 5 hr), 2% of the dose is eliminated as trichloroethanol by the lung (half-life 10 to 12 hr) and 58% is eliminated as urinary metabolites. The remaining 30% of the dose has been postulated to be metabolized by additional pathways or routes of elimination of one or more unknown metabolites.
[USEPA; Health Assessment Document: Trichloroethylene (Draft) p.4-22 (1983) EPA-600/8-82-006B]**PEER REVIEWED**

The ratio between **trichloroethylene** exposure and urinary trichloroacetic acid excretion appears to decrease with age.
[Grandjean E et al; Br J Ind Med 12: 131 (1955) as cited in USEPA; Ambient Water Quality Criteria Document: Trichloroethylene p.C-10 (1980) EPA 440/5/80-007]**PEER REVIEWED**

Pure **trichloroethylene** is absorbed through mouse abdominal skin at a rate of 55 nmol/sq cm/min.
[Tsuruta H; Ind Health 16: 145-8 (1978) as cited in Health and Safety Executive Monograph: Trichloroethylene #6 p.3 (1982)]**PEER REVIEWED**

When (14)C-**trichloroethylene** was administered by im injection at a dose of 50 mg/kg, the radioactivity excreted in the urine and feces ranged from 40-60% of the dose in chimpanzees, 11-28% in baboons, and 7-40% in rhesus monkeys.
[Muller WF et al; Chemosphere 11: 215-8 (1982) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.4-23 (1983) EPA-600/8-82-006B]**PEER REVIEWED**

When 18 mg/kg of **trichloroethylene** in 5 ml of water or corn oil was intragastrically administered to fasting rats (400 g), the peak blood concn (5.6 minutes for aqueous solution) averaged 15 times higher for water than for corn oil solution (14.7 vs <1.0 ug/ml). The peak blood concn was reached faster for water than for oil solution, which exhibited a second delayed peak 80 minutes post-absorption.
[Withey JR et al; J Appl Toxicol 3 (5): 249-53 (1983) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.4-2 (1983) EPA-600/8-82-006B]**PEER REVIEWED**

In humans, the blood/air partition coefficient ranges from 9 to 15. Daily body uptake has been estimated to be approximately 6 mg/kg body weight, for an exposure of 4 hr at 378 mg/cu m and /is not influenced/ by the quantity of adipose tissue.
[Monster AC et al; Int Arch Occup Environ Health 42: 283-92 (1979) as cited in WHO; Environ Health Criteria: Trichloroethylene p.42 (1985)]**PEER REVIEWED**

Trichloroethylene retention varies according to physical activity. Under laboratory conditions, human volunteers at rest exposed to concentrations of 540 or 1080 mg/cu m for 30 minutes, 50% of the quantity inhaled was retained. The percentage retained decreased from 50% to 25% when activity rose from rest to a 150 watt workload, but, because of increased ventilation, the absolute amount absorbed still increased.
[Astrand I, Ovrum P; Scand J Work Environ Health 2: 199-211 (1976) as cited in WHO; Environ Health Criteria: Trichloroethylene p.42 (1985)]**PEER REVIEWED**

Trichlororethylene is expired from the lungs for 2 days after exposure, & traces may be present on the 3rd day. About 8% of the retained material is excreted as metabolites in the feces, but most is excreted in the urine. /It was/ found that an average of 73% of the **trichloroethylene** retained by men & women after inhalation could be recovered in the urine as follows: monochloroacetic acid, 4%; trichloroacetic acid, 19%; & trichloroethanol, 50%. In humans, excretion of the metabolites of **trichloroethylene** is fastest for monochloroacetic acid, intermediate for trichloroethanol, & slowest for trichloroacetic acid. Following the use of **trichloroethylene** as an anesthetic, trichloroacetic acid may be detected in the urine for 5-12 days. Following accidental ingestion of **trichloroethylene**, trichloroacetic acid was found in the serum & urine for 27 days.
[Hayes, W.J., Jr., E.R. Laws Jr., (eds.). Handbook of Pesticide Toxicology Volume 1. General Principles. New York, NY: Academic Press, Inc., 1991. 155]**PEER REVIEWED**

Trichloroethylene & its metabolites appear to cross the placenta readily in many species. In mice, inhalation of **trichloroethylene** resulted in accumulation of its metabolite, trichloroacetic acid, in amniotic fluid.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 121 (1995)]**PEER REVIEWED**

A physiologically based pharmacokinetic (PBPK) model was developed that provides a comprehensive description of the kinetics of **trichloroethylene** (**TCE**) & its metabolites, trichloroethanol (TCOH),

trichloroacetic acid (TCA), & dichloroacetic acid (DCA), in the mouse, rat, & human for both oral & inhalation exposure. The model includes descriptions of the three principal target tissues for cancer identified in animal bioassays: liver, lung, & kidney. Cancer dose metrics provided in the model include the area under the concn curve (AUC) for TCA & DCA in the plasma, the peak concn & AUC for chloral in the tracheobronchial region of the lung, & the production of a thioacetylating intermediate from dichlorovinylcysteine in the kidney. Addtl dose metrics provided for noncancer risk assessment include the peak concns & AUCs for **TCE** & TCOH in the blood, as well as the total metab of **TCE** divided by the body weight. Sensitivity & uncertainty analyses were performed on the model to evaluate its suitability for use in a pharmacokinetic risk assessment for **TCE**. Model predictions of **TCE**, TCA, DCA, & TCOH concns in rodents & humans are in good agreement with a variety of experimental data, suggesting that the model should provide a useful basis for evaluating cross-species differences in pharmacokinetics for these chemicals. In the case of the lung & kidney target tissues, however, only limited data are available for establishing cross-species pharmacokinetics. As a result, PBPK model calculations of target tissue dose for lung & kidney should be used with caution.
[Clewell HJ 3rd et al; Environ Health Perspect 108 (2): 283-305 (2000)]**PEER REVIEWED**

Trichloroethylene (**TCE**) pharmacokinetics have been studied in experimental animals & humans for over 30 yr. Compartmental & physiologically based pharmacokinetic (PBPK) models have been developed for the uptake, distribution, & metab of **TCE** & the production, distribution, metab, & elimination of P450-mediated metabolites of **TCE**. **TCE** is readily taken up into systemic circulation by oral & inhalation routes of exposure & is rapidly metabolized by the hepatic P450 system and to a much lesser degree, by direct conjugation with glutathione. Recent PBPK models for **TCE** & its metabolites have focused on the major metabolic pathway for metab of **TCE** (P450-mediated metabolic pathway). This article briefly reviews selected published compartmental & PBPK models for **TCE**. Trichloroacetic acid (TCA) is considered a principal metabolite responsible for **TCE**-induced live r cancer in mice. Liver cancer in mice was considered a critical effect by the U.S. EPA for deriving the current maximum contaminant level for **TCE** in water. In the literature both whole blood & plasma measurements of TCA are reported in mice & humans. To reduce confusion about disparately measured & model-predicted levels of TCA in plasma & whole blood, model-predicted outcomes are compared for first-generation (plasma) & second-generation (whole blood) PBPK models published by Fisher & colleagues. Qualitatively, animals & humans metabolize **TCE** in a similar fashion, producing the same metabolites. Quantitatively, PBPK models for **TCE** & its metabolites are important tools for providing dosimetry comparisons between experimental animals & humans. **TCE** PBPK models can be used today to aid in crafting scientifically sound public health decisions for **TCE**.
[Fisher JW; Environmental Health Perspectives 108 (2): 265-273 (2000)]**PEER REVIEWED**

Trichloroethylene (**TCE**) ... is oxidized by high-affinity, low-capacity cytochrome P450 isozymes & subsequently converted to metabolites, some of which are carcinogenic in mice & rats. Although the initial oxidation step is known to be rate-limiting & saturable, the oral dosage-range over which saturation materializes is unclear. One objective of this study was to characterize the dose-dependency of GI absorption of **TCE** & its kinetics over a wide range of oral bolus doses. A related objective was to investigate cause(s) of the apparent saturation kinetics observed. ... /**TCE** was/ given in doses of 2 to 1200 mg/kg bw via the stomach tube. ... The rate of GI absorption of **TCE** diminished as the dosage increased. Pharmacokinetic analysis indicated that **TCE** was eliminated by capacity-limited hepatic metab, with incursion into nonlinear kinetics with bolus doses :8 to 16 mg/kg. Effects of p-nitrophenol, a competitive metabolic inhibitor, were manifest at a high, but not at a low **TCE** dose. Gavage bolus doses as high as 1200 mg/kg did not cause rapid elevation of serum enzyme levels, typical of the solvation of hepatocellular membranes observed after portal vein admin of **TCE** ... . No evidence of cytochrome

P4502E1 (CYP2E1) destruction was seen with oral doses up to 1000 mg/kg. Instead, CYP2E1 activity was induced as early as 1 h postdosing. Induction was maximal at 12 hr, then returned toward controls during the next 12 h. Pretreatment with cycloheximide did not reduce CYP2E1 activity in rats given 432 or 1000 mg **TCE**/kg, suggesting that binding of **TCE** to CYP2E1 may stabilize the isozyme. Metabolic saturation, in concert with relatively slow GI absorption, are responsible for the prolonged elevation of blood **TCE** levels in rats given high **TCE** doses, while suicidal inactivation of CYP2E1 & hepatocellular injury apparently play little role.
[Lee KM et al; Toxicology and Applied Pharmacology 164 (1): 55-64 (2000)]**PEER REVIEWED**

... To assess the dermal bioavailability of **trichloroethylene** (**TCE**), exhaled breath was monitored ... using an ion trap mass spectrometer (MS/MS) to track the uptake & elimination of **TCE** from dermal exposures in rats & humans. A physiologically based pharmacokinetic (PBPK) model was used to estimate total bioavailability. Male F344 rats were exposed to **TCE** in water or soil under occluded or nonoccluded conditions by applying a patch to a clipper-shaved area of the back. Rats were placed in off-gassing chambers & chamber air **TCE** concn was quantified for 3-5 h post-dosing using the MS/MS. Human volunteers were exposed either by whole-hand immersion or by attaching patches containing **TCE** in soil or water on each forearm. Volunteers were provided breathing air via a face mask to eliminate inhalation exposure, & exhaled breath was analyzed using the MS/MS. The total **TCE** absorbed & the dermal permeability coefficient (KP) were estimated for each individual by optimization of the PBPK model to the exhaled breath data & the changing media &/or dermal patch concns. Rat skin was significantly more permeable than human skin. Estimates for KP in a water matrix were 0.31 : 0.01 cm/h & 0.015 : 0.003 cm/hr in rats & humans, respectively. KP estimates were more than three times higher from water than soil matrices in both species. KP values calculated using the standard Fick's Law equation were strongly affected by exposure length & volatilization of **TCE**. In comparison, KP values estimated using noninvasive real-time breath analysis coupled with the PBPK model were consistent, regardless of volatilization, exposure concentration, or duration.
[Poet TS et al; Toxicological Sciences 56 (1): 61-72 (2000)]**PEER REVIEWED**

In lifetime bioassays, **trichloroethylene** (**TCE**, CAS No. 79-01-6) causes liver tumors in mice following gavage, liver & lung tumors in mice following inhalation, & kidney tumors in rats following gavage or inhalation. Recently developed pharmacokinetic models provide estimates of internal, target-organ doses of the **TCE** metabolites thought responsible for these tumor responses. Dose-response analyses following recently proposed methods for carcinogen risk assessment from the U.S. EPA are conducted on the animal tumor data using the pharmacokinetic dosimeters to derive a series of alternative projections of the potential carcinogenic potency of **TCE** in humans exposed to low environmental concns. Although mechanistic considerations suggest action of possibly nonlinear processes, dose-response shapes in the observable range of tumor incidence evince little sign of such patterns. Results depend on which of several alternative pharmacokinetic analyses are used to define target-organ doses. Human potency projections under the U.S. EPA linear method based on mouse liver tumors & internal dosimetry equal or somewhat exceed calculations based on admin dose, & projections based on mouse liver tumors exceed those from mouse lung or rat kidney tumors. Estimates of the carcinogenic potency of the two primary oxidative metabolites of **TCE**--trichloroacetic acid & dichloroacetic acid, which are mouse liver carcinogens in their own right--are also made, but it is not clear whether the carcinogenic potency of **TCE** can be quantitatively ascribed to metabolic generation of these metabolites.
[Rhomberg LR; Environ Health Perspect 108 (2): 343-358 (2000)]**PEER REVIEWED**

Regulatory agencies are challenged to conduct risk assessments on chemical mixtures without full information on toxicological interactions that may occur at real-world, low-dose exposure levels. The present study was undertaken to investigate the pharmacokinetic impact of low-dose coexposures to

toluene & **trichloroethylene** in vivo in male F344 rats using a real-time breath analysis system coupled with physiologically based pharmacokinetic (PBPK) modeling. Rats were exposed to compounds alone or as a binary mixture, at low (5 to 25 mg/kg) or high (240 to 800 mg/kg) dose levels. Exhaled breath from the exposed animals was monitored for the parent cmpds & a PBPK model was used to analyze the data. At low doses, exhaled breath kinetics from the binary mixture exposure compared with those obtained during single exposures, thus indicating that no metabolic interaction occurred with the se low doses. In contract, at higher doses the binary PBPK model simulating independent metab was found to under predict the exhaled breath concn, suggesting an inhibition of metab. Therefore the binary mixture PBPK model was used to compare the measured exhaled breath levels from high- & low-dose exposures with the predicted levels under various metabolic interaction simulations (competitive, noncompetitive, or uncompetitive inhibition). Of these simulations, the optimized competitive metabolic interaction description yielded a Ki value closest to the Km of the inhibitor solvent, indicating that competitive inhibition is the most plausible type of metabolic interaction between these two solvents.
[Thrall KD; Poet TS; J of Toxicology and Environmental Health Part A 59 (8): 653-670 (2000)]**PEER REVIEWED**

Biological Half-Life:

THE BIOL HALF-LIVES OF THE URINARY METABOLITES OF HUMANS OCCUPATIONALLY EXPOSED TO **TRICHLOROETHYLENE** WAS APPROX 41 HR.
[IKEDA M, IMAMURA T; INT ARCH ARBEITSMED 31 (3): 209-24 (1973)]**PEER REVIEWED**

The half-life of **trichloroethylene** in exhaled air & in the blood depends on the length of exposure & on the time of sampling after exposure. ... Maximum concn /of trichloroethanol/ in blood & urine /is reached/ almost directly after exposure. ... concn decr with a half-life of about 10-15 hr. ... Concn of trichloroacetic acid in both the blood & urine incr for up to 20-40 hr after /a single/ exposure. ... concn decr with a half-life of about 70-100 hr.
[WHO; Environ Health Criteria 50: Trichloroethylene p.48 (1985)]**PEER REVIEWED**

Mechanism of Action:

TCE WAS INCUBATED WITH RAT LIVER MICROSOME, NADPH AND RNA (FROM YEAST). THE METABOLITES WERE IRREVERSIBLY BOUND TO MICROSOMAL PROTEINS. HYDROLYSIS OF RNA & SEPARATION OF NUCLEOSIDES SHOWED DIFFERENT ALKYLATION PRODUCTS ARISING FROM **TCE** & VINYL CHLORIDE. ... NEWBORN RATS WERE EXPOSED FOR 10 WEEKS TO 2000 PPM VINYL CHLORIDE OR **TRICHLOROETHYLENE** (8H/DAY; 5 DAYS/WEEK). AFTER THIS PERIOD LIVERS OF THE ANIMALS WERE STAINED FOR NUCLEOSIDE-5-TRIPHOSPHATASE. WHEREAS THE VINYL CHLORIDE EXPOSED RATS SHOWED FOCAL HEPATOCELLULAR DEFICIENCIES IN THIS ENZYME, WHICH ARE SUPPOSED TO REPRESENT AN EARLY SIGN OF MALIGNANCY, NO SUCH CHANGES WERE INDUCED BY **TRICHLOROETHYLENE** EXPOSURE.
[LAIB RJ ET AL; J CANCER RES CLIN ONCOL 94 (2): 139-47 (1979)]**PEER REVIEWED**

BINDING CONSTANTS (KS) FOR INTERACTION WITH RAT LIVER MICROSOMAL P450 FOR ITS METAB TO CHLORAL HYDRATE WERE NOT ALTERED BY INDUCTION WITH PHENOBARBITAL, 3-METHYLCHOLANTHRENE OR SPIRONOLACTONE. **TCE** APPEARED TO BE ACTIVATED BY CYTOCHROME TO ACTIVELY ALTER HEME MOIETY OF THE CYTOCHROME P450.
[COSTA AK ET AL; BIOCHEM PHARMACOL 29 (3): 433-9 (1980)]**PEER REVIEWED**

Interactions:

DISULFIRAM IS SAID TO INHIBIT THE OXIDATION /OF **TRICHLOROETHYLENE**/ IN MAN TO THE MORE TOXIC TRICHLOROETHANOL (AND THENCE TO TRICHLOROACETIC ACID) ...
[Gosselin, R.E., H.C. Hodge, R.P. Smith, and M.N. Gleason. Clinical Toxicology of Commercial Products. 4th ed. Baltimore: Williams and Wilkins, 1976.,p. II-112]**PEER REVIEWED**

IN VITRO, ADDITION OF **TCE** DECR METAB OF ETHYLMORPHINE & HEXOBARBITAL BY RAT HEPATIC MICROSOMES. IN VIVO, **TCE** INHIBITED HEXOBARBITAL METABOLISM IN RATS.
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BIOCHEM & TOXICOLOGICAL EFFECTS OF COMBINED EXPOSURE TO 1,1,1-TRICHLOROETHANE (500 PPM) & **TCE** (200 PPM) FOR 4 DAYS 6 HR DAILY CAUSED ACCUM OF 1,1,1-TRICHLOROETHANE IN PERIRENAL FAT. FURTHER EXPOSURE ON DAY 5 CAUSED RAPID INCR IN VARIOUS ORGAN CONTENTS OF BOTH SOLVENTS WITH DEPRESSION OF BRAIN RNA.
[VAINIO H ET AL; XENOBIOTICA 8 (3): 191-6 (1978)]**PEER REVIEWED**

Rabbits were given 10 mg/kg doses of caffeine 30 minutes prior to exposure to 6000 ppm (32,280 mg/cu m) of **trichloroethylene** under dynamic airflow conditions. Epinephrine was infused until arrhythmias occurred after 7.5, 15, 30, 45, and 60 minutes of exposure and 15 and 30 minutes post-exposure. An increase in epinephrine-induced arrhythmias in **trichloroethylene**-exposed rabbits was observed when the animals were treated with caffeine and challenged with doses of epinephrine as low as 0.5 ug/kg.
[White JF, Carlson GP; Fund Appl Toxicol 2: 125-9 (1982) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.5-6 (1983) EPA-600/ 8-82-006B]**PEER REVIEWED**

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[Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 348]**PEER REVIEWED**

Studies /conducted/ with rats /indicate/ that the effects of **trichloroethylene** were more pronounced in the animals that were fed a high carbohydrate diet than those on a high protein diet. /Concentration of **trichloroethylene** not specified/
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Criteria 50: Trichloroethylene p.61 (1985)]**PEER REVIEWED**

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[Carlson GP; Res Comm Chem Pathol Pharmacol 7: 637 (1974) as cited in USEPA; Ambient Water Quality Document: Trichloroethylene p.C-19 (1980) EPA-440/5/80-007]**PEER REVIEWED**

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[Stewart RD et al; Arch Environ Health 29: 1 (1974)]**PEER REVIEWED**

... The induction of the hepatic microsomal mixed-function oxidase system by drugs, taken for therapeutic reasons, or by exposure to certain environmental chemicals (e.g., phenobarbital, toluene, PCBs) can bring about an incr rate of **trichloroethylene** metabolism.
[WHO; Environ Health Criteria 50: Trichloroethylene p.46 (1985)]**PEER REVIEWED**

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[Orlowski J et al; Bromatologia I Chemia ToksykologicznaOKSYKOLOGICZNA 33 (1): 15-21 (2000)]**PEER REVIEWED**

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[Herren F et al; Toxicol Appl Pharmacol 90: 183-9 (1987)]**PEER REVIEWED**

Pharmacology:

Therapeutic Uses:

Anesthetics, Inhalation; Solvents
[National Library of Medicine's Medical Subject Headings online file (MeSH, 1999)]**PEER REVIEWED**

Trichloroethylene ... is no longer used /as anesthetic agent/.
[Gilman, A.G., L.S.Goodman, and A. Gilman. (eds.). Goodman and Gilman's The Pharmacological Basis of Therapeutics. 7th ed. New York: Macmillan Publishing Co.,

Inc., 1985. 292]**PEER REVIEWED**

MEDICATION (VET): INHALATION ANESTHETIC
[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1516]**PEER REVIEWED**

Dental anesthetic. /Former use in USA/
[WHO; Environ Health Criteria 50: Trichloroethylene p.31 (1985)]**PEER REVIEWED**

INHALATION ANALGESIC. /Former use in USA/
[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1516]**PEER REVIEWED**

Drug Warnings:

TRICHLOROETHYLENE HAS BEEN REPORTED TO CAUSE CONVULSIONS IN CHILDREN; THEREFORE, IT SHOULD NOT BE USED IN PATIENTS WITH CONVULSIVE DISORDERS.
[Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980. 986]**PEER REVIEWED**

Patients exposed to **trichloroethylene** should be warned of the potential adverse effects of ethanol ingestion.
[Hansten, P.D. Drug Interactions. 4th ed. Philadelphia: Lea and Febiger, 1979. 219]**PEER REVIEWED**

Isopropanol and acetone ... cause enhanced hepatotoxicity with ... **trichloroethylene**.
[Amdur, M.O., J. Doull, C.D. Klaasen (eds). Casarett and Doull's Toxicology. 4th ed. New York, NY: Pergamon Press, 1991. 348]**PEER REVIEWED**

...Its anesthetic action is weak. Its low volatility appears in part to be responsible for this effect. ... Apparatus that employs bubbling oxygen assists in accelarating the volatility of the anesthetic to increase its potency. Because of its inherent weakness as an anesthetic, induction of anesthesia is slow. Cardiac arrhythmias produced by the anesthetic are unfavorable. **Trichloroethylene** cannot be used in a closed circuit with soda lime because of formation of a toxic product.
[Booth, N.H., L.E. McDonald (eds.). Veterinary Pharmacology and Therapeutics. 5th ed. Ames, Iowa: Iowa State University Press, 1982. 195]**PEER REVIEWED**

Relaxation of abdominal musculature is poor during **trichloroethylene** anesthesia.This effect is similar to other agents (eg, ketamine, alpha-chloralose) that do not induce Stage III anesthesia. **Trichloroethylene** is considered unsatisfactory for this type of surgery unless it is used in conjunction with a skeletal muscle relaxant. It has very little if any effect upon uterine function. It readly crosses the placenta to reach the fetal circulation of sheep, goats, and probably other species.
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[Herren F et al; Toxicol Appl Pharmacol 90: 183-9 (1987)]**PEER REVIEWED**

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Trichloroethylene's production and use in degreasing operations as well as in plastics, appliances, jewellery, automobile, plumbing fixtures, textiles, paper, glass and printing industries may result in its release to the environment through various waste streams. If released to air, a vapor pressure of 69 mm Hg at 25 deg C indicates **trichloroethylene** will exist solely as a vapor in the ambient atmosphere. Vapor-phase **trichloroethylene** will be degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals; the half-life for this reaction in air is estimated to be 7 hours. If released to soil, **trichloroethylene** is expected to have high mobility based upon an average Koc of 101, measured in 32 soils. Volatilization from moist soil surfaces is expected to be an important fate process based upon a Henry's Law constant of 9.85X10-3 atm-cu m/mole. **Trichloroethylene** is expected to volatilize from dry soil surfaces based upon its vapor pressure. Cometabolic biodegradation of **trichloroethylene** has been reported under aerobic conditions where additional nutrients have been added. Under anaerobic conditions, as might be seen in flooded soils, sediments or aquifer environments, **trichloroethylene** is slowly biodegraded via reductive dechlorination; the extent and rate

of degradation is dependent upon the strength of the reducing environment. **Trichloroethylene** half-lives in the field for aquifer studies range from 35 days to over 6 years. If released into water, **trichloroethylene** is not expected to adsorb to suspended solids and sediment based on an average Koc value of 101. Volatilization from water surfaces will be an important fate process based upon this compound's Henry's Law constant. Estimated volatilization half-lives for a model river and model lake are 3.5 hours and 5 days, respectively. Volatilization half-lives in an experimental field mesocosm ranged from 10.7 to 28 days. BCF values in fish ranging from 4 to 39 suggest bioconcentration in aquatic organisms is moderate to low. Occupational exposure to **trichloroethylene** has been shown to occur through inhalation and dermal contact with this compound at workplaces where **trichloroethylene** is produced or used. Extensive monitoring data indicate that the general population may be exposed to **trichloroethylene** via inhalation of ambient air, ingestion of food and drinking water, and dermal contact with this compound and other consumer products containing **trichloroethylene**. **Trichloroethylene** is widely detected in groundwater. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

TRICHLOROETHYLENE WHEN PRESENT IN AIR NEAR OPEN ARC WELDING MAY BE DECOMP TO LEVELS OF PHOSGENE DANGEROUS TO HEALTH, WHEREAS THE HCL AND CL2 FORMED SIMULTANEOUSLY MAY NOT ALWAYS PROVIDE AN ADEQUATE WARNING AGAINST THE PRESENCE OF PHOSGENE.
[RINZEMA LC; INT ARCH ARBEITSMED 28 (2): 151 (1971)]**PEER REVIEWED**

Many industrial workers, operating room personnel and dentists are regularly exposed to **TCE**, some to large doses. The general public encounters **trichloroethylene** in cleaning fluids, some decaffeinated coffees and spice extracts.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-165]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 392,805 workers (169,851 of these are female) are potentially exposed to **trichloroethylene** in the US(1). Occupational exposure to **trichloroethylene** may occur through inhalation and dermal contact with this compound at workplaces where **trichloroethylene** is produced or used(SRC). Extensive monitoring data indicate that the general population may be exposed to **trichloroethylene** via inhalation of ambient air, ingestion of food and drinking water, and dermal contact with this compound and other products containing **trichloroethylene**(SRC).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983)]**PEER REVIEWED**

An open-top and an enclosed conveyor-loaded production **trichloroethylene** vapor degreasers had average emission factors of 2.6 g **TCE**/min and 0.67 g **TCE**/min, respectively(1). Waste gases from aluminum plasma-etching processes (using chlorine containing etchants) during semiconductor production contained **trichloroethylene** at an average concn of 315.70 ng /l(2). The number of US workers exposed to **TCE** is estimated to be 283,000(3). Operating room levels range from 0.3-103 ppm, with an estimated 5000 medical, dental and hospital personnel being routinely exposed(1). Air levels at a dial assembly workshop in Japan measured 25-100 ppm; degreasing room levels, 150-250 ppm(3). **Trichloroethylene** was detected in 6% of 7705 solvent air samples reported from different industries in Norway and stored in the EXPO occupational exposure database(4).
[(1) Wadden RA et al; Am Ind Hyg Asssoc J 50: 496-500 (1989) (2) Bauer S and Wolff I; in Mat Res Soc Symp Proc 447: 35-41 (1997) (3) IARC; Cadmium, Nickel, Some Epoxides, Miscellaneous Industrial Chemicals and General Consideration on Volatile Anaesthetics 11: 263 (1976) (4) Fjeldstad PE, Woldbaek T; A National Exposure Database Special Publ. - Royal Soc Chem (Natl Inst Occup Hlth, Oslo, Norway)

108(Clean Air Work): 303-10 (1992)]**PEER REVIEWED**

23-41% of **trichloroethylene** in feed water to showers was lost with a water temperature of 23 to 40 deg C(1). **Trichloroethylene** was detected in chlorinated swimming pool water from a pool in Gdansk, Poland at concns of not detected (detection limit, on average, 0.01 ug/cu dm) to 13.3 ug/cu dm for 4 different dates in 1991(2).
[(1) Tancrede M et al; Atmos Environ 26A: 1103-11 (1992) (2) Biziuk M et al; Intern J Environ Anal Chem 50: 109-15 (1993)]**PEER REVIEWED**

Body Burden:

Therapeutic or normal blood level 0.1-9 mg%
[Winek, C.L. Drug and Chemical Blood-Level Data 1985. Pittsburgh, PA: Allied Fischer Scientific, 1985.]**PEER REVIEWED**

PERSONAL AIR: The exhaled breath of 73% of 26 smokers and 81% of 43 nonsmokers contained **trichloroethylene** at unreported concns(1). Breath of 12.5% of 50 individuals living in the Los Angeles area contained **trichloroethylene**(2). 51.2% of personal air samples collected from these 50 individuals contained **trichloroethylene**(2). Increased personal air exposures were reported following solvent use, household cleaning, furniture stripping, visiting a dry cleaning shop, photo developing and using paint remover of up to 220 ug/cu m from a baseline of <2 ug/cu m(3). Personal air samples of Los Angeles and Contra Costa residents contained **trichloroethylene** at concns of 7.8 (n=110, Los Angeles residents, February 1984), 6.4(n=50, Los Angeles residents, May 1984) and 3.8 (n=67, Contra Costa residents, June 1984)(4).
[(1) Gordon SM; J Chrom 511: 291-302 (1990) (2) Hartwell TD et al; Atmos Environ 26A: 1519-27 (1992) (3) Wallace LA et al; pp. 2-181 to 2-185 in 4th Int Conf on Indoor Air Quality and Climate. Germany (1987) (4) Wallace LA et al; Atmos Environ 22: 2141-63 (1988)]**PEER REVIEWED**

Blood samples from 179 of 277 people from the general population contained **trichloroethylene** at a mean concn of 458 ng/l; a mean blood concn of 763 ng/l was reported from 63 of 113 urban workers as compared to 180 ng/l from 82 of 127 workers(1). Blood samples collected from workers exposed to **trichloroethylene** in 4 dry-cleaning shops (air concns ranged from 25-40 ppm) contained this compound (median=3.39 umol /l after work (range=0.46-12.71), 0.38 umol /l before work (range=0.15-3.58)(2). Urine samples from the same workers contained the **trichloroethylene** metabolite, trichloroethanol (median=54.89 umol/mol creatinine, range=5.30-177.67 after work; median=9.70 umol/mol creatinine, range=0.38-35.65 before work)(2). Kidney (n=9), lung (n=13), and muscle (n=16) tissues collected from humans in Turku, Finland in 1987 contained **trichloroethylene** at 0.7, 0.02, and 0.2 ug/kg, respectively(3). 20% of composite adipose tissue samples collected in FY82 (n=46 composite samples) contained **trichloroethylene**(4). Breathing air samples from 30 residents of Tokyo, Japan had a mean concn of 2.0 ug/cu m **trichloroethylene** with a calculated daily intake due to breathing ambient air of 40 ug/person (men 24.9 ug/person; women 51.5 ug/person)(5). Breath samples of Los Angeles and Contra Costa residents contained **trichloroethylene** at concns of 1.6 (n=110, Los Angeles residents, February 1984), 1.0 (n=50, Los Angeles residents, May 1984) and 0.6 (n=67, Contra Costa residents, June 1984)(6).
[(1) Brugnone F et al; Med Lav 85: 370-89 (1994) (2) Kender LJ et al; Arch Environ Hlth 46: 174-78 (1991) (3) Kroneld R; Bull Environ Contam Toxicol 42: 873-77 (1989) (4) Onstot JD, Stanley JS; Identification of SARA Compounds in Adipose Tissue. Washington DC: US EPS, Office of Toxic Substances, USEPA-560/5-89-003 (1989) (5) Nakahama T et al; Jpn J Toxicol Environ Hlth; 43: 280-84 (1997) (6) Wallace LA et al; Atmos Environ 22: 2141-63 (1988)]**PEER REVIEWED**

Trichloroethylene was detected in mother's milk samples from 4 US urban areas, with 8 of 8 samples testing pos(1). Concns in post-mortem wet tissue samples were 1-32 ppb(2). Breath samples Love Canal

residents, Niagara Falls, NY contained a trace of **trichloroethylene** with 4 of 9 samples pos; blood - 0.09.50 ppb, 6 of 9 samples pos; and urine - 40-550 parts/trillion, 9 of 9 samples pos(3). Concns in whole blood specimens from 250 subjects ranged from not detected to 1.5 ppb, with a 0.4 ppb avg(4).
[(1) Pellizzari ED et al; Bull Contam Toxicol 28: 322-8 (1982) (2) IARC Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man 11: 263-76 (1976) (3) Barkley J et al; Biomed Mass Spectrom 7: 139-47 (1980) (4) Antoine SR et al; Bull Environ Toxicol 36: 364-71 (1986)]**PEER REVIEWED**

Trichloroethylene was detected in the blood of 13 of 677 samples taken from non-occupationally exposed Americans (detection limit= 0.010 ppb(1). **Trichloroethylene** was measured in blood samples collected from 79 humans at concns ranging from <0.015 to 0.090 ug/l(2). Exhaled breath from humans following both inhalation and dermal exposures during showering or dermal exposure following bathing using normal tap water contained **trichloroethylene** at concns up to 0.32 ug/cu m/ug/l(3).
[(1) Ashley DL et al; Clin Chem 40: 1401-4 (1994) (2) Skender L et al; Arch Environ Hlth 49: 445-51 (1994) (3) Weisel CP, Jo W-K; Environ Hlth Perspect 104: 48-51 (1996)]**PEER REVIEWED**

Natural Pollution Sources:

Trichloroethylene is not known to occur as a natural product.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 550 (1979)]**PEER REVIEWED**

Artificial Pollution Sources:

Trichloroethylene's production and use in degreasing operations in five main industrial groups (furniture and fixtures, fabricated metal products, electric and electronic equipment, transport equipment and miscellaneous manufacturing industries)(1) may result in its release to the environment through various waste streams(SRC). It is also used in plastics, appliances, jewellery, automobile, plumbing fixtures, textiles, paper, glass and printing industries(1). Air emissions from metal degreasing plants contain **trichloroethylene**(2); it has also been reported in wastewater from metal finishing, paint and ink formulation, electrical/electronic components, and rubber processing industries(3).
[(1) IARC Monographs; Dry Cleaning, Some Chlorinated Solvents and Other Industrial Chemicals, IARC/World Health Organization, Lyon, France, Vol 63, p. 80 (1995) (2) Ewing BB et al; Monitoring to Detect Previously Unrecognized Pollutants in Surface Waters. USEPA-560/6-77-015 p. 74 (1977) (3) USEPA; Treatability Manual pp.I.12.23-1 to I.12-23-5 USEPA-600/2-82-001A (1981)]**PEER REVIEWED**

Environmental Fate:

TERRESTRIAL FATE: Based on a classification scheme(1), an average Koc value of 101, based on measurements in 32 soils(2), indicates that **trichloroethylene** is expected to have high mobility in soil(SRC). Volatilization of **trichloroethylene** from moist soil surfaces is expected to be an important fate process(SRC) given a Henry's Law constant of 9.85X10-3 atm-cu m/mole(3). The potential for volatilization of **trichloroethylene** from dry soil surfaces may exist(SRC) based upon a vapor pressure of 69 mm Hg(4). The initial percentage of **trichloroethylene** in the gas (24, 52, 57%), liquid (5, 3, 4%) and adsorbed (71, 45, 39%) phases was determined in three soils, respectively (Rindge, 11.2% organic matter, 35.4% moisture; Yolo, 2.2% organic matter, 11.7% moisture; Reiff, 1.4% organic matter, 13.9% moisture)(5). **Trichloroethylene** is resistant to aerobic biodegradation although biodegradation may proceed cometabolically(5,6). Under anaerobic conditions, as might be seen in soil microsites, flooded soils or aquifer sites, **trichloroethylene** is slowly biodegraded via reductive dechlorination; the extent and rate of degradation is dependent upon the strength of the reducing environment(7).
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Rathbun RE; Transport, Behavior,

and Fate of Volatile Organic Compounds in Streams. USGS Professional Paper 1589, PB98-163397(1998) (3) Leighton DT Jr, Calo JM; J Chem Eng Data 26: 382-85 (1981) (4) Boublik T et al; The Vapour Pressures of Pure Substances, Amsterdam, The Netherlands: Elsevier Science Publ p. 87 (1984) (5) Fan S, Scow KM; Appl Environ Microbiol 59: 1911-18 (1993) (6) El-Farham YH et al; Wat Res Research 34: 437-45 (1998) (7) McCarty PL; Symp Nat Atten Chlor Org Ground Water USEPA/540/R-96/509 pp. 5-9 (1996)]**PEER REVIEWED**

AQUATIC FATE: Based on a classification scheme(1), an average Koc value of 101, based on measurements in 32 soils(2), indicates that **trichloroethylene** is not expected to adsorb to suspended solids and sediment(SRC). Volatilization from water surfaces is expected to be a major fate process for this compound in water(3) based upon a Henry's Law constant of 9.85X10-3 atm-cu m/mole(4). Using this Henry's Law constant and an estimation method(3), volatilization half-lives for a model river and model lake are 3.5 hours and 5 days, respectively(SRC). **Trichloroethylene** volatilization half-lives from a mesocosm field experiment in Narragansett Bay ranged from 10.7 to 28 days(5). **Trichloroethylene** is not degraded under aerobic conditions although cometabolic biodegradation has been reported under conditions where additional nutrients have been added(6-8). Under anaerobic conditions, as might be seen in sediments or groundwater, **trichloroethylene** is slowly biodegraded via reductive dechlorination; the extent and rate of degradation is dependent upon the strength of the reducing environment(9). According to a classification scheme(10), BCF values ranging from 4.0 in carp(11) to 39 in rainbow trout(12), suggests the potential for bioconcentration in aquatic organisms is low to moderate.
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Meylan WM et al; Environ Sci Technol 26: 1560-67 (1992) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9, 15-1 to 15-29 (1990) (4) Leighton DT Jr, Calo JM; J Chem Eng Data 26: 382-85 (1981) (5) Wakeham SG et al; Environ Sci Technol 17: 611-17 (1983) (6) Hopkins GD, McCarty PL; Environ Sci Technol 29: 1628-37 (1995) (7) Semprini L et al; Ground Water 28: 715-27 (1990) (8) Semprini L et al; Ground Water 29: 239-50 (1991) (9) McCarty PL; Symp Nat Atten Chlor Org Ground Water USEPA/540/R-96/509 pp. 5-9 (1996) (10) Franke C et al; Chemosphere 29: 1501-14 (1994) (11) Chemicals Inspection and Testing Institute; Biodeg Bioaccum Data Existing Chem Based on the CSCL Japan, ISBN 4-89074-101-1, Ministry of Internatl Trade & Industry, Japan p. 2-24 (1992) (12) Lyman WJ; Handbook of Chemical Property Estimation Methods Ann Arbor Sci, MI p. 5-9 (1981)]**PEER REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), **trichloroethylene**, which has a vapor pressure of 69 mm Hg at 25 deg C(2), is expected to exist solely as a vapor in the ambient atmosphere. Vapor-phase **trichloroethylene** is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals(SRC); the half-life for this reaction in air is estimated to be 7 days(SRC), calculated from its rate constant of 2.36X10-12 cu cm/molecule-sec at 25 deg C(3). Phosgene, dichloroacetyl chloride, chloroform and formyl chloride are formed from the reaction of **trichloroethylene** with hydroxyl radicals(4-6).
[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Boublik T et al; The Vapour Pressures of Pure Substances, Amsterdam, The Netherlands: Elsevier Science Publ p. 87 (1984) (3) Atkinson R; J Phys Chem Ref Data Monograph No. 2 p. 116 (1994) (1989) (4) Kao AS; J Air Waste Manage Assoc 44: 683-96 (1994) (5) Gay BW et al; Environ Sci Tech 10: 58-67 (1976) (6) Cupitt LT; Fate of Toxic and Hazardous Materials in the Air Environment USEPA-600/3-80-084 (1980)]**PEER REVIEWED**

Environmental Biodegradation:

AEROBIC: Under aerobic conditions, **trichloroethylene** is biodegraded only in the presence of another compound that can support microbial growth in a process called cometabolism; biodegradation is generally complete and vinyl chloride is not produced(2). Indigenous sources of carbon associated with soil organic matter did not support cometabolic degradation of **trichloroethylene** in a soil study(3).

Trichloroethylene was aerobically degraded in a column composed of aquifer sediments by 9 and 87% during the first 6.5 months and the following 3.5 months, respectively; the initial loss of 9% may have been due to abiotic losses such as adsorption or volatilization(1). cis-1,2-Dichloroethylene was reported as the major product of **trichloroethylene** degradation in this experiment(1). **Trichloroethylene** was mineralized by up to 30% in microcosms containing soil and vegetation from a former **trichloroethylene**-contaminated site (4). Microcosms which were either non-vegetated or sterile showed mineralization of **trichloroethylene**, measured as CO2 production, of 10 to 15% and 5 to 10%, respectively(4).
[(1) Enzien MV et al; Appl Environ Microbiol 60: 2200-4 (1994) (2) El-Farham YH et al; Wat Res Research 34: 437-45 (1998) (3) Fan S, Scow KM; Appl Environ Microbiol 59: 1911-18 (1993)(4) Anderson TA, Walton BT; Environ Toxicol Chem 14: 2041-2047 (1995)]**PEER REVIEWED**

AEROBIC: In a municipal activated sludge plant, 47.3, 47.8, and 0.0% of the influent **trichloroethylene** concn (at 40.7 ug/l) was biodegraded, stripped and found in the waste sludge, respectively (effluent concn of 2.0 ug/l)(1). Two laboratory scale activated sludge reactors (AS-L, AS-H) and 2 biological aerated filter reactors (BAF-L, BAF-H) under high- and low-loaded conditions were used to study the removal of **trichloroethylene** during wastewater treatment(2). The average influent concn was 32.1 ug /l; effluent concns for AS-L, AS-H, BAF-L, and BAF-H were 5.3, 6.1, 2.3, and 9.7 ug/l, respectively(2). Loss due to biodegradation was 0, 0, 58, and 3% influent loadings, respectively, while loss due to stripping was 66, 85, 34, and 67% influent loadings, respectively(2).
[(1) Parker WJ et al; Wat Environ Res 65: 58-65 (1993) (2) Clapp LW et al; Water Environ Res 66: 153-60 (1994)]**PEER REVIEWED**

ANAEROBIC: 90% of **trichloroethylene** initially added to contaminated bed sediments from a freshwater lake and incubated under methanogenic conditions for 60 days was degraded; ethene (46%), methane(9%) and carbon dioxide (12%) were produced during its degradation(1). Biodegradation rates for **trichloroethylene** in anaerobic groundwater field studies were reported as follows: Dover Air Force Base, DE (half-life of 2.8 years; methanogenic, redox>50 mV)(2); Vejen Landfill, Denmark (4 in situ microcosms, methanogenic, no biodegradation over 180 days(5), Grindsted Landfill, Denmark (methanogenic/iron- and sulfate-reducing conditions, 924 day monitoring period, half-lives=533-2310 days)(6), Plattsburgh Air Force Base, NY (3 transects, half-lives of 0.56 years, 1.82 years, and no degradation)(7), Tibbetts Road Superfund site, NH (3 transects, half-lives=1.17 to 1.69 years)(8), St. Joseph, MI (half-lives of 1.82, 0.53, 0.745, 0.495 years)(9,10), St. Joseph, MI (half-lives of 113, 124, and 433 days for 3 different transects)(3), Picatinny Arsenal, NJ (half- life of 0.578 years(10); half-life of 2.2 years(11)), Sacramento, CA (half-life of 0.63 years)(10), Necco Park, NY (half-life of 1 year)(10), Plattsburgh Air Force Base, NY (half-lives of 0.53 years, 3.01 years and no biodegradation)(10), San Francisco, CA (half-life of 0.16 years)(10), Cecil Field, FL (half-lives of 0.095 to 0.21 years)(10), Eielson Air Force Base, Alaska (half-life of 3.8 years), and Cape Canaveral Air Station, Florida (half-life of 2.4 years)(12). **Trichloroethylene** was degraded under methanogenic and sulfate-reducing conditions in a fractured bedrock aquifer to ethene(4).
[(1) Bradley PM, Chapelle FH; Environ Sci Technol 33: 653-56 (1999) (2) Ellis DE et al; in Symp Nat Atten Chlorin Org Ground Water USEPA/540/R-96/509 (1996) (3) Weaver JW et al; Field-Derived Transform Rates Model Nat Bioatten Trichloroethene and its Degrad Prod. Ada, OK: Nat Risk Manag Res Lab, USEPA/600/A-95/142 NTIS PB96-139092 (1995) (4) Major D et al; pp. 197-203 in Int Biorem, Pap Int In-Situ On-Site Bioreclam Symp, 3rd. Hinchee RE et al, eds. Columbus, OH: Battelle Press (1995) (5) Nielsen PH et al; J Contam Hydrol 20: 51-66 (1995) (6) Rugge K et al; Wat Res Research 35: 1231-46 (1999) (7) Wiedemeier TH et al; pp 74-82 in Symp Nat Atten Chlor Org Groundwater, USEPA/540/R-96/509 (1996) (8) Wilson BH et al; in Symp Nat Atten Chlor Organ Ground Water, USEPA/540/R-96/509 (1996) (9) Wilson JT et al; Intrinsic Biorem of JP-4 Jet Fuel. USEPA/540/R-94/515 (1994) (10) Wilson JT et al; in Symp Nat Atten Chlorin Org Ground Water. USEPA/540/R-96/509 (1996) (11) Imbrigiotta TE et al; pp. 83-89 in Symp Nat Atten Chlor Org Ground Water

USEPA/540/R-96/509 (1996) (12) Swanson M et al; in Symp Nat Atten Chlor Org Ground Water, USEPA USEPA/540/R-96/509 p. 166 (1996)]**PEER REVIEWED**

Biodegradation rates for **trichloroethylene** in anaerobic aquifer microcosm studies were reported as follows: Wilder's Grove, NC landfill (methanogenic, lag phase of <41 to >300 days; degradation complete within 40 to 110 days once started)(1), Dover Air Force Base, DE(methanogenic, half-lives of 57 and 267 days for 2 locations at site)(2), Picatinny Arsenal, NJ (first-order rate constant of 0.001 to 0.02 per week)(3), Picatinny Arsenal, NJ (half-lives of 1.1, 1.65, and 3.3 years)(6), Picatinny Arsenal, NJ (first-order rate constant of 0.004 to 0.035 per week)(7), Vejen Landfill, Denmark(4 microcosms, methanogenic, no degradation over 140-180 days)(4), Tibbetts Road Superfund site, NH (half-lives of 0.188 years(5), 0.144 years(6)), St. Joseph, MI (half-lives of 0.385 and 0.58 years), and Traverse City, MI (half-life of 0.385 years)(6). In situ microcosm studies were conducted in both polluted aerobic and anaerobic and in unpolluted aerobic aquifer conditions in the Vejen City landfill; **trichloroethylene** was not degraded under either oxygen condition over a 90-day period(9). **Trichloroethylene** is reductively dechlorinated forming cis-1,2-dichloroethylene initially, then vinyl chloride and possibly ethene and ethane depending on the strength of the reducing environment(8). Under iron or sulfate-reducing conditions, cis-1,2-dichloroethylene is the major metabolite of **trichloroethylene** biodegradation while ethene is the major metabolite under methanogenic conditions(10).
[(1) Johnston JJ et al; J Contam Hydrol 23: 263-83 (1996) (2) Lige JE et al; pp. 313-320 in Biorem Chlor Solvents, Pap Int In Situ On-Site Bioreclam Symp. 3rd. Hinchee RE et al, eds. Columbus, OH: Battelle Press (1995) (3) Martin M, Imbrigiotta TE; pp. 109-15 in USEPA Symp Natural Atten Ground Water, Denver, CO EPA/600/R-94/162 (1994) (4) Nielsen PH et al; J Contam Hydrol 20: 51-66 (1995) (5) Wilson BH et al; pp. 21-28 in Symp Nat Atten Chlor Org Ground Water, USEPA/540/R-96/509 (1996) (6) Wilson JT et al; in Symp Nat Atten Chlorin Org Ground Water, USEPA/540/R-96/509 (1996) (7) Ehlke TA, Imbrigiotta TE; in Symp Nat Atten Chlor Org Ground Water. Hyatt Regency Dallas. Dallas, TX. USEPA EPA/540/R-96/509 (1996) (8) McCarty PL; pp. 5-9 in Symp Nat Atten Chlor Org Ground Water USEPA/540/R-96/509 (1996) (9) Nielson PH et al; Chemosphere 25: 449-62 (1992) (10) Lendvay JM et al; Environ Sci Technol 32: 3472-78 (1998)]**PEER REVIEWED**

ANAEROBIC: Mass balance analysis of the loss of **trichloroethylene** from an aquifer beneath Picatinny Arsenal showed that 78, 11, and 11% of the **trichloroethylene** annually removed was due to biodegradation, advective transport to a local water body, and advection-driven volatilization, respectively(1).
[(1) Imbrigiotta TE et al; pp. 83-89 in Symp Nat Atten Chlor Org Ground Water, USEPA/540/R-96/509 (1996)]**PEER REVIEWED**

Environmental Abiotic Degradation:

The rate constant for the vapor-phase reaction of **trichloroethylene** with photochemically-produced hydroxyl radicals has been measured as 2.36X10-12 cu cm/molecule-sec at 25 deg C(1). This corresponds to an atmospheric half-life of about 7 days at an atmospheric concn of 5X10+5 hydroxyl radicals per cu cm(1). Atmospheric residence time based upon reaction with hydroxyl radical is 5 to 6 days(2-4) with the production of phosgene, dichloroacetyl chloride, chloroform and formyl chloride(3,6,7). The rate constant for the vapor-phase reaction of **trichloroethylene** with nitrate radicals has been measured as 2.93X10-16 cu cm/molecule-sec at 25 deg C(13). This corresponds to an atmospheric half-life of about 114 days at an atmospheric concn of 2.4X10+8 nitrate radicals per cu cm(14). Ozone depletion potential values for **trichloroethylene** range from 0.083 to 0.13 relative to CFC-11(8). The mean value for the gas scavenging ratio for **trichloroethylene** is 3.7 at 8 deg C(9). **Trichloroethylene** is relatively reactive under smog conditions(12) with 60% degradation in 140 min(6) and 50% degradation in 1 to 3.5 hours(11) reported. **Trichloroethylene** is not hydrolyzed by water under normal conditions(10). **Trichloroethylene** absorbs light greater than 290 nm weakly; therefore, direct photolysis is not expected to be an important fate prcoess(10). However, slow photooxidation in water

has been noted (half-life of l0.7 months)(11).
[(1) Atkinson R; J Phys Chem Ref Data. Monograph 2. P. 116 (1994) (2) Chang JS, Kaufman F; J Chem Phys 66: 4989-94 (1977) (3) Cupitt LT; Fate of Toxic and Hazardous Materials in the Air Environment USEPA-600/3-80-084 (1980) (4) Singh HB et al; Atmos Environ 15: 601-12 (1981) (5) Kao AS; J Air Waste Manage Assoc 44: 683-96 (1994) (6) Gay BW et al; Environ Sci Tech 10: 58-67 (1976) (7) Itoh N et al; Chemosphere 28: 2029-40 (1994) (8) Kindler TP et al; J Geophys Res 100: 1235-51 (1995) (9) Rathbun RE; Transport, Behavior, and Fate of Volatile Organic Compounds in Streams, US Geological Survey Prof Paper 1589, USGS, NTIS PB98-163-397 (1998) (10) Callahan MA et al; Water-Related Environmental Fate of 129 Priority Pollutants - Vol II USEPA-440/4-79-029B (1979) (11) Dilling WL; Environ Sci Tech 9: 833-8 (1975) (12) Yanagihara S et al; pp. 472-7 in Photochemical Reactivities of Hydrocarbons Proc Int Clean Air Congress, 4th (1977) (13) Sabljic A, Gusten H; Atmos Environ 24A: 73-78 (1990) (14) Atkinson R et al; Atmos Env 24: 2647-81 (1990)]**PEER REVIEWED**

Two pilot-scale activated sludge systems (flow rate 35 gpm; hydraulic retention time 7.5 hours; SRT of 4 days) fed municipal wastewater were spiked with 0.25 mg/l **trichloroethylene** in combination with 46 other compounds; 103% removal of **trichloroethylene** was obtained through stripping(1).
[(1) Bhattacharya SK et al; Removal and Fate of RCRA and CERCLA Toxic Organic Pollutants in Wastewater Treatment. Cincinnati, OH: US EPA USEPA/600/S2-89/026 (1990)]**PEER REVIEWED**

Environmental Bioconcentration:

BCF values of 17 and 39(1) were measured in bluegill sunfish and rainbow trout, respectively. In carp, BCF values of 4.3 to 17 and 4.0 to 16.0 were reported for **trichloroethylene** at 70 and 7 ug/l, respectively(2). A BCF of 302 was measured in a green alga(4). According to a classification scheme(3), these BCF values suggest the potential for bioconcentration in aquatic organisms is moderate to low. Marine monitoring data suggest only moderate bioconcentration (2-25 times) of **trichloroethylene**(5,6).
[(1) Lyman WJ; Handbook of Chemical Property Estimation Methods Ann Arbor Sci, MI p. 5-9(1981) (2) Chemicals Inspection and Testing Institute; Biodegradation and bioaccumulation data of existing chemicals based on the CSCL Japan. Japan Chemical Industry Ecology - Toxicology and Information Center. ISBN 4-89074-101-1 p. 2-24 (1992) (3) Franke C et al; Chemosphere 29: 1501-14 (1994) (4) Rathbun RE; Transport, Behavior, and Fate of Volatile Organic Compounds in Streams, US Geological Survey Prof Paper 1589, USGS, NTIS PB98-163-397 (1998) (5) Dickson AG, Riley JP; Marine Pollut Bull 7: 167-9 (1976) (6) Pearson CR, McConnell G; Proc Roy Soc London Ser B 189: 305-32 (1975)]**PEER REVIEWED**

Soil Adsorption/Mobility:

Measured Koc values of 100(1), 110(2), 72 to 180 (organic matter of <1.0 to 5%(3), 66(8), 49 (peat soil)(10), 72, 96, 142(5) and 58 (peat soil)(5). The average Kd value for **trichloroethylene**, applied with a mixture of organic compounds to low organic, subsurface soils (average foc=0.00017), was 0.093(4). Kp values of 1.06 (coarse sand), 0.67 (silty-clay loam), 0.17 (fine sand), 6.0 (podzolic sand, % organic content=0.90), 4.2 (sandy soil, % organic content=6.07), 32 (peat soil, % organic content=59.3) and 1.24 (Bandelier tuff, % organic content=0.11) have been reported for **trichloroethylene**(11). A study of 32 soils(foc range of 0.0012 to 0.31) reported an average Koc of 101(5). Koc values for **trichloroethylene** in a loess sand, weathered shale, and unweathered shale were 123, 363, and 2691, respectively(6). In nine different soils (foc ranging from 0.13 to 1.2%), Koc values ranged from 69 to 209(7). **Trichloroethylene** from soil samples which had been contaminated for 18 years was found to be resistant to desorption, requiring extended periods of time for equilibration(9). According to a classification scheme(12), these Koc values generally suggest that **trichloroethylene** is expected to have moderate to high mobility in soil. **Trichloroethylene** partitioned from an aqueous solution of Bandelier tuff under equilibrium conditions to 64-81% in water, 16-23% in vapor phase, and 2-20% in the tuff(13).

[(1) Bahnick DA, Doucette WJ; Chemosphere 17: 1703-15 (1988) (2) Borisover MD, Graber ER; Chemosphere 34: 1761-76 (1997) (3) Brigmon RL et al; J Soil Contam 7: 433-53 (1998) (4) Carmichael LM et al; J Environ Qual 28: 888-97 (1999) (5) Rathbun RE; Transport, Behavior, and Fate of Volatile Organic Compounds in Streams. USGS Professional Paper 1589, NTIS PB98 163397 (1998) (6) Grathwohl P; Environ Sci Technol 24: 1687-93 (1990) (7) Mouvet C et al; J Hydrol 149: 163-82 (1993) (8) Sahoo D, Smith JA; Environ Sci Technol 31: 1910-15 (1997) (9) Pavlostathis SG, Jaglal K; Environ Sci Technol 25: 274-79 (1991) (10) Chiou CT, Kile DE; Environ Sci Technol 32: 338-43 (1998) (11) Fuentes HR et al; Haz Waste Haz Mater 7: 347-59 (1990) (12) Swann RL et al; Res Rev 85: 17-28 (1983) (13) Fuentes HR et al; Haz Waste Haz Mater 7: 347-59 (1990)]**PEER REVIEWED**

In a field groundwater test, no sorption of **trichloroethylene** onto organic carbon or mineral surfaces present in the sand aquifer was observed(1). Two field studies, both of shallow confined aquifers, reported retardation factors from 5 to 9 (foc=0.11%) and 11.4 (foc=0.11%)(2). In undisturbed rock cores from the Coventry sandstone aquifer system (foc=0.7 to 0.8%), **trichloroethylene** had a retardation factor of less than 3 indicating that it should migrate readily with water(2). Other column studies using sand aquifer material reported retardation factors from 1.1 to 4.7(2). A retardation factor of 1.1 was reported for **trichloroethylene** in the aquifer underlying the Canadian Forces Base in Borden, Ontario(3). The initial percentage of **trichloroethylene** in the gas (24, 52, 57%), liquid (5, 3, 4%) and adsorbed (71, 45, 39%) phases was determined in three soils, respectively (Rindge, 11.2% organic matter, 35.4% moisture; Yolo, 2.2% organic matter, 11.7% moisture; Reiff, 1.4% organic matter, 13.9% moisture)(9). Sorption in these soils followed reversible, linear sorption isotherms(9). Sorption of **trichloroethylene** vapor to soil is possible; linear sorption coefficients of **trichloroethylene** from the vapor phase were about one to four orders of magnitude greater than those from the aqueous phase based on studies using six different US EPA soils and sediments under varying moisture contents(10).

[(1) Benker E et al; in Proc Prague Conf IAHS Publ No 225(Groundwater Quality: Remediation and Protection): 61-9 (1995) (2) Bourg ACM et al; J Hydrol 149: 187-207 (1993) (3) Broholm K et al; Environ Sci Technol 33: 681-90 (1999) (4) Wilson JT et al; J Environ Qual 10: 501-6 (1981) (5) Sontheimer H; J Amer Water Works Assoc 72: 386-90 (1980) (6) Schwarzenbach RP et al; Environ Sci Technol 17: 472-9 (1983) (7) Zoeteman BCJ et al; Chemosphere 9: 231-49 (1980) (8) Rogers RD, McFarlane JC; Environ Monit Assess 1: 155-62 (1981) (9) Fan S, Scow KM; Appl Environ Microbiol 59: 1911-18 (1993) (10) Shimizu Y et al; Wat Sci Tech 26: 79-87 (1992)]**PEER REVIEWED**

Volatilization from Water/Soil:

The Henry's Law constant for **trichloroethylene** is 9.85X10-3 atm-cu m/mole(1). This Henry's Law constant indicates that **trichloroethylene** is expected to volatilize rapidly from water surfaces(2). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec)(2) is estimated as 3.5 hours(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(2) is estimated as 5 days(SRC). Half-lives of evaporation from laboratory water surfaces (distilled water) have been reported to be on the order of several minutes to hours, depending upon the turbulence(4,5). Half-lives of **trichloroethylene** from an experimental marine ecosystem (MERL) under field conditions and during periods when volatilization appeared to dominate ranged from 10.7 to 28 days; turbulence is expected to be greater in open water resulting in even faster half-lives(6). The potential for volatilization of **trichloroethylene** from dry soil surfaces exists(SRC) based upon a vapor pressure of 69 mm Hg(3).

[(1) Leighton DT Jr, Calo JM; J Chem Eng Data 26: 382-85 (1981) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (3) Boublik T et al; The Vapour Pressures of Pure Substances, Amsterdam, The Netherlands: Elsevier Science Publ p. 87 (1984) (4) Dilling WL; Environ Sci Technol 9: 833-8 (1975) (5) Lyman WJ et al; Handbook of Chemical Property Estimation Methods NY: McGraw-Hill pp. 15-25 (1981) (6) Wakeham SG et al; Environ Sci Technol 17: 611-7 (1983)]**PEER REVIEWED**

The transport behavior of **trichloroethylene** vapor in a section of unsaturated sands and silts at a field site in Borden, Ontario was studied(1). Movement of **trichloroethylene** vapor through unsaturated layers was shown to be lateral based on the density-induced advective flow of the contaminated soil gas(1). Gas-phase diffusion coefficients for **trichloroethylene** in tuff soils with varying moisture content were measured(2). Under wet conditions (12-15% moisture), diffusion coefficients of 0.0022-0.0067 and 0.0067-0.0070 sq cm/sec were determined for **trichloroethylene**; under dry conditions (1-3% moisture, diffusion coefficients of 0.0211-0.0230 and 0.0237-0.0292 sq cm/sec were determined(2). Soil diffusion coefficients were measured for **trichloroethylene** at 3 different soil porosities (0.29 to 0.43); values ranged from 0.254X10-3 to 1.986X10-3 sq cm/sec, with the larger values associated with higher soil porosity levels(4). The total amount of **trichloroethylene** that volatilizes in 100 days may be reduced from 84.6% volatilized without vapor sorption to 73.2% in a soil with increasing water content with depth, based on a flexible finite element transport model(3). Using the same model, vapor sorption enhanced the rate of volatilization in 100 days for a soil with low water content at depth from 72.4% without vapor sorption to 90.3% with vapor sorption(3). Very dry soil conditions combined with a soil type having strong vapor sorption characteristics may significantly retard the transport of **trichloroethylene** (in the vapor phase)(3).
[(1) Hughes BM et al; pp. 81-88 in Subsurface Contamination by Immiscible Fluids. Weyer, ed. Rotterdam, The Netherlands: Balkema, ISBN 90-6191-1753 (1992) (2) Fuentes HR et al; J Environ Qual 20: 215-21 (1991) (3) Culver TB et al; Wat Res Research 27: 2259-70 (1991) (4) Hutter GM et al; Wat Environ Res 64: 69-77 (1992)]**PEER REVIEWED**

Environmental Water Concentrations:

GROUNDWATER: **Trichloroethylene** was the most frequently detected organic chemical and in highest concentration; 28% of wells from 8 states sampled positive with a max conc reported at 35,000 ppb(2); 38.5% of 13 US cities tested positive with a mean concn 29.72 ppb, range 0.2-125 ppb(1). A study in New Jersey of 670 wells showed that 1.8% and 4.0% of wells had concn >100 ppb and >10 ppb, respectively(3). Groundwater samples in the Netherlands collected from 1976-78, at 232 pumping stations, showed that 67% were positive (>0.01 ppb) for **trichloroethylene**(4).
[(1) Council on Environmental Quality Contamination of Groundwater by Toxic Organic Chemicals pp. 26-34 (1980) (2) Dyksen JE, Hess AF III; J Amer Water Work Assoc 394-403 (1982) (3) Wilson JT, Wilson BH; ApplEnviron Microbial 49: 243-3 (1985) (4) Zoeteman BCJ et al; Sci Total Environ 21: 187-202 (1981)]**PEER REVIEWED**

GROUNDWATER: **Trichloroethylene** concns measured at 6 landfill sites in southern Ontario ranged from below the method detection limit (not given)(3 of 6 sites) to 21 ug/l(1). 10 of 27 groundwater sites in Kanagawa Prefecture, Japan (samples collected 1995-1998), contained **trichloroethylene** at concns from <0.1 to 220 ug/l(2). In a study of groundwater beneath 27 Swedish landfills, median and maximum concns of <0.1 and 5.0 ug/l **trichloroethylene** were reported(3). 13% of groundwater alluvial wells monitored in Denver metropolitan in 1993 contained **trichloroethylene** (max concn 2 ug/l)(4). **Trichloroethylene** was detected in 10.1% (n=208 wells) of groundwater samples collected in urban areas by the National Water-Quality Assessment Program at a maximum concn of 230 ug/l (reporting limit=0.2 ug/l; 3 wells exceeded MCL or health advisory level)(5). An assessment of untreated ambient groundwater in the US from 1985 to 1995 was conducted as part of the National Water-Quality Assessment Program; **trichloroethylene** was detected in 11.6% of urban wells (n=406) and 1.6% of rural wells (n=2542)(6). 26 of 1,083 shallow wells and 14 of 277 deep wells sampled in 15 cities in Japan in 1983 contained measurable concns of **trichloroethylene**(7). Of 210 urban wells and springs sampled during the USGS National water-Quality Assessment Program, 10% contained **trichloroethylene**(8).
[(1) Barker JF; Water Poll Res J Canada 22: 33-48 (1987) (2) Abe A; Sci Total Environ 227: 41-7 (1999) (3) Assmuth TW, Strandberg T; Water Air Soil Pollut 69:

179-99 (1993) (4) Bruce BW, McMahon PB; J Hydrol 186: 129-51 (1996) (5) Kolpin DW et al; pp. 469-74 in Groundwater in the Urban Environment: Problems, Processes and Management, Chilton et al, eds. Rotterdam, The Netherlands: Balkema ISBN 90-5410-837-1 (1997) (6) Squillace PJ et al; Environ Sci Technol 33: 4176-87 (1999) (7) Tase N; Environ Geol Water Sci 20: 15-20 (1992) (8) Squillace PT et al; Div Environ Chem Preprints Extend Abst 37: 372-3 (1997)]**PEER REVIEWED**

DRINKING WATER: 28 of 113 US public water supplies tested positive for **trichloroethylene**, mean 2.1 ppb(1). **Trichloroethylene** was found in finished groundwater in 36% of 25 US cities at a mean concn of 6.76 ppb, range 0.11-53.0 ppb(2). Samples from the Love Canal, Niagara Falls, NY showed that 7 of 9 samples tested positive, with a concn range of 10-250 parts/trillion(3). 466 random samples of finished groundwater showed that 6.4% pos, 1 ppb median concn, 78 ppb max concn(4). State data, 2894 samples, showed that 28.0% tested positive for **trichloroethylene** from a trace to 35,000 ppb; in the US National Screening Program, of 142 samples, 25.4% tested positive with a trace to 53 ppb and in a Community Water Supply Survey, 3.3% of 452 samples were positive, with a concn range of 0.5-210 ppb(5).
[(1) Brass HJ et al; Drinking Water Qual Enhancement Source Prot pp. 393-416 (1977) (2) Council on Environmental Quality Contamination of Groundwater by Toxic Organic Chemicals pp. 26-34 (1980) (3) Barkley J et al; Biomed Mass Spectrom 7: 139-47 (1980) (4) Cotruvo JA; Sci Total Environ 47: 7-26 (1985) (5) Cotruvo JA et al; pp. 511-30 In: Organic Carcinogens in Drinking Water (1986)]**PEER REVIEWED**

DRINKING WATER: **Trichloroethylene** was detected in drinking water from Zagreb, Croatia at concns ranging from <0.05 to 22.93 ug/l(1). **Trichloroethylene** tap water concns ranged from 0.03 to 2.1 ug/l according to the EPA's National Organics Monitoring Survey, published in 1977(2). Concns of **trichloroethylene** in groundwater before and after treatment from June 1995 to May 1996 at a water-pumping station in Zagreb, Croatia, ranged from 5.05-12.90 ug/l (mean=8.55 ug/l) and 2.16 to 15.29 ug/l (mean=8.53 ug/l), respectively(3). The Eau Clair Municipal Well field, WI, supplies drinking water to 57,600 residents; concns of **trichloroethylene** in water samples at this site ranged from 0.02 to 13 ug/l(4). This is currently listed as a Superfund site(4). **Trichloroethylene** was measurable in 8, 12, and 66% of collected drinking water samples in Los Angeles (Jan/Feb 1984), Los Angeles (May 1984), and Contra Costa (June 1984), respectively(5).
[(1) Skender L et al; Arch Environ Hlth 49: 445-51 (1994) (2) Tancrede MV, Yanagisawa Y; J Air Waste Manage Assoc 40: 1658-63 (1990) (3) Vedrina-Dragojevic I, Dragojevic D; Sci Total Environ 203: 253-59 (1997) (4) Canter LW, Sabatini DA; Intern J Environ Studies 46: 35-57 (1994) (5) Wallace LA et al; Atmos Environ 22: 2141-63 (1988)]**PEER REVIEWED**

SURFACE WATER: **Trichloroethylene** concns of 1-24 ppb were measured in industrial rivers in US, with Lake Erie - 188 ppb, 88 of 204 samples pos(1). It is the third most frequently detected compound in Ohio River - 2427 of 4972 samples pos, 86% 0.1-1.0 ppb(2). Samples from Zurich, Switzerland lake surface contained 38 ppb, and at a 30 m depth - 65 ppb(3). Results reported in the USEPA STORET database of 9,295 data points, showed that 28.0% were positive for **trichloroethylene**, 0.10 ppb median(4).
[(1) Ewing BB et al; Monitoring to Detect Previously Unrecognized Pollutants in Surface Waters USEPA-560/6-77-015 p. 74 (1977) (2) Ohio River Valley Water Sanit Comm 190-81 Assessment of Water Quality Conditions (1982) (3) Grob K, Grob G; J Chromatogr 90: 303-13 (1974) (4) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985)]**PEER REVIEWED**

SURFACE WATER: **Trichloroethylene** was present in water samples from Jackfish Bay, Lake Superior, at concns from 4.1 to 120 ng/l; Jackfish Bay receives 94,000 cu m/d of bleached-kraft mill effluent(1). Estuarine waters containing **trichloroethylene** were collected from sites in the UK (Humber, <10-40.6 ng/l; Tees, <10-269; Tyne, <10-43.7; Wear, <10-132; Tweed, <10; Mersey, 250-4200), The Netherlands/Belgium (Scheldt in 1987-1989, <10-1570; Scheldt in 1993, 54.7), Germany (Elbe, <700),

and the US (Back River, <132-30,000 and 260-13800; Brazos river, 6-280)(2). Seawaters (beach, bay, fjord, coastal and shelf seawaters) containing **trichloroethylene** were collected from the following sites: Liverpool Bay, UK (<3600 ng/l), Swansea Bay, UK (<10), Byfjorden, Sweden(0.28 ng/l), Skagerrak (<2.6 to <5.8), Firth of Forth, UK (<10), Moray Forth, UK(<10), North Minch, UK (<10), Bristol Channel, UK (<10), Belgian continental shelf (4.9- 7.3)(2). Open seawaters containing **trichloroethylene** were collected from the following sites: the NE Atlantic Ocean (5-11 ng/l), Antarctica in 1990 (3.8 ng/l), Sea of Japan in 1991 (<10 ng/l), and the East Pacific Ocean in 1981 (0.1 to 0.7 ng/l)(2). **Trichloroethylene** was measured in two sites in the River Elbe near Hamburg in 1992/1993; at Zollenspieker, upstream of Hamburg, concns ranged from 20-132 ng/l (median=57 ng/l) and at Seemannshoft, downstream of Hamburg, concns ranged from 13-117 ng/l (median=39 ng/l)(3). **Trichloroethylene** was found in water samples collected from 30 sites within the urban rivers and estuaries of Osaka, Japan; a median concn of 0.39 ug/l (78 of 136 samples positive, range=0.31-45 ug/l) was reported(4). The average concn of **trichloroethylene** in marine water samples was 0.3 ppb, max 3.6 ppb(6). A mean concn of 14.93 ng/l was reported for **trichloroethylene** based on data collected in the southern North Sea from Sept 1994 to December 1995(5).
[(1) Comba ME et al; Environ Toxicol Chem 13: 1065-74 (1994) (2) Dewulf J, Van Langenhove H; Wat Res 31: 1825-38 (1997) (3) Gotz R et al; Chemosphere 36: 2085-2101 (1998) (4) Yamamoto K et al; Environ Pollut 95: 135-43 (1997) (5) Dewulf JP et al; Environ Sci Technol 32: 903-911 (1998) (6) Dyksen JE, Hess AF III; J Amer Water Work Assoc 394-403 (1982)]**PEER REVIEWED**

RAIN/SNOW/FOG: Concns of **trichloroethylene** in rainwater from La Jolla, California cnotained 5 parts/trillion, and from an industrial area in England 150 parts/trillion(4). Samples from 7 rain events in Portland, OR, Feb-Apr 1984 showed were 100% pos, concns ranging from 0.78-16 parts/trillion, 5.6 avg(5). 117 rain samples collected over 1991 in Kobe, Japan contained unmeasurable concns of **trichloroethylene** (<0.001 mg/l)(1). Cloud water samples were collected during 1987 and 1988 at Mt. Mitchell State Park, NC; concns of **trichloroethylene** ranged from 0-6.7 ng/ml with an average concn of 1.38 ng/ml(2). Surface snow, snow collected from 0.5 m depth and surface ice sampled in the Terranova Bay area in Antarctica, 1991-1992, contained **trichloroethylene** at 14, 8.5, and 11 ng/l, respectively(3). Snow collected from a snow pit at 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 m contained **trichloroethylene** at concns of 5.7, 2.9, 8.3, 8.9, 3.9, 8.0, and 9.0 ng /l, respectively (Terranova Bay area, Antarctica, 1992-1993)(3). Snow samples from Southern California contained 30 parts/trillion, central California 1.5 parts/trillion, and Alaska 39 parts/trillion(4).
[(1) Adachi A, Kobayashi T; Bull Environ Contam Toxicol 52: 9-12 (1994) (2) Aneja VP; J Air Waste Manage Assoc 43: 1239-44 (1993) (3) Zoccolillo L et al; Intern J Environ Anal Chem 63: 91-98 (1996) (4) SU C, Goldberg ED; Mar Pollut Transfer 1976: 353-74 (1976) (5) Ligocki MP et al; Atmos Environ 19: 1609-17 (1985)]**PEER REVIEWED**

Effluent Concentrations:

Landfill gas at seven U.K. waste disposal sites contained **trichloroethylene** at <0.1 (4 sites) to 152 mg/cu m(1). Gas samples from 3 old and 1 active municipal landfills in Southern Finland contained **trichloroethylene** at average concns of 0.1 to 5.25 mg/cu m and a maximum concn of 13 mg/cu m(2). Average **trichloroethylene** concns of 710 and 2079 ppbV were measured in samples of landfill gas(3). 6% of urban runoff samples (n=86) from 4 of 19 different cities contained **trichloroethylene** at concns from 0.3 to 10 ug/l(4). Emissions of **trichloroethylene** from hazardous waste incinerators in the US were estimated as 81.8 ng/l or 0.7 tons/yr(5). Primary sludge from seven US publicly owned treatment works contained **trichloroethylene** at 35-284 ug/l(6). Stationary source emissions of 2640 tons/yr **trichloroethylene** were reported for The Netherlands in 1980(7). Landfill gas from 6 abandoned hazardous waste sites and 1 sanitary landfill contained **trichloroethylene** at mean concns of 0.08 to 2.43 ppbV and an overall maximum value of 12.3 ppbV(8). Emissions from a municipal waste incineration

plant contained **trichloroethylene** at 4.0 ug/cu m(9). Bleaching effluent from 3 different kraft pulp mills in Finland contained **trichloroethylene** at concns of 0.1 to 0.7 ug/l(10). **Trichloroethylene** has been identified in spent chlorination and alkali extraction liquors from pulp bleaching(11). Effluent from 4 wastewater treatment plants in the Great Lakes basin contained **trichloroethylene** at concns of <1 to 1 ppb(12). **Trichloroethylene** was reported in the flue gas from the combustion of pulverized coal at minimum and maximum concns of 4.747X10-7 and 5.685X10-7 lb/10+6 Btu, respectively(13). The combustion of waste plastics containing vinyl chloride polymer in an incinerator resulted in concns of **trichloroethylene** in the exhaust gas of 47-82 ug/cu m, depending on the combustion and exit chamber temperatures(14). Concn of **trichloroethylene** in sewage sludge generally ranges from 1 to 10 mg/kg dry weight(15). Pyrolysis of military HC smokepots resulted in the production of **trichloroethylene**(16). Leachate samples from 5 hazardous waste landfills and 4 sanitary landfills contained **trichloroethylene** at concns of 30 to 9500 ug/l and 2.3 to 7.9 ug/l, respectively(17). Emissions from coal-fired power stations contained **trichloroethylene** at concns of 5.7 ug/N-cu m; the concn in coal is 0.02 ug/g(18). Diesel engines are reported to emit 4.5 ug/N-cu m(18).
[(1) Allen MR et al; Environ Sci Technol 31: 1054-61 (1997) (2) Assmuth T, Kalevi K; Chemosphere 24: 1207-16 (1992) (3) Brosseau J, Heitz M; Atmos Environ 28: 285-93 (1994) (4) Cole RH et al; J WPCF 56: 898-908 (1984) (5) Dempsey CR; J Air Waste Manage Assoc 43: 1374-79 (1993) (6) Feiler HD et al; pp. 53-7 in Natl Conf Munic Ind Sludge Util Disposal. Silver Springs, MD: Inf Transfer (1980) (7) Guicherit R, Schulting FL; Sci Total Environ 43: 193- 219 (1985) (8) Harkov R et al; J Environ Sci Health A20: 491-501 (1985) (9) Jay K, Steiglitz L; Chemosphere 30: 1249-60 (1995) (10) Juuit S et al; Chemosphere 33: 2431-40 (1996) (11) Kringstad KP, Lindstrom K; Environ Sci Technol 18: 236A-48A (1984) (12) Michael LC et al; Environ Sci Technol 25: 150-55 (1991) (13) Miller CA et al; Environ Sci Technol 28: 1150-58 (1994) (14) Nishikawa H et al; Chemosphere 25: 1953-60 (1992) (15) O'Connor GA; Sci Total Environ 185: 71-81 (1996) (16) Schaeffer DJ et al; J Hazard Mater 17: 315-28 (1988) (17) Foerst C et al; Intern J Environ Anal Chem 37: 287-93 (1989) (18) Garcia JP et al; Atmos Environ 26A: 1589-97 (1992)]**PEER REVIEWED**

Trichloroethylene was detected not quantified in wastewater in vicinity of a specialty chemicals plant(1). Industries with mean **trichloroethylene** concns greater than 75 ppb: paint and ink formulation, electrical/electronic components, and rubber processing mean range, 7-530 ppb, max range 3-1600 ppb(2). Concn results of **trichloroethylene** reported in the USEPA STORET database are as follows: 1,480 data points, 19.6% pos, 5.0 ppb median(3). Groundwater samples at 178 CERCLA hazardous waste disposal sites were 51.3% pos(4). **Trichloroethylene** was detected in MN municipal solid waste landfills: leachates from 6 sites, 83.3% pos, 0.7-125 ppb; contaminated groundwater (by inorganic indices), 13 sites, 69.2% pos, 0.2-144 ppb; other groundwater (apparently not contaminated as indicated by inorganic indices), 7 sites, 28.6% pos, 0.2-6.8 ppb(5).
[(1) Hites RA et al; ACS Symp Ser 94: 63-90 (1979) (2) USEPA; Treatability Manual pp. I.12.23-3 USEPA-600/2-82-001A (1981) (3) Staples CA et al; Environ Toxicol Chem 4: 131-42 (1985) (4) Plumb RH Jr; Groundwater Monit Rev 7: 94-100 (1987) (5) Sabel GV, Clark TP; Waste Manag Res 2: 119-30 (1984)]**PEER REVIEWED**

Off-gas from a conventional activated sludge treatment facility contained **trichloroethylene** at average concns of 175, 86, and 242 mg/cu m for three different weeks of operation in 1995/1996 (1). **Trichloroethylene** represented 1.1% of the total mass distribution of different species emitted in 1990 from the United Kingdom(2). Influent and effluent samples collected from the 14 water pollution control plants (11 with full secondary treatment)in New York city between 1989 and 1993 contained **trichloroethylene** at concn ranges of 1 to 46 ug /l (27% positive, n=84) and 2 to 3 ug /l (7% positive, n=84), respectively(3). Groundwater samples collected from beneath an active landfill in Orange County, Florida, in 1989/1990 and 1992/1993 contained **trichloroethylene** at concns ranging from below detection to 9.21 ug/l and 0.09 to 0.54 ug/l, respectively(4). 30 of 49 Superfund sites citing municipal well contamination, distributed in 21 US states, contained **trichloroethylene** in groundwater samples(5). Emissions of **trichloroethylene** from wastewater treatment plants in Los Angeles, CA were

366, 12, 3, and 5 kg/yr for Hyperion, Terminal Island, Tillman, and LA-Glendale plants, respectively(6). **Trichloroethylene** was emitted during coal combustion at concns ranging from 4.747X10-7 to 5.685X10-7 lb/10+6 Btu(7). Concns of **trichloroethylene** in municipal landfill leachate ranged from 1 to 15 mg /l; concns in landfill gases ranged from 1.2 to 175 mg/cu m (median 0.66 mg/cu m)(8). **Trichloroethylene** was emitted from 8 municipal solid waste composting facilities at a maximum concn of 1300 ug/cu m; fresh, mid-aged, old, and curing compost contained **trichloroethylene** at average concns of 98, 3, 3, and 2 ug/cu m, respectively(9). Global atmospheric emission fluxes of **trichloroethylene** were reported in 1988 to 1992; values ranged from 197 to 241 kt/year(10).
[(1) Zhu H et al; J Air Waste Manage Assoc 49: 434-43 (1999) (2) Derwent RG; in Volatile Org Compds in the Atmos. Hester RE, Harrison RM, eds. Cambridge, UK: Royal Soc Chem. Issues Environ Sci Technol 4: 1-15 (1995) (3) Stubin AI et al; Water Environ Res 68: 1037-44 (1996) (4) Chen SC, Zoltek J; Chemosphere 31: 3455-64 (1995) (5) Canter LW, Sabatini DA; Intern J Environ Studies 46: 35-57 (1994) (6) Mayer GJ et al; Wat Environ Res 66: 140-44 (1994) (7) Miller CA et al; Environ Sci Technol 28: 1150-58 (1994) (8) Roy WR; pp. 411-46 in Contam Groundwaters. Adriano DC et al, eds. Northwood, UK: Sci Rev (1994) (9) Eitzer BD; Environ Sci Technol 29: 896-902 (1995) (10) Sidebottom H, Franklin J; Pure Appl Chem 68: 1757-69 (1996)]**PEER REVIEWED**

Sediment/Soil Concentrations:

SEDIMENT: **Trichloroethylene** was not detected in sediment in the vicinity of a specialty chemicals plant(1). The compound was detected in marine sediments from Liverpool Bay, England at a max of 9.9 ppb(2). It has been reported in the USEPA STORET database, based on 338 data points where 6.0% were reported positive, at <5.0 ppb median concn(3). **Trichloroethylene** was detected in sediment from Lake Pontchartrain at Passes; from 3 sites, 66.7% were positive at a concn of 0.1-0.2 ppb, wet weight(4).

[(1) Hites RA et al; ACS Symp Ser 94: 63-90 (1979) (2) Pearson CR, McConnell G; Proc Roy Soc Lond B 189: 305-32 (1975) (3) Staples CA et al; Environ Total Chem 4: 131-42 (1985) (4) Ferrario JB et al; Bull Environ Contam Toxicol 34: 246-55 (1985)]**PEER REVIEWED**

SOIL: Average concns of **trichloroethylene** in a pine and agricultural soil ranged from 0.08 to 0.8 and <0.01 to 0.06 ug/kg dry weight, respectively(1).
[(1) Hoekstra EJ et al; Chemosphere 38: 2875-83 (1999)]**PEER REVIEWED**

Atmospheric Concentrations:

Global concn of **trichloroethylene** has been reported as follows: avg 8 parts/trillion, Northern hemisphere 15-16 parts/trillion, Southern hemisphere <3 parts/trillion(1,2). Concns in major USA cities have been reported at a mean concn of 96-483 parts/trillion, with a max of 236-3097 parts/trillion, and a min of 5-36 parts/trillion(3,4). Sampling studies conducted in Portland, OR, from Feb-Apr 1984, showed a concn in air (ng/cu m) during 7 rain envents as follows: 100% pos, 240-3900, 1537 avg(11). Industrial area concns have been reported at a 1.2 ppb mean; urban/suburban- 0.25 ppb mean, and rural- trace-0.10 ppb(5-7). Results from a study based in England are as follows: industrial 40-60 ppb, suburban 1-20 ppb, rural 5 ppb(8). Air samples taken from the Love Canal region, Niagara Falls, NY resulted in 2 of 3 samples being pos (1.6 and 3.4 ppb), and home basement levels estimated at 0.83 ppb(9). Waste disposal site in Edison, NJ showed **trichloroethylene** concns ranging from a trace-61 ppb(10).
[(1) Singh HB et al; Atmospheric Distributions, Sources and Sinks of Selected Hydrocarbons, Halocarbons, SF6 and NO2 USEPA-600/3-79-107 p. 4 (1979) (2) Cox RA et al; Atmos Environ 10: 305-8 (1976) (3) Singh HB et al; Atmos Environ 15: 601-12 (1981) (4) Singh HB et al; Environ Sci Technol 16: 872-80 (1982) (5) Bozzelli JW, Kebbekus BB; J Environ Sci Health 17: 693-13 (1982) (6) Grimsrud EP, Rasmussen RA; Atmos Environ 9: 1014-7 (1975) (7) Lillian D et al; Environ Sci Technol 9: 1042-8 (1975) (8) Pearson CR, McConnell G; Proc R Soc Lond B 189: 305-32 (1975) (9) Barkley

J et al; Biomed Mass Spectrom 7: 139-47 (1980) (10) Pellizzari ED; Environ Sci Technol 16: 781-5 (1982) (11) Ligocki MP et al; Atmos Environ 19: 1609-17 (1985)]**PEER REVIEWED**

URBAN/SUBURBAN: Air samples collected in Bilbao, Spain in March 1996 contained **trichloroethylene** at a mean concn of 0.7 ppbV(1). 14.6% of air samples collected outside 50 homes in the Los Angeles area contained **trichloroethylene**(2). Mean concns of 1.0 (n=103) and 2.1 (n=83) ug/cu m were reported in air samples collected from 1986 to 1990 in Southeast Chicago and East St. Louis, respectively(3). Air samples collected as part of the Urban Baseline VOC Measurement Program in the District of Columbia from March 1990 to March 1991 contained **trichloroethylene** in 66.07% of the samples at a mean concn of 0.33 ppbv (range=0.17-2.83 ppbv)(4). A maximum outdoor air concn of <2 ug/cu m was reported in a study of 300 Dutch homes(5). **Trichloroethylene** was measured in air samples collected from urban and suburban locations in Chicago at average concns of 0.82-1.16 and 0.52 ug/cu m, respectively(6). The national VOC database, representing 300 cities from 42 states, reports outdoor air samples (n=3021) contained **trichloroethylene** at average and median concns of 0.495 and 0.158 ppbv, respectively (data reported up to 1985)(7).
[(1) Alonso L et al; J Air Waste Manage Assoc 49: 916-24 (1999) (2) Hartwell TD et al; Atmos Environ 26A: 1519-27 (1992) (3) Sweet CW, Vermette, SJ; Environ Sci Technol 26: 165-73 (1992) (4) Hendler AH, Crow WL; Proc Ann Meet Air Waste Manage Assoc, 85thMeeting, Kansas City, MS, 92-75.05, 94-08743-2-9 (1992) (5) Otson R, Fellin P; pp. 335-421 in Gaseous Pollutants: Characterization and Cycling, Nriagu JO, ed. NY, NY: John Wiley Sons, Inc, Chp 9 (1992) (6) Scheff PA, Wadden RA; Environ Sci Technol 27: 617-25 (1993) (7) Shah JJ, Singh HB; Environ Sci Technol 22: 1381-88 (1988)]**PEER REVIEWED**

URBAN/SUBURBAN: **Trichloroethylene** was detected in air samples set up by the North Rhine-Westphalia State Centre for Air Quality Control and Noise Abatement (76 stationary stations and 8 mobile monitoring stations); annual average concns in 1990 ranged from 0.17 to 0.62 ug/cu m(1). Air samples collected in Porto Alegre, Brazil from March 1996 to April 1997 contained **trichloroethylene** at an average concn of 0.367 ppb (range=0.1-1.2 ppb, n=23, 6 samples at detection limit of 0.1 ppb)(2). 32% of air samples collected at 10 different locations in Boston, Chicago, Houston and the Seattle/Tacoma area in 1988/1989 as part of the Toxic Air Monitoring System network contained **trichloroethylene** at concns greater than 0.10 ppbv(3). Yearly mean concns of **trichloroethylene** across several Canadian cities in 1990 and in the US were 0.28 (maximum=20 ug/cu m) and 6.0 ug/cu m, respectively(4). Air samples collected between 1994 and 1996 at a site in Phoenix, AZ and at Tucson, AZ contained **trichloroethylene** at average concns of 0.05 (range 0.00 to 0.26 ppbv) and 0.04 ppbv (range 0.00 to 0.25 ppbv), respectively(5).
[(1) Pfeffer H-U; Sci Total Environ 146/147: 263-73 (1994) (2) Grosjean E et al; Environ Sci Technol 33: 1970-78 (1999) (3) Evans GF et al; J Air Waste Manage Assoc 42: 1319-23 (1992) (4) Bunce NJ, Schneider UA; J Photochem Photobiol A: Chem 81: 93-101 (1994) (5) Zielinska B et al; J Air Waste Manage Assoc 48: 1038-50 (1998)]**PEER REVIEWED**

INDOOR: Indoor air samples, collected from 12 Canadian homes in November/December 1986 contained **trichloroethylene** at concns from below detection (detection limit not stated) to 2 ug/cu m (average concn of 0.5 ug/cu m, average concn in Feb/March of 1.6 ug/cu m); ambient air collected outside each home contained **trichloroethylene** at below detection to 2 ug/cu m with an average of 0.2 ug/cu m in November/December and 0.8 in Feb/March(1). A WHO summary of indoor air studies from homes in Italy, The Netherlands, USA, and Germany reported that the average home in these studies contained 5 ug/cu m **trichloroethylene**(2). 50% of air samples collected from the kitchens of 50 homes in the Los Angeles area contained **trichloroethylene**(3). Indoor air samples from nonsmoking and smoking homes contained **trichloroethylene** at mean concns of 1.84 (range of 0.00 to 9.08 ug/cu m) and 0.66 (range of 0.00 to 3.41 ug/cu m) ug/cu m, respectively(4). Air samples collected from a newly constructed office facility in 1987/1988 contained **trichloroethylene** at concns of 16.4, 7.2, 58.2, and

14.8 ug/cu m at four different sampling events; air samples collected from the roof contained this compound at 0.9 ug/cu m(5). 27% of indoor air samples from 26 "sick" houses contained **trichloroethylene** at concns ranging from not detected to 4.30 ug/cu m; 50 "normal" houses contained **trichloroethylene** at mean and median concns of 0.97 and 0.25 ug/cu m (max= 20.38 ug/cu m)(6).
[(1) Chan CC et al; J Air Waste Manage Assoc 40: 62-67 (1990) (2) Crump DR; Issues Environ Sci Technol 4: 109-24 (1995) (3) Hartwell TD et al; Atmos Environ 26A: 1519-27 (1992) (4) Heavner DL et al; Environ Internat 21: 3-21 (1995) (5) Hodgson AT et al; J Air Waste Manage Assoc 41: 1461-68 (1991) (6) Kostiainen R; Atmos Environ 29: 693-700 (1995)]**PEER REVIEWED**

INDOOR AIR: An emission rate of 3.6 ug/sq m/hr was measured for the release of **trichloroethylene** from linoleum tile(1). A summary of US studies monitoring VOCs in indoor air reports that **trichloroethylene** has been measured at an average concn of 1.347 ppb in 2134 measurements(1). A maximum indoor air concn of 106 ug/cu m was reported in a study of 300 Dutch homes(1). **Trichloroethylene** was reported in air samples during a study of West German homes with a concn range of <1.0 to 1200 ug/cu m (mean concn of 13 ug/cu m)(1). Air samples collected from 757 randomly selected Canadian homes in 1992 contained **trichloroethylene** at unreported concns(2).
[(1) Otson R, Fellin P; pp. 335-421 in Gaseous Pollutants: Characterization and Cycling, Nriagu JO, ed, NY, NY: John Wiley & Sons, Inc, Chp 9 (1992) (2) Otson R; pp. 66-76 in Volatile Organic Compounds in the Environment. Wang W et al, eds. ASTM STP 1261 (1996)]**PEER REVIEWED**

RURAL/REMOTE: Mean concns of **trichloroethylene** in air samples collected from Talladega National Forest were 0.2 ppb(1). Air samples collected from 4 forests in southwest Germany between 1986 and 1988 contained **trichloroethylene** at mean concns of 0.45, 0.55, 0.5, and 0.45 ug/cu m(2). A mean concn of 0.6 ug/cu m (n=23) was reported in air samples collected from 1987 to 1990 from a rural site near Champaign, IL(3). Concns of **trichloroethylene** were measured in air samples collected above the Pacific Ocean (1977, mean=0.07 ug/cu m), Panama Canal Zone (1977, 0.08 ug/cu m), and in the northern hemisphere (1985, 0.06-0.09 ug/cu m) and southern hemisphere (1981, <0.02 ug/cu m). Air samples from rural locations contained **trichloroethylene**: Badger Pass, CA (1977, mean=0.06 ug/cu m, range=0.005-0.09 ug/cu m), Whiteface Mountains, NY (1974, mean=0.5 ug/cu, range=<0.3-1.9 ug/cu m), Reese River, NV (1977, mean=0.06 ug/cu m, range=0.005-0.09 ug/cu m), Jetmar, KS (1978, mean=0.07 ug/cu m, range=0.04-0.11 ug/cu m)(4). **Trichloroethylene** was measured in marine air masses surveyed over an area in the western Pacific between 43 deg N, 150 deg E and 4 deg N, 113 deg E in September 1994 at mean and median concns of 3.52 and 0.32 parts/trillion volume, respectively (range=0.03-141.2 parts/trillion volume)(5). Ambient concns of **trichloroethylene** in air samples from the western Pacific, 1991 to 1994, ranged from 0.36 to 70 parts/trillion volume with mean concns from 3 different cruises of 1.90 to 9.5 parts/trillion volume(6). The national VOC database reports remote and rural median concns of 0.013 (n=14) and 0.010 (n=84) ppbv for **trichloroethylene**(7).
[(1) Duce RA et al; Rev Geophys Space Physics 21: 921-52 (1983) (2) Frank W, Frank H; Atmos Environ 24A: 1735-39 (1990) (3) Sweet CW, Vermette, SJ; Environ Sci Technol 26: 165-73 (1992) (4) IARC; Monographs on the Evaluation of Carcinogenic Risks to Humans. Dry Cleaning, Some Chlorinated Solvents and Other Industrial Chemicals, 63: 86 (1995) (5) Quack B, Suess E; J Geophys Res 104: 1663-78 (1999) (6) Yokouchi Y et al; J Geophys Res. 102: 8805-9 (1997) (7) Shah JJ, Singh HB; Environ Sci Technol 22: 1381-88 (1988)]**PEER REVIEWED**

RURAL/REMOTE: Air samples from the Antarctic from April 1985 to February 1986 contained **trichloroethylene** at 3.1X10-11 mol/cu m(1). **Trichloroethylene** concns in Arctic air samples peaked in December and January and declined to almost zero in June/July(2). A mean concn of 141.1 parts/trillion volume was measured for **trichloroethylene** in the air above the southern North Sea during cruises from Sept 1994 to Dec 1995(3). Air samples collected between 1994 and 1996 at a site in Payson, AZ and at Casa Grande, AZ contained **trichloroethylene** at avg concns of 0.10 (range 0.00 to 1.13 ppbv) and 0.09 ppbv (range 0.00 to 1.46 ppbv), respectively(4).

[(1) Tulupov PE et al; Meteorol Gidrol 68-72 (1989) (2) Yokouchi Y, Barrie LA; Kankyo Kagaku 5: 506-7 (1995) (3) Dewulf JP et al; Environ Sci Technol 32: 903-911 (1998) (4) Zielinska B et al; J Air Waste Manage Assoc 48: 1038-50 (1998)]**PEER REVIEWED**

Food Survey Values:

Trichloroethylene was detected in the following food samples: intermediates grain-based food (1984): 9 varieties, 44.4% pos, 0.77-2.7 ppb, 1.9 ppb (max concn in yellow corn meal; wheat, corn, oats (1984)), 10, 2, and 1 samples, respectively: not detected(1). Sampling table-ready foods showed **trichloroethylene** concns as follows: 19 varieties, 47% pos, 1.7-8.0 ppb, 1.5 ppb avg, max concn in plain granola; butter, 7 samples, 100% pos; 1.6-20 ppb, 9.7 ppb avg; margarine, 7 samples, 100% pos, 3.7-980 ppb, 4.3 ppb avg of pos, max concn in Mozzarella cheese(2). Trace amounts of **trichloroethylene** were detected in extracted edible oils(1). It was also detected in meat, beverages, dairy products, fruits and vegetables, oil and fats, range 0.02-60 ug/kg(1). Concns of **trichloroethylene** in food samples were as follows: Cheshire cheese: 3 mg/kg; English butter: 10 mg/kg; eggs: 0.6 mg/kg; shin of beef: 16 mg/kg; beef fat: 12 mg/kg; pig liver: 22 mg/kg; margarine: 6 mg/kg; olive oil (Spanish): 9 mg/kg; cod liver oil: 19 mg/kg; vegetable oil for frying: 7 mg/kg; fruit juices: 5 mg/kg; light beer: 0.7 mg/kg; freeze-dried coffee: 4 mg/kg; tea in bags: 60 mg/kg; Yugoslavian wine: 0.02; potatoes: 3 mg/kg; apples: 5 mg/kg; pears: 5 mg/kg; fresh bread: 7 mg/kg(3).
[(1) Heikes DL, Hopper ML; J Assoc Off Anal Chem 69: 990-8 (1986) (2) Heikes DL; J Assoc Off Anal Chem 70: 215-26 (1987) (3) McConnell G et al; Endeavour 34: 13-8 (1975)]**PEER REVIEWED**

5 of 372 samples of food, obtained from the Food and Drug Administration's "market basket" collections, contained **trichloroethylene** at concns ranging from 2 to 94 ng/g (mean=49 ng/g)(1). **Trichloroethylene** was present in samples of butter from not detected to 0.3 ug/kg, in margarine at concns from not detected to 0.4 ug/kg, in peanut butter at concns from not detected to 0.7 ug/kg, and in pastry mix at a concn of 0.2 ug/kg(2). Floured chickpeas contained **trichloroethylene** at unreported concns(3). **Trichloroethylene** has been reported as a component of chicken meat volatiles(4).
[(1) Daft JL; J Agric Food Chem 37: 560-64 (1989) (2) Page BD, LaCroix GM; J AOAC Internat 78: 1416-28 (1995) (3) Rembold H et al; J Agric Food Chem 37: 659-62 (1989) (4) Shahidi F et al; CRC Crit Rev Food Sci Nature 24: 141-243 (1986)]**PEER REVIEWED**

Plant Concentrations:

Tree cores obtained from bald cypress, tupelo, sweet gum, oak, sycamore, and loblolly pine growing over shallow groundwater contaminated with **trichloroethylene** contained this compound at concns from <50 to 35,040 nmol /l (n=138, sampled January-February 1998, Savannah River Site, SC)(1).
[(1) Vroblesky DA et al; Environ Sci Technol 33: 510-15 (1999)]**PEER REVIEWED**

Fish/Seafood Concentrations:

Conger conger (eel): gill, gut: 29 ng/g; brain, muscle: 62-70 ng/g; Gaddus morhua (cod): stomach, muscle: 7-8 ng/g; brain, liver: 56-66 ng/g; Pollachius birens (coal fish): muscle: 8 ng/g; alimentary canal: 306 ng/g; Scylliorhinus canicula (dog fish): muscle, gut, brain: 40-41 ng/g; liver: 479 ng/g; Trisopterus luscus (bib): gill: 40 ng/g; muscle, skeletal tissue: 185-187 ng/g.
[Verschueren, K. Handbook of Environmental Data on Organic Chemicals. 3rd ed. New York, NY: Van Nostrand Reinhold Co., 1996. 1788]**PEER REVIEWED**

Trichloroethylene has been reported in marine fish at the following concns: flesh - 0.04-1.1 ppm, liver - 0.66-20.0 ppb, mussels - 50 day exposure 1.37 ppm(1). Shelfish from Lake Pontachartrain at Passes contained the following concns: oysters, 5 samples, 2.2 ppb avg; clams, composite samples from 2 sites,

5.7 and 0.8 ppb(2).
[(1) Pearson CR, McConnell G; Proc R Soc Lond B 189: 305-32 (1975) (2) Ferrario JB et al; Bull Environ Contam Toxicol 34: 246-55 (1985)]**PEER REVIEWED**

Animal Concentrations:

Clams collected in 1995/1996 from the Ariho, Koe and Okita Rivers, Japan, did not contain measurable quantities of **trichloroethylene** (detection limit <0.5 ug/kg)(1). Earthworms collected from a forest site adjacent to a former landfill site and chemical plant in West Germany during 1989 contained **trichloroethylene** at concns below detection (detection limit not reported) to 170 ng/g wet weight(2). In a sampling study conducted near Liverpool Bay, UK, **trichloroethylene** concns in Alca torda (Razorbill Auk), Uria aalge (Guillemot), and Rissa tridactyla (Kittiwake) sea bird eggs were 23-33 mg/kg. Levels of 2.4 mg/kg for Phalacrocrax aristotelis (Shag) were also noted(3).
[(1) Gotoh M et al; Bull Environ Contam Toxicol, 60: 74-80 (1998) (2) Back H, Susser P; Sol Biol Biochem 24: 1745-48 (1992) (3) Pearson CR, McConnell G; Proc R Soc London Ser B 189: 305-22 (1975)]**PEER REVIEWED**

Milk Concentrations:

Trichloroethylene has been detected in dairy products(1). In mother's milk samples from 4 U.S. urban areas, 8 of 8 samples tested positive for the compound(2). The concn of **trichloroethylene** in fresh milk was 0.3 mg/kg(3).
[(1) IARC; Monographs of the Evaluation of Carcinogenic Risk of Chemicals to Man 11: 283-76 (1976) (2) Pellizzari ED et al; Bull Environ Contam Toxicol 28: 322-8 (1982) (3) McConnell G et al; Endeavour 34: 13-8 (1975)]**PEER REVIEWED**

Other Environmental Concentrations:

Trichloroethylene was found in 2.2% of 1159 household products; automotive products (0.1% weight/weight, 1.2% positive hits in category), household cleaner/polishes (0.0%, 0.9%), paint-related products (3.0%, 1.1%), fabric and leather treatments (0.0%, 2.2%), cleaners for electronic equipment (0.3%, 1.4%), oils, greases and lubricants (0.3%, 1.8%), adhesive-related products (34.7%, 2.6%) and miscellaneous products (33.9%, 14.1%)(1). Household cleaning agents and pesticides contained **trichloroethylene** at an average concn of 7 ug/cu m (2). **Trichloroethylene** was identified in 3 of 26 samples of hobby glue at 0.007 to 0.15 weight percent(3). In the European Community, **trichloroethylene** is used by some producers during the decaffeinating of coffee(4).
[(1) Sack TM et al; Atmos Environ 26A: 1063-70 (1992) (2) Wallace LA et al; Atmos Environ 21: 385-93 (1987) (3) Rastogi SC; Bull Environ Contam Toxicol 51: 501-7 (1993) (4) Passant NR et al; Atmos Environ 27A: 2555-66 (1993)]**PEER REVIEWED**

Environmental Standards & Regulations:

CERCLA Reportable Quantities:

Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or greater than its reportable quantity of 100 lb or 45.4 kg. The toll free number of the NRC is (800) 424-8802; In the Washington D.C. metropolitan area (202) 426-2675. The rule for determining when notification is required is stated in 40 CFR 302.4 (section IV. D.3.b).
[40 CFR 302.4 (7/1/2000)]**PEER REVIEWED**

RCRA Requirements:

U228; As stipulated in 40 CFR 261.33, when **trichloroethylene**, as a commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate, becomes a waste, it must be managed according to Federal and/or State hazardous waste regulations. Also defined as a hazardous waste is any residue, contaminated soil, water, or other debris resulting from the cleanup of a spill, into water or on dry land, of this waste. Generators of small quantities of this waste may qualify for partial exclusion from hazardous waste regulations (40 CFR 261.5).
[40 CFR 261.33 (7/1/2000)]**PEER REVIEWED**

D040; A solid waste containing **trichloroethylene** may or may not become characterized as a hazardous waste when subjected to the Toxicity Characteristic Leaching Procedure listed in 40 CFR 261.24, and if so characterized, must be managed as a hazardous waste.
[40 CFR 261.24 (7/1/2000)]**PEER REVIEWED**

F002; When **trichloroethylene** is a spent solvent, it is classified as a hazardous waste from a nonspecific source (F002), as stated in 40 CFR 261.31, and must be managed according to state and/or federal hazardous waste regulations.
[40 CFR 261.31 (7/1/2000)]**PEER REVIEWED**

Atmospheric Standards:

This action promulgates standards of performance for equipment leaks of Volatile Organic Compounds (VOC) in the Synthetic Organic Chemical Manufacturing Industry (SOCMI). The intended effect of these standards is to require all newly constructed, modified, and reconstructed SOCMI process units to use the best demonstrated system of continuous emission reduction for equipment leaks of VOC, considering costs, non air quality health and environmental impact and energy requirements. **Trichloroethylene** is produced, as an intermediate or a final product, by process units covered under this subpart.
[40 CFR 60.489 (7/1/2000)]**PEER REVIEWED**

Listed as a hazardous air pollutant (HAP) generally known or suspected to cause serious health problems. The Clean Air Act, as amended in 1990, directs EPA to set standards requiring major sources to sharply reduce routine emissions of toxic pollutants. EPA is required to establish and phase in specific performance based standards for all air emission sources that emit one or more of the listed pollutants. **Trichloroethylene** is included on this list.
[Clean Air Act as amended in 1990, Sect. 112 (b) (1) Public Law 101-549 Nov. 15, 1990]**PEER REVIEWED**

Clean Water Act Requirements:

Toxic pollutant designated pursuant to section 307(a)(1) of the Federal Water Pollution Control Act and is subject to effluent limitations.
[40 CFR 401.15 (7/1/2000)]**QC REVIEWED**

Trichloroethylene is designated as a hazardous substance under section 311(b)(2)(A) of the Federal Water Pollution Control Act and further regulated by the Clean Water Act Amendments of 1977 and 1978. These regulations apply to discharges of this substance. This designation includes any isomers and hydrates, as well as any solutions and mixtures containing this substance.
[40 CFR 116.4 (7/1/2000)]**QC REVIEWED**

Federal Drinking Water Standards:

EPA 5 ug/l

[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

State Drinking Water Standards:

(FL) FLORIDA 3 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(NJ) NEW JERSEY 1 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

State Drinking Water Guidelines:

(AZ) ARIZONA 3.2 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(CT) CONNECTICUT 5 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(ME) MAINE 5 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(MN) MINNESOTA 30 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

FDA Requirements:

Trichloroethylene is an indirect food additive for use as a component of adhesives.
[21 CFR 175.105 (4/1/2000)]**PEER REVIEWED**

Tolerances are established for residues of **trichloroethylene** resulting from its use as a solvent in the manufacture of foods as follows: decaffeinated ground coffee 25 ppm; decaffeinated soluble (instant) coffee extract 10 ppm; and spice oleoresins 30 ppm (provided that if residues of other chlorinated solvents are also present, the total of all residues of such solvents in spice oleoresins shall not exceed 30 ppm).
[21 CFR 173.290 (4/1/2000)]**PEER REVIEWED**

Allowable Tolerances:

Tolerances are established for residues of **trichloroethylene** resulting from its use as a solvent in the manufacture of foods as follows: decaffeinated ground coffee 25 ppm; decaffeinated soluble (instant) coffee extract 10 ppm; and spice oleoresins 30 ppm (provided that if residues of other chlorinated solvents are also present, the total of all residues of such solvents in spice oleoresins shall not exceed 30 ppm).

[21 CFR 173.290 (4/1/2000)]**PEER REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

C2-H-Cl3
PEER REVIEWED

Molecular Weight:

131.39
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-164]**PEER REVIEWED**

Color/Form:

CLEAR, COLORLESS, OR BLUE MOBILE LIQUID
[Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980. 986]**PEER REVIEWED**

Colorless liquid (unless dyed blue).
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 316]**PEER REVIEWED**

Odor:

Ethereal odor
[Verschueren, K. Handbook of Environmental Data on Organic Chemicals. 3rd ed. New York, NY: Van Nostrand Reinhold Co., 1996. 1784]**PEER REVIEWED**

Sweet smelling
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V4 (93) 40]**PEER REVIEWED**

Characteristic odor resembling that of chloroform
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

Boiling Point:

87.2 deg C
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-164]**PEER REVIEWED**

Melting Point:

-84.7 deg C
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-164]**PEER REVIEWED**

Corrosivity:

Non-corrosive
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed.

Park Ridge, NJ: Noyes Data Corporation, 1985. 883]**PEER REVIEWED**

Critical Temperature & Pressure:

Critical temperature: 300.2 deg C; Critical pressure: 4.986 MPa
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V6 (93) 42]**PEER REVIEWED**

Density/Specific Gravity:

1.4642 @ 20 deg C/4 deg C
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

Heat of Combustion:

-6.56 kJ/g
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V6 (93) 42]**PEER REVIEWED**

Heat of Vaporization:

8,314.7 gcal/gmole
[Weast, R.C. (ed.) Handbook of Chemistry and Physics. 67th ed. Boca Raton, FL: CRC Press, Inc., 1986-87.,p. C-671]**PEER REVIEWED**

Octanol/Water Partition Coefficient:

log Kow= 2.61
[Hansch, C., Leo, A., D. Hoekman. Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. Washington, DC: American Chemical Society., 1995. 4]**PEER REVIEWED**

Solubilities:

Soluble in ethanol, diethyl ether, acetone, and chloroform
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 (95) 75]**PEER REVIEWED**

Miscible in oil.
[Health and Safety Executive Monograph: Trichloroethylene #6 p.2 (1982)]**PEER REVIEWED**

In water, 1,280 mg/l @ 25 deg C
[Horvath AL et al; J Phys Chem Ref Data 28: 449 (1999)]**PEER REVIEWED**

Spectral Properties:

SADTLER REF NUMBER: 185 (IR, PRISM); MAX ABSORPTION: LESS THAN 200 NM (VAPOR)
[Weast, R.C. (ed.). Handbook of Chemistry and Physics. 60th ed. Boca Raton, Florida: CRC Press Inc., 1979.,p. C-298]**PEER REVIEWED**

Index of refraction: 1.4773 @ 20 deg C/D
[Lide, D.R. (ed.). CRC Handbook of Chemistry and Physics. 79th ed. Boca Raton, FL: CRC Press Inc., 1998-1999.,p. 3-164]**PEER REVIEWED**

IR: 62 (Sadtler Research Laboratories IR Grating Collection)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 627]**PEER REVIEWED**

NMR: 9266 (Sadtler Research Laboratories Spectral Collection)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 627]**PEER REVIEWED**

MASS: 583 (Atlas of Mass Spectral Data, John Wiley & Sons, New York)
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V1 627]**PEER REVIEWED**

Intense mass spectral peaks: 60 m/z, 95 m/z, 130 m/z
[Pfleger, K., H. Maurer and A. Weber. Mass Spectral and GC Data of Drugs, Poisons and their Metabolites. Parts I and II. Mass Spectra Indexes. Weinheim, Federal Republic of Germany. 1985.167]**PEER REVIEWED**

Surface Tension:

29.3 dynes/cm = 0.0293 N/m at 20 deg C
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Vapor Density:

4.53 /Air=1/
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

Vapor Pressure:

69 mm Hg @ 25 deg C
[Boublik, T., Fried, V., and Hala, E., The Vapour Pressures of Pure Substances. Second Revised Edition. Amsterdam: Elsevier, 1984. 87]**PEER REVIEWED**

Viscosity:

0.00550 poise at 25 deg C
[Flick, E.W. Industrial Solvents Handbook. 3rd ed. Park Ridge, NJ: Noyes Publications, 1985. 143]**PEER REVIEWED**

Other Chemical/Physical Properties:

Percent in saturated air: 10.2 (25 DEG C); Equivalencies: 1 mg/l= 185.8 ppm and 1 ppm= 5.38 mg/cu m @ 25 deg C, 760 mm Hg)
[Clayton, G.D., F.E. Clayton (eds.) Patty's Industrial Hygiene and Toxicology. Volumes 2A, 2B, 2C, 2D, 2E, 2F: Toxicology. 4th ed. New York, NY: John Wiley & Sons Inc., 1993-1994. 4194]**PEER REVIEWED**

Ratio of Specific Heats of Vapor (gas) : 1.116
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Olive oil/water partition coefficient 522:1 at 37 deg C.

[Sato A, Nakajima T; Arch Envir Health 43: 69-75 (1979) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p. 3-3 (1983) EPA-600/8-82-006B]**PEER REVIEWED**

Liquid heat capacity: 0.231 Btu/lb-F; saturated vapor pressure: 1.166 lb/sq in; saturated vapor density: 0.02695 lb/cu ft (all at 70 deg F)
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Saturated liquid density: 90.770 lb/cu ft; ideal gas heat capacity: 0.146 Btu/lb-F (All at 75 deg F)
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Weight per gallon @ 20 deg C: 12.20 lb.
[Flick, E.W. Industrial Solvents Handbook. 3rd ed. Park Ridge, NJ: Noyes Publications, 1985. 143]**PEER REVIEWED**

Partition coefficients at 37 deg C for **trichloroethylene** into blood = 9.5; into oil = 718.
[Sato A, Nakajima T; Scand J Work Environ Health 13: 81-93 (1987)]**PEER REVIEWED**

Dielectric constant: @ 16 deg C 3.42; coefficient of cubic expansion: 0.00119 (at 0-40 deg C); heat of formation: -42.3 kJ/mol (liquid), -7.78 kJ/mol (vapor); latent heat of vaporization: 238 kJ/kg (at boiling point)
[Kirk-Othmer Encyclopedia of Chemical Technology. 4th ed. Volumes 1: New York, NY. John Wiley and Sons, 1991-Present.,p. V6 (93) 42]**PEER REVIEWED**

Henry's Law Constant=9.85X10-3 atm-cu m/mol @ 25 deg C
[Leighton DT Jr, Calo JM; J Chem Eng Data 26: 382-85 (1981)]**PEER REVIEWED**

Hydroxyl radical rate constant = 2.36X10-12 cu cm/molecule-sec at 25 deg C
[Atkinson R; J Phys Chem Ref Data Monograph No. 2 (1994)]**PEER REVIEWED**

Slowly dec (with formation of HCl) by light in the presence of moisture
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

Will not attack the common metals even in the presence of moisture
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1125]**PEER REVIEWED**

Photo-oxidized in air by sunlight (half-time, five days) giving phosgene and dichloroacetyl chloride
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 (95) 76]**PEER REVIEWED**

Chemical Safety & Handling:

Hazards Summary:

Trichloroethylene (**TCE**) is a hazardous substance due primarily to its toxicity. Effects result from both high-level, acute and lower-level, chronic exposures. Protection must be afforded against both dermal contact and inhalation. Dermal protection is accomplished by routinely wearing neoprene constructed gloves, worksuit, apron, and shoes. Safety goggles or a face shield is necessary to protect against splash potential. The TLV for **TCE** is 50 ppm with a short term exposure limit (STEL) of 200 ppm. These

levels should be attained through local exhaust (pressure/vacuum) ventilation. If the STEL is exceeded, an organic vapor-acid canister respirator or air-supplied, self-contained breathing apparatus (in emergencies) is recommended. The ethereal, chloroform-like odor of **TCE** is detectable at 50 ppm, with levels above 200 ppm becoming disagreeable. Its clear, colorless appearance and liquid form do not serve similarly as warnings against dermal contact. The potential fire hazard from **TCE** alone is low. However, **TCE**, when exposed to flames or an electric arc in the presence of iron, copper, zinc, or aluminum, can form phosgene, a highly toxic gas. Also, **TCE** in the presence of heat and strong oxidizers (eg, tetraoxide) reacts violently. Even without a heat source, **TCE** can react with strong alkali (eg, sodium hydroxide) to form the dangerously toxic, flammable and explosive dichloroacetylene. Perchloric acid also reacts violently with **TCE**. Further **TCE** forms impact-explosive mixtures with finely divided aluminum, beryllium, lithium, magnesium or titanium. **TCE** should be packaged in steel drums. These drums should be stored in a cool, dry, well-ventilated area because **TCE** will slowly decompose to corrosive HCL when exposed to light & moisture. Should a **TCE** fire occur, it may be combated with water, fog, dry chemical, carbon dioxide or foam extinguisher. Spills of **TCE** should be isolated by flushing with water to an impoundment. Density stratification will cause the formation of a bottom **TCE** layer which can be pumped and containerized.
PEER REVIEWED

DOT Emergency Guidelines:

Health: Vapors may cause dizziness or suffocation. Exposure in an enclosed area may be very harmful. Contact may irritate or burn skin and eyes. Fire may produce irritating and/or toxic gases. Runoff from fire control or dilution water may cause pollution.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

Fire or explosion: Some of these materials may burn, but none ignite readily. Most vapors are heavier than air. Air/vapor mixtures may explode when ignited. Container may explode in heat of fire.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

Public safety: CALL Emergency Response Telephone Number ... . Isolate spill or leak area immediately for at least 25 to 50 meters (80 to 160 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Many gases are heavier than air and will spread along ground and collect in low or confined areas (sewers, basements, tanks). Keep out of low areas. Ventilate closed spaces before entering.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

Protective clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Structural firefighters' protective clothing will only provide limited protection.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

Evacuation: ... Fire: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

Fire: Small fires: Dry chemical, CO2 or water spray. Large fires: Dry chemical, CO2, alcohol-resistant

foam or water spray. Move containers from fire area if you can do it without risk. Dike fire control water for later disposal; do not scatter the material. Fire involving tanks or car/trailer loads: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

Spill or leak: Eliminate all ignition sources (no smoking, flares, sparks or flames in immediate area). Stop leak if you can do it without risk. Small liquid spills: Take up with sand, earth or other noncombustible absorbent material. Large spills: Dike far ahead of liquid spill for later disposal. Prevent entry into waterways, sewers, basements or confined areas.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

First aid: Move victim to fresh air. Call 911 or emergency medical service. Apply artificial respiration if victim is not breathing. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. For minor skin contact, avoid spreading material on unaffected skin. Wash skin with soap and water. Keep victim warm and quiet. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-160]**QC REVIEWED**

Odor Threshold:

10 mg/l (in water) /Purity not specified/
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1133]**PEER REVIEWED**

5.00X10-1 mg/l (liquid) (detection in water)
[Fazzalari, F.A. (ed.). Compilation of Odor and Taste Threshold Values Data. ASTM Data Series DS 48A (Committee E-18). Philadelphia, PA: American Society for Testing and Materials, 1978. 159]**PEER REVIEWED**

2.14X10+1 ppm (recognition in air) (chemically pure)
[Fazzalari, F.A. (ed.). Compilation of Odor and Taste Threshold Values Data. ASTM Data Series DS 48A (Committee E-18). Philadelphia, PA: American Society for Testing and Materials, 1978. 159]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Exposure to **trichloroethylene** vapor may cause irritation of the eyes, nose, and throat.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 884]**PEER REVIEWED**

Liquid: irritating to skin and eyes.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Fire Potential:

FIRE HAZARD: LOW, WHEN EXPOSED TO HEAT. HIGH CONCN OF **TRICHLOROETHYLENE** VAPOR IN HIGH TEMP AIR CAN BE MADE TO BURN MILDLY IF APPLIED WITH STRONG FLAME. THOUGH SUCH CONDITION IS DIFFICULT TO PRODUCE, FLAMES OR ARCS SHOULD NOT BE USED IN CLOSED EQUIPMENT WHICH CONTAINS ANY SOLVENT RESIDUE OR VAPOR.
[Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984. 2622]**PEER REVIEWED**

At normal handling temperatures, **trichloroethylene** behaves as a non-flammable, non-burnable substance.
[WHO; Environ Health Criteria 50: Trichloroethylene p.31 (1985)]**PEER REVIEWED**

NFPA Hazard Classification:

Health: 2. 2= Materials that, on intense or continued (but not chronic) exposure, could cause temporary incapacitation or possible residual injury, including those requiring the use of respiratory protective equipment that has an independent air supply. These materials are hazardous to health, but areas may be entered freely if personnel are provided with full-face mask self-contained breathing apparatus that provides complete eye protection.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-88]**PEER REVIEWED**

Flammability: 1. 1= This degree includes materials that must be preheated before ignition will occur, such as Class IIIB combustible liquids and solids and semi-solids whose flash point exceeds 200 deg F (93.4 deg C), as well as most ordinary combustible materials. Water may cause frothing if it sinks below the surface of the burning liquid and turns to steam. However, a water fog that is gently applied to the surface of the liquid will cause frothing that will extinguish the fire.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-88]**PEER REVIEWED**

Reactivity: 0. 0= This degree includes materials that are normally stable, even under fire exposure conditions, and that do not react with water. Normal fire fighting procedures may be used.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-88]**PEER REVIEWED**

Flammable Limits:

Lower flammable limit: 8% by volume at 25 deg C; Upper flammable limit: 10.5% by volume at 25 deg C
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-88]**PEER REVIEWED**

Lower flammable limit: 7.8% by volume at 100 deg C; Upper flammable limit: 52% by volume at 100 deg C
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-88]**PEER REVIEWED**

Autoignition Temperature:

420 DEG C (788 DEG F)
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-88]**PEER REVIEWED**

Fire Fighting Procedures:

Approach fire from upwind to avoid hazardous vapors and toxic decomposition products. Use water spray to keep fire-exposed containers cool. Use water spray, dry chemical, foam, or carbon dioxide. Extinguish fire using agent suitable for surrounding fire.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-130]**PEER REVIEWED**

If material involved in fire: Extinguish fire using agent suitable for type of surrounding fire. (Material itself does not burn or burns with difficulty.)
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 1073]**PEER REVIEWED**

Toxic Combustion Products:

Combustion may produce irritants and toxic gas including hydrogen chloride.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-130]**PEER REVIEWED**

Explosive Limits & Potential:

UPPER (77 DEG F) 10.5% VOL; LOWER (77 DEG F) 8% VOL
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 316]**PEER REVIEWED**

UPPER 90% VOL; LOWER 12.5% VOL
[Sax, N.I. Dangerous Properties of Industrial Materials. 6th ed. New York, NY: Van Nostrand Reinhold, 1984. 2622]**PEER REVIEWED**

... Under ordinary conditions of use, **trichloroethylene** is non-flammable and non-explosive... .
[International Labour Office. Encyclopaedia of Occupational Health and Safety. 4th edition, Volumes 1-4 1998. Geneva, Switzerland: International Labour Office, 1998.,p. 104.244]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

Strong caustics and alkalis; chemically-active metals (such as barium, lithium, sodium, magnesium, titanium, and beryllium).
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 316]**PEER REVIEWED**

1-Chloro-2,3-epoxypropane, the mono- and di-2,3-epoxypropyl ethers of 1,4-butanediol, and 2,2-bis-4(2',3'-epoxypropoxy)-phenyl-propane can, in presence of catalytic quantities of halide ions, cause dehydrochlorination of **trichloroethylene** to dichloroacetylene, which causes minor explosions when the mixture is boiled under reflux.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 223]**PEER REVIEWED**

Granular barium in contact with **trichloroethylene** is susceptible to detonation.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 78]**PEER REVIEWED**

Mixtures of powdered beryllium with **trichloroethylene** will flash on heavy impact.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 85]**PEER REVIEWED**

Mixtures of lithium shavings and **trichloroethylene** are impact-sensitive and willexplode, sometimes violently.

[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1315]**PEER REVIEWED**

Mixtures of powdered magnesium with **trichloroethylene** will flash on heavy impact.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1322]**PEER REVIEWED**

Mixtures of powdered titanium and **trichloroethylene** flash or spark under heavy impact.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1464]**PEER REVIEWED**

Trichloroethylene reacts violently with the anhydrous perchloric acid.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 963]**PEER REVIEWED**

Mixtures of dinitrogen tetraoxide with **trichloroethylene** react violently on heating to 150 deg C.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1352]**PEER REVIEWED**

Mixture of liquid oxygen with dichloromethane, 1,1,1-trichloroethane, **trichloroethylene**, and chlorinated dye penetrants 1 and 2 exploded violently when initiated with a blasting cap.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1408]**PEER REVIEWED**

In the presence of strong alkali (eg, sodium hydroxide), **trichloroethylene** can decompose into dichloroacetylene, an explosive, flammable, and highly toxic compound.
[Humphrey JH, McClelland M; Brit Med J 1: 315-8 (1944) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.3-2 (1984) EPA-600/8-82-006B]**PEER REVIEWED**

Formation of phosgene, a highly toxic gas, was observed when **trichloroethylene** came into contact with iron, copper, zinc, or aluminum over the temperature range 250 deg C to 600 deg C.
[Sjoberg B; Svensk Kem Tid 64: 63-79 (1952) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.3-2 (1982) EPA-600/8-82-006B]**PEER REVIEWED**

Mixtures of **trichloroethylene** and oxygen will ignite at temperatures above 25.5 deg C when the **trichloroethylene** concentration is between 10.3 and 64.5%.
[Jones G, Scott G; Report of Investigation 3666. US Bureau of Mines Washington, DC (1942) as cited in USPEA; Health Assessment Document: Trichloroethylene (Draft) p.3-1 (1983) EPA-600/8-82-006B]**PEER REVIEWED**

PHOTOREACTIVE LIQUID; WILL NOT ATTACK COMMON METALS EVEN IN PRESENCE OF MOISTURE
[Sax, N.I. and R.J. Lewis, Sr. (eds.). Hawley's Condensed Chemical Dictionary. 11th ed. New York: Van Nostrand Reinhold Co., 1987. 1176]**PEER REVIEWED**

An emulsion, formed during extraction of a strongly alkaline liquor with **trichloroethylene**, decomposed with the evolution of the spontaneously flammable gas, dichloroacetylene. This reaction could also occur if alkaline metal-stripping preparations were used in conjunction with **trichloroethylene** degreasing preparations, some of which also contain amine inhibitors which could cause the same reaction.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 223]**PEER REVIEWED**

Mixtures of dinitrogen tetraoxide with **trichloroethylene** are explosive when subjected to shock of 25 g TNT equivalent or less.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1352]**PEER REVIEWED**

Aluminum powder reaction when /exposed/ to **trichloroethylene**.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 25]**PEER REVIEWED**

Incompatibilities: Strong caustics; when acidic reacts with aluminum; chemical active metals-barium, lithium, sodium, magnesium, titanium.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 883]**PEER REVIEWED**

Hazardous Decomposition:

SLOWLY DECOMPOSED WITH FORMATION OF HYDROCHLORIC ACID BY LIGHT IN PRESENCE OF MOISTURE
[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1516]**PEER REVIEWED**

Autoxidation products, such as phosgene and dichloroacetylene, added stabilizers, such as epichlorohydrin, and decomp products, such as chlorine and hydrochloric acid, may be responsible for some of the toxic and carcinogenic effects reported for **trichloroethylene**.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-165]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH considers **trichloroethylene** to be a potential occupational carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 316]**PEER REVIEWED**

Protective Equipment & Clothing:

Wear appropriate personal protective clothing to prevent skin contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

Facilities for quickly drenching the body should be provided within the immediate work area for emergency use where there is a possibility of exposure. [Note: It is intended that these facilities provide a sufficient quantity or flow of water to quickly remove the substance from any body areas likely to be exposed. The actual determination of what constitutes an adequate quick drench facility depends on the specific circumstances. In certain instances, a deluge shower should be readily available, whereas in others, the availability of water from a sink or hose could be considered adequate.]
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

Eyewash fountains should be provided in areas where there is any possbility that workers could be exposed to the substance; this is irrespective of the recommendation involving the wearing of eye protection.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

Recommendations for respirator selection. Condition: At concentrations above the NIOSH REL, or where there is no REL, at any detectable concentration: Respirator Class(es): Any self-contained

breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode. Any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Escape from suddenly occurring respiratory hazards: Respirator Class(es): Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister. Any appropriate escape-type, self-contained breathing apparatus.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

ORGANIC VAPOR-ACID CANISTER; SELF-CONTAINED BREATHING APPARATUS FOR EMERGENCIES; NEOPRENE OR VINYL GLOVES; CHEMICAL SAFETY GOGGLES; FACE-SHIELD; NEOPRENE SAFETY SHOES; NEOPRENE SUIT OR APRON FOR SPLASH PROTECTION.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

/Wear/ positive-pressure hose masks, airline masks or an industrial canister-type gas mask fitted with an appropriate canister for absorbing **trichloroethylene** vapor are acceptable.
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 2215]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Dispensers of liq detergent /should be available./ ... Safety pipettes should be used for all pipetting. ... In animal laboratory, personnel should ... wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. ... Gowns ... /should be/ of distinctive color, this is a reminder that they are not to be worn outside the laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

Cleaning of confined spaces presents serious hazards: the gas should be dispelled by mobile ventilators before workers are permitted to enter, safety belts & lifelines & respiratory protective equipment of the self-contained or supplied-air type should be avail, & another worker should be posted outside for supervision & rescue, if necessary.
[International Labour Office. Encyclopaedia of Occupational Health and Safety. 4th edition, Volumes 1-4 1998. Geneva, Switzerland: International Labour Office, 1998.,p. 65.13]**PEER REVIEWED**

Preventive Measures:

Recommended ventilation design concentrations: 100 ppm; dilution rate: 30,000 cu ft air/lb solvent flow.
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 608]**PEER REVIEWED**

PVC and natural rubber should not be used when cleaning up a **TCE** spill. Equipment should not be iron or metal, or be susceptible to hydrogen chloride.
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.]**PEER REVIEWED**

Processes employing **trichloroethylene** should be designed so that the operator is not exposed to direct contact with the solvent or its vapor. Open electric heaters, high-temp processes, arc welding or open flames should not be used in environments with **trichloroethylene** vapor. ... Workers should be given instruction in the safe handling ... and be well acquainted with the hazards that may result from improper use. ... Adequate sanitary facilities should be provided and workers encouraged to wash before eating and at the end of the shift.
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 2215]**PEER REVIEWED**

Trichloroethylene should not be stored near foodstuffs, strong acids, alkalis, or oxidizing agents.
[WHO; Environ Health Criteria 50: Trichloroethylene p.32 (1985)]**PEER REVIEWED**

Stop discharge if possible. Keep people away. Avoid contact with liquid and vapor. Call fire department. Isolate and remove discharged material. Notify local health and pollution control agencies.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Avoid long contact with skin.
[Int'l Tech Info Inst; Tox & Haz Indus Chem Safety Manual, 510, 1982]**PEER REVIEWED**

Contact lenses should not be worn when working with this chemical.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

SRP: The scientific literature for the use of contact lenses in industry is conflicting. The benefit or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In any event, the usual eye protection equipment should be worn even when contact lenses are in place.
PEER REVIEWED

The worker should immediately wash the skin when it becomes contaminated.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

Work clothing that becomes wet or significantly contaminated should be removed and replaced.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 317]**PEER REVIEWED**

If material not involved in fire: Keep material out of water sources and sewers. Build dikes to contain flow as necessary.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 1074]**PEER REVIEWED**

Personnel protection: Keep upwind. ... Avoid breathing vapors or dusts. Wash away any material which

may have contacted the body with copious amounts of water or soap and water.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 1074]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Smoking, drinking, eating, storage of food or of food & beverage containers or utensils, & the application of cosmetics should be prohibited in any laboratory. All personnel should remove gloves, if worn, after completion of procedures in which carcinogens have been used. They should ... wash ... hands, preferably using dispensers of liq detergent, & rinse ... thoroughly. Consideration should be given to appropriate methods for cleaning the skin, depending on nature of the contaminant. No standard procedure can be recommended, but the use of organic solvents should be avoided. Safety pipettes should be used for all pipetting. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": In animal laboratory, personnel should remove their outdoor clothes & wear protective suits (preferably disposable, one-piece & close-fitting at ankles & wrists), gloves, hair covering & overshoes. ... Clothing should be changed daily but ... discarded immediately if obvious contamination occurs ... /also,/ workers should shower immediately. In chemical laboratory, gloves & gowns should always be worn ... however, gloves should not be assumed to provide full protection. Carefully fitted masks or respirators may be necessary when working with particulates or gases, & disposable plastic aprons might provide addnl protection. If gowns are of distinctive color, this is a reminder that they should not be worn outside of lab. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Operations connected with synth & purification ... should be carried out under well-ventilated hood. Analytical procedures ... should be carried out with care & vapors evolved during ... procedures should be removed. ... Expert advice should be obtained before existing fume cupboards are used ... & when new fume cupboards are installed. It is desirable that there be means for decreasing the rate of air extraction, so that carcinogenic powders can be handled without ... powder being blown around the hood. Glove boxes should be kept under negative air pressure. Air changes should be adequate, so that concn of vapors of volatile carcinogens will not occur. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.8]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Vertical laminar-flow biological safety cabinets may be used for containment of in vitro procedures ... provided that the exhaust air flow is sufficient to provide an inward air flow at the face opening of the cabinet, & contaminated air plenums that are under positive pressure are leak-tight. Horizontal laminar-flow hoods or safety cabinets, where filtered air is blown across the working area towards the operator, should never be used ... Each cabinet or fume cupboard to be used ... should be tested before work is begun (eg, with fume bomb) & label fixed to it, giving date of test & avg air-flow measured. This test should be repeated periodically & after any structural changes. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Principles that apply to chem or biochem lab also apply to microbiological & cell-culture labs ... Special consideration should be given to route of admin. ... Safest method of administering volatile carcinogen is by injection of a soln. Admin by topical application, gavage, or intratracheal instillation should be performed under hood. If chem will be exhaled, animals should be kept under hood during this period. Inhalation exposure requires special equipment. ... Unless specifically required, routes of admin other than in the diet should be used. Mixing of carcinogen in diet should be carried out in sealed mixers under fume hood, from which the exhaust is fitted with an efficient particulate filter. Techniques for cleaning mixer & hood should be devised before expt begun. When mixing diets, special protective clothing &, possibly, respirators may be required. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.9]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When ... admin in diet or applied to skin, animals should be kept in cages with solid bottoms & sides & fitted with a filter top. When volatile carcinogens are given, filter tops should not be used. Cages which have been used to house animals that received carcinogens should be decontaminated. Cage-cleaning facilities should be installed in area in which carcinogens are being used, to avoid moving of ... contaminated /cages/. It is difficult to ensure that cages are decontaminated, & monitoring methods are necessary. Situations may exist in which the use of disposable cages should be recommended, depending on type & amt of carcinogen & efficiency with which it can be removed. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": To eliminate risk that ... contamination in lab could build up during conduct of expt, periodic checks should be carried out on lab atmospheres, surfaces, such as walls, floors & benches, & ... interior of fume hoods & airducts. As well as regular monitoring, check must be carried out after cleaning-up of spillage. Sensitive methods are required when testing lab atmospheres. ... Methods ... should ... where possible, be simple & sensitive. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Rooms in which obvious contamination has occurred, such as spillage, should be decontaminated by lab personnel engaged in expt. Design of expt should ... avoid contamination of permanent equipment. ... Procedures should ensure that maintenance workers are not exposed to carcinogens. ... Particular care should be taken to avoid contamination of drains or ventilation ducts. In cleaning labs, procedures should be used which do not produce aerosols or dispersal of dust, ie, wet mop or vacuum cleaner equipped with high-efficiency particulate filter on exhaust, which are avail commercially, should be used. Sweeping, brushing & use of dry dusters or mops should be prohibited. Grossly contaminated cleaning materials should not be re-used ... If gowns or towels are contaminated, they should not be sent to laundry, but ... decontaminated or burnt, to avoid any hazard to laundry personnel. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.10]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Doors leading into areas where carcinogens are used ... should be marked distinctively with appropriate labels. Access ... limited to persons involved in expt. ... A prominently displayed notice should give the name of the Scientific Investigator or other person who can advise in an emergency & who can inform others (such as firemen) on the handling of carcinogenic substances. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.11]**PEER REVIEWED**

Stability/Shelf Life:

RELATIVELY STABLE IN AIR
[Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965. 189]**PEER REVIEWED**

UNSTABLE IN LIGHT AND MOISTURE
[Osol, A. (ed.). Remington's Pharmaceutical Sciences. 16th ed. Easton, Pennsylvania: Mack Publishing Co., 1980. 985]**PEER REVIEWED**

Shipment Methods and Regulations:

PRECAUTIONS FOR "CARCINOGENS": Procurement ... of unduly large amt ... should be avoided. To avoid spilling, carcinogens should be transported in securely sealed glass bottles or ampoules, which should themselves be placed inside strong screw-cap or snap-top container that will not open when dropped & will resist attack from the carcinogen. Both bottle & the outside container should be appropriately labelled. ... National post offices, railway companies, road haulage companies & airlines have regulations governing transport of hazardous materials. These authorities should be consulted before ... material is shipped. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": When no regulations exist, the following procedure must be adopted. The carcinogen should be enclosed in a securely sealed, watertight container (primary container), which should be enclosed in a second, unbreakable, leakproof container that will withstand chem attack from the carcinogen (secondary container). The space between primary & secondary container should be filled with absorbent material, which would withstand chem attack from the carcinogen & is sufficient to absorb the entire contents of the primary container in the event of breakage or leakage. Each secondary container should then be enclosed in a strong outer box. The space between the secondary container & the outer box should be filled with an appropriate quantity of shock-absorbent material. Sender should use fastest & most secure form of transport & notify recipient of its departure. If parcel is not received when expected, carrier should be informed so that immediate effort can be made to find it. Traffic schedules should be consulted to avoid ... arrival on weekend or holiday ... /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

No person may /transport,/ offer or accept a hazardous material for transportation in commerce unless that person is registered in conformance ... and the hazardous material is properly classed, described, packaged, marked, labeled, and in condition for shipment as required or authorized by ... /the hazardous

materials regulations (49 CFR 171-177)./
[49 CFR 171.2 (7/1/2000)]**PEER REVIEWED**

The International Air Transport Association (IATA) Dangerous Goods Regulations are published by the IATA Dangerous Goods Board pursuant to IATA Resolutions 618 and 619 and constitute a manual of industry carrier regulations to be followed by all IATA Member airlines when transporting hazardous materials.
[IATA. Dangerous Goods Regulations. 41st Ed.Montreal, Canada and Geneva, Switzerland: International Air Transport Association, Dangerous Goods Regulations, 2000. 229]**PEER REVIEWED**

The International Maritime Dangerous Goods Code lays down basic principles for transporting hazardous chemicals. Detailed recommendations for individual substances and a number of recommendations for good practice are included in the classes dealing with such substances. A general index of technical names has also been compiled. This index should always be consulted when attempting to locate the appropriate procedures to be used when shipping any substance or article.
[IMDG; International Maritime Dangerous Goods Code; International Maritime Organization p.6273 (1998)]**PEER REVIEWED**

Storage Conditions:

STORE IN COOL, DRY, WELL-VENTILATED LOCATION. SEPARATE FROM ACTIVE METALS. ISOLATE FROM OPEN FLAMES AND COMBUSTIBLES.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-130]**PEER REVIEWED**

Store **trichloroethylene** in cans or in dark glass bottles to minimize decomposition.
[Noweir M et al; Am Ind Hyg Assoc 33: 454-60 (1973) as cited in USEPA; Health Assessment Document: Trichloroethylene (Draft) p.3-2 (1983) EPA-600/ 8-82-006B]**PEER REVIEWED**

All containers for **trichloroethylene** should bear a label giving the following or similar information: **TRICHLOROETHYLENE**-WARNING Vapor harmful. Use only with adequate ventilation. /safe handling & storage of chemicals/
[International Labour Office. Encyclopaedia of Occupational Health and Safety. 4th edition, Volumes 1-4 1998. Geneva, Switzerland: International Labour Office, 1998.,p. 61.10]**PEER REVIEWED**

... May be stored satisfactorily in galvanized iron, black iron, or steel containers.
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 2155]**PEER REVIEWED**

Preserve **trichloroethylene** in sealed, light-resistant ampules or in frangible, light-resistant glass tubes.
[Budavari, S. (ed.). The Merck Index - Encyclopedia of Chemicals, Drugs and Biologicals. Rahway, NJ: Merck and Co., Inc., 1989. 1516]**PEER REVIEWED**

Storage temp: ambient
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Storage areas should be cool, well-ventilated, flame-proof, and shielded from direct sunlight, high-temperature surfaces, or sparks.
[WHO; Environ Health Criteria 50: Trichloroethylene p.32 (1985)]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Storage site should be as close as practical to lab in which carcinogens are to be used, so that only small quantities required for ... expt need to be carried.

Carcinogens should be kept in only one section of cupboard, an explosion-proof refrigerator or freezer (depending on chemicophysical properties ...) that bears appropriate label. An inventory ... should be kept, showing quantity of carcinogen & date it was acquired ... Facilities for dispensing ... should be contiguous to storage area. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.13]**PEER REVIEWED**

Cleanup Methods:

Contain and isolate spill by using clay/bentonite dams, interceptor trenches, or impoundments. /SRP: If time permits, pits, ponds, lagoons, soak holes, or holding areas should be sealed with an impermeable flexible membrane liner./ Construct swale to divert uncontaminated portion of watershed around contaminated portion. ... Density stratification and impoundment -- remove product from bottom layer by pumping through manifold or polyethylene rope mop collection or remove clarified upper portion by skimmers or siphon. Treatment is required for both clarified and concentrated fractions. Treatment alternatives include powdered activated carbon, granular activated carbon, and biodegradation. /Other/ treatment alternatives for contaminated soils include well point collection and treatment of leachates as for contaminated waters, bentonite/cement injection to immobilize spill.
[Kayser, R., D. Sterling, D. Viviani (eds.). Intermedia Priority Pollutant Guidance Documents. Washington, DC: U.S.Environmental Protection Agency, July 1982.,p. 8-1]**PEER REVIEWED**

Waste water treatment: evaporation from water at 25 deg C of 1 ppm solution: 50% after 19-24 min, 90% after 63-80 min
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1134]**PEER REVIEWED**

Environmental considerations: Land spill: Dig a pit, pond, lagoon, holding area to contain liquid or solid material. /SRP: If time permits, pits, ponds, lagoons, soak holes, or holding areas should be sealed with an impermeable flexible membrane liner./ Dike surface flow using soil, sand bags, foamed polyurethane, or foamed concrete. Absorb bulk liquid with fly ash or cement powder.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 1074]**PEER REVIEWED**

Environmental consideration: Water spill: If dissolved, in region of 10 ppm or greater concentations, apply activated carbon at ten times the spilled amount. Remove trapped material with suction hoses. Use mechanical dredges or lifts to remove immobilized masses of pollutants and precipitates.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 1074]**PEER REVIEWED**

Environmental considerations: Air spill: Apply water spray or mist to knock down vapors. Combustion products include corrosive or toxic vapors.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 1074]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": A high-efficiency particulate arrestor (HEPA) or charcoal filters can be used to minimize amt of carcinogen in exhausted air ventilated safety cabinets, lab hoods, glove boxes or animal rooms ... Filter housing that is designed so that used filters can be transferred into plastic bag without contaminating maintenance staff is avail commercially. Filters should be placed in plastic bags immediately after removal ... The plastic bag should be sealed immediately ... The sealed

bag should be labelled properly ... Waste liquids ... should be placed or collected in proper containers for disposal. The lid should be secured & the bottles properly labelled. Once filled, bottles should be placed in plastic bag, so that outer surface ... is not contaminated ... The plastic bag should also be sealed & labelled. ... Broken glassware ... should be decontaminated by solvent extraction, by chemical destruction, or in specially designed incinerators. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

Disposal Methods:

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste numbers U228, D040, and F002 must conform with USEPA regulations in storage, transportation, treatment and disposal of waste.
[40 CFR 240-280, 300-306, 702-799 (7/1/2000)]**PEER REVIEWED**

Incineration, preferably after mixing with another combustible fuel. Care must be exercised to assure complete combustion to prevent the formation of phosgene. An acid scrubber is necessary to remove the halo acids produced. An alternative to disposal for **trichloroethylene** is recovery and recycling.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 885]**PEER REVIEWED**

Group I Containers: Combustible containers from organic or metallo-organic pesticides (except organic mercury, lead, cadmium, or arsenic compounds) should be disposed of in pesticide incinerators or in specified landfill sites. /Organic or metallo-organic pesticides/
[40 CFR 165 (7/1/87)]**PEER REVIEWED**

This compound should be susceptible to removal from wastewater by air stripping.
[USEPA/ORD; Innovative and Alternative Technology Assessment Manual pp. 3-5, 3-11-3-12 (1980)]**PEER REVIEWED**

Chemical Treatability of **Trichloroethylene**; Concentration Process: Activated Carbon; Chemical Classification: Halogens; Scale of Study: Pilot Scale/Continuous Flow; Type of Wastewater Used: Hazardous Material Spill; Influent Concentration: 21 ppb; Results of Study: 98.6% removal with 0.3 ppb detected in effluent after 8.5 min contact time (250,000 gal spilled materials treated with EPA mobile treatment trailer).
[Becker DL, Wilson SC; Carbon Adsorption Handbook (1978) p.167-213 as cited in USEPA; Management of Hazardous Waste Leachate, EPA Contract No. 68-03-2766 p.E-161 (1982)]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for **trichloroethylene**: Concentration process: Biological treatment.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-51 (1982)]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for **trichloroethylene**: Concentration process: Chemical precipitation.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-67 (1982)]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for **trichloroethylene**: Concentration process: Stripping.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-106 (1982)]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for **trichloroethylene**:
Concentration process: Solvent extraction.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-118 (1982)]**PEER REVIEWED**

The following wastewater treatment technology has been investigated for **trichloroethylene**:
Concentration process: Activated carbon.
[USEPA; Management of Hazardous Waste Leachate, EPA Contract No.68-03-2766 p.E-161 (1982)]**PEER REVIEWED**

Trichloroethylene is a waste chemical stream constituent which may be subjected to ultimate disposal by controlled incineration. Incineration, preferably after mixing with another combustible fuel; care must be exercised to assure complete combustion to prevent the formation of phosgene. An acid scrubber is necessary to remove the halo acids produced.
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.2-10 (1981) EPA 68-03-3025]**PEER REVIEWED**

A potential candidate for rotary kiln incineration at a temperature range of 820 to 1,600 deg C and residence times of seconds for liquids and gases, and hours for solids. A potential candidate for fluidized bed incineration at a temperature range of 450 to 980 deg C and residence times of seconds for liquids and gases, and longer for solids. A potential candidate for liquid injection incineration at a temperature range of 650 to 1,600 deg C and a residence time of 0.1 to 2 seconds.
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-16 (1981) EPA 68-03-3025]**PEER REVIEWED**

Recovering: Incineration, preferably after mixing with another combustible fuel. Care must be exercised to assure complete combustion to prevent the formation of phosgene. An acid scrubber is necessary to remove the halo acids produced. An alternative to disposal for **TCE** /**trichloroethylene**/ is recovery and recycling. Recommendable method: Incineration. Not recommendable method: Discharge to sewer.
[United Nations. Treatment and Disposal Methods for Waste Chemicals (IRPTC File). Data Profile Series No. 5. Geneva, Switzerland: United Nations Environmental Programme, Dec. 1985. 181]**PEER REVIEWED**

Incineration & evaporation: Small quantities may be poured onto a 10% soda ash and sand mixture, then placed in a paper container and incinerated. Wastes from cleaning operations should be stored in a well ventilated area until they can be incinerated or chemically treated to reduce the toxicity. Residues may be poured on sand, soil or ashes, at a safe distance from occupied areas and allowed to evaporate in the atmosphere.
[United Nations. Treatment and Disposal Methods for Waste Chemicals (IRPTC File). Data Profile Series No. 5. Geneva, Switzerland: United Nations Environmental Programme, Dec. 1985. 181]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": There is no universal method of disposal that has been proved satisfactory for all carcinogenic compounds & specific methods of chem destruction ... published have not been tested on all kinds of carcinogen-containing waste. ... summary of avail methods & recommendations ... /given/ must be treated as guide only. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.14]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Incineration may be only feasible method for disposal of contaminated laboratory waste from biological expt. However, not all incinerators are suitable for this purpose. The most efficient type ... is probably the gas-fired type, in which a first-stage combustion with a less than stoichiometric air:fuel ratio is followed by a second stage with excess air. Some ... are

designed to accept ... aqueous & organic-solvent solutions, otherwise it is necessary ... to absorb soln onto suitable combustible material, such as sawdust. Alternatively, chem destruction may be used, esp when small quantities ... are to be destroyed in laboratory. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": HEPA (high-efficiency particulate arrestor) filters ... can be disposed of by incineration. For spent charcoal filters, the adsorbed material can be stripped off at high temp & carcinogenic wastes generated by this treatment conducted to & burned in an incinerator. ... LIQUID WASTE: ... Disposal should be carried out by incineration at temp that ... ensure complete combustion. SOLID WASTE: Carcasses of lab animals, cage litter & misc solid wastes ... should be disposed of by incineration at temp high enough to ensure destruction of chem carcinogens or their metabolites. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.15]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": ... Small quantities of ... some carcinogens can be destroyed using chem reactions ... but no general rules can be given. ... As a general technique ... treatment with sodium dichromate in strong sulfuric acid can be used. The time necessary for destruction ... is seldom known ... but 1-2 days is generally considered sufficient when freshly prepd reagent is used. ... Carcinogens that are easily oxidizable can be destroyed with milder oxidative agents, such as saturated soln of potassium permanganate in acetone, which appears to be a suitable agent for destruction of hydrazines or of compounds containing isolated carbon-carbon double bonds. Concn or 50% aqueous sodium hypochlorite can also be used as an oxidizing agent. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.16]**PEER REVIEWED**

PRECAUTIONS FOR "CARCINOGENS": Carcinogens that are alkylating, arylating or acylating agents per se can be destroyed by reaction with appropriate nucleophiles, such as water, hydroxyl ions, ammonia, thiols & thiosulfate. The reactivity of various alkylating agents varies greatly ... & is also influenced by sol of agent in the reaction medium. To facilitate the complete reaction, it is suggested that the agents be dissolved in ethanol or similar solvents. ... No method should be applied ... until it has been thoroughly tested for its effectiveness & safety on material to be inactivated. For example, in case of destruction of alkylating agents, it is possible to detect residual compounds by reaction with 4(4-nitrobenzyl)-pyridine. /Chemical Carcinogens/
[Montesano, R., H. Bartsch, E.Boyland, G. Della Porta, L. Fishbein, R. A. Griesemer, A.B. Swan, L. Tomatis, and W. Davis (eds.). Handling Chemical Carcinogens in the Laboratory: Problems of Safety. IARC Scientific Publications No. 33. Lyon, France: International Agency for Research on Cancer, 1979.17]**PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

Permissible Exposure Limit: Table Z-2 8-hr Time Weighted Avg: 100 ppm.
[29 CFR 1910.1000 (7/1/2000)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-2 Acceptable Ceiling Concentration: 200 ppm.

[29 CFR 1910.1000 (7/1/2000)]**PEER REVIEWED**

Permissible Exposure Limit: Table Z-2 Acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift. Concentration: 300 ppm. Maximum Duration: 5 minutes in any 2 hours.
[29 CFR 1910.1000 (7/1/2000)]**PEER REVIEWED**

Vacated 1989 OSHA PEL TWA 50 ppm (270 mg/cu m); STEL 200 ppm (1080 mg/cu m) is still enforced in some states.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 372]**PEER REVIEWED**

Threshold Limit Values:

8 hr Time Weighted Avg (TWA) 50 ppm; Short Term Exposure Limit (STEL) 100 ppm
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 68]**PEER REVIEWED**

BEI (Biological Exposure Index) for **Trichloroethylene**: Trichloroacetic acid in urine at end of workweek is 100 mg/g creatinine. The determinant is nonspecific, since it is observed after exposure to other chemicals. (1986 Adoption)
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 102]**PEER REVIEWED**

BEI (Biological Exposure Index) for **Trichloroethylene**: Trichloroacetic acid and trichloroethanol in urine at end of shift at end of workweek is 300 mg/g creatinine. The determinant is nonspecific, since it is observed after exposure to other chemicals. (1986 adoption)
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 102]**PEER REVIEWED**

BEI (Biological Exposure Index) for **Trichloroethylene**: **Trichloroethylene** in end-exhaled air. The biological determinant is an indicator of exposure to the chemical, but the quantitative interpretation of the measurement is ambiguous. These determinants should be used as a screening test if a quantitative test is not practical or as a confirmatory test if the quantitative test is not specific and the origin of the determinant is in question.
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 102]**PEER REVIEWED**

A5: Not suspected as a human carcinogen.
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 68]**PEER REVIEWED**

BEI (Biological Exposure Index) for **Trichloroethylene**: Free trichloroethanol in blood at end of shift at end of workweek is 4 mg/l. The determinant is nonspecific, since it is observed after exposure to other chemicals. (1986 adoption)
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 102]**PEER REVIEWED**

BEI (Biological Exposure Index) for **Trichloroethylene**: **Trichloroethylene** in blood. The biological determinant is an indicator of exposure to the chemical, but the quantitative interpretation of the

measurement is ambiguous. These determinants should be used as a screening test if a quantitative test is not practical or as a confirmatory test if the quantitative test is not specific and the origin of the determinant is in question. (1993 adoption) /No value specified in text/
[American Conference of Governmental Industrial Hygienists. TLVs and BEIs. Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. Cincinnati, OH. 2000. 102]**PEER REVIEWED**

NIOSH Recommendations:

NIOSH considers **trichloroethylene** to be a potential occupational carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 316]**PEER REVIEWED**

NIOSH usually recommends that occupational exposures to carcinogens be limited to the lowest feasible concentration.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 316]**PEER REVIEWED**

Recommended Exposure Limit: 60 Min Ceiling Value: 2 ppm. /During the usage of **trichloroethylene** as an anesthetic agent/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 316]**PEER REVIEWED**

Recommended Exposure Limit: 10 Hr Time-Weighted Avg: 25 ppm. /During exposures to **trichloroethylene** other than as an anesthetic agent/
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 316]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

NIOSH considers **trichloroethylene** to be a potential occupational carcinogen.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 316]**PEER REVIEWED**

Other Occupational Permissible Levels:

Occupational exposure limits used in various countries are as follows: (time-weighted values) Australia: 535 mg/cu m; Austria: 260 mg/cu m; Belgium: 535 mg/cu m; Bulgaria: 10 mg/cu m; Czechoslovakia: 250 mg/cu m, ceiling value 1250 mg/cu m; Egypt: 267; Finland: 260 mg/cu m; France: 405 mg/cu m, ceiling value 1080 mg/cu m; German Democratic Republic: 250 mg/cu m, ceiling limit: 750 mg/cu m; Germany, Federal Republic: 260 mg/cu m; Hungary: 50 mg/cu m; Italy: 400 mg/cu m, skin irritation 1000 mg/cu m; Japan: 268 mg/cu m; Netherlands: 190 mg/cu m; Poland: 50 mg/cu m (ceiling value); Romania: 200 mg/cu m, 300 mg/cu m (ceiling value); Spain: 535 mg/cu m; Sweden: 110 mg/cu m, short-term exposure limit 250 mg/cu m; Switzerland: 260 mg/cu m; United Kingdom: 535 mg/cu m; USSR: 10 mg/cu m (ceiling value); Yugoslavia: 200 mg/cu m.
[WHO; Environ Health Criteria 50: Trichloroethylene p.34 (1985)]**PEER REVIEWED**

Emergency Response Planning Guidelines (ERPG): ERPG(1) 100 ppm (no more than mild, transient effects) for up to 1 hr exposure; ERPG(2) 500 ppm (without serious, adverse effects) for up to 1 hr exposure; ERPG(3) 5000 ppm (not life threatening) up to 1 hr exposure.
[American Industrial Hygiene Association. The AIHA 2000 Emergency Response Planning Guidelines and Workplace Environmental Exposure Level Guides Handbook. AIHA Press, Fairfax, VA. 2000. 26]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

For **Trichloroethylene** (USEPA/OPP Pesticide Code: 081202) there are 0 labels match. /SRP: Not registered for current use in the U.S., but approved pesticide uses may change periodically and so federal, state and local authorities must be consulted for currently approved uses./
[U.S. Environmental Protection Agency/Office of Pesticide Program's Chemical Ingredients Database on Trichloroethylene (79-01-6). Available from the Database Query page at http://www.cdpr.ca.gov/docs/epa/epamenu.htm as of october 24, 2002.]**QC REVIEWED**

Therap cat: anesthetic (inhalation)/former use/; Therap cat (vet): anesthetic (inhalation)
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

IN GAS PURIFICATION, AS A SOLVENT OF SULFUR & PHOSPHORUS
[Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965. 190]**PEER REVIEWED**

Aerospace operations (flushing liquid oxygen)
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1125]**PEER REVIEWED**

AGENT IN REMOVAL OF BASTING THREADS IN TEXTILE PROCESSING
[SRI]**PEER REVIEWED**

CHEM INT FOR 1,1,2,2-TETRACHLOROETHYL SULFENYL CHLORIDE
[SRI]**PEER REVIEWED**

SOLVENT BASE FOR METAL PHOSPHATIZING SYSTEMS
[SRI]**PEER REVIEWED**

SOLVENT IN CHARACTERIZATION TEST FOR ASPHALT
[SRI]**PEER REVIEWED**

ENTRAINER FOR RECOVERY OF FORMIC ACID
[SRI]**PEER REVIEWED**

Used as household cleaner; with trichloroethane it is used in most typewriter correction fluid. /SRP: Former use/
[Arena, J.M. and Drew, R.H. (eds.) Poisoning-Toxicology, Symptoms, Treatments. 5th ed. Springfield, IL: Charles C. Thomas Publisher, 1986. 257]**PEER REVIEWED**

Used in wool-fabric scouring
[CONSIDINE. CHEMICAL AND PROCESS TECHNOL ENCYC 1974 p.1109]**PEER REVIEWED**

Intermediate in the production of pentachloroethane.
[WHO; Environ Health Criteria 50: Trichloroethylene p.30 (1985)]**PEER REVIEWED**

Carrier solvent for the active ingredients of insecticides, and fungicides.
[WHO; Environ Health Criteria 50: Trichloroethylene p.30 (1985)]**PEER REVIEWED**

MEDICATION
PEER REVIEWED

MEDICATION (VET)
PEER REVIEWED

Used in the preparation of insecticidal fumigants.
[Hayes, W.J., Jr., E.R. Laws, Jr., (eds.). Handbook of Pesticide Toxicology. Volume 2. Classes of Pesticides. New York, NY: Academic Press, Inc., 1991. 690]**PEER REVIEWED**

Trichloroethylene was used earlier as an extraction solvent for natural fats and oils, such as palm, coconut and soya bean oils. It was also an extraction solvent for spices, hops and the decaffeination of coffee. The United States Food and Drug Administration banned these uses of **trichloroethylene**...its use in cosmetic and drug products was also discontinued...It was used as both an anesthetic and an analgesic in obstetrics. /Former uses/
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 (95) 80]**PEER REVIEWED**

Trichloroethylene has been used, in limited quantities, to control relative molecular mass in the manufacture of polyvinyl chloride. It has also been used as a solvent in the rubber industry, some adhesive formulations and in research laboratories. In the textile industry, it is used as a carrier solvent for spotting fluids and as a solvent in dyeing and finishing. It is also used as a solvent in printing inks, paint, lacquers, varnishes, adhesives and paint strippers.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 (95) 80]**PEER REVIEWED**

The major use of **trichloroethylene** is in metal cleaning or degreasing. **Trichloroethylene** is used in degreasing operations in five main industrial groups: furniture and fixtures, fabricated metal products, electric and electronic equipment, transport equipment and miscellaneous manufacturing industries. It is also used in plastics, appliances, jewellery, automobile, plumbing fixtures, textiles, paper, glass and printing industries.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 (95) 80]**PEER REVIEWED**

Used as a chemical intermediate in the synthesis of captafol; chloroacetic acid; 1-chloro-2,2,2-trifluoroethane
[Ashford, R.D. Ashford's Dictionary of Industrial Chemicals. London, England: Wavelength Publications Ltd., 1994. 905]**PEER REVIEWED**

Stabilized grades are produced for vapor cleaning applications
[Ashford, R.D. Ashford's Dictionary of Industrial Chemicals. London, England: Wavelength Publications Ltd., 1994. 905]**PEER REVIEWED**

Use of **trichloroethylene** in fluorocarbon production and as a metal cleaning and degreasing solvent are both increasing. In vapor degreasing, **trichloroethylene** has regained some market share as a result of the phaseout of 1,1,1-trichloroethane for emissive uses. Growth prospects for **trichloroethylene** as a fluorocarbon feedstock hold more potential, however, particularly its use as a precursor for the workhorse hydrofluorocarbon product, HFC-134a.
[Chemical Marketing Reporter; Chemical Profile Trichloroethylene. Dec 8, 1997. NY, NY: Schnell Pub Co (1997)]**PEER REVIEWED**

Manufacturers:

Dow Chemical USA, Hq, 2030 Dow Center, Midland, MI 48674, (517) 636-1000; Production site: Freeport, TX 77541
[SRI International. 2000 Directory of Chemical Producers -- United States. SRI Consulting, Menlo Park: CA 2000 946]**PEER REVIEWED**

PPG Industries, Inc., Hq, One PPG Place, 36 East, Pittsburgh, PA 15272, (412) 434-3131; Chemicals Group; Production site: Lake Charles, LA 70602
[SRI International. 2000 Directory of Chemical Producers -- United States. SRI Consulting, Menlo Park: CA 2000 946]**PEER REVIEWED**

Methods of Manufacturing:

Until 1968, about 85% of United States production capacity of **trichloroethylene** was based on acetylene. The acetylene-based process consists of two steps: acetylene is first chlorinated to 1,1,2,2-tetrachloroethane, with a ferric chloride, phosphorus chloride or antimony chloride catalyst, and the product is then dehydrohalogenated to **trichloroethylene**. The current method of manufacture is from ethylene or 1,2-dichloroethane. In a process used by one plant in the United States, **trichloroethylene** is produced by noncatalytic chlorination of ethylene dichloride and other C2 hydrocarbons with a mixture of oxygen and chlorine or hydrogen chloride.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 (95) 79]**PEER REVIEWED**

Ethylene dichloride + chlorine (chlorination; coproduced with perchloroethylene)
[Ashford, R.D. Ashford's Dictionary of Industrial Chemicals. London, England: Wavelength Publications Ltd., 1994. 905]**PEER REVIEWED**

Ethylene dichloride + chlorine + oxygen (oxychlorination/dehydrochlorination; coproduced with perchloroethylene)
[Ashford, R.D. Ashford's Dictionary of Industrial Chemicals. London, England: Wavelength Publications Ltd., 1994. 905]**PEER REVIEWED**

General Manufacturing Information:

Since there are now only two producers (Dow & PPG), the USITC stopped publicly reporting production and other statistics at the end of 1982
[CHEMICAL PRODUCTS SYNOPSIS: Trichloroethylene, 1985]**PEER REVIEWED**

Depending on the condition, dissociation of HCl at elevated temperatures in the presence of carbon in a chemical plasma will produce 1,1,2-trichloroethane, 1,2-dichloroethane, **trichloroethylene**, and perchloroethylene.
[Kirk-Othmer Encyclopedia of Chemical Technology. 3rd ed., Volumes 1-26. New York, NY: John Wiley and Sons, 1978-1984.,p. V12 1008 (1980)]**PEER REVIEWED**

Cancelled for use in fumigant mixture or as a solvent with other ingredient on grains.
[Farm Chemicals Handbook 2000. Willoughby, OH: Meister Publishing Co. p. C 394 (2000)]**PEER REVIEWED**

Formulations/Preparations:

Trichloroethylene for medicinal purposes may contain thymol as a preservative. Industrial grades ... may contain stabilizers, such as triethanolamine.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

Grades: USP; technical; high purity; electronic; metal degreasing; extraction.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1125]**PEER REVIEWED**

Trichloroethylene is available in the USA in high-purity, electronic USP, technical, metal degreasing and extraction grades
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 545 (1979)]**PEER REVIEWED**

Commercial grades of **trichloroethylene**, formulated to meet use requirements, differ in the amount and type of added inhibitor. Typical grades contain >99% **trichloroethylene**; they include a neutrally inhibited vapor-degreasing grade and a technical grade for use in formulations.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 (95) 76]**PEER REVIEWED**

Stabilizers that have been used in formulations of **trichloroethylene** include neutral inhibitors and free-radical scavengers, amyl alcohol, n-propanol, isobutanol, 2-pentanol, diethylamine, triethylamine, dipropylamine, diisopropylamine, diethanolamine, triethanolamine, morpholine, N-methylmorpholine, aniline, acetone, ethyl acetate, borate esters, ethylene oxide, propylene oxide, 1,2-epoxybutane, cyclohexene oxide, butadiene dioxide, styrene oxide, pentene oxide, 2,3-epoxy-1-propenol, 3-methoxy-1,2-epoxypropane, stearates, 2,2,4-trimethyl-1-pentene, 2-methyl-1,2-epoxypropanol, epoxycyclopentanol, epichlorohydrin, tetrahydrofuran, tetrahydropyran, 1,4-dioxane, dioxalane, trioxane, alkoxyaldehyde hydrazones, methyl ethyl ketone, nitromethanes, nitropropanes, phenol, ortho-cresol, thymol, para-tert-butylphenol, para-tert-amylphenol, isoeugenol, pyrrole, N-methylpyrrole, N-ethylpyrrole, (2-pyrryl)trimethylsilane, glycidyl acetate, isocyanates and thiazoles.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 (95) 76]**PEER REVIEWED**

Impurities:

Acidity (as hydrochloric acid), 0.0005% max; alkalinity (as sodium hydroxide), 0.001% max; residue on evaporation, 0.005% max; antioxidants, such as amine (0.001-0.01% or more) or combinations of epoxides such as epichlorohydrin & esters (0.2-2% total)
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 547 (1979)]**PEER REVIEWED**

Apart from added stabilizers, commercial grades of **trichloroethylene** should not contain more than the following amounts of impurities: water, 100 ppm; acidity (as HCl), 5 ppm; insoluble residue, 10 ppm. Free chlorine should not be detectable.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 (95) 76]**PEER REVIEWED**

Impurities that have been found in commercial **trichloroethylene** products include: carbon tetrachloride, chloroform, 1,2-dichloroethane, trans-1,2-dichloroethylene, cis-1,2-dichloroethylene, pentachloroethane, 1,1,1,2-tetrachloroethane, 1,1,2,2-tetrachloroethane, 1,1,1-trichloroethane, 1,1,2-trichloroethane, 1,1-dichloroethylene, tetrachloroethylene, bromodichloromethane, bromodichloroethylene, and benzene.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 (95) 76]**PEER REVIEWED**

Consumption Patterns:

Demand: (1982): 240 million pounds; (1983): Est 235 million pounds; 1987: Est 215 million pounds.
[Kavaler. Chem Market Reporter (1983)]**PEER REVIEWED**

Vapor degreasing of fabricated metal parts, 80%; chemical intermediate, 5%; miscellaneous used, 5%; exports, 10% (1985)
[CHEMICAL PROFILE: Trichloroethylene, 1986]**PEER REVIEWED**

Vapor degreasing of fabricated metal parts, 66%; chemical intermediates, miscellaneous domestic uses, 5%; exports, 22%.
[Kavaler. Chem Market Reporter (1983)]**PEER REVIEWED**

Vapor degreasing of fabricated metal parts, 65%; chemical intermediates and miscellaneous uses, 35%.
[Chemical Marketing Reporter; Chemical Profile Trichloroethylene. Dec 8, 1997. NY, NY: Schnell Pub Co (1997)]**PEER REVIEWED**

Demand: 1996: 180 million pounds; 1997: 190 million pounds; 2001: 230 million pounds (includes exports)
[Chemical Marketing Reporter; Chemical Profile Trichloroethylene. Dec 8, 1997. NY, NY: Schnell Pub Co (1997)]**PEER REVIEWED**

U. S. Production:

USA production: (1981): 258,182 pounds.
[United States International Trade Commission. Synthetic Organic Chemicals-- United States Production and Sales, 1981. USITC Publications 1291 Washington, DC: United States International Trade Commission, 1981.1132]**PEER REVIEWED**

Production quantities (1976): 610X10+6 pounds.
[Fishbein L; Potential Indust Carcins and Mutagens p.35 (1977) USEPA 560/ 5-77-005]**PEER REVIEWED**

(1985) 7.72X10+10 g /Estimated/
[CHEMICAL PRODUCTS SYNOPSIS: Trichloroethylene, 1985]**PEER REVIEWED**

(1991) 320 million lb
[SRI. 1992 Directory of Chemical Producers-United States of America. Menlo Park, CA: SRI International, 1992. 1032]**PEER REVIEWED**

U. S. Imports:

(1985) 1.98X10+10 g
[BUREAU OF THE CENSUS. U.S. IMPORTS FOR CONSUMPTION AND GENERAL IMPORTS 1985 p.1-584]**PEER REVIEWED**

Imports last year totaled approximately 10 million pounds, averaging 12 million pounds during the period.
[Chemical Marketing Reporter; Chemical Profile Trichloroethylene. Dec 8, 1997. NY, NY: Schnell Pub Co (1997)]**PEER REVIEWED**

U. S. Exports:

(1985) 1.06X10+10 g
[BUREAU OF THE CENSUS. U.S. EXPORTS, SCHEDULE E, 1985 p.2-69]**PEER REVIEWED**

Exports were 65 million pounds during 1996, but averaged 83 million pounds per year in the 1992-1996 period.
[Chemical Marketing Reporter; Chemical Profile Trichloroethylene. Dec 8, 1997. NY, NY: Schnell Pub Co (1997)]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

GAS CHROMATOGRAPHY USED TO DETERMINE HUMAN SERUM AND ADIPOSE TISSUE LEVELS OF VOLATILE PURGEABLE HALOGENATED HYDROCARBONS.
[PEOPLES AJ ET AL; PREPR PAP NATL MEET--AM CHEM SOC DIV ENVIRON CHEM 18 (2): 485-6 (1978)]**PEER REVIEWED**

Practical recommendation for the biologic monitoring of exposure to **trichloroethylene** is as following: Biological parameter: trichloroethanol. Biological material: Urine. /SRP: Permissable/ value: 150 mg/g creatinine /From table/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 1000]**PEER REVIEWED**

Practical recommendation for the biologic monitoring of exposure to **trichloroethylene** is as following: Biological parameter: trichloroacetic acid. Biological material: plasma. Permissable value: 5 mg/100 ml /After 5-day exposure, from table/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 1000]**PEER REVIEWED**

Practical recommendation for the biologic monitoring of exposure to **trichloroethylene** is as following: Biological parameter: trichloroethanol. Biological material: plasma. Permissable value: 0.25 mg/100 ml /After 5-day exposure, from table/
[Klaassen, C.D., M.O. Amdur, Doull J. (eds.). Casarett and Doull's Toxicology. The Basic Science of Poisons. 5th ed. New York, NY: McGraw-Hill, 1995. 1000]**PEER REVIEWED**

Matrix: breath; conventional reference range: < 1 ppm; international recommended reference range: <8 umolar
[Tietz, N.W. (ed.). Clinical Guide to Laboratory Tests. Philadelphia, PA: W.B. Saunders Co., 1983. 112]**PEER REVIEWED**

A method is presented which is suitable for the analysis of certain halocarbons in blood and tissue samples. Among these halocarbons is ... **trichloroethylene**. ... Blood samples are warmed and an inert gas is passed through the sample to extract the volatile halocarbons. Treated samples are macerated in water, then treated the same as for blood samples. A Tenax gas chromatography cartridge is used to trap the vapors which are then recovered by thermal desorption and analyzed on gas chromatography/mass spectrometry. The limits of detection of this method are approximately 3 ng/ml for a 10 ml blood sample and 6 ng/g for 5 g tissue samples.
[Pellizzari ED et al; Environmental Carcinogens Selected Methods of Analysis 7: 435-44 (1985)]**PEER REVIEWED**

Analytic Laboratory Methods:

RECOVERIES WERE FROM FORTIFIED WHEAT SAMPLES, USING GAS LIQUID CHROMATOGRAPHIC COLUMN & ELECTRON CAPTURE DETECTOR.
[CLOWER M JR; J ASSOC OFF ANAL CHEM 63 (3): 539 (1980)]**PEER REVIEWED**

Trichloroethylene in grain is analyzed by gas chromatography with source-heated electron capture detector and glass-lined injection block. Construct calibration curve daily of peak heights against ng fumigant/125 ml acetone for suitable range.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed.

and Supplements. Washington, DC: Association of Analytical Chemists, 1990,p. VI 290-1]**PEER REVIEWED**

Trichloroethylene in spice oleoresins is analyzed by gas chromatographic method.
[Association of Official Analytical Chemists. Official Methods of Analysis. 15th ed. and Supplements. Washington, DC: Association of Analytical Chemists, 1990,p. VII 1175]**PEER REVIEWED**

Fujiwara Test: **Trichloroethylene** is treated with pyridine in an alkaline environment. Solution absorbance is then determined at 535 or 470 nm (absorptivity: 18-32 l/g/cm with a sensitivity of about 1 mg/kg.
[WHO; Environ Health Criteria 50: Trichloroethylene p.22 (1985)]**PEER REVIEWED**

Infra-red spectroscopy: In the gaseous phase, quantities are determined by measuring the optical density at the selected wavelength of 11.8 um. ... This corresponds to a detection sensitivity of not less than 0.5 ug/l.
[Fishbein L; Chromatography of Environmental Hazards Vol 2, pp.471-90 (1973) as cited in WHO; Environ Health Criteria 50: Trichloroethylene p.22 (1985)]**PEER REVIEWED**

High-resolution gas chromatography with electron capture detector/mass spectrophotometry...for determination of **trichloroethylene** in soil /has been utilized/ as a confirmatory technique with a detection threshold of approximately 10 mg/kg (10 ppm).
[DeLeon IR et al; J Chromatogr Sci 18: 85-8 (1980) as cited in WHO; Environ Health Criteria 50: Trichloroethylene p.26 (1985)]**PEER REVIEWED**

EPA Method 8010. Direct Injection or Purge and Trap Gas Chromatography with halogen-specific detector for the analysis of halogenated volatile organics including **trichloroethylene** in solid waste. Under the prescribed conditions for **trichloroethylene**, the method has a detection limit of 0.12 ug/l. Precision and method accuracy were found to be directly related to the concentration of the parameter and essentially independent of the sample matrix.
[USEPA; Test Methods for Evaluating Solid Waste SW-846 (1986)]**PEER REVIEWED**

EPA Method 502.1. Volatile Halogenated Organic Compounds in Water by Purge and Trap Gas Chromatography. Revision 2.0. Analysis by GC with electrolytic conductivity detection. Detection limit= 0.001 ug/l in drinking water.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 502.2. Volatile Organic Compounds in Water by Purge and Trap Capillary Column Gas Chromatography with Photoionization and Electrolytic Conductivity Detectors in Series. Revision 2.0. Detection limit= 0.01 ug/l in drinking water.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 503.1. Volatile Aromatic and Unsaturated Organic Compounds in Water by Purge and Trap Gas Chromatography" Revision 2.0 Analysis by gas chromatography with photoionization detection. Detection limit= 0.01 ug/l in drinking water.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 524.1. Measurement of Purgeable Organic Compounds in Water by Packed Column Gas Chromatography and Mass Spectrometry. Revision 3.0. Detection limit= 0.4 ug/l in drinking water.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 524.2. Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry. Revision 4.0. Detection limit= 0.19 ug/l in drinking water.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 551. Determination of Chlorination Disinfection Byproducts and Chlorinated Solvents in Drinking Water by Liquid-Liquid Extraction and Gas Chromatography with Electron-Capture Detection. Detection limit= 0.002 ug/l in drinking water.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 601. Purgeable Halocarbons in Wastewater by Gas Chromatography with Electrolytic Conductivity Detection. Detection limit= 0.120 ug/l in drinking water.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 624. Protocol for the Analysis of Purgeable Organic Priority Pollutants in Industrial and Municipal Wastewater. Detection limit= 1.9 ug/l in wastewater.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 8240. Determination of Volatile Organics Compounds by Gas Chromatography/Mass Spectrometry (GC/MS). Estimated quantitation limit= 5 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 8021. Analysis of Halogenated and Aromatic Volatiles By Gas Chromatography using Electrolytic Conductivity and Photoionization Detectors in Series: Capillary Column Technique. Detection limit= 0.01-0.02 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 8260B. Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS): Capillary Column Technique.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EPA Method 1624. Volatile Organic Compounds by Isotope Dilution GCMS. Detection limit= 2 ug/kg in soil.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

NIOSH Method: 3701. Analtye: **Trichloroethylene**. Matrix: Air. Procedure: Gas chromatography (portable), photoionization detector. For **trichloroethylene** this method has an estimated detection limit of 0.25 ng/injection/sample. The precision/RSD is 0.078 and the recovery is not given. Applicability: The working range is 10 to 1000 ppm (54 to 5100 mg/cu m) in relatively non-complex atmospheres where **trichloroethylene** is known to be present. Interferences: None found.
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

NIOSH Method: 1022. Analyte: **Trichloroethylene**. Matrix: Air. Procedure: Gas chromatography, flame ionization detector. For **trichloroethylene** this method has an estimated detection limit of 0.01 mg/sample. The precision/RSD is 0.038 @ 1.6 to 6.4 mg/sample and the recovery is not given. Applicability: The working range is 27 to 875 ppm (150 to 4700 mg/cu m for a 3.4 liter air sample.

Interferences: None studied.
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

Gas chromatograph/mass spectrometric analysis of volatiles including **trichloroethylene**. The Contract Required Quantitation Limits are 5.0 ug/kg in solids at low level, 500 ug/kg in solids at medium level, and 5 ug/l in water as used in EPA Contract Laboratory Program.
[USEPA/OST; List of Lists: A Catalog of Analytes and Methods p.510 (1991) OST Pub 21W-4005]**PEER REVIEWED**

EPA Method 0-3115. Purge and trap gas chromatography/mass spectrometric method for the determination of organic substances including **trichloroethylene** in water and fluvial sediments. The estimated detection limit is 3 ug/l as used in US Geological Survey Techniques of Water Resources.
[USEPA/OST; List of Lists: A Catalog of Analytes and Methods p.510 (1991) OST Pub 21W-4005]**PEER REVIEWED**

Sampling Procedures:

Water samples were collected in 125 ml serum vial that had been cleaned by detergent wash, distilled water rinse, dichromic acid wash, and oven-drying at 150 deg C. Vials were completely filled and stored at 4 deg C. Minimum loss occurred during storage at 4 deg C up to 28 days.
[Dietz EA, Singley KF; Anal Chem 51: 1809-14 (1979) as cited in USEPA; Health Assessment Document: Trichloroethylene p.3-13 (1984) EPA-600/8-82-006B]**PEER REVIEWED**

Sampling ... /is conducted by utilizing/ activated carbon felt badges.
[Hirayama T, Ikeda M; Am Ind Hyg Assoc J 40: 1091-6 (1979) as cited in WHO; Environ Health Criteria 50: Trichloroethylene p.26 (1985)]**PEER REVIEWED**

Sampling ... /is conducted by utilizing/ activated carbon tubes.
[Shipman AJ, Whim BP; Ann Occupat Hyg 23: 197-204 (1980) as cited in WHO; Environ Health Criteria 50: Trichloroethylene p.26 (1985)]**PEER REVIEWED**

EPA Method 8010. For the analysis of solid waste, a representative sample (solid or liquid) is collected in a standard 40-ml glass screw-cap VOA vial equipped with a Teflon-faced silicone septum. Sample agitation, as well as contamination of the sample with air, must be avoided. Two vials are filled per sample location, then placed in separate plastic bags for shipment and storage.
[USEPA; Test Methods for Evaluating Solid Waste SW-846 (1986)]**PEER REVIEWED**

NIOSH Method: 3701. Analyte: **Trichloroethylene**. Matrix: Air. Sampler: Air bag (Tedlar). Flow Rate: 0.02 to 0.05 l/min or higher; fill bag to equal to or greater than 80% of capacity; spot samples possible. Sample Stability: Bags should be analyzed as soon after collection as possible (equal to or greater than 4 hrs).
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

NIOSH Method: 1022. Analyte: **Trichloroethylene**. Matrix: Air. Sampler: Solid sorbent tube (coconut shell charcoal 100 mg/50 mg). Flow Rate: 0.01 to 0.2 l/min. Sample Size: 3.4 liters. Shipment: Routine. Sample Stability: Not determined.
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

Special References:

Special Reports:

Health and Safety Executive Monograph: **Trichloroethylene** #6 (1982).

USEPA; Ambient Water Quality Criteria Document: **Trichloroethylene** (1980) EPA-440/5/80-007.

NTP; Division of Toxicology Research and Testing; Management Status Report; 07/22/92; p.27. NTP TR No 002; Route: oral, gavage; Species: rats and mice. NTIS No PB264122/AS.

WHO; Environ Health Criteria 50: **Trichloroethylene** (1985).

Municipal Environmental Research Laboratory; USEPA, Survey of Two Municipal Wastewater Treatment Plants for Toxic Substances, March (1977)

DHHS/ATSDR; Toxicological Profile for **Trichloroethylene** (Update) TP-92/19 (1993)

NTP TR No 243; Route: gavage; Species: rats and mice. NTIS No PB91111815/AS.
[NTP; Division of Toxicology Research and Testing; Management Status Report; 07/07/93; p.272]

Bruening T; Bolt HM; Critical Reviews in Toxicology 30 (3): 253-285 (2000). Renal toxicity and carcinogenicity of **trichloroethylene**: Key results, mechanisms, and controversies.

Lash LH; Parker JC; Scott CS; Environ Health Perspect 108 (2): 225-240 (2000). Modes of action of **trichloroethylene** for kidney tumorigenesis.

Moore MM; Harrington-Brock K; Environmental Health Perspectives 108 (2): 215-223 (2000). Mutagenicity of **trichloroethylene** and its metabolites: implications for the risk assessment of **trichloroethylene**.

Wartenberg D; Reyner D; Scott C; Environmental Health Perspectives 108 (2): 161-176 (2000). **Trichloroethylene** is an organic chemical that has been used in dry cleaning, for metal degreasing, and as a solvent for oils and resins. It has been shown to cause liver and kidney cancer in experimental animals. This article reviews over 80 published papers and letters on the cancer epidemiology of people exposed to **trichloroethylene**.

U.S. Department of Health & Human Services/National Toxicology Program; Tenth Report on Carcinogens. National Institutes of Environmental Health Sciences. The Report on Carcinogens is an informational scientific and public health document that identifies and discusses substances (including agents, mixtures, or exposure circumstances) that may pose a carcinogenic hazard to human health. **Trichloroethylene** (79-01-6) was first listed in the Ninth Report on Carcinogens (2000) as reasonably anticipated to be a human carcinogen.

Synonyms and Identifiers:

Synonyms:

ACETYLENE TRICHLORIDE
PEER REVIEWED

AI3-00052
PEER REVIEWED

ALGYLEN
PEER REVIEWED

ANAMENTH
PEER REVIEWED

BENZINOL
PEER REVIEWED

Caswell No 876
PEER REVIEWED

CECOLENE
PEER REVIEWED

CHLORILEN
PEER REVIEWED

1-CHLORO-2,2-DICHLOROETHYLENE
PEER REVIEWED

Chlorylea, Chorylen, CirCosolv, Crawhaspol, Dow-Tri, Dukeron, Per-A-Clor, Triad, Trial, TRI-Plus M, Vitran
PEER REVIEWED

DENSINFLUAT
PEER REVIEWED

1,1-Dichloro-2-chloroethylene
PEER REVIEWED

Pesticide Code: 081202
QC REVIEWED

EPA Pesticide Chemical Code 081202
PEER REVIEWED

ETHENE, TRICHLORO-
PEER REVIEWED

ETHINYL TRICHLORIDE
PEER REVIEWED

ETHYLENE TRICHLORIDE
PEER REVIEWED

ETHYLENE, TRICHLORO-
PEER REVIEWED

FLECK-FLIP
PEER REVIEWED

FLOCK FLIP
PEER REVIEWED

FLUATE
PEER REVIEWED

GERMALGENE
PEER REVIEWED

LANADIN
PEER REVIEWED

LETHURIN
PEER REVIEWED

NARCOGEN
PEER REVIEWED

NARKOSOID
PEER REVIEWED

NCI-C04546
PEER REVIEWED

NIALK
PEER REVIEWED

NSC 389
PEER REVIEWED

PERM-A-CHLOR
PEER REVIEWED

PETZINOL
PEER REVIEWED

PHILEX
PEER REVIEWED

THRETHYLEN
PEER REVIEWED

THRETHYLENE
PEER REVIEWED

TRETHYLENE
PEER REVIEWED

TRI
PEER REVIEWED

TRIASOL
PEER REVIEWED

Trichloraethen (German)
PEER REVIEWED

Trichloraethylen, tri (German)

PEER REVIEWED

TRICHLORAN
PEER REVIEWED

TRICHLOREN
PEER REVIEWED

Trichlorethene (French)
PEER REVIEWED

TRICHLORETHYLENE
PEER REVIEWED

Trichlorethylene, tri (French)
PEER REVIEWED

TRICHLOROETHENE
PEER REVIEWED

1,1,2-**TRICHLOROETHYLENE**
PEER REVIEWED

TRICLENE
PEER REVIEWED

Tricloretene (Italian)
PEER REVIEWED

Tricloroetilene (Italian)
PEER REVIEWED

Trielin
PEER REVIEWED

Trielina (Italian)
PEER REVIEWED

TRIKLONE
PEER REVIEWED

TRILENE
PEER REVIEWED

TRIMAR
PEER REVIEWED

TRI-PLUS
PEER REVIEWED

VESTROL
PEER REVIEWED

Formulations/Preparations:

Trichloroethylene for medicinal purposes may contain thymol as a preservative. Industrial grades ... may contain stabilizers, such as triethanolamine.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and

Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1643]**PEER REVIEWED**

Grades: USP; technical; high purity; electronic; metal degreasing; extraction.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1125]**PEER REVIEWED**

Trichloroethylene is available in the USA in high-purity, electronic USP, technical, metal degreasing and extraction grades
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V20 545 (1979)]**PEER REVIEWED**

Commercial grades of **trichloroethylene**, formulated to meet use requirements, differ in the amount and type of added inhibitor. Typical grades contain >99% **trichloroethylene**; they include a neutrally inhibited vapor-degreasing grade and a technical grade for use in formulations.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 (95) 76]**PEER REVIEWED**

Stabilizers that have been used in formulations of **trichloroethylene** include neutral inhibitors and free-radical scavengers, amyl alcohol, n-propanol, isobutanol, 2-pentanol, diethylamine, triethylamine, dipropylamine, diisopropylamine, diethanolamine, triethanolamine, morpholine, N-methylmorpholine, aniline, acetone, ethyl acetate, borate esters, ethylene oxide, propylene oxide, 1,2-epoxybutane, cyclohexene oxide, butadiene dioxide, styrene oxide, pentene oxide, 2,3-epoxy-1-propenol, 3-methoxy-1,2-epoxypropane, stearates, 2,2,4-trimethyl-1-pentene, 2-methyl-1,2-epoxypropanol, epoxycyclopentanol, epichlorohydrin, tetrahydrofuran, tetrahydropyran, 1,4-dioxane, dioxalane, trioxane, alkoxyaldehyde hydrazones, methyl ethyl ketone, nitromethanes, nitropropanes, phenol, ortho-cresol, thymol, para-tert-butylphenol, para-tert-amylphenol, isoeugenol, pyrrole, N-methylpyrrole, N-ethylpyrrole, (2-pyrryl)trimethylsilane, glycidyl acetate, isocyanates and thiazoles.
[IARC. Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Geneva: World Health Organization, International Agency for Research on Cancer, 1972-PRESENT. (Multivolume work).p. V63 (95) 76]**PEER REVIEWED**

Shipping Name/ Number DOT/UN/NA/IMO:

UN 1710; **Trichloroethylene**

IMO 6.1; **Trichloroethylene**

Standard Transportation Number:

49 411 71; **Trichloroethylene**

EPA Hazardous Waste Number:

U228; A toxic waste when a discarded commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or manufacturing chemical intermediate.

F002; A hazardous waste from nonspecific sources when a spent solvent.

D040; A waste containing **trichloroethylene** may or may not be characterized as a hazardous waste

following testing by the Toxicity Characteristic Leaching Procedure as prescribed by the Resource Conservation and Recovery Act (RCRA) regulations.

Administrative Information:

Hazardous Substances Databank Number: 133

Last Revision Date: 20030829

Last Review Date: Reviewed by SRP on 1/20/2001

Update History:

Complete Update on 2003-08-29, 1 fields added/edited/deleted
Complete Update on 03/05/2003, 3 fields added/edited/deleted.
Field Update on 02/14/2003, 1 field added/edited/deleted.
Field Update on 11/08/2002, 1 field added/edited/deleted.
Complete Update on 10/16/2002, 2 fields added/edited/deleted.
Complete Update on 08/06/2002, 1 field added/edited/deleted.
Complete Update on 05/13/2002, 1 field added/edited/deleted.
Complete Update on 01/14/2002, 1 field added/edited/deleted.
Complete Update on 08/09/2001, 1 field added/edited/deleted.
Complete Update on 05/23/2001, 92 fields added/edited/deleted.
Field Update on 05/15/2001, 1 field added/edited/deleted.
Field Update on 09/12/2000, 1 field added/edited/deleted.
Complete Update on 02/08/2000, 1 field added/edited/deleted.
Complete Update on 02/02/2000, 1 field added/edited/deleted.
Complete Update on 01/11/2000, 8 fields added/edited/deleted.
Field Update on 11/18/1999, 1 field added/edited/deleted.
Field Update on 09/21/1999, 1 field added/edited/deleted.
Complete Update on 06/03/1999, 3 fields added/edited/deleted.
Field Update on 05/17/1999, 1 field added/edited/deleted.
Field Update on 05/04/1999, 1 field added/edited/deleted.
Complete Update on 03/29/1999, 1 field added/edited/deleted.
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Complete Update on 06/11/1996, 2 fields added/edited/deleted.
Complete Update on 05/17/1996, 2 fields added/edited/deleted.

Complete Update on 04/16/1996, 29 fields added/edited/deleted.
Field Update on 01/18/1996, 1 field added/edited/deleted.
Field Update on 09/26/1995, 1 field added/edited/deleted.
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Field Update on 01/24/1995, 1 field added/edited/deleted.
Field Update on 12/19/1994, 1 field added/edited/deleted.
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Complete Update on 03/25/1994, 1 field added/edited/deleted.
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Complete Update on 01/12/1994, 92 fields added/edited/deleted.
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Field Update on 09/16/1993, 1 field added/edited/deleted.
Field Update on 08/03/1993, 1 field added/edited/deleted.
Field update on 12/11/1992, 1 field added/edited/deleted.
Complete Update on 08/17/1992, 87 fields added/edited/deleted.
Complete Update on 04/27/1992, 1 field added/edited/deleted.
Complete Update on 01/23/1992, 1 field added/edited/deleted.
Complete Update on 09/26/1991, 2 fields added/edited/deleted.
Complete Update on 10/22/1990, 1 field added/edited/deleted.
Complete Update on 06/28/1990, 12 fields added/edited/deleted.
Field Update on 05/14/1990, 1 field added/edited/deleted.
Field Update on 01/15/1990, 1 field added/edited/deleted.
Complete Update on 01/11/1990, 9 fields added/edited/deleted.
Field Update on 05/05/1989, 1 field added/edited/deleted.
Field Update on 03/01/1989, 1 field added/edited/deleted.
Complete Update on 09/23/1988, 2 fields added/edited/deleted.
Complete Update on 08/18/1988, 114 fields added/edited/deleted.
Complete Update on 07/24/1985
Created 19830401 by GCF

Record Length: 321413.0

Trichloroethylene

CASRN: 79-01-6
For other data, click on the Table of Contents

Status:

STATUS OF DATA FOR **Trichloroethylene**

File First On-Line 03/31/1987

Category (section)	Status	Last Revised
Oral RfD Assessment (I.A.)	no data	08/01/1992
Inhalation RfC Assessment (I.B.)	no data	
Carcinogenicity Assessment (II.)	withdrawn	07/01/1994

Substance Identification:

Substance Name:

Trichloroethylene

CAS Registry Number: 79-01-6

I. Chronic Health Hazard Assessment for Noncarcinogenic Effects:

I.A. Reference Dose for Chronic Oral Exposure (RfD):

Substance Name --**Trichloroethylene**
CASRN -- 79-01-6

Not available at this time.

I.B. Reference Concentration for Chronic Inhalation Exposure (RfC):

Substance Name --**Trichloroethylene**
CASRN -- 79-01-6

Not available at this time.

II. Carcinogenicity Assessment for Lifetime Exposure:

Substance Name --**Trichloroethylene**
CASRN -- 79-01-6

The carcinogen assessment summary for this substance has been withdrawn following further review. A

new carcinogen summary is in preparation by the CRAVE Work Group.

Agency Work Group Review -- 12/04/1986, 04/06/1989, 05/30/1989, 09/22/1993, 06/09/1994

EPA Contacts:

Please contact the IRIS Hotline for all questions concerning this assessment or IRIS, in general, at (301)345-2870 (phone), (301)345-2876 (FAX) or Hotline.IRIS@epamail.epa.gov (internet address).

VI. Bibliography:

VII. Revision History:

Substance Name --**Trichloroethylene**
CASRN -- 79-01-6

Date	Section	Description
03/01/1988	II.B.3.	Text revised
03/01/1988	II.B.4.	Confidence statement revised
03/01/1988	II.C.2.	Text added
03/01/1988	II.C.4.	Confidence statement revised
03/01/1988	II.D.4.	Documentation corrected
05/01/1989	II.	Carcinogen assessment summary noted as pending change
06/01/1989	II.D.3.	Primary contact changed
07/01/1989	II.	Withdrawn; new assessment verified (in preparation)
12/01/1989	I.B.	Inhalation RfD now under review
06/01/1990	IV.A.1.	Area code for EPA contact corrected
06/01/1990	IV.F.1.	EPA contact changed
01/01/1992	IV.	Regulatory actions updated
04/01/1992	IV.A.1.	CAA regulatory action withdrawn
07/01/1992	II.	EPA contact changed; work group review dates added
08/01/1992	I.A.	Oral RfD now under review
11/01/1993	II.	Work group review date added
07/01/1994	II.	Work group review date added
08/01/1995	I.A., I.B., II.	EPA's RfD/RfC and CRAVE workgroups were discontinued in May, 1995. Chemical substance reviews that were not completed by September 1995 were taken out of IRIS review. The IRIS Pilot Program replaced the workgroup functions beginning in September, 1995.
04/01/1997	III., IV., V.	Drinking Water Health Advisories, EPA Regulatory Actions, and Supplementary Data were removed from IRIS on or before April 1997. IRIS users were directed to the appropriate EPA Program Offices for this information.
01/02/1998	I., II.	This chemical is being reassessed under the IRIS Program.

TETRAHYDROFURAN

CASRN: 109-99-9

For other data, click on the Table of Contents

Human Health Effects:

Toxicity Summary:

HUMAN TOXICITY: Data pertaining to the toxicity of **tetrahydrofuran** (THF) in humans is quite limited. The probable oral lethal dose in humans is 50-500 mg/kg. Severe occipital headaches were reported in the testing for pharmacological properties of THF & among technicians performing animal experiments. Toxicity (TCLo) is expected following exposure to a 2.5% concn of THF. ANIMAL TOXICITY: Animal studies indicate that THF is only "MODERATELY TOXIC" from acute exposure with the lowest reported LD50's of 1900-2900 mg/kg by oral route. Median lethal concns by inhalation varied with the duration of exposure but were >20,000 ppm with all species for exposures of 1 hr or less. Reports of animal studies document irritation of the skin & mucous membranes, including the eyes, nose, & upper respiratory tract, as the predominant effect from lower exposures (about 100-200 ppm). High acute doses (about 25,000 ppm) produced anesthesia with delayed induction & recovery periods, accompanied by a fall in blood pressure & strong respiratory stimulation. The margin of safety between anesthesia & death is small. Other effects recorded are those of damage to liver, kidneys, & lung after prolonged exposures to levels of THF >1000 ppm. Toxic manifestations varied somewhat with the route of exposure with irritation of upper respiratory tract observed with inhaled THF & inflammation of the GI tract following oral ingestion. The only report on carcinogenicity is that of a test for skin tumors in which THF was applied to the skin of mice twice/wk for 25 exposures with an observation period of 17.5 months. No carcinogenic effect was observed. THF was negative when tested for mutagenicity using the Ames test; however, it would appear to enhance the mutagenicity of certain tryptophan-pyrolysate substances. No information is presented on metabolism, absorption, & distribution. The only report on excretion is the finding of THF in mother's milk.
PEER REVIEWED

Human Toxicity Excerpts:

... SEVERE OCCIPITAL HEADACHE REPORTED IN INVESTIGATORS TESTING ITS PHARMACOLOGICAL PROPERTIES.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-408]**PEER REVIEWED**

Signs and symptoms accompanied by a marked decrease in the number of white blood cells were observed in researchers engaged in experimental spinning of synthetic fibers. These effects were suspected to be due to poisoning by **tetrahydrofuran** which was used as a solvent for polyvinyl chloride. ...
[Hariguchi S; Sumitomo Bulletin of Industrial Health 17: 69-75 (1981)]**PEER REVIEWED**

Tetrahydrofuran can cause dermatitis on prolonged exposure.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Exposure to THF has been reported to be irritating to the skin, eyes, and mucous membranes; no specific concn for irritation has been described. Individuals exposed to high concn of THF have elevated

circulating enzymes and have complained of nausea, tinnitus, and occipital headache.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1518]**PEER REVIEWED**

Liver biopsy confirmed fatty degeneration and siderosis along with elevated gamma glutamyl transferase and alanine aminotransferase occurred in one adult male occupationally exposed to THF.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1518]**PEER REVIEWED**

/Case study:/ A polyvinyl chloride pipe insulator ... /was exposed/ to THF ... /for/ 2 wks in a poorly ventilated, confined space. After hospitalization for acute appendicitis with enflurane anesthesia, the patient developed cerebral convulsions. ... /It was/ suggested that the interaction of the anesthetic & occupational exposure to THF may have contributed to the onset of the convulsions.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1518]**PEER REVIEWED**

Two cases of occupational exposure to THF were reported ... The symptoms included irritation of mucous membranes, nausea, headache, dizziness, and possible cytolytic hepatitis. The effects on mucous membranes and the central nervous system resolved within a few hours after cessation of exposure.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1518]**PEER REVIEWED**

This study /was conducted/ in a video tape manufacturing facility in Singapore where workers were exposed to mixed solvents consisting of methyl ethyl ketone (MEK), cyclohexanone (CHE), **tetrahydrofuran** (THF), and toluene (TOL). The objectives were to quantify workers' exposure to the various solvents and to evaluate if there were any neurobehavioral changes among workers compared to controls. Nineteen exposed workers out of a workforce of 45 were studied. Twenty six workers (with no exposure) matched for ethnic group, age, years of education served as controls. Eight hr personal environmental samples were analyzed for the 19 workers along with symptom questionnaires, clinical exam, and neurobehavioral tests including the Santa Ana Dexterity, Finger Tapping, Digit Span, and Visual Reproduction tests. The mean TWA concn /for the cmpds/ were all below the threshold limit values (TLVs). However, the total solvents concn index exceeded unity in one of the work areas. Significant differences were /noted/ for prevalence of headache, and eye and nose irritation among the exposed workers. There were also significant differences for the Santa Ana test for both hands, Digit Span test and Visual Reproduction test. ... No dose effect relation between behavioral scores and airborne solvent exposure was noted. ...
[Chia Se et al; Neurotoxicol 14 (1): 51-6 (1993)]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Strong irritant to skin & mucous membranes ...
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-408]**PEER REVIEWED**

Vapor: Irritating to eyes, nose and throat. ... Liquid: Irritating to skin and eyes.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Medical Surveillance:

Consider the points of attack /eyes, skin, resp system, CNS/ in preplacement and periodic physical exam.

[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 848]**PEER REVIEWED**

The following medical procedures should be made available to each employee who is exposed to **tetrahydrofuran** at potentially hazardous levels: (1) Initial Medical Screening: Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from **tetrahydrofuran** exposure. These are skin, liver, kidney, and chronic respiratory diseases. (2) Periodic Medical Examination: Any employee developing the above listed conditions should be referred for further medical examination.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

The assessment of **tetrahydrofuran** can be accomplished through measurement of **tetrahydrofuran** where airborne exposure levels were found to correlate with urinary **tetrahydrofuran** levels, when measured at a specified time post **tetrahydrofuran** exposure. However, no information was located which demonstrated a correlation between urinary **tetrahydrofuran** levels and the onset of adverse health effects. Urine Reference Ranges: Normal - Not established; Exposed - BEI (sampling time is end of shift, measured as **tetrahydrofuran**: 8 mg/l (Notice of intent to establish); Toxic - not established.
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 1124]**PEER REVIEWED**

Chest Radiography: Chest radiographs are widely used to assess pulmonary diesase. They are useful for detecting early lung early lung cancer in asymptomatic people, and especially for detecting of peripheral tumors such as adenocarcinomas. However, even though OSHA mandates this test for exposure to some toxicants such as asbestos, experts' views on the risk-to-benefit ratio in detection of pulmonary disease conflict, so routine annual chest x-rays are not recommended for all people.
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 1125]**PEER REVIEWED**

Pulmonary Function Tests: The tests that have been found to be practical for population monitoring include: Spirometry and expiratory flow-volume curves; Determination of lung volumes; Diffusing capacity for carbon monoxide; Single-breath nitrogen washout; Inhalation challenge tests; Serial measurements of peak expiratory flow; Exercise testing.
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 1125]**PEER REVIEWED**

Evaluation of Peripheral Neuropathy: Nerve conduction study; Electromyography; Quantitative sensory testing; Thermography.
[Ryan, R.P., C.E. Terry, S.S. Leffingwell (eds.) Toxicology Desk Reference 5th ed. Volumes 1-2. Taylor & Francis Philadelphia, PA. 2000 1126]**PEER REVIEWED**

Populations at Special Risk:

Persons with existing skin disorders may be more susceptible to the effects /of **tetrahydrofuran** exposure/.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

Probable Routes of Human Exposure:

Tetrahydrofuran can affect the body if it is inhaled, swallowed, or comes in contact with the eyes or skin.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

90,000 workers in 3,000 plants are exposed from the following industries: special trade contractors, chem and allied products, electric gas & sanitary services. Occupations with potential exposure are electricians, agriculture and biological technicians, and electric power linemen and cablemen.
[NIOSH. National Occupational Hazard Survey as cited in Chemical Selection Working Group Profile #446: Tetrahydrofuran (1979)]**PEER REVIEWED**

Worker exposure during application of coatings to cellophane film by an open process was evaluated. Maximum THF vapor concn was 20 ppm. During rethreading operation 10-46 ppm (TWA) were reported and exposure of hands to liquid THF occurred.
[Rosensteel RE, Thoburn TW; Health Haz Evaluation, Olin Corp, Pisgah Forest, NC, Toxicity Determination Report 74-4-175 (1975) as cited in Hazard Profile: Exposure Information on THF p.9 (1979)]**PEER REVIEWED**

Workers were exposed to THF while joining PVC casing to PVC pipe with cement containing THF. Of 4 conc measured, 1 registered 20 ppm for a 20 min period.
[Gilles D, Hatch L; Health Hazard Evaluation, Water Well Drilling Companies, W Tennessee Gov Rep Announce Index (US) 77 (1): 104 (1976) as cited in Hazard Profile: Exposure Information on THF p9 (1979)]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 303,049 workers (24,842 of these are female) are potentially exposed to **tetrahydrofuran** in the US(1). Occupational exposure to **tetrahydrofuran** may occur through inhalation and dermal contact with this compound at workplaces where **tetrahydrofuran** is produced or used(SRC). Occupational exposure to **tetrahydrofuran** was studied in the air, blood, and urine of 58 male workers in a video tape manufacturing plant; exposure was through inhalation of **tetrahydrofuran** vapors and direct dermal contact(2).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983) (2) Ong CN et al; Brit J Indus Medicine 48: 616-621 (1991)]**PEER REVIEWED**

Body Burden:

In 4 urban areas, **tetrahydrofuran** was detected in Mother's milk in 1 of 12 samples(1).
[(1) Pellizzari ED et al; Bull Environ Toxicol 28: 322-8 (1982)]**PEER REVIEWED**

Emergency Medical Treatment:

Emergency Medical Treatment:

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The following Overview, *** **TETRAHYDROFURAN** ***, is relevant for this HSDB record chemical.

Life Support:

o This overview assumes that basic life support measures have been instituted.

Clinical Effects:

0.2.1 SUMMARY OF EXPOSURE
0.2.1.1 ACUTE EXPOSURE
A. INGESTION - **Tetrahydrofuran** may cause nausea, dizziness, headache, and CNS depression.
B. INHALATION - Vapors may be a respiratory tract irritant, or produce nausea, dizziness, and CNS depression with general anesthesia.
C. OCULAR - **Tetrahydrofuran** is an eye irritant.
D. DERMAL - **Tetrahydrofuran** will cause burning and dermatitis on prolonged skin exposure.
0.2.1.2 CHRONIC EXPOSURE
A. Clinical symptoms were accompanied by a marked decrease in the number of white blood cells in chronic occupational exposures.
0.2.4 HEENT
0.2.4.1 ACUTE EXPOSURE
A. Profuse salivation and irritation of eyes and mucous membranes may be noted.
0.2.5 CARDIOVASCULAR
0.2.5.1 ACUTE EXPOSURE
A. Hypotension may be noted.
0.2.6 RESPIRATORY
0.2.6.1 ACUTE EXPOSURE
A. Upper respiratory irritation or stimulation may be noted.
0.2.7 NEUROLOGIC
0.2.7.1 ACUTE EXPOSURE
A. Occipital headache and dizziness are common. Anesthesia lasting 6 to 8 hours may occur with inhalation of high concentrations.
0.2.8 GASTROINTESTINAL
0.2.8.1 ACUTE EXPOSURE
A. Nausea and gastrointestinal irritation may be noted.
0.2.9 HEPATIC
0.2.9.1 ACUTE EXPOSURE
A. Liver damage may result following **tetrahydrofuran** exposures.
0.2.14 DERMATOLOGIC
0.2.14.1 ACUTE EXPOSURE
A. **Tetrahydrofuran** is irritating in concentrations of 20% or greater.
0.2.20 REPRODUCTIVE HAZARDS
A. At the time of this review, no studies were found on the potential reproductive effects of THF in humans.
0.2.21 CARCINOGENICITY
0.2.21.2 HUMAN OVERVIEW
A. At the time of this review, no studies were found on the carcinogenic potential of THF in humans.
0.2.21.3 ANIMAL OVERVIEW
A. THF was not carcinogenic when applied to the skin of mice (HSDB), but did enhance the tumorigenicity of benzo(a)pyrene metabolites on mouse skin.
0.2.22 GENOTOXICITY
A. THF caused DNA damage in mammalian cells (HSDB, 2000).

It was mutagenic in E. coli (RTECS, 2000), but not in the Ames Salmonella/microsome assay (HSDB, 2000). It did not increase DNA repair in human cells and was inactive for producing sex-linked recessive lethal mutations in fruit flies, sperm abnormalities in mice, and dominant lethal mutations in male rats (McGregor, 1981). It strongly enhanced the mutagenicity of pyrolysis products of tryptophane in Salmonella (Arimoto et al, 1982).

Laboratory:

A. Monitor hepatic and renal function.

Treatment Overview:

0.4.2 ORAL EXPOSURE

A. DILUTION: Immediately dilute with 4 to 8 ounces (120 to 240 mL) of water or milk (not to exceed 4 ounces/120 mL in a child).

B. EMESIS: Ipecac-induced emesis is not recommended because of the potential for CNS depression.

C. ACTIVATED CHARCOAL: Administer charcoal as a slurry (240 mL water/30 g charcoal). Usual dose: 25 to 100 g in adults/adolescents, 25 to 50 g in children (1 to 12 years), and 1 g/kg in infants less than 1 year old.

D. GASTRIC LAVAGE: Consider after ingestion of a potentially life-threatening amount of poison if it can be performed soon after ingestion (generally within 1 hour). Protect airway by placement in Trendelenburg and left lateral decubitus position or by endotracheal intubation. Control any seizures first.

1. CONTRAINDICATIONS: Loss of airway protective reflexes or decreased level of consciousness in unintubated patients; following ingestion of corrosives; hydrocarbons (high aspiration potential); patients at risk of hemorrhage or gastrointestinal perforation; and trivial or non-toxic ingestion.

E. Treatment of CNS depression is symptomatic.

F. Monitor renal and hepatic function.

G. HYPOTENSION: Infuse 10 to 20 mL/kg isotonic fluid. If hypotension persists, administer dopamine (5 to 20 mcg/kg/min) or norepinephrine (ADULT: begin infusion at 0.5 to 1 mcg/min; CHILD: begin infusion at 0.1 mcg/kg/min); titrate to desired response.

0.4.3 INHALATION EXPOSURE

A. INHALATION: Move patient to fresh air. Monitor for respiratory distress. If cough or difficulty breathing develops, evaluate for respiratory tract irritation, bronchitis, or pneumonitis. Administer oxygen and assist ventilation as required. Treat bronchospasm with inhaled beta2 agonist and oral or parenteral corticosteroids.

B. Treatment should include recommendations listed in the ORAL EXPOSURE section when appropriate.

0.4.4 EYE EXPOSURE

A. DECONTAMINATION: Irrigate exposed eyes with copious amounts of room temperature water for at least 15 minutes. If irritation, pain, swelling, lacrimation, or photophobia persist, the patient should be seen in a health care facility.

0.4.5 DERMAL EXPOSURE

A. DECONTAMINATION: Remove contaminated clothing and wash exposed area thoroughly with soap and water. A

physician may need to examine the area if irritation or pain persists.

Range of Toxicity:

A. 25,000 ppm will produce anesthesia in humans.

[Rumack BH POISINDEX(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003. Hall AH & Rumack BH (Eds): TOMES(R) Information System Micromedex, Inc., Englewood, CO, 2003; CCIS Volume 118, edition expires Nov, 2003.]**PEER REVIEWED**

Antidote and Emergency Treatment:

Basic treatment: Establish a patent airway. Suction if necessary. Watch for signs of respiratory insufficiency and assist ventilations if necessary. Administer oxygen by nonrebreather mask at 10 to 15 L/min. Provide a low-stimulus environment. Monitor for shock and treat if necessary ... . Anticipate seizures and treat if necessary ... . For eye contamination, flush eyes immediately with water. Irrigate each eye continuously with normal saline during transport ... . Do not use emetics. For ingestion, rinse mouth and administer 5 ml/kg up to 200 ml of water for dilution if the patient can swallow, has a strong gag reflex, and does not drool. Treat frostbite by rapid rewarming ... . /Ethers and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 224]**PEER REVIEWED**

Advanced treatment: Consider orotracheal or nasotracheal intubation for airway control in the patient who is unconscious or in respiratory arrest. Monitor cardiac rhythm and treat arrhythmias if necessary ... . Start an IV with D5W /SRP: "To keep open", minimal flow rate/. Use lactated Ringer's if signs of hypovolemia are present. Watch for signs of fluid overload. For hypotension with signs of hypovolemia, administer fluid cautiously. Consider vasopressors for hypotension with a normal fluid volume. Treat seizures with diazepam ... . Use proparacaine hydrochloride to assist eye irrigation ... . /Ethers and related compounds/
[Bronstein, A.C., P.L. Currance; Emergency Care for Hazardous Materials Exposure. 2nd ed. St. Louis, MO. Mosby Lifeline. 1994. 225]**PEER REVIEWED**

Inhalation Developmental Toxicology Studies: Teratology Study of **Tetrahydrofuran** (CAS No. 109-99-9) in Mice and Rats NTP Study: TER88047 ABSTRACT **Tetrahydrofuran** (THF), a four-carbon cyclic ether, is widely used as an industrial solvent. Although it has been used in large quantities for many years, few long-term toxicology studies, and no reproductive or developmental studies, have been conducted on THF. This study addresses the potential for THF to cause developmental toxicity in rodents by exposing Sprague-Dawley rats and Swiss (CD-1®) mice to 0, 600, 1800, or 5000 ppm **tetrahydrofuran** (THF) vapors, 6 hours per day, 7 days per week. Each treatment group consisted of 10 virgin females (for comparison), and 33 positively mated rats or mice. Positively mated mice were exposed on days 6-17 of gestation (dg), and rats on 6-19 dg. The day of plug or sperm detection was designated as 0 dg. Body weights were obtained throughout the study period, and uterine and fetal body weights were obtained at sacrifice (rats, 20 dg; mice, 18 dg). Implants were enumerated and their status recorded and live fetuses were examined for gross, visceral, skeletal, and soft-tissue craniofacial defects. The only overt symptom exhibited by pregnant rats was a reduction in body weight gain for the 5000-ppm group and there were no maternal deaths. However, mean body weights of virgin females were not affected, thus indicating that pregnancy was a factor in the toxicological response. The pregnancy rate was 93%. The mean gravid uterine weight and the extragestational weight gain (EGWG; sacrifice body weight minus gravid uterine weight minus 0 dg weight) were reduced for the 5000-ppm group relative to the control, but the difference was not significant. There were no treatment-related

effects on the number of implantations, the mean percent of live pups/litter and resorptions/litter, or on the fetal sex ratio. Fetal weights were significantly reduced for the 5000-ppm exposure group relative to controls. The mean percent affected fetuses per litter was not significantly different among treatment groups for any individual malformation or variation or for combined totals. Mice exhibited overt symptoms of toxicity at the 1800- and 5000-ppm THF concentrations. Approximately 30% of the animals in the 1800-ppm group, and all in the 5000-ppm group, were subject to narcosis. Approximately 27% of the pregnant animals and 30% virgins in the 5000-ppm group died during the first six days of exposure; consequently, this group was removed from exposure to prevent further mortality. There were no maternal deaths in either the 600 or 1800-ppm exposure groups. As in rats, the mean body weights of virgin mice at sacrifice were not significantly affected by exposure to THF. Mean body weights of pregnant mice and uterine weights were significantly less than controls for the 5000- and 1800-ppm groups at sacrifice. The EGWG was also significantly reduced for the 5000-ppm group. There was no effect on the number of implantations per dam, and the mean pregnancy rate for all mated mice was 86%. There was a significant reduction in the mean percent of live pups/litter for the 1800- and 5000-ppm groups and a corresponding increase in the percent of resorptions/litter. Pregnant females in the 5000-ppm exposure group that survived to the scheduled sacrifice had litters with a 95% incidence of resorption. Neither fetal weight nor the sex ratio was affected in the 600- or 1800-ppm groups. The mean percent affected fetuses per litter was not significantly different among treatment groups for any individual malformation or for combined totals. There was an exposure-correlated increase in the incidence of reduced sternebral ossifications; however differences between groups were not significant. Swiss (CD-1®) mice appeared to be much more susceptible to the toxic effects of THF, manifested as narcosis, mortality, and intrauterine death, than were the rats. The rats appeared unaffected by THF exposure except for a slight, but significant, decrease in maternal and fetal weight at the 5000-ppm level. Interestingly, in mice the reduction in maternal weight gain and the increase in intrauterine death at the 1800-ppm level were not accompanied by a treatment-associated decline in live fetal weight, nor by an increase in the incidence of fetal malformations. These facts suggest that in mice, if the conceptus survives, development as assessed by this experimental design, continues in a normal fashion. Report Date: August 1988
[Department of Health & Human Services/National Institute of Environmental Health Sciences, National Toxicology Program; ???TITLE???, NTP Study No. _____ (???report year???) available at http://ntp-server.niehs.nih.gov/htdocs/pub-TT0.html as of ???enter date the information was found, e.g. August 8, 2002???]**QC REVIEWED**

Animal Toxicity Studies:

Toxicity Summary:

HUMAN TOXICITY: Data pertaining to the toxicity of **tetrahydrofuran** (THF) in humans is quite limited. The probable oral lethal dose in humans is 50-500 mg/kg. Severe occipital headaches were reported in the testing for pharmacological properties of THF & among technicians performing animal experiments. Toxicity (TCLo) is expected following exposure to a 2.5% concn of THF. ANIMAL TOXICITY: Animal studies indicate that THF is only "MODERATELY TOXIC" from acute exposure with the lowest reported LD50's of 1900-2900 mg/kg by oral route. Median lethal concns by inhalation varied with the duration of exposure but were >20,000 ppm with all species for exposures of 1 hr or less. Reports of animal studies document irritation of the skin & mucous membranes, including the eyes, nose, & upper respiratory tract, as the predominant effect from lower exposures (about 100-200 ppm). High acute doses (about 25,000 ppm) produced anesthesia with delayed induction & recovery periods, accompanied by a fall in blood pressure & strong respiratory stimulation. The margin of safety between anesthesia & death is small. Other effects recorded are those of damage to liver, kidneys, & lung after prolonged exposures to levels of THF >1000 ppm. Toxic manifestations varied somewhat with the route

of exposure with irritation of upper respiratory tract observed with inhaled THF & inflammation of the GI tract following oral ingestion. The only report on carcinogenicity is that of a test for skin tumors in which THF was applied to the skin of mice twice/wk for 25 exposures with an observation period of 17.5 months. No carcinogenic effect was observed. THF was negative when tested for mutagenicity using the Ames test; however, it would appear to enhance the mutagenicity of certain tryptophan-pyrolysate substances. No information is presented on metabolism, absorption, & distribution. The only report on excretion is the finding of THF in mother's milk.
PEER REVIEWED

Non-Human Toxicity Excerpts:

A single 4 hr inhalation of THF in rabbits in the range of 100 to 12,000 ppm resulted in a transient dose related decrease of tracheal ciliary activity. Single or repeated exposures have been associated with cytolytic hepatitis and fatty degeneration of the liver.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1517]**PEER REVIEWED**

... Concentrations of THF >25,000 ppm were required to produce anesthesia. The anesthetic properties were rather poor in that onset was delayed & recovery poor; this was accompanied by pronounced hypotension & marked respiratory hyperpnea. There was a narrow margin of safety between anesthesia & death in dogs & mice.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1517]**PEER REVIEWED**

... When dogs inhaled 200 ppm THF 6 hr/day for 3 to 4 weeks, an observable effect on pulse pressure was recorded; however, no demonstrable histopathologic changes were found despite extended exposure of 9 weeks, followed by an additional 3 week exposure at up to 400 ppm.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1517]**PEER REVIEWED**

ACUTE ORAL ADMIN /OF **TETRAHYDROFURAN** TO CATS/ WAS FOUND ... TO CAUSE INFLAMMATION, NECROSIS & HEMORRHAGE OF GASTROINTESTINAL TRACT. KIDNEYS SHOWED INJURY TO TUBULES. ... INFLAMMATION /OF LIVER/ & CONGESTION & EDEMA /OF LUNGS, WERE OBSERVED/.
[Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965. 701]**PEER REVIEWED**

THF was irritating to rabbits when applied topically in aq soln exceeding 20% concn.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1517]**PEER REVIEWED**

Male rats that inhaled more than 5000 ppm THF for 12 weeks at 4 hr/day showed signs of systemic intoxication, skin and respiratory tract irritation, liver function disturbance, and abnormalities in glucose metabolism. Although systemic effects were not observed after similar exposures at lower concn, slight respiratory tract irritation occurred in some rats that inhaled concn less than 200 ppm.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1517]**PEER REVIEWED**

/CNS DEPRESSANT/ ... DOSE /OF **TETRAHYDROFURAN**/. BY INHALATION, FOR MICE, 6.7 VOL % IN 5 MIN; 1.1 VOL % IN 43 MIN; FOR DOGS, 5.6 VOL % (OXYGEN MIXT) FOR 2 HR.

[Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965. 701]**PEER REVIEWED**

RABBITS EXPOSED TO **TETRAHYDROFURAN** (THF) @ 12,000 PPM FOR 4 HR HAD PARALYSIS OF THE NASAL CILIARY FUNCTION DUE TO THE ABSENCE OF CILIARY BEATING, WHILE MORPHOLOGICAL DAMAGE OF CILIATED CELLS WAS NOT SO SEVERE. MODERATE DESTRUCTIVE CASES, PARTIAL DESTRUCTION OF THE OUTER CELLULAR MEMBRANE WAS RECOGNIZED. THE FALLING OFF OR ABSENCE OF CILIATED CELLS WAS NEVER OBSERVED.
[OHASHI Y ET AL; SUMITOMO SANGYO EISEI 18: 89-93 (1982)]**PEER REVIEWED**

RATS WERE EXPOSED TO **TETRAHYDROFURAN** AT 200 OR 1000 PPM, 4 HR/WK FROM 12 TO 24 WK OF AGE. THE LOWER CONCN CAUSED SLIGHT DAMAGE WHEREAS THE HIGHER CONCN CAUSED SEVERE DAMAGE TO THE NASAL & TRACHEAL EPITHELIUM. THE DEGREE INCL DECR NUMBER OF CILIA, VACUOLIZATION & INCR DENSE GRANULES OF THE CYTOPLASM.
[HORIGUCHI S ET AL; SEIKATSU EISEI 25 (4): 176-7 (1981)]**PEER REVIEWED**

2.2 vol % **Tetrahydrofuran** killed 50% of exposed mice in less than 2 hr. Anesthesia was marked by prolonged induction, profuse salivation, poor muscular relaxation, fall in blood pressure, respiratory stimulation, and a narrow margin of safety.
[Gosselin RE et al; Chemical Hazards of the Workplace p.471 (1978)]**PEER REVIEWED**

Tetrahydrofuran tested negative for sex-linked recessive lethal heritable genetic effects in Drosophila in FY 1983. /No additional data given/
[NTP; Fiscal Year 1984 Annual Plan p.82 (1984) NTP-84-023]**PEER REVIEWED**

In test results for cytogenetic effects in Chinese hamster ovary cells, **tetrahydrofuran** tested positive for chromosomal aberrations and negative for sister chromatid exchanges. /No additional data given/
[NTP; Fiscal Year 1984 Annual Plan p.75 (1984) NTP-84-023]**PEER REVIEWED**

Oral lethal dose of a 20% solution in rabbits 2.5 g/kg. ... A vapor concn of 2.2 vol % killed 50% of exposed mice in less than 2 hr.
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-408]**PEER REVIEWED**

Tetrahydrofuran (THF) was tested for mutagenicity in the Salmonella/microsome preincubation assay using the standard protocol approved by the National Toxicology Program. THF was tested at doses of 0.1, 0.33, 1.0, 3.3, and 10 mg/plate in as many as 5 Salmonella typhimurium strains (TA1535, TA1537, TA97, TA98, and TA100) in the presence and absence of rat or hamster liver S-9. **Tetrahydrofuran** was negative in these tests and the highest ineffective dose tested in any Salmonella typhimurium strain was 10 mg/plate.
[Mortelmans K et al; Environ Mutagen 8: 1-119 (1986)]**PEER REVIEWED**

Rats were exposed to 100, 200, 1000 or 5000 ppm **tetrahydrofuran** for 4 hr/day for 12 weeks. 100 and 200 ppm had no significant effects except for slight mucosal irritation. 1000 ppm affected liver function as indicated by serum chemistry tests. 5000 ppm caused marked local irritant symptoms and morphological damage of the respiratory mucosae, and affected white blood cell counts, blood sugar levels and liver functions.
[Katahira T et al; Japanese Journal of Industrial Health 24 (4): 379-87 (1982)]**PEER REVIEWED**

The LD50 of **tetrahydrofuran** dissolved in olive oil was approximately 2500 mg/kg in mice and dissolved in saline was 1900 and 2900 mg/kg in mice and rats, respectively. The median lethal

concentration was approximately 21000 ppm in rats when **tetrahydrofuran** was inhaled for 3 hr. Rats exposed to 100-200 ppm of **tetrahydrofuran** showed no significant effects, except for slight local irritant symptoms such as redness of the nose and eyelids. Almost all rats exposed to > 5000 ppm of **tetrahydrofuran** displayed marked local irritant symptoms, such as edema or opacity of the cornea, salivation, and discharge or bleeding in nasal mucosa. A cataleptoid posture, coma, and clonic muscle spasms indicating irritant symptoms of the central nervous system were also observed.
[Katahira T et al; Sangyo Igaku 24 (4): 373-8 (1982)]**PEER REVIEWED**

Muscle acetylcholinesterase activity increased in a concentration dependent manner in male rats that inhaled 200, 1000, or 2000 ppm for 18 weeks at 6 hr/day. THF concentrations in brain and peripheral fat appeared to decrease after 2 weeks. At 200 ppm, hepatic protein and mixed function oxidase activity were increased. At 2000 ppm, liver function was inhibited. Increased skeletal muscle succinate dehydrogenase activity was noted. In a 13 week study inhalation study, ataxia was reported in rats at 5000 ppm and ... /CNS depression/ was reported in mice at 1800 ppm. Hepatocytomegaly developed in mice of both sexes at 5000 ppm; uterine atrophy and degeneration of the adrenal cortex occurred in the female mice.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1517]**PEER REVIEWED**

High concn (1x10-2 M) of THF inhibited the in vitro activity of rat hepatic cytochrome p-450 by 80%.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1518]**PEER REVIEWED**

Sensory irritation in mice exposed to chemical emissions was investigated using a modification of an ASTM standard protocol. Samples of carpet, ceiling tile, wallcovering, resilient flooring, and veneer were tested as typical indoor products. Sensory irritation during head only animal exposure was assessed by monitoring changes in respiratory frequency and waveform when test products were continuously ventilated at either 23 or 70 deg C. Animals /were exposed/ to 1 hr exposures to product emissions, corresponding to 1, 4, 24 and 27 elapsed hr of product exposure. Sensory irritation was generally not observed when products were tested at 23 deg C, but could be induced during at least one exposure period from all products except the carpet sample at 70 deg C. Although the total volatile organic cmpd emissions from a given product tested at elevated temperature incr between 5 and 30 fold from the emissions at ambient temperature, gas chemicals showed differences in the relative chemical compositions of the test atmospheres. ... Incr the temperature to 70 deg C may incr the total chemical concn of product emissions, it may not produce a chemical exposure comparable to that at ambient conditions. Since most human exposure to product emissions occurs at ambient conditions, the significance of irritation at elevated temperatures is ... questionable.
[Muller WJ, Black MS; Amer Indust Hyg Assoc J 56 (8): 794-803 (1995)]**PEER REVIEWED**

Sprague-Dawley rats and Swiss CD-1 mice were exposed to 0, 600, 1,800 or 5,000 ppm **tetrahydrofuran** ... vapors 6 hr/day, 7 days/wk (6-19 days of gestation) for rats; 6-17 days of gestation for mice). Body weights of pregnant rats in the 5,000 ppm group were reduced at /sacrifice/. There were no effects on the percentage of live rat fetuses/litter or on the fetal sex ratio. Fetal body weight was significantly reduced in the 5,000 ppm group, but the incidence of abnormalities was not incr. Mice in the 1,800 ppm and 5,000 ppm group were sedated during exposure; approx 27% of the mice in the 5,000 ppm group died. Mean body and uterine weights of mice were reduced for the 1,800 and 5,000 ppm groups at /sacrifice/ (18 days of gestation), but adjusted maternal weight gain was not affected at 1,800 ppm. There was a reduction in the percentage of live fetuses/litter for the mice in the 1,800 and 5,000 ppm groups (95% resorptions in the 5,000 ppm group). Fetal weight and sex ratio in mice were not

affected. An incr in the incidence of reduced sternebral ossifications was correlated to **tetrahydrofuran** concn, although differences between groups were not statistically significant. There were no incr in the incidences of any other malformations or variations. These results suggest that **tetrahydrofuran** may be embryotoxic in mice, but if the conceptus survives, development as assessed by this experimental design continues in a normal fashion. The no observable adverse effect level (NOAEL) for maternal toxicity was 1,800 ppm in both rats and mice. The NOAEL for developmental toxicity was 1,800 ppm in rats and 600 ppm in mice.
[Mast TJ et al; Fundam Appl Toxicol 18 (2): 255-65 (1992)]**PEER REVIEWED**

... CONCLUSIONS: Under the conditions of these 2 yr inhalation studies, there was some evidence of carcinogenic activity of **tetrahydrofuran** in male F344/N rats based on incr incidences of renal tubule adenoma or carcinoma (combined). There was no evidence of carcinogenic activity of **tetrahydrofuran** in female F344/N rats exposed to 200, 600 or 1,800 ppm or male B6C3F1 mice exposed to 200, 600 or 1,800 ppm. There was clear evidence of carcinogenic activity of **tetrahydrofuran** in female B6C3F1 mice based on incr incidences of hepatocellular neoplasms.
[Toxicology & Carcinogenesis Studies of Tetrahydrofuran in F344/N Rats and B6C3F1 Mice p.6 Technical Report Series No. 475 (1998) NIH Publication No. 98-3965 U.S. Department of Health and Human Services, National Toxicology Program, National Institute of Environmental Health Sciences, Research Triangle Park, NC 27709]**PEER REVIEWED**

National Toxicology Program Studies:

... Groups of 50 male and 50 female F344/N rats were exposed to 0, 200, 600 or 1,800 ppm **tetrahydrofuran** by inhalation 6 hr/day, 5 days/wk for 105 wk. ... Groups of 50 male and 50 female B6C3F1 mice were exposed to 0, 200, 600 or 1,800 ppm **tetrahydrofuran** by inhalation, 6 hr/day, 5 days/wk for 105 wk. ... CONCLUSIONS: Under the conditions of these 2 yr inhalation studies, there was some evidence of carcinogenic activity of **tetrahydrofuran** in male F344/N rats based on incr incidences of renal tubule adenoma or carcinoma (combined). There was no evidence of carcinogenic activity of **tetrahydrofuran** in female F344/N rats exposed to 200, 600 or 1,800 ppm or male B6C3F1 mice exposed to 200, 600 or 1,800 ppm. There was clear evidence of carcinogenic activity of **tetrahydrofuran** in female B6C3F1 mice based on incr incidences of hepatocellular neoplasms.
[Toxicology & Carcinogenesis Studies of Tetrahydrofuran in F344/N Rats and B6C3F1 Mice p.6 Technical Report Series No. 475 (1998) NIH Publication No. 98-3965 U.S. Department of Health and Human Services, National Toxicology Program, National Institute of Environmental Health Sciences, Research Triangle Park, NC 27709]**PEER REVIEWED**

... This study addresses the potential for /**Tetrahydrofuran**/ (THF) to cause developmental toxicity in rodents by exposing Sprague-Dawley rats & Swiss (CD-1) mice to 0, 600, 1,800, or 5,000 ppm **tetrahydrofuran** (THF) vapors, 6 hr/day, 7 days/wk. Each treatment group consisted of 10 virgin females (for comparison), & 33 positively mated rats or mice. Positively mated mice were exposed on days 6-17 of gestation (dg), & rats on 6-19 /day of gestation/. The day of plug or sperm detection was designated as 0 /day of gestation/. Body weights were obtained throughout the study period, & uterine & fetal body weights were obtained at sacrifice (rats, 20 /day of gestation; mice, 18 /day of gestation/). Implants were enumerated & their status recorded & live fetuses were examined for gross, visceral, skeletal, & soft-tissue craniofacial defects. The only overt symptom exhibited by pregnant rats was a reduction in body weight gain for the 5,000-ppm group & there were no maternal deaths. However, mean body weights of virgin females were not affected, thus indicating that pregnancy was a factor in the toxicological response. The pregnancy rate was 93%. The mean gravid uterine weight & the extragestational weight gain (EGWG; sacrifice body weight minus gravid uterine weight minus 0 /day of gestation/ weight) were reduced for the 5000-ppm group relative to the control, but the difference was

not significant. There were no treatment-related effects on the number of implantations, the mean % of live pups/litter & resorptions/litter, or on the fetal sex ratio. Fetal weights were significantly reduced for the 5,000-ppm exposure group relative to controls. The mean % affected fetuses/litter was not significantly different among treatment groups for any individual malformation or variation or for combined totals. Mice exhibited overt symptoms of toxicity at the 1,800- & 5,000-ppm THF concns. Approx 30% of the animals in the 1,800-ppm group, & all in the 5,000-ppm group, were subject to narcosis. Approx 27% of the pregnant animals & 30% virgins in the 5,000-ppm group died during the first 6 days of exposure; consequently, this group was removed from exposure to prevent further mortality. There were no maternal deaths in either the 600 or 1,800-ppm exposure groups. As in rats, the mean body weights of virgin mice at sacrifice were not significantly affected by exposure to THF. Mean body weights of pregnant mice & uterine weights were significantly less than controls for the 5,000- & 1,800-ppm groups at sacrifice. The EGWG was also significantly reduced for the 5,000-ppm group. There was no effect on the number of implantations/dam, & the mean pregnancy rate for all mated mice was 86%. There was a significant reduction in the mean % of live pups/litter for the 1,800- & 5,000-ppm groups & a corresponding incr in the % of resorptions/litter. Pregnant females in the 5,000-ppm exposure group that survived to the scheduled sacrifice had litters with a 95% incidence of resorption. Neither fetal weight nor the sex ratio was affected in the 600- or 1,800-ppm groups. The mean % affected fetuses/litter was not significantly different among treatment groups for any individual malformation or for combined totals. There was an exposure-correlated incr in the incidence of reduced sternebral ossifications; however differences between groups were not significant. Swiss (CD-1) mice appeared to be much more susceptible to the toxic effects of THF, manifested as narcosis, mortality, & intrauterine death, than were the rats. The rats appeared unaffected by THF exposure except for a slight, but significant, decr in maternal & fetal weight at the 5,000-ppm level. Interestingly, in mice the reduction in maternal weight gain & the incr in intrauterine death at the 1,800-ppm level were not accompanied by a treatment-associated decline in live fetal weight, nor by an incr in the incidence of fetal malformations. These facts suggest that in mice, if the conceptus survives, development as assessed by this experimental design, continues in a normal fashion.
[Department of Health & Human Services/National Institute of Environmental Health Sciences, National Toxicology Program; Inhalation Developmental Toxicology Studies: Teratology Study of Tetrahydrofuran (CAS No. 109-99-9) in Mice and Rats, NTP Study No. TER88047 (August 1988) available at http://ntp-server.niehs.nih.gov/htdocs/pub-TT0.html as of August 19, 2002]**QC REVIEWED**

Non-Human Toxicity Values:

Toxicity threshold (cell multiplication inhibition test) Pseudomonas putida (bacteria) 580 mg/l
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1087]**PEER REVIEWED**

LD50 Mouse inhalation 6.7%/30 min
[Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965. 701]**PEER REVIEWED**

LC50 Rat inhalation 80,975 ppm/1 hr
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1088]**PEER REVIEWED**

LC50 Rat inhalation 62,000 ppm/2 hr
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1088]**PEER REVIEWED**

LC50 Rat inhalation 18,000-22,000 ppm/4 hr
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New

York, NY: Van Nostrand Reinhold Co., 1983. 1088]**PEER REVIEWED**

LC50 Rat inhalation 21,000 ppm/3 hr
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 3108]**PEER REVIEWED**

Growth inhibition Microcystis (blue green algae) 225 mg/l (pH 7.0)
[Bringmann G; Vom Wasser 50: 145-60 (1975)]**PEER REVIEWED**

Toxicity threshold (cell multiplication inhibition test) Uronema parduczi Chatton-Lwoff (protozoa) 858 mg/l
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1087]**PEER REVIEWED**

Toxicity threshold (cell multiplication inhibition test) Microcystis aeruginosa (algae) 225 mg/l
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1088]**PEER REVIEWED**

LD50 Rat oral 3.2 ml/kg, older rats
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1517]**PEER REVIEWED**

LD50 Rat oral 2.3 ml/kg, 14 day old males
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1517]**PEER REVIEWED**

LD50 Rat oral 3.6 ml/kg, young adults
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1517]**PEER REVIEWED**

LD50 Rat oral 1650 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 3108]**PEER REVIEWED**

LD50 Rat ip 2900 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 3108]**PEER REVIEWED**

LD50 Mouse ip 1900 mg/kg
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 3108]**PEER REVIEWED**

Ecotoxicity Values:

LC50 Pimephales promelas (fathead minnow) 2160 mg/l 96 hr flow-through bioassay, wt 0.12 g, water hardness 45.5 mg/l CaCO3, temp: 25 + or - 1 deg C, pH 7.5, dissolved oxygen greater than 60% of saturation
[Veith GD et al; Canadian J Fisheries Aquat Sci 40 (6): 743-8 (1983)]**PEER REVIEWED**

TSCA Test Submissions:

Tetrahydrofuran (CAS# 109-99-9) was evaluated for the effect on cell proliferation. F344/N rats and B6C3F1 mice were exposed to **tetrahydrofuran** at concentrations of 0, 200, 600, and 1800 ppm in a 13-week inhalation toxicity study sponsored by NTP (NTP TR475). The kidneys of male rats and the

livers of female mice (10/species/exposure group) were embedded in paraplast, then processed and stained for the Proliferating Cell Nuclear Antigen (PCNA). There was a slight increase in PCNA in the liver of mice from the high dose group with a minimal decrease in the other groups. The rat kidneys showed a minimal decrease in all tubular compartments, being most pronounced in the low dose group. Because the study was based on a single time point observation and there was no clear increase in cell proliferation, no conclusions could be drawn concerning the tumorigenicity potential of **tetrahydrofuran**.
[Tetrahydrofuran Task Force; Tetrahydrofuran (THF) Study on Cell Proliferation in F344/N Rats and B6C3F1 Mice; 8/31/98; EPA Doc No. 86-990000001; Fiche No. OTS0573851]**UNREVIEWED**

Tetrahydrofuran (CAS# 109-99-9) was evaluated for developmental toxicity. In part I of the experiment the test material was administered to 14, 7, 7, 7, and 7 CD rats by inhalation at exposure levels of 0, 200, 500, 2500, and 5000 ppm, respectively on gestational days 6-15. In part II, 29, 87, and 38 CD rats were administered the test material by inhalation at exposure levels of 0, 1000, and 5000 ppm, respectively from days 6-15 of gestation. In both parts I and II, no maternal deaths occurred but the 5000 ppm exposure induced significant decreases in feed consumption ($p<0.05$) and body weight gain ($p<0.05$) along with absence of response to noise stimulus during the exposure period, followed by lethargy and incoordination for 1 hour post-exposure. No toxic responses were observed at 200 or 500 ppm (part I). At 1000 ppm (part II) and 2500 ppm (part I) only a reduced response to a noise stimulus was observed in comparison to controls. The mean number of implantations per dam and the incidence of malformed fetuses were not exposure related (among part I or part II). At 5000 ppm, the fetal variations of reduced weight and less ossified sternae were significantly different ($p<0.05$) from controls (for both part I and part II). Embryotoxicity expressed as developmental delay occurred at 5000 ppm.
[E I DuPont De Nemours & Co; Tetrahydrofuran (THF) Inhalation Effect on the Rat Conceptus; 1982; EPA Doc No. 86-940000744S; Fiche No. OTS0557154]**UNREVIEWED**

Tetrahydrofuran (CAS #109-99-9) was evaluated for subchronic toxicity in dogs (breed not specified). Four dogs were exposed (6 hrs./5 days/9 wks.) to the test material at 200 ppm (average weekly concentration) followed by 366 ppm (average weekly exposure) for 3 additional weeks at 6 hrs./5 days/week for a total of 12 weeks. Two of the four dogs were then exposed an additional two successive days to 2,100 ppm (approximate). Blood pressure measurements were taken morning and afternoon four weeks preceding exposure period (control period) and before and after daily exposures. A decrease in pulse pressure was noted in 3 dogs after 3 to 4 weeks' exposure at 200 ppm accompanied by a decrease in systolic pressure in 2 dogs (153-B & 153-C), while the third (153-A) experienced an increase in diastolic pressure. In general, two dogs (153-A & 153-D) showed an increase in diastolic and systolic pressure, dog# 153-B showed an increase in diastolic pressure, and dog# 153-C showed a steady drop in systolic and diastolic pressure. At 366 ppm, blood pressure was decreased in 3 of 4 dogs. When exposed to 2,100 ppm (dogs #153-A & 153-C), the diastolic, systolic, and pulse pressure dropped sharply on the second day. Dog #153-C showed a steady drop in hemoglobin count and a considerably higher than control level white blood count. There were no other significant gross or microscopic effects observed in the heart, lungs, spleen, pancreas, or kidney.
[E I DuPont De Nemours & Co; Toxicity of Tetrahydrofuran; 1947; EPA Doc No. 86940000738S; Fiche No. OTS0557148]**UNREVIEWED**

Metabolism/Pharmacokinetics:

Metabolism/Metabolites:

In vitro studies indicated that THF was first hydroxylated by the microsomal enzymes and further cleaved to the straight chain fatty acid in the presence of cytosol.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of

the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1518]**PEER REVIEWED**

Absorption, Distribution & Excretion:

EXCRETION OF **TETRAHYDROFURAN** IN MOTHER'S MILK REPORTED IN 1 OF 12 SAMPLES COLLECTED IN 4 URBAN AREAS IN NEW JERSEY, PENNSYLVANIA, AND LOUISIANA.
[PELLIZZARI ED ET AL; BULL ENVIRONM CONTAM TOXICOL 28: 322-8 (1982)]**PEER REVIEWED**

Adult male rats exposed to **tetrahydrofuran** vapor at 8.2 (200 ppm), 41 (1,000 ppm) or 82 mumol/l (2,000 ppm) for 2 to 18 weeks, five days a week, 6 hrs daily, showed dose-dependent brain and perirenal fat solvent burden linearly correlated to each other. After two weeks of exposure, the body burden of **tetrahydrofuran** seems to decrease. This might have been caused by increased oxidative metabolism as enhanced 7-ethoxycoumarin-O-deethylase activity was detected in liver and kidneys in the second week and onwards. The exposure also caused inhibition of alcohol and formaldehyde dehydrogenase activities in liver at the highest dose. Biochemical effects in the cerebellum were not detected, while gluteal muscle specimens showed increased succinate dehydrogenase activity in a dose-related manner. This points to effects on the energy metabolism. Muscle acetylcholine esterase activity was also increased showing possible effects on the myoneural junctions.
[Elovaara E et al; Acta Pharmacol Toxicol 54 (3): 221-6 (1984)]**PEER REVIEWED**

When healthy volunteers were exposed at 100 or 400 ppm THF in air, the percentage of expired THF was 35% in males with normal breathing, 25% in males with deep breathing, and 19% in females with deep breathing. Three hour exposures at 50 ppm THF resulted in 40% expiration of THF in males with normal breathing and 27% in males with deep breathing. The elimination half life of THF was 30 minutes. In subjects exposed at 50 ppm THF in air for 6 hours, traces of THF were present at 3 hours after the end of exposure. In individuals exposed at 200 ppm THF for 3 hours, THF blood concn were higher at 1 hour after the end of exposure than immediately after cessation of exposure.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1518]**PEER REVIEWED**

Biological Half-Life:

When healthy volunteers were exposed at 100 or 400 ppm THF in air, ... the elimination half life of THF was 30 minutes.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1518]**PEER REVIEWED**

Pharmacology:

Environmental Fate & Exposure:

Environmental Fate/Exposure Summary:

Tetrahydrofuran's production and use as a solvent for natural and synthetic resins and in organic synthesis may result in its release to the environment through various waste streams. If released to air, a vapor pressure of 162 mm Hg at 25 deg C indicates **tetrahydrofuran** will exist solely as a vapor in the ambient atmosphere. Vapor-phase **tetrahydrofuran** will be degraded in the atmosphere by reaction with

photochemically-produced hydroxyl and nitrate radicals; the half-life for these reactions in air are about 1 and 3 days, respectively. If released to soil, **tetrahydrofuran** is expected to have very high mobility based upon Koc values of 23 and 18. Volatilization from moist soil surfaces is expected to be an important fate process based upon a Henry's Law constant of 7.1X10-5 atm-cu m/mole. **Tetrahydrofuran** may volatilize from dry soil surfaces based upon its vapor pressure. **Tetrahydrofuran** added to surface soil had an abiotic half-life of 5.7 days. If released into water, **tetrahydrofuran** is not expected to adsorb to suspended solids and sediment based upon the Koc. **Tetrahydrofuran** is expected to biodegrade under aerobic conditions but may be resistant to biodegradation in anaerobic environments. In the modified MITI screening test, **tetrahydrofuran** at 30 mg/l was completely biodegraded in 14 days using an activated sludge inoculum. **Tetrahydrofuran** at 50 mg C/l was resistant to anaerobic biodegradation with a lag period of greater than 60 days using a primary digesting sludge as an inoculum. Volatilization from water surfaces is expected to be an important fate process based upon this compound's Henry's Law constant. Estimated volatilization half-lives for a model river and model lake are 13.1 hrs and 6.6 days, respectively. An estimated BCF of 3 suggests the potential for bioconcentration in aquatic organisms is low. Hydrolysis is not expected to occur due to the lack of hydrolyzable functional groups. Occupational exposure to **tetrahydrofuran** may occur through inhalation and dermal contact with this compound at workplaces where **tetrahydrofuran** is produced or used. (SRC)
PEER REVIEWED

Probable Routes of Human Exposure:

Tetrahydrofuran can affect the body if it is inhaled, swallowed, or comes in contact with the eyes or skin.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.1]**PEER REVIEWED**

90,000 workers in 3,000 plants are exposed from the following industries: special trade contractors, chem and allied products, electric gas & sanitary services. Occupations with potential exposure are electricians, agriculture and biological technicians, and electric power linemen and cablemen.
[NIOSH. National Occupational Hazard Survey as cited in Chemical Selection Working Group Profile #446: Tetrahydrofuran (1979)]**PEER REVIEWED**

Worker exposure during application of coatings to cellophane film by an open process was evaluated. Maximum THF vapor concn was 20 ppm. During rethreading operation 10-46 ppm (TWA) were reported and exposure of hands to liquid THF occurred.
[Rosensteel RE, Thoburn TW; Health Haz Evaluation, Olin Corp, Pisgah Forest, NC, Toxicity Determination Report 74-4-175 (1975) as cited in Hazard Profile: Exposure Information on THF p.9 (1979)]**PEER REVIEWED**

Workers were exposed to THF while joining PVC casing to PVC pipe with cement containing THF. Of 4 conc measured, 1 registered 20 ppm for a 20 min period.
[Gilles D, Hatch L; Health Hazard Evaluation, Water Well Drilling Companies, W Tennessee Gov Rep Announce Index (US) 77 (1): 104 (1976) as cited in Hazard Profile: Exposure Information on THF p9 (1979)]**PEER REVIEWED**

NIOSH (NOES Survey 1981-1983) has statistically estimated that 303,049 workers (24,842 of these are female) are potentially exposed to **tetrahydrofuran** in the US(1). Occupational exposure to **tetrahydrofuran** may occur through inhalation and dermal contact with this compound at workplaces where **tetrahydrofuran** is produced or used(SRC). Occupational exposure to **tetrahydrofuran** was studied in the air, blood, and urine of 58 male workers in a video tape manufacturing plant; exposure

was through inhalation of **tetrahydrofuran** vapors and direct dermal contact(2).
[(1) NIOSH; National Occupational Exposure Survey (NOES) (1983) (2) Ong CN et al; Brit J Indus Medicine 48: 616-621 (1991)]**PEER REVIEWED**

Body Burden:

In 4 urban areas, **tetrahydrofuran** was detected in Mother's milk in 1 of 12 samples(1).
[(1) Pellizzari ED et al; Bull Environ Toxicol 28: 322-8 (1982)]**PEER REVIEWED**

Artificial Pollution Sources:

Tetrahydrofuran's production and use as a solvent for natural and synthetic resins (e.g., vinyls), in top-coating solutions, and in organic synthesis(1) may result in its release to the environment through various waste streams(SRC).
[(1) Lewis RJ Sr, ed; Hawley's Condensed Chemical Dictionary. 13th ed. NY, NY: John Wiley and Sons Inc, p. 1087 (1997)]**PEER REVIEWED**

Environmental Fate:

TERRESTRIAL FATE: Based on a classification scheme(1), Koc values of 23 and 18(2), indicates that **tetrahydrofuran** is expected to have very high mobility in soil(SRC). Volatilization of **tetrahydrofuran** from moist soil surfaces is expected to be an important fate process(SRC) given a Henry's Law constant of 7.1X10-5 atm-cu m/mole(3). The potential for volatilization of **tetrahydrofuran** from dry soil surfaces may exist(SRC) based upon a vapor pressure of 162 mm Hg(4). **Tetrahydrofuran** is expected to biodegrade under aerobic conditions but may be resistant to biodegradation in anaerobic environments(SRC). In the modified MITI screening test, **tetrahydrofuran** at 30 mg/l was completely biodegraded in 14 days using an activated sludge inoculum(5); however, the EEC manometric respirometric method, tested in 22 different laboratories, gave a mean of 34% of the theoretical BOD within 28 days(6). **Tetrahydrofuran** at 50 mg C/l was resistant to anaerobic biodegradation with a lag period of greater than 60 days (the incubation period) using a primary digesting sludge as an inoculum; no gas production was seen during this time(7). **Tetrahydrofuran**, added to the surface of 2 different soil samples which had been sterilized to prevent microbial degradation, had a disappearance half-life of 5.7 days(8).
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Walton BT et al; J Environ Qual 21: 552-58 (1992) (3) Cabani S et al; Trans Faraday Soc 67: 1943-50 (1971) (4) Daubert TE, Danner RP; Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation, NY: Hemisphere Pub Corp (1989) (5) Chemicals Inspection and Testing Institute; Japan Chemical Industry Ecology-Toxicology and Information Center. ISBN 4-89074-101-1 (1992) (6) Painter HA, King EF; Ring Test Program 1983-84. Assessment of Biodegradability of Chemicals in Water by Manometric Respirometry. Comm Eur Communities, Eur 9962 (1985) (7) Battersby NS, Wilson V; Appl Environ Microbiol 55: 433-39 (1989) (8) Anderson TA et al; J Environ Qual 20: 420-24 (1991)]**PEER REVIEWED**

AQUATIC FATE: Based on a classification scheme(1), Koc values of 23 and 18(2) indicates that **tetrahydrofuran** should not adsorb to suspended solids and sediment(SRC). Volatilization from water surfaces is expected(3) based upon a Henry's Law constant of 7.1X10-5 atm-cu m/mole(4). Using this Henry's Law constant and an estimation method(3), volatilization half-lives for a model river and model lake are 13.1 hrs and 6.6 days, respectively(SRC). According to a classification scheme(5), an estimated BCF of 3(SRC), from its log Kow of 0.46(6) and a regression-derived equation(7), suggests the potential for bioconcentration in aquatic organisms is low(SRC). **Tetrahydrofuran** is expected to biodegrade under aerobic conditions but may be resistant to biodegradation in anaerobic environments(SRC). In the modified MITI screening test, **tetrahydrofuran** at 30 mg/l was completely biodegraded in 14 days using an activated sludge inoculum(8); however, the EEC manometric respirometric method, tested in 22

different laboratories, gave a mean of 34% of the theoretical BOD within 28 days(9). **Tetrahydrofuran** at 50 mg C/l was resistant to anaerobic biodegradation with a lag period of greater than 60 days (the incubation period) using a primary digesting sludge as an inoculum; no gas production was seen during this time(10).
[(1) Swann RL et al; Res Rev 85: 17-28 (1983) (2) Walton BT et al; J Environ Qual 21: 552-58 (1992) (3) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 4-9, 15-1 to 15-29 (1990) (4) Cabani S et al; Trans Faraday Soc 67: 1943-50 (1971) (5) Franke C et al; Chemosphere 29: 1501-14 (1994) (6) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 9 (1995) (7) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999) (8) Chemicals Inspection and Testing Institute; Japan Chemical Industry Ecology-Toxicology and Information Center. ISBN 4-89074-101-1 (1992) (9) Painter HA, King EF; Ring Test Program 1983-84. Assessment of Biodegradability of Chemicals in Water by Manometric Respirometry. Comm Eur Communities, Eur 9962 (1985) (10) Battersby NS, Wilson V; Appl Environ Microbiol 55: 433-39 (1989)]**PEER REVIEWED**

ATMOSPHERIC FATE: According to a model of gas/particle partitioning of semivolatile organic compounds in the atmosphere(1), **tetrahydrofuran**, which has a vapor pressure of 162 mm Hg at 25 deg C(2), will exist solely as a vapor in the ambient atmosphere(SRC). Vapor-phase **tetrahydrofuran** is degraded in the atmosphere by reaction with photochemically-produced hydroxyl radicals and nitrate radicals(SRC); the half-lives for these reactions in air are about 1 day(3) and 3 days(4), respectively. Butyrolactone and alpha-hydroxytetrahydrofuran were formed as products during the photooxidation of **tetrahydrofuran**(5).
[(1) Bidleman TF; Environ Sci Technol 22: 361-367 (1988) (2) Daubert TE, Danner RP; Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation, NY: Hemisphere Pub Corp (1989) (3) Atkinson R; J Phys Chem Ref Data. Monograph 1 (1989) (4) Atkinson R et al; J Phys Chem 92: 3454-57 (1988) (5) Stenberg VI et al; J Org Chem 35: 1774-77 (1970)]**PEER REVIEWED**

Environmental Biodegradation:

At concns of 0.5, 5 and 10 mg/l, THF was detected in distilled water for 1-2, 6-8 and 10 days, respectively. In presence of microbial contamination degradation took 2-3 days less. The chemical and biochemical oxidation of THF is accompanied by considerable consumption of dissolved O2.
[Pozdnyakova AG; Gig Sanit 34 (9): 114 (1969) as cited in USEPA; Chem Hazard Info Profile: THF p. 258 (1979)]**PEER REVIEWED**

Tetrahydrofuran at 50 mg C/l was resistant to anaerobic biodegradation with a lag period of greater than 60 days (the incubation period) using a primary digesting sludge as an inoculum; no gas production was seen during this time(1). In the prolonged Closed Bottle Test, using an activated sludge inoculum, **tetrahydrofuran** reached 39, 57 and 61 % of the theoretical BOD in 28, 42, and 56 days, respectively(2). Using the EEC manometric respirometric method in 22 different laboratories, **tetrahydrofuran** reached a mean of 34% of the theoretical BOD within 28 days(3). In the modified MITI screening test, **tetrahydrofuran** at 30 mg/l was completely biodegraded in 14 days using an activated sludge inoculum(4).
[(1) Battersby NS, Wilson V; Appl Environ Microbiol 55: 433-39 (1989) (2) Van Ginkel CG, Stroo CA; Ecotoxicol Environ Safety 24: 319-27 (1992) (3) Painter HA, King EF; Ring Test Program 1983-84. Assessment of Biodegradability of Chemicals in Water by Manometric Respirometry. Comm Eur Communities, Eur 9962 (1985) (4) Chemicals Inspection and Testing Institute; Japan Chemical Industry Ecology-Toxicology and Information Center. ISBN 4-89074-101-1 (1992)]**PEER REVIEWED**

Greater than 90% removal of **tetrahydrofuran**, at an initial concentration of 1.082 mg/l, was seen following activated sludge treatment; using a biological aerated filter reactor, **tetrahydrofuran**, at 496 ug/l, had a removal of 54%(1). A pilot-scale activated sludge system, operated at a hydraulic retention

time of 7.5 hours and a flow rate of 35 gpm gave an average removal of 76.4% for **tetrahydrofuran**; an average of 10.2% of this was due to stripping, 1.2% was due to sludge adsorption(2). Biodegradation increased during this test(2) indicating some acclimation of the microbial population(SRC). Pilot-scale extended aeration wastewater treatment plants with dual media secondary effluent filters were able to completely remove **tetrahydrofuran** (initial concentrations between 50-100 ug/l) under both acclimated and non-acclimated conditions(3).
[(1) Clapp LW et al; Water Environ Res 66: 153-60 (1994) (2) Dobbs RA, Bhattacharya SK; pp 68-81 in USEPA 600/9-90-037. Proc 16th Ann Haz Waste Res Symp. Cincinnati, OH (1990) (3) Safferman SI, Bhattacharya SK; Treatability of RCRA Compounds in a BOD/Nitrification Wastewater Treatment System with Dual Media Filtration. Risk Reduction Engineering Laboratory Cincinnati, OH. USEPA/600/S2-90/013 (1990)]**PEER REVIEWED**

Environmental Abiotic Degradation:

The rate constant for the vapor-phase reaction of **tetrahydrofuran** with photochemically-produced hydroxyl radicals has been estimated as 1.6X10-11 cu cm/molecule-sec at 25 deg C(1). This corresponds to an atmospheric half-life of about 1 day at an atmospheric concentration of 5X10+5 hydroxyl radicals per cu cm(SRC). Butyrolactone and alpha-hydroxytetrahydrofuran were formed as products during the photooxidation of **tetrahydrofuran**(2). A rate constant for the vapor-phase reaction of **tetrahydrofuran** with nitrate radicals was measured as 4.88X10-15 cu cm/molecule sec(3). This corresponds to an atmospheric half-life of about 3 days(SRC) at an atmospheric concentration of 5X10+8 nitrate radicals per cu cm(4). **Tetrahydrofuran** is moderately reactive in photochemical smog conditions where nitrogen oxides are present; reactions occur in time scales of hours(5-7). Acrolein and formaldehyde have been reported as reaction products(6). **Tetrahydrofuran** is stable to photooxidation in water(8,9). **Tetrahydrofuran** is not expected to undergo hydrolysis in the environment due to the lack of hydrolyzable functional groups(10).
[(1) Atkinson R; J Phys Chem Red Data. Monograph 1 (1989) (2) Stenberg VI et al; J Org Chem 35:1774-77 (1970) (3) Atkinson R et al; J Phys Chem 92: 3454-57 (1988) (4) Kwok ESC et al; Environ Sci Technol 30: 329-334 (1996) (5) Levy A; Adv Chem Ser 124: 70-94 (1973) (6) Popav VA; Gig Sanit 36: 7-10 (1971) (7) Farley FF; pp. 713-27 in Inter Conf Photochem Oxidant Pollut Control. Wahsington, DC: USEPA-560/6/77-015A (1977) (8) Anbar M, Neta P; Int J Appl Radiation and Isotopes 18: 493-523 (1967) (9) Hendry DG et al; J Phys Chem Ref Data 3: 944-78 (1974) (10) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 7-4, 7-5 (1990)]**PEER REVIEWED**

Environmental Bioconcentration:

An estimated BCF of 3 was calculated for **tetrahydrofuran**(SRC), using a log Kow of 0.46(1) and a regression-derived equation(2). According to a classification scheme(3), this BCF suggests the potential for bioconcentration in aquatic organisms is low(SRC).
[(1) Hansch C et al; Exploring QSAR. Hydrophobic, Electronic, and Steric Constants. ACS Prof Ref Book. Heller SR, consult. ed., Washington, DC: Amer Chem Soc p. 9 (1995) (2) Meylan WM et al; Environ Toxicol Chem 18: 664-72 (1999) (3) Franke C et al; Chemosphere 29: 1501-14 (1994)]**PEER REVIEWED**

Soil Adsorption/Mobility:

Koc values of 23 and 18 were determined for **tetrahydrofuran** using a zero headspace extractor vessel in Captina silt loam (pH = 4.97, organic carbon = 1.49%) and McLaurin sandy loam (pH = 4.43, organic carbon=0.66%), respectively(1). According to a classification scheme(2), this estimated Koc value suggests that **tetrahydrofuran** is expected to have very high mobility in soil(SRC). A retardation factor of 1.0 was measured for **tetrahydrofuran** in a ground water system in Indiana(3). A retardation factor of

2.2, based on plume length, was measured for **tetrahydrofuran** in an aquifer beneath a landfill in Ottawa, Ontario(4). A column packed with aquifer material was used to measure a retardation factor of 1.2 for **tetrahydrofuran**(5).
[(1) Walton BT et al; J Environ Qual 21: 552-58 (1992) (2) Swann RL et al; Res Rev 85: 23 (1983) (3) Nyer EK et al; Ground Water Monitoring Rev 11: 80-82 (1991) (4) Patterson RJ et al; Wat Sci Tech 17: 57-69 (1985) (5) Priddle MW, Jackson RE; Ground Water 29: 260-66 (1991)]**PEER REVIEWED**

Volatilization from Water/Soil:

The Henry's Law constant for **tetrahydrofuran** is 7.1X10-5 atm-cu m/mole(1). This Henry's Law constant indicates that **tetrahydrofuran** is expected to volatilize from water surfaces(2). Based on this Henry's Law constant, the volatilization half-life from a model river (1 m deep, flowing 1 m/sec, wind velocity of 3 m/sec)(2) is estimated as 13.1 hours(SRC). The volatilization half-life from a model lake (1 m deep, flowing 0.05 m/sec, wind velocity of 0.5 m/sec)(2) is estimated as 6.6 days(SRC). **Tetrahydrofuran**'s Henry's Law constant indicates that volatilization from moist soil surfaces may occur(SRC). The potential for volatilization of **tetrahydrofuran** from dry soil surfaces may exist(SRC) based upon a vapor pressure of 162 mm Hg(3).
[(1) Cabani S et al; Trans Faraday Soc 67: 1943-50 (1971) (2) Lyman WJ et al; Handbook of Chemical Property Estimation Methods. Washington, DC: Amer Chem Soc pp. 15-1 to 15-29 (1990) (3) Daubert TE, Danner RP; Physical and Thermodynamic Properties of Pure Chemicals: Data Compilation, NY: Hemisphere Pub Corp (1989)]**PEER REVIEWED**

Environmental Water Concentrations:

SURFACE WATER: The avg concn of **tetrahydrofuran** in 14 heavily industrialized river basins in the US (201 sites) was >1 ppb (29 sites positive; range, 1-318 ppb)(1). **Tetrahydrofuran** was identified in water samples taken from the Puerto Rico offshore industrial waste dumpsite in 1978 at unreported concentrations(2). **Tetrahydrofuran** was detected in the Dutch surface waters at concns ranging from 1.1 to 6.4 ug/l (detection limit = 0.03 ug/l)(3).
[(1) Ewing BB et al; Monitoring to Detect Previously Unrecognized Pollutants in Surface Water USEPA-560/6-77-015 p. 74 (1977) (2) Brooks JM et al; pp. 171-98 in Wastes Ocean V1 Duedall, IW ed. NY, NY: Wiley (1983) (3) Miermans CJH et al; Chemosphere 40: 39-48 (2000)]**PEER REVIEWED**

DRINKING WATER: **Tetrahydrofuran** was detected in treated drinking water at levels ranging from 0.2-0.8 ug/l in the Niagara River area(1). **Tetrahydrofuran** was detected in drinking water at unreported concentrations(2).
[(1) Komsta E et al; Bull Environ Contam Toxicol 41: 515-22 (1988) (2) Kool HJ et al; Crit Rev Env Control 12: 307-57 (1982)]**PEER REVIEWED**

GROUND WATER: **Tetrahydrofuran** was detected in 3 groundwater wells (maximum concn = 560 ug/l) in a study measuring VOCs in 51 Wisconsin solid waste landfills(1). **Tetrahydrofuran** was detected at unreported concentrations in groundwater on one Department of Energy research and defense production facility(2) and in groundwater from the Biscayne Aquifer Study area in Florida at a maximum concentration of 400 ug/l(3). **Tetrahydrofuran** was detected in an aquifer beneath the Gloucester Landfill near Ottawa, Canada where organic chemicals were disposed of between 1969 and 1980(4). Groundwater sampled under two waste disposal sites in Minnesota contained **tetrahydrofuran** at concentrations from 24-3900 ug/l(5). Leachates from 3 of 5 landfill sites in Connecticut contained **tetrahydrofuran**; Cheshire site = 60 ug/l, Norwich site = 20 ug/l, Danbury site = 330 ug/l(6). **Tetrahydrofuran** was detected in contaminated ground water in The Netherlands with a maximum concentration of 3 ug/l(7).
[(1) Battista JR, Connelly JP; VOC Contamination at Selected Wisconsin

Landfills-Sampling Results and Policy Implications. Wisconsin Dept of Natural Resources, Madison, WI 53707. Publ-SW-094-89 (1989) (2) Riley RG, Zachara JM; Chemical Contaminants of DOE Lands and Selection of Contaminant Mixtures for Subsurface Science Research. DOE/ER-05471 (NTIS DE92014826). Richland WA: Pac Northwest Lab (1993) (3) Canter LW, Sabatini DA; Intern J Environ Studies 46: 35-57 (1994) (4) Patterson RJ et al; Wat Sci Tech 17: 57-69 (1985) (5) Sabel GV, Clark TP; Waste Manag Res 2: 119-30 (1984) (6) Sawhney BL, Lozloski RP; J Environ Qual 13: 349-52 (1984) (7) Zoeteman BCJ et al; Sci Total Environ 21: 187-202 (1981)]**PEER REVIEWED**

Effluent Concentrations:

30 samples taken between 1973-1976 ranged from 0 ug/l (Olin Corp, Brandenbury, KY, Ohio River/Wabash River) to 450,000 ug/l (General Electric, Mt Vernon, IN, Ohio River). Other notably high concn were 1000 ug/l (M/T Chem, Carrloton, KY, Ohio River), 850 ug/l (Olin Corp, IN, Ohio River/ Wabash River), and 318 ug/l (Ashtabula, OH).
[EPA Storet data storage system as cited in Hazard Profile: Exposure Info on Tetrahydrofuran p.4-5 (1979)]**PEER REVIEWED**

Leachate from the Rochester Municipal Landfill contained **tetrahydrofuran** at 0.43 mg/l(1). Effluent samples taken from a plant that finished polyester fabrics contained **tetrahydrofuran** at unreported concentrations(2). **Tetrahydrofuran** was reported in the vehicle exhaust gases from a gasoline engine at unreported concentrations(3). Effluent from a sewage treatment plant in Barceloneta, Puerto Rico, receiving waste from several pharmaceutical industries contained **tetrahydrofuran** at unreported concentrations(4). Ambient air samples from 2 of 5 hazardous waste sites in New Jersey contained **tetrahydrofuran** at unreported concentrations(5).
[(1) Brown KW, Donnelly KC; Haz Waste Haz Mater 5: 1-26 (1988) (2) Gordon AW, Gordon M; Trans Ky Acad Sci 42: 149-57 (1981) (3) Hampton CV et al; Environ Sci Technol 16: 287-98 (1982) (4) Kennicutt MCII et al; Chemosphere 13: 535-48 (1984) (5) LaRegina J, Bozzelli JW; Environ Prog 5: 18-26 (1986)]**PEER REVIEWED**

20 of 1043 common household compounds contained **tetrahydrofuran** at unreported concentrations(1). **Tetrahydrofuran** was identified but not quantified as a volatile organic compound released from textile floor coverings(2). **Tetrahydrofuran** was identified as a major constituent of PVC primer and adhesive and was found to be leached into the water surrounding bonded joints at concentrations ranging from 215-63,000 ug/l (concentrations given for the first wash for 7 different products)(3); 6 and 8 months following PVC pipe installation **tetrahydrofuran** concentrations in the surrounding water were 13 and 7.5 ppm, respectively(5). Volatile organic compounds measured from a sludge landfill simulator contained **tetrahydrofuran** at unreported concentrations(4). The concn of **tetrahydrofuran** in landfill leachate ranges from 18 to 1,400 ug/l(6).
[(1) Sack TM et al; Atmos Environ 26A: 1063-70 (1992) (2) Sollinger S et al; Atmos Environ 28: 2369-78 (1994) (3) Sosebee JBJR et al; Contamination of Groundwater Samples with Poly(Vinyl Chloride) Adhesives and Poly(Vinyl Chloride) Primer from Monitor Wells. ASTM Spec Tech Publ 805. (Hazar Ind Solid Waste Test): 38-50 (1983) (4) Vogt WG, Walsh JJ; in Proc - APCA Annu Meet. 78th. 6: 1-17 (1985) (5) Wang TC, Bricker JL; Bull Environ Contam Toxicol 23: 620-23 (1979) (6) Roy WR; p. 418 in Contam Groundwaters. Adriano DC et al, eds. Northwood, England: Sci Rev (1994)]**PEER REVIEWED**

Sediment/Soil Concentrations:

Tetrahydrofuran was detected at unreported concentrations in soil on one Department of Energy research and defense production facility(1).
[(1) Riley RG, Zachara JM; Chemical Contaminants of DOE Lands and Selection of Contaminant Mixtures for Subsurface Science Research. DOE/ER-05471 (NTIS DE92014826). Richland WA: Pac Northwest Lab (1993)]**PEER REVIEWED**

Atmospheric Concentrations:

Atmospheric air 500 m from a furan factory contained 0.173 mg/m3 **tetrahydrofuran**.
[Makeicheva; Inst Saint Gig Profzabol 8: 52 (1974) as cited in Hazard Profile: Exposure Information on THF p.9 (1979)]**PEER REVIEWED**

URBAN: Urban air samples, reported in the VOCs database update, from an unreported location(s) contained **tetrahydrofuran** at a median concentration of 0.283 ppbv(1).
[(1) Shah JJ, Heyerdahl EK; National Ambient Volatile Organic Compounds (VOCs) Database Update. USEPA/600/3-88/010 (1988)]**PEER REVIEWED**

INDOOR AIR: **Tetrahydrofuran** was detected at an average concentration of 1058 ug/cu m in new and recently renovated buildings(1).
[(1) Rothweiler H et al; Atmos Environ 26A: 2219-25 (1992)]**PEER REVIEWED**

Food Survey Values:

THF has been identified in coffee aroma.
[Fenarali's Handbook of Flavor Ingredients, 2nd ed p.664 (1975) as cited in Chemical Selection Working Groups Profile #446: Tetrahydrofuran (1979)]**PEER REVIEWED**

Tetrahydrofuran was detected as a volatile compound, isolated from floured chickpea seed(1). This compound was identified in the volatile component of cooked chicken(2).
[(1) Rembold H et al; J Agric Food Chem 37: 659-62 (1989) (2) Shahidi F et al; CRC Crit Rev Food Sci Nature 24: 141-243 (1986)]**PEER REVIEWED**

Milk Concentrations:

In 4 urban areas, **tetrahydrofuran** was detected in Mother's milk in 1 of 12 samples(1).
[(1) Pellizzari ED et al; Bull Environ Toxicol 28: 322-8 (1982)]**PEER REVIEWED**

Environmental Standards & Regulations:

TSCA Requirements:

Section 8(a) of TSCA requires manufacturers of this chemical substance to report preliminary assessment information concerned with production, exposure, and use to EPA as cited in the preamble in 51 FR 41329.
[40 CFR 712.30 (7/1/2001)]**PEER REVIEWED**

Pursuant to section 8(d) of TSCA, EPA promulgated a model Health and Safety Data Reporting Rule. The section 8(d) model rule requires manufacturers, importers, and processors of listed chemical substances and mixtures to submit to EPA copies and lists of unpublished health and safety studies. **Tetrahydrofuran** is included on this list.
[40 CFR 716.120 (7/1/2001)]**PEER REVIEWED**

A testing consent order is in effect for **tetrahydrofuran** for health effects testing. FR citation: 1/23/95.
[40 CFR 799.5000 (7/1/2001)]**PEER REVIEWED**

CERCLA Reportable Quantities:

Persons in charge of vessels or facilities are required to notify the National Response Center (NRC) immediately, when there is a release of this designated hazardous substance, in an amount equal to or

greater than its reportable quantity of 1000 lb or 454 kg. The toll free number of the NRC is (800) 424-8802; In the Washington D.C. metropolitan area (202) 426-2675. The rule for determining when notification is required is stated in 40 CFR 302.4 (section IV. D.3.b).
[40 CFR 302.4 (7/1/2001)]**PEER REVIEWED**

RCRA Requirements:

U213; As stipulated in 40 CFR 261.33, when **tetrahydrofuran**, as a commercial chemical product or manufacturing chemical intermediate or an off-specification commercial chemical product or a manufacturing chemical intermediate, becomes a waste, it must be managed according to Federal and/or State hazardous waste regulations. Also defined as a hazardous waste is any residue, contaminated soil, water, or other debris resulting from the cleanup of a spill, into water or on dry land, of this waste. Generators of small quantities of this waste may qualify for partial exclusion from hazardous waste regulations (40 CFR 261.5).
[40 CFR 261.33 (7/1/2001)]**PEER REVIEWED**

State Drinking Water Guidelines:

(MA) MASSACHUSETTS 1300 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(MI) MICHIGAN 230 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(NH) NEW HAMPSHIRE 154 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

(WI) WISCONSIN 50 ug/l
[USEPA/Office of Water; Federal-State Toxicology and Risk Analysis Committee (FSTRAC). Summary of State and Federal Drinking Water Standards and Guidelines (11/93)]**QC REVIEWED**

FDA Requirements:

Tetrahydrofuran is an indirect food additive for use only as a component of adhesives.
[21 CFR 175.105 (4/1/2001)]**PEER REVIEWED**

Chemical/Physical Properties:

Molecular Formula:

C4-H8-O
[Weast, R.C. and M.J. Astle. CRC Handbook of Data on Organic Compounds. Volumes I and II. Boca Raton, FL: CRC Press Inc. 1985.,p. V2 328]**PEER REVIEWED**

Molecular Weight:

72.11
[Lide, DR (ed.). CRC Handbook of Chemistry and Physics. 81st Edition. CRC Press LLC,

Boca Raton: FL 2000,p. 3-171]**PEER REVIEWED**

Color/Form:

Colorless, mobile liquid
[Sax, N.I. Dangerous Properties of Industrial Materials. Vol 1-3 7th ed. New York, NY: Van Nostrand Reinhold, 1989. 3208]**PEER REVIEWED**

Water-white liquid
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1087]**PEER REVIEWED**

Colorless liquid
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 302]**PEER REVIEWED**

Odor:

Ether-like odor
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1574]**PEER REVIEWED**

FAINT FRUITY ODOR
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Taste:

PUNGENT TASTE
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 2164]**PEER REVIEWED**

Boiling Point:

65 deg C @ 760 mm Hg
[Lide, DR (ed.). CRC Handbook of Chemistry and Physics. 81st Edition. CRC Press LLC, Boca Raton: FL 2000,p. 3-171]**PEER REVIEWED**

Melting Point:

-108.3 deg C
[Lide, DR (ed.). CRC Handbook of Chemistry and Physics. 81st Edition. CRC Press LLC, Boca Raton: FL 2000,p. 3-171]**PEER REVIEWED**

Corrosivity:

Tetrahydrofuran will attack some forms of plastics, rubber, and coatings.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Critical Temperature & Pressure:

Critical temperature: 268.0 deg C; critical pressure: 51.2 atm

[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 536]**PEER REVIEWED**

Density/Specific Gravity:

0.8892 @ 20 deg C
[Lide, DR (ed.). CRC Handbook of Chemistry and Physics. 81st Edition. CRC Press LLC, Boca Raton: FL 2000,p. 3-171]**PEER REVIEWED**

Heat of Combustion:

-14,990 BTU/lb= -8330 cal/g= -348.8X10+5 J/kg
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Heat of Vaporization:

180 BTU/lb= 98.1 cal/g= 4.1X10+5 J/kg
[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 546]**PEER REVIEWED**

Octanol/Water Partition Coefficient:

Log Kow= 0.46
[Hansch, C., Leo, A., D. Hoekman. Exploring QSAR - Hydrophobic, Electronic, and Steric Constants. Washington, DC: American Chemical Society., 1995. 9]**PEER REVIEWED**

Solubilities:

30% IN WATER @ 25 DEG C
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 2164]**PEER REVIEWED**

Miscible with alcohols, ketones, esters, hydrocarbons, and ethers.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1574]**PEER REVIEWED**

Very soluble in acetone, benzene, ether, ethanol, and chloroform
[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994.,p. V3 2868]**PEER REVIEWED**

Miscible in water at 25 deg C
[Riddick, J.A., W.B. Bunger, Sakano T.K. Techniques of Chemistry 4th ed., Volume II. Organic Solvents. New York, NY: John Wiley and Sons., 1985. 309]**PEER REVIEWED**

Spectral Properties:

Index of refraction: 1.4050 @ 20 deg C/D
[Lide, DR (ed.). CRC Handbook of Chemistry and Physics. 81st Edition. CRC Press LLC, Boca Raton: FL 2000,p. 3-171]**PEER REVIEWED**

UV cutoff for spectro grade: 220 NM
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1574]**PEER REVIEWED**

Tetrahydrofuran, 99.5%, exhibits its two strongest infrared absorption bands at wavelengths of 9.4 and 11.0 microns.
[Aldrich; The Aldrich Microfiche Library of Chemical Indices (1983)]**PEER REVIEWED**

UV Absorbance, maximum: 1.00 at 225 nm, 0.50 at 240 nm, 0.25 at 250 nm, 0.08 at 270 nm, 0.02 at 290 nm, 0.01 at 320-400 ppm /'Photrex' Reagent, for spectrometry, 1.00 cm path length vs distilled water/
[JT Baker Chemical Co; Reagents and Laboratory Products Catalog 860C p.137 (1986)]**PEER REVIEWED**

IR: 74 (Sadtler Research Laboratories Prism Collection)
[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994.,p. V3 2868]**PEER REVIEWED**

1H-NMR: 77 (Varian Associates NMR Spectra Catalogue)
[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994.,p. V3 2868]**PEER REVIEWED**

MASS: 61288 (NIST/EPA/MSDC Mass Spectral Database 1990 Version)
[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994.,p. V3 2868]**PEER REVIEWED**

13C-NMR: 73 (Johnson and Jankowski: Carbon-13 NMR Spectra, J Wiley and Sons, NY)
[Lide, D.R., G.W.A. Milne (eds.). Handbook of Data on Organic Compounds. Volume I. 3rd ed. CRC Press, Inc. Boca Raton ,FL. 1994.,p. V3 2868]**PEER REVIEWED**

Surface Tension:

26.4 dynes/cm @ 25 deg C
[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 536]**PEER REVIEWED**

Vapor Density:

2.56 (Air= 1)
[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 536]**PEER REVIEWED**

Vapor Pressure:

1.62X10+2 mm Hg @ 25 deg C
[Daubert, T.E., R.P. Danner. Physical and Thermodynamic Properties of Pure Chemicals Data Compilation. Washington, D.C.: Taylor and Francis, 1989.]**PEER REVIEWED**

Relative Evaporation Rate:

8 (Butyl acetate= 1)
[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 536]**PEER REVIEWED**

Viscosity:

0.53 cP @ 20 deg C
[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 536]**PEER REVIEWED**

Other Chemical/Physical Properties:

CONVERSION FACTOR: 1 PPM= 2.94 MG/CU M; 1 MG/L= 340 PPM
[Browning, E. Toxicity and Metabolism of Industrial Solvents. New York: American Elsevier, 1965. 700]**PEER REVIEWED**

RATIO OF SPECIFIC HEATS OF VAPOR (GAS): (EST) 1.083
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Saturated liquid density: 55.230 lb/cu ft; saturated vapor pressure: 2.913 lb/sq in; saturated vapor density: 0.03660 lb/cu ft (all at 75 deg F)
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Liquid heat capacity: 0.401 BTU/lb-F at 70 deg F
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Ideal gas heat capacity: 0.375 BTU/lb-F at 100 deg F
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Dielectric constant: 7.4 at 25 deg C
[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 536]**PEER REVIEWED**

Electrical conductivity: 1.5X10-8 mohm/cm @ 25 deg C
[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 536]**PEER REVIEWED**

Dipole moment: 1.75 debyes @ 25 deg C
[Flick, E.W. (ed.). Industrial Solvents Handbook 4 th ed. Noyes Data Corporation., Park Ridge, NJ., 1991. 536]**PEER REVIEWED**

Enthalpy of formation: -51.67 kcal/mole (liquid)
[Dean, J.A. Handbook of Organic Chemistry. New York, NY: McGraw-Hill Book Co., 1987.,p. 5-38]**PEER REVIEWED**

Enthalpy of sublimation @ 298 K: 7.65 kcal/mole
[Dean, J.A. Handbook of Organic Chemistry. New York, NY: McGraw-Hill Book Co., 1987.,p. 5-72]**PEER REVIEWED**

Critical volume: 224 cu cm/mole
[Dean, J.A. Handbook of Organic Chemistry. New York, NY: McGraw-Hill Book Co., 1987.,p. 5-88]**PEER REVIEWED**

Vapor pressure = 0.06 atm at 0 deg C, 0.11 atm at 10 deg C, 0.173 atm at 20 deg C, 0.26 atm at 30 deg C

[Verschueren, K. Handbook of Environmental Data on Organic Chemicals. Volumes 1-2. 4th ed. John Wiley & Sons. New York, NY. 2001 1972]**PEER REVIEWED**

Henry's law constant: 7.05X10-5 atm-cu m/mole @ 25 deg C
[Cabani S et al; Trans Faraday Soc 67: 1943-50 (1971)]**PEER REVIEWED**

Hydroxyl radical reaction rate constant: 1.61X10-11 cu cm/molecule-sec @ 25 deg C
[Atkinson R; J Phys Chem Ref Data. Monograph 1 (1989)]**PEER REVIEWED**

Chemical Safety & Handling:

Hazards Summary:

Tetrahydrofuran (THF) is a very hazardous substance due primarily to its flammable and explosive properties. Toxicity is also of concern and must be considered in the safe handling and storage of THF. Irritation from dermal contact with THF warrants the wearing of neoprene gloves and safety glasses for protection during the routine handling of this substance. Toxic, as well as flammable, concentrations of THF in air can be avoided by compliance with the TLV of 200 ppm. However, in emergency situations, such as fires involving THF or when the Short Term Exposure Limit (STEL) of 250 ppm is exceeded, a self-contained breathing apparatus and an approved organic vapor cannister, respectively, are needed. THF is highly volatile with a low flash point (1 deg F) and flammability limit of 2%. Its heavier-than-air vapors can travel at low profile for considerable distances and flash back to the point of origin. Further, unstabilized THF forms peroxides upon exposure to air or light, which, if allowed to accumulate above 1% become thermally explosive. THF also reacts explosively with lithium-aluminum alloys. In consideration of the above, THF should be contained in tightly sealed dark glass bottles or steel drums affixed with the DOT-required label, "Flammable Liquid". Should THF leak from containment vessels, its faint, fruity smell, is detectable at 50 ppm and may serve as a warning. Containers should be stored in cool, dark, well-ventilated areas, away from ignition sources and oxidizing materials. Should a THF fire occur, it may be combated with dry chemical or CO2 extinguishants. Water may be ineffective in firefighting. However, if a leak or spill has not ignited, it may be flushed with water for cooling and diluting if conditions of ignition threaten. Knock down vapors with water spray. Spills or leaks should be absorbed with paper or dissolved in petroleum ether or alcohol (of a higher molecular weight than butyl alcohol); then collected and removed for outdoor evaporation or safe incineration.
PEER REVIEWED

DOT Emergency Guidelines:

Fire or explosion: HIGHLY FLAMMABLE: Will be easily ignited by heat, sparks or flames. Vapors may form explosive mixtures with air. Vapors may travel to source of ignition and flash back. Most vapors are heavier than air. They will spread along ground and collect in low or confined areas (sewers, basements, tanks). Vapor explosion hazard indoors, outdoors or in sewers. Those substances designated with a "P" may polymerize explosively when heated or involved in a fire. Runoff to sewer may create fire or explosion hazard. Containers may explode when heated. Many liquids are lighter than water.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-127]**QC REVIEWED**

Health: Inhalation or contact with material may irritate or burn skin and eyes. Fire may produce irritating, corrosive and/or toxic gases. Vapors may cause dizziness or suffocation. Runoff from fire control may cause pollution.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-127]**QC REVIEWED**

Public safety: CALL Emergency Response Telephone Number ... . Isolate spill or leak area immediately for at least 25 to 50 meters (80 to 160 feet) in all directions. Keep unauthorized personnel away. Stay upwind. Keep out of low areas. Ventilate closed spaces before entering.

[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-127]**QC REVIEWED**

Protective clothing: Wear positive pressure self-contained breathing apparatus (SCBA). Structural firefighters' protective clothing will only provide limited protection.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-127]**QC REVIEWED**

Evacuation: ... Fire: If tank, rail car or tank truck is involved in a fire, ISOLATE for 800 meters (1/2 mile) in all directions; also, consider initial evacuation for 800 meters (1/2 mile) in all directions.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-127]**QC REVIEWED**

Fire: CAUTION: All these products have a very low flash point: Use of water spray when fighting fire may be inefficient. Small fires: Dry chemical, CO2, water spray or alcohol-resistant foam. Large fires: Water spray, fog or alcohol-resistant foam. Use water spray or fog; do not use straight streams. Move containers from fire area if you can do it without risk. Fire involving Tanks or Car/Trailer loads: Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Cool containers with flooding quantities of water until well after fire is out. Withdraw immediately in case of rising sound from venting safety devices or discoloration of tank. ALWAYS stay away from tanks engulfed in fire. For massive fire, use unmanned hose holders or monitor nozzles; if this is impossible, withdraw from area and let fire burn.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-127]**QC REVIEWED**

Spill or leak: ELIMINATE all ignition sources (no smoking, flares, sparks or flames in immediate area). All equipment used when handling the product must be grounded. Do not touch or walk through spilled material. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. A vapor suppressing foam may be used to reduce vapors. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. Use clean non-sparking tools to collect absorbed material. Large spills: Dike far ahead of liquid spill for later disposal. Water spray may reduce vapor; but may not prevent ignition in closed spaces.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-127]**QC REVIEWED**

First aid: Move victim to fresh air. Call 911 or emergency medical service. Apply artificial respiration if victim is not breathing. Administer oxygen if breathing is difficult. Remove and isolate contaminated clothing and shoes. In case of contact with substance, immediately flush skin or eyes with running water for at least 20 minutes. Wash skin with soap and water. Keep victim warm and quiet. Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.
[U.S. Department of Transportation. 2000 Emergency Response Guidebook. RSPA P 5800.8 Edition. Washington, D.C: U.S. Government Printing Office, 2000,p. G-127]**QC REVIEWED**

Odor Threshold:

20-50 ppm
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

7.3-10.2 mg/cu m (recognition in air)
[Verschueren, K. Handbook of Environmental Data of Organic Chemicals. 2nd ed. New York, NY: Van Nostrand Reinhold Co., 1983. 1089]**PEER REVIEWED**

Low: 7.37 mg/cu m; High: 177.0 mg/cu m /From table/
[Ruth JH; Am Ind Hyg Assoc J 47: A-142-51 (1986)]**PEER REVIEWED**

Skin, Eye and Respiratory Irritations:

Strong irritant to skin & mucous membranes ...
[Gosselin, R.E., R.P. Smith, H.C. Hodge. Clinical Toxicology of Commercial Products. 5th ed. Baltimore: Williams and Wilkins, 1984.,p. II-408]**PEER REVIEWED**

Vapor: Irritating to eyes, nose and throat. ... Liquid: Irritating to skin and eyes.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Fire Potential:

Flammable, dangerous fire risk.
[Sax, N.I. and R.J. Lewis, Sr. (eds.). Hawley's Condensed Chemical Dictionary. 11th ed. New York: Van Nostrand Reinhold Co., 1987. 1135]**PEER REVIEWED**

A very dangerous fire hazard when exposed to heat, flame, oxidizers.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 3108]**PEER REVIEWED**

NFPA Hazard Classification:

Health: 2. 2= Materials that, on intense or continued (but not chronic) exposure, could cause temporary incapacitation or possible residual injury, including those requiring the use of respiratory protective equipment that has an independent air supply. These materials are hazardous to health, but areas may be entered freely if personnel are provided with full-face mask self-contained breathing apparatus that provides complete eye protection.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-85]**PEER REVIEWED**

Flammability: 3. 3= This degree includes Class IB and IC flammable liquids and materials that can be easily ignited under almost all normal temperature conditions. Water may be ineffective in controlling or extinguishing fires in such materials.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-85]**PEER REVIEWED**

Reactivity: 1. 1= This degree includes materials that are normally stable, but that may become unstable at elevated temperatures and pressures and materials that will react with water with some release of energy, but not violently. Fires involving these materials should be approached with caution.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 325-85]**PEER REVIEWED**

Flammable Limits:

LOWER: 2% UPPER: 11.8% (% BY VOL)
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-126]**PEER REVIEWED**

Flash Point:

6 deg F (closed cup); -4 deg F (open cup)
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

-14.5 deg C (closed cup)
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1415]**PEER REVIEWED**

Autoignition Temperature:

321 DEG C (610 DEG F)
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-126]**PEER REVIEWED**

Fire Fighting Procedures:

Approach fire from upwind to avoid hazardous vapors and toxic decompositions. Use water spray, dry chemical, "alcohol resistant" foam, or carbon dioxide. Use water spray to keep fire-exposed containers cool.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-126]**PEER REVIEWED**

If material on fire or involved in fire: Do not extinguish fire unless flow can be stopped or safely confined. Use water in flooding quantities as fog. Solid streams of water may be ineffective. Cool all affected containers with flooding quantities of water. Apply water from as far a distance as possible. Use "alcohol" foam, dry chemical or carbon dioxide.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 1040]**PEER REVIEWED**

Evacuation: If fire becomes uncontrollable or container is exposed to direct flame--consider evacuation of one-third (1/3) mile radius.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 1040]**PEER REVIEWED**

Closed containers may rupture violently when heated.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-126]**PEER REVIEWED**

Toxic Combustion Products:

When heated, an irritating vapor is generated.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Firefighting Hazards:

Vapor is heavier than air and may travel considerable distance to source of ignition and flash back.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-126]**PEER REVIEWED**

Explosive Limits & Potential:

Explosive in the form of vapor when exposed to heat or flame. In common with ethers, unstabilized **tetrahydrofuran** forms thermally explosive peroxides on exposure to air.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 3108]**PEER REVIEWED**

Explosive reaction with /potassium hydroxide; sodium aluminum hydride; sodium hydroxide/; sodium tetrahydroaluminate. Reacts with 2-aminophenol + potassium dioxide to form an explosive product. Reacts with lithium tetrahydroaluminate or borane to form explosive hydrogen gas.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 3108]**PEER REVIEWED**

Hazardous Reactivities & Incompatibilities:

UNSTABILIZED **TETRAHYDROFURAN** FORMS THERMALLY EXPLOSIVE PEROXIDES ON EXPOSURE TO AIR. STORED THF MUST ALWAYS BE TESTED FOR PEROXIDES PRIOR TO DISTILLATION. PEROXIDES CAN BE REMOVED BY TREATMENT WITH STRONG FERROUS SULFATE SOLN MADE SLIGHTLY ACIDIC WITH SODIUM BISULFATE.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 3108]**PEER REVIEWED**

An attempt to remove peroxides /from **tetrahydrofuran**/ by shaking with solid ferrous sulfate before distillation did not prevent explosion of the distillation residue. Alkali treatment to destroy peroxides appears not to be safe.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 467]**PEER REVIEWED**

Peroxidized material /**tetrahydrofuran**/ should not be dried with sodium or potassium hydroxide, as explosions may occur.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 467]**PEER REVIEWED**

Tetrahydrofuran had been dried over the aluminate and then stored over calcium hydride for 2 yr to prevent peroxide formation. Subsequent addition of more aluminate caused a strong exotherm and ignition of liberated hydrogen.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 45]**PEER REVIEWED**

During synthesis of sodium tetrahydroaluminate from its elements in **tetrahydrofuran**, a violent explosion occurred when absorption of hydrogen had stopped. This was attributed to deposition of solid above the liquid level, overheating and reaction with solvent to give butoxyaluminohydrides. Vigorous stirring and avoiding overheating are essential.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 46]**PEER REVIEWED**

Rapid addition of bromine to the dried solvent /**tetrahydrofuran**/ to make a 10% solution caused a vigorous reaction with gas evolution. ... Photocatalyzed bromination of the solvent may have been involved. ...
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 102]**PEER REVIEWED**

Addition of anhydrous chlorides (hafnium tetrachloride, titanium tetrachloride, and zirconium tetrachloride) directly to **tetrahydrofuran** caused a violent exothermic reaction.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA:

Butterworth-Heinemann Ltd., 1990 1049]**PEER REVIEWED**

2-Aminophenol was being oxidized in **tetrahydrofuran** solution at 65 deg C using a larger than normal proportion of potassium dioxide. When stirring was stopped after 6 hr, a violent explosion occurred. ... attributed to formation of tetrahydrofuranyl hydroperoxide by the excess dioxide.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 1305]**PEER REVIEWED**

EXPLOSIONS MAY ... OCCUR WHEN /**TETRAHYDROFURAN**/ IS BROUGHT INTO CONTACT WITH LITHIUM-ALUMINUM ALLOYS.
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 2164]**PEER REVIEWED**

SAFETY IN HANDLING **TETRAHYDROFURAN** IN LAB IS DISCUSSED IN RELATION TO AN EXPLOSION WHICH OCCURRED IN A UNIVERSITY LAB DURING REFLUXING OF **TETRAHYDROFURAN** WITH CALCIUM HYDRIDE.
[COATES JS; CHEM ENG NEWS 56 (6): 3 (1978)]**PEER REVIEWED**

A glass bottle containing a 1 m solution /which is stabilized with 5 mol% of sodium tetrahydroborate/ of the complex /borane-**tetrahydrofuran**/ in THF exploded after 2 wk in undisturbed lab storage out of direct sunlight at 15 deg C. ... Tetrahydroborate content may in fact have destabilized the borane-THF reagent, with generation of hydrogen pressure in the closed bottle.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 3rd ed. Boston, MA: Butterworths, 1985. 61]**PEER REVIEWED**

A violent explosion during reflux of the solvent /**tetrahydrofuran**/ with calcium hydride was attributed to cleavage of the cyclic ether by overheated excess hydride.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 467]**PEER REVIEWED**

Using potassium hydroxide /or sodium hydroxide/ to dry impure **tetrahydrofuran**, which can contain peroxides, is hazardous. Serious explosions can occur.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 491-194]**PEER REVIEWED**

Strong oxidizers, lithium-alluminum alloys [Note: Peroxides may accumulate upon prolonged storage in presence of air].
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 302]**PEER REVIEWED**

Hazardous Decomposition:

When heated to decomp it emits acrid smoke & irritating fumes.
[Lewis, R.J. Sax's Dangerous Properties of Industrial Materials. 9th ed. Volumes 1-3. New York, NY: Van Nostrand Reinhold, 1996. 3108]**PEER REVIEWED**

Upon contact with air, THF may decompose into explosive peroxides & carbon monoxide.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1517]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

2000 ppm (Based on 10% of the lower explosion limit for safety considerations even though the relevant toxicological data indicated that irreversible health efects or impairment of escape existed only at higher concentrations.)

[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 302]**PEER REVIEWED**

Protective Equipment & Clothing:

THE WEARING OF PERSONAL PROTECTIVE EQUIPMENT IS RECOMMENDED FOR WORKERS WHO ARE DIRECTLY EXPOSED TO ... /**TETRAHYDROFURAN**/.
[International Labour Office. Encyclopedia of Occupational Health and Safety. Vols. I&II. Geneva, Switzerland: International Labour Office, 1983. 2164]**PEER REVIEWED**

Wear special protective clothing and positive pressure self-contained breathing apparatus.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-126]**PEER REVIEWED**

Employees should be provided with and required to use impervious clothing, gloves, face-shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with **tetrahydrofuran**. Employees should be provided with and required to use splash-proof goggles where there is any possibility of liquid **tetrahydrofuran** contacting the eyes.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Personnel protection: ... Wear appropriate chemical protective gloves, boots, and goggles.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 1040]**PEER REVIEWED**

Breakthrough times less (usually significantly less) than one hour reported by (normally) two or more testers for natural rubber (Nat. rub), neoprene (Neop), neoprene/natural rubber (neop/nat rub), nitrile rubber (nitrile), polyethylene (PE), chlorinated polyethylene (CPE), polyvinyl alcohol (PVA) and polyvinyl chloride (PVC). No data for butyl rubber (butyl), nitrile rubber/polyvinyl chloride (nitrile/PVC), polyurethane (PU) and viton.
[ACGIH; Guidelines Select of Chem Protect Clothing Volume #1 Field Guide p.55 (1983)]**PEER REVIEWED**

Wear appropriate personal protective clothing to prevent skin contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 302]**PEER REVIEWED**

Wear appropriate eye protection to prevent eye contact.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 302]**PEER REVIEWED**

Recommendations for respirator selection. Max concn for use: 2000 ppm. Respirator Class(es): Any supplied-air respirator operated in a continuous flow mode. Eye protection needed. Any chemical cartridge respirator with a full facepiece and organic vapor cartridge(s). Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister. Any powered, air-purifying respirator with organic vapor cartridge(s). Eye protection needed. Any self-contained breathing apparatus with a full facepiece. Any supplied-air respirator with a full facepiece.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 302]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Emergency or planned entry into unknown concn or IDLH conditions: Respirator Class(es): Any self-contained breathing apparatus that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode. Any supplied-air

respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive-pressure mode.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 302]**PEER REVIEWED**

Recommendations for respirator selection. Condition: Escape from suddenly occurring respiratory hazards: Respirator Class(es): Any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister. Any appropriate escape-type, self-contained breathing apparatus.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 302]**PEER REVIEWED**

Preventive Measures:

Avoid long contact with skin.
[ITII. Toxic and Hazardous Industrial Chemicals Safety Manual. Tokyo, Japan: The International Technical Information Institute, 1988. 510]**PEER REVIEWED**

Contact lenses should not be worn when working with this chemical.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 302]**PEER REVIEWED**

SRP: The scientific literature for the use of contact lenses in industry is conflicting. The benefit or detrimental effects of wearing contact lenses depend not only upon the substance, but also on factors including the form of the substance, characteristics and duration of the exposure, the uses of other eye protection equipment, and the hygiene of the lenses. However, there may be individual substances whose irritating or corrosive properties are such that the wearing of contact lenses would be harmful to the eye. In those specific cases, contact lenses should not be worn. In any event, the usual eye protection equipment should be worn even when contact lenses are in place.
PEER REVIEWED

TETRAHYDROFURAN SHOULD BE USED WITH GREAT CARE & SHOULD BE TESTED FOR ABSENCE OF PEROXIDES WITH POTASSIUM IODIDE-STARCH PAPER EVERY TIME IT IS USED.
[HALONBRENNER R, KLAEUI W; CHEM ENG NEWS 56 (6): 3 (1978)]**PEER REVIEWED**

If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health. In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.2]**PEER REVIEWED**

Clothing wet with liquid **tetrahydrofuran** should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of **tetrahydrofuran** from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the **tetrahydrofuran** the person performing the operation should be informed of **tetrahydrofuran**'s hazardous properties. Any clothing which becomes contaminated with liquid **tetrahydrofuran** should be removed immediately and not reworn until the **tetrahydrofuran** is removed from the clothing.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No.

81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Skin that becomes wet with liquid **tetrahydrofuran** should be promptly washed or showered to remove any **tetrahydrofuran**.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Personnel protection: Avoid breathing vapors. Keep upwind. ... Do not handle broken packages unless wearing appropriate personal protective equipment. Wash away any material which may have contacted the body with copious amounts of water or soap and water.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 1041]**PEER REVIEWED**

If material not on fire and not involved in fire: Keep sparks, flames, and other sources of ignition away. Keep material out of water sources and sewers. Build dikes to contain flow as necessary. Attempt to stop leak without undue personnel hazard. Use water spray to disperse vapors and dilute standing pools of liquid.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 1041]**PEER REVIEWED**

Evacuation: If material leaking (not on fire) consider evacuation from downwind area based on amount of material spilled, location and weather conditions.
[Association of American Railroads. Emergency Handling of Hazardous Materials in Surface Transportation. Washington, DC: Association of American Railroads, Bureau of Explosives, 1994. 1041]**PEER REVIEWED**

The worker should immediately wash the skin when it becomes contaminated.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 302]**PEER REVIEWED**

Work clothing that becomes wet should be immediately removed due to its flammability hazard.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 302]**PEER REVIEWED**

Stability/Shelf Life:

Tetrahydrofuran will auto-oxidize in the presence of light & O2 to form resinous products that color water from pink to brown at conc above 100-250 mg/l.
[USEPA; Chemical Hazard Information Profile: Tetrahydrofuran p.258 (1979)]**PEER REVIEWED**

May form, organic peroxides when exposed to air or light but usually inhibited against peroxide formation.
[Prager, J.C. Environmental Contaminant Reference Databook Volume 1. New York, NY: Van Nostrand Reinhold, 1995. 720]**PEER REVIEWED**

Upon contact with air, THF may decompose into explosive peroxides & carbon monoxide.
[American Conference of Governmental Industrial Hygienists, Inc. Documentation of the Threshold Limit Values and Biological Exposure Indices. 6th ed. Volumes I, II, III. Cincinnati, OH: ACGIH, 1991.1517]**PEER REVIEWED**

Shipment Methods and Regulations:

No person may /transport,/ offer or accept a hazardous material for transportation in commerce unless that person is registered in conformance ... and the hazardous material is properly classed, described, packaged, marked, labeled, and in condition for shipment as required or authorized by ... /the hazardous materials regulations (49 CFR 171-177)./
[49 CFR 171.2 (7/1/2000)]**PEER REVIEWED**

The International Air Transport Association (IATA) Dangerous Goods Regulations are published by the IATA Dangerous Goods Board pursuant to IATA Resolutions 618 and 619 and constitute a manual of industry carrier regulations to be followed by all IATA Member airlines when transporting hazardous materials.
[IATA. Dangerous Goods Regulations. 42nd Ed. Montreal, Canada and Geneva, Switzerland: International Air Transport Association, Dangerous Goods Regulations, 2001. 231]**PEER REVIEWED**

The International Maritime Dangerous Goods Code lays down basic principles for transporting hazardous chemicals. Detailed recommendations for individual substances and a number of recommendations for good practice are included in the classes dealing with such substances. A general index of technical names has also been compiled. This index should always be consulted when attempting to locate the appropriate procedures to be used when shipping any substance or article.
[IMDG; International Maritime Dangerous Goods Code; International Maritime Organization p.3144, 3282 (1998)]**PEER REVIEWED**

Storage Conditions:

Store in a cool, dry, well-ventilated location. Store away from heat, oxidizing materials, and sunlight. Outside or detached storage is preferred. Inside storage should be a standard flammable liquids storage warehouse, room, or cabinet.
[Fire Protection Guide to Hazardous Materials. 12 ed. Quincy, MA: National Fire Protection Association, 1997.,p. 49-126]**PEER REVIEWED**

STORAGE TEMPERATURE: AMBIENT.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Distillation or alkali treatment of stabilized tetrahyrofuran removes the involatile anti-oxidant, and the solvent must be restabilized or stored under nitrogen to prevent formation during storage, which should not exceed a few days duration in the absence of stabilizer.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 4th ed. Boston, MA: Butterworth-Heinemann Ltd., 1990 467]**PEER REVIEWED**

Cleanup Methods:

Absorb with paper. Evaporate completely all spilled surface. Dispose by burning the paper after complete ventilation of vapor.
[Prager, J.C. Environmental Contaminant Reference Databook Volume 1. New York, NY: Van Nostrand Reinhold, 1995. 720]**PEER REVIEWED**

Disposal Methods:

Generators of waste (equal to or greater than 100 kg/mo) containing this contaminant, EPA hazardous waste number U213, must conform with USEPA regulations in storage, transportation, treatment and disposal of waste.
[40 CFR 240-280, 300-306, 702-799 (7/1/89)]**PEER REVIEWED**

A good candidate for liquid injection incineration at a temperture range of 650 to 1,600 deg C and a residence time of 0.1 to 2 seconds. Also, a good candidate for rotary kiln incineration at a temperature range of 820 to 1,600 deg C and residence times of seconds for liquids and gases, and hours for solids. Also, a good candidate for fluidized bed incineration at a temperature range of 450 to 980 deg C and residence times of seconds for liquids and gases, and longer for solids.
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.3-15 (1981) EPA 68-03-3025]**PEER REVIEWED**

Tetrahydrofuran is a waste chemical stream constituent which may be subjected to ultimate disposal by controlled incineration. In controlled waste containing peroxides, perforation of a container of the waste form a safe distance is followed by open burning.
[USEPA; Engineering Handbook for Hazardous Waste Incineration p.2-9 (1981) EPA 68-03-3025]**PEER REVIEWED**

Occupational Exposure Standards:

OSHA Standards:

Permissible Exposure Limit: Table Z-1 8-hr Time Weighted Avg: 200 ppm (590 mg/cu m).
[29 CFR 1910.1000 (7/1/2001)]**PEER REVIEWED**

Vacated 1989 OSHA PEL TWA 200 ppm (590 mg/cu m); STEL 250 ppm (735 mg/cu m) is still enforced in some states.
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 372]**PEER REVIEWED**

Threshold Limit Values:

8 hr Time Weighted Avg (TWA): 200 ppm; 15 min Short Term Exposure Limit (STEL): 250 ppm.
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.56]**PEER REVIEWED**

Biological Exposure Index (BEI): Determinant: **tetrahydrofuran** in urine; Sampling Time: end of shift; BEI: 8 mg/l.
[American Conference of Governmental Industrial Hygienists. TLVs & BEIs: Threshold limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices for 2002. Cincinnati, OH. 2002.93]**PEER REVIEWED**

NIOSH Recommendations:

Recommended Exposure Limit: 10 Hr Time-Weighted Avg: 200 ppm (590 mg/cu m).
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 302]**PEER REVIEWED**

Recommended Exposure Limit: 15 Min Short-Term Exposure Limit: 250 ppm (735 mg/cu m).
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 302]**PEER REVIEWED**

Immediately Dangerous to Life or Health:

2000 ppm (Based on 10% of the lower explosion limit for safety considerations even though the relevant toxicological data indicated that irreversible health efects or impairment of escape existed only at higher concentrations.)
[NIOSH. NIOSH Pocket Guide to Chemical Hazards. DHHS (NIOSH) Publication No. 97-140. Washington, D.C. U.S. Government Printing Office, 1997. 302]**PEER REVIEWED**

Other Occupational Permissible Levels:

Recommended occupational exposure level /(Netherlands)/ Time-weighted average (TWA) 300 mg/cu m (100 ppm)/8 hr
[Directorate of Labor; Expert Committee for Occupational Standards. 35 pp. (1991)]**PEER REVIEWED**

Manufacturing/Use Information:

Major Uses:

Solvent for high polymers, esp. polyvinyl chloride. As reaction medium for Grignard & metal hydride reactions. In the synthesis of butyrolactone, succinic acid, 1,4-butanediol diacetate. Solvent in histological techniques.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1574]**PEER REVIEWED**

SOLVENT FOR FAT OILS, UNVULCANIZED RUBBER; FOR MAKING ADIPIC ACID
[Lefaux, R. Practical Toxicology of Plastics. Cleveland: CRC Press Inc., 1968. 117]**PEER REVIEWED**

Solvent in preparation of printing inks, adhesives, lacquers, & other coatings; Grignard reagent in synthesis of motor fuels, vitamins, hormones, pharmaceuticals, synthetic perfumes, organometallic cmpds, & insecticides.
[Mackison, F. W., R. S. Stricoff, and L. J. Partridge, Jr. (eds.). NIOSH/OSHA - Occupational Health Guidelines for Chemical Hazards. DHHS(NIOSH) Publication No. 81-123 (3 VOLS). Washington, DC: U.S. Government Printing Office, Jan. 1981.3]**PEER REVIEWED**

Solvent for natural & synthetic resins, particularly vinyls, in topcoating solutions, polymer coating, cellophane, protective coatings, adhesives, magnetic tapes, printing inks, etc., Grignard reactions, lithium aluminum hydride reductions, & polymerizations; chemical intermediate & monomer.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1087]**PEER REVIEWED**

Solvent for production of tetraethyl & tetramethyl lead.
[Sittig, M. Handbook of Toxic and Hazardous Chemicals and Carcinogens, 1985. 2nd ed. Park Ridge, NJ: Noyes Data Corporation, 1985. 643]**PEER REVIEWED**

Polyacetal resin comonomer; solvent (Grignard reagents, tetraethylead production, solution styrene-butadiene rubber production, magnetic tape production, polyvinyl chloride/rubber bonding, printing plates); vinylidene copolymer solvent (cellophane coatings).
[Ashford, R.D. Ashford's Dictionary of Industrial Chemicals. London, England: Wavelength Publications Ltd., 1994. 875]**PEER REVIEWED**

Manufacturers:

BASF Corp., Chemical Div., Chemical Intermediates, 3000 Continental Dr - North, Mount Olive, NJ 07828-1234, (973) 426-2600; Production site: Geismar, LA 70734
[SRI International. 2000 Directory of Chemical Producers -- United States. SRI Consulting, Menlo Park: CA 2000 935]**PEER REVIEWED**

DuPont, DuPont Specialty Chemicals, 1007 Market St., Wilmington, DE 19898, (800) 441-7515. DuPont Performance, Specialty and Fine Chemicals; Production site: La Porte, TX 77571
[SRI International. 2000 Directory of Chemical Producers -- United States. SRI Consulting, Menlo Park: CA 2000 935]**PEER REVIEWED**

Lyondell Chemical Co., 1221 McKinney St., Suite 700, Houston, TX 77010, (713) 652-7200; Production site: Channelview, TX 77530
[SRI International. 2000 Directory of Chemical Producers -- United States. SRI Consulting, Menlo Park: CA 2000 935]**PEER REVIEWED**

Penn Specialty Chemicals, Inc., Six Tower Bridge, 181 Washington St., Suite 450, Conshohocken, PA 19428, (877) 895-PENN; Production site: Memphis, TN 38108
[SRI International. 2000 Directory of Chemical Producers -- United States. SRI Consulting, Menlo Park: CA 2000 935]**PEER REVIEWED**

Methods of Manufacturing:

Manufactured by catalytic hydrogenation of maleic anhydride.
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1574]**PEER REVIEWED**

(1) Catalytic hydrogenation of furan with nickel catalyst. (2) Acid-catalyzed dehydration of 1,4-butanediol.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1087]**PEER REVIEWED**

Decarboxylation of furfural with zinc-chromium-molybdenum catalyst with hydroxylation to THF.
[USEPA; Chemical Hazard Information Profile: Tetrahydrofuran p.254 (1979)]**PEER REVIEWED**

Reaction of acetylene and formaldehyde under high pressure and copper catalysis to yield butanediol which is then dehydrated to THF.
[USEPA; Chemical Hazard Information Profile: Tetrahydrofuran p.254 (1979)]**PEER REVIEWED**

DuPont announced the commercialization of a moving-bed recycle-based technology for the oxidation of butane to maleic anhydride... for hydrogenation to **tetrahydrofuran**
[Gerhartz, W. (exec ed.). Ullmann's Encyclopedia of Industrial Chemistry. 5th ed.Vol A1: Deerfield Beach, FL: VCH Publishers, 1985 to Present.,p. VA3 528]**PEER REVIEWED**

General Manufacturing Information:

0.025% BUTYLATED HYDROXYTOLUENE (BHT) PRESENT TO PREVENT PEROXIDE FORMATION.
[U.S. Coast Guard, Department of Transportation. CHRIS - Hazardous Chemical Data. Volume II. Washington, D.C.: U.S. Government Printing Office, 1984-5.]**PEER REVIEWED**

Commercial material is supplied stabilized with a phenolic antioxidant which is effective under normal

closed storage conditions in preventing the formation and accumulation of peroxide. ... Copper chloride /is used/ for removal of trace amt of peroxides. ... The use of lithium tetrahydroaluminum is only recommended for drying **tetrahydrofuran** which is peroxide-free and is not grossly wet. ... Peroxides in THF may be destroyed by passing through activated carbon at 20-66 deg C with contact time > 2 min.
[Bretherick, L. Handbook of Reactive Chemical Hazards. 3rd ed. Boston, MA: Butterworths, 1985. 448]**PEER REVIEWED**

Formulations/Preparations:

Grades: technical, spectrophotometric.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1574]**PEER REVIEWED**

Liquid, industrial, 99.5% grades
[Kuney, J.H. (ed.). CHEMCYCLOPEDIA 90. Washington, DC: American Chemical Society, 1990. 123]**PEER REVIEWED**

99.9%, HPLC, spectrophotometric, anhydrous, UV, nonspectro reagent grades
[Kuney, J.H. (ed.). CHEMCYCLOPEDIA 90. Washington, DC: American Chemical Society, 1990. 324]**PEER REVIEWED**

Impurities:

Stabilized to prevent excess peroxide formation on storage: with 0.05-1.0% p-cresol, 0.05-0.1% hydroquinone, or less than 0.01-0.1% 4,4'-thiobis(6-tert-butyl-m-cresol): Bordner, Hinegardner, and Campbell, US patents 2,489,260, 2,525,410 and 3,029,257 (1949, 1950, and 1962, all to Du Pont).
[Budavari, S. (ed.). The Merck Index - An Encyclopedia of Chemicals, Drugs, and Biologicals. Whitehouse Station, NJ: Merck and Co., Inc., 1996. 1574]**PEER REVIEWED**

Peroxide (as hydrogen peroxide): 0.015%, water: 0.02%
[JT Baker Chemical Co; Reagents and Laboratory Products Catalog 860C p.137 (1986)]**PEER REVIEWED**

Consumption Patterns:

Resin solvent 40%, Chemical Int 40%, Grignard reaction solvent 20%.
[NTP; Summary of Data for Chemical Selection: Tetrahydrofuran p.2 (1979)]**PEER REVIEWED**

SOLVENT FOR RESINS, 40%; CHEMICAL INTERMEDIATE, 40%; REACTION SOLVENT, 20% (1977)
[SRI]**PEER REVIEWED**

Polytetrahydrofuran, 68%; coating solvent, 23%; other (reaction solvent, thiophane), 9% (1983)
[CHEMICAL PRODUCTS SYNOPSIS: Tetrahydrofuran, 1984]**PEER REVIEWED**

U. S. Production:

(1977) AT LEAST 2.72X10+10 G
[SRI]**PEER REVIEWED**

(1982) 4.85X10+10 G
[SRI]**PEER REVIEWED**

(1985) 5.46X10+10 g

[USITC. SYN ORG CHEM-U.S. PROD/SALES 1985 p.29]**PEER REVIEWED**

(1987) 1.42X10+8 lb
[USITC. SYN ORG CHEM-U.S. PROD/SALES 1987 p.3-2]**PEER REVIEWED**

(1988) 9.38X10+7 lb
[USITC. SYN ORG CHEM-U.S. PROD/SALES 1988 p.3-2]**PEER REVIEWED**

94,353,000 kg in 1993
[United States International Trade Commission. Synthetic Organic Chemicals - United States Production and Sales, 1993. USITC Publication 2810, Nov. 1994. Washington, D.C.,p. 3-169]**PEER REVIEWED**

U. S. Imports:

(1974) 4.2X10+5 lb/yr
[US International Trade Commission (1977) as cited in USEPA; Chemical Hazard Information Profile: Tetrahydrofuran p.254 (1979)]**PEER REVIEWED**

(1975) 8.2X10+4 lb/yr
[US International Trade Commission (1977) as cited in USEPA; Chemical Hazard Information Profile: Tetrahydrofuran p.254 (1979)]**PEER REVIEWED**

(1985) 1.24X10+8 g
[BUREAU OF THE CENSUS. U.S. IMPORTS FOR CONSUMPTION AND GENERAL IMPORTS 1985 p. 1-585]**PEER REVIEWED**

(1986) 8.12X10+4 lb
[BUREAU OF THE CENSUS. US IMPORTS FOR CONSUMPTION AND GENERAL IMPORTS 1986 P.1-531]**PEER REVIEWED**

U. S. Exports:

(1978) 4.99X10+9 G
[SRI]**PEER REVIEWED**

(1983) 6.73X10+9 G
[SRI]**PEER REVIEWED**

(1985) 1.71X10+8 g
[BUREAU OF THE CENSUS. U.S. EXPORTS, SCHEDULE E, 1985 p.2-72]**PEER REVIEWED**

(1987) 9.50X10+6 lb
[BUREAU OF THE CENSUS. U. S. EXPORTS, SCHEDULE E, DECEMBER 1987, P.2-77]**PEER REVIEWED**

(1988) 1.01X10+7 lb
[BUREAU OF THE CENSUS. U. S. EXPORTS, SCHEDULE E, DECEMBER 1988, P.2-80]**PEER REVIEWED**

Laboratory Methods:

Clinical Laboratory Methods:

Tetrahydrofuran can be separated from biological fluids after injection onto packed gas chromatography columns with flame ionization detector or in a closed vessel or by controlled temp diffusion from the liquid phase into the air above the sample (head space). **Tetrahydrofuran** has a

relative retention time of 0.78 min (ethanol= 1.9 min).
[Sunshine, Irving (ed.) Methodology for Analytical Toxicology. Cleveland: CRC Press, Inc., 1975. 407]**PEER REVIEWED**

Occupational exposure to **tetrahydrofuran** was studied by analysis of environmental air, blood, alveolar air, and urine from 58 workers in a video tape manufacturing plant /by using/ head space gas chromatography with a FID detector.
[Ong CN, et al; Br J Ind Med 48 (9): 616-21 (1991)]**PEER REVIEWED**

Analytic Laboratory Methods:

NIOSH Method 1609. Analyte: **tetrahydrofuran**; Matrix: air; Technique: gas chromatography, flame ionization detector; Desorption: 0.5 ml carbon disulfide, stand 30 min; Range: 0.5 to 13 mg/sample; Precision (relative standard deviation): 0.16 @ 3 to 11.8 mg/sample; Est limit of detection: 0.05 mg/sample; Interferences: high humidity may reduce the breakthrough volume of the charcoal tube.
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

Method outlines the use of gas chromatography/microwave-induced plasma for the detection of organic oxygenated compounds in simple mixtures. **Tetrahydrofuran** had 99% recovery, with a detection limit of 40 ng oxygen in a complex system.
[Bradley C, Carnahan JW; Anal Chem 60:858-863 (1988)]**PEER REVIEWED**

/Determination of **tetrahydrofuran** by/ use of solvent optimization software for rapid selection of conditions for reversed phase high performance liquid chromatography.
[Pichini S et al; J Chromat 697 (1-2): 383-8 (1995)]**PEER REVIEWED**

AREAL Method IP-1B. Determination of Volatile Organic Compounds (VOCs) in Indoor Air using Solid Absorbent Tubes. This method is applicable to the sampling and analysis of volatile organic compounds in indoor air. Detection limit = 1.2 ng.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EMSLC Method 524.2. Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry. This method is applicable to surface water, ground water, and drinking water in any treatment stage. Detection limit = 1.6 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

EAD Method 1666. Volatile Organic Compounds Specific to the Pharmaceutical Manufacturing Industry by Isotope Dilution GC/MS. The method contains two options for the analysis of volatile organic compounds in waters, soils, and municipal sludges by isotope dilution GC/MS. Detection limit = 20 ug/l.
[USEPA; EMMI. EPA's Environmental Monitoring Methods Index. Version 1.1. PC# 4082. Rockville, MD: Government Institutes (1997)]**PEER REVIEWED**

Sampling Procedures:

NIOSH Method 1609. Analyte: **tetrahydrofuran**; Matrix: air; Sampler: solid sorbent tube (coconut shell charcoal, 100 mg/50 mg); Flow rate: 0.01 to 0.2 l/min; Vol: min 1 l, max 9 l; Sample stability: not determined
[U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. NIOSH Manual

of Analytical Methods. 4th ed. Methods A-Z & Supplements. Washington, DC: U.S. Government Printing Office, Aug 1994.]**PEER REVIEWED**

Special References:

Special Reports:

Chemical Selection Working Group Profile No. 446, **Tetrahydrofuran** (1979).

USEPA; Chemical Hazard Information Profile: **Tetrahydrofuran** (1979).

Health & Safety Executive; Criteria Document Summaries-Synopses of the Data Used in Setting Occupational Exposure Limits. HSE Books, PO Box 1999, Sudbury, Suffolk, UK C010 6FS (1995) This document contains summaries of the data considered by the Health and Safety Commission of the United Kingdom in setting occupational exposure standards. ...

European Commission; Occupational Exposure Limits. Recommendations of the Scientific Expert Group 1991-1992. Office for Official Publications of the European Communities, 2985 Luxembourg. 85pp. (1994). This document contains recommendations of the Scientific Advisory Group for a series of 26 substances ... /which include/ ... proposed occupational exposure limits. ...

Toxicology & Carcinogenesis Studies of **Tetrahydrofuran** in F344/N Rats and B6C3F1 Mice p.6 Technical Report Series No. 475 (1998) NIH Publication No. 98-3965 U.S. Department of Health and Human Services, National Toxicology Program, National Institute of Environmental Health Sciences, Research Triangle Park, NC 27709

Synonyms and Identifiers:

Related HSDB Records:

89 [FURAN] (Analog)

Synonyms:

BUTANE, 1,4-EPOXY-
PEER REVIEWED

BUTANE ALPHA, DELTA-OXIDE
PEER REVIEWED

BUTYLENE OXIDE
PEER REVIEWED

CYCLOTETRAMETHYLENE OXIDE
PEER REVIEWED

DIETHYLENE OXIDE
PEER REVIEWED

1,4-EPOXYBUTANE
PEER REVIEWED

FURANIDINE
PEER REVIEWED

FURAN, TETRAHYDRO-
PEER REVIEWED

HYDROFURAN
PEER REVIEWED

NCI-C60560
PEER REVIEWED

OXACYCLOPENTANE
PEER REVIEWED

OXOLANE
PEER REVIEWED

TETRAHYDROFURAAN (DUTCH)
PEER REVIEWED

TETRAHYDROFURANNE (FRENCH)
PEER REVIEWED

TETRAIDROFURANO (ITALIAN)
PEER REVIEWED

TETRAMETHYLENE OXIDE
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THF
PEER REVIEWED

Formulations/Preparations:

Grades: technical, spectrophotometric.
[Lewis, R.J., Sr (Ed.). Hawley's Condensed Chemical Dictionary. 13th ed. New York, NY: John Wiley & Sons, Inc. 1997. 1574]**PEER REVIEWED**

Liquid, industrial, 99.5% grades
[Kuney, J.H. (ed.). CHEMCYCLOPEDIA 90. Washington, DC: American Chemical Society, 1990. 123]**PEER REVIEWED**

99.9%, HPLC, spectrophotometric, anhydrous, UV, nonspectro reagent grades
[Kuney, J.H. (ed.). CHEMCYCLOPEDIA 90. Washington, DC: American Chemical Society, 1990. 324]**PEER REVIEWED**

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Appendix E
California EPA Public Health Goal for Lead in Drinking Water
California EPA Public Health Goals for Nitrate and Nitrite in Drinking Water

Public Health Goal for
LEAD
in Drinking Water

Prepared by

Pesticide and Environmental Toxicology Section
Office of Environmental Health Hazard Assessment
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PREFACE

Drinking Water Public Health Goal of the Office of Environmental Health Hazard Assessment

This Public Health Goal (PHG) technical support document provides information on health effects from contaminants in drinking water. The PHG describes concentrations of contaminants at which adverse health effects would not be expected to occur, even over a lifetime of exposure. PHGs are developed for chemical contaminants based on the best available toxicological data in the scientific literature. These documents and the analyses contained in them provide estimates of the levels of contaminants in drinking water that would pose no significant health risk to individuals consuming the water on a daily basis over a lifetime.

The California Safe Drinking Water Act of 1996 (amended Health and Safety Code, Section 116365) requires the Office of Environmental Health Hazard Assessment (OEHHA) to adopt PHGs for contaminants in drinking water based exclusively on public health considerations. The Act requires OEHHA to adopt PHGs that meet the following criteria:

1. PHGs for acutely toxic substances shall be set at levels at which scientific evidence indicates that no known or anticipated adverse effects on health will occur, plus an adequate margin-of-safety.
2. PHGs for carcinogens or other substances which can cause chronic disease shall be based solely on health effects without regard to cost impacts and shall be set at levels which OEHHA has determined do not pose any significant risk to health.
3. To the extent the information is available, OEHHA shall consider possible synergistic effects resulting from exposure to two or more contaminants.
4. OEHHA shall consider the existence of groups in the population that are more susceptible to adverse effects of the contaminants than a normal healthy adult.
5. OEHHA shall consider the contaminant exposure and body burden levels that alter physiological function or structure in a manner that may significantly increase the risk of illness.
6. In cases of scientific ambiguity, OEHHA shall use criteria most protective of public health and shall incorporate uncertainty factors of noncarcinogenic substances for which scientific research indicates a safe dose-response threshold.
7. In cases where scientific evidence demonstrates that a safe dose-response threshold for a contaminant exists, then the PHG should be set at that threshold.
8. The PHG may be set at zero if necessary to satisfy the requirements listed above.
9. OEHHA shall consider exposure to contaminants in media other than drinking water, including food and air and the resulting body burden.
10. PHGs adopted by OEHHA shall be reviewed periodically and revised as necessary based on the availability of new scientific data.

PHGs adopted by OEHHA are for use by the California Department of Health Services (DHS) in establishing primary drinking water standards (State Maximum Contaminant Levels, or MCLs). Whereas PHGs are to be based solely on scientific and public health considerations without regard to economic cost considerations, drinking water standards adopted by DHS are to consider economic factors and technical feasibility. For this reason PHGs are only one part of the information used by DHS for establishing drinking water standards. PHGs established by

OEHHA exert no regulatory burden and represent only non-mandatory goals. By federal law, MCLs established by DHS must be at least as stringent as the federal MCL if one exists.

PHG documents are developed for technical assistance to DHS, but may also benefit federal, state and local public health officials. While the PHGs are calculated for single chemicals only, they may, if the information is available, address hazards associated with the interactions of contaminants in mixtures. Further, PHGs are derived for drinking water only and are not to be utilized as target levels for the contamination of environmental waters where additional concerns of bioaccumulation in fish and shellfish may pertain. Often environmental water contaminant criteria are more stringent than drinking water PHGs, to account for human exposures to a single chemical in multiple environmental media and from bioconcentration by plants and animals in the food chain.

TABLE OF CONTENTS

LIST OF CONTRIBUTORS ii

PREFACE iii

SUMMARY 1

INTRODUCTION 1

CHEMICAL PROFILE 1

ENVIRONMENTAL OCCURRENCE 2

- Air 2
- Soil 2
- Water 3

PHARMACOKINETICS 3

- Absorption 3
- Distribution 4
- Excretion 4

TOXICOLOGY 4

- Toxicological Effects in Animals 4
  - Acute Effects 4
  - Chronic Effects 5
  - Genetic Toxicity 5
- Toxicological Effects in Humans 5
  - Acute Effects 5
  - Chronic Effects 6

DOSE-RESPONSE ASSESSMENT 9

- Noncarcinogenic Effects 9
- Carcinogenic Effects 10

CALCULATION OF PHG 11

- Carcinogenic Endpoint 11
- Noncarcinogenic Endpoints 11

RISK CHARACTERIZATION 12

OTHER STANDARDS AND REGULATORY LEVELS 13

REFERENCES 14

SUMMARY

A Public Health Goal (PHG) of 2 ppb is developed for lead in drinking water based on the neurobehavioral effects of lead in children and the hypertensive effects of lead in adults. Lead has been known as a toxic metal since ancient times, and has been studied for its toxic effects since the middle ages. It is a widespread contaminant in the human environment and occurs in drinking water as a consequence of leaching from plumbing containing lead. Lead may also enter drinking water from other sources, for example, directly from soil contaminated with lead or deposited from air emissions. Lead has multiple toxic effects on the human body. Among its most serious noncarcinogenic effects are decreased intelligence in children and increased blood pressure in adults. Lead is a carcinogen in laboratory animals and a probable human carcinogen. The U.S. Environmental Protection Agency (U.S. EPA) has adopted a Maximum Contaminant Level Goal (MCLG) of zero for lead in drinking water based on "occurrence of low level effects" and because U.S. EPA classifies lead as a Class B_2 carcinogen. Based on the toxicological data for noncarcinogenic endpoints, and potential human exposures, a PHG of 0.002 mg/L (2 ppb) is calculated for lead in drinking water.

INTRODUCTION

The purpose of this document is to develop and propose a PHG for lead in drinking water. Lead may be present in surface water or ground water sources, but more frequently it enters tap water in the distribution systems, often at the individual home. Lead pipes and solder corrode and leach lead into tap water. Tap water is used for drinking directly and also for the preparation of foods and beverages. Lead has toxic effects on all systems of the body, particularly on the gastrointestinal tract, hematopoietic system, kidneys and central nervous system.

CHEMICAL PROFILE

Lead is a metallic element, the 82nd element on the periodic table. Naturally occurring lead has an average atomic weight of 207.2. It is made up mainly of three stable isotopes with atomic weights of 208 (52%), 206 (26%) and 207 (21%). There are also naturally occurring radioactive isotopes of lead. Small amounts of lead are produced by the decay of heavier radioactive elements, both natural and synthetic (CRC Handbook of Chemistry and Physics, 1994). Lead is a bluish gray or gray-white metal with a bright silvery luster. It is very soft, highly malleable and ductile. Lead is a poor conductor of electricity, and is resistant to corrosion.

The melting point of metallic lead is 327.4°C; its boiling point is 1,740°C. The density of metallic lead is 11.34 g/cm^3 at 20°C. Metallic lead is soluble in nitric or sulfuric acid, but insoluble in water or organic solvents. Lead salts such as lead nitrate and lead acetate are soluble in water. The usual valence states of lead are 0, +2 and +4. Lead can easily be alloyed with antimony, tin or other metals. Common lead salts include: acetate, chloride, chromate, nitrate, oxide, phosphate and sulfate. Lead can also be part of organic compounds, and can be chelated by various ligands (CRC Handbook of Chemistry and Physics, 1994).

Lead is easily obtained from its most common ore, galena (PbS). Because lead is so easily obtained, it was one of the first used metals, and remains one of the most used metals. Lead is mentioned in the book of Exodus, and other ancient literature. The many commercial uses of lead follow from the physical and chemical properties described above. For its malleability and

workability lead is used in piping, roofing and other structural uses. Because of its resistance to corrosion it is very long-lasting; some ancient Roman water pipes are still in use. Lead is also used in making containers for corrosive liquids. Metallic lead and lead dioxide are used in storage batteries for automobiles and other applications. In the past, organolead compounds were used to boost octane (reduce knock) in gasolines, but this use has been eliminated in California. Lead and lead salts have been widely used in paints and pigments, and in glazes for ceramics. Cable coverings are made from lead because of its electrical resistance and ductility. Lead is used to make bullets and shot. Because of its low melting point lead is used (with other metals) to make solder. Lead is used for radiation shielding around diagnostic x-ray machines and other sources of radiation (CRC Handbook of Chemistry and Physics, 1994; U.S. EPA, 1986).

In the past lead was included in a number of medicines such as antiseptics and astringents, but these are no longer recommended because of the cumulative toxic effects of lead in the body.

ENVIRONMENTAL OCCURRENCE

Lead is widely distributed in the environment. It is found in all media including air, water, food and soil.

Air

The use of tetraethyl lead as a gasoline additive resulted in widespread air pollution. Over the last two decades, the amount of lead in the air has been greatly reduced by the introduction of unleaded gasolines (OEHHA, 1997). Leaded gasolines are still widely used in many other countries.

Smelters and refineries emit lead into the air. Lead in contaminated soil becomes airborne when soil particles are picked up by the wind, or when soil is disturbed by digging, grading, plowing or gardening. The average level of lead in ambient air in California is 0.04 to 0.06 $\mu g/m^3$. Most of this lead is in the form of lead-containing particles (OEHHA, 1997).

Soil

Contamination of soil by lead is widespread in California and elsewhere. Lead has been deposited in soil in a number of ways. Much of the lead in soil came from the combustion of leaded gasoline. Lead from lead paint has also been deposited in soil, particularly around older homes. Land disposal of lead storage batteries has also contributed to soil contamination in many sites. Some of these lead storage battery disposal sites have very high levels of lead contamination, up to a few percent of the soil.

A national survey of soil lead in the United States (U.S.) found levels that ranged from 10 ppm to 700 ppm, with an average of about 15 ppm (Shacklette *et al.*, 1971). Fifteen parts per million has also been given as the average naturally occurring soil lead level (Lovering, 1976). The California Department of Health Services (DHS) conducted a survey of residential soil lead levels in parts of

three major cities suspected to have high lead concentrations: Oakland, Sacramento and Los Angeles (DHS, 1991). The median residential soil lead levels for these three cities were:

Oakland	880 ppm
Sacramento	230 ppm
Los Angeles	190 ppm

In all three cities there were some household soil samples with thousands of parts per million of lead.

Water

Environmental bodies of water become contaminated from contact with soil. In addition, drinking water becomes contaminated in the distribution systems because of lead in plumbing and solder. Lead enters drinking water from lead in pipes and and fixtures and from lead solder used to join pipes (Mahaffey, 1985). This is particularly troublesome in older homes. In newer homes the use of lead in pipes and solder has been greatly reduced or eliminated (Mahaffey, 1985). In addition to homes, older public buildings such as schools and theaters may also have problems with lead contamination of drinking water (Mahaffey, 1985).

According to Pocock *et al.* (1983), "Individual blood lead can be considerably increased by raised household tap water lead concentrations." After studying middle-aged men in 24 British towns, they estimated that the mean blood lead level is 43% higher for men when the concentration of lead in first-draw domestic tap water is 100 µg/L compared with lead-free water. This study demonstrates that tap water lead may be a significant source of exposure for some populations.

PHARMACOKINETICS

When lead is ingested in drinking water or foods, a fraction of it is absorbed into the bloodstream via the gastrointestinal tract. Lead in the bloodstream becomes deposited in tissues, mainly in bone. Blood lead is also excreted via the feces and urine.

Absorption

Children absorb more lead than do adults (Ragan, 1983). This has been clearly demonstrated in a number of studies. Absorption of lead into the blood from the gastrointestinal tract appears to be low in human beings compared to animals, although it is higher in children than in adults (Ragan, 1983). This is one reason why children are more sensitive than adults to lead exposure by the oral route. Children absorb about 40 to 50% of ingested lead, whereas adults absorb only at 5 to 15% (Ragan, 1983).

Heard and Chamberlain (1982) performed experiments with eight adult male volunteers who ingested ^{203}Pb in the presence and in the absence of calcium and phosphate. With no minerals present, uptake averaged 63.3%. The two minerals together (200 mg Ca and 140 mg phosphate) reduced this to 10.6%, but neither mineral by itself was nearly as effective as the two together.

James *et al.* (1985) estimated absorption of lead from drinking water for adults at 2 to 10% during meals, and 40 to 60% between meals. O'Flaherty (1993) suggested a value of 8% based on a review of the literature, and demonstrated that this absorption factor works well for predicting

adult blood lead levels from exposure via drinking water and food. Bowers *et al.* (1994) have derived an uptake slope factor of 0.037 µg/dL blood per µg/day based on data correlating adult blood lead with lead in household drinking water.

Distribution

Once lead is absorbed into the bloodstream it becomes distributed throughout the body. It is deposited in various tissues including the bones, kidneys and central nervous system. Long-term storage of lead is mainly in the bones.

Lead which is absorbed from the gastrointestinal tract enters the blood. The lead which is not eliminated in the urine or feces is distributed into the tissues of the body including the bone, brain and kidneys (Rabinowitz, 1991). The residence time of lead in the soft tissues (brain and kidneys) is much shorter than in the bone. Lead accumulates in the bone with time, and lead levels in the bone generally increase with age (Rabinowitz, 1991). The storage of lead in bone depends on the diet; higher levels of calcium and iron in the diet tend to protect against deposition of lead into the bone (Rabinowitz, 1991; Silbergeld, 1991). During pregnancy lead is often remobilized from bone and may be transferred from mother to fetus (Silbergeld, 1991). High blood lead levels may indicate recent exposure, or in some cases they may reflect remobilization of lead from bone storage (Silbergeld, 1991).

Rothenberg *et al.* (1994) studied blood lead levels of women during normal pregnancies in Mexico City. They found that the women's blood lead levels decreased during the period from the 12th to 20th week of pregnancy, but increased almost linearly from the 20th week to delivery. It remains to be determined whether this pattern of decrease followed by increase is general; and if it is general, it remains to be explained (Rothenberg *et al.*, 1994).

Excretion

Absorbed lead is excreted mainly through the urine, but also in the bile and to a small extent in sweat, hair and fingernails (Rabinowitz, 1991).

TOXICOLOGY

Toxicological Effects in Animals

Acute Effects

Mean lethal dose (LD_{50}) values for lead compounds were not found in the literature, however there are lowest lethal dose (LD_{Lo}) values ranging from 20,500 mg/kg for lead sulfate in guinea pigs to 191 mg/kg for lead acetate in the dog (Sax, 1984). These are the lowest doses expected to cause death. The available data do not permit a comparison of the acute toxicity of the different lead compounds (ATSDR, 1991). Acute oral exposure of rats to lead acetate at 390 mg/kg-day caused increased fetal resorptions, retarded skeletal development and maternal toxicity (Kennedy *et al.*, 1975).

Spontaneously hypertensive Sprague-Dawley rats were given drinking water containing 100 mg/L lead as lead acetate for three weeks (Nakhoul et al., 1992). There was no change in the systolic blood pressure of the animals for the first eight days of exposure even in these genetically susceptible rats. However, by day 12 through 20, they systolic pressure of the rats was significantly higher than for the controls.

Histological changes induced by lead from lead acetate in intestines, kidney and liver were evaluated in Sprague-Dawley rats by Karmakar et al. (1986). A dose of 44 mg/kg for durations of 9, 15 or 30 days was evaluated in groups of five rats. After nine days, mild shortening of the intestinal villi was seen in two of five rats and histological changes in the liver were observed in all rats. No renal abnormalities were observed. After 15 days, intestinal and liver abnormalities had progressed and affected more animals than at nine days; three of five rats showed histological kidney abnormalities.

Chronic Effects

Numerous experiments in laboratory animals have demonstrated that lead has a wide variety of toxic effects across many different organ systems (ATSDR, 1991).

The effects of lead acetate in drinking water on the reproductive systems of male and female rats have been studied by a number of investigators. The best studies relate the oral dose to the blood lead level produced. Chowdury *et al.* (1984) observed reduced sperm counts in male rats that had blood lead levels of 72 µg/dL. No effects were observed in male rats with blood lead levels of 54 µg/dL. Both male and female rats were studied by Hildebrad *et al.* (1973). They observed irregular estrus cycles in female rats with blood lead levels of 30 µg/dL. Ovarian follicular cysts were produced in female rats with 53 µg/dL blood lead levels. They found increased prostate weight in male rats with 19 µg/dL of blood lead, and testicular damage in male rats with 30 µg/dL blood lead.

Orally administered lead acetate has been demonstrated to cause cancer in animals (Azar *et al*., 1973). This study yielded a dose-dependent increase in the incidence of kidney tumors in rats and has been used to estimate the cancer potency of lead by the oral route (ATSDR, 1991; OEHHA, 1997).

Genetic Toxicity

Lead acetate gave conflicting results for structural chromosomal aberrations in Syrian or Chinese hamster cells (Bauchinger and Schmid, 1972; Robison *et al.*, 1984). Lead sulfide and lead nitrate were mutagenic at the hypoxanthine-guanine phosphoribosyltransferase (HPRT) locus in Chinese hamster V79 cells (Zelikoff, *et al.*, 1988). Tests of lead for mutagenicity in bacterial systems (*Salmonella typhimurium, Bacillus subtilis*) have yielded negative results (ATSDR, 1991).

Toxicological Effects in Humans

Acute Effects

The principal gastrointestinal effect of lead in humans is colic. This is a painful condition which involves cramps and gastrointestinal distress. Colic occurs immediately after acute exposures by

ingestion or inhalation. It corresponds to blood lead levels in the range of approximately 30 to 50 µg/dL of blood. Colic occurs most frequently to workers who are exposed to lead in the workplace in the form of either lead-bearing dust or lead fumes from soldering or welding (Meiklejohn, 1963).

Chronic Effects

Chronic exposure to lead has been demonstrated to affect many systems of the body including the nervous system, kidneys, gastrointestinal system and the reproductive system. The effects occur at different levels of exposure, as illustrated by Figure 1 which shows the lowest level at which each of the chronic effects is observed in children.

Neurobehavioral Effects

When children or fetuses receive high doses of lead (resulting in blood lead levels near 100 µg/dL) encephalopathy may result. Lead encephalopathy is characterized by dullness, irritability, poor attention span, headache, muscular tremor, loss of memory and hallucinations. More severe cases exhibit delirium, convulsions, paralysis, coma and death (Kumar *et al.*, 1987). Children suffer encephalopathy at lower doses than adults. Encephalopathy during the 12 to 15 months after birth, during which the child's brain is developing, may lead to irreversible brain damage (Hutton, 1987; ATSDR, 1991).

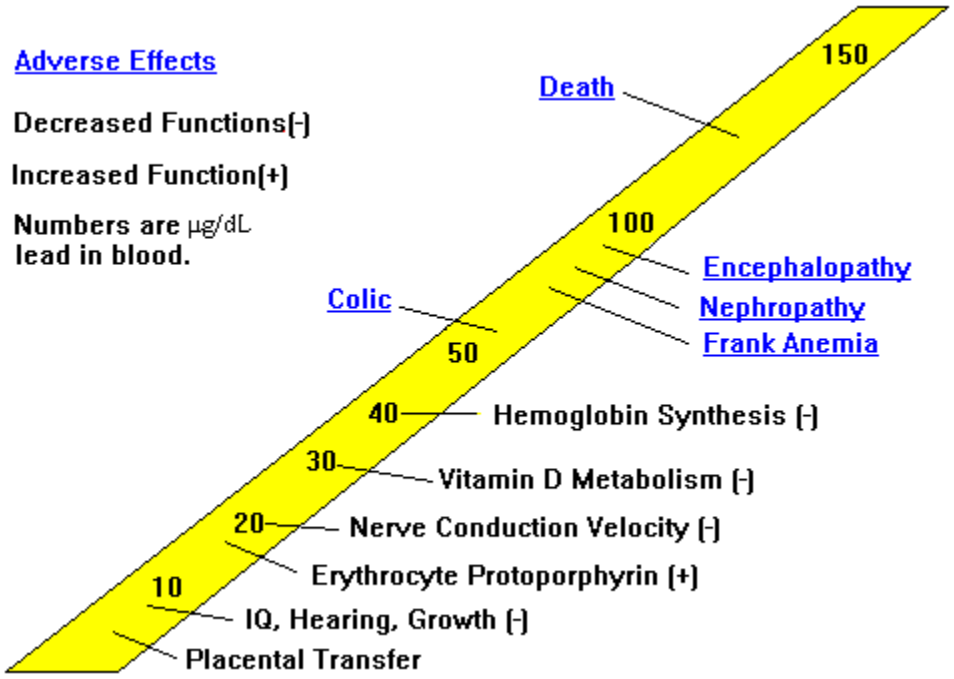

Figure 1: Lowest Demonstrated Effect Levels of Inorganic Lead in Children[1]

[1] The numbers in the diagram are not necessarily the lowest levels at which lead exerts an effect. They are levels at which studies have adequately demonstrated an effect.

Neurotoxic effects at lower blood lead levels than those which cause encephalopathy (below 100 μg/dL) may in some cases result in irreversible brain damage (exhibited as a decrease in learning ability) as well as in damage to the peripheral nervous system (Hutton, 1987; ATSDR, 1991).

There have been numerous studies of the effects of low lead exposure on the intelligence of children in the U.S. and other countries. The well-known work of Needleman indicates that blood lead levels as low as 10 μg/dL may cause deficits in learning ability in very young children. Children who had umbilical cord blood lead levels at birth of 10 μg/dL or higher had poorer performance on intelligence tests and in school (Needleman, 1987). Earlier, Needleman had looked at the effect of lead on children's IQ and classroom behavior using lead levels in shed deciduous teeth as an indicator of lead exposure (Needleman, 1982). These studies showed that children with higher lead exposures had lower intelligence scores, particularly in the verbal and language-processing skills. The high-lead children also had impaired auditory processing.

A four-year follow-up of these children showed that they had poorer classroom attention than the children with less lead exposure (Needleman, 1982). Schwartz and Otto (1991) demonstrated that children with blood lead levels of 10 μg/dL had impaired hearing compared with children with blood lead levels of 6 μg/dL.

Several long-term prospective studies (for example Bellinger *et al.*, 1992; Dietrich *et al.*, 1993; and Baghurst *et al.*, 1992) have also indicated an association between post-natal blood lead and IQ in children up to 10 years of age. This suggests the persistence of the effects of lead on intelligence.

Additional studies of young children have been conducted in other countries including Australia and Scotland with similar results (Yule and Rutter, 1985; ATSDR, 1991). In Australia, a cohort in the town of Port Pirie has been studied for many years. The most recent results from this cohort indicate that there is an inverse relation between tooth lead concentration and intellectual development (McMichael *et al.*, 1994). In this case tooth lead was used as an index of cumulative exposure.

Based on these studies of IQ in children and blood lead levels from the U.S. and other countries, it appears that there is good evidence that very low blood lead levels (10 μg/dL or lower) can have a deleterious effect (a decrease of several IQ points) on the learning ability and intellectual development of young children. A decrease of only a few IQ points may be very significant on a population level in terms of increased need for remedial education (CDC, 1991).

The principal studies of the effects of lead on the learning abilities of children should be corroborated by studies in animals, but in practice this is difficult to do because animals cannot be given intelligence tests comparable to those administered to children. However, there have been studies in rodents and primates which indicate that lead exposure to neonatal or fetal animals has histological effects in the brains of these animals (Bushnell and Bowman, 1979). More recent studies in primates and rodents have demonstrated deficits in higher neurobehavioral function at blood lead levels of 15 μg/dL in primates and 20 μg/dL in rodents (Davis *et al.*, 1990).

The mechanism(s) by which lead causes neurobehavioral dysfunction in children is not known at this time. There is evidence that lead may interfere with calcium-modulated neurotransmitter pathways, disrupt the blood-brain barrier or do both (Goldstein, 1993). Lead at picomolar

concentrations has been shown to affect the function of protein kinase C isolated from rat brains (Markovac, 1988). It has been postulated that lead binds to protein kinase C at the presynaptic terminals in the brain and interferes with release of neurotransmitters (Markovac and Goldstein, 1988). Lead has been shown to enhance the neurotoxicity of certain neural proteins, which suggests the possibility that lead may harm the nervous system by causing autoimmune responses to native neural proteins (Waterman *et al.*, 1994). All of these proposed mechanisms are possible, but at this time the most significant contributors to the neurotoxicity of lead cannot be determined from the scientific information available.

Anemia and Hypertensive Effects

When lead levels are in the 50 to 100 µg/dL range, anemia may result. Anemia may be a consequence of several factors including the suppression of the heme synthesis pathway leading to shortage of hemoglobin, and the increased fragility of red blood cell membranes resulting in shorter life span of the red blood cells. The effect on the heme synthesis pathway leads to an increase of blood protoporphyrin levels. In fact these can be used as a biological monitoring method to detect lead exposure (Alessio and Foa, 1983).

Epidemiological studies indicate that increased blood lead levels result in hypertension, especially in middle aged males (Schwartz, 1991). Animal models (rats) have also shown a relationship between blood lead and hypertension. Hypertension may also be caused in females or other age groups, but it has been most extensively studied in middle aged males. The blood lead level at which this effect appears to begin is approximately 10 µg/dL (Schwartz, 1991). Therefore, the lowest-observed-adverse-effect-level (LOAEL) for this effect is approximately the same as that for decreased IQ in children. It therefore seems prudent to regard 10 µg/dL as a minimum toxic level for both children and adults.

Hypertension or "high blood pressure" increases the risk of cardiovascular diseases leading to heart attacks or strokes (Schwartz, 1991; Pirkle *et al.*, 1985). Therefore, an agent which increases the mean blood pressure would have an effect on mortality in a population, increasing mortality and decreasing life expectancy. The number of years of life lost can be calculated, since a relationship can be established between blood lead levels and hypertension (Schwartz, 1991; Pirkle *et al.*, 1985; Harlan *et al.*, 1985).

Kidney Effects

Lead exposure, at doses intermediate between those that cause intelligence deficits and those that lead to encephalopathy, may result in nephropathy, manifested as impaired kidney function and the presence of glucose, amino acids and other biochemicals in the urine (Fowler and DuVal, 1991). This effect has been demonstrated in humans and animals. The mechanism involves structural changes in the kidney tissue which lead to blockage of the kidney tubules (Fowler and DuVal, 1991).

Reproductive Effects

The effects of lead acetate in drinking water on the reproductive systems of male and female rats have been studied by a number of investigators. The best studies relate the oral dose to the blood lead levels produced. Chowdhury *et al.* (1984) observed reduced sperm counts in male rats that had blood lead levels of 72 µg/dL. No effects were observed in male rats with blood lead levels of

54 µg/dL. Both male and female rats were studied by Hildebrand *et al.* (1973). They observed irregular estrus cycles in female rats with blood lead levels of 30 µg/dL. Ovarian follicular cysts were produced in female rats with 53 µg/dL blood lead levels. They found increased prostate weight in male rats with 19 µg/dL of blood lead, and testicular damage in male rats with 30 µg/dL.

Lead has long been used as an abortifacient in humans (Meiklejohn, 1963). Women who worked in the ceramics industry in Britain around the end of the 19th century appeared to have an increased incidence of stillbirths due to accidental or deliberate ingestion of the lead glaze material (Meiklejohn, 1963).

Cancer

Orally administered lead acetate has been demonstrated to cause cancer in animals (i.e., it increased the incidence of kidney tumors in rats) (Azar *et al*., 1973). This study has been used as the basis for estimating the cancer potency of lead (ATSDR, 1991; OEHHA, 1997). Lead is regarded by the International Agency for Research on Cancer (IARC) and the U.S. Environmental Protection Agency (U.S. EPA) as an animal carcinogen and probable human carcinogen (IARC, 1987; U.S. EPA, 1989). Given that lead acetate is carcinogenic in rats (Azar *et al.*, 1973), other ionic salts would probably be carcinogenic as well.

Summary of Chronic Health Effects in Humans

The most significant health effects from the public health and regulatory point of view are the ones which occur at the lowest blood lead levels, because these affect the greatest part of the population. For children these are the effects on intelligence and behavior. For adults the critical health effect is the increase in blood pressure. Both of these health effects are of concern in the vicinity of approximately 10 µg/dL blood lead. As both of the critical health effects for lead may occur near 10 µg/dL, this level may be considered a level of concern for both children and adults. Other health effects such as kidney and gastrointestinal effects occur at higher blood lead levels. See Figure 1 for a summary of these effects and the blood lead levels at which they occur.

DOSE-RESPONSE ASSESSMENT

Noncarcinogenic Effects

The critical health end points for lead are intelligence deficits in children, and hypertension in adults. The PHG is developed based on intelligence deficits in children, as this is the best documented health end point that occurs at very low levels of exposure, and because it results in a lower PHG than the hypertension end point.

Based on studies correlating blood lead levels with decreased IQ in children, the Centers for Disease Control (CDC) has identified 10 µg/dL (blood) as the lowest blood lead level of concern (CDC, 1991). Using an IEUBK model (Version 0.99d, 1994), OEHHA determined that for children between 12 and 24 months a blood lead level increase of 0.35 µg/dL results from each increment in drinking water intake of 1.0 µg/day (OEHHA, 1997). This was based on a calculation using the default values for exposure from dust, air, paint and other sources.

Therefore, the lead intake level that would correspond to the level of concern for children can be calculated as follows:

$$\text{Lead intake} = \frac{10\ \mu g/dL\ \text{(blood)}}{0.35\ \mu g/dL\ \text{per}\ \mu g/day}$$

$$= 28.6\ \mu g/day$$

This is the daily lead intake that corresponds to a blood lead level of 10 µg/dL. In other words, 28.6 µg/day can be used as a benchmark for daily oral intake from water that corresponds to a level of concern for neurological effects in children.

Carcinogenic Effects

The best study for assessment of the carcinogenic effects of lead by the oral route is the study by Azar *et al.* (1973). In this experiment rats were administered lead acetate in their diet. Kidney tumors were produced in a dose-related manner. Table 1 shows the data from this experiment.

Table 1. Kidney Tumor Incidence in Rats Administered Lead Acetate in the Diet (Azar *et al.* 1973).

Dose (mg/kg-day)	Number of Rats in Dose Group	Number of Rats with Tumors
0.23	20	0
0.39	100	0
1.40	50	0
4.78	50	0
10.9	50	0
42.3*	20	5
79.7*	20	10
167*	20	16

*The groups with only 20 rats per dose group were also studied for two years but were begun several months after the other dose groups.

From these data, a q_1^* (animal) was calculated using Global 86. The p value for the Chi Square test was 0.82, indicating a good fit of the data to the linearized multistage model. The q_1^* (animal) is 1.53×10^{-3} $(mg/kg\text{-}day)^{-1}$. An equivalent human q_1^* was calculated using the formula

$$q_1^*\ \text{(human)} = q_1^*\ \text{(animal)} \times (\text{human body weight/rat body weight})^{0.25}$$

$$= 1.53 \times 10^{-3}\ (mg/kg\text{-}day)^{-1} \times (70\ kg/0.3\ kg)^{0.25}$$
$$= 5.98 \times 10^{-3}\ (mg/kg\text{-}d)^{-1}$$

An oral cancer slope factor (CSF) was calculated using the formula:

$$CSF = 0.1 \div LED_{10}$$

The LED_{10} is the 95% lower-bound on dose resulting in a 10% tumor incidence as calculated by, for example, Global 86. For the rat kidney tumor data, the LED_{10} is 68.8 mg/kg-day, and the CSF (rat) is 0.1 ÷ 68.8 mg/kg-day = 1.45×10^{-3} $(mg/kg\text{-}day)^{-1}$.

The CSF for the rat data was converted to a CSF for humans using the same body weight scaling as described for the q_1*. This calculation yielded a CSF (human) of 5.68×10^{-3} $(mg/kg\text{-}day)^{-1}$. Therefore, the CSF (human) is approximately the same as the q_1* (human). This CSF (human) was used to calculate a PHG based on carcinogenicity, as described below.

CALCULATION OF PHG

Carcinogenic Endpoint

A public health-protective concentration (C) for lead (in mg/L) in drinking water can be calculated using the general equation for carcinogenic endpoints:

$$C = \frac{R \times BW}{CSF \times L/day} = mg/L$$

where,

R	=	*De minimis* theoretical excess individual lifetime cancer risk value of 1×10^{-6}
BW	=	Adult male body weight default value (70 kg)
CSF	=	Cancer slope factor calculated previously [5.68×10^{-3} $(mg/kg\text{-}day)^{-1}$]
L/day	=	Volume of daily water consumption for an adult (2 L/day).

Therefore,

$$C = \frac{1 \times 10^{-6} \times 70\ kg}{5.68 \times 10^{-3}\ (mg/kg\text{-}day)^{-1} \times 2\ L/day}$$

$$= 6.16 \times 10^{-3}\ mg/L = 0.006\ mg/L\ (rounded) = 6\ ppb.$$

Noncarcinogenic Endpoints

A public health-protective concentration (C) for lead (in mg/L) in drinking water can also be calculated using the general equation for noncarcinogenic endpoints:

$$C = \frac{NOAEL \times RSC}{UF \times L/day} = mg/L$$

where,

NOAEL	=	No-observed-adverse-effect-level or for lead is substituted with the "level of concern" for children (28.6 μg/day)
RSC	=	Relative source contribution of 20% (0.2)
UF	=	Uncertainty factor of 3-fold
L/day	=	Daily volume of consumption of drinking water for a child (1 L/day).

The NOAEL is substituted in this equation by a level of concern of 28.6 µg/day derived previously for children. CDC's level of concern for lead in blood is somewhat arbitrary, but has been consistently lowered over the last two decades, and may be lowered again in the future. There is some uncertainty as to whether this level is protective for all children. There are children in the population whose blood lead levels are already above the concern level. For these individuals any increase in blood lead level would simply add to an already adverse blood lead level. In calculating the PHG for noncarcinogenic effects, an uncertainty factor of three was applied to account for the uncertainty with regard to the degree of protection offered by the estimated level of concern, because no threshold has been observed for the noncarcinogenic effects of lead and there is a wide distribution of blood lead levels in the population of children (African-American children have higher levels than the general population).

For purposes of the PHG calculation, children are assumed to consume 1 L of water/day. The drinking water contribution to children's lead exposure is estimated to range from 5% to over 50% (U.S. EPA, 1991) depending on the immediate environment in which the child lives. For children exposed to lead in paint, or lead in air and soil (e.g., living near roadways where lead deposits from engine exhaust still persist), U.S. EPA determined that drinking water exposure to lead would be on the lower end of this range. Therefore, in calculating a public health-protective concentration, we assume that drinking water exposures would contribute 20% of the total exposure to lead to account for exposures in children living in areas where high environmental concentrations of lead still persist.

Therefore,

$$C = \frac{28.6\ \mu g/day \times 0.2}{3 \times 1\ L/day}$$

$$= 0.0019\ mg/L = 0.002\ mg/L\ (rounded) = 2\ ppb.$$

The public health-protective concentration for lead based on the carcinogenic endpoint is 6 ppb. This is higher than the public health-protective concentration of 2 ppb calculated for noncarcinogenic effects. Therefore, the Public Health Goal (PHG) developed for lead in drinking water is 0.002 mg/L (2 ppb) based on noncarcinogenic effects.

RISK CHARACTERIZATION

The health risks of exposure to lead are well established by a large body of research. For the noncarcinogenic effects upon which this PHG is based (i.e., neurobehavioral effects to children and hypertensive effects to adults), the research has been conducted on human populations. Therefore, there is no uncertainty based on extrapolation from animals to humans for these effects. The carcinogenic effect data is based on animal experimentation. In assessing the risk from carcinogenicity, there is uncertainty in extrapolating from animals to humans. The Azar *et al.* (1973) study is the best available data for calculating a CSF.

Humans, especially children, may vary in their sensitivity to lead in drinking water because of differences in nutrition, exposure to lead from other sources and metabolic and genetic differences. Adults may vary in their sensitivity to the hypertensive effects of lead.

The calculated PHG utilizes an RSC of 20% (0.2). This value is justified for certain subpopulations of children living in areas where lead in the environment still persists in moderate to high levels. Higher RSCs (up to 50%) might be justified for the general population because of the recent declines in relative contribution from air, water and food. The use of a higher RSC would increase the calculated PHG for noncarcinogenic endpoints for lead in drinking water.

OTHER STANDARDS AND REGULATORY LEVELS

U.S. EPA has adopted a Maximum Contaminant Level Goal (MCLG) of zero for lead in drinking water, based on "occurrence of low level effects" and because U.S. EPA classifies lead as a Class B_2 carcinogen (U.S. EPA, 1997; Fed. Reg. 56: 32112, July 15, 1991) U.S. EPA has not adopted a Maximum Contaminant Level (MCL) for lead in drinking water because they regard the development of such a level as "not feasible" (U.S. EPA, 1997; Fed. Reg. 56: 32112, July 15, 1991). U.S. EPA relies on the "treatment approach" described in the final rule (Fed. Reg. 56: 32112, July 15, 1991) to achieve the objective of reducing exposures to lead. U.S. EPA has also set an "action level" for lead in drinking water of 15 ppb (40 CFR 141, 142; Fed. Reg. 56: 26461-26564). This is a level the U.S. EPA believes is feasible for public water systems to attain by such measures as adjusting the physical characteristics of the water (pH, hardness) which affect the corrosivity of the water. U.S. EPA has set a National Ambient Air Quality Standard of 1.5 $\mu g/m^3$ (Fed.Reg. 43: 41258, October 5, 1978).

The lead and copper rule is a Federal and State drinking water standard (Title 22 CCR, section 64672.3) that specifies requirements for lead in drinking water systems (measured at the customers' taps). The action level (15 ppb) is used to determine the treatment requirements that a water system must complete. The action level for lead is exceeded if the concentration of lead in more than 10 percent of the tap water samples collected during any monitoring period (conducted in accordance with 22 CCR sections 64682 to 64685) is greater than 15 ppb. Failure to comply with the applicable requirements for lead and copper is a violation of primary drinking water standards for these substances (22 CCR Chapter 17.5). Therefore, for all practical purposes the standard described in the lead and copper rule is an MCL.

U.S. EPA has set a National Ambient Air Quality Standard of 1.5 $\mu g/m^3$ (Fed. Reg. 43: 41258, October 5, 1978).

Lead is listed as a carcinogen and as a reproductive and developmental toxic chemical under the Safe Drinking Water and Toxic Enforcement Act of 1986, "Proposition 65" (California Health and Safety Code, Chapter 6.6, section 25249.5 *et seq*.). Lead is listed as a reproductive and developmental toxic chemical because of its effects on IQ during development. Under this program the level set for warning against possible reproductive and developmental effects is 0.5 µg/day for any one source of exposure.

REFERENCES

ATSDR (1990). Toxicological profile for lead (draft for public comment) prepared by Clement International Corporation for the Agency for Toxic Substances and Disease Registry.

Azar, A., Trochimowicz, H.J., Maxfield, M.E. (1973). Review of lead studies in animals carried out at Haskell Laboratory -- two-year feeding study and response to hemorrhage study. In: *Proceedings, international symposium, environmental health aspects of lead*. Commission of the European Communities, Directorate General for Dissemination of Knowledge. Centre for Information and Documentation, Luxembourg, pp. 199-210.

Baghurst, P.A., McMichael, A.J., Wigg, N.R., Vimpani, G.W., Robertson, E.F., Roberts, R.J., Tong, S.L. (1992). Environmental exposure to lead and children's intelligence at the age of seven years: the Port Pirie cohort study. *New England Journal of Medicine* **327**, 1279-1284.

Bauchinger, M., Schmid, E. (1972). Chromosomemenanalysen in Zellkulturen des chinesischen Hamsters nach Applikation von Bleiacetat. *Mutation Research* **14**, 95-100.

Bellinger, D.C., Stiles, K M., Needleman, H.L. (1992). Low-level lead exposure, intelligence and academic achievement: a long-term follow-up study. *Pediatrics* **90**, 855-861.

Bowers, T.S., Beck, B.D., Karam, H.S. (1994). Assessing the relationship between environmental lead concentrations and adult blood lead levels. *Risk Analysis* **14**, 183-189.

Bushnell, P., Bowman, R. (1979). Reversal of learning deficits in young monkeys exposed to lead. *Pharmacol. Biochem. Behav*. **10**, 733-742.

CDC (1991). Preventing lead poisonings in young children, a statement by the Centers for Disease Control (October 1991). USDHHS, PHS, CDC.

Chowdhury, A.R., Dewan, A., Ghandhi, D.N. (1984) Toxic effect of lead on the testes of rat. Biomed Biochim Acta. **25**, 55-62.

CRC Handbook of Chemistry and Physics (1994). Edited by Lide, D.R. and Frederikse, H.P.R. CRC Press, Inc. Boca Raton

Davis, J., Otto, D., Weil, D., Grant, L. (1990). The comparative developmental neurotoxicity of lead in humans and animals. *Neurotoxcol. Teratol*. **12**, 215-229.

DHS (1991). Childhood lead poisoning prevention, California Department of Health Services. June 6, 1991.

Dietrich, K.N., Berger, O.G., Succop, P.A., Hammond, P.B., Bornschein, R.L. (1993). The developmental consequences of low to moderate prenatal and postnatal lead exposure: intellectual attainment in the Cincinnati lead study cohort following school entry. *Neurotoxicol. Teratol*. **15**, 37-44.

Goldstein, G. W. (1993). Evidence that lead acts as a calcium substitute in second messenger metabolism. *NeuroToxicology* **14,** 97-102.

Heard, M.J., Chamberlain, A.C. (1982). Effect of minerals and food on uptake of lead from the gastrointestinal tract in humans. *Human Toxicology* **1**, 411-415.

Hilderbrand, D.C., Der, R., Griffin, W.T., *et al*. (1973). Affect of lead acetate on reproduction. **115**, 1058-1065.

Hutton, M. (1987). Human health concerns of lead, mercury, cadmium and arsenic. In: *Lead, mercury, cadmium and arsenic in the environment.* Edited by T.C. Hutchinson and K.M. Meema, SCOPE. Published by John Wiley and Sons, Ltd., N.Y., Toronto.

James, H.M., Hilburn, M.E., Blair, J.A. (1985). Effects of meal and meal times on uptake of lead from the gastrointestinal tract in humans. *Human Toxicology* **4**, 401-407.

Karmakar, N., Saxena, R., Anand, S. (1986). Histopathological changes induced in rat tissues by oral intake of lead acetate. *Environ. Res*. **41**, 23-28.

Kennedy, G., Arnold, D., Calandra, J. (1975). Teratogenic evaluation of lead compounds in mice and rats. *Food Cosmet. Toxicol*. **13**, 629-632.

Kumar, S., Jain, S., Aggarwal, C., Ahuja, G. (1987). Encephalopathy due to inorganic lead exposure in an adult. *Japanese J. Med*. **26**, 253-254.

Lovering, T. (1976). Lead in the environment. *U.S. Geol. Survey Profes. Paper* **957**, 1.

Mahaffey, K.R. (1985). Dietary and environmental lead: human health effects. NIOSH. Elsevier.

Markovac, J., Goldstein, G.W. (1988). Picomolar concentrations of lead stimulate brain protein kinase C. *Nature* **334**, 71-73.

McMichael, A.J., Baghurst, P.A., Vimpani, G.V., Wigg, N.R., Robertson, E.F., Tong, S. (1994). Tooth lead levels and IQ in school-age children: the Port Pirie cohort study. **140**, 489-499.

Meiklehohn, A. (1963). The successful prevention of lead poisoning in the glazing of earthenware in the North Staffordshire potteries. *Brit. J. Indust. Med*. **20**, 169-180.

Nakhoul, R., Kayne, L.E., Brautbar, N., Hu, M., McDonough, A., Eggena, P., Golub, M.S., Berger, M., Chang, C., Jamgotchian, N., and Lee, D.B.N. (1992). Rapid hypertensinogenic effect of lead: studies in spontaneously hypertensive rat. *Toxicol. Ind. Health* **8,** 89-102.

Needleman, H. (1982). The neurobehavioral consequences of low lead exposure in childhood. *Neurobehavioral Toxicol. and Teratol*. **4**, 729-732.

Needleman, H. (1987). Low level lead exposure in the fetus and young child. *Neurotoxicology* **8**, 389-394.

OEHHA (1997). Technical support document: health effects of airborne inorganic lead. Office of Environmental Health Hazard Assessment and Air Resources Board, California Environmental Protection Agency. Release date: March 1997.

O'Flaherty, E.J. (1993). Physiologically based models for bone-seeking elements IV: kinetics of lead disposition in humans. **118**, 16-29.

Pocock, S.J., Shaper, A.G., Walker, M., Wale, C.J., Clayton, B., Delves, T., Lacey, R.F., Packham, R.F., Powell, P. (1983). Effects of tap water lead, water hardness, alcohol and cigarettes on blood lead concentrations. **37**, 1-7.

Rabinowitz, M.B. (1991). Toxicokinetics of bone lead. **91,** 33-37.

Ragan, H. (1983). The bioavailability of iron, lead and cadmium via gastrointestinal absorption: a review. *Sci. Total Environ*. **28**, 317-326.

Robison, S.H., Cantoni, O., Costa, M. (1984). Analysis of metal-induced DNA lesions and DNA-repair replication in mammalian cells. **131**, 173-181.

Rothenberg, S.J., Karchmer, S., Schnaas, L., Perroni, E., Zea, F., Alba, J.F. (1994). Changes in serial blood lead levels during pregnancy. **102**, 876-880.

Schwartz, J. Otto, D. (1991). Lead and minor hearing impairment. *Arch. Environ. Health* **46**, 300-305.

Shacklette, H., Hamilton, J., Boerngen, J., Bowles, J. (1971). Elemental composition of surficial materials in the coterminous United States*: U.S. Geological Survey Profes. Paper* **574-D**, 71.

Silbergeld, E. (1991). Lead in bone: implications for toxicology during pregnancy and lactation. **91**, 63-70.

U.S. EPA (1997). Integrated Risk Information System (IRIS), U.S. Environmental Protection Agency.

U.S. EPA (1991). Maximum contaminant level goals and national primary drinking water regulations for lead and copper; final rule. Federal Register, Friday, June 7, 1991, Vol. 56, No. 110, pp. 26460-26469. 40 CFR Parts 141 and 142.

U.S. EPA (1986). Air quality criteria for lead. Environmental Criteria and Assessment Office, Research Triangle Park, N.C. EPA-600/8-83/028aF.

Waterman, S.J., El-Fawal, H.A.N., Snyder, C.A. (1994). Lead alters the immunogenicity of two neural proteins: a potential mechanism for the progression of lead-induced neurotoxicity. **102**, 1052-1056.

Yule, W., Rutter, M. (1985). Effect of lead on children's behavior and cognitive performance: a critical review. In: *Dietary and environmental lead: human health effects*. Edited by K.R. Mahaffey. Published by Elsevier, Amsterdam.

Zelikoff, J.T., Li, J.H., Hartwig, A. (1988). Genetic toxicology of lead compounds. *Carcinogenesis* **9**, 1727-1732.

Public Health Goals for
NITRATE AND NITRITE
in Drinking Water

Prepared by

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PREFACE

Drinking Water Public Health Goal of the Office of Environmental Health Hazard Assessment

This Public Health Goal (PHG) technical support document provides information on health effects from contaminants in drinking water. The PHG describes concentrations of contaminants at which adverse health effects would not be expected to occur, even over a lifetime of exposure. PHGs are developed for chemical contaminants based on the best available toxicological data in the scientific literature. These documents and the analyses contained in them provide estimates of the levels of contaminants in drinking water that would pose no significant health risk to individuals consuming the water on a daily basis over a lifetime.

The California Safe Drinking Water Act of 1996 (amended Health and Safety Code, Section 116365) requires the Office of Environmental Health Hazard Assessment (OEHHA) to adopt PHGs for contaminants in drinking water based exclusively on public health considerations. The Act requires OEHHA to adopt PHGs that meet the following criteria:

1. PHGs for acutely toxic substances shall be set at levels at which scientific evidence indicates that no known or anticipated adverse effects on health will occur, plus an adequate margin-of-safety.
2. PHGs for carcinogens or other substances which can cause chronic disease shall be based solely on health effects without regard to cost impacts and shall be set at levels which OEHHA has determined do not pose any significant risk to health.
3. To the extent the information is available, OEHHA shall consider possible synergistic effects resulting from exposure to two or more contaminants.
4. OEHHA shall consider the existence of groups in the population that are more susceptible to adverse effects of the contaminants than a normal healthy adult.
5. OEHHA shall consider the contaminant exposure and body burden levels that alter physiological function or structure in a manner that may significantly increase the risk of illness.
6. In cases of scientific ambiguity, OEHHA shall use criteria most protective of public health and shall incorporate uncertainty factors of noncarcinogenic substances for which scientific research indicates a safe dose-response threshold.
7. In cases where scientific evidence demonstrates that a safe dose-response threshold for a contaminant exists, then the PHG should be set at that threshold.
8. The PHG may be set at zero if necessary to satisfy the requirements listed above.
9. OEHHA shall consider exposure to contaminants in media other than drinking water, including food and air and the resulting body burden.
10. PHGs adopted by OEHHA shall be reviewed periodically and revised as necessary based on the availability of new scientific data.

PHGs adopted by OEHHA are for use by the California Department of Health Services (DHS) in establishing primary drinking water standards (State Maximum Contaminant Levels, or MCLs). Whereas PHGs are to be based solely on scientific and public health considerations without regard to economic cost considerations, drinking water standards adopted by DHS are to consider economic factors and technical feasibility. For this reason PHGs are only one part of the information used by DHS for establishing drinking water standards. PHGs established by

OEHHA exert no regulatory burden and represent only non-mandatory goals. By federal law, MCLs established by DHS must be at least as stringent as the federal MCL if one exists.

PHG documents are developed for technical assistance to DHS, but may also benefit federal, state and local public health officials. While the PHGs are calculated for single chemicals only, they may, if the information is available, address hazards associated with the interactions of contaminants in mixtures. Further, PHGs are derived for drinking water only and are not to be utilized as target levels for the contamination of environmental waters where additional concerns of bioaccumulation in fish and shellfish may pertain. Often environmental water contaminant criteria are more stringent than drinking water PHGs, to account for human exposures to a single chemical in multiple environmental media and from bioconcentration by plants and animals in the food chain.

TABLE OF CONTENTS

LIST OF CONTRIBUTORS ii

PREFACE iii

SUMMARY 1

INTRODUCTION 1

HUMAN EXPOSURE 1

TOXICOLOGY 2

- Methemoglobinemia 2
- Reproductive and Developmental Toxicity 3
- Carcinogenicity 3
- Other Health Effects 4

DOSE-RESPONSE ASSESSMENT 4

- Nitrate 4
- Nitrite 5
- Joint Nitrate and Nitrite 5

CALCULATION OF PHGS 5

RISK CHARACTERIZATION 6

REFERENCES 8

SUMMARY

OEHHA developed Public Health Goals (PHGs) of 45 ppm for nitrate (equivalent to 10 ppm nitrate-nitrogen), 1 ppm for nitrite-nitrogen and 10 ppm for joint nitrate/nitrite (expressed as nitrogen) in drinking water. The calculation of these PHGs is based on the protection of infants from the occurrence of methemoglobinemia, the principal toxic effect observed in humans exposed to nitrate or nitrite. The PHGs are equivalent to California's current drinking water standards for nitrate (45 mg/L nitrate), nitrite (1 mg/L nitrite-nitrogen) and 10 mg/L (joint nitrate/nitrite expressed as nitrogen) which were adopted by the California Department of Health Services (DHS) in 1994 from the U.S. Environmental Protection Agency's (U.S. EPA's) Maximum Contaminant Levels (MCLs) promulgated in 1991. Following our review of the current literature and a reevaluation of the bases for calculating the MCLs for these compounds, we determined that there was no scientific basis to propose alternative PHGs. Therefore, OEHHA adopts PHGs of 45 mg/L (45 ppm) for nitrate, 1 mg/L (1 ppm) for nitrite-nitrogen and 10 mg/L (10 ppm) for joint nitrate/nitrite (expressed as nitrogen) in drinking water.

INTRODUCTION

California's current drinking water standard for nitrate is 45 mg nitrate/L (equivalent to 10 mg nitrate-nitrogen/L) and for nitrite is 1 mg nitrite-nitrogen/L. In addition, there is a joint nitrate/nitrite standard of 10 mg/L, expressed on a nitrogen basis. These values were adopted by the DHS in 1994 from U.S. EPA's MCLs promulgated in 1991. The standards are based on the occurrence of methemoglobinemia, the principal toxic effect observed in humans exposed to nitrate or nitrite. In developing PHGs for nitrate and nitrite, we evaluated the basis for U.S. EPA's MCLs. In addition, a search of the scientific literature was conducted to determine if there are any new data that would support the development of numbers different from the current values[1]. It is important to note that Office of Environmental Health Hazard Assessment (OEHHA) staff have conducted peer-reviewed, published evaluations of the hazards of nitrate and nitrite in drinking water that were important to the development of PHGs (Fan *et al.*, 1987; Fan and Steinberg, 1996). The results of our present evaluation are described below.

HUMAN EXPOSURE

Human exposure to nitrates and nitrites results primarily from dietary ingestion, particularly from vegetables and cured meats. The average adult daily intake from food in the United States has been estimated to be 40 to 100 mg for nitrate, and 0.3 to 2.6 mg for nitrite. Exposure estimates indicate that for more than 99% of the adult population in the United States, only 1 to 3% of nitrate and nitrite intake comes from drinking water. Drinking water becomes an important contributor to total nitrate exposure only in areas of notable contamination (NRC, 1981; 1995). For infants, the exposure scenarios are somewhat different. For breast-fed infants, total nitrate exposure is negligible. For bottle-fed infants consuming drinking water used to prepare their formula, drinking water can be a substantial exposure pathway. At the MCL of 10 mg nitrate-nitrogen/L, the daily intake for a 4 kg infant consuming 0.64 L/day of water used to prepare formula would be approximately 1.6 mg/kg-day.

[1] A copy of the literature review is available to the public upon request.

TOXICOLOGY

Methemoglobinemia

Methemoglobinemia is the primary adverse health effect associated with human exposure to nitrate or nitrite. To cause methemoglobinemia, nitrate must be converted to nitrite. Nitrite causes the oxidation of normal hemoglobin to methemoglobin which is unable to transport oxygen from lungs to tissues. Bacteria in the gastrointestinal system mediate the conversion of nitrate to nitrite. Consequently the risk of methemoglobinemia from ingestion of nitrate depends not only on the dose of nitrate by also on the number and type of enteric bacteria. Low levels of methemoglobin occur in individuals with typical values ranging from 0.5 to 2.0% (NRC, 1981). While methemoglobinemia can be clinically diagnosed at levels of 1%, methemoglobin levels up to 10% are generally not considered adverse. At levels above 10%, methemoglobinemia causes cyanosis, and at higher concentrations, asphyxia (WHO, 1996; U.S. EPA, 1997).

Infants are generally recognized as the subpopulation most susceptible to nitrate induced methemoglobinemia (U.S. EPA, 1990; U.S. EPA, 1997). Several factors make infants particularly sensitive to methemoglobinemia including: 1) infants have a greater total fluid intake per unit body weight than adults, 2) the gastrointestinal system in infants normally has a high pH that allows bacterial proliferation and nitrate catalysis to nitrite, 3) frequent occurrences of infant gastroenteritis may favor the development of methemoglobin when the upper gastrointestinal tract becomes colonized with bacteria, 4) fetal hemoglobin is more readily oxidized than adult hemoglobin and 5) infants have half the methemoglobin reductase activity of older children and adults and are therefore less capable of metabolizing excess methemoglobin (Winton *et al.*, 1971; NRC, 1981; Kross *et al.*, 1992).

There are other individuals who may be predisposed to the development of nitrate-induced methemoglobinemia due to altered physiological states. These include pregnant women and possibly others with glucose-6-phosphate dehydrogenase deficiency, adults with reduced gastric acidity (e.g., from diseases including achlorohydria or atrophic gastritis) and those with a lack of methemoglobin reductase (U.S. EPA, 1997; NRC, 1981).

Since the mid 1950's, more than 2,000 cases of infantile methemoglobinemia have been reported world-wide. Most cases are associated with exposure concentrations greater than 20 mg nitrate-nitrogen/L in drinking water that was used to prepare infant formula. Cases of infantile methemoglobinemia associated with nitrate exposure concentrations of 11 to 20 mg nitrate-nitrogen/L are usually associated with concomitant exposure to water contaminated with bacteria. Thorough reviews of the literature on the occurrence of methemoglobinemia in infants are provided by U.S. EPA (1990), Fan *et al.* (1987), and Fan and Steinberg (1996).

Only two reports were found documenting cases of infantile methemoglobinemia resulting from ingestion of nitrate-contaminated water since the development of the federal standard in 1991. In Wisconsin, a six-week-old girl was found to have a methemoglobin level of 21.4% after having been hospitalized twice, first for dehydration and vomiting, and later for acute weight loss and limited consumption of formula. Water samples taken during the infant's hospitalization contained 9.9 and 58 mg nitrate-nitrogen/L as collected from the reverse-osmosis unit and from the well that supplied water to the house, respectively. In addition, an early morning first draw sample collected from the kitchen faucet contained copper levels six-times the federal MCL. The infant's condition

was attributed to her being given formula mixed with water contaminated with both nitrate and copper (MMWR, 1993). In a recent report from Poland (Lutynski *et al.*, 1996), it was noted that from 1979 to 1992, the Poison Information Center in Krakow documented 239 cases of methemoglobinemia from Krakow and neighboring provinces. Of the 239 cases, 216 involved infants who were fed with nitrate-contaminated well water and carrot soup. Exposure concentrations were not given, and water supplies in the area were characterized as being of very poor quality.

Reproductive and Developmental Toxicity

In a recent report by the National Research Council (NRC, 1995), the authors concluded that while data from recent epidemiological studies have suggested an association between maternal nitrate exposure from drinking water and developmental effects in offspring, a definite conclusion on the cause-and-effect relationship cannot be drawn.

Most of the studies in experimental animals have been conducted with nitrite. Data have shown reproductive and developmental toxicity associated with exposure to nitrite, but the effects occurred mostly at very high exposure concentrations which can also produce maternal methemoglobinemia. Teratogenic effects have not been observed in rats, mice, hamsters or rabbits (Fan *et al.*, 1987; Fan and Steinberg, 1996; NRC, 1995).

Since the development of the federal standard in 1991, one report was identified of spontaneous abortions possibly related to consumption of nitrate-contaminated well water in Indiana (MMWR, 1996). Four women living in close proximity reported a total of eight spontaneous abortions from 1991 to 1994. Nitrate concentrations of 19 to 29 mg nitrate-nitrogen/L were measured in well-water sources. Term births occurred before or after the period when each of the four women consumed nitrate-contaminated water. The investigation did not establish a causal link between nitrate exposure from drinking water and spontaneous abortion, but the findings indicate the need for further assessment of the possible effects of nitrate on human reproduction. Developmental effects were reported in rat pups from dams consuming sodium nitrite (2,000 ppm) in drinking water (Nyakas *et al.*, 1994). The observed effects on behavior and adrenal function were attributed to fetal hypoxia caused by severe methemoglobinemia in the pregnant rats.

Carcinogenicity

Concern has been raised about a possible increased risk of cancer in humans from the endogenous and exogenous formation of N-nitroso compounds from nitrite, many of which are carcinogenic in animals. However, recent epidemiological studies have not supported an association between nitrate or nitrite exposure from drinking water and increased cancer rates in humans. In experimental animals, nitrate and nitrite have not been shown to be carcinogenic. Nitrite has only been shown to be carcinogenic in animals when administered concurrently with nitrosable amines, apparently as a result of the endogenous formation of carcinogenic amines (WHO, 1996; NRC, 1995; Fan and Steinberg, 1996).

In addition to the cancer studies evaluated by the World Health Organization (WHO, 1996), the National Research Council (NRC, 1995) and U.S. EPA (1991), three recent epidemiological studies were identified examining the effects of nitrate exposure on human cancer risk. The results of one case-control study from Germany (Steindorf *et al.*, 1994) suggest the absence of an association between low nitrate levels in drinking water (16 mg nitrate-nitrogen/L) and the risk of

brain tumors. Two studies by Morales-Suarez-Varela were published on the impact of elevated nitrate concentrations in drinking water (greater than 50 ppm) on cancer incidence and mortality in Valencia, Spain (Morales-Suarez-Varela *et al.*, 1993; Morales-Suarez-Varela *et al.*, 1995). The authors suggest a possible association between elevated nitrate concentrations in drinking water and cancer of the bladder and stomach. However, a definite cause-and-effect relationship was not shown. Another case-control study conducted in Nebraska examined nitrate in drinking water and the risk of non-Hodgkin's lymphoma (Ward *et al.*, 1996). Authors reported that long-term exposure to elevated nitrate in drinking water (greater than 50 ppm) may contribute to the risk of non-Hodgkin's lymphoma, but again, no cause-and-effect relationship was shown.

Other Health Effects

Inorganic and organic nitrite compounds can produce hypotension in humans as a result of direct action on smooth muscle. Therapeutic doses of 30 to 60 mg sodium nitrite are typically used to treat angina pectorus. Organic nitrates can also produce hypotension, although through an indirect mechanism of action, while inorganic nitrate does not produce the effect (U.S. EPA, 1990).

DOSE-RESPONSE ASSESSMENT

The current state and federal MCLs for nitrates and nitrites are based on the occurrence of infantile methemoglobinemia resulting from ingestion of nitrate-contaminated water. The two principal studies used as the basis of these standards are described below.

Bosch *et al.* (1950) evaluated 139 cases of cyanosis due to methemoglobinemia reported in Minnesota from 1947 to 1949. The 139 cases, which included 14 deaths, occurred in infants under six months of age. Nitrate concentrations were measured in 129 wells used to supply water to the infants with methemoglobinemia. None of the wells contained nitrate concentrations less than 10 mg nitrate-nitrogen/L. Only two of the wells contained 10 to 20 mg nitrate-nitrogen/L, however in both of these cases the diagnosis of methemoglobinemia was considered questionable. Coliform organisms were detected in 45 of 51 samples tested for bacterial contamination.

Walton (1951) reported results of a survey conducted by the American Public Health Association that identified 278 cases of infantile methemoglobinemia associated with consumption of nitrate-contaminated water. Water nitrate concentrations were available for 214 of the 278 cases. Of the 214 cases, none occurred from water nitrate concentrations less than 10 mg nitrate-nitrogen/L, and only five cases (2%) involved infants exposed to 11 to 20 mg nitrate-nitrogen/L. More than 80% of the infants were exposed to nitrate concentrations greater than 50 mg nitrate-nitrogen/L. Data on bacteriological contamination of the water and/or incidence of gastrointestinal disease among the infants were not reported.

Nitrate

Based primarily on the studies of Bosch *et al.* (1950) and Walton (1951), with support from a large number of additional epidemiological and case studies in humans (including Cornblath and Hartmann, 1948; Simon *et al.*, 1964; Toussaint and Selenka, 1970; Craun *et al.*, 1981; see U.S. EPA, 1990 for descriptions of these and other studies) a no-observed-adverse-effect-level (NOAEL) is identified to be 10 mg nitrate-nitrogen/L. An uncertainty factor of one was applied because the available data provide an adequate NOAEL for the critical toxic effect (methemoglobinemia) in the most sensitive human subpopulation (infants). Therefore, the MCL is

10 mg nitrate-nitrogen/L, or 45 mg nitrate/L (U.S. EPA, 1997), based on early clinical signs of cyanosis associated with methemoglobinemia in infants.

Nitrite

There are no reliable quantitative data on nitrite and methemoglobinemia in humans. While nitrite has been shown to cause methemoglobinemia in animals, humans appear to be more sensitive to nitrite-induced methemoglobin formation. Therefore, the MCL for nitrite was derived by extrapolation of nitrate toxicity data in humans. Based on data which indicate that the fraction of nitrate reduced to nitrite in adults is at least 5%, and knowing that nitrate reduction in infants is significantly greater than in adults (due to the presence of gastrointestinal bacteria), the conversion rate is estimated to be at least 10% in infants (U.S. EPA, 1990).

Using the same NOAEL selected for nitrate of 10 mg nitrate-nitrogen/L (from Bosch *et al.*, 1950; Walton, 1951), an uncertainty factor of one was applied because the NOAEL was of the critical toxic effect (methemoglobinemia) in the most sensitive human subpopulation (infants). In addition, the NOAEL was multiplied by 0.1 to account for the estimated conversion rate of nitrate to nitrite by gastrointestinal tract bacteria in infants, as described above. Therefore, the MCL for nitrite is 1 mg nitrite-nitrogen/L (U.S. EPA, 1990; U.S. EPA, 1997).

Joint Nitrate and Nitrite

U.S. EPA set a joint standard for the sum of the concentration of nitrate and nitrite at 10 mg/L as nitrogen. The combined standard does not replace the individual MCLs for nitrate or nitrite, therefore the maximum contribution from nitrite cannot exceed 1 mg nitrite-nitrogen/L (U.S. EPA, 1991).

CALCULATION OF PHGS

Public health-protective concentrations (C, in mg/L) are calculated using the general formula for noncarcinogenic endpoints:

$$C = \frac{NOAEL \times BW \times RSC}{UF \times L/day} = mg/L$$

where,

NOAEL	=	No-observed-adverse-effect-level (10 mg nitrate-nitrogen/L)
BW	=	Body weight (not applicable)
RSC	=	Relative source contribution (not applicable)
UF	=	Uncertainty factor (one)
L/day	=	Volume of daily drinking water consumption (not applicable).

In the case of nitrate and nitrite, the NOAEL is based on human data for nitrate exposure from drinking water in the most sensitive population (infants). Therefore, the uncertainty factor for human variability is one. No other uncertainty factors are applied. For nitrite, the NOAEL is multiplied by 0.1 to account for the estimated conversion rate of nitrate to nitrite by gastrointestinal tract bacteria in infants, as previously described.

OEHHA staff support U.S. EPA's previous analysis on nitrate and nitrite. The values consider the conversion of nitrate to nitrite, nitrite-induced formation of methemoglobin, and the general absence of methemoglobinemia occurring at nitrate-nitrogen levels below 10 mg/L based on world-wide epidemiological evidence. The values are protective for infants, the most sensitive population. Review of updated information compiled since the development of the MCLs in 1991 support the earlier findings. In addition, no cases of methemoglobinemia occurring at or below the MCL have been identified in the United States. Therefore, OEHHA adopts the following PHGs:

nitrate	=	10 mg nitrate-nitrogen/L (10 ppm nitrate-nitrogen)
	=	45 mg nitrate/L (45 ppm nitrate),
nitrite	=	1 mg nitrite-nitrogen/L (1 ppm) and
joint nitrate/nitrite	=	10 mg/L (10 ppm), expressed on a nitrogen basis.

These PHGs, as well as current federal MCLs for nitrate and nitrite, should be adequately protective against methemoglobinemia in infants, as well as any potential reproductive or developmental effects.

RISK CHARACTERIZATION

Although there are an enormous amount of data on the occurrence of methemoglobinemia in infants ingesting nitrate-contaminated water, there are some uncertainties in the database used for the development for the MCL:

1. The concentration of nitrate is not known in all reported cases of methemoglobinemia, and cases of nitrate-induced infantile methemoglobinemia have been reported in other countries at levels below the MCL. While the reports that indicate cases occurring below the MCL are of uncertain quality (largely due to a lack of controls for the presence of confounding factors), there is the possibility that methemoglobinemia resulting from nitrate ingestion could occur at a nitrate level lower than the MCL.

2. It is possible that methemoglobinemia is more likely associated with nitrate plus bacterial contamination of drinking water. Bacterial contamination favors the conversion of nitrate to nitrite as well as the occurrence of diarrhea, which in infants can increase the risk of methemoglobinemia.

3. There could be unidentified differences among the study populations, including nutritional status, that could contribute to differences in the reported findings. Vitamin C can help reduce the risk of methemoglobinemia from nitrate (NRC, 1995) and some populations have a higher vitamin C intake level than others.

4. There are no known requirements for reporting cases of methemoglobinemia.

5. Infant illness or death from nitrate-induced methemoglobinemia may be misdiagnosed, perhaps as sudden-infant-death-syndrome (Johnson and Kross, 1990).

In light of the above, a particular public health concern regarding the methemoglobinemia data is the finding of a lowest-observed-adverse-effect-level (LOAEL) of 11 to 20 mg nitrate-nitrogen/L with no clear delineation of a NOAEL. It is important to note that, in the United States no cases of methemoglobinemia have been reported at a nitrate concentration at or below the MCL.

Animal experimental data have shown reproductive and developmental toxicity associated with high exposure levels to nitrate and nitrite, which are not likely to be encountered in drinking water. The lowest concentrations associated with developmental effects were reported at 1,000 ppm sodium nitrite in water, with a NOAEL at or around 500 ppm (Roth *et al.*, 1987; Roth and Smith, 1988). At an MCL of 45 ppm nitrate, and assuming a 10% conversion of nitrate to nitrite, the amount of nitrate ingestion from two liters of water would be several hundred times less than this NOAEL (Fan and Steinberg, 1996).

U.S. EPA has adopted a joint standard to account for the possibility of the simultaneous occurrence of nitrate and nitrite in drinking water. The equilibrium of nitrate and nitrite in aqueous environments greatly favors nitrate. Nitrite levels can become significant with bacterial contamination and anaerobic conditions (U.S. EPA, 1990); in such cases nitrite levels would be expected to be high, exceeding the nitrite MCL of 1 mg/L. In light of the environmental characteristics of nitrate and nitrite, and in keeping with U.S. EPA, we have concluded that the joint MCL of 10 mg/L (with the contribution from nitrite not exceeding 1 mg nitrite-nitrogen/L) adequate for the protection of public health.

REFERENCES

Bosch H, Rosefield A, Huston R, Shipman H, Woodward F (1950). Methemoglobinemia and Minnesota well supplies. *Journal of the American Water Works Association* **42**:161-70.

Cornblath M, Hartmann A (1948). Methemoglobinemia in young infants. *J. Pediatr.* **33**:421-5.

Craun G, Greathouse D, Gunderson D (1981). Methaemoglobin levels in young children consuming high nitrate well water in the United States. *Int. J. Epidemiol* **10**(4):309-17.

Fan AM, Steinberg VE (1996). Health implications of nitrate and nitrite in drinking water: an update on methemoglobinemia occurrence and reproductive and developmental toxicity. *Regul. Toxicol. Pharmacol.* **23**:35-43.

Fan A, Willhite C, Book SA (1987). Evaluation of the Nitrate Drinking Water Standard with Reference to Infant Methemoglobinemia and Potential Reproductive Toxicity. *Regul. Toxicol. Pharmacol.* **7**:135-48.

Johnson CJ, Kross BC (1990). Continuing importance of nitrate contamination of groundwater and wells in rural areas. *Am. J. Ind. Med.* **18**(4):449-56.

Kross BC, Ayebo AD, Fuortes LJ (1992). Methemoglobinemia: nitrate toxicity in rural America. *Am. Fam. Physician* **46**(1):183-8.

Lutynski R, Steczek-Wojdyla M, Wojdyla Z, Kroch S (1996). The concentrations of nitrates and nitrites in food products and environment and the occurrence of acute toxic methemoglobinemias. *Przegl Lek* **53**(4):351-5.

MMWR (1993). Methemoglobinemia in an infant--Wisconsin, 1992. *Morb. Mortal. Wkly Rep.* **42**(12):217-9. [published *erratum* appears in MMWR *Morb. Mortal. Wkly Rep*. 1993 Apr 9;42(13):255 and 1993 May 7;42(17):342].

MMWR (1996). Spontaneous abortions possibly related to ingestion of nitrate-contaminated well water - LaGrange County, Indiana, 1991-1994. *Morb. Mortal. Wkly Rep.* **45**(26):569-72.

Morales-Suarez-Varela M, Llopis-Gonzalez A, Tejerizo-Perez ML (1995). Impact of nitrates in drinking water on cancer mortality in Valencia, Spain. *Eur. J. Epidemiol.* **11**(1):15-21.

Morales-Suarez-Varela M, Llopis-Gonzalez A, Tejerizo-Perez ML, Ferrandiz-Ferragud J (1993). Concentration of nitrates in drinking water and its relationship with bladder cancer. *J. Environ. Pathol. Toxicol. Oncol*. **12**(4):229-36.

NRC (1981). The Health Effects of Nitrate, Nitrite, and N-Nitroso Compounds. National Research Council, Washington, DC: National Academy Press.

NRC (1995). Nitrate and Nitrite in Drinking Water. National Research Council,Washington, DC: National Academy Press.

Nyakas C, Buwalda B, Markel E, Korte SM, Luiten PG (1994). Life-spanning behavioural and adrenal dysfunction induced by prenatal hypoxia in the rat is prevented by the calcium antagonist nimodipine. *Eur. J. Neurosci.* **6**(5):746-53.

Roth AC, Herkert GE, Bercz JP, Smith MK (1987). Evaluation of the developmental toxicity of sodium nitrite in Long-Evans rats. *Fundam. Appl. Toxicol.* **9**:668-77.

Roth AC, Smith MK (1988). Nitrite-induced iron deficiency in the neonatal rat. *Toxicol. Appl. Pharmacol.* **96**:43-51.

Simon C, Manzke H, Kay H, Mrowetz G (1964). Occurrence, pathogenesis, and possible prophylaxis of nitrite induced methemoglobinemia. *Zeitschr. Kinderheilk* **91**:124-38.

Steindorf K, Schlehofer B, Becher H, Hornig G, Wahrendorf J (1994). Nitrate in drinking water. A case-control study on primary brain tumours with an embedded drinking water survey in Germany. *Int. J. Epidemiol.* **23**(3):451-7.

Toussaint W, Selenka F (1970). Methemoglobinemia formation in infants: A contribution to drinking water hygiene in Rhine. *Hesse. Mschr. Kinderheilk* **June**:282-4.

U.S. EPA (1990). Drinking water criteria document on nitrate/nitrite. Prepared by Life Systems, Inc., Cleveland, Ohio, for the Criteria and Standards Division, Office of Drinking Water, U.S. Environmental Protection Agency, Washington DC. PB-91-142836.

U.S. EPA (1997). "Integrated Risk Information System (IRIS)" data base access. U.S. Environmental Protection Agency, April 1997.

U.S. EPA (1991). National primary drinking water regulations: Final rule. U.S. Environmental Protection Agency, 40 CFR Parts 141, 142, and 143. *Federal Register* **56**(20):3526-97.

Walton G (1951). Survey of literature relating to infant methemoglobinemia due to nitrate-contaminated water. *Am. J. Public Health* **41**:986-96.

Ward M, Mark S, Cantor K, Weisenburger D, Correa-Villasenor A, Zahm SH (1996). Drinking water nitrate and the risk of non-hodgkin's lymphoma. *Epidemiology* **7**(5):465-71.

Winton E, Tardiff R, McCabe L (1971). Nitrate in drinking water. *J. Amer. Water Works Assn.* **63**:95-8.

WHO (1996). Guidelines for drinking-water quality. Second edition. Volume 2. Health Criteria and other supporting information. World Health Organization, Geneva.

Appendix F
Excel Spreadsheet for Carcinogenic Risk Calculations

CALCULATIONS FOR INDIVIDUAL AND CUMULATIVE CANCER RISK AT EACH WSTF PFPP MONITORING WELL

Risk calculated on mean result from 8/18/01-8/18/03.
Risk calculated on one-half of most recent analytical detection limit where result was ND. All NDMA and DMN results were corrected for extraction efficiency. Values for arsenic and lead taken from 1/1/1988-8/18/2003.
Bolded values indicate the use of one half of the reporting limit.

BLM-02-482 & 630		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.9	**2.37E-04**	**4.02E-03**
nitroDMA	0.42	**1.11E-04**	**1.88E-03**
TCE	194.62	**4.08E-04**	**7.05E-03**
PCE	9.87	**1.96E-06**	**1.52E-05**
Chloroform	0.25	**3.53E-08**	**4.76E-07**
Acrylonitrile	1.14	**2.63E-06**	**3.00E-05**
Tetrahydrofuran	0.79	**3.03E-08**	**4.96E-07**
Arsenic	0.11	**3.46E-06**	**2.49E-06**
Lead	7.289	**1.44E-07**	**6.25E-07**
Cum. Risk:		**7.63E-04**	**1.30E-02**

BLM-07-509		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0056	**1.48E-06**	**2.50E-05**
nitroDMA	0.0035	**9.22E-07**	**1.56E-05**
TCE	0.23	**4.82E-07**	**8.34E-06**
PCE	0.21	**4.18E-08**	**3.23E-07**
Chloroform	0.18	**2.54E-08**	**3.42E-07**
Acrylonitrile	1.05	**2.42E-06**	**2.76E-05**
Tetrahydrofuran	0.47	**1.80E-08**	**2.95E-07**
Arsenic	**1.5**	**4.71E-05**	**3.40E-05**
Lead	0.27	**5.35E-09**	**2.32E-08**
Cum. Risk:		**5.25E-05**	**1.12E-04**

CALCULATIONS FOR INDIVIDUAL AND CUMULATIVE CANCER RISK AT EACH WSTF PFPP MONITORING WELL

Risk calculated on mean result from 8/18/01-8/18/03.
Risk calculated on one-half of most recent analytical detection limit where result was ND. All NDMA and DMN results were corrected for extraction efficiency. Values for arsenic and lead taken from 1/1/1988-8/18/2003.
Bolded values indicate the use of one half of the reporting limit.

BLM-10-517		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0066	**1.74E-06**	**2.95E-05**
nitroDMA	0.0038	**1.00E-06**	**1.70E-05**
TCE	0.21	**4.40E-07**	**7.61E-06**
PCE	0.18	**3.58E-08**	**2.77E-07**
Chloroform	0.17	**2.40E-08**	**3.23E-07**
Acrylonitrile	0.9	**2.07E-06**	**2.36E-05**
Tetrahydrofuran	0.5	**1.92E-08**	**3.14E-07**
Arsenic	**1.5**	**4.71E-05**	**3.40E-05**
Lead	**2.6**	**5.15E-08**	**2.23E-07**
Cum. Risk:		**5.24E-05**	**1.13E-04**

BLM-17-493 & 550		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	2.55	**6.72E-04**	**1.14E-02**
nitroDMA	1.46	**3.85E-04**	**6.53E-03**
TCE	159	**3.33E-04**	**5.76E-03**
PCE	8.2	**1.63E-06**	**1.26E-05**
Chloroform	0.19	**2.69E-08**	**3.61E-07**
Acrylonitrile	1.15	**2.65E-06**	**3.02E-05**
Tetrahydrofuran	0.474	**1.82E-08**	**2.98E-07**
Arsenic	**1.5**	**4.71E-05**	**3.40E-05**
Lead	2.85	**5.65E-08**	**2.44E-07**
Cum. Risk:		**1.44E-03**	**2.38E-02**

CALCULATIONS FOR INDIVIDUAL AND CUMULATIVE CANCER RISK AT EACH WSTF PFPP MONITORING WELL

Risk calculated on mean result from 8/18/01-8/18/03.
Risk calculated on one-half of most recent analytical detection limit where result was ND. All NDMA and DMN results were corrected for extraction efficiency. Values for arsenic and lead taken from 1/1/1988-8/18/2003.
Bolded values indicate the use of one half of the reporting limit.

BLM-37		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.015	**3.95E-06**	**6.70E-05**
nitroDMA	0.0039	**1.03E-06**	**1.74E-05**
TCE	0.31	**6.49E-07**	**1.12E-05**
PCE	0.23	**4.58E-08**	**3.54E-07**
Chloroform	0.19	**2.69E-08**	**3.61E-07**
Acrylonitrile	1.15	**2.65E-06**	**3.02E-05**
Tetrahydrofuran	1.51	**5.80E-08**	**9.49E-07**
Arsenic	2.83	**8.89E-05**	**6.41E-05**
Lead	1.07	**2.12E-08**	**9.18E-08**
Cum. Risk:		**9.73E-05**	**1.92E-04**

JP-1-424		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0061	**1.61E-06**	**2.73E-05**
nitroDMA	0.0037	**9.75E-07**	**1.65E-05**
TCE	0.24	**5.03E-07**	**8.70E-06**
PCE	0.21	**4.18E-08**	**3.23E-07**
Chloroform	0.18	**2.54E-08**	**3.42E-07**
Acrylonitrile	1.02	**2.35E-06**	**2.68E-05**
Tetrahydrofuran	0.3	**1.15E-08**	**1.88E-07**
Arsenic	**1.5**	**4.71E-05**	**3.40E-05**
Lead	**3**	**5.95E-08**	**2.57E-07**

Cum. Risk:		**5.26E-05**	**1.14E-04**

CALCULATIONS FOR INDIVIDUAL AND CUMULATIVE CANCER RISK AT EACH WSTF PFPP MONITORING WELL

Risk calculated on mean result from 8/18/01-8/18/03.
Risk calculated on one-half of most recent analytical detection limit where result was ND. All NDMA and DMN results were corrected for extraction efficiency. Values for arsenic and lead taken from 1/1/1988-8/18/2003.
Bolded values indicate the use of one half of the reporting limit.

JP-2-447		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0064	**1.69E-06**	**2.86E-05**
nitroDMA	0.0038	**1.00E-06**	**1.70E-05**
TCE	0.24	**5.03E-07**	**8.70E-06**
PCE	0.22	**4.38E-08**	**3.39E-07**
Chloroform	0.19	**2.69E-08**	**3.61E-07**
Acrylonitrile	1.02	**2.35E-06**	**2.68E-05**
Tetrahydrofuran	0.57	**2.19E-08**	**3.58E-07**
Arsenic	**1.5**	**4.71E-05**	**3.40E-05**
Lead	0.88	**1.74E-08**	**7.55E-08**
Cum. Risk:		**5.27E-05**	**1.16E-04**

JP-3		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0064	**1.69E-06**	**2.86E-05**
nitroDMA	0.0039	**1.03E-06**	**1.74E-05**
TCE	0.24	**5.03E-07**	**8.70E-06**
PCE	0.22	**4.38E-08**	**3.39E-07**
Chloroform	0.19	**2.69E-08**	**3.61E-07**
Acrylonitrile	1.01	**2.33E-06**	**2.65E-05**
Tetrahydrofuran	0.65	**2.50E-08**	**4.08E-07**

Arsenic	1.76	**5.53E-05**	**3.99E-05**
Lead	0.682	**1.35E-08**	**5.85E-08**
Cum. Risk:		**6.09E-05**	**1.22E-04**

CALCULATIONS FOR INDIVIDUAL AND CUMULATIVE CANCER RISK AT EACH WSTF PFPP MONITORING WELL

Risk calculated on mean result from 8/18/01-8/18/03.
Risk calculated on one-half of most recent analytical detection limit where result was ND. All NDMA and DMN results were corrected for extraction efficiency. Values for arsenic and lead taken from 1/1/1988-8/18/2003.
Bolded values indicate the use of one half of the reporting limit.

PL-1-486		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.024	**6.32E-06**	**1.07E-04**
nitroDMA	0.007	**1.84E-06**	**3.13E-05**
TCE	137.5	**2.88E-04**	**4.98E-03**
PCE	3.8	**7.56E-07**	**5.85E-06**
Chloroform	0.18	**2.54E-08**	**3.42E-07**
Acrylonitrile	1.08	**2.49E-06**	**2.84E-05**
Tetrahydrofuran	0.47	**1.80E-08**	**2.95E-07**
Arsenic	**1.5**	**4.71E-05**	**3.40E-05**
Lead	1.2	**2.38E-08**	**1.03E-07**
Cum. Risk:		**3.46E-04**	**5.19E-03**

PL-2-504		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0061	**1.61E-06**	**2.73E-05**
nitroDMA	0.0038	**1.00E-06**	**1.70E-05**
TCE	144	**3.02E-04**	**5.22E-03**
PCE	1.23	**2.45E-07**	**1.89E-06**
Chloroform	0.18	**2.54E-08**	**3.42E-07**

Acrylonitrile	1.08	**2.49E-06**	**2.84E-05**
Tetrahydrofuran	0.47	**1.80E-08**	**2.95E-07**
Arsenic	**1.5**	**4.71E-05**	**3.40E-05**
Lead	0.55	**1.09E-08**	**4.72E-08**
Cum. Risk:		**3.54E-04**	**5.33E-03**

CALCULATIONS FOR INDIVIDUAL AND CUMULATIVE CANCER RISK AT EACH WSTF PFPP MONITORING WELL

Risk calculated on mean result from 8/18/01-8/18/03.
Risk calculated on one-half of most recent analytical detection limit where result was ND. All NDMA and DMN results were corrected for extraction efficiency. Values for arsenic and lead taken from 1/1/1988-8/18/2003.
Bolded values indicate the use of one half of the reporting limit.

PL-3-453		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.006	**1.58E-06**	**2.68E-05**
nitroDMA	0.0036	**9.49E-07**	**1.61E-05**
TCE	0.22	**4.61E-07**	**7.97E-06**
PCE	0.2	**3.98E-08**	**3.08E-07**
Chloroform	0.18	**2.54E-08**	**3.42E-07**
Acrylonitrile	1.3	**2.99E-06**	**3.42E-05**
Tetrahydrofuran	0.44	**1.69E-08**	**2.76E-07**
Arsenic	**1.5**	**4.71E-05**	**3.40E-05**
Lead	**10**	**1.98E-07**	**8.58E-07**
Cum. Risk:		**5.32E-05**	**1.21E-04**

PL-4-464		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0057	**1.50E-06**	**2.55E-05**
nitroDMA	0.003	**7.90E-07**	**1.34E-05**
TCE	10.23	**2.14E-05**	**3.71E-04**

PCE	0.2	**3.98E-08**	**3.08E-07**
Chloroform	0.26	**3.67E-08**	**4.95E-07**
Acrylonitrile	1.18	**2.72E-06**	**3.10E-05**
Tetrahydrofuran	0.42	**1.61E-08**	**2.64E-07**
Arsenic	**2.5**	**7.85E-05**	**5.66E-05**
Lead	0.625	**1.24E-08**	**5.36E-08**
Cum. Risk:		**1.05E-04**	**4.98E-04**

CALCULATIONS FOR INDIVIDUAL AND CUMULATIVE CANCER RISK AT EACH WSTF PFPP MONITORING WELL

Risk calculated on mean result from 8/18/01-8/18/03.
Risk calculated on one-half of most recent analytical detection limit where result was ND. All NDMA and DMN results were corrected for extraction efficiency. Values for arsenic and lead taken from 1/1/1988-8/18/2003.
Bolded values indicate the use of one half of the reporting limit.

PL-5		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	1.25	**3.29E-04**	**5.59E-03**
nitroDMA	0.11	**2.90E-05**	**4.92E-04**
TCE	10.43	**2.18E-05**	**3.78E-04**
PCE	0.21	**4.18E-08**	**3.23E-07**
Chloroform	0.18	**2.54E-08**	**3.42E-07**
Acrylonitrile	1.16	**2.67E-06**	**3.05E-05**
Tetrahydrofuran	0.64	**2.46E-08**	**4.02E-07**
Arsenic	1.93	**6.06E-05**	**4.37E-05**
Lead	2.5	**4.96E-08**	**2.14E-07**
Cum. Risk:		**4.44E-04**	**6.53E-03**

PL-6		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0092	**2.42E-06**	**4.11E-05**
nitroDMA	0.0038	**1.00E-06**	**1.70E-05**

TCE	0.23	**4.82E-07**	**8.34E-06**
PCE	0.21	**4.18E-08**	**3.23E-07**
Chloroform	0.18	**2.54E-08**	**3.42E-07**
Acrylonitrile	1.27	**2.93E-06**	**3.34E-05**
Tetrahydrofuran	18	**6.91E-07**	**1.13E-05**
Arsenic	12.33	**3.87E-04**	**2.79E-04**
Lead	0.37	**7.33E-09**	**3.17E-08**
Cum. Risk:		**3.95E-04**	**3.91E-04**

CALCULATIONS FOR INDIVIDUAL AND CUMULATIVE CANCER RISK AT EACH WSTF PFPP MONITORING WELL

Risk calculated on mean result from 8/18/01-8/18/03.
Risk calculated on one-half of most recent analytical detection limit where result was ND. All NDMA and DMN results were corrected for extraction efficiency. Values for arsenic and lead taken from 1/1/1988-8/18/2003.
Bolded values indicate the use of one half of the reporting limit.

PL-7		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0064	**1.69E-06**	**2.86E-05**
nitroDMA	0.0036	**9.49E-07**	**1.61E-05**
TCE	0.22	**4.61E-07**	**7.97E-06**
PCE	0.18	**3.58E-08**	**2.77E-07**
Chloroform	0.19	**2.69E-08**	**3.61E-07**
Acrylonitrile	1.27	**2.93E-06**	**3.34E-05**
Tetrahydrofuran	0.44	**1.69E-08**	**2.76E-07**
Arsenic	**2.5**	**7.85E-05**	**5.66E-05**
Lead	**2.5**	**4.96E-08**	**2.14E-07**
Cum. Risk:		**8.46E-05**	**1.44E-04**

PL-8		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0068	**1.79E-06**	**3.04E-05**
nitroDMA	0.0044	**1.16E-06**	**1.97E-05**

TCE	0.22	**4.61E-07**	**7.97E-06**
PCE	0.2	**3.98E-08**	**3.08E-07**
Chloroform	0.18	**2.54E-08**	**3.42E-07**
Acrylonitrile	1.12	**2.58E-06**	**2.94E-05**
Tetrahydrofuran	0.72	**2.76E-08**	**4.52E-07**
Arsenic	3.9	**1.22E-04**	**8.83E-05**
Lead	0.69	**1.37E-08**	**5.92E-08**
Cum. Risk:		**1.29E-04**	**1.77E-04**

CALCULATIONS FOR INDIVIDUAL AND CUMULATIVE CANCER RISK AT EACH WSTF PFPP MONITORING WELL

Risk calculated on mean result from 8/18/01-8/18/03.
Risk calculated on one-half of most recent analytical detection limit where result was ND. All NDMA and DMN results were corrected for extraction efficiency. Values for arsenic and lead taken from 1/1/1988-8/18/2003.
Bolded values indicate the use of one half of the reporting limit.

PL-10		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0074	**1.95E-06**	**3.31E-05**
nitroDMA	0.0048	**1.26E-06**	**2.15E-05**
TCE	0.23	**4.82E-07**	**8.34E-06**
PCE	0.23	**4.58E-08**	**3.54E-07**
Chloroform	0.18	**2.54E-08**	**3.42E-07**
Acrylonitrile	1.27	**2.93E-06**	**3.34E-05**
Tetrahydrofuran	1.73	**6.64E-08**	**1.09E-06**
Arsenic	2.34	**7.35E-05**	**5.30E-05**
Lead	0.586	**1.16E-08**	**5.03E-08**
Cum. Risk:		**8.03E-05**	**1.51E-04**

ST-1-473, 541, & 630		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	2.89	**7.62E-04**	**1.29E-02**

nitroDMA	1.37	**3.61E-04**	**6.12E-03**
TCE	356	**7.45E-04**	**1.29E-02**
PCE	19	**3.78E-06**	**2.93E-05**
Chloroform	0.28	**3.96E-08**	**5.33E-07**
Acrylonitrile	1.25	**2.88E-06**	**3.28E-05**
Tetrahydrofuran	0.95	**3.65E-08**	**5.97E-07**
Arsenic	0.24	**7.54E-06**	**5.44E-06**
Lead	2.2	**4.36E-08**	**1.89E-07**
Cum. Risk:		**1.88E-03**	**3.20E-02**

CALCULATIONS FOR INDIVIDUAL AND CUMULATIVE CANCER RISK AT EACH WSTF PFPP MONITORING WELL

Risk calculated on mean result from 8/18/01-8/18/03.
Risk calculated on one-half of most recent analytical detection limit where result was ND. All NDMA and DMN results were corrected for extraction efficiency. Values for arsenic and lead taken from 1/1/1988-8/18/2003.
Bolded values indicate the use of one half of the reporting limit.

ST-2-466		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0069	**1.82E-06**	**3.08E-05**
nitroDMA	0.0036	**9.49E-07**	**1.61E-05**
TCE	0.38	**7.96E-07**	**1.38E-05**
PCE	0.16	**3.18E-08**	**2.46E-07**
Chloroform	0.16	**2.26E-08**	**3.04E-07**
Acrylonitrile	0.9	**2.07E-06**	**2.36E-05**
Tetrahydrofuran	0.5	**1.92E-08**	**3.14E-07**
Arsenic	0.07	**2.20E-06**	**1.59E-06**
Lead	2.86	**5.67E-08**	**2.45E-07**
Cum. Risk:		**7.91E-06**	**8.70E-05**

ST-3-486, 586, 666, & 735	**w/inhalation**	**w/inhalation**

Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	2.35	**6.19E-04**	**1.05E-02**
nitroDMA	0.691	**1.82E-04**	**3.09E-03**
TCE	259	**5.42E-04**	**9.39E-03**
PCE	12.34	**2.45E-06**	**1.90E-05**
Chloroform	0.17	**2.40E-08**	**3.23E-07**
Acrylonitrile	1.35	**3.11E-06**	**3.55E-05**
Tetrahydrofuran	1.74	**6.68E-08**	**1.09E-06**
Arsenic	0.1	**3.14E-06**	**2.27E-06**
Lead	3.75	**7.43E-08**	**3.22E-07**
Cum. Risk:		**1.35E-03**	**2.30E-02**

CALCULATIONS FOR INDIVIDUAL AND CUMULATIVE CANCER RISK AT EACH WSTF PFPP MONITORING WELL

Risk calculated on mean result from 8/18/01-8/18/03.
Risk calculated on one-half of most recent analytical detection limit where result was ND. All NDMA and DMN results were corrected for extraction efficiency. Values for arsenic and lead taken from 1/1/1988-8/18/2003.
Bolded values indicate the use of one half of the reporting limit.

ST-4-481, 589, & 690		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0085	**2.24E-06**	**3.80E-05**
nitroDMA	0.0037	**9.75E-07**	**1.65E-05**
TCE	1.53	**3.20E-06**	**5.54E-05**
PCE	0.16	**3.18E-08**	**2.46E-07**
Chloroform	0.15	**2.12E-08**	**2.85E-07**
Acrylonitrile	1.27	**2.93E-06**	**3.34E-05**
Tetrahydrofuran	0.5	**1.92E-08**	**3.14E-07**
Arsenic	0.08	**2.51E-06**	**1.81E-06**
Lead	2.6	**5.15E-08**	**2.23E-07**
Cum. Risk:		**1.19E-05**	**1.46E-04**

ST-5		w/inhalation	w/inhalation
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.007	**1.84E-06**	**3.13E-05**
nitroDMA	0.0036	**9.49E-07**	**1.61E-05**
TCE	0.23	**4.82E-07**	**8.34E-06**
PCE	0.22	**4.38E-08**	**3.39E-07**
Chloroform	0.19	**2.69E-08**	**3.61E-07**
Acrylonitrile	1.06	**2.44E-06**	**2.79E-05**
Tetrahydrofuran	0.85	**3.26E-08**	**5.34E-07**
Arsenic	1.94	**6.09E-05**	**4.39E-05**
Lead	3.7	**7.33E-08**	**3.17E-07**
Cum. Risk:		**6.68E-05**	**1.29E-04**

CALCULATIONS FOR INDIVIDUAL AND CUMULATIVE CANCER RISK AT EACH WSTF PFPP MONITORING WELL

Risk calculated on mean result from 8/18/01-8/18/03.
Risk calculated on one-half of most recent analytical detection limit where result was ND. All NDMA and DMN results were corrected for extraction efficiency. Values for arsenic and lead taken from 1/1/1988-8/18/2003.
Bolded values indicate the use of one half of the reporting limit.

ST-6		w/inhalation	w/inhalation
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0054	**1.42E-06**	**2.41E-05**
nitroDMA	0.0035	**9.22E-07**	**1.56E-05**
TCE	51	**1.07E-04**	**1.85E-03**
PCE	0.48	**9.55E-08**	**7.39E-07**
Chloroform	0.17	**2.40E-08**	**3.23E-07**
Acrylonitrile	0.97	**2.23E-06**	**2.55E-05**
Tetrahydrofuran	1.15	**4.41E-08**	**7.22E-07**
Arsenic	3.16	**9.93E-05**	**7.16E-05**
Lead	0.87	**1.72E-08**	**7.46E-08**
Cum. Risk:		**2.11E-04**	**1.99E-03**

ST-7		w/inhalation	w/inhalation
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0057	**1.50E-06**	**2.55E-05**
nitroDMA	0.0043	**1.13E-06**	**1.92E-05**
TCE	0.23	**4.82E-07**	**8.34E-06**
PCE	0.22	**4.38E-08**	**3.39E-07**
Chloroform	0.19	**2.69E-08**	**3.61E-07**
Acrylonitrile	1.11	**2.56E-06**	**2.92E-05**
Tetrahydrofuran	0.47	**1.80E-08**	**2.95E-07**
Arsenic	2.4	**7.54E-05**	**5.44E-05**
Lead	0.58	**1.15E-08**	**4.97E-08**
Cum. Risk:		**8.11E-05**	**1.38E-04**

CALCULATIONS FOR INDIVIDUAL AND CUMULATIVE CANCER RISK AT EACH WSTF PFPP MONITORING WELL

Risk calculated on mean result from 8/18/01-8/18/03.
Risk calculated on one-half of most recent analytical detection limit where result was ND. All NDMA and DMN results were corrected for extraction efficiency. Values for arsenic and lead taken from 1/1/1988-8/18/2003.
Bolded values indicate the use of one half of the reporting limit.

WW-1-452		w/inhalation	w/inhalation
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0071	**1.87E-06**	**3.17E-05**
nitroDMA	0.0042	**1.11E-06**	**1.88E-05**
TCE	0.23	**4.82E-07**	**8.34E-06**
PCE	0.22	**4.38E-08**	**3.39E-07**
Chloroform	0.18	**2.54E-08**	**3.42E-07**
Acrylonitrile	1.27	**2.93E-06**	**3.34E-05**
Tetrahydrofuran	0.44	**1.69E-08**	**2.76E-07**
Arsenic	**1.5**	**4.71E-05**	**3.40E-05**
Lead	1.6	**3.17E-08**	**1.37E-07**
Cum. Risk:		**5.36E-05**	**1.27E-04**

WW-2		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0058	**1.53E-06**	**2.59E-05**
nitroDMA	0.0036	**9.49E-07**	**1.61E-05**
TCE	0.22	**4.61E-07**	**7.97E-06**
PCE	0.2	**3.98E-08**	**3.08E-07**
Chloroform	0.18	**2.54E-08**	**3.42E-07**
Acrylonitrile	1.12	**2.58E-06**	**2.94E-05**
Tetrahydrofuran	0.81	**3.11E-08**	**5.09E-07**
Arsenic	12.44	**3.91E-04**	**2.82E-04**
Lead	0.75	**1.49E-08**	**6.43E-08**
Cum. Risk:		**3.96E-04**	**3.62E-04**

CALCULATIONS FOR INDIVIDUAL AND CUMULATIVE CANCER RISK AT EACH WSTF PFPP MONITORING WELL

Risk calculated on mean result from 8/18/01-8/18/03.
Risk calculated on one-half of most recent analytical detection limit where result was ND. All NDMA and DMN results were corrected for extraction efficiency. Values for arsenic and lead taken from 1/1/1988-8/18/2003.
Bolded values indicate the use of one half of the reporting limit.

WW-3		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.006	**1.58E-06**	**2.68E-05**
nitroDMA	0.0039	**1.03E-06**	**1.74E-05**
TCE	0.22	**4.61E-07**	**7.97E-06**
PCE	0.2	**3.98E-08**	**3.08E-07**
Chloroform	0.18	**2.54E-08**	**3.42E-07**
Acrylonitrile	1.11	**2.56E-06**	**2.92E-05**
Tetrahydrofuran	77.44	**2.97E-06**	**4.86E-05**
Arsenic	1.7	**5.34E-05**	**3.85E-05**
Lead	0.64	**1.27E-08**	**5.49E-08**

Cum. Risk:		**6.21E-05**	**1.69E-04**

WW-4		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0068	**1.79E-06**	**3.04E-05**
nitroDMA	0.006	**1.58E-06**	**2.68E-05**
TCE	0.22	**4.61E-07**	**7.97E-06**
PCE	0.2	**3.98E-08**	**3.08E-07**
Chloroform	0.18	**2.54E-08**	**3.42E-07**
Acrylonitrile	1.05	**2.42E-06**	**2.76E-05**
Tetrahydrofuran	0.44	**1.69E-08**	**2.76E-07**
Arsenic	3.21	**1.01E-04**	**7.27E-05**
Lead	0.65	**1.29E-08**	**5.57E-08**
Cum. Risk:		**1.07E-04**	**1.66E-04**

CALCULATIONS FOR INDIVIDUAL AND CUMULATIVE CANCER RISK AT EACH WSTF PFPP MONITORING WELL

Risk calculated on mean result from 8/18/01-8/18/03.
Risk calculated on one-half of most recent analytical detection limit where result was ND. All NDMA and DMN results were corrected for extraction efficiency. Values for arsenic and lead taken from 1/1/1988-8/18/2003.
Bolded values indicate the use of one half of the reporting limit.

WW-5		**w/inhalation**	**w/inhalation**
Chemical	ppb	**Industry**	***24yAd+6yrCh***
nitrosoDMA	0.0074	**1.95E-06**	**3.31E-05**
nitroDMA	0.0048	**1.26E-06**	**2.15E-05**
TCE	0.23	**4.82E-07**	**8.34E-06**
PCE	0.22	**4.38E-08**	**3.39E-07**
Chloroform	0.18	**2.54E-08**	**3.42E-07**

Acrylonitrile	1.08	**2.49E-06**	**2.84E-05**
Tetrahydrofuran	0.75	**2.88E-08**	**4.71E-07**
Arsenic	2.82	**8.86E-05**	**6.39E-05**
Lead	0.98	**1.94E-08**	**8.41E-08**
Cum. Risk:		**9.49E-05**	**1.56E-04**

Appendix G
Excel Spreadsheet for Non-Carcinogenic Hazard Calculations

Hazard Indices for Plume Front Monitoring Wells

Updated November 2003 for PFPP with data from 8/19/2001-8/18/2003

bromacil results from 1/1/2000-8/18/2003
cadmium, arsenic, lead, nickel 1/1/1988-8/18/2003
nitrate/nitrite RfDo = .16

BLM-2 Group **Chemical**	**Mean Conc. ppb**	**TH = 1.0** **AdultOral+Inh**		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.140	0.305236				0.305236
Bromacil	0.060	0.000016	(no inh.)			0.000016
Chloroform	0.250	0.040511				0.040511
F-11	160.000	0.124213			0.124213	
F-21	0.418	0.067734			0.067734	
F-113	476.923	0.008033			0.008033	
F-123A	0.980	0.000761			0.000761	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	9.870	0.034998				0.034998
TCE	194.620	20.441587				20.441587
Tetrahydrofuran	0.790	0.001362				0.001362
Arsenic	0.110	0.010047	(no inh.)	0.010047		
Cadmium	0.117	0.006412	(no inh.)	0.006412		
Chromium III	150.800	0.002755	(no inh.)	0.002755		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**21.043664**		**0.019213**	**0.200741**	**20.823710**
					21.044	

BLM-7-509 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.050	0.281138				0.281138
Bromacil		0.000000	(no inh.)			0.000000
Chloroform	0.180	0.029168				0.029168
F-11	0.400	0.000311			0.000311	
F-21	0.173	0.028033			0.028033	
F-113	0.255	0.000004			0.000004	
F-123A	0.307	0.000238			0.000238	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	0.210	0.000745				0.000745
TCE	0.230	0.024158				0.024158
Tetrahydrofuran	0.470	0.000810				0.000810
Arsenic	**1.500**	0.137000	(no inh.)	0.137000		
Cadmium	**2.500**	0.137000	(no inh.)	0.137000		
Chromium III	62.525	0.001142	(no inh.)	0.001142		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**0.639747**		**0.275142**	**0.028586**	**0.336018**
					0.640	

Hazard Indices for Plume Front Monitoring Wells

Updated November 2003 for PFPP with data from 8/19/2001-8/18/2003

bromacil results from 1/1/2000-8/18/2003
cadmium, arsenic, lead, nickel 1/1/1988-8/18/2003
nitrate/nitrite RfDo = .16

BLM-10-517 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	0.900	0.240976				0.240976
Bromacil	0.003	0.000001	(no inh.)			0.000001
Chloroform	0.170	0.027547				0.027547
F-11	0.334	0.000259			0.000259	
F-21	0.174	0.028195			0.028195	
F-113	0.215	0.000004			0.000004	
F-123A	0.326	0.000253			0.000253	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	0.180	0.000638				0.000638
TCE	0.210	0.022057				0.022057
Tetrahydrofuran	0.500	0.000862				0.000862
Arsenic	**1.500**	0.137000	(no inh.)	0.137000		
Cadmium	**2.500**	0.137000	(no inh.)	0.137000		
Chromium III	33.950	0.000620	(no inh.)	0.000620		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**0.595412**		**0.274620**	**0.028711**	**0.292081**
					0.595	

BLM-17 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.150	0.307914				0.307914
Bromacil	0.583	0.000160	(no inh.)			0.000160
Chloroform	0.190	0.030788				0.030788
F-11	182.222	0.141465			0.141465	
F-21	1.722	0.279037			0.279037	
F-113	640.000	0.010780			0.010780	
F-123A	2.410	0.001871			0.001871	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	8.200	0.029076				0.029076
TCE	159.000	16.700300				16.700300
Tetrahydrofuran	0.474	0.000817				0.000817
Arsenic	**1.500**	0.137000	(no inh.)	0.137000		
Cadmium	6.117	0.335212	(no inh.)	0.335212		
Chromium III	14.525	0.000265	(no inh.)	0.000265		
Nickel	**0.020**	0.000027	(no inh.)	0.000027		
HAZARD INDEX:		**17.974712**		**0.472504**	**0.433153**	**17.069054**
					17.975	

Hazard Indices for Plume Front Monitoring Wells

Updated November 2003 for PFPP with data from 8/19/2001-8/18/2003

bromacil results from 1/1/2000-8/18/2003
cadmium, arsenic, lead, nickel 1/1/1988-8/18/2003
nitrate/nitrite RfDo = .16

BLM-37	**Mean Conc.**	**TH = 1.0**				
Chemical	ppb	AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.150	0.307914				0.307914
Bromacil	0.003	0.000001	(no inh.)			0.000001
Chloroform	0.190	0.030788				0.030788
F-11	0.447	0.000347			0.000347	
F-21	0.170	0.027547			0.027547	
F-113	0.286	0.000005			0.000005	
F-123A	0.304	0.000236			0.000236	
Nitrate/Nitrite N	10.500	0.001798	(no inh.)	0.001798		
PCE	0.230	0.000816				0.000816
TCE	0.310	0.032560				0.032560
Tetrahydrofuran	1.510	0.002602				0.002602
Arsenic	2.830	0.258473	(no inh.)	0.258473		
Cadmium	0.301	0.016495	(no inh.)	0.016495		
Chromium III	2.288	0.000042	(no inh.)	0.000042		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**0.679624**		**0.276808**	**0.028135**	**0.374681**
					0.680	

JP-1-424	**Mean Conc.**	**TH = 1.0**				
Chemical	ppb	AdultOral+Inh (Individual HQ)		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.020	0.273106				0.273106
Bromacil	0.003	0.000001	(no inh.)			0.000001
Chloroform	0.180	0.029168				0.029168
F-11	0.540	0.000419			0.000419	
F-21	0.168	0.027223			0.027223	
F-113	0.331	0.000006			0.000006	
F-123A	0.273	0.000212			0.000212	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	0.210	0.000745				0.000745
TCE	0.240	0.025208				0.025208
Tetrahydrofuran	0.300	0.000517				0.000517
Arsenic	**1.500**	0.137000	(no inh.)	0.137000		
Cadmium	**2.500**	0.137000	(no inh.)	0.137000		
Chromium III	9.497	0.000173	(no inh.)	0.000173		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**0.630777**		**0.274173**	**0.027860**	**0.328744**
					0.631	

Hazard Indices for Plume Front Monitoring Wells

Updated November 2003 for PFPP with data from 8/19/2001-8/18/2003

bromacil results from 1/1/2000-8/18/2003
cadmium, arsenic, lead, nickel 1/1/1988-8/18/2003
nitrate/nitrite RfDo = .16

JP-2-447 **Chemical**	**Mean Conc. ppb**	**TH = 1.0 AdultOral+Inh**		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.020	0.273106				0.273106
Bromacil	0.003	0.000001	(no inh.)			0.000001
Chloroform	0.190	0.030788				0.030788
F-11	0.459	0.000356			0.000356	
F-21	0.163	0.026413			0.026413	
F-113	0.284	0.000005			0.000005	
F-123A	0.261	0.000203			0.000203	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	0.220	0.000780				0.000780
TCE	0.240	0.025208				0.025208
Tetrahydrofuran	0.570	0.000982				0.000982
Arsenic	**1.500**	0.137000	(no inh.)	0.137000		
Cadmium	**2.500**	0.137000	(no inh.)	0.137000		
Chromium III	0.865	0.000016	(no inh.)	0.000016		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**0.631858**		**0.274016**	**0.026977**	**0.330865**
					0.632	

JP-3 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.010	0.270428				0.270428
Bromacil	0.003	0.000001	(no inh.)			0.000001
Chloroform	0.190	0.030788				0.030788
F-11	0.449	0.000349			0.000349	
F-21	0.170	0.027547			0.027547	
F-113	0.317	0.000005			0.000005	
F-123A	0.290	0.000225			0.000225	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	0.220	0.000780				0.000780
TCE	0.240	0.025208				0.025208
Tetrahydrofuran	0.650	0.001120				0.001120
Arsenic	1.760	0.160747	(no inh.)	0.160747		
Cadmium	0.452	0.024770	(no inh.)	0.024770		
Chromium III	1.340	0.000024	(no inh.)	0.000024		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**0.541992**		**0.185541**	**0.028126**	**0.328325**
					0.542	

Hazard Indices for Plume Front Monitoring Wells

Updated November 2003 for PFPP with data from 8/19/2001-8/18/2003

bromacil results from 1/1/2000-8/18/2003
cadmium, arsenic, lead, nickel 1/1/1988-8/18/2003
nitrate/nitrite RfDo = .16

PL-1-486 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.080	0.289171				0.289171
Bromacil	0.010	0.000003	(no inh.)			0.000003
Chloroform	0.180	0.029168				0.029168
F-11	108.125	0.083941			0.083941	
F-21	0.171	0.027709			0.027709	
F-113	163.750	0.002758			0.002758	
F-123A	0.321	0.000249			0.000249	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	3.800	0.013474				0.013474
TCE	137.500	14.442083				14.442083
Tetrahydrofuran	0.470	0.000810				0.000810
Arsenic	**1.500**	0.137000	(no inh.)	0.137000		
Cadmium	**2.500**	0.137000	(no inh.)	0.137000		
Chromium III	40.320	0.000737	(no inh.)	0.000737		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**15.164103**		**0.274737**	**0.114658**	**14.774709**
					15.164	

PL-2-504 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.080	0.289171				0.289171
Bromacil		0.000000	(no inh.)			0.000000
Chloroform	0.180	0.029168				0.029168
F-11	142.500	0.110628			0.110628	
F-21	0.171	0.027709			0.027709	
F-113	61.375	0.001034			0.001034	
F-123A	0.320	0.000248			0.000248	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	1.230	0.004361				0.004361
TCE	144.000	15.124800				15.124800
Tetrahydrofuran	0.470	0.000810				0.000810
Arsenic	**1.500**	0.137000	(no inh.)	0.137000		
Cadmium	**2.500**	0.137000	(no inh.)	0.137000		
Chromium III	91.033	0.001663	(no inh.)	0.001663		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**15.863592**		**0.275663**	**0.139619**	**15.448310**
					15.864	

Hazard Indices for Plume Front Monitoring Wells

Updated November 2003 for PFPP with data from 8/19/2001-8/18/2003

bromacil results from 1/1/2000-8/18/2003
cadmium, arsenic, lead, nickel 1/1/1988-8/18/2003
nitrate/nitrite RfDo = .16

PL-3-453	**Mean Conc.**	**TH = 1.0**				
Chemical	ppb	AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.300	0.348076				0.348076
Bromacil	0.003	0.000001	(no inh.)			0.000001
Chloroform	0.180	0.029168				0.029168
F-11	0.386	0.000300			0.000300	
F-21	0.161	0.026089			0.026089	
F-113	0.253	0.000004			0.000004	
F-123A	0.261	0.000203			0.000203	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	0.200	0.000709				0.000709
TCE	0.220	0.023107				0.023107
Tetrahydrofuran	0.440	0.000758				0.000758
Arsenic	**1.500**	0.137000	(no inh.)	0.137000		
Cadmium	**2.500**	0.137000	(no inh.)	0.137000		
Chromium III	19.200	0.000351	(no inh.)	0.000351		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**0.702765**		**0.274351**	**0.026595**	**0.401819**
					0.703	

PL-4-464	**Mean Conc.**	**TH = 1.0**				
Chemical	ppb	AdultOral+Inh (Individual HQ)		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.18	0.315946				0.315946
Bromacil	0.003	0.000001	(no inh.)			0.000001
Chloroform	0.260	0.042131				0.042131
F-11	11.616	0.009018			0.009018	
F-21	0.163	0.026413			0.026413	
F-113	2.687	0.000045			0.000045	
F-123A	0.285	0.000221			0.000221	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	0.200	0.000709				0.000709
TCE	10.230	1.074491				1.074491
Tetrahydrofuran	0.420	0.000724				0.000724
Arsenic	**2.500**	0.228333	(no inh.)	0.228333		
Cadmium	**2.500**	0.137000	(no inh.)	0.137000		
Chromium III	8.750	0.000160	(no inh.)	0.000160		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**1.835192**		**0.365493**	**0.035697**	**1.434002**
					1.835	

Hazard Indices for Plume Front Monitoring Wells

Updated November 2003 for PFPP with data from 8/19/2001-8/18/2003

bromacil results from 1/1/2000-8/18/2003
cadmium, arsenic, lead, nickel 1/1/1988-8/18/2003
nitrate/nitrite RfDo = .16

PL-5	**Mean Conc.**	**TH = 1.0**				
Chemical	ppb	AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.160	0.310591				0.310591
Bromacil	0.006	0.000002	(no inh.)			0.000002
Chloroform	0.180	0.029168				0.029168
F-11	3.201	0.002485			0.002485	
F-21	2.650	0.429412			0.429412	
F-113	0.949	0.000016			0.000016	
F-123A	0.675	0.000524			0.000524	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	0.210	0.000745				0.000745
TCE	10.430	1.095498				1.095498
Tetrahydrofuran	0.640	0.001103				0.001103
Arsenic	1.930	0.176273	(no inh.)	0.176273		
Cadmium	0.063	0.003452	(no inh.)	0.003452		
Chromium III	6.100	0.000111	(no inh.)	0.000111		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**2.049380**		**0.179837**	**0.432437**	**1.437106**
					2.049	

PL-6	**Mean Conc.**	**TH = 1.0**				
Chemical	ppb	AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.270	0.340044				0.340044
Bromacil	0.004	0.000001	(no inh.)			0.000001
Chloroform	0.180	0.029168				0.029168
F-11	0.443	0.000344			0.000344	
F-21	0.174	0.028195			0.028195	
F-113	0.263	0.000004			0.000004	
F-123A	0.353	0.000274			0.000274	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	0.210	0.000745				0.000745
TCE	0.230	0.024158				0.024158
Tetrahydrofuran	18.000	0.031023				0.031023
Arsenic	12.330	1.126140	(no inh.)	1.126140		
Cadmium	2.950	0.161660	(no inh.)	0.161660		
Chromium III	22.900	0.000418	(no inh.)	0.000418		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**1.742174**		**1.288218**	**0.028818**	**0.425138**
					1.742	

Hazard Indices for Plume Front Monitoring Wells

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bromacil results from 1/1/2000-8/18/2003
cadmium, arsenic, lead, nickel 1/1/1988-8/18/2003
nitrate/nitrite RfDo = .16

PL-7 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.270	0.340044				0.340044
Bromacil	0.003	0.000001	(no inh.)			0.000001
Chloroform	0.190	0.030788				0.030788
F-11	0.240	0.000186			0.000186	
F-21	0.170	0.027547			0.027547	
F-113	0.200	0.000003			0.000003	
F-123A	0.337	0.000262			0.000262	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	0.180	0.000638				0.000638
TCE	0.220	0.023107				0.023107
Tetrahydrofuran	0.440	0.000758				0.000758
Arsenic	**2.500**	0.228333	(no inh.)	0.228333		
Cadmium	**2.500**	0.137000	(no inh.)	0.137000		
Chromium III	2.272	0.000042	(no inh.)	0.000042		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**0.788710**		**0.365375**	**0.027999**	**0.395336**
					0.789	

PL-8 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.120	0.299881				0.299881
Bromacil	0.003	0.000001	(no inh.)			0.000001
Chloroform	0.180	0.029168				0.029168
F-11	0.368	0.000286			0.000286	
F-21	0.160	0.025927			0.025927	
F-113	0.259	0.000004			0.000004	
F-123A	0.271	0.000210			0.000210	
Nitrate/Nitrite N	1900.000	0.325375	(no inh.)	0.325375		
PCE	0.200	0.000709				0.000709
TCE	0.220	0.023107				0.023107
Tetrahydrofuran	0.720	0.001241				0.001241
Arsenic	3.900	0.356200	(no inh.)	0.356200		
Cadmium	0.544	0.029811	(no inh.)	0.029811		
Chromium III	2.522	0.000046	(no inh.)	0.000046		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**1.091966**		**0.711432**	**0.026427**	**0.354107**
					1.092	

Hazard Indices for Plume Front Monitoring Wells

Updated November 2003 for PFPP with data from 8/19/2001-8/18/2003

bromacil results from 1/1/2000-8/18/2003
cadmium, arsenic, lead, nickel 1/1/1988-8/18/2003
nitrate/nitrite RfDo = .16

PL-10	**Mean Conc.**	**TH = 1.0**				
Chemical	ppb	AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.270	0.340044				0.340044
Bromacil	0.003	0.000001	(no inh.)			0.000001
Chloroform	0.180	0.029168				0.029168
F-11	0.397	0.000308			0.000308	
F-21	0.166	0.026899			0.026899	
F-113	0.288	0.000005			0.000005	
F-123A	0.312	0.000242			0.000242	
Nitrate/Nitrite N	619.000	0.106004	(no inh.)	0.106004		
PCE	0.230	0.000816				0.000816
TCE	0.230	0.024158				0.024158
Tetrahydrofuran	1.730	0.002982				0.002982
Arsenic	2.340	0.213720	(no inh.)	0.213720		
Cadmium	0.774	0.042415	(no inh.)	0.042415		
Chromium III	3.049	0.000056	(no inh.)	0.000056		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**0.786816**		**0.362195**	**0.027454**	**0.397167**
					0.787	

ST-1 Group	**Mean Conc.**	**TH = 1.0**				
Chemical	ppb	AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.250	0.334689				0.334689
Bromacil	0.080	0.000022	(no inh.)			0.000022
Chloroform	0.280	0.045372				0.045372
F-11	388.636	0.301711			0.301711	
F-21	0.815	0.132064			0.132064	
F-113	758.636	0.012778			0.012778	
F-123A	1.711	0.001328			0.001328	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	19.000	0.067372				0.067372
TCE	356.000	37.391867				37.391867
Tetrahydrofuran	0.950	0.001637				0.001637
Arsenic	0.240	0.021920	(no inh.)	0.021920		
Cadmium	0.099	0.005425	(no inh.)	0.005425		
Chromium III	45.150	0.000825	(no inh.)	0.000825		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**38.317010**		**0.028170**	**0.447882**	**37.840958**
					38.317	

Hazard Indices for Plume Front Monitoring Wells

Updated November 2003 for PFPP with data from 8/19/2001-8/18/2003

bromacil results from 1/1/2000-8/18/2003
cadmium, arsenic, lead, nickel 1/1/1988-8/18/2003
nitrate/nitrite RfDo = .16

ST-2-466 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	0.900	0.240976				0.240976
Bromacil		0.000000	(no inh.)			0.000000
Chloroform	0.160	0.025927				0.025927
F-11	0.265	0.000206			0.000206	
F-21	0.174	0.028195			0.028195	
F-113	0.235	0.000004			0.000004	
F-123A	0.345	0.000268			0.000268	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	0.160	0.000567				0.000567
TCE	0.380	0.039913				0.039913
Tetrahydrofuran	0.500	0.000862				0.000862
Arsenic	0.070	0.006393	(no inh.)	0.006393		
Cadmium	0.127	0.006960	(no inh.)	0.006960		
Chromium III	2.585	0.000047	(no inh.)	0.000047		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**0.350317**		**0.013400**	**0.028673**	**0.308244**
					0.350	

ST-3 Group Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.350	0.361464				0.361464
Bromacil	0.007	0.000002	(no inh.)			0.000002
Chloroform	0.170	0.027547				0.027547
F-11	215.385	0.167211			0.167211	
F-21	2.233	0.361841			0.361841	
F-113	316.545	0.005332			0.005332	
F-123A	2.694	0.002091			0.002091	
Nitrate/Nitrite N		0.000000		0.000000		
PCE	12.340	0.043756				0.043756
TCE	259.000	27.203633				27.203633
Tetrahydrofuran	1.700	0.002930				0.002930
Arsenic	0.100	0.009133		0.009133		
Cadmium	0.500	0.027400		0.027400		
Chromium III	44.200	0.000807		0.000807		
Nickel		0.000000		0.000000		
HAZARD INDEX:		**28.213147**		**0.037341**	**0.536474**	**27.639332**
					28.213	

Hazard Indices for Plume Front Monitoring Wells

Updated November 2003 for PFPP with data from 8/19/2001-8/18/2003

bromacil results from 1/1/2000-8/18/2003
cadmium, arsenic, lead, nickel 1/1/1988-8/18/2003
nitrate/nitrite RfDo = .16

ST-4 Group Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.270	0.340044				0.340044
Bromacil	0.007	0.000002	(no inh.)			0.000002
Chloroform	0.150	0.024306				0.024306
F-11	0.337	0.000262			0.000262	
F-21	0.166	0.026899			0.026899	
F-113	0.644	0.000011			0.000011	
F-123A	0.325	0.000252			0.000252	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	0.160	0.000567				0.000567
TCE	1.530	0.160701				0.160701
Tetrahydrofuran	0.500	0.000862				0.000862
Arsenic	0.080	0.007307	(no inh.)	0.007307		
Cadmium	1.270	0.069596	(no inh.)	0.069596		
Chromium III	1.143	0.000021	(no inh.)	0.000021		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**0.630829**		**0.076924**	**0.027424**	**0.526482**
					0.631	

ST-5 Group Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.060	0.283816				0.283816
Bromacil	0.024	0.000006	(no inh.)			0.000006
Chloroform	0.190	0.030788				0.030788
F-11	0.435	0.000338			0.000338	
F-21	0.171	0.027709			0.027709	
F-113	0.273	0.000005			0.000005	
F-123A	0.291	0.000226			0.000226	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	0.220	0.000780				0.000780
TCE	0.230	0.024158				0.024158
Tetrahydrofuran	0.850	0.001465				0.001465
Arsenic	1.940	0.177187	(no inh.)	0.177187		
Cadmium	0.125	0.006850	(no inh.)	0.006850		
Chromium III	1.655	0.000030	(no inh.)	0.000030		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**0.553357**		**0.184067**	**0.028277**	**0.341013**
					0.553	

Hazard Indices for Plume Front Monitoring Wells

Updated November 2003 for PFPP with data from 8/19/2001-8/18/2003

bromacil results from 1/1/2000-8/18/2003
cadmium, arsenic, lead, nickel 1/1/1988-8/18/2003
nitrate/nitrite RfDo = .16

ST-6 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	0.970	0.259718				0.259718
Bromacil	0.021	0.000006	(no inh.)			0.000006
Chloroform	0.170	0.027547				0.027547
F-11	4.600	0.003571			0.003571	
F-21	21.176	3.431408			3.431408	
F-113	3.941	0.000066			0.000066	
F-123A	6.782	0.005265			0.005265	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	0.480	0.001702				0.001702
TCE	51.000	5.356700				5.356700
Tetrahydrofuran	1.150	0.001982				0.001982
Arsenic	3.160	0.288613	(no inh.)	0.288613		
Cadmium	0.516	0.028277	(no inh.)	0.028277		
Chromium III	3.271	0.000060	(no inh.)	0.000060		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**9.404916**		**0.316950**	**3.440311**	**5.647655**
					9.405	

ST-7 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.110	0.297203				0.297203
Bromacil	0.003	0.000001	(no inh.)			0.000001
Chloroform	0.190	0.030788				0.030788
F-11	0.435	0.000338			0.000338	
F-21	0.171	0.027709			0.027709	
F-113	0.273	0.000005			0.000005	
F-123A	0.291	0.000226			0.000226	
Nitrate/Nitrite N	10.500	0.001798	(no inh.)	0.001798		
PCE	0.220	0.000780				0.000780
TCE	0.230	0.024158				0.024158
Tetrahydrofuran	0.470	0.000810				0.000810
Arsenic	2.400	0.219200	(no inh.)	0.219200		
Cadmium	0.474	0.025975	(no inh.)	0.025975		
Chromium III	1.234	0.000023	(no inh.)	0.000023		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**0.629013**		**0.246996**	**0.028277**	**0.353740**
					0.629	

Hazard Indices for Plume Front Monitoring Wells

Updated November 2003 for PFPP with data from 8/19/2001-8/18/2003

bromacil results from 1/1/2000-8/18/2003
cadmium, arsenic, lead, nickel 1/1/1988-8/18/2003
nitrate/nitrite RfDo = .16

WW-1-452 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.270	0.340044				0.340044
Bromacil	0.003	0.000001	(no inh.)			0.000001
Chloroform	0.180	0.029168				0.029168
F-11	0.346	0.000269			0.000269	
F-21	0.164	0.026575			0.026575	
F-113	0.280	0.000005			0.000005	
F-123A	0.300	0.000233			0.000233	
Nitrate/Nitrite N		0.000000	(no inh.)	0.000000		
PCE	0.220	0.000780				0.000780
TCE	0.230	0.024158				0.024158
Tetrahydrofuran	0.440	0.000758				0.000758
Arsenic	**1.500**	0.137000	(no inh.)	0.137000		
Cadmium	**2.500**	0.137000	(no inh.)	0.137000		
Chromium III	7.000	0.000128	(no inh.)	0.000128		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**0.696117**		**0.274128**	**0.027081**	**0.394908**
					0.696	

WW-2 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.120	0.299881				0.299881
Bromacil	0.003	0.000001	(no inh.)			0.000001
Chloroform	0.180	0.029168				0.029168
F-11	0.344	0.000267			0.000267	
F-21	0.159	0.025765			0.025765	
F-113	0.253	0.000004			0.000004	
F-123A	0.278	0.000216			0.000216	
Nitrate/Nitrite N	3000.000	0.513750	(no inh.)	0.513750		
PCE	0.200	0.000709				0.000709
TCE	0.220	0.023107				0.023107
Tetrahydrofuran	0.810	0.001396				0.001396
Arsenic	12.440	1.136187	(no inh.)	1.136187		
Cadmium	0.477	0.026140	(no inh.)	0.026140		
Chromium III	1.469	0.000027	(no inh.)	0.000027		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**2.056617**		**1.676103**	**0.026252**	**0.354262**
					2.057	

Hazard Indices for Plume Front Monitoring Wells

Updated November 2003 for PFPP with data from 8/19/2001-8/18/2003

bromacil results from 1/1/2000-8/18/2003
cadmium, arsenic, lead, nickel 1/1/1988-8/18/2003
nitrate/nitrite RfDo = .16

WW-3 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.110	0.297203				0.297203
Bromacil	0.006	0.000002	(no inh.)			0.000002
Chloroform	0.180	0.029168				0.029168
F-11	0.350	0.000272			0.000272	
F-21	0.160	0.025927			0.025927	
F-113	0.250	0.000004			0.000004	
F-123A	0.280	0.000217			0.000217	
Nitrate/Nitrite N	910.000	0.155838	(no inh.)	0.155838		
PCE	0.200	0.000709				0.000709
TCE	0.220	0.023107				0.023107
Tetrahydrofuran	77.440	0.133468				0.133468
Arsenic	1.700	0.155267	(no inh.)	0.155267		
Cadmium	0.640	0.035072	(no inh.)	0.035072		
Chromium III	1.610	0.000029	(no inh.)	0.000029		
Nickel		0.000000	(no inh.)	0.000000		
HAZARD INDEX:		**0.856283**		**0.346206**	**0.026420**	**0.483657**
					0.856	

WW-4 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.050	0.281138				0.281138
Bromacil	0.005	0.000001	(no inh.)			0.000001
Chloroform	0.180	0.029168				0.029168
F-11	0.390	0.000303			0.000303	
F-21	0.160	0.025927			0.025927	
F-113	0.250	0.000004			0.000004	
F-123A	0.270	0.000210			0.000210	
Nitrate/Nitrite N	670.000	0.114738		0.114738		
PCE	0.200	0.000709				0.000709
TCE	0.220	0.023107				0.023107
Tetrahydrofuran	0.440	0.000758				0.000758
Arsenic	3.210	0.293180		0.293180		
Cadmium	0.380	0.020824		0.020824		
Chromium III	1.620	0.000030		0.000030		
Nickel		0.000000		0.000000		
HAZARD INDEX:		**0.790097**		**0.428771**	**0.026443**	**0.334882**
					0.790	

Hazard Indices for Plume Front Monitoring Wells

Updated November 2003 for PFPP with data from 8/19/2001-8/18/2003

bromacil results from 1/1/2000-8/18/2003
cadmium, arsenic, lead, nickel 1/1/1988-8/18/2003
nitrate/nitrite RfDo = .16

WW-5 Chemical	**Mean Conc.** ppb	**TH = 1.0** AdultOral+Inh		***ELEMENTS***	***FREONS***	***OTHER***
Acrylonitrile	1.080	0.289171				0.289171
Bromacil	0.003	0.000001	(no inh.)			0.000001
Chloroform	0.180	0.029168				0.029168
F-11	0.440	0.000342			0.000342	
F-21	0.170	0.027547			0.027547	
F-113	0.270	0.000005			0.000005	
F-123A	0.310	0.000241			0.000241	
Nitrate/Nitrite N	3430.000	0.587388	(no inh.)	0.587388		
PCE	0.220	0.000780				0.000780
TCE	0.230	0.024158				0.024158
Tetrahydrofuran	0.750	0.001293				0.001293
Arsenic	0.282	0.025756	(no inh.)	0.025756		
Cadmium	0.800	0.043840	(no inh.)	0.043840		
Chromium III	1.340	0.000024	(no inh.)	0.000024		
Nickel	**0.040**	0.000055	(no inh.)	0.000055		
HAZARD INDEX:		**1.029767**		**0.657063**	**0.028134**	**0.344570**
					1.030	

Appendix H - Specific Geologic Information

N-NITROSODIMETHYLAMINE (NDMA) CONCENTRATIONS IN GROUNDWATER AT NASA-WSTF & VICINITY (AUGUST 2003)

R2E R3E

R3E

T20S

T21S

T20S

T21S

N230000

N220000

E400000

E410000

2035 R3E

30 29 28 27 26 25

31 32 33 34 35 36

6 5 4 3 2 1

7 8 9 10 11

700 AREA LANDFILL

200 AREA

600 AREA

100 AREA

400 AREA

300 AREA

WELL I (WATER WELL)

WELL K (WATER WELL)

WELL J (WATER WELL)

WW-5 ND

WW-2 ND

WW-4 ND

WW-3 ND

WW-1-452 ND

JP-3 ND

JP-2-447 ND

JP-1-424 ND

ST-4-589 20

ST-4-690 ND

ST-4-481 80

ST-5-DEEP ND

ST-5-481 ND Q

ST-3-986 2,380

ST-3-735 80

ST-3-486 1,380

ST-3-666 90

PFE-1

PFE-5

ST-6 ND

PFE-7

ST-2-466 ND

ST-1-630 680

ST-1-541 2,660

ST-1-473 30

ST-7 ND

PFE-2

PFE-6

PL-4-464 ND

PL-2-504 ND

PT-PZ-3

PT-PZ-2 ND

20 J (1645', 1815')

PL-6-B

PL-6-*

PL-5

PT-PZ-1

PFE-3

PT-PZ-4

PL-1-486 40

PL-3-453 ND

PFE-4A

PFE-4

PFI-1

PFI-2

PFI-3

PFI-4

PL-8 ND

PL-7 ND

PL-9

PL-10 ND

BLM-29

BLM-32 ND

ND BLM-5-527

BLM-30 900

BLM-18-430 50

ND BLM-8-418

BLM-1-435 4,370

BLM-22-570 20 J (620')

BLM-38 80

BLM-39 4,140 (385')

PILOT 3

MPE-1

MPE-2

MPE-3

MPE-4

MPE-5

MPE-6

PILOT 4

MW-2

BLM-36 470 (350')

BLM-9-419 5,590

BLM-33

BLM-34

IS-1

BLM-21-400 3,460

2,980

1,600

BLM-17-493

BLM-17-550

BLM-23-431 607 (1999')

PILOT 1

BLM-25-455 ND

1,260

BLM-2-630 760

BLM-2-482

BLM-6-488 ND

BLM-7-509 ND

BLM-10-517 ND

BLM-37 ND

BLM-11-*

ND BLM-28

BLM-12-*

BLM-13-300 ND

700-F-455 ND

700-G

700-E-458 ND

BLM-16-*

BLM-24-* ND

BLM-24-565

BLM-26-404 90

BLM-15-* 15,820

BLM-15-305

BLM-27-276 6,520

BLM-14-327 890 QD

700-B-519 20 J

700-H ND

700-D-186 ND

700-A-253 ND

700-J ND

BW-6-355 250

BW-6-295 1,030

BW-7-211 2,170

BW-1-268 20,730

BW-2-*

BW-4 340 (455')

NASA-9 6,570

NASA-6 22,550

NASA-1 10,290

400-C-143

400-C-118 5,490

400-A-151 36,560

400-B-* 30,000

30 J (195')

400-D

300-A-170 9,530

300-A-120 2,750

300-B-166

300-C-128 26,000

NASA-10 820

NASA-5 5,350

300-E 4,240 (138')

NASA-3 ND

300-D-153 ND

200-A-* 200-F 20 (225')

200-B-240 680

200-I ND

200-C ND

200-H

200-E-*

200-D-109 ND

200-D-240

600-PZ-2

600-C-210

BW-3-180

NASA-2

600-C-173

BLM-3-182 ND Q

NASA-7 ND

600-E ND

600-C

600-PZ-1

NASA-4 ND

BLM-4-*

600-D

NASA-8 ND

BLM-31

100-D-176 ND

100-B(2)-*

100-B-*

WB-7-*

WB-1 ND

100-A-182

200-C ND

100-E-261

WB-2

WB-6-*

WB-5 ND

WB-4

100-C-365

WB-3

WB-15

WB-14

WB-8

WB-9

0' 2000'

LEGEND

- 20 — GROUNDWATER MONITORING WELLS AND ANALYTICAL RESULT IN PARTS PER TRILLION (PPT) AS OF AUGUST 2003 BY EPA METHOD 607 (CORRECTED FOR EXTRACTION EFFICIENCY). ANALYTICAL RESULTS 7/02-8/03 (MAX VALUE).
- (225') — DEPTH BELOW GROUND SURFACE OF ANALYTICAL RESULT
- ABANDONED WELL
- PIEZOMETER
- PLUME-FRONT EXTRACTION WELL (ON-LINE)
- PLUME-FRONT EXTRACTION WELL (INACTIVE)
- PLUME-FRONT INJECTION WELL
- MID-PLUME EXTRACTION WELL
- 10 — NDMA CONCENTRATION LINE (PPT)

(DRAFTED 8-11-2003)

N-NITRODIMETHYLAMINE (DMN) CONCENTRATIONS IN GROUNDWATER AT NASA-WSTF & VICINITY (AUGUST 2003)

R2E R3E R3E

T20S T21S T20S T21S

N230000 N220000

E400000 E410000

2035 R3E

30 29 28 27 26 25

31 32 33 34 35 36

6 5 4 3 2

7 8 9 10 11

700 AREA LANDFILL

200 AREA

600 AREA

100 AREA

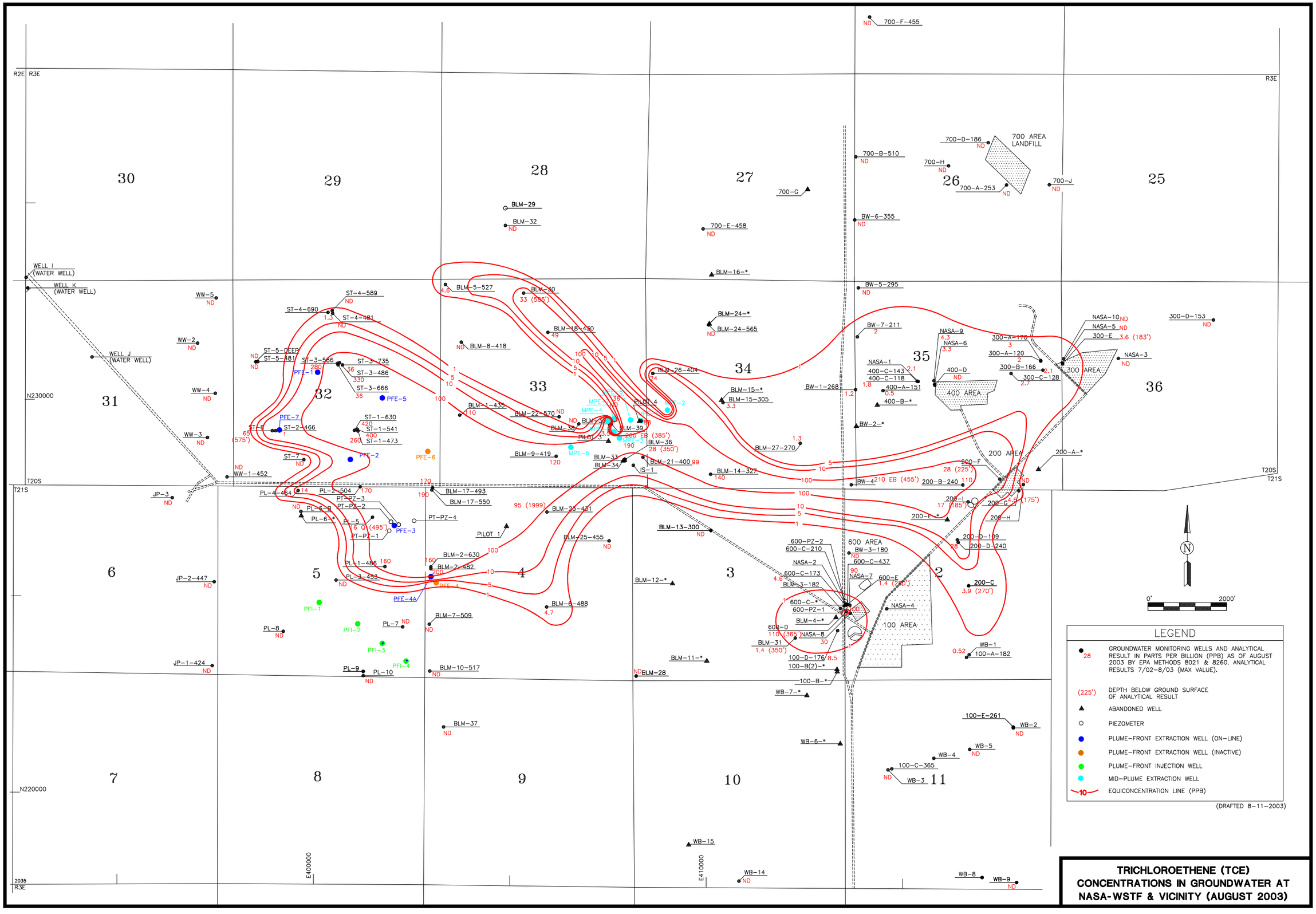
400 AREA

0' 2000'

LEGEND

- 50 — GROUNDWATER MONITORING WELLS AND ANALYTICAL RESULT IN PARTS PER TRILLION (PPT) AS OF AUGUST 2003 BY EPA METHOD 607 (CORRECTED FOR EXTRACTION EFFICIENCY). ANALYTICAL RESULTS 7/02–8/03 (MAX VALUE).
- (225') — DEPTH BELOW GROUND SURFACE OF ANALYTICAL RESULT
- ABANDONED WELL
- PIEZOMETER
- PLUME–FRONT EXTRACTION WELL (ON–LINE)
- PLUME–FRONT EXTRACTION WELL (INACTIVE)
- PLUME–FRONT INJECTION WELL
- MID–PLUME EXTRACTION WELL
- 10 — EQUICONCENTRATION LINE (PPT)

(DRAFTED 8–11–2003)



TRICHLOROETHENE (TCE) CONCENTRATIONS IN GROUNDWATER AT NASA-WSTF & VICINITY (AUGUST 2003)

TETRACHLOROETHENE (PCE) CONCENTRATIONS IN GROUNDWATER AT NASA-WSTF & VICINITY (AUGUST 2003)

R2E R3E

R3E

T20S T21S

T20S T21S

N230000

N220000

E400000

E410000

2035 R3E

30 29 28 27 26 25

31 32 33 34 35 36

6 5 4 3 2 1

7 8 9 10 11

WELL I (WATER WELL)

WELL K (WATER WELL)

WELL J (WATER WELL)

WW-5 ND

WW-2 ND

WW-4 ND

WW-3 ND

WW-1-452 ND

JP-3 ND

JP-2-447 ND

JP-1-424 ND

ST-4-589 ND

ST-4-690 ND

ST-4-481 ND

ST-5-DEEP ND

ST-5-481 ND

ST-3-586 14

ST-3-735 0.92

ST-3-486 20

ST-3-666 1.3

PFE-1

PFE-5

PFE-7

ST-6 0.78 (575')

ST-2-466 ND

ST-1-630 15

ST-1-541 22

ST-1-473 5.1

ST-7 ND

PFE-2

PFE-6

PFE-3

PFE-4

PFE-4A

PFI-1

PFI-2

PFI-3

PFI-4

BLM-29

BLM-32 ND

BLM-5-527 ND

BLM-30 1.3 (585')

BLM-18-430 1.7

BLM-8-418 ND

BLM-1-435 2.4

BLM-22-570 ND

BLM-38 ND

BLM-32 ND

BLM-39 9.5 (385')

MPE-8 1.4

MPE-4 ND

MPE-6 ND

MPE-5 ND

MPE-3 ND

MPE-2

MPE-1 1.6

PILOT 4

PILOT 3

BLM-36 9.4

1 (350')

BLM-9-419 5.6

BLM-33 5.7

BLM-34 ND

BLM-21-400 IS-1

PILOT 1

BLM-14-327 9.4

BLM-27-270 ND

BLM-17-493 8.8

BLM-17-550 7.9

BLM-23-431 3.8 (1999)

BLM-25-455 ND

BLM-2-630 6.6

BLM-2-482 11

BLM-6-488 ND

BLM-7-509 ND

BLM-10-517 ND

BLM-37 ND

BLM-13-300 ND

BLM-12-*

BLM-11-*

BLM-28 ND

BLM-16-*

BLM-24-* ND

BLM-24-565 ND

BLM-26-404 0.42 J

BLM-15-* ND

BLM-15-305 ND

PL-4-464 ND

PL-2-504 1.4

PT-PZ-3

PT-PZ-2

PL-6-B ND

PL-6-*

PL-5 ND

PT-PZ-1

PT-PZ-4

PL-1-486 4.5

PL-3-453 ND

PL-8 ND

PL-7 ND

PL-9

PL-10 ND

700-F-455 ND

700-B-510 ND

700-H ND

700-D-186 ND

700 AREA LANDFILL

700-A-253 ND

700-J ND

700-G

700-E-458 ND

BW-6-355 ND

BW-5-295 ND

BW-7-211 ND

BW-1-268 ND

BW-2-*

BW-3-180 ND

BW-4 11 (355')

NASA-9 ND

NASA-6 ND

NASA-1 ND

400-C-143 ND

400-C-118 ND

400-A-151 ND

400-B-* ND

400-D ND

400 AREA

300-A-170 ND

300-A-120 ND

300-B-166 ND

300-C-128 ND

NASA-10 ND

NASA-5 ND

300-E ND

300 AREA

NASA-3 ND

300-D-153 ND

200 AREA

0.55 (225') 200-F

200-A-*

200-B-240 5.9

200-I 0.7 (165')

200-G ND

200-H

200-E-*

200-D-109 0.7 J

200-D-240

200-C ND

600 AREA

600-PZ-2

600-C-210

NASA-2

600-C-173 ND

BLM-3-182

600-C-* 600-PZ-1

BLM-4-*

600-D ND

NASA-8 ND

BLM-31 ND

100-D-176 ND

100-B(2)-*

100-B-*

WB-7-*

NASA-7 ND

600-E ND

NASA-4 ND

100 AREA

WB-1 ND

100-A-182

100-E-261

WB-2 ND

WB-6-*

WB-5 ND

WB-4

100-C-365 ND

WB-3

WB-15

WB-14 ND

WB-8

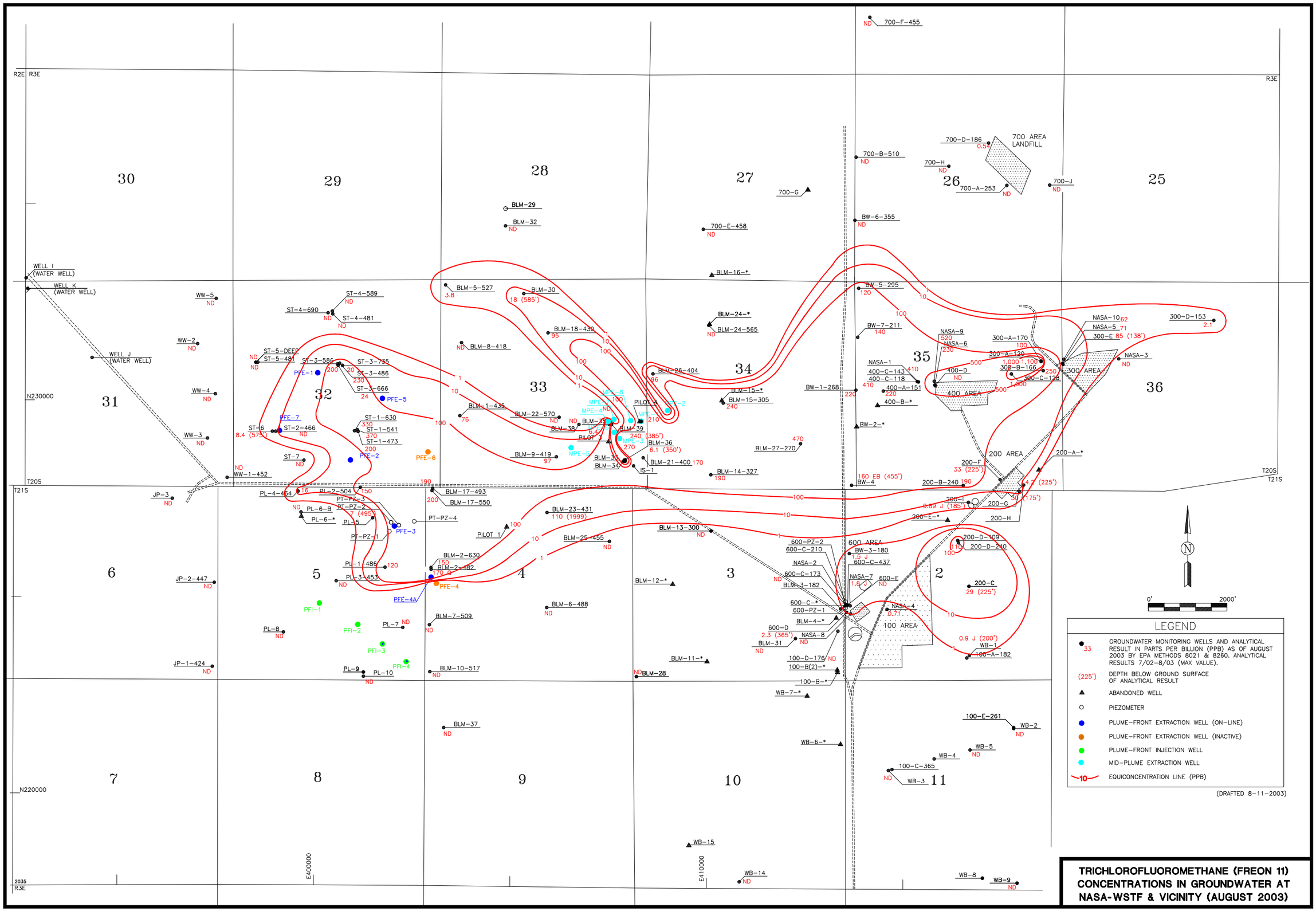
WB-9 ND

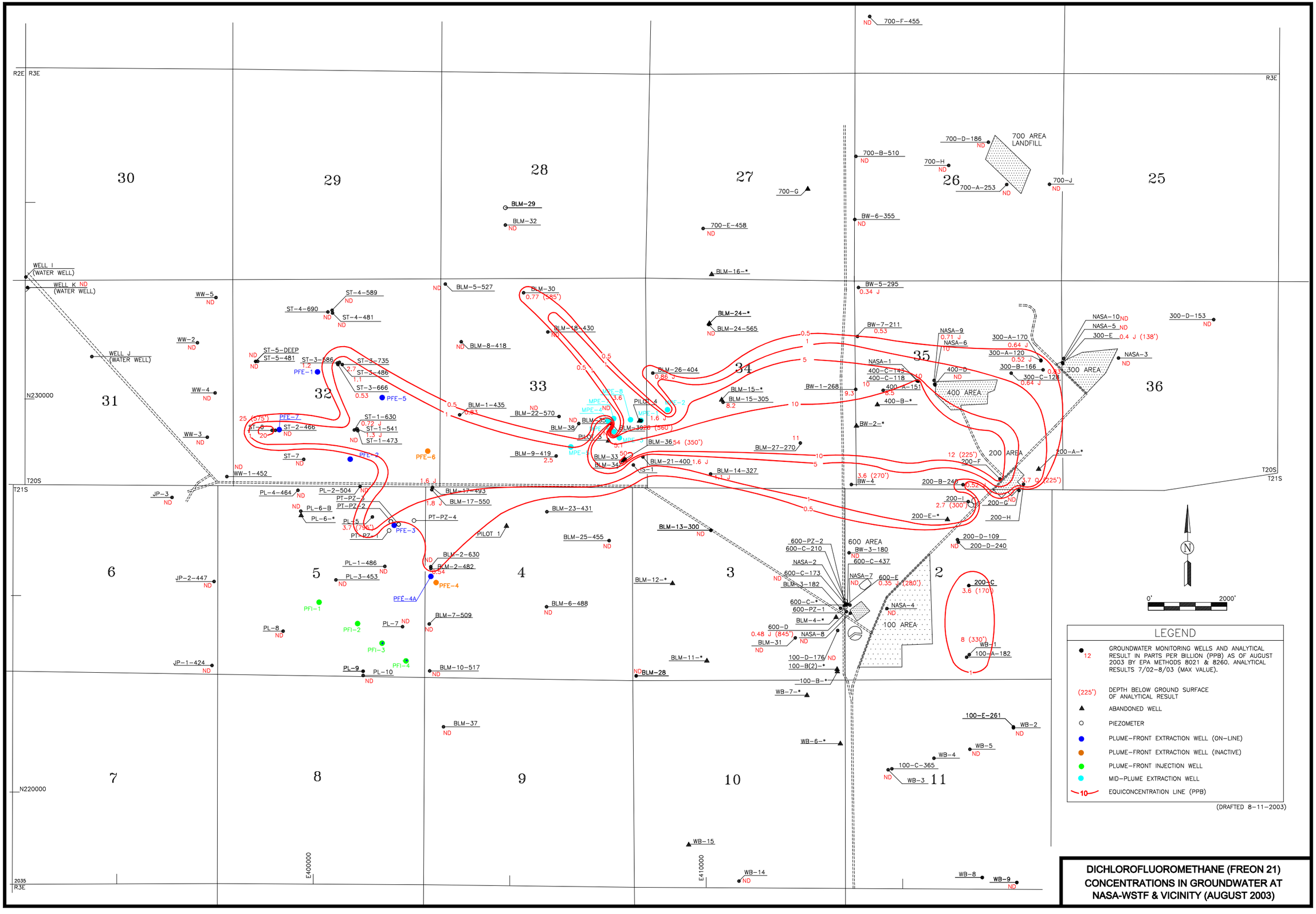
0' 2000'

LEGEND

- 0.55 — GROUNDWATER MONITORING WELLS AND ANALYTICAL RESULT IN PARTS PER BILLION (PPB) AS OF AUGUST 2003 BY EPA METHODS 8021 & 8260. ANALYTICAL RESULTS 7/02–8/03 (MAX VALUE).
- (225') — DEPTH BELOW GROUND SURFACE OF ANALYTICAL RESULT
- ABANDONED WELL
- PIEZOMETER
- PLUME–FRONT EXTRACTION WELL (ON–LINE)
- PLUME–FRONT EXTRACTION WELL (INACTIVE)
- PLUME–FRONT INJECTION WELL
- MID–PLUME EXTRACTION WELL
- 5 — EQUICONCENTRATION LINE (PPB)

(DRAFTED 8–11–2003)


R2E R3E
R3E
T20S
T21S
T20S
T21S
30
29
28
27
26
25
31
32
33
34
35
36
6
5
4
3
2
1
7
8
9
10
11
N230000
N220000
2035
R3E
E400000
E410000
WELL I (WATER WELL)
WELL K (WATER WELL)
WELL J (WATER WELL)
WW-5 ND
WW-2 ND
WW-4 ND
WW-3 ND
WW-1-452 ND
JP-3 ND
JP-2-447 ND
JP-1-424 ND
ST-4-589 ND
ST-4-690 ND
ST-4-481 ND
ST-5-DEEP ND
ST-5-481 ND
ST-3-586 200
ST-3-735 20
ST-3-486 230
ST-3-666 24
PFE-1
PFE-5
PFE-7
ST-6 8.4 (575')
ST-2-466 ND
ST-1-630 330
ST-1-541 370
ST-1-473 200
PFE-2
ST-7 ND
PFE-6
BLM-29
BLM-32 ND
BLM-5-527 3.8
BLM-30 18 (585')
BLM-18-430 95
BLM-8-418 ND
BLM-1-435 76
BLM-22-570 ND
BLM-9-419 97
BLM-26-404 96
BLM-15-* 240
BLM-15-305
MPE-8 100
MPE-4 ND
MPE-1 210
PILOT 4
PFE-2
BLM-38
BLM-39 240 (385')
PILOT 3
MPE-3 270
BLM-36 6.1 (350')
MPE-5
BLM-35
BLM-34
BLM-21-400 170
IS-1
BLM-14-327 190
700-F-455 ND
700-G
700-E-458 ND
BLM-16-*
BLM-24-*
BLM-24-565 ND
BLM-27-270 470
700-B-510 ND
700-H ND
700-D-186 0.54
700 AREA LANDFILL
700-A-253 ND
700-J ND
BW-6-355 ND
BW-5-295 120
BW-7-211 140
BW-1-268 220
BW-2-* 160 EB (455')
BW-4
NASA-9 520
NASA-6 230
NASA-1 410
400-C-143
400-C-118
400-A-151 220
400-B-*
400-D ND
400 AREA
300-A-170 100
300-A-120 1,000 1,100
300-B-166 250
300-C-126 1,600
300 AREA
NASA-10 62
NASA-5 71
300-E 85 (138')
300-D-153 2.1
NASA-3 ND
200 AREA
200-A-*
200-F 33 (225')
200-B-240 190
200-I 0.89 J (185')
200-G 47 (175')
200-H
200-E-* 4.7 (225')
200-D-109 110
200-D-240 100
200-C 29 (225')
600 AREA
BW-3-180 1.5 J
600-C-437
600-PZ-2
600-C-210
NASA-2
600-C-173 ND
BLM-3-182
NASA-7 1.8 J
600-E ND
600-C-* 600-PZ-1
NASA-4 0.71
100 AREA
BLM-4-*
600-D 2.3 (365')
NASA-8 ND
BLM-31 ND
100-D-176 ND
100-B(2)-*
100-B-*
WB-7-*
WB-1 0.9 J (200')
100-A-182
BLM-13-300 ND
BLM-12-*
BLM-11-*
BLM-28 ND
BLM-25-455 ND
BLM-23-431 110 (1999)
BLM-6-488 ND
BLM-7-509 ND
BLM-10-517 ND
BLM-37 ND
BLM-17-493 200
BLM-17-550
BLM-2-630 150
BLM-2-482 70 G
PFE-4
PFE-4A
PT-PZ-4
PT-PZ-3
PT-PZ-2 7 (495')
PT-PZ-1
PILOT 1
PL-4-464 16
PL-2-504 150
PL-6-B
PL-6-*
PL-5
PFE-3
PL-1-486 120
PL-3-453 ND
PFI-1
PFI-2
PFI-3
PFI-4
PL-8 ND
PL-7 ND
PL-9
PL-10 ND
JP-3 ND
190
100-E-261
WB-2 ND
WB-6-*
WB-5 ND
WB-4
100-C-365 ND
WB-3
WB-15
WB-14 ND
WB-8
WB-9 ND
0'
2000'
LEGEND
33 GROUNDWATER MONITORING WELLS AND ANALYTICAL RESULT IN PARTS PER BILLION (PPB) AS OF AUGUST 2003 BY EPA METHODS 8021 & 8260. ANALYTICAL RESULTS 7/02-8/03 (MAX VALUE).
(225') DEPTH BELOW GROUND SURFACE OF ANALYTICAL RESULT
ABANDONED WELL
PIEZOMETER
PLUME-FRONT EXTRACTION WELL (ON-LINE)
PLUME-FRONT EXTRACTION WELL (INACTIVE)
PLUME-FRONT INJECTION WELL
MID-PLUME EXTRACTION WELL
10 EQUICONCENTRATION LINE (PPB)
(DRAFTED 8-11-2003)
TRICHLOROFLUOROMETHANE (FREON 11) CONCENTRATIONS IN GROUNDWATER AT NASA-WSTF & VICINITY (AUGUST 2003)

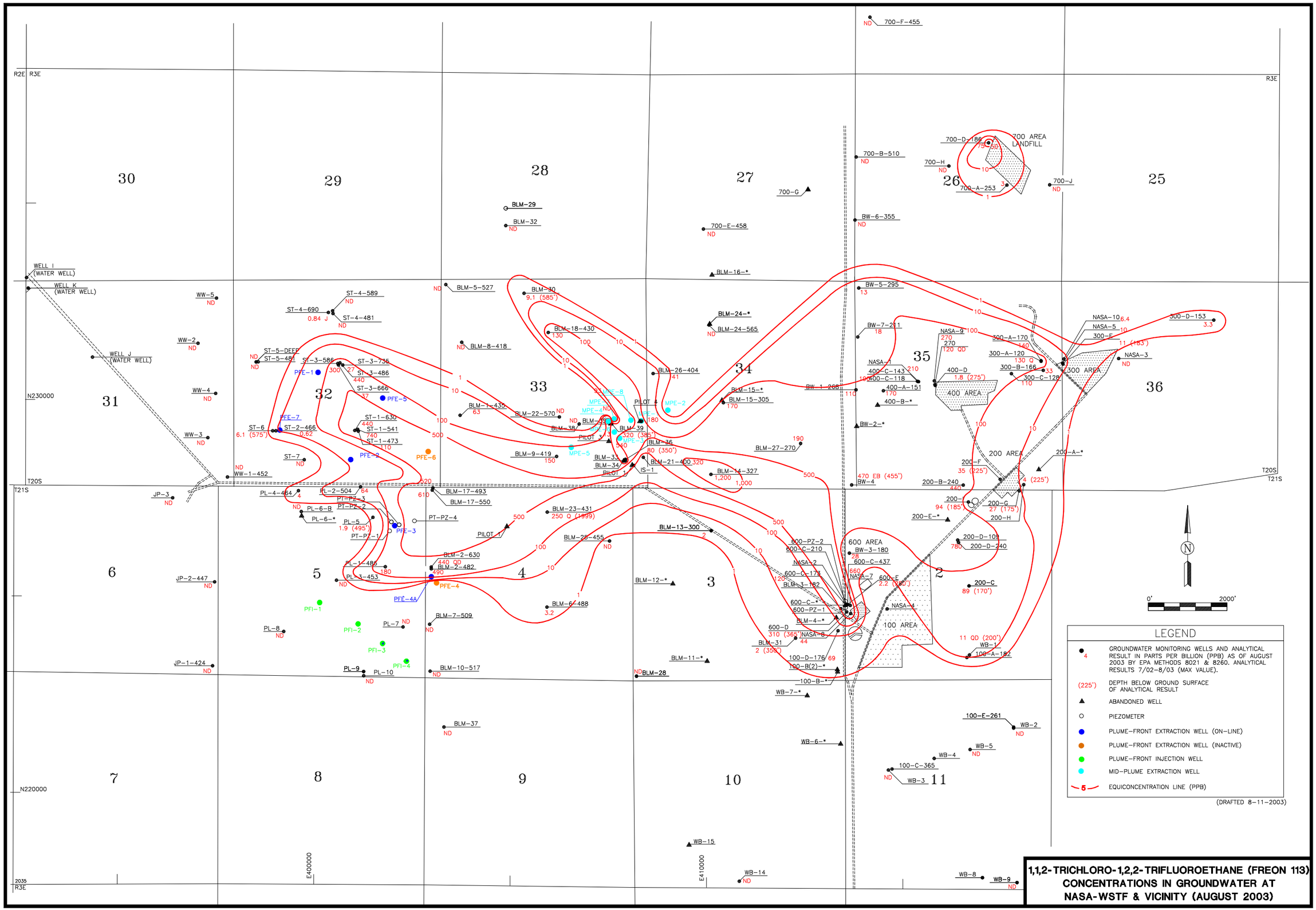


LEGEND

- 12 — GROUNDWATER MONITORING WELLS AND ANALYTICAL RESULT IN PARTS PER BILLION (PPB) AS OF AUGUST 2003 BY EPA METHODS 8021 & 8260. ANALYTICAL RESULTS 7/02–8/03 (MAX VALUE).
- (225') — DEPTH BELOW GROUND SURFACE OF ANALYTICAL RESULT
- ▲ — ABANDONED WELL
- ○ — PIEZOMETER
- ● — PLUME–FRONT EXTRACTION WELL (ON–LINE)
- ● — PLUME–FRONT EXTRACTION WELL (INACTIVE)
- ● — PLUME–FRONT INJECTION WELL
- ● — MID–PLUME EXTRACTION WELL
- 10 — EQUICONCENTRATION LINE (PPB)

(DRAFTED 8–11–2003)

DICHLOROFLUOROMETHANE (FREON 21) CONCENTRATIONS IN GROUNDWATER AT NASA-WSTF & VICINITY (AUGUST 2003)


R2E R3E
R3E
T20S
T21S
N230000
N220000
E400000
E410000
2035
R3E
30
29
28
27
26
25
31
32
33
34
35
36
6
5
4
3
2
1
7
8
9
10
11
700 AREA LANDFILL
700-D-186 75 (68')
700-H ND
700-A-253 3
1
700-J ND
700-F-455 ND
700-B-510 ND
700-G
BW-6-355 ND
700-E-458 ND
BLM-29
BLM-32 ND
BLM-16-*
BW-5-295 13
BW-7-211 18
BLM-24-*
BLM-24-565 ND
BLM-30 9.1 (585')
BLM-5-527 ND
BLM-8-418 ND
BLM-18-430 130
BLM-26-404 41
BLM-15-* 170
BLM-15-305
BW-1 268 110
BW-2-*
400-A-151 170
400-B-*
400-C-143 210
400-C-118 190
NASA-1
NASA-9 270 270 120 QD
400-D 1.8 (275')
400 AREA
300-A-170 140
300-A-120 130 Q
300-B-166 33
300-C-128 110
300 AREA
NASA-10 6.4
NASA-5 10
300-F 11 (183')
300-D-153 3.3
NASA-3 ND
200 AREA
200-A-*
200-F 35 (225')
200-B-240 440
200-I 94 (185')
200-G 27 (175')
200-H
200-E-*
200-D-109 780
200-D-240
200-C 89 (170')
11 QD (200')
WB-1
100-A-182
600 AREA
BW-3-180 28
600-C-437 660
NASA-7
600-F 2.2 (160')
600-PZ-2
600-C-210
NASA-2
600-C-173 120
BLM-3-182
600-C-* 600-PZ-1
BLM-4-*
NASA-4
100 AREA
600-D 310 (365')
NASA-8 44
BLM-31 2 (350')
100-D-176 69
100-B(2)-*
100-B-*
BLM-28 ND
BLM-11-*
BLM-12-*
BLM-13-300 2
BLM-25-455 ND
BLM-23-431 250 Q (1999)
BLM-14-327 1,200 1,000
BLM-27-270 190
BLM-21-400 320
IS-1
BLM-33
BLM-34
PILOT 1
BLM-36 80 (350')
BLM-39 320 (385')
BLM-35
BLM-38
PILOT 3
BLM-22-570 ND
BLM-1-435 63
BLM-9-419 150
BLM-17-493 610
BLM-17-550
BLM-2-630 440 QD
BLM-2-482 490
BLM-6-488 3.2
BLM-7-509 ND
BLM-10-517 ND
BLM-37 ND
WB-15
WB-14 ND
WB-8
WB-9 ND
WB-6-*
WB-4
WB-5 ND
WB-2 ND
100-E-261
100-C-365 ND
WB-3
470 EB (455')
BW-4
ST-4-589 ND
ST-4-690 0.84 J
ST-4-481 ND
ST-5-DEEP ND
ST-5-481 ND
ST-3-586 300
ST-3-735 27
ST-3-486 440
ST-3-666 37
PFE-1
PFE-5
PFE-7
ST-6 6.1 (575')
ST-2-466 0.62
ST-1-630 440
ST-1-541 740
ST-1-473 110
ST-7 ND
PFE-2
PFE-6
WW-1-452 ND
WW-5 ND
WW-2 ND
WW-4 ND
WW-3 ND
WELL I (WATER WELL)
WELL K (WATER WELL)
WELL J (WATER WELL)
JP-3 ND
JP-2-447 ND
JP-1-424 ND
PL-4-464 4
PL-2-504 64
PT-PZ-3
PT-PZ-2
PL-6-B ND
PL-6-* ND
PL-5 1.9 (495')
PT-PZ-1
PT-PZ-4
PFE-3
PL-1-485 180
PL-3-453 ND
PFE-4
PFE-4A
PFI-1
PFI-2
PFI-3
PFI-4
PL-8 ND
PL-7 ND
PL-9 ND
PL-10 ND
MPE-1
MPE-2
MPE-3
MPE-4
MPE-5
MPE-6
MPE-7
MPE-8
PILOT 5
PILOT 6
0'
2000'
N
LEGEND
4 GROUNDWATER MONITORING WELLS AND ANALYTICAL RESULT IN PARTS PER BILLION (PPB) AS OF AUGUST 2003 BY EPA METHODS 8021 & 8260. ANALYTICAL RESULTS 7/02-8/03 (MAX VALUE).
(225') DEPTH BELOW GROUND SURFACE OF ANALYTICAL RESULT
ABANDONED WELL
PIEZOMETER
PLUME-FRONT EXTRACTION WELL (ON-LINE)
PLUME-FRONT EXTRACTION WELL (INACTIVE)
PLUME-FRONT INJECTION WELL
MID-PLUME EXTRACTION WELL
5 EQUICONCENTRATION LINE (PPB)
(DRAFTED 8-11-2003)
1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON 113)
CONCENTRATIONS IN GROUNDWATER AT
NASA-WSTF & VICINITY (AUGUST 2003)

1,2-DICHLORO-1,1,2-TRIFLUOROETHANE (FREON 123A) CONCENTRATIONS IN GROUNDWATER AT NASA-WSTF & VICINITY (AUGUST 2003)

R2E R3E

R3E

T20S T21S

T20S T21S

2035 R3E

N230000

N220000

E400000

E410000

0' 2000'

LEGEND

- 39 — GROUNDWATER MONITORING WELLS AND ANALYTICAL RESULT IN PARTS PER BILLION (PPB) AS OF AUGUST 2003 BY EPA METHODS 8021 OR 8260. ANALYTICAL RESULTS MAXIMUM VALUE (7/02–8/03)
- (330') — DEPTH BELOW GROUND SURFACE OF ANALYTICAL RESULT
- ABANDONED WELL
- PIEZOMETER
- PLUME–FRONT EXTRACTION WELL (ON–LINE)
- PLUME–FRONT EXTRACTION WELL (INACTIVE)
- PLUME–FRONT INJECTION WELL
- MID–PLUME EXTRACTION WELL
- 1 — F123A CONCENTRATION LINE (PPB)

(DRAFTED 8–11–2003)

700 AREA LANDFILL

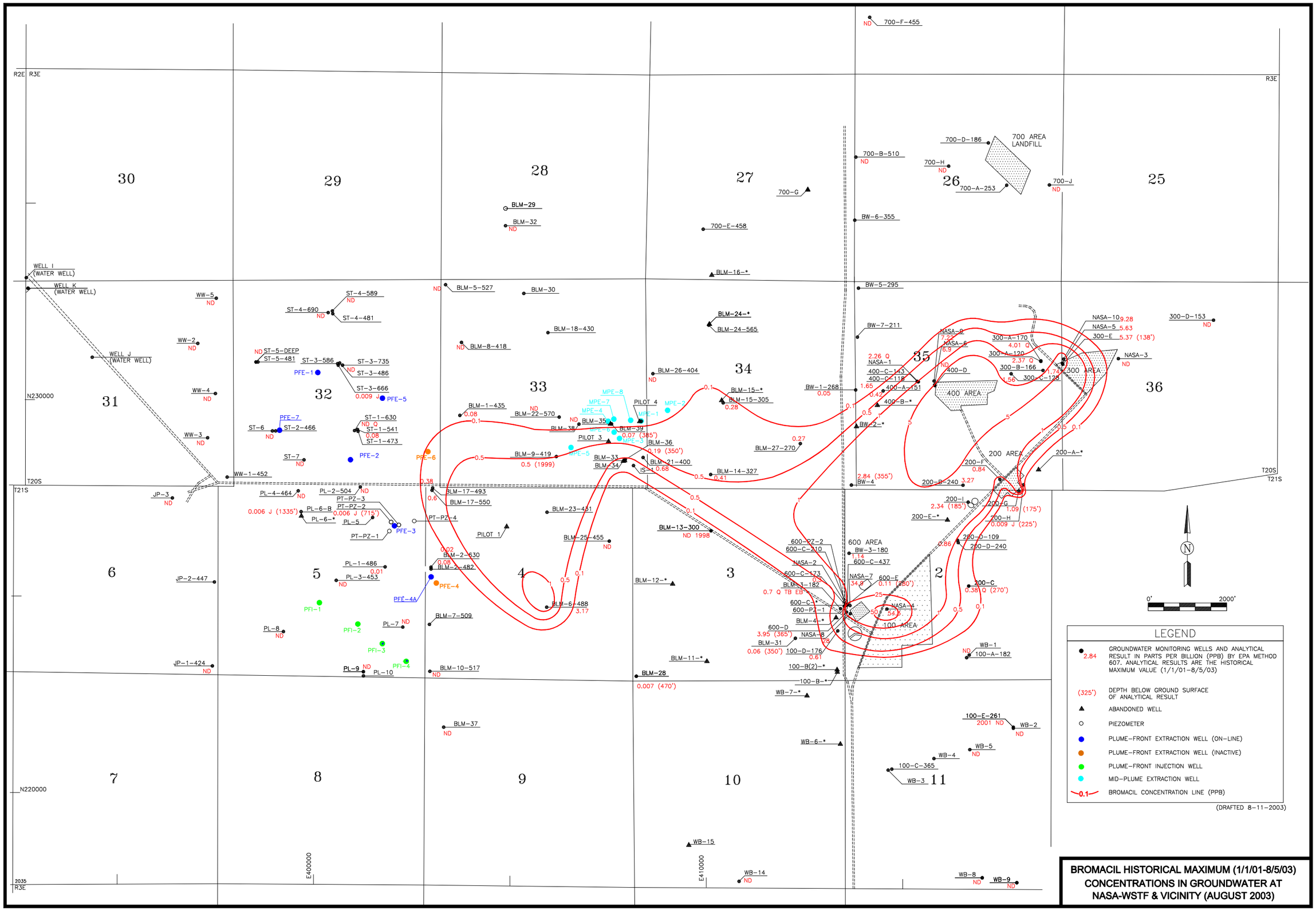
100 AREA

200 AREA

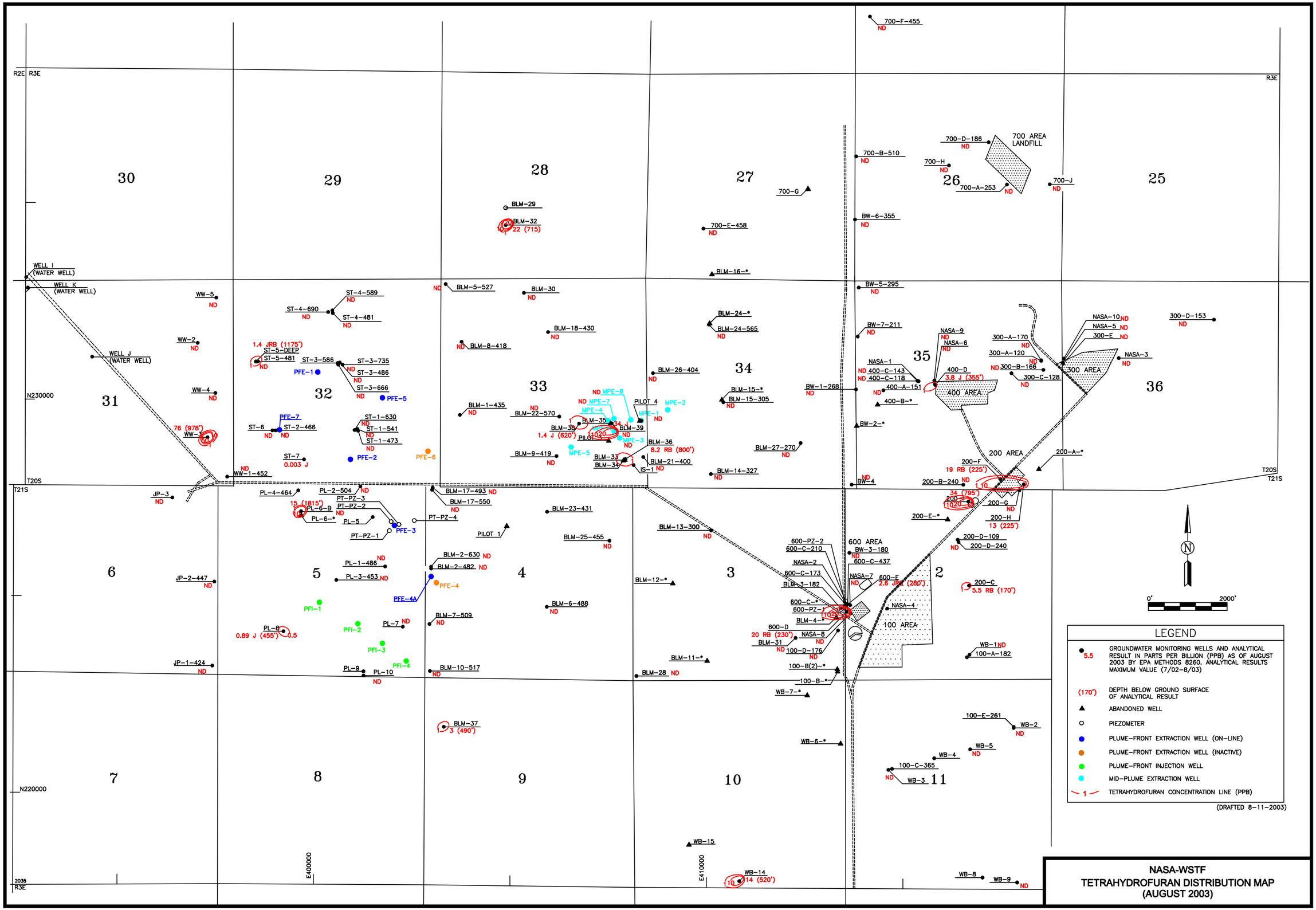
300 AREA

400 AREA

600 AREA



BROMACIL HISTORICAL MAXIMUM (1/1/01-8/5/03) CONCENTRATIONS IN GROUNDWATER AT NASA-WSTF & VICINITY (AUGUST 2003)


R2E R3E
R3E
T20S
T21S
30
29
28
27
26
25
31
32
33
34
35
36
6
5
4
3
2
1
7
8
9
10
11
N230000
N220000
E400000
E410000
2035
R3E
WELL I (WATER WELL)
WELL K (WATER WELL)
WELL J (WATER WELL)
WW-5 ND
WW-2 ND
WW-4 ND
76 (978')
WW-1 (617')
WW-1-452 ND
JP-3 ND
JP-2-447 ND
JP-1-424 ND
ST-4-589 ND
ST-4-690 ND
ST-4-481 ND
1.4 JRB (1175')
ST-5-DEEP
ST-5-481 ND
ST-3-586
ST-3-735 ND
ST-3-486 ND
ST-3-666 ND
PFE-1
PFE-5
PFE-7
ST-6 ND
ST-2-466 ND
ST-1-630 ND
ST-1-541 ND
ST-1-473 ND
ST-7 0.003 J
PFE-2
PFE-6
PL-4-464
15 (1815')
PL-2-504 ND
PT-PZ-3
PT-PZ-2
PL-6-B ND
PL-6-*
PL-5
PT-PZ-1
PFE-3
PT-PZ-4
PL-1-486 ND
PL-3-453 ND
PFE-4A
PFE-4
PFI-1
PFI-2
PFI-3
PFI-4
PL-8 0.89 J (455') 0.5
PL-7 ND
PL-9
PL-10 ND
BLM-29
BLM-32 22 (715')
BLM-5-527 ND
BLM-30 ND
BLM-18-430 ND
BLM-8-418 ND
BLM-26-404 ND
BLM-1-435 ND
BLM-22-570 ND
BLM-38 1.4 J (620')
BLM-35 34
BLM-39 1420
PILOT 4
PILOT 3
MPE-8 ND
MPE-7 ND
MPE-4
MPE-1 ND
MPE-2
MPE-3 ND
MPE-5
BLM-36 8.2 RB (800')
BLM-33
BLM-34
BLM-21-400
IS-1 ND
BLM-9-419 ND
BLM-14-327 ND
BLM-27-270 ND
BLM-15-*
BLM-15-305 ND
BLM-24-*
BLM-24-565 ND
BLM-16-*
BLM-17-493 ND
BLM-17-550 ND
BLM-23-431
BLM-25-455 ND
BLM-13-300 ND
BLM-2-630 ND
BLM-2-482 ND
BLM-6-488 ND
BLM-7-509 ND
BLM-10-517 ND
BLM-11-*
BLM-28 ND
BLM-12-*
BLM-37 3 (490')
700-F-455 ND
700-G
700-E-458 ND
700-B-510 ND
700-H ND
700-D-186 ND
700-A-253 ND
700-J ND
700 AREA LANDFILL
BW-6-355 ND
BW-5-295 ND
BW-7-211 ND
BW-1-268 ND
BW-2-*
BW-4 ND
NASA-1 ND
400-C-143 ND
400-C-118 ND
400-A-151 ND
400-B-*
NASA-9 ND
NASA-6 ND
400-D 3.8 J (355')
400 AREA
300-A-170 ND
300-A-120 ND
300-B-166 ND
300-C-128 ND
NASA-10 ND
NASA-5 ND
300-E ND
300 AREA
NASA-3 ND
300-D-153 ND
200 AREA
200-A-*
200-F 19 RB (225')
200-B-240 ND
34 (795')
200-C 1020
200-G ND
200-H 13 (225')
200-E-*
200-D-109 ND
200-D-240
200-C 5.5 RB (170')
600 AREA
BW-3-180 ND
600-C-437
NASA-2
NASA-7 ND
600-E 2.6 JRB (280')
600-PZ-2
600-C-210
600-C-173
BLM-3-182
600-C-*
600-PZ-1 (1025')
BLM-4-*
NASA-4
100 AREA
600-D 20 RB (230')
NASA-8 ND
BLM-31 ND
100-D-176 ND
100-B(2)-*
100-B-*
WB-7-*
WB-6-*
WB-1 ND
100-A-182
100-E-261
WB-2 ND
WB-5 ND
WB-4
100-C-365 ND
WB-3
WB-15
WB-14 14 (520')
WB-8
WB-9 ND
0'
2000'
N
LEGEND
5.5 GROUNDWATER MONITORING WELLS AND ANALYTICAL RESULT IN PARTS PER BILLION (PPB) AS OF AUGUST 2003 BY EPA METHODS 8260. ANALYTICAL RESULTS MAXIMUM VALUE (7/02-8/03)
(170') DEPTH BELOW GROUND SURFACE OF ANALYTICAL RESULT
ABANDONED WELL
PIEZOMETER
PLUME-FRONT EXTRACTION WELL (ON-LINE)
PLUME-FRONT EXTRACTION WELL (INACTIVE)
PLUME-FRONT INJECTION WELL
MID-PLUME EXTRACTION WELL
1 TETRAHYDROFURAN CONCENTRATION LINE (PPB)
(DRAFTED 8-11-2003)
NASA-WSTF
TETRAHYDROFURAN DISTRIBUTION MAP
(AUGUST 2003)

NASA/WSTF
CHROMIUM DISTRIBUTION MAP
(AUGUST 2003)

R2E R3E — R3E

T20S — T21S

N230000 — N220000

E400000 — E410000

2035 R3E

30 29 28 27 26 25

31 32 33 34 35 36

6 5 4 3 2 1

7 8 9 10 11

WELL I (WATER WELL)
WELL K (WATER WELL)
WELL J (WATER WELL)

WW-5 0.002 J (ALL)
WW-2 0.003 J (495')
WW-4 0.004 J (594')
WW-3 0.005 J (569')
WW-1-452 0.006 J
ST-7 0.003 J
ST-6 0.12 (975') 0.01
PFE-7
ST-2-466 0.004 J
ST-1-630 ND
ST-1-541 ND
ST-1-473 0.01
0.049 QD
PFE-2 ND
PFE-6 ND
ST-4-589 ND
ST-4-690 0.009 J
ST-4-481 ND
ST-5-DEEP 0.002 J (985')
ST-5-481 0.002 J
ST-3-586 0.007 J
ND
PFE-1 ND
ST-3-735 ND
ST-3-486 0.09
ST-3-666 0.006 J
PFE-5 ND
JP-3 0.004 J (515')
JP-2-447 ND
JP-1-424 0.026
PL-4-464 0.017
PL-2-504 0.114
PT-PZ-3 0.032 (1815')
PT-PZ-2 0.012 (985')
PL-6-B
PL-6-* 0.001
PL-5 0.01
PFE-3
PT-PZ-1
PT-PZ-4
PL-1-486 0.039 QD
PL-3-453 0.013
PFE-4A 0.004 J
PFE-4
PFI-1 ND
PFI-2 ND
PFI-3 ND
PFI-4 ND
PL-8 0.001 0.006 J (965')
PL-7 ND
PL-9 ND
PL-10 0.003 J (484', 962') 0.001
BLM-17-493 0.013
BLM-17-550 0.0034 2001
BLM-2-630 0.545
BLM-2-482 0.098
BLM-10-517 0.05
BLM-37 0.004 J (885')
BLM-6-488 0.145
BLM-7-509 0.075
BLM-23-431
BLM-25-455 ND
PILOT 1
BLM-29
BLM-32 0.001 0.003 J (580', 645')
BLM-5-527 ND
BLM-30 ND
BLM-18-430 ND
BLM-8-418 ND
BLM-1-435 ND
BLM-22-570 ND
BLM-38 0.001
BLM-35 0.001
BLM-39 0.003 J
PILOT 3
BLM-9-419 ND
MPE-8 0.003 J
MPE-7 0.002 J
MPE-4 ND
MPE-1 0.001
MPE-2 ND
PILOT 4 ND
BLM-39 0.004 J (385')
MPE-3 ND
MPE-5
BLM-36 0.006 J (800')
BLM-33
BLM-34
BLM-21-400
IS-1 ND
0.002 J (480', 620')
BLM-26-404 ND
BLM-15-* 0.002 J
BLM-15-305
BLM-24-* 0.01
BLM-24-565 0.022
BLM-16-*
BLM-14-327 ND
BLM-27-270 0.022 0.01
BLM-13-300 0.003 J 0.001
BLM-12-*
BLM-11-*
BLM-28 0.095 (470')
0.1
0.01
0.001
700-F-455 0.001 0.007 J
700-G
700-E-458 0.01 0.018
700-B-510 0.024
700-D-186 0.002 J
700 AREA LANDFILL
700-H 0.003 J (535')
700-A-253 ND
700-J 0.003 J
BW-6-355 0.006 J
0.001
BW-5-295 0.01 0.015
BW-7-211 0.008 J
NASA-9 0.126
NASA-6 0.029
NASA-1 ND
400-C-143 0.001
400-C-118 0.005 J
400-A-151 0.01
400-D 0.002 J (195', 355')
BW-1-268 0.019
400-B-* 0.01
BW-2-*
400 AREA
300-A-170 0.006 J
300-A-120 0.005 J
300-B-166 0.011 0.01
300-C-128 0.003 J
300 AREA
NASA-10 0.006 J
NASA-5 0.022
300-E 0.005 J (183')
NASA-3 ND
300-D-153 0.003 J 0.001
200 AREA
200-A-* 0.003 J (ALL) 200-F 0.001
BW-4 0.003 J (355')
200-B-240 0.003 J
0.006 J (675') 200-I
200-G 0.005 J (175', 220')
200-H 0.006 J (433')
200-E-*
200-D-109 ND
200-D-240
200-C ND
600 AREA
BW-3-180 0.03
600-C-437
NASA-7 0.192
600-F 0.002 J
0.001
600-PZ-2
600-C-210
NASA-2
600-C-173 0.007 J
BLM-3-182
600-C-* 0.001
600-PZ-1
BLM-4-*
NASA-4
100 AREA
600-D 0.003 J (635')
BLM-31
NASA-8 0.052 J
100-D-176 0.703
100-B(2)-*
100-B-*
WB-7-*
WB-1 ND
100-A-182
100-E-261
WB-2 ND
WB-6-*
WB-5 0.006 J (280')
WB-4 0.001
100-C-365
WB-3 0.002 J (330')
WB-15
WB-14 ND
WB-8
WB-9 ND

N
0' 2000'

LEGEND

- 0.006 J — GROUNDWATER MONITORING WELLS AND ANALYTICAL RESULT IN PARTS PER MILLION (PPM) AS OF AUGUST 2003 BY EPA METHODS 6010, ANALYTICAL RESULTS MAXIMUM VALUE (7/02-8/03)
- (280') — DEPTH BELOW GROUND SURFACE OF ANALYTICAL RESULT
- ▲ — ABANDONED WELL
- ○ — PIEZOMETER
- ● — PLUME-FRONT EXTRACTION WELL (ON-LINE)
- ● — PLUME-FRONT EXTRACTION WELL (INACTIVE)
- ● — PLUME-FRONT INJECTION WELL
- ● — MID-PLUME EXTRACTION WELL
- 0.001 — CHROMIUM CONCENTRATION LINE (PPM)

(DRAFTED 8-11-2003)

Statistical Comparison of Chromium Levels Between PVC and Stainless Steel Well Casings

August 17, 1997

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Summary of Results

Statistical analyses were conducted to determine if differences in chromium levels existed between wells with PVC casings and wells with stainless steel casings at NASA White Sands Test Facility (WSTF). Due to complexities in the design structure of the data, simple analyses were performed on two transformations of the data provided in order to see if there was agreement between the two approaches. Both analyses indicated that a statistically significant difference in chromium levels exists between the two casing types, using a 0.05 significance level. See Figures 1 and 2 for plots of the two data transformations. See Tables 1 and 2 for statistical results from the two analyses.

Introduction and Comments

The goal of the analyses presented here has been to determine and document any differences in chromium levels between well casings made of PVC and stainless steel. Data available for the analyses came from measurements on 145 wells at 80 different sites at WSTF. Some sites had multi-wells, with the number of wells ranging from one to eight. Of the 145 wells, 57 had PVC casings while 88 had stainless steel casings. Of the 80 sites, 23 had wells with PVC casings and 57 had wells with stainless steel casings. Well measurements were taken between 12/30/87 and 10/9/96. Some wells had measurements taken on only three different dates, while others had measurements taken on up to 24 occasions. From one to ten sample measurements (repeats) were recorded for each sampling occasion.

As repeat measurements on the same sampling occasions do not represent replication on different experimental units, any such repeat measurements were simply averaged to give a single observation value. When a non-detection occurred, a value of one half the MDL for chromium (1/2 of 0.001 mg/L) was substituted for analysis purposes.

Having multiple wells at a site and having numerous measurements over time lends to the possibility of conducting repeated measures analyses. However, both the number of wells per site and the sampling dates at each site were very inconsistent, making a repeated measures analysis unreasonable. Figure 3 illustrates the sampling occasions for the different wells, and demonstrates the huge variation in measurement periods between wells. Motivation for performing a repeated measures analysis comes from its ability to account for correlations between measurements repeated over time at each well, and similarly, its ability to account for correlations between multiple wells at each site. While these "repeated measurements" each contain potentially valuable information, the information in them is probably not wholly unique, due to the fact that they are collected from the same well (at various time periods) or at the same site (for different wells). Therefore, it is unreasonable to treat these repeated measurements as true replications.

The treatment of primary interest for this analysis is casing type, which in a repeated measures analysis would be applied to the whole plot experimental units, which are the sites in our study. Information contained in the "repeated measurements" has relatively minimal bearing on the conclusions drawn about the effect of the whole plot treatment, in this case, the effect of casing type. Consequently, two sample t-tests were performed. The data used to perform the first t-test were derived by averaging the data for each *well* over the most recent five years of data, that is, between 10/9/91 and 10/9/96. The most recent five year time period was chosen in order to reduce over representation of "older" data for some wells which have been monitored longer, which may be correlated with a variety of important factors such as casing type, instrumentation, or measurement processes. The data used to perform the second analysis of variance were derived by averaging the data for each *site* over the most recent five years of data. Using sites as the experimental unit in the analysis, instead of wells, should results in a more conservative test - that is, a test which is less likely to conclude a difference in chromium levels exists between casing types.

Analyses

Both statistical analyses were conducted using a 0.05 significance level. Before either analysis was begun, Folded Form F tests were conducted to test for unequal variances between the observations (the five year means in this case) for the two casing classifications. For the five year well means, a significant difference in the variances was found (p-value < 0.0001). Consequently, Satterthwaite's Approximate t-test was used for the comparison of chromium levels for this data. The t-test showed significant difference in the chromium levels for the two casings (p-value = 0.0003), and the estimates of the mean chromium levels for each casing type are shown in Table 1, along with the t-test results.

The Folded Form F test for the five year average site data indicated no significant difference between the variances of chromium levels between the two casing types (p-value = 0.2313). Hence, a standard t-test was performed to test for differences in chromium levels. A statistically significant difference was found in the levels of chromium associated with PVC and stainless steel casing types for the site data (p-value = 0.0403). The t-test results and the estimates of the mean chromium levels for each casing type are shown in Table 2.

Figure 1. Mean chromium levels for each well plotted by casing type. Horizontal lines indicate the group means for each casing type.

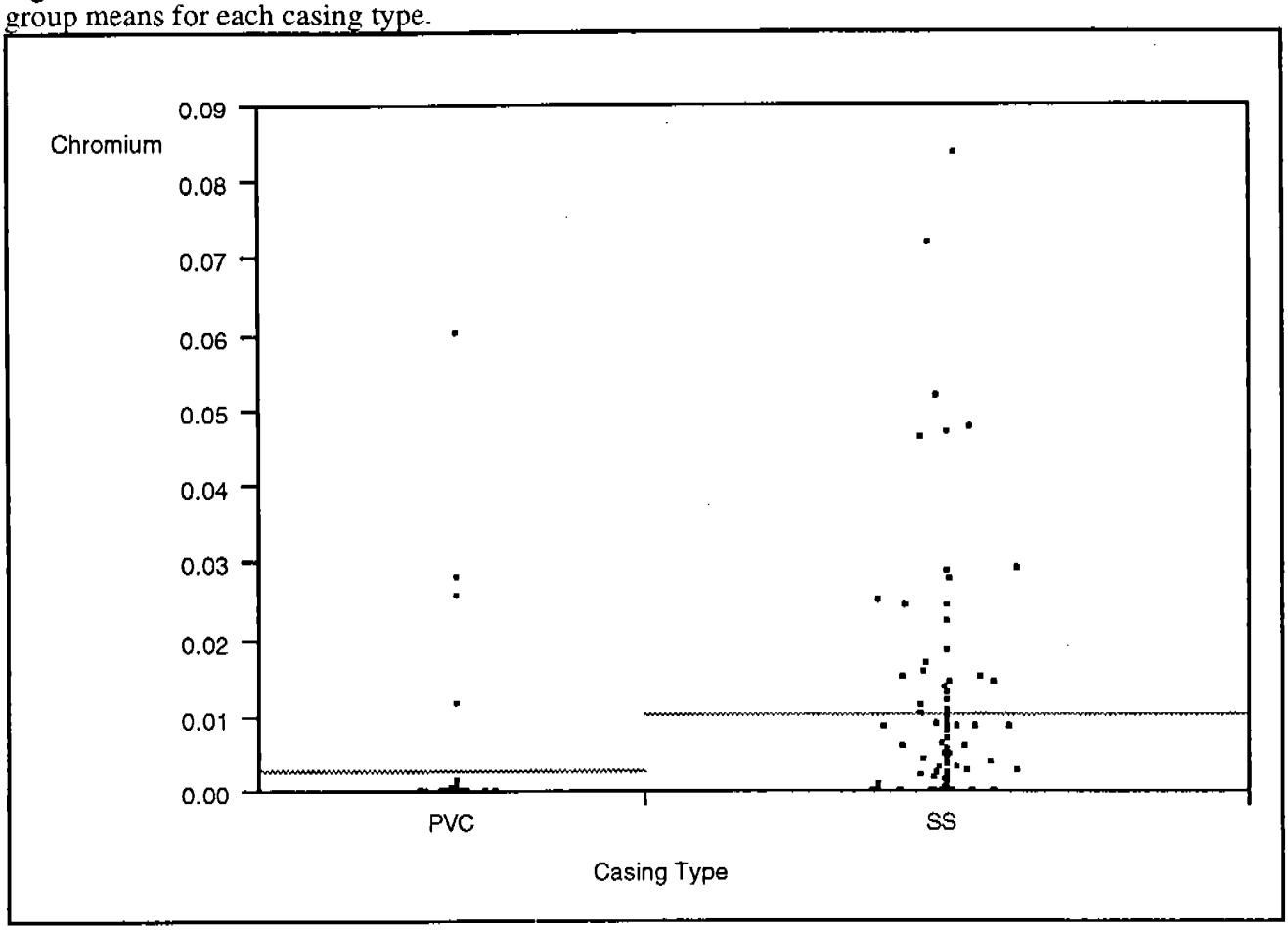


Figure 2. Mean chromium levels for each site plotted by casing type. Horizontal lines indicate the group means for each casing type.

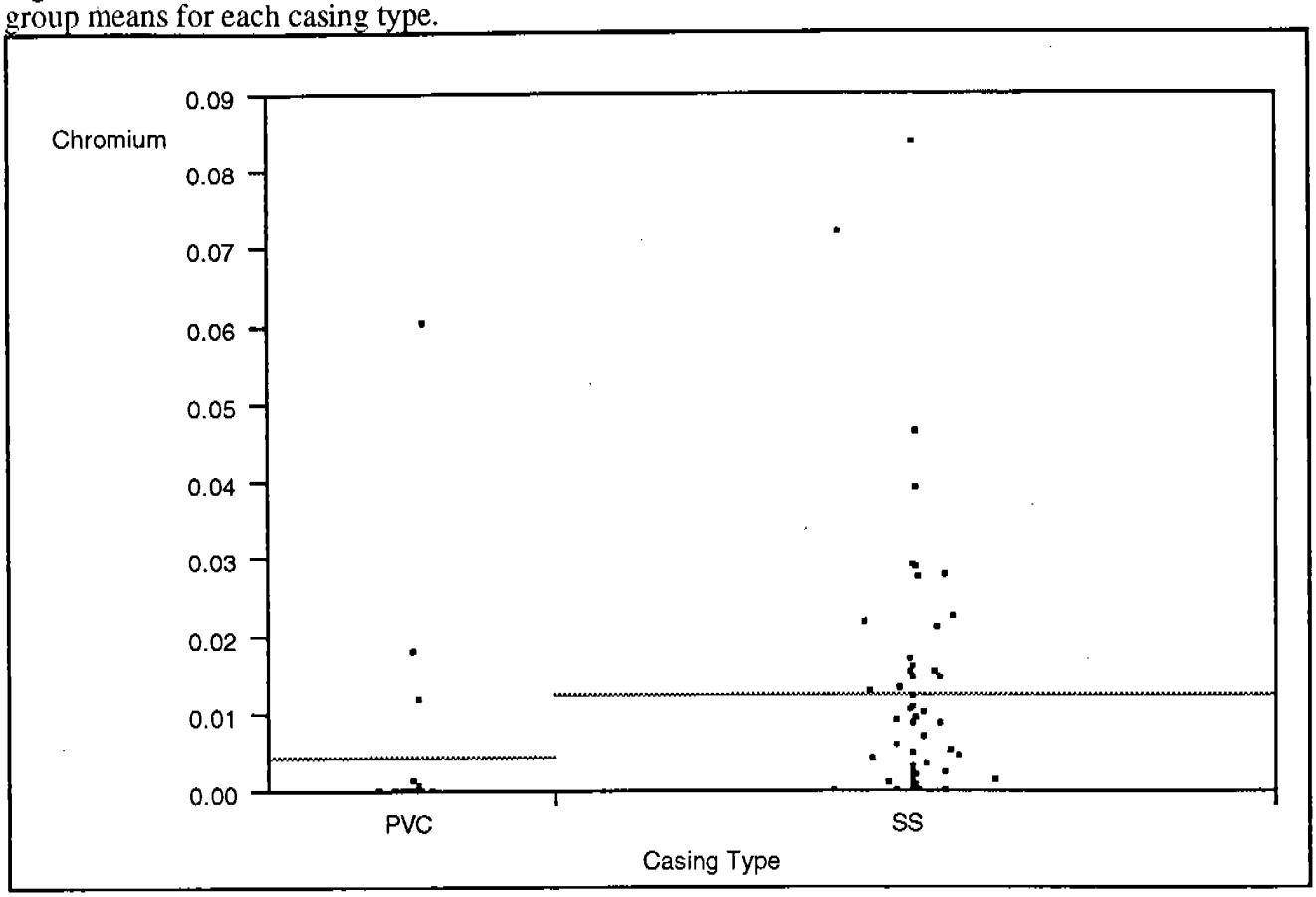


Figure 3. Plot of test days versus well number. Test day indicates days when one or more samples were taken for a particular well, and is the number of days since January 1, 1960. Well number is a whole number assigned to each well to facilitate plotting.

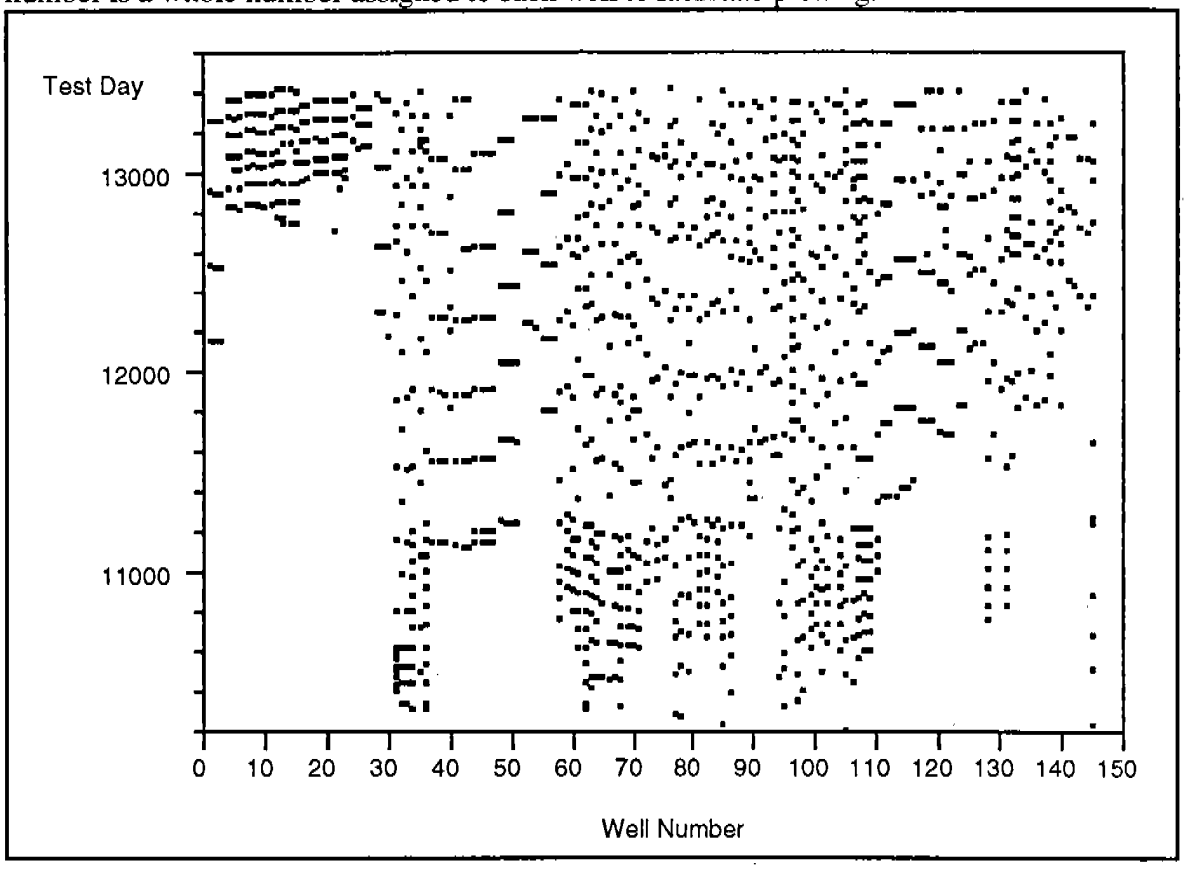


Table 1. Satterthwaite's approximate t-test results for the analysis of the five year means for each well, along with mean chromium level estimates associated with each casing type.

Variances Unequal	T	DF	Prob>|T|
	-3.7425	142.4	0.0003

Casing Type	LS Mean Estimate
PVC	0.002786
Stainless Steel	0.010524

Table 2. Standard t-test results for the analysis of the five year means for each well, along with mean chromium level estimates associated with each casing type.

Variances Equal	T	DF	Prob>|T|
	-2.0851	78.0	0.0403

Casing Type	LS Mean Estimate
PVC	0.004507
Stainless Steel	0.012481

Plume-Front Remediation Well Design Summary

Well Name	Casing Material	Casing Diameter OD / Average ID (inches)	Well Depth (feet bgs)	Screened Interval (feet bgs)	Length of Screen (feet)	Screen Slot (inches)	Static Water Level (feet bgs)
Plume-Front Extraction Wells							
PFE-1	SDR 17 PVC	10.75 / 9.41	768.40	389.00-748.10	359.10	0.085	423
PFE-2	SDR 17 PVC	10.75 / 9.41	896.18	397.51-875.83	478.32	0.085	434
PFE-3[1]	SDR 21 PVC: Carbon Steel:	6.90 / 6.05 10.75 / 10.02	836.12 838.47	477.08-816.02 507.72-828.44	338.94 320.70	0.080 0.050	452
PFE-4	SDR 17 PVC	9.05 / 7.90	876.52	397.43-856.23	458.80	0.085	476
PFE-4A	SDR 17 PVC	10.75 / 9.41	697.27	397.95-677.26	279.31	0.085	470
PFE-5	SDR 17 PVC	9.05 / 7.90	817.00	417.98-797.03	379.05	0.085	451
PFE-6	SDR 17 PVC	9.05 / 7.90	539.42	434.47-534.07	99.60	0.085	474
PFE-7	SDR 17 PVC	10.75 / 9.41	697.58	398.02-677.58	279.56	0.085	411
Plume-Front Injection Wells							
PFI-1	SDR 17 PVC	9.05 / 7.90	996.58	418.15-976.57	558.42	0.085	419
PFI-2	SDR 17 PVC	9.05 / 7.90	996.62	418.13-976.67	558.54	0.085	437
PFI-3	SDR 17 PVC	9.05 / 7.90	996.89	417.95-976.89	558.94	0.085	447
PFI-4	SDR 17 PVC	9.05 / 7.90	897.68	397.88-877.75	479.87	0.085	458

SDR = Standard Dimension Ratio. It is a strength rating for PVC casing.
OD = Outside Diameter
ID = Inside Diameter
bgs = below ground surface
PFE-3[1]: Well was originally completed in 1990 with carbon steel casing. Due to casing deterioration, the well was rehabilitated/reinstalled in 2003 with a PVC sleeve inside the original carbon steel casing.
+ Extraction Wells PFE-4 and PFE-6 will not be part of the on-line remediation system.

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

BOREHOLE LITHOLOGIC LOG

Location ID: **PFE-1**

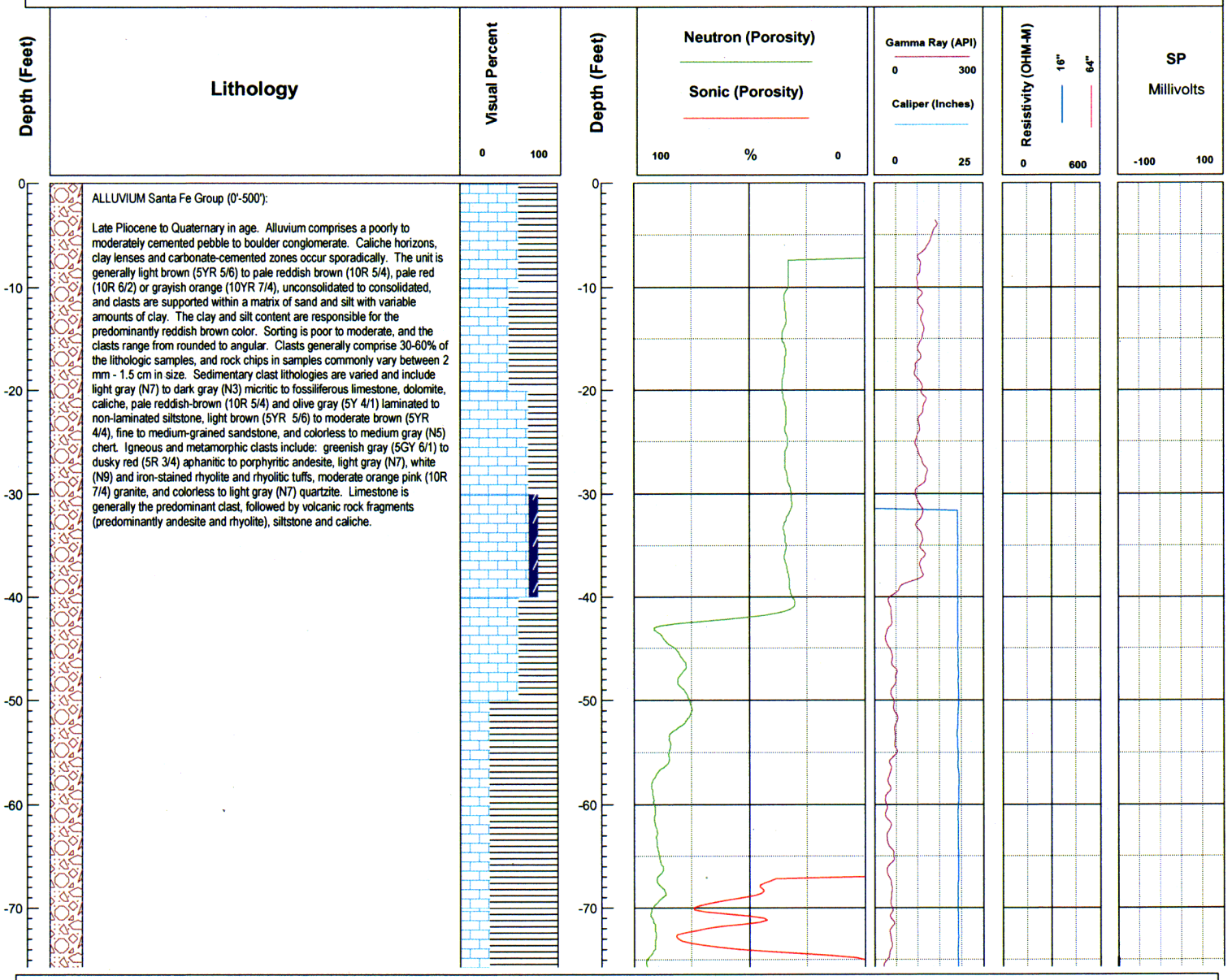
Site ID: **NASA-WSTF, Doña Ana County, NM**

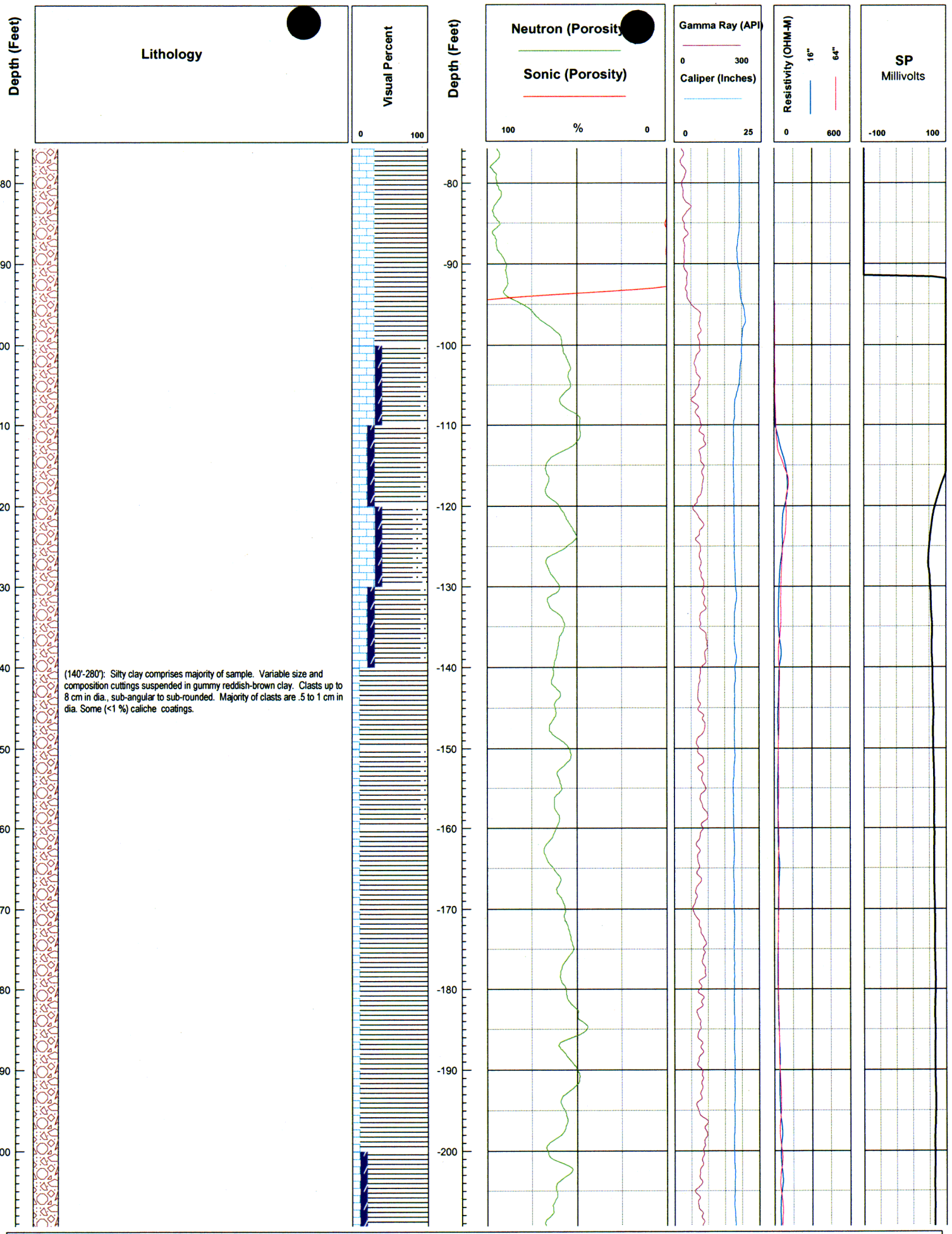
Township and Range: **SE 1/4, SE 1/4, NW 1/4, Sec 32, T20S R3E**
NM State Plane Coordinates (NAD 83): **230594.03N 400160.61E (Preliminary)**
Elevation (Brass Cap): **4486.20' (Preliminary)**
Total Depth of Borehole (bgs): **788'**
Depth to Bedrock (bgs): **700'**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Juan Aguilar**

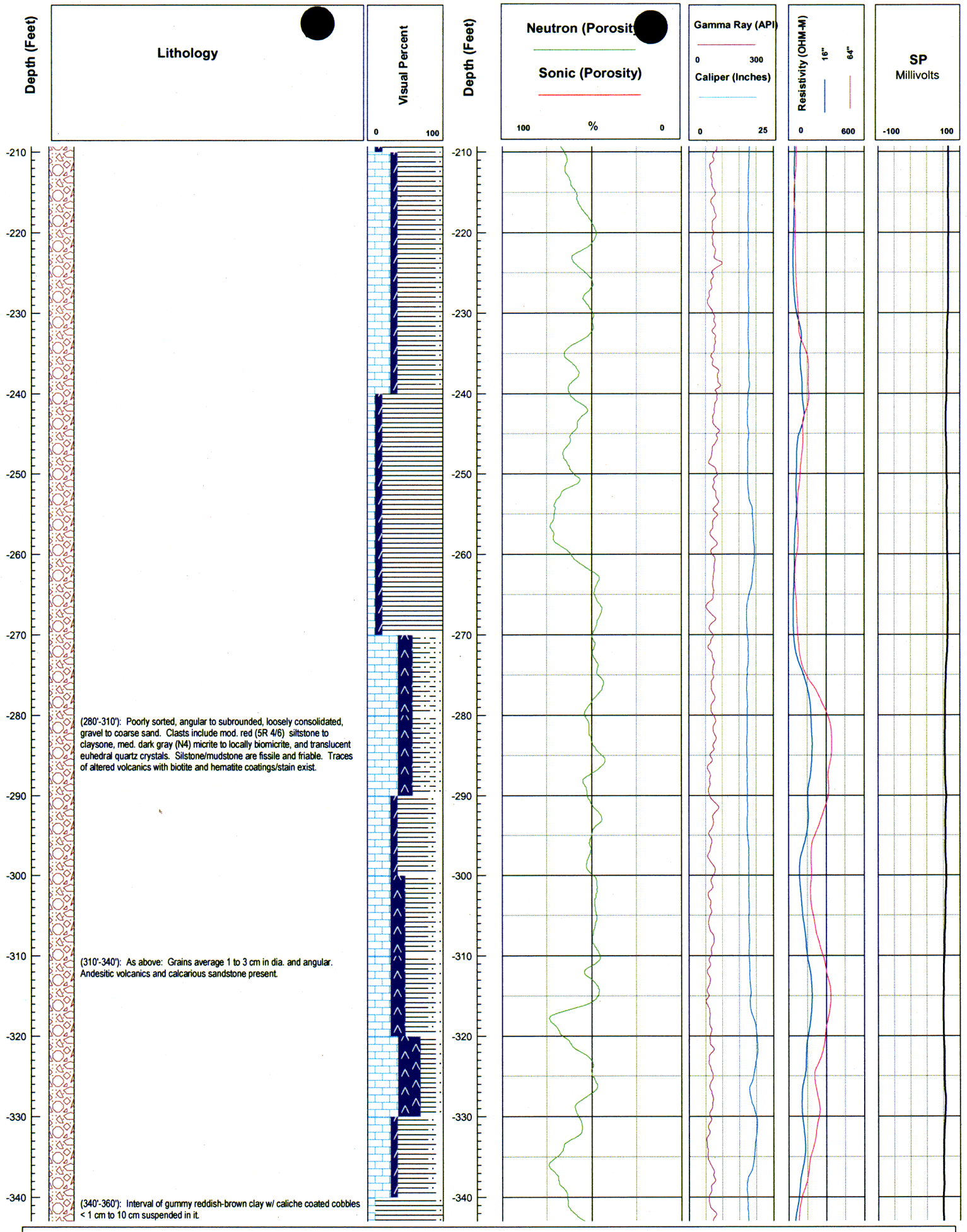
Depth to Groundwater (bgs): **422.63'**
Surface Casing Depth and Diameter: **20" OD Steel set to 96'**
Borehole Diameter: **17.5"**
Geologist Field Rep: **M.C., G.G., L.H.M., J.P., M.R., J.K**
Dates Drilling Started and Completed: **1/10/00 to 1/24/00**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Plume-Front Extraction Well**

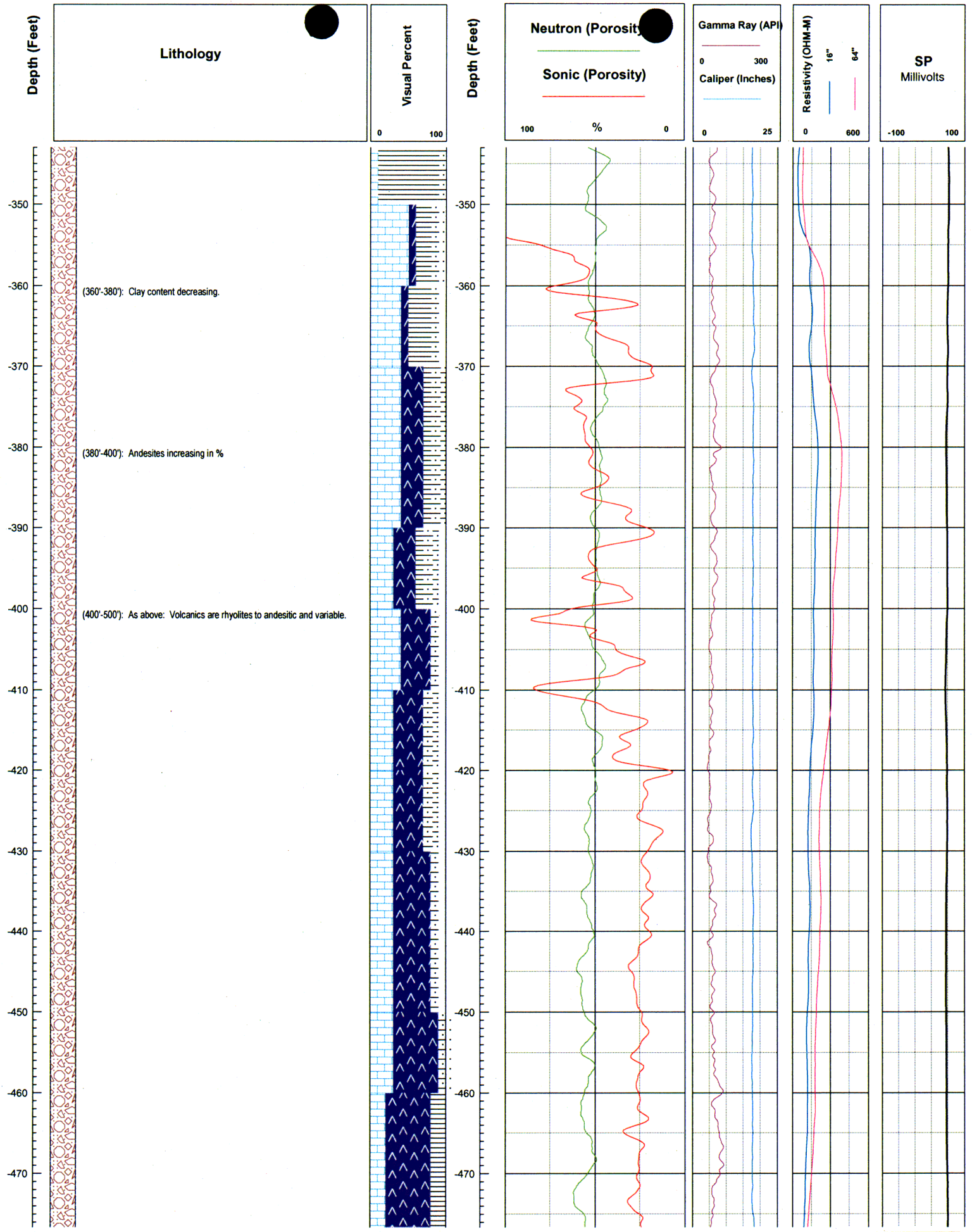
Explanation:

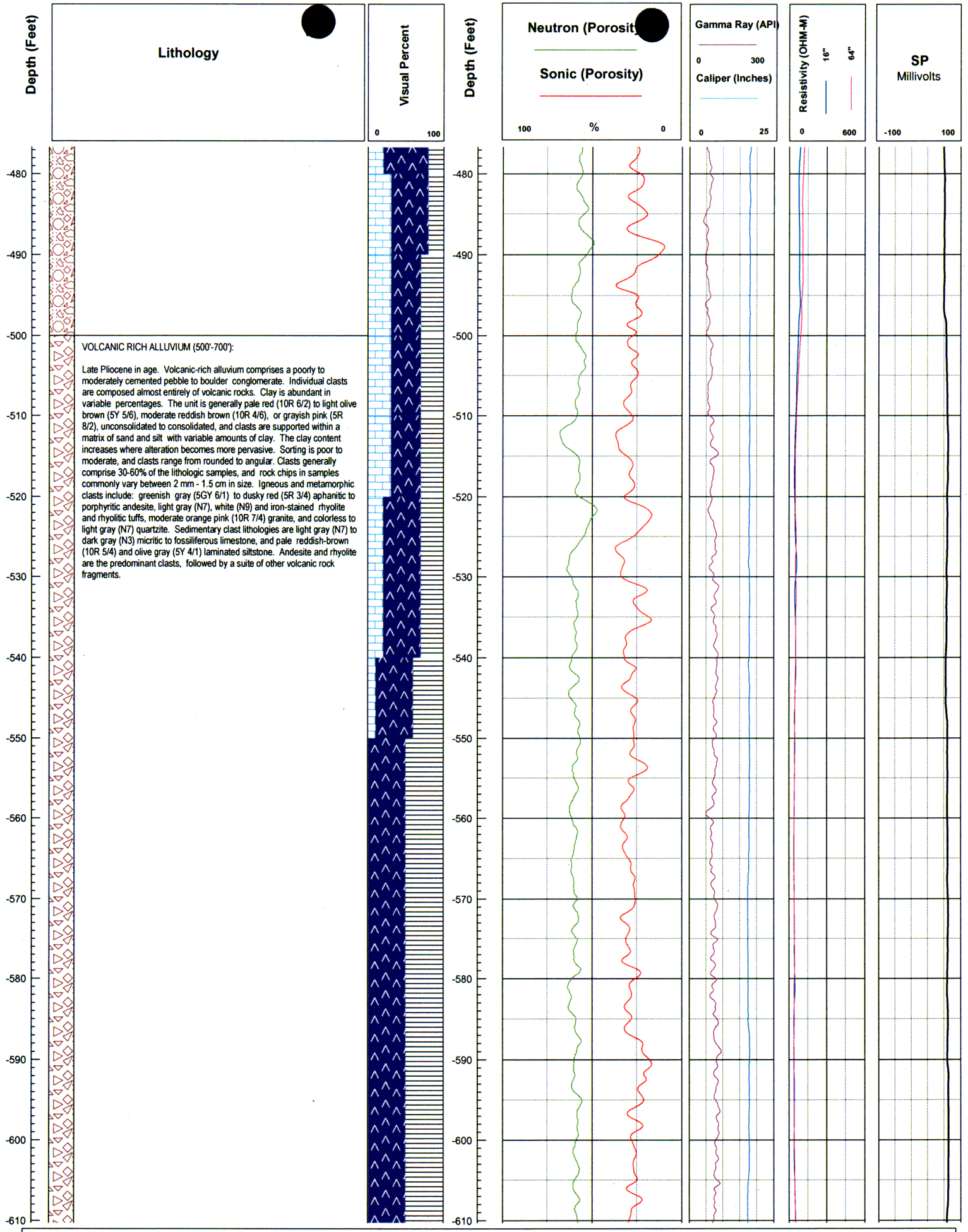
Alluvium | Volcanic Alluvium | Clay | Silt | Sand | Sandstone | Siltstone | Shale | Limestone | Rhyolite | Andesite | Undiffer. Volcanics

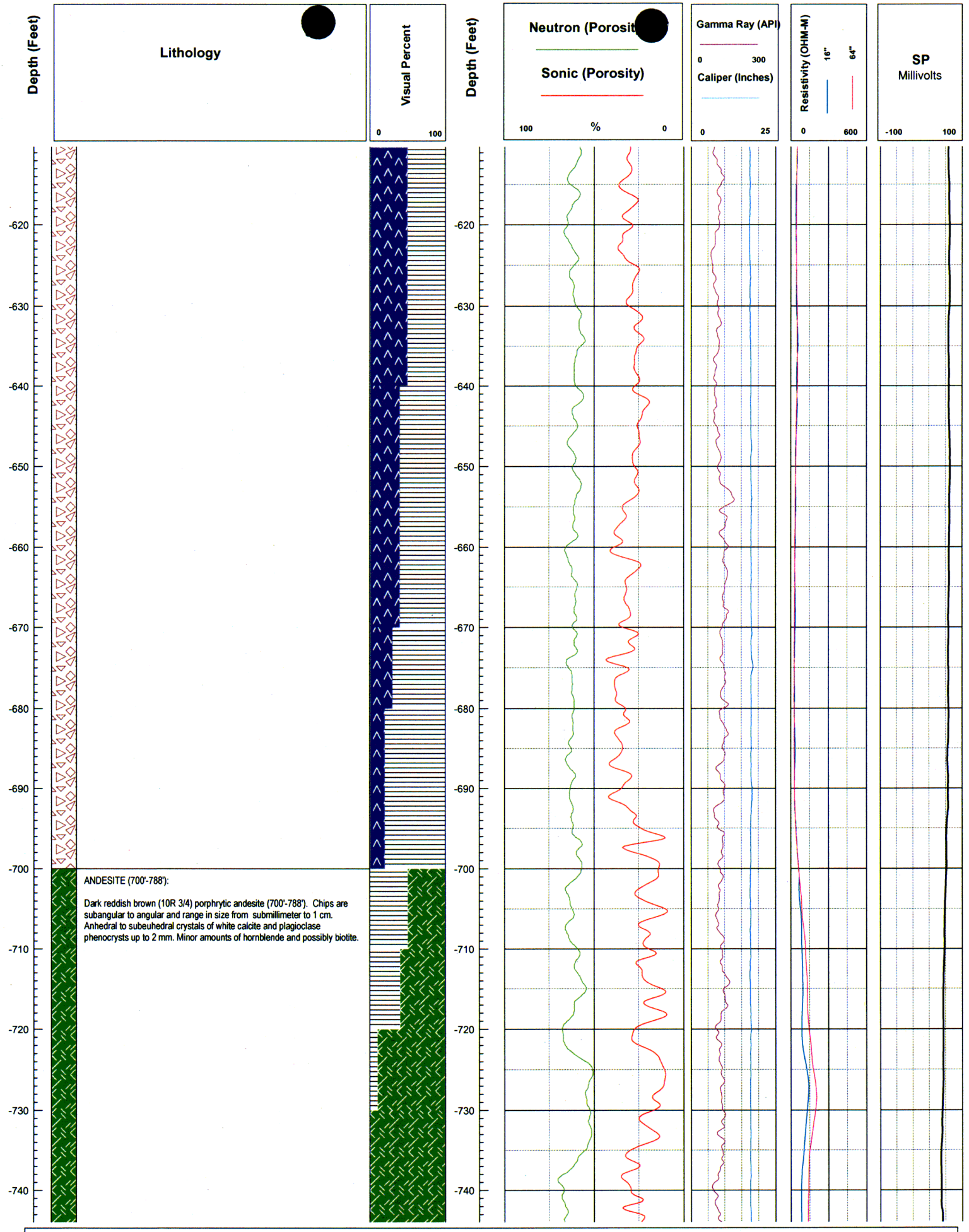


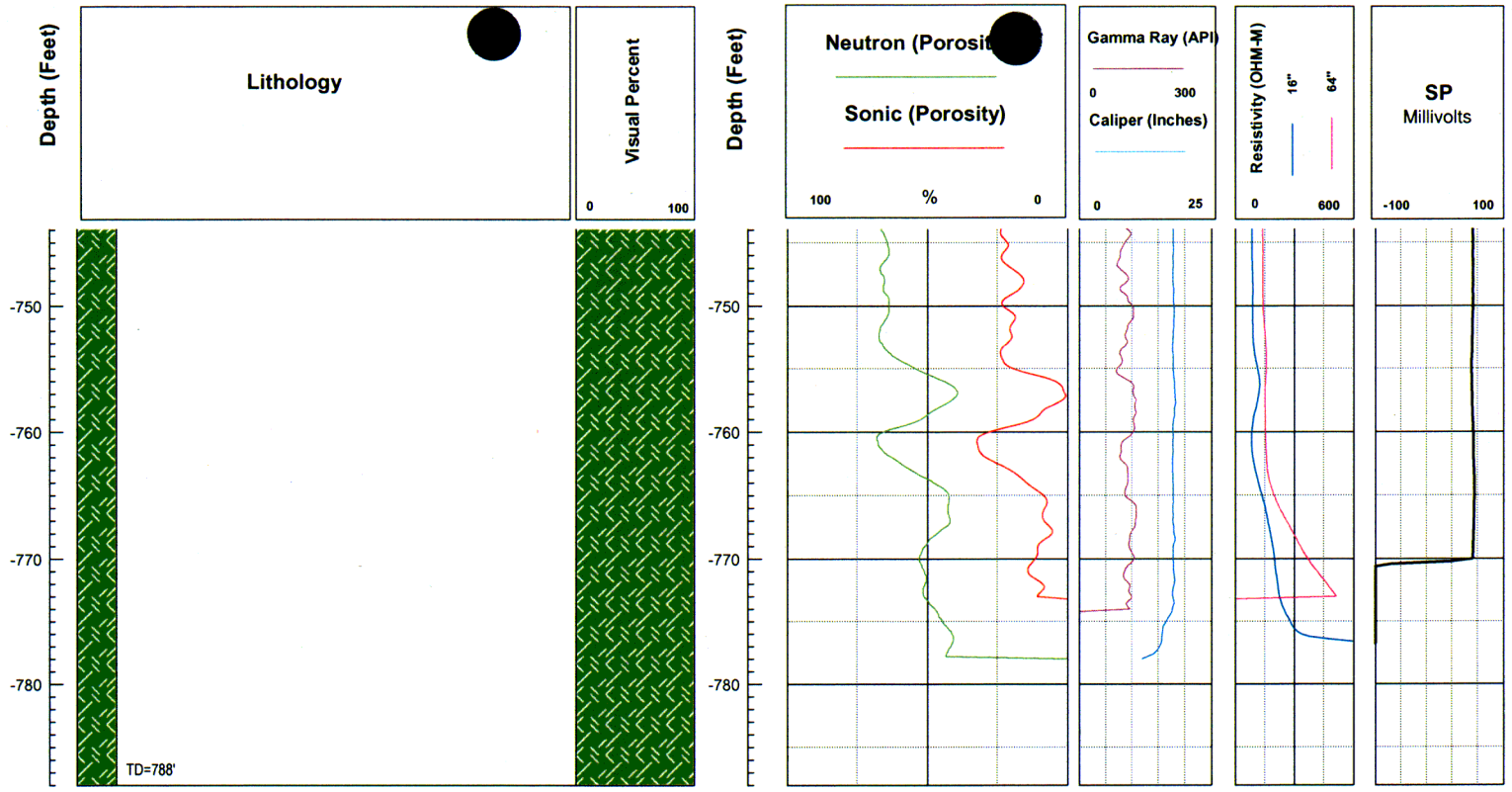

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
(140'-280'): Silty clay comprises majority of sample. Variable size and composition cuttings suspended in gummy reddish-brown clay. Clasts up to 8 cm in dia., sub-angular to sub-rounded. Majority of clasts are .5 to 1 cm in dia. Some (<1 %) caliche coatings.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340
(280'-310'): Poorly sorted, angular to subrounded, loosely consolidated, gravel to coarse sand. Clasts include mod. red (5R 4/6) siltstone to claysone, med. dark gray (N4) micrite to locally biomicrite, and translucent euhedral quartz crystals. Silstone/mudstone are fissile and friable. Traces of altered volcanics with biotite and hematite coatings/stain exist.
(310'-340'): As above: Grains average 1 to 3 cm in dia. and angular. Andesitic volcanics and calcarious sandstone present.
(340'-360'): Interval of gummy reddish-brown clay w/ caliche coated cobbles < 1 cm to 10 cm suspended in it.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470
(360'-380'): Clay content decreasing.
(380'-400'): Andesites increasing in %
(400'-500'): As above: Volcanics are rhyolites to andesitic and variable.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-480
-490
-500
-510
-520
-530
-540
-550
-560
-570
-580
-590
-600
-610
VOLCANIC RICH ALLUVIUM (500'-700'):
Late Pliocene in age. Volcanic-rich alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Individual clasts are composed almost entirely of volcanic rocks. Clay is abundant in variable percentages. The unit is generally pale red (10R 6/2) to light olive brown (5Y 5/6), moderate reddish brown (10R 4/6), or grayish pink (5R 8/2), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay content increases where alteration becomes more pervasive. Sorting is poor to moderate, and clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Sedimentary clast lithologies are light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, and pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated siltstone. Andesite and rhyolite are the predominant clasts, followed by a suite of other volcanic rock fragments.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-620
-630
-640
-650
-660
-670
-680
-690
-700
-710
-720
-730
-740
ANDESITE (700'-788'):
Dark reddish brown (10R 3/4) porphrytic andesite (700'-788'). Chips are subangular to angular and range in size from submillimeter to 1 cm. Anhedral to subeuhedral crystals of white calcite and plagioclase phenocrysts up to 2 mm. Minor amounts of hornblende and possibly biotite.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-750
-760
-770
-780
TD=788'

NASA JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

BOREHOLE LITHOLOGIC LOG

Location ID: **PFE-2**

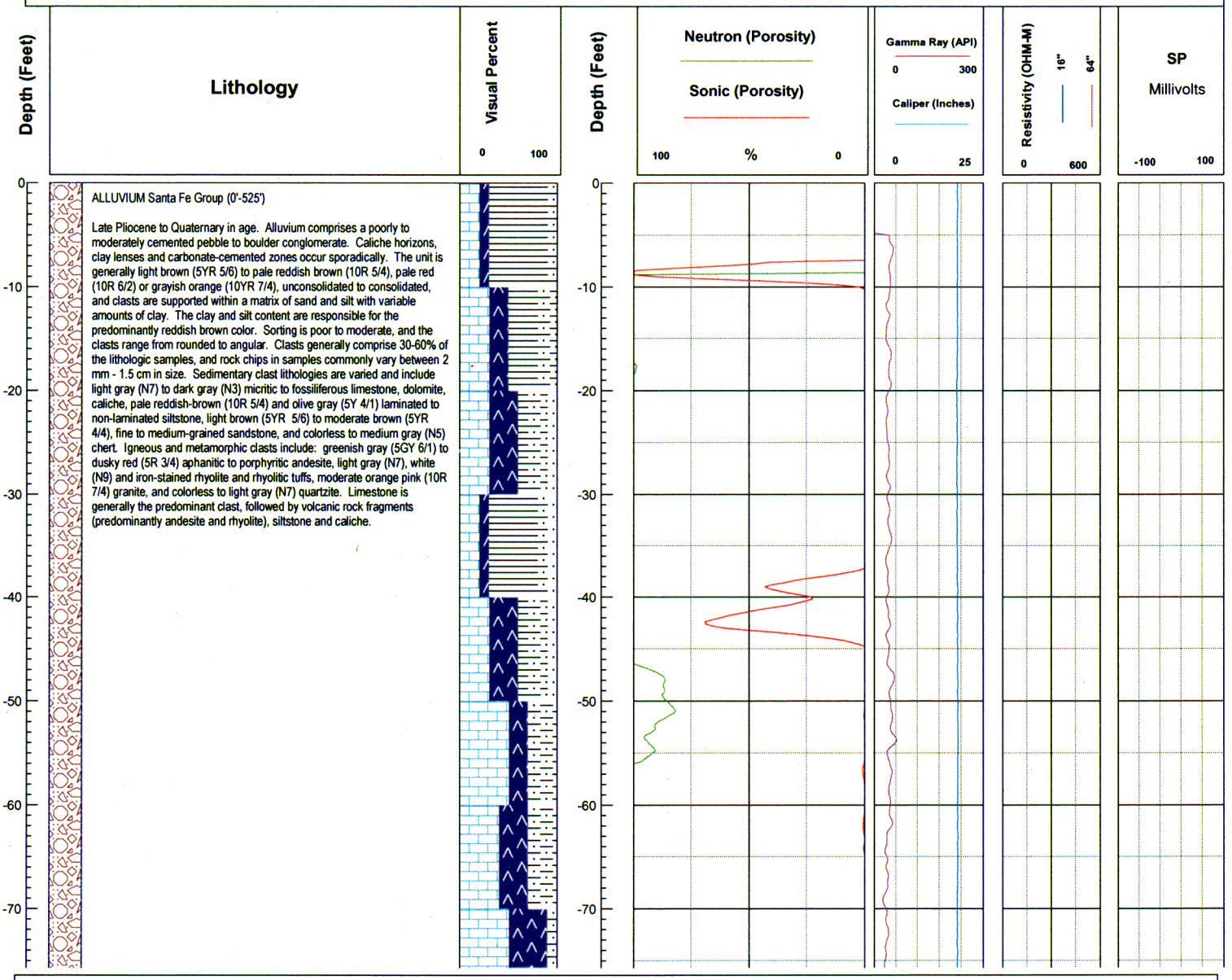
Site ID: **NASA-WSTF, Doña Ana County, NM**

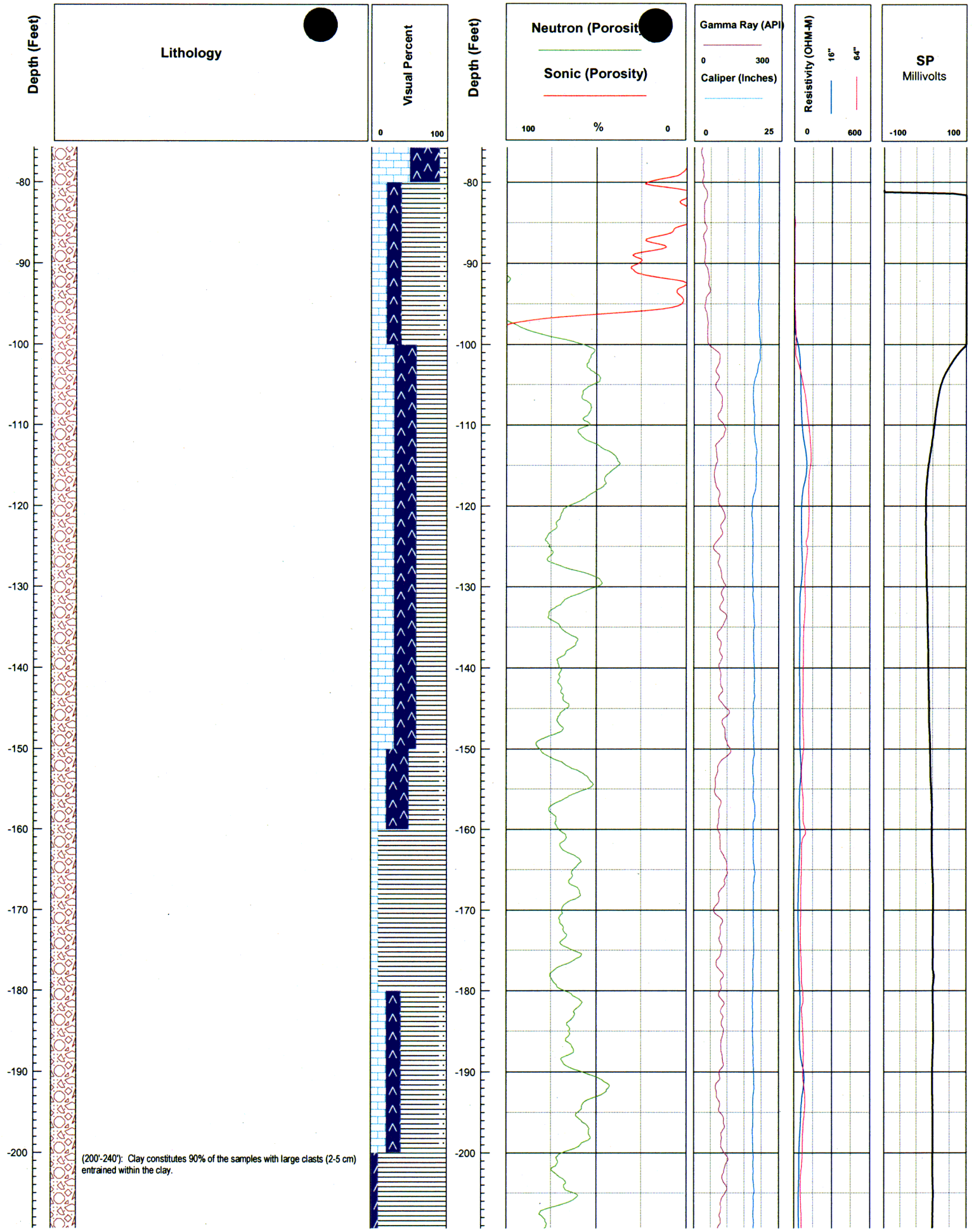
Township and Range: **SW 1/4, SW 1/4, SE 1/4, Sec 32, T20S, R3E**
NM State Plane Coordinates (NAD 83): **228515.50N 400870.10E (Preliminary)**
Elevation (Brass Cap): **4499.31' (Preliminary)**
Total Depth of Borehole (bgs): **912'**
Depth to Bedrock (bgs): **700'**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Juan Aguilar**

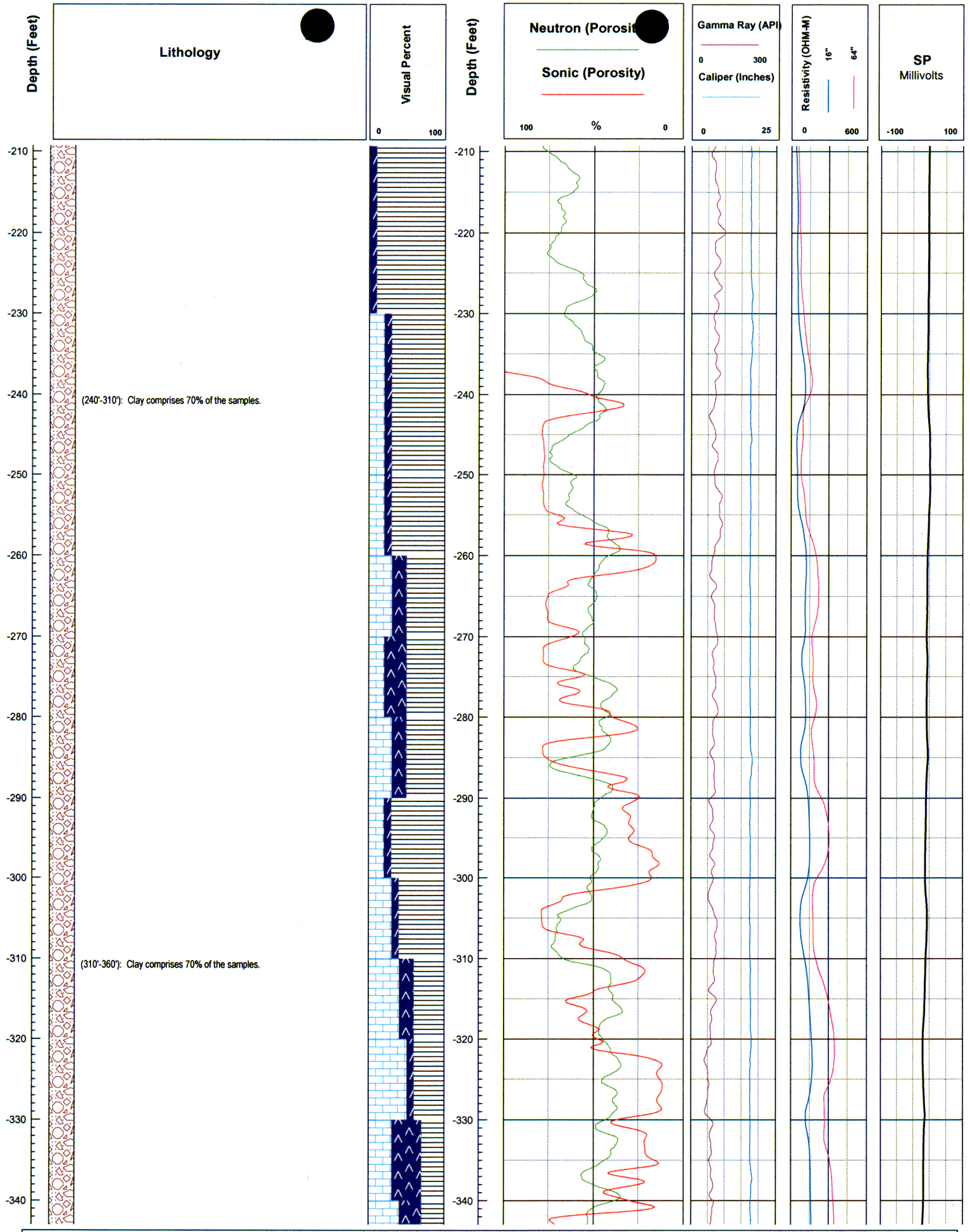
Depth to Groundwater (bgs): **434.24'**
Surface Casing Depth and Diameter: **20" OD Steel set to 100'**
Borehole Diameter: **17.5"**
Geologist Field Rep: **M.C., G.G., L.H.M., J.P., J.K.**
Dates Drilling Started and Completed: **2/6/00 to 2/22/00**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Plume-Front Extraction Well**

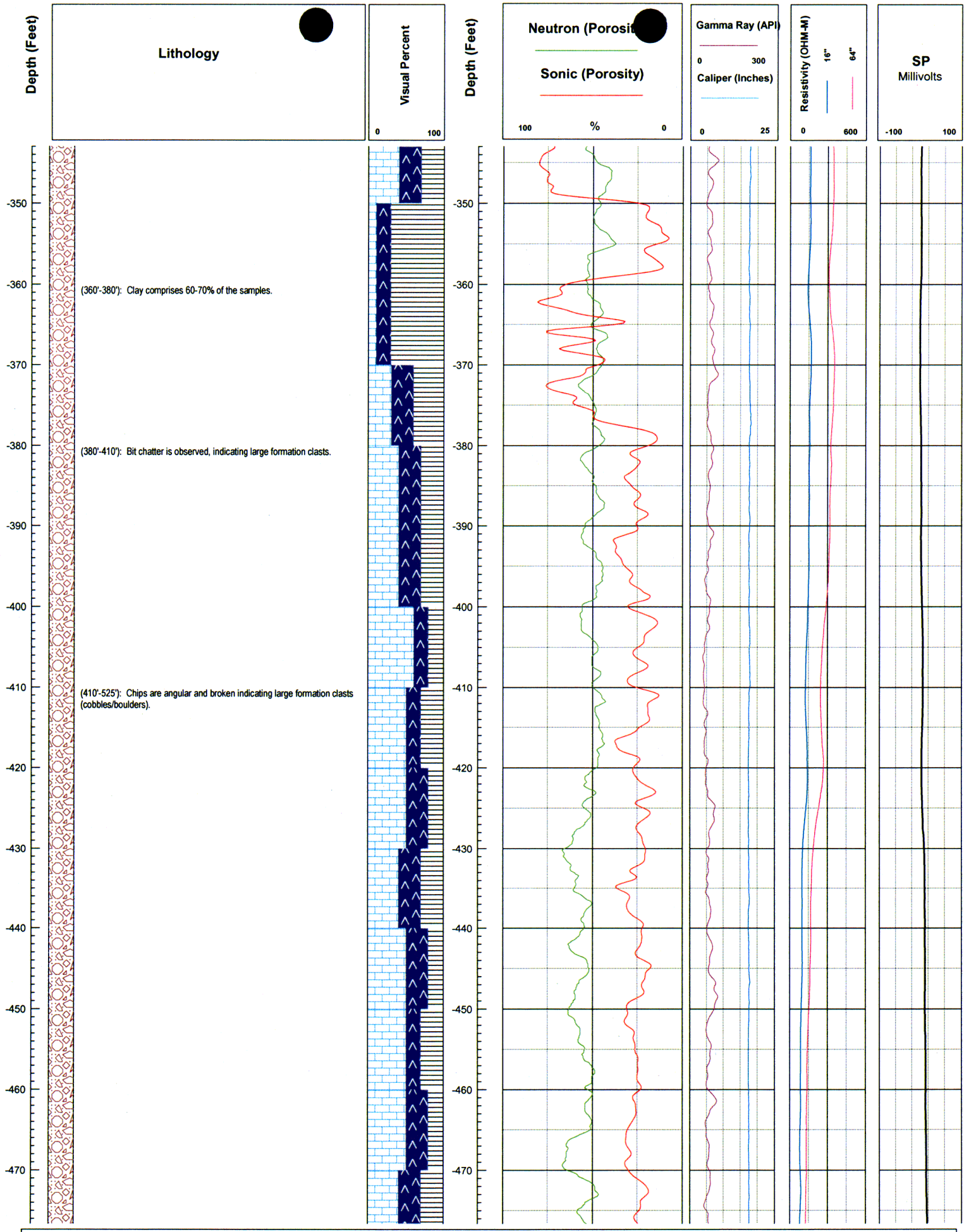
Explanation:

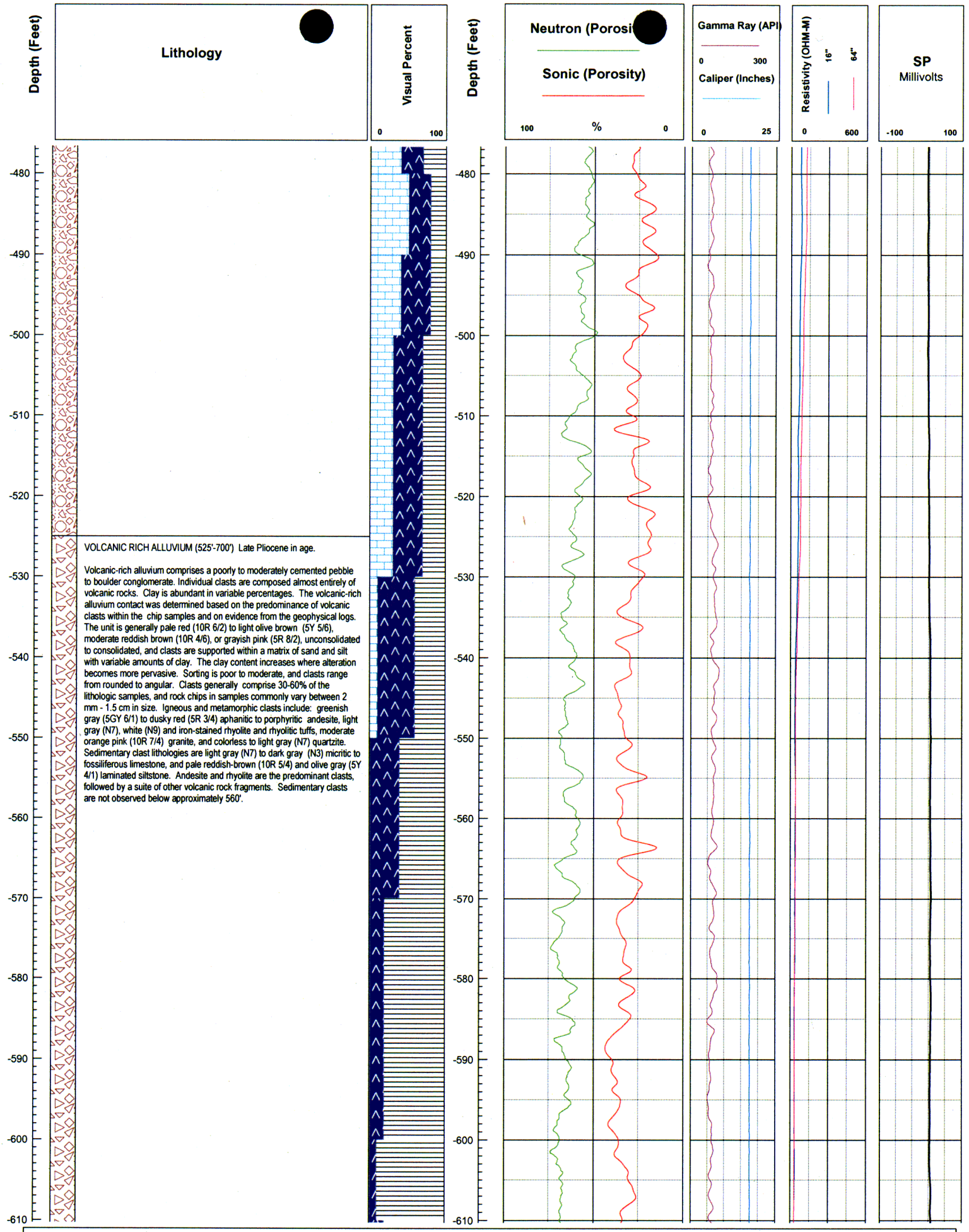
Alluvium | Volcanic Alluvium | Clay | Silt | Sand | Sandstone | Siltstone | Shale | Limestone | Rhyolite | Andesite | Undiffer. Volcanics

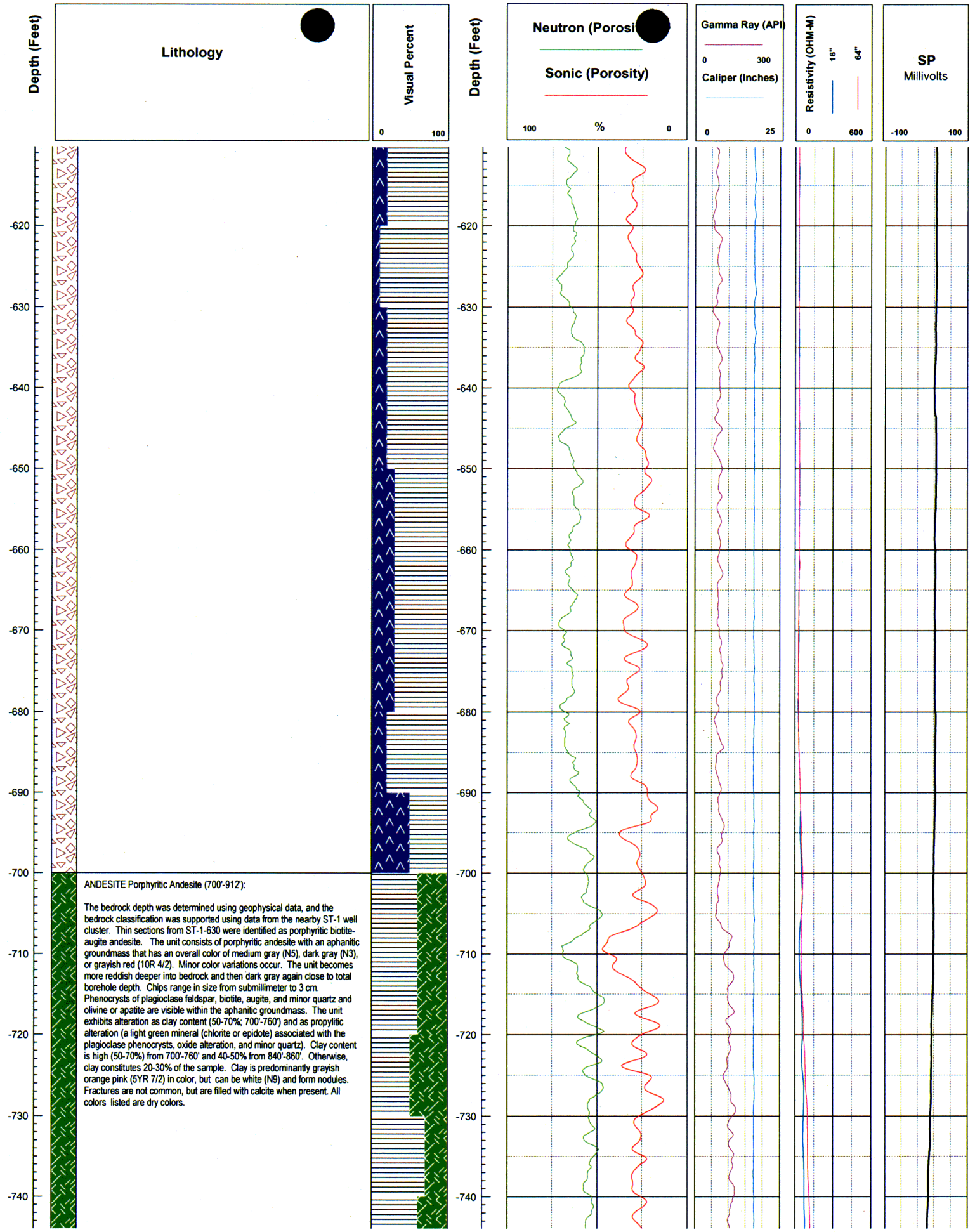


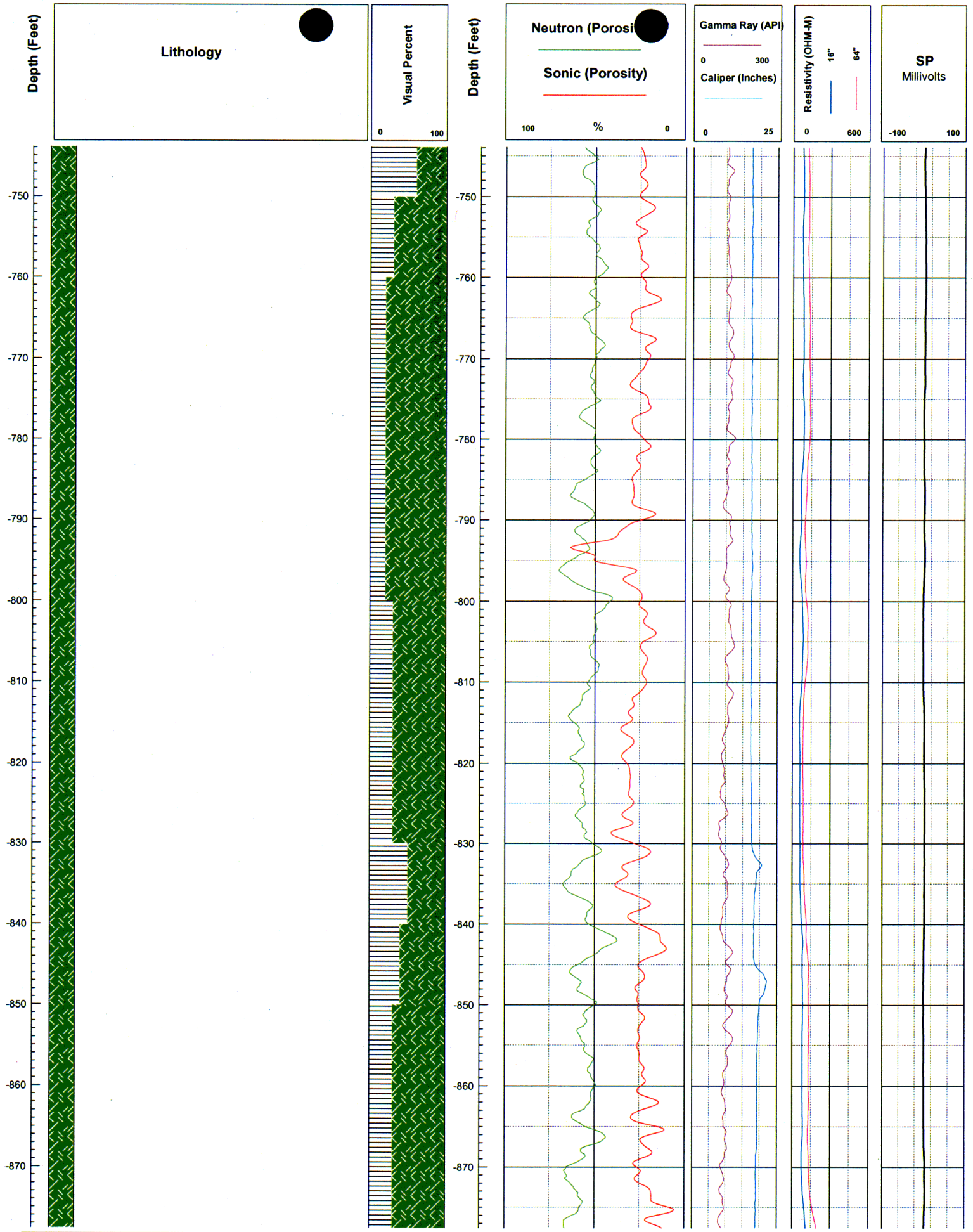

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
(200'-240'): Clay constitutes 90% of the samples with large clasts (2-5 cm) entrained within the clay.

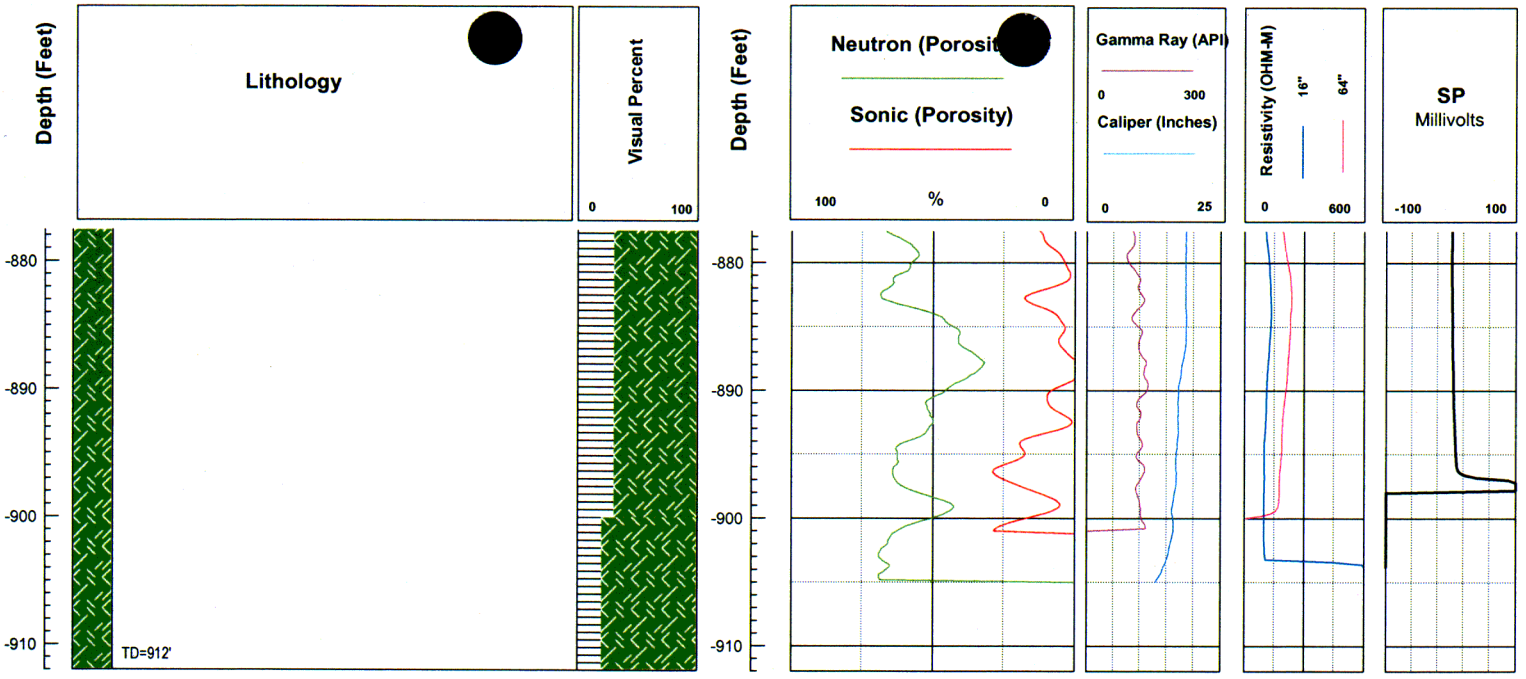

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340
(240'-310'): Clay comprises 70% of the samples.
(310'-360'): Clay comprises 70% of the samples.


Depth (Feet)
Lithology
Visual Percent
0
100
(360'-380'): Clay comprises 60-70% of the samples.
(380'-410'): Bit chatter is observed, indicating large formation clasts.
(410'-525'): Chips are angular and broken indicating large formation clasts (cobbles/boulders).
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-480
-490
-500
-510
-520
-530
-540
-550
-560
-570
-580
-590
-600
-610
VOLCANIC RICH ALLUVIUM (525'-700') Late Pliocene in age.
Volcanic-rich alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Individual clasts are composed almost entirely of volcanic rocks. Clay is abundant in variable percentages. The volcanic-rich alluvium contact was determined based on the predominance of volcanic clasts within the chip samples and on evidence from the geophysical logs. The unit is generally pale red (10R 6/2) to light olive brown (5Y 5/6), moderate reddish brown (10R 4/6), or grayish pink (5R 8/2), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay content increases where alteration becomes more pervasive. Sorting is poor to moderate, and clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Sedimentary clast lithologies are light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, and pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated siltstone. Andesite and rhyolite are the predominant clasts, followed by a suite of other volcanic rock fragments. Sedimentary clasts are not observed below approximately 560'.

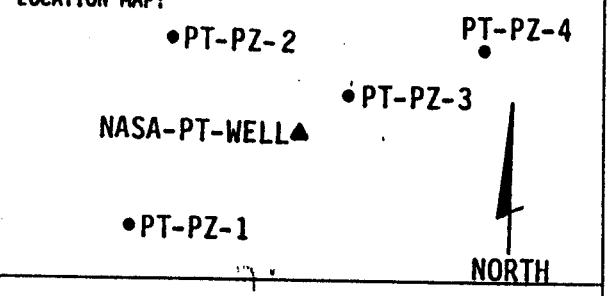

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-620
-630
-640
-650
-660
-670
-680
-690
-700
-710
-720
-730
-740
ANDESITE Porphyritic Andesite (700'-912'):
The bedrock depth was determined using geophysical data, and the bedrock classification was supported using data from the nearby ST-1 well cluster. Thin sections from ST-1-630 were identified as porphyritic biotite-augite andesite. The unit consists of porphyritic andesite with an aphanitic groundmass that has an overall color of medium gray (N5), dark gray (N3), or grayish red (10R 4/2). Minor color variations occur. The unit becomes more reddish deeper into bedrock and then dark gray again close to total borehole depth. Chips range in size from submillimeter to 3 cm. Phenocrysts of plagioclase feldspar, biotite, augite, and minor quartz and olivine or apatite are visible within the aphanitic groundmass. The unit exhibits alteration as clay content (50-70%; 700'-760') and as propylitic alteration (a light green mineral (chlorite or epidote) associated with the plagioclase phenocrysts, oxide alteration, and minor quartz). Clay content is high (50-70%) from 700'-760' and 40-50% from 840'-860'. Otherwise, clay constitutes 20-30% of the sample. Clay is predominantly grayish orange pink (5YR 7/2) in color, but can be white (N9) and form nodules. Fractures are not common, but are filled with calcite when present. All colors listed are dry colors.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-750
-760
-770
-780
-790
-800
-810
-820
-830
-840
-850
-860
-870


Depth (Feet)
Lithology
Visual Percent
0
100
-880
-890
-900
-910
TD=912'
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100

LITHOLOGIC LOG

LOCATION MAP:



SE 1/4 SW 1/4 NE 1/4 NE 1/4 S 5 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: NASA-PT-Well

SITE COORDINATES (ft.):

N 226752.14 E 402084.23

GROUND ELEVATION (ft. MSL): 4524.19(IC)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud and Air-Foam Rotary

DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 21 September 1989 DATE COMPLETED: 03/29/90

FIELD REP.: Cooper/Egan

COMMENTS: 7 7/8" pilot drilled from 0'-855' using air foam rotary. Pilot hole reamed in two passes to 18" using mud rotary. Top of bedrock (Andesite) at 845'.

LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			7	Cuttings 0'-50'	0'-80' Clay-Rich Alluvium (Santa Fe Group): Moderate yellowish brown (10 Y/R 5/4); cuttings range in size from less than 0.1 inch to 0.8 inches; are angular blocks or flakes, and are poorly sorted. Formation is an unconsolidated to poorly-consolidated polygenetic conglomerate. Lithologic constituents include limestone, caliche, rhyolite, andesite and quartz. Comments: Alluvium in this interval is clay rich.
10			13		0'-5' Silty sand and gravel with hard caliche horizon present.
15			10		5'-10' Same as above but with less caliche.
20			8		10'-20' Clay-rich sandy gravel.
25			10		20'-30' Sandy to gravelly clay.
30			9		30'-40' Clay-rich sandy gravel.
35			10		
40			8		40'-55' Clay-rich gravelly sand.
45			13		
50			11		

LOCATION ID: NASA-PT-Well

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 50'-115'	
50			11		
55			7		55'-60' Sandy clay.
60			11		60'-65' Clay-rich gravelly sand.
65			9		65'-70' Sandy clay.
70			12		70'-75' Clay-rich sandy gravel.
75			17		75'-80' Sandy clay.
80			15		80'-550' Gravelly Alluvium (Santa Fe Group): Medium dark gray (N4) when wet; cuttings are less than 0.1 inch to 0.5 inches and average 0.3 inches; angular flakes and blocks. Natural grains are clay, silt and fine to coarse-grained sand that is subangular to well rounded. The alluvium is poorly sorted. The formation is an unconsolidated to consolidated polygenetic conglomerate. Lithology of cuttings include limestone, rhyolite, andesite, quartz, sandstone, siltstone and some caliche as cuttings/grains, coatings on grains, or as matrix material. Comments: Individual clay layers exist but decrease in frequency with depth.
85			4		80'-85' Sandy gravel.
90			4		85'-95' Clay-rich sandy gravel.
95			4		95'-110' Gravelly sand.
100			3		
105			4		
110			3		110'-140' Clay-rich sandy gravel.
115			6		

LOCATION ID: NASA-PT-Well

Depth	Visual %	Lith.	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 115'-180'	
115			6		
120			4		
125			5		
130			4		
135			3		
140			3		140'-145' Gravelly clay.
145			3		145'-175' Clay-rich sandy gravel.
150			4		
155			5		
160			6		
165			3		
170			4		
175			3		175'-185' Gravelly clay.
180			3		

LOCATION ID: NASA-PT-Well

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 180'-245'	
180			3		
185			3		185'-190' Clay-rich sandy gravel.
190			3		
195			3		
200			3		
205			3		
210			4		
215			4		
220			7		
225			7		
230			3		
235			4		
240			4		
245			10		

LOCATION ID: NASA-PT-Well

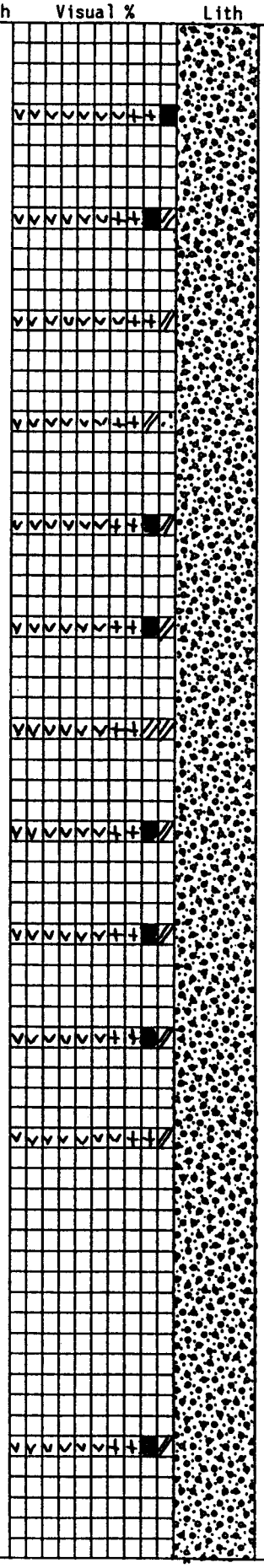
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245			10	Cuttings (cont'd) 245'-310'	
250			3		
255			10		
260			8		
265			4		
270			3		
275			5		
280			5		
285			5		
290			9		
295			6		
300			6		
305			6		
310			5		

LOCATION ID: NASA-PT-Well

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 310'-375'	
310			5		
315			7		
320			8		
325			4		
330			9		
335			5		335'-345' Caliche is probably from the conglomerate matrix (matrix supported).
340			4		
345			4		
350			15		
355			4		
360			7		
365			10		365'-370' High percentage of rhyolite in igneous fraction of cuttings.
370			4		
375			4		

LOCATION ID: NASA-PT-Well

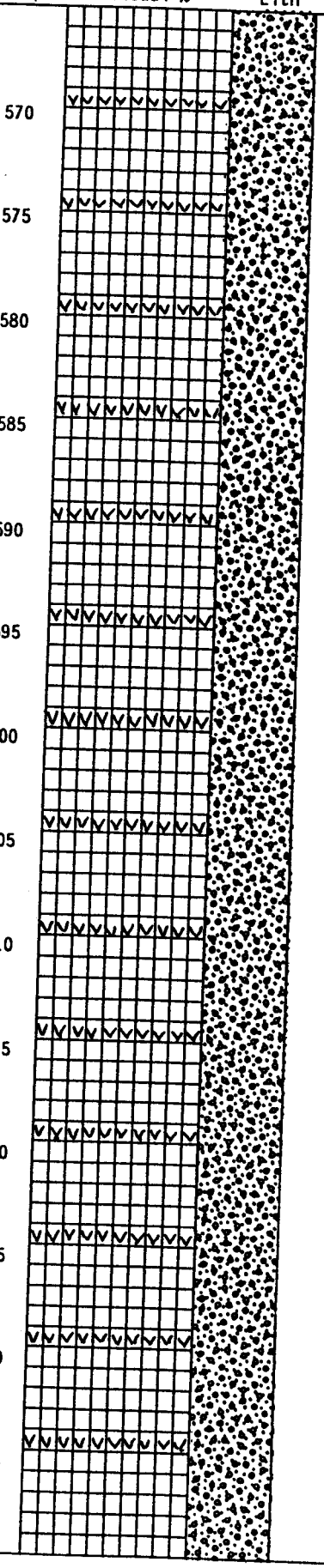
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
375			4	Cuttings (cont'd) 375'-440'	375'-455' Quartz is a constituent present in alluvial cuttings, but less than 10%.
380			4		
385			5		
390			6		
395			7		
400			4		400'-430' Slight decrease in cutting size to 0.25-0.3 inches. Increase in the amount of fines (not clay).
405			4		405'-410' Signs of consolidation in cuttings. Well-cemented alluvium fragments present.
410			5		
415			4		
420			4		
425			3		
430			5		
435			4		
440			5		



Depth	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
		Cuttings (cont'd) 440'-489'	
440	5		
445	8		
450	4		
455	3		
460	7		460'-490' Decrease in average cutting size to 0.2 inches.
465	4		
470	4		
475	4		
480	4		
485	4		
		Core Interval 489'-499'	
490	4		489'-499' **CORE INTERVAL** (See Attached Description)
495	52		
500	31	Cuttings 499'-505'	
505	4		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 505'-560'	
505			4		
510			4		
515			3		
520			3		
525			3		
530			3		
535			3 1/2		
540			4		
545			3 1/2		
550			3		550'-844' Andesite-Rich Alluvium: Dusky Red (5 R 3/4); average cutting size 0.2 inches; very angular to subrounded; moderately sorted aphanitic, microporphyritic, to porphyritic andesite with some siltstone, rhyolite and limestone. Multiple colors of andesites present and grades into a predominantly medium gray (N5) colored andesite.
555			4		
560			3	Core Interval 560'-570'	560'-570' **CORE INTERVAL** (See Attached Description)
565			70		
570			80		

LOCATION ID: NASA-PT-Well



Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
80	Core Interval (cont'd) 560'-570'	
2	Cuttings 570'-635'	570'-575' First sign of tuff cuttings present in samples.
4		580'-650' Decrease in average cutting size to ≈ 0.15 inches.
4		
3		
4		
5		
3		
5		
5		
3		
3		
5		
3		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 635'-650'	
635			3		
640			3		
645			3		
650			4	Core 650'-660'	650'-660' **CORE INTERVAL** (See Attached Description)
655			47		
660			62	Cuttings (cont'd) 660'-700'	
665			3		
670			4		
675			17		
680			9		
685			7		
690			5		
695			6		
700			4		

LOCATION ID: NASA-PT-Well

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 700'-740'	
700					
705			3		
710			3		
715			2		
720			2		
725			3		
730			4		
735			3		
740			3	Core 740'-750'	740'-750' **CORE INTERVAL** (See Attached Description)
745			101		
750			82		
755			3.5		
760			4		
765			3.5		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
765			3.5		
770			2		
775			3		
780			3.5		
785			3.5		
790			3		
795			3		
800			3		
805			4		
810			4		
815			5		
820			3	Core 820'-828'	820'-828' **CORE INTERVAL** (See Attached Description)
825			50		
830			65	Cuttings (cont'd) (830'-855')	

LOCATION ID: NASA-PT-Well

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
835			Drillograph Off		
840			7		
845			6		844'-855' Oreion Andesite: Medium dark gray (N4) to grayish black (N2) porphyritic andesite. Small calcite veins seen in some cuttings, some calcite among cuttings. Cuttings angular (99%).
850			15		
855			17		855' Total depth of well.

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

BOREHOLE LITHOLOGIC LOG

Location ID: **PFE-4**

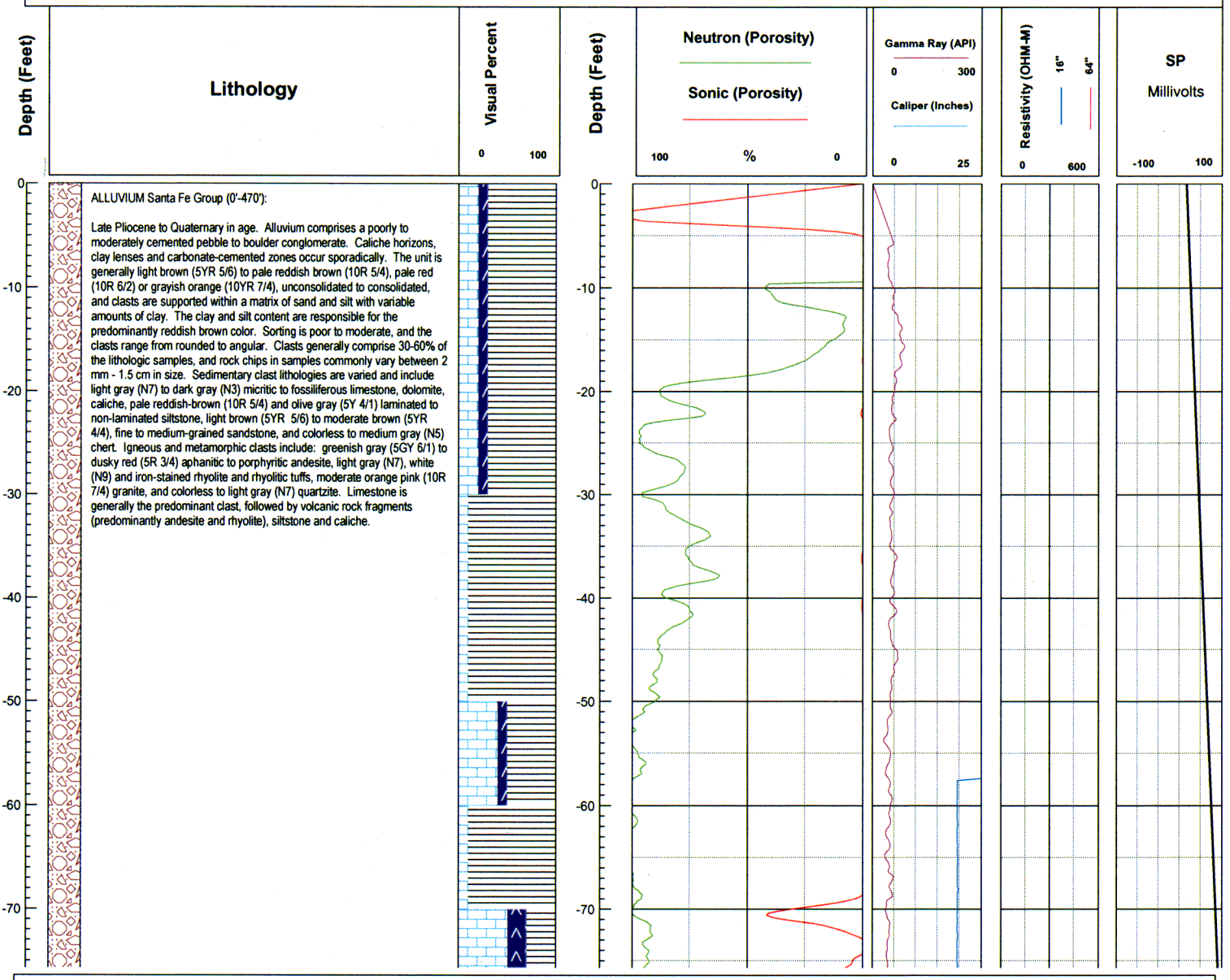
Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **NW 1/4, NW 1/4, SW 1/4, Sec 4, T21S R3E**
NM State Plane Coordinates (NAD 83): **224968.01N 403513.70E (Preliminary)**
Elevation (Brass Cap): **4520.52' (Preliminary)**
Total Depth of Borehole (bgs): **894'**
Depth to Bedrock (bgs): **850'**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Juan Aguilar**

Depth to Groundwater (bgs): **475.60'**
Surface Casing Depth and Diameter: **20" OD Steel set to 110'**
Borehole Diameter: **17.5"**
Geologist Field Rep: **M.C., G.G., L.H.M., J.P., M.S., R.W.**
Dates Drilling Started and Completed: **2/29/00 to 3/16/00**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Plume-Front Extraction Well**

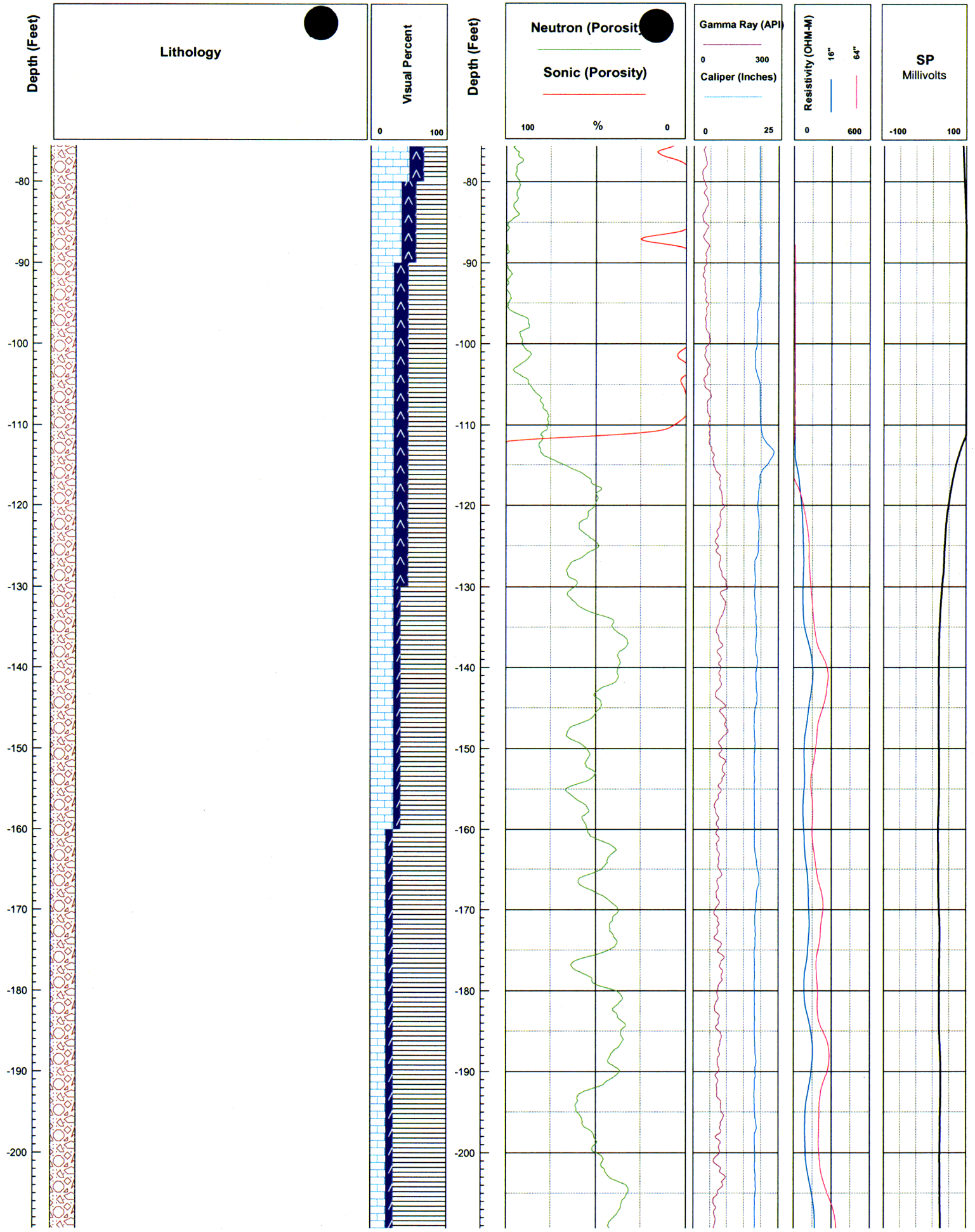
Explanation:

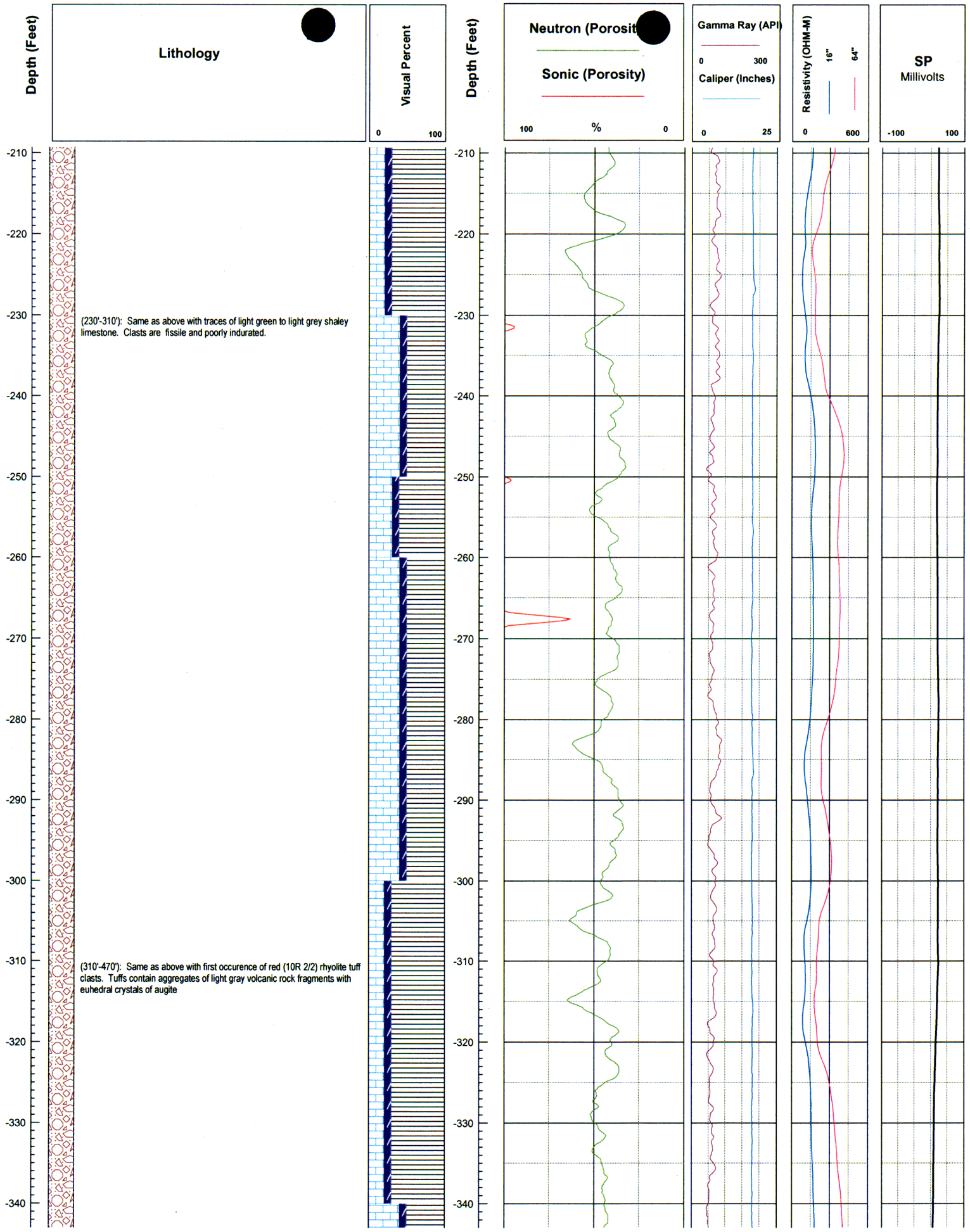
Alluvium | Volcanic Alluvium | Clay | Silt | Sand | Sandstone | Siltstone | Shale | Limestone | Rhyolite | Andesite | Undiffer. Volcanics

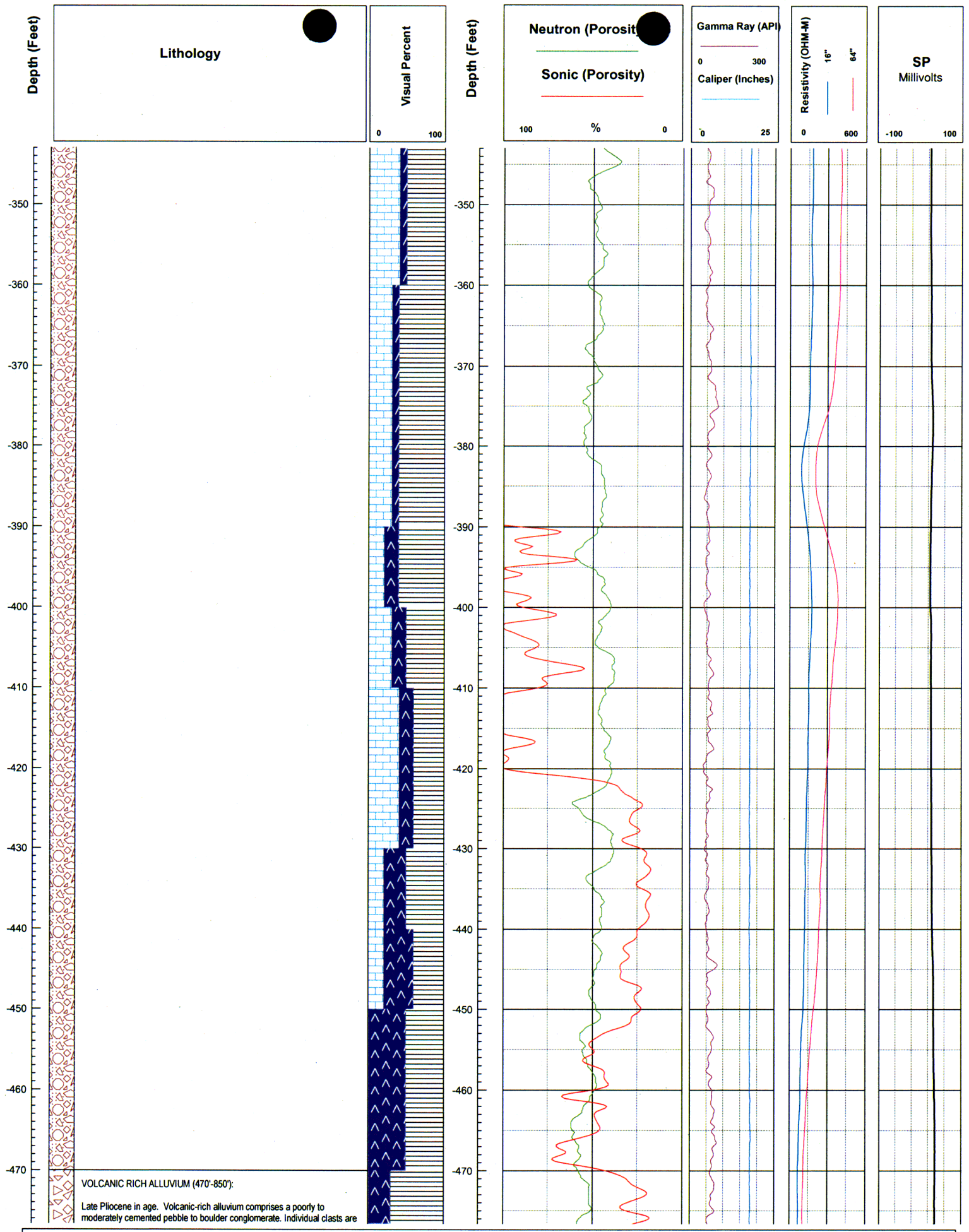


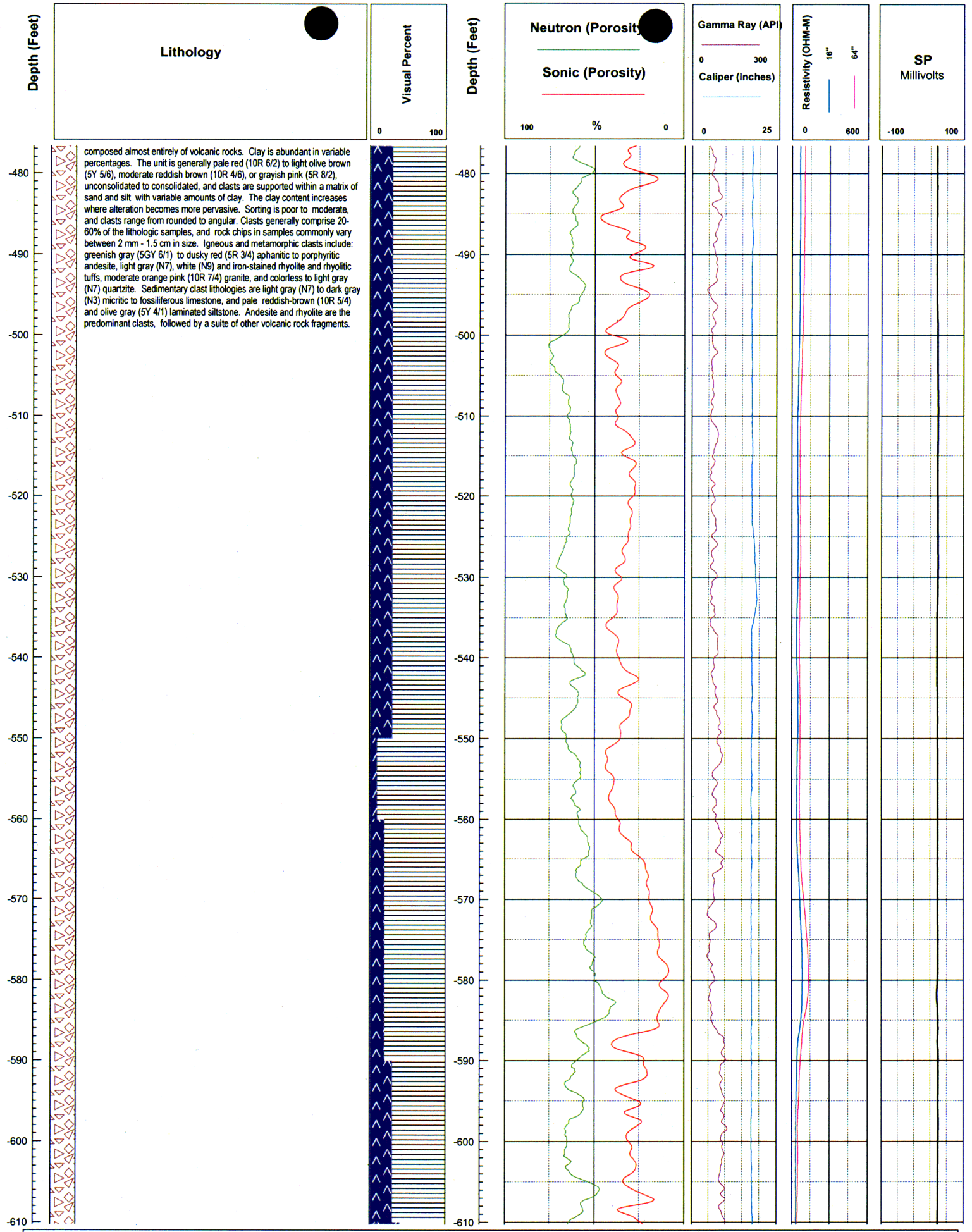
ALLUVIUM Santa Fe Group (0'-470'):

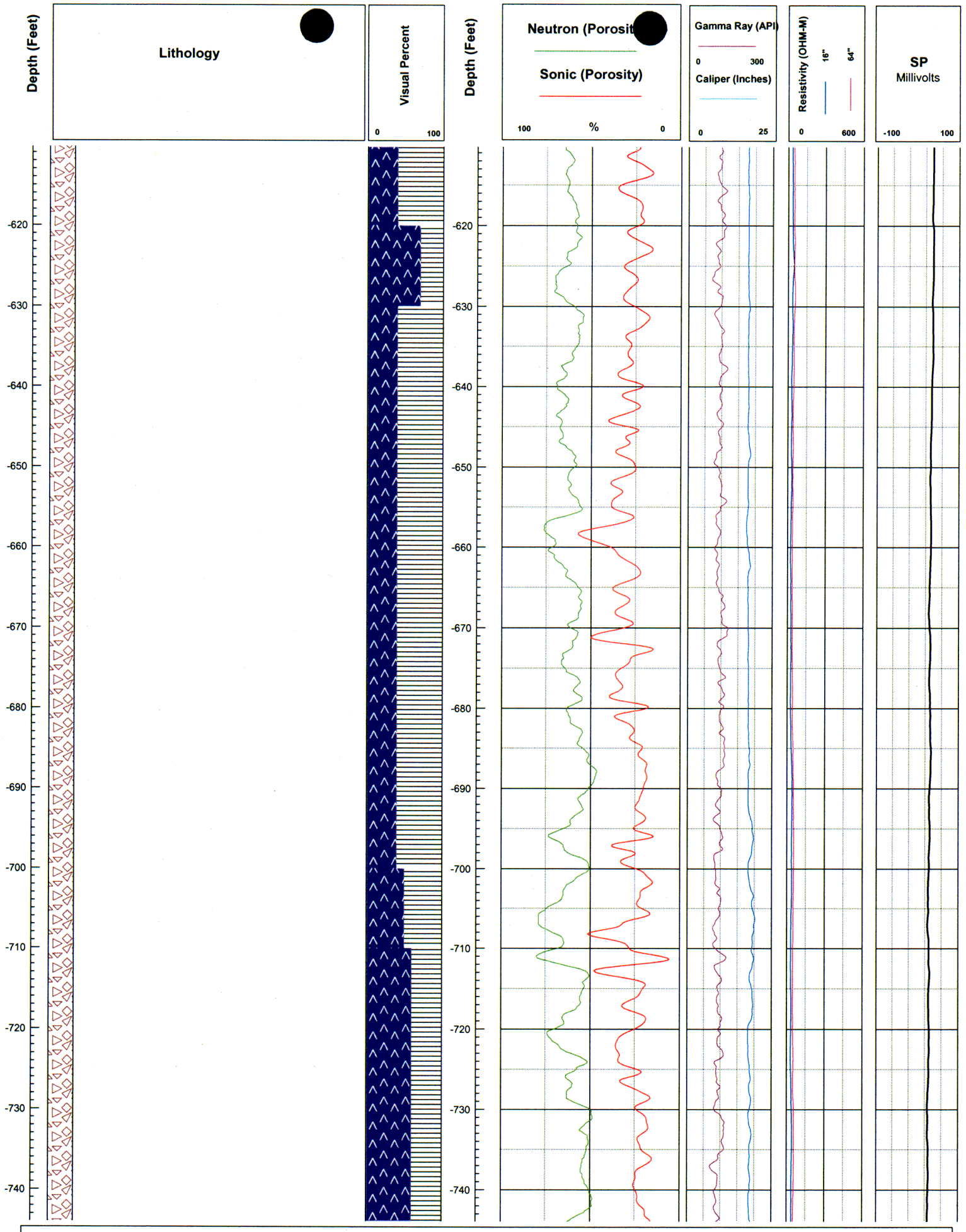
Late Pliocene to Quaternary in age. Alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Caliche horizons, clay lenses and carbonate-cemented zones occur sporadically. The unit is generally light brown (5YR 5/6) to pale reddish brown (10R 5/4), pale red (10R 6/2) or grayish orange (10YR 7/4), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay and silt content are responsible for the predominantly reddish brown color. Sorting is poor to moderate, and the clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Sedimentary clast lithologies are varied and include light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, dolomite, caliche, pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated to non-laminated siltstone, light brown (5YR 5/6) to moderate brown (5YR 4/4), fine to medium-grained sandstone, and colorless to medium gray (N5) chert. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Limestone is generally the predominant clast, followed by volcanic rock fragments (predominantly andesite and rhyolite), siltstone and caliche.

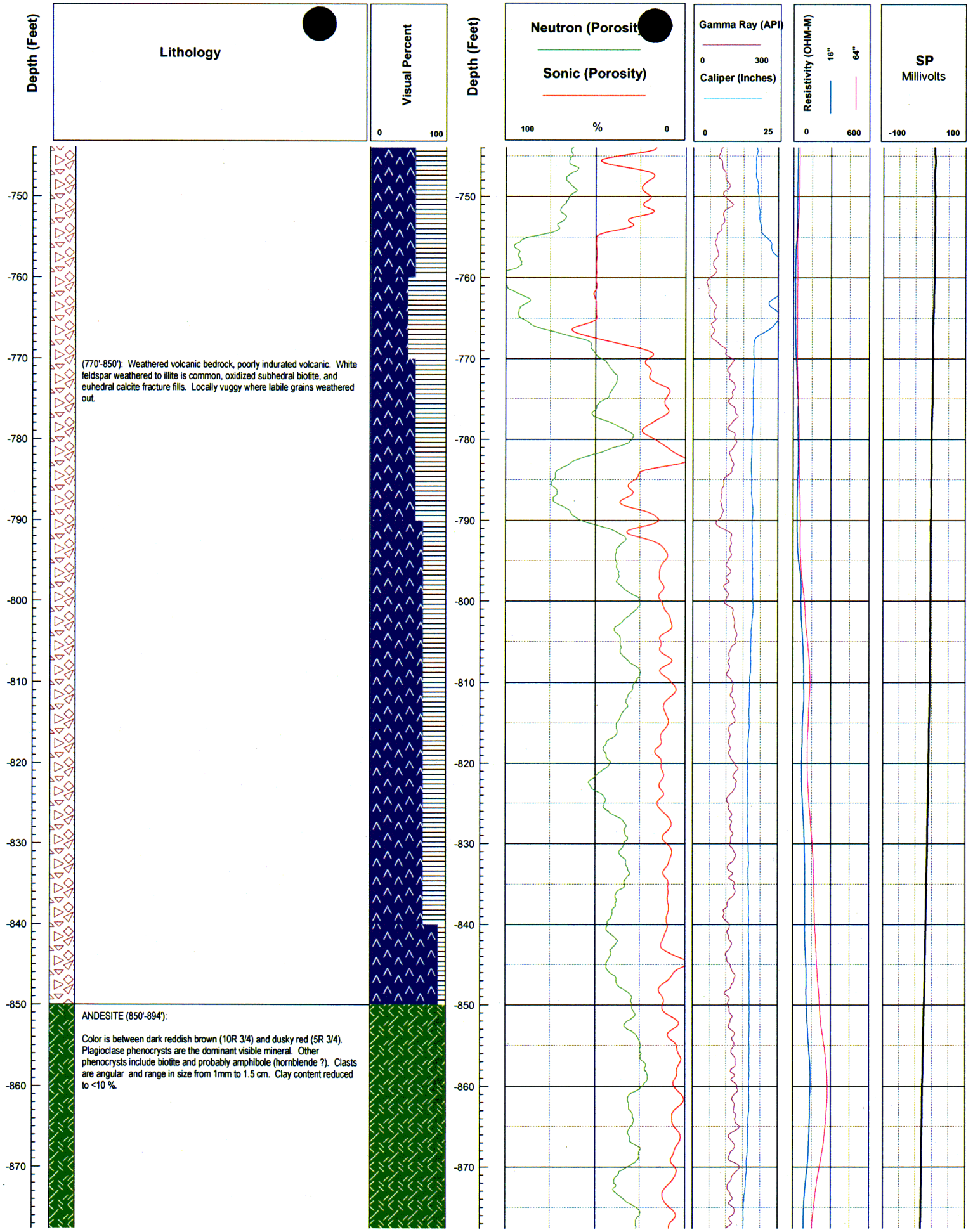

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200

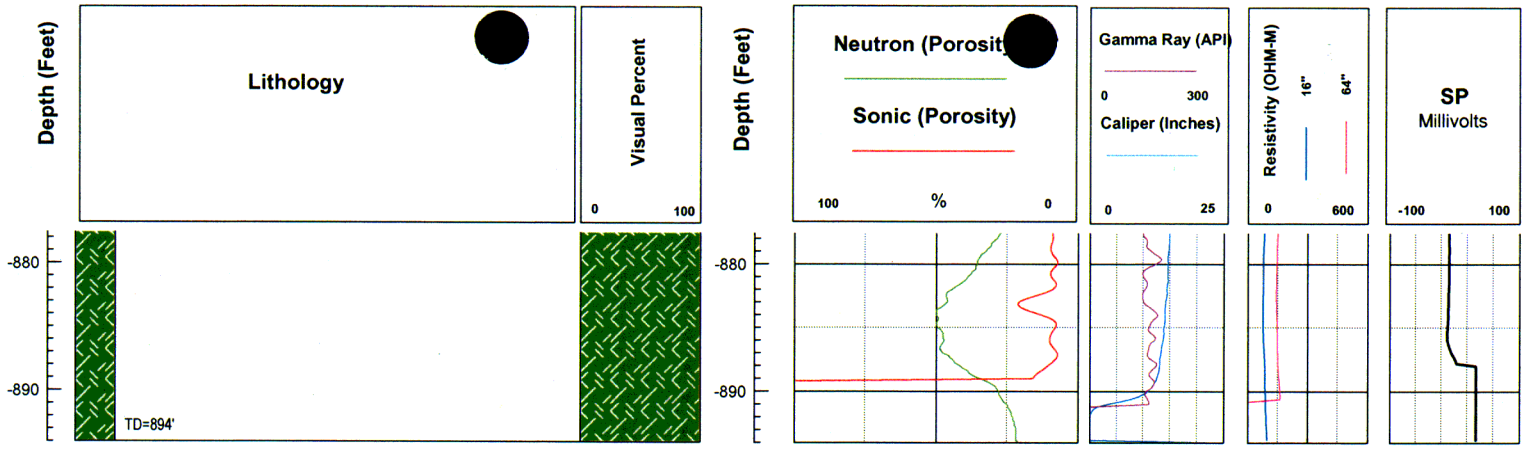

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340
(230'-310'): Same as above with traces of light green to light grey shaley limestone. Clasts are fissile and poorly indurated.
(310'-470'): Same as above with first occurence of red (10R 2/2) rhyolite tuff clasts. Tuffs contain aggregates of light gray volcanic rock fragments with euhedral crystals of augite


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470
VOLCANIC RICH ALLUVIUM (470'-850'):
Late Pliocene in age. Volcanic-rich alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Individual clasts are


Depth (Feet)
Lithology
Visual Percent
0
100
composed almost entirely of volcanic rocks. Clay is abundant in variable percentages. The unit is generally pale red (10R 6/2) to light olive brown (5Y 5/6), moderate reddish brown (10R 4/6), or grayish pink (5R 8/2), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay content increases where alteration becomes more pervasive. Sorting is poor to moderate, and clasts range from rounded to angular. Clasts generally comprise 20-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Sedimentary clast lithologies are light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, and pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated siltstone. Andesite and rhyolite are the predominant clasts, followed by a suite of other volcanic rock fragments.
-480
-490
-500
-510
-520
-530
-540
-550
-560
-570
-580
-590
-600
-610
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-620
-630
-640
-650
-660
-670
-680
-690
-700
-710
-720
-730
-740


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-750
-760
-770
-780
-790
-800
-810
-820
-830
-840
-850
-860
-870
(770'-850'): Weathered volcanic bedrock, poorly indurated volcanic. White feldspar weathered to illite is common, oxidized subhedral biotite, and euhedral calcite fracture fills. Locally vuggy where labile grains weathered out.
ANDESITE (850'-894'):
Color is between dark reddish brown (10R 3/4) and dusky red (5R 3/4). Plagioclase phenocrysts are the dominant visible mineral. Other phenocrysts include biotite and probably amphibole (hornblende ?). Clasts are angular and range in size from 1mm to 1.5 cm. Clay content reduced to <10 %.


Depth (Feet)
Lithology
Visual Percent
0
100
-880
-890
TD=894'
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-880
-890

NASA JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

BOREHOLE LITHOLOGIC LOG

Location ID: **PFE-5**

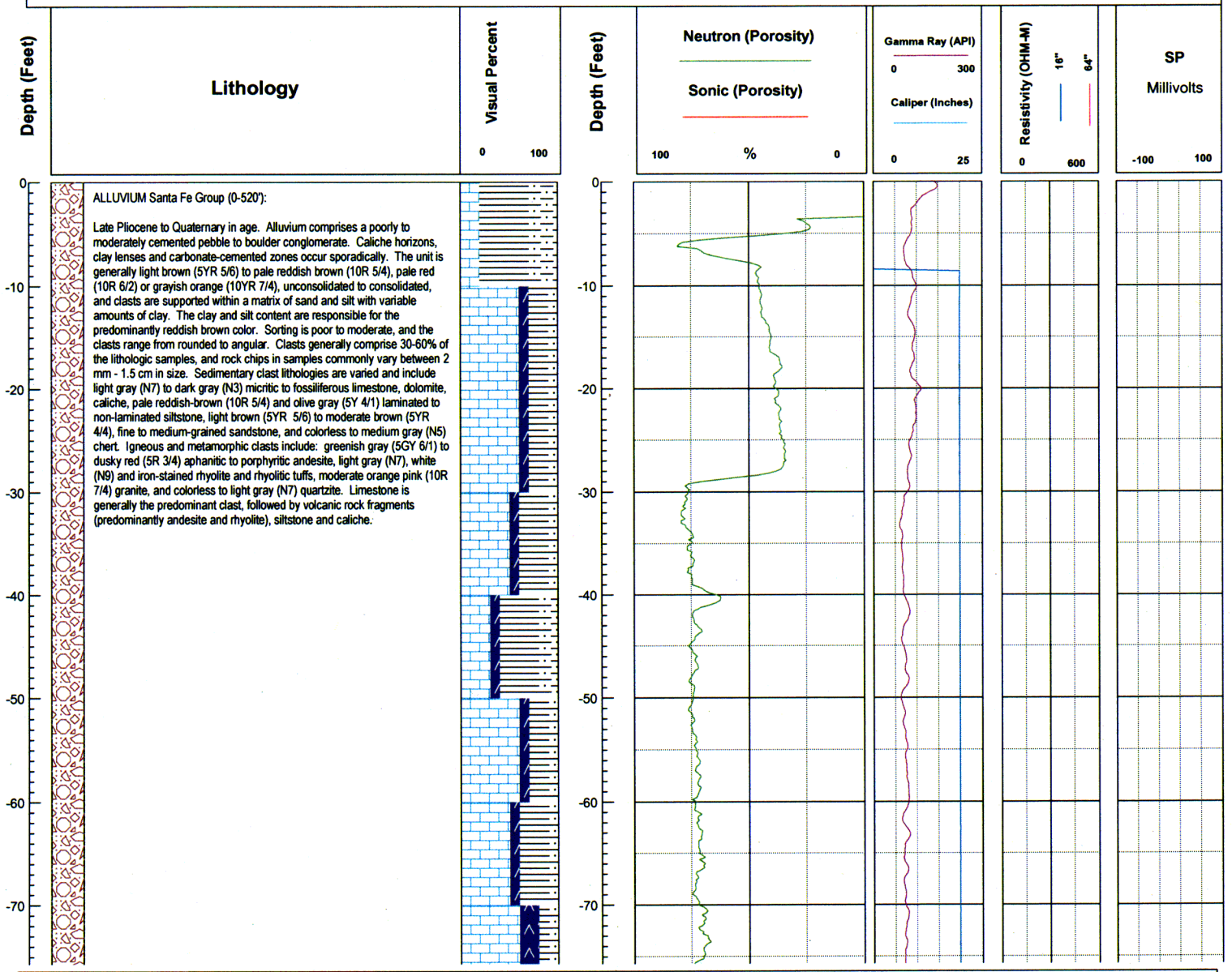
Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **NE 1/4, NW 1/4, SE 1/4, Sec 32, T20S R3E**
NM State Plane Coordinates (NAD 83): **229941.22N 401927.78E (Preliminary)**
Elevation (Brass Cap): **4516.71' (Preliminary)**
Total Depth of Borehole (bgs): **940'**
Depth to Bedrock (bgs): **590'**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Juan Aguilar**

Depth to Groundwater (bgs): **451.30'**
Surface Casing Depth and Diameter: **20" OD Steel set to 100'**
Borehole Diameter: **17.5"**
Geologist Field Rep: **M.C., G.G., L.H.M., J.P., M.R., J.K.**
Dates Drilling Started and Completed: **11/3/99 to 11/22/99**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Plume-Front Extraction Well**

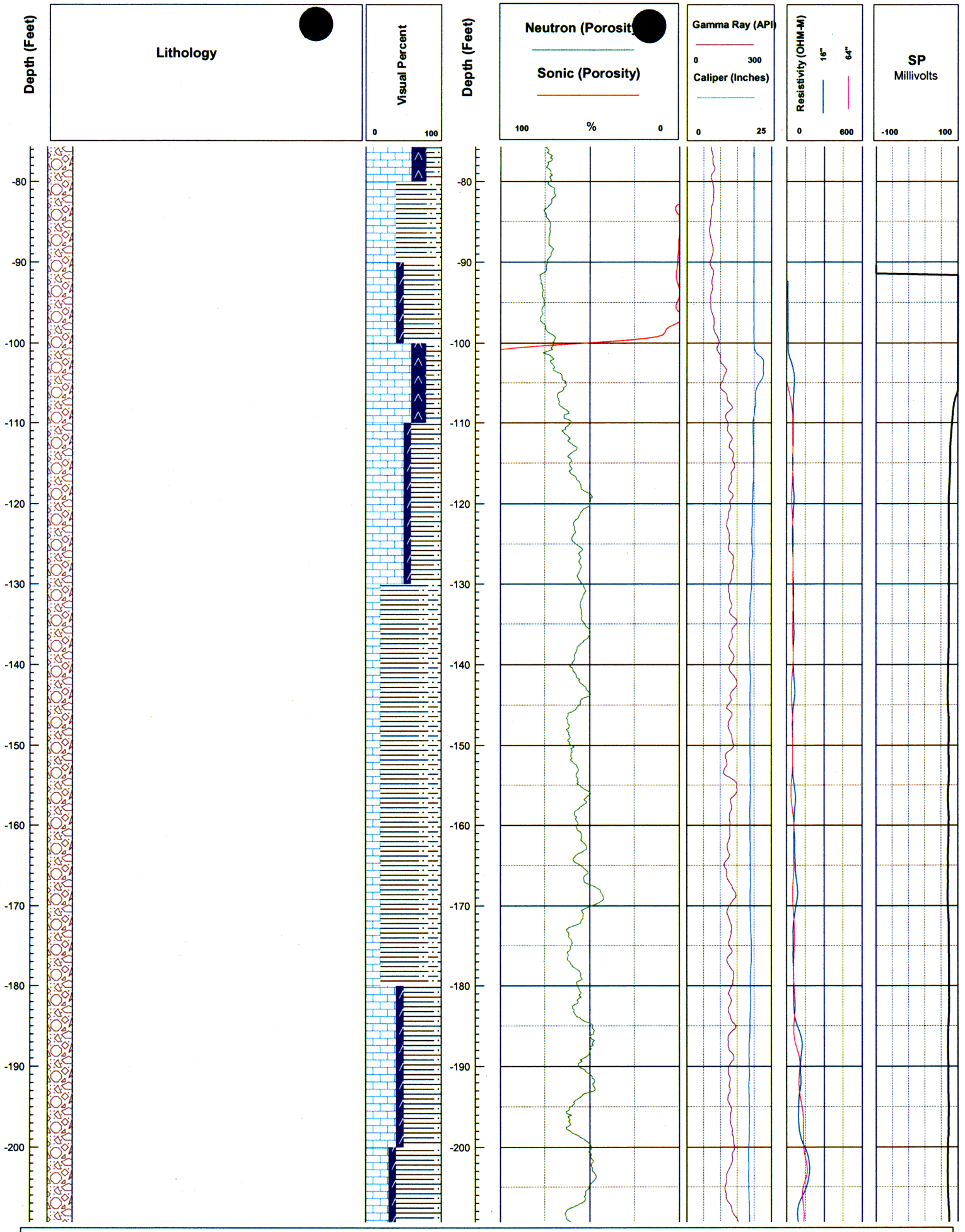
Explanation:

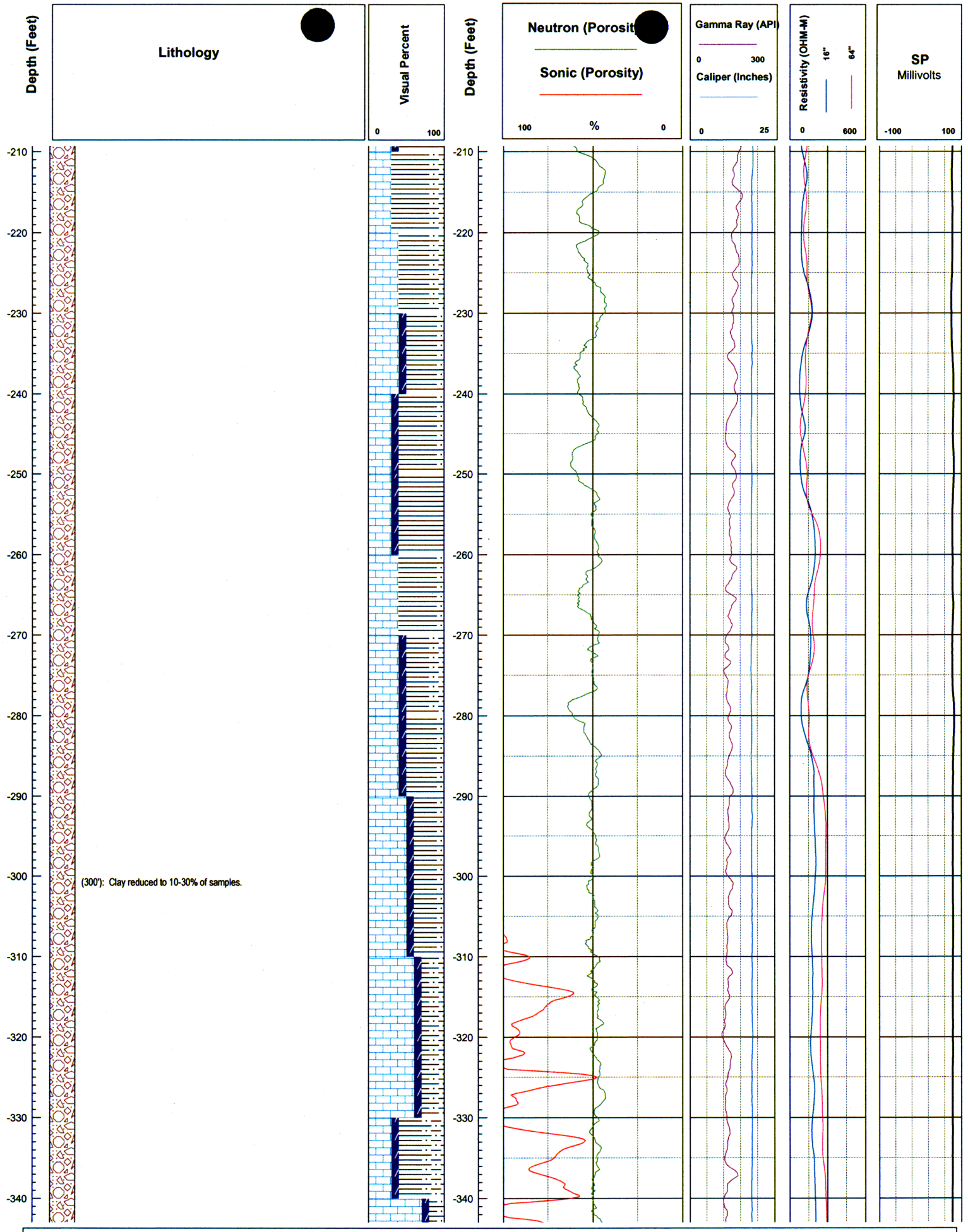
Alluvium | Volcanic Alluvium | Clay | Silt | Sand | Sandstone | Siltstone | Shale | Limestone | Rhyolite | Andesite | Undiffer. Volcanics

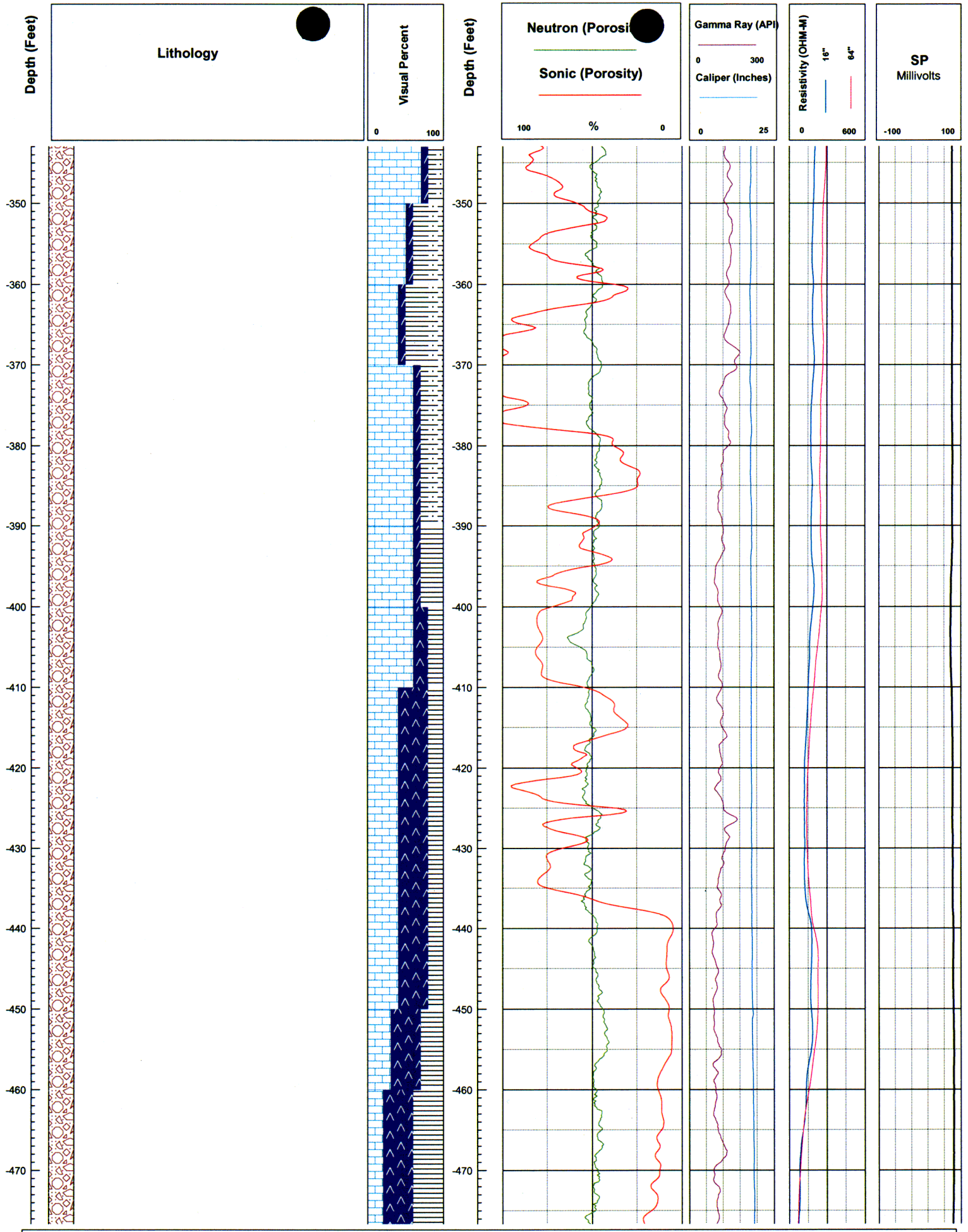


ALLUVIUM Santa Fe Group (0-520'):

Late Pliocene to Quaternary in age. Alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Caliche horizons, clay lenses and carbonate-cemented zones occur sporadically. The unit is generally light brown (5YR 5/6) to pale reddish brown (10R 5/4), pale red (10R 6/2) or grayish orange (10YR 7/4), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay and silt content are responsible for the predominantly reddish brown color. Sorting is poor to moderate, and the clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Sedimentary clast lithologies are varied and include light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, dolomite, caliche, pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated to non-laminated siltstone, light brown (5YR 5/6) to moderate brown (5YR 4/4), fine to medium-grained sandstone, and colorless to medium gray (N5) chert. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Limestone is generally the predominant clast, followed by volcanic rock fragments (predominantly andesite and rhyolite), siltstone and caliche.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340
(300'): Clay reduced to 10-30% of samples.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-350
-360
-370
-380
-390
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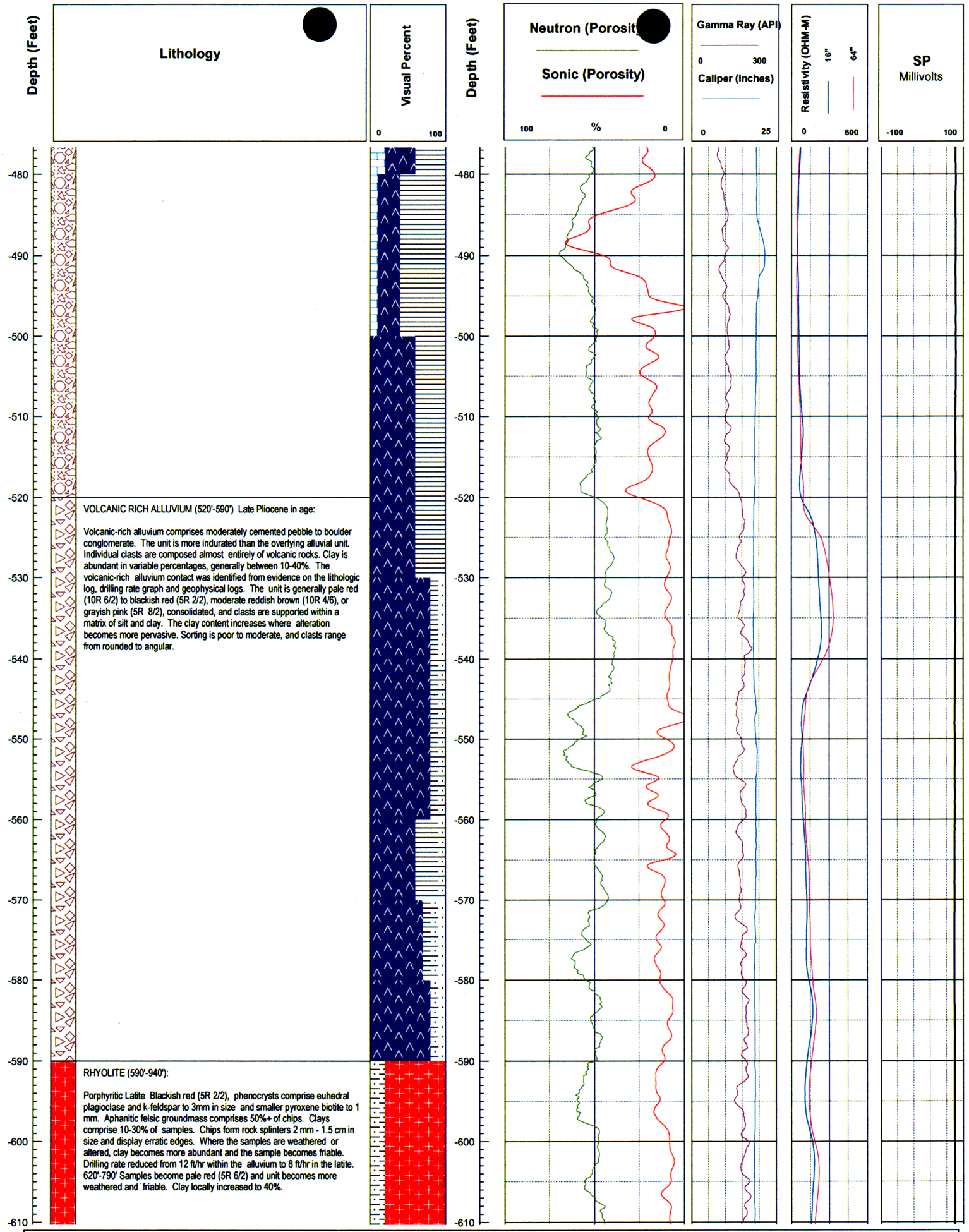
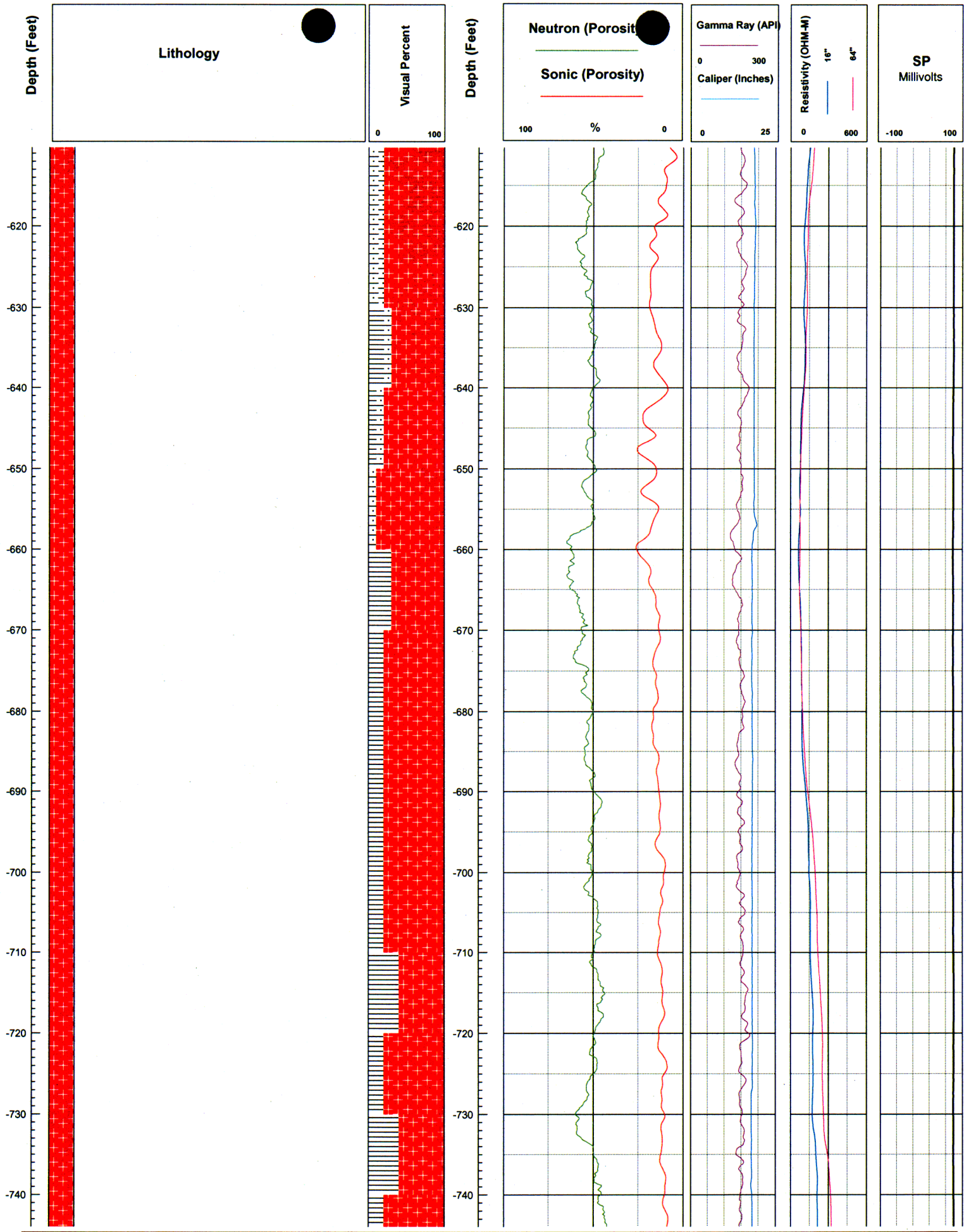
-450
-460
-470


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-480
-490
-500
-510
-520
-530
-540
-550
-560
-570
-580
-590
-600
-610
VOLCANIC RICH ALLUVIUM (520'-590') Late Pliocene in age:
Volcanic-rich alluvium comprises moderately cemented pebble to boulder conglomerate. The unit is more indurated than the overlying alluvial unit. Individual clasts are composed almost entirely of volcanic rocks. Clay is abundant in variable percentages, generally between 10-40%. The volcanic-rich alluvium contact was identified from evidence on the lithologic log, drilling rate graph and geophysical logs. The unit is generally pale red (10R 6/2) to blackish red (5R 2/2), moderate reddish brown (10R 4/6), or grayish pink (5R 8/2), consolidated, and clasts are supported within a matrix of silt and clay. The clay content increases where alteration becomes more pervasive. Sorting is poor to moderate, and clasts range from rounded to angular.
RHYOLITE (590'-940'):
Porphyritic Latite Blackish red (5R 2/2), phenocrysts comprise euhedral plagioclase and k-feldspar to 3mm in size and smaller pyroxene biotite to 1 mm. Aphanitic felsic groundmass comprises 50%+ of chips. Clays comprise 10-30% of samples. Chips form rock splinters 2 mm - 1.5 cm in size and display erratic edges. Where the samples are weathered or altered, clay becomes more abundant and the sample becomes friable. Drilling rate reduced from 12 ft/hr within the alluvium to 8 ft/hr in the latite. 620'-790' Samples become pale red (5R 6/2) and unit becomes more weathered and friable. Clay locally increased to 40%.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-620
-630
-640
-650
-660
-670
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-690
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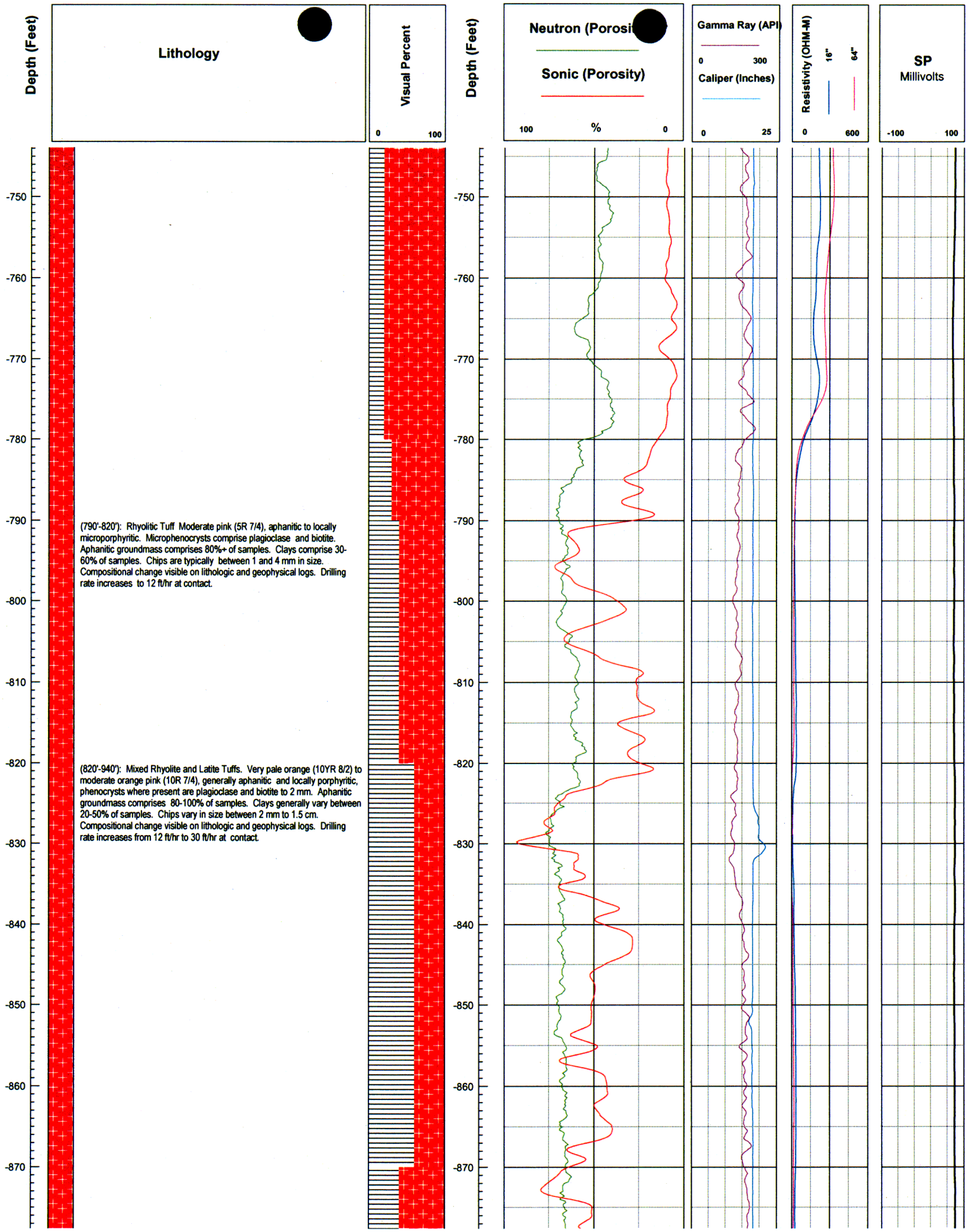
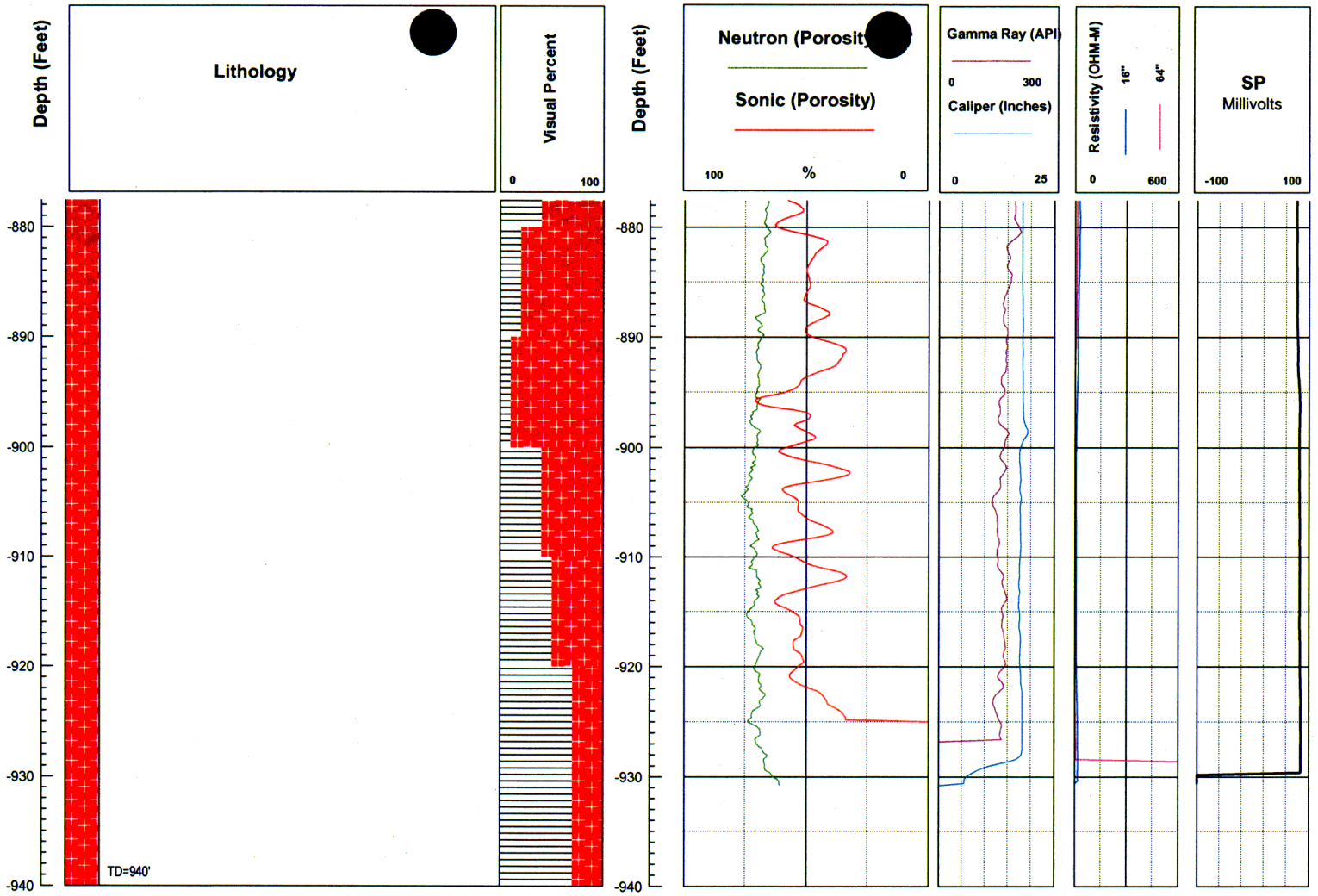
-710
-720
-730
-740


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-750
-760
-770
-780
-790
-800
-810
-820
-830
-840
-850
-860
-870
(790'-820'): Rhyolitic Tuff Moderate pink (5R 7/4), aphanitic to locally microporphyritic. Microphenocrysts comprise plagioclase and biotite. Aphanitic groundmass comprises 80%+ of samples. Clays comprise 30-60% of samples. Chips are typically between 1 and 4 mm in size. Compositional change visible on lithologic and geophysical logs. Drilling rate increases to 12 ft/hr at contact.
(820'-940'): Mixed Rhyolite and Latite Tuffs. Very pale orange (10YR 8/2) to moderate orange pink (10R 7/4), generally aphanitic and locally porphyritic, phenocrysts where present are plagioclase and biotite to 2 mm. Aphanitic groundmass comprises 80-100% of samples. Clays generally vary between 20-50% of samples. Chips vary in size between 2 mm to 1.5 cm. Compositional change visible on lithologic and geophysical logs. Drilling rate increases from 12 ft/hr to 30 ft/hr at contact.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-880
-890
-900
-910
-920
-930
-940
TD=940'

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

BOREHOLE LITHOLOGIC LOG

Location ID: **PFE-6**

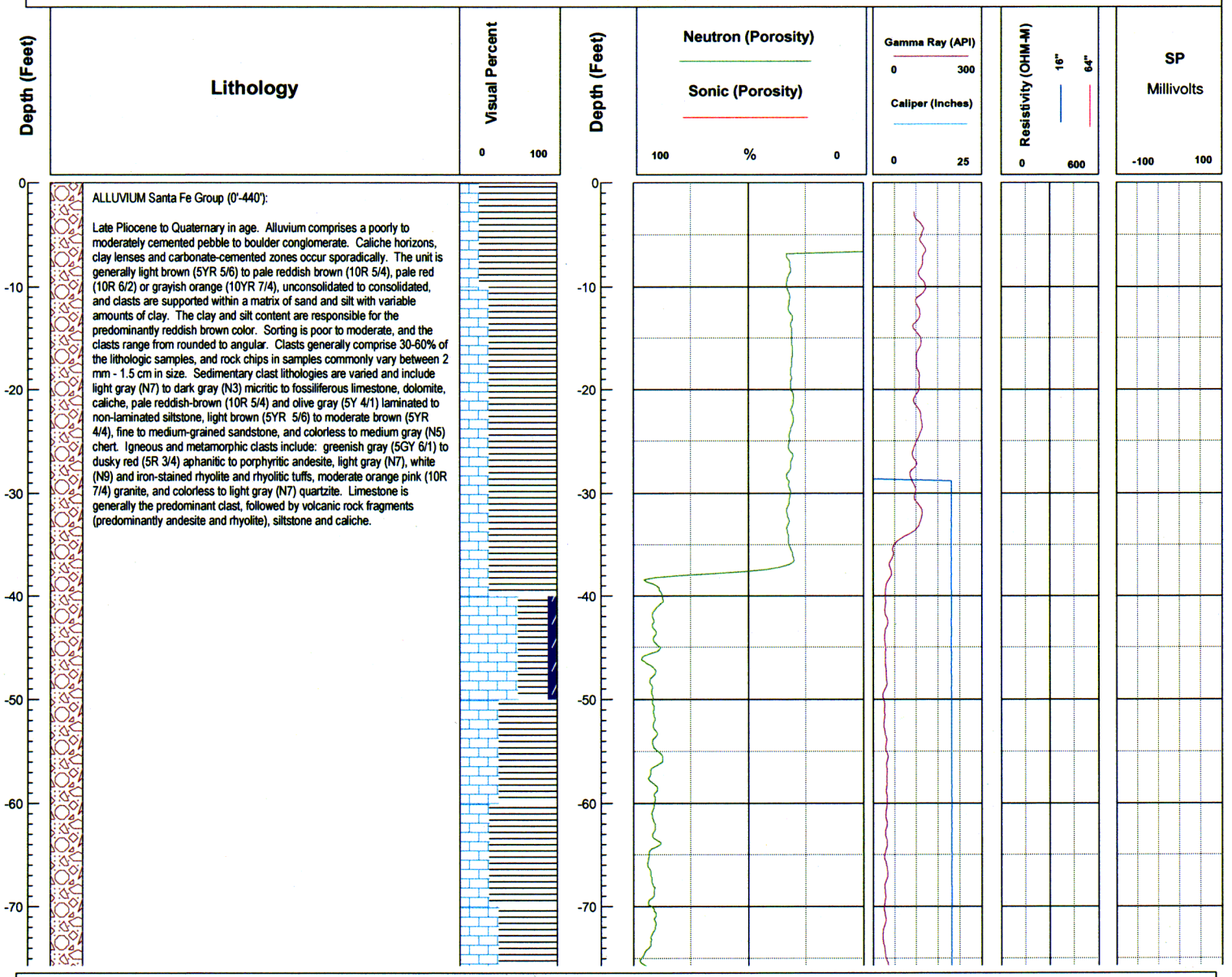
Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **NE 1/4, SE 1/4, SE 1/4, Sec 32, T20S, R3E**
NM State Plane Coordinates (NAD 83): **228689.60N 402987.21E (Preliminary)**
Elevation (Brass Cap): **4538.05' (Preliminary)**
Total Depth of Borehole (bgs): **602'**
Depth to Bedrock (bgs): **500'**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Juan Aguilar**

Depth to Groundwater (bgs): **473.15'**
Surface Casing Depth and Diameter: **20" OD Steel set to 101'**
Borehole Diameter: **17.5"**
Geologist Field Rep: **M.C., G.G., L.H.M., J.K., J.P., M.R.**
Dates Drilling Started and Completed: **12/9/99 to 12/22/99**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Plume-Front Extraction Well**

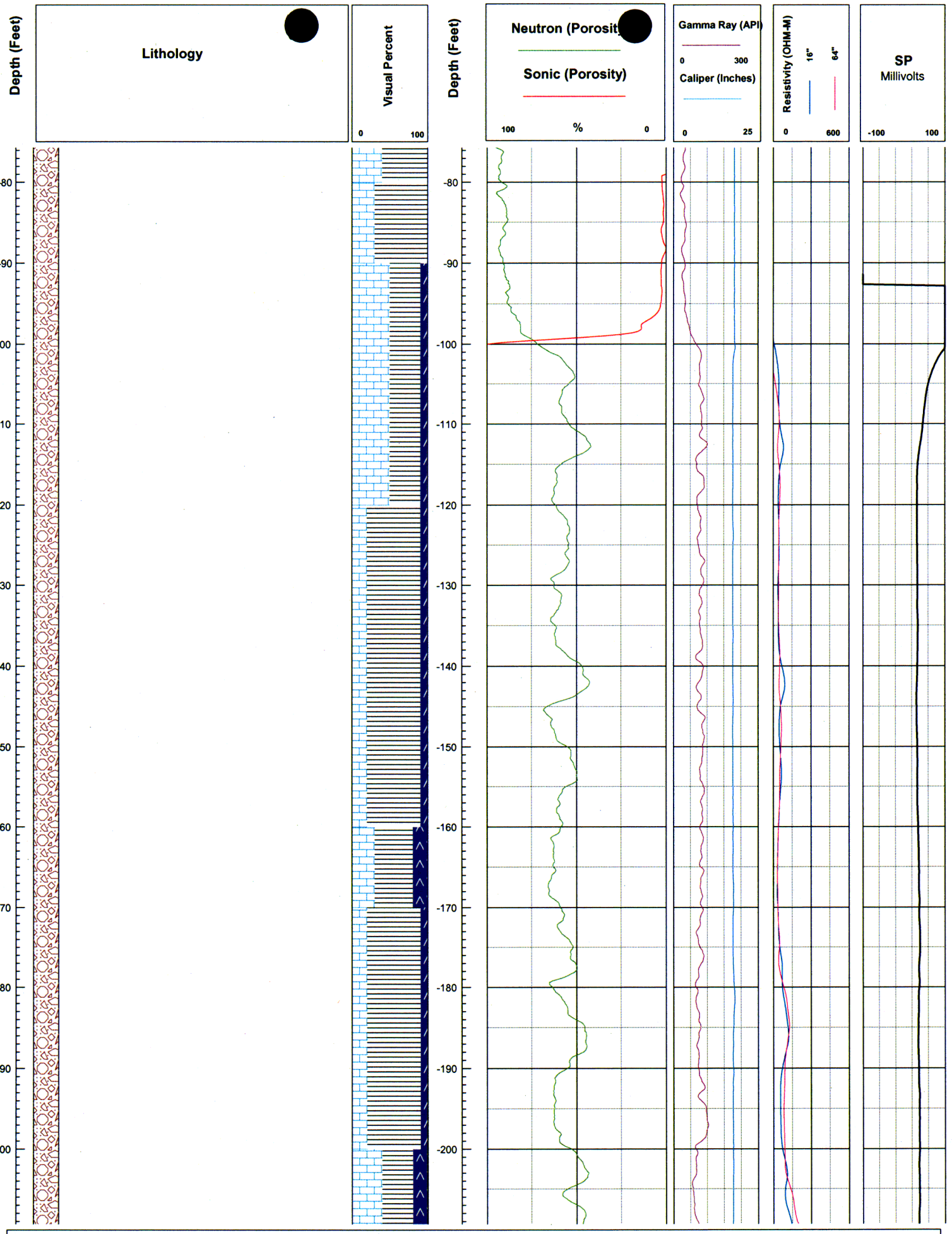
Explanation:

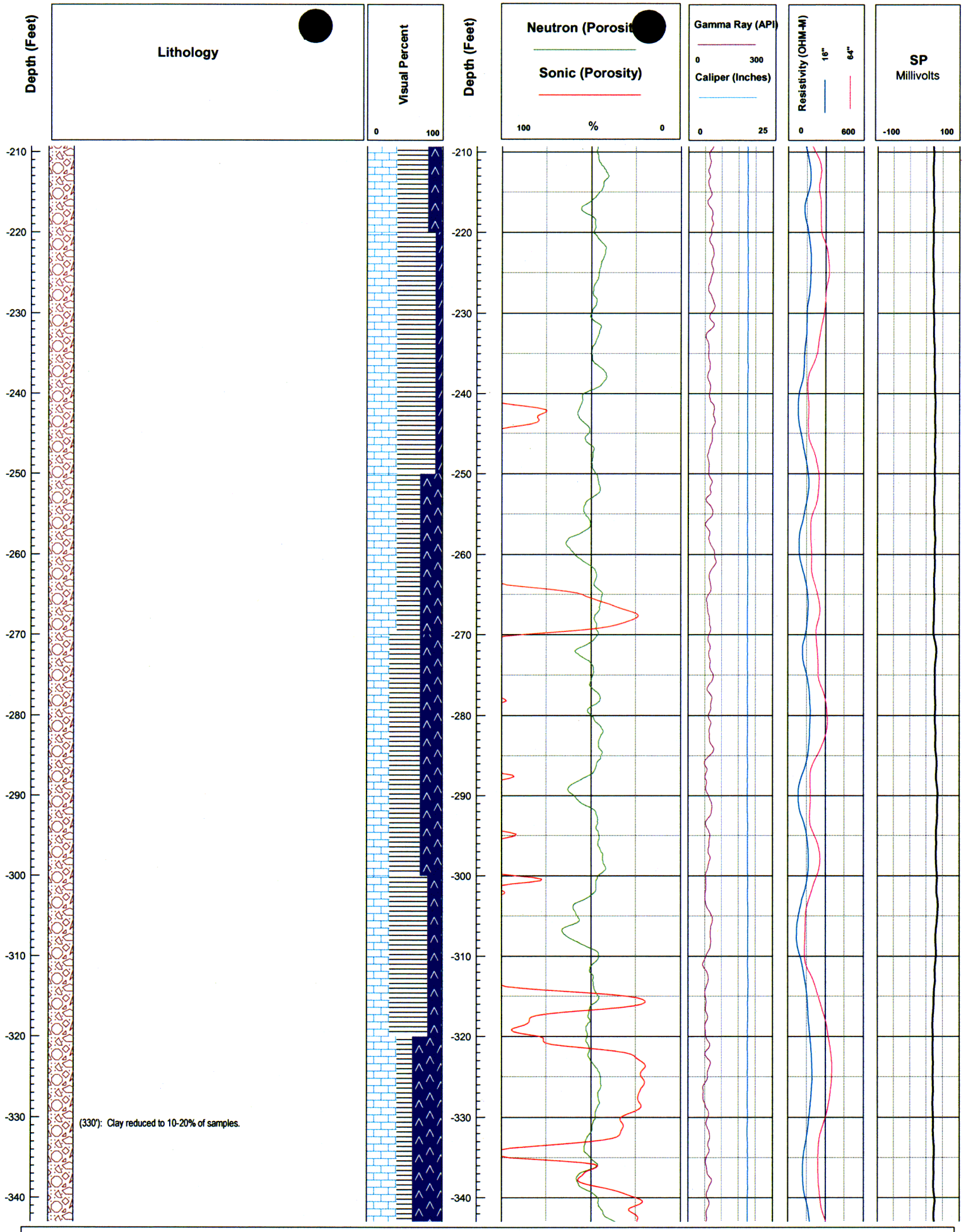
Alluvium | Volcanic Alluvium | Clay | Silt | Sand | Sandstone | Siltstone | Shale | Limestone | Rhyolite | Andesite | Undiffer. Volcanics

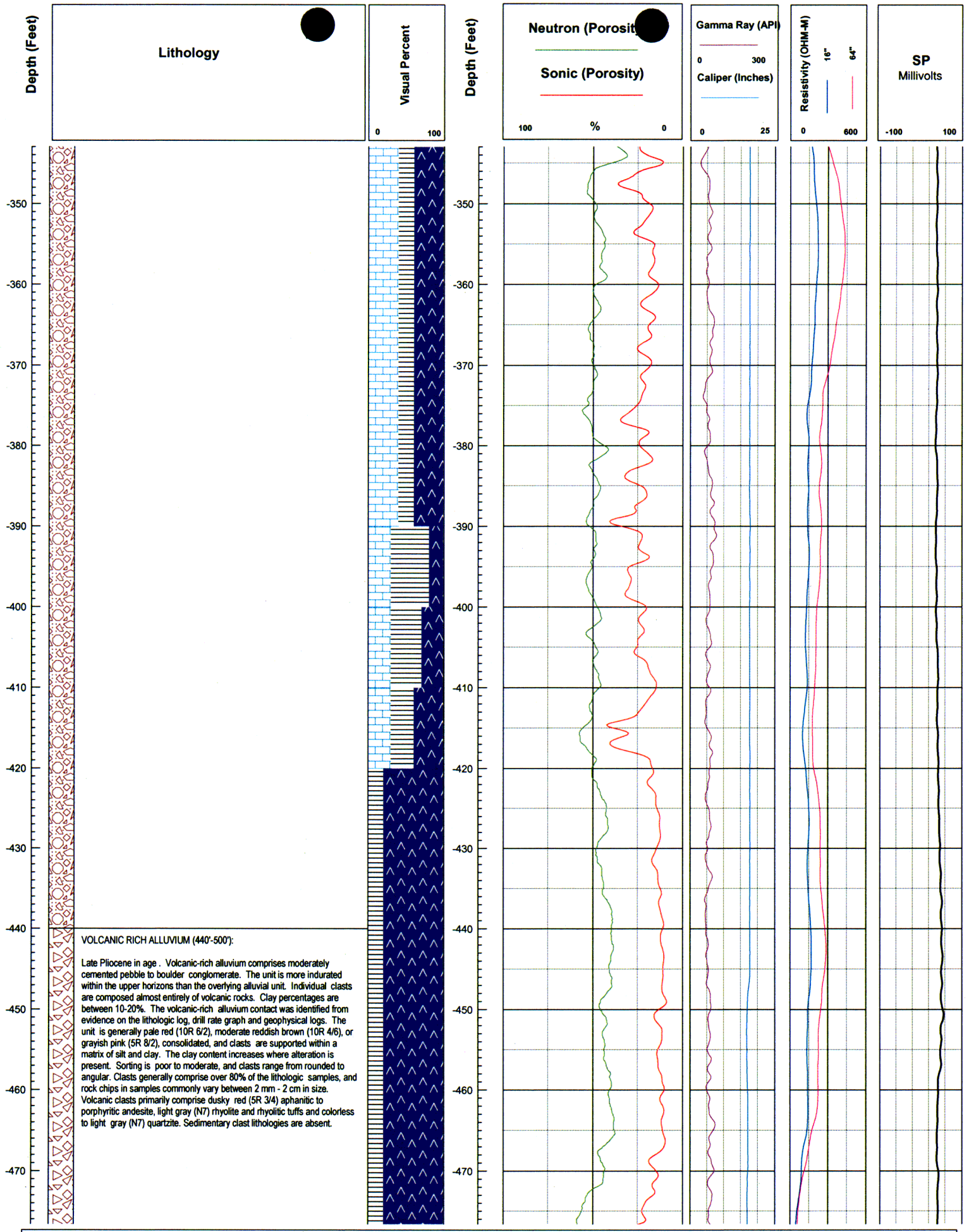


ALLUVIUM Santa Fe Group (0'-440'):

Late Pliocene to Quaternary in age. Alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Caliche horizons, clay lenses and carbonate-cemented zones occur sporadically. The unit is generally light brown (5YR 5/6) to pale reddish brown (10R 5/4), pale red (10R 6/2) or grayish orange (10YR 7/4), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay and silt content are responsible for the predominantly reddish brown color. Sorting is poor to moderate, and the clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Sedimentary clast lithologies are varied and include light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, dolomite, caliche, pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated to non-laminated siltstone, light brown (5YR 5/6) to moderate brown (5YR 4/4), fine to medium-grained sandstone, and colorless to medium gray (N5) chert. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Limestone is generally the predominant clast, followed by volcanic rock fragments (predominantly andesite and rhyolite), siltstone and caliche.

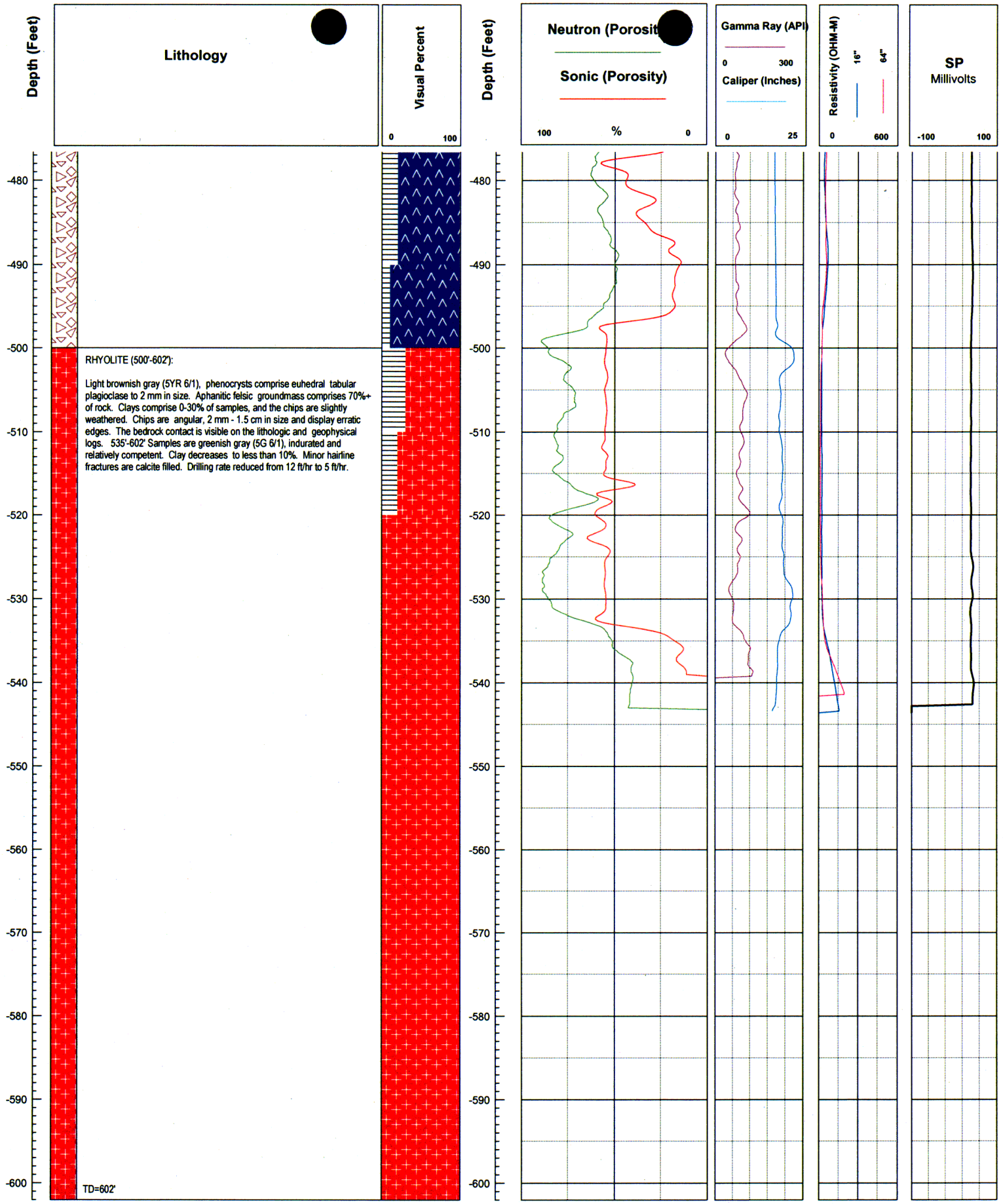

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340
(330'): Clay reduced to 10-20% of samples.



VOLCANIC RICH ALLUVIUM (440'-500'):

Late Pliocene in age . Volcanic-rich alluvium comprises moderately cemented pebble to boulder conglomerate. The unit is more indurated within the upper horizons than the overlying alluvial unit. Individual clasts are composed almost entirely of volcanic rocks. Clay percentages are between 10-20%. The volcanic-rich alluvium contact was identified from evidence on the lithologic log, drill rate graph and geophysical logs. The unit is generally pale red (10R 6/2), moderate reddish brown (10R 4/6), or grayish pink (5R 8/2), consolidated, and clasts are supported within a matrix of silt and clay. The clay content increases where alteration is present. Sorting is poor to moderate, and clasts range from rounded to angular. Clasts generally comprise over 80% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 2 cm in size. Volcanic clasts primarily comprise dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7) rhyolite and rhyolitic tuffs and colorless to light gray (N7) quartzite. Sedimentary clast lithologies are absent.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-480
-490
-500
-510
-520
-530
-540
-550
-560
-570
-580
-590
-600
RHYOLITE (500'-602'):
Light brownish gray (5YR 6/1), phenocrysts comprise euhedral tabular plagioclase to 2 mm in size. Aphanitic felsic groundmass comprises 70%+ of rock. Clays comprise 0-30% of samples, and the chips are slightly weathered. Chips are angular, 2 mm - 1.5 cm in size and display erratic edges. The bedrock contact is visible on the lithologic and geophysical logs. 535'-602' Samples are greenish gray (5G 6/1), indurated and relatively competent. Clay decreases to less than 10%. Minor hairline fractures are calcite filled. Drilling rate reduced from 12 ft/hr to 5 ft/hr.
TD=602'

BOREHOLE LITHOLOGIC LOG

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

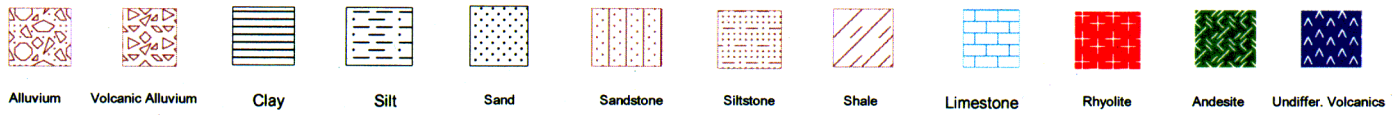
Location ID: **PFE-7**

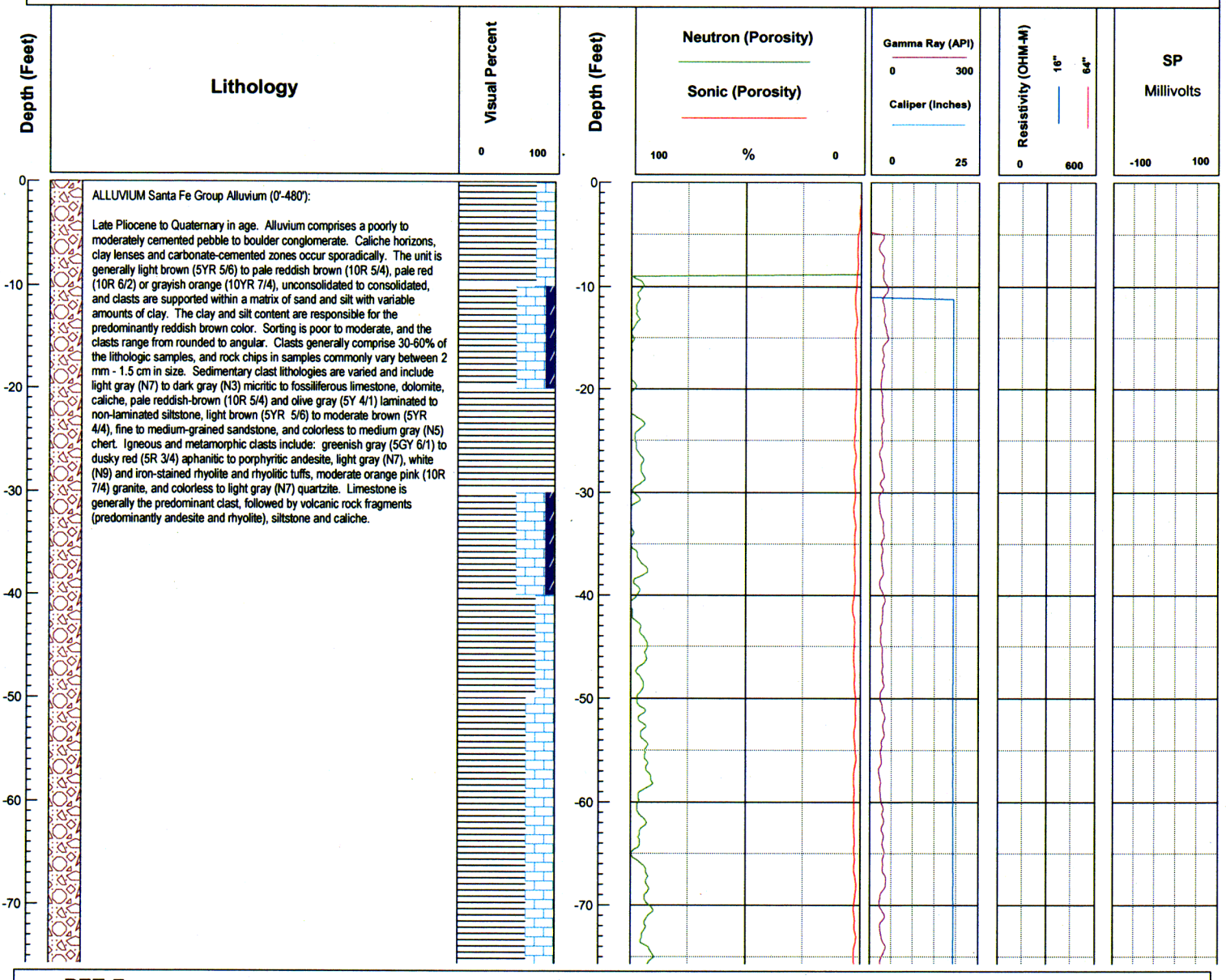
Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **NE1/4 SW 1/4 SW 1/4 Sec 32 T20S R3E**
NM State Plane Coordinates (NAD 83): **3599227.80N 344149.90E (Preliminary)**
Elevation (Brass Cap): **4493.44' (Preliminary)**
Total Depth of Borehole (bgs): **720'**
Depth to Bedrock (bgs): **N/A**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling, Co.**
Driller: **Davis Gaddy**

Depth to Groundwater (bgs): **413.14'**
Surface Casing Depth and Diameter: **20" OD Steel set to 117'**
Borehole Diameter: **17.5"**
Geologist Field Rep: **M.C., G.G., L.H.M., J.P., M.S., R.W.**
Dates Drilling Started and Completed: **7/12/01 to 7/19/01**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Plume-Front Extraction Well**

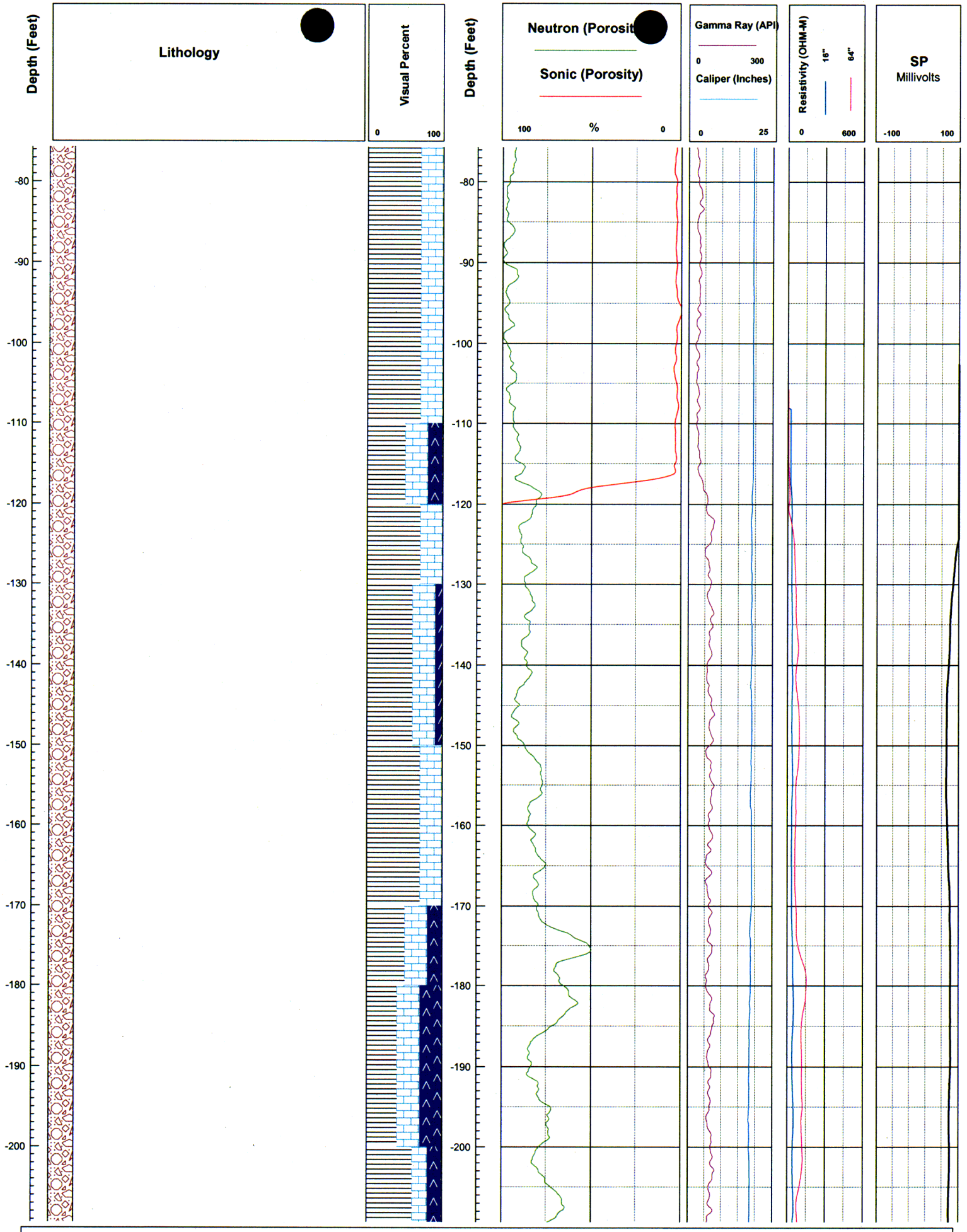
Explanation:

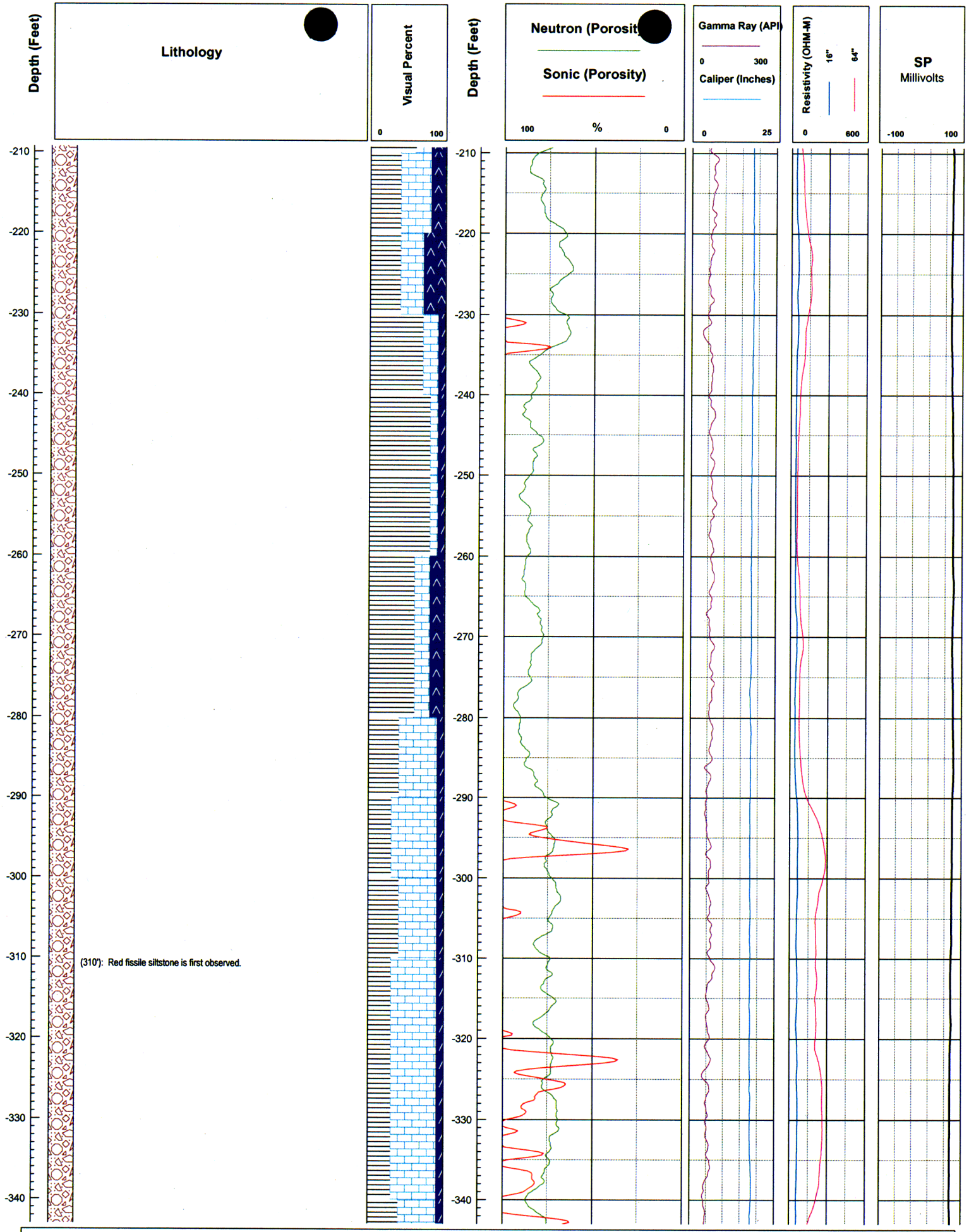


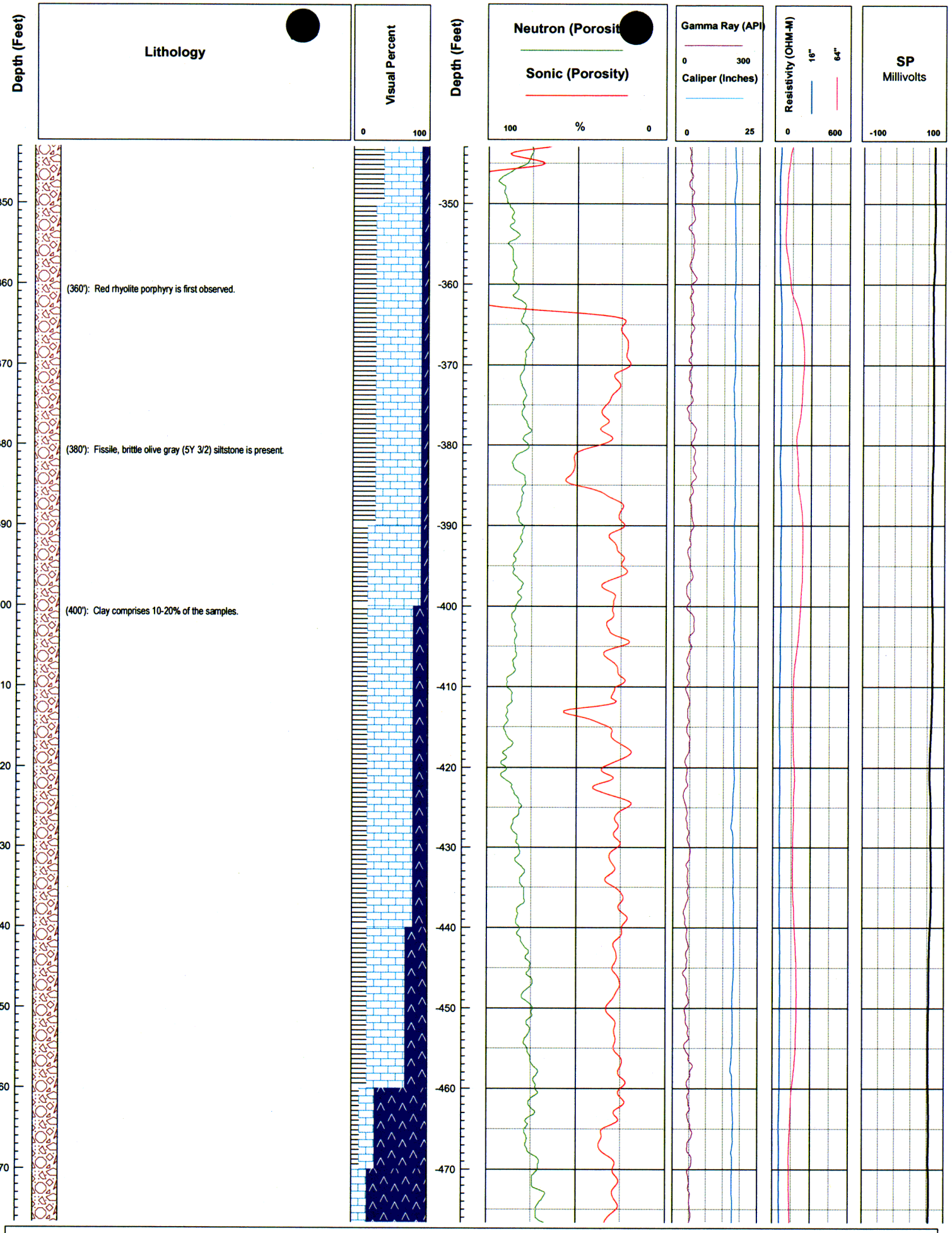


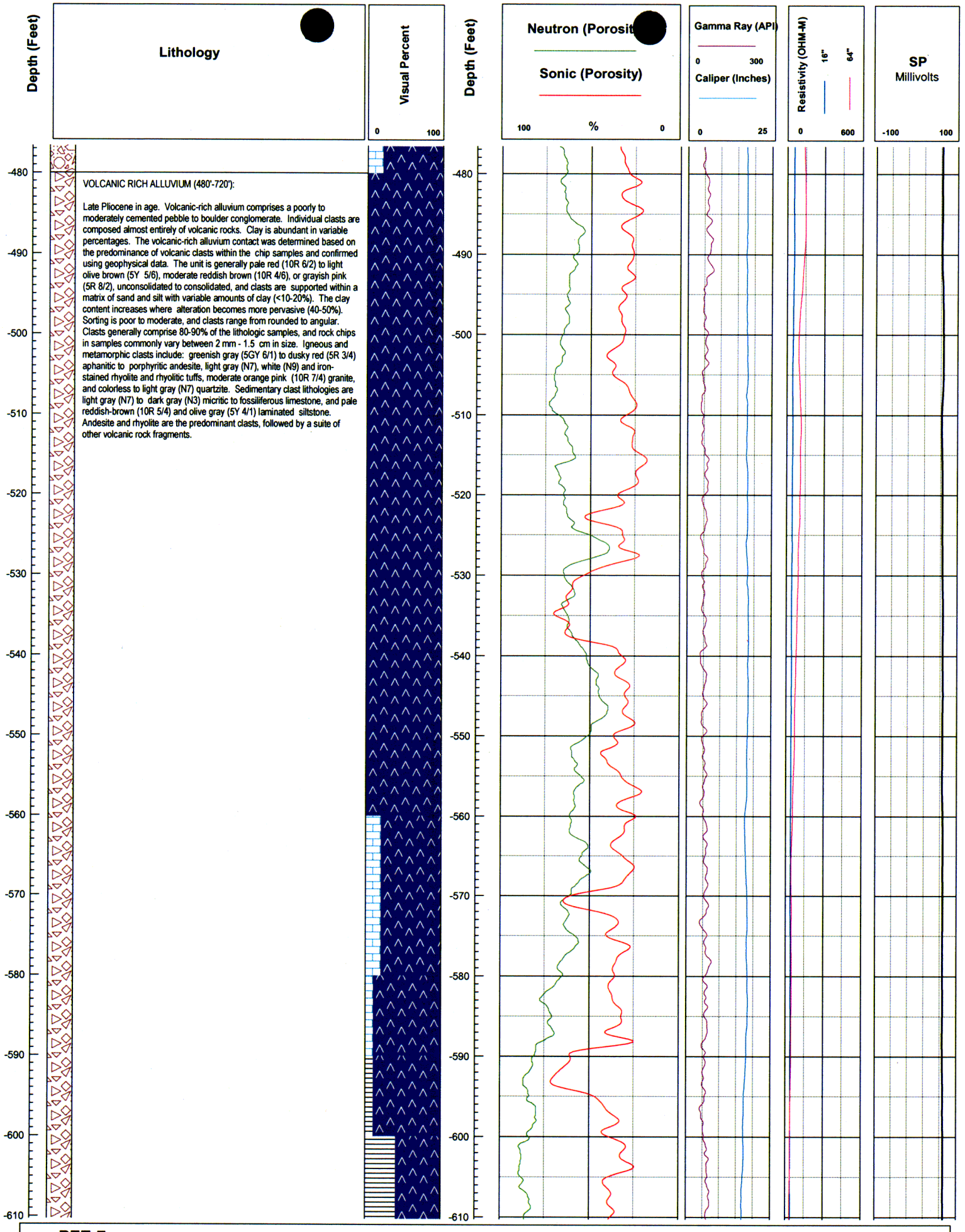
ALLUVIUM Santa Fe Group Alluvium (0'-480'):

Late Pliocene to Quaternary in age. Alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Caliche horizons, clay lenses and carbonate-cemented zones occur sporadically. The unit is generally light brown (5YR 5/6) to pale reddish brown (10R 5/4), pale red (10R 6/2) or grayish orange (10YR 7/4), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay and silt content are responsible for the predominantly reddish brown color. Sorting is poor to moderate, and the clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Sedimentary clast lithologies are varied and include light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, dolomite, caliche, pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated to non-laminated siltstone, light brown (5YR 5/6) to moderate brown (5YR 4/4), fine to medium-grained sandstone, and colorless to medium gray (N5) chert. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Limestone is generally the predominant clast, followed by volcanic rock fragments (predominantly andesite and rhyolite), siltstone and caliche.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200

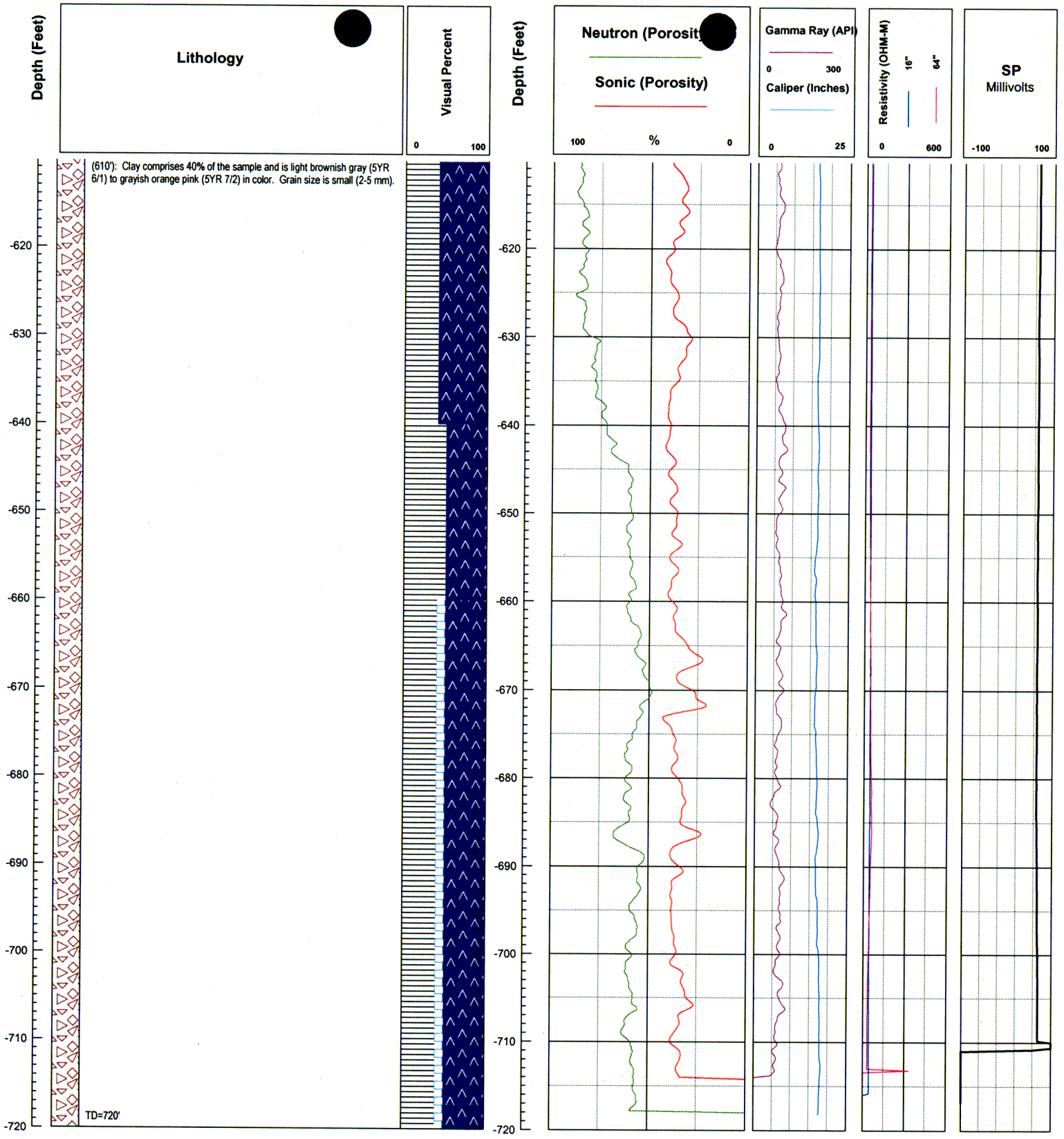

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340
(310'): Red fissile siltstone is first observed.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470
(360'): Red rhyolite porphyry is first observed.
(380'): Fissile, brittle olive gray (5Y 3/2) siltstone is present.
(400'): Clay comprises 10-20% of the samples.



VOLCANIC RICH ALLUVIUM (480'-720'):

Late Pliocene in age. Volcanic-rich alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Individual clasts are composed almost entirely of volcanic rocks. Clay is abundant in variable percentages. The volcanic-rich alluvium contact was determined based on the predominance of volcanic clasts within the chip samples and confirmed using geophysical data. The unit is generally pale red (10R 6/2) to light olive brown (5Y 5/6), moderate reddish brown (10R 4/6), or grayish pink (5R 8/2), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay (<10-20%). The clay content increases where alteration becomes more pervasive (40-50%). Sorting is poor to moderate, and clasts range from rounded to angular. Clasts generally comprise 80-90% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Sedimentary clast lithologies are light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, and pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated siltstone. Andesite and rhyolite are the predominant clasts, followed by a suite of other volcanic rock fragments.


Depth (Feet)
Lithology
Visual Percent
0
100
(610'): Clay comprises 40% of the sample and is light brownish gray (5YR 6/1) to grayish orange pink (5YR 7/2) in color. Grain size is small (2-5 mm).
TD=720'
-620
-630
-640
-650
-660
-670
-680
-690
-700
-710
-720
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

BOREHOLE LITHOLOGIC LOG

Location ID: **PFI-1**

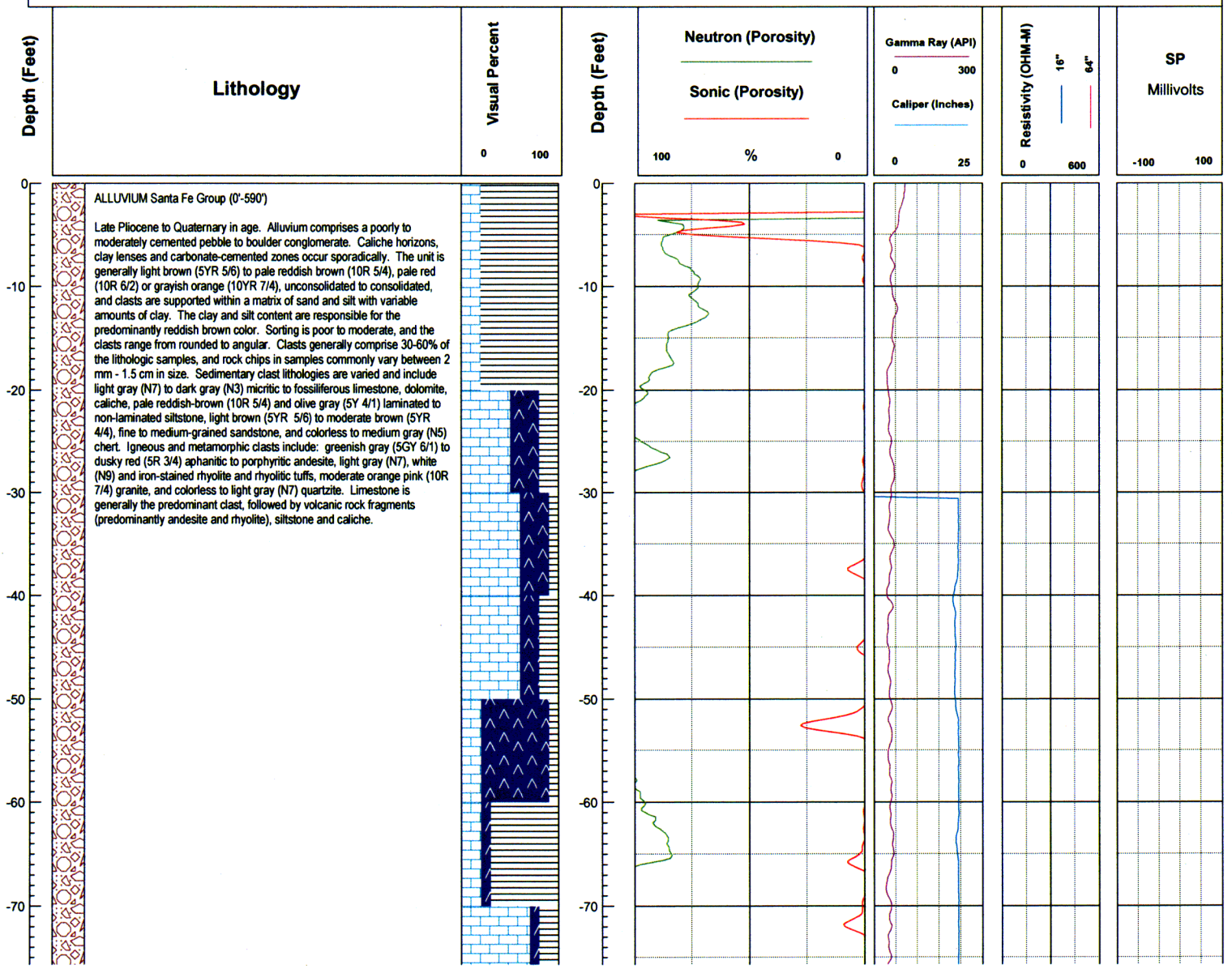
Site ID: **NASA-WSTF, Doña Ana County, NM**

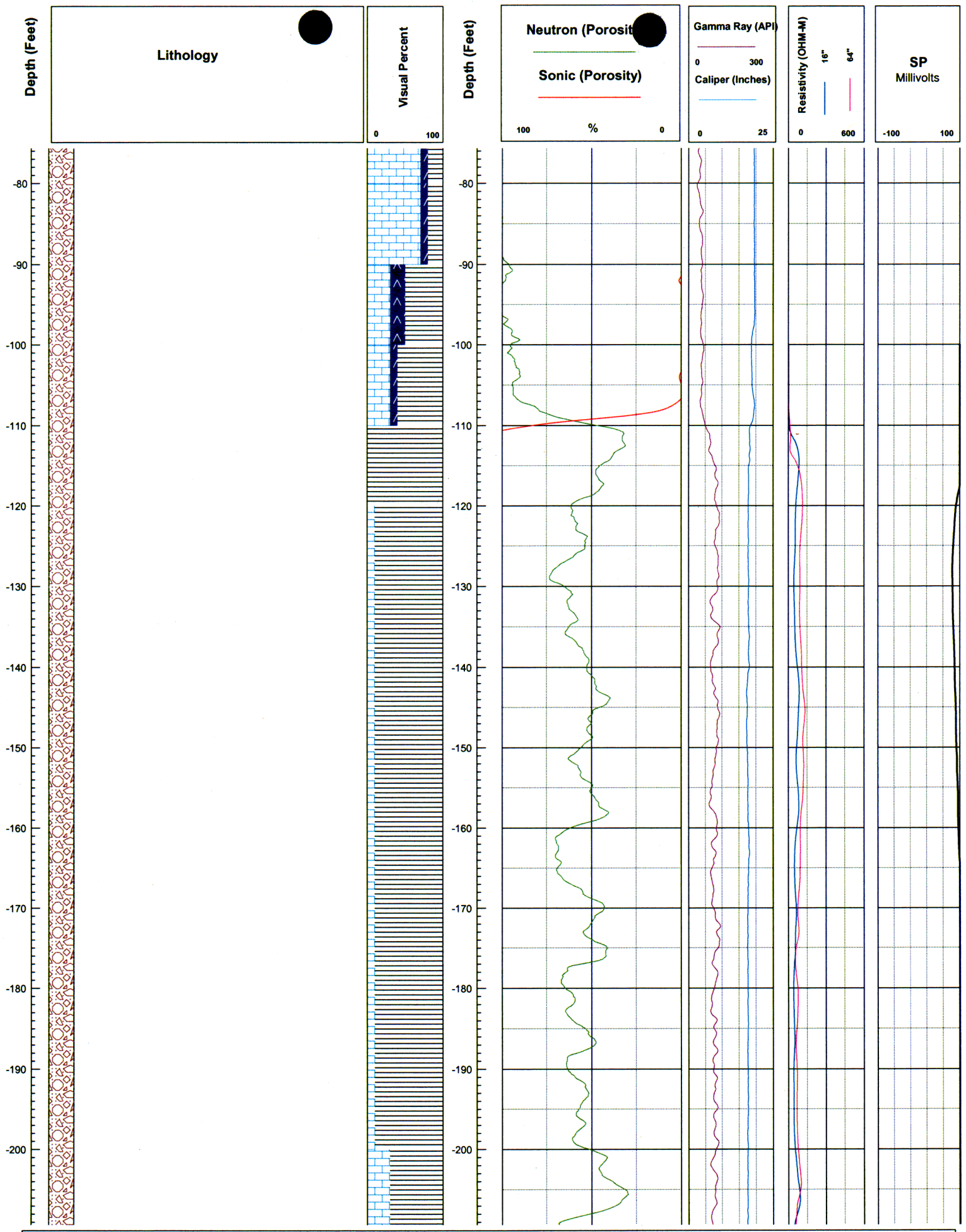
Township and Range: **NE 1/4, NE 1/4, SW 1/4, Sec 5, T21S, R3E**
NM State Plane Coordinates (NAD 83): **224784.25N 400154.82E (Preliminary)**
Elevation (Brass Cap): **4484.86' (Preliminary)**
Total Depth of Borehole (bgs): **1,020'**
Depth to Bedrock (bgs): **N/A**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Juan Aguilar**

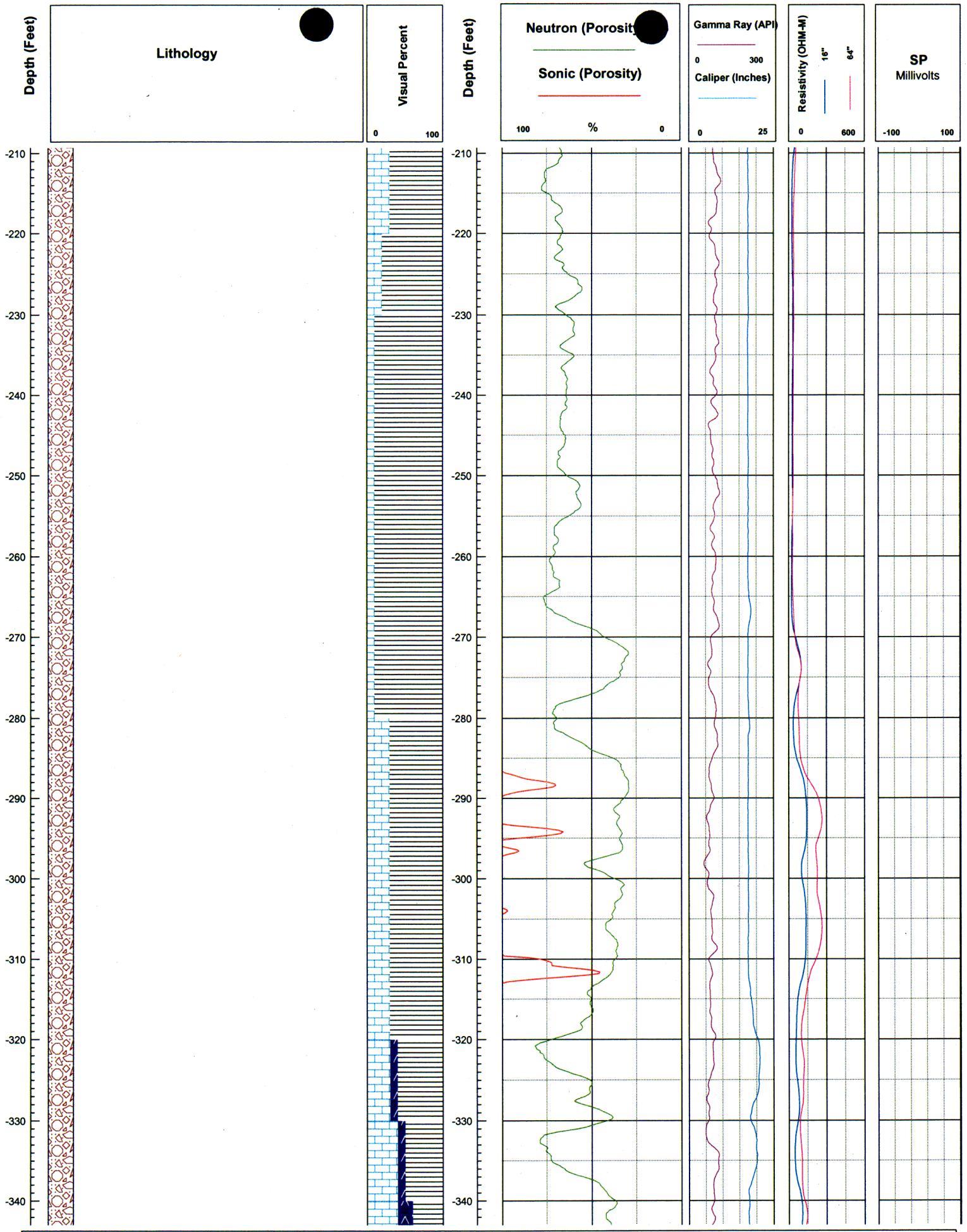
Depth to Groundwater (bgs): **419.18'**
Surface Casing Depth and Diameter: **20" OD Steel set to 111'**
Borehole Diameter: **17.5"**
Geologist Field Rep: **M.C., G.G., L.H.M., J.P., M.S., R.W.**
Dates Drilling Started and Completed: **3/28/00 to 4/12/00**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Plume-Front Injection Well**

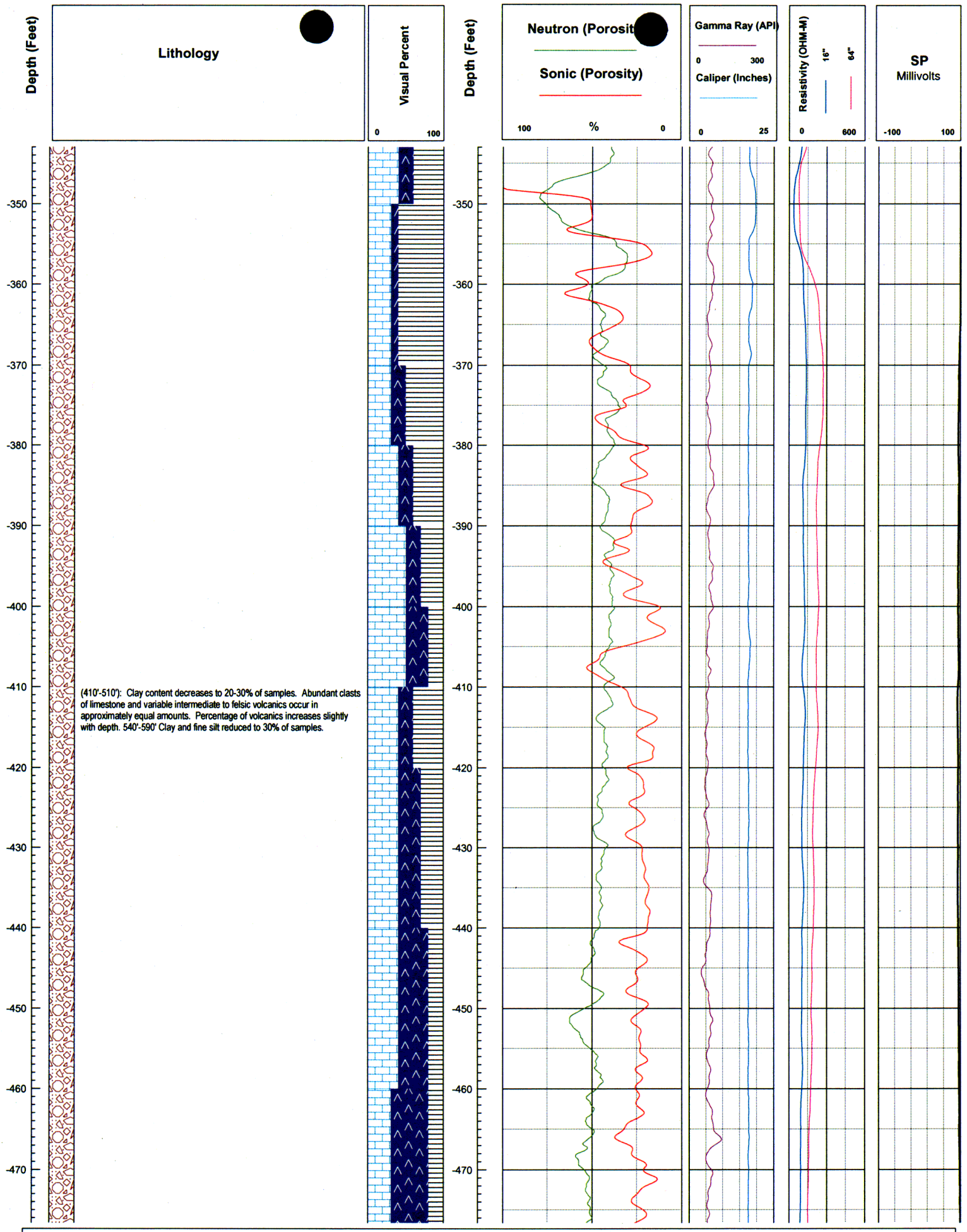
Explanation:

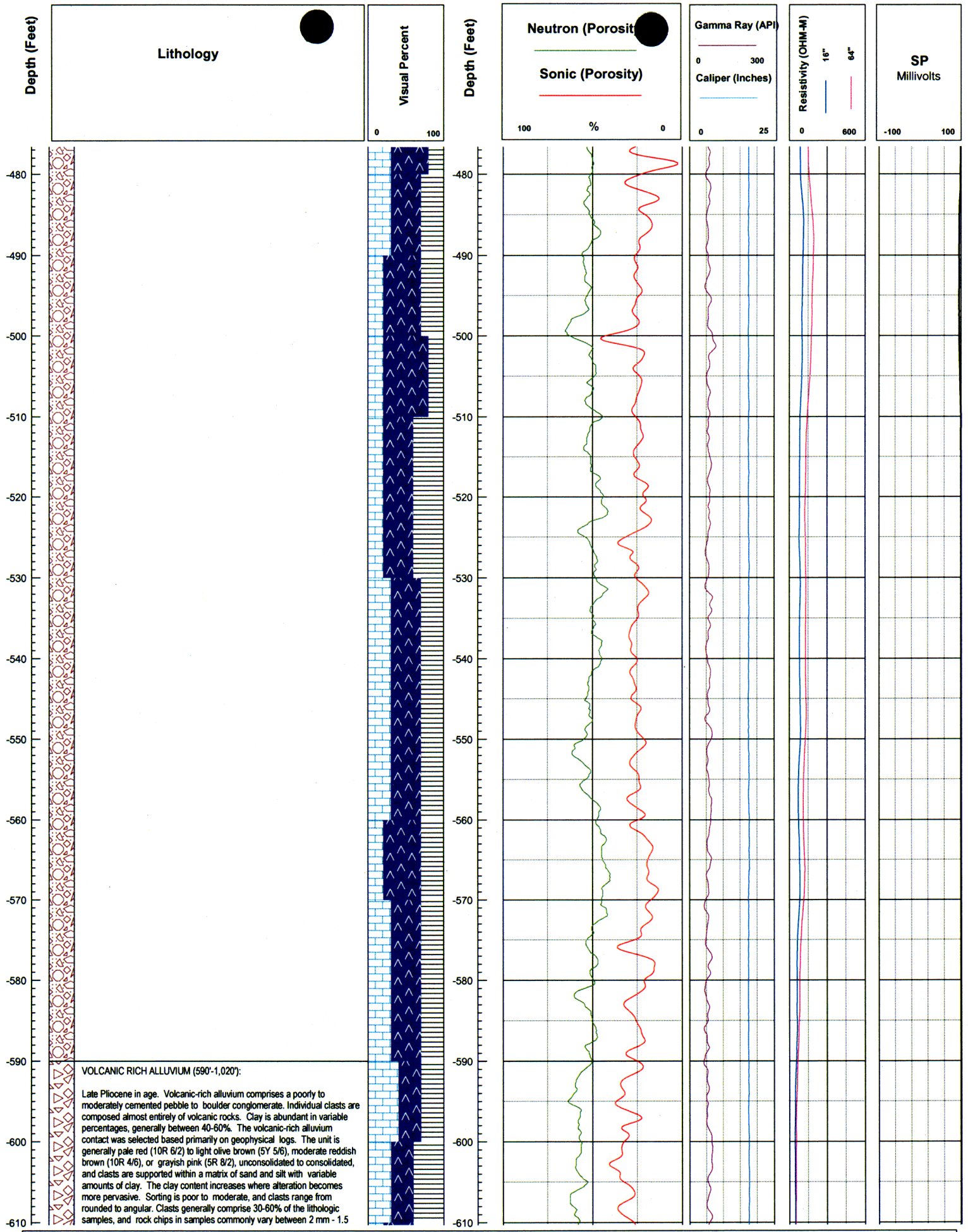
Alluvium | Volcanic Alluvium | Clay | Silt | Sand | Sandstone | Siltstone | Shale | Limestone | Rhyolite | Andesite | Undiffer. Volcanics

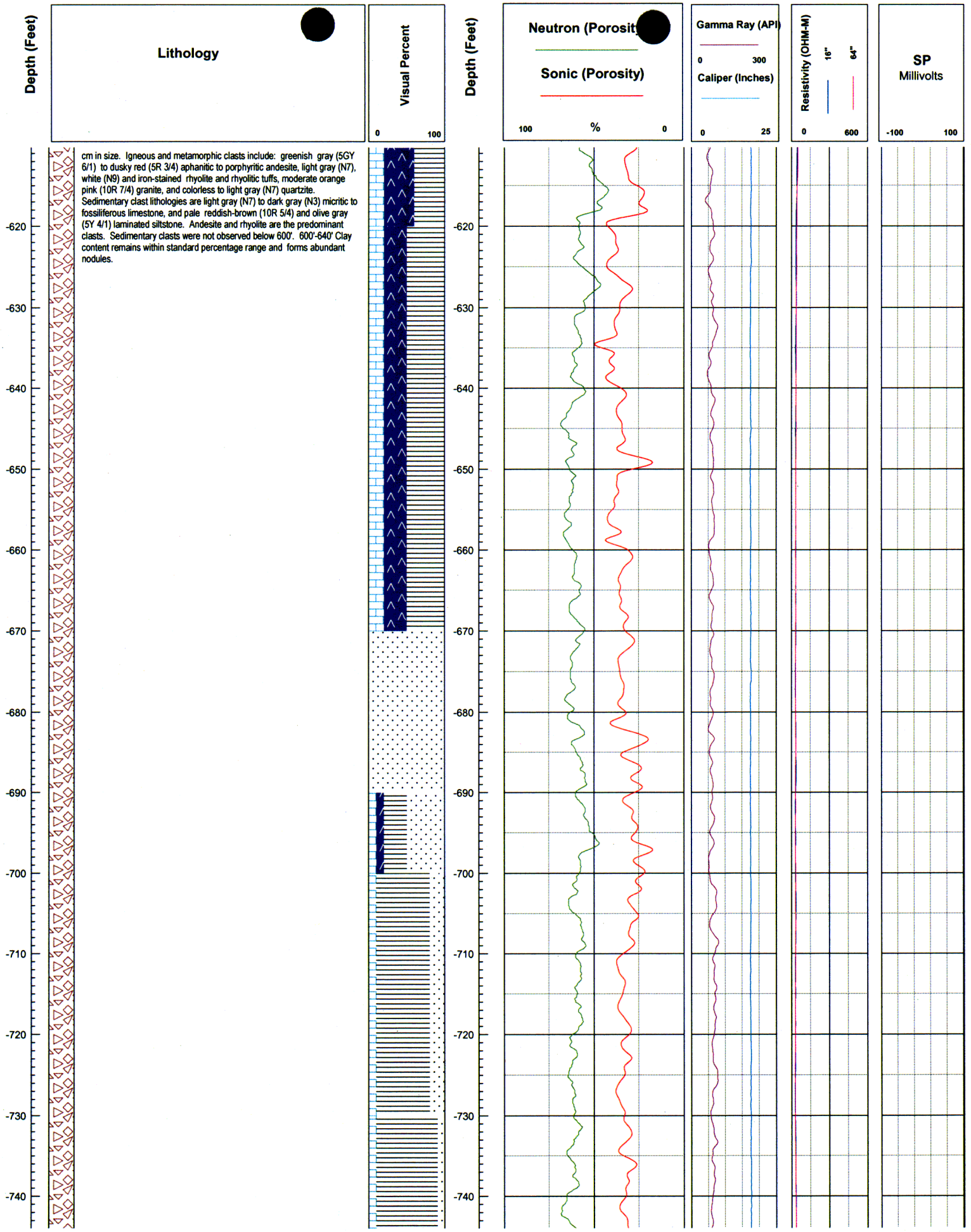


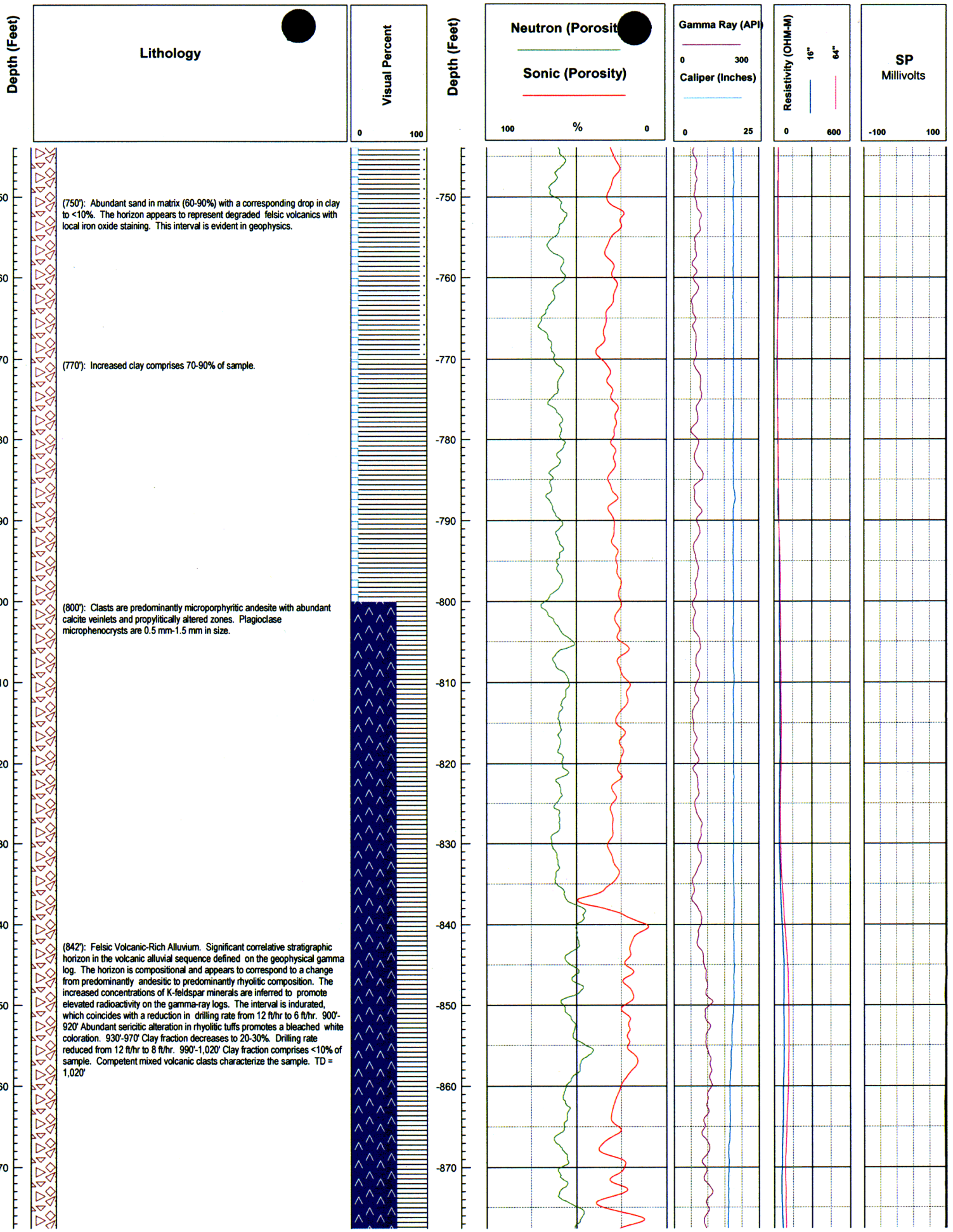

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200

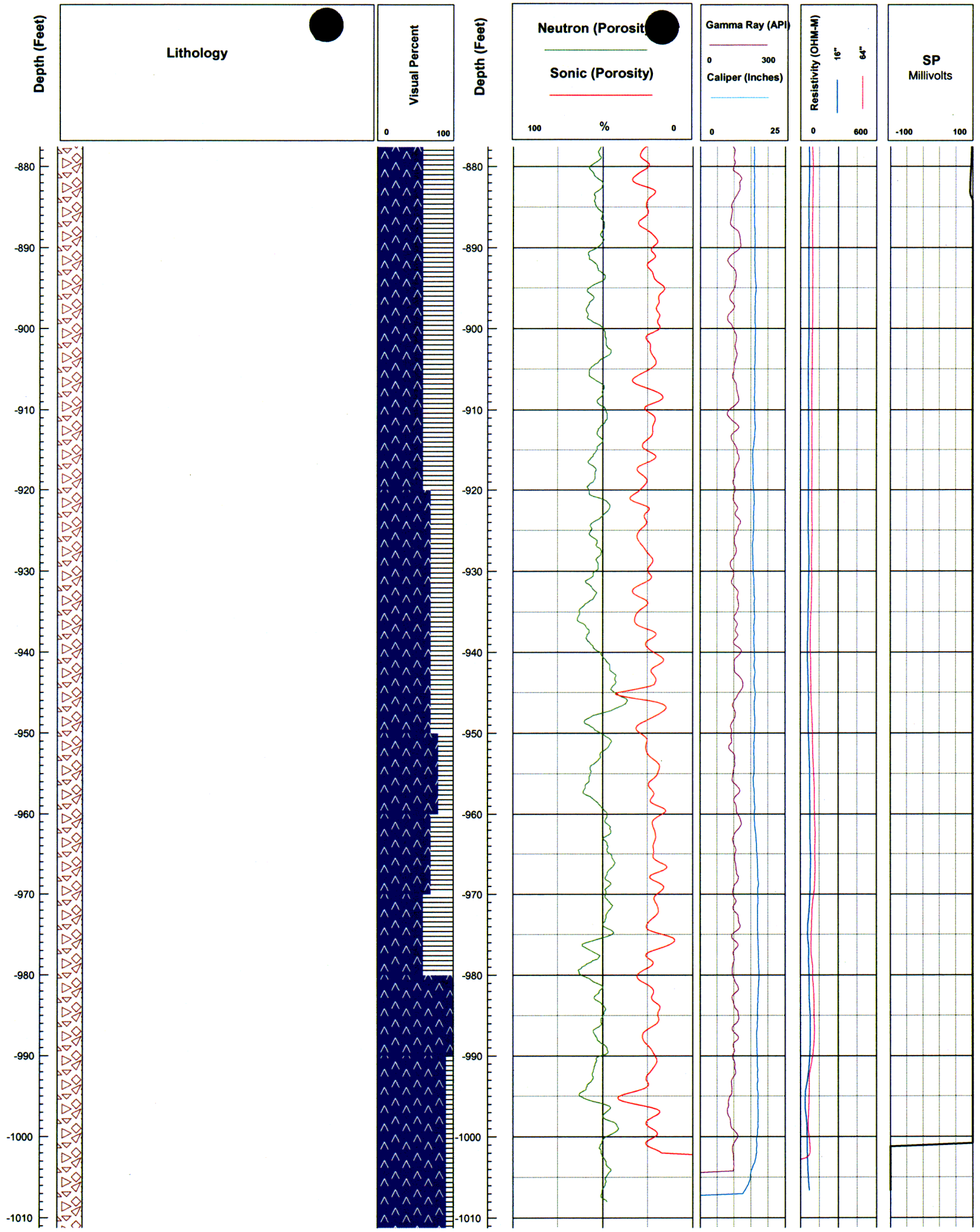

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470
(410'-510'): Clay content decreases to 20-30% of samples. Abundant clasts of limestone and variable intermediate to felsic volcanics occur in approximately equal amounts. Percentage of volcanics increases slightly with depth. 540'-590' Clay and fine silt reduced to 30% of samples.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-480
-490
-500
-510
-520
-530
-540
-550
-560
-570
-580
-590
-600
-610
VOLCANIC RICH ALLUVIUM (590'-1,020'):
Late Pliocene in age. Volcanic-rich alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Individual clasts are composed almost entirely of volcanic rocks. Clay is abundant in variable percentages, generally between 40-60%. The volcanic-rich alluvium contact was selected based primarily on geophysical logs. The unit is generally pale red (10R 6/2) to light olive brown (5Y 5/6), moderate reddish brown (10R 4/6), or grayish pink (5R 8/2), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay content increases where alteration becomes more pervasive. Sorting is poor to moderate, and clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5


Depth (Feet)
Lithology
Visual Percent
0
100
cm in size. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Sedimentary clast lithologies are light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, and pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated siltstone. Andesite and rhyolite are the predominant clasts. Sedimentary clasts were not observed below 600'. 600'-640' Clay content remains within standard percentage range and forms abundant nodules.
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-620
-630
-640
-650
-660
-670
-680
-690
-700
-710
-720
-730
-740


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-750
-760
-770
-780
-790
-800
-810
-820
-830
-840
-850
-860
-870
(750'): Abundant sand in matrix (60-90%) with a corresponding drop in clay to <10%. The horizon appears to represent degraded felsic volcanics with local iron oxide staining. This interval is evident in geophysics.
(770'): Increased clay comprises 70-90% of sample.
(800'): Clasts are predominantly microporphyritic andesite with abundant calcite veinlets and propylitically altered zones. Plagioclase microphenocrysts are 0.5 mm-1.5 mm in size.
(842'): Felsic Volcanic-Rich Alluvium. Significant correlative stratigraphic horizon in the volcanic alluvial sequence defined on the geophysical gamma log. The horizon is compositional and appears to correspond to a change from predominantly andesitic to predominantly rhyolitic composition. The increased concentrations of K-feldspar minerals are inferred to promote elevated radioactivity on the gamma-ray logs. The interval is indurated, which coincides with a reduction in drilling rate from 12 ft/hr to 6 ft/hr. 900'-920' Abundant sericitic alteration in rhyolitic tuffs promotes a bleached white coloration. 930'-970' Clay fraction decreases to 20-30%. Drilling rate reduced from 12 ft/hr to 8 ft/hr. 990'-1,020' Clay fraction comprises <10% of sample. Competent mixed volcanic clasts characterize the sample. TD = 1,020'


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-880
-890
-900
-910
-920
-930
-940
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-960
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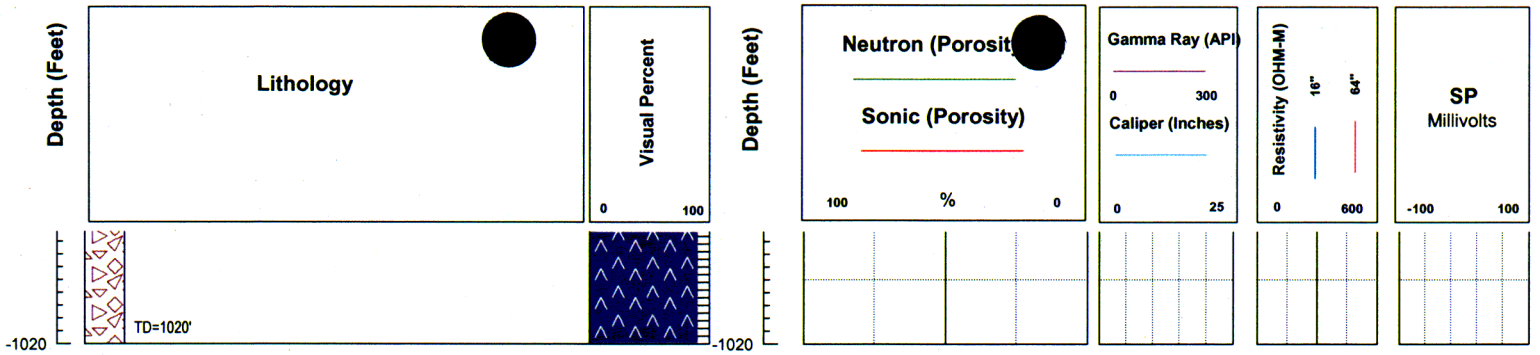
-990
-1000
-1010


Depth (Feet)
Lithology
Visual Percent
0
100
TD=1020'
-1020
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-1020

BOREHOLE LITHOLOGIC LOG

NASA JSC - White Sands Test Facility, Las Cruces, New Mexico, USA

Location ID: **PFI-2**

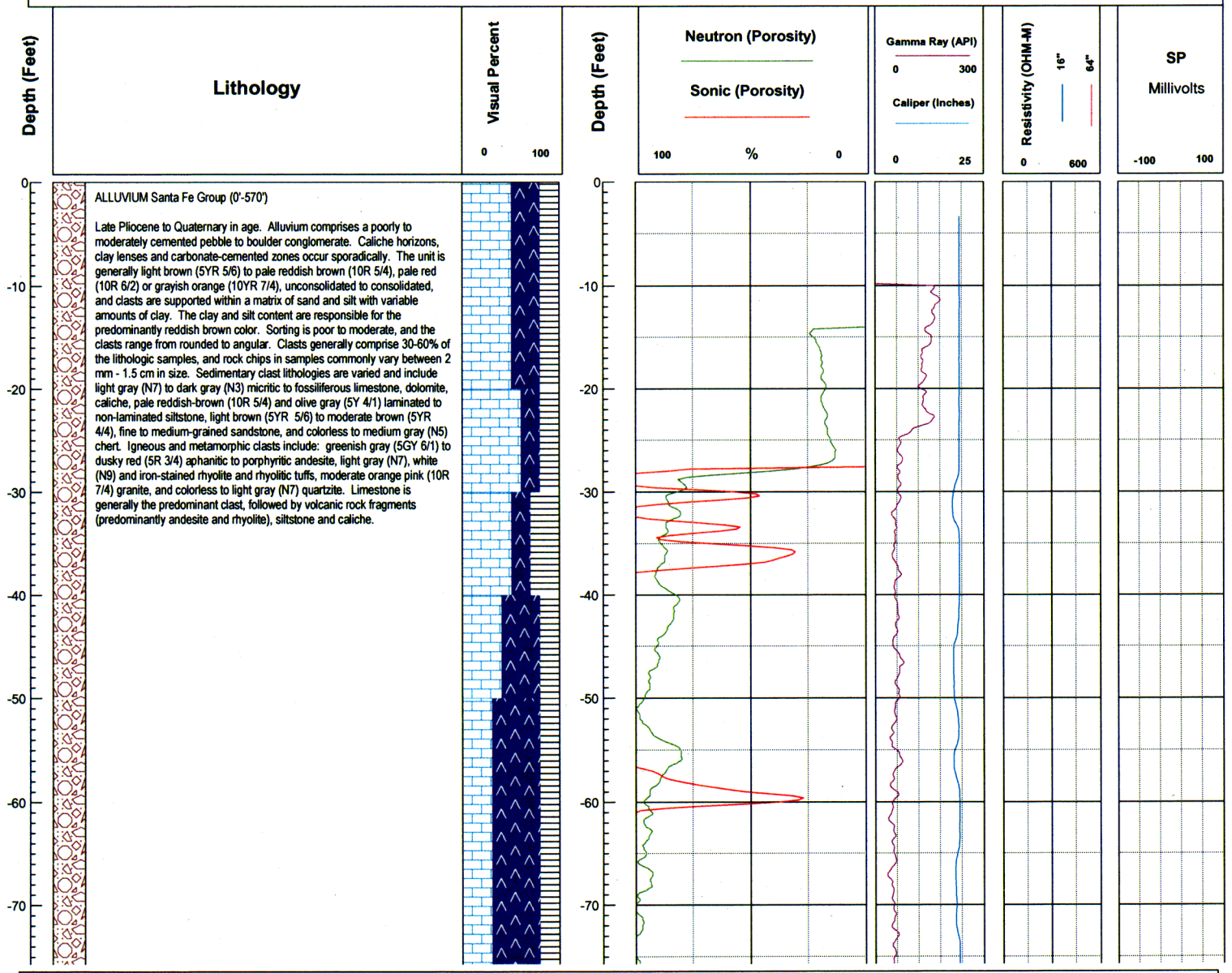
Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **SE 1/4, NW 1/4, SE 1/4 Sec 5, T21S, R3E**
NM State Plane Coordinates (NAD 83): **224294.66N 401254.50E (Preliminary)**
Elevation (Brass Cap): **4481.14' (Preliminary)**
Total Depth of Borehole (bgs): **1,020'**
Depth to Bedrock (bgs): **N/A**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co**
Driller: **Juan Aguilar**

Depth to Groundwater (bgs): **436.64'**
Surface Casing Depth and Diameter: **20" OD Steel set to 115'**
Borehole Diameter: **17.5"**
Geologist Field Rep: **M.C., G.G., L.H.M., J.P., M.S., J.K.**
Dates Drilling Started and Completed: **5/28/00 to 6/14/00**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Plume-Front Injection Well**

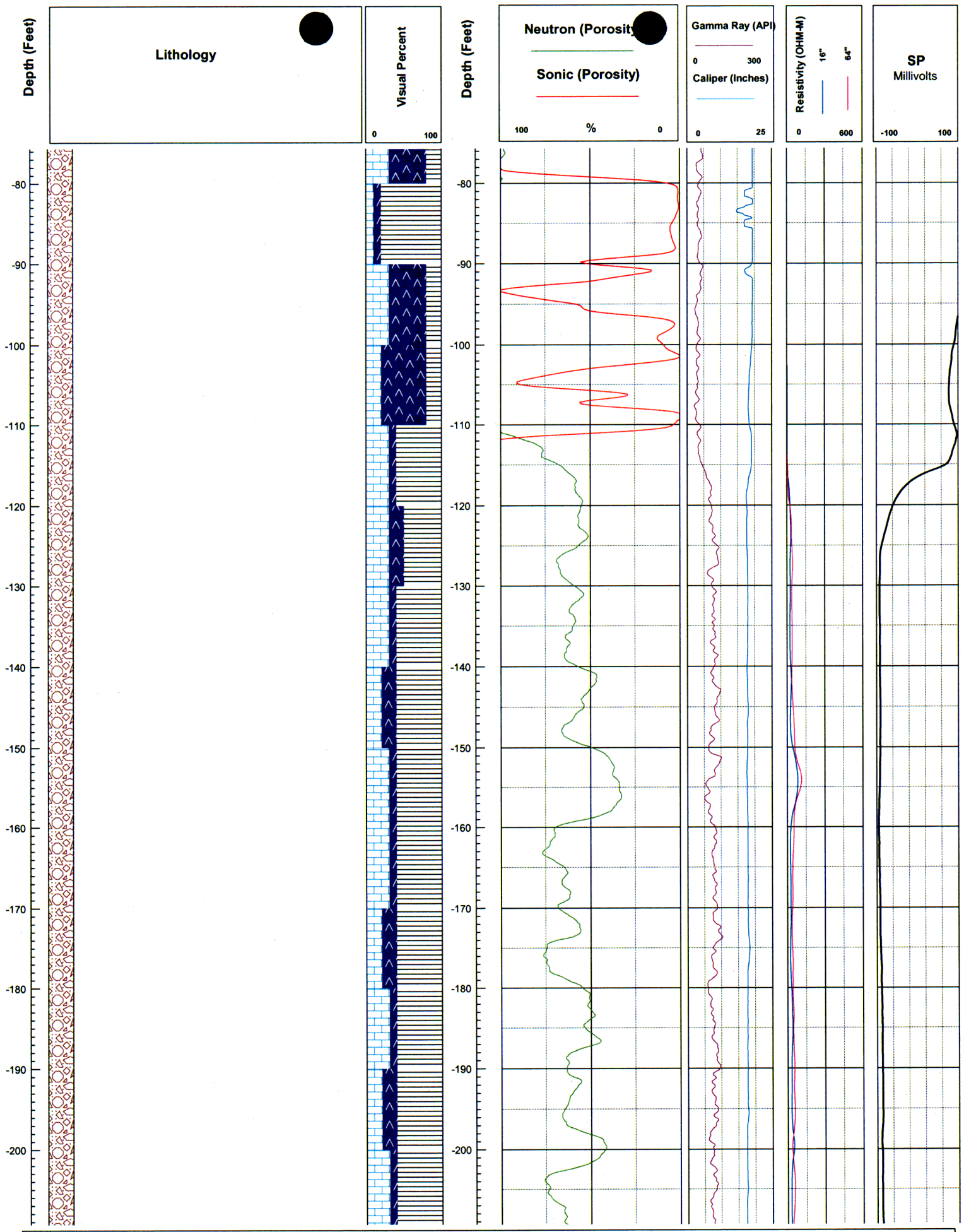
Explanation:

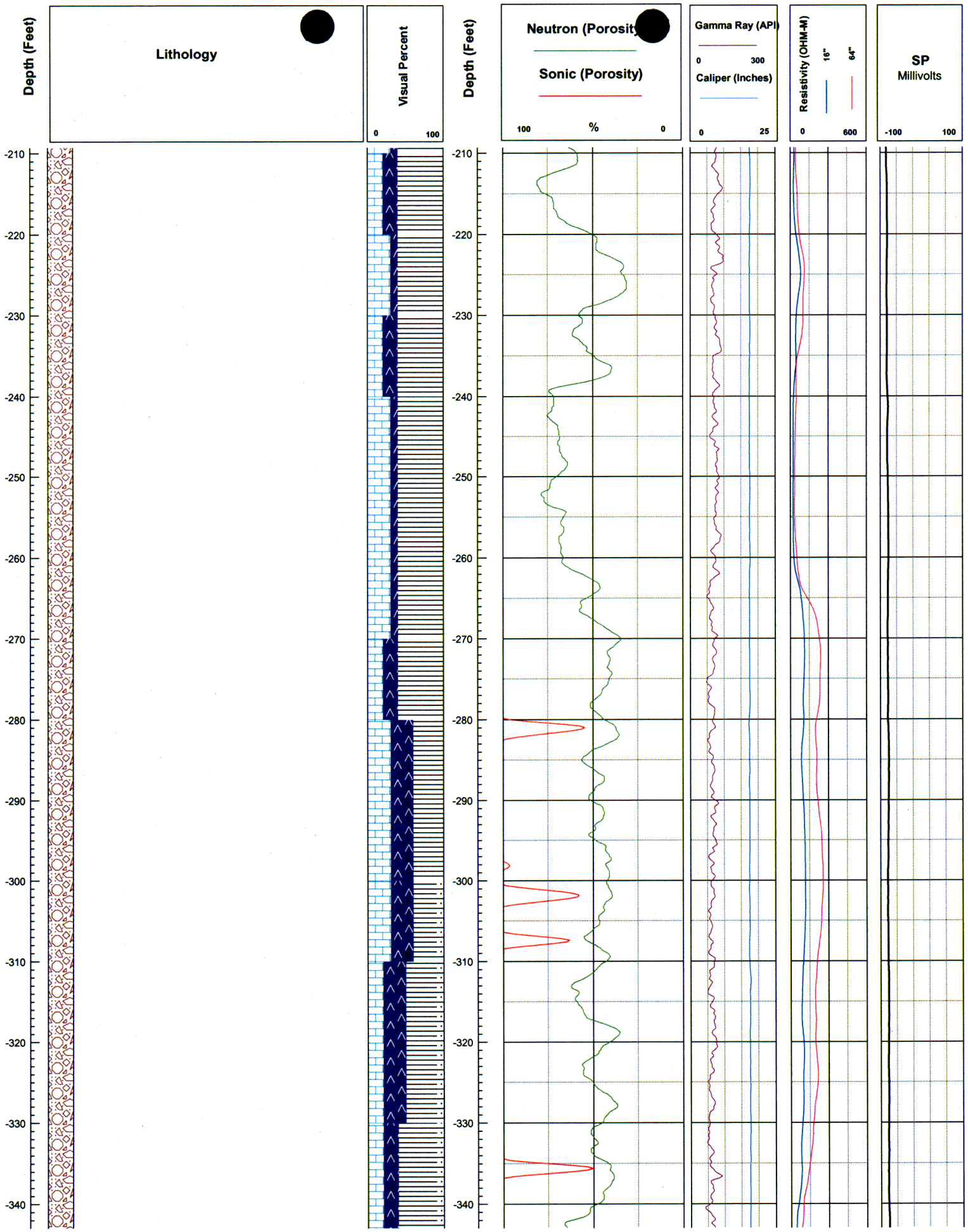
Alluvium | Volcanic Alluvium | Clay | Silt | Sand | Sandstone | Siltstone | Shale | Limestone | Rhyolite | Andesite | Undiffer. Volcanics

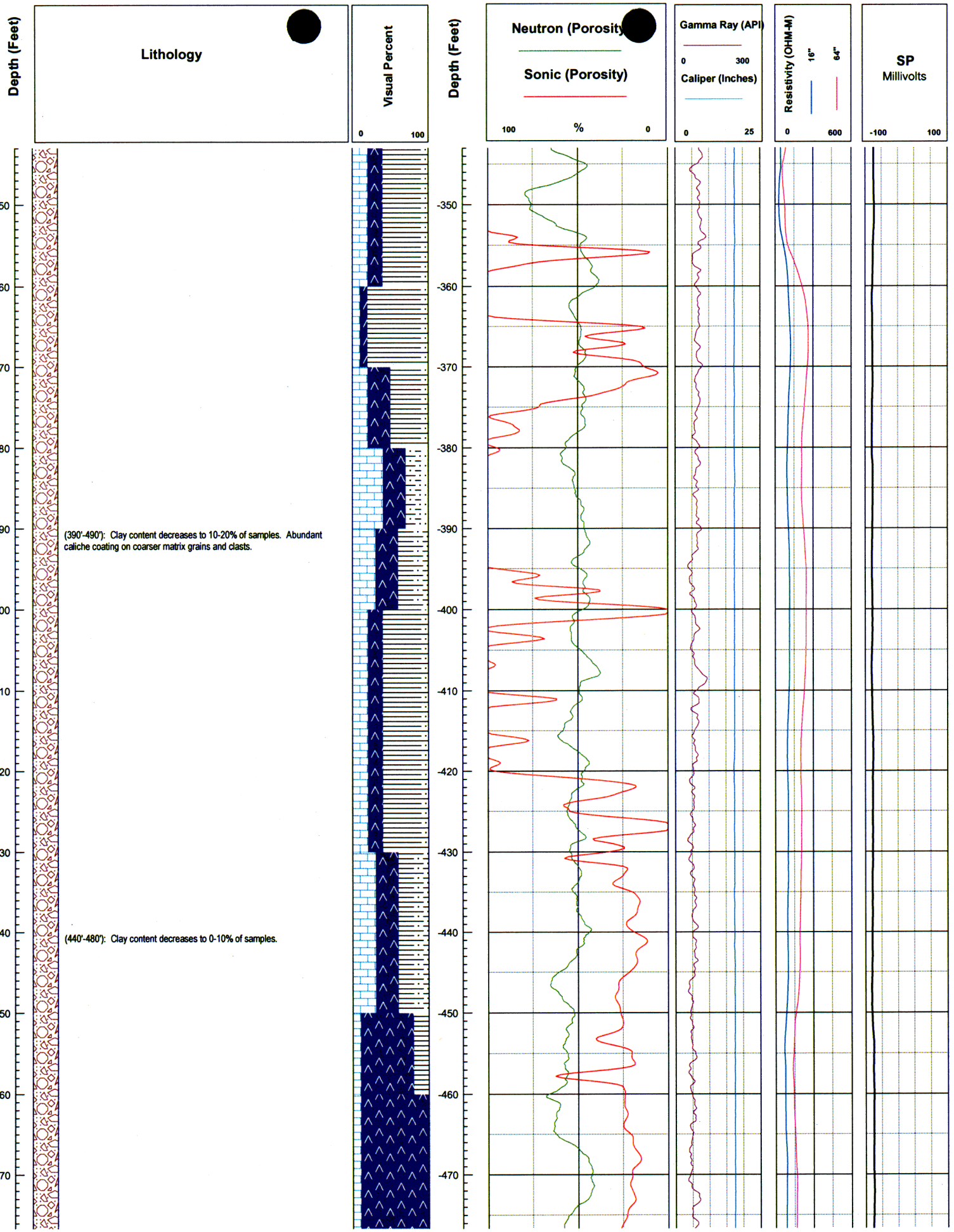


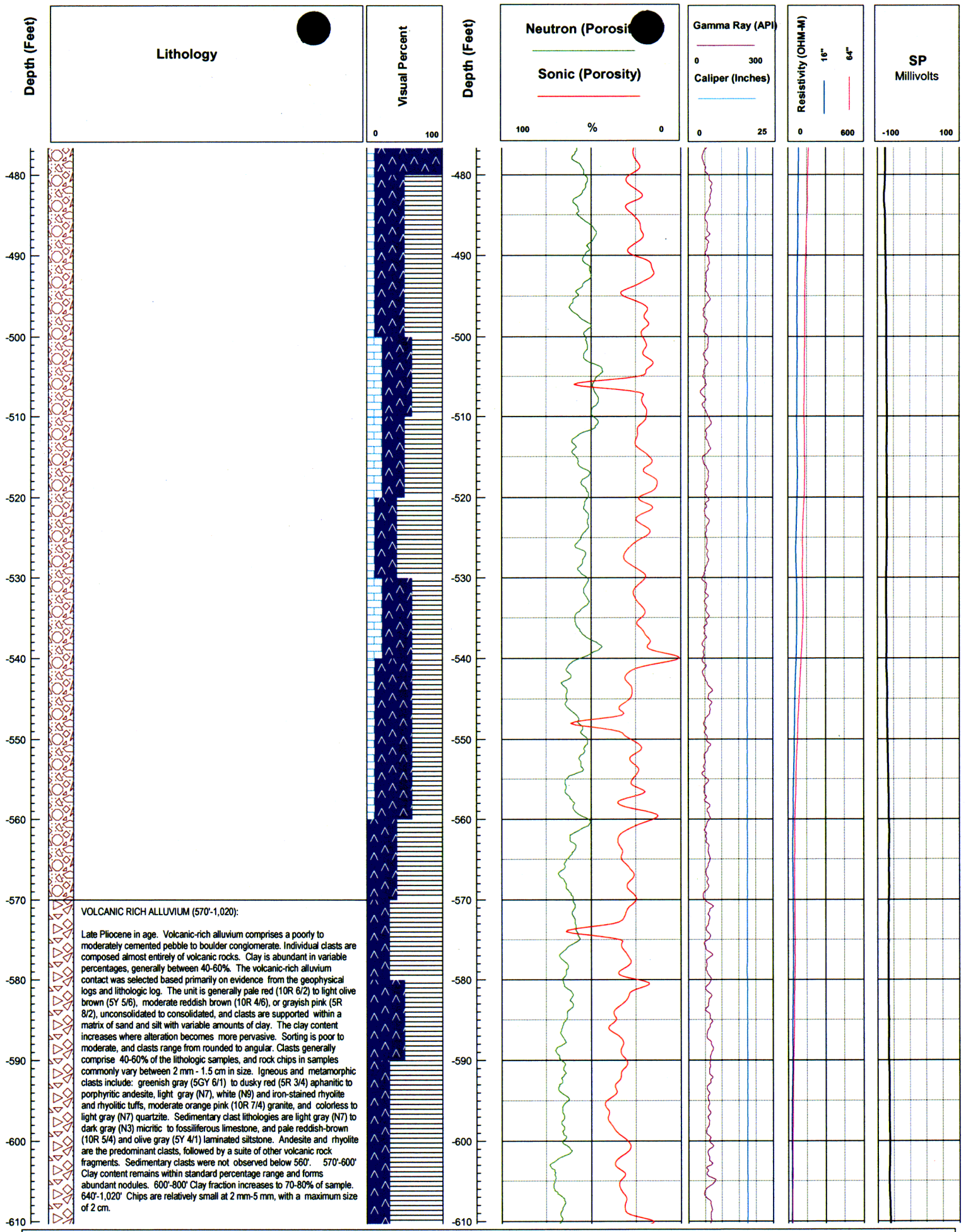
ALLUVIUM Santa Fe Group (0'-570')

Late Pliocene to Quaternary in age. Alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Caliche horizons, clay lenses and carbonate-cemented zones occur sporadically. The unit is generally light brown (5YR 5/6) to pale reddish brown (10R 5/4), pale red (10R 6/2) or grayish orange (10YR 7/4), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay and silt content are responsible for the predominantly reddish brown color. Sorting is poor to moderate, and the clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Sedimentary clast lithologies are varied and include light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, dolomite, caliche, pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated to non-laminated siltstone, light brown (5YR 5/6) to moderate brown (5YR 4/4), fine to medium-grained sandstone, and colorless to medium gray (N5) chert. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Limestone is generally the predominant clast, followed by volcanic rock fragments (predominantly andesite and rhyolite), siltstone and caliche.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200

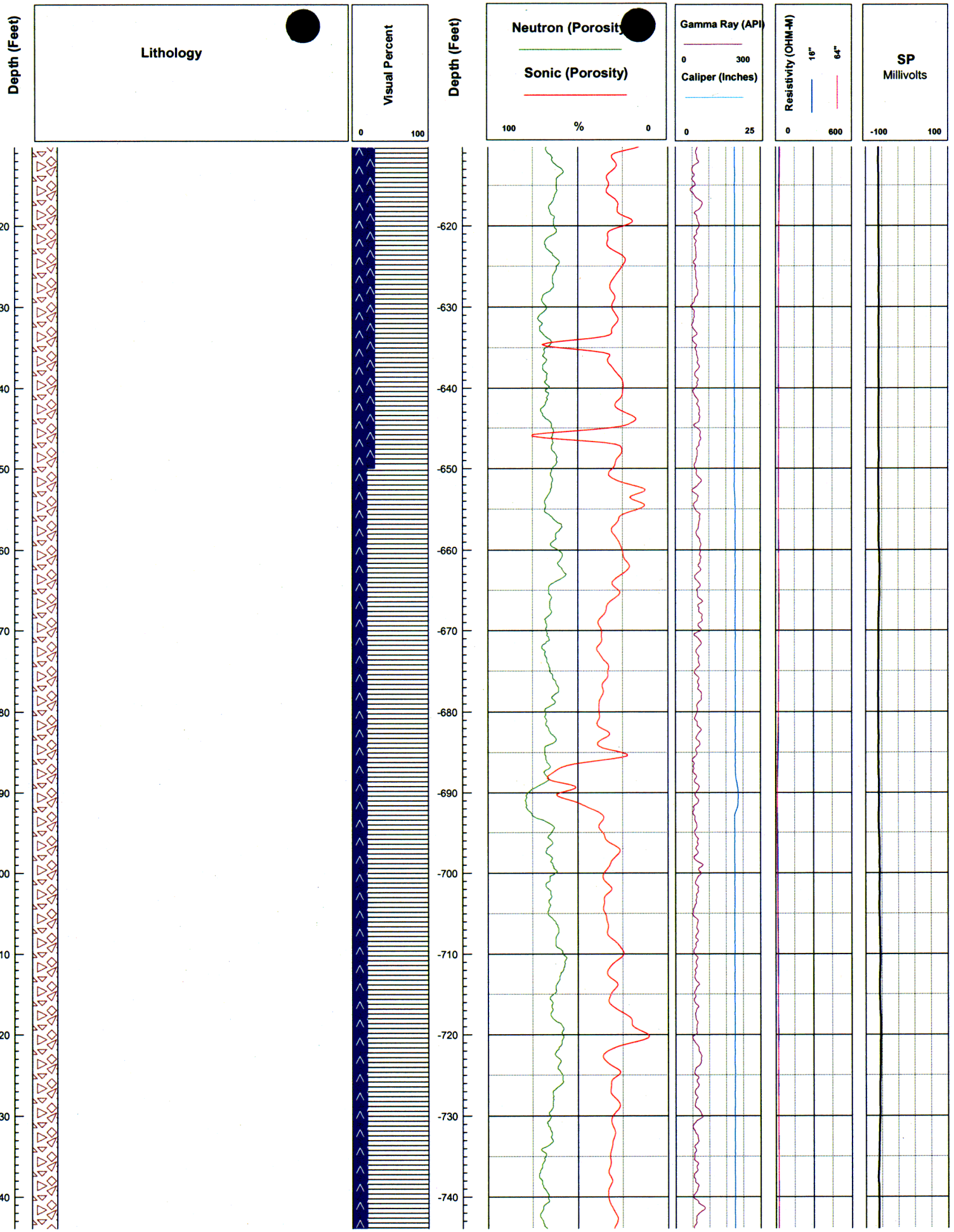

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340

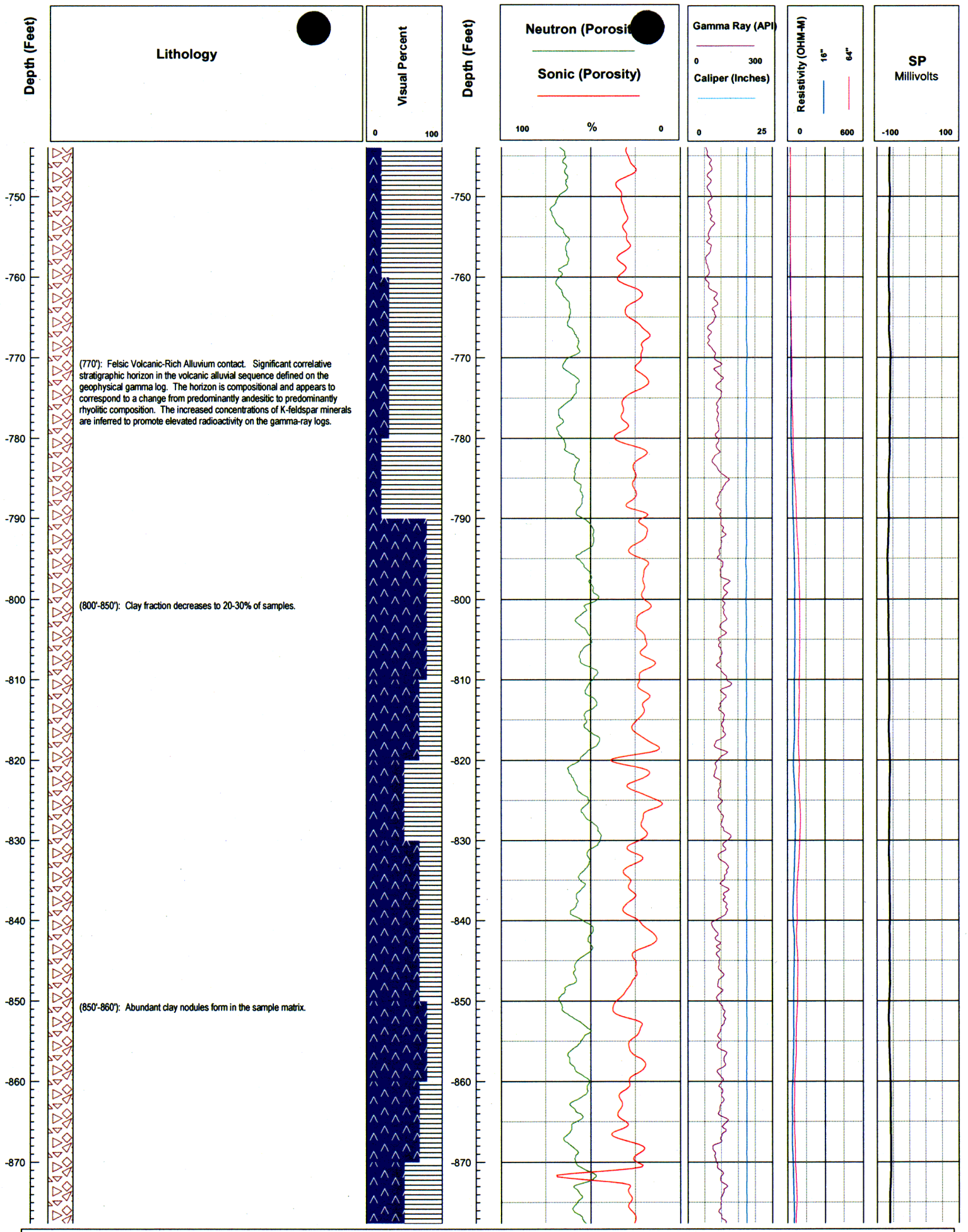

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470
(390'-490'): Clay content decreases to 10-20% of samples. Abundant caliche coating on coarser matrix grains and clasts.
(440'-480'): Clay content decreases to 0-10% of samples.

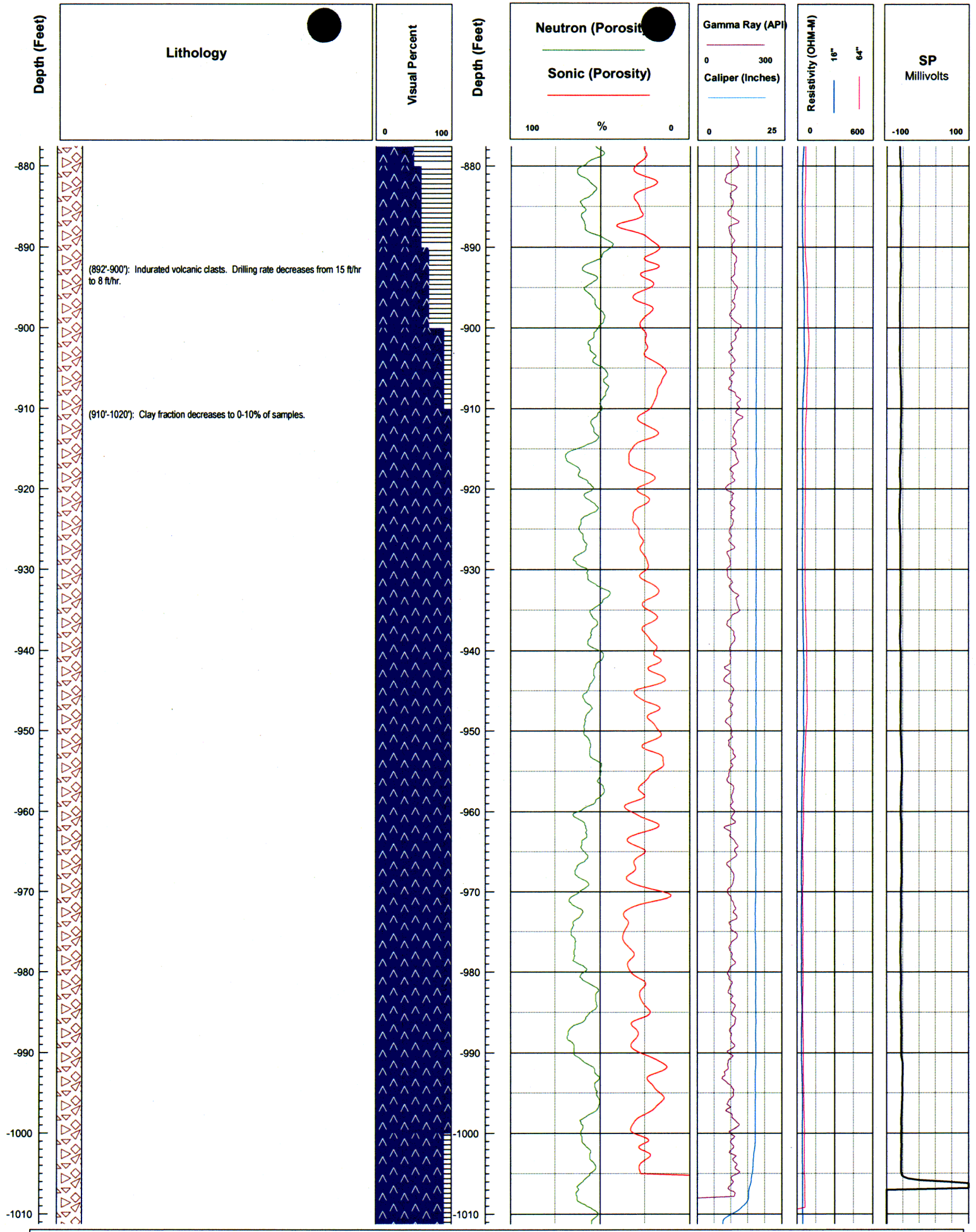


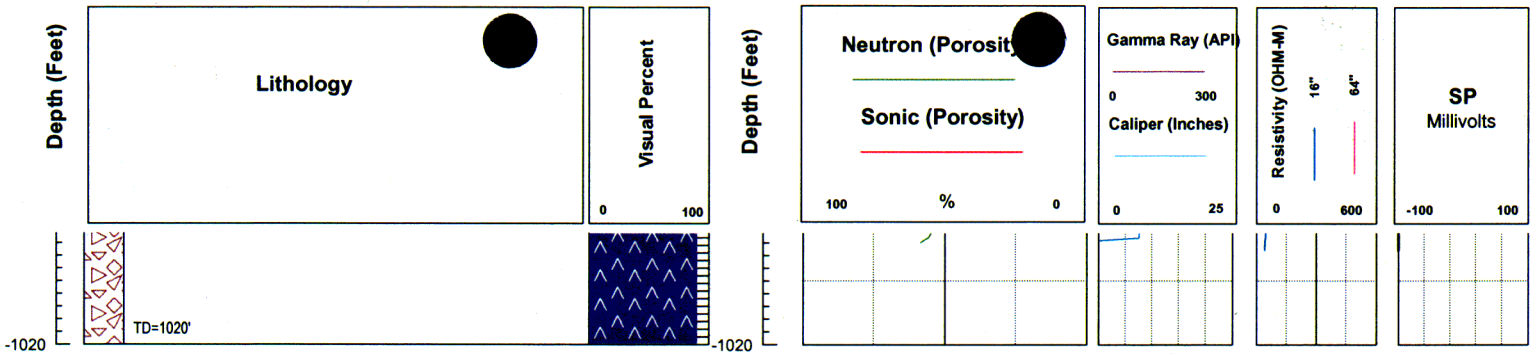
VOLCANIC RICH ALLUVIUM (570'-1,020):

Late Pliocene in age. Volcanic-rich alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Individual clasts are composed almost entirely of volcanic rocks. Clay is abundant in variable percentages, generally between 40-60%. The volcanic-rich alluvium contact was selected based primarily on evidence from the geophysical logs and lithologic log. The unit is generally pale red (10R 6/2) to light olive brown (5Y 5/6), moderate reddish brown (10R 4/6), or grayish pink (5R 8/2), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay content increases where alteration becomes more pervasive. Sorting is poor to moderate, and clasts range from rounded to angular. Clasts generally comprise 40-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Sedimentary clast lithologies are light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, and pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated siltstone. Andesite and rhyolite are the predominant clasts, followed by a suite of other volcanic rock fragments. Sedimentary clasts were not observed below 560'. 570'-600' Clay content remains within standard percentage range and forms abundant nodules. 600'-800' Clay fraction increases to 70-80% of sample. 640'-1,020' Chips are relatively small at 2 mm-5 mm, with a maximum size of 2 cm.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-620
-630
-640
-650
-660
-670
-680
-690
-700
-710
-720
-730
-740


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-750
-760
-770
-780
-790
-800
-810
-820
-830
-840
-850
-860
-870
(770'): Felsic Volcanic-Rich Alluvium contact. Significant correlative stratigraphic horizon in the volcanic alluvial sequence defined on the geophysical gamma log. The horizon is compositional and appears to correspond to a change from predominantly andesitic to predominantly rhyolitic composition. The increased concentrations of K-feldspar minerals are inferred to promote elevated radioactivity on the gamma-ray logs.
(800'-850'): Clay fraction decreases to 20-30% of samples.
(850'-860'): Abundant clay nodules form in the sample matrix.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
(892'-900'): Indurated volcanic clasts. Drilling rate decreases from 15 ft/hr to 8 ft/hr.
(910'-1020'): Clay fraction decreases to 0-10% of samples.
-880
-890
-900
-910
-920
-930
-940
-950
-960
-970
-980
-990
-1000
-1010


Depth (Feet)
Lithology
Visual Percent
0
100
TD=1020'
-1020
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-1020

NASA JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

BOREHOLE LITHOLOGIC LOG

Location ID: **PFI-3**

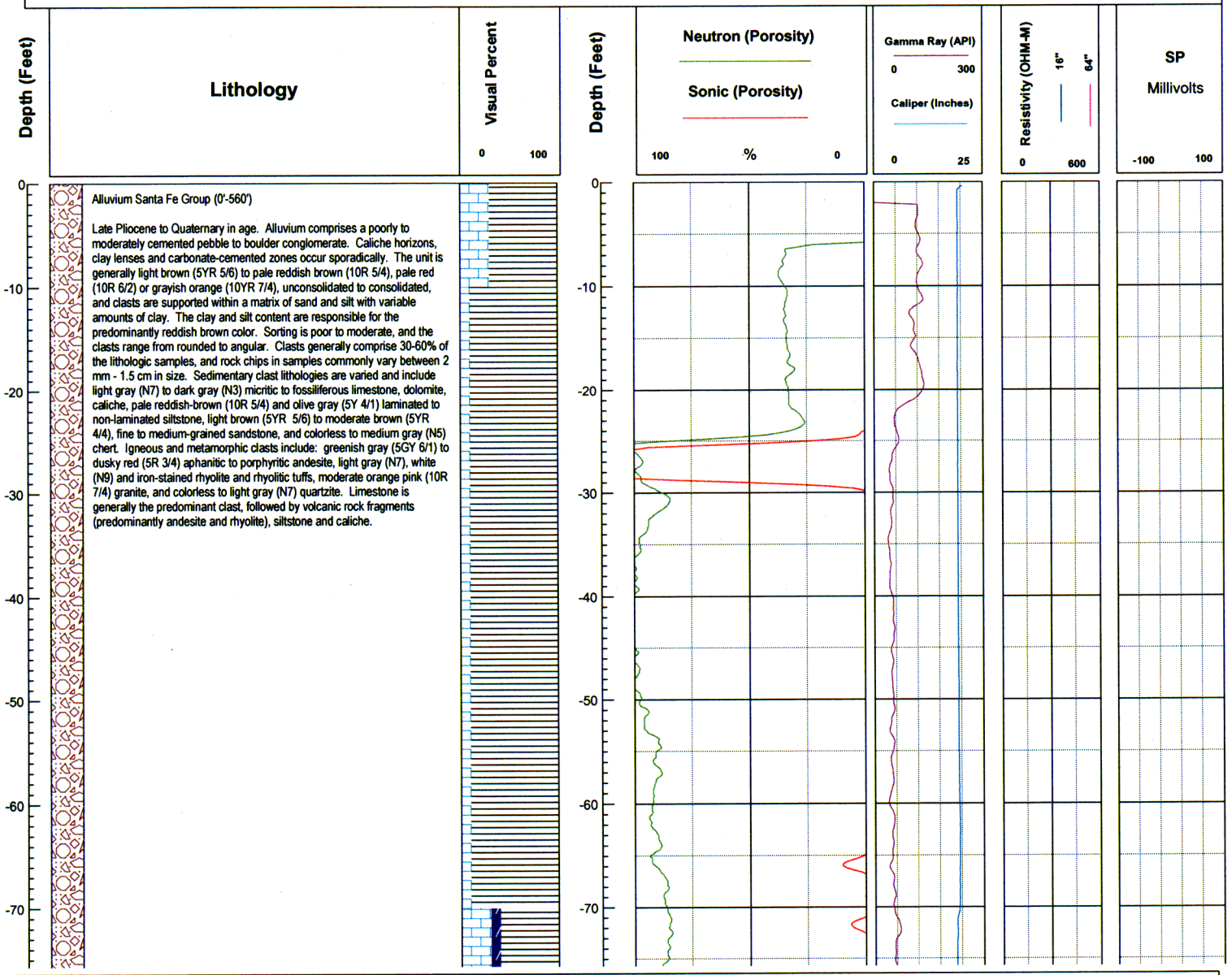
Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **NW 1/4, SE 1/4, SE 1/4, Sec 5, T21S, R3E**
NM State Plane Coordinates (NAD 83): **223717.90N 401771.04E (Preliminary)**
Elevation (Brass Cap): **4498.87' (Preliminary)**
Total Depth of Borehole (bgs): **1,020'**
Depth to Bedrock (bgs): **N/A**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Juan Aguilar**

Depth to Groundwater (bgs): **446.74'**
Surface Casing Depth and Diameter: **20" OD Steel set to 111.5'**
Borehole Diameter: **17.5"**
Geologist Field Rep: **M.C., G.G., L.H.M., J.P., M.S.**
Dates Drilling Started and Completed: **5/2/00 to 5/16/00**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Plume-Front Injection Well**

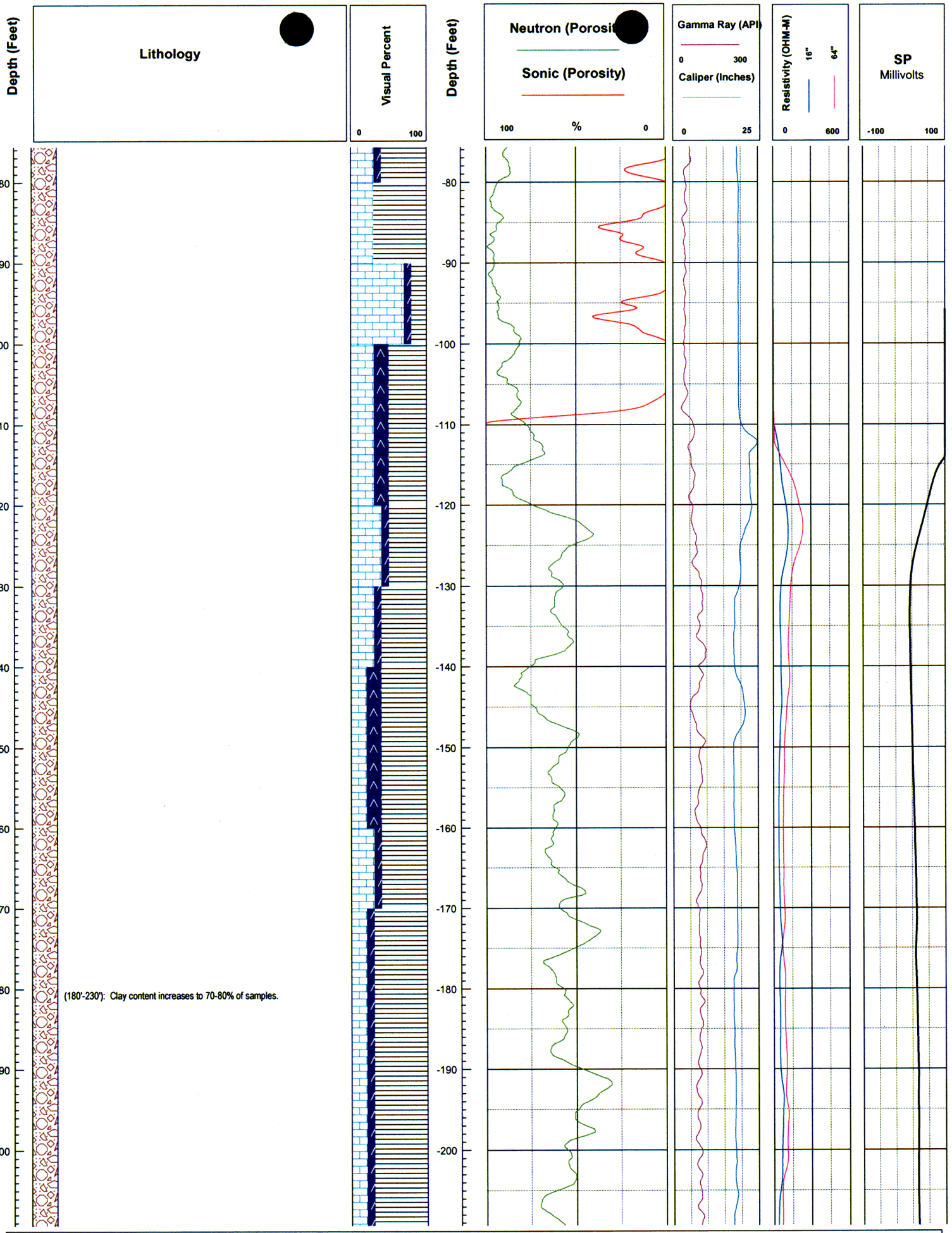
Explanation:

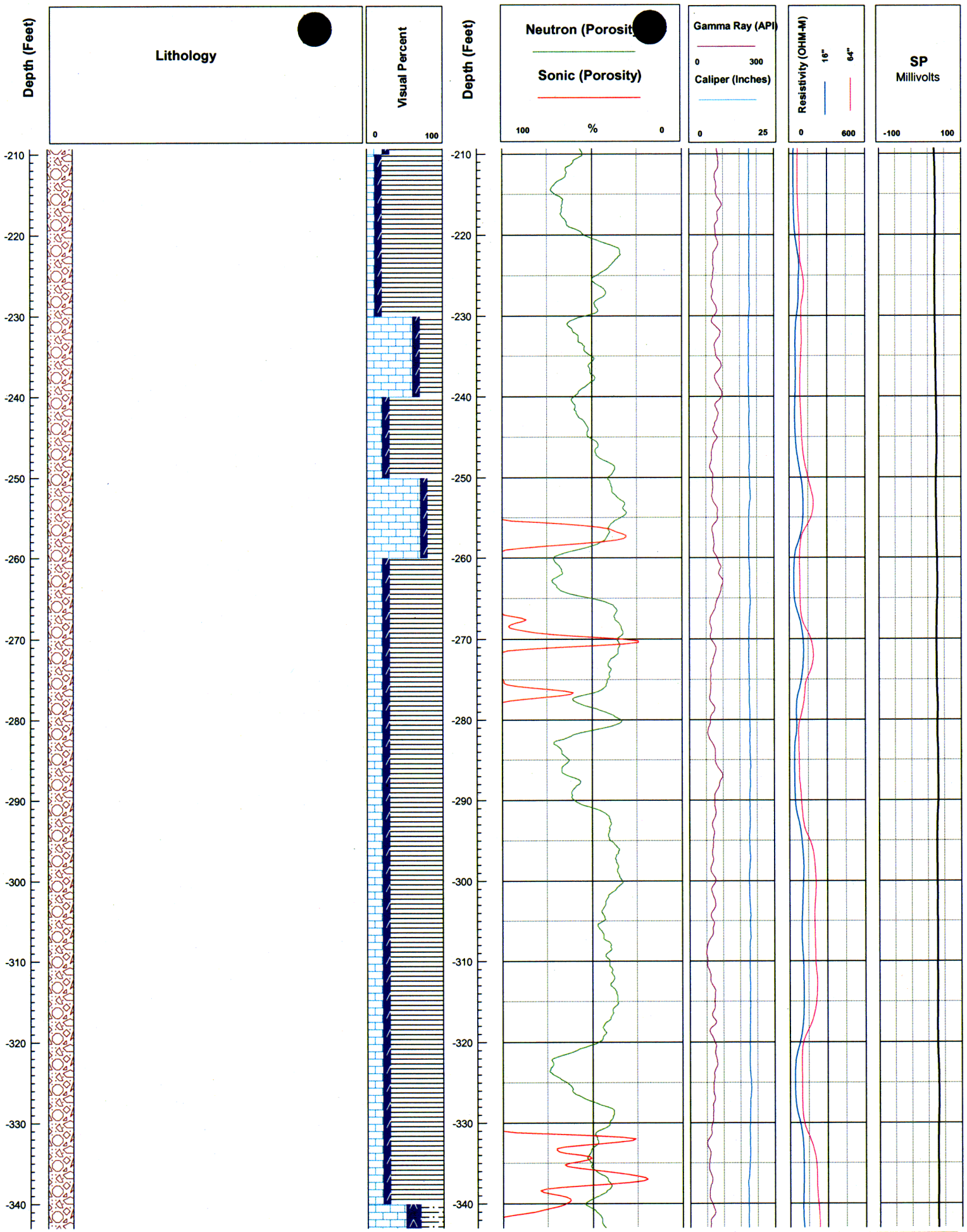
Alluvium | Volcanic Alluvium | Clay | Silt | Sand | Sandstone | Siltstone | Shale | Limestone | Rhyolite | Andesite | Undiffer. Volcanics

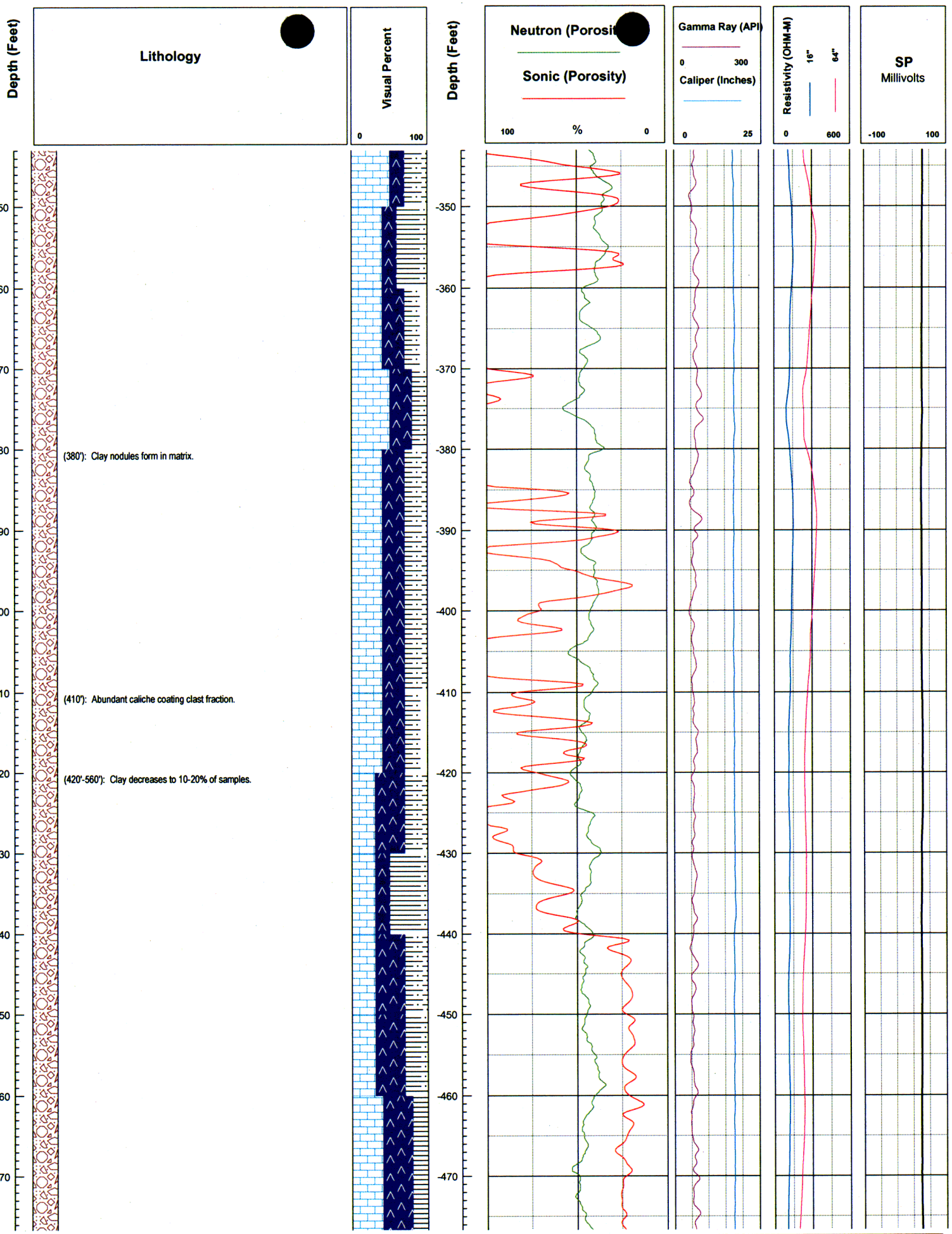


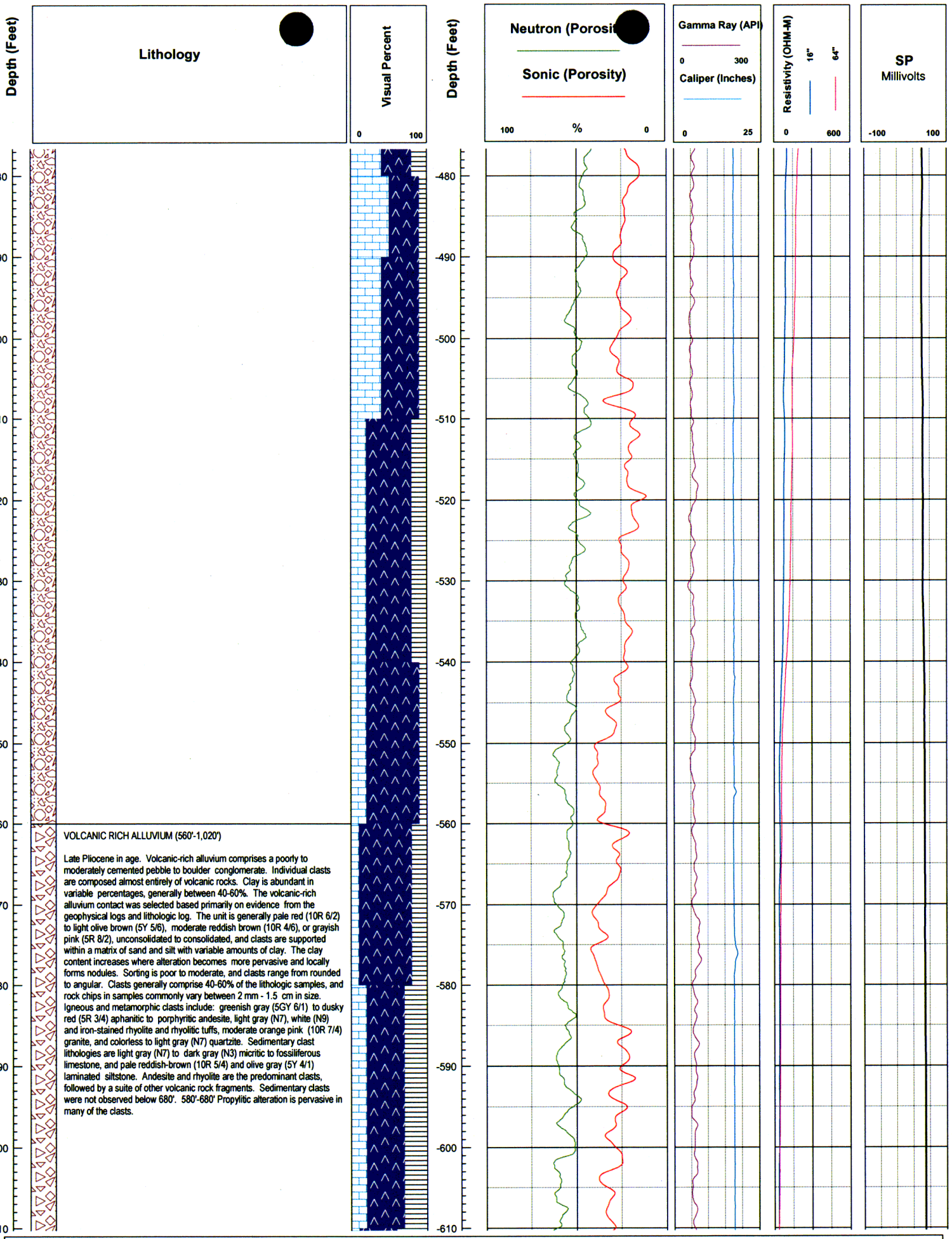
Alluvium Santa Fe Group (0'-560')

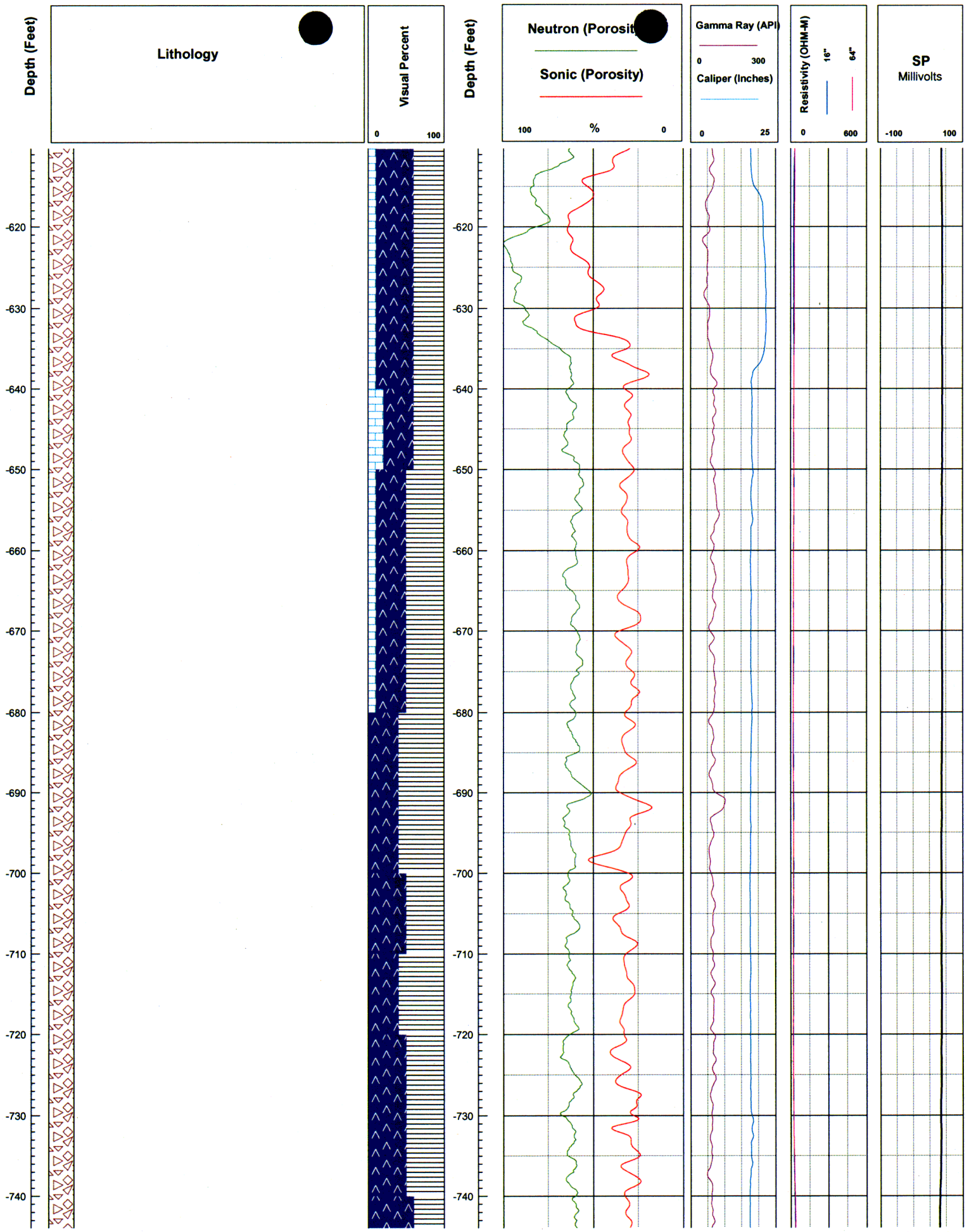
Late Pliocene to Quaternary in age. Alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Caliche horizons, clay lenses and carbonate-cemented zones occur sporadically. The unit is generally light brown (5YR 5/6) to pale reddish brown (10R 5/4), pale red (10R 6/2) or grayish orange (10YR 7/4), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay and silt content are responsible for the predominantly reddish brown color. Sorting is poor to moderate, and the clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Sedimentary clast lithologies are varied and include light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, dolomite, caliche, pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated to non-laminated siltstone, light brown (5YR 5/6) to moderate brown (5YR 4/4), fine to medium-grained sandstone, and colorless to medium gray (N5) chert. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Limestone is generally the predominant clast, followed by volcanic rock fragments (predominantly andesite and rhyolite), siltstone and caliche.

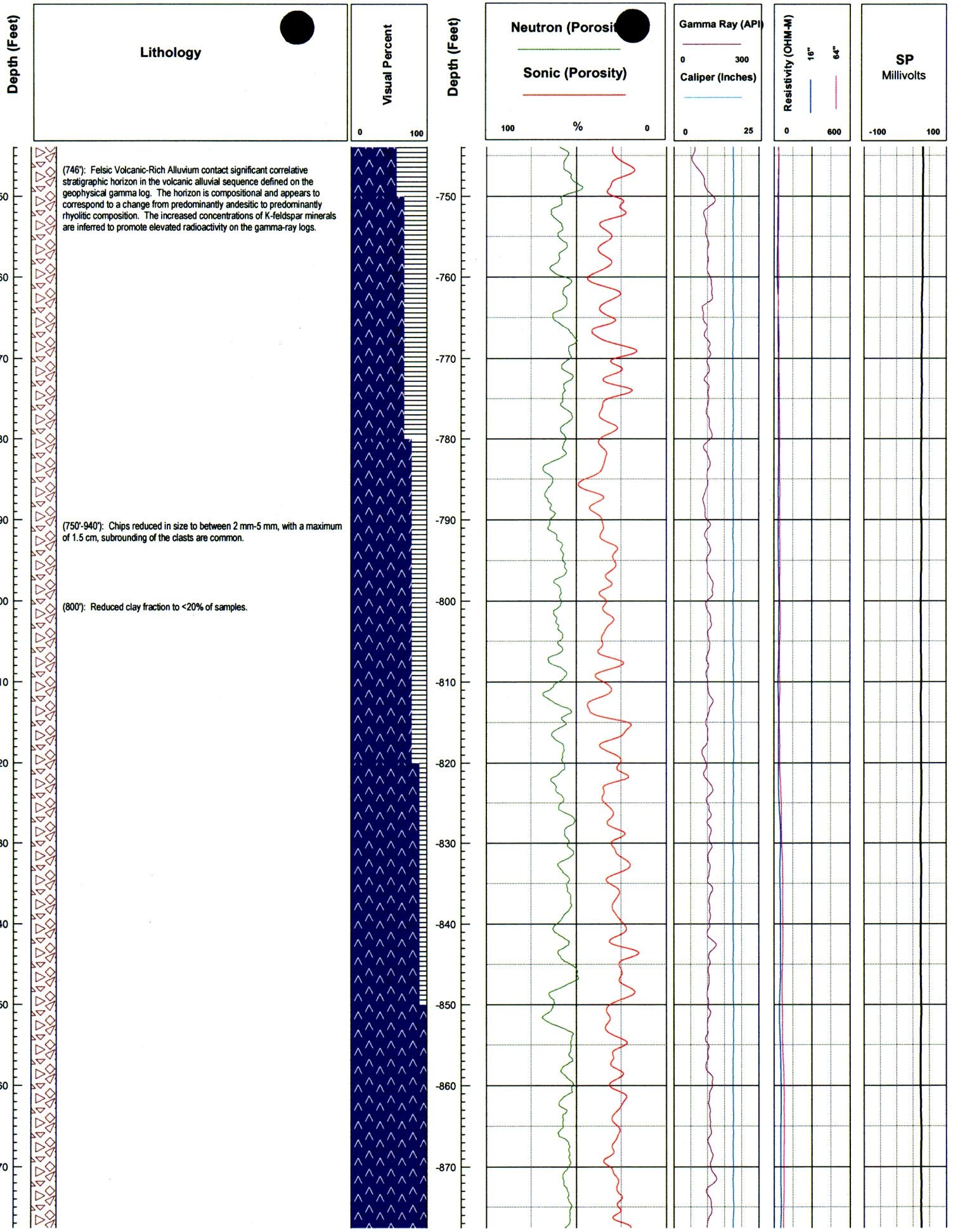

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
(180'-230'): Clay content increases to 70-80% of samples.

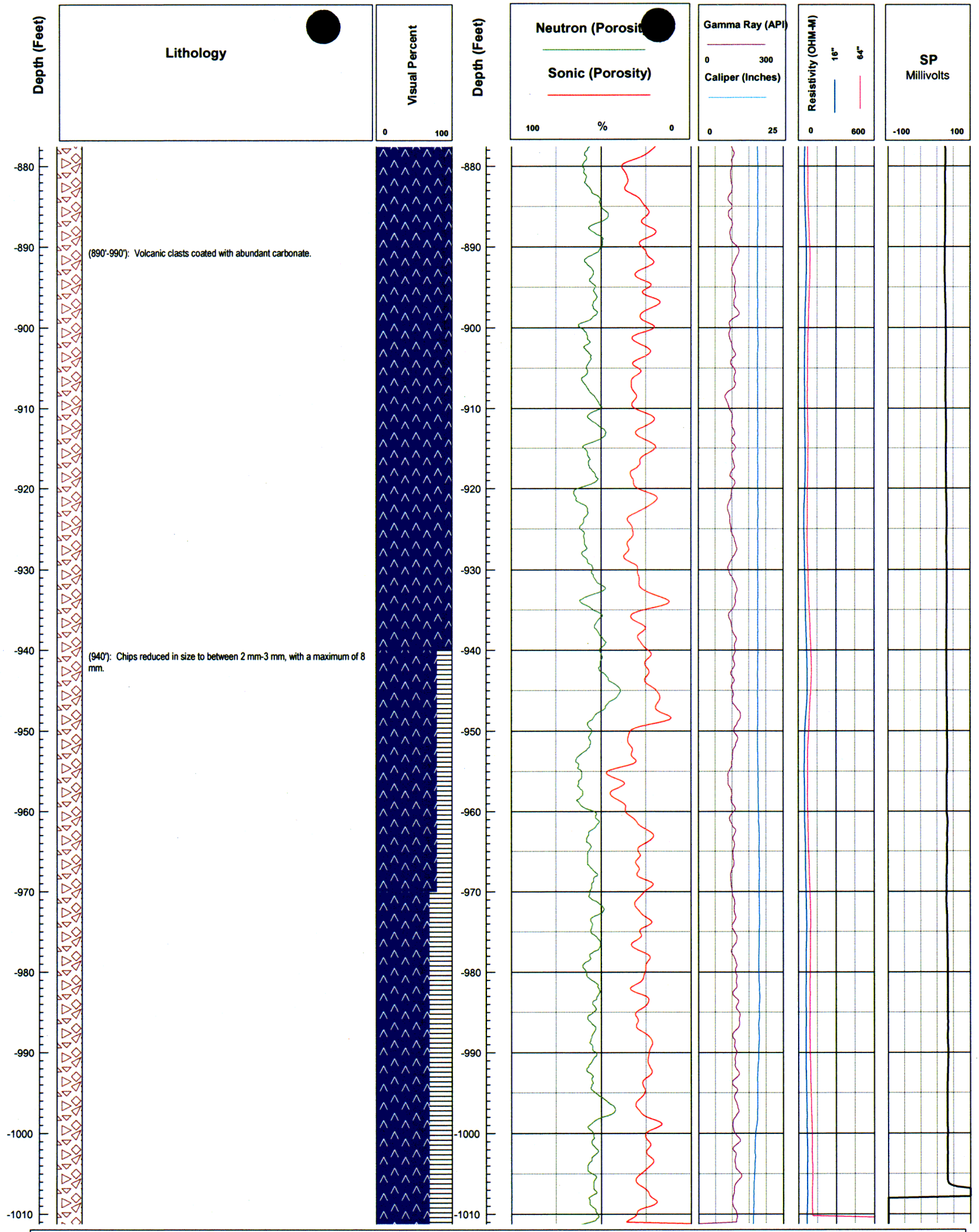

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340

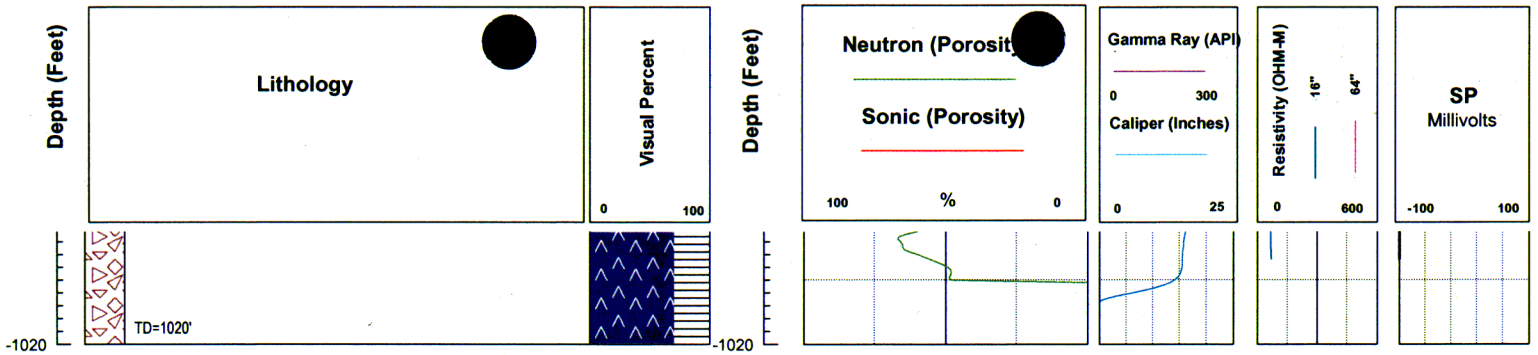

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470
(380'): Clay nodules form in matrix.
(410'): Abundant caliche coating clast fraction.
(420'-560'): Clay decreases to 10-20% of samples.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-480
-490
-500
-510
-520
-530
-540
-550
-560
-570
-580
-590
-600
-610
VOLCANIC RICH ALLUVIUM (560'-1,020')
Late Pliocene in age. Volcanic-rich alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Individual clasts are composed almost entirely of volcanic rocks. Clay is abundant in variable percentages, generally between 40-60%. The volcanic-rich alluvium contact was selected based primarily on evidence from the geophysical logs and lithologic log. The unit is generally pale red (10R 6/2) to light olive brown (5Y 5/6), moderate reddish brown (10R 4/6), or grayish pink (5R 8/2), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay content increases where alteration becomes more pervasive and locally forms nodules. Sorting is poor to moderate, and clasts range from rounded to angular. Clasts generally comprise 40-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Sedimentary clast lithologies are light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, and pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated siltstone. Andesite and rhyolite are the predominant clasts, followed by a suite of other volcanic rock fragments. Sedimentary clasts were not observed below 680'. 580'-680' Propylitic alteration is pervasive in many of the clasts.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-620
-630
-640
-650
-660
-670
-680
-690
-700
-710
-720
-730
-740


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
(746'): Felsic Volcanic-Rich Alluvium contact significant correlative stratigraphic horizon in the volcanic alluvial sequence defined on the geophysical gamma log. The horizon is compositional and appears to correspond to a change from predominantly andesitic to predominantly rhyolitic composition. The increased concentrations of K-feldspar minerals are inferred to promote elevated radioactivity on the gamma-ray logs.
(750'-940'): Chips reduced in size to between 2 mm-5 mm, with a maximum of 1.5 cm, subrounding of the clasts are common.
(800'): Reduced clay fraction to <20% of samples.
-750
-760
-770
-780
-790
-800
-810
-820
-830
-840
-850
-860
-870


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-880
-890
-900
-910
-920
-930
-940
-950
-960
-970
-980
-990
-1000
-1010
(890'-990'): Volcanic clasts coated with abundant carbonate.
(940'): Chips reduced in size to between 2 mm-3 mm, with a maximum of 8 mm.


Depth (Feet)
Lithology
Visual Percent
0
100
TD=1020'
-1020
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-1020

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

BOREHOLE LITHOLOGIC LOG

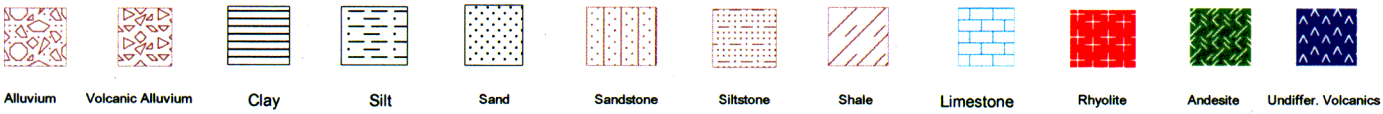
Location ID: **PFI-4**

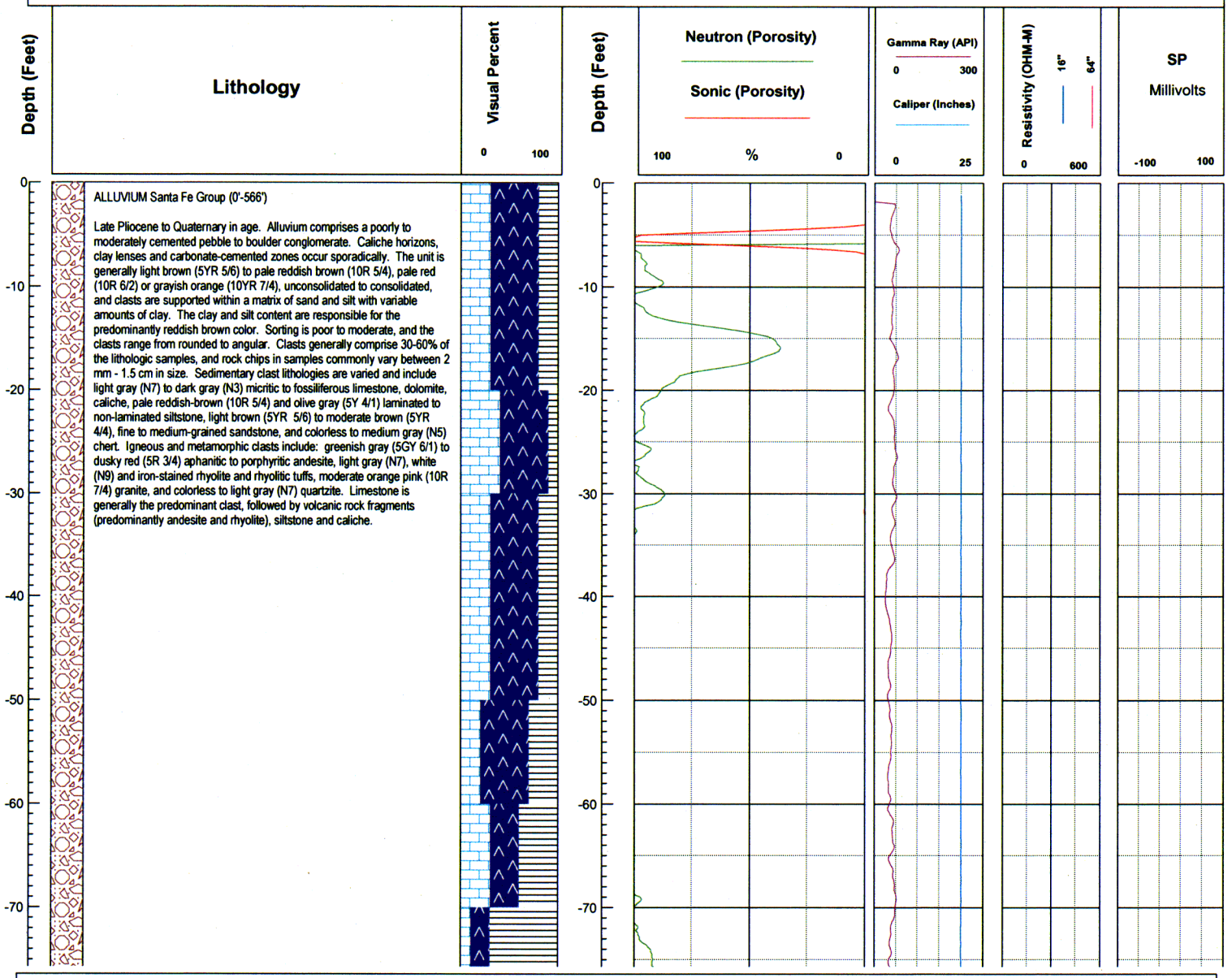
Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **SE 1/4, SE 1/4, SE 1/4, Sec 5, T21S, R3E**
NM State Plane Coordinates (NAD 83): **223293.22N 402374.66E (Preliminary)**
Elevation (Brass Cap): **4516.74' (Preliminary)**
Total Depth of Borehole (bgs): **911'**
Depth to Bedrock (bgs): **890'**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Juan Aguilar**

Depth to Groundwater (bgs): **457.86'**
Surface Casing Depth and Diameter: **20" OD Steel set to 115'**
Borehole Diameter: **17.5"**
Geologist Field Rep: **L.H.M., J.P., M.S., R.W.**
Dates Drilling Started and Completed: **6/25/00 to 7/9/00**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Plume-Front Injection Well**

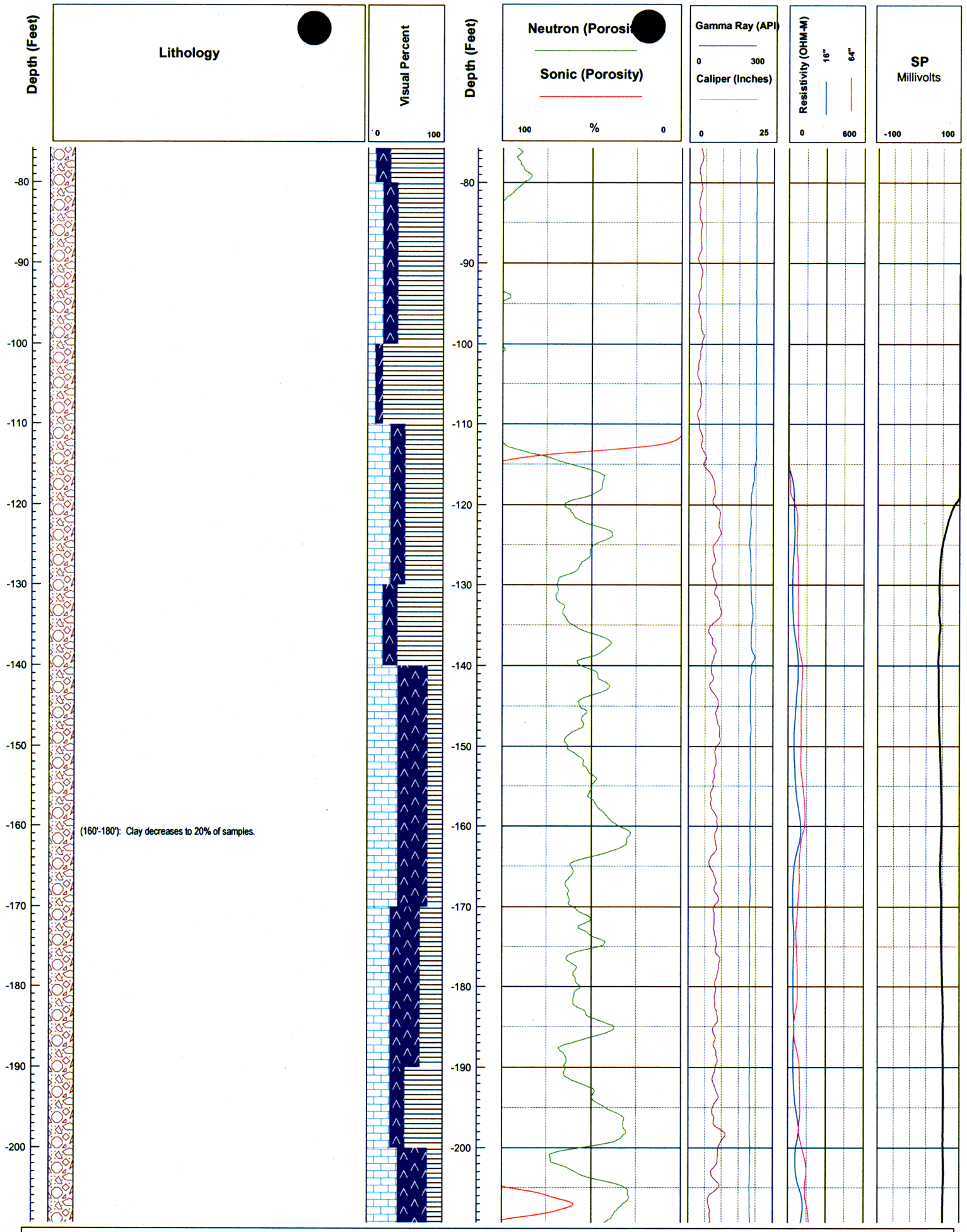
Explanation:

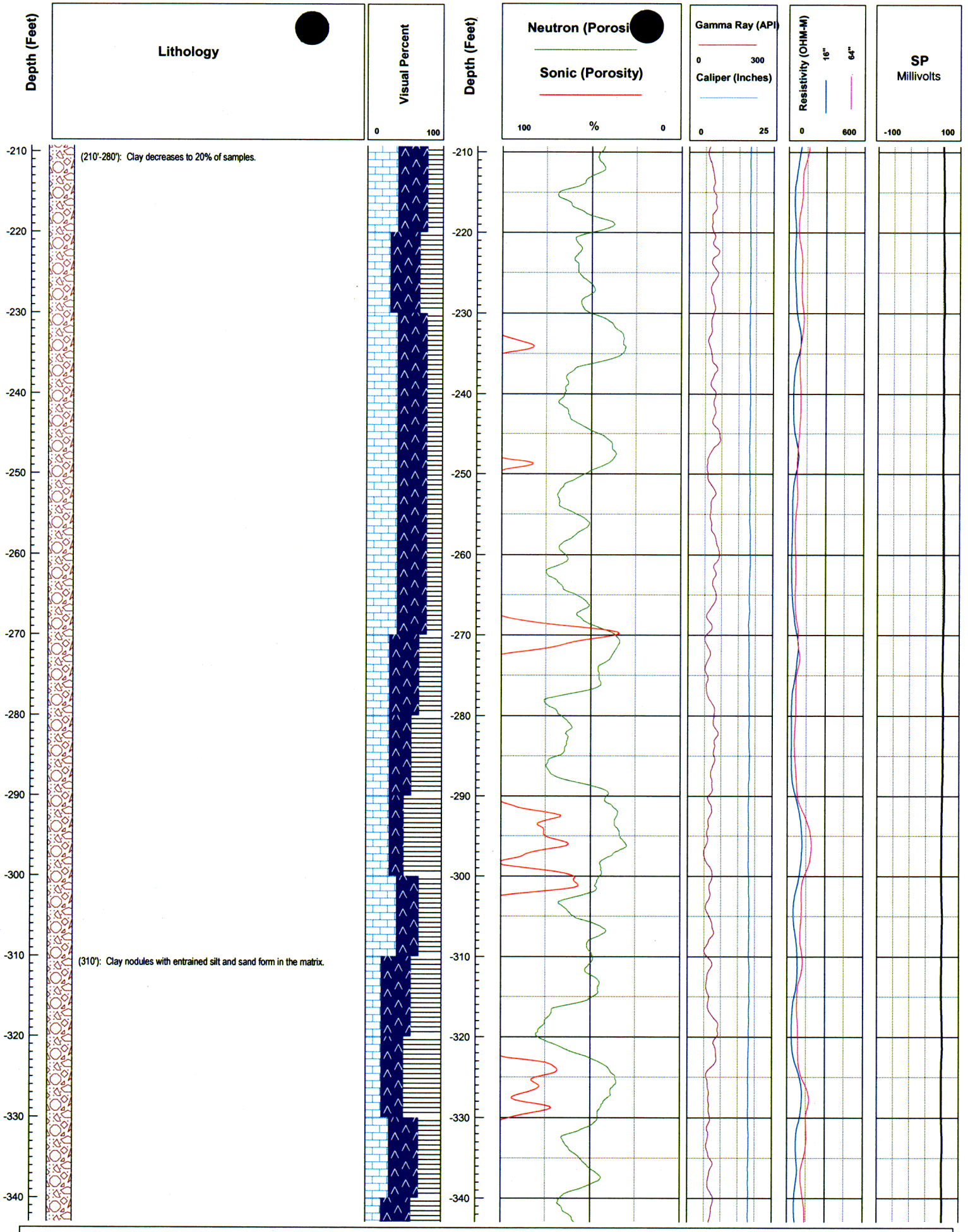


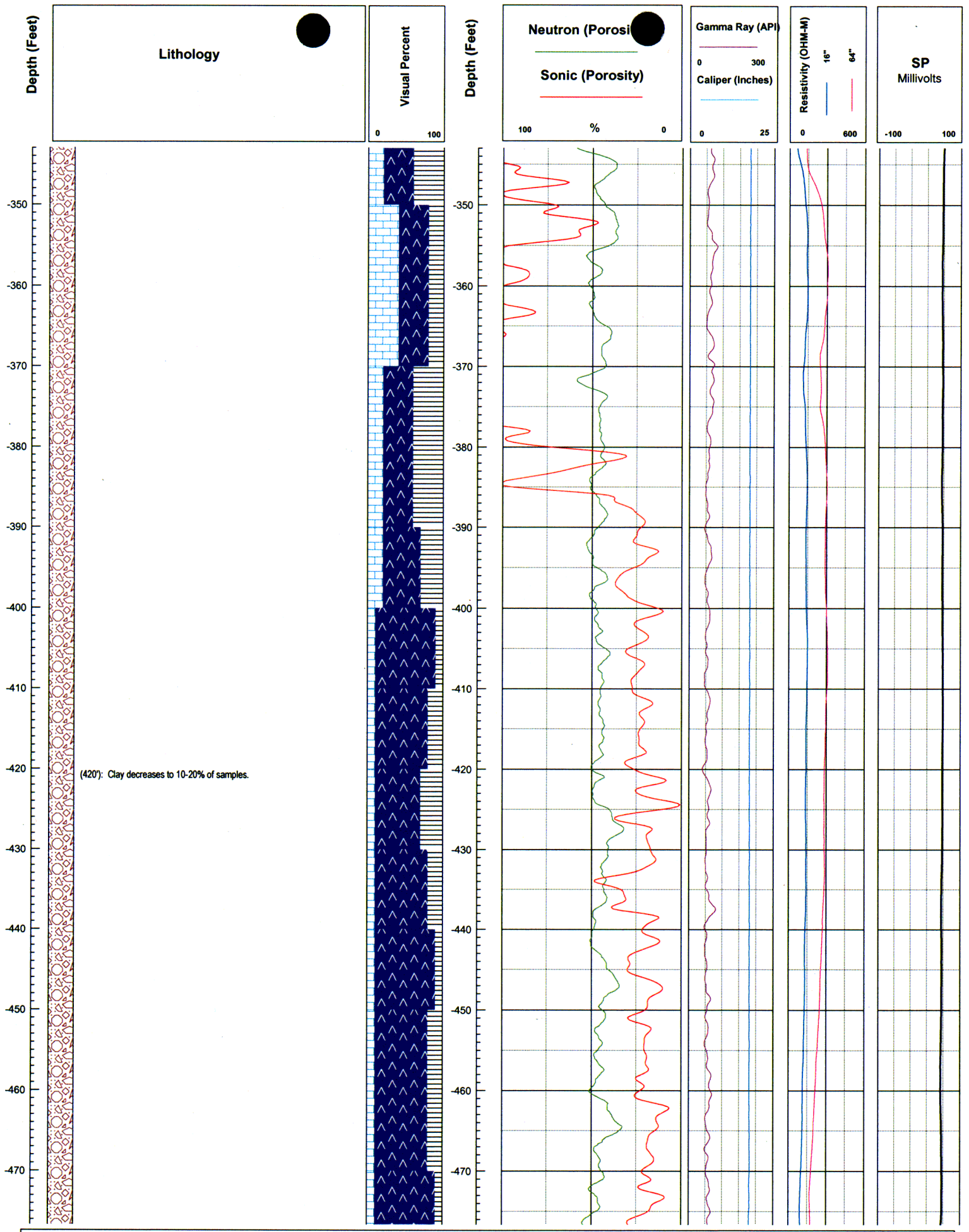


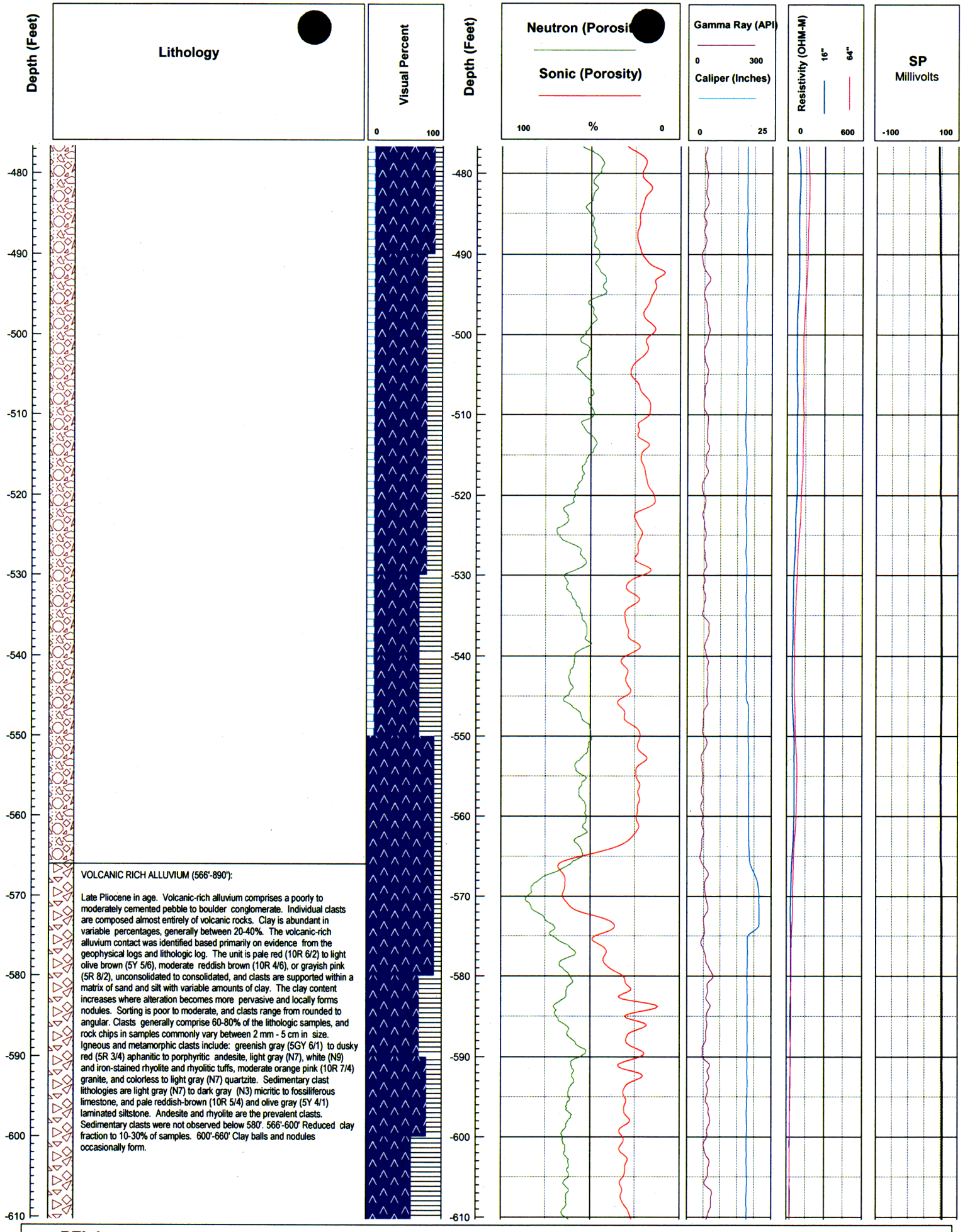
ALLUVIUM Santa Fe Group (0'-566')

Late Pliocene to Quaternary in age. Alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Caliche horizons, clay lenses and carbonate-cemented zones occur sporadically. The unit is generally light brown (5YR 5/6) to pale reddish brown (10R 5/4), pale red (10R 6/2) or grayish orange (10YR 7/4), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay and silt content are responsible for the predominantly reddish brown color. Sorting is poor to moderate, and the clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Sedimentary clast lithologies are varied and include light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, dolomite, caliche, pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated to non-laminated siltstone, light brown (5YR 5/6) to moderate brown (5YR 4/4), fine to medium-grained sandstone, and colorless to medium gray (N5) chert. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Limestone is generally the predominant clast, followed by volcanic rock fragments (predominantly andesite and rhyolite), siltstone and caliche.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
(160'-180'): Clay decreases to 20% of samples.

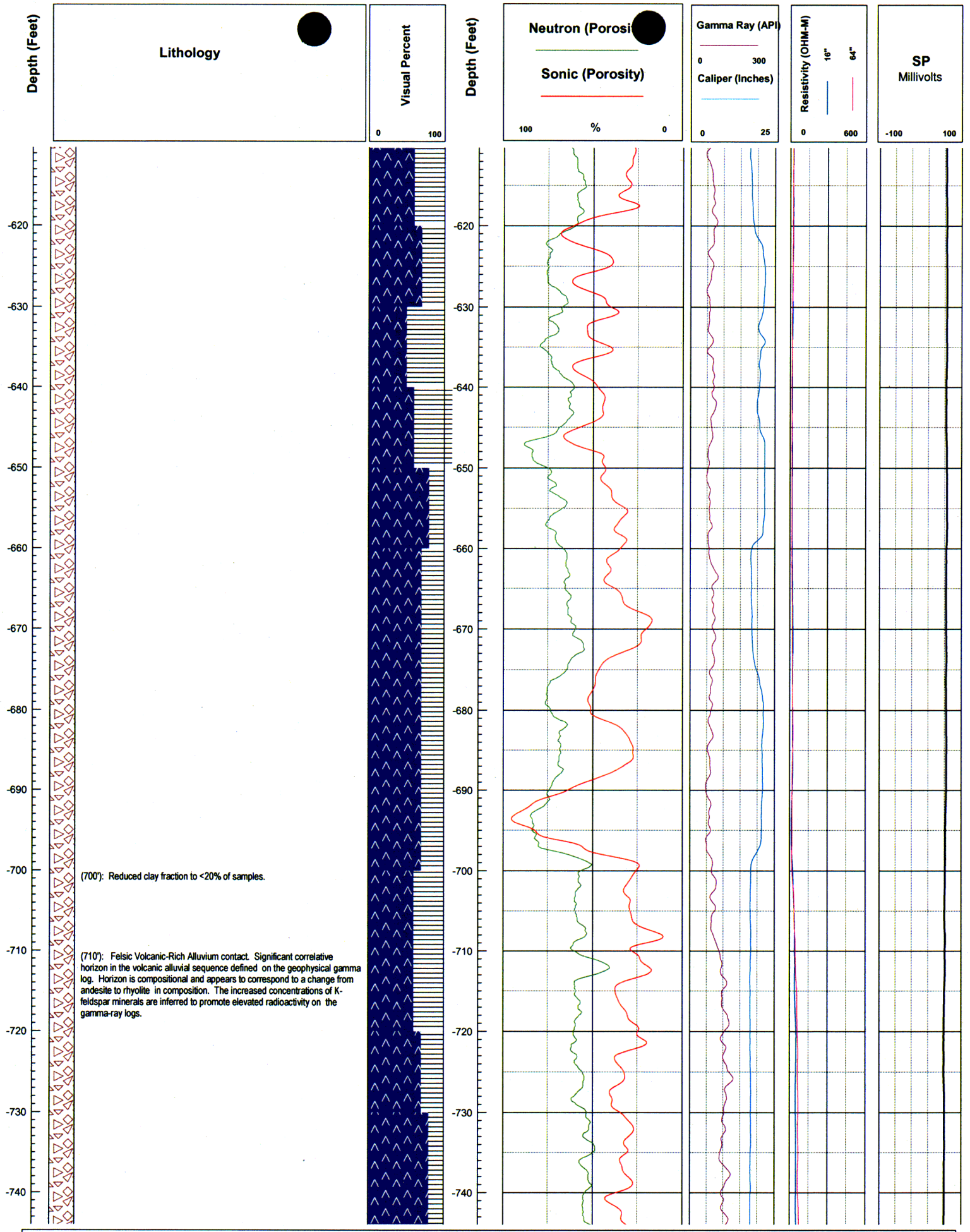

Depth (Feet)
Lithology
Visual Percent
0
100
(210'-280'): Clay decreases to 20% of samples.
(310'): Clay nodules with entrained silt and sand form in the matrix.
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340

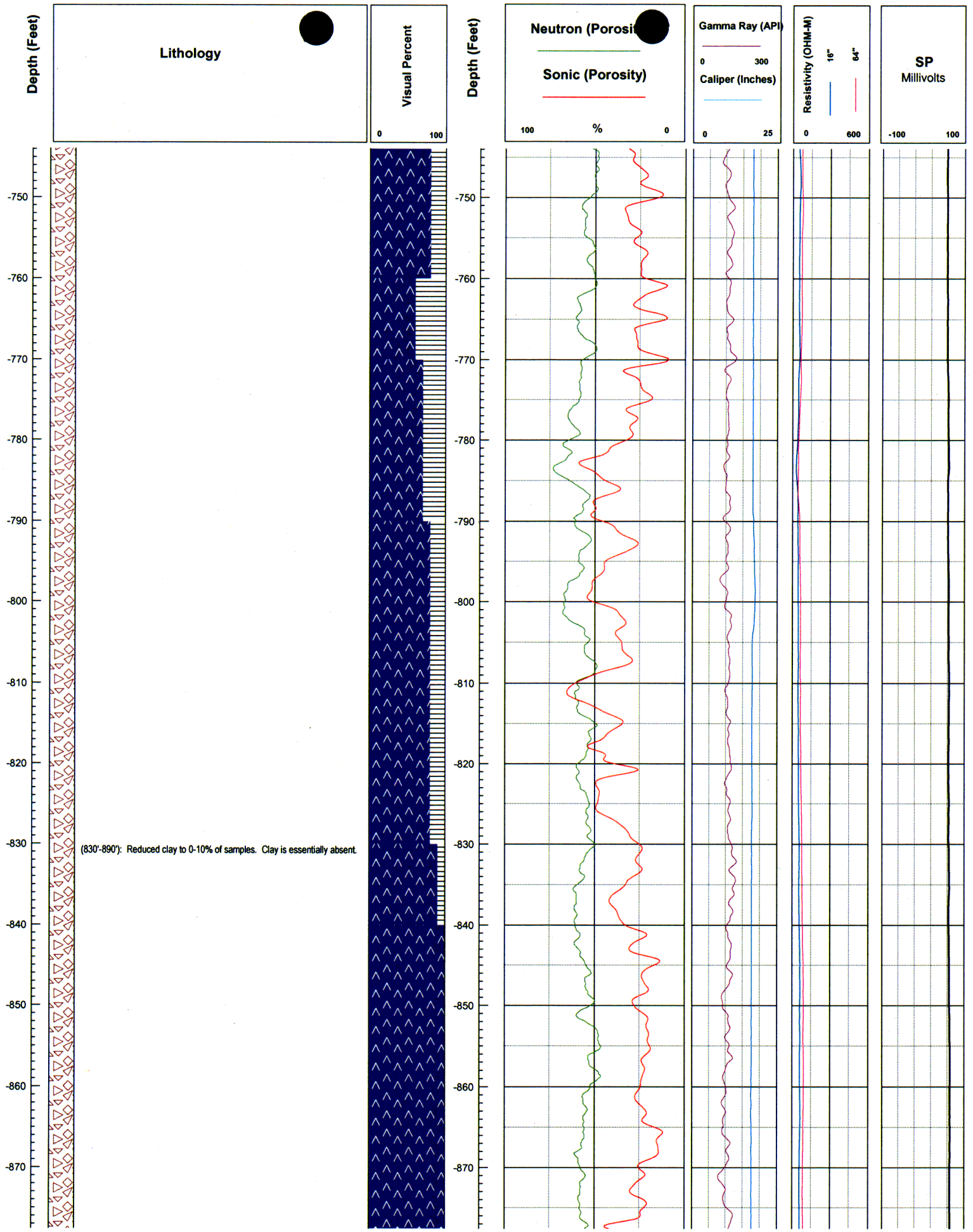

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470
(420'): Clay decreases to 10-20% of samples.

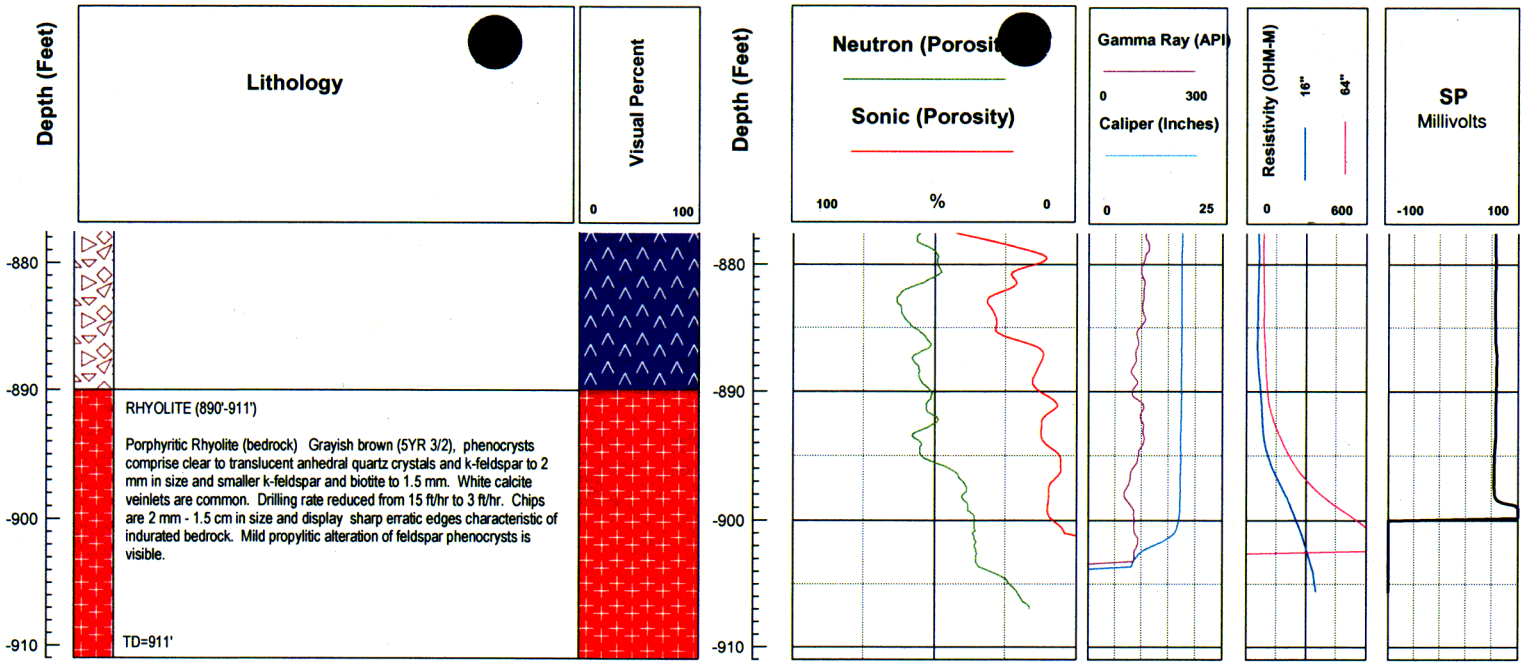


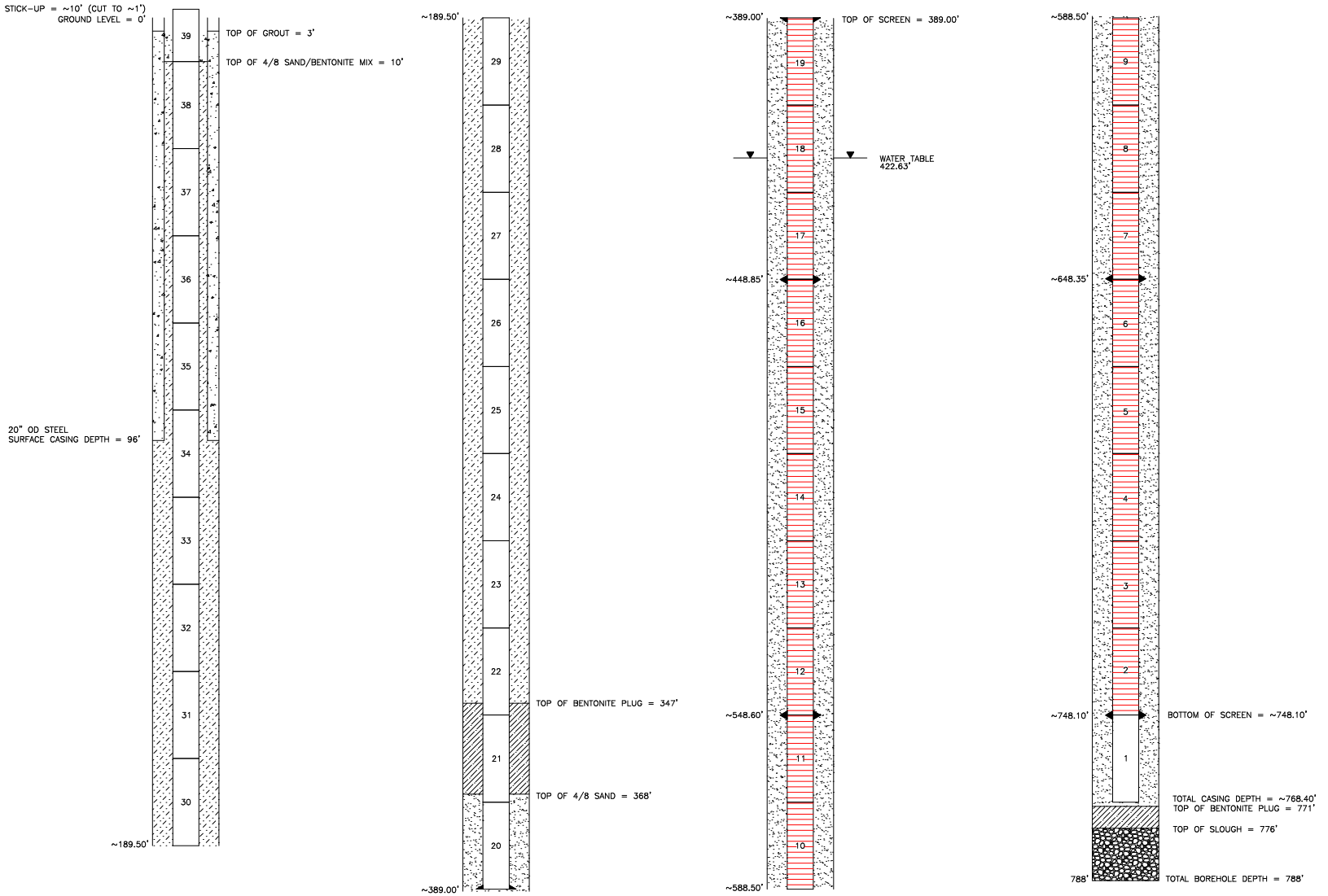
VOLCANIC RICH ALLUVIUM (566'-890'):

Late Pliocene in age. Volcanic-rich alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Individual clasts are composed almost entirely of volcanic rocks. Clay is abundant in variable percentages, generally between 20-40%. The volcanic-rich alluvium contact was identified based primarily on evidence from the geophysical logs and lithologic log. The unit is pale red (10R 6/2) to light olive brown (5Y 5/6), moderate reddish brown (10R 4/6), or grayish pink (5R 8/2), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay content increases where alteration becomes more pervasive and locally forms nodules. Sorting is poor to moderate, and clasts range from rounded to angular. Clasts generally comprise 60-80% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 5 cm in size. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Sedimentary clast lithologies are light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, and pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated siltstone. Andesite and rhyolite are the prevalent clasts. Sedimentary clasts were not observed below 580'. 566'-600' Reduced clay fraction to 10-30% of samples. 600'-660' Clay balls and nodules occasionally form.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-620
-630
-640
-650
-660
-670
-680
-690
-700
-710
-720
-730
-740
(700'): Reduced clay fraction to <20% of samples.
(710'): Felsic Volcanic-Rich Alluvium contact. Significant correlative horizon in the volcanic alluvial sequence defined on the geophysical gamma log. Horizon is compositional and appears to correspond to a change from andesite to rhyolite in composition. The increased concentrations of K-feldspar minerals are inferred to promote elevated radioactivity on the gamma-ray logs.

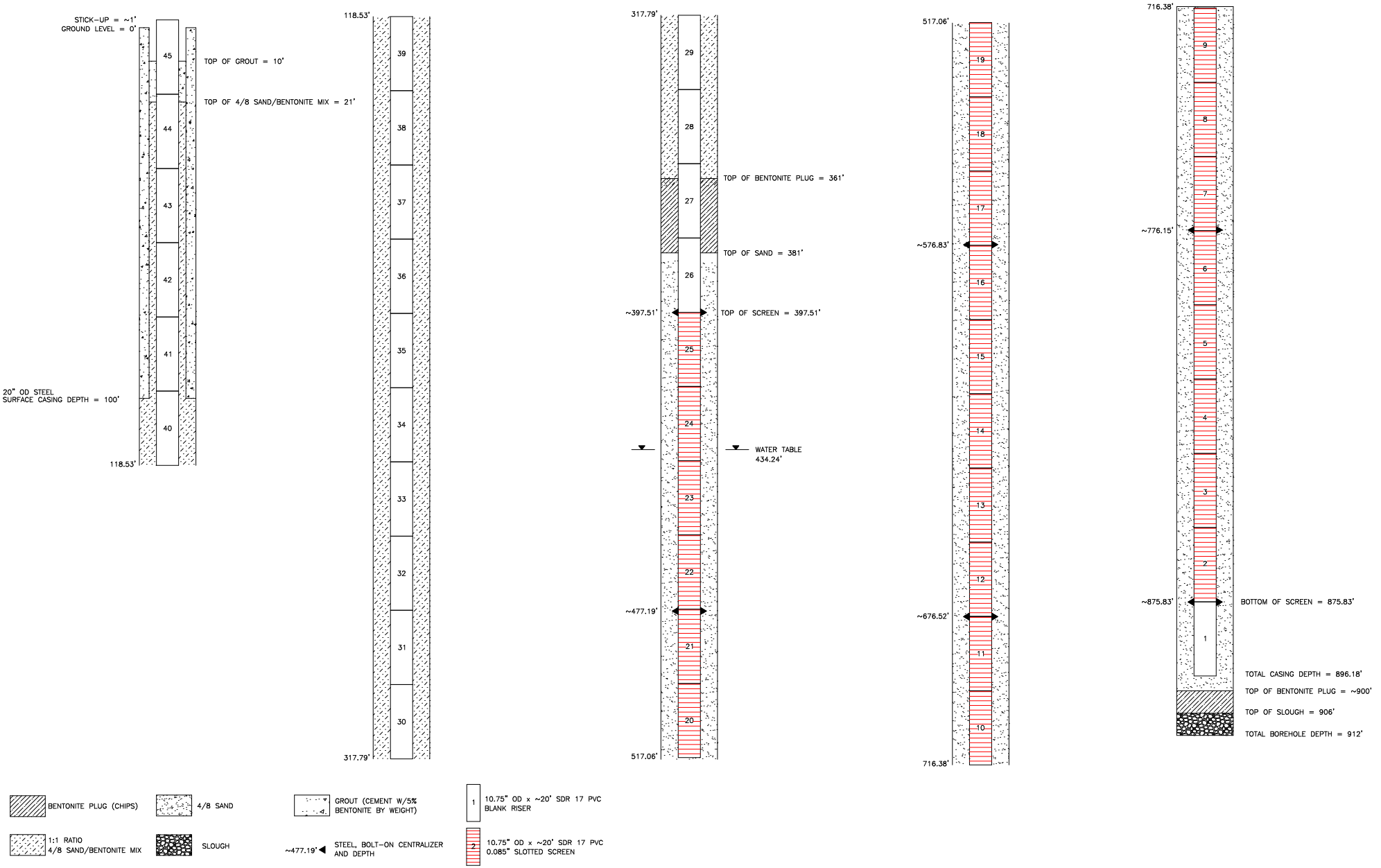

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-750
-760
-770
-780
-790
-800
-810
-820
-830
-840
-850
-860
-870
(830'-890'): Reduced clay to 0-10% of samples. Clay is essentially absent.


Depth (Feet)
Lithology
Visual Percent
0
100
-880
-890
-900
-910
RHYOLITE (890'-911')
Porphyritic Rhyolite (bedrock) Grayish brown (5YR 3/2), phenocrysts comprise clear to translucent anhedral quartz crystals and k-feldspar to 2 mm in size and smaller k-feldspar and biotite to 1.5 mm. White calcite veinlets are common. Drilling rate reduced from 15 ft/hr to 3 ft/hr. Chips are 2 mm - 1.5 cm in size and display sharp erratic edges characteristic of indurated bedrock. Mild propylitic alteration of feldspar phenocrysts is visible.
TD=911'
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100



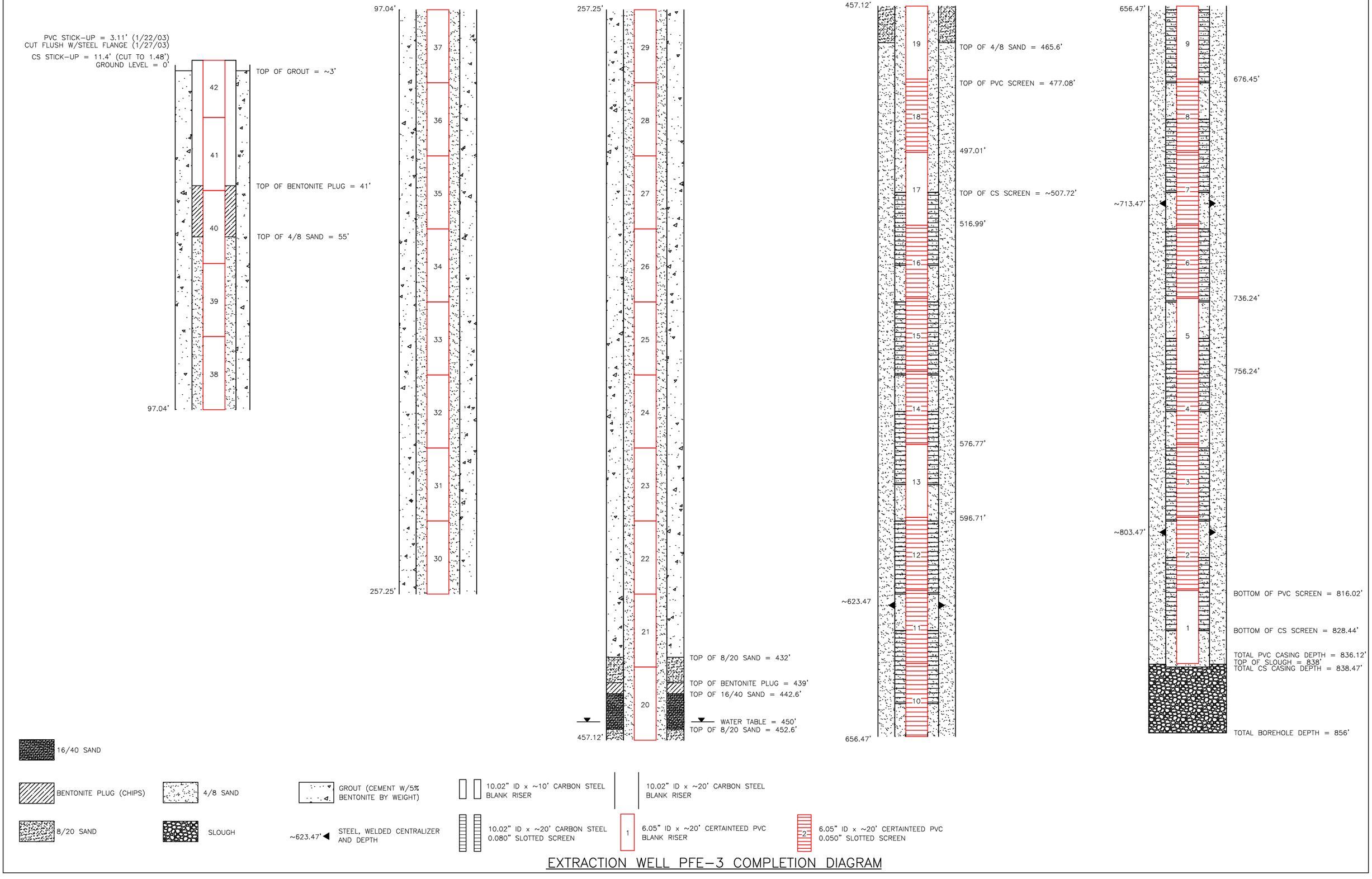
EXTRACTION WELL PFE-1 COMPLETION DIAGRAM

3567

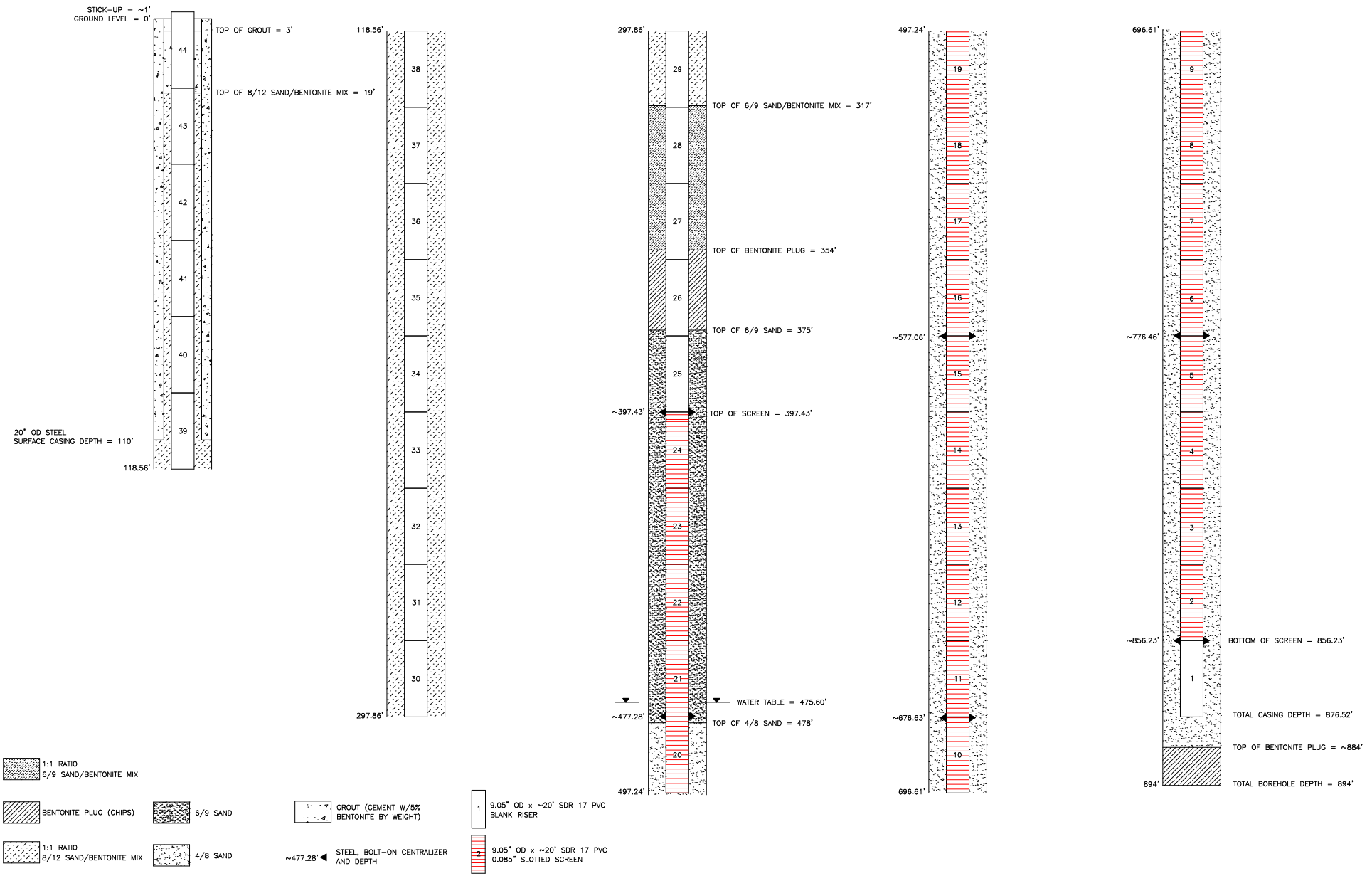


EXTRACTION WELL PFE-2 COMPLETION DIAGRAM

3568

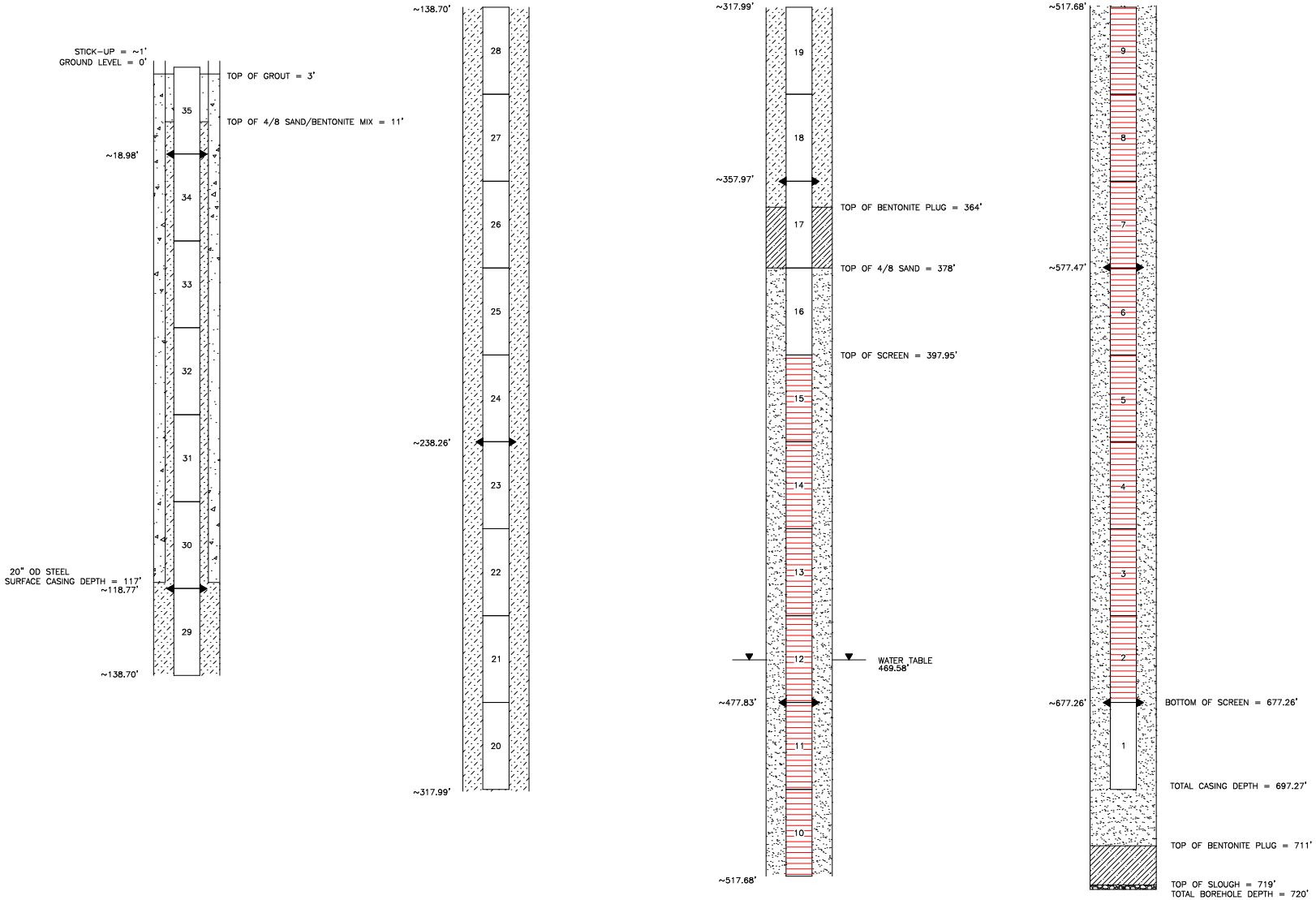


EXTRACTION WELL PFE-3 COMPLETION DIAGRAM

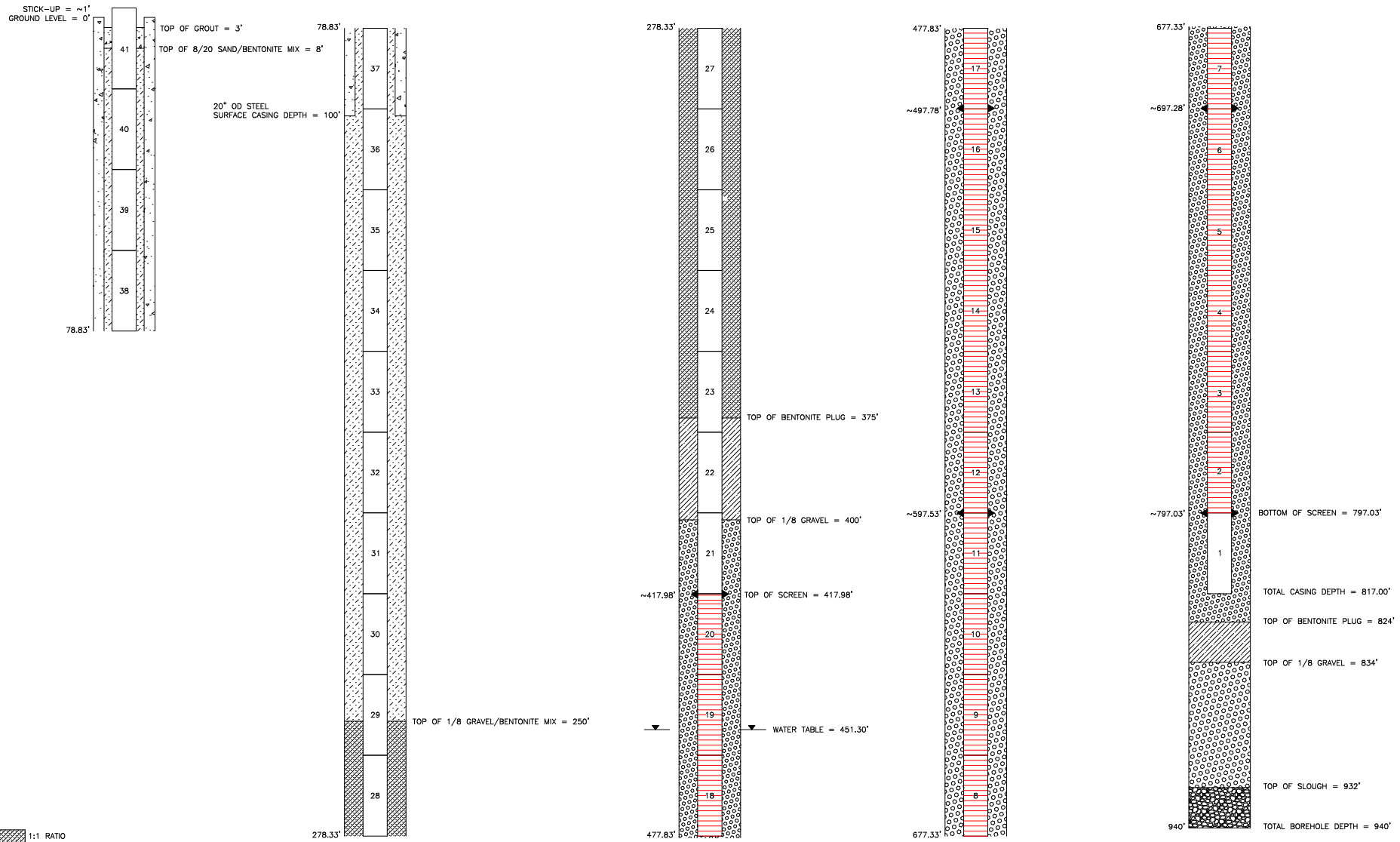


EXTRACTION WELL PFE-4 COMPLETION DIAGRAM

3570

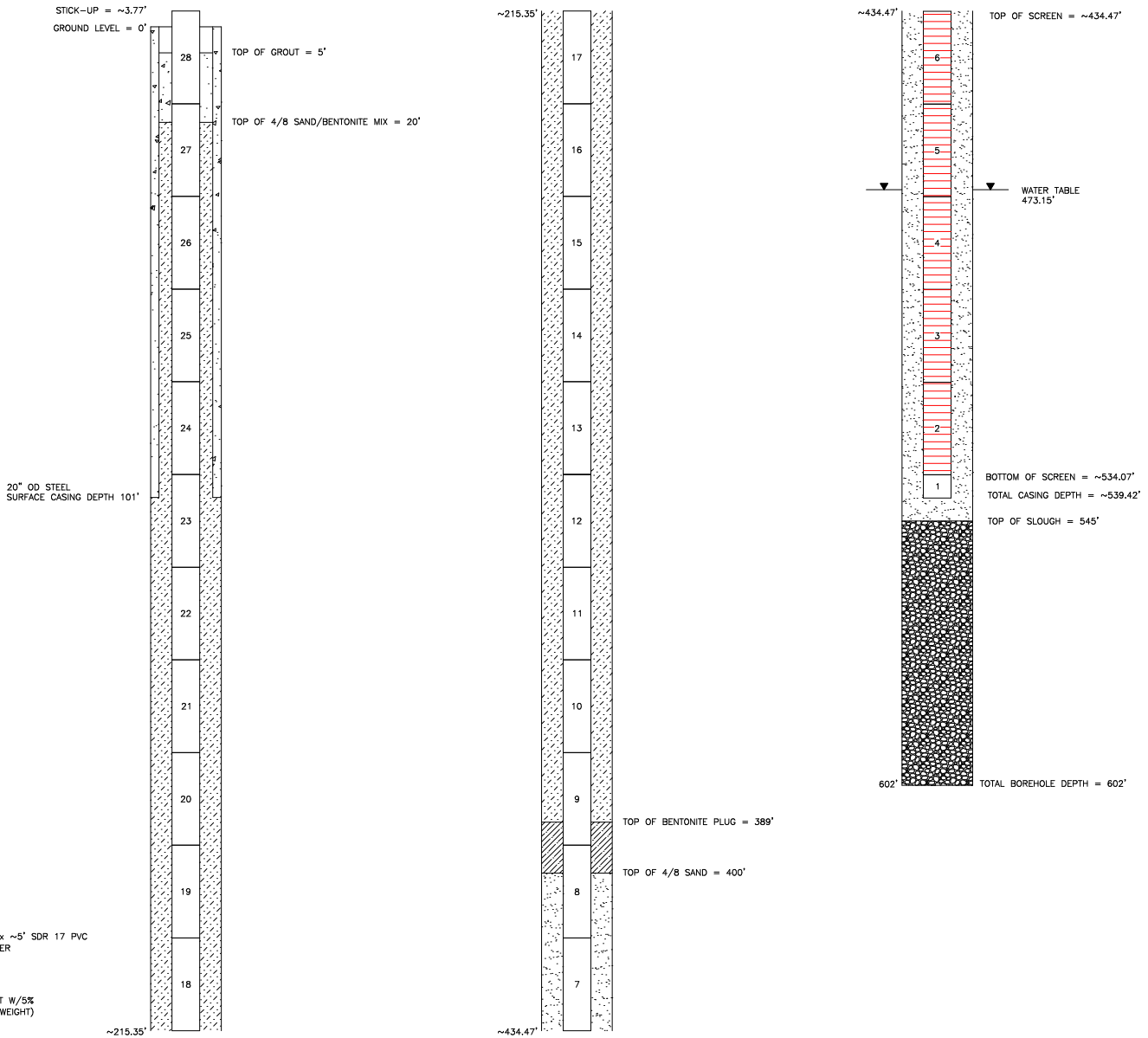


EXTRACTION WELL PFE-4A COMPLETION DIAGRAM



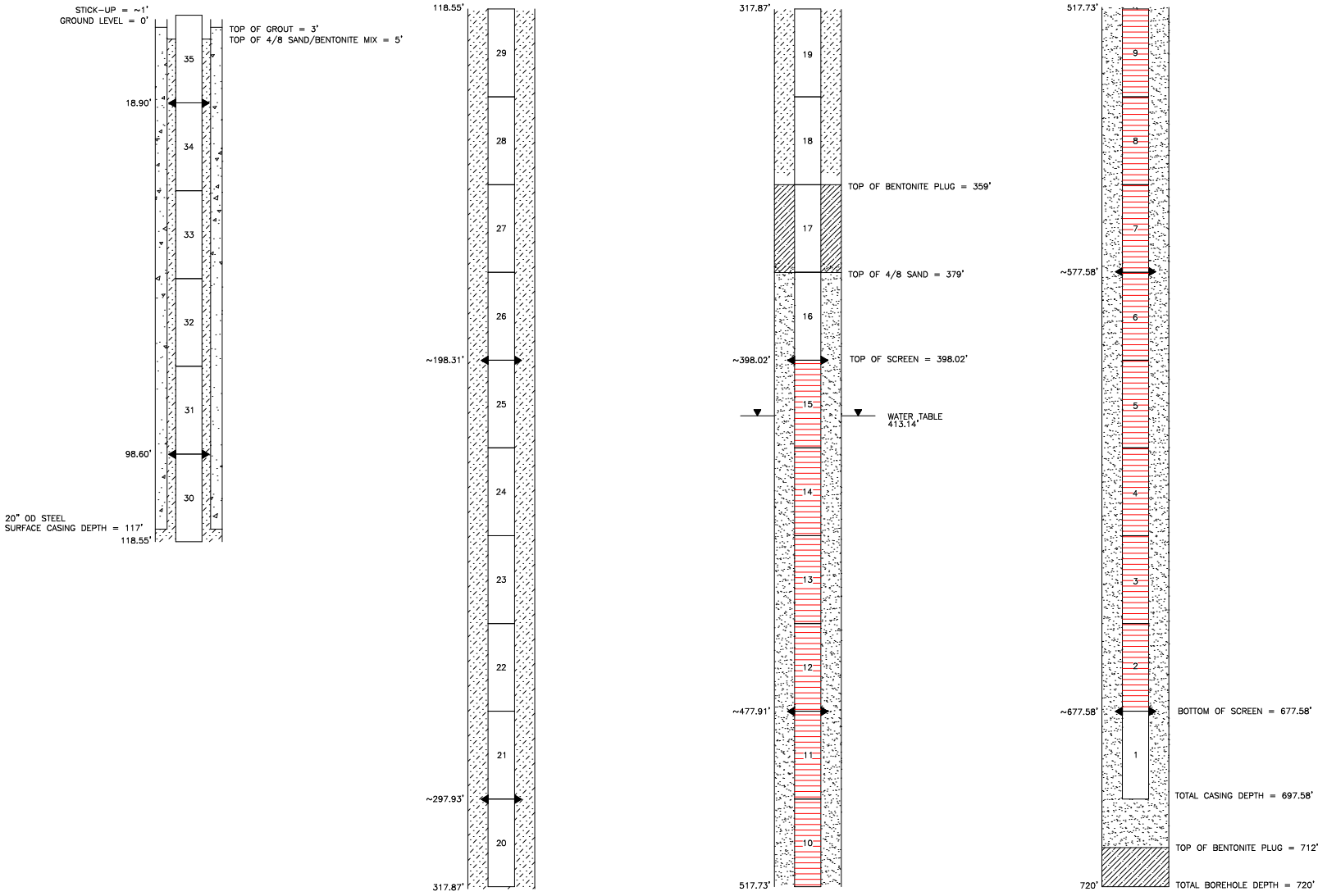
EXTRACTION WELL PFE-5 COMPLETION DIAGRAM

3572

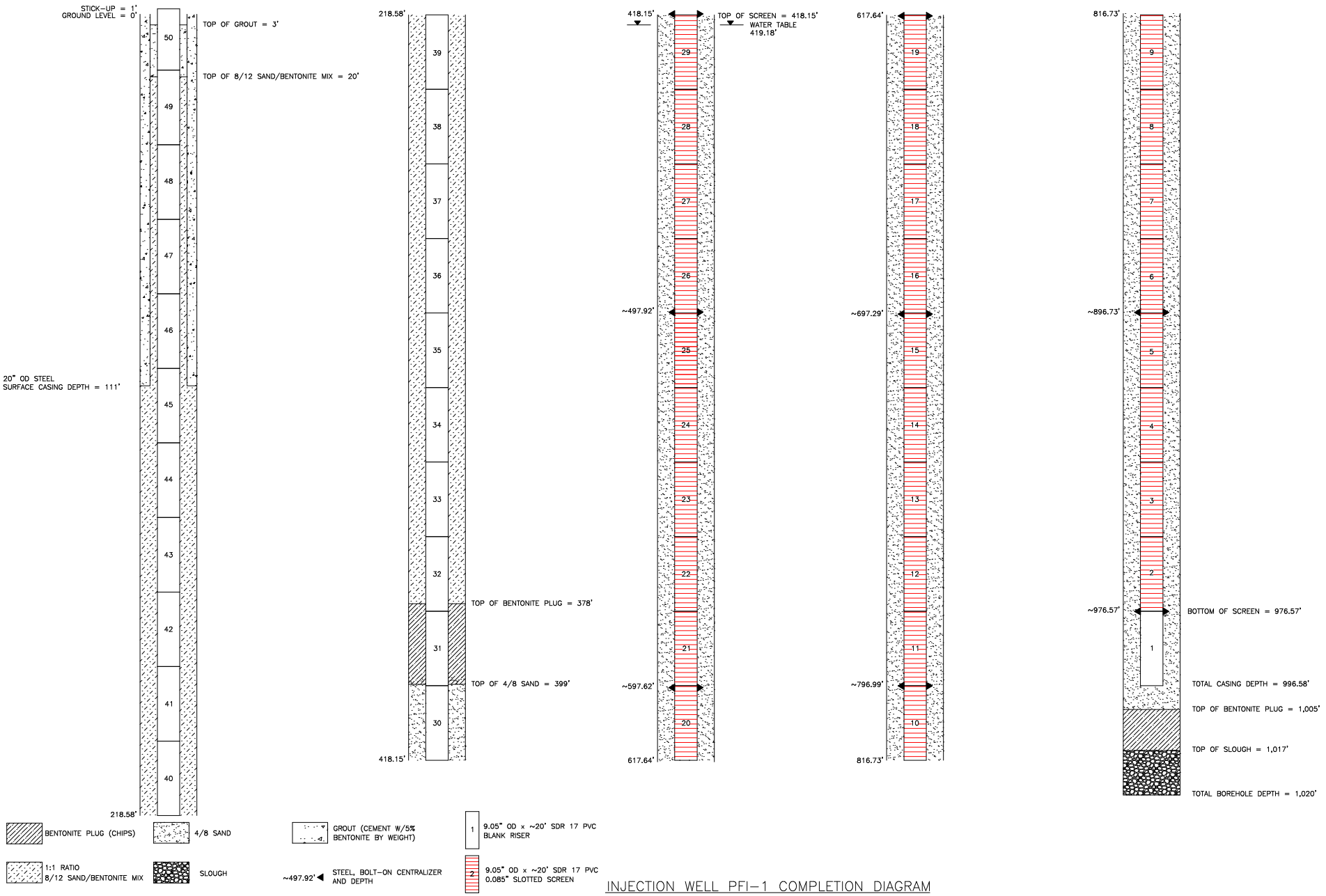


EXTRACTION WELL PFE-6 COMPLETION DIAGRAM

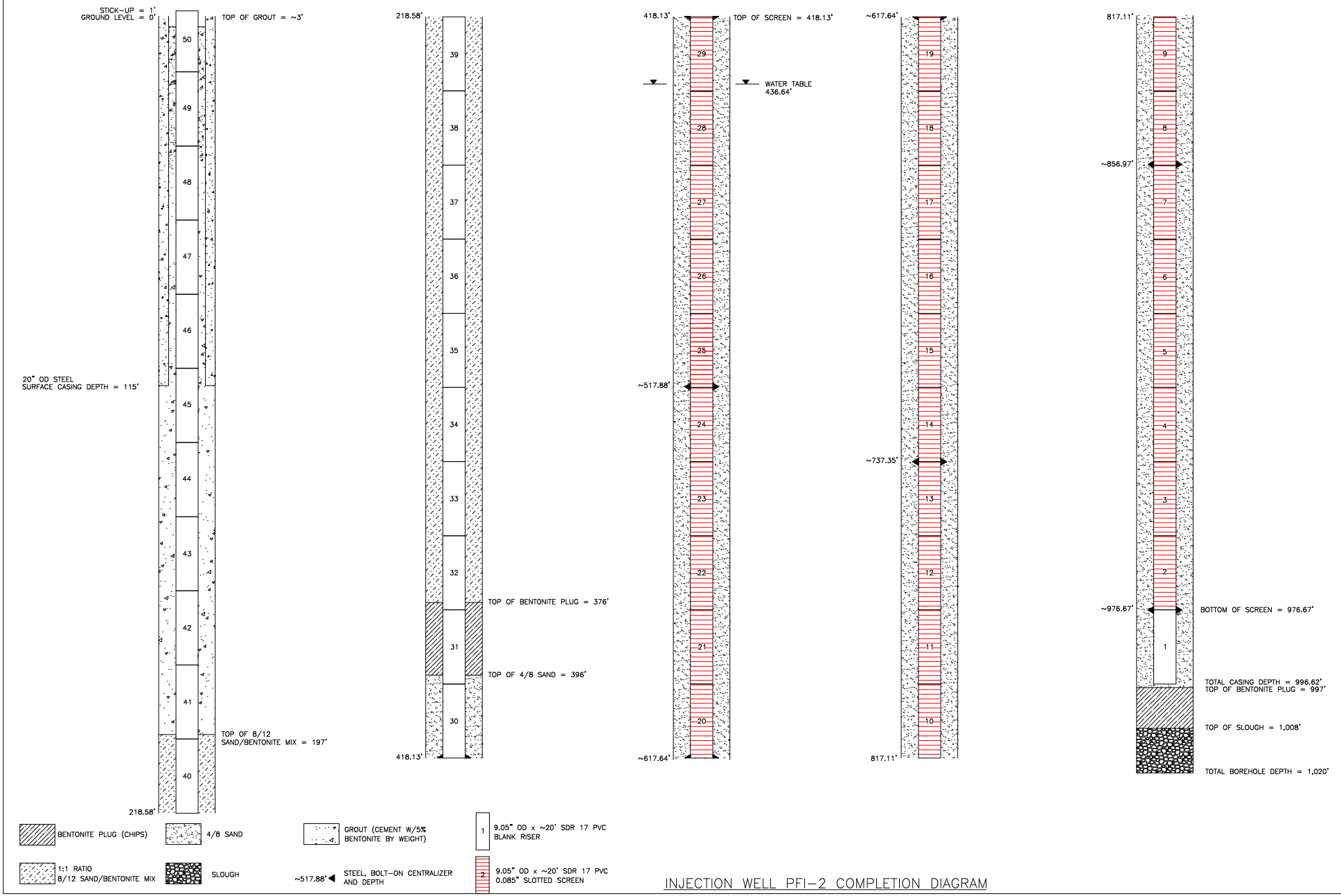
3573



EXTRACTION WELL PFE-7 COMPLETION DIAGRAM

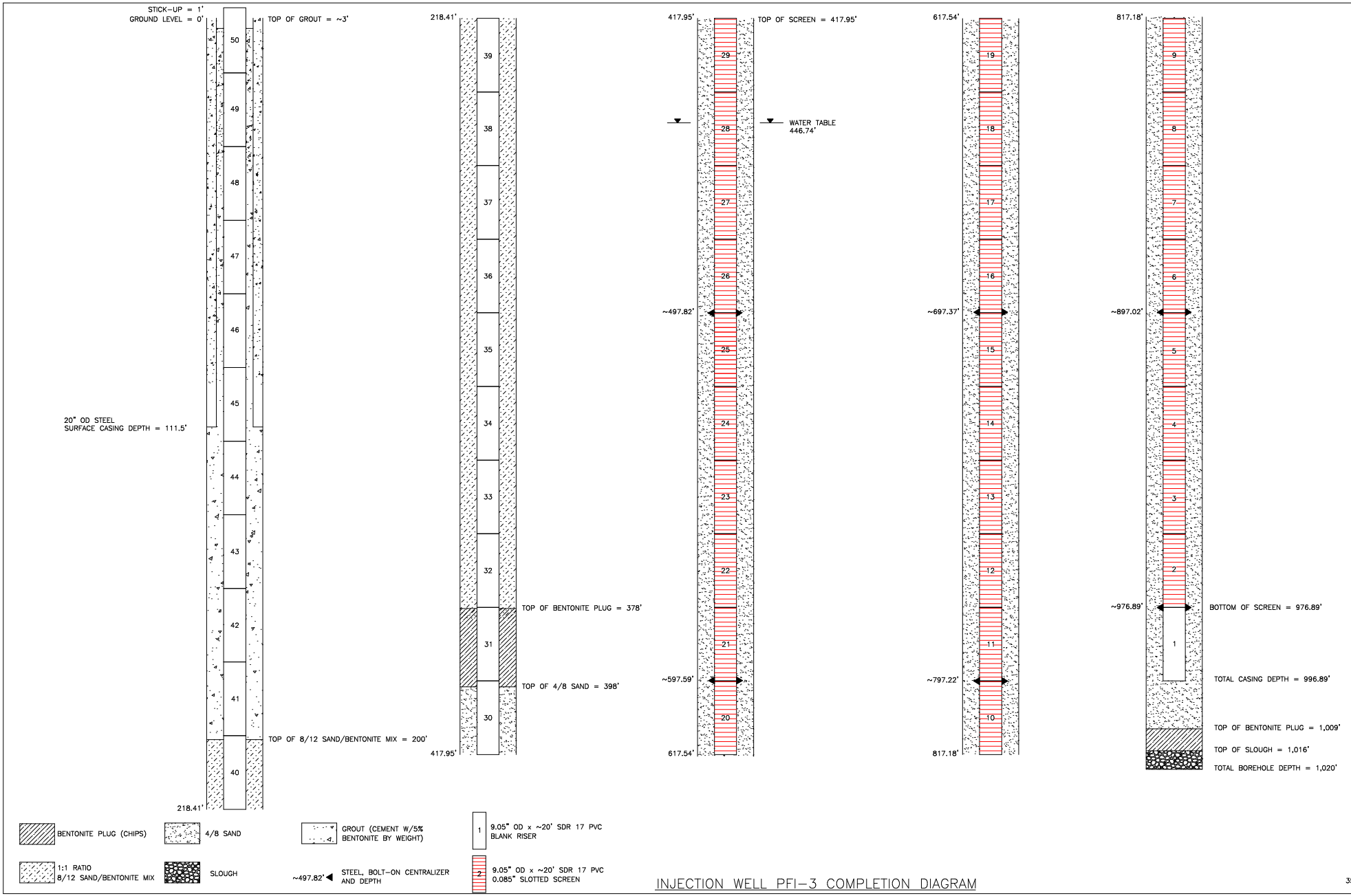


INJECTION WELL PFI-1 COMPLETION DIAGRAM



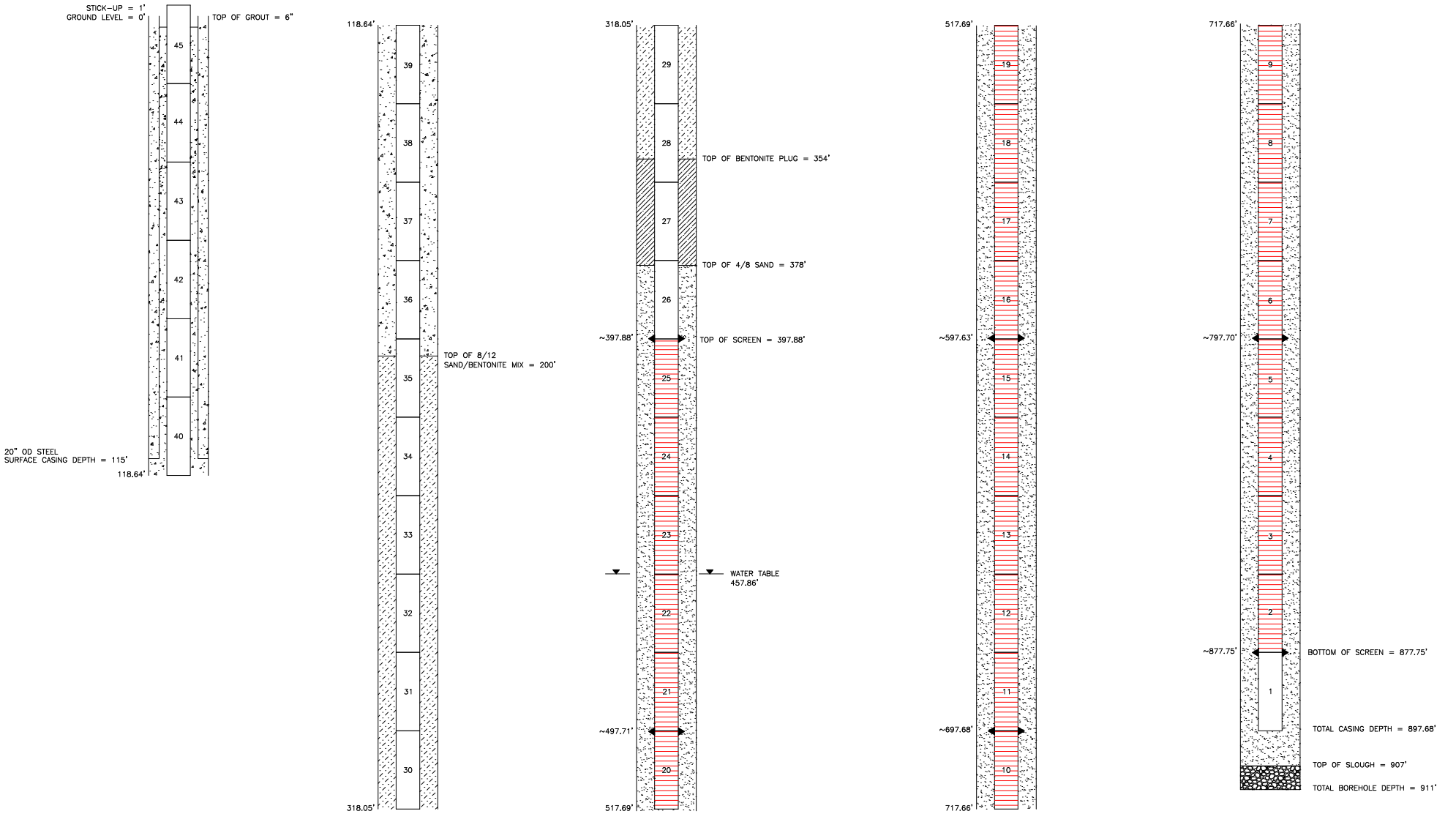
INJECTION WELL PFI-2 COMPLETION DIAGRAM

3576



INJECTION WELL PFI-3 COMPLETION DIAGRAM

3577



INJECTION WELL PFI-4 COMPLETION DIAGRAM

3578

CORE DESCRIPTION
NASA-PT-Well
489'-499' (Run #1)
(100% Recovery, RQD = 57% (Fair))

Gravelly Alluvium (Santa Fe Group): Consolidated to unconsolidated, gravel to cobble polygenetic conglomerate. Alluvium is multicolored, but overall pale yellowish brown (10 YR 6/2) when wet. Wide grain-size distribution from silt- and sand-size particles to 4 inch clasts; very angular but some clasts are subrounded; poorly sorted. Cobbles and gravel are supported in finer-grained carbonate-cemented matrix. The predominate alluvial clasts is porphyritic andesite that can be medium gray (N5), dusky red (5 R 3/4), or grayish green (10 GY 5/2); other lithologies include rhyolite, siltstone, claystone and lesser amounts of limestone and sandstone.

The characteristics of the alluvium described above suggest deposition in a high-energy (hydraulic) environment close to the local uplift. Estimated visual porosity in the core is variable, 5-25%. The medium-grained fraction appears the least cemented and yields the most porosity while fine- and coarse-grained fractions are well cemented resulting in lower yields.

Sedimentary structures present are composite beds of fining-upward sequences and slight imbrication:

489.0' - 489.5'	Clasts up to 2 inches; poorly sorted; matrix supported. Estimated visual porosity less than 5%.
489.5' - 490.9'	Upward fining sequence. Well cemented clasts up to 2 inches fine upwards to poorly- to moderately-cemented medium to small gravel with some sand and silt. Estimated visual porosity of fine grained fraction is 10-20%.
490.9' - 492.0'	Upward fining sequence. Clasts up to 2 inches fine upwards to coarse sand with some gravels. This interval is well-cemented. Estimated visual porosity is 5-7%.
492.0' - 495.2'	Largest upward fining sequence. Well cemented clasts up to 4 inches fine upwards to coarse gravel then coarse sand and gravel. Coarse sand and gravel is poorly- to moderately cemented; some imbrication of oblate clasts; estimated visual porosity 10-20%.
495.2' - 496.1'	Clasts up to 1 inch; moderately- to poorly-sorted; well cemented. Estimated visual porosity 5-7%.
496.1' - 499.0'	Average grain size less than 1 inch; moderately sorted; unconsolidated.

CORE DESCRIPTION
NASA-PT-Well
560'-570' (Run #2)
(3% Recovery, RQD does not apply)

Andesite-Rich Alluvium (Santa Fe Group): Grayish red (10 R 4/2) to pale red (10 R 6/2) wet, poorly sorted, moderately- to well-cemented, pebble to boulder conglomerate. Clasts consist of very angular to subrounded aphanitic, microporphyritic and porphyritic andesites that range in color from predominately dusky red (5 R 3/4) to grey, green, and yellow. Clast size ranges from 0.1 inches to 1.5 inches and part of a tuff boulder was retrieved. Clasts are supported in a fine-grained silt, carbonate, and possibly clay matrix. No sedimentary structures are present, but sample size is very small.

Estimated visual porosity is 10-15% and water production while drilling indicates formation is fairly transmissive.

CORE DESCRIPTION
NASA-PT-Well
650'-660' (Run #3)
(100% recovery, RQD = 4% (very poor))

Andesite-Rich Alluvium: Grayish red (10 R 4/2), wet, poorly- to moderately-sorted, unconsolidated to well-cemented, pebble to cobble conglomerate. Clasts consist of very angular to subrounded aphanitic, microporphyric to porphyritic andesites that range in color from predominantly dusky red (5 R 3/4) to grey, green, and yellow. Clasts size ranges from less than 0.1 inch to 3.5 inches. Clasts are supported in a finer-grained silt, fine sand and carbonate matrix or, in some areas, a pure carbonate matrix.

Sedimentary structures are difficult to discern in core because of the amount of breakage. Bedding is apparent in the interval 650.5'-651.2'. Finer-grains grade sharply into coarse grains, with no intermediate grain size. This indicates a large and rapid increase in the flow regime. The remainder of the core represents massive, poorly-sorted alluvium, some slight to definitive imbrication is present.

Porosity in this core interval is greater than the core taken from 560'-570'. This core interval is less-cemented (more friable) and contains larger pore spaces coated with crystalline calcite. Estimated visual porosity is 20-30%. This interval is capable of transmitting large quantities of water.

CORE DESCRIPTION
NASA-PT-Well
740'-750' (Run #4)
(50% recovery, RQD = 40% (poor))

Pebble to Boulder Andesite-Rich Alluvium (Santa Fe Group): The alluvium is a multicolored, poorly-to moderately-sorted, semi-consolidated, pebble to boulder andesite-rich conglomerate. The conglomerate is mostly matrix supported but has small zones which are grained supported. The matrix is a white to yellowish white carbonate and clay cement containing silt and sand particles. This matrix supports pebble-size clasts to boulders up to 7.5 inches. Within the matrix, small fractures are healed with white calcite cement. Sand grains within the matrix are composed of small pieces of andesite, tuff and phenocrysts weathered from said rocks. Clasts contained in the conglomerate are predominately (≥ 95%) porphyritic andesites, other clasts include multiple colors of tuff. There are varying degrees of weathering of most andesite and tuff clasts and the phenocrysts in them. Andesites have a wide range of colors and phenocryst size (from less than 1mm to 12mm) and 99-100% of the andesites are porphyritic. Tuffs are soft and are weathering to clay. Oxidation of biotite, plagioclase altering to clay, and pyroxenes altering to epidote are some of the indicators of weathering. Vugs are present in some andesite clasts. Euhedral calcite line some of these vugs while others are not lined.

The conglomerate shows no distinct signs of bedding or imbrication, however, it is noted that there are zones of similar clast size within a small area. These zones are discontinuous and make no distinct bedding feature. Some areas within the conglomerate are well-cemented while others are poorly-cemented and crumble easily. 80% of this core is consolidated and 20% is unconsolidated.

CORE DESCRIPTION
NASA-PT-Well
820'-828' (Run #5)
RQD (Not applicable)
(20-25% Recovery)

Andesite-rich Pebble to Boulder Alluvium (Santa Fe Group): The core consists of gravel and boulder fragments of andesite. Most clasts are subrounded, others are angular. The largest clast is at least 4.75", possibly as large as 8.75" in diameter, and is a slightly weathered dark gray porphyritic andesite. The andesite contains anhedral and euhedral white plagioclase phenocrysts and vugs filled with white calcite. Some smaller clasts of andesite contain vugs filled with silica (chalcedony). Cemented to the large andesite clast is a matrix- to grain-supported silt and sandy, pebble to gravel alluvium. No distinct sedimentary structures, such as imbrication or bedding, are present. Smaller clasts of gray andesite contain phenocrysts of weathered biotite and plagioclase. Some surfaces where the matrix of the alluvium contacts the andesite clasts there is anhedral and euhedral calcite visible. The matrix of the alluvium is a sandy carbonate and clay cement and is white to dirty white in color. Cementation varies from well-cemented to poorly-cemented.

Plume-Front Remediation Well Development and Analytical Summary

Well	Date Completed	Dates Developed	Static Water Level Pre-Development	Water Level Post Development	Depth of Pump For Sampling (Screened Zone)	Dates Sampled	Sampling Sets	NDMA (ppb)	DMN (ppb)	TCE (ppb)	PCE (ppb)	Freon 113 (ppb)	Freon 21 (ppb)	Freon 11 (ppb)
Plume-Front Extraction Wells														
PFE-1	2/3/00	2/9/00-	420'	422.63'	720'	6/28/00	3	0.19	0.04	64	2.2	74	0.16	49
		6/29/00			(389'-748')			0.38	0.05	69	1.6	82	ND	42
								0.36	0.07	75	2.2	86	0.15	54
						6/29/00	1	0.36	0.07	72	2.3	83	0.16	52
PFE-2	2/22/00	4/15/00-	425'	434.24'	855'	7/12/00	2	ND	ND	49	0.78J	25	ND	35
		7/21/00			(398'-876')			ND	ND	48	0.78J	26	ND	42
						7/21/00	2	ND	ND	57	1	33	ND	47
								ND	ND	55	0.89J	32	ND	70
PFE-3	1/9/90	1/11/90-	450.5'	452.44'	616'	3/28/90-	6	NA	NA	413	16.3	411	19.4	473
(NASA PT)		3/29/90			(508'-828')	3/30/90		NA	NA	396	16.2	391	20.7	444
								NA	NA	373	14.8	375	8.6	424
								NA	NA	378	14.8	373	10.4	428
								NA	NA	395	16.3	396	9.6	435
								NA	NA	397	16.4	409	10.1	427
					507.7'-527.8'	6/12/91	3	3.89	NA	230	7	140	1	89
					598'-618'									
					718.3'-738.3'	7/17/91	1	0.94	NA	320	11	400	3	290
						11/24/98	1	2.64	1.230	290	15	720	ND	240
PFE-4	3/21/00	4/18/00-	425'	475.60'	839'	5/30/00	1	ND	ND	ND	ND	ND	ND	ND
		6/8/00			(397'-856')	6/7/00	1	ND	ND	ND	ND	0.25	ND	ND
				475.78'		6/8/00	1	ND	ND	ND	ND	0.52	ND	ND
						10/31/00	1	ND	ND	0.56J	ND	0.82	ND	0.35
PFE-4A	8/22/01	8/23/01-	475'		609'	8/26/01	4	ND	ND	150	3.5	100	ND	110
		8/26/01			(398'-697')			ND	ND	140	3.2	100	ND	110
				469.98'				ND	ND	150	3.2	100	ND	110
								ND	ND	150	3.7	110	ND	110
						9/4/01	3	ND	ND	190	4.2	140	0.12	170
								ND	ND	210	4.4	130	0.14	170
								ND	ND	180	4.1	140	ND	160
						9/5/01	1	ND	ND	180	3.9	140	ND	180
PFE-5	12/5/99	2/1/00-	436'	451.30'	775'	4/27/00	1	1.14	0.92	150	7.1	36	ND	56
		5/11/00			(418'-797')	5/2/00	1	1.48	1	160	7.6	49	0.98	88
						5/5/00	1	1.21	0.82	150	6.3	44	0.78	53
						5/11/00	1	1.60	0.96	160	7	55	0.88	62
PFE-6		4/20/00		473.58'	(434'-534')	4/20/00	1	2.63	1.800	210	10	660	2.3	370
PFE-7	7/29/01	8/27/01	415'		616'	8/27/01	4	ND	ND	16	0.21	8.7	ND	14
					(308'-678')			ND	ND	16	0.24J	9	ND	14
				411.11'	516'			ND	ND	17	0.32J	8.8	ND	15
								ND	ND	16	0.22J	9.2	ND	15
Plume-Front Injection Wells														
PFI-1	4/29/00	8/18/00-	ND	419.18	800'	8/18/00	1	ND	ND	ND	ND	ND	ND	ND
		9/1/00			(418'-977')	9/1/00	4	ND	ND	0.44J	ND	0.45J	ND	ND
								ND	ND	ND	ND	ND	ND	ND
								ND	ND	ND	ND	ND	ND	ND
								ND	ND	ND	ND	ND	ND	ND
						11/17/00	3	NA	NA	ND	ND	ND	ND	ND
										ND	ND	ND	ND	ND
										ND	ND	ND	ND	0.95

Well	Date Completed	Dates Developed	Static Water Level Pre-Development	Water Level Post Development	Depth of Pump For Sampling (Screened Zone)	Dates Sampled	Sampling Sets	NDMA (ppb)	DMN (ppb)	TCE (ppb)	PCE (ppb)	Freon 113 (ppb)	Freon 21 (ppb)	Freon 11 (ppb)
Plume-Front Injection Wells (Continued)														
PFI-2	6/23/00	8/19/00-	ND	436.64	710'	8/19/00	1	ND	ND	ND	ND	ND	ND	ND
		9/6/00			(418'-977')	9/6/00	4	ND	ND	0.27J	ND	ND	ND	ND
								ND	ND	ND	ND	ND	ND	ND
								ND	ND	ND	ND	ND	ND	ND
								ND	ND	0.38J	ND	ND	ND	ND
						11/18/00	3	NA	NA	ND	ND	ND	ND	ND
										ND	ND	ND	ND	ND
										ND	ND	ND	ND	ND
PFI-3	5/27/00	8/23/00-	ND	446.74	710'	8/24/00	1	ND	ND	ND	ND	ND	ND	ND
		9/9/00			(418'-977')	9/8/00	2	ND	ND	ND	ND	ND	ND	ND
								ND	ND	ND	ND	ND	ND	ND
					560'	9/9/00	2	ND	ND	ND	ND	ND	ND	ND
								ND	ND	ND	ND	ND	ND	ND
PFI-4	7/21/00	8/20/00-	ND	457.86		8/20/00	1	ND	ND	ND	ND	ND	ND	ND
		9/10/00			710'	9/10/00	4	ND	ND	ND	ND	ND	ND	ND
					(398'-878')			ND	ND	ND	ND	ND	ND	ND
								ND	ND	ND	ND	ND	ND	ND
								ND	ND	ND	ND	ND	ND	ND

Notes:

NDMA and DMN analytical data represent maximum value obtained by EPA Method 607, corrected for extraction efficiency.

TCE, PCE, Freon 113, Freon 21, and Freon 11 analytical data represent maximum value obtained by EPA Methods 8010/8240/8021/8260.

J Indicates that the result is an estimated value less than the reporting limit, but greater than or equal to the detection limit.

Analytical data collected from extraction and injection wells are useful for engineering purposes only and do not reflect optimal sampling conditions. These data provide an estimation of contaminant levels and should not be afforded the same level of confidence as data collected from wells constructed specifically for groundwater monitoring.

Remediation Well Analytical Data

Results Above Non-Detect

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-1	28-Jun-00	0006280945	HVOA	8021	127-18-4	Tetrachloroethene	1.8	1.8	ug/L	0.5	0.18		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	75-69-4	Trichlorofluoromethane	49	49	ug/L	0.5	0.055		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	72	72	ug/L	1.2	0.18		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	79-01-6	Trichloroethene	58	58	ug/L	1.2	0.16		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	108-88-3	Toluene	0.47	0.47	ug/L	1	0.29	J	0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	127-18-4	Tetrachloroethene	2.2	2.2	ug/L	1	0.36		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	75-35-4	1,1-Dichloroethene	0.38	0.38	ug/L	1	0.2	J	0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	75-43-4	Dichlorofluoromethane	0.16	0.16	ug/L	2	0.12	J	0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	75-69-4	Trichlorofluoromethane	49	49	ug/L	2	0.28		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	74	74	ug/L	2	0.21		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	79-01-6	Trichloroethene	64	64	ug/L	2	0.22		0	07-Jul-00
PFE-1	28-Jun-00	0006280959	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.14	0.14	ppb	0.01	0.005		75	13-Jul-00
PFE-1	28-Jun-00	0006280959	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.03	0.03	ppb	0.01	0.005		75	13-Jul-00
PFE-1	28-Jun-00	0006281001	RCRA	RCRA	7782-49-2	Selenium	0.0021	0.0021	mg/L	0.005	0.0012	J	0	17-Jul-00
PFE-1	28-Jun-00	0006281001	RCRA	RCRA	7440-38-2	Arsenic	0.0014	0.0014	mg/L	0.005	0.0013	J	0	15-Jul-00
PFE-1	28-Jun-00	0006281001	RCRA	RCRA	7440-39-3	Barium	0.027	0.027	mg/L	0.01	0.00043		0	03-Aug-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	127-18-4	Tetrachloroethene	1.5	1.5	ug/L	0.5	0.18		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	75-69-4	Trichlorofluoromethane	42	42	ug/L	0.5	0.055		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	67	67	ug/L	1.2	0.18		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	79-01-6	Trichloroethene	64	64	ug/L	1.2	0.16		0	11-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	127-18-4	Tetrachloroethene	1.6	1.6	ug/L	0.5	0.18		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	75-69-4	Trichlorofluoromethane	41	41	ug/L	0.5	0.055		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	82	82	ug/L	1.2	0.18		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	79-01-6	Trichloroethene	69	69	ug/L	1.2	0.16		0	12-Jul-00
PFE-1	28-Jun-00	0006281227	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.16	0.16	ppb	0.01	0.005		42	13-Jul-00
PFE-1	28-Jun-00	0006281227	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.02	0.02	ppb	0.01	0.005		42	13-Jul-00
PFE-1	28-Jun-00	0006281231	RCRA	RCRA	7782-49-2	Selenium	0.0022	0.0022	mg/L	0.005	0.0012	J	0	17-Jul-00
PFE-1	28-Jun-00	0006281231	RCRA	RCRA	7440-39-3	Barium	0.03	0.030	mg/L	0.01	0.0021		0	30-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	127-18-4	Tetrachloroethene	1.8	1.8	ug/L	0.5	0.18		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	75-69-4	Trichlorofluoromethane	54	54	ug/L	1.2	0.055		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	78	78	ug/L	1.2	0.18		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	79-01-6	Trichloroethene	67	67	ug/L	1.2	0.16		0	11-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	127-18-4	Tetrachloroethene	2.2	2.2	ug/L	1	0.36		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	75-35-4	1,1-Dichloroethene	0.4	0.40	ug/L	1	0.2	J	0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	75-43-4	Dichlorofluoromethane	0.15	0.15	ug/L	2	0.12	J	0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	75-69-4	Trichlorofluoromethane	50	50	ug/L	2	0.28		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	86	86	ug/L	2	0.21		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	79-01-6	Trichloroethene	75	75	ug/L	2	0.22		0	07-Jul-00
PFE-1	28-Jun-00	0006281357	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.15	0.15	ppb	0.01	0.005		42	13-Jul-00
PFE-1	28-Jun-00	0006281357	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.03	0.03	ppb	0.01	0.005		42	13-Jul-00
PFE-1	28-Jun-00	0006281401	RCRA	RCRA	7782-49-2	Selenium	0.0016	0.0016	mg/L	0.005	0.0012	J	0	17-Jul-00
PFE-1	28-Jun-00	0006281401	RCRA	RCRA	7440-38-2	Arsenic	0.0015	0.0015	mg/L	0.005	0.0013	J	0	15-Jul-00
PFE-1	28-Jun-00	0006281401	RCRA	RCRA	7440-39-3	Barium	0.03	0.030	mg/L	0.01	0.0021		0	30-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	127-18-4	Tetrachloroethene	2	2.0	ug/L	0.5	0.18		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	75-69-4	Trichlorofluoromethane	43	43	ug/L	0.5	0.055		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	50	50	ug/L	0.5	0.18		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	79-01-6	Trichloroethene	54	54	ug/L	0.5	0.16		0	12-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	127-18-4	Tetrachloroethene	2.3	2.3	ug/L	1	0.36		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	75-35-4	1,1-Dichloroethene	0.39	0.39	ug/L	1	0.2	J	0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	75-43-4	Dichlorofluoromethane	0.16	0.16	ug/L	2	0.12	J	0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	75-69-4	Trichlorofluoromethane	52	52	ug/L	2	0.28		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	83	83	ug/L	2	0.21		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	79-01-6	Trichloroethene	72	72	ug/L	2	0.22		0	10-Jul-00
PFE-1	28-Jun-00	0006290902	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.15	0.15	ppb	0.01	0.005		42	13-Jul-00

Remediation Well Analytical Data

Results Above Non-Detect

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-1	28-Jun-00	0006290902	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.03	0.03	ppb	0.01	0.005		42	13-Jul-00
PFE-1	28-Jun-00	0006290906	RCRA	RCRA	7782-49-2	Selenium	0.0018	0.0018	mg/L	0.005	0.0012	J	0	17-Jul-00
PFE-1	28-Jun-00	0006290906	RCRA	RCRA	7440-38-2	Arsenic	0.0015	0.0015	mg/L	0.005	0.0013	J	0	15-Jul-00
PFE-1	28-Jun-00	0006290906	RCRA	RCRA	7440-39-3	Barium	0.027	0.027	mg/L	0.01	0.0021		0	30-Jul-00
PFE-1	28-Jun-00	0006290908	CATIONS	6010	7439-89-6	Iron	0.25	0.25	mg/L	0.1	0.012		0	24-Jul-00
PFE-1	28-Jun-00	0006290908	CATIONS	6010	7439-95-4	Magnesium	53.8	53.8	mg/L	0.2	0.011		0	24-Jul-00
PFE-1	28-Jun-00	0006290908	CATIONS	6010	7440-09-7	Potassium	4.3	4.3	mg/L	5	0.18	J	0	24-Jul-00
PFE-1	28-Jun-00	0006290908	CATIONS	6010	7440-23-5	Sodium	58.8	58.8	mg/L	5	0.35		0	24-Jul-00
PFE-1	28-Jun-00	0006290908	CATIONS	6010	7440-70-2	Calcium	81.5	81.5	mg/L	0.2	0.048		0	24-Jul-00
PFE-1	28-Jun-00	0006290910	ANIONS	ANIONS		Fluoride	0.67	0.67	mg/L	0.1	0.01		0	15-Jul-00
PFE-1	28-Jun-00	0006290910	ANIONS	ANIONS		Chloride	40	40	mg/L	3	0.1		0	17-Jul-00
PFE-1	28-Jun-00	0006290910	ANIONS	ANIONS		Sulfate	250	250	mg/L	100	2		0	17-Jul-00
PFE-1	28-Jun-00	0006290910	ANIONS	ANIONS		Total Alkalinity	183	183	mg/L	5	0.5		0	11-Jul-00
PFE-1	28-Jun-00	0006290912	NO2,NO3	353.2		Nitrate-Nitrite	1.6	1.6	mg/L	0.1	0.021		0	12-Jul-00
PFE-1	28-Jun-00	0006290914	TDS	160.1		Total Dissolved Solids	799	799	mg/L	10	5.4		0	06-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	75-69-4	Trichlorofluoromethane	31	31	ug/L	0.5	0.055		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	18	18	ug/L	0.5	0.18		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	79-01-6	Trichloroethene	36	36	ug/L	0.5	0.16		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	108-88-3	Toluene	4.1	4.1	ug/L	1	0.29		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	127-18-4	Tetrachloroethene	0.78	0.78	ug/L	1	0.36	J	0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	75-69-4	Trichlorofluoromethane	35	35	ug/L	2	0.28		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	25	25	ug/L	1	0.21		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	79-01-6	Trichloroethene	49	49	ug/L	1	0.22		0	18-Jul-00
PFE-2	12-Jul-00	0007120831	RCRA	RCRA	7782-49-2	Selenium	0.002	0.0020	mg/L	0.005	0.0012	J	0	21-Jul-00
PFE-2	12-Jul-00	0007120831	RCRA	RCRA	7439-97-6	Mercury	0.000054	0.000054	mg/L	0.0002	0.000028	J RB	0	05-Aug-00
PFE-2	12-Jul-00	0007120831	RCRA	RCRA	7440-39-3	Barium	0.028	0.028	mg/L	0.01	0.0021		0	30-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	75-69-4	Trichlorofluoromethane	35	35	ug/L	0.5	0.055		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	20	20	ug/L	0.5	0.18		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	79-01-6	Trichloroethene	31	31	ug/L	0.5	0.16		0	20-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	108-88-3	Toluene	0.81	0.81	ug/L	1	0.29	J	0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	127-18-4	Tetrachloroethene	0.78	0.78	ug/L	1	0.36	J	0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	79-01-6	Trichloroethene	48	48	ug/L	1	0.22		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	75-69-4	Trichlorofluoromethane	38	38	ug/L	2	0.28		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	26	26	ug/L	1	0.21		0	19-Jul-00
PFE-2	12-Jul-00	0007121359	RCRA	RCRA	7782-49-2	Selenium	0.002	0.0020	mg/L	0.005	0.0012	J	0	21-Jul-00
PFE-2	12-Jul-00	0007121359	RCRA	RCRA	7439-97-6	Mercury	0.000055	0.000055	mg/L	0.0002	0.000028	J RB	0	05-Aug-00
PFE-2	12-Jul-00	0007121359	RCRA	RCRA	7440-22-4	Silver	0.0017	0.0017	mg/L	0.01	0.00056	J	0	29-Jul-00
PFE-2	12-Jul-00	0007121359	RCRA	RCRA	7440-47-3	Chromium	0.0051	0.0051	mg/L	0.01	0.0011	J RB	0	29-Jul-00
PFE-2	12-Jul-00	0007121359	RCRA	RCRA	7440-39-3	Barium	0.026	0.026	mg/L	0.01	0.0021		0	29-Jul-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	75-69-4	Trichlorofluoromethane	50	50	ug/L	1.2	0.055		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	33	33	ug/L	0.5	0.18		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	79-01-6	Trichloroethene	47	47	ug/L	0.5	0.16		0	01-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	108-88-3	Toluene	0.59	0.59	ug/L	1	0.29	J	0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	127-18-4	Tetrachloroethene	1	1.0	ug/L	1	0.36		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	67-64-1	Acetone	3.6	3.6	ug/L	10	1.9	J RB	0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	75-69-4	Trichlorofluoromethane	47	47	ug/L	2	0.28		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	23	23	ug/L	1	0.21		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	79-01-6	Trichloroethene	57	57	ug/L	2	0.22		0	02-Aug-00
PFE-2	12-Jul-00	0007211232	RCRA	RCRA	7782-49-2	Selenium	0.0017	0.0017	mg/L	0.005	0.0012	J	0	15-Aug-00
PFE-2	12-Jul-00	0007211232	RCRA	RCRA	7439-97-6	Mercury	0.000054	0.000054	mg/L	0.0002	0.000028	J RB	0	05-Aug-00
PFE-2	12-Jul-00	0007211232	RCRA	RCRA	7440-39-3	Barium	0.024	0.024	mg/L	0.01	0.0021		0	24-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	75-69-4	Trichlorofluoromethane	70	70	ug/L	1.2	0.055		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	32	32	ug/L	0.5	0.18		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	79-01-6	Trichloroethene	44	44	ug/L	0.5	0.16		0	01-Aug-00

Remediation Well Analytical Data

Results Above Non-Detect

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-2	12-Jul-00	0007211506	VOA	8260	108-88-3	Toluene	0.34	0.34	ug/L	1	0.29	J	0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	127-18-4	Tetrachloroethene	0.89	0.89	ug/L	1	0.36	J	0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	75-69-4	Trichlorofluoromethane	43	43	ug/L	2	0.28		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	21	21	ug/L	1	0.21		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	79-01-6	Trichloroethene	55	55	ug/L	1	0.22		0	02-Aug-00
PFE-2	12-Jul-00	0007211518	CATIONS	6010	7439-89-6	Iron	0.6	0.60	mg/L	0.1	0.012		0	18-Aug-00
PFE-2	12-Jul-00	0007211518	CATIONS	6010	7439-95-4	Magnesium	55.3	55.3	mg/L	0.2	0.011		0	18-Aug-00
PFE-2	12-Jul-00	0007211518	CATIONS	6010	7440-09-7	Potassium	4	4.0	mg/L	5	0.18	J	0	18-Aug-00
PFE-2	12-Jul-00	0007211518	CATIONS	6010	7440-23-5	Sodium	51.3	51.3	mg/L	5	0.35		0	18-Aug-00
PFE-2	12-Jul-00	0007211518	CATIONS	6010	7440-70-2	Calcium	85.7	85.7	mg/L	0.2	0.048		0	18-Aug-00
PFE-2	12-Jul-00	0007211520	ANIONS	ANIONS		Fluoride	0.64	0.64	mg/L	0.1	0.01		0	08-Aug-00
PFE-2	12-Jul-00	0007211520	ANIONS	ANIONS		Chloride	37.2	37	mg/L	3	0.1		0	25-Jul-00
PFE-2	12-Jul-00	0007211520	ANIONS	ANIONS		Sulfate	279	279	mg/L	100	2		0	25-Jul-00
PFE-2	12-Jul-00	0007211520	ANIONS	ANIONS		Total Alkalinity	203	203	mg/L	5	0.5		0	02-Aug-00
PFE-2	12-Jul-00	0007211522	NO2,NO3	353.2		Nitrate-Nitrite	1	1.0	mg/L	0.1	0.021		0	03-Aug-00
PFE-2	12-Jul-00	0007211524	TDS	160.1		Total Dissolved Solids	848	848	mg/L	10	5.4		0	27-Jul-00
PFE-2	12-Jul-00	0007211526	NH3	350.1	7664-41-7	Ammonia as N	0.073	0.073	mg/L	0.1	0.029	J	0	01-Aug-00
PFE-3	24-Nov-98	9811241020	HVOA	8010	127-18-4	Tetrachloroethene	12	12	ug/L	0.5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	75-69-4	Trichlorofluoromethane	180	180	ug/L	0.5	0	G	0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	720	720	ug/L	12	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	79-01-6	Trichloroethene	200	200	ug/L	12	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	1.7	1.7	ug/L	5	0	J	0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	127-18-4	Tetrachloroethene	15	15	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	67-64-1	Acetone	87	87	ug/L	20	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	75-35-4	1,1-Dichloroethene	5.9	5.9	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	75-69-4	Trichlorofluoromethane	240	240	ug/L	25	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	700	700	ug/L	25	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	79-01-6	Trichloroethene	290	290	ug/L	25	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241034	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.66	0.66	ppb	0.01	0		25	02-Dec-98
PFE-3	24-Nov-98	9811241034	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.86	0.86	ppb	0.01	0		70	02-Dec-98
PFE-3	24-Nov-98	9811241036	RCRA	RCRA	7439-89-6	Iron	22600	22600	mg/L	0.1	0		0	14-Dec-98
PFE-3	24-Nov-98	9811241036	RCRA	RCRA	7439-96-5	Manganese	929	929	mg/L	0.01	0		0	14-Dec-98
PFE-3	24-Nov-98	9811241036	RCRA	RCRA	7440-39-3	Barium	21.6	21.6	mg/L	0.01	0		0	14-Dec-98
PFE-3	24-Nov-98	9811241038	CATIONS	6010	7439-89-6	Iron	0.7	0.70	mg/L	0.1	0		0	22-Dec-98
PFE-3	24-Nov-98	9811241038	CATIONS	6010	7439-95-4	Magnesium	66.9	66.9	mg/L	0.2	0		0	22-Dec-98
PFE-3	24-Nov-98	9811241038	CATIONS	6010	7440-09-7	Potassium	3.3	3.3	mg/L	5	0	J	0	22-Dec-98
PFE-3	24-Nov-98	9811241038	CATIONS	6010	7440-23-5	Sodium	38	38.0	mg/L	5	0		0	22-Dec-98
PFE-3	24-Nov-98	9811241038	CATIONS	6010	7440-70-2	Calcium	116	116	mg/L	0.2	0		0	22-Dec-98
PFE-3	24-Nov-98	9811241040	ANIONS	ANIONS		Fluoride	0.82	0.82	mg/L	0.1	0		0	11-Dec-98
PFE-3	24-Nov-98	9811241040	ANIONS	ANIONS		Chloride	51.9	51.9	mg/L	15	0		0	15-Dec-98
PFE-3	24-Nov-98	9811241040	ANIONS	ANIONS		Sulfate	304	304	mg/L	100	0		0	15-Dec-98
PFE-3	24-Nov-98	9811241040	ANIONS	ANIONS		Total Alkalinity	212	212	mg/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241042	NO2,NO3	353.2		Nitrate-Nitrite	2.1	2.1	mg/L	0.1	0		0	09-Dec-98
PFE-3	24-Nov-98	9811241044	TDS	160.1		Total Dissolved Solids	893	893	mg/L	10	0		0	30-Nov-98
PFE-3	24-Nov-98	9811241046	NH3	350.1	7664-41-7	Ammonia as N	0.16	0.16	mg/L	0.1	0		0	11-Dec-98
PFE-3	17-Jul-91	9107171445,1447	HVOA	8010	75-43-4	Dichlorofluoromethane	3	3	ug/L	0.5	0		0	25-Jul-91
PFE-3	17-Jul-91	9107171445,1447	HVOA	8010	75-69-4	Trichlorofluoromethane	290	290	ug/L	0.5	0		0	25-Jul-91
PFE-3	17-Jul-91	9107171445,1447	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	400	400	ug/L	0.5	0		0	25-Jul-91
PFE-3	17-Jul-91	9107171445,1447	HVOA	8010	79-01-6	Trichloroethene	320	320	ug/L	0.5	0		0	25-Jul-91
PFE-3	17-Jul-91	9107171445,1447	HVOA	8010	127-18-4	Tetrachloroethene	11	11	ug/L	1	0		0	25-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	75-69-4	Trichlorofluoromethane	270	270	ug/L	5	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	340	340	ug/L	5	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	79-01-6	Trichloroethene	250	250	ug/L	5	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	127-18-4	Tetrachloroethene	7	7	ug/L	5	0		0	26-Jul-91

Remediation Well Analytical Data

Results Above Non-Detect

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-3	17-Jul-91	9107171457	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.3	0.3	ug/L	0.1	0		32	26-Jul-91
PFE-3	17-Jul-91	9107171503	RCRA	RCRA	7440-39-3	Barium	0.029	0.029	mg/L	0.01	0		0	12-Aug-91
PFE-3	17-Jul-91	9107171503	RCRA	RCRA	7439-92-1	Lead	0.022	0.022	mg/L	0.005	0		0	13-Aug-91
PFE-3	21-Jun-91	9106121230,1232	HVOA	8010	75-43-4	Dichlorofluoromethane	1	1.0	ug/L	0.5	0		0	21-Jun-91
PFE-3	21-Jun-91	9106121230,1232	HVOA	8010	75-69-4	Trichlorofluoromethane	89	89	ug/L	0.5	0		0	21-Jun-91
PFE-3	21-Jun-91	9106121230,1232	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	140	140	ug/L	0.5	0		0	21-Jun-91
PFE-3	21-Jun-91	9106121230,1232	HVOA	8010	79-01-6	Trichloroethene	220	220	ug/L	0.5	0		0	21-Jun-91
PFE-3	21-Jun-91	9106121230,1232	HVOA	8010	127-18-4	Tetrachloroethene	7	7.0	ug/L	1	0		0	21-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	75-69-4	Trichlorofluoromethane	70	70	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	120	120	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	79-01-6	Trichloroethene	230	230	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121254	RCRA	RCRA	7440-39-3	Barium	0.018	0.018	mg/L	0.01	0		0	12-Jul-91
PFE-3	21-Jun-91	9106121242	VOA	8240	75-69-4	Trichlorofluoromethane	66	66	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121248	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.7	0.7	ug/L	0.1	0		18	14-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	110	110	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	79-01-6	Trichloroethene	220	220	ug/L	5	0		0	13-Jun-91
PFE-3	28-Mar-90	9003291250	HVOA	8010	79-01-6	Trichloroethene	373	373	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281341	HVOA	8010	75-43-4	Dichlorofluoromethane	19.4	19.4	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281341	HVOA	8010	75-69-4	Trichlorofluoromethane	435	435	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281341	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	396	396	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281341	HVOA	8010	79-01-6	Trichloroethene	395	395	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281341	HVOA	8010	127-18-4	Tetrachloroethene	16.3	16.3	ug/L	1	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281420	HVOA	8010	75-43-4	Dichlorofluoromethane	20.7	20.7	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281420	HVOA	8010	75-69-4	Trichlorofluoromethane	427	427	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281420	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	409	409	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281420	HVOA	8010	79-01-6	Trichloroethene	397	397	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281420	HVOA	8010	127-18-4	Tetrachloroethene	16.4	16.4	ug/L	1	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291226	HVOA	8010	75-43-4	Dichlorofluoromethane	8.6	8.6	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291226	HVOA	8010	75-69-4	Trichlorofluoromethane	473	473	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291226	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	411	411	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291226	HVOA	8010	79-01-6	Trichloroethene	413	413	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291226	HVOA	8010	127-18-4	Tetrachloroethene	16.3	16.3	ug/L	1	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291235	HVOA	8010	75-43-4	Dichlorofluoromethane	10.4	10.4	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291235	HVOA	8010	75-69-4	Trichlorofluoromethane	444	444	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291235	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	391	391	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291235	HVOA	8010	79-01-6	Trichloroethene	396	396	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291235	HVOA	8010	127-18-4	Tetrachloroethene	16.2	16.2	ug/L	1	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291250	HVOA	8010	75-43-4	Dichlorofluoromethane	9.6	9.6	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291250	HVOA	8010	75-69-4	Trichlorofluoromethane	424	424	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291250	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	375	375	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291250	HVOA	8010	127-18-4	Tetrachloroethene	14.8	14.8	ug/L	1	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291303	HVOA	8010	75-43-4	Dichlorofluoromethane	10.1	10.1	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291303	HVOA	8010	75-69-4	Trichlorofluoromethane	428	428	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291303	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	373	373	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291303	HVOA	8010	79-01-6	Trichloroethene	378	378	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291303	HVOA	8010	127-18-4	Tetrachloroethene	14.8	14.8	ug/L	1	0		0	29-Mar-90
PFE-4	31-Oct-00	0010311415	VOA	8260	108-88-3	Toluene	0.63	0.63	ug/L	1	0.29	J	0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	75-69-4	Trichlorofluoromethane	0.35	0.35	ug/L	2	0.28	J	0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0.82	0.82	ug/L	1	0.21	J	0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	79-01-6	Trichloroethene	0.56	0.56	ug/L	1	0.22	J	0	10-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	108-88-3	Toluene	0.6	0.60	ug/L	1	0.29	J	0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	75-69-4	Trichlorofluoromethane	0.31	0.31	ug/L	2	0.28	J	0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0.69	0.69	ug/L	1	0.21	J	0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	79-01-6	Trichloroethene	0.54	0.54	ug/L	1	0.22	J	0	11-Nov-00

Remediation Well Analytical Data

Results Above Non-Detect

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4	31-Oct-00	0010311431	RCRA	RCRA	7782-49-2	Selenium	0.0013	0.0013	mg/L	0.005	0.00082	J	0	18-Nov-00
PFE-4	31-Oct-00	0010311431	RCRA	RCRA	7439-97-6	Mercury	0.00003	0.000030	mg/L	0.0002	0.000028	J	0	20-Nov-00
PFE-4	31-Oct-00	0010311431	RCRA	RCRA	7440-39-3	Barium	0.041	0.041	mg/L	0.01	0.0015		0	27-Nov-00
PFE-4	30-May-00	0005301221	RCRA	RCRA	7782-49-2	Selenium	0.0018	0.0018	mg/L	0.005	0.0012	J	0	22-Jun-00
PFE-4	30-May-00	0005301221	RCRA	RCRA	7440-39-3	Barium	0.032	0.032	mg/L	0.01	0.0015		0	21-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0.25	0.25	ug/L	1	0.21	J	0	14-Jun-00
PFE-4	30-May-00	0006070957	RCRA	RCRA	7782-49-2	Selenium	0.0022	0.0022	mg/L	0.005	0.0012	J	0	07-Jul-00
PFE-4	30-May-00	0006070957	RCRA	RCRA	7440-39-3	Barium	0.026	0.026	mg/L	0.01	0.0015		0	12-Jul-00
PFE-4	30-May-00	0006080836	VOA	8260	108-88-3	Toluene	0.3	0.30	ug/L	1	0.29	J	0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0.52	0.52	ug/L	1	0.21	J	0	14-Jun-00
PFE-4	30-May-00	0006080846	RCRA	RCRA	7782-49-2	Selenium	0.0018	0.0018	mg/L	0.005	0.0012	J	0	07-Jul-00
PFE-4	30-May-00	0006080846	RCRA	RCRA	7440-39-3	Barium	0.026	0.026	mg/L	0.01	0.0015		0	12-Jul-00
PFE-4	30-May-00	0006080848	CATIONS	6010	7439-89-6	Iron	0.34	0.34	mg/L	0.1	0.012		0	23-Jun-00
PFE-4	30-May-00	0006080848	CATIONS	6010	7439-95-4	Magnesium	57.2	57.2	mg/L	0.2	0.011		0	24-Jun-00
PFE-4	30-May-00	0006080848	CATIONS	6010	7440-09-7	Potassium	4.3	4.3	mg/L	5	0.18	J	0	23-Jun-00
PFE-4	30-May-00	0006080848	CATIONS	6010	7440-23-5	Sodium	52.6	52.6	mg/L	5	0.35		0	23-Jun-00
PFE-4	30-May-00	0006080848	CATIONS	6010	7440-70-2	Calcium	95.8	95.8	mg/L	0.2	0.048		0	24-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Fluoride	0.92	0.92	mg/L	0.1	0.01		0	21-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Chloride	39	39	mg/L	3	0.1	SP G	0	22-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Sulfate	315	315	mg/L	50	1	G	0	22-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Total Alkalinity	194	194	mg/L	5	0.5		0	20-Jun-00
PFE-4	30-May-00	0006080852	NO2,NO3	353.2		Nitrate-Nitrite	0.83	0.83	mg/L	0.1	0.01		0	20-Jun-00
PFE-4	30-May-00	0006080854	TDS	160.1		Total Dissolved Solids	783	783	mg/L	10	5.4		0	15-Jun-00
PFE-4	30-May-00	0006080856	NH3	350.1	7664-41-7	Ammonia as N	0.045	0.045	mg/L	0.1	0.029	J	0	12-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Fluoride	0.92	0.92	mg/L	0.1	0.01		0	21-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Chloride	39	39	mg/L	3	0.1	SP G	0	22-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Sulfate	315	315	mg/L	50	1	G	0	22-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Total Alkalinity	194	194	mg/L	5	0.5		0	20-Jun-00
PFE-4A	04-Sep-01	0109041646	RCRA	RCRA	7782-49-2	Selenium	0.0015	0.0015	mg/L	0.005	0.00082	J	0	18-Sep-01
PFE-4A	04-Sep-01	0109041646	RCRA	RCRA	7440-38-2	Arsenic	0.00077	0.00077	mg/L	0.005	0.00065	J	0	18-Sep-01
PFE-4A	04-Sep-01	0109041646	RCRA	RCRA	7439-97-6	Mercury	0.00065	0.00065	mg/L	0.0002	0.00003		0	24-Sep-01
PFE-4A	04-Sep-01	0109041646	RCRA	RCRA	7440-39-3	Barium	0.029	0.029	mg/L	0.01	0.00083		0	23-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	127-18-4	Tetrachloroethene	4.1	4.1	ug/L	0.5	0.18		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	75-09-2	Methylene chloride	0.9	0.90	ug/L	5	0.18	J	0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	75-69-4	Trichlorofluoromethane	120	120	ug/L	5	0.2		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	120	120	ug/L	5	0.22		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	79-01-6	Trichloroethene	150	150	ug/L	5	0.16	SP	0	08-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	127-18-4	Tetrachloroethene	4	4.0	ug/L	0.5	0.18		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	75-09-2	Methylene chloride	1.8	1.8	ug/L	5	0.18	J	0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	75-69-4	Trichlorofluoromethane	120	120	ug/L	5	0.2		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	120	120	ug/L	5	0.22		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	79-01-6	Trichloroethene	150	150	ug/L	5	0.16		0	10-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	108-88-3	Toluene	1.5	1.5	ug/L	1	0.29		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	127-18-4	Tetrachloroethene	3.7	3.7	ug/L	1	0.36		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	67-64-1	Acetone	51	51	ug/L	10	1.9		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	75-69-4	Trichlorofluoromethane	160	160	ug/L	8	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	140	140	ug/L	4	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109041758	RCRA	RCRA	7440-38-2	Arsenic	0.0011	0.0011	mg/L	0.005	0.00065	J	0	18-Sep-01
PFE-4A	04-Sep-01	0109041758	RCRA	RCRA	7439-97-6	Mercury	0.000047	0.000047	mg/L	0.0002	0.00003	J	0	24-Sep-01
PFE-4A	04-Sep-01	0109041758	RCRA	RCRA	7440-39-3	Barium	0.029	0.029	mg/L	0.01	0.00083		0	23-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	127-18-4	Tetrachloroethene	3.9	3.9	ug/L	0.5	0.18		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	75-69-4	Trichlorofluoromethane	180	180	ug/L	5	0.2		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	120	120	ug/L	5	0.22		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	79-01-6	Trichloroethene	150	150	ug/L	5	0.16		0	10-Sep-01

Remediation Well Analytical Data

Results Above Non-Detect

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	04-Sep-01	0109050851	VOA	8260	127-18-4	Tetrachloroethene	3.6	3.6	ug/L	1	0.36		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	67-64-1	Acetone	54	54	ug/L	10	1.9		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	75-69-4	Trichlorofluoromethane	160	160	ug/L	8	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	140	140	ug/L	4	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	79-01-6	Trichloroethene	180	180	ug/L	4	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109050901	RCRA	RCRA	7782-49-2	Selenium	0.001	0.0010	mg/L	0.005	0.00082	J	0	18-Sep-01
PFE-4A	04-Sep-01	0109050901	RCRA	RCRA	7439-97-6	Mercury	0.000047	0.000047	mg/L	0.0002	0.00003	J	0	24-Sep-01
PFE-4A	04-Sep-01	0109050901	RCRA	RCRA	7440-39-3	Barium	0.03	0.030	mg/L	0.01	0.00083		0	23-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	120	120	ug/L	5	0.22		0	08-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	79-01-6	Trichloroethene	180	180	ug/L	4	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	108-88-3	Toluene	1.6	1.6	ug/L	1	0.29		0	06-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	127-18-4	Tetrachloroethene	4.2	4.2	ug/L	0.5	0.18		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	75-69-4	Trichlorofluoromethane	120	120	ug/L	5	0.2		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	130	130	ug/L	5	0.22		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	79-01-6	Trichloroethene	160	160	ug/L	5	0.16		0	08-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	108-88-3	Toluene	32	32	ug/L	1	0.29		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	127-18-4	Tetrachloroethene	3.8	3.8	ug/L	1	0.36		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	67-64-1	Acetone	52	52	ug/L	10	1.9		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	75-43-4	Dichlorofluoromethane	0.12	0.12	ug/L	2	0.12	J	0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	75-69-4	Trichlorofluoromethane	170	170	ug/L	8	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	140	140	ug/L	4	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	79-01-6	Trichloroethene	190	190	ug/L	4	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109041606	RCRA	RCRA	7782-49-2	Selenium	0.0012	0.0012	mg/L	0.005	0.00082	J	0	18-Sep-01
PFE-4A	04-Sep-01	0109041606	RCRA	RCRA	7440-38-2	Arsenic	0.0011	0.0011	mg/L	0.005	0.00065	J	0	18-Sep-01
PFE-4A	04-Sep-01	0109041606	RCRA	RCRA	7439-97-6	Mercury	0.000033	0.000033	mg/L	0.0002	0.00003	J	0	24-Sep-01
PFE-4A	04-Sep-01	0109041606	RCRA	RCRA	7440-39-3	Barium	0.029	0.029	mg/L	0.01	0.00083		0	23-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	127-18-4	Tetrachloroethene	4.4	4.4	ug/L	0.5	0.18		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	75-69-4	Trichlorofluoromethane	120	120	ug/L	5	0.2		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	79-01-6	Trichloroethene	170	170	ug/L	5	0.16		0	08-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	108-88-3	Toluene	17	17	ug/L	1	0.29		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	127-18-4	Tetrachloroethene	3.9	3.9	ug/L	1	0.36		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	67-64-1	Acetone	44	44	ug/L	10	1.9		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	75-43-4	Dichlorofluoromethane	0.14	0.14	ug/L	2	0.12	J	0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	75-69-4	Trichlorofluoromethane	170	170	ug/L	8	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	130	130	ug/L	4	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	79-01-6	Trichloroethene	210	210	ug/L	4	0.22		0	06-Sep-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	127-18-4	Tetrachloroethene	3.2	3.2	ug/L	0.5	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	75-69-4	Trichlorofluoromethane	100	100	ug/L	1.2	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	86	86	ug/L	1.2	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	79-01-6	Trichloroethene	110	110	ug/L	1.2	0.16		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	108-88-3	Toluene	2.4	2.4	ug/L	1	0.29		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	127-18-4	Tetrachloroethene	3.5	3.5	ug/L	1	0.36		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	67-64-1	Acetone	37	37	ug/L	10	1.9		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	75-69-4	Trichlorofluoromethane	110	110	ug/L	10	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	100	100	ug/L	5	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	79-01-6	Trichloroethene	150	150	ug/L	5	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261000	RCRA	RCRA	7782-49-2	Selenium	0.0013	0.0013	mg/L	0.005	0.00082	J	0	12-Sep-01
PFE-4A	26-Aug-01	0108261000	RCRA	RCRA	7439-97-6	Mercury	0.000031	0.000031	mg/L	0.0002	0.00003	J	0	18-Sep-01
PFE-4A	26-Aug-01	0108261000	RCRA	RCRA	7440-39-3	Barium	0.03	0.030	mg/L	0.01	0.00083		0	07-Sep-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	127-18-4	Tetrachloroethene	3.2	3.2	ug/L	0.5	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	75-69-4	Trichlorofluoromethane	110	110	ug/L	1.2	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	48	48	ug/L	1.2	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	79-01-6	Trichloroethene	120	120	ug/L	1.2	0.16		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	108-88-3	Toluene	4.5	4.5	ug/L	1	0.29		0	29-Aug-01

Remediation Well Analytical Data

Results Above Non-Detect

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	26-Aug-01	0108261014	VOA	8260	127-18-4	Tetrachloroethene	3.2	3.2	ug/L	1	0.36		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	67-64-1	Acetone	33	33	ug/L	10	1.9		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	75-69-4	Trichlorofluoromethane	100	100	ug/L	8	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	100	100	ug/L	4	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	79-01-6	Trichloroethene	140	140	ug/L	4	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261024	RCRA	RCRA	7782-49-2	Selenium	0.002	0.0020	mg/L	0.005	0.00082	J	0	12-Sep-01
PFE-4A	26-Aug-01	0108261024	RCRA	RCRA	7440-39-3	Barium	0.032	0.032	mg/L	0.01	0.00083		0	07-Sep-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	127-18-4	Tetrachloroethene	3.2	3.2	ug/L	0.5	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	75-69-4	Trichlorofluoromethane	100	100	ug/L	1.2	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	88	88	ug/L	1.2	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	79-01-6	Trichloroethene	120	120	ug/L	1.2	0.16		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	100	100	ug/L	4	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	108-88-3	Toluene	3.3	3.3	ug/L	1	0.29		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	127-18-4	Tetrachloroethene	3.2	3.2	ug/L	1	0.36		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	67-64-1	Acetone	33	33	ug/L	10	1.9		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	75-69-4	Trichlorofluoromethane	110	110	ug/L	8	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	79-01-6	Trichloroethene	150	150	ug/L	4	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261122	RCRA	RCRA	7782-49-2	Selenium	0.00098	0.00098	mg/L	0.005	0.00082	J	0	12-Sep-01
PFE-4A	26-Aug-01	0108261122	RCRA	RCRA	7440-22-4	Silver	0.0043	0.0043	mg/L	0.01	0.00062	J	0	06-Sep-01
PFE-4A	26-Aug-01	0108261122	RCRA	RCRA	7440-43-9	Cadmium	0.001	0.0010	mg/L	0.005	0.00029	J	0	06-Sep-01
PFE-4A	26-Aug-01	0108261122	RCRA	RCRA	7440-39-3	Barium	0.03	0.030	mg/L	0.01	0.00083		0	07-Sep-01
PFE-4A	26-Aug-01	0108261122	RCRA	RCRA	7440-47-3	Chromium	0.0043	0.0043	mg/L	0.01	0.0034	J	0	06-Sep-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	127-18-4	Tetrachloroethene	3.7	3.7	ug/L	0.5	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	75-69-4	Trichlorofluoromethane	110	110	ug/L	1.2	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	93	93	ug/L	1.2	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	79-01-6	Trichloroethene	120	120	ug/L	1.2	0.16		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	79-01-6	Trichloroethene	150	150	ug/L	4	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	110	110	ug/L	4	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	108-88-3	Toluene	1.4	1.4	ug/L	1	0.29		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	127-18-4	Tetrachloroethene	3.3	3.3	ug/L	1	0.36		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	128-37-0	Butylated hydroxytoluene	1.5	1.5	ug/L	0	0	TIC	0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	67-64-1	Acetone	37	37	ug/L	10	1.9		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	75-69-4	Trichlorofluoromethane	110	110	ug/L	8	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261206	RCRA	RCRA	7440-38-2	Arsenic	0.00068	0.00068	mg/L	0.005	0.00065	J	0	11-Sep-01
PFE-4A	26-Aug-01	0108261206	RCRA	RCRA	7440-22-4	Silver	0.0041	0.0041	mg/L	0.01	0.00062	J	0	06-Sep-01
PFE-4A	26-Aug-01	0108261206	RCRA	RCRA	7440-43-9	Cadmium	0.00083	0.00083	mg/L	0.005	0.00029	J	0	06-Sep-01
PFE-4A	26-Aug-01	0108261206	RCRA	RCRA	7440-39-3	Barium	0.029	0.029	mg/L	0.01	0.00083		0	07-Sep-01
PFE-4A	26-Aug-01	0108261206	RCRA	RCRA	7440-47-3	Chromium	0.0036	0.0036	mg/L	0.01	0.0034	J	0	06-Sep-01
PFE-4A	26-Aug-01	0108261208	CATIONS	6010	7439-89-6	Iron	0.57	0.57	mg/L	0.1	0.0051		0	06-Sep-01
PFE-4A	26-Aug-01	0108261208	CATIONS	6010	7439-95-4	Magnesium	64.4	64.4	mg/L	0.2	0.021		0	06-Sep-01
PFE-4A	26-Aug-01	0108261208	CATIONS	6010	7440-09-7	Potassium	4.5	4.5	mg/L	5	0.5	J	0	06-Sep-01
PFE-4A	26-Aug-01	0108261208	CATIONS	6010	7440-23-5	Sodium	40.8	40.8	mg/L	5	2		0	06-Sep-01
PFE-4A	26-Aug-01	0108261208	CATIONS	6010	7440-70-2	Calcium	106	106	mg/L	0.2	0.029		0	06-Sep-01
PFE-4A	26-Aug-01	0108261210	ANIONS	ANIONS		Fluoride	0.8	0.80	mg/L	0.1	0.012		0	04-Sep-01
PFE-4A	26-Aug-01	0108261210	ANIONS	ANIONS		Chloride	42.1	42	mg/L	3	0.1		0	06-Sep-01
PFE-4A	26-Aug-01	0108261210	ANIONS	ANIONS		Sulfate	304	304	mg/L	100	2		0	06-Sep-01
PFE-4A	26-Aug-01	0108261210	ANIONS	ANIONS		Total Alkalinity	220	220	mg/L	5	0.5		0	06-Sep-01
PFE-4A	26-Aug-01	0108261212	NO2,NO3	353.2		Nitrate-Nitrite	1.3	1.3	mg/L	0.1	0.021		0	07-Sep-01
PFE-4A	26-Aug-01	0108261214	TDS	160.1		Total Dissolved Solids	830	830	mg/L	10	4.8		0	30-Aug-01
PFE-4A	26-Aug-01	0108261216	NH3	350.1	7664-41-7	Ammonia as N	0.049	0.049	mg/L	0.1	0.031	J	0	07-Sep-01
PFE-5	27-Apr-00	0004271015	HVOA	8021	75-43-4	Dichlorofluoromethane	1.7	1.7	ug/L	0.5	0.31		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	75-69-4	Trichlorofluoromethane	34	34	ug/L	0.5	0.055		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	30	30	ug/L	0.5	0.18		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	79-01-6	Trichloroethene	140	140	ug/L	1.2	0.16		0	05-May-00

Remediation Well Analytical Data

Results Above Non-Detect

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-5	27-Apr-00	0004271015	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	1.4	1.4	ug/L	5	0.35	J	0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	127-18-4	Tetrachloroethene	5.3	5.3	ug/L	0.5	0.18		0	05-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0.72	0.72	ug/L	1	0.32	J	0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	108-88-3	Toluene	2.7	2.7	ug/L	1	0.29		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	127-18-4	Tetrachloroethene	7.1	7.1	ug/L	1	0.1		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	75-35-4	1,1-Dichloroethene	0.94	0.94	ug/L	1	0.2	J	0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	75-43-4	Dichlorofluoromethane	0.76	0.76	ug/L	2	0.12	J	0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	75-69-4	Trichlorofluoromethane	56	56	ug/L	2	0.28		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	36	36	ug/L	1	0.21		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	79-01-6	Trichloroethene	150	150	ug/L	5	0.1		0	04-May-00
PFE-5	27-Apr-00	0004271029	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.89	0.89	ppb	0.01	0.005		63	03-May-00
PFE-5	27-Apr-00	0004271029	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.58	0.58	ppb	0.01	0.005		63	03-May-00
PFE-5	27-Apr-00	0004271031	RCRA	RCRA	7440-39-3	Barium	0.021	0.021	mg/L	0.01	0.0015		0	05-May-00
PFE-5	27-Apr-00	0005011231	RCRA	RCRA	7782-49-2	Selenium	0.0016	0.0016	mg/L	0.005	0.0012	J	0	15-May-00
PFE-5	27-Apr-00	0005011231	RCRA	RCRA	7439-97-6	Mercury	0.000039	0.000039	mg/L	0.0002	0.000028	J	0	10-May-00
PFE-5	27-Apr-00	0005011231	RCRA	RCRA	7440-39-3	Barium	0.026	0.026	mg/L	0.01	0.0015		0	08-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	127-18-4	Tetrachloroethene	6.7	6.7	ug/L	0.5	0.18		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	75-69-4	Trichlorofluoromethane	88	88	ug/L	2.5	0.055		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	28	28	ug/L	0.5	0.18		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	79-01-6	Trichloroethene	150	150	ug/L	2.5	0.16		0	16-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0.7	0.70	ug/L	1	0.32	J	0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	108-88-3	Toluene	1.2	1.2	ug/L	1	0.29		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	127-18-4	Tetrachloroethene	7.6	7.6	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	67-66-3	Chloroform	0.24	0.24	ug/L	1	0.23	J	0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	75-35-4	1,1-Dichloroethene	0.8	0.80	ug/L	1	0.2	J	0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	75-43-4	Dichlorofluoromethane	0.98	0.98	ug/L	2	0.12	J	0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	75-69-4	Trichlorofluoromethane	53	53	ug/L	13	0.28		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	49	49	ug/L	6.7	0.21		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	79-01-6	Trichloroethene	160	160	ug/L	6.7	0.1		0	11-May-00
PFE-5	27-Apr-00	0005021234	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.8	0.80	ppb	0.01	0.005		54	16-May-00
PFE-5	27-Apr-00	0005021234	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.54	0.54	ppb	0.01	0.005		54	16-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	127-18-4	Tetrachloroethene	4.9	4.9	ug/L	0.5	0.18		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	75-69-4	Trichlorofluoromethane	48	48	ug/L	0.5	0.055		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	27	27	ug/L	0.5	0.18		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	79-01-6	Trichloroethene	130	130	ug/L	2.5	0.16	SP	0	17-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0.56	0.56	ug/L	1	0.32	J	0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	108-88-3	Toluene	1.9	1.9	ug/L	1	0.29		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	127-18-4	Tetrachloroethene	6.3	6.3	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	75-35-4	1,1-Dichloroethene	0.75	0.75	ug/L	1	0.2	J	0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	75-43-4	Dichlorofluoromethane	0.78	0.78	ug/L	2	0.12	J	0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	75-69-4	Trichlorofluoromethane	53	53	ug/L	2	0.28		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	44	44	ug/L	1	0.21		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	79-01-6	Trichloroethene	150	150	ug/L	4	0.1		0	11-May-00
PFE-5	27-Apr-00	0005050943	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.81	0.81	ppb	0.01	0.005		67	16-May-00
PFE-5	27-Apr-00	0005050943	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.55	0.55	ppb	0.01	0.005		67	16-May-00
PFE-5	27-Apr-00	0005050947	RCRA	RCRA	7440-39-3	Barium	0.023	0.02	mg/L	0.01	0.0015		0	18-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	127-18-4	Tetrachloroethene	6	6.0	ug/L	0.5	0.18		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	75-69-4	Trichlorofluoromethane	62	62	ug/L	2.5	0.055		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	43	43	ug/L	0.5	0.18		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	79-01-6	Trichloroethene	140	140	ug/L	2.5	0.16	SP	0	24-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0.68	0.68	ug/L	1	0.32	J	0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	75-43-4	Dichlorofluoromethane	0.88	0.88	ug/L	2	0.12	J	0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	75-69-4	Trichlorofluoromethane	56	56	ug/L	8	0.28		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	127-18-4	Tetrachloroethene	7	7.0	ug/L	1	0.1		0	16-May-00

Remediation Well Analytical Data

Results Above Non-Detect

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-5	27-Apr-00	0005111007	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	55	55	ug/L	4	0.21		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	79-01-6	Trichloroethene	160	160	ug/L	4	0.1		0	16-May-00
PFE-5	27-Apr-00	0005111013	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.75	0.75	ppb	0.01	0.005		47	16-May-00
PFE-5	27-Apr-00	0005111013	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.45	0.45	ppb	0.01	0.005		47	16-May-00
PFE-5	27-Apr-00	0005111017	RCRA	RCRA	7439-92-1	Lead	0.0026	0.0026	mg/L	0.003	0.0015	J	0	22-May-00
PFE-5	27-Apr-00	0005111017	RCRA	RCRA	7782-49-2	Selenium	0.002	0.0020	mg/L	0.005	0.0012	J	0	24-May-00
PFE-5	27-Apr-00	0005111017	RCRA	RCRA	7440-39-3	Barium	0.024	0.024	mg/L	0.01	0.0015		0	23-May-00
PFE-5	27-Apr-00	0005111019	CATIONS	6010	7439-95-4	Magnesium	60.8	60.8	mg/L	0.2	0.011		0	19-May-00
PFE-5	27-Apr-00	0005111019	CATIONS	6010	7440-23-5	Sodium	56.6	56.6	mg/L	5	0.35		0	18-May-00
PFE-5	27-Apr-00	0005111019	CATIONS	6010	7439-89-6	Iron	0.47	0.47	mg/L	0.1	0.012		0	18-May-00
PFE-5	27-Apr-00	0005111019	CATIONS	6010	7440-09-7	Potassium	3.4	3.4	mg/L	5	0.18	J	0	18-May-00
PFE-5	27-Apr-00	0005111019	CATIONS	6010	7440-70-2	Calcium	95.6	95.6	mg/L	0.2	0.048		0	18-May-00
PFE-5	27-Apr-00	0005111021	ANIONS	ANIONS		Fluoride	0.78	0.78	mg/L	0.1	0.01		0	19-May-00
PFE-5	27-Apr-00	0005111021	ANIONS	ANIONS		Sulfate	316	316	mg/L	50	1	SP	0	24-May-00
PFE-5	27-Apr-00	0005111021	ANIONS	ANIONS		Chloride	48	48	mg/L	3	0.1		0	24-May-00
PFE-5	27-Apr-00	0005111021	ANIONS	ANIONS		Total Alkalinity	192	192	mg/L	5	0.5		0	23-May-00
PFE-5	27-Apr-00	0005111023	NO2,NO3	353.2		Nitrate-Nitrite	2.3	2.3	mg/L	0.1	0.01		0	15-May-00
PFE-5	27-Apr-00	0005111025	TDS	160.1		Total Dissolved Solids	810	810	mg/L	10	5.4		0	17-May-00
PFE-5	27-Apr-00	0005111027	NH3	350.1	7664-41-7	Ammonia as N	0.049	0.049	mg/L	0.1	0.029	J	0	15-May-00
PFE-6	19-Apr-00	0004191257	RCRA	RCRA	7439-97-6	Mercury	0.00003	0.000030	mg/L	0.0002	0.000028	J	0	27-Apr-00
PFE-6	19-Apr-00	0004191257	RCRA	RCRA	7440-39-3	Barium	0.041	0.041	mg/L	0.01	0.0015		0	30-Apr-00
PFE-6	19-Apr-00	0004191257	RCRA	RCRA	7439-92-1	Lead	0.0017	0.0017	mg/L	0.003	0.0015	J	0	04-May-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	127-18-4	Tetrachloroethene	10	10	ug/L	0.5	0.18		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	75-69-4	Trichlorofluoromethane	370	370	ug/L	12	0.055		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	660	660	ug/L	12	0.18		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	79-01-6	Trichloroethene	210	210	ug/L	12	0.16		0	27-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	127-18-4	Tetrachloroethene	10	10	ug/L	1	0.1		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	67-66-3	Chloroform	0.31	0.31	ug/L	1	0.23	J	0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	75-43-4	Dichlorofluoromethane	2.3	2.3	ug/L	2	0.12		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	75-69-4	Trichlorofluoromethane	210	210	ug/L	27	0.28		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	490	490	ug/L	13	0.21		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	79-00-5	1,1,2-Trichloroethane	0.24	0.24	ug/L	1	0.1	J	0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	79-01-6	Trichloroethene	210	210	ug/L	13	0.1		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	75-35-4	1,1-Dichloroethene	2.8	2.8	ug/L	1	0.2		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	2.2	2.2	ug/L	1	0.32		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	108-88-3	Toluene	51	51	ug/L	1	0.29		0	29-Apr-00
PFE-6	19-Apr-00	0004200809	NDMA	607	62-75-9	N-Nitrosodimethylamine	1.42	1.4	ppb	0.01	0.005		54	03-May-00
PFE-6	19-Apr-00	0004200809	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.97	0.97	ppb	0.01	0.005		54	03-May-00
PFE-6	19-Apr-00	0004200811	RCRA	RCRA	7440-39-3	Barium	0.038	0.038	mg/L	0.01	0.0015		0	30-Apr-00
PFE-6	19-Apr-00	0004200813	CATIONS	6010	7439-89-6	Iron	2.7	2.7	mg/L	0.1	0.01		0	01-May-00
PFE-6	19-Apr-00	0004200813	CATIONS	6010	7439-95-4	Magnesium	66.6	66.6	mg/L	0.2	0.01		0	30-Apr-00
PFE-6	19-Apr-00	0004200813	CATIONS	6010	7440-09-7	Potassium	3.5	3.5	mg/L	5	0.18	J	0	01-May-00
PFE-6	19-Apr-00	0004200813	CATIONS	6010	7440-23-5	Sodium	48.5	48.5	mg/L	5	0.35		0	01-May-00
PFE-6	19-Apr-00	0004200813	CATIONS	6010	7440-70-2	Calcium	120	120	mg/L	0.2	0.04		0	30-Apr-00
PFE-6	19-Apr-00	0004200815	ANIONS	ANIONS		Fluoride	0.81	0.81	mg/L	0.1	0.01		0	26-Apr-00
PFE-6	19-Apr-00	0004200815	ANIONS	ANIONS		Chloride	53.2	53.2	mg/L	15	0.5		0	30-Apr-00
PFE-6	19-Apr-00	0004200815	ANIONS	ANIONS		Sulfate	332	332	mg/L	100	2		0	30-Apr-00
PFE-6	19-Apr-00	0004200815	ANIONS	ANIONS		Total Alkalinity	227	227	mg/L	5	0.5		0	04-May-00
PFE-6	19-Apr-00	0004200817	NO2,NO3	353.2		Nitrate-Nitrite	2.2	2.2	mg/L	0.4	0.04		0	24-Apr-00
PFE-6	19-Apr-00	0004200819	TDS	160.1		Total Dissolved Solids	886	886	mg/L	10	5.4		0	26-Apr-00
PFE-6	19-Apr-00	0004200821	NH3	350.1	7664-41-7	Ammonia as N	0.12	0.12	mg/L	0.1	0.02		0	26-Apr-00
PFE-7	27-Aug-01	0108271440	HVOA	8021	127-18-4	Tetrachloroethene	0.21	0.21	ug/L	0.5	0.18	J	0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	75-69-4	Trichlorofluoromethane	12	12	ug/L	0.5	0.2		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	7.9	7.9	ug/L	0.5	0.22		0	31-Aug-01

Remediation Well Analytical Data

Results Above Non-Detect

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-7	27-Aug-01	0108271440	HVOA	8021	79-01-6	Trichloroethene	13	13	ug/L	0.5	0.16		0	31-Aug-01
PFE-7	27-Aug-01	0108271446	VOA	8260	108-88-3	Toluene	3.8	3.8	ug/L	1	0.29		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	67-64-1	Acetone	5.2	5.2	ug/L	10	1.9	J RB FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	75-69-4	Trichlorofluoromethane	14	14	ug/L	2	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	8.7	8.7	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	78-93-3	2-Butanone (MEK)	1.2	1.2	ug/L	5	0.93	J FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	79-01-6	Trichloroethene	16	16	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	108-88-3	Toluene	4	4.0	ug/L	1	0.29		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	75-69-4	Trichlorofluoromethane	14	14	ug/L	2	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	8.6	8.6	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	79-01-6	Trichloroethene	16	16	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271508	RCRA	RCRA	7782-49-2	Selenium	0.0018	0.0018	mg/L	0.005	0.00082	J	0	12-Sep-01
PFE-7	27-Aug-01	0108271508	RCRA	RCRA	7440-43-9	Cadmium	0.00047	0.00047	mg/L	0.005	0.00029	J	0	14-Sep-01
PFE-7	27-Aug-01	0108271508	RCRA	RCRA	7440-39-3	Barium	0.04	0.040	mg/L	0.01	0.00083		0	14-Sep-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	127-18-4	Tetrachloroethene	0.24	0.24	ug/L	0.5	0.18	J	0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	75-69-4	Trichlorofluoromethane	12	12	ug/L	0.5	0.2		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	7.8	7.8	ug/L	0.5	0.22		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	79-01-6	Trichloroethene	13	13	ug/L	0.5	0.16		0	31-Aug-01
PFE-7	27-Aug-01	0108271516	VOA	8260	108-88-3	Toluene	3.2	3.2	ug/L	1	0.29		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	75-69-4	Trichlorofluoromethane	15	15	ug/L	2	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	9	9.0	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	79-01-6	Trichloroethene	17	17	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271526	RCRA	RCRA	7782-49-2	Selenium	0.0013	0.0013	mg/L	0.005	0.00082	J SP	0	12-Sep-01
PFE-7	27-Aug-01	0108271526	RCRA	RCRA	7440-39-3	Barium	0.039	0.039	mg/L	0.01	0.00083		0	14-Sep-01
PFE-7	27-Aug-01	0108271528	RCRA-D	RCRA	7782-49-2	Selenium	0.0017	0.0017	mg/L	0.005	0.00082	J	0	12-Sep-01
PFE-7	27-Aug-01	0108271528	RCRA-D	RCRA	7440-39-3	Barium	0.039	0.039	mg/L	0.01	0.00083		0	14-Sep-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	127-18-4	Tetrachloroethene	0.32	0.32	ug/L	0.5	0.18	J	0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	75-69-4	Trichlorofluoromethane	12	12	ug/L	0.5	0.2		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	8.1	8.1	ug/L	0.5	0.22		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	79-01-6	Trichloroethene	14	14	ug/L	0.5	0.16		0	31-Aug-01
PFE-7	27-Aug-01	0108271606	VOA	8260	108-88-3	Toluene	3.5	3.5	ug/L	1	0.29		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	75-69-4	Trichlorofluoromethane	15	15	ug/L	2	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	8.8	8.8	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	79-01-6	Trichloroethene	16	16	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271616	RCRA	RCRA	7782-49-2	Selenium	0.0014	0.0014	mg/L	0.005	0.00082	J	0	12-Sep-01
PFE-7	27-Aug-01	0108271616	RCRA	RCRA	7440-43-9	Cadmium	0.00048	0.00048	mg/L	0.005	0.00029	J	0	14-Sep-01
PFE-7	27-Aug-01	0108271616	RCRA	RCRA	7440-39-3	Barium	0.04	0.040	mg/L	0.01	0.00083		0	14-Sep-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	127-18-4	Tetrachloroethene	0.22	0.22	ug/L	0.5	0.18	J	0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	75-69-4	Trichlorofluoromethane	14	14	ug/L	0.5	0.2		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	9.1	9.1	ug/L	0.5	0.22		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	79-01-6	Trichloroethene	15	15	ug/L	0.5	0.16		0	31-Aug-01
PFE-7	27-Aug-01	0108271636	VOA	8260	108-88-3	Toluene	2.3	2.3	ug/L	1	0.29		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	127-18-4	Tetrachloroethene	0.37	0.37	ug/L	1	0.36	J	0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	75-69-4	Trichlorofluoromethane	15	15	ug/L	2	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	9.2	9.2	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	79-01-6	Trichloroethene	17	17	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271646	RCRA	RCRA	7782-49-2	Selenium	0.0017	0.0017	mg/L	0.005	0.00082	J	0	12-Sep-01
PFE-7	27-Aug-01	0108271646	RCRA	RCRA	7440-39-3	Barium	0.038	0.038	mg/L	0.01	0.00083		0	14-Sep-01
PFE-7	27-Aug-01	0108271648	CATIONS	6010	7439-89-6	Iron	0.22	0.22	mg/L	0.1	0.0051		0	11-Sep-01
PFE-7	27-Aug-01	0108271648	CATIONS	6010	7439-95-4	Magnesium	63.3	63.3	mg/L	0.2	0.021		0	11-Sep-01
PFE-7	27-Aug-01	0108271648	CATIONS	6010	7440-09-7	Potassium	3.8	3.8	mg/L	5	0.5	J	0	11-Sep-01
PFE-7	27-Aug-01	0108271648	CATIONS	6010	7440-23-5	Sodium	51.9	51.9	mg/L	5	2		0	11-Sep-01
PFE-7	27-Aug-01	0108271648	CATIONS	6010	7440-70-2	Calcium	100	100	mg/L	0.2	0.029		0	11-Sep-01
PFE-7	27-Aug-01	0108271650	ANIONS	ANIONS		Fluoride	0.62	0.62	mg/L	0.1	0.012		0	04-Sep-01

Remediation Well Analytical Data

Results Above Non-Detect

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-7	27-Aug-01	0108271650	ANIONS	ANIONS		Chloride	39.9	40	mg/L	3	0.1		0	06-Sep-01
PFE-7	27-Aug-01	0108271650	ANIONS	ANIONS		Sulfate	322	322	mg/L	100	2		0	06-Sep-01
PFE-7	27-Aug-01	0108271650	ANIONS	ANIONS		Total Alkalinity	232	232	mg/L	5	0.5		0	07-Sep-01
PFE-7	27-Aug-01	0108271652	NO2,NO3	353.2		Nitrate-Nitrite	0.81	0.81	mg/L	0.1	0.021	SP	0	07-Sep-01
PFE-7	27-Aug-01	0108271654	TDS	160.1		Total Dissolved Solids	807	807	mg/L	10	4.8		0	31-Aug-01
PFE-7	27-Aug-01	0108271656	NH3	350.1	7664-41-7	Ammonia as N	0.17	0.17	mg/L	0.1	0.031		0	10-Sep-01

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-1	28-Jun-00	0006280945	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	127-18-4	Tetrachloroethene	1.8	1.8	ug/L	0.5	0.18		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	75-69-4	Trichlorofluoromethane	49	49	ug/L	0.5	0.055		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	72	72	ug/L	1.2	0.18		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	79-01-6	Trichloroethene	58	58	ug/L	1.2	0.16		0	07-Jul-00
PFE-1	28-Jun-00	0006280945	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	108-88-3	Toluene	0.47	0.47	ug/L	1	0.29	J	0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	127-18-4	Tetrachloroethene	2.2	2.2	ug/L	1	0.36		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	07-Jul-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-1	28-Jun-00	0006280951	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.95		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	75-35-4	1,1-Dichloroethene	0.38	0.38	ug/L	1	0.2	J	0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	75-43-4	Dichlorofluoromethane	0.16	0.16	ug/L	2	0.12	J	0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	75-69-4	Trichlorofluoromethane	49	49	ug/L	2	0.28		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	74	74	ug/L	2	0.21		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	79-01-6	Trichloroethene	64	64	ug/L	2	0.22		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	07-Jul-00
PFE-1	28-Jun-00	0006280951	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	07-Jul-00
PFE-1	28-Jun-00	0006280959	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.14	0.14	ppb	0.01	0.005		75	13-Jul-00
PFE-1	28-Jun-00	0006280959	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.03	0.03	ppb	0.01	0.005		75	13-Jul-00
PFE-1	28-Jun-00	0006281001	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	15-Jul-00
PFE-1	28-Jun-00	0006281001	RCRA	RCRA	7782-49-2	Selenium	0.0021	0.0021	mg/L	0.005	0.0012	J	0	17-Jul-00
PFE-1	28-Jun-00	0006281001	RCRA	RCRA	7440-38-2	Arsenic	0.0014	0.0014	mg/L	0.005	0.0013	J	0	15-Jul-00
PFE-1	28-Jun-00	0006281001	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	25-Jul-00
PFE-1	28-Jun-00	0006281001	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0032		0	03-Aug-00
PFE-1	28-Jun-00	0006281001	RCRA	RCRA	7440-39-3	Barium	0.027	0.027	mg/L	0.01	0.00043		0	03-Aug-00
PFE-1	28-Jun-00	0006281001	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.0031		0	03-Aug-00
PFE-1	28-Jun-00	0006281001	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0028		0	03-Aug-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	127-18-4	Tetrachloroethene	1.5	1.5	ug/L	0.5	0.18		0	11-Jul-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-1	28-Jun-00	0006281215	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	75-69-4	Trichlorofluoromethane	42	42	ug/L	0.5	0.055		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	67	67	ug/L	1.2	0.18		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	79-01-6	Trichloroethene	64	64	ug/L	1.2	0.16		0	11-Jul-00
PFE-1	28-Jun-00	0006281215	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	11-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	127-18-4	Tetrachloroethene	1.6	1.6	ug/L	0.5	0.18		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	75-69-4	Trichlorofluoromethane	41	41	ug/L	0.5	0.055		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	82	82	ug/L	1.2	0.18		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	79-01-6	Trichloroethene	69	69	ug/L	1.2	0.16		0	12-Jul-00
PFE-1	28-Jun-00	0006281221	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	12-Jul-00
PFE-1	28-Jun-00	0006281227	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.16	0.16	ppb	0.01	0.005		42	13-Jul-00
PFE-1	28-Jun-00	0006281227	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.02	0.02	ppb	0.01	0.005		42	13-Jul-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-1	28-Jun-00	0006281231	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	15-Jul-00
PFE-1	28-Jun-00	0006281231	RCRA	RCRA	7782-49-2	Selenium	0.0022	0.0022	mg/L	0.005	0.0012	J	0	17-Jul-00
PFE-1	28-Jun-00	0006281231	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	15-Jul-00
PFE-1	28-Jun-00	0006281231	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	25-Jul-00
PFE-1	28-Jun-00	0006281231	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00056		0	30-Jul-00
PFE-1	28-Jun-00	0006281231	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00029		0	30-Jul-00
PFE-1	28-Jun-00	0006281231	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0011		0	30-Jul-00
PFE-1	28-Jun-00	0006281231	RCRA	RCRA	7440-39-3	Barium	0.03	0.030	mg/L	0.01	0.0021		0	30-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	127-18-4	Tetrachloroethene	1.8	1.8	ug/L	0.5	0.18		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	75-69-4	Trichlorofluoromethane	54	54	ug/L	1.2	0.055		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	78	78	ug/L	1.2	0.18		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	79-01-6	Trichloroethene	67	67	ug/L	1.2	0.16		0	11-Jul-00
PFE-1	28-Jun-00	0006281345	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	11-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	108-88-3	Toluene	0	ND	ug/L	1	0.29		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	07-Jul-00

Remediation Well Analytical Data

PFE-1

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-1	28-Jun-00	0006281351	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	127-18-4	Tetrachloroethene	2.2	2.2	ug/L	1	0.36		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.95		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	75-35-4	1,1-Dichloroethene	0.4	0.40	ug/L	1	0.2	J	0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	75-43-4	Dichlorofluoromethane	0.15	0.15	ug/L	2	0.12	J	0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	75-69-4	Trichlorofluoromethane	50	50	ug/L	2	0.28		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	86	86	ug/L	2	0.21		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	79-01-6	Trichloroethene	75	75	ug/L	2	0.22		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	07-Jul-00
PFE-1	28-Jun-00	0006281351	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	07-Jul-00
PFE-1	28-Jun-00	0006281357	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.15	0.15	ppb	0.01	0.005		42	13-Jul-00
PFE-1	28-Jun-00	0006281357	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.03	0.03	ppb	0.01	0.005		42	13-Jul-00
PFE-1	28-Jun-00	0006281401	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	15-Jul-00
PFE-1	28-Jun-00	0006281401	RCRA	RCRA	7782-49-2	Selenium	0.0016	0.0016	mg/L	0.005	0.0012	J	0	17-Jul-00
PFE-1	28-Jun-00	0006281401	RCRA	RCRA	7440-38-2	Arsenic	0.0015	0.0015	mg/L	0.005	0.0013	J	0	15-Jul-00
PFE-1	28-Jun-00	0006281401	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	25-Jul-00
PFE-1	28-Jun-00	0006281401	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00056		0	30-Jul-00
PFE-1	28-Jun-00	0006281401	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00029		0	30-Jul-00
PFE-1	28-Jun-00	0006281401	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0011		0	30-Jul-00
PFE-1	28-Jun-00	0006281401	RCRA	RCRA	7440-39-3	Barium	0.03	0.030	mg/L	0.01	0.0021		0	30-Jul-00

Remediation Well Analytical Data

PFE-1

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-1	28-Jun-00	0006290850	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	127-18-4	Tetrachloroethene	2	2.0	ug/L	0.5	0.18		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	75-69-4	Trichlorofluoromethane	43	43	ug/L	0.5	0.055		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	50	50	ug/L	0.5	0.18		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	79-01-6	Trichloroethene	54	54	ug/L	0.5	0.16		0	12-Jul-00
PFE-1	28-Jun-00	0006290850	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	12-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	108-88-3	Toluene	0	ND	ug/L	1	0.29		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	127-18-4	Tetrachloroethene	2.3	2.3	ug/L	1	0.36		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	10-Jul-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-1	28-Jun-00	0006290856	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.95		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	75-35-4	1,1-Dichloroethene	0.39	0.39	ug/L	1	0.2	J	0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	75-43-4	Dichlorofluoromethane	0.16	0.16	ug/L	2	0.12	J	0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	75-69-4	Trichlorofluoromethane	52	52	ug/L	2	0.28		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	83	83	ug/L	2	0.21		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	79-01-6	Trichloroethene	72	72	ug/L	2	0.22		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	10-Jul-00
PFE-1	28-Jun-00	0006290856	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	10-Jul-00
PFE-1	28-Jun-00	0006290902	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.15	0.15	ppb	0.01	0.005		42	13-Jul-00
PFE-1	28-Jun-00	0006290902	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.03	0.03	ppb	0.01	0.005		42	13-Jul-00
PFE-1	28-Jun-00	0006290906	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	15-Jul-00
PFE-1	28-Jun-00	0006290906	RCRA	RCRA	7782-49-2	Selenium	0.0018	0.0018	mg/L	0.005	0.0012	J	0	17-Jul-00
PFE-1	28-Jun-00	0006290906	RCRA	RCRA	7440-38-2	Arsenic	0.0015	0.0015	mg/L	0.005	0.0013	J	0	15-Jul-00
PFE-1	28-Jun-00	0006290906	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	25-Jul-00
PFE-1	28-Jun-00	0006290906	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00056		0	30-Jul-00
PFE-1	28-Jun-00	0006290906	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00029		0	30-Jul-00
PFE-1	28-Jun-00	0006290906	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0011		0	30-Jul-00
PFE-1	28-Jun-00	0006290906	RCRA	RCRA	7440-39-3	Barium	0.027	0.027	mg/L	0.01	0.0021		0	30-Jul-00
PFE-1	28-Jun-00	0006290908	CATIONS	6010	7439-89-6	Iron	0.25	0.25	mg/L	0.1	0.012		0	24-Jul-00
PFE-1	28-Jun-00	0006290908	CATIONS	6010	7439-95-4	Magnesium	53.8	53.8	mg/L	0.2	0.011		0	24-Jul-00
PFE-1	28-Jun-00	0006290908	CATIONS	6010	7440-09-7	Potassium	4.3	4.3	mg/L	5	0.18	J	0	24-Jul-00
PFE-1	28-Jun-00	0006290908	CATIONS	6010	7440-23-5	Sodium	58.8	58.8	mg/L	5	0.35		0	24-Jul-00
PFE-1	28-Jun-00	0006290908	CATIONS	6010	7440-70-2	Calcium	81.5	81.5	mg/L	0.2	0.048		0	24-Jul-00
PFE-1	28-Jun-00	0006290910	ANIONS	ANIONS		Fluoride	0.67	0.67	mg/L	0.1	0.01		0	15-Jul-00
PFE-1	28-Jun-00	0006290910	ANIONS	ANIONS		Chloride	40	40	mg/L	3	0.1		0	17-Jul-00
PFE-1	28-Jun-00	0006290910	ANIONS	ANIONS		Sulfate	250	250	mg/L	100	2		0	17-Jul-00

Remediation Well Analytical Data

PFE-1

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-1	28-Jun-00	0006290910	ANIONS	ANIONS		Total Alkalinity	183	183	mg/L	5	0.5		0	11-Jul-00
PFE-1	28-Jun-00	0006290912	NO2,NO3	353.2		Nitrate-Nitrite	1.6	1.6	mg/L	0.1	0.021		0	12-Jul-00
PFE-1	28-Jun-00	0006290914	TDS	160.1		Total Dissolved Solids	799	799	mg/L	10	5.4		0	06-Jul-00
PFE-1	28-Jun-00	0006290916	NH3	350.1	7664-41-7	Ammonia as N	0	ND	mg/L	0.1	0.029		0	12-Jul-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-2	12-Jul-00	0007120815	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	75-69-4	Trichlorofluoromethane	31	31	ug/L	0.5	0.055		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	18	18	ug/L	0.5	0.18		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	79-01-6	Trichloroethene	36	36	ug/L	0.5	0.16		0	18-Jul-00
PFE-2	12-Jul-00	0007120815	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	108-88-3	Toluene	4.1	4.1	ug/L	1	0.29		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	10		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	127-18-4	Tetrachloroethene	0.78	0.78	ug/L	1	0.36	J	0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	18-Jul-00

Remediation Well Analytical Data

PFE-2

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-2	12-Jul-00	0007120821	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.95		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	75-69-4	Trichlorofluoromethane	35	35	ug/L	2	0.28		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	25	25	ug/L	1	0.21		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	79-01-6	Trichloroethene	49	49	ug/L	1	0.22		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	18-Jul-00
PFE-2	12-Jul-00	0007120821	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	18-Jul-00
PFE-2	12-Jul-00	0007120827	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		58	27-Jul-00
PFE-2	12-Jul-00	0007120827	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		58	27-Jul-00
PFE-2	12-Jul-00	0007120831	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	21-Jul-00
PFE-2	12-Jul-00	0007120831	RCRA	RCRA	7782-49-2	Selenium	0.002	0.0020	mg/L	0.005	0.0012	J	0	21-Jul-00
PFE-2	12-Jul-00	0007120831	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	21-Jul-00
PFE-2	12-Jul-00	0007120831	RCRA	RCRA	7439-97-6	Mercury	0.000054	0.000054	mg/L	0.0002	0.000028	J RB	0	05-Aug-00
PFE-2	12-Jul-00	0007120831	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00056		0	30-Jul-00
PFE-2	12-Jul-00	0007120831	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00029		0	30-Jul-00
PFE-2	12-Jul-00	0007120831	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0011		0	30-Jul-00
PFE-2	12-Jul-00	0007120831	RCRA	RCRA	7440-39-3	Barium	0.028	0.028	mg/L	0.01	0.0021		0	30-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	20-Jul-00

Remediation Well Analytical Data

PFE-2

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-2	12-Jul-00	0007121343	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	75-69-4	Trichlorofluoromethane	35	35	ug/L	0.5	0.055		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	20	20	ug/L	0.5	0.18		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	79-01-6	Trichloroethene	31	31	ug/L	0.5	0.16		0	20-Jul-00
PFE-2	12-Jul-00	0007121343	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	20-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	108-88-3	Toluene	0.81	0.81	ug/L	1	0.29	J	0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	127-18-4	Tetrachloroethene	0.78	0.78	ug/L	1	0.36	J	0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	79-01-6	Trichloroethene	48	48	ug/L	1	0.22		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	19-Jul-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-2	12-Jul-00	0007121349	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.95		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	75-69-4	Trichlorofluoromethane	38	38	ug/L	2	0.28		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	26	26	ug/L	1	0.21		0	19-Jul-00
PFE-2	12-Jul-00	0007121349	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	19-Jul-00
PFE-2	12-Jul-00	0007121357	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		51	27-Jul-00
PFE-2	12-Jul-00	0007121357	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		51	27-Jul-00
PFE-2	12-Jul-00	0007121359	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	21-Jul-00
PFE-2	12-Jul-00	0007121359	RCRA	RCRA	7782-49-2	Selenium	0.002	0.0020	mg/L	0.005	0.0012	J	0	21-Jul-00
PFE-2	12-Jul-00	0007121359	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	21-Jul-00
PFE-2	12-Jul-00	0007121359	RCRA	RCRA	7439-97-6	Mercury	0.000055	0.000055	mg/L	0.0002	0.000028	J RB	0	05-Aug-00
PFE-2	12-Jul-00	0007121359	RCRA	RCRA	7440-22-4	Silver	0.0017	0.0017	mg/L	0.01	0.00056	J	0	29-Jul-00
PFE-2	12-Jul-00	0007121359	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00029		0	29-Jul-00
PFE-2	12-Jul-00	0007121359	RCRA	RCRA	7440-47-3	Chromium	0.0051	0.0051	mg/L	0.01	0.0011	J RB	0	29-Jul-00
PFE-2	12-Jul-00	0007121359	RCRA	RCRA	7440-39-3	Barium	0.026	0.026	mg/L	0.01	0.0021		0	29-Jul-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	01-Aug-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-2	12-Jul-00	0007211216	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	75-69-4	Trichlorofluoromethane	50	50	ug/L	1.2	0.055		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	33	33	ug/L	0.5	0.18		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	79-01-6	Trichloroethene	47	47	ug/L	0.5	0.16		0	01-Aug-00
PFE-2	12-Jul-00	0007211216	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	01-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	108-88-3	Toluene	0.59	0.59	ug/L	1	0.29	J	0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	127-18-4	Tetrachloroethene	1	1.0	ug/L	1	0.36		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	67-64-1	Acetone	3.6	3.6	ug/L	10	1.9	J RB	0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.95		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	02-Aug-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-2	12-Jul-00	0007211222	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	75-69-4	Trichlorofluoromethane	47	47	ug/L	2	0.28		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	23	23	ug/L	1	0.21		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	79-01-6	Trichloroethene	57	57	ug/L	2	0.22		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	02-Aug-00
PFE-2	12-Jul-00	0007211222	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	02-Aug-00
PFE-2	12-Jul-00	0007211230	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		54	28-Jul-00
PFE-2	12-Jul-00	0007211230	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		54	28-Jul-00
PFE-2	12-Jul-00	0007211232	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	31-Jul-00
PFE-2	12-Jul-00	0007211232	RCRA	RCRA	7782-49-2	Selenium	0.0017	0.0017	mg/L	0.005	0.0012	J	0	15-Aug-00
PFE-2	12-Jul-00	0007211232	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	31-Jul-00
PFE-2	12-Jul-00	0007211232	RCRA	RCRA	7439-97-6	Mercury	0.000054	0.000054	mg/L	0.0002	0.000028	J RB	0	05-Aug-00
PFE-2	12-Jul-00	0007211232	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00056		0	24-Aug-00
PFE-2	12-Jul-00	0007211232	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00029		0	24-Aug-00
PFE-2	12-Jul-00	0007211232	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0011		0	24-Aug-00
PFE-2	12-Jul-00	0007211232	RCRA	RCRA	7440-39-3	Barium	0.024	0.024	mg/L	0.01	0.0021		0	24-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	01-Aug-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-2	12-Jul-00	0007211500	HVOA	8021	75-69-4	Trichlorofluoromethane	70	70	ug/L	1.2	0.055		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	32	32	ug/L	0.5	0.18		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	79-01-6	Trichloroethene	44	44	ug/L	0.5	0.16		0	01-Aug-00
PFE-2	12-Jul-00	0007211500	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	01-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	108-88-3	Toluene	0.34	0.34	ug/L	1	0.29	J	0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	127-18-4	Tetrachloroethene	0.89	0.89	ug/L	1	0.36	J	0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.95		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	75-69-4	Trichlorofluoromethane	43	43	ug/L	2	0.28		0	02-Aug-00

Remediation Well Analytical Data

PFE-2

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-2	12-Jul-00	0007211506	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	21	21	ug/L	1	0.21		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	79-01-6	Trichloroethene	55	55	ug/L	1	0.22		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	02-Aug-00
PFE-2	12-Jul-00	0007211506	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	02-Aug-00
PFE-2	12-Jul-00	0007211512	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		54	28-Jul-00
PFE-2	12-Jul-00	0007211512	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		54	28-Jul-00
PFE-2	12-Jul-00	0007211518	CATIONS	6010	7439-89-6	Iron	0.6	0.60	mg/L	0.1	0.012		0	18-Aug-00
PFE-2	12-Jul-00	0007211518	CATIONS	6010	7439-95-4	Magnesium	55.3	55.3	mg/L	0.2	0.011		0	18-Aug-00
PFE-2	12-Jul-00	0007211518	CATIONS	6010	7440-09-7	Potassium	4	4.0	mg/L	5	0.18	J	0	18-Aug-00
PFE-2	12-Jul-00	0007211518	CATIONS	6010	7440-23-5	Sodium	51.3	51.3	mg/L	5	0.35		0	18-Aug-00
PFE-2	12-Jul-00	0007211518	CATIONS	6010	7440-70-2	Calcium	85.7	85.7	mg/L	0.2	0.048		0	18-Aug-00
PFE-2	12-Jul-00	0007211520	ANIONS	ANIONS		Fluoride	0.64	0.64	mg/L	0.1	0.01		0	08-Aug-00
PFE-2	12-Jul-00	0007211520	ANIONS	ANIONS		Chloride	37.2	37	mg/L	3	0.1		0	25-Jul-00
PFE-2	12-Jul-00	0007211520	ANIONS	ANIONS		Sulfate	279	279	mg/L	100	2		0	25-Jul-00
PFE-2	12-Jul-00	0007211520	ANIONS	ANIONS		Total Alkalinity	203	203	mg/L	5	0.5		0	02-Aug-00
PFE-2	12-Jul-00	0007211522	NO2,NO3	353.2		Nitrate-Nitrite	1	1.0	mg/L	0.1	0.021		0	03-Aug-00
PFE-2	12-Jul-00	0007211524	TDS	160.1		Total Dissolved Solids	848	848	mg/L	10	5.4		0	27-Jul-00
PFE-2	12-Jul-00	0007211526	NH3	350.1	7664-41-7	Ammonia as N	0.073	0.073	mg/L	0.1	0.029	J	0	01-Aug-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-3	24-Nov-98	9811241020	HVOA	8010	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	108-90-7	Chlorobenzene	0	ND	ug/L	2	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	127-18-4	Tetrachloroethene	12	12	ug/L	0.5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	67-66-3	Chloroform	0	ND	ug/L	0.5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	74-83-9	Bromomethane	0	ND	ug/L	5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	74-87-3	Chloromethane	0	ND	ug/L	5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	75-00-3	Chloroethane	0	ND	ug/L	5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	75-01-4	Vinyl chloride	0	ND	ug/L	1	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	75-09-2	Methylene chloride	0	ND	ug/L	5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	75-25-2	Bromoform	0	ND	ug/L	5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	75-69-4	Trichlorofluoromethane	180	180	ug/L	0.5	0	G	0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	720	720	ug/L	12	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	79-01-6	Trichloroethene	200	200	ug/L	12	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241020	HVOA	8010	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0		0	08-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	1.7	1.7	ug/L	5	0	J	0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	100-41-4	Ethylbenzene	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	100-42-5	Styrene	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	107-02-8	Acrolein	0	ND	ug/L	100	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	107-05-1	Allyl chloride	0	ND	ug/L	10	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	107-06-2	1,2-Dichloroethane	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	107-12-0	Propionitrile	0	ND	ug/L	20	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	107-13-1	Acrylonitrile	0	ND	ug/L	100	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	108-05-4	Vinyl acetate	0	ND	ug/L	10	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	20	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	108-88-3	Toluene	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	108-90-7	Chlorobenzene	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	109-99-9	Tetrahydrofuran	0	ND	ug/L	10	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	123-91-1	1,4-Dioxane	0	ND	ug/L	500	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	124-48-1	Dibromochloromethane	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	126-98-7	Methacrylonitrile	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	126-99-8	Chloroprene	0	ND	ug/L	5	5		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	127-18-4	Tetrachloroethene	15	15	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	1330-20-7	Xylenes (total)	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	10	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	5	0		0	03-Dec-98

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-3	24-Nov-98	9811241026	VOA	8240	56-23-5	Carbon tetrachloride	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	591-78-6	2-Hexanone	0	ND	ug/L	20	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	67-63-0	2-Propanol	0	ND	ug/L	300	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	67-64-1	Acetone	87	87	ug/L	20	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	67-66-3	Chloroform	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	71-43-2	Benzene	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	74-83-9	Bromomethane	0	ND	ug/L	10	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	74-87-3	Chloromethane	0	ND	ug/L	10	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	74-88-4	Iodomethane	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	74-95-3	Dibromomethane	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	75-00-3	Chloroethane	0	ND	ug/L	10	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	75-01-4	Vinyl chloride	0	ND	ug/L	10	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	75-05-8	Acetonitrile	0	ND	ug/L	100	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	75-09-2	Methylene chloride	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	75-15-0	Carbon disulfide	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	75-25-2	Bromoform	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	75-27-4	Bromodichloromethane	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	75-34-3	1,1-Dichloroethane	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	75-35-4	1,1-Dichloroethene	5.9	5.9	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	75-43-4	Dichlorofluoromethane	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	75-69-4	Trichlorofluoromethane	240	240	ug/L	25	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	10	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	700	700	ug/L	25	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	78-83-1	Isobutyl alcohol	0	ND	ug/L	200	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	78-87-5	1,2-Dichloropropane	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	78-93-3	2-Butanone	0	ND	ug/L	20	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	79-01-6	Trichloroethene	290	290	ug/L	25	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	80-62-6	Methyl methacrylate	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	96-12-8	1,2-Dibromo-3-chloropropane	0	ND	ug/L	10	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241026	VOA	8240	97-63-2	Ethyl methacrylate	0	ND	ug/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241034	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.66	0.66	ppb	0.01	0		25	02-Dec-98
PFE-3	24-Nov-98	9811241034	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.86	0.86	ppb	0.01	0		70	02-Dec-98
PFE-3	24-Nov-98	9811241036	RCRA	RCRA	7439-89-6	Iron	22600	22600	mg/L	0.1	0		0	14-Dec-98
PFE-3	24-Nov-98	9811241036	RCRA	RCRA	7439-96-5	Manganese	929	929	mg/L	0.01	0		0	14-Dec-98
PFE-3	24-Nov-98	9811241036	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0		0	14-Dec-98
PFE-3	24-Nov-98	9811241036	RCRA	RCRA	7440-39-3	Barium	21.6	21.6	mg/L	0.01	0		0	14-Dec-98
PFE-3	24-Nov-98	9811241036	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0		0	14-Dec-98
PFE-3	24-Nov-98	9811241036	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0		0	14-Dec-98
PFE-3	24-Nov-98	9811241036	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0		0	15-Dec-98
PFE-3	24-Nov-98	9811241036	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.005	0		0	18-Dec-98
PFE-3	24-Nov-98	9811241036	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.01	0		0	17-Dec-98
PFE-3	24-Nov-98	9811241036	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0		0	14-Dec-98
PFE-3	24-Nov-98	9811241038	CATIONS	6010	7439-89-6	Iron	0.7	0.70	mg/L	0.1	0		0	22-Dec-98
PFE-3	24-Nov-98	9811241038	CATIONS	6010	7439-95-4	Magnesium	66.9	66.9	mg/L	0.2	0		0	22-Dec-98
PFE-3	24-Nov-98	9811241038	CATIONS	6010	7440-09-7	Potassium	3.3	3.3	mg/L	5	0	J	0	22-Dec-98
PFE-3	24-Nov-98	9811241038	CATIONS	6010	7440-23-5	Sodium	38	38.0	mg/L	5	0		0	22-Dec-98
PFE-3	24-Nov-98	9811241038	CATIONS	6010	7440-70-2	Calcium	116	116	mg/L	0.2	0		0	22-Dec-98
PFE-3	24-Nov-98	9811241040	ANIONS	ANIONS		Fluoride	0.82	0.82	mg/L	0.1	0		0	11-Dec-98
PFE-3	24-Nov-98	9811241040	ANIONS	ANIONS		Chloride	51.9	51.9	mg/L	15	0		0	15-Dec-98

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-3	24-Nov-98	9811241040	ANIONS	ANIONS		Sulfate	304	304	mg/L	100	0		0	15-Dec-98
PFE-3	24-Nov-98	9811241040	ANIONS	ANIONS		Total Alkalinity	212	212	mg/L	5	0		0	03-Dec-98
PFE-3	24-Nov-98	9811241042	NO2,NO3	353.2		Nitrate-Nitrite	2.1	2.1	mg/L	0.1	0		0	09-Dec-98
PFE-3	24-Nov-98	9811241044	TDS	160.1		Total Dissolved Solids	893	893	mg/L	10	0		0	30-Nov-98
PFE-3	24-Nov-98	9811241046	NH3	350.1	7664-41-7	Ammonia as N	0.16	0.16	mg/L	0.1	0		0	11-Dec-98
PFE-3	17-Jul-91	9107171445,1447	HVOA	8010	75-43-4	Dichlorofluoromethane	3	3	ug/L	0.5	0		0	25-Jul-91
PFE-3	17-Jul-91	9107171445,1447	HVOA	8010	75-09-2	Dichloromethane	0	ND	ug/L	2	0		0	25-Jul-91
PFE-3	17-Jul-91	9107171445,1447	HVOA	8010	75-69-4	Trichlorofluoromethane	290	290	ug/L	0.5	0		0	25-Jul-91
PFE-3	17-Jul-91	9107171445,1447	HVOA	8010	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0		0	25-Jul-91
PFE-3	17-Jul-91	9107171445,1447	HVOA	8010	67-66-3	Trichloromethane	0	ND	ug/L	0.5	0		0	25-Jul-91
PFE-3	17-Jul-91	9107171445,1447	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	400	400	ug/L	0.5	0		0	25-Jul-91
PFE-3	17-Jul-91	9107171445,1447	HVOA	8010	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0		0	25-Jul-91
PFE-3	17-Jul-91	9107171445,1447	HVOA	8010	79-01-6	Trichloroethene	320	320	ug/L	0.5	0		0	25-Jul-91
PFE-3	17-Jul-91	9107171445,1447	HVOA	8010	127-18-4	Tetrachloroethene	11	11	ug/L	1	0		0	25-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	107-06-2	1,2-Dichloroethane	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	74-87-3	Chloromethane	0	ND	ug/L	20	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	75-01-4	Vinyl chloride	0	ND	ug/L	20	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	75-00-3	Chloroethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	17-Jul-91	9107171451	VOA	8240	75-09-2	Dichloromethane	0	ND	ug/L	5	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	75-43-4	Dichlorofluoromethane	0	ND	ug/L	5	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	74-83-9	Bromomethane	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	75-35-4	1,1-Dichloroethene	0	ND	ug/L	5	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	75-69-4	Trichlorofluoromethane	270	270	ug/L	5	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	75-34-3	1,1-Dichloroethane	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	156-60-5	t-1,2-Dichloroethene	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	67-66-3	Trichloromethane	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	340	340	ug/L	5	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	5	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	56-23-5	Tetrachloromethane	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	75-27-4	Bromodichloromethane	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	78-87-5	1,2-Dichloropropane	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	10061-01-5	c-1,3-Dichloropropene	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	79-01-6	Trichloroethene	250	250	ug/L	5	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	71-43-2	Benzene	0	ND	ug/L	5	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	124-48-1	Dibromochloromethane	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	75-25-2	Tribromomethane	0	ND	ug/L	20	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	110-75-8	2-Chloroethyl vinyl ether	0	ND	ug/L	25	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	10061-02-6	t-1,3-Dichloropropene	0	ND	ug/L	20	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	127-18-4	Tetrachloroethene	7	7	ug/L	5	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	108-88-3	Toluene	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	108-90-7	Chlorobenzene	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	100-41-4	Ethylbenzene	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	67-64-1	Acetone	0	ND	ug/L	50	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	78-93-3	2-Butanone	0	ND	ug/L	50	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	108-05-4	Vinyl acetate	0	ND	ug/L	50	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	67-63-0	2-Propanol	0	ND	ug/L	300	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	50	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	591-78-6	2-Hexanone	0	ND	ug/L	50	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	100-42-5	Styrene	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171451	VOA	8240	1330-20-7	Xylenes	0	ND	ug/L	10	0		0	26-Jul-91
PFE-3	17-Jul-91	9107171457	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.3	0.3	ug/L	0.1	0		32	26-Jul-91

Remediation Well Analytical Data

PFE-3 (NASA PT)

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-3	17-Jul-91	9107171503	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0		0	13-Aug-91
PFE-3	17-Jul-91	9107171503	RCRA	RCRA	7440-39-3	Barium	0.029	0.029	mg/L	0.01	0		0	12-Aug-91
PFE-3	17-Jul-91	9107171503	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0		0	12-Aug-91
PFE-3	17-Jul-91	9107171503	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0		0	12-Aug-91
PFE-3	17-Jul-91	9107171503	RCRA	RCRA	7439-92-1	Lead	0.022	0.022	mg/L	0.005	0		0	13-Aug-91
PFE-3	17-Jul-91	9107171503	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0		0	13-Aug-91
PFE-3	17-Jul-91	9107171503	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.005	0		0	14-Aug-91
PFE-3	17-Jul-91	9107171503	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0		0	12-Aug-91
PFE-3	21-Jun-91	9106121230,1232	HVOA	8010	75-43-4	Dichlorofluoromethane	1	1.0	ug/L	0.5	0		0	21-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	107-06-2	1,2-Dichloroethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121230,1232	HVOA	8010	75-09-2	Dichloromethane	0	ND	ug/L	2	0		0	21-Jun-91
PFE-3	21-Jun-91	9106121230,1232	HVOA	8010	75-69-4	Trichlorofluoromethane	89	89	ug/L	0.5	0		0	21-Jun-91
PFE-3	21-Jun-91	9106121230,1232	HVOA	8010	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0		0	21-Jun-91
PFE-3	21-Jun-91	9106121230,1232	HVOA	8010	67-66-3	Trichloromethane	0	ND	ug/L	0.5	0		0	21-Jun-91
PFE-3	21-Jun-91	9106121230,1232	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	140	140	ug/L	0.5	0		0	21-Jun-91
PFE-3	21-Jun-91	9106121230,1232	HVOA	8010	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0		0	21-Jun-91
PFE-3	21-Jun-91	9106121230,1232	HVOA	8010	79-01-6	Trichloroethene	220	220	ug/L	0.5	0		0	21-Jun-91
PFE-3	21-Jun-91	9106121230,1232	HVOA	8010	127-18-4	Tetrachloroethene	7	7.0	ug/L	1	0		0	21-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	74-87-3	Chloromethane	0	ND	ug/L	20	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	75-01-4	Vinyl chloride	0	ND	ug/L	20	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	75-00-3	Chloroethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	75-09-2	Dichloromethane	0	ND	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	75-43-4	Dichlorofluoromethane	0	ND	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	74-83-9	Bromomethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	75-35-4	1,1-Dichloroethene	0	ND	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	75-69-4	Trichlorofluoromethane	70	70	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	75-34-3	1,1-Dichloroethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	156-60-5	t-1,2-Dichloroethene	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	67-66-3	Trichloromethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	107-06-2	1,2-Dichloroethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	120	120	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	56-23-5	Tetrachloromethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	75-27-4	Bromodichloromethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	78-87-5	1,2-Dichloropropane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	10061-01-5	c-1,3-Dichloropropene	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	79-01-6	Trichloroethene	230	230	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	71-43-2	Benzene	0	ND	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	124-48-1	Dibromochloromethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	75-25-2	Tribromomethane	0	ND	ug/L	20	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	110-75-8	2-Chloroethyl vinyl ether	0	ND	ug/L	25	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	10061-02-6	t-1,3-Dichloropropene	0	ND	ug/L	20	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	127-18-4	Tetrachloroethene	0	ND	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	108-88-3	Toluene	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	108-90-7	Chlorobenzene	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	100-41-4	Ethylbenzene	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	67-64-1	Acetone	0	ND	ug/L	50	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	78-93-3	2-Butanone	0	ND	ug/L	50	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	108-05-4	Vinyl acetate	0	ND	ug/L	50	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	67-63-0	2-Propanol	0	ND	ug/L	300	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	50	0		0	13-Jun-91

Remediation Well Analytical Data

PFE-3 (NASA PT)

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-3	21-Jun-91	9106121236	VOA	8240	591-78-6	2-Hexanone	0	ND	ug/L	50	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	100-42-5	Styrene	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121236	VOA	8240	1330-20-7	Xylenes	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121254	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0		0	16-Jul-91
PFE-3	21-Jun-91	9106121254	RCRA	RCRA	7440-39-3	Barium	0.018	0.018	mg/L	0.01	0		0	12-Jul-91
PFE-3	21-Jun-91	9106121254	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0		0	12-Jul-91
PFE-3	21-Jun-91	9106121254	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0		0	12-Jul-91
PFE-3	21-Jun-91	9106121254	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.005	0		0	12-Jul-91
PFE-3	21-Jun-91	9106121254	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0		0	15-Jul-91
PFE-3	21-Jun-91	9106121254	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.005	0		0	15-Jul-91
PFE-3	21-Jun-91	9106121254	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0		0	12-Jul-91
PFE-3	21-Jun-91	9106121242	VOA	8240	74-87-3	Chloromethane	0	ND	ug/L	20	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	75-01-4	Vinyl chloride	0	ND	ug/L	20	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	75-00-3	Chloroethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	75-09-2	Dichloromethane	0	ND	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	75-43-4	Dichlorofluoromethane	0	ND	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	74-83-9	Bromomethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	75-35-4	1,1-Dichloroethene	0	ND	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	75-69-4	Trichlorofluoromethane	66	66	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	75-34-3	1,1-Dichloroethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	156-60-5	t-1,2-Dichloroethene	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	67-66-3	Trichloromethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121248	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.7	0.7	ug/L	0.1	0		18	14-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	110	110	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	56-23-5	Tetrachloromethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	75-27-4	Bromodichloromethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	78-87-5	1,2-Dichloropropane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	10061-01-5	c-1,3-Dichloropropene	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	79-01-6	Trichloroethene	220	220	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	71-43-2	Benzene	0	ND	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	124-48-1	Dibromochloromethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	75-25-2	Tribromomethane	0	ND	ug/L	20	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	110-75-8	2-Chloroethyl vinyl ether	0	ND	ug/L	25	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	10061-02-6	t-1,3-Dichloropropene	0	ND	ug/L	20	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	127-18-4	Tetrachloroethene	0	ND	ug/L	5	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	108-88-3	Toluene	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	108-90-7	Chlorobenzene	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	100-41-4	Ethylbenzene	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	67-64-1	Acetone	0	ND	ug/L	50	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	78-93-3	2-Butanone	0	ND	ug/L	50	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	108-05-4	Vinyl acetate	0	ND	ug/L	50	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	67-63-0	2-Propanol	0	ND	ug/L	300	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	50	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	591-78-6	2-Hexanone	0	ND	ug/L	50	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	100-42-5	Styrene	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	21-Jun-91	9106121242	VOA	8240	1330-20-7	Xylenes	0	ND	ug/L	10	0		0	13-Jun-91
PFE-3	28-Mar-90	9003291250	HVOA	8010	79-01-6	Trichloroethene	373	373	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281341	HVOA	8010	75-43-4	Dichlorofluoromethane	19.4	19.4	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281341	HVOA	8010	75-09-2	Dichloromethane	0	ND	ug/L	2	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281341	HVOA	8010	75-69-4	Trichlorofluoromethane	435	435	ug/L	0.5	0		0	29-Mar-90

Remediation Well Analytical Data

PFE-3 (NASA PT)

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-3	28-Mar-90	9003281341	HVOA	8010	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281341	HVOA	8010	67-66-3	Trichloromethane	0	ND	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281341	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	396	396	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281341	HVOA	8010	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281341	HVOA	8010	79-01-6	Trichloroethene	395	395	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281341	HVOA	8010	127-18-4	Tetrachloroethene	16.3	16.3	ug/L	1	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281420	HVOA	8010	75-43-4	Dichlorofluoromethane	20.7	20.7	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281420	HVOA	8010	75-09-2	Dichloromethane	0	ND	ug/L	2	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281420	HVOA	8010	75-69-4	Trichlorofluoromethane	427	427	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281420	HVOA	8010	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281420	HVOA	8010	67-66-3	Trichloromethane	0	ND	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281420	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	409	409	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281420	HVOA	8010	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281420	HVOA	8010	79-01-6	Trichloroethene	397	397	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003281420	HVOA	8010	127-18-4	Tetrachloroethene	16.4	16.4	ug/L	1	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291226	HVOA	8010	75-43-4	Dichlorofluoromethane	8.6	8.6	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291226	HVOA	8010	75-09-2	Dichloromethane	0	ND	ug/L	2	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291226	HVOA	8010	75-69-4	Trichlorofluoromethane	473	473	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291226	HVOA	8010	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291226	HVOA	8010	67-66-3	Trichloromethane	0	ND	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291226	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	411	411	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291226	HVOA	8010	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291226	HVOA	8010	79-01-6	Trichloroethene	413	413	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291226	HVOA	8010	127-18-4	Tetrachloroethene	16.3	16.3	ug/L	1	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291235	HVOA	8010	75-43-4	Dichlorofluoromethane	10.4	10.4	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291235	HVOA	8010	75-09-2	Dichloromethane	0	ND	ug/L	2	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291235	HVOA	8010	75-69-4	Trichlorofluoromethane	444	444	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291235	HVOA	8010	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291235	HVOA	8010	67-66-3	Trichloromethane	0	ND	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291235	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	391	391	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291235	HVOA	8010	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291235	HVOA	8010	79-01-6	Trichloroethene	396	396	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291235	HVOA	8010	127-18-4	Tetrachloroethene	16.2	16.2	ug/L	1	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291250	HVOA	8010	75-43-4	Dichlorofluoromethane	9.6	9.6	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291250	HVOA	8010	75-09-2	Dichloromethane	0	ND	ug/L	2	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291250	HVOA	8010	75-69-4	Trichlorofluoromethane	424	424	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291250	HVOA	8010	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291250	HVOA	8010	67-66-3	Trichloromethane	0	ND	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291250	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	375	375	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291250	HVOA	8010	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291250	HVOA	8010	127-18-4	Tetrachloroethene	14.8	14.8	ug/L	1	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291303	HVOA	8010	75-43-4	Dichlorofluoromethane	10.1	10.1	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291303	HVOA	8010	75-09-2	Dichloromethane	0	ND	ug/L	2	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291303	HVOA	8010	75-69-4	Trichlorofluoromethane	428	428	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291303	HVOA	8010	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291303	HVOA	8010	67-66-3	Trichloromethane	0	ND	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291303	HVOA	8010	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	373	373	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291303	HVOA	8010	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291303	HVOA	8010	79-01-6	Trichloroethene	378	378	ug/L	0.5	0		0	29-Mar-90
PFE-3	28-Mar-90	9003291303	HVOA	8010	127-18-4	Tetrachloroethene	14.8	14.8	ug/L	1	0		0	29-Mar-90

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4	31-Oct-00	0010311415	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	108-88-3	Toluene	0.63	0.63	ug/L	1	0.29	J	0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	75-69-4	Trichlorofluoromethane	0.35	0.35	ug/L	2	0.28	J	0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0.82	0.82	ug/L	1	1	J	0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	10-Nov-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4	31-Oct-00	0010311415	VOA	8260	79-01-6	Trichloroethene	0.56	0.56	ug/L	1	0.22	J	0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	10-Nov-00
PFE-4	31-Oct-00	0010311415	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	10-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	108-88-3	Toluene	0.6	0.60	ug/L	1	0.29	J	0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	75-69-4	Trichlorofluoromethane	0.31	0.31	ug/L	2	0.28	J	0	11-Nov-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4	31-Oct-00	0010311421	VOA-D	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0.69	0.69	ug/L	1	0.21	J	0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	79-01-6	Trichloroethene	0.54	0.54	ug/L	1	0.22	J	0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	11-Nov-00
PFE-4	31-Oct-00	0010311421	VOA-D	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	11-Nov-00
PFE-4	31-Oct-00	0010311427	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		34	09-Nov-00
PFE-4	31-Oct-00	0010311427	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		34	09-Nov-00
PFE-4	31-Oct-00	0010311431	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.005	0.0013		0	16-Nov-00
PFE-4	31-Oct-00	0010311431	RCRA	RCRA	7782-49-2	Selenium	0.0013	0.0013	mg/L	0.005	0.00082	J	0	18-Nov-00
PFE-4	31-Oct-00	0010311431	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.00065		0	18-Nov-00
PFE-4	31-Oct-00	0010311431	RCRA	RCRA	7439-97-6	Mercury	0.00003	0.000030	mg/L	0.0002	0.000028	J	0	20-Nov-00
PFE-4	31-Oct-00	0010311431	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00054		0	27-Nov-00
PFE-4	31-Oct-00	0010311431	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.0005		0	27-Nov-00
PFE-4	31-Oct-00	0010311431	RCRA	RCRA	7440-39-3	Barium	0.041	0.041	mg/L	0.01	0.0015		0	27-Nov-00
PFE-4	31-Oct-00	0010311431	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	27-Nov-00
PFE-4	30-May-00	0005301205	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	06-Jun-00
PFE-4	30-May-00	0005301205	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	06-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	08-Jun-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4	30-May-00	0005301211	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	108-88-3	Toluene	0	ND	ug/L	1	0.29		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.95		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	08-Jun-00

Remediation Well Analytical Data

PFE-4

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4	30-May-00	0005301211	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	08-Jun-00
PFE-4	30-May-00	0005301211	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	08-Jun-00
PFE-4	30-May-00	0005301217	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		63	05-Jun-00
PFE-4	30-May-00	0005301217	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		63	05-Jun-00
PFE-4	30-May-00	0005301221	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.002	0.0015		0	22-Jun-00
PFE-4	30-May-00	0005301221	RCRA	RCRA	7782-49-2	Selenium	0.0018	0.0018	mg/L	0.005	0.0012	J	0	22-Jun-00
PFE-4	30-May-00	0005301221	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	22-Jun-00
PFE-4	30-May-00	0005301221	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	09-Jun-00
PFE-4	30-May-00	0005301221	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00054		0	21-Jun-00
PFE-4	30-May-00	0005301221	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.0005		0	21-Jun-00
PFE-4	30-May-00	0005301221	RCRA	RCRA	7440-39-3	Barium	0.032	0.032	mg/L	0.01	0.0015		0	21-Jun-00
PFE-4	30-May-00	0005301221	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	21-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	20-Jun-00
PFE-4	30-May-00	0006070941	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	20-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	14-Jun-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4	30-May-00	0006070947	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	108-88-3	Toluene	0	ND	ug/L	1	0.29		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.95		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0.25	0.25	ug/L	1	0.21	J	0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	14-Jun-00
PFE-4	30-May-00	0006070947	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	14-Jun-00
PFE-4	30-May-00	0006070953	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		53	15-Jun-00
PFE-4	30-May-00	0006070953	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		53	15-Jun-00
PFE-4	30-May-00	0006070957	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	06-Jul-00
PFE-4	30-May-00	0006070957	RCRA	RCRA	7782-49-2	Selenium	0.0022	0.0022	mg/L	0.005	0.0012	J	0	07-Jul-00
PFE-4	30-May-00	0006070957	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	06-Jul-00
PFE-4	30-May-00	0006070957	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	03-Jul-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4	30-May-00	0006070957	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00054		0	12-Jul-00
PFE-4	30-May-00	0006070957	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.0005		0	12-Jul-00
PFE-4	30-May-00	0006070957	RCRA	RCRA	7440-39-3	Barium	0.026	0.026	mg/L	0.01	0.0015		0	12-Jul-00
PFE-4	30-May-00	0006070957	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	12-Jul-00
PFE-4	30-May-00	0006080830	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	21-Jun-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4	30-May-00	0006080830	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	21-Jun-00
PFE-4	30-May-00	0006080830	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	21-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	108-88-3	Toluene	0.3	0.30	ug/L	1	0.29	J	0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.95		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	14-Jun-00

Remediation Well Analytical Data

PFE-4

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4	30-May-00	0006080836	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0.52	0.52	ug/L	1	0.21	J	0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	14-Jun-00
PFE-4	30-May-00	0006080836	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	14-Jun-00
PFE-4	30-May-00	0006080842	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		32	15-Jun-00
PFE-4	30-May-00	0006080842	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		32	15-Jun-00
PFE-4	30-May-00	0006080846	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	06-Jul-00
PFE-4	30-May-00	0006080846	RCRA	RCRA	7782-49-2	Selenium	0.0018	0.0018	mg/L	0.005	0.0012	J	0	07-Jul-00
PFE-4	30-May-00	0006080846	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	06-Jul-00
PFE-4	30-May-00	0006080846	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	03-Jul-00
PFE-4	30-May-00	0006080846	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00054		0	12-Jul-00
PFE-4	30-May-00	0006080846	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.0005		0	12-Jul-00
PFE-4	30-May-00	0006080846	RCRA	RCRA	7440-39-3	Barium	0.026	0.026	mg/L	0.01	0.0015		0	12-Jul-00
PFE-4	30-May-00	0006080846	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	12-Jul-00
PFE-4	30-May-00	0006080848	CATIONS	6010	7439-89-6	Iron	0.34	0.34	mg/L	0.1	0.012		0	23-Jun-00
PFE-4	30-May-00	0006080848	CATIONS	6010	7439-95-4	Magnesium	57.2	57.2	mg/L	0.2	0.011		0	24-Jun-00
PFE-4	30-May-00	0006080848	CATIONS	6010	7440-09-7	Potassium	4.3	4.3	mg/L	5	0.18	J	0	23-Jun-00
PFE-4	30-May-00	0006080848	CATIONS	6010	7440-23-5	Sodium	52.6	52.6	mg/L	5	0.35		0	23-Jun-00
PFE-4	30-May-00	0006080848	CATIONS	6010	7440-70-2	Calcium	95.8	95.8	mg/L	0.2	0.048		0	24-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Fluoride	0.92	0.92	mg/L	0.1	0.01		0	21-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Chloride	39	39	mg/L	3	0.1	SP G	0	22-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Sulfate	315	315	mg/L	50	1	G	0	22-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Total Alkalinity	194	194	mg/L	5	0.5		0	20-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Fluoride	0.92	0.92	mg/L	0.1	0.01		0	21-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Chloride	39	39	mg/L	3	0.1	SP G	0	22-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Sulfate	315	315	mg/L	50	1	G	0	22-Jun-00
PFE-4	30-May-00	0006080850	ANIONS	ANIONS		Total Alkalinity	194	194	mg/L	5	0.5		0	20-Jun-00
PFE-4	30-May-00	0006080852	NO2,NO3	353.2		Nitrate-Nitrite	0.83	0.83	mg/L	0.1	0.01		0	20-Jun-00
PFE-4	30-May-00	0006080854	TDS	160.1		Total Dissolved Solids	783	783	mg/L	10	5.4		0	15-Jun-00
PFE-4	30-May-00	0006080856	NH3	350.1	7664-41-7	Ammonia as N	0.045	0.045	mg/L	0.1	0.029	J	0	12-Jun-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	04-Sep-01	0109041642	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		50	07-Sep-01
PFE-4A	04-Sep-01	0109041646	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0013		0	19-Sep-01
PFE-4A	04-Sep-01	0109041646	RCRA	RCRA	7782-49-2	Selenium	0.0015	0.0015	mg/L	0.005	0.00082	J	0	18-Sep-01
PFE-4A	04-Sep-01	0109041646	RCRA	RCRA	7440-38-2	Arsenic	0.00077	0.00077	mg/L	0.005	0.00065	J	0	18-Sep-01
PFE-4A	04-Sep-01	0109041646	RCRA	RCRA	7439-97-6	Mercury	0.00065	0.00065	mg/L	0.0002	0.00003		0	24-Sep-01
PFE-4A	04-Sep-01	0109041646	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00062		0	23-Sep-01
PFE-4A	04-Sep-01	0109041646	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00029		0	23-Sep-01
PFE-4A	04-Sep-01	0109041646	RCRA	RCRA	7440-39-3	Barium	0.029	0.029	mg/L	0.01	0.00083		0	23-Sep-01
PFE-4A	04-Sep-01	0109041646	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0034		0	23-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.28		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	127-18-4	Tetrachloroethene	4.1	4.1	ug/L	0.5	0.18		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.076		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.1		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.14		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.34		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.27		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.24		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	75-09-2	Methylene chloride	0.9	0.90	ug/L	5	0.18	J	0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.13		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	75-69-4	Trichlorofluoromethane	120	120	ug/L	5	0.2		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	120	120	ug/L	5	0.22		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	79-01-6	Trichloroethene	150	150	ug/L	5	0.16	SP	0	08-Sep-01
PFE-4A	04-Sep-01	0109041730	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	08-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.28		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	127-18-4	Tetrachloroethene	4	4.0	ug/L	0.5	0.18		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.076		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.1		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.5		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.14		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.34		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.27		0	10-Sep-01

Remediation Well Analytical Data

PFE-4A

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.24		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	75-09-2	Methylene chloride	1.8	1.8	ug/L	5	0.18	J	0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.13		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	75-69-4	Trichlorofluoromethane	120	120	ug/L	5	0.2		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	120	120	ug/L	5	0.22		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	79-01-6	Trichloroethene	150	150	ug/L	5	0.16		0	10-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	10-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	108-88-3	Toluene	1.5	1.5	ug/L	1	0.29		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	127-18-4	Tetrachloroethene	3.7	3.7	ug/L	1	0.36		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	67-64-1	Acetone	51	51	ug/L	10	1.9		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	06-Sep-01

Remediation Well Analytical Data

PFE-4A

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	04-Sep-01	0109041748	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	75-69-4	Trichlorofluoromethane	160	160	ug/L	8	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	140	140	ug/L	4	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	06-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	06-Sep-01
PFE-4A	04-Sep-01	0109041754	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		32	07-Sep-01
PFE-4A	04-Sep-01	0109041754	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		50	07-Sep-01
PFE-4A	04-Sep-01	0109041758	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0013		0	19-Sep-01
PFE-4A	04-Sep-01	0109041758	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.01	0.0016		0	19-Sep-01
PFE-4A	04-Sep-01	0109041758	RCRA	RCRA	7440-38-2	Arsenic	0.0011	0.0011	mg/L	0.005	0.00065	J	0	18-Sep-01
PFE-4A	04-Sep-01	0109041758	RCRA	RCRA	7439-97-6	Mercury	0.000047	0.000047	mg/L	0.0002	0.00003	J	0	24-Sep-01
PFE-4A	04-Sep-01	0109041758	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00062		0	23-Sep-01
PFE-4A	04-Sep-01	0109041758	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00029		0	23-Sep-01
PFE-4A	04-Sep-01	0109041758	RCRA	RCRA	7440-39-3	Barium	0.029	0.029	mg/L	0.01	0.00083		0	23-Sep-01
PFE-4A	04-Sep-01	0109041758	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0034		0	23-Sep-01
PFE-4A	04-Sep-01	0109050839	NDMA_LL-FB	NDMA_LL	62-75-9	N-Nitrosodimethylamine	37.8	38	ppt	0.5	0.2	FB	112	07-Sep-01
PFE-4A	04-Sep-01	0109050839	NDMA_LL-FB	NDMA_LL	4164-28-7	N-Nitrodimethylamine	6.6	6.6	ppt	0.5	0.4	FB	103	07-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.28		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	127-18-4	Tetrachloroethene	3.9	3.9	ug/L	0.5	0.18		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.076		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.1		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.14		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.34		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.27		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.24		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.13		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	75-69-4	Trichlorofluoromethane	180	180	ug/L	5	0.2		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	120	120	ug/L	5	0.22		0	10-Sep-01

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	04-Sep-01	0109050845	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	79-01-6	Trichloroethene	150	150	ug/L	5	0.16		0	10-Sep-01
PFE-4A	04-Sep-01	0109050845	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	10-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	127-18-4	Tetrachloroethene	3.6	3.6	ug/L	1	0.36		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	67-64-1	Acetone	54	54	ug/L	10	1.9		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	75-69-4	Trichlorofluoromethane	160	160	ug/L	8	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	140	140	ug/L	4	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	06-Sep-01

Remediation Well Analytical Data

PFE-4A

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	04-Sep-01	0109050851	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	79-01-6	Trichloroethene	180	180	ug/L	4	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	06-Sep-01
PFE-4A	04-Sep-01	0109050857	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		32	07-Sep-01
PFE-4A	04-Sep-01	0109050857	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		50	07-Sep-01
PFE-4A	04-Sep-01	0109050901	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0013		0	19-Sep-01
PFE-4A	04-Sep-01	0109050901	RCRA	RCRA	7782-49-2	Selenium	0.001	0.0010	mg/L	0.005	0.00082	J	0	18-Sep-01
PFE-4A	04-Sep-01	0109050901	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.00065		0	18-Sep-01
PFE-4A	04-Sep-01	0109050901	RCRA	RCRA	7439-97-6	Mercury	0.000047	0.000047	mg/L	0.0002	0.00003	J	0	24-Sep-01
PFE-4A	04-Sep-01	0109050901	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00062		0	23-Sep-01
PFE-4A	04-Sep-01	0109050901	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00029		0	23-Sep-01
PFE-4A	04-Sep-01	0109050901	RCRA	RCRA	7440-39-3	Barium	0.03	0.030	mg/L	0.01	0.00083		0	23-Sep-01
PFE-4A	04-Sep-01	0109050901	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0034		0	23-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	06-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	120	120	ug/L	5	0.22		0	08-Sep-01
PFE-4A	04-Sep-01	0109041642	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		32	07-Sep-01
PFE-4A	04-Sep-01	0109041736	HVOA-D	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	10-Sep-01
PFE-4A	04-Sep-01	0109041748	VOA	8260	79-01-6	Trichloroethene	180	180	ug/L	4	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109050851	VOA	8260	108-88-3	Toluene	1.6	1.6	ug/L	1	0.29		0	06-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.28		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	127-18-4	Tetrachloroethene	4.2	4.2	ug/L	0.5	0.18		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.076		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.1		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.14		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.34		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.27		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.24		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.13		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	75-69-4	Trichlorofluoromethane	120	120	ug/L	5	0.2		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	130	130	ug/L	5	0.22		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	79-01-6	Trichloroethene	160	160	ug/L	5	0.16		0	08-Sep-01
PFE-4A	04-Sep-01	0109041550	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	08-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	06-Sep-01

Remediation Well Analytical Data

PFE-4A

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	04-Sep-01	0109041556	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	108-88-3	Toluene	32	32	ug/L	1	0.29		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	127-18-4	Tetrachloroethene	3.8	3.8	ug/L	1	0.36		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	67-64-1	Acetone	52	52	ug/L	10	1.9		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	75-43-4	Dichlorofluoromethane	0.12	0.12	ug/L	2	0.12	J	0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	75-69-4	Trichlorofluoromethane	170	170	ug/L	8	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	140	140	ug/L	4	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	79-01-6	Trichloroethene	190	190	ug/L	4	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	06-Sep-01

Remediation Well Analytical Data

PFE-4A

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	04-Sep-01	0109041556	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	06-Sep-01
PFE-4A	04-Sep-01	0109041556	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	06-Sep-01
PFE-4A	04-Sep-01	0109041602	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		32	07-Sep-01
PFE-4A	04-Sep-01	0109041602	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		50	07-Sep-01
PFE-4A	04-Sep-01	0109041606	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0013		0	19-Sep-01
PFE-4A	04-Sep-01	0109041606	RCRA	RCRA	7782-49-2	Selenium	0.0012	0.0012	mg/L	0.005	0.00082	J	0	18-Sep-01
PFE-4A	04-Sep-01	0109041606	RCRA	RCRA	7440-38-2	Arsenic	0.0011	0.0011	mg/L	0.005	0.00065	J	0	18-Sep-01
PFE-4A	04-Sep-01	0109041606	RCRA	RCRA	7439-97-6	Mercury	0.000033	0.000033	mg/L	0.0002	0.00003	J	0	24-Sep-01
PFE-4A	04-Sep-01	0109041606	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00062		0	23-Sep-01
PFE-4A	04-Sep-01	0109041606	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00029		0	23-Sep-01
PFE-4A	04-Sep-01	0109041606	RCRA	RCRA	7440-39-3	Barium	0.029	0.029	mg/L	0.01	0.00083		0	23-Sep-01
PFE-4A	04-Sep-01	0109041606	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0034		0	23-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.28		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	127-18-4	Tetrachloroethene	4.4	4.4	ug/L	0.5	0.18		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.076		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.1		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.14		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.34		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.27		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.24		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.13		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	75-69-4	Trichlorofluoromethane	120	120	ug/L	5	0.2		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	79-01-6	Trichloroethene	170	170	ug/L	5	0.16		0	08-Sep-01
PFE-4A	04-Sep-01	0109041630	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	08-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	06-Sep-01

Remediation Well Analytical Data

PFE-4A

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	04-Sep-01	0109041636	VOA	8260	108-88-3	Toluene	17	17	ug/L	1	0.29		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	127-18-4	Tetrachloroethene	3.9	3.9	ug/L	1	0.36		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	67-64-1	Acetone	44	44	ug/L	10	1.9		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	75-43-4	Dichlorofluoromethane	0.14	0.14	ug/L	2	0.12	J	0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	75-69-4	Trichlorofluoromethane	170	170	ug/L	8	0.28		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	130	130	ug/L	4	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	79-01-6	Trichloroethene	210	210	ug/L	4	0.22		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	06-Sep-01
PFE-4A	04-Sep-01	0109041636	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	06-Sep-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	127-18-4	Tetrachloroethene	3.2	3.2	ug/L	0.5	0.18		0	29-Aug-01

Remediation Well Analytical Data

PFE-4A

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	26-Aug-01	0108260944	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.076		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.1		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.14		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.34		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.27		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.13		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	75-69-4	Trichlorofluoromethane	100	100	ug/L	1.2	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	86	86	ug/L	1.2	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	79-01-6	Trichloroethene	110	110	ug/L	1.2	0.16		0	29-Aug-01
PFE-4A	26-Aug-01	0108260944	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	108-88-3	Toluene	2.4	2.4	ug/L	1	0.29		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	127-18-4	Tetrachloroethene	3.5	3.5	ug/L	1	0.36		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	67-64-1	Acetone	37	37	ug/L	10	1.9		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	29-Aug-01

Remediation Well Analytical Data

PFE-4A

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	26-Aug-01	0108260950	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	75-69-4	Trichlorofluoromethane	110	110	ug/L	10	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	100	100	ug/L	5	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	79-01-6	Trichloroethene	150	150	ug/L	5	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	29-Aug-01
PFE-4A	26-Aug-01	0108260950	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	29-Aug-01
PFE-4A	26-Aug-01	0108260956	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		41	29-Aug-01
PFE-4A	26-Aug-01	0108260956	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		76	29-Aug-01
PFE-4A	26-Aug-01	0108261000	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0013		0	10-Sep-01
PFE-4A	26-Aug-01	0108261000	RCRA	RCRA	7782-49-2	Selenium	0.0013	0.0013	mg/L	0.005	0.00082	J	0	12-Sep-01
PFE-4A	26-Aug-01	0108261000	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.00065		0	11-Sep-01
PFE-4A	26-Aug-01	0108261000	RCRA	RCRA	7439-97-6	Mercury	0.000031	0.000031	mg/L	0.0002	0.00003	J	0	18-Sep-01
PFE-4A	26-Aug-01	0108261000	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00062		0	06-Sep-01
PFE-4A	26-Aug-01	0108261000	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00029		0	06-Sep-01
PFE-4A	26-Aug-01	0108261000	RCRA	RCRA	7440-39-3	Barium	0.03	0.030	mg/L	0.01	0.00083		0	07-Sep-01
PFE-4A	26-Aug-01	0108261000	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0034		0	06-Sep-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	127-18-4	Tetrachloroethene	3.2	3.2	ug/L	0.5	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.076		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.1		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.14		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.27		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	29-Aug-01

Remediation Well Analytical Data

PFE-4A

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	26-Aug-01	0108261008	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.13		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	75-69-4	Trichlorofluoromethane	110	110	ug/L	1.2	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	48	48	ug/L	1.2	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	79-01-6	Trichloroethene	120	120	ug/L	1.2	0.16		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	29-Aug-01
PFE-4A	26-Aug-01	0108261008	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.34		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	108-88-3	Toluene	4.5	4.5	ug/L	1	0.29		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	127-18-4	Tetrachloroethene	3.2	3.2	ug/L	1	0.36		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	67-64-1	Acetone	33	33	ug/L	10	1.9		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	29-Aug-01

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	26-Aug-01	0108261014	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	75-69-4	Trichlorofluoromethane	100	100	ug/L	8	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	100	100	ug/L	4	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	79-01-6	Trichloroethene	140	140	ug/L	4	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	29-Aug-01
PFE-4A	26-Aug-01	0108261014	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	29-Aug-01
PFE-4A	26-Aug-01	0108261020	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		41	29-Aug-01
PFE-4A	26-Aug-01	0108261020	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		76	29-Aug-01
PFE-4A	26-Aug-01	0108261024	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0013		0	10-Sep-01
PFE-4A	26-Aug-01	0108261024	RCRA	RCRA	7782-49-2	Selenium	0.002	0.0020	mg/L	0.005	0.00082	J	0	12-Sep-01
PFE-4A	26-Aug-01	0108261024	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.00065		0	11-Sep-01
PFE-4A	26-Aug-01	0108261024	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.00003		0	18-Sep-01
PFE-4A	26-Aug-01	0108261024	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00062		0	06-Sep-01
PFE-4A	26-Aug-01	0108261024	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00029		0	06-Sep-01
PFE-4A	26-Aug-01	0108261024	RCRA	RCRA	7440-39-3	Barium	0.032	0.032	mg/L	0.01	0.00083		0	07-Sep-01
PFE-4A	26-Aug-01	0108261024	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0034		0	06-Sep-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	127-18-4	Tetrachloroethene	3.2	3.2	ug/L	0.5	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.076		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.1		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.14		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.34		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.27		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.13		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	75-69-4	Trichlorofluoromethane	100	100	ug/L	1.2	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	88	88	ug/L	1.2	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	29-Aug-01

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	26-Aug-01	0108261106	HVOA	8021	79-01-6	Trichloroethene	120	120	ug/L	1.2	0.16		0	29-Aug-01
PFE-4A	26-Aug-01	0108261106	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	100	100	ug/L	4	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	108-88-3	Toluene	3.3	3.3	ug/L	1	0.29		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	127-18-4	Tetrachloroethene	3.2	3.2	ug/L	1	0.36		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	67-64-1	Acetone	33	33	ug/L	10	1.9		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	75-69-4	Trichlorofluoromethane	110	110	ug/L	8	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	29-Aug-01

Remediation Well Analytical Data

PFE-4A

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	26-Aug-01	0108261112	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	79-01-6	Trichloroethene	150	150	ug/L	4	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	29-Aug-01
PFE-4A	26-Aug-01	0108261112	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	29-Aug-01
PFE-4A	26-Aug-01	0108261118	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		41	29-Aug-01
PFE-4A	26-Aug-01	0108261118	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		76	29-Aug-01
PFE-4A	26-Aug-01	0108261122	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0013		0	10-Sep-01
PFE-4A	26-Aug-01	0108261122	RCRA	RCRA	7782-49-2	Selenium	0.00098	0.00098	mg/L	0.005	0.00082	J	0	12-Sep-01
PFE-4A	26-Aug-01	0108261122	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.00065		0	11-Sep-01
PFE-4A	26-Aug-01	0108261122	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.00003		0	18-Sep-01
PFE-4A	26-Aug-01	0108261122	RCRA	RCRA	7440-22-4	Silver	0.0043	0.0043	mg/L	0.01	0.00062	J	0	06-Sep-01
PFE-4A	26-Aug-01	0108261122	RCRA	RCRA	7440-43-9	Cadmium	0.001	0.0010	mg/L	0.005	0.00029	J	0	06-Sep-01
PFE-4A	26-Aug-01	0108261122	RCRA	RCRA	7440-39-3	Barium	0.03	0.030	mg/L	0.01	0.00083		0	07-Sep-01
PFE-4A	26-Aug-01	0108261122	RCRA	RCRA	7440-47-3	Chromium	0.0043	0.0043	mg/L	0.01	0.0034	J	0	06-Sep-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	127-18-4	Tetrachloroethene	3.7	3.7	ug/L	0.5	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.076		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.1		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.14		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.34		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.27		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.13		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	75-69-4	Trichlorofluoromethane	110	110	ug/L	1.2	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	93	93	ug/L	1.2	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	79-01-6	Trichloroethene	120	120	ug/L	1.2	0.16		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	29-Aug-01
PFE-4A	26-Aug-01	0108261150	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	79-01-6	Trichloroethene	150	150	ug/L	4	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	29-Aug-01

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	26-Aug-01	0108261156	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	110	110	ug/L	4	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	108-88-3	Toluene	1.4	1.4	ug/L	1	0.29		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	127-18-4	Tetrachloroethene	3.3	3.3	ug/L	1	0.36		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	128-37-0	Butylated hydroxytoluene	1.5	1.5	ug/L	0	0	TIC	0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	67-64-1	Acetone	37	37	ug/L	10	1.9		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	75-69-4	Trichlorofluoromethane	110	110	ug/L	8	0.28		0	29-Aug-01
PFE-4A	26-Aug-01	0108261156	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	29-Aug-01
PFE-4A	26-Aug-01	0108261204	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		41	29-Aug-01
PFE-4A	26-Aug-01	0108261204	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		76	29-Aug-01

Remediation Well Analytical Data

PFE-4A

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-4A	26-Aug-01	0108261206	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0013		0	10-Sep-01
PFE-4A	26-Aug-01	0108261206	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.005	0.00082		0	12-Sep-01
PFE-4A	26-Aug-01	0108261206	RCRA	RCRA	7440-38-2	Arsenic	0.00068	0.00068	mg/L	0.005	0.00065	J	0	11-Sep-01
PFE-4A	26-Aug-01	0108261206	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.00003		0	18-Sep-01
PFE-4A	26-Aug-01	0108261206	RCRA	RCRA	7440-22-4	Silver	0.0041	0.0041	mg/L	0.01	0.00062	J	0	06-Sep-01
PFE-4A	26-Aug-01	0108261206	RCRA	RCRA	7440-43-9	Cadmium	0.00083	0.00083	mg/L	0.005	0.00029	J	0	06-Sep-01
PFE-4A	26-Aug-01	0108261206	RCRA	RCRA	7440-39-3	Barium	0.029	0.029	mg/L	0.01	0.00083		0	07-Sep-01
PFE-4A	26-Aug-01	0108261206	RCRA	RCRA	7440-47-3	Chromium	0.0036	0.0036	mg/L	0.01	0.0034	J	0	06-Sep-01
PFE-4A	26-Aug-01	0108261208	CATIONS	6010	7439-89-6	Iron	0.57	0.57	mg/L	0.1	0.0051		0	06-Sep-01
PFE-4A	26-Aug-01	0108261208	CATIONS	6010	7439-95-4	Magnesium	64.4	64.4	mg/L	0.2	0.021		0	06-Sep-01
PFE-4A	26-Aug-01	0108261208	CATIONS	6010	7440-09-7	Potassium	4.5	4.5	mg/L	5	0.5	J	0	06-Sep-01
PFE-4A	26-Aug-01	0108261208	CATIONS	6010	7440-23-5	Sodium	40.8	40.8	mg/L	5	2		0	06-Sep-01
PFE-4A	26-Aug-01	0108261208	CATIONS	6010	7440-70-2	Calcium	106	106	mg/L	0.2	0.029		0	06-Sep-01
PFE-4A	26-Aug-01	0108261210	ANIONS	ANIONS		Fluoride	0.8	0.80	mg/L	0.1	0.012		0	04-Sep-01
PFE-4A	26-Aug-01	0108261210	ANIONS	ANIONS		Chloride	42.1	42	mg/L	3	0.1		0	06-Sep-01
PFE-4A	26-Aug-01	0108261210	ANIONS	ANIONS		Sulfate	304	304	mg/L	100	2		0	06-Sep-01
PFE-4A	26-Aug-01	0108261210	ANIONS	ANIONS		Total Alkalinity	220	220	mg/L	5	0.5		0	06-Sep-01
PFE-4A	26-Aug-01	0108261212	NO2,NO3	353.2		Nitrate-Nitrite	1.3	1.3	mg/L	0.1	0.021		0	07-Sep-01
PFE-4A	26-Aug-01	0108261214	TDS	160.1		Total Dissolved Solids	830	830	mg/L	10	4.8		0	30-Aug-01
PFE-4A	26-Aug-01	0108261216	NH3	350.1	7664-41-7	Ammonia as N	0.049	0.049	mg/L	0.1	0.031	J	0	07-Sep-01

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-5	27-Apr-00	0004271015	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	75-43-4	Dichlorofluoromethane	1.7	1.7	ug/L	0.5	0.31		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	75-69-4	Trichlorofluoromethane	34	34	ug/L	0.5	0.055		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	30	30	ug/L	0.5	0.18		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	79-01-6	Trichloroethene	140	140	ug/L	1.2	0.16		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	1.4	1.4	ug/L	5	0.35	J	0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	127-18-4	Tetrachloroethene	5.3	5.3	ug/L	0.5	0.18		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	05-May-00
PFE-5	27-Apr-00	0004271015	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	05-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0.72	0.72	ug/L	1	0.32	J	0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.1		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.1		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.1		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	108-88-3	Toluene	2.7	2.7	ug/L	1	0.29		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	1		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	127-18-4	Tetrachloroethene	7.1	7.1	ug/L	1	0.1		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	04-May-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-5	27-Apr-00	0004271021	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.1		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.1		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	75-35-4	1,1-Dichloroethene	0.94	0.94	ug/L	1	0.2	J	0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	75-43-4	Dichlorofluoromethane	0.76	0.76	ug/L	2	0.12	J	0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	75-69-4	Trichlorofluoromethane	56	56	ug/L	2	0.28		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	36	36	ug/L	1	0.21		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.1		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.1		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	79-01-6	Trichloroethene	150	150	ug/L	5	0.1		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	04-May-00
PFE-5	27-Apr-00	0004271021	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	04-May-00
PFE-5	27-Apr-00	0004271029	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.89	0.89	ppb	0.01	0.005		63	03-May-00
PFE-5	27-Apr-00	0004271029	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.58	0.58	ppb	0.01	0.005		63	03-May-00
PFE-5	27-Apr-00	0004271031	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	04-May-00
PFE-5	27-Apr-00	0004271031	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.005	0.0012		0	04-May-00
PFE-5	27-Apr-00	0004271031	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	04-May-00
PFE-5	27-Apr-00	0004271031	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	04-May-00
PFE-5	27-Apr-00	0004271031	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00054		0	05-May-00
PFE-5	27-Apr-00	0004271031	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.0005		0	05-May-00
PFE-5	27-Apr-00	0004271031	RCRA	RCRA	7440-39-3	Barium	0.021	0.021	mg/L	0.01	0.0015		0	05-May-00
PFE-5	27-Apr-00	0004271031	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	05-May-00
PFE-5	27-Apr-00	0005011231	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	08-May-00
PFE-5	27-Apr-00	0005011231	RCRA	RCRA	7782-49-2	Selenium	0.0016	0.0016	mg/L	0.005	0.0012	J	0	15-May-00
PFE-5	27-Apr-00	0005011231	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	15-May-00
PFE-5	27-Apr-00	0005011231	RCRA	RCRA	7439-97-6	Mercury	0.000039	0.000039	mg/L	0.0002	0.000028	J	0	10-May-00
PFE-5	27-Apr-00	0005011231	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00054		0	08-May-00
PFE-5	27-Apr-00	0005011231	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.0005		0	08-May-00
PFE-5	27-Apr-00	0005011231	RCRA	RCRA	7440-39-3	Barium	0.026	0.026	mg/L	0.01	0.0015		0	08-May-00
PFE-5	27-Apr-00	0005011231	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	08-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	16-May-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-5	27-Apr-00	0005021220	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	127-18-4	Tetrachloroethene	6.7	6.7	ug/L	0.5	0.18		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	75-69-4	Trichlorofluoromethane	88	88	ug/L	2.5	0.055		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	28	28	ug/L	0.5	0.18		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	79-01-6	Trichloroethene	150	150	ug/L	2.5	0.16		0	16-May-00
PFE-5	27-Apr-00	0005021220	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	16-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0.7	0.70	ug/L	1	0.32	J	0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	108-88-3	Toluene	1.2	1.2	ug/L	1	0.29		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	127-18-4	Tetrachloroethene	7.6	7.6	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.1		0	11-May-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-5	27-Apr-00	0005021226	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	67-66-3	Chloroform	0.24	0.24	ug/L	1	0.23	J	0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	75-35-4	1,1-Dichloroethene	0.8	0.80	ug/L	1	0.2	J	0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	75-43-4	Dichlorofluoromethane	0.98	0.98	ug/L	2	0.12	J	0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	75-69-4	Trichlorofluoromethane	53	53	ug/L	13	0.28		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	49	49	ug/L	6.7	0.21		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	79-01-6	Trichloroethene	160	160	ug/L	6.7	0.1		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	11-May-00
PFE-5	27-Apr-00	0005021226	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	11-May-00
PFE-5	27-Apr-00	0005021234	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.8	0.80	ppb	0.01	0.005		54	16-May-00
PFE-5	27-Apr-00	0005021234	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.54	0.54	ppb	0.01	0.005		54	16-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	127-18-4	Tetrachloroethene	4.9	4.9	ug/L	0.5	0.18		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	17-May-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-5	27-Apr-00	0005050931	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	75-69-4	Trichlorofluoromethane	48	48	ug/L	0.5	0.055		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	27	27	ug/L	0.5	0.18		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	79-01-6	Trichloroethene	130	130	ug/L	2.5	0.16	SP	0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	17-May-00
PFE-5	27-Apr-00	0005050931	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	17-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0.56	0.56	ug/L	1	0.32	J	0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	108-88-3	Toluene	1.9	1.9	ug/L	1	0.29		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	127-18-4	Tetrachloroethene	6.3	6.3	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.95		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	11-May-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-5	27-Apr-00	0005050937	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	75-35-4	1,1-Dichloroethene	0.75	0.75	ug/L	1	0.2	J	0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	75-43-4	Dichlorofluoromethane	0.78	0.78	ug/L	2	0.12	J	0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	75-69-4	Trichlorofluoromethane	53	53	ug/L	2	0.28		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	44	44	ug/L	1	0.21		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.1		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	79-01-6	Trichloroethene	150	150	ug/L	4	0.1		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	11-May-00
PFE-5	27-Apr-00	0005050937	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	11-May-00
PFE-5	27-Apr-00	0005050943	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.81	0.81	ppb	0.01	0.005		67	16-May-00
PFE-5	27-Apr-00	0005050943	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.55	0.55	ppb	0.01	0.005		67	16-May-00
PFE-5	27-Apr-00	0005050947	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	15-May-00
PFE-5	27-Apr-00	0005050947	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.005	0.0012		0	15-May-00
PFE-5	27-Apr-00	0005050947	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	15-May-00
PFE-5	27-Apr-00	0005050947	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	10-May-00
PFE-5	27-Apr-00	0005050947	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00054		0	18-May-00
PFE-5	27-Apr-00	0005050947	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.0005		0	18-May-00
PFE-5	27-Apr-00	0005050947	RCRA	RCRA	7440-39-3	Barium	0.023	0.02	mg/L	0.01	0.0015		0	18-May-00
PFE-5	27-Apr-00	0005050947	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	18-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	127-18-4	Tetrachloroethene	6	6.0	ug/L	0.5	0.18		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	75-69-4	Trichlorofluoromethane	62	62	ug/L	2.5	0.055		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	43	43	ug/L	0.5	0.18		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	79-01-6	Trichloroethene	140	140	ug/L	2.5	0.16	SP	0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	24-May-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-5	27-Apr-00	0005111001	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	24-May-00
PFE-5	27-Apr-00	0005111001	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	24-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0.68	0.68	ug/L	1	0.32	J	0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.1		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.1		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.1		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	108-88-3	Toluene	0	ND	ug/L	1	0.29		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.1		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.95		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	75-43-4	Dichlorofluoromethane	0.88	0.88	ug/L	2	0.12	J	0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	75-69-4	Trichlorofluoromethane	56	56	ug/L	8	0.28		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.1		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	127-18-4	Tetrachloroethene	7	7.0	ug/L	1	0.1		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.1		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	55	55	ug/L	4	0.21		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.1		0	16-May-00

Remediation Well Analytical Data

PFE-5

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-5	27-Apr-00	0005111007	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.1		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	79-01-6	Trichloroethene	160	160	ug/L	4	0.1		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	16-May-00
PFE-5	27-Apr-00	0005111007	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	16-May-00
PFE-5	27-Apr-00	0005111013	NDMA	607	62-75-9	N-Nitrosodimethylamine	0.75	0.75	ppb	0.01	0.005		47	16-May-00
PFE-5	27-Apr-00	0005111013	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.45	0.45	ppb	0.01	0.005		47	16-May-00
PFE-5	27-Apr-00	0005111017	RCRA	RCRA	7440-39-3	Barium	0.024	0.024	mg/L	0.01	0.0015		0	23-May-00
PFE-5	27-Apr-00	0005111017	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	23-May-00
PFE-5	27-Apr-00	0005111017	RCRA	RCRA	7439-92-1	Lead	0.0026	0.0026	mg/L	0.003	0.0015	J	0	22-May-00
PFE-5	27-Apr-00	0005111017	RCRA	RCRA	7782-49-2	Selenium	0.002	0.0020	mg/L	0.005	0.0012	J	0	24-May-00
PFE-5	27-Apr-00	0005111017	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	24-May-00
PFE-5	27-Apr-00	0005111017	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	17-May-00
PFE-5	27-Apr-00	0005111017	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00054		0	23-May-00
PFE-5	27-Apr-00	0005111017	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.0005		0	23-May-00
PFE-5	27-Apr-00	0005111019	CATIONS	6010	7439-95-4	Magnesium	60.8	60.8	mg/L	0.2	0.011		0	19-May-00
PFE-5	27-Apr-00	0005111019	CATIONS	6010	7440-23-5	Sodium	56.6	56.6	mg/L	5	0.35		0	18-May-00
PFE-5	27-Apr-00	0005111019	CATIONS	6010	7439-89-6	Iron	0.47	0.47	mg/L	0.1	0.012		0	18-May-00
PFE-5	27-Apr-00	0005111019	CATIONS	6010	7440-09-7	Potassium	3.4	3.4	mg/L	5	0.18	J	0	18-May-00
PFE-5	27-Apr-00	0005111019	CATIONS	6010	7440-70-2	Calcium	95.6	95.6	mg/L	0.2	0.048		0	18-May-00
PFE-5	27-Apr-00	0005111021	ANIONS	ANIONS		Fluoride	0.78	0.78	mg/L	0.1	0.01		0	19-May-00
PFE-5	27-Apr-00	0005111021	ANIONS	ANIONS		Sulfate	316	316	mg/L	50	1	SP	0	24-May-00
PFE-5	27-Apr-00	0005111021	ANIONS	ANIONS		Chloride	48	48	mg/L	3	0.1		0	24-May-00
PFE-5	27-Apr-00	0005111021	ANIONS	ANIONS		Total Alkalinity	192	192	mg/L	5	0.5		0	23-May-00
PFE-5	27-Apr-00	0005111023	NO2,NO3	353.2		Nitrate-Nitrite	2.3	2.3	mg/L	0.1	0.01		0	15-May-00
PFE-5	27-Apr-00	0005111025	TDS	160.1		Total Dissolved Solids	810	810	mg/L	10	5.4		0	17-May-00
PFE-5	27-Apr-00	0005111027	NH3	350.1	7664-41-7	Ammonia as N	0.049	0.049	mg/L	0.1	0.029	J	0	15-May-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-6	19-Apr-00	0004191257	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	04-May-00
PFE-6	19-Apr-00	0004191257	RCRA	RCRA	7439-97-6	Mercury	0.00003	0.000030	mg/L	0.0002	0.000028	J	0	27-Apr-00
PFE-6	19-Apr-00	0004191257	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00054		0	30-Apr-00
PFE-6	19-Apr-00	0004191257	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.0005		0	30-Apr-00
PFE-6	19-Apr-00	0004191257	RCRA	RCRA	7440-39-3	Barium	0.041	0.041	mg/L	0.01	0.0015		0	30-Apr-00
PFE-6	19-Apr-00	0004191257	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	30-Apr-00
PFE-6	19-Apr-00	0004191257	RCRA	RCRA	7439-92-1	Lead	0.0017	0.0017	mg/L	0.003	0.0015	J	0	04-May-00
PFE-6	19-Apr-00	0004191257	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.005	0.0012		0	04-May-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	127-18-4	Tetrachloroethene	10	10	ug/L	0.5	0.18		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	75-69-4	Trichlorofluoromethane	370	370	ug/L	12	0.055		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	660	660	ug/L	12	0.18		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	79-01-6	Trichloroethene	210	210	ug/L	12	0.16		0	27-Apr-00
PFE-6	19-Apr-00	0004200755	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	27-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.1		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	127-18-4	Tetrachloroethene	10	10	ug/L	1	0.1		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.1		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	75		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	67-66-3	Chloroform	0.31	0.31	ug/L	1	0.23	J	0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.1		0	29-Apr-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-6	19-Apr-00	0004200801	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	75-43-4	Dichlorofluoromethane	2.3	2.3	ug/L	2	0.12		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	75-69-4	Trichlorofluoromethane	210	210	ug/L	27	0.28		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	490	490	ug/L	13	0.21		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.1		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	79-00-5	1,1,2-Trichloroethane	0.24	0.24	ug/L	1	0.1	J	0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	79-01-6	Trichloroethene	210	210	ug/L	13	0.1		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	75-35-4	1,1-Dichloroethene	2.8	2.8	ug/L	1	0.2		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	2.2	2.2	ug/L	1	0.32		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.1		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.1		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.1		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	108-88-3	Toluene	51	51	ug/L	1	0.29		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	29-Apr-00
PFE-6	19-Apr-00	0004200801	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	29-Apr-00
PFE-6	19-Apr-00	0004200809	NDMA	607	62-75-9	N-Nitrosodimethylamine	1.42	1.4	ppb	0.01	0.005		54	03-May-00
PFE-6	19-Apr-00	0004200809	NDMA	607	4164-28-7	N-Nitrodimethylamine	0.97	0.97	ppb	0.01	0.005		54	03-May-00
PFE-6	19-Apr-00	0004200811	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	04-May-00
PFE-6	19-Apr-00	0004200811	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.005	0.0012		0	04-May-00
PFE-6	19-Apr-00	0004200811	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	04-May-00
PFE-6	19-Apr-00	0004200811	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	27-Apr-00
PFE-6	19-Apr-00	0004200811	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00054		0	30-Apr-00
PFE-6	19-Apr-00	0004200811	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.0005		0	30-Apr-00
PFE-6	19-Apr-00	0004200811	RCRA	RCRA	7440-39-3	Barium	0.038	0.038	mg/L	0.01	0.0015		0	30-Apr-00
PFE-6	19-Apr-00	0004200811	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	30-Apr-00
PFE-6	19-Apr-00	0004200813	CATIONS	6010	7439-89-6	Iron	2.7	2.7	mg/L	0.1	0.01		0	01-May-00

Remediation Well Analytical Data

PFE-6

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-6	19-Apr-00	0004200813	CATIONS	6010	7439-95-4	Magnesium	66.6	66.6	mg/L	0.2	0.01		0	30-Apr-00
PFE-6	19-Apr-00	0004200813	CATIONS	6010	7440-09-7	Potassium	3.5	3.5	mg/L	5	0.18	J	0	01-May-00
PFE-6	19-Apr-00	0004200813	CATIONS	6010	7440-23-5	Sodium	48.5	48.5	mg/L	5	0.35		0	01-May-00
PFE-6	19-Apr-00	0004200813	CATIONS	6010	7440-70-2	Calcium	120	120	mg/L	0.2	0.04		0	30-Apr-00
PFE-6	19-Apr-00	0004200815	ANIONS	ANIONS		Fluoride	0.81	0.81	mg/L	0.1	0.01		0	26-Apr-00
PFE-6	19-Apr-00	0004200815	ANIONS	ANIONS		Chloride	53.2	53.2	mg/L	15	0.5		0	30-Apr-00
PFE-6	19-Apr-00	0004200815	ANIONS	ANIONS		Sulfate	332	332	mg/L	100	2		0	30-Apr-00
PFE-6	19-Apr-00	0004200815	ANIONS	ANIONS		Total Alkalinity	227	227	mg/L	5	0.5		0	04-May-00
PFE-6	19-Apr-00	0004200817	NO2,NO3	353.2		Nitrate-Nitrite	2.2	2.2	mg/L	0.4	0.04		0	24-Apr-00
PFE-6	19-Apr-00	0004200819	TDS	160.1		Total Dissolved Solids	886	886	mg/L	10	5.4		0	26-Apr-00
PFE-6	19-Apr-00	0004200821	NH3	350.1	7664-41-7	Ammonia as N	0.12	0.12	mg/L	0.1	0.02		0	26-Apr-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-7	27-Aug-01	0108271440	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.28		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	127-18-4	Tetrachloroethene	0.21	0.21	ug/L	0.5	0.18	J	0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.076		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.1		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.14		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.34		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.27		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.13		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	75-69-4	Trichlorofluoromethane	12	12	ug/L	0.5	0.2		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	7.9	7.9	ug/L	0.5	0.22		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	79-01-6	Trichloroethene	13	13	ug/L	0.5	0.16		0	31-Aug-01
PFE-7	27-Aug-01	0108271440	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	31-Aug-01
PFE-7	27-Aug-01	0108271446	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	108-88-3	Toluene	3.8	3.8	ug/L	1	0.29		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	10		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	04-Sep-01

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-7	27-Aug-01	0108271446	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7	FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	67-64-1	Acetone	5.2	5.2	ug/L	10	1.9	J RB FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	75-69-4	Trichlorofluoromethane	14	14	ug/L	2	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	8.7	8.7	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	78-93-3	2-Butanone (MEK)	1.2	1.2	ug/L	5	0.93	J FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	79-01-6	Trichloroethene	16	16	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	04-Sep-01
PFE-7	27-Aug-01	0108271446	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	108-88-3	Toluene	4	4.0	ug/L	1	0.29		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	04-Sep-01

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-7	27-Aug-01	0108271452	VOA-D	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7	FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9	FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	75-69-4	Trichlorofluoromethane	14	14	ug/L	2	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	8.6	8.6	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93	FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	79-01-6	Trichloroethene	16	16	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	04-Sep-01
PFE-7	27-Aug-01	0108271452	VOA-D	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	04-Sep-01
PFE-7	27-Aug-01	0108271458	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		41	29-Aug-01
PFE-7	27-Aug-01	0108271458	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		76	29-Aug-01
PFE-7	27-Aug-01	0108271502	NDMA-D	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		41	29-Aug-01
PFE-7	27-Aug-01	0108271502	NDMA-D	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		76	29-Aug-01
PFE-7	27-Aug-01	0108271508	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0013		0	10-Sep-01
PFE-7	27-Aug-01	0108271508	RCRA	RCRA	7782-49-2	Selenium	0.0018	0.0018	mg/L	0.005	0.00082	J	0	12-Sep-01
PFE-7	27-Aug-01	0108271508	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.00065		0	11-Sep-01
PFE-7	27-Aug-01	0108271508	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.00003		0	18-Sep-01
PFE-7	27-Aug-01	0108271508	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00062		0	14-Sep-01
PFE-7	27-Aug-01	0108271508	RCRA	RCRA	7440-43-9	Cadmium	0.00047	0.00047	mg/L	0.005	0.00029	J	0	14-Sep-01
PFE-7	27-Aug-01	0108271508	RCRA	RCRA	7440-39-3	Barium	0.04	0.040	mg/L	0.01	0.00083		0	14-Sep-01
PFE-7	27-Aug-01	0108271508	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0034		0	14-Sep-01

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-7	27-Aug-01	0108271510	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.28		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	127-18-4	Tetrachloroethene	0.24	0.24	ug/L	0.5	0.18	J	0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.076		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.1		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.14		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.34		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.27		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.13		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	75-69-4	Trichlorofluoromethane	12	12	ug/L	0.5	0.2		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	7.8	7.8	ug/L	0.5	0.22		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	79-01-6	Trichloroethene	13	13	ug/L	0.5	0.16		0	31-Aug-01
PFE-7	27-Aug-01	0108271510	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	31-Aug-01
PFE-7	27-Aug-01	0108271516	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	108-88-3	Toluene	3.2	3.2	ug/L	1	0.29		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	04-Sep-01

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-7	27-Aug-01	0108271516	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7	FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9	FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	75-69-4	Trichlorofluoromethane	15	15	ug/L	2	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	9	9.0	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93	FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	79-01-6	Trichloroethene	17	17	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	04-Sep-01
PFE-7	27-Aug-01	0108271516	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	04-Sep-01
PFE-7	27-Aug-01	0108271522	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		41	29-Aug-01
PFE-7	27-Aug-01	0108271522	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		76	29-Aug-01
PFE-7	27-Aug-01	0108271526	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00062		0	14-Sep-01
PFE-7	27-Aug-01	0108271526	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0013		0	10-Sep-01
PFE-7	27-Aug-01	0108271526	RCRA	RCRA	7782-49-2	Selenium	0.0013	0.0013	mg/L	0.005	0.00082	J SP	0	12-Sep-01
PFE-7	27-Aug-01	0108271526	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.00065		0	11-Sep-01
PFE-7	27-Aug-01	0108271526	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.00003		0	18-Sep-01
PFE-7	27-Aug-01	0108271526	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00029		0	14-Sep-01
PFE-7	27-Aug-01	0108271526	RCRA	RCRA	7440-39-3	Barium	0.039	0.039	mg/L	0.01	0.00083		0	14-Sep-01
PFE-7	27-Aug-01	0108271526	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0034		0	14-Sep-01
PFE-7	27-Aug-01	0108271528	RCRA-D	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0013		0	10-Sep-01
PFE-7	27-Aug-01	0108271528	RCRA-D	RCRA	7782-49-2	Selenium	0.0017	0.0017	mg/L	0.005	0.00082	J	0	12-Sep-01
PFE-7	27-Aug-01	0108271528	RCRA-D	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.00065		0	11-Sep-01
PFE-7	27-Aug-01	0108271528	RCRA-D	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.00003		0	18-Sep-01
PFE-7	27-Aug-01	0108271528	RCRA-D	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00062		0	14-Sep-01
PFE-7	27-Aug-01	0108271528	RCRA-D	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00029		0	14-Sep-01
PFE-7	27-Aug-01	0108271528	RCRA-D	RCRA	7440-39-3	Barium	0.039	0.039	mg/L	0.01	0.00083		0	14-Sep-01
PFE-7	27-Aug-01	0108271528	RCRA-D	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0034		0	14-Sep-01

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-7	27-Aug-01	0108271600	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.28		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	127-18-4	Tetrachloroethene	0.32	0.32	ug/L	0.5	0.18	J	0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.076		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.1		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.14		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.34		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.27		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.13		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	75-69-4	Trichlorofluoromethane	12	12	ug/L	0.5	0.2		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	8.1	8.1	ug/L	0.5	0.22		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	79-01-6	Trichloroethene	14	14	ug/L	0.5	0.16		0	31-Aug-01
PFE-7	27-Aug-01	0108271600	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	31-Aug-01
PFE-7	27-Aug-01	0108271606	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	108-88-3	Toluene	3.5	3.5	ug/L	1	0.29		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	04-Sep-01

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-7	27-Aug-01	0108271606	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7	FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9	FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	75-69-4	Trichlorofluoromethane	15	15	ug/L	2	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	8.8	8.8	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93	FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	79-01-6	Trichloroethene	16	16	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	04-Sep-01
PFE-7	27-Aug-01	0108271606	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	04-Sep-01
PFE-7	27-Aug-01	0108271612	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		41	29-Aug-01
PFE-7	27-Aug-01	0108271612	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		76	29-Aug-01
PFE-7	27-Aug-01	0108271616	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0013		0	10-Sep-01
PFE-7	27-Aug-01	0108271616	RCRA	RCRA	7782-49-2	Selenium	0.0014	0.0014	mg/L	0.005	0.00082	J	0	12-Sep-01
PFE-7	27-Aug-01	0108271616	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.00065		0	11-Sep-01
PFE-7	27-Aug-01	0108271616	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.00003		0	18-Sep-01
PFE-7	27-Aug-01	0108271616	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00062		0	14-Sep-01
PFE-7	27-Aug-01	0108271616	RCRA	RCRA	7440-43-9	Cadmium	0.00048	0.00048	mg/L	0.005	0.00029	J	0	14-Sep-01
PFE-7	27-Aug-01	0108271616	RCRA	RCRA	7440-39-3	Barium	0.04	0.040	mg/L	0.01	0.00083		0	14-Sep-01
PFE-7	27-Aug-01	0108271616	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0034		0	14-Sep-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.28		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	127-18-4	Tetrachloroethene	0.22	0.22	ug/L	0.5	0.18	J	0	31-Aug-01

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-7	27-Aug-01	0108271630	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.076		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.1		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.14		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.34		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.27		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.13		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	75-69-4	Trichlorofluoromethane	14	14	ug/L	0.5	0.2		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	9.1	9.1	ug/L	0.5	0.22		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	79-01-6	Trichloroethene	15	15	ug/L	0.5	0.16		0	31-Aug-01
PFE-7	27-Aug-01	0108271630	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	31-Aug-01
PFE-7	27-Aug-01	0108271636	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	108-88-3	Toluene	2.3	2.3	ug/L	1	0.29		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	127-18-4	Tetrachloroethene	0.37	0.37	ug/L	1	0.36	J	0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7	FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9	FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	04-Sep-01

Remediation Well Analytical Data

PFE-7

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFE-7	27-Aug-01	0108271636	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	75-69-4	Trichlorofluoromethane	15	15	ug/L	2	0.28		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	9.2	9.2	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93	FB	0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	79-01-6	Trichloroethene	17	17	ug/L	1	0.22		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	04-Sep-01
PFE-7	27-Aug-01	0108271636	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	04-Sep-01
PFE-7	27-Aug-01	0108271642	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		41	29-Aug-01
PFE-7	27-Aug-01	0108271642	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		76	29-Aug-01
PFE-7	27-Aug-01	0108271646	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0013		0	10-Sep-01
PFE-7	27-Aug-01	0108271646	RCRA	RCRA	7782-49-2	Selenium	0.0017	0.0017	mg/L	0.005	0.00082	J	0	12-Sep-01
PFE-7	27-Aug-01	0108271646	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.00065		0	11-Sep-01
PFE-7	27-Aug-01	0108271646	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.00003		0	18-Sep-01
PFE-7	27-Aug-01	0108271646	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00062		0	14-Sep-01
PFE-7	27-Aug-01	0108271646	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00029		0	14-Sep-01
PFE-7	27-Aug-01	0108271646	RCRA	RCRA	7440-39-3	Barium	0.038	0.038	mg/L	0.01	0.00083		0	14-Sep-01
PFE-7	27-Aug-01	0108271646	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0034		0	14-Sep-01
PFE-7	27-Aug-01	0108271648	CATIONS	6010	7439-89-6	Iron	0.22	0.22	mg/L	0.1	0.0051		0	11-Sep-01
PFE-7	27-Aug-01	0108271648	CATIONS	6010	7439-95-4	Magnesium	63.3	63.3	mg/L	0.2	0.021		0	11-Sep-01
PFE-7	27-Aug-01	0108271648	CATIONS	6010	7440-09-7	Potassium	3.8	3.8	mg/L	5	0.5	J	0	11-Sep-01
PFE-7	27-Aug-01	0108271648	CATIONS	6010	7440-23-5	Sodium	51.9	51.9	mg/L	5	2		0	11-Sep-01
PFE-7	27-Aug-01	0108271648	CATIONS	6010	7440-70-2	Calcium	100	100	mg/L	0.2	0.029		0	11-Sep-01
PFE-7	27-Aug-01	0108271650	ANIONS	ANIONS		Fluoride	0.62	0.62	mg/L	0.1	0.012		0	04-Sep-01
PFE-7	27-Aug-01	0108271650	ANIONS	ANIONS		Chloride	39.9	40	mg/L	3	0.1		0	06-Sep-01
PFE-7	27-Aug-01	0108271650	ANIONS	ANIONS		Sulfate	322	322	mg/L	100	2		0	06-Sep-01
PFE-7	27-Aug-01	0108271650	ANIONS	ANIONS		Total Alkalinity	232	232	mg/L	5	0.5		0	07-Sep-01
PFE-7	27-Aug-01	0108271652	NO2,NO3	353.2		Nitrate-Nitrite	0.81	0.81	mg/L	0.1	0.021	SP	0	07-Sep-01
PFE-7	27-Aug-01	0108271654	TDS	160.1		Total Dissolved Solids	807	807	mg/L	10	4.8		0	31-Aug-01
PFE-7	27-Aug-01	0108271656	NH3	350.1	7664-41-7	Ammonia as N	0.17	0.17	mg/L	0.1	0.031		0	10-Sep-01

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	25-Jun-02	0206250930	CATIONS	6010	7440-09-7	Potassium	3.36	3.4	mg/l	2	1.92		0	01-Jul-02
PFI-1	25-Jun-02	0206250930	CATIONS	6010	7440-70-2	Calcium	108	108	mg/l	0.5	0.0842		0	01-Jul-02
PFI-1	25-Jun-02	0206250930	CATIONS	6010	7439-89-6	Iron	0	ND	mg/l	0.1	0.0333		0	01-Jul-02
PFI-1	25-Jun-02	0206250930	CATIONS	6010	7439-95-4	Magnesium	63.6	63.6	mg/l	0.5	0.0531		0	01-Jul-02
PFI-1	25-Jun-02	0206250930	CATIONS	6010	7440-23-5	Sodium	38.2	38.2	mg/l	0.5	0.238		0	01-Jul-02
PFI-1	25-Jun-02	0206250932	ANIONS	ANIONS	16887-00-6	Chloride	41.9	42	mg/l	2	0.19		0	08-Jul-02
PFI-1	25-Jun-02	0206250932	ANIONS	ANIONS	16984-48-8	Fluoride	1.06	1.1	mg/l	0.2	0.1		0	08-Jul-02
PFI-1	25-Jun-02	0206250932	ANIONS	ANIONS	14808-79-8	Sulfate	355	355	mg/l	8	0.1		0	08-Jul-02
PFI-1	25-Jun-02	0206250932	ANIONS	ANIONS	NA	Total Alkalinity	225	225	mg/l	2	0.6		0	08-Jul-02
PFI-1	25-Jun-02	0206250934	NO2,NO3	353.2	NA	Nitrate/nitrite Nitrogen	0.738	0.74	mg/l	0.05	0.002		0	08-Jul-02
PFI-1	25-Jun-02	0206250936	TDS	160.1	NA	Total Dissolved Solids	854	854	mg/l	10	0		0	28-Jun-02
PFI-1	25-Jun-02	0206250938	NH3	350.1	7664-41-7	Ammonia	0	ND	mg/l	0.05	0.005		0	10-Jul-02
PFI-1	17-Nov-00	0011170930	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	30-Nov-00
PFI-1	17-Nov-00	0011170930	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	30-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	2		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	29-Nov-00

Remediation Well Analytical Data

PFI-1

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	17-Nov-00	0011170936	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	108-88-3	Toluene	0.8	0.80	ug/L	1	0.29	J	0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	29-Nov-00
PFI-1	17-Nov-00	0011170936	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	29-Nov-00

Remediation Well Analytical Data

PFI-1

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	17-Nov-00	0011170942	VOA-D	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	108-88-3	Toluene	0.8	0.80	ug/L	1	0.29	J	0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	29-Nov-00
PFI-1	17-Nov-00	0011170942	VOA-D	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	29-Nov-00

Remediation Well Analytical Data

PFI-1

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	17-Nov-00	0011171040	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	30-Nov-00
PFI-1	17-Nov-00	0011171040	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	30-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	NA	Unknown	3.5	3.5	ug/L	0	0	J TIC	0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	108-88-3	Toluene	0.7	0.70	ug/L	1	0.29	J	0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	29-Nov-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	17-Nov-00	0011171046	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	29-Nov-00
PFI-1	17-Nov-00	0011171046	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	108-88-3	Toluene	0.68	0.68	ug/L	1	0.29	J	0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	29-Nov-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	17-Nov-00	0011171052	VOA-D	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	29-Nov-00
PFI-1	17-Nov-00	0011171052	VOA-D	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	30-Nov-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	17-Nov-00	0011171120	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	75-69-4	Trichlorofluoromethane	0.95	0.95	ug/L	0.5	0.055		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	30-Nov-00
PFI-1	17-Nov-00	0011171120	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	30-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	108-88-3	Toluene	0	ND	ug/L	1	0.29		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	67-64-1	Acetone	13	13	ug/L	10	1.9		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	29-Nov-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	17-Nov-00	0011171126	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	78-93-3	2-Butanone (MEK)	1.7	1.7	ug/L	5	0.93	J	0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	29-Nov-00
PFI-1	17-Nov-00	0011171126	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	108-88-3	Toluene	0	ND	ug/L	1	0.29		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	29-Nov-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	17-Nov-00	0011171132	VOA-D	8260	67-64-1	Acetone	1.9	1.9	ug/L	10	1.9	J	0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	29-Nov-00
PFI-1	17-Nov-00	0011171132	VOA-D	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	29-Nov-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	07-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	01-Sep-00	0009010801	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	07-Sep-00
PFI-1	01-Sep-00	0009010801	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	07-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	108-88-3	Toluene	2.8	2.8	ug/L	1	0.29		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	08-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	01-Sep-00	0009010807	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0.45	0.45	ug/L	1	0.21	J	0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	79-01-6	Trichloroethene	0.44	0.44	ug/L	1	0.22	J	0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	08-Sep-00
PFI-1	01-Sep-00	0009010807	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	08-Sep-00
PFI-1	01-Sep-00	0009010815	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		66	19-Sep-00
PFI-1	01-Sep-00	0009010815	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		66	19-Sep-00
PFI-1	01-Sep-00	0009010817	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	21-Sep-00
PFI-1	01-Sep-00	0009010817	RCRA	RCRA	7782-49-2	Selenium	0.0016	0.0016	mg/L	0.005	0.0012	J	0	21-Sep-00
PFI-1	01-Sep-00	0009010817	RCRA	RCRA	7440-38-2	Arsenic	0.0014	0.0014	mg/L	0.005	0.0013	J	0	21-Sep-00
PFI-1	01-Sep-00	0009010817	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	19-Sep-00
PFI-1	01-Sep-00	0009010817	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	13-Sep-00
PFI-1	01-Sep-00	0009010817	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	13-Sep-00
PFI-1	01-Sep-00	0009010817	RCRA	RCRA	7440-39-3	Barium	0.036	0.036	mg/L	0.01	0.0015		0	13-Sep-00
PFI-1	01-Sep-00	0009010817	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	13-Sep-00
PFI-1	01-Sep-00	0009010915	NDMA_LL-FB	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0.2	0.20	ppt	0.5	0.2	J	80	04-Oct-00
PFI-1	01-Sep-00	0009010915	NDMA_LL-FB	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		80	04-Oct-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	07-Sep-00
PFI-1	01-Sep-00	0009010931	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	07-Sep-00

Remediation Well Analytical Data

PFI-1

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	01-Sep-00	0009010931	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	07-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	108-88-3	Toluene	0.73	0.73	ug/L	1	0.29	J	0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	08-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	01-Sep-00	0009010939	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	08-Sep-00
PFI-1	01-Sep-00	0009010939	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	08-Sep-00
PFI-1	01-Sep-00	0009010945	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		66	19-Sep-00
PFI-1	01-Sep-00	0009010945	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		66	19-Sep-00
PFI-1	01-Sep-00	0009010949	NDMA_LL	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0.2	0.20	ppt	0.5	0.2	J	80	04-Oct-00
PFI-1	01-Sep-00	0009010949	NDMA_LL	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		80	04-Oct-00
PFI-1	01-Sep-00	0009010951	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	21-Sep-00
PFI-1	01-Sep-00	0009010951	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.005	0.0012		0	21-Sep-00
PFI-1	01-Sep-00	0009010951	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	21-Sep-00
PFI-1	01-Sep-00	0009010951	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	19-Sep-00
PFI-1	01-Sep-00	0009010951	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	13-Sep-00
PFI-1	01-Sep-00	0009010951	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	13-Sep-00
PFI-1	01-Sep-00	0009010951	RCRA	RCRA	7440-39-3	Barium	0.033	0.033	mg/L	0.01	0.0015		0	13-Sep-00
PFI-1	01-Sep-00	0009010951	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	13-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	12-Sep-00
PFI-1	01-Sep-00	0009011245	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	12-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	08-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	01-Sep-00	0009011251	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	108-88-3	Toluene	0.34	0.34	ug/L	1	0.29	J	0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	08-Sep-00
PFI-1	01-Sep-00	0009011251	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	08-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	01-Sep-00	0009011251	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	08-Sep-00
PFI-1	01-Sep-00	0009011257	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		66	19-Sep-00
PFI-1	01-Sep-00	0009011257	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		66	19-Sep-00
PFI-1	01-Sep-00	0009011301	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	25-Sep-00
PFI-1	01-Sep-00	0009011301	RCRA	RCRA	7782-49-2	Selenium	0.0018	0.0018	mg/L	0.005	0.0012	J	0	25-Sep-00
PFI-1	01-Sep-00	0009011301	RCRA	RCRA	7440-38-2	Arsenic	0.0017	0.0017	mg/L	0.005	0.0013	J	0	25-Sep-00
PFI-1	01-Sep-00	0009011301	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	19-Sep-00
PFI-1	01-Sep-00	0009011301	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	15-Sep-00
PFI-1	01-Sep-00	0009011301	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	15-Sep-00
PFI-1	01-Sep-00	0009011301	RCRA	RCRA	7440-39-3	Barium	0.033	0.033	mg/L	0.01	0.0015		0	15-Sep-00
PFI-1	01-Sep-00	0009011301	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	15-Sep-00
PFI-1	01-Sep-00	0009011415	NDMA_LL-FB	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0	ND	ppt	0.5	0.2		80	04-Oct-00
PFI-1	01-Sep-00	0009011415	NDMA_LL-FB	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		80	04-Oct-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	12-Sep-00
PFI-1	01-Sep-00	0009011425	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	12-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	08-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	01-Sep-00	0009011431	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	108-88-3	Toluene	0.36	0.36	ug/L	1	0.29	J	0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	08-Sep-00
PFI-1	01-Sep-00	0009011431	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	08-Sep-00
PFI-1	01-Sep-00	0009011437	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		66	19-Sep-00
PFI-1	01-Sep-00	0009011437	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		66	19-Sep-00
PFI-1	01-Sep-00	0009011441	NDMA_LL	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0	ND	ppt	0.5	0.2		80	04-Oct-00
PFI-1	01-Sep-00	0009011441	NDMA_LL	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		80	04-Oct-00
PFI-1	01-Sep-00	0009011445	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	25-Sep-00

Remediation Well Analytical Data

PFI-1

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	01-Sep-00	0009011445	RCRA	RCRA	7782-49-2	Selenium	0.0026	0.0026	mg/L	0.005	0.0012	J	0	25-Sep-00
PFI-1	01-Sep-00	0009011445	RCRA	RCRA	7440-38-2	Arsenic	0.0014	0.0014	mg/L	0.005	0.0013	J	0	25-Sep-00
PFI-1	01-Sep-00	0009011445	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	19-Sep-00
PFI-1	01-Sep-00	0009011445	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	15-Sep-00
PFI-1	01-Sep-00	0009011445	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	15-Sep-00
PFI-1	01-Sep-00	0009011445	RCRA	RCRA	7440-39-3	Barium	0.031	0.031	mg/L	0.01	0.0015		0	15-Sep-00
PFI-1	01-Sep-00	0009011445	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	15-Sep-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	24-Aug-00
PFI-1	18-Aug-00	0008181404	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	24-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	108-88-3	Toluene	1.3	1.3	ug/L	1	0.29		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	23-Aug-00

Remediation Well Analytical Data

PFI-1

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-1	18-Aug-00	0008181410	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	67-64-1	Acetone	2.5	2.5	ug/L	10	1.9	J RB	0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	23-Aug-00
PFI-1	18-Aug-00	0008181410	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	23-Aug-00
PFI-1	18-Aug-00	0008181416	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		76	23-Aug-00
PFI-1	18-Aug-00	0008181416	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		76	23-Aug-00
PFI-1	18-Aug-00	0008181420	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	07-Sep-00
PFI-1	18-Aug-00	0008181420	RCRA	RCRA	7782-49-2	Selenium	0.003	0.0030	mg/L	0.005	0.0012	J	0	08-Sep-00
PFI-1	18-Aug-00	0008181420	RCRA	RCRA	7440-38-2	Arsenic	0.002	0.0020	mg/L	0.005	0.0013	J	0	07-Sep-00
PFI-1	18-Aug-00	0008181420	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	29-Aug-00
PFI-1	18-Aug-00	0008181420	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00087		0	28-Aug-00
PFI-1	18-Aug-00	0008181420	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.0003		0	28-Aug-00
PFI-1	18-Aug-00	0008181420	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0011		0	28-Aug-00
PFI-1	18-Aug-00	0008181420	RCRA	RCRA	7440-39-3	Barium	0.058	0.058	mg/L	0.01	0.0021		0	28-Aug-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	24-Jun-02	0206241300	CATIONS	6010	7440-70-2	Calcium	97.6	97.6	mg/l	0.5	0.0842		0	01-Jul-02
PFI-2	24-Jun-02	0206241300	CATIONS	6010	7439-89-6	Iron	0	ND	mg/l	0.1	0.0333		0	01-Jul-02
PFI-2	24-Jun-02	0206241300	CATIONS	6010	7439-95-4	Magnesium	63.8	63.8	mg/l	0.5	0.0531		0	01-Jul-02
PFI-2	24-Jun-02	0206241300	CATIONS	6010	7440-09-7	Potassium	3.8	3.8	mg/l	2	1.92		0	01-Jul-02
PFI-2	24-Jun-02	0206241300	CATIONS	6010	7440-23-5	Sodium	53.1	53.1	mg/l	0.5	0.238		0	01-Jul-02
PFI-2	24-Jun-02	0206241302	ANIONS	ANIONS	16887-00-6	Chloride	42	42	mg/l	2	0.19		0	08-Jul-02
PFI-2	24-Jun-02	0206241302	ANIONS	ANIONS	16984-48-8	Fluoride	0.962	0.96	mg/l	0.2	0.1		0	08-Jul-02
PFI-2	24-Jun-02	0206241302	ANIONS	ANIONS	14808-79-8	Sulfate	354	354	mg/l	8	0.1		0	08-Jul-02
PFI-2	24-Jun-02	0206241302	ANIONS	ANIONS	NA	Total Alkalinity	228	228	mg/l	2	0.6		0	08-Jul-02
PFI-2	24-Jun-02	0206241304	NO2,NO3	353.2	NA	Nitrate/nitrite Nitrogen	0.98	0.98	mg/l	0.05	0.002		0	08-Jul-02
PFI-2	24-Jun-02	0206241306	TDS	160.1	NA	Total Dissolved Solids	834	834	mg/l	10	0		0	28-Jun-02
PFI-2	24-Jun-02	0206241308	NH3	350.1	7664-41-7	Ammonia	0	ND	mg/l	0.05	0.005		0	10-Jul-02
PFI-2	18-Nov-00	0011180824	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	27-Nov-00
PFI-2	18-Nov-00	0011180824	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	27-Nov-00
PFI-2	18-Nov-00	0011180830	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	2		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	01-Dec-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	18-Nov-00	0011180830	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	108-88-3	Toluene	0.5	0.50	ug/L	1	0.29	J	0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	01-Dec-00
PFI-2	18-Nov-00	0011180830	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	01-Dec-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	18-Nov-00	0011180836	VOA-D	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	108-88-3	Toluene	0.5	0.50	ug/L	1	0.29	J	0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	01-Dec-00
PFI-2	18-Nov-00	0011180836	VOA-D	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	01-Dec-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	18-Nov-00	0011180930	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	27-Nov-00
PFI-2	18-Nov-00	0011180930	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	27-Nov-00
PFI-2	18-Nov-00	0011180936	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	NA	Unknown	3.9	3.9	ug/L	0	0	J TIC	0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	108-88-3	Toluene	0.4	0.40	ug/L	1	0.29	J	0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	01-Dec-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	18-Nov-00	0011180936	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	01-Dec-00
PFI-2	18-Nov-00	0011180936	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	108-88-3	Toluene	0.42	0.42	ug/L	1	0.29	J	0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	01-Dec-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	18-Nov-00	0011180942	VOA-D	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	01-Dec-00
PFI-2	18-Nov-00	0011180942	VOA-D	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	27-Nov-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	18-Nov-00	0011181000	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	27-Nov-00
PFI-2	18-Nov-00	0011181000	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	27-Nov-00
PFI-2	18-Nov-00	0011181006	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	108-88-3	Toluene	0	ND	ug/L	1	0.29		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	01-Dec-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	18-Nov-00	0011181006	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	01-Dec-00
PFI-2	18-Nov-00	0011181006	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	108-88-3	Toluene	0	ND	ug/L	1	0.29		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	67-63-0	2-Propanol	0	ND	ug/L	75	0		0	01-Dec-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	18-Nov-00	0011181012	VOA-D	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	01-Dec-00
PFI-2	18-Nov-00	0011181012	VOA-D	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	01-Dec-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	16-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	06-Sep-00	0009060945	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	16-Sep-00
PFI-2	06-Sep-00	0009060945	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	16-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	108-88-3	Toluene	1	1.0	ug/L	1	0.29		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	12-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	06-Sep-00	0009060951	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	79-01-6	Trichloroethene	0.27	0.27	ug/L	1	0.22	J	0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	12-Sep-00
PFI-2	06-Sep-00	0009060951	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	12-Sep-00
PFI-2	06-Sep-00	0009060957	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		104	19-Sep-00
PFI-2	06-Sep-00	0009060957	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		104	19-Sep-00
PFI-2	06-Sep-00	0009061001	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	26-Sep-00
PFI-2	06-Sep-00	0009061001	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.005	0.0012		0	26-Sep-00
PFI-2	06-Sep-00	0009061001	RCRA	RCRA	7440-38-2	Arsenic	0.0014	0.0014	mg/L	0.005	0.0013	J	0	26-Sep-00
PFI-2	06-Sep-00	0009061001	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	26-Sep-00
PFI-2	06-Sep-00	0009061001	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	15-Sep-00
PFI-2	06-Sep-00	0009061001	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	15-Sep-00
PFI-2	06-Sep-00	0009061001	RCRA	RCRA	7440-39-3	Barium	0.027	0.027	mg/L	0.01	0.0015		0	15-Sep-00
PFI-2	06-Sep-00	0009061001	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	15-Sep-00
PFI-2	06-Sep-00	0009061300	NDMA_LL-FB	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0.2	0.20	ppt	0.5	0.2	J	80	04-Oct-00
PFI-2	06-Sep-00	0009061300	NDMA_LL-FB	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		80	04-Oct-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	17-Sep-00
PFI-2	06-Sep-00	0009061310	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	17-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	06-Sep-00	0009061310	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	17-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	108-88-3	Toluene	1.7	1.7	ug/L	1	0.29		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	12-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	06-Sep-00	0009061316	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	12-Sep-00
PFI-2	06-Sep-00	0009061316	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	12-Sep-00
PFI-2	06-Sep-00	0009061322	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		104	19-Sep-00
PFI-2	06-Sep-00	0009061322	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		104	19-Sep-00
PFI-2	06-Sep-00	0009061328	NDMA_LL	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0.3	0.30	ppt	0.5	0.2	J FB	80	04-Oct-00
PFI-2	06-Sep-00	0009061328	NDMA_LL	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		80	04-Oct-00
PFI-2	06-Sep-00	0009061330	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	26-Sep-00
PFI-2	06-Sep-00	0009061330	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.005	0.0012		0	26-Sep-00
PFI-2	06-Sep-00	0009061330	RCRA	RCRA	7440-38-2	Arsenic	0.0016	0.0016	mg/L	0.005	0.0013	J	0	26-Sep-00
PFI-2	06-Sep-00	0009061330	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	26-Sep-00
PFI-2	06-Sep-00	0009061330	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	15-Sep-00
PFI-2	06-Sep-00	0009061330	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	15-Sep-00
PFI-2	06-Sep-00	0009061330	RCRA	RCRA	7440-39-3	Barium	0.026	0.026	mg/L	0.01	0.0015		0	15-Sep-00
PFI-2	06-Sep-00	0009061330	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	15-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	18-Sep-00
PFI-2	06-Sep-00	0009061500	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	18-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	12-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	06-Sep-00	0009061506	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	108-88-3	Toluene	2.8	2.8	ug/L	1	0.29		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	12-Sep-00
PFI-2	06-Sep-00	0009061506	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	12-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	06-Sep-00	0009061506	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	12-Sep-00
PFI-2	06-Sep-00	0009061514	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		104	19-Sep-00
PFI-2	06-Sep-00	0009061514	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		104	19-Sep-00
PFI-2	06-Sep-00	0009061516	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	26-Sep-00
PFI-2	06-Sep-00	0009061516	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.005	0.0012		0	26-Sep-00
PFI-2	06-Sep-00	0009061516	RCRA	RCRA	7440-38-2	Arsenic	0.0017	0.0017	mg/L	0.005	0.0013	J	0	26-Sep-00
PFI-2	06-Sep-00	0009061516	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	26-Sep-00
PFI-2	06-Sep-00	0009061516	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	15-Sep-00
PFI-2	06-Sep-00	0009061516	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	15-Sep-00
PFI-2	06-Sep-00	0009061516	RCRA	RCRA	7440-39-3	Barium	0.025	0.025	mg/L	0.01	0.0015		0	15-Sep-00
PFI-2	06-Sep-00	0009061516	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	15-Sep-00
PFI-2	06-Sep-00	0009061652	NDMA_LL-FB	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0	ND	ppt	0.5	0.2		80	04-Oct-00
PFI-2	06-Sep-00	0009061652	NDMA_LL-FB	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		80	04-Oct-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	18-Sep-00
PFI-2	06-Sep-00	0009061700	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	18-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	12-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	06-Sep-00	0009061706	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	108-88-3	Toluene	1.1	1.1	ug/L	1	0.29		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	79-01-6	Trichloroethene	0.38	0.38	ug/L	1	0.22	J	0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	12-Sep-00
PFI-2	06-Sep-00	0009061706	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	12-Sep-00
PFI-2	06-Sep-00	0009061714	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		104	19-Sep-00
PFI-2	06-Sep-00	0009061714	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		104	19-Sep-00
PFI-2	06-Sep-00	0009061718	NDMA_LL	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0	ND	ppt	0.5	0.2		80	04-Oct-00
PFI-2	06-Sep-00	0009061718	NDMA_LL	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		80	04-Oct-00
PFI-2	06-Sep-00	0009061720	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	26-Sep-00

Remediation Well Analytical Data

PFI-2

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	06-Sep-00	0009061720	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.005	0.0012		0	26-Sep-00
PFI-2	06-Sep-00	0009061720	RCRA	RCRA	7440-38-2	Arsenic	0.0015	0.0015	mg/L	0.005	0.0013	J	0	26-Sep-00
PFI-2	06-Sep-00	0009061720	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	26-Sep-00
PFI-2	06-Sep-00	0009061720	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	15-Sep-00
PFI-2	06-Sep-00	0009061720	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	15-Sep-00
PFI-2	06-Sep-00	0009061720	RCRA	RCRA	7440-39-3	Barium	0.024	0.024	mg/L	0.01	0.0015		0	15-Sep-00
PFI-2	06-Sep-00	0009061720	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	15-Sep-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	24-Aug-00
PFI-2	19-Aug-00	0008191202	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	24-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	108-88-3	Toluene	1.4	1.4	ug/L	1	0.29		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	23-Aug-00

Remediation Well Analytical Data

PFI-2

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-2	19-Aug-00	0008191208	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	23-Aug-00
PFI-2	19-Aug-00	0008191208	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	23-Aug-00
PFI-2	19-Aug-00	0008191216	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		76	23-Aug-00
PFI-2	19-Aug-00	0008191216	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		76	23-Aug-00
PFI-2	19-Aug-00	0008191218	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	07-Sep-00
PFI-2	19-Aug-00	0008191218	RCRA	RCRA	7782-49-2	Selenium	0.0022	0.0022	mg/L	0.005	0.0012	J	0	08-Sep-00
PFI-2	19-Aug-00	0008191218	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	07-Sep-00
PFI-2	19-Aug-00	0008191218	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	29-Aug-00
PFI-2	19-Aug-00	0008191218	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00087		0	28-Aug-00
PFI-2	19-Aug-00	0008191218	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.0003		0	28-Aug-00
PFI-2	19-Aug-00	0008191218	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0011		0	28-Aug-00
PFI-2	19-Aug-00	0008191218	RCRA	RCRA	7440-39-3	Barium	0.036	0.036	mg/L	0.01	0.0021		0	28-Aug-00

Remediation Well Analytical Data

PFI-3

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-3	25-Jun-02	0206251300	CATIONS	6010	7440-70-2	Calcium	103	103	mg/l	0.5	0.0842		0	01-Jul-02
PFI-3	25-Jun-02	0206251300	CATIONS	6010	7439-89-6	Iron	0	ND	mg/l	0.1	0.0333		0	01-Jul-02
PFI-3	25-Jun-02	0206251300	CATIONS	6010	7439-95-4	Magnesium	66.1	66.1	mg/l	0.5	0.0531		0	01-Jul-02
PFI-3	25-Jun-02	0206251300	CATIONS	6010	7440-09-7	Potassium	3.5	3.5	mg/l	2	1.92		0	01-Jul-02
PFI-3	25-Jun-02	0206251300	CATIONS	6010	7440-23-5	Sodium	41.5	41.5	mg/l	0.5	0.238		0	01-Jul-02
PFI-3	25-Jun-02	0206251302	ANIONS	ANIONS	16887-00-6	Chloride	46.2	46	mg/l	2	0.19		0	08-Jul-02
PFI-3	25-Jun-02	0206251302	ANIONS	ANIONS	16984-48-8	Fluoride	1.04	1.0	mg/l	0.2	0.1		0	08-Jul-02
PFI-3	25-Jun-02	0206251302	ANIONS	ANIONS	14808-79-8	Sulfate	362	362	mg/l	8	0.1		0	08-Jul-02
PFI-3	25-Jun-02	0206251302	ANIONS	ANIONS	NA	Total Alkalinity	220	220	mg/l	2	0.6		0	08-Jul-02
PFI-3	25-Jun-02	0206251304	NO2,NO3	353.2	NA	Nitrate/nitrite Nitrogen	0.807	0.81	mg/l	0.05	0.002		0	08-Jul-02
PFI-3	25-Jun-02	0206251306	TDS	160.1	NA	Total Dissolved Solids	852	852	mg/l	10	0		0	28-Jun-02
PFI-3	25-Jun-02	0206251308	NH3	350.1	7664-41-7	Ammonia	0	ND	mg/l	0.05	0.005		0	10-Jul-02
PFI-3	08-Sep-00	0009081435	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	19-Sep-00
PFI-3	08-Sep-00	0009081435	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	1		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	19-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-3	08-Sep-00	0009081441	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	108-88-3	Toluene	1.2	1.2	ug/L	1	0.29		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009081441	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	19-Sep-00
PFI-3	08-Sep-00	0009081447	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-3	08-Sep-00	0009081447	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-3	08-Sep-00	0009081451	RCRA	RCRA	7440-39-3	Barium	0.021	0.021	mg/L	0.01	0.0015		0	21-Sep-00
PFI-3	08-Sep-00	0009081451	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	21-Sep-00
PFI-3	08-Sep-00	0009081451	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	21-Sep-00
PFI-3	08-Sep-00	0009081451	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	21-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-3	08-Sep-00	0009081451	RCRA	RCRA	7440-38-2	Arsenic	0.0018	0.0018	mg/L	0.005	0.0013	J	0	03-Oct-00
PFI-3	08-Sep-00	0009081451	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	03-Oct-00
PFI-3	08-Sep-00	0009081451	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	23-Sep-00
PFI-3	08-Sep-00	0009081451	RCRA	RCRA	7782-49-2	Selenium	0.0015	0.0015	mg/L	0.005	0.0012	J	0	05-Oct-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	19-Sep-00
PFI-3	08-Sep-00	0009081631	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	19-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-3	08-Sep-00	0009081637	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	108-88-3	Toluene	1	1.0	ug/L	1	0.29		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009081637	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	19-Sep-00
PFI-3	08-Sep-00	0009081645	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-3	08-Sep-00	0009081645	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-3	08-Sep-00	0009081649	NDMA_LL	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		100	10-Oct-00
PFI-3	08-Sep-00	0009081649	NDMA_LL	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0.3	0.30	ppt	0.5	0.2	J	100	10-Oct-00
PFI-3	08-Sep-00	0009081651	RCRA	RCRA	7440-39-3	Barium	0.021	0.021	mg/L	0.01	0.0015		0	21-Sep-00
PFI-3	08-Sep-00	0009081651	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	21-Sep-00
PFI-3	08-Sep-00	0009081651	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	21-Sep-00
PFI-3	08-Sep-00	0009081651	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	21-Sep-00
PFI-3	08-Sep-00	0009081651	RCRA	RCRA	7440-38-2	Arsenic	0.0016	0.0016	mg/L	0.005	0.0013	J	0	03-Oct-00
PFI-3	08-Sep-00	0009081651	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	03-Oct-00
PFI-3	08-Sep-00	0009081651	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	23-Sep-00
PFI-3	08-Sep-00	0009081651	RCRA	RCRA	7782-49-2	Selenium	0.0016	0.0016	mg/L	0.005	0.0012	J	0	05-Oct-00
PFI-3	08-Sep-00	0009081655	NDMA_LL-FB	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0	ND	ppt	0.5	0.2		77	10-Oct-00
PFI-3	08-Sep-00	0009081655	NDMA_LL-FB	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		77	10-Oct-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-3	08-Sep-00	0009090845	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	19-Sep-00
PFI-3	08-Sep-00	0009090845	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	19-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-3	08-Sep-00	0009090851	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	108-88-3	Toluene	0.46	0.46	ug/L	1	0.29	J	0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009090851	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	19-Sep-00
PFI-3	08-Sep-00	0009090859	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-3	08-Sep-00	0009090859	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-3	08-Sep-00	0009090901	RCRA	RCRA	7440-39-3	Barium	0.021	0.021	mg/L	0.01	0.0015		0	21-Sep-00
PFI-3	08-Sep-00	0009090901	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	21-Sep-00
PFI-3	08-Sep-00	0009090901	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	21-Sep-00
PFI-3	08-Sep-00	0009090901	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	21-Sep-00
PFI-3	08-Sep-00	0009090901	RCRA	RCRA	7440-38-2	Arsenic	0.0019	0.0019	mg/L	0.005	0.0013	J	0	03-Oct-00
PFI-3	08-Sep-00	0009090901	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	03-Oct-00
PFI-3	08-Sep-00	0009090901	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	23-Sep-00
PFI-3	08-Sep-00	0009090901	RCRA	RCRA	7782-49-2	Selenium	0.0015	0.0015	mg/L	0.005	0.0012	J	0	05-Oct-00
PFI-3	08-Sep-00	0009091021	NDMA_LL-FB	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0	ND	ppt	0.5	0.2		77	10-Oct-00
PFI-3	08-Sep-00	0009091021	NDMA_LL-FB	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		77	10-Oct-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	19-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-3	08-Sep-00	0009091025	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	19-Sep-00
PFI-3	08-Sep-00	0009091025	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	19-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-3	08-Sep-00	0009091031	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	108-88-3	Toluene	0.36	0.36	ug/L	1	0.29	J	0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	19-Sep-00
PFI-3	08-Sep-00	0009091031	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	19-Sep-00
PFI-3	08-Sep-00	0009091037	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-3	08-Sep-00	0009091037	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-3	08-Sep-00	0009091043	NDMA_LL	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0.2	0.20	ppt	0.5	0.2	J	77	10-Oct-00
PFI-3	08-Sep-00	0009091043	NDMA_LL	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		77	10-Oct-00
PFI-3	08-Sep-00	0009091045	RCRA	RCRA	7440-39-3	Barium	0.019	0.019	mg/L	0.01	0.0015		0	21-Sep-00
PFI-3	08-Sep-00	0009091045	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	21-Sep-00
PFI-3	08-Sep-00	0009091045	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	21-Sep-00
PFI-3	08-Sep-00	0009091045	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	21-Sep-00
PFI-3	08-Sep-00	0009091045	RCRA	RCRA	7440-38-2	Arsenic	0.0019	0.0019	mg/L	0.005	0.0013	J	0	03-Oct-00
PFI-3	08-Sep-00	0009091045	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	03-Oct-00
PFI-3	08-Sep-00	0009091045	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	23-Sep-00
PFI-3	08-Sep-00	0009091045	RCRA	RCRA	7782-49-2	Selenium	0.0015	0.0015	mg/L	0.005	0.0012	J	0	05-Oct-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	30-Aug-00

Remediation Well Analytical Data

PFI-3

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-3	24-Aug-00	0008240810	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	30-Aug-00
PFI-3	24-Aug-00	0008240810	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	108-88-3	Toluene	0.82	0.82	ug/L	1	0.29	J	0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	67-64-1	Acetone	2.9	2.9	ug/L	10	1.9	J	0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	30-Aug-00

Remediation Well Analytical Data

PFI-3

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-3	24-Aug-00	0008240816	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	30-Aug-00
PFI-3	24-Aug-00	0008240816	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	30-Aug-00
PFI-3	24-Aug-00	0008240822	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		76	27-Aug-00
PFI-3	24-Aug-00	0008240822	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		76	27-Aug-00
PFI-3	24-Aug-00	0008240826	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	20-Sep-00
PFI-3	24-Aug-00	0008240826	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.005	0.0012		0	20-Sep-00
PFI-3	24-Aug-00	0008240826	RCRA	RCRA	7440-38-2	Arsenic	0.0026	0.0026	mg/L	0.005	0.0013	J	0	20-Sep-00
PFI-3	24-Aug-00	0008240826	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	31-Aug-00
PFI-3	24-Aug-00	0008240826	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00087		0	12-Sep-00
PFI-3	24-Aug-00	0008240826	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.0003		0	12-Sep-00
PFI-3	24-Aug-00	0008240826	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0011		0	12-Sep-00
PFI-3	24-Aug-00	0008240826	RCRA	RCRA	7440-39-3	Barium	0.038	0.038	mg/L	0.01	0.0021		0	12-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-4	26-Jun-02	0206261330	CATIONS	6010	7440-70-2	Calcium	103	103	mg/l	0.5	0.0842		0	09-Jul-02
PFI-4	26-Jun-02	0206261330	CATIONS	6010	7439-89-6	Iron	0.00505	0.0050	mg/l	0.1	0.0333	J	0	09-Jul-02
PFI-4	26-Jun-02	0206261330	CATIONS	6010	7439-95-4	Magnesium	67.4	67.4	mg/l	0.5	0.0531		0	09-Jul-02
PFI-4	26-Jun-02	0206261330	CATIONS	6010	7440-09-7	Potassium	3.42	3.4	mg/l	2	1.92		0	09-Jul-02
PFI-4	26-Jun-02	0206261330	CATIONS	6010	7440-23-5	Sodium	44.8	44.8	mg/l	0.5	0.238		0	09-Jul-02
PFI-4	26-Jun-02	0206261332	ANIONS	ANIONS	16887-00-6	Chloride	44	44	mg/l	2	0.19		0	09-Jul-02
PFI-4	26-Jun-02	0206261332	ANIONS	ANIONS	16984-48-8	Fluoride	1	1.0	mg/l	0.2	0.1		0	09-Jul-02
PFI-4	26-Jun-02	0206261332	ANIONS	ANIONS	14808-79-8	Sulfate	339	339	mg/l	8	0.1		0	09-Jul-02
PFI-4	26-Jun-02	0206261332	ANIONS	ANIONS	NA	Total Alkalinity	211	211	mg/l	2	0.6		0	09-Jul-02
PFI-4	26-Jun-02	0206261334	NO2,NO3	353.2	NA	Nitrate/nitrite Nitrogen	0.851	0.85	mg/l	0.05	0.002		0	08-Jul-02
PFI-4	26-Jun-02	0206261336	TDS	160.1	NA	Total Dissolved Solids	803	803	mg/l	10	0		0	02-Jul-02
PFI-4	26-Jun-02	0206261338	NH3	350.1	7664-41-7	Ammonia	0	ND	mg/l	0.05	0.005		0	10-Jul-02
PFI-4	10-Sep-00	0009100900	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	19-Sep-00
PFI-4	10-Sep-00	0009100900	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	1		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	19-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-4	10-Sep-00	0009100906	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	108-88-3	Toluene	0.4	0.40	ug/L	1	0.29	J	0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009100906	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	19-Sep-00
PFI-4	10-Sep-00	0009100912	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-4	10-Sep-00	0009100912	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-4	10-Sep-00	0009100916	RCRA	RCRA	7440-39-3	Barium	0.036	0.036	mg/L	0.01	0.0015		0	21-Sep-00
PFI-4	10-Sep-00	0009100916	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	21-Sep-00
PFI-4	10-Sep-00	0009100916	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	21-Sep-00
PFI-4	10-Sep-00	0009100916	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	21-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-4	10-Sep-00	0009100916	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	03-Oct-00
PFI-4	10-Sep-00	0009100916	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	03-Oct-00
PFI-4	10-Sep-00	0009100916	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	23-Sep-00
PFI-4	10-Sep-00	0009100916	RCRA	RCRA	7782-49-2	Selenium	0.0016	0.0016	mg/L	0.005	0.0012	J	0	05-Oct-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	19-Sep-00
PFI-4	10-Sep-00	0009101030	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	19-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-4	10-Sep-00	0009101036	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	108-88-3	Toluene	0	ND	ug/L	1	0.29		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009101036	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	19-Sep-00
PFI-4	10-Sep-00	0009101042	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-4	10-Sep-00	0009101042	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-4	10-Sep-00	0009101046	RCRA	RCRA	7440-39-3	Barium	0.033	0.033	mg/L	0.01	0.0015		0	21-Sep-00
PFI-4	10-Sep-00	0009101046	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	21-Sep-00
PFI-4	10-Sep-00	0009101046	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	21-Sep-00
PFI-4	10-Sep-00	0009101046	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	21-Sep-00
PFI-4	10-Sep-00	0009101046	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	03-Oct-00
PFI-4	10-Sep-00	0009101046	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	03-Oct-00
PFI-4	10-Sep-00	0009101046	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	23-Sep-00
PFI-4	10-Sep-00	0009101046	RCRA	RCRA	7782-49-2	Selenium	0.0016	0.0016	mg/L	0.005	0.0012	J	0	05-Oct-00
PFI-4	10-Sep-00	0009101048	NDMA_LL-FB	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0	ND	ppt	0.5	0.2		77	10-Oct-00
PFI-4	10-Sep-00	0009101048	NDMA_LL-FB	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		77	10-Oct-00
PFI-4	10-Sep-00	0009101054	NDMA_LL	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0.3	0.30	ppt	0.5	0.2	J	77	10-Oct-00
PFI-4	10-Sep-00	0009101054	NDMA_LL	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		77	10-Oct-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-4	10-Sep-00	0009101230	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	23-Sep-00
PFI-4	10-Sep-00	0009101230	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	23-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	19-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-4	10-Sep-00	0009101236	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	108-88-3	Toluene	0	ND	ug/L	1	0.29		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009101236	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	19-Sep-00
PFI-4	10-Sep-00	0009101242	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-4	10-Sep-00	0009101242	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-4	10-Sep-00	0009101246	RCRA	RCRA	7440-39-3	Barium	0.028	0.028	mg/L	0.01	0.0015		0	21-Sep-00
PFI-4	10-Sep-00	0009101246	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	21-Sep-00
PFI-4	10-Sep-00	0009101246	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	21-Sep-00
PFI-4	10-Sep-00	0009101246	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	21-Sep-00
PFI-4	10-Sep-00	0009101246	RCRA	RCRA	7440-38-2	Arsenic	0	ND	mg/L	0.005	0.0013		0	03-Oct-00
PFI-4	10-Sep-00	0009101246	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	03-Oct-00
PFI-4	10-Sep-00	0009101246	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	23-Sep-00
PFI-4	10-Sep-00	0009101246	RCRA	RCRA	7782-49-2	Selenium	0.0013	0.0013	mg/L	0.005	0.0012	J	0	05-Oct-00
PFI-4	10-Sep-00	0009101350	NDMA_LL-FB	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0	ND	ppt	0.5	0.2		77	10-Oct-00
PFI-4	10-Sep-00	0009101350	NDMA_LL-FB	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		77	10-Oct-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	20-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-4	10-Sep-00	0009101400	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	20-Sep-00
PFI-4	10-Sep-00	0009101400	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	20-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	19-Sep-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-4	10-Sep-00	0009101406	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	108-88-3	Toluene	0	ND	ug/L	1	0.29		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	19-Sep-00
PFI-4	10-Sep-00	0009101406	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	19-Sep-00
PFI-4	10-Sep-00	0009101412	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-4	10-Sep-00	0009101412	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		97	19-Sep-00
PFI-4	10-Sep-00	0009101418	NDMA_LL	NDMA_LL	62-75-9	N-Nitrosodimethylamine	0	ND	ppt	0.5	0.2		77	10-Oct-00
PFI-4	10-Sep-00	0009101418	NDMA_LL	NDMA_LL	4164-28-7	N-Nitrodimethylamine	0	ND	ppt	0.5	0.3		77	10-Oct-00
PFI-4	10-Sep-00	0009101420	RCRA	RCRA	7440-39-3	Barium	0.028	0.028	mg/L	0.01	0.0015		0	21-Sep-00
PFI-4	10-Sep-00	0009101420	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0021		0	21-Sep-00
PFI-4	10-Sep-00	0009101420	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.0015		0	21-Sep-00
PFI-4	10-Sep-00	0009101420	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.00074		0	21-Sep-00
PFI-4	10-Sep-00	0009101420	RCRA	RCRA	7440-38-2	Arsenic	0.0014	0.0014	mg/L	0.005	0.0013	J	0	03-Oct-00
PFI-4	10-Sep-00	0009101420	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	03-Oct-00
PFI-4	10-Sep-00	0009101420	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	23-Sep-00
PFI-4	10-Sep-00	0009101420	RCRA	RCRA	7782-49-2	Selenium	0	ND	mg/L	0.005	0.0012		0	05-Oct-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.18		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	2	0.38		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.24		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	108-90-7	Chlorobenzene	0	ND	ug/L	0.5	0.27		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.18		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	127-18-4	Tetrachloroethene	0	ND	ug/L	0.5	0.18		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	156-59-2	cis-1,2-Dichloroethene	0	ND	ug/L	0.5	0.07		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	156-60-5	trans-1,2-Dichloroethene	0	ND	ug/L	0.5	0.099		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	0.5	0.35		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	56-23-5	Carbon tetrachloride	0	ND	ug/L	0.5	0.13		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	67-66-3	Chloroform	0	ND	ug/L	0.5	0.17		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	0.5	0.11		0	24-Aug-00

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-4	20-Aug-00	0008201330	HVOA	8021	74-83-9	Bromomethane	0	ND	ug/L	5	0.16		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	74-87-3	Chloromethane	0	ND	ug/L	5	0.16		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	75-00-3	Chloroethane	0	ND	ug/L	5	0.2		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	75-01-4	Vinyl chloride	0	ND	ug/L	1	0.15		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	75-09-2	Methylene chloride	0	ND	ug/L	5	0.18		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	75-25-2	Bromoform	0	ND	ug/L	5	0.24		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.15		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	75-34-3	1,1-Dichloroethane	0	ND	ug/L	0.5	0.05		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	75-35-4	1,1-Dichloroethene	0	ND	ug/L	0.5	0.14		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	75-43-4	Dichlorofluoromethane	0	ND	ug/L	0.5	0.31		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	75-69-4	Trichlorofluoromethane	0	ND	ug/L	0.5	0.055		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	0.5	0.18		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.24		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.3		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	79-01-6	Trichloroethene	0	ND	ug/L	0.5	0.16		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.4		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	5	0.35		0	24-Aug-00
PFI-4	20-Aug-00	0008201330	HVOA	8021	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	2	0.14		0	24-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	0	ND	ug/L	1	0.32		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	100-41-4	Ethylbenzene	0	ND	ug/L	1	0.28		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	100-42-5	Styrene	0	ND	ug/L	1	0.27		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	10061-01-5	cis-1,3-Dichloropropene	0	ND	ug/L	1	0.28		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	10061-02-6	trans-1,3-Dichloropropene	0	ND	ug/L	1	0.42		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	106-93-4	1,2-Dibromoethane (EDB)	0	ND	ug/L	1	0.36		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	107-02-8	Acrolein	0	ND	ug/L	20	4.7		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	107-05-1	Allyl chloride	0	ND	ug/L	2	0.2		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	107-06-2	1,2-Dichloroethane	0	ND	ug/L	1	0.28		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	107-12-0	Propionitrile	0	ND	ug/L	5	2.2		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	107-13-1	Acrylonitrile	0	ND	ug/L	20	2.4		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	108-05-4	Vinyl acetate	0	ND	ug/L	2	0.31		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	108-10-1	4-Methyl-2-pentanone	0	ND	ug/L	5	0.79		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	108-88-3	Toluene	1.1	1.1	ug/L	1	0.29		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	108-90-7	Chlorobenzene	0	ND	ug/L	1	0.3		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	109-99-9	Tetrahydrofuran	0	ND	ug/L	5	0.32		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	110-57-6	trans-1,4-Dichloro-2-butene	0	ND	ug/L	1	0.6		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	123-91-1	1,4-Dioxane	0	ND	ug/L	200	17		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	124-48-1	Dibromochloromethane	0	ND	ug/L	1	0.38		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	126-98-7	Methacrylonitrile	0	ND	ug/L	10	1.6		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	126-99-8	Chloroprene	0	ND	ug/L	1	0.22		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	127-18-4	Tetrachloroethene	0	ND	ug/L	1	0.36		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	1330-20-7	Xylenes (total)	0	ND	ug/L	1	0.95		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	306-83-2	2,2-Dichloro-1,1,1-Trifluoroethane	0	ND	ug/L	1	0.32		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	540-59-0	1,2-Dichloroethene (total)	0	ND	ug/L	1	0.53		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	56-23-5	Carbon tetrachloride	0	ND	ug/L	1	0.19		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	591-78-6	2-Hexanone	0	ND	ug/L	5	0.7		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	630-20-6	1,1,1,2-Tetrachloroethane	0	ND	ug/L	1	0.22		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	67-63-0	2-Propanol	0	ND	ug/L	75	7.4		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	67-64-1	Acetone	0	ND	ug/L	10	1.9		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	67-66-3	Chloroform	0	ND	ug/L	1	0.23		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	71-43-2	Benzene	0	ND	ug/L	1	0.21		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	71-55-6	1,1,1-Trichloroethane	0	ND	ug/L	1	0.26		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	74-83-9	Bromomethane	0	ND	ug/L	2	0.3		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	74-87-3	Chloromethane	0	ND	ug/L	2	0.3		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	74-88-4	Iodomethane	0	ND	ug/L	1	0.23		0	23-Aug-00

Remediation Well Analytical Data

PFI-4

wellname	event_date	sample_number	sample_type	analysis	casno	analyte	result	res_string	units	rep_limit	det_limit	qa_flag	extract_efficiency	date_anal
PFI-4	20-Aug-00	0008201336	VOA	8260	74-95-3	Dibromomethane	0	ND	ug/L	1	0.44		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	75-00-3	Chloroethane	0	ND	ug/L	2	0.25		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	75-01-4	Vinyl chloride	0	ND	ug/L	2	0.21		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	75-05-8	Acetonitrile	0	ND	ug/L	20	2.6		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	75-09-2	Methylene chloride	0	ND	ug/L	1	0.89		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	75-15-0	Carbon disulfide	0	ND	ug/L	1	0.19		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	75-25-2	Bromoform	0	ND	ug/L	1	0.32		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	75-27-4	Bromodichloromethane	0	ND	ug/L	1	0.22		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	75-34-3	1,1-Dichloroethane	0	ND	ug/L	1	0.17		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	75-35-4	1,1-Dichloroethene	0	ND	ug/L	1	0.2		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	75-43-4	Dichlorofluoromethane	0	ND	ug/L	2	0.12		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	75-69-4	Trichlorofluoromethane	0	ND	ug/L	2	0.28		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	75-71-8	Dichlorodifluoromethane	0	ND	ug/L	2	0.23		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	0	ND	ug/L	1	0.21		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	78-83-1	Isobutyl alcohol	0	ND	ug/L	50	11		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	78-87-5	1,2-Dichloropropane	0	ND	ug/L	1	0.21		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	78-93-3	2-Butanone (MEK)	0	ND	ug/L	5	0.93		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	79-00-5	1,1,2-Trichloroethane	0	ND	ug/L	1	0.39		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	79-01-6	Trichloroethene	0	ND	ug/L	1	0.22		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	79-34-5	1,1,2,2-Tetrachloroethane	0	ND	ug/L	1	0.31		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	80-62-6	Methyl methacrylate	0	ND	ug/L	1	0.3		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	0	ND	ug/L	2	0.25		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	96-18-4	1,2,3-Trichloropropane	0	ND	ug/L	1	0.29		0	23-Aug-00
PFI-4	20-Aug-00	0008201336	VOA	8260	97-63-2	Ethyl methacrylate	0	ND	ug/L	1	0.25		0	23-Aug-00
PFI-4	20-Aug-00	0008201342	NDMA	607	62-75-9	N-Nitrosodimethylamine	0	ND	ppb	0.01	0.005		76	23-Aug-00
PFI-4	20-Aug-00	0008201342	NDMA	607	4164-28-7	N-Nitrodimethylamine	0	ND	ppb	0.01	0.005		76	23-Aug-00
PFI-4	20-Aug-00	0008201346	RCRA	RCRA	7439-92-1	Lead	0	ND	mg/L	0.003	0.0015		0	07-Sep-00
PFI-4	20-Aug-00	0008201346	RCRA	RCRA	7782-49-2	Selenium	0.0014	0.0014	mg/L	0.005	0.0012	J	0	08-Sep-00
PFI-4	20-Aug-00	0008201346	RCRA	RCRA	7440-38-2	Arsenic	0.0014	0.0014	mg/L	0.005	0.0013	J	0	07-Sep-00
PFI-4	20-Aug-00	0008201346	RCRA	RCRA	7439-97-6	Mercury	0	ND	mg/L	0.0002	0.000028		0	29-Aug-00
PFI-4	20-Aug-00	0008201346	RCRA	RCRA	7440-22-4	Silver	0	ND	mg/L	0.01	0.00087		0	28-Aug-00
PFI-4	20-Aug-00	0008201346	RCRA	RCRA	7440-43-9	Cadmium	0	ND	mg/L	0.005	0.0003		0	28-Aug-00
PFI-4	20-Aug-00	0008201346	RCRA	RCRA	7440-47-3	Chromium	0	ND	mg/L	0.01	0.0011		0	28-Aug-00
PFI-4	20-Aug-00	0008201346	RCRA	RCRA	7440-39-3	Barium	0.045	0.045	mg/L	0.01	0.0021		0	28-Aug-00

Plume-Front Remediation Well Performance Summary

Well Name	Static Water Level (feet bgs)	Available Drawdown* (feet)	Design Performance			Preliminary Testing Performance					
			Design Flow Rate (gpm)	Percent Drawdown at Design Flow Rate*	Expected Drawdown at Design Flow Rate* (feet)	Testing Flow Rate (gpm)	Drawdown During Testing (feet)	Percentage of Available Drawdown Used*	Max. Theoretical Production Capacity* (gpm)	Specific Capacity at Testing* (gpm/foot)	Specific Capacity at Max Drawdown* (gpm/foot)
Plume-Front Extraction Wells											
PFE-1	423	337	331	14 %	47	250	30	9 %	1,390	8.33	4.12
PFE-2	434	452	258	10 %	45	230	40	9 %	1,280	5.75	2.83
PFE-3[1]	452	376	245	4 %	15	388	20	5 %	3,880	19.4	10.31
PFE-4+	475	391	50	2 %	8	40	7	2 %	1,330	5.7	3.40
PFE-4A	470	217	230	52 %	113	248	80	37 %	710	3.1	3.27
PFE-5	451	356	20	37 %	132	24	165	46 %	34	0.14	0.096
PFE-6+	468	62	NA	NA	NA	5	62	100 %	5	0.08	0.08
PFE-7	413	275	144	7 %	19	270	45	16 %	1,000	6.0	3.64
Plume-Front Injection Wells											
PFI-1	419	NA	-319	NA	NA	Not tested	NA	NA	NA	NA	NA
PFI-2	437	NA	-319	NA	NA	Not tested	NA	NA	NA	NA	NA
PFI-3	447	NA	-320	NA	NA	Not tested	NA	NA	NA	NA	NA
PFI-4	458	NA	-320	NA	NA	Not tested	NA	NA	NA	NA	NA

bgs = below ground surface
gpm = gallons per minute
Available Drawdown* = Well Depth (feet) – Static Water Level (feet) – pump (10 feet)
Percent Drawdown at Design Flow Rate*: Expected Drawdown at Design Rate/Available Drawdown. A percentage < 67 % is most economical (energy costs).
Expected Drawdown at Design Flow Rate*: Based on (Design Flow Rate/Max Production Capacity)
Percentage of Available Drawdown Used* = {(Available Drawdown (feet) – Drawdown During Testing (feet))/Available Drawdown (feet)} x 100
Maximum Theoretical Production Capacity*: Based on percentage of available drawdown used during testing at a specific rate under unconfined conditions.
Specific Capacity at Testing*: Q = Flow (gpm)/drawdown (feet)
Specific Capacity at Max Drawdown*: Based on percentage of available drawdown used during testing and under unconfined conditions.
PFE-3[1]: Data based on original well design and constant-rate pumping test performed in 1990. Well was rehabilitated in 2003 with a PVC sleeve installed.
+ Extraction Wells PFE-4 and PFE-6 will not be part of the on-line remediation system.

Reference: **Driscoll, F.G., 1989, Groundwater and Wells: Johnson Well Screens, p. 217.** Figure 9.11 and the accompanying text are used to calculate specific capacities, drawdowns, and production capacities in unconfined conditions.

Other Considerations:

- Aquifers are characterized as unconfined based on aquifer lithologies and characteristics observed during drilling and well installations. In some instances, confined conditions appeared to be present, but could not be confirmed. If confined or semi-confined conditions exist, specific capacities and production capacities could significantly exceed those calculated in this table, and drawdowns could be significantly smaller than those calculated.
- Well production estimates are most accurate when the data on which they are based are derived after at least 24 hours of continuous pumping or after drawdowns reach equilibrium. Most of the preliminary testing estimates in this table are derived from relatively short term pumping tests or from pulsed well development, due to the logistics at WSTF involved with storing and disposing of large quantities of contaminated development water. Actual conditions observed following activation of the remediation system may vary from those indicated by this table.
- Well data for this table were derived as each well was tested or developed, over the course of several years. Once the remediation system is activated, and all wells are pumping in unison, drawdowns may be influenced by the cumulative effect of all the wells and overlapping cones of depression.
- Other factors that could affect well production are: variations in seasonal rainfall (recharge) rates that cause fluctuations in the regional static water table, biofouling of well screens, and mineral encrustations on well screens.

Results of Plume-Front Remediation
Well Slug Testing

Well	K (ft/sec)	K (ft/day)	Method
PFI-1	3.66 X 10-5	3.16	Bouwer and Rice (Unconfined)
PFI-2	2.54 X 10-5	2.20	Bouwer and Rice (Unconfined)
PFI-3	4.11 X 10-5	3.55	Bouwer and Rice (Unconfined)
PFI-4	3.8 X 10-5	3.02	Bouwer and Rice (Unconfined)
PFE-1	5.05 X 10-5	3.72	Bouwer and Rice (Unconfined)
PFE-2	2.55 X 10-5	2.20	Bouwer and Rice (Unconfined)
PFE-4	1.93 X 10-5	1.66	Bouwer and Rice (Unconfined)
PFE-4A	2.13 X 10-5	1.84	Bouwer and Rice (Unconfined)
PFE-5	1.38 X 10-6	0.12	Bouwer and Rice (Unconfined)
PFE-6	1.87 X 10-6	0.16	Bouwer and Rice (Unconfined)
PFE-7	5.92 X 10-5	5.11	Bouwer and Rice (Unconfined)

DRAFT REPORT

AQUIFER PUMPING TEST REPORT
NASA WELL PT

December 5, 1990

Prepared for:

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Table of Contents

1.0 Executive Summary 1

2.0 Wells and Piezometers 4
2.1 Pumping Test Well, NASA Well PT 4
2.2 Piezometers 6
2.3 Monitoring Wells 7

3.0 Flow Rate and Water Level Measurement 8
3.1 NASA Well PT 10
3.2 Piezometers 12
3.2.1 Test Preparation 12
3.2.2 Manual Recording 12
3.2.3 Digital Recording 14
3.3 Monitoring Wells 14
3.4 Barometric Pressure Measurements 15

4.0 Data Reduction 17
4.1 Barometric Corrections 17
4.2 Selection of Data Sets for Analysis 18

5.0 Hydrogeologic Model: Unconfined To Leaky-confined, Anisotropic Alluvial Aquifer 19
5.1 Evidence for a Faulted Alluvial Fan Sequence 21
5.2 Evidence for Leaky-Confined Conditions 22
5.3 Evidence for Unconfined Conditions 23
5.4 Expected Anisotropy in Alluvial Fan Aquifers 24
5.5 Interpreted Hydrogeologic Model 25

6.0 Estimating Aquifer Parameters 27
6.1 Pumping Phase Analysis: Theis' Drawdown Method (Lohman, 1979) 27
6.2 Recovery Test Analyses: Theis' Recovery Method (1935) 31
6.3 Pumping and Recovery Data Analysis - Jacob-Cooper (1946) Approximation . 32
6.4 Leaky-Confined Aquifer with Vertical Movement - Cooper (1963) and Hantusch (1960) Methods 34
6.5 Unconfined Aquifer: Delayed Yield - Boulton (1954) 36
6.6 Distance-Drawdown Analysis - Cooper and Jacob (1946) 41
6.7 Boundary Analysis - Stallman (1963) 44

7.0 Summary of Aquifer Test Results 48

8.0 References 50

List of Figures

Figure

1	Well Location Map	1
2	Flowmeter – Analog Output	1
3	Discharge: Weir vs. Flowmeter	1
4	Pumping Well Drawdown vs. Time	1
5	Ground Water Elevations Prior to Pumping Test	1
6	Hydrographs: Wells Outside the Radius of Influence	1
7	Hydrographs: Wells Within the Radius of Influence	1
8	Cross-Sections A-A′ and B-B'	1
9	Apparent Impermeable Boundary Location Map	1

List of Tables

Table

1	Piezometer Data Summary	1
2	Monitoring Well Data Summary	1
3	Flowmeter Readings	1
4	Weir Readings	1
5	Deviations from the Theis-Type Curve	1
6	Cooper-Jacob Analyses	1
7	Leaky-Confined Aquifer Analyses	1
8	Summary Table: Aquifer Characteristics	1

List of Appendices

Appendix

A Well Completion Diagrams and Lithologic Logs
B Water Level Data and Field Notes
C Data Logger: Raw Data
D Barograph Record
E Theis Drawdown Analysis
F Theis Recovery Analysis
G Jacob-Cooper Analyses
H Leaky-Confined Methods: Cooper and Hantusch
I Boulton – Delayed Yield Analyses
J Cooper and Jacob – Distance-Drawdown Analyses
K Boundary Analysis

1.0 Executive Summary

Characterization of aquifer hydrologic parameters is critical to the evaluation of dissolved-phase contaminant migration. Transmissivity, hydraulic conductivity and storage coefficient are intrinsic aquifer properties which describe the amount of water held and transmitted through a particular cross section of the aquifer. These properties are used to numerically describe the ground-water flow regime so that computer models can simulate past, present, and future contaminant migration. However, the predictive capabilities of any numerical model are only as reliable as the quality of the data input. Because simulations of contaminant migration will guide the risk assessment and corrective actions, hydrologic parameters should be defined as accurately as possible to provide a reasonable degree of confidence in the results of the contaminant transport model. To better quantify hydrologic characteristics in and near the basin-forming fault zone, an aquifer pumping test was performed.

The aquifer pumping test was conducted from June 4 to 17, 1990, at the NASA-White Sands Test Facility (NASA-WSTF) to characterize the hydrologic properties of the alluvial aquifer near the basin-forming fault zone. The aquifer pumping test was conducted at an average discharge rate of 388 gpm from 0900 hours on June 4 to 0745 hours on June 8,

1990; recovery was initiated at 0745 on June 8, 1990, and water level measurements were obtained through June 17, 1990. The pumping well, NASA Well PT, was designed and installed specifically for this aquifer pumping test. Four piezometers were installed at radii ranging from 94 to 497 feet from Well PT to permit measurement of drawdown and recovery in the immediate vicinity of the pumping well. Drawdown was also recorded in fourteen monitoring wells located at distances of up to 0.9 miles from the pumping well. The water discharged during the aquifer pumping test was treated in an air stripper and piped to a drainage ditch approximately 2,000 feet north of Well PT where it was discharged to grade. The pumping test data were analyzed using aquifer pumping and recovery test analyses developed by Theis (1935), Cooper and Jacob (1946), Cooper (1963), Hantusch (1960), Boulton (1954), and Stallman (1963).

Aquifer pumping test analyses and geologic interpretations suggest that the test area lies within a retrograding, westward thickening alluvial fan sequence adjacent to the basin-forming boundary fault zone. Depending on the location of monitoring points with respect to the basin-forming fault, the aquifer behaves as either a leaky confined or an unconfined aquifer. Leaky-confined conditions were interpreted for wells near the boundary fault zone and westward towards the basin axis with an average apparent transmissivity of 0.154 ft^2/s and an average storage coefficient of 4.95×10^{-4}. Unconfined conditions were observed in wells BLM-17-493, BLM-2-482, and BLM-2-630 at locations east of the interpreted fault

zone. Transmissivity values for the unconfined aquifer averaged 0.332 ft^2/s with an average storage coefficient of 1.5×10^{-5} and specific yield of 0.0148.

An apparent low permeability boundary was encountered in most wells approximately 700 minutes into the pumping test. The effects of this low permeability boundary were especially apparent in well BLM-2-630. The low permeability boundary observed from data obtained from BLM-2-630 is interpreted as a decrease in transmissivity due to the thinning of the alluvial sediments and/or an increasing reliance on ground water obtained from bedrock aquifers abutting the alluvions on the upgradient (east) edge of the basin-forming fault zone. The low permeability boundary was encountered at a distance of approximately 1,800 feet east of the pumping well (NASA well PT).

2.0 Wells and Piezometers

2.1 Pumping Test Well, NASA Well PT

The aquifer pumping test well, NASA Well PT, is located in Section 5 of Township 21 South, Range 3 East NMPM (lat. = 32°30'52.838", long. = 106°39'03.462"). Well PT was drilled in alluvial deposits from September 20, 1989 to December 18, 1989, to a total depth of 856 feet below grade. A 7-7/8 inch pilot borehole was drilled using air-foam rotary drilling techniques to the total depth of 856 feet below grade. Orejon Andesite bedrock was encountered at 844 feet below grade. The pilot hole was subsequently reamed to a diameter of 18 inches using mud rotary drilling to a total depth of 844 feet below grade, the top of bedrock.

Well PT was completed at a total depth of 838 feet below grade in December 1989 and January 1990. The well was completed with 10-inch diameter carbon steel casing and 0.08-inch (80 slot) continuous wire-wound screen to a total depth of 838.5 feet below grade (see well completion diagram in appendix A). The screened interval is 507.7 to 828.4 feet with 20-foot screened sections alternating with 10-foot blank sections. The result is a 220-foot section of screened aquifer over a 321-foot borehole length. A sand filter pack was

installed (4/8 grade silica sand) to an estimated depth of 465.6 feet below grade. Finer sands (8/20 and 16/40 grade silica sand) were installed above the filter pack and were followed by the installation of a bentonite plug. The well was then grouted to the surface using a cement-bentonite grout.

In March 1990, a Frankling Company 60-horsepower submersible pump on a 5-inch by 609-foot-long riser pipe was installed in Well PT. The pump intake was set at 616 feet below grade; a 5-inch check valve was installed 21 feet above the pump intake. The pump was tested at an initial average discharge rate of 430 gallons per minute (gpm). Initially, discharge waters were described as rust-colored and turbid, but cleared after continued pumping. Further pumping was performed to develop the well prior to the aquifer pumping test. Approximately 36,000 gallons of water were produced during well development. The water discharged during well development was stored in three containment pools capable of holding up to 37,500 gallons at total capacity.

A high-energy depositional environment located close to the area of local uplift is interpreted from the pebble-to-cobble conglomerate alluvial sediments penetrated at Well PT. This interpretation is supported by core descriptions (see appendix A) and geophysical logs. These sediments are considered to be part of the Santa Fe Group alluvium. Alluvial materials encountered in the borehole ranged from unconsolidated gravelly alluvium to semi-

consolidated, pebble to boulder, andesite-rich alluvium. Upward fining sequences were observed in core recovered from 489 to 499 feet. Well PT is interpreted to be completed within a westward-thickening alluvial fan sequence. Clastic andesite-rich alluvium was encountered from 550 to 844 feet. Clast sizes coarsened with increasing depth and ranged from pebbles to boulder-sized clasts with diameters up to 7.5 inches. The Santa Fe Group alluvium can be generalized as a basin-fill deposit consisting of poorly to highly consolidated, pebble to boulder conglomerate with sand, silt, and clay layers distributed throughout the sequence.

2.2 Piezometers

Four temporary piezometers, PT-PZ-1 through PT-PZ-4 (see figure 1 and table 1), were installed to provide access for water level measurements within a 500-foot radius of Well PT. The piezometers were located on three distinct directional axes to accommodate the use of Papadopolus' method (1965) for analyzing aquifer pumping tests in anisotropic aquifers. Each piezometer is discussed briefly in the following sections. Detailed lithologic data and completion diagrams for each piezometer are provided in appendix A.

Table 1

Piezometer Data Summary

Piezometer	Northing*	Easting*	Radial Distance From Well PT (feet)	Ground Surface Elevation (feet, msl)	Top Of Casing Elevation (feet, msl)	Initial Depth To Water** (feet)	Initial Water Table Elevation (feet, msl)	Elevation Top Of Screen (feet, msl)	Screened Lithology
PT-PZ-1	226620.89	401932.56	200.58	4520.50	4521.47	450.50	4070.97	4035.50	Gravelly sand with minor silt and clay. Limestone and rhyolite clasts present
PT-PZ-2	226849.93	401977.90	144.46	4519.50	4520.63	449.34	4071.29	4015.65	Andesite-rich alluvium, less than 10% calcite present
PT-PZ-3	226776.73	402174.62	93.68	4523.92	4525.02	456.41	4068.61	4008.48	Poorly to moderately-cemented, andesite-rich alluvium
PT-PZ-4	226875.56	402565.38	496.73	4530.57	4531.72	460.17	4071.55	4020.61	Fine to medium sand, andesite-rich alluvium

*White Sands Transverse Mercator System

**Depth to water is measured from the top of casing.

0109/004/PTPZ.PRN

2.3 Monitoring Wells

Fourteen groundwater monitoring wells (see figure 1 and table 2) were selected as observation wells for the Well PT aquifer pumping test. These wells are as follows: PL-1-486, PL-2-504, PL-3-453, PL-4-464, ST-1-473, ST-2-466, WW-1-452, JP-2-447, BLM-17-493, BLM-2-482, BLM-2-630, BLM-7-509, BLM-6-488, and BLM-9-419. These monitoring wells were selected as observation points on the basis of their proximity to Well PT.

The primary objective of monitoring water levels in these wells was to detect and record the aquifer response at varying distances and directions from the pumping well. Water level measurements from wells that proved to be beyond the influence of the pumping well provided data on natural water level fluctuations. All monitoring wells were completed with 10 or 20 feet lengths of 0.020-inch (20 slot) continuous slot screen and a filter pack of 8/20 grade silica sand. Detailed well construction and lithologic information on these monitoring wells is provided in the Aquifer Test Report - Well J (Geoscience Consultants, Ltd., 1990b) and the Third Hydrogeologic Investigation Report (Geoscience Consultants, Ltd., 1990a). Table 2 summarizes pertinent information for each monitoring well.

NASA MONITORING WELLS
JANUARY 23, 1991

WELL	NORTHING	EASTING	ELEVATION (BRASS CAP)	ELEVATION (INNER CASING)	TOTAL DEPTH	BEDROCK DRILL DEPTH	SCREEN INTERVAL	DATE STARTED	DATE COMPLETED
100-A-182	223399.14	416627.43	4842.36	4844.74	221.0	87 LIMESTONE (Panther Seep ?)	182.00'-192.40'	05-08-89	05-30-89
100-B(2)-*	223085.99	413332.71	4756.61	N/A	400.0	185 ANDESITE (Orejon)	N/A	08-09-89	10-02-89
100-B-*	223036.40	413337.51	4756.79	N/A	401.0	210 ANDESITE (Orejon)	364.59'-385.32'	06-07-89	07-12-89
100-C-365	220524.21	414724.78	4816.82	4818.50	400.0	232 ANDESITE (Orejon)	365.00'-385.80'	07-17-89	09-18-89
100-E-261	221626.63	417825.58	4900.99	4902.39	283.6	144 LIMESTONE (Panther Seep)	260.90'-271.30'	06-21-89	07-07-89
200-A-*	228184.29	418460.37	4891.27	N/A	150.0	70 LIMESTONE	N/A	01-15-87	0
200-B-*	227791.68	416532.79	4838.39	N/A	150.0	145 LIMESTONE (Hueco?)	N/A	01-26-87	0
200-B-240	227788.02	416536.69	4837.77	4840.00	260.0	145 LIMESTONE	239.80'-250.10'	01-26-87	01-11-89
200-C-*	226584.70	416792.69	No BC	4794.77	23.0	Not Reached by 23'	8.00'- 23.00'	0	0
200-D-109	226387.74	416394.52	4785.79	4788.64	140.1	115 LIMESTONE (?)	108.80'-129.50'	03-07-87	03-12-87
200-D-240	226327.40	416415.61	4785.25	4787.97	280.0	95 LIMESTONE	239.60'-250.00'	06-29-88	07-20-88
200-E-*	226903.94	416140.90	4818.36	N/A	300.0	150 LIMESTONE	N/A	01-04-89	02-01-89
300-A-120	230939.97	418518.75	4911.67	4913.70	152.0	115 ANDESITE (Orejon)	120.00'-146.00'	01-27-87	02-03-87
300-A-170	230954.59	418517.47	4911.28	4913.70	182.0	102 ANDESITE (Orejon)	170.00'-175.50'	02-23-87	03-26-87
300-B-166	230709.38	418573.16	4931.92	4934.33	192.2	110 ANDESITE (Orejon)	165.50'-175.90'	02-19-87	10-09-87
300-C-128	230624.52	417761.85	4877.27	4880.37	170.3	92 ANDESITE (Orejon)	128.20'-154.30'	03-04-87	03-09-87
300-D-153	231987.23	422914.50	5108.71	5110.97	194.0	75 LIMESTONE (Panther Seep ?)	153.10'-173.80'	03-25-88	04-04-88
400-A-151	230188.95	414503.08	4795.09	4797.56	187.0	185 ANDESITE (Orejon)	150.50'-175.60'	01-29-87	02-09-87
400-B-*	229824.56	414356.15	No BC	N/A	60.0	Not Reached by 60'	N/A	02-05-87	0
400-C-118	230425.68	415380.10	4808.74	4811.02	154.6	150 ANDESITE (Orejon)	118.00'-143.00'	02-13-87	02-17-87
400-C-143	230429.32	415368.65	4808.55	4810.87	163.0	147 ANDESITE (Orejon)	143.00'-153.40'	02-12-89	02-20-87
600-C-*	224767.41	413532.47	4743.13	N/A	70.0	Not Reached by 70'	N/A	0	08-13-88
600-C-173	224771.75	413541.82	4744.01	4746.39	202.6	150 ANDESITE (Orejon)	172.50'-193.20'	02-02-87	02-25-87
600-C-210	224778.40	413570.97	4744.31	4747.10	230.0	148 ANDESITE (Orejon)	210.00'-220.30'	02-21-87	02-20-87
600-C-437	224783.71	413594.64	4745.64	4747.18	500.0	145 ANDESITE (Orejon)	436.90'-447.20'	08-07-87	02-08-88
600-PZ-1	224705.40	413540.12	0	4746.60	300.0	152 ANDESITE (Orejon)	265.00'-270.00'	04-17-89	04-21-89
600-PZ-2	224867.84	413541.70	0	4744.20	442.0	137 ANDESITE (Orejon)	429.65'-434.65'	04-24-89	04-27-89
700-A-253	235422.96	417647.81	4908.14	4910.54	287.0	149 ANDESITE (Orejon)	253.00'-263.40'	10-30-89	11-09-89
700-B-510	236139.75	413809.71	4805.89	4807.88	550.0	285 ANDESITE (Orejon)	510.00'-530.84'	06-25-90	08-14-90
700-D-186	236500.18	417181.92	4885.28	4887.44	205.0	180 LIMESTONE (Hueco)	186.00'-196.30'	11-10-89	12-21-89
700-E-458	234304.94	409922.66	4717.77	4720.28	515.0	285 ANDESITE (Orejon)	458.10'-478.90'	02-16-90	03-12-90
700-F-455	0	0	0	0	526.0	305 ANDESITE (Orejon)	455.00'-475.03'	09-24-90	0
BLM-01-435	229564.66	403726.68	4551.67	4553.14	500.0	457 ANDESITE (Orejon)	435.30'-445.70'	09-23-87	11-13-87
BLM-02-482	225654.81	402994.10	4535.48	4537.75	550.0	Not Reached by 550'	482.40'-492.80'	10-11-87	10-25-87
BLM-02-630	225701.70	402992.49	4535.35	4537.75	670.0	657 ANDESITE (Orejon)	629.50'-639.80'	05-12-88	06-13-88
BLM-03-182	224681.46	413418.22	4743.93	4746.39	215.5	162 ANDESITE (Orejon)	182.30'-203.00'	01-31-87	02-10-87
BLM-04-*	224427.17	413322.99	4743.81	N/A	28.0	Not Reached by 28'	N/A	02-01-87	08-13-88
BLM-05-527	232891.85	403363.61	4551.80	4553.95	570.0	363 RHYOLITE	527.30'-537.70'	03-04-88	04-04-88
BLM-06-488	224682.43	405938.50	4588.36	4590.50	506.0	350 ANDESITE (Orejon)	487.70'-498.20'	04-03-90	04-18-90
BLM-07-509	224244.56	402952.81	4529.80	4531.50	557.0	Not Reached by 557'	509.30'-519.70'	04-27-88	05-17-88
BLM-08-418	231423.04	403768.31	4556.33	4558.68	452.0	418 TUFF (Cueva ?)	418.00'-428.40'	06-13-88	06-28-88
BLM-09-419	228517.55	406183.31	4602.24	4604.39	557.0	340 TUFF (Cueva ?)	419.30'-440.00'	10-05-88	11-09-88
BLM-10-517	223050.75	402963.97	4533.71	4535.77	568.0	Not Reached by 568'	516.60'-526.90'	02-09-88	03-03-88
BLM-11-*	223307.46	410017.89	4677.35	N/A	400.0	253 ANDESITE (Orejon)	N/A	08-21-89	09-07-89
BLM-12-*	225265.22	409153.79	4647.61	N/A	495.0	255 ANDESITE (Orejon)	N/A	05-01-89	06-20-89

0 DATA NOT AVAILABLE
* PLUGGED AND ABANDONED WELL
N/A NOT APPLICABLE

NASA MONITORING WELLS
JANUARY 23, 1991

WELL	NORTHING	EASTING	ELEVATION (BRASS CAP)	ELEVATION (INNER CASING)	TOTAL DEPTH	BEDROCK DRILL DEPTH	SCREEN INTERVAL	DATE STARTED	DATE COMPLETED
BLM-13-300	226664.58	410157.20	4665.98	4668.47	322.0	220 RHYOLITE	300.40'-310.80'	08-16-88	09-02-88
BLM-14-327	228060.48	410112.62	4675.54	4676.73	355.0	270 RHYOLITIC TUFF	327.00'-337.42'	08-30-90	09-27-90
BLM-15-*	229947.52	410393.56	4702.60	N/A	340.0	255 TUFF (Cueva ?)	N/A	02-27-89	03-29-89
BLM-15-305	229884.04	410430.31	4703.69	4704.93	325.0	256 TUFF (Cueva ?)	305.00'-315.30'	03-30-89	04-14-89
BLM-16-*	233136.77	410139.75	0	0	547.0	307 ANDESITE (Orejon)	0	10-18-89	0
BLM-17-493	227717.58	403034.06	4538.13	4539.97	560.0	550 ANDESITE (Orejon)	492.80'-513.50'	02-01-89	02-27-89
BLM-17-550	227659.43	403018.75	4538.24	4540.27	600.0	585 ANDESITE (Orejon)	550.44'-560.86'	08-10-90	09-10-90
BLM-18-430	231671.53	405970.80	4609.84	4611.99	500.0	375 AIR-FALL TUFF (Cueva?)	430.00'-450.80'	08-29-89	09-19-89
BLM-22-570	229559.96	406254.11	4606.84	4608.87	608.5	325 FLOW BANDED RHYOLITE	570.21'-591.69'	07-13-90	08-24-90
BLM-23-431	227100.37	405946.17	4588.96	4590.49	505.5	352 ANDESITE (Orejon)	430.82'-441.25'	06-04-90	06-25-90
BLM-24-565	231861.46	410062.79	0	4715.77	605.0	328 ASH-FLOW TUFF	564.85'-584.88'	07-13-90	09-20-90
BW-1-269	230212.08	413805.48	4772.15	4774.05	300.0	185 ANDESITE (Orejon)	268.10'-288.80'	07-11-88	12-07-88
BW-2-*	229283.99	413823.32	4778.18	N/A	330.0	234 ANDESITE (Orejon)	N/A	07-13-88	04-07-89
BW-3-180	226092.45	413634.63	4734.03	4736.52	232.0	171 ANDESITE (Orejon)	179.60'-200.30'	08-12-88	08-24-88
BW-5-295	232803.78	413875.15	4814.52	4816.58	311.3	224 ANDESITE (Orejon)	294.90'-305.20'	01-16-89	02-04-89
BW-7-211	231556.89	413849.70	4798.64	4800.22	230.0	175 ANDESITE (Orejon)	211.30'-221.60'	11-11-88	01-12-88
J-PZ-1	231177.95	394218.32	0	4400.76	425.0	Not Reached by 425'	416.60'-421.60'	02-13-89	02-15-89
J-PZ-2	231204.26	394217.98	0	4401.44	607.0	Not Reached by 607'	568.00'-573.00'	02-06-89	02-12-89
J-PZ-3	231683.21	394506.42	0	4405.28	425.0	Not Reached by 425'	416.50'-421.40'	02-23-89	02-23-89
J-PZ-4	230438.74	394999.98	0	4408.42	395.0	Not Reached by 395'	387.60'-392.61'	02-16-89	02-17-89
J-PZ-5	231154.34	393866.97	0	4397.02	425.0	Not Reached by 425'	416.30'-421.10'	02-21-89	02-22-89
JP-1-424	223189.30	397426.37	4444.09	4447.02	490.0	Not Reached by 490'	424.00'-434.30'	10-31-87	12-05-87
JP-2-447	225325.05	397477.96	4446.17	4449.13	470.0	Not Reached by 470'	446.50'-456.90'	08-02-88	08-15-88
NASA-01	230419.79	415398.59	4808.99	4809.12	285.0	0	100.00'-260.00'	0	08-08-83
NASA-02	224780.48	413559.93	4743.85	4744.75	400.0	0	90.00'-390.00'	0	07-13-84
NASA-03	231009.33	420492.04	5010.42	5012.39	165.0	143 LIMESTONE	118.75'-138.75'	02-25-85	02-27-85
NASA-04	224673.48	414597.78	4770.74	4773.08	175.0	125 LIMESTONE (?)	146.20'-166.20'	02-28-85	03-04-85
NASA-05	230892.15	419064.06	4925.53	4927.54	150.0	125 LIMESTONE	110.25'-130.25'	03-05-85	03-06-85
NASA-06	230344.77	415814.50	4821.03	4822.79	175.0	150 ANDESITE (Orejon)	127.60'-147.60'	03-06-85	03-07-85
NASA-07	224762.69	413658.69	4747.23	4750.29	233.0	145 ANDESITE (Orejon)	177.20'-197.20'	03-26-85	03-28-85
NASA-08	224554.83	413667.47	4751.35	4754.47	235.0	140 ANDESITE (Orejon)	172.00'-192.00'	03-28-85	04-01-85
NASA-09	230440.11	415799.47	4822.23	4823.93	180.0	165 ANDESITE (Orejon)	129.56'-149.56'	04-01-85	04-03-85
NASA-10	230997.76	419096.54	4935.48	4937.25	150.0	100 ANDESITE (Orejon)	110.00'-130.00'	04-03-85	04-12-85
NASA-PT-WELL	226752.14	402084.23	0	4524.19	856.0	845 ANDESITE (Orejon)	507.72'-828.44'	09-21-89	03-29-90
PL-1-486	225709.35	401823.62	4518.14	4520.35	537.0	Not Reached by 537'	486.00'-496.40'	09-07-88	10-08-88
PL-2-504	227742.47	401193.52	4508.04	4510.35	532.0	Not Reached by 532'	504.00'-514.40'	09-22-88	11-28-88
PL-3-453	225366.27	400579.73	4496.89	4499.20	497.0	Not Reached by 497'	453.40'-463.80'	10-24-88	11-09-88
PL-4-464	227645.70	399612.69	4480.88	4483.40	494.5	Not Reached by 494'	463.96'-474.36'	01-03-90	01-23-90
PL-5	0	0	0	0	1023	1007' ANDESITE (Orejon)	6 Screen Zones	10-02-90	11-10-90
PL-6-*	0	0	0	0	2000	Not Reached by 2000'	N/A	10-19-90	0
PL-6-B	0	0	0	0	1920	Not Reached by 1920'	9 Screen Zones	11-30-90	01-15-91
PT-PZ-1	226620.89	401932.56	No BC	4521.47	500.0	Not Reached by 500'	485.00'-490.00'	10-11-89	10-13-89
PT-PZ-2	226849.93	401977.90	No BC	4520.63	515.0	Not Reached by 515'	503.85'-508.85'	01-15-90	01-18-90
PT-PZ-3	226776.73	402174.62	No BC	4525.02	533.4	Not Reached by 533'	515.44'-520.44'	01-17-90	01-22-90
PT-PZ-4	226875.56	402565.38	No BC	4531.72	530.0	Not Reached by 530'	508.81'-513.91'	01-22-90	01-25-90

0 DATA NOT AVAILABLE
* PLUGGED AND ABANDONED WELL
N/A NOT APPLICABLE

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NASA MONITORING WELLS
JANUARY 23, 1991

WELL	NORTHING	EASTING	ELEVATION (BRASS CAP)	ELEVATION (INNER CASING)	TOTAL DEPTH	BEDROCK DRILL DEPTH	SCREEN INTERVAL	DATE STARTED	DATE COMPLETED
T-1-473	229161.29	401136.07	4503.64	4505.85	522.0	Not Reached by 522'	472.70'-483.10'	05-15-89	05-30-89
T-2-466	229170.17	399036.88	4467.22	4470.19	494.0	Not reached by 494'	465.70'-476.20'	07-31-89	08-18-89
B-1	223464.63	416613.89	4840.94	4842.43	359.0	105 LIMESTONE (Panther Seep)	3 Screen Zones	01-16-90	04-12-90
B-2	221601.22	417825.10	4901.00	4902.63	382.2	126 LIMESTONE (Panther Seep)	3 Screen Zones	01-24-90	04-13-90
B-3	220535.45	414630.63	4812.16	4813.41	491.0	241 ANDESITE (Orejon)	4 Screen Zones	01-29-90	04-09-90
B-4	220830.09	415796.38	0	4846.08	482.5	277 ANDESITE (Orejon)	4 Screen Zones	03-13-90	04-06-90
B-5	221057.44	416710.22	0	4873.58	410.0	160 LIMESTONE (Panther Seep)	4 Screen Zones	04-23-90	06-14-90
B-6-A	221189.17	413415.71	4775.34	N/A	545.0	289 ANDESITE (Orejon)	N/A	05-03-90	05-30-90
B-7-A	222419.95	412565.88	4745.53	N/A	370.0	235 ANDESITE (Orejon)	N/A	04-26-90	05-24-90
W-1-452	227994.74	397803.86	4455.09	4457.37	488.0	Not Reached by 488'	451.90'-462.20'	01-05-88	01-21-88

0 DATA NOT AVAILABLE
* PLUGGED AND ABANDONED WELL
N/A NOT APPLICABLE

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3.0 Flow Rate and Water Level Measurement

To ensure the successful measurement and recording of data during the aquifer pumping test, the following independent groundwater elevation measurement and recording systems were used:

- Water levels in twelve monitoring wells and four piezometers were measured manually using Solinst and Fisher M-scope electronic water level indicators. Groundwater elevation data were recorded on well-specific forms.

- An In Situ, Inc. Hermit Model 1000 data logging and pressure transducer system (10 and 30 psi transducers) was used to automatically record water levels in wells BLM-2-482 and BLM-2-630.

- A data logging and pressure transducer system constructed by GCL was used to automatically record water levels in the pumping well and the four temporary piezometers.

The In Situ, Inc. and GCL automatic data logging systems used pressure transducers which were submerged in the wells or piezometers to sense changes in water levels. These changes were recorded in a digital format at prescribed time intervals in the logging unit memory.

Groundwater discharge from Well PT was measured using external strap-on transducers and a Badger Meter Inc. Model 4100 ultrasonic flowmeter with both digital and analog output devices. Periodic digital flowmeter readings were manually recorded throughout the pumping test and are presented in table 3. The flowmeter analog record is shown as figure 2.

Flowmeter failures occurred periodically during evening hours. Failures occurred from 0053 to 0804 on June 6, 1990; from 0302 to 0800 on June 7, 1990; and from 2352 on June 7, 1990, with periodic starts and stops from 0541 to 0745 until the end of the pumping test at 0745, June 8, 1990. Measurements made during the flowmeter failures indicated that minimum voltage needed for satisfactory operation of the flowmeter was not available. The cause of the late-night to early-morning voltage drops are not known.

To provide a crude estimate of discharge during periods when the flowmeter was not operating, a rectangular v-notch weir with end contractions was constructed of plywood in

Table 3

Flowmeter Readings

Date	Time	Discharge (gpm)	Date	Time	Discharge (gpm)
6-4-90	0902	400		1545	399
	0902	410		1600	396
	0903	415		1615	395
	0904	411		1625	392
	0905	408		1630	398
	0910	412		1645	393
	0913	406		1652	399
	0920	409		1700	402
	0933	402		1715	395
	0945	402		1730	398
	1000	406		1745	406
	1008	407		1800	398
	1015	409		1808	403
	1030	404		1815	419
	1035	401		1830	385
	1100	398		1852	396
	1115	399		1905	406
	1126	402		1915	400
	1130	402		1930	400
	1145	403		1940	416
	1205	401		1955	410
	1215	399		2010	398
	1230	398		2025	413
	1245	394		2039	410
	1300	397		2111	398
	1318	402		2125	401
	1330	396		2145	407
	1342	393		2210	409
	1355	398		2225	399
	1400	401		2240	398
	1410	401		2256	405
	1415	404		2310	399
	1430	370		2325	396
	1447	400		2340	392
	1500	397		2350	399
	1515	396			
	1530	392			
	1540	401			

Table 3 (cont'd)

Flowmeter Readings

Date	Time	Discharge (gpm)	Date	Time	Discharge (gpm)
6-5-90	0005	404		0928	406
	0036	402		0944	401
	0047	396		1000	403
	0100	369		1015	407
	0108	359		1029	402
	0118	384		1044	400
	0136	358		1100	411
	0142	375		1115	404
	0146	399		1130	394
	0203	364		1145	392
	0225	405		1204	388
	0245	415		1215	390
	0300	400		1230	397
	0322	382		1245	390
	0337	376		1300	398
	0351	395		1316	391
	0405	410		1330	399
	0420	403		1353	398
	0433	399		1403	400
	0450	397		1417	398
	0457	356		1439	407
	0506	360		1446	402
	0525	424		1500	406
	0530	444		1515	396
	0540	417		1530	407
	0600	396		1545	404
	0622	404		1600	402
	0635	385		1629	403
	0645	406		1646	410
	0700	410		1701	405
	0715	407		1714	400
	0730	405		1730	401
	0745	412		1745	400
	0801	396		1802	392
	0815	397		1817	400
	0830	390		1842	403
	0845	389		1904	407
	0900	297		1923	405
	0918	403		1953	403

Table 3 (cont'd)

Flowmeter Readings

Date	Time	Discharge (gpm)	Date	Time	Discharge (gpm)
6-5-90	2022	410		1230	401
	2044	414		1244	404
	2057	402		1255	399
	2110	402		1325	409
	2148	400		1335	400
	2203	394		1356	397
	2223	376		1415	400
	2244	402		1446	395
	2302	380		1500	406
	2314	378		1518	397
	2318	368		1530	396
	2338	365		1546	403
	2353	355		1601	402
				1620	407
6-6-90	0011	375		1635	414
	0013	388		1645	410
	0019	347		1700	406
	0029	331		1720	404
	0046	310		1750	400
	0114	91		1803	391
	0120	255		1832	408
				1900	415
	0804	501		1920	417
	0810	481		1926	412
	0819	449		1944	408
	0930	460		1950	415
	0945	461		2012	420
	0955	406		2020	412
	1010	403		2100	414
	1025	410		2111	418
	1030	401		2126	404
	1045	402		2142	410
	1051	407		2153	393
	1058	406		2214	374
	1115	401		2224	380
	1139	389		2225	397
	1147	409		2227	410
	1159	398		2235	350
	1215	392		2236	396

Table 3 (cont'd)

Flowmeter Readings

Date	Time	Discharge (gpm)	Date	Time	Discharge (gpm)
6-6-90	2240	376		0832	405
	2242	374		0850	416
	2243	407		0900	401
	2251	373		0915	416
	2254	404		0930	412
	2304	409		0945	393
	2316	357		1000	406
	2345	397		1016	394
				1030	403
6-7-90	0003	405		1045	398
	0015	404		1059	407
	0029	390		1114	404
	0033	375		1115	413
	0050	366		1130	410
	0052	368		1145	404
	0055	375		1200	405
	0059	382		1215	405
	0105	398		1230	405
	0115	361		1245	397
	0118	350		1300	403
	0227	407		1315	397
	0234	420		1330	405
	0235	397		1346	402
	0241	450		1400	403
	0251	415		1414	410
	0255	410		1430	409
				1447	399
	0541	409		1500	409
	0547	445		1515	415
	0556	415		1530	406
	0600	390		1546	409
	0623	405		1600	411
	0630	235		1615	408
	0800	414		1630	414
	0810	411		1645	412
	0820	416		1700	410
	0825	430		1720	418
	0827	409		1730	422

Table 3 (cont'd)

Flowmeter Readings

Date	Time	Discharge (gpm)	Date	Time	Discharge (gpm)
6-7-90	1745	408			
	1800	414			
	1814	425			
	1850	414			
	1904	411			
	1951	420			
	2003	405			
	2026	431			
	2040	420			
	2121	422			
	2148	419			
	2209	400			
	2210	374			
	2212	390			
	2247	405			
	2302	437			
	2319	400			
	2333	395			
6-8-90	0723	392			
	0726	444			

0109/004/FLOMTR.TBL

accordance with design specifications provided in Driscoll (1986). The weir was placed in the drainage ditch at the discharge line terminus. Measurements of water height (stage) in the weir were recorded at various periods during the pumping test. Discharge rates (in gpm) were calculated from the weir stage readings using Appendix 16.A-1 of Driscoll (1986). Flow readings measured at the weir ranged from 235 to 376 gpm and were generally lower by 17 to 25 percent than readings obtained from the flowmeter. The average discharge rate measured in the weir from June 6 until the end of the pumping test (June 8) was approximately 325.5 gpm. It should be noted that flow through the weir reflected the amount of water discharged from the holding tank beneath the air stripper, which was continuously adjusted by hand to prevent over/underflow. Therefore, the weir did not provide a direct measurement of discharge from Well PT. Tabulated weir readings are provided in table 4. Figure 3 provides a comparison of flowmeter readings versus weir discharge measurements obtained during weir calibration and throughout the remainder of the pumping test.

3.1 NASA Well PT

The aquifer pumping test was initiated at 0900 on June 4, 1990. The flow rate was adjusted to 400 gpm and stabilized in about ten to twenty minutes. Discharge was measured

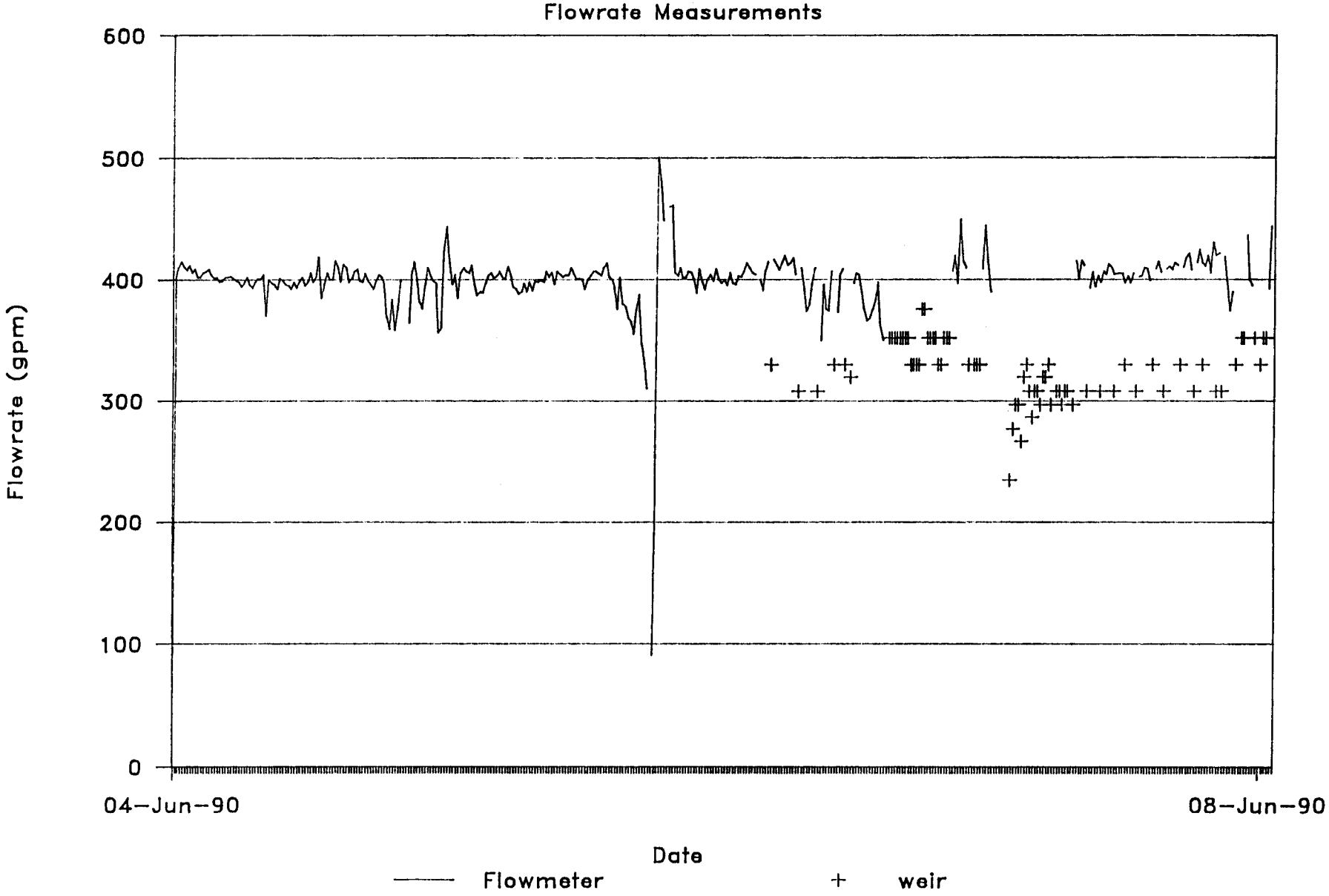
Table 4

Weir Readings

Date	Time	Discharge (gpm)	Date	Time	Discharge (gpm)
6-6-90	1910	330		0805	297
	2136	308		0808	267
	2230	308		0809	320
	2250	330		0810	320
	2306	330		0813	330
	2330	320		0814	287
				0815	308
				0816	297
6-7-90	0122	352		0819	320
	0141	352		0820	297
	0142	352		0821	320
	0144	352		0822	320
	0146	352		0824	330
	0148	352		0826	308
	0150	352		0827	308
	0152	352		0829	297
	0153	330		0830	308
	0154	330		0831	308
	0155	330		0833	297
	0157	330		0938	308
	0159	376		1045	308
	0200	376		1145	308
	0201	352		1245	330
	0203	352		1345	308
	0204	352		1450	330
	0206	352		1545	308
	0207	330		1647	330
	0209	330		1748	308
	0210	352		1850	330
	0212	352		2040	308
	0214	352		2128	308
	0258	330		2230	330
	0318	330		2250	352
	0405	330		2300	352
	0502	330		2335	352
	0721	235			
	0754	277	6-8-90	0117	330
	0800	297		0522	352
				0640	352

Figure 3

NASA - WSTF WELL PT PUMPTEST



using the externally mounted digital/analog flowmeter. Digital readings of flow were also manually recorded, at least hourly, by the pump operator. Figure 2 shows the analog recording of pump discharge during the aquifer test (note that readings of 0 gpm correspond to times when minimum voltage requirements were not met and the flowmeter was not operational). Based on flowmeter readings, the time-weighted average discharge during the pumping test was approximately 388 gallons per minute.

Water was pumped into and treated on-site by an air stripper. Stripper effluent was routed through a pipeline for discharge to a drainage ditch approximately 2,000 feet north of the pumping test site. Discharge at this location prevented flooding at the test site and minimized risks that infiltration of discharged waters might affect the aquifer test.

Water level measurements in Well PT were obtained for a portion of the test by the GCL data logging system. Figure 4 shows the water level measurements obtained during the pumping leg of the aquifer test. Recovery measurements were only recorded for the first 21.4 hours due to a failure in the data logging unit. Manual measurements were considered, but it was determined that it was not possible to set a prove below the water table with the external pipe couples located on the riser pipe.

3.2 Piezometers

3.2.1 Test Preparation

Water level indicators were calibrated against one another in a single well (WW-1-452) so that corrections for variations in tape stretch and response could be accounted for in case of equipment failure. Probe calibration data are provided in appendix C.

Water levels in piezometers were recorded for five days (24-hour readings) prior to the aquifer pumping test to detect natural fluctuations in water level and to verify that the aquifer was at equilibrium. Figure 5 shows the static water level measurements recorded in all piezometers and monitoring wells measured during this period. Water level fluctuations were very similar and correspond to fluctuations in barometric pressure. Water level elevations in new piezometers ranged from 4,068.61 to 4,071.55 feet, msl, immediately prior to the test indicating that the piezometric surface was nearly horizontal and at equilibrium at the onset of the test.

3.2.2 Manual Recording

Water levels were recorded at progressively greater time intervals during pumping (see appendix B). During the first two hours, recording intervals were increased from 15 seconds to 15 minutes. Water levels were recorded hourly for the next six hours; at two-hour intervals for the next six hours; and at four-hour intervals during the remainder of the pumping phase of the test.

Digital wristwatches were used for time-keeping and were synchronized with the internal clock on the GCL data logger. All personnel were informed of the start time of the pumping and recovery phases of the test and water level measurements were initiated at the appointed times. Synchronized watches were used because they were simpler to operate and were more reliable than either audible or radio signals.

Field data reduction included conversion of water level measurements to drawdown by application of barometric corrections derived from the barograph and background wells. The reduced data were then plotted by hand to monitor the progress of the aquifer test and to aid in deciding the termination point of the pumping phase. Field records are reproduced in appendix B.

3.2.3 Digital Recording

About one week prior to the scheduled pumping test date, pressure transducers to test and calibrate the data logging systems were installed in each piezometer. Final calibration of test equipment was performed three days prior to the pumping test. The multi-channel GCL data logger was calibrated by suspending the transducers in the piezometers and marking the transducer cables at measured intervals. "Zero" settings were then made by raising the transducers to just above the water surface. "Span" settings were made with transducers submerged to nominal test depths. The linearity of response was then determined using intermediate depth settings. Calibrations were evaluated and repeated as necessary until successful calibration was achieved.

Pumping, manual recording, and digital recording were all started simultaneously at 0900 hours on June 4, 1990, using the digital clocks synchronized to the GCL data logger internal clock. The same initialization procedures were used when the pump was shut off for the recovery phase of the test. Due to equipment malfunction, the GCL data logger recording was terminated within 24 hours into both the pumping and recovery phases of the test.

3.3 Monitoring Wells

Water levels in monitoring wells were recorded at hourly intervals for the first twelve hours of the test and every four hours thereafter. The same measurement schedule was used for the recovery phase of the test.

The Hermit 1000 data logger was used to record water level changes in BLM-2-482 and BLM-2-630. The Hermit 1000 was calibrated by entering scale factors for each transducer in accordance with the manufacturer's published procedures. The Hermit 1000 provided complete measurements of both drawdown and recovery in the BLM-2 well cluster. Digital dta are reproduced in appendix C.

3.4 Barometric Pressure Measurements

Local barometric pressure was recorded prior to, during, and after the pumping test using a Cole-Palmer strip chart barograph. The barograph was periodically calibrated by marking the chart with absolute air pressure readings for the test site elevation obtained from the Atmospheric Science Laboratory located at the White Sands Missile Range. Absolute atmospheric pressures were corrected for the elevation of the barograph at the WSTF (4,808 feet, msl) and transcribed for computer plotting. The barograph record for the

pumping test is provided in appendix D.

4.0 Data Reduction

4.1 Barometric Corrections

Changes in static water levels in a confined aquifer due to barometric pressure variations must be filtered from water elevation data prior to detailed analysis. Data from "background" wells (wells within the same aquifer that are not affected by pumping stresses) exhibiting barometric fluctuations was subtracted from water level data from other observation wells to get corrected (residual) drawdown data. Figure 6 shows hydrographs of five background monitoring wells observed during the pumping and recovery phases of the test. These monitoring wells were beyond the influence of the pumping well and do not reflect any measurable drawdown. Decreasing barometric pressure causes a rise in water level (i.e., negative drawdown). The aquifer at the pump test site has a high barometric efficiency (meaning that there is an almost instantaneous response in water table elevation to changes in barometric pressure, see figure 6). A barometric efficiency of 100% was assumed based on the magnitude of the aquifer response to variations in barometric pressure. Based on the lack of measurable drawdown in response to pumping, wells PL-4-464, WW-1-452, BLM-9-419, BLM-6-488, and JP-2-447 were selected as background wells for continued monitoring during the recovery phase of the aquifer test.

Figure 7 shows hydrographs for four monitoring wells within a 1,000- to 2,700-foot radius of the pumping well. These wells showed measurable response to aquifer pumping only after data were corrected for barometric effects. Because barometric fluctuations (expressed in feet of water) were as high as ±0.28 feet, barometric variations could easily mask small changes in drawdown in the far reaches of the radius of influence of the pumping well.

4.2 Selection of Data Sets for Analysis

When both digital and manually recorded data were collected for a particular observation well, one data set was selected for analysis on the basis of completeness and absence of anomalies. For example, since the data recorded by the GCL data logger best satisfied these criteria for the piezometers cluster, the data from the GCL data logger was used for the quantitative analyses of these wells. Water level data were converted to drawdown, corrected for barometric fluctuations, and plotted on graph paper. Data from wells PL-4, WW-1, BLM-9, BLM-6, and JP-2 were excluded from quantitative analysis because the magnitude of water level fluctuations in these wells during the aquifer pumping test was less than the barometric correction.

Figure 6

Hydrograph for Wells Outside The Radius of Influence

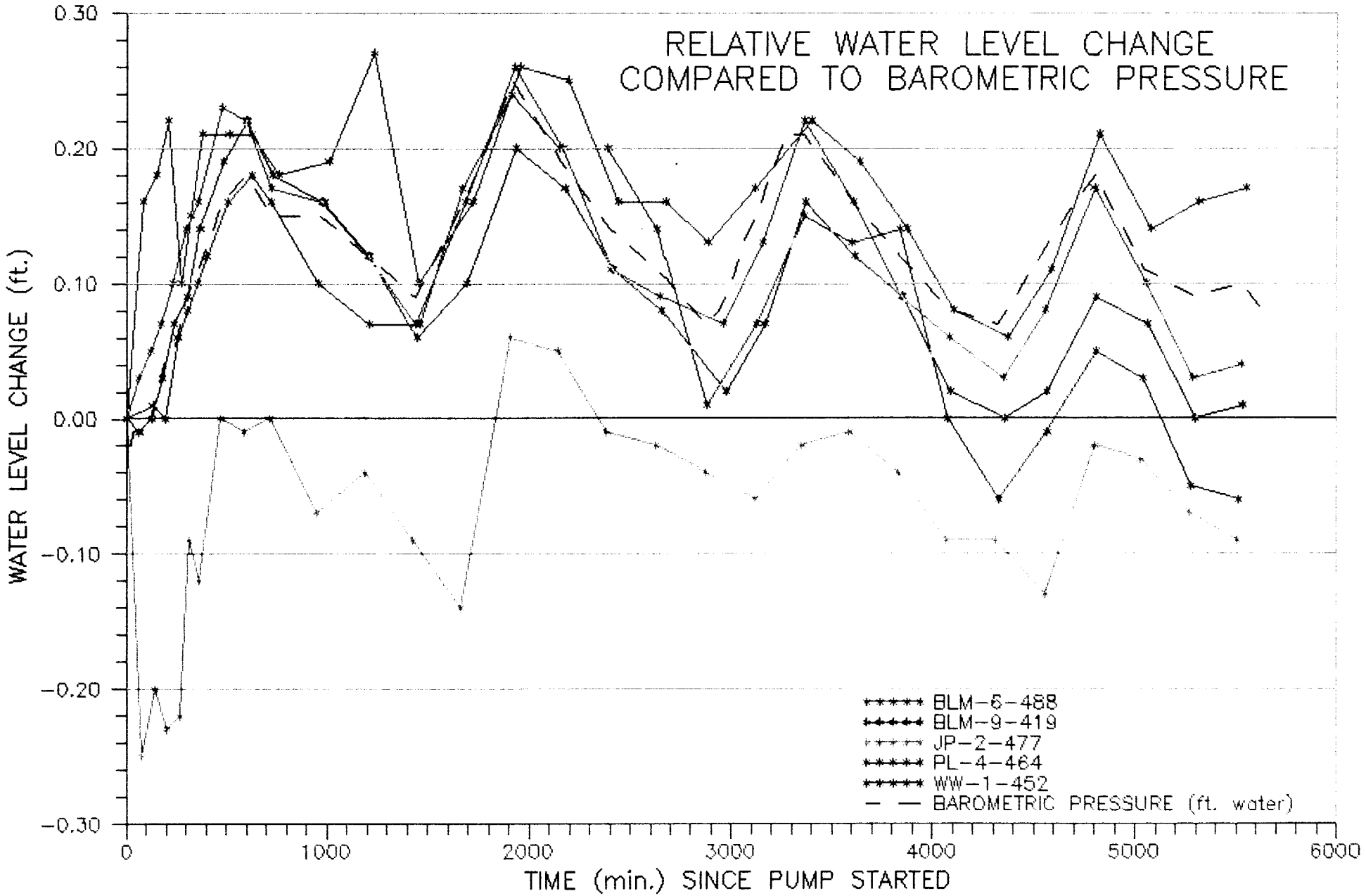
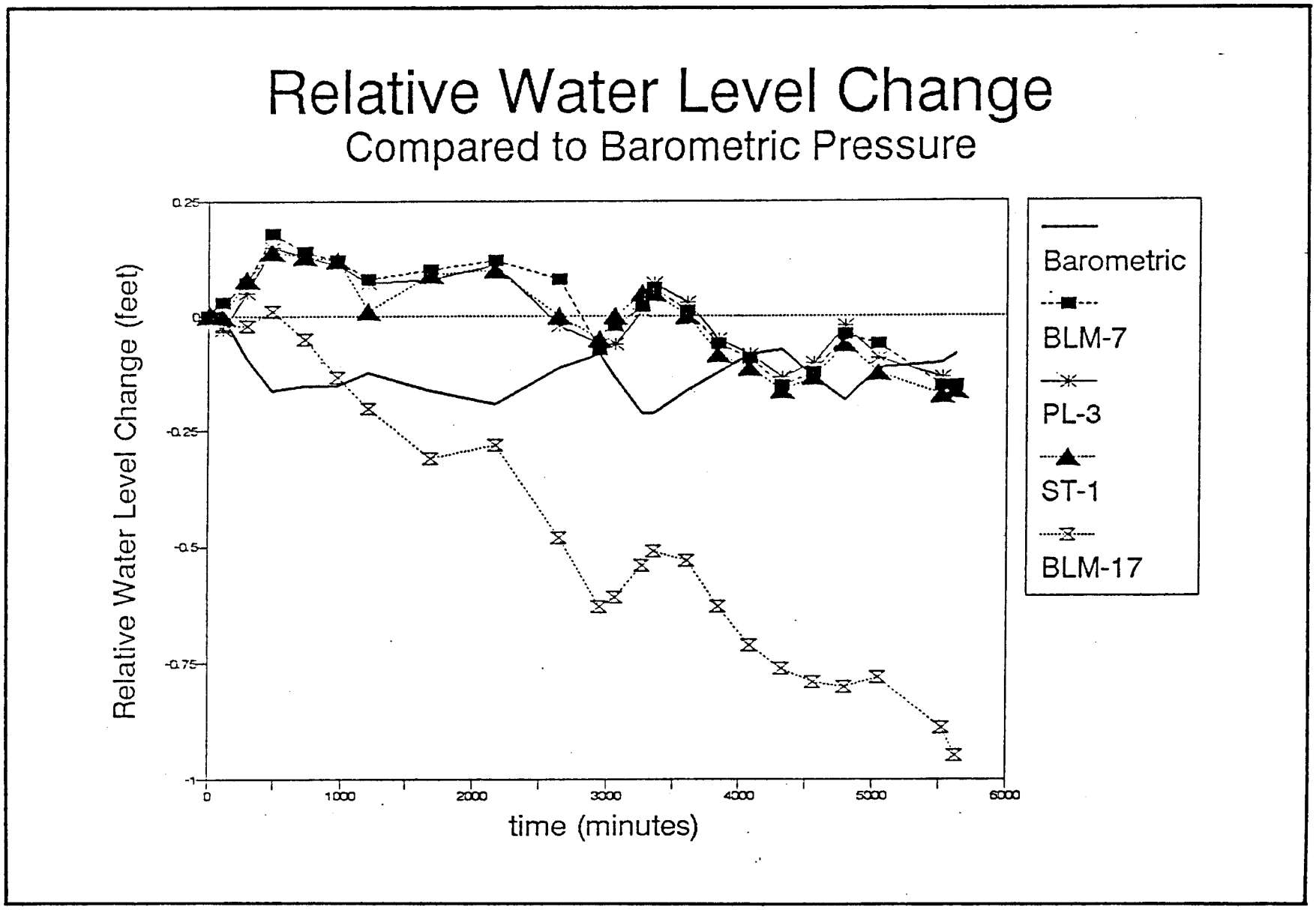


Figure 7
Hydrograph For Wells Within
The Radius of Influence



5.0 Hydrogeologic Model: Unconfined To Leaky-confined, Anisotropic Alluvial Aquifer

Subsurface lithologies encountered during drilling were recorded during drilling of all monitor wells (see previous hydrogeologic reports [GCL 1989, 1990a] and appendix A of this document). In addition, both the depths at which water was first encountered during drilling and the eventual static water level (swl) after completion were recorded. Based largely on these observations and on previously published reports (Seager, 1981, and others), a conceptual model of the WSTF area was constructed which includes (1) the depositional, erosional, and structural processes that, historically, have affected the site, (2) the resulting stratigraphic and structural framework, and (3) the current hydrologic conditions which have evolved.

According to the conceptual model, the Santa Fe Group alluvium was derived by erosion of the underlying igneous and sedimentary bedrock. The uplifted area to the east, which resulted from various episodes of tertiary volcanism, igneous intrusion, and associated faulting, provided the major source of the Santa Fe sediments. The eroded sediments were deposited westward toward the center of the Jornada basin producing a lithologic unit representing an alluvial fan megasequence. The megasequence is composed of many smaller, fan-shaped, coalescing depositional units.

Alluvial deposits thicken in a westward direction as a result of both depositional and tectonic processes. At the eastern edge of the piedmont, a thin veneer of alluvium overlies and forms the upper surface of the eroded and incised bedrock pediment surface. The thin alluvial veneer thickens into a megasequence of alluvial fan sediments that spread outward from the eastern uplifted areas to the down-warped basin center. At least one episode of normal faulting, represented by the previously referenced basin-forming fault zone, served to further thicken the alluvial sediments.

As sediments were transported from the uplift areas to the basin center, an orderly decrease in the potential and kinetic energy of the transport mechanisms occurred. This has resulted in a horizontal sequence of sediments which fine westward, toward the basin center. Accordingly, extensive deposits of fine-grained sediments, which may act as confining layers for the aquifer, are found primarily in the western part of the WSTF site.

According to the proposed conceptual model, the NASA-WSTF aquifer behaves as an unconfined aquifer in some areas and a confined aquifer in others. Unconfined conditions appear to exist to the east of the basin-forming fault zone (near wells BLM-17 and BLM-2-482). The aquifer appears to be confined at its westward boundary with the transition from

confined to unconfined conditions occurring gradually in the vicinity of the basin-forming fault zone.

5.1 Evidence for a Faulted Alluvial Fan Sequence

Alluvial fan deposits are the result of various depositional processes including channelized flow, sheet flow, aeolian deposition, and mass movement (creep, slump, etc.) This combination of depositional processes typically produces lithologic units (fan sequences) that exhibit a high degree of variability both vertically and horizontally. The vertical and horizontal coalescence of individual fan sequences produces larger "megasequences". It is common for both the individual fan sequences and the larger megasequences to coarsen upward and fine basinward.

All wells and piezometers in the vicinity of Well PT penetrate Santa Fe Group alluvium. Cross-section A-A' (see figure 8) illustrates the vertical distribution of lithologies within the alluvium near the fault zone. As shown on figure 8, the alluvium consists of a sequence of interbedded clays, sands, and gravels. Although cuttings resolution was lost in the saturated zone, it is believed that the strata continue to alternate between coarse and fine sequences. The observed sequence of lithologies is consistent with an alluvial fan depositional model.

The base of the alluvial aquifer at Well PT is 844 feet below grade; Orejon Andesite underlies the alluvial sediments at this location. Bedrock was encountered at about 657 feet below grade in BLM-2-630 and at approximately 1,010 feet below grade in Westbay well PL-5. The pumping well, Well PT, appears to be in a zone of fault-induced alluvial thickening. This zone is interpreted as the basin-forming fault zone. Alluvial sediments thicken to over 2,000 feet below grade (as demonstrated in the first abandoned boring for Westbay well PL-6) west of the basin-forming fault zone. East of the fault zone, the alluvium is relatively thin, and continues to thin at a rather regular rate toward the edge of the fan sequence. The abrupt thinning which occurs at the fault zone could be expected to produce an apparent "low-permeability" boundary condition during aquifer testing.

5.2 Evidence for Leaky-Confined Conditions

Leaky-confined conditions exist when a confined aquifer is overlain either by a discrete semi-permeable unit or by numerous non-contiguous overlapping lenses of low permeability materials. In alluvial fan sequences, such low-permeability lenses are usually composed of clay or tightly-cemented, clastic materials. These low-permeability strata exist in the vicinity of the basin-forming fault zone, which is underlain by alluvial sediments containing numer-

ous clay rich strata. Accordingly, the expected aquifer condition in the vicinity of the basin-forming fault zone is leaky-confined. This interpretation is consistent with the alluvial fan model, which predicts that the percentage of fine clastic material will increase in the westward direction, towards the basin axis.

Well-PT is located at a point near and slightly west of the eastern edge of the basin-forming fault zone. Its position on the alluvial fan megasequence is at the transition of the mid to outer fan deposits. At this location, distal, fine-grained sediments comprise a large portion of the total stratigraphic sequence.

5.3 Evidence for Unconfined Conditions

Unconfined conditions would exist in an alluvial fan aquifer when confining or semi-confining clay layers are absent. Wells east of the interpreted basin-forming fault exhibited unconfined conditions when drilled. Lithologic logs for wells BLM-17-493, BLM-2-482, and BLM-2-630 show less clay, especially at depths greater than 200 feet below grade (< 10% clays were noted on all three boring logs). With the exception of a clayey interval at a depth of about 515 to 525 feet in BLM-2-630, clay layers were not noted in or near the

saturated zone in these wells. The clayey interval in BLM-2-630 may act as a partial confining layer to the lower portion of the saturated sediments.

5.4 Expected Anisotropy in Alluvial Fan Aquifers

Alluvial fan deposits are the result of various depositional processes including channelized flow. Deposits which result from channelized flow within an alluvial fan system are typically coarse grained and among the best-sorted of the various types of alluvial fan deposits. Hence, they represent one of the more permeable alluvial fan units.

Channel flow deposits tend to be linear in nature and aligned with their depositional channel. While considerable local variation in channel orientation may be expected, in general, channels will tend to be oriented radially from the fan apex. In a longitudinally extensive fan megasequence like the Santa Fe Alluvium, such as ~~however~~, the major axial vector of channelized deposits will be perpendicular to the mountain front from which their sediments were derived. Such a preferred channel-deposit orientation would produce anisotropy in aquifer transmissivity, such that the major axis of anisotropy would be approximately parallel to the axis of the channel deposits or perpendicular to the upland axis. The local orientation of transmissivity would, like the channel deposits themselves, be spatially variable. Yet the average

trend of the major axis of transmissivity should be perpendicular to the mountain front or, in the case of the NASA-WSTF site, approximately east-west.

5.5 Interpreted Hydrogeologic Model

For the purposes of hydraulic interpretation, the elements of the conceptual hydrogeologic model and the expected hydraulic conditions in the NASA Well-PT pump test area may be summarized as follows:

- Well PT fully penetrates an alluvial fan aquifer in the area of the basin-forming fault zone.

- Due to an increase in the amount of fine-grained sediment toward the basin center, aquifer conditions within the alluvium change from unconfined in the east to confined in the basin center. The eastward edge of the transition zone, which is characterized by leaky-confined conditions, is located near and sub-parallel to the basin forming fault zone.

- Aquifer conditions near Well PT are leaky-confined and change to unconfined conditions near BLM-17 and the BLM-2 cluster

- Alluvial deposits abruptly thin on the upthrown (eastern) side of the basin forming fault zone. An apparent "low-permeability" boundary may be ~~encountered as~~ a result of the thinning alluvium to the east of the basin-forming fault zone.

- Alluvial deposits thicken dramatically (to over 2,000 feet) west of the basin-forming fault zone (at monitoring wells PL-3, JP-2, WW-1).

The NASA Well PT pumping test provided an opportunity to test and refine the geologic/hydrologic conceptual model of the site. In the following sections, the results of the NASA Well-PT aquifer test are analyzed with regard to the hydrogeologic model described in this chapter.

6.0 Estimating Aquifer Parameters

Aquifer parameters: transmissivity, storage coefficient, specific yield, and hydraulic conductivity were estimated from water level responses to aquifer pumping and recovery measured in wells and piezometers obtained during the aquifer pumping test. Using the proposed hydrogeologic model as a conceptual framework (see section 5.0), drawdown-time plots of pumping data were evaluated for conformity to the Theis curve. Deviations from the Theis curve are attributed to several factors, depending on observation well location and the type of deviation. Leaky-confined conditions, delayed gravity drainage (unconfined aquifer only), and impermeable boundary effects are thought to be responsible for observed deviations. Aquifer pumping test data were also analyzed by the distance-drawdown (Cooper and Jacob, 1946), boundary analysis (Stallman, 1963 - in Lohman, 1979), and Papadopulos (1965) anisotropy method. These methods were used to evaluate the radius of pumping well influence, well efficiency, distance to the apparent low permeability boundary and aquifer anisotropy.

6.1 Pumping Phase Analysis: Theis' Drawdown Method (Lohman, 1979)

Hydrographs showing the final corrected drawdowns (using barometric and probe corrections) for piezometers and observation wells are provided in appendix E. The hydrographs were analyzed using the curve-matching technique developed by C. V. Theis (1935) as modified by Hantush and Jacob (Lohman, 1979). Computer-plotted hydrographs were matched to the type curves provided by Lohman (1979) and the match points were selected from best-fit approximations to the type curve. The Theis equation was used to calculate aquifer parameters:

$$s = \frac{Q}{4 \pi T} W(u)$$

where: $W(u)$ = well function
Q = discharge
T = transmissivity
s = drawdown

$$u = \frac{r^2 S}{4 T t}$$

where: r = radius
S = storage coefficient
t = time

Type curve matching is effective only when the Theis assumptions are approximated. The governing assumptions of the Theis equation are as follows:

- The aquifer is confined, homogeneous, and isotropic.

- The aquifer is of infinite areal extent.

- The pumping well fully penetrates the aquifer.

- The pumping well has an infinitely small diameter (i.e., not of significance after several minutes of pumping).

- Water removed from storage is instantaneously discharged with decline in head.

For convenience in mathematical computation, the match points were selected such that the values of u (variable of integration) and W(u) (well function) were equal to one (or a multiple of ten). The values of s (drawdown) and t (time) at each match point can be read from the figures provided in appendix E. Aquifer transmissivity and storage coefficient were calculated for each piezometer based on the Theis equation (see appendix E). The transmissivities calculated from piezometer data ranged from 0.172 to 0.287 ft^2/s, with an average value of 0.215 ft^2 /s. The average storage coefficient was 2.97×10^{-4}, a value characteristic of a leaky-confined aquifer.

The apparent storage coefficients calculated from the Theis approximation are affected by aquifer anisotropy and variations in flow direction caused by leaky-confined and unconfined aquifer conditions. Casing storage was not a factor in this test due to the high discharge rate. Under test conditions, casing storage effects were negligible after approximately two minutes. Small-scale fluctuations in the initial sixty seconds of data, possibly caused by variations in pumping rate, manual data recording, or transducer instability, were not graphed on the drawdown curves in appendix E.

As summarized in table 5, many of the piezometers and observation wells showed significant deviation from the Theis curve. For example, the drawdown-time curve for BLM-2-482 showed a delayed yield response characteristic of gravity drainage in unconfined aquifers. BLM-2-482 exhibited unconfined conditions when drilled and is located upgradient of the fault zone; the saturated alluvium thins dramatically to the east. Most of the piezometers completed near Well PT displayed characteristics of a leaky confined aquifer and at late time, the effects of a low permeability boundary (probably due to the thinning alluvium east of the fault zone). The shape of the drawdown-time curve and knowledge of the hydrogeologic conditions were used to select appropriate methods of analysis to determine aquifer characteristics. Recovery and pumping data were evaluated by using the Theis and Cooper-Jacob approximations for all observation wells where u was less than 0.05.

Table 5

Deviations From The Theis Type Curve

Well No.	Deviation	Time to Deviation	Effect	Possible Cause	Recommended Analysis
PZ-1	Yes	15 min.	-	leaky artesian aquifer	Cooper Hantusch
PZ-2	Yes	15 min.	-	leaky artesian aquifer	Cooper Hantusch
PZ-3	Yes	15 min.	-	leaky artesian aquifer	NA
		> 700 min.	+	impermeable boundary	Theis
PZ-4	Yes	15 min.	-	leaky artesian aquifer	Cooper Hantusch
		> 700 min.	+	impermeable boundary	Theis
BLM-17	Yes	>100 min.	-	delayed yield (unconfined)	Boulton
		> 700 min.	+	impermeable boundary	Stallman
BLM-2(s)	Yes	115 min.	-	delayed yield (unconfined)	Boulton
		> 1800 min.	+	impermeable boundary	Stallman
BLM-2(d)	Yes	< 15 min.	-	fully penetrating piezometer	Theis
		> 3600 min.	+	impermeable boundary	Stallman
PL-1-486	Yes	> 1200 min.	+	impermeable boundary	Jacob-Cooper
PL-2-504	Yes	> 1000 min.	+	impermeable boundary	Jacob-Cooper
PL-3-453	Yes	<1000 min.	+	aquifer heterogeneities	Jacob-Cooper
ST-1-473	Yes	< 2000 min.	+	aquifer heterogeneities	NA

Abbreviations: + = greater than expected drawdown
- = less than expected drawdown
NA = not analyzed due to erratic data curves

6.2 Recovery Test Analyses: Theis' Recovery Method (1935)

Recovery data were collected from each of the piezometers for a period of about 11 days (267 hours) after termination of the aquifer pumping test at Well PT. Data collected from the GCL data logger were not used as the data logger malfunctioned approximately 21.4 hours into the recovery portion of the aquifer test. Manual water level measurements that were corrected for barometric influences were analyzed using the Theis recovery method (from Kruseman and De Ridder, 1983). Recovery data for piezometers PT-PZ-1 through PT-PZ-4 are provided in appendix E. The Theis recovery method was not used in the evaluation of recovery data obtained from other observation wells due to the deviations in response summarized in table 5.

Results of recovery analyses indicate apparent aquifer transmissivities range from 0.155 ft^2/s to 0.191 ft^2/s. The average apparent transmissivity for leaky-confined conditions is 0.174 ft^2/s; these results are in good agreement with transmissivity values obtained from the pumping data analysis (T_{ave} = 0.215 ft^2/s). Storage coefficients cannot be determined using the Theis recovery method. The recovery curve and data calculations for each piezometer are provided in appendix F.

6.3 Pumping and Recovery Data Analysis - Jacob-Cooper (1946) Approximation

The Jacob-Cooper approximation to the Theis non-equilibrium equation is based upon the assumption that when u is less than 0.05, the non-equilibrium equation is linear. Drawdown (linear) is plotted against time (logarithmic scale). The resulting plot should approximate a straight line. All of the assumptions governing the Theis non-equilibrium equation (see section 6.1) apply. Values of W(u) and u also display a linear relationship in accordance with the following equation:

$$W(u) = 2.3 \log u - 0.5772$$

For small values of u, the plotted line parallels the asymptote with a slope of -2.3. The following equations can than be used to solve for transmissivity and the storage coefficient:

$$T = \frac{2.3\ Q}{4\ \pi\ s_{lc}} \quad \text{and} \quad S = \frac{2.25\ T\ t_o}{r^2}$$

where: Q = discharge rate
s_{lc} = change in drawdown over one log cycle
r = radius from observation point to pumping well
t_o = time at zero drawdown

Values of T and S are calculated from drawdown changes measured from semi-log plots of pumping and recovery data. Results of calculations performed using the Cooper-Jacob approximation are shown in table 6. Semi-log plots and calculations are provided in appendix G. Late time pumping test data (drawdown vs. time) were used to calculate T and S, as early time data violate Theis assumptions ($u > 0.05$). Late time data violated Theis assumptions for wells ST-1-473 and PL-3-453. Transmissivity and storage coefficients were calculated from pumping data for the following wells: PL-2-504, BLM-2-630, BLM-17-493, and BLM-7-509. An average transmissivity of 0.110 ft^2/s (excludes BLM-7-509) and an average storage coefficient of 1.00×10^{-2} were obtained using this method.

Water level recovery data may also be evaluated by plotting the recovery vs. log time using the Cooper-Jacob approximation. The following equations apply for recovery data analysis:

$$T = \frac{2.3\,Q}{4\,\pi\,s'_{lc}} \quad \text{and} \quad S = \frac{2.25\,T\,t'_o}{r^2}$$

where: s'_{lc} = change in recovery over one log cycle
t'_o = time at zero recovery

The average transmissivity calculated from recovery data was 0.194 ft^2/s; the average storage coefficient was 2.10×10^{-3}.

Table 6

Jacob-Cooper Analyses

Well No.	Data Analyzed	Transmissivity (ft^2/s)	Storage Coefficient
PT-PZ-1	p	0.112	2.16×10^{-2}
	r	0.223	5.93×10^{-3}
PT-PZ-2	p	0.104	1.63×10^{-2}
	r	0.203	1.16×10^{-3}
PT-PZ-3	p	0.101	1.10×10^{-2}
	r	0.186	9.96×10^{-4}
PT-PZ-4	p	0.104	4.78×10^{-3}
	r	0.211	1.85×10^{-3}
BLM-2-630	p	0.100	1.05×10^{-3}
	r	0.147	5.54×10^{-4}
PL-2-504	p	0.130	6.52×10^{-3}
BLM-17-493	p	0.116	8.43×10^{-3}
BLM-7-509	p	0.391	1.05×10^{-2}
	Pumping Average:	**0.145**	**1.00×10^{-2}**
	Recovery Average:	**0.242**	**2.10×10^{-3}**
	Average:	**0.164**	**6.97×10^{-3}**

p = pumping average
r = recovery data

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6.4 Leaky-Confined Aquifer with Vertical Movement - Cooper (1963) and Hantusch (1960) Methods

Deviations from the Theis curve may be expected when leakage in the confining beds changes as a result of pumping. This change in leakage (whether positive or negative) results in an increase in water supplied to the aquifer. The leakance of the confining bed is defined as the ratio of vertical hydraulic conductivity, K', and the thickness of the confining layer (b'). Cooper (1963) computed values for type curves based on the following equations:

$$s = \frac{Q}{4 \pi T} L(u,v)$$

where: $L(u,v)$ = Leakance Function

$$u = \frac{r^2 S}{4 T t}$$

$$v = \frac{r}{2} \left\{ \frac{K'}{b' T} \right\}^{1/2}$$

$$S = 4 T \frac{t/r^2}{1/u}$$

$$K' = 4 T \frac{v^2}{r^2} = \frac{S \{v^2/u\}}{t}$$

As K' and v approach zero, the leakance function approximates the well function (W(u)) and thus, the Theis curve.

Alternatively, the Hantusch method (1960) for leaky-confined aquifers not only accounts for changes in leakance, but also takes into account water storage in the confining beds. As leakage through the aquitards approaches zero and the release of water from confining bed storage is negligible, the Theis curve approximation becomes valid. The governing equations for the Hantusch leaky-confined aquifer method are as follows:

$$T = \frac{Q}{4 \pi s} H(u,\beta)$$

where: $$u = \frac{r^2 S}{4 T t}$$

$$\beta = \frac{r}{4 b} \left[\left\{ \frac{K' S'_s}{K S_s} \right\}^{1/2} + \left\{ \frac{K'' S''_s}{K S_s} \right\}^{1/2} \right]$$

The results of transmissivity and storage coefficient calculations using the Cooper and Hantusch approximations for leaky confined aquifers are summarized in table 7. Actual calculations are provided in appendix H.

The Hantusch model seems to best fit the hydrogeologic conditions at the site because it not only accounts for leakance through confining beds (cemented horizons and/or zones

Table 7

Leaky-Confined Aquifer Analyses

Piezometer No.	Analytical Method	Transmissivity (ft^2/s)	Storage Coefficient	Leakance (sec-1)
PT-PZ-1	Cooper	0.191	1.30 x 10	2.98 x 10
	Hantusch	0.160	5.80 x 10	NA
PT-PZ-2	Cooper	0.229	6.69 x 10	7.38 x 10
	Hantusch	0.138	9.90 x 10	NA
PT-PZ-3	Analyses not attempted due to difficulties with curve matching			
PT-PZ-4	Cooper	0.275	1.65 x 10	5.93 x 10
	Hantusch	0.164	7.87 x 10	NA
Averages:	**Cooper**	**0.232**	**7.11×10^{-3}**	**5.43×10^{-5}**
	Hantusch	**0.154**	**7.86×10^{-4}**	**NA**

Note: The Hantusch model accounts for both confining bed leakance and storage within the confining layers. This model fits the proposed hydrogeologic model for the site better than the Cooper model, which accounts only for the leakance through the confining layers.

with caliche), but also considers contributions of water from confining bed storage. As cemented horizons are interpreted to be the confining beds west of the boundary fault zone, it is likely that upon a decrease in head in response to pumping, these lenses would contribute water to the aquifer. Data from the piezometers was used for well PT as the shape of the drawdown versus time curve suggested a leaky artesian aquifer response. Average transmissivity calculated using the Hantusch method was 0.154 ft^2/s. The average storage coefficient was 7.86×10^{-4}. Values for transmissivity and storage values calculated using the Hantusch method are more likely to be representative of actual aquifer conditions than those calculated by the Cooper approximation or other confined aquifer approximations.

6.5 Unconfined Aquifer: Delayed Yield - Boulton (1954)

Transient state hydraulics in unconfined aquifers are evaluated using the Boussinesq equation to obtain a solution analogous to the Theis equation. This solution may be written as follows:

$$s_c = \frac{Q}{4 \pi T_c} W \frac{\{ r^2 S_y \}}{4 T_c t}$$

Solution methods are analogous to those used for Theis curve analysis. However, for an unconfined aquifer, the measured drawdown-time curve departs from the ideal as a result of delayed gravity drainage. Delayed gravity drainage results in variations in storage coefficient with time. At early time, the initial releases of water come from compressible storage, whereas at late time, water is released from the matrix by gravity drainage. Horizontal flow assumptions of the Theis equation are violated.

Boulton (1954) developed a model describing the delayed gravity yield for unconfined aquifers using the following assumptions:

- Dupuit assumptions hold:

  -Horizontal flow prevails.

  -The gradient along a vertical is the slope of the free surface.

  -No seepage face is encountered.

- Two sources of storage contribute water to the well:

  -Instantaneous release of water from normal, compression storage.

  -Delayed yield is the result of gravity drainage from matrix storage.

Under pumping conditions, water is removed from the aquifer at a rate which is faster than that at which materials can drain. Thus, the phenomenon of delayed yield in an unconfined aquifer is the result of unsaturated drainage of previously saturated sediments at or below the water table. The solution to the equation derived by Boulton involves plotting drawdown vs. time on log-log paper and using type curves to match early time and late time data. Calculations are performed to obtain values for transmissivity, specific yield (matrix storage) and storage coefficient (confined, compressible storage). The governing equation for the Boulton method is as follows:

$$s = \frac{Q}{4 \pi T} W \{u_A, u_B, r/\beta)$$

where: $$u_A = \frac{r^2 S}{4 T t} \quad \text{and} \quad u_B = \frac{r^2 Sy}{4 T t}$$

The type curves plot W $\{u_A, u_B, r/\beta\}$ vs. $1/u_A$ and $1/u_B$. Solutions for transmissivity, specific yield, and storage coefficient are obtained as follows:

$$T = \frac{Q W \{u_A, u_B, r/\beta\}}{4 \pi s_{mp}}$$

$$S = \frac{u_A 4 T t}{r^2}$$

$$Sy = \frac{u_B \; 4 \; T \; t}{r^2}$$

$$\alpha = \frac{T \; [r/\beta]^2}{r^2 \; S_y}$$

where: s_{mp} = match point drawdown

r/β = factor for type curve selected

Sy = specific yield

The parameter α is the delay index and is an empirical constant describing the rate of release by gravity drainage; α has no physical significance.

Well BLM-2-482 shows a classic delayed gravity response as shown in appendix I. Three legs of the drawdown curve are evident and they deviate significantly from the classic Theis curve. At early time, the water level declines faster than the materials can drain. Water produced by the well is being released from compressible storage. Flow lines are essentially horizontal and the storage coefficient approximates confined storage. At intermediate time, the arrival of delayed gravity drainage slows the rate of drawdown. Vertical flow occurs near the well bore and is analogous to a leaky aquitard response. At late time, as the drawdown cone expands, the rate of water level decline slows as drainage from matrix storage (specific yield) keeps pace with the rate of water withdrawal. Horizontal flow is reestablished at late time.

Semi-log plots of drawdown vs. time for unconfined aquifers will violate the fundamental assumptions of radial flow to the well bore. Thus analysis of drawdown and recovery data from BLM-2-482 by straight-line (semi-log) methods is not appropriate as the aquifer exhibits delayed yield conditions at this location.

In an unconfined aquifer, greater drawdown will occur in piezometers screened near the base of the aquifer due to vertical head gradients. This phenomenon is observed in BLM-2-630 where drawdown at the end of the test was 2.55 feet as compared to 1.06 feet in BLM-2-482. In addition, boundary effects are noted in the drawdown vs. time plots for BLM-2-630 at about 3,600 minutes into the test. The boundary effect is also apparent in late time data for BLM-2-482 as the steepening drawdown in the third leg of the drawdown curve fails to approximate a Theis curve. This boundary effect may be attributed to a thinning of saturated alluvium to the north and east due to structural controls and faulting.

The average transmissivity value calculated for BLM-2-482 using Boulton's delayed yield model was 0.205 ft^2/s. This is consistent with transmissivity values calculated from other observation wells. Storage coefficients were 1.50×10^{-5} (confined storage) and 0.0148 (specific yield). The confined storage coefficient suggests a leaky-confined response was observed initially. The specific yield, describing the removal of water from matrix storage by gravity, is consistent with published values for unconsolidated to semi-consolidated alluvial sediments.

The delay index (α) was 3.81×10^{-6}; it has no physical meaning and is simply a function of distance from the pumping well.

6.6 Distance-Drawdown Analysis - Cooper and Jacob (1946)

The areal effects of the pumping test were evaluated by plotting observation well distance from the pumping well versus observed drawdown at late time in the pumping test. This procedure is valid only at late time ($t > \{r^2 S_y\}/ T$). Based on specific yield and transmissivity values calculated for an unconfined aquifer (the most conservative case), t should be greater than 2,491 minutes. A distance-drawdown plot for 3,000 and 5,000 minutes is provided in appendix J. Transmissivity and storage coefficient values may be calculated as follows:

$$T = \frac{528\ Q}{s_{lc}} \quad \text{and} \quad S = \frac{0.3\ T\ t}{r_o^2}$$

where: Q = discharge rate in gpm
s_{lc} = drawdown over one log cycle (in feet)
T = transmissivity, in gpd/ft
r_o = distance at zero drawdown (feet)
t = time (days)

The resulting transmissivity for t = 3,000 minutes was 69,682 gpd/ft or 0.108 ft^2/s. The storage coefficient was 7.11 x 10^{-3} which is consistent with a leaky-confined aquifer interpretation. The radius of influence at 3,000 minutes was 2,475 feet (distance at zero drawdown). The radius of influence for 0.5 feet of drawdown at t = 3,000 minutes was approximately 1,600 feet.

Corresponding calculations at t = 5,000 minutes yielded a transmissivity of 0.108 ft^2/s and a storage coefficient of 9.26 x 10^{-3}. The radius of influence was about 2,800 feet; at 0.5 ft. of drawdown, the radius of influence was 1,800 feet.

Distance-drawdown curves can also be used to predict aquifer responses when monitoring points are not available at the desired locations. The slope of the distance-drawdown curve (2.94) should be about twice that of a time-drawdown graph (1.12) for the same test. For a given aquifer, this ratio of slopes should be constant at a given pumping rate. The ratio for this test was 2.63 for the discharge rate of 388 gpm. These relationships can also be used to predict drawdown and well interference effects at pumping rates different from the tested rate. This relationship may be useful to predict recovery well influence near the fault zone. Since the change in drawdown over a log cycle varies directly with the discharge rate, by determining drawdown at an observation point through which all curves must pass, a distance-drawdown curve may be constructed for other pumping rates.

Well efficiency may also be estimated from the distance-drawdown graphs. Extending the straight line representing the cone of depression to a point just outside the well provides an estimate of the theoretical drawdown in a 100% efficient well. The theoretical drawdown for Well PT should be approximately 10.2 feet. The maximum measured drawdown in well PT was 20.34 feet. This suggests that Well PT is only 50 % efficient. Factors contributing to well inefficiency may be attributed to design and/or construction factors. Possible factors affecting the efficiency of Well PT are listed below.

- Insufficient open area in the well screen resulting in high entrance velocities and, therefore, large head losses. This may be related to the alternating screened interval/blank casing construction and the position of the pump intake relative to the screened intervals.

- Variations in filter pack size that restrict flow into the well screen may also be responsible for excessive head losses.

- Inadequate well development resulting in reduced formation permeability in the vicinity of the well. This may also be related to well construction and position of the pump intake.

- Non-ideal aquifer conditions making theoretical value too optimistic.

6.7 Boundary Analysis - Stallman (1963)

The hydrogeologic conditions at the NASA-WSTF site violate the Theis assumption where the aquifer is presumed to be infinite in extent. The alluvium east of the basin-forming fault zone ranges in saturated thickness from about 150 to 200 feet and thickens progressively westward to saturated thicknesses greater than 500 feet. The thinning of the alluvial sediments should appear as an impermeable or barrier boundary effect.

Image well methods can be used to locate barrier or recharge boundaries. At the NASA-WSTF site, the thinning alluvium is actually a lesser transmissivity area and not a true barrier boundary; however, the effects on drawdown during the pumping test should be similar. The semi-log plot of drawdown vs. t/r^2 for BLM-2-630 was evaluated. The presence of an impermeable boundary was noted at approximately 3,600 minutes into the pumping test. The transmissivity of the drawdown curve at $t < 3{,}600$ minutes is about 0.184 ft^2/s; whereas the transmissivity calculated for the portion of the drawdown curve affected by the boundary

was only 0.089 ft^2/s. This difference approximates a factor of 2 and suggests a less impermeable boundary is affecting the cone of depression.

Stallman (1963) developed a type curve solution for a single-boundary problem. Using the additive properties of the Theis equation and image well theory, s_o, the drawdown in an observation well is a sum of two components: s_p, the drawdown caused by the pumping well; and s_i, the drawdown or recharge caused by the image well. Under these conditions, the Theis equation may be rewritten as follows:

$$s = \frac{Q}{4 \pi T} [W(u)_p \pm W(u)_i] = \frac{Q}{4 \pi T} \Sigma W(u)$$

where: $u_p = \frac{r_p^2 S}{4 T t}$ and $u_i = \frac{r_i^2 S}{4 T t} = \left[\frac{r_i}{r_p}\right]^2 u_p$

$$k = \frac{r_i}{r_p}$$

r_p = distance from pumped well to observation well

r_i = distance from pumped well to image well

Solutions to Stallman's equations are obtained by curve matching a logarithmic drawdown-time plot. Values of Σ W(u) and $1/u_p$ are selected for corresponding values of s_o and t. Values for transmissivity and storage coefficient are calculated using the following equations:

$$T = \frac{Q}{4 \pi s_o} \Sigma W(u)$$

$$S = \frac{4 T t u_p}{r_p^2}$$

$$k = \frac{r_i}{r_p}$$

For BLM-2-630, using the type curve for k = 1.6, transmissivity was calculated at 0.184 ft^2/s and the storage coefficient was 6.39×10^{-4}. The distance from the pumping well to the boundary is approximately 1,800 feet (or about 400 feet east of the BLM-2 cluster).

An equivalent analysis performed for BLM-17-493 using the type curve for k = 2.5, yielded the following: transmissivity of 0.382 ft^2/s, storage coefficient of 5.51×10^{-3}, and a distance to the boundary from the pumping well of 2,370 feet. The location of the interpreted boundary is shown on figure 9. This boundary is consistent with the saturated alluvial isopach map suggesting the saturated alluvium thins dramatically east of the BLM-2 cluster; whereas near BLM-17, the alluvium thins more gradually. The boundary may also reflect the change from alluvial to bedrock aquifer lithologics.

Other apparent boundary effects were noted approximately 700 and 1,000 minutes into the pumping test in the piezometers near the pumping well. These boundary effects may represent thinning saturated alluvium between different fault blocks in the area between Well PT

and the BLM-2 cluster. However, due to deviations from the Theis curve caused by delayed yield effects (leaky-confined aquifer model), accurate curve matching was not possible for piezometer drawdown data. Thus, analysis of distances to these lesser boundaries observed in piezometer drawdown data could not be quantitatively analyzed.

7.0 Summary of Aquifer Test Results

The alluvial aquifer in the vicinity of NASA Well PT is interpreted to be in a complex basin-forming fault zone. Aquifer conditions range from unconfined east of the fault zone to leaky-confined in the vicinity of Well PT and wells north, west, and south.

Aquifer characteristics calculated by the Hantusch (1960) method (leaky-confined aquifers with storage in confining beds) are as follows: average transmissivity = 0.154 ft^2/s and average storage coefficient = 7.86×10^{-4}. These values are considered to be representative of aquifer characteristics near Well PT.

Wells completed in the alluvial aquifer east of the basin-forming boundary fault zone showed classic unconfined aquifer responses during the pumping test. Well BLM-2-482 exhibited a classic delayed gravity drainage response. Transmissivity, storage coefficient, and specific yield values were calculated using Boulton's (1954) delayed yield model, with the following results: average transmissivity = 0.205 ft^2/s; storage coefficient = 1.50×10^{-5}; and specific yield = 0.0148. Boundary analyses performed on wells BLM-2-630 and BLM-17-493 suggest that the thinning saturated alluvium east of the boundary fault zone is acting as a less permeable boundary located approximately 1,800 feet east of Well PT.

Table 8 summarizes the results of all aquifer test analyses discussed in section 6.0. For all wells, the average transmissivity is about 0.196 ft^2/s and the average storage coefficient is 4.76×10^{-3}. These values are consistent with the values obtained from the NASA Well J pumping test, local slug test results and published pumping test results for the region. Hydrologic characteristics established during this aquifer pumping test will be used to model contaminant transport.

Table 8

Summary Table: Aquifer Characteristics

Well No.	Analytical Method	Hydrogeologic Model	Transmissivity (ft^2/s)	Storage Coefficient
PT-PZ-1	Theis (p)	Confined aquifer	0.172	8.68×10^{-4}
	Theis (r)		0.191	NA
	Jacob-Cooper (p)		0.112	2.16×10^{-2}
	Jacob-Cooper (r)		0.222	5.93×10^{-3}
	Cooper	Leaky-confined	0.191	1.30×10^{-2}
	Hantusch		0.160*	5.80×10^{-4}*
		Average:	**0.175**	**8.40×10^{-3}**
PT-PZ-2	Theis (p)	Confined aquifer	0.215	1.09×10^{-4}
	Theis (r)		0.170	NA
	Jacob-Cooper (p)		0.104	1.63×10^{-2}
	Jacob-Cooper (r)		0.203	1.16×10^{-3}
	Cooper	Leaky-confined	0.229	6.69×10^{-3}
	Hantusch		0.138*	9.90×10^{-4}*
		Average:	**0.177**	**5.05×10^{-3}**
PT-PZ-3	Theis (p)	Confined aquifer	0.184	1.15×10^{-4}
	Theis (r)		0.155	NA
	Jacob-Cooper (p)		0.101	1.10×10^{-2}
	Jacob-Cooper (r)		0.186*	9.96×10^{-4}*
		Average:	**0.157**	**4.04×10^{-3}**
PT-PZ-4	Theis (p)	Confined aquifer	0.287	9.48×10^{-5}
	Theis (r)		0.180	NA
	Jacob-Cooper (p)		0.104	4.78×10^{-3}
	Jacob-Cooper (r)		0.211	1.85×10^{-3}
	Cooper	Leaky-confined	0.275	1.65×10^{-3}
	Hantusch		0.164*	7.87×10^{-4}*
		Average:	**0.204**	**1.83×10^{-3}**

*Considered the most accurate hydrogeologic model for the particular well location

Table 8 (cont'd)

Summary Table: Aquifer Characteristics

Well No.	Analytical Method	Hydrogeologic Model	Transmissivity (ft^2/s)	Storage Coefficient
PL-2-504	Jacob-Cooper (p)	Confined aquifer	0.130	6.52×10^{-3}
BLM-7-509	Jacob-Cooper (p)	Confined aquifer	0.391	1.05×10^{-2}
BLM-2-482	Boulton	Unconfined aquifer	0.205	1.50×10^{-5} $S_y = 0.0148$
BLM-2-630	Jacob-Cooper (p)	Confined aquifer	0.100	1.05×10^{-3}
	Jacob-Cooper (r)	0.147	5.54×10^{-4}	
	Stallman	Boundary Analysis	0.184	6.39×10^{-4}
		Average:	**0.144**	**7.48×10^{-4}**
BLM-17-493	Jacob-Cooper (p)	Confined aquifer	0.116	8.43×10^{-3}
	Boulton	Unconfined aquifer	0.460	6.00×10^{-3}
	Stallman	Boundary Analysis	0.382	5.51×10^{-3}
		Average:	**0.319**	**6.65×10^{-3}**
All Wells		**Average:**	**0.196**	**4.76×10^{-3}**
Various	Cooper	Distance-Drawdown		
		t = 3000 min.	0.108	7.11×10^{-3}
		t = 5000 min.	0.108	9.26×10^{-3}

*Considered the most accurate hydrogeologic model for the particular well location.

8.0 References

Boulton, N. S., 1954, Unsteady Radial Flow to a Pumped Well Allowing for Delayed Yield from Storage, International Association of Scientific Hydrology, Publication 27, p. 472-477.

Cooper, H. H., Jr., 1963, Type Curves for Nonsteady Radial Flow in an Infinite Leaky Artesian Aquifer, in Bentall, Ray, compiler, Shortcuts and Special Problems in Aquifer Tests: U.S. Geological Survey, Water Supply Paper 1545-C, p. C48-C55.

Cooper, H. H., Jr., and Jacob, C. E., 1946, A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-Field History, American Geophysical Union Transactions, Vol. 27, No. 4, p. 526-534.

Driscoll, F. G., 1986, Groundwater and Wells, 2nd Edition, Johnson Division, St. Paul, Minnesota, p. 1108

Geoscience Consultants, Ltd., 1989. Second Interim Hydrogeologic Report, NASA-JSC, White Sands Test Facility, Las Cruces, New Mexico, unpublished.

Geoscience Consultants, Ltd., 1990a. Third Interim Hydrogeologic Report, NASA-JSC, White Sands Test Facility, Las Cruces, New Mexico, unpublished.

Geoscience Consultants, Ltd., 1990b. Aquifer Test Report - Well J, NASA-JSC, White Sands Test Facility, Las Cruces, New Mexico, unpublished.

Hantusch, M. S., 1960, Modification of the Theory of Leaky Aquifers, Journal of Geophysical Research, Vol. 65, No. 11, p. 3713-3725.

Kruseman, G. P. and De Ridder, N. A., 1983. Analysis and Evaluation of Pumping Test Data. International Institute for Land Reclamation and Improvement - ILRI, Wgenigen, The Netherlands, p. 200.

Lohman, W. S., 1979, Ground-Water Hydraulics. U.S. Geological Survey, Professional Paper 708, p. 70.

Reed, J. E., 1980, Type Curves for Selected Problems of Flow to Wells in Confined Aquifers. U.S. Geological Survey, Techniques of Water Resources Investigations, Book 3, Chapter B3.

Seager, W. R., 1981, Geology of Organ Mountains and Southern San Andreas Mountains, New Mexico, N.M. Bureau of Mines and Mineral Resources, Geology Memoir 36.

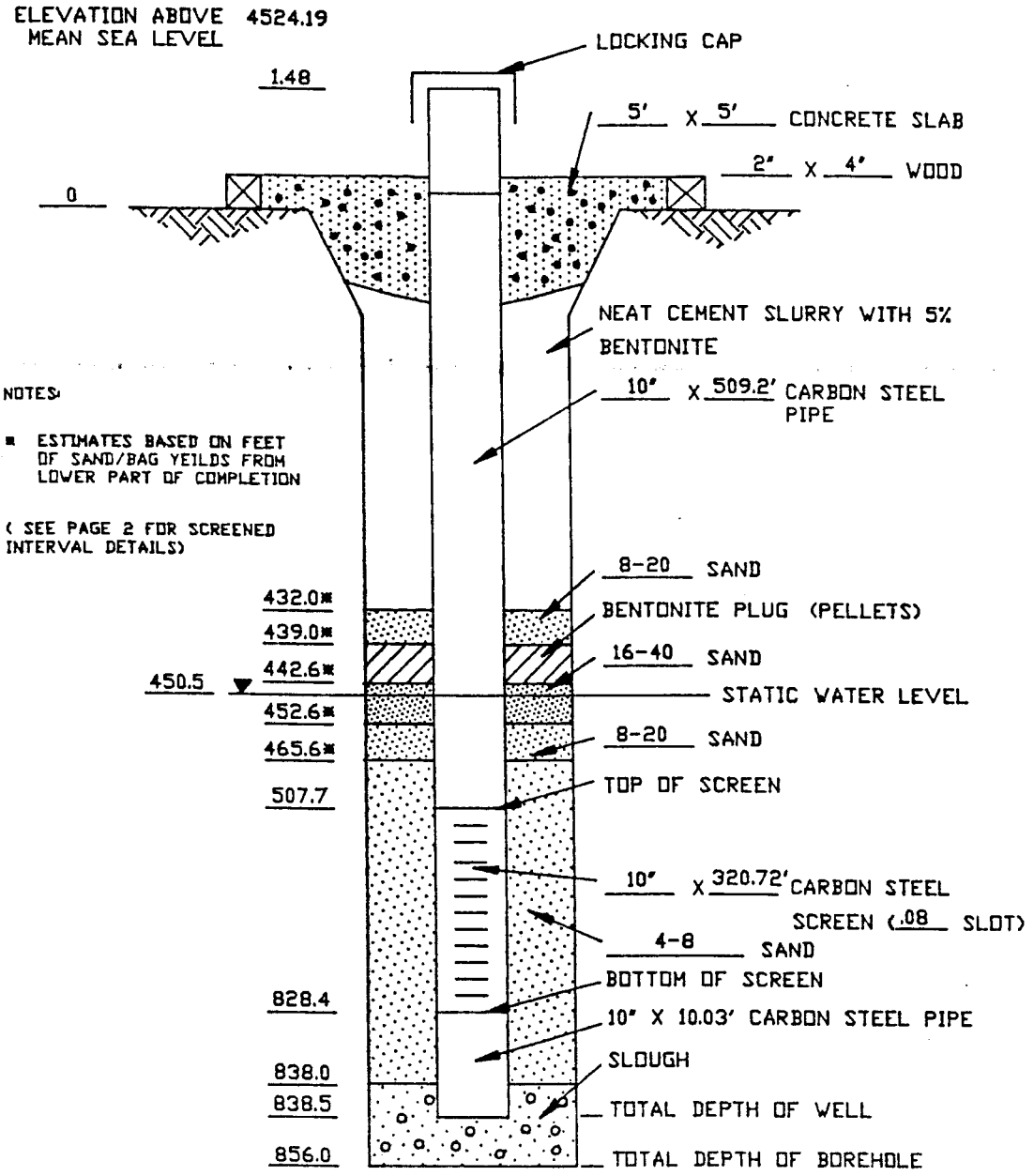
Stallman, R. W., 1963, Type Curves for the Solution of Single Boundary Problems, in Bentall, Ray, Compiler, Shortcuts and Special Problems in Aquifer Tests, U.S. Geological Survey, Water Supply Paper 1545-C, p. C45-C47.

Theis, C. V., 1935, The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-Water Storage, American Geophysical Union Transactions, Vol. 16, p. 519-524.

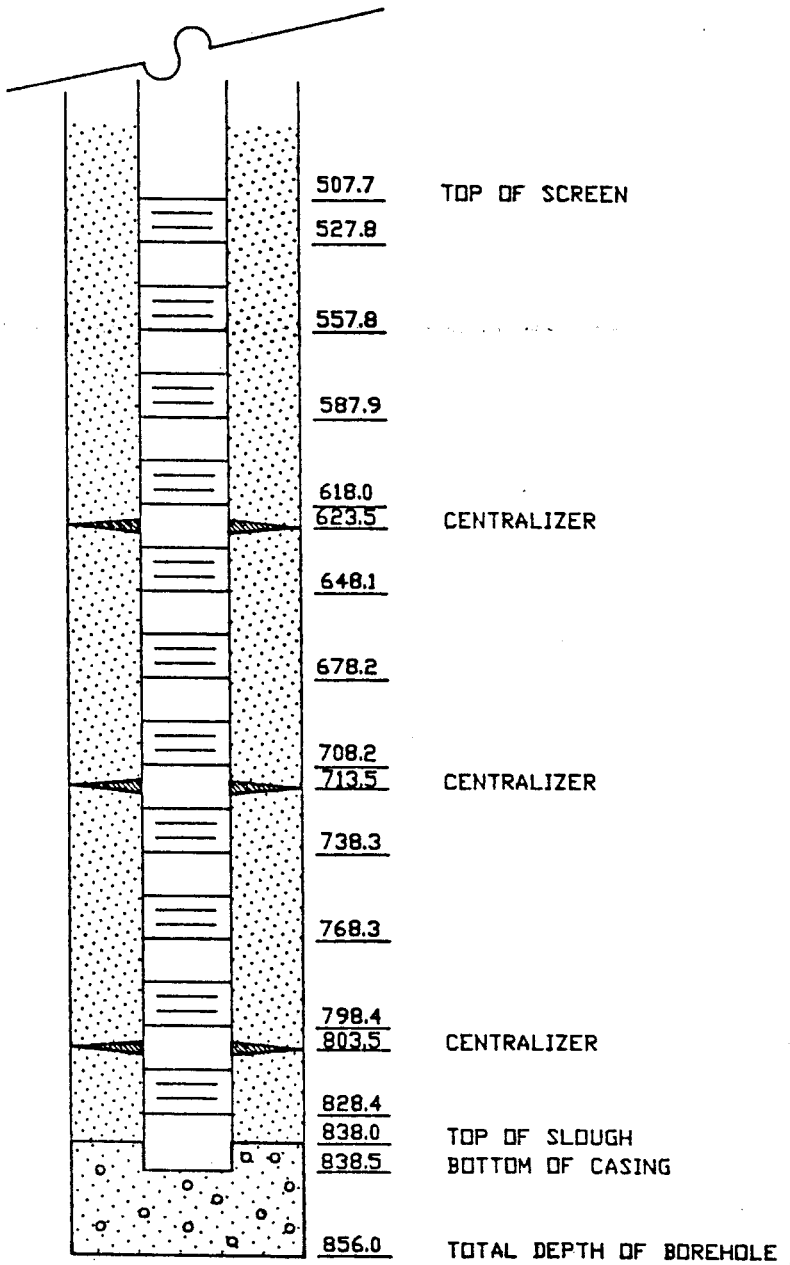
Walton, W. C., 1987, Groundwater Pumping Tests: Design and Analysis, Lewis Publishers, National Water Well Association, Chelsea, Michigan, 201 pp.

Appendix A

Well Completion Diagrams and Lithologic Logs



NASA-PT-WELL COMPLETION DIAGRAM



NASA-PT-WELL COMPLETION DIAGRAM (page 2)
SCREENED INTERVAL DETAILS

DRAFT

WELL SUMMARY page 1 of 6

Location ID: NASA PT Well Field Representative(s): R. Cooper/P. Egan

Northing: 226752.14 Easting: 402084.23

Date Started: 09/21/89 Date Completed: 03/29/90

Drilling Method: Mud & Air-Foam Rotary Drilling Contractor: Larjon Drilling

Driller: T. Crawford

Total Depth Borehole: 856' Total Depth Well Casing: 838.47'

Total Depth Surface Casing: No surface casing

Diameter Well Casing: 10" Diameter Surface Casing: No surface casing

Length of Bottom Blank: 10.03

Type of Screen: 10' carbon steel, continuous wire wound 0.08 slot

Screen Interval: 507.72' to 828.44'

Water First Detected: 489' Water Level Open Borehole: 450.5' (G.L.)

Water Level Cased Borehole: 452.44' (T.O.C.)

Bentonite Gel Use: 164 bags

Quik-Foam Use: 50 gallons, 95 gallons E-Z mud (Also used 12 1/2 bags Drispack, 8 bags Impermex, 1 bag Cellex).

Estimated Water Use: 76,925 gallons used to drill borehole and thin drilling fluids for completion.

Well Casing: 10" carbon steel x 497.72'
10" carbon steel (20' screen alternating with 10' blank) x 330.72'

4in x 3ft SCD 40 PVC:
4in x 5ft SCD 40 PVC:
4in x 10ft SCD 40 PVC:
4in x 20ft SCD 40 PVC:
Total SCD 40 PVC pipe: ft

stock SS centralizers:
custom SS centralizers:
4"x2' SS locking riser:
4" SS locking cap:
4" SS female cap:

4in x 3ft SCD 5 SS pipe:
4in x 5ft SCD 5 SS pipe:
4in x 10ft SCD 5 SS pipe:
4in x 20ft SCD 5 SS pipe:
Total SCD 5 SS pipe: ft

4in x 5ft SCD 10 SS pipe:
4in x 10ft SCD 10 SS pipe:
4in x 20ft SCD 10 SS pipe:
Total SCD 10 SS pipe: ft

Well Completion:

100# bags 16/40 sand:	10	bags
100# bags 10/20 sand:	0	bags
100# bags 8/14 sand:	0	bags
100# bags 8/20 sand:	20	bags
100# bags 4/8 sand:	359	bags
94# bags cement:	283	bags (mixed with 1488 gallons water)
5 gal. buckets bentonite:	3 1/2	buckets
50# bentonite powder:	32	bags
Benseal:	0	bags

Surface Casing: No surface casing installed.

94# bags cement:	bags
50# bags bentonite powder:	bags
Grout:	bags

Pertinent Field Notes:

09/20/89	Set-up for drilling using mud rotary. Worked on portable mud pump. -Cooper
09/21/89	Steam-cleaned BE Rig and drill pipe. Spud well, drilled pilot hole to 70', 12¼" bit. Drilled through an upper caliche zone and then very clay-rich alluvium with interbedded sands and gravels. 1500 gallons water used. - Cooper
09/22/89	Reamed pilot hole to 16" from 0'-79'. Set temporary 10" steel surface casing. Started preparing for air-foam drilling. 1200 gallons water used. - Cooper
09/25/89	Finish setting up for air-foam drilling. Drilled from 79' to 209' with 7 7/8" bit. Drilled through silty and clay-rich alluvium interbedded with silty sands and gravels. Replace radiator hose on the BE rig. 900 gallons water used. - Cooper
09/26/89	Drill, air-foam, 7 7/8" bit, 209'-489'. No water detected while drilling. Water detected while blowing hole after 45 minutes. 900 gallons water used for drilling. - Egan
09/27/89	Water level in open borehole is 451.45' (from top of deflector). Inspect air compressor filters. Change both filters. Core alluvium 489'-499'; 100% recovery. 600 gallons water used during drilling. -Egan

09/28/89 Samples taken from yesterdays core by G. Contaldo (I.D. #8909280800 for sieve analysis, #8909280830 for TOC analysis). Continue drilling 7 7/8" pilot, 489'-560'. Core 560'-570'. 1000 gallons water used for drilling and coring. - Egan

09/29/89 Remove core from core barrel. Approximately 2% recovery of andesite-rich alluvium. Samples taken by G. Contaldo, (#8909290900 for sieve analysis and #8909290930 for TOC analysis). Continue 7 7/8" pilot 560'-650'. Bit trip at 650'. Attach core bit. Trip into surface casing. 700 gallons water used. - Egan

10/02/89 Resume trip in and core 650'-660'. 100% recovery of andesite-rich alluvium. Trip into surface casing with 7 7/8" bit. 200 gallons water used. - Egan

10/03/89 Trip remainder of drill pipe in to 650'. Resume drilling 7 7/8" pilot hole 650' (ream core hole 650'-660') to 740'. No bedrock encountered. Drilling through andesite-rich alluvium. Water usage ≈ 200 gallons. - Egan

10/04/89 Trip into hole to 740'. Core with Christensen core tool from 740'-750'. Some difficulties coring; may be close to limits of coring with air-foam. Trip out and remove 40% consolidated core and approximately 10% unconsolidated. Trip into surface casing. Water usage was 225 gallons. Took samples for sieve analysis and TOC. - Cooper

10/05/89 Finish tripping into hole and start reaming 740'-750' to 7 7/8". Drill from 750'-820'. Bedrock was not encountered. Trip out of hole and put on coring tool for tomorrow. - Cooper

10/06/89 Set up to core using fluid instead of air and foam. E-Z mud and water was used (approx. 4000 gallons mixed with E-Z/Mud) as the fluid. Core from 820'-828' with only approx. 2' of recovery, most of which was a large cobble. - Cooper

10/09/89 Ream core interval from 820'-828' and drill 828' to 855.5'. Encounter bedrock between 828' and 855.5'. Air filter and hose burned up on main compressor and were replaced. Check auxiliary compressor and filter was in good condition. Hydraulic hose on rig sprung a leak while tripping out and was replaced. Hole TD ≈ 856'. Water usage ≈ 200 gallons. - Cooper

10/10/89 Samples for TOC taken from core interval 820'-828', samples for sieve analysis were not taken. Start moving equipment and cleaning up to start BLM-16. Work on this well temporarily halted until the well completion is designed and materials ordered. Work will resume when shipment of completion materials is confirmed. - Cooper

11/29/89 Resume work on NASA Well PT. Drill pipe and rig deck brought to NASA, steam cleaned and set up on well pad. Drill rig is being repaired at Larjon's shop. - Egan

12/01/89 Repairs on drill rig complete. Rig and associated tools and equipment steam cleaned and brought to well pad. Begin rigging up. -Egan

12/05/89 Preparation for drilling. Minor rig repairs. - Egan

12/06/89 Finished repairs on rig. Pull temporary surface casing. Mix mud and start circulation. Begin reaming, first pass. Ream pilot hole, 79'-125', 12 ½" button bit. Used 10 truck loads of water (≈ 19,000 gal. water), 74 bag economy gel, and 10 gal. E-Z mud to mix drilling fluid. - Egan

12/07/89 Continue reaming, first pass; 125'-305'. Some problems with mud mixture lifting cuttings out of borehole. - Egan

12/08/89 Continue reaming, first pass; 305'-385'. Still having problems lifting cuttings. Not much footage today; a lot of time spent on adjusting the consistency of the drilling mud to sufficiently lift cuttings. - Egan

12/09/89 Change to 12 ¼" tricone bit for harder formation. Continue reaming, 385'-525'. - Egan

12/10/89 Continue reaming 525'-695'. - Egan

12/11/89 Continue reaming 695'-855'. Circulate mud. First pass of reaming complete. - Egan

12/12/89 Set up to ream, second pass. Ream 0-65', 17 7/8" bit. - Contaldo

12/13/89 Continue reaming, second pass, 65'-245'. - Egan

12/14/89 Continue reaming, second pass, 245'-365'. - Egan

12/15/89 Remove cuttings from mud pit with backhoe. Re-mix mud. Continue reaming, second pass, 365'-445'. - Egan

12/16/89 Circulate mud in pits to mix. Freezing temperatures overnight are causing mud to separate in pits. Continue reaming, 445'-585'. - Morse

12/17/89 Continue reaming, second pass, 585'-695'. - Contaldo

12/18/89 Continue reaming, second pass, 695'-856'. Welders on site to begin welding well casing blanks and screens to 30' lengths. Mud thinned by circulating fresh water down drill stem. Fresh water was circulated all night. - Kirby

12/19/89 Continue circulating fresh water to thin mud (used 12,000 gallons water to thin mud). Weld and install 10" carbon steel screen and casing. Bottom of casing at 838.47'. Screened interval 497.72'-828.44'. 1.60' of stick-up. Casing installation was hindered at ≈ 300' and tremie had to be removed from hole. Completion will have to be conducted with limited use of the tremie. - Kirby/Egan

12/20/89 Install 110 bags of 4-8 sand for the filter pack. - Egan

12/21/89 Attempt to surge 4-8 sand with surge block, but surge block becomes stuck in sediment at bottom of well in sump. Spend all day trying to free surge block. Finally free by pumping water down 1 ¾" tremie pipe. Bond logs run by Mick Peterson of SW Surveys to determine sand level in well annulus. Bond logs appear to work well. Sand is yielding ≈ 1 foot per bag. Install more 4-8 sand and run bond log again. Sand continues to yield ≈ 1 foot per bag. Can run sounder now and measure top of sand. Send logger home. - Egan/Kirby

12/22/89 Add remainder of 4-8 sand and surge to settle. Measure top of gravel pack measured with sounder at 465.6'. Sounder continually getting caught between borehole wall and casing during gravel pack installation. It was decided that the remainder of the completion materials will be installed but not sounded. Locations of completion layers above gravel pack will be estimated. Install 8-20 sand above 4-8 gravel pack, 16-40 sand, then bentonite plug. Install 8-20 sand above plug to 432'. Install first load of grout (100 bags). - Egan/Kirby

* * BREAK FOR CHRISTMAS * *

01/02/90 Install 2 loads of grout (200 bags). - Egan

01/05/90 Finish grout to surface (7 bags). - Contaldo/Egan

01/09/90 Bubbled filtered air at 80 PSI/450 CFM and blew water out of well to break loose the mudcake on the borehole wall and blow drilling mud from the well. Initial well clean-up -- not development. - Cooper

01/10/90 No work done on well; all mud pits are full and we are waiting for new ones to be dug by Lockheed. Two hours of stand-by for Larjon. - Cooper

01/11/90 New mud pits excavated by facilities to contain discharge water from air-jetting/lifting. Air-jetted 4 more screened intervals to break down mud cake. - Egan

01/12/90 Jet 1 more screened interval. Install more drill pipe to 25' from bottom of well casing and air-jet/lift until mud pits are full. Discharge water is almost turbid-free. Stop work on this well until pump development begins in March. - Egan

03/20/90 Column pipe, 60 Hp pump, and pulling unit brought to NASA late in the day. - Egan

03/21/90 Spent most of day scrubbing column pipe inside and out with Alconox and steam cleaning. Splice pump wire to pump. - Egan

03/22/90 Install 60 Hp submersible pump on 5" x 609' column pipe in production well with intake at 616'. One 5" check valve installed 21' above top of pump. 3-conductor pump wire spliced at ≈ 100' below surface. - Kirby

03/26/90 Install most of discharge line at production well. - Egan

03/28/90 Install remainder of discharge line, connect pump wire to power box. Lockheed constructs first containment pool. Test pump then discharge to completely fill pool (≈ 12,500 gallons). Initial discharge is full of rust and turbid. Estimated pump rate is 430 gpm. - Egan

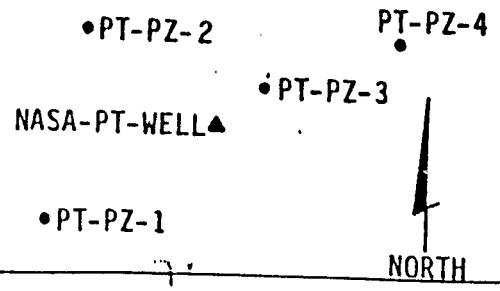
03/29/90 Lockheed constructs remaining two containment pools. Pump well to develop and sample pH, T°, conductivity, and turbidity. Pump until all three pools are full. Development parameters stabilize before pumping is terminated (see development sheet for details). Estimated pump rate is 389 gpm. Total water volume pumped into pools is 35,395 gallons. Well is ready for pump test. - Egan

Please put same sentence in both spots.

Lockheed takes samples ~~for~~ of discharge for VOC analysis.

LITHOLOGIC LOG

LOCATION MAP:



SE 1/4 SW 1/4 NE 1/4 NE 1/4 S 5 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: NASA-PT-Well

SITE COORDINATES (ft.):

N 226752.14 E 402084.23

GROUND ELEVATION (ft. MSL): @ 4526

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud and Air-Foam Rotary

DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 21 September 1989 DATE COMPLETED:

FIELD REP.: Cooper/Egan

COMMENTS: 7 7/8" pilot drilled from 0'-855' using air foam rotary. Pilot hole reamed in two passes to 18" using mud rotary. Top of bedrock (Andesite) at 845'.

LOCATION DESCRIPTION:

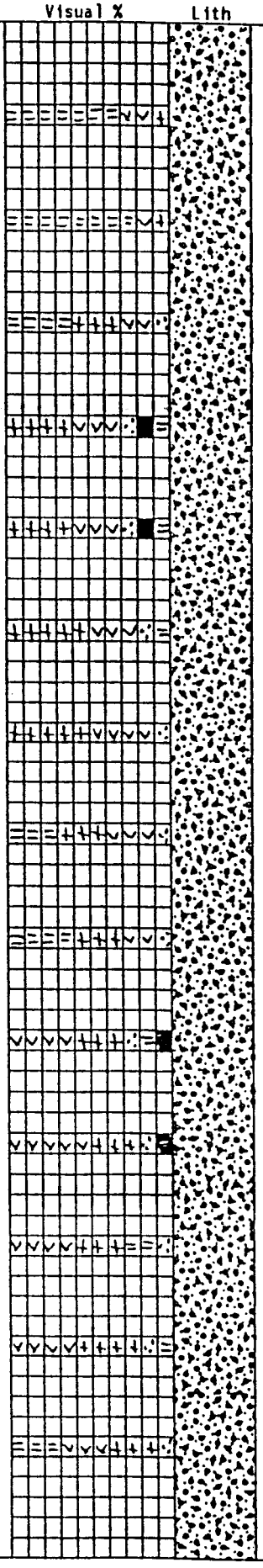
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			7	Cuttings 0'-50'	0'-80' Clay-Rich Alluvium (Santa Fe Group): Moderate yellowish brown (10 Y/R 5/4); cuttings range in size from less than 0.1 inch to 0.8 inches; are angular blocks or flakes, and are poorly sorted. Formation is an unconsolidated to poorly-consolidated polygenetic conglomerate. Lithologic constituents include limestone, caliche, rhyolite, andesite and quartz. Comments: Alluvium in this interval is clay rich.
10			13		0'-5' Silty sand and gravel with hard caliche horizon present.
15			10		5'-10' Same as above but with less caliche.
20			8		10'-20' Clay-rich sandy gravel.
25			10		20'-30' Sandy to gravelly clay.
30			9		30'-40' Clay-rich sandy gravel.
35			10		
40			8		40'-55' Clay-rich gravelly sand.
45			13		
50			11		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 50'-115'	
50			11		
55			7		55'-60' Sandy clay.
60			11		60'-65' Clay-rich gravelly sand.
65			9		65'-70' Sandy clay.
70			12		70'-75' Clay-rich sandy gravel.
75			17		75'-80' Sandy clay.
80			15		80'-550' Gravelly Alluvium (Santa Fe Group): Medium dark gray (N4) when wet; cuttings are less than 0.1 inch to 0.5 inches and average 0.3 inches; angular flakes and blocks. Natural grains are clay, silt and fine to coarse-grained sand that is subangular to well rounded. The alluvium is poorly sorted. The formation is an unconsolidated to consolidated polygenetic conglomerate. Lithology of cuttings include limestone, rhyolite, andesite, quartz, sandstone, siltstone and some caliche as cuttings/grains, coatings on grains, or as matrix material. Comments: Individual clay layers exist but decrease in frequency with depth.
85			4		80'-85' Sandy gravel.
90			4		85'-95' Clay-rich sandy gravel.
95			4		95'-110' Gravelly sand.
100			3		
105			4		
110			3		110'-140' Clay-rich sandy gravel.
115			6		

LOCATION ID: NASA-PT-Well

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 115'-180'	
115			6		
120			4		
125			5		
130			4		
135			3		
140			3		140'-145' Gravelly clay.
145			3		145'-175' Clay-rich sandy gravel.
150			4		
155			5		
160			6		
165			3		
170			4		
175			3		175'-185' Gravelly clay.
180			3		

LOCATION ID: NASA-PT-Well

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 180'-245'	
180			3		
185			3		185'-190' Clay-rich sandy gravel.
190			3		
195			3		
200			3		
205			3		
210			4		
215			4		
220			7		
225			7		
230			3		
235			4		
240			4		
245			10		

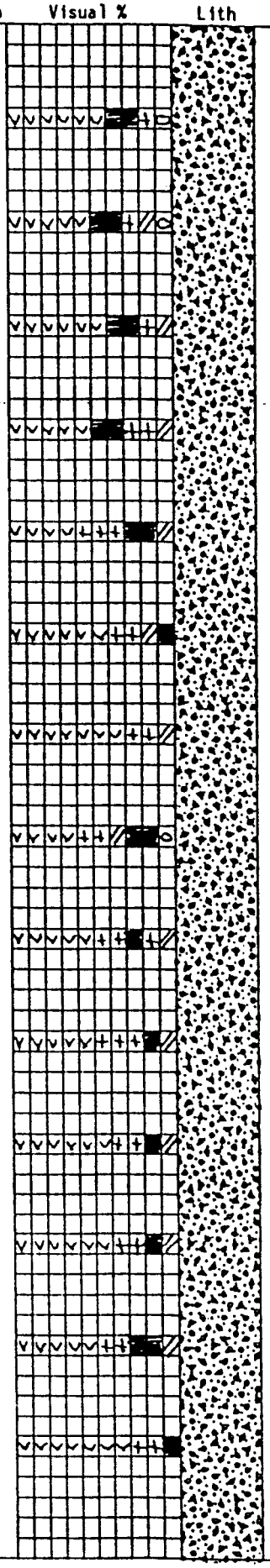
LOCATION ID: NASA-PT-Well

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245			10	Cuttings (cont'd) 245'-310'	
250			3		
255			10		
260			8		
265			4		
270			3		
275			5		
280			5		
285			5		
290			9		
295			6		
300			6		
305			6		
310			5		

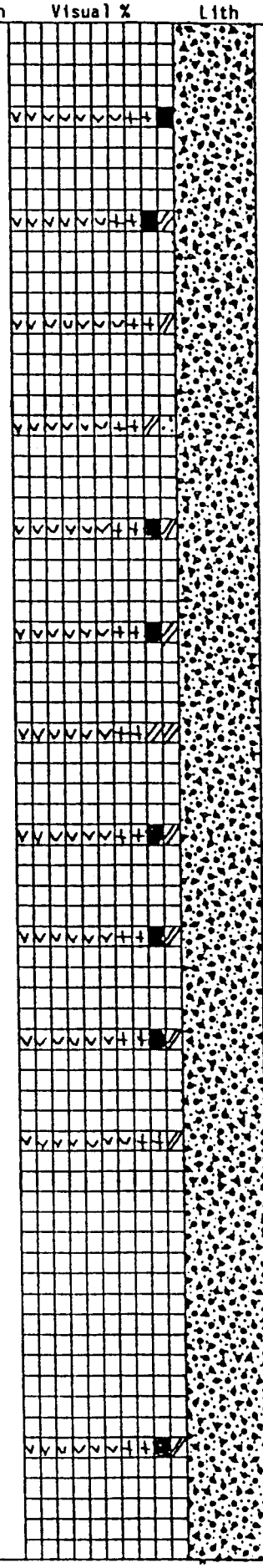
LOCATION ID: NASA-PT-Well

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 310'-375'	
310			5		
315			7		
320			8		
325			4		
330			9		
335			5		335'-345' Caliche is probably from the conglomerate matrix (matrix supported).
340			4		
345			4		
350			15		
355			4		
360			7		
365			10		365'-370' High percentage of rhyolite in igneous fraction of cuttings.
370			4		
375			4		

LOCATION ID: NASA-PT-Well

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 375'-440'	
375			4		375'-455' Quartz is a constituent present in alluvial cuttings, but less than 10%.
380			4		
385			5		
390			6		
395			7		
400			4		400'-430' Slight decrease in cutting size to 0.25-0.3 inches. Increase in the amount of fines (not clay).
405			4		405'-410' Signs of consolidation in cuttings. Well-cemented alluvium fragments present.
410			5		
415			4		
420			4		
425			3		
430			5		
435			4		
440			5		

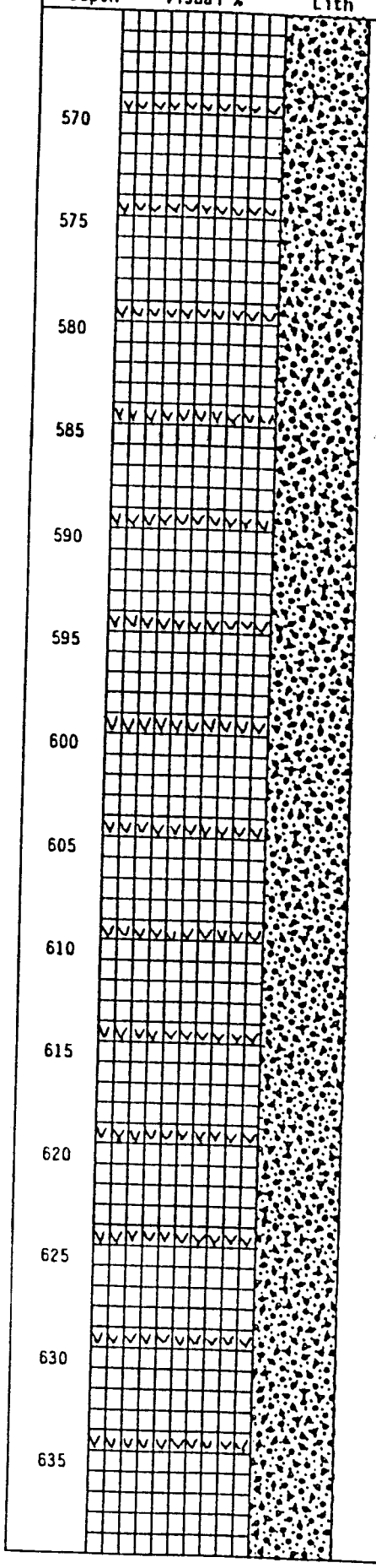
LOCATION ID: NASA-PT-Well



Depth	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
		Cuttings (cont'd) 440'-489'	
440	5		
445	8		
450	4		
455	3		
460	7		460'-490' Decrease in average cutting size to 0.2 inches.
465	4		
470	4		
475	4		
480	4		
485	4		
		Core Interval 489'-499'	
490	4		489'-499' **CORE INTERVAL** (See Attached Description)
495	52		
500	31	Cuttings 499'-505'	
505	4		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 505'-560'	
505			4		
510			4		
515			3		
520			3		
525			3		
530			3		
535			3 1/2		
540			4		
545			3 1/2		
550			3		550'-844' Andesite-Rich Alluvium: Dusky Red (5 R 3/4); average cutting size 0.2 inches; very angular to subrounded; moderately sorted aphanitic, microporphyritic, to porphyritic andesite with some siltstone, rhyolite and limestone. Multiple colors of andesites present and grades into a predominantly medium gray (N5) colored andesite.
555			4		
560			3	Core Interval 560'-570'	560'-570' **CORE INTERVAL** (See Attached Description)
565			70		
570			80		

LOCATION ID: NASA-PT-Well



Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
80	Core Interval (cont'd) 560'-570'	
	Cuttings 570'-635'	570'-575' First sign of tuff cuttings present in samples.
2		
4		580'-650' Decrease in average cutting size to ≈ 0.15 inches.
4		
3		
4		
5		
3		
5		
5		
3		
3		
5		
3		

LOCATION ID: NASA-PT-Well

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 635'-650'	
635			3		
640			3		
645			3		
650			4	Core 650'-660'	650'-660' **CORE INTERVAL** (See Attached Description)
655			47		
660			62	Cuttings (cont'd) 660'-700'	
665			3		
670			4		
675			17		
680			9		
685			7		
690			5		
695			6		
700			4		

LOCATION ID: NASA-PT-Well

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 700'-740'	
700					
705			3		
710			3		
715			2		
720			2		
725			3		
730			4		
735			3		
740			3	Core 740'-750'	740'-750' **CORE INTERVAL** (See Attached Description)
745			101		
750			82		
755			3.5		
760			4		
765			3.5		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
765			3.5		
770			2		
775			3		
780			3.5		
785			3.5		
790			3		
795			3		
800			3		
805			4		
810			4		
815			5		
820			3	Core 820'-828'	820'-828' **CORE INTERVAL** (See Attached Description)
825			50		
830			65	Cuttings (cont'd) (830'-855')	

LOCATION ID: NASA-PT-Well

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
835			Drillograph Off		
840			7		
845			6		844'-855' Orejon Andesite: Medium dark gray (N4) to grayish black (N2) porphyritic andesite. Small calcite veins seen in some cuttings, some calcite among cuttings. Cuttings angular (99%).
850			15		
855			17		855' Total depth of well.

CORE DESCRIPTION
NASA-PT-Well
489'-499' (Run #1)
(100% Recovery, RQD = 57% (Fair))

Gravelly Alluvium (Santa Fe Group): Consolidated to unconsolidated, gravel to cobble polygenetic conglomerate. Alluvium is multicolored, but overall pale yellowish brown (10 YR 6/2) when wet. Wide grain-size distribution from silt- and sand-size particles to 4-inch clasts; very angular but some clasts are subrounded; poorly sorted. Cobbles and gravel are supported in finer-grained carbonate-cemented matrix. The predominate alluvial clasts is porphyritic andesite that can be medium gray (N5), dusky red (5 R 3/4), or grayish green (10 GY 5/2); other lithologies include rhyolite, siltstone, claystone and lesser amounts of limestone and sandstone.

The characteristics of the alluvium described above suggest deposition in a high-energy (hydraulic) environment close to the local uplift. Estimated visual porosity in the core is variable, 5-25%. The medium-grained fraction appears the least cemented and yields the most porosity while fine- and coarse-grained fractions are well cemented resulting in lower yields.

Sedimentary structures present are composite beds of fining-upward sequences and slight imbrication:

489.0' - 489.5'	Clasts up to 2 inches; poorly sorted; matrix supported. Estimated visual porosity less than 5%.
489.5' - 490.9'	Upward fining sequence. Well cemented clasts up to 2 inches fine upwards to poorly- to moderately-cemented medium to small gravel with some sand and silt. Estimated visual porosity of fine grained fraction is 10-20%.
490.9' - 492.0'	Upward fining sequence. Clasts up to 2 inches fine upwards to coarse sand with some gravels. This interval is well-cemented. Estimated visual porosity is 5-7%.
492.0' - 495.2'	Largest upward fining sequence. Well cemented clasts up to 4 inches fine upwards to coarse gravel then coarse sand and gravel. Coarse sand and gravel is poorly- to moderately cemented; some imbrication of oblate clasts; estimated visual porosity 10-20%.
495.2' - 496.1'	Clasts up to 1 inch; moderately- to poorly-sorted; well cemented. Estimated visual porosity 5-7%.
496.1' - 499.0'	Average grain size less than 1 inch; moderately sorted; unconsolidated.

CORE DESCRIPTION
NASA-PT-Well
560'-570' (Run #2)
(3% Recovery, RQD does not apply)

Andesite-Rich Alluvium (Santa Fe Group): Grayish red (10 R 4/2) to pale red (10 R 6/2) wet, poorly sorted, moderately- to well-cemented, pebble to boulder conglomerate. Clasts consist of very angular to subrounded aphanitic, microporphyritic and porphyritic andesites that range in color from predominately dusky red (5 R 3/4) to grey, green, and yellow. Clast size ranges from 0.1 inches to 1.5 inches and part of a tuff boulder was retrieved. Clasts are supported in a fine-grained silt, carbonate, and possibly clay matrix. No sedimentary structures are present, but sample size is very small.

Estimated visual porosity is 10-15% and water production while drilling indicates formation is fairly transmissive.

CORE DESCRIPTION
NASA-PT-Well
650'-660' (Run #3)
(100% recovery, RQD = 4% (very poor))

Andesite-Rich Alluvium: Grayish red (10 R 4/2), wet, poorly- to moderately-sorted, unconsolidated to well-cemented, pebble to cobble conglomerate. Clasts consist of very angular to subrounded aphanitic, microporphyric to porphyritic andesites that range in color from predominantly dusky red (5 R 3/4) to grey, green, and yellow. Clasts size ranges from less than 0.1 inch to 3.5 inches. Clasts are supported in a finer-grained silt, fine sand and carbonate matrix or, in some areas, a pure carbonate matrix.

Sedimentary structures are difficult to discern in core because of the amount of breakage. Bedding is apparent in the interval 650.5'-651.2'. Finer-grains grade sharply into coarse grains, with no intermediate grain size. This indicates a large and rapid increase in the flow regime. The remainder of the core represents massive, poorly-sorted alluvium, some slight to definitive imbrication is present.

Porosity in this core interval is greater than the core taken from 560'-570'. This core interval is less-cemented (more friable) and contains larger pore spaces coated with crystalline calcite. Estimated visual porosity is 20-30%. This interval is capable of transmitting large quantities of water.

CORE DESCRIPTION
NASA-PT-Well
740'-750' (Run #4)
(50% recovery, RQD = 40% (poor))

Pebble to Boulder Andesite-Rich Alluvium (Santa Fe Group): The alluvium is a multicolored, poorly-to moderately-sorted, semi-consolidated, pebble to boulder andesite-rich conglomerate. The conglomerate is mostly matrix supported but has small zones which are grained supported. The matrix is a white to yellowish white carbonate and clay cement containing silt and sand particles. This matrix supports pebble-size clasts to boulders up to 7.5 inches. Within the matrix, small fractures are healed with white calcite cement. Sand grains within the matrix are composed of small pieces of andesite, tuff and phenocrysts weathered from said rocks. Clasts contained in the conglomerate are predominately (≥ 95%) porphyritic andesites, other clasts include multiple colors of tuff. There are varying degrees of weathering of most andesite and tuff clasts and the phenocrysts in them. Andesites have a wide range of colors and phenocryst size (from less than 1mm to 12mm) and 99-100% of the andesites are porphyritic. Tuffs are soft and are weathering to clay. Oxidation of biotite, plagioclase altering to clay, and pyroxenes altering to epidote are some of the indicators of weathering. Vugs are present in some andesite clasts. Euhedral calcite line some of these vugs while others are not lined.

The conglomerate shows no distinct signs of bedding or imbrication, however, it is noted that there are zones of similar clast size within a small area. These zones are discontinuous and make no distinct bedding feature. Some areas within the conglomerate are well-cemented while others are poorly-cemented and crumble easily. ~~80%~~ Eighty percent of this core is consolidated and 20% is unconsolidated.

CORE DESCRIPTION
NASA-PT-Well
820'-828' (Run #5)
RQD (Not applicable)
(20-25% Recovery)

Andesite-rich Pebble to Boulder Alluvium (Santa Fe Group): The core consists of gravel and boulder fragments of andesite. Most clasts are subrounded, others are angular. The largest clast is at least 4.75", possibly as large as 8.75" in diameter, and is a slightly weathered dark gray porphyritic andesite. The andesite contains anhedral and euhedral white plagioclase phenocrysts and vugs filled with white calcite. Some smaller clasts of andesite contain vugs filled with silica (chalcedony). Cemented to the large andesite clast is a matrix- to grain-supported silt and sandy, pebble to gravel alluvium. No distinct sedimentary structures, such as imbrication or bedding, are present. Smaller clasts of gray andesite contain phenocrysts of weathered biotite and plagioclase. Some surfaces where the matrix of the alluvium contacts the andesite clasts, there is anhedral and euhedral calcite visible. The matrix of the alluvium is a sandy carbonate and clay cement and is white to dirty white in color. Cementation varies from well-cemented to poorly-cemented.

LOCATION: NASA-PT-Well

HYDRAULIC CONDITIONS: Apparent Confined Alluvial Aquifer

PERTINENT OBSERVATIONS: Drilled 209' to 489' with no visual indication of formation water in discharge. Blew hole with air to clear cuttings from borehole for 45 minutes. After 30 minutes of blowing hole, formation water was detected in discharge. Let recover overnight. Water level in borehole the next day was 451.45' (measured from top of deflector shield).

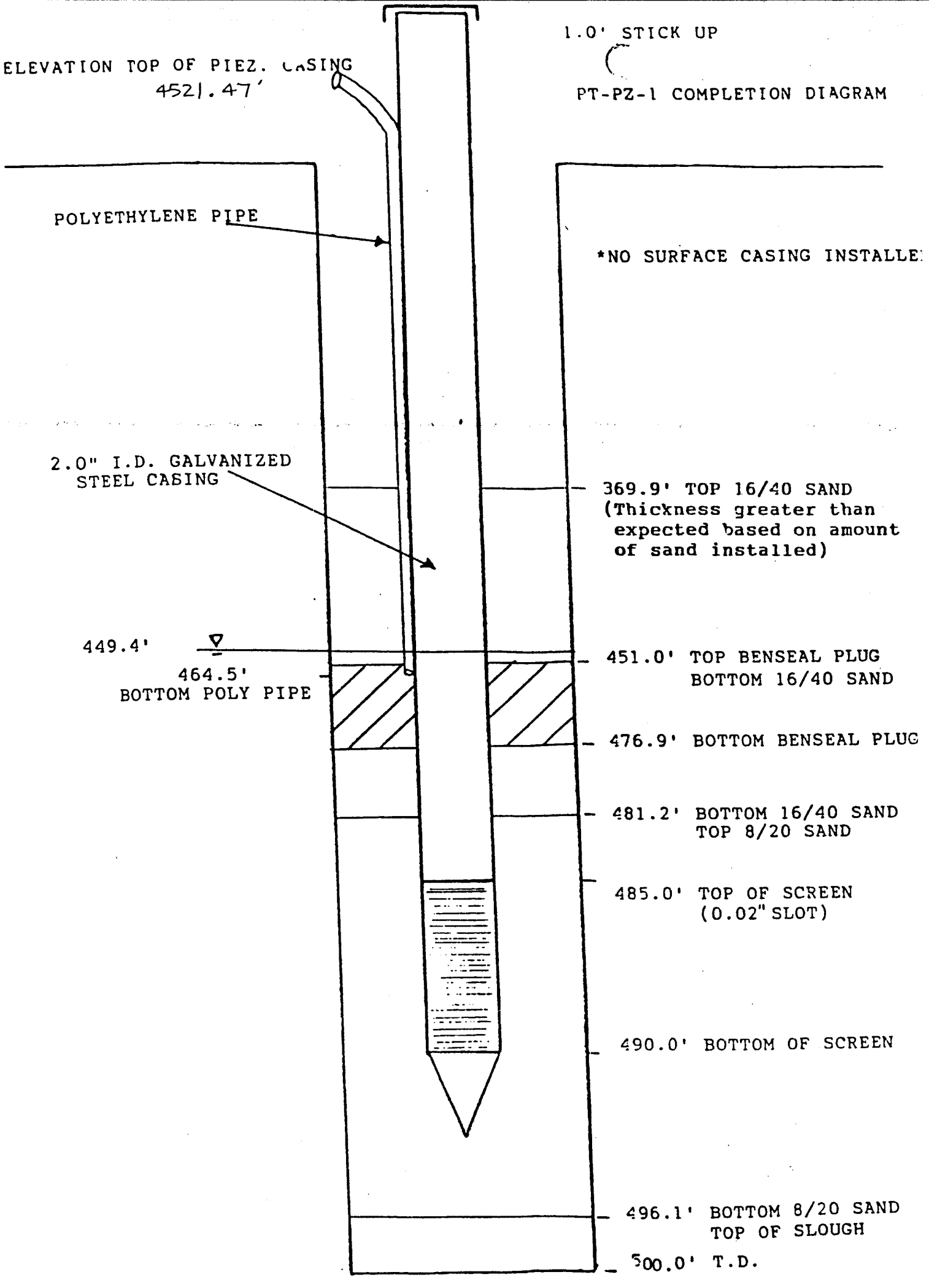
MONITOR WELL DEVELOPMENT

WELL: NASA-PT-WELL

Water Level
pre-development 452.42'(TC)
post-development_____

Date	Time	Method	Delta Volume (gallons)	Total Volume (gallons)	pH	T°C	Cond	Turbidity (NTU)	Initials	Comments
03/28/90	1300	Pump	0	@ 10,000	—	—	—	3.2	PSE	Start pump development. Discharge is approximately 430 GPM. Initial discharge is very turbid (Rusty and silty), but clears up in about 10 minutes.
03/28/90	1328	Pump	—	@ 12,046	—	—	—	—	PSE	Pump off.
03/29/90	1207	Pump	0	@ 12,046	—	—	—	—	PSE	Pump on. Pump rate approximately 389 GPM.
03/29/90	1216	Pump	—	—	7.33	24	1100	>10	PSE	
03/29/90	1231	Pump	—	—	7.20	24	1100	3.8	PSE	
03/29/90	1242	Pump	—	—	7.08	23	1095	2.5	PSE	
03/29/90	1255	Pump	—	—	7.07	23	1095	1.7	PSE	
03/29/90	1310	Pump	—	—	7.07	24	1090	1.7	PSE	
03/29/90	1315	Pump	—	@ 35,395	—	—	—	—	—	Pump off. Well developed.

@ = approximately


1.0' STICK UP
ELEVATION TOP OF PIEZ. CASING
4521.47'
PT-PZ-1 COMPLETION DIAGRAM
POLYETHYLENE PIPE
*NO SURFACE CASING INSTALLED
2.0" I.D. GALVANIZED STEEL CASING
369.9' TOP 16/40 SAND
(Thickness greater than expected based on amount of sand installed)
449.4'
451.0' TOP BENSEAL PLUG
BOTTOM 16/40 SAND
464.5'
BOTTOM POLY PIPE
476.9' BOTTOM BENSEAL PLUG
481.2' BOTTOM 16/40 SAND
TOP 8/20 SAND
485.0' TOP OF SCREEN
(0.02" SLOT)
490.0' BOTTOM OF SCREEN
496.1' BOTTOM 8/20 SAND
TOP OF SLOUGH
500.0' T.D.

WELL SUMMARY page 1 of 2

Location ID: PT-PZ-1 Field Representative(s): R. Cooper, G. Contaldo

Northing: 226620.89 Easting: 401932.56

Date Started: 10/11/89 Date Completed: 10/13/89

Drilling Method: Air-Foam Rotary Drilling Contractor: Larjon

Driller: T. Crawford

Total Depth Borehole: 500.0' Total Depth Well Casing: 490.0'

Total Depth Surface Casing: No surface casing

Diameter Well Casing: 2" I.D. Diameter Surface Casing: N/A

Length of Bottom Blank: N/A

Type of Screen: 5' well point 0.02 slot

Screen Interval: 485' to 490'

Water First Detected: 490' Water Level Open Borehole: 449.4' (Ground Surface)

Water Level Cased Borehole: 448.75' (Ground Surface)

E-Z Mud use: 5 gallons

Quik-Foam Use: 5 gallons

Estimated Water Use: 2,800 gallons used for drilling.

Well Casing: 2" I.D. galvanized steel casing with 5' well point screen (will remove after pump test).

4in x 3ft SCD 40 PVC:	0	stock SS centralizers:	0
4in x 5ft SCD 40 PVC:	0	custom SS centralizers:	0
4in x 10ft SCD 40 PVC:	0	4"x2' SS locking riser:	0
4in x 20ft SCD 40 PVC:	0	4" SS locking cap:	0
Total SCD 40 PVC pipe:	0 ft	4" SS female cap:	0

4in x 3ft SCD 5 SS pipe:	0		
4in x 5ft SCD 5 SS pipe:	0	4in x 5ft SCD 10 SS pipe:	0
4in x 10ft SCD 5 SS pipe:	0	4in x 10ft SCD 10 SS pipe:	0
4in x 20ft SCD 5 SS pipe:	0	4in x 20ft SCD 10 SS pipe:	0
Total SCD 5 SS pipe:	0 ft	Total SCD 10 SS pipe:	0 ft

Location ID: PT-PZ-1

Well Completion:

100# bags 16/40 sand:	2.5	bags
100# bags 10/20 sand:	0	bags
100# bags 8/14 sand:	0	bags
100# bags 8/20 sand:	2.5	bags
94# bags cement:	0	bags
5 gal. buckets bentonite:	0	buckets
50# bentonite powder:	0	bags
Benseal:	0.5	bags

Surface Casing:

94# bags cement:	0	bags
50# bags bentonite powder:	0	bags
Grout:	0	bags

Pertinent Field Notes:

10/11/89 Drilled from 0'-100' using air-foam rotary with 6¼" bit. - Contaldo

10/12/89 Drilled from 100'-500' using air-foam rotary with 6¼" bit. Groundwater first observed at 490', quantity of water increased dramatically after blowing borehole at 500'. - Contaldo

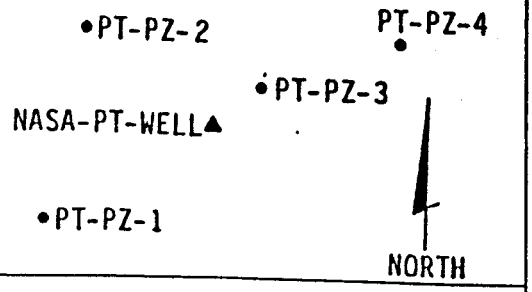
10/13/89 Measured water level in open borehole at 449.40' (ground surface). Sounded bottom of borehole at 496.06' (ground surface). Installed temporary piezometer. Screened interval from 485'-490'. Sounded top of 8/20 sand at 481.16', top of 16/40 sand at 476.86'. Pumped benseal plug above 16/40 sand. - Contaldo

10/16/89 Measured water level in cased borehole at 448.75' (ground surface). Added 1 bag of 16/40 sand and sounded top of sand at 369.86' (16/40 sand apparently bridged within the borehole). - Egan

01/25/90 Develop piezometer by air jetting with ¼" poly pipe. Volume of water discharging is low, but water cleans up after 2½ hours of jetting and lifting. Water level measured prior to and after jetting indicates communication with aquifer is good. Piezometer is ready for pump test. - Egan

LITHOLOGIC LOG

LOCATION MAP:



SE 1/4 SW 1/4 NE 1/4 NE 1/4 S 5 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: PT-PZ-1

SITE COORDINATES (ft.):

N 226620.89 E 401932.56

GROUND ELEVATION (ft. MSL): 4521.47 (T.O.C.)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Air-Foam Rotary

DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 10/10/89 DATE COMPLETED: 10/13/89

FIELD REP.: R. Cooper/G. Contaldo

COMMENTS: 0'-500' Air-Foam rotary with 6 1/4" bit. Total depth = 500'. Observation piezometer for NASA well - PT pump test. Piezometer will be removed after test.

LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
			Drillograph 0'-500'	0'-500' Cuttings	
5			3		
10			3		
15			4		
20			5		
25			3		
30			3		
35			3		
40			3		
45			3		
50			2		

0'-500' Alluvium (Santa Fe Group): Grayish orange (10 YR 7/4) to moderate brown (5 YR 4/4) lenticular, polygenetic pebble to boulder alluvium containing clay, silt and fine- to coarse-grained sand, interbedded with thin to thick sandy to gravelly clay lenses. Cuttings range in size from less than 1mm (0.04 inches) to 35mm (1.4 inches) and are subrounded to angular in shape. Alluvium contains clasts of light gray (N7) to grayish black (N2) limestone and dolomite, white (N9) iron-stained rhyolite and mottled white and red rhyolite, multiple colors of aphanitic to porphyritic andesite including pale reddish brown (10 R 5/4), very dusky red (5 R 2/6), greenish gray (5 GY 6/1) and grayish black (N2) to medium gray (N5). Lesser amounts of moderate brown (5 YR 4/4 to 5 YR 3/4) sandstone, dusky red (5 R 3/4) to dark reddish brown (10 R 3/4) siltstone and greenish gray (5 GY 6/1) siltstone, milky white to translucent quartz, moderate reddish brown (10 R 4/6) granite, white (N9) calcite, and white phenocrysts of plagioclase and brilliant green (5 G 6/6) to moderate green (5 G 5/6) epidote weathered out of the matrix.

This formation has clay lenses ranging in thickness from less than 5 feet thick to at least 40 feet thick. Clays contain sand and gravel in small amounts and clay lenses are sometimes separated by thin lenses of sand and gravel. Volcanic clasts predominate through the entire section, however, the upper 385 feet is not as volcanic rich as the lower section.

Subtle changes in volcanic fractions make it difficult to delineate change from a rhyolite-rich fraction of the section. Gray andesites resemble limestone and are difficult to differentiate.

0'-10' Gravel size cutting angular to rounded or subrounded. Mostly (iron-stained) rhyolite cuttings.

LOCATION ID: PT-PZ-1

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
50			2	Cuttings (cont'd) 0'-500'	10'-15' Most cuttings angular pebble size to coarse sand size. 15'-20' Sandy gravel with approximately 10% clay. 20'-30' Gravelly clay. 30'-35' Sandy clay.
55			2		35'-45' Clay-rich and gravels. 45'-60' Gravelly clay.
60			2		60'-70' Sandy gravel.
65			2		
70			3		70'-105' Clay-rich sandy gravel.
75			2		
80			3		
85			3		
90			3		
95			4		
100			4		
105			4		105'-115' Gravelly clay.
110			3		
115			3		

LOCATION ID: PT-PZ-1

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 0'-500'	
115			3		115'-125' Clay-rich sandy gravel.
120			2		125'-145' Sandy to gravelly clay.
125			3		
130			3		
135			3		
140			3		
145			3		145'-150' Volcanic-rich gravel.
150			5		150'-190' Sandy to gravelly clay.
155			3		
160			2		
165			3		
170			3		
175			2		
180			2		

LOCATION ID: PT-PZ-1

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 0'-500'	
180			2		
185			3		
190			3		190'-195' Gravel to boulder lens.
195			4		195'-220' Sandy to gravelly clay.
200			3		
205			3		
210			3		
215			4		
220			3		220'-235' Sandy gravel.
225			3		
230			3		
235			4		235'-245' Sandy to gravelly clay.
240			2		
245			3		

LOCATION ID: PT-PZ-1

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 0'-500'	
245			3		245'-250' Sandy gravel.
250			6		250'-255' Gravelly clay.
255			5		255'-275' Sandy gravels to boulders.
260			6		
265			8		
270			6		
275			5		275'-280' Gravelly clay.
280			3		280'-300' Sandy gravels to boulders.
285			5		
290			4		
295			4		
300			3		300'-305' Clay-rich sandy gravel.
305			3		305'-325' Sandy gravels to boulders.
310			5		

LOCATION ID: PI-PZ-1

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 0'-500'	
310			5		
315			4		
320			5		
325			5		325'-335' Gravelly clay.
330			8		
335			8		335'-340' Sandy gravels to boulders.
340			10		340'-345' Gravel.
345			3		
350			5		
355			4		
360			3		360'-365' Clay-rich sandy gravel.
365			3		365'-370' Sandy gravel.
370			4		370'-375' Clay-rich gravelly sand.
375			4		

LOCATION ID: PT-PZ-1

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 0'-500'	
375			4		
380			6		380'-385' Gravelly sand.
385			3		385'-390' Gravelly sand. 80% of igneous fraction is angular white iron-stained rhyolite.
390			5		390'-395' Sample still has a high percentage of rhyolite as described above.
395			4		395'-400' Gravelly sand.
400			3		400'-405' Sandy gravel.
405			4		405'-410' Clayey sand.
410			4		410'-425' Sandy gravel.
415			5		
420			4		
425			4		425'-440' Sandy gravel with minor silt and clay.
430			3		
435			4		
440			3		

LOCATION ID: PT-PZ-1

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 0'-500'	
440			3		440'-445' Sandy gravel.
445			4		445'-460' Gravelly sand with minor silt and clay.
450			3		
455			4		
460			3		460'-475' Sandy gravel.
465			3		
470			4		
475			3		475'-500' Gravelly sand with minor silt and clay.
480			3		
485			4		
490			4		
495			3		
500			2		Total Depth = 500'
505					

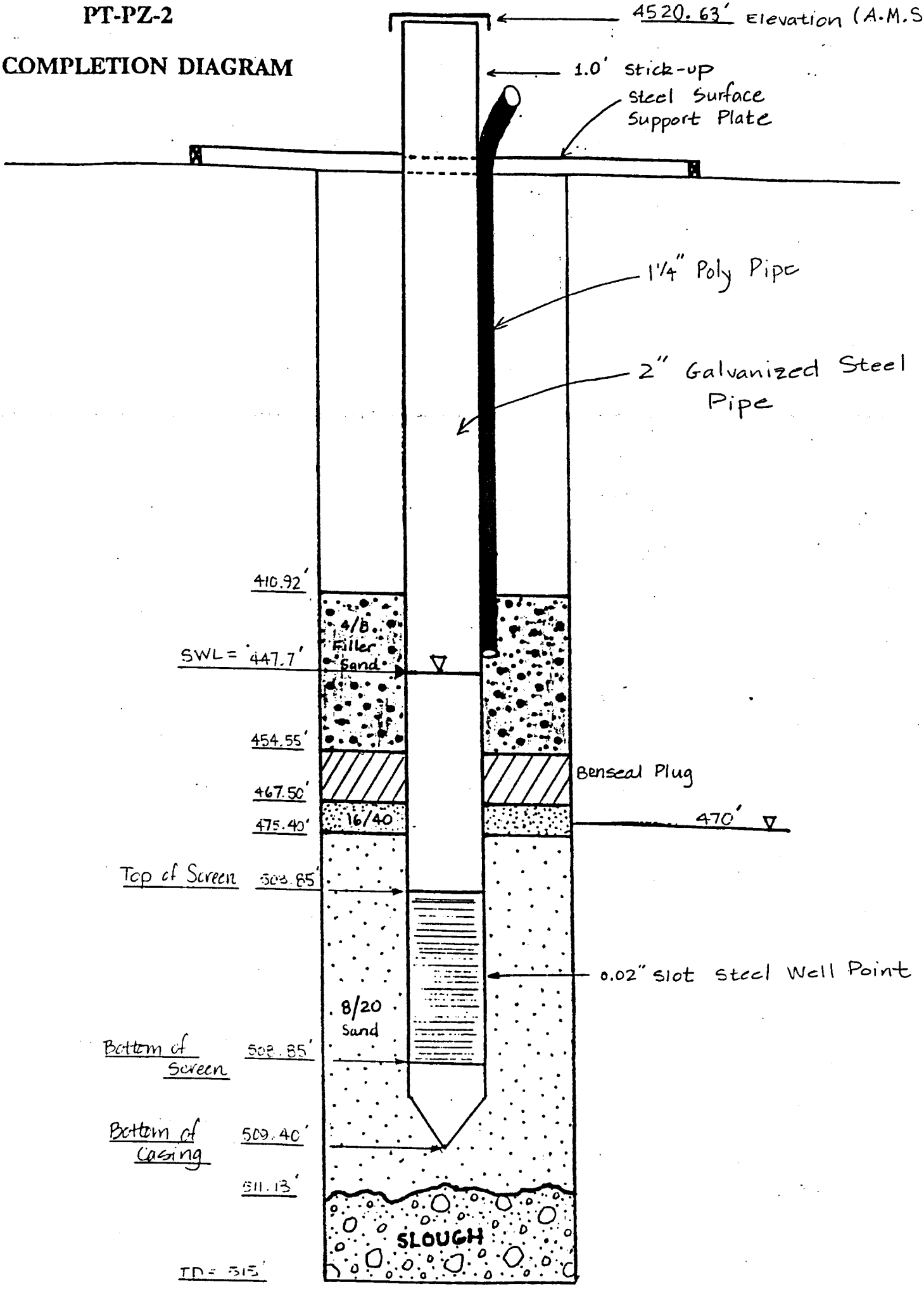
LOCATION: PT-PZ-1

HYDRAULIC CONDITIONS: Unconfined to semi-confined Alluviul Aquifer - Porous Flow

PERTINENT OBSERVATION: Groundwater first observed at 490' while drilling. Quantity of groundwater increased dramatically after blowing borehole at 500'. Static water level, measured one day after drilling to total depth, is 449.4' (ground surface). Static water level in cased borehole is 448.75' (ground surface).

PT-PZ-2

COMPLETION DIAGRAM



WELL SUMMARY

Location ID: PT-PZ-2 Field Representative(s): P.S. Egan

Date Started: 01/15/90 Date Completed: 01/18/90

Northing: 226849.93 Easting: 401977.90

Brass Cap: N/A Outer Casing: N/A Inner Casing: 4520.63

Drilling Method: Air-Foam Rotary Drilling Contractor: Larjon Drilling Co.

Driller: J. Gower

Total Depth Borehole: 515' Total Depth Well Casing: 509.40'

Total Depth Surface Casing: no surface casing

Diameter Well Casing: 2" Diameter Surface Casing: no surface casing

Length of Bottom Blank: no bottom blank

Type of Screen: steel well point 0.02 slot

Screen Interval: 503.85' to 508.85'

Water First Detected: 470' Water Level Open Borehole: 438.96' (g.l.)

Water Level Cased Borehole: 447.70' (g.l.)

Quik-Foam Use: not recorded

Estimated Water Use: 1,800 gallons

Well Casing: 2" galvanized steel x 510.4' (including well point)

4in x 3ft SCD 40 PVC:
4in x 5ft SCD 40 PVC:
4in x 10ft SCD 40 PVC:
4in x 20ft SCD 40 PVC:
Total SCD 40 PVC pipe: ft

stock SS centralizers:
custom SS centralizers:
4"x2' SS locking riser:
4" SS locking cap:
4" SS female cap: ft

4in x 3ft SCD 5 SS pipe:
4in x 5ft SCD 5 SS pipe:
4in x 10ft SCD 5 SS pipe:
4in x 20ft SCD 5 SS pipe:
Total SCD 5 SS pipe: ft

4in x 5ft SCD 10 SS pipe:
4in x 10ft SCD 10 SS pipe:
4in x 20ft SCD 10 SS pipe:
Total SCD 10 SS pipe: ft

Well Completion:

100# bags 16/40 sand:	2	bags
100# bags 10/20 sand:		bags
100# bags 8/14 sand:		bags
100# bags 8/20 sand:	13	bags
100# bags 4/8 sand:	7	bags
94# bags cement:		bags
5 gal. buckets bentonite:		buckets
50# bentonite powder:		bags
Benseal:	¼	bag for plug

Surface Casing: No surface casing

94# bags cement:	bags
50# bags bentonite powder:	bags
Grout:	bags

Pertinent Field Notes:

01/15/90 Spud piezometer. Drill 0'-410', 6½" tricone bit using air-foam rotary. Drilling is rapid through predominantly clay and clay-rich alluvium. 1,350 gallons water used for drilling. - Egan

01/16/90 Continue drilling 410'-515'. Water observed immediately after making connection at 470'. T.D. hole 45' into aquifer at 515'. 450 gallons water used for drilling. SWL in open borehole at 438.96', but borehole conditions were poor so reading may contain some error. Install 2" piezometer casing and steel well point. Bottom of casing at 509.4', screened interval ≈ 504'-509'. Install 2 bags 8/20. - Egan.

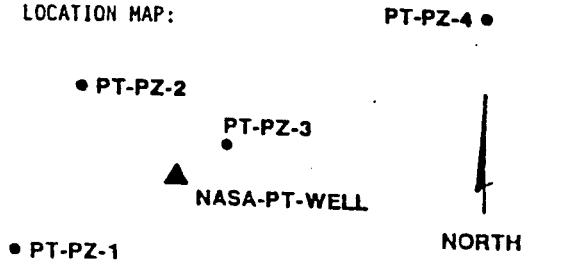
01/17/90 Install remainder of 8/20 gravel pack (8 bags) and 16/40 (2 bags). Pump benseal plug at top of aquifer and let cure overnight. Mobilize drilling equipment to PT-PZ-3. - Egan

01/18/90 Sound top of Benseal plug at 454.55' (13' of plug). Install filler sand to approximatly 37' above static water level (This number is estimated because the sounder could not make it down borehole annulus to top of sand. Sand calculations from this piezometer were used for estimate). Secure piezometer head.

01/25/90 Develop piezometer by air-jetting with ¾" poly pipe. Volume of water discharging is low, but water cleans up after 2 hours of air jetting/lifting. Fluid levels measured prior to and after jetting indicate communication with aquifer is good. (Piezometer recovered completely by the time air jetting tube was removed from casing.) Piezometer is ready for pump test. - Egan

LITHOLOGIC LOG

LOCATION MAP:



SE 1/4 SW 1/4 NE 1/4 NE 1/4 S 5 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: PT-PZ-2

SITE COORDINATES (ft.):

N 226849.93 E 401977.90

GROUND ELEVATION (ft. MSL): 4520.63 (T.C.)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Air-Foam Rotary

DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 01/15/90 DATE COMPLETED: 01/18/90

FIELD REP.: P.S. Egan

COMMENTS: 6¼" bit; air-foam rotary; 0'-515'. Total Depth = 515'. No bedrock encountered. Temporary piezometer for Private Land Pump Test.

LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			(Timed manually by driller every 15 feet)	Cuttings 0'-50'	0'-450' Alluvium (Santa Fe Group): Alluvium is multi-colored, but predominant color is medium gray (N5); cuttings are 0.2 inches average diameter, angular flakes to blocky, moderate- to poorly-sorted. Natural grains include subrounded to rounded sand, silt and clay; Samples frequently have a bimodal grain-size distribution and occasionally are uniform in size and shape; poorly- to moderately-cemented. Polygenetic pebble to boulder conglomerate. Caliche present at surface and caliche or clay present at various intervals throughout the section. Alluvium becomes volcanic-rich (andesite) with depth. Cutting lithologies include gray (N5) micritic limestone, white (N9) rhyolite, dusky red (5 R 3/4), dark gray (N3), and grayish green (10 GY 5/2) andesite, brown sandstone, dusky red and olive green siltstone, clear quartz, white calcite and reddish granite.
10					
15			10		
20					
25					0'-25' Alluvium is very coarse-grained, clay and silt-rich (cuttings up to 2 inches in diameter).
30			13		25'-30' Clay-rich interval.
35			4		
40					
45					
50			7		

LOCATION ID: PT-PZ-2

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
50			7	Cuttings (cont'd) 50'-115'	
55					
60					
65			9		65'-70' Caliche present as individual grains and also as coating on grains.
70					
75					
80			14		
85					
90					
95			9		
100					
105					
110			8		
115					

LOCATION ID: PT-PZ-2

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
115				Cuttings (cont'd) 115'-180'	
120					
125			13		
130					
135					
140			8		140'-230' Samples are clay-rich (90-100% clay).
145					
150					
155			7		
160					
165					
170			8		
175					
180					

LOCATION ID: PT-PZ-2

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180				Cuttings (cont'd) 180'-245'	
185			7		
190					
195					
200			6		
205					
210					
215			6		
220					
225					
230			8		230'-265' Clay is gradually becoming gravelly clay then clayey gravel.
235					
240					
245			7		

LOCATION ID: PT-PZ-2

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245			7	Cuttings (cont'd) 245'-310'	
250					
255					
260			9		
265					265'-270' First observation of gray and green andesite in cuttings.
270					265'- Cuttings are fairly uniform in size and shape. Average cutting size is 0.15 inches.
275			9		
280					
285					285'-295' Sandy clay.
290			7		
295					
300					
305			10		
310					

LOCATION ID: PT-PZ-2

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310				Cutting (cont'd) 310'-375'	
315					
320			19		
325					325'-335' Clay-rich interval. Sandy clay.
330					
335			11		
340					
345					345'-350' White calcite is present in cuttings, but less than 10%.
350			13		
355					
360					
365			14		365'-375' Decrease in average cutting size to 0.05-0.1 inch. Rhyolite is predominant lithology within volcanic fraction.
370					
375					

LOCATION ID: PT-PZ-2

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
375				Cuttings (cont'd) 375'-440'	375'-410' Clay-rich interval.
380			11		
385					
390					
395			13		
400					
405					
410			9		
415					415'-515' Formation appears to be getting harder. Cuttings are more angular and bit is chattering in some intervals.
420					415'-425' Calcite present in cuttings.
425			8		
430					
435					435'-445' Decrease in cutting size to less than 0.1 inch average. Cuttings are fairly uniform.
440			6		

LOCATION ID: PT-PZ-2

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
440			6	Cuttings (cont'd) 440'-505'	
445					
450					450'-515' Andesite-Rich Alluvium (Santa Fe Group): Dusky red (5 R 3/4) and dark gray (N3) porphyritic and aphanitic andesite with green phenocrysts predominate samples. Volcanics comprise 90-100% of cuttings.
455			9		
460					
465					
470			6		
475					
480					480'-515' Calcite present in samples, but less than 10%.
485			6		
490					
495					
500			5		
505					

LOCATION ID: PT-PZ-2

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
505				Cuttings (cont'd) 505'-515'	
510					
515			6		TD = 515'
520					
525					
530					
535					
540					
545					
550					
555					
560					
565					
570					

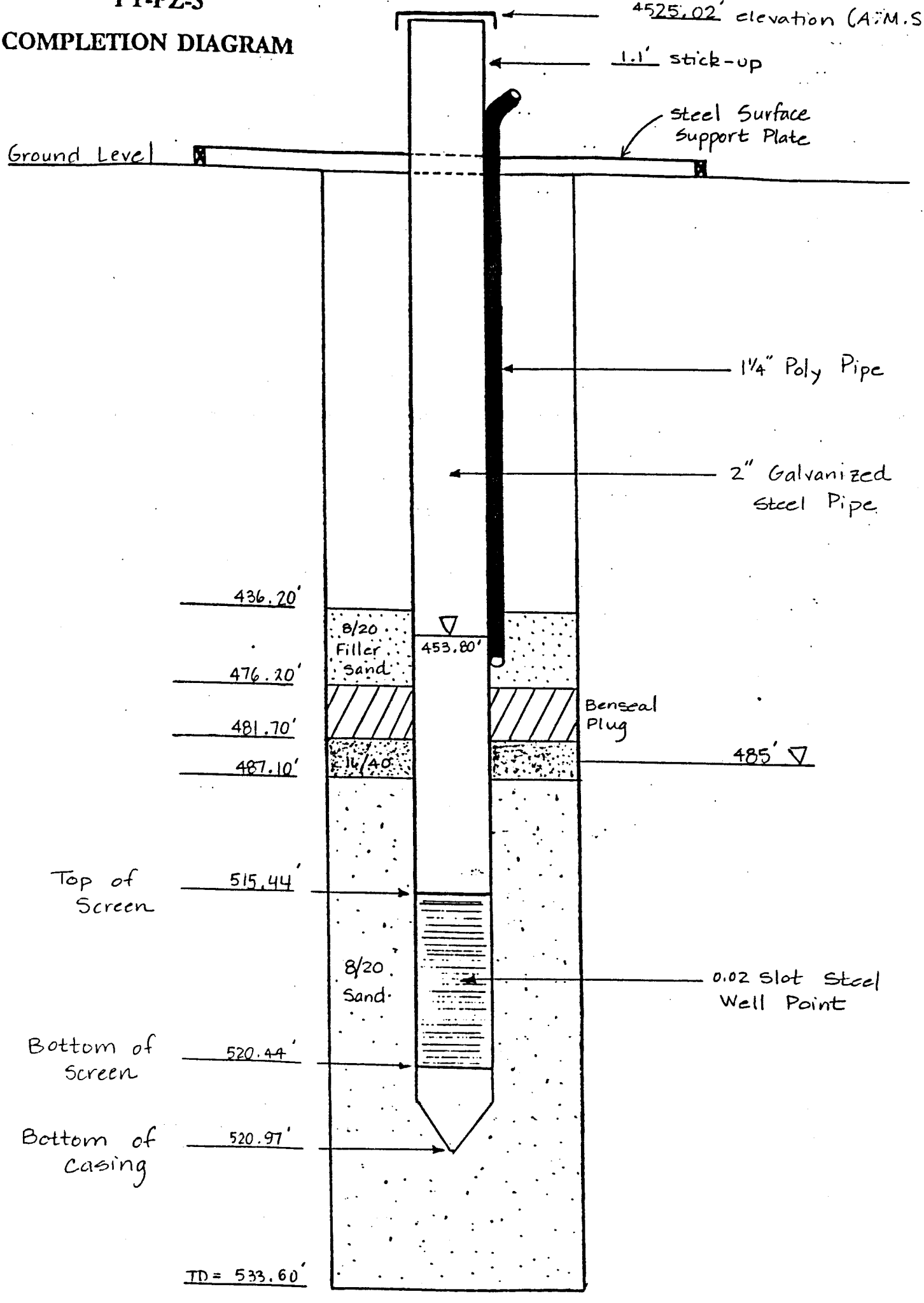
LOCATION: PT-PZ-2

HYDRAULIC CONDITIONS: Apparent Artesian Alluvial Aquifer

PERTINENT OBSERVATIONS: Water observed in drilling fluid discharge at 470'. Water level in cased borehole after overnight recovery was 447.70' (ground level).

PT-PZ-3

COMPLETION DIAGRAM



WELL SUMMARY

Location ID: PT-PZ-3 Field Representative(s): P.S. Egan

Date Started: 01/17/90 Date Completed: 01/22/90

Northing: 226776.73 Easting: 402174.62

Brass Cap: N/A Outer Casing: N/A Inner Casing: 4525.02

Drilling Method: Air-Foam Rotary Drilling Contractor: Larjon Drilling Co.

Driller: J. Gower

Total Depth Borehole: 533.6' Total Depth Well Casing: 520.97'

Total Depth Surface Casing: no surface casing

Diameter Well Casing: 2" Diameter Surface Casing: no surface casing

Length of Bottom Blank: no bottom blank

Type of Screen: steel well point 0.02 slot

Screen Interval: 515.44' to 520.44'

Water First Detected: 485' Water Level Open Borehole: 453.7 (g.l.)

Water Level Cased Borehole: 453.8' (T.O.C.)

Quik-Foam Use: not recorded

Estimated Water Use: 1,920 gallons water

Well Casing: 2" galvanized steel x 522.07' (including screen)

4in x 3ft SCD 40 PVC:
4in x 5ft SCD 40 PVC:
4in x 10ft SCD 40 PVC:
4in x 20ft SCD 40 PVC:
Total SCD 40 PVC pipe: ft

stock SS centralizers:
custom SS centralizers:
4"x2' SS locking riser:
4" SS locking cap:
4" SS female cap: ft

4in x 3ft SCD 5 SS pipe:
4in x 5ft SCD 5 SS pipe:
4in x 10ft SCD 5 SS pipe:
4in x 20ft SCD 5 SS pipe:
Total SCD 5 SS pipe: ft

4in x 5ft SCD 10 SS pipe:
4in x 10ft SCD 10 SS pipe:
4in x 20ft SCD 10 SS pipe:
Total SCD 10 SS pipe: ft

Well Completion:

100# bags 16/40 sand:	5	bags
100# bags 10/20 sand:		bags
100# bags 8/14 sand:		bags
100# bags 8/20 sand:	16	bags

94# bags cement:		bags
5 gal. buckets bentonite:		buckets
50# bentonite powder:		bags
Benseal:	¼	bag for plug

Surface Casing: No surface casing

94# bags cement:	bags
50# bags bentonite powder:	bags
Grout:	bags

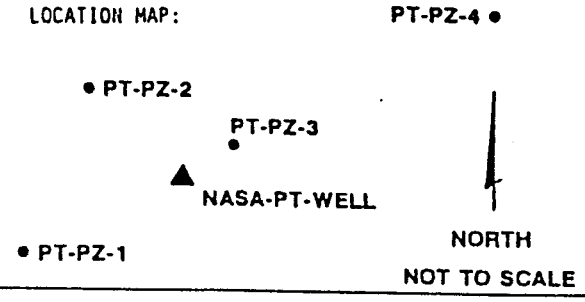
Pertinent Field Notes:

01/17/90	Spud piezometer hole #3 using air-foam rotary, 6½" tricone bit. Drill 0'-140'. Used 300 gallons water. - Egan
01/18/90	Continue drilling, 140'-530'. Observed water in drilling fluid discharge at 485'. T.D. piezometer 45' into the aquifer at 530'. - Egan.
01/19/90	Install 2" piezometer casing and attached poly pipe. Install gravel pack to top of water-bearing horizon, then pump benseal plug. - Egan
01/22/90	Sound top of benseal plug through poly pipe. Have a 5.5' thick plug. Install 10 bags of filler sand. Thickness of filler sand had to be estimated because cannot sound through poly pipe or down annulus. Extra sand was installed to be sure sand is above SWL. Demobilize and mobilize to PT-PZ-4. Secure PT-PZ-3 at surface. - Egan.
01/25/90	Develop piezometer via air-jetting and air-lifting. Jet for 1 hour and stop for day. - Egan

01/26/90 Continue air jetting piezometer. Jet for another 1½ hours. Water from discharge is clear. Static water levels taken prior to and after jetting indicate communication with aquifer is good. Water level completely recovers by the time poly pipe is removed from casing (approx. 20 min.). Piezometer #3 is ready for pump test. - Egan

LITHOLOGIC LOG

LOCATION MAP:



SE 1/4 SW 1/4 NE 1/4 NE 1/4 S 5 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: PT-PZ-3

SITE COORDINATES (ft.):

N 226776.73 E 402174.62

GROUND ELEVATION (ft. MSL): 4525.02 (T.C.)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Air-Foam Rotary

DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 01/17/90 DATE COMPLETED: 01/22/90

FIELD REP.: P.S. Egan

COMMENTS: 6¼" bit; Air-Foam Rotary; 0'-530'. Bedrock not encountered. Temporary piezometer for Private Land Pump Test.

LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			(Timed manually by driller every 15 feet)	Cuttings 0'-50'	0'-530' Alluvium (Santa Fe Group): Alluvium is multi-colored, but predominant color is medium gray (N5); cuttings large for the first 175', up to 1.5 inches in diameter, then decrease to 0.3 inches average, angular flakes to blocky, moderate to poorly sorted. Natural grains include fine to medium sand, silt, and clay; Samples frequently exhibit a bimodal grain-size distribution, but occasionally are uniform in size and shape; poorly- to moderately-cemented. Polygenetic pebble to boulder conglomerate. Caliche present at surface and clay present at various intervals within the upper section. Alluvium becomes volcanic-rich at bottom of section (480'-530'). Cutting lithologies include gray (N5) micritic limestone, white (N9) rhyolite, dusky red (5 R 3/4), dark gray (N3), and grayish green (10 GY 5/2) aphanitic to porphyritic andesite, and minor amounts of sandstone, siltstone, quartz, granite and calcite.
10					
15			10		0'-275' Clay-rich alluvium.
20					15'-20' Clayey gravel.
25					5'-175' Some cuttings in samples very large. Up to 1.5 inches in diameter.
30			13		
35			4		35'-50' Gravelly clay to clay zone.
40					
45					
50			7		

LOCATION ID: PT-PZ-3

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
50			7	Cuttings (cont'd) 50'-115'	50'-60' Clayey gravel.
55					
60					
65			9		65'-75' Clayey gravel.
70					
75					
80			8		
85					
90					
95			9		
100					
105					
110			8		
115					

LOCATION ID: PT-PZ-3

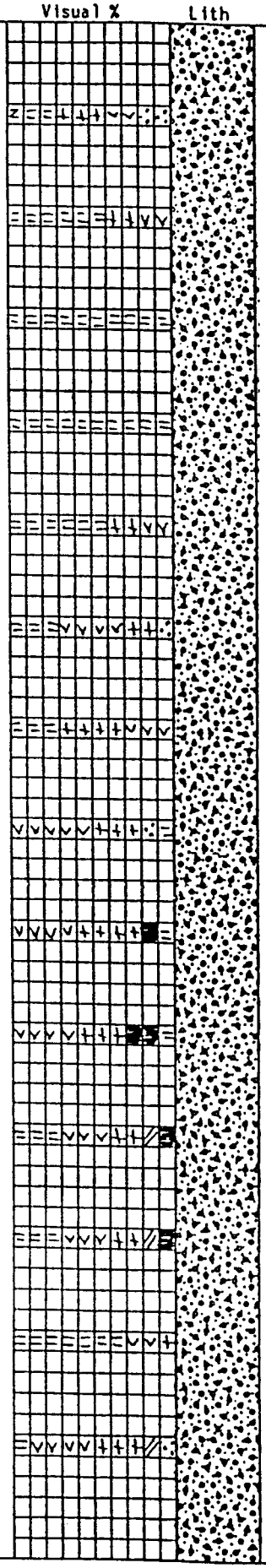
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
115				Cuttings (cont'd) 115'-180'	
120					
125			13		
130					
135					
140			8		
145					
150					
155			7		
160					
165					
170			8		
175					
180					

LOCATION ID: PT-PZ-3

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180				Cuttings (cont'd) 180'-245'	
185			7		185'-195' Clay interval.
190					
195					
200			6		
205					
210					
215			6		
220					220'-235' Increase in average cutting size to 0.4 inches.
225					
230			8		
235					
240					
245			7		

LOCATION ID: PT-PZ-3

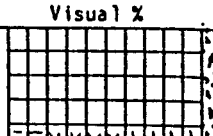
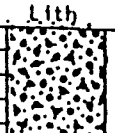
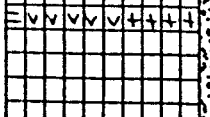
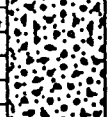
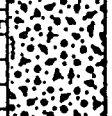
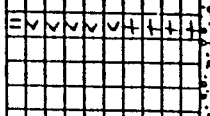
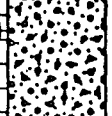
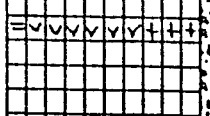
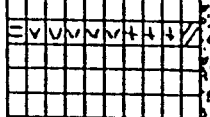
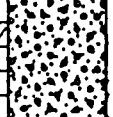
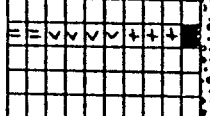
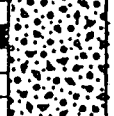
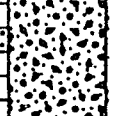
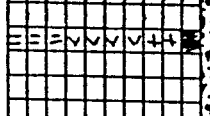
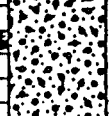
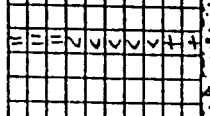
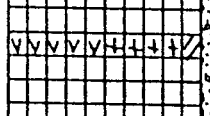
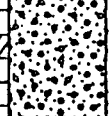
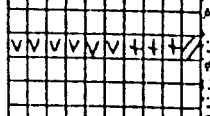
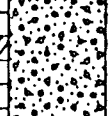
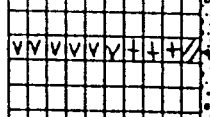
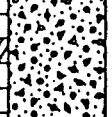
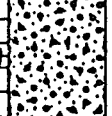
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245			7	Cuttings (cont'd) 245'-310'	
250					
255					
260			9		
265					
270					
275			9		
280					
285					
290			7		
295					
300					
305			10		
310					



LOCATION ID: PT-PZ-3

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310				Cutting (cont'd) 310'-375'	
315					
320			19		
325					
330					
335			11		
340					
345					345'-355' Clay-rich interval.
350			13		
355					
360					
365			14		
370					
375					

LOCATION ID: PT-PZ-3

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
375				Cuttings (cont'd) 375'-440'	
380			11		
385					
390					
395			13		
400					
405					
410			9		
415					
420					
425			8		
430					
435					
440			6		

LOCATION ID: PT-PZ-3

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
440			6	Cuttings (cont'd) 440'-505'	
445					
450					
455			9		
460					
465					
470			6		
475					
480					480'-500' Alluvium is gradually becoming volcanic-rich (andesite).
485			6		
490					
495					
500			5		500'-530' Andesite-Rich Alluvium (Santa Fe Group): Alluvium is composed predominantly of dusky red, green, and gray andesite and lesser amounts of rhyolite.
505					

LOCATION ID: PT-PZ-3

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
505				Cuttings (cont'd) 505'-530'	
510					
515			6		
520					
525					525'-530' Drilling foam changed from gray to purple.
530			6		TD = 530'
535					
540					
545					
550					
555					
560					
565					
570					

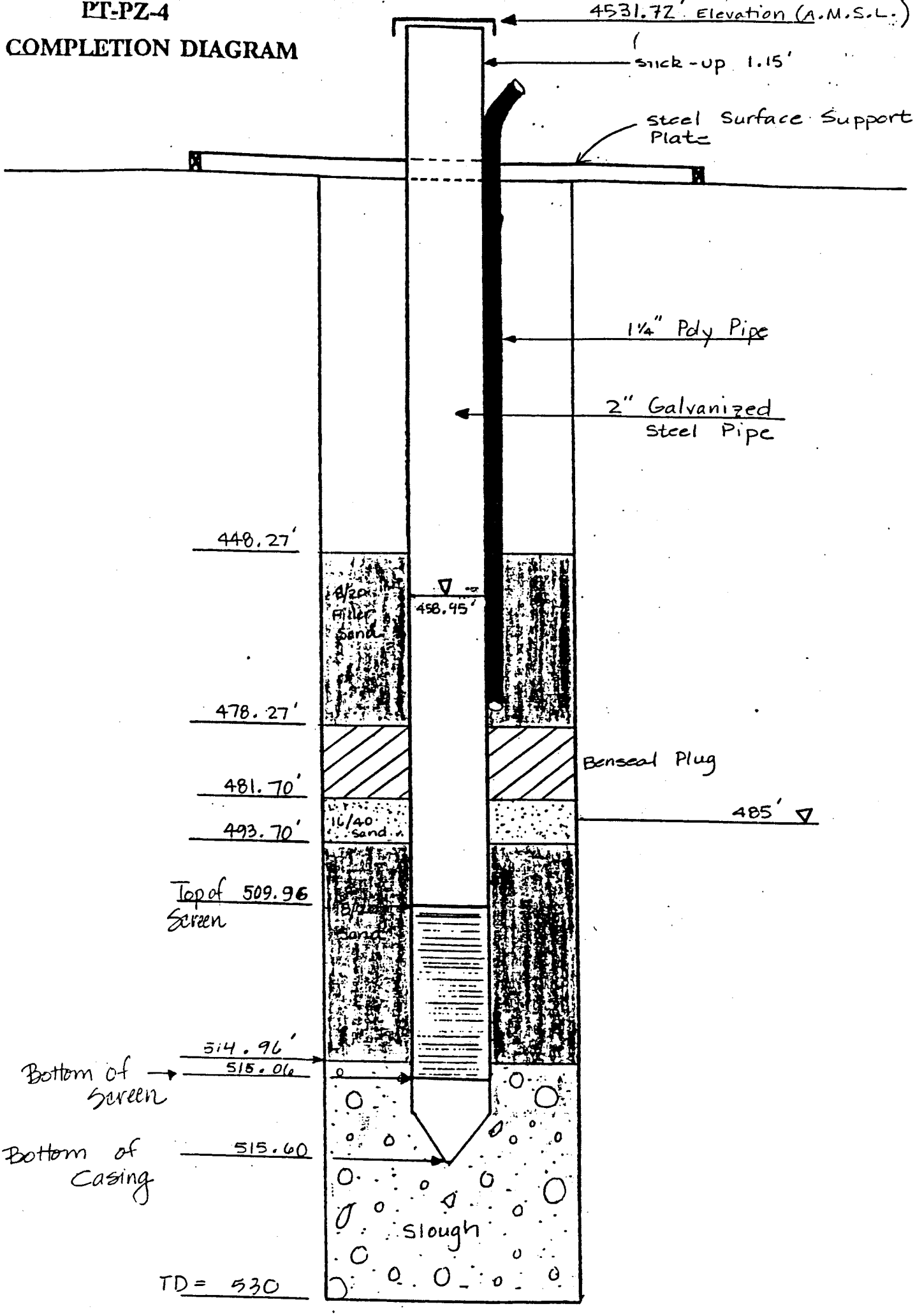
LOCATION: PT-PZ-3

HYDRAULIC CONDITIONS: Apparent Artesian Alluvial Aquifer

PERTINENT OBSERVATIONS: Water observed in drilling fluid discharge at 485'. Water level measured in borehole at 453.7' (g.l.) after overnight recovery.

PT-PZ-4

COMPLETION DIAGRAM



WELL SUMMARY

Location ID: PT-PZ-4 Field Representative(s): P.S. Egan

Date Started: 01/22/90 Date Completed: 01/25/90

Northing: 226875.56 Easting: 402565.38

Brass Cap: N/A Outer Casing: N/A Inner Casing: 4531.72

Drilling Method: Air-Foam Rotary Drilling Contractor: Larjon Drilling Co.

Driller: J. Gower

Total Depth Borehole: 530' Total Depth Well Casing: 514.45'

Total Depth Surface Casing: no surface casing

Diameter Well Casing: 2" Diameter Surface Casing: no surface casing

Length of Bottom Blank: no bottom blank

Type of Screen: steel well point 0.02 slot

Screen Interval: 508.81' to 513.91'

Water First Detected: 485' Water Level Open Borehole: 459.32' (gl)

Water Level Cased Borehole: 448.27' (g.l.)

Quik-Foam Use: not recorded

Estimated Water Use: 2,249 gallons

Well Casing: 2" galvanized steel x 515.6' (including screen)

4in x 3ft SCD 40 PVC:		stock SS centralizers:	
4in x 5ft SCD 40 PVC:		custom SS centralizers:	
4in x 10ft SCD 40 PVC:		4"x2' SS locking riser:	
4in x 20ft SCD 40 PVC:		4" SS locking cap:	
Total SCD 40 PVC pipe:	ft	4" SS female cap:	ft
4in x 3ft SCD 5 SS pipe:			
4in x 5ft SCD 5 SS pipe:		4in x 5ft SCD 10 SS pipe:	
4in x 10ft SCD 5 SS pipe:		4in x 10ft SCD 10 SS pipe:	
4in x 20ft SCD 5 SS pipe:		4in x 20ft SCD 10 SS pipe:	
Total SCD 5 SS pipe:	ft	Total SCD 10 SS pipe:	ft

Well Completion:

100# bags 16/40 sand:	3	bags
100# bags 10/20 sand:		bags
100# bags 8/14 sand:		bags
100# bags 8/20 sand:	16	bags

94# bags cement:		bags
5 gal. buckets bentonite:		buckets
50# bentonite powder:		bags
Benseal:	¼	bag for plug

Surface Casing: No surface casing

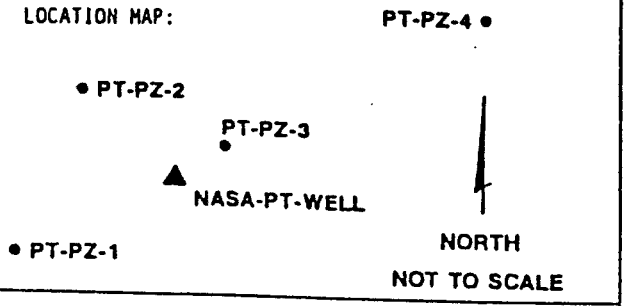
94# bags cement:	bags
50# bags bentonite powder:	bags
Grout:	bags

Pertinent Field Notes:

01/15/90	Spud piezometer hole #4. Drill, air-foam rotary, 6½" tricone bit, 0'-140'. - Egan
01/23/90	Continue drilling, 140'-530'. Observe water in drilling fluid discharge at 485'. T.D. hole at 530', 45' into the aquifer. - Egan.
01/24/90	Fluid level in open borehole measured at 459.32'. Sound bottom of borehole at 514.96' (15' of slough in hole). Install piezometer casing with poly pipe attached. Install 8/20 gravel pack and 16/40 to top of water horizon. Pump benseal plug. - Egan.
01/25/90	Sound top of benseal plug and measure SWL in piezometer casing. Install 10 bags of 18/20 filler sand to ≈ 11' above SWL. - Egan
01/26/90	Develop piezometer by air-jetting and lifting. Jet piezometer for ≈ 1¾ hours. Discharge is clean. Fluid levels prior to and after jetting indicate communication with aquifer is good. (Piezometer recovered completely by the time poly pipe was removed from casing - approx. 10 min.) Piezometer is ready for pump test. - Egan

LITHOLOGIC LOG

LOCATION MAP:



SE 1/4 SW 1/4 NE 1/4 NE 1/4 S 5 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: PT-PZ-4

SITE COORDINATES (ft.):

N 226875.56 E 402565.38

GROUND ELEVATION (ft. MSL): 4531.72 (T.C.)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Air-Foam Rotary

DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 01/22/90 DATE COMPLETED: 01/25/90

FIELD REP.: P.S. Egan

COMMENTS: 6¼" bit, Air-Foam Rotary; Total Depth = 530'. Bedrock not encountered. Temporary piezometer for Private Land Pump Test.

LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			(Timed manually by driller every 15 feet)	Cuttings 0'-50'	0'-530' Alluvium (Santa Fe Group): Alluvium is multi-colored, but predominant color is medium gray (N5); cuttings are 0.2 inches average diameter, angular flakes to blocky, moderate to poor sorting. Natural grains include fine to medium sand, silt, and clay; samples frequently exhibit a bimodal grain-size distribution, but occasionally are uniform in size and shape; poorly- to moderately-cemented. Polygenetic pebble to boulder conglomerate. Caliche present at surface to 20' and thick and thin clay zones present throughout section. Alluvium becomes volcanic-rich (dusky red (5 R 3/4) andesite) at bottom of section (480'-530'). Cutting lithologies include gray (N5) micritic limestone, white (N9) rhyolite, dusky red (5 R 3/4) dark gray (N3) and grayish green (10 GY 52) aphanitic to porphyritic andesite, and minor amounts of sandstone, siltstone, quartz, granite and calcite.
10					
15			11		
20					0'-20' Silty, sandy gravel.
25					20'-170' Clay-rich alluvium.
30			13		
35					
40					
45					
50			13		

LOCATION ID: PT-PZ-4

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
50			13	Cuttings (cont'd) 50'-115'	
55					
60					
65			11		
70					
75					
80			7		
85					
90					
95			11		
100					
105					
110			7		
115					

LOCATION ID: PT-PZ-4

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
115				Cuttings (cont'd) 115'-180'	
120					
125			10		
130					
135					
140			11		
145					
150					
155			7		
160					
165					
170			6		170'-220' Clay lens. Samples are 100% clay.
175					
180					

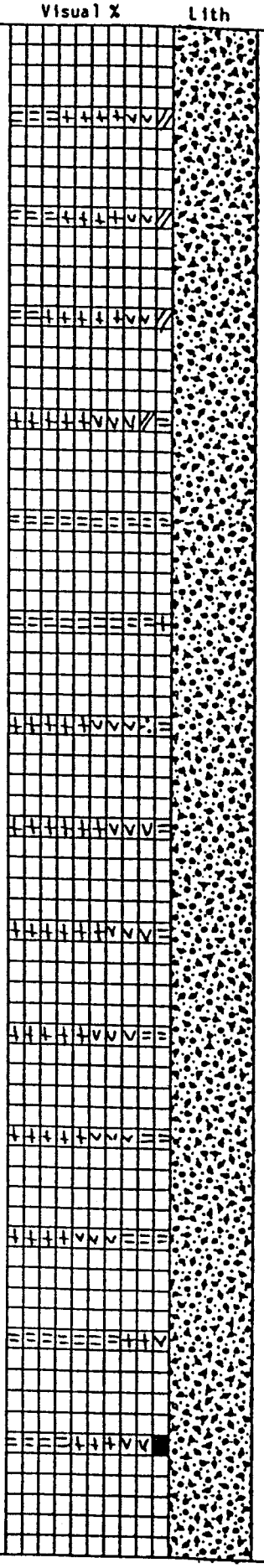
LOCATION ID: PT-PZ-4

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180				Cuttings (cont'd) 180'-245'	
185			7		
190					
195					
200			6		
205					
210					
215			7		
220					
225					225'-235' Clayey gravel zone.
230			11		
235					235'-250' Samples become more clay-rich.
240					
245			8		

LOCATION ID: PT-PZ-4

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245			8	Cuttings (cont'd) 245'-310'	
250					
255					
260			12		
265					
270					
275			9		
280					
285					
290			8		290'-300' Silty-clay zone.
295					
300					
305			11		
310					

LOCATION ID: PT-PZ-4

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310				Cuttings (cont'd) 310'-375'	
315					
320			7		
325					325'-335' Silty-clay interval.
330					
335			18		
340					
345					
350			11		
355					
360					
365			10		365'-375' Clay-rich interval.
370					
375					

LOCATION ID: PT-PZ-4

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
375				Cuttings (cont'd) 375'-440'	
380			10		
385					
390					
395			10		
400					
405					405'-460' Clay-rich zone.
410			11		
415					
420					
425			10		
430					
435					
440			8		

LOCATION ID: PT-PZ-4

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
440			8	Cuttings (cont'd) 440'-505'	
445					
450					
455			9		
460					
465					
470			9		
475					
480					480' Foam changes to a purple color. 480'-530' Andesite-rich alluvium. 480'-495' Poor returns. Mostly finely ground purple andesite that has the appearance of clay.
485			11		
490					
495					
500			7		
505					

LOCATION ID: PT-PZ-4

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
505				Cuttings (cont'd) 505'-530'	
510					
515			7		
520					
525					
530			8		TD = 530'
535					
540					
545					
550					
555					
560					
565					
570					

LOCATION: PT-PZ-4

HYDRAULIC CONDITIONS: Apparent Artesian Alluvial Aquifer

PERTINENT OBSERVATIONS: Observed water in drilling fluid while drilling at 485'. Water level in open borehole after overnight recovery was 459.32' (g.l.).

Appendix B

Water Level Data and Field Notes

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well:Pz-1 r(ft)= 201

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	900	0.00	0.00E+00	450.52	0.02	0.00	450.50	0.00
		0.25	6.19E-06	450.52	0.02	0.00	450.50	0.00
		0.50	1.24E-05	450.55	0.02	0.00	450.53	-0.03
		0.75	1.86E-05	450.58	0.02	0.00	450.56	-0.06
	901	1.00	2.48E-05	450.60	0.02	0.00	450.58	-0.08
		1.25	3.09E-05	450.67	0.02	0.00	450.65	-0.15
		1.50	3.71E-05	450.70	0.02	0.00	450.68	-0.18
	902	2.00	4.95E-05	450.77	0.02	0.00	450.75	-0.25
	903	3.00	7.43E-05	450.91	0.02	0.00	450.89	-0.39
	904	4.00	9.90E-05	451.00	0.02	0.00	450.98	-0.48
	905	5.00	1.24E-04	451.08	0.02	0.00	451.06	-0.56
	906	6.00	1.49E-04	451.14	0.02	0.00	451.12	-0.62
	907	7.00	1.73E-04	451.20	0.02	0.00	451.18	-0.68
	908	8.00	1.98E-04	451.25	0.02	0.00	451.23	-0.73
	909	9.00	2.23E-04	451.28	0.02	0.00	451.26	-0.76
	910	10.00	2.48E-04	451.31	0.02	0.00	451.29	-0.79
	915	15.00	3.71E-04	451.42	0.02	0.00	451.40	-0.90
	920	20.00	4.95E-04	451.50	0.02	0.00	451.48	-0.98
	925	25.00	6.19E-04	451.55	0.02	0.00	451.53	-1.03
	930	30.00	7.43E-04	451.58	0.01	0.00	451.57	-1.07
	945	45.00	1.11E-03	451.67	0.01	0.00	451.66	-1.16
	1000	60.00	1.49E-03	451.73	0.01	0.00	451.72	-1.22
	1057	117.00	2.90E-03	451.85	0.00	0.00	451.85	-1.35
	1204	184.00	4.55E-03	451.92	-0.04	0.00	451.96	-1.46
	1258	238.00	5.89E-03	451.95	-0.05	0.00	452.00	-1.50
	1358	298.00	7.38E-03	451.98	-0.09	0.00	452.07	-1.57
	1457	357.00	8.84E-03	451.99	-0.11	0.00	452.10	-1.60
	1657	477.00	1.18E-02	452.01	-0.16	0.00	452.17	-1.67
	1857	597.00	1.48E-02	452.03	-0.18	0.00	452.21	-1.71
	2100	720.00	1.78E-02	452.11	-0.15	0.00	452.26	-1.76
6/5/90	105	965.00	2.39E-02	452.24	-0.15	0.00	452.39	-1.89
	500	1200.00	2.97E-02	452.43	-0.12	0.00	452.55	-2.05
	858	1438.00	3.56E-02	452.42	-0.09	0.00	452.51	-2.01
	1258	1678.00	4.15E-02	452.48	-0.16	0.00	452.64	-2.14
	1658	1918.00	4.75E-02	452.46	-0.25	0.00	452.71	-2.21
	2059	2159.00	5.34E-02	452.54	-0.19	0.00	452.73	-2.23
6/6/90	105	2405.00	5.95E-02	452.77	-0.14	0.00	452.91	-2.41
	454	2634.00	6.52E-02	452.87	-0.11	0.00	452.98	-2.48
	858	2878.00	7.12E-02	453.01	-0.07	0.00	453.08	-2.58
	958	2938.00	7.27E-02	452.93	-0.08	0.00	453.01	-2.51
	1058	2998.00	7.42E-02	452.90	-0.10	0.00	453.00	-2.50
	1200	3060.00	7.57E-02	452.90	-0.13	0.00	453.03	-2.53
	1258	3118.00	7.72E-02	452.89	-0.15	0.00	453.04	-2.54
	1530	3270.00	8.09E-02	452.84	-0.21	0.00	453.05	-2.55
	1658	3358.00	8.31E-02	452.83	-0.21	0.00	453.04	-2.54
	2102	3602.00	8.92E-02	452.89	-0.16	0.00	453.05	-2.55
6/7/90	54	3834.00	9.49E-02	453.07	-0.12	0.00	453.19	-2.69
	457	4077.00	1.01E-01	453.12	-0.08	0.00	453.20	-2.70
	900	4320.00	1.07E-01	453.12	-0.07	0.00	453.19	-2.69
	1305	4565.00	1.13E-01	453.16	-0.13	0.00	453.29	-2.79
	1658	4798.00	1.19E-01	453.12	-0.18	0.00	453.30	-2.80

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: P1-1-486 r(ft)= 1075

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	737	0.00	0.00E+00	450.63	0.02	0.00	450.61	0.00
	1052	112.00	9.69E-05	450.79	0.00	0.00	450.79	-0.18
	1151	171.00	1.48E-04	450.82	-0.04	0.00	450.86	-0.25
	1251	231.00	2.00E-04	450.79	-0.05	0.00	450.84	-0.23
	1348	288.00	2.49E-04	450.78	-0.09	0.00	450.87	-0.26
	1439	339.00	2.93E-04	450.75	-0.10	0.00	450.85	-0.24
	1526	386.00	3.34E-04	450.74	-0.11	0.00	450.85	-0.24
	1708	488.00	4.22E-04	450.71	-0.16	0.00	450.87	-0.26
	1905	605.00	5.24E-04	450.71	-0.18	0.00	450.89	-0.28
	2121	741.00	6.41E-04	450.76	-0.15	0.00	450.91	-0.30
6/5/90	115	975.00	8.44E-04	450.79	-0.15	0.00	450.94	-0.33
	529	1229.00	1.06E-03	450.89	-0.11	0.00	451.00	-0.39
	915	1455.00	1.26E-03	450.93	-0.09	0.00	451.02	-0.41
	1301	1681.00	1.45E-03	450.90	-0.16	0.00	451.06	-0.45
	1712	1932.00	1.67E-03	450.84	-0.23	0.00	451.07	-0.46
	2111	2171.00	1.88E-03	450.91	-0.19	0.00	451.10	-0.49
6/6/90	109	2409.00	2.08E-03	451.04	-0.14	0.00	451.18	-0.57
	512	2652.00	2.29E-03	451.10	-0.11	0.00	451.21	-0.60
	949	2929.00	2.53E-03	451.17	-0.08	0.00	451.25	-0.64
	1110	3010.00	2.60E-03	451.12	-0.10	0.00	451.22	-0.61
	1210	3070.00	2.66E-03	451.10	-0.12	0.00	451.22	-0.61
	1319	3139.00	2.72E-03	451.12	-0.15	0.00	451.27	-0.66
	1716	3376.00	2.92E-03	451.04	-0.21	0.00	451.25	-0.64
	2110	3610.00	3.12E-03	451.11	-0.17	0.00	451.28	-0.67
6/7/90	109	3849.00	3.33E-03	451.22	-0.12	0.00	451.34	-0.73
	510	4090.00	3.54E-03	451.27	-0.08	0.00	451.35	-0.74
	921	4341.00	3.76E-03	451.31	-0.07	0.00	451.38	-0.77
	1320	4580.00	3.96E-03	451.28	-0.13	0.00	451.41	-0.80
	1722	4822.00	4.17E-03	451.25	-0.18	0.00	451.43	-0.82
	2113	5053.00	4.37E-03	451.38	-0.12	0.00	451.50	-0.89
6/8/90	107	5287.00	4.58E-03	451.40	-0.09	0.00	451.49	-0.88
	508	5528.00	4.78E-03	451.44	-0.10	0.00	451.54	-0.93
	659	5639.00	4.88E-03	451.46	-0.08	0.00	451.54	-0.93

AQUIFER TEST DATA

Owner NASA - WS [redacted] Address [redacted] Dona [redacted] NM

Date 6/4/90 Company performing test GCL Measured by SEIKE/GAITHER

Well No. PZ-1 Distance from pumping well _____ Type of test Pump Test No. _____

Measuring equipment Electronic Water Level Indicator - Audible (LCs) Pg 1 of 6

Time Data
Pump on: Date 6/4/90 Time 0900 (t_o)
Pump off: Date _____ Time _____ (t'_o)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level 450.52
Measuring point casing top (south)
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	ΔS Water level change s or s'	S* adjusted - map	Discharge measurement	Rate		
0	6/4	0900:00	0.00				450.52			0.00					SET PROBE LC1 @ 0745-6/4/90 WL 450.50
15s	6/4	0900:15	0.25				450.52			0.00					* DENOTES AN UNSCHEDULED MEASURING EVENT
30s	6/4	0900:30	0.50				450.55			0.03					ΔS vs. t is fluctuating probably as a result of initial adjustments to Q after pump was turned on - operator error should not be more than ±0.005 ft and ± 2 seconds - SEE PUMPING RATE DATA SHEET
45s	6/4	0900:45	0.75				450.58			0.06					
60s	6/4	0901:00	1.00				450.60			0.08					
75s	6/4	0901:15	1.25				450.67			0.15					
90s	6/4	0901:30	1.50				450.70			0.18					
2m	6/4	0902	2				450.77			0.25					
3m	6/4	0903	3				450.91			0.39					
4m	6/4	0904	4				451.00			0.48					
5m	6/4	0905	5				451.08			0.56					
6m	6/4	0906	6				451.14			0.62					
7m	6/4	0907	7				451.20			0.68					
8m	6/4	0908	8				451.25			0.73					
9m	6/4	0909	9				451.28			0.76					
10m	6/4	0910	10				451.31			0.79					
15m	6/4	0915	15				451.42			0.90					
20m	6/4	0920	20				451.50			0.98					
25m	6/4	0925	25				451.55			1.03					
30m	6/4	0930	30				451.58			1.06					
45m	6/4	0945	45				451.67			1.15					
1H	6/4	1000	60				451.73	+.02		1.21	1.19				
2H	6/4	1057	117				451.85	0		1.33	1.33				
3H	6/4	1204	184				451.92	-.03		1.40	1.43				
4H	6/4	1258	238				451.95	-.05		1.43	1.48				
5H	6/4	1358	298				451.98	-.09		1.46	1.55				
6H	6/4	1457	357				451.99	-.11		1.47	1.58				
8H	6/4	1657	477				452.01	-.17		1.49	1.66				
10H	6/4	1857	597				452.03	-.18		1.51	1.69				END OF SHIFT - MLT

AQUIFER TEST DATA

Owner NASA - USTF Address _____ County Dona Ana State NM

Date 6/4/90 Company performing test GCL Measured by GAITHER / SELKE

Well No. PZ-1 Distance from pumping well _____ Type of test Pump Test No. _____

Measuring equipment LCS1 Pg 2 of 6

Time Data
Pump on: Date _____ Time _____ (t_o)
Pump off: Date _____ Time _____ (t'_o)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Adjusted drawdown s*	Discharge measurement	Rate		Comments on factors affecting test data
12H	6/4/90	2100	720				452.11	-.15		1.59	1.74				
16H	6/5/90	0105	965				452.24	-.14		1.72	1.86				
20H	6/5	0500	1200				452.43	-.12		1.91	2.03				
24H	6/5	0858	1438				452.42	-.09		1.90	1.99				START SHIFT - MWS EVERY 4 Hours
	6/5	1258	1678				452.48	-.15		1.96	2.11				
	6/5	1658	1918				452.46	-.22		1.94	2.16				END SHIFT - MWS
	6/5	2059	2159				452.54	-.19		2.02	2.21				
	6/6	0105	2405				452.77	-.13		2.25	2.38				PUMP ON FULL - FLOW METER IS DOWN - MWS - SEE LOG
	6/6	0454	2634				452.87	-.10		2.35	2.45				
	6/6	0858	2878				453.01	-.07		2.49	2.56				START SHIFT - MWS
*	6/6	0958	2938				452.93	-.08		2.41	2.49				FLOW METER RESTART ~0830 RESEALED SENSORS METER
*	6/6	1058	2998				452.90	-.10		2.38	2.48				OFF FROM 0920-0930 4606PM
*	6/6	1200	3060				452.90	-.12		2.38	2.50			Em	0930 - METER ON AND WORKING OK - 1400 6PM
	6/6	1258	3118				452.89	-.14		2.37	2.51				* TAKE 1 HR MEASUREMENTS
*	6/6	1530	3270				452.84	-.20		2.36	2.56				
	6/6	1658	3358				452.83	-.20		2.35	2.55				END SHIFT - MWS
	6/6	2102	3602				452.89	-.18		2.37	2.55				
	6/7	0054	3834				453.07	-.11		2.55	2.66				
	6/7	0457	4077				453.12	-.10		2.60	2.70				END SHIFT
	6/7	0900	4320				453.12	-.07		2.60	2.67				
	6/7	1305	4565				453.16	-.10		2.64	2.74				
	6/7	1658	4798				453.12			2.60					END SHIFT - MWS
	6/7	2102	5042				453.17			2.65					
	6/8	0104	5284				453.38			2.86					
	6/8	0501	5521				453.42			2.90					
	6/8	0745					453.24								

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: PZ-2 r(ft)= 144

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	900	0.00	0.00E+00	449.36	0.02	0.00	449.34	0.00
		0.25	1.21E-05	449.60	0.02	0.00	449.58	-0.24
		0.50	2.41E-05	449.96	0.02	0.00	449.94	-0.60
		0.75	3.62E-05	450.21	0.02	0.00	450.19	-0.85
	901	1.00	4.82E-05	450.30	0.02	0.00	450.28	-0.94
		1.25	6.03E-05	450.36	0.02	0.00	450.34	-1.00
		1.50	7.23E-05	450.42	0.02	0.00	450.40	-1.06
	902	2.00	9.65E-05	450.48	0.02	0.00	450.46	-1.12
	903	3.00	1.45E-04	450.60	0.02	0.00	450.58	-1.24
	904	4.00	1.93E-04	450.67	0.02	0.00	450.65	-1.31
	905	5.00	2.41E-04	450.73	0.02	0.00	450.71	-1.37
	906	6.00	2.89E-04	450.79	0.02	0.00	450.77	-1.43
	907	7.00	3.38E-04	450.82	0.02	0.00	450.80	-1.46
	908	8.00	3.86E-04	450.88	0.02	0.00	450.86	-1.52
	909	9.00	4.34E-04	450.89	0.02	0.00	450.87	-1.53
	910	10.00	4.82E-04	450.91	0.02	0.00	450.89	-1.55
	915	15.00	7.23E-04	451.03	0.02	0.00	451.01	-1.67
	920	20.00	9.65E-04	451.10	0.02	0.00	451.08	-1.74
	925	25.00	1.21E-03	451.17	0.02	0.00	451.15	-1.81
	930	30.00	1.45E-03	451.19	0.01	0.00	451.18	-1.84
	945	45.00	2.17E-03	451.31	0.01	0.00	451.30	-1.96
	1000	60.00	2.89E-03	451.36	0.01	0.00	451.35	-2.01
	1059	119.00	5.74E-03	451.51	0.00	0.00	451.51	-2.17
	1202	182.00	8.78E-03	451.59	-0.04	0.00	451.63	-2.29
	1300	240.00	1.16E-02	451.63	-0.05	0.00	451.68	-2.34
	1401	301.00	1.45E-02	451.67	-0.09	0.00	451.76	-2.42
	1459	359.00	1.73E-02	451.69	-0.11	0.00	451.80	-2.46
	1659	479.00	2.31E-02	451.72	-0.16	0.00	451.88	-2.54
	1859	599.00	2.89E-02	451.74	-0.18	0.00	451.92	-2.58
	2103	723.00	3.49E-02	451.82	-0.15	0.00	451.97	-2.63
6/5/90	107	967.00	4.66E-02	451.98	-0.15	0.00	452.13	-2.79
	506	1206.00	5.82E-02	452.20	-0.12	0.00	452.32	-2.98
	901	1441.00	6.95E-02	452.13	-0.09	0.00	452.22	-2.88
	1300	1680.00	8.10E-02	452.21	-0.16	0.00	452.37	-3.03
	1700	1920.00	9.26E-02	452.20	-0.25	0.00	452.45	-3.11
	2101	2161.00	1.04E-01	452.28	-0.19	0.00	452.47	-3.13
6/6/90	107	2407.00	1.16E-01	452.58	-0.14	0.00	452.72	-3.38
	456	2636.00	1.27E-01	452.69	-0.11	0.00	452.80	-3.46
	900	2880.00	1.39E-01	452.83	-0.07	0.00	452.90	-3.56
	1000	2940.00	1.42E-01	452.66	-0.09	0.00	452.75	-3.41
	1100	3000.00	1.45E-01	452.63	-0.11	0.00	452.74	-3.40
	1202	3062.00	1.48E-01	452.63	-0.13	0.00	452.76	-3.42
	1300	3120.00	1.50E-01	452.63	-0.15	0.00	452.78	-3.44
	1534	3274.00	1.58E-01	452.59	-0.21	0.00	452.80	-3.46
	1700	3360.00	1.62E-01	452.55	-0.21	0.00	452.76	-3.42
	2104	3604.00	1.74E-01	452.60	-0.16	0.00	452.76	-3.42
6/7/90	100	3840.00	1.85E-01	452.86	-0.12	0.00	452.98	-3.64
	500	4080.00	1.97E-01	452.87	-0.08	0.00	452.95	-3.61
	902	4322.00	2.08E-01	452.82	-0.07	0.00	452.89	-3.55
	1307	4567.00	2.20E-01	452.89	-0.13	0.00	453.02	-3.68
	1700	4800.00	2.31E-01	452.85	-0.18	0.00	453.03	-3.69

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date 6/4 90 Company performing test GCL Measured by TERAUDS/SELKE/GAITTER

Well No. PZ-2 Distance from pumping well _____ Type of test Pump Test No. _____

Measuring equipment Electronic Water Level Indicator - Audible LC: 2 Pg 1 of 6

Time Data
Pump on: Date 6/4 Time 0900 (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data 0836
Static water level 449.36
Measuring point casing top
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

Comments on factors affecting test data

SGT Pkgs LC: 2 @ 0735 - 6/4/90 w/ 449.35.
* DENOTES AN UNSCHEDULED MEASURING EVENT

	6/4 Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Δs Water level change s or s'		Discharge measurement	Rate		
0	09	00	0.00				449	36		0.00					
15s		15s	0.25				449	60		0.24					
30s		30s	0.50				449	96		0.60					
45s		46s	0.77				450	21		0.85					
60s	09	01	1.00				450	30		0.94					
75s		75s	1.25				450	36		1.00					
90s		90s	1.50				450	42		1.06					
2m	09	02	2				450	48		1.12					450.54 2m 30s
3m	09	03	3				450	60		1.24					450.63 3m 30s
4m	09	04	4				450.67	63		1.31					450.72 4m 30s
5m	09	05	5				450	73		1.37					450.76 5m 30s
6m	09	06	6				450	79		1.43					450.81 6m 30s
7m	09	07	7				450	82		1.46					450.86 7m 30s
8m	09	08	8				450	88		1.52					450.89 8m 30s
9m	09	09	9				450	89		1.53					450.90 9m 30s
10m	09	10	10				450	91		1.55					450.96 12m 30s
15m	09	15	15				451	03		1.67					451.07 17m 30s
20m	09	20	20				451	10		1.74					451.15 22m 30s
25m	09	25	25				451	17		1.81					451.18 27m 30s
30m	09	30	30				451	19		1.83					451.25 37m 30s
45m	09	45	45				451	31		1.95					451.33 52m 30s
1H	10	00	60				451	36	+.02	2.00	1.98				
2H	6/4	1059	119				451.51	0		2.15	2.15				
3H	6/4	1202	182				451.59	-.03		2.23	2.26				
4H	6/4	1300	240				451.63	-.05		2.27	2.32				
5H	6/4	1401	301				451.67	-.09		2.31	2.40				
6H	6/4	1459	359				451.69	-.11		2.33	2.44				
8H	6/4	1659	479				451.72	-.17		2.36	2.53				
10H	6/4	1859	599				451.74	-.18		2.38	2.56				END OF SHIFT - MMS

AQUIFER TEST DATA

Owner NASA - USTF Address _____ County Dona Ana State NM

Date 6/4/90 Company performing test GCL Measured by GAITHER / SELICE

Well No. PZ-2 Distance from pumping well _____ Type of test Pump Test No. _____

Measuring equipment LCS 2 Pg 2 of

Time Data
Pump on: Date _____ Time _____ (t₀)
Pump off: Date _____ Time _____ (t₀')
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'	s*	Discharge measurement	Rate		Comments on factors affecting test data
2H	6/4/90	2103	723				451.82	-.15		2.96	2.61				
6H	6/5/90	0107	967				451.98	-.14		2.62	2.76				
0H	6/5	0506	1206				452.20	-.12		2.84	2.96				
4H	6/5	0901	1441				452.13	-.09		2.77	2.86				START SHIFT - MWS EVERY 4 Hours
	6/5	1300	1680				452.21	-.15		2.85	3.00				
	6/5	1700	1920				452.28	-.22		2.84	3.06				END SHIFT - MWS
	6/5	2101	2161				452.28	-.19		2.92	3.11				
	6/6	0107	2407				452.58	-.13		3.22	3.35				PUMP ON FULL - METER DOWN - SEE LOG
	6/6	0456	2636				452.69	-.10		3.33	3.43				
	6/6	0900	2880				452.83	-.07		3.47	3.54				START SHIFT - MWS SEE COMMENTS ON PZ-1
*	6/6	1000	2940				452.66	-.08		3.30	3.38			*	1 HR MEASUREMENT
*	6/6	1100	3000				452.63	-.10		3.27	3.37				
*	6/6	1202	3062				452.63	-.12		3.27	3.39			EM	
	6/6	1300	3120				452.63	-.14		3.27	3.41				
*	6/6	1534	3274				452.59	-.20		3.23	3.43				
	6/6	1700	3360				452.55	-.20		3.19	3.39				END SHIFT - MWS
	6/6	2104	3614				452.60	-.18		3.24	3.42				
	6/7	0100	3840				452.86	-.11		3.50	3.61				
	6/7	0500	4080				452.87	-.10		3.51	3.61				ERASURE
	6/7	0902	4322				452.82	-0.07		3.46	3.53				
	6/7	1307	4567				452.88	-0.11		3.53	3.64				
	6/7	1700	4800				452.85			3.49					END SHIFT - MWS
	6/7	2104	5044				452.89			3.53					
	6/8	0107	5287				453.18			3.82					
	6/8	0503	5523				453.23			3.87					
	6/8	0745					453.05								

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: PZ-3 r(ft)= 94

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	856	0.00	0.00E+00	456.43	0.02	0.00	456.41	0.00
		0.25	2.83E-05	457.35	0.02	0.00	457.33	-0.92
		0.50	5.66E-05	457.60	0.02	0.00	457.58	-1.17
		0.75	8.49E-05	457.80	0.02	0.00	457.78	-1.37
	901	1.00	1.13E-04	457.95	0.02	0.00	457.93	-1.52
		1.25	1.41E-04	458.00	0.02	0.00	457.98	-1.57
		1.50	1.70E-04	458.05	0.02	0.00	458.03	-1.62
	902	2.00	2.26E-04	458.13	0.02	0.00	458.11	-1.70
	903	3.00	3.40E-04	458.28	0.02	0.00	458.26	-1.85
	904	4.00	4.53E-04	458.35	0.02	0.00	458.33	-1.92
	905	5.00	5.66E-04	458.43	0.02	0.00	458.41	-2.00
	906	6.00	6.79E-04	458.50	0.02	0.00	458.48	-2.07
	907	7.00	7.92E-04	458.53	0.02	0.00	458.51	-2.10
	908	8.00	9.05E-04	458.57	0.02	0.00	458.55	-2.14
	909	9.00	1.02E-03	458.59	0.02	0.00	458.57	-2.16
	910	10.00	1.13E-03	458.62	0.02	0.00	458.60	-2.19
	915	15.00	1.70E-03	458.73	0.02	0.00	458.71	-2.30
	920	20.00	2.26E-03	458.82	0.02	0.00	458.80	-2.39
	925	25.00	2.83E-03	458.89	0.02	0.00	458.87	-2.46
	930	30.00	3.40E-03	458.93	0.01	0.00	458.92	-2.51
	945	45.00	5.09E-03	459.03	0.01	0.00	459.02	-2.61
	1000	60.00	6.79E-03	459.11	0.01	0.00	459.10	-2.69
	1101	121.00	1.37E-02	459.28	0.00	0.00	459.28	-2.87
	1155	175.00	1.98E-02	459.38	-0.04	0.00	459.42	-3.01
	1302	242.00	2.74E-02	459.43	-0.05	0.00	459.48	-3.07
	1403	303.00	3.43E-02	459.48	-0.09	0.00	459.57	-3.16
	1501	361.00	4.09E-02	459.51	-0.11	0.00	459.62	-3.21
	1702	482.00	5.45E-02	459.55	-0.16	0.00	459.71	-3.30
	1902	602.00	6.81E-02	459.58	-0.18	0.00	459.76	-3.35
	2105	725.00	8.21E-02	459.64	-0.15	0.00	459.79	-3.38
6/5/90	113	973.00	1.10E-01	459.85	-0.15	0.00	460.00	-3.59
	508	1208.00	1.37E-01	460.11	-0.12	0.00	460.23	-3.82
	903	1443.00	1.63E-01	459.99	-0.09	0.00	460.08	-3.67
	1302	1682.00	1.90E-01	460.08	-0.16	0.00	460.24	-3.83
	1703	1923.00	2.18E-01	460.09	-0.25	0.00	460.34	-3.93
	2103	2163.00	2.45E-01	460.16	-0.19	0.00	460.35	-3.94
6/6/90	108	2408.00	2.73E-01	460.52	-0.14	0.00	460.66	-4.25
	458	2638.00	2.99E-01	460.64	-0.11	0.00	460.75	-4.34
	902	2882.00	3.26E-01	460.81	-0.07	0.00	460.88	-4.47
	1002	2942.00	3.33E-01	460.56	-0.09	0.00	460.65	-4.24
	1102	3002.00	3.40E-01	460.52	-0.11	0.00	460.63	-4.22
	1204	3064.00	3.47E-01	460.53	-0.13	0.00	460.66	-4.25
	1302	3122.00	3.53E-01	460.52	-0.15	0.00	460.67	-4.26
	1536	3276.00	3.71E-01	460.50	-0.21	0.00	460.71	-4.30
	1703	3363.00	3.81E-01	460.43	-0.21	0.00	460.64	-4.23
	2106	3606.00	4.08E-01	460.48	-0.17	0.00	460.65	-4.24
6/7/90	104	3844.00	4.35E-01	460.80	-0.12	0.00	460.92	-4.51
	503	4083.00	4.62E-01	460.80	-0.08	0.00	460.88	-4.47
	904	4324.00	4.89E-01	460.71	-0.07	0.00	460.78	-4.37
	1308	4568.00	5.17E-01	460.78	-0.13	0.00	460.91	-4.50
	1702	4802.00	5.43E-01	460.75	-0.18	0.00	460.93	-4.52
	2105	5045.00	5.71E-01	460.77	-0.11	0.00	460.88	-4.47

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date 6/4/90 Company performing test GCL Measured by CANAVAN/Selke/GAITHER

Well No. PZ-3 Distance from pumping well _____ Type of test Pump Test No. _____

Measuring equipment Electronic Water Level Indicator - Audible - LCS 3 Pg 1 of

Time Data
Pump on: Date 6/4/90 Time 0900 (t_n)
Pump off: Date _____ Time _____ (t'_n)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level 456.43
Measuring point casing top
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

Comments on factors affecting test data

SET PROBE LC-3@0751 - 6/4/90 WL 456.41
* DENOTES AN UNSCHEDULED MEASURING EVENT

To 0900 WL 456.43

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	AS Water level change s or s'		Discharge measurement	Rate		
6/4	1:28 0856	0			*	456.43			0					
6/4		0.25			GCL	457.35			0.92					
6/4		0.50				457.6			1.17					
6/4		0.75				457.8			1.37					
6/4	0901	1.00				457.95			1.52					
6/4		1.25				458.0			1.57					
6/4		1.50				458.05			1.62					
6/4	0902	2				458.13			1.70					
6/4	0903	3				458.28			1.85					
6/4	0904	4				458.35			1.92					
6/4	0905	5				458.43			2.00					
6/4	0906	6				458.6			2.07					
6/4	0907	7				458.53			2.10					
6/4	0908	8				458.56			2.14					
6/4	0909	9				458.59			2.16					
6/4	0910	10				458.62			2.19					
6/4	0915	15				458.73			2.30					
6/4	0920	20				458.82			2.39					
6/4	0925	25				458.89			2.46					
6/4	0930	30				458.93			2.50					
6/4	0945	45				459.03			2.60					
6/4	0954 1000	54 60				459.08 459.11	+.02		2.65 2.68	2.66				
6/4	1101	121				459.28	0		2.85	2.85				
6/4	1155	175				459.38	-.03		2.95	2.98				
6/4	1302	242				459.43	-.05		3.00	3.05				
6/4	1403	303				459.48	-.09		3.05	3.14				
6/4	1501	361				459.51	-.11		3.08	3.19				
6/4	1702	482				459.55	-.17		3.12	3.29				
6/4	1902	602				459.58	-.18		3.15	3.43				END OF SHIFT - MWS

AQUIFER TEST DATA

Owner NASA - WSTF Address _____ County Dona Ana State NM

Date 6/4/90 Company performing test GCL Measured by GAITHER / SELICE

Well No. PZ-3 Distance from pumping well _____ Type of test Pump Test No. _____

Measuring equipment LCS 3 Pg 2of6

Time Data
Pump on: Date _____ Time _____ (t₀)
Pump off: Date _____ Time _____ (t'₀)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'	s*	Discharge measurement	Rate		Comments on factors affecting test data
12H	6/4/90	2105	725				459.64	-.15		3.21	3.36				
16H	6/5/90	0113	973				459.85	-.14		3.42	3.56				
20H	6/5	0508	1208				460.11	-.12		3.68	3.80				
24H	6/5	0903	1443				459.99	-.09		3.56	3.65				START SHIFT - MWS EVERY 4 Hours
	6/5	1362	1682				460.08	-.15		3.65	3.80				
	6/5	1703	1923				460.09	-.22		3.66	3.90				END SHIFT - MWS
	6/5	2103	2163				460.16	-.19		3.73	3.92				
	6/6	0108	2408				~~460.52~~	-.13		~~4.09~~	4.22				PUMP ON FULL - METER DOWN - SEE LOG
	6/6	0458	2638				460.64	-.10		4.28	4.31				
	6/6	0902	2882				460.81	-.07		4.38	4.45				START SHIFT - MWS SEE COMMENTS ON PZ-1
*	6/6	1002	2942				460.56	-.08		4.13	4.21			*	14R MEASUREMENT
*	6/6	1102	3002				460.52	-.10		4.09	4.29				
*	6/6	1204	3064				460.53	-.12		4.10	4.22			EM	
	6/6	1302	3122				460.52	-.14		4.09	4.23				
*	6/6	1536	3276				460.50	-.20		4.07	4.27				
	6/6	1703	3363				460.43	-.20		4.00	4.20				END SHIFT - MWS
	6/6	2106	3606				460.48	-.18		4.05	4.23				
	6/7	0104	3844				460.80	-.11		4.37	4.48				
	6/7	0503	4083				460.80	-.16		4.37	4.47				END SHIFT
	6/7	0904	4324				460.71	-0.07		4.28	4.35				
	6/7	1308	4568				460.78	-0.11		4.35	4.46				
	6/7	1702	4802				460.75			4.32					END SHIFT - MWS
	6/7	2105	5045				460.77			4.34					
	6/8	0109	5289				461.13			4.70					
	6/8	~~0505~~ 0545	5525				~~461.17~~ 460.05			4.74					46
	6/8	0739					460.54								

6/8/90	109	5288.00	5.99E-01	461.13	-0.09	0.00	461.22	-4.81
	505	5525.00	6.25E-01	461.17	-0.10	0.00	461.27	-4.86
	739	5679.00	6.43E-01	460.54	-0.07	0.00	460.61	-4.20

end

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: PZ-4 r(ft)= 497

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	900	0.00	0.00E+00	460.19	0.02	0.00	460.17	0.00
		0.25	1.01E-06	460.19	0.02	0.00	460.17	0.00
		0.50	2.02E-06	460.24	0.02	0.00	460.22	-0.05
		0.75	3.04E-06	460.30	0.02	0.00	460.28	-0.11
	901	1.00	4.05E-06	460.35	0.02	0.00	460.33	-0.16
		1.25	5.06E-06	460.40	0.02	0.00	460.38	-0.21
		1.50	6.07E-06	460.44	0.02	0.00	460.42	-0.25
	902	2.00	8.10E-06	460.49	0.02	0.00	460.47	-0.30
	903	3.00	1.21E-05	460.58	0.02	0.00	460.56	-0.39
	904	4.00	1.62E-05	460.63	0.02	0.00	460.61	-0.44
	905	5.00	2.02E-05	460.68	0.02	0.00	460.66	-0.49
	906	6.00	2.43E-05	460.73	0.02	0.00	460.71	-0.54
	907	7.00	2.83E-05	460.76	0.02	0.00	460.74	-0.57
	908	8.00	3.24E-05	460.78	0.02	0.00	460.76	-0.59
	909	9.00	3.64E-05	460.82	0.02	0.00	460.80	-0.63
	910	10.00	4.05E-05	460.83	0.02	0.00	460.81	-0.64
	915	15.00	6.07E-05	460.92	0.02	0.00	460.90	-0.73
	920	20.00	8.10E-05	460.96	0.02	0.00	460.94	-0.77
	925	25.00	1.01E-04	461.00	0.02	0.00	460.98	-0.81
	930	30.00	1.21E-04	461.05	0.01	0.00	461.04	-0.87
	945	45.00	1.82E-04	461.13	0.01	0.00	461.12	-0.95
	1000	60.00	2.43E-04	461.18	0.01	0.00	461.17	-1.00
	1100	120.00	4.86E-04	461.32	0.00	0.00	461.32	-1.15
	1158	178.00	7.21E-04	461.37	-0.04	0.00	461.41	-1.24
	1300	240.00	9.72E-04	461.44	-0.05	0.00	461.49	-1.32
	1405	305.00	1.23E-03	461.46	-0.09	0.00	461.55	-1.38
	1504	364.00	1.47E-03	461.48	-0.11	0.00	461.59	-1.42
	1705	485.00	1.96E-03	461.50	-0.16	0.00	461.66	-1.49
	1905	605.00	2.45E-03	461.54	-0.18	0.00	461.72	-1.55
	2106	726.00	2.95E-03	461.61	-0.15	0.00	461.76	-1.59
6/5/90	119	979.00	3.96E-03	461.76	-0.15	0.00	461.91	-1.74
	512	1212.00	4.91E-03	461.95	-0.12	0.00	462.07	-1.90
	907	1447.00	5.86E-03	461.97	-0.09	0.00	462.06	-1.89
	1306	1686.00	6.83E-03	462.04	-0.16	0.00	462.20	-2.03
	1706	1926.00	7.80E-03	462.03	-0.25	0.00	462.28	-2.11
	2113	2173.00	8.80E-03	462.13	-0.22	0.00	462.35	-2.18
6/6/90	111	2411.00	9.76E-03	462.35	-0.14	0.00	462.49	-2.32
	500	2640.00	1.07E-02	462.45	-0.11	0.00	462.56	-2.39
	905	2885.00	1.17E-02	462.60	-0.07	0.00	462.67	-2.50
	1005	2945.00	1.19E-02	462.54	-0.09	0.00	462.63	-2.46
	1105	3005.00	1.22E-02	462.51	-0.11	0.00	462.62	-2.45
	1207	3067.00	1.24E-02	462.51	-0.13	0.00	462.64	-2.47
	1305	3125.00	1.27E-02	462.51	-0.15	0.00	462.66	-2.49
	1538	3278.00	1.33E-02	462.47	-0.21	0.00	462.68	-2.51
	1706	3366.00	1.36E-02	462.45	-0.21	0.00	462.66	-2.49
	2107	3607.00	1.46E-02	462.52	-0.16	0.00	462.68	-2.51
6/7/90	109	3849.00	1.56E-02	462.69	-0.12	0.00	462.81	-2.64
	508	4088.00	1.66E-02	462.75	-0.08	0.00	462.83	-2.66
	908	4328.00	1.75E-02	462.78	-0.07	0.00	462.85	-2.68

	1706	4586.00	1.95E-02	462.75	-0.16	-0.04	462.89	-2.72
	2108	5048.00	2.04E-02	462.80	-0.11	-0.04	462.87	-2.70
6/8/90	111	5291.00	2.14E-02	463.00	-0.10	-0.04	463.06	-2.89
	508	5526.00	2.24E-02	463.09	-0.10	-0.04	463.15	-2.98
	744	5684.00	2.30E-02	462.98	-0.08	-0.04	463.02	-2.85

end

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by KIRBY/SELKE/GAITHER

Well No. PZ-4 Distance from pumping well _____ Type of test Pump Test No. _____

Measuring equipment Electronic Water Level Indicator - Audible LCs 4 Pg 1of6

Time Data
Pump on: Date 6-4-90 Time 0900 (t)
Pump off: Date _____ Time _____ (t')
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level 460.19
Measuring point TOC.
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

SWL = 460.19 @0804 6-4-90.
PROBE LCs 4
*DENOTES AN UNSCHEDULED MEASURING EVENT

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Δs Water level change s or s'	s*	Discharge measurement	Rate		
06-4-90	0900:00	0.0				460.19			0					
15s	0900:15	0.25				11			0					
30s	0900:30	0.50				460.21			0.05					
45s	0900:45	0.75				460.30			0.11					
60s	0901:00	1.00				460.35			0.16					
75s	0901:15	1.25				460.40			0.21					
90s	0901:30	1.50				460.44			0.25					
2m	0902	2				460.49			0.30					
3m	0903	3				460.58			0.39					
4m	0904	4				460.63			0.44					
5m	0906	5				460.68			0.49	✓				
6m	0906	6				460.73			0.54	✓				
7m	0907	7				460.76			0.57					
8m	0908	8				460.78			0.59					
9m	0909	9				460.82			0.63					
10m	0910	10				460.83			0.64					
15m	0915	15				460.92			0.73					
20m	0920	20				460.96			0.77					
25m	0925	25				461.00			0.81					
30m	0930	30				461.05			0.86					
45m	0945	45				461.13			0.94	✓				
1H	1000	60				461.18	+.02		0.99	0.97				
2H	1100	120				461.32	0		1.13	1.13				
3H	1158 1200	178				461.37	-.03		1.18	1.21				
4H	1300	240				461.44	-.05		1.25	1.30				
5H	1400 1405	305				461.46	-.09		1.27	1.36				
6H	1500 1504	364				461.48	-.11		1.29	1.40				
8H	1700 1705	485				461.50	-.17		1.31	1.48				
10H	1900 1905	605				461.54	-.18		1.35	1.53				END OF SHIFT - MWS

AQUIFER TEST DATA

Owner NASA - WSTF Address _____ County Dona Ana State NM

Date 6/4/96 Company performing test GCL Measured by GAITHER/SPIKE

Well No. PZ-4 Distance from pumping well _____ Type of test Pump Test No. _____

Measuring equipment LCS 4 P, 2 of

Time Data
Pump on: Date _____ Time _____ (t_p)
Pump off: Date _____ Time _____ (t'_p)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments on factors affecting test data
12H	6/4/96	2108	1728				461.61	-.15		1.42	1.57				
16H	6/5/96	0119	979				461.76	-.14		1.57	1.71				
20H	6/5	0512	1212				461.95	-.12		1.76	1.88				
24H	6/5	0907	1447				461.97	-.09		1.78	1.87				START SHIFT - MWS EVERY 4 Hours
	6/5	1306	1686				462.09	-.15		1.89	2.00				
	6/5	1706	1926				462.03	-.22		1.84	2.06				END SHIFT - MWS
	6/5	2113	2173				462.13	-.19		1.94	2.13				
	6/6	0311	2411				462.35	-.13		2.16	2.29				PUMP ON FULL - METER DOWN - SEE LOG
	6/6	0500	2640				462.45	-.10		2.26	2.36				
	6/6	0905	2885				462.60	-.07		2.41	2.48				START SHIFT - MWS SEE COMMENTS ON PZ-1
*	6/6	1005	2945				462.54	-.08		2.35	2.43			*	1 HR MEASUREMENT
*	6/6	1105	3005				462.51	-.10		2.32	2.42				
*	6/6	1207	3067				462.51	-.12		2.32	2.44			ELG	
	6/6	1305	3125				462.51	-.14		2.32	2.46				
*	6/6	1538	3278				462.47	-.20		2.28	2.48				
	6/6	1706	3360				462.45	-.20		2.26	2.46				END SHIFT - MWS
	6/6	2107	3607 2407	2407 3607	1.50 0.67		462.52	-.18		2.33	2.51				
	6/7	0109	3849				462.69	-.11		2.50	2.61				
	6/7	0508	4088				462.75	-.10		2.56	2.66				End Shift. AA.
	6/7	0908	4328				462.78	-.07		2.59	2.66			**	FIXED SHORT IN PROBE - NOW 0.04' TOO LONG
**	6/7	1530	4770 4772				462.75	-.10		2.54 2.64	2.74			**	462.79 - 0.04 = 462.75
**	6/7	1706	4806				462.75			2.54 2.64				**	462.79 - 0.04 = 462.75 END SHIFT - MWS
(4)	6/7	2108	5048				462.80			2.61				(4)	462.84 - 0.04 = 462.80
	6/8	0111	5291				463.00			2.81					463.04 - .04 = 463.00
	6/8	0508	5528				463.09			2.90					463.09 - .04 = 463.05
	6/8	0744					462.98								

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: P1-2-504 r(ft)= 1332

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	735	0.00	0.00E+00	439.94	0.02	0.00	439.92	0.00
	1010	70.00	3.95E-05	440.17	0.01	0.00	440.16	-0.24
	1111	131.00	7.38E-05	440.20	0.00	0.00	440.20	-0.28
	1207	187.00	1.05E-04	440.22	-0.04	0.00	440.26	-0.34
	1308	248.00	1.40E-04	440.22	-0.05	0.00	440.27	-0.35
	1411	311.00	1.75E-04	440.18	-0.09	0.00	440.27	-0.35
	1511	371.00	2.09E-04	440.17	-0.11	0.00	440.28	-0.36
	1713	493.00	2.78E-04	440.17	-0.16	0.00	440.33	-0.41
	1911	611.00	3.44E-04	440.18	-0.18	0.00	440.36	-0.44
	2118	738.00	4.16E-04	440.24	-0.15	0.00	440.39	-0.47
6/5/90	130	990.00	5.58E-04	440.30	-0.15	0.00	440.45	-0.53
	515	1215.00	6.85E-04	440.39	-0.12	0.00	440.51	-0.59
	914	1454.00	8.20E-04	440.46	-0.09	0.00	440.55	-0.63
	1321	1701.00	9.59E-04	440.41	-0.16	0.00	440.57	-0.65
	1727	1947.00	1.10E-03	440.36	-0.23	0.00	440.59	-0.67
	2125	2185.00	1.23E-03	440.45	-0.19	0.00	440.64	-0.72
6/6/90	125	2425.00	1.37E-03	440.58	-0.14	0.00	440.72	-0.80
	523	2663.00	1.50E-03	440.64	-0.11	0.00	440.75	-0.83
	926	2906.00	1.64E-03	440.75	-0.07	0.00	440.82	-0.90
	1120	3020.00	1.70E-03	440.71	-0.10	0.00	440.81	-0.89
	1200	3060.00	1.72E-03	440.66	-0.12	0.00	440.78	-0.86
	1313	3133.00	1.77E-03	440.69	-0.15	0.00	440.84	-0.92
	1716	3376.00	1.90E-03	440.63	-0.21	0.00	440.84	-0.92
	2120	3620.00	2.04E-03	440.70	-0.17	0.00	440.87	-0.95
6/7/90	119	3859.00	2.18E-03	440.81	-0.12	0.00	440.93	-1.01
	512	4092.00	2.31E-03	440.85	-0.08	0.00	440.93	-1.01
	937	4357.00	2.46E-03	440.92	-0.08	0.00	441.00	-1.08
	1312	4572.00	2.58E-03	440.90	-0.13	0.00	441.03	-1.11
	1708	4808.00	2.71E-03	440.84	-0.18	0.00	441.02	-1.10
	2124	5064.00	2.85E-03	440.94	-0.12	0.00	441.06	-1.14
6/8/90	127	5307.00	2.99E-03	441.03	-0.09	0.00	441.12	-1.20
	517	5537.00	3.12E-03	441.04	-0.10	0.00	441.14	-1.22
	646	5626.00	3.17E-03	441.06	-0.08	0.00	441.14	-1.22

end

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. PL-2-504 Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data
Pump on: Date 6/4 Time 0900 (t_w)
Pump off: Date _____ Time _____ (t'_w)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t'/t		TOC (FT) Water level measurement	Correction or Conversion	Water level	UNC. Water level change s or s'	CORR. s'	Discharge measurement	Rate		Comments on factors affecting test data
0	6-4	0735	0				439.94	—		0					PROBE #
1h	"	1010	~~446~~ 1070				440.17	.02	440.15	-0.23	-.21			GC	ROU. # 2 (A 1ST)
2h	"	1111		131			440.20	0.0	440.20	-0.26	-.26			"	"
3h	"	1207		187			440.22	-.03	440.25	-0.29	-.31			"	"
4h	"	1308		248			440.22	-.05	440.27	-0.28	-.33			"	"
5h	"	1411		311			440.18	-.09	440.27	-0.24	-.33			"	"
6h	"	1511		371			440.17	-.11	440.28	-0.23	-.34			"	"
8h	"	1713	493	435			440.17	-.17	440.34	-0.23	-.40			"	"
10h	"	1911	611	554			440.18	-.18	440.36	-0.24	-.42			"	"
12h	"	2118	738	646			~~440.24~~	440.24 -.14	440.38	-0.30	-.44			BAL	"
16h	6/5	0130	990	930			440.30	-.14	440.44	-0.36	-.50			"	"
20h	"	0515	1215	1155			440.39	-.12	440.51	-0.45	-.57			"	"
24h	"	0914	1454	1394			440.46	-.09	440.55	-0.52	-.61			GC	"
28h	"	1321	1701	1641			440.41	-.16	440.57	-0.41	-.63			V	Every 4 hours
32h	"	1727	1947				440.36	-.23	440.59	-0.42	-.65			"	"
36h	"	2125	2185				440.25	-.16	440.61	-0.51	-.67			BAL	"
40	6/6	0135	2425				440.58	-.13	440.71	-0.64	-.77			"	"
44	6/6	0523	2663				440.64	-.10	440.74	-0.70	-.80			"	"
48	6/6	0926	2906				440.75	-.07	440.82	-0.81	-.88			MGC	"
52	"	1313	3133	*			440.69	-.14	440.83	-0.75	-.89			PSE	"
56	"	1716	3376				440.63	-0.20	440.83		-.89			PSE	"
60	"	2120	3620				440.70	-.18	440.88		-.94			BAL	"
64	6/7	0114	~~3859~~				440.81	-.11	440.92		-.98			"	"
68	"	0512	4092				440.85	-.10	440.95		-1.01			"	"
72	"	0937	4357				440.92	-.07						DB	"
76	"	1312	4572				440.90							"	"
80	"	1708	4808				440.89							"	"
84	"	2124	5064				440.94							"	"
88	6/8	0127	5307				441.03							BAL/	"
92	"	0517	5537				441.04							IKS/BAL	"
		0646	5626				441.06							IKS	"

* NEXT PAGE

AQUIFER TEST DATA

Owner _____ Address _____ County _____ State _____

Date _____ Company performing test _____ Measured by _____

Well No. PL-2-504 Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment HOURLY

Time Data
Pump on: Date _____ Time _____ (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments on factors affecting test data
~~50~~ 6/6	1120	~~3000~~ 3020				440.71			-0.77				MGC	Rover #2 (ABQ #2)
~~59~~ "	1200	3060				440.66			-0.72				JK	
~~60~~	1313	3133	*		440.69	440.69			-0.75				PSE	
~~60~~	2131	3631												

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: ST-1-473 r(ft)= 2589

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	738	0.00	0.00E+00	434.68	0.02	0.00	434.66	0.00
	1017	77.00	1.15E-05	434.69	0.01	0.00	434.68	-0.02
	1115	135.00	2.01E-05	434.68	0.00	0.00	434.68	-0.02
	1212	192.00	2.86E-05	434.66	-0.04	0.00	434.70	-0.04
	1312	252.00	3.76E-05	434.63	-0.05	0.00	434.68	-0.02
	1415	315.00	4.70E-05	434.60	-0.09	0.00	434.69	-0.03
	1515	375.00	5.59E-05	434.59	-0.11	0.00	434.70	-0.04
	1721	501.00	7.47E-05	434.54	-0.16	0.00	434.70	-0.04
	1916	616.00	9.19E-05	434.52	-0.18	0.00	434.70	-0.04
	2127	747.00	1.11E-04	434.55	-0.15	0.00	434.70	-0.04
6/5/90	137	997.00	1.49E-04	434.56	-0.15	0.00	434.71	-0.05
	920	1460.00	2.18E-04	434.67	-0.09	0.00	434.76	-0.10
	1331	1711.00	2.55E-04	434.59	-0.17	0.00	434.76	-0.10
	1732	1952.00	2.91E-04	434.52	-0.24	0.00	434.76	-0.10
	2131	2191.00	3.27E-04	434.58	-0.15	0.00	434.73	-0.07
6/6/90	132	2432.00	3.63E-04	434.64	-0.13	0.00	434.77	-0.11
	531	2671.00	3.98E-04	434.68	-0.10	0.00	434.78	-0.12
	916	2896.00	4.32E-04	434.73	-0.07	0.00	434.80	-0.14
	1304	3124.00	4.66E-04	434.68	-0.15	0.00	434.83	-0.17
	1726	3386.00	5.05E-04	434.63	-0.21	0.00	434.84	-0.18
	2130	3630.00	5.42E-04	434.68	-0.16	0.00	434.84	-0.18
6/7/90	125	3865.00	5.77E-04	434.76	-0.12	0.00	434.88	-0.22
	517	4097.00	6.11E-04	434.79	-0.08	0.00	434.87	-0.21
	941	4361.00	6.51E-04	434.84	-0.08	0.00	434.92	-0.26
	1315	4575.00	6.83E-04	434.81	-0.13	0.00	434.94	-0.28
	1715	4815.00	7.18E-04	434.74	-0.18	0.00	434.92	-0.26
	2131	5071.00	7.57E-04	434.80	-0.11	0.00	434.91	-0.25
6/8/90	129	5309.00	7.92E-04	434.85	-0.09	0.00	434.94	-0.28
	525	5545.00	8.27E-04	434.84	-0.10	0.00	434.94	-0.28

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. ST-1-473 Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data
Pump on: Date 6/4 Time 0900 (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	TOC (FT) Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Discharge measurement	Rate		Comments on factors affecting test data
													PROBE #1
0	6-4	07:38				434.68	.01	434.67	—			GC	Rover 2 (A/B2)
1h	"	1017	99			434.69	.02	434.67	0			"	"
2h	"	1115	135			434.68	-.01	434.69	-.02			"	"
3h	"	1212	192			434.67	-.03 434.66	434.69	-.02			"	"
4h	"	1312 ~~1313~~	252			434.66	-.05 434.63	434.68	-.01			"	"
5h	"	1415	315			434.60	-.09	434.69	-.02			"	"
6h	"	1515	375			434.59	-.11	434.70	-.03			"	"
8h	"	1721	501			434.54	-.18	434.72	-.05			"	"
10h	"	1916	616			434.52	-.18	434.70	-.03			"	"
12h	"	2127	747			434.55	-.14	434.69	-.02			BAL	
16h	6/5	0137	997			434.56	-.15	434.71	-.04			"	"
20h	"	~~2333~~				~~434.62~~						"	"
24h	"	0920	1460			434.67	-.09	434.76	-.09			GC	"
28h	"	1331	1711			434.58	-.17	434.76	-.09			"	Every 4 hours
32h	"	1732	1952			434.52	-.23	434.75	-.08			GC	"
36h	"	2131	2191			434.58	-.16	434.74	-.07			BAL	"
40h	6/6	0132	2432			434.64	-.12	434.76	-.09			"	"
44h	6/6	0531	2671			434.68	-.10	434.78	-.11			"	"
48h	6/6	0916	2896			434.73	-.07	434.80	-.13			P.E.	"
52	"	1304	3124			434.68	-.14	434.82	-.15			MC	"
56	"	1726	3386			434.63	-.20	434.83	-.16			MC	"
60	"	2130	3630			434.68	-.18	434.86	-.19			BAL	"
64	6/7	0125	3865			434.76	-.11	434.87	-.20			"	"
68	"	0521	4097			434.79	-.10	434.89	-.22			"	"
72	"	0941	4361			434.84			-.23			GC	"
76	"	1315	4575			434.81						"	"
80	"	1715	4815			434.74						"	"
84	"	2131	5071			434.80						"	"
88	6/8	0129	5309			434.85						BAL/KS	"
92	"	0525	5545			434.84						KS/BAL	"
												KS	"

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: P1-3-453 r(ft)= 2046

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	746	0.00	0.00E+00	428.95	0.02	0.00	428.93	0.00
	1101	121.00	2.89E-05	428.98	0.00	0.00	428.98	-0.05
	1201	181.00	4.32E-05	428.96	-0.04	0.00	429.00	-0.07
	1300	240.00	5.73E-05	428.93	-0.05	0.00	428.98	-0.05
	1356	296.00	7.07E-05	428.90	-0.09	0.00	428.99	-0.06
	1446	346.00	8.27E-05	428.87	-0.10	0.00	428.97	-0.04
	1531	391.00	9.34E-05	428.85	-0.12	0.00	428.97	-0.04
	1716	496.00	1.18E-04	428.80	-0.16	0.00	428.96	-0.03
	1912	612.00	1.46E-04	428.78	-0.18	0.00	428.96	-0.03
	2131	751.00	1.79E-04	428.82	-0.14	0.00	428.96	-0.03
6/5/90	127	987.00	2.36E-04	428.84	-0.15	0.00	428.99	-0.06
	534	1234.00	2.95E-04	428.88	-0.11	0.00	428.99	-0.06
	923	1463.00	3.49E-04	428.98	-0.09	0.00	429.07	-0.14
	1308	1688.00	4.03E-04	428.87	-0.16	0.00	429.03	-0.10
	1720	1940.00	4.63E-04	428.78	-0.23	0.00	429.01	-0.08
	2118	2178.00	5.20E-04	428.84	-0.19	0.00	429.03	-0.10
6/6/90	117	2417.00	5.77E-04	428.92	-0.14	0.00	429.06	-0.13
	518	2658.00	6.35E-04	428.97	-0.11	0.00	429.08	-0.15
	1003	2943.00	7.03E-04	429.01	-0.08	0.00	429.09	-0.16
	1326	3146.00	7.52E-04	428.96	-0.15	0.00	429.11	-0.18
	1723	3383.00	8.08E-04	428.88	-0.21	0.00	429.09	-0.16
	2118	3618.00	8.64E-04	428.92	-0.17	0.00	429.09	-0.16
6/7/90	118	3858.00	9.22E-04	429.00	-0.12	0.00	429.12	-0.19
	517	4097.00	9.79E-04	429.03	-0.08	0.00	429.11	-0.18
	928	4348.00	1.04E-03	429.08	-0.07	0.00	429.15	-0.22
	1326	4586.00	1.10E-03	429.05	-0.13	0.00	429.18	-0.25
	1730	4830.00	1.15E-03	428.97	-0.18	0.00	429.15	-0.22
	2119	5059.00	1.21E-03	429.04	-0.12	0.00	429.16	-0.23
6/8/90	115	5295.00	1.26E-03	429.07	-0.09	0.00	429.16	-0.23
	515	5535.00	1.32E-03	429.10	-0.10	0.00	429.20	-0.27

end

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. PL-3-453 Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data 0900
Pump on: Date 6/4 Time 9AM (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments on factors affecting test data
6/4 AM														
0 6/4	1:46					428.96								
1h(2h)	1101	121				428.98	-.02							ABQs #1
2h(3h)	1201	181				428.96	+.02							"
3h(4h)	1300	240				428.93	+.03							"
4h(5h)	1356	296				428.90	+.03							
5h	1446	346				428.87	+.03							
6h	1531	291				428.85	+.02							
8h	1716	496				428.80	+.05							
10h	1912	612				428.78	+.02							
12h	2131	751				428.82	-.04							
16h 6/5	0127	987 1003				428.84	-.02							
20h	0534	1234				428.88	-.04							
24h	0923	1463				428.92	-.04							
28h	1308	1688				428.87	+.05							
32h	1720	1940				428.78	+.09							Every 4 hours
36h	2118	2178				428.84	-.06							
40h	0117	2417				428.92	-.08							
44h	0518	2658				428.97	-.05							
48h 6/6	1003	2943				429.01	-.04						PSG	
52 "	1326	3146				428.96	+.05						JK	
56 "	1723	3383				428.88	-.08							
60	2118	3618				428.92								
64 6/7	0118	3858				429.00								
68 "	0517	4097				429.03								
72 "	0928	4348				429.08								
76 "	1326	4586				429.05								
80 "	1730	4830				428.97								
84	2119	5059				429.04								
88 6/8	0115	5295				429.07								
	0515				JK	429.10								

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: PL-4-464 r(ft)= 2628

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	807	0.00	0.00E+00	413.41	0.02	0.00	413.39	0.00
	1111	131.00	1.90E-05	413.40	0.00	0.00	413.40	-0.01
	1211	191.00	2.77E-05	413.41	-0.04	0.00	413.45	-0.06
	1317	257.00	3.72E-05	413.35	-0.05	0.00	413.40	-0.01
	1406	306.00	4.43E-05	413.33	-0.09	0.00	413.42	-0.03
	1456	356.00	5.15E-05	413.31	-0.11	0.00	413.42	-0.03
	1540	400.00	5.79E-05	413.29	-0.14	0.00	413.43	-0.04
	1725	505.00	7.31E-05	413.25	-0.16	0.00	413.41	-0.02
	1921	621.00	8.99E-05	413.23	-0.18	0.00	413.41	-0.02
	2100	720.00	1.04E-04	413.25	-0.15	0.00	413.40	-0.01
6/5/90	56	956.00	1.38E-04	413.31	-0.15	0.00	413.46	-0.07
	512	1212.00	1.75E-04	413.34	-0.12	0.00	413.46	-0.07
	856	1463.00	2.12E-04	413.34	-0.09	0.00	413.43	-0.04
	1247	1667.00	2.41E-04	413.24	-0.16	0.00	413.40	-0.01
	1652	1912.00	2.77E-04	413.17	-0.23	0.00	413.40	-0.01
	2052	2152.00	3.12E-04	413.21	-0.19	0.00	413.40	-0.01
6/6/90	52	2392.00	3.46E-04	413.21	-0.14	0.00	413.35	0.04
	451	2631.00	3.81E-04	413.27	-0.11	0.00	413.38	0.01
	900	2880.00	4.17E-04	413.40	-0.07	0.00	413.47	-0.08
	1304	3124.00	4.52E-04	413.34	-0.15	0.00	413.49	-0.10
	1657	3357.00	4.86E-04	413.26	-0.21	0.00	413.47	-0.08
	2055	3595.00	5.21E-04	413.28	-0.17	0.00	413.45	-0.06
6/7/90	53	3833.00	5.55E-04	413.27	-0.12	0.00	413.39	0.00
	454	4074.00	5.90E-04	413.41	-0.08	0.00	413.49	-0.10
	902	4322.00	6.26E-04	413.47	-0.07	0.00	413.54	-0.15
	1304	4564.00	6.61E-04	413.42	-0.13	0.00	413.55	-0.16
	1703	4803.00	6.95E-04	413.36	-0.18	0.00	413.54	-0.15
	2054	5034.00	7.29E-04	413.38	-0.12	0.00	413.50	-0.11
6/8/90	51	5271.00	7.63E-04	413.46	-0.09	0.00	413.55	-0.16
	452	5512.00	7.98E-04	413.47	-0.10	0.00	413.57	-0.18

end

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. PL-4-464 Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data 0900
Pump on: Date 6/4 Time 9AM (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments on factors affecting test data
0	6/4	8:07					413.41								
2h		1111	131 ~~172~~				~~443.4~~		+.01						Rov. #1
3h		1211	191 ~~+31~~				413.41		-.00						
4h		1317	257 ~~+97~~				413.35		+.01						
5h	6/5	1406	306 ~~246~~				413.33		+.02						
5h	1456	~~1356~~	356				~~413.31~~		+.02						
6h		1540	400				413.29		+.02						
8h		1725	505				413.25		+.04						
10h		1921	621				413.23		+.02						
12h		~~2100~~	720				~~413.25~~		-.02						
16h	6/5	0056	956 1016				413.21		-.01						
20h		0500	1356				413.34		-.02						Rover #1 Not Working
24h		0856	1436				413.34		0.00						
28h		1247	1667 ~~1727~~				413.24		+.10						Every 4 hours.
32h		1652	1912 ~~1972~~				413.17		+.07						
36		2052	2152 ~~2212~~				413.21		-.04						
40	6/6	0052	2392 ~~2452~~				413.21		.00						
44		0451	2631 ~~2691~~				413.27		-.06						
48	6/6	09?	~2880				413.40		-.13					MGC	
52	"	1304	3124				413.34		+.06						
56	"	1657	3357 3417				413.26		+.08						
60		2055	3595 3655				413.28								
64	6/7	0053	3833 ~~3893~~				~~413.27~~								
68	"	0454	4074 4134				413.41								
72	"	0902	4322				413.47	-0.07						JK	
76	"	1304	4564				413.42								
80	"	1703	4803				413.36							MGC	
84		2054	5034				413.38								
88	6/8	0051	5271				413.46								
92		0452	5512				413.47								

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: BLM-17-493 r(ft)= 1354

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	900	0.00	0.00E+00	465.52	0.02	0.00	465.50	0.00
	905	5.00	2.73E-06	465.51	0.02	0.00	465.49	0.01
	910	10.00	5.45E-06	465.50	0.02	0.00	465.48	0.02
	915	15.00	8.18E-06	465.50	0.02	0.00	465.48	0.02
	920	20.00	1.09E-05	465.50	0.02	0.00	465.48	0.02
	925	25.00	1.36E-05	465.51	0.02	0.00	465.49	0.01
	930	30.00	1.64E-05	465.51	0.01	0.00	465.50	0.00
	940	40.00	2.18E-05	465.52	0.01	0.00	465.51	-0.01
	950	50.00	2.73E-05	465.52	0.01	0.00	465.51	-0.01
	1000	60.00	3.27E-05	465.53	0.01	0.00	465.52	-0.02
	1015	75.00	4.09E-05	465.53	0.00	0.00	465.53	-0.03
	1030	90.00	4.91E-05	465.53	0.00	0.00	465.53	-0.03
	1045	105.00	5.73E-05	465.54	0.00	0.00	465.54	-0.04
	1100	120.00	6.55E-05	465.54	0.00	0.00	465.54	-0.04
	1130	150.00	8.18E-05	465.54	-0.02	0.00	465.56	-0.06
	1200	180.00	9.82E-05	465.54	-0.04	0.00	465.58	-0.08
	1230	210.00	1.15E-04	465.54	-0.04	0.00	465.58	-0.08
	1300	240.00	1.31E-04	465.54	-0.05	0.00	465.59	-0.09
	1330	270.00	1.47E-04	465.54	-0.07	0.00	465.61	-0.11
	1400	300.00	1.64E-04	465.54	-0.09	0.00	465.63	-0.13
	1430	330.00	1.80E-04	465.54	-0.10	0.00	465.64	-0.14
	1500	360.00	1.96E-04	465.53	-0.11	0.00	465.64	-0.14
	1600	420.00	2.29E-04	465.52	-0.14	0.00	465.66	-0.16
	1646	466.00	2.54E-04	465.51	-0.15	0.00	465.66	-0.16
	1800	540.00	2.95E-04	465.51	-0.18	0.00	465.69	-0.19
	1842	582.00	3.17E-04	465.52	-0.18	0.00	465.70	-0.20
	2002	662.00	3.61E-04	465.50	-0.16	0.00	465.66	-0.16
	2050	710.00	3.87E-04	465.57	-0.15	0.00	465.72	-0.22
6/5/90	54	954.00	5.20E-04	465.65	-0.15	0.00	465.80	-0.30
	450	1190.00	6.49E-04	465.72	-0.12	0.00	465.84	-0.34
	854	1434.00	7.82E-04	465.83	-0.09	0.00	465.92	-0.42
	1250	1670.00	9.11E-04	465.83	-0.16	0.00	465.99	-0.49
	1641	1901.00	1.04E-03	465.76	-0.24	0.00	466.00	-0.50
	2054	2154.00	1.17E-03	465.80	-0.19	0.00	465.99	-0.49
6/6/90	53	2393.00	1.31E-03	465.92	-0.14	0.00	466.06	-0.56
	451	2631.00	1.44E-03	466.00	-0.11	0.00	466.11	-0.61
	935	2915.00	1.59E-03	466.15	-0.08	0.00	466.23	-0.73
	1102	3002.00	1.64E-03	466.15	-0.11	0.00	466.26	-0.76
	1206	3060.00	1.67E-03	466.13	-0.13	0.00	466.26	-0.76
	1320	3140.00	1.71E-03	466.09	-0.16	0.00	466.25	-0.75
	1646	3346.00	1.83E-03	466.03	-0.21	0.00	466.24	-0.74
	2050	3590.00	1.96E-03	466.05	-0.17	0.00	466.22	-0.72
6/7/90	50	3830.00	2.09E-03	466.15	-0.12	0.00	466.27	-0.77
	448	4068.00	2.22E-03	466.23	-0.08	0.00	466.31	-0.81
	852	4312.00	2.35E-03	466.28	-0.07	0.00	466.35	-0.85
	1249	4549.00	2.48E-03	466.31	-0.13	0.00	466.44	-0.94
	1650	4790.00	2.61E-03	466.32	-0.18	0.00	466.50	-1.00
	2053	5033.00	2.75E-03	466.30	-0.12	0.00	466.42	-0.92
6/8/90	51	5271.00	2.88E-03	466.39	-0.09	0.00	466.48	-0.98
	449	5509.00	3.00E-03	466.41	-0.10	0.00	466.51	-1.01
	738	5678.00	3.10E-03	466.47	-0.07	0.00	466.54	-1.04

end

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. BCM-17 Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level 465.55 @ 0837
Measuring point T.O.C. (north)
Elevation of measuring point 4539.97 M.S.L.

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s' (+) (−)		Discharge measurement	Rate		Comments on factors affecting test data
															Probe LCm #3
0	6/4	0900	0				465.52	+.03	465.49	0				PSE	"
5m	"	0905	5				465.51			+.1				"	"
10m	"	0910	10				465.50							"	"
15m	"	0915	15				465.50							"	"
20m	"	0920	20				465.50							"	"
25m	"	0925	25				465.51							"	"
30m	"	0930	30				465.51							"	"
40m	"	0940	40				465.52							"	"
50m	"	0950	50				465.52							"	"
1h	"	1000	60				465.53	.02	465.55	−.02				"	
75m	"	1015	75				465.53							"	
90m	"	1030	90				465.53							"	
105m	"	1045	105				465.54							"	
2h	"	1100	120				465.54	0.0	465.54	−.05				"	
2.5h	"	1130	150				465.54							"	
3h	"	1200	180				465.54	−.03	465.57	−.08				"	
3.5h	"	1230	210				465.54							"	
4h	"	1300	240				465.54	−.05	465.59	−.10				"	
4.5h	"	1330	270				465.54							"	
5.0h	"	1400	300				465.54	−.09	465.63	−.14				"	
5.5h	"	1430	330				465.54							"	
6h	"	1500	360				465.53	−.11	465.64	−.15				"	
7h	"	1600	420				465.52	−.14	465.66	−.17				"	
8h	"	~~1700~~ 1646	466				465.51	−.16	465.67	−.18				"	
9h	"	~~1800~~ 1800	540				465.51	−.19	465.70	−.21				"	
10h	"	~~1900~~ 1947	582				465.52	−.18	465.70	−.21				"	
11h	"	2000	662				465.50	−.16	465.66	−.17				BAL	
12h	"	~~2050~~ 2050	710				465.51	−.15	465.66	−.23				"	
16h	6/5	~~0054~~ 0100	954				465.65	−.14	465.79	−.30				"	

AQUIFER TEST DATA

Owner NASA - WSTF Address ____ County DONA ANA State NM

Date ____ Company performing test GCL Measured by ____

Well No. BCM-17 Distance from pumping well ____ Type of test ____ Test No. ____

Measuring equipment ____

Time Data
Pump on: Date ____ Time ____ (t_0)
Pump off: Date ____ Time ____ (t'_0)
Duration of aquifer test:
Pumping ____ Recovery ____

Water Level Data
Static water level ____
Measuring point ____
Elevation of measuring point ____

Discharge Data
How Q measured ____
Depth of pump/air line ____
Previous pumping? Yes ____ No ____
Duration ____ End ____

Comments on factors affecting test data

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
20h	6/5	0450	1190				466.72	-.12	465.84	-.35				BAL	Probe LCm #3
24h	"	0854	1434				465.83	-.09	465.92	-.43				GC	"
28h	"	1250	1670				465.83	-.14	465.97	-.48				"	"
32h	"	1641	1907				465.76	-.22	465.98	-.49				"	"
36h	"	2054	2154				465.80	-.19	465.99	-.50				BAL	"
40h	"	0053	2393				465.92	-.13	466.05	-.56				"	"
44h	"	0451	2631				466.00	-.10	466.10	-.61				"	"
48h	6/6	0935	2915	Secondary			466.15	-.07	466.22	-.73				PSE	"
52h	"	1320	3140				466.09	-.14	466.23	-.74				MC	"
56h	"	1646	3396				466.05	-.20	466.23	-.74				MC	"
60h	"	2050	3590				466.05	-.18	466.23	-.74				BAL	"
64h	6/7	0050	3830				466.15	-.11	466.26	-.77				"	"
68h	"	0448	4068				466.28	-.10	466.38	-.87				"	"
	"	0852	4312				466.28							GC	"
	"	1249	4549				466.31							GC	"
	"	1650	4790 ~~5031~~				466.32							"	"
	"	2053	~~5033~~ 5274				466.30							BAL/KS	"
	6/8	0051	5271 5572				466.39							KS/BAL	"
	"	0449	~~5509~~ 5810				466.41							KS	"
	6/8	0738	5678				466.47								

Page ____ of ____

AQUIFER TEST DATA

Owner _____ Address _____ County _____ State _____

Date _____ Company performing test _____ Measured by _____

Well No. BLM-17 (Hourly) Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data

Pump on: Date _____ Time _____ (t_o)
Pump off: Date _____ Time _____ (t'_o)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data

Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data

How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
6/6	1102	3002				466.15							PSE	LC_m #3 (ded.)
"	1206	3066				466.13							JK	"
"	1320	3140				466.09							MC	"
	~~0852~~					~~466.18~~							~~GC~~	"

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: BLM-2-482 r(ft)= 1425

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	0859	0	0.00E+00	0.00	0.02	0.00	-0.02	0.00
		5	2.46E-06	0.00	0.02	0.00	-0.02	0.00
		11	5.42E-06	0.00	0.02	0.00	-0.02	0.00
		15	7.39E-06	0.02	0.02	0.00	0.00	-0.02
		21	1.03E-05	0.04	0.02	0.00	0.02	-0.04
		25	1.23E-05	0.05	0.02	0.00	0.03	-0.05
		31	1.53E-05	0.06	0.01	0.00	0.05	-0.07
		41	2.02E-05	0.08	0.01	0.00	0.07	-0.09
		49	2.41E-05	0.07	0.01	0.00	0.06	-0.08
		61	3.00E-05	0.11	0.01	0.00	0.10	-0.12
		75	3.69E-05	0.13	0.01	0.00	0.12	-0.14
		91	4.48E-05	0.14	0.00	0.00	0.14	-0.16
		109	5.37E-05	0.17	0.00	0.00	0.17	-0.19
		119	5.86E-05	0.18	0.00	0.00	0.18	-0.20
		149	7.34E-05	0.19	-0.02	0.00	0.21	-0.23
		179	8.82E-05	0.18	-0.04	0.00	0.22	-0.24
		209	1.03E-04	0.18	-0.04	0.00	0.22	-0.24
		239	1.18E-04	0.17	-0.05	0.00	0.22	-0.24
		269	1.32E-04	0.17	-0.07	0.00	0.24	-0.26
		299	1.47E-04	0.15	-0.09	0.00	0.24	-0.26
		329	1.62E-04	0.14	-0.10	0.00	0.24	-0.26
		359	1.77E-04	0.14	-0.10	0.00	0.24	-0.26
		419	2.06E-04	0.12	-0.14	0.00	0.26	-0.28
		469	2.31E-04	0.09	-0.15	0.00	0.24	-0.26
		539	2.65E-04	0.08	-0.18	0.00	0.26	-0.28
		579	2.85E-04	0.08	-0.18	0.00	0.26	-0.28
		619	3.05E-04	0.09	-0.17	0.00	0.26	-0.28
		739	3.64E-04	0.12	-0.15	0.00	0.27	-0.29
		949	4.67E-04	0.18	-0.14	0.00	0.32	-0.34
		1179	5.81E-04	0.22	-0.14	0.00	0.36	-0.38
6/5/90		1449	7.14E-04	0.36	-0.09	0.00	0.45	-0.47
		1659	8.17E-04	0.36	-0.15	0.00	0.51	-0.53
		1899	9.35E-04	0.30	-0.24	0.00	0.54	-0.56
		2139	1.05E-03	0.34	-0.20	0.00	0.54	-0.56
		2379	1.17E-03	0.44	-0.14	0.00	0.58	-0.60
		2649	1.30E-03	0.52	-0.11	0.00	0.63	-0.65
6/6/90		2919	1.44E-03	0.67	-0.08	0.00	0.75	-0.77
		3009	1.48E-03	0.66	-0.11	0.00	0.77	-0.79
		3339	1.64E-03	0.57	-0.21	0.00	0.78	-0.80
		3579	1.76E-03	0.61	-0.17	0.00	0.78	-0.80
		3819	1.88E-03	0.72	-0.12	0.00	0.84	-0.86
		4059	2.00E-03	0.75	-0.08	0.00	0.83	-0.85
6/7/90		4329	2.13E-03	0.86	-0.07	0.00	0.93	-0.95
		4539	2.24E-03	0.88	-0.13	0.00	1.01	-1.03
		4779	2.35E-03	0.82	-0.18	0.00	1.00	-1.02
		5019	2.47E-03	0.85	-0.12	0.00	0.97	-0.99
		5259	2.59E-03	0.94	-0.09	0.00	1.03	-1.05
		5499	2.71E-03	0.95	-0.10	0.00	1.05	-1.07
		5619	2.77E-03	0.98	-0.08	0.00	1.06	-1.08

end

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: BLM-2-630 r(ft)= 1389

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	0859	0.0	0.00E+00	0.00	0.02	0.00	-0.02	0.00
		5.0	2.59E-06	0.01	0.02	0.00	-0.01	-0.01
		11.0	5.70E-06	0.03	0.02	0.00	0.01	-0.03
		15.0	7.77E-06	0.04	0.02	0.00	0.02	-0.04
		21.0	1.09E-05	0.07	0.02	0.00	0.05	-0.07
		25.0	1.30E-05	0.09	0.02	0.00	0.07	-0.09
		31.0	1.61E-05	0.12	0.01	0.00	0.11	-0.13
		41.0	2.13E-05	0.18	0.01	0.00	0.17	-0.19
		49.0	2.54E-05	0.23	0.01	0.00	0.22	-0.24
		61.0	3.16E-05	0.28	0.01	0.00	0.27	-0.29
		75.0	3.89E-05	0.36	0.01	0.00	0.35	-0.37
		91.0	4.72E-05	0.43	0.00	0.00	0.43	-0.45
		109.0	5.65E-05	0.49	0.00	0.00	0.49	-0.51
		119.0	6.17E-05	0.52	0.00	0.00	0.52	-0.54
		149.0	7.72E-05	0.61	-0.02	0.00	0.63	-0.65
		179.0	9.28E-05	0.68	-0.04	0.00	0.72	-0.74
		209.0	1.08E-04	0.74	-0.04	0.00	0.78	-0.80
		239.0	1.24E-04	0.78	-0.05	0.00	0.83	-0.85
		269.0	1.39E-04	0.82	-0.07	0.00	0.89	-0.91
		299.0	1.55E-04	0.86	-0.09	0.00	0.95	-0.97
		329.0	1.71E-04	0.89	-0.10	0.00	0.99	-1.01
		359.0	1.86E-04	0.92	-0.10	0.00	1.02	-1.04
		419.0	2.17E-04	0.97	-0.14	0.00	1.11	-1.13
		469.0	2.43E-04	1.00	-0.15	0.00	1.15	-1.17
		539.0	2.79E-04	1.05	-0.18	0.00	1.23	-1.25
		579.0	3.00E-04	1.08	-0.18	0.00	1.26	-1.28
		619.0	3.21E-04	1.12	-0.17	0.00	1.29	-1.31
		739.0	3.83E-04	1.21	-0.15	0.00	1.36	-1.38
		949.0	4.92E-04	1.35	-0.14	0.00	1.49	-1.51
		1179.0	6.11E-04	1.49	-0.14	0.00	1.63	-1.65
6/5/90		1449.0	7.51E-04	1.63	-0.09	0.00	1.72	-1.74
		1659.0	8.60E-04	1.68	-0.15	0.00	1.83	-1.85
		1899.0	9.84E-04	1.64	-0.24	0.00	1.88	-1.90
		2139.0	1.11E-03	1.70	-0.20	0.00	1.90	-1.92
		2379.0	1.23E-03	1.85	-0.14	0.00	1.99	-2.01
		2649.0	1.37E-03	1.98	-0.11	0.00	2.09	-2.11
6/6/90		2919.0	1.51E-03	2.17	-0.08	0.00	2.25	-2.27
		3009.0	1.56E-03	2.15	-0.11	0.00	2.26	-2.28
		3339.0	1.73E-03	2.01	-0.21	0.00	2.22	-2.24
		3579.0	1.86E-03	2.02	-0.17	0.00	2.19	-2.21
		3819.0	1.98E-03	2.15	-0.12	0.00	2.27	-2.29
		4059.0	2.10E-03	2.20	-0.08	0.00	2.28	-2.30
6/7/90		4329.0	2.24E-03	2.25	-0.07	0.00	2.32	-2.34
		4539.0	2.35E-03	2.29	-0.13	0.00	2.42	-2.44
		4779.0	2.48E-03	2.23	-0.18	0.00	2.41	-2.43
		5019.0	2.60E-03	2.24	-0.12	0.00	2.36	-2.38
		5259.0	2.73E-03	2.39	-0.09	0.00	2.48	-2.50
		5499.0	2.85E-03	2.43	-0.10	0.00	2.53	-2.55
		5619.0	2.91E-03	2.47	-0.08	0.00	2.55	-2.57

end

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: BLM-7-509 r(ft)= 2654

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	756	0.00	0.00E+00	463.62	0.02	0.00	463.60	0.00
	1041	101.00	1.43E-05	463.59	0.00	0.00	463.59	0.01
	1141	161.00	2.29E-05	463.61	-0.04	0.00	463.65	-0.05
	1239	219.00	3.11E-05	463.59	-0.05	0.00	463.64	-0.04
	1342	282.00	4.00E-05	463.55	-0.09	0.00	463.64	-0.04
	1431	339.00	4.81E-05	463.51	-0.10	0.00	463.61	-0.01
	1518	378.00	5.37E-05	463.51	-0.11	0.00	463.62	-0.02
	1659	479.00	6.80E-05	463.44	-0.16	0.00	463.60	0.00
	1857	597.00	8.48E-05	463.42	-0.18	0.00	463.60	0.00
	2113	733.00	1.04E-04	463.48	-0.15	0.00	463.63	-0.03
6/5/90	109	969.00	1.38E-04	463.50	-0.15	0.00	463.65	-0.05
	523	1223.00	1.74E-04	463.54	-0.12	0.00	463.66	-0.06
	906	1446.00	2.05E-04	463.58	-0.09	0.00	463.67	-0.07
	1255	1675.00	2.38E-04	463.52	-0.16	0.00	463.68	-0.08
	1702	1922.00	2.73E-04	463.46	-0.23	0.00	463.69	-0.09
	2102	2162.00	3.07E-04	463.50	-0.19	0.00	463.69	-0.09
6/6/90	101	2401.00	3.41E-04	463.51	-0.14	0.00	463.65	-0.05
	501	2641.00	3.75E-04	463.54	-0.11	0.00	463.65	-0.05
	941	2921.00	4.15E-04	463.69	-0.08	0.00	463.77	-0.17
	1313	3133.00	4.45E-04	463.64	-0.15	0.00	463.79	-0.19
	1709	3369.00	4.78E-04	463.56	-0.21	0.00	463.77	-0.17
	2105	3605.00	5.12E-04	463.61	-0.17	0.00	463.78	-0.18
6/7/90	104	3844.00	5.46E-04	463.68	-0.12	0.00	463.80	-0.20
	503	4083.00	5.80E-04	463.71	-0.08	0.00	463.79	-0.19
	910	4330.00	6.15E-04	463.77	-0.07	0.00	463.84	-0.24
	1314	4574.00	6.49E-04	464.74	-0.13	0.00	464.87	-1.27
	1714	4814.00	6.83E-04	463.66	-0.18	0.00	463.84	-0.24
	2105	5045.00	7.16E-04	463.68	-0.12	0.00	463.80	-0.20
6/8/90	100	5280.00	7.50E-04	463.77	-0.09	0.00	463.86	-0.26
	501	5521.00	7.84E-04	463.77	-0.10	0.00	463.87	-0.27

end

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. BLM-7-509 Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Δ	Discharge measurement	Rate		Comments on factors affecting test data
															Rov. #1 (ABQ)
0	6/4	7:56	-				463.62								"
1h		1041	101				463.59	0		+.03	0.03				"
2h		1141	161				463.64	0.03		-.02	0.02				"
3h		1239	219				463.59	0.05		+.02	0.02				"
4h		1342	282				463.55	0.05		+.04	0.01				"
5h		1431	339				463.61	0.10		+.04	0.01				"
6h		1518	378				463.51	0.12		.00	0.01				"
8h		1659	479				463.44	0.13		+.07	0.01				"
10h		1857	597				463.42	0.19		+.02	0.01				"
12h		2113	733				463.48	0.14		-.06	0.00				"
16h		0109	969				463.50	0.14		-.02	0.02				"
20h		0523	1233				463.54	0.11		-.04	0.03				"
24h		0906	1446				463.58	0.09		-.04	0.01				"
28h		1255	1675				463.52	0.15		+.06	0.05				Every 4 hours
32h		1702	1922				463.46	0.22		+.06	0.01				"
36h		0902	2162				463.50	0.18		-.04	0.010				"
40h		0101	2401				463.5	0.13		-.01	0.02				"
44h		0501	2641				463.54	0.10		-.03	0.02				"
48h	6/6	0941	3081				463.69	0.08		-.15	0.15			PSE	"
52	"	1313	3133				463.64	0.14		+.05	0.16			GC	"
56	"	1709	3369				463.56	0		+.08					
60		2105	3605				463.61								
64	6/7	0104	3842				463.68								
68	"	0503	4083				463.71								
72	"	0910	4330				463.77								
76	"	1314	4574				463.74								
80	"	1714	4814				463.66								
84		2105	5045				463.68								
88	6/8	0100	5287				463.71								
92		0501	5528				463.71								

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: BLM-6-488 r(ft)= 0

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	750	0.00	ERR	374.73	0.02	0.00	374.71	0.00
	958	58.00	ERR	374.70	0.01	0.00	374.69	0.02
	1059	119.00	ERR	374.68	0.00	0.00	374.68	0.03
	1154	174.00	ERR	374.66	-0.04	0.00	374.70	0.01
	1254	234.00	ERR	374.63	-0.05	0.00	374.68	0.03
	1359	299.00	ERR	374.59	-0.09	0.00	374.68	0.03
	1458	358.00	ERR	374.57	-0.11	0.00	374.68	0.03
	1658	478.00	ERR	374.50	-0.16	0.00	374.66	0.05
	1856	596.00	ERR	374.51	-0.18	0.00	374.69	0.02
	2100	720.00	ERR	374.56	-0.15	0.00	374.71	0.00
6/5/90	110	970.00	ERR	374.57	-0.15	0.00	374.72	-0.01
	500	1200.00	ERR	374.61	-0.12	0.00	374.73	-0.02
	902	1442.00	ERR	374.66	-0.09	0.00	374.75	-0.04
	1303	1683.00	ERR	374.57	-0.16	0.00	374.73	-0.02
	1711	1931.00	ERR	374.47	-0.23	0.00	374.70	0.01
	2109	2169.00	ERR	374.53	-0.19	0.00	374.72	-0.01
6/6/90	108	2408.00	ERR	374.62	-0.14	0.00	374.76	-0.05
	506	2646.00	ERR	374.64	-0.11	0.00	374.75	-0.04
	1020	2960.00	ERR	374.66	-0.08	0.00	374.74	-0.03
	1332	3152.00	ERR	374.60	-0.16	0.00	374.76	-0.05
	1659	3359.00	ERR	374.51	-0.21	0.00	374.72	-0.01
	2103	3603.00	ERR	374.57	-0.17	0.00	374.74	-0.03
6/7/90	103	3843.00	ERR	374.64	-0.12	0.00	374.76	-0.05
	459	4079.00	ERR	374.67	-0.08	0.00	374.75	-0.04
	923	4343.00	ERR	374.70	-0.07	0.00	374.77	-0.06
	1254	4554.00	ERR	374.65	-0.13	0.00	374.78	-0.07
	1655	4795.00	ERR	374.56	-0.18	0.00	374.74	-0.03
	2109	5049.00	ERR	374.63	-0.12	0.00	374.75	-0.04
6/8/90	104	5284.00	ERR	374.70	-0.09	0.00	374.79	-0.08
	502	5522.00	ERR	374.69	-0.10	0.00	374.79	-0.08

end

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. BLM-6-488 Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_o)
Pump off: Date _____ Time _____ (t'_o)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	(FT) T.O.C. Water level measurement	Correction or Conversion	Corr. Water level	Water level change s or s'	+ Discharge measurement −	Rate	OPERATORS	Comments on factors affecting test data
0	6-4	0750				374.73'	.02	374.71	0			GC	PROBE #
1h	"	0958	58			374.70'	.02	374.68	+.03			"	ROV. # 2 (ABQ#2)
2h	"	1059	119			374.68'	—	374.68	+.03			"	"
3h	"	1154	174			374.66'	-.03	374.69	+.02			"	"
4h	"	1254	234			374.63'	-.05	374.68	+.03			"	"
5h	"	1359	299			374.59'	-.09	374.68	+.03			"	"
6h	"	1458	358			374.57	-.11	374.68	+.03			"	"
8h	"	1658	478			374.50'	-.17	374.67	+.02			"	"
10h	"	1856 1705	596			374.51'	-.18	374.69	+.02			"	"
12h	6	2100	720			374.56	-.15	374.71	0.0			BAL	"
16h	6/5	0110	970			374.57	-.14	374.71	0.0			"	—
20h	"	0500	1200			374.61	-.12	374.73	-.02			"	"
24h	"	0902	1442			374.66'	-.09	374.75	-.04			GC	"
28h	"	1303	1683			374.57	-.15	374.72	-.01			"	Every 4 hours
32h	"	1711	1931			374.47	-.22	374.69	+.02			EM	"
36h	"	2109	2169			374.53	-.19	374.72	-.01			BAL	"
40	6/6	0108	2408			374.67	-.13	374.75	-.04			"	"
44	6/6	0506	2646			374.[illegible]	[illegible]	374.74	-.03			"	"
48	6/6	1020	2960			374.66	-.09	374.75	-.04			MGC	"
52	"	1332	3152			374.60	-.15		-.02			MGC	"
56	"	1659	3359			374.51	-.20		-.02			PSE	"
60	"	2103	3603			374.57	-0.18		-.02			BAL	"
64	6/7	0103	3843			374.64	-.11		-.02			"	"
68	"	0459	4079			374.6[illegible]	-.10		-.04			"	"
72	"	0923	4343			374.70	-.07		-.04			DB	"
76	"	1254	4554			374.65						GC	"
80	"	1655	4795			374.56 374.64						DB	"
84	"	2109	5049			374.63						BAL	"
88	6/8	0104	5284			374.[illegible]						KS	"
92	6/8	0502	5572			374.69						KS	"

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: BLM-9-419 r(ft)= 4463

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	754	0.00	0.00E+00	363.52	0.02	0.00	363.50	0.00
	1004	64.00	3.21E-06	363.53	0.01	0.00	363.52	-0.02
	1105	125.00	6.28E-06	363.52	0.00	0.00	363.52	-0.02
	1200	180.00	9.04E-06	363.49	-0.04	0.00	363.53	-0.03
	1300	240.00	1.20E-05	363.45	-0.05	0.00	363.50	0.00
	1404	304.00	1.53E-05	363.43	-0.09	0.00	363.52	-0.02
	1503	367.00	1.84E-05	363.38	-0.11	0.00	363.49	0.01
	1705	485.00	2.43E-05	363.33	-0.16	0.00	363.49	0.01
	1904	604.00	3.03E-05	363.30	-0.18	0.00	363.48	0.02
	2109	729.00	3.66E-05	363.34	-0.15	0.00	363.49	0.01
6/5/90	123	983.00	4.94E-05	363.36	-0.15	0.00	363.51	-0.01
	510	1210.00	6.07E-05	363.40	-0.12	0.00	363.52	-0.02
	908	1448.00	7.27E-05	363.46	-0.09	0.00	363.55	-0.05
	1314	1694.00	8.50E-05	363.42	-0.16	0.00	363.58	-0.08
	1717	1937.00	9.72E-05	363.32	-0.23	0.00	363.55	-0.05
	2117	2177.00	1.09E-04	363.35	-0.19	0.00	363.54	-0.04
6/6/90	117	2417.00	1.21E-04	363.41	-0.14	0.00	363.55	-0.05
	515	2655.00	1.33E-04	363.44	-0.11	0.00	363.55	-0.05
	1032	2972.00	1.49E-04	363.50	-0.09	0.00	363.59	-0.09
	1344	3164.00	1.59E-04	363.45	-0.16	0.00	363.61	-0.11
	1710	3370.00	1.69E-04	363.36	-0.21	0.00	363.57	-0.07
	2110	3610.00	1.81E-04	363.40	-0.17	0.00	363.57	-0.07
6/7/90	110	3850.00	1.93E-04	363.43	-0.12	0.00	363.55	-0.05
	506	4086.00	2.05E-04	363.50	-0.08	0.00	363.58	-0.08
	932	4352.00	2.18E-04	363.52	-0.08	0.00	363.60	-0.10
	1300	4560.00	2.29E-04	363.50	-0.13	0.00	363.63	-0.13
	1705	4805.00	2.41E-04	363.43	-0.18	0.00	363.61	-0.11
	2115	5055.00	2.54E-04	363.45	-0.12	0.00	363.57	-0.07
6/8/90	113	5293.00	2.66E-04	363.52	-0.09	0.00	363.61	-0.11
	509	5529.00	2.78E-04	363.51	-0.10	0.00	363.61	-0.11

end

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. BLM-9-419 Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t1)
Pump off: Date _____ Time _____ (t2)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____ + SUB -DD
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	BARO. Correction or Conversion	Calc. Water level	Water level change s or s'		Discharge measurement	Rate		Comments on factors affecting test data
															PROBE #4
0	6-4	0754					363.50	.02	363.50	0				GC	ROU. #2 (ABQ #2)
1h 10:00	"	1004	64				363.53	.02	363.51	-.01				"	"
2h 11:00	"	1105	125				363.52	0.0	363.52	-.02				"	"
3h 12:00	"	1200	180				363.49	-.03	363.52	-.02				"	"
4h 13:00	"	1300	240				363.45	-.05	363.50	0.0				"	"
5h 14:00	"	1404	304				363.43	-.09	363.52	-0.2				"	"
6h 15:00	"	1503	367				363.38	-.11	363.49	+0.01				"	"
8h 17:00	"	1705	485				363.33	-.17	363.50	0.0				"	"
10h 19:00	"	1904	604				363.30	-.18	363.48	+0.02				"	"
12h 21:00	"	2109	729				363.34	-.15	363.49	+0.01				BAL	"
16h 01:00	6/5	0123	960				363.36	-.15	363.51	-0.01				"	"
20h 05:00	"	0510	1210				363.40	-.12	363.52	+0.02				"	"
24h 09:00	"	0908	1448				363.46	-.09	363.55	+.05				GC	"
~~30h~~ 1300	"	1314	1694				363.42	-.15	363.57	+.07				GC	"
32h	"	1717	1937				363.32	-.22	363.54	-0.01				GC	EVERY 4 hours
36h	"	2117	2177				363.35	-.18	363.53	-0.03				BAL	ACB #2
40	6/6	0117	2417				363.41	-.13	363.54	-0.04				"	"
44	6/6	0515	2655				363.44	-.10	363.54	-0.04				"	"
48	6/6	1032	2972				363.50	-.08	363.58	-0.08				PSE	"
52	"	1344	3164				363.45	-.15						PSE	"
56	"	1710	3370				363.36	-.20						MC	"
60	"	2110	3610				363.40	-.18						BAL	"
64	6/7	0110	3850				363.48	-.11						"	"
68	"	0506	4086				363.50	-.10						"	"
72	"	0912	4352				363.52	-.07		-0.07				PB	"
76	"	1300	4560				363.50							"	"
80	"	1705	4805				363.43							"	"
84	"	2115	5055				363.45							BAL/KS	"
88	6/8	0113	5293				363.52							KS	"
92	"	0509	5529				363.51							KS	"

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: JP-2-447 r(ft)= 4822

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	822	0.00	0.00E+00	378.25	0.02	0.00	378.23	0.00
	1014	74.00	3.18E-06	378.50	0.01	0.00	378.49	-0.26
	1123	143.00	6.15E-06	378.45	0.00	0.00	378.45	-0.22
	1223	203.00	8.73E-06	378.48	-0.04	0.00	378.52	-0.29
	1327	267.00	1.15E-05	378.47	-0.07	0.00	378.54	-0.31
	1414	314.00	1.35E-05	378.34	-0.09	0.00	378.43	-0.20
	1506	366.00	1.57E-05	378.37	-0.11	0.00	378.48	-0.25
	1649	469.00	2.02E-05	378.25	-0.16	0.00	378.41	-0.18
	1847	587.00	2.52E-05	378.26	-0.18	0.00	378.44	-0.21
	2049	709.00	3.05E-05	378.25	-0.15	0.00	378.40	-0.17
6/5/90	47	947.00	4.07E-05	378.32	-0.15	0.00	378.47	-0.24
	445	1185.00	5.10E-05	378.29	-0.12	0.00	378.41	-0.18
	846	1426.00	6.13E-05	378.34	-0.09	0.00	378.43	-0.20
	1240	1660.00	7.14E-05	378.39	-0.16	0.00	378.55	-0.32
	1645	1905.00	8.19E-05	378.19	-0.23	0.00	378.42	-0.19
	2044	2144.00	9.22E-05	378.20	-0.19	0.00	378.39	-0.16
6/6/90	44	2384.00	1.03E-04	378.26	-0.14	0.00	378.40	-0.17
	444	2624.00	1.13E-04	378.27	-0.11	0.00	378.38	-0.15
	849	2869.00	1.23E-04	378.29	-0.07	0.00	378.36	-0.13
	1257	3117.00	1.34E-04	378.31	-0.15	0.00	378.46	-0.23
	1648	3348.00	1.44E-04	378.27	-0.21	0.00	378.48	-0.25
	2045	3585.00	1.54E-04	378.26	-0.17	0.00	378.43	-0.20
6/7/90	45	3825.00	1.65E-04	378.29	-0.12	0.00	378.41	-0.18
	444	4064.00	1.75E-04	378.34	-0.08	0.00	378.42	-0.19
	850	4310.00	1.85E-04	378.34	-0.07	0.00	378.41	-0.18
	1253	4553.00	1.96E-04	378.38	-0.13	0.00	378.51	-0.28
	1655	4795.00	2.06E-04	378.27	-0.18	0.00	378.45	-0.22
	2044	5024.00	2.16E-04	378.28	-0.12	0.00	378.40	-0.17
6/8/90	43	5263.00	2.26E-04	378.32	-0.09	0.00	378.41	-0.18
	443	5503.00	2.37E-04	378.34	-0.10	0.00	378.44	-0.21

end

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. JP-2-447 Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_o)
Pump off: Date _____ Time _____ (t_o')
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change ± cor or s'	−DD +Inc Δ corr	Discharge measurement	Rate		Comments on factors affecting test data
0	6/4	0822					378.25								
1h		1014	114				378.50	3.0		+.25	0.25				ROV. #1
2h		1123	143				378.45	-.03		+.05	0.23				
3h		1223	203				378.42	-.05		-.03	0.28				
4h		1327	267				378.47	-.08		+.01	0.20				
5h		1414	314				378.34	-.10		+.07	0.19				
6h		1506	366				378.37	-.12		-.03	0.24				
8h		1649	529				378.35	-.17		+.08	0.17				
10h		1847	647				378.26	-.19		-.01	0.20				
12h	↓	2049	769				378.25	-.22		+.01	0.14				
16h	6/5	0041	1007				378.32	-.14		-.07	0.21				
20h		0445	1245				378.29	-.11		+.03	0.15				
24h		0846	1486				378.34	-.09		-.04	0.18				
28hr		1240	1880				378.39	-.15		-.05	0.29				
32hr		1645	1905				378.19	-.32		+.20	0.16				Every 4 hours
36		2044	2304				378.20	-.18		+.01	0.13				
40		0044	2384				378.26	-.13		-.06	0.14				
44	↓	0444	2684				378.27	-.10		-.01	0.12				
48	6/6	0849	2889				378.31	378.29		-.02	0.12			MGC	
52		1257	3177				378.31	-.12		-.02	0.18				
56		1648	3348 3408				378.27			+.04					
60		2045	3585 3645				378.26								
64	6-7	0045	3825 3885				378.29								
68	"	0444	4064 4124				378.34								
72	"	0850	4310 4370				378.34	-0.07							
76	"	1253	4553 4613				378.38								
80		1655	4795 4856				378.27								
84		2044	5024 5084				378.28								
88	6/8	0043	5263 5323				378.32								
92		0443	5503				378.34								

Primary form for Nasa Well-PT Pump Test

Pumping Phase Data T(0)=9:00am

Well: MW-1-542 r(ft)= 4457

Date	Time	t(min)	t/r2	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s
6/4/90	813	0.00	0.00E+00	386.79	0.02	0.00	386.77	0.00
	1024	84.00	4.23E-06	386.63	0.01	0.00	386.62	0.15
	1130	150.00	7.55E-06	386.61	-0.02	0.00	386.63	0.14
	1230	210.00	1.06E-05	386.57	-0.04	0.00	386.61	0.16
	1334	274.00	1.38E-05	386.69	-0.07	0.00	386.76	0.01
	1421	321.00	1.62E-05	386.64	-0.09	0.00	386.73	0.04
	1517	377.00	1.90E-05	386.58	-0.11	0.00	386.69	0.08
	1729	509.00	2.56E-05	386.58	-0.17	0.00	386.75	0.02
	1923	623.00	3.14E-05	386.58	-0.18	0.00	386.76	0.01
	2137	757.00	3.81E-05	386.61	-0.14	0.00	386.75	0.02
6/5/90	146	1006.00	5.06E-05	386.60	-0.15	0.00	386.75	0.02
	533	1233.00	6.21E-05	386.52	-0.11	0.00	386.63	0.14
	925	1456.00	7.33E-05	386.69	-0.09	0.00	386.78	-0.01
	1340	1720.00	8.66E-05	386.63	-0.17	0.00	386.80	-0.03
	1740	1960.00	9.87E-05	386.53	-0.24	0.00	386.77	0.00
	2137	2197.00	1.11E-04	386.54	-0.17	0.00	386.71	0.06
6/6/90	139	2439.00	1.23E-04	386.63	-0.13	0.00	386.76	0.01
	536	2676.00	1.35E-04	386.63	-0.10	0.00	386.73	0.04
	902	2882.00	1.45E-04	386.66	-0.07	0.00	386.73	0.04
	1253	3113.00	1.57E-04	386.62	-0.15	0.00	386.77	0.00
	1735	3395.00	1.71E-04	386.57	-0.22	0.00	386.79	-0.02
	2135	3635.00	1.83E-04	386.60	-0.16	0.00	386.76	0.01
6/7/90	129	3869.00	1.95E-04	386.65	-0.12	0.00	386.77	0.00
	522	4102.00	2.06E-04	386.71	-0.08	0.00	386.79	-0.02
	950	4370.00	2.20E-04	386.73	-0.08	0.00	386.81	-0.04
	1321	4581.00	2.31E-04	386.68	-0.13	0.00	386.81	-0.04
	1720	4820.00	2.43E-04	386.58	-0.18	0.00	386.76	0.01
	2136	5076.00	2.56E-04	386.65	-0.11	0.00	386.76	0.01
6/8/90	133	5313.00	2.67E-04	386.63	-0.10	0.00	386.73	0.04
	530	5550.00	2.79E-04	386.62	-0.10	0.00	386.72	0.05

end

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. WW-1-452 Distance from pumping well _____ Type of test Pump Test No. _____

Measuring equipment _____

Time Data
Pump on: Date 6-4-90 Time 0900 (a)
Pump off: Date 6-8-90 Time 0745 (b)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data: Probe marked in inches

	Date	Clock time	Time since pump started t min	Time since pump stopped t'	t/t'	Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Discharge measurement	Rate	✓	
													DEDICATED M-SCOPE
0	6-4	8:13				386.95	.02	386.93	0			MC	"
1h	"	1024	84			386.75	.01	386.74	.1			"	"
2h	"	1130	150			386.73	-.02	386.75	.1			"	"
3h	"	1230	210			386.68	-.04	386.72	.2			"	"
4h	"	1334	274			386.83	-.07	386.90	-.1			"	"
5h	"	1421	321			386.77	-.10	386.87	.1			"	"
6h	"	1517	377			386.70	-.11	386.81	.2			GC	"
8h	"	1729	509			386.70	-.18	386.88	0			"	"
10h	"	1923	623			386.70	-.17	386.87	.0			"	"
12h	"	2131	GC 757			386.73	-.14					BAL	"
16h	6/5	0146	1086			386.72	-.15		+ -			~	"
20h	"	0533	1233			386.62	-.11		+ -			"	"
24h	"	0925	1465			386.83	-.09					GC	"
28h		1340	1720			386.76	-.17					GC	Every 4 hours
32h	"	1740	1960			386.64	-.23					GC	"
36h	"	2137	2197			386.65	-.16					BAL	"
40	6/6	0139	2439			386.75	-.12					"	"
44	6/6	0536	2676			386.75	-.10					"	"
48	6/6	0902	2882			386.79	-.07					MC	"
52	"	1253	3113			386.74	-.14					MC	"
56	"	1735	3395			386.68	-.20					MC	"
60	"	2135	3635			386.72	-.18					BAL	"
64	6/7	0129	3869			386.78	-.11					"	"
68	"	0522	4102			386.85	-.10					"	"
72	"	0950	4370			386.87	-.07		+0.01			GC	"
76	"	1321	4581			386.82						"	"
80	"	1720	4820			386.69						"	"
84	"	2136	5076			386.78						BAL/KS	"
88	6/8	0133	5313			386.76						KS/BAL	"
92	"	0530	5550			386.74						KS	"

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. PL-1-486 Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_o)
Pump off: Date _____ Time _____ (t_p)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point T.O.C.
Elevation of measuring point 4520.35

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	T.O.C. (North side) Water level measurement	Correction or Conversion	Water level	Water level change (+ = drawdown, − = recovery) s or s'	Discharge measurement	Rate	s* (corrected)	Comments
0	6/4	7:37	0			450.63			0			0	Rev. #1
1h		1052	112			450.79	0.0		0.16			0.16	
2h	59	1151	171			450.82	-0.03		0.19			0.22	
3h	60	1251	231			450.79	-0.05		0.16			0.21	
4h	57	1348	288			450.78	-0.08		0.15			0.23	
5h	51	1439	339			450.75	-0.10		0.12			0.22	
6h	47	1526	386			450.74	-0.12		0.11			0.23	
8h	105 1108	1649	488			450.71	-0.17		0.08			0.25	
10h	105	1905	513			450.71	-0.19		0.08			0.27	
12h	136	2121	729			450.76	-0.14		0.13			0.27	
16h	6/5 0015					450.79	-0.14		0.18			0.30	
20h		0529			450.99 ?	450.89	-0.11		0.26			0.37	
24h		0915				450.93	-0.09		0.30			0.39	
28h		1301				450.90	-0.15		0.27			0.42	Every 4 hours
32h		1712				450.86	-0.22		0.21			0.43	
36h		2111				450.91	-0.18		0.28			0.46	
40h		0109				451.04	-0.13		0.41			0.54	
44h		0512				451.10	-0.10		0.47			0.57	
48	6/6	0949				451.17	-0.08		0.54		0.62	MGC	
			go to next page										

AQUIFER TEST DATA

Owner _____ Address _____ County _____ State _____

Date _____ Company performing test _____ Measured by _____

Well No. PL-1 Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate	Q corrected	
~~3850~~ 6/6	1110					451.12	-0.10		0.49			0.59 ↙	PSE	Rover #1
~~3851~~ "	1210					451.10	-0.12		0.47				0.59	
~~3852~~ "	1319					451.12	-0.14		0.49				0.63	
~~3856~~ "	1716					451.04								
~~3860~~	2110					451.11								
~~3864~~ 6/7	0109					451.22								
~~3868~~	0510					451.27								
6/7	0921					451.31								
"	1320					451.28								
"	1722					451.25								
	2113					451.38								
6/8	0107					451.40								
	0508					451.44								
	0659					451.46								
	~~0757~~					~~451.43~~								

Primary form for Nasa Well-PT Pump Test

Recovery Phase Data

Well: PZ-1 r(ft)=201
Prepump SWL (corr) = 450.50'

Date	Time	t(min)	t'(min)	t/t'	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s'	s-s'
6/8/90	0745:00	5685.00	0.00	ERR	453.27	-0.07	0.00	453.34	-2.84	0.00
	0745:15	5685.25	0.25	22741.00	453.27	-0.07	0.00	453.34	-2.84	0.00
	0745:30	5685.50	0.50	11371.00	453.27	-0.07	0.00	453.34	-2.84	0.00
	0745:45	5685.75	0.75	7581.00	453.27	-0.07	0.00	453.34	-2.84	0.00
	0746:00	5686.00	1.00	5686.00	453.27	-0.07	0.00	453.34	-2.84	0.00
	0746:15	5686.25	1.25	4549.00	453.23	-0.07	0.00	453.30	-2.80	0.04
	0746:30	5686.50	1.50	3791.00	453.20	-0.07	0.00	453.27	-2.77	0.07
	0747	5687.00	2.00	2843.50	453.12	-0.07	0.00	453.19	-2.69	0.15
	0748	5688.00	3.00	1896.00	453.02	-0.07	0.00	453.09	-2.59	0.25
	0749	5689.00	4.00	1422.25	452.93	-0.07	0.00	453.00	-2.50	0.34
	0750	5690.00	5.00	1138.00	452.88	-0.07	0.00	452.95	-2.45	0.39
	0751	5691.00	6.00	948.50	452.81	-0.07	0.00	452.88	-2.38	0.46
	0752	5692.00	7.00	813.14	452.76	-0.07	0.00	452.83	-2.33	0.51
	0753	5693.00	8.00	711.63	452.72	-0.07	0.00	452.79	-2.29	0.55
	0754	5694.00	9.00	632.67	452.69	-0.07	0.00	452.76	-2.26	0.58
	0755	5695.00	10.00	569.50	452.67	-0.07	0.00	452.74	-2.24	0.60
	0800	5700.00	15.00	380.00	452.58	-0.07	0.00	452.65	-2.15	0.69
	0805	5705.00	20.00	285.25	452.51	-0.07	0.00	452.58	-2.08	0.76
	0810	5710.00	25.00	228.40	452.48	-0.07	0.00	452.55	-2.05	0.79
	0815	5715.00	30.00	190.50	452.45	-0.07	0.00	452.52	-2.02	0.82
	0830	5730.00	45.00	127.33	452.38	-0.07	0.00	452.45	-1.95	0.89
	0845	5745.00	60.00	95.75	452.35	-0.06	0.00	452.41	-1.91	0.93
	0945	5805.00	120.00	48.38	452.25	-0.07	0.00	452.32	-1.82	1.02
	1046	5866.00	181.00	32.41	452.16	-0.09	0.00	452.25	-1.75	1.09
	1145	5925.00	240.00	24.69	452.09	-0.11	0.00	452.20	-1.70	1.14
	1245	5985.00	300.00	19.95	452.03	-0.15	0.00	452.18	-1.68	1.16
	1346	6046.00	361.00	16.75	451.97	-0.16	0.00	452.13	-1.63	1.21
	1545	6165.00	480.00	12.84	451.84	-0.20	0.00	452.04	-1.54	1.30
	1745	6285.00	600.00	10.48	451.75	-0.21	0.00	451.96	-1.46	1.38
	1935	6395.00	710.00	9.01	451.72	-0.20	0.00	451.92	-1.42	1.42
	2332	6632.00	947.00	7.00	451.68	-0.15	0.00	451.83	-1.33	1.51
6/9/90	0320	6860.00	1175.00	5.84	451.65	-0.11	0.00	451.76	-1.26	1.58
	0804	7144.00	1459.00	4.90	451.66	-0.04	0.00	451.70	-1.20	1.64
	1747	7671.00	2042.00	3.76	451.46	-0.16	0.00	451.62	-1.12	1.72
6/10/90	0816	8596.00	2911.00	2.95	451.50	0.01	0.00	451.49	-0.99	1.85
	1735	9155.00	3470.00	2.64	451.35	-0.10	0.00	451.45	-0.95	1.89
6/11/90	0855	10075.00	4390.00	2.29	451.36	0.00	0.00	451.36	-0.86	1.98
	1722	10582.00	4897.00	2.16	451.15	-0.10	0.00	451.25	-0.75	2.09
6/12/90	0724	11424.00	5739.00	1.99	451.15	-0.09	0.00	451.24	-0.74	2.10
	1600	11940.00	6255.00	1.91	451.02	-0.20	0.00	451.22	-0.72	2.12
6/13/90	0755	12895.00	7210.00	1.79	451.07	-0.10	0.00	451.17	-0.67	2.17
	1604	13384.00	7699.00	1.74	450.97	-0.21	0.00	451.18	-0.68	2.16
6/14/90	0922	14422.00	8737.00	1.65	451.12	-0.03	0.00	451.15	-0.65	2.19
	1652	16266.00	9187.00	1.77	450.97	-0.19	0.00	451.16	-0.66	2.18
6/15/90	1606	16266.00	10581.00	1.54	450.89	-0.21	0.00	451.10	-0.60	2.24
6/16/90	0845	17265.00	11580.00	1.49	450.97	-0.11	0.00	451.08	-0.58	2.26
6/17/90	0745	18645.00	12960.00	1.44	451.04	-0.03	0.00	451.07	-0.57	2.27
6/19/90	0946	21646.00	15961.00	1.36	450.93	-0.15	0.00	451.08	-0.58	2.26

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Data June 8, 1990 Company performing test GCL Measured by SELKE

Well No. PZ-1 Distance from pumping well _____ Type of test Recovery Test No. _____

Measuring equipment PRE-TEST STATIC WATER LEVEL (@6-4-90, 0745) = 450.50'

Time Data
Pump on: Date 6/4/90 Time 0900 (t_p)
Pump off: Date 6/8/90 Time 0745 (t_p')
Duration of aquifer test:
Pumping 94.75 hrs Recovery _____

Water Level Data
Static water level 450.52
Measuring point TOC - South
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

SET PROBE LG 1 @ 0745 - 6/4/90 @ 450.50.

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
0	6/8	0745:00	5685	0	—		453.27			2.77					START SHIFT - MWS
15s	6/8	0745:15		.25	22740		453.27								
30s	6/8	0745:30		.50			453.27								
45s	6/8	0745:45		.75			453.27								
60s	6/8	0746:00	5686	1	5686		453.27								
75s	6/8	0746:15		1.25			453.23			2.73					
90s	6/8	0746:30		1.50			453.20			2.7					
2m	6/8	0747	5687	2	2844		453.12			2.62					
3m	6/8	0748	5688	3	1896		453.02			2.52					
4m	6/8	0749	5689	4	1422		452.93			2.43					
5m	6/8	0750	5690	5	1138		452.88			2.38					
6m	6/8	0751	5691	6	949		452.81			2.31					
7m	6/8	0752	5692	7	813		452.76			2.26					
8m	6/8	0753	5693	8	712		452.72			2.22					
9m	6/8	0754	5694	9	633		452.69			2.19					
10m	6/8	0755	5695	10	570		452.67			2.17					
15m	6/8	0800	5700	15	380		452.58			2.08					
20m	6/8	0805	5705	20	285		452.51			2.01					
25m	6/8	0810	5710	25	228		452.48			1.98					
30m	6/8	0815	5715	30	191		452.45			1.95					
45m	6/8	0830	5730	45	127		452.38			1.88					
1H	6/8	0845	5745	60	96		452.35			1.85					
2H	6/8	0945	5805	120	48		452.25			1.75					
3H	"	1046	5866	181	32		452.16			1.66					
4H		1146	5925	240	25		452.09			1.59					
5H		1245	5985	300	20		452.03			1.53					
6H		1346	6046	361	17		451.97			1.47				ECM	
8H		1545	6165	480	13		451.84			1.34				ECM	
10H		1745	6285	600	10.5		451.75			1.25					

AQUIFER TEST DATA

Owner NASA - WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. PZ-1 Distance from pumping well _____ Type of test RECOVERY Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments on factors affecting test data
															Target Recovery Level 450.78 '
12H		0935	63965	710	9		451.72			1.22					
16H		0832	66325	947	=		451.68			1.18					
20H	6/9	0320	68600	1135	6		451.65			1.15					
24H	"	0804	71445	1459	5		451.62			1.16				EM	Every 4 Hours
	"	1747	76711	20473	4		451.46			0.96				EM	
	6/10	0816	85961	2911	3		451.50			1.0				PSE	
	"	1735	91555	3470	2.6		451.35			0.85				JK	
	6/11	0855	100755	4390	2.3		451.36			0.86				GC	
	6/11	1722	105821	4897	2.16		451.15			0.63				MC/PSE	
	6/12	0724	114245	5739	2.0		451.15			0.63				DB	
	"	1600	119405	6255	1.9		451.02			0.50				MC	
	6/13	0855	128465	7210	1.8		451.07			0.55				EM	.29' to recovery
	6/13	1604	133845	7699	1.74		450.97			0.45				GC	.19 TO RECOVERY
	6/14	0922	144225	8737	1.65		451.12			0.60				GC	.34 TO RECOVERY
	6/14	1652	148725	9187	1.62		450.97			0.45				JR	.19 " "
	6/15	0924	158405	10179	1.55		450.20			0.32				JR	BAD READING
	6/15	1606	162665	10581	1.54		450.89			0.37				MC	.11' to recovery
	6/16	0845	172055	11580	1.50		450.97			0.45				MC	.19 " "
	6/17	0745	180485	12960	1.42		451.04			0.52				GC	.26 " "
	6/19	0946	216465	15960	1.36		450.93			0.41				EM	

Primary form for Nasa Well-PT Pump Test

Recovery Phase Data

Well: PZ-2 r(ft)=144
Prepump SWL (corr) = 449.34'

Date	Time	t(min)	t'(min)	t/t'	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s'	s-s'
6/8/90	0745:00	5685.00	0.00	ERR	453.05	-0.07	0.00	453.12	-3.78	0.00
	0745:15	5685.25	0.25	22741.00	452.95	-0.07	0.00	453.02	-3.68	0.10
	0745:30	5685.50	0.50	11371.00	452.70	-0.07	0.00	452.77	-3.43	0.35
	0745:45	5685.75	0.75	7581.00	452.50	-0.07	0.00	452.57	-3.23	0.55
	0746:00	5686.00	1.00	5686.00	452.38	-0.07	0.00	452.45	-3.11	0.67
	0746:15	5686.25	1.25	4549.00	452.30	-0.07	0.00	452.37	-3.03	0.75
	0746:30	5686.50	1.50	3791.00	452.22	-0.07	0.00	452.29	-2.95	0.83
	0747	5687.00	2.00	2843.50	452.10	-0.07	0.00	452.17	-2.83	0.95
	0748	5688.00	3.00	1896.00	451.97	-0.07	0.00	452.04	-2.70	1.08
	0749	5689.00	4.00	1422.25	451.90	-0.07	0.00	451.97	-2.63	1.15
	0750	5690.00	5.00	1138.00	451.86	-0.07	0.00	451.93	-2.59	1.19
	0751	5691.00	6.00	948.50	451.82	-0.07	0.00	451.89	-2.55	1.23
	0752	5692.00	7.00	813.14	451.78	-0.07	0.00	451.85	-2.51	1.27
	0753	5693.00	8.00	711.63	451.75	-0.07	0.00	451.82	-2.48	1.30
	0754	5694.00	9.00	632.67	451.73	-0.07	0.00	451.80	-2.46	1.32
	0755	5695.00	10.00	569.50	451.70	-0.07	0.00	451.77	-2.43	1.35
	0800	5700.00	15.00	380.00	451.63	-0.07	0.00	451.70	-2.36	1.42
	0805	5705.00	20.00	285.25	451.56	-0.07	0.00	451.63	-2.29	1.49
	0810	5710.00	25.00	228.40	451.53	-0.07	0.00	451.60	-2.26	1.52
	0815	5715.00	30.00	190.50	451.50	-0.07	0.00	451.57	-2.23	1.55
	0830	5730.00	45.00	127.33	451.42	-0.07	0.00	451.49	-2.15	1.63
	0845	5745.00	60.00	95.75	451.37	-0.06	0.00	451.43	-2.09	1.69
	0945	5805.00	120.00	48.38	451.23	-0.07	0.00	451.30	-1.96	1.82
	1050	5870.00	185.00	31.73	451.13	-0.09	0.00	451.22	-1.88	1.90
	1148	5928.00	243.00	24.40	451.05	-0.11	0.00	451.16	-1.82	1.96
	1248	5988.00	303.00	19.76	450.96	-0.15	0.00	451.11	-1.77	2.01
	1346	6046.00	361.00	16.75	450.89	-0.16	0.00	451.05	-1.71	2.07
	1547	6167.00	422.00	14.61	450.75	-0.20	0.00	450.95	-1.61	2.17
	1745	6285.00	600.00	10.48	450.66	-0.21	0.00	450.87	-1.53	2.25
	1936	6396.00	711.00	9.00	450.62	-0.20	0.00	450.82	-1.48	2.30
	2336	6636.00	951.00	6.98	450.57	-0.15	0.00	450.72	-1.38	2.40
6/9/90	0325	6865.00	1180.00	5.82	450.54	-0.11	0.00	450.65	-1.31	2.47
	0803	7143.00	1458.00	4.90	450.55	-0.04	0.00	450.59	-1.25	2.53
	1750	7730.00	2045.00	3.78	450.33	-0.16	0.00	450.49	-1.15	2.63
6/10/90	0814	8594.00	2909.00	2.95	450.38	0.01	0.00	450.37	-1.03	2.75
	1729	9149.00	3464.00	2.64	450.23	-0.09	0.00	450.32	-0.98	2.80
6/11/90	0852	10072.00	4387.00	2.30	450.22	0.00	0.00	450.22	-0.88	2.90
6/11/90	1719	10579.00	4894.00	2.16	450.12	-0.10	0.00	450.22	-0.88	2.90
6/12/90	0727	11427.00	5742.00	1.99	450.02	-0.09	0.00	450.11	-0.77	3.01
	1358	11818.00	6193.00	1.91	449.88	-0.16	0.00	450.04	-0.70	3.08
6/13/90	0758	12898.00	7213.00	1.79	449.92	-0.10	0.00	450.02	-0.68	3.10
	1606	13506.00	7701.00	1.75	449.82	-0.21	0.00	450.03	-0.69	3.09
6/14/90	0922	14422.00	8737.00	1.65	449.97	-0.03	0.00	450.00	-0.66	3.12
	1645	14865.00	9180.00	1.62	449.82	-0.19	0.00	450.01	-0.67	3.11
6/15/90	0921	15861.00	10176.00	1.56	449.85	-0.10	0.00	449.95	-0.61	3.17
	1603	16263.00	10578.00	1.54	449.74	-0.21	0.00	449.95	-0.61	3.17
6/16/90	0841	17261.00	11576.00	1.49	449.82	-0.11	0.00	449.93	-0.59	3.19
6/17/90	0747	18647.00	12962.00	1.44	449.88	-0.03	0.00	449.91	-0.57	3.21
6/19/90	0841	21581.00	15896.00	1.36	449.77	-0.13	0.00	449.90	-0.56	3.22

AQUIFER TEST DATA

Owner NASA - WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. PZ-2 Distance from pumping well _____ Type of test RECOVERY Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_o)
Pump off: Date _____ Time _____ (t'_o)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments on factors affecting test data
															Target Recovery Level 449.73'
12H		1936	6396	711	9		450.62			1.26					
16H		2336	6636	951	7		450.51			1.21					
20H	6/9	0325	6865	1180	6		450.54			1.18					
24H	11	0803	7143	1458	5		450.55			1.19				EM	~~Every 4 Hours~~
	11	1750	7730	2045	4		450.33			0.97				EM	
	6/10	0814	8594	2909	3		450.38			1.02				PSE	
	"	1729	9149	3464	2.6		450.23			0.87				JK	
	6/11	0852	10072	4387	2.3		450.22			0.86				GC	
	6/11	1719	10579	4894	2.16		450.02			0.66				PSE/MC	
	6/12	0727	11477	5742	1.99		450.02			0.66				DB	
	6/12	1358	11818	6193	1.9		449.88			0.52				ML	
	6/13	0758	12898	7213	1.8		449.92			0.56				EM	0.19' to Recovery
	6/13	1606	13506	7701	1.75		449.82			0.46				GL	0.09' TO RECOVERY
	6/14	0922	14477	8737	1.65		449.97			0.61				GL	0.24' TO RECOVERY
	6/14	1645	14865	9180	1.62		449.82			0.46				CR	.09' " "
6/15	6/14	0921	15861	10176	1.56		449.85			0.49				JR	.12' " "
	6/15	1603	16263	10578	1.54		449.74			0.38				MC	.01' " "
	6/16	0841	17261	11576	1.49		449.82			0.46				MC	.09 to recovery
	6/17	0747	18047	12962	1.43		449.88			0.52				GL	.15 " "
	6/19	0841	21581	15896	1.36		449.77			0.41				EM	

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. PZ-2 Distance from pumping well _____ Type of test Recovery Test No. _____

Measuring equipment PRE-PUMPING STATIC (6-4-90, 0836) = 449.36

Time Data
Pump on: Date _____ Time _____ (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	uncorrected Water level change s or s'		Discharge measurement	Rate		
0	6/8	0745	5685	0			453.05			3.69					ALB #2 Solinst-Ded.
15s	"	"					452.95			3.59					
30s	"	"					452.70			3.34					
45s	"	"					452.50			3.14					
60s	"	0746	5686	1	5686		452.38			3.02					
75s	"	"					452.30			2.94					
90s	"	"					452.22			2.86					
2m	"	0747	5687	2	2844		452.10			2.74					
3m	"	0748	5688	3	1896		451.97			2.61					
4m	"	0749	5689	4	1422		451.90			2.54					
5m	"	0750	5690	5	1138		451.86			2.5					
6m	"	0751	5691	6	949		451.82			2.46					
7m	"	0752	5692	7	813		451.78			2.42					
8m	"	0753	5693	8	712		451.75			2.39					
9m	"	0754	5694	9	633		451.73			2.37					
10m	"	0755	5695	10	570		451.70			2.34					
15m	"	0800	5700	15	380		451.63			2.27					
20m	"	0805	5705	20	285		451.56			2.2					
25m	"	0810	5710	25	228		451.53			2.17					
30m	"	0815	5715	30	191		451.50			2.14					
45m	"	0830	5730	45	127		451.42			2.06					
1H	"	0845	5745	60	96		451.37			2.01					
2H	"	0945	5805	120	48		451.23			1.87					
3H	"	1050	5870	185	32		451.13			1.77					
4H	"	1148	5928	243	24		451.05			1.69					
5H	"	1248	5988	303	20		450.96			1.6					
6H	"	1346	6046	361	17		450.89			1.53					ELM
8H	"	1548	6167	422	15		450.75			1.39					ELM
10H	"	1745	6285	600	10		450.66			1.30					JK

Primary form for Nasa Well-PT Pump Test

Recovery Phase Data

Well: PZ-3 r(ft)=94
Prepump SWL (corr) = 456.41'

Date	Time	t(min)	t'(min)	t/t'	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s'	s-s'
6/8/90	0745	5685.00	0.00	ERR	460.90	-0.07	0.00	460.97	-4.56	0.00
	0745:15	5685.25	0.25	22741.00	460.90	-0.07	0.00	460.97	-4.56	0.00
	0745:30	5685.50	0.50	11371.00	460.51	-0.07	0.00	460.58	-4.17	0.39
	0745:45	5685.75	0.75	7581.00	460.20	-0.07	0.00	460.27	-3.86	0.70
	0746	5686.00	1.00	5686.00	459.90	-0.07	0.00	459.97	-3.56	1.00
	0746:15	5686.25	1.25	4549.00	459.65	-0.07	0.00	459.72	-3.31	1.25
	0746:30	5686.50	1.50	3791.00	459.60	-0.07	0.00	459.67	-3.26	1.30
	0747	5687.00	2.00	2843.50	459.55	-0.07	0.00	459.62	-3.21	1.35
	0748	5688.00	3.00	1896.00	459.45	-0.07	0.00	459.52	-3.11	1.45
	0749	5689.00	4.00	1422.25	459.34	-0.07	0.00	459.41	-3.00	1.56
	0750	**5690.00**	**5.00**	**1138.00**	**459.25**	**-0.07**	**0.00**	**459.32**	**-2.91**	**1.65**
	0751	5691.00	6.00	948.50	459.20	-0.07	0.00	459.27	-2.86	1.70
	0752	5692.00	7.00	813.14	459.17	-0.07	0.00	459.24	-2.83	1.73
	0753	5693.00	8.00	711.63	459.14	-0.07	0.00	459.21	-2.80	1.76
	0754	5694.00	9.00	632.67	459.10	-0.07	0.00	459.17	-2.76	1.80
	0755	5695.00	10.00	569.50	459.07	-0.07	0.00	459.14	-2.73	1.83
	0800	5700.00	15.00	380.00	458.98	-0.07	0.00	459.05	-2.64	1.92
	0805	5705.00	20.00	285.25	458.90	-0.07	0.00	458.97	-2.56	2.00
	0810	5710.00	25.00	228.40	458.86	-0.07	0.00	458.93	-2.52	2.04
	0815	5715.00	30.00	190.50	458.81	-0.07	0.00	458.88	-2.47	2.09
	0820	5720.00	35.00	163.43	458.78	-0.07	0.00	458.85	-2.44	2.12
	0830	5730.00	45.00	127.33	458.73	-0.07	0.00	458.80	-2.39	2.17
	0845	5745.00	60.00	95.75	458.67	-0.06	0.00	458.73	-2.32	2.24
	0945	5805.00	120.00	48.38	458.50	-0.07	0.00	458.57	-2.16	2.40
	1045	5865.00	180.00	32.58	458.37	-0.09	0.00	458.46	-2.05	2.51
	1145	5925.00	240.00	24.69	458.26	-0.11	0.00	458.37	-1.96	2.60
	1245	5985.00	300.00	19.95	458.20	-0.15	0.00	458.35	-1.94	2.62
	1345	6045.00	360.00	16.79	458.10	-0.16	0.00	458.26	-1.85	2.71
	1549	6169.00	484.00	12.75	457.94	-0.20	0.00	458.14	-1.73	2.83
	1745	6285.00	600.00	10.48	457.85	-0.21	0.00	458.06	-1.65	2.91
	1939	6399.00	714.00	8.96	457.80	-0.20	0.00	458.00	-1.59	2.97
	2338	6638.00	953.00	6.97	457.74	-0.14	0.00	457.88	-1.47	3.09
6/9/90	0329	6869.00	1194.00	5.75	457.69	-0.11	0.00	457.80	-1.39	3.17
	0800	7140.00	1465.00	4.87	457.70	-0.04	0.00	457.74	-1.33	3.23
	1752	7732.00	2057.00	3.76	457.48	-0.16	0.00	457.64	-1.23	3.33
6/10/90	0820	8600.00	2925.00	2.94	457.48	0.01	0.00	457.47	-1.06	3.50
	1723	9143.00	3468.00	2.64	457.33	-0.09	0.00	457.42	-1.01	3.55
6/11/90	0840	10060.00	4385.00	2.29	457.32	0.00	0.00	457.32	-0.91	3.65
	1716	10576.00	4901.00	2.16	457.13	-0.10	0.00	457.23	-0.82	3.74
6/12/90	0730	11430.00	5755.00	1.99	457.12	-0.09	0.00	457.21	-0.80	3.76
	1556	11936.00	6261.00	1.91	457.00	-0.20	0.00	457.20	-0.79	3.77
6/13/90	0800	12900.00	7225.00	1.79	457.03	-0.10	0.00	457.13	-0.72	3.84
	1641	13388.00	7713.00	1.74	456.93	-0.21	0.00	457.14	-0.73	3.83
6/14/90	0928	14428.00	8753.00	1.65	457.07	-0.03	0.00	457.10	-0.69	3.87
	1641	14861.00	9186.00	1.62	456.92	-0.19	0.00	457.11	-0.70	3.86
6/15/90	0928	15868.00	10193.00	1.56	456.94	-0.10	0.00	457.04	-0.63	3.93
	1600	16260.00	10585.00	1.54	456.85	-0.21	0.00	457.06	-0.65	3.91
6/16/90	0839	17259.00	11584.00	1.49	456.92	-0.11	0.00	457.03	-0.62	3.94
6/17/90	0750	18650.00	12975.00	1.44	456.98	-0.03	0.00	457.01	-0.60	3.96
6/19/90	0840	21580.00	15905.00	1.36	456.87	-0.13	0.00	457.00	-0.59	3.97

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. PZ-3 Distance from pumping well _____ Type of test Recovery Test No. _____

Measuring equipment PRE-PUMPING SWL. (6-4-90, 0856) = 456.43

Time Data
Pump on: Date _____ Time _____ (t₀)
Pump off: Date 6/4 Time 0900 (t'₀)
Duration of aquifer test: Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

1.67
4.47
Comments on factors affecting test data

SWL = 460.54' @ 0739 (before pump off)

	Date	Clock time	Time since pump started t	Time since pump stopped t' (0715)	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s' (uncor)		Discharge measurement	Rate		
0	6/8	0745	5685	0	UNDEF.		460.90							PSE	LC_S #3 (ded.)
15s	"	"	5685.25	(.25) 15s	22741		460.90							"	
30s	"	"	5685.5	(.5) 30s	11371		460.51							"	
45s	"	"	5685.75	(.75) 45s	7581		460.20							"	
60s	"	0746	5686	1m	5686		459.90							"	
75s	"	"	5686.25	1.25	4549		459.65							"	
90s	"	"	5686.5	1.50	3791		459.60							"	
2m	"	0747	5687	2	2844		459.55							"	
3m	"	0748	5688	3	1896		459.45							"	
4m	"	0749	5689	4	1422		459.34							"	
5m	"	0750	5690	5	1138		459.25							"	
6m	"	0751	5691	6	949		459.20							"	
7m	"	0752	5692	7	813		459.17							"	
8m	"	0753	5693	8	712		459.14							"	
9m	"	0754	5694	9	633		459.10							"	
10m	"	0755	5695	10	569.5		459.07							"	
15m	"	0800	5700	15	380		458.98							"	
20m	"	0805	5705	20	285.25		458.90							"	
25m	"	0810	5710	25	229.4		458.86							"	
30m	"	0815	5715	30	190.5		458.81							"	
45m	"	0830	5730	45	127.3 (0820)	→	458.78 (0830)	→	458.73					"	
1H	"	0845	5745	60	95.75		458.67							"	
2H	"	0945	5805	120	48.4		458.50							"	
3H	"	1045	5865	180	32.6		458.37							"	
4H	"	1145	5925	240	24.7		458.26							"	
5H	"	1245	5985	300	19.9		~~461.~~ 458.20							"	
6H	"	1345	6045	360	16.8		458.10								
8H	"	~~1345~~ 1545	~~6165~~ 6285	~~480~~ 480	12.7		457.94							EW	
10H	"	1745	6285	600	10.5		457.85							JK	

AQUIFER TEST DATA

Owner NASA - WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. PZ-3 Distance from pumping well _____ Type of test RECOVERY Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_o)
Pump off: Date _____ Time _____ (t'_o)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

Comments on factors affecting test data

Target Recovery Level 456.88'

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments
12H	6/8	1945	6599	720	8.96		457.80								
16H	6/8	2338	6638	960	6.96		457.74								
20H	6/9	0329	6869	1200	5.75		457.68								
24H	6/9	0800	7140	1440	4.87		457.70							CM	Every 4 Hours
	"	1752	7732	2057	3.76		457.48							EM	
	6/10	0820	8600	2925	2.94		457.48							PSE	
	"	1723	9143	3468	2.64		457.33							JK	
	6/11	0840	10060	4385	2.29		457.32							GC	PROBE LEFT ON. BATTERY WEAK
	6/11	1716	10576	4901	2.16		457.13							PSE/mc	
	6/12	0730	11430	5755	1.99		457.12							DB	
	"	1556	11936	6261	1.90		457.00							MC	
	6/13	0800	12900	7225	1.78		457.03							EM	0.15' to recovery
	6/13	1608	13388	7713	1.73		456.93							GC	0.05' to recovery
	6/14	0928	14428	8753	1.65		457.07							GC	0.19' to recovery
	6/14	1641	14861	9186	1.62		456.92							JJC	0.04' " "
	6/15	0928	15868	10193	1.56		456.94							JK	0.06' " "
	"	1600	16260	10585	1.54		456.85							MC	.03' " "
	6/16	0839	17259	11584	1.49		456.92							MC	.04' " "
	6/17	0750	18260	12585	1.44		456.98							GC	.10' " "
	6/19	0845	21580	15905	1.36		456.87							EM	

Primary form for Nasa Well-PT Pump Test

Recovery Phase Data

Well: PZ-4 r(ft)=497
Prepump SWL (corr) = 460.17'

Date	Time	t(min)	t'(min)	t/t'	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s'	s-s'
6/8/90	0744	5685.00	0.00	ERR	462.98	-0.07	-0.04	463.01	-2.84	0.00
		5685.25	0.25	22741.00	462.98	-0.07	-0.04	463.01	-2.84	0.00
		5685.50	0.50	11371.00	463.00	-0.07	-0.04	463.03	-2.86	-0.02
		5685.75	0.75	7581.00	463.00	-0.07	-0.04	463.03	-2.86	-0.02
		5686.00	1.00	5686.00	463.00	-0.07	-0.04	463.03	-2.86	-0.02
		5686.50	1.50	3791.00	462.92	-0.07	-0.04	462.95	-2.78	0.06
		5687.00	2.00	2843.50	462.88	-0.07	-0.04	462.91	-2.74	0.10
		5688.00	3.00	1896.00	462.78	-0.07	-0.04	462.81	-2.64	0.20
		5689.00	4.00	1422.25	462.78	-0.07	-0.04	462.81	-2.64	0.20
		5690.00	5.00	1138.00	462.65	-0.07	-0.04	462.68	-2.51	0.33
		5691.00	6.00	948.50	462.60	-0.07	-0.04	462.63	-2.46	0.38
		5692.00	7.00	813.14	462.58	-0.07	-0.04	462.61	-2.44	0.40
		5693.00	8.00	711.63	462.56	-0.07	-0.04	462.59	-2.42	0.42
		5694.00	9.00	632.67	462.53	-0.07	-0.04	462.56	-2.39	0.45
		5695.00	10.00	569.50	462.52	-0.07	-0.04	462.55	-2.38	0.46
		5700.00	15.00	380.00	462.45	-0.07	-0.04	462.48	-2.31	0.53
		5705.00	20.00	285.25	462.38	-0.07	-0.04	462.41	-2.24	0.60
		5710.00	25.00	228.40	462.38	-0.07	-0.04	462.41	-2.24	0.60
		5715.00	30.00	190.50	462.34	-0.07	-0.04	462.37	-2.20	0.64
		5730.00	45.00	127.33	462.28	-0.07	-0.04	462.31	-2.14	0.70
		5745.00	60.00	95.75	462.25	-0.06	-0.04	462.27	-2.10	0.74
		5805.00	120.00	48.38	462.14	-0.07	-0.04	462.17	-2.00	0.84
		5868.00	183.00	32.07	462.03	-0.09	-0.04	462.08	-1.91	0.93
		5930.00	245.00	24.20	461.98	-0.11	-0.04	462.05	-1.88	0.96
		5989.00	304.00	19.70	461.89	-0.15	-0.04	462.00	-1.83	1.01
		6051.00	366.00	16.53	461.80	-0.16	-0.04	461.92	-1.75	1.09
		6173.00	488.00	12.65	461.67	-0.20	-0.04	461.83	-1.66	1.18
		6278.00	593.00	10.59	461.60	-0.21	-0.04	461.77	-1.60	1.24
		6403.00	718.00	8.92	461.51	-0.20	0.00	461.71	-1.54	1.30
		6640.00	955.00	6.95	461.48	-0.14	-0.04	461.58	-1.41	1.43
6/9/90	331	6871.00	1186.00	5.79	461.48	-0.11	-0.04	461.55	-1.38	1.46
		7138.00	1453.00	4.91	461.47	-0.04	-0.04	461.47	-1.30	1.54
		7722.00	2037.00	3.79	461.28	-0.16	-0.04	461.40	-1.23	1.61
6/10/90	812	8592.00	2907.00	2.96	461.26	0.01	0.00	461.25	-1.08	1.76
		9153.00	3468.00	2.64	461.14	-0.10	-0.04	461.20	-1.03	1.81
6/11/90	859	10079.00	4394.00	2.29	461.13	0.00	-0.04	461.09	-0.92	1.92
		10575.00	4890.00	2.16	460.88	-0.10	0.00	460.98	-0.81	2.03
6/12/90	736	11436.00	5751.00	1.99	460.92	-0.08	-0.04	460.96	-0.79	2.05
		11933.00	6248.00	1.91	460.80	-0.20	-0.04	460.96	-0.79	2.05
6/13/90	750	12890.00	7205.00	1.79	460.83	-0.10	-0.04	460.89	-0.72	2.12
		13393.00	7708.00	1.74	460.72	-0.21	-0.04	460.89	-0.72	2.12
6/14/90	932	14432.00	8747.00	1.65	460.87	-0.05	-0.04	460.88	-0.71	2.13
		14855.00	9170.00	1.62	460.70	-0.19	-0.04	460.85	-0.68	2.16
6/15/90	934	15874.00	10189.00	1.56	460.74	-0.11	-0.04	460.81	-0.64	2.20
		16254.00	10569.00	1.54	460.62	-0.21	-0.04	460.79	-0.62	2.22
6/16/90	854	17274.00	11569.00	1.49	460.71	-0.11	-0.04	460.78	-0.61	2.23
6/17/90	756	18656.00	12971.00	1.44	460.76	-0.03	-0.04	460.75	-0.58	2.26
6/19/90	855	21595.00	15910.00	1.36	460.65	-0.13	-0.04	460.74	-0.57	2.27

AQUIFER TEST DATA

Owner NASA - WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. PZ-4 Distance from pumping well _____ Type of test RECOVERY Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_o)
Pump off: Date _____ Time _____ (t'_o)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments on factors affecting test data
															Target Recovery Level: 460.47'
															-0.04
12H		1943		720			461.51*								*corrected for probe
16H		2340		960			461.48								
20H	6/9	0331		1200			461.48								
24H	"	0758		1440			461.47								
	"	1742		2137			461.28							EM	Every 4 Hours
	6/10	0812		6462			461.26*							EM	
	"	1733		5468			461.14	-.04	461.00					PSE	
	6/11	0859		7394			461.13							JK	
	6/11	1715		4890			460.88*							GC	
	6/12	0736		5751			460.92							MC/PSE	
	6/12	1553		6248			460.8							DB	
	6/13	0750		7205			460.83							MC	
	6/13	1613		7708			460.72							EM	0.36' to recovery
	6/14	0932		8747			460.87							GC	0.25' to recovery
	6/14	1635		9170			460.70							GC	0.40' to recovery
	6/15	0934		10189			460.74							MC	0.23' " "
	6/15	1554		10569			460.62	-.04	460.58					JR	0.27' " "
	6/16	0854		11581			460.71		460.67					mc	0.11 " "
	6/17	0756		12971			460.76							mc	.20 " "
	6/19	0855		14470			460.65							GC	.25 " "
														GM	

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County Dona Ana State NM

Date _____ Company performing test GCL Measured by _____

Well No. PZ-4 Distance from pumping well _____ Type of test Recovery Test No. _____

Measuring equipment PRE-PUMPING SWL (6-4-90, 0804) = 460.19

Time Data
Pump on: Date _____ Time _____ (t_o)
Pump off: Date _____ Time _____ (t_o')
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

Comments on factors affecting test data

PROBE CORRECTION FACTOR: −0.04 ft. (PROBE #3)

	Date	Water Level Measur. Clock-time	Time since pump started t	Time since pump stopped (m / s) t'	t/t'	Clock Fi MO Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments
0	6/8/90	462.98		0		0744	-.04	462.94						
15s		462.98		.25		0745 15	"	462.94						
30s		463.00		.5		0745 30	"	462.96						
45s		463.00		.75		~~0745~~ 45		462.96						
60s		463.00		1		0746		462.96						
75s		MISSED		1.25		0746 15								
90s		462.98		1.5		0745 30		462.98						
2m		462.88		2		0747		462.84						
3m		462.	78	3		0748		462.74						
4m		462	78	4		0749		462.74						
5m		462	65	5		0750		462.4						
6m		462	60	6		0751		462.56						
7m		462	58	7		0752		462.54						
8m		462	56	8		0753		462.52						
9m		462	53	9		0754		462.49						
10m		462	52	10		0755		462.48						
15m		462	45	15		0800		462.41						
20m		462	38	20		0805		462.34						
25m		462	38	25		0810		462.34						
30m		462	34	30		0815		462.30						
45m		462	28	45		0830		462.24						
1H		462	25	60		0845		462.21						
2H		462.	14	120		0945		462.10						
3H		462.	03	180		1048		~~460.~~	461.99					PSE
4H		461.	98	240		1150		461.94	~~461~~					PSE
5H		461.	89	300		1249	↓	461.85						PSE
6H		461.	80	360		1351		461.76						ECM
8H		461.	67	~~480~~		1553		461.59						
10H		461	60	~~600~~		1738	↓	461.56						JK

Primary form for Nasa Well-PT Pump Test

Recovery Phase Data

Well: PL-1 r(ft)= 1.075
Prepump SWL (corr) = 450.61'

Date	Time	t(min)	t'(min)	t/t'	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s'	s-s'
6/8/90	0659	5639.00	0.00	ERR	451.46	-0.08	0.00	451.54	-0.93	0.00
	0758	5698.00	13.00	438.00	451.43	-0.07	0.00	451.50	-0.89	0.04
	0806	5706.00	21.00	272.00	451.39	-0.07	0.00	451.46	-0.85	0.08
	0815	5715.00	30.00	191.00	451.38	-0.07	0.00	451.45	-0.84	0.09
	0829	5729.00	44.00	130.00	451.36	-0.07	0.00	451.43	-0.82	0.11
	0849	5749.00	64.00	90.00	451.35	-0.06	0.00	451.41	-0.80	0.13
	0905	5765.00	80.00	72.00	451.34	-0.06	0.00	451.40	-0.79	0.14
	0935	5795.00	110.00	53.00	451.34	-0.07	0.00	451.41	-0.80	0.13
	1034	5754.00	169.00	35.00	451.32	-0.08	0.00	451.40	-0.79	0.14
	1136	5916.00	231.00	26.00	451.30	-0.10	0.00	451.40	-0.79	0.14
	1236	**5976.00**	**291.00**	**21.00**	**451.27**	**-0.14**	**0.00**	**451.41**	**-0.80**	**0.13**
	1340	6040.00	355.00	17.00	451.23	-0.16	0.00	451.39	-0.78	0.15
	1552	6172.00	487.00	13.00	451.15	-0.20	0.00	451.35	-0.74	0.19
	1747	6287.00	602.00	10.00	451.11	-0.21	0.00	451.32	-0.71	0.22
	2012	6432.00	747.00	9.00	451.10	-0.20	0.00	451.30	-0.56	0.24
	2312	6612.00	927.00	7.00	451.12	-0.16	0.00	451.28	-0.67	0.26
	2350	6650.00	965.00	7.00	451.14	-0.14	0.00	451.28	-0.67	0.26
6/9/90	0344	6884.00	1199.00	6.00	451.16	-0.11	0.00	451.27	-0.66	0.27
	0745	7134.00	1449.00	5.00	451.23	-0.04	0.00	451.27	-0.66	0.27
	1717	7697.00	2012.00	4.00	451.11	-0.15	0.00	451.26	-0.65	0.28
6/10/90	0754	8574.00	2889.00	3.00	451.24	0.01	0.00	451.23	-0.62	0.31
	1707	9127.00	3442.00	2.70	451.04	-0.09	0.00	451.13	-0.52	0.41
6/11/90	0826	10046.00	4361.00	2.30	451.16	0.00	0.00	451.16	-0.55	0.38
	1738	10598.00	4913.00	2.20	450.94	-0.11	0.00	451.05	-0.44	0.49
6/12/90	0745	11440.00	5755.00	2.00	451.03	-0.08	0.00	451.11	-0.50	0.43
	1510	11890.00	6205.00	1.90	450.87	-0.18	0.00	451.05	-0.44	0.49
6/13/90	0730	12870.00	7185.00	1.80	450.97	-0.11	0.00	451.08	-0.47	0.46
	1544	13364.00	7679.00	1.70	450.82	-0.21	0.00	451.03	-0.42	0.51
6/14/90	0900	14400.00	8715.00	1.65	451.04	-0.03	0.00	451.07	-0.46	0.47
	1700	14880.00	9195.00	1.62	450.82	-0.19	0.00	451.01	-0.40	0.53
6/15/90	0903	15843.00	10158.00	1.56	450.98	-0.10	-0.13	450.95	-0.34	0.59
	1623	16283.00	10598.00	1.54	450.81	-0.21	0.00	451.02	-0.41	0.52
6/16/90	0904	17284.00	11599.00	1.49	450.94	-0.11	0.00	451.05	-0.44	0.49
6/17/90	0725	18625.00	12940.00	1.44	451.02	-0.04	0.00	451.06	-0.45	0.48

AQUIFER TEST DATA

Owner _____ Address _____ County _____ State _____

Date _____ Company performing test _____ Measured by _____

Well No. PL-1-486 Distance from pumping well _____ Type of test RECOVERY Test No. _____

Measuring equipment Pump #6 0745 6/8/90

Time Data
Pump on: Date _____ Time _____ (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

Comments on factors affecting test data

~~LAST: 451.44~~
ΔS: 0.83

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
6/4	0737	~~3065~~				450.63								Pre-pump SWL
6/8	0659	~~5639~~ 5627	0	UNDEF.		451.46			0.83				PSE	Rover #1
	0758	~~5698~~ 5686	13	~~438~~ 437		451.43			0.80					
	0904	~~5706~~ 5694	21	~~282~~ 271		451.39			0.76					
	0815	~~5715~~ 5703	30	~~151~~ 140		451.38			0.75					
	0829	~~5729~~ 5717	44	130		451.36			0.73					
	0849	~~5749~~ 5737	64	90		451.35			0.72					
	0905	~~5765~~ 5753	80	72		451.34			0.71					
	0935	~~5795~~ 5783	110	53		451.34			0.71					
	1034	~~5854~~ 5842	169	35		451.32			0.69					
	1136	~~5916~~ 5904	231	26		451.30			0.67					
	1236	~~5976~~ 5964	291	21		451.27			0.64					
	1340	~~6040~~ 6028	355	17		451.23			0.60					28% recovered
	1552	~~6172~~ 6160	487	13		451.15			0.52					
	1739	~~6359~~ 6347	602	10		451.11			0.48					
6/8	2012	~~6432~~ 6420	~~1476~~ 1476	9		451.10			0.47					Rover #1 not working
"	2312	~~6612~~ 6600	~~922~~ 922	7		451.12			0.49					pull #2 & use as
"	2350	6650	965	7		451.14			0.51					Roving probe for
6/9	0344	~~6884~~ 6872	11:99 HAT	6		451.16			0.53					PL-1 & PL-2 #1
"	0754	7134	1449	5		451.23			0.60				EM	Rehung Rover w/new battery.
"	1717	~~7697~~ 7819	2012	4		451.11			0.48				EM	
6/10	0754	8574	2889	3		451.24			0.61				PSE	Rover #1
"	1709	~~9127~~ 9247	3442	2.7		451.09			0.41				JK	"
6/11	0826	10046	4361	2.3		451.16			0.53				GL	"
6/11	1738	10598	4913	2.2		450.94							PSE/MC	"
6/12	0740	11440	5755	2.0		451.03							EM	"
6/12	1510	11890	6205	1.9		450.67							MC	
6/13	0730	12870	7185	1.8		450.97							EM	0.26' from recovery
EK 6/13	1544	13364	7679	1.7		450.82							GG	0.11 - FROM REC.

To here

AQUIFER TEST DATA

Owner _____ Address _____ County _____ State _____

Date _____ Company performing test _____ Measured by _____

Well No. PL-1-486 Distance from pumping well _____ Type of test Recovery Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data .22
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

Target Recovery Level 450.91'
ROV. #1

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
6/14	0900	14400	8715	1.65		451.04							GC	0.33' FROM REC. (ROV. #1)
6/14	1700	14880	9195	1.62		450.82							JR	0.11' " " (ROV. #1)
6/15	0903	15843	10158	1.56		450.98							GC	0.27' " "? (ROV. #2)
6/15	1623	16283	10698	1.54		450.81							MC	0.10' " " (ROV #1)
6/16	0904	17284	11599	1.49		450.94							MC	.23 " " (ROV. #1)
6/17	0725	18629	12940	1.44		451.02							GC	.31 " " (ROV #1)
OK TO HERE		↑	↑	↑										

Primary form for Nasa Well-PT Pump Test

Recovery Phase Data

Well: PL-2 r(ft)= 1,332
Prepump SWL (corr) = 439.92'

Date	Time	t(min)	t'(min)	t/t'	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s'	s-s'
6/8/90	0646	5626.00	0.00	ERR	441.06	-0.08	0.00	441.14	-1.22	0.00
		5694.00	9.00	632.67	441.08	-0.07	0.00	441.15	-1.23	-0.01
		5703.00	18.00	316.83	441.00	-0.07	0.00	441.07	-1.15	0.07
		5706.00	21.00	271.71	440.96	-0.07	0.00	441.03	-1.11	0.11
		5724.00	39.00	146.77	440.93	-0.07	0.00	441.00	-1.08	0.14
		5745.00	60.00	95.75	440.91	-0.06	0.00	440.97	-1.05	0.17
		5760.00	75.00	76.80	440.90	-0.06	0.00	440.96	-1.04	0.18
		5790.00	105.00	55.14	440.88	-0.07	0.00	440.95	-1.03	0.19
		5850.00	165.00	35.45	440.85	-0.08	0.00	440.93	-1.01	0.21
		5910.00	225.00	26.27	440.83	-0.10	0.00	440.93	-1.01	0.21
		5972.00	287.00	20.81	440.79	-0.13	0.00	440.92	-1.00	0.22
		6035.00	350.00	17.24	440.76	-0.16	0.00	440.92	-1.00	0.22
		6166.00	481.00	12.82	440.65	-0.20	0.00	440.85	-0.93	0.29
		6280.00	595.00	10.55	440.60	-0.21	0.00	440.81	-0.89	0.33
		6407.00	722.00	8.87	440.60	-0.20	0.00	440.80	-0.88	0.34
		6602.00	917.00	7.20	440.61	-0.05	0.00	440.66	-0.74	0.48
		6642.00	957.00	6.94	440.64	-0.05	0.00	440.69	-0.77	0.45
6/9/90	0335	6875.00	1190.00	5.78	440.66	0.01	0.00	440.65	-0.73	0.49
		7117.00	1432.00	4.97	440.73	-0.02	0.00	440.75	-0.83	0.39
		7715.00	2030.00	3.80	440.50	-0.05	0.00	440.55	-0.63	0.59
6/10/90	0825	8605.00	2920.00	2.95	440.69	0.00	0.00	440.69	-0.77	0.45
		9137.00	3452.00	2.65	440.52	-0.09	0.00	440.61	-0.69	0.53
6/11/90	0838	10058.00	4418.00	2.28	440.64	0.00	0.00	440.64	-0.72	0.50
		10566.00	4926.00	2.14	440.45	-0.10	0.00	440.55	-0.63	0.59
6/12/90	0725	11425.00	5740.00	1.99	440.49	-0.09	0.00	440.58	-0.66	0.56
		11921.00	6236.00	1.91	440.31	-0.20	0.00	440.51	-0.59	0.63
6/13/90	0743	12883.00	7198.00	1.79	440.44	-0.10	0.00	440.54	-0.62	0.60
		13370.00	7685.00	1.74	440.29	-0.21	0.00	440.50	-0.58	0.64
6/14/90	0905	14405.00	8720.00	1.65	440.51	-0.03	0.00	440.54	-0.62	0.60
		14843.00	9098.00	1.63	440.34	-0.18	0.00	440.52	-0.60	0.62
6/15/90	0912	15852.00	10167.00	1.56	440.43	-0.10	0.00	440.53	-0.61	0.61
		16246.00	10561.00	1.54	440.31	-0.21	0.00	440.52	-0.60	0.62
6/16/90	0820	17240.00	11555.00	1.49	440.41	-0.11	0.00	440.52	-0.60	0.62

AQUIFER TEST DATA

Owner _____ Address _____ County _____ State _____

Date _____ Company performing test _____ Measured by _____

Well No. ~~PL-2-S53~~ PL-2-S64 Distance from pumping well _____ Type of test RECOVERY Test No. _____

Measuring equipment Pump off 0745 6/8/00

Time Data
Pump on: Date _____ Time _____ (t_o)
Pump off: Date _____ Time _____ (t'_o)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

Rover #2
Comments on factors affecting test data
~~Pump #2~~

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Discharge measurement	Rate		Comments
												~~LAST 129.10~~
												~~Δs=0.25 (B)~~
												Δs = 1.12'
6/4	0735	QA ✓			439.94							Pre-pump SWL
✓ 6/8	0646	5626	0	0	441.06			1.12			MGC	Rover #2 Ded.
	0754	5694	9	632	441.08			1.14			ELM	
	0803	5703	18	317	441.0			1.06			↓	
	0806	5706	21	272	440.96			1.02				
	0824	5724	39	147	440.93			0.99				
	0845	5745	60	96	440.91			0.97				
1.00	0900	5760	75	77	440.90			0.96				
	0930	5790	105	55	440.88			0.94				
	1030	5850	165	35	440.85			0.91				
	1130	5910	225	26	440.83			0.89				
	1232	5972	287	21	440.79			0.85				
	1335	6035	350	17	440.76			0.82				~~27% Recov~~
	1546	6166	481	13	440.65			0.71				27% Recovery
	1740	6280	595	10.5	440.60			0.66				
	1947	6407	722	9	440.60			0.66				
	2302	6602	917	7	440.61			0.67				Pulled probe for DL-
	2342	6642	957	7	440.64			0.70				Rehung Rover #2
6/9	0335	6875	1190	6	440.66			0.72				
"	0737	7117	1432	5	440.73			0.79			EM	Pulled probe and secured well to prevent vandalism
"	0735	7115	2030	4	440.50			0.56			EM	
6/10	0825	8005	2120	3	440.69			0.75			PSE	Rover #2
"	1777	9137	3452	2.6	440.52			0.58			JK	"
6/11	0838	10058	4418	2.3	440.64			0.70			GC	"
6/11	1706	10516	4926	2.1	440.45			0.51			PSE/MC	"
6/12	0725	11435	5740	2.0	440.49			0.55			EM	"
6/12	1541	11921	6236	1.9	440.31			0.37			MC	"
6/13	0743	12883	7198	1.8	440.44			0.50			Em	0.38' to recovery
6/13	1550	13370	7685	1.74	440.29			0.35			GL	0.23 TO REC.

AQUIFER TEST DATA

Owner _____ Address _____ County _____ State _____

Date _____ Company performing test _____ Measured by _____

Well No. PL-2-504 Distance from pumping well _____ Type of test Recovery Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_0)
Pump off: Date _____ Time _____ (t_0')
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

Rover #2

Target W.L. = 440.06'

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Unl. Water level change s or s'		Discharge measurement	Rate		
6/14	0905	14405	8720	1.65		440.51'			0.57				GL	0.45' TO REC'y
6/14	1623	14843	9098	1.63		440.34'			0.40				JR	0.28' " "
6/15	0912	15852	10167	1.56		440.43'			0.49				GL	0.37' " "
6/15	1546	16246	10561	1.54		440.31			0.37				DSE	0.25' " "
6/16	0820	17240	11555	1.49		440.41			0.47				ML	.35' " "
6/17	0730	18630	12945	1.44		440.50			0.56				GL	.46' " "

Primary form for Nasa Well-PT Pump Test

Recovery Phase Data

Well: BLM-17 r(ft)=1354
Prepump SWL (corr) = 465.50'

Date	Time	t(min)	t'(min)	t/t'	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s'	s-s'
6/8/90	0738	5678.00	0.00	ERR	466.47	-0.07	0.00	466.54	-1.04	0.00
	0749	5689.00	4.00	1422.25	466.45	-0.07	0.00	466.52	-1.02	0.02
	0750	5690.00	5.00	1138.00	466.44	-0.07	0.00	466.51	-1.01	0.03
	0751	5691.00	6.00	948.50	466.44	-0.07	0.00	466.51	-1.01	0.03
	0752	5692.00	7.00	813.14	466.44	-0.07	0.00	466.51	-1.01	0.03
	0753	5693.00	8.00	711.63	466.44	-0.07	0.00	466.51	-1.01	0.03
	0754	5693.00	9.00	632.56	466.44	-0.07	0.00	466.51	-1.01	0.03
	0755	5695.00	10.00	569.50	466.44	-0.07	0.00	466.51	-1.01	0.03
	0800	5700.00	15.00	380.00	466.43	-0.07	0.00	466.50	-1.00	0.04
	0805	5705.00	20.00	285.25	466.43	-0.07	0.00	466.50	-1.00	0.04
	0810	5710.00	25.00	228.40	466.42	-0.07	0.00	466.49	-0.99	0.05
	0815	5715.00	30.00	190.50	466.41	-0.07	0.00	466.48	-0.98	0.06
	0830	5730.00	45.00	127.33	466.38	-0.07	0.00	466.45	-0.95	0.09
	0845	5745.00	60.00	95.75	466.37	-0.06	0.00	466.43	-0.93	0.11
	0945	5805.00	120.00	48.38	466.33	-0.07	0.00	466.40	-0.90	0.14
	1045	5865.00	180.00	32.58	466.30	-0.09	0.00	466.39	-0.89	0.15
	1145	5925.00	240.00	24.69	466.25	-0.11	0.00	466.36	-0.86	0.18
	1245	5985.00	300.00	19.95	466.18	-0.15	0.00	466.33	-0.83	0.21
	1345	6045.00	360.00	16.79	466.13	-0.16	0.00	466.29	-0.79	0.25
	1545	6165.00	480.00	12.84	466.10	-0.20	0.00	466.30	-0.80	0.24
	1743	6283.00	598.00	10.51	466.00	-0.21	0.00	466.19	-0.69	0.35
	1949	6409.00	720.00	8.90	465.93	-0.20	0.00	466.13	-0.63	0.41
	2347	6647.00	960.00	6.92	465.94	-0.14	0.00	466.08	-0.58	0.46
6/9/90	0340	6880.00	1200.00	5.73	465.94	-0.11	0.00	466.05	-0.55	0.49
	0750	7130.00	1445.00	4.93	465.99	-0.04	0.00	466.03	-0.53	0.51
	1728	7708.00	2023.00	3.81	465.85	-0.15	0.00	466.00	-0.50	0.54
6/10/90	0734	8554.00	2869.00	2.98	466.11	0.01	0.00	466.10	-0.60	0.44
	1655	9115.00	3430.00	2.66	465.93	-0.09	0.00	466.02	-0.52	0.52
6/11/90	1749	10609.00	4924.00	2.15	465.71	-0.11	0.00	465.82	-0.32	0.72
6/12/90	0735	11435.00	5750.00	1.99	465.93	-0.08	0.00	466.01	-0.51	0.53
	1452	11872.00	6367.00	1.86	465.81	-0.18	0.00	465.99	-0.49	0.55
6/13/90	0723	12863.00	7178.00	1.79	465.88	-0.12	0.00	466.00	-0.50	0.54
	1530	13350.00	7665.00	1.74	465.73	-0.20	0.00	465.93	-0.43	0.61
6/14/90	0845	14385.00	8700.00	1.65	465.89	-0.03	0.00	465.92	-0.42	0.62
	1713	14893.00	9208.00	1.62	465.75	-0.19	0.00	465.94	-0.44	0.60
6/15/90	0855	15835.00	10150.00	1.56	465.72	-0.10	0.00	465.82	-0.32	0.72
	1631	16291.00	10606.00	1.54	465.60	-0.22	0.00	465.82	-0.32	0.72
6/16/90	0921	17301.00	11616.00	1.49	465.79	-0.11	0.00	465.90	-0.40	0.64
6/17/90	0715	18615.00	12930.00	1.44	465.88	-0.04	0.00	465.92	-0.42	0.62

AQUIFER TEST DATA

Owner NASA WSTF Address County Doña Ana State NM

Date 6-8-90 Company performing test GCL Measured by CONTALDO/

Well No. BLM-17 Distance from pumping well Type of test Recovery Test No.

Measuring equipment FISHER M-SCOPE

Time Data
Pump on: Date Time (t_n)
Pump off: Date Time (t'_n)
Duration of aquifer test:
Pumping Recovery

Water Level Data
Static water level
Measuring point
Elevation of measuring point

Discharge Data
How Q measured
Depth of pump/air line
Previous pumping? Yes No
Duration End

Probe LC#3
Comments on factors affecting test data

465.55' @ t_o
466.41' @ TEST END
DRAWDOWN

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	DSOO 6/14 t	Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Discharge measurement	Rate		
6-8	0738	0		—	5678	466.47 466.45						GC	466.41' -465.55' = 0.86' = Δh
"	0749	30s											
"		60s											
"		90s											
"		2m											
"		3m											
"	0749	4m	4	1422	5689	466.45							
"	0750	5m	5	1138	5690	466.44							
"	0751	6M	6	9485	5691	466.44							
"	0752	7m	7	813	5692	466.44							
"	0753	8m	8	712	5693	466.44							
"	0754	9m	9	633	5694	466.44							
"	0755	10m	10	570	5695	466.44							
"	0800	15m	15	380	5700	466.43							
"	0805	20m	20	285	5705	466.43							
"	0810	25m	25	228	5710	466.42							
"	0815	30m	30	191	5715	466.41							
"	0830	45m	45	127	5730	466.38							
"	0845	1h	60m	96	5745	466.37							
"	0945	2h	120m	48	5805	466.33							C/O RECOVERY
"	1045	3h	180	33	5865	466.30							
"	1145	4h	240	25	5925	466.25							
"	1245	5h	300	20	5985	466.18							25.29 29.1 34
"	1345	6h	360	17	6045	466.13							30.34 34.9 40
"	1545	8h	480	13	6165	466.10							
5/15 "	1743	10h	600 598	11	6283	466.98							
19	1949	12h	720	9	6409	466.93							
	2347	16h	960	7	6661	466.94							
6/9	0340	20h	1200	5.7	6892	466.94							
		24h 28h	1440										

AQUIFER TEST DATA

Owner _____ Address _____ County _____ State _____

Date _____ Company performing test _____ Measured by _____

Well No. BLM-17 Distance from pumping well _____ Type of test Recovery Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

Probe LC #3
Target Recovery level
465.64'

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
6/9	0750	7130	1445	5		465.99							EM	Pulled probe/scratched
"	1728	7708	3023	4		465.85							EM	
6/10	0734	8554	3869	3		466.11							PSE	LC #3
"	1655	9115	3130	2.7		465.93							JK	"
6/11	0745	10005	4320	2.3		N/A							GC	COULD NOT GET PROBE UNTANGLED (hand)
"	1749	10609	4924	2.2		465.71							MC	LC #3
6/12	0735	11435	5751	2		465.93							EM	"
6/12	1452	11872	6367	1.86		465.89							MC	
6/13	0723	12863	7178	1.8		465.88							EM	0.24' from Recovery
6/13	1530	13350	7665	1.74		465.73							GC	0.09' FROM REC.
6/14	0845	14385	8700	1.65		465.89							GC	0.25' " "
6/14	1713	14893	9208	1.62		465.75							MC	0.11' " "
6/15	0855	15835	10150	1.56		465.72							GC	0.08' " "
6/15	1631	16291	10606	1.53		465.60							PSE	.04' above target
6/16	0921	17301	11616	1.49		465.79							MC	.15 from rec.
6/17	0715	18015	12330	1.43		465.88							GC	.24 " "

Primary form for Nasa Well-PT Pump Test

Recovery Phase Data

Well: BLM-2-462 r(ft)=1389

Date	Time	t(min)	t'(min)	t/t'	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s'	s-s'
6/8/90	0745	5685.00	0.00	ERR	1.01	-0.07	0.00	1.08	0.00	0.00
		5685.25	0.25	22741.00	1.01	-0.07	0.00	1.08	0.00	0.00
		5685.50	0.50	11371.00	1.01	-0.07	0.00	1.08	0.00	0.00
		5685.75	0.75	7581.00	1.01	-0.07	0.00	1.08	0.00	0.00
	0746	5686.00	1.00	5686.00	1.01	-0.07	0.00	1.08	0.00	0.00
		5686.25	1.25	4549.00	1.01	-0.07	0.00	1.08	0.00	0.00
		5686.50	1.50	3791.00	1.01	-0.07	0.00	1.08	0.00	0.00
	0747	5687.00	2.00	2843.50	1.01	-0.07	0.00	1.08	0.00	0.00
	0748	5688.00	3.00	1896.00	1.01	-0.07	0.00	1.08	0.00	0.00
	0749	5689.00	4.00	1422.25	1.00	-0.07	0.00	1.07	0.01	0.01
	0750	5690.00	5.00	1138.00	1.00	-0.07	0.00	1.07	0.01	0.01
	0751	5691.00	6.00	948.50	1.00	-0.07	0.00	1.07	0.01	0.01
	0752	5692.00	7.00	813.14	1.00	-0.07	0.00	1.07	0.01	0.01
	0753	5693.00	8.00	711.63	0.99	-0.07	0.00	1.06	0.02	0.02
	0754	5694.00	9.00	632.67	0.99	-0.07	0.00	1.06	0.02	0.02
	0755	5695.00	10.00	569.50	0.99	-0.07	0.00	1.06	0.02	0.02
	0800	5700.00	15.00	380.00	0.99	-0.07	0.00	1.06	0.02	0.02
	0805	5707.00	20.00	285.35	0.98	-0.07	0.00	1.05	0.03	0.03
	0810	5710.00	25.00	228.40	0.98	-0.07	0.00	1.05	0.03	0.03
	0815	5715.00	30.00	190.50	0.98	-0.07	0.00	1.05	0.03	0.03
	0820	5720.00	35.00	163.43	0.98	-0.07	0.00	1.05	0.03	0.03
	0830	5730.00	45.00	127.33	0.98	-0.07	0.00	1.05	0.03	0.03
	0845	5745.00	60.00	95.75	0.99	-0.06	0.00	1.05	0.03	0.03
	0945	5805.00	120.00	48.38	1.00	-0.07	0.00	1.07	0.01	0.01
	1045	5865.00	180.00	32.58	0.98	-0.09	0.00	1.07	0.01	0.01
	1145	5925.00	240.00	24.69	0.93	-0.11	0.00	1.04	0.04	0.04
	1245	5985.00	300.00	19.95	0.90	-0.15	0.00	1.05	0.03	0.03
	1345	6045.00	360.00	16.79	0.85	-0.16	0.00	1.01	0.07	0.07
	1549	6169.00	484.00	12.75	0.76	-0.20	0.00	0.96	0.12	0.12
	1745	6285.00	600.00	10.48	0.72	-0.21	0.00	0.93	0.15	0.15
	1939	6399.00	714.00	8.96	0.69	-0.20	0.00	0.89	0.19	0.19
9/9/90	2338	6638.00	953.00	6.97	0.71	-0.14	0.00	0.85	0.23	0.23
	0329	6869.00	1194.00	5.75	0.71	-0.11	0.00	0.82	0.26	0.26
	0800	7140.00	1465.00	4.87	0.78	-0.04	0.00	0.82	0.26	0.26
	1752	7732.00	2057.00	3.76	0.65	-0.16	0.00	0.81	0.27	0.27
6/10/90	0820	8600.00	2925.00	2.94	0.77	0.01	0.00	0.76	0.32	0.32
	1723	9143.00	3468.00	2.64	0.65	-0.09	0.00	0.74	0.34	0.34
6/11/90	0840	10060.00	4385.00	2.29	0.71	0.00	0.00	0.71	0.37	0.37
	1716	10576.00	4901.00	2.16	0.54	-0.10	0.00	0.64	0.44	0.44
6/12/90	0730	11430.00	5755.00	1.99	0.54	-0.09	0.00	0.63	0.45	0.45
	1556	11936.00	6261.00	1.91	0.45	-0.20	0.00	0.65	0.43	0.43
6/13/90	0800	12900.00	7225.00	1.79	0.52	-0.10	0.00	0.62	0.46	0.46
	1608	13388.00	7713.00	1.74	0.43	-0.21	0.00	0.64	0.44	0.44
6/14/90	0928	14428.00	8753.00	1.65	0.61	-0.03	0.00	0.64	0.44	0.44
	1641	14961.00	9186.00	1.63	0.45	-0.19	0.00	0.64	0.44	0.44
6/15/90	0928	15868.00	10193.00	1.56	0.51	-0.10	0.00	0.61	0.47	0.47
	1600	16260.00	10585.00	1.54	0.40	-0.21	0.00	0.61	0.47	0.47
6/16/90	0839	17259.00	11584.00	1.49	0.50	-0.11	0.00	0.61	0.47	0.47
6/17/90	0745	18650.00	12975.00	1.44	0.58	-0.03	0.00	0.61	0.47	0.47
6/19/90	0840	21580.00	15905.00	1.36	0.48	-0.13	0.00	0.61	0.47	0.47

Primary form for Nasa Well-PT Pump Test

Recovery Phase Data

Well: BLM-2-630 r(ft)=1425

Date	Time	t(min)	t'(min)	t/t'	WL(uc)	Bar Cor	Prob Cor	Cor WL	Cor s'	s-s'
6/8/90	0745	5685.00	0.00	ERR	2.50	-0.07	0.00	2.57	0.00	0.00
		5685.25	0.25	22741.00	2.50	-0.07	0.00	2.57	0.00	0.00
		5685.50	0.50	11371.00	2.51	-0.07	0.00	2.58	-0.01	-0.01
		5685.75	0.75	7581.00	2.50	-0.07	0.00	2.57	0.00	0.00
	0746	5686.00	1.00	5686.00	2.51	-0.07	0.00	2.58	-0.01	-0.01
		5686.25	1.25	4549.00	2.51	-0.07	0.00	2.58	-0.01	-0.01
		5686.50	1.50	3791.00	2.51	-0.07	0.00	2.58	-0.01	-0.01
	0747	5687.00	2.00	2843.50	2.51	-0.07	0.00	2.58	-0.01	-0.01
	0748	5688.00	3.00	1896.00	2.51	-0.07	0.00	2.58	-0.01	-0.01
	0749	5689.00	4.00	1422.25	2.51	-0.07	0.00	2.58	-0.01	-0.01
	0750	5690.00	5.00	1138.00	2.51	-0.07	0.00	2.58	-0.01	-0.01
	0751	5691.00	6.00	948.50	2.51	-0.07	0.00	2.58	-0.01	-0.01
	0752	5692.00	7.00	813.14	2.51	-0.07	0.00	2.58	-0.01	-0.01
	0753	5693.00	8.00	711.63	2.51	-0.07	0.00	2.58	-0.01	-0.01
	0754	5694.00	9.00	632.67	2.51	-0.07	0.00	2.58	-0.01	-0.01
	0755	5695.00	10.00	569.50	2.50	-0.07	0.00	2.57	0.00	0.00
	0800	5700.00	15.00	380.00	2.48	-0.07	0.00	2.55	0.02	0.02
	0805	5705.00	20.00	285.25	2.46	-0.07	0.00	2.53	0.04	0.04
	0810	5710.00	25.00	228.40	2.44	-0.07	0.00	2.51	0.06	0.06
	0815	5715.00	30.00	190.50	2.41	-0.07	0.00	2.48	0.09	0.09
	0820	5720.00	35.00	163.43	2.39	-0.07	0.00	2.46	0.11	0.11
	0830	5730.00	45.00	127.33	2.33	-0.07	0.00	2.40	0.17	0.17
	0845	5745.00	60.00	95.75	2.25	-0.06	0.00	2.31	0.26	0.26
	0945	5805.00	120.00	48.38	2.01	-0.07	0.00	2.08	0.49	0.49
	1045	5865.00	180.00	32.58	1.84	-0.09	0.00	1.93	0.64	0.64
	1145	5925.00	240.00	24.69	1.70	-0.11	0.00	1.81	0.76	0.76
	1245	5985.00	300.00	19.95	1.58	-0.15	0.00	1.73	0.84	0.84
	1345	6045.00	360.00	16.79	1.47	-0.16	0.00	1.63	0.94	0.94
	1549	6169.00	484.00	12.75	1.27	-0.20	0.00	1.47	1.10	1.10
	1745	6285.00	600.00	10.48	1.10	-0.21	0.00	1.31	1.26	1.26
	1939	6399.00	714.00	8.96	1.03	-0.20	0.00	1.23	1.34	1.34
	2338	6638.00	953.00	6.97	0.95	-0.14	0.00	1.09	1.48	1.48
6/9/90	0329	6869.00	1194.00	5.75	0.90	-0.11	0.00	1.01	1.56	1.56
	0800	7140.00	1465.00	4.87	0.89	-0.04	0.00	0.93	1.64	1.64
	1752	7732.00	2057.00	3.76	0.70	-0.16	0.00	0.86	1.71	1.71
6/10/90	0820	8600.00	2925.00	2.94	0.71	0.10	0.00	0.61	1.96	1.96
	1723	9143.00	3468.00	2.64	0.60	0.09	0.00	0.51	2.06	2.06
6/11/90	0840	10060.00	4385.00	2.29	0.58	0.00	0.00	0.58	1.99	1.99
	1716	10576.00	4901.00	2.16	0.44	-0.10	0.00	0.54	2.03	2.03
	0730	11430.00	5755.00	1.99	0.41	-0.09	0.00	0.50	2.07	2.07
	1556	11936.00	6261.00	1.91	0.38	-0.20	0.00	0.58	1.99	1.99
6/13/90	0800	12900.00	7225.00	1.79	0.34	-0.10	0.00	0.44	2.13	2.13
	1608	13388.00	7713.00	1.74	0.30	-0.21	0.00	0.51	2.06	2.06
6/14/90	0928	14428.00	8753.00	1.65	0.41	-0.03	0.00	0.44	2.13	2.13
	1641	14861.00	9186.00	1.62	0.31	-0.19	0.00	0.50	2.07	2.07
6/15/90	0928	15868.00	10193.00	1.56	0.32	-0.10	0.00	0.42	2.15	2.15
	1600	16260.00	10585.00	1.54	0.25	-0.21	0.00	0.46	2.11	2.11
6/16/90	0839	17259.00	11584.00	1.49	0.31	-0.11	0.00	0.42	2.15	2.15
6/17/90	0750	18650.00	12975.00	1.44	0.39	-0.03	0.00	0.42	2.15	2.15
6/19/90	0840	21580.00	15905.00	1.36	0.32	-0.13	0.00	0.45	2.12	2.12

Minimum Reading 15min

PUMP TEST FLOW METER READINGS

INITIAL GALCONS 485,000 gals

DATE	TIME	FLOW RATE (GPM)	
6/4/90	9:02	400	
	9:02.5	410	
	9:03	415	
	9:04	411	
	9:05.5	408	
	9:10	412	
	9:13	406	489,000 gals/uns
	9:20	409	492,000 gals (cycling between 400 and 412 gpm)
	9:33	402	498,000 gals
	9:45	402	502,000 gals
	10:00	406	508,000 g
	10:08	407	511K g
	10:15	409	
	10:30	404	
	10:35	401	
	1100	402	
	1110	398	
	1115	399	
	1126	402	543,000 gals
	1130	402	545,000
	1145	403	550,000
	1205	401	
	1215	399	
	1230	398	
	1245	394	
	100	397	Slight valve Increase
	1318	402	

DATE	TIME	FLOW RATE (GPM)	
6/4/90	1330	396	Slight value increase 592,000 gal.
	1342	393	597,000 gal.
	1355	398	
	1400	401	2:00pm
	1410	401	
	1415	404	
	1430	370	- well 3 pump turn on caused pressure surge
	1447	400	623,000 gal.
	150	397	628,000
	15-	39[illegible]	
	1530	392	Slight value increase
	1540	401	
	1545	399	
	1600	396	653,000
	1615	395	
	1625	392	Slight value increase
	1630	398	664,000
	1645	393	Slight value increase
	1652	399	
	1700	402	675,000
	1715	395	
	1730	398	value increase
	1745	406	
	1800	398	
	1808	403	
	1915	419	Value decrease
	1836	385	

PUMP TEST FLOW METER READINGS

DATE	TIME	FLOW RATE (GPM)		DATE	TIME	FLOW RATE (GPM)	
6/4/90	1852	396	721,000	6/5/90		Inside Digital Reading is 10gpm less than outside reading	
	1905	406		6/4	0142	375 ↓	
6/4/90	1915	400			0146	399 another turn on valve	
	1930	400			0152	+1/4 turn 886K	
	1940	416	740,000		0154	+1/4 turn 888K	
	1955	410	746,000		0203	364 892K ↓ open valve, rate still ↓	
	2010	398	752,000			Voltage = 116; pump may be giving ou	
	2025	413	758,000		0225	405 900K	
	2039	410	764,000		0245	415 909K	
	2111	398	775,000		0300	406 914K	
	2125	401	782,000		0322	382 923K	
	2145	407	791K		1837	376 929K	
	2210	409	800K		0351	395 934K	
	2225	399	807,000		0405	410 940K	
	2240	398	813		0420	403 946K	
	2256	405	819,000		0433	399 952K	
	2310	399	825,000		450	397 958K	
	2325	396 ADJUST FLOW + 1/8 turn	830		0457	356 961K	
	2340	392	836,000		0506	360 964K + 1/8 turn	
	2350	399	840K		525	424 971K	
6/5/90	0005	404 ADJUST FLOW + 1/8 turn	847K		0530	444 - 1/8 TURN	
	0026	402	859K		0540	417 978K	
	0047	396	863K		0600	396 986K	
	0100	367 + 1/8 turn	868K		0622	404	
	0108	359 + 1/4 turn	871,000		0635	385	
	0118	384 + 1/8 turn	875K		0645	406	
	0136	358 + 1/8 + 1/8 + 1/8			0700	410 (1011K)	

PUMP TEST FLOW METER READINGS

DATE	TIME	FLOW RATE (GPM)		DATE	TIME	FLOW RATE (GPM)	
6-5-90	0715	407	(1017 K)	6-5-90	1403	400	(1180 K)
6-5-90	0730	405	(1023 K)	"	1417	398	(1185K)
"	0745	412	(1029 K)	"	1431	407	(1194K)
"	0801	396	(1036 K)	"	1446	402	(1197K)
"	0915	387	(1041 K)	"	~~1417~~ 1500	~~398~~ 406	~~(1185K)~~ (1202K)
"	0830	390	(1047 K)	"	~~1431~~	~~407~~	~~(1194K)~~
	0845	389	valve up enter reading +10gpm		1515	396	(1208K)
	~~0900~~	397	valve up		1530	407	(1214K)
	0918	403			1545	404	(1220K)
	0928	406			1600	402	(1227K)
	0944	401	(1076K)		1616	404	(1234K)
	1000	403	(1083K)		1627	403	(1238K)
	1015	407	(1089K)		1646	410	dropped back to 403 at 1648 no change to value
	1029	402			1701	405 & 412	still fluctuating between 402 (1255K)
	1044	400	(1101K)		1714	400	closed valve ~ 1/4" (1256K)
	1100	411	(1107K)		1730	401	(1263K)
	1115	404	(1113K)		1745	400	(1269K)
	1130	394	(1119K)		1802	392	(1276K)
	1145	392	(1125K)		1817	400	(1282K)
	1204	388	valve up (1132K)		1842	403	1292 K
	1215	390	(1137K)		1904	407	1301K
	1230	397	(1143K)		1923	407	1309K
	1245	390	valve up (1149K)		1953	405	1321 K
	1300	398	(1155K)		2022	403	1333 K
	1316	391	(1161 K)		2046	410	1342 K
	1330	399	(1166 K)		2057	414	close 2 1/4" 1347 K
	1353	398	(1176 K)		2110	402	1353K
					2148	400	1369K

PUMP TEST FLOW METER READINGS

DATE	TIME	FLOW RATE (GPM)		DATE	TIME	FLOW RATE (GPM)	
~~6-5-90~~	~~1417~~	~~398~~	~~(1485K) ngc~~	6/6	1030	401	
~~6/5 2203~~	2203	394	1374K		1045	402	(1515K)
"	2223	376	1383 IC		1051	407	(1518K)
6/5	2241	402	1391 IC		1053	406	(1520K)
6/5	2302	380 +1/8	1398 IC		1115	401	(1528 IC)
"	2314	378 +1/4	1403 IC		1139	389 valve up	(1537K)
"	2324	368 +1/4 +1/4 +1/4 +1/4 +1/4 +1/2 +1/4 +1/4	1404 IC		1147	409	(1540K)
					1159	398	(1545K)
	2338	365 Valve wide open	1411K		1215	392 valve up	(1555K)
	2358	355 "	1417K		1230	401	(1557K)
↓	2411	375 "	1424 IC		1244	404	(1562K)
6/6	0013	388 "	1425K		1255	399	
	0019	347 "	1427 IC		1325	409	(1579K)
	0029	331 "	1430K		1335	400 valve up	
	0046	310	1435K		1356	397	(1592K)
	0053	000 METER CRATERED	1438K		1415	400	
	0114	91	1438K		1446	395	
↓	0120	255	1435K		1500	406	(1617K)
6/6	0806	501 METER KICK ON			1518	397	(1625K)
	1810	481 closed valve 4 full turns			1530	396 Valve Up	(1630K)
	0819	449	(1456K)		1544	403	(1636K)
	0920	turned off meter and cleaned sensors - new silicone			1601	402	(1643K)
	0930	Meter on 460	(1484)		1620	407	(1650)
	0945	461	(1491)		1635	414	(1657)
	0955	406	(1495)		1645	410	
	1010	403			1700	406	
↓	1625	416	(1507)		1720	404	

5 & 7

PUMP TEST FLOW METER READINGS

DATE	TIME	FLOW RATE (GPM)		DATE	TIME	FLOW RATE (GPM)	
6/6	1730			6/6	2304	409	1814K
6/6	1750	400	(1686K)		2316	357 +1/4	1818K
	1803	391			2325	397	1830K
	1832	408		6/7	0003	405	1837K
	K700	415	1717K		0015	404	1842K
	K720	417 - 1/8 turn	1723K		0029	390	1848K
	K726	412 - 1/8 turn			0033	375	1850K
	1944	408	~~1054~~ 1737K		0050	366 +1/8	1856K
	1950	415	1735K		0052	368 +1/8	
	2012	420	1744K		0055	375 +1/8	
	2020	412 -1/8 turn	1748K		0059	382 +1/8	
	2100	414 - 1/8 turn	1764K		0105	358	1862K
	2111	418 - 1/8 turn	1769K		0115	361 +1/8	
	2126	404	1775K		0118	350 +1/4 OPEN - NO CAV	1867K
	2142	410	1782K		0119	000 - NS FLOW METER CRASHED	
	2153	393	1786K		0221	407 IMMED. AFTER RESTART	1868K
	2214	374 +1/8 +1/8 +1/4	1794K		0234	down 1/8 420	
	2224	385 +1/4	1798K		0235	397	1871K
	2225	397			0241	450 down 1 turn	
	2227	410 gpm			0251	415	1878K
	2235	350	1802K		0255	410 1/8 down	1880K
	2236	396	1803K		0302	Ø Flow meter down again! 115.4V	
	2240	376 +1/8 down					
	2242	374 +1/8 turn	1805K		0541	409 116.2V Flow meter back on	
	2243	~~395~~ 407 gpm			0547	445 1/4 Down + 1/8 down	
	2251	373 +1/8 turn			0556	415 - 1/2	1891K
	2254	404	1810K		0600	390	

PUMP TEST FLOW METER READINGS

DATE	TIME	FLOW RATE (GPM)		DATE	TIME	FLOW RATE (GPM)	
6-7	0615	FLOW METER OFF		6/7	1215	405	(2007K)
	0619	FLOW METER BACK ON			1230	405	(2013K)
	623	405 THEN METER OFF			1245	397	
	0625	FLOW METER BACK ON			1300	403	
	0630	235	(1899K)		1315	397	
	715	off			1330	405	
	0800	Meter on 414			1346	402	(2044K)
	0810	411			1400	403	(2049K)
	0820	416	(1911 K)		1414	410	(2055K)
	0825	430	(1913 K)		1430	409	(2061K)
	0827	409			1447	399	(2068K)
	0830	405	(1917 K)		1500	409	(2074K)
	850	416			1515	415	(2080K)
	0900	401			1530	406	(2086K)
	0915	416			1546	409	(2093K)
	0930	412			1600	411	
	0945	393	(1946K)		1615	408	
	1000	406	(1952K)		1630	414	(2111K)
	1016	394	(1959K)		1645	412	
	1030	403	(1964K)		1700	410	(2123K)
	1045	398 valve up 1/4"	(1970K)		1720	418	
	1059	402	(1976K)		1730	422	Valve down
	1114	404	(1982K)		1745	408	
	1115	413	"		1800	414	
	1130	410 ~~404~~	(1989K)		1814	425	2154K 117.2V
	1145	404			1830	414	2165K
	1200	405	(2001K)		~~1844~~ 1904	411	2174K

PUMP TEST FLOW METER READINGS

DATE	TIME	FLOW RATE (GPM)		DATE	TIME	FLOW RATE (GPM)
6/7	1951	420	2194 K			
	2003	405	2199 K			
	2026	431	2209 K			
	2040	420				
	~~2121~~ 2037	422	2231 K			
	2144	419	2243 K			
	~~2209~~ 2009	400	2251 K			
	~~2210~~ 2010	374	-1/4 turn + 1/4 out			
	~~2212~~ 2012	390	+ 1/8 + 1/4 + 1/4 2254 K			
2247	~~2249~~ 2049	405	2265 K			
	2302	437	2270 K			
	2319	400	2278 K			
	2333	395	2288 K			
	2352	298 → ∅	Flow meter down V = 116.4			
	0723	392	(2292 K)			
	0726	444 → ∅	FLOWMETER DOWN			
	0745	PUMP OFF - END OF TEST				

AQUIFER TEST DATA

Owner _____ Address _____ County _____ State _____

Date _____ Company performing test _____ Measured by _____

Well No. Weir (12" x 2' x 12" Sides Ruler 1.5" on top.) Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	(inches) Water level measurement	Correction or Conversion	Water level	Water level change s or s'	CALC. (GPM) Discharge measurement	FLOW METER (GPM) Rate	Comments on factors affecting test data
6/6	1910				9.25				330	415	OUTSIDE METER USED FOR FLOW METER
"	2017				9.0				308	404	
"	2230				9.00				308	405	
"	2250				9.25				330	374	
"	2306				9.25				330	388	
"	2330				9.16				320	404	
6/7	0122				9.50				352	Ø	Flow meter OUT
	0141				9.50				"		
	0142				9.50				"		
	0144				9.50				"		
	0146				9.50				"		
	0148				9.50				"		
	0150				9.50				"		
	0152				9.50				"		
	0153				9.25				330		
	0154				9.25				330		
	0155				9.25				330		
	0157				9.25				330		
	0159				9.15				376		
	0200				9.75				376		
	0201				9.50				352		
	0203				9.50				352		
	0204				9.50				352		
	0206				9.50				352		
	0207				9.25				330		
	0209				9.25				330		
	0210				9.50				352		
	0212				9.50				352		
	0214				9.50				352	400	Flow meter back on line. 0228.

AQUIFER TEST DATA

Owner _____ Address _____ County _____ State _____

Date _____ Company performing test _____ Measured by _____

Well No. Weir Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_o)
Pump off: Date _____ Time _____ (t'_o)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement (in inches)	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement (Weir)	Rate (Flow Meter)		
6/7	0258					9.25					330	390		☆ Valve by 1 turn
	0318					9.25					330	0		Flow meter off
	0405					9.25					330	0		" "
	0700					9.25					330	0		" "
	0726					8 3/16"		8.19			235			
	0754					8 10/16"		8.63			277			
	0800					8 7/8"		8.88			297	414		
	0805					8 7/8"		8.88			297			
	0806					8.5"		8.5			267			
	0809					9 1/8"		9.13			320			
	0810					9.25					330	411		≈ Flow meter on
	0813					9.0					308			
	0814					8.75"					287			
	0815					9.0					308			
	0816					9.0					308			
	0819					8 7/8"		8.88			297			
	0820					9 1/8		9.13			320	416		
	0821					9 1/8		9.13			320			
	0822					9 1/4		9.25			330			
	0824					8 7/8		8.88			297			
	0826					9.0					308	430		
	0827					9.0					308	409		
	0829					8 7/8		8.88			297			
	0830					9.0					308			
	0831					9.0					308	405		
	0833					8 7/8		8.88			297			
	0938					9.0"					308	412 @	9.30	
	1045					9.0					308	398		
	1145					9.0					308			

AQUIFER TEST DATA

Owner _____ Address _____ County _____ State _____

Date _____ Company performing test _____ Measured by _____

Well No. W2112 Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		WEIR (GPM) Discharge measurement	FLOW METER Rate		Comments on factors affecting test data
6-7-90	1245					9.25"					330	397		83.1 %
	1345					9.00"					308	402		76.6 %
	1450					9.25"					330	399		82.7 %
	1545					9.00"					308	409		75.3 %
	1647					9.25"					330			
	1748					9.00"					308			
	1850					9.25"					330	414		
	2041					9.00"					308	427		
	2128					9.00					308	425		
	2230					9.25					330	380		
	2250					9.50					352	400		
	2300					9.50					352	429		
	2335					9.50					352	395		
6/8	0117					9.25					330	Ø		Flowmeter down 2
	0522					9.50					352	Ø		
	0640					9.50					352	Ø		
		Pump off				0745		6/8/90						

Appendix C

Data Logger: Raw Data

Appendix C

Data Logger: Raw Data

Background Data PT Well and Piezometers

FILE NAME: DATA.2
NO. OF STATIONS = 5
NO. OF PERIODS = 1
START TIME= 18:00 SETUP TIME= Thursday May 31st 1990, 17:40:10
LENGTH OF PERIOD 1 = 90 HRS
INTERVAL FOR PERIOD 1 = 1 HRS
LOGGING ON: Thursday May 31st 1990, 18:00:01 PERIOD: 1 INTERVAL: 3600

1	0.00	?1	OT READY	2	0.01	?2	OT READY	30.01
?3	OT READY		4	0.02	?4	OT READY	5	0.02 ?5OT
READY			PZ-3	NASA-PT	PZ-1	PZ-2	PZ-4	
6	60.00		1+00020.32	2+00062.31	3+00020.20	4+00020.69	5+00015.30	
11	119.99		1+00020.31	2+00062.32	3+00020.20	4+00020.69	5+00015.32	
16	180.00		1+00020.31	2+00062.33	3+00020.20	4+00020.69	5+00015.34	
21	240.00		1+00020.30	2+00062.33	3+00020.18	4+00020.68	5+00015.33	
26	299.99		1+00020.29	2+00062.34	3+00020.17	4+00020.67	5+00015.31	
31	359.99		1+00020.28	2+00062.35	3+00020.17	4+00020.66	5+00015.31	
36	419.99		1+00020.28	2+00062.36	3+00020.17	4+00020.67	5+00015.30	
41	479.99		1+00020.28	2+00062.37	3+00020.16	4+00020.67	5+00015.31	
46	539.99		1+00020.27	2+00062.38	3+00020.16	4+00020.66	5+00015.31	
51	599.99		1+00020.27	2+00062.38	3+00020.15	4+00020.66	5+00015.30	
56	659.99		1+00020.27	2+00062.38	3+00020.15	4+00020.66	5+00015.30	
61	719.99		1+00020.26	2+00062.38	3+00020.15	4+00020.65	5+00015.29	
66	779.99		1+00020.24	2+00062.35	3+00020.12	4+00020.62	5+00015.26	
71	839.99		1+00020.21	2+00062.33	3+00020.09	4+00020.59	5+00015.22	
76	899.99		1+00020.20	2+00062.31	3+00020.09	4+00020.59	5+00015.19	
81	959.99		1+00020.21	2+00062.32	3+00020.10	4+00020.60	5+00015.16	
86	1019.99		1+00020.22	2+00062.32	3+00020.11	4+00020.62	5+00015.15	
91	1080.00		1+00020.23	2+00062.33	3+00020.11	4+00020.61	5+00015.11	
96	1139.99		1+00020.25	2+00062.34	3+00020.14	4+00020.63	5+00015.08	
101	1199.99		1+00020.27	2+00062.36	3+00020.15	4+00020.66	5+00015.07	
106	1259.99		1+00020.29	2+00062.38	3+00020.18	4+00020.68	5+00015.14	
111	1320.00		1+00020.31	2+00062.39	3+00020.20	4+00020.70	5+00015.18	
116	1379.99		1+00020.31	2+00062.37	3+00020.20	4+00020.70	5+00015.25	
121	1440.00		1+00020.32	2+00062.39	3+00020.20	4+00020.70	5+00015.30	
126	1499.99		1+00020.31	2+00062.35	3+00020.19	4+00020.69	5+00015.31	
131	1560.00		1+00020.29	2+00062.34	3+00020.16	4+00020.67	5+00015.31	
136	1620.00		1+00020.27	2+00062.31	3+00020.14	4+00020.63	5+00015.28	
141	1679.99		1+00020.23	2+00062.29	3+00020.10	4+00020.60	5+00015.26	
146	1739.99		1+00020.21	2+00062.28	3+00020.08	4+00020.58	5+00015.23	
151	1800.00		1+00020.19	2+00062.28	3+00020.06	4+00020.57	5+00015.21	
156	1859.99		1+00020.17	2+00062.27	3+00020.05	4+00020.55	5+00015.19	
161	1919.99		1+00020.17	2+00062.29	3+00020.04	4+00020.55	5+00015.19	
166	1980.00		1+00020.16	2+00062.29	3+00020.04	4+00020.54	5+00015.18	
171	2039.99		1+00020.16	2+00062.29	3+00020.03	4+00020.53	5+00015.18	
176	2099.99		1+00020.13	2+00062.28	3+00020.01	4+00020.51	5+00015.16	
181	2160.00		1+00020.11	2+00062.25	3+00019.97	4+00020.48	5+00015.13	
186	2220.00		1+00020.06	2+00062.22	3+00019.93	4+00020.44	5+00015.08	
191	2279.99		1+00020.03	2+00062.20	3+00019.90	4+00020.40	5+00015.04	
196	2340.00		1+00020.01	2+00062.18	3+00019.88	4+00020.38	5+00014.99	
201	2399.99		1+00020.00	2+00062.16	3+00019.87	4+00020.37	5+00014.92	
206	2460.00		1+00019.99	2+00062.15	3+00019.87	4+00020.38	5+00014.85	
211	2519.99		1+00020.00	2+00062.15	3+00019.88	4+00020.38	5+00014.76	
216	2579.99		1+00020.01	2+00062.16	3+00019.90	4+00020.39	5+00014.75	
221	2639.99		1+00020.03	2+00062.17	3+00019.91	4+00020.41	5+00014.67	
226	2699.99		1+00020.04	2+00062.18	3+00019.93	4+00020.43	5+00014.74	
231	2759.99		1+00020.06	2+00062.21	3+00019.95	4+00020.45	5+00014.81	
236	2819.99		1+00020.08	2+00062.21	3+00019.96	4+00020.46	5+00014.90	
241	2879.99		1+00020.09	2+00062.22	3+00019.97	4+00020.47	5+00014.99	

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246     2939.99          1+00020.10  2+00062.21  3+00019.96  4+00020.47  5+00015.07
251     3000.00          1+00020.09  2+00062.20  3+00019.95  4+00020.46  5+00015.11
256     3060.00          1+00020.07  2+00062.22  3+00019.94  4+00020.45  5+00015.09
261     3119.99          1+00020.06  2+00062.21  3+00019.93  4+00020.44  5+00015.08
266     3179.99          1+00020.06  2+00062.22  3+00019.93  4+00020.43  5+00015.08
271     3239.99          1+00020.05  2+00062.24  3+00019.93  4+00020.44  5+00015.07
276     3300.00          1+00020.06  2+00062.26  3+00019.93  4+00020.44  5+00015.08
281     3359.99          1+00020.06  2+00062.27  3+00019.94  4+00020.45  5+00015.09
286     3419.99          1+00020.07  2+00062.26  3+00019.94  4+00020.46  5+00015.09
291     3479.99          1+00020.06  2+00062.29  3+00019.93  4+00020.45  5+00015.12
296     3539.99          1+00020.05  2+00062.27  3+00019.92  4+00020.43  5+00015.08
301     3599.99          1+00020.04  2+00062.28  3+00019.90  4+00020.42  5+00015.06
306     3659.99          1+00020.02  2+00062.26  3+00019.89  4+00020.40  5+00015.04
311     3720.00          1+00019.99  2+00062.23  3+00019.85  4+00020.37  5+00015.00
316     3780.00          1+00019.98  2+00062.20  3+00019.84  4+00020.36  5+00014.95
321     3839.99          1+00019.97  2+00062.19  3+00019.84  4+00020.35  5+00014.87
326     3899.99          1+00019.98  2+00062.20  3+00019.86  4+00020.37  5+00014.71
331     3959.99          1+00020.00  2+00062.20  3+00019.87  4+00020.38  5+00014.57
336     4019.99          1+00020.02  2+00062.20  3+00019.89  4+00020.40  5+00014.43
341     4079.99          1+00020.04  2+00062.22  3+00019.91  4+00020.42  5+00014.50
346     4139.99          1+00020.07  2+00062.23  3+00019.93  4+00020.44  5+00014.55
351     4199.99          1+00020.09  2+00062.27  3+00019.96  4+00020.47  5+00014.68
356     4259.99          1+00020.12  2+00062.28  3+00019.98  4+00020.49  5+00014.80
361     4320.00          1+00020.13  2+00062.28  3+00020.00  4+00020.51  5+00014.92
366     4379.99          1+00020.14  2+00062.27  3+00020.00  4+00020.51  5+00015.06
371     4439.99          1+00020.13  2+00062.29  3+00020.00  4+00020.51  5+00015.14
376     4500.00          1+00020.13  2+00062.29  3+00019.98  4+00020.50  5+00015.15
381     4560.00          1+00020.12  2+00062.32  3+00019.98  4+00020.49  5+00015.14
386     4620.00          1+00020.11  2+00062.32  3+00019.97  4+00020.49  5+00015.13
391     4680.00          1+00020.12  2+00062.36  3+00019.98  4+00020.51  5+00015.14
396     4739.99          1+00020.12  2+00062.36  3+00019.98  4+00020.51  5+00015.14
401     4799.99          1+00020.13  2+00062.38  3+00019.99  4+00020.51  5+00015.14
406     4860.00          1+00020.14  2+00062.38  3+00020.00  4+00020.52  5+00015.15
411     4919.99          1+00020.14  2+00062.38  3+00020.00  4+00020.51  5+00015.15
416     4980.00          1+00020.13  2+00062.38  3+00019.99  4+00020.51  5+00015.15
421     5040.00          1+00020.10  2+00062.36  3+00019.96  4+00020.48  5+00015.13
426     5100.00 ?1       OT READY        427     5100.00 ?2       OT READY        42851
00.01   ?3       OT READY        429     5100.01 ?4       OT READY        430     5100.
02      ?5       OT READY
LOGGING OFF: Monday June 4th 1990, 07:01:11
LOGGING ON: Monday June 4th 1990, 07:01:29 PERIOD: 1 INTERVAL: 3600
LOGGING OFF: Monday June 4th 1990, 07:01:38
```

AQUIFER TEST DATA

Owner _____ Address _____ County _____ State _____

Date _____ Company performing test _____ Measured by _____

Well No. _____ Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	+ = DD − = Rec. Δs ~~Rate~~		Background H_2O Levels Well #	Probe
5/31	1656					374.29			0.0		374.29	0.0		BLM-6	R2
6/1	1125					376.98			+2.6	Corrected to R2 -2.58 = 374.4		+0.11		"	LC-3
6/2	0948					374.75			-.46		374.62	+0.33		"	R1
6/3	1039					374.80			-.51		374.67	+0.38		"	R1
6/4	0750					374.73			-.44		374.73	+0.44		"	R2
5/31	1700					463.38			0.0		463.25	0.0		BLM-7	R1
6/1	1106					465.82			-2.44		463.24	-0.01		"	LC-3
6/2	0927					463.53			-.15		463.53	+0.28		"	R2
6/3	1056					463.49			-.11		463.49	+0.24		"	R2
6/4	0756					463.62			-.24		463.49	+0.24		"	R1
5/31	1709					363.29			0.0		363.29	0.00		BLM-9	R2
6/1	1130					363.62			-.33		363.65	+0.36		"	LC-4
6/2	0956					363.71			-.42		363.58	+0.29		"	R1
6/3	1030					363.66			-.37		363.53	+0.24		"	R1
6/4	0754					363.52			-.23		363.52	+0.23		"	R2
														"	
5/31	1642					466.15			0.0		466.15	0.00		BLM-17	R2
6/1	1051					465.25			-0.9		465.84	-0.31		"	LC-3
6/2	0915					465.61			+.54		466.20	+0.05		"	"
6/3	1050					465.65			+.50		466.24	+0.09		"	"
6/4	0837					465.55			+.60		465.55	-0.60		"	R2

AQUIFER TEST DATA

Owner _____ Address _____ County _____ State _____

Date _____ Company performing test _____ Measured by _____

Well No. _____ Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_o)
Pump off: Date _____ Time _____ (t'_o)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	+ DD - REC Rate		Background H_2O Levels Well #	Probe
5/31	1643					450.38			0.0		450.25	0.00		PL-1	R1
6/1	1110					450.20			+.18		450.23	-0.02		"	LC 2
6/2	0932					450.54			-.16		450.54	+0.29		"	R2
6/3	1110					450.54			-.16		450.54	+0.29		"	R2
6/4	0737					450.63			-.25		450.50	+0.25		"	R1
5/31	1721					439.62			0.0		439.49	0.00		PL-2	R1
6/1	0928					442.32			-2.7		439.74	+0.25		"	LCS 3
6/2	1002					440.17			-.55		440.04	+0.55		"	R1
6/3	1126					440.14			-.52		440.01	+0.52		"	R1
6/4	0735					439.94			-.32		439.94	+0.45		"	R2
5/31	1652					428.67			0.0		428.54	0.00		PL-3	R1
6/1	1112					428.83			-.16		428.74	+0.20		"	LC 4
6/2	0938					428.86			-.19		428.86	+0.32		"	R2
6/3	1105					428.88			-.21		428.88	+0.34		"	R2
6/4	0746					428.95			-.28		428.82	+0.28		"	R1
5/31	1709					413.08			0.0		412.95	0.00		PL-4	R1
6/1	1037					413.03			+.05		413.03	+0.08		"	R2
6/2	1022					413.28			-.20		413.28	+0.33		"	R2
6/3	1143					413.30			-.22		413.30	+0.35		"	R2
6/4	0807					413.41			-.33		413.28	+0.33		"	R1

AQUIFER TEST DATA

Owner _____ Address _____ County _____ State _____

Date _____ Company performing test _____ Measured by _____

Well No. _____ Distance from pumping well _____ Type of test _____ Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_0)
Pump off: Date _____ Time _____ (t'_0)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Background H_2O Levels Well #	Probe
5/31	1731					434.37			0.0		434.37	0.00		ST-1	R2
6/1	0941					437.07			-2.7		434.37	0.00		"	LC-5
6/2	1007					434.90			-.53		434.77	+0.40		"	R1
6/3	1134					434.88			-.51		434.75	+0.38		"	R1
6/4	0738					434.68			-.31		434.68	+0.31		"	R2
5/31	1717					387.15			0.0		387.02	0.00		WW-1	R1
6/1	0915					387.30			-.15		387.17	+0.15		"	R1
6/2	1030					386 9 3/4" =		386.81	+.34		387.44	+0.42		"	Ded. M Scope
6/3	1152					386 10" =		386.83	+.32		387.46	+0.44		"	"
6/4	0813					386.9 1/2" =		386.79	+.36		387.42	+0.40		"	"
5/31	1727					378.81			0.00		378.81	0.00		JP-2	R1
6/1	1011					378.25			+.56		378.92	+0.11		"	LCM2
6/2	1040					378.52			+.29		379.19	+0.38		"	"
6/3	1204					378.49			+.32		379.16	+0.35		"	"
6/4	0822					378.25			+.56		378.92	+0.11		"	"

BLM-2482

BACKGROUND

#$%&'()*+,-./0123456789:
$%&'()*+,-./0123456789:;
%&'()*+,-./0123456789:;<
&'()*+,-./0123456789:;<=
'()*+,-./0123456789:;<=>
()*+,-./0123456789:;<=>?
)*+,-./0123456789:;<=>?@
*+,-./0123456789:;<=>?@A
+,-./0123456789:;<=>?@AB
,-./0123456789:;<=>?@ABC
-./0123456789:;<=>?@ABCD
./0123456789:;<=>?@ABCDE
Ready

SE1000B
Environmental Logger
06/04 08:03

Unit# 00670 Test# 1

INPUT 1: Level (F)

Reference	0.00
Scale factor	30.02
Offset	- 0.18

Step# 0 05/31 16:16

Elapsed Time	Value
0.0000	0.00
60.0000	0.02
120.000	0.05
180.000	0.06
240.000	0.07
300.000	0.08
360.000	0.07
420.000	0.07
480.000	0.07
540.000	0.08
600.000	0.08
660.000	0.08
720.000	0.08
780.000	0.09
840.000	0.08
900.000	0.04
960.000	0.01
1020.00	0.01
1080.00	0.03
1140.00	0.05
1200.00	0.06
1260.00	0.08
1320.00	0.10
1380.00	0.14
1440.00	0.17
1500.00	0.16
1560.00	0.18
1620.00	0.18
1680.00	0.15
1740.00	0.13
1800.00	0.10
1860.00	0.08
1920.00	0.07
1980.00	0.06
2040.00	0.06
2100.00	0.06
2160.00	0.04
2220.00	0.02
2280.00	- 0.00
2340.00	- 0.04
2400.00	- 0.09
2460.00	- 0.11
2520.00	- 0.12
2580.00	- 0.11
2640.00	- 0.10
2700.00	- 0.08
2760.00	- 0.06
2820.00	- 0.03
2880.00	- 0.01
2940.00	0.00
3000.00	0.01

```
1920.00          0.07
1980.00          0.06
2040.00          0.06
2100.00          0.06
2160.00          0.04
2220.00          0.02
2280.00         -0.00
2340.00         -0.04
2400.00         -0.09
2460.00         -0.11
2520.00         -0.12
2580.00         -0.11
2640.00         -0.10
2700.00         -0.08
2760.00         -0.06
2820.00         -0.03
2880.00         -0.01
2940.00          0.00
3000.00          0.01
3060.00          0.01
3120.00          0.01
3180.00          0.01
3240.00          0.00
3300.00          0.00
3360.00          0.00
3420.00          0.01
3480.00          0.01
3540.00          0.02
3600.00          0.02
3660.00          0.01
3720.00          0.00
3780.00         -0.03
3840.00         -0.06
3900.00         -0.08
3960.00         -0.08
4020.00         -0.06
4080.00         -0.04
4140.00         -0.00
4200.00          0.00
4260.00          0.03
4320.00          0.06
4380.00          0.08
4440.00          0.11
4500.00          0.11
4560.00          0.12
4620.00          0.11
4680.00          0.10
4740.00          0.10
4800.00          0.11
4860.00          0.10
4920.00          0.11
4980.00          0.12
5040.00          0.11
5100.00          0.11
5160.00          0.07
5220.00          0.05
END
```

BLM-2-630
BACKGROUND

BACKGROUND
BLM-2-630

SE1000B
Environmental Logger
06/04 08:07

Unit# 00670 Test# 1

INPUT 2: Level (F)

Reference	0.00
Scale factor	10.02
Offset	- 0.02

Step# 0 05/31 16:16

Elapsed Time	Value
0.0000	0.00
60.0000	0.04
120.000	0.05
180.000	0.06
240.000	0.08
300.000	0.09
360.000	0.09
420.000	0.09
480.000	0.10
540.000	0.11
600.000	0.11
660.000	0.11
720.000	0.11
780.000	0.11
840.000	0.11
900.000	0.08
960.000	0.06
1020.00	0.07
1080.00	0.09
1140.00	0.11
1200.00	0.12
1260.00	0.15
1320.00	0.17
1380.00	0.20
1440.00	0.23
1500.00	0.22
1560.00	0.24
1620.00	0.23
1680.00	0.23
1740.00	0.21
1800.00	0.19
1860.00	0.18
1920.00	0.18
1980.00	0.17
2040.00	0.17
2100.00	0.17
2160.00	0.16
2220.00	0.14
2280.00	0.11
2340.00	0.07
2400.00	0.04
2460.00	0.03
2520.00	0.03
2580.00	0.04
2640.00	0.05
2700.00	0.07
2760.00	0.09
2820.00	0.12
2880.00	0.13
2940.00	0.15
3000.00	0.16
3060.00	0.16
3120.00	0.16
3180.00	0.16
3240.00	0.15
3300.00	0.15
3360.00	0.16
3420.00	0.17
3480.00	0.18
[illegible]	[illegible]

600.000	0.11
660.000	0.11
720.000	0.11
780.000	0.11
840.000	0.11
900.000	0.11
960.000	0.08
1020.00	0.06
1080.00	0.07
1140.00	0.09
1200.00	0.11
1260.00	0.12
1320.00	0.15
1380.00	0.17
1440.00	0.20
1500.00	0.23
1560.00	0.22
1620.00	0.24
1680.00	0.23
1740.00	0.23
1800.00	0.21
1860.00	0.19
1920.00	0.18
1980.00	0.18
2040.00	0.17
2100.00	0.17
2160.00	0.17
2220.00	0.16
2280.00	0.14
2340.00	0.11
2400.00	0.07
2460.00	0.04
2520.00	0.03
2580.00	0.03
2640.00	0.04
2700.00	0.05
2760.00	0.07
2820.00	0.09
2880.00	0.12
2940.00	0.13
3000.00	0.15
3060.00	0.16
3120.00	0.16
3180.00	0.16
3240.00	0.16
3300.00	0.15
3360.00	0.15
3420.00	0.16
3480.00	0.17
3540.00	0.18
3600.00	0.18
3660.00	0.18
3720.00	0.17
3780.00	0.15
3840.00	0.12
3900.00	0.10
3960.00	0.08
4020.00	0.09
4080.00	0.11
4140.00	0.13
4200.00	0.16
4260.00	0.19
4320.00	0.21
4380.00	0.25
4440.00	0.26
Ready	0.28
4500.00	0.28
4560.00	0.28
4620.00	0.28
4680.00	0.27
4740.00	0.27
4800.00	0.28
4860.00	0.28
4920.00	0.29
4980.00	0.30
5040.00	0.30
5100.00	0.30
5160.00	0.26
5220.00	0.24
END	

: Background Water levels

Well	5/31/90			6/1/90		
	Time	DTW (TOC)	Probe	Time	DTW (TOC)	Probe
BLM-17-493	1642	466.15	R2	1051	465.25	$LC_M 3$
BLM-6	1656	374.29	R2	1125	376.98	$LC_S 3$
BLM-9-419	1709	363.29	R2	1130	363.62	$LC_S 4$
PL-2-504	1721	439.62	R2	0928	442.32	$LC_S 3$
ST-1-473	1731	434.37	R2	0941	437.07	$LC_S 5$
PL-1-486	1643	450.38	R1	1110	450.20	$LC_S 2$
PL-3-458	1652	428.67	R1	1112	428.83	$LC_S 4$
BLM-7-509	1700	463.38	R1	1106	465.82	$LC_S 3$
PL-4-464	1709	413.08	R1	1037	413.03	R2
WW-1-452	1717	387.15	R1	0915	387.30	R1
JP-2	1727	378.81	R1	1011	378.25	$LC_M 2$

Calibration:

Water Level Indicator Calibration : WW-1-452

Rover 2	R2	0824	387.17
	$LC_S 1$	0827	387.46
	$LC_S 3$	0832	389.75
	$LC_S 2$	0838	387.14
	$LC_M 2$	0844	386.50 ⇐ DEDICATED JP-2
	$LC_M 3$	0856	386.58 ⇐ DEDICATED BLM-17
	$LC_M 1$	0857	386.54 ⇐ DEDICATED WW-1
Rover 1	R1	0915	387.30

JP-2

~~R2~~ 2 1032 ~~413~~

	$LC_S 4$	1019	379.01
	$LC_M 2$	1011	378.25 ⇐ Dedicated JP-2

Relative Probe Measurements; Calibrated to Rover #2

R_2	0.00
LC_S1	−0.29
LC_S2	+0.03
LC_S3	−2.58
$R1$	−0.13
LC_S4	−0.09
LC_M3	+0.59
LC_S5	−2.70
LC_M1	+0.63
LC_M2	+0.67

+ = Shallower

− = Deeper

42-381 50 SHEETS 5 SQUARE
42-382 100 SHEETS 5 SQUARE
42-389 200 SHEETS 5 SQUARE
NATIONAL

CALCULATION OF r

Pump Test Well

N 226752.14

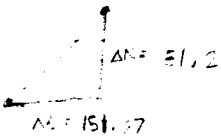
E 402084.23

r = 0

PT-PZ-1

N 226620.89

E 401932.56



r = 201' (200.5751')

PT-PZ-2

N 226820.93

E 401977.90

ΔN = 97.79'

ΔE = 106.33'

r = 144' (144.4609')

PT-PZ-3

N = 226776.73

E = 402174.62

ΔN = 24.50

ΔE = 90.39

r = 94 (93.6751')

PT-PZ-4

N = 226875.56

E = 402345.38

ΔN = 123.42

ΔE = 481.15

r = 497 (496.7271')

PL-1-496

N = 225709.35

E = 401823.62

ΔN = 1042.79

ΔE = 260.61

r = 1,075' (1,074.8621')

PL-2-504

N = 227742.47

E = 401193.52

ΔN = 990.33

ΔE = 890.71

r = 1,332 (1,331.9601')

WELL	DISTANCE (FT)	CORRECTED ΔS @ $t = 4350$ MIN (FT) (+ = RISE)	
PZ-4	497'	2.66	
PZ-3	94'	4.35	
PZ-2	144'	3.53	
PZ-1	201'	2.67	
PL-1-486	1,075'	0.68	
PL-2-504	1,332'	1.05	
PL-3-453	2,046'	0.20	
PL-4-464	2,628'	0.13	
ST-1-473	2,589'	0.23	
WW-1-452	4,457'	+0.01	NP
BLM-17-493	1,354'	0.86	
BLM-9-419	4,463'	0.07	NP
BLM-7-509	2,654	+0.08	NP
BLM-2-630	1,389'	2.30	
BLM-2-482	1,425'	0.92	
JP-2-447	4,822'	0.16	
BLM-6	NO SURVEY DATA		
NASA-PT		40.85'	

NP = ONLY ΔS OF $> 0.10'$ ARE PLOTTED

Dave Test Well

N = 226752.14

E = 402094.23

PK-3-453

N 225366.27 ΔN = 1,385.87 r = 2,046'

E 400579.73 ΔE = 1,504.50 (2,045.5209')

PL-4-464

N 227645.70 ΔN = 893.56 r = 2,628'

E 399012.69 ΔE = 2471.54 (2,628.1095')

ST-1-473

N 229161.29 ΔN = 2409.15 r = 2,589'

E 401136.07 ΔE = 948.16 (2,589.0174)

WW-1-452

N 227994.74 ΔN = 1,242.60 r = 4,457'

E 397803.86 ΔE = 4,280.37 (4,457.0867)

BLM-17-493

N 227717.58 ΔN = 965.44 r = 1,354

E 403034.06 ΔE = 949.83 (1,354.3454)

BLM-9-419

N 228517.55 ΔN = 1765.41 r = 4,463

E 406183.31 ΔE = 4099.08 (4,463.0852)

NASA-DT-WELL

N 226752.14

E 402084.23

BLM-07-509

N 224244.56 ΔN = 2507.58'

E 402952.81 ΔE = 868.58'

r = 2,654'

(2,653.7499)

BLM-02-650

N 225701.70 ΔN = 1050.44

E 402990.49 ΔE = 908.26

r = 1,389'

(1,388.65[illegible]2)

BLM-02-482

N 225654.81 ΔN = 1097.33

E 402994.10 ΔE = 909.87

r = 1,425

1,425.4812

BLM-06-

NO SURVEY

JP-2-447

N 225325.05 ΔN = 1427.09

E 397477.96 ΔE = 4606.27

r = 4,822'

(4,822.2722)

WELL	DISTANCE (FT)	CORRECTED ΔS @ $t = 4350$ MIN (FT) (+ = RISE)	
PZ-4	497'	2.66	
PZ-3	94'	4.35	
PZ-2	144'	3.53	
PZ-1	201'	2.67	
PL-1-486	1,075'	0.68	
PL-2-504	1,332'	1.05	
PL-3-453	2,046'	0.20	
PL-4-464	2,628'	0.13	
ST-1-473	2,589'	0.23	
WW-1-452	4,457'	+0.01	NP
BLM-17-493	1,354'	0.86	
BLM-9-419	4,463'	0.07	NP
BLM-7-509	2,654	(+)0.08	NP
BLM-2-630	1,389'	2.30	
BLM-2-482	1,425'	0.92	
JP-2-447	4,822'	0.16	
BLM-6	NO SURVEY DATA		
NASA-PT		40.85'	

NP = ONLY ΔS OF $> 0.10'$ ARE PLOTTED

Pump test Start up (HANDFILE #1)

Start 9:00

FILE NAME: DATA.1
NO. OF STATIONS = 5
NO. OF PERIODS = 6
START TIME= 08:59 SETUP TIME= Monday June 4th 1990, 08:22:54
LENGTH OF PERIOD 1 = 6 MINS
INTERVAL FOR PERIOD 1 = 5 SECS
LENGTH OF PERIOD 2 = 10 MINS
INTERVAL FOR PERIOD 2 = 10 SECS
LENGTH OF PERIOD 3 = 20 MINS
INTERVAL FOR PERIOD 3 = 30 SECS
LENGTH OF PERIOD 4 = 2 HRS 30 MINS
INTERVAL FOR PERIOD 4 = 1 MINS
LENGTH OF PERIOD 5 = 9 HRS
INTERVAL FOR PERIOD 5 = 30 MINS
LENGTH OF PERIOD 6 = 170 HRS
INTERVAL FOR PERIOD 6 = 1 HRS
CHECK/CHANGE SETTINGS Monday June 4th 1990, 08:25:40
FILE NAME: DATA.1 PZ-3 NASA-PT PZ-1 PZ-2 PZ-4
LOGGING ON: Monday June 4th 1990, 08:59:00 PERIOD: 1 INTERVAL: 5

1	0.00		1+00020.06	2+00062.45	3+00019.91	4+00020.43	5+00015.01
6	0.08		1+00020.06	2+00062.42	3+00019.92	4+00020.44	5+00015.01
11	0.16		1+00020.06	2+00062.40	3+00019.92	4+00020.44	5+00015.01
16	0.24		1+00020.06	2+00062.38	3+00019.92	4+00020.44	5+00015.01
21	0.32		1+00020.06	2+00062.37	3+00019.92	4+00020.44	5+00015.01
26	0.41		1+00020.06	2+00062.35	3+00019.92	4+00020.44	5+00015.01
31	0.49		1+00020.06	2+00062.34	3+00019.92	4+00020.44	5+00015.01
36	0.57		1+00020.06	2+00062.32	3+00019.92	4+00020.44	5+00015.01
41	0.66		1+00020.06	2+00062.31	3+00019.92	4+00020.44	5+00015.01
46	0.74		1+00020.06	2+00062.30	3+00019.92	4+00020.43	5+00015.01
51	0.82		1+00020.06	2+00062.30	3+00019.92	4+00020.44	5+00015.01
56	0.91		1+00020.06	2+00062.28	3+00019.92	4+00020.43	5+00015.01
61	0.99	To	1+00020.06	2+00062.28	3+00019.92	4+00020.44	5+00015.01
66	1.07		1+00020.05	2+00054.62	3+00019.93	4+00020.43	5+00015.01
71	1.16		1+00019.88	2+00046.85	3+00019.92	4+00020.31	5+00015.01
76	1.24		1+00019.65	2+00043.01	3+00019.92	4+00020.17	5+00015.01
81	1.32		1+00019.35	2+00041.20	3+00019.91	4+00020.05	5+00015.01
86	1.41		1+00019.12	2+00040.55	3+00019.91	4+00019.90	5+00014.99
91	1.49		1+00018.93	2+00040.59	3+00019.91	4+00019.82	5+00014.98
96	1.57		1+00018.79	2+00041.06	3+00019.89	4+00019.73	5+00014.97
101	1.66		1+00018.65	2+00041.86	3+00019.88	4+00019.64	5+00014.96
106	1.74		1+00018.58	2+00043.02	3+00019.88	4+00019.60	5+00014.94
111	1.82		1+00018.53	2+00044.52	3+00019.85	4+00019.55	5+00014.91
116	1.91		1+00018.51	2+00045.36	3+00019.84	4+00019.51	5+00014.90
121	1.99		1+00018.50	2+00045.88	3+00019.82	4+00019.52	5+00014.88
126	2.07		1+00018.49	2+00046.13	3+00019.81	4+00019.48	5+00014.86
131	2.16		1+00018.49	2+00046.25	3+00019.79	4+00019.48	5+00014.84
136	2.24		1+00018.48	2+00046.33	3+00019.79	4+00019.45	5+00014.84
141	2.33		1+00018.47	2+00046.35	3+00019.76	4+00019.44	5+00014.81
146	2.41		1+00018.46	2+00046.36	3+00019.75	4+00019.43	5+00014.81
151	2.49		1+00018.45	2+00046.35	3+00019.74	4+00019.41	5+00014.81
156	2.57		1+00018.44	2+00046.33	3+00019.72	4+00019.39	5+00014.78
161	2.66		1+00018.43	2+00046.31	3+00019.71	4+00019.38	5+00014.78
166	2.74		1+00018.41	2+00046.28	3+00019.70	4+00019.37	5+00014.77
171	2.83		1+00018.40	2+00046.21	3+00019.68	4+00019.36	5+00014.76
176	2.91		1+00018.39	2+00046.11	3+00019.67	4+00019.35	5+00014.75
181	2.99		1+00018.37	2+00045.86	3+00019.66	4+00019.32	5+00014.74
[illegible]	3.07		1+00018.36	2+00045.63	3+00019.64	4+00019.32	5+00014.73
191	3.16		1+00018.34	2+00045.47	3+00019.64	4+00019.30	5+00014.73

196	196	3.24	3.24	1+00018.28	2+00045.65	3+00019.62	4+00019.29	5+00014.71
206		3.41		1+00018.28	2+00045.47	3+00019.60	4+00019.26	5+00014.70
211		3.49		1+00018.27	2+00045.58	3+00019.59	4+00019.25	5+00014.69
216		3.57		1+00018.26	2+00045.65	3+00019.59	4+00019.22	5+00014.69
221		3.66		1+00018.25	2+00045.67	3+00019.57	4+00019.23	5+00014.68
226		3.74		1+00018.24	2+00045.68	3+00019.56	4+00019.22	5+00014.67
231		3.82		1+00018.23	2+00045.69	3+00019.55	4+00019.22	5+00014.67
236		3.91		1+00018.23	2+00045.67	3+00019.55	4+00019.21	5+00014.66
241		3.99		1+00018.22	2+00045.66	3+00019.54	4+00019.19	5+00014.66
246		4.08		1+00018.21	2+00045.65	3+00019.52	4+00019.19	5+00014.64
251		4.16		1+00018.21	2+00045.65	3+00019.51	4+00019.19	5+00014.64
256		4.24		1+00018.20	2+00045.62	3+00019.50	4+00019.18	5+00014.64
261		4.32		1+00018.19	2+00045.62	3+00019.50	4+00019.17	5+00014.63
266		4.41		1+00018.18	2+00045.59	3+00019.49	4+00019.18	5+00014.62
271		4.49		1+00018.17	2+00045.59	3+00019.48	4+00019.14	5+00014.62
276		4.58		1+00018.17	2+00045.57	3+00019.48	4+00019.15	5+00014.61
281		4.66		1+00018.16	2+00045.56	3+00019.47	4+00019.14	5+00014.61
286		4.74		1+00018.15	2+00045.56	3+00019.46	4+00019.13	5+00014.60
291		4.82		1+00018.14	2+00045.55	3+00019.45	4+00019.12	5+00014.60
296		4.91		1+00018.14	2+00045.54	3+00019.46	4+00019.12	5+00014.60
301		4.99		1+00018.13	2+00045.52	3+00019.44	4+00019.11	5+00014.59
306		5.07		1+00018.13	2+00045.52	3+00019.43	4+00019.10	5+00014.58
311		5.16		1+00018.12	2+00045.51	3+00019.42	4+00019.10	5+00014.58
316		5.24		1+00018.11	2+00045.50	3+00019.42	4+00019.10	5+00014.57
321		5.32		1+00018.11	2+00045.48	3+00019.41	4+00019.09	5+00014.57
326		5.41		1+00018.10	2+00045.48	3+00019.40	4+00019.08	5+00014.57
331		5.49		1+00018.10	2+00045.46	3+00019.40	4+00019.09	5+00014.56
336		5.57		1+00018.09	2+00045.46	3+00019.39	4+00019.07	5+00014.56
341		5.66		1+00018.09	2+00045.43	3+00019.39	4+00019.07	5+00014.55
346		5.74		1+00018.08	2+00045.43	3+00019.38	4+00019.06	5+00014.55
351		5.83		1+00018.07	2+00045.42	3+00019.37	4+00019.06	5+00014.55
356		5.91		1+00018.07	2+00045.41	3+00019.37	4+00019.05	5+00014.55
361		5.99		1+00018.06	2+00045.41	3+00019.37	4+00019.05	5+00014.54

LOGGING ON: Monday June 4th 1990, 09:05:02 PERIOD: 2 INTERVAL: 10

366	6.16	1+00018.06	2+00045.40	3+00019.35	4+00019.04	5+00014.53
371	6.33	1+00018.04	2+00045.37	3+00019.34	4+00019.03	5+00014.53
376	6.49	1+00018.04	2+00045.36	3+00019.33	4+00019.00	5+00014.51
381	6.66	1+00018.03	2+00045.35	3+00019.32	4+00019.01	5+00014.51
386	6.82	1+00018.02	2+00045.33	3+00019.31	4+00019.00	5+00014.51
391	6.99	1+00018.01	2+00045.31	3+00019.31	4+00019.00	5+00014.51
396	7.16	1+00018.01	2+00045.29	3+00019.29	4+00018.98	5+00014.50
401	7.32	1+00018.00	2+00045.30	3+00019.29	4+00018.98	5+00014.49
406	7.49	1+00017.99	2+00045.29	3+00019.28	4+00018.96	5+00014.49
411	7.66	1+00017.98	2+00045.26	3+00019.27	4+00018.97	5+00014.48
416	7.83	1+00017.97	2+00045.24	3+00019.26	4+00018.96	5+00014.47
421	7.99	1+00017.97	2+00045.22	3+00019.26	4+00018.96	5+00014.47
426	8.16	1+00017.96	2+00045.22	3+00019.25	4+00018.94	5+00014.46
431	8.32	1+00017.96	2+00045.21	3+00019.24	4+00018.94	5+00014.46
436	8.49	1+00017.95	2+00045.20	3+00019.23	4+00018.94	5+00014.45
441	8.66	1+00017.94	2+00045.19	3+00019.23	4+00018.92	5+00014.45
446	8.82	1+00017.93	2+00045.19	3+00019.22	4+00018.92	5+00014.44
451	8.99	1+00017.93	2+00045.17	3+00019.22	4+00018.91	5+00014.44
456	9.16	1+00017.92	2+00045.14	3+00019.20	4+00018.91	5+00014.43
461	9.33	1+00017.91	2+00045.12	3+00019.20	4+00018.90	5+00014.43
466	9.49	1+00017.91	2+00045.12	3+00019.19	4+00018.89	5+00014.43
471	9.66	1+00017.90	2+00045.09	3+00019.19	4+00018.89	5+00014.42
476	9.82	1+00017.90	2+00045.09	3+00019.18	4+00018.88	5+00014.42
481	9.99	1+00017.89	2+00045.09	3+00019.19	4+00018.86	5+00014.41

491	10.32	1+00017.88	2+00045.06	3+00019.17	4+00018.87	5+00014.41
496	10.49	1+00017.88	2+00045.06	3+00019.16	4+00018.87	5+00014.40
501	10.66	1+00017.87	2+00045.05	3+00019.15	4+00018.86	5+00014.39
506	10.82	1+00017.86	2+00045.06	3+00019.14	4+00018.85	5+00014.39
511	10.99	1+00017.85	2+00045.06	3+00019.15	4+00018.85	5+00014.39
516	11.16	1+00017.86	2+00045.04	3+00019.13	4+00018.84	5+00014.38
521	11.32	1+00017.85	2+00045.04	3+00019.13	4+00018.84	5+00014.38
526	11.49	1+00017.85	2+00045.03	3+00019.13	4+00018.83	5+00014.38
531	11.66	1+00017.84	2+00045.02	3+00019.12	4+00018.83	5+00014.37
536	11.83	1+00017.84	2+00045.01	3+00019.12	4+00018.83	5+00014.37
541	11.99	1+00017.83	2+00045.01	3+00019.11	4+00018.82	5+00014.36
546	12.16	1+00017.83	2+00045.01	3+00019.11	4+00018.82	5+00014.36
551	12.32	1+00017.82	2+00045.00	3+00019.10	4+00018.81	5+00014.35
556	12.49	1+00017.82	2+00044.99	3+00019.10	4+00018.80	5+00014.35
561	12.66	1+00017.82	2+00044.99	3+00019.10	4+00018.80	5+00014.35
566	12.83	1+00017.81	2+00044.99	3+00019.09	4+00018.80	5+00014.34
571	12.99	1+00017.81	2+00044.99	3+00019.09	4+00018.80	5+00014.34
576	13.16	1+00017.81	2+00044.97	3+00019.09	4+00018.80	5+00014.34
581	13.32	1+00017.80	2+00044.97	3+00019.09	4+00018.79	5+00014.34
586	13.49	1+00017.80	2+00044.97	3+00019.08	4+00018.79	5+00014.33
591	13.66	1+00017.80	2+00044.97	3+00019.08	4+00018.78	5+00014.33
596	13.82	1+00017.79	2+00044.95	3+00019.08	4+00018.78	5+00014.32
601	13.99	1+00017.79	2+00044.93	3+00019.07	4+00018.77	5+00014.32
606	14.16	1+00017.78	2+00044.91	3+00019.07	4+00018.77	5+00014.32
611	14.32	1+00017.78	2+00044.92	3+00019.07	4+00018.77	5+00014.32
616	14.49	1+00017.76	2+00044.90	3+00019.06	4+00018.76	5+00014.31
621	14.66	1+00017.77	2+00044.89	3+00019.06	4+00018.76	5+00014.31
626	14.82	1+00017.77	2+00044.88	3+00019.06	4+00018.76	5+00014.31
631	14.99	1+00017.76	2+00044.89	3+00019.05	4+00018.76	5+00014.31
636	15.16	1+00017.76	2+00044.89	3+00019.05	4+00018.75	5+00014.31
641	15.32	1+00017.76	2+00044.87	3+00019.05	4+00018.75	5+00014.30
646	15.49	1+00017.75	2+00044.86	3+00019.04	4+00018.75	5+00014.30
651	15.66	1+00017.75	2+00044.87	3+00019.04	4+00018.74	5+00014.30
656	15.82	1+00017.75	2+00044.86	3+00019.04	4+00018.74	5+00014.30
661	15.99	1+00017.74	2+00044.84	3+00019.04	4+00018.74	5+00014.29
666	16.16	1+00017.75	2+00044.84	3+00019.03	4+00018.73	5+00014.28
LOGGING ON: Monday June 4th 1990, 09:15:12 PERIOD: 3 INTERVAL: 30						
671	16.66	1+00017.73	2+00044.80	3+00019.02	4+00018.72	5+00014.28
676	17.16	1+00017.73	2+00044.77	3+00019.01	4+00018.72	5+00014.28
681	17.66	1+00017.72	2+00044.75	3+00019.00	4+00018.70	5+00014.27
686	18.16	1+00017.70	2+00044.73	3+00019.00	4+00018.70	5+00014.26
691	18.66	1+00017.68	2+00044.70	3+00018.99	4+00018.69	5+00014.25
696	19.16	1+00017.69	2+00044.66	3+00018.98	4+00018.68	5+00014.25
701	19.66	1+00017.69	2+00044.65	3+00018.98	4+00018.68	5+00014.24
706	20.16	1+00017.67	2+00044.66	3+00018.97	4+00018.67	5+00014.23
711	20.66	1+00017.66	2+00044.65	3+00018.96	4+00018.66	5+00014.23
716	21.16	1+00017.66	2+00044.62	3+00018.96	4+00018.65	5+00014.23
721	21.66	1+00017.65	2+00044.62	3+00018.95	4+00018.65	5+00014.22
726	22.16	1+00017.65	2+00044.60	3+00018.94	4+00018.64	5+00014.21
731	22.66	1+00017.64	2+00044.59	3+00018.94	4+00018.63	5+00014.21
736	23.16	1+00017.63	2+00044.58	3+00018.93	4+00018.63	5+00014.20
741	23.66	1+00017.62	2+00044.58	3+00018.93	4+00018.62	5+00014.20
746	24.16	1+00017.62	2+00044.55	3+00018.92	4+00018.62	5+00014.19
751	24.66	1+00017.61	2+00044.49	3+00018.92	4+00018.61	5+00014.19
756	25.16	1+00017.61	2+00044.49	3+00018.91	4+00018.61	5+00014.18
761	25.66	1+00017.60	2+00044.49	3+00018.91	4+00018.60	5+00014.18
766	26.16	1+00017.60	2+00044.49	3+00018.89	4+00018.60	5+00014.16
771	26.66	1+00017.59	2+00044.48	3+00018.89	4+00018.59	5+00014.17
776	27.16	1+00017.58	2+00044.47	3+00018.89	4+00018.58	5+00014.17
781	27.66	1+00017.58	2+00044.46	3+00018.88	4+00018.58	5+00014.16

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786     28.16           1+00017.57  2+00044.46  3+00018.88  4+00018.57  5+00014.16
791     28.66           1+00017.57  2+00044.46  3+00018.88  4+00018.57  5+00014.15
796     29.16           1+00017.56  2+00044.44  3+00018.87  4+00018.56  5+00014.14
801     29.66           1+00017.56  2+00044.42  3+00018.87  4+00018.56  5+00014.14
806     30.16           1+00017.55  2+00044.42  3+00018.86  4+00018.56  5+00014.14
811     30.66           1+00017.55  2+00044.41  3+00018.86  4+00018.55  5+00014.13
816     31.16           1+00017.55  2+00044.41  3+00018.86  4+00018.55  5+00014.13
821     31.66           1+00017.53  2+00044.39  3+00018.85  4+00018.54  5+00014.13
826     32.16           1+00017.54  2+00044.39  3+00018.85  4+00018.54  5+00014.12
831     32.66           1+00017.53  2+00044.38  3+00018.85  4+00018.54  5+00014.11
836     33.16           1+00017.53  2+00044.35  3+00018.85  4+00018.53  5+00014.12
841     33.66           1+00017.53  2+00044.34  3+00018.84  4+00018.53  5+00014.11
846     34.16           1+00017.52  2+00044.32  3+00018.84  4+00018.52  5+00014.11
851     34.66           1+00017.52  2+00044.31  3+00018.83  4+00018.52  5+00014.10
856     35.16           1+00017.51  2+00044.31  3+00018.83  4+00018.52  5+00014.10
861     35.66           1+00017.51  2+00044.28  3+00018.82  4+00018.51  5+00014.09
866     36.16           1+00017.50  2+00044.28  3+00018.82  4+00018.51  5+00014.09
LOGGING ON: Monday June 4th 1990, 09:35:13 PERIOD: 4 INTERVAL: 60
871     37.16           1+00017.50  2+00044.26  3+00018.82  4+00018.50  5+00014.08
876     38.16           1+00017.49  2+00044.24  3+00018.81  4+00018.50  5+00014.06
881     39.16           1+00017.48  2+00044.23  3+00018.80  4+00018.49  5+00014.06
886     40.16           1+00017.48  2+00044.21  3+00018.80  4+00018.48  5+00014.05
891     41.16           1+00017.48  2+00044.18  3+00018.79  4+00018.48  5+00014.05
896     42.16           1+00017.46  2+00044.14  3+00018.79  4+00018.47  5+00014.04
901     43.16           1+00017.46  2+00044.14  3+00018.78  4+00018.47  5+00014.05
906     44.16           1+00017.45  2+00044.09  3+00018.78  4+00018.46  5+00014.03
911     45.16           1+00017.44  2+00044.08  3+00018.77  4+00018.45  5+00014.03
916     46.16           1+00017.46  2+00044.12  3+00018.77  4+00018.45  5+00014.03
921     47.16           1+00017.44  2+00044.12  3+00018.76  4+00018.44  5+00014.01
926     48.16           1+00017.42  2+00044.05  3+00018.76  4+00018.44  5+00014.00
931     49.16           1+00017.42  2+00044.05  3+00018.71  4+00018.43  5+00014.00
936     50.16           1+00017.42  2+00044.03  3+00018.65  4+00018.42  5+00013.99
941     51.16           1+00017.41  2+00043.99  3+00018.58  4+00018.42  5+00013.99
946     52.16           1+00017.41  2+00043.99  3+00018.51  4+00018.42  5+00013.98
951     53.16           1+00017.40  2+00043.95  3+00018.41  4+00018.41  5+00013.97
956     54.16           1+00017.39  2+00043.93  3+00018.34  4+00018.41  5+00013.96
961     55.16           1+00017.39  2+00043.93  3+00018.24  4+00018.40  5+00013.96
966     56.16           1+00017.39  2+00043.91  3+00018.13  4+00018.40  5+00013.95
971     57.16           1+00017.38  2+00043.90  3+00018.02  4+00018.39  5+00013.95
976     58.16           1+00017.38  2+00043.88  3+00017.88  4+00018.39  5+00013.95
981     59.16           1+00017.37  2+00043.87  3+00017.73  4+00018.38  5+00013.95
986     60.16           1+00017.37  2+00043.83  3+00017.56  4+00018.38  5+00013.94
LOGGING OFF: Monday June 4th 1990, 10:30:29
LOGGING ON: Monday June 4th 1990, 10:30:36 PERIOD: 4 INTERVAL: 60
994     91.60   ?1      OT READY        995     91.61   *2      +00043.73       99691
.61     *3      +00018.63       997     91.62   *4      +00018.30       998     91.62
*5      +00013.79               2+00043.73  3+00018.63  4+00018.30  5+00013.79
999     91.64           1+00017.26  2+00043.69  3+00018.63  4+00018.29  5+00013.78
1004    91.68           1+00017.26  2+00043.68  3+00018.63  4+00018.29  5+00013.78
1009    91.72           1+00017.26  2+00043.66  3+00018.63  4+00018.29  5+00013.78
1014    91.76           1+00017.26  2+00043.64  3+00018.64  4+00018.30  5+00013.78
1019    91.80           1+00017.26  2+00043.62  3+00018.64  4+00018.29  5+00013.78
1024    91.84           1+00017.26  2+00043.59  3+00018.64  4+00018.29  5+00013.78
1029    91.87           1+00017.26  2+00043.59  3+00018.64  4+00018.29  5+00013.78
1034    91.91           1+00017.26  2+00043.58  3+00018.64  4+00018.29  5+00013.78
1039    91.95           1+00017.26  2+00043.57  3+00018.64  4+00018.29  5+00013.77
1044    91.99           1+00017.26  2+00043.56  3+00018.64  4+00018.29  5+00013.78
1049    92.03           1+00017.26  2+00043.53  3+00018.64  4+00018.29  5+00013.77
1054    92.07           1+00017.26  2+00043.51  3+00018.64  4+00018.29  5+00013.77
1059    92.11           1+00017.26  2+00043.50  3+00018.63  4+00018.29  5+00013.77
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1064    92.15           1+00017.26  2+00043.50  3+00018.63  4+00018.29  5+00013.77
1069    92.18           1+00017.26  2+00043.49  3+00018.61  4+00018.29  5+00013.77
1074    92.22           1+00017.26  2+00043.48  3+00018.62  4+00018.29  5+00013.77
1079    92.26           1+00017.26  2+00043.48  3+00018.61  4+00018.29  5+00013.77
1084    92.30           1+00017.26  2+00043.47  3+00018.61  4+00018.29  5+00013.77
1089    92.34           1+00017.26  2+00043.47  3+00018.59  4+00018.29  5+00013.78
1094    92.38           1+00017.26  2+00043.46  3+00018.59  4+00018.29  5+00013.78
1099    92.42           1+00017.26  2+00043.46  3+00018.58  4+00018.29  5+00013.77
1104    92.46           1+00017.26  2+00043.46  3+00018.58  4+00018.29  5+00013.77
1109    92.49           1+00017.26  2+00043.45  3+00018.55  4+00018.29  5+00013.78
1114    92.53           1+00017.26  2+00043.45  3+00018.56  4+00018.29  5+00013.77
1119    92.57           1+00017.26  2+00043.44  3+00018.56  4+00018.29  5+00013.77
1124    92.61           1+00017.26  2+00043.44  3+00018.55  4+00018.29  5+00013.78
1129    92.65           1+00017.25  2+00043.44  3+00018.54  4+00018.29  5+00013.77
1134    92.69           1+00017.26  2+00043.44  3+00018.54  4+00018.29  5+00013.77
1139    92.73           1+00017.26  2+00043.43  3+00018.52  4+00018.29  5+00013.77
1144    92.76           1+00017.26  2+00043.44  3+00018.51  4+00018.29  5+00013.77
1149    93.16           1+00017.26  2+00043.39  3+00018.46  4+00018.29  5+00013.77
1154    94.16           1+00017.26  2+00043.36  3+00018.29  4+00018.29  5+00013.76
1159    95.16           1+00017.25  2+00043.36  3+00018.10  4+00018.28  5+00013.75
1164    96.16           1+00017.25  2+00043.36  3+00017.88  4+00018.28  5+00013.74
1169    97.16           1+00017.25  2+00043.36  3+00017.63  4+00018.28  5+00013.76
1174    98.16           1+00017.25  2+00043.41  3+00017.37  4+00018.28  5+00013.76
LOGGING OFF: Monday June 4th 1990, 10:44:27
LOGGING ON: Monday June 4th 1990, 10:44:30 PERIOD: 4 INTERVAL: 60
1180    105.51  ?1      OT READY        1181    105.51  *2      +00043.71       11821
05.52   *3      +00017.54       1183    105.52  *4      +00018.26       1184    105.5
3       *5      +00013.70               2+00043.71  3+00017.54  4+00018.26  5+00013.7
0
1185    105.55          1+00017.22  2+00043.67  3+00017.49  4+00018.26  5+00013.70
1190    105.59          1+00017.22  2+00043.65  3+00017.44  4+00018.26  5+00013.70
1195    105.62          1+00017.22  2+00043.63  3+00017.41  4+00018.25  5+00013.70
1200    105.66          1+00017.22  2+00043.62  3+00017.38  4+00018.25  5+00013.70
1205    105.70          1+00017.22  2+00043.58  3+00017.35  4+00018.25  5+00013.70
LOGGING OFF: Monday June 4th 1990, 10:45:39
CHECK/CHANGE SETTINGS Monday June 4th 1990, 10:45:53
FILE NAME: DATA.1
NEW NO. OF PERIODS = 3
NEW START TIME= 10:50  REFERENCE: Monday June 4th 1990, 10:46:18
NEW LENGTH OF PERIOD 1= 1 HRS
NEW INTERVAL FOR PERIOD 1= 1 MINS
NEW LENGTH OF PERIOD 2= 9 HRS
NEW INTERVAL FOR PERIOD 2= 30 MINS
NEW LENGTH OF PERIOD 3= 170 HRS
NEW INTERVAL FOR PERIOD 3= 1 HRS
CHECK/CHANGE SETTINGS Monday June 4th 1990, 10:47:44
FILE NAME: DATA.1
LOGGING ON: Monday June 4th 1990, 10:48:12 PERIOD: 4 INTERVAL: 60
LOGGING OFF: Monday June 4th 1990, 10:48:36
CHECK/CHANGE SETTINGS Monday June 4th 1990, 10:48:47
FILE NAME: DATA.1
NEW START TIME= 11:00  REFERENCE: Monday June 4th 1990, 10:48:58
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(HARD file #2

FILE NAME: DATA.1
NO. OF STATIONS = 5
NO. OF PERIODS = 3
START TIME= 11:15 SETUP TIME= Monday June 4th 1990, 11:06:08
LENGTH OF PERIOD 1 = 1 HRS
INTERVAL FOR PERIOD 1 = 1 MINS
LENGTH OF PERIOD 2 = 9 HRS
INTERVAL FOR PERIOD 2 = 30 MINS
LENGTH OF PERIOD 3 = 170 HRS PZ-3
INTERVAL FOR PERIOD 3 = 1 HRS ~ NASA-PT PZ-1 PZ-2 PZ-4
LOGGING ON: Monday June 4th 1990, 11:15:01 PERIOD: 1 INTERVAL: 60

1	0.00	1+00017.14	2+00043.18	3+00018.57	4+00018.19	5+00013.53
6	0.99 +30 min	1+00017.14	2+00042.99	3+00018.57	4+00018.19	5+00013.52
11	1.99	1+00017.14	2+00042.94	3+00018.57	4+00018.19	5+00013.51
16	2.99	1+00017.14	2+00042.93	3+00018.57	4+00018.19	5+00013.49
21	3.99	1+00017.13	2+00042.93	3+00018.57	4+00018.19	5+00013.48
26	4.99	1+00017.13	2+00042.94	3+00018.57	4+00018.18	5+00013.48
31	6.00	1+00017.13	2+00042.98	3+00018.57	4+00018.18	5+00013.47
36	6.99	1+00017.13	2+00043.01	3+00018.57	4+00018.18	5+00013.49
41	7.99	1+00017.13	2+00043.03	3+00018.57	4+00018.18	5+00013.50
46	8.99	1+00017.13	2+00043.02	3+00018.57	4+00018.17	5+00013.50
51	9.99	1+00017.13	2+00043.03	3+00018.57	4+00018.17	5+00013.51
56	10.99	1+00017.12	2+00043.03	3+00018.57	4+00018.17	5+00013.51
61	11.99	1+00017.12	2+00043.03	3+00018.57	4+00018.17	5+00013.51
66	12.99	1+00017.12	2+00043.03	3+00018.56	4+00018.16	5+00013.51
71	14.00	1+00017.12	2+00043.02	3+00018.56	4+00018.16	5+00013.50
76	14.99	1+00017.12	2+00043.05	3+00018.56	4+00018.16	5+00013.49
81	15.99	1+00017.11	2+00043.02	3+00018.55	4+00018.16	5+00013.50
86	16.99	1+00017.11	2+00043.01	3+00018.56	4+00018.16	5+00013.50
91	17.99	1+00017.11	2+00042.99	3+00018.55	4+00018.16	5+00013.47
96	18.99	1+00017.11	2+00043.01	3+00018.55	4+00018.16	5+00013.43
101	19.99	1+00017.10	2+00043.01	3+00018.55	4+00018.15	5+00013.44
106	20.99	1+00017.10	2+00043.02	3+00018.55	4+00018.15	5+00013.45
111	21.99	1+00017.10	2+00043.01	3+00018.54	4+00018.15	5+00013.42
116	22.99	1+00017.10	2+00043.00	3+00018.54	4+00018.14	5+00013.44
121	23.99	1+00017.10	2+00042.99	3+00018.54	4+00018.15	5+00013.46
126	24.99	1+00017.10	2+00042.99	3+00018.54	4+00018.14	5+00013.43
131	25.99	1+00017.10	2+00042.96	3+00018.54	4+00018.14	5+00013.43
136	26.99	1+00017.09	2+00042.95	3+00018.54	4+00018.14	5+00013.41
141	27.99	1+00017.09	2+00042.94	3+00018.54	4+00018.14	5+00013.41
146	28.99	1+00017.09	2+00042.95	3+00018.53	4+00018.14	5+00013.43
151	29.99	1+00017.09	2+00042.95	3+00018.54	4+00018.14	5+00013.45
156	30.99	1+00017.09	2+00042.92	3+00018.53	4+00018.13	5+00013.43
161	31.99	1+00017.09	2+00042.93	3+00018.54	4+00018.13	5+00013.42
166	32.99	1+00017.08	2+00042.91	3+00018.53	4+00018.13	5+00013.41
171	33.99	1+00017.08	2+00042.91	3+00018.52	4+00018.13	5+00013.40
176	34.99	1+00017.08	2+00042.90	3+00018.53	4+00018.12	5+00013.43
181	35.99	1+00017.08	2+00042.91	3+00018.52	4+00018.12	5+00013.42
186	36.99	1+00017.07	2+00042.91	3+00018.53	4+00018.12	5+00013.42
191	37.99	1+00017.07	2+00042.88	3+00018.52	4+00018.12	5+00013.40
196	38.99	1+00017.07	2+00042.87	3+00018.52	4+00018.12	5+00013.40
201	39.99	1+00017.07	2+00042.84	3+00018.51	4+00018.12	5+00013.41
206	40.99	1+00017.07	2+00042.83	3+00018.52	4+00018.12	5+00013.39
211	41.99	1+00017.07	2+00042.83	3+00018.52	4+00018.11	5+00013.36
216	42.99	1+00017.07	2+00042.86	3+00018.51	4+00018.11	5+00013.38
221	43.99	1+00017.07	2+00042.85	3+00018.51	4+00018.11	5+00013.36
226	44.99	1+00017.06	2+00042.85	3+00018.51	4+00018.11	5+00013.36
231	45.99	1+00017.06	2+00042.82	3+00018.51	4+00018.10	5+00013.36

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236     46.99           1+00017.06  2+00042.82  3+00018.51  4+00018.11  5+00013.36
241     47.99           1+00017.06  2+00042.80  3+00018.50  4+00018.11  5+00013.37
246     48.99           1+00017.06  2+00042.79  3+00018.50  4+00018.10  5+00013.37
251     49.99           1+00017.06  2+00042.82  3+00018.50  4+00018.10  5+00013.35
256     50.99           1+00017.05  2+00042.80  3+00018.50  4+00018.10  5+00013.34
261     52.00           1+00017.05  2+00042.80  3+00018.50  4+00018.10  5+00013.34
266     52.99           1+00017.05  2+00042.81  3+00018.49  4+00018.10  5+00013.34
271     53.99           1+00017.05  2+00042.76  3+00018.50  4+00018.09  5+00013.34
276     54.99           1+00017.05  2+00042.76  3+00018.49  4+00018.10  5+00013.31
281     55.99           1+00017.05  2+00042.75  3+00018.49  4+00018.09  5+00013.28
286     57.00           1+00017.04  2+00042.75  3+00018.49  4+00018.09  5+00013.27
291     57.99           1+00017.05  2+00042.76  3+00018.49  4+00018.09  5+00013.26
296     58.99           1+00017.05  2+00042.75  3+00018.49  4+00018.09  5+00013.27
301     59.99           1+00017.04  2+00042.74  3+00018.48  4+00018.09  5+00013.27
LOGGING ON: Monday June 4th 1990, 12:15:03 PERIOD: 2 INTERVAL: 1800
LOGGING OFF: Monday June 4th 1990, 12:42:21
LOGGING ON: Monday June 4th 1990, 12:42:28 PERIOD: 2 INTERVAL: 1800
LOGGING OFF: Monday June 4th 1990, 12:42:48
CHECK/CHANGE SETTINGS Monday June 4th 1990, 12:42:51
FILE NAME: DATA.1
LOGGING ON: Monday June 4th 1990, 12:43:04 PERIOD: 2 INTERVAL: 1800
LOGGING OFF: Monday June 4th 1990, 12:53:44
LOGGING ON: Monday June 4th 1990, 12:54:25 PERIOD: 2 INTERVAL: 1800
LOGGING OFF: Monday June 4th 1990, 12:56:34
LOGGING ON: Monday June 4th 1990, 12:57:34 PERIOD: 2 INTERVAL: 1800
LOGGING OFF: Monday June 4th 1990, 13:32:18
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Never started)
Period 2!

HARDfile #3

FILE NAME: DATA.2
NO. OF STATIONS = 5
NO. OF PERIODS = 4
IMMEDIATE START Monday June 4th 1990, 13:52:41
LENGTH OF PERIOD 1 = 5 MINS
INTERVAL FOR PERIOD 1 = 30 SECS
LENGTH OF PERIOD 2 = 2 HRS
INTERVAL FOR PERIOD 2 = 1 MINS
LENGTH OF PERIOD 3 = 9 HRS
INTERVAL FOR PERIOD 3 = 30 MINS
LENGTH OF PERIOD 4 = 170 HRS
INTERVAL FOR PERIOD 4 = 1 HRS
CHECK/CHANGE SETTINGS Monday June 4th 1990, 13:54:03
FILE NAME: DATA.2
NEW START TIME= 14:00 REFERENCE: Monday June 4th 1990, 13:54:13
LOGGING ON: Monday June 4th 1990, 14:00:01 PERIOD: 1 INTERVAL: 30
1 0.00 ?1 OT READY 2 0.01 ?2 OT READY 30.01
?3 OT READY 4 0.02 ?4 OT READY 5 0.02 ?5OT
READY

#2 ended at 12:15
#3 Starts at 14:00
1 hr 45 min later
= 105 min

- Start 2:00 pm

		PZ-3	NASA-PT	PZ-1	PZ-2	PZ-4
6	0.49	1+00016.95	2+00042.36	3+00018.47	4+00018.03	5+00013.16
11	0.99	1+00016.95	2+00042.26	3+00018.47	4+00018.03	5+00013.19
16	1.50	1+00016.95	2+00042.17	3+00018.47	4+00018.03	5+00013.20
21	1.99	1+00016.94	2+00042.15	3+00018.47	4+00018.03	5+00013.20
26	2.49	1+00016.95	2+00042.18	3+00018.47	4+00018.03	5+00013.20
31	2.99	1+00016.95	2+00042.19	3+00018.47	4+00018.04	5+00013.21
36	3.49	1+00016.95	2+00042.19	3+00018.47	4+00018.03	5+00013.24
41	3.99	1+00016.95	2+00042.20	3+00018.47	4+00018.03	5+00013.24
46	4.49	1+00016.95	2+00042.20	3+00018.47	4+00018.04	5+00013.23
51	4.99	1+00016.95	2+00042.21	3+00018.47	4+00018.04	5+00013.22
LOGGING ON: Monday June 4th 1990, 14:05:04 PERIOD: 2 INTERVAL: 60						
56	5.99	1+00016.95	2+00042.23	3+00018.47	4+00018.03	5+00013.20
61	6.99	1+00016.95	2+00042.28	3+00018.47	4+00018.03	5+00013.16
66	7.99	1+00016.95	2+00042.27	3+00018.47	4+00018.03	5+00013.16
71	8.99	1+00016.95	2+00042.29	3+00018.47	4+00018.03	5+00013.14
76	9.99	1+00016.95	2+00042.27	3+00018.47	4+00018.03	5+00013.16
81	10.99	1+00016.95	2+00042.31	3+00018.47	4+00018.03	5+00013.16
86	11.99	1+00016.95	2+00042.29	3+00018.47	4+00018.02	5+00013.19
91	12.99	1+00016.95	2+00042.29	3+00018.47	4+00018.02	5+00013.22
96	13.99	1+00016.95	2+00042.29	3+00018.47	4+00018.02	5+00013.21
101	14.99	1+00016.94	2+00042.30	3+00018.46	4+00018.02	5+00013.21
106	15.99	1+00016.94	2+00042.28	3+00018.47	4+00018.02	5+00013.19
111	16.99	1+00016.94	2+00042.26	3+00018.47	4+00018.02	5+00013.15
116	17.99	1+00016.94	2+00042.30	3+00018.47	4+00018.02	5+00013.16
121	18.99	1+00016.94	2+00042.31	3+00018.46	4+00018.02	5+00013.15
126	19.99	1+00016.94	2+00042.31	3+00018.47	4+00018.02	5+00013.14
131	20.99	1+00016.94	2+00042.28	3+00018.47	4+00018.02	5+00013.13
136	21.99	1+00016.94	2+00042.29	3+00018.46	4+00018.02	5+00013.16
141	22.99	1+00016.94	2+00042.27	3+00018.46	4+00018.01	5+00013.17
146	23.99	1+00016.94	2+00042.26	3+00018.46	4+00018.01	5+00013.16
151	24.99	1+00016.94	2+00042.27	3+00018.46	4+00018.01	5+00013.17
156	25.99	1+00016.94	2+00042.25	3+00018.46	4+00018.01	5+00013.20
161	26.99	1+00016.94	2+00042.26	3+00018.46	4+00018.01	5+00013.20
166	27.99	1+00016.94	2+00042.25	3+00018.45	4+00018.01	5+00013.19
171	28.99	1+00016.93	2+00042.24	3+00018.45	4+00018.01	5+00013.19
176	29.99	1+00016.93	2+00042.24	3+00018.45	4+00018.01	5+00013.20
181	30.99	1+00016.93	2+00042.21	3+00018.45	4+00018.01	5+00013.22
186	31.99	1+00016.93	2+00042.22	3+00018.45	4+00018.00	5+00013.22
191	33.00	1+00016.92	2+00042.23	3+00018.45	4+00018.00	5+00013.18

196	33.99	1+00016.93	2+00042.24	3+00018.45	4+00018.01	5+00013.20
201	34.99	1+00016.93	2+00042.22	3+00018.44	4+00018.00	5+00013.21
206	35.99	1+00016.93	2+00042.22	3+00018.44	4+00018.00	5+00013.21
211	36.99	1+00016.93	2+00042.22	3+00018.44	4+00018.00	5+00013.20
216	37.99	1+00016.93	2+00042.20	3+00018.43	4+00018.00	5+00013.19
221	38.99	1+00016.93	2+00042.21	3+00018.43	4+00017.99	5+00013.19
226	39.99	1+00016.93	2+00042.21	3+00018.44	4+00018.00	5+00013.17
231	40.99	1+00016.93	2+00042.21	3+00018.43	4+00017.99	5+00013.15
236	41.99	1+00016.93	2+00042.18	3+00018.43	4+00017.99	5+00013.14
241	42.99	1+00016.92	2+00042.21	3+00018.42	4+00017.99	5+00013.12
246	43.99	1+00016.92	2+00042.22	3+00018.43	4+00017.99	5+00013.14
251	44.99	1+00016.93	2+00042.21	3+00018.43	4+00017.99	5+00013.18
256	45.99	1+00016.93	2+00042.19	3+00018.43	4+00017.98	5+00013.22
261	46.99	1+00016.93	2+00042.19	3+00018.42	4+00017.99	5+00013.21
266	47.99	1+00016.92	2+00042.19	3+00018.42	4+00017.99	5+00013.21
271	48.99	1+00016.92	2+00042.19	3+00018.42	4+00017.98	5+00013.17
276	49.99	1+00016.92	2+00042.18	3+00018.42	4+00017.98	5+00013.18
281	50.99	1+00016.92	2+00042.17	3+00018.42	4+00017.98	5+00013.20
286	51.99	1+00016.92	2+00042.17	3+00018.41	4+00017.98	5+00013.17
291	52.99	1+00016.92	2+00042.16	3+00018.41	4+00017.98	5+00013.17
296	53.99	1+00016.92	2+00042.16	3+00018.42	4+00017.97	5+00013.18
301	54.99	1+00016.92	2+00042.15	3+00018.42	4+00017.97	5+00013.17
306	55.99	1+00016.92	2+00042.15	3+00018.42	4+00017.97	5+00013.13
311	56.99	1+00016.92	2+00042.16	3+00018.41	4+00017.98	5+00013.09
316	57.99	1+00016.92	2+00042.16	3+00018.42	4+00017.97	5+00013.08
321	58.99	1+00016.96	2+00042.28	3+00018.42	4+00018.00	5+00013.16
326	59.99	1+00016.92	2+00042.14	3+00018.41	4+00017.97	5+00013.13
331	60.99	1+00016.92	2+00042.14	3+00018.41	4+00017.97	5+00013.15
336	61.99	1+00016.91	2+00042.12	3+00018.41	4+00017.97	5+00013.15
341	62.99	1+00016.91	2+00042.12	3+00018.41	4+00017.97	5+00013.13
346	63.99	1+00016.91	2+00042.10	3+00018.41	4+00017.97	5+00013.10
351	64.99	1+00016.91	2+00042.10	3+00018.41	4+00017.96	5+00013.10
356	66.00	1+00016.91	2+00042.10	3+00018.40	4+00017.96	5+00013.16
361	66.99	1+00016.91	2+00042.07	3+00018.40	4+00017.96	5+00013.19
366	67.99	1+00016.91	2+00042.09	3+00018.40	4+00017.96	5+00013.19
371	68.99	1+00016.91	2+00042.06	3+00018.40	4+00017.96	5+00013.20
376	69.99	1+00016.91	2+00042.06	3+00018.40	4+00017.96	5+00013.23
381	71.00	1+00016.90	2+00042.05	3+00018.40	4+00017.96	5+00013.23
386	71.99	1+00016.90	2+00042.06	3+00018.40	4+00017.96	5+00013.22
391	72.99	1+00016.90	2+00042.04	3+00018.40	4+00017.96	5+00013.18
396	73.99	1+00016.90	2+00042.04	3+00018.40	4+00017.95	5+00013.16
401	74.99	1+00016.90	2+00042.05	3+00018.40	4+00017.96	5+00013.17
406	75.99	1+00016.90	2+00042.03	3+00018.39	4+00017.95	5+00013.20
411	76.99	1+00016.90	2+00042.02	3+00018.39	4+00017.95	5+00013.20
416	77.99	1+00016.90	2+00042.02	3+00018.39	4+00017.95	5+00013.19
421	78.99	1+00016.90	2+00042.01	3+00018.39	4+00017.95	5+00013.16
426	79.99	1+00016.90	2+00042.02	3+00018.39	4+00017.94	5+00013.16
431	80.99	1+00016.90	2+00042.01	3+00018.39	4+00017.94	5+00013.19
436	82.00	1+00016.90	2+00042.01	3+00018.39	4+00017.94	5+00013.20
441	82.99	1+00016.90	2+00042.01	3+00018.38	4+00017.94	5+00013.20
446	83.99	1+00016.89	2+00042.01	3+00018.38	4+00017.94	5+00013.17
451	84.99	1+00016.90	2+00042.02	3+00018.38	4+00017.94	5+00013.16
456	85.99	1+00016.90	2+00042.02	3+00018.39	4+00017.94	5+00013.14
461	86.99	1+00016.90	2+00042.03	3+00018.38	4+00017.94	5+00013.15
466	87.99	1+00016.89	2+00042.02	3+00018.38	4+00017.94	5+00013.14
471	89.00	1+00016.89	2+00042.01	3+00018.38	4+00017.94	5+00013.13
476	89.99	1+00016.89	2+00042.01	3+00018.38	4+00017.94	5+00013.13
481	90.99	1+00016.89	2+00041.96	3+00018.37	4+00017.94	5+00013.17
486	91.99	1+00016.89	2+00041.96	3+00018.37	4+00017.93	5+00013.18
491	92.99	1+00016.89	2+00041.96	3+00018.37	4+00017.93	5+00013.21

496	93.99	1+00016.89	2+00041.94	3+00018.37	4+00017.93	5+00013.20
501	94.99	1+00016.89	2+00041.93	3+00018.37	4+00017.93	5+00013.18
506	95.99	1+00016.89	2+00041.94	3+00018.37	4+00017.93	5+00013.16
511	96.99	1+00016.88	2+00041.93	3+00018.37	4+00017.93	5+00013.18
516	97.99	1+00016.88	2+00041.95	3+00018.37	4+00017.92	5+00013.17
521	99.00	1+00016.88	2+00041.93	3+00018.37	4+00017.93	5+00013.20
526	99.99	1+00016.88	2+00041.92	3+00018.37	4+00017.92	5+00013.22
531	100.99	1+00016.88	2+00041.92	3+00018.37	4+00017.92	5+00013.21
536	101.99	1+00016.88	2+00041.93	3+00018.37	4+00017.92	5+00013.22
541	102.99	1+00016.88	2+00041.96	3+00018.37	4+00017.92	5+00013.24
546	103.99	1+00016.88	2+00041.96	3+00018.36	4+00017.92	5+00013.24
551	104.99	1+00016.88	2+00041.96	3+00018.36	4+00017.92	5+00013.23
556	105.99	1+00016.88	2+00041.94	3+00018.36	4+00017.92	5+00013.22
561	106.99	1+00016.88	2+00041.92	3+00018.36	4+00017.92	5+00013.23
566	107.99	1+00016.88	2+00041.92	3+00018.36	4+00017.92	5+00013.25
571	108.99	1+00016.88	2+00041.92	3+00018.36	4+00017.92	5+00013.27
576	109.99	1+00016.88	2+00041.92	3+00018.36	4+00017.91	5+00013.27
581	110.99	1+00016.88	2+00041.91	3+00018.36	4+00017.91	5+00013.26
586	111.99	1+00016.88	2+00041.90	3+00018.36	4+00017.91	5+00013.24
591	112.99	1+00016.88	2+00041.91	3+00018.36	4+00017.91	5+00013.24
596	113.99	1+00016.88	2+00041.89	3+00018.36	4+00017.91	5+00013.23
601	114.99	1+00016.87	2+00041.88	3+00018.36	4+00017.91	5+00013.20
606	115.99	1+00016.87	2+00041.89	3+00018.36	4+00017.91	5+00013.22
611	116.99	1+00016.88	2+00041.89	3+00018.36	4+00017.91	5+00013.21
616	117.99	1+00016.87	2+00041.89	3+00018.35	4+00017.91	5+00013.20
621	118.99	1+00016.88	2+00041.92	3+00018.35	4+00017.91	5+00013.21
626	119.99	1+00016.88	2+00041.92	3+00018.35	4+00017.91	5+00013.25
631	120.99	1+00016.88	2+00041.88	3+00018.35	4+00017.91	5+00013.24
636	122.00	1+00016.87	2+00041.90	3+00018.35	4+00017.91	5+00013.22
641	122.99	1+00016.88	2+00041.92	3+00018.35	4+00017.91	5+00013.20
646	123.99	1+00016.88	2+00041.89	3+00018.35	4+00017.91	5+00013.21
651	124.99	1+00016.88	2+00041.88	3+00018.34	4+00017.91	5+00013.21
656	125.99	1+00016.87	2+00041.88	3+00018.35	4+00017.90	5+00013.20

LOGGING ON: Monday June 4th 1990, 16:06:03 PERIOD: 3 INTERVAL: 1800

661	156.00	1+00016.87	2+00041.74	3+00018.39	4+00017.95	5+00013.32
666	186.00	1+00016.86	2+00041.70	3+00018.42	4+00017.96	5+00013.36
671	215.99	1+00016.84	2+00041.55	3+00018.42	4+00017.95	5+00013.42
676	245.99	1+00016.82	2+00041.46	3+00018.41	4+00017.94	5+00013.60
681	276.00	1+00016.87	2+00042.02	3+00018.43	4+00017.97	5+00013.55
686	305.99	1+00016.84	2+00041.81	3+00018.41	4+00017.95	5+00013.60
691	336.00	1+00016.82	2+00041.81	3+00018.39	4+00017.94	5+00013.62
696	366.00	1+00016.80	2+00041.78	3+00018.38	4+00017.92	5+00013.64
701	396.00	1+00016.79	2+00041.72	3+00018.36	4+00017.91	5+00013.63
706	425.99	1+00016.78	2+00041.71	3+00018.35	4+00017.90	5+00013.62
711	455.99	1+00016.76	2+00041.71	3+00018.34	4+00017.89	5+00013.61
716	485.99	1+00016.74	2+00041.66	3+00018.32	4+00017.86	5+00013.58
721	515.99	1+00016.72	2+00041.62	3+00018.30	4+00017.84	5+00013.57
726	545.99	1+00016.70	2+00041.59	3+00018.17	4+00017.82	5+00013.54
731	576.00	1+00016.68	2+00041.56	3+00017.98	4+00017.80	5+00013.52
736	605.99	1+00016.62	2+00041.08	3+00017.76	4+00017.77	5+00013.49
741	636.00	1+00016.60	2+00041.02	3+00017.48	4+00017.75	5+00013.49
746	666.00	1+00016.59	2+00040.94	3+00017.11	4+00017.75	5+00013.48

LOGGING ON: Tuesday June 5th 1990, 01:06:04 PERIOD: 4 INTERVAL: 3600
LOGGING OFF: Tuesday June 5th 1990, 01:27:52
LOGGING ON: Tuesday June 5th 1990, 01:30:33 PERIOD: 4 INTERVAL: 3600
LOGGING OFF: Tuesday June 5th 1990, 01:55:10
LOGGING ON: Tuesday June 5th 1990, 01:56:03 PERIOD: 4 INTERVAL: 3600
LOGGING OFF: Tuesday June 5th 1990, 02:59:43
CHECK/CHANGE SETTINGS Tuesday June 5th 1990, 03:01:34
FILE NAME: DATA.2

LOGGING ON: Tuesday June 5th 1990, 03:02:36 PERIOD: 4 INTERVAL: 3600
LOGGING OFF: Tuesday June 5th 1990, 03:03:35

Hardfile #4

#3 ended 1:06 AM 6/5

#4 starts 3:04 am

118 min d.t.

FILE NAME: DATA.3
NO. OF STATIONS = 5
NO. OF PERIODS = 2
IMMEDIATE START Tuesday June 5th 1990, 03:04:04
LENGTH OF PERIOD 1 = 5 MINS
INTERVAL FOR PERIOD 1 = 5 SECS
LENGTH OF PERIOD 2 = 170 HRS
INTERVAL FOR PERIOD 2 = 1 HRS

PZ → NASA-PT PZ-1 PZ-2 PZ-4

LOGGING ON: Tuesday June 5th 1990, 03:05:23 PERIOD: 1 INTERVAL: 5

1	0.00	1+00016.42	2+00039.75	3+00018.12	4+00017.61	5+00013.39
6	0.07	1+00016.42	2+00039.74	3+00018.12	4+00017.61	5+00013.39
11	0.16	1+00016.42	2+00039.73	3+00018.12	4+00017.61	5+00013.39
16	0.24	1+00016.42	2+00039.74	3+00018.13	4+00017.60	5+00013.39
21	0.32	1+00016.42	2+00039.73	3+00018.12	4+00017.61	5+00013.39
26	0.41	1+00016.42	2+00039.73	3+00018.12	4+00017.61	5+00013.39
31	0.49	1+00016.42	2+00039.74	3+00018.12	4+00017.61	5+00013.39
36	0.57	1+00016.42	2+00039.75	3+00018.12	4+00017.61	5+00013.39
41	0.66	1+00016.42	2+00039.74	3+00018.12	4+00017.60	5+00013.39
46	0.74	1+00016.42	2+00039.75	3+00018.12	4+00017.61	5+00013.39
51	0.82	1+00016.42	2+00039.75	3+00018.12	4+00017.61	5+00013.39
56	0.91	1+00016.42	2+00039.75	3+00018.12	4+00017.60	5+00013.39
61	0.99	1+00016.42	2+00039.75	3+00018.12	4+00017.61	5+00013.39
66	1.08	1+00016.42	2+00039.75	3+00018.12	4+00017.61	5+00013.39
71	1.16	1+00016.42	2+00039.75	3+00018.12	4+00017.61	5+00013.39
76	1.24	1+00016.42	2+00039.75	3+00018.13	4+00017.61	5+00013.39
81	1.33	1+00016.42	2+00039.75	3+00018.12	4+00017.61	5+00013.39
86	1.41	1+00016.42	2+00039.75	3+00018.12	4+00017.61	5+00013.39
91	1.49	1+00016.42	2+00039.75	3+00018.12	4+00017.61	5+00013.39
96	1.57	1+00016.42	2+00039.75	3+00018.13	4+00017.61	5+00013.39
101	1.66	1+00016.42	2+00039.75	3+00018.12	4+00017.61	5+00013.39
106	1.74	1+00016.42	2+00039.75	3+00018.12	4+00017.60	5+00013.39
111	1.82	1+00016.42	2+00039.75	3+00018.13	4+00017.60	5+00013.39
116	1.91	1+00016.42	2+00039.75	3+00018.12	4+00017.60	5+00013.39
121	1.99	1+00016.42	2+00039.76	3+00018.13	4+00017.60	5+00013.39
126	2.07	1+00016.43	2+00039.76	3+00018.13	4+00017.61	5+00013.39
131	2.16	1+00016.42	2+00039.77	3+00018.12	4+00017.61	5+00013.39
136	2.24	1+00016.42	2+00039.77	3+00018.13	4+00017.61	5+00013.39
141	2.32	1+00016.42	2+00039.77	3+00018.13	4+00017.60	5+00013.39
146	2.41	1+00016.42	2+00039.76	3+00018.12	4+00017.61	5+00013.39
151	2.49	1+00016.42	2+00039.77	3+00018.12	4+00017.60	5+00013.39
156	2.57	1+00016.42	2+00039.77	3+00018.12	4+00017.61	5+00013.39
161	2.66	1+00016.41	2+00039.77	3+00018.13	4+00017.60	5+00013.39
166	2.74	1+00016.42	2+00039.78	3+00018.12	4+00017.61	5+00013.39
171	2.82	1+00016.42	2+00039.76	3+00018.13	4+00017.60	5+00013.39
176	2.91	1+00016.42	2+00039.77	3+00018.12	4+00017.61	5+00013.39
181	2.99	1+00016.42	2+00039.77	3+00018.13	4+00017.61	5+00013.39
186	3.08	1+00016.42	2+00039.77	3+00018.12	4+00017.61	5+00013.38
191	3.16	1+00016.41	2+00039.77	3+00018.13	4+00017.61	5+00013.39
196	3.24	1+00016.42	2+00039.77	3+00018.13	4+00017.60	5+00013.39
201	3.33	1+00016.42	2+00039.77	3+00018.13	4+00017.60	5+00013.39
206	3.41	1+00016.42	2+00039.77	3+00018.13	4+00017.61	5+00013.39
211	3.49	1+00016.42	2+00039.77	3+00018.13	4+00017.61	5+00013.39
216	3.58	1+00016.42	2+00039.77	3+00018.13	4+00017.60	5+00013.39
221	3.66	1+00016.41	2+00039.80	3+00018.13	4+00017.61	5+00013.38
226	3.74	1+00016.41	2+00039.80	3+00018.13	4+00017.60	5+00013.39
231	3.83	1+00016.41	2+00039.80	3+00018.13	4+00017.61	5+00013.38
236	3.91	1+00016.42	2+00039.81	3+00018.13	4+00017.61	5+00013.38
241	3.99	1+00016.42	2+00039.81	3+00018.13	4+00017.60	5+00013.38

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246     4.07            1+00016.42  2+00039.80  3+00018.13  4+00017.60  5+00013.39
251     4.16            1+00016.42  2+00039.81  3+00018.13  4+00017.60  5+00013.38
256     4.24            1+00016.42  2+00039.81  3+00018.13  4+00017.60  5+00013.39
261     4.32            1+00016.41  2+00039.81  3+00018.14  4+00017.61  5+00013.38
266     4.41            1+00016.42  2+00039.82  3+00018.13  4+00017.61  5+00013.38
271     4.49            1+00016.41  2+00039.81  3+00018.13  4+00017.61  5+00013.39
276     4.57            1+00016.42  2+00039.82  3+00018.13  4+00017.61  5+00013.38
281     4.66            1+00016.42  2+00039.81  3+00018.13  4+00017.60  5+00013.39
286     4.74            1+00016.42  2+00039.82  3+00018.14  4+00017.61  5+00013.38
291     4.82            1+00016.42  2+00039.83  3+00018.13  4+00017.61  5+00013.39
296     4.91            1+00016.42  2+00039.83  3+00018.13  4+00017.60  5+00013.38
301     4.99            1+00016.42  2+00039.83  3+00018.12  4+00017.61  5+00013.38
LOGGING ON: Tuesday June 5th 1990, 03:10:25 PERIOD: 2 INTERVAL: 3600
306     65.00           1+00016.37  2+00039.76  3+00018.09  4+00017.57  5+00013.36
311     125.00          1+00016.32  2+00039.73  3+00018.04  4+00017.51  5+00013.32
316     184.99          1+00016.57  2+00042.27  3+00018.12  4+00017.69  5+00013.38
321     244.99          1+00016.56  2+00042.32  3+00018.12  4+00017.68  5+00013.35
LOGGING OFF: Tuesday June 5th 1990, 07:28:50
LOGGING ON: Tuesday June 5th 1990, 07:44:00 PERIOD: 2 INTERVAL: 3600
LOGGING OFF: Tuesday June 5th 1990, 07:44:48
LOGGING ON: Tuesday June 5th 1990, 07:44:52 PERIOD: 2 INTERVAL: 3600
LOGGING OFF: Tuesday June 5th 1990, 08:14:14
```

BLM-2-482

FINAL DRAWDOWN DATA

FINAL DRAWDOWN DATA
BLM-2-482

SE1000B
Environmental Logger
06/08 06:47

Unit# 00670 Test# 0

INPUT 1: Level (F)

Reference	0.00
Scale factor	30.02
Offset	- 0.18

Step# 0 06/04 08:59

	Elapsed Time	Value
	0.0000	0.00
	0.0033	0.00
	0.0066	0.00
	0.0099	0.00
	0.0133	0.00
	0.0166	0.00
	0.0200	0.00
	0.0233	0.00
	0.0266	0.00
	0.0300	0.00
	0.0333	0.00
	0.0500	0.00
	0.0666	0.00
	0.0833	0.00
	0.1000	0.00
	0.1166	0.00
	0.1333	0.00
	0.1500	0.00
	0.1666	0.00
	0.1833	0.00
	0.2000	0.00
	0.2166	0.00
	0.2333	0.00
	0.2500	0.00
	0.2666	0.00
	0.2833	0.00
	0.3000	0.00
	0.3166	0.00
	0.3333	0.00
	0.4167	0.00
	0.5000	0.00
	0.5833	0.00
	0.6667	0.00
	0.7500	0.00
	0.8333	0.00
	0.9167	0.00
9:00	1.0000	0.00
	1.0833	0.00
	1.1667	0.00
	1.2500	0.00
	1.3333	0.00
	1.4166	0.00
	1.5000	0.00
	1.5833	0.00
	1.6667	0.00
	1.7500	0.00
	1.8333	0.00
	1.9167	0.00
9:01	2.0000	0.00
	2.5000	0.00
9:02	3.0000	0.00
	3.5000	0.00
9:03	4.0000	0.00
	4.5000	0.00
9:04	5.0000	0.00
	[illegible]	0.00
905	[illegible]	0.00

	2.5000		0.00
9:02	3.0000		0.00
	3.5000		0.00
9:03	4.0000		0.00
	4.5000		0.00
9:04	5.0000		0.00
	5.5000		0.00
905	6.0000		0.00
	6.5000		0.00
	7.0000		0.00
	7.5000		0.00
	8.0000		0.00
	8.5000	-	0.00
	9.0000		0.00
	9.5000	-	0.00
0909	10.0000	-	0.00
0911	12.0000	-	0.00
0913	14.0000	-	0.01
0915	16.0000	-	0.02
0917	18.0000	-	0.02
0919	20.0000	-	0.03
0921	22.0000	-	0.04
0923	24.0000	-	0.04
0925	26.0000	-	0.05
	28.0000	-	0.05
	30.0000	-	0.06
	32.0000	-	0.06
	34.0000	-	0.06
0935	36.0000	-	0.06
	38.0000	-	0.07
	40.0000	-	0.07
	42.0000	-	0.08
	44.0000	-	0.08
0945	46.0000	-	0.08
	48.0000	-	0.09
	50.0000	-	0.09
	52.0000	-	0.09
	54.0000	-	0.09
955	56.0000	-	0.10
	58.0000	-	0.10
	60.0000	-	0.11
	62.0000	-	0.11
	64.0000	-	0.11
1005	66.0000	-	0.11
	68.0000	-	0.12
	70.0000	-	0.12
	72.0000	-	0.12
	74.0000	-	0.12
1015	76.0000	-	0.13
	78.0000	-	0.13
	80.0000	-	0.13
	82.0000	-	0.13
	84.0000	-	0.13
1025	86.0000	-	0.14
	88.0000	-	0.14
	90.0000	-	0.14
	92.0000	-	0.14
	94.0000	-	0.15
1035	96.0000	-	0.15
	98.0000	-	0.15
	100.000	-	0.15
	110.000	-	0.17
	120.000	-	0.18
	130.000	-	0.18
	140.000	-	0.18
	150.000	-	0.19
	160.000	-	0.19
	170.000	-	0.18
	180.000	-	0.18
	190.000	-	0.18
	200.000	-	0.18
	210.000	-	0.18
	220.000	-	0.18
	230.000	-	0.18
	240.000	-	0.17
	250.000	-	0.17
	260.000	-	0.17
	270.000	-	0.17
	[illegible]	-	[illegible]

230.000	[illegible]
240.000	0.17
250.000	0.17
260.000	0.17
270.000	0.17
280.000	0.16
290.000	0.16
300.000	0.15
310.000	0.15
320.000	0.15
330.000	0.14
340.000	0.15
350.000	0.14
360.000	0.14
370.000	0.13
380.000	0.13
390.000	0.13
400.000	0.12
410.000	0.12
420.000	0.12
430.000	0.11
440.000	0.11
450.000	0.10
460.000	0.10
470.000	0.09
480.000	0.09
490.000	0.09
500.000	0.10
510.000	0.09
520.000	0.09
530.000	0.09
540.000	0.08
550.000	0.07
560.000	0.08
570.000	0.08
580.000	0.08
590.000	0.08
600.000	0.08
610.000	0.09
620.000	0.09
740.000	[illegible]
750.000	0.12
760.000	0.13
770.000	0.13
780.000	0.14
790.000	0.15
800.000	0.15
810.000	0.16
820.000	0.16
830.000	0.17
840.000	0.16
850.000	0.17
860.000	0.18
870.000	0.18
880.000	0.18
890.000	0.18
900.000	0.19
910.000	0.19
920.000	0.19
930.000	0.18
940.000	0.18
950.000	0.18
960.000	0.18
970.000	0.18
980.000	0.18
990.000	0.18
1000.00	0.18
1030.00	0.18
1060.00	0.18
1090.00	0.19
1120.00	0.19
1150.00	0.21
1180.00	0.22
1210.00	0.24
1240.00	0.25
1270.00	0.25
1300.00	0.26
1330.00	0.28
1360.00	0.31
1390.00	0.33
[illegible]	[illegible]

1240.00	-	0.25
1270.00	-	0.25
1300.00	-	0.26
1330.00	-	0.28
1360.00	-	0.31
1390.00	-	0.33
1420.00	-	0.35
1450.00	-	0.36
1480.00	-	0.36
1510.00	-	0.36
1540.00	-	0.36
1570.00	-	0.37
1600.00	-	0.37
1630.00	-	0.36
1660.00	-	0.36
1690.00	-	0.36
1720.00	-	0.34
1750.00	-	0.35
1780.00	-	0.33
1810.00	-	0.33
1840.00	-	0.31
1870.00	-	0.31
1900.00	-	0.30
1930.00	-	0.31
1960.00	-	0.29
1990.00	-	0.30
2020.00	-	0.30
2050.00	-	0.31
2080.00	-	0.32
2110.00	-	0.33
2140.00	-	0.34
2170.00	-	0.35
2200.00	-	0.36
2230.00	-	0.39
2260.00	-	0.41
2290.00	-	0.42
2320.00	-	0.43
2350.00	-	0.44
2380.00	-	0.44
2410.00	-	0.45
2440.00	-	0.45
2470.00	-	0.46
2500.00	-	0.47
2530.00	-	0.48
2560.00	-	0.48
2590.00	-	0.49
2620.00	-	0.51
2650.00	-	0.52
2680.00	-	0.53
2710.00	-	0.54
2740.00	-	0.55
2770.00	-	0.58
2800.00	-	0.60
2830.00	-	0.62
2860.00	-	0.64
2890.00	-	0.66
2920.00	-	0.67
2950.00	-	0.67
2980.00	-	0.67
3010.00	-	0.66
3040.00	-	0.66
3070.00	-	0.65
3100.00	-	0.64
3130.00	-	0.64
3160.00	-	0.62
3190.00	-	0.61
3220.00	-	0.59
3250.00	-	0.60
3280.00	-	0.59
3310.00	-	0.57
3340.00	-	0.57
3370.00	-	0.58
3400.00	-	0.57
3430.00	-	0.57
3460.00	-	0.57
3490.00	-	0.58
3520.00	-	0.59
[illegible]	-	[illegible]

3400.00	-	0.57
3430.00	-	0.57
3460.00	-	0.57
3490.00	-	0.58
3520.00	-	0.59
3550.00	-	0.60
3580.00	-	0.61
3610.00	-	0.62
3640.00	-	0.63
3670.00	-	0.64
3700.00	-	0.67
3730.00	-	0.69
3760.00	-	0.70
3790.00	-	0.71
3820.00	-	0.72
3850.00	-	0.72
3880.00	-	0.73
3910.00	-	0.73
3940.00	-	0.73
3970.00	-	0.73
4000.00	-	0.74
4030.00	-	0.75
4060.00	-	0.75
4090.00	-	0.76
4120.00	-	0.78
4150.00	-	0.79
4180.00	-	0.79
4210.00	-	0.80
4240.00	-	0.81
4270.00	-	0.83
4300.00	-	0.85
4330.00	-	0.86
4360.00	-	0.87
4390.00	-	0.88
4420.00	-	0.88
4450.00	-	0.88
4480.00	-	0.88
4510.00	-	0.89
4540.00	-	0.88
4570.00	-	0.87
4600.00	-	0.86
4630.00	-	0.86
4660.00	-	0.84
4690.00	-	0.83
4720.00	-	0.83
4750.00	-	0.82
4780.00	-	0.82
4810.00	-	0.81
4840.00	-	0.80
4870.00	-	0.80
4900.00	-	0.80
4930.00	-	0.81
4960.00	-	0.83
4990.00	-	0.84
5020.00	-	0.85
5050.00	-	0.87
5080.00	-	0.89
5110.00	-	0.90
5140.00	-	0.91
5170.00	-	0.93
5200.00	-	0.93
5230.00	-	0.94
5260.00	-	0.94
5290.00	-	0.94
5320.00	-	0.94
5350.00	-	0.94
5380.00	-	0.93
5410.00	-	0.93
5440.00	-	0.93
5470.00	-	0.94
5500.00	-	0.95
5530.00	-	0.95
5560.00	-	0.96
5590.00	-	0.97
5620.00	-	0.98

END

BLM-2-630

FINAL DRAWDOWN DATA

FINAL DRAWDOWN DATA BLM-2-630

SE1000B
Environmental Logger
06/08 06:57

Unit# 00670 Test# 0

INPUT 2: Level (F)

Reference	0.00
Scale factor	10.02
Offset	- 0.02

Step# 0 06/04 08:59

Elapsed Time	Value
0.0000	- 0.00
0.0033	- 0.00
0.0066	- 0.00
0.0099	- 0.00
0.0133	- 0.00
0.0166	- 0.00
0.0200	- 0.00
0.0233	- 0.00
0.0266	- 0.00
0.0300	- 0.00
0.0333	- 0.00
0.0500	- 0.00
0.0666	- 0.00
0.0833	- 0.00
0.1000	- 0.00
0.1166	- 0.00
0.1333	- 0.00
0.1500	- 0.00
0.1666	- 0.00
0.1833	- 0.00
0.2000	- 0.00
0.2166	- 0.00
0.2333	- 0.00
0.2500	- 0.00
0.2666	- 0.00
0.2833	- 0.00
0.3000	- 0.00
0.3166	- 0.00
0.3333	- 0.00
0.4167	- 0.00
0.5000	- 0.00
0.5833	- 0.00
0.6667	- 0.00
0.7500	- 0.00
0.8333	- 0.00
0.9167	- 0.00
1.0000	- 0.00
1.0833	- 0.00
1.1667	- 0.00
1.2500	- 0.00
1.3333	- 0.01
1.4166	- 0.00
1.5000	- 0.00
1.5833	- 0.00
1.6667	- 0.00
1.7500	- 0.00
1.8333	- 0.00
1.9167	- 0.00
2.0000	- 0.00
2.5000	- 0.01
3.0000	- 0.01
3.5000	- 0.01
4.0000	- 0.01
4.5000	- 0.31
[illegible]	[illegible]
[illegible]	- 0.31

2.5000	–	0.01
3.0000	–	0.01
3.5000	–	0.01
4.0000	–	0.01
4.5000	–	0.01
5.0000	–	0.01
5.5000	–	0.01
6.0000	–	0.01
6.5000	–	0.01
7.0000	–	0.01
7.5000	–	0.01
8.0000	–	0.02
8.5000	–	0.02
9.0000	–	0.02
9.5000	–	0.02
10.0000	–	0.02
12.0000	–	0.03
14.0000	–	0.03
16.0000	–	0.04
18.0000	–	0.05
20.0000	–	0.06
22.0000	–	0.07
24.0000	–	0.08
26.0000	–	0.09
28.0000	–	0.10
30.0000	–	0.12
32.0000	–	0.12
34.0000	–	0.14
36.0000	–	0.15
38.0000	–	0.16
40.0000	–	0.17
42.0000	–	0.18
44.0000	–	0.20
46.0000	–	0.21
48.0000	–	0.22
50.0000	–	0.23
52.0000	–	0.24
54.0000	–	0.25
56.0000	–	0.26
58.0000	–	0.27
60.0000	–	0.28
62.0000	–	0.29
64.0000	–	0.30
66.0000	–	0.31
68.0000	–	0.32
70.0000	–	0.33
72.0000	–	0.34
74.0000	–	0.35
76.0000	–	0.36
78.0000	–	0.37
80.0000	–	0.38
82.0000	–	0.39
84.0000	–	0.39
86.0000	–	0.40
88.0000	–	0.41
90.0000	–	0.42
92.0000	–	0.43
94.0000	–	0.43
96.0000	–	0.44
98.0000	–	0.45
100.000	–	0.46
110.000	–	0.49
120.000	–	0.52
130.000	–	0.55
140.000	–	0.58
150.000	–	0.61
160.000	–	0.63
170.000	–	0.66
180.000	–	0.68
190.000	–	0.70
200.000	–	0.71
210.000	–	0.74
220.000	–	0.75
230.000	–	0.77
240.000	–	0.78
250.000	–	0.80
260.000	–	0.81
270.000	–	0.82

230.000	-	0.77
240.000	-	0.78
250.000	-	0.80
260.000	-	0.81
270.000	-	0.82
280.000	-	0.84
290.000	-	0.85
300.000	-	0.86
310.000	-	0.88
320.000	-	0.88
330.000	-	0.89
340.000	-	0.90
350.000	-	0.91
360.000	-	0.92
370.000	-	0.93
380.000	-	0.94
390.000	-	0.95
400.000	-	0.96
410.000	-	0.96
420.000	-	0.97
430.000	-	0.98
440.000	-	0.99
450.000	-	0.99
460.000	-	1.00
470.000	-	1.00
480.000	-	1.01
490.000	-	1.02
500.000	-	1.03
510.000	-	1.03
520.000	-	1.04
530.000	-	1.05
540.000	-	1.05
550.000	-	1.06
560.000	-	1.07
570.000	-	1.08
580.000	-	1.08
590.000	-	1.09
600.000	-	1.10
610.000	-	1.11
620.000	-	1.12
630.000	-	1.12
640.000	-	1.13
650.000	-	1.14
660.000	-	1.15
670.000	-	1.16
680.000	-	1.17
690.000	-	1.17
700.000	-	1.18
710.000	-	1.19
720.000	-	1.19
730.000	-	1.20
740.000	-	1.21
750.000	-	1.22
760.000	-	1.23
770.000	-	1.24
780.000	-	1.25
790.000	-	1.25
800.000	-	1.26
810.000	-	1.27
820.000	-	1.28
830.000	-	1.29
840.000	-	1.29
850.000	-	1.30
860.000	-	1.31
870.000	-	1.32
880.000	-	1.32
890.000	-	1.33
900.000	-	1.34
910.000	-	1.34
920.000	-	1.34
930.000	-	1.35
940.000	-	1.36
950.000	-	1.35
960.000	-	1.36
970.000	-	1.36
980.000	-	1.37
990.000	-	1.37
1000.00	-	1.37
1010.00	-	1.38

970.000	-	1.36
980.000	-	1.37
990.000	-	1.37
1000.00	-	1.37
1030.00	-	1.39
1060.00	-	1.40
1090.00	-	1.43
1120.00	-	1.45
1150.00	-	1.47
1180.00	-	1.49
1210.00	-	1.52
1240.00	-	1.54
1270.00	-	1.55
1300.00	-	1.56
1330.00	-	1.57
1360.00	-	1.59
1390.00	-	1.60
1420.00	-	1.62
1450.00	-	1.63
1480.00	-	1.65
1510.00	-	1.66
1540.00	-	1.67
1570.00	-	1.68
1600.00	-	1.68
1630.00	-	1.68
1660.00	-	1.68
1690.00	-	1.68
1720.00	-	1.67
1750.00	-	1.67
1780.00	-	1.66
1810.00	-	1.65
1840.00	-	1.65
1870.00	-	1.64
1900.00	-	1.64
1930.00	-	1.64
1960.00	-	1.64
1990.00	-	1.64
2020.00	-	1.65
2050.00	-	1.66
2080.00	-	1.67
2110.00	-	1.69
2140.00	-	1.70
2170.00	-	1.72
2200.00	-	1.74
2230.00	-	1.76
2260.00	-	1.78
2290.00	-	1.80
2320.00	-	1.81
2350.00	-	1.83
2380.00	-	1.85
2410.00	-	1.87
2440.00	-	1.88
2470.00	-	1.90
2500.00	-	1.92
2530.00	-	1.93
2560.00	-	1.94
2590.00	-	1.95
2620.00	-	1.97
2650.00	-	1.98
2680.00	-	2.00
2710.00	-	2.02
2740.00	-	2.04
2770.00	-	2.06
2800.00	-	2.09
2830.00	-	2.12
2860.00	-	2.14
2890.00	-	2.16
2920.00	-	2.17
2950.00	-	2.18
2980.00	-	2.16
3010.00	-	2.15
3040.00	-	2.14
3070.00	-	2.13
3100.00	-	2.12
3130.00	-	2.10
3160.00	-	2.09
3190.00	-	2.07
3220.00	-	2.06
3250.00	-	2.04
3280.00	-	2.03

3160.00	-	2.09
3190.00	-	2.07
3220.00	-	2.06
3250.00	-	2.04
3280.00	-	2.03
3310.00	-	2.02
3340.00	-	2.01
3370.00	-	2.01
3400.00	-	2.00
3430.00	-	2.00
3460.00	-	1.99
3490.00	-	2.00
3520.00	-	2.01
3550.00	-	2.02
3580.00	-	2.02
3610.00	-	2.04
3640.00	-	2.05
3670.00	-	2.06
3700.00	-	2.07
3730.00	-	2.09
3760.00	-	2.11
3790.00	-	2.13
3820.00	-	2.15
3850.00	-	2.16
3880.00	-	2.17
3910.00	-	2.18
3940.00	-	2.19
3970.00	-	2.20
4000.00	-	2.20
4030.00	-	2.20
4060.00	-	2.20
4090.00	-	2.21
4120.00	-	2.22
4150.00	-	2.23
4180.00	-	2.23
4210.00	-	2.22
4240.00	-	2.21
4270.00	-	2.21
4300.00	-	2.23
4330.00	-	2.25
4360.00	-	2.26
4390.00	-	2.27
4420.00	-	2.28
4450.00	-	2.29
4480.00	-	2.29
4510.00	-	2.30
4540.00	-	2.29
4570.00	-	2.29
4600.00	-	2.28
4630.00	-	2.27
4660.00	-	2.26
4690.00	-	2.25
4720.00	-	2.25
4750.00	-	2.23
4780.00	-	2.23
4810.00	-	2.22
4840.00	-	2.21
4870.00	-	2.20
4900.00	-	2.20
4930.00	-	2.20
4960.00	-	2.22
4990.00	-	2.23
5020.00	-	2.24
5050.00	-	2.25
5080.00	-	2.27
5110.00	-	2.29
5140.00	-	2.31
5170.00	-	2.33
5200.00	-	2.36
5230.00	-	2,37
5260.00	-	2.39
5290.00	-	2.40
5320.00	-	2.41
5350.00	-	2.41
5380.00	-	2.41
5410.00	-	2.41

3610.00	-	2.04
3640.00	-	2.05
3670.00	-	2.06
3700.00	-	2.07
3730.00	-	2.09
3760.00	-	2.11
3790.00	-	2.13
3820.00	-	2.15
3850.00	-	2.16
3880.00	-	2.17
3910.00	-	2.18
3940.00	-	2.19
3970.00	-	2.20
4000.00	-	2.20
4030.00	-	2.20
4060.00	-	2.20
4090.00	-	2.21
4120.00	-	2.22
4150.00	-	2.23
4180.00	-	2.23
4210.00	-	2.22
4240.00	-	2.21
4270.00	-	2.21
4300.00	-	2.23
4330.00	-	2.25
4360.00	-	2.26
4390.00	-	2.27
4420.00	-	2.28
4450.00	-	2.29
4480.00	-	2.29
4510.00	-	2.30
4540.00	-	2.29
4570.00	-	2.29
4600.00	-	2.28
4630.00	-	2.27
4660.00	-	2.26
4690.00	-	2.25
4720.00	-	2.25
4750.00	-	2.23
4780.00	-	2.23
4810.00	-	2.22
4840.00	-	2.21
4870.00	-	2.20
4900.00	-	2.20
4930.00	-	2.20
4960.00	-	2.22
4990.00	-	2.23
5020.00	-	2.24
5050.00	-	2.25
5080.00	-	2.27
5110.00	-	2.29
5140.00	-	2.31
5170.00	-	2.33
5200.00	-	2.36
5230.00	-	2.37
5260.00	-	2.39
5290.00	-	2.40
5320.00	-	2.41
5350.00	-	2.41
5380.00	-	2.41
5410.00	-	2.41
5440.00	-	2.42
5470.00	-	2.43
5500.00	-	2.43
5530.00	-	2.44
5560.00	-	2.45
5590.00	-	2.46
5620.00	-	2.47

END

Recovery Test

FILE NAME: DATA.8
NO. OF STATIONS = 5
NO. OF PERIODS = 4
START TIME= 07:45 SETUP TIME= Friday June 8th 1990, 07:36:19
LENGTH OF PERIOD 1 = 5 MINS
INTERVAL FOR PERIOD 1 = 5 SECS
LENGTH OF PERIOD 2 = 25 MINS
INTERVAL FOR PERIOD 2 = 30 SECS
LENGTH OF PERIOD 3 = 1 HRS 30 MINS
INTERVAL FOR PERIOD 3 = 1 MINS
LENGTH OF PERIOD 4 = 24 HRS
INTERVAL FOR PERIOD 4 = 30 MINS
CHECK/CHANGE SETTINGS Friday June 8th 1990, 07:37:37
FILE NAME: DATA.8 PZ3 PT PZ1 PZ-2 PZ-4
LOGGING ON: Friday June 8th 1990, 07:45:01 PERIOD: 1 INTERVAL: 5

1	0.00 —	1+00015.50	2+00040.61	3+00017.20	4+00016.66	5+00012.24
6	0.08	1+00015.50	2+00040.57	3+00017.21	4+00016.66	5+00012.24
11	0.16	1+00015.47	2+00040.54	3+00017.20	4+00016.66	5+00012.23
16	0.24	1+00015.48	2+00040.52	3+00017.19	4+00016.65	5+00012.23
21	0.32	1+00015.50	2+00040.52	3+00017.19	4+00016.65	5+00012.23
26	0.41	1+00015.47	2+00040.53	3+00017.18	4+00016.65	5+00012.24
31	0.49 —	1+00015.47	2+00040.84	3+00017.19	4+00016.65	5+00012.23
36	0.57 -	1+00015.50	2+00043.64	3+00017.18	4+00016.65	5+00012.23
41	0.66 -	1+00015.53	2+00048.18	3+00017.18	4+00016.69	5+00012.23
46	0.74 —	1+00015.63	2+00051.11	3+00017.18	4+00016.76	5+00012.22
51	0.82 -	1+00015.78	2+00052.86	3+00017.18	4+00016.83	5+00012.22
56	0.91 -	1+00015.93	2+00053.99	3+00017.18	4+00016.91	5+00012.22
61	0.99	1+00016.06	2+00054.54	3+00017.18	4+00016.96	5+00012.23
66	1.08 -	1+00016.18	2+00054.97	3+00017.19	4+00017.04	5+00012.23
71	1.16	1+00016.28	2+00055.28	3+00017.19	4+00017.10	5+00012.24
76	1.24	1+00016.36	2+00055.48	3+00017.20	4+00017.16	5+00012.26
81	1.32 —	1+00016.43	2+00055.65	3+00017.20	4+00017.21	5+00012.24
86	1.41	1+00016.50	2+00055.77	3+00017.21	4+00017.24	5+00012.27
91	1.49 -	1+00016.54	2+00055.86	3+00017.22	4+00017.29	5+00012.29
96	1.57	1+00016.59	2+00055.94	3+00017.23	4+00017.32	5+00012.31
101	1.66	1+00016.64	2+00056.01	3+00017.24	4+00017.35	5+00012.31
106	1.74	1+00016.67	2+00056.08	3+00017.25	4+00017.37	5+00012.33
111	1.82	1+00016.71	2+00056.14	3+00017.25	4+00017.40	5+00012.33
116	1.91	1+00016.74	2+00056.19	3+00017.26	4+00017.43	5+00012.34
121	1.99 —	1+00016.75	2+00056.23	3+00017.28	4+00017.45	5+00012.35
126	2.08	1+00016.78	2+00056.28	3+00017.27	4+00017.47	5+00012.37
131	2.16	1+00016.81	2+00056.31	3+00017.29	4+00017.49	5+00012.38
136	2.24	1+00016.83	2+00056.34	3+00017.30	4+00017.51	5+00012.38
141	2.32	1+00016.85	2+00056.39	3+00017.31	4+00017.52	5+00012.40
146	2.41	1+00016.87	2+00056.42	3+00017.33	4+00017.54	5+00012.41
151	2.49	1+00016.89	2+00056.45	3+00017.33	4+00017.55	5+00012.41
156	2.57 -	1+00016.91	2+00056.47	3+00017.33	4+00017.57	5+00012.42
161	2.66	1+00016.92	2+00056.51	3+00017.35	4+00017.58	5+00012.43
166	2.74	1+00016.93	2+00056.53	3+00017.35	4+00017.60	5+00012.44
171	2.82	1+00016.95	2+00056.56	3+00017.36	4+00017.61	5+00012.44
176	2.91	1+00016.96	2+00056.59	3+00017.37	4+00017.63	5+00012.46
181	2.99 —	1+00016.98	2+00056.61	3+00017.38	4+00017.63	5+00012.46
186	3.07	1+00017.00	2+00056.63	3+00017.39	4+00017.64	5+00012.46
191	3.16	1+00016.99	2+00056.66	3+00017.40	4+00017.65	5+00012.47
196	3.24	1+00017.01	2+00056.69	3+00017.40	4+00017.67	5+00012.48
201	3.33	1+00017.02	2+00056.70	3+00017.42	4+00017.68	5+00012.49
206	3.41	1+00017.03	2+00056.72	3+00017.43	4+00017.68	5+00012.49
211	3.49 —	1+00017.04	2+00056.75	3+00017.44	4+00017.69	5+00012.50

216	3.57	1+00017.05	2+00056.75	3+00017.44	4+00017.70	5+00012.50
221	3.66	1+00017.07	2+00056.77	3+00017.45	4+00017.71	5+00012.51
226	3.74	1+00017.08	2+00056.80	3+00017.46	4+00017.71	5+00012.51
231	3.82	1+00017.08	2+00056.83	3+00017.47	4+00017.72	5+00012.52
236	3.91	1+00017.09	2+00056.84	3+00017.47	4+00017.73	5+00012.52
241	3.99	1+00017.10	2+00056.85	3+00017.48	4+00017.74	5+00012.53
246	4.07 —	1+00017.12	2+00056.87	3+00017.49	4+00017.74	5+00012.53
251	4.16	1+00017.10	2+00056.88	3+00017.50	4+00017.75	5+00012.53
256	4.24	1+00017.12	2+00056.91	3+00017.50	4+00017.75	5+00012.54
261	4.32	1+00017.12	2+00056.91	3+00017.51	4+00017.76	5+00012.54
266	4.41	1+00017.13	2+00056.94	3+00017.52	4+00017.77	5+00012.55
271	4.49	1+00017.14	2+00056.94	3+00017.52	4+00017.78	5+00012.55
276	4.58 —	1+00017.14	2+00056.96	3+00017.53	4+00017.78	5+00012.56
281	4.66	1+00017.15	2+00056.98	3+00017.54	4+00017.79	5+00012.56
286	4.74	1+00017.16	2+00056.98	3+00017.54	4+00017.79	5+00012.55
291	4.82	1+00017.16	2+00057.01	3+00017.55	4+00017.80	5+00012.57
296	4.91	1+00017.17	2+00057.02	3+00017.55	4+00017.80	5+00012.57
301	4.99 —	1+00017.18	2+00057.03	3+00017.56	4+00017.81	5+00012.58
LOGGING ON: Friday June 8th 1990, 07:50:03 PERIOD: 2 INTERVAL: 30						
306	5.49	1+00017.21	2+00057.10	3+00017.59	4+00017.84	5+00012.59
311	5.99 —	1+00017.23	2+00057.17	3+00017.62	4+00017.86	5+00012.62
316	6.49	1+00017.25	2+00057.23	3+00017.64	4+00017.88	5+00012.63
321	6.99 —	1+00017.27	2+00057.28	3+00017.66	4+00017.90	5+00012.64
326	7.49	1+00017.30	2+00057.34	3+00017.69	4+00017.92	5+00012.66
331	7.99 —	1+00017.32	2+00057.39	3+00017.71	4+00017.93	5+00012.67
336	8.50	1+00017.33	2+00057.42	3+00017.72	4+00017.95	5+00012.68
341	8.99 —	1+00017.35	2+00057.48	3+00017.74	4+00017.96	5+00012.69
346	9.49	1+00017.36	2+00057.51	3+00017.76	4+00017.98	5+00012.70
351	9.99 —	1+00017.38	2+00057.54	3+00017.76	4+00017.99	5+00012.71
356	10.49	1+00017.39	2+00057.58	3+00017.78	4+00018.00	5+00012.72
361	10.99	1+00017.40	2+00057.61	3+00017.79	4+00018.02	5+00012.72
366	11.50	1+00017.41	2+00057.64	3+00017.80	4+00018.02	5+00012.73
371	11.99	1+00017.43	2+00057.68	3+00017.82	4+00018.03	5+00012.74
376	12.49	1+00017.44	2+00057.70	3+00017.83	4+00018.04	5+00012.75
381	12.99	1+00017.44	2+00057.73	3+00017.84	4+00018.05	5+00012.76
386	13.49	1+00017.45	2+00057.75	3+00017.84	4+00018.06	5+00012.76
391	13.99	1+00017.46	2+00057.77	3+00017.86	4+00018.07	5+00012.76
396	14.49	1+00017.47	2+00057.79	3+00017.86	4+00018.08	5+00012.77
401	14.99 —	1+00017.48	2+00057.81	3+00017.87	4+00018.08	5+00012.78
406	15.49	1+00017.48	2+00057.84	3+00017.88	4+00018.09	5+00012.78
411	15.99	1+00017.50	2+00057.86	3+00017.88	4+00018.10	5+00012.78
416	16.50	1+00017.50	2+00057.88	3+00017.89	4+00018.11	5+00012.79
421	16.99	1+00017.51	2+00057.89	3+00017.90	4+00018.11	5+00012.79
426	17.49	1+00017.51	2+00057.92	3+00017.90	4+00018.12	5+00012.79
431	17.99	1+00017.52	2+00057.94	3+00017.91	4+00018.13	5+00012.80
436	18.49	1+00017.53	2+00057.96	3+00017.92	4+00018.13	5+00012.80
441	18.99	1+00017.53	2+00057.96	3+00017.92	4+00018.13	5+00012.81
446	19.49	1+00017.54	2+00057.99	3+00017.93	4+00018.14	5+00012.81
451	19.99 —	1+00017.54	2+00058.00	3+00017.94	4+00018.15	5+00012.81
456	20.49	1+00017.55	2+00058.02	3+00017.94	4+00018.15	5+00012.81
461	20.99	1+00017.57	2+00058.03	3+00017.95	4+00018.16	5+00012.82
466	21.49	1+00017.57	2+00058.04	3+00017.95	4+00018.16	5+00012.82
471	21.99	1+00017.57	2+00058.06	3+00017.95	4+00018.17	5+00012.82
476	22.49	1+00017.57	2+00058.08	3+00017.96	4+00018.17	5+00012.82
481	22.99	1+00017.58	2+00058.09	3+00017.96	4+00018.17	5+00012.83
486	23.49	1+00017.58	2+00058.10	3+00017.97	4+00018.18	5+00012.83
491	23.99	1+00017.59	2+00058.11	3+00017.97	4+00018.18	5+00012.83
496	24.49	1+00017.60	2+00058.13	3+00017.97	4+00018.19	5+00012.83
501	24.99 —	1+00017.60	2+00058.14	3+00017.97	4+00018.19	5+00012.85
506	25.49	1+00017.60	2+00058.16	3+00017.98	4+00018.20	5+00012.84

Rec 3

511	25.99	1+00017.61	2+00058.16	3+00017.98	4+00018.20	5+00012.84
516	26.49	1+00017.61	2+00058.18	3+00017.98	4+00018.20	5+00012.85
521	26.99	1+00017.61	2+00058.18	3+00017.99	4+00018.21	5+00012.85
526	27.49	1+00017.62	2+00058.19	3+00017.99	4+00018.21	5+00012.85
531	28.00	1+00017.62	2+00058.22	3+00017.99	4+00018.22	5+00012.86
536	28.49	1+00017.62	2+00058.22	3+00017.99	4+00018.22	5+00012.86
541	28.99	1+00017.63	2+00058.23	3+00018.00	4+00018.22	5+00012.86
546	29.49	1+00017.63	2+00058.24	3+00018.00	4+00018.23	5+00012.86
551	29.99 —	1+00017.64	2+00058.26	3+00018.00	4+00018.23	5+00012.87
LOGGING ON: Friday June 8th 1990, 08:15:03 PERIOD: 3 INTERVAL: 60						
556	30.99	1+00017.65	2+00058.28	3+00018.01	4+00018.24	5+00012.86
561	31.99	1+00017.65	2+00058.30	3+00018.02	4+00018.24	5+00012.87
566	32.99	1+00017.66	2+00058.32	3+00018.03	4+00018.25	5+00012.87
571	33.99	1+00017.67	2+00058.33	3+00018.03	4+00018.25	5+00012.88
576	34.99 —	1+00017.67	2+00058.36	3+00018.04	4+00018.26	5+00012.88
581	36.00	1+00017.68	2+00058.38	3+00018.04	4+00018.27	5+00012.89
586	36.99	1+00017.68	2+00058.39	3+00018.04	4+00018.27	5+00012.89
591	37.99	1+00017.69	2+00058.40	3+00018.05	4+00018.28	5+00012.90
596	38.99	1+00017.69	2+00058.42	3+00018.04	4+00018.28	5+00012.90
601	39.99 —	1+00017.70	2+00058.44	3+00018.05	4+00018.28	5+00012.90
606	40.99	1+00017.71	2+00058.44	3+00018.05	4+00018.29	5+00012.90
611	41.99	1+00017.71	2+00058.47	3+00018.05	4+00018.29	5+00012.91
616	42.99	1+00017.72	2+00058.49	3+00018.06	4+00018.30	5+00012.92
621	43.99	1+00017.72	2+00058.50	3+00018.06	4+00018.30	5+00012.92
626	44.99 —	1+00017.73	2+00058.52	3+00018.06	4+00018.31	5+00012.92
631	45.99	1+00017.74	2+00058.53	3+00018.07	4+00018.30	5+00012.92
636	46.99	1+00017.74	2+00058.55	3+00018.07	4+00018.31	5+00012.93
641	47.99	1+00017.74	2+00058.56	3+00018.07	4+00018.32	5+00012.93
646	48.99	1+00017.75	2+00058.57	3+00018.07	4+00018.32	5+00012.92
651	49.99 —	1+00017.75	2+00058.58	3+00018.08	4+00018.33	5+00012.93
656	50.99	1+00017.76	2+00058.59	3+00018.08	4+00018.33	5+00012.93
661	52.00	1+00017.76	2+00058.61	3+00018.08	4+00018.33	5+00012.93
666	52.99	1+00017.77	2+00058.62	3+00018.08	4+00018.33	5+00012.93
671	53.99	1+00017.77	2+00058.64	3+00018.08	4+00018.34	5+00012.93
676	54.99 —	1+00017.78	2+00058.65	3+00018.09	4+00018.34	5+00012.93
681	55.99	1+00017.78	2+00058.66	3+00018.09	4+00018.34	5+00012.93
686	56.99	1+00017.78	2+00058.67	3+00018.09	4+00018.35	5+00012.93
691	57.99	1+00017.78	2+00058.68	3+00018.09	4+00018.35	5+00012.93
696	58.99	1+00017.79	2+00058.69	3+00018.09	4+00018.35	5+00012.93
701	59.99 —	1+00017.79	2+00058.71	3+00018.10	4+00018.35	5+00012.93
706	60.99	1+00017.80	2+00058.71	3+00018.10	4+00018.36	5+00012.93
711	61.99	1+00017.80	2+00058.73	3+00018.10	4+00018.36	5+00012.93
716	62.99	1+00017.80	2+00058.74	3+00018.10	4+00018.36	5+00012.93
721	63.99	1+00017.81	2+00058.74	3+00018.10	4+00018.37	5+00012.93
726	64.99	1+00017.81	2+00058.74	3+00018.10	4+00018.37	5+00012.93
731	65.99	1+00017.81	2+00058.76	3+00018.10	4+00018.37	5+00012.94
736	66.99	1+00017.81	2+00058.77	3+00018.10	4+00018.37	5+00012.94
741	67.99	1+00017.82	2+00058.78	3+00018.11	4+00018.37	5+00012.94
746	68.99	1+00017.82	2+00058.79	3+00018.11	4+00018.38	5+00012.94
751	69.99	1+00017.82	2+00058.80	3+00018.11	4+00018.38	5+00012.94
756	70.99	1+00017.83	2+00058.81	3+00018.11	4+00018.38	5+00012.94
761	71.99	1+00017.83	2+00058.83	3+00018.12	4+00018.38	5+00012.93
766	72.99	1+00017.83	2+00058.82	3+00018.12	4+00018.38	5+00012.93
771	73.99	1+00017.84	2+00058.84	3+00018.12	4+00018.39	5+00012.92
776	74.99 —	1+00017.84	2+00058.85	3+00018.12	4+00018.39	5+00012.92
781	75.99	1+00017.84	2+00058.85	3+00018.12	4+00018.39	5+00012.91
786	76.99	1+00017.85	2+00058.87	3+00018.12	4+00018.39	5+00012.92
791	77.99	1+00017.85	2+00058.87	3+00018.12	4+00018.40	5+00012.93
796	78.99	1+00017.85	2+00058.89	3+00018.12	4+00018.40	5+00012.93
801	79.99	1+00017.85	2+00058.89	3+00018.13	4+00018.40	5+00012.95

806	80.99	1+00017.86	2+00058.89	3+00018.13	4+00018.40	5+00012.96
811	81.99	1+00017.86	2+00058.91	3+00018.13	4+00018.40	5+00012.97
816	82.99	1+00017.86	2+00058.91	3+00018.13	4+00018.41	5+00012.97
821	83.99	1+00017.86	2+00058.92	3+00018.14	4+00018.41	5+00012.98
826	84.99	1+00017.87	2+00058.92	3+00018.14	4+00018.41	5+00012.99
831	85.99	1+00017.87	2+00058.93	3+00018.14	4+00018.42	5+00012.99
836	87.00	1+00017.87	2+00058.94	3+00018.14	4+00018.42	5+00013.00
841	87.99	1+00017.88	2+00058.96	3+00018.14	4+00018.42	5+00013.00
846	88.99	1+00017.88	2+00058.96	3+00018.14	4+00018.42	5+00012.99
851	89.99 -	1+00017.88	2+00058.97	3+00018.14	4+00018.42	5+00012.98
856	90.99	1+00017.89	2+00058.98	3+00018.14	4+00018.42	5+00012.98
861	91.99	1+00017.89	2+00058.98	3+00018.14	4+00018.42	5+00012.97
866	92.99	1+00017.89	2+00058.99	3+00018.15	4+00018.43	5+00012.98
871	93.99	1+00017.89	2+00059.01	3+00018.15	4+00018.43	5+00012.98
876	94.99	1+00017.89	2+00059.00	3+00018.15	4+00018.43	5+00012.97
881	95.99	1+00017.89	2+00059.01	3+00018.15	4+00018.43	5+00012.96
886	96.99	1+00017.90	2+00059.01	3+00018.15	4+00018.43	5+00012.96
891	97.99	1+00017.90	2+00059.02	3+00018.15	4+00018.44	5+00012.95
896	99.00	1+00017.90	2+00059.02	3+00018.15	4+00018.44	5+00012.95
901	99.99	1+00017.91	2+00059.02	3+00018.15	4+00018.44	5+00012.95
906	100.99	1+00017.91	2+00059.04	3+00018.15	4+00018.44	5+00012.95
911	101.99	1+00017.91	2+00059.05	3+00018.16	4+00018.44	5+00012.95
916	102.99	1+00017.91	2+00059.05	3+00018.16	4+00018.44	5+00012.96
921	103.99	1+00017.92	2+00059.08	3+00018.16	4+00018.45	5+00012.96
926	104.99 -	1+00017.91	2+00059.08	3+00018.16	4+00018.44	5+00012.96
931	106.00	1+00017.92	2+00059.08	3+00018.16	4+00018.45	5+00012.97
936	107.00	1+00017.92	2+00059.09	3+00018.16	4+00018.45	5+00012.97
941	108.00	1+00017.92	2+00059.09	3+00018.16	4+00018.45	5+00012.97
946	108.99	1+00017.92	2+00059.10	3+00018.16	4+00018.45	5+00012.97
951	109.99	1+00017.93	2+00059.10	3+00018.17	4+00018.45	5+00012.97
956	110.99	1+00017.93	2+00059.11	3+00018.17	4+00018.45	5+00012.97
961	111.99	1+00017.93	2+00059.11	3+00018.17	4+00018.46	5+00012.97
966	112.99	1+00017.93	2+00059.12	3+00018.17	4+00018.46	5+00012.98
971	113.99	1+00017.94	2+00059.13	3+00018.17	4+00018.46	5+00012.98
976	114.99	1+00017.94	2+00059.14	3+00018.17	4+00018.46	5+00012.98
981	115.99	1+00017.94	2+00059.14	3+00018.17	4+00018.47	5+00012.98
986	116.99	1+00017.95	2+00059.15	3+00018.17	4+00018.46	5+00012.98
991	118.00	1+00017.95	2+00059.16	3+00018.18	4+00018.47	5+00012.98
996	119.00	1+00017.95	2+00059.17	3+00018.17	4+00018.47	5+00012.98
1001	119.99 -	1+00017.95	2+00059.18	3+00018.17	4+00018.47	5+00012.98

LOGGING ON: Friday June 8th 1990, 09:45:03 PERIOD: 4 INTERVAL: 1800

1006	149.99 -	1+00018.00	2+00059.25	3+00018.23	4+00018.53	5+00012.94
1011	179.99	1+00018.06	2+00059.41	3+00018.28	4+00018.58	5+00012.85
1016	209.99 -	1+00018.10	2+00059.54	3+00018.33	4+00018.62	5+00012.77
1021	239.99	1+00018.14	2+00059.65	3+00018.36	4+00018.67	5+00012.76
1026	269.99 -	1+00018.19	2+00059.74	3+00018.40	4+00018.71	5+00012.71
1031	299.99 -	1+00018.24	2+00059.83	3+00018.44	4+00018.75	5+00012.56
1036	329.99	1+00018.28	2+00059.91	3+00018.48	4+00018.79	5+00012.67
1041	360.00 -	1+00018.32	2+00059.98	3+00018.51	4+00018.83	5+00012.69
1046	389.99	1+00018.37	2+00060.06	3+00018.54	4+00018.86	5+00013.01
1051	419.99 -	1+00018.40	2+00060.12	3+00018.57	4+00018.90	5+00012.74
1056	449.99	1+00018.44	2+00060.18	3+00018.60	4+00018.93	5+00012.52
1061	480.00 -	1+00018.48	2+00060.25	3+00018.61	4+00018.96	5+00013.16

LOGGING OFF: Friday June 8th 1990, 15:58:33
LOGGING ON: Friday June 8th 1990, 16:08:33 PERIOD: 4 INTERVAL: 1800
LOGGING OFF: Friday June 8th 1990, 16:10:00

Recovery

21.5 min behind

501.5 + reading

FILE NAME: DATA.9
NO. OF STATIONS = 5
NO. OF PERIODS = 2
START TIME= 16:20 SETUP TIME= Friday June 8th 1990, 16:14:27
LENGTH OF PERIOD 1 = 2 MINS
INTERVAL FOR PERIOD 1 = 30 SECS
LENGTH OF PERIOD 2 = 24 HRS
INTERVAL FOR PERIOD 2 = 1 HRS
LOGGING ON: Friday June 8th 1990, 16:20:01 PERIOD: 1 INTERVAL: 30

1	—	0.00	501.5	1+00018.52	2+00060.59	3+00018.63	4+00018.99	5+00013.38
6		0.49		1+00018.52	2+00060.48	3+00018.64	4+00018.99	5+00013.38
11		0.99		1+00018.52	2+00060.41	3+00018.64	4+00018.99	5+00013.38
16		1.49		1+00018.52	2+00060.38	3+00018.64	4+00018.99	5+00013.38
21		1.99		1+00018.52	2+00060.36	3+00018.65	4+00018.99	5+00013.38

LOGGING ON: Friday June 8th 1990, 16:22:03 PERIOD: 2 INTERVAL: 3600

26	—	61.99	563.5	1+00018.57	2+00060.39	3+00018.69	4+00019.04	5+00013.38
31	—	121.99	623.5	1+00018.64	2+00060.49	3+00018.74	4+00019.09	5+00013.49
36	—	181.99	683.49	1+00018.67	2+00060.58	3+00018.75	4+00019.12	5+00013.63
41	—	241.99	742.5	1+00018.69	2+00060.62	3+00018.77	4+00019.13	5+00013.68
46	-	302.00	803.5	1+00018.70	2+00060.66	3+00018.78	4+00019.15	5+00013.71
51	-	362.00	863.5	1+00018.71	2+00060.73	3+00018.79	4+00019.16	5+00013.73
56	-	422.00	923.5	1+00018.74	2+00060.77	3+00018.80	4+00019.17	5+00013.75
61	-	482.00	983.5	1+00018.74	2+00060.79	3+00018.80	4+00019.17	5+00013.75
66		542.00	1043.5	1+00018.74	2+00060.81	3+00018.81	4+00019.19	5+00013.75
71	—	602.00	1103.5	1+00018.76	2+00060.86	3+00018.82	4+00019.20	5+00013.78
76	—	661.99	1163.5	1+00018.78	2+00060.90	3+00018.72	4+00019.22	5+00013.79
81		721.99	1223.5	1+00018.79	2+00060.94	3+00018.45	4+00019.23	5+00013.81
86	—	781.99	1283.5	1+00018.79	2+00060.95	3+00018.04	4+00019.23	5+00013.81

LOGGING OFF: Saturday June 9th 1990, 08:01:11

RECOVERY FROM DATA LOGGER:

NASA WELL PT			*	PZ-1	
t´	XD	s´	*	XD	s´
0.00	40.61	0.00	*	17.20	0.00
0.49	40.84	0.23	*	17.19	-0.01
0.57	43.64	3.03	*	17.18	-0.02
0.66	48.18	7.57	*	17.18	-0.02
0.74	51.11	10.50	*	17.18	-0.02
0.82	52.86	12.25	*	17.18	-0.02
0.91	53.99	13.38	*	17.18	-0.02
1.08	54.97	14.36	*	17.19	-0.01
1.32	55.65	15.04	*	17.20	0.00
1.49	55.86	15.25	*	17.22	0.02
1.99	56.23	15.62	*	17.28	0.08
2.57	56.47	15.86	*	17.33	0.13
2.99	56.61	16.00	*	17.38	0.18
3.49	56.75	16.14	*	17.44	0.24
4.07	56.87	16.26	*	17.49	0.29
4.58	56.96	16.35	*	17.53	0.33
4.99	57.03	16.42	*	17.56	0.36
5.99	57.17	16.56	*	17.62	0.42
6.99	57.28	16.67	*	17.66	0.46
7.99	57.39	16.78	*	17.71	0.51
8.99	57.48	16.87	*	17.74	0.54
9.99	57.54	16.93	*	17.76	0.56
14.99	57.81	17.20	*	17.87	0.67
19.99	58.00	17.39	*	17.94	0.74
24.99	58.14	17.53	*	17.97	0.77
29.99	58.26	17.65	*	18.00	0.80
34.99	58.36	17.75	*	18.04	0.84
39.99	58.44	17.83	*	18.05	0.85
44.99	58.52	17.91	*	18.06	0.86
49.99	58.58	17.97	*	18.08	0.88
54.99	58.65	18.04	*	18.09	0.89
59.99	58.71	18.10	*	18.10	0.90
74.99	58.85	18.24	*	18.12	0.92
89.99	58.97	18.36	*	18.14	0.94
104.99	59.08	18.47	*	18.16	0.96
119.99	59.18	18.57	*	18.17	0.97
149.99	59.25	18.64	*	18.23	1.03
209.99	59.54	18.93	*	18.33	1.13
269.99	59.74	19.13	*	18.40	1.20
299.99	59.83	19.22	*	18.44	1.24
360.00	59.98	19.37	*	18.51	1.31
419.99	60.12	19.51	*	18.57	1.37
480.00	60.25	19.64	*	18.61	1.41
501.50	60.59	19.98	*	18.63	1.43
563.50	60.39	19.78	*	18.69	1.49
623.50	60.49	19.88	*	18.74	1.54
683.50	60.58	19.97	*	18.75	1.55
742.50	60.62	20.01	*	18.77	1.57
803.50	60.68	20.07	*	18.78	1.58
863.50	60.73	20.12	*	18.79	1.59
923.50	60.77	20.16	*	18.80	1.60
983.50	60.79	20.18	*	18.80	1.60
1103.50	60.86	20.25	*	18.82	1.62
1163.50	60.90	20.29	*	18.72	1.52
1283.50	60.95	20.34	*	18.04	0.84

BLM-2-482

FINAL RECOVERY DATA

BLM-2-482 FINAL RECOVERY DATA

Read

SE1000B
Environmental Logger
06/19 12:20

Unit# 00670 Test# 0

INPUT 1: Level (F)

Reference	0.00
Scale factor	30.02
Offset	- 0.18

Step# 0 06/08 07:43

Elapsed Time	Value
0.0000	- 1.01
0.0033	- 1.01
0.0066	- 1.01
0.0099	- 1.01
0.0133	- 1.01
0.0166	- 1.01
0.0200	- 1.01
0.0233	- 1.01
0.0266	- 1.01
0.0300	- 1.01
0.0333	- 1.01
0.0500	- 1.01
0.0666	- 1.01
0.0833	- 1.01
0.1000	- 1.01
0.1166	- 1.01
0.1333	- 1.01
0.1500	- 1.01
0.1666	- 1.01
0.1833	- 1.01
0.2000	- 1.01
0.2166	- 1.01
0.2333	- 1.01
0.2500	- 1.01
0.2666	- 1.01
0.2833	- 1.01
0.3000	- 1.01
0.3166	- 1.01
0.3333	- 1.01
0.4167	- 1.01
0.5000	- 1.01
0.5833	- 1.01
0.6667	- 1.01
0.7500	- 1.01
0.8333	- 1.01
0.9167	- 1.01
1.0000	- 1.01
1.0833	- 1.01
1.1667	- 1.01
1.2500	- 1.01
1.3333	- 1.01
1.4166	- 1.01
1.5000	- 1.01
1.5833	- 1.01
1.6667	- 1.01
1.7500	- 1.01
1.8333	- 1.01
1.9167	- 1.01
2.0000	- 1.01
2.5000	- 1.01
3.0000	- 1.01
3.5000	- 1.01
4.0000	- 1.00
4.5000	- 1.00
5.0000	- 1.00
5.5000	- 1.00
6.0000	- 1.00
6.5000	- 1.00
7.0000	- 1.00
	- 1.00

5.5000	-	1.00
6.0000	-	1.00
6.5000	-	1.00
7.0000	-	1.00
7.5000	-	1.00
8.0000	-	0.99
8.5000	-	0.99
9.0000	-	0.99
9.5000	-	0.99
10.0000	-	0.99
12.0000	-	0.99
14.0000	-	0.99
16.0000	-	0.99
18.0000	-	0.98
20.0000	-	0.98
22.0000	-	0.98
24.0000	-	0.98
26.0000	-	0.98
28.0000	-	0.98
30.0000	-	0.98
32.0000	-	0.98
34.0000	-	0.98
36.0000	-	0.98
38.0000	-	0.98
40.0000	-	0.98
42.0000	-	0.98
44.0000	-	0.98
46.0000	-	0.98
48.0000	-	0.98
50.0000	-	0.98
52.0000	-	0.98
54.0000	-	0.98
56.0000	-	0.98
58.0000	-	0.99
60.0000	-	0.99
62.0000	-	0.99
64.0000	-	0.99
66.0000	-	0.99
68.0000	-	0.99
70.0000	-	0.99
72.0000	-	0.99
74.0000	-	0.99
76.0000	-	0.99
78.0000	-	0.99
80.0000	-	0.99
82.0000	-	0.99
84.0000	-	0.99
86.0000	-	0.98
88.0000	-	0.98
90.0000	-	0.99
92.0000	-	0.99
94.0000	-	0.99
96.0000	-	0.99
98.0000	-	0.99
100.000	-	0.99
110.000	-	0.99
120.000	-	1.00
130.000	-	0.99
140.000	-	0.99
150.000	-	0.99
160.000	-	0.99
170.000	-	0.98
180.000	-	0.98
190.000	-	0.97
200.000	-	0.97
210.000	-	0.96
220.000	-	0.95
230.000	-	0.94
240.000	-	0.93
250.000	-	0.93
260.000	-	0.92
270.000	-	0.91
280.000	-	0.91
290.000	-	0.91
300.000	-	0.90
310.000	-	0.88
320.000	-	0.88
330.000	-	0.88
340.000	-	0.86
350.000	-	0.86

380.000	-	0.83
390.000	-	0.82
400.000	-	0.82
410.000	-	0.82
420.000	-	0.80
430.000	-	0.79
440.000	-	0.80
450.000	-	0.79
460.000	-	0.77
470.000	-	0.76
480.000	-	0.76
490.000	-	0.76
500.000	-	0.74
510.000	-	0.74
520.000	-	0.74
530.000	-	0.74
540.000	-	0.74
550.000	-	0.73
560.000	-	0.73
570.000	-	0.73
580.000	-	0.72
590.000	-	0.72
600.000	-	0.72
610.000	-	0.71
620.000	-	0.71
630.000	-	0.71
640.000	-	0.70
650.000	-	0.70
660.000	-	0.70
670.000	-	0.70
680.000	-	0.69
690.000	-	0.69
700.000	-	0.69
710.000	-	0.69
720.000	-	0.69
730.000	-	0.69
740.000	-	0.69
750.000	-	0.69
760.000	-	0.69
770.000	-	0.69
780.000	-	0.70
790.000	-	0.70
800.000	-	0.70
810.000	-	0.70
820.000	-	0.70
830.000	-	0.70
840.000	-	0.71
850.000	-	0.71
860.000	-	0.71
870.000	-	0.70
880.000	-	0.70
890.000	-	0.70
900.000	-	0.70
910.000	-	0.70
920.000	-	0.71
930.000	-	0.71
940.000	-	0.71
950.000	-	0.71
960.000	-	0.71
970.000	-	0.72
980.000	-	0.72
990.000	-	0.72
1000.00	-	0.72
1030.00	-	0.73
1060.00	-	0.73
1090.00	-	0.73
1120.00	-	0.72
1150.00	-	0.72
1180.00	-	0.71

1060.00	-	0.73
1090.00	-	0.73
1120.00	-	0.72
1150.00	-	0.72
1180.00	-	0.71
1210.00	-	0.71
1240.00	-	0.72
1270.00	-	0.73
1300.00	-	0.73
1330.00	-	0.74
1360.00	-	0.75
1390.00	-	0.76
1420.00	-	0.77
1450.00	-	0.78
1480.00	-	0.79
1510.00	-	0.80
1540.00	-	0.81
1570.00	-	0.81
1600.00	-	0.82
1630.00	-	0.81
1660.00	-	0.81
1690.00	-	0.80
1720.00	-	0.79
1750.00	-	0.79
1780.00	-	0.79
1810.00	-	0.77
1840.00	-	0.76
1870.00	-	0.73
1900.00	-	0.73
1930.00	-	0.71
1960.00	-	0.70
1990.00	-	0.69
2020.00	-	0.66
2050.00	-	0.65
2080.00	-	0.65
2110.00	-	0.65
2140.00	-	0.64
2170.00	-	0.64
2200.00	-	0.66
2230.00	-	0.67
2260.00	-	0.68
2290.00	-	0.69
2320.00	-	0.70
2350.00	-	0.70
2380.00	-	0.71
2410.00	-	0.72
2440.00	-	0.72
2470.00	-	0.72
2500.00	-	0.72
2530.00	-	0.73
2560.00	-	0.71
2590.00	-	0.71
2620.00	-	0.71
2650.00	-	0.71
2680.00	-	0.71
2710.00	-	0.71
2740.00	-	0.71
2770.00	-	0.72
2800.00	-	0.73
2830.00	-	0.73
2860.00	-	0.74
2890.00	-	0.76
2920.00	-	0.77
2950.00	-	0.78
2980.00	-	0.78
3010.00	-	0.78
3040.00	-	0.77
3070.00	-	0.77
3100.00	-	0.78
3130.00	-	0.76
3160.00	-	0.75
3190.00	-	0.75
3220.00	-	0.73
3250.00	-	0.73
3280.00	-	0.71
3310.00	-	0.70
3340.00	-	0.68
3370.00	-	0.67
3400.00	-	0.66
3430.00	-	0.66

3430.00	-	0.66
3460.00	-	0.65
3490.00	-	0.64
3520.00	-	0.63
3550.00	-	0.63
3580.00	-	0.63
3610.00	-	0.64
3640.00	-	0.64
3670.00	-	0.64
3700.00	-	0.65
3730.00	-	0.66
3760.00	-	0.66
3790.00	-	0.67
3820.00	-	0.66
3850.00	-	0.66
3880.00	-	0.66
3910.00	-	0.68
3940.00	-	0.69
3970.00	-	0.68
4000.00	-	0.67
4030.00	-	0.67
4060.00	-	0.68
4090.00	-	0.68
4120.00	-	0.67
4150.00	-	0.67
4180.00	-	0.67
4210.00	-	0.66
4240.00	-	0.67
4270.00	-	0.67
4300.00	-	0.68
4330.00	-	0.69
4360.00	-	0.70
4390.00	-	0.71
4420.00	-	0.72
4450.00	-	0.72
4480.00	-	0.71
4510.00	-	0.69
4540.00	-	0.69
4570.00	-	0.68
4600.00	-	0.67
4630.00	-	0.65
4660.00	-	0.64
4690.00	-	0.63
4720.00	-	0.61
4750.00	-	0.59
4780.00	-	0.59
4810.00	-	0.56
4840.00	-	0.55
4870.00	-	0.54
4900.00	-	0.54
4930.00	-	0.52
4960.00	-	0.51
4990.00	-	0.52
5020.00	-	0.52
5050.00	-	0.52
5080.00	-	0.54
5110.00	-	0.56
5140.00	-	0.54
5170.00	-	0.54
5200.00	-	0.54
5230.00	-	0.54
5260.00	-	0.54
5290.00	-	0.53
5320.00	-	0.54
5350.00	-	0.54
5380.00	-	0.53
5410.00	-	0.53
5440.00	-	0.52
5470.00	-	0.52
5500.00	-	0.51
5530.00	-	0.51
5560.00	-	0.51
5590.00	-	0.51
5620.00	-	0.52
5650.00	-	0.52
5680.00	-	0.53
5710.00	-	0.54
5740.00	-	0.54
5770.00	-	0.56
5800.00	-	0.56
5830.00	-	0.57

5740.00	-	0.54
5770.00	-	0.56
5800.00	-	0.56
5830.00	-	0.57
5860.00	-	0.57
5890.00	-	0.57
5920.00	-	0.57
5950.00	-	0.56
5980.00	-	0.55
6010.00	-	0.54
6040.00	-	0.54
6070.00	-	0.53
6100.00	-	0.51
6130.00	-	0.50
6160.00	-	0.49
6190.00	-	0.47
6220.00	-	0.46
6250.00	-	0.45
6280.00	-	0.43
6310.00	-	0.42
6340.00	-	0.40
6370.00	-	0.40
6400.00	-	0.38
6430.00	-	0.38
6460.00	-	0.38
6490.00	-	0.38
6520.00	-	0.39
6550.00	-	0.39
6580.00	-	0.41
6610.00	-	0.42
6640.00	-	0.43
6670.00	-	0.43
6700.00	-	0.43
6730.00	-	0.44
6760.00	-	0.44
6790.00	-	0.43
6820.00	-	0.43
6850.00	-	0.43
6880.00	-	0.42
6910.00	-	0.43
6940.00	-	0.43
6970.00	-	0.44
7000.00	-	0.45
7030.00	-	0.45
7060.00	-	0.45
7090.00	-	0.46
7120.00	-	0.48
7150.00	-	0.49
7180.00	-	0.50
7210.00	-	0.52
7240.00	-	0.53
7270.00	-	0.54
7300.00	-	0.53
7330.00	-	0.54
7360.00	-	0.53
7390.00	-	0.53
7420.00	-	0.53
7450.00	-	0.51
7480.00	-	0.51
7510.00	-	0.50
7540.00	-	0.49
7570.00	-	0.48
7600.00	-	0.47
7630.00	-	0.46
7660.00	-	0.45
7690.00	-	0.43
7720.00	-	0.43
7750.00	-	0.41
7780.00	-	0.40
7810.00	-	0.39
7840.00	-	0.40
7870.00	-	0.39
7900.00	-	0.40
7930.00	-	0.41
7960.00	-	0.41
7990.00	-	0.42
8020.00	-	0.43
8050.00	-	0.44
8080.00	-	0.45
8110.00	-	0.46

	-	0.42
8020.00	-	0.43
8050.00	-	0.44
8080.00	-	0.45
8110.00	-	0.46
8140.00	-	0.46
8170.00	-	0.47
8200.00	-	0.48
8230.00	-	0.48
8260.00	-	0.49
8290.00	-	0.49
8320.00	-	0.49
8350.00	-	0.50
8380.00	-	0.51
8410.00	-	0.51
8440.00	-	0.52
8470.00	-	0.53
8500.00	-	0.54
8530.00	-	0.54
8560.00	-	0.55
8590.00	-	0.56
8620.00	-	0.58
8650.00	-	0.59
8680.00	-	0.60
8710.00	-	0.60
8740.00	-	0.61
8770.00	-	0.60
8800.00	-	0.59
8830.00	-	0.58
8860.00	-	0.58
8890.00	-	0.56
8920.00	-	0.55
8950.00	-	0.54
8980.00	-	0.53
9010.00	-	0.52
9040.00	-	0.51
9070.00	-	0.50
9100.00	-	0.48
9130.00	-	0.47
9160.00	-	0.45
9190.00	-	0.45
9220.00	-	0.43
9250.00	-	0.42
9280.00	-	0.42
9310.00	-	0.41
9340.00	-	0.41
9370.00	-	0.40
9400.00	-	0.41
9430.00	-	0.41
9460.00	-	0.42
9490.00	-	0.43
9520.00	-	0.44
9550.00	-	0.44
9580.00	-	0.44
9610.00	-	0.44
9640.00	-	0.45
9670.00	-	0.44
9700.00	-	0.44
9730.00	-	0.43
9760.00	-	0.43
9790.00	-	0.43
9820.00	-	0.44
9850.00	-	0.44
9880.00	-	0.45
9910.00	-	0.45
9940.00	-	0.46
9970.00	-	0.47
10000.0	-	0.47
10030.0	-	0.48
10060.0	-	0.48
10090.0	-	0.50
10120.0	-	0.51
10150.0	-	0.52
10180.0	-	0.51
10210.0	-	0.50
10240.0	-	0.50
10270.0	-	0.49
10300.0	-	0.49
10330.0	-	0.49
10360.0	-	0.47
10390.0	-	0.48
[illegible]	-	0.45

10270.0	-	0.49
10300.0	-	0.49
10330.0	-	0.49
10360.0	-	0.47
10390.0	-	0.48
10420.0	-	0.45
10450.0	-	0.44
10480.0	-	0.43
10510.0	-	0.42
10540.0	-	0.41
10570.0	-	0.41
10600.0	-	0.39
10630.0	-	0.39
10660.0	-	0.36
10690.0	-	0.36
10720.0	-	0.34
10750.0	-	0.34
10780.0	-	0.34
10810.0	-	0.34
10840.0	-	0.34
10870.0	-	0.34
10900.0	-	0.35
10930.0	-	0.35
10960.0	-	0.36
10990.0	-	0.36
11020.0	-	0.37
11050.0	-	0.37
11080.0	-	0.38
11110.0	-	0.38
11140.0	-	0.39
11170.0	-	0.39
11200.0	-	0.38
11230.0	-	0.39
11260.0	-	0.39
11290.0	-	0.40
11320.0	-	0.40
11350.0	-	0.41
11380.0	-	0.42
11410.0	-	0.43
11440.0	-	0.44
11470.0	-	0.45
11500.0	-	0.46
11530.0	-	0.48
11560.0	-	0.49
11590.0	-	0.50
11620.0	-	0.50
11650.0	-	0.50
11680.0	-	0.50
11710.0	-	0.51
11740.0	-	0.50
11770.0	-	0.49
11800.0	-	0.49
11830.0	-	0.48
11860.0	-	0.47
11890.0	-	0.46
11920.0	-	0.46
11950.0	-	0.45
11980.0	-	0.44
12010.0	-	0.43
12040.0	-	0.41
12070.0	-	0.41
12100.0	-	0.40
12130.0	-	0.39
12160.0	-	0.39
12190.0	-	0.39
12220.0	-	0.39
12250.0	-	0.40
12280.0	-	0.41
12310.0	-	0.42
12340.0	-	0.42
12370.0	-	0.44
12400.0	-	0.45
12430.0	-	0.45
12460.0	-	0.45
12490.0	-	0.45
12520.0	-	0.45
12550.0	-	0.45
12580.0	-	0.45
12610.0	-	0.45
12640.0	-	0.45
[illegible]	-	0.45

12580.0	-	0.45
12610.0	-	0.45
12640.0	-	0.45
12670.0	-	0.45
12700.0	-	0.46
12730.0	-	0.47
12760.0	-	0.48
12790.0	-	0.49
12820.0	-	0.50
12850.0	-	0.51
12880.0	-	0.52
12910.0	-	0.54
12940.0	-	0.55
12970.0	-	0.57
13000.0	-	0.58
13030.0	-	0.59
13060.0	-	0.60
13090.0	-	0.61
13120.0	-	0.60
13150.0	-	0.60
13180.0	-	0.59
13210.0	-	0.59
13240.0	-	0.58
13270.0	-	0.58
13300.0	-	0.56
13330.0	-	0.55
13360.0	-	0.55
13390.0	-	0.54
13420.0	-	0.54
13450.0	-	0.52
13480.0	-	0.51
13510.0	-	0.51
13540.0	-	0.50
13570.0	-	0.49
13600.0	-	0.49
13630.0	-	0.49
13660.0	-	0.49
13690.0	-	0.49
13720.0	-	0.49
13750.0	-	0.50
13780.0	-	0.51
13810.0	-	0.51
13840.0	-	0.52
13870.0	-	0.53
13900.0	-	0.53
13930.0	-	0.53
13960.0	-	0.53
13990.0	-	0.52
14020.0	-	0.52
14050.0	-	0.52
14080.0	-	0.52
14110.0	-	0.51
14140.0	-	0.52
14170.0	-	0.54
14200.0	-	0.54
14230.0	-	0.54
14260.0	-	0.54
14290.0	-	0.55
14320.0	-	0.56
14350.0	-	0.58
14380.0	-	0.59
14410.0	-	0.60
14440.0	-	0.61
14470.0	-	0.61
14500.0	-	0.61
14530.0	-	0.61
14560.0	-	0.61
14590.0	-	0.60
14620.0	-	0.59
14650.0	-	0.58
14680.0	-	0.57
14710.0	-	0.56
14740.0	-	0.55
14770.0	-	0.53
14800.0	-	0.53
14830.0	-	0.51
14860.0	-	0.50
14890.0	-	0.46
14918.0	-	0.46

14800.0	-	0.53
14830.0	-	0.51
14860.0	-	0.50
14890.0	-	0.46
14920.0	-	0.46
14950.0	-	0.44
14980.0	-	0.43
15010.0	-	0.42
15040.0	-	0.41
15070.0	-	0.41
15100.0	-	0.41
15130.0	-	0.42
15160.0	-	0.42
15190.0	-	0.44
15220.0	-	0.45
15250.0	-	0.45
15280.0	-	0.46
15310.0	-	0.46
15340.0	-	0.45
15370.0	-	0.45
15400.0	-	0.44
15430.0	-	0.43
15460.0	-	0.43
15490.0	-	0.43
15520.0	-	0.43
15550.0	-	0.42
15580.0	-	0.42
15610.0	-	0.42
15640.0	-	0.42
15670.0	-	0.42
15700.0	-	0.42
15730.0	-	0.42
15760.0	-	0.42
15790.0	-	0.43
15820.0	-	0.44
15850.0	-	0.45
15880.0	-	0.47
15910.0	-	0.48
15940.0	-	0.48
15970.0	-	0.48
16000.0	-	0.48
16030.0	-	0.47
16060.0	-	0.46
16090.0	-	0.45

END

BLM-2-630

FINAL RECOVERY DATA

BLM-2-630 FINAL RECOVERY DATA

SE1000B
Environmental Logger
06/19 12:39

Unit# 00670 Test# 0

INPUT 2: Level (F)

Reference	0.00
Scale factor	10.02
Offset	- 0.02

Step# 0 06/08 07:43

Elapsed Time	Value
0.0000	- 2.50
0.0033	- 2.50
0.0066	- 2.50
0.0099	- 2.50
0.0133	- 2.50
0.0166	- 2.50
0.0200	- 2.50
0.0233	- 2.50
0.0266	- 2.50
0.0300	- 2.50
0.0333	- 2.50
0.0500	- 2.50
0.0666	- 2.50
0.0833	- 2.50
0.1000	- 2.50
0.1166	- 2.50
0.1333	- 2.50
0.1500	- 2.50
0.1666	- 2.50
0.1833	- 2.50
0.2000	- 2.50
0.2166	- 2.50
0.2333	- 2.50
0.2500	- 2.50
0.2666	- 2.50
0.2833	- 2.50
0.3000	- 2.50
0.3166	- 2.50
0.3333	- 2.50
0.4167	- 2.50
0.5000	- 2.51
0.5833	- 2.50
0.6667	- 2.51
0.7500	- 2.50
0.8333	- 2.50
0.9167	- 2.51
1.0000	- 2.51
1.0833	- 2.51
1.1667	- 2.51
1.2500	- 2.51
1.3333	- 2.51
1.4166	- 2.51
1.5000	- 2.51
1.5833	- 2.51
1.6667	- 2.51
1.7500	- 2.51
1.8333	- 2.51
1.9167	- 2.51
2.0000	- 2.51
2.5000	- 2.51
3.0000	- 2.51
3.5000	- 2.51
4.0000	- 2.51
4.5000	- 2.51
5.0000	- 2.51
5.5000	- 2.51
[illegible]	- [illegible]
[illegible]	- [illegible]
[illegible]	- 2.51

5.0000	2.51
5.5000	2.51
6.0000	2.51
6.5000	2.51
7.0000	2.51
7.5000	2.51
8.0000	2.51
8.5000	2.51
9.0000	2.51
9.5000	2.51
10.0000	2.50
12.0000	2.50
14.0000	2.49
16.0000	2.48
18.0000	2.47
20.0000	2.46
22.0000	2.45
24.0000	2.44
26.0000	2.43
28.0000	2.42
30.0000	2.41
32.0000	2.40
34.0000	2.39
36.0000	2.37
38.0000	2.37
40.0000	2.35
42.0000	2.34
44.0000	2.33
46.0000	2.32
48.0000	2.31
50.0000	2.30
52.0000	2.29
54.0000	2.28
56.0000	2.27
58.0000	2.26
60.0000	2.25
62.0000	2.24
64.0000	2.24
66.0000	2.23
68.0000	2.22
70.0000	2.21
72.0000	2.20
74.0000	2.19
76.0000	2.18
78.0000	2.17
80.0000	2.16
82.0000	2.15
84.0000	2.15
86.0000	2.14
88.0000	2.13
90.0000	2.12
92.0000	2.12
94.0000	2.11
96.0000	2.10
98.0000	2.09
100.000	2.08
110.000	2.04
120.000	2.01
130.000	1.98
140.000	1.94
150.000	1.92
160.000	1.89
170.000	1.86
180.000	1.84
190.000	1.81
200.000	1.79
210.000	1.77
220.000	1.75
230.000	1.72
240.000	1.70
250.000	1.68
260.000	1.66
270.000	1.64
280.000	1.62
290.000	1.60
300.000	1.58

270.000	-	1.64
280.000	-	1.62
290.000	-	1.60
300.000	-	1.58
310.000	-	1.56
320.000	-	1.55
330.000	-	1.53
340.000	-	1.51
350.000	-	1.49
360.000	-	1.47
370.000	-	1.45
380.000	-	1.44
390.000	-	1.42
400.000	-	1.40
410.000	-	1.38
420.000	-	1.36
430.000	-	1.35
440.000	-	1.33
450.000	-	1.32
460.000	-	1.30
470.000	-	1.29
480.000	-	1.27
490.000	-	1.26
500.000	-	1.24
510.000	-	1.23
520.000	-	1.22
530.000	-	1.20
540.000	-	1.19
550.000	-	1.18
560.000	-	1.16
570.000	-	1.15
580.000	-	1.14
590.000	-	1.13
600.000	-	1.12
610.000	-	1.11
620.000	-	1.10
630.000	-	1.09
640.000	-	1.08
650.000	-	1.07
660.000	-	1.06
670.000	-	1.06
680.000	-	1.05
690.000	-	1.04
700.000	-	1.03
710.000	-	1.03
720.000	-	1.02
730.000	-	1.02
740.000	-	1.01
750.000	-	1.01
760.000	-	1.00
770.000	-	1.00
780.000	-	1.00
790.000	-	0.99
800.000	-	0.99
810.000	-	0.99
820.000	-	0.99
830.000	-	0.98
840.000	-	0.98
850.000	-	0.98
860.000	-	0.98
870.000	-	0.97
880.000	-	0.97
890.000	-	0.96
900.000	-	0.96
910.000	-	0.96
920.000	-	0.96
930.000	-	0.96
940.000	-	0.95
950.000	-	0.95
960.000	-	0.95
970.000	-	0.95
980.000	-	0.95
990.000	-	0.95
1000.00	-	0.95
1030.00	-	0.95
1060.00	-	0.93
1090.00	-	0.93
1120.00	-	0.92
1150.00	-	0.90
1180.00	-	0.90

1090.00	-	0.93
1120.00	-	0.92
1150.00	-	0.90
1180.00	-	0.90
1210.00	-	0.89
1240.00	-	0.88
1270.00	-	0.88
1300.00	-	0.87
1330.00	-	0.87
1360.00	-	0.88
1390.00	-	0.88
1420.00	-	0.88
1450.00	-	0.89
1480.00	-	0.89
1510.00	-	0.90
1540.00	-	0.91
1570.00	-	0.91
1600.00	-	0.91
1630.00	-	0.91
1660.00	-	0.91
1690.00	-	0.91
1720.00	-	0.90
1750.00	-	0.89
1780.00	-	0.88
1810.00	-	0.87
1840.00	-	0.85
1870.00	-	0.83
1900.00	-	0.81
1930.00	-	0.79
1960.00	-	0.76
1990.00	-	0.74
2020.00	-	0.72
2050.00	-	0.70
2080.00	-	0.69
2110.00	-	0.68
2140.00	-	0.67
2170.00	-	0.67
2200.00	-	0.67
2230.00	-	0.68
2260.00	-	0.68
2290.00	-	0.69
2320.00	-	0.69
2350.00	-	0.70
2380.00	-	0.71
2410.00	-	0.71
2440.00	-	0.71
2470.00	-	0.72
2500.00	-	0.72
2530.00	-	0.72
2560.00	-	0.70
2590.00	-	0.70
2620.00	-	0.69
2650.00	-	0.69
2680.00	-	0.68
2710.00	-	0.68
2740.00	-	0.68
2770.00	-	0.68
2800.00	-	0.68
2830.00	-	0.69
2860.00	-	0.69
2890.00	-	0.70
2920.00	-	0.71
2950.00	-	0.72
2980.00	-	0.72
3010.00	-	0.73
3040.00	-	0.73
3070.00	-	0.73
3100.00	-	0.73
3130.00	-	0.73
3160.00	-	0.73
3190.00	-	0.72
3220.00	-	0.71
3250.00	-	0.69
3280.00	-	0.68
3310.00	-	0.67
3340.00	-	0.65
3370.00	-	0.64
3400.00	-	0.62
3430.00	-	0.61
3460.00	-	0.60

3370.00	-	0.64
3400.00	-	0.62
3430.00	-	0.61
3460.00	-	0.60
3490.00	-	0.59
3520.00	-	0.57
3550.00	-	0.56
3580.00	-	0.56
3610.00	-	0.55
3640.00	-	0.55
3670.00	-	0.55
3700.00	-	0.56
3730.00	-	0.56
3760.00	-	0.56
3790.00	-	0.57
3820.00	-	0.57
3850.00	-	0.57
3880.00	-	0.57
3910.00	-	0.58
3940.00	-	0.59
3970.00	-	0.59
4000.00	-	0.58
4030.00	-	0.58
4060.00	-	0.58
4090.00	-	0.57
4120.00	-	0.57
4150.00	-	0.56
4180.00	-	0.56
4210.00	-	0.55
4240.00	-	0.56
4270.00	-	0.56
4300.00	-	0.56
4330.00	-	0.56
4360.00	-	0.57
4390.00	-	0.58
4420.00	-	0.58
4450.00	-	0.59
4480.00	-	0.58
4510.00	-	0.58
4540.00	-	0.58
4570.00	-	0.58
4600.00	-	0.57
4630.00	-	0.57
4660.00	-	0.56
4690.00	-	0.55
4720.00	-	0.54
4750.00	-	0.52
4780.00	-	0.51
4810.00	-	0.49
4840.00	-	0.48
4870.00	-	0.46
4900.00	-	0.44
4930.00	-	0.43
4960.00	-	0.41
4990.00	-	0.41
5020.00	-	0.41
5050.00	-	0.40
5080.00	-	0.41
5110.00	-	0.42
5140.00	-	0.41
5170.00	-	0.40
5200.00	-	0.40
5230.00	-	0.41
5260.00	-	0.41
5290.00	-	0.41
5320.00	-	0.41
5350.00	-	0.41
5380.00	-	0.41
5410.00	-	0.41
5440.00	-	0.40
5470.00	-	0.40
5500.00	-	0.40
5530.00	-	0.39
5560.00	-	0.39
5590.00	-	0.39
5620.00	-	0.39
5650.00	-	0.39
5680.00	-	0.39
5710.00	-	0.40
5740.00	-	0.41
[illegible]	-	0.41

5680.00	-	0.39
5710.00	-	0.40
5740.00	-	0.41
5770.00	-	0.41
5800.00	-	0.41
5830.00	-	0.42
5860.00	-	0.42
5890.00	-	0.42
5920.00	-	0.42
5950.00	-	0.42
5980.00	-	0.42
6010.00	-	0.42
6040.00	-	0.42
6070.00	-	0.41
6100.00	-	0.40
6130.00	-	0.39
6160.00	-	0.38
6190.00	-	0.37
6220.00	-	0.36
6250.00	-	0.34
6280.00	-	0.33
6310.00	-	0.31
6340.00	-	0.30
6370.00	-	0.28
6400.00	-	0.27
6430.00	-	0.26
6460.00	-	0.26
6490.00	-	0.25
6520.00	-	0.25
6550.00	-	0.25
6580.00	-	0.26
6610.00	-	0.26
6640.00	-	0.27
6670.00	-	0.28
6700.00	-	0.28
6730.00	-	0.29
6760.00	-	0.29
6790.00	-	0.29
6820.00	-	0.29
6850.00	-	0.29
6880.00	-	0.29
6910.00	-	0.29
6940.00	-	0.30
6970.00	-	0.30
7000.00	-	0.30
7030.00	-	0.31
7060.00	-	0.31
7090.00	-	0.31
7120.00	-	0.32
7150.00	-	0.33
7180.00	-	0.33
7210.00	-	0.34
7240.00	-	0.35
7270.00	-	0.35
7300.00	-	0.35
7330.00	-	0.35
7360.00	-	0.35
7390.00	-	0.35
7420.00	-	0.36
7450.00	-	0.35
7480.00	-	0.35
7510.00	-	0.34
7540.00	-	0.34
7570.00	-	0.34
7600.00	-	0.33
7630.00	-	0.32
7660.00	-	0.31
7690.00	-	0.31
7720.00	-	0.30
7750.00	-	0.29
7780.00	-	0.27
7810.00	-	0.26
7840.00	-	0.26
7870.00	-	0.26
7900.00	-	0.25
7930.00	-	0.25
7960.00	-	0.25
7990.00	-	0.25
8020.00	-	0.25

7930.00	-	0.25
7960.00	-	0.25
7990.00	-	0.25
8020.00	-	0.26
8050.00	-	0.26
8080.00	-	0.27
8110.00	-	0.28
8140.00	-	0.28
8170.00	-	0.29
8200.00	-	0.30
8230.00	-	0.31
8260.00	-	0.31
8290.00	-	0.32
8320.00	-	0.32
8350.00	-	0.33
8380.00	-	0.33
8410.00	-	0.34
8440.00	-	0.35
8470.00	-	0.36
8500.00	-	0.36
8530.00	-	0.37
8560.00	-	0.38
8590.00	-	0.38
8620.00	-	0.39
8650.00	-	0.40
8680.00	-	0.41
8710.00	-	0.41
8740.00	-	0.41
8770.00	-	0.40
8800.00	-	0.39
8830.00	-	0.39
8860.00	-	0.39
8890.00	-	0.38
8920.00	-	0.38
8950.00	-	0.37
8980.00	-	0.36
9010.00	-	0.35
9040.00	-	0.35
9070.00	-	0.34
9100.00	-	0.33
9130.00	-	0.32
9160.00	-	0.31
9190.00	-	0.31
9220.00	-	0.30
9250.00	-	0.28
9280.00	-	0.27
9310.00	-	0.27
9340.00	-	0.26
9370.00	-	0.25
9400.00	-	0.25
9430.00	-	0.25
9460.00	-	0.25
9490.00	-	0.25
9520.00	-	0.26
9550.00	-	0.26
9580.00	-	0.26
9610.00	-	0.26
9640.00	-	0.27
9670.00	-	0.26
9700.00	-	0.26
9730.00	-	0.26
9760.00	-	0.26
9790.00	-	0.27
9820.00	-	0.27
9850.00	-	0.28
9880.00	-	0.29
9910.00	-	0.29
9940.00	-	0.30
9970.00	-	0.30
10000.0	-	0.31
10030.0	-	0.31
10060.0	-	0.31
10090.0	-	0.32
10120.0	-	0.32
10150.0	-	0.33
10180.0	-	0.32
10210.0	-	0.31
10240.0	-	0.31
10270.0	-	0.31
10300.0	-	0.31

10240.0	-	0.31
10270.0	-	0.31
10300.0	-	0.31
10330.0	-	0.30
10360.0	-	0.30
10390.0	-	0.29
10420.0	-	0.28
10450.0	-	0.27
10480.0	-	0.27
10510.0	-	0.26
10540.0	-	0.26
10570.0	-	0.25
10600.0	-	0.25
10630.0	-	0.24
10660.0	-	0.22
10690.0	-	0.21
10720.0	-	0.20
10750.0	-	0.19
10780.0	-	0.19
10810.0	-	0.18
10840.0	-	0.18
10870.0	-	0.18
10900.0	-	0.18
10930.0	-	0.18
10960.0	-	0.19
10990.0	-	0.19
11020.0	-	0.19
11050.0	-	0.20
11080.0	-	0.20
11110.0	-	0.20
11140.0	-	0.21
11170.0	-	0.21
11200.0	-	0.21
11230.0	-	0.22
11260.0	-	0.22
11290.0	-	0.23
11320.0	-	0.24
11350.0	-	0.25
11380.0	-	0.25
11410.0	-	0.26
11440.0	-	0.27
11470.0	-	0.28
11500.0	-	0.29
11530.0	-	0.30
11560.0	-	0.31
11590.0	-	0.31
11620.0	-	0.31
11650.0	-	0.31
11680.0	-	0.31
11710.0	-	0.30
11740.0	-	0.30
11770.0	-	0.30
11800.0	-	0.29
11830.0	-	0.28
11860.0	-	0.27
11890.0	-	0.27
11920.0	-	0.27
11950.0	-	0.26
11980.0	-	0.25
12010.0	-	0.25
12040.0	-	0.25
12070.0	-	0.24
12100.0	-	0.23
12130.0	-	0.23
12160.0	-	0.23
12190.0	-	0.23
12220.0	-	0.24
12250.0	-	0.24
12280.0	-	0.24
12310.0	-	0.24
12340.0	-	0.25
12370.0	-	0.25
12400.0	-	0.26
12430.0	-	0.26
12460.0	-	0.26
12490.0	-	0.26
12520.0	-	0.26
12550.0	-	0.26
12580.0	-	0.26
12610.0	-	0.26
[illegible]	-	0.26

12550.0	0.26
12580.0	0.26
12610.0	0.26
12640.0	0.26
12670.0	0.27
12700.0	0.27
12730.0	0.28
12760.0	0.29
12790.0	0.31
12820.0	0.31
12850.0	0.33
12880.0	0.34
12910.0	0.36
12940.0	0.38
12970.0	0.39
13000.0	0.39
13030.0	0.40
13060.0	0.41
13090.0	0.41
13120.0	0.40
13150.0	0.40
13180.0	0.39
13210.0	0.39
13240.0	0.38
13270.0	0.37
13300.0	0.36
13330.0	0.35
13360.0	0.35
13390.0	0.34
13420.0	0.33
13450.0	0.32
13480.0	0.32
13510.0	0.32
13540.0	0.31
13570.0	0.31
13600.0	0.31
13630.0	0.31
13660.0	0.31
13690.0	0.31
13720.0	0.32
13750.0	0.32
13780.0	0.32
13810.0	0.33
13840.0	0.33
13870.0	0.34
13900.0	0.34
13930.0	0.33
13960.0	0.33
13990.0	0.33
14020.0	0.33
14050.0	0.32
14080.0	0.32
14110.0	0.32
14140.0	0.33
14170.0	0.34
14200.0	0.35
14230.0	0.36
14260.0	0.37
14290.0	0.38
14320.0	0.39
14350.0	0.40
14380.0	0.42
14410.0	0.43
14440.0	0.43
14470.0	0.44
14500.0	0.44
14530.0	0.43
14560.0	0.43
14590.0	0.42
14620.0	0.42
14650.0	0.40
14680.0	0.39
14710.0	0.38
14740.0	0.37
14770.0	0.35
14800.0	0.33
14830.0	0.32
14860.0	0.31
14890.0	0.29
14920.0	0.28

14830.0	-	0.32
14860.0	-	0.31
14890.0	-	0.29
14920.0	-	0.28
14950.0	-	0.26
14980.0	-	0.26
15010.0	-	0.25
15040.0	-	0.25
15070.0	-	0.25
15100.0	-	0.25
15130.0	-	0.26
15160.0	-	0.26
15190.0	-	0.27
15220.0	-	0.28
15250.0	-	0.28
15280.0	-	0.29
15310.0	-	0.29
15340.0	-	0.28
15370.0	-	0.28
15400.0	-	0.27
15430.0	-	0.26
15460.0	-	0.25
15490.0	-	0.26
15520.0	-	0.25
15550.0	-	0.25
15580.0	-	0.25
15610.0	-	0.25
15640.0	-	0.25
15670.0	-	0.25
15700.0	-	0.26
15730.0	-	0.26
15760.0	-	0.27
15790.0	-	0.28
15820.0	-	0.29
15850.0	-	0.30
15880.0	-	0.31
15910.0	-	0.32
15940.0	-	0.33
15970.0	-	0.33
16000.0	-	0.32
16030.0	-	0.32
16060.0	-	0.31
16090.0	-	0.30

END

Appendix D

Barograph Record

NASA Well P-T
Barometric Values

Clock Time	Elapse Time	Barometric Correction	Clock Time	Elapse Time	Barometric Correction
6-4-90 0800	-60	+.02	1100	1540	-0.11
0900	0	+.02	1200	1620	-0.13
1000	60	+.01	1300	1680	-0.16
1100	120	0.0	1400	1740	-0.17
1200	180	-0.04	1500	1800	-0.20
1300	240	-0.05	1600	1860	-0.22
1400	300	-0.09	1700	1920	-0.23
1500	360	-0.11	1800	1980	-0.24
1600	420	-0.14	1900	2040	-0.23
1700	480	-0.16	2000	2100	-0.22
1800	540	-0.18	2100	2160	-0.19
1900	600	-0.18	2200	2220	-0.15
2000	660	-0.16	2300	2280 2260	-0.14
2100	720	-0.15	2400	2320	-0.14
2200	780	-0.14	6-6-90 0100	2380	-0.14
2300	840	-0.13	0200	2440	-0.13
2400	900	-0.12	0300	2500	-0.13
6-5-90 0100	960	-0.15	0400	2560	-0.12
0200	1020	-0.15	0500	2620	-0.11
0300	1080	-0.16	0600	2680	-0.10
0400	1140	-0.15	0700	2740	-0.09
0500	1200	-0.12	0800	2800	-0.08
0600	1260	-0.10	0900	2860	-0.07
0700	1320	-0.09	1000	2920	-0.08
0800	1380	-0.09	1100	2980	-0.10
0900	1440	-0.09	1200	3040	-0.12
1000	1500	-0.10	1300	3100	-0.15

Barometric Values

Clock Time	Elapse Time	Barometric Correction	Clock Time	Elapse Time	Barometric Correction
1400	3160	-0.16	1800	4840	-0.19
1500	3220	-0.19	1900	4900	-0.17
1600	3280	-0.21	2000	4960	-0.15
1700	3340	-0.21	2100	5020	-0.12
1800	3400	-0.22	2200	5080	-0.10
1900	3460	-0.21	2300	5140	-0.09
2000	3520	-0.20	2400	5200	-0.09
2100	3580	-0.17	6-8-90 0100	5260	-0.09
2200	3640	-0.15	0200	5320	-0.10
2300	3700	-0.13	0300	5380	-0.11
2400	3760	-0.12	0400	5440	-0.10
6-7-90 0100	3820	-0.12	0500	5500	-0.10
0200	3880	-0.12	0600	5560	-0.10
0300	3940	-0.11	0700	5620	-0.08
0400	4000	-0.10	0745	5625 End of Pumping	
0500	4060	-0.08	0800		-0.07
0600	4120	-0.08	0900		-0.06
0700	4180	-0.07	1000		-0.07
0800	4240	-0.07	1100		-0.09
0900	4300	-0.07	1200		-0.11
1000	4360	-0.08	1300		-0.15
1100	4420	-0.08	1400		-0.16
1200	4480	-0.10	1500		-0.19
1300	4540	-0.13	1600		-0.20
1400	4600	-0.14	1700		-0.21
1500	4660	-0.15	1800		-0.21
1600	4720	-0.17	1900		-0.21
1700	4780	-0.18	2000		-0.20
			2100		-0.18

Barometric Values

Clock Time	Elapse Time	Barometric Correction	Clock Time	Elapse Time	Barometric Correction
2200		-0.16	0200	-0.06	
2300		-0.16	0300	-0.05	
2400		-0.14	0400	-0.05	
6-9-90 0100		-0.13	0500	-0.04	
0200		-0.12	0600	-0.03	
0300		-0.11	0700	0.00	
0400		-0.11	0800	+0.01	
0500		-0.10	0900	0.00	
0600		-0.06	1000	0.00	
0700		-0.05	1100	-0.02	
0800		-0.04	1200	-0.02	
0900		-0.03	1300	-0.05	
1000		-0.03	1400	-0.07	
1100		-0.05	1500	-0.09	
1200		-0.05	1600	-0.09	
1300		-0.05	1700	-0.09	
1400		-0.08	1800	-0.10	
1500		-0.10	1900	-0.09	
1600		-0.13	2000	-0.07	
1700		-0.15	2100	-0.06	
1800		-0.16	2200	-0.05	
1900		-0.15	2300	-0.04	
2000		-0.13	2400	-0.05	
2100		-0.10	6/11/90 0100	-0.03	
2200		-0.08	0200	-0.03	
2300		-0.07	0300	-0.02	
2400		-0.05	0400	-0.02	
6-10/90 0100		-0.05	0500	-0.02	

Barometric Values

Clock Time	Elapse Time	Barometric Correction	Clock Time	Elapse Time	Barometric Correction
6-11-90 cont. 0600		-0.01	1000		-0.09
0700		0.00	1100		-0.10
0800		0.00 End 6 Chart	1200		-0.11
0900	10080	0.00	1300		-0.14
1000		0.00	1400		-0.16
1100		0.00	1500		-0.18
1200		-0.04	1600		-0.20
1300		-0.06	1700		-0.23
1400		-0.08	1800		-0.24
1500		-0.09	1900		-0.24
1600		-0.10	2000		-0.23
1700		-0.10	2100		-0.22
1800		-0.11	2200		-0.20
1900		-0.10	2300		-0.18
2000		-0.10	2400		-0.17
2100		-0.10	6-13-90 0100		-0.17
2200		-0.10	0200		-0.17
2300		-0.10	0300		-0.17
2400		-0.10	0400		-0.16
6-12-90 0100		-0.10	0500		-0.15
0200		-0.10	0600		-0.13
0300		-0.11	0700		-0.12
0400		-0.11	0800		-0.10
0500		-0.10	0900		-0.10
0600		-0.10	1000		-0.11
0700		-0.09	1100		-0.12
0800		-0.08	1200		-0.13
0900		-0.08	1200		-0.16

Barometric Values

Clock Time	Elapse Time	Barometric Correction	Clock Time	Elapse Time	Barometric Correction
6-13-90 1400		-0.18	1800		-0.21
1500		-0.20	1900		-0.20
1600		-0.21	2000		-0.20
1700		-0.23	2100		-0.18
1800		-0.23	2200		-0.16
1900		-0.22	2300		-0.15
2000		-0.21	2400		-0.14
2100		-0.19	6-15-90 0100		-0.15
2200		-0.16	0200		-0.15
2300		-0.14	0300		-0.15
2400		-0.13	0400		-0.14
6-14-90 0100		-0.12	0500		-0.13
0200		-0.11	0600		-0.12
0300		-0.10	0700		-0.11
0400		-0.09	0800		-0.10
0500		-0.08	0900		-0.10
0600		-0.06	1000		-0.11
0700		-0.04	1100		-0.12
0800		-0.03	1200		-0.12
0900		-0.03	1300		-0.17
1000		-0.06	1400		-0.17
1100		-0.08	1500		-0.19
1200		-0.09	1600		-0.21
1300		-0.13	1700		-0.23
1400		-0.14	1800		-0.25
1500		-0.16	1900		-0.26
1600		-0.18	2000		-0.25
1700		-0.19	2100		-0.24

Barometric Values

Clock Time	Elapse Time	Barometric Correction
0600		-0.01
0700		0.00
0800		0.00 End of chart
0900		
1000		
1100		
1200		
1300		
1400		
1500		
1600		
1700		
1800		
1900		
2000		
2100		
6-15-90 2200	cont.	-0.22
2300		-0.20
2400		-0.19
6-16-90 0100		-0.19
0200		-0.18
0300		-0.18
0400		-0.17
0500		-0.15
0600		-0.13
0700		-0.12
0800		-0.11
0900		-0.11

Clock Time	Elapse Time	Barometric Correction
6-16-90 cont 1000		-0.11
1100		-0.12
1200		-0.13
1300		-0.16
1400		-0.17
1500		-0.19
1600		-0.20
1700		-0.21
1800		-0.21
1900		-0.20
2000		-0.19
2100		-0.17
2200		-0.13
2300		-0.12
2400		-0.12
6-17-90 0100		-0.12
0200		-0.12
0300		-0.12
0400		-0.10
0500		-0.09
0600		-0.06
0700		-0.04
0800		-0.03
0900		-0.02
1000		-0.03
1100		-0.05
1200		-0.08
1300		

Appendix E

Theis Drawdown Analysis

Theis: Pumping Data Analyses - Piezometers
(Reference: Lohman, 1983, 4th Printing)

Governing Equations:

$$T = \frac{Q}{4 \pi s} W(u)$$

$$u = \frac{r^2 S}{4 T t}$$

$$S = \frac{4 T t u}{r^2}$$

Q = 388 gpm = 0.865 cfs

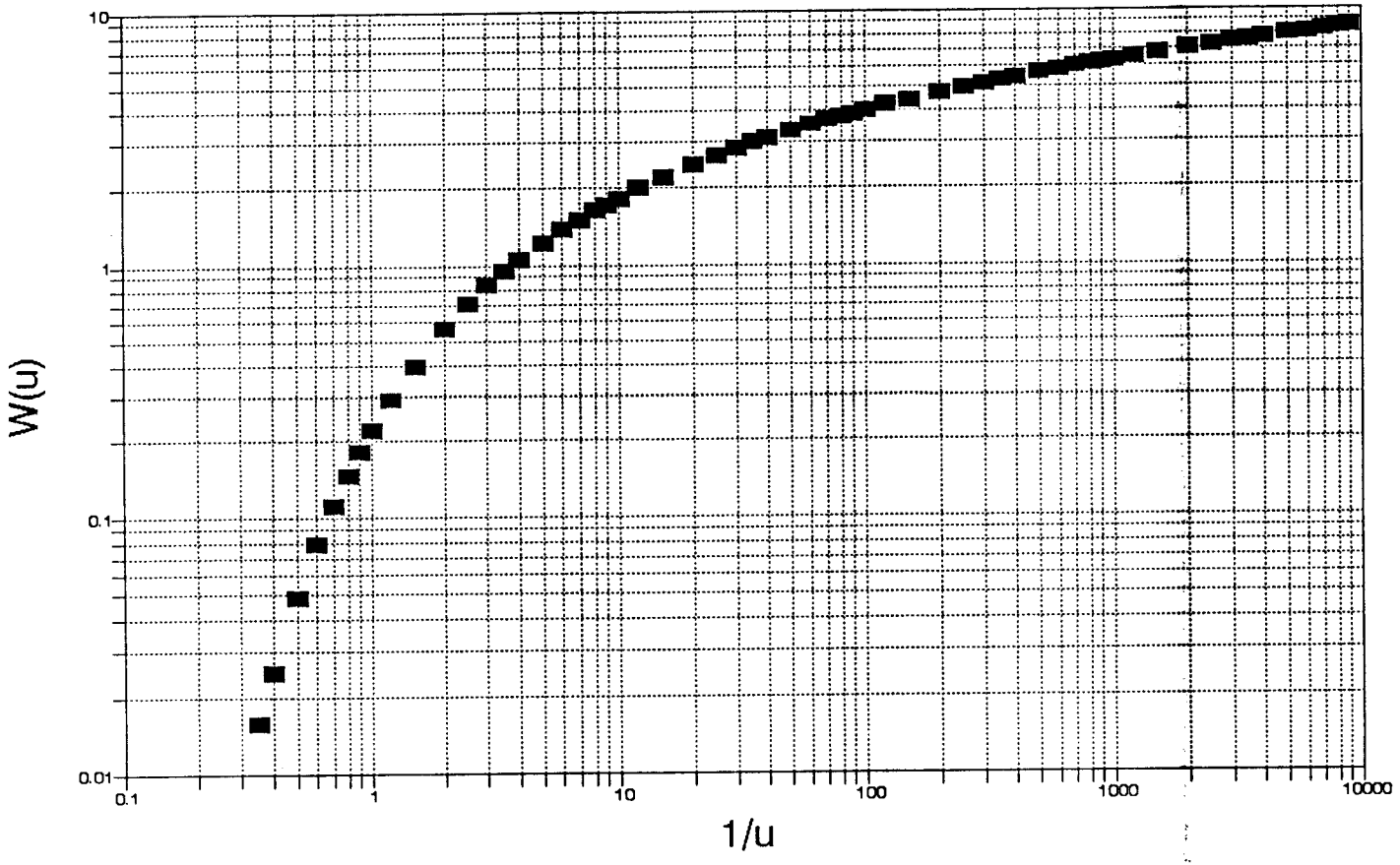
Match Points:

	PT-PZ-1	PT-PZ-2	PT-PZ-3	PT-PZ-4
W(u)	1	10	10	1
1/u	1	10	10	1
u	1	0.1	0.1	1
s (ft)	0.40	3.2	3.75	0.24
t (sec)	51	26.4	13.8	20.4
r (ft)	201	144	94	497
	---	---	---	---
T (ft^2/s)	0.172	0.215	0.184	0.287
S	8.68×10^{-4}	1.09×10^{-4}	1.15×10^{-4}	9.48×10^{-5}

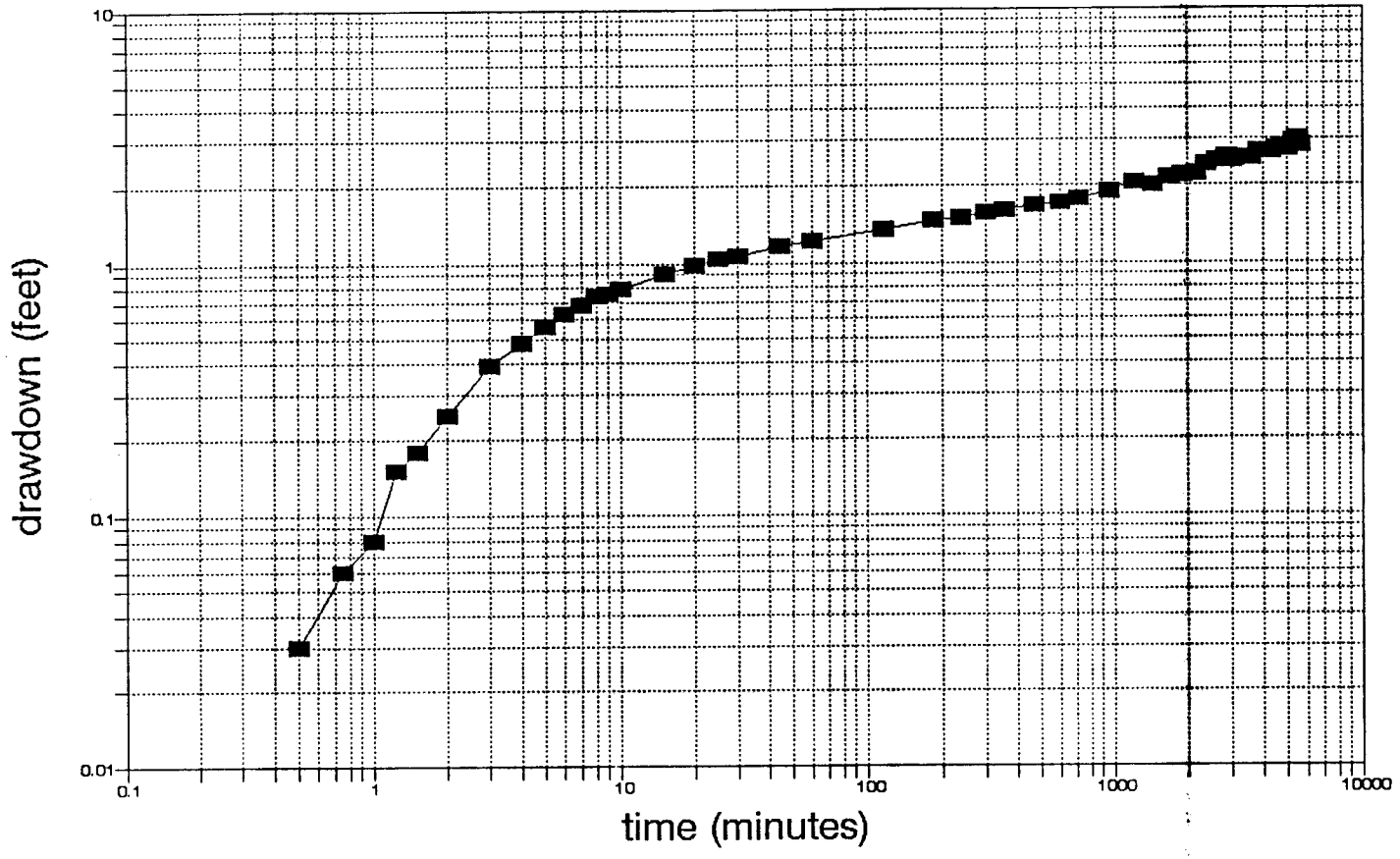
T_{ave} = 0.215 ft^2/s S_{ave} = 2.97 x 10^{-4}

Theis Type Curve

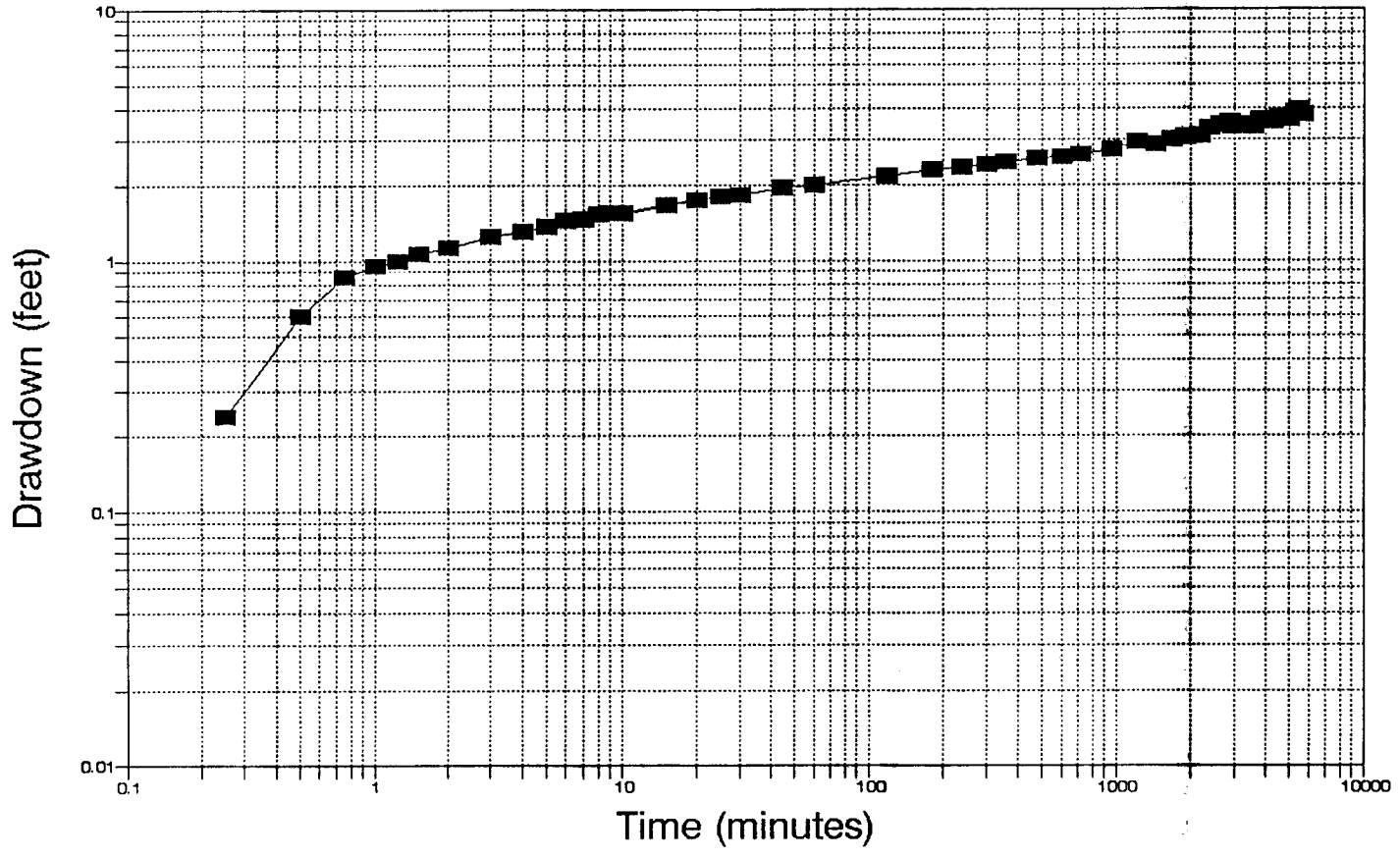
W(u) vs. 1/u



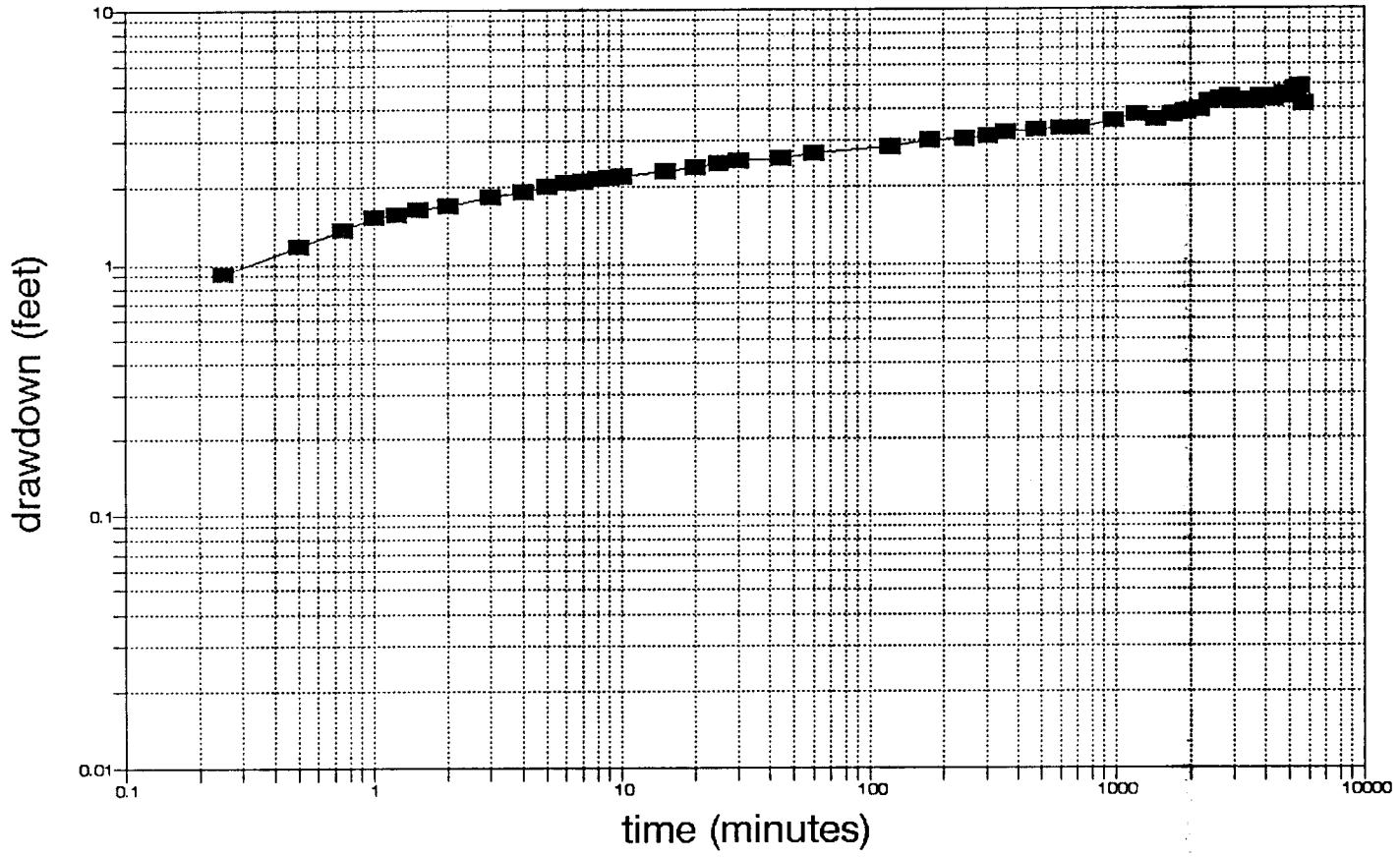
PZ-1
Pumping Data



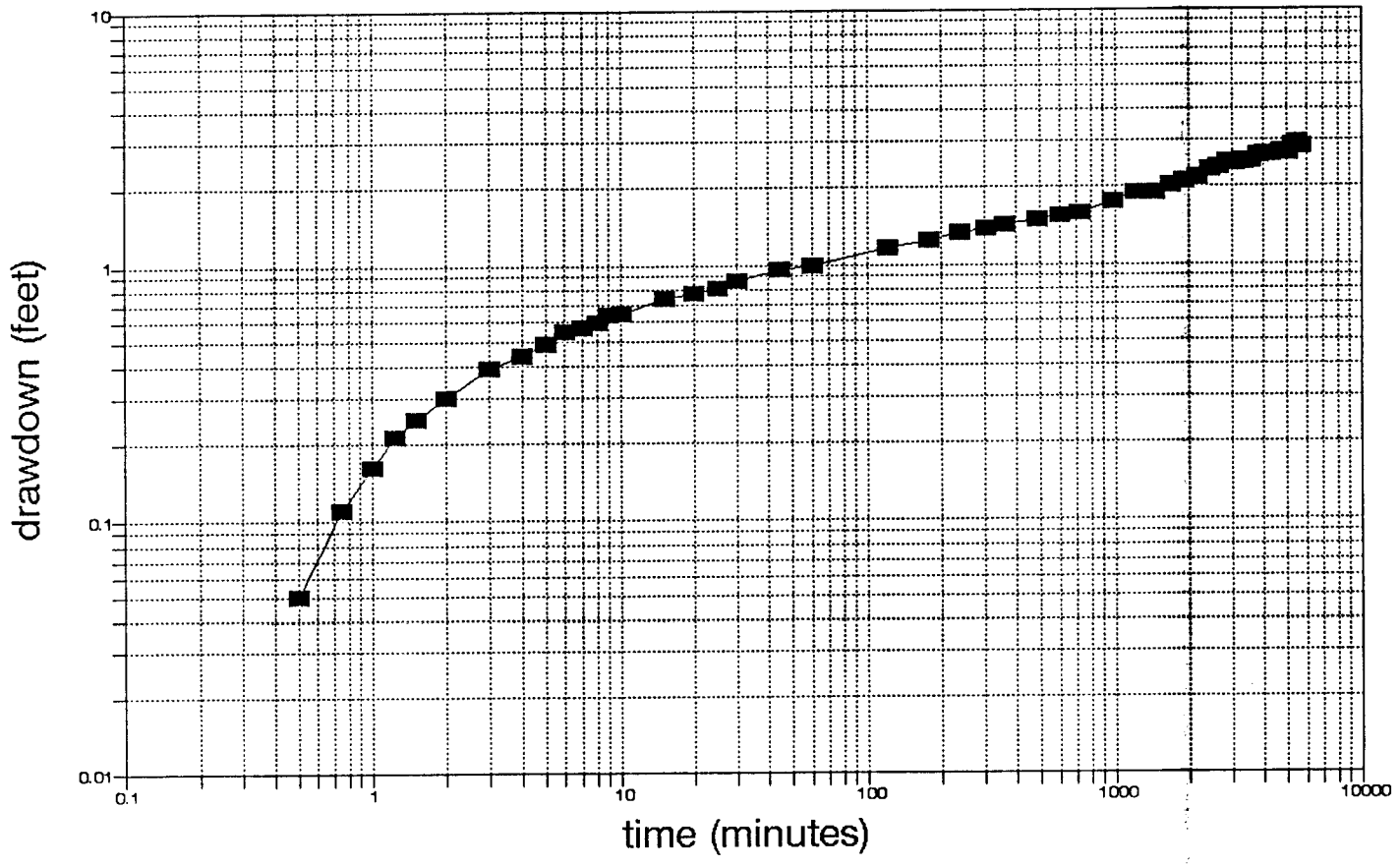
PZ-2
Pumping Data



PZ-3
Pumping Data

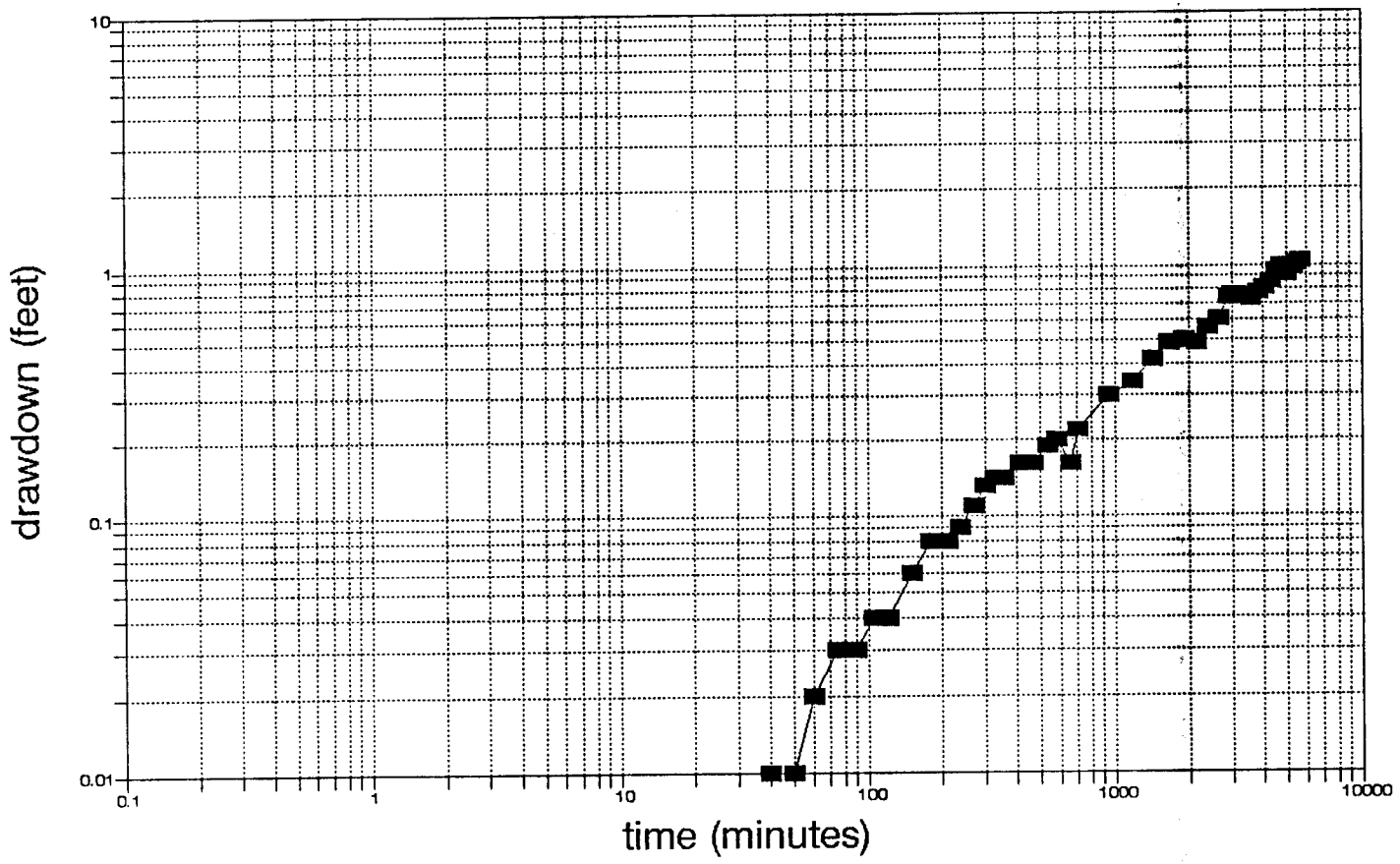


PZ-4
Pumping Data



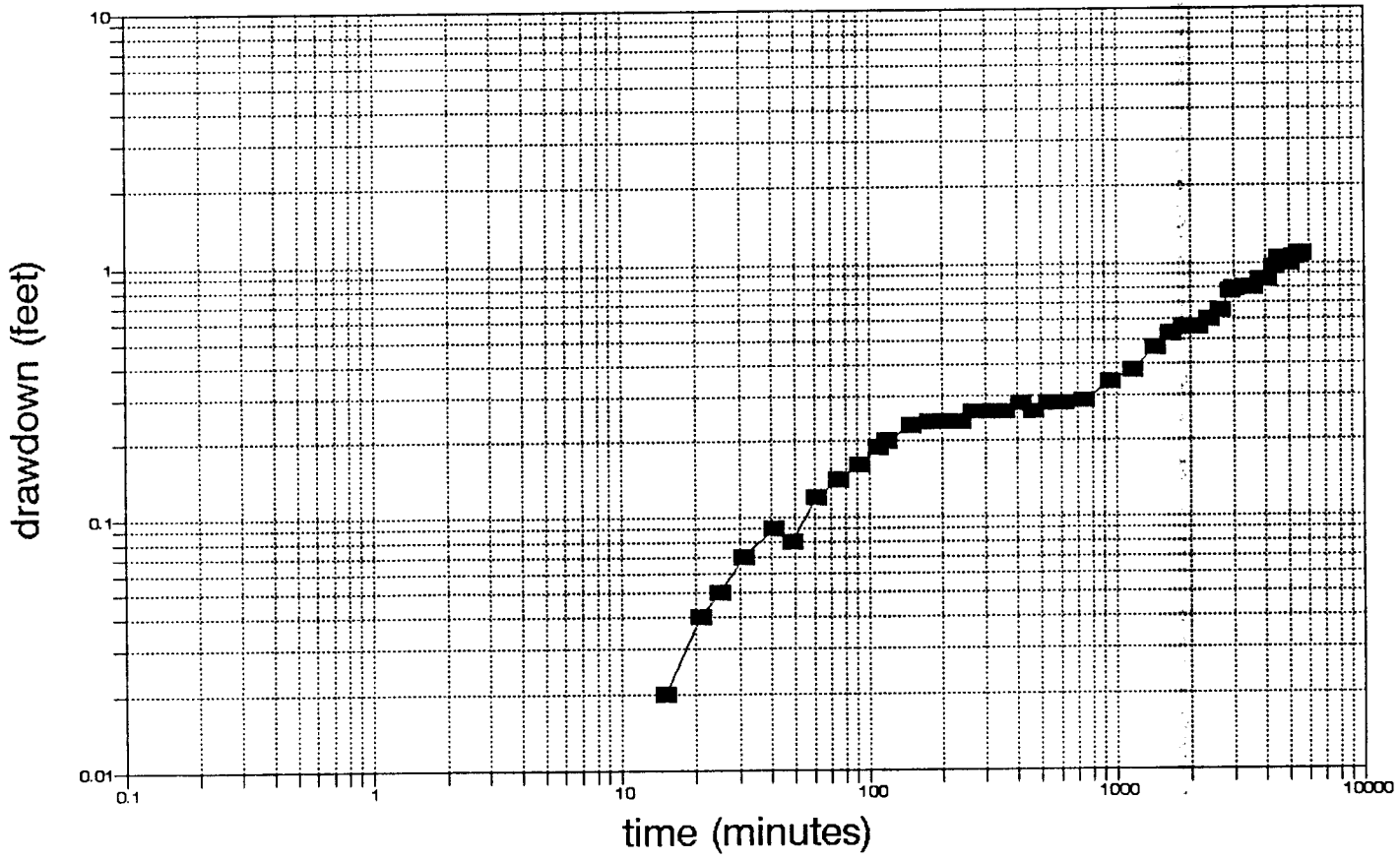
BLM-17-493

Pumping Data



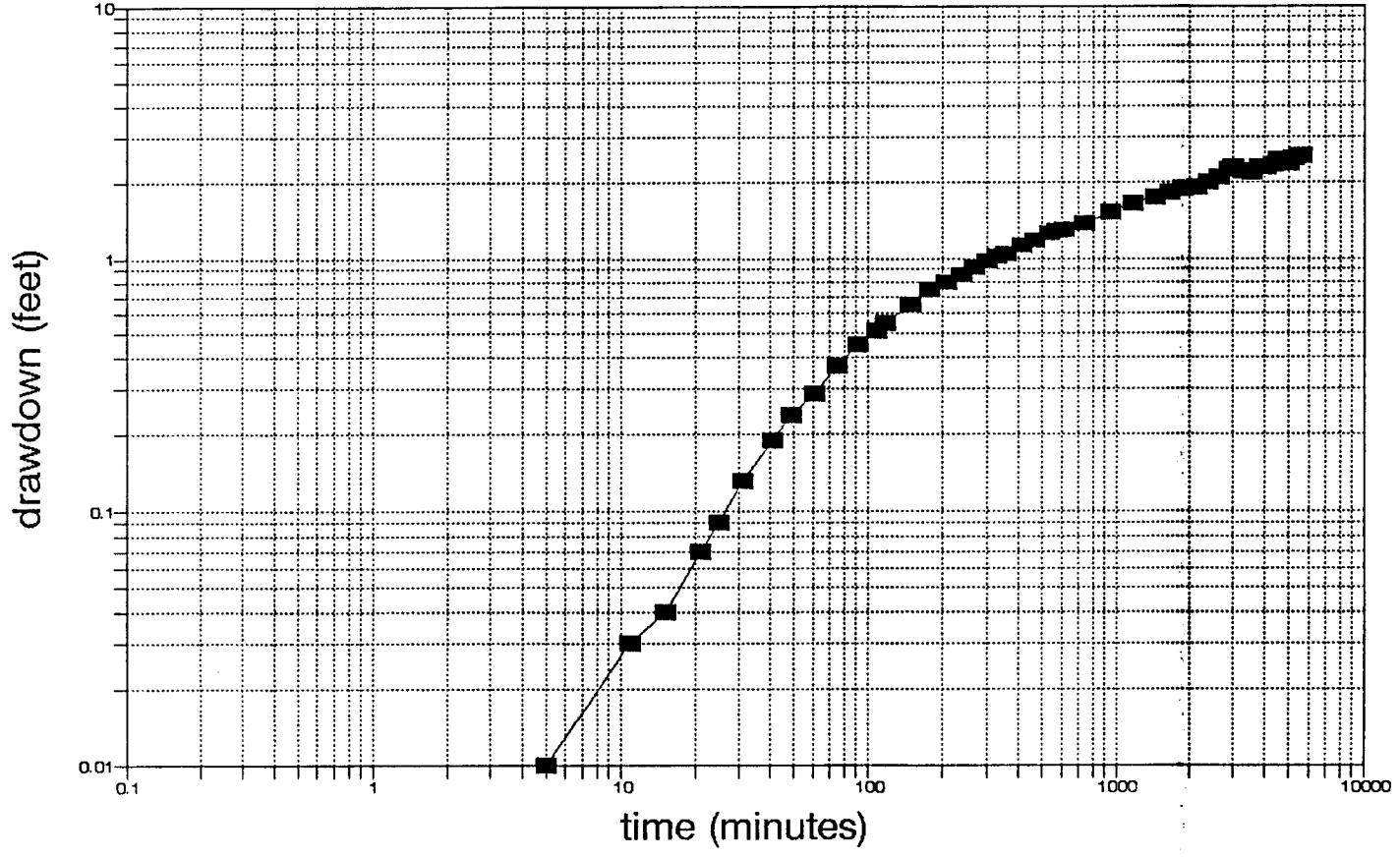
BLM-2-482

Pumping Data

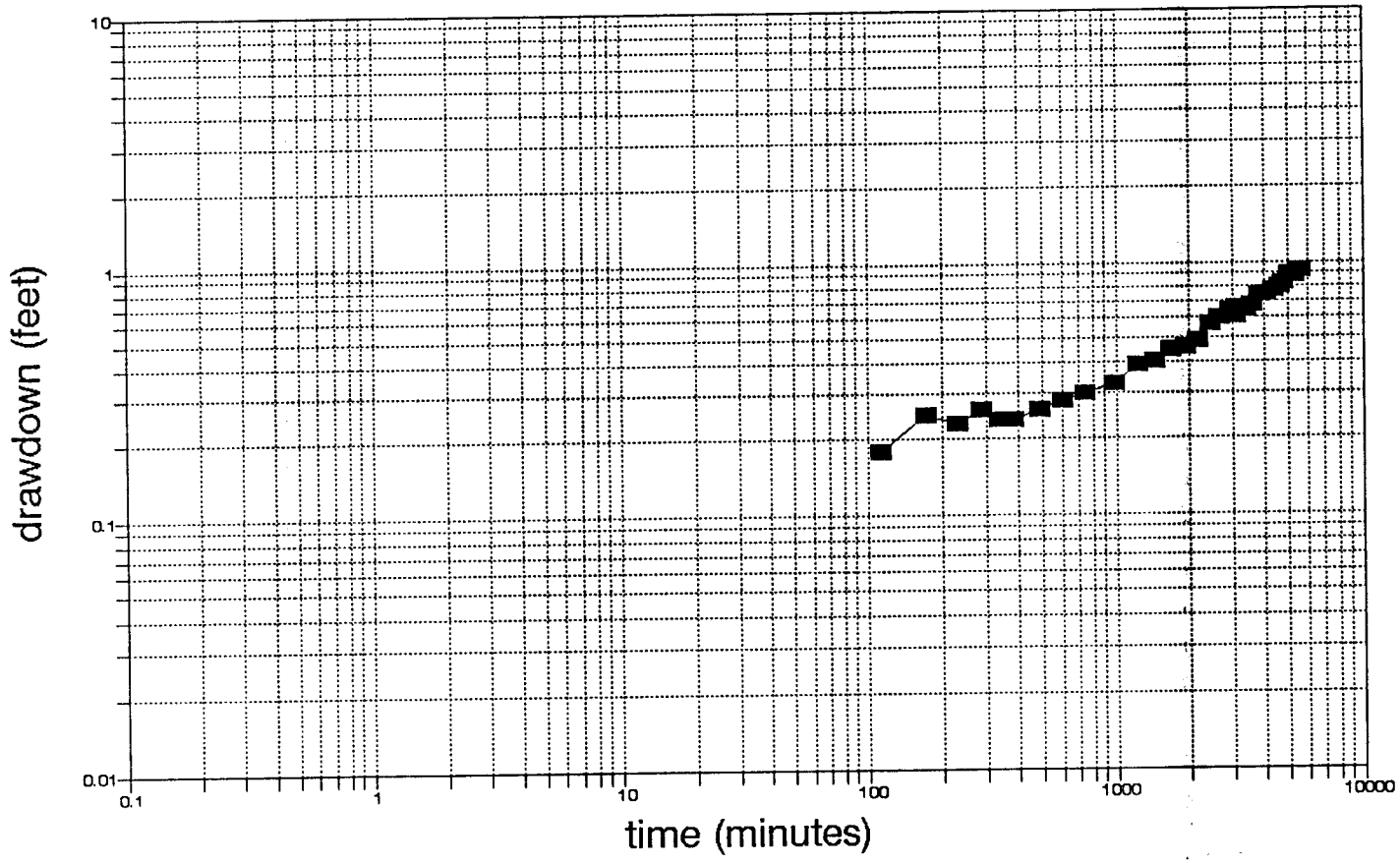


BLM-2-630

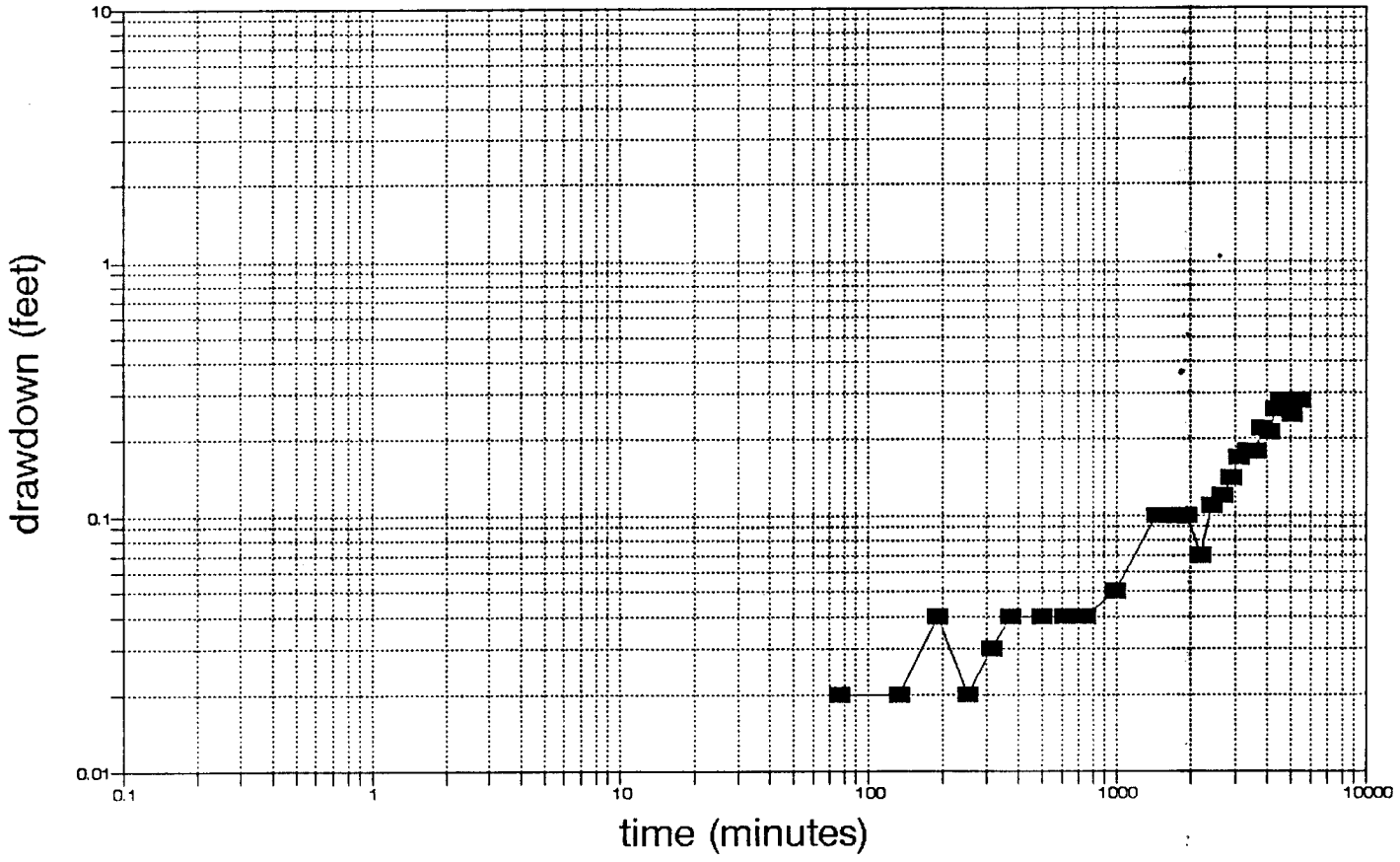
Pumping Data



PL-1-486
Pumping Data

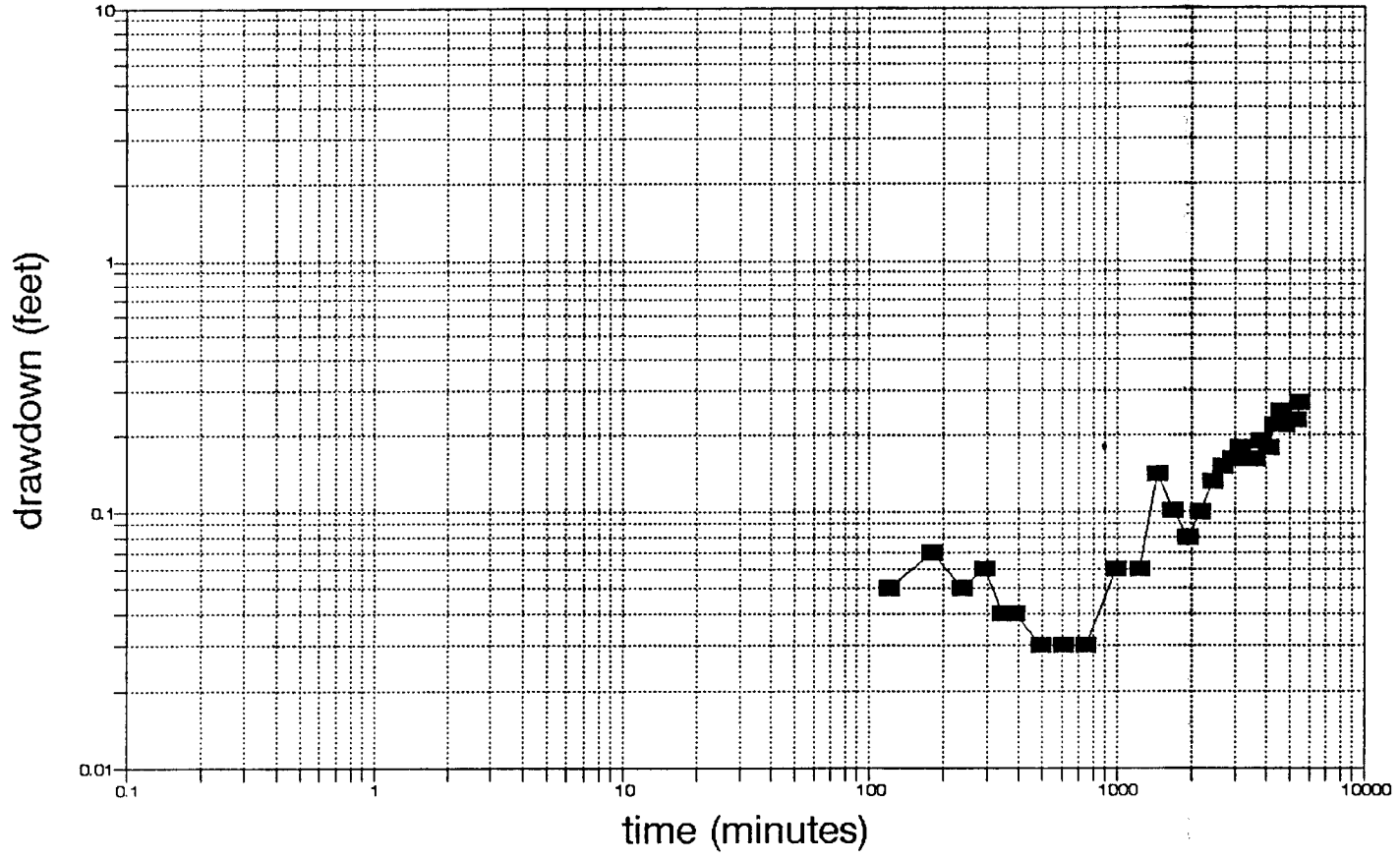


ST-1-473
Pumping Data

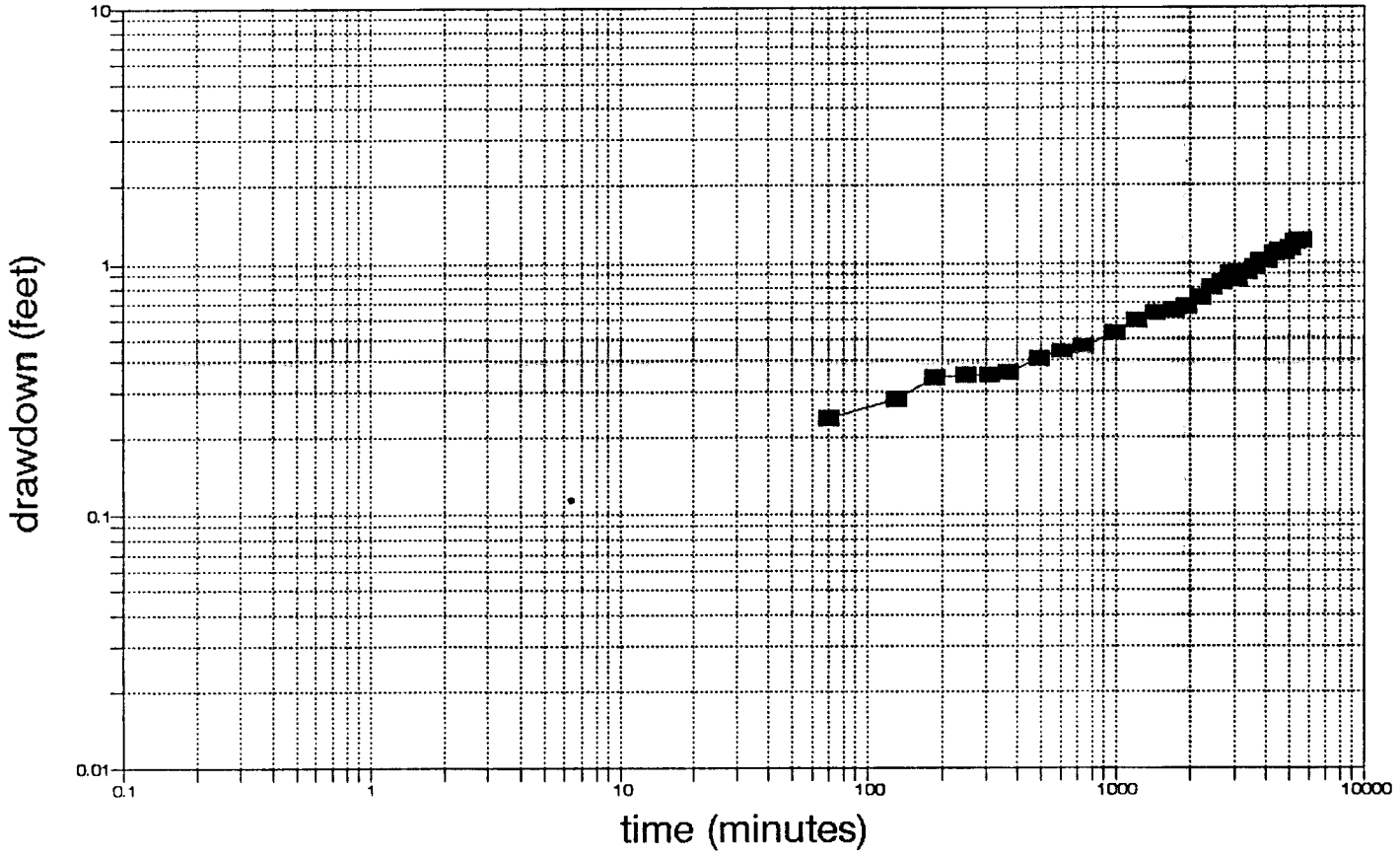


PL-3-453

Pumping Data



PL-2-504
Pumping Data



Appendix F

Theis Recovery Analysis

Theis Recovery Analyses

(Residual drawdown vs. time)

Governing Equation: $T = \frac{2.3\ Q}{4\ \pi\ s_{lc}}$

Q = 388 gpm = 0.865 cfs

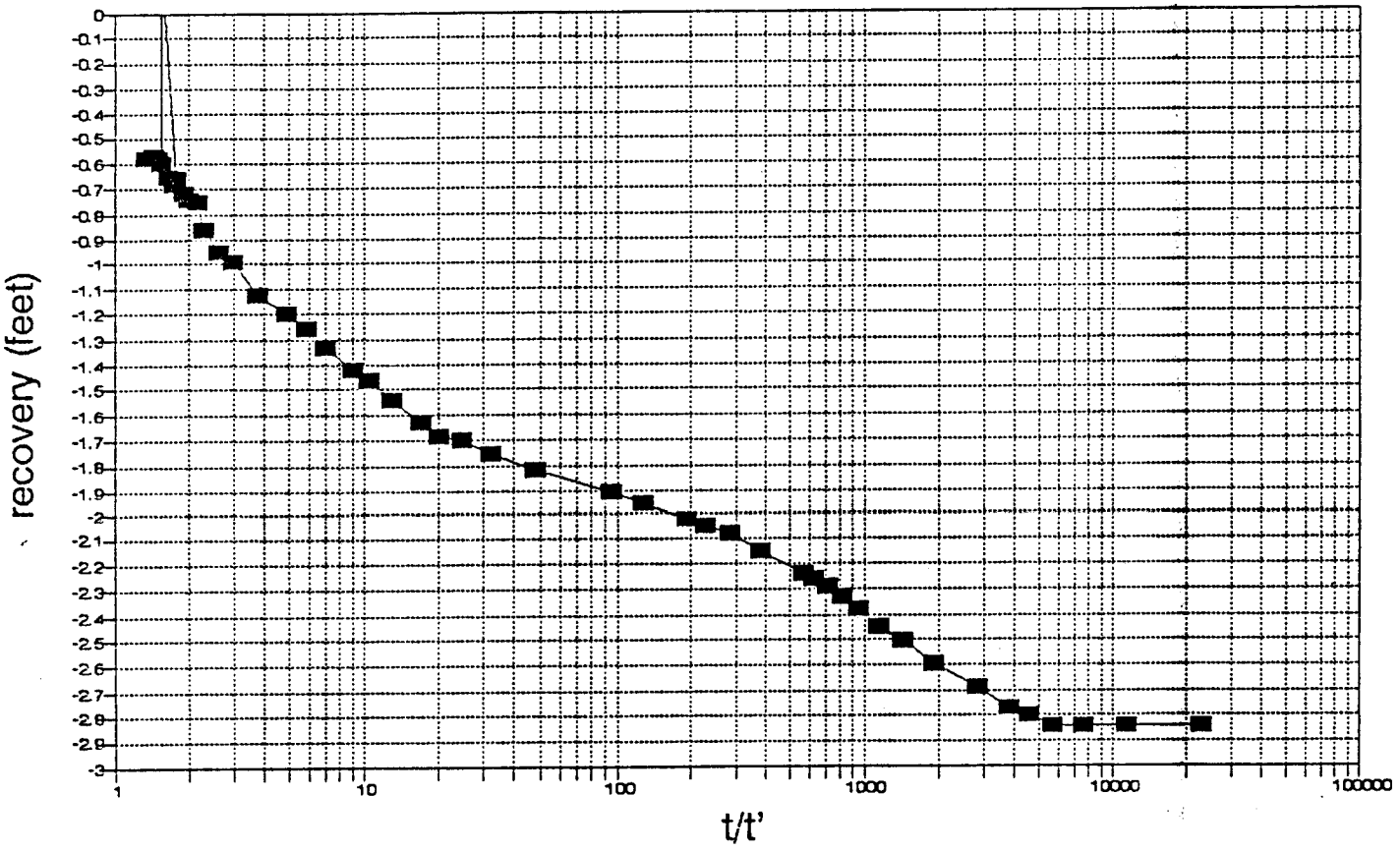
Curve Analyses:

	PT-PZ-1	PT-PZ-2	PT-PZ-3	PT-PZ-4
s_{lc}	0.83	0.93	1.02	0.88
T (ft^2/s)	0.191	0.170	0.155	0.180

T_{ave} = 0.174 ft^2/s

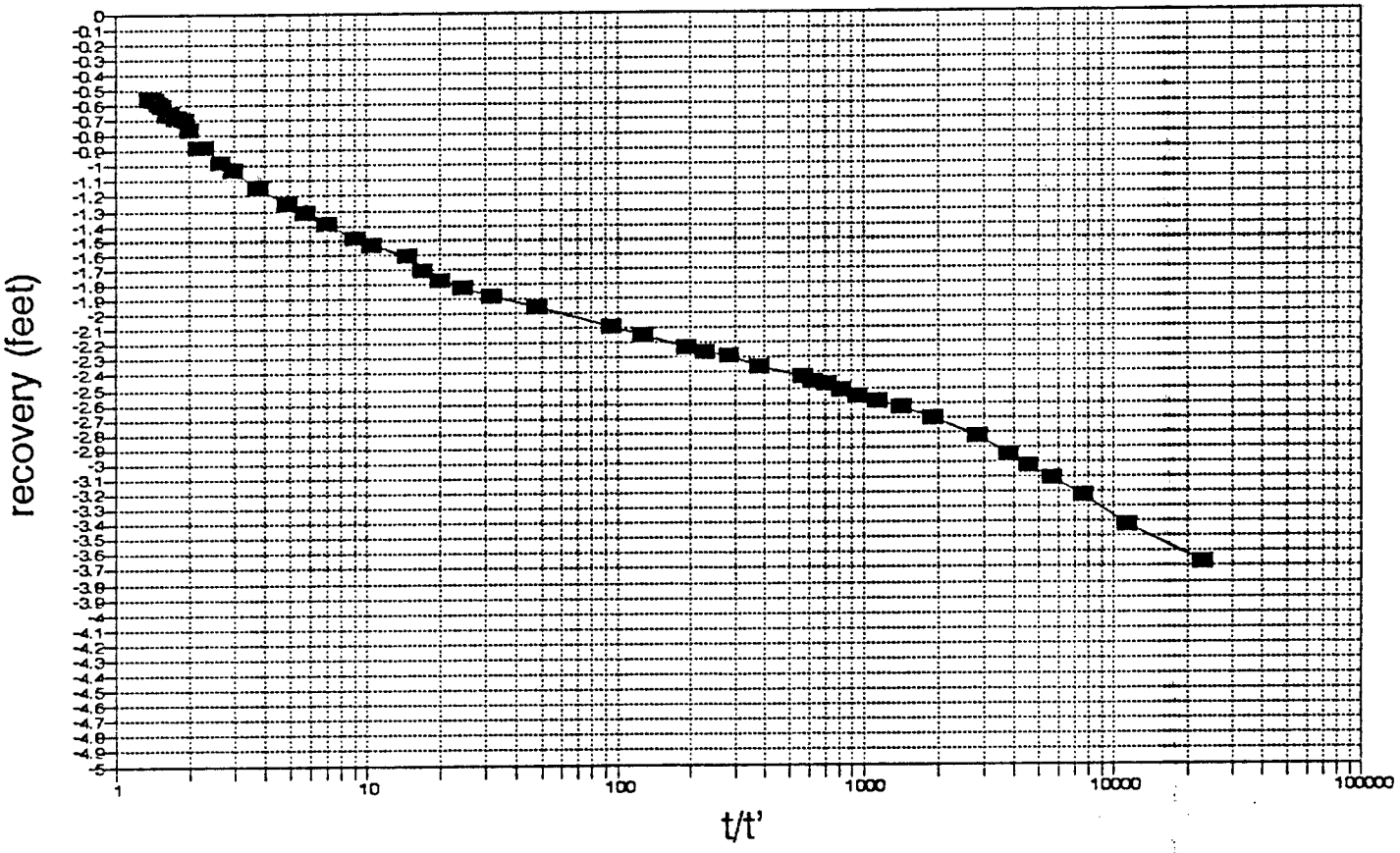
PT-PZ-1

Theis Recovery Plot



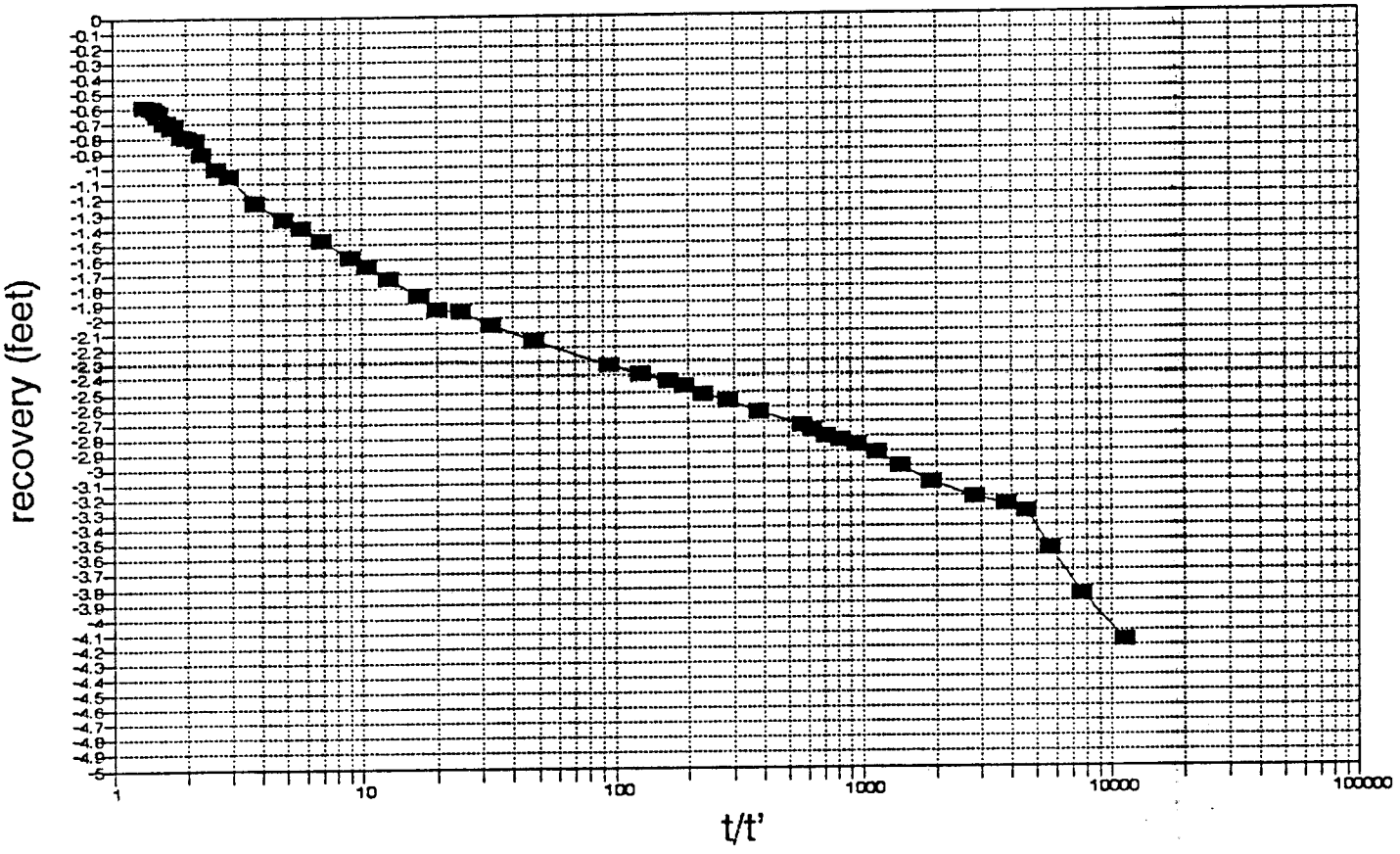
PT-PZ-2

Theis Recovery Plot



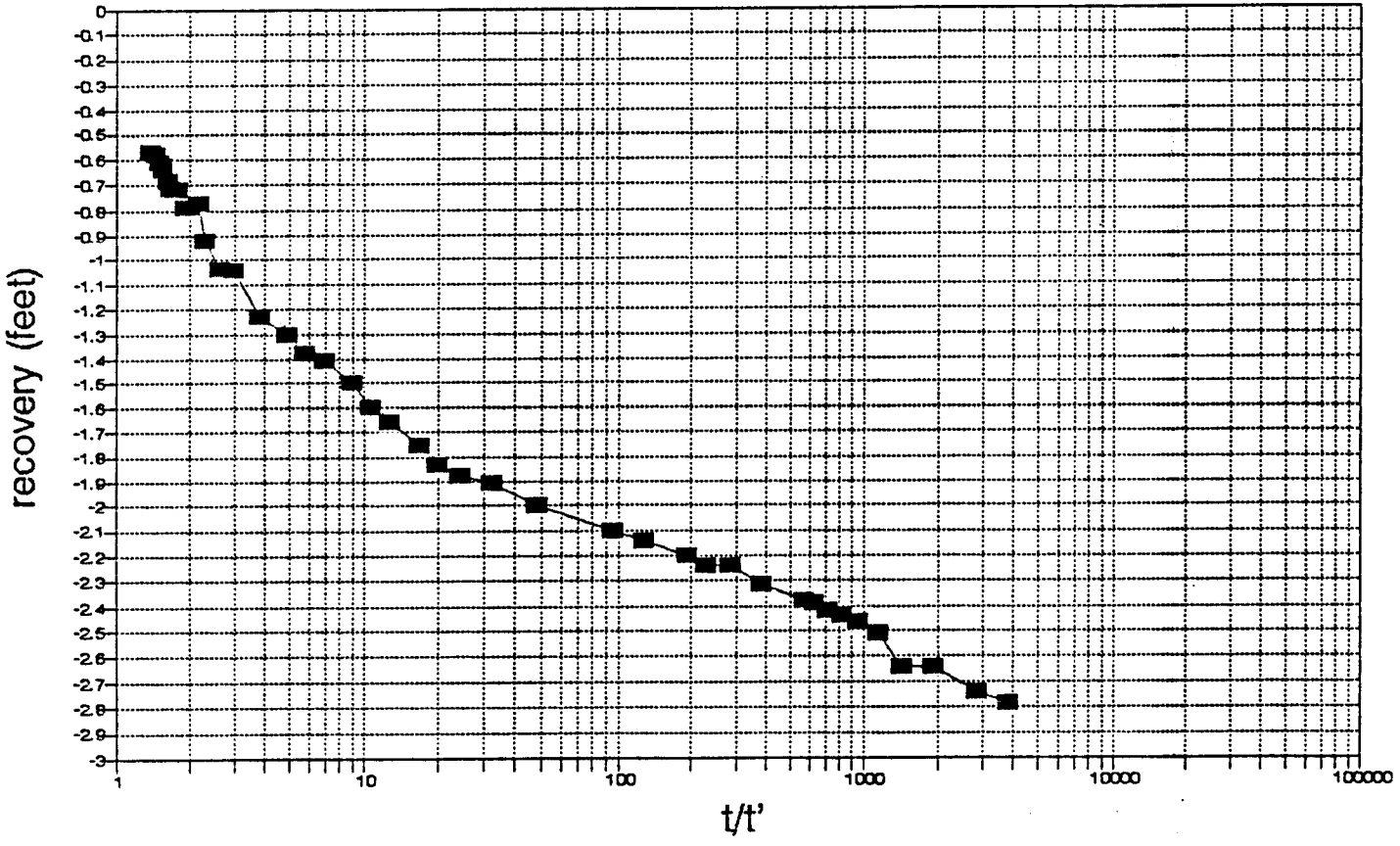
PT-PZ-3

Theis Recovery Plot



PT-PZ-4

Theis Recovery Plot



Appendix G

Jacob-Cooper Analyses

Jacob-Cooper Analyses: Pumping Data

Governing Equations: $T = \frac{2.3\ Q}{4\ \pi\ s_{lc}}$

$S = \frac{2.25\ T\ t_o}{r^2}$

Q = 388 gpm = 0.865 cfs

Curve Analyses:

	PT-PZ-1	**PT-PZ-2**	**PT-PZ-3**	**PT-PZ-4**
s_{lc}	1.42	1.52	1.56	1.52
T (ft^2/s)	0.112	0.104	0.101	0.104
t_o (min)	58	24	7.1	84
r (ft)	201	144	94	497
S	2.16×10^{-2}	1.63×10^{-2}	1.10×10^{-2}	4.78×10^{-3}

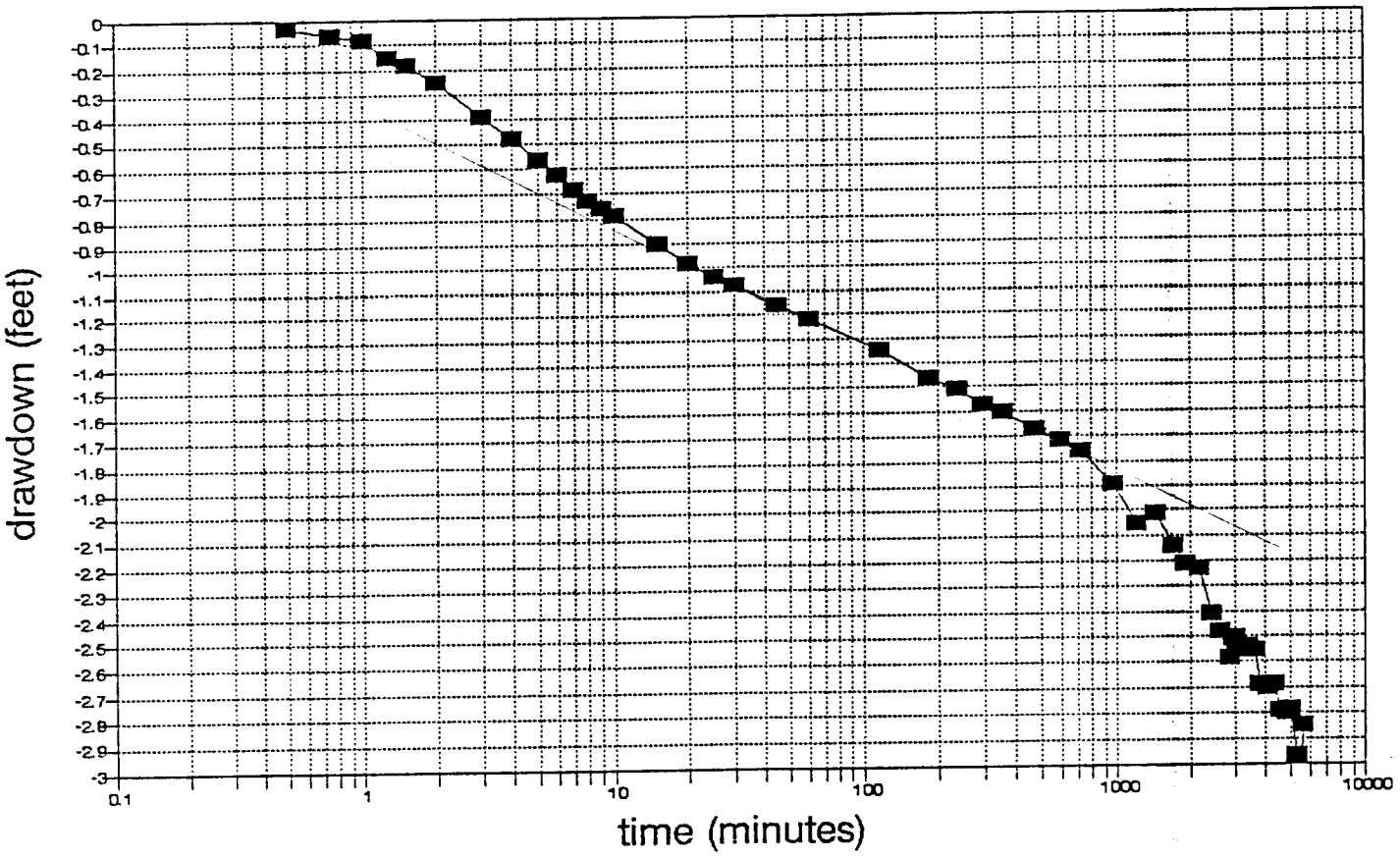
	BLM-17-493	**BLM-7-509**	**BLM-2-630**	**PL-2-504**
s_{lc}	1.37	0.405	1.58	1.22
T (ft^2/s)	0.116	0.391	0.100	0.130
t_o (min)	990	1400	150	660
r (ft)	1354	2654	1389	1332
S	8.43×10^{-3}	1.05×10^{-2}	1.05×10^{-3}	6.52×10^{-3}

T_{ave} = 0.110 ft^2/s (excludes BLM-7-509)

S_{ave} = 1.00×10^{-2}

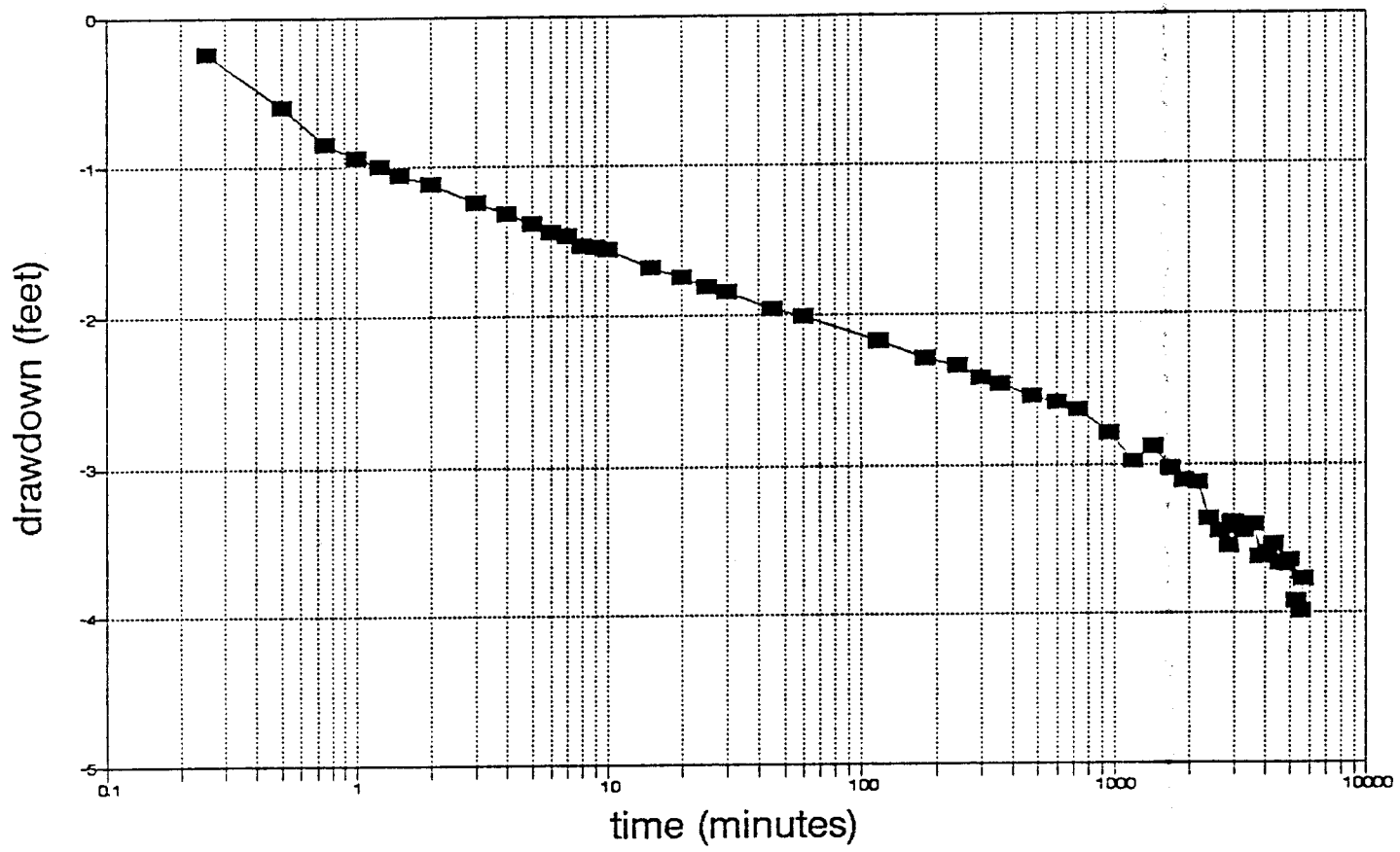
PT-PZ-1

Pumping Data



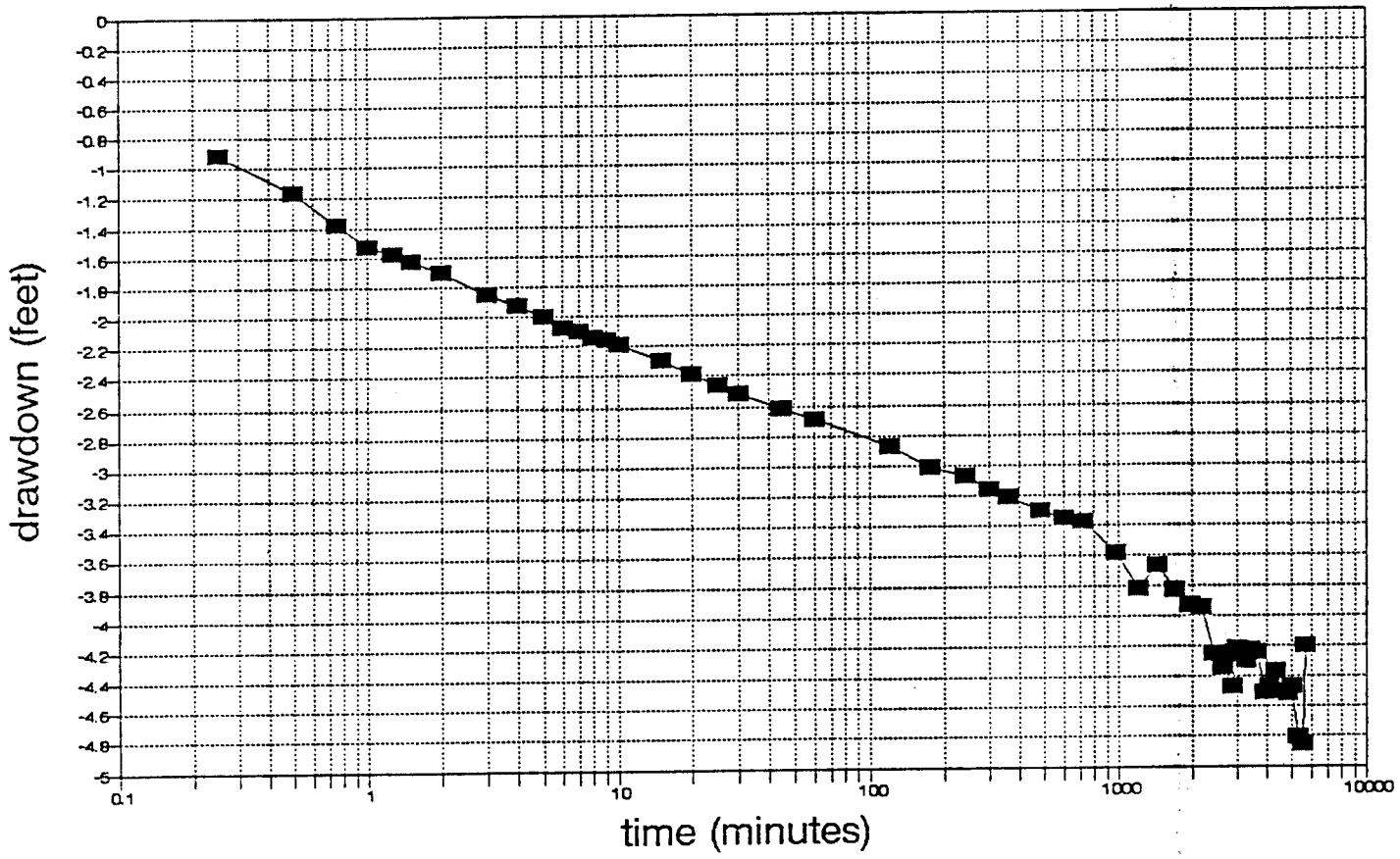
PT-PZ-2

Pumping Data



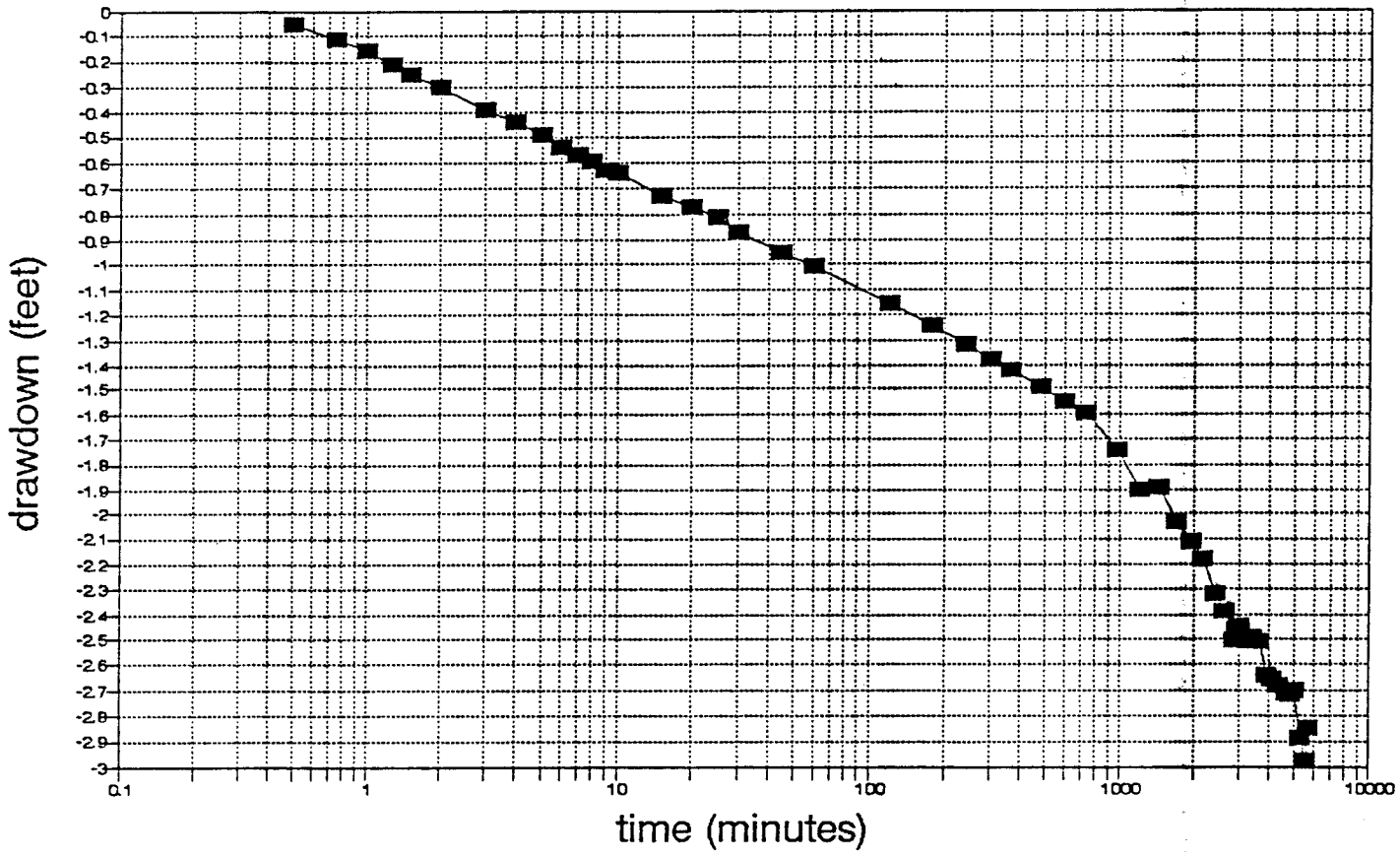
PT-PZ-3

Pumping Data



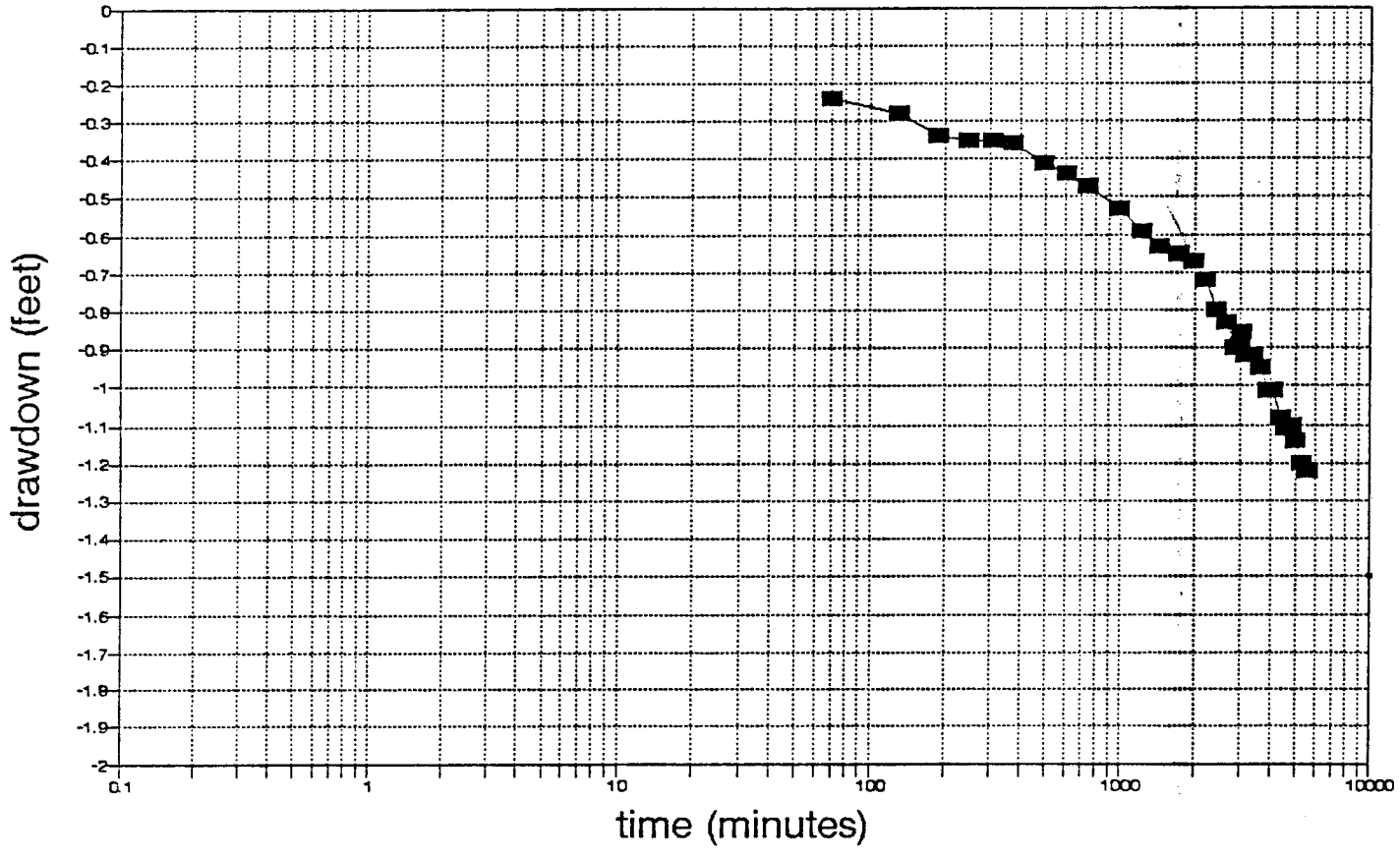
PT-PZ-4

Pumping Data



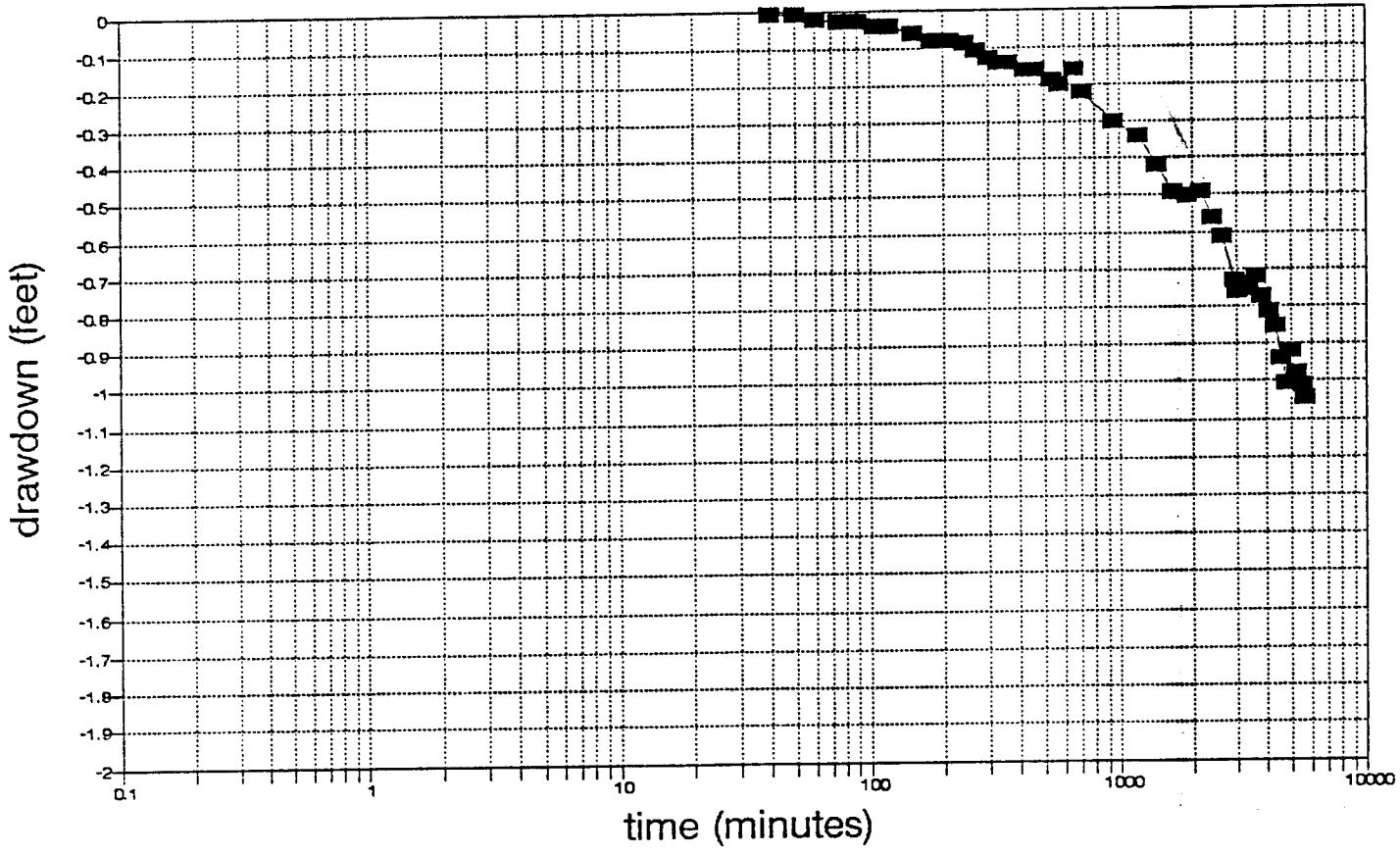
PL-2-504

Pumping Data



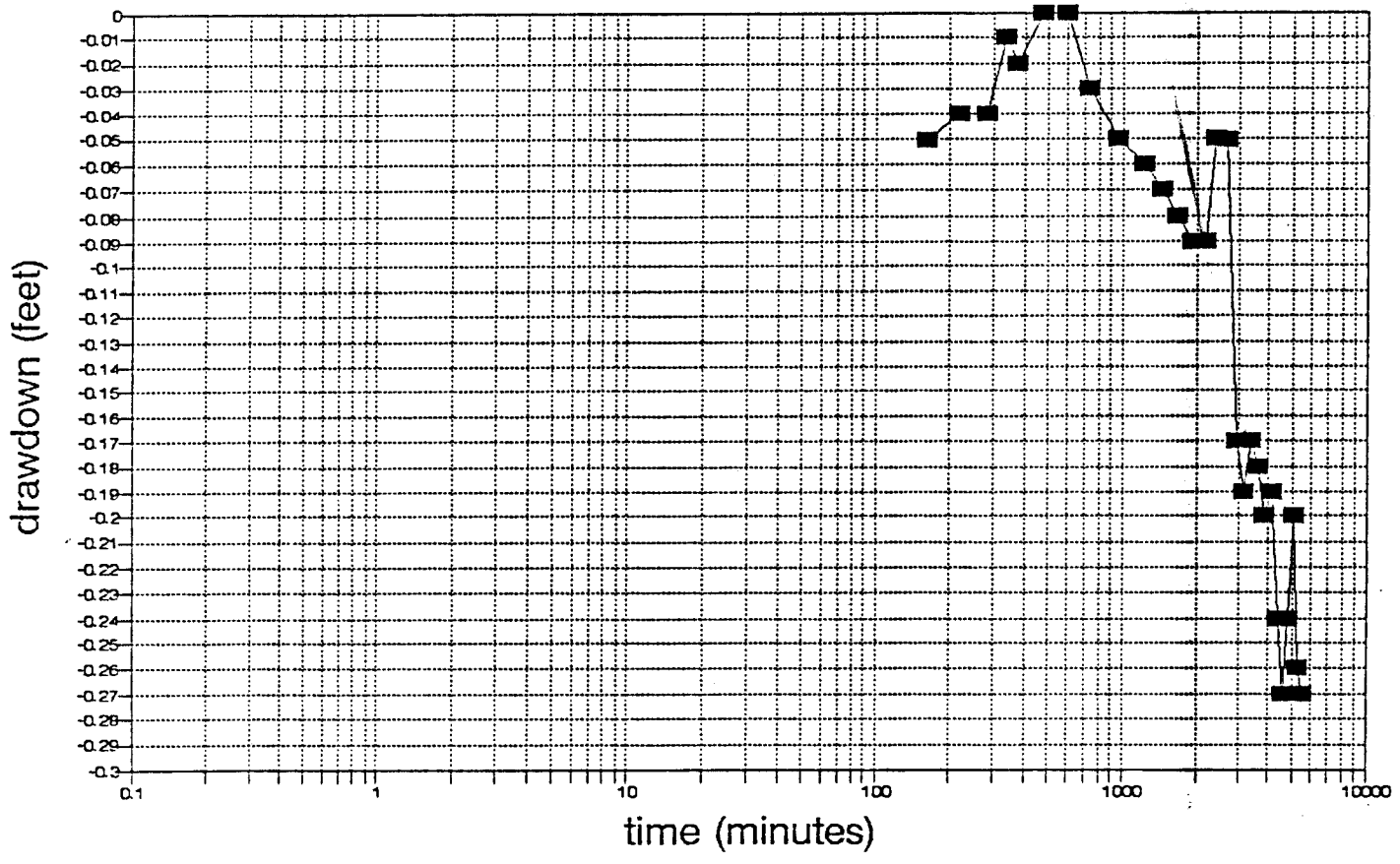
BLM-17-493

Pumping Data



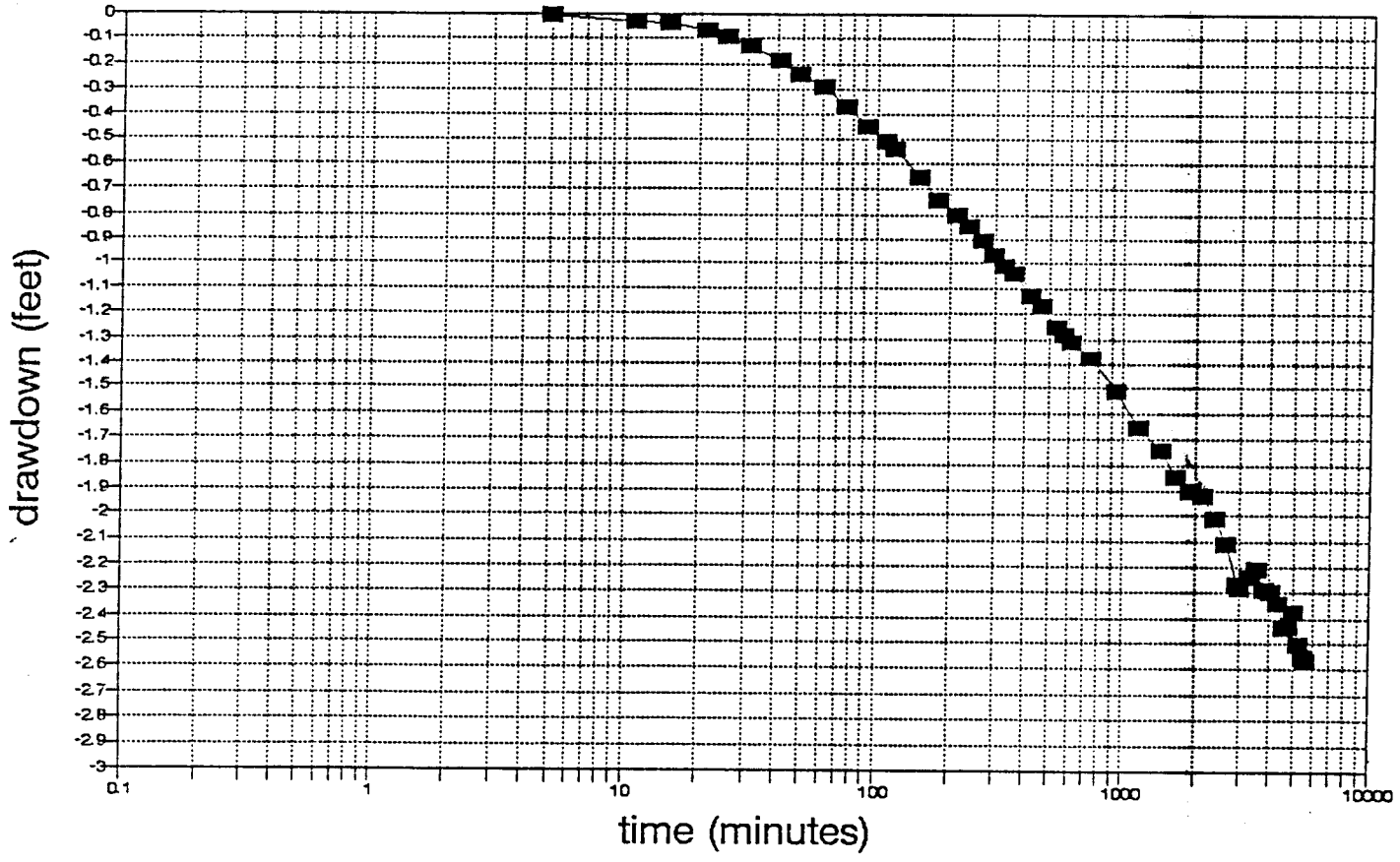
BLM-7-509

Pumping Data



BLM-2-630

Pumping Data



Jacob-Cooper Analyses: Recovery Data

Governing Equations:

$$T = \frac{2.3\ Q}{4\ \pi\ s_{ic}}$$

$$S = \frac{2.25\ T\ t_o}{r^2}$$

Q = 388 gpm = 0.865 cfs

Curve Analyses:

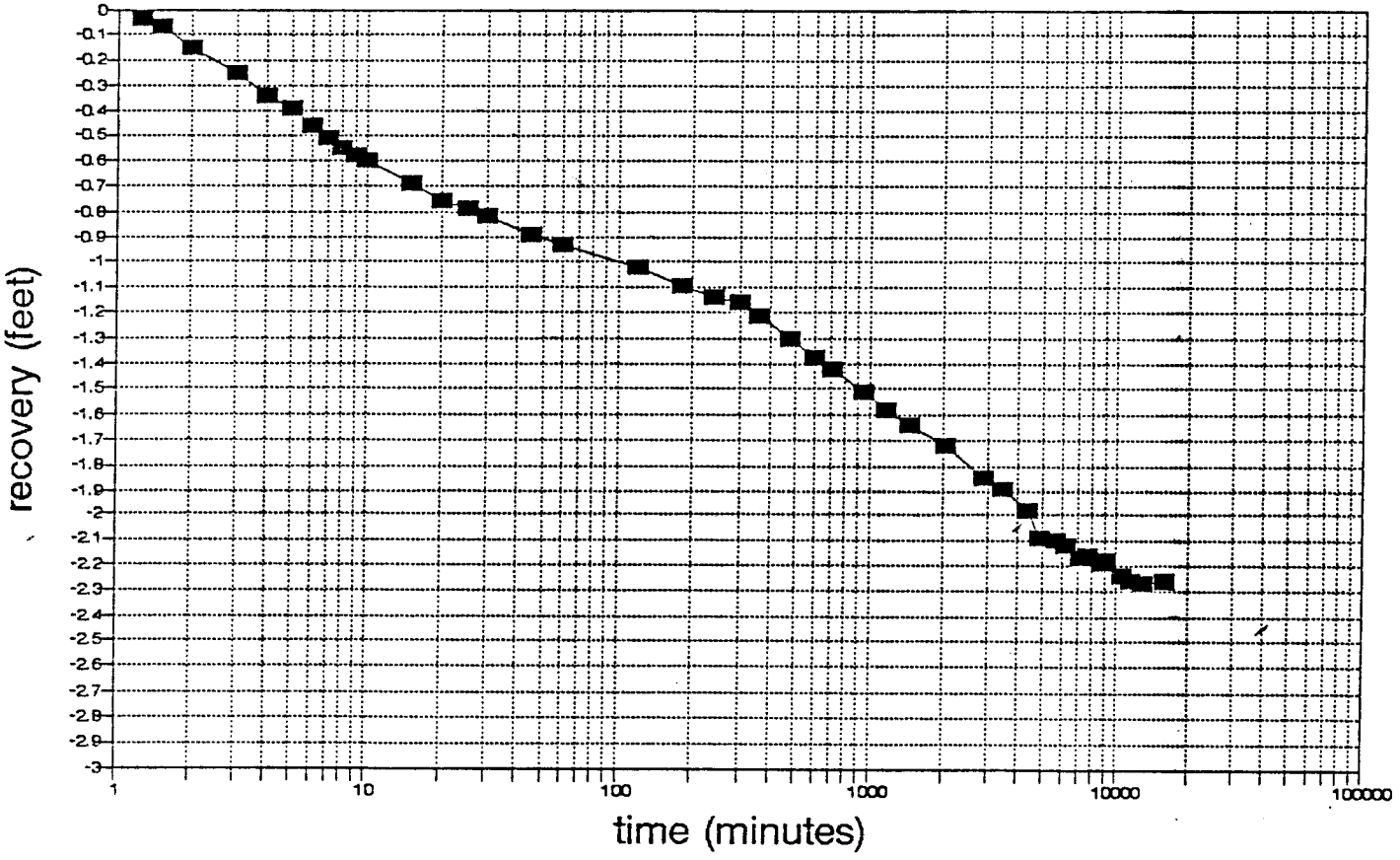
	PT-PZ-1	PT-PZ-2	PT-PZ-3	PT-PZ-4	BLM-2-630
s_{ic} (ft)	0.71	0.78	0.85	0.75	1.08
T (ft^2/s)	0.223	0.203	0.186	0.211	0.147
t_o (min)	8	0.88	0.35	16	54
r (ft)	201	144	94	497	1389
S	5.93×10^{-3}	1.16×10^{-3}	9.96×10^{-4}	1.85×10^{-3}	5.54×10^{-4}

T_{ave} = 0.194 ft^2/s

S_{ave} = 2.10×10^{-3}

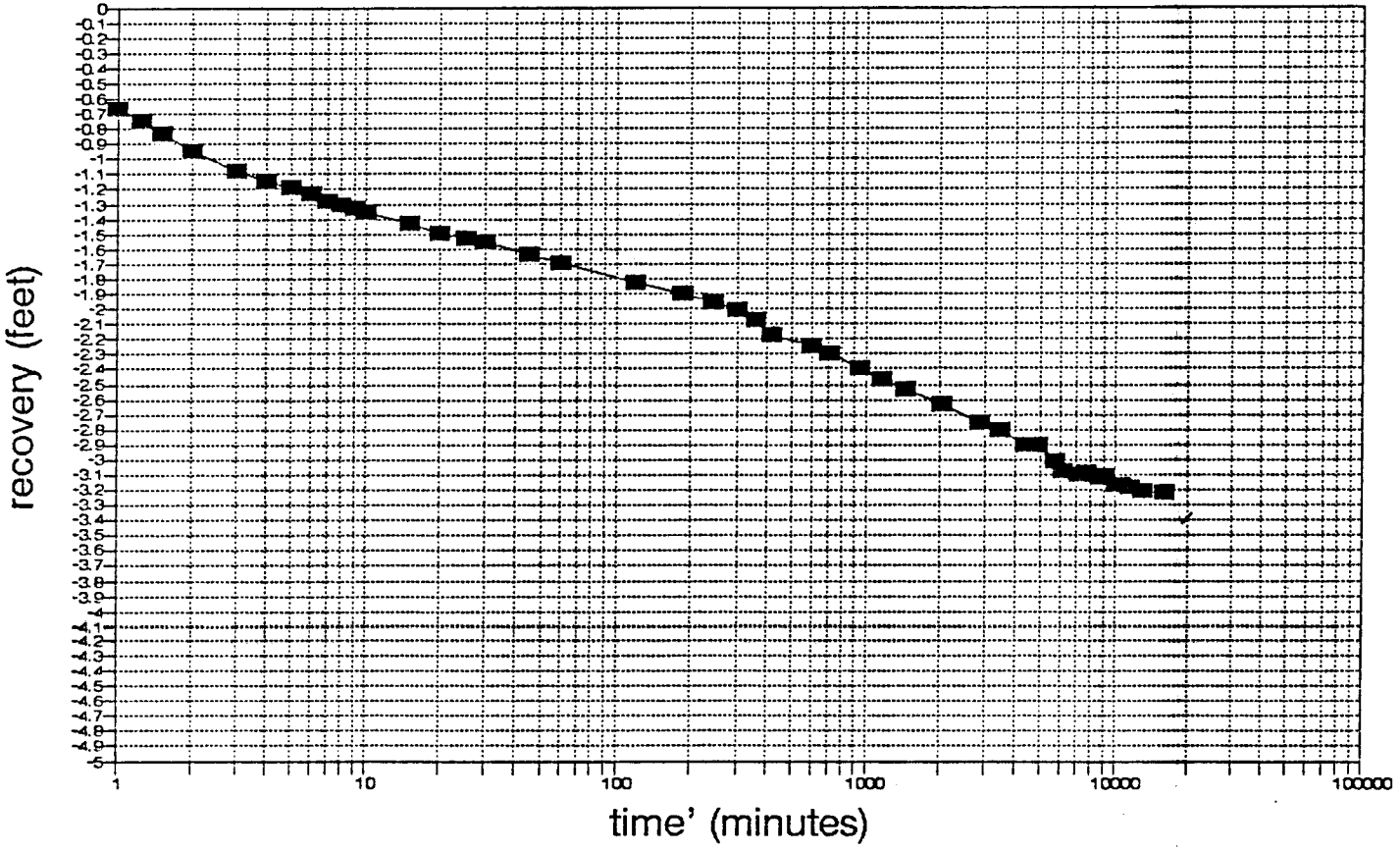
PT-PZ-1

Recovery Data



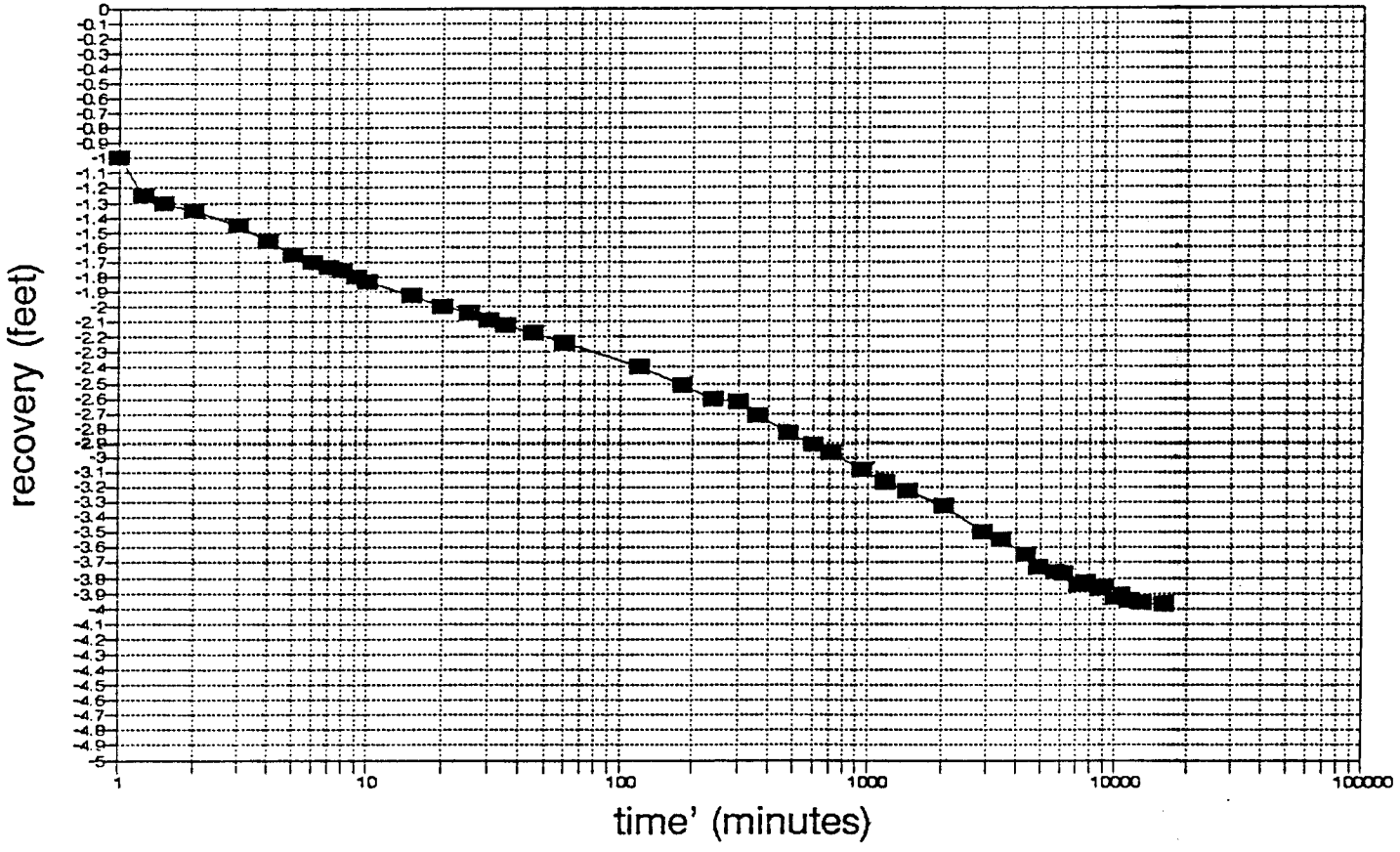
PT-PZ-2

Recovery Data



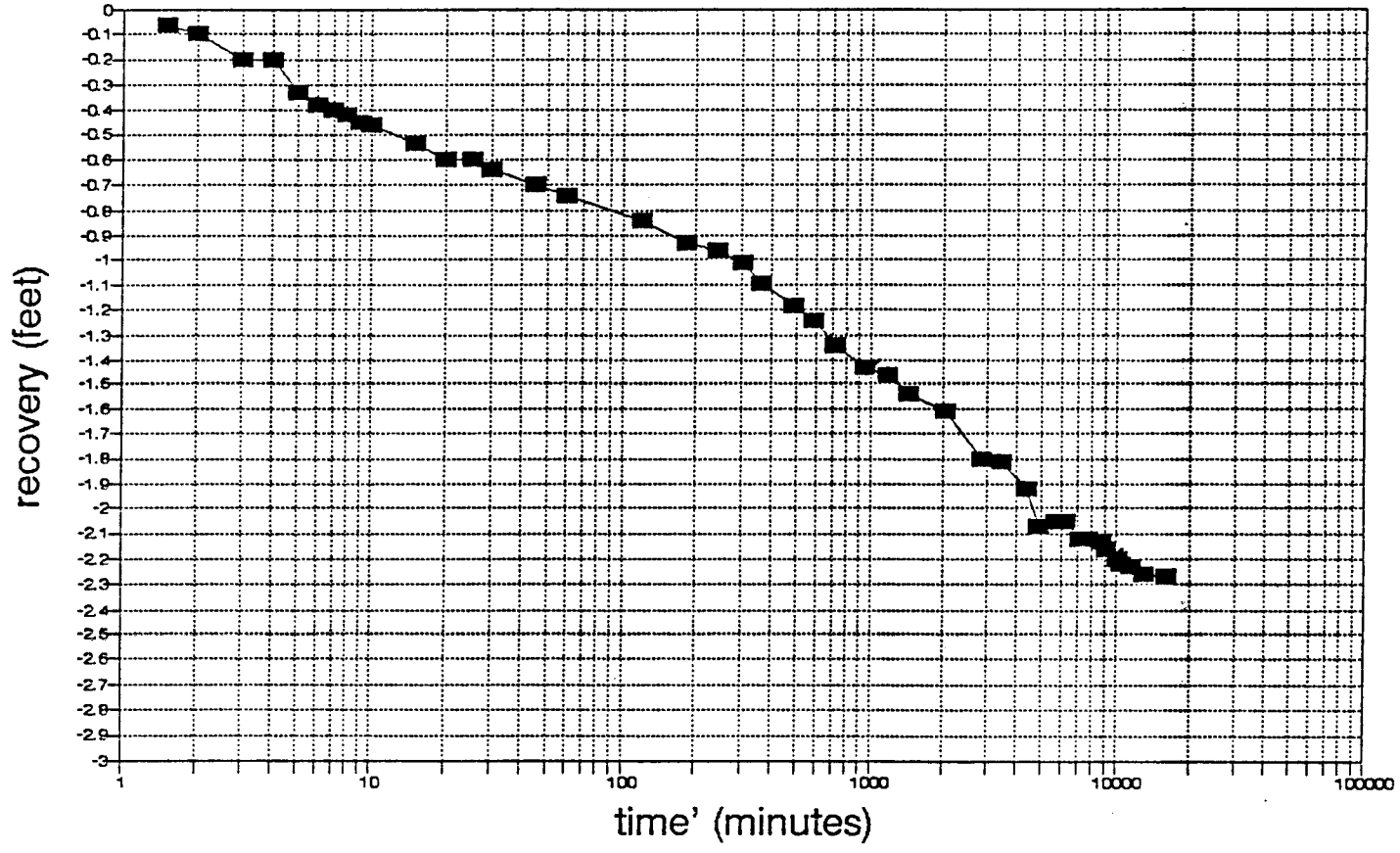
PT-PZ-3

Recovery Data



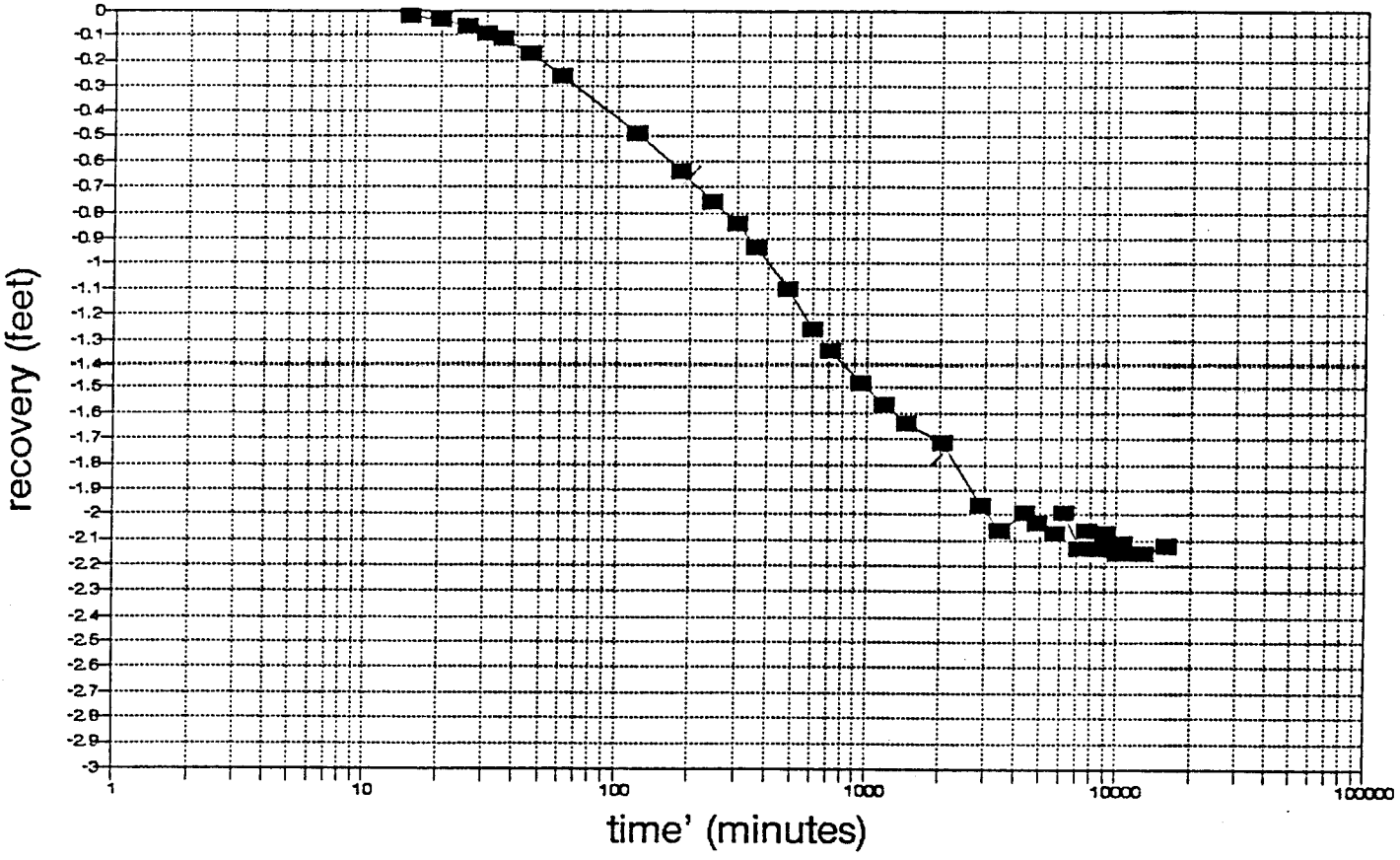
PT-PZ-4

Recovery Data



BLM-2-630

Recovery Data



Appendix H

Leaky-Confined Methods: Cooper and Hantusch

Cooper (1963) Leaky-Confined Aquifer

Governing Equations:

$$T = \frac{Q}{4\pi s} L(u,v)$$

$$S = 4T \frac{t/r^2}{1/u}$$

$$K'/b' = 4T \frac{v^2}{r^2} = \frac{S\,[v^2/u]}{t}$$

$$u = \frac{r^2 S}{4 T t}$$

$$v = \frac{r}{2} \left[\frac{K'}{b' T} \right]^{1/2}$$

Match Points: **Q = 388 gpm = 0.865 cfs**

	PT-PZ-1	PT-PZ-2	PT-PZ-4	
L (u,v)	1	1	1	
1/u	0.01	0.01	0.01	
s (ft)	0.36	0.30	0.25	
t/r^2	1.7×10^{-4}	7.3×10^{-5}	1.5×10^{-5}	
T (ft^2/s)	0.191	0.229	0.275	T_{ave} = 0.232 ft^2/s
S	1.30×10^{-2}	6.69×10^{-3}	1.65×10^{-3}	$S_{ave} = 7.11 \times 10^{-3}$
K'/b'	2.98×10^{-5}	7.38×10^{-5}	5.93×10^{-5}	$K'/b'_{ave} = 5.43 \times 10^{-5}$

Hantusch (1960) Leaky-Confined Aquifer with Confining Bed Storage

Governing Equations:

$$T = \frac{Q}{4\pi s} H(u,\beta)$$

$$u = \frac{r^2 S}{4 T t}$$

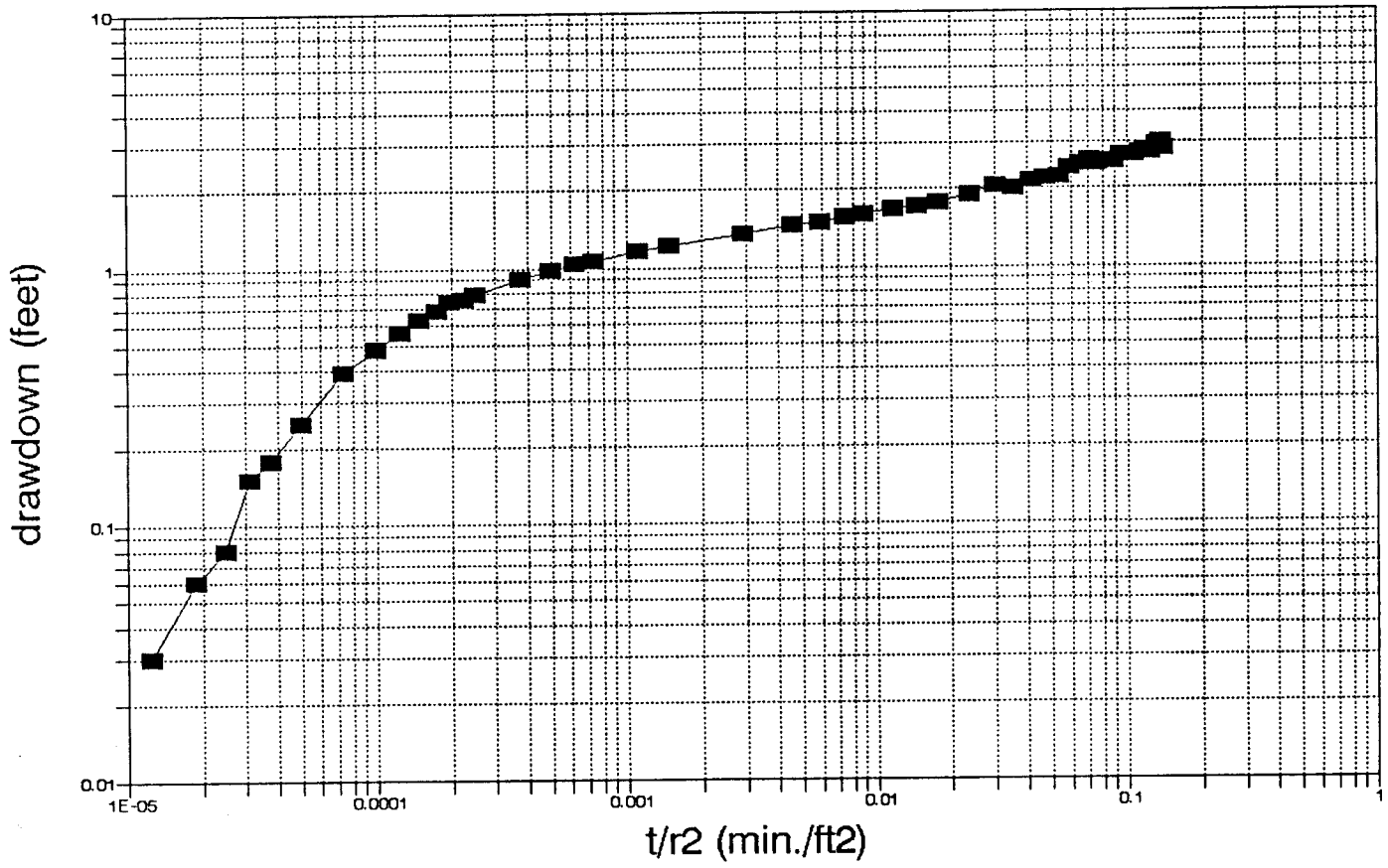
$$\beta = \frac{r}{4b}\left[\left\{\frac{K' S_s'}{K S_s}\right\}^{1/2} + \left\{\frac{K'' S_s''}{K S_s}\right\}^{1/2}\right]$$

Match Points: **Q = 388 gpm = 0.865 cfs**

	PT-PZ-1	PT-PZ-2	PT-PZ-4	
H (u,B)	1	1	1	
1/u	1	10	1	
s (ft)	0.43	0.50	0.42	
t/r^2	1.51×10^{-5}	3.0×10^{-5}	2.0×10^{-5}	
t (min)	0.61	0.62	4.94	
B	0.1	0.1	0.2	
T (ft^2/s)	0.160	0.138	0.164	$T_{ave} = 0.154\ ft^2/s$
S	5.80×10^{-4}	9.90×10^{-4}	7.87×10^{-4}	$S_{ave} = 7.86 \times 10^{-4}$

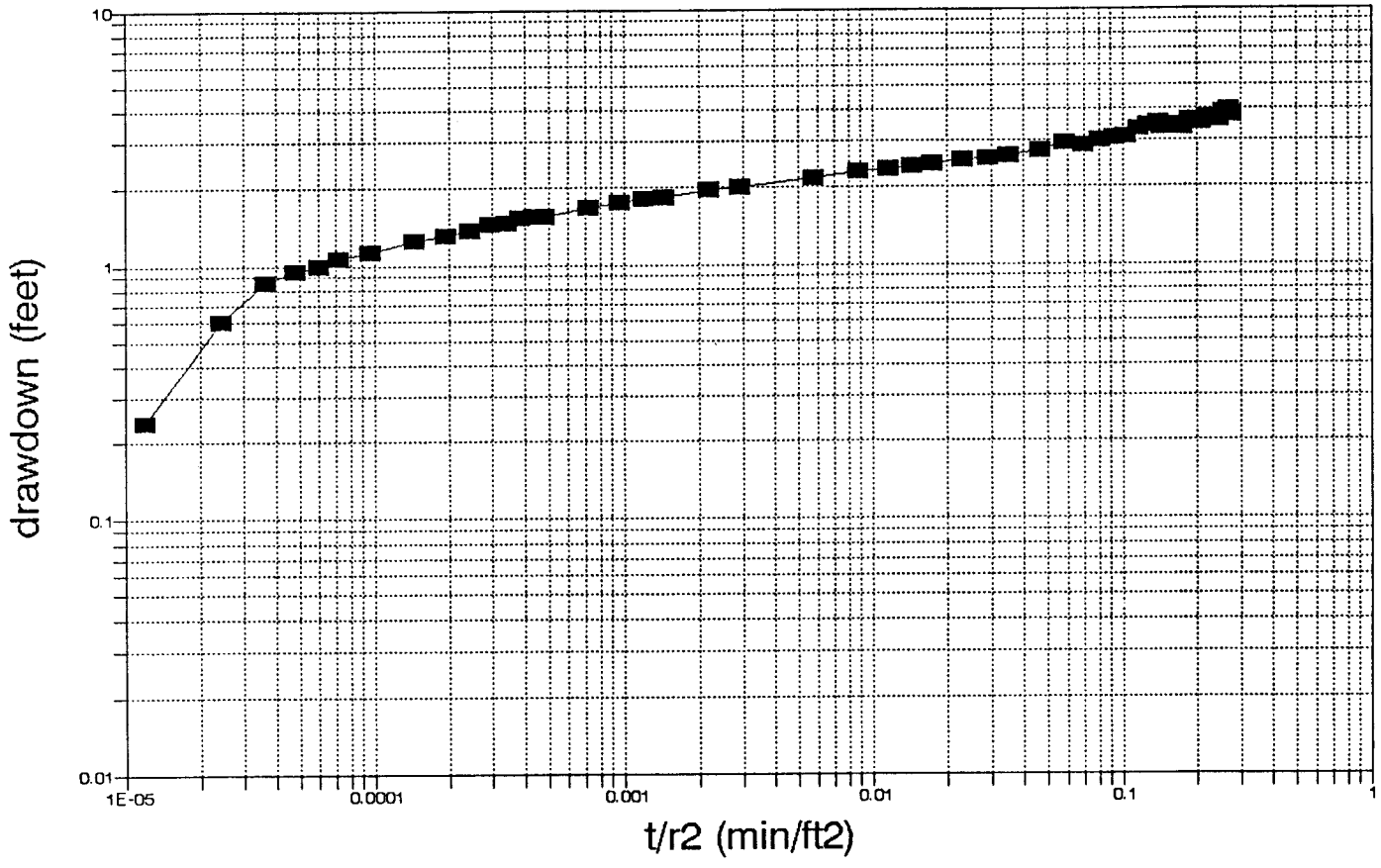
PT-PZ-1

Pumping Data



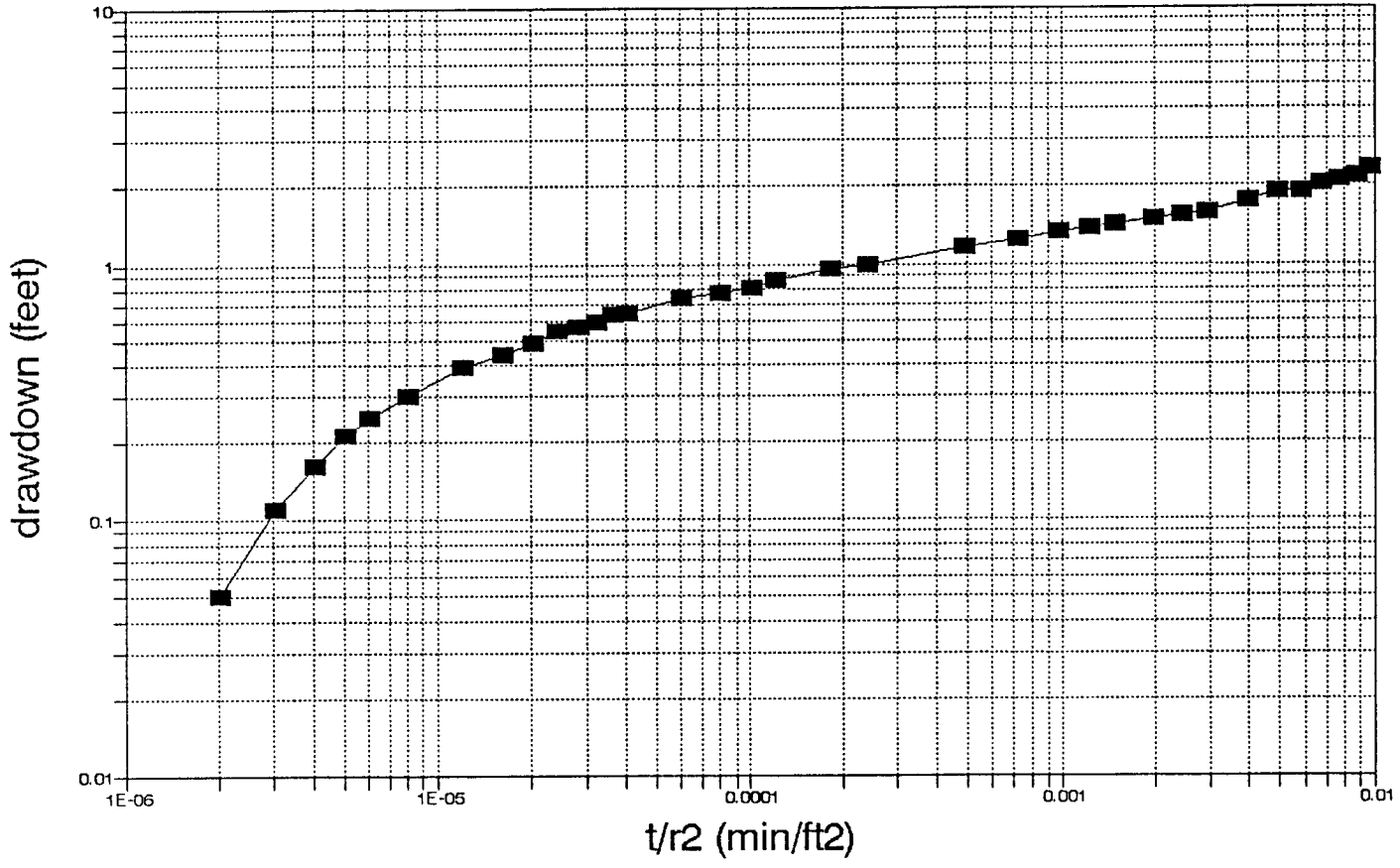
PT-PZ-2

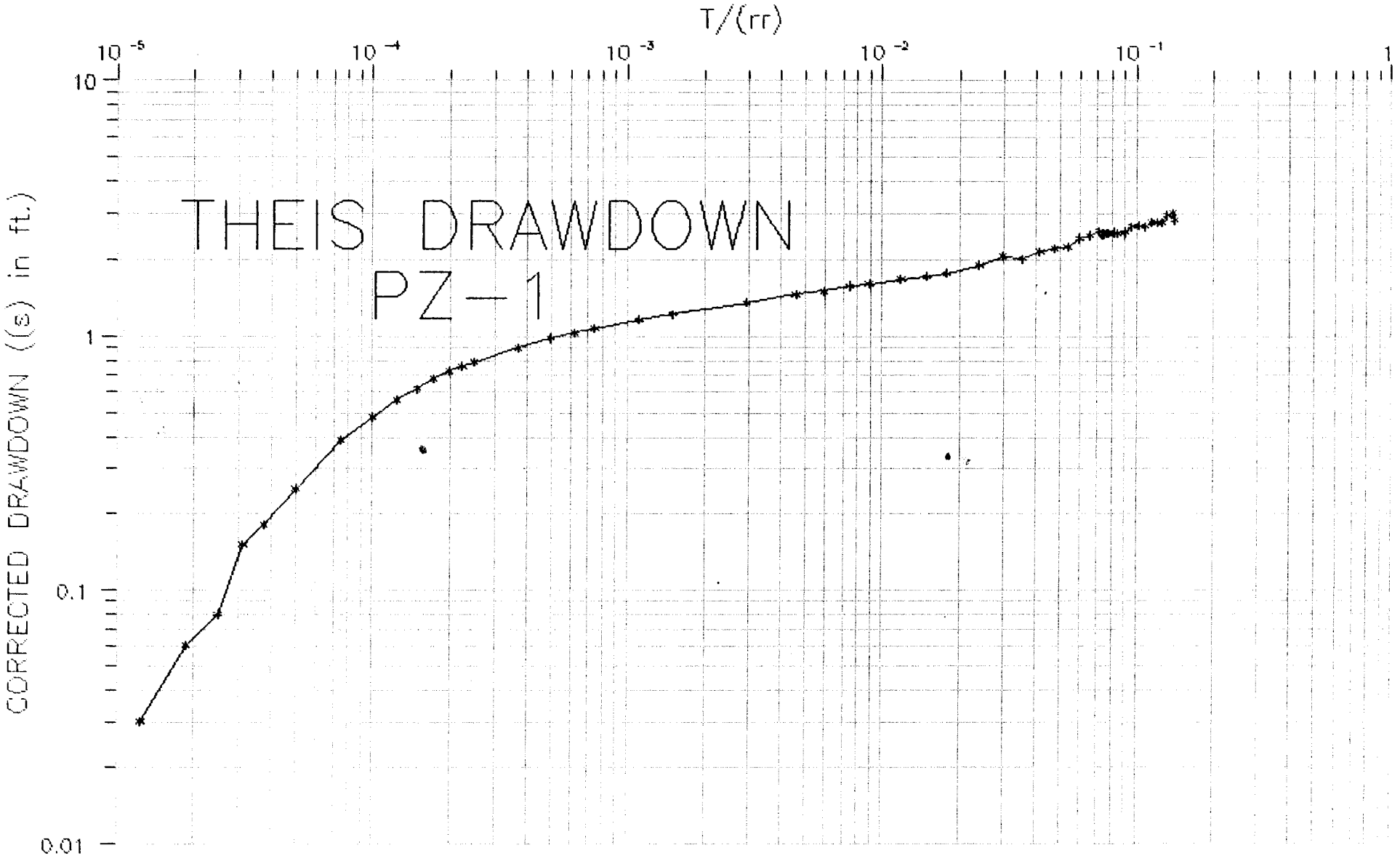
Pumping Data



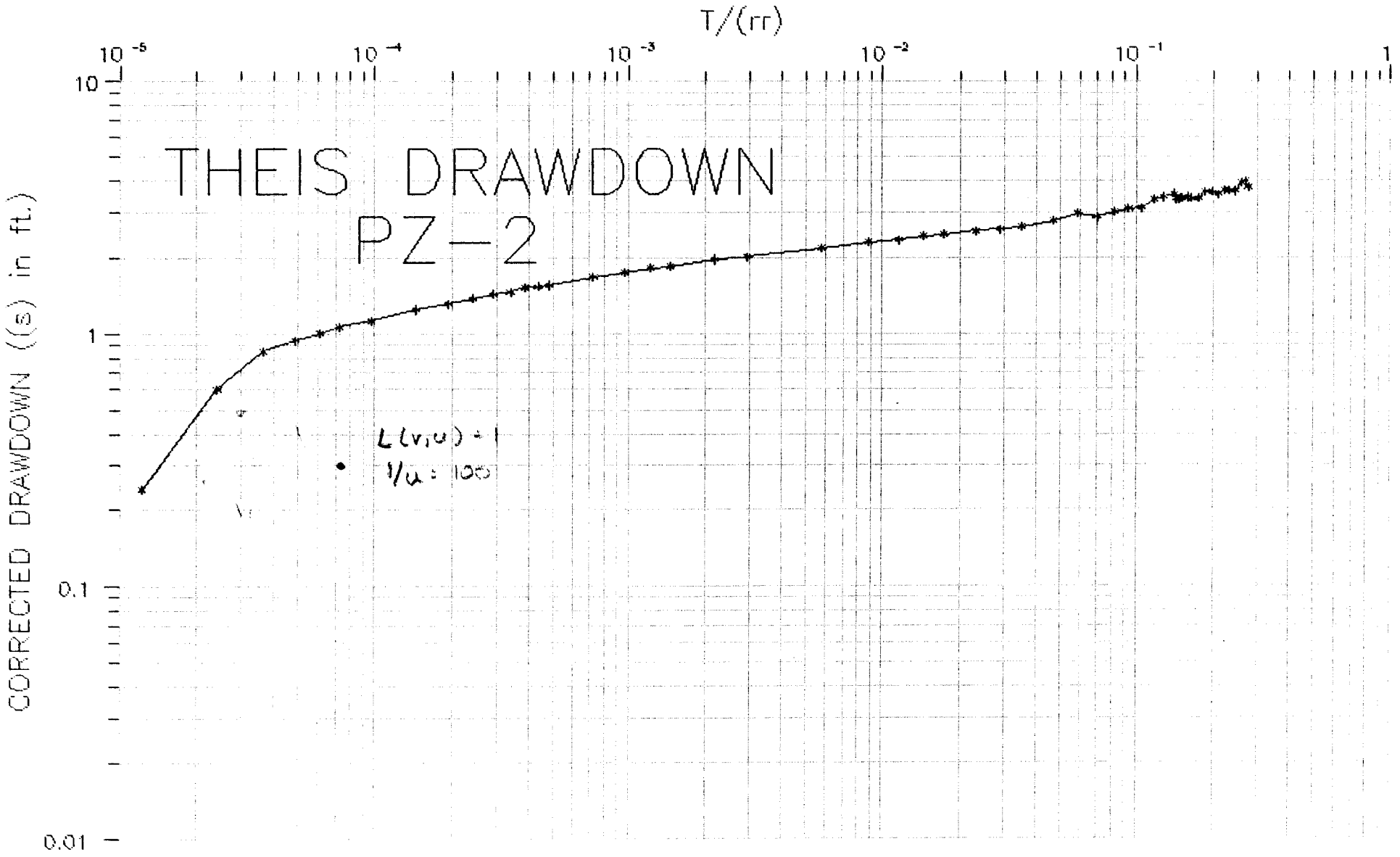
PT-PZ-4

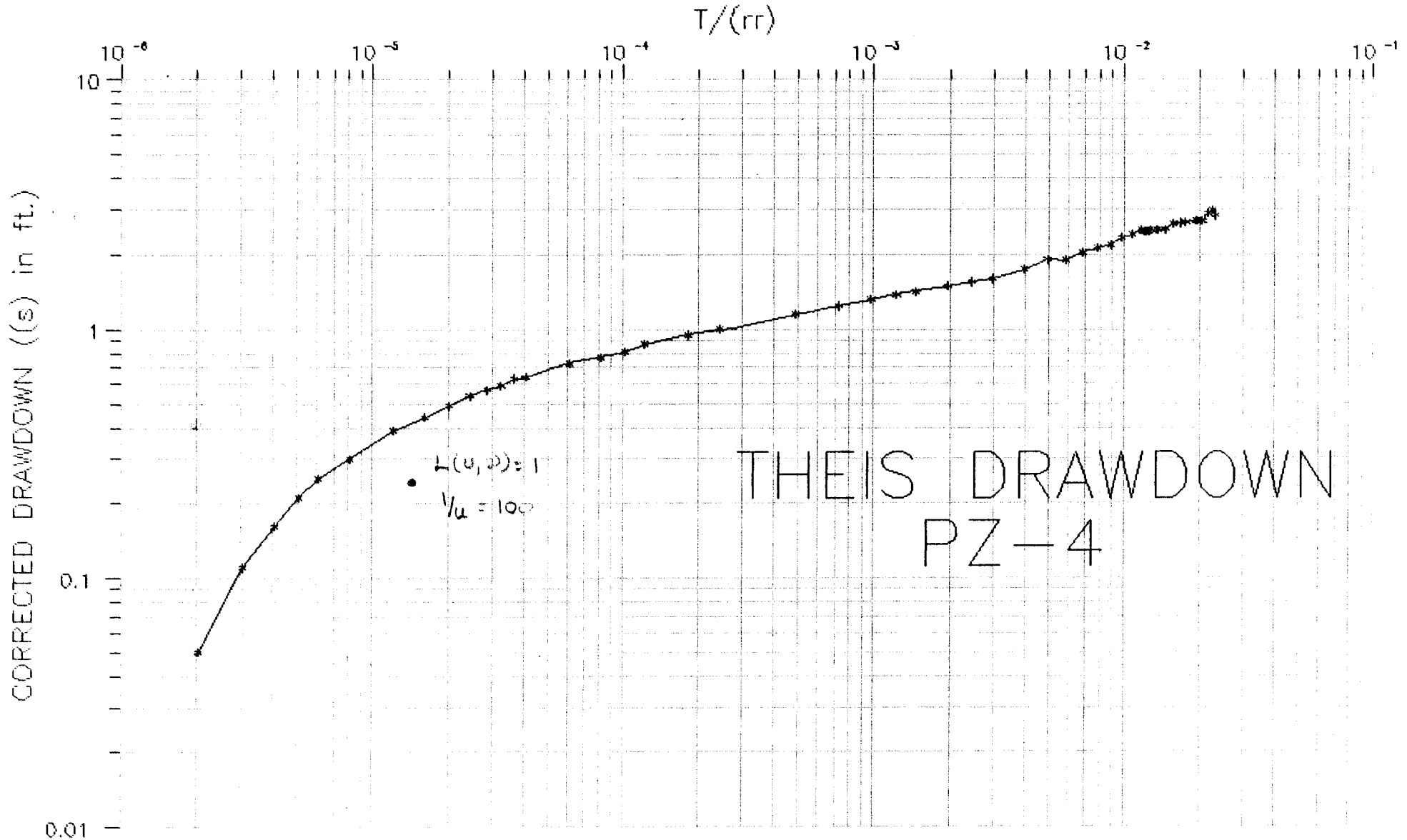
Pumping Data




T/(rr)
10 -5
10 -4
10 -3
10 -2
10 -1
1
10
1
0.1
0.01
CORRECTED DRAWDOWN ((s) in ft.)
THEIS DRAWDOWN
PZ-1

$r^2/u = 1.0$


T/(rr)
10 -5
10 -4
10 -3
10 -2
10 -1
1
10
1
0.1
0.01
CORRECTED DRAWDOWN ((s) in ft.)
THEIS DRAWDOWN
PZ-2
L(r,u) = 1
1/u = 105


T/(rr)
10 -6
10 -5
10 -4
10 -3
10 -2
10 -1
10
1
0.1
0.01
CORRECTED DRAWDOWN ((s) in ft.)
W(u, β) = 1
1/u = 100
THEIS DRAWDOWN
PZ-4

$r^2/u^2 = 2.0$

Appendix I

Boulton – Delayed Yield Analyses

Boulton (1954) Delayed Yield Analyses
(Unconfined Aquifers)

Governing Equations:

$$\text{Early Time:}\quad T = \frac{Q}{4\pi s_{mp}} W(u_A, r/\beta)$$

$$S = \frac{u_A 4 T t}{r^2}$$

$$\text{Late Time:}\quad T = \frac{Q}{4\pi s_{mp}} W(u_B, r/\beta)$$

$$S_y = \frac{u_B 4 T t}{r^2}$$

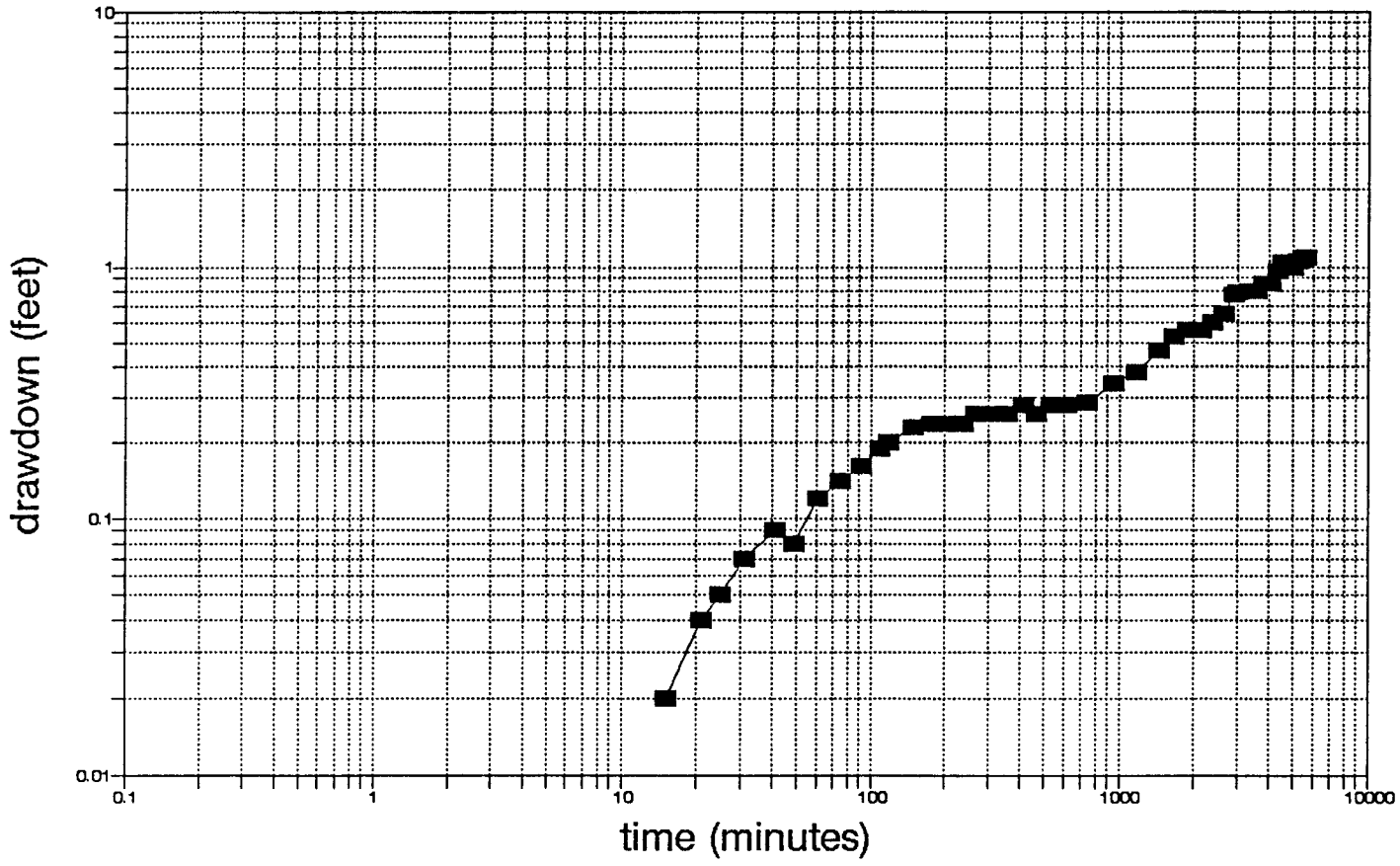
$$\alpha = \frac{T \{r/\beta\}^2}{r^2 S_y}$$

Match Point: **Q = 388 gpm = 0.865 cfs; r = 1425 ft**

	BLM-2-482 (early time)	**BLM-2-482 (late time)**
$W(u_A,u_B,r/B)$	1	1
u_A	1	NA
u_B	NA	1
s (ft)	0.18	2.4
t (min)	20.	4150.
T (ft^2/s)	0.382	0.0287
S	1.50×10^{-5}	NA
S_y	NA	0.0148
α	3.81×10^{-6}	

BLM-2-482

Drawdown vs. time



Appendix J

Cooper and Jacob – Distance-Drawdown Analyses

Distance-Drawdown Analyses

Governing Equations:

$$T = \frac{528\ Q}{s_{lc}}$$

$$S = \frac{0.3\ T\ t}{r_o^2}$$

Q = 388 gpm = 0.865 cfs

I. t = 3000 minutes

$$T = \frac{528\ (388\ gpm)}{2.94} = 69{,}682\ gpd/ft = 0.108\ ft^2/s$$

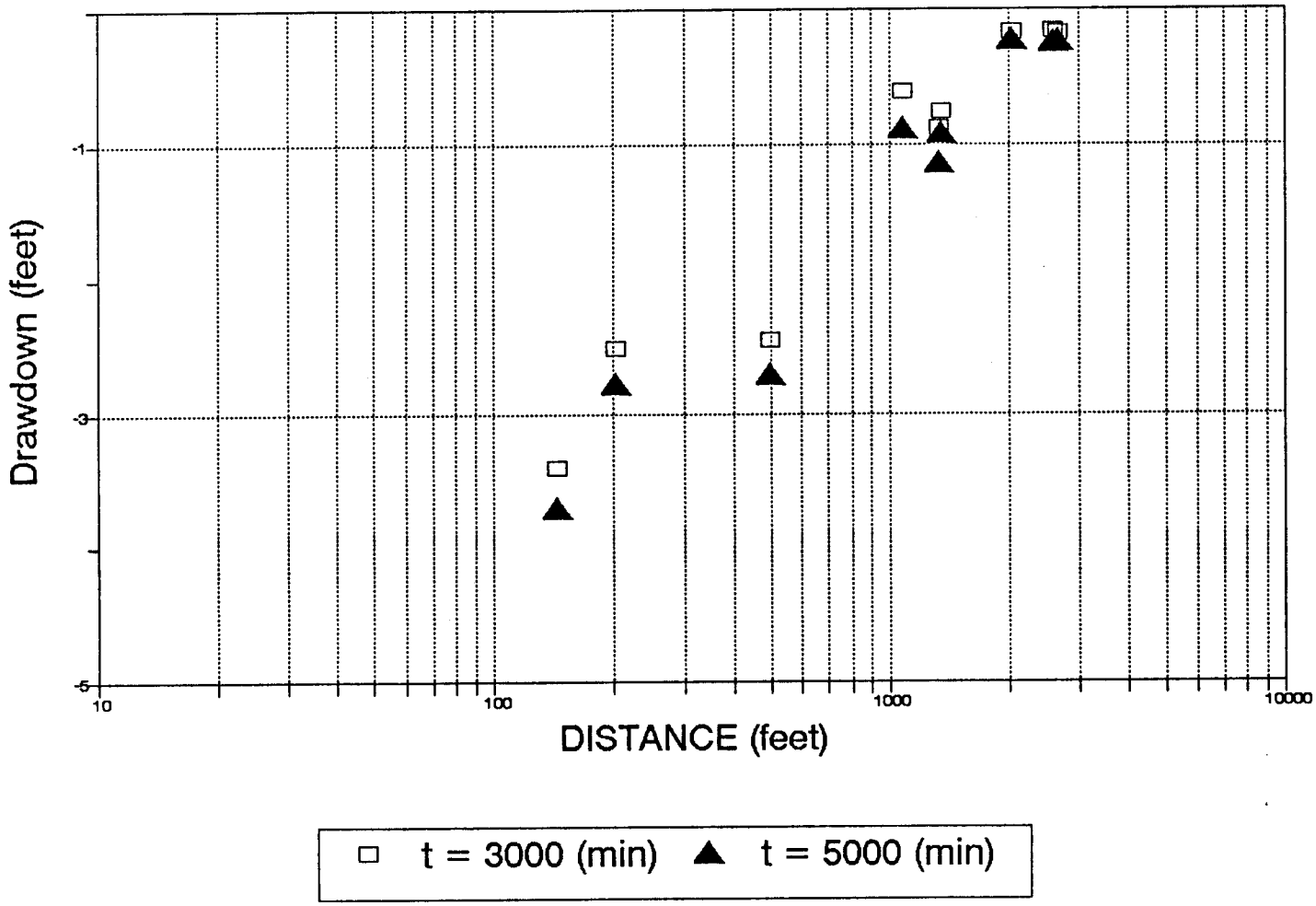
$$S = \frac{0.3\ (69{,}682)\ (3000/1440)}{(2475)^2} = 7.11 \times 10^{-3}$$

II. t = 5000 minutes

$$T = \frac{528\ (388\ gpm)}{2.94} = 69{,}682\ gpd/ft = 0.108\ ft^2/s$$

$$S = \frac{0.3\ (69{,}682)\ (5000/1440)}{(2800)^2} = 9.26 \times 10^{-3}$$

DISTANCE-DRAWDOWN ANALYSIS



Appendix K

Boundary Analysis

Stallman (1963) Boundary Analysis

Governing Equations:

$$T = \frac{Q}{4 \pi s_{mp}} \Sigma W(u)$$

$$S = \frac{4 T t u_p}{r_p^2}$$

$$k = \frac{r_i}{r_p}$$

Q = 388 gpm = 0.865 cfs

Match Point:	**BLM-2-630 (k = 1.6)**	**BLM-17-493 (k = 2.5)**
E W(u)	1	1
$1/u_p$	1	1
s_{mp}	0.375	0.180
t/r^2	1.45×10^{-5}	6.0×10^{-5}
t (min)	27.98	110
r_p	1389	1354
T (ft^2/s)	0.184	0.382
S	6.39×10^{-4}	5.51×10^{-3}
r_i	2222	3385
$r_{boundary}$ (ft)	1806	2370

FINAL

AQUIFER TEST REPORT
WELL J

FINAL REPORT

NASA-JSC WHITE SANDS TEST FACILITY
LAS CRUCES, NEW MEXICO

April 2, 1990

NASA
National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
White Sands Test Facility
Post Office Drawer MM
Las Cruces, New Mexico 88004
AC 505 524-5011

FINAL

AQUIFER TEST REPORT
WELL J

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TABLE OF CONTENTS

1.0 EXECUTIVE SUMMARY 1

2.0 WELLS AND PIEZOMETERS 2
2.1 WATER SUPPLY WELLS 2
2.2 PIEZOMETERS 3
2.3 MONITOR WELLS 6

3.0 PUMPING AND WATER LEVEL RECORDING 8
3.1 WELL J 8
3.2 PIEZOMETERS
3.2.1 Test Preparation 11
3.2.2 Manual Recording 11
3.2.3 Digital Recording 13
3.3 MONITOR WELLS 14
3.4 BAROMETRIC PRESSURE RECORDING 14

4.0 DATA REDUCTION
4.1 BAROMETRIC CORRECTION 15
4.2 SELECTION OF DATA SETS FOR ANALYSIS 15

5.0 INTERPRETATION: LEAKY-CONFINED, ANISOTROPIC ALLUVIAL AQUIFER 19
5.1 EVIDENCE FOR AN ALLUVIAL FAN SEQUENCE 19
5.2 EVIDENCE FOR LEAKY CONFINED CONDITIONS 19
5.3 EVIDENCE FOR ANISOTROPY 20
5.4 ESTIMATING AQUIFER PARAMETERS 21
5.4.1 Pumping Phase Analysis: Theis' Drawdown Method 21
5.4.2 Recovery Phase Analysis: Theis' Recovery Method 21
5.4.3 Determination of the Principle Axes of Transmissivity: Papadopulos' Method 24

6.0 SUMMARY OF AQUIFER TEST RESULTS 29

7.0 REFERENCES 30

LIST OF FIGURES

FIGURE 3-1	DISCHARGE DURING THE AQUIFER TEST AT WELL J, NASA-WSTF	9
FIGURE 3-2	RESPONSE OF PIEZOMETER JPZ-1	10
FIGURE 3-3	WATER LEVEL FLUCTUATION IN PIEZOMETERS JPZ-1 THROUGH JPZ-5 PRIOR TO WELL J AQUIFER TEST	12
FIGURE 4-1	WATER LEVEL CHANGE IN SIX DISTANT MONITOR WELLS DURING THE AQUIFER TEST AT WELL J	16
FIGURE 4-2	WATER LEVEL CHANGE IN THREE MONITOR WELLS, COMPARED TO THE CHANGE IN BAROMETRIC PRESSURE	17
FIGURE 5-1	WELL J AQUIFER TEST: PIEZOMETER HYDROGRAPHS	22

LIST OF TABLES

TABLE 2-1	PIEZOMETER DATA SUMMARY	4
TABLE 5-1	ESTIMATED AQUIFER PARAMETERS FOR PUMPING PHASE DATA USING THE THEIS METHOD	23
TABLE 5-2	ESTIMATED AQUIFER PARAMETERS FOR RECOVERY PHASE DATA USING THE THEIS METHOD	25

LIST OF APPENDICES

APPENDIX A	LITHOLOGIC AND COMPLETION INFORMATION FOR WELLS AND PIEZOMETERS
APPENDIX B	FIELD RECORDS OF MANUAL RECORDING OF AQUIFER TEST AT WELL J
APPENDIX C	RAW DIGITAL DATA FROM AQUIFER TEST AT WELL J
APPENDIX D	BAROGRAPH RECORD
APPENDIX E	CALCULATION OF AQUIFER PARAMETERS BASED ON THEIS' DRAWDOWN AND RECOVERY METHODS
APPENDIX F	CALCULATION OF AQUIFER PARAMETERS BASED ON PAPADOPULOS' METHOD

LIST OF PLATES

PLATE 2-1	WELL LOCATION AND FACILITY MAP NASA-WSTF AND VICINITY
PLATE 2-2	SPONTANEOUS POTENTIAL AND RESISTIVITY LOGS FOR JPZ-2 AND WELL J
PLATE 5-1	CROSS SECTION LOCATION MAP NASA-WSTF AND VICINITY
PLATE 5-2	CROSS SECTION A-A' NASA-WSTF AND VICINITY
PLATE 6-1	SUMMARY OF RESULTS OF HYDRAULIC TESTS NASA-WSTF AND VICINITY

1.0 EXECUTIVE SUMMARY

NASA-White Sands Test Facility (NASA-WSTF) conducted a multiple well aquifer test on March 9-13, 1989 to characterize the hydraulic properties of the thick alluvial aquifer of the Jornada del Muerto Basin located west of the facility boundary. One of WSTF's water supply wells (Well J) was used as the pumping well and five temporary piezometers were installed at different radii ranging from 150 to 1000 feet from Well J to permit drawdown and recovery measurements in the immediate pumping well vicinity. Drawdown was also recorded in six groundwater monitoring wells located at distances from 0.9 to 1.7 miles from the pumping well. The data were analyzed using pumping and recovery methods developed by C.V. Theis (Lohman, 1979) and I.S. Papadopulos (1976).

Pump test results and geologic interpretations indicate that the aquifer study area is located within a prograding alluvial fan sequence and behaves as a leaky confined aquifer with an average apparent transmissivity of 1.6 to 1.7 x 10^{-1} ft^2/sec based on Theis' methods of drawdown and recovery analyses. The Papadopulos method was used to evaluate horizontal, anisotropic conditions in the aquifer. The major axis of transmissivity was determined to be oriented N80°W with a magnitude of 2.3 x 10^{-1} ft^2/sec. The minor axis of transmissivity is oriented N10°E with a magnitude of 1.1 x 10^{-1} ft^2/sec. These values indicate that lateral groundwater flow at Well J may be slightly more to the northwest than the direction predicted from observed hydraulic gradients. The true storage coefficient is 0.00029.

Observations at a two piezometer cluster completed in the alluvial aquifer demonstrated the existence of a downward, vertical hydraulic gradient. Head difference in the piezometers suggest a vertical gradient of 0.002.

2.0 WELLS AND PIEZOMETERS

2.1 WATER SUPPLY WELLS

WSTF water supply wells, Wells I and J, are located in Sections 30 and 31, T.20.S, R.3.E, respectively (Plate 2-1). Well J was selected as the pumping well because of its documented high capacity and its proximity to other observation wells.

Well J was drilled in 1963 to a total depth of 939 feet in alluvial deposits and completed at a depth of 850 feet below grade. The borehole diameter is 16 inches and the well was completed with 12-3/4 inch outside diameter casing with 3/16 x 2 inch mill-slot screen. A natural filter pack was utilized. The screened (slotted) intervals are from 419 to 697 feet and 737 to 840 feet below grade (see completion diagram in Appendix A). The pump bowls were set at a depth of 540 feet.

The Well J resistivity log (Plate 2-2) indicates that a coarsening upward sequence exists in the alluvial section between 372 to 842 feet in depth. This is interpreted as being an alluvial fan sequence based on geophysical logs, lithology log (Appendix A) and geologic analysis of the depositional environment. The alluvium encountered in this and all other wells discussed in this report is considered to be part of the Quaternary/Tertiary Santa Fe Group. The Santa Fe Group can be generalized as a basin-fill deposit consisting of poorly to moderately consolidated, pebble to cobble conglomerate with sand, silt and clay layers distributed throughout.

The existing turbine pump installed in Well J was used in the aquifer test and produced an average discharge rate of 542 gallons per minute. Stagnant water from the well casing was discharged to grade adjacent to the Well J pumphouse during the first two minutes of the test. The water was then directed into a pipeline connected to Well I and discharged to grade at that location (approximately 2500 feet to the northwest).

Well I was also drilled in 1963 to a total depth of 860 feet in alluvial sediments. Based on the lithology log (Appendix A) the sequence is believed to be a coarsening upward, alluvial fan sequence similar to that encountered in Well J.

2.2 PIEZOMETERS

Five temporary piezometers, JPZ-1 through JPZ-5 (Plate 2-1, Table 2-1), were installed to permit water level recording within a 1000 foot radius from Well J during the aquifer test. The piezometers were located on three distinct directional axes to accommodate the use of Papadopulos' method (1965) for analyzing aquifer tests in anisotropic aquifers. Each piezometer was completed with a 5-foot, 0.020 inch slot well-point. Detailed lithologic data and completion diagrams are included in Appendix A for piezometer JPZ-1 through JPZ-5.

JPZ-1, located approximately 150 feet west of Well J, was drilled to a total depth of 425 feet and completed with the top of the screen located at 417 feet below grade. Silica sand (8/20 grade) was used to construct a filter pack around the screen to a depth of 391 feet. 16/40 grade silica sand was introduced into the annulus to a depth of 310 feet. This piezometer was developed by air-jetting.

Sediments encountered during drilling of JPZ-1 were predominantly clay to a depth of 385 feet (top of aquifer). From 385 feet to total depth the aquifer sediments consisted of alluvial sand and gravel (Appendix A). Static water level was determined to be 330.92 feet below top-of-casing immediately prior to the test.

JPZ-2, located adjacent to JPZ-1, was drilled to a total depth of 607 feet and completed with the top of the screen located at 568 feet below grade. No filter pack was installed since the formation collapsed around the screen forming a natural filter pack. Pumping and air-jetting were used in well development. This piezometer penetrated the deepest into the water bearing zone and was logged with geophysical tools to aid in interpretation and screen placement. The resistivity log from JPZ-2 (Plate 2-2) is virtually identical to the one from Well J.

The top of the aquifer was encountered at a depth of 373 feet below grade and a coarsening upward sequence is evident from a depth of 500 feet extending to the end of the geophysical log. The well-site geologist's notes and lithologic log (Appendix A) show the sediments to be predominantly clay from approximately 70 to 370 feet in depth. Sand and gravel dominate below 370 feet.

TABLE 2-1

PIEZOMETER DATA SUMMARY

PIEZOMETER	NORTHING[1]	EASTING[1]	ELEVATION[2]	DEPTH TO WATER[2]	PREPUMPING WATER ELEVATION[3]	DEPTH TO SCREEN
JPZ-1	231177.75	394218.25	4401.31	330.92	4070.89	417′
JPZ-2	231204.34	394217.92	4401.45	330.89	4070.56	568′
JPZ-3	231683.11	394506.37	4405.92	335.17	4070.75	417′
JPZ-4	230438.45	394999.64	NO DATUM: SURVEY ERROR	338.19	NO DATUM: SURVEY ERROR	388′
JPZ-5	231154.68	393866.88	4397.48	326.54	4070.94	416′

[1] White Sands Transverse Mercator System
[2] Reference Point: Top of casing (in feet)
[3] Reference Point: Mean sea level (in feet)

Immediately prior to the test, static water level was determined to be 330.89 feet below top-of-casing. JPZ-1 and JPZ-2 comprised a piezometer nest used to measure vertical gradients within the aquifer.

JPZ-3, located approximately 500 feet northeast of Well J, was drilled to a total depth of 425 feet and completed with the top of the screen at 417 feet below grade. A natural filter pack surrounds the well screen and the piezometer was developed by air-jetting.

Sediments from ground surface to a depth of 45 feet were predominantly silt and silty clay. Lithology observed from 45 to 395 feet is predominantly clay. From 395 feet to total depth, coarse, gravelly alluvium was encountered. Static water level was determined to be 335.17 feet below top-of-casing.

JPZ-4, located approximately 1000 feet southeast of Well J, was drilled to a total depth of 395 feet and completed with the top of the screen at 388 feet below ground level. A filter pack of 8/20 grade sand was placed around the well screen to a depth of 378 feet. Natural formation material (slough) collapsed above the gravel pack to a depth of 323 feet. The piezometer was developed by bailing and air jetting to promote the formation of a natural gravel pack around the well screen.

Sediments from ground surface to a depth of 350 feet were predominantly clay. Cemented gravelly alluvium was encountered at 350 feet and extended to total depth. Water was first encountered at a depth of 365 feet below ground level and static water level was determined to be 338.19 feet below top-of-casing.

JPZ-5, located approximately 500 west of Well J, was drilled to a total depth of 425 feet and completed with the top of the screen at 416 feet below ground level. A natural filter pack surrounds the well screen to a depth of 416 feet below grade. An 8/20 grade sand was installed above the natural pack and the piezometer was developed by air-jetting.

Sediments were predominantly clay from ground surface to a depth of 400 feet, where gravelly alluvium was encountered. Water was first detected at a depth of 390 feet below ground level and

static water level was determined to be 326.54 feet below top-of-casing immediately prior to the test.

2.3 MONITOR WELLS

Six groundwater monitoring wells (Plate 2-1) were selected as observation wells for the aquifer test: WW-1-452, JP-2-447, PL-2-504, PL-3-453, BLM-8-418, and BLM-5-527. These wells were selected on the basis of their proximity to Well J. The primary objective in monitoring these wells was to detect and record aquifer response over large distances from the pumping well. Water level measurements from any wells that proved to be beyond the influence of the test would also provide secondary data on natural background water level variations. All monitoring wells were completed with 0.020 inch continuous slot screen and a filter pack of 8/20 grade silica sand. Detailed construction and lithologic information for each of these wells can be found in Appendix A.

Monitor well WW-1-452, located 4700 feet southeast of Well J, was drilled to a total depth of 488 feet and completed with a screened interval from 451.9 to 462.2 feet below ground level. Water was first detected at a depth of approximately 450 feet. Static water level immediately prior to the test was 386.55 feet below top-of-casing. This well penetrates a poorly to moderately consolidated, pebble to cobble conglomerate from ground surface to total depth. Intervals of finer-grained material were noted from 370 feet to total depth.

Monitor well JP-2-447, located approximately 6600 feet south of Well J, was drilled to a total depth of 470 feet and completed with a screened interval from 446.5 to 456.9 feet below ground level. Water was first detected between 440 and 450 feet. Static water level in the completed well was 373.8 feet below top-of-casing immediately prior to the test. This well is installed in alluvium with a high clay content (10-50%) from a depth of 125 to 315 feet. Heaving sands were encountered from 460 to 470 feet below ground level.

Monitor well PL-3-453, located approximately 8300 feet southeast of Well J, was drilled to a total depth of 497 feet and completed with a screened interval from 453.4 to 463.8 feet below ground surface. Clay-rich alluvium was encountered from ground surface to a depth of 90 feet. From 90 feet to total depth the sediments were a gravelly alluvium. Water was first detected at ap-

proximately 457 feet below ground level during drilling of the well. Static water level in the completed well was observed at 428.05 feet below top-of-casing prior to the test.

Monitor well PL-2-504, located approximately 7700 feet from well J, was drilled to a total depth of 532 feet and completed with a screened interval from 504.0 to 514.4 feet below ground level. The first five feet of alluvium was cemented with caliche. From 5 feet to total depth the alluvium was gravelly. Clay layers were noted in the upper part of the section, principally from: 45 to 50 feet, 65 to 100 feet, 115 to 120 feet, 155 to 170 feet, and 195 to 200 feet. Water was first detected at approximately 485 feet and static water level in the completed well was determined to be 435.5 feet below top-of-casing immediately prior to the test.

Monitor well BLM-8-418, located approximately 9200 feet east of Well J, is one of two wells completed in a bedrock aquifer. The total depth of the borehole was 452 feet and the well was completed with a screened interval from 418 to 428.4 feet below ground surface. A clay-rich alluvium was encountered from ground surface to a depth of 105 feet. From 105 to 425 feet a coarser, unconsolidated to moderately consolidated, pebble to boulder conglomerate was observed. A vesicular, air-fall tuff was encountered at a depth of 410 feet and extended to total depth. A detailed core description can be found in Appendix A. Water was first detected at a depth of 426 feet. Static water level in the completed well was determined to be 321.93 feet below top-of-casing prior to the test.

Monitor well BLM-5-527, located approximately 9200 feet east of Well J, was also completed in bedrock. This borehole was drilled to a total depth of 560 feet and the well was completed with a screened interval from 527.3 to 537.7 feet below ground level. Sediments consisted of gravelly alluvium from ground surface to a depth of 35 feet. A poorly to well-consolidated pebble to cobble conglomerate was encountered from 35 to 365 feet. A fractured, flow-banded rhyolite was encountered at 365 feet and extended to total depth of the well (see core descriptions in Appendix A). Water was first detected between 528 and 560 feet below ground level. Static water level was determined to be 479.79 feet below top-of-casing prior to the test.

3.0 PUMPING AND WATER LEVEL RECORDING

To assure successful recording and completeness of pump test data during the test, three independent recording systems were employed:

- All water levels were measured manually with electronic water level probes.
- An In Situ Hermit 2000 data logging and transducer system was used to automatically record water levels in the piezometers.
- A data logging and transducer system constructed by GCL was used to provide a back up system for the Hermit 2000 transducers and data logger in all piezometers.

The In Situ and GCL data logging systems used separate pressure transducers submerged in the piezometers to sense changes in water levels. These changes were automatically recorded in a digital format in the logging unit's memories.

3.1 WELL J

The WSTF water supply tank was filled and all pumping was ceased two days prior to the test to allow aquifer conditions at Well J to recover. The existing pump in Well J was used in the aquifer test and the discharge through the pipeline was measured with an externally mounted digital flow meter. Discharge was recorded hourly by the pump operator. Figure 3-1 is a graph of the pump discharge during the aquifer test. The time weighted average discharge during the test was 542 gallons per minute.

Water was initially discharged through a short pipe at Well J to clear the casing of loose rust and scale during the first two minutes of pumping. The water was then redirected through a water supply line connected to Well I and discharged to grade at that location (2500 feet away). Discharge at this location prevented flooding at the test site and eliminated risks that discharged water might affect the aquifer test. A perturbation in the drawdown response was observed during the rerouting of the discharge (Figure 3-2).

Water level recording in Well J proved to be impractical. Pump lubricating oil floating on top of the water fouled the water level probe making accurate readings impossible. In addition, the access

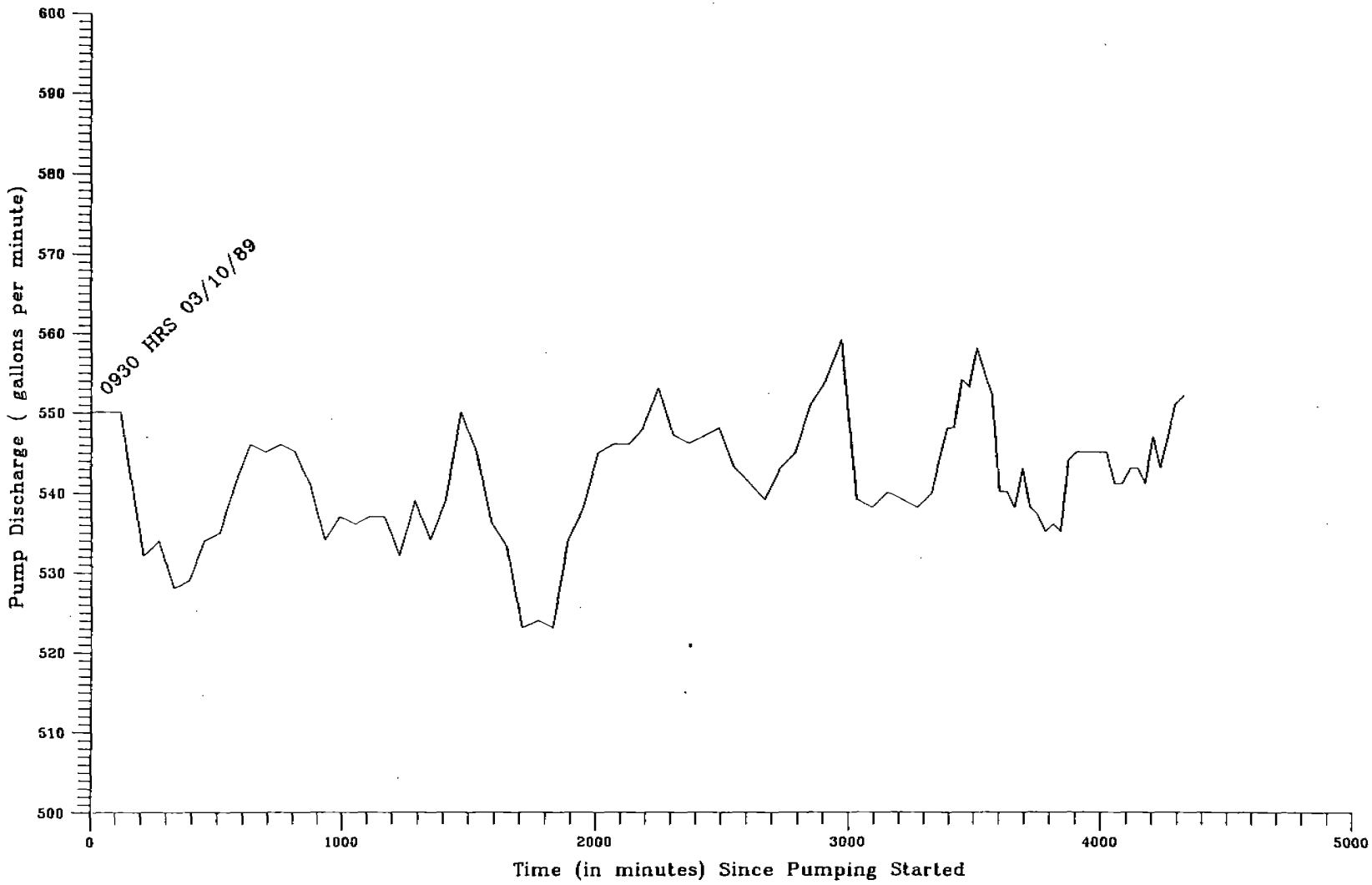


FIGURE 3–1. DISCHARGE DURING THE AQUIFER TEST AT WELL J, NASA–WSTF.

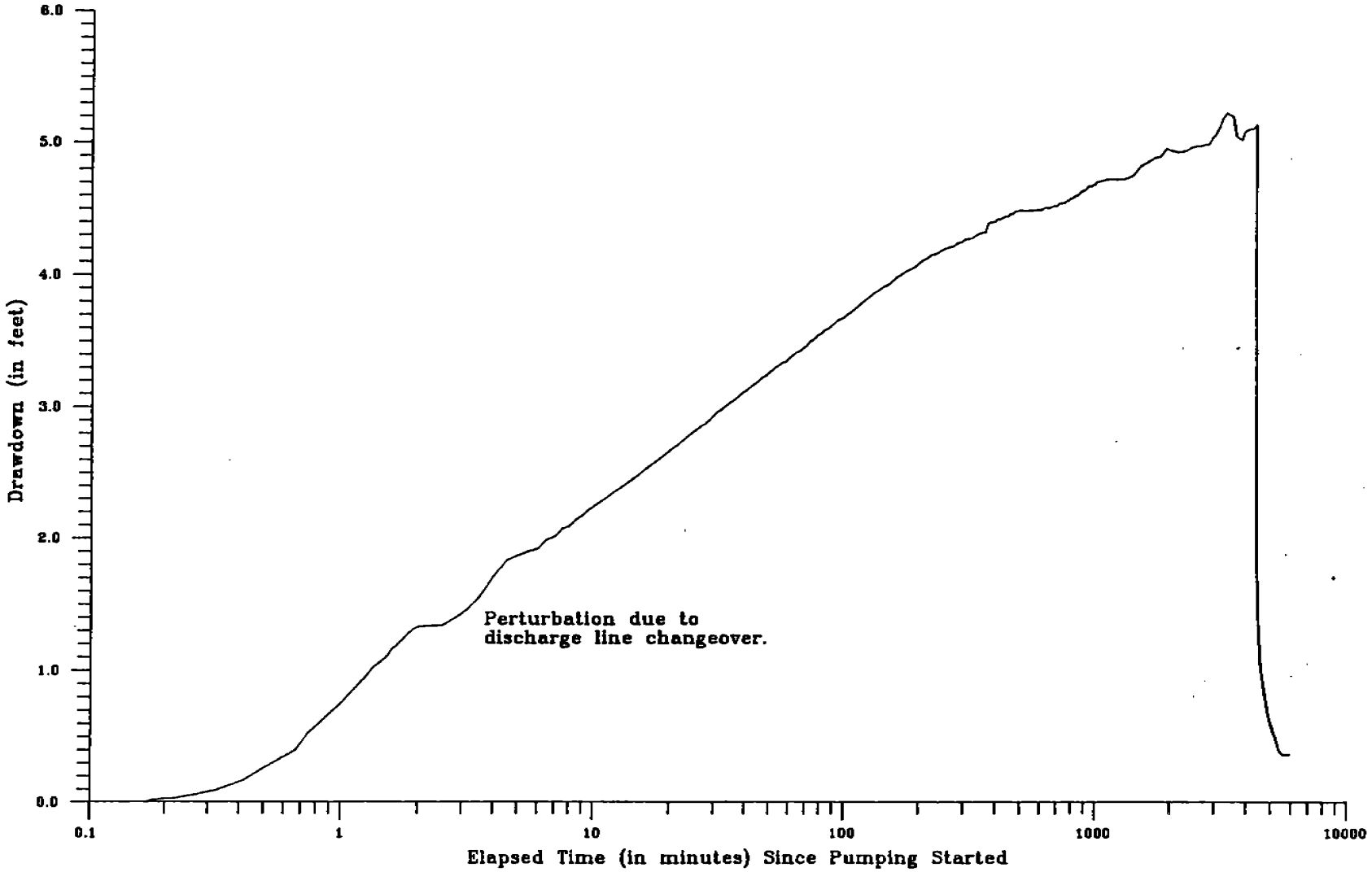


FIGURE 3-2. RESPONSE OF PIEZOMETER JPZ-1.

port was too small to accept the transducer units. A smaller transducer housing was fabricated and installed for the recovery phase of the test; unfortunately that housing developed a leak and the transducer failed. Water levels were not recorded in Well I because an obstruction in the well casing made it impossible to reach the water level with a probe.

3.2 PIEZOMETERS

3.2.1 Test Preparation

Water levels in the piezometers were recorded at two hour intervals beginning fifteen and a half hours prior to the test to confirm that the aquifer had reached equilibrium. Figure 3-3 shows the water level fluctuations recorded in all piezometers during this period. Water level fluctuations were very similar and indicate barometric effects. Water level elevations in the piezometers were in the range of 4070.6 to 4070.9 feet above mean sea level (A.M.S.L.) immediately prior to the test indicating that the piezometric surface was nearly horizontal and at equilibrium at the onset of the test.

Differences in piezometric surface elevations were observed in the JPZ-1 (4070.89 ft. A.M.S.L.) and JPZ-2 (4070.56 ft. A.M.S.L.) piezometer cluster prior to the test. The screen in JPZ-2 is located 151 feet deeper than that in JPZ-1 and differences in water level elevations represent a potential downward vertical gradient of 0.002.

3.2.2 Manual Recording

Water levels were recorded at progressively greater intervals during the first two hours of pumping (Appendix B). They were then recorded hourly for the next six hours, at two hour intervals for the next six hours, and at four hour intervals during the remainder of the pumping phase. The same recording schedule was followed during the recovery phase of the test. Variations between individual probes were corrected by calibrating them against each other at the same time in a single well.

Wristwatches were used for time keeping, synchronized with the internal clock in the In Situ data logger. All personnel were informed of the start time of the pumping and/or recovery phase and

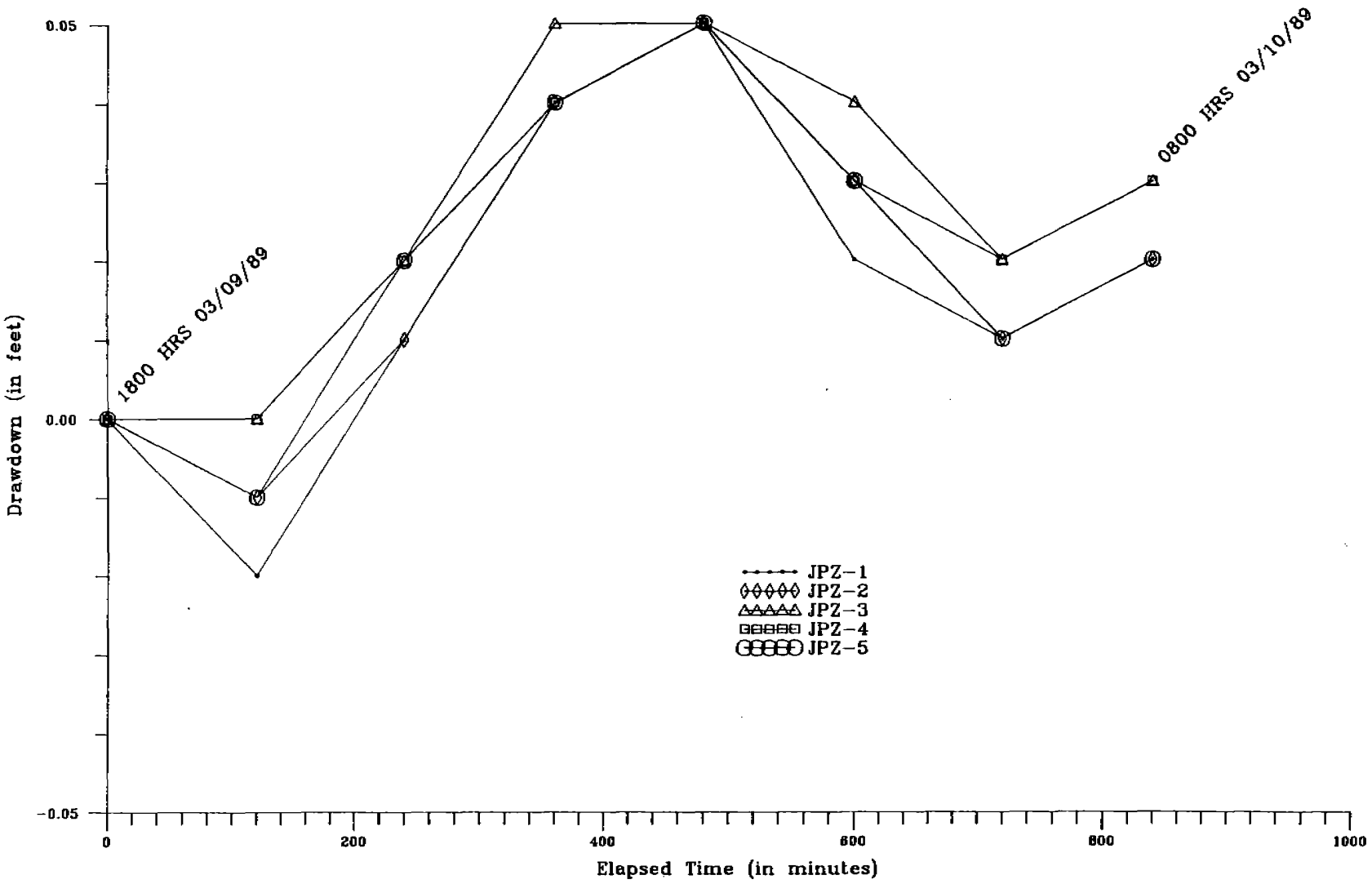


FIGURE 3-3. WATER LEVEL FLUCTUATION IN PIEZOMETERS JPZ-1 THROUGH JPZ-5 PRIOR TO WELL J AQUIFER TEST.

recordings were begun at the appointed time. The use of synchronized watches proved to be simpler and more reliable than either audible or radio signals.

Field data reduction comprised converting water levels to drawdown, applying barometric corrections derived from background wells, and plotting data by hand to monitor test progress and aid in decision making. Field records are reproduced in Appendix B.

3.2.3 Digital Recording

Transducers were installed in the piezometers to test and calibrate the systems two weeks prior to the scheduled test date. During the week immediately prior to the test, a "dry run" was conducted, including pump start and recording, to familiarize all personnel with their responsibilities.

Final calibration of test equipment was performed two days prior to the test. The GCL data logger was calibrated by suspending the transducers in the piezometers and marking the transducer cables at measured intervals. "Zero" settings were then made by raising the transducers to just above the water surface. "Span" settings were made with transducers submerged to nominal test depth. The linearity of response was then checked using intermediate depth settings. Calibrations were checked by the same method and repeated if necessary.

Calibration of the In Situ Hermit 2000 consisted of entering scale factors for each transducer into the logging unit. The response of each transducer was checked using the method described for the GCL data logger. Both data logging systems were tested during the "dry run" prior to the actual aquifer test.

The internal clock in the Hermit 2000 data logger was selected as the master clock and all other clocks were synchronized with it. Pumping, manual recording and digital recording were all started simultaneously using the synchronized clocks. The same procedure was used when the pump was shut off for the recovery phase of the test.

After termination of the aquifer test all digitally recorded data were down loaded to a computer for reduction and plotting. The raw data are reproduced in Appendix C.

3.3 MONITOR WELLS

Water levels in monitoring wells were recorded at hourly intervals for the first twelve hours and every four hours thereafter. That schedule was repeated during the recovery phase of the test.

An Enviro-Labs EL-120 data logger and manual recordings were used to record water level changes at WW-1-452. The EL-120 was set up and calibrated in the same manner as the other data loggers.

Water level data were reduced in the field, corrections applied, converted to drawdown, and plotted on graph paper.

3.4 BAROMETRIC PRESSURE RECORDING

Barometric pressure variations during the test were recorded with a strip chart barograph. The barograph was calibrated periodically by marking the chart with an absolute air pressure reading obtained from Atmospheric Science Laboratory located at the White Sands Missile Range. Absolute atmospheric pressures were corrected for the elevation of the barograph at WSTF (4808 feet above mean-level) and transcribed for computer plotting. The barograph record for the pump test is reproduced in Appendix D.

4.0 DATA REDUCTION

4.1 BAROMETRIC CORRECTION

Changes in static water levels in a confined aquifer due to barometric fluctuations must be filtered from data prior to detailed analysis. Barometric effects on "background" well data (wells within the same aquifer which are unaffected by pumping stresses) can be subtracted from other observation wells to get corrected (residual) drawdown data. Figure 4-1 shows the hydrographs of the six distant monitoring wells which were observed during the test. The vertical axis reflects "Drawdown", therefore, negative numbers indicate a rise in water level.

The hydrographs of BLM-5-527, PL-2-504, and PL-3-453 show a rise in water levels during the test and are very similar in form despite their wide geographical separation. The data indicates that these wells are unaffected by pumping at Well J and may be considered background wells. PL-3-453 was selected as the background well that would be monitored during the recovery phase.

Monitor wells WW-1-452 and JP-2-447 showed less rise in water levels than the three background wells indicating that they were possibly affected by pumping of Well J. Monitor well BLM-8-418 is believed to be hydraulically isolated from other wells in the area based on anomalous water levels reported in the Second Interim Hydrogeologic Report (Geoscience Consultants, Ltd, 1989) and the anomalous response observed during the test.

Figure 4-2 shows the hydrographs of monitor wells WW-1-452, JP-2-447, and PL-3-453 as compared to recorded changes in barometric pressure during the test. Barometric pressure and drawdowns are plotted as changes in feet of water for ease of comparison. In confined aquifers decreasing barometric pressure causes a rise (or negative drawdown) in water level. It is clear from Figure 4-2 that the response of PL-3-453 is delayed and dampened with respect to barometric changes and that other background wells (PL-2-504, BLM-5-567) respond similarly. For these reasons, the responses observed at PL-3-453 were used as barometric corrections to be subtracted from the responses of all other wells.

4.2 SELECTION OF DATA SETS FOR ANALYSIS

Where several sets of data were collected for an observation well, one set was selected for analysis

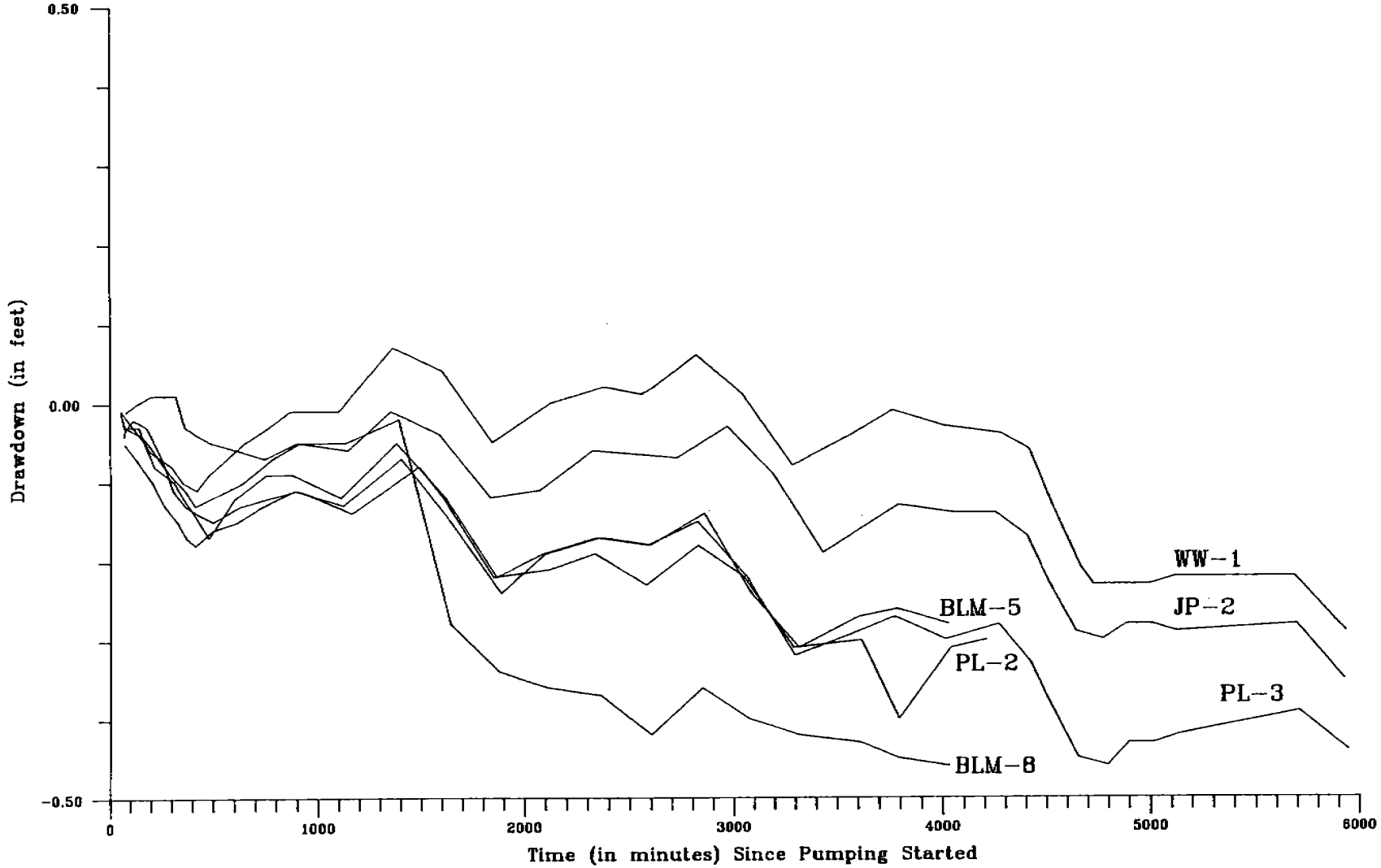


FIGURE 4-1. WATER LEVEL CHANGE IN SIX DISTANT MONITOR WELLS DURING THE AQUIFER TEST AT WELL J.

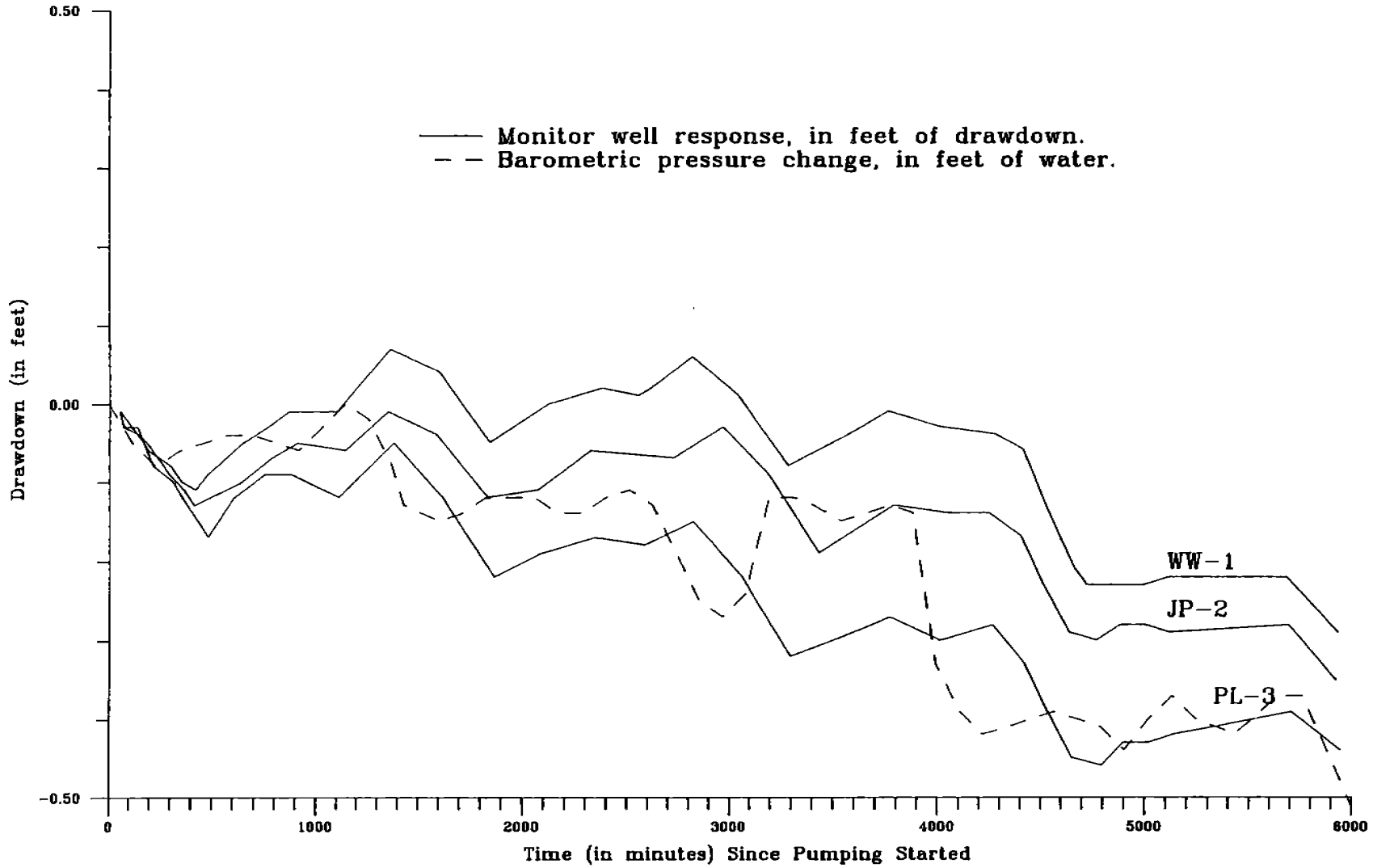


FIGURE 4-2. WATER LEVEL CHANGE IN THREE MONITOR WELLS, COMPARED TO THE CHANGE IN BAROMETRIC PRESSURE.

on the basis of completeness and freedom from obvious anomalies. The data recorded from the In Situ Hermit 2000 data logger proved to be the best data set and was used for quantitative analysis for this test. Wells JP-2-447 and WW-1-452 were excluded from quantitative analysis because the magnitudes of their responses were less than the barometric correction. JPZ-2 which was completed with its screened interval located deeper in the aquifer was treated separately in the analysis of pump test data.

5.0 INTERPRETATION: LEAKY-CONFINED, ANISOTROPIC ALLUVIAL AQUIFER

Geologic data support an interpretation that the aquifer in the vicinity of Well J is an alluvial fan sequence which behaves as a confined aquifer with leakage from below. This hypothesis was supported by evaluation of the pump test data and formed the basis for the quantitative analysis of the aquifer test data which follows.

5.1 EVIDENCE FOR AN ALLUVIAL FAN SEQUENCE

All wells and piezometers in the vicinity of Well J penetrate alluvial deposits of the Santa Fe Group. Plate 5-1 shows the location of cross section A-A' (Plate 5-2), which illustrates the vertical distribution of lithologies within the alluvium. All five piezometers drilled for the test penetrate a thick clay layer (QT_{a1} on cross section A-A') from near ground surface to a depth of 350 to 400 feet below ground level. Immediately below the clay layer, a coarser, gravelly alluvium with interbedded fine-grain layers (QT_{a3} on cross section A-A') was encountered. Monitor well WW-1-452 encountered a smaller percentage of clay (QT_{a2} on cross section A-A') than wells to the north and south. This condition may be due to the lobate shape of alluvial fan deposits. The resistivity logs from piezometer JPZ-2 and Well J (see Plate 2-2) show the clay layer as a zone of low resistance to a depth of 380 and 372 feet, respectively. Below those depths, the resistivity increases markedly as coarser materials are encountered. Several "shale kicks", or zones of low resistivity which are indicative of finer grained material, are noted in the upper portion of the aquifer. At greater depths in the aquifer resistivity decreases, indicating a higher percentage of fine sediments in the alluvium. The bottom of the aquifer is interpreted to be at a depth of 834 feet where the resistivity indicates a preponderance of clays in the sediments. This coarsening-upward sequence and the nature of the sediments are typical of a prograding alluvial fan sequence.

5.2 EVIDENCE FOR LEAKY CONFINED CONDITIONS

The thick clay layer noted in all five piezometers (see Plate 5-2) indicates the presence of an upper confining layer overlying the saturated gravelly alluvium. A sudden influx of water into the borehole was observed in four of the five piezometers upon entering the coarser sediments during drilling. Water levels rose from 27 to 60 feet above the depths where water was first detected in these boreholes. Water was detected within the clay layers in JPZ-3 and no rise in static water level was observed upon penetrating into the coarser sediments. This latter condition could result

from fractures in the clay permitting water to rise into the confining layer and migrate horizontally along thin permeable beds. All piezometers with the exception of JPZ-3 clearly exhibited confined conditions. Therefore, the leakage observed in JPZ-3 is considered to be of local areal extent.

Cross section A-A' (Plate 5-2) shows that the bottom of the clay layer is above the piezometric surface in the vicinity of monitor well WW-1-452. The upper confining layer in this area may be a series of thin clay layers or zones of highly cemented alluvium.

Relatively little information is available concerning the lower confining bed within the alluvium. The resistivity log from Well J (see Plate 2-2) indicates an increasing clay content to a depth of 930 feet below ground surface. While there are no data on hydraulic conditions below 930 feet, it is possible that the alluvial fan sequence might be repeated at depth. Whether or not that is the case, the saturated sediments beneath the alluvial fan sequence are a potential source of leakage into the aquifer.

5.3 EVIDENCE FOR ANISOTROPY

A prograding alluvial fan sequence has been proposed as a model for the aquifer conditions encountered based on geologic interpretations and the depositional environment observed at WSTF. Sediments on an alluvial fan are deposited in channels, which generally radiate from the apex. While considerable local variation in channel orientation can be expected, on the average, channels will be oriented perpendicular to mountain from which their sediments were derived. This preferred channel orientation would produce an anisotropy in the transmissivity of the sediments such that the major axis of anisotropy would be approximately parallel to the channels and approximately perpendicular to the mountain front. While the orientation of the transmissivity axes would be spatially variable, the average trend of the major axis would be perpendicular to the mountain front or approximately east-west.

Based on these geologic interpretations it is reasonable to adopt the following model for the purposes of hydraulic interpretation:

The Well J fully penetrates a leaky-confined anisotropic aquifer of "infinite" areal extent, whose piezometric surface was horizontal prior to pumping.

5.4 ESTIMATING AQUIFER PARAMETERS

5.4.1 Pumping Phase Analysis: Theis' Drawdown Method

Hydrographs showing the final corrected drawdowns for piezometers JPZ-1, JPZ-2, JPZ-3, JPZ-4, and JPZ-5 are reproduced in Figure 5-1. The hydrographs were analyzed using the curve-match method developed by C.V. Theis as modified by Hantush and Jacob (Lohman, 1979). Computer plotted hydrographs were matched to the type curves provided by Lohman and the match points were picked by hand. For convenience in computation, the match points were chosen so that the values of u (the variable of integration in the Theis equation) and W(u) (the well function) were equal to one. The values of s (drawdown) and t (time) at each match point can be read from Figure 5-1, and are shown in Appendix E. Aquifer transmissivity and storage coefficient for the pumping phase of the test were then computed for each piezometer according to the standard formulae. The results of calculations are presented in Table 5-1, and the calculations are reproduced in Appendix E. The apparent storage coefficients derived by this method are affected by aquifer anisotropy, which is probably responsible for the variation in computed values for that parameter. Hantush leakage parameter (β) is similarly affected and is therefore not reported. Casing storage was not a factor in this test due to the high discharge rate. Under test conditions, the effect of casing storage became negligible after approximately two minutes. Small-scale fluctuations in the initial 30 seconds of data from JPZ-3, possibly caused by manual data recording or transducer instability, were not graphed on drawdown curves in Figure 5-1.

Piezometer JPZ-2 was screened deeper in the aquifer than JPZ-1 and showed a slightly lower apparent transmissivity. Decreasing transmissivity with depth would be consistent with a coarsening upward alluvial fan sequence and, while the evidence from JPZ-1 and JPZ-2 is not conclusive, it does support that hypothesis.

5.4.2 Recovery Phase Analysis: Theis' Recovery Method

Recovery data were collected from each of the observation piezometers for a period of 27 hours after termination of pumping from Well J. Data collected from the In Situ data logger were

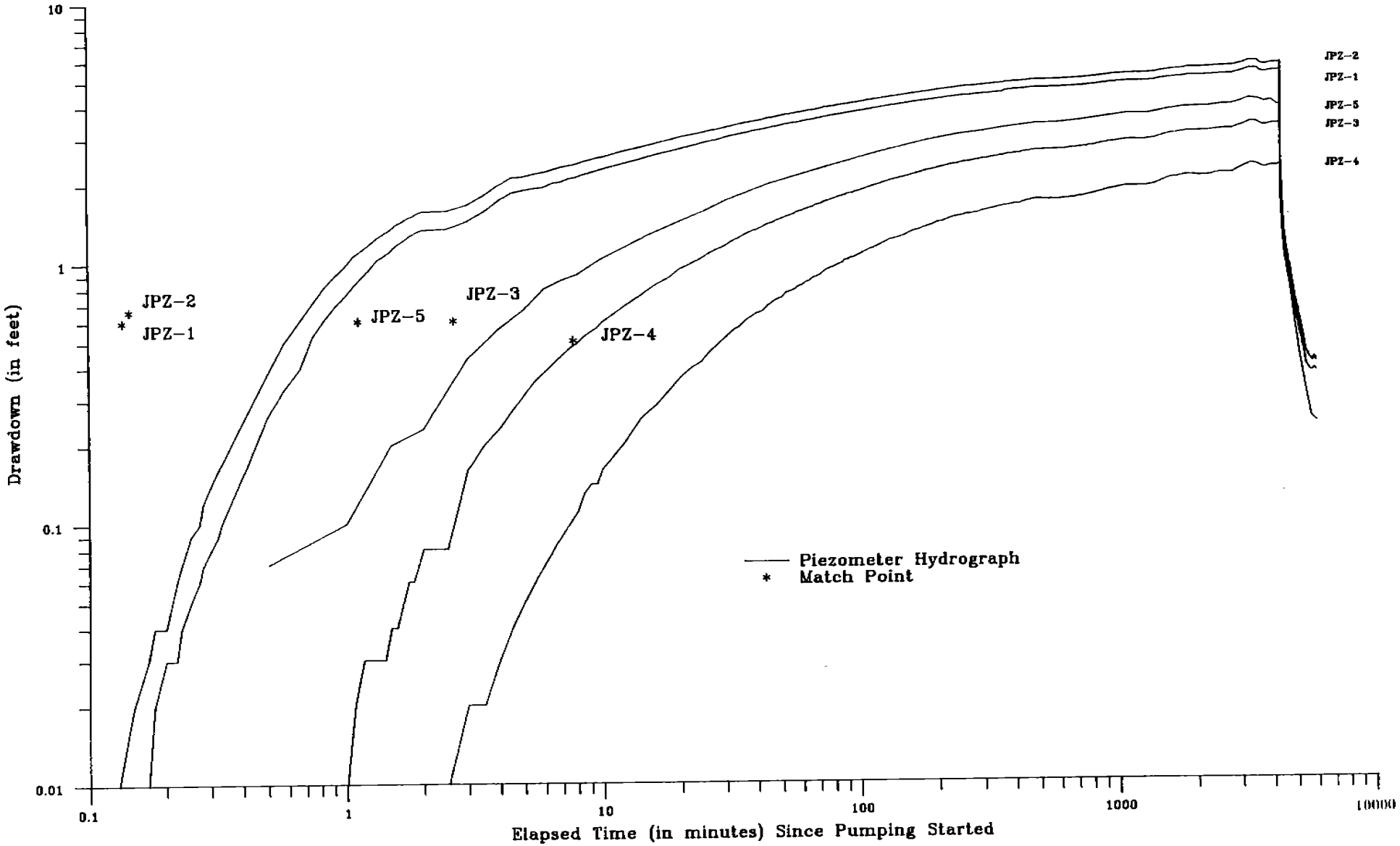


FIGURE 5-1. WELL J AQUIFER TEST: PIEZOMETER HYDROGRAPHS.

TABLE 5-1

ESTIMATED AQUIFER PARAMETERS FOR PUMPING PHASE DATA
USING THE THEIS METHOD

PIEZOMETER	APPARENT TRANSMISSIVITY (ft^2/sec)	APPARENT STORAGE COEFFICIENT	DISTANCE FROM PUMPING WELL (Feet)
JPZ-1	0.16	0.00023	150
JPZ-2	0.15	0.00023	147
JPZ-3	0.16	0.00041	494
JPZ-4	0.19	0.00036	999
JPZ-5	0.16	0.00017	501

Average apparent transmissivity 0.16 ft^2/sec.

Average apparent storage coefficient 0.00028.

corrected for barometric influences and analyzed using Theis' recovery method (from Kruseman and De Ridden, 1983). Recovery data can be found in Appendix B and C.

Results of recovery data analysis indicate apparent aquifer transmissivities range from 0.15 ft^2/s to 0.22 ft^2/s. The average apparent transmissivity of all individual results is 0.17 ft^2/s (Table 5-2). These results are in good agreement with values obtained from the pumping data analysis. The storage coefficient cannot be determined by the Theis recovery method. The recovery curve and data calculations for each piezometer is given in Appendix E.

Review of the recovery plots indicate that the intersection of the data with the graph does not occur at the graph origin ($s' = 0$, $t/t' = 1$) as expected in a true Theisian aquifer. The cause of this offset is interpreted to be a reduction in aquifer storage resulting from a pressure decrease which developed during the pumping period.

5.4.3 Determination of the Principle Axes of Transmissivity: Papadopulos' Method

The transmissivities and storage coefficients derived from drawdown or recovery analyses are apparent values. Papadopulos' method uses an "average" of these apparent transmissivities as input for computing the transmissivity tensor and the true storage coefficient.

Papadopulos' Method (1965) uses the two dimensional "transmissibility [transmissivity] tensor" **T**, which can be expressed in matrix notation as:

$$T = \begin{vmatrix} T_{xx} & T_{xy} \\ T_{xy} & T_{yy} \end{vmatrix}$$

where **x** and **y** are arbitrary orthogonal axes. This equation can be reduced to:

$$T = \begin{vmatrix} T_{\xi\xi} & 0 \\ 0 & T_{\eta\eta} \end{vmatrix}$$

TABLE 5-2

ESTIMATED AQUIFER PARAMETERS FOR RECOVERY PHASE DATA
USING THE THEIS METHOD

PIEZOMETER	APPARENT TRANSMISSIVITY (ft^2/sec)	APPARENT STORAGE COEFFICIENT
JPZ-1	0.15	NA
JPZ-2	0.15	NA
JPZ-3	0.17	NA
JPZ-4	0.22	NA
JPZ-5	0.16	NA

Average apparent transmissivity 0.17 ft^2/sec.

NA = Method not applicable to determine storage coefficient.

for the principal axes of transmissivity, ξ and η. Papadopulos (1965) further states:

> The distribution of drawdown around a well of constant discharge which fully penetrates an infinite anisotropic artesian aquifer is described by the following boundary value problem

$$T_{xx} \frac{\partial^2 s}{\partial x^2} + 2T_{xy} \frac{\partial^2 s}{\partial x \partial y} + T_{yy} \frac{\partial^2 s}{\partial y^2} + Q\delta(x)\delta(y) = S \frac{\partial s}{\partial t} \qquad (1)$$

$$s(x,y,0) = 0 \qquad (2)$$

$$s(\pm\infty,y,t) = 0 \qquad (3)$$

$$s(x,\pm\infty,t) = 0 \qquad (4)$$

> where s is the drawdown, T_{xy}, T_{yy} and T_{xx} the components of the transmissibility [transmissivity] tensor, S the storage coefficient, Q the discharge of the well, δ the Dirac delta function, x and y the coordinates of an arbitrary set of orthogonal axes with origin at the well, and t the time since the flow started.

Papadopulos solves this equation by taking the inverse Fourier transform with respect to y, the inverse Laplace transform, and the inverse Fourier transform with respect to x to obtain the solution:

$$s = \frac{Q}{4\pi \sqrt{T_{xx} T_{yy} - T_{xy}^2}} W(u_{xy}) \qquad (5)$$

where

$$W(u) = \int_u^\infty \frac{e^{-u}}{u} du \qquad (6)$$

and

$$u_{xy} = \frac{S}{4t} \quad \frac{T_{xx}y^2 + T_{yy}x^2 - 2T_{xy}xy}{T_{xx}\,T_{yy} - T_{xy}^2} \qquad (7)$$

Curve-matching is used as in the familiar Theis' method. Three piezometers located on different azimuths from the pumped well are selected and their drawdowns (**s**) are plotted as a function of inverse time (**1/t**) on log-log paper of the same scale as the type curve. The curves are then superimposed and, while keeping the axes parallel, shifted relative to each other until a reasonable match is obtained. Any convenient match-point can be chosen. The match-point values of $W(u_{xy})$ and s, for each piezometer, are substituted into equation (5), which is then solved for $(T_{xx}T_{yy}-T^2_{xy})$. The values thus obtained are the apparent transmissivities obtained earlier from Theis' method. According to Papadopulos, these values should be approximately the same and when they are not "judgement" should be used to obtain an average.

The average value of $(T_{xx}T_{yy}-T^2_{xy})$ and the match-point values for u_{xy} and **1/t** are then substituted into equation (7); yielding three equations, which can be solved for the three unknowns: ST_{xx}, ST_{yy}, and ST_{xy}. S is obtained by solving these products for T_{xx}, T_{yy}, and T_{xy} in terms of S and substituting into $(T_{xx}T_{yy}-T^2_{xy})$, whose value is known. The values of T_{xx}, T_{yy}, and T_{xy} are determined by substitution S into the products: ST_{xx}, ST_{yy}, and ST_{xy}, whose values were determined previously then substituted into the products: ST_{xx}, ST_{yy}, and ST_{xy} whose values are known.

Finally, the maximum ($T_{\xi\xi}$) and minimum ($T_{\eta\eta}$) principal axes of transmissivity and their orientations are found by substituting into the following equations:

$$T_{\xi\xi} = 1/2\ \{(T_{xx}+T_{yy})+[(T_{xx}-T_{yy})^2+4T^2_{xy}]^{1/2}\}$$

$$T_{\eta\eta} = 1/2\ \{(T_{xx}+T_{yy})-[(T_{xx}-T_{yy})^2+4T^2_{xy}]^{1/2}\}$$

$$\theta = \arctan\ ((T_{\xi\xi}-T_{xx})/T_{xy})$$

θ is the angle between the x axis and the ξ axis, positive in the counterclockwise direction.

The complete calculations for the Well J pump test based on Papadopulos' method are reproduced in Appendix F.

The values obtained from these calculations using pumping phase data are:

$S = 0.00029$

$T_{\xi\xi} = 2.3 \times 10^{-1}$ ft^2/sec

$T_{\eta\eta} = 1.1 \times 10^{-1}$ ft^2/sec

$\theta = -10°$

6.0 SUMMARY OF AQUIFER TEST RESULTS

The thick alluvial aquifer in the vicinity of NASA water supply Well J is interpreted to be a leaky-confined anisotropic aquifer approximately 470 feet thick. Leakage into the aquifer is considered to occur from below.

Transmissivity (T) values derived from Theis analyses range from 0.15 ft^2/s to 0.22 ft^2/s and average 0.17 ft^2/s for the five observation piezometers. The average storage coefficient calculated from pumping data is 0.00028. Papadopulos' (1965) method suggests the presence aquifer anisotropy with a maximum transmissivity ($T_{\xi\xi}$) of 0.23 ft^2/s oriented N80°W and a minimum transmissivity ($T_{\eta\eta}$) of 0.11 ft^2/s oriented N10°E. The true storage coefficient derived from this method is 0.00029.

The calculated aquifer transmissivity and storage coefficient are similar to, and consistent with, transmissivities calculated in published pump test results in the region. The data are also consistent with slug tests results from NASA monitor wells within other portions of the thick alluvial aquifer. The results of all hydraulic tests performed at WSTF to date are shown on Plate 6-1.

The major axis of transmissivity is approximately perpendicular to the mountain source areas and is consistent with an alluvial fan depositional model for aquifer sediments. The observed anisotropy suggests that lateral groundwater movement at Well J may be slightly more northwest (10°) of the flow direction predicted from local hydraulic gradients.

Vertical movement of groundwater at Well J is suggested from the piezometer nest at JPZ-1 and JPZ-2. A downward vertical gradient of 0.002 exists in the area as defined by head differences between these piezometers.

7.0 REFERENCES

Geoscience Consultants, Ltd., 1989. Second Interim Hydrogeologic Report, NASA-JSC White Sands Test Facility, Las Cruces, New Mexico, unpublished.

Kruseman, G.P. and De Ridder, N.A., 1983. Analysis and Evaluation of Pumping Test Data. International Institute for Land Reclamation and Improvement ILRI, Wageningen, The Netherlands, 200 pp.

Lohman, W.S., 1979. Ground-Water Hydraulics. U.S. Geological Survey, Professional Paper 708, 70 pp.

Papadopulos, I.S., 1965. Non-steady Flow to a Well in an Infinite Anisotropic Aquifer. International Association of Scientific Hydrology, Symposium of Dubrovnik, p. 20-31.

APPENDIX A

LITHOLOGIC AND COMPLETION INFORMATION
FOR WELLS AND PIEZOMETERS

CORPS OF ENGINEERS
NEAR LAS CRUCES
DONA ANA COUNTY, NEW MEXICO
WATER WELLS "I" & "J"

Layne Texas Company

"The Way to Water"

WATER WELLS - TURBINE PUMPS - WATER CONDITIONING - CORE DRILLING

P. O. BOX 9000

HOUSTON 11, TEXAS

HOUSTON -:- DALLAS

PAGE 1 OF 1
FILE NO. 2785
DATE 5/29/63

WELL LOG

CUSTOMER LOCATION

FOR Corps of Engineers

LOCATION WELL Las Cruces

SURVEY Sec. 31-20S-3E, FIELD NE1/4-NE1/4-SW1/4

COUNTY Dona Ana STATE New Mexico

OTHER LAND MARKS

WELL DATA

NAME WELL WELL NO. 1

ELEVATION DATUM

AT C OR

TEST HOLE SIZE 9-7/8" TO 1000'

DATE STARTED DRILLING 4-1-63

DATE FINISHED DRILLING 4-8-63

DRILLER C. Mercer RIG NO. 18

TYPE MUD NO. SACKS

ELECTRIC LOG Yes TYPE Schlumberger

SURVEY TYPE

OTHER DRILLER: Jerry Alvis

N233200 E392700

DEPTH STRATA	EACH STRATUM	DESCRIPTION FORMATION	SAMPLES DEPTH	TYPE	NUMBER
0		Surface			
2	2	Surface soil			
39	37	Caliche & clay			
102	63	Clay & gravel			
345	243	Clay & sandy clay			
445	100	Clay & gravel			
470	25	Gravel & boulders			
1000	530	Cemented gravel & clay streaks			

Total depth 1000 ft.

LAYNE TEXAS COMPANY

HOUSTON -:- DALLAS

S. O. 7054-63
PAGE 1 OF 1
FILE NO. 2785
DATE 5/29/63

MATERIAL SETTING

CUSTOMER LOCATION

FOR Corps of Engineers

LOCATION WELL Las Cruces

SURVEY SEC. 31-20S-3E, FIELD NE1/4, NE1/4-SW1/4

COUNTY Dona Ana STATE New Mexico

OTHER LAND MARKS

WELL DATA

NAME WELL WELL NO. I

ELEVATION DATUM

TYPE WELL Straight

SURFACE CASING CEMENTED Yes NO. SACKS 30

SIZE HOLE UNDERREAMED No DEPTH

GRAVEL TYPE None NO. CU. YDS.

TYPE SCREEN Mill Slotted GAGE 3/16"

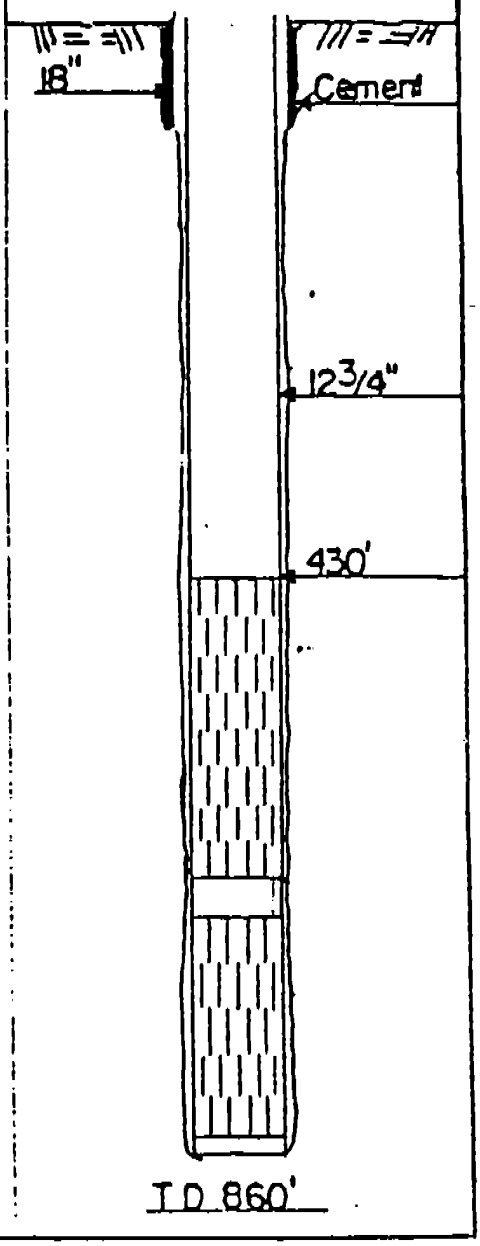
DRILLER C. Mercer RIG NO. 18

OTHER Jerry Alvis

DEPTH	LENGTH	SIZE, KIND, WEIGHT MATERIAL
+1'		18" O.D. SURFACE CASING 1' ABOVE GROUND
+1'		12-3/4" OD LINER 1' ABOVE GROUND
0		SURFACE
30'	31'	18" O.D. SURFACE CASING
430'	431'	12-3/4" O.D. BLANK LINER
660'	230'	12-3/4" OD MILL SLOTTED SCREEN 3/16" GA.
680'	20'	12-3/4" O.D. BLANK PIPE
850'	170'	12-3/4" O.D. MILL SLOTTED SCREEN 3/16" GA.
860'	10'	12-3/4" O.D. BLANK PIPE

TOTAL DEPTH 860 FT.

SKETCH



HOUSTON -:- DALLAS

PAGE 1 OF 1
FILE NO. 2785
DATE 5/29/63

WATER WELL TEST

CUSTOMER LOCATION

TEST FOR CORPS OF ENGINEERS
LOCATION OF WELL LAS CRUCES
SURVEY SEC. 31-20S-3E, FIELD NE1/4, NE1/4-SW1/4
COUNTY DONA ANA STATE NEW MEXICO
DESCRIPTION OF LAND MARKS

WELL DATA

NAME WELL WELL NO. I
ELEVATION DATUM
WELL SIZE 18" x 12-3/4" x
TOTAL DEPTH 860' TOP SCREEN 430'
GRAVEL WELL NO STRAIGHT WELL YES
TYPE SCREEN MILL SLOTTED GAGE 3/16"
TEMPERATURE OF WATER
WATER CONDITION CLEAR-NO SAND

WATER MEASURING DEVICE

ORIFICE SIZE 6"x8" LENGTH 5'
OTHER USED ELECTRICAL TAPE FOR MEASUREMENT

TEST PUMP DATA

DEPTH SETTING TOP OF BOWL 500'
LENGTH AIR LINE 500' SIZE 1"
TYPE BOWL NO. STAGES
LENGTH BOWL 14' SUCTION LT

SAND CONTENT 0 OZ PER 100 GAL.
WATER SAMPLE TAKEN NO SAMPLES
BACTERIOLOGICAL SAMPLE TAKEN

ACTIVE STATIC HEAD AFTER PUMP STOPPED

5 MIN	329.93 FT.	20 MIN.	326.26 FT.
10 MIN	327.95 FT.	25 MIN	325.77 FT.
15 MIN	326.97 FT	30 MIN	325.34 FT.

DRAWDOWN SPECIFIC CAPACITY

DATE HOUR	AIR LINE GAGE	PUMPING LEVEL	DISCH. PRESS.	HEAD ON ORIFICE INCHES	GPM	RPM	OPERATOR	REMARKS
5/1/63						850		
12:00 N		386.55		43	1010			
1:00 PM		386.88		43	1010			
2:00		388.57		43.25	1015			
3:00		388.27		42	1000			
4:00		387.26		42.50	1007			
5:00		389.00		42.50	1007			
6:00		389.41		42.50	1007			
7:00		390.27		44	1023			
8:00		389.50		42.50	1007			
9:00		389.72		43	1010			
10:00		390.40		43.25	1015			
11:00		391.40		44.50	1029			
12:00 M		389.55		42.25	1004			5/2/63
1:00 AM		389.55		42	1001			
2:00		390.50		43.50	1018			
3:00		389.65		43.50	1017			
4:00		390.50		43.50	1018			
5:00		391.00		43.50	1018			
6:00		390.65		43	1012			
7:00		390.25		42.50	1007			
8:00		390.24		42.50	1007			
9:00		389.65		42	1000			
10:00		389.53		41.50	996			
1:00		389.90		42	1000			
2:00 N		391.04		43.25	1015			

OBSERVERS

FOR OWNER

C. MERCER & JERRY ALVIS
FOR LAYNE TEXAS CO.

FORM NO 55.

HOUSTON -:- DALLAS

FILE NO. 2785

DATE 6/13/63

WELL LOG

CUSTOMER LOCATION

FOR Corps of Engineers

LOCATION WELL 20 Mi. S. of Las Cruces

SURVEY SEC. 3 LT-20-S- FIELD R-3-E

COUNTY Dona Ana STATE New Mexico

OTHER LAND MARKS

WELL DATA

NAME WELL WELL NO. J

ELEVATION DATUM

RT C GR

TEST HOLE SIZE TD 937'

DATE STARTED DRILLING 5-14-63

DATE FINISHED DRILLING 5-25-63

DRILLER C. Mercer RIG NO. 18

TYPE MUD Baroco NO SACKS 100

ELECTRIC LOG Yes TYPE Schlumberger

SURVEY TYPE

OTHER

N 231210 E 394375

DEPTH STRATA	EACH STRATUM	DESCRIPTION FORMATION	SAMPLES DEPTH	SAMPLES TYPE	SAMPLES NUMBER
0		Surface			
2	2	Sandy soil			
22	20	Sand & gravel			
40	18	Gravel & caliche			
355	315	Sandy clay & gravel			
891	536	Cemented gravel & clay			
892	1	Rock			
937	45	Cemented gravel-clay			

Total depth 937 feet

LAYNE TEXAS COMPANY

HOUSTON -:- DALLAS

MATERIAL SETTING

S O 7054-63
PAGE 1 OF 1
FILE NO 2785
DATE 6/13/63

CUSTOMER LOCATION

FOR CORPS OF ENGINEERS

LOCATION WELL 20 Mi. S. of LAS CRUCES

SURVEY SEC. 31-T-20-S BLOCK R-3-E

COUNTY DONA ANA STATE NEW MEXICO

OTHER LAND MARKS

WELL DATA

NAME WELL WELL NO. J

ELEVATION DATUM

TYPE WELL STRAIGHT

SURFACE CASING CEMENTED YES NO. SACKS 40

SIZE HOLE UNDERREAMED 12-3/4 DEPTH 850'

GRAVEL TYPE NONE NO. CU. YDS.

TYPE SCREEN MILL SLOTTED GAGE 3/16"

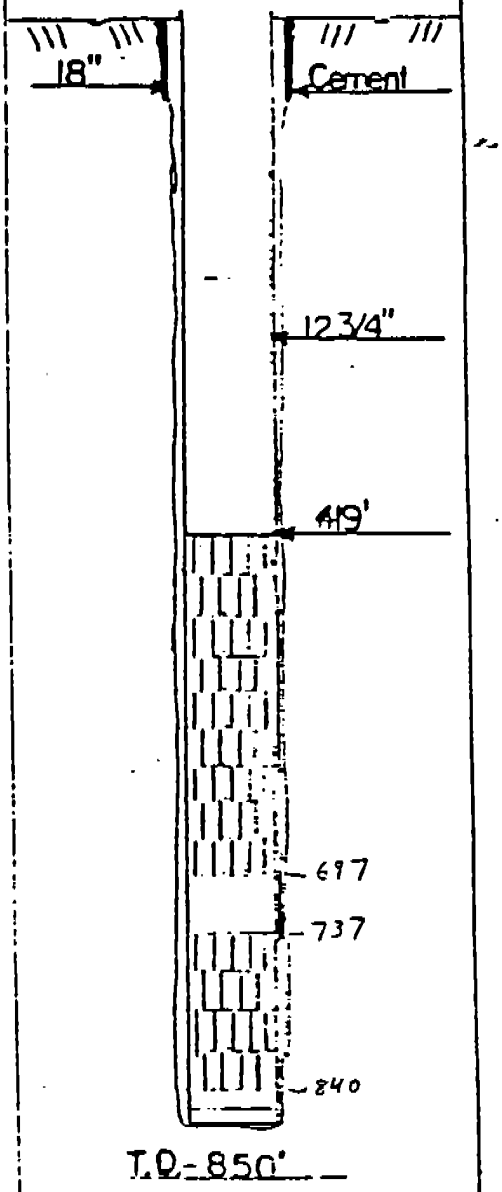
DRILLER C. MERCER RIG NO 18

OTHER JERRY ALVIS & S.H. THOMPSON

DEPTH	LENGTH	SIZE, KIND, WEIGHT MATERIAL
+2.50'		12-3/4" O.D. LINER 2.50' ABOVE GROUND
0		SURFACE
31'	31'	18" O.D. SURFACE PIPE
419'	421.50'	12-3/4" O.D. BLANK LINER
697'	278'	12-3/4" O.D. MILL SLOTTED SCREEN, 3/16" GA.
737'	40'	12-3/4" O.D. BLANK PIPE
840'	103'	12-3/4" O.D. MILL SLOTTED PIPE, 3/16" GA.
850'	10'	12-3/4" O.D. BLANK PIPE

TOTAL DEPTH 850 FEET

SECTION



HOUSTON -:- DALLAS

WATER WELL TEST

PAGE 1 OF 1
FILE NO. 2783
DATE 6/13/63

CUSTOMER LOCATION

TEST FOR Corps of Engineers

LOCATION OF WELL 20 Mi. S. of Las Cruces

SURVEY Sec. 31-T-20-R-3-E FIELD

COUNTY Dona Ana STATE New Mexico

DESCRIPTION OF LAND MARKS

WELL DATA

NAME WELL WELL NO. J

ELEVATION DATUM

WELL SIZE 18" x 12-3/4" x 12-3/4" REAMED

TOTAL DEPTH 850' TOP SCREEN 419'

GRAVEL WELL STRAIGHT WELL Yes

TYPE SCREEN Mill Slotted GAGE 3/16"

TEMPERATURE OF WATER 76° F.

WATER CONDITION Clear-No Sand

WATER MEASURING DEVICE

ORIFICE SIZE 8"x6" LENGTH 4'

OTHER Used Electrical Tape for Measurement

TEST PUMP DATA

DEPTH SETTING TOP OF BOWL 540'

LENGTH AIR LINE 540' SIZE 1"

TYPE BOWL THC - 12" NO STAGES 7

LENGTH BOWL SUCTION LT

SAND CONTENT 0 OZ. PER 100 GAL.

WATER SAMPLE TAKEN No Samples

BACTERIOLOGICAL SAMPLE TAKEN

DRAWDOWN SPECIFIC CAPACITY

ACTIVE STATIC HEAD AFTER PUMP STOPPED

5 MIN	43.55 FT.	20 MIN	45.52 FT.
10 MIN	44.54 FT.	25 MIN	45.83 FT.
15 MIN	45.10 FT.	30 MIN.	45.09 FT.

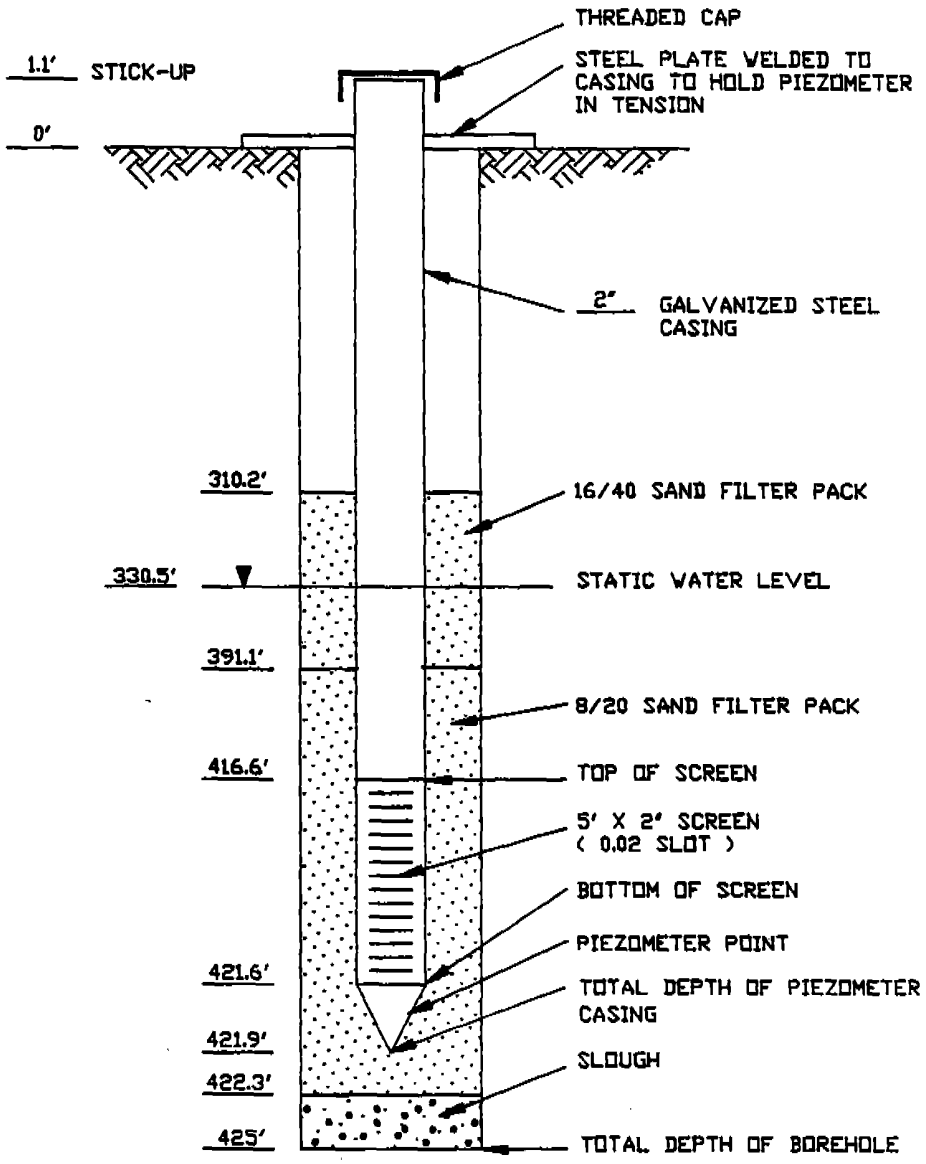
DATE HOUR	AIR LINE GAGE	PUMPING LEVEL	DISCH. PRESS	HEAD ON ORIFICE INCHES	GPM	RPM	OPERATOR	REMARKS
5/30/63								
6:00 AM		383.88	00	44.50	1030	850		
7:00		383.23	00	42	1001	850		
8:00		383.28	00	42	1001	850		
9:00		385.66	00	41.50	1000	850		
10:00		385.93	00	42	1000	850		
11:00		386.77	00	44	1023	875		
12:00 N		385.56	00	41.50	996	850		
1:00 PM		385.93	00	42.50	1007	850		
2:00		385.87	00	42	1007	850		
3:00		386.53	00	43	1012	860		
4:00		387.53	00	43	1012	850		
5:00		385.43	00	43	1012	850		
6:00		385.49	00	43.50	1018	850		
7:00		384.40	00	41	990	850		
8:00		385.15	00	42.50	1007	850		
9:00		385.47	00	42.50	1007	850		
10:00		386.93	00	43	1012	850		
11:00		385.95	00	42	1001	850		
12:00 N-5/31/63		386.60	00	43.50	1018	850		
1:00 AM		387.26	00	44	1023	850		
2:00		386.76	00	43	1012	850		
3:00		387.06	00	43.50	1018	850		
4:00		385.76	00	43.50	1018	850		
5:00		387.63	00	45	1034	850		
6:00		385.64	00	42	1001	850		

OBSERVERS

FOR OWNER

S. H. Thompson
FOR LAYNE TEXAS CO.

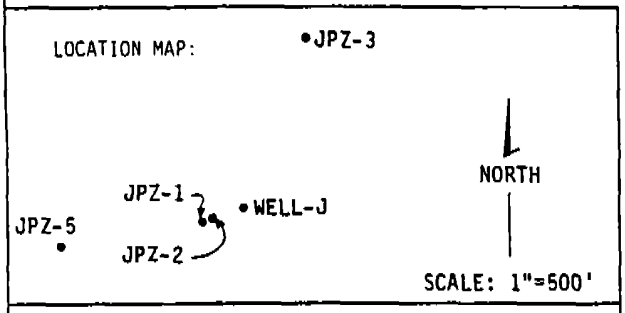
FORM NO. 11



PIEZOMETER JPZ-1 COMPLETION DIAGRAM

LITHOLOGIC LOG

LOCATION MAP:



1/4 NW 1/4 SE 1/4 NW 1/4 S 31 T 20S R 3E

SITE ID: NASA-WSTF LOCATION ID: JPZ-1 (Piezometer)

SITE COORDINATES (ft.):

N 231177.95 E 394218.32

GROUND ELEVATION (ft. MSL): 4400.76 (T.C.)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Air-Foam Rotary

DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 13 February 1989 DATE COMPLETED: 15 February 1989

FIELD REP.: P.S. Egan

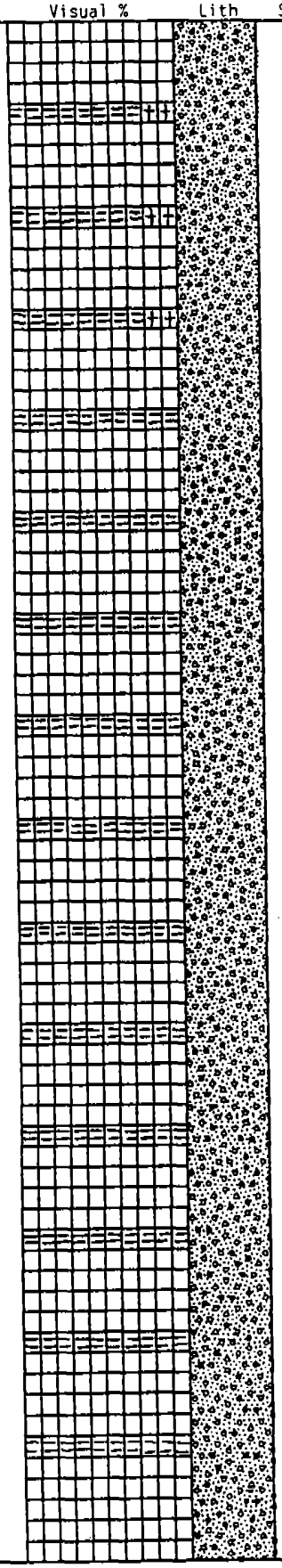
COMMENTS: 0'-425' 6 1/2" borehole. Bedrock not encountered. Total Depth (T.D.) = 425'

LOCATION DESCRIPTION: Piezometer #1 of the Well J Piezometer nest. Second piezometer installed at this location.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			(No drillograph, drill times recorded by driller every 15 feet)	Cuttings 0'-425'	0'-425' Alluvium (Santa Fe Group): Moderate yellowish brown (10YR 5/4) to medium dark gray (N4). True formation grains consist of clay, silt, sand, and gravel that dominate the upper section to approximately 380'. Sand grains range in size from very fine (less than 0.01 inch) to very coarse (0.075 inches), are subrounded to well rounded, and are well-sorted. Gravel ranges in size from 0.2 inches to 0.7 inches, is subangular to subrounded, moderately sorted, and may exist as cuttings and/or natural grains. From 380'-425' (T.D.) samples are predominantly cuttings. Cuttings are uniform, suggesting a hardening of the formation, average 0.075 inches in size, and are angular flakes and chips. This formation is a poorly-sorted, unconsolidated to consolidated polygenetic conglomerate. Cutting lithologies are diverse: micritic limestone, medium gray (N5) to dark gray (N3), frequently dolomitized, occasionally biomicritic, moderate pink (5Y 7/4) to white rhyolite with iron oxidation rims around mafic phenocrysts, light olive gray (5Y 3/2) porphyritic andesite with some pyroxene phenocryst alteration to epidote, transparent to milky quartz, grayish olive (10Y 4/2) to dusky red (5R 3/4) siltstone, and minor amounts of reddish granite, chert, sandstone, and caliche. Comments: The upper portion of this section is predominantly clay, sandy-clay, and/or, gravelly clay. The piezometer is located on the distal flanks of an alluvial fan. Penetration rates were rapid throughout the entire section, averaging approximately 9 minutes per 15' joint of drill pipe.
10					
15					
20			6		
25					
30					
35			8		
40					
45					0'-55' Very coarse gravel (up to 1.2 inches), sand, and silt in samples with clay, but in small quantities.
50			8		

LOCATION ID: JPZ-1 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
50			8		
55					
60					
65			4		65'-380' Samples are 100% clay or silty clay.
70					
75					
80			8		
85					
90					
95			7		
100					
105					
110			7		
115					



LOCATION ID: JPZ-1 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
115				Cuttings (cont'd)	
120					
125			6		
130					
135					
140			9		
145					
150					
155			7		
160					
165					
170			13		
175					
180					

LOCATION ID: JPZ-1 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180				Cuttings (cont'd)	
185			9		
190					
195					
200			11		
205					
210					
215			17		
220					
225					
230			11		
235					
240					
245			14		

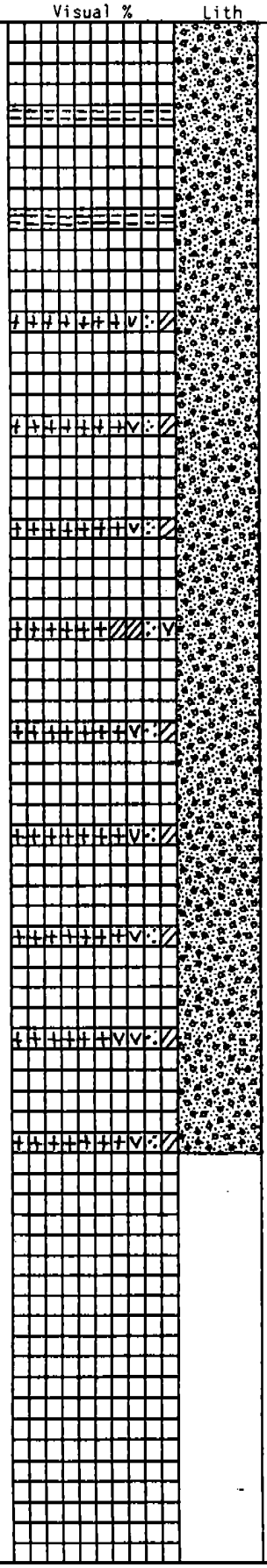
LOCATION ID: JPZ-1 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245			14	Cuttings (cont'd)	
250					
255					
260			14		
265					
270					
275			8		
280					
285					
290			9		
295					
300					
305			14		
310					

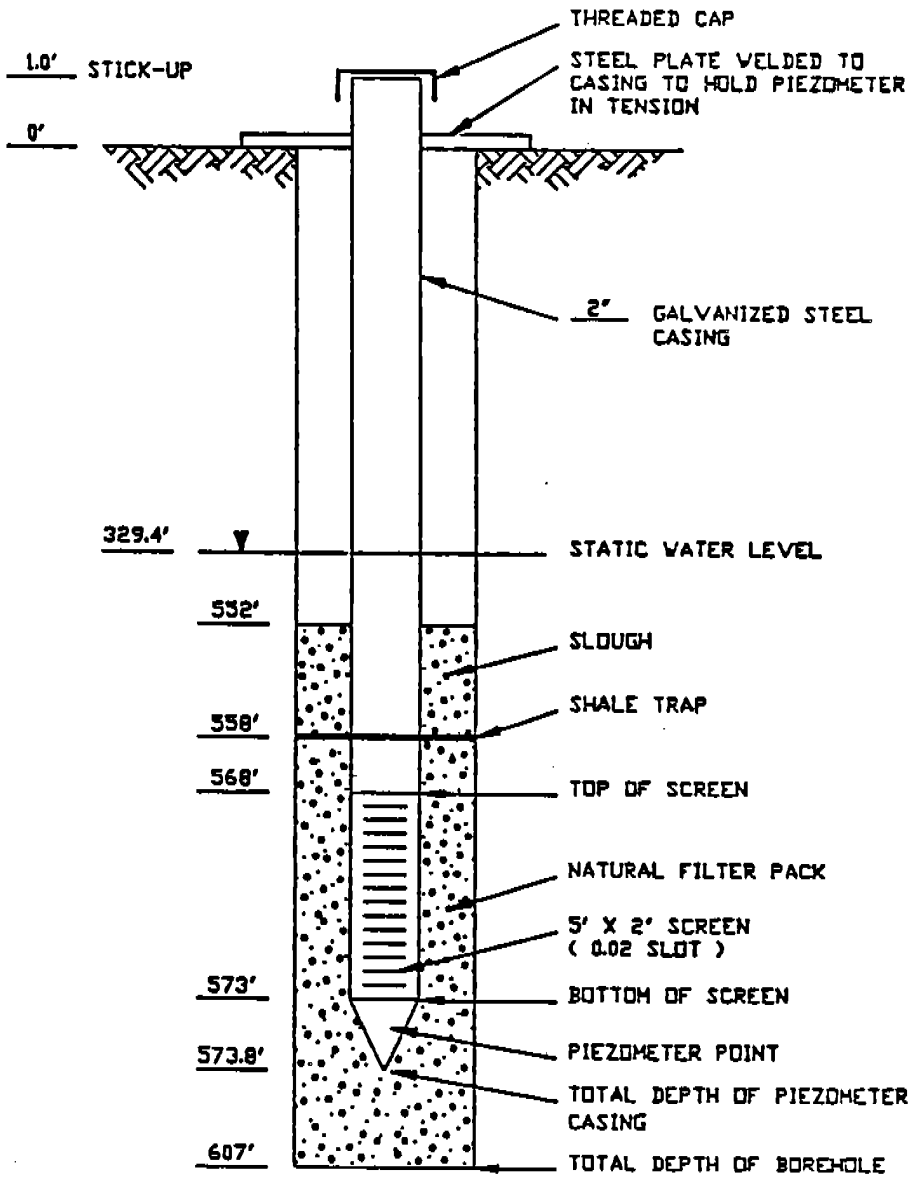
LOCATION ID: JPZ-1 (Piezometer)

Depth	Visual %	Lith.	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310				Cuttings (cont'd)	
315					
320			7		
325					
330					
335			8		
340					
345					
350			9		
355					
360					
365			10		
370					
375					

LOCATION ID: JPZ-1 (Piezometer)



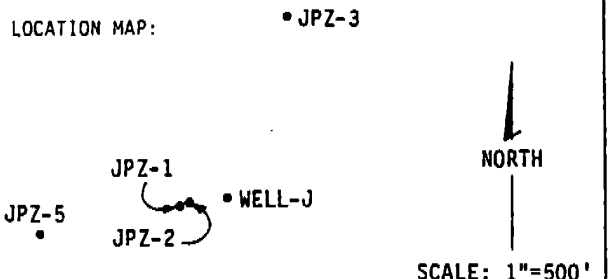
Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
	Cuttings (cont'd)	
13		380'-425' Formation changes from clay to hard, fractured alluvium. Probably top of water bearing unit.
		390' Definite signs of water: Thinning of foam and increased discharge volume. Bit behavior indicates fractures.
7		
10		
7		425' = Total Depth (T.D.)



PIEZOMETER JPZ-2 COMPLETION DIAGRAM

LITHOLOGIC LOG

LOCATION MAP:



NW 1/4 SE 1/4 NW 1/4 1/4 S 31 T 20S R 3E

SITE ID: NASA-WSTF LOCATION ID: JPZ-2 (Piezometer)

SITE COORDINATES (ft.):

N 231204.26 E 394217.98

GROUND ELEVATION (ft. MSL): 4401.44 (T.C.)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud Rotary

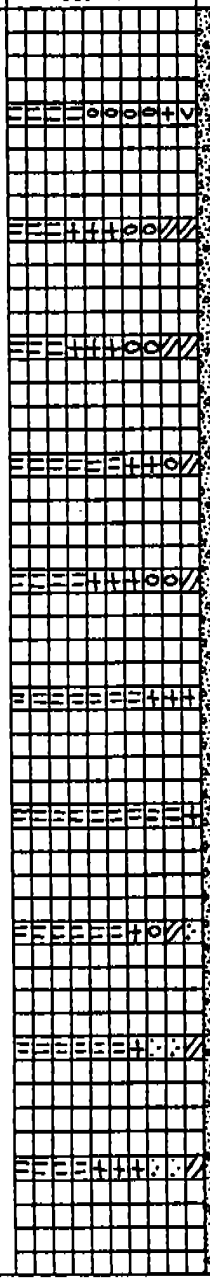
DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 08 February 1989 DATE COMPLETED: 12 February 1989

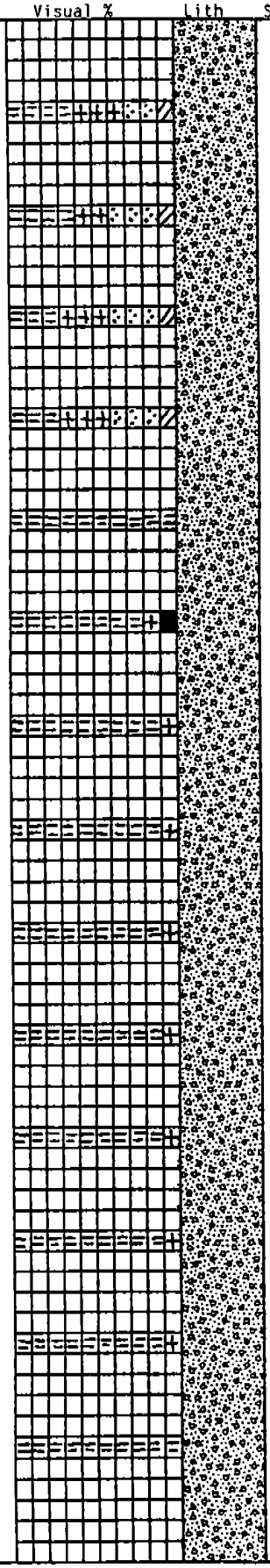
FIELD REP.: P.S. Egan

COMMENTS: 6 3/4" borehole, 0'-390'; 6 1/2" borehole, 390'-607'. Bedrock not encountered. Total Depth (T.D.) = 607'.

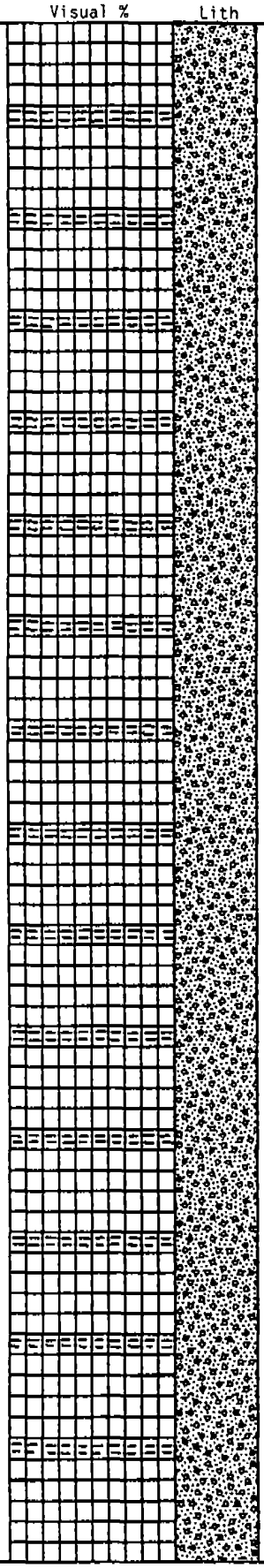
LOCATION DESCRIPTION: First Piezometer installed at Well J.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5 10 15 20 25 30 35 40 45 50			No drillograph on Frank's Rig. Each joint was timed by driller (every 20'). 14 7	Cuttings 0'-607'	0'-607' (T.D.) Alluvium (Santa Fe Group): Moderate yellowish brown (10YR 5/4) to medium dark gray (N4). True formation grains consist of clay, silt, sand, and gravel that dominate the upper section to approximately 390'. Sand grains range in size from very fine (less than 0.01 inch) to very coarse (0.075 inches), are subrounded to well rounded, and are well-sorted. Gravel ranges in size from 0.2 inches to 0.7 inches, is subangular to subrounded, moderately sorted, and exists as cuttings and natural grains. From 390'-607' (T.D.) samples are predominately cuttings. Cuttings are uniform, suggesting a hardening of the formation, average 0.075 inches in size, and are angular flakes and chips. This formation is a poorly-sorted, unconsolidated to consolidated polygenetic conglomerate. Cutting lithologies are diverse: micritic limestone, medium gray (N5) to dark gray (N3), frequently dolomitized, occasionally biomicritic, moderate pink (5Y 7/4) to white rhyolite with iron oxidation rims around mafic phenocryst, light olive gray (5Y 3/2) porphyritic andesite with some pyroxene phenocrysts alteration to epidote, transparent to milky quartz, grayish olive (10Y 4/2) to dusky red (5R 3/4) siltstone, and minor amounts of reddish granite, chert, sandstone, and caliche. Comments: The upper portion of this section is predominantly clay, sandy-clay, and/or, gravelly clay. The piezometer is located on the distal flanks of an alluvial fan. Penetration rates were rapid but decreased significantly when the bit encountered older, coarser-grained, and well-cemented or indurated alluvium in the lower half of the section. A thick caliche horizon was observed at the surface. 0'-5' Abundant caliche and clay in sample. A thick caliche horizon is observed on walls of mud pit. 15'-20' Sample is primarily clay, silt and fine sand.

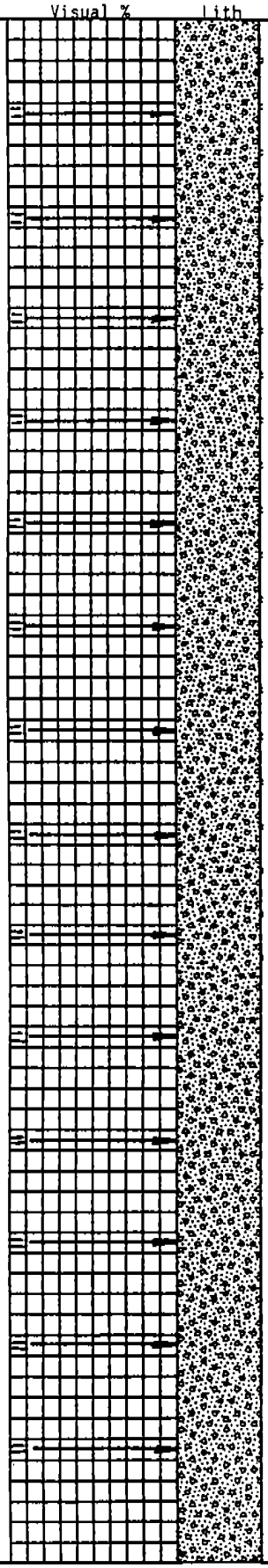
LOCATION ID: JPZ-2 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
50			8	Cuttings (cont'd)	25'-30' Sample contains silt and fine sand. 30'-35' Sample contains silt and fine and medium-grained sand. 35'-40' Sample is a sandy-clay. Sand is well-rounded and well sorted. 40'-55' Gravel, fine to very coarse sand, and silt present in clay. 55'-65' Sample contains abundant well-rounded, well-sorted coarse to fine sand and less clay. Some gravel is present. 65'-70' Silt is present with clay. 70'-75' Some gravel clasts of limestone and sandstone present with clay. 75'-235' Small amounts of gravel, sand, and silt present with clay. 115'-330' Samples consist of mostly clay and silty clay with small amounts of sand.
55					
60					
65					
70					
75			10		
80					
85					
90					
95			13		
100					
105					
110					
115			8		

LOCATION ID: JPZ-2 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
115			8		
120					
125					
130					
135			12		
140					
145					
150					
155			15		
160					
165					
170					
175			15		
180					

LOCATION ID: JPZ-2 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180				Cuttings (cont'd)	
185					
190					
195			15		
200					
205					
210					
215			13		
220					
225					
230					
235			10		
240					
245					

LOCATION ID: JPZ-2 (Piezometer)

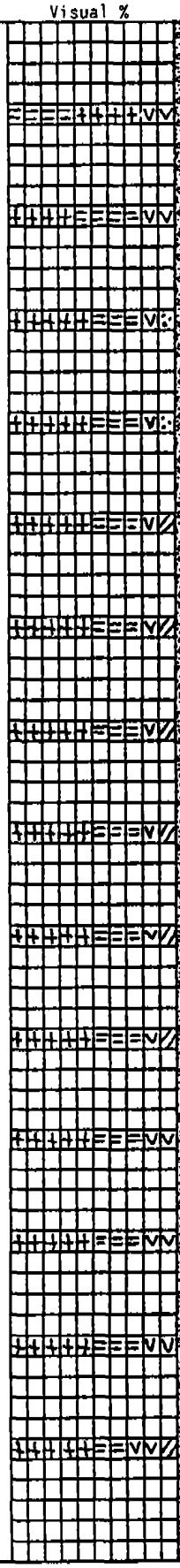
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245				Cuttings (cont'd)	
250			14		
255					
260					
265					
270			10		270'-280' One sample for this interval.
275					
280					280'-290' One sample for this interval. Some sand is present in clay.
285					
290			10		290'-300' One sample for this interval. 290'-330' Amount of sand in clay is slowly increasing.
295					
300					300'-310' One sample for this interval.
305					
310			13		

LOCATION ID: JPZ-2 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
310			13		310'-320' One sample for this interval.
315					
320					320'-330' One sample for this interval.
325					
330			9		330'-350' Clay contains medium- to coarse-grained, well sorted sand. Sandy-clay zone.
335					
340					
345					
350			9		
355					
360					
365					365'-370' Increase in amount of sand.
370			13		
375					

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375					
380					
385					
390			31		390' Trip out carbide fish hook bit, trip in tricone button bit due to hardening of formation.
395					390'-395' Increase in clay content to 70% of sample.
400					390'-607' Samples are predominantly gravel and sand. Cuttings in samples are uniform in size due to harder formation. Average cutting size is .05 inch.
405					
410			46		
415					
420					
425					425'-430' Increase in clay content to 80% of sample.
430			54		
435					
440					

LOCATION ID: JPZ-2 (Piezometer)

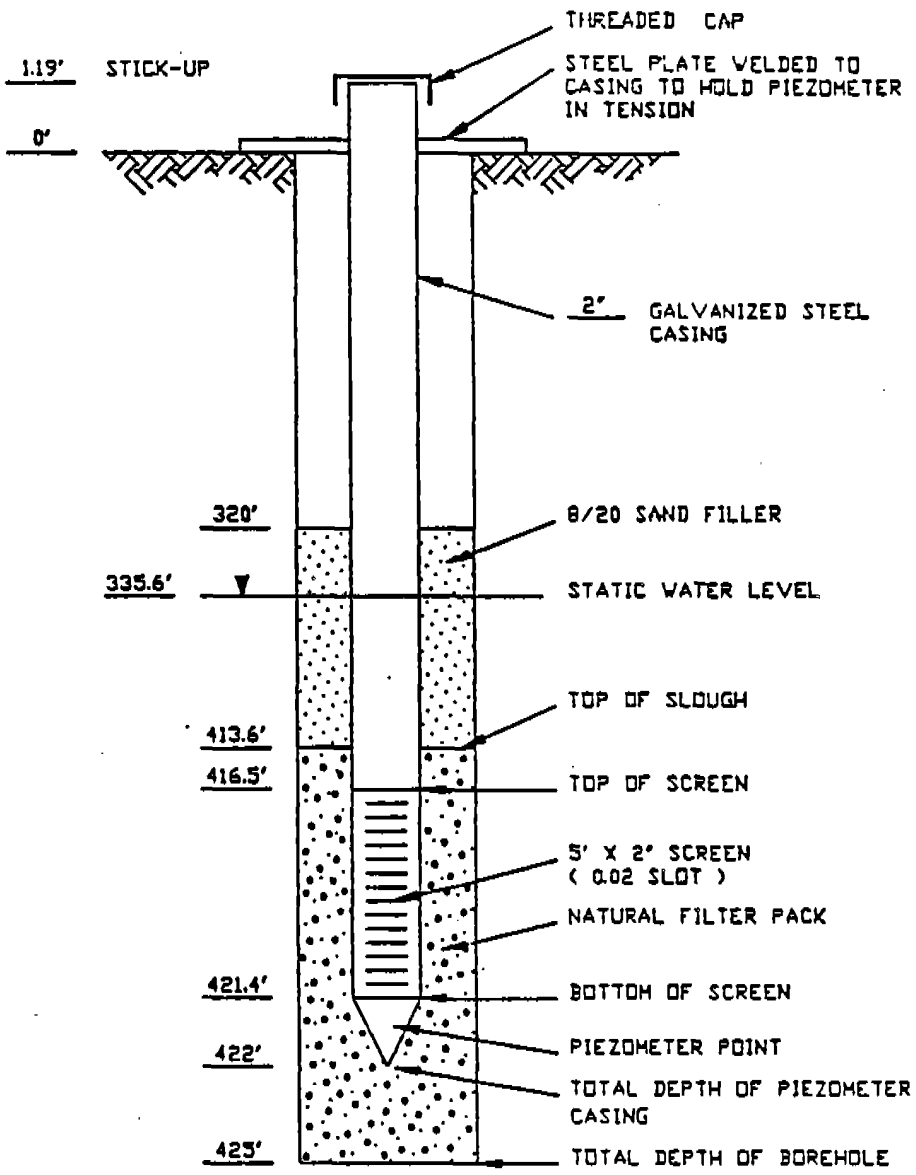
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
440			45	Cuttings (cont'd)	
445					
450					
455					
460					
465					
470			51		
475					
480					
485					
490			45		
495					
500					
505					

LOCATION ID: JPZ-2 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
505				Cuttings (cont'd)	
510			55		
515					
520					
525					
530			44		
535					
540					
545					545'-550' Much of the rhyolite in the sample is stained purple instead of the usual reddish iron stain. May be indicating an oxidation zone/fracture.
550			53		
555					
560					
565					
570			57		

LOCATION ID: JPZ-2 (Piezometer)

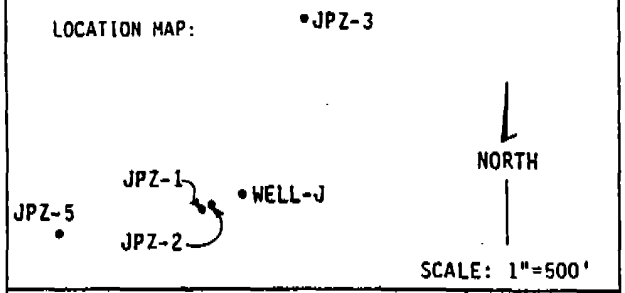
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
570			57		
575					
580					
585					
590			55		
595					
600					
605					
			54		T.D. = 607'
610					
615					
620					
625					
630					
635					



PIEZOMETER JPZ-3 COMPLETION DIAGRAM

LITHOLOGIC LOG

LOCATION MAP:



1/4 NW 1/4 SE 1/4 NW 1/4 S 31 T 20S R 3E

SITE ID: NASA-WSTF LOCATION ID: JPZ-3 (Piezometer)

SITE COORDINATES (ft.):

N 231683.21 E 394506.42

GROUND ELEVATION (ft. MSL): 4405.28 (T.C.)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Air-Foam Rotary

DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 23 February 1989 DATE COMPLETED: 23 February 1989

FIELD REP.: P.S. Egan

COMMENTS: 0'-425', 6 3/4" borehole. Total Depth = 425'. Bedrock not encountered.

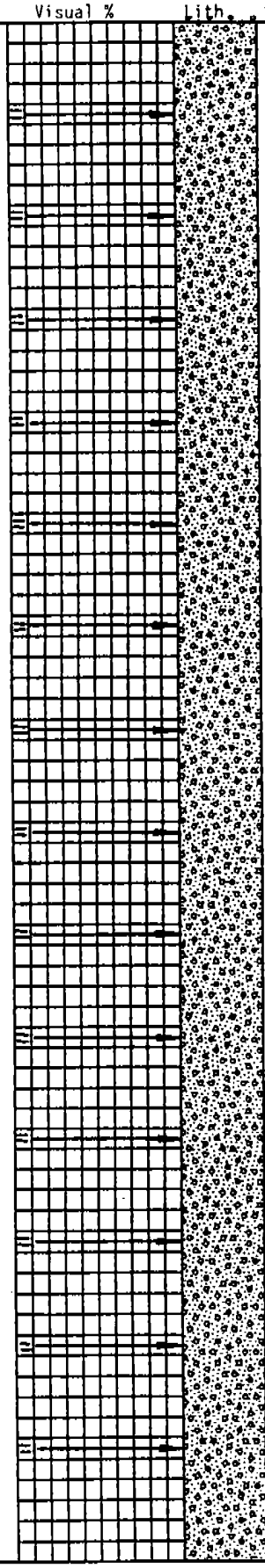
LOCATION DESCRIPTION: Piezometer #3 of the Well J Piezometer nest. 5th and final piezometer installed.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			(Drill times recorded by driller every 15 feet)	Cuttings 0'-425'	0'-425' (T.D.) Alluvium (Santa Fe Group): Moderate yellowish brown (10YR 5/4) to medium dark gray (N4). True formation grains consist of clay, silt, sand, and gravel that dominate the upper section to approximately 380' (cuttings). Sand grains range in size from very fine (less than 0.01 inch) to very coarse (0.075 inches), are subrounded to well rounded, and are well-sorted. Gravel ranges in size from 0.2 inches to 0.7 inches, is subangular to subrounded, moderately sorted, and exists as cuttings and natural grains. From 390'-425' (T.D.) samples are predominately cuttings. Cuttings average 0.075 inches in size, and are angular flakes and chips. This formation is a poorly-sorted, unconsolidated to consolidated polygenetic conglomerate. Cutting lithologies are diverse: micritic limestone, medium gray (N5) to dark gray (N3), frequently dolomitized, occasionally biomicritic, moderate pink (5Y 7/4) to white rhyolite with iron oxidation rims around mafic phenocryst, light olive gray (5Y 3/2) porphyritic andesite with some pyroxene phenocrysts altered to epidote, transparent to milky quartz, grayish olive (10Y 4/2) to dusky red (5R 3/4) siltstone, and minor amounts of reddish granite, chert, sandstone, and caliche. Comments: The upper portion of this section is predominantly clay, sandy-clay, and/or, gravelly clay. A lithology change from clay to coarse, gravelly alluvium occurs at 390'. The piezometer is located on the distal flanks of an alluvial fan.
10					
15					
20			6		
25					
30					
35			3		
40					0'-20' Samples are mostly silt with some clay and a few clasts of gravel.
45					20'-25' Increased clay content in silt. 25'-35' Samples very silty. 35'-40' Increased clay content in silt.
50			3		45'-50' Sample is silty-clay.

LOCATION ID: JPZ-3 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
50			3	Cuttings (cont'd)	
55					
60					60'-390' Samples bagged every 10' but described every 5' because of homogeneity of this part of formation. Samples are 100% clay or silty clay.
65			4		
70					
75					
80			5		
85					
90					
95			5		
100					
105					
110			5		
115					

LOCATION ID: JPZ-3 (Piezometer)

Depth	Visual %	Lith.	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
115				Cuttings (cont'd)	
120					
125			6		
130					
135					
140			6		
145					
150					
155			7		
160					
165					
170			5		
175					
180					

LOCATION ID: JPZ-3 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
180					
185			6		
190					
195					
200			8		
205					
210					
215			5		
220					
225					
230			7		
235					
240					
245			9		

LOCATION ID: JPZ-3 (Piezometer)

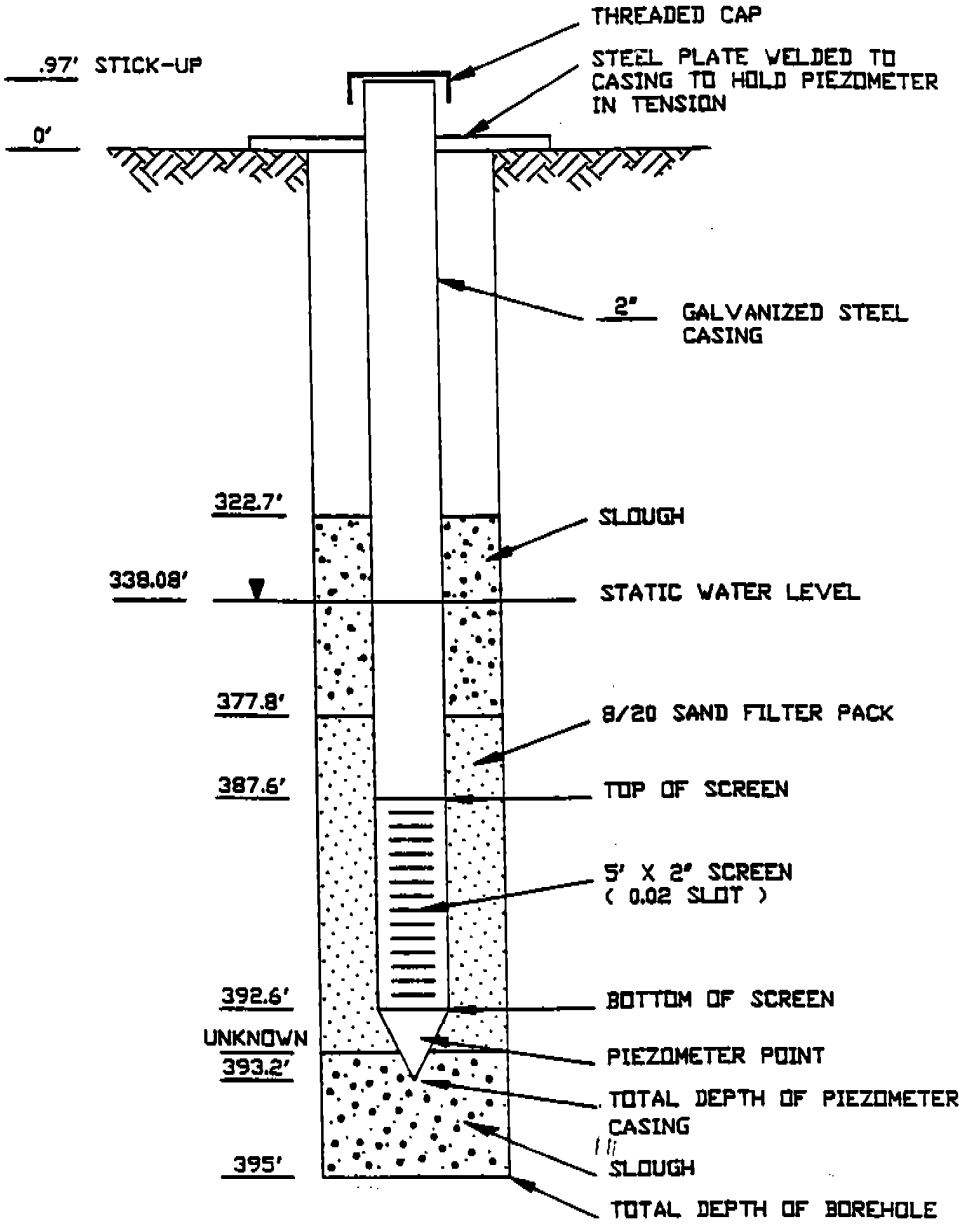
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			9		
250					
255					
260			7		
265					
270					
275			7		
280					
285					
290			6		
295					
300					
305			6		
310					

LOCATION ID: JPZ-3 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
310					
315					
320			7		
325					
330					
335			6		335' First signs of water.
340					
345					
350			4		
355					
360					
365			6		
370					
375					

LOCATION ID: JPZ-3 (Piezometer)

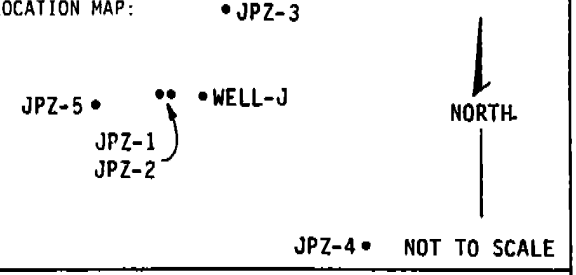
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
375				Cuttings (cont'd)	
380			8		380'-425' Bit behavior (chattering and grabbing) indicates we are out of clays and into coarse-grained alluvium. Evidence not as definitive in cuttings (probably due to lag time for cuttings to arrive at surface).
385					
390					
395			6		395'-425' Cuttings indicate coarse, gravelly alluvium present.
400					395'-425' Increase in drill times due to type of bit in hole. Fishtail works well in clays but not in harder, gravelly alluvium.
405					405'-415' Decrease in cutting size to 0.1" average. Cuttings are uniform.
410			40		
415					
420					
425			25		T.D. = 425'
430					
435					
440					



PIEZOMETER JPZ-4 COMPLETION DIAGRAM

LITHOLOGIC LOG

LOCATION MAP:



1/4 NW 1/4 SE 1/4 NW 1/4 S 31 T 20S R 3E

SITE ID: NASA-WSTF LOCATION ID: JPZ-4 (Piezometer)

SITE COORDINATES (ft.):

N 230438.74 E 394999.98

GROUND ELEVATION (ft. MSL): 4408.42 (T.C.)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Air-Foam Rotary

DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 02/16/89 DATE COMPLETED: 02/17/89

FIELD REP.: P.S. Egan

COMMENTS: 6 3/4" borehole 0'-290', 6 1/2" borehole 290'-395'. Bedrock not encountered. Total Depth (T.D.) = 395'

LOCATION DESCRIPTION: Piezometer #4 of the Well J piezometer nest. Third piezometer installed.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
5			(No drillograph, drill times recorded by driller every 15 feet)	Cuttings 0'-395' (TD)	0'-395'	Alluvium (Santa Fe Group): Moderate yellowish brown (10YR 5/4) to medium dark gray (N4). True formation grains consist of clay, silt, sand, and gravel that dominate the upper section to approximately 345'. Sand grains range in size from very fine (less than 0.01 inch) to very coarse (0.075 inches), are subrounded to well rounded, and are well-sorted. Gravel ranges in size from 0.2 inches to 0.7 inches, is subangular to subrounded, moderately sorted, and may exist as cuttings and/or natural grains. From 345'-395' (T.D.) samples are predominately cuttings (one interval of silty clay exists at 360'-365'). Cuttings are uniform, suggesting a hardening of the formation, average 0.075 inches in size, and are angular flakes and chips. This formation is a poorly-sorted, unconsolidated to consolidated polygenetic conglomerate. Cutting lithologies are diverse: micritic limestone, medium gray (N5) to dark gray (N3), frequently dolomitized, occasionally biomicritic, moderate pink (5Y 7/4) to white rhyolite with iron oxidation rims around mafic phenocrysts, light olive gray (5Y 3/2) porphyritic andesite with some pyroxene phenocrysts altered to epidote, transparent to milky quartz, grayish olive (10Y 4/2) to dusky red (5R 3/4) siltstone, and minor amounts of reddish granite, chert, sandstone, and caliche. Comments: The upper portion of this section is predominantly clay, sandy-clay, and/or, gravelly clay. The piezometer is located on the distal flanks of an alluvial fan. Penetration rates were rapid but decreased when the bit encountered older, coarser-grained, and well-cemented or indurated alluvium in the lower half of the section. A thick caliche horizon was observed at the surface.
10						
15						
20			9			
25						
30						
35			10			
40						
45						
50			8		0'-20'	Clay is reddish brown in color and very silty.

LOCATION ID: JPZ-4 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	20'-35' Clay contains large gravel clasts up to 2 inches in size. Clay also remains silty.
50			8		30'-35' Fine sand present in clay.
					35'-50' Clay contains fine sand and a few gravel clasts.
55					50'-55' Clay contains very large cuttings. (probably cut cobbles) and is very silty.
60					55'-65' Gravelly, silty clay present.
65			8		65'-100' Silty clay.
70					
75					
80			9		
85					
90					
95			10		
100					100'-345' Samples are 100% clay or silty clay.
105					
110			9		
115					

LOCATION ID: JPZ-4 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
115				Cuttings (cont'd)	
120					
125			5		
130					
135					
140			8		
145					
150					
155			9		
160					
165					
170			10		
175					
180					

LOCATION ID: JPZ-4 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180				Cuttings (cont'd)	
185			7		
190					
195					
200			6		
205					
210					
215			6		
220					
225					
230			8		
235					
240					
245			8		

LOCATION ID: JPZ-4 (Piezometer)

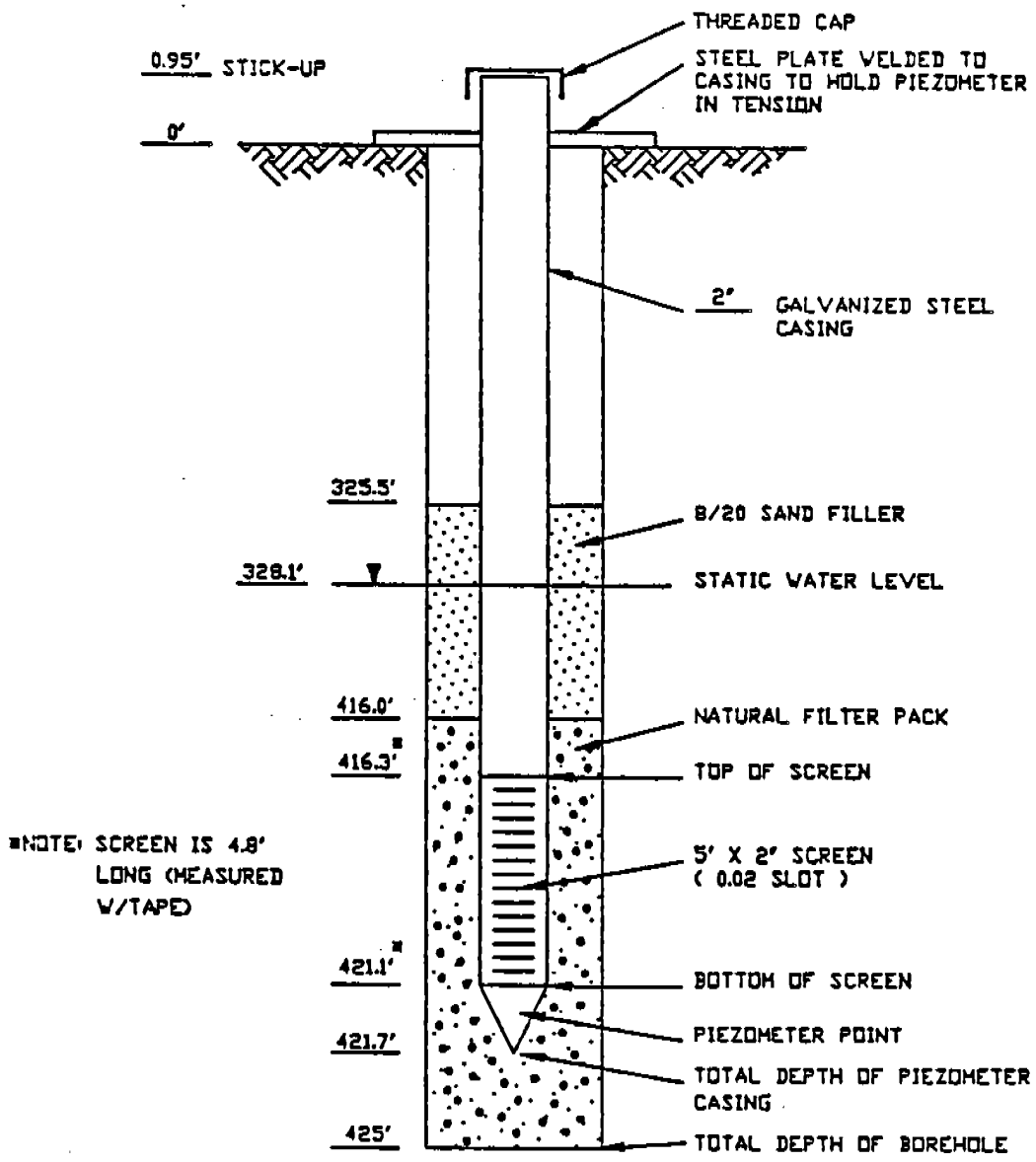
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			8		
250					
255					
260			8		
265					
270					
275			9		
280					
285					
290			6		290'-345' A few clasts of gravel and some sand present in clay. Some gravel clasts are up to 1.5 inches in diameter.
295					
300					
305			9		
310					

LOCATION ID: JPZ-4 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
310					
315					
320			7		
325					
330					
335			8		
340					
345					345'-360' Hard, fractured gravel encountered.
350			7		350'-360' Cuttings are large. Average size is .75 inch.
355					
360					360'-365' Sample is silty clay with gravel and sand clasts.
365			9		365' First signs of water. 365'-380' Cutting size has decreased to .1 inch and is uniform.
370					370'-375' Crystalline calcite characteristic of fracture fill present.
375					

LOCATION ID: JPZ-4 (Piezometer)

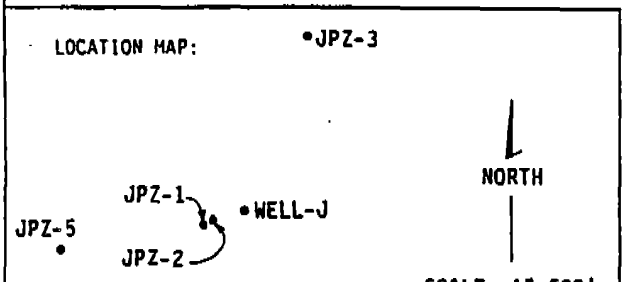
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375					
380			11		380'-395' Increase in average cutting size to 0.3 inches.
385					385'-395' Crystalline calcite characteristic of fracture fill is present.
390					390'-395' Some cuttings show caliche cement and fractures filled with calcite. Crystalline calcite is present as cuttings.
395			10		Total Depth (T.D.) = 395'
400					
405					
410					
415					
420					
425					
430					
435					
440					



PIEZOMETER JPZ-5 COMPLETION DIAGRAM

LITHOLOGIC LOG

LOCATION MAP:



1/4 NW 1/4 SE 1/4 NW 1/4 S 31 T 20S R 3E

SITE ID: NASA-WSTF LOCATION ID: JPZ-5 (Piezometer)

SITE COORDINATES (ft.):

N 231154.34 E 393866.97

GROUND ELEVATION (ft. MSL): 4397.02 (T.C.)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Air-Foam Rotary

DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 21 February 1989 DATE COMPLETED: 22 February 1989

FIELD REP.: P.S. Egan

COMMENTS: 6 3/4" borehole, 0-350'. 6 1/2" borehole 350'-425'. Total Depth (T.D.) = 425'. Bedrock not encountered.

LOCATION DESCRIPTION: Piezometer #5 of the Well J Piezometer nest. Fourth piezometer installed.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			(No drillograph. Drill times for each 15' joint recorded by driller.)	Cuttings 0'-425'	0'-425' (T.D.) Alluvium (Santa Fe Group): Moderate yellowish brown (10YR 5/4) to medium dark gray (N4). True formation grains consist of clay, silt, sand, and gravel that dominate the upper section to approximately 395' (cuttings). Sand grains range in size from very fine (less than 0.01 inch) to very coarse (0.075 inches), are subrounded to well rounded, and are well-sorted. Gravel ranges in size from 0.2 inches to 0.7 inches, is subangular to subrounded, moderately sorted, and exists as cuttings and natural grains. From 395'-425' (T.D.) samples are predominately cuttings. Cuttings are uniform, average 0.075 inches in size, and are angular flakes and chips. This formation is a poorly-sorted, unconsolidated alluvium. Cutting lithologies are diverse: micritic limestone, medium gray (N5) to dark gray (N3), frequently dolomitized, occasionally biomicritic; moderate pink (5Y 7/4) to white rhyolite with iron oxidation rims around mafic phenocrysts, light olive gray (5Y 3/2) porphyritic andesite with some pyroxene phenocrysts altered to epidote, transparent to milky quartz, grayish olive (10Y 4/2) to dusky red (5R 3/4) siltstone, and minor amounts of reddish granite, chert, sandstone, and caliche. Comments: The upper portion of this section is predominantly clay, sandy-clay, and/or, gravelly clay. Penetration rates were rapid through the clay and continued rapidly through the alluvium, suggesting unconsolidated alluvium. The piezometer is located on the distal flanks of an alluvial fan.
10					
15					
20			9		
25					
30					
35			5		
40					0'-15' Clay contains abundant silt and very fine sand.
45					15'-25' Samples contain unsorted clasts of gravel (up to 2 inches in size), very coarse to medium sand, and silt.
50			5		

LOCATION ID: JPZ-5 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
50			5	Cuttings (cont'd)	25'-90' Samples are predominantly silty clay. Small amounts of sand and few clasts of gravel present. The presence of clasts may be a result of uphole contamination.
55					
60					
65			4		
70					
75					
80			7		
85					
90					90'-165' Samples are 100% clay and/or silty clay.
95			4		
100					
105					
110			6		
115					

LOCATION ID: JPZ-5 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
115					
120					
125			7		
130					
135					
140			10		
145					
150					
155			10		
160					
165					165'-170' Few clast of gravel approximately 0.2 inches in size, possibly contamination from uphole.
170			5		170'-390' Samples are 100% clay and/or silty clay.
175					
180					

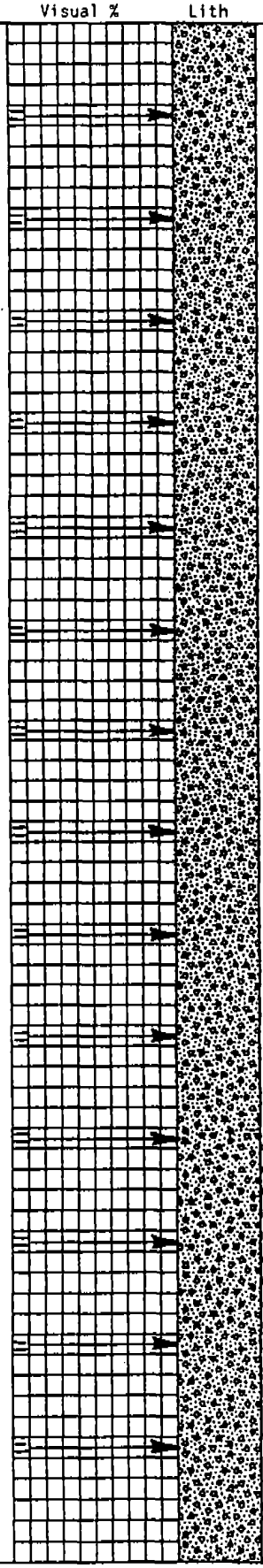
LOCATION ID: JPZ-5 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
180					
185			6		
190					
195					
200			6		
205					
210					
215			6		
220					
225					
230			8		
235					
240					
245			8		

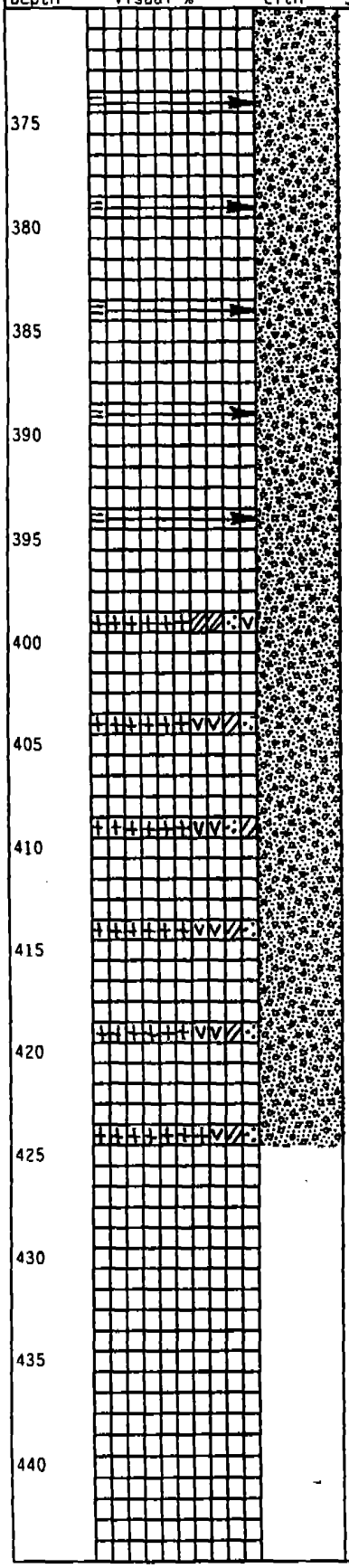
LOCATION ID: JPZ-5 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			8		
250					
255					
260			9		
265					
270					
275			6		
280					
285					
290			7		
295					
300					
305			10		
310					

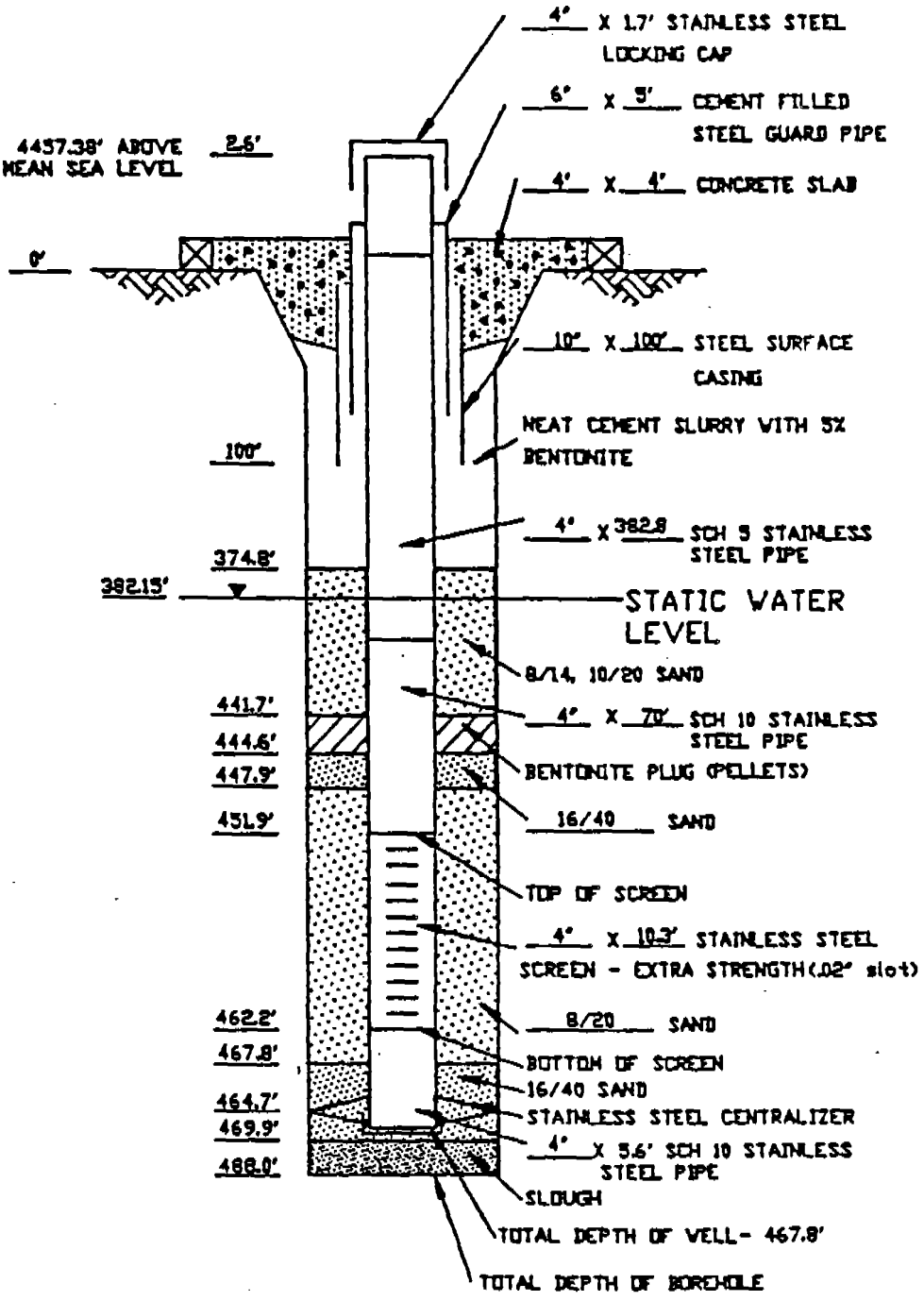
LOCATION ID: JPZ-5 (Piezometer)

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310				Cuttings (cont'd)	
315					
320			10		
325					
330					
335			8		
340					
345					
350			8		
355					
360					
365			9		
370					
375					

LOCATION ID: JPZ-5 (Piezometer)



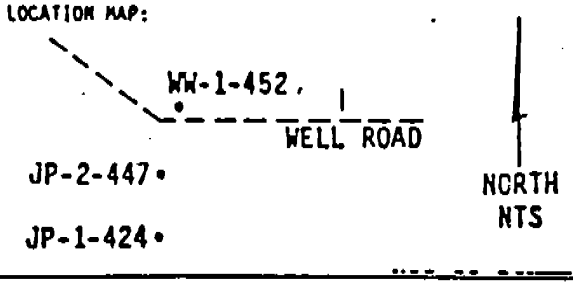
Depth	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
		Cuttings (cont'd)	
375			
380	6		
385			
390			390'-395' Sand and some gravel present with clay in sample.
			390' Water first detected.
395	8		395'-425' Lithology change from clay to cuttings of gravelly alluvium. Penetration rates do not increase. Alluvium probably unconsolidated.
400			395'-410' Cuttings are small and uniform. Average cuttings size is 0.1 inches.
405			
410	6		410'-425' Increase in cutting size to 0.3 inches.
415			
420			
425	5		T.D. = 425'
430			
435			
440			



MONITOR WELL VW-1-452 COMPLETION DIAGRAM

LITHOLOGIC LOG

LOCATION MAP:



SE 1/4 SE 1/4 SE 1/4 SE 1/4 S 31 T 20S R 3E

SITE ID: NASA-WSTF LOCATION ID: WW-1-452

SITE COORDINATES (ft.):

N 227994.74 E 397803.86

GROUND ELEVATION (ft. MSL): 4455.09 (BRASS CAP)

STATE: NEW MEXICO COUNTY: DONA ANA

DRILLING METHOD: AIR-FOAM ROTARY

DRILLING CONTR.: LARJON

DATE STARTED: 5 JANUARY 1988 DATE COMPLETED: 21 JANUARY 1988

FIELD REP.: COOPER, KASZUBA

COMMENTS: 7 7/8" PILOT HOLE 0'-100', 14 1/2" BOREHOLE 0'-100', 9 7/8" BOREHOLE 100'-488', TOTAL DEPTH = 488'. TOP OF BEDROCK: NOT REACHED.

LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				0'-488' cuttings	0'-5' SURFICIAL SILTY CLAY Moderate orange pink (5YR 8/4) silty clay. Sample is silt-size powder.
5					5'-488' ALLUVIUM (Santa Fe Group) Unwashed sample is moderate orange pink (5YR 8/4). Washed sample has varied colors due to different lithologies of cuttings but has an overall color of medium gray (N5) to dark gray (N3). Average cutting size is 0.1 to 0.2 inches and ranges from 0.02 to 1.0 inches. Cuttings are mostly angular and blocky, with some flakes present, and are poorly sorted. The lithology is a poorly to moderately consolidated pebble to cobble conglomerate containing clasts of light gray (N7) to grayish black (N2) micritic limestone with < 10% allochems; white (N9) and red and white mottled rhyolite with iron staining; light olive gray (5Y 3/2) andesite with some pyroxene alteration to epidote; transparent bluish white (5B 9/1) to light bluish gray (5B 7/1) quartzite with cuttings containing iron staining; moderate reddish orange (10R 6/6) to moderate reddish brown (10R 4/6) granite; moderate red (5R 4/6) to moderate reddish brown (10R 4/6) siltstone (Abo); traces of light gray (N7) to grayish black (N2) chert; moderate orange pink (5YR 8/4) clay varying from < 10% to 50% of sample, clay often forms balls when samples are washed.
10			begin drillograph		
15			5		
20			3		
25			3		25'-30' Significant decrease in cutting size.
30			4		30'-50' Increase in cutting size.
35			3.5		
40			2.5		
45			3		
50			3		

LOCATION ID: W-1-452

Depth	Visual %	Lith	Drilling Time Scale: min.	Sample Type and Interval	Lithologic Description	
50			3		50'-70'	Decrease in cutting size.
55			7		55'-60'	Individual grains of epidote, probably crushed or broken up andesite cuttings.
60			4			
65			4			
70			5		70'-100'	Slight increase in cutting size.
75			3			
80			4.5			
85			3.5			
90			4.5			
95			4			
100			3.5			
105			-		105'-235'	Clay content increases significantly.
110			2.25			
115			2.25			

LOCATION ID: MW-1-452

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
115			2.25			
120			2.25			
125			2.25			
130			2.25		130'-140'	Decrease in average size of cuttings to ≤0.1 inches.
135			2.25			
140			2.25		140'-170'	Increase in average size of cuttings to 0.1-0.2 inches.
145			2.25			
150			2.25			
155			2			
160			2			
165			2			
170			2		170'-235'	Decrease in average size of cuttings to ≤0.1 inch.
175			2			
180			2			

LOCATION ID: W-1-452

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180			2		
185			2		
190			2		
195			2		
200			2		
205			2		
210			2		
215			2.25		
220			2.25		
225			2.25		
230			2.25		
235			2		235'-250' Increase in average size of cuttings to 0.1-0.2 inches. Clay content decreases significantly.
240			2		
245			2		

LOCATION ID: W-1-452

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245			2		
250			2		250'-310' Samples collected at 10' intervals (poor circulation to surface).
255			1.75		250'-390' Decrease in average size of cuttings to ≤0.1 inches, cuttings more angular. Alluvium either richer in cobbles and boulders or more consolidated.
260			1.75		
265			1.75		
270			1.75		
275			2		
280			2		
285			3		
290			3		
295			2.5		
300			2.5		
305			2.5		
310			2.5		

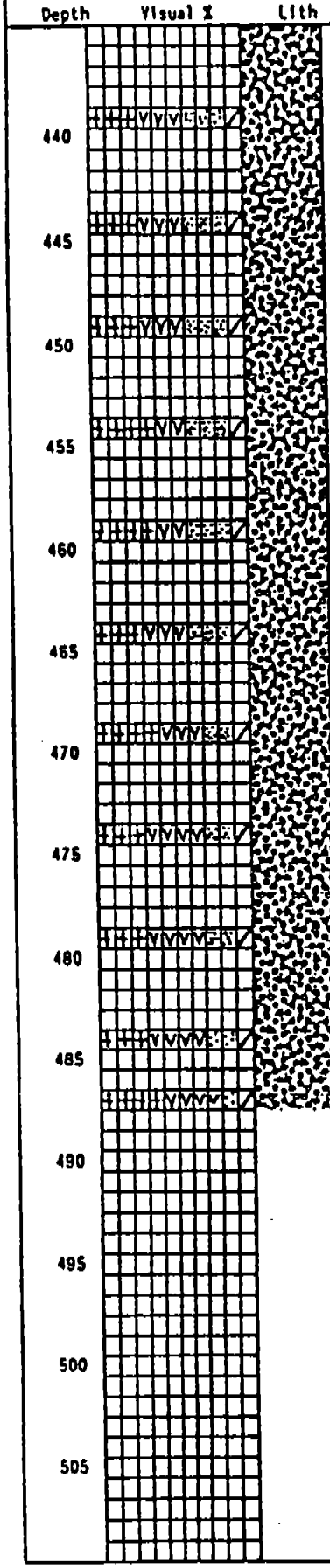
LOCATION ID: W-1-452

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310			2.5		310'-485' Resume 5' sample interval.
315			3		
320			7.5		
325			6.5		
330			4		
335			4.5		
340			7.5		
345			9.5		
350			4		
355			2.5		
360			2.5		
365			6.5		
370			14.5		
375			6		

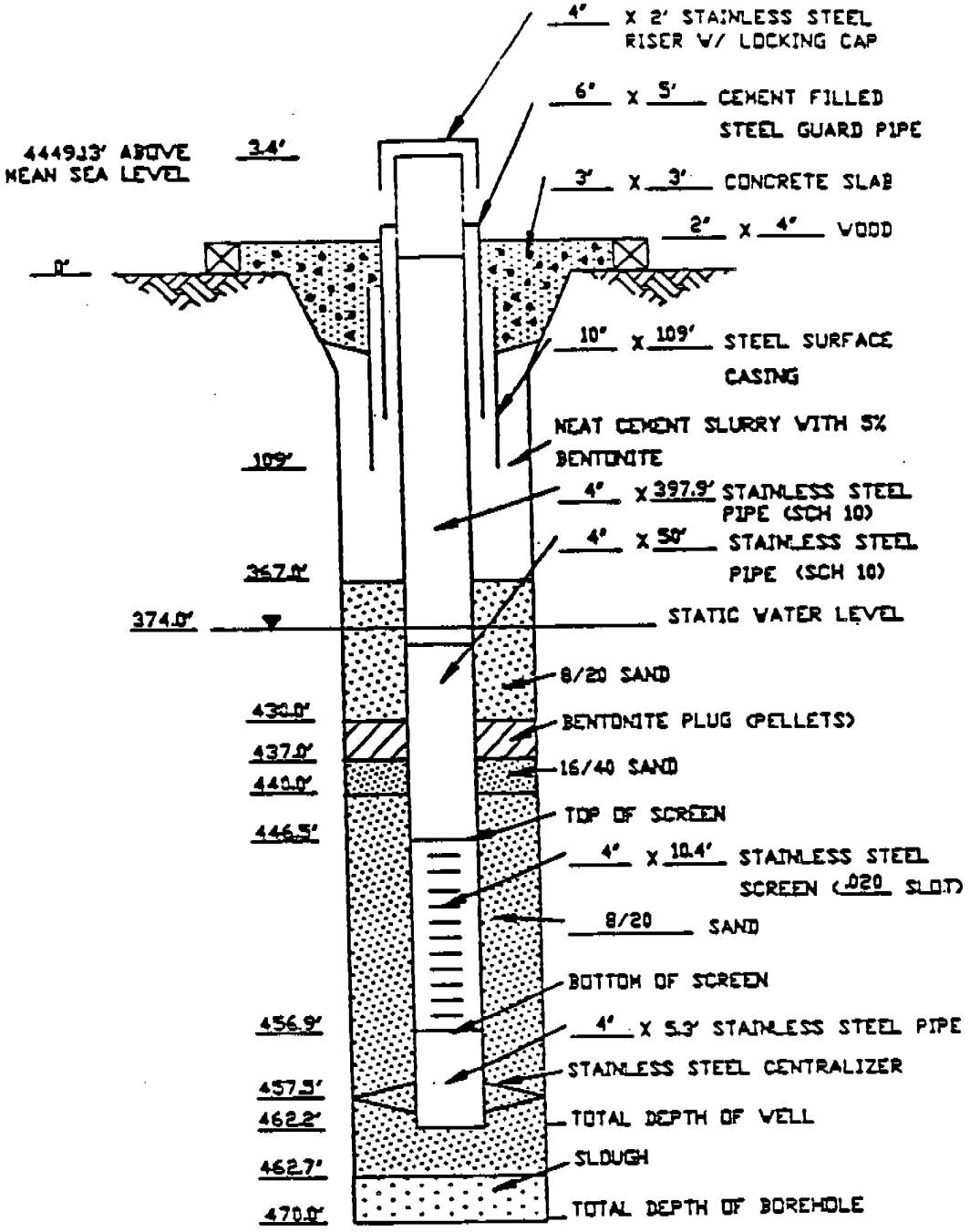
LOCATION ID: WW-1-452

Depth	Visual %	Lith	Drilling Time Scale:	Sample Type and Interval	Lithologic Description
375			6		
380			6		
385			7		
390			13		390'-488' Decrease in average size of cuttings to <0.1 inches, cuttings angular. Alluvium either richer in cobbles and/or boulders or more consolidated.
395			6		
400			17		
405			14		
410			10		
415			9		
420			9		
425			10		
430			6		
435			6		
440			7		

LOCATION ID: VW-1-452



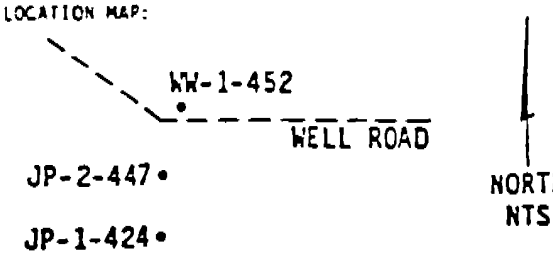
Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
7		440'-450' Penetration rates decrease significantly, pressure gauges suggest ground water encountered.
20		
20		
3		
8.5		
10.5		
7		
4		
12		
7		484'-488' Slough plugs bit, bit stuck.
		Total Depth = 488'.



MONITOR WELL JP-2-447 COMPLETION DIAGRAM

LITHOLOGIC LOG

LOCATION MAP:



NE 1/4 NE 1/4 NE 1/4 SE 1/4 S 6 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: JP-2-447

SITE COORDINATES (ft.):

N 225325.05 E 337477.96

GROUND ELEVATION (ft. MSL): 4445.17 (Brass Cap)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: AIR-FOAM ROTARY

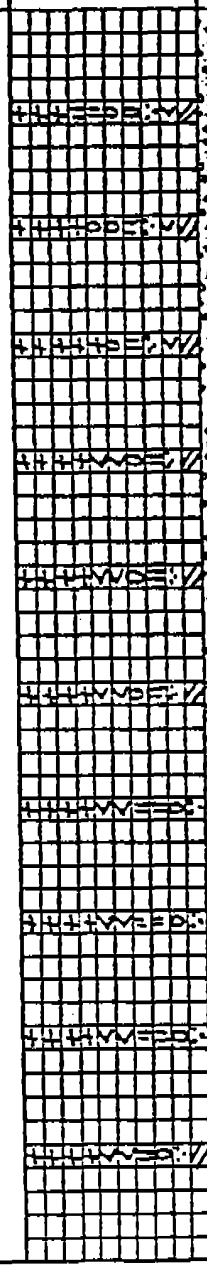
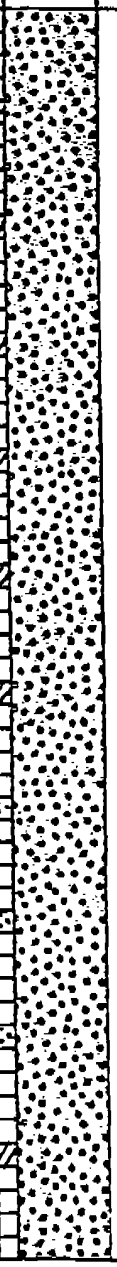
DRILLING CONTR.: LARJON

DATE STARTED: 2 AUGUST 1988 DATE COMPLETED: 15 AUGUST 1988

FIELD REP.: J. KIRBY, R. COOPER

COMMENTS: 9 7/8" pilot hole 0'-110', 14 3/4" borehole 0'-110', 9 7/8" borehole 110'-470'. Total depth = 470. Top of bedrock not reached.

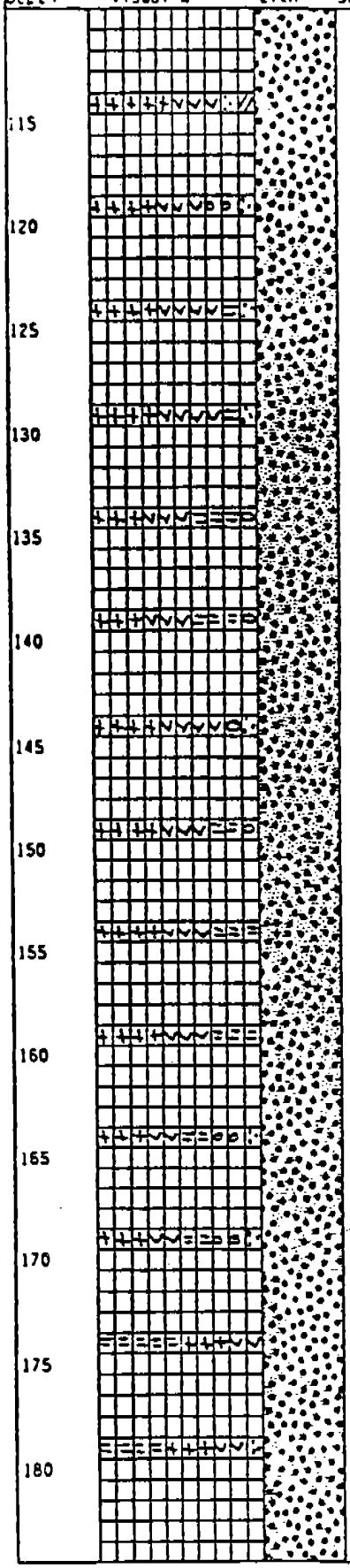
LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			3	0'-470' cuttings	0'-470' SANTA FE GROUP ALLUVIUM: Unwashed samples are moderate orange pink (5YR 8/4) to light brown (5YR 6/4) due to clay and/or matrix content. Washed samples have varied color due to different lithologies of the cuttings but have an overall color of medium gray (N5) to dark gray (N3). Cuttings range in size from silt size (<0.5 mm, <0.02 inches) to 10 mm (0.4 inches). The average cutting size is between 2 and 3 mm (0.08-0.12 inches). Cuttings are rounded to angular. Subrounded to rounded cuttings are smaller, whole clasts from the alluvium. A poorly- to moderately-consolidated, pebble to cobble alluvium with intermittent clay and caliche zones. Alluvium contains clasts of light gray (N7) to grayish black (N2) micritic limestone with < 10% allochems; white (N1) calcite; white (N9) and red and white mottled rhyolite with varying amounts of iron staining; light olive gray (5Y 3/2) and very dark red (5R 2/6) andesite with some pyroxene alteration to epidote; translucent bluish white (5B 9/1) to light bluish gray quartz; iron stained quartzite; iron-stained calcite-cemented quartz sandstone; moderate reddish orange (10R 6/6) to moderate reddish brown (10R 4/6) granite; moderate red (5R 4/6) to moderate reddish brown (10R 4/6) and greenish gray (5GY 6/1) to greenish gray (5G 6/1) siltstone; very pale orange (10YR 8/2) to pale yellowish brown (10YR 6/2) caliche; moderate orange pink (5YR 8/4) to light brown (5YR 6/4) clay varying from < 10% to 50% of sample. The clay from intervals containing abundant clay often forms balls when the samples are washed. Reaming in and out of borehole was necessary due to swelling clays. EZ-Mud was used in the drilling fluid to reduce the swelling. The amount of carbonate cuttings decreases, and the amount of igneous cuttings increases with depth. Amount of andesite cuttings increases significantly and rhyolite decreases slightly with depth.
10			12		
15			9		
20			3		
25			5		
30			3		
35			3.5		
40			2		
45			2		
50			3		

LOCATION ID: JF-2-447

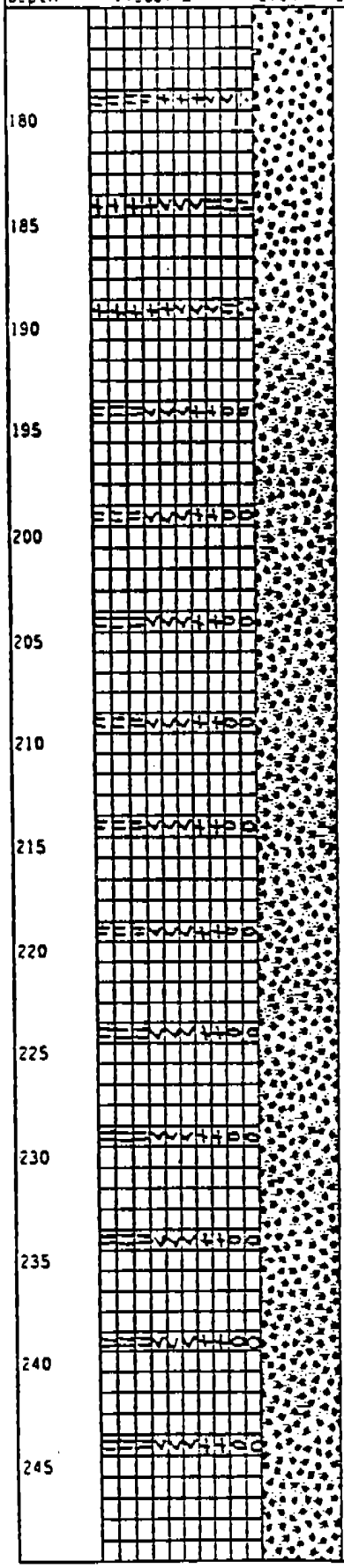
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
					5'-10' Decrease in clay content.
					10'-15' Decrease in caliche content, increase in limestone content.
50			3		30'-45' Increase in clay content.
55			5		
60			2		60'-70' Increase in clay content.
65			2		
70			3		70'-75' Decrease in clay content.
75			3.5		
80			4		
85			2		
90			2.5		90'-115' Increase in amount of caliche and caliche coatings and cutting size [max. 12 mm (0.48 inches), average 5 mm (0.2 inches)].
95			2.5		
100			3		
105			2.5		
110			3		
115			5		115'-170' Slight decrease in cutting size to an average size of 3 mm (0.12 inches). This interval has intermittent caliche zones.

LOCATION ID: JP-2-447



Depth	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
115	5		
120	4		
125	10		125'-315' Abundant clay content in cuttings ranges in value from 10-50%. Caliche is also found sporadically in this interval.
130	5		
135	3.5		
140	4		
145	4		
150	4.5		
155	3		
160	4		
165	2.5		
170	3		170'-210' Slight decrease in cutting size to an average size of 1-2 mm (0.04-0.08 inches).
175	4		
180	5		

LOCATION ID: [illegible]-2-447



Sample Type and Interval

Lithologic Description

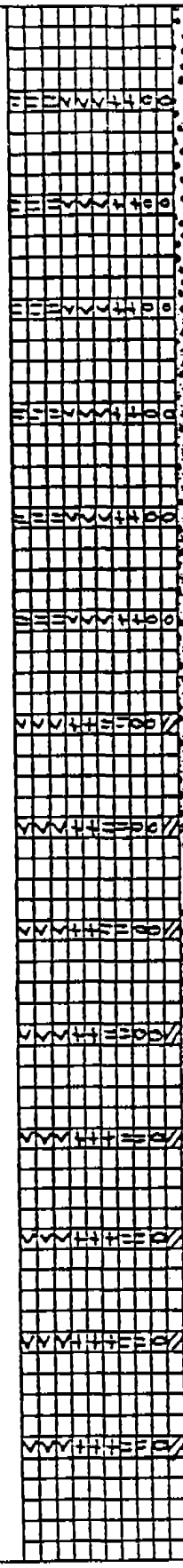
185'-470' Igneous clasts become the predominant clast. Andesite content increases and rhyolite content decreases with depth.

195'-210' One sample gathered for this 20' interval.

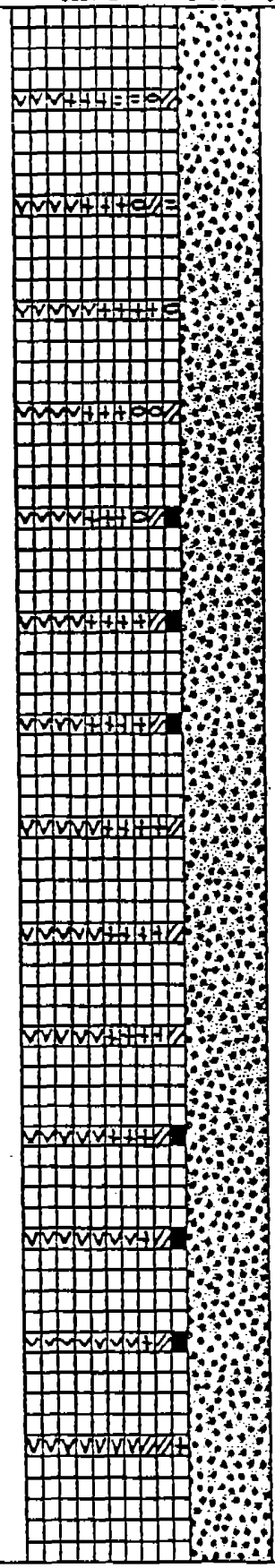
210'-230' One sample gathered for this 20' interval. Slight increase in average cutting size to 3 mm (0.12 inches).

230'-250' One sample gathered for this 20' interval. Decrease in average cutting size to 1-2 mm (0.04-0.08 inches).

LOCATION ID: JP-2-447

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245			2.5		
250			2.5		250'-270' One sample gathered for this interval.
255			3		
260			4		
265			4		
270			4		270'-290' One sample gathered for this interval.
275			2		
280			2.5		
285			4		
290			5		290'-310' One sample gathered for this interval. First noticeable amounts of epidote in andesite cuttings.
295			2		
300			3		
305			4		
310			3		

LOCATION ID: JP-2-447



Sample Type and Interval

Lithologic Description

320'-325' Increase in average cutting size to 3 mm (0.12 inches).

325'-335' Decrease in average cutting size to 1-2 mm (0.04-0.08 inches).

335'-355' Slight increase in average cutting size to 2-3 mm (0.08-0.12 inches).

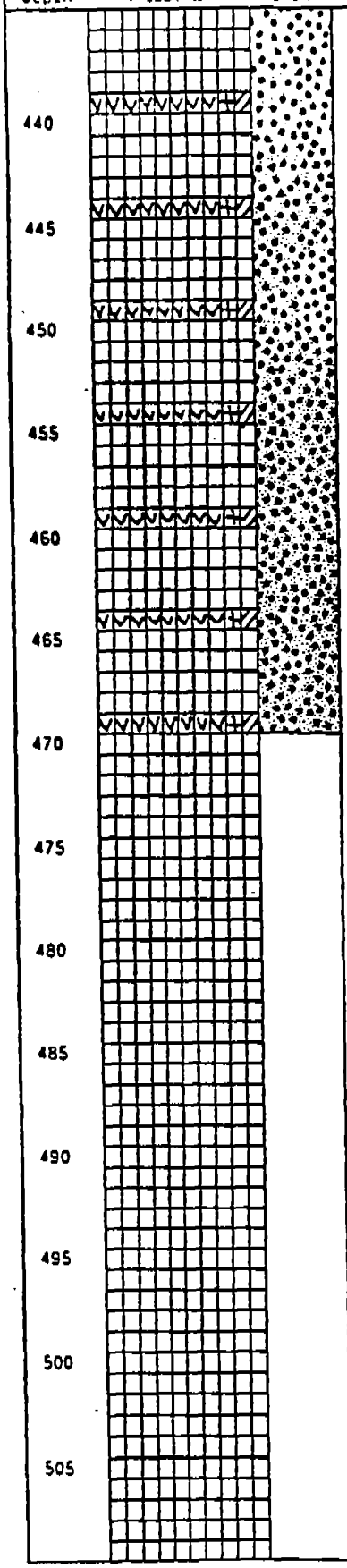
355'-365' Slight decrease in average cutting size to 1-2 mm (0.04-0.08 inches).

365'-385' Slight increase in average cutting size to 2-3 mm (0.08-0.12 inches).

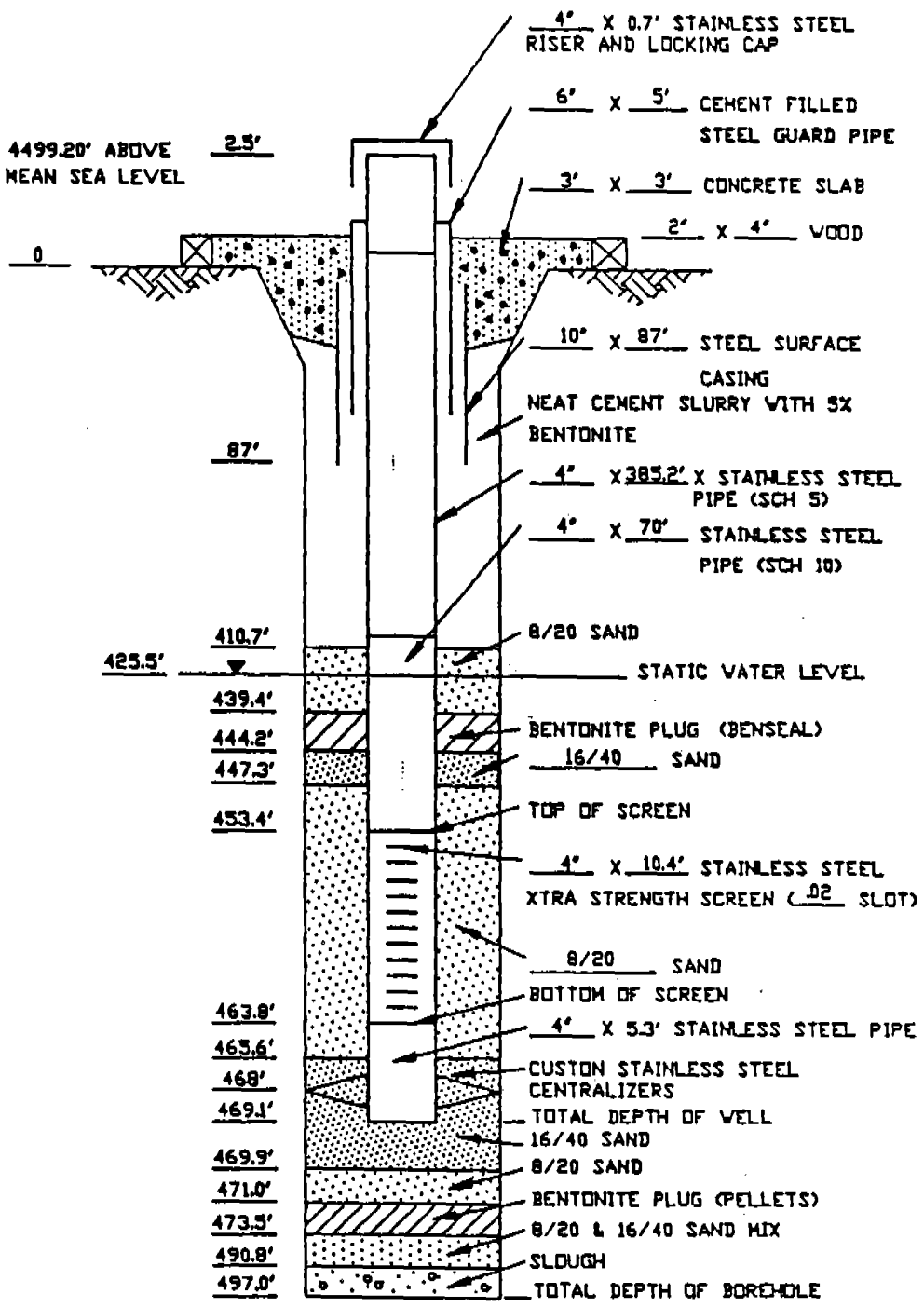
LOCATION ID: JP-2-447

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
375			2		
380			4		
385			4.5		385'-390' Slight increase in average cutting size to 3-4 mm (0.12-0.16 inches).
390			7		390'-450' Slight decrease in average cutting size to 2-3 mm (0.08-0.12 inches).
395			4.5		
400			4.5		
405			15		
410			4		
415			7		
420			4		
425			5		
430			6		
435			3		
440			5		

LOCATION ID: JP-2-447



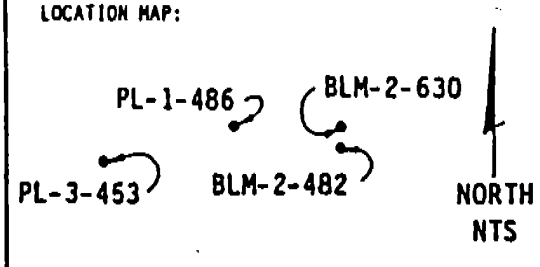
Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5		
5		
6		450'-470' One sample gathered for this interval. Cutting sizes range from a silt size (<0.05 mm) to 2 mm (0.08 mm).
5		
9.5		460'-470' Heaving sands in this interval. After cuttings are blown out and the bit is raised, the bit sticks from the hole sloughing around it approximately 9 to 10 feet.
5.5		
9		Total depth = 470'.



MONITOR WELL PL-3-453 COMPLETION DIAGRAM

LITHOLOGIC LOG

LOCATION MAP:



NW 1/4 NW 1/4 NW 1/4 SE 1/4 S 5 T 21S R 3E

LOCATION DESCRIPTION:

SITE ID: NASA-WSTF LOCATION ID: PL-3-453

SITE COORDINATES (ft.):

N 225366.27 E 400579.73

GROUND ELEVATION (ft. MSL): 4496.89 (BRASS CAP)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud/Air Foam Rotary

DRILLING CONTR.: Larjon

DATE STARTED: 24 October 1988 DATE COMPLETED: 9 November 1988

FIELD REP.: P.S. Egan, J.P. Kaszuba

COMMENTS: Mud rotary, 0'-89', 12 1/4" pilot hole reamed to 16", 0'-85', Air Foam rotary with 9 7/8" bit, 90'-297, Bedrock not reached. Total Depth (TD): 497'. Drift survey: 9.5 ft.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			38	Cuttings 0'-497'	0'-90' Clay-Rich Alluvium (Santa Fe Group): Moderate yellowish brown (10YR 5/4); cuttings range in size from <.004 to .06 inches, are small thin flakes to blocky clasts, and are poorly to moderately-sorted. Natural grains consist of fine to medium-grained sand and silt. The lithology is an unconsolidated, clay-rich, gravelly, polygenetic conglomerate. Much of the clay contains fine-grained sand and silt and the percentage of pure clay increases towards the bottom of the interval. Alluvial clasts consist of limestone, rhyolite, quartzite, siltstone, granite, and minor amounts of sandstone, described in further detail below.
10			42		
15			35		
20			33		
25			61		
30			49		30'-35' Gravelly interval.
35			40		
40			24		40'-45' Large amount of fine-grained sand present in clay.
45			42		
50			40		

LOCATION ID: PL-3-453

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
50			40		
55			30		
60			41		
65			22		
70			35		
75			56		
80			49		
85			33		
90			28		
95			5		
100			5		
105			4		
110			3		
115			3		

90'-497' Gravelly Alluvium (Santa Fe Group): Grayish black (N2) to medium light gray (N6) when wet. Cuttings range in size from less than .1 inches to 2 inches, are angular flakes to blocky clasts, and are poorly to moderately sorted. Natural grains are clay, silt and fine- to course-grained sand. The alluvium is unconsolidated but becomes more indurated with depth (general increase in drill time with depth). The lithology is an unconsolidated to semi-consolidated, gravelly to boulder (bit behavior), polygenetic conglomerate. Thick clay layers occur throughout the upper section of the alluvium. Driller comments alluvium is hard, consistent, and fractured. Cutting lithologies are grayish black (N2) to medium light gray (N6) micritic limestone with occasional calcite-filled fractures; white (N9) to moderate red (5R 5/4) rhyolite that exhibits iron oxidation rims around phenocrysts of pyrite; dusky red (5R 3/4) to grayish olive (10Y 4/2) siltstone; moderate red (5R 4/6) granite; transparent quartz; medium gray (N5) and grayish purple (5P 4/2) porphyritic andesite containing euhedral to subhedral phenocrysts of white plagioclase frequently altered to moderate yellow green (5GY 7/4) epidote; and minor amounts of sandstone and caliche.

90'-235' Replace Frank's mud rotary with CP air rotary drilling rig. Samples from air drilling are not exhibiting the gross amounts of clay as did the first 90' of samples from mud rotary drilling. Clay seems to be distributed throughout most samples and diminishes to less than 10% by 235'.

LOCATION ID: PL-3-453

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
115			3		
120			3		
125			3.5		
130			4.5		
135			3		
140			3		
145			3		
150			3		
155			4		
160			3		
165			4		
170			3.5		
175			3		
180			3		

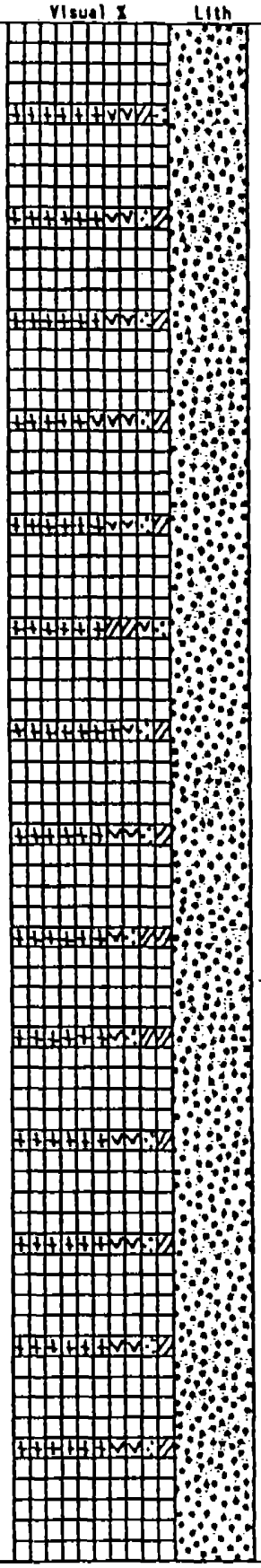
LOCATION ID: PL-3-453

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
180			3		
185			3.5		185'-497' Average grain size has decreased to .1 inch.
190			5		185'-190' First occurrence of purple andesite in cuttings (only a few grains).
195			3.5		195'-200 Observed a clast of limestone cemented with caliche to a larger limestone clast. Observe caliche in cuttings. First occurrence of grey andesite.
200			3		200'-205' Notable amount of sand present in samples.
205			3		
210			3		
215			3		
220			2.5		
225			4		
230			5		
235			3		235'-497' Clay in samples has diminished to less than 10%.
240			2.5		
245			4.5		

LOCATION ID: PL-3-453

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			4.5		
250			4		
255			5		
260			8		260'-290' Samples contain abundant fine-grained sands.
265			4.5		
270			3		
275			5		
280			5		
285			3.5		
290			6		
295			4		
300			5		
305			4		
310			5		

LOCATION ID: PL-3-453



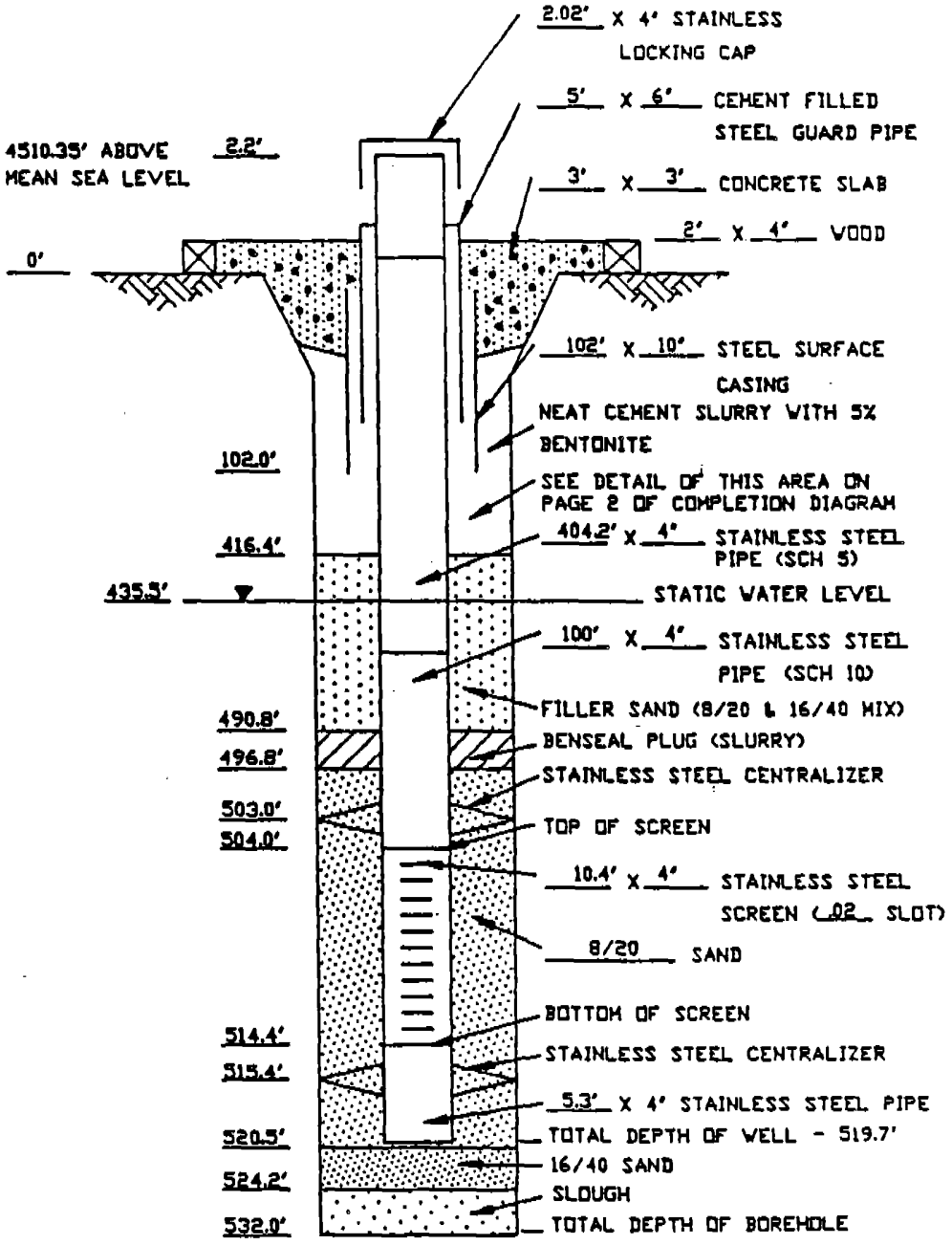
Depth	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
		Cuttings (cont'd)	
310	5		
315	4		
320	8		
325	6		
330	4		
335	5		
340	3.5		
345	3		
350	4		
355	4		
360	4		
365	5		
370	6		370'-375 Limestone exhibits calcite-filled fractures.
375	5		

LOCATION ID: PL-3-453

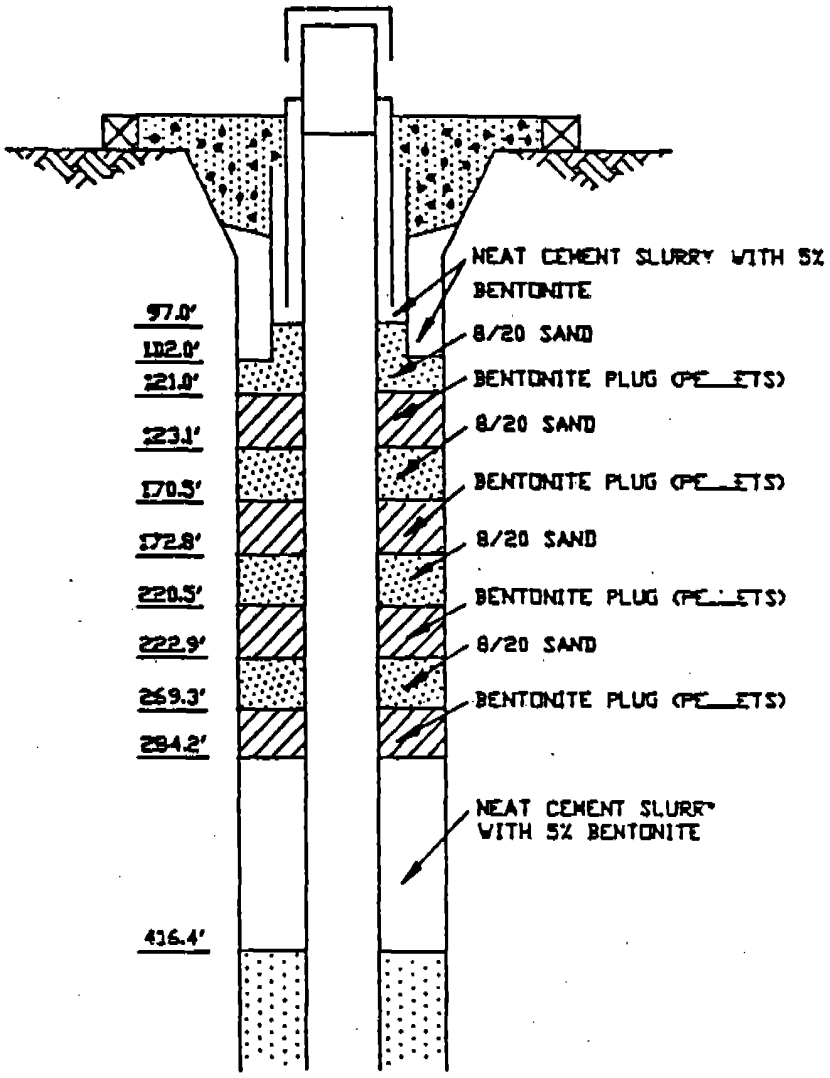
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375			5		
380			3		
385			4.5		
390			3		
395			5		
400			6.5		
405			4.5		
410			5		
415			4		
420			4		420'-497' The percentage of both gray and purple andesite in cuttings gradually increasing.
425			7		
430			4		
435			4		
440			7		

LOCATION ID: PL-3-453

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
440			7		
445			4		
450			5		
455			5		
460			3		
465			3		
470			6		
475			6		
480			6		
485			6		
490			6		
495			5		
			2		Total Depth = 497'
500					
505					



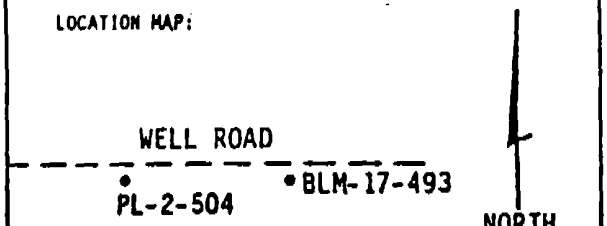
MONITOR WELL PL-2-504 COMPLETION DIAGRAM



MONITOR WELL PL-2-504 COMPLETION DIAGRAM
(DETAIL)

LITHOLOGIC LOG

LOCATION MAP:



NE 1/4 NE 1/4 NW 1/4 NE 1/4 S 5 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: PL-2-504

SITE COORDINATES (ft.):

N 227742.47 E 401193.52

GROUND ELEVATION (ft. MSL): 4508.04 (BRASS CAP)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: MUD/AIR-FOAM ROTARY

DRILLING CONTR.: LARJON

DATE STARTED: 22 SEPT. 88 DATE COMPLETED: 28 NOV. 88

FIELD REP.: P. S. EGAN

COMMENTS: 9 7/8" pilot hole reamed to 16" with mud rotary, 0-100'. 9 7/8" bit with air foam, 100'-532'. Total Depth (TD) = 532'. Bedrock not reached. Borehole drift = 29'.

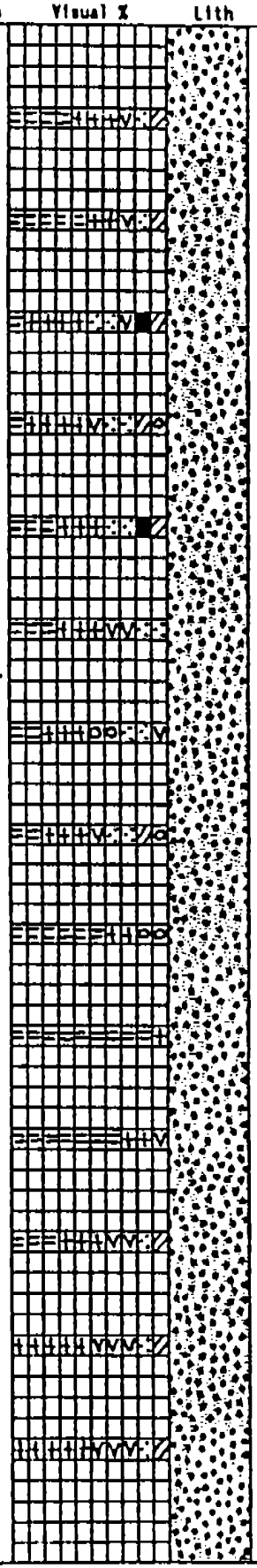
LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
5			68	0'-532'(TD) cuttings	0'-5'	Surficial Caliche: Grayish pink (5R 8/2) to yellowish gray (5Y 8/1). Small amount of caliche in cuttings but surface of well pad exhibits chalky dust and large clasts of caliche. Extremely long drilling time for first 5'.
10			19		5'-532'	Gravelly Alluvium (Santa Fe Group): Dusky yellowish brown (10Y 2/2) to moderate yellowish brown (10YR 5/4) when clay content is high. Cuttings range in size from less than .1 to .8 inches, are angular to subrounded and poorly sorted. Natural grains are up to .2 inches in size, are subangular to rounded and poorly-sorted. The alluvium is unconsolidated in the upper portion but consolidated to semi-consolidated in the lower portions (variations in drilling time). The lithology is an unconsolidated to consolidated, gravelly to boulder (longer drill times, bit behavior), polygenetic conglomerate. Cutting lithologies are grayish black (N2) to medium light gray (N6) micritic limestone with occasional calcite-filled fractures less than .1 to .2 inches thick, white (N9) to moderate red (5R 5/4) rhyolite which frequently exhibits oxidation rims around phenocrysts of magnetic or pyrite, dusky red (5R 3/4) to grayish olive (10Y 4/2) siltstone, moderate red (5R 4/6) granite, light gray (N7) to translucent quartz and quartzite, medium gray (N5) and grayish purple (5P 4/2) porphyritic andesite containing euhedral to subhedral phenocrysts of white plagioclase, frequently altered to moderate yellow green (5GY 7/4) epidote, and minor amounts of sandstone and caliche. Thick clay layers occur throughout the upper section of the alluvium. Caliche is present as hard pan at the surface and lesser amounts as thin lenses or coatings on clasts throughout the section.
15			12			
20			13			
25			24			
30			41			
35			17			
40			57			
45			42			
50			30			

LOCATION ID: PL-2-504

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
					10'-15'	Clay-rich interval.
					10'-50'	Increase in average cutting size to .4 inches.
50			30		40'-50'	Clay-rich zone. Clay is slowing drill rate.
55			10		50'-55'	Decrease in average cutting size to .1 inches..
					55'-60'	Increase in average cutting size to .5 inches.
60			42		60'-80'	Decrease in average cutting size to .4 inches.
65			74		65'-100'	Clay-rich interval. Clay is slowing drill rate.
70			9			
75			15			
80			15		80'-85'	Decrease in average cutting size to .1 inches.
85			19			
90			29			
95			21			
100			30		100'-292'	Drilling is rapid.
					100'-105'	Sample is 100% cement cuttings (from grouting of surface casing).
105			3 1/2			
110			4		110'-135'	Cuttings increase in size to .3 inches average.
115			3			

LOCATION ID: PL-2-504

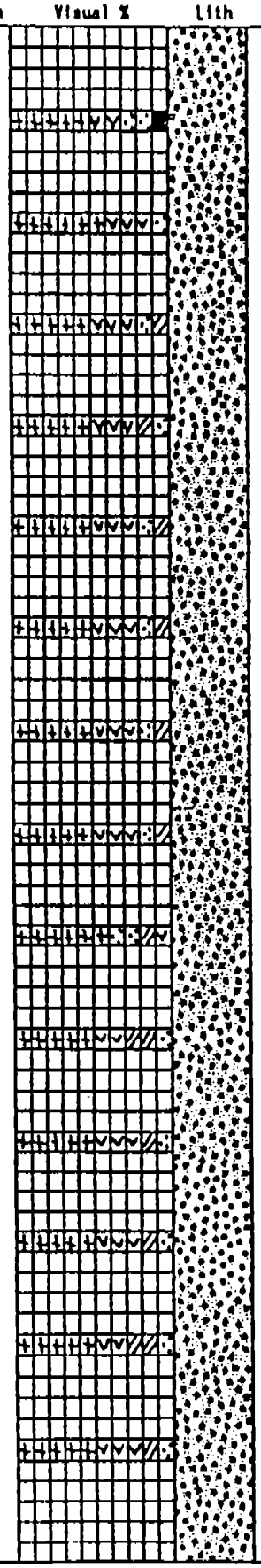


Depth	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
115	3			
120	4 1/2		120'-125'	First occurrence of gray andesite in cuttings.
125	5			
130	4			
135	4		135'-140'	First occurrence of purple andesite in cuttings.
			135'-TD	Average cutting size remains fairly consistent at .1 to .2 inches.
140	4			
145	4			
150	5		150'-165'	Clay-rich interval.
155	5		155'-160'	Caliche, volcanics, quartzite, and siltstone present in sample but less than 10% relative to clay content.
160	4		160'-165'	Quartzite and siltstone also present but less than 10%.
165	4		165'-170'	Purple and gray andesite amount in volcanic fraction increasing, but rhyolite continues to predominate.
170	3 1/2			
175	3 1/2			
180	2 1/2			

LOCATION ID: PL-2-504

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180			2 1/2		
185			3		
190			7		190'-200' Clay-rich interval.
					190'-195' Quartz also present, but less than 10% relative to clay.
195			5 1/2		195'-200' Quartz, siltstone and caliche present but less than 10%.
200			4 1/2		
205			6		
210			4 1/2		
215			3 1/2		
220			3 1/2		
225			3		
230			4 1/2		
235			5		
240			9		
245			6 1/2		

LOCATION ID: PL-2-504



Depth	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
245	6 1/2		245'-250'	Increase in the amount of andesite in the volcanic fraction to approximately 40%.
250	4			
255	4			
260	4			
265	10			
270	6		270'-275'	Increase in amount of andesite in volcanic fraction to 35%.
275	4			
280	5			
285	12		292'-532'	The average drilling rate is slower than the first 292 feet. Alluvium is becoming harder.
290	4			
295	5			
300	8			
305	7			
310	8			

LOCATION ID: PL-2-504

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310			8		
315			7		
320			8		
325			10		
330			8		
335			5		
340			7		
345			11		
350			34		
355			81		
360			14		
365			9		
370			12		
375			25		

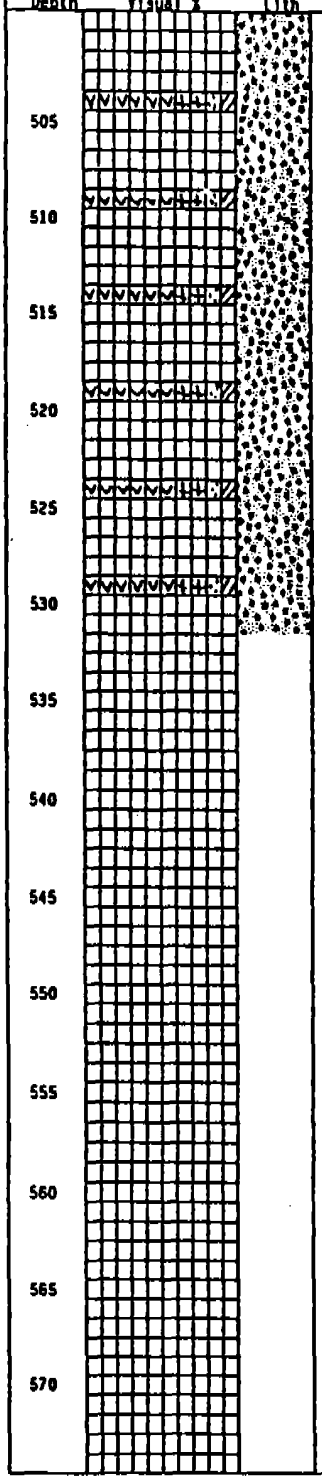
LOCATION ID: PL-2-504

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
375			25		
380			9		
385			19		
390			15	390'-410'	Samples contain either a dark reddish brown (10R 3/4) sandstone or a highly oxidized rhyolite.
395			15		
400			7		
405			15		
410			14		
415			14		
420			8		
425			12		
430			18		
435			8	435'-532'	Volcanics have become the predominant clast.
440			4		

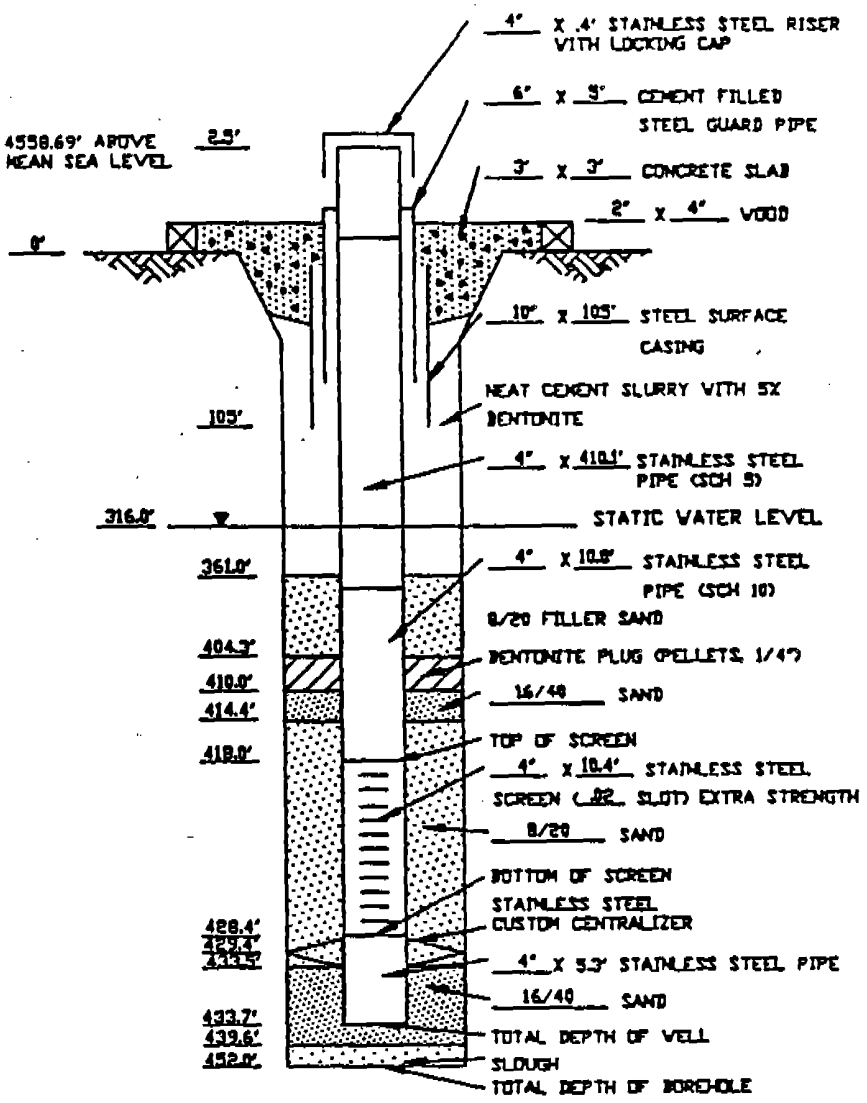
LOCATION ID: PL-2-504

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
440			4		
445			4		
450			3		
455			6		
460			5		
465			9		
470			7		
475			8		
480			8		
485			18		
490			14		
495			12		
500			15		
505			10		

LOCATION ID: PL-2-504



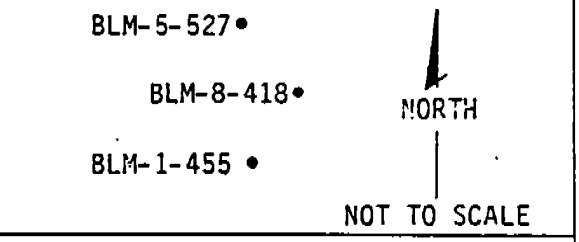
Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
10	505'-532'	One sample represents this interval.
8		
12		
11		
18		
8	TD = 532'	



COMPLETION DIAGRAM BLM-8-418

LITHOLOGIC LOG

LOCATION MAP:



NW 1/4 NW 1/4 SW 1/4 NW 1/4 S 33 T 20S R 3E

SITE ID: NASA-WSTF LOCATION ID: BLM-8-418

SITE COORDINATES (ft.):

N 231423.04 E 403768.31

GROUND ELEVATION (ft. MSL): 4556.33 (BRASS CAP)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: AIR-FOAM ROTARY

DRILLING CONTR.: LARJON

DATE STARTED: 13 JUNE 1988 DATE COMPLETED: 28 JUNE 1988

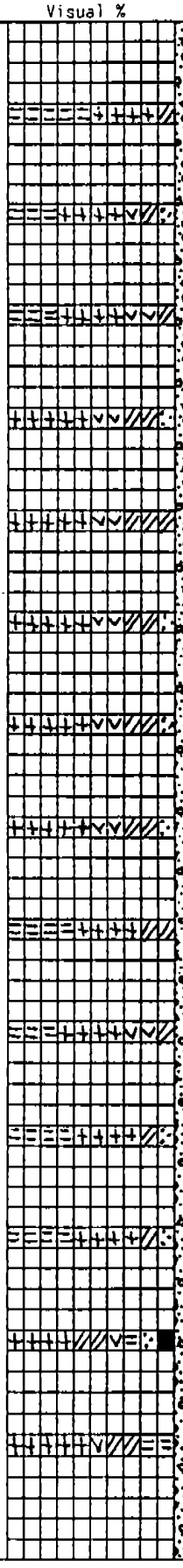
FIELD REP.: P. EGAN, C. WERDEN, S. DUBYK

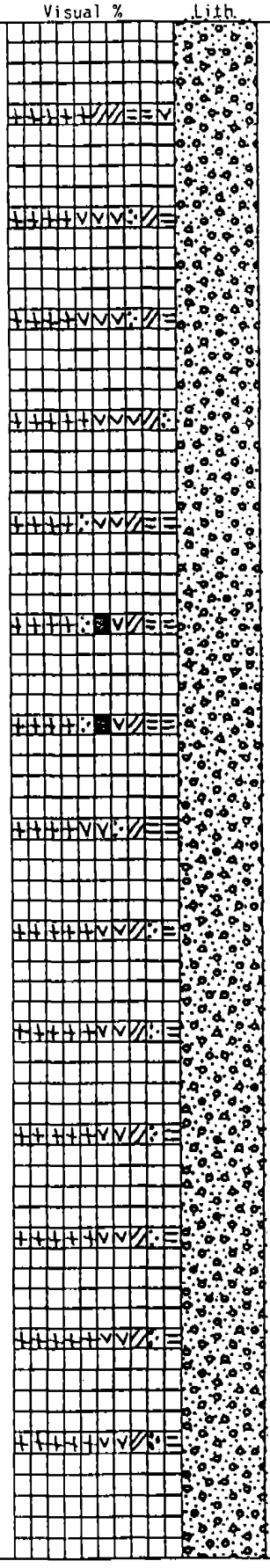
COMMENTS: Total Depth (TD) = 452'. 14 3/4" borehole 0'-105', 9 7/8" borehole 105'-TD. Depth to bedrock = 418' (geophysical logs). Borehole drift = 23'.

LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				0'-432' cuttings	0'-105' SURFICIAL AND CLAY-RICH ALLUVIUM: The predominant color of the interval is pale yellowish brown (10 YR 6/2). Cuttings are large (up to 1 inch) blocky fragments in a clay/silt matrix. The lithology is an unconsolidated, poorly-sorted, clayey, silty gravelly alluvium. The interval is very clay and silt rich. Sandy soil is present at surface and decreases towards bottom of interval. Most of the fines lost when samples were washed.Clasts consist of limestone, rhyolite, siltstone, quartzite, and caliche.
5			9.5		0'-5' Sample is mostly clayey, silty sand with few lithic clasts.
10			21		10'-15' Significant decrease in cutting size. Cuttings are uniform in size and shape. Bit chattering and jumping at this interval. Presumed boulder present
15			6		15'-35' Clay present in amounts < 10%.
20			5		
25			4		
30			4		30'-35' Clast size increases to 2 inches.
35			3		
40			3		35'-50' Clay-rich zone present.
45			3		
50			4		50'-60' Clay percentage is gradually lessening.

LOCATION ID: BLM-8-418

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
50			4		
55			4		
60			5		
65			4		65'-80' 10-15% fines present.
70			4		
75			11		
80			4		80'-85' 20% fines present.
85			3		85'-105' Clay-rich zone present.
90			5		
95			7		
100			5		
105			4		105'-425' ALLUVIUM (Santa Fe Group): There is a variety of color in the alluvium but the predominant color is dark gray (N3) when wet. Average cutting size is 0.3 inches with cuttings up to 1 inch. Cutting shapes range from angular chips to blocky fragments. The lithology is an unconsolidated to moderately consolidated (longer drilling times), poorly sorted, pebble to possible boulder polygenetic conglomerate. Contains clasts of light gray (N7) to dark gray (N3) micritic limestone, light
110			4.5		
115			4.5		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
115			4.5		105'-425' ALLUVIUM (Santa Fe Group) Continued: gray (N7) andesite, grayish red purple (5RP 4/2) porphyritic andesite (occurs more frequently in lower part of section with the plagioclase phenocrysts altering to epidote), white (N9) rhyolite with varying degrees of iron oxidation as rims around mafic phenocrysts (pyrite, magnetite ?), transparent to white to yellowish gray (5Y 8/1) quartzite, dusky red (5R 3/4) to light olive gray (5Y 5/2) siltstone and minor amounts of reddish granite and sandstone.
120			5		
125			4		115'-120' Silt present with clay.
130			5		
135			5		
140			3		
145			6.5		
150			3.5		
155			6		
160			12		
165			4		
170			4		
175			4		
180			5		180'-185' Decrease in cutting size to ~ .1 inches.

LOCATION ID: BLM-8-418

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180			5		
185			5		
190			5		
195			4		
200			6		
205			5		
210			3		
215			3		
220			3.5		
225			5		
230			3.5		
235			7		235'-240' Limestone clasts displaying brecciation, calcite-filled fractures and micro-fractures.
240			10.5		
245			9		

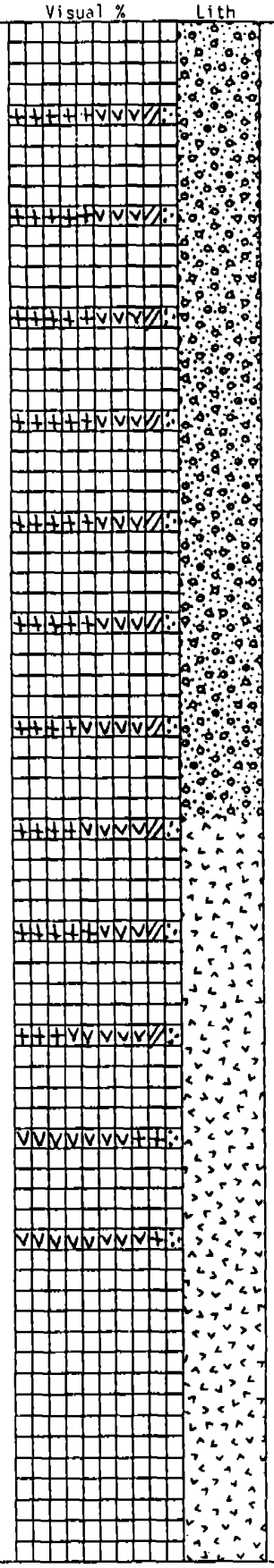
LOCATION ID: BLM-8-418

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245			9		
250			13		
255			11		
260			15		
265			13		
270			7		
275			10		
280			11		
285			11		
290			9		290'-295' Increase in amount of white rhyolite cuttings.
295			19		
300			30		
305			14		
310			15		

LOCATION ID: BLM-8-418

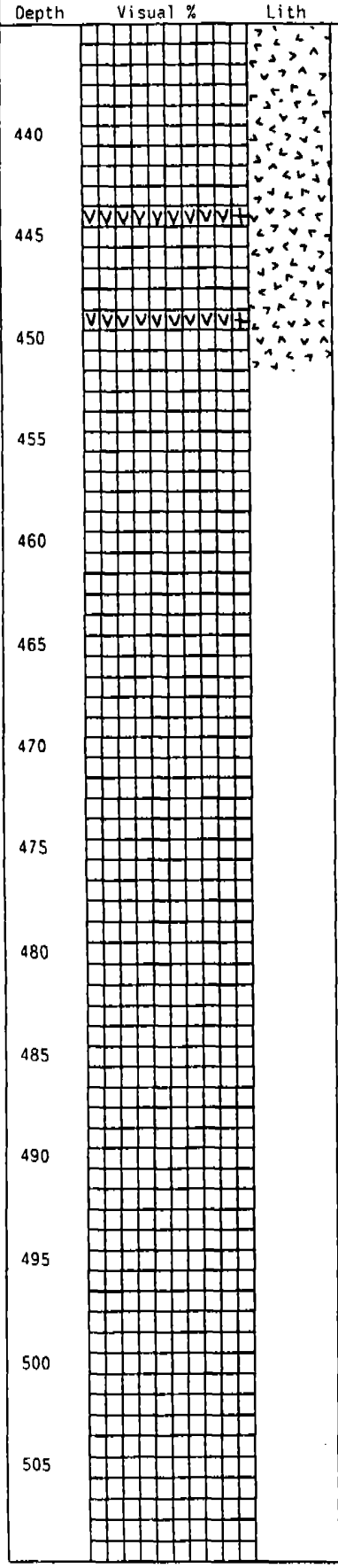
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310			15		
315			19		315'-320' Decrease in siltstone and quartz content. Predominantly limestone and rhyolite present.
320			10		
325			10		
330			15		
335			28		
340			23		
345			26		
350			20		
355			47		355'-360' First occurrence of purple andesite.
360			23		
365			33		
370			29		
375			54		

LOCATION ID: BLM-8-418



Depth	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
375	54		
380	29		
385	48		385'-390' Purple andesite and grayish andesite with epidote becoming more noticeable in volcanic fraction.
390	43		390' Longer drilling times due to problems with stabilizers. Stabilizer diameter too large for hole. Cuttings are caught up in the reduced annular space and slow bit down. Repair stabilizers over weekend break (machine to a smaller diameter).
395	6		390'-400' See trace amounts of flow banded rhyolite cuttings in samples.
400	10		
405	21.5		
410	21		
415	7.5		410'-415' Drilling time has significantly decreased. Presumed bedrock contact, although samples blown out borehole remain predominately alluvium. (Gray tuff cuttings present, but less than 20% of sample).
420	7		
425	6.5		410'-452' VESICULAR TUFF (Cueva Tuff): Samples are pinkish gray (5 YR 8/1) tuff. Cuttings are an average of .3 inches in diameter, sub-angular to subrounded, and soft (some cuttings can be crushed between fingers). Tuff cuttings contain abundant lithic fragments that are dark brown to black or glassy. The lithology is a vesicular, lithic-crystal rhyolite (?) ash flow tuff. Uphole contamination by alluvial clasts is present in samples (up to 40% at top of interval, decreasing to ~ 10% at T.D.).
430	5	432'-442' core	
435	stop time		426' Water first detected.
440			

LOCATION ID: BLM-8-418



Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
		432'-442' **** core interval **** 100% recovery See attached description
begin time		
	442'-452' cuttings	442'-452' Cuttings are predominantly tuff, but some uphole contamination by alluvium is present in samples (~10%).
4		
4		
		Total Depth = 452'.

CORE DESCRIPTION
BLM-8-418
432' - 442'
(100% Recovery, RQD = 98%, Excellent rock quality)

CUEVA TUFF:

Pinkish gray (5 YR 8/1), dry, to light gray (N7), wet, massive, vesicular lithic-crystal rhyolite (?) ash-flow tuff. The tuff displays no apparent flow structure, is poorly welded, and soft (can be scratched with fingernail but not indented with thumb).

The tuff is rich in lithic and glassy fragments. Phenocrysts and pumaceous clasts are also present. Exotic fragments total 40-50% of the sample. Lithic fragments range in size from .04 inches to several inches and consist of andesite, granite, and pumice. Smaller lithic fragments are unidentifiable in hand sample. Phenocrysts range in size from <.04 inches to .16 inches, are subhedral to anhedral, and consist of quartz, feldspar, and mafic minerals (garnet?)

Fractures are present throughout the core sample. Fractures range from .12 inches to .5 inches thick and are oriented 20^0-45^0 from vertical. Post-fracture features include thin zones of complete or partial tuff alteration along fractures and prismatic, milky, calcite filling veins and veinlets. Zones of tuff alteration are lighter in color, gray orange pink (5 yr 7/2) to medium light gray (N6), and very effervescent.

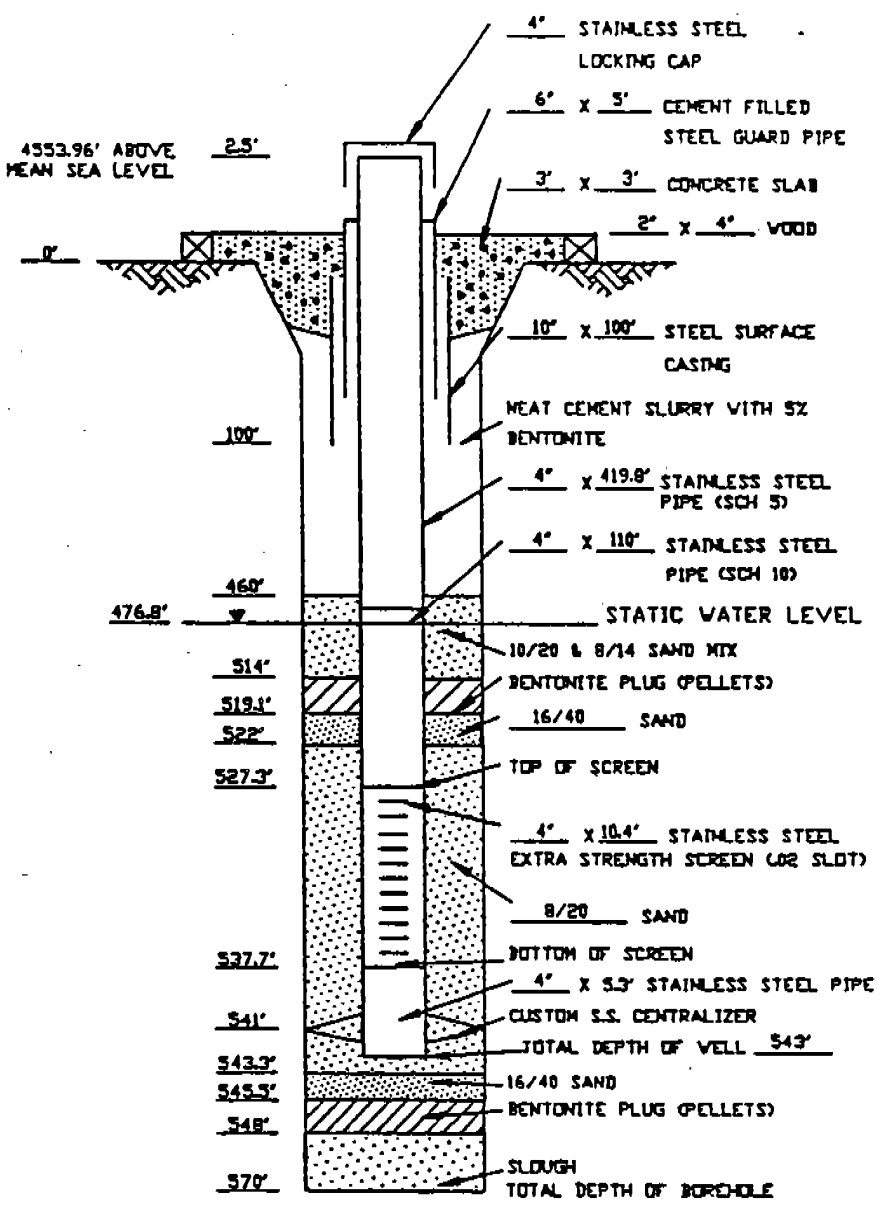
432.5'-433' A large clast (1.25 inches) of pumice and a xenolith (3.5 inches) of grayish red purple (5RP 4/2) andesite are present. An area of alteration occurs above the andesite xenolith.

433.5'-435' A large fracture is present displaying thick (up to 2 inches) zones of tuff alteration. The altered tuff is very soft and friable. Also present are veins filled with milky prismatic calcite and a vug filled with transparent euhedral calcite.

437.5'-441' This interval contains two fractures ranging from .25 to .50 inches thick. The fractures are oriented 45^0 from vertical and are perpendicular to each other. Both fractures exhibit zones of partial or complete alteration of the tuff.

The tuff has a visual porosity of approximately 35%. This rock unit is probably highly transmissive because of the abundant vesicles and fractures present.

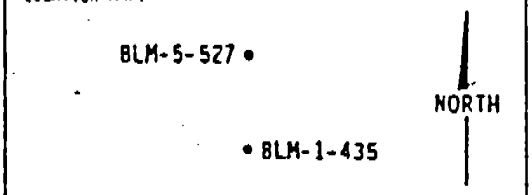
Note: Core pieces are sequentially numbered from top to bottom, with directional arrows in the up direction.



MONITOR WELL BLH-S-527 COMPLETION DIAGRAM

LITHOLOGIC LOG

LOCATION MAP:



NW 1/4 NW 1/4 NW 1/4 NW 1/4 S 33 T 20S R 3E

SITE ID: NASA-WSTF LOCATION ID: BLM-5-527

SITE COORDINATES (ft.):

N 232891.85 E 403363.61

GROUND ELEVATION (ft. MSL): 4554.88 (BRASS CAP)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: AIR-FOAM ROTARY

DRILLING CONTR.: LARJOM

DATE STARTED: 4 MARCH 1988 DATE COMPLETED: 4 APRIL 1988

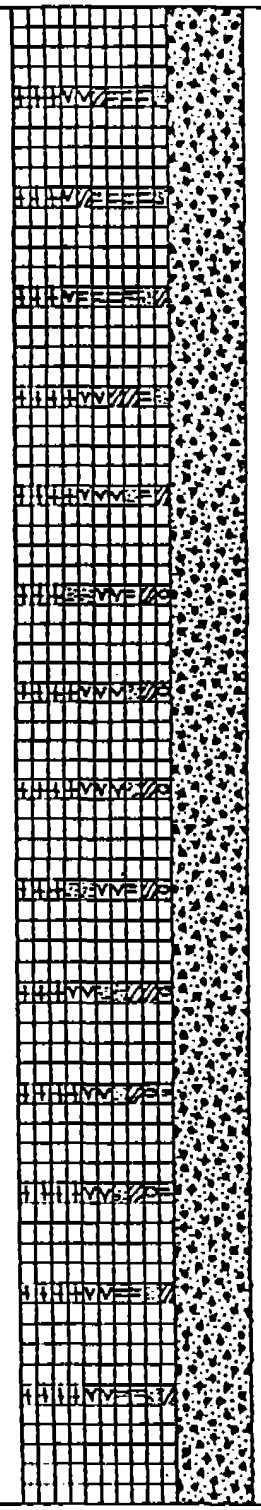
FIELD REP.: COOPER

COMMENTS: 0'-100' 8 3/4", 0'-100' 14 3/4" ream, 100'-560' 9 7/8", 0'-100' steel casing, 560'-570' 2" core, Bedrock at 363', Total depth = 570'.

LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				0'-560' cuttings	* Note: In the following descriptions, grains are true formational grains. Cuttings have been broken or chipped by the drill bit and do not represent the true size and shape of grains within the formation.
5			8		
10			4		0'-35' SURFICIAL ALLUVIUM: Unwashed samples throughout the interval are grayish orange (10YR 7/4) due to clay and silt content. Washed samples are 80% dark gray due to carbonate clasts and 20% multicolor from siltstones and volcanic clasts. Average cutting and grain size is 0.5 mm (0.2 inches), cuttings and grains range in size from 1 mm (0.04 inches) to 20 mm (0.75 inches). Grains in sample are rounded to subrounded, cuttings are blocky angular to angular chips. The lithology is an unconsolidated to poorly-consolidated gravelly alluvium with low clay content. Some hard caliche layers are present near the surface. The alluvium contains clasts of light to dark gray (N7 to N2) limestone and dolomite, white (N9) rhyolite with some iron staining, greenish gray (5GY 6/1) andesite, dusky red (5R 3/4) to dark reddish brown (10R 3/4) siltstone, transparent to milky gray quartzite.
15			4		
20			7		
25			6		
30			4		25'-35' Clay lens, significant increase in clay content in cuttings.
35			6		35'-365' GRAVELLY ALLUVIUM (Santa Fe Group): Unwashed samples are moderate orange pink (5YR 8/4) to light brown (5YR 6/4) in clay-rich zones and light gray (N7) to medium dark gray (N4) in zones containing little clay. Cutting and grain sizes range throughout interval from silt-size to 25 mm (1.0 inch). Grains from alluvium are subangular to rounded, whereas cuttings are subangular to angular. Numerous grains and cuttings throughout the interval have a caliche coating. The lithology is a poorly- to well-consolidated pebble to cobble conglomerate. It contains clasts of light gray (N7) to dark gray (N3) limestone, light gray (N7) dolomite, dirty white to white (N9) rhyolite with some iron
40			4		
45			2.5		
50			3		

LOCATION ID: BLM-S-527

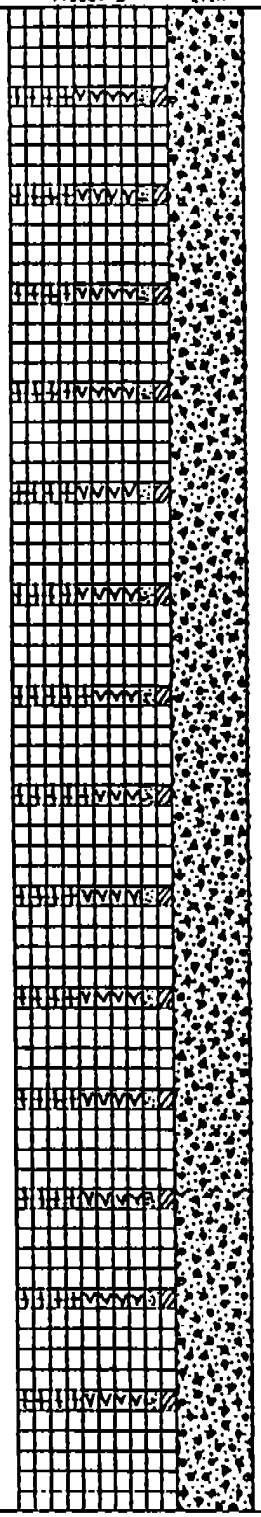


Depth	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
50	3		35'-365'	GRAVELLY ALLUVIUM Continued: staining, grayish green (10GY 5/2) andesite, pale red purple (5RP 6/2) andesite, dark reddish brown (10R 3/4) to dusky red (5R 3/4) siltstone (Abo), transparent to milky gray quartzite, and small amounts of moderate brown (5YR 4/4) sandstone, granite and caliche in upper part of the interval.
55	3		35'-70'	Significant increase in cutting size, average size is 5 mm, sizes range from fine-grained sand to 20 mm (0.8 inches). Clay-rich zone containing the above-mentioned clasts. Clays balls up when samples are washed. Limestone is the predominant cutting and rhyolite is the predominant (~90%) igneous cuttings.
60	3			
65	3		45'-60'	Clay-rich lens, very sticky and balls up when washed.
70	1.5		70'-85'	Significant decrease in cutting size, average cutting size is 1 mm (0.05 inches). Well-consolidated zone containing ≤ 10% clay, very hard and bouldery. Limestone still predominant cutting and rhyolite predominant igneous cutting.
75	21			
80	10			
85	4.5		85'-190'	Average cutting size is 5 mm (0.2 inches), clay-rich zone with percentages ranging from 10% to 60%. Cuttings are mostly limestone, rhyolite, with quartzite and siltstone also present. Clay forms balls when samples are washed.
90	10			
95	5			
100	5			
105	4			
110	5			
115	3			

LOCATION ID: BLM-5-527

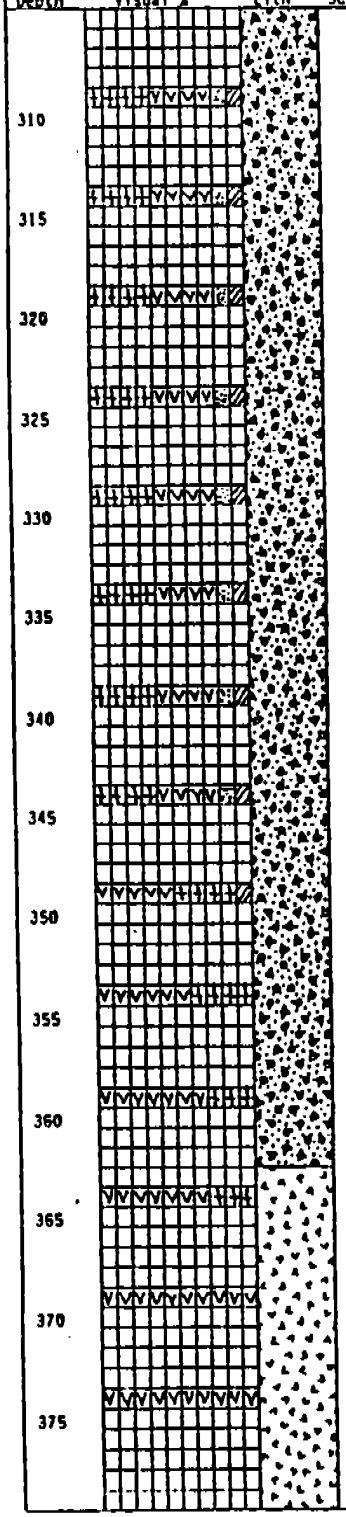
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
115			3		
120			9	120'-130'	Samples mixed together, overall percentage for 3 samples at 120'.
125			4		
130			4		
135			5		
140			4		
145			3		
150			3		
155			3.5		
160			4		
165			2		
170			4		
175			4.5		
180			3		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
180			3			
185			3.5			
190			2		190'-350'	Limestone is predominant cutting but volcanic percentage increases with depth and limestone and volcanic percentages become more equal. White (N9) rhyolite is predominant igneous cutting.
195			3			
200			2		200'-230'	Significant decrease in cutting size to average of 2 mm (0.08 inches).
205			3			
210			3			
215			2			
220			2			
225			3			
230			4		230'-300'	Increase in cutting size to average 4 mm (0.02 inches).
235			4			
240			4			
245			4			



Depth	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245	4		
250	4		
255	4.5		
260	4		
265	6		
270	4.5		
275	4		
280	18		
285	5		
290	6		
295	7		
300	15		300'-350' Significant decrease in cutting size to an average of ≤ 1 mm (0.04 inches). Cuttings so small that visual percentage is very hard to estimate.
305	5.5		
310	7		

LOCATION ID: BLH-5-527

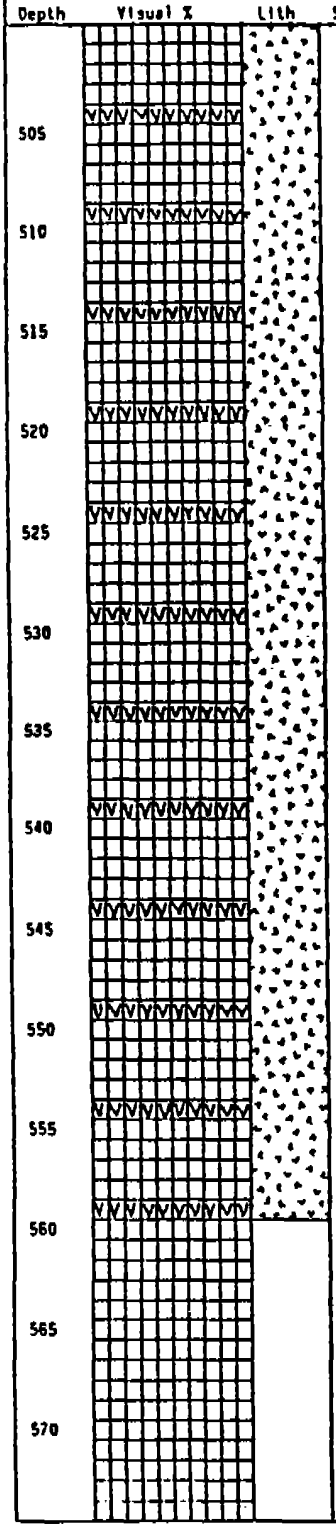


Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
7			
5			
41			
10			
8			
7			
8			
12			
12		350'-365'	Increase in cutting size to average of 2-3 mm (0.12 inches). White (N9) rhyolite is predominant cutting with limestone percentage decreasing with depth. Amount of pale red purple andesite also increases slightly.
9			
12			
30		363'-560'	FLOW BANDED RHYOLITE: Dark reddish brown (10R 3/4) to dusky red (5R 3/4) with light bluish gray (5B 5/1) banding. Cuttings angular from 363'-515'; cuttings are subrounded to angular, 515'-525'; cuttings are angular, 525'-560'. Cuttings range in size from silt-size to 3 mm (0.12 inches). Cuttings show gradual color change with depth from predominantly dark reddish brown with light bluish gray banding to predominantly light bluish gray mottled with dark reddish brown. Color change is possibly due to greater exposure to oxygen near the surface causing oxidation of the rhyolite. Rhyolite is very dense and hard, however.
46			
38			

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
					363'-560' FLOW BANDED RHYOLITE Continued: fracture zones drill significantly easier. Thin section observations indicate rhyolite is composed of 98-99% microcrystalline, equigranular matrix of sanidine, plagioclase (?) and quartz and 1-2% phenocrysts of quartz and sanidine.
375			38		
380			33		
385			30		
390			26		
395			37		
400			43		400'-430' Cuttings still angular but very fine-grained, average is < 1 mm (<0.04 inches), mostly silt size to very fine sand size cuttings present with very few greater than 1 mm (0.04 inches).
405			25		
410			34		
415			19		
420			43		
425			15		
430			17		430'-440' Cuttings angular, average cutting size is 2 mm (0.08 inches) and ranges from silt size to 3 mm (0.12 inches).
			Drillograph broken 430'-440'		
435			--		
440			--		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
440			--			
445			440'-445' 53		445'-465'	Cuttings are silt size and pale brown (5YR 5/2) to moderate yellowish brown (10YR 5/4) in color.
450			51			
455			62			
460			61			
465			34		465'-490'	Cutting size increases due to use of a thicker foam which lifts cuttings better and prevents them from being pulverized by the drill bit. Average size is 2 mm (0.08 inches).
470			17			
475			11			
480			32			
485			33			
490			16		490'-500'	Significant decrease in cutting size. Cuttings are silt size < 1mm (<0.04 inches) and angular.
495			11			
500			22		500'-505'	Slight increase in cutting size to 1 to 2 mm (0.04-0.08 inches). Cuttings still angular.
505			9		505'-515'	Significant decrease in size of cuttings to silt size < 1mm (<0.04 inches). Cuttings are angular.

LOCATION ID: BLM-S-527



Depth	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
505	9			
510	23			
515	10		515'-525'	Significant increase in cutting size to 3 mm (0.12 inches) average size. Cuttings are subrounded to angular. Subrounded cuttings could be subrounded grains of the flow banded rhyolite. Rounding of the grains is possibly due to water permeating through a fracture zone and rounding brecciated fragments, or from an erosional surface between rhyolite flows.
520	18			
525	15		525'-548'	Significant decrease in cutting size to ≤ 1 mm (≤0.04 inches).
530	11		528'-552'	Possible fracture zone, significant increase in drilling rate. No cutting returns from 528'-548' during drilling. Unable to determine cutting shape due to cutting size.
535	8			
540	4.5			
545	4.5			
550	6		548'-550'	Cuttings are silt size < 1mm (<0.04 inches).
555	16		550'-560'	Increase in cutting size to 1-2 mm (0.04-0.08 inches). Sparse amounts of subrounded grains present.
560	16	560'-570 core	560'-570'	***** core interval ***** see attached description - 2.5% recovery, core barrel collapsed.
565				
570			Total Depth = 570'.	

CORE DESCRIPTION
BLM-5-527
560'-570'
~2.5% RECOVERY

FLOW-BANDED RHYOLITE:

A microcrystalline-holocrystalline flow-banded rhyolite containing < 1% sandine microphenocrysts in a matrix of sanidine, plagioclase (?) and quartz. Banding is dusky red (5R 3/4) and bluish white (5B 9/1) to very light gray (N8). The dusky red bands are finer crystalline than the light gray bands. Black (N1) magnetite phenocrysts (< 0.5 mm) show hematite haloes in thin section. Zircons, brookite or rutile, and skeletal hornblende xenocrysts are also visible in thin section. Fractures were evident during drilling but none are present in the core.

There is no visible porosity in either macroscopic or microscopic view. The rhyolite is therefore not transmissive and fluid flow is controlled by fractures. The rhyolite probably originated as a dike but could be a flow.

APPENDIX B

FIELD RECORDS OF MANUAL RECORDING OF
AQUIFER TEST AT WELL J

AQUIFER TEST DATA

Owner NASA-WSTF Address ______ County ______ State ______

Date 3/10/89 Company performing test GCL Measured by ______

Well No. JPZ-1 Distance from pumping well 149.2 Type of test PUMP/RECOVERY Test No ______

Measuring equipment PROBE # ABQ 2

Time Data
Pump on: Date 3/10 Time 0930 (t)
Pump off: Date ______ Time ______ (t')
Duration of aquifer test:
Pumping ______ Recovery ______

Water Level Data 0708
Static water level 330.92'
Measuring point -TOC
Elevation of measuring point 4401.81

Discharge Data
How Q measured DIGITAL
Depth of pump/air line ______
Previous pumping? Yes ____ No ____
Duration ______ End ______

Comments on factors affecting test data

NOMINAL ELAPSED TIME	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	t/r²	Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Barometric correction ADD (ft H₂O)	S corrected for barometric	Rate		Comments
0s		0930					330.94			0	0				
30s		0930:30	0.5			2.25 x10^-5	331.4			0.49					
60s		0931	1.0			4.49 x10^-5	331.8			0.88					
90s		0931:30	1.5			6.74 x10^-5	332.1			1.180					
2m		0932	2.0			8.98 x10^-5	332.3			1.38	.001				
3m		0933	3.0			1.35 x10^-4	332.38			1.46					
4m		0934	4.0			1.80 x10^-4	332.66			1.74					
5m		0935	5.0			2.25 x10^-4	332.82			1.90	.002				
6m		0936	6.0			2.70 x10^-4	332.90			1.98					
7m		0937	7.0			3.14 x10^-4	332.97			2.05	.003				
8m		0938	8.0			3.59 x10^-4	333.04			2.12					
10m		0940	10.0			4.49 x10^-4	333.20			2.28	.004				
15m		0945	15.0			6.74 x10^-4	333.44			2.52	.006	2.53			
20m		0950	20			8.98 x10^-4	333.63			2.71	.008	2.72			
25m		0955	25			1.12 x10^-3	333.78			2.86	.009	2.87			
30m		1000	30			1.35 x10^-3	333.89			2.97	.011	2.98			
45m		1015	45			2.02 x10^-3	334.14			3.22	.017	3.24			
75m		1045	77			3.46 x10^-3	334.46			3.54	.029	3.57			+2.0 m (1047)
2h		1130	118			5.3 x10^-3	334.71			3.79	.045	3.84			-2.0 m
3h		1230	182			8.18 x10^-3	334.95			4.03	.069	4.10			+2.0 m
4h		1330	238			1.07 x10^-2	335.07			4.15	.08	4.23			-2.0 m (1328)
5h		1420	302			1.36 x10^-2	335.15			4.23	.07	4.30			+2.0 m
6h		1530	358			1.61 x10^-2	335.22			4.30	.06	4.36			1528
8h		1730	482			2.17 x10^-2	335.31			4.39	.04	4.43			+2.0 m (1732)
10h		1933 (1930 struck)	603			2.71 x10^-2	335.37			4.45	.03	4.48			335.39 if outer lip used
12h	3/10/89	2141	731			3.28 x10^-2	335.44			4.52	.03	4.55			
16h	3/11/89	0001	871			3.91 x10^-2	335.53			4.61	.05	4.66			
20h	"	0404	1114			5.00 x10^-2	335.60			4.68	.05	4.73			
24h	"	[illegible]	1320			5.93 x10^-2	335.67			4.75	.01	4.76			

AQUIFER TEST DATA

Owner NASA - WSTF Address _____ County _____ State _____

Date 3/11/89 Company performing test GCL Measured by _____

Well No. JPZ-1 Distance from pumping well 149.2 Type of test PUMP/RECOVERY Test No _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t_p)
Pump off: Date _____ Time _____ (t'_p)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level 330.92
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	s or s'	Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Barometric Correction (ft H_2O)	5 corrected for Barometric Discharge measurement	Rate		
3-11-89	1135	1565			7.01 $\times 10^{-1}$	335.73			4.81	.10	4.91			
	1543	1810			1.11 $\times 10^{-2}$	335.72			4.80	.15	4.95			
	1927	2037			8.15 $\times 10^{-1}$	335.73			4.81	.12	4.93			
	2345	2293			1.85 $\times 10^{-3}$	335.79			4.87	.12	4.99			
3/12	0342	2532			1.49 $\times 10^{-1}$	335.81			4.89	.14	5.03			
"	0727	2971			1.28 $\times 10^{-1}$	335.81			4.92	.10	5.02			
"	1134	3034			1.35 $\times 10^{-3}$	335.88			4.96	.17	5.13			
"	1831	3241			1.06 $\times 10^{-1}$	335.92			5.00	.26	5.26			
"	2024	7534			6.59 $\times 10^{-1}$	335.89			4.92	.23	5.15			
	0342	3732			1.61 $\times 10^{-1}$	335.75			4.83	.24	5.07			
	0359	3975			4.79 $\times 10^{-1}$	335.82			4.90	.25	5.15			
	0719	4189			1.99 $\times 10^{-4}$	335.83			4.91	.25	5.16			

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County _____ State _____

Date 3/10/89 Company performing test GCL Measured by _____

Well No. JPZ-2 Distance from pumping well 144.5' Type of test PUMP/RECOVERY Test No. _____

Measuring equipment PROBE #2 to 45m (335.99) PROBE #ABQ 2 (335.76) THEREAFTER

Time Data
Pump on: Date _____ Time _____ (I.)
Pump off: Date _____ Time _____ (F.)
Duration of aquifer test: Pumping _____ Recovery _____

Water Level Data 0711
Static water level 330.89'
Measuring point T.O.C.
Elevation of measuring point 4401.45

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

Start 4:30

NOMINAL ELAPSED TIME	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	t/t'²	Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Discharge measurement	Rate		Comments on factors affecting test data
0s	3/10/89	4:30 30	0		0		331.34			0				PROBE #2 SUBTRACT
30s		4:30 30	30s		0.5	2.39 x10⁻⁵	331.24			0.35				.26 TO NORMALIZE TO
60s		4:31	60s		1.0	4.79 x10⁻⁵	331.84			0.95				ABQ #2
90s		4:31 30	90s		1.5	7.18 x10⁻⁵	331.20			1.31				
2m		4:32	2m		2.0	9.58 x10⁻⁵	330.42			1.53				
3m		4:33	3m		3.0	1.44 x10⁻⁴	330.51			1.62				
4m		4:34	4m		4.0	1.92 x10⁻⁴	330.35			1.96				
5m		4:35	5m		5.0	2.39 x10⁻⁴	330.18			2.09				
6m		4:36	6m		6.0	2.87 x10⁻⁴	333.04			2.15				
7m		4:37	7m		7.0	3.35 x10⁻⁴	333.13			2.24				
8m		4:38	8m		8.0	3.83 x10⁻⁴	333.20			2.31				
10m		4:40	10m		10	4.79 x10⁻⁴	333.35			2.46				
15m		4:45	15m		15	7.18 x10⁻⁴	333.62			2.73				
20m		4:50	20m		20	9.58 x10⁻⁴	333.80			2.91				
25m		4:55	25m		25	1.20 x10⁻³	333.95			3.06				
30m		5:00	30m		30	1.44 x10⁻³	334.07			3.18				
45m		5:15	45m		45	2.15 x10⁻³	334.34			3.45				PROBE #2
75m		5:45	75m		75	3.59 x10⁻³	334.44			3.77				-2.0 m (1043) PROBE ABQ 2
2h		6:30	2h		120	5.75 x10⁻³	334.70			4.07				+2.0 m
3h		7:30	3h		180	8.62 x10⁻³	334.90			4.27				-2.0 m
4h		1330	4h		240	1.15 x10⁻²	335.14			4.41				+2.0 m (1332)
5h		1430	5h		300	1.44 x10⁻²	335.11			4.48				-2.0m
6h		1530	6h		360	1.72 x10⁻²	335.21			4.58				1532
8h		1730	8h		480	2.30 x10⁻²	335.26			4.65				-2.0m (1723)
10h	1940	1930	10h		610	2.92 x10⁻²	335.34			4.71				
12h	3/10/89	2130	12h		724	3.47 x10⁻²	335.41			4.78				All s has been
16h	3/11/89	0130 0008	16h		878	4.20 x10⁻²	335.50			4.87				normalized to probe
20h		0530 0359	20h		1109	5.31 x10⁻²	335.57			4.94				#2 (0.26 added)
24h		0930 0735	24h		1325	6.37 x10⁻²	335.64			5.01				

AQUIFER TEST DATA

Owner NASA - WSTF Address _____ County _____ State _____

Date 3/11/89 Company performing test GCL Measured by _____

Well No. JP7-2 Distance from pumping well 144.5 Type of test PUMP/RECOVERY Test No _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t)
Pump off: Date _____ Time _____ (t')
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level 330.89
Measuring point TOC
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	t/r²	Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Discharge measurement	Rate		
	1130	1560			7.97×10^{-2}	335.71	+.26		5.08				
	1645	1815			8.69×10^{-2}	335.70			5.07				
	1924	2034			9.79×10^{-2}	335.73			5.10				
	2344	2294			1.10×10^{-1}	335.77			5.14				
3/12	0338	2528			1.21×10^{-1}	335.78			5.15				
	0734	2764			1.32×10^{-1}	335.83			5.20				
	1130	3000			1.44×10^{-1}	335.87			5.24				
	1535	3245			1.55×10^{-1}	335.91			5.28				
	0021	3531			1.69×10^{-1}	335.83			5.20				
	2347	3337			1.79×10^{-1}	335.73	+.26		5.10				
	0342	3972			1.40×10^{-1}	335.79	+.26		5.16				
	0727	4197			2.01×10^{-1}	335.82			4.93				

AQUIFER TEST DATA

Owner NASA- WSTF Address _____ County _____ State _____

Date 3/10/89 Company performing test GCL Measured by _____

Well No JPZ-3 Distance from pumping well 493.6 Type of test PUMP/RECOVERY Test No _____

Measuring equipment PROBE # 3

Time Data
Pump on: Date _____ Time _____ (t_i)
Pump off: Date _____ Time _____ (t_f)
Duration of equiler test:
Pumping _____ Recovery _____

Water Level Data 0723:30
Static water level 335.17'
Measuring point T.O.C.
Elevation of measuring point 4405.92

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

NOMINAL ELAPSED TIME	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	s	Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments on factors affecting test data
0s	3-10	9:30	0				335.17								
30s	"		0.5 30			2.05 ×10⁻⁶	335.18			0.01					
60s	"	9:31	1.0			4.10 ×10⁻⁶	335.20			0.03					
90s	"		1.5			6.16 ×10⁻⁶	335.22			0.05					
2m	"	9:32	2			8.21 ×10⁻⁶	335.26			0.09					
3m	"	9:33	3			1.23 ×10⁻⁵	335.35			0.18					
4m	"	9:34	4			1.64 ×10⁻⁵	335.42			0.25					
5m	"	9:35	5			2.05 ×10⁻⁵	335.50			0.33					
6m	"	9:36	6			2.46 ×10⁻⁵	335.56			0.39					
7m	"	9:37	7			2.87 ×10⁻⁵	335.62			0.45					
8m	"	9:38	8			3.28 ×10⁻⁵	335.68			0.51					
10m	"	9:40	10			4.10 ×10⁻⁵	335.77			0.60					
15m	"	9:45	15			6.16 ×10⁻⁵	335.96			0.79					
20m	"	9:50	20			8.21 ×10⁻⁵	336.11			0.94					
25m	"	9:55	25			1.03 ×10⁻⁴	336.22			1.05					
30m	"	10:00	30			1.23 ×10⁻⁴	336.33			1.16					
45m	"	10:15	45			1.85 ×10⁻⁴	336.55			1.38					
75m	"	10:45	75			3.08 ×10⁻⁴	336.83			1.66					
2h	"	11:30	120			4.93 ×10⁻⁴	337.09			1.92					
3h	"	12:30	180			7.39 ×10⁻⁴	337.29			2.12					
4h	"	1:30	240			9.85 ×10⁻⁴	337.41			2.24					
5h	"	2:30	300			1.23 ×10⁻³	337.46			2.31					
(6h)	3-11	3:30	360			1.48 ×10⁻³	337.53			2.36				7h	4:30 337.56 K
8h	"	5:30	480			1.97 ×10⁻³	337.59			2.42					
10h	"	7:30	617			2.53 ×10⁻³	337.67			2.50					
12h	3/10/89	9:30	737	✓		3.00 ×10⁻³	337.73			2.56					
16h	3-11	1:30	883	✓		3.82 ×10⁻³	337.82			2.65					
20h	"	5:30	1122	✓		4.61 ×10⁻³	337.88			2.71					
24h	"	9:30	1322	✓		5.42 ×10⁻³	337.94			2.77	.01	2.78			

AQUIFER TEST DATA

Owner NASA - WSTF Address _____ County _____ State _____

Date 3/11/89 Company performing test GCL Measured by _____

Well No. JPZ-3 Distance from pumping well 619.6 Type of test PUMP/RECOVERY Test No _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t.)
Pump off: Date _____ Time _____ (t')
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level 339.17
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
3/11	1136	1466				338.05			2.89	.10	2.98			
"	15:42	1872				337.97			2.80	.15	2.95			Med pump rate drop
	1938	2049				337.98			2.81	.12	2.93			
	2350	2300	/			338.03			2.86	.12	2.98			
3/12	0398	2638	/			338.06			2.89	.14	3.03			
	0746	2776	/			338.09			2.92	.11	3.03			
	1145	3015	/			338.12			2.95	.17	3.12			
	1547	3257	/			338.12			2.95	.26	3.21			
	2033	3543	/			338.09			2.92	.23	3.15			
	0359	3749				338.03			2.86	.23	3.09			
3/13	0352	3942				338.07			2.90	.26	3.16			
	0755	4225	/			338.09			2.92	.25	3.17			
				Shut Down Pump										RECOVERY
0s	3/13 0930	4320	0	0		338.10			2.93	-.30				
30s	09 30:30	4320.5	0.5	9641		338.07			2.90	-.30				
60s	09:31	4321	1.0	4321		338.06			2.89	-.30				
90s	09:31:30	4321.5	1.5	2881		338.05			2.88	-.30				
2m	0932	4322	2	2161		338.00			2.83	-.30				
3m	0933	4323	3	1441		337.90			2.73					
4m	0934	4324	4	1081		337.81			2.64					
5m	0935	4325	5	865		337.75			2.58					
6m	0936	4326	6	721		337.69			2.52					
7m	0937	4327	7	618.1		337.63			2.46					
8m	0938	4328	8	541		337.58			2.41					
10m	0940	4330	10	433		337.49			2.32					
15m	0945	4335	15	289		337.31			2.14					
20m	0950	4340	20	217		337.16			1.99					
25m	0955	4345	25	173.8		337.05			1.88	-.31				

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County _____ State _____

Date 3/13/89 Company performing test GCL Measured by _____

Well No. JPZ-3 Distance from pumping well 493.6 Type of test PUMP/RECOVERY Test No _____

Measuring equipment Probe #3

Time Data
Pump on: Date _____ Time _____ (L)
Pump off: Date _____ Time _____ (L)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level 335.17
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

	Date	Clock time	Time since pump started t (min)	Time since pump stopped t' (min)	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Barometric correction	Discharge measurement	Rate		
30 m	3/13	1000	9350				336.95			1.78	-.31				
45 m		1015	9365				336.72			1.55	-.31	--			
		1030	9380				336.57			1.40	-.32				
2 h		1135	9445				336.14			.97	-.34				
3 h		1230	9500				335.95			.78	-.37				
4 h		1336	9566				335.77			.62	-.41				
5 h		1435	9625				335.68			.51	-.44				
6 h		1535	9686				335.60			.43	-.45				
7 h		1631	9741				335.54			.37	-.46				
8 h		1730	9800												NO READING
9 h		1830	9860				335.45			.28	-.44				
10 h		1930	9920												
		2030	9983				335.38			.21	-.43				
		2130	5100				335.32			.15	-.42				
	3/14/89	0750	5666				335.18			.01	-.39				
		1218	5926				335.12			-.05	-.41				

AQUIFER TEST DATA

Owner NASA - WSTF Address ______ County ______ State ______

Date 3/10/89 Company performing test GCL Measured by ______

Well No. JPZ-4 Distance from pumping well 903.6' Type of test PUMP/RECOVERY Test No ______

Measuring equipment PROBE ~~#A261~~ ~~OR~~ LOANER

Time Data
Pump on: Date ______ Time ______ (t_0)
Pump off: Date ______ Time ______ (t_0')
Duration of aquifer test: Pumping ______ Recovery ______

Water Level Data
Static water level 103.08 m (0731 4^m)
Measuring point ______
Elevation of measuring point ______

Discharge Data
How Q measured ______
Depth of pump/air line ______
Previous pumping? Yes ____ No ____
Duration ______ End ______

Comments on factors affecting test data

NOMINAL ELAPSED TIME	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	t/r^2	Water level measurement	Correction or Conversion	Water level	Water level change s or s'	BARO CORR ft H_2O	s corrected for Baro	Rate		Comments
0s	3/10	9:30					103.09			0.03					
30s	"	9:30:30	0.5			6.12×10^{-7}	103.09			0.03					
60s	"	9:31	1.0			1.22×10^{-6}	103.09			0.03					
90s	"	9:31:30	1.5			1.84	103.09			0.03					
2m	"	9:32	2.0			2.45	103.09			0.03	.001				
3m	"	9:33	3.0			3.67	103.095			0.035					
4m	"	9:34	4.0			4.90	103.10			0.04					
5m	"	9:35	5.0			6.12	103.11			0.10	.002				
6m	"	9:36	6.0			7.35	103.11			0.10					
7m	"	9:37	7.0			8.57	103.115			0.11	.003				
8m	"	9:38	8.0			9.80	103.121			0.13					
10m	"	9:40	10.0			1.22×10^{-5}	103.130			0.15	.004	.16			
15m	"	9:45	15.0			1.84	103.170			0.30	.006	.31			
20m	"	9:50	20.0			2.45	103.195			0.37	.008	.40			
25m	"	9:55	25.0			3.06	103.220			0.46	.009	.47			
30m	"	10:00	30.0			3.67	103.240			0.52	.011	.53			
45m	"	10:15	45.0			5.51	103.290			0.69	.017	.71			
85m	"	10:55	85.0			1.04×10^{-4}	103.376		0.97	[illegible]	.03	1.00			
2h	"	11:40	130			1.59	103.435			1.16	.05	1.21			
3h	"	12:40	190			2.33	103.480			1.31	.07	1.38			
4h	"	1:40	250			3.06	103.520		1.44	[illegible]	.07	1.51			
5h	"	2:40	310			3.80	103.535			1.49	.07	1.56			
6h	see side	3:40	370			4.53	103.545			1.53	.06	1.59			7h 4:40p 103.561
8h	"	5:40	490			6.00	103.567			1.58	.04	1.62			
10h	1953	~~7:40~~	623			7.63	103.561			1.33	.03	1.61			
12h	2153	~~9:40~~	743	/		9.10	103.581			1.64	.03	1.67			reading double checked
16h	3-11	5620	890			1.09×10^{-3}	103.605			[illegible]	.05	1.77			reading double checked
20h	"	0418	1128			1.38×10^{-3}	103.629			1.80	.02	1.82			
24h	"	0739	1329			1.63×10^{-3}	103.642			1.84	.01	1.85			

AQUIFER TEST DATA

Owner NASA- WSTF Address _____ County _____ State _____

Date 3/11/89 Company performing test GCL Measured by _____

Well No JPZ-4 Distance from pumping well 903.6 Type of test PUMP/ RECOVERY Test No _____

Measuring equipment METRIC GAUGE DURING PUMPING PROBE ABOVE DURING RECOVERY

Time Data
Pump on: Date _____ Time _____ (t-)
Pump off: Date _____ Time _____ (t')
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level 103,08 (338.11)
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/r	s/Q	Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Specific Capacity gpm/ft	Discharge measurement	Rate		Comments
3/11	1145	1537			1.97 $\times 10^{-3}$	103.655			1.89	.11	2.00			
	1552	1822			2.33 $\times 10^{-3}$	103.650			1.87	.14	2.01			
	1945	2055			2.53 $\times 10^{-3}$	103.695			1.85	.12	1.97			
3/12	2400	2310			2.27 $\times 10^{-3}$	103.670			1.94	.12	2.06			
	0356	2546			2.1 $\times 10^{-3}$	103.661			1.91	.14	2.05			double checked
	0753	2783			2.41 $\times 10^{-3}$	103.673			1.95	.10	2.05			
	1148	3018			3.79 $\times 10^{-3}$	103.680			1.97	.17	2.14			
	1551	3261			3.09 $\times 10^{-3}$	103.675			1.95	.26	2.21			
	2040	3550			4.17 $\times 10^{-3}$	103.670			1.94	.23	2.17			
103.7 3/13	0003	3753			4.20 $\times 10^{-3}$	103.669			1.90	.23	2.13			
	0400	3940			3.64 $\times 10^{-3}$	103.665			1.93	.26	2.19			
	0905					103.672 m			1.94					Last water reading
	0910	4300			5.37 $\times 10^{-3}$	340.09			1.94	.26	2.20			First Foot Reading

AQUIFER TEST DATA

Owner NASA-USTF Address _____ County Dona Ana State NM

Date 3-13-89 Company performing test GCL Measured by Morse

Well No JPZ-4 Distance from pumping well 900' Type of test Recovery Test No. _____

Measuring equipment Solinst W.L. Probe # ALb 1

Time Data
Pump on Date ____ Time ____ (L)
Pump off Date ____ Time ____ (L)
Duration of aquifer test:
Pumping ____ Recovery ____

Water Level Data
Static water level 338.13
Measuring point ____
Elevation of measuring point ____

Discharge Data
How Q measured ____
Depth of pump/air line ____
Previous pumping? Yes ____ No ____
Duration ____ End ____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	1/t		Water level measurement (ft)	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
3/13	0930	9300				340.07			1.94					Recovery
30s		9307.5				340.07			1.94					
45s		9321				340.07			1.94					
90s		9321.5				340.06			1.93					
2m		9322				340.05			1.92					
3m		9323				340.04			1.91					
4m		9324				340.03			1.90					
5m		9325				340.02			1.89					
6m		9326				339.98			1.85					
7m		9327				339.96			1.83					
8m		9328				339.94			1.81					
10m	0940	9330				339.90			1.77					
15m	0945	9335				339.79			1.76					
20m	0950	9340				339.70			1.57					
25m	0955	9345				339.63			1.50					
30m	1000	9350				339.56			1.43					
40m	1015	9365				339.40			1.27					
1h	1030	9380				339.27			1.14					
2h	1130	9440				338.95			0.82					
3h	1230	9500				338.77			.64					
4h	1330	9560				338.65			.52					
5h	1430	9620				338.59			.42					
6h	1530	9680				338.48			.35					
7h	1630	9740				338.43			.30					
9h	1830	9860				338.35			.22					
11h	2030	9980				338.27			.14					
13h	2230	10100				338.22			.09					
15h	0030	10200				338.11			.02					
17h	0230	10340				338.05			-.08					

AQUIFER TEST DATA

Owner NMSU Address _____ County _____ State NM

Date Mar 10-13, 1989 Company performing test GCL Measured by _____

Well No JPZ-5 Distance from pumping well 499.5 Type of test Pumping/Recovery Test No _____

Measuring equipment LOGGER

Time Data
Pump on Date 3/7/89 Time 0930 (L)
Pump off. Date 3/13/89 Time 0930 (D)
Duration of aquifer test:
Pumping 144Cm Recovery _____

Water Level Data 07:10:40
Static water level 99.53 m
Measuring point T.O.C.
Elevation of measuring point 4397.47

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

NOMINAL ELAPSED TIME

/ Date	/ Clock time	Time since pump started t	Time since pump stopped t'	t/t'	s/Q²	(meters) / Water level measurement	Correction or Conversion	Water level	ft Water level change s or s'	Discharge measurement	Rate		Comments on factors affecting test data
0s	3/7/89 09:30:00					99.54			0.03				
30s	09:30:30	0.5			2.00 x10⁻⁴	99.55			0.04				
60s	09:31:00	1.0			4.01	99.56			0.05				
90s	09:31:30	1.5			6.01	99.59			0.08				
2m	09:32	2.0			8.02	99.60			0.09				
3m	09:33	3.0			1.20 x10⁻³	99.66			0.15				
4m	09:34	4.0			1.60	99.70			0.19				
5m	09:35	5.0			2.00	99.73			0.22				
6m	09:36	6.0			2.40	99.77			0.24				
7m	09:37	7.0			2.81	99.79			0.26				
8m	09:38	8.0			3.21	99.80			0.27				
10m	09:40	10.0			4.01	99.84			0.31				
15m	09:45	15.0			6.01	99.91			0.38				
20m	09:50	20.0			8.02	99.96			0.43				
25m	09:55	25			1.00 x10⁻³	100.00			0.47				
30m	10:00	30			1.20	100.04			0.51				
45m	10:15	45			1.80	100.12			0.59				
75m	10:45	75			3.01	100.21			0.68				
2h	11:30	120			4.81	100.30			0.77				
3h	12:30	180			7.21	100.37			0.84				
4h	13:30	240			9.62	100.41			0.88				
5h	14:30	300			1.20 x10⁻³	100.43			0.90				
6h	15:30	360			1.44	100.45			0.92				
8h	17:30	480			1.68	100.47			0.94				
10h	19:30	600			2.39	100.490			0.96				
12h	21:30	720			2.88	100.516			0.98				
14h	3/10/89 23:30	840			3.46	100.545			1.01				
20h	3/11/89 05:30	1080			4.42	100.568			3.91				
24h	09:30	1320			5.3 x10⁻³	100.583			3.45				

AQUIFER TEST DATA

Owner NASA Address _____ County _____ State NM

Date 3/11/89 Company performing test GCL Measured by _____

Well No JP7-5 Distance from pumping well 499.5 Type of test PUMP / RECOVERY Test No _____

Measuring equipment See Comments

Time Data
Pump on: Date _____ Time _____ (t.)
Pump off: Date _____ Time _____ (t')
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level 99.53
Measuring point TOC
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	t/r²	Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
3-11-89	1145	1575			6.3 ×10⁻³	100.610			3.54	.11	3.65			
"	1650	1920			7.7 ×10⁻³	100.682			3.52	.15	3.67			
	1930	2090			8.38 ×10⁻³	100.605			3.53	.13	3.66			
	2334	2314			9.25 ×10⁻³	100.619			3.57	.11	3.68			
3-12	0336	2676			1.07 ×10⁻²	100.630			3.61	.13	3.74			
	0739	2919			1.17 ×10⁻²	100.639			3.64	.11	3.75			
	1139	3009			1.21 ×10⁻²	100.649			3.67	.17	3.94			
	1540	3250			1.30 ×10⁻²	100.653			3.70	.26	3.96			
	2027	3537			1.41 ×10⁻²	100.640			3.64	.23	3.87			
	2350	3740	✓		1.50 ×10⁻²	100.648			3.57	.23	3.80			
3-13	0347	3977	↓		1.59 ×10⁻²	100.631			3.61	.27	3.88			
	0730	4200	↓		1.68 ×10⁻²	100.295			3.46	.24	3.70			ABQ² 2 = 330.28'
0s	0930	4320				330.25			3.46			RECOVERY		PROBE CHANGED (9:29:10)
30s	0930:30	4320.5				330.28			3.46					(9:29:40) (max level)
60s	0931	4321				330.25			3.43					(9:30:10)
90s	0931:30	4321.5				330.13			3.31					(9:30:40)
2m	0932	4322				330.00			3.18					(9:31:10)
3m	0933	4323				329.92			3.06					(9:32:10)
4m	0934	4324				329.70			2.88					(9:33:10)
5m	0935	4325				329.60			2.78					(9:34:10)
6m	0936	4326				329.50			2.68					(9:35:10)
7m	0937	4327				329.44			2.62					(9:36:10)
8m	0938	4328				329.37			2.55					(9:37:10)
10m	0940	4330				329.26			2.44					(9:39:10)
15m	0945	4335				329.03			2.21					(9:44:10)
20m	0950	4340				328.86			2.04					(9:49:10)
25m	0955	4345				328.72			1.90					(9:54:10)
30m	1000	4350				328.61			1.79					(9:59:10)
45m	1015	4365				328.37			1.55					(10:14:10)

AQUIFER TEST DATA

Owner NASA - WSTF Address _____ County _____ State _____

Date 3/13/89 Company performing test GCL Measured by _____

Well No. JPZ-5 Distance from pumping well 499.5 Type of test PUMP/RECOVERY Test No. _____

Measuring equipment _____

Time Data
Pump on: Date _____ Time _____ (t.)
Pump off: Date _____ Time _____ (t')
Duration of aquifer test: Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		Comments on factors affecting test data
3-13	1030	4360				328.08			1.26					(10:37:10)
	1130	4420				327.76			.94					
	1225	4495				327.53			.71					
	1330	4560				327.36			.54					
	1425	4620				327.24			.42					
	1525	4680				327.15			.33					
	1625	4745				327.07			.25					
	1725	4805				326.98			.16					
	2029	4989				326.89			.07					
	2239	5094				326.82			.00					
3/14/89	0749	5659				326.67			-.15					
	1208	5918				326.62			-.20					

AQUIFER TEST DATA

Owner NASA- WSTF Address _____ County _____ State _____

Date 3/10/89 Company performing test GCL Measured by _____

Well No. WW-1-452 Distance from pumping well ≈ 4710' Type of test AQUIFER (3-DAY PUMP) Test No. _____

Measuring equipment PROBE #2

Time Data
Pump on: Date 03/10/89 Time 0930 (t.)
Pump off: Date _____ Time _____ (t')
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data ≈739
Static water level 386.55'
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

NOMINAL ELAPSED TIME	Date	Clock time	Time since pump started t	Time since pump stopped t'	t	t/r²	Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Gate Discharge measurement Gate	Gate Discharge measurement Carter	Rate		Comments on factors affecting test data
0	3-10 89	9:30										0	0			NOTE PROBE 1 @ 386.43
60m		10:30	60		60	2.70 x10⁻⁴	386.53			-.02	-.02	.02	0			PROBE #2 @ 386.52
75m		10:45	75 138		75	3.52 x10⁻⁶	386.52	Probe Switch		-.03	-.03	.03	0			
2h		11:30	120 201		141	6.36	386.48	1.09		-.01	-.03	.05	.02			SWITCH TO PROBE #1
3h		12:30	180 261		193	8.70	386.40			-.08	-.06	.06	0			(+) drawdown
4h		1:39	249		249	1.12 x10⁻⁵	386.31			-.09	-.07	.07	0			(-) rise in WL
5h		2:30	300		302	1.36	386.38	1		-.02	-.01	.07	-.01			
6h		1625	355		345	1.60	386.45			-.10	-.10	.06	-.04			CHANGE BACK TO PROBE #2
8h		1631	421		421	1.90	386.44			-.11	-.11	.05	-.06			
6h		1726	476		476	2.15	386.46			-.09	-.09	.05	-.04			
12h		2016	646		646	2.91	386.50			-.05	-.05	.03	-.02			
14h		2212	762		762	3.43	386.43	+.09		-.03	-.03	.03	0			CHANGE TO PROBE #1
20h		2356	866		866	3.90	386.46			+.02 -.01	-.01	.05	.04			
24h	3-11-89	0949			1099	4.95 x10⁻⁵	386.44				-.01	.03	.02			PROBE 1 + .01 = PROBE 2
		0810			1360	6.13 x10⁻⁵	386.53				.07	.01	.08			
		1210			1600	9.21 x10⁻⁵	386.50				.04	.11	.15			
		1613			1843	8.31 x10⁻⁵	386.41				-.05	.13	.08			
		2052			2122	9.57 x10⁻⁵	386.46				0.02	.12	.12			
	3/12	0105			2375	1.07 x10⁻⁴	386.41	+.09			0.02	.13	.15			
		0703			2553	1.15	386.47	+.09			0.01	.14	.15			
		0908			2615	1.18	386.49				0.02	.12	.14			
		0815			2815	1.27	386.52				0.06	.10	.16			
		1209			3039	1.37	386.47				0.01	.18	.19			
		1611			3281	1.48	386.38				-0.08	.27	.19			Pump stopped 0.1' Fell in recovery
		2058			3566	1.61	386.42				-0.04	.23	.19			
		0008			3758	1.69 x10⁻⁴	386.45				-0.01	.23	.22			
		0406			3996	1.80 x10⁻⁴	386.43				+0.03	.26	.23			
		0843			4273	1.93 x10⁻⁴	386.42	+.09			-0.01	.26	.22			

AQUIFER TEST DATA

Owner NASA - WSTF Address _____ County _____ State _____

Date 3/13/89 Company performing test GCL Measured by _____

Well No. WW-1-452 Distance from pumping well ~4170 Type of test Recovery Test No. _____

Measuring equipment PROBE #1 +.09 TO HORIBOUGH TO PROBE #2

Time Data
Pump on: Date _____ Time _____ (t_i)
Pump off: Date _____ Time _____ (t_f)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level _____
Measuring point _____
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ___ No ___
Duration _____ End _____

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
3-13	1162	4412				386.40	+.09		-.06					
	1252	4522				386.33			-.13					
	1515	4665				386.25			-.21					
	1615	4720				386.23			-.23					
	1640	4870				386.23			-.23					
	2043	4993				386.23			-.23					
	2238	5108				386.24			-.22					
3/14/89	0912	5682				386.29	1.09		-.22					
	1222	5932				386.19	1.09		-.29					

Page ____ of ____

AQUIFER TEST DATA

Owner NASA-WSTF Address ____ County ____ State ____

Date 3/10/89 Company performing test GCL Measured by ____

Well No. JP-2-447 Distance from pumping well 6660 Type of test Pump Test No. ____

Measuring equipment PROBE # 2

Time Data	Water Level Data 0834	Discharge Data	Comments on factors affecting test data
Pump on: Date ____ Time ____ (t_0) Pump off: Date ____ Time ____ (t_0') Duration of aquifer test: Pumping ____ Recovery ____	Static water level 378.23' Measuring point ____ Elevation of measuring point ____	How Q measured ____ Depth of pump/air line ____ Previous pumping? Yes ____ No ____ Duration ____ End ____	

NOMINAL ELAPSED TIME	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Barometric correction (ft H_2O)	Corrected for Barometric (~~Discharge measured~~)	Rate		Comments
															PROBE 1 + .09 = PROBE 2
0	3-10-89	9:30										0			
60m		10:33	53			1.19 x 10^-6	378.22			-.01	.02	.01			
75m		10:41 →	71			1.60	378.20			-.03	.03	0			
2h		~~11:30~~ 1200	150			3.38	378.1	+.09		-.04	.05	.01			CHANGE TO PROBE #1
3h		12:30	186			4.19	378.08	↓		-.05	.06	.01			
4h		1:30	240			5.41	378.07	↓		-.07	.07	0			
5h		2:23	293			6.61	378.05	↓		-.09	.07	-.02			
6h		1535	365			8.23	378.12			-.11	.06	-.05			CHANGE BACK TO PROBE #2
8h		1629	414			9.33	378.10			-.13	.05	-.08			
10h		1735	485			1.09 x 10^-5	378.11			-.12	.05	-.07			
12h		2008	638			1.44	378.13			-.10	.03	-.07			
16h		2228	778			1.75	378.07	+.09		-.07	.03	-.04			CHANGE TO PROBE #1
20h		0039	909			2.05	378.09	↓		-.05	.05	0			
24h		0432	1142			2.57	378.08	↓		-.06	.03	-.03			
		759	1349			3.04	378.13	↓		-.01	.01	0			
		11:56	1586			3.58	378.10	↓		-.04	.11	.07			
		16:[illegible]	1834			4.13	378.02	↓		-.12	.13	.01			
		2001	2071			4.67	378.03	↓		-.11	.12	.01			
	3/12/89	0011	2321			5.23	378.08	↓		-.06	.13	.07			
		0412	2722			6.19	378.07	+.09		-.07	.12	.05			
		0915	2965			6.68	378.11	↓		-.03	.17	.14			
		1155	3185			7.18	378.05	↓		-.09	.19	.10			
		1600	3439			7.73	377.95	↓		-.19	.19	0			
		2153	3783			8.53	378.01	↓		-.13	.22	.09			
		0052	~~[illegible]~~ 3852			[illegible]	378.01	↓		-.13	.23	.10			
		0453	~~3203~~ 4043			9.96	378.00	↓		-.14	.22	.08			
		0815	4245	4245		9.57	378.00	+.09		-.14	.22	.08			

AQUIFER TEST DATA

Owner NASA - WSTF Address _____ County _____ State _____

Date 3/13/89 Company performing test GCL Measured by _____

Well No. SP-2-447 Distance from pumping well 6660' Type of test Recovery Test No. _____

Measuring equipment PROBE #1 ADD +.09 TO ALL READINGS TO NORMALIZE TO PROBE #2

Time Data
Pump on: Date ___ Time ___ (t)
Pump off: Date ___ Time ___ (t')
Duration of aquifer test:
Pumping ___ Recovery ___

Water Level Data
Static water level 378.23
Measuring point ___
Elevation of measuring point ___

Discharge Data
How Q measured ___
Depth of pump/air line ___
Previous pumping? Yes ___ No ___
Duration ___ End ___

Comments on factors affecting test data

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
3/13	1654	4404				377.97	+.09		-.17					
	1241	4511				377.91			-.23					
	1448	4638				377.85			-.29					
	1655	4768				377.84			-.30					
	1850	4880				377.86			-.28					
	2052	5002				377.86			-.28					
	2245	5115				377.85			-.29					
3/14	0822	5692				377.86	1.09		-.28					
	1213	5123				377.79			-.35					

AQUIFER TEST DATA

Owner NASA - WSTF Address _____ County _____ State _____

Date 3/10/89 Company performing test GCL Measured by _____

Well No PL-2-504 Distance from pumping well ~7668' Type of test PUMP/RECOVERY Test No _____

Measuring equipment PROBE ABQ #1

Time Data
Pump on: Date _____ Time _____ (1)
Pump off: Date _____ Time _____ (2)
Duration of aquifer test: Pumping _____ Recovery _____

Water Level Data
Static water level 438.71
Measuring point T.O.C.
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

NOMINAL ELAPSED TIME	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion		Water level	Water level change s or s'	Δp ft H2O	Discharge measurement (5 cubic cm from Barco)	Rate		
0	3-10-89	933	0													
60m		1038	1 hr		66		438.67				-.04	.02	-.02			
75m		1053	75m		82		438.68				-.03	.03	0			
2h		1135	2h		115		438.69				-.02	.05	.03			
3h		1238	3h		180		438.68				-.03	.06	.03			
4h		1345	4h		255		438.64				-.07	.07	0			
5h		1438	5h		308		438.60				-.11	.07	-.04			
6h		1535	6h		365		438.58				-.13	.06	-.07			
8h		1635	8h		425		438.57				-.14	.06	-.08			
10h		1750	10h		500		438.54				-.15	.05	-.10			
12h		1956	12h		626		438.58				-.13	.03	-.10			
16h	3-11-89	0005	16h	2208	958		438.59				-.12	.03	-.09			
24h			20h	5036	900		438.60				-.11	.05	-.06			
			24h	2424	1162		438.57				-.14	.02	-.12			
		0750			1486		438.63				-.08	.06	-.02			
		1215	1605				438.59				-.12	.11	-.01			
		1620	1950				438.49				-.22	.14	-.08			
		2045	2115				438.50				-.21	.12	-.09			
	3/12	0002	2332				438.51				-.19	.12	-.07			
		0424	2574				438.48				-.23	.14	-.09			
		0834	2824				438.53				-.18	.11	-.07			
		1216	3046				438.49				-.22	.18	-.04			
		1619	3289				438.40				-.31	.26	-.05			
		2194	3614				438.41				-.30	.23	-.07			
	3/13	0049	3714				438.31				-.40	.23	-.17			
		0445	4035				438.40				-.31	.25	-.06			
		0733	4203				438.41				-.30	.25	-.05			

Page ____ of ____

AQUIFER TEST DATA

Owner NASA-WSTF Address ____ County ____ State ____

Date 3/10/89 Company performing test GCL Measured by ____

Well No. PL-3-453 Distance from pumping well ~8300' Type of test Pump Test No. ____

Measuring equipment PROBE #1

Time Data
Pump on: Date ____ Time ____ (1)
Pump off: Date ____ Time ____ (2)
Duration of aquifer test:
Pumping ____ Recovery ____

Water Level Data 0758
Static water level 428.05'
Measuring point ____
Elevation of measuring point ____

Discharge Data
How Q measured ____
Depth of pump/air line ____
Previous pumping? Yes ____ No ____
Duration ____ End ____

Comments on factors affecting test data

EARL HM 526-4424

NOMINAL CAPPED TIME

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
3/10	10:35	0												
	10:36	56				428.09'			-.01					
	11:25	115				428.02'			-.03					
	12:22	172				425.00			-.05					
	1309	219				427.97			-.07					
	1444	314				427.95			-.10					
	1527	357				427.93			-.12					
	1613	433				427.90			-.15					
	1729	179				427.85			-.17					
	1932	602				427.93			-.12					
	2200	750				427.96			-.09					
3-11-89	0007	877				427.96			-.09					
	0358	1108				427.93			-.12					
	0527	1377				428.01			-.05					
	1226	1616				427.93			-.12					
	1635	1865				427.83			-.22					
	2015	2245				427.86			-.19					
3/12/89	0031	2391				427.88			-.17					
	0432	2582				427.87			-.18					
	0830	2830				427.90			-.15					
	1250	3040				427.93			-.22					
	1625	3295				427.73			-.32					
	2015	3585				427.76			-.29					
3/13	0018	3748				427.78			-.27					
	0419	4009				427.75			-.30					
	0833	4063				427.77			-.28					

AQUIFER TEST DATA

Owner NASA - WSTF Address ___ County ___ State ___

Date 3/13/89 Company performing test GCL Measured by ___

Well No. PL-3-453 Distance from pumping well ~8300' Type of test Recovery Test No. ___

Measuring equipment PROBE #1

Time Data
Pump on: Date ___ Time ___ (L)
Pump off: Date ___ Time ___ (2)
Duration of aquifer test:
Pumping ___ Recovery ___

Water Level Data
Static water level 428.05
Measuring point ___
Elevation of measuring point ___

Discharge Data
How Q measured ___
Depth of pump/air line ___
Previous pumping? Yes ___ No ___
Duration ___ End ___

Comments on factors affecting test data

2 hr schedule
Pump shut 3/13 0730

Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate	
3-13	1112	4422				427.92			-.33				
	1303	4533				427.66			-.39				
	1502	4652				427.60			-.45				
	1729	4799				427.59			-.46				
	1906	4896				427.62			-.43				
	2105	5015				427.62			-.43				
	2257	5127				427.63			-.42				
3/14	0826	5706				427.66			-.39				
	1234	6114				427.61			-.44				

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County _____ State _____

Date 3/10/89 Company performing test GCL Measured by _____

Well No. B41-S-527 Distance from pumping well 9170' Type of test PUMP/RECOVERY Test No. _____

Measuring equipment PROBE #1

Time Data
Pump on Date 3/9/89 Time ~0930 (L)
Pump off, Date _____ Time _____ (L)
Duration of aquifer test:
Pumping _____ Recovery _____

Water Level Data
Static water level 479.79
Measuring point T.O.C.
Elevation of measuring point _____

Discharge Data
How Q measured _____
Depth of pump/air line _____
Previous pumping? Yes ____ No ____
Duration _____ End _____

Comments on factors affecting test data

NOMINAL ELAPSED TIME

	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'	1/r2	Water level measurement	Correction or Conversion	Water level	Water level change s or s'	Discharge measurement	Rate		Comments
0				t										
1h	3/10	10:39	09	69		8.21 x 10^-7	479.74			-.05				(+) drawdown
2h	1	11:38	59	128		7.02	479.72			-.07				(-) rise in WL
3h		12:57	79	207		9.39	479.69			-.10				
4h		1:57	60	267		7.19	479.66			-.13				
5h		2:58	61	328		7.35	479.64			-.15				
6h		3:41	43	371		5.11	479.63			-.17				
7h		4:25	44	415		5.33	479.61			-.18				
8h		5:17	52	497		9.75	479.63			-.16				
10h		7:02	115	612		1.37 x 10^-6	479.64			-.15				
12h		9:13	12	733		1.49	479.66			-.13				
16h	3/11	0018	155	888		1.84	479.68			-.11				
20h		0409		1119			479.66			-.13				
24h		0850		1400			479.72			-.07				
		1250		1640			479.64			-.15				
		1656		1886			479.55			-.24				
		2028		2098			479.60			-.19				
	3/12	0046		2356			479.62			-.17				
		0445		2595			479.61			-.18				
		0904		2854			479.65			-.14				
		1250		3080			479.55			-.24				
		1646		3315			479.48			-.31				
		2130		3600			479.52			-.27				
		0030		3780			479.53			-.26				
		0931		4031			479.51			-.28				

AQUIFER TEST DATA

Owner NASA-WSTF Address _____ County _____ State _____

Date 3/10/89 Company performing test GCL Measured by _____

Well No. BLM-8-418 Distance from pumping well ~9200' Type of test PUMP/RECOVERY Test No. _____

Measuring equipment PROBE #1

Time Data	Water Level Data DBII	Discharge Data	Comments on factors affecting test data
Pump on: Date _____ Time _____ (t.)	Static water level 321.93'	How Q measured _____	
Pump off: Date _____ Time _____ (t')	Measuring point _____	Depth of pump/air line _____	
Duration of aquifer test: Pumping _____ Recovery _____	Elevation of measuring point _____	Previous pumping? Yes ____ No ____ Duration _____ End _____	

Nominal Elapsed Time	Date	Clock time	Time since pump started t	Time since pump stopped t'	t/t'		Water level measurement	Correction or Conversion	Water level	Water level change s or s'		Discharge measurement	Rate		
0															
1h	3/10	10:46	76				321.92			-.01					
2h	1	11:43	133				321.93			0.00					
3h	/	1251	201				321.94			.01					
4h		1352	262				321.94			.01					
5h		1453	323				321.94			.01					
6h		1535	365				321.90			-.03					
7h		1632	422				321.89			-.04					
8h		1740	490				321.88			-.05					
10h		1949	619				321.87			-.06					
12h		2150	740				321.86			-.07					
16h	3/11/89	0024	894				321.88			-.05					
20h		0418	1128				321.88			-.05					
24h		0840	1390				321.91			-.02					
		1244	1639				321.65			-.28					
		1649	1879				321.59			-.34					
		2035	2105				321.57			-.36					
	3/12/89	0052	2362				321.56			-.37					
		0452	2602				321.51			-.42					
		0956	2906				321.58			-.36					
		1245	3075				321.53			-.40					
		1639	3309				321.51			-.42					
		2138	3608				321.50			-.43					
		0037	3787				321.48			-.45					
		0438	4028				321.47			-.46					

APPENDIX C

RAW DIGITAL DATA FROM AQUIFER TEST
AT WELL J

DRAWDOWN DATA FROM
IN SITU HERMIT 2000
DATA LOGGER

Well J Aquifer Test
Piezometer: JPZ-1
Pump Start: 0930 hrs 03/10/89
Pump Stop: 0930 hrs 03/13/89

SE2000
Environmental Logger
03/16 08:31

Unit# 0000001 Test# 0

INPUT 1: Level (F) TOC

Reference	0.000
Scale factor	19.928
Offset	0.000
SG	1.000

Step 0 03/09 18:00:02

Elapsed Time	Value
0.0000	-0.012
120.000	-0.025
240.000	0.000
360.000	0.025
480.000	0.037
600.000	0.012
720.000	0.000
840.000	0.012

END

SE2000
Environmental Logger
03/16 08:34

Unit# 0000001 Test# 1

INPUT 1: Level (F) TOC

Reference	0.000
Scale factor	19.928
Offset	0.000
SG	1.000

Step 0 03/10 09:30:00

Elapsed Time	Value
0.0000	0.000
0.0083	0.000
0.0166	0.000
0.0250	0.000
0.0333	0.000
0.0416	0.000
0.0500	0.000
0.0583	0.000
0.0666	0.000
0.0750	0.000
0.0833	0.000
0.1000	0.000
0.1166	0.000
0.1333	0.006
0.1500	0.006
0.1666	0.012
0.1833	0.018
0.2000	0.025
0.2166	0.031
0.2333	0.037
0.2500	0.050
0.2666	0.056
0.2833	0.069

0.3000	0.075	9.0000	2.175
0.3166	0.088	9.5000	2.206
0.3333	0.100	10.0000	2.238
0.4166	0.169	12.0000	2.351
0.5000	0.257	14.0000	2.445
0.5833	0.326	16.0000	2.533
0.6666	0.402	18.0000	2.602
0.7500	0.528	20.0000	2.671
0.8333	0.609	22.0000	2.728
0.9166	0.691	24.0000	2.791
1.0000	0.748	26.0000	2.841
1.0833	0.817	28.0000	2.885
1.1666	0.892	30.0000	2.929
1.2500	0.955	32.0000	2.973
1.3333	1.018	34.0000	3.011
1.4166	1.062	36.0000	3.042
1.5000	1.100	38.0000	3.080
1.5833	1.163	40.0000	3.112
1.6666	1.200	42.0000	3.137
1.7500	1.238	44.0000	3.168
1.8333	1.276	46.0000	3.200
1.9166	1.307	48.0000	3.225
2.0000	1.326	50.0000	3.250
2.5000	1.339	52.0000	3.275
3.0000	1.433	54.0000	3.300
3.5000	1.552	56.0000	3.319
4.0000	1.710	58.0000	3.332
4.5000	1.829	60.0000	3.357
5.0000	1.873	62.0000	3.376
5.5000	1.904	64.0000	3.401
6.0000	1.923	66.0000	3.413
6.5000	1.986	68.0000	3.432
7.0000	2.011	70.0000	3.451
7.5000	2.074	72.0000	3.470
8.0000	2.087	74.0000	3.483
8.5000	2.137	76.0000	3.501

78.0000	3.520	350.000	4.193
80.0000	3.533	360.000	4.193
82.0000	3.545	370.000	4.250
84.0000	3.564	380.000	4.256
86.0000	3.571	390.000	4.262
88.0000	3.589	400.000	4.268
90.0000	3.602	410.000	4.268
92.0000	3.615	420.000	4.275
94.0000	3.627	430.000	4.281
96.0000	3.640	440.000	4.281
98.0000	3.652	450.000	4.287
100.000	3.659	460.000	4.294
110.000	3.715	470.000	4.300
120.000	3.765	480.000	4.300
130.000	3.809	490.000	4.306
140.000	3.847	500.000	4.306
150.000	3.885	510.000	4.312
160.000	3.916	520.000	4.319
170.000	3.948	530.000	4.319
180.000	3.973	540.000	4.325
190.000	3.992	550.000	4.331
200.000	4.017	560.000	4.338
210.000	4.042	570.000	4.344
220.000	4.061	580.000	4.350
230.000	4.073	590.000	4.356
240.000	4.092	600.000	4.363
250.000	4.099	610.000	4.369
260.000	4.111	620.000	4.375
270.000	4.124	630.000	4.375
280.000	4.136	640.000	4.382
290.000	4.149	650.000	4.388
300.000	4.155	660.000	4.394
310.000	4.162	670.000	4.400
320.000	4.174	680.000	4.407
330.000	4.180	690.000	4.413
340.000	4.187	700.000	4.419

710.000	4.426
720.000	4.432
730.000	4.438
740.000	4.444
750.000	4.451
760.000	4.457
770.000	4.463
780.000	4.470
790.000	4.476
800.000	4.482
810.000	4.488
820.000	4.495
830.000	4.501
840.000	4.501
850.000	4.514
860.000	4.520
870.000	4.526
880.000	4.532
890.000	4.539
900.000	4.539
910.000	4.545
920.000	4.551
930.000	4.558
940.000	4.558
950.000	4.564
960.000	4.564
970.000	4.570
980.000	4.570
990.000	4.570
1000.00	4.576
1100.00	4.589
1200.00	4.614
1300.00	4.639
1400.00	4.683
1500.00	4.715
1600.00	4.721
1700.00	4.715
1800.00	4.690
1900.00	4.715
2000.00	4.715
2100.00	4.715
2200.00	4.734
2300.00	4.759
2400.00	4.778
2500.00	4.784
2600.00	4.784
2700.00	4.796
2800.00	4.822
2900.00	4.847
3000.00	4.853
3100.00	4.866
3200.00	4.891
3300.00	4.885
3400.00	4.878
3500.00	4.878
3600.00	4.740
3700.00	4.727
3800.00	4.727
3900.00	4.778
4000.00	4.784
4100.00	4.796
4200.00	4.809

END

SE2000
Environmental Logger
03/16 09:14

Unit# 0000001 Test# 1

Well J Aquifer Test
Piezometer: JPZ-2
Pump Start: 0930 hrs 03/10/89
Pump Stop: 0930 hrs 03/13/89

SE2000
Environmental Logger
03/16 10:18

Unit# 0000001 Test# 0

INPUT 2: Level (F) TOC

Reference	0.000
Scale factor	20.220
Offset	0.000
SG	1.000

Step 0 03/09 18:00:02

Elapsed Time	Value
0.0000	-0.012
120.000	-0.019
240.000	0.000
360.000	0.031
480.000	0.038
600.000	0.019
720.000	0.000
840.000	0.012

END

SE2000
Environmental Logger
03/16 10:19

Unit# 0000001 Test# 1

INPUT 2: Level (F) TOC

Reference	0.000
Scale factor	20.220
Offset	0.000
SG	1.000

Step 0 03/10 09:30:00

Elapsed Time	Value
0.0000	0.000
0.0083	0.006
0.0166	0.006
0.0250	0.006
0.0333	0.006
0.0416	0.006
0.0500	0.006
0.0583	0.006
0.0666	0.006
0.0750	0.006
0.0833	0.006
0.1000	0.006
0.1166	0.006
0.1333	0.012
0.1500	0.019
0.1666	0.025
0.1833	0.038
0.2000	0.044
0.2166	0.057
0.2333	0.070
0.2500	0.089
0.2666	0.102
0.2833	0.121

0.3000	0.140	9.0000	2.430
0.3166	0.159	9.5000	2.468
0.3333	0.172	10.0000	2.487
0.4166	0.274	12.0000	2.615
0.5000	0.376	14.0000	2.711
0.5833	0.503	16.0000	2.800
0.6666	0.612	18.0000	2.876
0.7500	0.714	20.0000	2.959
0.8333	0.810	22.0000	3.010
0.9166	0.905	24.0000	3.061
1.0000	0.969	26.0000	3.119
1.0833	1.058	28.0000	3.164
1.1666	1.122	30.0000	3.202
1.2500	1.180	32.0000	3.253
1.3333	1.237	34.0000	3.291
1.4166	1.288	36.0000	3.329
1.5000	1.333	38.0000	3.361
1.5833	1.390	40.0000	3.393
1.6666	1.428	42.0000	3.425
1.7500	1.467	44.0000	3.457
1.8333	1.505	46.0000	3.483
1.9166	1.537	48.0000	3.514
2.0000	1.562	50.0000	3.540
2.5000	1.569	52.0000	3.565
3.0000	1.652	54.0000	3.585
3.5000	1.786	56.0000	3.610
4.0000	1.964	58.0000	3.636
4.5000	2.092	60.0000	3.655
5.0000	2.105	62.0000	3.674
5.5000	2.156	64.0000	3.699
6.0000	2.194	66.0000	3.712
6.5000	2.239	68.0000	3.731
7.0000	2.290	70.0000	3.750
7.5000	2.322	72.0000	3.770
8.0000	2.347	74.0000	3.808
8.5000	2.398	76.0000	3.801

78.0000	3.814	350.000	4.554
80.0000	3.833	360.000	4.561
82.0000	3.846	370.000	4.567
84.0000	3.865	380.000	4.573
86.0000	3.878	390.000	4.580
88.0000	3.891	400.000	4.586
90.0000	3.904	410.000	4.592
92.0000	3.916	420.000	4.592
94.0000	3.935	430.000	4.599
96.0000	3.948	440.000	4.605
98.0000	3.955	450.000	4.612
100.000	3.974	460.000	4.618
110.000	4.025	470.000	4.624
120.000	4.076	480.000	4.631
130.000	4.120	490.000	4.631
140.000	4.165	500.000	4.637
150.000	4.203	510.000	4.644
160.000	4.235	520.000	4.644
170.000	4.267	530.000	4.650
180.000	4.293	540.000	4.650
190.000	4.318	550.000	4.656
200.000	4.350	560.000	4.663
210.000	4.369	570.000	4.669
220.000	4.395	580.000	4.675
230.000	4.407	590.000	4.682
240.000	4.427	600.000	4.688
250.000	4.446	610.000	4.688
260.000	4.459	620.000	4.701
270.000	4.471	630.000	4.707
280.000	4.484	640.000	4.714
290.000	4.497	650.000	4.720
300.000	4.503	660.000	4.726
310.000	4.516	670.000	4.733
320.000	4.529	680.000	4.739
330.000	4.535	690.000	4.739
340.000	4.548	700.000	4.752

710.000	4.758
720.000	4.765
730.000	4.771
740.000	4.777
750.000	4.784
760.000	4.790
770.000	4.797
780.000	4.803
790.000	4.809
800.000	4.816
810.000	4.816
820.000	4.829
830.000	4.829
840.000	4.835
850.000	4.848
860.000	4.854
870.000	4.860
880.000	4.867
890.000	4.867
900.000	4.873
910.000	4.880
920.000	4.886
930.000	4.886
940.000	4.892
950.000	4.899
960.000	4.899
970.000	4.905
980.000	4.905
990.000	4.905
1000.00	4.911
1100.00	4.924
1200.00	4.950
1300.00	4.975
1400.00	5.020
1500.00	5.052
1600.00	5.071
1700.00	5.071
1800.00	5.052
1900.00	5.077
2000.00	5.077
2100.00	5.084
2200.00	5.103
2300.00	5.128
2400.00	5.147
2500.00	5.154
2600.00	5.154
2700.00	5.167
2800.00	5.186
2900.00	5.211
3000.00	5.218
3100.00	5.237
3200.00	5.269
3300.00	5.262
3400.00	5.256
3500.00	5.256
3600.00	5.103
3700.00	5.084
3800.00	5.084
3900.00	5.141
4000.00	5.147
4100.00	5.160
4200.00	5.173

END

SE2000
Environmental Logger
03/16 10:25

Unit# 0000001 Test# 1

Well J Aquifer Test
Piezometer: JPZ-3
Pump Start: 0930 hrs 03/10/89
Pump Stop: 0930 hrs 03/13/89

SE2000
Environmental Logger
03/16 10:51

Unit# 0000001 Test# 0

INPUT 3: Level (F) TOC

Reference	0.000
Scale factor	19.984
Offset	0.003
SG	1.000

Step 0 03/09 18:00:02

Elapsed Time	Value
0.0000	-0.012
120.000	-0.012
240.000	0.006
360.000	0.037
480.000	0.044
600.000	0.025
720.000	0.006
840.000	0.018

END

SE2000
Environmental Logger
03/16 10:52

Unit# 0000001 Test# 1

INPUT 3: Level (F) TOC

Reference	0.000
Scale factor	19.984
Offset	0.003
SG	1.000

Step 0 03/10 09:30:00

Elapsed Time	Value
0.0000	0.006
0.0083	0.012
0.0166	0.012
0.0250	0.012
0.0333	0.012
0.0416	0.012
0.0500	0.012
0.0583	0.012
0.0666	0.012
0.0750	0.012
0.0833	0.012
0.1000	0.000
0.1166	0.006
0.1333	0.006
0.1500	0.000
0.1666	0.006
0.1833	0.006
0.2000	0.000
0.2166	0.000
0.2333	0.006
0.2500	0.006
0.2666	0.006
0.2833	0.006

0.3000	0.006	9.0000	0.542
0.3166	0.006	9.5000	0.561
0.3333	0.006	10.0000	0.586
0.4166	0.006	12.0000	0.668
0.5000	0.006	14.0000	0.737
0.5833	0.006	16.0000	0.806
0.6666	0.012	18.0000	0.863
0.7500	0.006	20.0000	0.926
0.8333	0.006	22.0000	0.970
0.9166	0.012	24.0000	1.015
1.0000	0.012	26.0000	1.059
1.0833	0.018	28.0000	1.097
1.1666	0.025	30.0000	1.122
1.2500	0.025	32.0000	1.172
1.3333	0.031	34.0000	1.204
1.4166	0.025	36.0000	1.235
1.5000	0.037	38.0000	1.267
1.5833	0.044	40.0000	1.292
1.6666	0.050	42.0000	1.323
1.7500	0.056	44.0000	1.349
1.8333	0.063	46.0000	1.374
1.9166	0.069	48.0000	1.399
2.0000	0.075	50.0000	1.418
2.5000	0.081	52.0000	1.443
3.0000	0.163	54.0000	1.462
3.5000	0.201	56.0000	1.481
4.0000	0.233	58.0000	1.506
4.5000	0.271	60.0000	1.525
5.0000	0.308	62.0000	1.538
5.5000	0.346	64.0000	1.557
6.0000	0.378	66.0000	1.569
6.5000	0.409	68.0000	1.595
7.0000	0.435	70.0000	1.607
7.5000	0.466	72.0000	1.620
8.0000	0.491	74.0000	1.639
8.5000	0.516	76.0000	1.651

78.0000	1.670	350.000	2.326
80.0000	1.683	360.000	2.332
82.0000	1.695	370.000	2.339
84.0000	1.708	380.000	2.345
86.0000	1.721	390.000	2.351
88.0000	1.733	400.000	2.357
90.0000	1.746	410.000	2.364
92.0000	1.759	420.000	2.364
94.0000	1.765	430.000	2.370
96.0000	1.784	440.000	2.376
98.0000	1.790	450.000	2.383
100.000	1.803	460.000	2.383
110.000	1.853	470.000	2.389
120.000	1.897	480.000	2.395
130.000	1.941	490.000	2.402
140.000	1.979	500.000	2.402
150.000	2.011	510.000	2.408
160.000	2.042	520.000	2.408
170.000	2.074	530.000	2.420
180.000	2.099	540.000	2.427
190.000	2.118	550.000	2.427
200.000	2.143	560.000	2.433
210.000	2.162	570.000	2.439
220.000	2.181	580.000	2.446
230.000	2.200	590.000	2.452
240.000	2.212	600.000	2.458
250.000	2.231	610.000	2.465
260.000	2.244	620.000	2.465
270.000	2.250	630.000	2.471
280.000	2.269	640.000	2.477
290.000	2.275	650.000	2.484
300.000	2.288	660.000	2.490
310.000	2.294	670.000	2.496
320.000	2.307	680.000	2.502
330.000	2.313	690.000	2.509
340.000	2.320	700.000	2.509

710.000	2.521
720.000	2.528
730.000	2.534
740.000	2.540
750.000	2.547
760.000	2.547
770.000	2.553
780.000	2.566
790.000	2.566
800.000	2.572
810.000	2.578
820.000	2.584
830.000	2.584
840.000	2.597
850.000	2.603
860.000	2.603
870.000	2.616
880.000	2.622
890.000	2.629
900.000	2.629
910.000	2.635
920.000	2.641
930.000	2.647
940.000	2.647
950.000	2.647
960.000	2.654
970.000	2.660
980.000	2.660
990.000	2.660
1000.00	2.660
1100.00	2.679
1200.00	2.698
1300.00	2.723
1400.00	2.774
1500.00	2.799
1600.00	2.818
1700.00	2.811
1800.00	2.792
1900.00	2.792
2000.00	2.792
2100.00	2.799
2200.00	2.818
2300.00	2.837
2400.00	2.862
2500.00	2.862
2600.00	2.868
2700.00	2.881
2800.00	2.900
2900.00	2.931
3000.00	2.931
3100.00	2.925
3200.00	2.931
3300.00	2.931
3400.00	2.919
3500.00	2.919
3600.00	2.862
3700.00	2.849
3800.00	2.849
3900.00	2.868
4000.00	2.881
4100.00	2.887
4200.00	2.900

END

SE2000
Environmental Logger
03/16 10:58

Unit# 0000001 Test# 1

Well J Aquifer Test
Piezometer: JPZ-4
Pump Start: 0930 hrs 03/10/89
Pump Stop: 0930 hrs 03/13/89

SE2000
Environmental Logger
03/16 11:03

Unit# 0000001 Test# 0

INPUT 4: Level (F) TOC

Reference	0.000
Scale factor	19.928
Offset	0.000
SG	1.000

Step 0 03/09 18:00:02

Elapsed Time	Value
0.0000	-0.012
120.000	-0.012
240.000	0.006
360.000	0.031
480.000	0.037
600.000	0.018
720.000	0.006
840.000	0.018

END

SE2000
Environmental Logger
03/16 11:04

Unit# 0000001 Test# 1

INPUT 4: Level (F) TOC

Reference	0.000
Scale factor	19.928
Offset	0.000
SG	1.000

Step 0 03/10 09:30:00

Elapsed Time	Value
0.0000	0.000
0.0083	0.006
0.0166	0.000
0.0250	0.000
0.0333	0.000
0.0416	0.006
0.0500	0.006
0.0583	0.006
0.0666	0.006
0.0750	0.006
0.0833	0.006
0.1000	0.006
0.1166	0.000
0.1333	0.000
0.1500	0.000
0.1666	0.006
0.1833	0.006
0.2000	0.000
0.2166	0.006
0.2333	0.006
0.2500	0.006
0.2666	0.000
0.2833	0.000

0.3000	0.006	9.0000	0.138
0.3166	0.000	9.5000	0.144
0.3333	0.000	10.0000	0.157
0.4166	0.006	12.0000	0.201
0.5000	0.000	14.0000	0.245
0.5833	0.000	16.0000	0.282
0.6666	0.006	18.0000	0.320
0.7500	0.000	20.0000	0.358
0.8333	0.006	22.0000	0.389
0.9166	0.006	24.0000	0.414
1.0000	0.006	26.0000	0.446
1.0833	0.006	28.0000	0.477
1.1666	0.006	30.0000	0.502
1.2500	0.006	32.0000	0.528
1.3333	0.006	34.0000	0.553
1.4166	0.006	36.0000	0.578
1.5000	0.006	38.0000	0.597
1.5833	0.006	40.0000	0.616
1.6666	0.006	42.0000	0.634
1.7500	0.012	44.0000	0.660
1.8333	0.006	46.0000	0.678
1.9166	0.006	48.0000	0.697
2.0000	0.006	50.0000	0.710
2.5000	0.006	52.0000	0.735
3.0000	0.018	54.0000	0.748
3.5000	0.018	56.0000	0.760
4.0000	0.031	58.0000	0.779
4.5000	0.037	60.0000	0.792
5.0000	0.050	62.0000	0.811
5.5000	0.056	64.0000	0.823
6.0000	0.069	66.0000	0.836
6.5000	0.081	68.0000	0.848
7.0000	0.094	70.0000	0.861
7.5000	0.100	72.0000	0.873
8.0000	0.113	74.0000	0.886
8.5000	0.125	76.0000	0.899

78.0000	0.911	350.000	1.439
80.0000	0.924	360.000	1.446
82.0000	0.930	370.000	1.452
84.0000	0.943	380.000	1.452
86.0000	0.955	390.000	1.458
88.0000	0.968	400.000	1.458
90.0000	0.974	410.000	1.464
92.0000	0.987	420.000	1.464
94.0000	0.993	430.000	1.471
96.0000	1.005	440.000	1.477
98.0000	1.012	450.000	1.483
100.000	1.024	460.000	1.483
110.000	1.062	470.000	1.490
120.000	1.100	480.000	1.490
130.000	1.137	490.000	1.496
140.000	1.163	500.000	1.496
150.000	1.194	510.000	1.502
160.000	1.219	520.000	1.502
170.000	1.244	530.000	1.508
180.000	1.263	540.000	1.508
190.000	1.282	550.000	1.515
200.000	1.301	560.000	1.521
210.000	1.313	570.000	1.521
220.000	1.332	580.000	1.527
230.000	1.345	590.000	1.534
240.000	1.357	600.000	1.540
250.000	1.364	610.000	1.540
260.000	1.376	620.000	1.546
270.000	1.383	630.000	1.552
280.000	1.395	640.000	1.559
290.000	1.402	650.000	1.559
300.000	1.414	660.000	1.565
310.000	1.420	670.000	1.571
320.000	1.427	680.000	1.578
330.000	1.427	690.000	1.584
340.000	1.439	700.000	1.590

710.000	1.596
720.000	1.603
730.000	1.603
740.000	1.609
750.000	1.615
760.000	1.622
770.000	1.628
780.000	1.634
790.000	1.640
800.000	1.640
810.000	1.647
820.000	1.653
830.000	1.659
840.000	1.659
850.000	1.672
860.000	1.672
870.000	1.678
880.000	1.684
890.000	1.691
900.000	1.697
910.000	1.697
920.000	1.703
930.000	1.703
940.000	1.710
950.000	1.710
960.000	1.710
970.000	1.716
980.000	1.716
990.000	1.722
1000.00	1.722
1100.00	1.735
1200.00	1.754
1300.00	1.779
1400.00	1.823
1500.00	1.848
1600.00	1.867
1700.00	1.854
1800.00	1.835
1900.00	1.823
2000.00	1.823
2100.00	1.823
2200.00	1.842
2300.00	1.860
2400.00	1.886
2500.00	1.886
2600.00	1.886
2700.00	1.898
2800.00	1.923
2900.00	1.942
3000.00	1.948
3100.00	1.936
3200.00	1.930
3300.00	1.923
3400.00	1.917
3500.00	1.911
3600.00	1.886
3700.00	1.873
3800.00	1.879
3900.00	1.886
4000.00	1.892
4100.00	1.898
4200.00	1.911

END

SE2000
Environmental Logger
03/16 11:10

Unit# 0000001 Test# 1

Well J Aquifer Test
Piezometer: JPZ-5
Pump Start: 0930 hrs 03/10/89
Pump Stop: 0930 hrs 03/13/89

SE2000
Environmental Logger
03/16 11:15

Unit# 0000001 Test# 0

INPUT 5: Level (F) TOC

Reference	0.000
Scale factor	19.970
Offset	0.000
SG	1.000

Step 0 03/09 18:00:02

Elapsed Time	Value
0.0000	-0.006
120.000	-0.018
240.000	0.006
360.000	0.031
480.000	0.037
600.000	0.018
720.000	0.000
840.000	0.012

END

SE2000
Environmental Logger
03/16 11:16

Unit# 0000001 Test# 1

INPUT 5: Level (F) TOC

Reference	0.000
Scale factor	19.970
Offset	0.000
SG	1.000

Step 0 03/10 09:30:00

Elapsed Time	Value
0.0000	0.000
0.0083	0.000
0.0166	0.000
0.0250	-0.006
0.0333	-0.006
0.0416	-0.006
0.0500	-0.006
0.0583	-0.006
0.0666	0.006
0.0750	0.000
0.0833	0.000
0.1000	0.000
0.1166	0.000
0.1333	-0.006
0.1500	-0.006
0.1666	0.000
0.1833	0.000
0.2000	0.000
0.2166	0.000
0.2333	0.000
0.2500	-0.006
0.2666	0.000
0.2833	-0.006

0.3000	-0.006	9.0000	0.940
0.3166	0.000	9.5000	0.965
0.3333	0.000	10.0000	0.997
0.4166	0.000	12.0000	1.098
0.5000	0.000	14.0000	1.186
0.5833	0.006	16.0000	1.262
0.6666	0.012	18.0000	1.332
0.7500	0.018	20.0000	1.395
0.8333	0.031	22.0000	1.452
0.9166	0.037	24.0000	1.502
1.0000	0.050	26.0000	1.553
1.0833	0.056	28.0000	1.597
1.1666	0.088	30.0000	1.635
1.2500	0.101	32.0000	1.672
1.3333	0.113	34.0000	1.717
1.4166	0.126	36.0000	1.748
1.5000	0.145	38.0000	1.786
1.5833	0.151	40.0000	1.811
1.6666	0.170	42.0000	1.843
1.7500	0.195	44.0000	1.868
1.8333	0.208	46.0000	1.893
1.9166	0.227	48.0000	1.925
2.0000	0.233	50.0000	1.950
2.5000	0.233	52.0000	1.969
3.0000	0.404	54.0000	1.994
3.5000	0.460	56.0000	2.013
4.0000	0.517	58.0000	2.039
4.5000	0.580	60.0000	2.058
5.0000	0.637	62.0000	2.077
5.5000	0.688	64.0000	2.095
6.0000	0.732	66.0000	2.114
6.5000	0.770	68.0000	2.133
7.0000	0.808	70.0000	2.152
7.5000	0.845	72.0000	2.165
8.0000	0.871	74.0000	2.184
8.5000	0.909	76.0000	2.196

78.0000	2.215	350.000	2.922
80.0000	2.228	360.000	2.922
82.0000	2.241	370.000	2.929
84.0000	2.253	380.000	2.929
86.0000	2.272	390.000	2.929
88.0000	2.285	400.000	2.922
90.0000	2.297	410.000	2.916
92.0000	2.310	420.000	2.904
94.0000	2.323	430.000	2.891
96.0000	2.335	440.000	2.878
98.0000	2.348	450.000	2.878
100.000	2.361	460.000	2.872
110.000	2.417	470.000	2.872
120.000	2.468	480.000	2.878
130.000	2.512	490.000	2.878
140.000	2.550	500.000	2.878
150.000	2.588	510.000	2.885
160.000	2.626	520.000	2.885
170.000	2.657	530.000	2.891
180.000	2.676	540.000	2.891
190.000	2.708	550.000	2.897
200.000	2.733	560.000	2.904
210.000	2.752	570.000	2.910
220.000	2.765	580.000	2.916
230.000	2.784	590.000	2.922
240.000	2.803	600.000	2.922
250.000	2.821	610.000	2.929
260.000	2.834	620.000	2.935
270.000	2.847	630.000	2.941
280.000	2.859	640.000	2.948
290.000	2.872	650.000	2.954
300.000	2.885	660.000	2.960
310.000	2.891	670.000	2.967
320.000	2.904	680.000	2.973
330.000	2.910	690.000	2.979
340.000	2.916	700.000	2.986

710.000	2.992
720.000	2.998
730.000	3.005
740.000	3.011
750.000	3.017
760.000	3.023
770.000	3.030
780.000	3.042
790.000	3.049
800.000	3.049
810.000	3.055
820.000	3.061
830.000	3.068
840.000	3.074
850.000	3.080
860.000	3.087
870.000	3.093
880.000	3.099
890.000	3.106
900.000	3.112
910.000	3.118
920.000	3.118
930.000	3.124
940.000	3.131
950.000	3.131
960.000	3.137
970.000	3.143
980.000	3.143
990.000	3.150
1000.00	3.150
1100.00	3.169
1200.00	3.188
1300.00	3.213
1400.00	3.257
1500.00	3.270
1600.00	3.225
1700.00	3.213
1800.00	3.194
1900.00	3.200
2000.00	3.194
2100.00	3.200
2200.00	3.213
2300.00	3.238
2400.00	3.263
2500.00	3.263
2600.00	3.270
2700.00	3.276
2800.00	3.301
2900.00	3.327
3000.00	3.333
3100.00	3.333
3200.00	3.345
3300.00	3.333
3400.00	3.327
3500.00	3.320
3600.00	3.238
3700.00	3.219
3800.00	3.219
3900.00	3.251
4000.00	3.257
4100.00	3.270
4200.00	3.276

END

SE2000
Environmental Logger
03/16 11:21

Unit# 0000001 Test# 1

RECOVERY DATA FROM
IN SITU HERMIT 2000
DATA LOGGER

JPZ-1 Recovery

INPUT 1: Level (F) TOC

Reference	0.000
Scale factor	19.928
Offset	0.000
SG	1.000

Step 1 03/13 09:30:02

Elapsed Time	Value
0.0000	4.815
0.0083	4.822
0.0166	4.815
0.0250	4.815
0.0333	4.815
0.0416	4.815
0.0500	4.815
0.0583	4.815
0.0666	4.815
0.0750	4.815
0.0833	4.815
0.1000	4.809
0.1166	4.809
0.1333	4.803
0.1500	4.796
0.1666	4.790
0.1833	4.784
0.2000	4.771
0.2166	4.759
0.2333	4.740
0.2500	4.727
0.2666	4.708
0.2833	4.690
0.3000	4.671
0.3166	4.652
0.3333	4.627
0.4166	4.514
0.5000	4.394
0.5833	4.275
0.6666	4.155
0.7500	4.055
0.8333	3.948
0.9166	3.847
1.0000	3.759
1.0833	3.677
1.1666	3.608
1.2500	3.539
1.3333	3.483
1.4166	3.432
1.5000	3.394
1.5833	3.350
1.6666	3.319
1.7500	3.288
1.8333	3.262
1.9166	3.237
2.0000	3.225
2.5000	3.137
3.0000	3.099
3.5000	3.061
4.0000	3.011
4.5000	2.961
5.0000	2.917
5.5000	2.866
6.0000	2.822
6.5000	2.785
7.0000	2.741
7.5000	2.703
8.0000	2.665
8.5000	2.627
9.0000	2.596
9.5000	2.565

JPZ-1 Recovery

10.0000	2.533	82.0000	1.244
12.0000	2.426	84.0000	1.225
14.0000	2.332	86.0000	1.213
16.0000	2.250	88.0000	1.200
18.0000	2.175	90.0000	1.181
20.0000	2.112	92.0000	1.169
22.0000	2.055	94.0000	1.163
24.0000	1.999	96.0000	1.150
26.0000	1.948	98.0000	1.137
28.0000	1.904	100.000	1.125
30.0000	1.860	110.000	1.068
32.0000	1.823	120.000	1.018
34.0000	1.785	130.000	0.968
36.0000	1.747	140.000	0.924
38.0000	1.716	150.000	0.886
40.0000	1.684	160.000	0.855
42.0000	1.653	170.000	0.817
44.0000	1.622	180.000	0.785
46.0000	1.596	190.000	0.760
48.0000	1.571	200.000	0.723
50.0000	1.546	210.000	0.704
52.0000	1.521	220.000	0.685
54.0000	1.496	230.000	0.653
56.0000	1.477	240.000	0.634
58.0000	1.452	250.000	0.609
60.0000	1.433	260.000	0.584
62.0000	1.408	270.000	0.572
64.0000	1.395	280.000	0.546
66.0000	1.376	290.000	0.528
68.0000	1.357	300.000	0.521
70.0000	1.339	310.000	0.502
72.0000	1.320	320.000	0.484
74.0000	1.307	330.000	0.471
76.0000	1.288	340.000	0.452
78.0000	1.269	350.000	0.446
80.0000	1.257	360.000	0.427

JPZ-1 Recovery

370.000	0.414	730.000	0.138
380.000	0.408	740.000	0.138
390.000	0.389	750.000	0.132
400.000	0.377	760.000	0.132
410.000	0.370	770.000	0.119
420.000	0.358	780.000	0.119
430.000	0.345	790.000	0.113
440.000	0.333	800.000	0.113
450.000	0.333	810.000	0.106
460.000	0.320	820.000	0.100
470.000	0.308	830.000	0.094
480.000	0.301	840.000	0.094
490.000	0.289	850.000	0.088
500.000	0.282	860.000	0.088
510.000	0.270	870.000	0.081
520.000	0.270	880.000	0.075
530.000	0.257	890.000	0.069
540.000	0.257	900.000	0.069
550.000	0.245	910.000	0.069
560.000	0.245	920.000	0.062
570.000	0.238	930.000	0.062
580.000	0.232	940.000	0.056
590.000	0.226	950.000	0.050
600.000	0.220	960.000	0.050
610.000	0.213	970.000	0.044
620.000	0.207	980.000	0.037
630.000	0.201	990.000	0.037
640.000	0.194	1000.00	0.031
650.000	0.182	1100.00	-0.006
660.000	0.182	1200.00	-0.025
670.000	0.176	1300.00	-0.025
680.000	0.169	1400.00	-0.025
690.000	0.163	1500.00	-0.044
700.000	0.157	1600.00	-0.069
710.000	0.150	END	
720.000	0.144		

JP2-2 Recovery

INPUT 2: Level (F) TOC

Reference	0.000
Scale factor	20.220
Offset	0.000
SG	1.000

Step 1 03/13 09:30:02

Elapsed Time	Value
0.0000	5.179
0.0083	5.179
0.0166	5.179
0.0250	5.179
0.0333	5.179
0.0416	5.179
0.0500	5.179
0.0583	5.179
0.0666	5.173
0.0750	5.173
0.0833	5.173
0.1000	5.167
0.1166	5.160
0.1333	5.154
0.1500	5.135
0.1666	5.122
0.1833	5.103
0.2000	5.077
0.2166	5.058
0.2333	5.033
0.2500	5.001
0.2666	4.969
0.2833	4.937
0.3000	4.911
0.3166	4.880
0.3333	4.848
0.4166	4.688
0.5000	4.548
0.5833	4.414
0.6666	4.286
0.7500	4.171
0.8333	4.063
0.9166	3.967
1.0000	3.878
1.0833	3.795
1.1666	3.725
1.2500	3.668
1.3333	3.610
1.4166	3.565
1.5000	3.527
1.5833	3.489
1.6666	3.457
1.7500	3.431
1.8333	3.406
1.9166	3.387
2.0000	3.368
2.5000	3.285
3.0000	3.240
3.5000	3.202
4.0000	3.151
4.5000	3.093
5.0000	3.042
5.5000	2.991
6.0000	2.947
6.5000	2.902
7.0000	2.857
7.5000	2.819
8.0000	2.781
8.5000	2.743
9.0000	2.711
9.5000	2.679

JPZ-2 Recovery

10.0000	2.653	82.0000	1.314
12.0000	2.532	84.0000	1.294
14.0000	2.436	86.0000	1.282
16.0000	2.353	88.0000	1.269
18.0000	2.277	90.0000	1.250
20.0000	2.213	92.0000	1.243
22.0000	2.149	94.0000	1.231
24.0000	2.098	96.0000	1.218
26.0000	2.041	98.0000	1.205
28.0000	1.996	100.000	1.192
30.0000	1.952	110.000	1.135
32.0000	1.913	120.000	1.078
34.0000	1.875	130.000	1.027
36.0000	1.837	140.000	0.982
38.0000	1.798	150.000	0.950
40.0000	1.767	160.000	0.912
42.0000	1.735	170.000	0.873
44.0000	1.709	180.000	0.842
46.0000	1.677	190.000	0.810
48.0000	1.652	200.000	0.784
50.0000	1.626	210.000	0.759
52.0000	1.601	220.000	0.733
54.0000	1.575	230.000	0.708
56.0000	1.556	240.000	0.682
58.0000	1.530	250.000	0.663
60.0000	1.511	260.000	0.637
62.0000	1.492	270.000	0.618
64.0000	1.467	280.000	0.606
66.0000	1.448	290.000	0.580
68.0000	1.428	300.000	0.567
70.0000	1.409	310.000	0.548
72.0000	1.390	320.000	0.535
74.0000	1.371	330.000	0.523
76.0000	1.358	340.000	0.503
78.0000	1.339	350.000	0.459
80.0000	1.326	360.000	0.478

JP2-2 Recovery

370.000	0.465	730.000	0.184
380.000	0.459	740.000	0.178
390.000	0.452	750.000	0.172
400.000	0.433	760.000	0.172
410.000	0.421	770.000	0.165
420.000	0.408	780.000	0.159
430.000	0.401	790.000	0.159
440.000	0.382	800.000	0.153
450.000	0.369	810.000	0.146
460.000	0.363	820.000	0.140
470.000	0.357	830.000	0.140
480.000	0.344	840.000	0.133
490.000	0.344	850.000	0.127
500.000	0.331	860.000	0.127
510.000	0.325	870.000	0.121
520.000	0.318	880.000	0.114
530.000	0.312	890.000	0.114
540.000	0.306	900.000	0.108
550.000	0.293	910.000	0.108
560.000	0.293	920.000	0.102
570.000	0.287	930.000	0.102
580.000	0.280	940.000	0.095
590.000	0.274	950.000	0.095
600.000	0.267	960.000	0.089
610.000	0.255	970.000	0.082
620.000	0.255	980.000	0.082
630.000	0.242	990.000	0.076
640.000	0.236	1000.00	0.070
650.000	0.229	1100.00	0.031
660.000	0.223	1200.00	0.019
670.000	0.223	1300.00	0.012
680.000	0.210	1400.00	0.012
690.000	0.204	1500.00	0.000
700.000	0.204	1600.00	-0.031
710.000	0.197	END	
720.000	0.191		

JPZ-3 Recovery

INPUT 3: Level (F) TOC

Reference	0.000
Scale factor	19.984
Offset	0.003
SG	1.000

Step 1 03/13 09:30:02

Elapsed Time	Value
0.0000	2.906
0.0083	2.912
0.0166	2.912
0.0250	2.912
0.0333	2.912
0.0416	2.912
0.0500	2.912
0.0583	2.912
0.0666	2.912
0.0750	2.912
0.0833	2.912
0.1000	2.906
0.1166	2.906
0.1333	2.906
0.1500	2.906
0.1666	2.906
0.1833	2.906
0.2000	2.906
0.2166	2.906
0.2333	2.906
0.2500	2.906
0.2666	2.906
0.2833	2.906
0.3000	2.906
0.3166	2.906
0.3333	2.906
0.4166	2.906
0.5000	2.887
0.5833	2.900
0.6666	2.906
0.7500	2.906
0.8333	2.893
0.9166	2.900
1.0000	2.893
1.0833	2.881
1.1666	2.887
1.2500	2.881
1.3333	2.874
1.4166	2.856
1.5000	2.849
1.5833	2.856
1.6666	2.843
1.7500	2.837
1.8333	2.818
1.9166	2.811
2.0000	2.818
2.5000	2.755
3.0000	2.698
3.5000	2.666
4.0000	2.622
4.5000	2.591
5.0000	2.566
5.5000	2.528
6.0000	2.502
6.5000	2.471
7.0000	2.452
7.5000	2.420
8.0000	2.402
8.5000	2.370
9.0000	2.345
9.5000	2.326

JPZ-3 Recovery

10.0000	2.294	82.0000	1.210
12.0000	2.225	84.0000	1.197
14.0000	2.149	86.0000	1.185
16.0000	2.086	88.0000	1.166
18.0000	2.030	90.0000	1.160
20.0000	1.992	92.0000	1.147
22.0000	1.929	94.0000	1.134
24.0000	1.885	96.0000	1.122
26.0000	1.840	98.0000	1.109
28.0000	1.803	100.000	1.097
30.0000	1.777	110.000	1.052
32.0000	1.727	120.000	0.996
34.0000	1.695	130.000	0.958
36.0000	1.664	140.000	0.914
38.0000	1.639	150.000	0.876
40.0000	1.607	160.000	0.844
42.0000	1.582	170.000	0.813
44.0000	1.557	180.000	0.781
46.0000	1.532	190.000	0.750
48.0000	1.506	200.000	0.731
50.0000	1.487	210.000	0.699
52.0000	1.462	220.000	0.680
54.0000	1.443	230.000	0.655
56.0000	1.424	240.000	0.636
58.0000	1.405	250.000	0.611
60.0000	1.387	260.000	0.592
62.0000	1.368	270.000	0.580
64.0000	1.349	280.000	0.561
66.0000	1.330	290.000	0.542
68.0000	1.311	300.000	0.535
70.0000	1.298	310.000	0.510
72.0000	1.286	320.000	0.498
74.0000	1.267	330.000	0.479
76.0000	1.254	340.000	0.466
78.0000	1.242	350.000	0.453
80.0000	1.223	360.000	0.441

JP2-3 Recovery

370.000	0.428	730.000	0.163
380.000	0.416	740.000	0.163
390.000	0.403	750.000	0.157
400.000	0.397	760.000	0.151
410.000	0.390	770.000	0.151
420.000	0.378	780.000	0.145
430.000	0.365	790.000	0.138
440.000	0.353	800.000	0.138
450.000	0.346	810.000	0.132
460.000	0.334	820.000	0.126
470.000	0.327	830.000	0.126
480.000	0.321	840.000	0.119
490.000	0.308	850.000	0.119
500.000	0.302	860.000	0.113
510.000	0.290	870.000	0.107
520.000	0.283	880.000	0.107
530.000	0.283	890.000	0.100
540.000	0.277	900.000	0.094
550.000	0.271	910.000	0.094
560.000	0.264	920.000	0.094
570.000	0.264	930.000	0.088
580.000	0.252	940.000	0.088
590.000	0.252	950.000	0.081
600.000	0.245	960.000	0.075
610.000	0.233	970.000	0.075
620.000	0.233	980.000	0.069
630.000	0.220	990.000	0.063
640.000	0.214	1000.00	0.056
650.000	0.208	1100.00	0.025
660.000	0.208	1200.00	0.006
670.000	0.201	1300.00	0.006
680.000	0.195	1400.00	0.000
690.000	0.189	1500.00	-0.012
700.000	0.182	1600.00	-0.037
710.000	0.176	END	
720.000	0.176		

JPZ-4 Recovery

INPUT 4: Level (F) TOC

Reference	0.000
Scale factor	19.928
Offset	0.000
SG	1.000

Step 1 03/13 09:30:02

Elapsed Time	Value
0.0000	1.917
0.0083	1.917
0.0166	1.930
0.0250	1.923
0.0333	1.923
0.0416	1.923
0.0500	1.923
0.0583	1.923
0.0666	1.917
0.0750	1.917
0.0833	1.923
0.1000	1.917
0.1166	1.917
0.1333	1.917
0.1500	1.917
0.1666	1.917
0.1833	1.917
0.2000	1.917
0.2166	1.917
0.2333	1.917
0.2500	1.917
0.2666	1.917
0.2833	1.917
0.3000	1.917
0.3166	1.917
0.3333	1.917
0.4166	1.917
0.5000	1.917
0.5833	1.917
0.6666	1.917
0.7500	1.917
0.8333	1.911
0.9166	1.911
1.0000	1.917
1.0833	1.911
1.1666	1.911
1.2500	1.917
1.3333	1.911
1.4166	1.911
1.5000	1.904
1.5833	1.911
1.6666	1.911
1.7500	1.911
1.8333	1.911
1.9166	1.911
2.0000	1.904
2.5000	1.904
3.0000	1.898
3.5000	1.892
4.0000	1.886
4.5000	1.867
5.0000	1.854
5.5000	1.848
6.0000	1.835
6.5000	1.823
7.0000	1.816
7.5000	1.798
8.0000	1.791
8.5000	1.779
9.0000	1.766
9.5000	1.754

JP2-4 Recovery

10.0000	1.747	82.0000	0.980
12.0000	1.703	84.0000	0.974
14.0000	1.659	86.0000	0.961
16.0000	1.622	88.0000	0.949
18.0000	1.590	90.0000	0.943
20.0000	1.552	92.0000	0.930
22.0000	1.521	94.0000	0.924
24.0000	1.490	96.0000	0.917
26.0000	1.464	98.0000	0.905
28.0000	1.433	100.000	0.892
30.0000	1.414	110.000	0.848
32.0000	1.383	120.000	0.811
34.0000	1.364	130.000	0.779
36.0000	1.339	140.000	0.741
38.0000	1.320	150.000	0.710
40.0000	1.295	160.000	0.685
42.0000	1.276	170.000	0.660
44.0000	1.257	180.000	0.634
46.0000	1.238	190.000	0.616
48.0000	1.219	200.000	0.597
50.0000	1.207	210.000	0.565
52.0000	1.188	220.000	0.546
54.0000	1.169	230.000	0.528
56.0000	1.156	240.000	0.528
58.0000	1.137	250.000	0.490
60.0000	1.125	260.000	0.477
62.0000	1.106	270.000	0.458
64.0000	1.093	280.000	0.446
66.0000	1.081	290.000	0.433
68.0000	1.068	300.000	0.408
70.0000	1.056	310.000	0.402
72.0000	1.043	320.000	0.383
74.0000	1.031	330.000	0.377
76.0000	1.018	340.000	0.358
78.0000	1.005	350.000	0.358
80.0000	0.993	360.000	0.345

JPZ-4 Recovery

370.000	0.333	730.000	0.106
380.000	0.326	740.000	0.106
390.000	0.314	750.000	0.100
400.000	0.301	760.000	0.094
410.000	0.289	770.000	0.094
420.000	0.282	780.000	0.088
430.000	0.282	790.000	0.088
440.000	0.270	800.000	0.081
450.000	0.251	810.000	0.075
460.000	0.251	820.000	0.075
470.000	0.245	830.000	0.069
480.000	0.238	840.000	0.069
490.000	0.232	850.000	0.062
500.000	0.220	860.000	0.062
510.000	0.213	870.000	0.056
520.000	0.213	880.000	0.050
530.000	0.207	890.000	0.050
540.000	0.201	900.000	0.044
550.000	0.194	910.000	0.044
560.000	0.194	920.000	0.044
570.000	0.188	930.000	0.044
580.000	0.182	940.000	0.037
590.000	0.176	950.000	0.031
600.000	0.169	960.000	0.031
610.000	0.163	970.000	0.025
620.000	0.163	980.000	0.025
630.000	0.157	990.000	0.018
640.000	0.150	1000.00	0.012
650.000	0.144	1100.00	-0.018
660.000	0.138	1200.00	-0.031
670.000	0.132	1300.00	-0.031
680.000	0.132	1400.00	-0.031
690.000	0.125	1500.00	-0.044
700.000	0.119	1600.00	-0.069
710.000	0.119	END	
720.000	0.113		

JPZ-5 Recovery

INPUT 5: Level (F) TOC

Reference	0.000
Scale factor	19.970
Offset	0.000
SG	1.000

Step 1 03/13 09:30:02

Elapsed Time	Value
0.0000	3.276
0.0083	3.276
0.0166	3.276
0.0250	3.276
0.0333	3.276
0.0416	3.276
0.0500	3.276
0.0583	3.276
0.0666	3.276
0.0750	3.270
0.0833	3.276
0.1000	3.276
0.1166	3.276
0.1333	3.276
0.1500	3.282
0.1666	3.270
0.1833	3.263
0.2000	3.270
0.2166	3.270
0.2333	3.270
0.2500	3.270
0.2666	3.270
0.2833	3.276
0.3000	3.270
0.3166	3.270
0.3333	3.282
0.4166	3.270
0.5000	3.270
0.5833	3.263
0.6666	3.257
0.7500	3.238
0.8333	3.225
0.9166	3.207
1.0000	3.194
1.0833	3.181
1.1666	3.156
1.2500	3.137
1.3333	3.112
1.4166	3.087
1.5000	3.074
1.5833	3.049
1.6666	3.030
1.7500	3.011
1.8333	2.967
1.9166	2.967
2.0000	2.948
2.5000	2.859
3.0000	2.777
3.5000	2.720
4.0000	2.670
4.5000	2.619
5.0000	2.575
5.5000	2.537
6.0000	2.493
6.5000	2.455
7.0000	2.424
7.5000	2.392
8.0000	2.373
8.5000	2.329
9.0000	2.297
9.5000	2.272

JPZ-5 Recovery

10.0000	2.241	82.0000	0.997
12.0000	2.146	84.0000	0.984
14.0000	2.064	86.0000	0.965
16.0000	1.988	88.0000	0.959
18.0000	1.919	90.0000	0.940
20.0000	1.862	92.0000	0.928
22.0000	1.799	94.0000	0.915
24.0000	1.748	96.0000	0.909
26.0000	1.698	98.0000	0.890
28.0000	1.654	100.000	0.877
30.0000	1.622	110.000	0.820
32.0000	1.578	120.000	0.770
34.0000	1.540	130.000	0.719
36.0000	1.502	140.000	0.675
38.0000	1.470	150.000	0.637
40.0000	1.439	160.000	0.599
42.0000	1.407	170.000	0.561
44.0000	1.382	180.000	0.530
46.0000	1.357	190.000	0.498
48.0000	1.325	200.000	0.467
50.0000	1.306	210.000	0.441
52.0000	1.281	220.000	0.416
54.0000	1.256	230.000	0.391
56.0000	1.231	240.000	0.366
58.0000	1.212	250.000	0.347
60.0000	1.193	260.000	0.321
62.0000	1.167	270.000	0.303
64.0000	1.155	280.000	0.284
66.0000	1.130	290.000	0.265
68.0000	1.111	300.000	0.252
70.0000	1.098	310.000	0.233
72.0000	1.073	320.000	0.214
74.0000	1.060	330.000	0.202
76.0000	1.041	340.000	0.189
78.0000	1.029	350.000	0.170
80.0000	1.010	360.000	0.157

JP2-5 Recovery

370.000	0.145
380.000	0.132
390.000	0.113
400.000	0.107
410.000	0.088
420.000	0.082
430.000	0.075
440.000	0.056
450.000	0.050
460.000	0.037
470.000	0.025
480.000	0.018
490.000	0.012
500.000	0.000
510.000	-0.006
520.000	-0.012
530.000	-0.018
540.000	-0.025
550.000	-0.037
560.000	-0.044
570.000	-0.050
580.000	-0.056
590.000	-0.063
600.000	-0.069
610.000	-0.075
620.000	-0.082
630.000	-0.088
640.000	-0.094
650.000	-0.107
660.000	-0.107
670.000	-0.119
680.000	-0.119
690.000	-0.126
700.000	-0.132
710.000	-0.138
720.000	-0.145
730.000	-0.151
740.000	-0.157
750.000	-0.164
760.000	-0.164
770.000	-0.170
780.000	-0.176
790.000	-0.183
800.000	-0.183
810.000	-0.189
820.000	-0.195
830.000	-0.202
840.000	-0.202
850.000	-0.208
860.000	-0.214
870.000	-0.220
880.000	-0.220
890.000	-0.227
900.000	-0.227
910.000	-0.233
920.000	-0.233
930.000	-0.239
940.000	-0.246
950.000	-0.246
960.000	-0.252
970.000	-0.258
980.000	-0.258
990.000	-0.265
1000.00	-0.271
1100.00	-0.315
1200.00	-0.328
1300.00	-0.328
1400.00	-0.334
1500.00	-0.347
1600.00	-0.378
END	

DRAWDOWN/RECOVERY DATA
FROM GCL DATA LOGGER

Well J Aquifer Test
Piezometer: JPZ-1
Pump Start: 0930 hrs 03/10/89
Pump Stop: 0930 hrs 03/13/89

Elapsed Time (min.)	Drawdown (feet)
0.15	0.00
0.31	0.12
0.48	0.27
0.65	0.49
0.81	0.65
0.98	0.78
1.48	1.13
1.98	1.33
2.48	1.43
2.98	1.45
3.48	1.55
3.98	1.69
4.48	1.82
4.98	1.84
6.98	2.00
8.98	2.17
10.98	2.28
12.98	2.39
14.98	2.46
16.98	2.56
18.98	2.62
23.98	2.78
28.98	2.90
33.98	3.00
38.98	3.09
43.98	3.18
48.98	3.23
53.98	3.28
58.98	3.35
78.98	3.53
98.98	3.67
118.98	3.79
138.98	3.86
158.98	3.93
178.98	4.00
238.98	4.13
298.98	4.21
358.98	4.23
418.98	4.31
478.98	4.31
496.35	4.31
556.34	4.30
616.34	4.29
736.34	4.29
1216.34	4.32
3974.02	4.66
3984.01	4.61
3994.01	4.60
4004.01	4.59
4014.01	4.60
4024.01	4.60
4034.01	4.62
4044.01	4.63
4054.01	4.64
4064.01	4.65
4074.01	4.66
4084.01	4.69
4094.01	4.70
4104.01	4.69
4114.01	4.70
4124.01	4.67
4134.01	4.70
4144.01	4.69
4154.01	4.64
4164.01	4.65
4174.01	4.65

4184.01	4.65
4194.01	4.63
4204.01	4.67
4214.01	4.68
4224.01	4.65
4234.01	4.62
4244.01	4.66
4254.01	4.67
4264.01	4.67
4274.01	4.64
4284.01	4.62
4294.01	4.64
4319.02	4.64
4319.09	4.64
4319.18	4.64
4319.26	4.64
4319.34	4.64
4319.43	4.64
4319.51	4.65
4319.59	4.67
4319.68	4.66
4319.76	4.66
4319.84	4.64
4319.93	4.64
4320.01	4.64
4320.09	4.64
4320.18	4.63
4320.26	4.57
4320.34	4.46
4320.43	4.34
4320.51	4.23
4320.59	4.09
4320.67	4.00
4320.76	3.87
4320.84	3.77
4320.93	3.67
4321.01	3.58
4321.18	3.43
4321.34	3.30
4321.51	3.21
4321.68	3.15
4321.84	3.05
4322.01	3.02
4322.51	2.91
4323.01	2.89
4323.51	2.85
4324.01	2.78
4324.51	2.85
4325.01	2.81
4325.51	2.75
4326.01	2.70
4328.01	2.55
4330.01	2.42
4332.01	2.31
4334.01	2.21
4336.01	2.12
4338.01	2.05
4340.01	1.98
4345.01	1.83
4350.01	1.73
4355.01	1.61
4360.01	1.51
4365.01	1.44
4370.01	1.39
4375.01	1.32
4380.01	1.20
4400.01	1.07
4420.01	0.96
4440.01	0.86
4460.01	0.73
4480.01	0.71
4500.01	0.64

4560.01	0.45
4620.01	0.35
4680.01	0.19
4740.01	0.15
4800.01	-0.01
4860.01	-0.13
4920.01	-0.29
4980.01	-0.42
5099.36	-0.57
5190.05	-0.61
5250.04	-0.63
5310.04	-0.60
5370.04	-0.74
5430.04	-0.76
5490.04	-0.84
5550.04	-0.84
5610.04	-0.87
5670.04	-0.84
5730.04	-0.55
5790.04	-0.36
5850.04	-0.12
5910.04	-0.08

Well J Aquifer Test
Piezometer: JPZ-2
Pump Start: 0930 hrs 03/10/89
Pump Stop: 0930 hrs 03/13/89

Elapsed Time (min.)	Drawdown (feet)
0.15	0.00
0.32	0.17
0.48	0.40
0.65	0.61
0.82	0.80
0.98	0.95
1.48	1.29
1.98	1.49
2.48	1.51
2.98	1.57
3.48	1.70
3.98	1.88
4.48	1.98
4.98	2.02
6.98	2.17
8.98	2.31
10.98	2.44
12.98	2.55
14.98	2.65
16.98	2.71
18.98	2.80
23.98	2.94
28.98	3.07
33.98	3.18
38.98	3.27
43.98	3.36
48.98	3.41
53.98	3.47
58.98	3.53
78.98	3.72
98.98	3.86
118.98	3.96
138.98	4.07
158.98	4.14
178.98	4.25
238.98	4.36
298.98	4.43
358.98	4.49
418.98	4.53
478.98	4.55
496.35	4.56
556.34	4.58
616.34	4.61
736.34	4.71
1216.34	4.94
3974.02	5.18
3984.01	5.20
3994.01	5.20
4004.01	5.20
4014.01	5.19
4024.01	5.18
4034.01	5.17
4044.01	5.17
4054.01	5.17
4064.01	5.17
4074.01	5.16
4084.01	5.15
4094.01	5.15
4104.01	5.15
4114.01	5.15
4124.01	5.14
4134.01	5.13
4144.01	5.14
4154.01	5.15
4164.01	5.15
4174.01	5.16

4184.01	5.16
4194.01	5.16
4204.01	5.14
4214.01	5.15
4224.01	5.16
4234.01	5.17
4244.01	5.17
4254.01	5.16
4264.01	5.16
4274.01	5.16
4284.01	5.16
4294.01	5.16
4319.02	5.16
4319.10	5.17
4319.18	5.16
4319.26	5.17
4319.35	5.17
4319.43	5.16
4319.51	5.16
4319.60	5.16
4319.68	5.15
4319.76	5.16
4319.85	5.17
4319.93	5.16
4320.01	5.16
4320.10	5.15
4320.18	5.10
4320.26	4.98
4320.35	4.84
4320.43	4.67
4320.51	4.54
4320.60	4.40
4320.68	4.27
4320.76	4.17
4320.85	4.05
4320.93	3.95
4321.01	3.87
4321.18	3.72
4321.35	3.60
4321.51	3.52
4321.68	3.45
4321.85	3.41
4322.01	3.37
4322.51	3.29
4323.01	3.25
4323.51	3.20
4324.01	3.15
4324.51	3.10
4325.01	3.05
4325.51	3.00
4326.01	2.95
4328.01	2.79
4330.01	2.66
4332.01	2.54
4334.01	2.44
4336.01	2.37
4338.01	2.28
4340.01	2.22
4345.01	2.05
4350.01	1.93
4355.01	1.83
4360.01	1.75
4365.01	1.67
4370.01	1.61
4375.01	1.55
4380.01	1.49
4400.01	1.31
4420.01	1.17
4440.01	1.09
4460.01	0.97
4480.01	0.91
4500.01	0.83

4560.01	0.67
4620.01	0.59
4680.01	0.48
4740.01	0.40
4800.01	0.35
4860.01	0.31
4920.01	0.27
4980.01	0.24
5099.37	0.17
5190.06	0.14
5250.05	0.12
5310.05	0.09
5370.05	0.07
5430.05	0.06
5490.05	0.04
5550.05	0.03
5610.05	0.05
5670.05	0.05
5730.05	0.07
5790.05	0.08
5850.05	0.08
5910.05	0.07

Well J Aquifer Test
Piezometer: JPZ-3
Pump Start: 0930 hrs 03/10/89
Pump Stop: 0930 hrs 03/13/89

Elapsed Time (min.)	Duration (feet)
0.16	0.00
0.33	0.00
0.49	0.00
0.66	0.00
0.83	0.00
0.99	0.02
1.49	0.04
1.99	0.08
2.49	0.13
2.99	0.16
3.49	0.20
3.99	0.23
4.49	0.27
4.99	0.31
6.99	0.43
8.99	0.52
10.99	0.62
12.99	0.69
14.99	0.76
16.99	0.83
18.99	0.87
23.99	1.00
28.99	1.11
33.99	1.19
38.99	1.27
43.99	1.34
48.99	1.40
53.99	1.46
58.99	1.51
78.99	1.67
98.99	1.79
118.99	1.89
138.99	1.98
158.99	2.05
178.99	2.10
238.99	2.23
298.99	2.30
358.99	2.35
418.99	2.38
478.99	2.39
496.37	2.40
556.35	2.42
616.35	2.45
736.35	2.53
1216.35	2.69
3974.03	3.07
3984.02	3.03
3994.02	3.02
4004.02	3.01
4014.02	3.01
4024.02	3.00
4034.02	3.00
4044.02	3.01
4054.02	3.00
4064.02	3.00
4074.02	3.00
4084.02	2.99
4094.02	3.00
4104.02	3.00
4114.02	3.00
4124.02	3.00
4134.02	3.00
4144.02	3.01
4154.02	3.02
4164.02	3.03
4174.02	3.04

4184.02	3.05	4321.02	2.84
4194.02	3.06	4321.19	2.84
4204.02	3.04	4321.36	2.81
4214.02	3.06	4321.52	2.81
4224.02	3.07	4321.69	2.79
4234.02	3.06	4321.86	2.77
4244.02	3.06	4322.02	2.77
4254.02	3.06	4322.52	2.70
4264.02	3.05	4323.02	2.66
4274.02	3.05	4323.52	2.62
4284.02	3.05	4324.02	2.57
4294.02	3.06	4324.52	2.55
4319.03	2.85	4325.02	2.52
4319.11	2.85	4325.52	2.48
4319.19	2.85	4326.02	2.46
4319.27	2.85	4328.02	2.35
4319.36	2.86	4330.02	2.25
4319.44	2.85	4332.02	2.17
4319.52	2.85	4334.02	2.10
4319.61	2.86	4336.02	2.03
4319.69	2.85	4338.02	1.99
4319.77	2.85	4340.02	1.94
4319.86	2.85	4345.02	1.82
4319.94	2.85	4350.02	1.72
4320.02	2.85	4355.02	1.63
4320.11	2.86	4360.02	1.55
4320.19	2.85	4365.02	1.48
4320.27	2.85	4370.02	1.43
4320.36	2.85	4375.02	1.38
4320.44	2.86	4380.02	1.33
4320.52	2.84	4400.02	1.18
4320.61	2.85	4420.02	1.05
4320.69	2.85	4440.02	0.96
4320.77	2.85	4460.02	0.86
4320.86	2.84	4480.02	0.79
4320.94	2.85	4500.02	0.71

4560.02	0.59
4620.02	0.50
4680.02	0.36
4740.02	0.32
4800.02	0.25
4860.02	0.21
4920.02	0.17
4980.02	0.15
5099.38	0.13
5190.07	0.17
5250.06	0.16
5310.06	0.14
5370.06	0.15
5430.06	0.12
5490.06	0.10
5550.06	-0.05
5610.06	-0.03
5670.06	-0.02
5730.06	-0.01
5790.06	-0.01
5850.06	-0.02
5910.06	-0.03

Well J Aquifer Test
Piezometer: JPZ-4
Pump Start: 0930 03/10/89
Pump Stop: 0930 03/13/89

Elapsed Time (min.)	Duration (feet)
0.14	0.00
0.31	0.00
0.47	0.00
0.64	0.00
0.81	0.00
0.97	0.00
1.47	0.01
1.97	0.01
2.47	0.02
2.97	0.02
3.47	0.03
3.97	0.03
4.47	0.04
4.97	0.05
6.97	0.10
8.97	0.14
10.97	0.18
12.97	0.22
14.97	0.26
16.97	0.30
18.97	0.34
23.97	0.42
28.97	0.49
33.97	0.55
38.97	0.61
43.97	0.66
48.97	0.71
53.97	0.75
58.97	0.78
78.97	0.91
98.97	1.00
118.97	1.08
138.97	1.15
158.97	1.21
178.97	1.26
238.97	1.36
298.97	1.39
358.97	1.42
418.97	1.42
478.97	1.42
496.34	1.41
556.33	1.43
616.33	1.47
736.33	1.55
1216.33	1.69
3974.02	1.82
3984.00	1.83
3994.00	1.82
4004.00	1.82
4014.00	1.83
4024.00	1.82
4034.00	1.82
4044.00	1.82
4054.00	1.84
4064.00	1.83
4074.00	1.83
4084.00	1.82
4094.00	1.82
4104.00	1.83
4114.00	1.83
4124.00	1.83
4134.00	1.83
4144.00	1.84
4154.00	1.84
4164.00	1.86
4174.00	1.88

4184.00	1.89	4321.00	1.89
4194.00	1.89	4321.17	1.89
4204.00	1.89	4321.34	1.89
4214.00	1.89	4321.50	1.89
4224.00	1.91	4321.67	1.89
4234.00	1.91	4321.84	1.89
4244.00	1.91	4322.00	1.88
4254.00	1.90	4322.50	1.88
4264.00	1.90	4323.00	1.87
4274.00	1.90	4323.50	1.87
4284.00	1.90	4324.00	1.86
4294.00	1.90	4324.50	1.85
4319.02	1.89	4325.00	1.84
4319.09	1.89	4325.50	1.83
4319.17	1.89	4326.00	1.82
4319.25	1.89	4328.00	1.77
4319.34	1.89	4330.00	1.74
4319.42	1.89	4332.00	1.69
4319.50	1.89	4334.00	1.65
4319.59	1.89	4336.00	1.61
4319.67	1.89	4338.00	1.57
4319.75	1.89	4340.00	1.53
4319.84	1.89	4345.00	1.46
4319.92	1.89	4350.00	1.40
4320.00	1.89	4355.00	1.34
4320.09	1.89	4360.00	1.29
4320.17	1.89	4365.00	1.24
4320.25	1.89	4370.00	1.19
4320.34	1.89	4375.00	1.15
4320.42	1.89	4380.00	1.12
4320.50	1.89	4400.00	1.00
4320.59	1.89	4420.00	0.89
4320.67	1.89	4440.00	0.83
4320.75	1.89	4460.00	0.74
4320.84	1.89	4480.00	0.67
4320.92	1.89	4500.00	0.61

4560.00	0.48
4620.00	0.41
4680.00	0.30
4740.00	0.25
4800.00	0.18
4860.00	0.14
4920.00	0.11
4980.00	0.08
5099.36	0.02
5190.05	-0.01
5250.04	-0.03
5310.04	-0.05
5370.04	-0.05
5430.04	-0.08
5490.04	-0.09
5550.04	-0.10
5610.04	-0.08
5670.04	-0.06
5730.04	-0.05
5790.04	-0.05
5850.04	-0.06
5910.04	-0.08

Well J Aquifer Test
Piezometer: JPZ-5
Pump Start: 0930 hrs 03/10/89
Pump Stop: 0930 hrs 03/13/89

Elapsed Time (min.)	Drawdown (feet)
0.16	0.00
0.32	0.00
0.49	0.01
0.66	0.03
0.82	0.05
0.99	0.06
1.49	0.16
1.99	0.26
2.49	0.35
2.99	0.44
3.49	0.48
3.99	0.54
4.49	0.61
4.99	0.67
6.99	0.84
8.99	0.96
10.99	1.07
12.99	1.17
14.99	1.25
16.99	1.32
18.99	1.40
23.99	1.54
28.99	1.66
33.99	1.76
38.99	1.84
43.99	1.92
48.99	1.99
53.99	2.05
58.99	2.11
78.99	2.30
98.99	2.44
118.99	2.57
138.99	2.67
158.99	2.76
178.99	2.82
238.99	3.00
298.99	3.08
358.99	3.13
418.99	3.10
478.99	3.07
496.36	3.05
556.35	3.06
616.35	3.06
736.35	3.12
1216.35	3.28
3974.03	3.37
3984.02	3.37
3994.02	3.37
4004.02	3.37
4014.02	3.37
4024.02	3.36
4034.02	3.36
4044.02	3.36
4054.02	3.35
4064.02	3.35
4074.02	3.35
4084.02	3.34
4094.02	3.34
4104.02	3.34
4114.02	3.34
4124.02	3.34
4134.02	3.34
4144.02	3.33
4154.02	3.34
4164.02	3.33
4174.02	3.33

4184.02	3.34
4194.02	3.33
4204.02	3.34
4214.02	3.34
4224.02	3.33
4234.02	3.34
4244.02	3.34
4254.02	3.35
4264.02	3.34
4274.02	3.35
4284.02	3.35
4294.02	3.35
4319.03	3.36
4319.10	3.36
4319.19	3.36
4319.27	3.36
4319.35	3.36
4319.44	3.36
4319.52	3.36
4319.60	3.36
4319.69	3.36
4319.77	3.36
4319.85	3.36
4319.94	3.36
4320.02	3.36
4320.10	3.36
4320.19	3.36
4320.27	3.36
4320.35	3.37
4320.44	3.36
4320.52	3.35
4320.60	3.34
4320.69	3.34
4320.77	3.32
4320.85	3.31
4320.94	3.29
4321.02	3.28
4321.19	3.24
4321.35	3.19
4321.52	3.15
4321.69	3.11
4321.85	3.06
4322.02	3.03
4322.52	2.94
4323.02	2.86
4323.52	2.80
4324.02	2.74
4324.52	2.69
4325.02	2.65
4325.52	2.61
4326.02	2.57
4328.02	2.43
4330.02	2.32
4332.02	2.22
4334.02	2.14
4336.02	2.06
4338.02	1.99
4340.02	1.93
4345.02	1.80
4350.02	1.69
4355.02	1.59
4360.02	1.51
4365.02	1.45
4370.02	1.38
4375.02	1.32
4380.02	1.28
4400.02	1.11
4420.02	0.99
4440.02	0.91
4460.02	0.81
4480.02	0.74
4500.02	0.68

4560.02	0.54
4620.02	0.46
4680.02	0.34
4740.02	0.26
4800.02	0.19
4860.02	0.11
4920.02	0.05
4980.02	-0.01
5099.37	-0.10
5190.06	-0.16
5250.05	-0.19
5310.05	-0.21
5370.05	-0.22
5430.05	-0.24
5490.05	-0.27
5550.05	-0.30
5610.05	-0.32
5670.05	-0.33
5730.05	-0.32
5790.05	-0.31
5850.05	-0.29
5910.05	-0.28

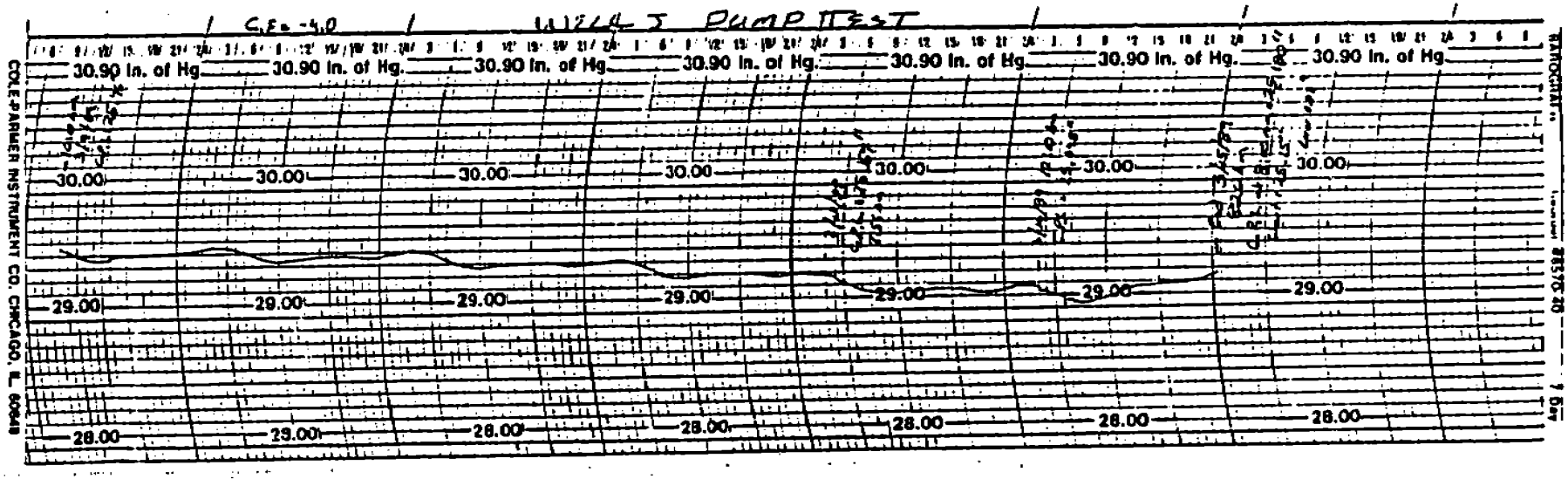
Well J Aquifer Test
Monitor Well: ww-1-452
Pump Start: 0930 03/10/89
Pump Stop: 0930 03/13/89

Clock Time	Water Depth Above XDCR
18:00 HRS 1	1.67
20:00 HRS 1	1.66
1	1.65
22:00 HRS 89/03/09 #01	
00:00 HRS 1	1.64
02:00 HRS 1	1.63
04:00 HRS 1	1.63
06:00 HRS 1	1.62
08:00 HRS 1	1.60
09:00 HRS 1	1.59
10:00 HRS 1	1.59
11:00 HRS 1	1.60
12:00 HRS 1	1.61
13:00 HRS 1	1.62
14:00 HRS 1	1.65
15:00 HRS 1	1.67
16:00 HRS 1	1.69
17:00 HRS 1	1.69
18:00 HRS 1	1.69
19:00 HRS 1	1.68
20:00 HRS 1	1.67
21:00 HRS 1	1.65
22:00 HRS 1	1.63
1	1.64
23:00 HRS 89/03/10 #01	
00:00 HRS 1	1.61
01:00 HRS 1	1.61
02:00 HRS 1	1.61
03:00 HRS 1	1.61
04:00 HRS 1	1.61
05:00 HRS 1	1.60
06:00 HRS 1	1.58
07:00 HRS 1	1.57
08:00 HRS 1	1.55
09:00 HRS 1	1.53
10:00 HRS 1	1.54
11:00 HRS 1	1.54
12:00 HRS 1	1.56
13:00 HRS 1	1.59
14:00 HRS 1	1.62
15:00 HRS 1	1.63
16:00 HRS 1	1.65
17:00 HRS 1	1.65
18:00 HRS 1	1.65
19:00 HRS 1	1.65
20:00 HRS 1	1.65
21:00 HRS 1	1.63
22:00 HRS 1	1.63
1	1.62
23:00 HRS 89/03/11 #01	
00:00 HRS 1	1.62
01:00 HRS 1	1.62
21:00 HRS 1	1.68
22:00 HRS 1	1.68
1	1.67
23:00 HRS 89/03/12 #01	
00:00 HRS 1	1.67
01:00 HRS 1	1.67
02:00 HRS 1	1.68
03:00 HRS 1	1.68
04:00 HRS 1	1.69
05:00 HRS 1	1.68
06:00 HRS 1	1.67
07:00 HRS 1	1.66
08:00 HRS 1	1.67
09:00 HRS 1	1.67

09:30 HRS 1 1.66
10:00 HRS 1 1.67
10:30 HRS 1 1.68
11:00 HRS 1 1.70
11:30 HRS 1 1.72
12:00 HRS 1 1.73
12:30 HRS 1 1.76
13:00 HRS 1 1.76
13:30 HRS 1 1.79
14:00 HRS 1 1.81
14:30 HRS 1 1.82
15:00 HRS 1 1.84
15:30 HRS 1 1.84
16:00 HRS 1 1.85
16:30 HRS 1 1.86
17:00 HRS 1 1.87
17:30 HRS 1 1.87
18:00 HRS 1 1.87
18:30 HRS 1 1.87
19:00 HRS 1 1.86
19:30 HRS 1 1.86
20:00 HRS 1 1.87
20:30 HRS 1 1.87
21:00 HRS 1 1.87
21:30 HRS 1 1.87
22:00 HRS 1 1.87
22:30 HRS 1 1.87
23:00 HRS 1 1.87
1 1.87
23:30 HRS 89/03/13 #01
00:00 HRS 1 1.88
00:30 HRS 1 1.88
01:00 HRS 1 1.88
01:30 HRS 1 1.89
02:00 HRS 1 1.89
02:30 HRS 1 1.91
03:00 HRS 1 1.92
03:30 HRS 1 1.92
04:00 HRS 1 1.93
04:30 HRS 1 1.91
05:00 HRS 1 1.91
05:30 HRS 1 1.91
06:00 HRS 1 1.91
06:30 HRS 1 1.90
07:00 HRS 1 1.89
07:30 HRS 1 1.88
08:00 HRS 1 1.87
09:00 HRS 1 1.87
10:00 HRS 1 1.87
11:00 HRS 1 1.89
12:00 HRS 1 1.91
13:00 HRS 1 1.95
14:00 HRS 1 1.97
1 1.99
15:00 HRS 89/03/14 #01

APPENDIX D

BAROGRAPH RECORD


C.E.=4.0
WELL 3 PUMP TEST
30.90 In. of Hg.
30.00
29.00
28.00
COLE-PARMER INSTRUMENT CO. CHICAGO, IL. 60648

APPENDIX E

CALCULATION OF AQUIFER PARAMETERS
BASED ON THEIS' DRAWDOWN AND RECOVERY METHODS

THEIS' CURVE-MATCH CALCULATIONS

WELL J $Q = 542$ gpm $= 72.5$ ft³/min

JPZ-1 $r = 150$ ft

$W(u) = 1$ $u = 1$

$s = 0.60$ ft $t = 0.135$ min

$$T = \frac{Q}{4\pi s} W(u) = \frac{72.5 \text{ ft}^3/\text{min}}{4\pi (60 \text{ ft})} (1) = 9.62 \text{ ft}^2/\text{min} = 0.16 \text{ ft}^2/\text{sec}$$

$$S = \frac{4Ttu}{r^2} = \frac{4 (9.62 \text{ ft}^2/\text{min})(0.135 \text{ min})(1)}{(150 \text{ ft})^2} = 0.00023$$

JPZ-2 $r = 147$ ft

$W(u) = 1$ $u = 1$

$s = 0.66$ ft $t = 0.144$ min

$$T = \frac{Q}{4\pi s} W(u) = \frac{72.5 \text{ ft}^3/\text{min}}{4\pi (0.66 \text{ ft})} (1) = 8.74 \text{ ft}^2/\text{min} = 0.15 \text{ ft}^2/\text{sec}$$

$$S = \frac{4Ttu}{r^2} = \frac{4 (8.74 \text{ ft}^2/\text{min})(0.144 \text{ min})(1)}{(147 \text{ ft})^2} = 0.00023$$

JPZ-3 $r = 494$ ft

$W(u) = 1$ $u = 1$

$s = 0.60$ ft $t = 2.63$ min

$$T = \frac{Q}{4\pi s} W(u) = \frac{72.5 \text{ ft}^3/\text{min}}{4\pi (0.60 \text{ ft})} (1) = 9.62 \text{ ft}^2/\text{min} = 0.16 \text{ ft}^2/\text{SEC}$$

$$S = \frac{4Tt u}{r^2} = \frac{4 (9.62 \text{ ft}^2/\text{min}) (2.63 \text{ min}) (1)}{(494 \text{ ft})^2} = 0.00041$$

JPZ-4 $r = 999$ ft

$W(u) = 1$ $u = 1$

$s = 0.50$ ft $t = 7.7$ min

$$T = \frac{Q}{4\pi s} W(u) = \frac{72.5 \text{ ft}^3/\text{min}}{4\pi (0.50 \text{ ft})} (1) = 11.54 \text{ ft}^2/\text{min} = 0.19 \text{ ft}^2/\text{SEC}$$

$$S = \frac{4Tt u}{r^2} = \frac{4 (11.54 \text{ ft}^2/\text{min}) (7.7 \text{ min}) (1)}{(999 \text{ ft})^2} = 0.00036$$

JPZ-5 $r = 501$ ft

$W(u) = 1$ $u = 1$

$s = 0.60$ ft $t = 1.11$ min

$$T = \frac{Q}{4\pi s} W(u) = \frac{72.5 \text{ ft}^3/\text{min}}{4\pi (0.60 \text{ ft})} (1) = 9.62 \text{ ft}^2/\text{min} = 0.16 \text{ ft}^2/\text{SEC}$$

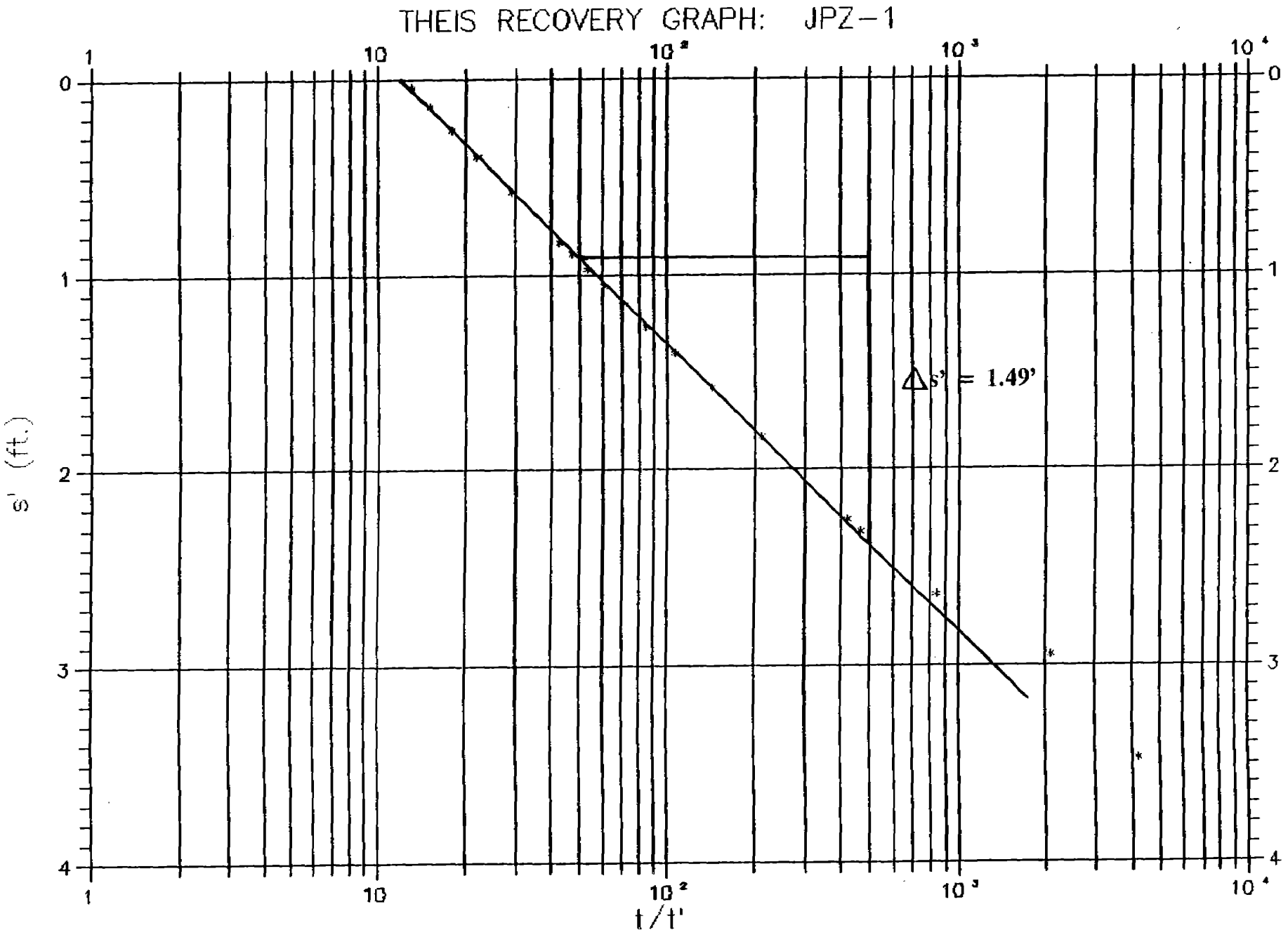
$$S = \frac{4Tt u}{r^2} = \frac{4 (9.62 \text{ ft}^2/\text{min}) (1.11 \text{ min}) (1)}{(501 \text{ ft})^2} = 0.00017$$

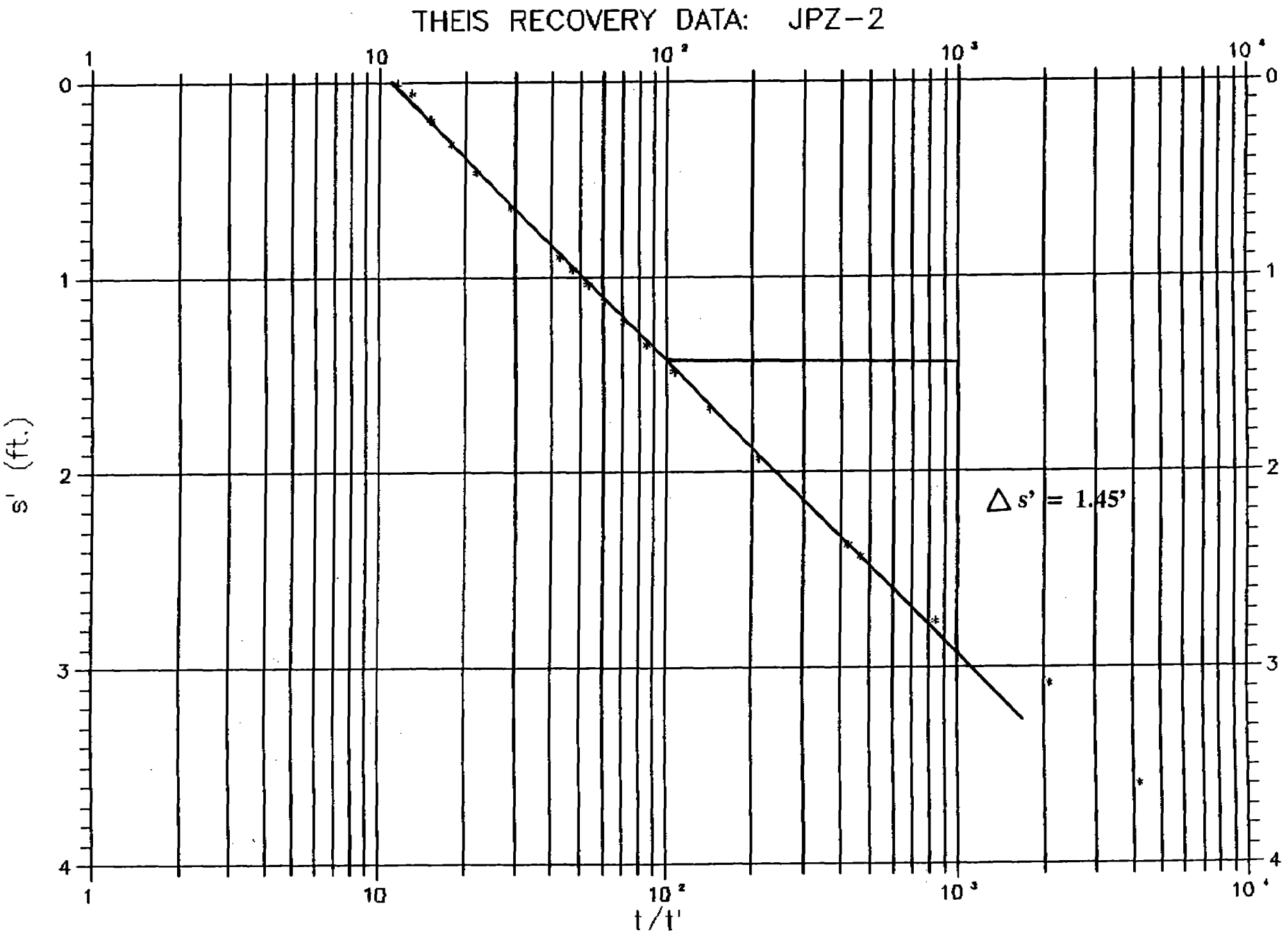
WELL-J PUMP TEST: PIEZOMETER DATA FOR PLOTTING RECOVERY CURVES.

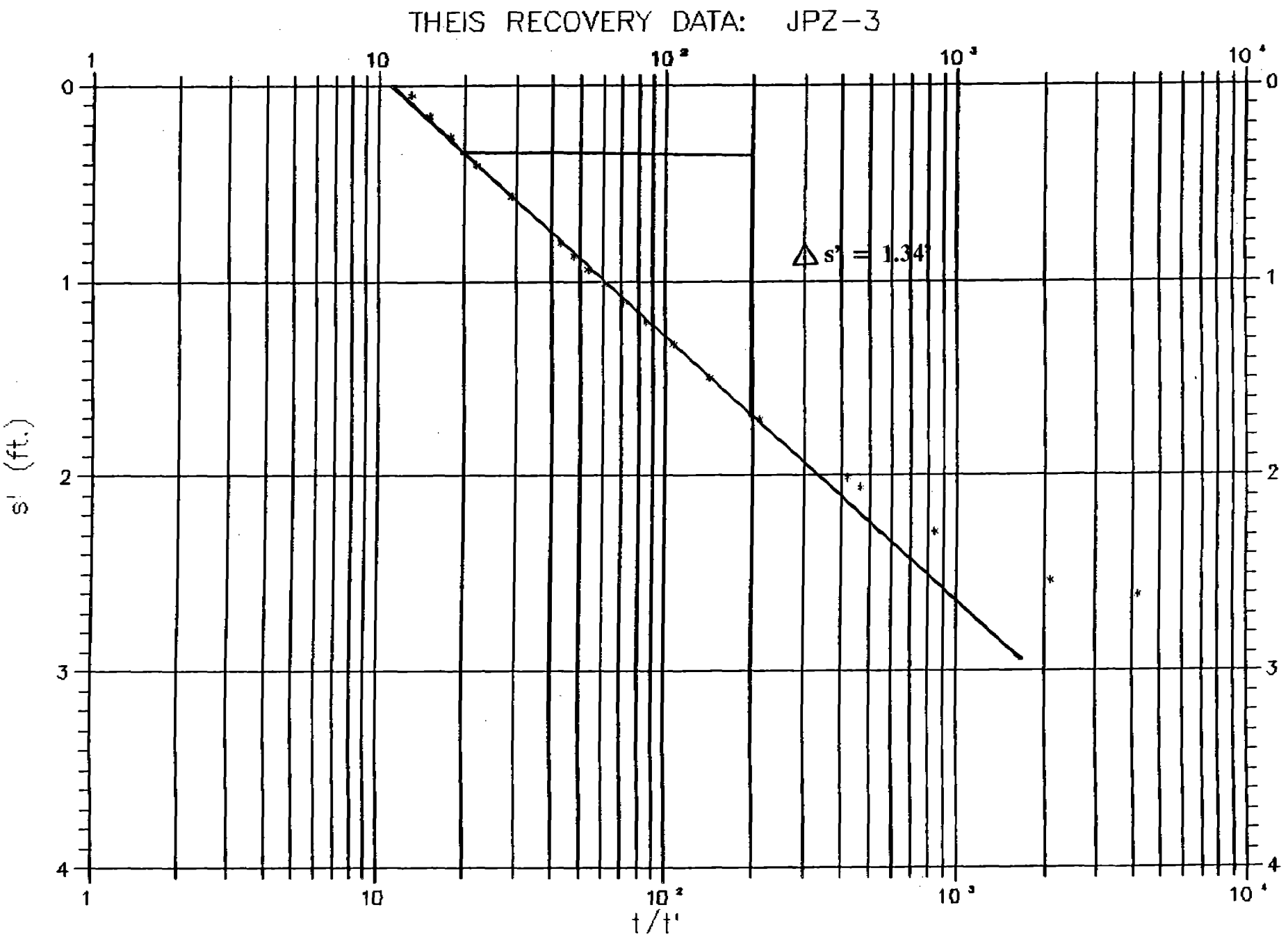
	JPZ-1	JPZ-2	JPZ-3	JPZ-4	JPZ-5
X AXIS t/t'	s'	s'	s'	s'	s'
--	4.815	5.179	2.906	1.917	3.276
4201	3.476	3.595	2.610	1.634	2.911
2101	2.942	3.085	2.535	1.621	2.665
841	2.634	2.759	2.283	1.571	2.292
468	2.314	2.429	2.063	1.484	2.015
421	2.251	2.371	2.012	1.465	1.959
211	1.830	1.931	1.710	1.270	1.580
141	1.579	1.671	1.496	1.133	1.341
106	1.403	1.486	1.326	1.014	1.158
85	1.266	1.346	1.207	0.927	1.026
71	1.153	1.231	1.107	0.845	0.913
61	1.057	1.127	1.016	0.774	0.816
53.5	0.972	1.041	0.938	0.708	0.725
47.6	0.893	0.962	0.872	0.655	0.652
43	0.835	0.902	0.807	0.602	0.587
29	0.578	0.642	0.568	0.402	0.329
22	0.400	0.461	0.408	0.274	0.144
17.8	0.264	0.318	0.266	0.145	0.002
15	0.148	0.194	0.162	0.035	---
13	0.046	0.059	0.053	---	---
11.5	---	0.007	---	---	---
10.3	---	---	---	---	---
9.4	---	---	---	---	---
8.6	---	---	---	---	---
8	---	---	---	---	---
7.5	---	---	---	---	---
7	---	---	---	---	---
6.6	---	---	---	---	---
6.3	---	---	---	---	---
5.9	---	---	---	---	---
5.7	---	---	---	---	---
5.4	---	---	---	---	---
5.2	---	---	---	---	---
4.2	---	---	---	---	---
3.6	---	---	---	---	---

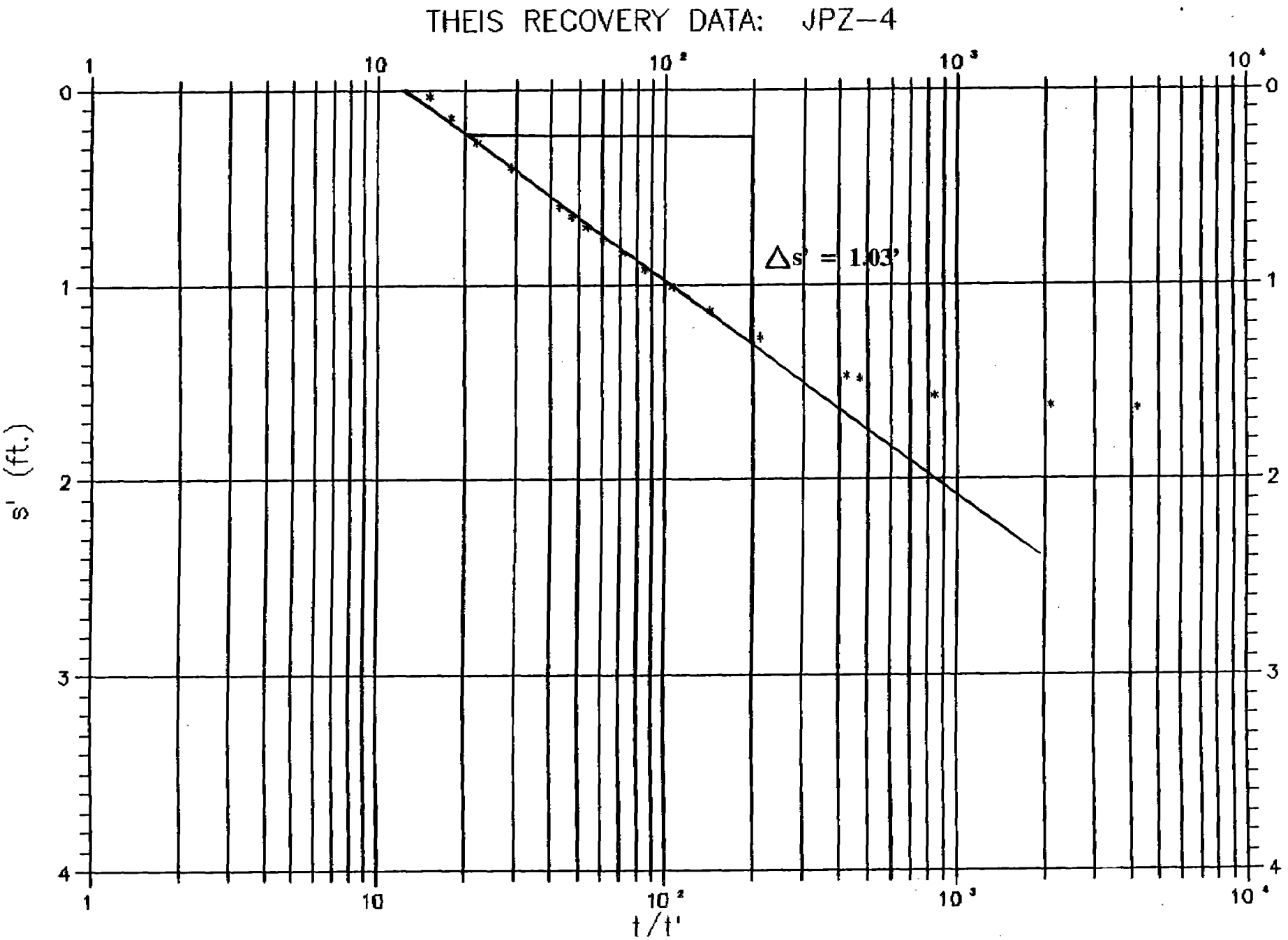
NEGATIVE VALUES INDICATED BY --- .
S' VALUES CORRECTED FOR BAROMETRIC CHANGES.

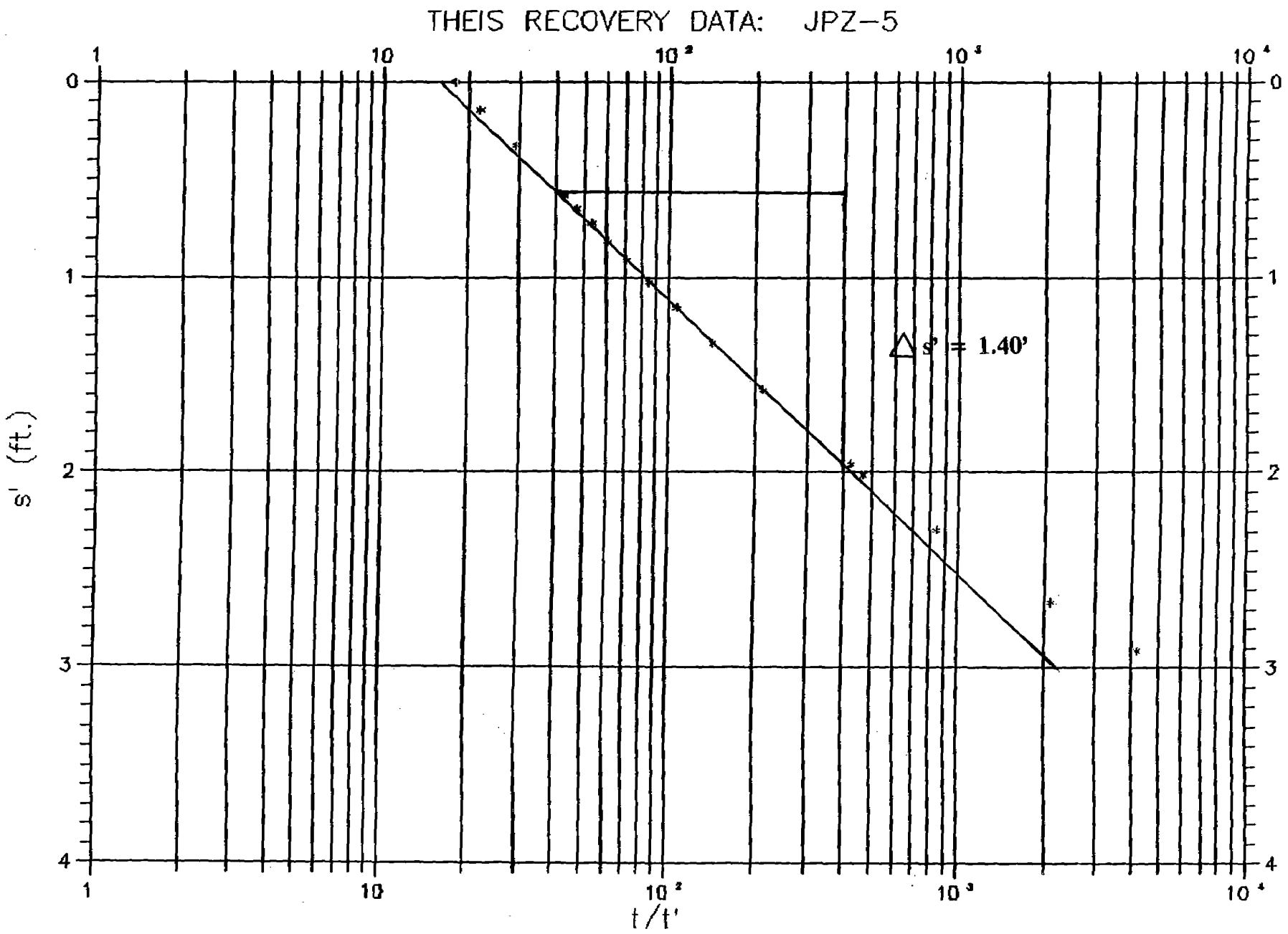
A:\JPZ.WK1


THEIS RECOVERY GRAPH: JPZ-1
s' (ft.)
t/t'
Δs' = 1.49'
1
10
10²
10³
10⁴
0
1
2
3
4


THEIS RECOVERY DATA: JPZ-2
s' (ft.)
t/t'
Δ s' = 1.45'
1
10
10 ²
10 ³
10 ⁴
0
1
2
3
4


THEIS RECOVERY DATA: JPZ-3
1
10
10 ²
10 ³
10 ⁴
0
1
2
3
4
s' (ft.)
Δs' = 1.34'
t/t'


THEIS RECOVERY DATA: JPZ-4
Δs' = 1.03'
s' (ft.)
t/t'
1
10
10²
10³
10⁴
0
1
2
3
4


THEIS RECOVERY DATA: JPZ-5
s' (ft.)
t/t'
Δs' = 1.40'
1
10
10²
10³
10⁴
0
1
2
3
4

Theis Recovery Data Calculations

1) JPZ-1

$Q = 542$ gpm

$\Delta s = 1.49'$ from graph

$$T = \frac{264Q}{\Delta s} = \frac{264 \cdot 542 \text{ gpm}}{1.49 \text{ ft}} = 96,032 \text{ gpd/ft}$$

$$= 12,830 \text{ ft}^2/\text{day}$$

$$= 0.15 \text{ ft}^2/\text{s}$$

2) JPZ-2

$Q = 542$ gpm

$\Delta s = 1.45$ ft

$$T = \frac{264Q}{\Delta s} = \frac{264 \cdot 542 \text{ gpm}}{1.45 \text{ ft}} = 98,681 \text{ gpd/ft}$$

$$= 13,184 \text{ ft}^2/\text{day}$$

$$= 0.15 \text{ ft}^2/\text{s}$$

3) JPZ-3

$Q = 542$ gpm

$\Delta s = 1.34$ ft

$$T = \frac{264Q}{\Delta s} = \frac{264 \cdot 542 \text{ gpm}}{1.34 \text{ ft}} = 106,782 \text{ gpd/ft}$$

$$= 14,266 \text{ ft}^2/\text{day}$$

$$= 0.17 \text{ ft}^2/\text{s}$$

4) JPZ-4

$Q = 542$ gpm

$\Delta s = 1.03$ ft

$$T = \frac{264Q}{\Delta s} = \frac{264 \cdot 542 \text{ gpm}}{1.03 \text{ ft}} = 138,920 \text{ gpd/ft}$$

$= 18,560 \text{ ft}^2/\text{day}$

$= 0.22 \text{ ft}^2/\text{s}$

5) JPZ-5

$Q = 542$ gpm

$\Delta s = 1.4$ ft

$$T = \frac{264Q}{\Delta s} = \frac{264 \cdot 542 \text{ gpm}}{1.40 \text{ ft}} = 102,206 \text{ gpd/ft}$$

$= 13,655 \text{ ft}^2/\text{day}$

$= 0.16 \text{ ft}^2/\text{s}$

APPENDIX F

CALCULATION OF AQUIFER PARAMETERS
BASED ON PAPADOPULOS' METHOD

PAPADOPULOS' CURVE-MATCH CALCULATIONS

WELL J $x = 0$ $y = 0$

$Q = 542\ gpm = 72.5\ ft^3/min$

JPZ-1 $x = -147\ ft$ $y = -32.3\ ft$

$W(u) = 1$ $u = 1$

$s = 0.60\ ft$ $t = 0.135\ min$

$$\sqrt{T_{xx}T_{yy} - T_{xy}^2} = \frac{Q}{4\pi s} W(u) = \frac{72.5\ ft^2/min}{4\pi (0.60\ ft)} (1) = 9.62\ ft^2/min$$

JPZ-2 $x = -147\ ft$ $y = -5.7\ ft$

$W(u) = 1$ $u = 1$

$s = 0.66\ ft$ $t = 0.144\ min$

$$\sqrt{T_{xx}T_{yy} - T_{xy}^2} = \frac{Q}{4\pi s} W(u) = \frac{72.5\ ft^3/min}{4\pi (0.66\ ft)} (1) = 8.74\ ft^2/min$$

JPZ-3 $x = 141\ ft$ $y = 473\ ft$

$W(u) = 1$ $u = 1$

$s = 0.60\ ft$ $t = 2.63\ min$

$$\sqrt{T_{xx}T_{yy} - T_{xy}^2} = \frac{Q}{4\pi s} W(u) = \frac{72.5\ ft^3/min}{4\pi (0.60 ft)} (1) = 9.62\ ft^2/min$$

JPZ-4 $x = 635$ $y = -772$

$W(u) = 1$ $u = 1$

$s = 0.50$ ft $t = 7.7$ min

$$\sqrt{T_{xx}T_{yy} - T_{xy}^2} = \frac{Q}{4\pi s} W(u) = \frac{72.5 \text{ ft}^3/\text{min}}{4\pi (0.50 \text{ ft})}(1) = 11.54 \text{ ft}^2/\text{min}$$

JPZ-5 $x = -498$ $y = -55.3$

$W(u) = 1$ $u = 1$

$s = 0.60$ ft $t = 1.11$ min

$$\sqrt{T_{xx}T_{yy} - T_{xy}^2} = \frac{Q}{4\pi s} W(u) = \frac{72.5 \text{ ft}^3/\text{min}}{4\pi (0.60 \text{ ft})}(1) = 9.62 \text{ ft}^2/\text{min}$$

PIEZOMETER	$\sqrt{T_{xx}T_{yy} - T_{xy}^2}$
JPZ-1	9.62 ft²/min
JPZ-2	8.74
JPZ-3	9.62
JPZ-4	11.54
JPZ-5	9.62

TAKE 9.62 ft²/min AS AN "AVERAGE" VALUE OF: $\sqrt{T_{xx}T_{yy} - T_{xy}^2}$

$$T_{xx}T_{yy} - T_{xy}^2 = 92.54 \text{ ft}^4/\text{min}^2$$

TO CALCULATE MAJOR AND MINOR AXES OF TRANSMISSIVITY AND TRUE STORAGE COEFFICIENT TAKE THREE PIEZOMETERS AT THREE DIFFERENT DISTANCES AND DIRECTIONS FROM PUMPED WELL: JPZ-1, JPZ-3, JPZ-4

$$u_{xy} = \frac{S}{4t} \quad \frac{T_{xx}y^2 + T_{yy}x^2 - 2T_{xy}xy}{T_{xx}T_{yy} - T_{xy}^2}$$

$$u_{xy} = \frac{y^2 \$T_{xx} + x^2 \$T_{yy} - 2xy \$T_{xy}}{4t\,(T_{xx}T_{yy} - T_{xy}^2)}$$

SUBSTITUTE KNOWN VALUES OF $u_{xy}, x, y, (T_{xx}T_{yy} - T_{xy}^2)$ FOR JPZ-1, JPZ-3, JPZ-4 TO GET A SYSTEM OF THREE EQUATIONS IN THREE UNKNOWNS:

JPZ-1 $$1 = \frac{(-32.3)^2 \$T_{xx} + (-147)^2 \$T_{yy} - 2(-147)(-32.3)\$T_{xy}}{4\,(0.135)\,(92.54)}$$

JPZ-3 $$1 = \frac{(473)^2 \$T_{xx} + (141)^2 \$T_{yy} - 2(141)(473)\$T_{xy}}{4\,(2.63)(92.54)}$$

JPZ-4 $$1 = \frac{(-772)^2 \$T_{xx} + (635)^2 \$T_{yy} - 2(635)(-772)\$T_{xy}}{4\,(7.7)(92.54)}$$

THESE REDUCE TO:

$$1 = 20.9\,\$T_{xx} + 432\,\$T_{yy} - 190\,\$T_{xy}$$

$$1 = 230\,\$T_{xx} + 20.4\,\$T_{yy} - 137\,\$T_{xy}$$

$$1 = 209\,\$T_{xx} + 141\,\$T_{yy} + 344\,\$T_{xy}$$

WHICH CAN BE SOLVED USING THE MATRIX AND SIMEQ ALGORITHMS IN THE 'HEWLETT-PACKARD "MATH PAC".

0.00398	1	0	0
0.00198	0	1	0
−0.000323	0	0	1

$0.00398 = \zeta T_{xx}$ $\quad T_{xx} = 0.00398 / \zeta$ $\quad (ft^2/min)$

$0.00198 = \zeta T_{yy}$ $\quad T_{yy} = 0.00198 / \zeta$ $\quad (ft^2/min)$

$-0.000323 = \zeta T_{xy}$ $\quad T_{xy} = -0.000323 / \zeta$ $\quad (ft^2/min)$

SUBSTITUTING!

$$9.62\ ft^2/min = \sqrt{T_{xx} T_{yy} - T_{xy}^2} = \sqrt{\left(\frac{0.00398}{\zeta}\right)\left(\frac{0.00198}{\zeta}\right) - \left(\frac{-0.000323}{\zeta}\right)^2}$$

$$\zeta = \frac{\sqrt{(0.00398)(0.00198) - (-0.000323)^2}}{9.62} = 0.00029$$

$\zeta = 0.00029$

$T_{xx} = 13.7\ ft^2/min$

$T_{yy} = 6.83\ ft^2/min$

$T_{xy} = -1.11\ ft^2/min$

$$T_{\xi\xi} = \frac{(T_{xx} + T_{yy}) + \sqrt{(T_{xx} - T_{yy})^2 + 4\ T_{xy}^2}}{2}$$

$$= \frac{(13.7 + 6.83) + \sqrt{(13.7 - 6.83)^2 + 4\,(-1.11)^2}}{2}$$

$$T_{\xi\xi} = 13.9 \text{ ft}^2/\text{min}$$

$$T_{\eta\eta} = \frac{(T_{xx} + T_{yy}) - \sqrt{(T_{xx} - T_{yy})^2 + 4\,T_{xy}^2}}{2}$$

$$= \frac{(13.7 + 6.83) - \sqrt{(13.7 - 6.83)^2 + 4\,(-1.11)^2}}{2}$$

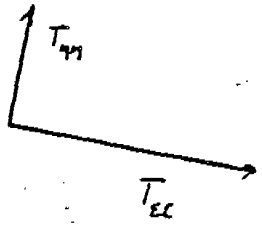
$$T_{\eta\eta} = 6.66 \text{ ft}^2/\text{min}$$

$$\theta = \tan^{-1}\frac{T_{\xi\xi} - T_{xx}}{T_{xy}} = \tan^{-1}\frac{13.9 - 13.7}{-1.11} = 10.2^\circ$$

$$T_{\xi\xi} = 13.9 \text{ ft}^2/\text{min} = 0.23 \text{ ft}^2/\text{sec}$$

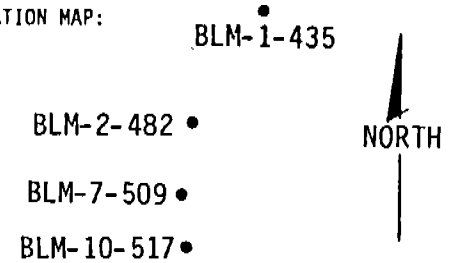
$$T_{\eta\eta} = 6.66 \text{ ft}^2/\text{min} = 0.11 \text{ ft}^2/\text{sec}$$

$$\theta = -10.2^\circ$$



LITHOLOGIC LOG

LOCATION MAP:



SW 1/4 SW 1/4 SW 1/4 SW 1/4 S 4 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: BLM-10-517

SITE COORDINATES (ft.):

N 223050.75 E 402963.97

GROUND ELEVATION (ft. MSL): 4533.71 (BRASS CAP)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: AIR-FOAM ROTARY

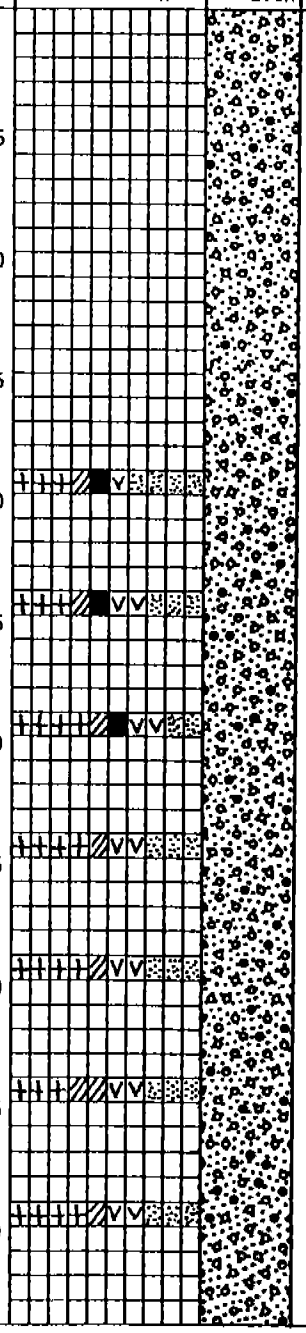
DRILLING CONTR.: LARJON

DATE STARTED: 9 FEBRUARY 1988 DATE COMPLETED: 3 MARCH 1988

FIELD REP.: J.P. KASZUBA, R. COOPER

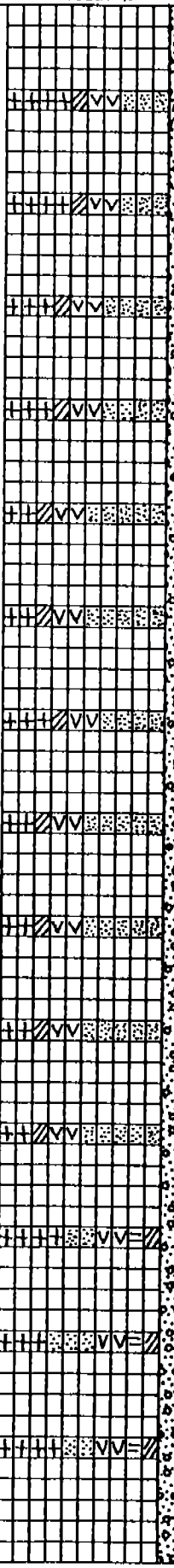
COMMENTS: 8 3/4" BOREHOLE 0'-100', REAMED TO 14 3/4" 0'-100'. 9 7/8" 100'-568'. TOTAL DEPTH = 568'. BEDROCK NOT REACHED.

LOCATION DESCRIPTION:

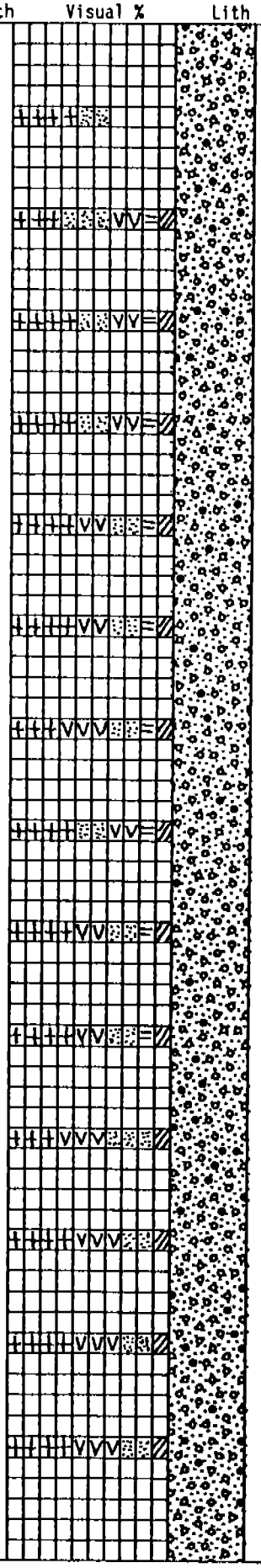


Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
0'-10' unavailable	0'-568' cuttings	0'-15'	SURFICIAL SAND AND GRAVEL: Grayish orange (10YR 7/4) to moderate yellowish brown (10YR 5/4) sand and gravel; fine-grained sand, minor gravel up to 7 mm (0.25 inches) in diameter; subrounded to rounded; poorly sorted. Unconsolidated sand and gravel with minor clay (< 10%).
begin drillograph			
2		15'-568'	ALLUVIUM (Santa Fe Group)
2		15'-45'	Light brown (5YR 6/4) to grayish brown (5YR 3/2); silt through sand to gravel and cuttings up to 1 inch in diameter; rounded to angular; poorly sorted. Unconsolidated. Gravelly alluvium containing abundant silt. Pebbles and cuttings include dark gray (N3) to grayish black (N2) limestone, dusky red (5R 3/4) siltstone, light gray (N7) to dark yellowish orange (10YR 6/6) rhyolite, light olive gray (5Y 6/1) andesite, medium light gray (N6) chert and white (N9) to colorless quartz.
5			
9			
4			
11			
4		45'-125'	Pale brown (5YR 5/2) to grayish brown (5YR 3/2); silt through coarse-grained sand; cuttings less than 2 mm (0.1 inches) to 5 mm (0.2 inches) in diameter, average 2 mm (0.1 inch), rarely 12 mm (0.5 inches); subangular to angular; moderately well-sorted. Unconsolidated (?). May represent alluvium with abundant cobbles ± boulders or consolidated alluvium. Cutting lithologies as above.
11			

LOCATION ID: BLM-10-517

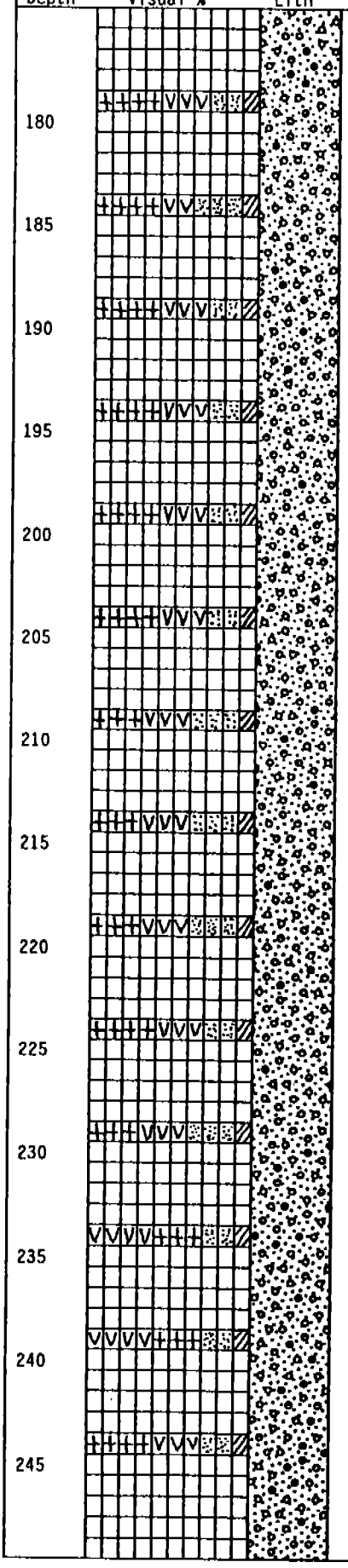
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
50			11			
55			15			
60			11		60'-65'	Average cutting size increases to 7 mm (0.25 inches).
65			6		65'-115'	Average cutting size decreases to 2 mm (0.1 inches).
70			16			
75			11			
80			7.5			
85			11.5			
90			26			
95			19			
100			5			
105			5			
110			5			
115			4			

LOCATION ID: BLM-10-517



Depth	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
115	4			
120	7		120'-135'	Slight increase in volcanic fragments, more light olive gray (5Y 6/1) andesite.
125	4		125'-205'	Limestone most abundant cutting in samples.
130	7			
135	3			
140	3.5		140'-145'	Increased amounts of rhyolite, weathered light olive gray (5Y 6/1) andesite and grayish purple (5P 4/2) andesite.
145	5			
150	6			
155	7			
160	7		160'-170'	Increased amounts of rhyolite and grayish purple (5P 4/2) andesite.
165	8			
170	4		170'-180'	Increased amounts of fine-grained size cuttings.
175	7			
180	5			

LOCATION ID: BLM-10-517



Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
5			
4			
4			
5			
6			
3		205'-355'	Limestone and igneous percentages are fairly equal and combined percentages make up from 70-80% of samples. Most of igneous cuttings are andesites (75%). Of the andesite cuttings, 75% are light olive gray (5Y 6/1) andesite and 25% dusky red (5R 3/4) andesite.
3			
2			
4			
4			
7			
3			
7		240'-275'	Significant decrease in cutting size, average 1-2 mm (0.04 inches) in size.
16			

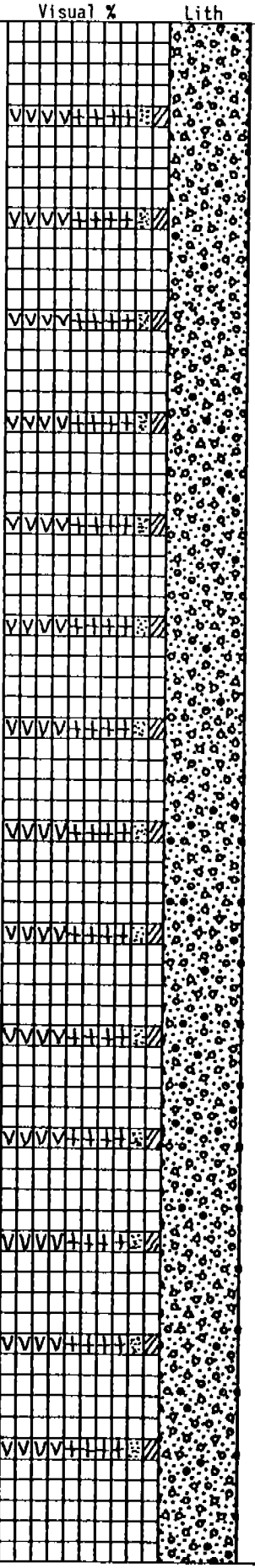
LOCATION ID: BLM-10-517

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245			16		
250			5		
255			7		
260			5		
265			8		
270			3		
275			5	275'-305'	Slight increase in cutting size, average 3-4 mm (0.15 inches).
280			3		
285			9		
290			5		
295			5		
300			5		
305			5		
310			3		

LOCATION ID: BLM-10-517

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310			3		
315			6		
320			21		
325			6		
330			7		
335			8		
340			11		
345			25		
350			10		
355			10		355'-568' Volcanics most abundant cutting with increasing percentage with depth. Also dusky red (5R 3/4) andesite percentage increases significantly from 560'-568'.
360			10		355'-365' Significant decrease in cutting size, average 2 mm in size.
365			5		365'-370' Average cutting size 2-3 mm (0.12 inches).
370			7		370'-430' Significant decrease in cutting size, average 1 mm (0.04 inches) in size.
375			7		

LOCATION ID: BLM-10-517

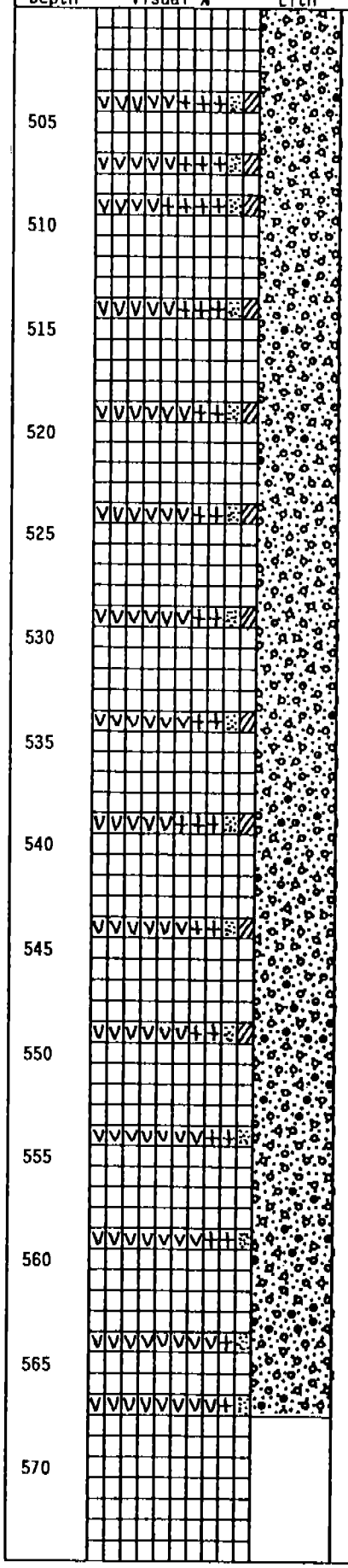


Depth	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
375	7			
380	3			
385	3			
390	4			
395	4			
400	2.5			
405	18		405'-420'	Some caliche present but < 10%.
410	11.5			
415	9			
420	7			
425	6			
430	6		430'	Slight increase in cutting size, average 2-3 mm (0.12 inches).
435	6			
440	10			

LOCATION ID: BLM-10-517

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
440			10		
445			14		445'-455' Significant increase in cutting size, average size 4-6 mm (0.24 inches).
450			6		
455			6		455'-480' Decrease in cutting size, average 2-3 mm (0.12 inches).
460			14		460'-485' Caliche < 10%.
465			9		
470			33		
475			6		
480			9		480'-485' Slight increase in cutting size, some large cuttings of white calcite present.
485			7		480'-490' Decrease in cutting size, average 1-2 mm (0.08 inches).
490			9		490'-508' Significant increase in cutting size, average 4-5 mm (0.20 inches).
495			9		
500			4		
505			6		

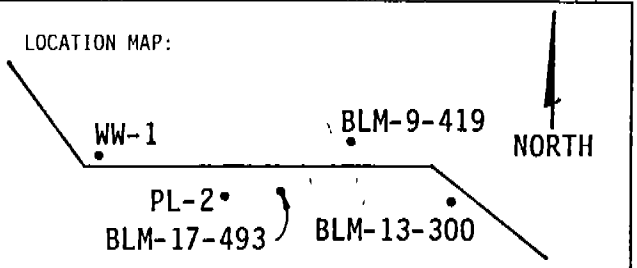
LOCATION ID: BLM-10-517



Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
6			
7		510'-525'	Average cutting size 4-5 mm (0.20 inches).
4.5			
10			
4		525'-550'	Decrease in cutting size to 1-2 mm (0.08 inches) average.
6			
6			
6			
6			
5		550'-568'	Slight decrease in cutting size.
5			
8		560'-568'	Increase in andesite percentage, ~ 80% to 90% of volcanics are dusky red (5R 3/4) to blackish red (5R 2/2) andesite when wet.
4			
3		Total Depth = 568'.	

LITHOLOGIC LOG

LOCATION MAP:



NW1/4 NW1/4 NW1/4 NW1/4 S 4 T 21S R 3E

LOCATION DESCRIPTION:

SITE ID: NASA-WSTF LOCATION ID: BLM-17-493

SITE COORDINATES (ft.):

N 227717.21 E 403033.96

GROUND ELEVATION (ft. MSL): 4538.13 (B.C.)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud & Air-Foam Rotary

DRILLING CONTR.: Larjon Drilling

DATE STARTED: 1 February 1989 DATE COMPLETED: 27 February 1989

FIELD REP.: R. Cooper

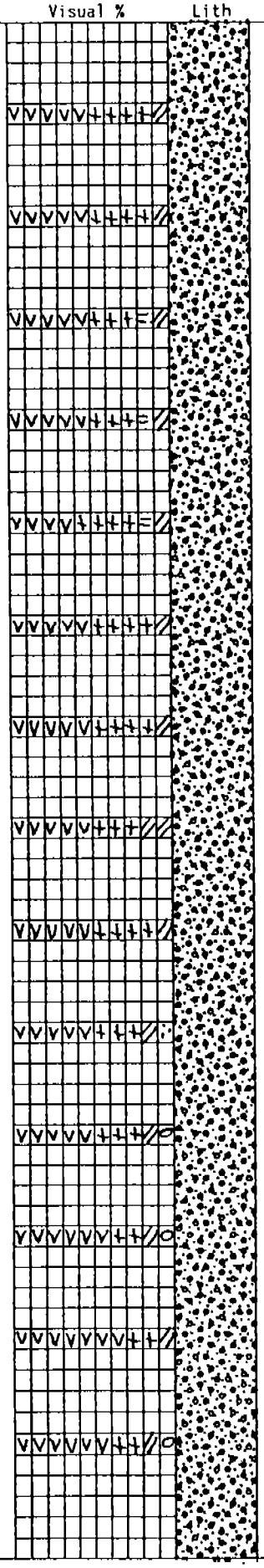
COMMENTS: 0'-75' drilled using mud rotary. 10" x 75' steel surface casing. 75'-56' drilled 9 7/8" borehole using air-foam rotary. TD = 560'. Bedrock at 550'.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			19	0-560' cuttings	0-550' Alluvium (Santa Fe Group): Cutting samples are multicolor and have no predominant color except in clay-rich zones which are light brown (5 YR 6/4) to moderate brown (5 YR 4/4). Cuttings range in size from silt size to 20 mm (0.8 inches) with an average size of 3-5 mm (0.12-0.20 inches). Cuttings are rounded to angular. Rounded to sub-rounded cuttings are formational grains that comprise 5-30% of each sample. The alluvium is a unconsolidated to moderately well consolidated, poorly sorted pebble to boulder conglomerate containing intermittent clay and sand lenses. Alluvium contains clasts of white (N9) and red and white mottled rhyolite with varying amounts of iron-staining; light olive green (5 Y 3/2) and very dark red (5 R 2/6) and medium dark gray (N4) porphyritic andesite with some pyroxene alteration to epidote; moderate reddish brown (10 R 4/6) to moderate red (5 R 4/6) and greenish gray (5 GY 6/1) siltstone; light gray (N7) to grayish black (N2) micritic limestone with <10% allochems; white (N9) calcite; moderate brown (5 YR 4/4) iron-stained sandstone; iron-stained quartzite; translucent to blue white (5 B 9/1) quartz; light brown (5 YR 6/4) and moderate brown (5 YR 4/4) clay ranging in amount from less than 10% to 90% in the upper 200' to less than 10% between 200' and the alluvium-bedrock contact at 550'. Igneous clasts are predominant cuttings and increase in abundance with depth. Rhyolite is the most abundant igneous cutting from 0'-460'. A transition from rhyolite-rich to andesite-rich alluvium occurs between 460' and 470'. In most samples above 520', except in clay-rich zones, a cutting composed of carbonate-cemented conglomerate is present. Due to the similarity in appearance between these cuttings and that of a caliche soil horizon, these cuttings will be referred to as caliche. The caliche is pinkish gray (5 YR 8/1) to yellowish gray (5 Y 8/1) in color.
10			18		
15			27		
20			26		
25			21		
30			65		
35			43		
40			12		
45			12		
50			43		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
50					50'-175' Clay-rich alluvium varying in color from light brown (5 YR 6/4) to moderate brown (5 YR 4/4).
55			29		
60			67		
65			31		
70			28		
75			61		75'-560' Change in drilling method from mud rotary to air-foam rotary.
80			4		
85			3.5		
90			4.5		
95			4.5		
100			5		
105			4.5		
110			5.5		
115			6		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
115					
120			5		
125			5		
130			4		
135			5		
140			5		
145			4.5		
150			5		
155			4.5		
160			5		
165			3		
170			3		
175			4.5		175'-460' Samples remain very similar, amount of carbonate and igneous cuttings change slightly.
180			5		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180					
185			4		
190			4		
195			5		
200			4.5		
205			7		
210			6		
215			5		
220			7		
225			5		
230			5		
235			6		
240			5		
245			9		

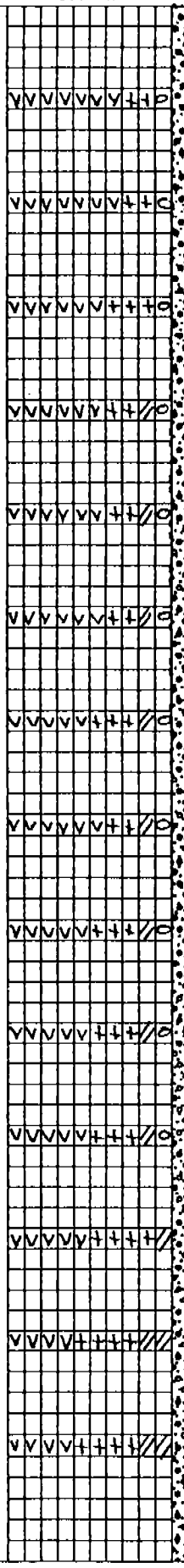


LOCATION ID: BLM-17-493

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245					
250			12		
255			8		
260			9		
265			12		
270			6		
275			7		
280			6.5		
285			8		
290			5.5		
295			11		
300			19		
305			7		
310			6		

LOCATION ID: BLM-17-493

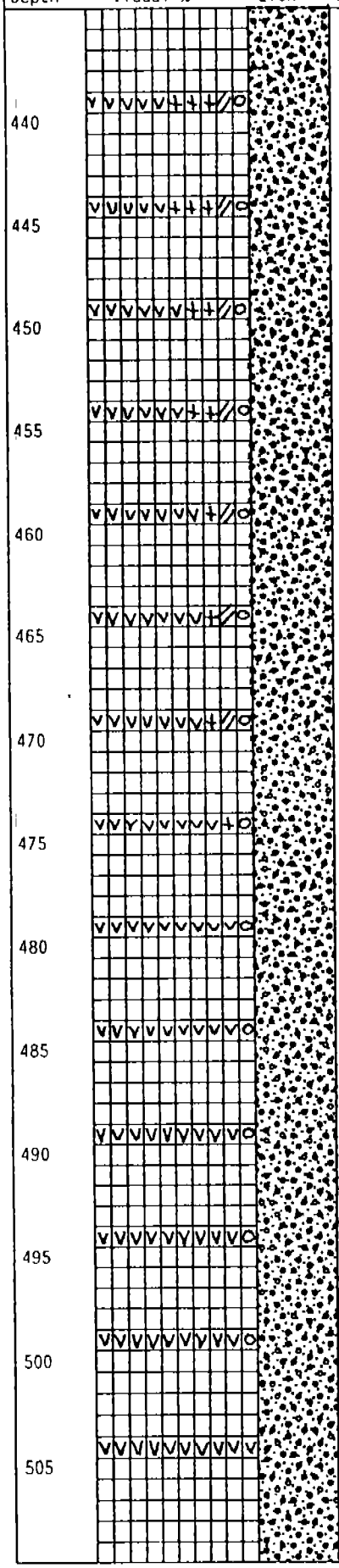
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310					
315			6		
320			6		
325			6		
330			8		
335			8		
340			5		
345			8		
350			9		
355			7		
360			8		
365			15		
370			5.5		
375			8		



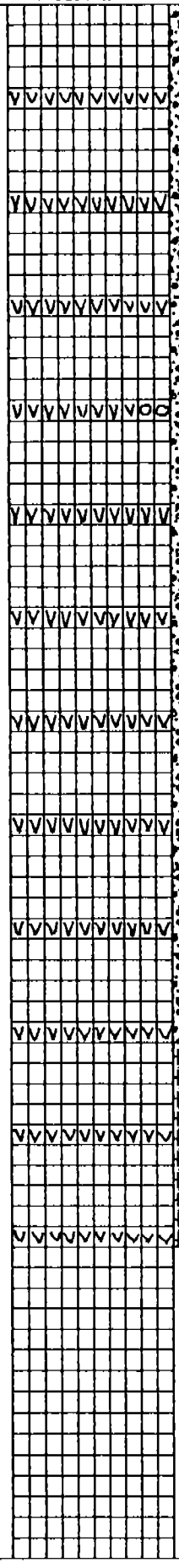
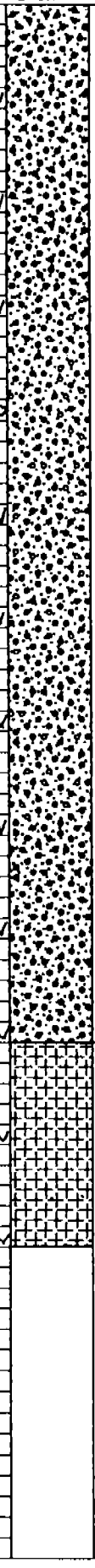
LOCATION ID: BLM-17-493

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
375					
380			6		
385			5.5		
390			6.5		
395			8		
400			6		
405			6		
410			6		
415			15		
420			21		
425			16		
430			18		
435			22		
440			24		

LOCATION ID: BLM-17-493

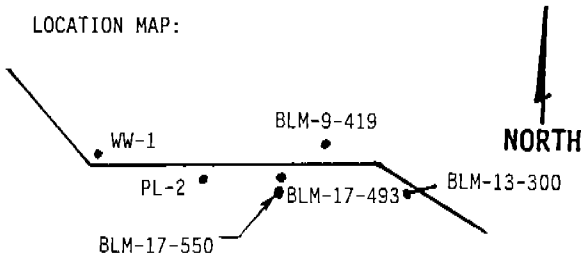


Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
13		
10		
7		
8		460'-470' Transition zone from rhyolite-rich alluvium to andesite-rich alluvium.
7		460'-500' Caliche cuttings still present in samples.
12		470' Distinct color change in drilling foam coming out of the hole. Foam changed from a tan color to a purplish gray color.
6.5		470'-480' First occurrence of pinkish gray (5 YR 8/1) to light gray (N7) crystal-vitric tuff. Trace amounts of tuff present.
7		480'-490' Tuff percentage increased to 10-15% of sample.
10		
6		490'-500' Trace amounts of tuff present.
6		
495'-515' No drillograph available		500'-515' Increase in tuff percentage up to 20% of each sample. No visible caliche in samples.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
505					
510			-		
515			-		515'-550' Trace amounts of tuff present. 515'-520' Caliche cuttings present in sample.
520			5		
525			4		525'-540' Cutting shapes change from mostly angular to mostly subrounded. This interval is a moderately consolidated, coarse-grained sand composed of volcanic rock fragments. No caliche fragments present.
530			7		
535			7		
540			4		540'-550' Cuttings become mostly angular in shape.
545			7		
550			6		550'-560' Orejon Andesite: Blackish red (5 R 2/2) to grayish black (N2) when wet and very dark red (5 R 2/6) to dark gray (N3) when dry porphyritic andesite containing pyrite, altered pyroxene and plagioclase phenocrysts. Alteration is exhibited mostly in the pyroxenes altering to epidote. Phenocrysts range from 0.5 mm to 2 mm (.02 inches to .08 inches). Cuttings are angular in shape and 2-3 mm (.08-.12 inches) in size.
555			37		
560			34		Total Depth = 560'
565					
570					

LITHOLOGIC LOG

LOCATION MAP:



NW 1/4 NW 1/4 NW 1/4 NW 1/4 S4 T21S R3E

SITE ID: NASA-WSTF LOCATION ID: BLM-17-550

SITE COORDINATES (ft.):

N 227659.43 E 403018.75

GROUND ELEVATION (ft. MSL): 4538.24 (BC)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud Rotary/Air-foam Rotary

DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 08/10/90 DATE COMPLETED: 09/10/90

FIELD REP.: D. Menzie, M. Canavan, G. Contaldo

COMMENTS: Mud Rotary 0'-70' with 7 7/8" bit, ream 0'-70 with 16" bit, 70' of 10" surface casing, drill air-foam rotary 70'-600' with 9 7/8" bit, top of bedrock 585'; total depth 600'.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
			(Timed by driller)	Cuttings 0-600'	0'-585' Alluvium (Santa Fe Group): Samples range in color from light brown (5 YR 6/4) to moderate brown (5 YR 4/4) and cuttings in samples are multicolored. Samples comprised of cuttings range in size from much less than 0.1 inches (silt-size) to 1.3 inches with an average size of 0.1 to 0.2 inches. Cuttings are rounded to angular with smaller alluvial grains in samples being rounded to subrounded and larger cuttings clasts being angular to subangular. Samples represent a poorly sorted, unconsolidated to moderately consolidated, polygenetic, pebble to boulder conglomerate. Clay and caliche-bearing intervals which occur within the alluvium are noted below. Cuttings which represent lithologies of clasts within the alluvium are composed of light gray (N7) to dark gray (N3) limestone, grayish red (5 R 5/2) to greenish gray (5 GY 6/1) siltstone, white (N9) iron-stained rhyolite, grayish pink (5 R 6/2) porphyritic andesite, moderate brown (5 YR 4/4) sandstone, pinkish gray (5 YR 8/1) caliche, and small amounts of multi-colored chert and colorless to white (N9) calcite. Clay-rich intervals containing 10%-80% clay occur in the upper 200' of alluvium. Rhyolite is the predominant igneous clast above 400' and andesite is the predominant igneous clast below 450'. The igneous fraction of the cuttings increases significantly with depth forming an andesite-rich alluvium below 450'.
5			7		
10			12		
15			13		
20			9		20'-35' Clay-rich interval, 30% to 70% clay. Cuttings clasts are rounded to angular and range in size from less than 0.1 inches to 1.3 inches. Increase in cutting times.
25			45		
30			34		
35			42		
40			9		
45			29		45'-55' Clay-rich interval, 20% to 50% clay.
50			47		

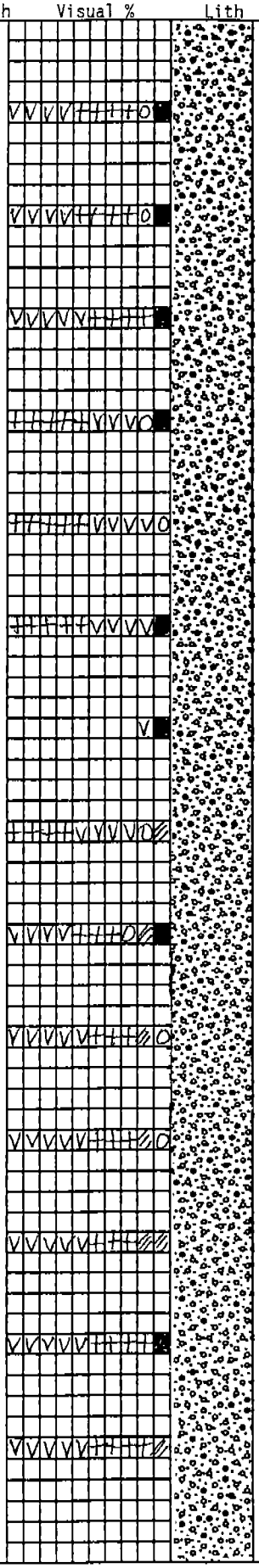
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
50			47		
55			31		
60			21		
65			49		65'-80' Clay-rich interval, clay content 60% to 80%.
70			13		70'-600' Change from mud rotary to air-foam rotary drilling.
75			(drillograph) 3		70'-90' Cuttings samples contain 10% to 40% grout. Decrease in cutting times.
80			4		
85			5		
90			6		90'-140' Clay-rich interval, clay content 30% to 70%. Cuttings range in size from less than 0.1 inches to 0.7 inches and average 0.3 inches in size. Cuttings are rounded to angular. The smaller cuttings are predominately rounded to subrounded and the larger cuttings are angular to subrounded.
95			5		
100			3		
105			4		
110			4		
115			5		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
115			5		
120			4		
125			5		
130			5		
135			5		
140			3		
145			4		
150			5		
155			5		
160			6		
165			4		
170			3		170'-180' Clay-rich interval, clay content 20%. Cuttings range in size from less than 0.1 inches to 0.5 inches and average 0.2 inches in size.
175			5		
180			4		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
180			4		
185			5		
190			4		190'-280' Cuttings rounded to angular. Cuttings range in size from less than 0.1 inches to 0.8 inches. Average cutting size 0.2 inches. Andesite first occurs in cuttings at 215'. Clay-rich intervals are thinner and less frequent below 190'.
195			3		
200			4		
205			4		
210			4		
215			4		
220			5		
225			4		
230			5		
235			5		
240			5		
245			6		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			6		
250			8		
255			8		255'-270' Caliche content 20%.
260			11		
265			4		
270			4		
275			6		
280			8		280'-390' Cuttings range in size from much less than 0.1 inches to 0.4 inches. Average cutting size is 0.1 inches. Cuttings are rounded to angular with rounded to subrounded cuttings ranging from 40% to 70%.
285			7		
290			6		
295			4		
300			7		
305			8		
310			7		

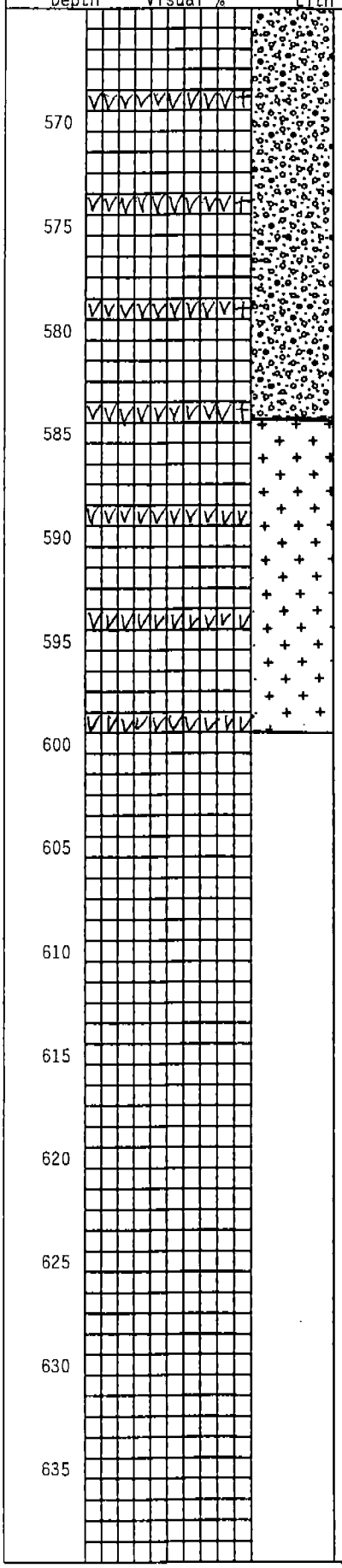
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
310			7		
315			7		
320			6		
325			10		
330			6		
335			7		
340			6		
345			5		
350			8		
355			6		
360			10		
365			10		
370			8		
375			5		



Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375			5		
380			5		
385			6		
390			6		390'-570' Cuttings range in size from less than 0.1 inches to 0.3 inches. Average cuttings size is 0.1 inches. Cuttings are rounded to angular. Rounded to subrounded cuttings comprise 50-60% of samples.
395			8		
400			5		400'-450' Rhyolite and andesite in equal amounts form the bulk of the volcanic fraction.
405			6		
410			6		
415			8		
420			9		
425			15		425'-440' Increase in drilling times.
430			16		
435			16		
440			12		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
440			12		
445			8		
450			6		
455			8		
460			8		460'-465' Increase in caliche to 30%.
465			6		
470			6		470'-585' Andesite-rich Alluvium (Santa Fe Group): Significant color change in samples and drilling foam are initial indications of alluvium becoming andesite-rich. Blackish gray (N5) to grayish red (10 R 4/2) aphanitic to porphyritic andesite containing 10 to 20% plagioclase and pyroxene phenocrysts forms the major fraction (60 to 95%) of the cuttings. Average cuttings size is 0.2 inches and cuttings range from less than 0.1 inches to 0.4 inches. Cuttings are rounded to angular. Limestone and siltstone form the minor fraction (5 to 40%) of the cuttings with lessor amounts of rhyolite, calcite and sandstone.
475			5		
480			6		480'-485' Foam and cuttings distinctly purple. Andesite forms 80% of volcanic fraction.
485			9		
490			5		485'-490' Possible water being produced by formation noticed while joint added.
495			5		
500			5		
505			5		

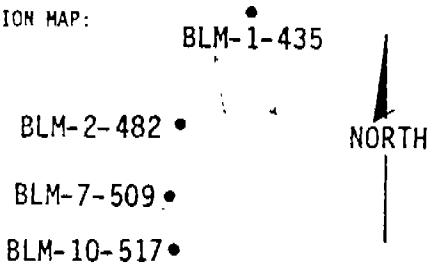
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
505			5		
510			6		
515			4		
520			4		520'-585' Reddish tuff present in cuttings. Cuttings rounded to angular but predominately rounded to subrounded.
525			3		
530			4		
535			5		
540			5		540'-565' Observed possible formation water at joint add on. Drilling times fast, no indication of bedrock.
545			5		
550			4		
555			3		
560			5		
565			6		
570			9		



Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
	Cuttings (cont'd)	
9		570'-600' Cuttings range in size from 0.1 inches to 0.4 inches. Average cuttings size is 0.2 inches. Cuttings are rounded to angular with angular cuttings increasing in abundance with depth.
6		
6		
7		585'-600' Orejon Andesite: Grayish black (N2) to blackish red (5 R 2/2) porphyritic andesite. Cuttings are angular to subangular and range in size from 0.1 inches to 0.4 inches. Average cuttings size is 0.2 inches. Cuttings of Porphyritic andesite contain phenocrysts of plagioclase and pyroxene ranging in size from 0.01 inches to 0.08 inches. Alteration of plagioclase to serrucite and pyroxene to epidote is evident. Calcite from fracture fillings is present in small amounts.
6		
5		
7		585'-600' Cuttings are 95% angular andesite (5% uphole contamination). Probable bedrock contact at 585'.
		Total Depth (TD) = 600'

LITHOLOGIC LOG

LOCATION MAP:



SW 1/4 SW 1/4 SW 1/4 NW 1/4 S 4 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: BLM-2-482.4

SITE COORDINATES (ft.):

N 225654.8 E 402994.1

GROUND ELEVATION (ft. MSL): 4535.48 (BRASS CAP)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: AIR-FOAM ROTARY

DRILLING CONTR.: LARJON

DATE STARTED: 11 OCTOBER 1987 DATE COMPLETED: 25 OCTOBER 1987

FIELD REP.: COOPER, KASZUBA, MORSE

COMMENTS: Total Depth = 550'. Bedrock not reached.

LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			16	0'-430' cuttings	0'-38' SURFICIAL ALLUVIUM: The color of the samples throughout the interval is 60% grayish orange (10YR 7/4) to 40% light to dark gray. Average cutting size is 0.1 inches with cuttings up to 0.75 inches. Cutting shapes range from flakes to blocky angular fragments. Grains in samples range from silt-size to 0.1 inches, are sub-rounded to angular and are 10-15% of a sample. The lithology is an unconsolidated to poorly consolidated gravelly alluvium which consists of transparent to milky-gray, mostly iron-stained quartzite; light to dark gray limestone mostly chips and flakes; dusky red (5R 5/4) siltstone (Abo), small tabular chips; dirty white rhyolite with iron staining; fairly high clay content, light brown (5YR 6/4) in color; < 10% white calcite chips; some caliche layers throughout with sporadic occurrent in samples.
10			5		
15			4		
20			12		
25			25		10'-15' Significant increase in clay content. 20'-25' Significant decrease in clay content and cutting size.
30			10		30'-70' Increase in cutting size and clay content.
35			5		
40			11		38'-475' GRAVELLY ALLUVIUM (Santa Fe Group): Color of unwashed cuttings is moderate orange pink (5YR 84) to light brown (5YR 6/4) due to clay content. Color of washed cuttings is light gray (N 7) to dark gray (N 3). Average cutting size is 0.1 inches and ranges in size from <0.1 to 1 inch. Cuttings are mostly angular blocky shapes with some flakes present, moderately sorted. Average grain-size is 0.1 inches and ranges from silt-size to 0.75 inches. Grains are subrounded to angular. The lithology is a poorly to moderately consolidated fine-grained sand to cobble conglomerate containing clasts of light gray (N 7) to dark gray (N 3) limestone;
45			11		
50			16		

LOCATION ID: BLM-2-482.4

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
50			16		38'-475' GRAVELLY ALLUVIUM (Santa Fe Group) Continued: dirty white to white (N 9) to moderate red (5R 5/4) rhyolite with significant amounts of iron staining; grayish green (10GY 5/2) and grayish red purple (5RP 4/2) andesite with epidote in lower part of section; transparent to light gray (N 7) quartzite and chert; moderate red (5R 4/6) to dusky red (5R 3/4) siltstone (Abo); light brown (5YR 5/6) to moderate brown (5YR 4/4) calcite cemented sandstone; possibly some limonite; some caliche mostly in upper part of section; light brown to moderate orange pink clay matrix.
55			10		
60			15		
65			8		
70			8		70'-75' Clay is very sticky and balls up while washing sample.
75			12		75'-90' Significant decrease in cutting size.
80			16		
85			10		
90			18		90'-100' Slight increase in cutting size.
95			13		95'-475' Noticeable increase in sandstone content but < 10% of sample, sandstone has a calcite cement.
100			20		100'-105' Large chert fragments, grayish green and grayish red purple andesite more abundant than before.
105			3		105'-155' Very significant increase in cutting size with cuttings up to 1 inch in size.
110			3		
115			2.5		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
					GRAVELLY ALLUVIUM (Santa Fe Group) Continued
115			2.5		
120			5		
125			5		
130			4.5		
135			3.5		135'-140' Clay content is < 10%.
140			3		
145			5		
150			5		
155			3.5		
160			5		160'-185' Cutting size decrease.
165			6		
170			4		
175			5		175'-475' Red and white mingled rhyolite more abundant.
180			8		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
					GRAVELLY ALLUVIUM (Santa Fe Group) Continued
180			8		
185			6.5		185'-305' Cutting size increase and clay content usually < 10%.
190			3.5		
195			3		
200			3		
205			6		
210			4		
215			3		
220			4		
225			9		
230			7		
235			4		
240			2.5		
245			3.5		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
					GRAVELLY ALLUVIUM (Santa Fe Group) Continued	
245			3.5			
250			7.5			
255			8		255'-475'	Significant increase in volcanics especially rhyolite.
260			7		260'-475'	Increase in grayish green andesite, granite fragments have become > 10% throughout most of the rest of the section.
265			7			
270			10		270'-475'	Epidote has become very noticeable in andesite.
275			2		275'-475'	Iron-stained (?) mineral possibly limonite, also iron veins or fracture fills in rhyolite cuttings, clay and siltstone <10%.
280			4			
285			5			
290			7			
295			4			
300			10			
305			26		305'-315'	Noticeable increase in volcanic percentage.
310			3			

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
					GRAVELLY ALLUVIUM (Santa Fe Group) Continued
310			3		
315			9		
320			11		
325			8.5		
330			26		
335			5		
340			6		
345			6		
350			7		
355			3		355'-360' Increase in cutting size.
360			7		
365			8		365'-395' Significant decrease in cutting size.
370			11		
375			5		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
					GRAVELLY ALLUVIUM (Santa Fe Group) Continued	
375			5			
380			4			
385			4			
390			5			
395			5		395'-480'	Andesite with epidote more abundant.
400			5			
405			7			
410			10			
415			5		415'-430'	Volcanics are much more abundant ≥ 40%.
420			5			
425			7			
430			8	430'-440' core	430'-440'	******* core interval ********* See attached description.
435			--			
440			--		440'-450'	Still increasing percentage of volcanics ≥ 70%.

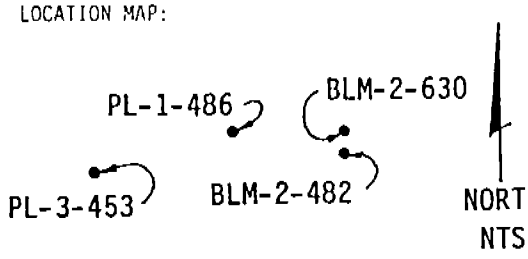
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
					GRAVELLY ALLUVIUM (Santa Fe Group) Continued
440				440'-490' cuttings	
445			5		
450			5		
455			4		455'-530' Volcanics predominantly comprised of grayish red (5R 4/2) to blackish red (5R 2/2) Orejon andesite. Epidote alteration of plagioclase and matrix (not as fracture filling) in ~ 10% of Orejon cuttings results in color changes to pale olive (10Y 6/2) and greenish gray (5GY 6/1).
460			5		460' Water level.
465			3		
470			4		
475			2.5		475'-550' ALLUVIUM (Andesite rich): Significant color change in samples, muds are purplish color, average cutting size is 0.1 inches, ranges in size from <0.1 inches to 0.25 inches, dusky red (5R 3/4) to blackish red (5R 2/2) andesite volcanics are 95% of sample, clasts of limestone, sandstone and other volcanics still present. Possible volcaniclastic.
480			2.5		
485			2.5		
490			3	490'-500' core	490'-500' ***** core interval ***** See attached description.
495			--		
500			--	500'-550' cuttings	
505			2		

LOCATION ID: BLM-2-482.4

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
					ALLUVIUM (Andesite Rich) Continued
505			2		
510			2		
515			3		
520			3		
525			3		
530			3		
535			3		535'-550' No sample returns.
540			3		
545			3		
550			3		Total Depth = 550'.
555					
560					
565					
570					

LITHOLOGIC LOG

LOCATION MAP:



NW 1/4 SW 1/4 SW 1/4 NW 1/4 S 4 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: BLM-2-630

SITE COORDINATES (ft.):

N 225701.70 E 402992.49

GROUND ELEVATION (ft. MSL): 4535.35 (BRASS CAP)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: AIR-FOAM ROTARY

DRILLING CONTR.: LARJON

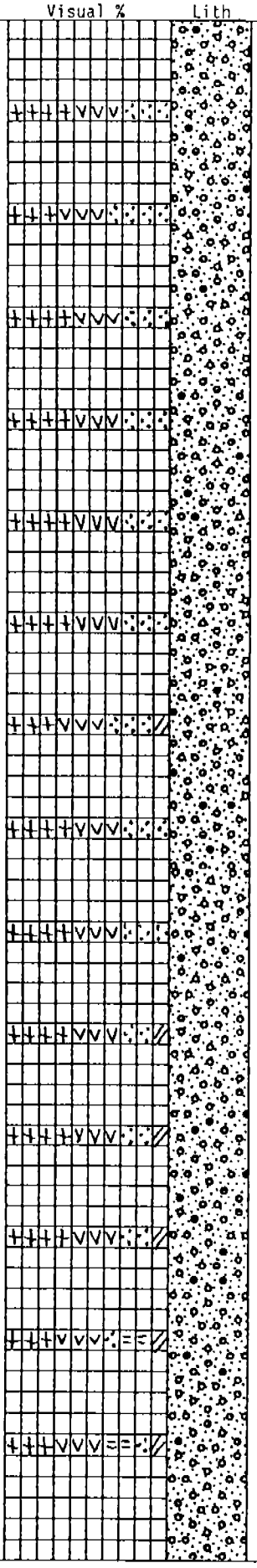
DATE STARTED: 12 MAY 1988 DATE COMPLETED: 13 JUNE 1988

FIELD REP.: P. EGAN, J. KASZUBA

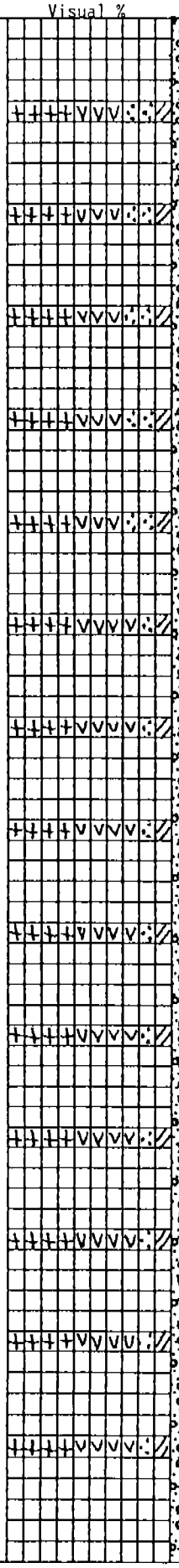
COMMENTS: Top of bedrock @ 657'. Total depth = 670'. Borehole drifted 60'. 14 3/4" borehole 0'-100', 9 7/8" borehole 100'- TD.

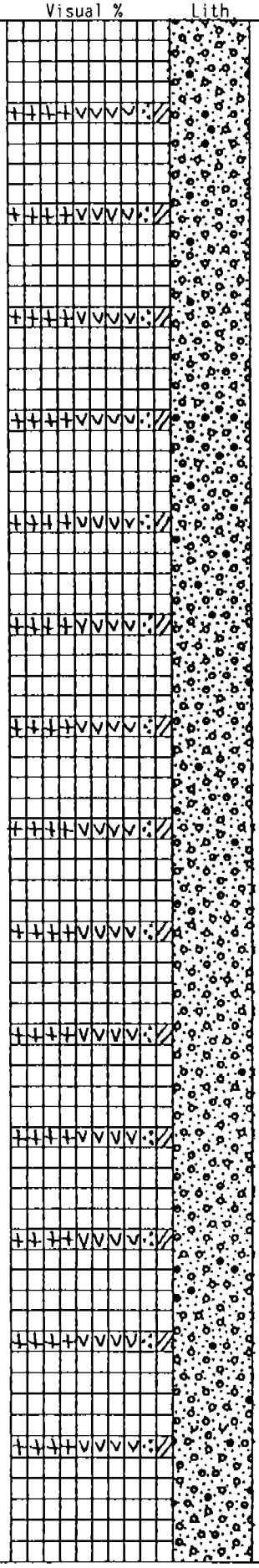
LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			8	0'-550' cuttings	0'-35' SURFICIAL ALLUVIUM: The color of the samples throughout the interval is diverse but predominantly medium dark gray (N4) and grayish orange pink (5YR 7/2). Average cutting size is 0.04 inches with cuttings up to 0.5 inches. Cutting shapes range from angular flakes to blocky fragments. The lithology is a poorly sorted, unconsolidated, gravelly, sandy soil. Samples in this interval contain gravel clasts of limestone, rhyolite, caliche, quartzite, sandstone and siltstone up to 30% in a sandy soil matrix with clay and silt.
10			6.5		
15			14		0'-5' Abundant caliche grains and caliche coating on other grains. Clay present, but < 10%. Sand abundant in sample.
20			16		10'-15' Caliche coating on grains.
25			19		15'-20' Rhyolite is most abundant constituent in volcanic fraction.
30			21		
35			11		35'-475' GRAVELLY ALLUVIUM (Santa Fe Group): The predominant color of the samples throughout the interval is dark gray (N3). Average cutting size is 0.1 inches with cuttings up to 0.3 inches. Cutting shapes range from flakes to blocky fragments. The lithology is an unconsolidated to moderately consolidated (?) (longer drilling times), poorly sorted, pebble to possible boulder polygenetic conglomerate. Clasts are composed of medium dark gray (N4) to grayish black (N2) micritic to sparse biomicritic limestone, light gray (N7) to grayish red purple (5RP 4/2) porphyritic andesite containing plagioclase phenocrysts (occurs more frequently in lower part of section displaying
40			10		
45			21		
50			23.5		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
					35'-657' ALLUVIUM (Santa Fe Group) Continued: epidote alteration of plagioclase), white (N9) rhyolite with varying degrees of iron oxidation rims around mafic phenocrysts (pyrite or magnetite), transparent to white (N9) quartzite, dusky red (5R 3/4) to light olive gray (5Y 5/2) siltstone and minor amounts of granite and sandstone.
50			23.5		
55			12		
60			21		60'-65' Silt present, ~ 15%.
65			24		
70			11		
75			10		
80			11		
85			24		
90			11.5		
95			7		
100			10		
105			6		
110			6		110'-115' Increase in cutting size.
115			5		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
115			5		
120			7.5		
125			7		
130			6		
135			6		
140			7		
145			7		145'-150' First occurrence of grayish green andesite containing epidote, but in very small amounts.
150			4		
155			4		
160			4		
165			4		
170			3		
175			3.5		
180			3.5		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180			3.5		
185			7		185'-190' Rhyolite abundant in volcanic fraction.
190			2.5		
195			3		
200			3		
205			3		205'-210' Purple andesite appears in cuttings.
210			6		
215			6		
220			4.5		
225			6.5		225'-230' Amount of purple andesite increases.
230			5		
235			5		
240			4.5		
245			5		



Depth	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245	5		
250	8		250'-255' Decrease in cutting size to ~ 1mm. Abundant green epidote fragments.
255	7		
260	9.5		260'-265' Purple andesite comprises ~ 40% of volcanic fraction.
265	5		
270	5		
275	14		
280	10		
285	10		
290	5		
295	6		
300	6.5		300'-305' Significantly less rhyolite in volcanic fraction. Volcanics are mostly green-gray and purple andesite.
305	3.5		
310	9		

LOCATION ID: BLM-2-630

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310			9		
315			6		
320			5		
325			4		
330			6		
335			15		
340			9		
345			10		
350			6		
355			7		
360			11.5		
365			15		
370			8		
375			8		

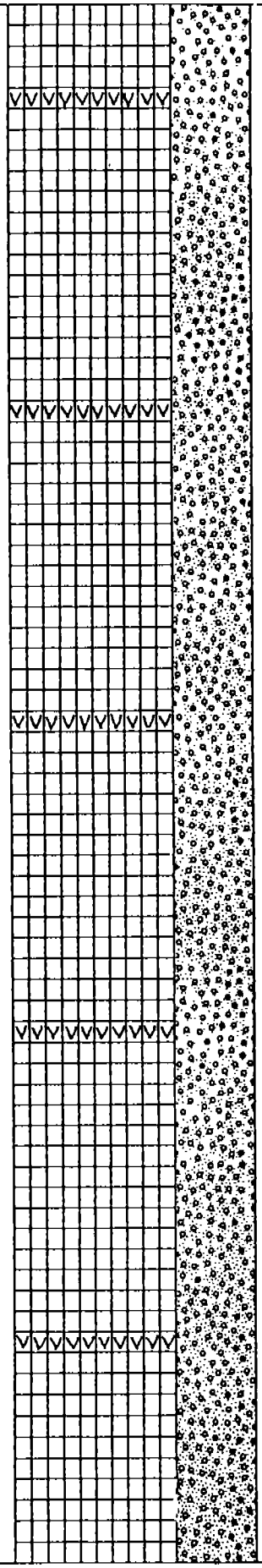
Depth	Visual %	Litb	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
375			8		
380			7		
385			9		
390			18		
395			17		
400			17		
405			22		
410			10		
415			5.5		
420			7.5		
425			10		
430			6.5		
435			5		435'-475' Volcanics (purple andesite) becoming more abundant.
440			10		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
440			10		
445			6		
450			4		450'-455' Less than 10% caliche present as grains and as coating on other grains.
455			4		
460			5		
465			5		
470			7		
475			3		475'-657' ANDESITE-RICH GRAVELLY ALLUVIUM (Santa Fe Group): Alluvium has become andesite rich. Significant color change in samples. Penetration rate has increased. Drilling fluid has changed to a purplish color. Samples are grayish red purple (5RP 4/2) when wet and medium gray (N5) when dry. Average cutting size is 0.2 inches and ranges in size from < 0.1 inches to 0.25 inches. Sample consists of 95% aphanitic andesite containing minor (< 15%) anhedral to euhedral plagioclase phenocrysts. Average phenocryst size is 0.05 inches. Remaining 5% of sample contains limestone, calcite or other volcanic clasts.
480			3		
485			4		480'-485' Rusty orange limonite that is < 10% present as friable grains and coatings on some grains.
490			4		
495			3		
500			4		500'-505' Calcite is less than 10% and present in large milky transparent clasts displaying cleavage surfaces. Possibly fracture filling.
505			4		

LOCATION ID: BLM-2-630

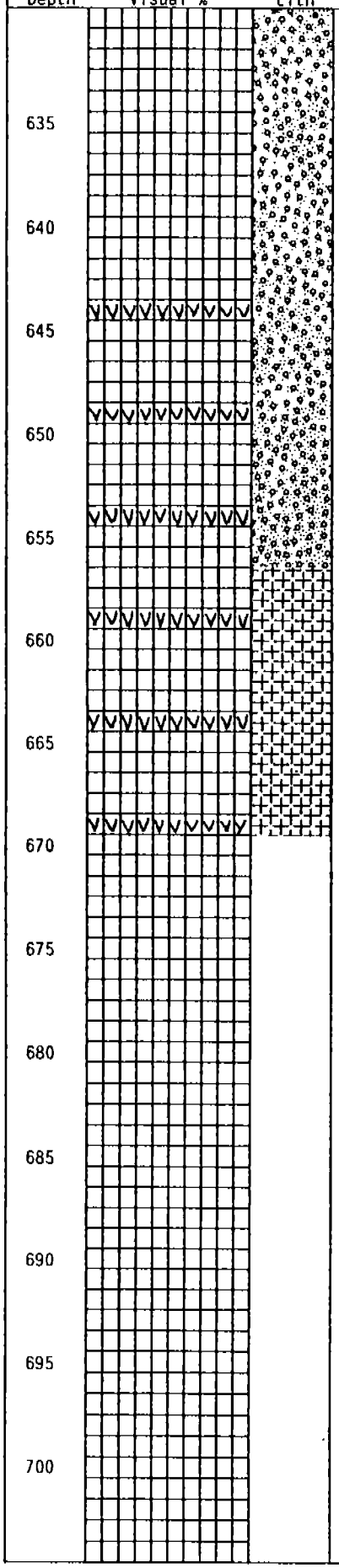
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
505			4		
510			2		510'-525' Poor sample return. One sample represents 15'. Significant decrease in cutting size to 1 mm.
515			5		
520			6		
525			7		
530			6		530'-550' Poor sample return. One sample represents 20'.
535			6		
540			5		
545			6		
550			6.5	550'-560' core	550'-560' *** core interval *** No recovery
555			3.5		550'-570' Sample recovery poor. One sample represents 20'.
560			5	560'-670' cuttings	
565			6		
570			4		570'-585' One sample collected.

LOCATION ID: BLM-2-630



Depth	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
570	4		
575	3		
580	3		
585	4.5		585'-600' One sample collected.
590	4		
595	4		
600	3		600'-615' One sample collected.
605	4		
610	3		
615	4		615'-630' One sample collected.
620	2		
625	4		
630	6		630'-645' One sample collected.
635	6		

LOCATION ID: BLM-2-630



Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
6		
8		
8		645'-660' One sample collected.
5		
6		
		657' Orejon Andesite contact.
10		657'-670' OREJON ANDESITE: Drilling rate has significantly decreased and bit is chattering. Cuttings have become more uniform in size and shape and are 100% grayish red purple (5RP 4/2) andesite. Cuttings are very angular and flake-shaped. The average cutting size is 0.2 inches and ranges from < 0.1 to 0.3 inches. The andesite is porphyritic, containing < 15% anhedral to euhedral phenocrysts of white plagioclase and lesser amounts of a mafic mineral (biotite, hornblende ?).
12		
42		Total depth = 670'.

NASA
JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

BOREHOLE LITHOLOGIC LOG

Location ID: **BLM-37**

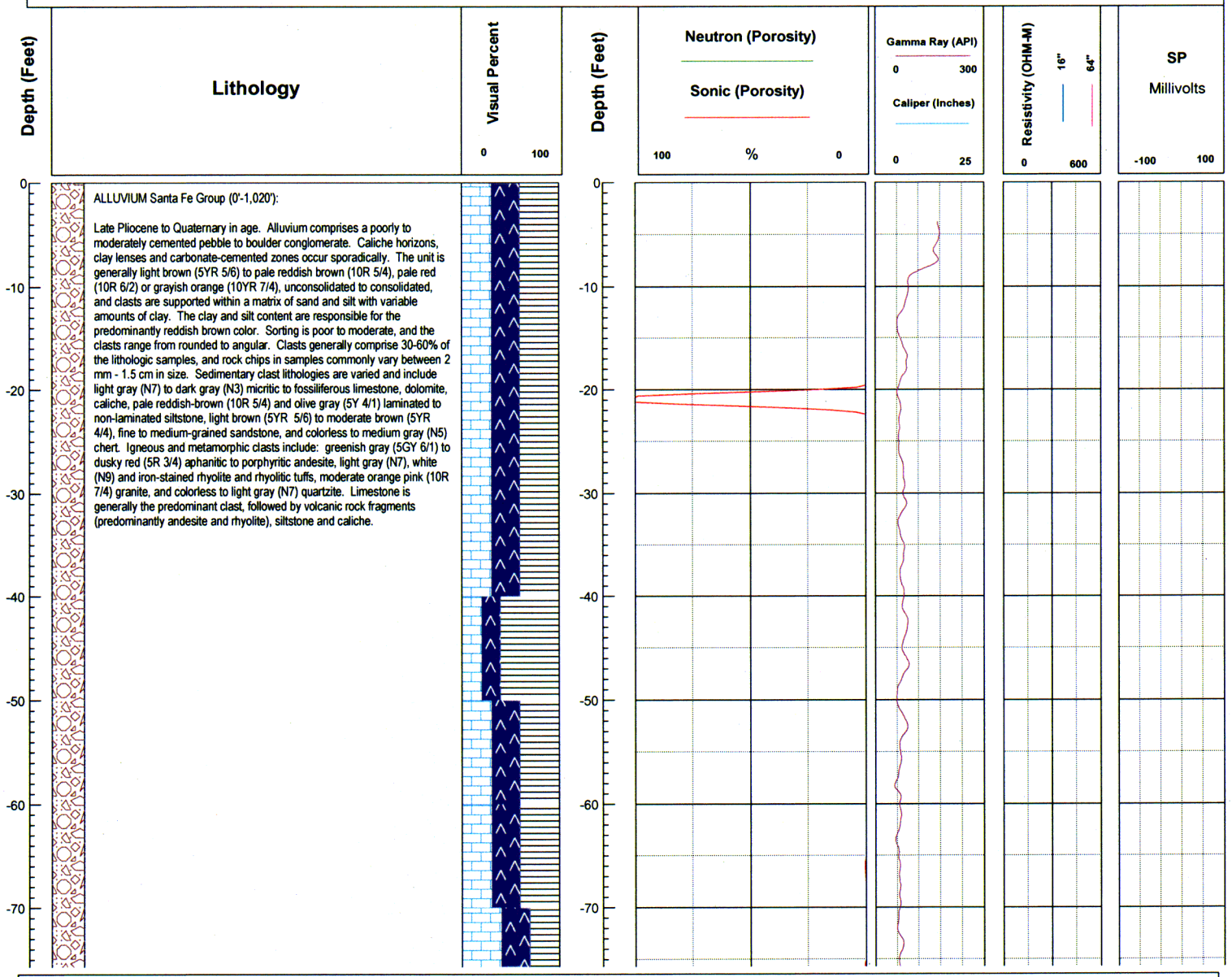
Site ID: **NASA-WSTF, Doña Ana County, NM**

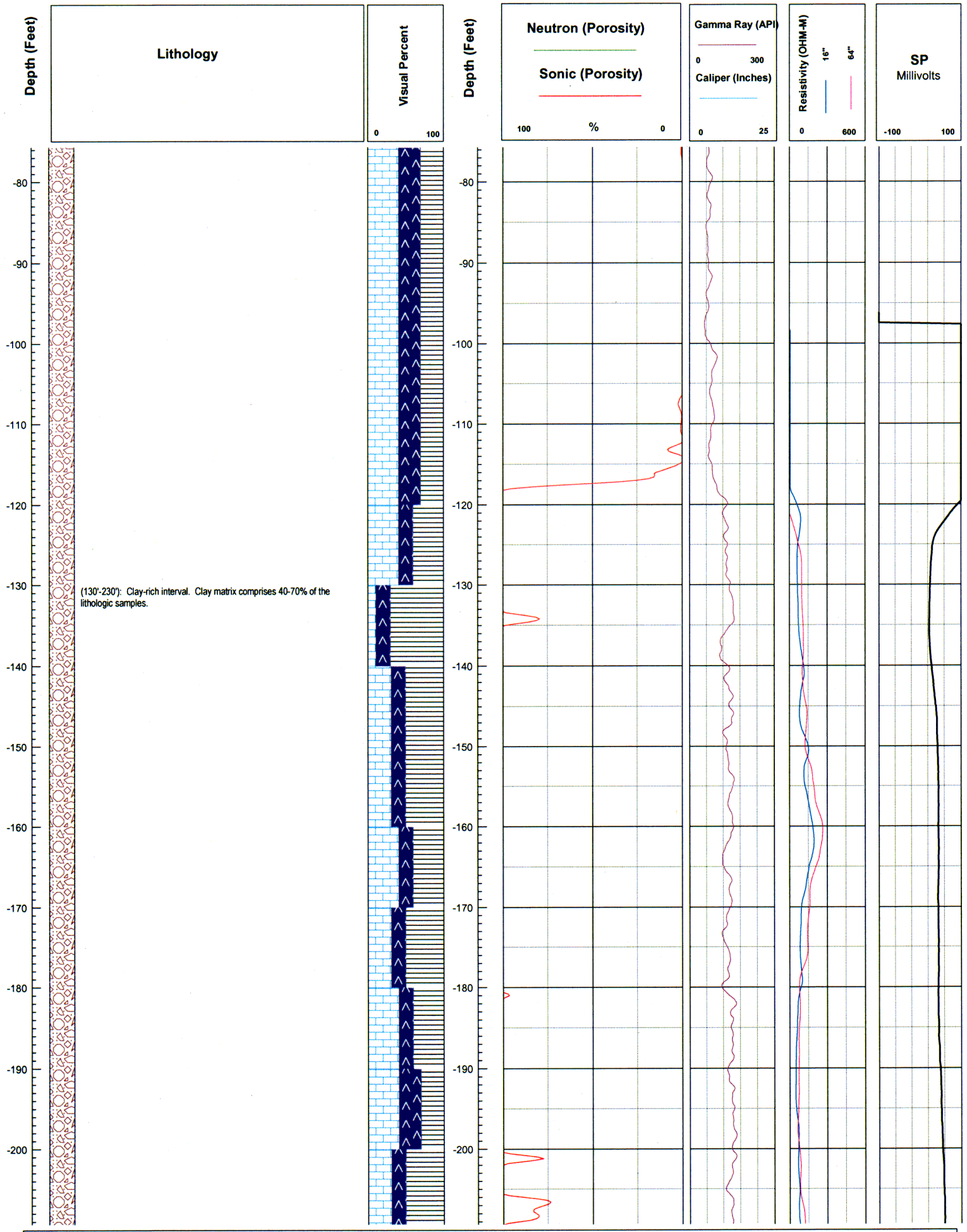
Township and Range: **SW 1/4, NW 1/4, NW 1/4, Sec 9, T21S R3E**
NM State Plane Coordinates (NAD 83): **221630.18N 403315.95E (Preliminary)**
Elevation (Brass Cap): **4546.08' (Preliminary)**
Total Depth of Borehole (bgs): **1,020'**
Depth to Bedrock (bgs): **N/A**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Juan Aguilar**

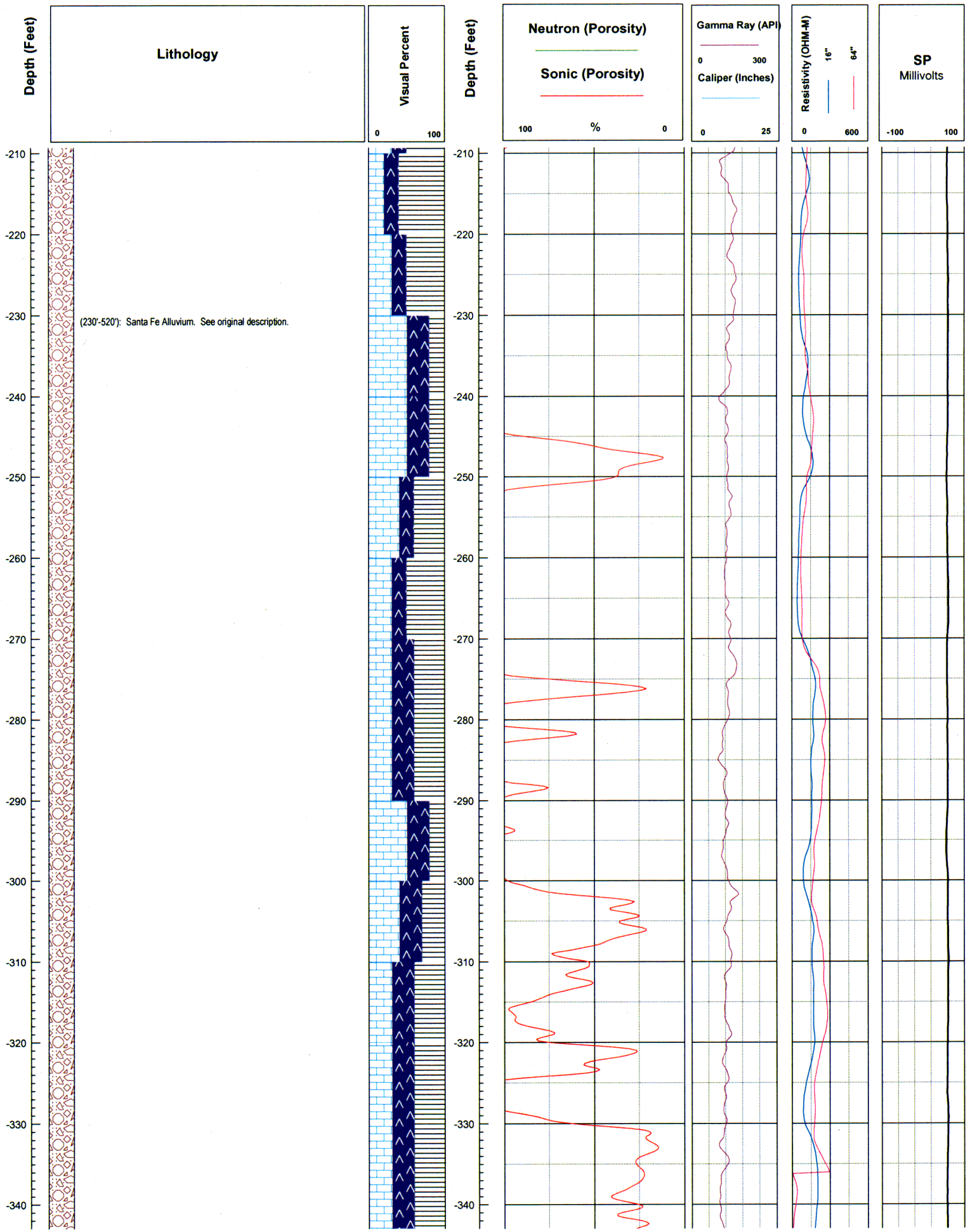
Depth to Groundwater (bgs): **482.86'**
Surface Casing Depth and Diameter: **14" OD steel set to 120'**
Borehole Diameter: **12.25"**
Geologist Field Rep: **L.H.M., M.M., J.P., M.R.,**
Dates Drilling Started and Completed: **4/27/99 to 5/11/99**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Retrofit Westbay in 4.5" OD stainless steel**
No neutron porosity or caliper logs available.

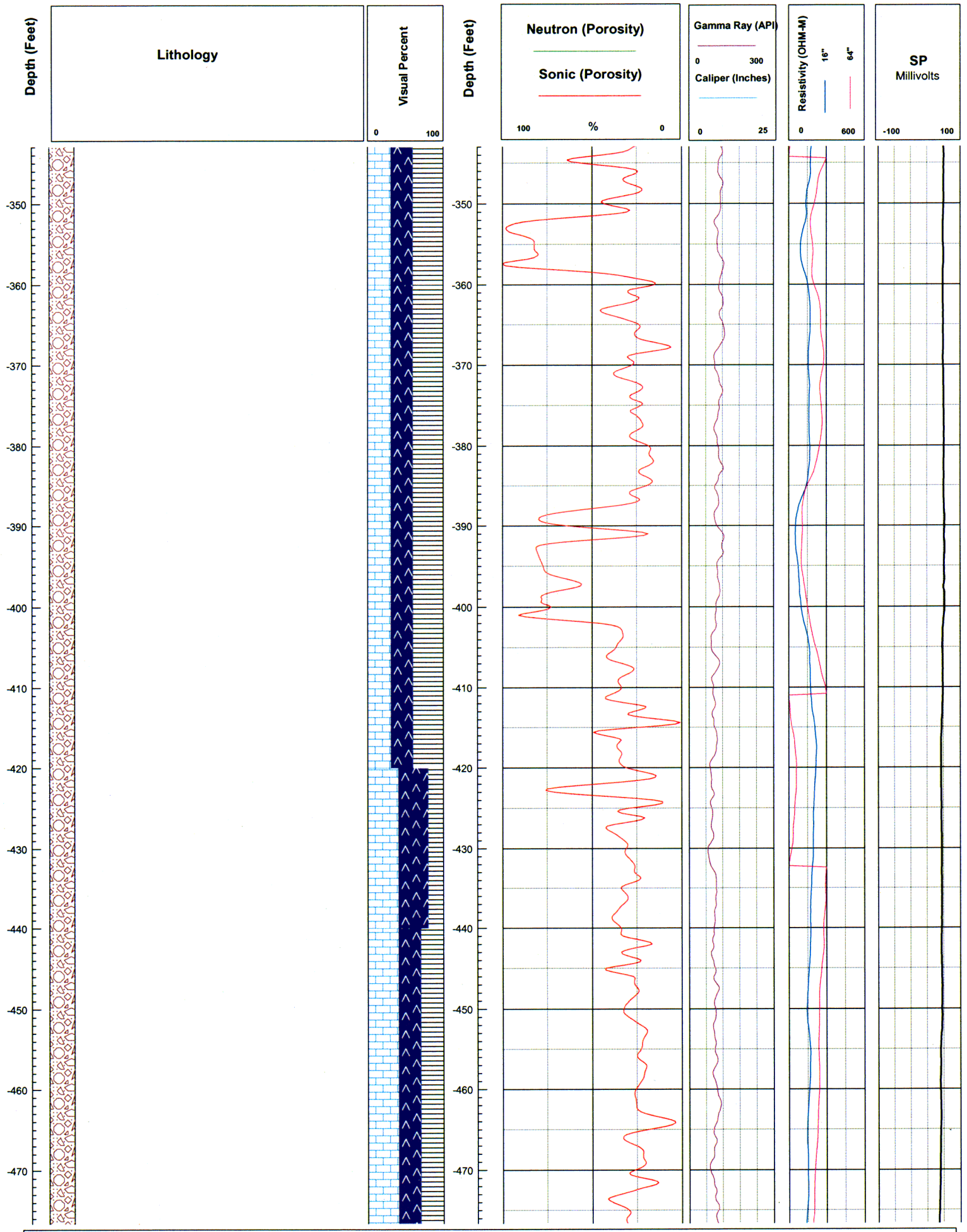
Explanation:

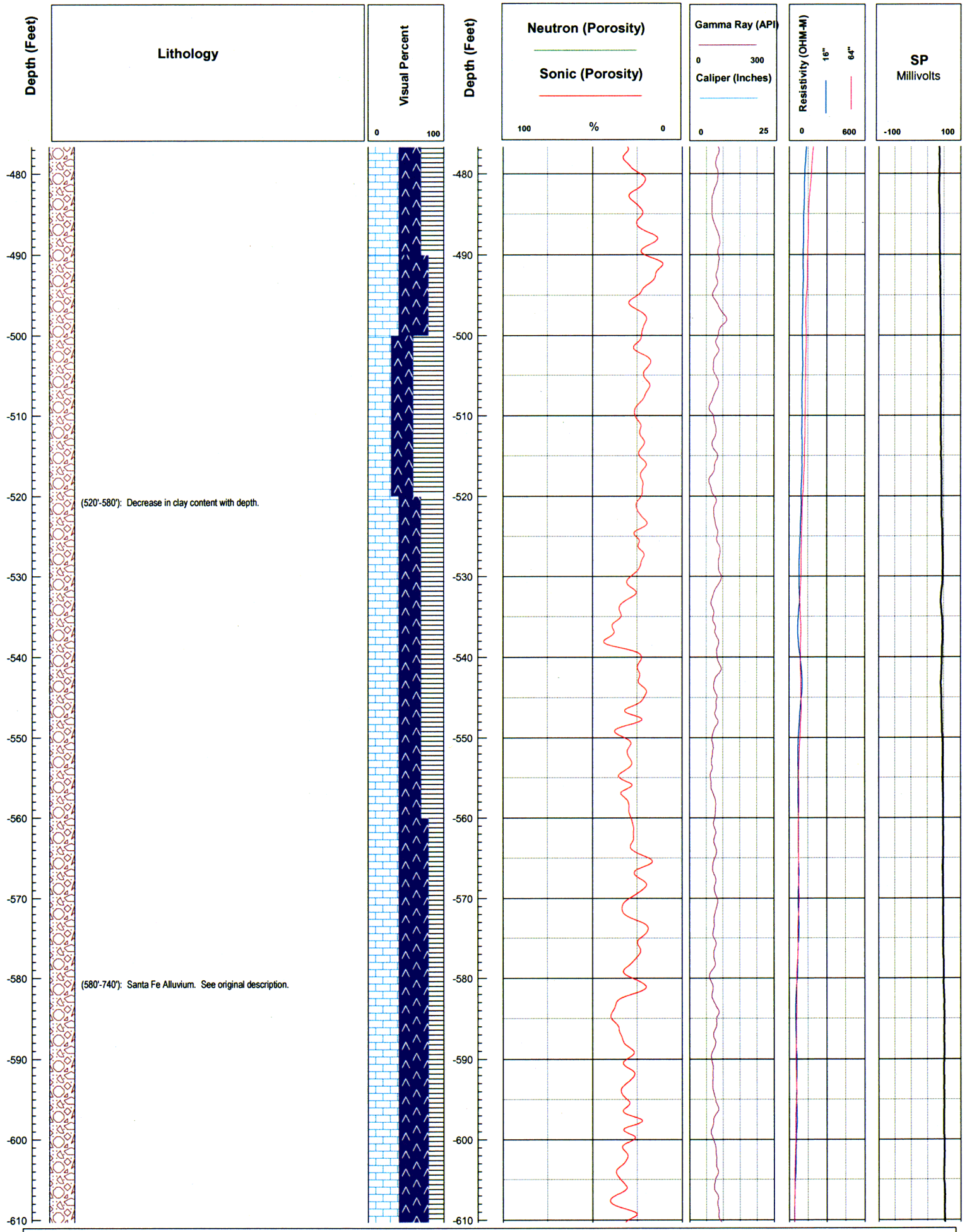
Alluvium | Volcanic Alluvium | Clay | Silt | Sand | Sandstone | Siltstone | Shale | Limestone | Rhyolite | Andesite | Undiffer. Volcanics

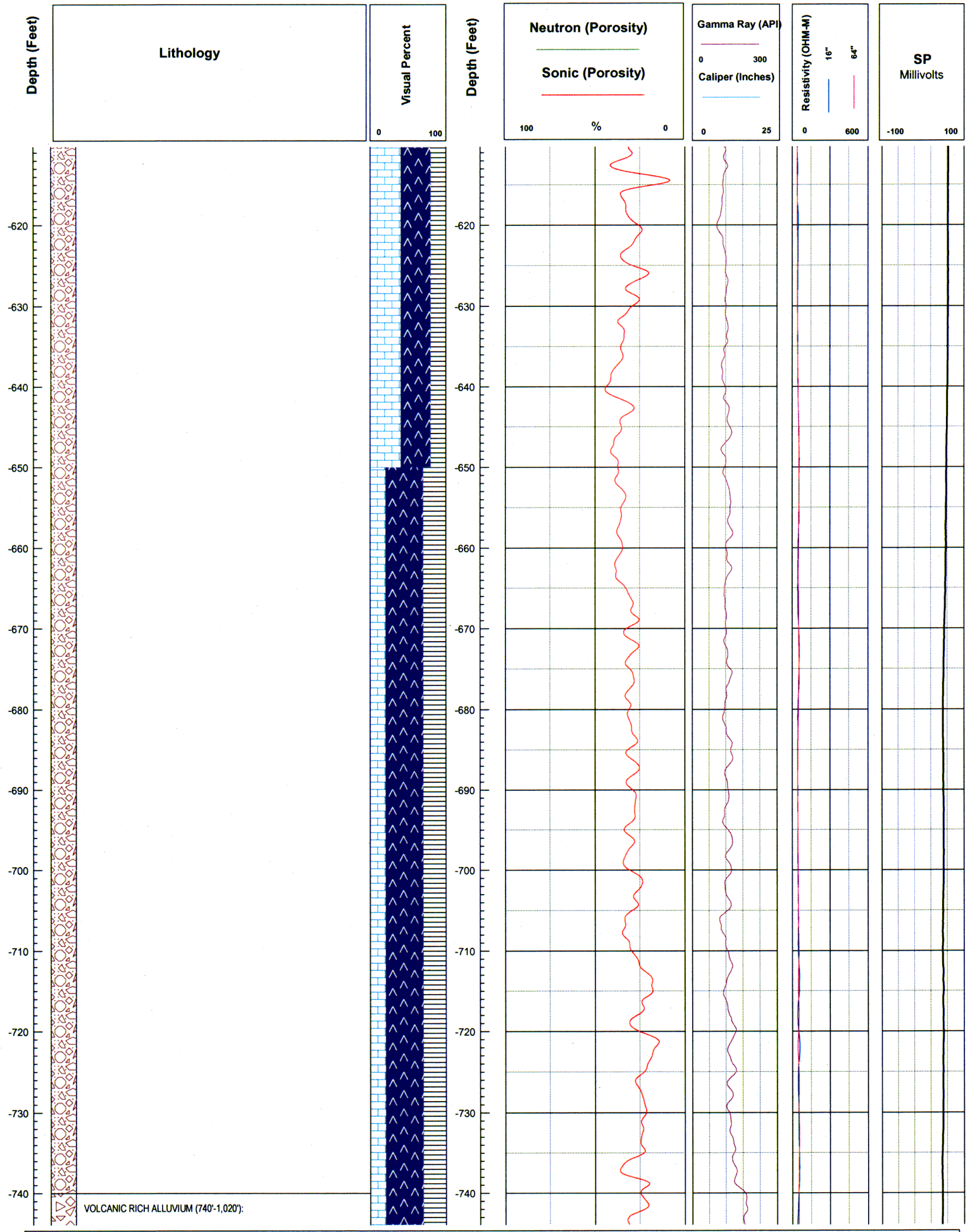


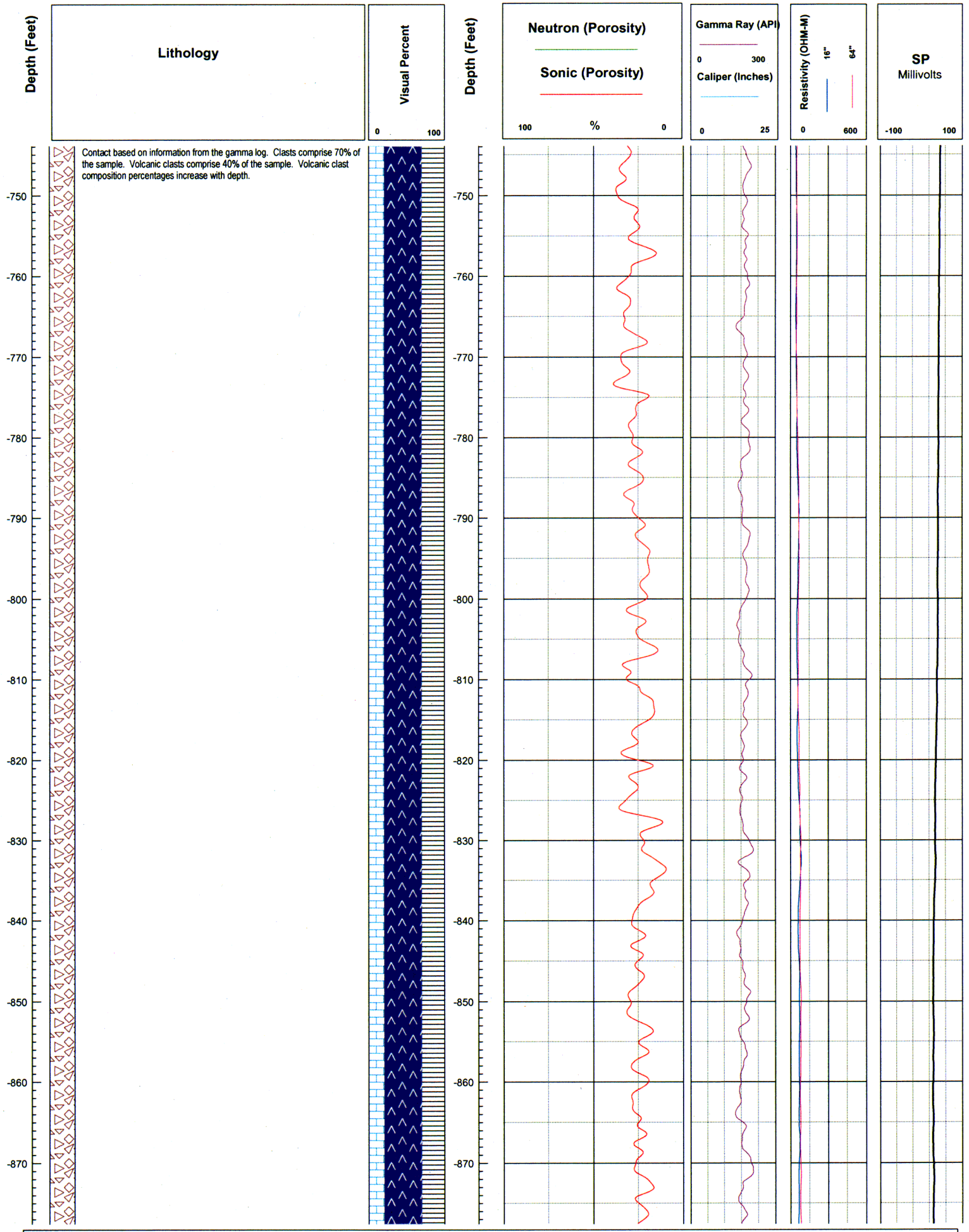

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
(130'-230'): Clay-rich interval. Clay matrix comprises 40-70% of the lithologic samples.

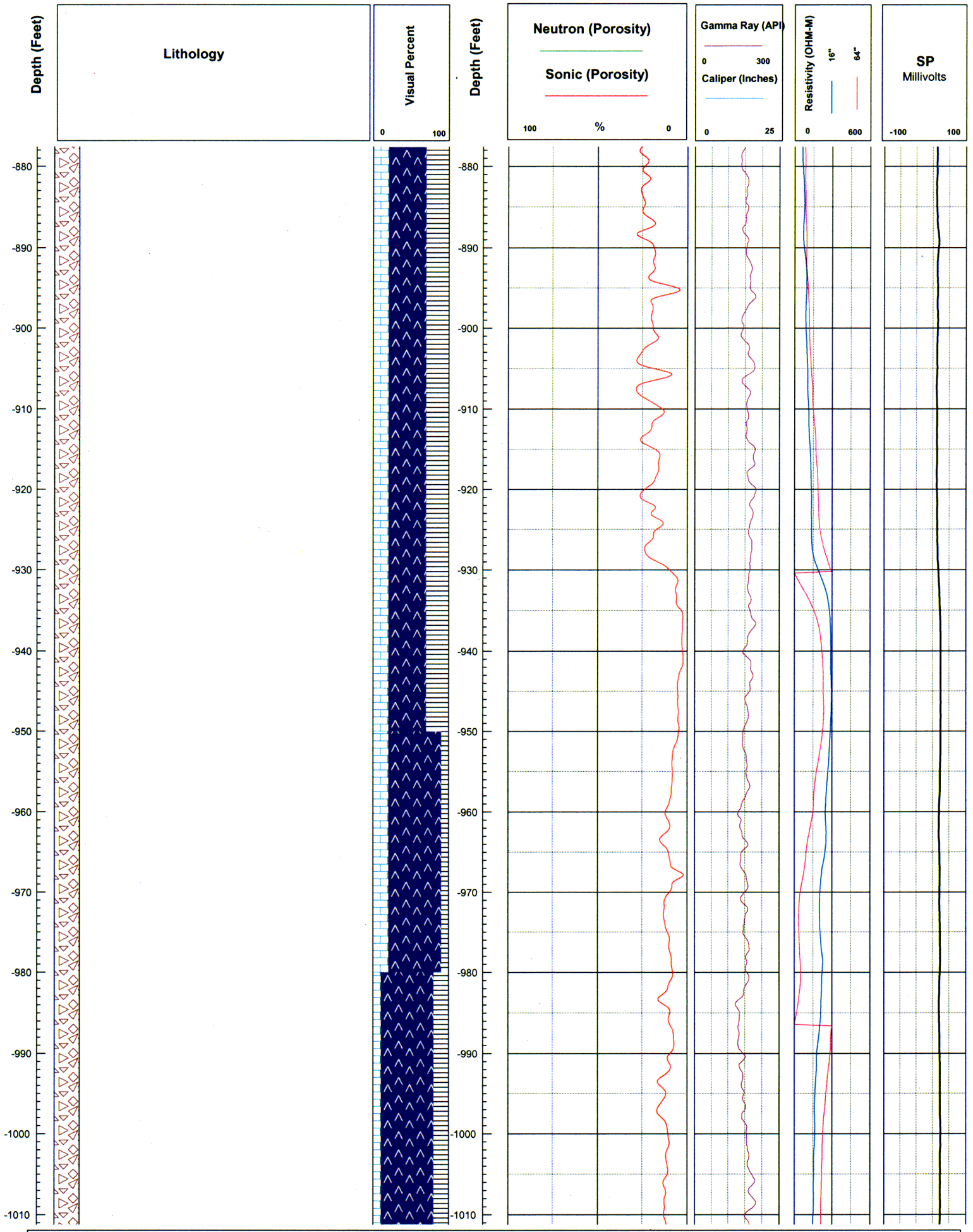

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340
(230'-520'): Santa Fe Alluvium. See original description.

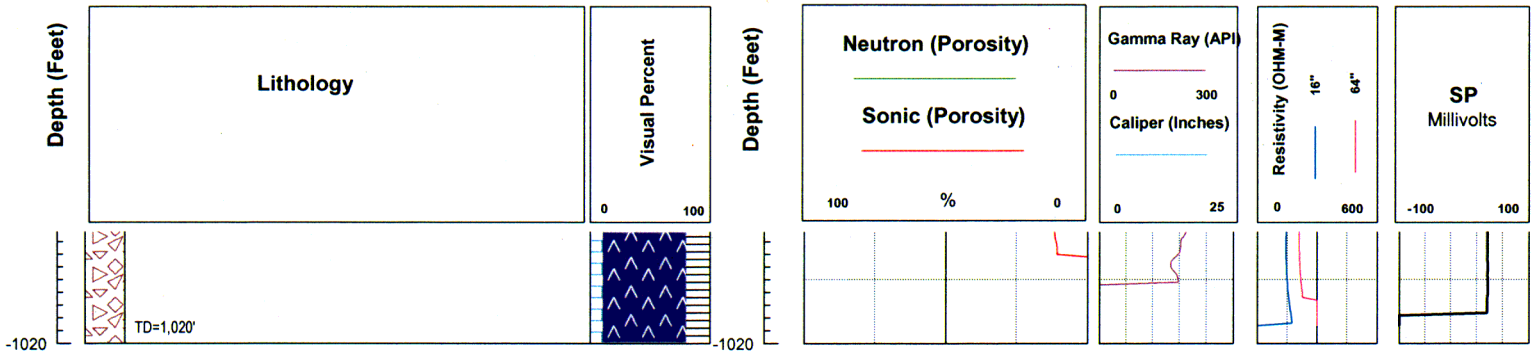

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-480
-490
-500
-510
-520
-530
-540
-550
-560
-570
-580
-590
-600
-610
(520'-580'): Decrease in clay content with depth.
(580'-740'): Santa Fe Alluvium. See original description.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-620
-630
-640
-650
-660
-670
-680
-690
-700
-710
-720
-730
-740
VOLCANIC RICH ALLUVIUM (740'-1,020'):

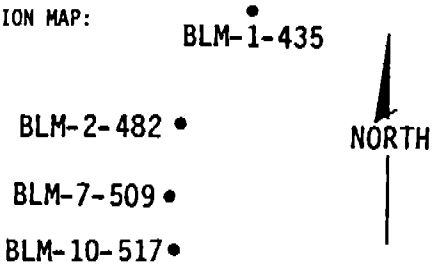

Depth (Feet)
Lithology
Visual Percent
0
100
Contact based on information from the gamma log. Clasts comprise 70% of the sample. Volcanic clasts comprise 40% of the sample. Volcanic clast composition percentages increase with depth.
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-750
-760
-770
-780
-790
-800
-810
-820
-830
-840
-850
-860
-870


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-880
-890
-900
-910
-920
-930
-940
-950
-960
-970
-980
-990
-1000
-1010


Depth (Feet)
Lithology
Visual Percent
0
100
TD=1,020'
-1020
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-1020

LITHOLOGIC LOG

LOCATION MAP:



NW 1/4 SW 1/4 NW 1/4 SW 1/4 S 4 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: BLM-7-509

SITE COORDINATES (ft.):

N 224244.56 E 402952.81

GROUND ELEVATION (ft. MSL): 4529.30 (BRASS CAP)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: AIR-FOAM ROTARY

DRILLING CONTR.: LARJON

DATE STARTED: 27 APRIL 1988 DATE COMPLETED: 17 MAY 1988

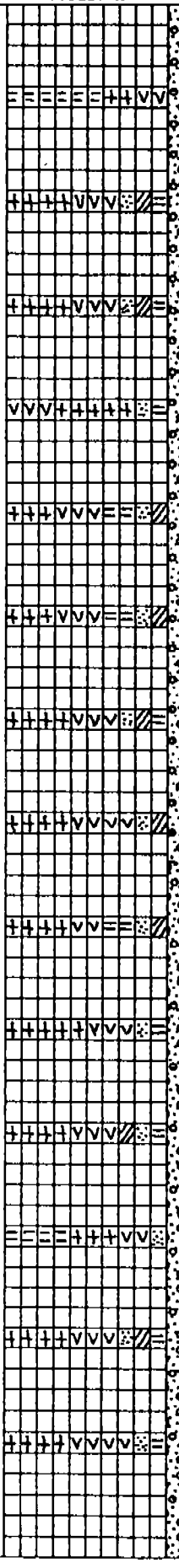
FIELD REP.: R. COOPER, P. EGAN

COMMENTS: 0'-105' 8 3/4" BIT. 0'-107' 14 3/4" BIT REAM. 107'-557' 9 7/8" BIT. TOTAL DEPTH = 557'. BEDROCK NOT REACHED.

LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
			Begin drillograph	0'-557' cuttings	0'-557'	GRAVELLY ALLUVIUM (Santa Fe Group): The overall color of the alluvium is ~ 50% medium dark gray (N4) to grayish black (N2) and 50% grayish orange (10YR 7/4). Average cutting size is 0.16 inches and up to 1 inch. Cutting shapes range from flakes to blocky fragments. Grains that are not cuttings range from silt-size to 0.08 inches, are angular to subrounded and are up to 15% of a sample. The lithology is an unconsolidated, poorly-sorted, pebble to boulder conglomerate including clay, silt and sand. Lithology of clasts includes light gray (N7) to grayish black (N2) micritic to sparse biomicritic limestone, grayish orange (10YR 7/4) to pale reddish brown (10R 5/4) and white (N9) mottled rhyolite containing iron-stain oxidation rims around mafic phenocrysts (magnetite?), grayish green (10GY 5/2) and grayish red purple (5RP 4/2) to dusky red (5R 3/4) porphyritic andesite with epidote increasing in lower part of section. Minor amounts (up to 10%) of dusky red (5R 3/4) siltstone (Abo), transparent to white (N9) quartzite, moderate yellowish brown (10YR 5/4) clay (in some intervals up to 60%), moderate red (5R 4/6) granite, and caliche as grains and/or coating on other grains.
5			5			
10			12			
15			8			
20			5			
25			8		25'-30'	98% of volcanics present are rhyolite (mottled red and white and white with iron staining).
30			4			
35			3			
40			3.5			
45			6		45'-50'	Clay rich zone, > 10% quartzite and siltstone present.
50			3			

LOCATION ID: BLM-7-509

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
50			3		
55			3		
60			4.5		
65			3.5		
70			3.5		
75			4		
80			5		
85			4		
90			3		
95			9		
100			4		100'-105' Clay rich zone.
105			5.5		
110			4		110'-115' Clay content ranges from 10% to 20%.
115			4		

LOCATION ID: BLM-7-509

Depth	Visual % / Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
115		4			
120		6			
125		16			
130		4			
135		4		135'-140'	Clay content ranges from 30% to 40%.
140		7.5			
145		12.5			
150		2.5		150'-165'	Visual percentage of clay is not representative of actual interval. Much of the clay and silt was lost through driller's sampler.
155		3.5		150'-557'	Siltstone present but less than 10% of sample.
160		5			
165		5.5			
170		3			
175		3.5			
180		4.5			

LOCATION ID: BLM-7-509

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
180			4.5			
185			5.5			
190			4			
195			8.5		195'	First occurrence of grayish red purple (5RP 4/2) andesite and grayish green (10GY 5/2) andesite containing altered phenocrysts of pale green epidote.
200			11			
205			4.5			
210			3			
215			4.5			
220			4.5			
225			4.5		225'-230'	Percentage of grayish green andesite (containing green epidote) in volcanic fraction increases. Grayish red purple andesite comprises < 10%.
230			5			
235			6			
240			10			
245			9		245'-250'	Average cutting size increased to 0.3 inches.

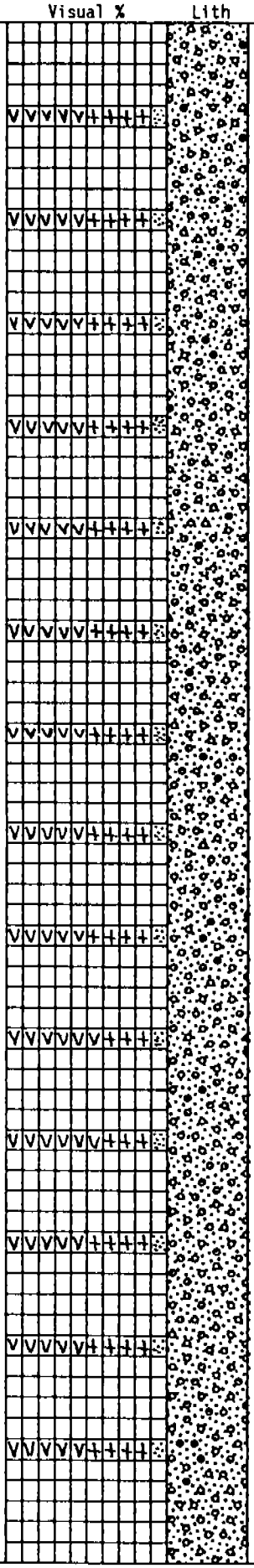
LOCATION ID: BLM-7-509

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245			9		
250			3		250'-557' Clay content is < 10%.
255			5		
260			5		
265			5		265'-285' Caliche is present, < 10%.
270			4.5		
275			2		
280			5		
285			6.5		
290			3.5		
295			6		
300			7		
305			4		
310			5		

LOCATION ID: BLM-7-509

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310			5		
315			9		
320			6		
325			11		
330			8.5		
335			8.5		
340			11.5		
345			8		345'-355' Drilling through an extremely hard zone.
350			54.5		
355			5		
360			8		
365			10		
370			13.5		
375			9.5		

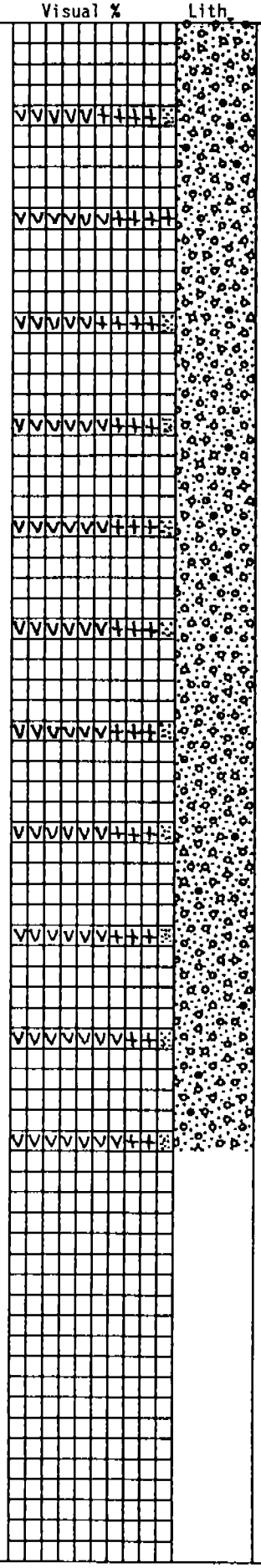
LOCATION ID: BLM-7-509



Depth	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
375	9.5			
380	6			
385	6			
390	6			
395	6		395'-400'	Increase in amount of grayish red purple andesite. Grayish red purple andesite percentage equals grayish green andesite percentage.
400	13		400'-405'	Grayish red purple andesite is more abundant than grayish green andesite.
405	6		405'-410'	Caliche is present, < 10%.
410	3		410'-415'	Rhyolite percentage increases to ~ 40% of volcanics.
415	12.5			
420	8.5			
425	6		425'-430'	Significant decrease in cutting size, average size is 0.04 inches.
430	7			
435	8.5			
440	9.5		440'-445'	Grayish red purple andesite comprises ~ 40% of volcanic fraction.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
440			9.5			
445			7.5		445'-450'	Epidote is very noticeable. Increase in grayish green andesite to ~ 30% of volcanic fraction.
450			6.5			
455			6			
460			11			
465			7			
470			5			
475			13		475-'480'	Grayish green andesite percentage equal to grayish red purple andesite percentage.
480			16			
485			13			
490			15.5			
495			15			
500			12			
505			17.5			

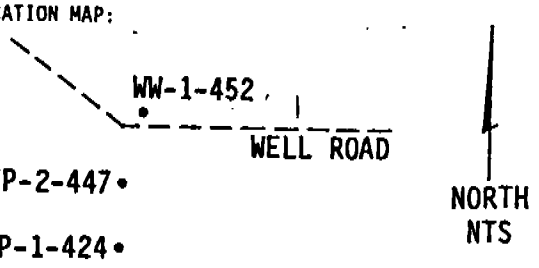
LOCATION ID: BLM-7-509



Depth	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
505	17.5			
510	8			
515	14			
520	11			
525	16		525'	First appearance of water. Foam thins, slugs of water blown from borehole.
530	14			
535	18			
540	4.5		540'-545'	Color change in foam from light gray to light grayish purple.
545	4.5			
550	5		550'	Increase in grayish red purple andesite to ~ 65% of volcanic fraction. This increase is cause of color change in foam at 540'-545'.
555	5			
			Total depth = 557'.	
560				
565				
570				

LITHOLOGIC LOG

LOCATION MAP:



SE 1/4 SE 1/4 SE 1/4 SE 1/4 S 6 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: JP-1-424

SITE COORDINATES (ft.):

N 223189.3 E 397426.37

GROUND ELEVATION (ft. MSL): 4444.09 (BRASS CAP)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: AIR-FOAM ROTARY

DRILLING CONTR.: LARJON

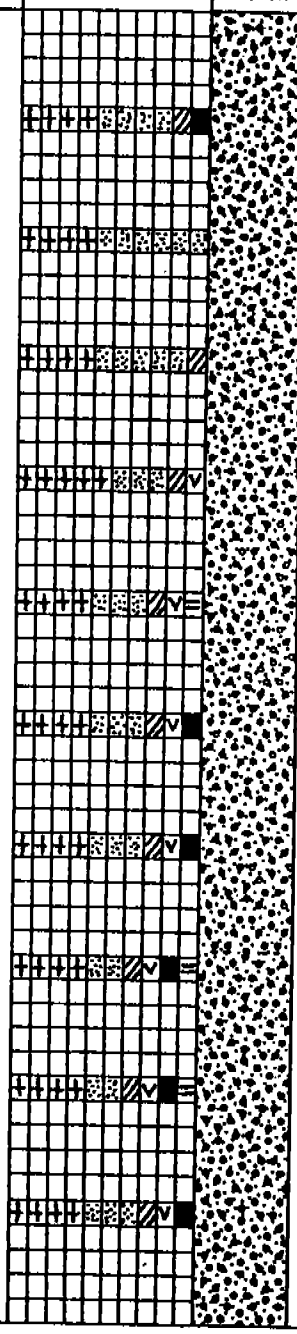
DATE STARTED: 31 October 1987 DATE COMPLETED: 25 November 1987

FIELD REP.: JP KASZUBA

COMMENTS: No penetration rates 0'-100'. 12 1/4" bit 0'-100'. 7 7/8" bit 100'-490'. Total Depth = 490'. Bedrock not reached.

LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval
			0'-100' not available	0'-490' cuttings

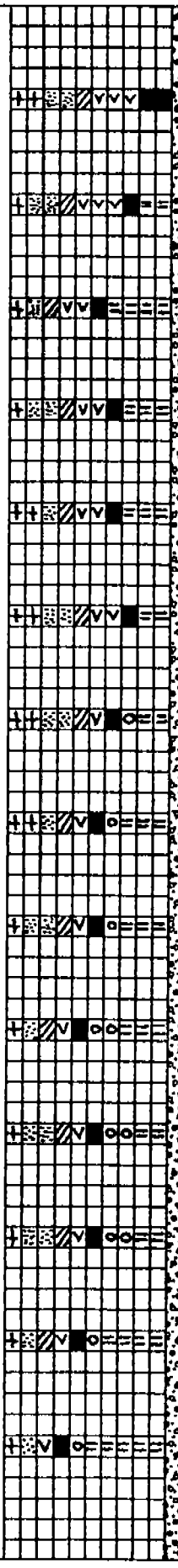


Lithologic Description

0'-5'	SURFICIAL ALLUVIUM: Moderate brown (5YR 4/4); fine to medium-grained sand; sub-rounded to subangular; poorly-sorted. Unconsolidated sand. Clastic lithologies include colorless quartz and calcite, grayish black (N2) limestone, moderate red (5R 4/6) siltstone and grayish orange pink (5YR 7/12) sandstone.
5'-490'	ALLUVIUM (Santa Fe Group)
5'-15'	Pale brown (5YR 5/2) to light brown (5YR 6/4); cuttings are ≤ 0.1 inches diameter; rounded to angular; moderately sorted. Unconsolidated (?) sand and gravel. Cutting lithologies include colorless quartz, grayish black (N2) limestone, moderate red (5R 5/4) siltstone and white (N9) rhyolite.
15'-60'	Light brown (5YR 6/4) to pale yellowish brown (10YR 6/2); cuttings are up to 0.25 inches diameter; average ~ 0.1 inch diameter; subrounded to subangular; moderate sorting. Poorly consolidated (?). Conglomerate comprised of silts through boulders. Clay present @ 20'-60' in amounts < 10% except where noted. Cutting lithologies include colorless quartz and calcite, medium gray (N5) to medium dark gray (N4) limestone, dusky red (5R 3/4) siltstone, grayish orange pink (5YR 7/12) sandstone, medium light gray (N6) chert, white (N9) rhyolite and light brown (5YR 6/4) caliche.
20'-25'	Clay present as nodules among cuttings.
35'-45'	Clay present as nodules among cuttings.
35'-60'	Slight increase in average size of cuttings.

Depth	Visual %	Lith	Drilling Time Scale: min.	Sample Type and Interval	Lithologic Description
					ALLUVIUM (Santa Fe Group) Continued
50					
55					
60					60'-130' Light brown (5YR 6/4) to pale yellowish brown (10YR 6/2); cuttings are ≤ 0.1 inch diameter, subrounded to angular, poorly sorted. Poorly consolidated (?). Conglomerate comprised of silts through boulders. Clay present @ 60'-130' in amounts of < 10% except where noted. Cutting lithologies include colorless quartz and calcite, medium gray (N5) to dark gray (N3) limestone, dusky red (5R 3/4) to moderate red (5R 5/4) siltstone, grayish orange pink (5YR 7/12) sandstone, medium light gray (N6) chert, white (N9) rhyolite and light brown (5YR 6/4) caliche.
65					
70					
75					70'-75' Significant decrease in cutting size, average <0.1 inch diameter
80					
85					
90					
95					
100			Begin drillograph		100'-110' Clay present as nodules among cuttings.
105			3		100'-130' Change in drill bits (12 1/4" to 7 7/8") and concurrent increase in penetration rates results in increase in size (~ 0.2 inch diameter average, 0.5 inch diameter maximum) of cuttings.
110			4		
115			5		

LOCATION ID: JP-1-424

Depth	Visual %	Lith	Drilling Time Scale: min.	Sample Type and Interval	Lithologic Description
					ALLUVIUM (Santa Fe Group) Continued
115			5		115'-180' Clay present as nodules among cuttings, comprises significant proportion of lithology.
120			5.5		115'-180' Caliche present as fracture fillings in limestone and as a coating on rounded limestone cuttings.
125			6		
130			8		130'-150' Grayish orange (10YR 7/4) to dark yellowish orange (10YR 6/6); cuttings are 0.1 inch diameter average, 0.4 inch diameter maximum; subrounded to subangular; poorly sorted. Poorly consolidated (?). Conglomerate comprised of clays and silts through pebbles and cobbles. Cutting lithologies include colorless quartz, grayish black (N2) limestone, dusky red (5R 3/4) siltstone, light gray (N7) to medium dark gray (N4) chert, very pale orange (10YR 8/2) to white (N9) rhyolite and light brown (5YR 6/4) caliche.
135			4.5		
140			7		140'-180' Caliche fragments present among cuttings as a cement binding sand-size fragments of all lithologies noted above.
145			8.5		
150			6.5		150'-180' Dark yellowish orange (10YR 6/6); cuttings are 0.1 inch diameter average, 0.25 inch diameter maximum; rounded to subangular; moderately well sorted. Poorly consolidated (?). Clayey conglomerate comprised of clays and silts through sands and gravels. Cutting lithologies include colorless quartz, grayish black (N2) limestone, dusky red (5R 3/4) siltstone, light gray (N7) chert, white (N9) rhyolite and light brown (5YR 6/4) caliche.
155			3		
160			4.5		
165			3		
170			4		
175			3.5		
180			14		180'-190' Grayish orange (10YR 7/4) clay. Unconsolidated (?).

Depth	Visual %	Lith	Drilling Time Scale: min.	Sample Type and Interval	Lithologic Description
					ALLUVIUM (Santa Fe Group) Continued
180			14		180'-190' Not enough returns of cuttings to collect a sample. Clay comprises 100% of the few cuttings circulated to the surface. Drills like clay.
185			17		
190			17.5		190'-210' One sample collected for 20' interval.
195			7		190'-370' Grayish orange (10YR 7/4) to grayish brown (5YR 3/2); cuttings average 0.1 inch diameter, maximum 0.3 inch diameter, rounded to angular; moderate sorting. Poorly consolidated (?). Conglomerate containing silts through gravels ± cobbles. Boulders (?) occur where drilling rates decrease significantly (as noted below). Cutting lithologies include colorless quartz, grayish black (N2) limestone, dusky red (5R 3/4) siltstone, light gray (N7) chert, moderate brown (5YR 3/4) sandstone, white (N9) rhyolite, pale purple (5P 6/2) to grayish purple (5P 4/2) andesite and light brown (5YR 6/4) caliche.
200			3.5		
205			5.5		205'-210' Drilling rate decreases, greater amounts of cobbles ± boulders present (?).
210			18.5		210'-220' One sample collected for 10' interval.
215			2.5		
220			5		
225			6		225'-330' Drilling rate decreases, greater amounts of cobbles ± boulders present (?).
230			24		230'-270' One sample collected for each 20' interval.
235			2.5		
240			3		
245			2.5		

Depth	Visual %	Lith	Drilling Time Scale: min.	Sample Type and Interval	Lithologic Description
					ALLUVIUM (Santa Fe Group) Continued
245			2.5		245'-250' Drilling rate decreases, greater amounts of cobbles ± boulders present (?).
250			15		
255			3		
260			3		
265			3		
270			3		270'-285' Drilling rate decreases, greater amounts of cobbles ± boulders present (?).
					270'-290' One sample collected for each 10' interval.
275			5.5		
280			16		
285			12		
290			3		290'-350' One sample collected for each 20' interval.
					290'-360' Orejon andesite comprises significant amount of volcanic constituent (~ 50%). Color of Orejon ranges from pale purple (5P 6/2) to grayish purple (5P 4/2).
295			4		
300			4		
305			4		
310			4		

Depth	Visual %	Lith	Drilling Time Scale: min.	Sample Type and Interval	Lithologic Description
					ALLUVIUM (Santa Fe Group) Continued
310			4		
315			3		
320			5		
325			6		
330			6		
335			2.5		
340			3		
345			5.5		
350			5		350'-360' Resume 5' sample intervals.
355			3.5		
360			11.5		359'-362' Drill through large boulder. 360'-380' One sample collected for each 10' interval. 360'-490' Orejon andesite comprises significant component of cuttings.
365			40		
370			9		370'-490' Medium dark gray (N4) to grayish brown (5YR 3/2); cuttings average ≤ 0.1 inch diameter, maximum 0.25 inch diameter, subangular to angular; well sorted. Consolidated (?). Gravelly sandstone (?). Andesite cuttings contain epidote alteration of feldspars and matrix.
375			5		

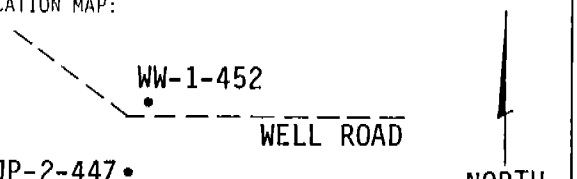
Depth	Visual %	Lith	Drilling Time Scale: min.	Sample Type and Interval	Lithologic Description
375			5		370'-490' ALLUVIUM (Santa Fe Group) Continued: Lithologies include colorless quartz, dark gray (N3) limestone, dusky red (5R 3/4) siltstone, medium gray (N5) to light gray (N7) chert, dark yellowish brown (10YR 4/2) sandstone, white (N9) to dark yellowish orange (10YR 6/6) rhyolite and grayish purple (5P 4/2) to medium bluish gray (5B 5/1) andesite.
380			5		380'-390' Resume 5' sample interval.
385			6		
390			6		390'-400' One sample for 10' interval.
395			3		
400			9		400'-440' Resume 5' sample interval.
405			6		
410			6		
415			3		
420			4		
425			4		
430			4.5		
435			2.5		
440			7		

LOCATION ID: JP-1-424

Depth	Visual %	Lith	Drilling Time Scale: min.	Sample Type and Interval	Lithologic Description
					ALLUVIUM (Santa Fe Group) Continued
440			7		440'-450' One sample for 10' interval.
445			3.5		
450			7.5		450'-460' Resume 5' sample interval.
455			5.5		
460			4.5		460'-470' One sample for 10' interval.
465			3.5		
470			3.5		470'-490' One sample for 20' interval, poor sample.
475			3.5		
480			3.5		
485			3.5		
490			6		Total Depth = 490'.
495					
500					
505					

LITHOLOGIC LOG

LOCATION MAP:



NE 1/4 NE 1/4 NE 1/4 SE 1/4 S 6 T 21S R 3E

SITE ID: NASA-WSIF LOCATION ID: JP-2-447

SITE COORDINATES (ft.):

N 225325.05 E 397477.96

GROUND ELEVATION (ft. MSL): 4446.17 (Brass Cap)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: AIR-FOAM ROTARY

DRILLING CONTR.: LARJON

DATE STARTED: 2 AUGUST 1988 DATE COMPLETED: 15 AUGUST 1988

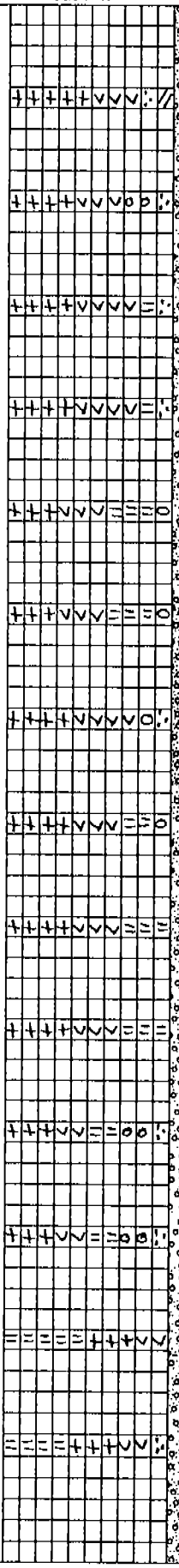
FIELD REP.: J. KIRBY, R. COOPER

COMMENTS: 9 7/8" pilot hole 0'-110', 14 3/4" borehole 0'-110', 9 7/8" borehole 110'-470'. Total depth = 470. Top of bedrock not reached.

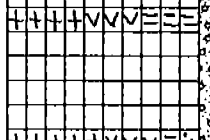
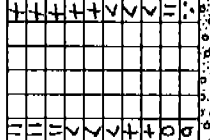
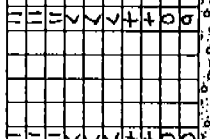
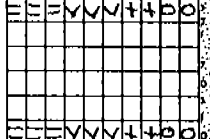
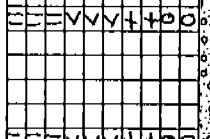
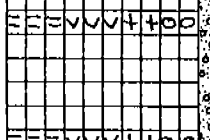
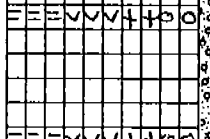
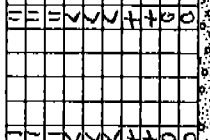
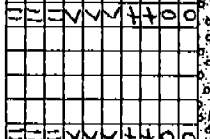
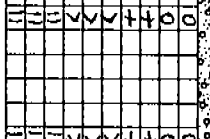
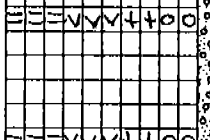
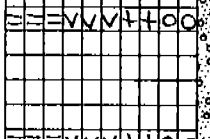
LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			3	0'-470' cuttings	0'-470' SANTA FE GROUP ALLUVIUM: Unwashed samples are moderate orange pink (5YR 8/4) to light brown (5YR 6/4) due to clay and/or matrix content. Washed samples have varied color due to different lithologies of the cuttings but have an overall color of medium gray (N5) to dark gray (N3). Cuttings range in size from silt size (<0.5 mm, <0.02 inches) to 10 mm (0.4 inches). The average cutting size is between 2 and 3 mm (0.08-0.12 inches). Cuttings are rounded to angular. Subrounded to rounded cuttings are smaller, whole clasts from the alluvium. A poorly- to moderately-consolidated, pebble to cobble alluvium with intermittent clay and caliche zones. Alluvium contains clasts of light gray (N7) to grayish black (N2) micritic limestone with < 10% allochems; white (N1) calcite; white (N9) and red and white mottled rhyolite with varying amounts of iron staining; light olive gray (5Y 3/2) and very dark red (5R 2/6) andesite with some pyroxene alteration to epidote; translucent bluish white (5B 9/1) to light bluish gray quartz; iron stained quartzite; iron-stained calcite-cemented quartz sandstone; moderate reddish orange (10R 6/6) to moderate reddish brown (10R 4/6) granite; moderate red (5R 4/6) to moderate reddish brown (10R 4/6) and greenish gray (5GY 6/1) to greenish gray (5G 6/1) siltstone; very pale orange (10YR 8/2) to pale yellowish brown (10YR 6/2) caliche; moderate orange pink (5YR 8/4) to light brown (5YR 6/4) clay varying from < 10% to 50% of sample. The clay from intervals containing abundant clay often forms balls when the samples are washed. Reaming in and out of borehole was necessary due to swelling clays. EZ-Mud was used in the drilling fluid to reduce the swelling. The amount of carbonate cuttings decreases, and the amount of igneous cuttings increases with depth. Amount of andesite cuttings increases significantly and rhyolite decreases slightly with depth.
10			12		
15			9		
20			3		
25			5		
30			3		
35			3.5		
40			2		
45			2		
50			3		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
50			3		5'-10' Decrease in clay content. 10'-15' Decrease in caliche content, increase in limestone content. 30'-45' Increase in clay content.
55			5		
60			2		60'-70' Increase in clay content.
65			2		
70			3		70'-75' Decrease in clay content.
75			3.5		
80			4		
85			2		
90			2.5		90'-115' Increase in amount of caliche and caliche coatings and cutting size [max. 12 mm (0.48 inches), average 5 mm (0.2 inches)].
95			2.5		
100			3		
105			2.5		
110			3		
115			5		115'-170' Slight decrease in cutting size to an average size of 3 mm (0.12 inches). This interval has intermittent caliche zones.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
115			5		
120			4		
125			10		125'-315' Abundant clay content in cuttings ranges in value from 10-50%. Caliche is also found sporadically in this interval.
130			5		
135			3.5		
140			4		
145			4		
150			4.5		
155			3		
160			4		
165			2.5		
170			3		170'-210' Slight decrease in cutting size to an average size of 1-2 mm (0.04-0.08 inches).
175			4		
180			5		

LOCATION ID: JP-2-447

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180			5		
185			5		185'-470' Igneous clasts become the predominant clast. Andesite content increases and rhyolite content decreases with depth.
190			4		
195			3		195'-210' One sample gathered for this 20' interval.
200			3		
205			7.5		
210			3		210'-230' One sample gathered for this 20' interval. Slight increase in average cutting size to 3 mm (0.12 inches).
215			2		
220			2		
225			3		
230			3		230'-250' One sample gathered for this 20' interval. Decrease in average cutting size to 1-2 mm (0.04-0.08 inches).
235			2		
240			2		
245			2.5		

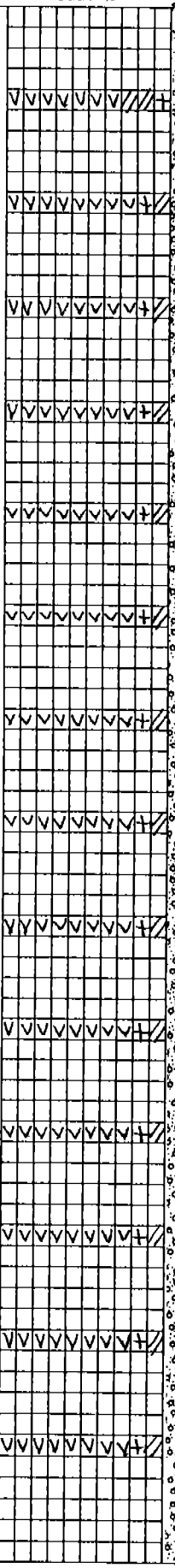
LOCATION ID: JP-2-447

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245			2.5		
250			2.5		250'-270' One sample gathered for this interval.
255			3		
260			4		
265			4		
270			4		270'-290' One sample gathered for this interval.
275			2		
280			2.5		
285			4		
290			5		290'-310' One sample gathered for this interval. First noticeable amounts of epidote in andesite cuttings.
295			2		
300			3		
305			4		
310			3		

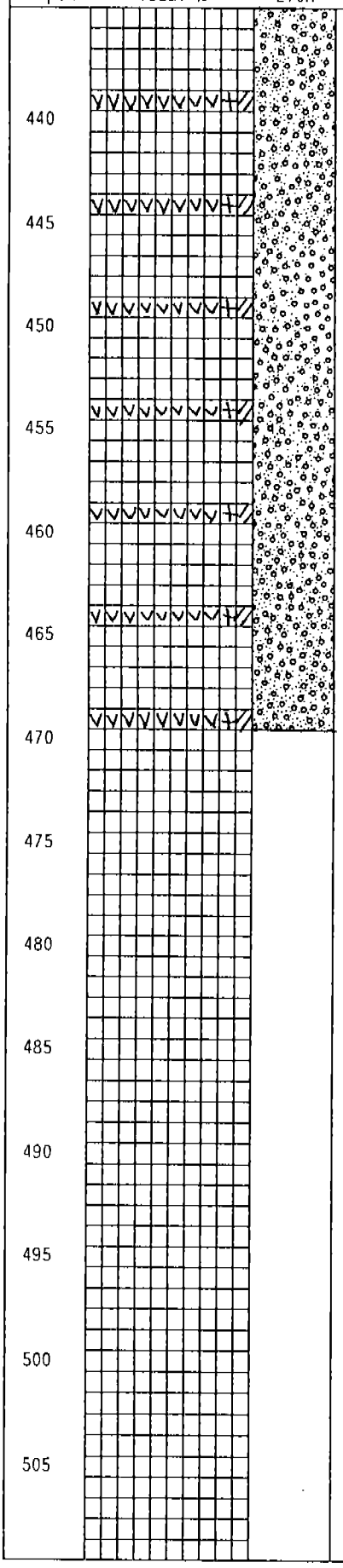
LOCATION ID: JP-2-447

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310			3		
315			7		
320			5		320'-325' Increase in average cutting size to 3 mm (0.12 inches).
325			6		325'-335' Decrease in average cutting size to 1-2 mm (0.04-0.08 inches).
330			5		
335			3		335'-355' Slight increase in average cutting size to 2-3 mm (0.08-0.12 inches).
340			7.5		
345			5.5		
350			5		
355			6		355'-365' Slight decrease in average cutting size to 1-2 mm (0.04-0.08 inches).
360			4		
365			4		365'-385' Slight increase in average cutting size to 2-3 mm (0.08-0.12 inches).
370			5		
375			2		

LOCATION ID: JP-2-447

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
375			2		
380			4		
385			4.5		385'-390' Slight increase in average cutting size to 3-4 mm (0.12-0.16 inches).
390			7		390'-450' Slight decrease in average cutting size to 2-3 mm (0.08-0.12 inches).
395			4.5		
400			4.5		
405			15		
410			4		
415			7		
420			4		
425			5		
430			6		
435			3		
440			5		

LOCATION ID: JP-2-447



Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5		
5		
6		450'-470' One sample gathered for this interval. Cutting sizes range from a silt size (<0.05 mm) to 2 mm (0.08 mm).
5		
9.5		460'-470' Heaving sands in this interval. After cuttings are blown out and the bit is raised, the bit sticks from the hole sloughing around it approximately 9 to 10 feet.
5.5		
9		Total depth = 470'.

BOREHOLE LITHOLOGIC LOG

NASA JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

Location ID: **JP-3**

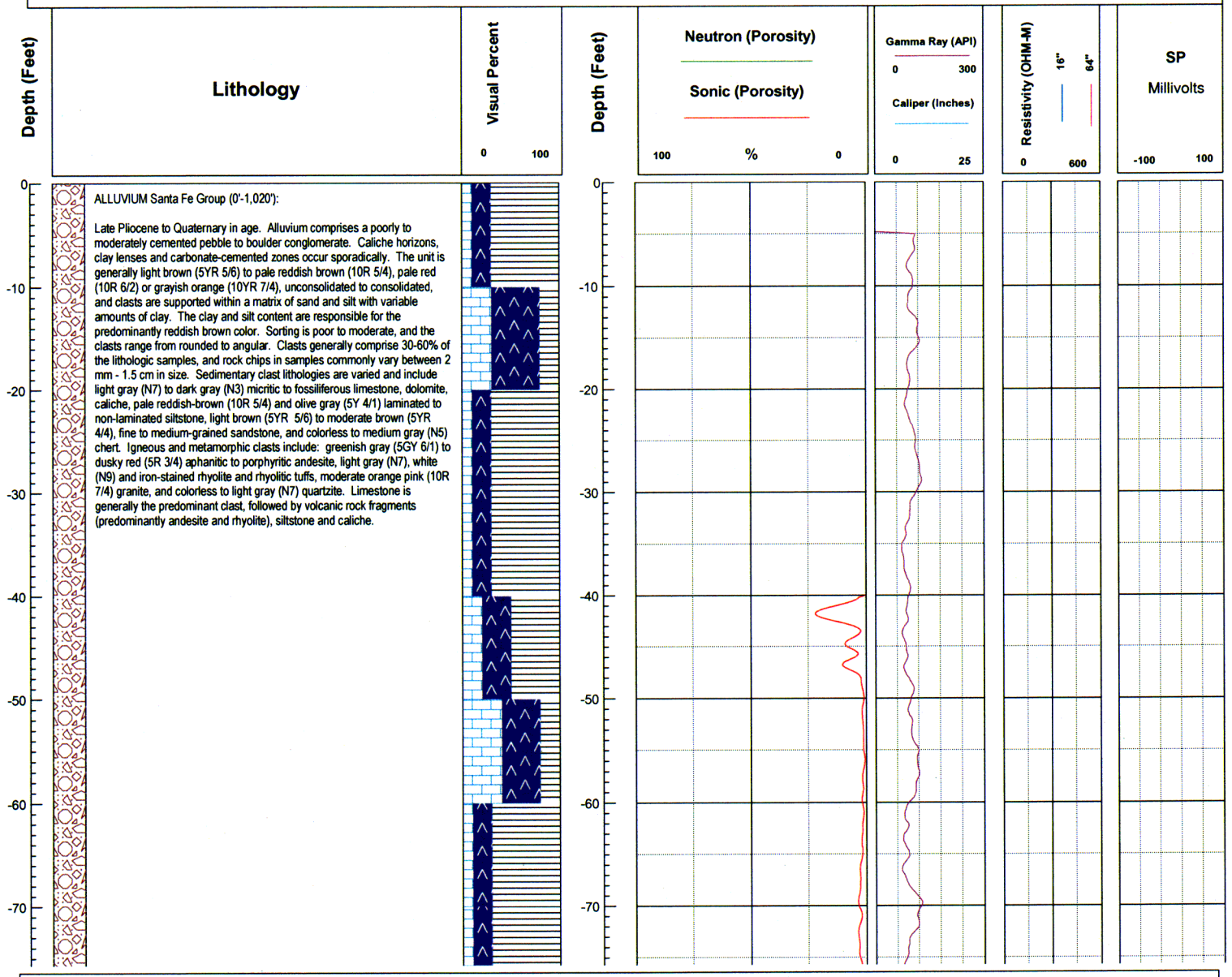
Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **NW 1/4, NE 1/4, NE 1/4, Sec 6, T21S R3E**
NM State Plane Coordinates (NAD 83): **227464.71N 396409.23E (Preliminary)**
Elevation (Brass Cap): **4433.54' (Preliminary)**
Total Depth of Borehole (bgs): **1,020'**
Depth to Bedrock (bgs): **N/A**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Paul Hollar**

Depth to Groundwater (bgs): **369.24'**
Surface Casing Depth and Diameter: **14" OD steel set to 103'**
Borehole Diameter: **12.25"**
Geologist Field Rep: **G.G., L.H.M., M.M.,**
Dates Drilling Started and Completed: **1/23/99 to 2/21/99**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Retrofit Westbay inside 4.5" OD steel**
No neutron or caliper log available.

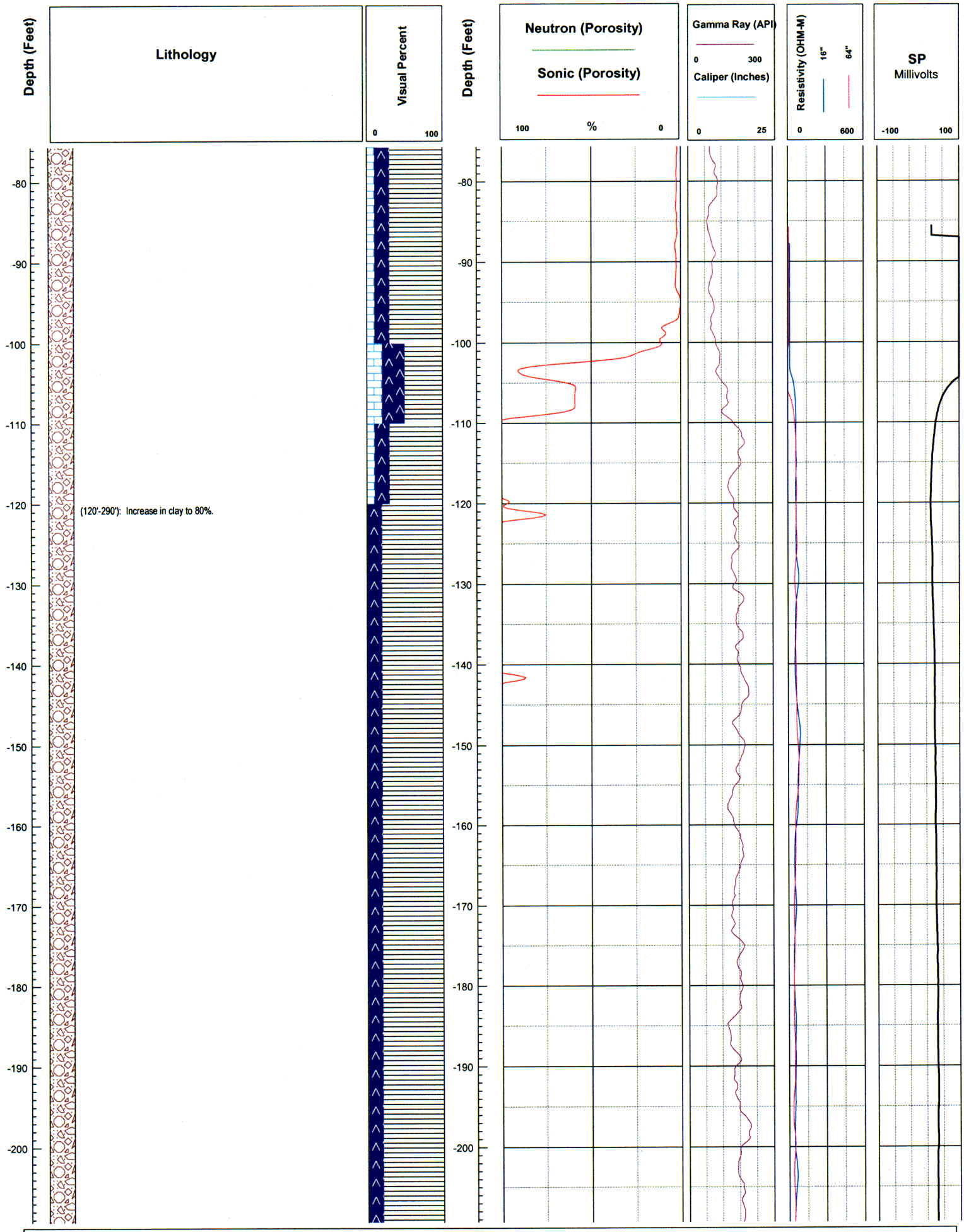
Explanation:

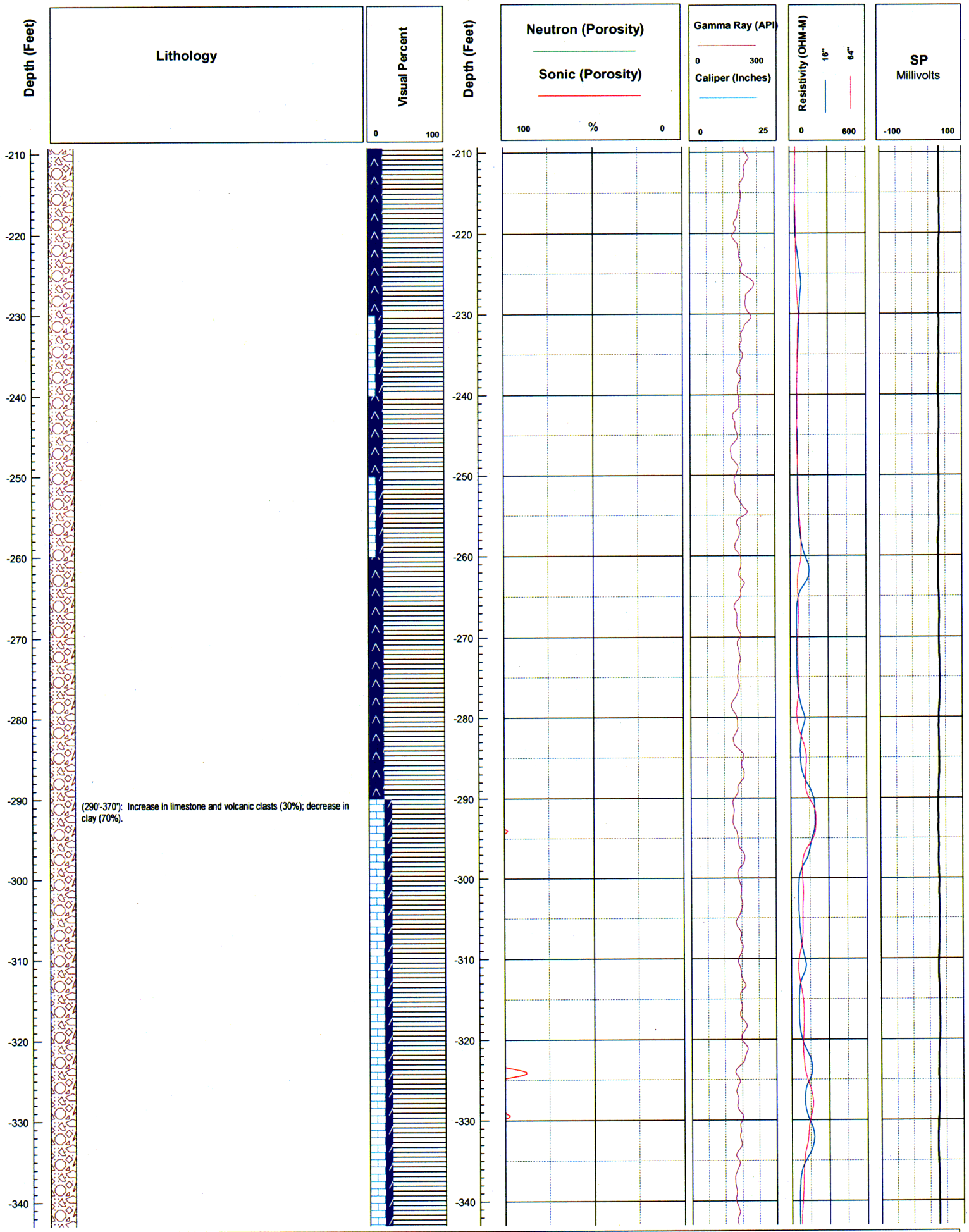
Alluvium | Volcanic Alluvium | Clay | Silt | Sand | Sandstone | Siltstone | Shale | Limestone | Rhyolite | Andesite | Undiffer. Volcanics

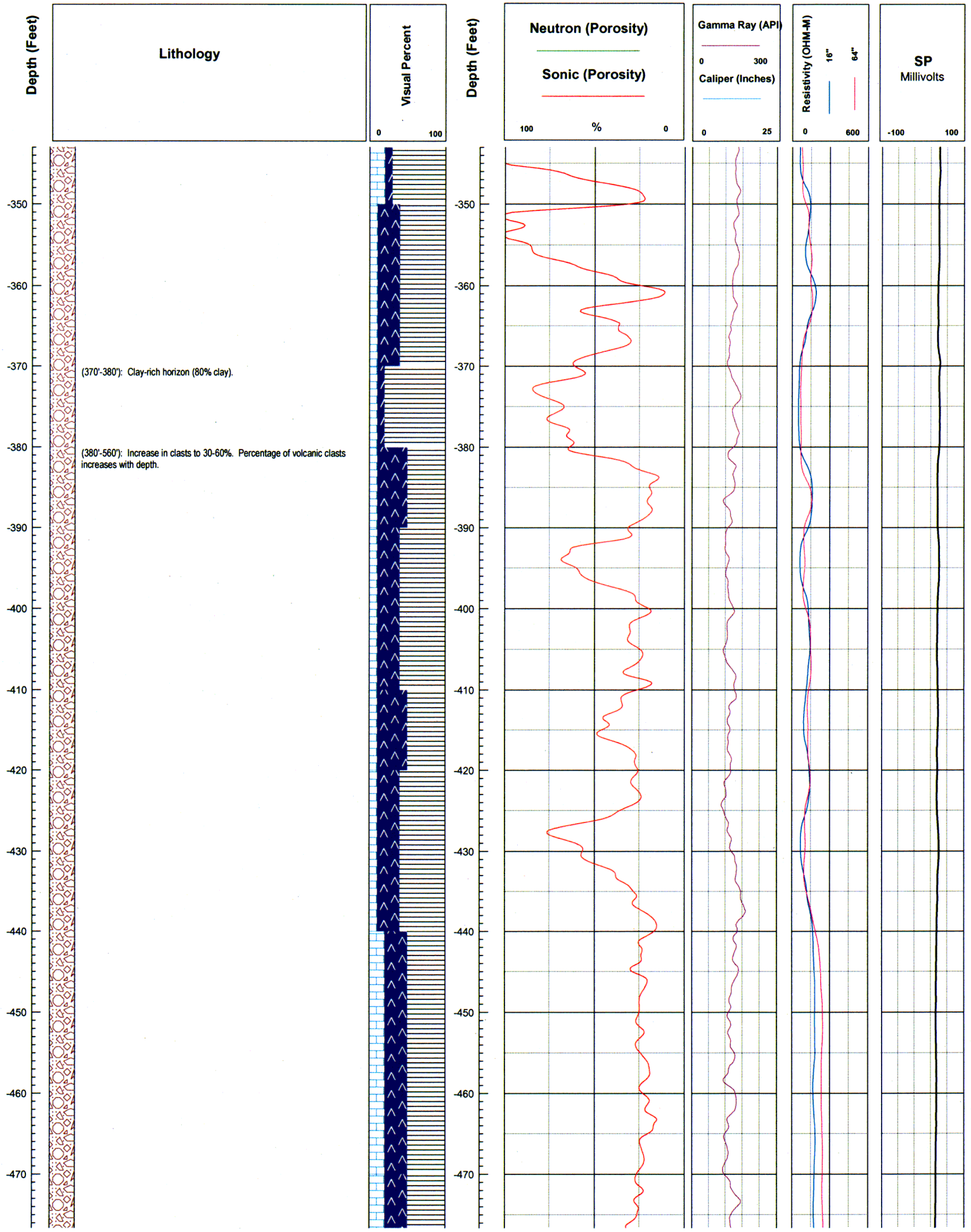


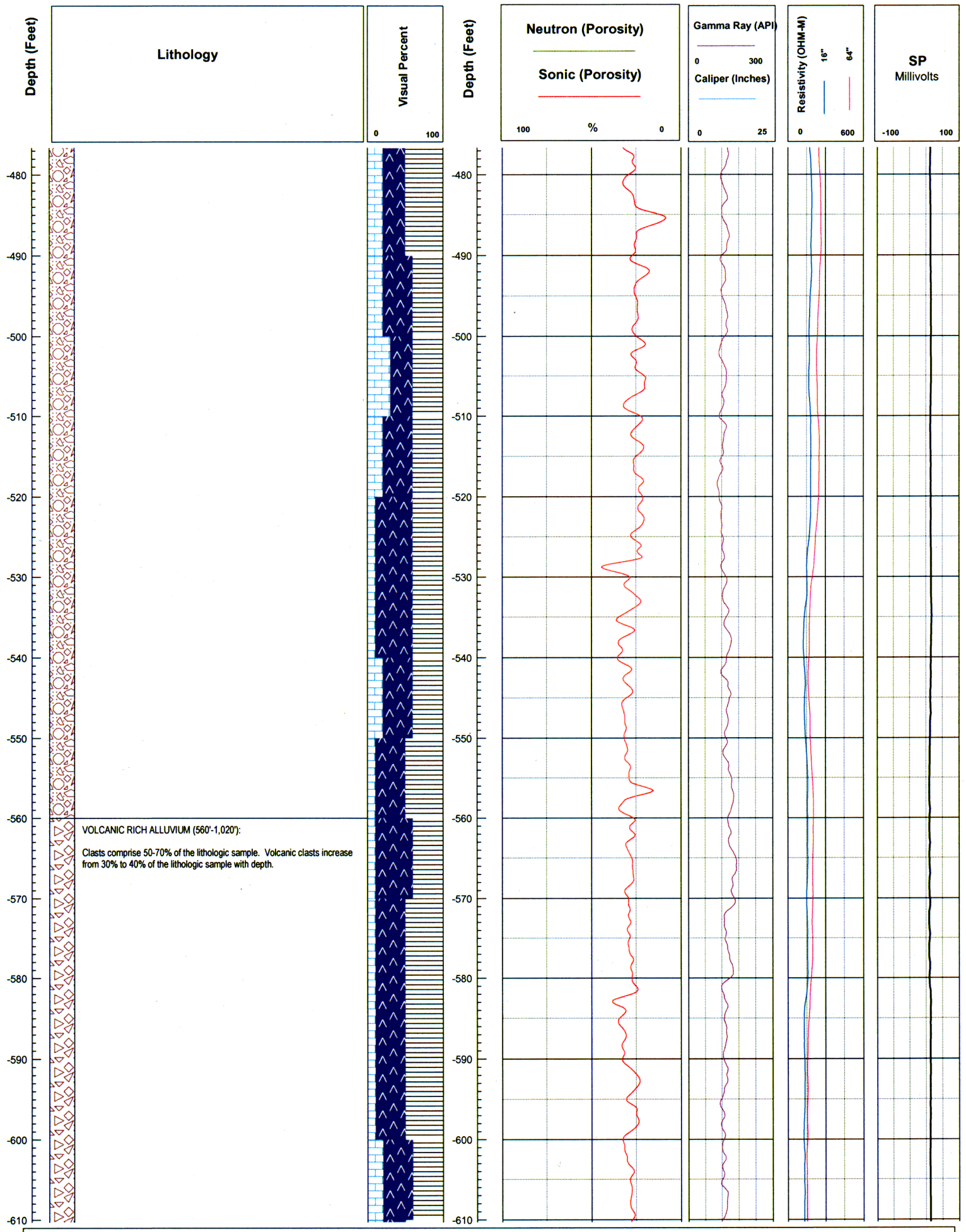
ALLUVIUM Santa Fe Group (0'-1,020'):

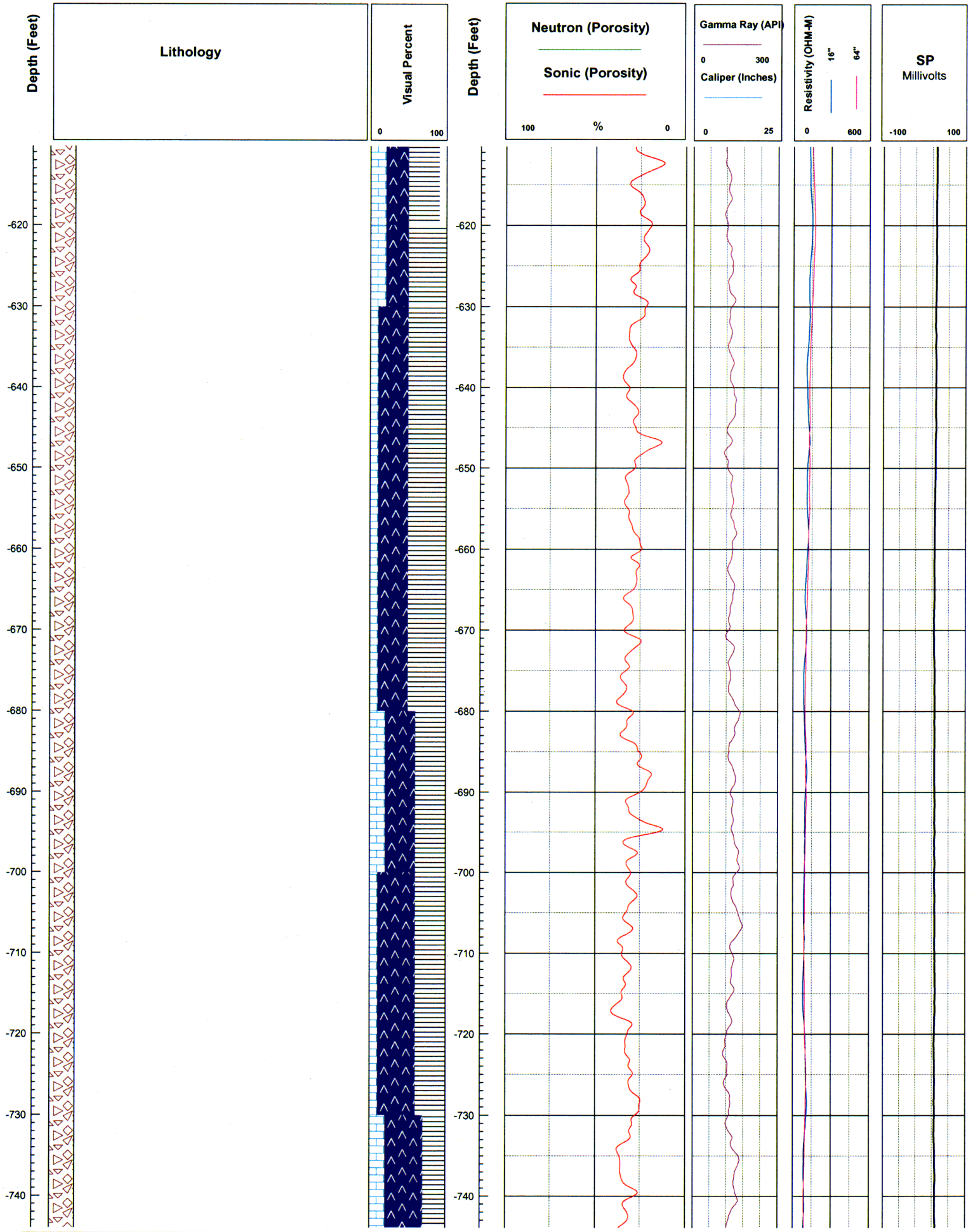
Late Pliocene to Quaternary in age. Alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Caliche horizons, clay lenses and carbonate-cemented zones occur sporadically. The unit is generally light brown (5YR 5/6) to pale reddish brown (10R 5/4), pale red (10R 6/2) or grayish orange (10YR 7/4), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay and silt content are responsible for the predominantly reddish brown color. Sorting is poor to moderate, and the clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Sedimentary clast lithologies are varied and include light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, dolomite, caliche, pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated to non-laminated siltstone, light brown (5YR 5/6) to moderate brown (5YR 4/4), fine to medium-grained sandstone, and colorless to medium gray (N5) chert. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Limestone is generally the predominant clast, followed by volcanic rock fragments (predominantly andesite and rhyolite), siltstone and caliche.

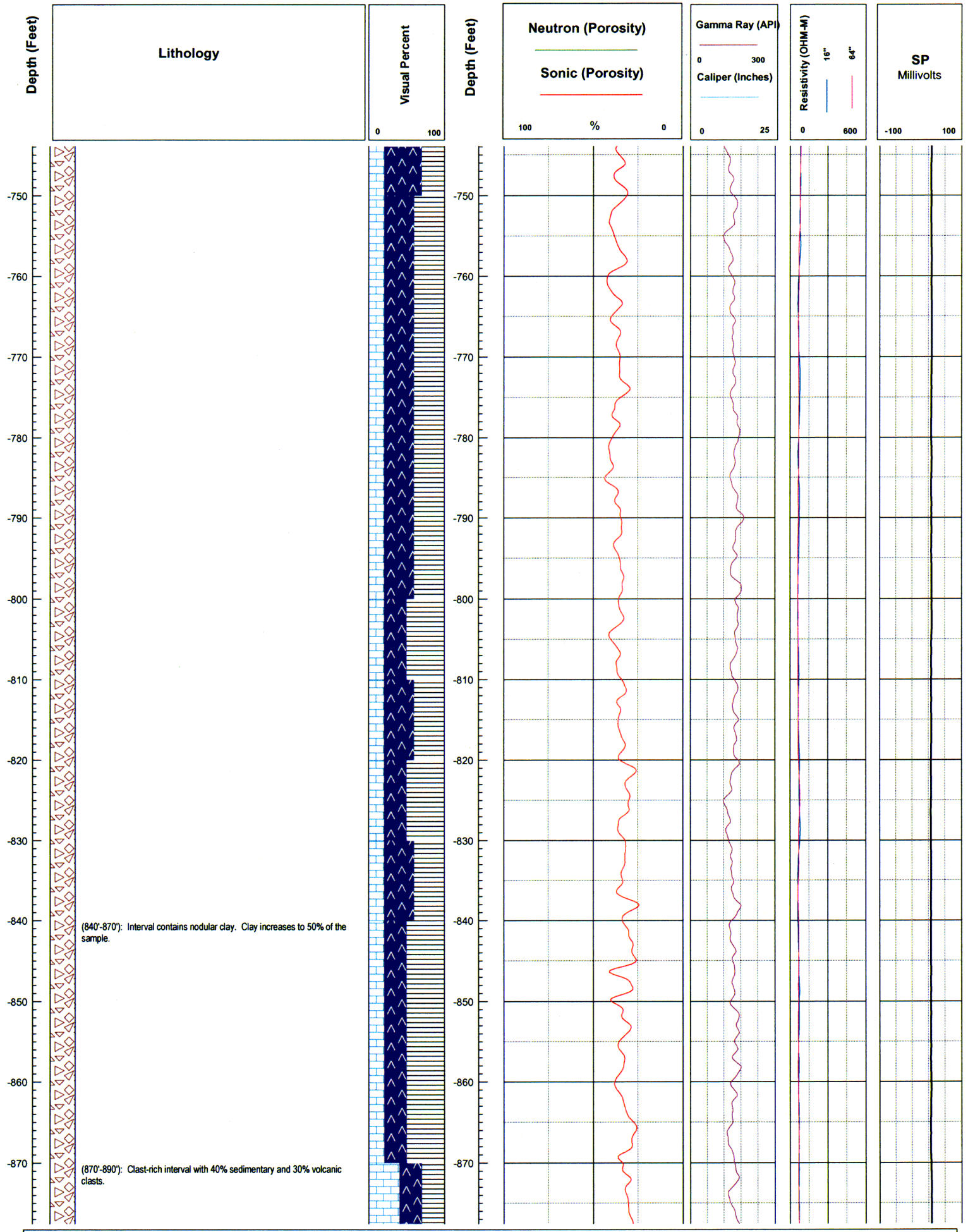

Depth (Feet)
Lithology
Visual Percent
0
100
(120'-290'): Increase in clay to 80%.
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200

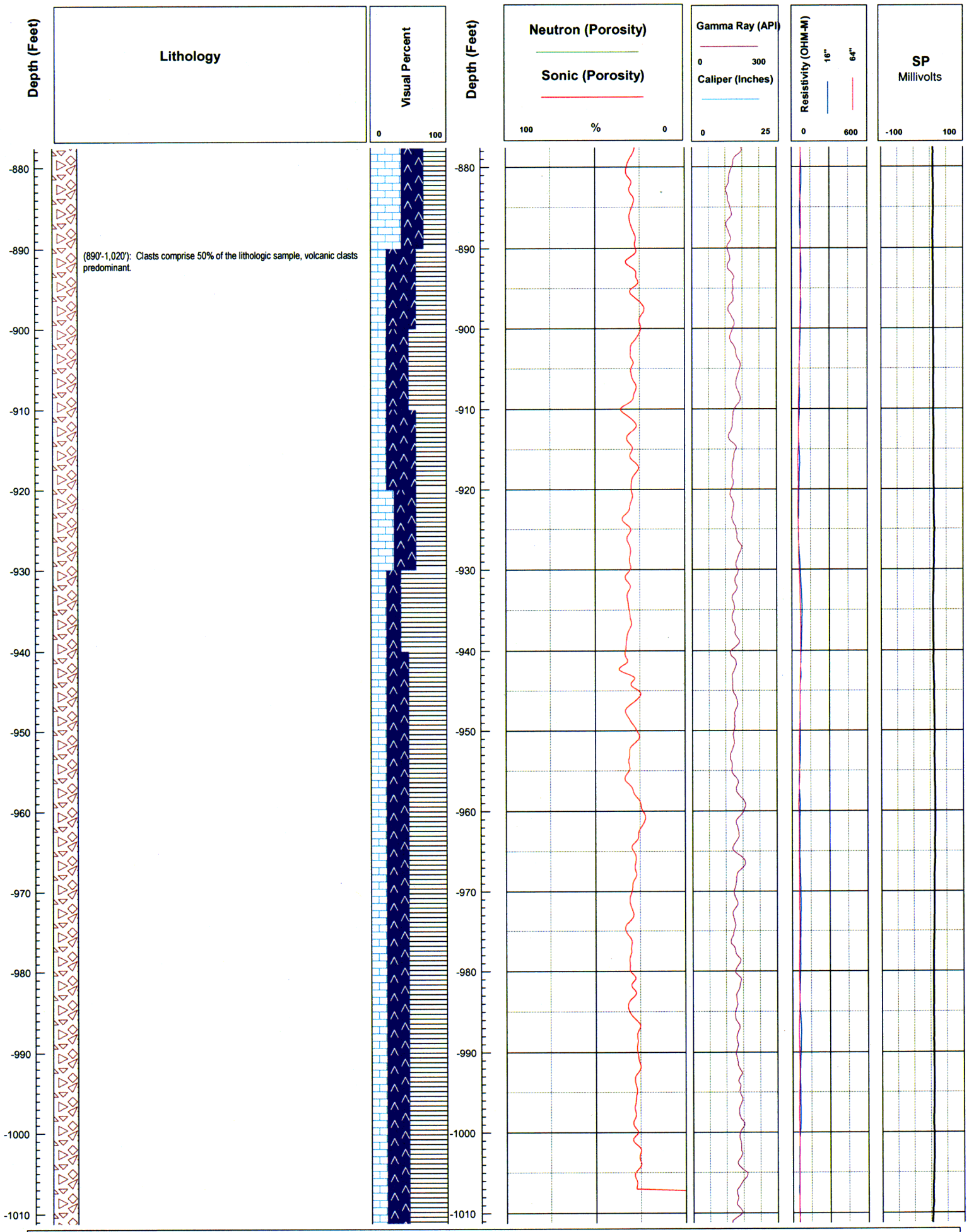

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340
(290'-370'): Increase in limestone and volcanic clasts (30%); decrease in clay (70%).

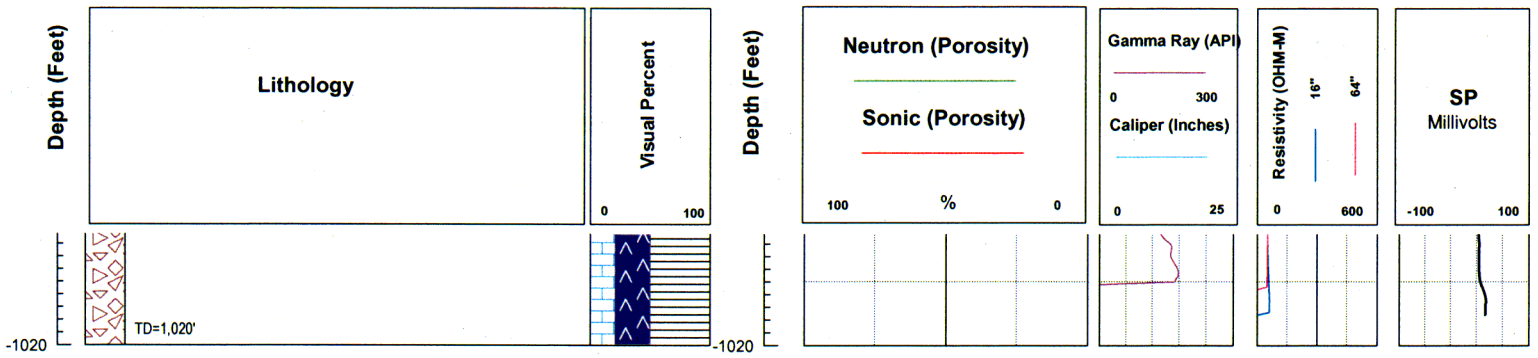

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470
(370'-380'): Clay-rich horizon (80% clay).
(380'-560'): Increase in clasts to 30-60%. Percentage of volcanic clasts increases with depth.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-480
-490
-500
-510
-520
-530
-540
-550
-560
-570
-580
-590
-600
-610
VOLCANIC RICH ALLUVIUM (560'-1,020'):
Clasts comprise 50-70% of the lithologic sample. Volcanic clasts increase from 30% to 40% of the lithologic sample with depth.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-620
-630
-640
-650
-660
-670
-680
-690
-700
-710
-720
-730
-740

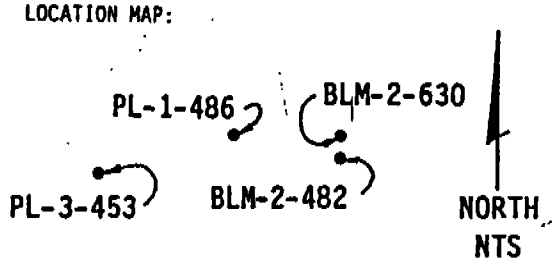

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-750
-760
-770
-780
-790
-800
-810
-820
-830
-840
-850
-860
-870
(840'-870'): Interval contains nodular clay. Clay increases to 50% of the sample.
(870'-890'): Clast-rich interval with 40% sedimentary and 30% volcanic clasts.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-880
-890
-900
-910
-920
-930
-940
-950
-960
-970
-980
-990
-1000
-1010
(890'-1,020'): Clasts comprise 50% of the lithologic sample, volcanic clasts predominant.


Depth (Feet)
Lithology
Visual Percent
0
100
-1020
TD=1,020'
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-1020

LITHOLOGIC LOG

LOCATION MAP:



NW 1/4 SW 1/4 SE 1/4 NE 1/4 S 5 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: PL-1-486
SITE COORDINATES (ft.):
N 225709.35 E 401823.62
GROUND ELEVATION (ft. MSL): 4518.14 (BRASS CAP)
STATE: NEW MEXICO COUNTY: DOÑA ANA
DRILLING METHOD: MUD & AIR-FOAM ROTARY
DRILLING CONTR.: LARJON
DATE STARTED: 7 SEPTEMBER 1988 DATE COMPLETED: 8 OCTOBER 1988
FIELD REP.: R. COOPER, J. KASZUBA
COMMENTS: 9 7/8" pilot hole reamed to 16" with mud rotary, 0'-103'. 9 7/8" bit with air-foam 103'-532'. 8" Dennison core 532'-537'. Total depth = 537'. Bedrock not encountered.
LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
				0'-532' cuttings	0'-537'	ALLUVIUM (SANTA FE GROUP): Moderate brown (5YR 4/4) to grayish brown (5YR 3/2); cuttings range in size from less than 0.1 inches to 0.40 inches and are angular to subrounded, moderately sorted. Unconsolidated to moderately consolidated (?), polygenetic, pebble to boulder conglomerate. Clay-rich zones noted below. Lithology of cuttings which represent alluvial clasts: light gray (N7) to grayish black (N2) micritic limestone recrystalized to sparite in some samples, dark reddish brown (10R 3/4) to dusky red (5R 3/4) siltstone, grayish green (10GY 5/2) siltstone, white (N9) iron-stained rhyolite, light gray (N7) rhyolite, moderate reddish brown (10R 4/6) to dark reddish brown (10R 3/4) granite, dark gray (N3) aphanitic andesite, very dark red (5R 2/6) porphyritic andesite containing phenocrysts of plagioclase less than 0.1 inches (1 to 2 mm) in diameter, light gray (N7) porphyritic andesite containing plagioclase phenocrysts which are altered to epidote, and white (N9) calcite.
5			56		0'-110'	Average cutting size ranges from 0.1 to 0.2 inches.
10			62		15'-40'	Caliche and siltstone present in amounts less than 10%.
15			10		40'-100'	Siltstone cuttings present in amounts less than 10%.
20			10			
25			20			
30			20			
35			52			
40			53			
45			26			
50			11			

LOCATION ID: PL-1-486

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
50			11		
55			20		
60			32		
65			9		
70			10		
75			48		
80			22		
85			16		
90			16		
95			30		100'-235' Penetration rates are very rapid.
100			27		100'-115' Sample predominantly composed of cement from grout (surface casing).
105			100'-110' not recorded		
110			begin drillograph		110'-150' Increase in average cutting size to 0.2 to 0.4 inches.
115			3.5		

LOCATION ID: PL-1-486

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
115			3.5		115'-125'	Clay-rich zone present.
120			3.5			
125			3.5			
130			3.5		130'-135'	Clay-rich zone present.
135			3.5			
140			3.5			
145			3.5			
150			3.5		150'-160'	Decrease in average cutting size to 0.1 to 0.2 inches.
155			3			
160			3		160'-190'	Increase in average cutting size to 0.2 to 0.4 inches.
165			3		160'-205'	Cuttings of cement present (grout caving from above).
170			4		170'-190'	Clay-rich zone present.
175			3.5			
180			3.5			

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
180			3.5			
185			3.5			
190			3.5		190'-200	Decrease in average cutting size to less than 0.1 inches.
195			3			
200			3		200'-240'	Increase in average cutting size to 0.1 to 0.2 inches.
205			3			
210			3			
215			3			
220			3			
225			3			
230			3			
235			9		230'-250'	Decrease in penetration rates, bit not turning smoothly. Drilling through boulders (?).
240			14		240'-250'	Decrease in average cutting size to less than 0.1 inches. Cuttings are predominantly angular flakes.
245			6			

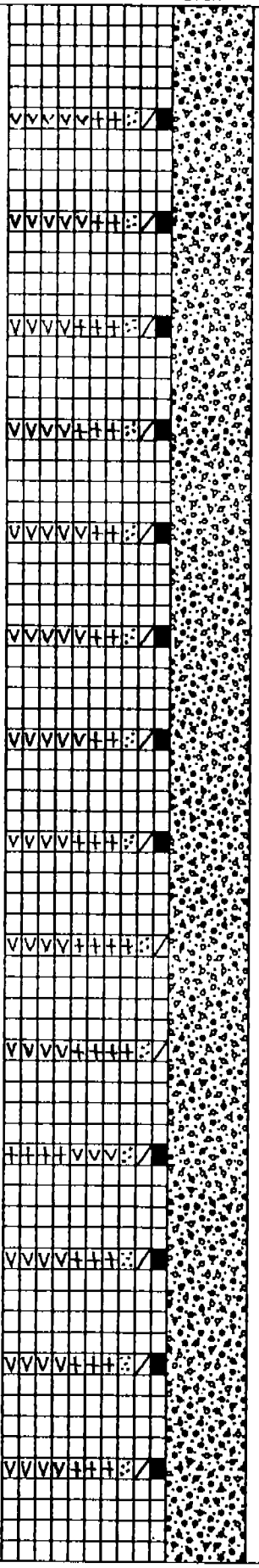
LOCATION ID: PL-1-486

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245			6		
				250'-260'	Resume rapid penetration rates
250			6	250'-270'	Increase in average cutting size to 0.1 to 0.2 inches.
255			4		
260			5	260'-530'	Decrease in penetration rates. Occasional intervals are drilled rapidly.
265			14		
270			11	270'-530'	Increased range of cutting sizes occurs as a result of drilling with stiff foam (Quik-Foam/EZ-Mud mixture).
275			10	270'-290'	Decrease in average cutting sizes to less than 0.1 inches. Cuttings range up to 0.2 inches.
280			13		
285			10		
290			8	290'-310'	Increase in average cutting size to 0.2 to 0.4 inches.
295			7		
300			7		
305			6		
310			6		

LOCATION ID: PL-1-486

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310			6		310'-390' Decrease in average cutting sizes to 0.1 to 0.3 inches.
315			4.5		
320			6		
325			5		
330			8		
335			11		335'-530' Andesite is most abundant cutting in samples as noted in visual percent column.
340			9		
345			11		
350			11		350'-375' Light gray (N7) porphyritic andesite (containing plagioclase phenocrysts altered to epidote) comprises at least half of igneous cuttings.
355			14		
360			9		
365			11		
370			15		
375			7		

LOCATION ID: PL-1-486

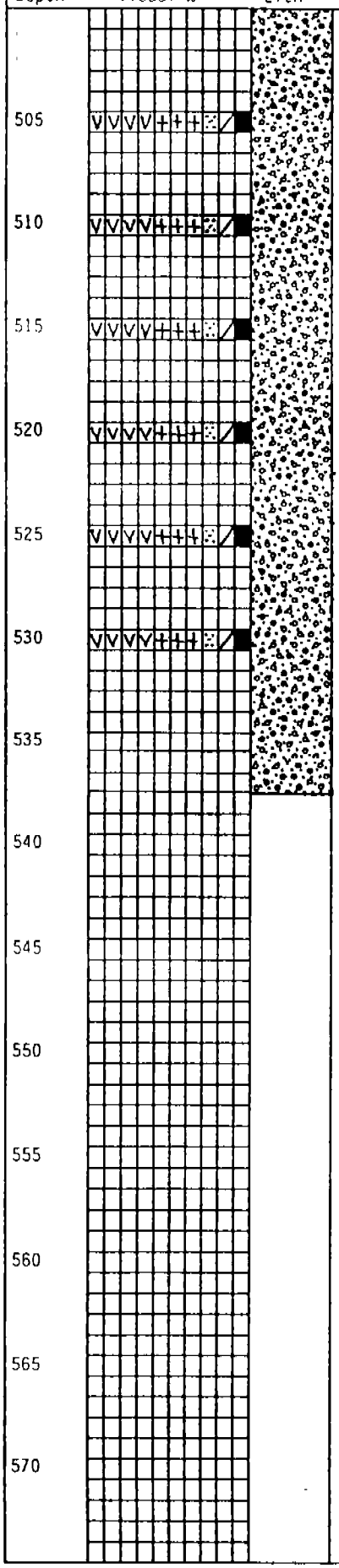


Depth	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
375	7		
380	8		
385	9		
390	4	390'-450'	Decrease in average cutting size to 0.1 to 0.2 inches. Size decrease corresponds to refilling of water truck and is probably result of thinner air-foam and EZ-mud.
395	22		
400	6		
405	8		
410	8		
415	11		
420	6		
425	6		
430	9		
435	10		
440	9		

LOCATION ID: PL-1-486

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
440			9		
445			11		
450			6		450'-470' Increase in average cutting size to 0.1 to 0.3 inches. Cutting size increase corresponds to addition of more Quik-Foam to drilling fluid (more viscous fluid circulates larger cuttings to surface).
455			7		
460			7		
465			7		
470			5		470'-490' Decrease in average cutting size to 0.1 inches. Cutting size decrease corresponds to a thinning of drilling fluid from water-bearing zone. Thinner foam does not lift coarse cuttings.
475			4		
480			7		
485			11		
490			7		490'-510' Increase in average cutting size to 0.1 to 0.2 inches. Cutting size increase corresponds to addition of Quik-Foam to drilling fluid.
495			3		
500			3		
505			8		

LOCATION ID: PL-1-486



Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
8			
5		510'-515'	Decrease in average cutting size to 0.1 inches.
6		515'-530'	Increase in average cutting size to 0.1 to 0.2 inches.
5			
6			
3	532'-537' core	532'-537'	****core interval**** see attached description
End Drillograph		Total Depth = 537'.	

NASA JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

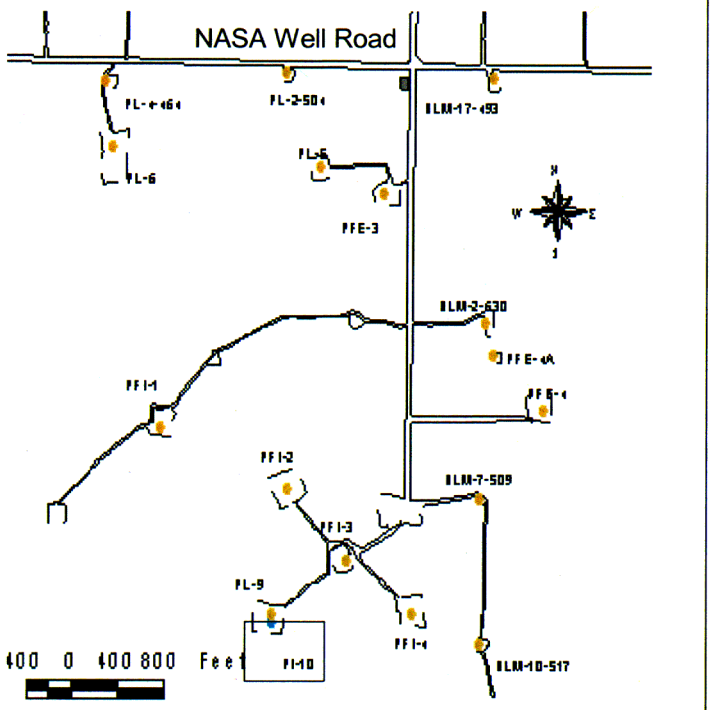
Lynx, Ltd.

Location ID: **PL-10** Site ID: **NASA-WSTF**

Location Map

County and State: **Dona Ana County, New Mexico**
Township and Range: **SE 1/4, SW 1/4, SE 1/4, Sec 5, T21S R3E**
Site Coordinates: **3597417.83N 344621.92E**
Elevation (Brass Cap): **Pending**
Total Depth of Borehole: **1,025'** Driller: **Gabe Cardenas**
Depth to Bedrock: **N/A**
Depth to Groundwater: **439.82'**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Surface Casing Depth and Diameter: **14" OD Steel set to 112'**
Hole Diameter: **12.25"**
Lynx Field Reps: **M.C., G.G., J.P., M.S., L.H.M., R.W.**
Drilling Date Start and Completed: **7/01/02 to 7/26/02**
Geophysical Contractor and Logger:
Southwest Geophysical Services Inc. Mick Peterson

Comments: **MP 55 Replacement Well for PL-9**



Explanation

Alluvium | Volcanic Alluvium | Limestone | Clay | Volcanics | Sand

Depth (Feet)

Lithology

Visual Percent 0 100

Depth (Feet)

Neutron (Porosity) 60 0
Sonic (Porosity)

Gamma Ray (API) 0 200
Caliper (Inches) 11 21

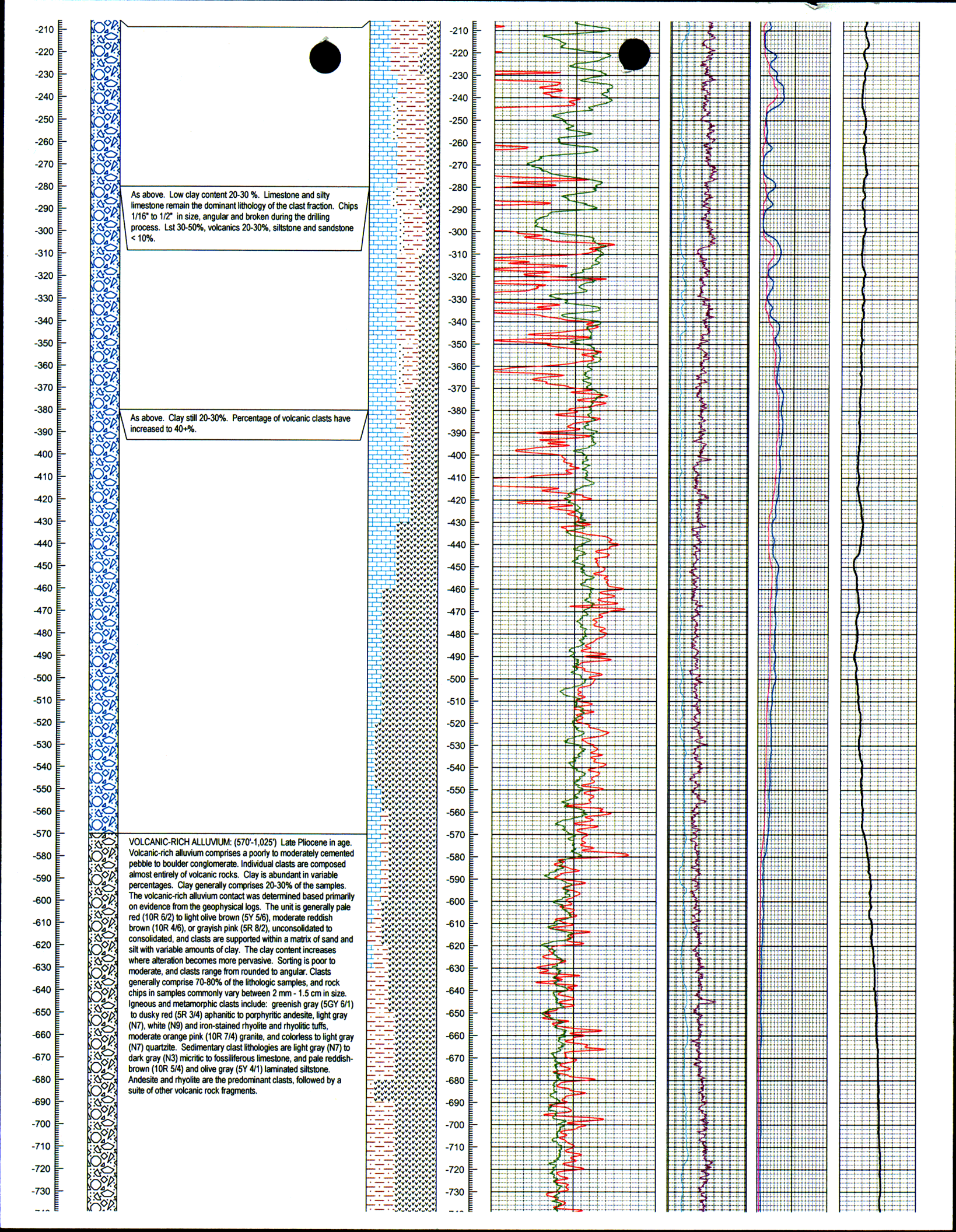
Resistivity (OHM-M) Short Normal Long Normal 0 200

SP Millivolts 25 125

ALLUVIUM: Santa Fe Group (0-570') Late Pliocene to Quaternary in age. Alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Caliche horizons, clay lenses and carbonate-cemented zones occur sporadically. The unit is generally light brown (5YR 5/6) to pale reddish brown (10R 5/4), pale red (10R 6/2) or grayish orange (10YR 7/4), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. Clay generally comprises 30-60% of the samples. The clay and silt content are responsible for the predominantly reddish brown color. Sorting is poor to moderate, and the clasts range from rounded to angular. Clasts generally comprise 40-70% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Sedimentary clast lithologies are varied and include light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, dolomite, caliche, pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated to non-laminated siltstone, light brown (5YR 5/6) to moderate brown (5YR 4/4), fine to medium-grained sandstone, and colorless to medium gray (N5) chert. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Limestone is generally the predominant clast, followed by volcanic rock fragments (predominantly andesite and rhyolite), siltstone and caliche.

As above. Moderate clay content 40-50 %

0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200


As above. Low clay content 20-30 %. Limestone and silty limestone remain the dominant lithology of the clast fraction. Chips 1/16" to 1/2" in size, angular and broken during the drilling process. Lst 30-50%, volcanics 20-30%, siltstone and sandstone < 10%.
As above. Clay still 20-30%. Percentage of volcanic clasts have increased to 40+%.
VOLCANIC-RICH ALLUVIUM: (570'-1,025') Late Pliocene in age. Volcanic-rich alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Individual clasts are composed almost entirely of volcanic rocks. Clay is abundant in variable percentages. Clay generally comprises 20-30% of the samples. The volcanic-rich alluvium contact was determined based primarily on evidence from the geophysical logs. The unit is generally pale red (10R 6/2) to light olive brown (5Y 5/6), moderate reddish brown (10R 4/6), or grayish pink (5R 8/2), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay content increases where alteration becomes more pervasive. Sorting is poor to moderate, and clasts range from rounded to angular. Clasts generally comprise 70-80% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Sedimentary clast lithologies are light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, and pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated siltstone. Andesite and rhyolite are the predominant clasts, followed by a suite of other volcanic rock fragments.
-210
-220
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-250
-260
-270
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-330
-340
-350
-360
-370
-380
-390
-400
-410
-420
-430
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-470
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-550
-560
-570
-580
-590
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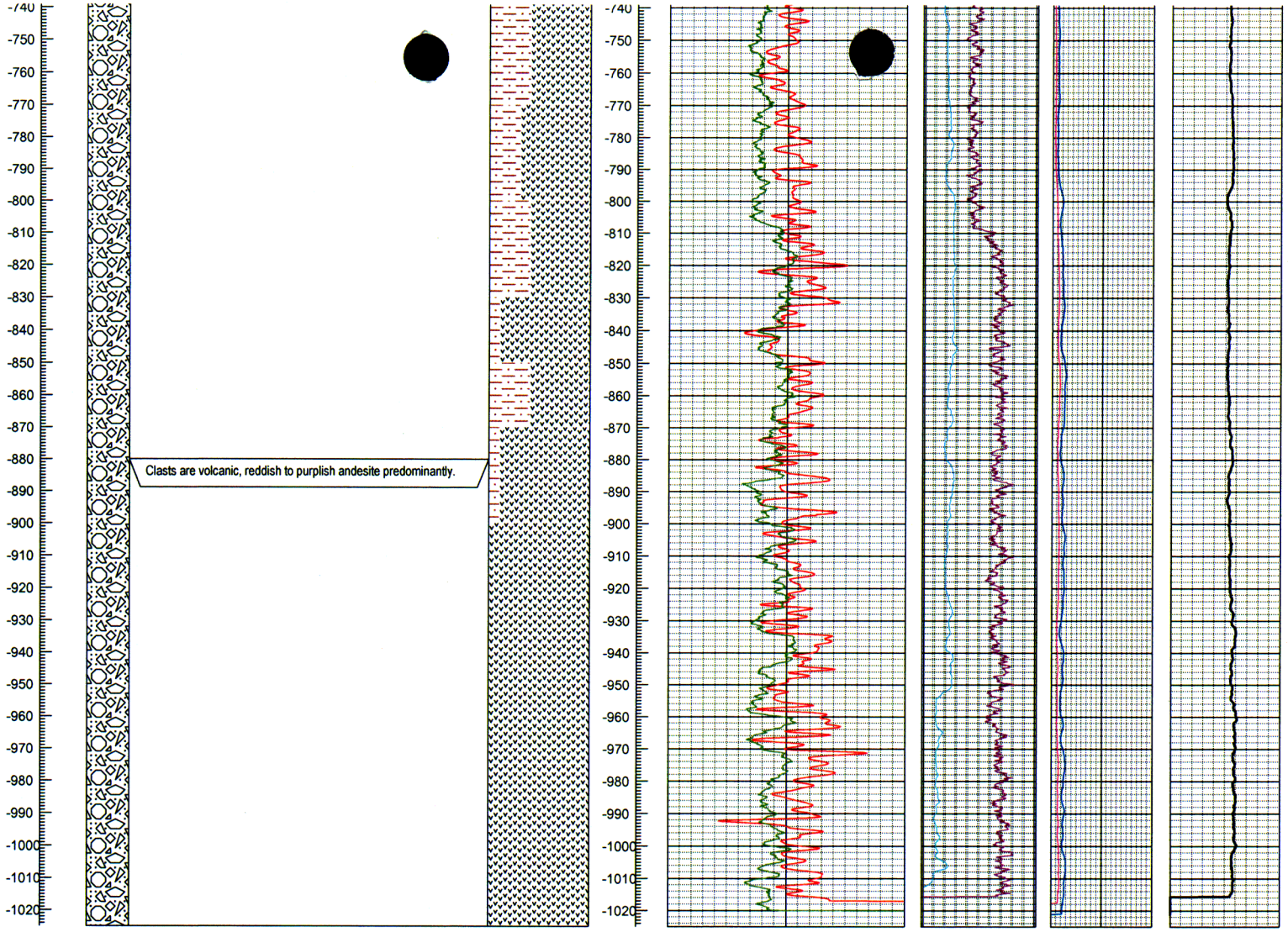
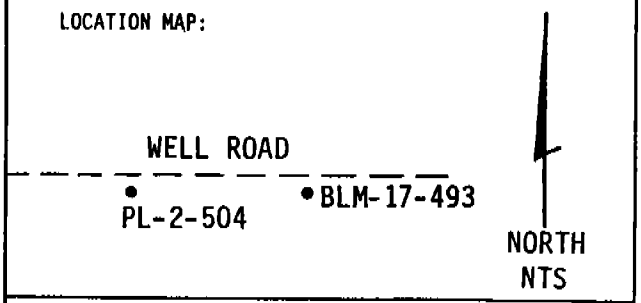
-680
-690
-700
-710
-720
-730


-740
-750
-760
-770
-780
-790
-800
-810
-820
-830
-840
-850
-860
-870
-880
-890
-900
-910
-920
-930
-940
-950
-960
-970
-980
-990
-1000
-1010
-1020
Clasts are volcanic, reddish to purplish andesite predominantly.

LITHOLOGIC LOG

LOCATION MAP:



NE 1/4 NE 1/4 NW 1/4 NE 1/4 S 5 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: PL-2-504

SITE COORDINATES (ft.):

N 227742.47 E 401193.52

GROUND ELEVATION (ft. MSL): 4508.04 (BRASS CAP)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: MUD/AIR-FOAM ROTARY

DRILLING CONTR.: LARJON

DATE STARTED: 22 SEPT. 88 DATE COMPLETED: 28 NOV. 88

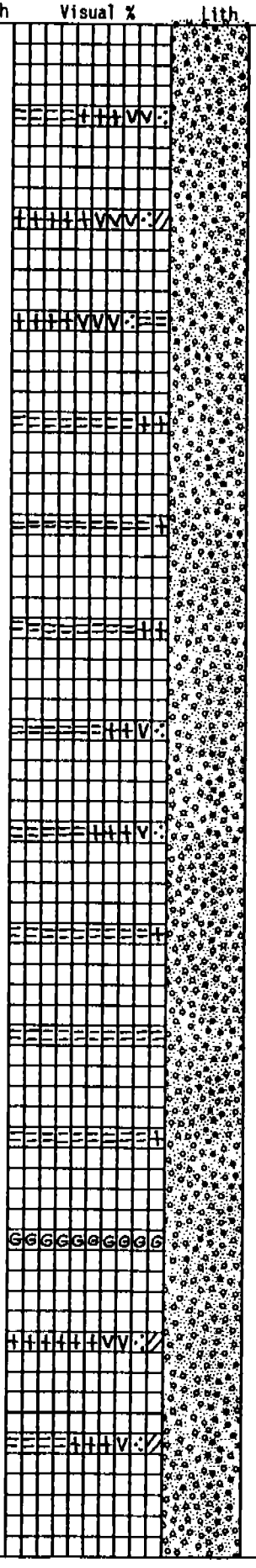
FIELD REP.: P. S. EGAN

COMMENTS: 9 7/8" pilot hole reamed to 16" with mud rotary, 0-100'. 9 7/8" bit with air foam, 100'-532', Total Depth (TD) = 532'. Bedrock not reached. Borehole drift = 29'.

LOCATION DESCRIPTION:

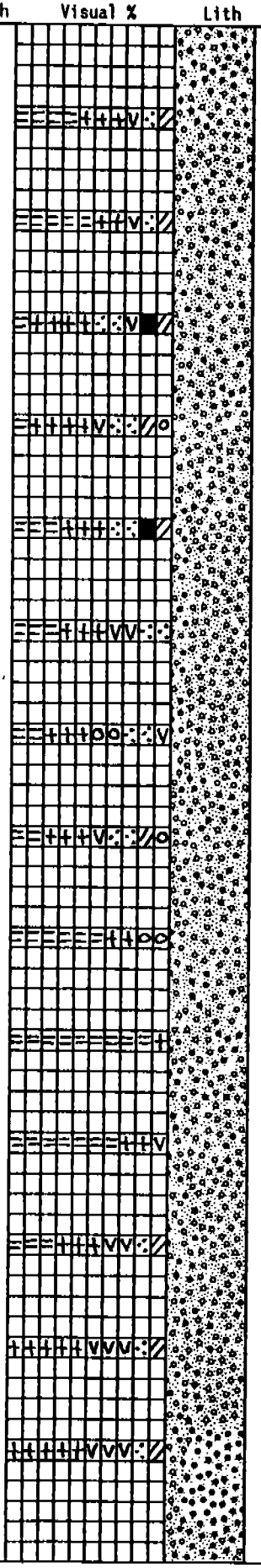
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
				0'-532'(TD) cuttings	0'-5'	Surficial Caliche: Grayish pink (5R 8/2) to yellowish gray (5Y 8/1). Small amount of caliche in cuttings but surface of well pad exhibits chalky dust and large clasts of caliche. Extremely long drilling time for first 5'.
5			68			
10			19		5'-532'	Gravelly Alluvium (Santa Fe Group): Dusky yellowish brown (10Y 2/2) to moderate yellowish brown (10YR 5/4) when clay content is high. Cuttings range in size from less than .1 to .8 inches, are angular to subrounded and poorly sorted. Natural grains are up to .2 inches in size, are subangular to rounded and poorly-sorted. The alluvium is unconsolidated in the upper portion but consolidated to semi-consolidated in the lower portions (variations in drilling time). The lithology is an unconsolidated to consolidated, gravelly to boulder (longer drill times, bit behavior), polygenetic conglomerate. Cutting lithologies are grayish black (N2) to medium light gray (N6) micritic limestone with occasional calcite-filled fractures less than .1 to .2 inches thick, white (N9) to moderate red (5R 5/4) rhyolite which frequently exhibits oxidation rims around phenocrysts of magnetic or pyrite, dusky red (5R 3/4) to grayish olive (10Y 4/2) siltstone, moderate red (5R 4/6) granite, light gray (N7) to translucent quartz and quartzite, medium gray (N5) and grayish purple (5P 4/2) porphyritic andesite containing euhedral to subhedral phenocrysts of white plagioclase, frequently altered to moderate yellow green (5GY 7/4) epidote, and minor amounts of sandstone and caliche. Thick clay layers occur throughout the upper section of the alluvium. Caliche is present as hard pan at the surface and lesser amounts as thin lenses or coatings on clasts throughout the section.
15			12			
20			13			
25			24			
30			41			
35			17			
40			57			
45			42			
50			30			

LOCATION ID: PL-2-504



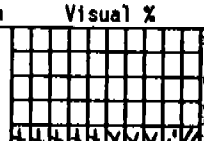
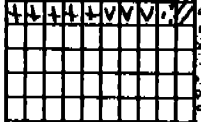
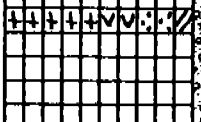
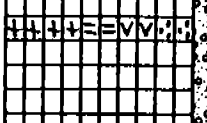
Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
		10'-15'	Clay-rich interval.
30		10'-50'	Increase in average cutting size to .4 inches.
		40'-50'	Clay-rich zone. Clay is slowing drill rate.
10		50'-55'	Decrease in average cutting size to .1 inches.
		55'-60'	Increase in average cutting size to .5 inches.
42		60'-80'	Decrease in average cutting size to .4 inches.
74		65'-100'	Clay-rich interval. Clay is slowing drill rate.
9			
15			
15		80'-85'	Decrease in average cutting size to .1 inches.
19			
29			
21			
30		100'-292'	Drilling is rapid.
		100'-105'	Sample is 100% cement cuttings (from grouting of surface casing).
3 1/2			
4		110'-135'	Cuttings increase in size to .3 inches average.
3			

LOCATION ID: PL-2-504



Depth	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
115	3			
120	4 1/2		120'-125'	First occurrence of gray andesite in cuttings.
125	5			
130	4			
135	4		135'-140'	First occurrence of purple andesite in cuttings.
			135'-TD	Average cutting size remains fairly consistent at .1 to .2 inches.
140	4			
145	4			
150	5		150'-165'	Clay-rich interval.
155	5		155'-160'	Caliche, volcanics, quartzite, and siltstone present in sample but less than 10% relative to clay content.
160	4		160'-165'	Quartzite and siltstone also present but less than 10%.
165	4		165'-170'	Purple and gray andesite amount in volcanic fraction increasing, but rhyolite continues to predominate.
170	3 1/2			
175	3 1/2			
180	2 1/2			

LOCATION ID: PL-2-504

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180			2 1/2		
185			3		
190			7		190'-200' Clay-rich interval. 190'-195' Quartz also present, but less than 10% relative to clay.
195			5 1/2		195'-200' Quartz, siltstone and caliche present but less than 10%.
200			4 1/2		
205			6		
210			4 1/2		
215			3 1/2		
220			3 1/2		
225			3		
230			4 1/2		
235			5		
240			9		
245			6 1/2		

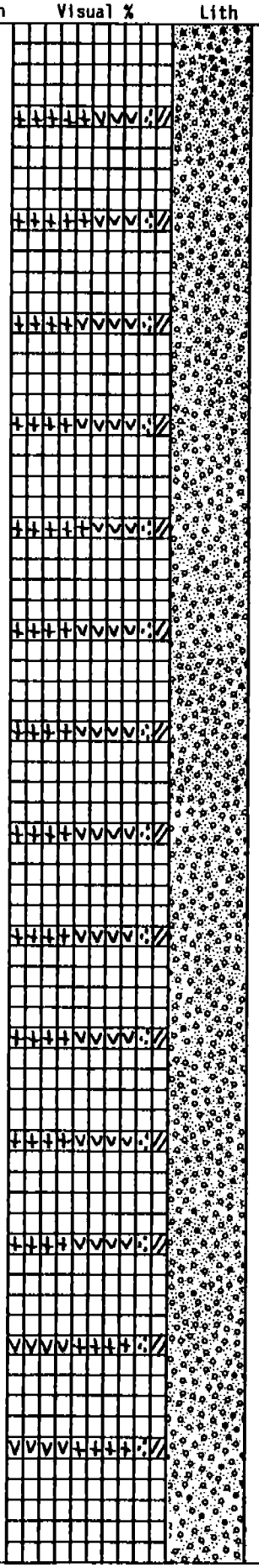
LOCATION ID: PL-2-504

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
245			6 1/2		245'-250'	Increase in the amount of andesite in the volcanic fraction to approximately 40%.
250			4			
255			4			
260			4			
265			10			
270			6		270'-275'	Increase in amount of andesite in volcanic fraction to 35%.
275			4			
280			5			
285			12		292'-532'	The average drilling rate is slower than the first 292 feet. Alluvium is becoming harder.
290			4			
295			5			
300			8			
305			7			
310			8			

LOCATION ID: PL-2-504

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310			8		
315			7		
320			8		
325			10		
330			8		
335			5		
340			7		
345			11		
350			34		
355			81		
360			14		
365			9		
370			12		
375			25		

LOCATION ID: PL-2-504

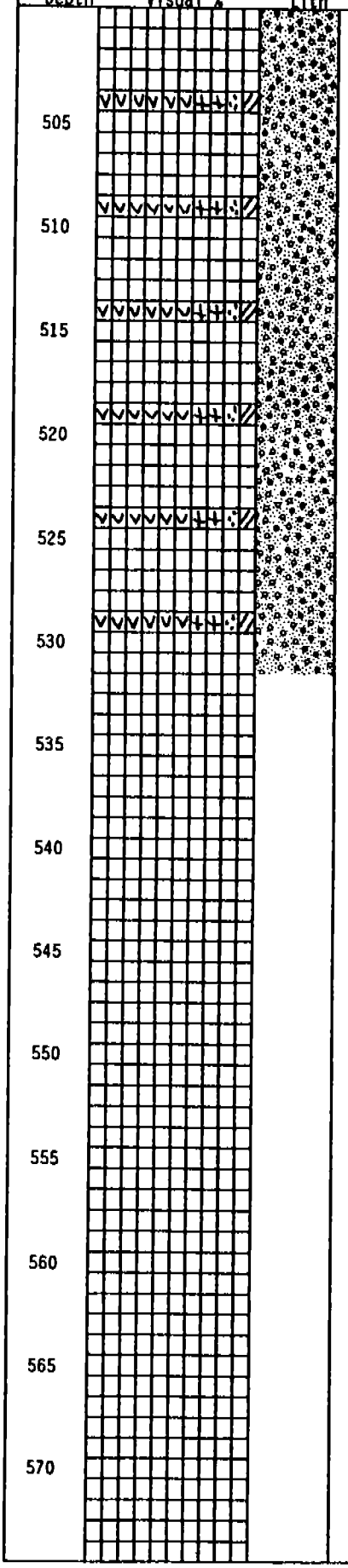


Depth	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
375	25		
380	9		
385	19		
390	15	390'-410'	Samples contain either a dark reddish brown (10R 3/4) sandstone or a highly oxidized rhyolite.
395	15		
400	7		
405	15		
410	14		
415	14		
420	8		
425	12		
430	18		
435	8	435'-532'	Volcanics have become the predominant clast.
440	4		

LOCATION ID: PL-2-504

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
440			4		
445			4		
450			3		
455			6		
460			5		
465			9		
470			7		
475			8		
480			8		
485			18		
490			14		
495			12		
500			15		
505			10		

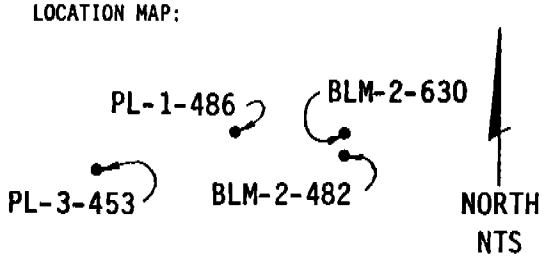
LOCATION ID: PL-2-504



Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
10	505'-532'	One sample represents this interval.
8		
12		
11		
16		
8	TD = 532'	

LITHOLOGIC LOG

LOCATION MAP:



NW 1/4 NW 1/4 NW 1/4 SE 1/4 S 5 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: PL-3-453
SITE COORDINATES (ft.):
N 225366.27 E 400579.73
GROUND ELEVATION (ft. MSL): 4496.89 (BRASS CAP)
STATE: NEW MEXICO COUNTY: DOÑA ANA
DRILLING METHOD: Mud/Air Foam Rotary
DRILLING CONTR.: Larjon
DATE STARTED: 24 October 1988 DATE COMPLETED: 9 November 1988
FIELD REP.: P.S. Egan, J.P. Kaszuba
COMMENTS: Mud rotary, 0'-89'. 12 1/4" pilot hole reamed to 16", 0'-85'. Air Foam rotary with 9 7/8" bit, 90'-297. Bedrock not reached. Total Depth (TD): 497'. Drift survey: 9.5 ft.

LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			38	Cuttings 0'-497'	0'-90' Clay-Rich Alluvium (Santa Fe Group): Moderate yellowish brown (10YR 5/4); cuttings range in size from <.004 to .06 inches, are small thin flakes to blocky clasts, and are poorly to moderately-sorted. Natural grains consist of fine to medium-grained sand and silt. The lithology is an unconsolidated, clay-rich, gravelly, polygenetic conglomerate. Much of the clay contains fine-grained sand and silt and the percentage of pure clay increases towards the bottom of the interval. Alluvial clasts consist of limestone, rhyolite, quartzite, siltstone, granite, and minor amounts of sandstone, described in further detail below.
10			42		
15			35		
20			33		
25			61		
30			49		30'-35' Gravelly interval.
35			40		
40			24		40'-45' Large amount of fine-grained sand present in clay.
45			42		
50			40		

LOCATION ID: PL-3-453

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
50			40		
55			30		
60			41		
65			22		
70			35		
75			56		
80			49		
85			33		
90			28		
95			5		
100			5		
105			4		
110			3		
115			3		

90'-497' Gravelly Alluvium (Santa Fe Group): Grayish black (N2) to medium light gray (N6) when wet. Cuttings range in size from less than .1 inches to 2 inches, are angular flakes to blocky clasts, and are poorly to moderately sorted. Natural grains are clay, silt and fine- to course-grained sand. The alluvium is unconsolidated but becomes more indurated with depth (general increase in drill time with depth). The lithology is an unconsolidated to semi-consolidated, gravelly to boulder (bit behavior), polygenetic conglomerate. Thick clay layers occur throughout the upper section of the alluvium. Driller comments alluvium is hard, consistent, and fractured. Cutting lithologies are grayish black (N2) to medium light gray (N6) micritic limestone with occasional calcite-filled fractures; white (N9) to moderate red (5R 5/4) rhyolite that exhibits iron oxidation rims around phenocrysts of pyrite; dusky red (5R 3/4) to grayish olive (10Y 4/2) siltstone; moderate red (5R 4/6) granite; transparent quartz; medium gray (N5) and grayish purple (5P 4/2) porphyritic andesite containing euhedral to subhedral phenocrysts of white plagioclase frequently altered to moderate yellow green (5GY 7/4) epidote; and minor amounts of sandstone and caliche.

90'-235' Replace Frank's mud rotary with CP air rotary drilling rig. Samples from air drilling are not exhibiting the gross amounts of clay as did the first 90' of samples from mud rotary drilling. Clay seems to be distributed throughout most samples and diminishes to less than 10% by 235'.

LOCATION ID: PL-3-453

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
115			3		
120			3		
125			3.5		
130			4.5		
135			3		
140			3		
145			3		
150			3		
155			4		
160			3		
165			4		
170			3.5		
175			3		
180			3		

LOCATION ID: PL-3-453

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
180			3		
185			3.5		185'-497' Average grain size has decreased to .1 inch.
190			5		185'-190' First occurrence of purple andesite in cuttings (only a few grains).
195			3.5		195'-200 Observed a clast of limestone cemented with caliche to a larger limestone clast. Observe caliche in cuttings. First occurrence of grey andesite.
200			3		200'-205' Notable amount of sand present in samples.
205			3		
210			3		
215			3		
220			2.5		
225			4		
230			5		
235			3		235'-497' Clay in samples has diminished to less than 10%.
240			2.5		
245			4.5		

LOCATION ID: PL-3-453

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			4.5		
250			4		
255			5		
260			8		260'-290' Samples contain abundant fine-grained sands.
265			4.5		
270			3		
275			5		
280			5		
285			3.5		
290			6		
295			4		
300			5		
305			4		
310			5		

LOCATION ID: PL-3-453

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
310			5		
315			4		
320			8		
325			6		
330			4		
335			5		
340			3.5		
345			3		
350			4		
355			4		
360			4		
365			5		
370			6		370'-375 Limestone exhibits calcite-filled fractures.
375			5		

LOCATION ID: PL-3-453

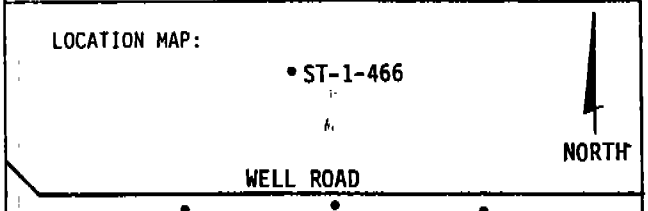
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375			5		
380			3		
385			4.5		
390			3		
395			5		
400			6.5		
405			4.5		
410			5		
415			4		
420			4		420'-497' The percentage of both gray and purple andesite in cuttings gradually increasing.
425			7		
430			4		
435			4		
440			7		

LOCATION ID: PL-3-453

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
440			7		
445			4		
450			5		
455			5		
460			3		
465			3		
470			6		
475			6		
480			6		
485			6		
490			6		
495			5		
			2		Total Depth = 497'
500					
505					

LITHOLOGIC LOG

LOCATION MAP:



NE 1/4 NE 1/4 NE 1/4 NW 1/4 S 5 T 21S R 3E

SITE ID: NASA-WSTF LOCATION ID: PL-4-464

SITE COORDINATES (ft.):

N 227645.70 E 399612.69

GROUND ELEVATION (ft. MSL): 4480.88 (B.C.)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud/Air-Foam Rotary

DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 01/03/90 DATE COMPLETED: 01/23/90

FIELD REP.: G. Contaldo

COMMENTS: 0'-55' mud rotary (12 ¼" hole reamed to 16" hole), 55'-495' air-foam rotary (9 7/8" hole). Total Depth = 495'.

LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
			Drillograph (0-55' Mud Rotary)	0-495' (cuttings)	0'-495' Alluvium (Santa Fe Group): Samples range in color from light brown (5 YR 6/4) to moderate brown (5 YR 4/4); samples comprised of cuttings which range in size from much less than 0.1 inches to 0.8 inches and average 0.3 to 0.4 inches; cuttings are rounded to angular and poorly sorted. Samples represent unconsolidated to moderately consolidated, polygenetic alluvium which contains clasts ranging in size from silts to boulders. Clays and caliche-bearing intervals which occur throughout the alluvium are noted below. Cuttings which represent lithologies of clasts occurring within the alluvium are composed of dark grey (N3) micritic limestone, moderate reddish brown (10 YR 4/6) to dusky red (5 R 3/4) siltstone, white (N9) iron-stained rhyolite, grayish pink (5 R 8/2) to moderate pink (5 R 7/4) granite, moderate brown (5 YR 4/4) to light brown (5 YR 6/4) clay, pinkish grey (5 YR 8/1) caliche, and grayish black (N2) to grayish red (10 R 4/2) andesite.
5			8		
10			7		
15			11		
20			8		
25			10		0'-75' Silt and clay-rich gravelly alluvium.
30			12		
35			17		
40			15		
45			19		
50			25		

LOCATION ID: PL-4-464

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
180			3		
185			3		185'-200' Silt and clay-rich gravelly alluvium.
190			3		
195			3		
200			3		200'-205' Sandy gravel alluvium.
205			6		205'-225' Silt and clay-rich gravelly alluvium.
210			3		
215			3		
220			3		
225			2		225'-495' Sandy gravel alluvium with caliche-bearing horizons.
230			4		
235			5		
240			4		
245			3		

LOCATION ID: PL-4-464

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			3		
250			3		
255			6		
260			3		
265			3		
270			3		
275			5		275'-305' Caliche-bearing horizon.
280			6		
285			4		
290			7		
295			4		
300			5		
305			4		
310			9		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
310			9		
315			6		
320			5		
325			8		
330			6		
335			6		
340			9		340'-365' Caliche-bearing horizon.
345			4		
350			4		
355			4		
360			5		
365			5		
370			5		
375			5		

LOCATION ID: PL-4-464

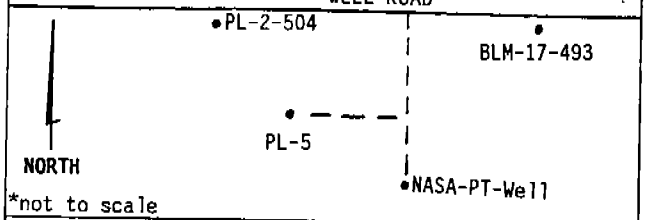
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375			5		
380			5		
385			11		
390			6		
395			5		
400			9		400'-425' Caliche-bearing horizon.
405			7		
410			6		
415			6		
420			5		
425			10		
430			5		
435			5		
440			15		

LOCATION ID: PL-4-464

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
440			15		
445			5		
450			5		
455			5		455'-480' Caliche-bearing horizon.
460			5		
465			5		
470			6		
475			5		
480			6		
485			5		
490			4		
495			5		Total Depth = 495'
500					
505					

LITHOLOGIC LOG

LOCATION MAP:



*not to scale

NW 1/4 SE 1/4 NW 1/4 NE 1/4 S5 T21S R3E

SITE ID: NASA-WSTF LOCATION ID: PL-5 (Westbay Well)

SITE COORDINATES (ft.):

N 226966.72 E 401507.49

GROUND ELEVATION (ft. MSL): 4512.60 (BC)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud Rotary

DRILLING CONTR.: Beylik Drilling, Inc.

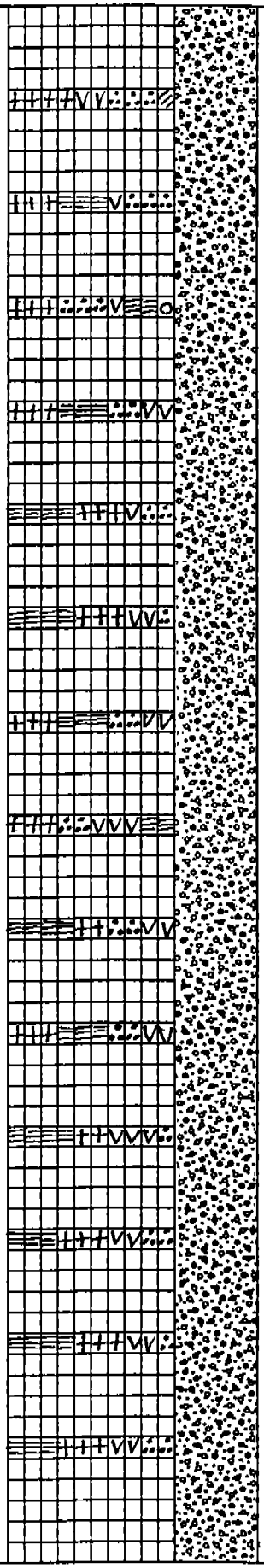
DATE STARTED: 10/02/90 DATE COMPLETED: 11/10/90

FIELD REP.: J. Rogers, C. Werden, S. Dubyk

COMMENTS: 20" tricone bit to 24.2'; 14" surface casing set to 24', 12¼" tricone bit to 1023'. Andesite-rich alluvium at 580', bedrock (andesite) encountered at 1007'. TD = 1023'

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			0'-185' not timed	Cuttings 0'-1023	0-1007' Alluvium (Santa Fe Group): Multicolored due to the many different lithologic constituents; cuttings range in size from <.1 to 1 inch and are angular to subrounded. Natural grains include clay, silt and fine to coarse, angular to rounded sand. Sorting is poor to medium. The formation is an unconsolidated to consolidated polygenetic cobble to boulder conglomerate. Lithologies comprising this conglomerate are limestone, caliche, rhyolite, andesite, quartz, sandstone, and siltstone. Comments: This section contains clay, gravelly-clay and sandy clay lenses from 0'-360', 545'-690', and 785'-885'. The andesite becomes the greatest volcanic fraction by 490' and the alluvium is considered andesite-rich by 580'.
10					
15					
20					
25					
30					30' Sand and gravel with much less clay. .1" - .3" angular fragments comprise 30% and rounded grains comprise 70% of sample.
35					
40					
45					45' Grain size increases and more natural grains are present. Subangular clasts are .1" - .4".
50					

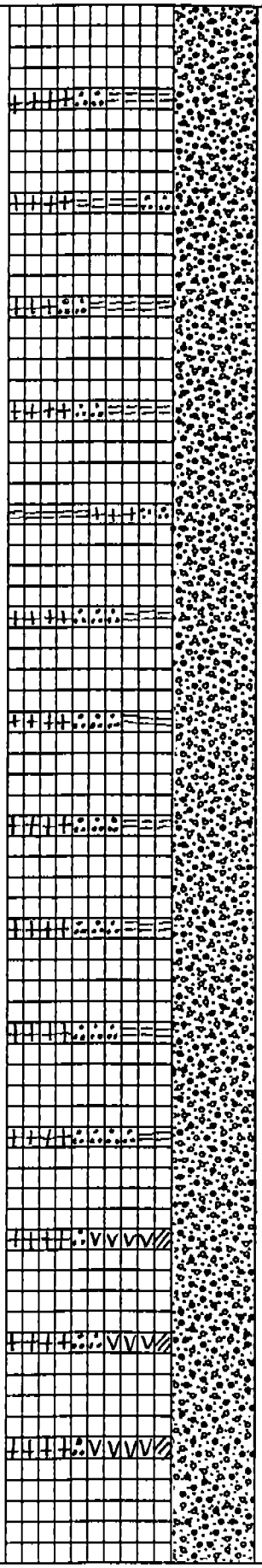
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
			0-185' not timed	Cuttings (cont'd)	
50			-		
55			-		55' Decrease in grain size. 60% of sample is predominantly rounded to subrounded (.1" - .2" diameter). 10% of the angular chips are limestone and rhyolite. Increase in caliche.
60			-		60' Increase in grain size. Subangular to angular limestone and rhyolite (.1" - .3" diameter).
65			-		
70			-		70' Increase in grain size, clay lense to 80'.
75			-		
80			-		80' Caliche cement on most larger cuttings. Predominately subangular to subrounded grains.
85			-		85' ~10% of sample is carbonate cement that can also be seen on cuttings. Decrease in grain size. 70% of sample predominantly subrounded (<.2" diameter).
90			-		
95			-		95'-100' Clay layer, sample consists of 80% coarse sand, 20% gravel, and minor caliche.
100			-		100'-105' Increase in grain size to gravels: 15% are .75" - 1.00", 20% are .25"-.75" and 65% are <.25 in diameter.
105			-		105'-110' Decrease in grain size. 95% of sample is ≤ 0.1", while 5% is .1-.5" in diameter. Coarse sand with no caliche.
110			-		110'-115' Increase in grain size. Sample consists of 70% gravel, 30% coarse sand, and minor clay.
115			-		

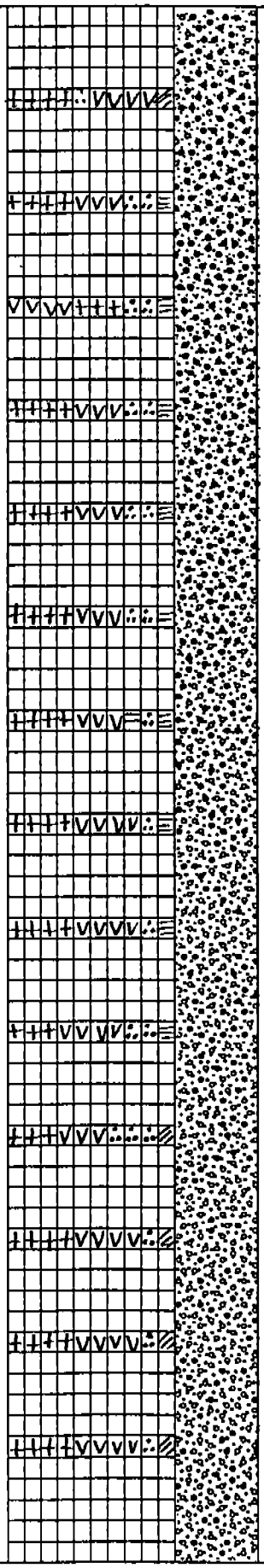
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
			0'-185' not timed	Cuttings (cont'd)	
115			-		115'-120' Minor decrease in grain size, increase in clay: Gravelly sand (60% gravel, 40% coarse sand).
120			-		120'-125' Increase in clay content, sample is gravelly sand as above.
125			-		125'-130' Gravelly sand, clay, no caliche.
130			-		130'-135' Increase in clay, gravelly clay sand. Gravel up to .5" diameter.
135			-		135'-140' Gravelly sand, gravel is angular to subrounded, coarse sand. Clay-rich, trace of caliche.
140			-		140'-145' Medium to coarse sand, 10% gravel to .3".
145			-		145'-150' Gravelly sand: gravel 10-15%, coarse sand. Gravel and sand angular to rounded.
150			-		150'-155' Sandy gravel: gravel to ~.5", rounded to angular. Coarse sand, rounded to subangular.
155			-		155'-160' Gravelly sand: gravels up to 10%, rounded to angular. Less clay, medium to coarse sand, rounded to subrounded.
160			-		160'-165' Sandy gravel: 65% gravel, 35% sand, gravel to .5", angular to subrounded, medium to coarse sand, rounded to angular.
165			-		
170			-		170'-175' Gravelly clayish sand. Gravel to .5". Medium to coarse sand.
					170'-175' Gravelly clayish sand. Gravel to .5". Medium to coarse sand.
175			-		175'-180' Gravelly clayish sand. Large chips from volcanic boulders. Gravel 5%. Coarse to medium sand both angular to subrounded.
180			-		

LOCATION ID: PL-5

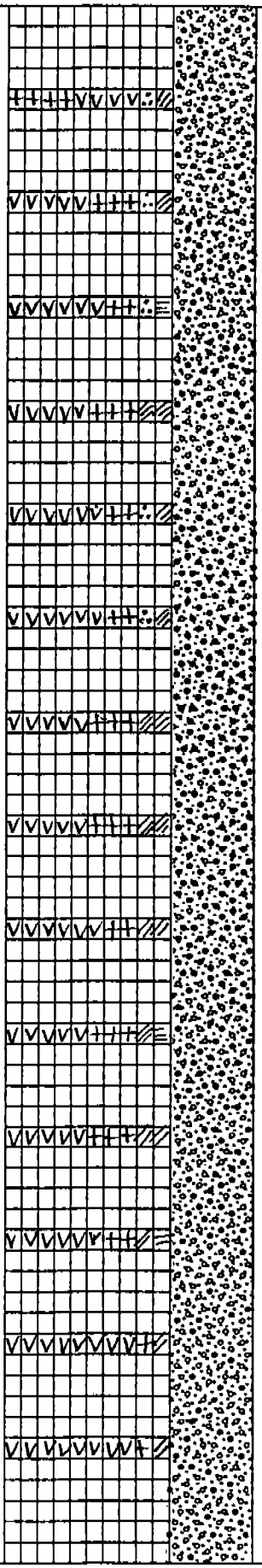
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
			(24 hour time)	Cuttings (cont'd)	
180			-		180'-185' Gravel/sand: predominantly paleozoic limestone, silicious shales, minor volcanics; same lithology in sand, medium to coarse grained, no clay.
185			185'-1020' drillograph		185'-190' Gravel/sand. Same as above, some effervescent clay.
190			53		190'-195' Clay, pale yellowish brown, cohesive, with gravel and sand, limestone, volcanics and sandstone.
195			29		195'-200' Gravel/sand; coarse sand to fine gravel, limestone, silicified shale, volcanics.
200			38		200'-205' Clayey gravel/sand; coarse sand and gravel, predominantly limestone and volcanics, with clay.
205			33		205'-210' Clayey gravel/sand. As above.
210			35		210'-215' Clayey gravel/sand, coarse sand to fine gravel, slight decrease in clay.
215			31		215'-220' Clayey gravel/sand, as above, slight decrease in clay, increased volcanics.
220			29		
225			24		
230			18		
235			16		
240			17		
245			77		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			77		245'-255' Clayey gravel/sand. Medium sand to fine gravel.
250			18		
255			17		255'-260' Limestone gravel, some clay, some quartzite. Boulder at 262'.
260			13		260'-270' Gravel/sand. Medium gravel, poorly sorted, angular to subrounded, limestone, quartzite. Some clay.
265			50		
270			25		270'-275' Clayey gravel; fine to coarse sand, fine to medium gravel. Predominately limestone, some quartzite.
275			10		275'-285' Gravel/sand some clay, coarse to fine sand. Gravel, poorly sorted. Predominately limestone and quartzite.
280			28		
285			12		285'-290' Slightly more clay.
290			24		290'-300' Gravel; sandy ranging from coarse sand to medium gravel. Predominately iron gravel. Moderately sorted, predominantly limestone.
295			19		
300			17		300'-305' Gravel; clayey, sandy ranging from fine sand to coarse gravel, predominantly fine gravel, poorly sorted. Increase in clay content.
305			37		305'-310' Gravel; clayey, sandy, same as above.
310			28		

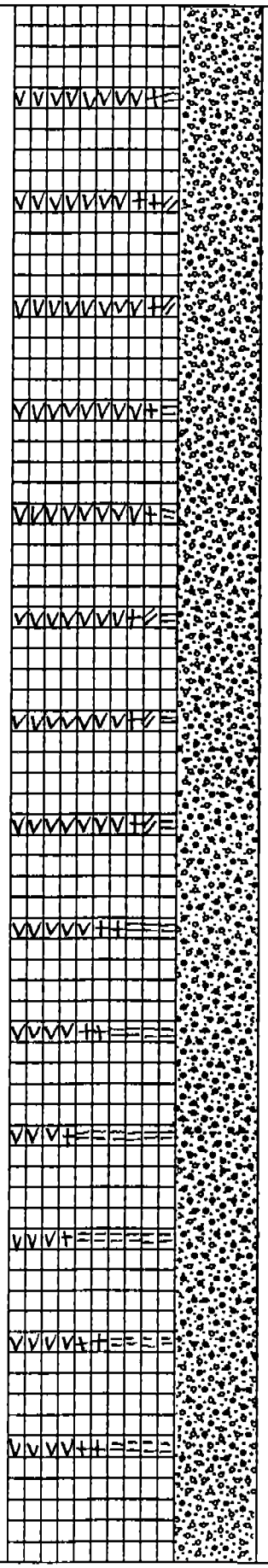
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
310			28		310'-315' Gravel; clayey. Sandy ranging from fine sand to medium gravel. Predominately fine gravel, poorly sorted subangular. Predominately limestone.
315			20		310'-315' Same as above, slightly more clay.
					315'-320' Gravel; clayey, sandy, ranging from fine sand to medium gravel. Predominantly fine gravel, poorly sorted. Predominantly limestone, some quartzite.
320			15		
					320'-325' Clay; sandy, few pebbles. Smooth yellowish brown.
325			20		
					325'-330' Sand; clayey, gravelly, ranging from fine sand to medium gravel. Predominantly coarse sand. Predominantly limestone and quartzite, poor to moderately sorted.
330			11		
					330'-335' Gravel; sandy, clayey ranging from fine sand to medium gravel. Predominantly fine gravel. Poorly sorted. Predominantly limestone.
335			15		
340			10		
345			81		345'-350' Gravel; sandy, clayey ranging from fine sand to medium gravel. Predominately fine gravel, poorly sorted.
350			14		350'-355' Predominately limestone. Some quartzite.
355			21		355'-360' Gravel; sandy, some clay ranges from fine sand to medium gravel, predominately fine gravel, moderately sorted.
360			23		360'-370' Limestone/volcanic gravel with little to no clay. Volcanics include mostly rhyolite.
365			60		
370			10		370'-375' Limestone/volcanic gravel, coarse sand, volcanics mostly rhyolite. Sandstone and siltstone.
375			10		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375					375'-380' Limestones/volcanic, gravelly sand. Volcanic mostly rhyolite, trace of andesite.
380			10		380'-385' Sand, coarse to medium. Gravels up to .25". Volcanic/limestone gravel. Rhyolite and minor andesite.
385					385'-390' Limestone/volcanic gravel. Predominant rhyolite as above. gravel < .2", angular, coarse sand.
390			32		390'-405' Limestone/volcanic gravel, coarse sand.
395			17		
400			15		
405			31		405'-410' Volcanic (rhyolite > andesite)/limestone sandy gravel. Gravels ≤ .25". Angular to subrounded. Sand coarse, angular to subrounded.
410			12		410'-415' Volcanic/limestone sandy gravel as above.
415			14		415'-420' Volcanic/limestone sandy gravel.
420			18		420'-425' Coarse gravel/sand, angular to subangular, gravel to .3".
425			53		425'-440' Limestone/volcanic arenite, coarse sand.
430			18		
435					
440			40		

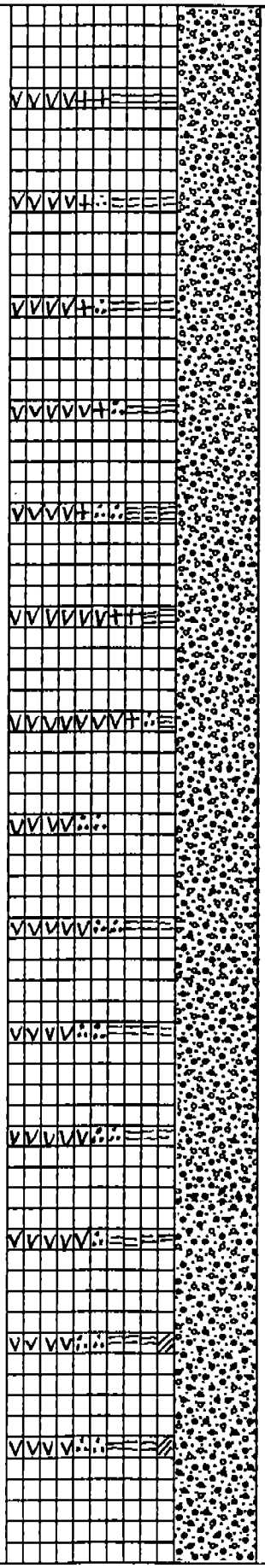
LOCATION ID: PL-5

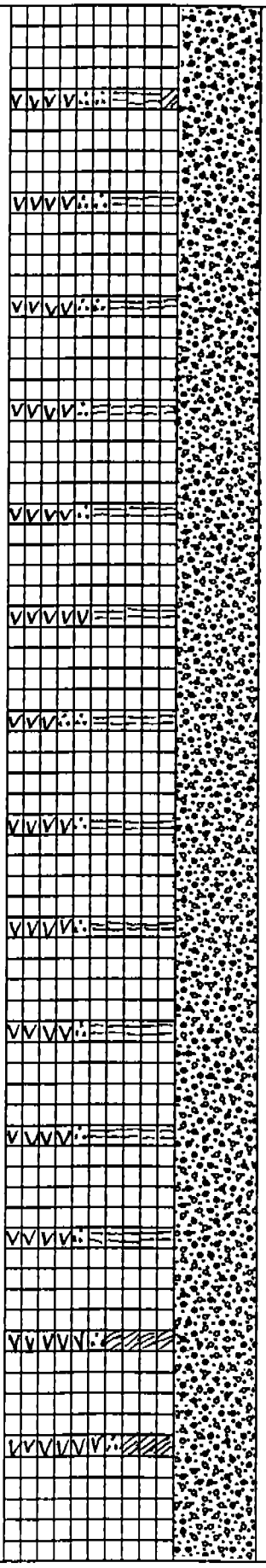
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
440					440'-445' Volcanic/carbonate gravel, coarse sand slight increase in average grain size, gravels ≤ .3". Calcium carbonate cement on grains.
445			31		445'450' Increase in volcanic fragments, same as above.
450			23		450'-455' Volcanic-rich gravel of coarse sand. Rhyolite > andesite.
455					
460			19		460'-465' Clays blue-grey (below water table?)
465			48		465'-475' Volcanic (buff rhyolite), light to dark grey limestone, buff siltstone chips' ≤ .3"
470			21		
475			23		475'-480' Slight increase in volcanics, rhyolite > andesite, chips ≤ 0.4".
480			29		480'-485' Same as above, ≤ 5% clay balls.
485			23		485'-490' Same as above, no clay.
490			22		490'-495' Volcanics - andesite > rhyolite, light to medium grey limestone, medium grey siltstone, a few clay balls ≤ 0.4" in sample.
495			25		495'-500' Increase in percent volcanics (andesite > rhyolite), no clay.
500			25		500'-505' Same as above; ≤ 0.5" angular to subrounded cuttings.
505			46		

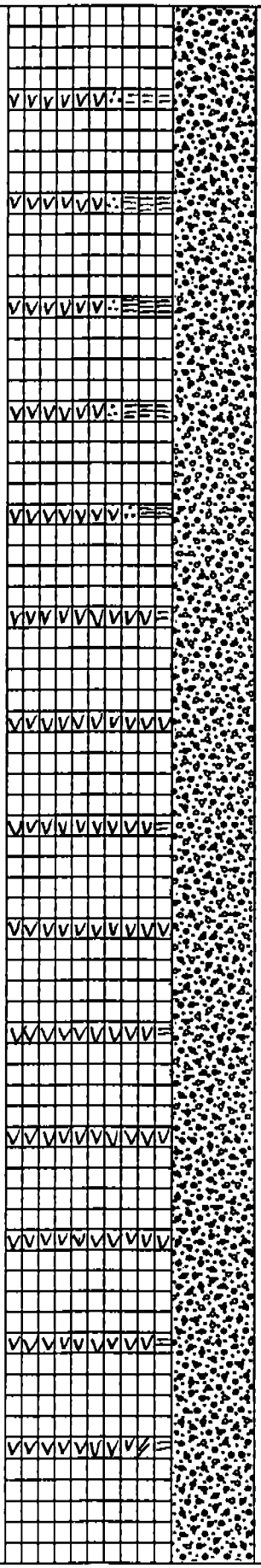
LOCATION ID: PL-5

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
505			-		505'-510' Volcanics, 75%, and 25% rhyolite, medium to dark grey limestone and siltstone. Cuttings are angular to rounded, < .06" in size.
510			39		510'-515' Same as above, slight increase in volcanic percent.
515			26		515'-525' Predominantly dark red, medium to dark grey and lesser tan-brown rhyolite, sparse limestone, few clay balls in sample.
520			22		525'-535' Same as above except slight increase in percent of limestone and siltstone fragments. Angular to subrounded, a few clay balls in sample. Slight decrease in particle size.
525			31		
530			43		
535			22		535'-540' Same as 525'-535'. Particle size ≤ 0.4". Gravels; sandy, clayey, ranging from fine sand to medium gravel. Predominately fine gravel, poorly sorted. Predominately igneous.
540			37		540'-545' Sands, gravels, very clayey. Predominately volcanics and limestone, angular, some siltstone chips.
545			77		545'-550' Same as above. Slightly more clayey. Purple cuttings, increase in andesite.
550			12		
555			22		555'-560' Same as above, slightly less clay content. Drilling indicates more cobbles and boulders.
560			12		560'-565' Sandy, very clayey, gravely. Predominately igneous, some quartzite, some carbonates, angular, poorly sorted. Drilling in this interval smooth.
565			19		
570			13		

LOCATION ID: PL-5

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
570			13		570'-575' Sands; very clayey, gravely, predominately igneous, some siltstone, quartzite and occasional limestone. Poorly sorted, subangular, occasional cobble.
575			17		575'-580' Same as above, slightly less clay - more sand.
580			10		580'-585' Andesite percentage is much greater than rhyolite, siltstone, limestone. Probable contact with andesite-rich alluvium.
585			18		585'-590' Increase in sedimentary cuttings, possibly from up-hole, lodged loose while tripping pipe.
590			-		590'-600' Andesite gravel, coarse sand, alluvium.
595			22		
600			16		600'-605' Sands; very clayey, gravely ranging from fine sand to medium gravel. Predominately coarse sand, moderately sorted. Predominately andesite, some rhyolite, predominately angular, gray and black.
605			-		605'-620' Same as above, slightly coarser material. Predominately fine gravel.
610			15		
615			17		
620			25		620'-625' Boulders at 627'.
625			24		625'-635' Same as above, increasing siltstone fragments.
630			16		
635			10		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
635			10	Cuttings (cont'd)	
640			10		638' Boulders @ 638 ft.
645			25		
650			5		
655			10		
660			20		
665			13		
670			5		
675			36		
680			28		
685			29		
690			17		690'-700' Sand and gravel conglomerate. Drilling hard, ranging from fine sand to cobbles. Predominately very coarse sand, angular. Predominately andesite, some clay decreasing with depth, poorly sorted, gray to black.
695			32		
700			43		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
700			43		700'-715' Andesite-rich alluvium, welded tuff.
705			-		
710			99		
715			46		715'-720' Calcite crystals and veinlets on volcanics.
720			41		720'-725' 95%+ volcanics; andesite, brick red, maroon, or grey. Occasional fragments of rhyolite, limestone, calcite, a few clay balls in sample. Angular to subrounded.
725			-		725'-730' Andesite, same colors as 720'-725', occasional calcite fragments. Angular to subrounded particles.
730			22		730'-735' Same as 720'-725'. Largest fragment 0.4".
735			23		735'-740' Same as 720'-725' except no clay in sample. Angular to subrounded particles.
740			19		740'-745' Same as 720'-725'.
745			44		745'-750' Andesite; brick red, maroon, medium brown, medium dark gray, occasional rhyolite fragment. < 1% clay, angular to subrounded.
750			22		
755			16		755'-760' Same as 745'-750' except clay 5-7%.
760			17		760'-765' Andesite; same as 745'-750', buff calcareous siltstone fragments ≤ 0.7", a few clay balls in sample.
765			54		

LOCATION ID: PL-5

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
765			18		
770			16		770'-775' Andesite; brick red, maroon, medium to dark grey. Occasional light tan rhyolite fragments, a few clay balls. Angular to subrounded particles ≤0.3".
775			17		775'-780' Andesite; same as 770'-775'. Very sparse limestone and calcite fragments, and clay.
780			38		780'-785' Andesite; same as 770'-775'. Medium brown clay with abundant imbedded rock fragments <5%. Tan light brown calcareous siltstone < 0.5"
785			14		785'-790' Same as 780'-785' except no siltstone.
790			19		790'-795' Same as 785'-790', silt. Decrease in clay percent.
795			19		795'-800' Same as 785'-790', except increase in clay percent.
800			54		800'-805' Same as 795'-800'.
805			14		805'-835' Andesite; brick red, maroon, medium dark grey particles ≤ 0.1". Angular to subrounded.
810			21		
815			20		
820			23		
825			18		
830			19		

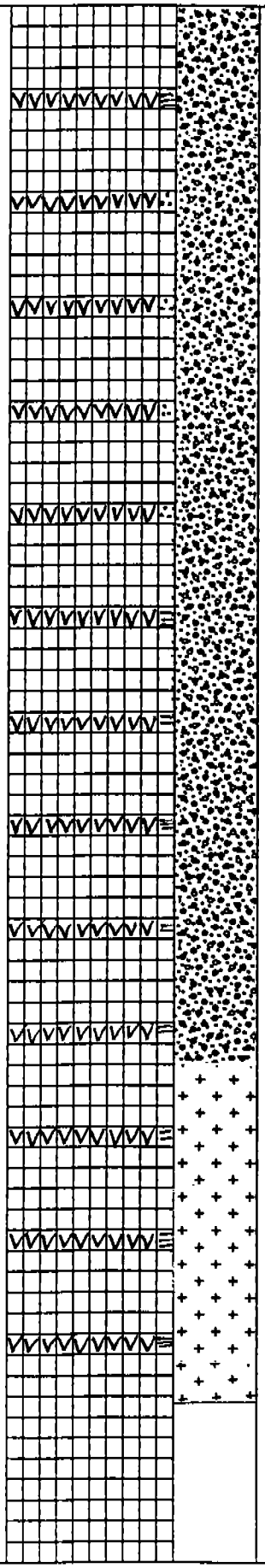
LOCATION ID: PL-5

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
830			18	Cuttings (cont'd)	
835			19		
840			9		
					843' Drilling hard, possibly bedrock contact.
845			20		
850			17		
855			35		
860			24		859' Believed to have encountered bedrock. Drilling chips typical of andesite bedrock. Will drill another 10'.
865			29		
870			25		869' Does not appear to be andesite bedrock.
875			65		
880			15		
885			16		885'-920' Slightly less clay content.
890			29		
895			55		

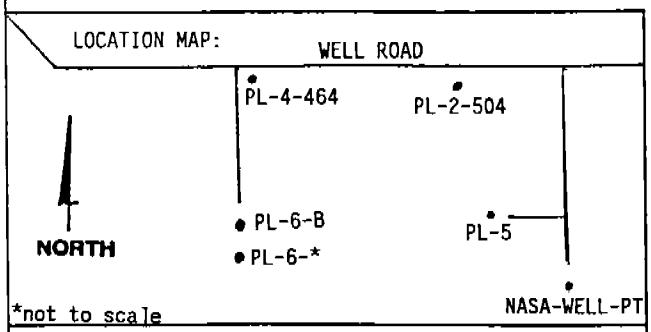
LOCATION ID: PL-5

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
895			-		
900			-		
905			-		
910			-		
915			80		
920			10		920'-950' Same as above, increase in rhyolite.
925			16		
930			10		930'-955' Increase in clay content.
935			8		
940			2		
945			34		
950			-		
955			-		955'-970' Same as above, less clay.
960			-		

LOCATION ID: PL-5

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
960			-		
965			-		
970			-		970'-975' Same as above, more angular.
975			-		
980			206		980'-995' Volcanic gravel/sand.
985			-		
990			13		
995			5		
1000			-		1000' -1005' Same as above and blue-grey clay.
1005			-		
1010			-		1007' -1020' Andesite (Orejon): Dark bluish-black aphanitic andesite. Cuttings are angular and uniform.
1015			-		
1020			-		1023' Total Depth (TD)
1025					

LITHOLOGIC LOG



SW 1/4 SW 1/4 NW 1/4 NE 1/4 S5 T21S R3E

SITE ID: NASA-WSTF LOCATION ID: PL-6-B

SITE COORDINATES (ft.):

N 227115.15 E 399683.92

GROUND ELEVATION (ft. MSL): 4481.69(BC)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud Rotary

DRILLING CONTR.: Beylik Drilling Inc.

DATE STARTED: 11-30-90 DATE COMPLETED: 1-15-90

FIELD REP.: Contaldo, Menzie, Morse, Werden, Rogers, Huber

COMMENTS: 0-16.5', rotary with 24" Auger bit, set 14" surface casing to 16.5', mud rotary with 12¼" bit (tricone) and roller reamer to 1920'; Total Depth = 1920'. No bedrock encountered.

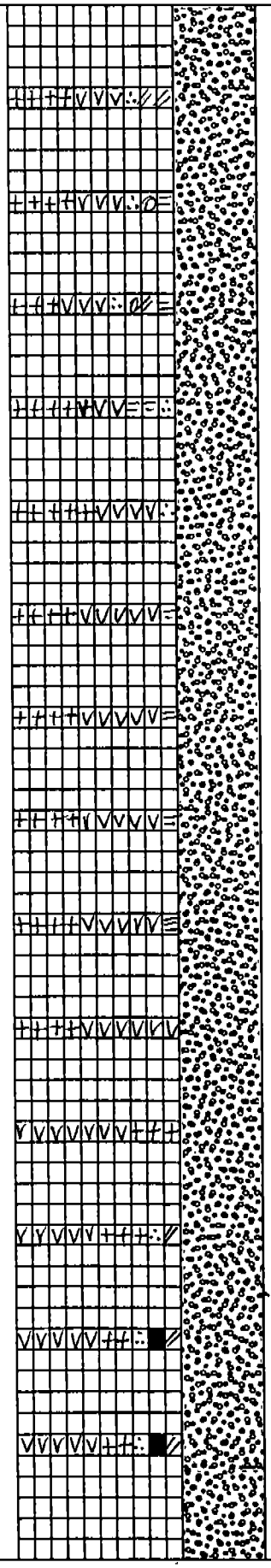
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
10			80	0-1920' (Cuttings - 10' grab samples)	0-650'	Alluvium (Santa Fe Group): Moderate yellowish brown (10 Y/R 5/4); cuttings range in size from less than 0.1 inch to 0.5 inch, occur as angular flakes or blocks, and are poorly sorted. Average cutting size is 0.2 inches. Formation is an unconsolidated to semi-consolidated polygenetic conglomerate. Individual clasts consist primarily of limestone with lesser amounts of andesite, caliche, rhyolite, sandstone, and quartz. This interval is relatively clay-rich. Variations in percent clay content, percent cutting lithology, and average cutting size are noted below.
20			-		10'	Well-graded gravel with silty clay (50%).
30			-		20'	Silty-clayey gravel
40			23		30'	Same as above
50			30		40'	Gravelly clay.
60			22		50'	Clay > sand/gravel.
70			16		60'	Gravelly alluvium.
80			34		70'	Same as above.
90			60		80'	Same as above.
100			30		90'	Clayey sand and gravel. Cuttings up to 0.5" in diameter.
					100'	Same as above.

LOCATION ID: PL-6-B

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
100			30		
110			40		110' Very clayey, few rock fragments or cuttings.
120			35		120' Very little clay. Cutting size decreases, predominately .1" - .2" in diameter, subrounded to subangular grains.
130			30		130' 80% clay. Bit bouncing at 131' - smooth drilling at 134"
140			35		140' Mostly clay.
150			30		
160			40		
170			33		170' 80% clay, 20% fine to coarse sand size cuttings.
180			35		
190			45		
200			25		
210			25		
220			27		220' Gravelly clay.
230			32		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
				Cuttings (cont'd)		
230			32		230'	Gravelly clay (same as above).
240			28		240'	Clay, < 5% cuttings (limestone). Cuttings may be from up-hole.
250			40		250'	Tan clay.
260			24		260'	Gravelly clay.
270			46		270'	Clay with medium-to fine-grained sand.
280			74		280'	Clayey gravel.
290			35		290'	Clayey.
300			30		300'	No clay, cuttings and grains small, 0.1" - 0.3" in diameter predominant. No cuttings larger than approximately 0.3" diameter.
310			50			
320			120			
330			115			
340			98			
350			41		350'	Sandy clay.
360			140		360'	Trace of clay, sedimentary (primarily limestone) and volcanic alluvium.

LOCATION ID: PL-6-B

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
				Cuttings (cont'd)		
360			140		360'	Sedimentary (primarily limestone) and volcanic alluvium, trace of clay.
370			125			
380			120			
390			150		390'	Increase in clay content.
400			175		400'	Mixed lithology alluvium. Rhyolite, andesite and limestone are major clasts. Few fines in sample.
410			120		410'	As above. Rhyolite is white, yellow and red in color, limestone is light to dark gray. Andesite is gray to reddish brown.
420			105		420'	An increase in maroon andesite clasts fragments. Limestone and rhyolite still dominant, some calcite present.
430			115			
440			113		440'	Limestone and volcanic cuttings - gravel, minor clay (drill mud?), cuttings similar in size and angular.
450			64		450'	No clay. Increase in volcanic fraction.
460			98		460'	Further increase in volcanic fraction.
470			150		470'	Very fine cuttings, all approximately 0.1" in diameter.
480			120			
490			135			

LOCATION ID: PL-6-B

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
				Cuttings (cont'd)		
490			135			
500			88		500'	Cutting size < .1 inches, mostly white iron-stained rhyolite and limestone. Minor amounts of andesite, siltstone, and quartz. Andesite fraction 10% to 15%.
510			45		500'-520'	Increase in drilling rate.
520			53			
530			91		530'	As above.
540			93			
550			75		550'	Medium to coarse sand size, lithology same as above.
560			78		560'	As above.
570			87		570'	As above - slight increase in cutting size. No clay.
580			90		580'	Slight increase in clay.
590			150		590'	Trace "flaky clay". This clay could be from mud cake on borehole wall.
600			35			
610			44			
620			47			

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
620			44		
630			40		630'-640' Mud "flakes" present in sample (< 10%).
640			40		
650			90		650'-1920' Volcanic-rich Alluvium: Cuttings range in color from very light gray (N8) to grayish black (N2) and range in size from less than 0.1 inch to 0.5 inches; are subrounded to angular, and are poorly sorted. Formation is a semi-consolidated to consolidated polygenetic conglomerate. Individual clasts are composed almost entirely of volcanic rocks. The volcanic rocks consist primarily of andesites, with several varieties of color and texture (see core description for PL-6-*), and lesser percentage (≈ 10%) of rhyolite (primarily flow-banded) and ash-flow tuff (< 10%), percent clay varies from < 10% to 20%. Variation in percent clay are noted below.
660			150		
670			56		
680			55		
690			70		660'-740' Same as above.
700			63		
710			61		
720			46		
730			128		
740			-		740' Cuttings are very uniform in size, average size .1".
750			165		750' Cuttings slightly coarser, average size ≈ .2".

LOCATION ID: PL-6-B

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
				Cuttings (cont'd)		
750			165			
760			145		760'	Same - cuttings are ≈ 0.2" and uniform as at 740'. Trace clay but <10%.
770			203		770'-780'	Same as above.
780			130			
790			210		790'	Maroon to reddish-purple andesite-rich alluvium. Trace calcite, epidote and altered andesite.
800			153			
810			122			
820			134		820'	Same. Trace clay (<10%).
830			240		830'	Same. Trace clay (< 10%), cuttings are coarse sand size ≈ 0.2", increase in calcite cuttings.
840			163		840'	Predominately black-gray and some maroon andesite-rich alluvium. Increase in clay content to 10%. Cuttings are finer ≈ 0.1" calcite and rhyolite.
850			185		850'	Maroon and black-gray andesite-rich alluvium. Calcite, rhyolite, and clay present in minor amounts.
860			156		860'	Slight increase in clay to 20%.
870			178		870'	Same as 860'.
880			291			

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
				Cuttings (cont'd)		
880			291		880'	Maroon to gray-black andesite with trace of clay and calcite (< 10%).
890			325		890'	Same as above.
900			-			
910			248		910'-920'	Maroon and black-gray andesite-rich volcanic alluvium with trace clay.
920			180			
930			145		930'	Maroon to gray-black andesite-rich alluvium with trace of clay and calcite (< 2%).
940			288		940'	Same as 930', slight increase in clay (< 5%).
950			240		950'	Same, increase in clay to ≈ 10%.
960			305		960'	Same, decrease in clay content to < 10%.
970			185		970'-1000'	Approximately 10% clay.
980			142			
990			114			
1000			247		1000'	Maroon to medium brown to gray-black andesite alluvium. Trace clay and calcite.
1010			225		1010'	Same as 1000'

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
				Cuttings (cont'd)		
1010			195			
1020			166		1020'	Same as above but decrease in clay content.
1030			195			
1040			122		1040'	Maroon to medium brown to gray-black andesite-rich volcanic alluvium. Trace of clay and calcite. Cuttings are coarser (≈ 0.2").
1050			142		1050'	Dark gray to black to maroon andesite, brick red tuff(?) and light gray rhyolite clasts. Calcite is white.
1060			120		1060'	Brick red to medium brown to gray-black andesite-rich alluvium. Occasional white calcite fragments. Clay ≤ 5%.
1070			174			
1080			241		1080'	Same as 1070', except decrease in clay.
1090			172		1090'-1100'	Same as 1080'.
1100			136			
1110			150		1110'-1120'	Brick red to dark gray to black aphanitic andesite. Clear and milky calcite comprises ≈ 15% of sample. Trace of clay (few balls in sample).
1120			-		1120'-1130'	Hardly any calcite in this sample and no clay.
1130			-		1130'-1140'	Cuttings slightly finer, angular to subangular.
1140			172		1140'-1150'	Trace clay.

LOCATION ID: PL-6-B

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
1140			172		
1150			115		1150'-1160' Less clay.
1160			76		
1170			82		1170'-1200' Decrease in percent clay to less than 10%, trace of calcite present.
1180			145		
1190			125		
1200			76		
1210			160		
1220			150		1220' Some formation clay present in the volcanic-rich alluvium.
1230			173		
1240			132		1240'-1250' Trace of clay.
1250			171		1250'-1260' Increase in % calcite.
1260			74		1260'-1270' Cuttings appear slightly weathered.
1270			73		1270'-1280' Trace of clay and calcite. Calcite is milky or clear. Much of the andesite is either highly weathered or arenitic.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
1270			73		
1280			157		
1290			98		1290'-1300' There is what appears to be some alluvium matrix cement (calcite) present in sample.
1300			85		
1310			125		
1320			86		
1330			135		
1340			-		1340' No sample collected at 1340'.
1350			-		1340'-1370' 90% of sample is angular cuttings that are uniform in size and shape. Average cutting size is ≈ 0.1 inch. Very little calcite (< 10%). Andesite is predominantly dark gray in color followed by brick red, aphanitic to slightly porphyritic, highly weathered.
1360			-		
1370			113		
1380			197		
1390			190		1390'-1410' Same as above.
1400			274		

LOCATION ID: PL-6-B

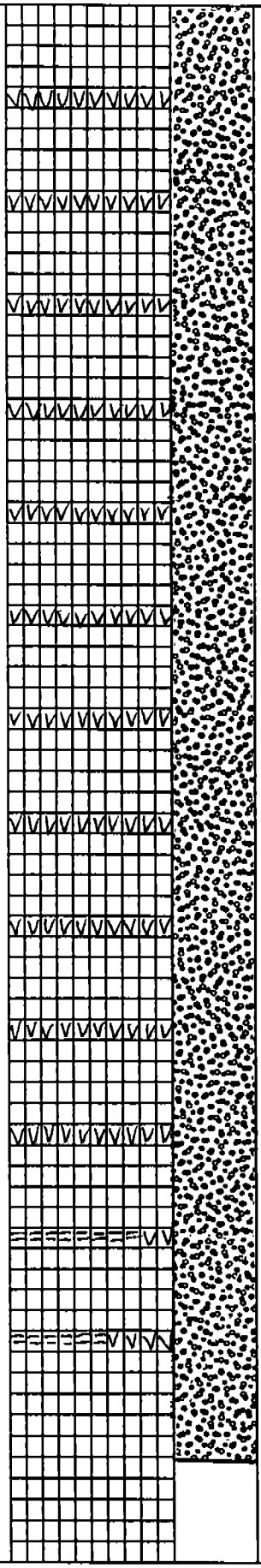
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
				Cuttings (cont'd)		
1400			274			
1410			181			
1420			140		1420'-1430'	Clay is present in about 10% of the sample. Caliche cemented grains are also at 10%.
1430			135			
1440			135		1440'	Decrease in percent clay to < 10%.
1450			110		1450'	Slight increase in percent caliche cuttings to ≈ 10%. Clay < 10%.
1460			159		1460'	Further increase in percent caliche cuttings to ≈ 20%. Clay < 10%.
1470			166		1470'	Slight decrease in percent caliche cuttings to ≈ 10%. Clay < 10%.
1480			126		1480'	Increase in percent caliche in cuttings. Clay is present (< 10%), but it looks like mud cake.
1490			149		1490'-1500'	No caliche.
1500			141			
1510			152		1510'	Increase in clay to ≥ 10%.
1520			117		1520'	Decrease in drill time. Clays ≥ 10% (white tan, and red clays). Increase in average cutting size.
1530			128			

LOCATION ID: PL-6-B

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
				Cuttings (cont'd)		
1530			128			
1540			181		1540'	Most cuttings are angular and range from .05" - .1" in diameter. Approximately 10% clay present. Some alluvial cement (calcite) is apparent.
1550			114		1550'	Less than 10% clay.
1560			128		1560'	Increased alluvial matrix cement (calcite).
1570			69			
1580			185			
1590			85		1590'	Calcite fragments present.
1600			68		1600'	Andesite-rich alluvium dominated by gray to black aphanitic andesite and maroon to red andesite and ash-flow tuff. Yellow (altered) tuff? and rhyolite also present. White calcite is found as above.
1610			80			
1620			85			
1630			90		1630'	Slight decrease in average cutting size to 0.1 inches. Lithology same as above.
1640			74		1640'	Slight increase in average cutting size to 0.15 inches.
1650			117		1650'	Increase in drill time.
1660			195		1660'	Further increase in drill time.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
				Cuttings (cont'd)		
1660			195			
1670			210			
1680			226			
1690			105		1690'-1700	Trace of clay.
1700			79			
1710			70		1710'-1720'	Slight decrease in grain size.
1720			95			
1730			81			
1740			144		1740'	Trace of clay.
1750			130		1750'	Increase in calcite.
1760			75			
1770			80			
1780			91			
1790			127			

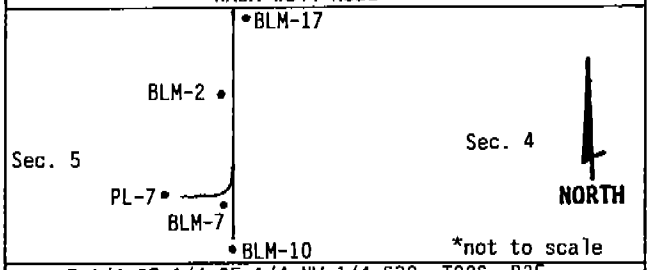
LOCATION ID: PL-6-B



Depth	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
		Cuttings (cont'd)	
1790	127		
1800	225		
1810	150		
1820	182		1820' Large % of black andesite present.
			1820'-1830' Cuttings are angular and fairly uniform in size (average .10").
1830	168		
1840	197		1840' Increase in brick red andesite. Decrease in black andesite.
1850	225		1850' Further increase in percent reddish andesite containing 10% calcite.
1860	270		1860' Further increase in percent reddish andesite and decrease in percent black andesite. Angular clasts of reddish andesite are seen cemented by calcite in some of the larger cuttings.
1870	202		1870' Slight decrease in percent reddish andesite (rhyolite?) cuttings and increase in percent blackish andesite cuttings.
1880	140		1880' Same as above.
1890	115		1890' Sample is ≈ 80% reddish andesite and 20% blackish andesite. Trace of clay.
1900	194		1900'-1910' Clay-rich
1910	110		
1920	-		1920' = Total Depth

LITHOLOGIC LOG

LOCATION MAP:



SE 1/4 SE 1/4 SE 1/4 NW 1/4 S32 T20S R3E

SITE ID: NASA-WSTF LOCATION ID: PL-7 (Westbay Well)

SITE COORDINATES (ft.):

N 224176.88 E 402274.51

GROUND ELEVATION (ft. MSL): 4519.12 (BC)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Air Foam Rotary

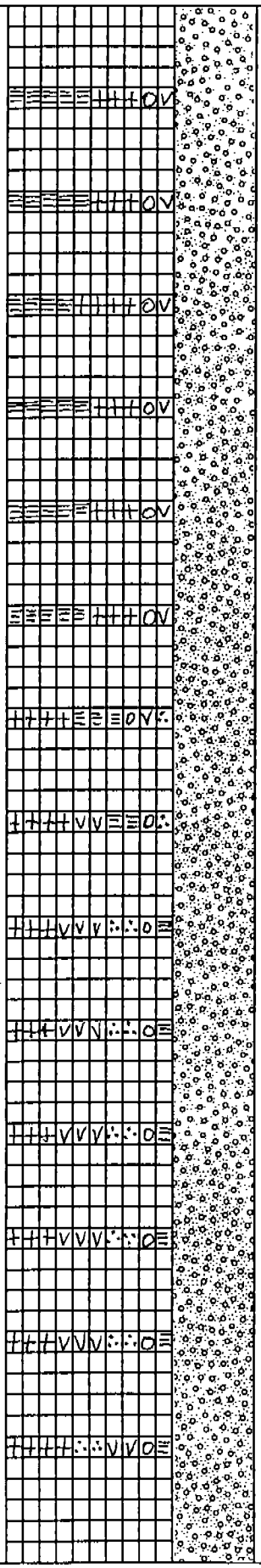
DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 10-13-92 DATE COMPLETED: 12/17/92

FIELD REP.: Canavan, Menzie, Kirby, Egan, Contaldo

COMMENTS: Drilled mud rotary (9 7/8") and reamed (16½") 0'-80'. Installed 80' of 14" surface casing. Drilled 80'-804' with air foam 9 7/8" borehole. Reamed 80'-675' to 13". Alluvium 0'-804'. No bedrock encountered.

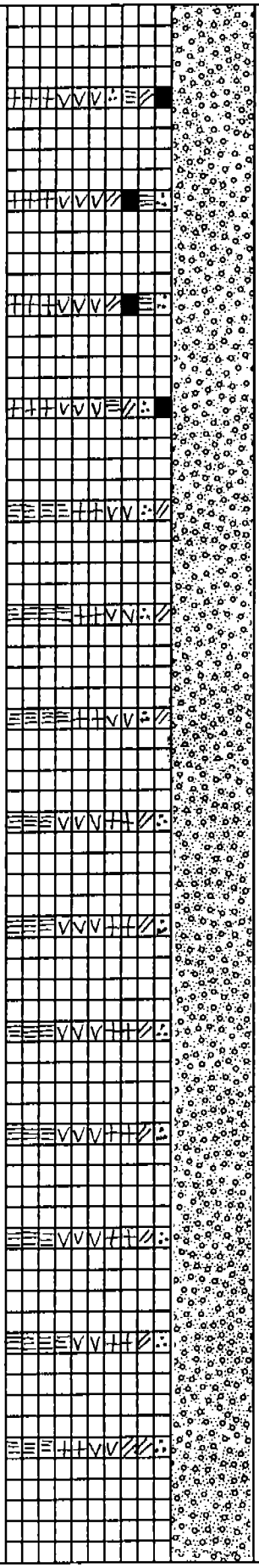
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			Timed by driller 24	Cuttings 0'-804' every 5'	0'-804' Alluvium (Santa Fe Group): Color of washed samples is medium dark to dark gray (N3-N4). Unwashed samples are tan to reddish brown where color is imparted by the clay content. Cuttings range in size from .05" to .5" in diameter and average .10". Samples consist of both natural gravel to sand grains and cuttings broken from cobble and possibly boulder size materials. Cuttings are angular chips and flakes while gravels are rounded to subangular grains. The unit can be described as an unconsolidated to moderatley consolidated pebble to boulder conglomerate. Sedimentary rock types present are micritic limestone, brown limonitic fine-grained sandstone, grayish green to brick red laminated to non-laminated siltstone. Limestones dominate the upper section while volcanics increase in abundance with depth. Volcanic rock types present include grayish purple, white and gold rhyolite porphyries, greenish gray epidotized to reddish purple andesite porphyry, red to pink coarse grained granite, a variety of quartzite, and microcrystaline quartz and striated feldspar mineral fragments.
10			10		
15			82		
20			44		
25			48		
30			44		
35			17		
40			65		
45			62		
50			40		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
50			40		
55			34		
60			16		
65			25		
70			49		
75			43		
80			50		80'-170' Cuttings are fine, and average ≤ .10" in diameter.
85			6		
90			4		
95			6		
100			6		
105			7		
110			15		
115			11		

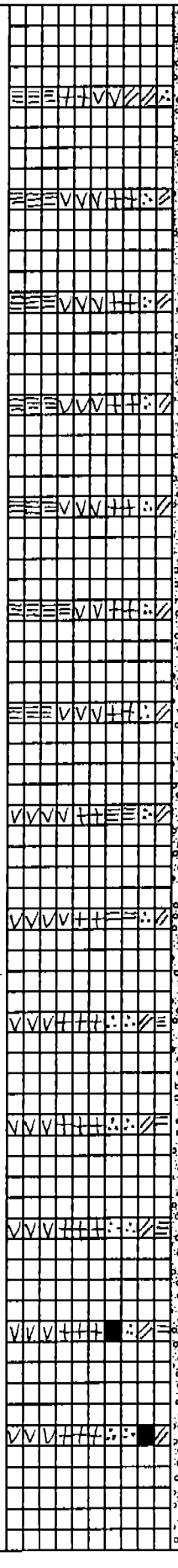
LOCATION ID: PL-7

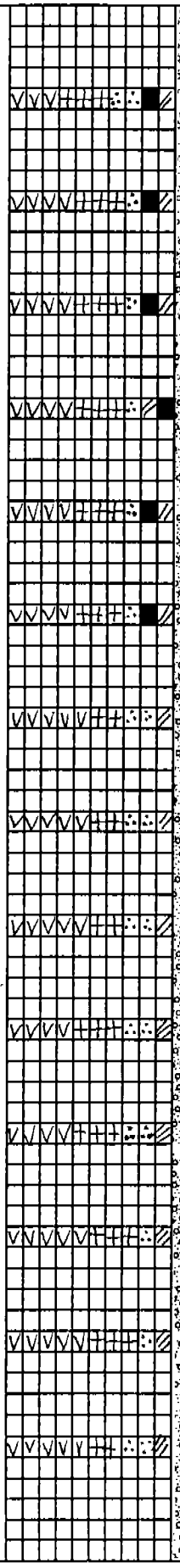
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
115			11		
120			18		
125			10		
130			7		
135			6		
140			10		
145			6		
150			6		
155			3		
160			4		
165			6		
170			4		
175			3		175'-195' Cuttings are becoming progressively rounded and larger in diameter.
180			3		

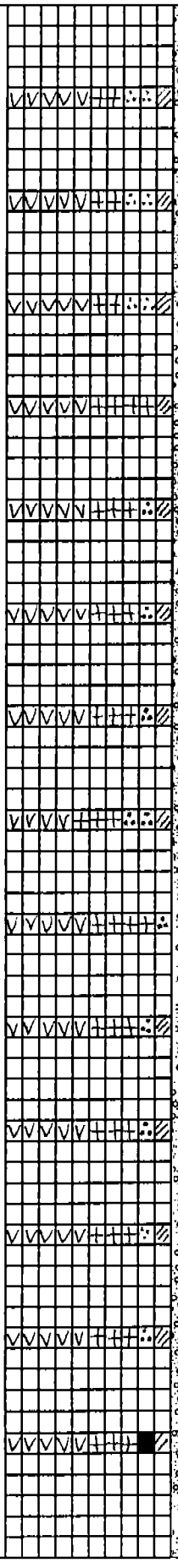
LOCATION ID: PL-7

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
180			3		
185			3		
190			3		
195			4		
200			3		200'-250' Cuttings range from .05"-.2" in diameter.
205			4		
210			3		
215			5		
220			4		
225			6		
230			3		
235			4		
240			3		
245			4		

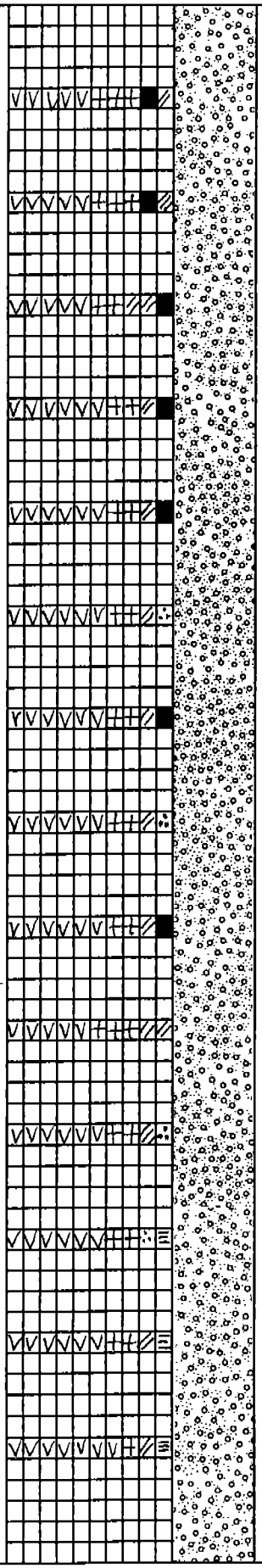
LOCATION ID: PL-7

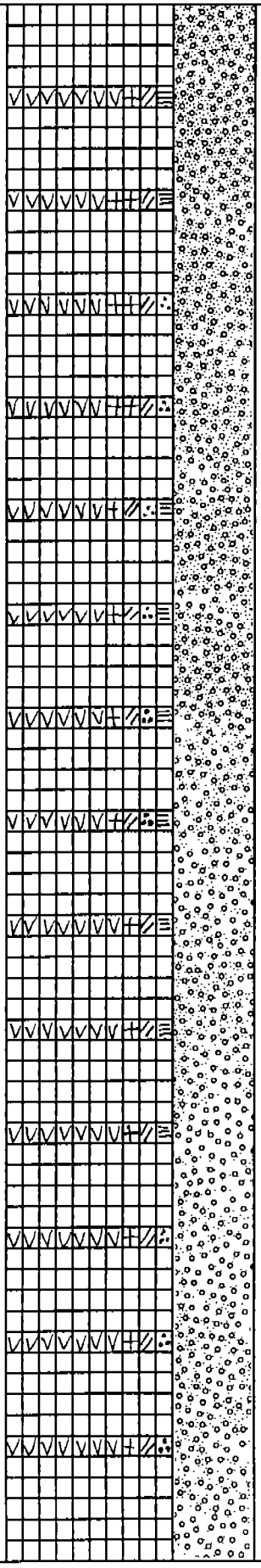
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			4		
250			4		250'-310' Cuttings are a uniform .10" in diameter and are subangular to subrounded.
255			8		
260			7		
265			12		
270			6		
275			14		
280			6		
285			7		
290			6		
295			7		
300			8		
305			7		305'-310' Andesite becomes apparent in sample.
310			13		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310			13	Cuttings (cont'd)	310'-315' Cuttings up to .5" in diameter present in sample.
315			8		315'-340' Samples consist of rounded to subangular gravel grains .2"-.4" in diameter.
320			7		
325			7		325'-330' Andesite is becoming more prevalent in volcanic fraction. Light purplish gray hornblende andesite and dark red-purple andesite with prominent white plagioclase phenochrysts are present.
330			5		
335			6		
340			6		340'-385' Cutting size is less than 0.1" to 0.3" and average less than 0.1".
345			6		
350			5		
355			4		
360			7		
365			9		
370			10		
375			9		

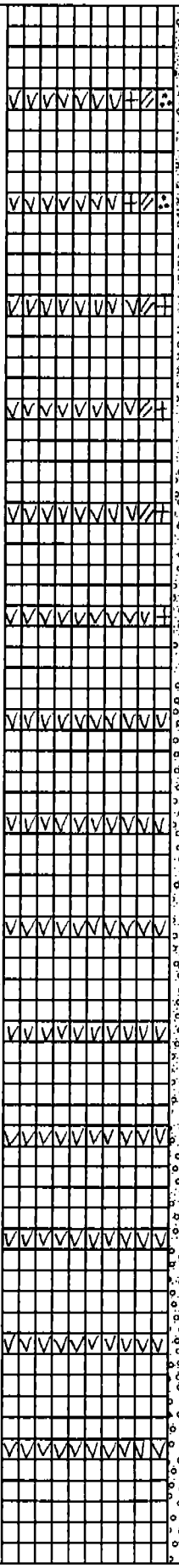
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
375			9	Cuttings (cont'd)	
380			11		
385			5		385'-460' Increase in average cutting size to 0.1". Cuttings are angular to subrounded.
390			8		
395			7		
400			8		
405			7		
410			9		
415			7		
420			7		
425			8		
430			6		
435			7		
440			6		

LOCATION ID: PL-7

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
440			6		
445			9		
450			4		
455			5		
460			8		460'-495' Cuttings are subangular to rounded formation grains .2" - .5" in diameter.
465			5		
470			5		
475			5		
480			5		
485			5		
490			7		
495			4		495'-510' Cuttings range from less than .1" to .4" in size and are angular to rounded.
500			6		
505			4		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
505			4	Cuttings (cont'd)	
510			6		510'-520' Formation gravel comprises cuttings. Grains are subangular to rounded and are .2"-.5" in diameter.
515			3		
520			4		
525			4		
530			6		
535			2		535'-540' Cuttings are .05"-.15" in diameter.
540			3		
545			3		
550			3		
555			3		
560			7		
565			6		565'-804' Volcanic-Rich Alluvium - Alluvium is volcanic-rich, comprised predominantly of greenish grey reddish purple and black andesite and andesite porphyry. A variety of rhyolites are also present.
570			4		

LOCATION ID: PL-7

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
570			4	Cuttings (cont'd)	
575			3		
580			2		
585			4		
590			4		590'-685' Cuttings range from < .1" - .5" in diameter.
595			5		
600			9		
605			10		
610			11		
615			5		
620			5		
625			6		
630			4		
635			5		

LOCATION ID: PL-7

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
635			5		
640			5		
645			5		
650			6		
655			4		
660			5		
665			3		
670			9		
675			10		
680			8		
685			14		
690			10		
695			16		
700			6		

LOCATION ID: PL-7

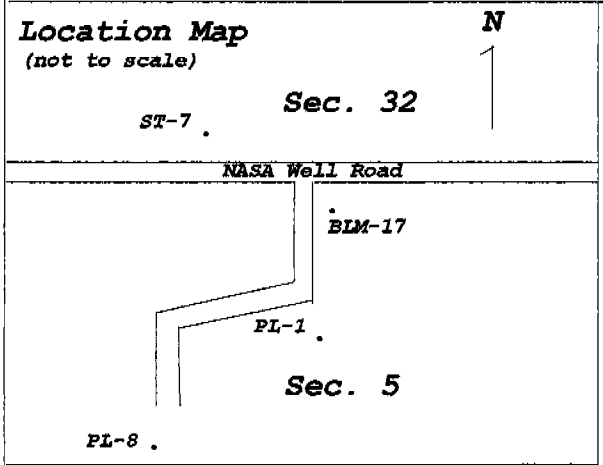
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
700			6		
705			5		
710			14		
715			16		
720			11		
725			14		
730			5		
735			8		
740			9		
745			9		
750			16		
755			17		
760			12		
765			5		

LOCATION ID: PL-7

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
765			5	Cuttings (cont'd)	
770			2		
775			4		
780			4		
785			6		
790			4		
795			5		
800			13		
805					TD = 804'
810					
815					
820					
825					
830					

WSTF We.. Borehole Lithologic/Geop..ysical log

Location Map
(not to scale)



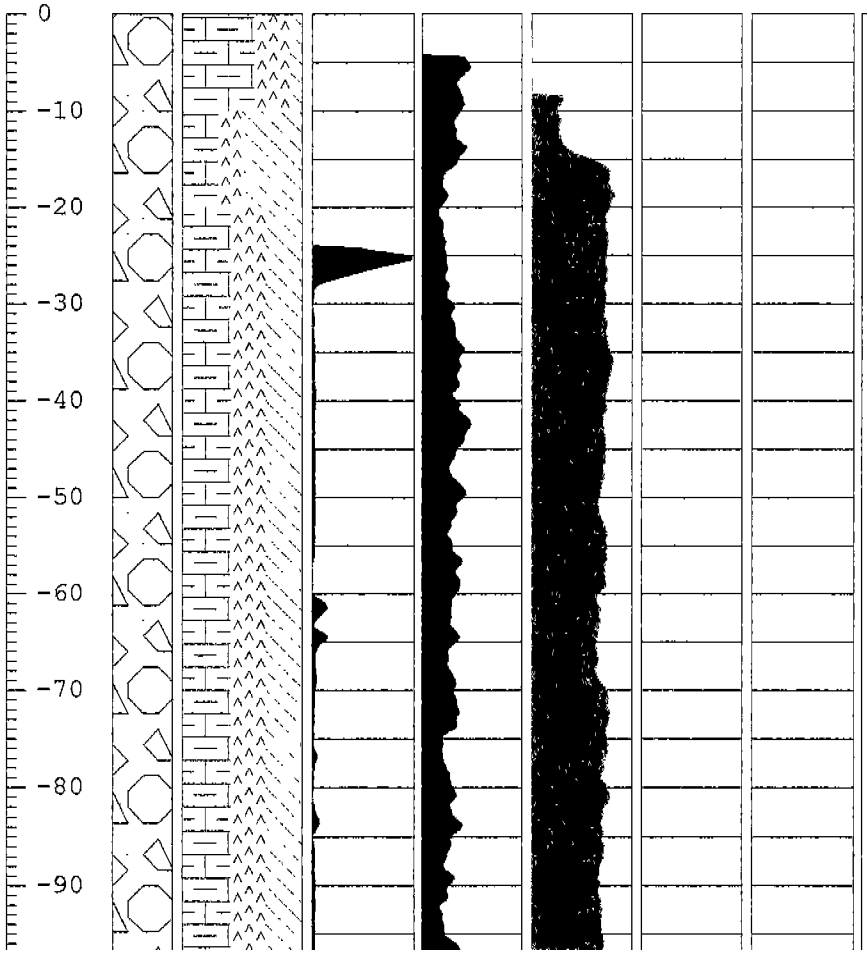
Location Description

Quarter 1: NE 1/4 Section: 5
Quarter 2: SW 1/4 Township: 21 S
Quarter 3: SW 1/4 Range: 3 E

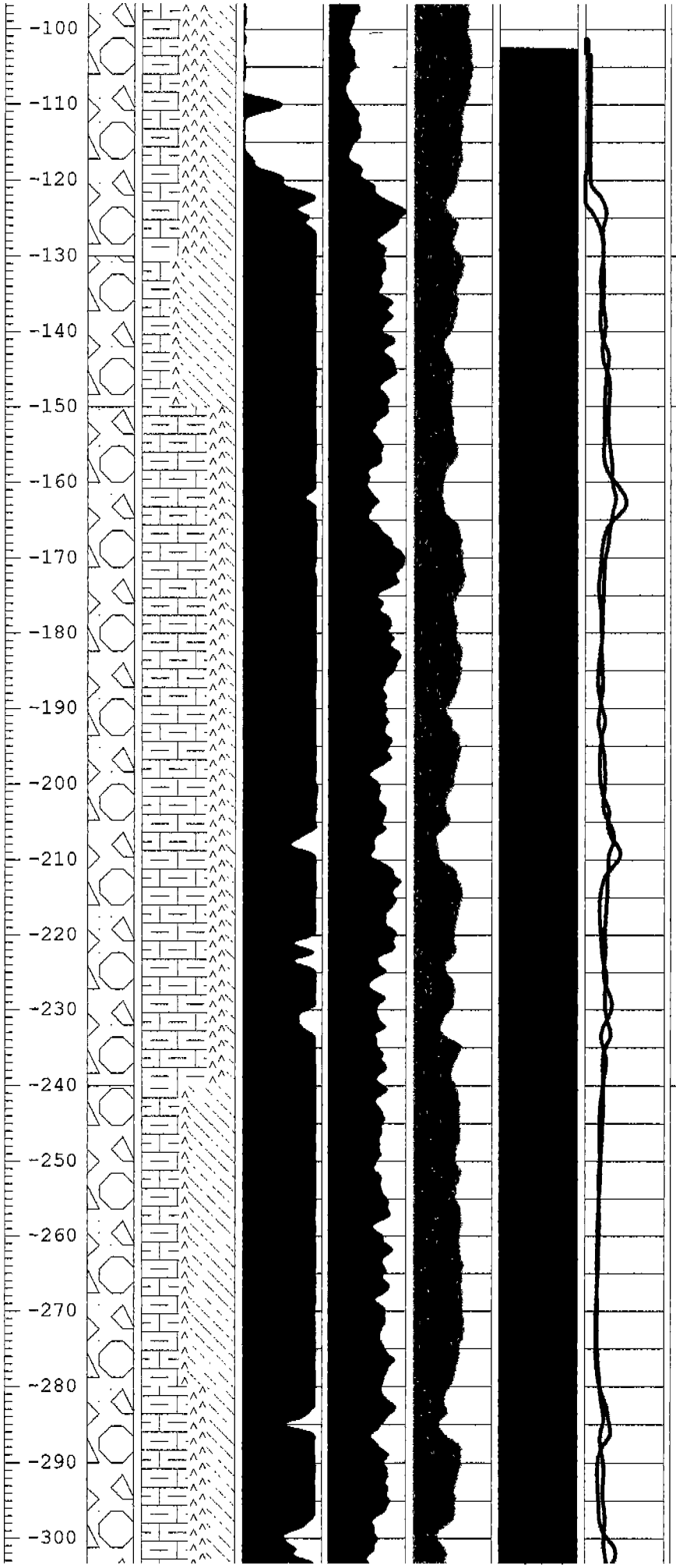
Site I.D: NASA-WSTF Location I.D: PL-8
County and State: Dona Ana County, New Mexico
Site Coordinates: N-224063.61 E-399235.94
Ground Elevation: 4469.63'
Total Depth of Borehole: 1,020'
Depth to Bedrock and Type: Not intercepted.
Depth to Groundwater from Geophysics: 375'
Drilling Method(s): Mud Rotary, reamed 17.5" to 122'; set 14" OD surface casing to 122'. Drilled 12.25" to 1,020'
Drilling Contractor: Stewart Brothers Drilling Co.
Geophysical Survey Contractor: Southwest Geophysical, Inc.
ATSC Field Representative(s): G. Giles, L. Hunnicutt-Mack, M. McClure, J. Pearson, and M. Rivera
Dates Drilling Started and Completed: 3/22/99 to 4/6/99
Comments: Retrofit Westbay well inside 4.5" OD stainless steel casing with four sampling zones. Lithologic samples collected every 10'.

Location Description: PL-8 is located approximately 2.5 miles west of the WSTF 100 Area and 1 mile south of the NASA well road.

Depth (Feet)	Lith-ology	Visual Percent 0 100	Sonic Porosity (Msec./ ft.) 0 120	Gamma API 50 200	Neutron API 0 75	SP (Mili-volts) -15 30	Resis-tivity (OHM-M) 64"-green 16"-red 0 100	Lithologic Description



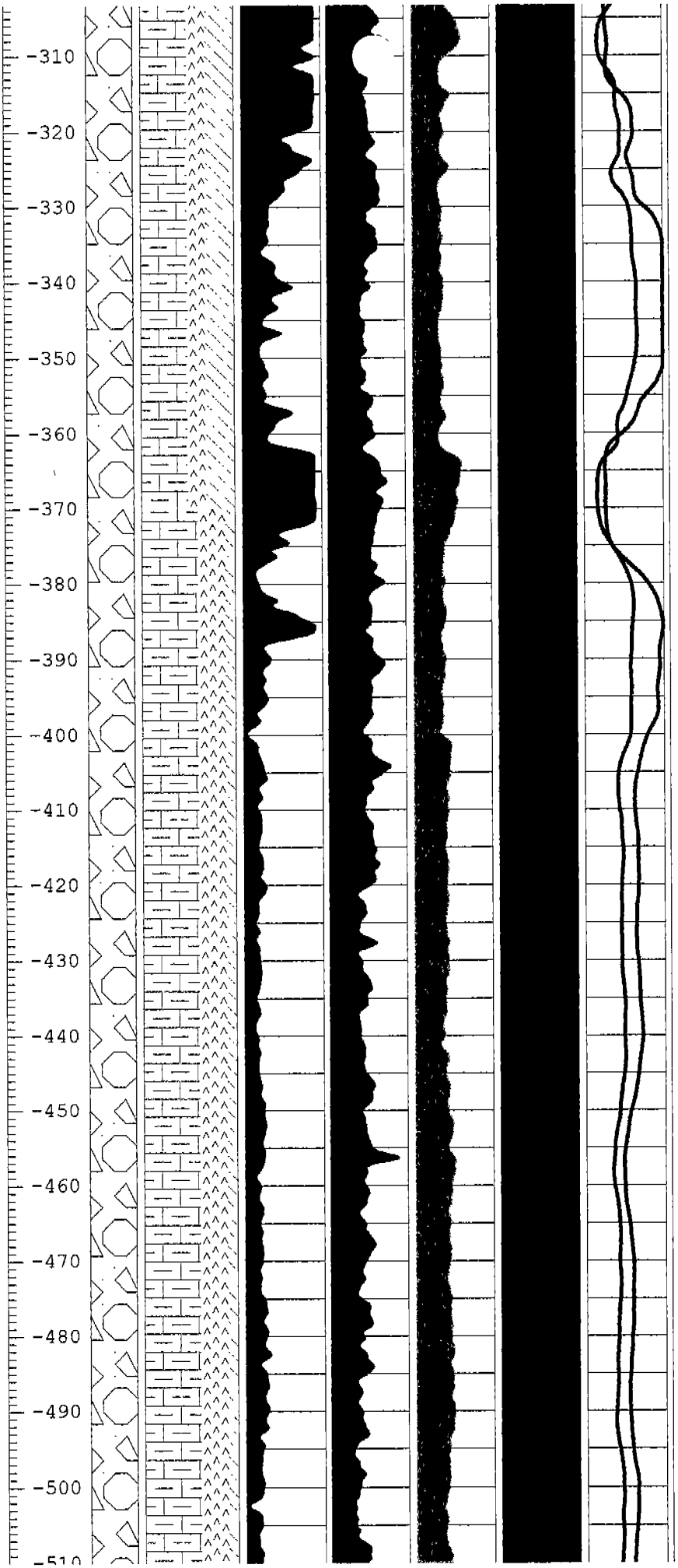
ALLUVIUM: Santa Fe Group (0-1,020 feet): The Santa Fe Group Alluvium is a poorly to moderately sorted polygenetic pebble conglomerate that consists predominantly of limestone and igneous clasts eroded from the nearby San Andres Mountains. Clasts generally comprise 30-60% of the lithologic samples. The following clast types were observed within the Santa Fe Alluvium: 1) 10-60% limestone clasts that are light gray (N6) to dark gray (N3), micritic, rounded to subangular, and display abundant hairline calcite-filled fractures, 2) 10-70% igneous clasts (both intrusive and extrusive) including moderate reddish brown (10R 4/6) to grayish red (5R 4/2) rhyolite, very light gray (N8) andesite to andesite porphyry, grayish orange (10YR 7/4) to very pale orange (10YR 8/2) rhyolite porphyry, moderate pink (5R 7/4) to grayish orange pink (10R 8/2) granite, grayish red (10R 4/2) to dark reddish brown (10R 3/4) quartzite and very light gray (N8) to medium light gray (N6) vitric lithic tuff, and 3) 10-60% dark reddish brown siltstone and clay. Siltstone and clay layers may be the result of in situ breakdown of volcanic clasts or may represent the muddy distal fan portion of alluvial fans. Note: the percent of volcanic clasts increases with depth.

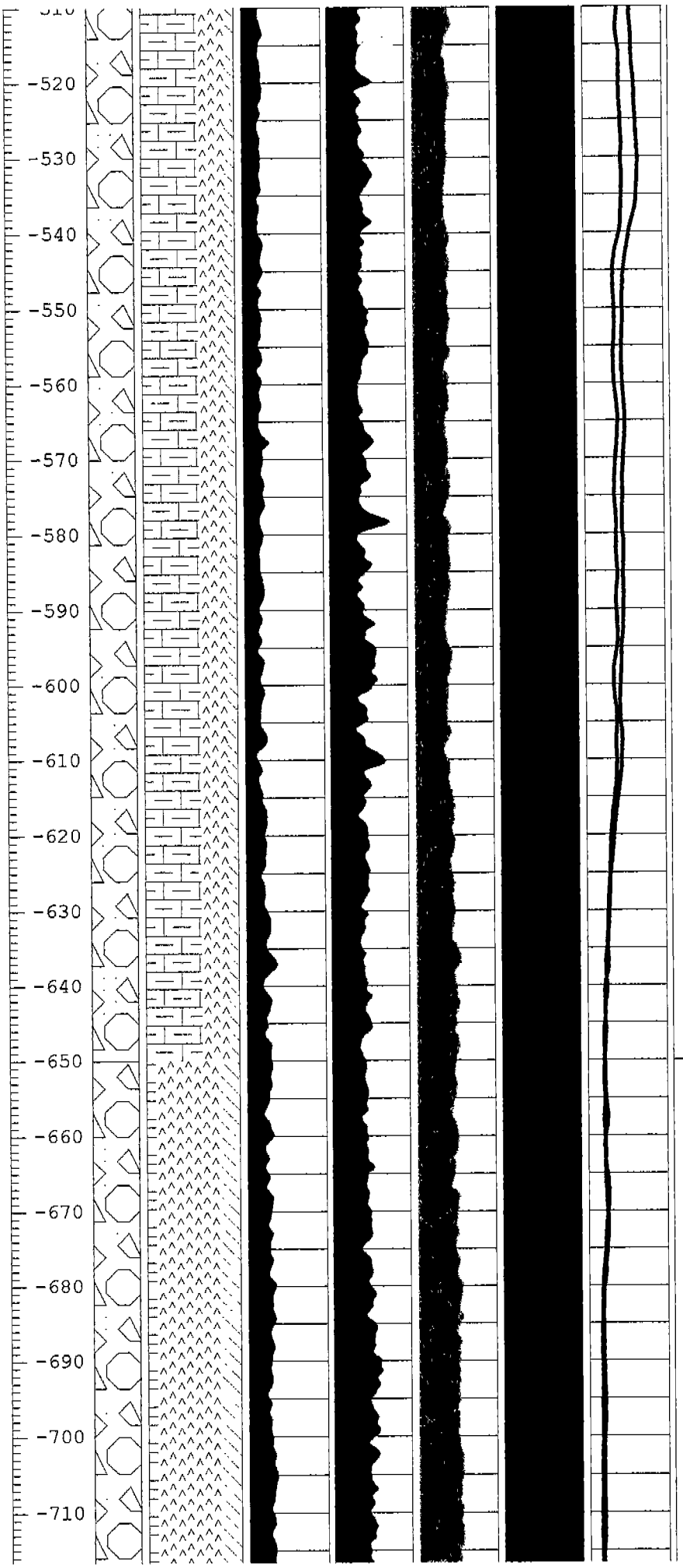


ALLUVIUM: (130-150 feet): Nodular clay-bearing interval.

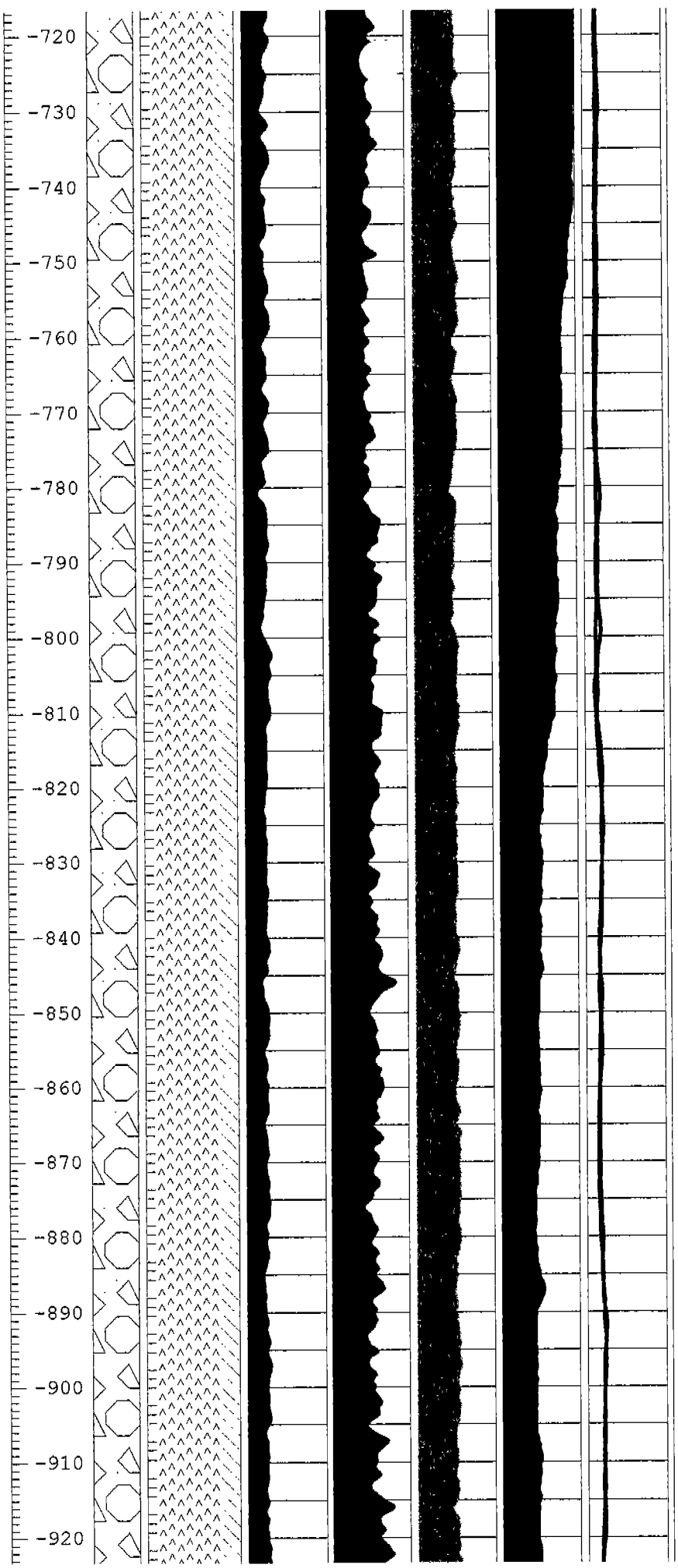
ALLUVIUM: (150-240 feet): Limestone-rich alluvium. Limestone clasts comprise 60% of the lithologic samples. Clay is reduced to 10%.

ALLUVIUM: (240-650 feet): Clasts comprise 50-80% of the sample. Limestone clasts are predominant.


-310
-320
-330
-340
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470
-480
-490
-500
-510



ALLUVIUM: (650-1,020 feet): Volcanic-Rich Alluvium. Clasts comprise 70% of the lithologic sample. Volcanic clasts comprise >80% of the clast fraction. The unit consists of 20% porphyritic rhyolite, 20% andesite, 20% altered volcanics, 10% volcanic tuff, 10% micritic limestone, and 20% clay.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-730
-740
-750
-760
-770
-780
-790
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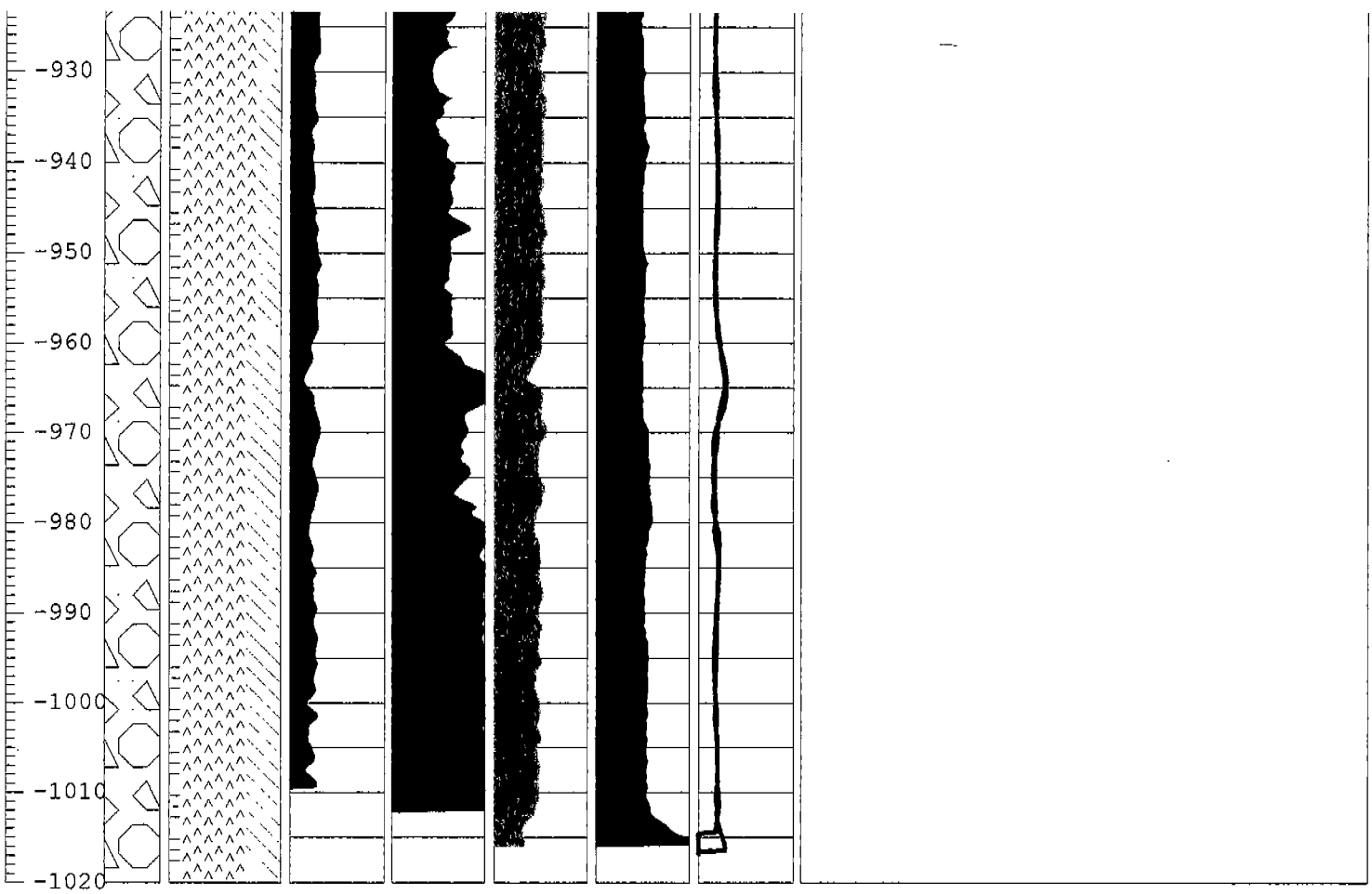
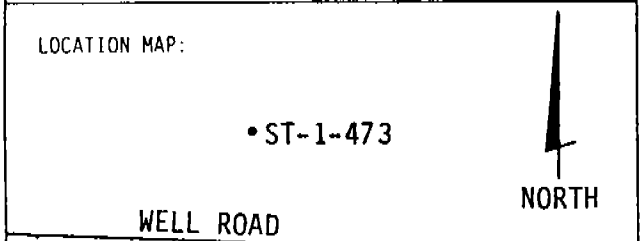
-810
-820
-830
-840
-850
-860
-870
-880
-890
-900
-910
-920


-930
-940
-950
-960
-970
-980
-990
-1000
-1010
-1020

LITHOLOGIC LOG

LOCATION MAP:



SW 1/4 SW 1/4 NW 1/4 SE 1/4 S 32 T 20S R 3E

SITE ID: NASA-WSTF LOCATION ID: ST-1-473

SITE COORDINATES (ft.):

N 229161.29 E 401136.07

GROUND ELEVATION (ft. MSL): 4503.64 (BRASS CAP)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud/Air-Foam Rotary

DRILLING CONTR.: Larjon

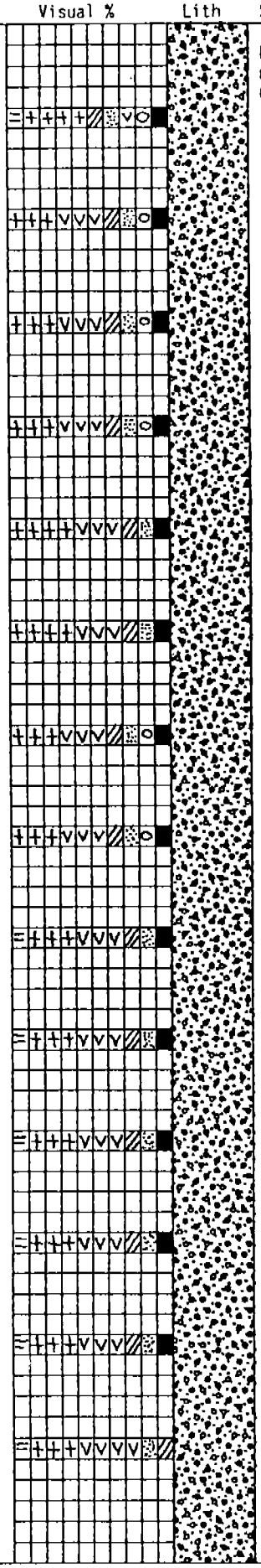
DATE STARTED: 15 May 1989 DATE COMPLETED: 30 May 1989

FIELD REP.: G. Contaldo/B. Cooper

COMMENTS: Mud Rotary 0-85' (9 7/8" pilot reamed to 16"); Air-Foam Rotary 82'-515' (9 7/8"); air-foam rotary core 515'-522'; Total depth = 522'; bedrock not reached.

LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5 10 15 20 25 30 35 40 45 50			(0-80' not available)	0'-515' cuttings	0-522' Alluvium (Santa Fe Group): Very light grey (N8) and grayish orange pink (10 R 8/2) to grayish black (N2); cuttings range in size from less than 1/32" (0.5 mm) to 0.6" (1.5 cm); angular to subrounded; poorly to moderately sorted. Unconsolidated to moderately consolidated, polygenetic, silty clay to cobble conglomerate including clay, silt, and sand. Lithologies include micritic limestone medium light grey (N6) to grayish black (N2), rhyolite, siltstone, andesite, quartzite, granite, tuff, sandstone, caliche (primarily as grain coating). Percentage of volcanic cuttings generally increases with depth. 0-50' High (10-30%) clay content, relatively large average cutting size 0.25-0.3" (6-7 mm).

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
			Drill time not available 0'-80'	Cuttings (cont'd)	
50					50'-85' Decrease in clay content (< 10%) and also slight increase in average cutting size 0.3"-0.4" (8-10 mm).
55					
60					
65					
70					
75					
80					
85			10		85'-160' Slight increase in clay content (approx. 10%) and also increase in percentage of volcanic in cuttings. Caliche coated grains are also less abundant.
90			4		
95			4		
100			3		
105			5		105'-115' Decrease in average cutting size to 0.15-0.2" (4-5 mm).
110			4		
115			3		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
115			3		115'-160' Increase in average cutting size to 0.2-0.25" (5-6 mm).
120			4		
125			4		
130			4		130'-160' Slight increase in percentage of sandstone cuttings.
135			4		
140			4		
145			4		
150			4		
155			3		
160			4		160'-220' Increase in percentage of rhyolite cuttings and decrease in percentage of sandstone cuttings.
165			4		
170			5		
175			3		
180			3		

LOCATION ID: ST-1-473

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180			3	Cuttings (cont'd)	
185			4		
190			3		195'-215' Slight increase in silt and clay content.
195			3		
200			3		
205			3		
210			4		
215			3		215'-240' Slight decrease in silt and clay content.
220			3		
225			5		
230			4		
235			4		
240			3		240'-260' Slight increase in silt and clay content.
245			3		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			3		
250			3		
255			2		
260			3		
265			5		
270			3		270'-515' Increase in percentage of igneous (primarily rhyolite and andesite) cuttings and slight decrease in percentage of limestone cuttings.
275			3		
280			3		
285			6		
290			3		
295			7		295'-325' Drilling rates begin to increase slightly indicating moderately indurated alluvium and/or possibly increase in clay content.
300			5		
305			8		
310			8		

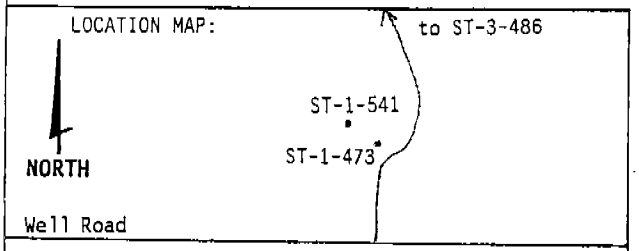
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
310			8		
315			7		
320			6		
325			5		325'-360' Decrease in clay content and slight increase in percentage of sandstone cuttings. Sandstone cuttings may be moderately indurated sands.
330			6		
335			6		
340			4		
345			7		
350			6		
355			4		
360			6		
365			9		365'-370' Slight increase in clay content.
370			5		
375			6		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375			6		
380			7		
385			5		
390			7		
395			5		
400			5		
405			5		
410			7		
415			7		
420			5		
425			6		
430			7		
435			5		
440			8		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
440			8		
445			4		445'-515' Drilling rates begin to decrease indicating that alluvium is becoming slightly less indurated and/or clay content decreases.
450			4		
455			4		
460			4		
465			3		
470			4		
475			3		
480			6		
485			4		
490			3		
495			3		
500			5		
505			4		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
505			4	Cuttings (cont'd)	
510			3		
515			3	515'-522' Core	**CORE INTERVAL** (See Attached Core Description)
520			85 (cored 7')		
525					
530					
535					
540					
545					
550					
555					
560					
565					
570					

LITHOLOGIC LOG



SW 1/4 SW 1/4 NW 1/4 SE 1/4 S32 T20S R3E

SITE ID: NASA-WSTF LOCATION ID: ST-1-541

SITE COORDINATES (ft.):

N 229207.06 E 40119.59

GROUND ELEVATION (ft. MSL): 4502.39 (B.C.)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud Rotary/Air Foam Rotary

DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 10/29/91 DATE COMPLETED: 11/19/91

FIELD REP.: D. Menzie

COMMENTS: 0'-82' Mud rotary. 12¼" pilot hole reamed to 16". 10" surface casing to 80'. 80'-585' air/foam rotary. Bedrock not reached. Total depth by drillograph is 585'.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
			Timed by driller	Cuttings	0'-365' Alluvium: (Santa Fe Group): Cutting samples consist of multicolored clasts with clay-rich intervals colored light brown (5 YR 6/4) to moderate brown (5 YR 4/4). Cuttings range in size from much less than 0.1 inches (clay and silt size) to 1.0 inches and average 0.1 inches in size. Cuttings are rounded to angular. Rounded and subrounded cuttings are formational grains and comprise 10-50% of individual samples. Angular and subangular cuttings include blocky formation clasts and flat chips broken during drilling. The alluvium is an unconsolidated to moderately consolidated, poorly sorted, pebble to boulder, polygenetic conglomerate. Intermittent clay and caliche-rich intervals are noted in the log. Cutting clasts representing various lithologies occurring in the alluvium are light gray (N7) to grayish-black (N2) limestone, white (N9) iron-stained rhyolite, moderate reddish-brown (10 R 4/6) to dusky red (5 R 3/4) siltstone, dusky brown (5 YR 2/2) sandstone, brownish-black (5 YR 2/1) to dark brownish red (10 R 3/4) andesite, brownish-gray (5 YR 4/1) to dark reddish-brown (10 R 3/4) tuff and lesser amounts of quartz, granite and caliche. Volcanic clasts of andesite and tuff increase gradually with depth such that samples below 365' indicate a volcanic-rich alluvium.
5			23		
10			18		
15			62		
20			17		
25			19		
30			11		
35			20		0'-82' Mud rotary.
40			31		0'-15' Clay-rich interval, clay content 50-60% cuttings range in size from > .1 inches to .2 inches and average less than .1 inches, cutting angular to subrounded.
45			15		15'-45' Increase in cutting size, range from .1 to .9 inches, average .4 inches, rounded to angular.
50			20		35'-45' Clay-rich interval, clay content 40-50%.
					50'-60' Decrease in cutting size to average .2 inches, range from less than .1 to .3 inches, angular chips predominate.

LOCATION ID: ST-1-541

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
				Cuttings (cont'd)		
50			20			
55			8			
60			13		60'-75'	Increase in cuttings size to average .4 inches, rounded and blocky clasts dominate.
65			16		65'-80'	Clay-rich interval, clay content 20-40%.
70			36			
75			25		75'-80'	Decrease in cutting size.
80			44		80'-120'	10-50% grout in cuttings, visual % is for formational clasts, clay content 10-30%.
					80'-130'	Increase in average cutting size to 0.3 inches.
85			9			
90			4			
95			2			
100			3			
105			2			
110			4			
115			4			

LOCATION ID: ST-1-541

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cónt'd)	
115			4		
120			3		
125			4		125'-215' Clay content 10-40%.
130			3		130'-135' Decrease in average cutting size to 0.1 inches.
135			3		135'-160' Increase in average cuttings size to 0.4 inches.
140			3		
145			3		
150			2		
155			3		
160			3		160'-205' Decrease in average cutting size to 0.2 inches.
165			3		
170			4		
175			2		
180			3		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
180			3		
185			2		
190			3		
195			2		
200			3		
205			2		205'-585' Cutting size pretty stable, ranges from less than 0.1 inches to 0.3 inches and averages about 0.1 inches.
210			3		210'-215' First caliche in cuttings ≥ 10%.
215			3		215'-220' Slight increase in drill time.
220			8		
225			2		
230			4		
235			4		235'-245' Caliche 10%.
240			2		
245			5		

LOCATION ID: ST-1-541

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			5		
250			3		250'-255' Slight increase in drill times. 250'-265' Caliche 10%.
255			6		
260			3		
265			4		
270			3		
275			4		275'-280' Slight increase in drill times. 275'-285' Caliche 10%.
280			7		
285			4		
290			3		290'-295' Caliche 10%.
295			4		295'-310' Clay 10%.
300			4		
305			4		
310			3		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
310			3		
315			4		
320			4		
325			4		325'-335' Caliche 10%.
330			5		330'-340' Volcanic clasts ≥ 60% of sample; consist of andesite, tuff and rhyolite.
335			5		
340			4		340'-345' Caliche 10%.
345			4		
350			5		350'-375' Caliche 10%.
355			5		
360			6		
365			5		365'-585' Volcanic-rich Alluvium (Santa Fe Group): Samples range in color from brownish gray (5 YR 4/1) to moderate reddish brown (10 R 4/6). Cuttings range in size from less than 0.1 inches to 0.3 inches and average 0.1 inches in size. Cuttings are subrounded to angular and poorly sorted. The volcanic-rich alluvium is a moderately consolidated, pebble to boulder, polygenetic conglomerate. Predominant cutting clast lithologies are brownish-black (5YR 2/1) to dark brownish-red (10 R 3/4) andesite and brownish-gray (5 YR 4/1) to dark reddish-brown (10 R 3/4) tuff. Additional lithologies in order of decreasing abundance include limestone, siltstone, rhyolite, siltstone and caliche.
370			3		
375			7		

LOCATION ID: ST-1-541

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375			7		
380			4		
385			5		
390			3		390'-395' Caliche 10%.
395			4		
400			3		
405			6		
410			5		
415			4		415'-545' Caliche 10% of sample. Consists of caliche-cemented sand and caliche-coated clasts larger than sand.
420			4		
425			3		
430			4		
435			4		
440			4		

LOCATION ID: ST-1-541

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
440			4		
445			4		
450			3		
455			4		
460			4		
465			3		
470			2		
475			3		
480			4		
485			4		
490			4		
495			4		
500			7		
505			2		

LOCATION ID: ST-1-541

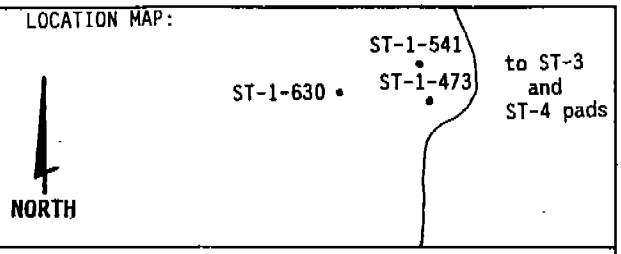
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
505			2		
510			2		510'-515' Slight increase in drill times.
515			8		
520			4		
525			5		
530			2		
535			2		
540			3		
545			3		
550			5		
555			5		
560			2		
565			2		
570			3		

LOCATION ID: ST-1-541

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
570			3		570'-585' Slight increase in drill times.
575			6		
580			7		
585			7		TD = 585' by drillograph.
590					
595					
600					
605					
610					
615					
620					
625					
630					
635					

LITHOLOGIC LOG

LOCATION MAP:



*not to scale

SW 1/4 SW 1/4 NW 1/4 SE 1/4 S32 T20S R3E

SITE ID: NASA-WSTF LOCATION ID: ST-1-630

SITE COORDINATES (ft.):

N 229179.820 E 401046.481

GROUND ELEVATION (ft. MSL): 4501.61

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud Rotary/Air Foam Rotary

DRILLING CONTR.: Larjon Drilling Co

DATE STARTED: 06/16/92 DATE COMPLETED: 07/21/92

FIELD REP.: M. Canavan, D. Menzie

COMMENTS: Drilled mud rotary 12¼" pilot hole 0'-85'. Reamed to 16" and installed 85' of 10" surface casing. Drilled air foam rotary 9 7/8" borehole 85'-698'. Bedrock (Tuff) encountered at 645. TD = 698'.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			Timed by driller	Cuttings (grab sample every 5')	Alluvium (Santa Fe Group): Multicolored formation clasts and cuttings comprise the alluvium at ST-1-630. Grains range from clay-size to cobble size and samples may be well-to poorly-sorted. Unit is an unconsolidated to semiconsolidated polygenetic pebble to boulder comglomerate. Clays comprise from 20%-80% of most samples from 0'-380' and these percentages are probably enhanced by the bentonite-mud drilling fluid. Lithology of clasts is highly variable. Limestone dominates samples from 0'-290' and is light gray (N8) to grayish black (N1) with no recognizable allochems. Other sedimentary rocks include greenish gray (5 GY 6/1) and dusky red (5 R 3/4) laminated to nonlaminated siltstone and light brown to yellow brown fine-grained sandstone. Caliche is present as cementing agent and grain coatings in upper 20' of unit. Volcanic clasts include various rhyolites, tuffs and andesites. Other miscellaneous rock types include quartzite, granite, chert and quartz and feldspar grains.
			18		
10			36		
15			20		
20			38		
25			11		
30			20		
35			18		
40			8		
45			14		
50			22		

0'-25' Cuttings range in size from < 0.1 inches to 0.3 inches. Average size is 0.1 inches. Grains are angular to rounded.

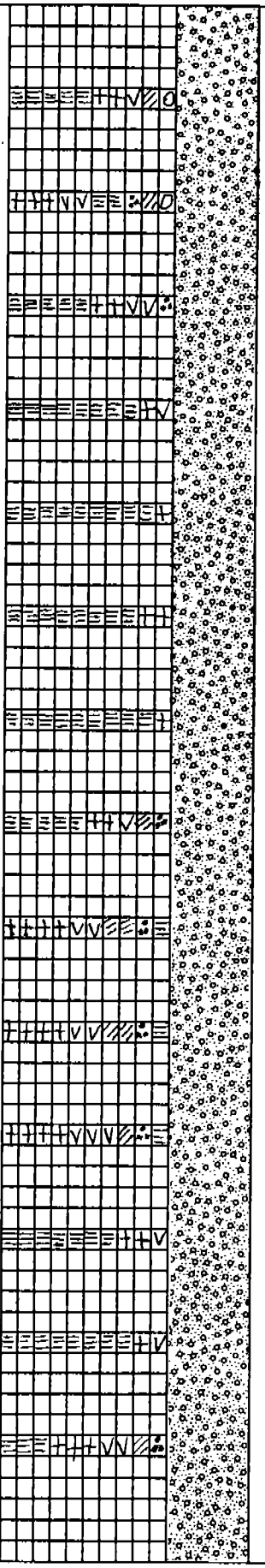
LOCATION ID: ST-1-630

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
50			22		
55			18		
60			16		
65			7		
70			6		
75			5		
80			15		
85			12		
90			6		
95			8		
100			12		
105			16		
110			11		
115			67		

LOCATION ID: ST-1-630

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
115			67		
120			21		
125			66		
130			7		
135			7		
140			202		
145			23		
150			93		
155			14		
160			5		
165			7		
170			10		
175			9		
180			7		

LOCATION ID: ST-1-630

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
180			7		
185			6		
190			9		
195			9		
200			10		
205			12		
210			10		
215			8		
220			5		
225			6		
230			5		
235			7		
240			13		
245			11		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245			11	Cuttings (cont'd)	
250			13		
255			12		
260			16		
265			7		
270			8		
275			17		
280			14		
285			16		
290			29		
295			9		
300			18		
305			27		
310			22		

LOCATION ID: ST-1-630

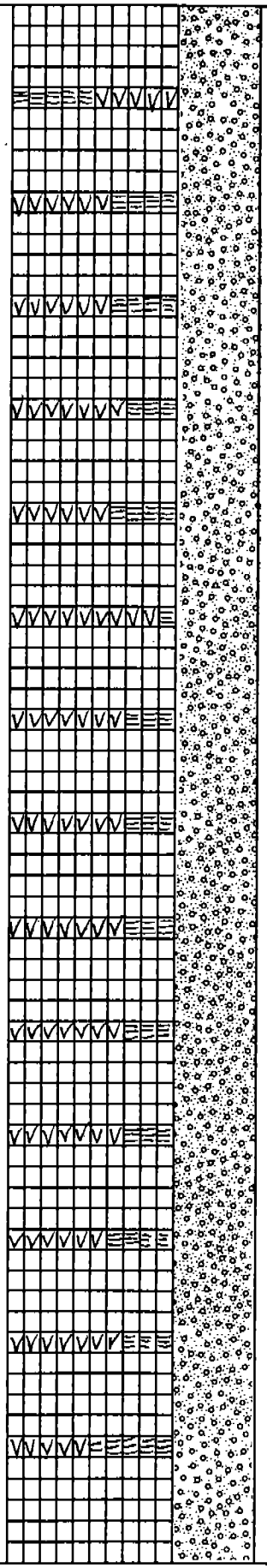
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
310			22		310'-320' Cuttings range from <.10" to .5" in diameter and are subrounded to angular.
315			27		315'-350' Clays are multi-colored. Stained by iron oxides to reddish and yellow-gold. Some grays and white.,
320			16		
325			29		
330			23		
335			14		
340			15		
345			15		
350			17		
355			29		
360			27		
365			42		
370			23		
375			33		

LOCATION ID: ST-1-630

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375			33		
380			34		380'-405' 50% of sample washes through screen.
385			19		385'-390' Sample not washed to show % of fines present. Sample is predominantly fine grained, .05" diameter or less.
390			8		
395			6		
400			18		
405			8		
410			7		
415			8		
420			9		
425			8		
430			7		
435			10		435'-440' 50% of sample is silt-sized. Sample not washed.
440			7		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
440			7		
445			5		445'-460' Grains average .10" in washed sample.
450			6		
455			6		
460			8		
465			8		465'-480' Grains are well rounded to rounded.
470			7		
475			6		
480			5		
485			4		
490			5		
495			5		
500			5		
					503' Last air foam sample.
505			12		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
505			503'-TD Mud rotary	Cuttings (cont'd)	503'-510' Sampled (shown here as 505'-510'). Note increase in clay %. Mud gel does not wash out formation muds as air foam does.
510			9		510'-645' Volcanic-Rich Alluvium: Unit is comprised of a wide variety of volcanics including green to purple, white, red and gold andesites, rhyolites, and gray to red tuffs and granites eroded and transported from surrounding volcanic highs. Clays represent highly altered zones in the volcanic rich alluvium.
515			9		
520			12		503'-525' Andesites increasing over rhyolites in volcanic %.
525			16		525'-530' Cuttings are slightly finer (≈ .10") and angular; may indicate increasing hardness.
530			12		
535			7		
540			5		
545			4		
550			13		
555			7		
560			8		
565			9		
570			9		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
570			9		
575			8		
580			7		
585			9		
590			7		590'-615' Grains are sub- to well-rounded and range from 0.10"-.25" in diameter. Andesite is the primary constituent, but rhyolites and tuffs are present as well. Possibly 5% calcite cementation of alluvial grains.
595			7		
600			8		
605			10		
610			21		
615			14		
620			19		620'-625' Cuttings are smaller and range from .05" to .25". Clay is buff tan colored but is becoming pinkish. Pink coloration probably due to presence of red tuff.
625			23		625'-630' Brick-red rhyolite more predominant. White calcite makes up 5% of sample.
630			25		630'-635' Clay is brick-red to pinkish tan.
635			17		

LOCATION ID: ST-1-630

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
635			17		
640			26		640'-645' Brick red tuff makes up 75% of the sample. Calcite is increasing in abundance (20%).
645			26		645' Bedrock (Tuff): Unit is a crystal lithic ashflow tuff. Groundmass is dense, blackish-red, and appears welded. Hornblende? phenocrysts show intense reaction rims or are altered to hematite completely. Large subhedral quartz phenocrysts, hematite?, biotite and ? feldspars are also present. Phenocrysts comprise up to 50% of the rock. Calcite is present as fracture fillings.
650			28		
655			20		
660			27		
665			28		
670			30		
675			23		
680			40		
685			47		
690			34		
695			34		
700			17 to 698'		TD = 698'

Lithologic Log Addendum

Well ST-1-630

Cuttings of the lithologic unit from well ST-1-630 were sent to the Department of Geological Sciences, New Mexico State University (NMSU), Las Cruces, New Mexico, for detailed petrographic analysis when identification of fine-grained, highly altered volcanic rocks at the NASA-WSTF site became difficult using conventional field methods. Petrographic reports from NMSU were received after the printing of these lithologic logs, hence the need for this addendum. The petrographic description from NMSU is included below.

Previous unit name based on field identification: **Tuff**

New Unit name based on petrographic analysis: **Andesite**

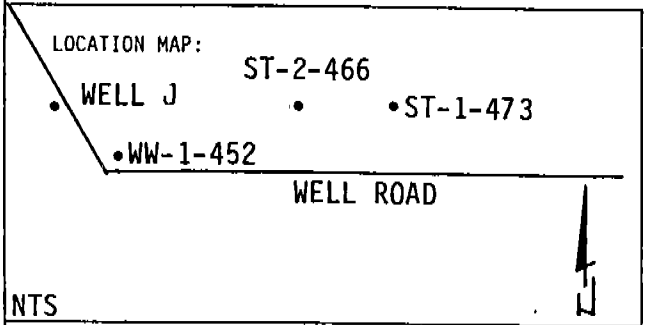
ST-1-630 (695' - 700')

Porphyritic biotite-augite andesite

Origin:	lava flow
Texture:	aphanitic porphyritic
Phenocryst mineralogy:	plagioclase + augite + biotite + FeTi oxides
Porosity:	low in rock but potentially high along calcite veins
Alteration:	thick veins of calcite are present, but otherwise fresh

Approximately 7% phenocrysts are surrounded by an intersertal to trachytic groundmass dominated by plagioclase and oxides. Plagioclase phenocrysts (3%, 0.1 - 1.4 mm) are zoned and resorbed, with euhedral clear rims. Augite phenocrysts (3%, 0.34 - 1.4 mm) are twinned and euhedral. Biotite phenocrysts (0.5%, 1 - 1.4 mm) are oxidized and exhibit yellow to red-brown pleochroism. FeTi oxides (0.5%, 0.3 - 0.45 mm) are present as microphenocrysts. Apatite (0.1 mm) exists in trace amounts within augite and plagioclase phenocrysts. A trace of quartz is present, in contact with augite, and is rounded and embayed. The porosity is low in the unfractured rock, but is potentially quite high along the veins. Alteration is mainly present in thick veins of clear calcite that contain fragments of phenocryst crystals and groundmass. The veins are 0.1 mm to 0.4 mm wide. Other than the veins, the rock is fairly fresh. This sample originated as a lava flow.

LITHOLOGIC LOG



SE 1/4 SE 1/4 NW 1/4 SW 1/4 S 32 T 20S R 3E

SITE ID: NASA-WSTF LOCATION ID: ST-2-466

SITE COORDINATES (ft.):

N 229170.17 E 399036.88

GROUND ELEVATION (ft. MSL): 4467.22 (BC)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud & Air-Foam Rotary

DRILLING CONTR.: Larion Drilling Co.

DATE STARTED: 31 July 1989 DATE COMPLETED: 18 August 1989

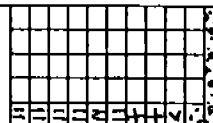
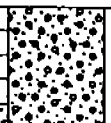
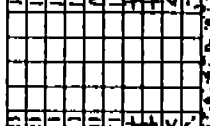
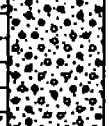
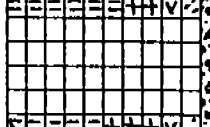
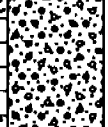
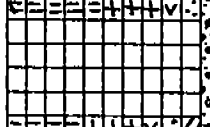
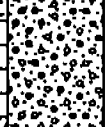
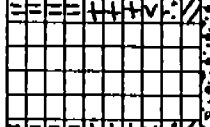
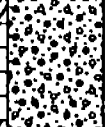
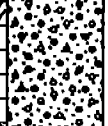
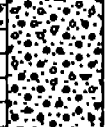
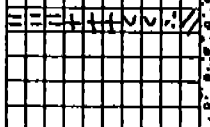
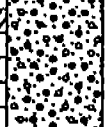
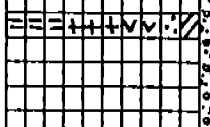
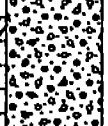
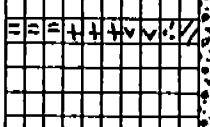
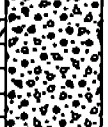
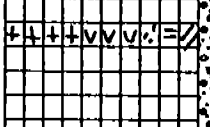
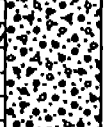
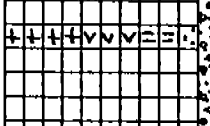
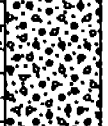
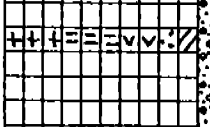
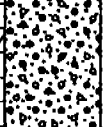
FIELD REP.: R. Cooper

COMMENTS: 0'-80', 12 1/4" pilot hole reamed to 16" borehole, using mud rotary; 10"x79' steel surface casing;

LOCATION DESCRIPTION: 80'-484', 9 7/8" borehole drilled with air-foam rotary, 484'-494' cored. TD = 494'

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			5	Cuttings (0-484')	0'-270' Clay Rich Alluvium: Moderate brown (5 YR 4/4) to moderate yellow brown (10 YR 5/4) clay rich alluvium. Cuttings in samples range from less than .5 mm to 7 mm (0.02-0.21 inches). The predominate cutting shape is subrounded to rounded grains. Angular cuttings are present in small amounts. Clasts in samples consist mostly of medium gray (N5) to grayish black (N2) limestone and white (N9) iron-stained rhyolite. Other clasts included multiple colors of quartzite, dusky red (5 R 3/4) to dark reddish brown (10 R 3/4) siltstone, light gray (N7) to greenish gray (5 GY 6/1) siltstone, moderate brown (5 YR 4/4) sandstone, grayish orange (10 YR 7/4) caliche.
10			7		
15			11		
20			5		0'-20' Sandy clay - Average cutting size 0.5-1mm (0.02-0.04in) 90% clay.
25			5		20'-25' Gravelly clay, 3-4 mm (0.12-0.16 in) average size up to 12 mm.
30			4		25'-40' Average cutting size .5-1mm(0.02-0.04 in) 90% clay.
35			4.5		
40			3.5		40'-45' Fine-medium grained sandy clay.
45			5		45'-50' Medium-grained sand to gravelly clay.
50			6		

LOCATION ID: ST-2-466

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
50				Cuttings (cont'd) 0'-484'	50'-60' Fine to coarse-grained sandy clay.
55			6		
60			6.5		60'-75' Coarse-grained sand to gravelly clay.
65			6		
70			6		
75			6		75'-95' Gravelly-clay.
80			7		
85			8		
90			4		
95			3		95'-100' Average cutting size 2-3 mm (0.08-0.12 in).
100			8		100'-115' Gravelly alluvium with 10% clay. Average cutting size is 4-5 mm (0.16-0.20 in).
105			5		
110			4		
115			4		

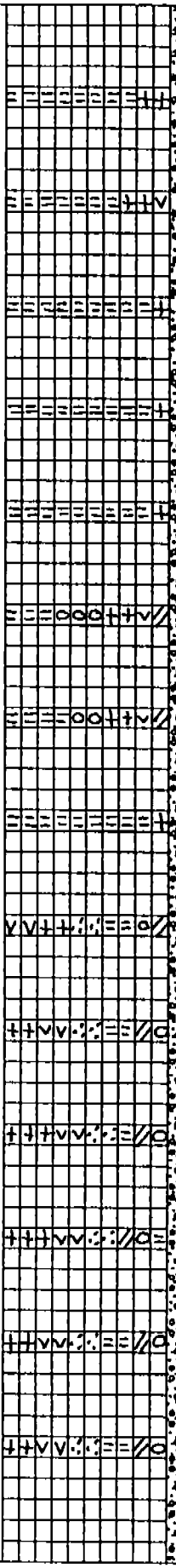
LOCATION ID: ST-2

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 0'-484'	
115					115'-130' Medium-grained sand to gravelly clay. Average cutting size 2-3 mm (0.08-0.12 in).
120			4		
125			4		
130			3		130'-155' Sandy clay.
135			4		
140			4		
145			4		
150			4		
155			3		155'-170' Caliche fragments present in cuttings but <10%; average cutting size 3-4 mm (0.12-0.16 in).
160			3		
165			3		
170			3		
175			3.5		
180			3		

LOCATION ID: ST-2-466

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd) 0'-484'	
180					180'-185' Caliche fragments present but <10%.
185			5		185'-190' Average cutting size 2-3 mm (0.08-0.12 in).
190			5		190'-210' Gravelly clay, average cutting size 4-5 mm (0.16-0.20 in). Caliche fragments present but <10%.
195			8		
200			4		
205			3		
210			7.5		210'-220' Sandy clay.
215			3		
220			9		220'-225' First sample with moderate pink (5 R 7/4) to light red (5 R 6/6) rhyolite.
225			4		220'-230' Gravelly clay.
230			3		230'-265' Sandy clay.
235			3		
240			3		
245			3		

LOCATION ID: ST-2-466

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245				Cuttings (cont'd) 0'-484'	
250			3		
255			3		
260			3		
265			3		
270			4		270'-484' Alluvium (Santa Fe Group): Multicolored cuttings in moderate brown (5 YR 4/4) clay. Cuttings in samples range in size from silt-size to 10 mm (0.4 in). The predominate cutting shape from 270'-455' is subrounded and from 455'-484' is angular. The predominant cutting from 270'-325' is limestone. Igneous cuttings are mostly rhyolite in this interval. Andesite cuttings become more abundant with depth and rhyolite fraction decreases. The formation is a weakly cemented, sandy, pebble to boulder conglomerate. Other cuttings include quartzite, siltstone, sandstone, caliche as described in the above clay-rich alluvium section. Andesite cuttings include, grayish black (N2) aphanitic andesite, dusky red (5 R 3/4) porphyritic andesite with 1-4 mm (0.04-0.16 in) phenocrysts of plagioclase and epidote, and medium gray (N4) porphyritic andesite with 1-4 mm (0.04-0.16 in) phenocrysts of plagioclase.
275			5		
280			3		
285			4		
290			3		
295			7		265'-275' Caliche in cuttings. Many of the caliche cuttings are subrounded to rounded. Pink rhyolite is not present in samples however white iron-stained rhyolite is still present.
300			4		280'-290' Clay rich sand and gravel; much less caliche in samples than in samples above; average cutting size 2-3 mm (0.08 - 0.12 in).
305			7		290'-310' Gravel with moderate to small amounts of clay.
310			7		

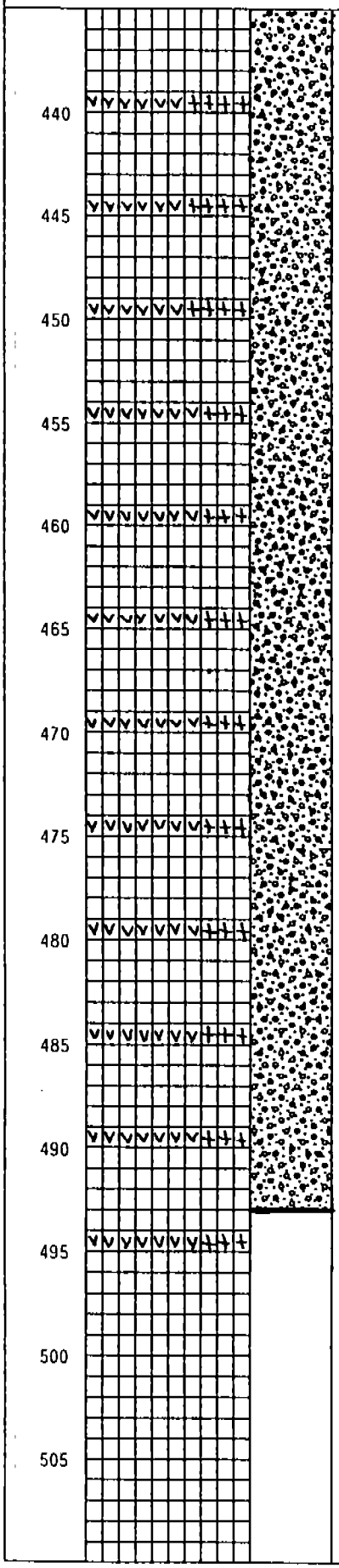
LOCATION ID: ST-2-466

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310				Cuttings (cont'd) 0'-484'	310'-315' Clay lens.
315			3		315'-225' Gravelly sand - average cutting size 2-3 mm (0.08-0.12 in).
320			3		
325			5		325' First noticeable occurrence of andesite with pyroxene phenocrysts altered to epidote.
330			6		325'-484' Igneous and carbonate cuttings are the predominant lithologies, however, there are still siltstone, quartzite, sandstone and other various lithologies present in much lesser percentages. Limestone and andesite cuttings are very hard to differentiate because of their similar texture; same dark gray to black color and caliche coatings on andesite effervescing the same as limestone.
335			7		
340			5		
345			6		
350			5		
355			8		
360			7		
365			6		
370			5		
375			8		

LOCATION ID: ST-2-466

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
375				Cuttings (cont'd) 0'-484'	
380			4		
385			6		
390			6		
395			9		
400			5		
405			6		
410			5		
415			5		
420			4		
425			4		425'-T.D. Andesite is becoming predominant igneous clast, however, there is no clearly defined depth for the change, rather a gradual change from the rhyolite predominance.
430			7		
435			6		
440			3		

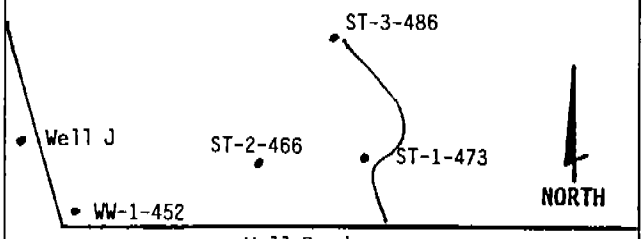
LOCATION ID: ST-2-466



Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
	Cuttings (cont'd) 0'-484'	
5		
4		
6		455'-484' Cuttings mostly angular indicating larger cobbles or boulders are being cut; average cutting size is 2-3 mm (0.08-0.12 in).
5		
5		
5		
11		
4		
5	Core Interval 484'-494'	484'-494' Alluvial core interval - 5 % recovery (see attached core description).
		494' Total depth of borehole.

LITHOLOGIC LOG

LOCATION MAP:



SE 1/4 SE 1/4 SE 1/4 NW 1/4 S32 T20S R3E

SITE ID: NASA-WSTF LOCATION ID: ST-3-486

SITE COORDINATES (ft.):

N 230899.085 E 400668.007

GROUND ELEVATION (ft. MSL): 4495.98

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud Rotary/Air Foam Rotary

DRILLING CONTR.: Larjon Drilling Co.

DATE STARTED: 07/18/91 DATE COMPLETED: 08/08/91

FIELD REP.: D. Menzie, J. Chapman-Fahey, M. Canavan

COMMENTS: Mud-rotary 0'-60' (12¼" mill tooth), ream to 16"; set 10" x 58' steel surface casing. Air-foam rotary 60'-510' (9 7/8" mill tooth). Total Depth = 510'. Bedrock not encountered.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
			Timed by driller	Cuttings	0'-58' Mud rotary drilling.
5			20		0'-510' Alluvium (Santa Fe Group): Color varies from light gray (N8) to grayish black (N1) and from pinkish gray (5 YR 8/1) to moderate reddish orange (10 R 6/6). Cuttings range in size from less than 0.1" to greater than 0.9", average 0.1" to 0.2", and are subrounded to angular. The unit is a poorly to moderately sorted polygenetic sandy, pebble to boulder conglomerate. Lithologies include light gray (N8) to grayish black (N1) limestone, moderate yellowish-brown (10 YR 5/4) to grayish red (10 R 4/2) siltstone, pinkish gray (5 YR 8/1) rhyolite, moderate reddish orange (10 R 6/6) caliche, and clay. Clay-rich zones occur between 5' and 10' and between 30' and 35', where clay constitutes 50% to 60% of the sample. Minor constituents include quartzite, granite and porphyritic hornblende andesite. The andesite increases with depth.
10			20		
15			15		
20			21		
25			45		0'-10' Clay-rich interval; clay content 50% - 60%.
30			17		0'-10' Cuttings predominantly subrounded to angular. Size ranges from much less than 0.1" to 0.3". Average size is less than 0.1".
35			16		10'-30' Increase in cutting size to an average of 0.3" to 0.4".
40			29		30'-45' Decrease in cutting size to 0.1" to 0.2".
45			25		35'-45' Clay-rich interval; clay content 50%-60%.
50			17		45'-50' Increase in cutting size from 0.1" to 0.9". Averaging 0.5".

LOCATION ID: ST-3-486

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings cont'd	
50					50'-290' Cutting size ranges from 0.1" to 0.3". Averaging 0.25". Grains are predominantly subrounded to subangular.
55			42		
60			Timed by drillograph		58'-510' Switch to air-foam rotary drilling. 60'-85' Clay content ≈ 10%.
65			3		
70			5		
75			3		
80			5		
85			4		
90			4		90'-110' Clay content ≈ 20%.
95			3		
100			4		
105			3		
110			3		
115			4		115' Clay content ≈ 10%.

LOCATION ID: ST-3-486

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings cont'd	
115			4		
120			6		
125			4		
130			6		
135			3		
140			5		
145			4		
150			5		
155			5		
160			5		
165			4		
170			3		
175			3		
180			3.5		

LOCATION ID: ST-3-486

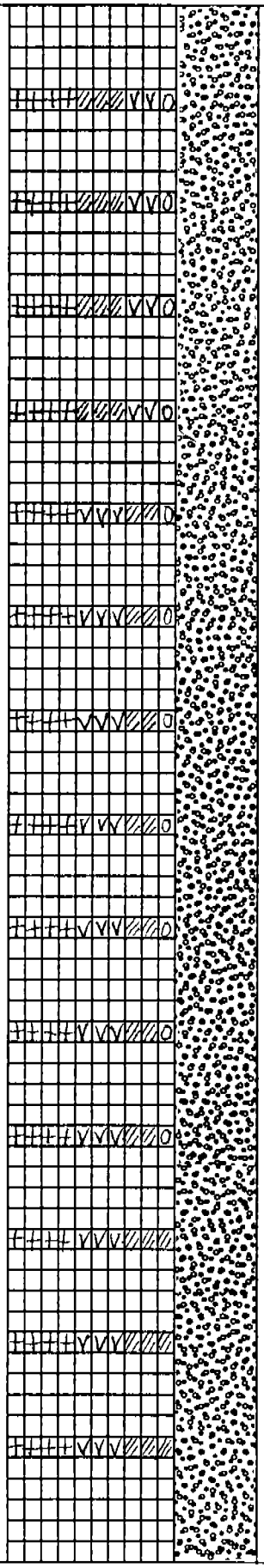
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings cont'd	
180			3.5		
185			3.5		
190			6		
195			3		
200			3		200' Clay content ≈ 10%.
205			2		
210			3		
215			5		
220			4		
225			4		
230			4		
235			2		
240			4		
245			5		

LOCATION ID: ST-3-486

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings cont'd	
245			5		
250			3		
255			9		
260			4		
265			6		
270			3		
275			3		
280			7		
285			3		
290			5		
295			4		295'-360' Cutting size decreases to an average of 0.1". Cuttings are predominantly subangular to subrounded.
300			11		
305			6		
310			9		

LOCATION ID: ST-3-486

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings cont'd	
310			9		
315			5		
320			5		
325			8		
330			12		
335			8		
340			4		
345			3		
350			5		
355			5		
360			9		360'-385' Cuttings range in size from 0.1" to 0.3"; average 0.2" and are predominantly subrounded to subangular.
365			5		
370			6		
375			5		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings cont'd	
375			5		
380			4		
385			4		385'-390' Decrease in cutting size to an average of 0.1".
390			6		390'-430' Increase in cutting size to an average of 0.2". Cuttings are predominantly subangular to angular.
395			5		
400			6		
405			4		
410			5		
415			9		
420			4		
425			9		
430			5		430'-510' Decrease in cutting size. Size ranges from much less than 0.1" to 0.3", averaging 0.1". Cuttings are predominantly subangular to angular.
435			4		
440			6		

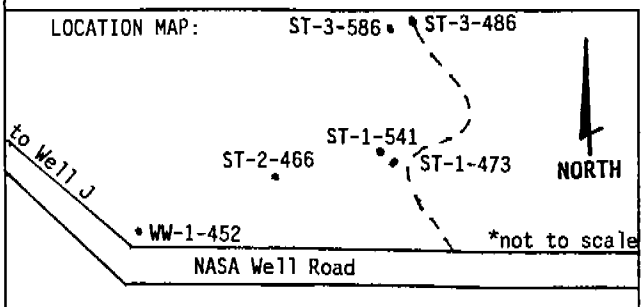
LOCATION ID: ST-3-486

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings cont'd	
440			6		
445			4		
450			5		
455			4		
460			22		460'-465' Increase in drill time.
465			5		
470			6		
475			3		
480			4		
485			4		
490			3		
495			4		
500			3		
505			2		

LOCATION ID: ST-3-486

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
505			2	Cuttings cont'd	505'-510' Increase in andesite in cuttings.
510			4		TD = 510' - (drillograph) TD = 509' - (geophysical logs) TD = 506.75' - (sounder)
515					
520					
525					
530					
535					
540					
545					
550					
555					
560					
565					
570					

LITHOLOGIC LOG



SE 1/4 SE 1/4 SE 1/4 NW 1/4 S32 T20S R3E

SITE ID: NASA-WSTF LOCATION ID: ST-3-586

SITE COORDINATES (ft.):

N 230882.58 E 400613.87

GROUND ELEVATION (ft. MSL): 4494.59' (BC)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud Rotary/Air Foam Rotary

DRILLING CONTR.: Larjon Drilling Co

DATE STARTED: 03/24/92 DATE COMPLETED: 04/10/92

FIELD REP.: D. Menzie

COMMENTS: 0'-80' mud rotary with 12¼" mill tooth bit. 0'-80' ream to 16" and set 79.5' surface casing (10"ID). Drill air/foam rotary with 9 7/8" button bit from 80'-615'. Total Depth = 615' by drillograph.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			Timed by driller 0'-80'	Cuttings grab sample, every 5' 0'-615'	0'-~~615'~~ 600' Alluvium (Santa Fe Group): Unwashed samples range in color from moderate brown (5 YR 3/4) to light gray (N8). Washed samples are dark gray to multicolored. Samples are comprised of cuttings which range in size from 1.0 inch to much less than 0.1 inches (clay and silt size). Average cutting size is 0.1 to 0.2 inches in size. Cuttings are subrounded to angular. Subrounded cuttings are formational grains and comprise 20%-60% of individual samples. Subangular and angular cuttings include blocky formation clasts and chips broken during drilling. The alluvium is an unconsolidated to moderately consolidated, poorly sorted, pebble to boulder polygenetic conglomerate. Intermittent clay and caliche intervals are noted in the log. Cuttings representing lithologies within the alluvium are dark gray (N3) to light olive gray (5 Y 5/2) micritic limestone, white (N9) iron-stained rhyolite, brownish black (5 YR 2/1) sandstone, moderate reddish brown (10 R 4/6) siltstone, light brownish gray (5 YR 6/1) andesite, white (N9) to light gray (N7) quartz, and light gray (N7) caliche. Minor amounts of tuff, granite, and quartzite occur. Andesite increases in abundance with depth until alluvium becomes volcanic-rich (≥ 50% of sample) at 500 ft. below ground surface.
10			7		
15			16		
20			12		
25			14		
30			21		
35			17		
40			17		
45			20		
50			9		
			15		

0'-80' Mud rotary.

0'-5' Clay-rich interval, clay content 50%. Caliche content 10%.

5'-35' Cuttings are subrounded to subangular. They range in size from 0.1 inches to 1.0 inches and average 0.3 inches in diameter.

10'-35' Clay-rich interval, clay content 10%-70%.

35'-50' Cuttings size decreases to average of 0.2 inches. Range in size from less than 0.1 to 0.5 inches.

40'-50' Caliche content 10%-20%.

LOCATION ID: ST-3-586

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
50			15		50'-75' Cuttings size increases to 0.5 inches average, range 0.1 to 0.9 subangular to subrounded.
55			20		55'-75' Clay-rich interval, clay content 20%-60%.
60			21		60'-80' Caliche content 10%-20%.
65			20		
70			31		70'-75' Decrease in drill times.
75			16		75'-80' Cuttings size decreases to 0.1 inches average. Size ranges from less than 0.1 to 0.4 inches.
80			40 Timed by drillograph		80'-95' Partly to mostly grout, visual % lithology is for non-grout cuttings. 80'-115' Cutting size increases to average of 0.3 inches.
85			11		80'-260' Decrease in drill times.
90			9		90'-160' Clay-rich interval, clay content 10%-30%.
95			6		95'-100' Caliche content 10%.
100			8		
105			8		
110			10		
115			8		

LOCATION ID: ST-3-586

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
115			8		115'-260' Cuttings size decrease to average 0.1 inches.
120			5		
125			9		125'-145' Caliche content 10%-20%.
130			7		
135			7		
140			8		
145			5		
150			6		
155			7		155'-180' Caliche content 10%-20%.
160			7		
165			8		165'-180' Clay-rich interval, clay content 10%.
170			5		
175			6		
180			5		

LOCATION ID: ST-3-586

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
180			5		
185			6		185'-235' Clay content 10%.
					185'-270' Caliche content 10%-20%.
190			5		
195			4		
200			6		
205			6		
210			6		
215			6		
220			4		
225			6		
230			7		
235			7		
240			5		
245			6		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			6		
250			8		250'-260' Clay content 10%.
255			5		
260			6		260'-300' Cuttings size increases to average of 0.2 inches.
					260'-265' Increase in drill times.
265			14		
270			4		
275			6		
280			5		
285			7		
290			4		290'-330' Caliche content 10%-20%.
295			3		295'-300' Clay content 10%.
300			5		300'-305' Increase in drill times.
					300'-505' Cuttings size decreases to average of 0.1 inches.
305			12		
310			8		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
310			8		310'-315' Clay content 10%.
315			9		
320			9		320'-325' Clay content 10%.
325			6		
330			8		
335			6		
340			4		
345			6		345'-355' Caliche content 10%.
350			8		
355			8		
360			6		360'-380' Caliche content 10%.
365			8		
370			7		
375			7		

LOCATION ID: ST-3-586

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375			7		
380			6		
385			9		
390			6		
395			5		
400			7		
405			8		
410			9		
415			7		415'-420' Caliche content 10%.
420			8		
425			7		
430			7		
435			7		
440			8		

LOCATION ID: ST-3-586

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
440			8		
445			5		
450			4		450'-465' Caliche content 10%.
455			5		
460			7		
465			4		
470			4		
475			5		
480			6		
485			5		
490			5		
495			5		
500			5		500'-~~615'~~ 600' Volcanic-rich Alluvium (Santa Fe Group): Samples range in color from brownish-gray (5 YR 4/1) to moderate reddish brown (10 R 4/6). Cuttings range in size from 0.1 inches to 0.4 inches and average 0.2 inches in size. Cuttings are sub-
505			4		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	rounded to angular and poorly sorted. The volcanic-rich alluvium is a moderately consolidated, pebble to boulder, polygenetic conglomerate. Predominant cutting clast lithologies are dark brownish red (10 R 3/4) to brownish-black (5 YR 2/1) andesite and brownish-gray (5 YR 4/1) to dark brownish-red (10 R 3/4) tuff. Additional lithologies include limestone, siltstone, rhyolite and caliche.
505			4		
510			4		
515			3		505'-615' Cuttings size increases to 0.2 inches.
520			5		
525			4		525'-530' Caliche content 10%.
530			5		
535			5		
540			3		
545			4		
550			3		
555			6		
560			8		
565			4		
570			6		

LOCATION ID: ST-3-586

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
570			6		
575			7		
580			7		
585			6		
590			11		
595			5		
600			6		600'-615' Tuff (Cueva Tuff?) see addendum to file
605			6		
610			9		610'-615' Increase in drill time.
615			20		Total Depth = 615' by drillograph.
620					
625					
630					
635					

Lithologic Log Addendum

Well ST-3-586

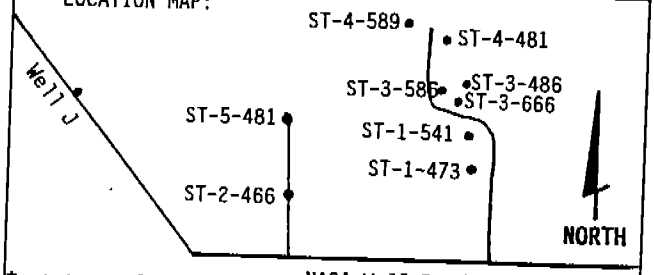
Cuttings of the lithologic unit from wells ST-3-666 and ST-3-735 were sent to the Department of Geological Sciences, New Mexico State University (NMSU), Las Cruces, New Mexico, for detailed petrographic analysis when identification of fine-grained, highly altered volcanic rocks at the NASA-WSTF site became difficult using conventional field methods. Petrographic reports from NMSU were received after the printing of these lithologic logs, hence the need for this addendum. Cuttings from ST-3-586 were never sent for petrographic analysis but are assumed to be of the same lithology as ST-3-666 and ST-3-735 because of their close proximity.

Previous unit name based on field identification: **Tuff**

New Unit name based on information from adjacent wells: **Andesite**

LITHOLOGIC LOG

LOCATION MAP:



*not to scale NASA Well Road

SE 1/4 SE 1/4 SE 1/4 NW 1/4 S32 T20S R3E

SITE ID: NASA-WSTF LOCATION ID: ST-3-666

SITE COORDINATES (ft.):

N 230842.33 E 400629.55

GROUND ELEVATION (ft. MSL): 4494.36' (BC)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud Rotary/Air Foam Rotary

DRILLING CONTR.: Larjon Drilling Co

DATE STARTED: 05/27/92 DATE COMPLETED: 06/12/92

FIELD REP.: D. Menzie, M. Canavan

COMMENTS: 0'-87' mud rotary 12¼" mill tooth bit. Ream to 16" from 0'-87'. Set 87' of 10" steel surface casing. 87'-704' air foam rotary 9 7/8" button bit. Volcanic-rich alluvium at 480'. Total depth = 704' by drillograph.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval
5			5	Cuttings Grab Sample every 5' 0'-704'
10			25	
15			15	
20			20	
25			32	
30			36	
35			37	
40			20	
45			19	
50			9	

Timed by driller

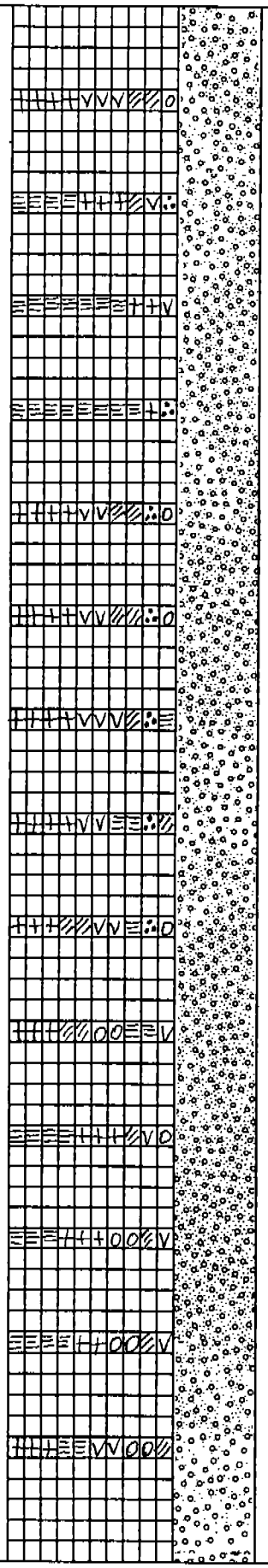
Lithologic Description

595
0'-704'

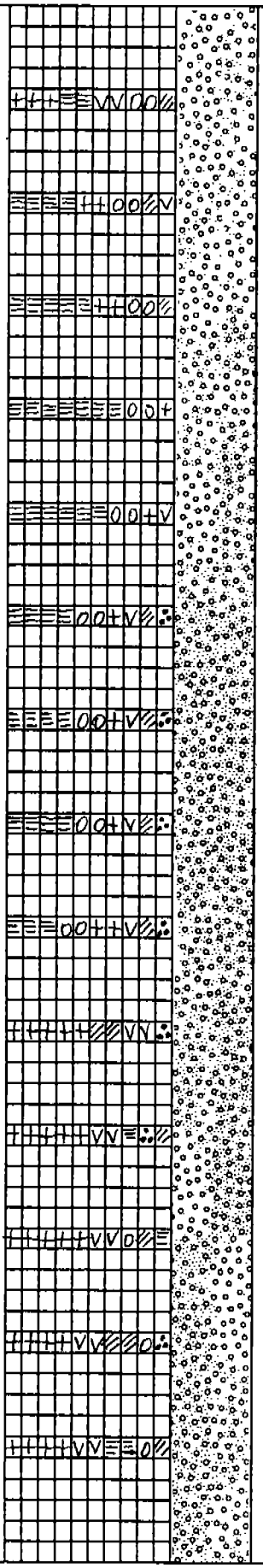
Alluvium (Santa Fe Group): Unwashed samples range in color from moderate brown (5 YR 3/4) to light gray (N8). Samples are comprised of cuttings which range in size from 0.9 inches to much less than 0.1 inches (clay and silt size). Average cutting size is 0.1 to 0.2 inches. Cuttings are rounded to angular. Rounded to subrounded cuttings are formation grains and comprise 20%-60% of individual samples. Subangular to angular cuttings include blocky formation clasts and chips broken during drilling. The alluvium is an unconsolidated to moderately consolidated, poorly sorted, pebble to boulder, polygenetic conglomerate. Intermittent clay and caliche intervals are noted in the log. Cuttings representing lithologies in the alluvium are dark gray (N3) to light olive gray (5 Y 5/2) micritic limestone, white (N9) iron-stained rhyolite, brownish black (5 YR 2/1) sandstone, moderate reddish brown (10 R 4/6) siltstone, light brownish gray (5 YR 6/1) andesite, moderate red (5 R 4/6) tuff, grayish red (5 R 4/2) rhyolite, white (N9) to light gray (N7) quartz, and light gray (N7) caliche. Minor amounts of granite, quartzite, chert, schist and gneiss occur. Andesite, tuff, and rhyolite increase in abundance with depth until the alluvium becomes volcanic-rich (≥ 50% of sample) at 480' below ground surface.

0'-87'	Mud rotary.
0'-35'	Cuttings are rounded to angular. Range in size from 0.5 inches to less than 0.1 inches. Average size is 0.2 inches.
0'-5'	Clay content 40%.
0'-10'	Caliche content 10%-20%.
10'-35'	Clay content 20%-90%.
15'-30'	Caliche content 10%-30%.
35'-60'	Cuttings range in size from 0.9 inches to 0.1 inches. Average cutting size is 0.3 inches.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	40'-45' Clay content 10%.
					45'-50' Caliche content 10%.
50			9		50'-65' Clay content 40%-80%.
55			21		
60			20		60'-385' Cuttings range in size from less than 0.1 inches to 0.5 inches and average 0.2 inches.
65			26		65'-75' Caliche content 10%.
70			30		
75			17		75'-155' Clay content 10%-70%.
80			28		
85			40 Timed by drillograph		87'-704' Air Foam Rotary.
					87'-95' 10%-30% of sample is grout. Visual % lithology is for formation cuttings only.
90			2		90'-155' Caliche content 10%-20%.
95			4		
100			4		
105			5		
110			5		
115			4		



LOCATION ID: ST-3-666

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
115			4		
120			7		
125			6		
130			5		
135			5		
140			3		
145			6		
150			6		
155			5		
160			4		160'-170' Clay content 10%.
165			4		165'-190' Caliche content 10%-20%.
170			12		
175			3		175'-185' Clay content 10%-20%.
180			5		

LOCATION ID: ST-3-666

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
180			5		
185			5		
190			5		
195			7		
200			5		200'-225' Caliche content 10%.
205			8		
210			4		
215			5		215'-220' Clay content 10%.
220			6		
225			5		
230			4		
235			9		
240			4		
245			7		

LOCATION ID: ST-3-666

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			7		
250			3		
255			11		
260			5		
265			6		
270			6		
275			6		
280			8		
285			4		
290			7		
295			6		
300			6		
305			7		
310			8		

LOCATION ID: ST-3-666

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
310			8		
315			5		
320			9		
325			7		
330			5		
335			4		
340			7		
345			10		
350			7		
355			6		
360			6		
365			10		
370			7		
375			8		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375			8		
380			9		
385			8		385'-405' Decrease in average cutting size to 0.1 inches, cuttings are angular to subangular.
390			8		
395			12		
400			8		
405			7		405'-515' Slight increase in cutting size to 0.2 inches.
410			9		
415			7		
420			6		
425			6		
430			6		
435			7		
440			4		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
440			4		
445			6		
450			5		
455			11		
460			6		
465			5		
470			4		
475			5		
480			4		480' ~~704~~ 595' Volcanic-rich Alluvium (Santa Fe Group): Samples range in color from light brownish gray (5 YR 6/1) to moderate red (5 R 4/6). Cuttings range in size from 0.6 inches to less than 0.1 inches. Average cutting size is 0.1 inches. Average cutting size is 0.1 to 0.2 inches. Cuttings are sub-rounded to angular and poorly sorted. The volcanic-rich alluvium is a moderately consolidated, pebble to boulder, polygenetic conglomerate. Predominant cutting lithologies are moderate red (5 R 4/6) tuff, light brownish gray (5 YR 6/1) andesite, and grayish red (5 R 4/2) rhyolite. Additional lithologies include minor amounts of clay, limestone, siltstone, and caliche.
485			4		
490			4		
495			4		
500			4		
505			4		

LOCATION ID: ST-3-666

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
505			4		
510			4		
515			5		515'-704' Cuttings range in size from less than 0.1 to 0.6 inches. Average size is 0.1 to 0.2 inches. Cuttings are subrounded to angular and poorly sorted.
520			4		
525			4		
530			6		
535			5		
540			5		
545			6		
550			5		
555			4		
560			4		
565			5		
570			9		

LOCATION ID: ST-3-666

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
570			9		
575			4		
580			5		
585			6		585'-590' Clay 10%.
590			9		590'-704' 95%-100% angular to subangular chips of red tuff, grayish red rhyolite and brownish gray andesite.
595			4		595'-704' TUFF (CUEVA TUFF?). See Addendum to file
600			5		
605			6		
610			13		
615			8		
620			8		
625			8		
630			6		
635			7		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
635			7		
640			9		
645			8		
650			9		
655			8		
660			8		660'-675' Clay balls in cuttings comprise 10% of sample.
665			7		
670			8		
675			14		
680			10		
685			10		685'-695' Clay balls in cuttings comprise 10%-20% of sample.
690			6		
695			6		
700			9		704' = TD by drillograph.

Lithologic Log Addendum

Well ST-3-666

Cuttings of the lithologic unit from well ST-3-666 were sent to the Department of Geological Sciences, New Mexico State University (NMSU), Las Cruces, New Mexico, for detailed petrographic analysis when identification of fine-grained, highly altered volcanic rocks at the NASA-WSTF site became difficult using conventional field methods. Petrographic reports from NMSU were received after the printing of these lithologic logs, hence the need for this addendum. The petrographic description from NMSU is included below.

Previous unit name based on field identification: **Tuff**

New Unit name based on petrographic analysis: **Andesite**

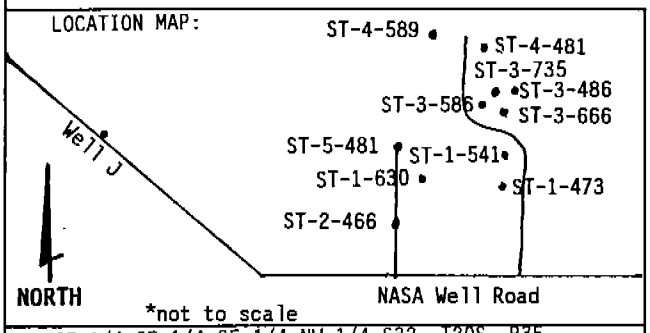
ST-3-666 (695' - 700')

Porphyritic biotite-augite andesite

Origin:	lava flow
Texture:	aphanitic porphyritic
Phenocryst mineralogy:	plagioclase + augite + biotite
Porosity:	low except along calcite veins
Alteration:	calcite veins

This sample is nearly identical to ST-1-630 (695' - 700'). In hand sample, the fragments appear to be heterogeneous, but the differences in color are related to the amount of calcite veining present. The paler pink fragments contain more calcite veins than the dark maroon fragments. Approximately 7% phenocrysts are surrounded by an intersertal to trachytic groundmass dominated by plagioclase and oxides. Plagioclase phenocrysts (3%, 0.1 - 1.4 mm) are zoned and resorbed, with euhedral clear rims. Augite phenocrysts (3%, 0.34 - 1.4 mm) are twinned and euhedral. Biotite phenocrysts (0.5%, 1 - 1.4 mm) are oxidized and exhibit yellow to red-brown pleochroism. FeTi oxides (0.5%, 0.3 - 0.45 mm) are present as microphenocrysts. Apatite (0.1 mm) exists in trace amounts within augite and plagioclase phenocrysts. A trace of quartz is present, in contact with augite, and is rounded and embayed. The porosity is low in the unfractured rock, but is potentially quite high along the veins. Alteration is mainly present in thick veins of clear calcite that contain fragments of phenocryst crystals and groundmass. The veins are 0.1 mm to 0.4 mm wide. Other than the veins, the rock is fairly fresh. This sample originated as a lava flow.

LITHOLOGIC LOG



SE 1/4 SE 1/4 SE 1/4 NW 1/4 S32 T20S R3E

SITE ID: NASA-WSTF LOCATION ID: ST-3-735

SITE COORDINATES (ft.):

N 230843.63 E 400740.70

GROUND ELEVATION (ft. MSL): 4496.62 (BC)

STATE: NEW MEXICO COUNTY: DOÑA ANA

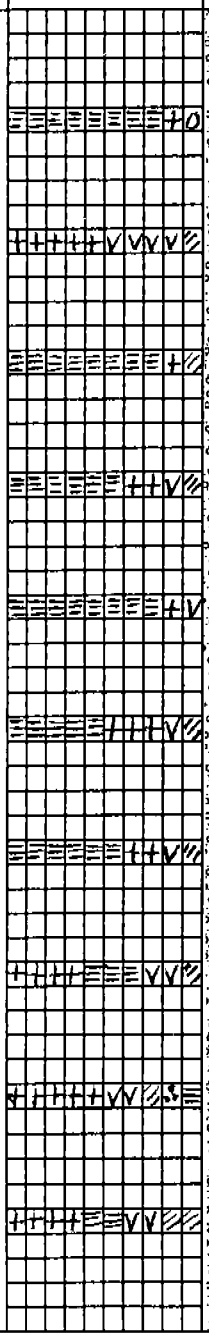
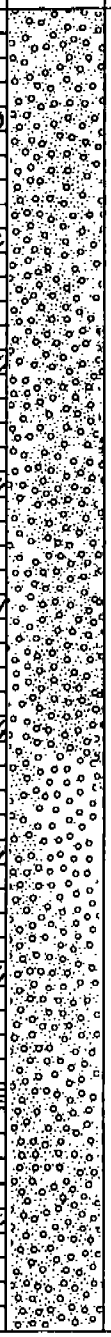
DRILLING METHOD: Mud Rotary/Air Foam Rotary

DRILLING CONTR.: Larjon Drilling Co.

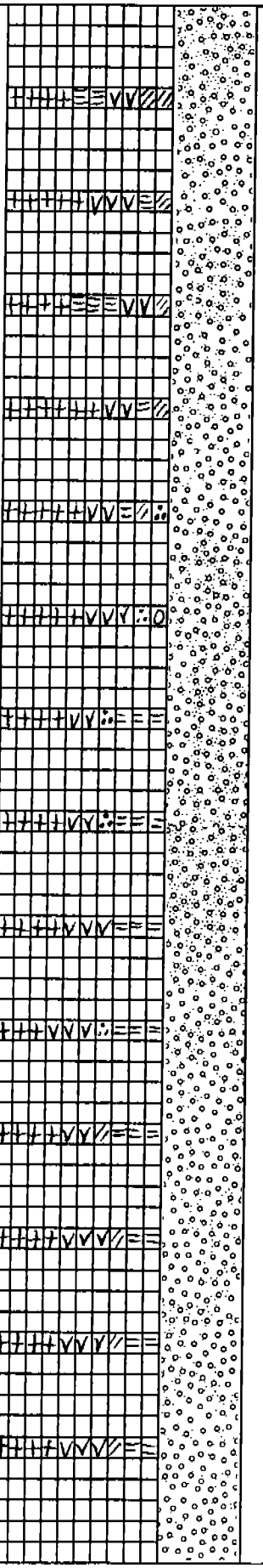
DATE STARTED: 07/22/92 DATE COMPLETED: 08/21/92

FIELD REP.: D. Menzie

COMMENTS: Drilled mud rotary pilot hole 0'-60' with 12¼" mill tooth bit. Reamed to 16" from 0'-60'. Set 60' of 14" steel surface casing. Drilled 60'-803' (7 7/8" borehole). Reamed 60'-800' to 12¼". Bedrock (tuff) at 610'. TD = 803'

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			Timed by driller 37 42 19 13 11 16 13 12 7 8	Cuttings (grab sample every 5')	0'-610' Alluvium (Santa Fe Group): Cuttings are highly variable in lithology, grainsize and grain shape. Samples are multicolored when washed but clay imparts a light brown (5 YR 6/4) color to unwashed samples. Shapes range from angular chips and flakes to rounded alluvial grains. Grain size ranges from clay size to >1.0" in diameter. Clay content in samples ranges from <10%, originating from interbedded laminations, to 80% indicating thick clay zones. A clay-rich interval is evident at 0'-40' with 10% to 20% clay being present throughout the remaining section. The unit is an unconsolidated to consolidated, poorly sorted, pebble to boulder polygenetic conglomerate. Lithologies represented in the samples are predominantly limestone and various volcanics. Limestones are medium gray (N5) to dark gray (N3), micritic, and contain few allochems. Other sedimentary rocks present are greenish gray (5 GY 6/1) and pale red (5 R 6/2) laminated to non-laminated siltstones; and poorly sorted fine-grained sandstones. Grey chert is present in small percentages. Volcanic constituents increase downward in section and include a variety of rhyolites, tuffs, andesites and fine-grained granites. By 560', alluvium is considered volcanic-rich. 0'-45' Cutting clasts range in size from less than 0.1 inches to 0.5 inches and average 0.3 inches in size. Cuttings are subrounded to angular. 45'-60' Cuttings size increases to an average of 0.5 inches. Sizes range from 0.4 to 0.7 inches. Grains are subrounded to angular.
10					
15					
20					
25					
30					
35					
40					
45					
50					

LOCATION ID: ST-3-735

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
50			8		
55			6		
60			11		
65			4		
70			5		
75			4		
80			4		80'-100' Clayey sand layer. >50% of cuttings are 0.1 inch or less.
85			4		
90			6		
95			4		
100			5		
105			4		
110			5		
115			4		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
115			4	Cuttings (cont'd)	
120			4		
125			5		
130			4		
135			4		
140			4		
145			4		
150			4		
155			4		
160			3		
165			4		
170			5		
175			4		
180			4		

LOCATION ID: ST-3-735

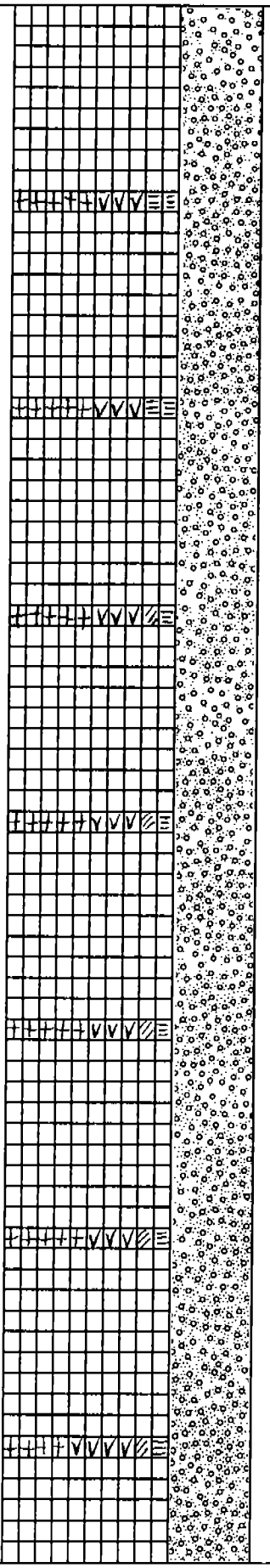
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
180			4		
185			3		
190			4		190'-203' Samples destroyed by downpour and flood on well pad.
195			4		
200			3		
205			2 (200'-203')		
210			1 (203'-210')		
215			3		
220			5		
225			4		
230			4		
235			5		
240			3		
245			4		

LOCATION ID: ST-3-735

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			4		
250			4		
255			3		
260			5		
265			6		
270			4		
275			4		
280			8		
285			3		
290			5		
295			3		
300			6		
305			5		
310			7		

LOCATION ID: ST-3-735

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310			7	Cuttings (cont'd)	
315			5		
320			3		
325			5		
330			5		
335			3		
340			5		
345			6		
350			3		
355			7		
360			8		
365			5		
370			5		
375			6		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375			6		
380			21		
385			7		
390			7		
395			4		
400			4		
405			5		
410			14		
415			5		
420			6		
425			6		
430			4		
435			5		
440			5		

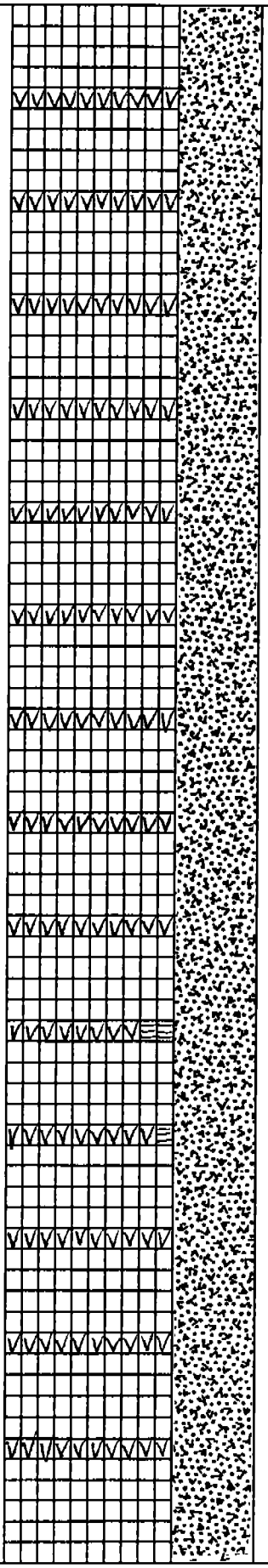
Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
440			5		
445			4		
450			4		
455			5		
460			4		
465			3		
470			4		
475			4		
480			3		
485			4		
490			3		
495			4		
500			3		
505			2		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
505			2		
510			4		510'-520' Increase in formation grain size to 0.3 inches (average).
515			4		
520			7		520' Purple volcanic fraction is increasing.
525			4		
530			3		
535			6		
540			3		
545			5		
550			6		
555			5		
560			6		560'-610' Volcanic-rich Alluvium: Predominate volcanic rock type is a grayish red (5 R 4/2) welded crystal-lithic ash flow tuff. White to gold rhyolites are present in minor percentages. Percent limestone and siltstone are decreasing. Cuttings may be angular chips to rounded formation gravels and range from <.10" to .5" in diameter.
565			8		
570			7		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
570			7	Cuttings (cont'd)	
575			6		
580			5		
585			8		
590			11		
595			15		
600			29		
605			27		
610			25		610'-803' Bedrock (Tuff): The unit is a pale red (5 R 6/2) to grayish red (5R 4/2) crystal-lithic ash flow tuff. Anhedral to subhedral phenocrysts are comprised of quartz and biotite and possibly feldspar. Phenocrysts average .05" in diameter and comprise up to 50% of the unit. Altered hornblende may be present in the groundmass. Groundmass is mottled to slightly flowbanded and may be welded and partially altered. Lithic fragments may be present in minor amounts.
615			23		
620			23		
625			36		
630			12		
635			10		

LOCATION ID: ST-3-735

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
635			10		
640			13		
645			12		
650			11		650'-725' Calcite from mineralized fractures makes up 5% of sample. Cuttings are fairly uniform ≈ .1"-.2" and angular to subangular.
655			8		
660			10		
665			8		
670			9		
675			9		
680			9		
685			9		
690			11		
695			6		
700			8		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
700			8		
705			6		
710			9		
715			10		
720			8		720'-725' Cuttings are finer-grained. (<.1")
725			11		725'-735' Cuttings are coarser grained .2"-.5". Subangular to rounded.
730			7		
735			10		735'-740' Cuttings are angular again. Similar to 650'-725'.
740			12		740'-745' 20% brown clay present.
745			15		
750			18		
755			11		
760			13		
765			20		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
765			20		
770			24		
775			10		
780			10		
785			10		
790			10		
795			15		
800			8 (to 803')		TD = 803'
805					
810					
815					
820					
825					
830					

Lithologic Log Addendum

Well ST-3-735

Cuttings of the lithologic unit from well ST-3-735 were sent to the Department of Geological Sciences, New Mexico State University (NMSU), Las Cruces, New Mexico, for detailed petrographic analysis when identification of fine-grained, highly altered volcanic rocks at the NASA-WSTF site became difficult using conventional field methods. Petrographic reports from NMSU were received after the printing of these lithologic logs, hence the need for this addendum. The petrographic description from NMSU is included below.

Previous unit name based on field identification: **Tuff**

New Unit name based on petrographic analysis: **Andesite**

ST-3-735 (600' - 610)

Porphyritic biotite-augite andesite

Origin:	lava flow
Texture:	aphanitic porphyritic
Phenocryst mineralogy:	plagioclase + augite + biotite + FeTi oxides
Porosity:	5% vesicles
Alteration:	minimal

This sample is very similar to ST-1-630 (695' - 700') and ST-3-666 (695' - 700') except that is much less altered. It is aphanitic porphyritic with phenocrysts of plagioclase, augite, biotite, and FeTi oxides in a groundmass of plagioclase, augite, and oxides. Approximately 7% phenocrysts are surrounded by an intersertal to trachytic groundmass dominated by plagioclase and oxides. Plagioclase phenocrysts (3%, 0.1 - 1.4 mm) are zoned and resorbed, with euhedral clear rims. Augite phenocrysts (3%, 0.34 - 1.4 mm) are twinned and euhedral. Biotite phenocrysts (0.5%, 1 - 1.4 mm) are oxidized and exhibit yellow to red-brown pleochroism. FeTi oxides (0.5%, 0.3 - 0.45 mm) are present as microphenocrysts. Apatite (0.1 mm) exists in trace amounts within augite and plagioclase phenocrysts. A trace of quartz is present, in contact with augite, and is rounded and embayed. The rock contains 5% vesicles. This sample is much fresher than other examples of this lithology, and lacks the calcite veins. This sample originated as an andesitic lava flow.

ST-3-735 (803')

Porphyritic biotite-augite andesite

Origin:	lava flow
Texture:	aphanitic porphyritic

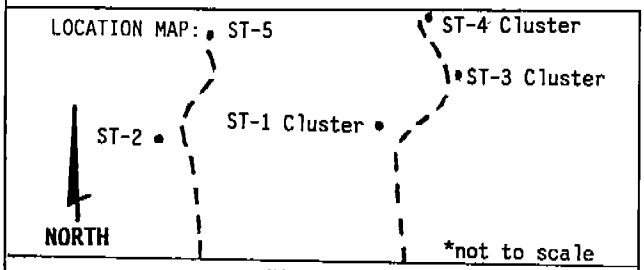
Lithologic Log Addendum

Well ST-3-735 (cont'd)

Phenocryst mineralogy:	plagioclase + augite + biotite
Porosity:	low, except along calcite veins
Alteration:	low, except for calcite veins and oxidation of biotite

This sample is similar to the other samples labelled ST-3. It contains 7% phenocrysts of plagioclase (3%), augite (3%), biotite (1%), with trace amounts of apatite and FeTi oxides in an intergranular groundmass of plagioclase, augite, and oxides. Primary porosity is very low to zero, but porosity along veins is moderate to high. Alteration consists largely of veins of calcite and oxidation of biotite, and is moderate in extent. The sample originated as a lava flow.

LITHOLOGIC LOG



SW 1/4 SE 1/4 NE 1/4 NW 1/4 S32 T20S R3E

SITE ID: NASA-WSTF LOCATION ID: ST-4-481

SITE COORDINATES (ft.):

N 232154.39 E 400492.51

GROUND ELEVATION (ft. MSL): 4493.16' (BC)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud Rotary/Air Foam Rotary

DRILLING CONTR.: Larjon Drilling Co

DATE STARTED: 04/08/92 DATE COMPLETED: 04/23/92

FIELD REP.: M. Canavan, D. Menzie

COMMENTS: Drill mud rotary 0'-85' (12¼ tricone milltooth). Ream to 16". Install 85' of 10" surface casing. Drill air/foam rotary 85'-510' with 9 7/8" mill tooth bit. Total Depth = 510'.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			Timed by driller 0'-85'	Cuttings every 5' 0'-510'	0'-510' Alluvium (Santa Fe Group): Unwashed samples range in color from moderate brown (5 YR 3/4) to light gray (N8). Washed samples are dark gray to multi-colored. Cuttings range in size from 1.0 inch to much less than 0.1 inches (clay and silt size). Average cutting size is 0.25 inches. Cuttings are subrounded to angular. Subrounded cuttings are formational grains and comprise 20% - 60% of samples. Subangular and angular cuttings include blocky formation clasts and chips broken during drilling. The Alluvium is an unconsolidated to consolidated, poorly sorted, pebble to boulder polygenetic conglomerate. Intermittent clay and caliche intervals are noted on log. Alluvial clasts consist of dark gray (N3) to light olive gray (5 Y 5/2) micritic limestone, white (N9) iron-stained rhyolite, brownish black (5 YR 2/1) sandstone, moderate reddish brown (10 R 4/6) siltstone, light brownish gray (5 YR 6/1) andesite, white (N9) to light gray (N7) quartz, and light gray (N7) caliche. Minor amounts of tuff, granite, and quartzite occur. Andesite increases in abundance with depth until alluvium becomes volcanic-rich (≥ 50% of sample) at 440'.
10			15		
15			21		
20			16		
25			16		
30			29		
35			21		
40			26		
45			14		
50			19		
			24		

LOCATION ID: ST-4-481

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
				Cuttings (cont'd)		
50			24			
55			29			
60			16		60'-65'	Cuttings average .5" in diameter and are subangular to angular.
65			15		65'-70'	Cuttings range from .10"-1.0" in diameter and are angular to subrounded. 80% of cuttings are natural gravels of .5" or greater.
70			23		70'-80'	Gummy pale brown clay.
75			14			
80			19		80'-85'	Cuttings are angular to subangular and average .25" in diameter.
85			17 Recorded by drillograph 85'-310'		85'	Start air/foam rotary.
90			6		90'-100'	Cuttings are subangular to rounded and range from .10" to .5".
95			4			
100			6		100'-105'	Cuttings are predominantly subrounded to rounded. Larger (.5"-.75") cuttings are limestone.
105			6			
110			8		110'	Average cutting size is getting smaller.
115			4			

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
115			4		
120			5		
125			5		
130			7		130' Average cutting size is .25".
135			7		
140			4		
145			4		145'-155' "0" symbol represents cemented alluvium (rounded clasts). Cuttings are fairly uniform .10"-.25" and are rounded to subangular.
150			5		
155			4		155' Cuttings average .25" and are subangular to rounded. Mudstone, quartz and sandstone are also present in lesser percentages.
160			14		
165			5		
170			4		
175			4		
180			4		

LOCATION ID: ST-4-481

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
180			4		
185			6		185'-260' "0" symbol represents cemented alluvium. Clasts of which are very well rounded. Sandstones and mudstones also prevalent. Cuttings are fairly uniform in size .10"-.25".
190			3		
195			4		
200			5		
205			5		
210			8		
215			2		
220			3		
225			6		
230			4		
235			4		
240			3		
245			3		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			3		
250			4		
255			5		
260			6		260'-305' Very fine-grained (.05") fraction comprises 20%-60% sample. Remainder of cuttings range from .10"-.5".
265			5		
270			5		
275			7		
280			3		
285			4		
290			5		
295			7		
300			6		
305			7		305' Cuttings are subangular to rounded.
310			8		

LOCATION ID: ST-4-481

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
310			8		310' Cuttings average .25".
315			4		
320			8		
325			6		
330			6		
335			5		335'-345' 5%-8% cemented alluvium cuttings present.
340			5		
345			7		
350			7		
355			7		
360			19		
365			6		
370			7		
375			14		

LOCATION ID: ST-4-481

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375			14		375'-385' Some nice greenish gray andesite cuttings.
380			6		
385			7		
390			6		
395			6		
400			8		
405			7		
410			9		
415			6		
420			6		
425			5		
430			6		
435			5		435'-440' Cuttings are subrounded to rounded and range from .1"-.25".
440			4		440'-510' Volcanic-Rich Alluvium.

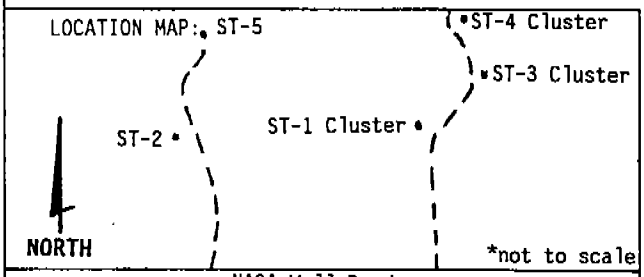
LOCATION ID: ST-4-481

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
440			4		
445			4		445'-510' Andesite increasing in percent of volcanics.
450			6		
455			6		
460			9		
465			3		
470			3		
475			5		
480			4		
485			3		
490			3		
495			5		
500			4		
505			3		

LOCATION ID: ST-4-481

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
505			3		
510			3		TD = 510'
515					
520					
525					
530					
535					
540					
545					
550					
555					
560					
565					
570					

LITHOLOGIC LOG



SW 1/4 SE 1/4 NE 1/4 NW 1/4 S32 T20S R3E
NE

SITE ID: NASA-WSTF LOCATION ID: ST-4-589

SITE COORDINATES (ft.):

N 232223.95 E 400481.62

GROUND ELEVATION (ft. MSL): 4494.13' (BC)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud Rotary/Air Foam Rotary

DRILLING CONTR.: Larjon Drilling Co

DATE STARTED: 05/06/92 DATE COMPLETED: 05/21/92

FIELD REP.: M. Canavan, D. Menzie

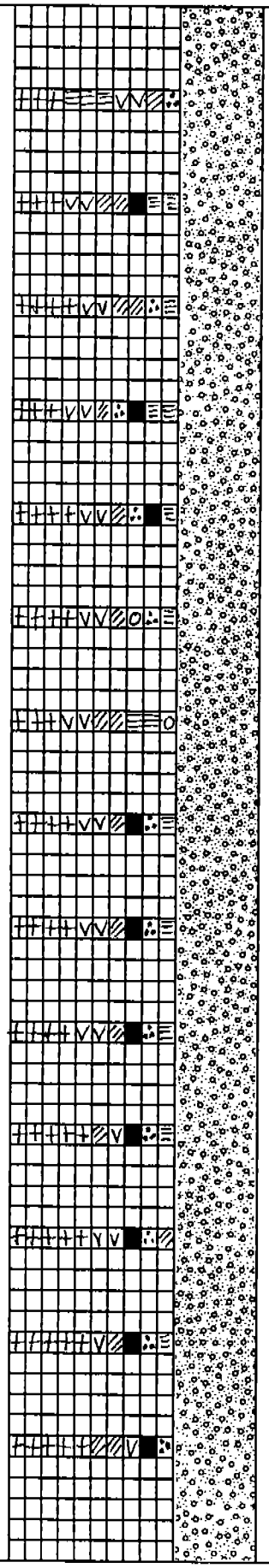
COMMENTS: Mud rotary 0'-85'(12¼"). Ream to 16". 85' x 10" permanent steel surface casing. Air/foam rotary 85'-610' (9 7/8"). Total depth = 610'.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5			Timed by driller	Cuttings 5' intervals 0'-610'	0'-610' Alluvium (Santa Fe Group): Samples range in color; moderate brown (5 YR 3/4) to light gray (N8). Cuttings range in size from 1.25 inches to less than 0.1 inches (clay and silt). Average cutting size is 0.1 inches. Cuttings are subrounded to angular. Subrounded cuttings are formation grains and comprise 20%-60% of samples. Subangular and angular cuttings include blocky formation clasts and chips broken during drilling. Alluvium is unconsolidated to moderately consolidated, poorly sorted, pebble to boulder polygenetic conglomerate. Intermittent clay and caliche layers noted. Alluvial clasts consist of dark gray (N3) to light olive gray (5 Y 5/2) micritic limestone, white (N9) iron-stained rhyolite, brownish black (5 YR 2/1) sandstone, moderate reddish brown (10 R 4/6) siltstone, light brownish gray (5 YR 6/1) andesite, white (N9) to light gray (N7) quartz, and light gray (N7) caliche. Minor amounts of tuff, granite, and quartzite. Andesitic fraction in cuttings increases with depth until alluvium becomes volcanic-rich (≥ 50% of sample) at 440'.
10			8		
15			11		
20			8		
25			27		
30			17		
35			9		0'-30' Cuttings are fairly uniform in size (averaging .10"-.25") and are angular to rounded.
40			31		30'-45' Gravel-size grains comprise 90% of non-clay cuttings and range from .5"-1.25" in size. They may be angular to rounded.
45			21		
50			18		
			25		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
50			25		50'-60' Cuttings similar to 0'-30' in size and sphericity.
55			29		
60			19		60'-70' Cuttings similar to 30'-45' in size and sphericity.
65			28		
70			33		
75			16		
80			29		
85			44 Start drillograph		85'-90' Sample 50% grout. 85' Color and consistency of foam discharge indicate that clay % may be higher than indicated by cuttings sample.
90			5		
95			5		
100			6		
105			10		
110			10		
115			8		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
115			8		
120			5		
125			5		
130			6		
135			9		
140			7		
145			6		
150			5		
155			5		
160			7		
165			22		
170			10.5		
175			3.5		
180			7		

LOCATION ID: ST-4-589

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
180			7		
185			6		
190			4		
195			4		
200			6		
205			8.5		
210			4.5	210'	Cuttings average .10"-.25" and are angular to rounded.
215			3.5		
220			4		
225			5		
230			4		
235			3		
240			7		
245			3		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
245			3		
250			3		
255			3		
260			6		
265			6		
270			7		270'-280' Cuttings decrease to .05"-.10" in size. Caliche-cemented alluvium present in small percentages.
275			7		
280			4		
285			5		
290			5		
295			7		
300			8		300'-385' Cuttings range from .05"-.50". Most average .1". Shapes are angular to rounded.
305			8		
310			7		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
310			7		
315			5		
320			9		
325			10		
330			7		
335			7		
340			8		
345			8		
350			9		
355			7		
360			7		360'-365' Small percentage (2%) cemented alluvium clasts present.
365			6		
370			8		
375			6		

LOCATION ID: ST-4-589

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375			6		
380			8		
385			11		385'-395' Samples are a pea-gravel. Grains are uniform in size (.2"-.4") and are sub- to well-rounded.
390			8		
395			7		395'-405' "0" symbol represents carbonate-cemented alluvium. Cuttings are .1"-.5" in diameter and angular to rounded.
400			17		
405			9		405'-435' 10% calcite included in limestone percentage.
410			7		410'-415' First appearance of andesite in cuttings. Cuttings are finer, averaging .10" and angular to sub-rounded.
415			7		
420			7		
425			7		
430			5		
435			4		
440			6		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
440			6		440'-610' Volcanic-Rich Alluvium: increase in volcanics; predominantly andesite and rhyolite.
445			7		
450			6		
455			7.5		
460			3.5		
465			5		
470			5		
475			6.5		
480			5.5		
485			4		
490			3.5		
495			3.5		
500			4		
505			4		

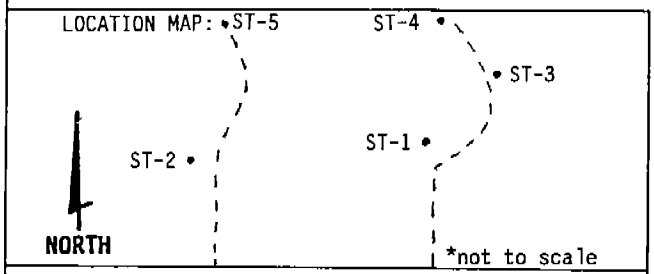
LOCATION ID: ST-4-589

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
505			4		
510			4		
515			4.5		
520			4		
525			4.5		
530			3		
535			5		
540			8		
545			3.5		
550			10		
555			7		
560			9		
565			7		
570			6		

LOCATION ID: ST-4-589

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
570			6		
575			15		
580			8		
585			7		
590			7		
595			6.5		
600			14.5		
605			8		
610			6.5		610' = Total Depth by drillograph
615					
620					
625					
630					
635					

LITHOLOGIC LOG



SW1/4 SE 1/4 NE 1/4 NW 1/4 S32 T20S R3E

NE

SITE ID: NASA-WSTF LOCATION ID: ST-4-690

SITE COORDINATES (ft.):

N 232181.75 E 400374.63

GROUND ELEVATION (ft. MSL): 4491.16' (B.C.)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: Mud Rotary/Air Foam Rotary

DRILLING CONTR.: Larjon Drilling Co

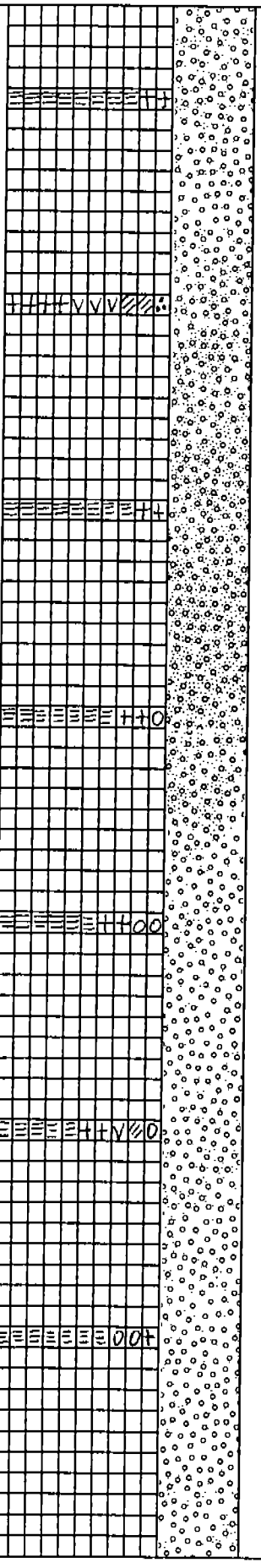
DATE STARTED: 08/18/92 DATE COMPLETED: 10/05/92

FIELD REP.: D. Menzie, M. Canavan

COMMENTS: Mud Rotary 12¼" pilot hole 0'-75'. Ream to 16" 0' 75'. Set 75' of 10" steel surface casing. Air-foam rotary with 9 7/8" button bit 75'-763'. Volcanic-rich alluvium at 455'. Volcanic bedrock (Tuff) at 605'. Total Depth is 763'.

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
5 10 15 20 25 30 35 40 45 50			Timed by driller 52 35 49 38 31	Cuttings grab sample every 10' to 610'every 5' from 620' to 760'	0'-605' Alluvium (Santa Fe Group): Samples range in color from moderate brown (5 YR 3/4) to light gray (N8). Samples are comprised of cuttings which range in size from 1.0 inches to much less than 0.1 inches (silt and clay size). Average cutting size is 0.1 to 0.2 inches. Cuttings are rounded to angular. Rounded to subrounded cuttings are formation grains and comprise 20%-60% of samples. Subangular to angular cuttings include blocky formation clasts and chips broken during drilling. The alluvium is an unconsolidated to moderately consolidated, poorly sorted, pebble to boulder, polygenetic conglomerate. Intermittent clay and caliche intervals are noted in the log. Alluvial clasts consist of dark gray (N3) to light olive gray (5 Y 5/2) micritic limestone, white (N9) iron-stained rhyolite, moderate reddish brown (10 R 4/6) siltstone, light brownish gray (5 YR 6/1) andesite, light gray (N7) to light brown (5 YR 6/4) tuff, white (N9) to light gray (N7) quartz, brownish black (5 YR 2/1) sandstone, grayish red (5 R 4/2) rhyolite, and light gray (N7) caliche. Minor amounts of granite, quartzite, chert, schist, and gneiss occur. Tuff (with lesser amounts of andesite and rhyolite) increases in abundance with depth until alluvium becomes Volcanic-rich (≥ 50% of sample) at 455' below ground surface. 0'-75' Mud Rotary. 0'-20' Clay content 10-60%. 0'-120' Cuttings are poorly sorted, rounded to angular, size ranges from much less than 0.1 inches (clay & silt) to 1.0 inches. Average size is about 0.4 inches. 40'-50' Clay content 80%.

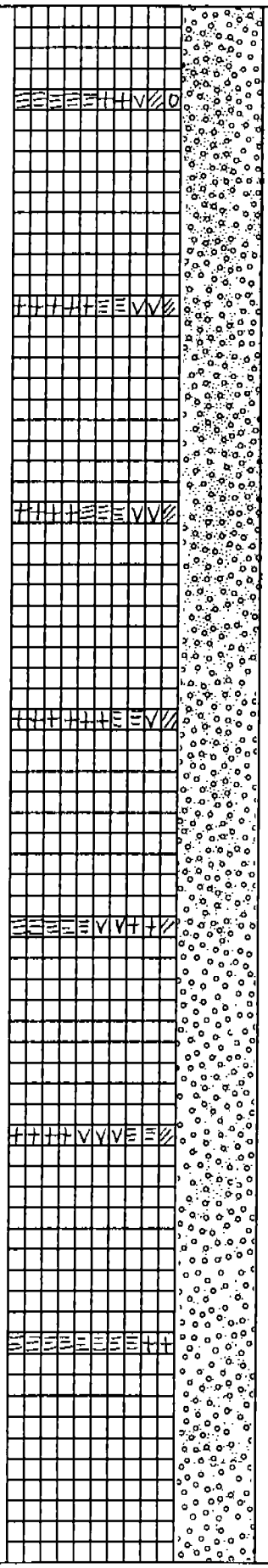
LOCATION ID: ST-4-690

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
50			31		
55					
60			60		60'-300' Clay content 10-80%.
65					
70			55		70'-120' Caliche content 10-20%.
75			Timed by drillograph from 75'.		75'-763' Air/foam rotary.
80			3		
85					
90			5		
95					
100			6		
105					
110			6		
115					

LOCATION ID: ST-4-690

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
115				Cuttings (cont'd)	
120			6		120'-290' Average cutting size decreases to about 0.3 inches.
125					
130			6		130'-150' Caliche content 10%.
135					
140			6		
145					
150			6		160'-180' Caliche content 10%.
155					
160			6		
165					
170			5		
175					
180			5		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180			5	Cuttings (cont'd)	
185					
190			5		
195					
200			6		
205					
210			6		
215					
220			5		
225					
230			5		
235					
240			5		
245					

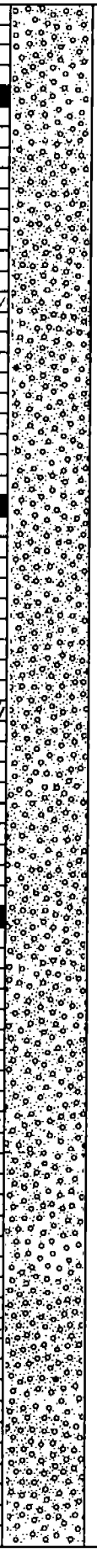


Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245				Cuttings (cont'd)	
250			4		
255					
260			4		
265					
270			4		
275					
280			7		
285					
290			7		290'-450' Average cutting size decreases to 0.2 inches.
295					
300			6		
305					
310			6		

LOCATION ID: ST-4-690

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
310			6		310'-330' Clay content 10%
315					
320			9		
325					
330			9		340'-350' Clay content 20%.
335					
340			9		
345					
350			9		
355					
360			8		
365					
370			10		
375					

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
375					
380			11		
385					
390			12		390'-400' Caliche content 10%.
395					
400			11		
405					
410			12		410'-420' Sample is made up of gravel .2"-.5".
415					
420			12		420'-430' Caliche content 10%.
425					
430			13		
435					
440			11		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
440			11	Cuttings (cont'd)	
445					
450			12		450'-605' Average cutting size decreases to 0.1 inches.
					450'-460' Increase in volcanic percentage.
455					455'-605' Volcanic-rich alluvium: Samples consist of light gray (N7), crystal-lithic, ash-flow tuff with lesser amounts of limestone, rhyolite, and siltstone. Volcanic fraction comprises 50% of sample at 455' and increases to 100% of sample at 520'. Cuttings are subrounded to subangular and range in size from less than 0.1 inches to 0.5 inches. The volcanic-rich alluvium is a poorly sorted, pebble to boulder, polygenetic conglomerate.
460			11		
465					
470			13		460'-470' Foam changes color to brownish purple.
475					
480			11		
485					
490			10		490' Cuttings are those that settled while drillers were making connection.
495					
500			9		
505					

LOCATION ID: ST-4-690

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
505				Cuttings (cont'd)	
510			12		
515					
520			9		
525					
530			8		
535					
540			10		
545					
550			12		
555					
560			14		
565					
570			24		

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
570			24	Cuttings (cont'd)	
575					
580			20		
585					
590			25		590'-610' Much cemented volcanic alluvium present 40-50%.
595					
600			21		
605					605'-763' Tuff (Cueva?): Samples range in color from pinkish gray (5 YR 8/1) to dark gray (N3). The tuff is extensively altered to clays from 605' to 670'. Samples of altered tuff range in color from pinkish gray (5 YR 8/1) to light brown (5 YR 6/4). The altered portion of the tuff is very soft and clasts are rounded to subrounded. The unaltered portion of the tuff is a dark gray (N3) to light brownish gray (5 YR 6/1) crystal-lithic, ash-flow tuff. Anhedral to subhedral phenocrysts are comprised of quartz, feldspar, and biotite. Clasts from unaltered portion of tuff are angular to subrounded and range in size from less than 0.1 inches to 0.6 inches.
610			23		610' Large clay "clasts" present and 1" diameter cuttings (alluvial clasts).
615					
620			30		
625			12		610'-665' Clay content 20-50%.
630			18		
635			18		

LOCATION ID: ST-4-690

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
				Cuttings (cont'd)	
635			18		
640			14		
645			16		
650			12		
655			12		
660			9		
			Drillograph broken		
665					
670					
675					
680					
685					
690					
695					
700					

LOCATION ID: ST-4-690

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
700				Cuttings (cont'd)	
705					
710					
715					
720					
725					
730					
735					
740					
745					
750					
755					
760					
765					763' = Total depth by drillograph

Lithologic Log Addendum

Well ST-4-690

Cuttings of the lithologic unit from well ST-4-690 were sent to the Department of Geological Sciences, New Mexico State University (NMSU), Las Cruces, New Mexico, for detailed petrographic analysis when identification of fine-grained, highly altered volcanic rocks at the NASA-WSTF site became difficult using conventional field methods. Petrographic reports from NMSU were received after the printing of these lithologic logs, hence the need for this addendum. The petrographic description from NMSU is included below.

Previous unit name based on field identification: **Tuff**

New Unit name based on petrographic analysis: **Tuff with Andesite**

ST-4-690 (665' - 670')

Ash-flow tuff

Origin:	ash-fall or ash-flow tuff
Texture:	fragmental, non-welded, weakly porphyritic
Phenocryst mineralogy:	plagioclase + sanidine + augite + biotite
Porosity:	up to 20% within grains, also along veins
Alteration:	clay throughout, calcite in veins

This sample has a very fine-grained, fragmental, moderately-welded ashy matrix that surrounds vesicular pumice fragments and approximately 5% phenocrysts. Plagioclase (2%, 0.1 mm), sanidine (2%, 0.1 mm), augite (0.5%, 0.08 mm), and biotite (0.5%, 0.08 mm) constitute the phenocryst assemblage. Porosity is very low within the grains, but possibly much higher along veins. Alteration is moderate. Clay is present throughout the rock, and calcite is found in veins. The sample probably originated as an ash-flow tuff.

ST-4-690 (705' - 710')

Volcanic rocks: welded crystal ash-flow tuff and biotite-augite andesite

This sample contains two main lithologies: welded ash-flow tuff and andesite. Together, they indicate a volcanic terrain.

Ash-flow tuff

Origin:	ash-flow tuff
Texture:	welded pyroclastic, porphyritic
Phenocryst mineralogy:	plagioclase + sanidine + quartz + augite + biotite + orthopyroxene

Lithologic Log Addendum

Well ST-4-690 (cont'd)

Porosity:	low
Alteration:	very low

The lighter-colored fragments in this sample are welded ash-flow tuff. Glassy pumice fragments and ash shards are moderately welded. Approximately 10% crystals are present, commonly broken. Plagioclase (0.2 - 1.0 mm) phenocrysts are resorbed. Euhedral sanidine (0.5 - 1.4 mm) and anhedral quartz (0.5 mm) phenocrysts are broken. Both orthopyroxene (0.1 - 0.3 mm) and augite (to 0.7 mm) are present with yellow to red-brown pleochroic biotite (to 0.6 mm). This sample originated as a welded ash-flow tuff. One fragment in the thin section is a hematite-cemented quartz arenite with recycled subrounded quartz grains. This could represent either an intercalated sandstone bed or, more likely, a lithic fragment in the ash-flow tuff.

Porphyritic biotite-augite andesite

Origin:	lava flow
Texture:	glassy porphyritic
Phenocryst mineralogy:	plagioclase + augite + biotite
Porosity:	very low
Alteration:	very low

This glassy lava contains 12% phenocrysts in a groundmass of glass with microlites of plagioclase, oxides and pyroxene. Plagioclase phenocrysts (6%, 0.15 - 3.0 mm) are resorbed. Euhedral augite phenocrysts (0.1 - 0.7 mm) constitute 4% of the rock. Biotite (0.7 mm, gold to red-brown pleochroism) and microphenocrysts of FeTi oxides each form 1% of the rock. These fragments were originally part of an andesitic lava flow.

ST-4-690 (760' - 763')

Porphyritic augite andesite

Origin:	lava flow
Texture:	aphanitic porphyritic
Phenocryst mineralogy:	plagioclase + augite + sanidine + FeTi oxides
Porosity:	low except along alteration veins
Alteration:	low to moderate, calcite and clay replacement of phenocrysts, calcite veins

Approximately 15% phenocrysts are present in a fine-grained matrix of plagioclase, augite, oxides, and devitrified glass. Plagioclase phenocrysts (9%, 0.07 - 1.7 mm) are subhedral to euhedral and somewhat resorbed. Augite phenocrysts (0.005 - 1.2 mm) are subhedral to

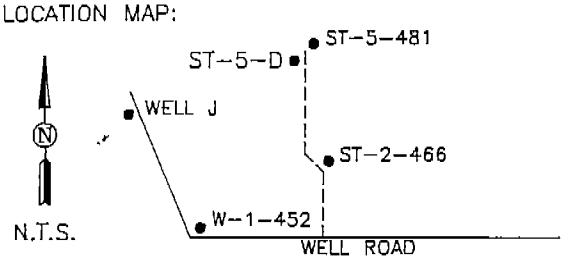
Lithologic Log Addendum

Well ST-4-690 (cont'd)

euhedral. Sanidine (0.5%, 0.5 mm) occurs as broken crystals. Subhedral FeTi oxides (0.05 - 0.15 mm) are present as microphenocrysts. A trace of apatite is present in augite and plagioclase phenocrysts. Porosity is generally low, except along veins. Alteration is not extensive, consisting largely of clay and hematite replacement of pyroxene and oxides, respectively. Plagioclase is still fresh. Calcite is present in veins. The sample originated as a lava flow.

ST-5-D LITHOLOGIC LOG

LOCATION MAP:



SE 1/4 SE 1/4 SW 1/4 NW 1/4 S 32 T 20S R 3E

SITE ID: NASA-WSTF LOCATION ID: ST-5-D
SITE COORDINATES (ft.):
N 230922.96 E 398537.26
GROUND ELEVATION (ft. MSL): 4458.74(BC)
STATE: NEW MEXICO COUNTY: DONA ANA
DRILLING METHOD: MUD/AIR FOAM ROTARY
DRILLING CONTR.: LARJON DRILLING CO.
DATE STARTED: 09-30-92 DATE COMPLETED: 06-29-93
FIELD REP.: M. CANAVAN, D. MENZIE, K. SUMMERS
COMMENTS: DRILLED MUD ROTARY 0-80' (12 1/4") TRI-CONE MILLTOOTH BIT). REAMED 0-80' TO 16 1/2". INSTALLED 83' OF 14" STEEL SURFACE CASING. DRILL 80-427' WITH 12 1/4" MILLTOOTH BIT. DRILL 427-1210' WITH 12 1/4" BUTTON BIT. TOTAL DEPTH BY DRILLOGRAPH IS 1210'.

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)
5				CUTTINGS GRAB SAMPLE EVERY 10' 0-380' AND 5' 380-1210'	0-585' ALLUVIUM (SANTA FE GROUP): CUTTINGS ARE HIGHLY VARIABLE IN LITHOLOGY, GRAIN SIZE AND GRAIN SHAPE. SAMPLES ARE MULTICOLORED WHEN WASHED BUT CLAY IMPARTS A LIGHT BROWN (5 YR 6/4) COLOR TO UNWASHED SAMPLES. SHAPES RANGE FROM ANGULAR CHIPS AND FLAKES TO ROUNDED ALLUVIAL GRAINS. GRAIN SIZE RANGES FROM CLAY SIZE TO 1.0 INCHES IN DIAMETER. CLAY CONTENT IN SAMPLES RANGES FROM <10% TO >95% WHERE THICK CLAY LENSES ARE PRESENT. CLAY-RICH AND CALICHE-RICH INTERVALS ARE NOTED IN THE LOG. THE UNIT IS AN UNCONSOLIDATED TO CONSOLIDATED, POORLY SORTED, PEBBLE TO BOULDER, POLYGENETIC CONGOLMERATE. LITHOLOGIES REPRESENTED IN SAMPLES ARE PREDOMINANTLY LIMESTONE, CLAY, RHYOLITE AND SILTSTONE. THE LIMESTONE IS MEDIUM GRAY (N5) TO DARK GRAY (N3), MICRITIC, AND CONTAINS A FEW ALLOCHEMS. OTHER SEDIMENTARY ROCKS PRESENT ARE GREENISH GRAY (5 GY 6/1) TO PALE RED (5 R 6/2), LAMINATED TO NON-LAMINATED SILSTONES; GRAY CHERT; AND MINOR AMOUNTS OF POORLY SORTED, FINE-GRAINED SANDSTONE. VOLCANIC CUTTINGS GENERALLY INCREASE IN ABUNDANCE WITH DEPTH AND INCLUDE RHYOLITES, TUFFS, AND ANDESITE. OTHER IGNEOUS ROCKS INCLUDE MEDIUM-TO FINE-GRAINED GRANITES AND MONZANITES. THE ALLUVIUM IS CONSIDERED VOLCANIC-RICH AT 585 FEET WHERE VOLCANIC CUTTINGS CONSTITUTE >50 PERCENT OF SAMPLES.
10			36		0-5' CLAY IS MOTTLED TAN TO MEDIUM BROWN. RARE CUTTINGS ARE .25-.50 INCHES IN DIAMETER.
15					5-10' CUTTINGS ARE FAIRLY UNIFORM .25-.50 INCHES IN DIAMETER AND ARE ANGULAR TO ROUNDED. CALICHE COATINGS ARE COMMON.
20			65		10-15' CLAY IS MOTTLED TAN TO MEDIUM BROWN. RARE CUTTINGS ARE .25-.50 INCHES IN DIAMETER.
25					15-20' 99 PERCENT REDDISH BROWN GUMMY CLAY.
30			96		20-30' GRAYISH TAN GUMMY CLAY WITH SOME REDDISH BROWN CLAY BALLS.
35					30-40' MULTICOLORED GRAVEL, PREDOMINANTLY BLACK TO GRAY LIMESTONE, SOME CALICHE AND IGNEOUS ROCKS. SUBANGULAR TO SUBROUNDED. SIZE RANGES <0.1 INCHES TO 1.0 INCHES; AVERAGE SIZE 0.4 INCHES.
40			33		40-50' MOSTLY ANGULAR CHIPS TO SUBROUNDED. SIZE RANGES <0.1 INCHES TO 0.4 INCHES. AVERAGE SIZE IS 0.1 INCHES.
45					
50			49		

ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)	
				CUTTINGS (CONT'D)		
60			38			
65						
70			47		70–80'	100 PERCENT SILTY CLAY.
75					80–100'	GRADUAL DECREASE IN SILTY CLAY CONTENT TO ~60 PERCENT. WASHED SAMPLES COMPOSED PRIMARILY OF CALICHE CUTTINGS.
80			92		80–160'	AVERAGE CUTTING SIZE EQUALS 0.2 INCHES.
85						
90			10			
95						
100			11		100–150'	INCREASE IN SILTY CLAY CONTENT TO 70–80 PERCENT. CALICHE CUTTINGS MOST ABUNDANT.
105						
110			8			
115					115'	SLIGHT DECREASE IN PENETRATION RATE.
120			12			

ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)	
				CUTTINGS (CONT'D)		
130			15			
135						
140			14			
145						
150			16			
155						
160			13		160'	DEVIATION SHOT EQUALS ZERO DEGREES (VERTICAL).
165						
170			14		170'	SLIGHT DECREASE IN CLAY CONTENT TO 60 PERCENT.
					170–190'	SLIGHT INCREASE IN AVERAGE CUTTING SIZE TO 0.3 INCHES.
175						
180			15			
185						
190			16		190–220'	SLIGHT INCREASE IN CLAY FRACTION TO 70–80 PERCENT.

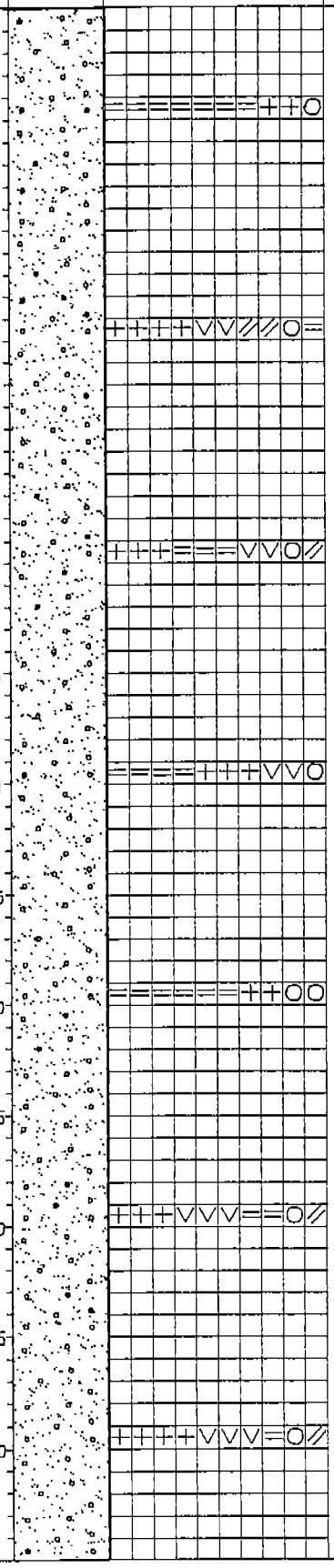
ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)
200			13	CUTTINGS (CONT'D)	
205					
210			19		
215					
220			21		220–270' CLAY CONTENT DECREASES TO 60 PERCENT.
225					
230			14		
235					
240			15		
245					
250			18		
255					255' DEVIATION SHOT EQUALS ZERO DEGREES (VERTICAL).
260			16		

ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)
270				CUTTINGS (CONT'D)	
			15		270–290' SHARP DECREASE IN CLAY CONTENT. DOWN TO 10–30 PERCENT.
275					
			17		
280					
285					
			16		290–310' INCREASE IN CLAY TO 40–70 PERCENT.
290					
295					
			26		
300					
305					
			15		310–385' DECREASE IN CLAY TO 10–20 PERCENT. MOSTLY GRAVEL. AVERAGE SIZE 0.3 INCHES.
310					
315					
			20		
320					
325					
			16		
330					

ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)
340		+++++VVV=O//	19	CUTTINGS (CONT'D)	
345					
350		+++VVVOO=//	36		350' DEVIATION SHOT RESULTS ARE ZERO DEGREES (VERTICAL).
355					
360		+++++VVV=O//	17		
365					
370		+++++VVV=O//	41		
375					
380		+++++VVV////	27		
385		+++++VVV//==			
390		+++++VV//===	29		
395		+++++VVV////			395–430' SLIGHT CUTTING SIZE REDUCTION. MANY CUTTINGS ARE MEDIUM TO VERY COARSE SAND–SIZE, ALTHOUGH PREDOMINANT SIZE REMAINS VERY COARSE SAND–TO SMALL PEBBLE–SIZE. UNWASHED CUTTINGS ARE VERY SILTY. SOME CLAY PRESENT. (OBSERVING RIG BEHAVIOR; CLAY APPEARS TO BE IN THIN "STRINGERS".)
400		+++++VV////	35		
		+++++VV//==			

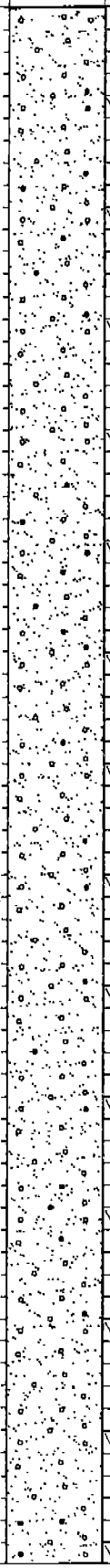
ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)	
				CUTTINGS (CONT'D)		
410			41		410–450'	APPEARS THAT "CLAY" IN CUTTINGS IS PARTIALLY BENTONITE GEL. SOME CALICHE COATINGS AT 430 FEET.
415						
420			33			
425						
430			55		430'	VERY HARD – SEEMS TO BE PARTIALLY CEMENTED GRAVEL AND COBBLES.
435						
440			99			
445						
450			108			
455						
460			85		460'	DEVIATION SHOT <1 DEGREE VERTICAL.
465						
470			83			

ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)
480			DRILLOGRAPH NOT WORKING	CUTTINGS (CONT'D)	
485					
490					
495					
500					
505					
510					
515			DRILLOGRAPH FIXED		
520					
525					
530			54		
535					
540			53		

ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)
				CUTTINGS (CONT'D)	
550			59		550' DEVIATION SHOT 1/2 DEGREE VERTICAL.
555					
560			42		
565					
570			55		
575					
580			49		
					587' BIT CHATTER.
585					585–1210' VOLCANIC–RICH ALLUVIUM (SANTA FE GROUP): CUTTINGS ARE SUBROUNDED TO ANGULAR, POORLY SORTED, AND RANGE IN SIZE FROM <0.1 INCHES TO 0.5 INCHES IN DIAMETER. THE UNIT IS A MODERATELY CONSOLIDATED, PEBBLE TO BOULDER, VOLCANIC CONGLOMERATE. LITHOLOGIES PRESENT IN CUTTINGS ARE GRAYISH–RED (5 R 4/2) TO DARK BROWNISH RED (10 R 3/4) ASH FLOW TUFFS AND BROWNISH–BLACK (5 YR 2/1) ANDESITES WITH LESSER AMOUNTS OF RHYOLITES AND CLAYS. OCCASIONAL LIMESTONE AND SILTSTONE OCCUR NEAR THE TOP 25 FEET OF THE UNIT. PREDOMINANTLY VOLCANIC IN ORIGIN.
590			66		
595					
600			74		600' SLIGHT INCREASE IN CLAY CONTENT. SAMPLE HAS GROUT CHIPS IN IT BROKEN AWAY FROM SOMEWHERE UP–HOLE.
605					605' STILL CLAYEY. DECREASE IN CUTTING SIZE.
610			67		

ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)	
620			59	CUTTINGS (CONT'D)	615'	ANOTHER INCREASE IN CLAY PERCENT.
625						
630			68		630–635'	FLOW–BANDED RHYOLITE, TUFF AND ANDESITE ARE MAIN FRACTIONS OF VOLCANIC CLASTS.
635						
640			64		640'	DEVIATION SHOT RESULTS ARE 1 DEGREE (VERTICAL).
645						
650			70			
655						
660			77			
665						
670			54			
675						
680			56			

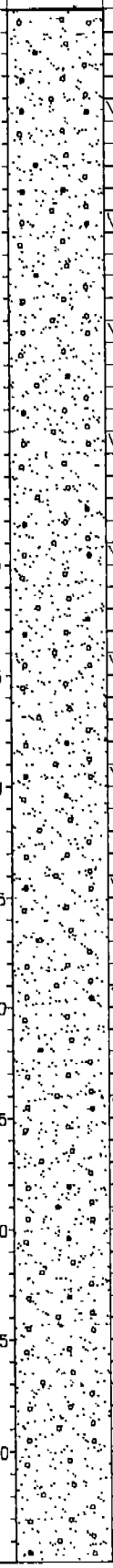
ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)
690			63	CUTTINGS (CONT'D)	
695					
700			60		
705					
710			49		
715					
720			67		
725					
730			56		
735					735' DEVIATION SHOT RESULTS ARE 1 DEGREE (VERTICAL).
740			56		
745					
750			66		

ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)
760			59	CUTTINGS (CONT'D)	
765					
770			52		
775					
780			83		
785					
790			79		790–805' LOTS OF BIT CHATTER. ANGULAR CHIPS AND FLAKES IN CUTTINGS. FRACTURE-FILL CALCITE PRESENT BUT <1 PERCENT.
795					
800			44		
805					
810			61		
815					
820			64		

ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)
				CUTTINGS (CONT'D)	825' DEVIATION SHOT IS JUST LESS THAN 1 DEGREE (VERTICAL).
830			75		
835					
840			62		
845					
850			90		
855					
860			86		
865					
870			57		
875					
880			59		
885					
890			54		

ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)	
900			51	CUTTINGS (CONT'D)	900'	CUTTINGS LOOK LIKE THEY ARE BECOMING MORE ANDESITE-RICH.
905						
910			51			
915						
920			72		920'	DEVIATION SHOT RESULTS ARE ZERO DEGREES (VERTICAL).
925						
930			73			
935						
940			68		940'	POSSIBLY WENT THROUGH A LARGE BOULDER.
945						
950			45			
955						
960			46			

ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)	
970			128	CUTTINGS (CONT'D)		
975						
980			73			
985						
990			113		990'	CUTTINGS AVERAGE 0.3 INCHES, RANGE IN SIZE FROM MUCH LESS THAN 0.1 INCHES (CLAY AND SILT SIZE) TO 0.5 INCHES, CUTTINGS ARE ANGULAR TO SUBROUNDED, LITHOLOGIES ARE MOSTLY RHYOLITE AND ANDESITE WITH LESSER AMOUNT OF TUFF?.
995						
1000			82			
1005						
1010			115		1010'	DEVIATION SHOT RESULTS ARE <1 DEGREE (VERTICAL).
1015						
1020			99			
1025						
1030			92			

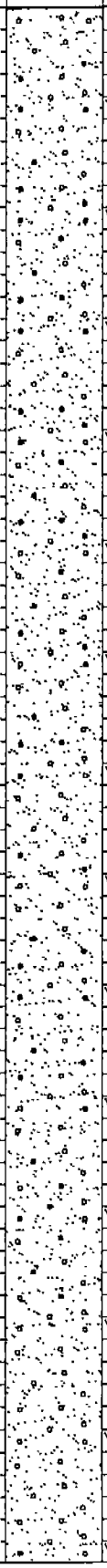
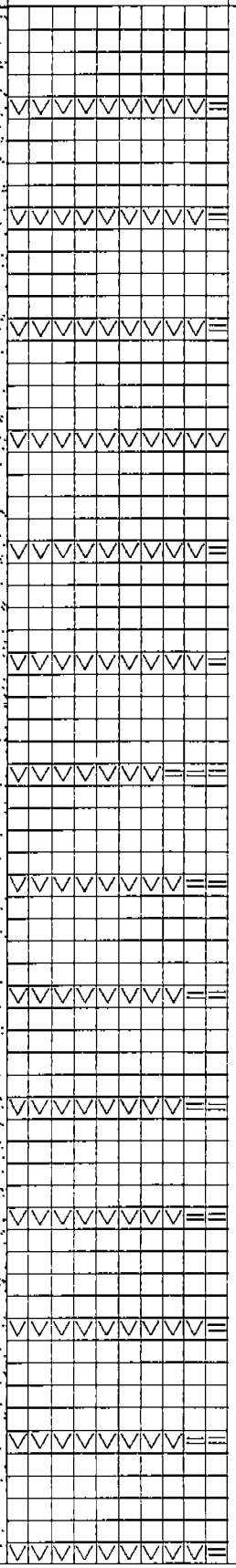
ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)
1040			75	CUTTINGS (CONT'D)	
1045					
1050			76		
1055					
1060			82		
1065					1085' COLOR CHANGE TO GRAY. CUTTINGS NOW PREDOMINANTLY AVERAGING .2 INCHES TO .25 INCHES IN DIAMETER. FLAT "CHIPS" COMMON. CONSISTS PRIMARILY OF GRAY TUFF(?).
1070			82		
1075					
1080			90		
1085					
1090			116		
1095					1095--1105' SAMPLES ARE PREDOMINANTLY ANDESITE. TUFF IN ABOVE SAMPLES COULD BE FROM LARGE BOULDERS WITHIN ALLUVIUM.
1100			150		1100' DEVIATION SHOT RESULTS ARE 1/2 DEGREE (VERTICAL).

ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

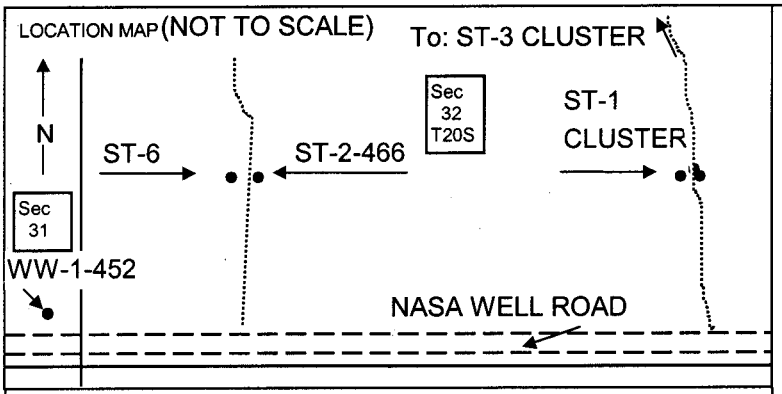
DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)
1110			150	CUTTINGS (CONT'D)	
1115					
1120			144		
1125					
1130			116		
1135					
1140			133		
1145					
1150			112		
1155					
1160			143		
1165					
1170			97		

ST-5-D LITHOLOGIC LOG
(Continued)

LOCATION ID: ST-5-D

DEPTH	LITH.	VISUAL %	DRILLING TIME SCALE: MIN.	SAMPLE TYPE AND INTERVAL	LITHOLOGIC DESCRIPTION (LITH., GRAIN SIZE PROPORTIONS, WET COLOR, RNDG., SRTG., CONSOL., DIST. FEATURES)	
				CUTTINGS (CONT'D)		
1180			80		1180'	DEVIATION SHOT RESULTS ARE <1 DEGREE (VERTICAL).
1185						
1190			90			
1195						
1200			80			
1205						
1210			101		1210'	TOTAL DEPTH BY DRILLOGRAPH. TD BY GEOPHYSICAL LOGGER WAS 1,209 FEET. FINAL DEVIATION BY GEOPHYSICAL LOGGER WAS 3 FEET OF STEP-OUT TOWARDS 352 DEGREES (NORTHERLY).
1220						
1225						
1230						
1235						
1240						
1245						

LITHOLOGIC LOG



SW ¼ SE ¼ NW ¼ SW ¼ S 32 T 20S R 3E

SITE ID: NASA-WSTF LOCATION ID: ST-6

SITE COORDINATES (ft.):

N: 229172.66 E: 398955.05

GROUND ELEVATION (ft. MSL): 4465.72 (BC)

STATE: New Mexico COUNTY: Dona Ana

DRILLING METHOD: Mud/Air Foam Rotary

DRILLING CONTR.: Stewart Brothers Drilling Co.

DATE STARTED/COMPLETED: 07/08/97 - 10/05/97

FIELD REP.: GILES/PEARSON/RUSSELL/EGAN

COMMENTS: Drilled Mud Rotary (8 ¾") to 40'; Reamed to 14 7/8" and set 10 ¾" surface casing to 40'. Drilled 9 7/8" to 1010' (TD). Set 4" SS with Westbay retrofit. (5 screen zones total)

LOCATION DESCRIPTION: ST-6 is located 2.8 miles northwest of the WSTF 100 Area and .25 miles north of the NASA Well Road.

Depth (ft)	Visual %	Lith	Drilling Time Scale: ft/hr	Sample Type and Interval	Lithologic Description
10	+ + + v v v o o // //		24	Grab Samples Every 10' 0'-1010'	**0' - 570'** : ALLUVIUM (Santa Fe Group): Samples range from grayish orange pink (5 YR 7/2) to light brown (5 YR 5/6) due to very high (20% - 80%) silty/gummy clay content. Individual clasts are highly variable in color and range from < .5 mm to 1.5 cm in diameter. Formational grains are rounded to subangular. Cuttings are subangular to angular. Formation is a poorly to moderately sorted polygenetic pebble conglomerate. Lithologies are highly variable and include rocks shed from surrounding highs of the southern San Andres Mountains. Limestones are miciritic to fossiliferous, are medium light gray (N6) to dark gray (N3), and may exhibit hair-line calcite-filled fractures. Massive to laminated greenish gray (5 GY 6/1) to dark reddish brown (10 R 3 /4) siltstones and a variety of igneous (predominantly volcanic) rock types characterize the formation. Very pale orange (10 YR 8/2) rhyolite porphyries, very light gray (N8) to medium light gray vitric to lithic crystal tuffs, arenaceous to argillaceous sandstones, quartzites, granites, and quartz/feldspar sands are also present.
20	+ + + v v v o o // //		40		
30	+ + + + + v v v o //		18		
40	+ + + + + + v v // ::		21		**0' - 80'** Santa Fe Group Alluvium is moderate to light brown in color with 2 mm to 3 cm diameter clasts. Subangular to subrounded, polygenetic, predominantly sedimentary clasts. Limestone/calcareous ss. Panther Seep/ Hueco Ls with microfossils. Caliche-cemented clasts are present. Black to red calcareous siltstones. Igneous clasts include pink to gray rhyolites, rhyodacites and granites.
50	+ + + + + + v v v //		10		
60	+ + + + + + v v v //		30		
70	+ + + + + v v v // //		17		
80	= = = = + + + v v v		30		**80' - 90'** Tan brown clayey silt comprises 60%-70% coarse subrounded to subangular gravel.
90	= = = = = + + + v v		21		
100	= = = = + + + + v v		60		

Depth (ft)	Visual %	Lith	Drilling Time Scale: ft/hr	Sample Type and Interval	Lithologic Description
110	= = = = = = + + v v		60	Grab Samples Every 10' 0'-1010'	**110' - 120'** Tan brown silty clay comprises 60% of the sample Gravel as before, made up mostly of limestone with a variety of volcanics.
120	= = = = = + + + v v		24		
130	= = = = = = = + + +		46		**130' - 140'** Sand size grains suspended in moderate brown (5 YR 4/4) clay.
140	= = = = = = = + + +		22		**140' - 170'** Tan brown silty clay makes up 60%-70%. Remainder is limestone-rich subrounded gravel and coarse sand.
150	= = = = = = + + + +		40		
160	= = = = = + + + v v		33		
170	= = = = = + + + v v		27		**170' - 180'** Gravel, fine to coarse, subrounded-subangular, and gray/tan to white. Tan brown clayey silt.
180	= = = = v v v + + +		60		**180' - 200'** Tan brown silty clay (85%). 15% fine to coarse gravel as before.
190	= = = = = = + + v v		25		
200	= = = = = = + + v v		60		
210	= = = = = = = = + +		12		
			35		
220	= = = = = v v + + ::				
			29		
230	= = = = = = = v v +				**230' - 240'** Brown, gray, white, fine to coarse, subrounded-subangular gravel with 30% gummy clay.
			43		
240	= = = = v v v + + +				

Depth (ft)	Visual %	Lith	Drilling Time Scale: ft/ht	Sample Type and Interval	Lithologic Description
250	= = = = = + + + v v		38	Grab Samples Every 10' 0'-1010'	**250'-270'** Clay increases from 50% - 90%.
260	= = = = = = = v v +		38		
270	= = = = = = = = v +		30		**270'-280'** Decrease in clay. Clasts are subangular to rounded and are sand to gravel size.
280	= = = = + + + v v v		27		**280'- 310'** Silty clay with sands and gravels. 5% grayish orange pink (10 R 8/2) caliche apparent.
290	= = = = + + + v v v		33		
300	= = = = + + + v v v		60		
310	= = = = + + + v v v		60		
320	= = = = + + + v v v		50		
330	= = = = + + + v v v		30		
340	= = = = + + + v v v		33		**340'- 350'** Moderate to well rounded sand-gravel size grains suspended in gummy clay.
350	= = = = v v v v + +		40		
360	= = = = + + + v v v		30		
370	= = = = + + + v v v		43		**370' - 400'** Caliche grains and coatings present. Clay is lighter in color, ranging from grayish orange pink (5 YR 7/2) to very pale orange (10 YR 8/2). Increasing percentages of volcanics. Very pale orange (10 YR 8/2) to dark yellowish orange (10 YR 6/6) rhyolite and grayish red purple (5 RP 4/2) andesite.
380	= = = = + + + v v v		19		

Depth (ft)	Visual %	Lith	Drilling Time Scale: ft/hr	Sample Type and Interval	Lithologic Description
390	= = = = + + + v v v		30	Grab Samples Every 10' 0'-1010'	
400	= = = = v v v + + o		26		
410	= = = = v v v + + ::		33		
420	= = = = v v v + + ::		20		
430	= = = = v v v v + +		32		
440	= = = = = v v v + +		43		
450	= = = = v v v v v +		46		**450' - 490'** Porphyritic Orejon Andesite and a variety of rhyolites dominate the moderate to well rounded gravels. Limestone and trace % of quartz sandstone also present.
460	= = = v v v v v v +		25		
470	= = = v v v v v v +		33		
480	= = = = = v v v v +		24		
490	= = = = = v v v v v		38		**490' - TD** VOLCANIC RICH ALLUVIUM: Consists of sand/gravel size clasts of volcanic and igneous rocks suspended in 20% to 50% clay. Volcanics consist of very pale orange (10 YR 8/2) to light brown (5 YR 5/6) and moderate red brown (10 YR 4/6) aphanetic rhyolite porphyries with 10% to 30% mafic phenocrysts. Andesite porphyry with tabular plagioclase phenocrysts (up to 40%) present. Aplitic granite fragments with predominately quartz and biotite are also present. Quartz/feldspar sands and other mafic alteration products of acidic volcanic suite are present as well.
500	= = = v v v v v v v		21		
510	= = = = v v v v v v		33		
520	= = = = v v v v v v		24		

Depth (ft)	Visual %	Lith	Drilling Time Scale: ft/hr	Sample Type and Interval	Lithologic Description
530			33	Grab Samples Every 10' 0'-1010'	
540			25		
550			35		
560			26		
570			17		**570'- 580'** Clay is pale red (10 R 6/2).
580			35		
590			Not Recorded		
600			"		**600' - 610'** Gravel is angular and coarser (average 5 cm).
610			"		
620			35		**620' - 800'** Volcanic alluvium is fine sand to fine gravel in size with volcanic rock types suspended in clay.
630			26		
640			35		
650			23		
660			40		

Depth (ft)	Visual %	Lith	Drilling Time Scale: ft/hr	Sample Type and Interval	Lithologic Description
670	= = = = = v v v v v		23	Grab Samples Every 10' 0'-1010'	
680	= = = v v v v v v v		35		
690	= = = = v v v v v v		19		
700	= = = v v v v v v v		38		
710	= = = v v v v v v v		25		
720	= = = v v v v v v v		33		
730	= = = v v v v v v v		32		**730' - 740'** Mixed volcanics and volcaniclastics. Rock types include welded lithic tuff, andesitic lahar, andesite porphyry and rhyolite. Sand to gravel size clasts are rounded to subangular.
740	= = v v v v v v v v		30		
750	= = = v v v v v v v		26		
760	= = = v v v v v v v		38		
770	= = v v v v v v v v		23		
780	= = v v v v v v v v		30		
790	= = = v v v v v v v		21		
800	= = v v v v v v v v		33		**800' - 1000'** Clay decreases slightly. Average grain size of clasts increases.

Depth (ft)	Visual %	Lith	Drilling Time Scale: ft/hr	Sample Type and Interval	Lithologic Description
810	= = v v v v v v v v		21	Grab Samples Every 10' 0'-1010'	
820	= = v v v v v v v v		24		
830	= = v v v v v v v v		22		
840	= = v v v v v v v v		33		
850	= = v v v v v v v v		46		**850' - 1000'** Predominantly andesitic lithology grades into predomantly rhyolite and rhyolitic tuffs. Silica rich chips are angular to well rounded. Chips are translucent gray with large quartz / mafic bladed phenocrysts to reddish brown (10 R 4/6) with 15% to 20% phenocrysts. Highly varied lithologies present. Crystal-lithic/vitric tuffs and weathered products. Hematite grains, quartz, feldspar, and mafics. Clay is gummy and variegated in color with iron-oxidized biotite and hornblende.
860	= = v v v v v v v v		24		
870	= = v v v v v v v v		35		
880	= = v v v v v v v v		46		
890	= = v v v v v v v v		40		
900	= = v v v v v v v v		19		
910	= = v v v v v v v v		43		
920	= = v v v v v v v v		27		
930	= = v v v v v v v v		46		
940	= = v v v v v v v v		23		

Depth (ft)	Visual %	Lith	Drilling Time Scale: ft/hr	Sample Type and Interval	Lithologic Description
950	= = v v v v v v v v		23	Grab Samples Every 10' 0'-1010'	
960	= = v v v v v v v v		14		
970	= = v v v v v v v v		19		
980	= = v v v v v v v v		12		
990	= = v v v v v v v v		27		
1000	= = v v v v v v v v		16		
1010	= = v v v v v v v v		25		**TD = 1010'**

BOREHOLE LITHOLOGIC LOG

NASA JSC - White Sands Test Facility, Las Cruces, New Mexico, USA

Location ID: **ST-7**

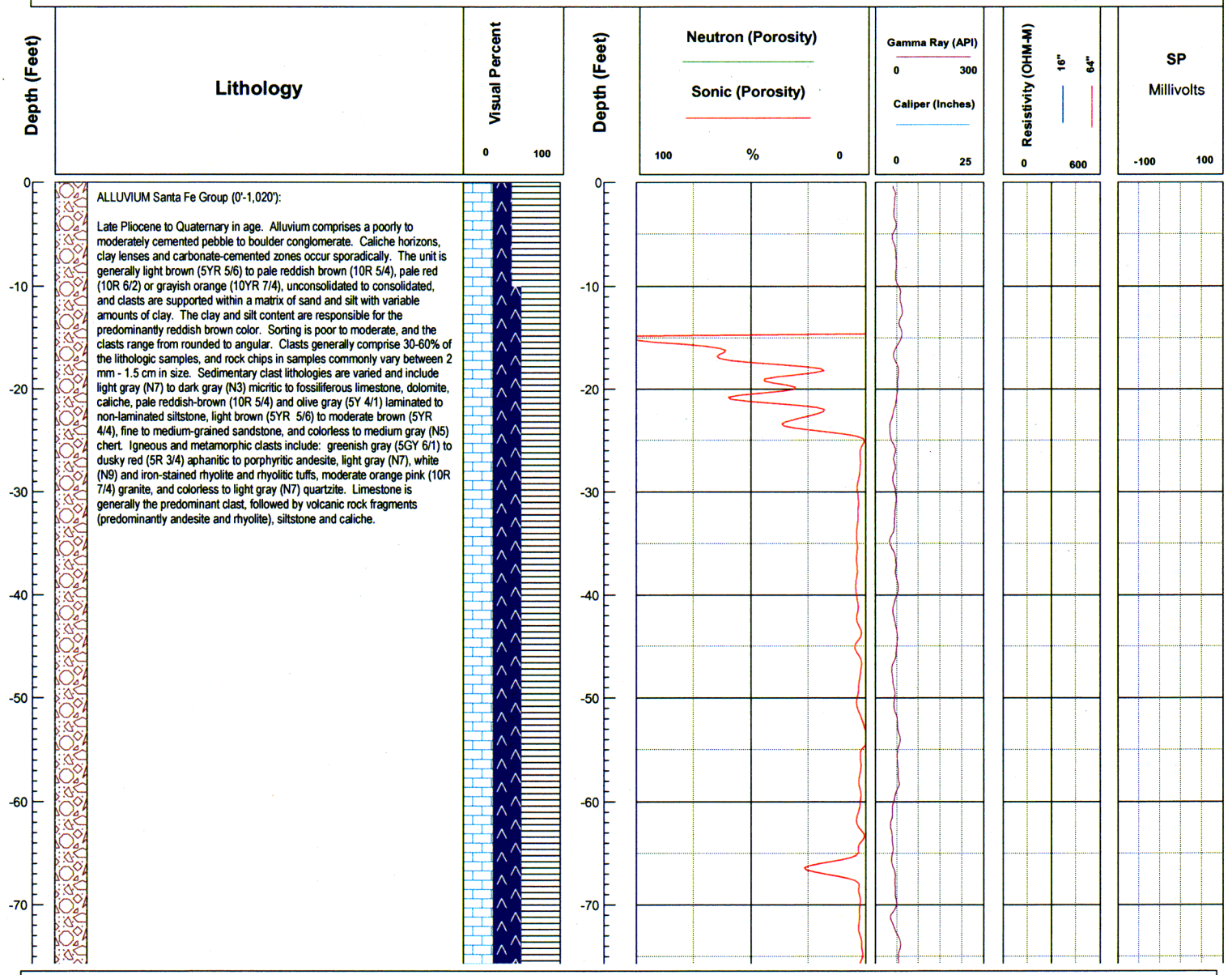
Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **W 1/2, SE 1/4, SW 1/4, Sec 32, T20S R3E**
NM State Plane Coordinates (NAD 83): **228434.04N 399760.52E (Preliminary)**
Elevation (Brass Cap): **4482.78' (Preliminary)**
Total Depth of Borehole (bgs): **1,020'**
Depth to Bedrock (bgs): **N/A**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Paul Hollar**

Depth to Groundwater (bgs): **416.98'**
Surface Casing Depth and Diameter: **14" OD steel set to 103'**
Borehole Diameter: **12.25"**
Geologist Field Rep: **L.H.M., M.M., J.P.,**
Dates Drilling Started and Completed: **1/26/99 to 3/16/99**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Retrofit Westbay inside 4.5" OD stainless**
No neutron porosity or caliper logs available.

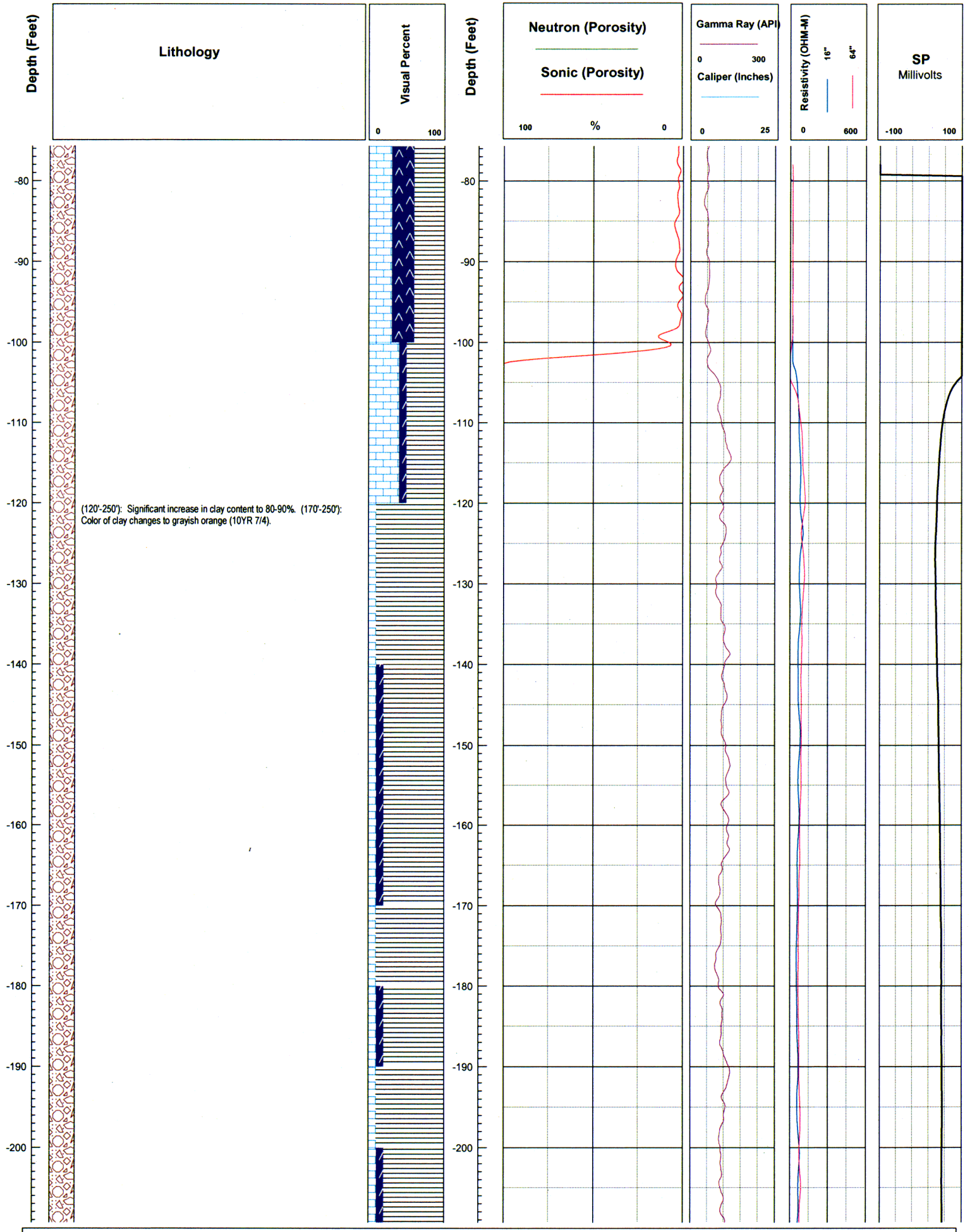
Explanation:

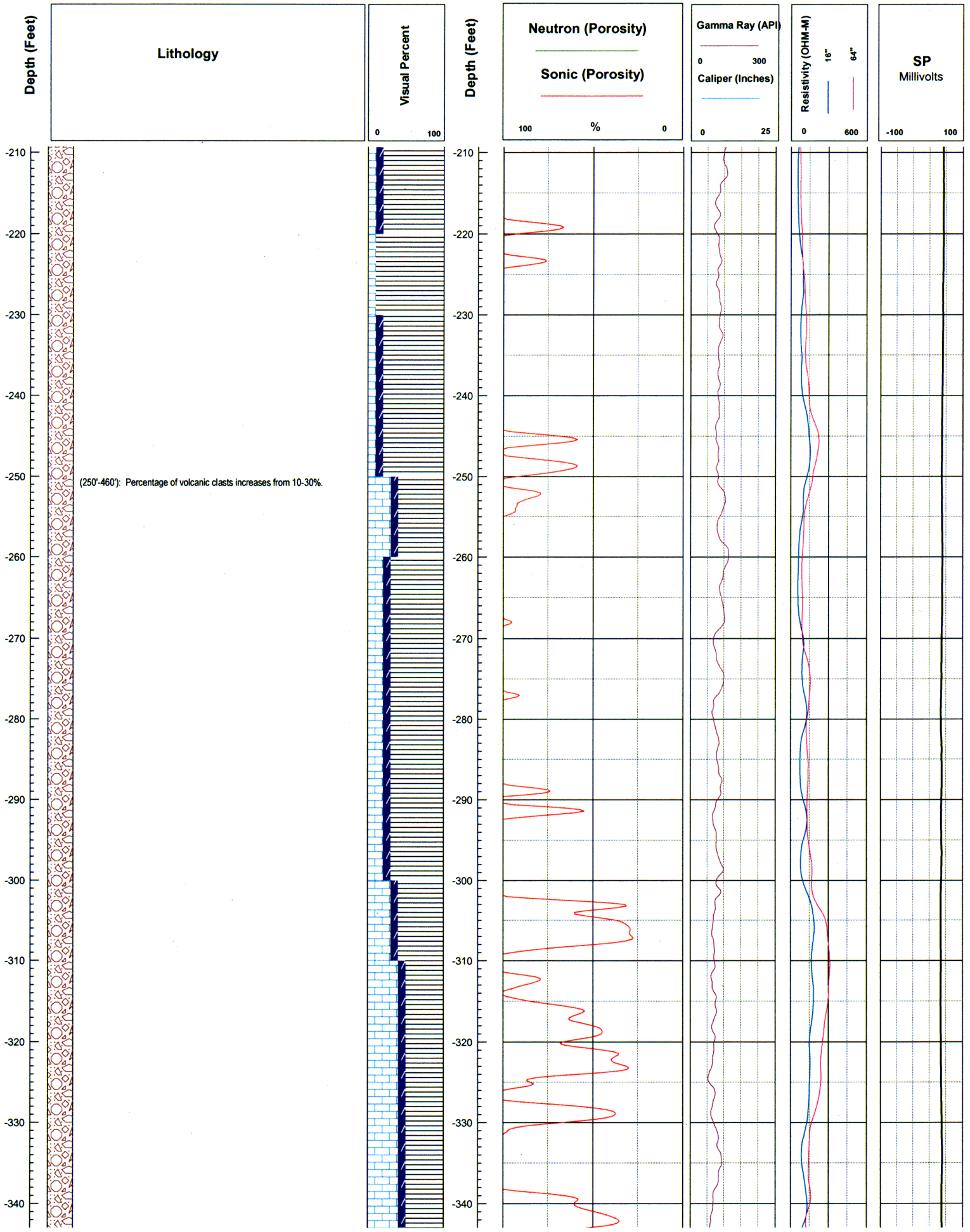
Alluvium | Volcanic Alluvium | Clay | Silt | Sand | Sandstone | Siltstone | Shale | Limestone | Rhyolite | Andesite | Undiffer. Volcanics

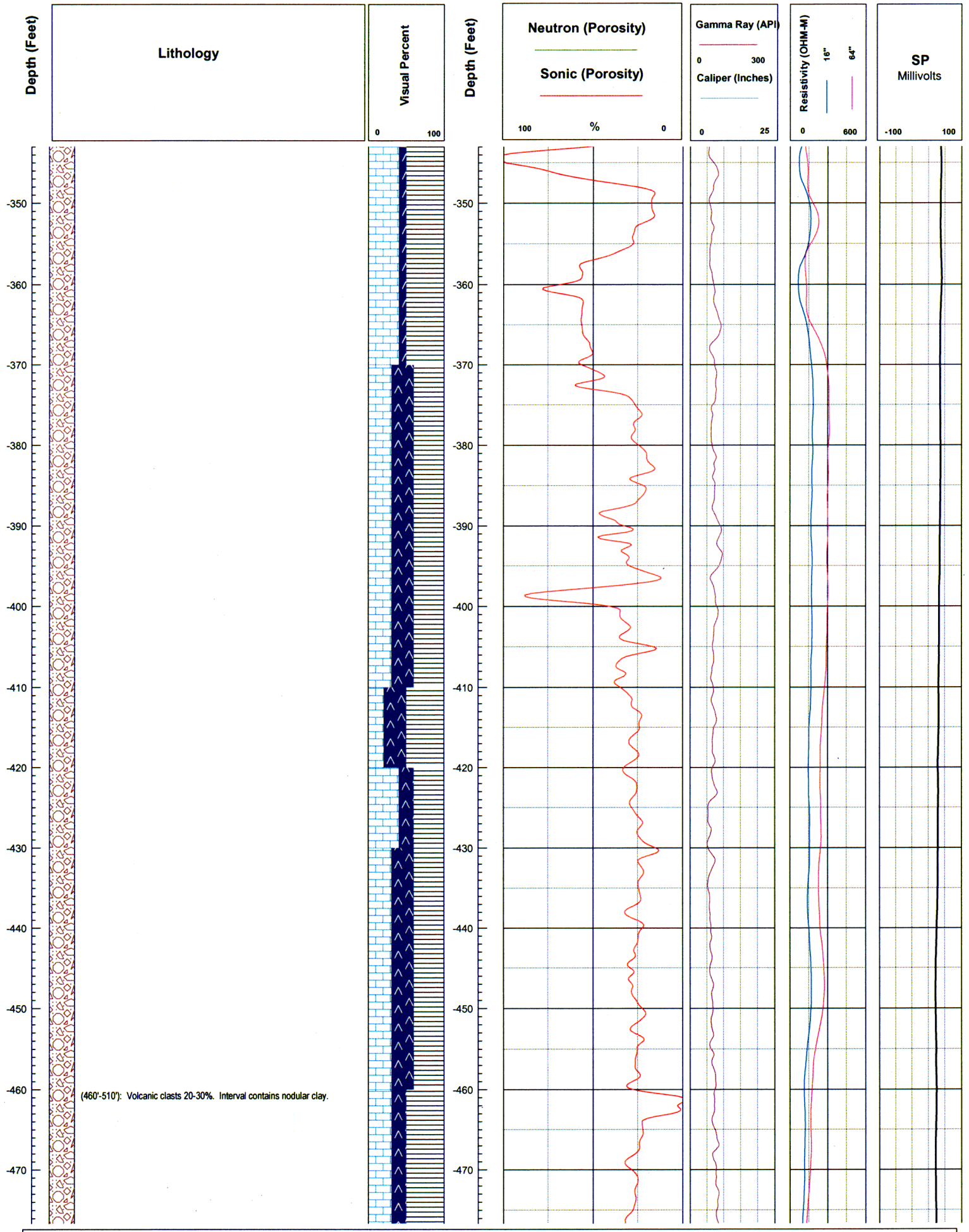


ALLUVIUM Santa Fe Group (0'-1,020'):

Late Pliocene to Quaternary in age. Alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Caliche horizons, clay lenses and carbonate-cemented zones occur sporadically. The unit is generally light brown (5YR 5/6) to pale reddish brown (10R 5/4), pale red (10R 6/2) or grayish orange (10YR 7/4), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay and silt content are responsible for the predominantly reddish brown color. Sorting is poor to moderate, and the clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Sedimentary clast lithologies are varied and include light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, dolomite, caliche, pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated to non-laminated siltstone, light brown (5YR 5/6) to moderate brown (5YR 4/4), fine to medium-grained sandstone, and colorless to medium gray (N5) chert. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Limestone is generally the predominant clast, followed by volcanic rock fragments (predominantly andesite and rhyolite), siltstone and caliche.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
(120'-250'): Significant increase in clay content to 80-90%. (170'-250'): Color of clay changes to grayish orange (10YR 7/4).


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340
(250'-460'): Percentage of volcanic clasts increases from 10-30%.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Lithology
Visual Percent
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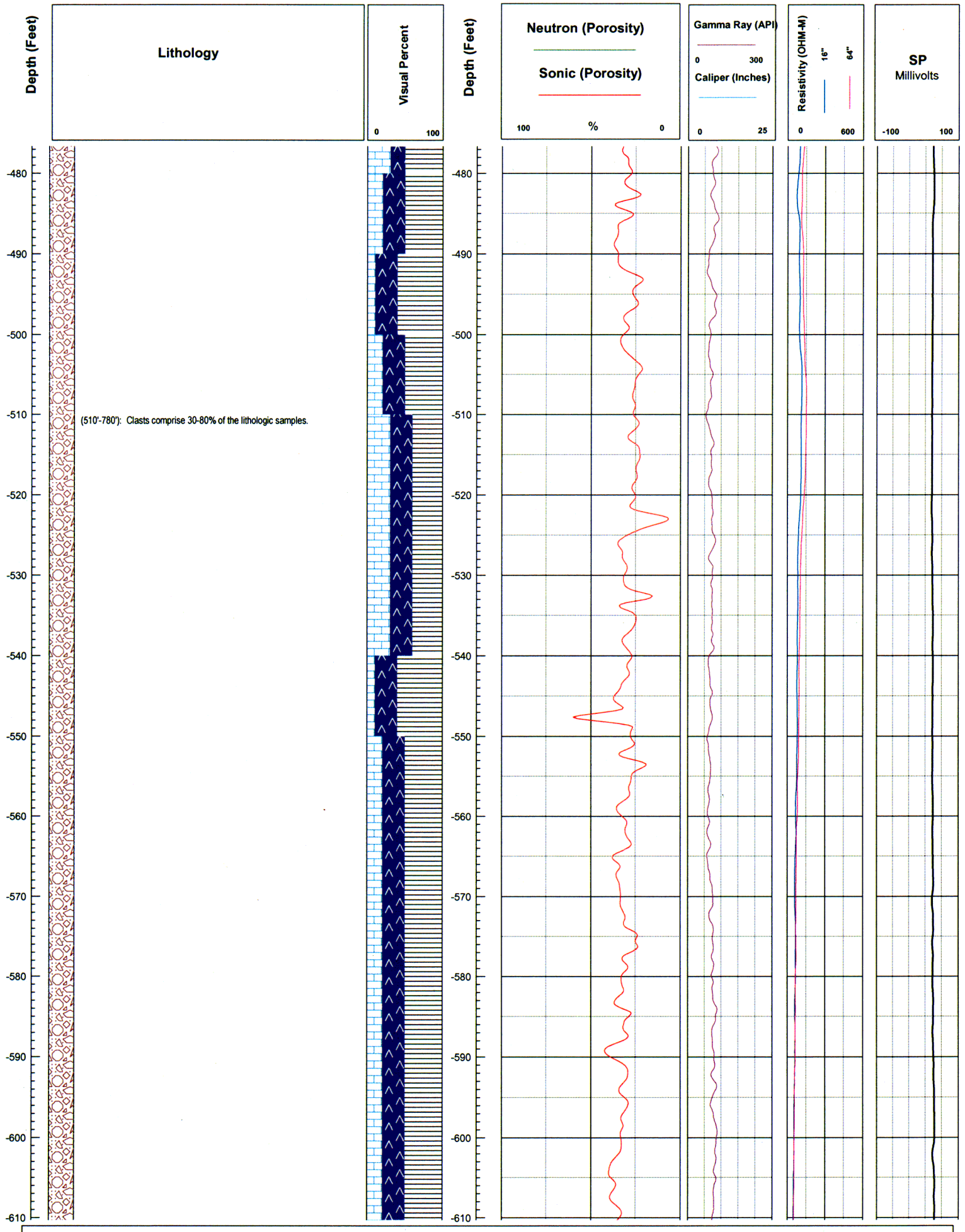
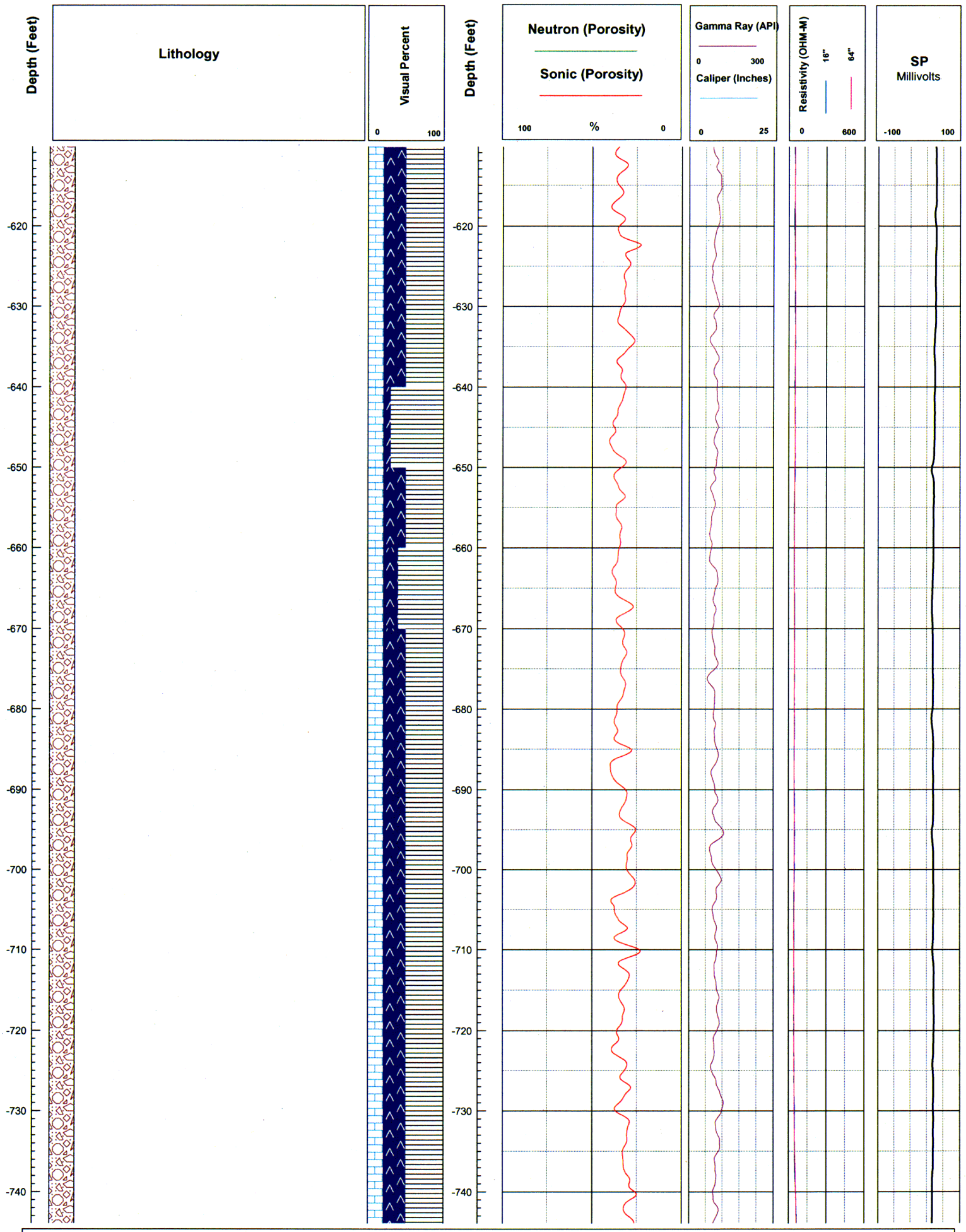
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470
(460'-510'): Volcanic clasts 20-30%. Interval contains nodular clay.


Depth (Feet)
Lithology
Visual Percent
0
100
(510'-780'): Clasts comprise 30-80% of the lithologic samples.
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-480
-490
-500
-510
-520
-530
-540
-550
-560
-570
-580
-590
-600
-610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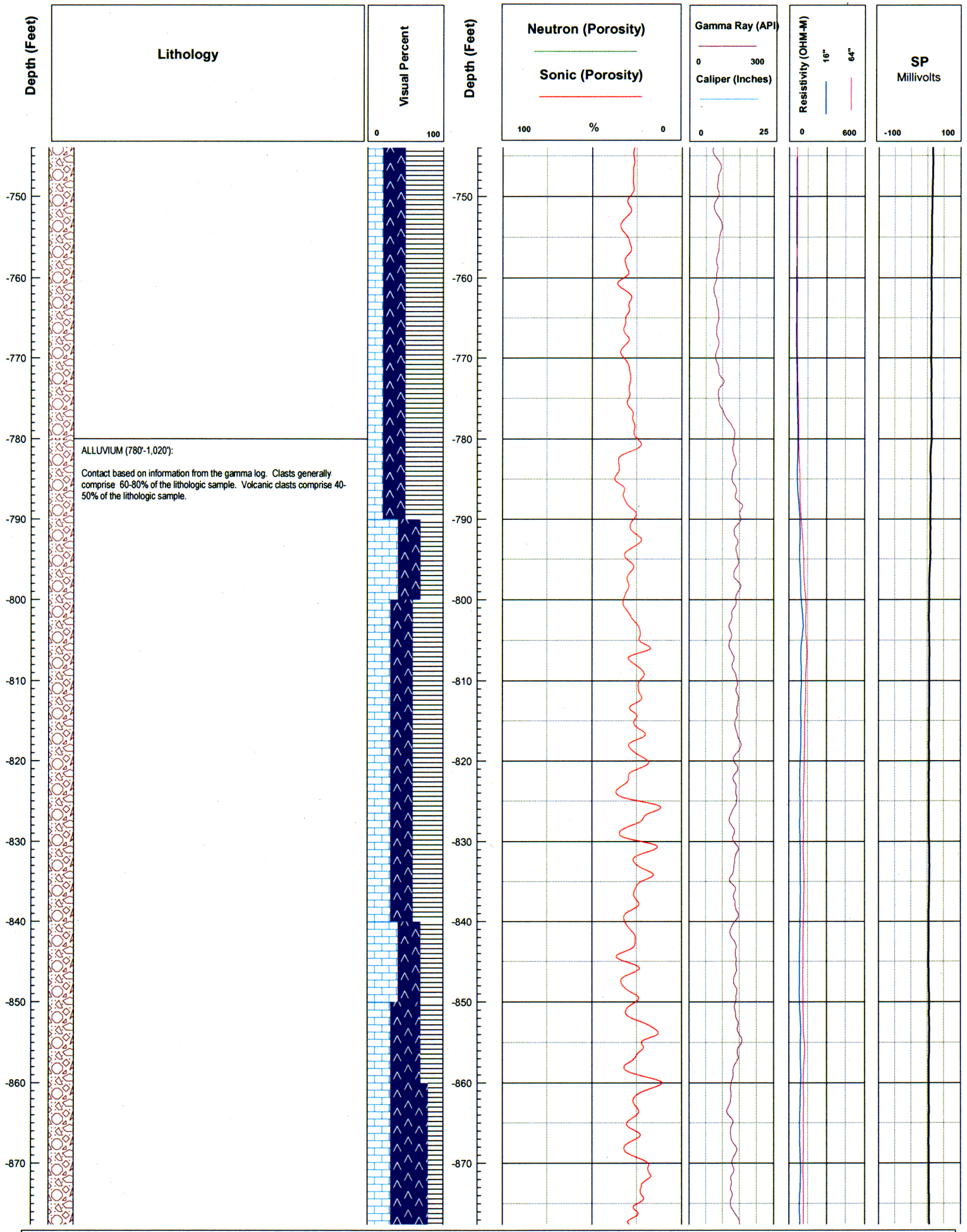
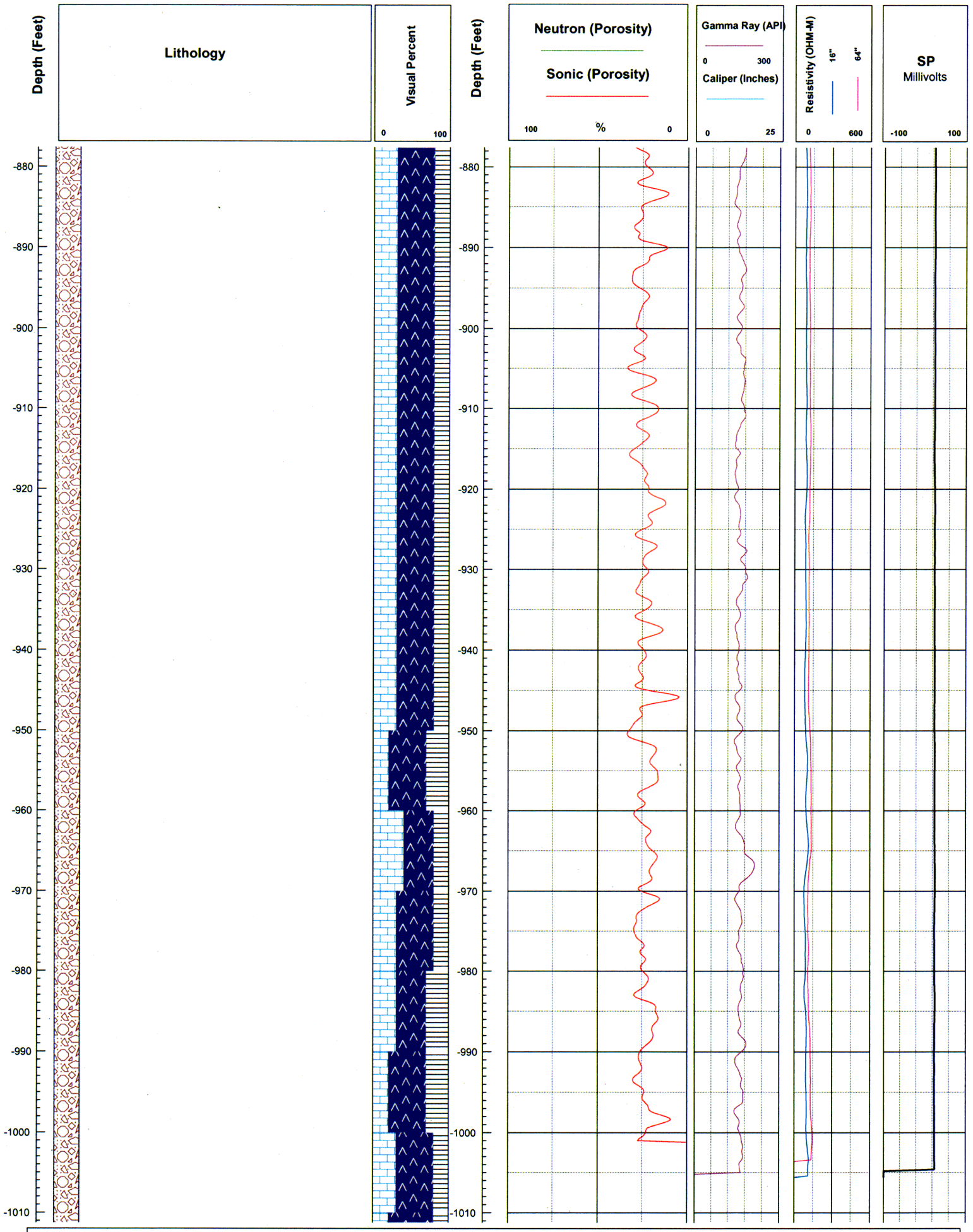
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-620
-630
-640
-650
-660
-670
-680
-690
-700
-710
-720
-730
-740


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-750
-760
-770
-780
-790
-800
-810
-820
-830
-840
-850
-860
-870
ALLUVIUM (780'-1,020'):
Contact based on information from the gamma log. Clasts generally comprise 60-80% of the lithologic sample. Volcanic clasts comprise 40-50% of the lithologic sample.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-880
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-910
-920
-930
-940
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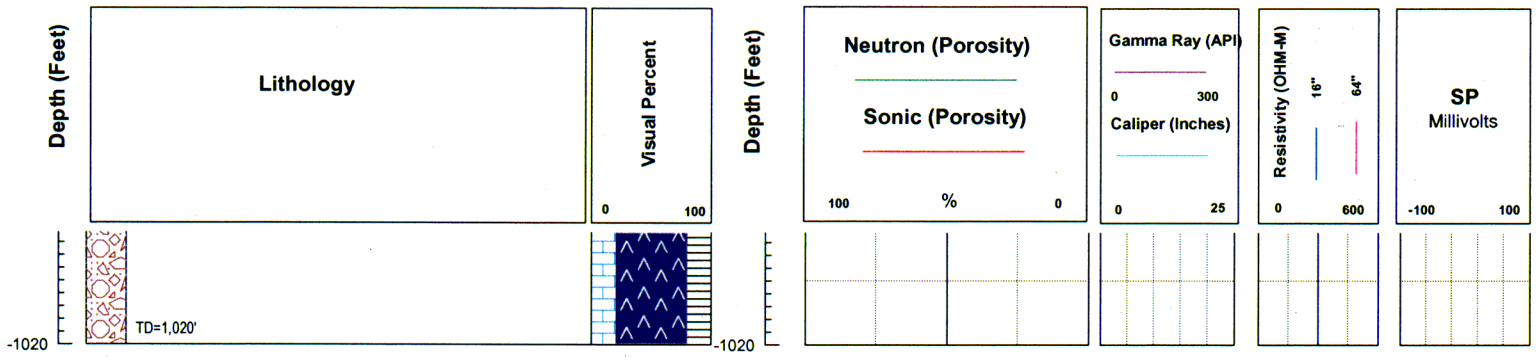
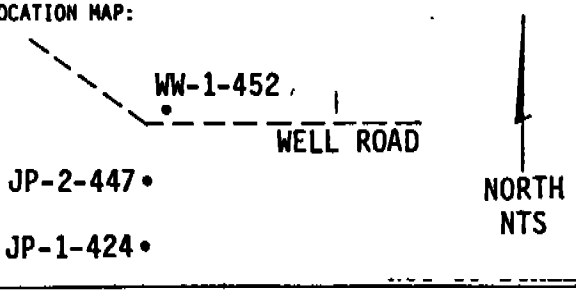
-960
-970
-980
-990
-1000
-1010


Depth (Feet)
Lithology
Visual Percent
0
100
TD=1,020'
-1020
Depth (Feet)
-1020
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100

LITHOLOGIC LOG

LOCATION MAP:



SE 1/4 SE 1/4 SE 1/4 SE 1/4 S 31 T 20S R 3E

SITE ID: NASA-WSTF LOCATION ID: WW-1-452

SITE COORDINATES (ft.):

N 227994.74 E 397803.86

GROUND ELEVATION (ft. MSL): 4455.09 (BRASS CAP)

STATE: NEW MEXICO COUNTY: DOÑA ANA

DRILLING METHOD: AIR-FOAM ROTARY

DRILLING CONTR.: LARJON

DATE STARTED: 5 JANUARY 1988 DATE COMPLETED: 21 JANUARY 1988

FIELD REP.: COOPER, KASZUBA

COMMENTS: 7 7/8" PILOT HOLE 0'-100'. 14 1/2" BOREHOLE 0'-100'. 9 7/8" BOREHOLE 100'-488'. TOTAL DEPTH = 488'. TOP OF BEDROCK: NOT REACHED.

LOCATION DESCRIPTION:

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
5				0'-488' cuttings	0'-5'	SURFICIAL SILTY CLAY Moderate orange pink (5YR 8/4) silty clay. Sample is silt-size powder.
10			begin drillograph		5'-488'	ALLUVIUM (Santa Fe Group) Unwashed sample is moderate orange pink (5YR 8/4). Washed sample has varied colors due to different lithologies of cuttings but has an overall color of medium gray (N5) to dark gray (N3). Average cutting size is 0.1 to 0.2 inches and ranges from 0.02 to 1.0 inches. Cuttings are mostly angular and blocky, with some flakes present, and are poorly sorted. The lithology is a poorly to moderately consolidated pebble to cobble conglomerate containing clasts of light gray (N7) to grayish black (N2) micritic limestone with < 10% allochems; white (N9) and red and white mottled rhyolite with iron staining; light olive gray (5Y 3/2) andesite with some pyroxene alteration to epidote; transparent bluish white (5B 9/1) to light bluish gray (5B 7/1) quartzite with cuttings containing iron staining; moderate reddish orange (10R 6/6) to moderate reddish brown (10R 4/6) granite; moderate red (5R 4/6) to moderate reddish brown (10R 4/6) siltstone (Abo); traces of light gray (N7) to grayish black (N2) chert; moderate orange pink (5YR 8/4) clay varying from < 10% to 50% of sample, clay often forms balls when samples are washed.
15			5			
20			3			
25			3		25'-30'	Significant decrease in cutting size.
30			4			
35			3.5		30'-50'	Increase in cutting size.
40			2.5			
45			3			
50			3			

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval		Lithologic Description
50			3		50'-70'	Decrease in cutting size.
55			7		55'-60'	Individual grains of epidote, probably crushed or broken up andesite cuttings.
60			4			
65			4			
70			5		70'-100'	Slight increase in cutting size.
75			3			
80			4.5			
85			3.5			
90			4.5			
95			4			
100			3.5			
105			-		105'-235'	Clay content increases significantly.
110			2.25			
115			2.25			

LOCATION ID: WW-1-452

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description	
115			2.25			
120			2.25			
125			2.25			
130			2.25		130'-140'	Decrease in average size of cuttings to ≤0.1 inches.
135			2.25			
140			2.25		140'-170'	Increase in average size of cuttings to 0.1-0.2 inches.
145			2.25			
150			2.25			
155			2			
160			2			
165			2			
170			2		170'-235'	Decrease in average size of cuttings to ≤0.1 inch.
175			2			
180			2			

LOCATION ID: WW-1-452

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
180			2		
185			2		
190			2		
195			2		
200			2		
205			2		
210			2		
215			2.25		
220			2.25		
225			2.25		
230			2.25		
235			2		235'-250' Increase in average size of cuttings to 0.1-0.2 inches. Clay content decreases significantly.
240			2		
245			2		

LOCATION ID: WW-1-452

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
245			2		
250			2		250'-310' Samples collected at 10' intervals (poor circulation to surface).
255			1.75		250'-390' Decrease in average size of cuttings to ≤0.1 inches, cuttings more angular. Alluvium either richer in cobbles and boulders or more consolidated.
260			1.75		
265			1.75		
270			1.75		
275			2		
280			2		
285			3		
290			3		
295			2.5		
300			2.5		
305			2.5		
310			2.5		

LOCATION ID: WW-1-452

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
310			2.5		310'-485' Resume 5' sample interval.
315			3		
320			7.5		
325			6.5		
330			4		
335			4.5		
340			7.5		
345			9.5		
350			4		
355			2.5		
360			2.5		
365			6.5		
370			14.5		
375			6		

LOCATION ID: WW-1-452

Depth	Visual %	Lith	Drilling Time Scale:	Sample Type and Interval	Lithologic Description
375			6		
380			6		
385			7		
390			13		390'-488' Decrease in average size of cuttings to <0.1 inches, cuttings angular. Alluvium either richer in cobbles and/or boulders or more consolidated.
395			6		
400			17		
405			14		
410			10		
415			9		
420			9		
425			10		
430			6		
435			6		
440			7		

LOCATION ID: WW-1-452

Depth	Visual %	Lith	Drilling Time Scale: min	Sample Type and Interval	Lithologic Description
440			7		440'-450' Penetration rates decrease significantly, pressure gauges suggest ground water encountered.
445			20		
450			20		
455			3		
460			8.5		
465			10.5		
470			7		
475			4		
480			12		
485			7		484'-488' Slough plugs bit, bit stuck.
					Total Depth = 488'.
490					
495					
500					
505					

BOREHOLE LITHOLOGIC LOG

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

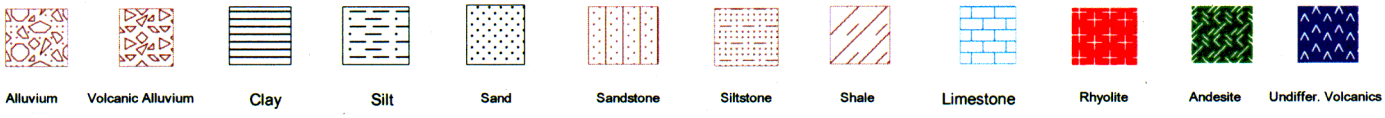
Location ID: **WW-2**

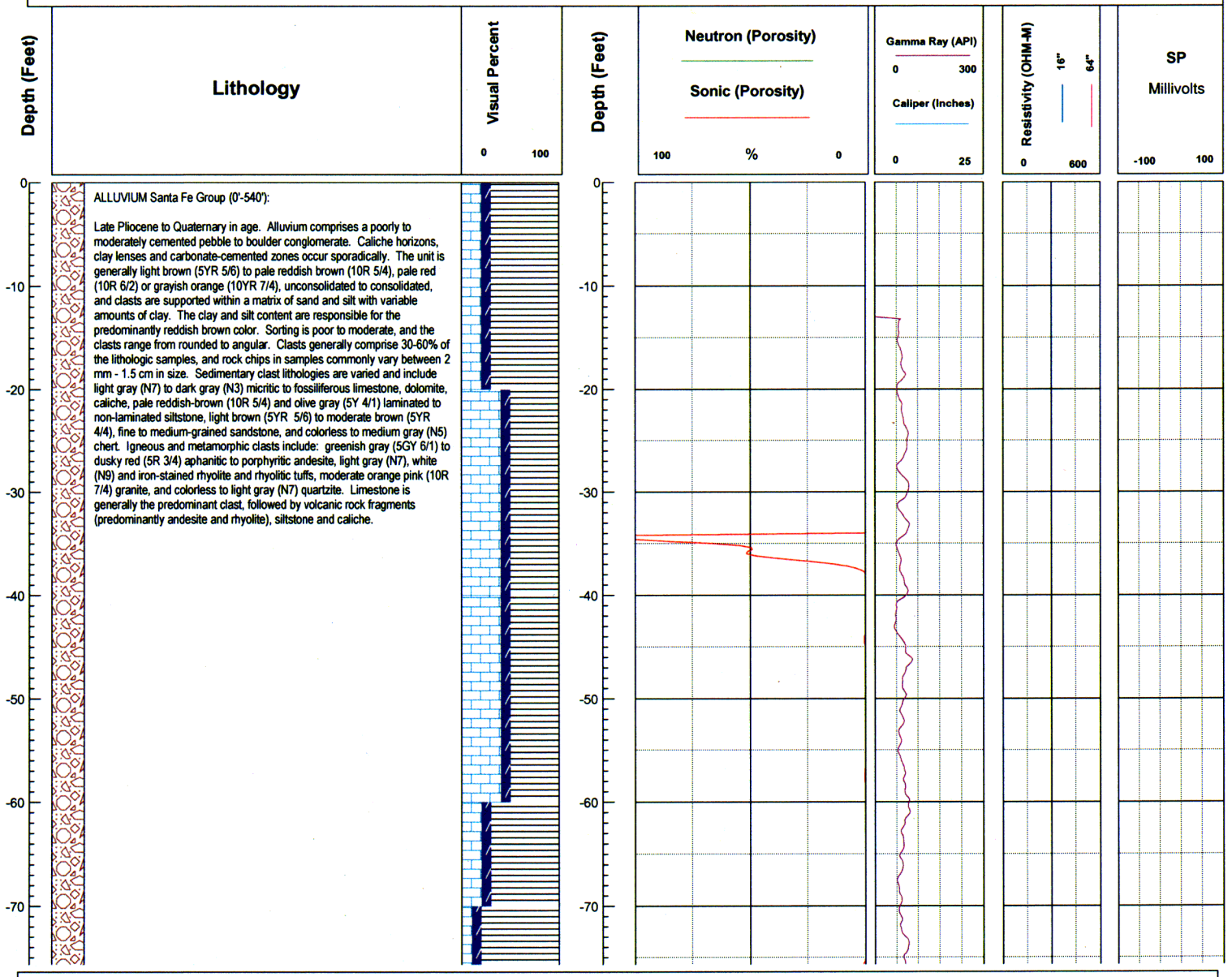
Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **NW 1/4, SE 1/4, NE 1/4, Sec 31, T20S R3E**
NM State Plane Coordinates (NAD 83): **231398.12N 397055.09E (Preliminary)**
Elevation (Brass Cap): **4436.45' (Preliminary)**
Total Depth of Borehole (bgs): **1,030'**
Depth to Bedrock (bgs): **N/A**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Paul Hollar**

Depth to Groundwater (bgs): **330' (from geophysics)**
Surface Casing Depth and Diameter: **14" OD steel set to 100'**
Borehole Diameter: **12.25"**
Geologist Field Rep: **M.C., G.G., L.H.M., M.M., J.P., M.R.,**
Dates Drilling Started and Completed: **1/8/99 to 1/21/99**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Retrofit Westbay well inside 4.5" OD stainless steel. No caliper log or neutron porosity log available.**

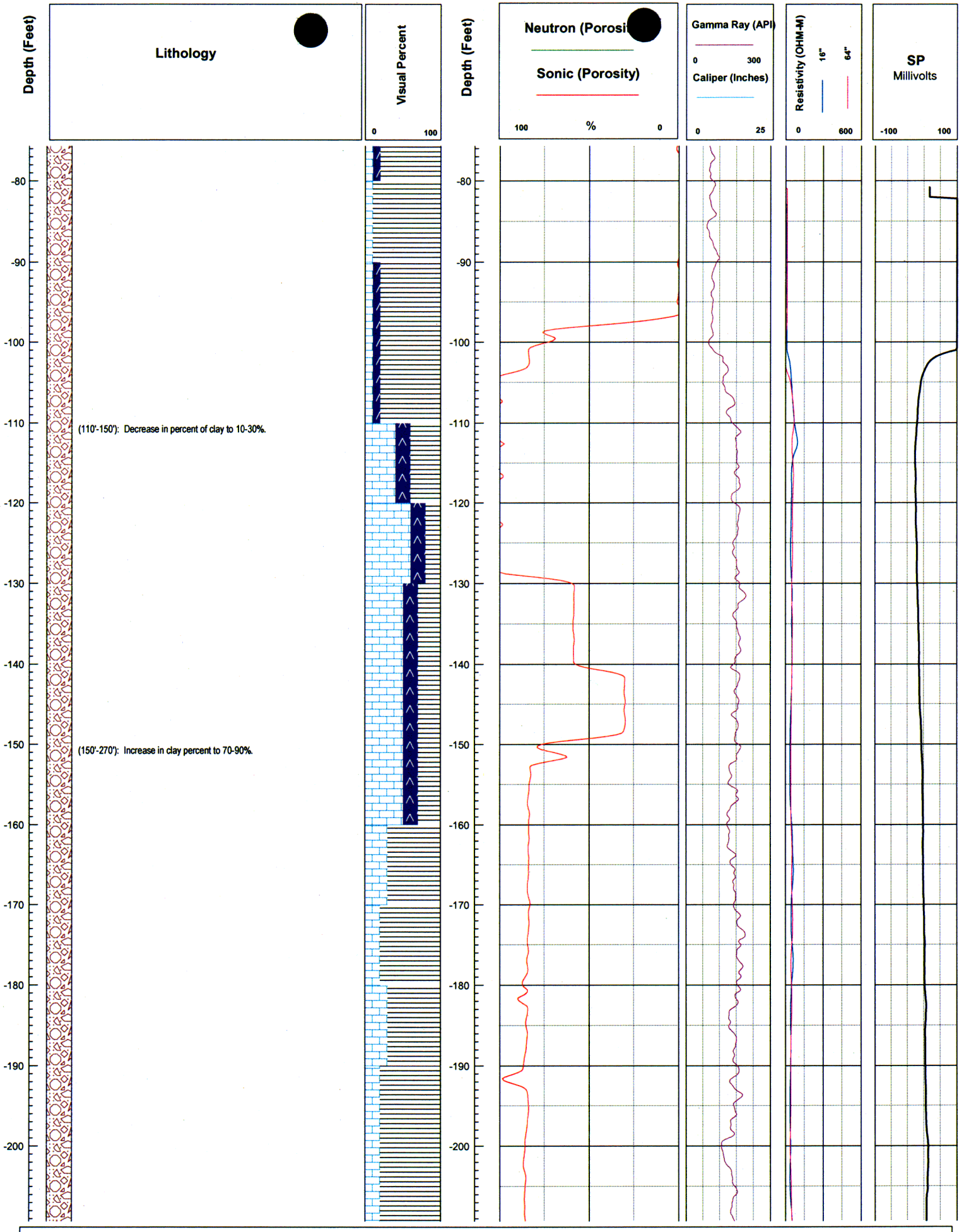
Explanation:

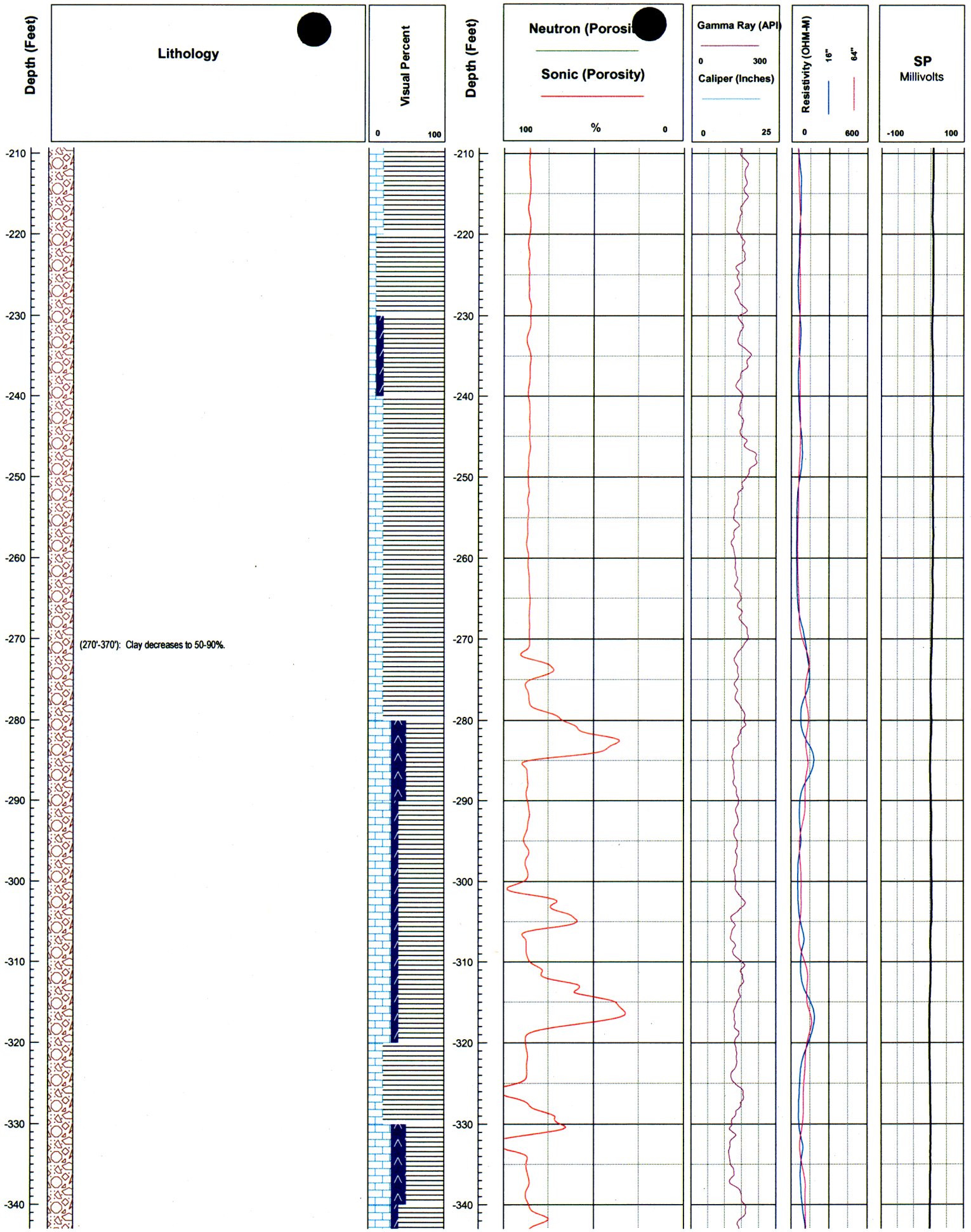




ALLUVIUM Santa Fe Group (0'-540'):

Late Pliocene to Quaternary in age. Alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Caliche horizons, clay lenses and carbonate-cemented zones occur sporadically. The unit is generally light brown (5YR 5/6) to pale reddish brown (10R 5/4), pale red (10R 6/2) or grayish orange (10YR 7/4), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay and silt content are responsible for the predominantly reddish brown color. Sorting is poor to moderate, and the clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Sedimentary clast lithologies are varied and include light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, dolomite, caliche, pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated to non-laminated siltstone, light brown (5YR 5/6) to moderate brown (5YR 4/4), fine to medium-grained sandstone, and colorless to medium gray (N5) chert. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Limestone is generally the predominant clast, followed by volcanic rock fragments (predominantly andesite and rhyolite), siltstone and caliche.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
(110'-150'): Decrease in percent of clay to 10-30%.
(150'-270'): Increase in clay percent to 70-90%.


Depth (Feet)
Lithology
Visual Percent
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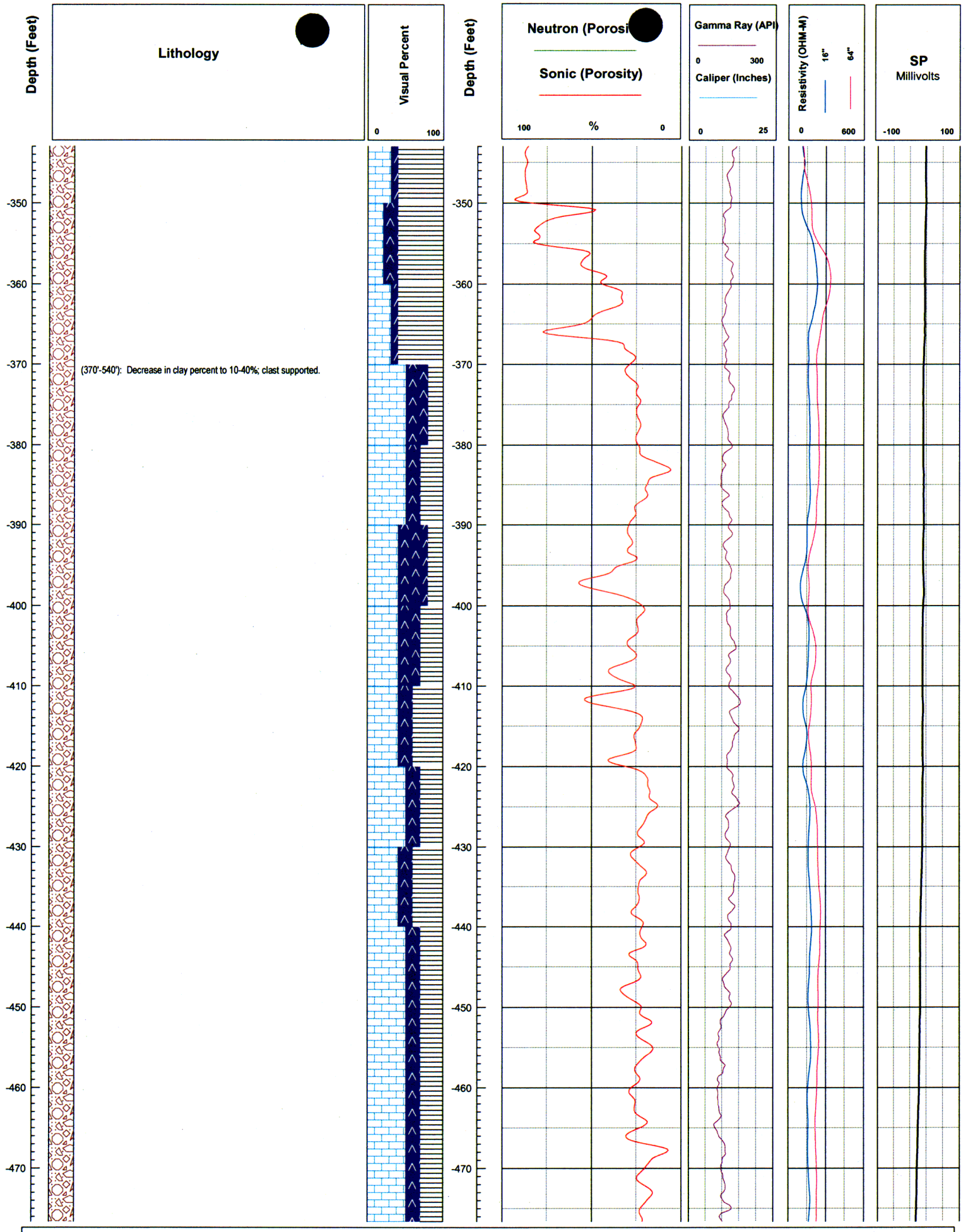
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340
(270'-370'): Clay decreases to 50-90%.


Depth (Feet)
Lithology
Visual Percent
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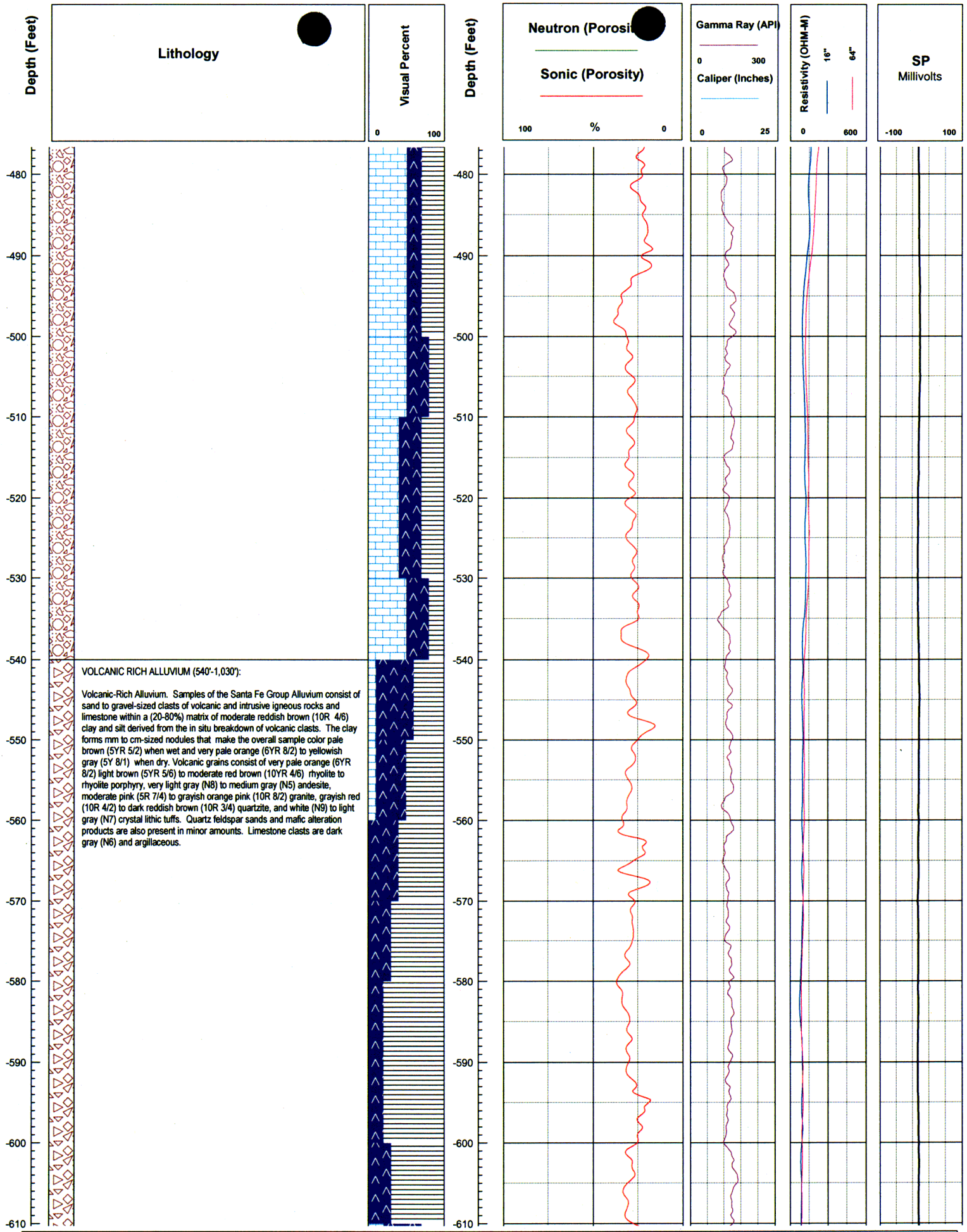
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470
(370'-540'): Decrease in clay percent to 10-40%; clast supported.


Depth (Feet)
Lithology
Visual Percent
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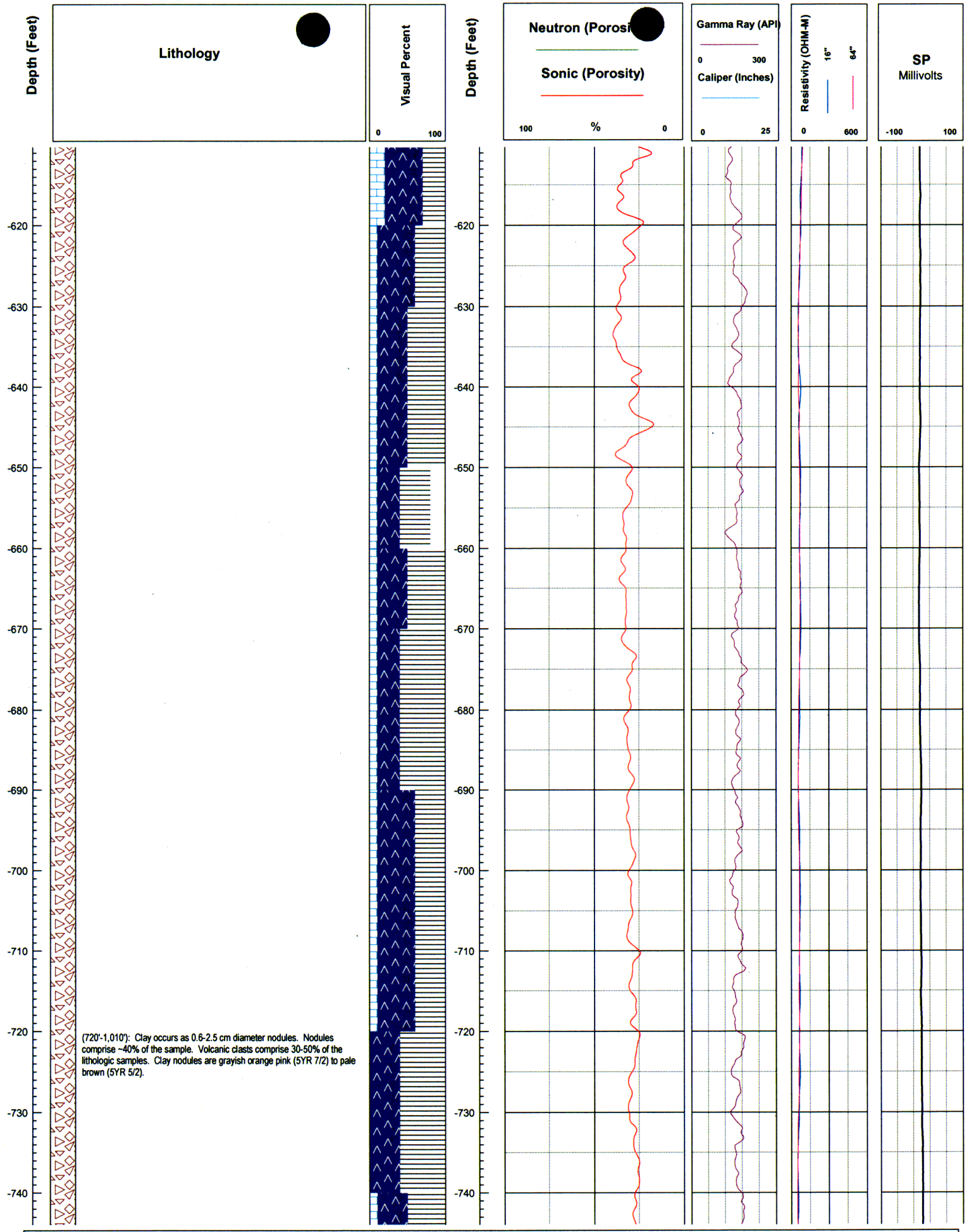
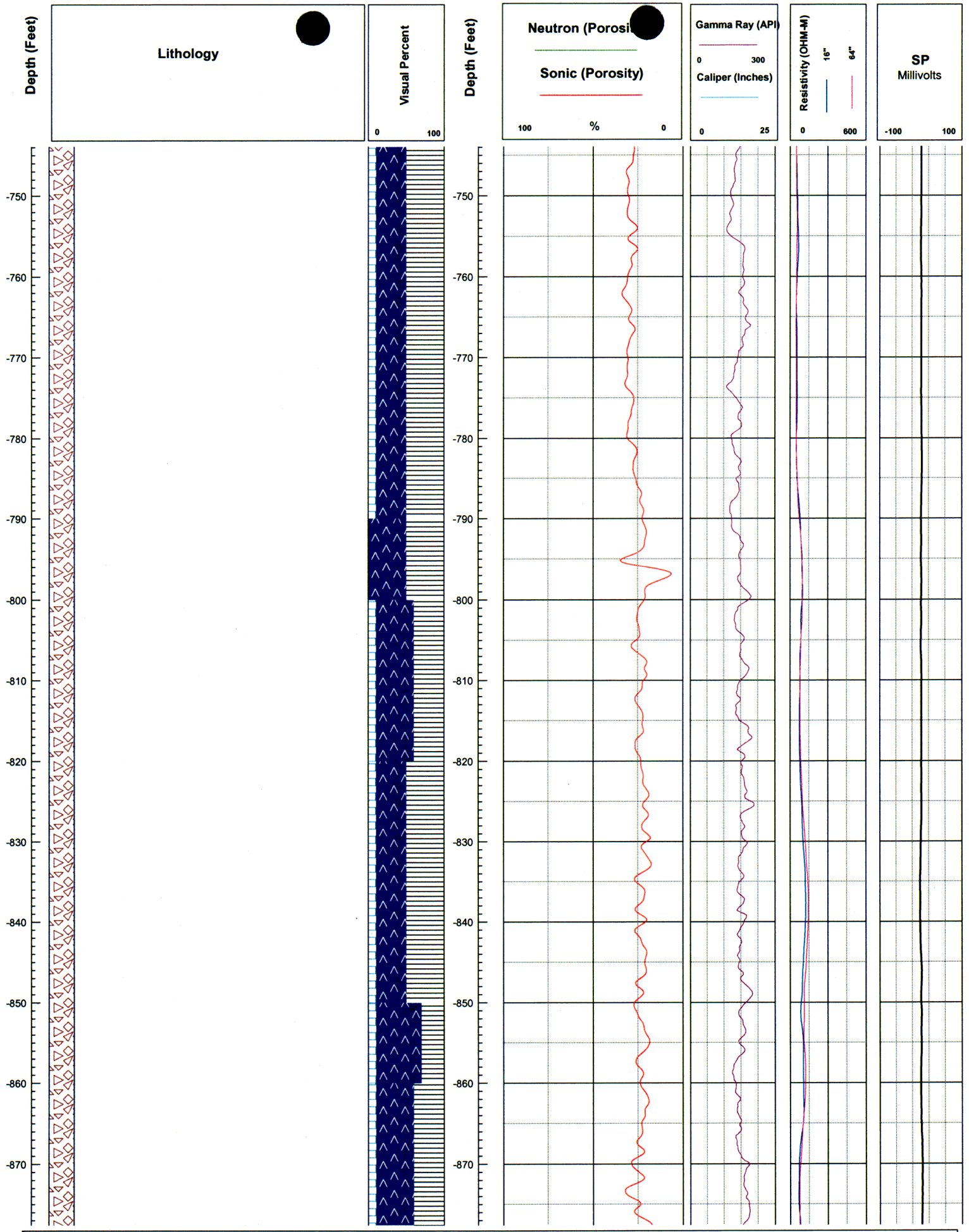
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-480
-490
-500
-510
-520
-530
-540
-550
-560
-570
-580
-590
-600
-610
VOLCANIC RICH ALLUVIUM (540'-1,030'):
Volcanic-Rich Alluvium. Samples of the Santa Fe Group Alluvium consist of sand to gravel-sized clasts of volcanic and intrusive igneous rocks and limestone within a (20-80%) matrix of moderate reddish brown (10R 4/6) clay and silt derived from the in situ breakdown of volcanic clasts. The clay forms mm to cm-sized nodules that make the overall sample color pale brown (5YR 5/2) when wet and very pale orange (6YR 8/2) to yellowish gray (5Y 8/1) when dry. Volcanic grains consist of very pale orange (6YR 8/2) light brown (5YR 5/6) to moderate red brown (10YR 4/6) rhyolite to rhyolite porphyry, very light gray (N8) to medium gray (N5) andesite, moderate pink (5R 7/4) to grayish orange pink (10R 8/2) granite, grayish red (10R 4/2) to dark reddish brown (10R 3/4) quartzite, and white (N9) to light gray (N7) crystal lithic tuffs. Quartz feldspar sands and mafic alteration products are also present in minor amounts. Limestone clasts are dark gray (N6) and argillaceous.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-620
-630
-640
-650
-660
-670
-680
-690
-700
-710
-720
-730
-740
(720'-1,010'): Clay occurs as 0.6-2.5 cm diameter nodules. Nodules comprise ~40% of the sample. Volcanic clasts comprise 30-50% of the lithologic samples. Clay nodules are grayish orange pink (5YR 7/2) to pale brown (5YR 5/2).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Lithology
Visual Percent
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Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
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%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
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-770
-780
-790
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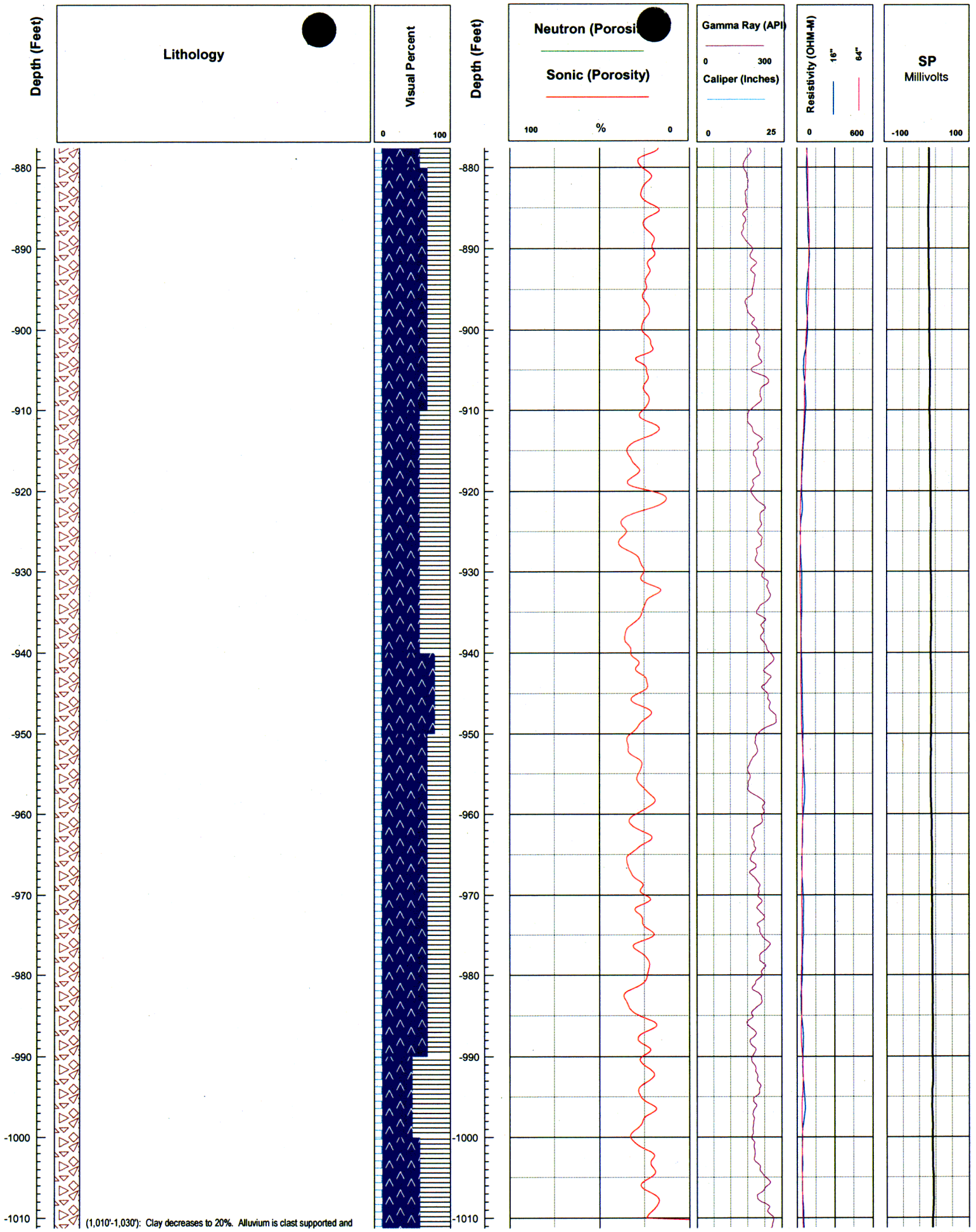
-850
-860
-870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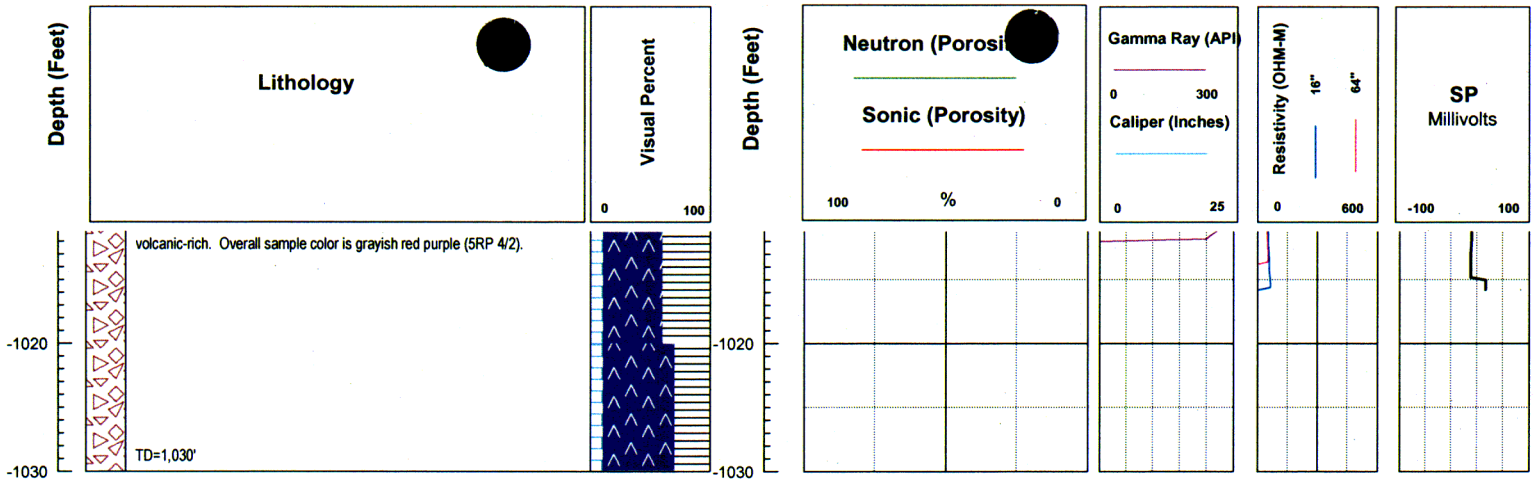
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-880
-890
-900
-910
-920
-930
-940
-950
-960
-970
-980
-990
-1000
-1010
(1,010'-1,030'): Clay decreases to 20%. Alluvium is clast supported and


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
volcanic-rich. Overall sample color is grayish red purple (5RP 4/2).
-1020
-1030
TD=1,030'
-1020
-1030

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

BOREHOLE LITHOLOGIC LOG

Location ID: **WW-3**

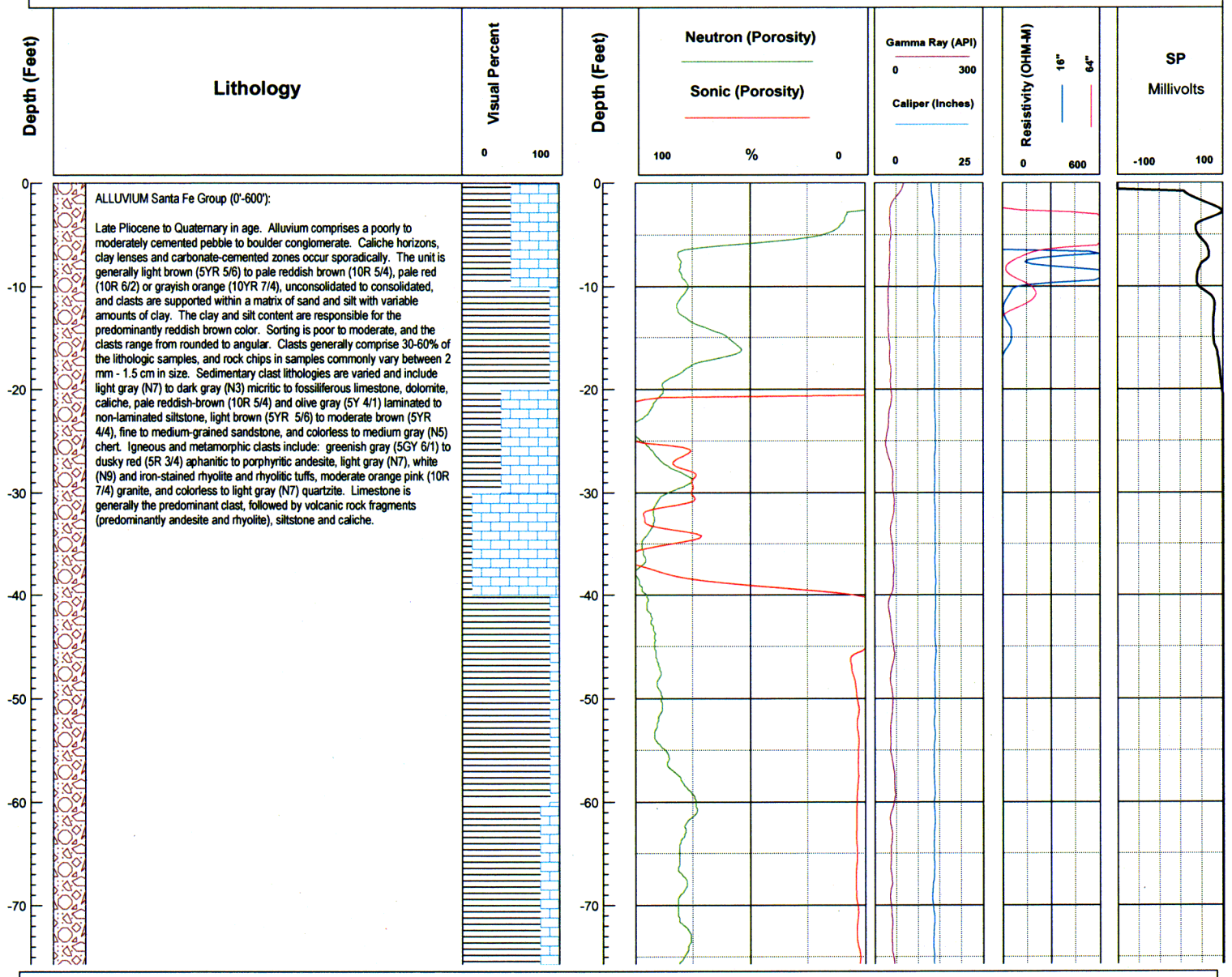
Site ID: **NASA-WSTF, Doña Ana County, NM**

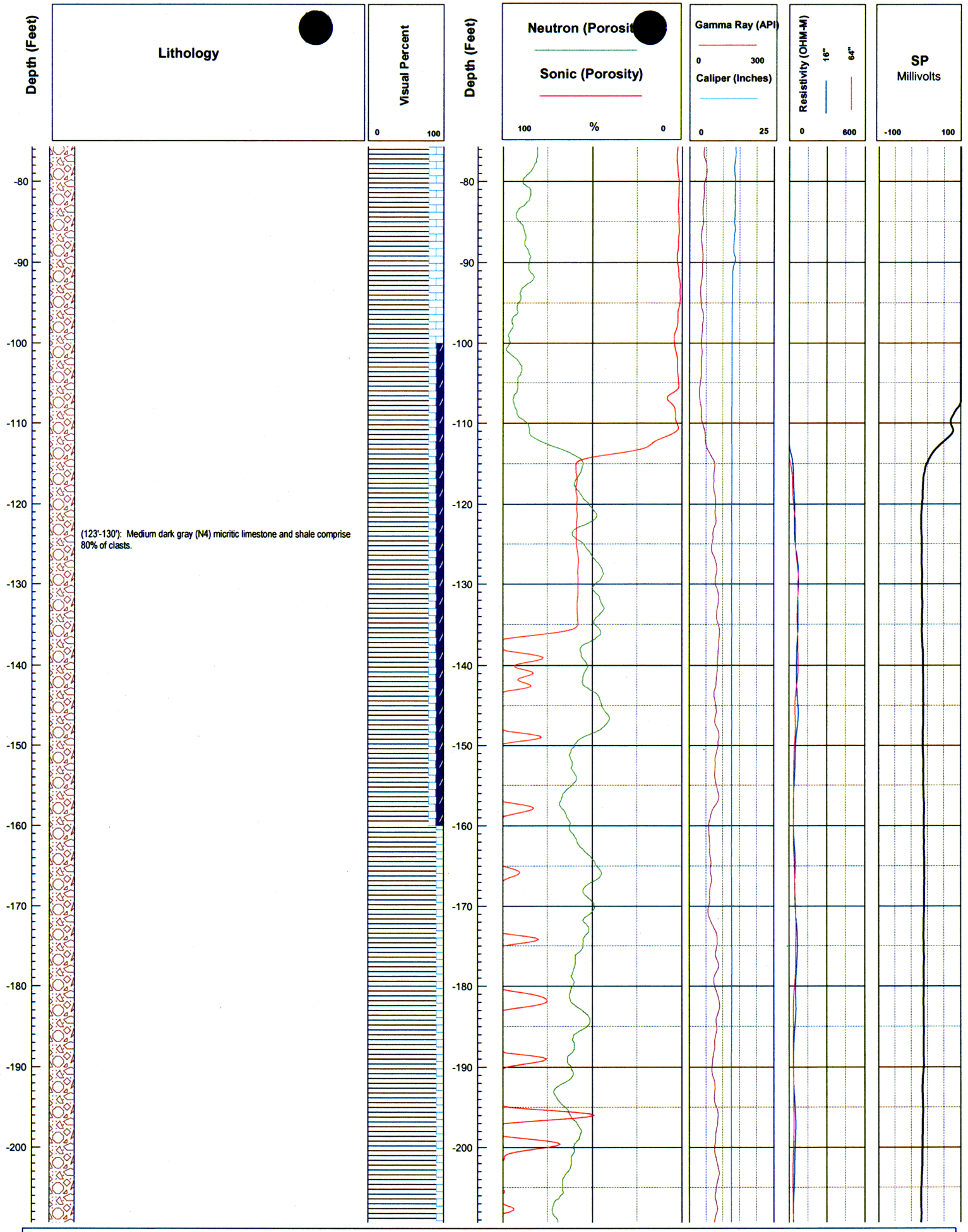
Township and Range: **NE 1/4, SE 1/4, SE 1/4, Sec 31, T20S R3E**
NM State Plane Coordinates (NAD 83): **3599199.33N 343472.89E (Preliminary)**
Elevation (Brass Cap): **4446.18' (Preliminary)**
Total Depth of Borehole (bgs): **1,025'**
Depth to Bedrock (bgs): **N/A**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Davis Gaddy**

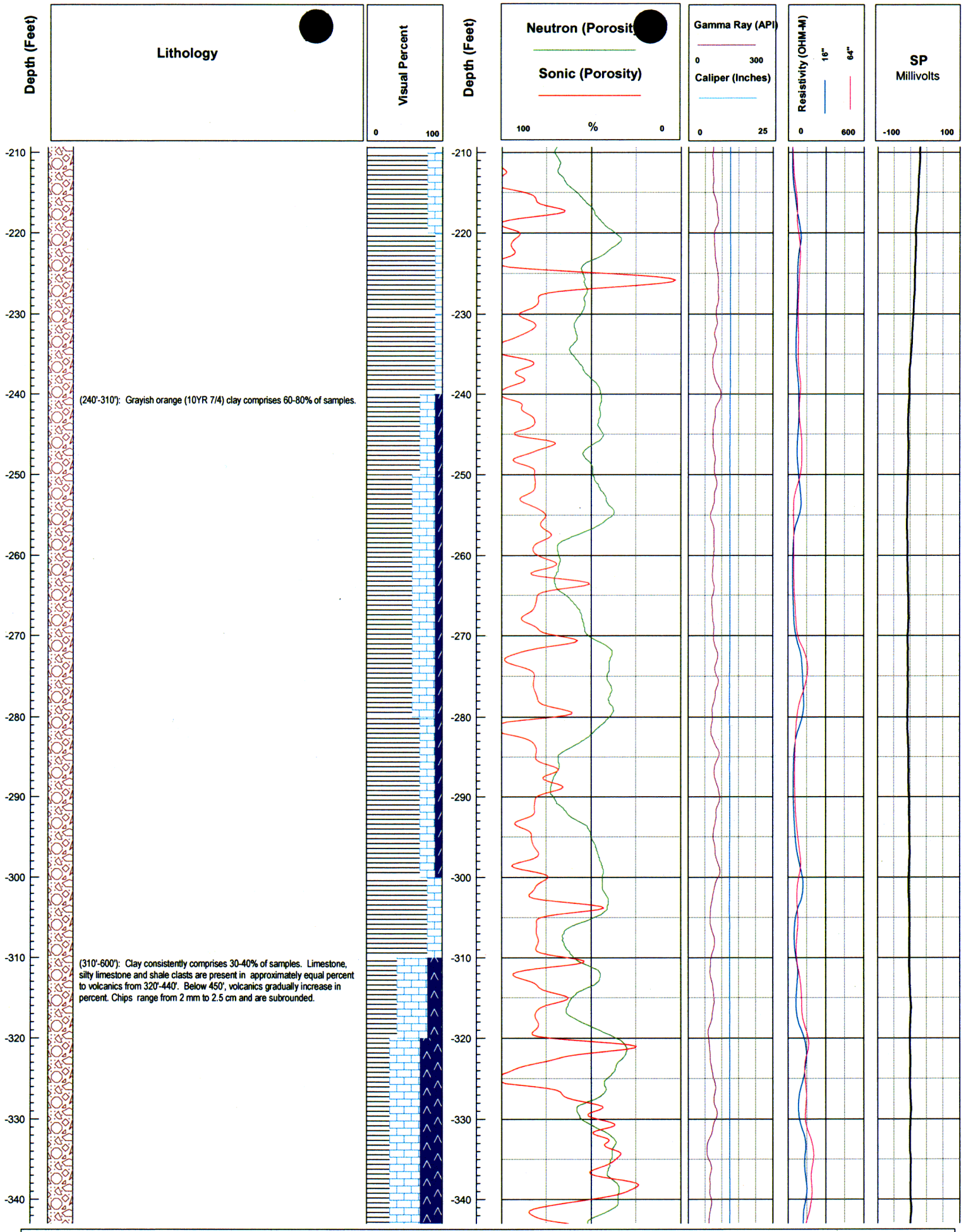
Depth to Groundwater (bgs): **386'**
Surface Casing Depth and Diameter: **14" OD Steel set to 112'**
Borehole Diameter: **12.25"**
Geologist Field Rep: **M.C., G.G., L.H.M., J.P., M.S., R.W.**
Dates Drilling Started and Completed: **2/14/01 to 3/3/01**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Westbay MP 55 Retrofit in 4.75" Schedule 80 PVC.**

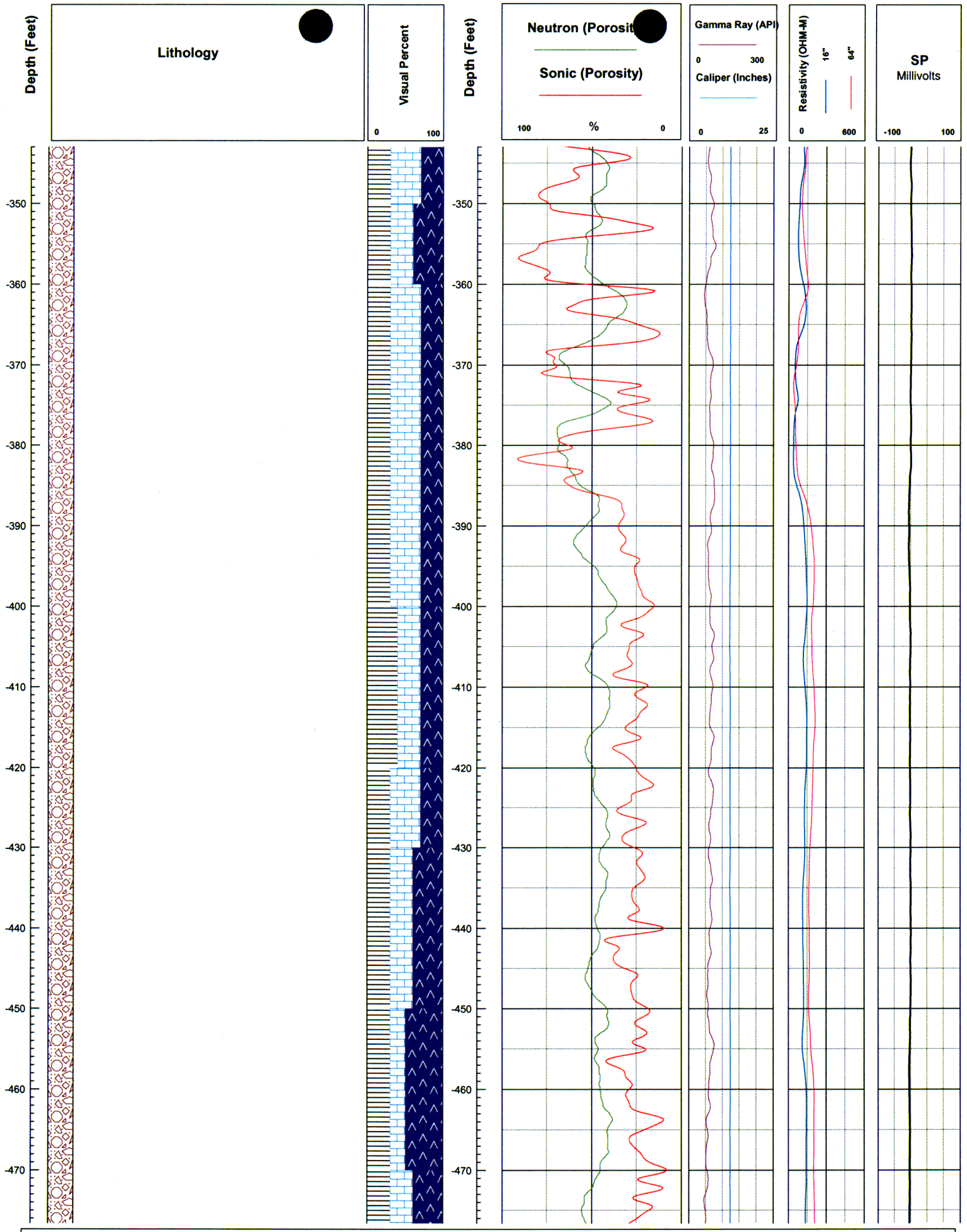
Explanation:

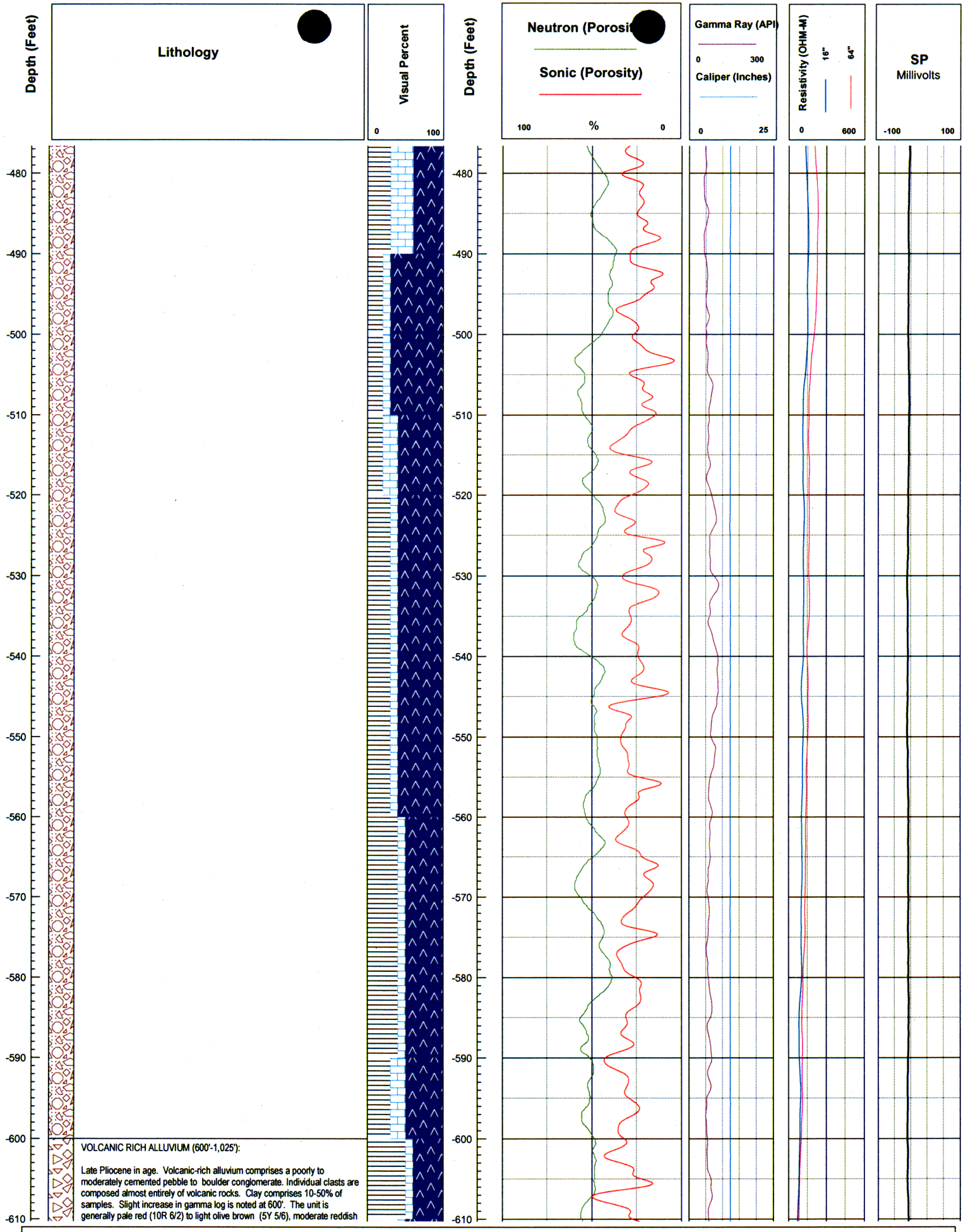
Alluvium | Volcanic Alluvium | Clay | Silt | Sand | Sandstone | Siltstone | Shale | Limestone | Rhyolite | Andesite | Undiffer. Volcanics

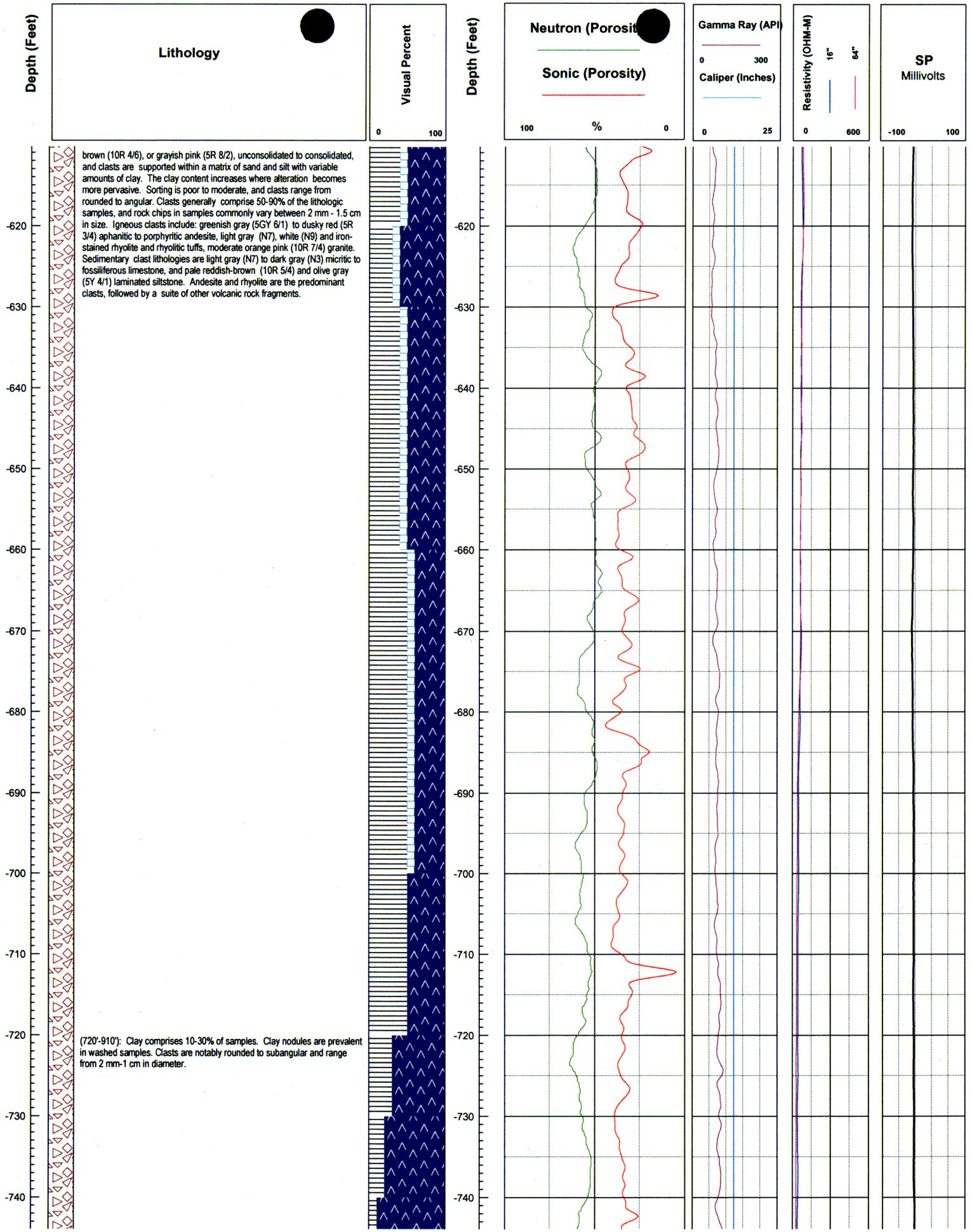


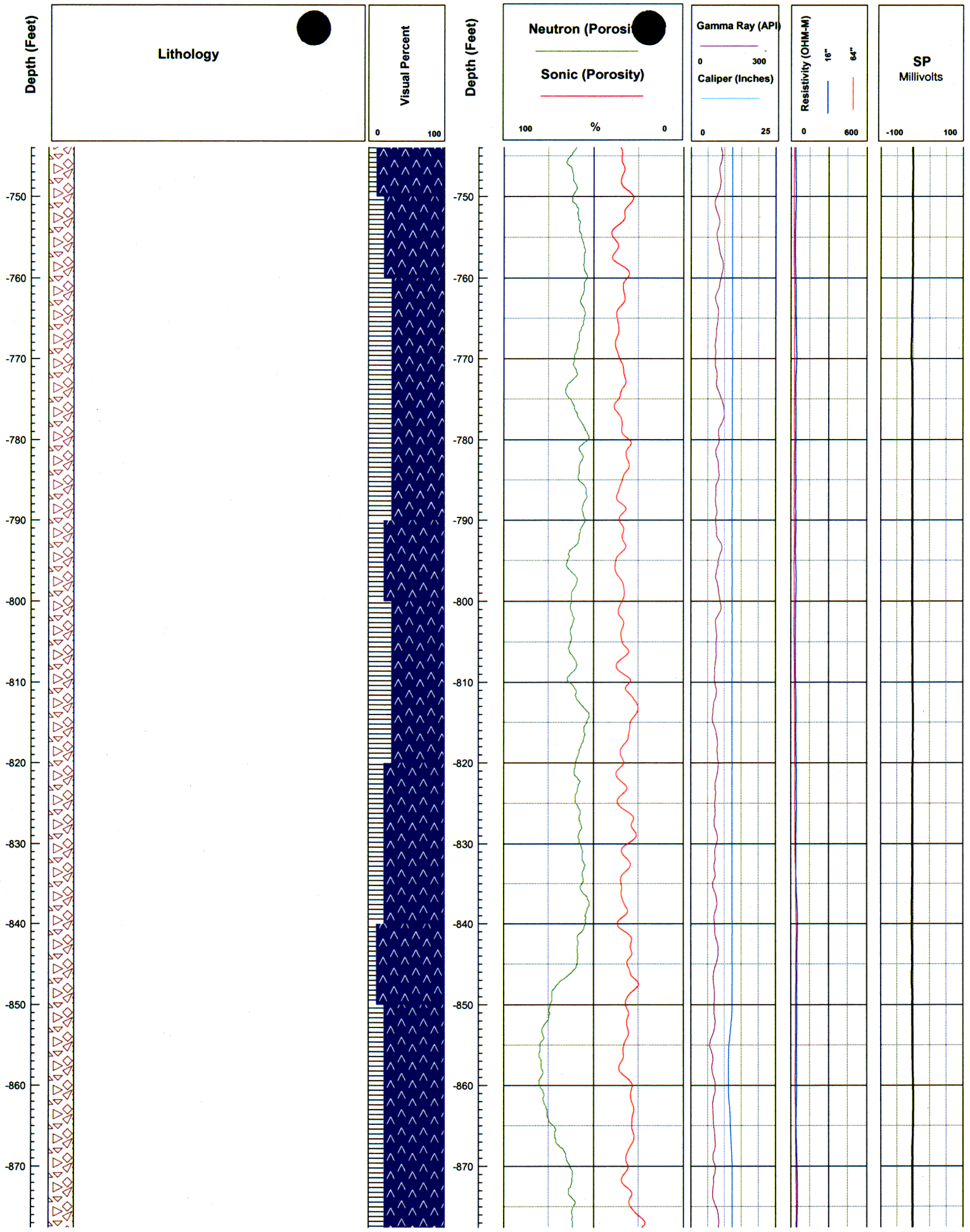

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
(123'-130'): Medium dark gray (N4) micritic limestone and shale comprise 80% of clasts.

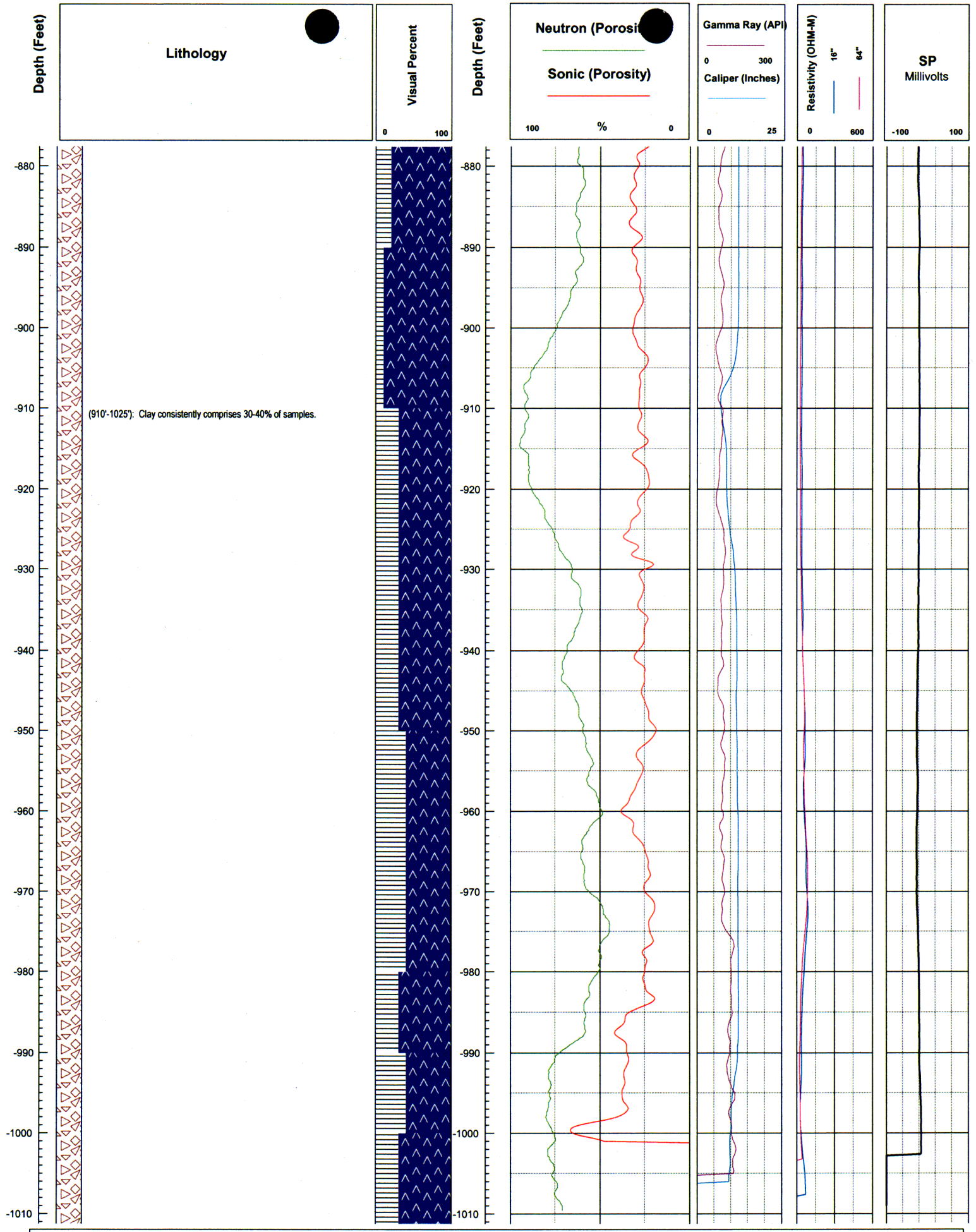

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340
(240'-310'): Grayish orange (10YR 7/4) clay comprises 60-80% of samples.
(310'-600'): Clay consistently comprises 30-40% of samples. Limestone, silty limestone and shale clasts are present in approximately equal percent to volcanics from 320'-440'. Below 450', volcanics gradually increase in percent. Chips range from 2 mm to 2.5 cm and are subrounded.

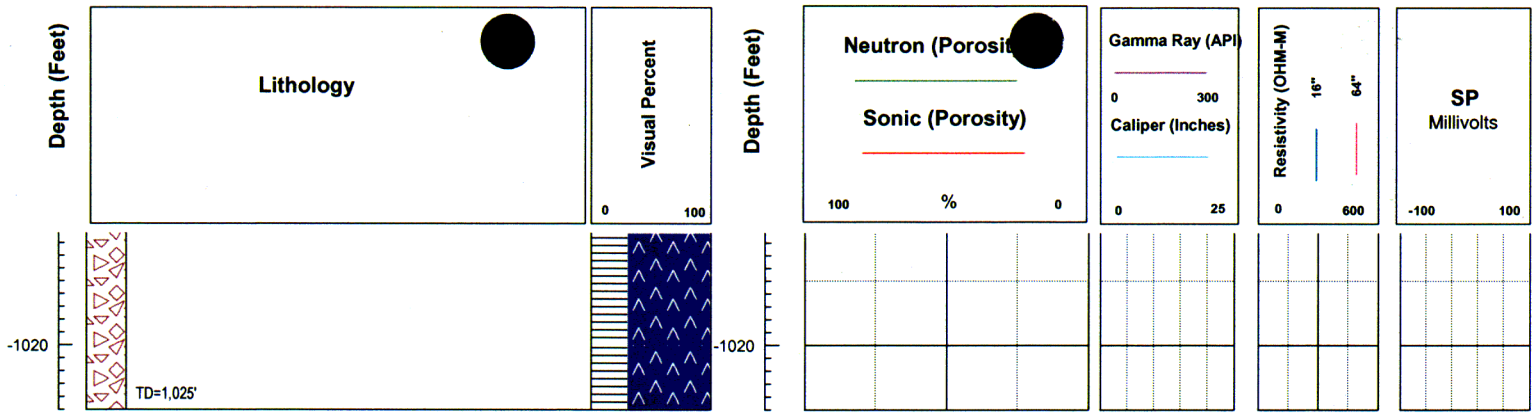

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-480
-490
-500
-510
-520
-530
-540
-550
-560
-570
-580
-590
-600
-610
VOLCANIC RICH ALLUVIUM (600'-1,025'):
Late Pliocene in age. Volcanic-rich alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Individual clasts are composed almost entirely of volcanic rocks. Clay comprises 10-50% of samples. Slight increase in gamma log is noted at 600'. The unit is generally pale red (10R 6/2) to light olive brown (5Y 5/6), moderate reddish


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-620
-630
-640
-650
-660
-670
-680
-690
-700
-710
-720
-730
-740
brown (10R 4/6), or grayish pink (5R 8/2), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay content increases where alteration becomes more pervasive. Sorting is poor to moderate, and clasts range from rounded to angular. Clasts generally comprise 50-90% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Igneous clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite. Sedimentary clast lithologies are light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, and pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated siltstone. Andesite and rhyolite are the predominant clasts, followed by a suite of other volcanic rock fragments.
(720'-910'): Clay comprises 10-30% of samples. Clay nodules are prevalent in washed samples. Clasts are notably rounded to subangular and range from 2 mm-1 cm in diameter.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosi
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-750
-760
-770
-780
-790
-800
-810
-820
-830
-840
-850
-860
-870


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-880
-890
-900
-910
-920
-930
-940
-950
-960
-970
-980
-990
-1000
-1010
(910'-1025'): Clay consistently comprises 30-40% of samples.


Depth (Feet)
Lithology
Visual Percent
0
100
-1020
TD=1,025'
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-1020

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

BOREHOLE LITHOLOGIC LOG

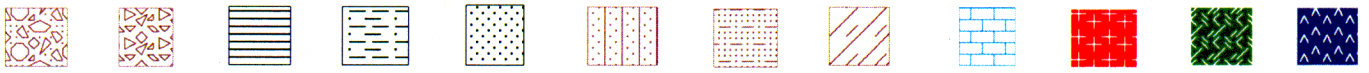
Location ID: **WW-4**

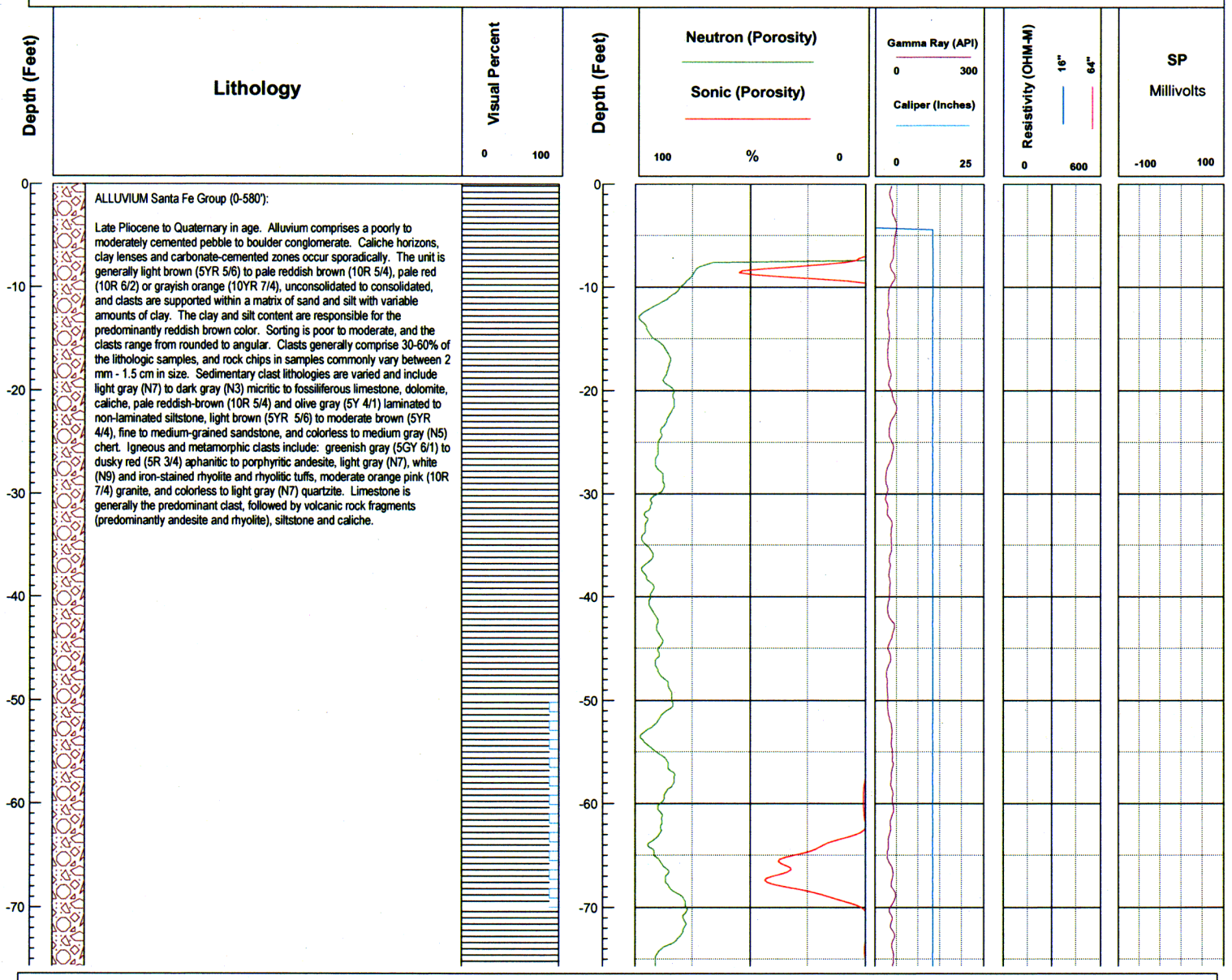
Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **NE 1/4, NE 1/4, SE 1/4, Sec 31, T20S R3E**
NM State Plane Coordinates (NAD 83): **3599575.12N 343532.31E (Preliminary)**
Elevation (Brass Cap): **4444.47' (Preliminary)**
Total Depth of Borehole (bgs): **1,020'**
Depth to Bedrock (bgs): **N/A**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Davis Gaddy**

Depth to Groundwater (bgs): **382'**
Surface Casing Depth and Diameter: **14" OD Steel set to 117'**
Borehole Diameter: **12.25"**
Geologist Field Rep: **M.C., G.G., L.H.M., J.P., M.S., R.W.**
Dates Drilling Started and Completed: **3/14/01 to 3/21/01**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Westbay MP 55 Retrofit in 4.75" ID Sched. 80 PVC casing.**

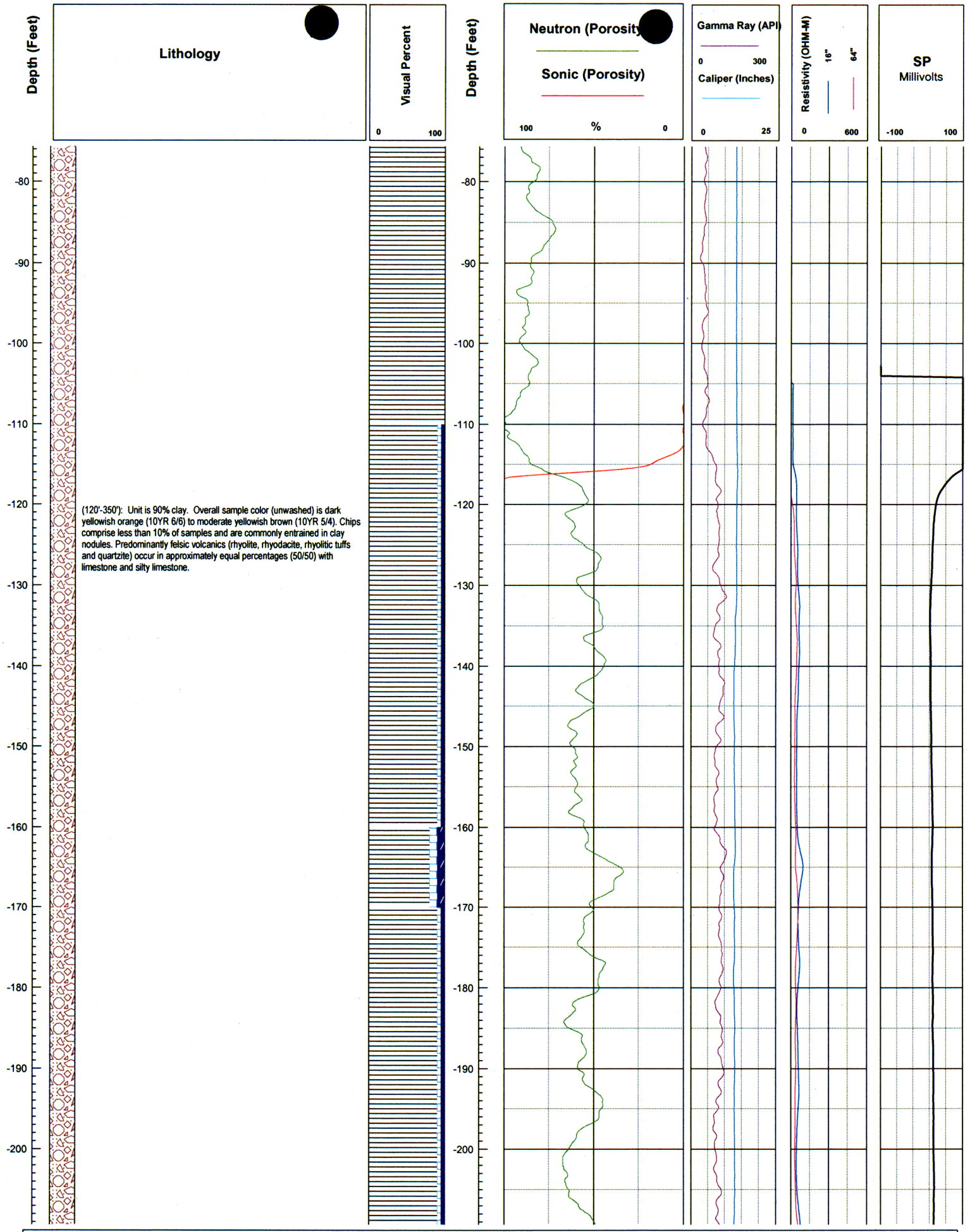
Explanation:

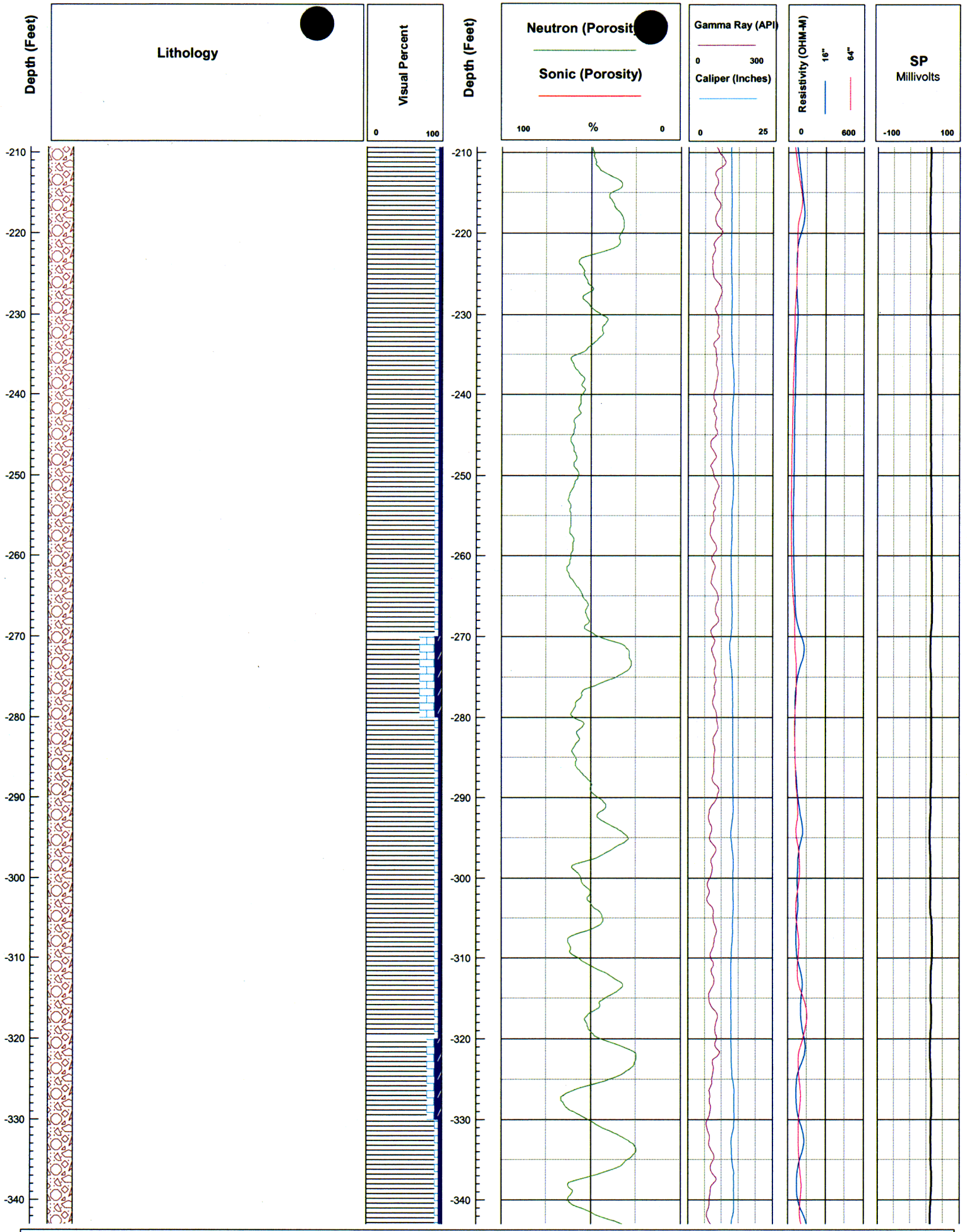


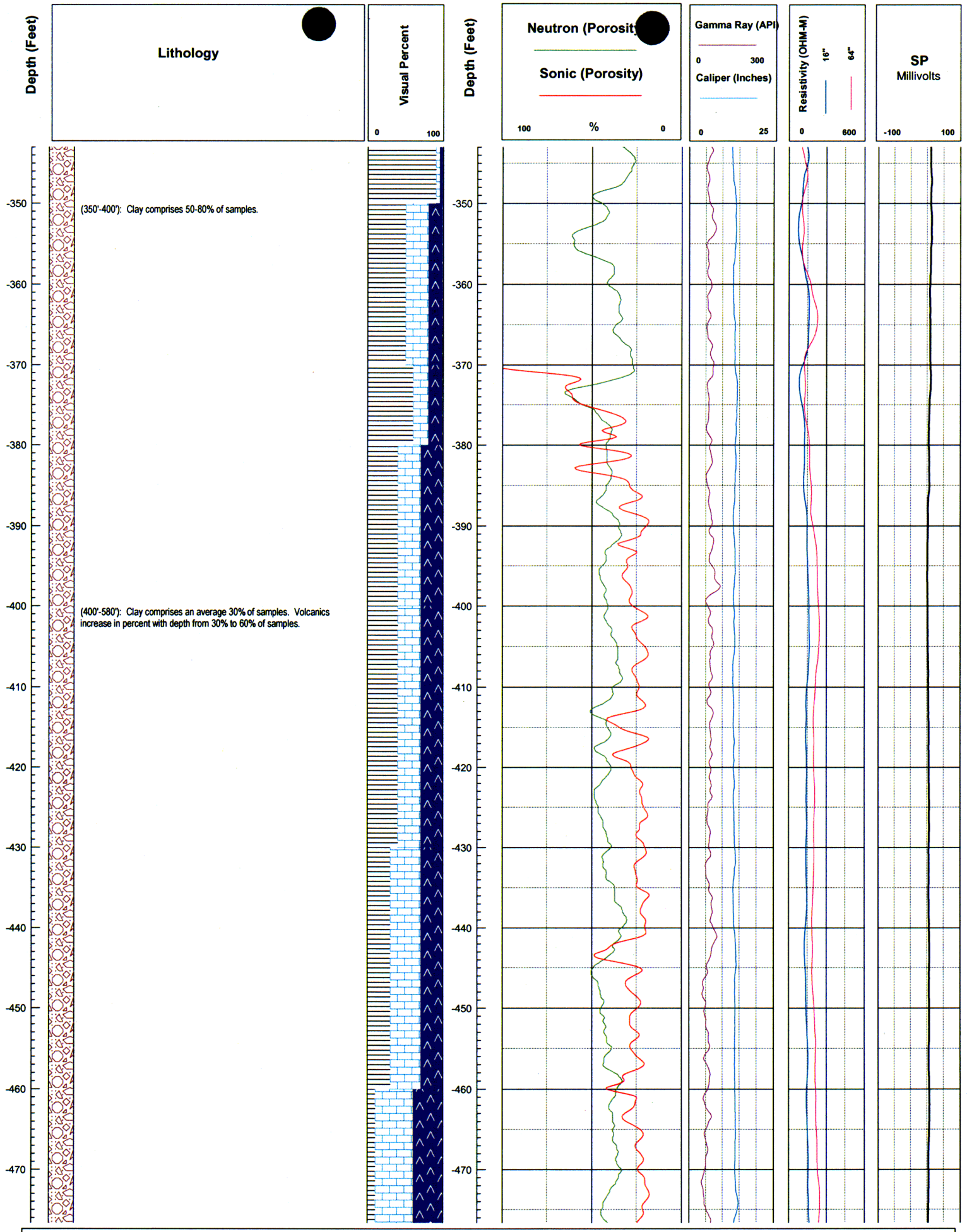


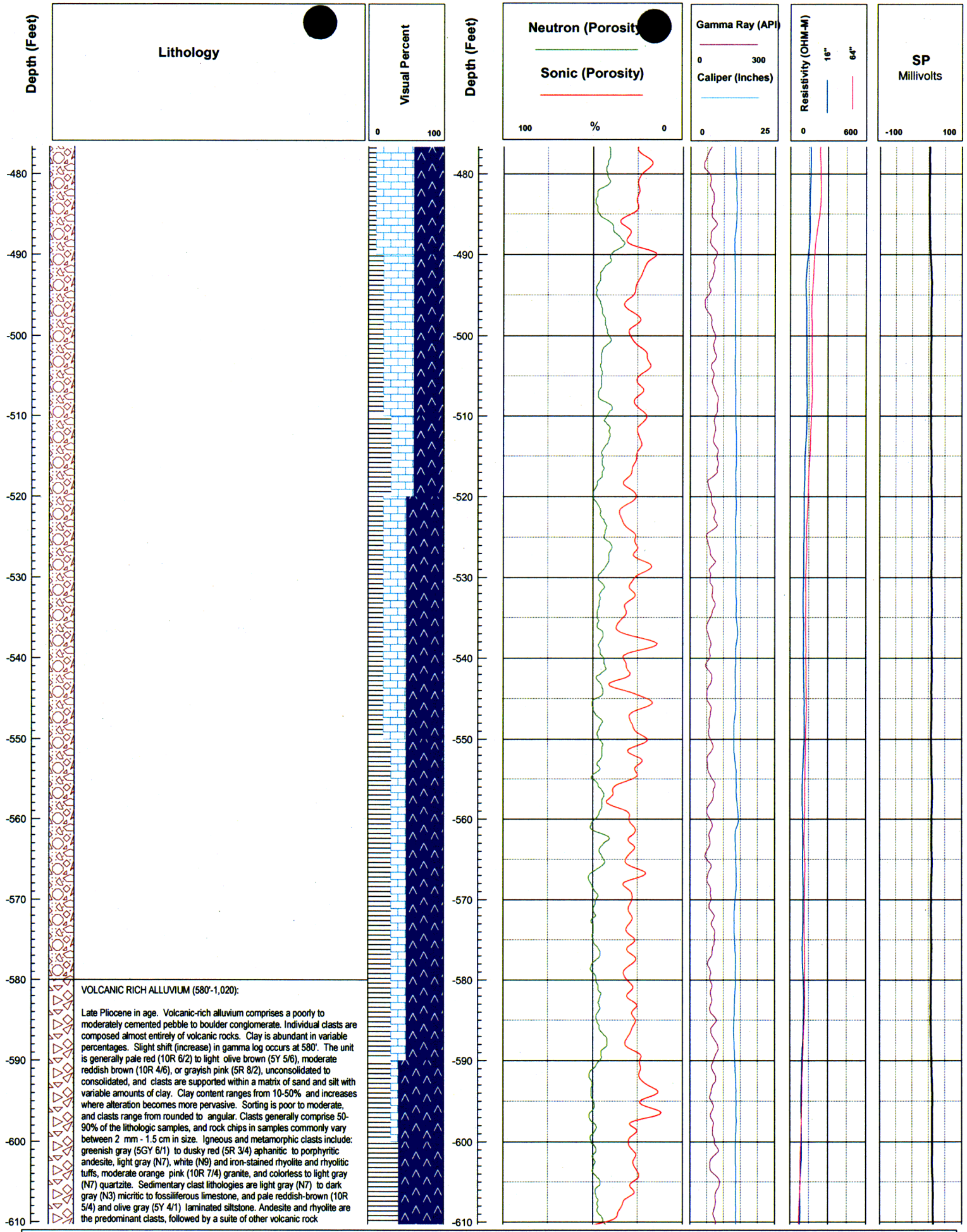
ALLUVIUM Santa Fe Group (0-580'):

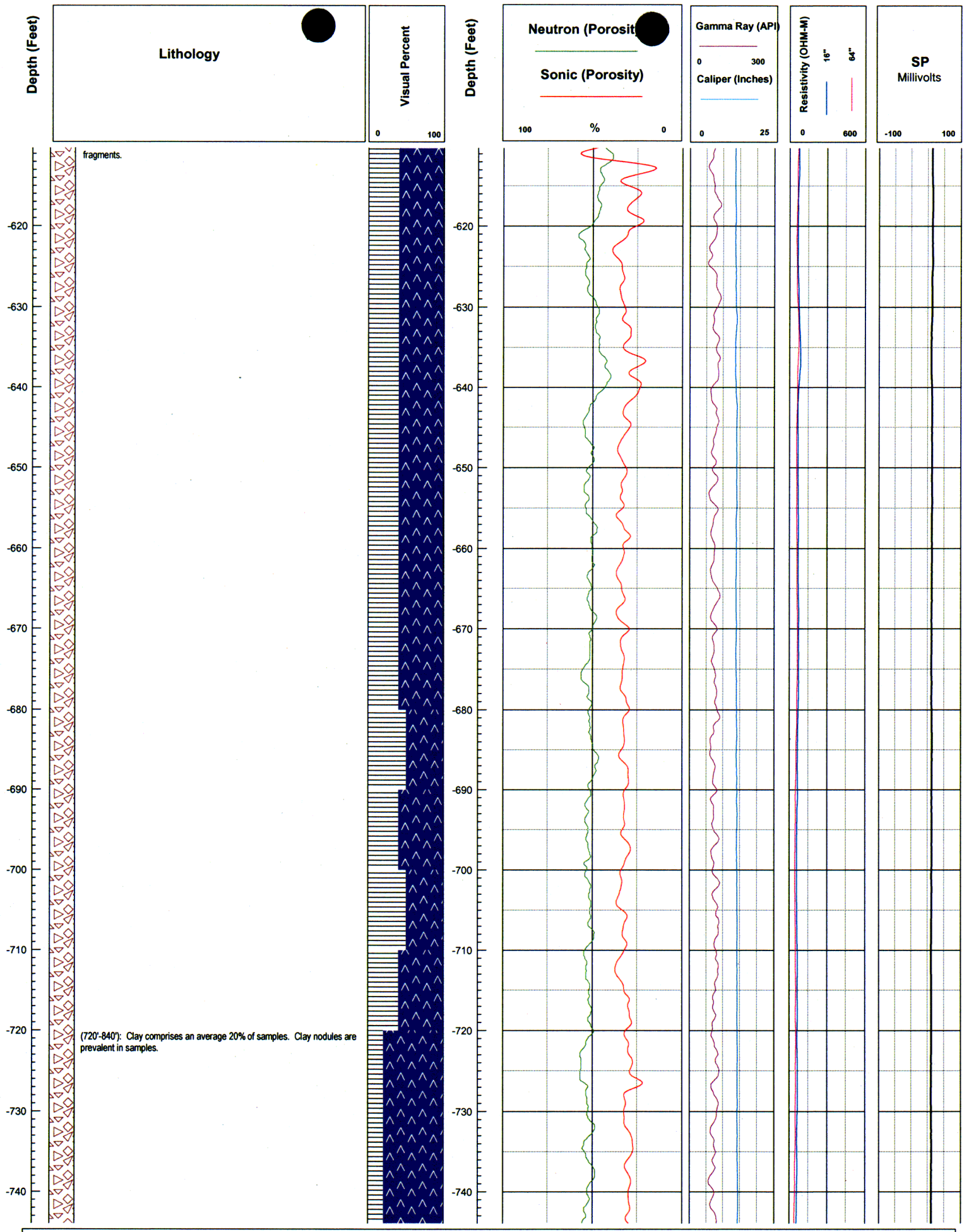
Late Pliocene to Quaternary in age. Alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Caliche horizons, clay lenses and carbonate-cemented zones occur sporadically. The unit is generally light brown (5YR 5/6) to pale reddish brown (10R 5/4), pale red (10R 6/2) or grayish orange (10YR 7/4), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay and silt content are responsible for the predominantly reddish brown color. Sorting is poor to moderate, and the clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Sedimentary clast lithologies are varied and include light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, dolomite, caliche, pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated to non-laminated siltstone, light brown (5YR 5/6) to moderate brown (5YR 4/4), fine to medium-grained sandstone, and colorless to medium gray (N5) chert. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Limestone is generally the predominant clast, followed by volcanic rock fragments (predominantly andesite and rhyolite), siltstone and caliche.

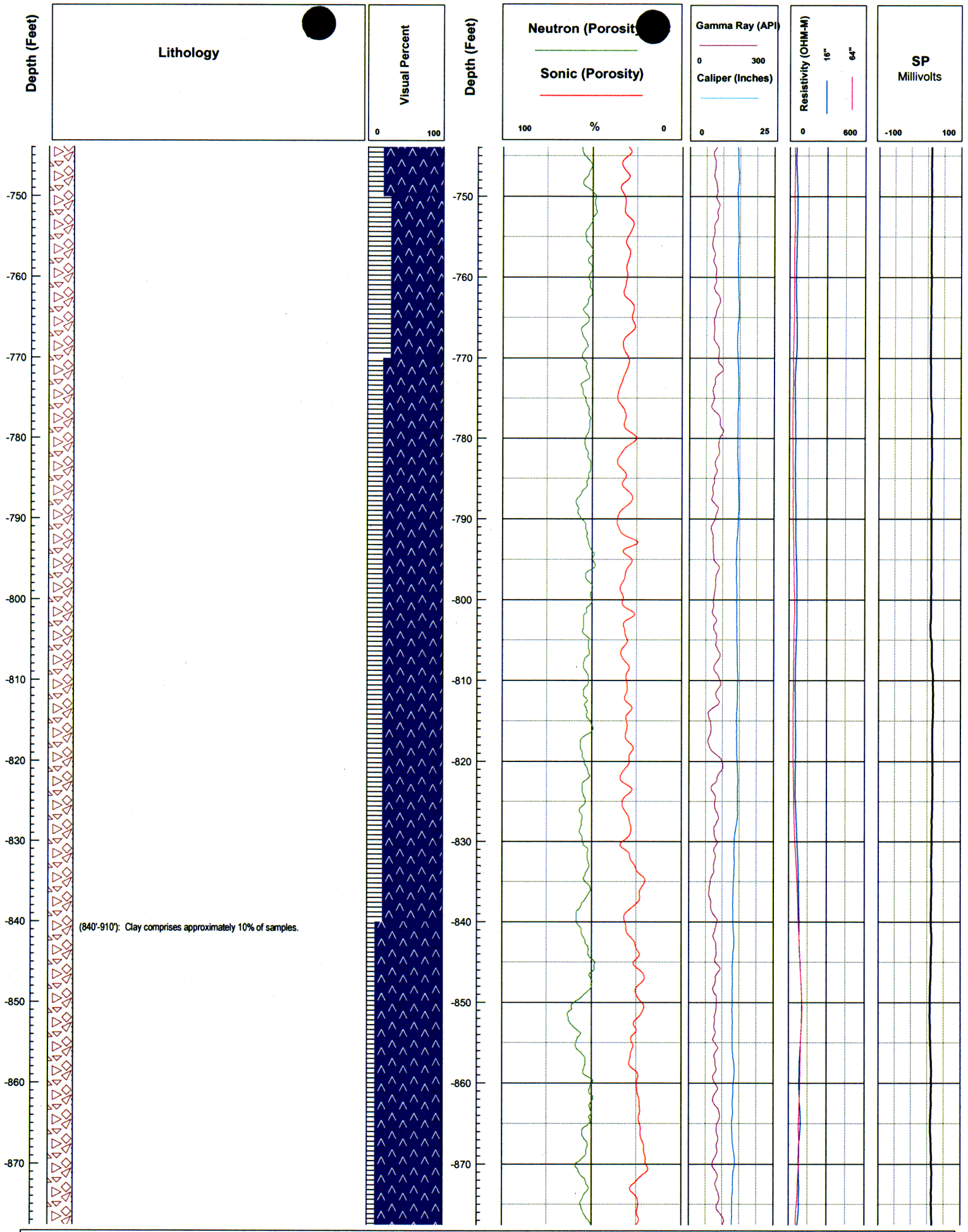

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
(120'-350'): Unit is 90% clay. Overall sample color (unwashed) is dark yellowish orange (10YR 6/6) to moderate yellowish brown (10YR 5/4). Chips comprise less than 10% of samples and are commonly entrained in clay nodules. Predominantly felsic volcanics (rhyolite, rhyodacite, rhyolitic tuffs and quartzite) occur in approximately equal percentages (50/50) with limestone and silty limestone.

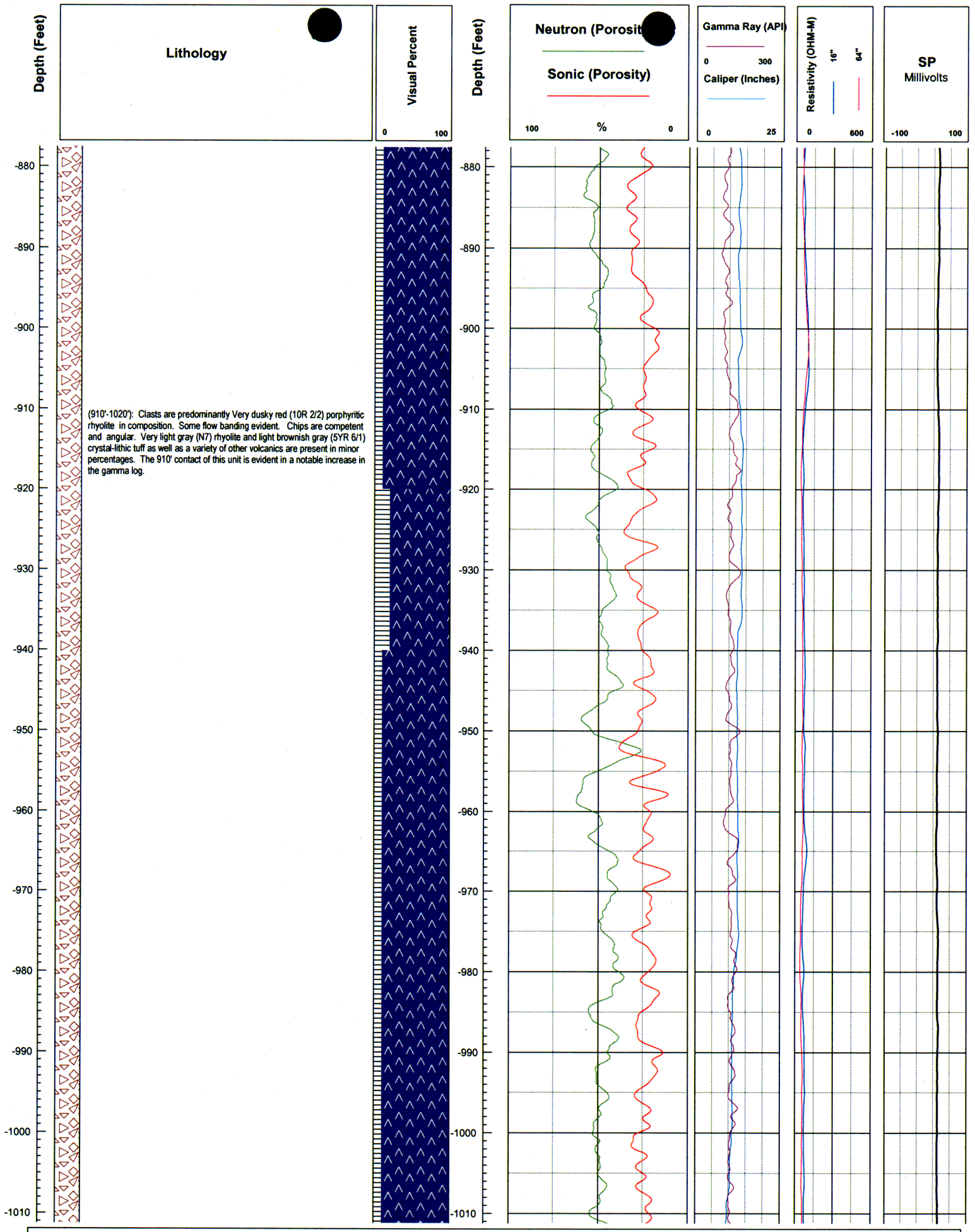

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340

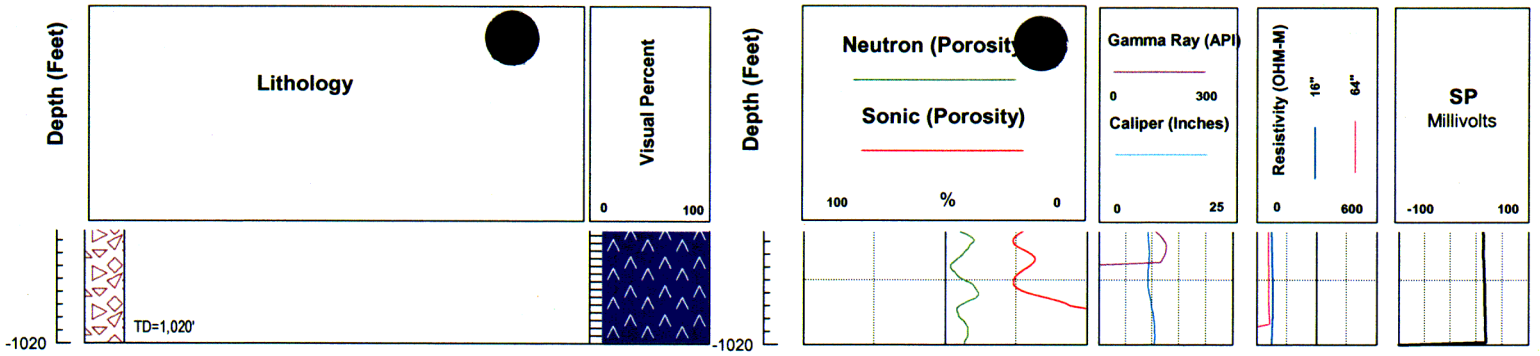

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470
(350'-400'): Clay comprises 50-80% of samples.
(400'-580'): Clay comprises an average 30% of samples. Volcanics increase in percent with depth from 30% to 60% of samples.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-480
-490
-500
-510
-520
-530
-540
-550
-560
-570
-580
-590
-600
-610
VOLCANIC RICH ALLUVIUM (580'-1,020):
Late Pliocene in age. Volcanic-rich alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Individual clasts are composed almost entirely of volcanic rocks. Clay is abundant in variable percentages. Slight shift (increase) in gamma log occurs at 580'. The unit is generally pale red (10R 6/2) to light olive brown (5Y 5/6), moderate reddish brown (10R 4/6), or grayish pink (5R 8/2), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. Clay content ranges from 10-50% and increases where alteration becomes more pervasive. Sorting is poor to moderate, and clasts range from rounded to angular. Clasts generally comprise 50-90% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Sedimentary clast lithologies are light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, and pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated siltstone. Andesite and rhyolite are the predominant clasts, followed by a suite of other volcanic rock


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
fragments.
(720'-840'): Clay comprises an average 20% of samples. Clay nodules are prevalent in samples.
-620
-630
-640
-650
-660
-670
-680
-690
-700
-710
-720
-730
-740


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-750
-760
-770
-780
-790
-800
-810
-820
-830
-840
-850
-860
-870
(840'-910'): Clay comprises approximately 10% of samples.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-880
-890
-900
-910
-920
-930
-940
-950
-960
-970
-980
-990
-1000
-1010
(910'-1020'): Clasts are predominantly Very dusky red (10R 2/2) porphyritic rhyolite in composition. Some flow banding evident. Chips are competent and angular. Very light gray (N7) rhyolite and light brownish gray (5YR 6/1) crystal-lithic tuff as well as a variety of other volcanics are present in minor percentages. The 910' contact of this unit is evident in a notable increase in the gamma log.


Depth (Feet)
Lithology
Visual Percent
0
100
TD=1,020'
-1020
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-1020

BOREHOLE LITHOLOGIC LOG

JSC - White Sands Test Facility
Las Cruces, New Mexico, USA

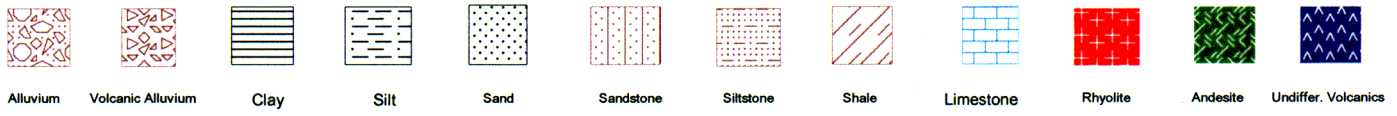
Location ID: **WW-5**

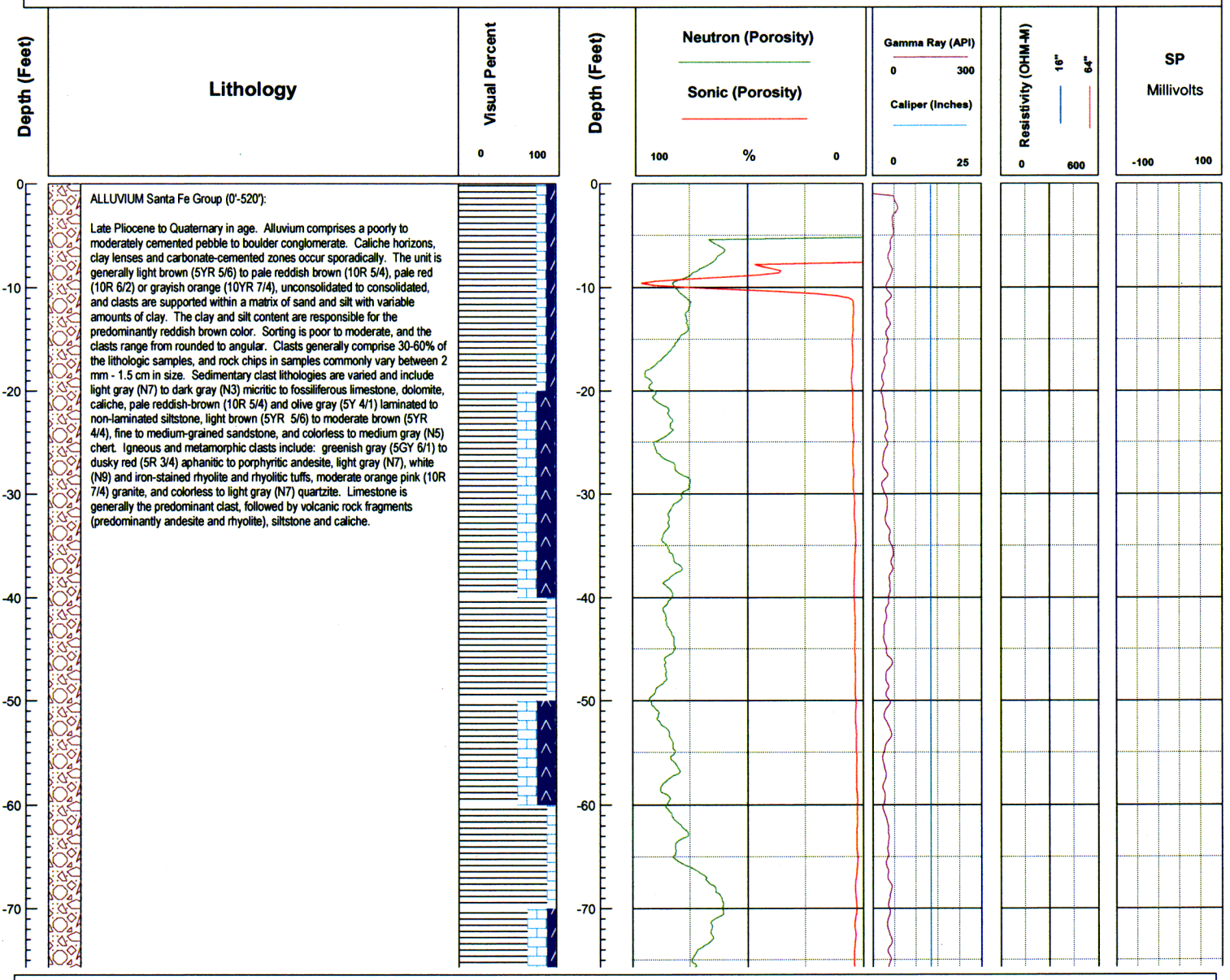
Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **NE 1/4, NE 1/4, NE 1/4, Sec 31, T20S, R3E**
NM State Plane Coordinates (NAD 83): **3600280.19N 343548.69E (Preliminary)**
Elevation (Brass Cap): **4440.06' (Preliminary)**
Total Depth of Borehole (bgs): **1,020'**
Depth to Bedrock (bgs): **N/A**
Drilling Method: **Mud Rotary**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Gabriel Cardenas**

Depth to Groundwater (bgs): **379.02'**
Surface Casing Depth and Diameter: **14" OD Steel set to 111'**
Borehole Diameter: **12.25"**
Geologist Field Rep: **M.C., G.G., L.H.M., J.P., M.S., R.W.**
Dates Drilling Started and Completed: **9/5/01 to 9/18/01**
Geophysical Contractor: **Southwest Geophysical Services, Inc.**
Logger: **Mick Peterson**
Comments: **Westbay MP 55 Retrofit in 4.75" ID Sched. 80 PVC casing.**

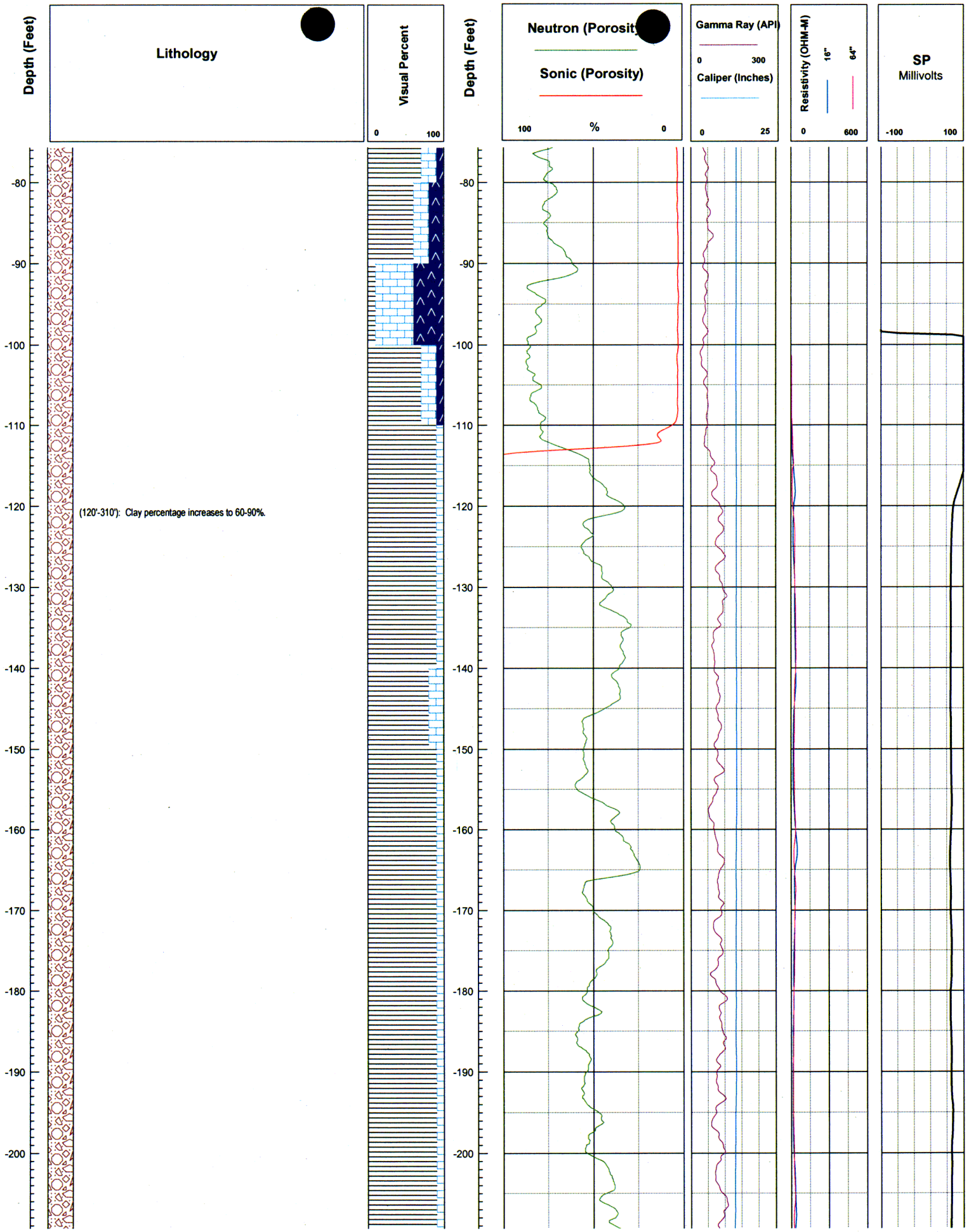
Explanation:

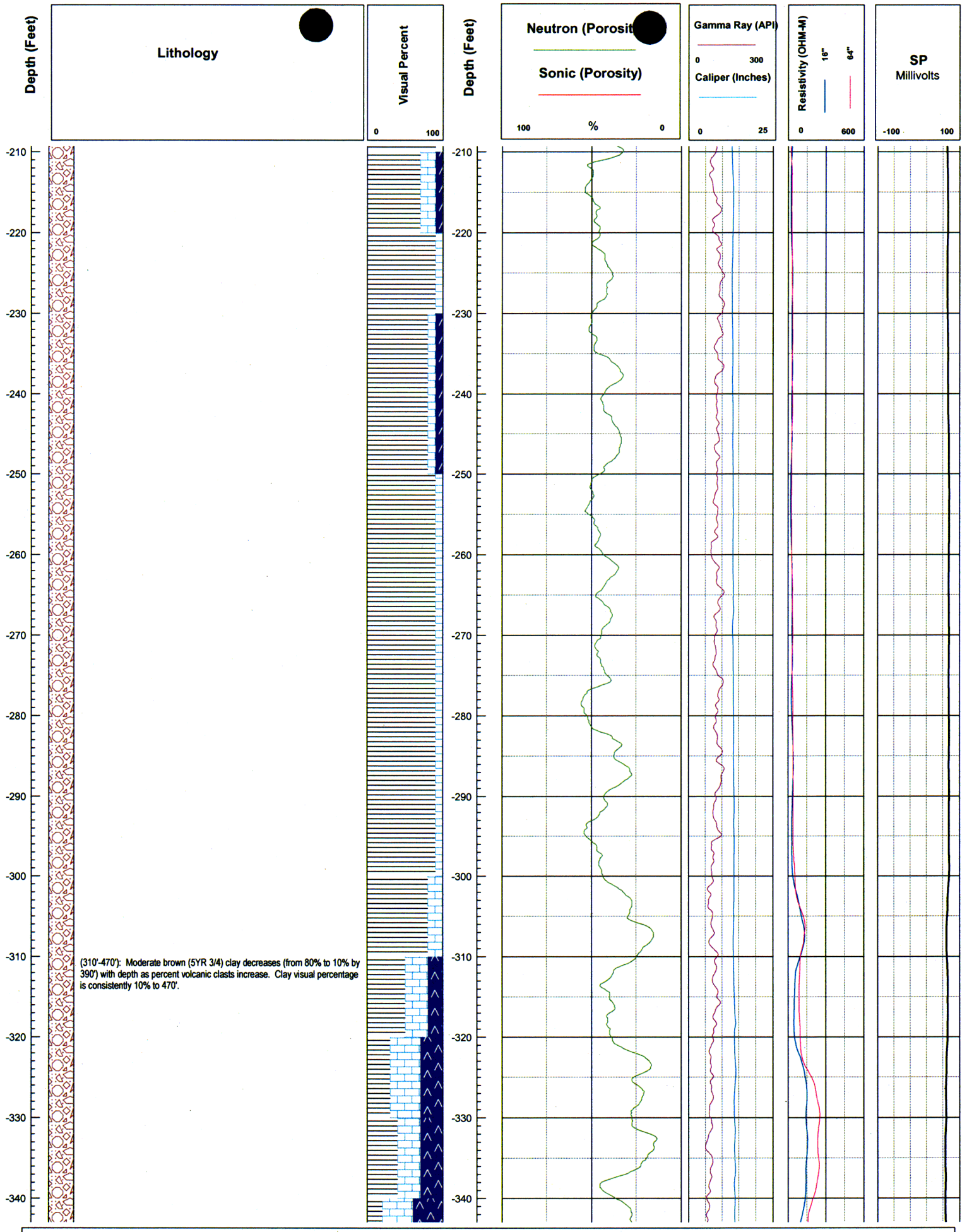


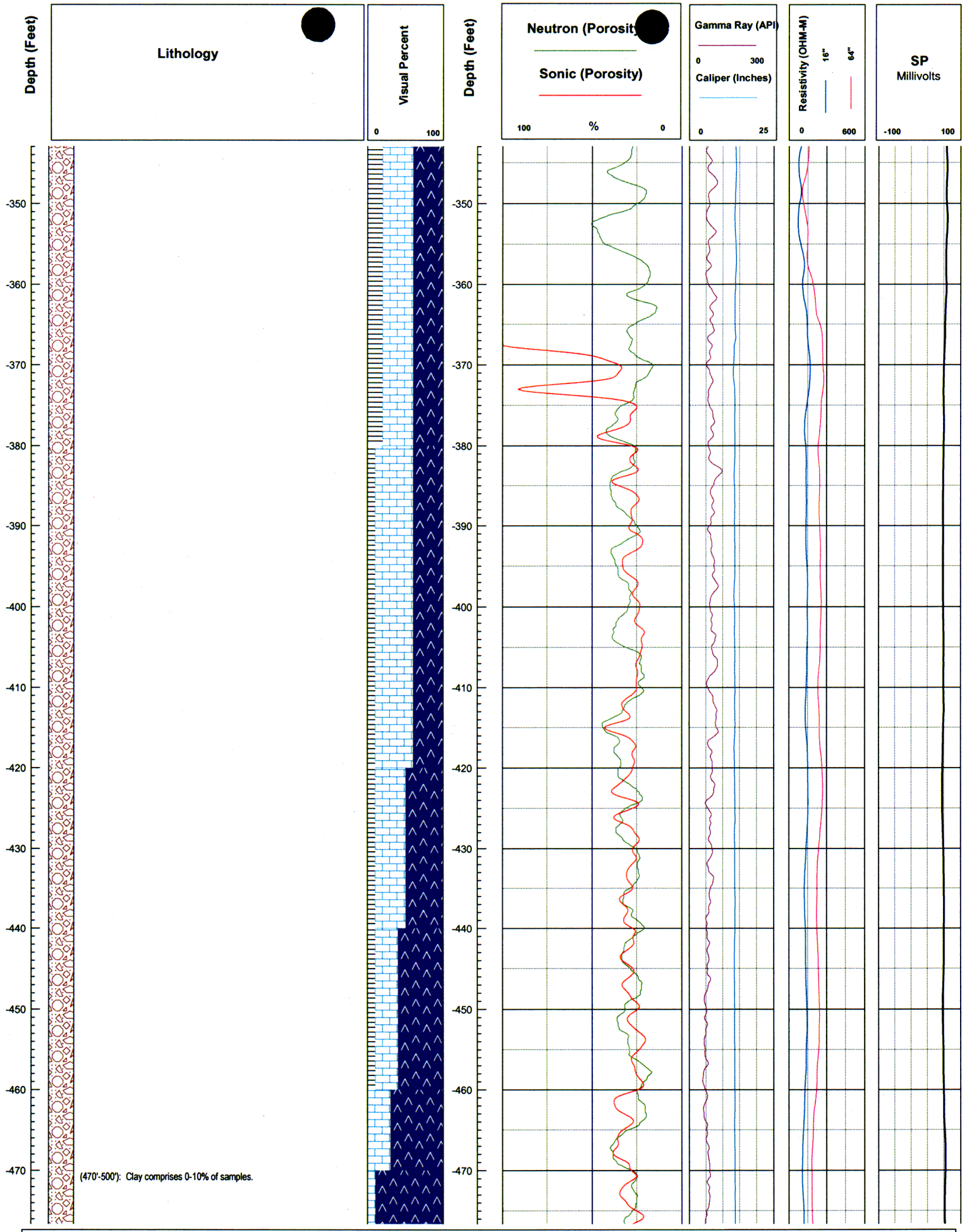


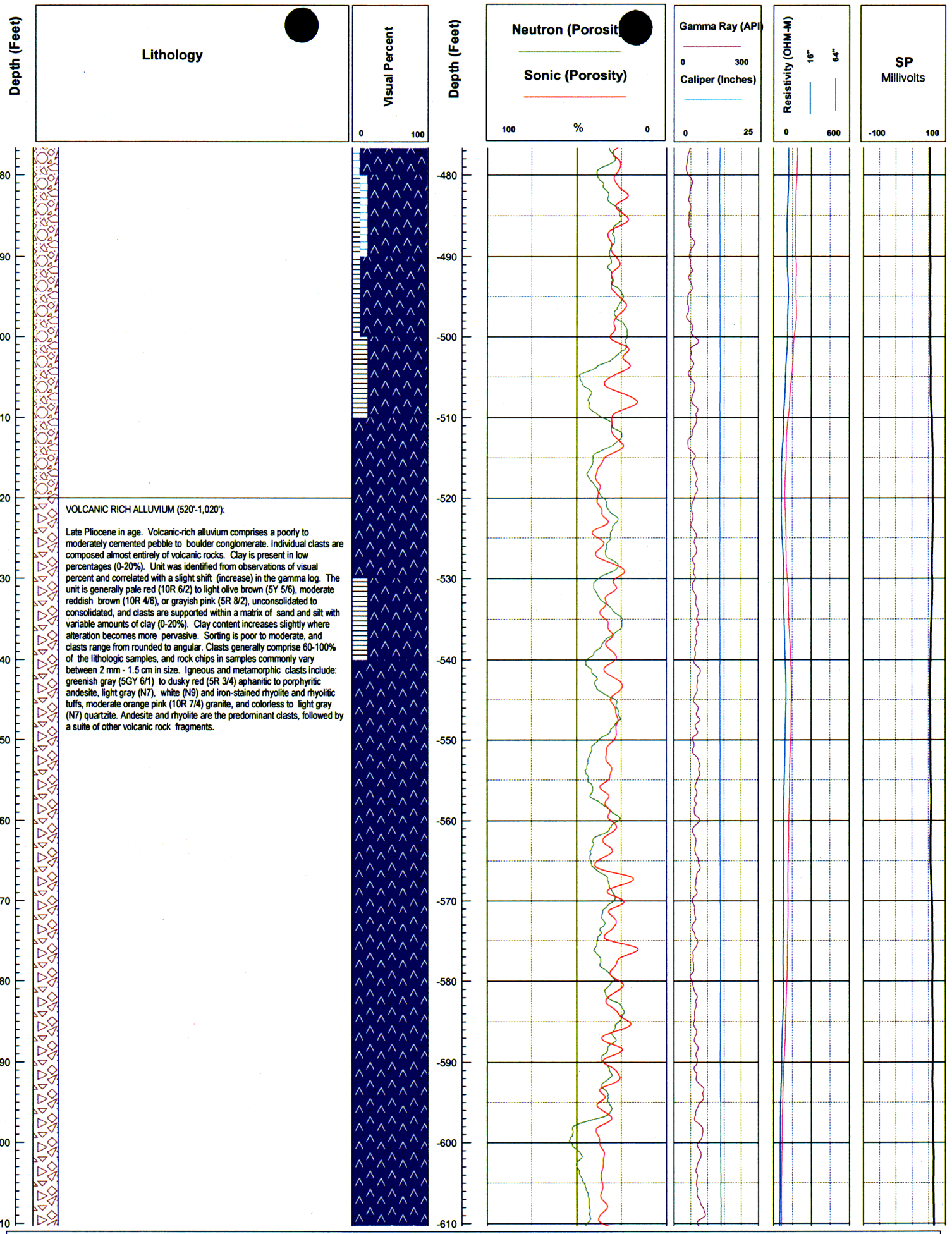
ALLUVIUM Santa Fe Group (0'-520'):

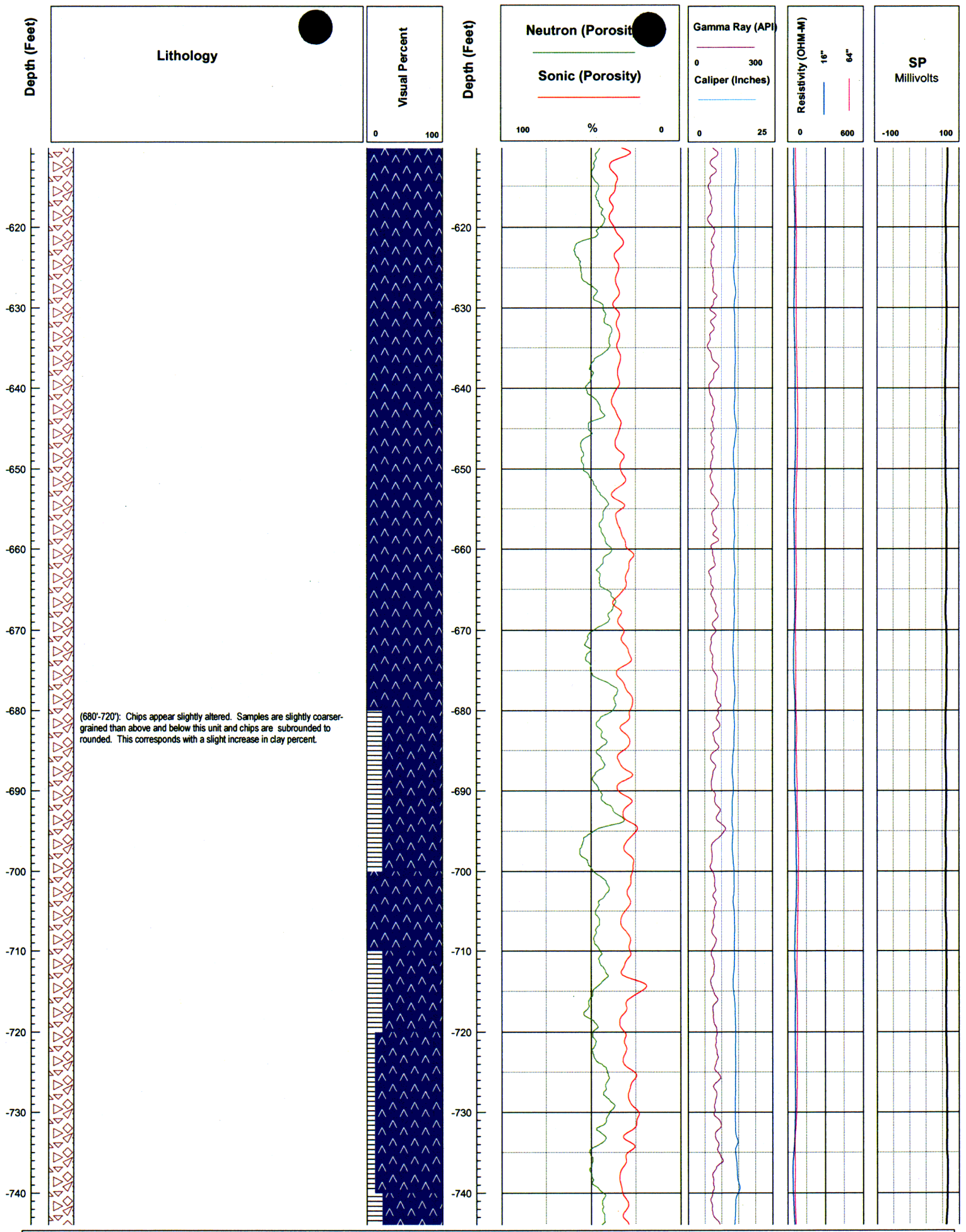
Late Pliocene to Quaternary in age. Alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Caliche horizons, clay lenses and carbonate-cemented zones occur sporadically. The unit is generally light brown (5YR 5/6) to pale reddish brown (10R 5/4), pale red (10R 6/2) or grayish orange (10YR 7/4), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay. The clay and silt content are responsible for the predominantly reddish brown color. Sorting is poor to moderate, and the clasts range from rounded to angular. Clasts generally comprise 30-60% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Sedimentary clast lithologies are varied and include light gray (N7) to dark gray (N3) micritic to fossiliferous limestone, dolomite, caliche, pale reddish-brown (10R 5/4) and olive gray (5Y 4/1) laminated to non-laminated siltstone, light brown (5YR 5/6) to moderate brown (5YR 4/4), fine to medium-grained sandstone, and colorless to medium gray (N5) chert. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Limestone is generally the predominant clast, followed by volcanic rock fragments (predominantly andesite and rhyolite), siltstone and caliche.

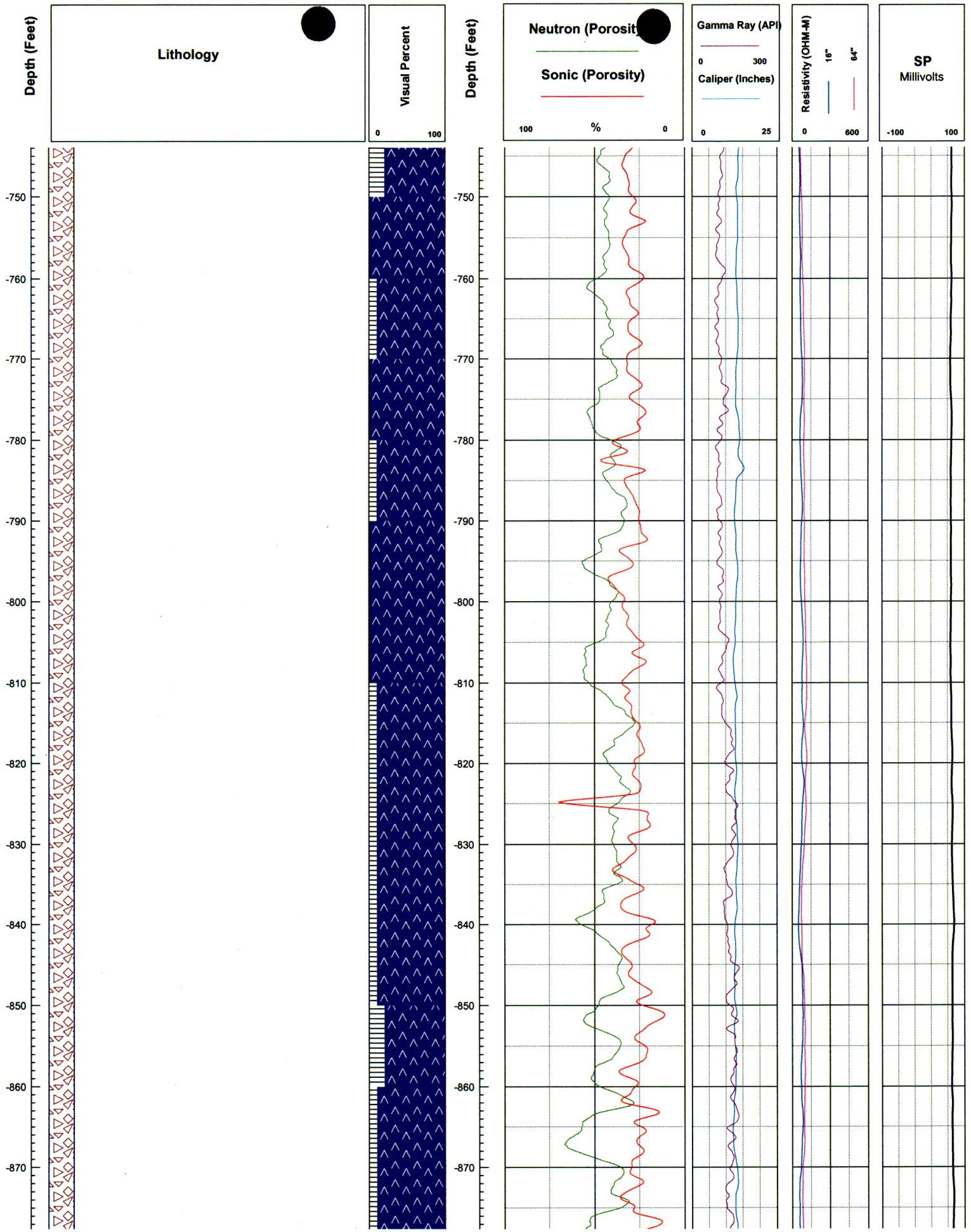

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
(120'-310'): Clay percentage increases to 60-90%.

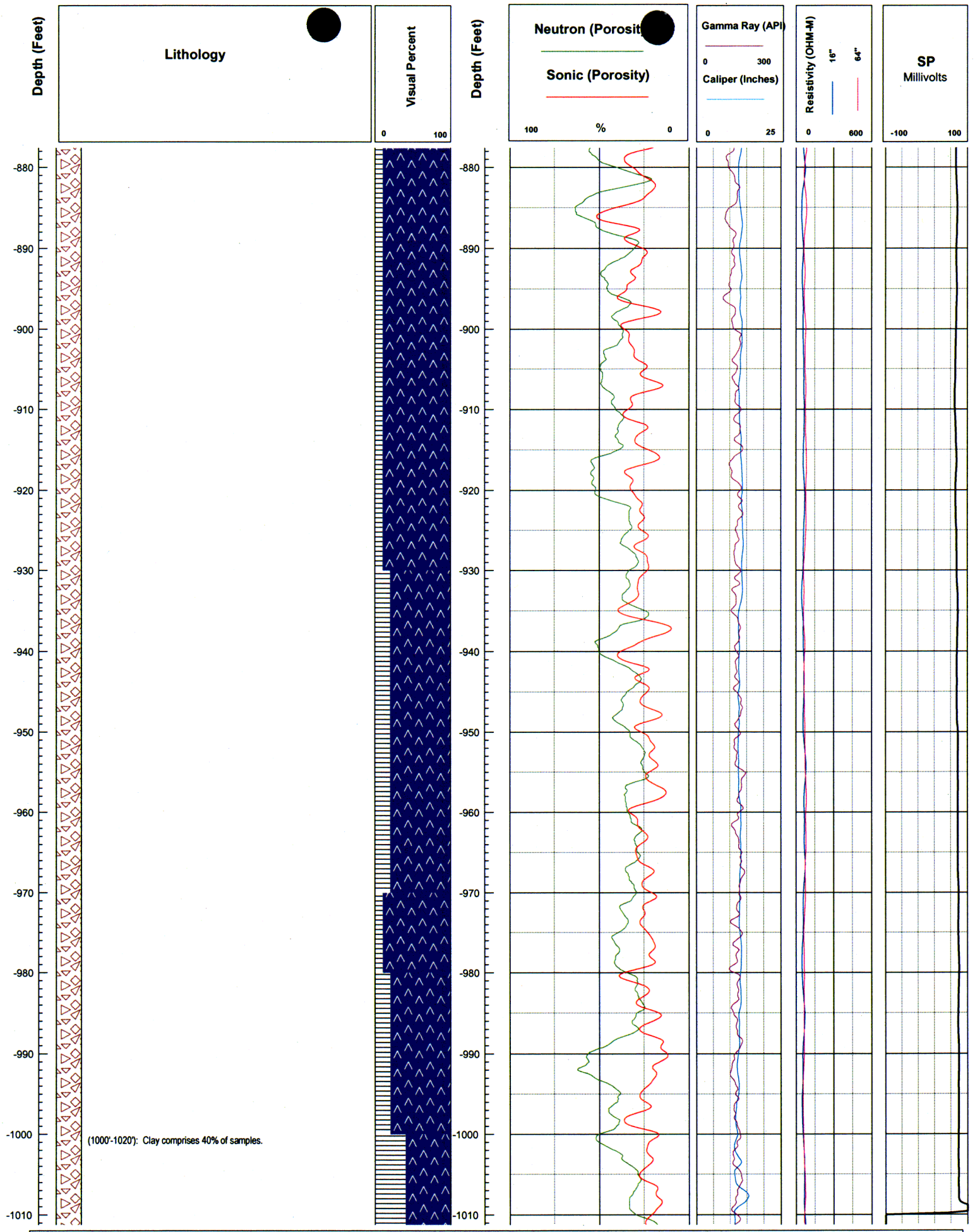

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-210
-220
-230
-240
-250
-260
-270
-280
-290
-300
-310
-320
-330
-340
(310'-470'): Moderate brown (5YR 3/4) clay decreases (from 80% to 10% by 390') with depth as percent volcanic clasts increase. Clay visual percentage is consistently 10% to 470'.

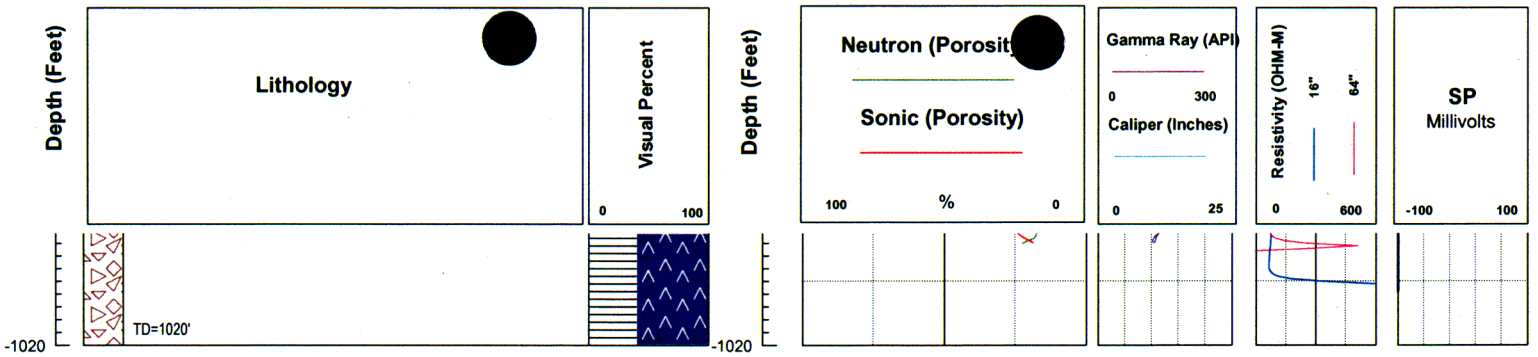

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-350
-360
-370
-380
-390
-400
-410
-420
-430
-440
-450
-460
-470
(470'-500'): Clay comprises 0-10% of samples.

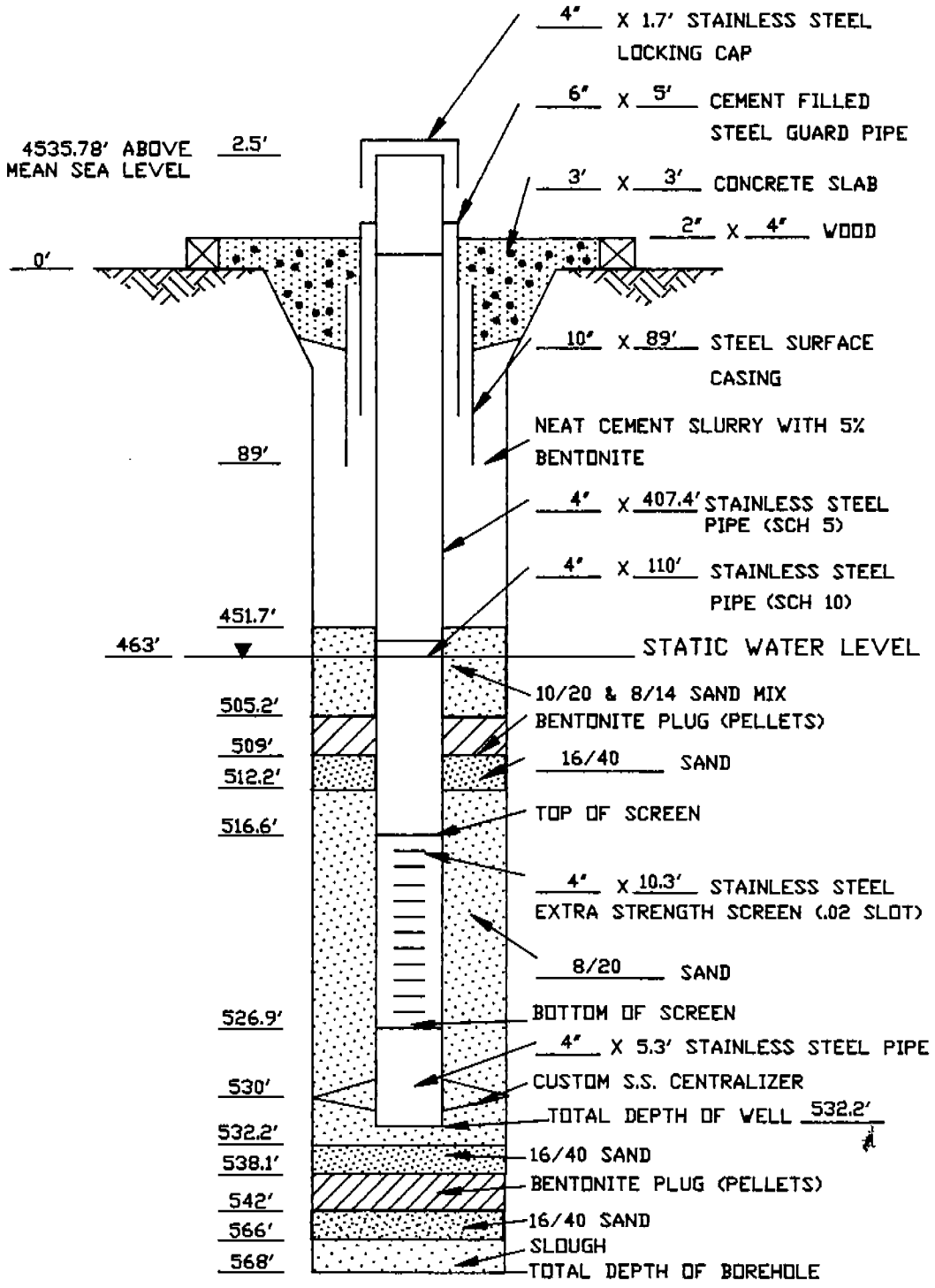

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-480
-490
-500
-510
-520
-530
-540
-550
-560
-570
-580
-590
-600
-610
VOLCANIC RICH ALLUVIUM (520'-1,020'):
Late Pliocene in age. Volcanic-rich alluvium comprises a poorly to moderately cemented pebble to boulder conglomerate. Individual clasts are composed almost entirely of volcanic rocks. Clay is present in low percentages (0-20%). Unit was identified from observations of visual percent and correlated with a slight shift (increase) in the gamma log. The unit is generally pale red (10R 6/2) to light olive brown (5Y 5/6), moderate reddish brown (10R 4/6), or grayish pink (5R 8/2), unconsolidated to consolidated, and clasts are supported within a matrix of sand and silt with variable amounts of clay (0-20%). Clay content increases slightly where alteration becomes more pervasive. Sorting is poor to moderate, and clasts range from rounded to angular. Clasts generally comprise 60-100% of the lithologic samples, and rock chips in samples commonly vary between 2 mm - 1.5 cm in size. Igneous and metamorphic clasts include: greenish gray (5GY 6/1) to dusky red (5R 3/4) aphanitic to porphyritic andesite, light gray (N7), white (N9) and iron-stained rhyolite and rhyolitic tuffs, moderate orange pink (10R 7/4) granite, and colorless to light gray (N7) quartzite. Andesite and rhyolite are the predominant clasts, followed by a suite of other volcanic rock fragments.


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-620
-630
-640
-650
-660
-670
-680
-690
-700
-710
-720
-730
-740
(680'-720'): Chips appear slightly altered. Samples are slightly coarser-grained than above and below this unit and chips are subrounded to rounded. This corresponds with a slight increase in clay percent.

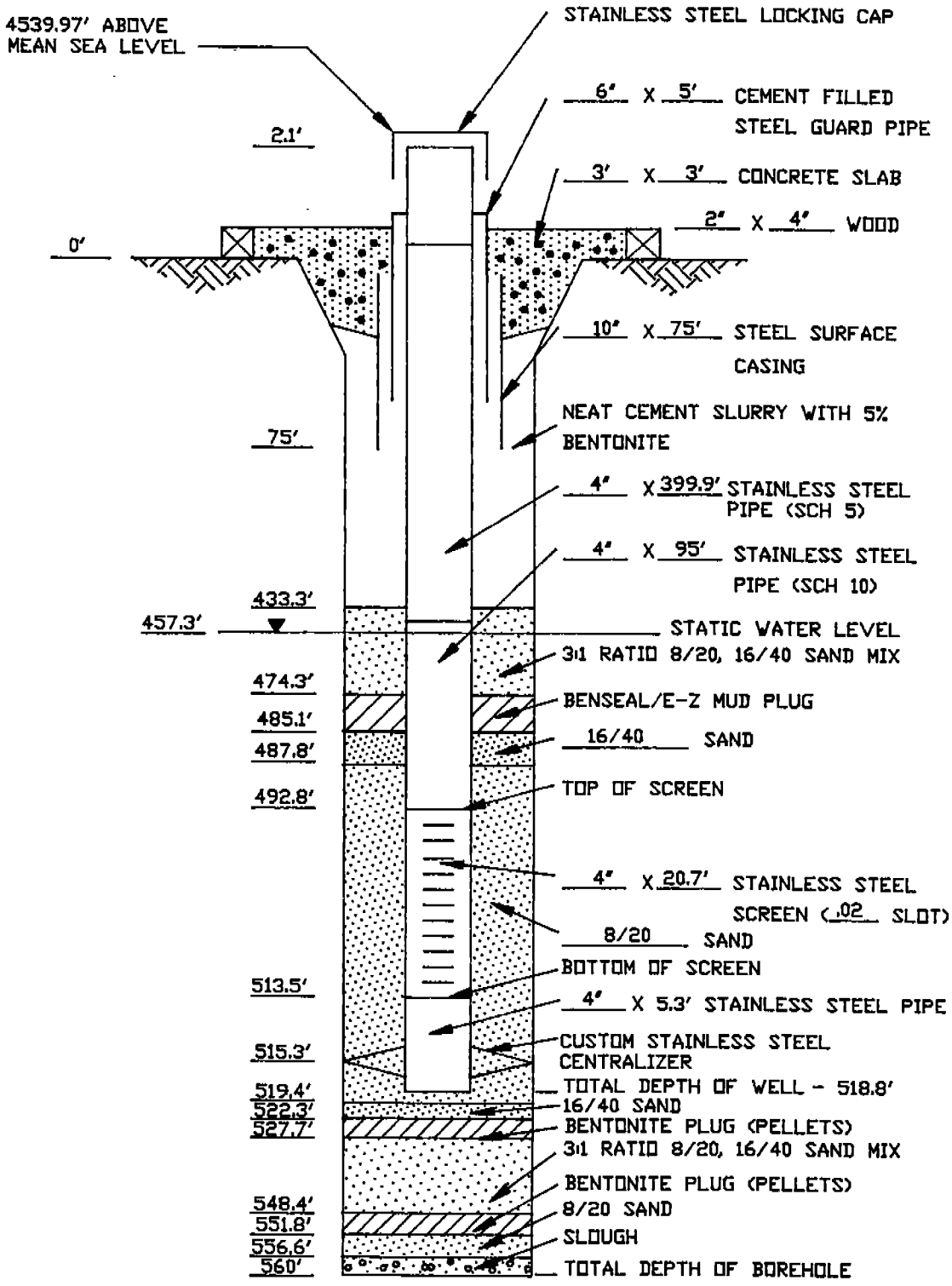

Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-750
-760
-770
-780
-790
-800
-810
-820
-830
-840
-850
-860
-870


Depth (Feet)
Lithology
Visual Percent
0
100
Depth (Feet)
Neutron (Porosit
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-880
-890
-900
-910
-920
-930
-940
-950
-960
-970
-980
-990
-1000
-1010
(1000'-1020'): Clay comprises 40% of samples.

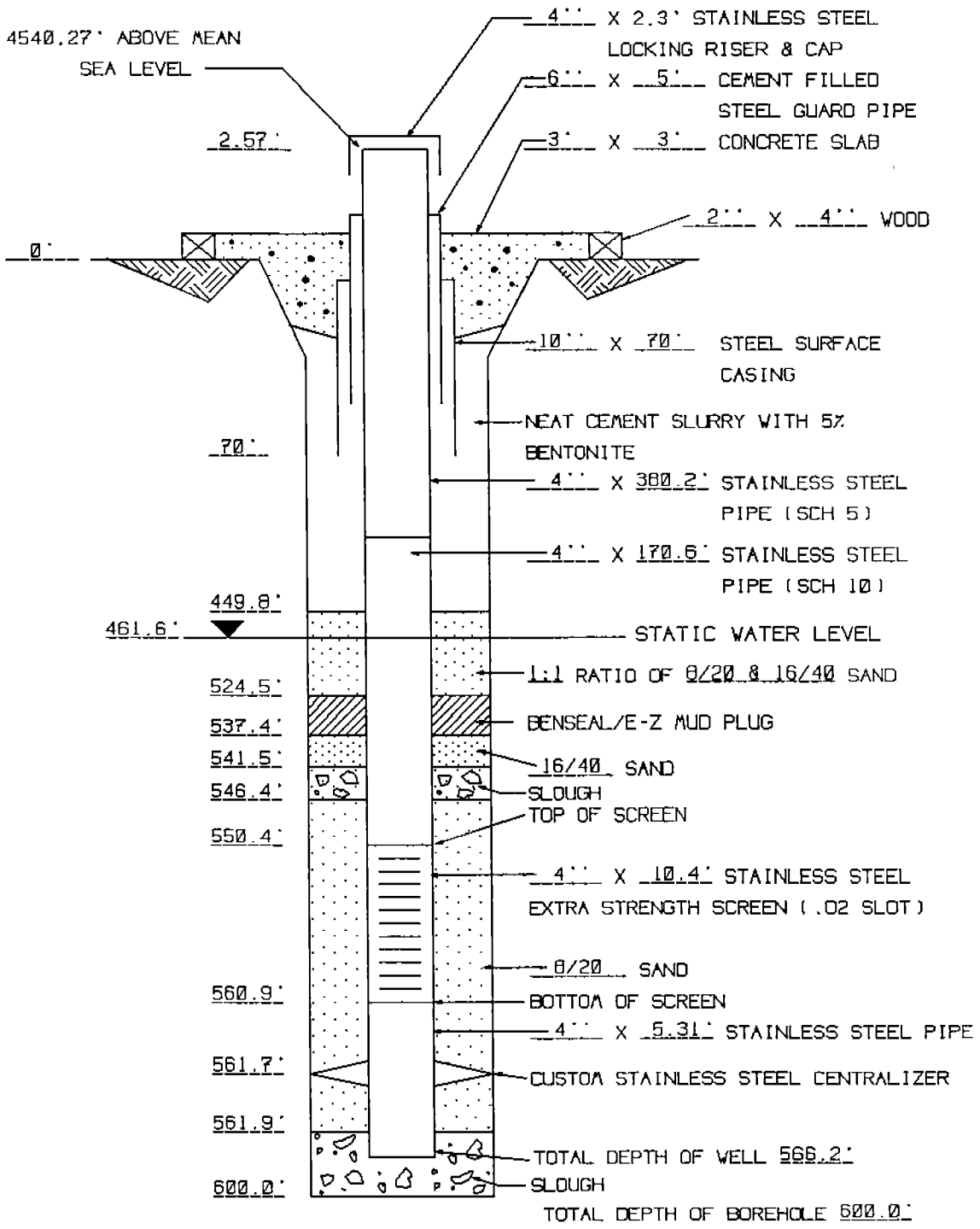

Depth (Feet)
Lithology
Visual Percent
0
100
TD=1020'
-1020
Depth (Feet)
Neutron (Porosity)
Sonic (Porosity)
100
%
0
Gamma Ray (API)
0
300
Caliper (Inches)
0
25
Resistivity (OHM-M)
16"
64"
0
600
SP
Millivolts
-100
100
-1020



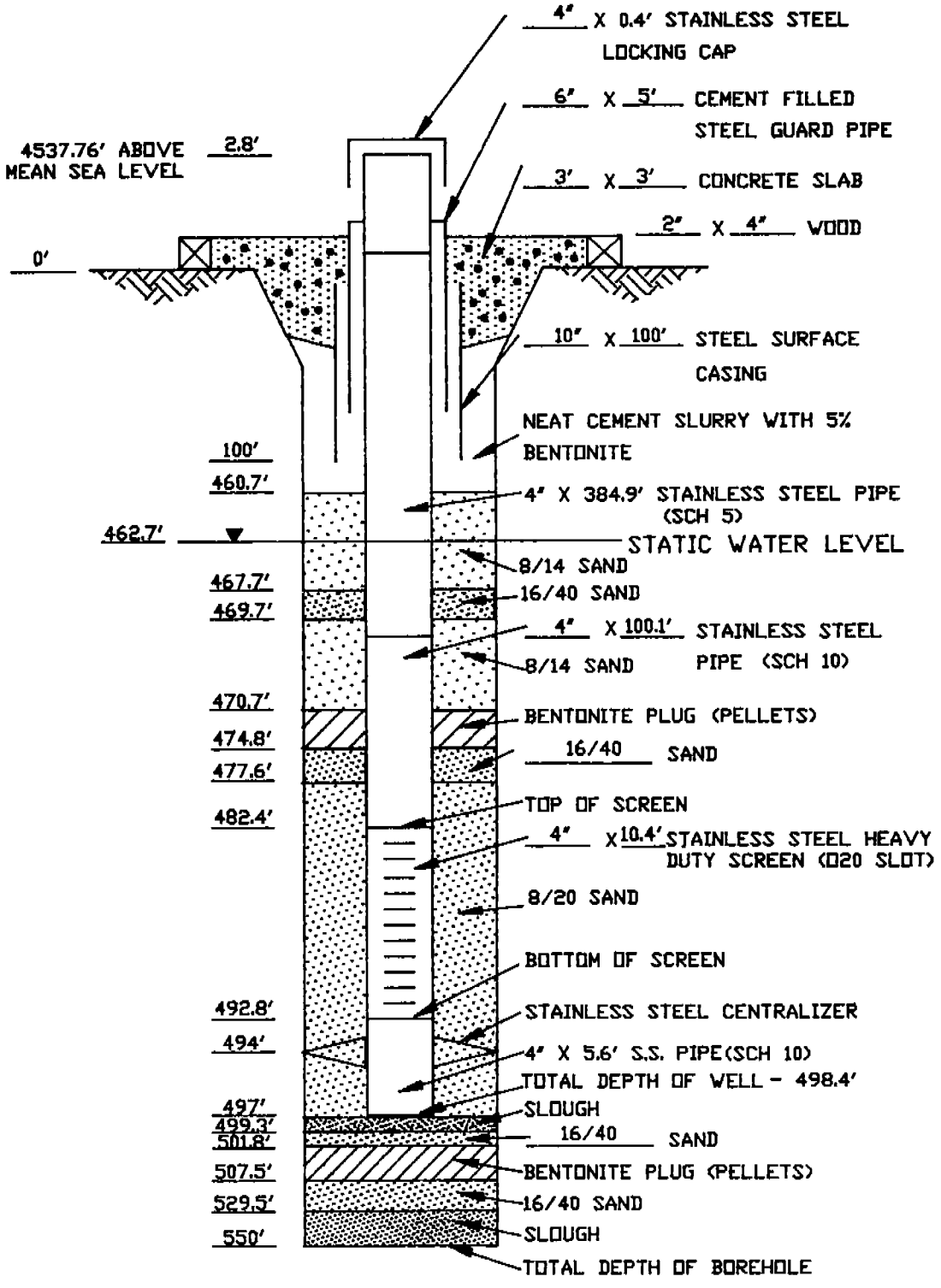
MONITOR WELL BLM-10-517 COMPLETION DIAGRAM



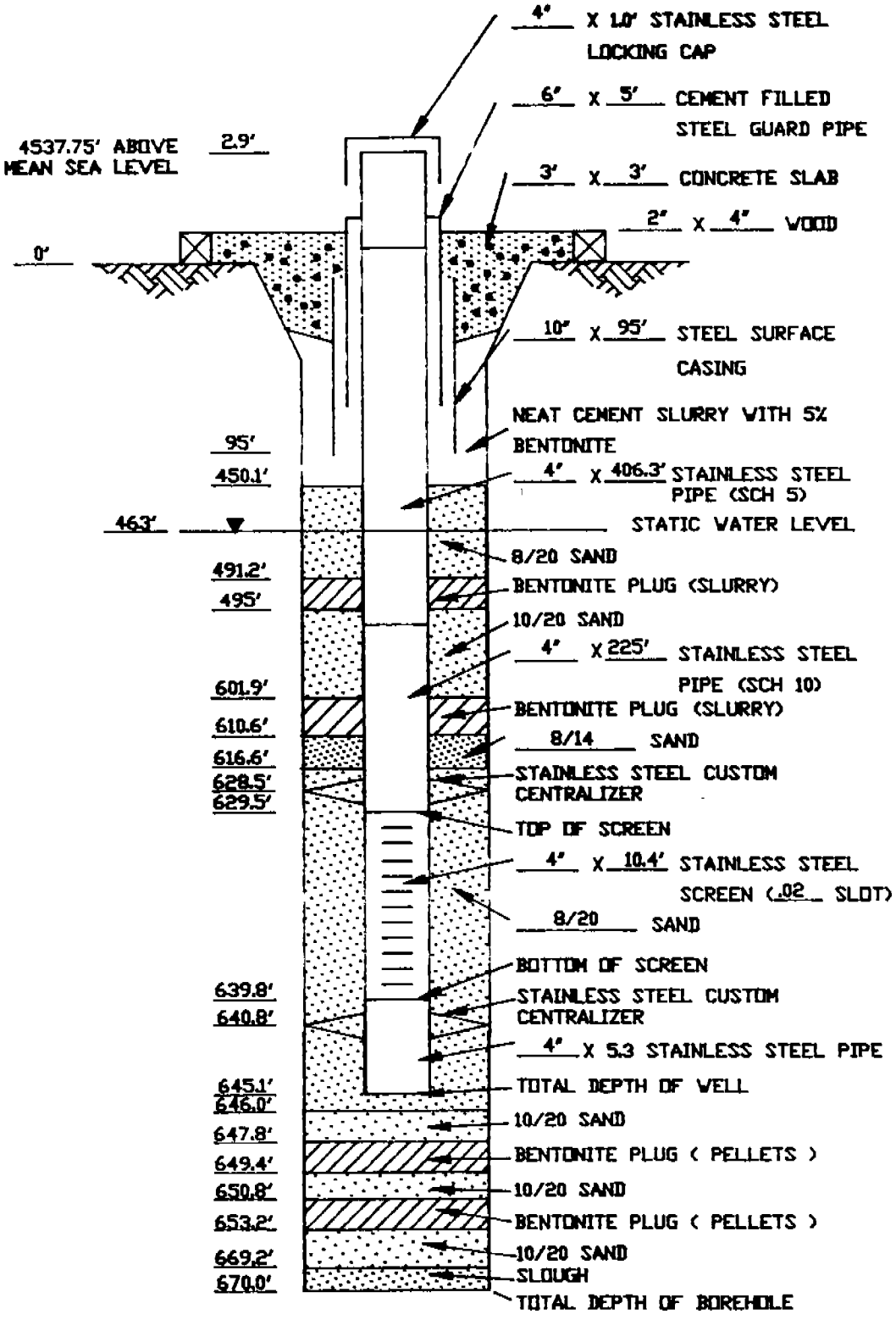
MONITOR WELL BLM-17-493 COMPLETION DIAGRAM



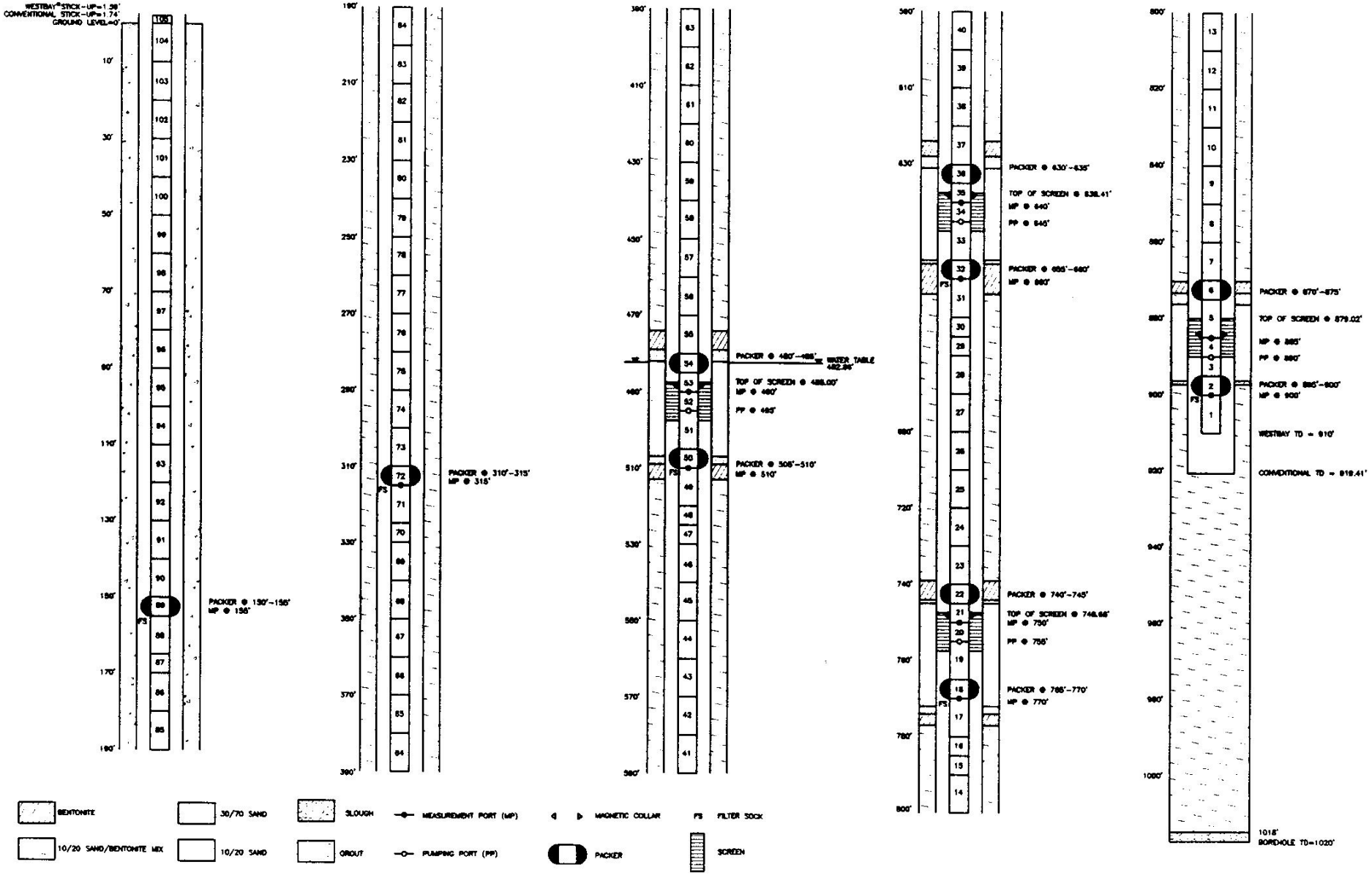
MONITOR WELL BLM-17-550 COMPLETION DIAGRAM



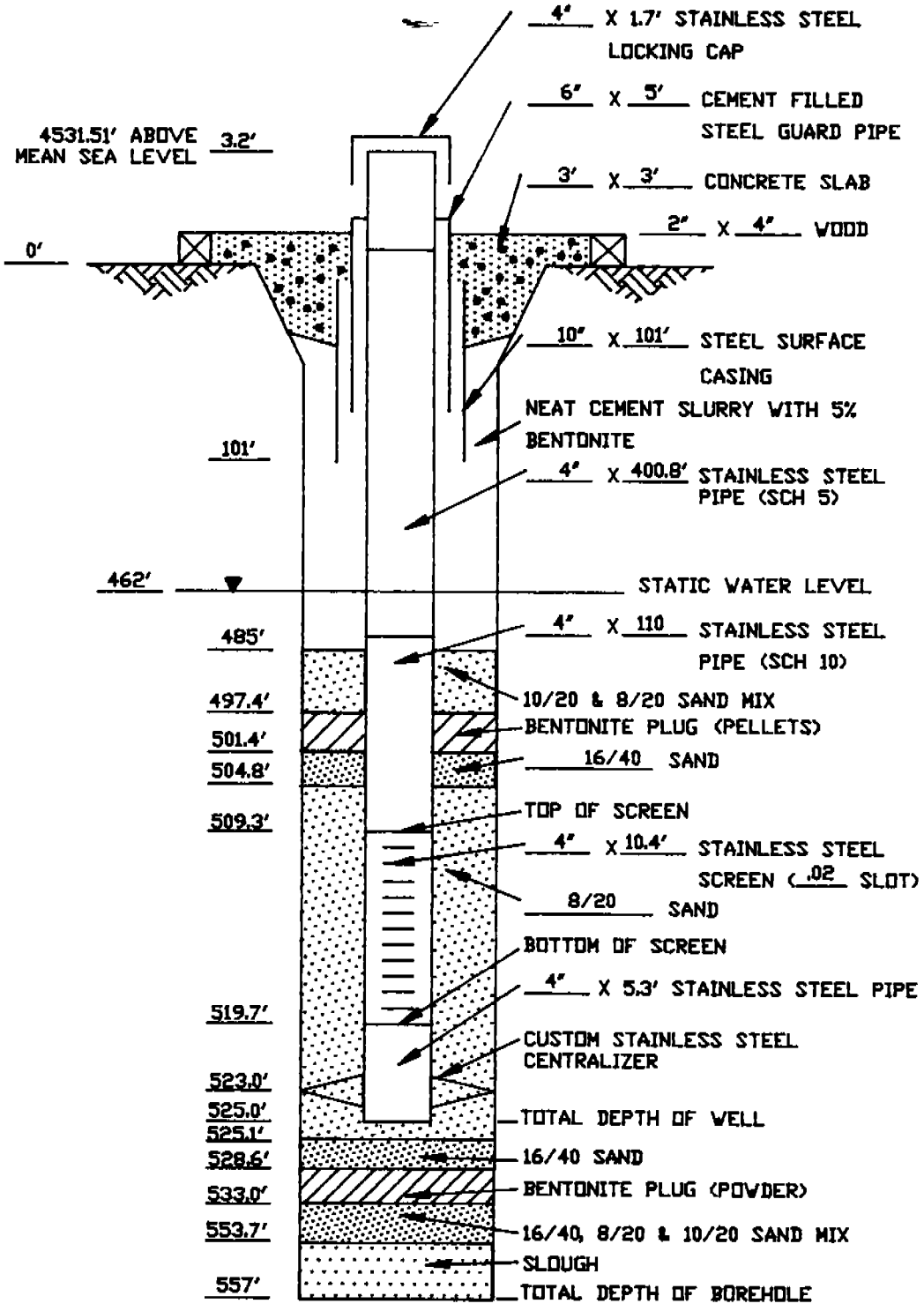
MONITOR WELL BLM-2-482 COMPLETION DIAGRAM



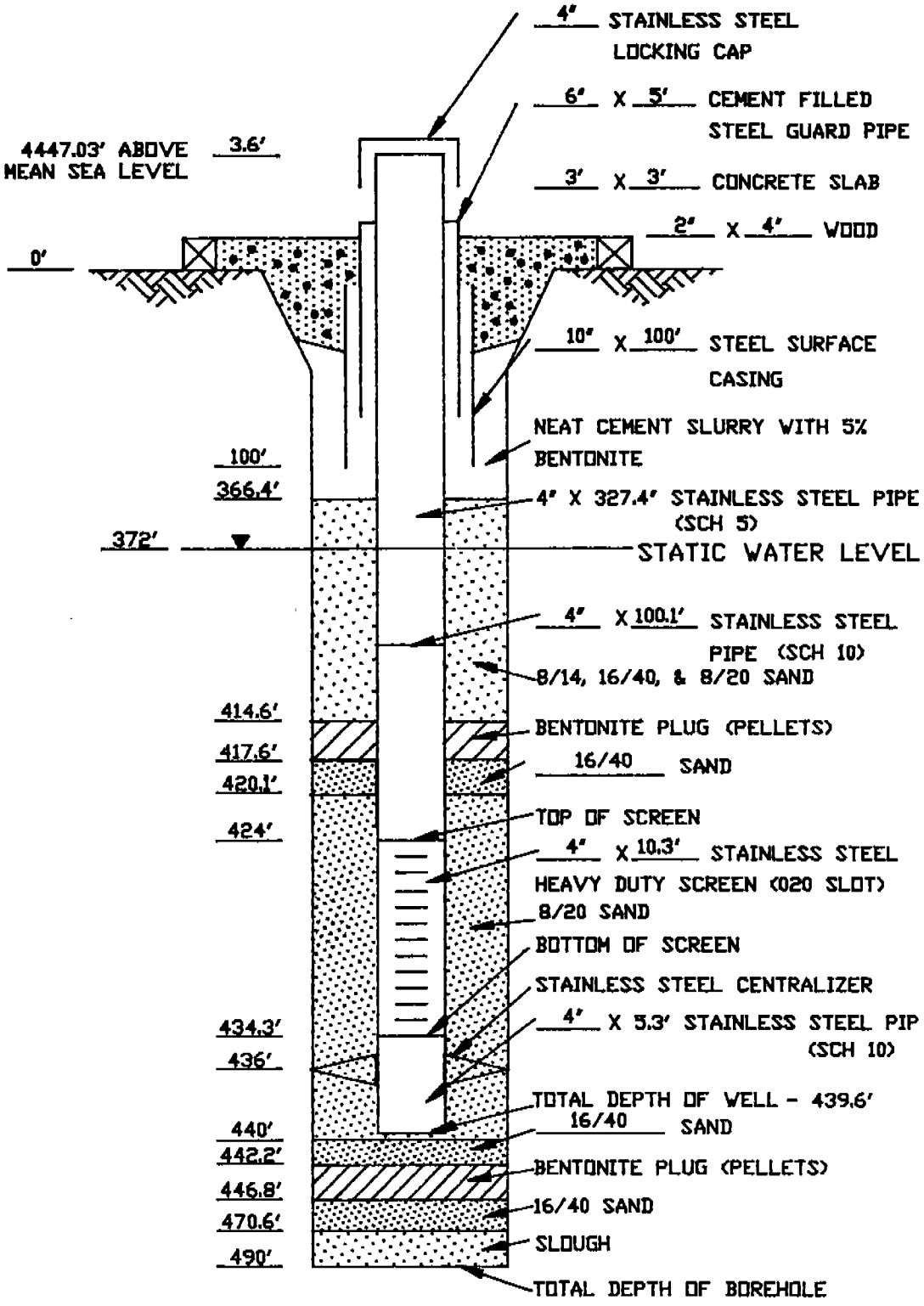
MONITOR WELL BLM-2-630 COMPLETION DIAGRAM



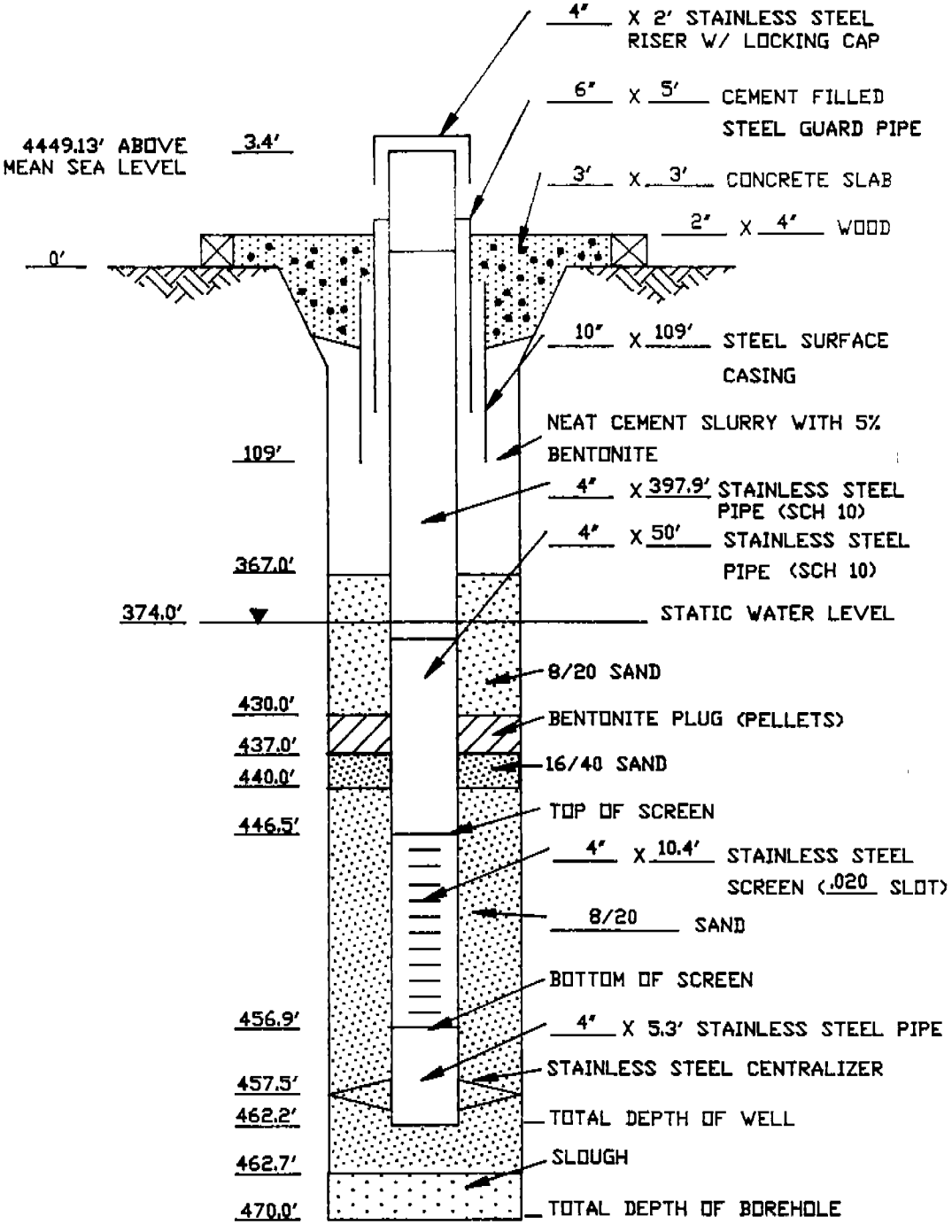
MONITOR WELL BLM-37 COMPLETION DIAGRAM



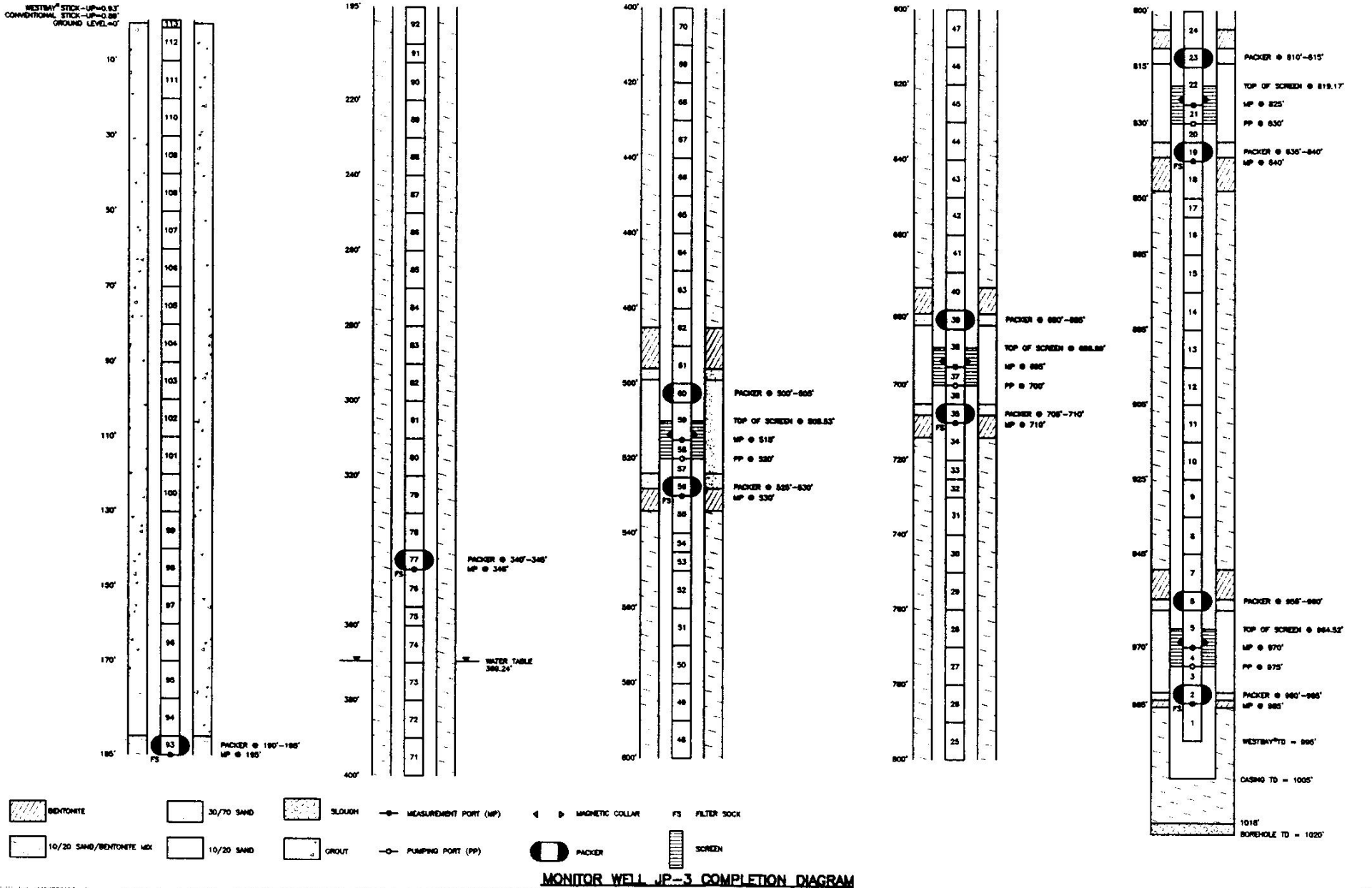
MONITOR WELL BLM-7-509 COMPLETION DIAGRAM



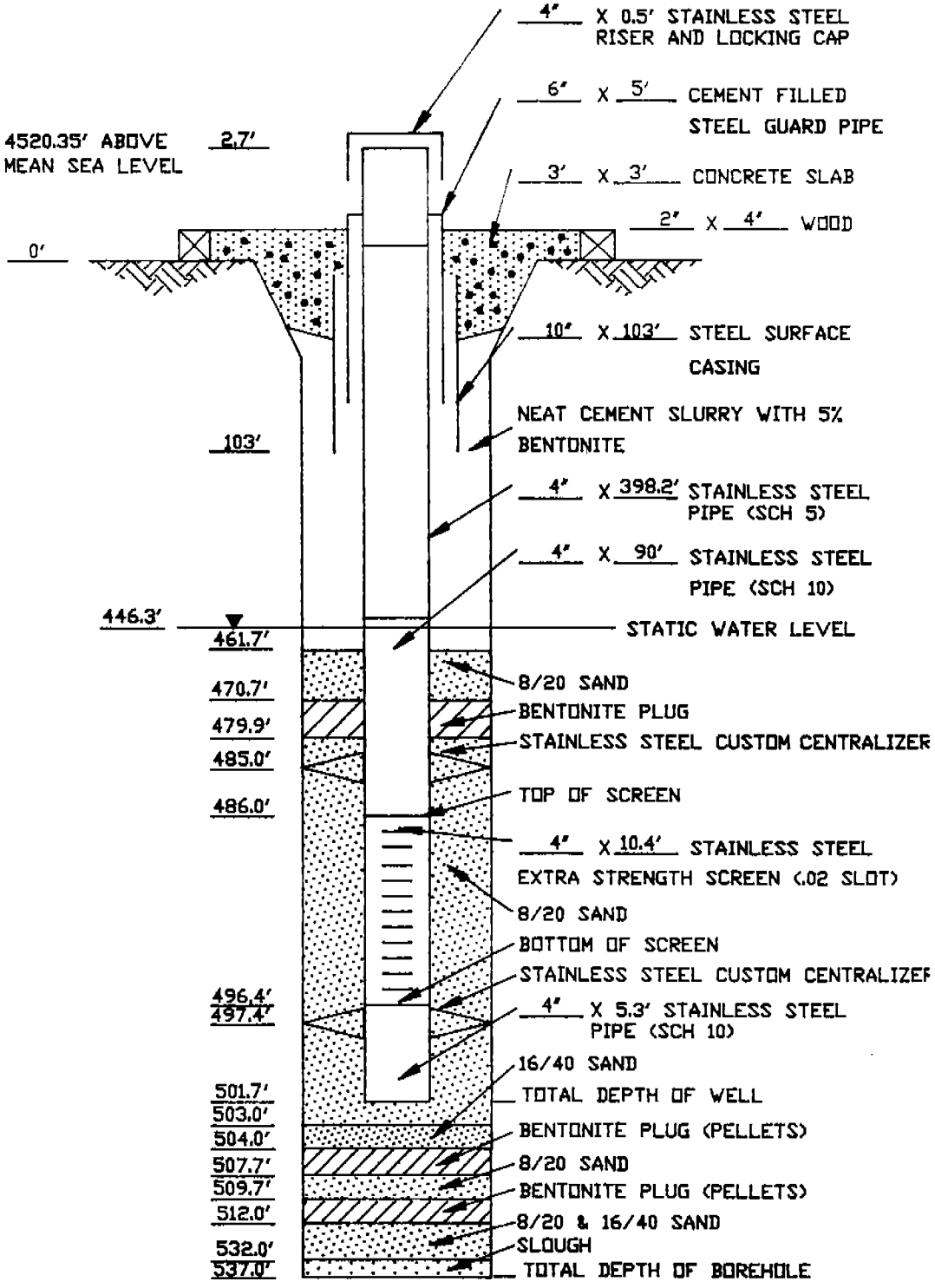
MONITOR WELL JP-1-424 COMPLETION DIAGRAM



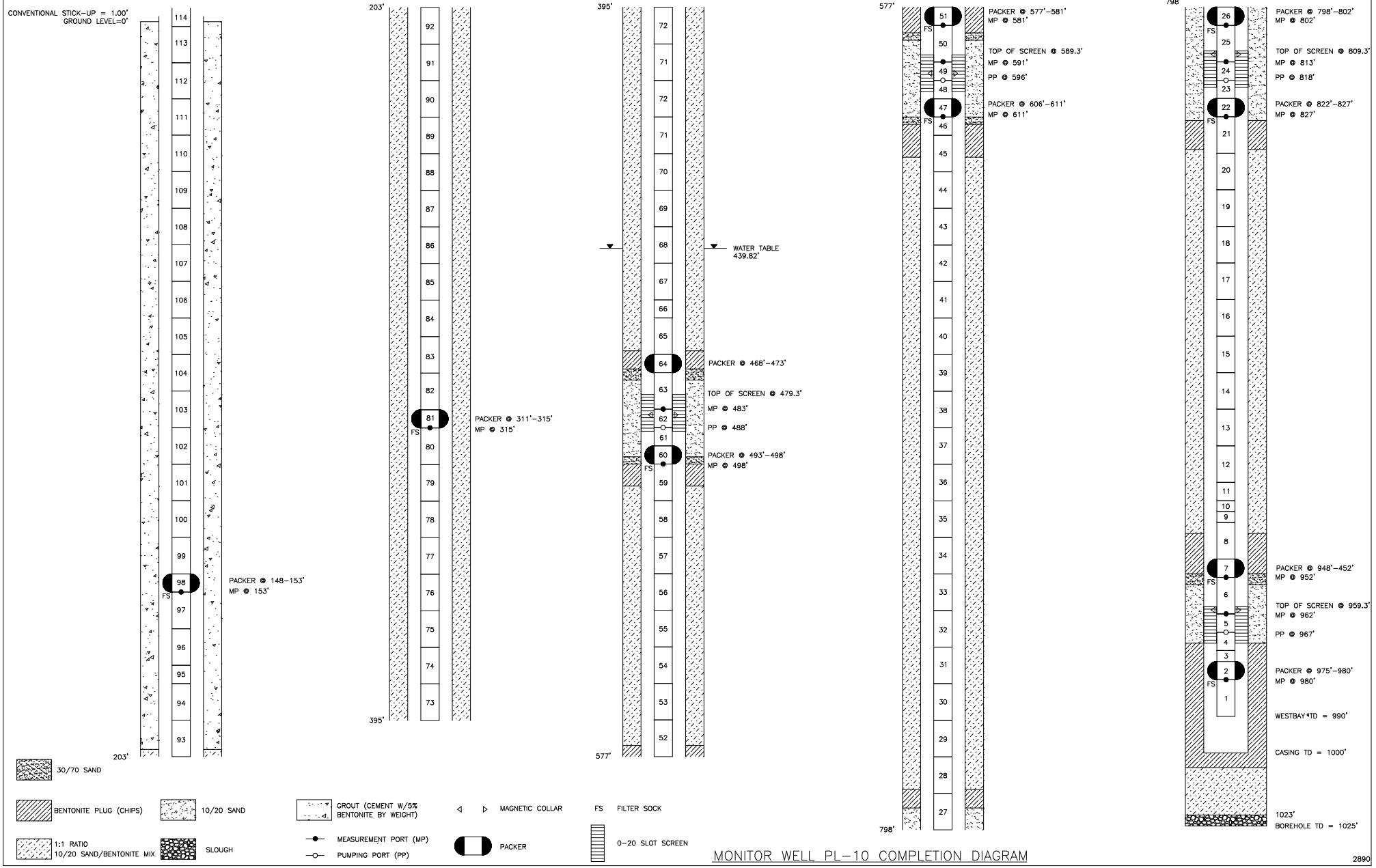
MONITOR WELL JP-2-447 COMPLETION DIAGRAM



MONITOR WELL JP-3 COMPLETION DIAGRAM



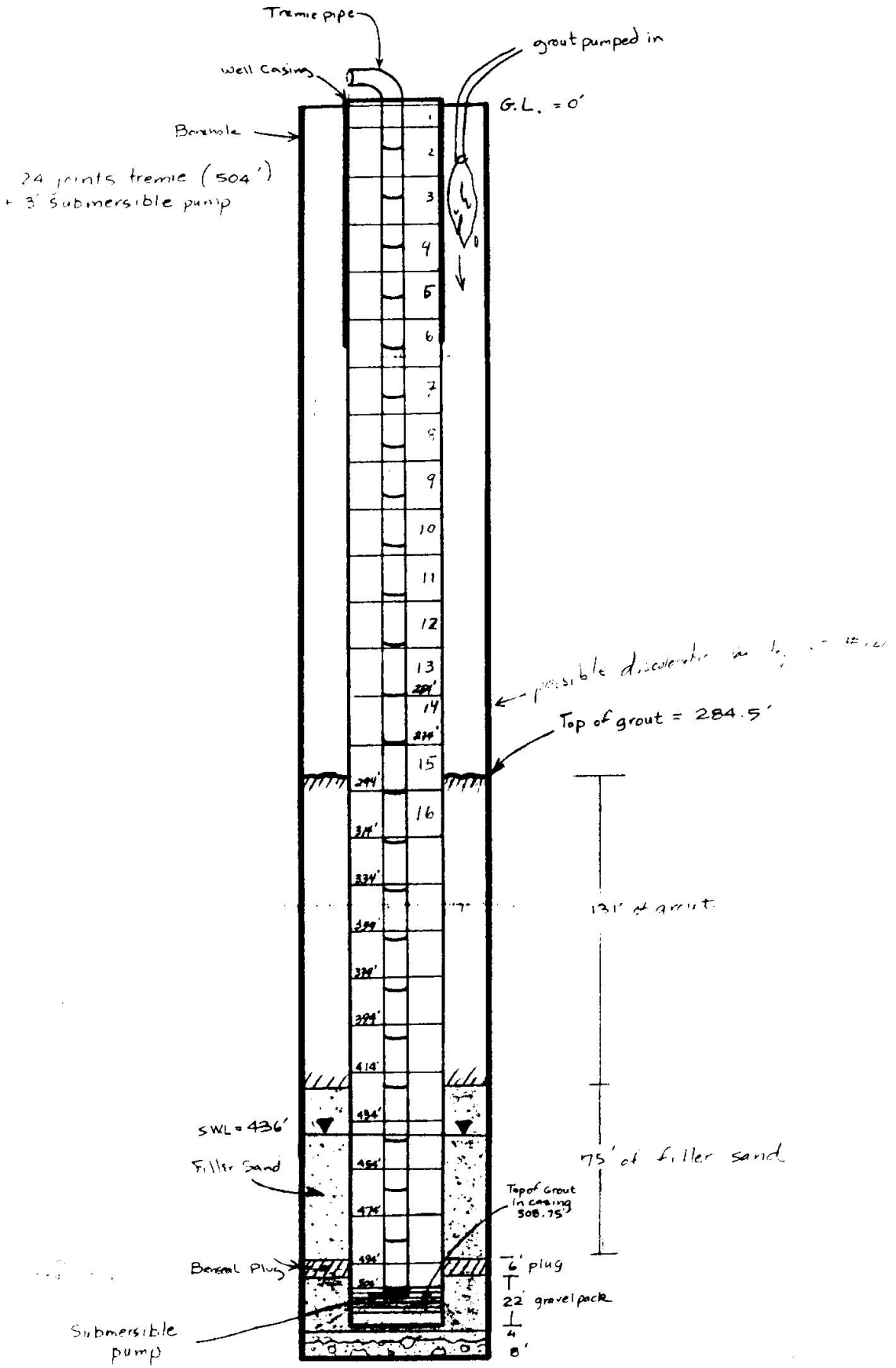
MONITOR WELL PL-1-486 COMPLETION DIAGRAM

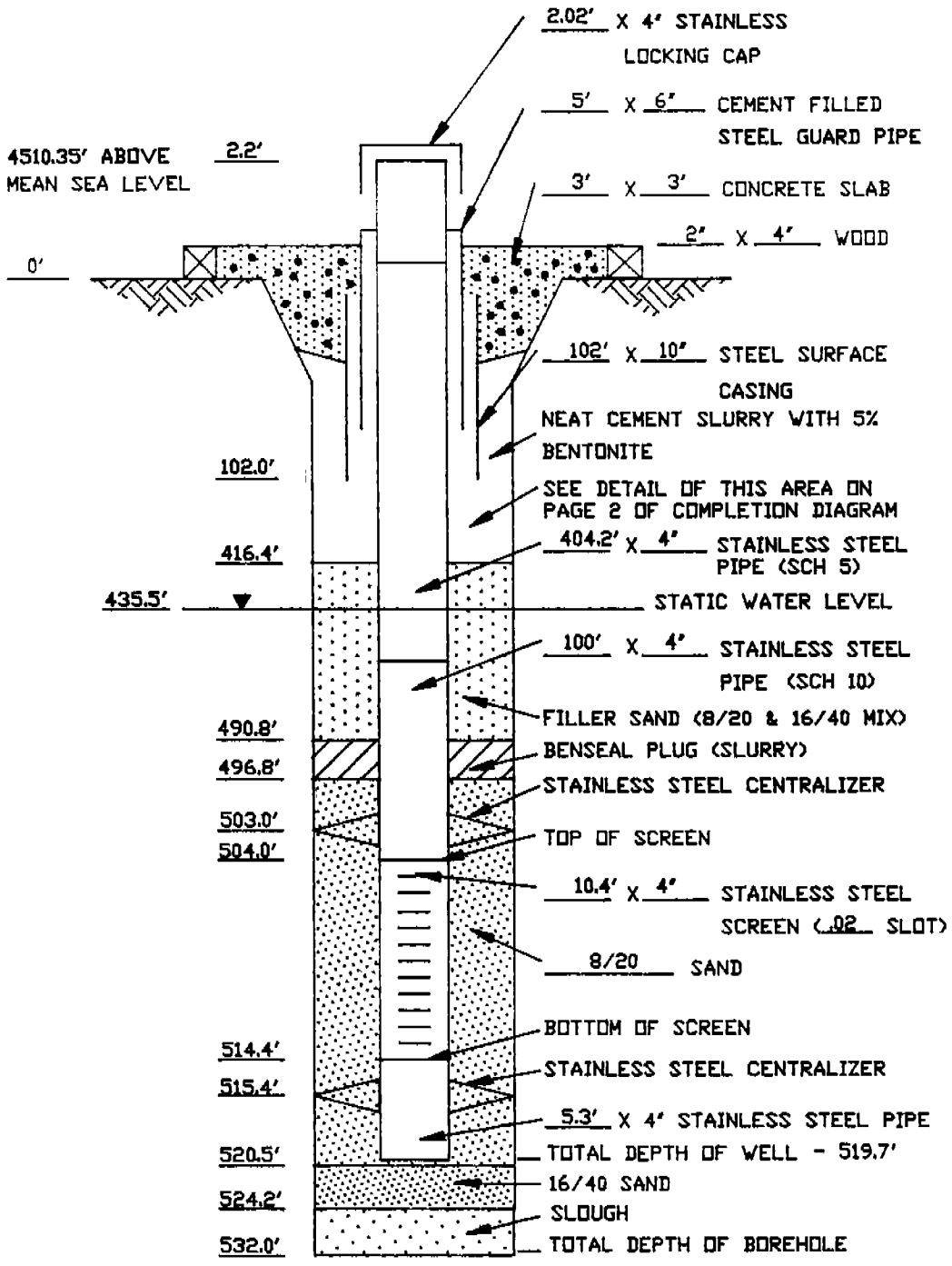


MONITOR WELL PL-10 COMPLETION DIAGRAM

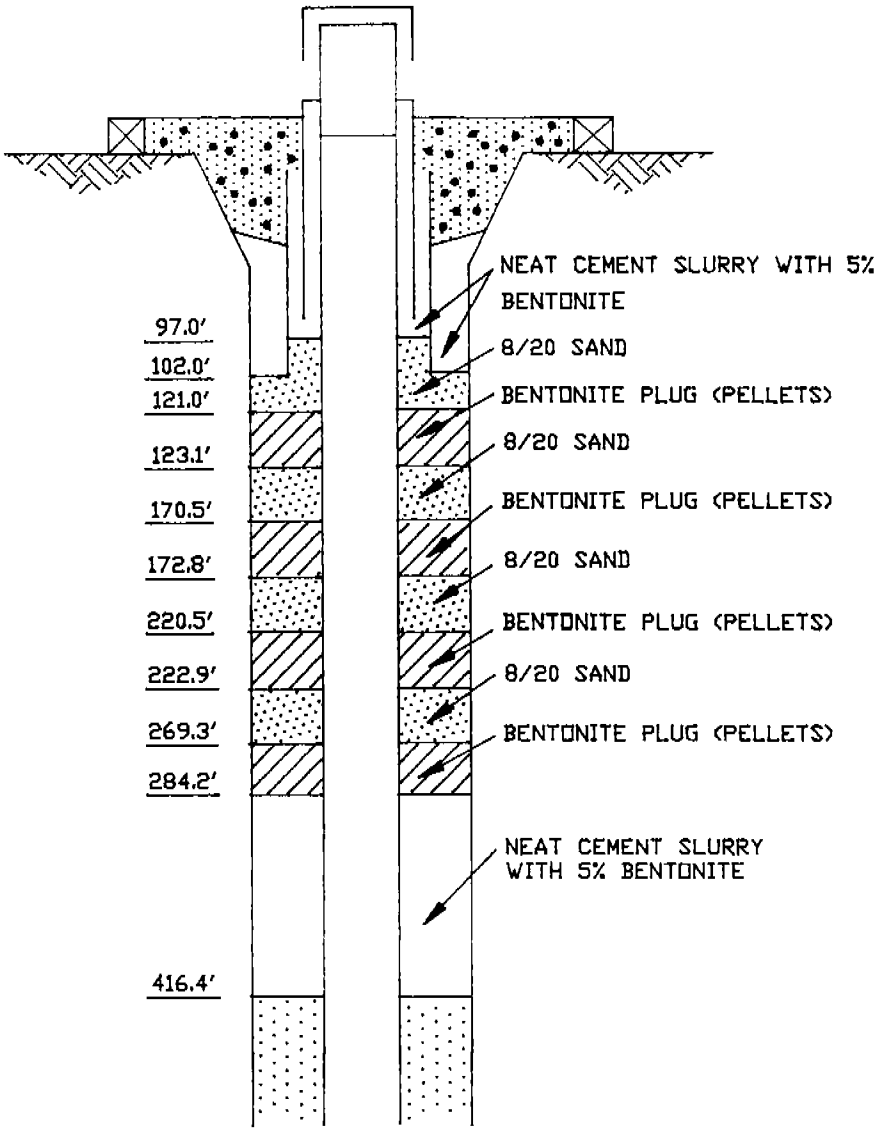
2890

PL-2-504

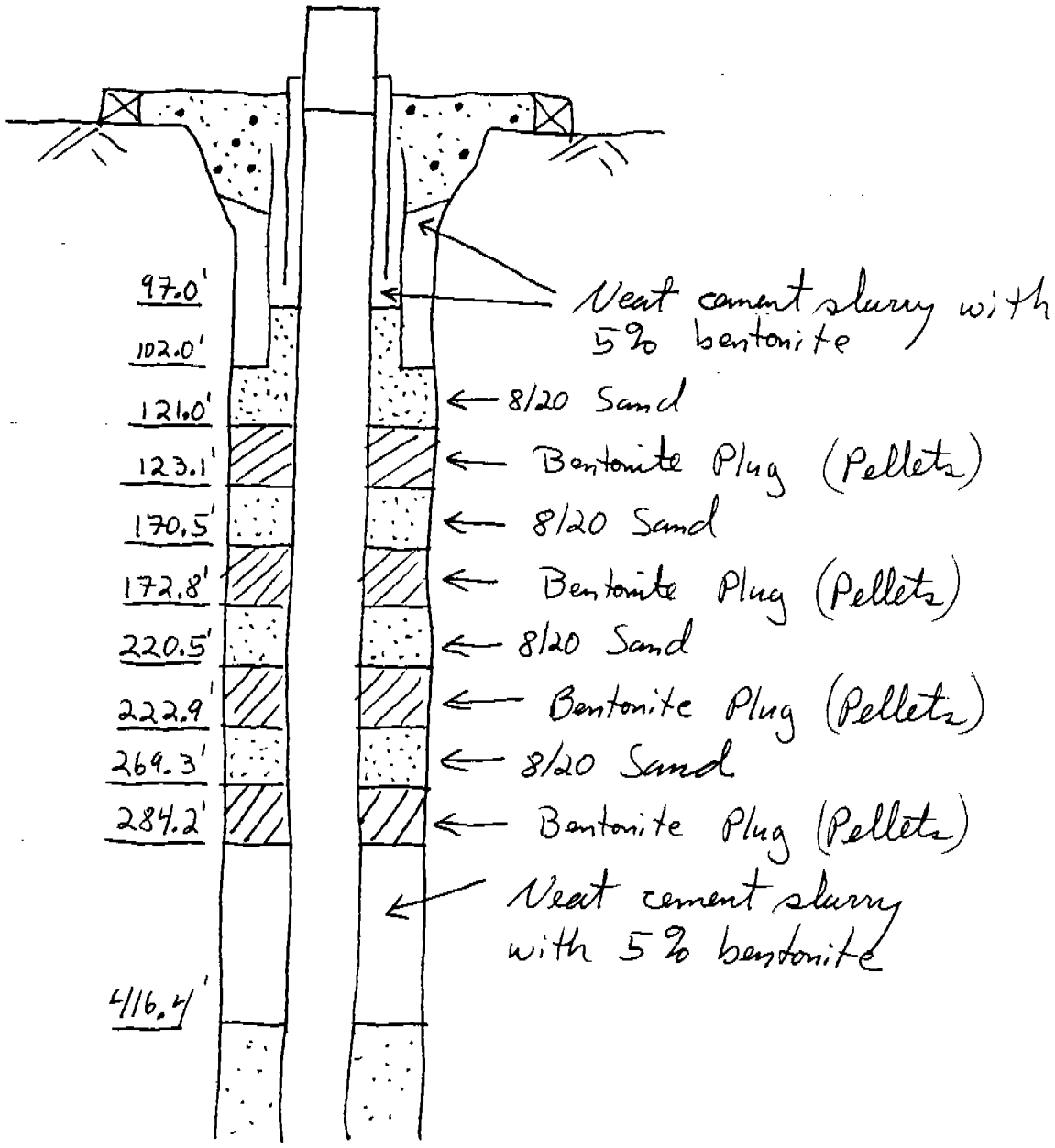

Tremie pipe
grout pumped in
well casing
G.L. = 0'
Borehole
24 joints tremie (504')
+ 3' submersible pump
1
2
3
4
5
6
7
8
9
10
11
12
13
294'
14
304'
15
294'
16
314'
334'
354'
374'
394'
414'
434'
SWL = 436'
Filter Sand
454'
474'
494'
508'
Top of grout = 284.5'
131' of grout
75' of filter sand
Top of Grout in casing 508.75'
Bental Plug
6' plug
22' gravel pack
4'
8'
Submersible pump

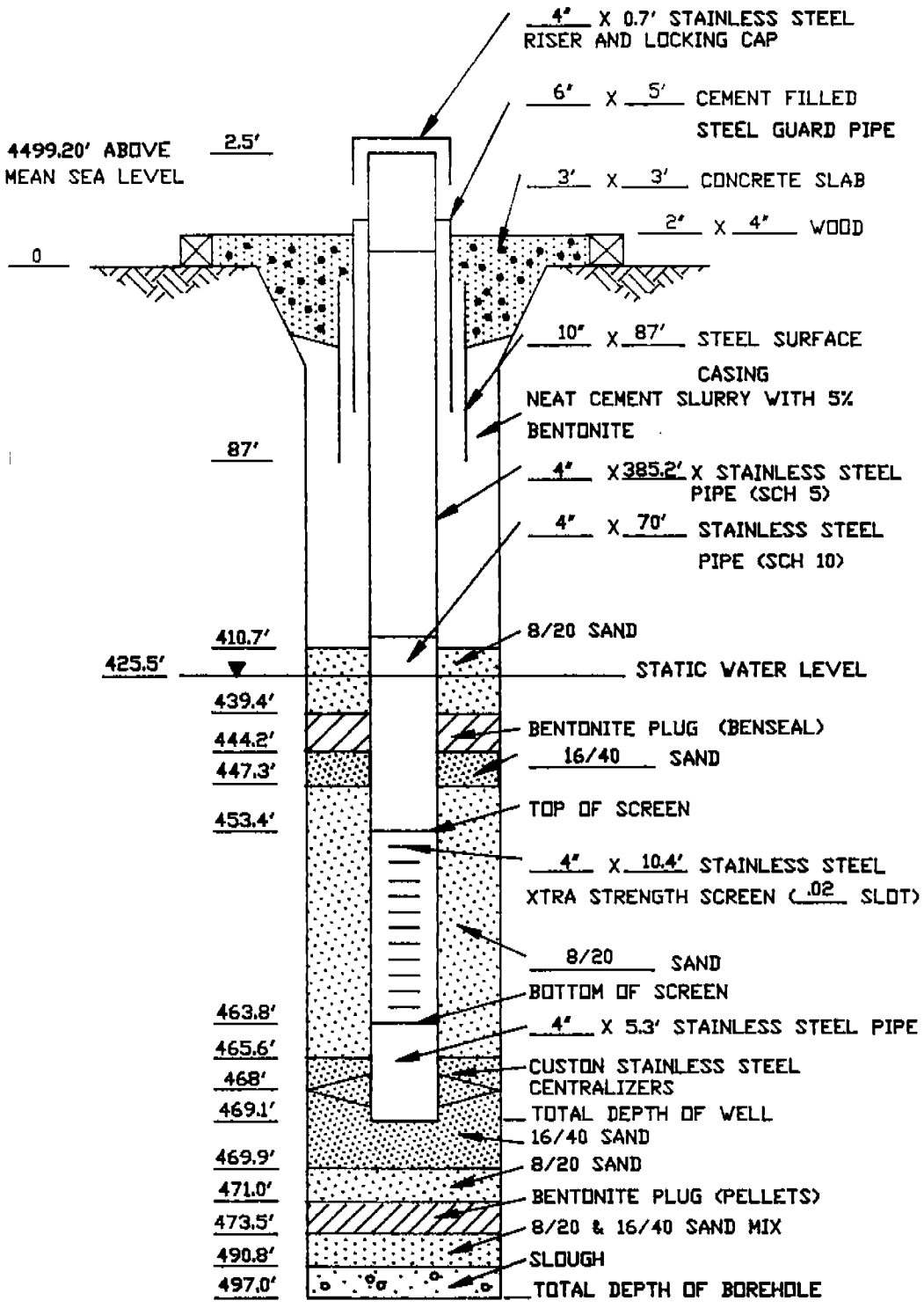


MONITOR WELL PL-2-504 COMPLETION DIAGRAM

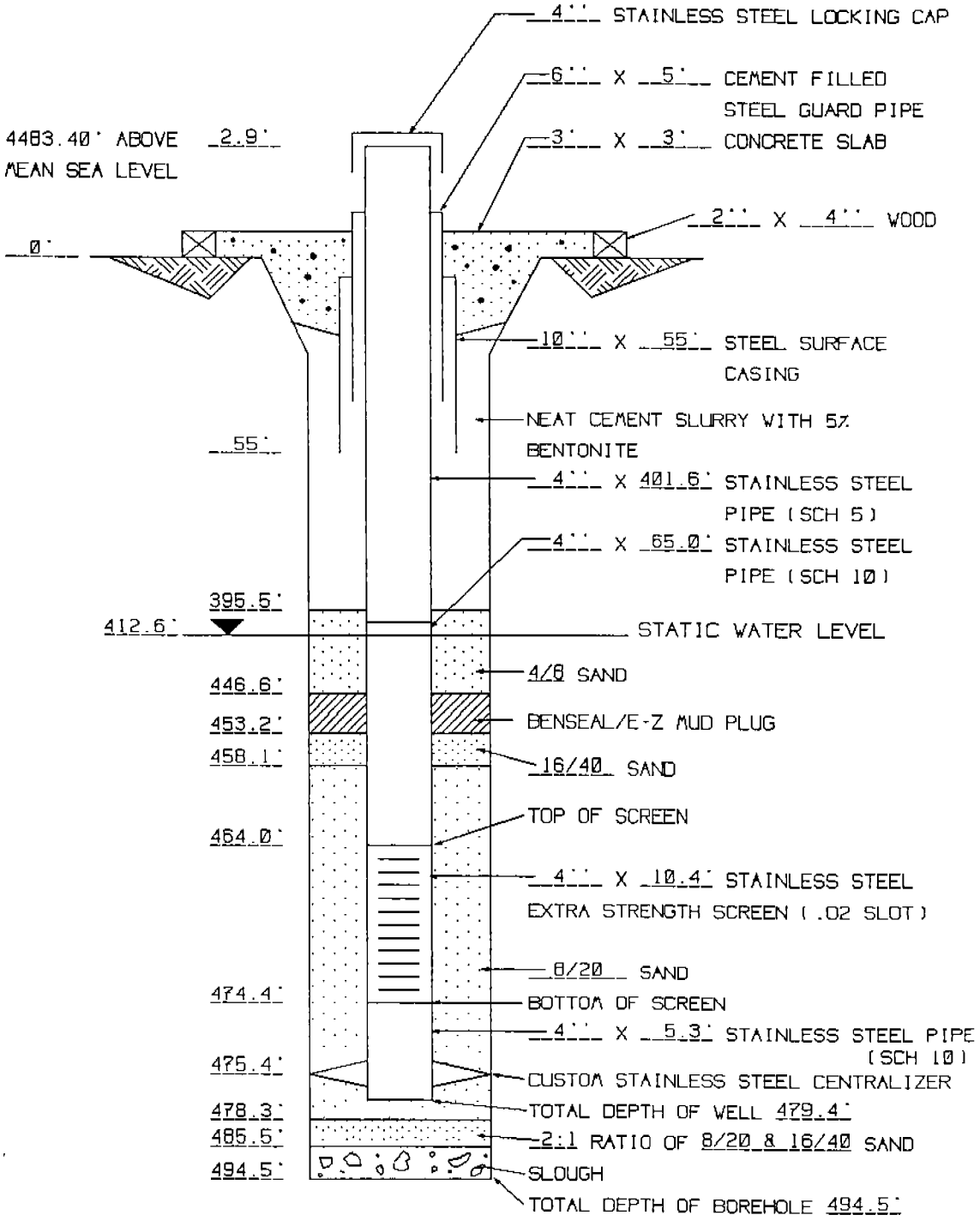


MONITOR WELL PL-2-504 COMPLETION DIAGRAM
(DETAIL)

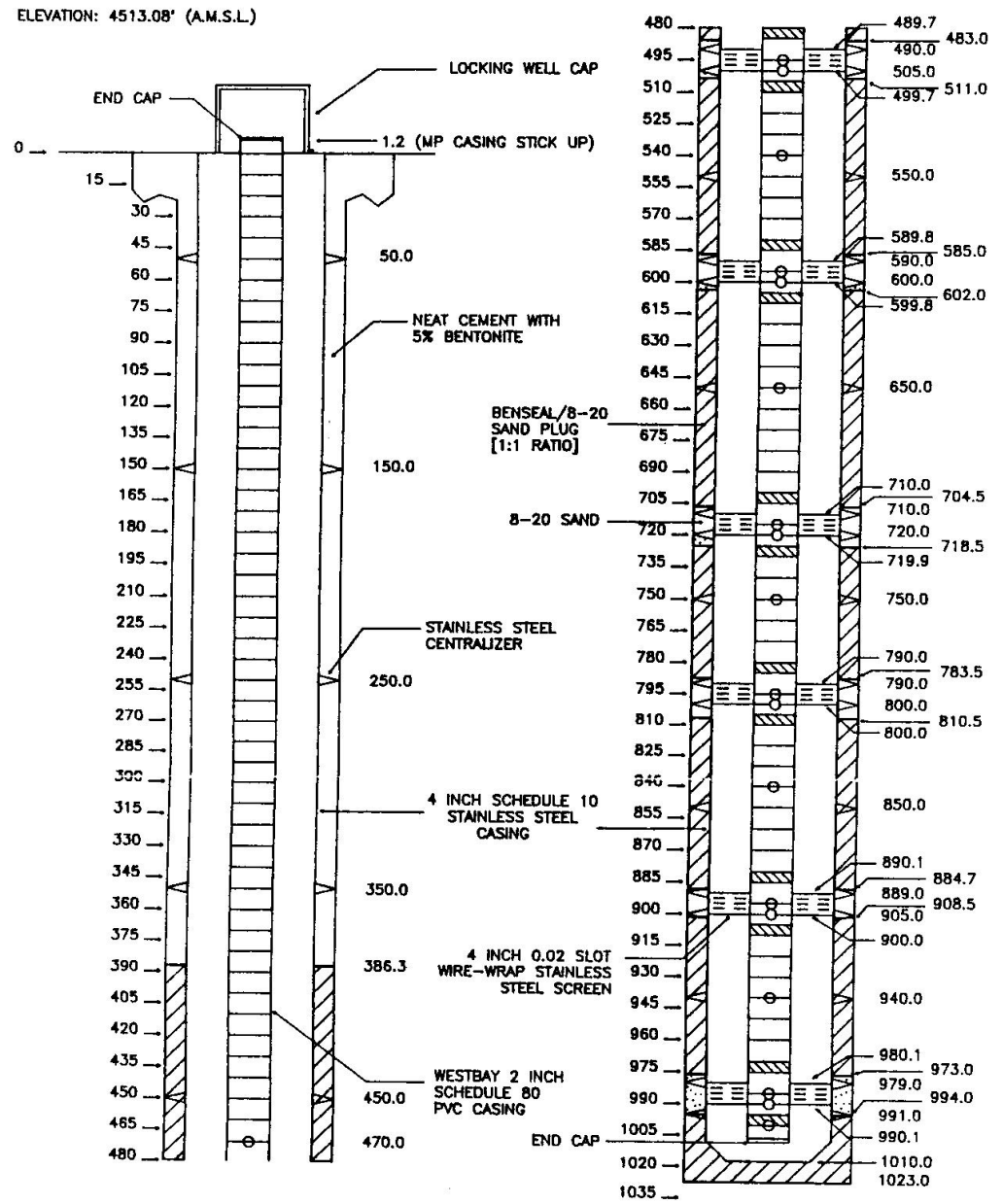

97.0'
102.0'
121.0'
123.1'
170.5'
172.8'
220.5'
222.9'
269.3'
284.2'
416.4'
Neat cement slurry with 5% bentonite
8/20 Sand
Bentonite Plug (Pellets)
8/20 Sand
Bentonite Plug (Pellets)
8/20 Sand
Bentonite Plug (Pellets)
8/20 Sand
Bentonite Plug (Pellets)
Neat cement slurry with 5% bentonite



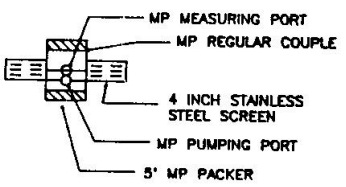
MONITOR WELL PL-3-453 COMPLETION DIAGRAM



MONITOR WELL PL-4-464 COMPLETION DIAGRAM

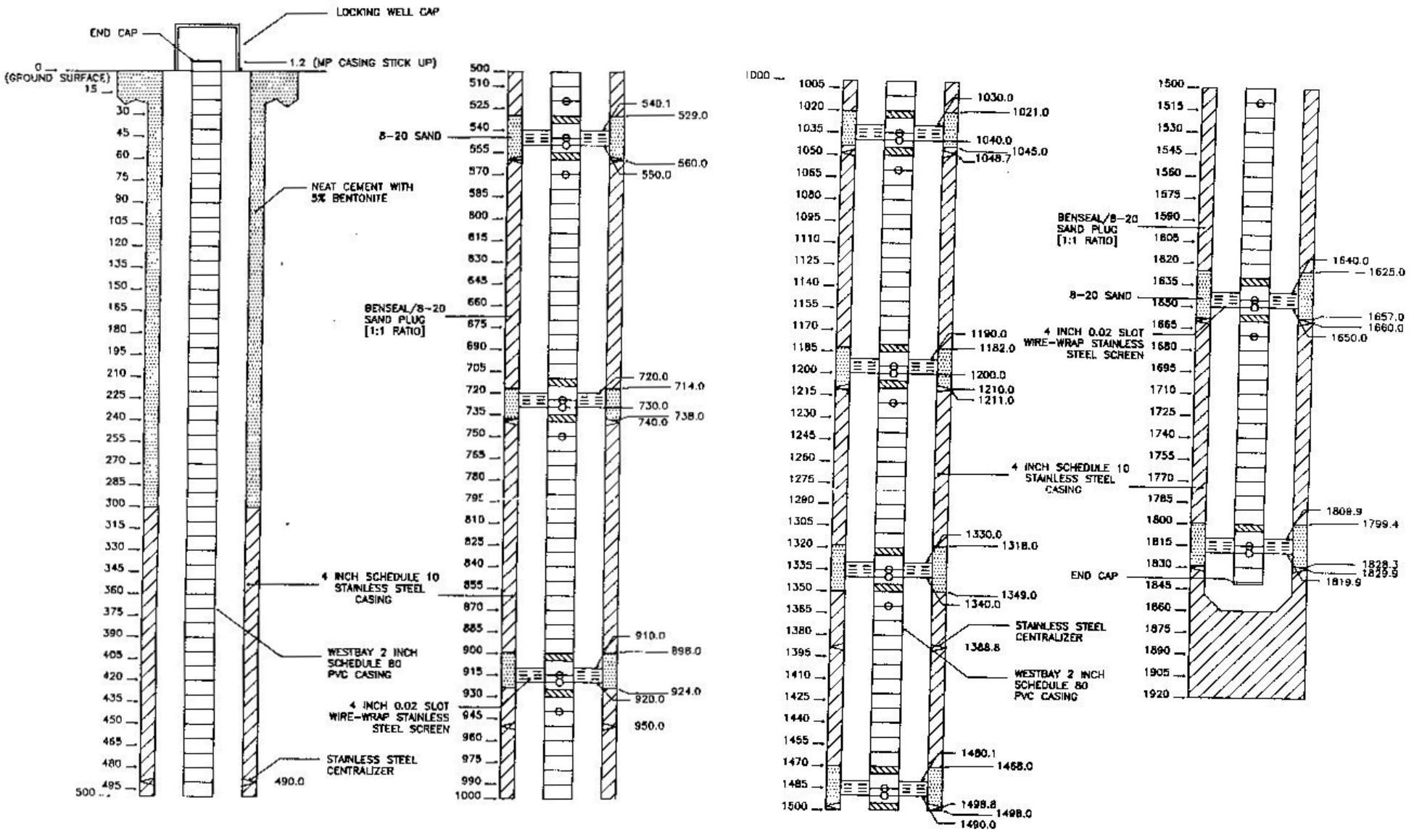


LEGEND

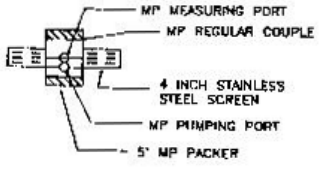


NOTE: ALL UNITS ARE IN FEET

Monitor Well PL-5 Completion Diagram

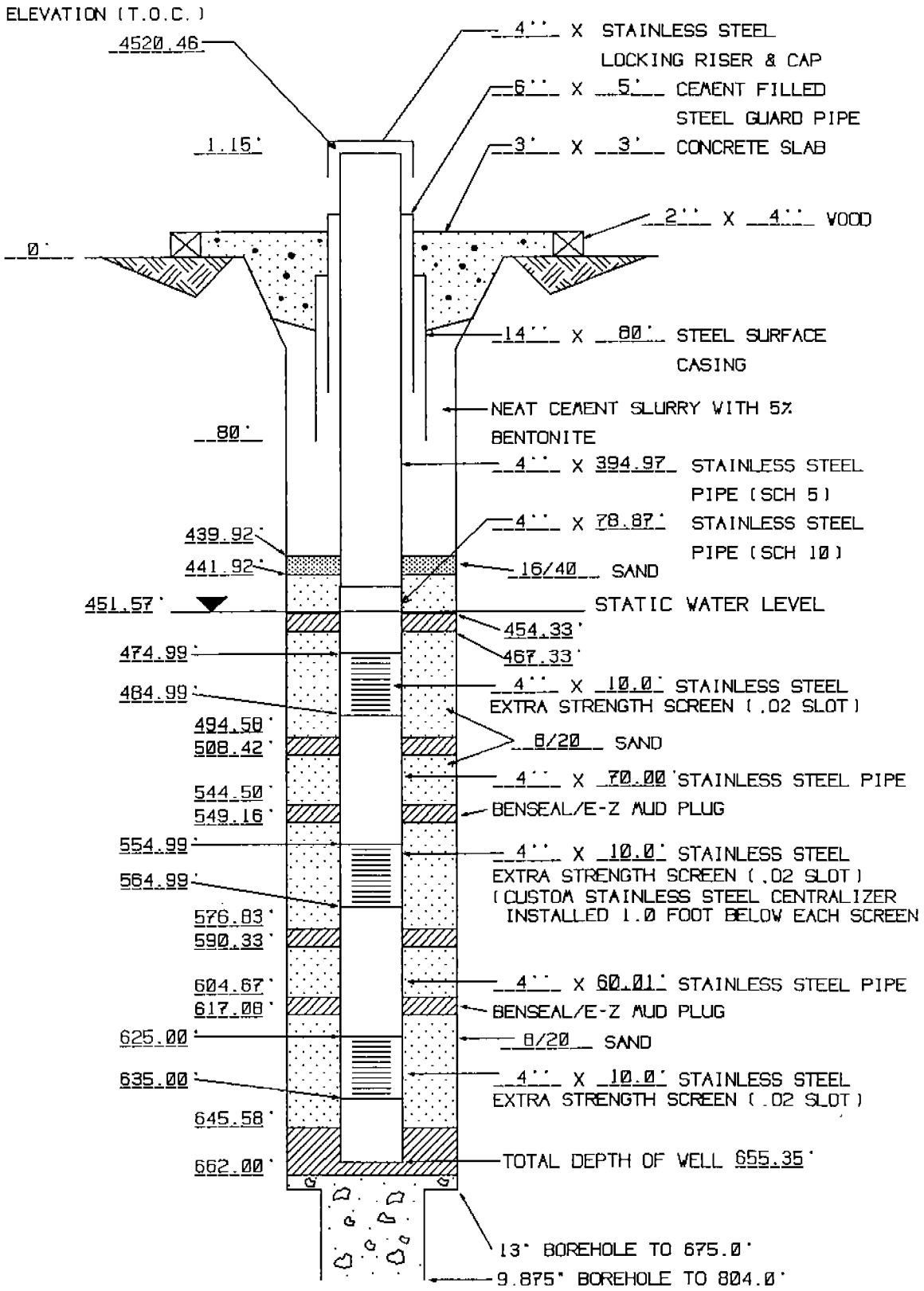


LEGEND

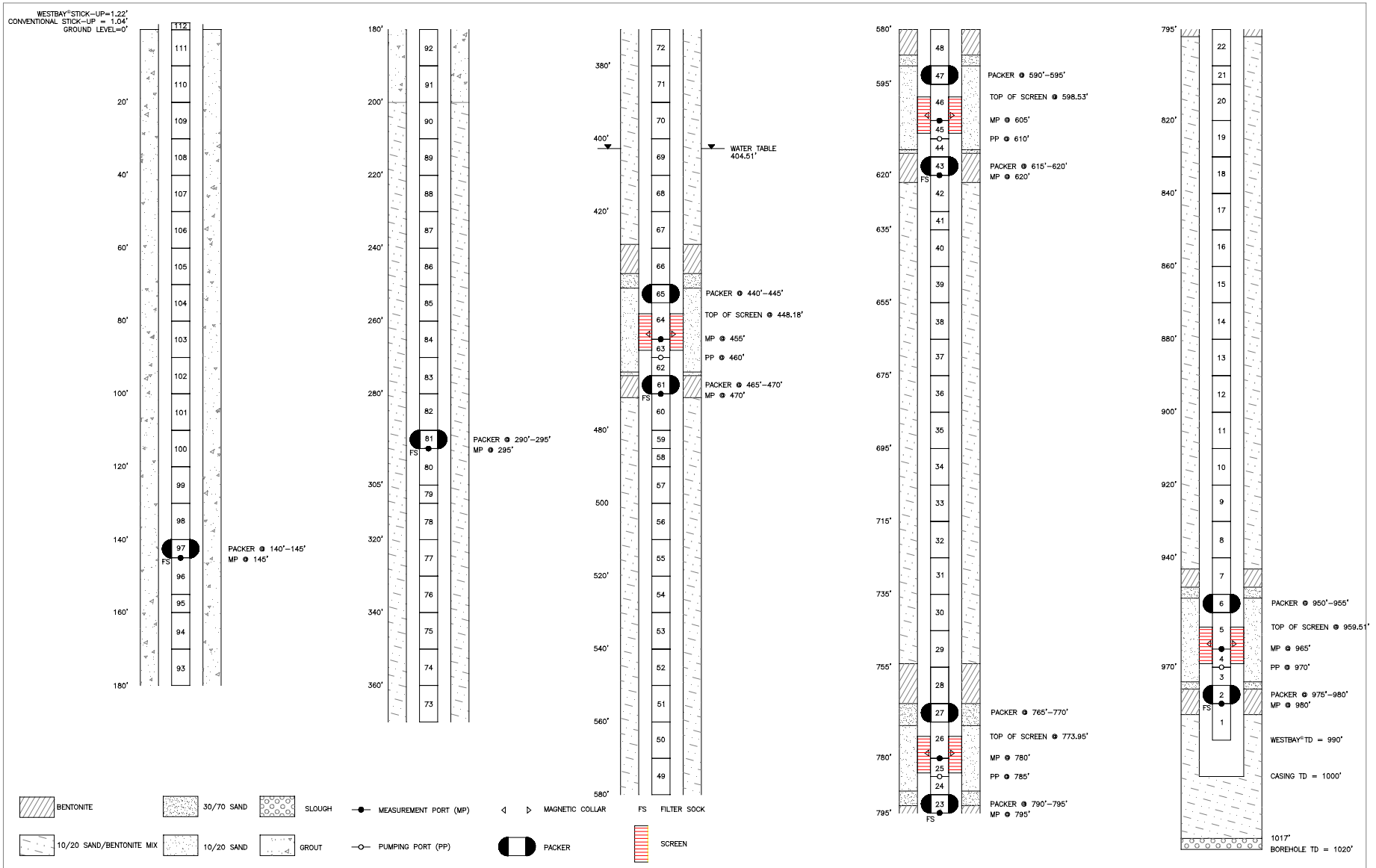


NOTE: ALL UNITS ARE IN FEET

Monitor Well PL-6-B Completion Diagram

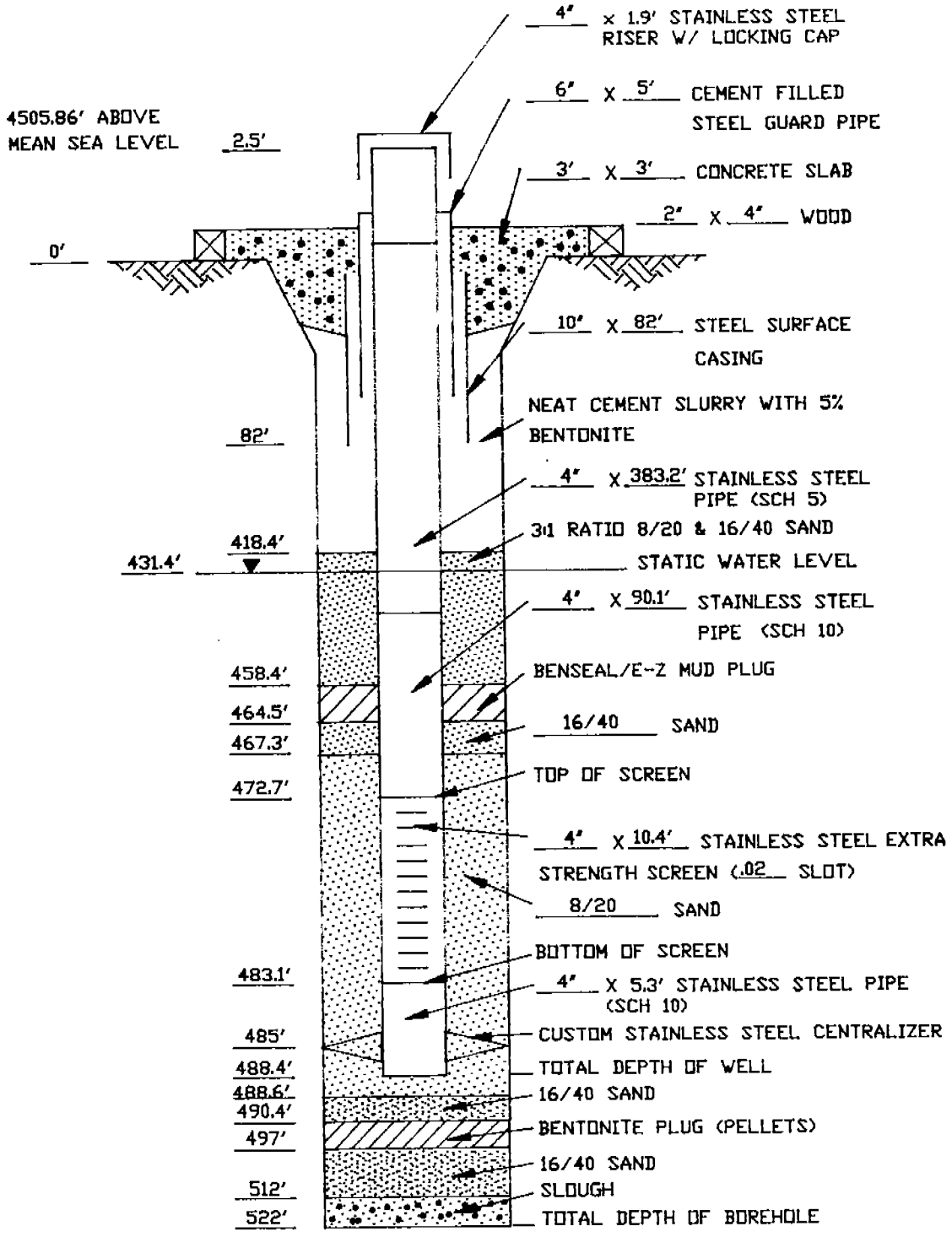


MONITOR WELL PL-7 COMPLETION DIAGRAM

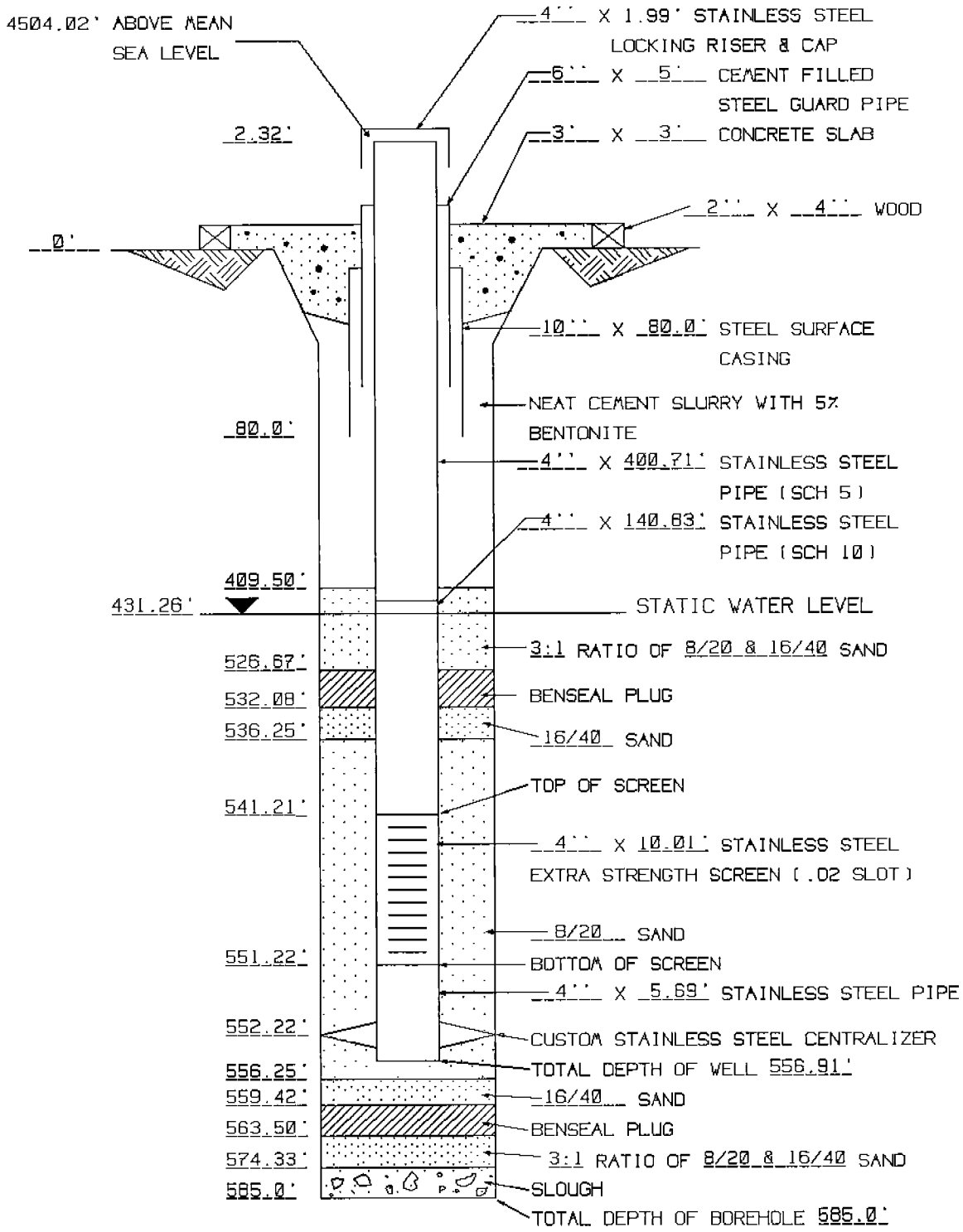


MONITOR WELL PL-8 COMPLETION DIAGRAM

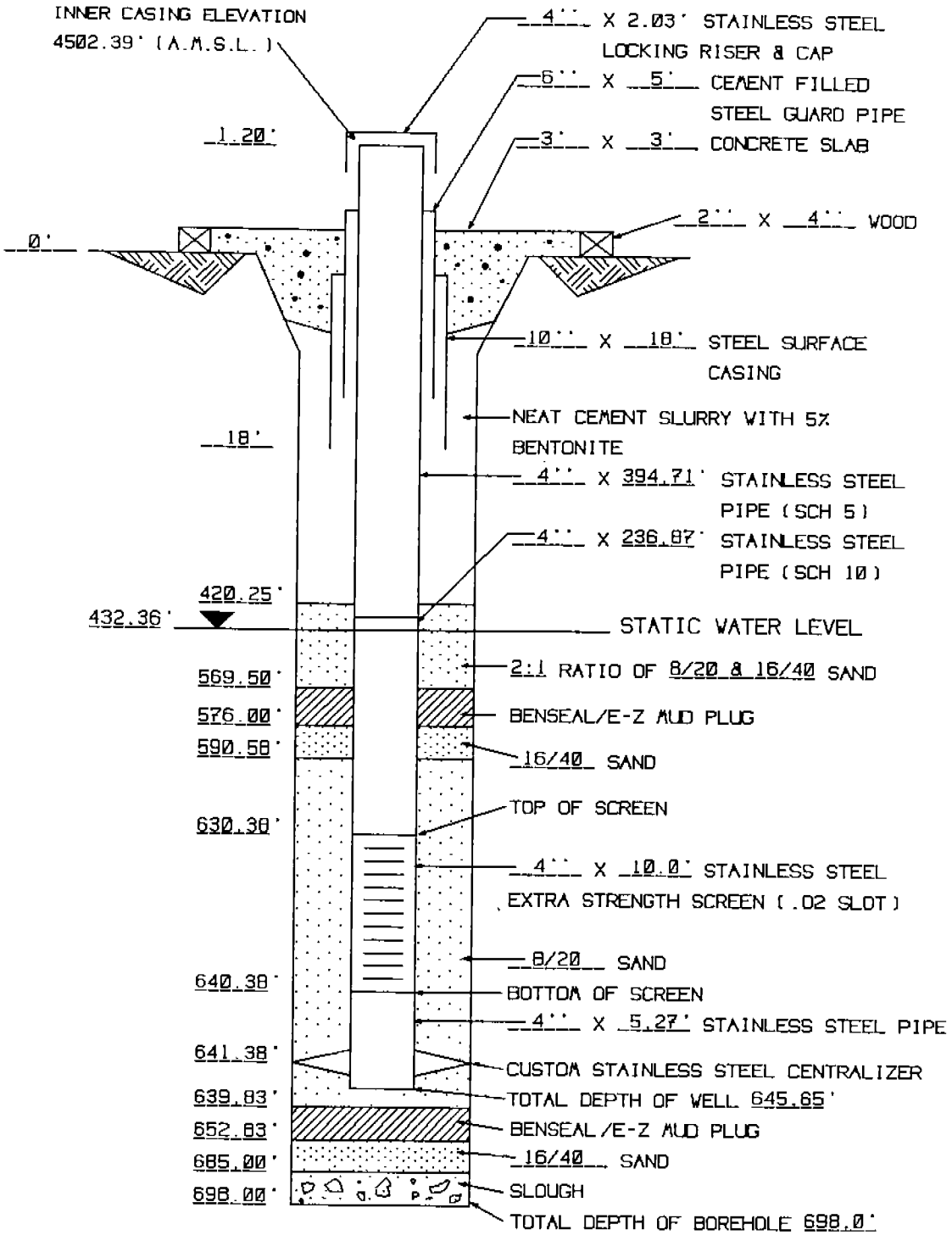
2890



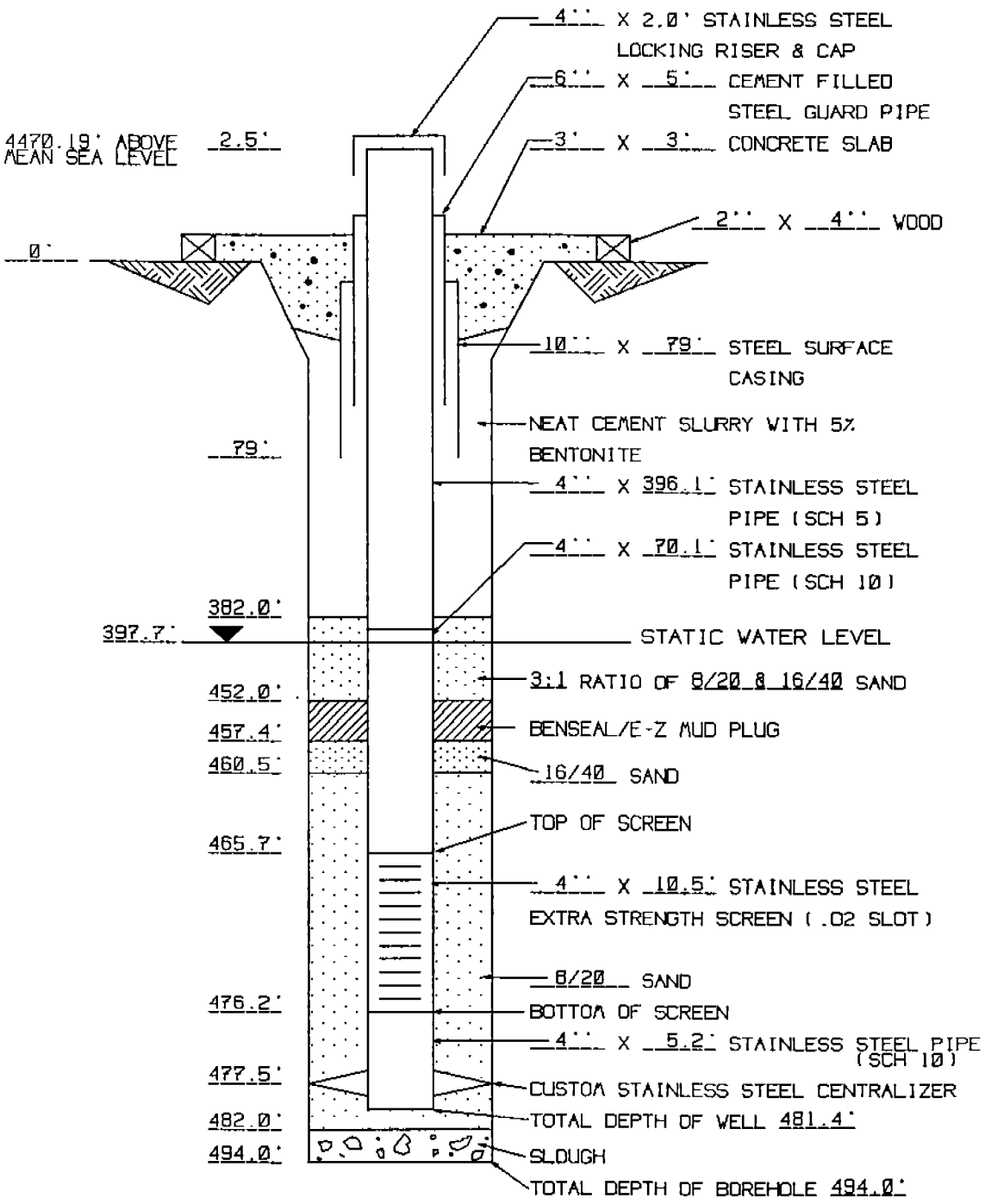
MONITOR WELL ST-1-473 COMPLETION DIAGRAM



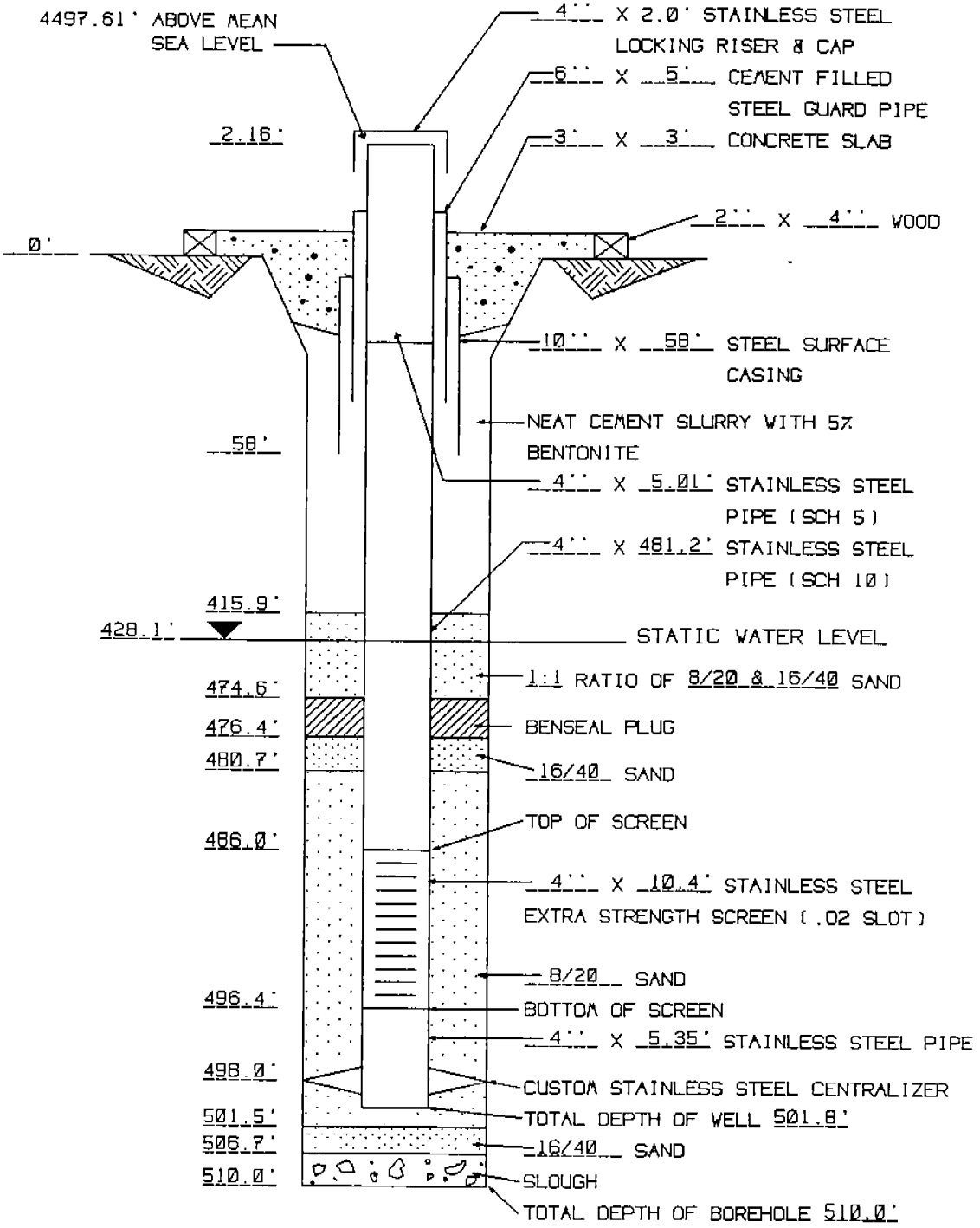
MONITOR WELL ST-1-541 COMPLETION DIAGRAM



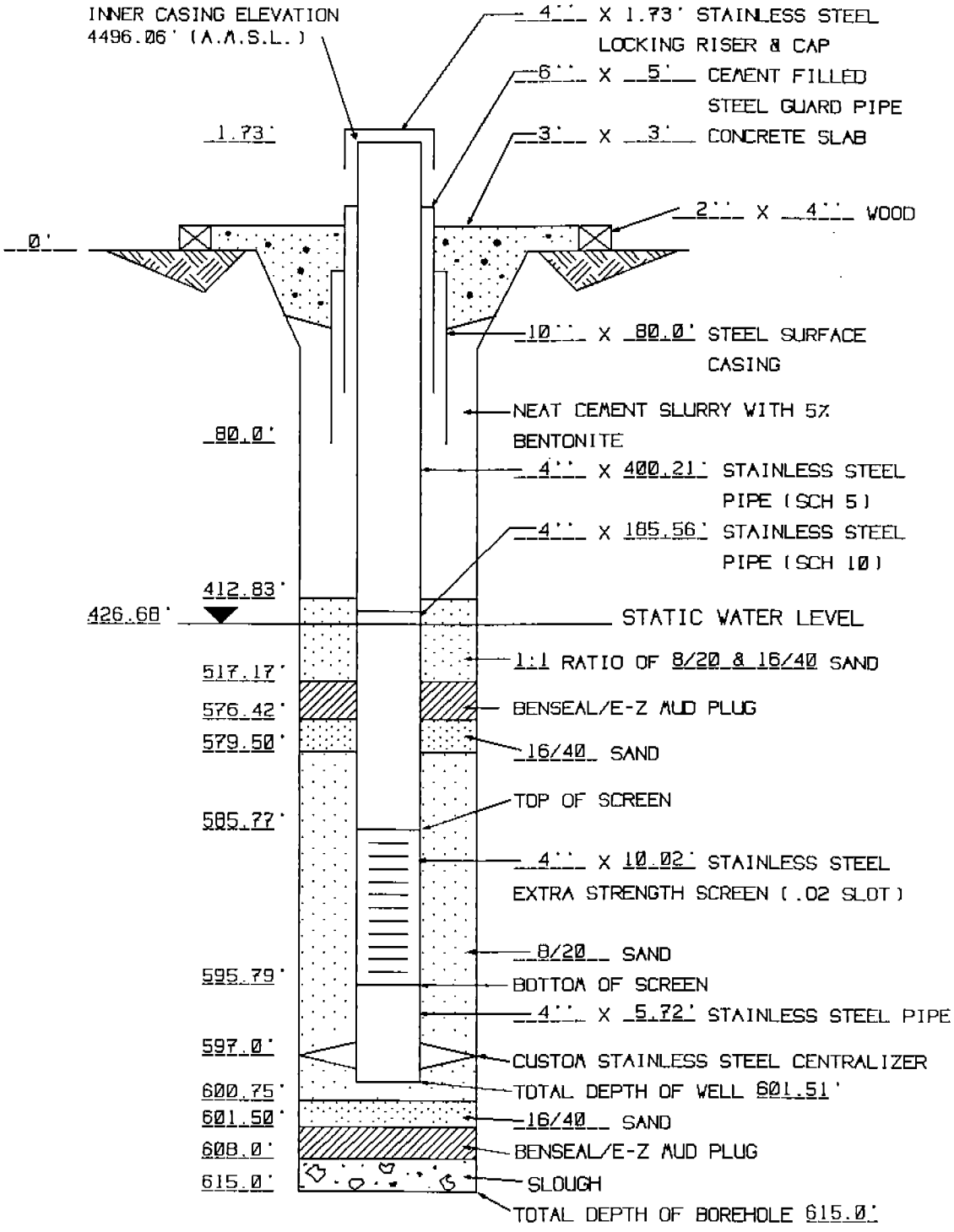
MONITOR WELL ST-1-630 COMPLETION DIAGRAM



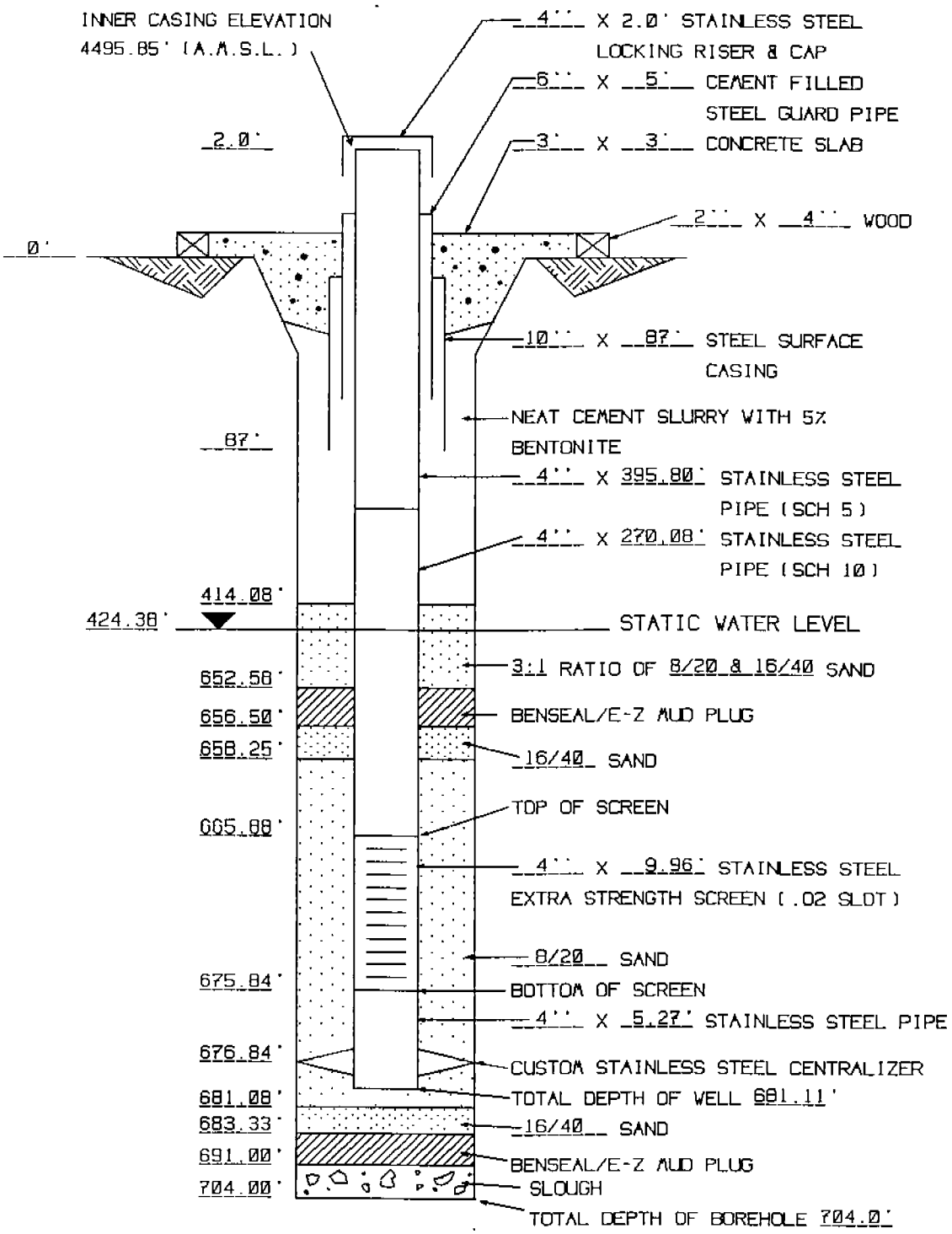
MONITOR WELL ST-2-466 COMPLETION DIAGRAM



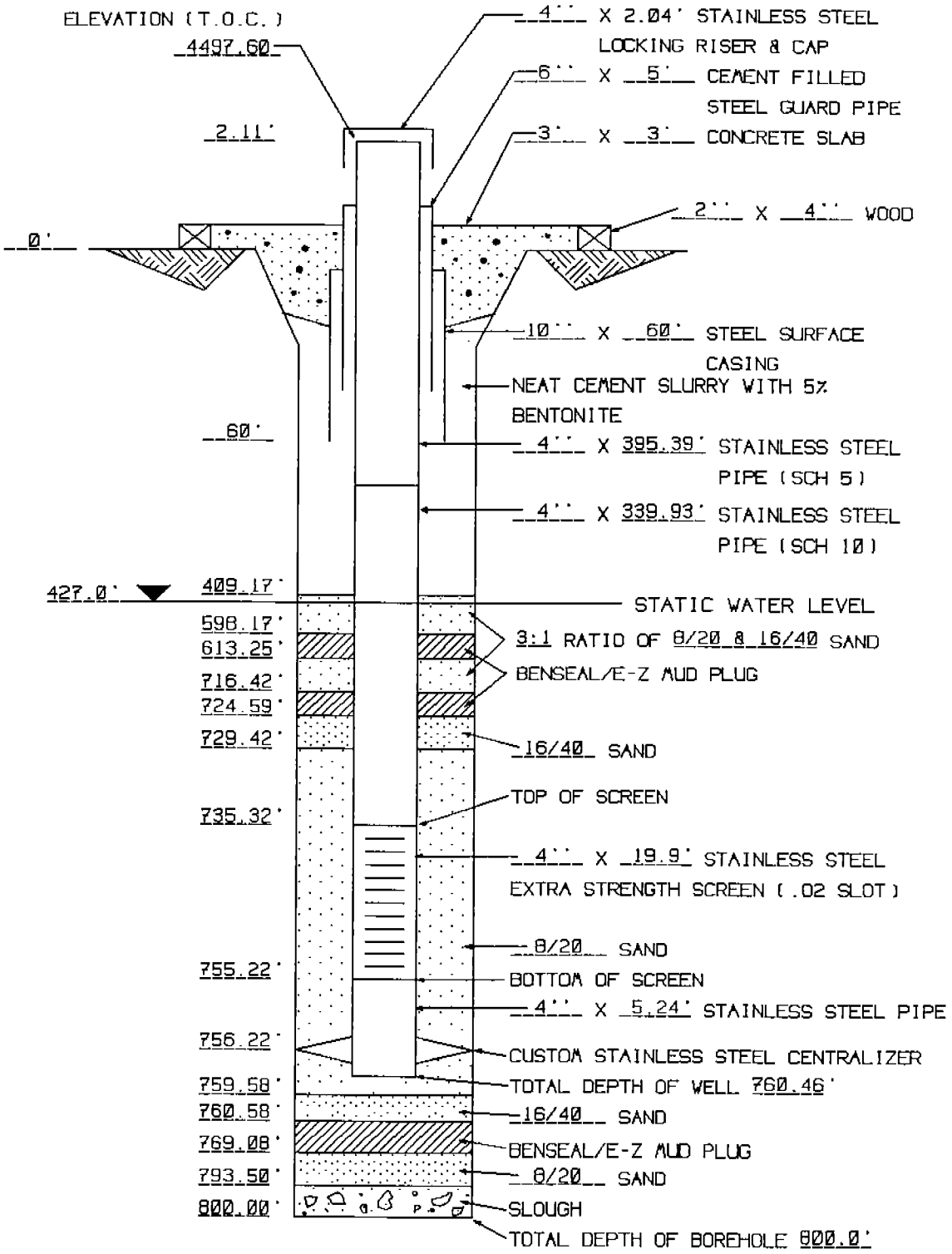
MONITOR WELL ST-3-486 COMPLETION DIAGRAM



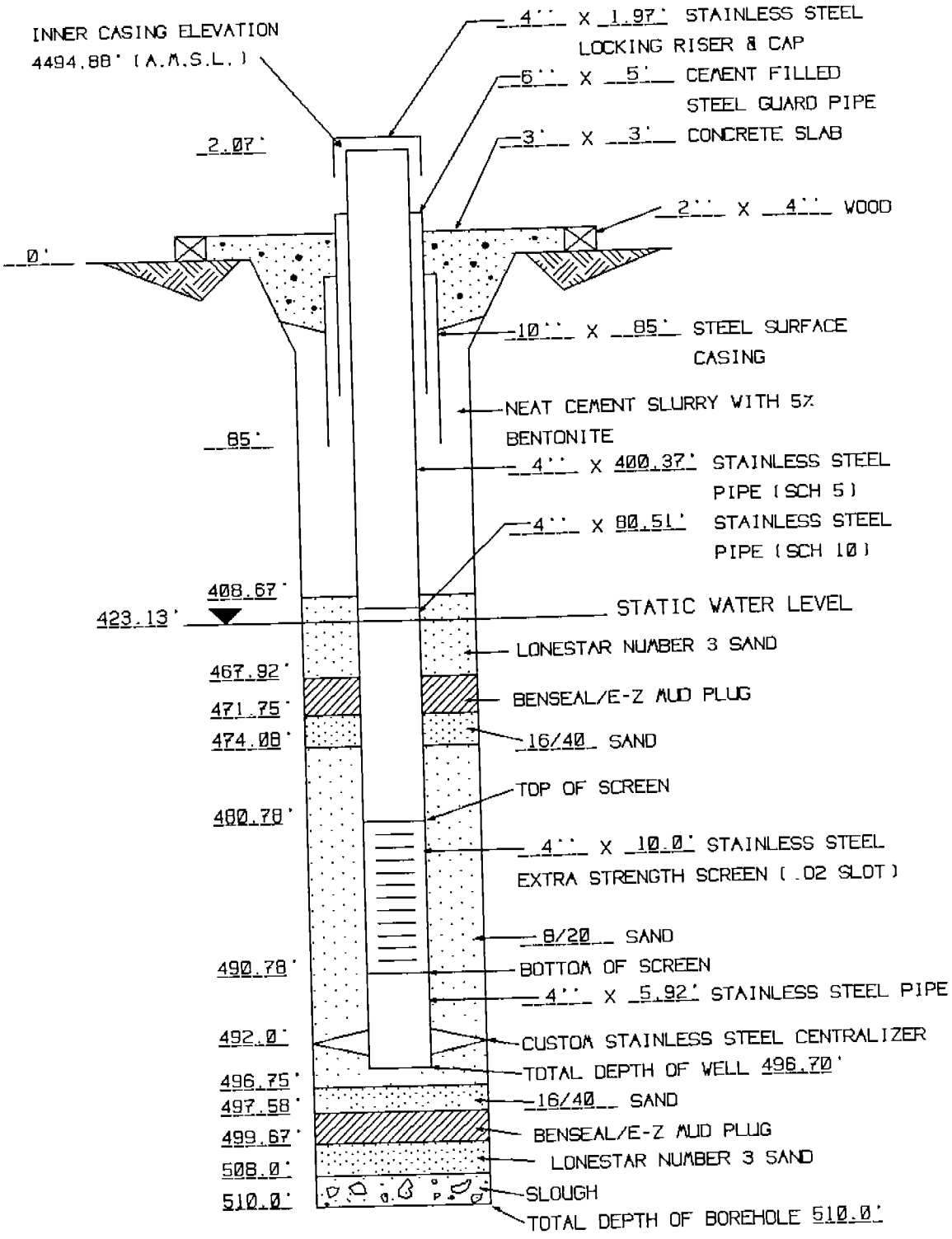
MONITOR WELL ST-3-586 COMPLETION DIAGRAM



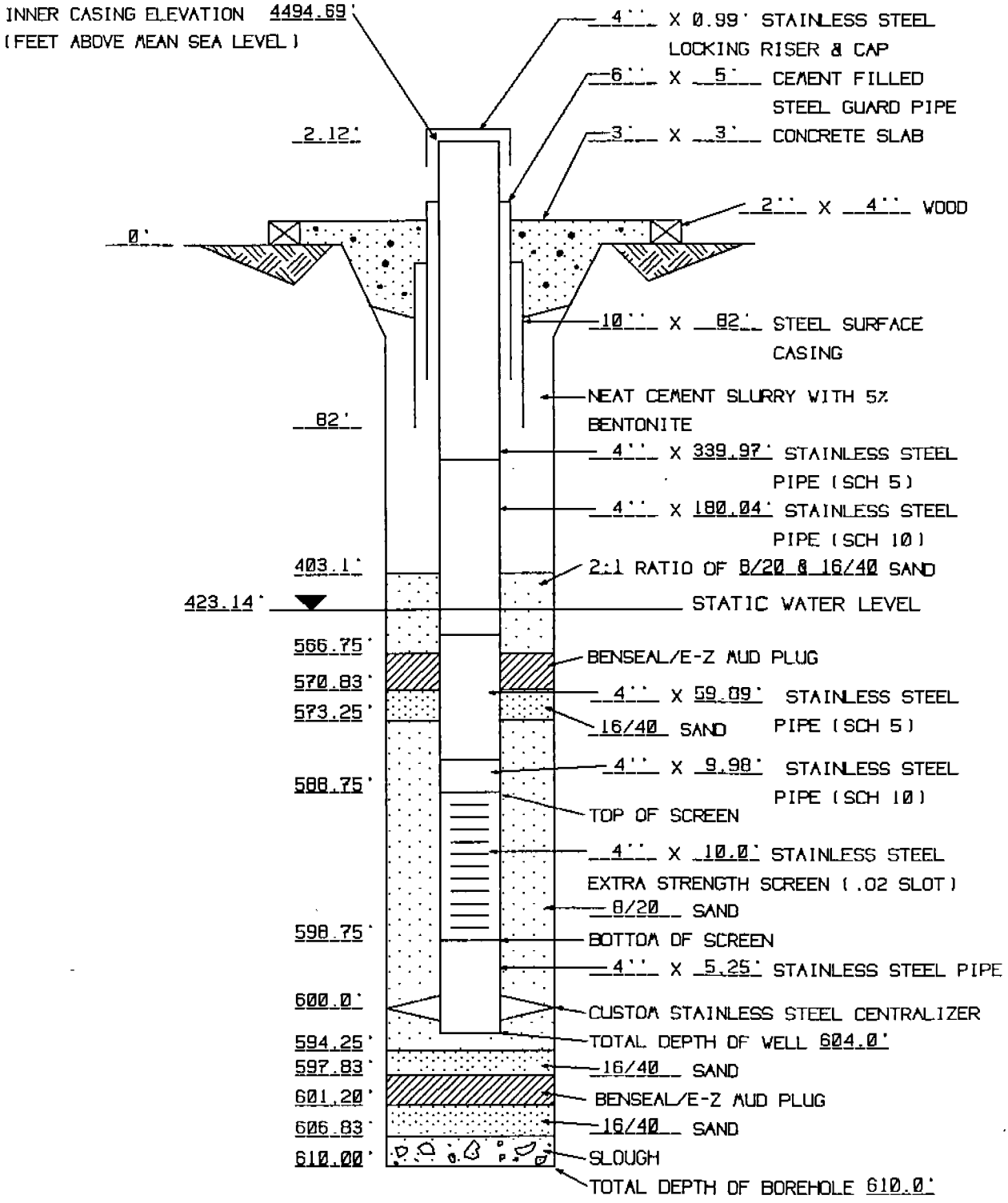
MONITOR WELL ST-3-666 COMPLETION DIAGRAM



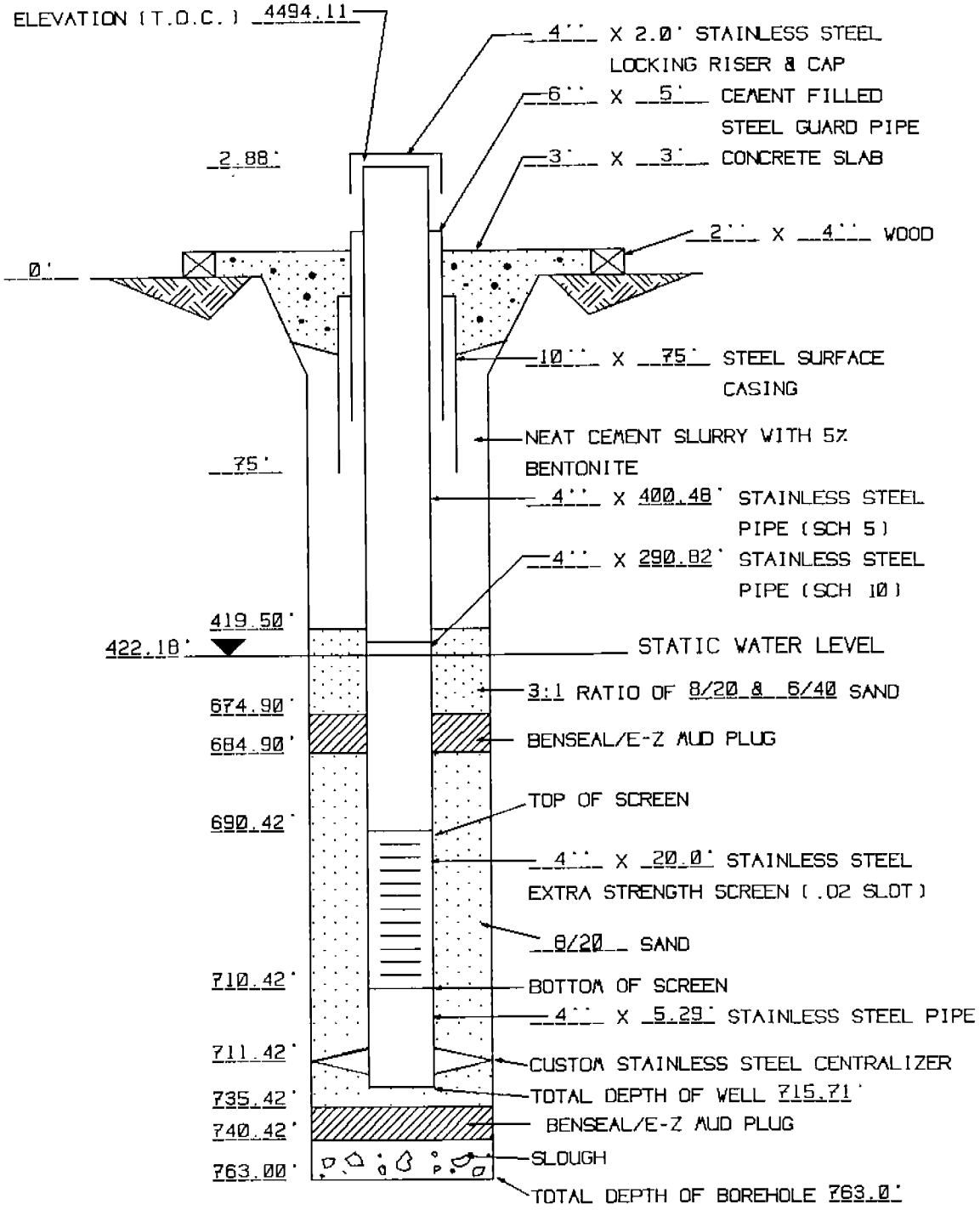
MONITOR WELL ST-3-735 COMPLETION DIAGRAM



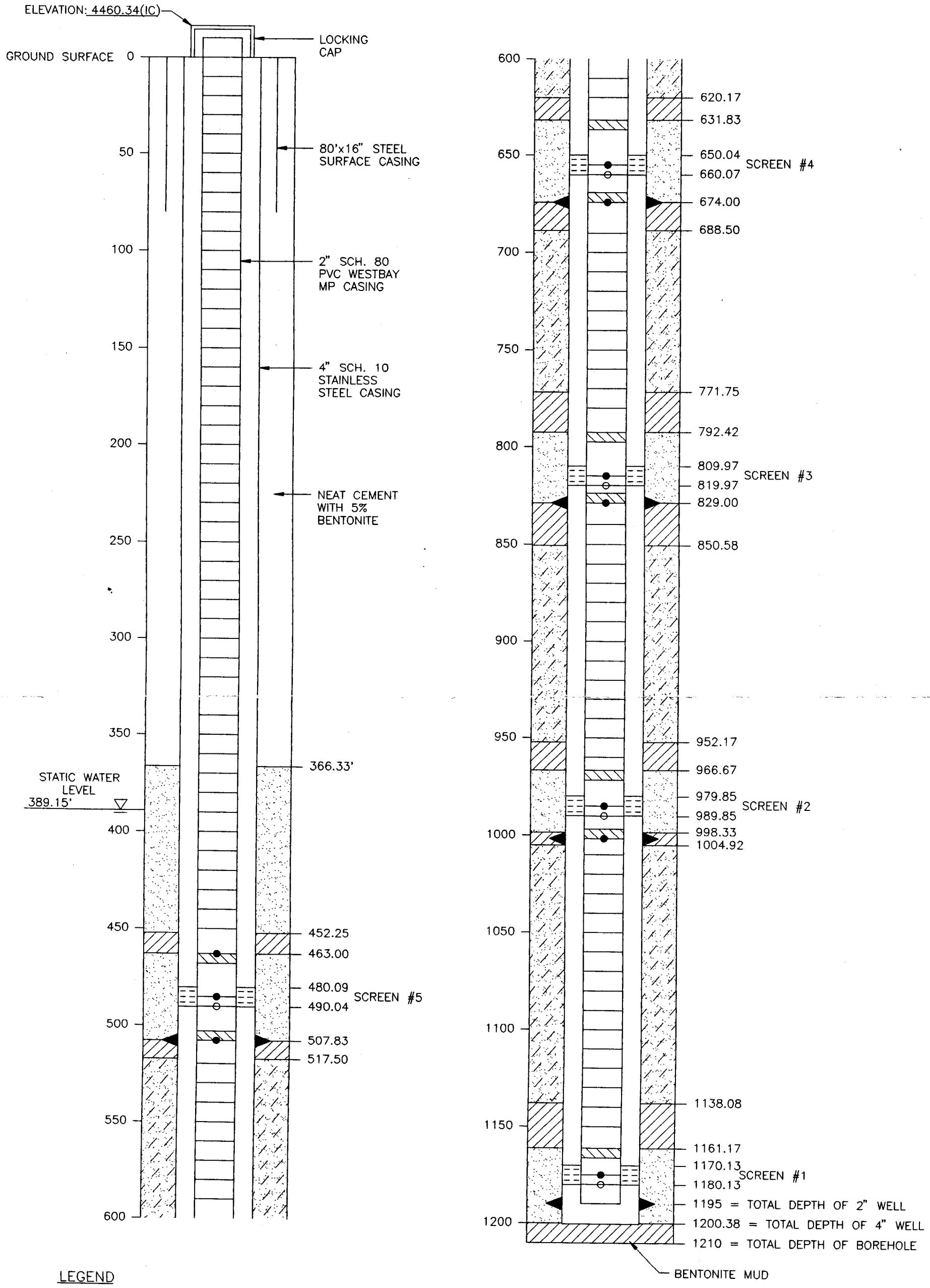
MONITOR WELL ST-4-481 COMPLETION DIAGRAM



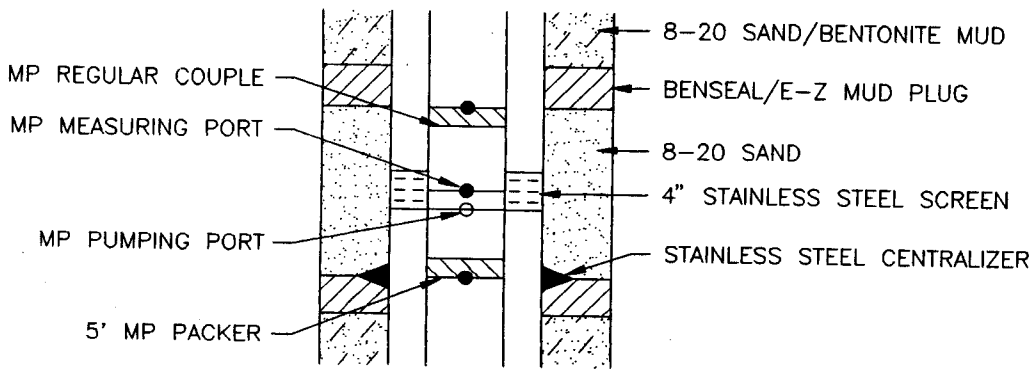
MONITOR WELL ST-4-589 COMPLETION



MONITOR WELL ST-4-690 COMPLETION DIAGRAM



LEGEND

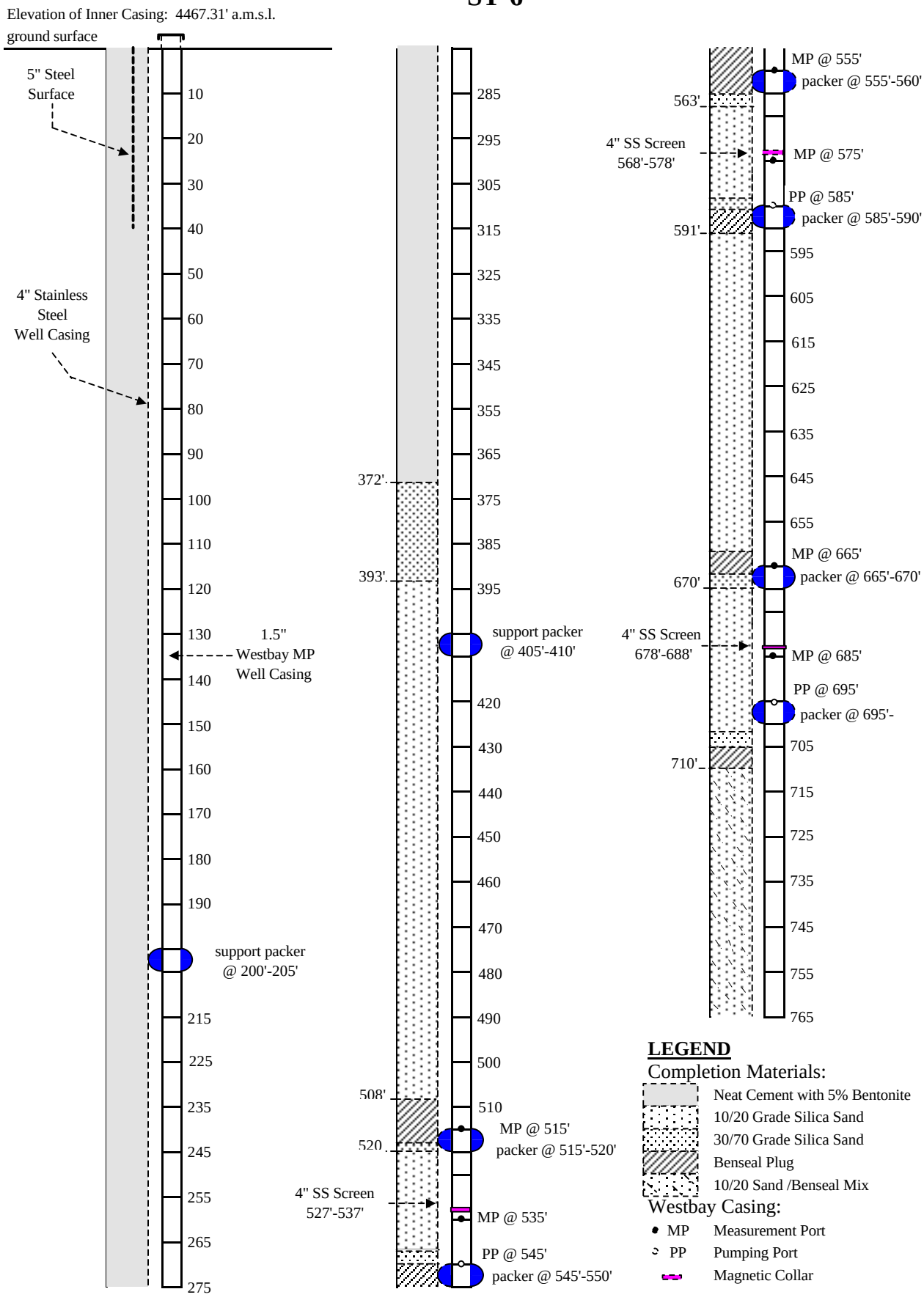


NOTE: ALL UNITS ARE FEET

ST-5-D WELL COMPLETION DIAGRAM

CLIENT: NASA-WSTF	
AUTHOR: PE	DATE: 5-27-93
DRAWN BY: JTN	REV. NO.: 1
CHECKED BY: PE	FILE: \NASA\ST-5-DCD.DWG

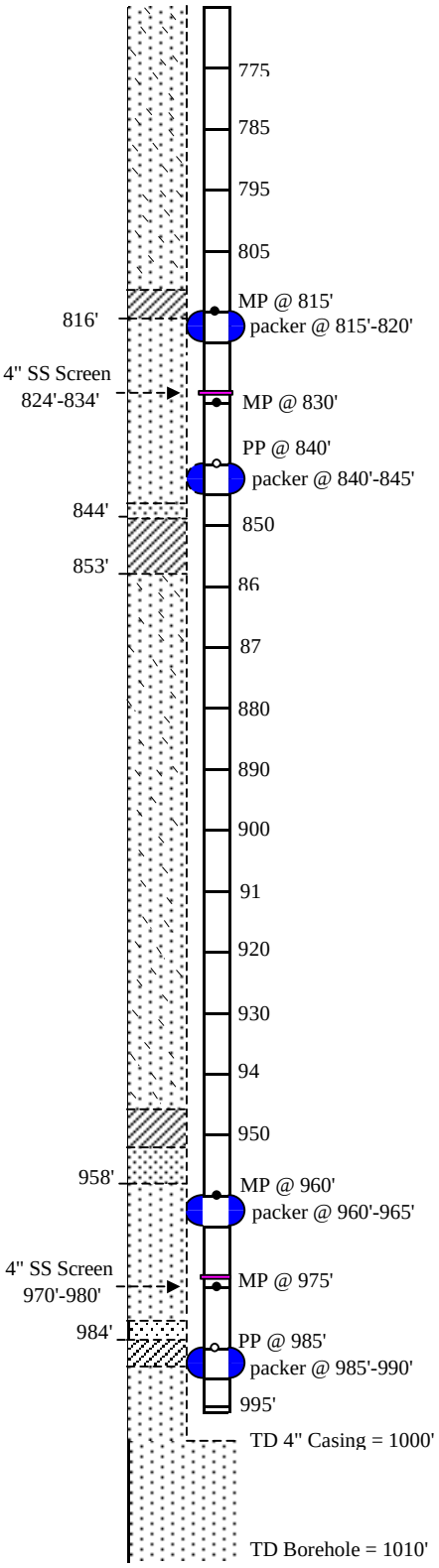
WESTBAY WELL COMPLETION DIAGRAM
ST-6



Installation Date: 10/5/97
Installed By: ATSC
Elevation (BC): 4465.72' a.m.s.l.

Drawn/Checked By: PSE/MGC
Borehole Depth: 1010'
MP Depth: 995'

WESTBAY WELL COMPLETION DIAGRAM
ST-6



LEGEND:

Completion Materials:

- Neat Cement with 5% Bentonite
- 10/20 Grade Silica Sand
- 30/70 Grade Silica Sand
- Benseal Plug
- 10/20 Sand and Benseal Mix

Westbay Casing:

- MP — Measurement Port
- PP — Pumping Port
- Magnetic Collar

NOTES:

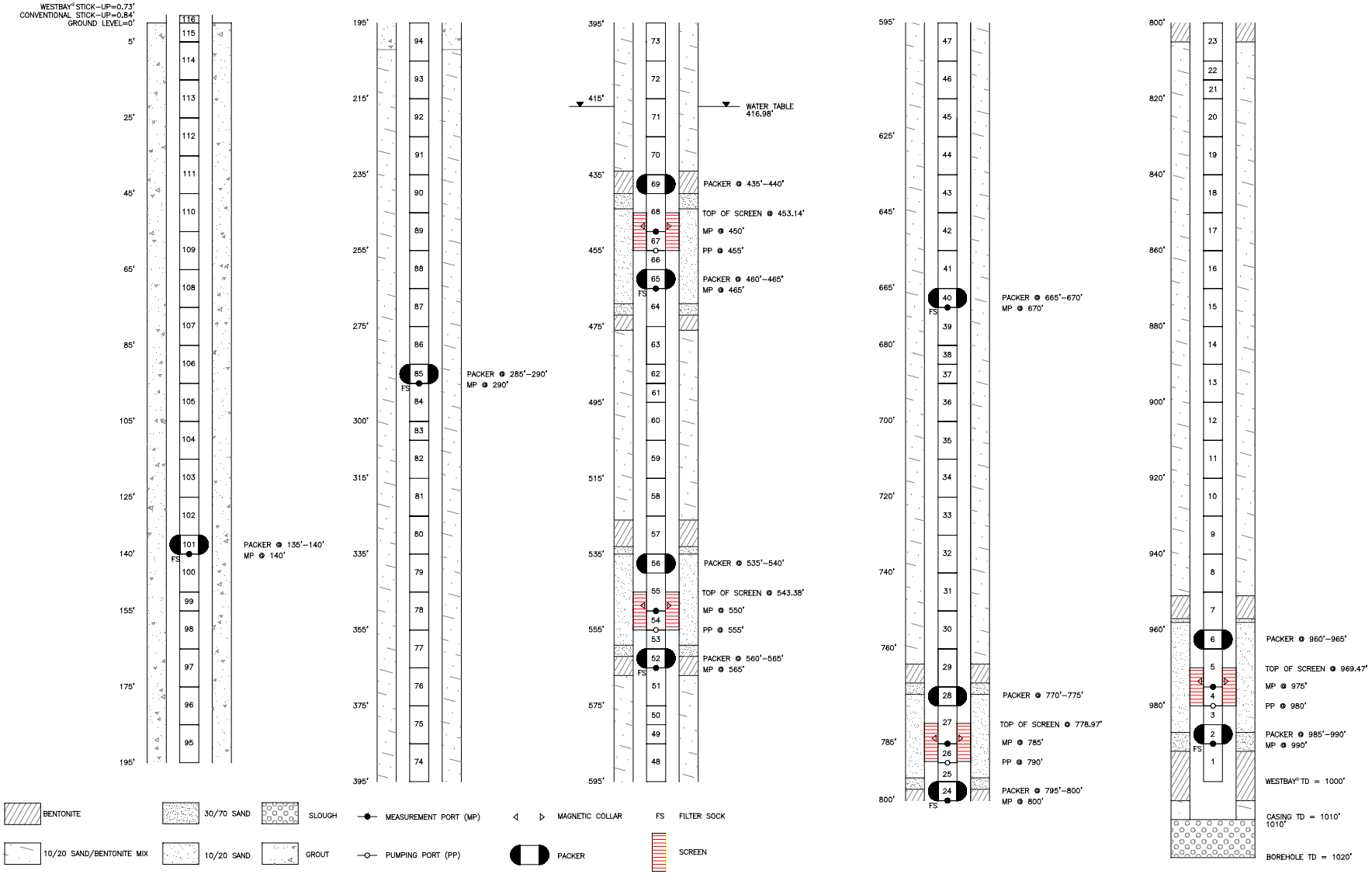
Westbay system is installed within 4" stainless steel casing

All MPs within sample zones have filter socks.

All couplings tested at @ 150 psi for one minute during installation

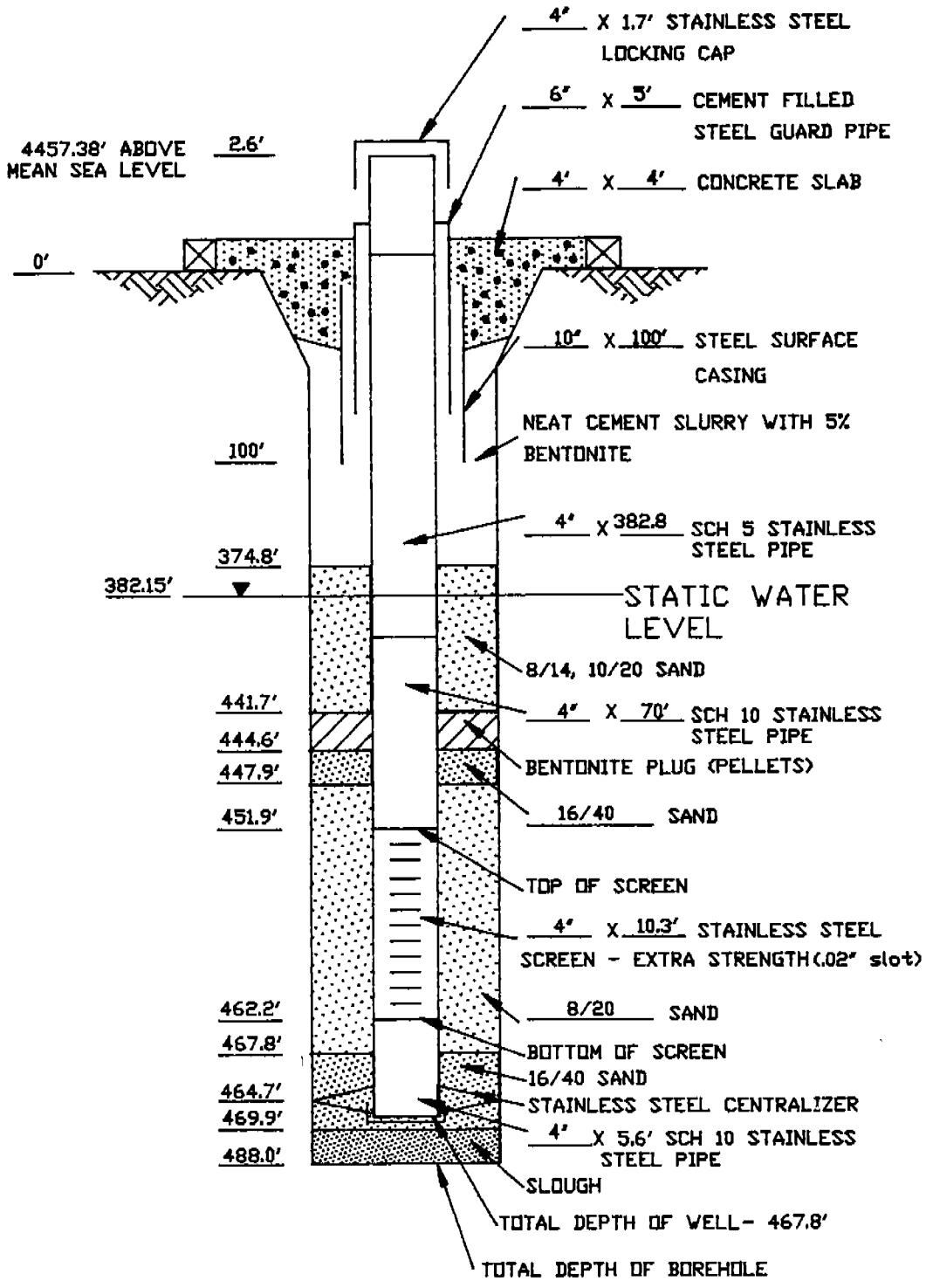
Installation Date: 10/5/97
Installed By: ATSC
Elevation (BC): 4465.72' a.m.s.l.

Drawn/Checked By: PSE/MGC
Borehole Depth: 1010'
MP Depth: 995'

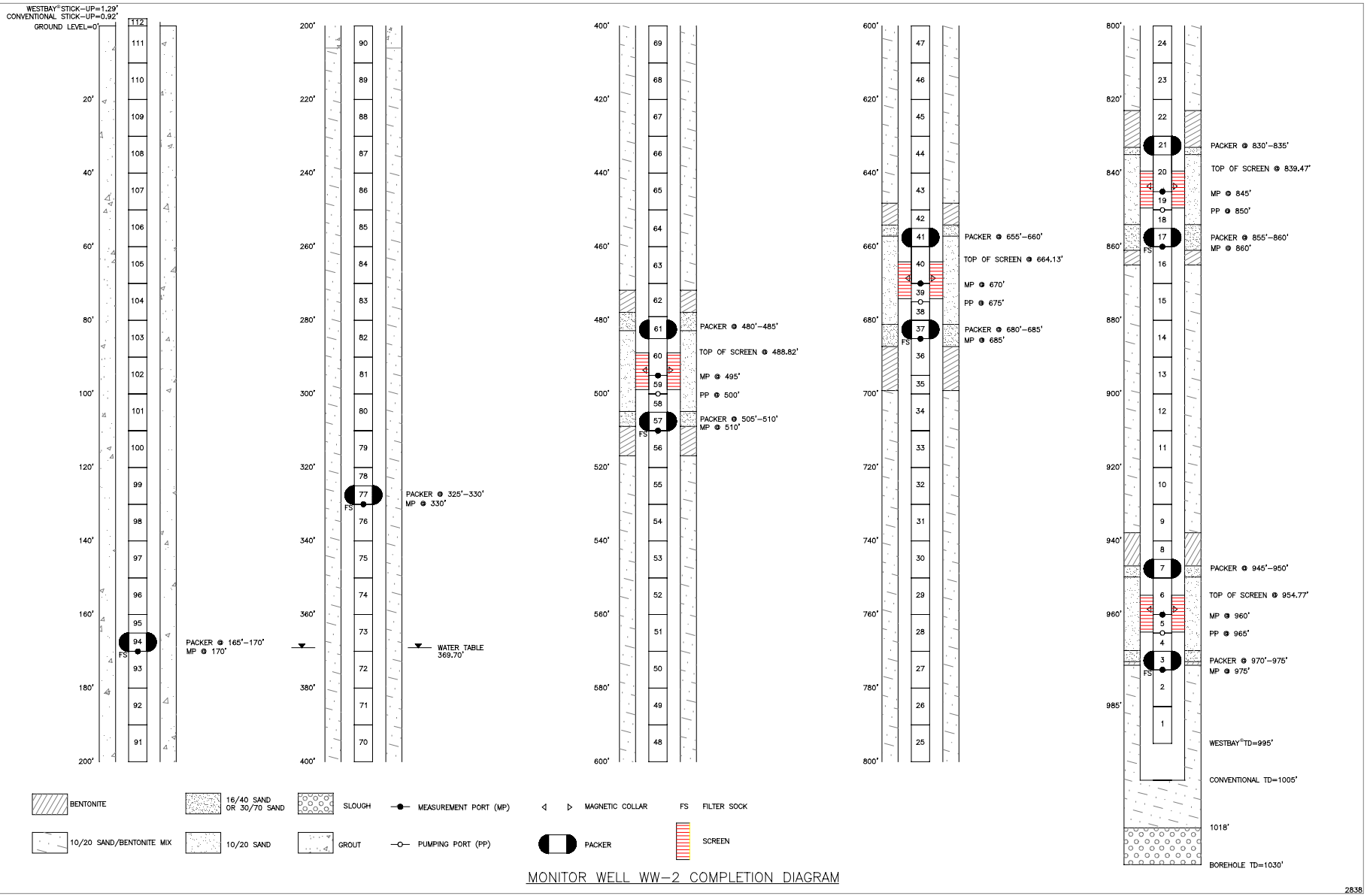


MONITOR WELL ST-7 COMPLETION DIAGRAM

2887

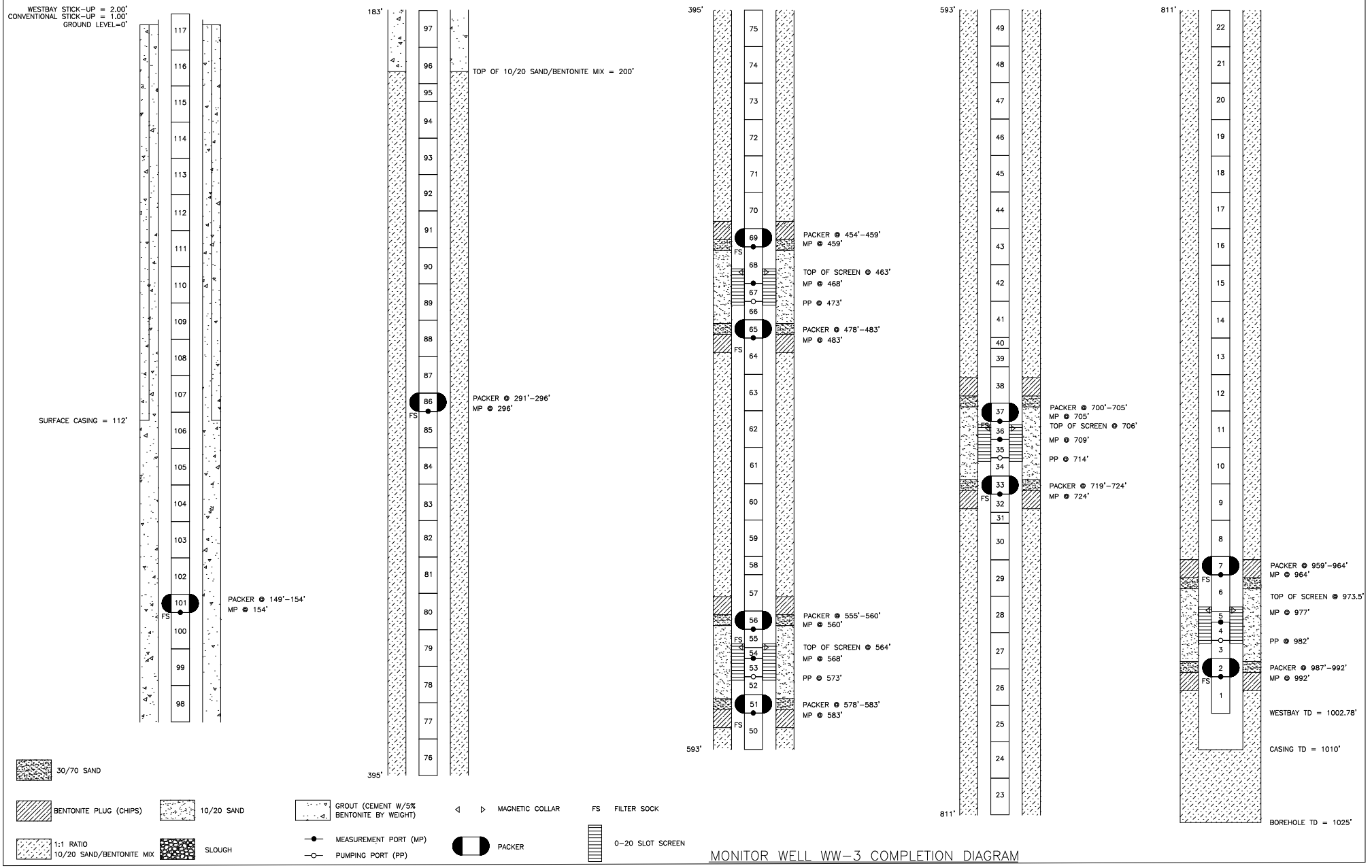


MONITOR WELL WW-1-452 COMPLETION DIAGRAM

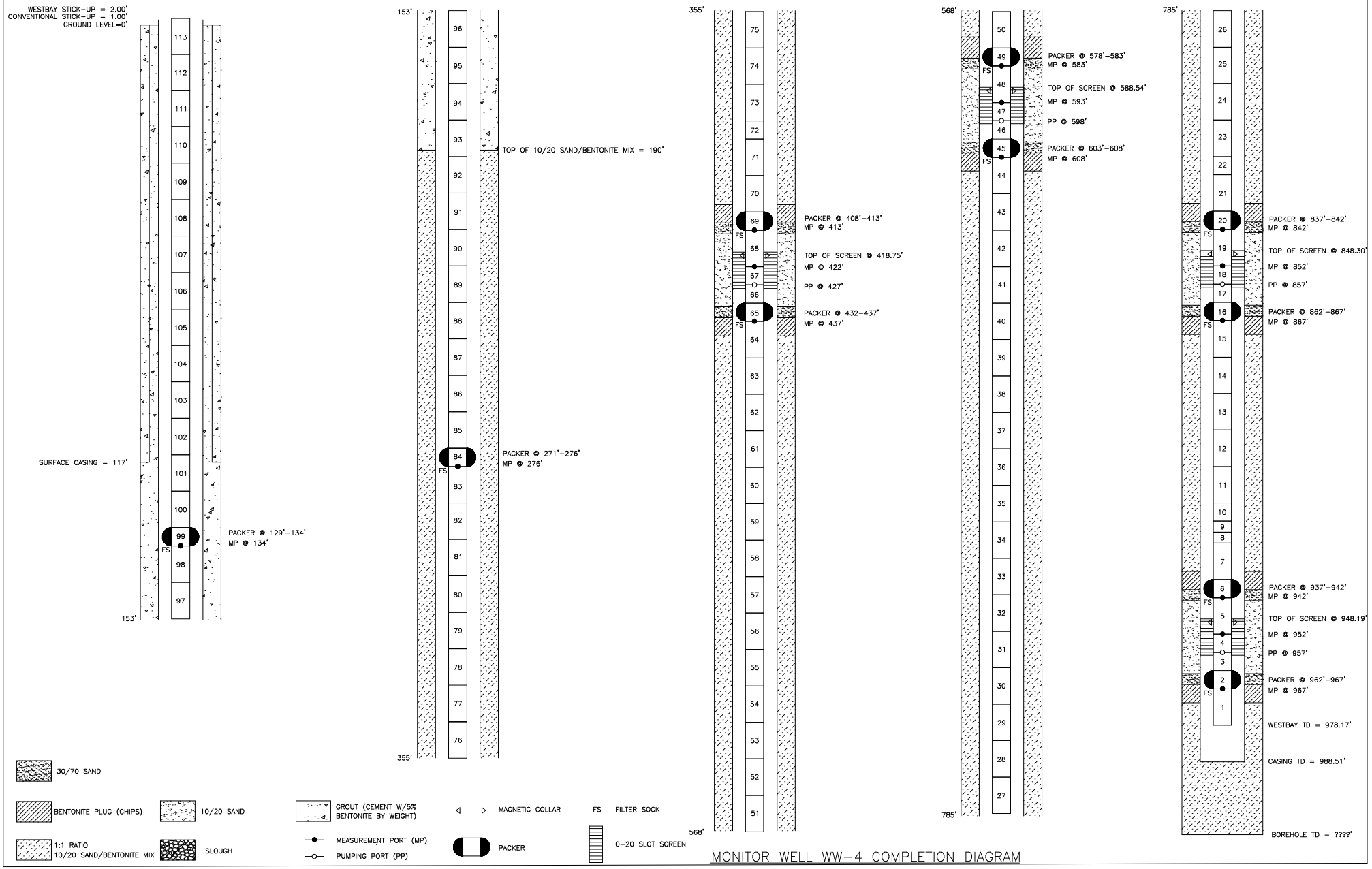


MONITOR WELL WW-2 COMPLETION DIAGRAM

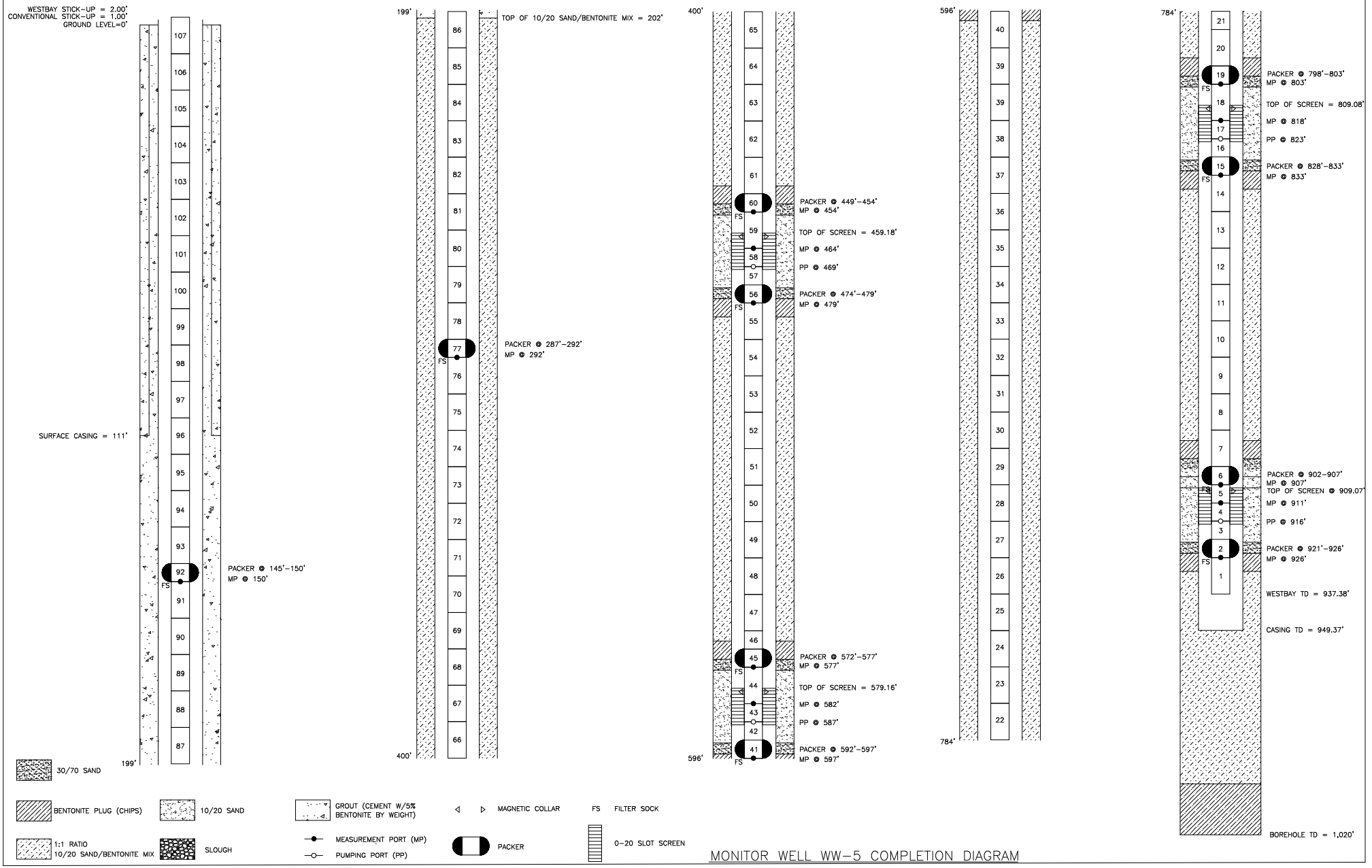
2838



MONITOR WELL WW-3 COMPLETION DIAGRAM



MONITOR WELL WW-4 COMPLETION DIAGRAM



MONITOR WELL WW-5 COMPLETION DIAGRAM

BLM-2-482.4 CORE INTERVAL DESCRIPTION
430'-440'

~ 2' CORE RECOVERY

Cobble to Boulder Conglomerate (?) (Santa Fe Group):

Core recovery was of cobble or boulder fragments of carbonates, rhyolite and andesite. Carbonate clasts are dark gray (N9) to light olive gray (5Y 5/2) micritic limestone which contains some fine crystalline sparry calcite and possible altered allochems.

Rhyolite clasts are very pale orange (10YR 8/6) to white (N9) which contain some iron staining.

Andesite clasts are light greenish gray (5G 8/1) and contain plagioclase and biotite phenocrysts ranging from 0.5 mm to 7 mm in size. Andesite cobbles are brecciated, clasts contain a higher plagioclase and biotite content in a finer-grained matrix. Due to the collapse of core barrel, a complete core could not be successfully recovered, and it is believed that these are cobbles or boulders out of a conglomerate even though no matrix was recovered.

BLM-2-482.4 CORE INTERVAL DESCRIPTION
490'-500'

- 3' CORE RECOVERY

Volcanic Litharenite:

Pale red purple (5RP 6/2) to grayish red purple (5RP 4/2), poorly sorted, weakly indurated, massive litharenite to pebble conglomerate. The rock is a grain supported, coarse-grained sandstone to pebble conglomerate which consists of 95% volcanic rock fragments and 5% carbonates, granite, quartz and calcite. Individual grains range from fine sand to pebble size (0.12 mm to 60 mm) and are moderately rounded to angular in shape. The rock is poorly sorted with large grains intermixed with sand size particles and tangential grain contacts are common. The average grain size is approximately 4 mm. The rock displayed some grade bedding of the clasts over short intervals, but it is poorly bedded to massive overall.

The rock is poorly to moderately indurated with a combination of silt and carbonate cement. The rock is soft and friable overall, however, thin well-cemented (carbonate cement) zones do exist. Carbonate-cement grain coatings are common.

Clasts are predominantly grayish red purple (5RP 4/2) to blackish red (5R 2/2) aphanitic to porphyritic andesite. Small (less than 1 mm) subhedral to euhedral phenocrysts of plagioclase and biotite are present within an aphanitic groundmass. Some severe alteration of the andesite clasts to a greenish gray (5G 8/1) color is observed in some fragments. Andesite rock fragments make up approximately 90% of the total lithic clasts. Pinkish gray (5YR 8/1) to moderate yellow (5Y 7/6), aphanitic rhyolite makes up approximately 5% of the rock fragments. Other lithic fragments observed include massive limestone, sandstone, granite, quartz and calcite.

Visual porosity of roughly 25% is present with voids up to 3 mm in size. Pore interconnection is estimated to be high and rock conductivity is likely to be high enough to transmit reasonable quantities of water.

CORE DESCRIPTION
PL-1-486
532'-537'

(3% Recovery, RQD does not apply)

Santa Fe Group:

Pale red (10R 6/2) dry, grayish red (5R 4/2) wet, poorly-sorted, moderately consolidated litharenitic pebble conglomerate. Clasts consist of subangular to subrounded andesite, limestone, sandstone and chert which range in size from fine-grained sand to pebbles up to 1-inch in diameter. Matrix is composed of silt, carbonate minerals, and clay (?). Clasts appear to be cemented with carbonate. Bedding is defined by 1-inch thick layers which are grain-supported and alternate with 1-inch thick layers which are matrix-supported. These beds may represent graded bedding, but the sample is too small to be certain. No fractures are present.

Visual porosity is estimated at 10% to 15%. This rock appears to be highly transmissive and permeable and will likely transmit large quantities of water.

Plume Front Conventional Monitoring Wells				
Well Name	Most Recent WL Date	Depth to Water (m)	Depth to Water (ft)	Groundwater Elevation
BLM-10-517	30-Jun-03	144.56	474.30	4061.51
BLM-17-493	30-Jun-03	144.18	473.05	4066.94
BLM-17-550	30-Jun-03	144.95	475.58	4064.72
BLM-2-482	30-Jun-03	144.64	474.56	4063.22
BLM-2-630	30-Jun-03	145.1	476.07	4061.47
JP-1-424	30-Jun-03	117.29	384.83	4063.14
JP-2-447	30-Jun-03	117.69	386.14	4063.14
PL-1-486	30-Jun-03	139.49	457.67	4062.68
PL-2-504	30-Jun-03	136.39	447.50	4062.82
PL-3-453	30-Jun-03	132.85	435.88	4063.35
PL-4-464	30-Jun-03	128.09	420.26	4063.16
ST-1-473	30-Jun-03	134.52	441.36	4064.53
ST-1-541	30-Jun-03	134.13	440.08	4063.97
ST-1-630	30-Jun-03	134.14	440.11	4062.3
ST-2-466	30-Jun-03	124.03	406.94	4063.27
ST-3-486	30-Jun-03	132.28	434.01	4063.63
ST-3-586	30-Jun-03	131.81	432.47	4063.62
ST-3-666	30-Jun-03	131.76	432.30	4063.57
ST-3-735	30-Jun-03	132.31	434.11	4063.52
ST-4-481	30-Jun-03	131.42	431.19	4063.72
ST-4-589	30-Jun-03	131.33	430.89	4063.82
ST-4-690	30-Jun-03	131.2	430.47	4063.67
WW-1-452	30-Jun-03	120.11	394.08	4063.29

Wellheads are in the process of being resurveyed.

Plume Front Westbay Monitoring Wells				
Well Name	Zone Depth (ft)	Most Recent WL Date	Water Depth (ft)*	Groundwater Elevation
* indicates that pressures have been converted to depths.				
BLM-37	490	05-May-03	483.49	4062.59
BLM-37	640	05-May-03	483.64	4062.44
BLM-37	750	05-May-03	483.89	4062.19
BLM-37	885	05-May-03	484.08	4062
JP-3	515	16-Jul-03	368.96	4064.58
JP-3	695	16-Jul-03	369.08	4064.46
JP-3	825	16-Jul-03	369.32	4064.22
JP-3	970	16-Jul-03	369.68	4063.86
PL-5	495	23-Jun-03	445.01	4067.59
PL-5	595	23-Jun-03	444.98	4067.62
PL-5	715	23-Jun-03	444.98	4067.62
PL-5	795	23-Jun-03	445.1	4067.5
PL-5	895	23-Jun-03	445.26	4067.34
PL-5	985	23-Jun-03	445.69	4066.91
PL-6	545	22-Jul-03	416.29	4065.17
PL-6	725	22-Jul-03	416.36	4065.1
PL-6	915	22-Jul-03	416.44	4065.02
PL-6	1035	22-Jul-03	416.48	4064.98
PL-6	1195	22-Jul-03	416.78	4064.68
PL-6	1335	22-Jul-03	417.15	4064.31
PL-6	1485	22-Jul-03	417.7	4063.76
PL-6	1645	22-Jul-03	418.41	4063.05
PL-6	1815	22-Jul-03	418.86	4062.6
PL-7	480	21-Apr-03	456.15	4062.97
PL-7	560	21-Apr-03	456.56	4062.56
PL-7	630	21-Apr-03	456.97	4062.15
PL-8	455	16-May-03	405.01	4064.62
PL-8	605	16-May-03	404.97	4064.66
PL-8	780	16-May-03	405.16	4064.47
PL-8	965	16-May-03	405.69	4063.94
PL-10	484	05-May-03	438.33	NA
PL-10	592	05-May-03	437.1	NA
PL-10	813	05-May-03	438.7	NA
PL-10	962	05-May-03	438.89	NA
ST-5	485	07-Jul-03	394.14	4064.6
ST-5	655	07-Jul-03	394.11	4064.63
ST-5	815	07-Jul-03	394.13	4064.61
ST-5	985	07-Jul-03	394.47	4064.27

Westbay Monitoring Well Static Water Levels

Well Name	Zone Depth (ft)	Most Recent WL Date	Water Depth (ft)*	Groundwater Elevation
ST-5	1175	07-Jul-03	395.15	4063.59
ST-6	535	10-Jul-03	401.94	4063.78
ST-6	575	10-Jul-03	401.96	4063.76
ST-6	685	10-Jul-03	402	4063.72
ST-6	830	10-Jul-03	402.06	4063.66
ST-6	975	10-Jul-03	402.47	4063.25
ST-7	450	06-May-03	416.89	4065.89
ST-7	550	06-May-03	416.94	4065.84
ST-7	785	06-May-03	417.29	4065.49
ST-7	975	06-May-03	417.51	4065.27
WW-2	495	25-Jun-03	372.48	4063.97
WW-2	670	25-Jun-03	372.67	4063.78
WW-2	845	25-Jun-03	372.66	4063.79
WW-2	960	25-Jun-03	373.1	4063.35
WW-3	469	05-Mar-03	380.78	NA
WW-3	569	05-Mar-03	381.1	NA
WW-3	710	05-Mar-03	381.62	NA
WW-3	978	05-Mar-03	383.32	NA
WW-4	423	02-Jul-03	376.54	NA
WW-4	594	02-Jul-03	377.16	NA
WW-4	853	02-Jul-03	377.75	NA
WW-4	953	02-Jul-03	378.24	NA
WW-5	464	13-May-03	358	NA
WW-5	582	13-May-03	377.11	NA
WW-5	814	13-May-03	378.38	NA
WW-5	912	13-May-03	378.39	NA

NA - GPS survey pending.

Groundwater Flow Rates (Conventional Monitor Wells)

Well Name	Screen Zone (ft)	K (ft/sec)
200-B-240	240-250	7.4×10^{-5}
200-D-240	240-250	9.6×10^{-5}
300 A-170	170-175.5	3.1×10^{-6}
300-B-166	166-176	3.1×10^{-5}
300- D-153	153-173	3.0×10^{-6}
400-C-143	143-153	6.0×10^{-5}
600-C-437	437-447	5.7×10^{-6}
BLM-1-435	435-445	9.7×10^{-8}
BLM-2-482	482-492	6.6×10^{-4}
BLM-2-630	630-640	3.0×10^{-4}
BLM-5-527	527-537	7.4×10^{-4}
BLM-5-527	527-537	2.2 x 10-4
BLM-6-488	488-498	2.8×10^{-5}
BLM-6-488	488-498	3.2×10^{-5}
BLM-7-509	509-519	3.3×10^{-4}
BLM-8-418	418-428	4.2×10^{-4}
BLM-9-419	419-439	2.1×10^{-7}
BLM-10-517	517-527	2.4×10^{-4}
BLM-13-300	300-310	2.5×10^{-6}
BLM-14-327	327-337	1.2×10^{-5}
BLM-15-305	305-315	4.8×10^{-6}
BLM-17-493	493-513	1.5×10^{-5}
BLM-17-493	493-513	1.7×10^{-5}
BLM-17-493	493-513	1.7×10^{-5}
BLM-17-550	550-560	2.8×10^{-5}
BLM-18-430	430-451	2.7×10^{-6}
BLM-21-400	400-410	5.0×10^{-7}
BLM-22-570	570-592	1.9×10^{-6}
BLM-23-431	419-436	6.1×10^{-8}
BLM-25-455	455-	9.6×10^{-6}
BLM-26-404	404-414	1.1 x 10-4
BLM-27-270	270-280	1.8×10^{-7}

Groundwater Flow Rates (Conventional Monitor Wells)

Well Name	Screen Zone (ft)	K (ft/sec)
BW-1-268	268-289	3.3×10^{-7}
JP-1-424	424-434	7.9×10^{-4}
JP-2-447	447-457	2.7×10^{-4}
PL-1-486	486-496	5.9×10^{-5}
PL-2-504	504-514	4.9×10^{-5}
PL-3-453	453-463	3.4×10^{-5}
PL-4-464	464-474	9.2×10^{-5}
ST-1-473	473-483	2.2×10^{-4}
ST-1-630	630-640	1.9×10^{-5}
ST-2-466	466-476	6.1×10^{-5}
ST-2-466	466-476	5.7×10^{-5}
ST-3-486	486-496	3.7×10^{-4}
ST-3-486	486-496	3.5×10^{-4}
ST-3-586	586-596	4.1×10^{-5}
ST-3-666	666-676	1.4×10^{-5}
ST-4-481	481-491	2.1×10^{-4}
ST-4-589	589-599	9.8×10^{-5}
ST-5-481	481-491	2.8 x 10-4
WW-1-452	452-462	2.2×10^{-4}
WW-1-452	452-462	2.2×10^{-4}
WW-1-452	452-462	2.2×10^{-4}

Groundwater Flow Rates (Westbay Monitor Wells)

Well Name	Meas. Port Depth (ft)	K (ft/sec)
200-F	225	2.45×10^{-8}
	370	6.60×10^{-7}
	420	2.69×10^{-7}
	570	2.61×10^{-6}
200-G	175	2.03×10^{-4}
	220	1.89×10^{-6}
	340	2.26×10^{-6}
	420	1.15×10^{-4}
	495	3.17×10^{-5}
200-H	331	1.12×10^{-5}
	433	1.71×10^{-4}
300-E	138	3.32×10^{-6}
	183	1.27×10^{-5}
	245	1.33×10^{-6}
	305	1.84×10^{-6}
	375	4.0×10^{-6}
700-H	355	8.69×10^{-7}
	540	3.14×10^{-5}
	675	2.10×10^{-6}
BLM-36	355	1.48×10^{-6}
	615	1.36×10^{-6}
	805	No Data
	865	1.67×10^{-6}
BLM-37	495	7.96×10^{-7}
	645	1.4×10^{-4}
	755	1.84×10^{-5}
	890	3.62×10^{-5}

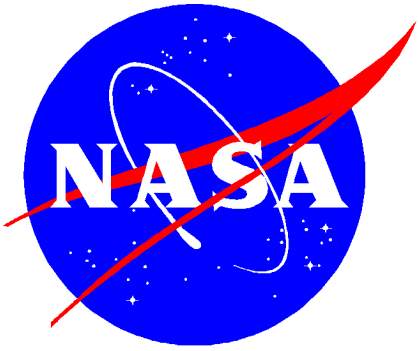
Groundwater Flow Rates (Westbay Monitor Wells)

Well Name	Meas. Port Depth (ft)	K (ft/sec)
BLM-38	485	6.40×10^{-7}
	625	2.44×10^{-7}
BLM-39	390	1.5×10^{-6}
	565	6.84×10^{-7}
JP-3	520	4.46×10^{-5}
	700	7.17×10^{-5}
	830	1.1×10^{-4}
	975	1.36×10^{-5}
PL-5	495	2.93×10^{-5}
	595	7.82×10^{-5}
	715	2.31×10^{-5}
	795	3.65×10^{-5}
	895	3.09×10^{-5}
	985	4.95×10^{-5}
PL-6-B	545	2.19×10^{-4}
	725	2.79×10^{-4}
	915	1.12×10^{-4}
	1035	1.03×10^{-4}
	1195	6.01×10^{-5}
	1335	3.0×10^{-5}
PL-8	460	5.77×10^{-5}
	610	2.47×10^{-5}
	780	6.29×10^{-7}
	965	2.36×10^{-6}
PL-9	490	1.15×10^{-5}
	600	1.32×10^{-5}
	820	1.42×10^{-5}
	970	9.25×10^{-5}
ST-6	545	2.29×10^{-5}
	585	5.75×10^{-5}
	695	4.53×10^{-5}
	840	3.08×10^{-5}
	975	4.4×10^{-3}

Groundwater Flow Rates (Westbay Monitor Wells)

Well Name	Meas. Port Depth (ft)	K (ft/sec)
ST-7	450	2.94×10^{-5}
	550	2.9×10^{-5}
	790	1.17×10^{-5}
	980	5.28×10^{-5}
WB-1	200	8.0×10^{-5}
	255	1.4×10^{-6}
	330	2.8×10^{-4}
WB-2	245	4.9×10^{-6}
	270	2.9×10^{-8}
	365	1.3×10^{-4}
WB-3	330	2.5×10^{-7}
	355	2.0×10^{-8}
	425	6.1×10^{-8}
	450	7.3×10^{-5}
WB-4	355	9.6×10^{-7}
	375	1.2×10^{-7}
	425	4.4×10^{-9}
	445	3.8×10^{-8}
WW-2	500	1.3×10^{-4}
	675	6.75×10^{-5}
	850	8.11×10^{-5}
	965	1.72×10^{-5}
WW-3	475	5.01×10^{-5}
	575	1.5×10^{-4}
	715	8.94×10^{-5}
	978	4.06×10^{-6}
WW-4	423	7.82×10^{-5}
	598	2.7×10^{-4}
	958	4.08×10^{-5}

Appendix I - Specific Data Collection Information



GROUNDWATER SAMPLING AND ANALYSIS PLAN

NASA JOHNSON SPACE CENTER

WHITE SANDS TEST FACILITY
LAS CRUCES, NEW MEXICO

September, 2003

1.0 EXECUTIVE SUMMARY

Under the provisions of the Resource Conservation and Recovery Act (RCRA), specific requirements are outlined to establish groundwater sampling and analysis programs. In accordance with these regulations, and pursuant to 20.4.1.500 NMAC incorporating 40 CFR 264.97, this document provides the NASA White Sands Test Facility (WSTF) with a Sampling and Analysis Plan that satisfies the regulatory requirements and provides personnel involved in the groundwater assessment and remediation projects with a basic understanding of the procedures for the collection and analysis of groundwater samples.

This Sampling and Analysis Plan (SAP), in conjunction with the WSTF Quality Assurance Project Plan (QAPP) and site-specific procedural documentation, provides basic site background information and written procedures concerning the following:

- groundwater monitoring wells;
- installation of groundwater monitoring wells;
- collection and preservation of groundwater samples;
- chain of custody documentation;
- groundwater sample shipment;
- analytical procedures;
- statistical analysis (as required); and
- analytical reports and data management.

The on-site environmental contractor organization is responsible for managing the groundwater assessment program at WSTF. This document is designed to be used in conjunction with the WSTF QAPP, the WSTF Plume-Front Stabilization Project Plan (PFSPP), and site-specific procedural documentation to ensure the consistency of all work involved in the collection and processing of groundwater samples. The current site-specific procedures include White Sands Test Facility Job Instructions (WJIs), Test Preparation Sheets (TPSs), and specific equipment Operations and Maintenance Manuals. All procedures established by these documents are written to comply with requirements and guidelines found in the Technical Enforcement Guidance Document (TEGD), Test Methods for Evaluating Solid Waste Physical/Chemical Methods (SW-846), RCRA Ground Water Monitoring: Draft Technical Guidance, and other applicable technical and regulatory guidance sources indicated in the References Section of this document.

This Sampling and Analysis Plan is reviewed and revised as necessary to ensure that the information provided reflects the future needs of the groundwater assessment and remediation programs, complies with future regulatory requirements, and is responsive to advances in scientific knowledge and technology. Copies of all revisions of this document are retained at WSTF to provide historical documentation of methodologies used throughout the groundwater assessment and remediation period.

2.0 SAMPLING OBJECTIVES

This section provides the purpose, scope, historical background, and objectives of the groundwater assessment program at WSTF.

2.1 Purpose

This document serves as a procedural outline for personnel engaged in groundwater sampling and analysis activities at WSTF. It is used in conjunction with site-specific procedural documentation and specific equipment Operations and Maintenance Manuals. Procedures outlined are consistent with those specified for use at sites subject to the requirements of RCRA, and have been adapted to meet the specific requirements of the WSTF groundwater assessment program.

The groundwater assessment program at WSTF was established to determine the nature and extent of the groundwater contamination plume that is present at WSTF as a result of historical releases of hazardous constituents. Groundwater sampling is performed as required by NASA's Post-Closure Care (PCC) Permit, 3008(h) Consent Order, the requirements of RCRA, and various Groundwater Monitoring Programs (GWMPs) or special project plans. Routine groundwater sampling has resulted in the delineation of NASA's contaminant plume and provided a comprehensive understanding of the groundwater contamination. This has allowed NASA to design and construct a state of the art pump and treat remediation system for corrective actions at the plume-front. Specific details related to NASA's corrective action are provided in the PFSPP and associated documentation.

2.2 Scope

This document is intended for use as an aid for training technical staff and as an informational guide for trained personnel involved in the collection and processing of WSTF groundwater samples. Adherence to the protocols presented in this document assures that samples are collected in a consistent manner, representative of actual groundwater conditions, shipped and tracked in an acceptable manner, and analyzed by appropriate EPA-recommended analytical methods.

In addition to this document, the WSTF QAPP provides the quality assurance steps necessary to substantiate collected groundwater data. The WSTF Quality Assurance Project Plan, used in conjunction with the WSTF SAP and PFSPP, provides protocols for the collection and analysis of groundwater samples.

2.3 Historical Background

During the course of operations at WSTF from the early 1960s to the early 1980s, hazardous constituents were released to the environment and eventually migrated to the groundwater. As mandated by RCRA, NASA established a detection monitoring program in May 1985 to investigate the presence of hazardous constituents in the groundwater. Groundwater monitoring wells were installed up gradient and down gradient of hazardous waste management units. Subsequent sampling and analysis of these wells detected hazardous waste contamination of the groundwater.

Based on the original information obtained from these wells, a groundwater assessment program was initiated in October 1986 to characterize the nature and extent of contamination. Using soil gas data, seismic reflection data, soil borings, and the installation and sampling of groundwater assessment wells, sufficient information was gathered to form a conceptual visualization of the contamination problem.

Analytical data collected indicates that groundwater contamination extends approximately two and a half miles west of the WSTF facility boundary. The types of hazardous constituents found in the groundwater include several halogenated volatile organic compounds and two semi-volatile compounds: N-nitrosodimethylamine (NDMA) and N-nitrodimethylamine. Additionally, there is some evidence of the presence of chromium and other metals, though a statistical analysis is required to determine the true extent of potential metals contamination.

NASA, with the support of EPA Region 6, has incorporated the use of Westbay Multi-Port (MP) well systems to complement existing conventional groundwater assessment wells. These wells are utilized to vertically profile specified areas where a three-dimensional understanding of the contamination plume is essential. The Westbay MP system is discussed in more detail in later sections of this document and in site-specific procedural documents.

Currently, over two hundred wells and Westbay MP monitoring zones are routinely sampled by WSTF personnel. Additional monitoring wells are drilled and installed as required to complement NASA's continuing efforts to fully assess and remediate the groundwater contamination plume at WSTF.

2.4 Objectives

The present objective of the groundwater assessment program is to collect and manage groundwater data to:

- monitor the distribution and migration of hazardous constituents;
- determine potential threats to the environment and human health;
- monitor the effectiveness of corrective measures used to remediate hazardous constituents released from each hazardous waste management unit;
- determine when the corrective measures have reduced released hazardous constituent concentrations to levels below compliance limits established in the GWMPs; and
- detect the presence of hazardous constituents not previously detected.

The on-site environmental contractor organization is tasked with the groundwater assessment project. This organization is staffed with groundwater, hydrogeological, and engineering personnel. Groundwater personnel are primarily involved in the collection and analysis of groundwater samples for assessment and remediation activities. Hydrogeological personnel are primarily involved in the installation of groundwater assessment and remediation wells and hydrogeologic interpretation of contaminant distribution and migration. Engineering personnel are responsible for the implementation of corrective actions and successful operation of groundwater treatment operations. An explanation of the functions of on-site environmental contractor personnel is provided in the WSTF QAPP.

3.0 GROUNDWATER MONITORING WELLS

This section provides general information related to WSTF's groundwater monitoring wells. Included in this section is a list of the monitoring wells and their designations, a summary of well construction information, and descriptions of well security and inspection.

3.1 Groundwater Monitoring Well Identification and Designation

In general, groundwater monitoring wells are identified by a three-part alphanumeric code stenciled on the protective outer casing or on one of the well's protective barrier posts. The exception to this are those monitoring wells that were installed as part of the original RCRA groundwater detection program, which are designated as NASA 3 through NASA 10. The designations of wells installed after March 1987 are determined by location of the well site or other unique descriptor, an alphanumeric identification digit, and the depth to the top of the screened interval or Westbay monitoring zone from ground level. Westbay wells, in their entirety, are designated only by the location of the well site or other unique descriptor and the alphanumeric identification digit. The designation of a specific sampling zone in the Westbay well incorporates the depth to that zone for three-part well zone designation and unique identification. A summary of WSTF's active groundwater monitoring wells is provided in Table 3.1. Well designations presented in this table supersede all previous designations.

Wells completed since January 1987 have a brass cap permanently cemented into the well pad. Each brass cap contains information regarding well coordinates, casing elevations, and well identification. From January 1987 to March 1987 these wells were originally identified according to site location and relative depth to other wells in the area (e.g., 600-C (Shallow)). These wells were renamed to reflect the identification system referenced above. However, the brass caps originally installed in the well pads reflect the original designations. A cross-reference detailing original and new well designations is provided in Table 3.2.

Groundwater monitoring wells at WSTF have been designated for a variety of sampling protocols. Specific project plans, including the GWMPs and the PFSPP, identify individual monitoring wells and establish the sampling and analysis requirements at those wells. This SAP does not specifically categorize monitoring wells based on their intended use in the assessment program, though it does provide the minimum monitoring requirements and frequencies for each well. Additional monitoring or increased sampling frequencies are provided in the specific project plans.

3.2 Groundwater Monitoring Well Construction

WSTF utilizes monitoring wells of varying designs for groundwater sampling. The construction design of groundwater monitoring wells is classified as either conventional or Westbay. The details of these designs are discussed below. In addition, detailed completion diagrams for each active WSTF monitoring well are available in Appendix A of this document.

TABLE 3.1
Summary of WSTF Groundwater Wells

Well ID	Date Completed	Elevation of Brass Cap (feet amsl)	Screened Interval or Depth to Westbay Sampling Zone(s) (feet)
100-A-182	05/30/89	4842.36	182.00-192.40
100-C-365	09/18/89	4816.82	365.00-385.80
100-D-176	05/14/97	5/15/97	176.00-196.00
100-E-261	07/07/89	4900.99	260.90-271.30
200-B-240	01/11/89	4837.77	239.80-250.10
200-C	01/21/93	4810.68	170, 225, 270
200-D-240	07/20/88	4785.25	239.60-250.00
200-F	10/11/94	4879.19	225, 370, 420, 570
200-G	11/14/94	4875.36	175, 220, 340, 420, 495
200-H	09/21/94	4882.13	225, 331, 433
200-I	06/23/97	4837.79	185, 300, 375, 490, 675, 795
200-SG-1	11/15/97	4787.17	123-138
300-A-120	02/03/87	4911.67	120.00-146.00
300-A-170	03/26/87	4911.28	170.00-175.50
300-B-166	10/09/87	4931.92	165.50-175.90
300-C-128	03/09/87	4877.27	128.20-154.30
300-D-153	04/04/88	5108.71	153.10-173.80
300-E	02/12/95	4926.31	138, 183
400-A-151	02/09/87	4795.09	150.50-175.60
400-C-118	02/17/87	4808.74	118.00-143.00
400-C-143	02/20/87	4808.55	143.00-153.40
400-D	03/27/95	4824.17	195, 275, 355
600-C-173	02/25/87	4744.01	172.50-193.20
600-D	06/15/95	4747.51	230, 365, 635, 845
600-E	10/10/97	4746.17	280
700-A-253	11/09/89	4908.14	253.00-263.40
700-B-510	08/18/90	4805.89	510.00-530.84
700-D-186	12/21/89	4885.28	186.00-196.30
700-E-458	03/12/90	4717.77	458.10-478.90
700-F-455	01/31/91	4763.62	455.00-475.03
700-H	8/18/99	6/9/99	350, 535, 670
700-J-200	6/7/99	6/2/99	200-220
BLM-1-435	11/13/87	4551.67	435.30-445.70
BLM-2-482	10/25/87	4535.48	482.40-492.80
BLM-2-630	06/13/88	4535.35	629.50-639.80
BLM-3-182	02/10/87	4743.93	182.30-203.00
BLM-5-527	04/04/88	4551.80	527.30-537.70

TABLE 3.1
Summary of WSTF Groundwater Wells

Well ID	Date Completed	Elevation of Brass Cap (feet amsl)	Screened Interval or Depth to Westbay Sampling Zone(s) (feet)
BLM-6-488	04/18/90	4588.36	487.70-498.20
BLM-7-509	05/17/88	4529.80	509.30-519.70
BLM-8-418	06/28/88	4556.33	418.00-428.40
BLM-9-419	11/09/88	4692.24	419.30-440.00
BLM-10-517	03/03/88	4533.71	516.60-526.90
BLM-13-300	09/02/88	4665.98	300.40-310.80
BLM-14-327	09/27/90	4675.54	327.00-337.42
BLM-15-305	04/14/89	4703.69	305.00-315.30
BLM-17-493	02/17/89	4528.13	492.80-513.50
BLM-17-550	09/10/90	4638.24	550.44-560.86
BLM-18-430	09/19/89	4609.84	430.00-450.80
BLM-21-400	07/02/91	4648.73	400.00-410.01
BLM-22-570	08/24/90	4606.84	570.21-591.69
BLM-23-431	06/25/90	4588.06	430.82-441.25
BLM-24-565	01/08/91	4713.84	564.85-584.88
BLM-25-455	10/23/91	4619.42	454.95-464.95
BLM-26-404	11/05/91	4664.97	404.00-414.00
BLM-27-270	08/08/91	4729.75	270.01-280.27
BLM-28	05/10/94	4639.30	425, 470, 525
BLM-30	05/15/95	4595.79	585
BLM-31	03/17/95	4726.98	350, 485
BLM-32	6/20/97	4595.84	580, 645, 715
BLM-36	2/5/99	4638.62	350, 610, 800, 860
BLM-37	10/1/99	4546.08	490, 640, 750, 885
BLM-38	8/23/99	4621.99	480, 620
BLM-39	6/18/99	4634.85	385, 560
BW-1-268	12/07/88	4772.15	268.10-288.80
BW-3-180	08/24/88	4734.03	179.60-200.30
BW-4	02/23/93	4750.75	270, 355, 455
BW-5-295	02/04/89	4814.52	294.90-305.20
BW-6-355	01/31/92	4815.23	355.00-375.53
BW-7-211	01/12/88	4798.64	211.30-221.60
JP-1-424	12/05/87	4444.09	424.00-434.30
JP-2-447	08/15/88	4446.17	446.50-456.90
JP-3	9/2/99	4433.54	515, 695, 825, 970
NASA 3	02/27/85	5010.42	118.75-138.75
NASA 4	03/04/85	4770.74	146.20-166.20

TABLE 3.1
Summary of WSTF Groundwater Wells

Well ID	Date Completed	Elevation of Brass Cap (feet amsl)	Screened Interval or Depth to Westbay Sampling Zone(s) (feet)
NASA 5	03/06/85	4925.53	119.25-130.25
NASA 6	03/07/85	4821.03	127.60-147.60
NASA 7	03/26/85	4747.23	177.20-197.20
NASA 8	04/01/85	4751.35	172.00-192.00
NASA 9	04/03/85	4822.23	129.56-149.56
NASA 10	04/12/82	4835.48	110.00-130.00
PL-1-486	10/08/88	4518.14	486.00-496.40
PL-2-504	11/28/88	4508.04	504.00-514.40
PL-3-453	11/09/88	4496.89	453.40-463.80
PL-4-464	01/23/90	4480.88	463.96-474.36
PL-5	11/10/90	4512.60	495, 595, 715, 795, 895, 985
PL-6-B	01/15/91	4481.69	545, 725, 915, 1195, 1335, 1485, 1645, 1815
PL-7	12/17/92	4519.12	480, 560, 630
PL-8	09/29/99	4469.63	455, 605, 780, 965
PL-10	09/13/02	4419.53	484, 592, 813, 962
ST-1-473	05/30/89	4503.64	472.70-483.10
ST-1-541	11/19/91	4502.39	541.21-551.22
ST-1-630	07/21/92	4501.61	630.38-640.38
ST-2-466	08/18/89	4467.22	465.70-476.20
ST-3-486	08/08/91	4495.98	486.00-496.42
ST-3-586	04/10/92	4494.59	585.77-595.79
ST-3-666	06/12/92	4494.36	665.88-675.84
ST-3-735	08/21/92	4496.62	735.32-755.22
ST-4-481	04/23/92	4493.16	480.78-490.78
ST-4-589	05/20/92	4493.13	588.75-598.75
ST-4-690	10/05/92	4491.16	690.42-710.42
ST-5-481	05/06/92	4459.24	480.75-490.78
ST-5	06/29/93	4458.74	485, 655, 815, 985, 1175
ST-6	10/05/97	4465.72	535, 575, 685, 830, 975
ST-7	7/16/99	4482.78	450, 550, 785, 975
WB-1	04/12/90	4840.94	200, 255, 330
WB-2	04/13/90	4901.00	245, 270, 365
WB-3	04/09/90	4812.16	330, 355, 425, 450
WB-4	04/06/90	4844.78	355, 375, 425, 445
WB-5	06/14/90	4872.41	250, 280, 345
WB-8	03/10/93	4961.68	275, 320, 410
WB-9	02/26/92	5001.61	310, 335, 360

TABLE 3.1
Summary of WSTF Groundwater Wells

Well ID	Date Completed	Elevation of Brass Cap (feet amsl)	Screened Interval or Depth to Westbay Sampling Zone(s) (feet)
WB-14	03/23/93	4731.68	520
WW-1-452	01/21/88	4455.09	451.90-462.20
WW-2	4/24/99	4436.45	495, 670, 845, 960
WW-3	04/29/01	4446.18	469, 569, 710, 968
WW-4	05/03/01	4444.47	423, 594, 853, 953
WW-5	10/18/01	4440.06	464, 582, 814, 912

TABLE 3.2
Well Designations Cross Reference

Brass Cap Designation	Revised Designation
200-D (S)	200-D-109
300-A (S)	300-A-120
300-A (M)	300-A-170
300-B (S)	300-B-166
300-C (S)	300-C-128
400-A (S)	400-A-151
400-C (S)	400-C-118
400-C (M)	400-C-143
600-C (S)	600-C-173
600-C (M)	600-C-210
600-C (D)	600-C-437

3.2.1 Conventional Monitoring Well Construction

Conventional monitoring wells are designed to monitor a single, discrete location within the water-bearing zone. Conventional monitoring wells consist of a single borehole in which the well casing is installed. The targeted zone is monitored using a segment of slotted, or screened, casing which accessed the formation surrounding this screened interval. Conventional wells are used to measure groundwater elevations and to collect groundwater samples that are representative of the groundwater in the vicinity of the screened interval.

The original eight detection wells installed at WSTF were two inches (5.08 cm) in diameter and constructed of PVC and stainless steel. All subsequent conventional wells are four inches (10.16 cm) in diameter and are constructed of PVC and/or stainless steel. The wells are screened at an interval that is either at or below the water table with 0.020-inch (0.051 cm) slotted stainless steel screen.

3.2.2 Westbay Multi-Port Monitoring Well Construction

Westbay Multi-Port systems are designed to monitor multiple water-bearing zones within a single borehole. The systems are currently in use at WSTF to collect groundwater samples, obtain piezometric water pressures, and perform hydraulic conductivity determinations. Data obtained from these wells are used to formulate a three-dimensional conceptualization of the groundwater contamination plume in critical areas.

The Westbay MP system is a multiple-level groundwater monitoring system that employs a single, closed access, PVC casing with valved ports to perform well monitoring activities. The valved ports are used to provide controlled access to a multiple number of monitoring zones within a single borehole. The Westbay system is installed in a borehole or in a multi-screened stainless steel monitoring well. Inflatable packers are integrated into the Westbay casing design and are individually inflated against the walls of the borehole or the stainless steel casing. These packers isolate specific monitoring zones.

Westbay wells are designed to provide direct access to formation water. This allows the collection of in situ groundwater samples and hydrogeological data. As a result of this design, the requirement to purge each zone prior to sample collection is eliminated. Specialized downhole instruments are used to access the valved ports within the well. Design specifics of the Westbay wells and the associated downhole equipment are provided in the site-specific procedural documentation and Westbay Operation and Maintenance Manuals

3.3 Groundwater Monitoring Well Security

Monitoring wells are equipped with locking caps that are secured at all times, except for sampling and analysis procedures conducted in accordance with this document. Keys are issued only to personnel directly involved in the collection of groundwater samples, well maintenance, or well inspection activities. Additionally, WSTF is a secure facility that is regularly patrolled by trained security forces tasked with restricting access to the facility to authorized personnel only.

3.4 Groundwater Monitoring Well Inspection

WSTF groundwater monitoring wells are inspected with a down-hole camera system to ensure well and sample integrity is maintained. All WSTF monitoring wells have been inspected as of the writing of this document. The down-hole camera system is utilized on an as-needed basis to perform additional inspections at the discretion of WSTF groundwater personnel. In addition, monitoring well sites are inspected annually to ensure safe and secure sampling locations are maintained at all times.

4.0 Installation of New Monitoring Wells

Groundwater monitoring wells are installed in accordance with the procedures established at WSTF over the course of several years and numerous well installations. Site-specific procedural documentation has been developed by WSTF groundwater personnel to aid in the proper and effective installation of monitoring wells to ensure the collection of representative groundwater samples from the varying geologic formations present at WSTF.

4.1 Conventional Monitoring Wells

The equipment requirements and standard procedures for the installation of conventional monitoring wells are provided in the site-specific procedural documentation presented in Attachment A.

4.2 Westbay Multi-Port Monitoring Wells

The equipment requirements and standard procedures for the installation of Westbay Multi-Port monitoring wells are provided in the site-specific procedural documentation presented in Attachment B.

5.0 Pre-Sampling Activities

As previously indicated, WSTF currently utilizes two basic monitoring well configurations for the collection of groundwater samples – conventional and Westbay. Conventional monitoring wells are further categorized depending on the purge and sample methods utilized at each monitoring well. In general, purging and sampling of conventional monitoring wells is performed either in a traditional manner (i.e. purge a set volume of groundwater prior to sample collection), or by utilizing low-flow techniques (i.e. a minimal volume of water is purged prior to sampling). Pre-sampling activities and equipment requirements differ based upon the specific sampling system and techniques in use at each monitoring well.

5.1 Conventional Monitoring Wells

Pre-sampling activities at conventional monitoring wells include, but are not limited to: decontamination of non-dedicated equipment; well site inspection; static water level measurement; and well purging, if required. These pre-sampling activities, as well as the equipment used at each type of conventional well, are described in detail in the site-specific procedural documentation provided with this document. The equipment and procedures for determining the static water level are provided in Attachment C. Procedures and equipment required for other pre-sampling activities are included in the conventional monitoring well sampling procedures provided in Attachment D (for traditional purge and sample monitoring wells) and Attachment E (for monitoring wells equipped with low-flow sampling equipment).

5.2 Westbay Multi-Port Monitoring Wells

Pre-sampling activities at Westbay monitoring wells include, but are not limited to: decontamination of non-dedicated equipment; well site inspection and pressure profiling. These pre-sampling activities and the equipment used are described in the site-specific procedural documentation provided with this document. The procedural and equipment requirements for pressure profiling are provided in Attachment F, while the remainder of the pre-sampling activities are detailed in the Westbay sampling procedural document, provided in Attachment G.

The procedural documents identified in this section are official NASA WSTF publications that satisfy site-specific requirements established by NASA. They are subject to review and revision as deemed necessary by WSTF personnel to accommodate changing site requirements, technological developments, and regulatory mandates. Document revisions that result in significant procedural changes are subject to an official review and approval cycle at WSTF. Revised procedural documents will be made available to NMED electronically following approval by WSTF responsible parties.

6.0 In-Situ and Field Analysis and Equipment

This section describes the field measurements, or indicator parameters, that are collected during the purging and sampling of groundwater monitoring wells. Generally, the first and last sample of groundwater collected at each sampling event is reserved for the measurement of indicator parameters. The collection of groundwater for the measurement of indicator parameters is an integral part of the groundwater sampling process. As a result, the process of collecting indicator parameters varies slightly depending on the specific monitoring well system in use. The site-specific procedural documentation used for groundwater monitoring activities at WSTF provide more detailed information related to the collection of indicator parameters. The following is a brief discussion of indicator parameters and required equipment and supplies for the different monitoring well configurations present at WSTF.

6.1 Conventional Monitoring Wells

As previously indicated, NASA uses several groundwater sampling systems in conventional monitoring wells. Indicator parameter collection techniques and the required supplies vary depending on the specific well system.

6.1.1 Dedicated Bladder Pumps

Many of the conventional monitoring wells at WSTF are equipped with dedicated bladder pumps. In addition, some of these monitoring wells also utilize a dedicated inflatable packer to isolate the screened interval and reduce the required volume of purge water. Indicator parameters are collected from all dedicated bladder pumps in a similar manner. Groundwater is collected directly from the bladder pump discharge tubing and is dispensed into a graduated beaker for parameter measurement. A small volume of groundwater is dispensed directly into the turbidity vial for use in the turbidity meter.

Indicator parameters are collected and recorded in "sets." Each set of indicator parameters consists of temperature, pH, conductivity, and turbidity. Generally, sampling personnel collect three sets of indicator parameters when sampling a well equipped with a dedicated bladder pump: the initial parameters are collected when approximately two casing volumes of water have been removed from the well; the secondary parameters are collected immediately prior to sampling when three casing volumes of water have been purged; and the third and final set is collected after all the necessary groundwater samples have been collected. The measurement of indicator parameters requires a variety of supplies, including, but not limited to: bladder pump and discharge tubing; the appropriate meters (pH, temperature, conductivity, and turbidity); calibration and/or check standards; and the required groundwater collection vessel (beaker, vial, etc.).

A complete list of requirements and procedures for the measurement of indicator parameters is provided in Attachment D.

6.1.2 Dedicated Low-Flow Bladder Pumps

A number of conventional monitoring wells at WSTF are sampled using dedicated low-flow bladder pumps. Indicator parameters are measured during low-flow purging operations in accordance with acceptable low-flow practices. Indicator parameters are monitored using an in-line flow cell, which is equipped with multiple probes and/or sensors that measure temperature, pH, conductivity, oxidation/reduction potential (ORP), and dissolved oxygen. Turbidity is generally measured separately using water collected upstream of the flow cell. The depth to water is also closely monitored and used as an indicator parameter to ensure minimal drawdown during low-flow sampling.

Indicator parameters are monitored throughout purging operations. When three consecutive sets of parameters have stabilized as required by the site-specific procedural documentation, purging is suspended and sample collection is initiated. These three sets are frequently referred to as initial parameters. A final set of indicator parameters is collected with the flow cell after the required groundwater samples have been collected.

Attachment E, which provides the low-flow sampling procedures, includes a more detailed description of the procedures, equipment, and supplies required to measure indicator parameters when sampling with low-flow bladder pumps.

6.1.3 Non-Dedicated Purge Pump and Bailers

When dedicated sampling systems are not practical, or fail to provide the over groundwater sample quality required at WSTF, non-dedicated purge pumps and bailers are used. When sampling with this equipment, indicator parameters are measured in a manner similar to that employed when sampling with dedicated bladder pumps. Three sets of indicator parameters are collected at the intervals specified in Section 6.1.1.

The initial and secondary parameters are measured using groundwater collected directly from the discharge tubing of the non-dedicated purge pump and dispensed into a graduated beaker or turbidity vial. The final set of indicator parameters is dispensed from the bailer into the appropriate vessel after all the required groundwater samples have been collected. The collection of indicator parameters requires a variety of supplies, including, but not limited to: purge pump and discharge tubing; the appropriate meters (pH, temperature, conductivity, and turbidity); calibration and/or check standards; bailer; and the required groundwater collection vessel (beaker, vial, etc.).

A complete description of the procedures, equipment, and supplies required for the collection of indicator parameters is provided in Attachment D.

6.2 Westbay Multi-Port Monitoring Wells

The collection of indicator parameters at Westbay monitoring wells utilizes much of the same equipment and supplies that are required by previous sections. Groundwater obtained from the initial sample collection "run" is used for the measurement of indicator parameters. When the Westbay probe and sampling assembly is brought to the surface, groundwater is dispensed directly from the lowermost sample bottle into a graduated beaker or turbidity vial.

Indicator parameters are collected in two sets, initial and final, each of which consists of temperature, pH, conductivity, and turbidity. Initial parameters are obtained using water collected before the groundwater samples, while the final parameters are those measured using the remaining water in the Westbay sampling assembly after the required groundwater samples have been collected. The collection of indicator parameters requires a variety of supplies, including, but not limited to: Westbay sampling probe and bottles; the appropriate meters (pH, temperature, conductivity, and turbidity); calibration and/or check standards; and the required groundwater collection vessel (beaker, vial, etc.).

A full listing of the equipment and supplies required for indicator parameter measurement is provided in the Westbay sampling procedural documentation in Attachment G.

7.0 Sampling Equipment

Equipment used for the collection of groundwater samples is designed to minimally alter sample integrity during the sample collection process. Equipment requirements for WSTF groundwater monitoring wells vary depending upon the type of monitoring well installed at the monitoring location. As previously indicated in this SAP, WSTF utilizes both conventionally installed monitoring wells and Westbay Multi-Port monitoring wells for groundwater assessment purposes. This section describes the groundwater sampling equipment utilized in each type of monitoring well currently installed at WSTF.

7.1 Conventional Monitoring Wells

Several types of dedicated and non-dedicated well sampling systems are used at WSTF due to the variability of sampling conditions encountered. Factors that influence the type of system selected for each conventional monitoring well include the depth to water, volume of water to be purged, water recovery rate, frequency of sampling, overall integrity of the well casing, and the cost of system installation. Table 7.1 summarizes the equipment utilized to collect groundwater samples from each of WSTF's conventional groundwater monitoring wells. The following sections provide a brief discussion of the basic sampling equipment used in conventional monitoring wells at WSTF.

7.1.1 Dedicated Bladder Pumps

Numerous conventional wells are equipped with dedicated positive displacement bladder pump systems. In this design, the wells are purged and sampled using the dedicated bladder pump. The pumps are constructed of stainless steel and Teflon. Samples are collected directly from Teflon-lined polyethylene or Teflon discharge tubing. These materials are used to minimize the sorptive effects of the tubing on sample quality. The pressure required to operate the bladder pumps is supplied by compressed nitrogen cylinders or liquid nitrogen dewars.

7.1.1.1 Bladder Pump Systems for Low-Flow Sampling

Many of the wells equipped with dedicated bladder pumps are designated for low flow sampling. Recent technological advancements in sampling procedures have shown that in specific cases, minimal purging is required to obtain representative groundwater samples. Wells equipped with low flow systems are purged only until indicator parameters stabilize. When these parameters are stable, sample collection is initiated. The measurement of indicator parameters was described in Section 6. Specific additional information on indicator parameters and low-flow purging and sampling procedures is provided in the site-specific procedural documentation included in Attachment E.

7.1.1.2 Bladder Pump Systems for Traditional Sampling

Certain conventional monitoring wells equipped with dedicated bladder pumps are sampled using traditional methods of purging and sampling. These wells are purged to remove at least three casing volumes of water prior to sampling. Purging methods and sample collection procedures are discussed in greater detail in later sections of this document and in the site-specific procedural documentation provided in Attachment D. Dedicated bladder pump systems are used in wells where the static water levels are relatively shallow and required purge volumes are small.

Table 7.1
Conventional Monitoring Well Dedicated Sampling Equipment

Bladder Pump Systems for Low-Flow Sampling		Bladder Pump Systems for Traditional Sampling	Inflatable Packer/ Bladder Pump Systems
100-A-182	BLM-22-570	200-SG-109	200-B-240
100-C-365	BLM-23-431	300-A-120	200-D-240
100-D-176	BLM-24-565	300-D-153	300-A-170
100-E-261	BLM-25-455	400-C-118	BLM-1-435
300-B-166	BLM-26-404	400-C-143	
300-C-128	BLM-27-270	NASA 3	
400-A-151	BW-1-268	NASA 4	
600-C-173	BW-3-180	NASA 5	
700-A-253	BW-5-295	NASA 6	
700-B-510	BW-6-355	NASA 7	
700-D-186	BW-7-211	NASA 8	
700-E-458	JP-1-424	NASA 9	
700-F-455	JP-2-447	NASA 10	
700-J-200	PL-1-486		
BLM-2-482	PL-2-504		
BLM-2-630	PL-3-453		
BLM-3-182	PL-4-464		
BLM-5-527	ST-1-473		
BLM-6-488	ST-1-541		
BLM-7-509	ST-1-630		
BLM-8-418	ST-2-466		
BLM-9-419	ST-3-486		
BLM-10-517	ST-3-586		
BLM-13-300	ST-3-666		
BLM-14-327	ST-3-735		
BLM-15-305	ST-4-481		
BLM-17-493	ST-4-589		
BLM-17-550	ST-4-690		
BLM-18-430	ST-5-481		
BLM-21-400	WW-1-452		

NOTE: Wells that are equipped with dedicated pump systems may periodically experience problems due to equipment malfunctions/static water level fluctuations. These problems may require WSTF to utilize the pneumatically driven pump/dedicated bailer technique for sampling until they can be corrected. If this alternate procedure is used, all corresponding documentation will reference the use of the alternate technique.

7.1.2 Dedicated Bladder Pump/Inflatable Packer Systems

Several wells are equipped with dedicated inflatable packer/bladder pump systems. In this system, an inflatable packer is used to isolate a zone in the well extending from just above the screened interval to the bottom of the well. This significantly reduces the amount of purge water required prior to sample collection. Water is purged and sampled from this zone using a dedicated stainless steel/Teflon bladder pump. Samples are collected directly from the Teflon-lined or Teflon discharge tubing to ensure sample quality. This type of sampling system is used in shallow wells where a relatively large amount of purging would be required if the packer was not used. Attachment D provides the site-specific procedural documentation for the purging and sampling of monitoring wells equipped with dedicated bladder pumps and packers.

7.1.3 Non-Dedicated Purge Pumps and Bailers

Although dedicated equipment is preferred for sample collection at WSTF, there are occasions when dedicated equipment is not feasible or is incapable of sample collection because of failure or current well and/or hydrogeologic conditions. Under specific circumstances, such as dedicated equipment failure, non-dedicated equipment is used to purge groundwater monitoring wells and to collect the required samples.

When sampling conditions preclude the use of dedicated sampling equipment, non-dedicated Teflon bailers are used to collect samples. The bailers are constructed of Teflon and are equipped with bottom-filling check valves. Bailers are lowered into the well for sample collection with a non-dedicated stainless steel cable. A non-dedicated pneumatically driven purge pump is used to evacuate the required volume of water prior to sampling with the bailer. This pump, if required, can be used to collect samples for inorganic analytes. Due to possible effects on sample integrity, this pump is not typically used to collect samples with volatilization potential. The procedures to be followed when purging and sampling with non-dedicated equipment are provided in Attachment D.

To eliminate cross-contamination between wells, the pneumatic pump and Teflon bailer are decontaminated prior to each use. To ensure that the decontamination procedures are effective and to determine the potential occurrence of field contamination, equipment blanks are required at regular intervals. Immediately prior to insertion into the monitoring well, purified deionized water is flushed over and/or through the pump and/or bailer collected in the appropriate sample container in order of sample volatility. Additionally, if inorganic samples are collected directly from the pump discharge, during a scheduled sampling event, equipment blanks are required for the corresponding inorganic analyses. Specific procedures for the decontamination of non-dedicated equipment and the collection of equipment blanks are provided in Attachment D.

7.2 Westbay Monitoring Wells

Westbay MP systems are designed to monitor multiple water-bearing zones within a single borehole using one casing string. The systems are currently in use at WSTF to collect

groundwater samples, obtain piezometric water pressures, and perform hydraulic conductivity determinations. Data obtained from these wells are used to formulate a three-dimensional conceptualization of the groundwater contamination plume in critical areas. Specific information and procedures for the use of Westbay monitoring wells are provided in the site-specific procedural documentation, included in Attachment F, Attachment G, and Attachment H.

7.2.1 MOSDAX Sampler Probe

The MOSDAX sampler probe is a non-dedicated electronic tool used to measure downhole fluid pressures and obtain in situ groundwater samples from Westbay MP well systems. The system is operated by a handheld controller. The controller displays pressure readings and controls the downhole fluid measurement and sample collection functions of the probe. The probe contains an electric strain-gauge pressure transducer for measuring fluid pressures within the Westbay standpipe and through the measurement port couplings located in each monitoring zone. The probe is equipped with an electronically controlled sample apparatus that, when appropriately activated, accesses a one-way valve in the Westbay well casing and collects a groundwater sample directly from the aquifer.

7.2.2 Stainless Steel Sample Bottles

Groundwater samples are collected from Westbay MP wells using the MOSDAX sampler probe and retrieved in a series of stainless steel sample bottles that are attached to the probe. Sample bottles are decontaminated prior to sample collection at each well, and equipment blanks are collected for analysis by the specific volatile analytical method(s) required at each well.

7.3 Other Equipment and Supplies

Lists of all equipment and supplies used for sample collection are provided in the site-specific procedural documentation for each type of sampling.

8.0 Sampling Procedures

Detailed procedures and technical information for all aspects of groundwater sampling at WSTF are provided in the site-specific procedural documentation. The Attachments of this SAP provide all required procedural information related to the groundwater assessment program at WSTF, including, but not limited to: sample collection procedures, the required equipment and supplies; equipment decontamination requirements; safety requirements; and other activities performed during routine groundwater monitoring.

9.0 Sample Collection and Supplies

This section identifies groundwater sample collection techniques and the order in which samples are collected, and discusses the additional supplies required during the course of sample collection. Also provided is a detailed description of the field logbook, which is a critical component of each groundwater sampling event. This section also describes sample handling procedures and records, which include sample identification, sample labeling, preservation methods, storage requirements, holding times, and custody requirements.

9.1 Sampling Techniques and Sequence

Sample collection procedures and techniques are thoroughly described in the site-specific procedural documentation, provided in the Attachments of this SAP. These documents were designed to address the needs of contractor environmental personnel actively engaged in the collection of groundwater samples at WSTF. As such, they provide detailed procedural guidance for groundwater monitoring activities.

To decrease the potential for volatilization of hazardous constituents from groundwater samples, the samples are generally collected in order of their decreasing sensitivity to volatilization (i.e. volatiles, NDMA, metals, etc.). The order in which groundwater samples are collected is recorded in the field logbook. In certain instances, project-specific requirements may dictate a deviation from this generalization. In these instances, the field logbook will be appropriately annotated to reflect the order of sample collection.

9.2 Supplemental Supplies

The collection of groundwater samples at WSTF requires the use of a variety of equipment and supplies. Previous sections of this SAP have identified the required sampling equipment, and described many of the supplies. Additional supplies include, but are not limited to: sample containers; sample preservatives; various solutions and standards; protective gear to protect sample integrity; ice and icechests for sample storage; blank water for field quality control samples; personal protective and safety gear; and a variety of replacement and repair parts. The site-specific procedural documentation, in conjunction with their referenced manufacturer's manuals, provides groundwater sampling personnel with a complete listing of the required equipment and supplies.

9.3 Field Logbook

A serially numbered field logbook is used to record all activities, observations, and measurements that take place in the field during sampling events. Records of the field activities should be sufficient to allow an individual, not associated with the sampling event, to recreate the events by reading the logbook. These documents serve as legal records of all field activities. All logbooks are maintained on-site for immediate availability.

Information that is recorded in the field logbook each time sampling is conducted includes:

- monitoring well identification/designation;
- date of the sampling event;
- site-specific procedural documentation to be used;
- identification of the members of the sampling party;
- climatic/weather conditions;
- initial static water level;
- calculated purge volume (if required – dependent on sampling equipment);
- purge rate, purge duration, purge time, and volume of water purged (if required);
- well evacuation method and equipment;
- sample collection method and equipment;
- decontamination procedures for non-dedicated equipment in use;
- indicator parameter measurements, equipment used, calibration or check standards, standard lot number(s) and most recent calibration date(s);
- identification of field quality control samples and source of blank water;
- groundwater sample collection sequence;
- unique sample identification number for each sample;
- type of sample container used for each sample;
- method(s) of preservation used for each sample;
- chemical analysis or analytical method to be performed on each sample;
- laboratory(ies) performing the analyses;
- problems encountered during field activities and any corrective actions implemented; and
- any other relevant field observations.

Individual field logbook entries vary depending on the type of well sampled, sampling equipment used, specific samples and quality control samples collected, and other project-specific requirements.

9.4 Sample Handling

9.4.1 Sample Identification

A unique ten digit number is assigned to each sample at the time of collection. An example of a sample number is 0308131030. In this example, 03 refers to the year (2003), 0813 refers to the date of collection (August 13), and 1030 refers to the time of collection (1030 hours, or 10:30 AM). This sample identification format is used for all samples, field blanks, and quality assurance samples.

9.4.2 Sample Labels and Seals

Sample labels are required to avoid sample misidentification, either in the field, during packaging, or at the analytical laboratory. Sample labels are affixed to each sample container by sampling personnel immediately after sample collection and preservation, if required.

Sample labels must include, at a minimum, the following:

- the unique sample number;
- identification of the well/zone being sampled;
- identification of the sampling personnel;
- the analysis required by the sample; and
- the preservation method utilized for the sample.

Sample seals are required to ensure that samples are not tampered with prior to analysis. Samples seals are filled out and affixed to each sample container by sampling personnel immediately after the sample label is affixed to the container. Sample seals must include, at a minimum, the following:

- the unique sample number;
- identification of the well/zone being sampled; and
- identification of the sampling personnel.

The current WSTF groundwater sample labels and seals are represented in Attachment I.

9.4.3 Sample Containers, Preservation, and Holding Times

Groundwater samples are collected, stored, and transported to the analytical laboratory only in laboratory-certified clean containers. In general, sample containers used at WSTF are polyethylene or glass. However, unusual or atypical sampling may require specialized sample containers.

In addition to the appropriate sample container, specific preservation methods are required to ensure the validity of groundwater samples upon arrival at the analytical laboratory. Sample preservation prevents or retards the chemical or biological degradation of the sample's chemical integrity. At a minimum, all samples are refrigerated at $4^{\circ} \pm 2^{\circ}$C. Additional chemical preservatives are required for certain groundwater samples.

Each type of sample also has a specified holding time, after which analysis should not be performed. Holding time is based on the constituents of interest and is the maximum time allowed between sample collection and preparation/analysis. Samples analyzed outside their specified holding times are reported with the appropriate data qualifier(s). Analytical data with holding time issues are only reported if resampling is considered unnecessary or impracticable.

Sample volumes, types of containers, sample preservation methods, and holding times are based on the guidance established in EPA SW-846 and upon the recommendations of the contracted laboratories employed by WSTF. Table 9.1 provides a summary of the containers, preservation methods, and maximum holding times for routine groundwater samples.

Table 9.1
Containers, Preservation, and Holding Times for Routine Samples

Analysis	Analytical Method[1]	Container	Preservation	Maximum Holding Time
Volatile Organics	EPA Method 8260 or Equivalent	3 – 40 ml glass vial	Zero headspace and cool to 4° ± 2°C	14 days
Nitrosamines/ Bromacil	EPA Method 607 or Equivalent	1 – 1 liter glass bottle	Cool to 4° ± 2°C	7 days
RCRA Metals	Various EPA Methods	1 – 500 ml poly bottle	HNO_3 to pH < 2 and cool to 4° ± 2°C	6 months[2]

[1] Indicates that this is the analytical method in use at time of publication. The analytical method is subject to change with advancements in analytical technology and implementation of more sensitive methods by the contracted laboratory(ies).

[2] Except for mercury, which has a holding time of 28 days.

Selected Post-Closure Care wells at WSTF are scheduled for annual Appendix IX sample collection and analysis. The containers, preservation methods, and holding times for Appendix IX analyses are provided in Table 9.2. Post-Closure Care monitoring wells and sampling requirements are discussed in Section 10 and in depth in NASA RCRA Permit Renewal Application and the Groundwater Monitoring Programs contained therein.

Groundwater sampling requirements for non-routine sampling activities are identified in project-specific work plans or procedural documents. Project-specific sample analyses, containers, preservation, and holding times will be provided in these plans when the information in Table 9.1 and Table 9.2 is insufficient.

9.4.4 Sample Storage

To prevent alteration of samples during collection, sample containers are cooled on ice prior to sample collection. Immediately following collection, preservation, and labeling, groundwater samples are placed on ice until they are transferred to refrigerated storage. Until shipment or transfer to the analytical laboratory, groundwater samples are stored in a dedicated refrigerator that maintains a constant temperature of 4° ± 2°C. Additionally, all collected samples that contain contaminants that are sensitive to volatilization are stored with the septum facing down. This procedure minimizes possible volatilization of the target compounds through the septum.

Table 9.2
Sample Containers, Preservation, and Holding Times for Appendix IX Analyses

Analysis	Analytical Method[1]	Sample Container	Sample Preservation	Maximum Holding Time
Volatile Organics Analysis (VOA)	EPA Method 8260	3 – 40 mL glass amber vial	Zero headspace and cool to 4°C ± 2°C	14 days
Nitrosamines	EPA Method 607	1 – 1 L glass amber bottle	Minimum headspace and cool to 4°C ± 2°C	7 days
Semi-volatile Organics Analysis (SVOA)	EPA Method 8270	2 – 1 L glass amber bottle	Minimum headspace and cool to 4°C ± 2°C	7 days
Pesticides	EPA Method 8081A	2 – 1 L glass amber bottle	Minimum headspace and cool to 4°C ± 2°C	7 days
PCBs	EPA Method 8082	2 – 1 L glass amber bottle	Minimum headspace and cool to 4°C ± 2°C	7 days
Dioxins/Furans	EPA Method 8290	2 – 1 L glass amber bottle	Minimum headspace and cool to 4°C ± 2°C	30 days
Herbicides	EPA Method 8151	2 – 1 L glass amber bottle	Minimum headspace and cool to 4°C ± 2°C	7 days
Phenols[2]	EPA Method 9066	1 – 1 L glass amber bottle	1 mL H_2SO_4, minimum headspace, and cool to 4°C ± 2°C	28 days
Total Cyanide[3]	EPA Method 9012	1 – 250 mL polyethylene bottle	200uL 50%NaOH, minimum headspace, and cool to 4°C ± 2°C	14 days
Total Sulfide[4]	EPA Method 9030	3 – 250 mL polyethylene bottle	1 mL 1N Zinc Acetate, 200uL 50%NaOH, minimum headspace, and cool to 4°C ± 2°C	14 days
Metals[5]	Several Methods (Table 12.3)	1 – 1 L polyethylene bottle	2 mL concentrated HNO_3 and minimum headspace	28 days

[1] Indicates that this is the analytical method in use at time of publication. The analytical method is subject to change with advancements in analytical technology and implementation of more sensitive methods by the contracted laboratory(ies).

[2] EPA Method 9066 requires that the samples be preserved to a pH < 4 with concentrated H_2SO_4 (approximately 10 uL). To avoid handling such small quantities in the field, the sample should be preserved with 1 mL 10% conc. H_2SO_4 by volume.

[3] EPA Method 9012 requires that the samples be preserved to a pH ≥ 12 with concentrated sodium hydroxide.

[4] EPA Method 9030 requires that the samples be preserved with four drops of 2N zinc acetate solution per 100 mL of sample and adjusted to a pH > 9 with 6N NaOH. Adequate preservation of WSTF groundwater is provided with 1 mL 1N zinc acetate and 200 uL 50% NaOH per 250 mL groundwater.

[5] Total Appendix IX Metals samples require preservation to a pH < 2 with concentrated HNO_3.

9.4.5 Sample Custody

A strict chain of custody is enforced for all groundwater samples collected at WSTF. Each sample is recorded on a designated chain of custody form. Chain of custody forms are used to track possession of groundwater samples from the time of collection through sample analysis and the reporting of analytical results to WSTF by the laboratories. Chain of custody forms provide legal documentation of possession throughout the entire sampling and analysis process. Each form must contain at least the following information:

- sample shipment and reporting information and addresses;
- unique sample number of each sample;
- sample type/matrix (aqueous/groundwater);
- sample collection location;
- number of containers for each sample;
- required chemical analysis or analytical method;
- date of sample shipment;
- signature(s), date(s), and time(s) of all personnel involved in sample custody;

A chain of custody form is completed for each shipment of samples and is included in the icechest during shipment or delivery to the analytical laboratory. A copy of the form is retained at WSTF with the shipping documentation. The original chain of custody accompanies the samples to the analytical laboratory, and is eventually returned with the analytical report from the laboratory to become a part of the permanent sampling and analytical records maintained at WSTF. The current WSTF chain of custody form is represented in Attachment J.

9.4.6 Sample Shipment/Delivery

Groundwater samples collected at WSTF are delivered or shipped to the contracted laboratories for analysis. Specific procedures are required to ensure that groundwater samples are transported to the respective analytical laboratories in an acceptable manner. Samples are inspected prior to packaging for correctness and completeness of labeling. Sample containers are then packaged as necessary to prevent breakage, transferred to an ice chest, and packed with ice. Sampling personnel complete the appropriate shipping documents and include a copy with the sample shipment.

The packed ice chest(s) and shipping documents are delivered to the WSTF Warehouse, where shipping personnel sign for custody of the samples. The ice chests are then secured and shipped via next-day delivery to the contracted laboratory. The laboratory custodian inspects the samples upon delivery, notifies WSTF if any irregularities are encountered, and signs and returns the chain of custody form(s) to WSTF. Specific instructions on sample handling, packing, delivery, and shipment are provided in the site-specific procedural documents for groundwater sampling.

10.0 Groundwater Sample Collection Schedule

NASA's substantial network of groundwater monitoring wells has been installed to fulfill the following primary requirements:

- provide post-closure care monitoring capabilities at each of the hazardous waste management units at WSTF in accordance with the PCC GWMPs;
- permit horizontal and vertical plume definition and conceptualization of the extent of the contamination plume;
- collect chemical and physical data from the groundwater to detect potential contaminant releases from current operations and to predict future contaminant migration as a result of historical operations and releases; and
- monitor the impacts and efficiency of current and potential corrective actions.

This section provides information related to the development and implementation of the groundwater sampling schedule. This section addresses routine groundwater monitoring at WSTF, and identifies the analytical requirements and sample collection frequencies for specific analyses at each monitoring well. Additional sampling requirements are defined by specific work plans, project plans, and monitoring plans/programs. Individual hazardous constituents are identified in the PCC Permit, the Permit's GWMPs, and/or in specific project plans. The purpose of this section of the SAP is to provide details related to routine groundwater monitoring and reporting and to serve as a foundation upon which the monitoring requirements of special projects can be built.

10.1 Sample Analytical Requirements

10.1.1 Routine Analyses

Historical analytical data from the WSTF groundwater monitoring wells indicate the presence of groundwater contamination from a variety of volatile organic compounds (including halogenated volatiles), N-nitrosodimethylamine (NDMA), N-nitrodimethylamine (DMN), bromacil, and heavy metals. Groundwater monitoring wells at WSTF are routinely sampled for these contaminants at various intervals.

10.1.2 Post-Closure Care Analyses

In addition to routine sampling requirements mentioned above, additional sampling is required for the PCC wells identified in the Permit and the GWMPs that direct groundwater monitoring during detection monitoring, compliance monitoring, and corrective action monitoring programs at WSTF. Several monitoring wells or Westbay zones in the 200, 300, 400, and 600 Areas may require semi-annual replicate sampling for the constituents identified previously in this section. The GWMP in effect at the time of sampling determines the necessity of replicate sampling. Monitoring wells/zones that are designated as Points of Compliance by the GWMP in effect require annual sampling for all Appendix IX analyses except dioxins and furans. Dioxin and furan samples are collected every three years due to their historical non-use at the WSTF facility. Information gathered from this activity ensures that WSTF continues to direct its

monitoring activities to the detection and evaluation of all hazardous constituents contained in the groundwater. This SAP reflects the Point of Compliance wells/zones – which require Appendix IX sampling – that are approved by NMED at the time of publication. Prior to sample collection activities, sampling personnel will contact the responsible contractor environmental personnel to determine exact sampling requirements as mandated by the GWMP or other project plan in effect at the time of sampling. The monitoring wells/zones that require replicate and Appendix IX sampling at the time of SAP publication are shown in Table 10.1. This table is subject to change depending on the GWMP in effect.

10.2 Sample Collection Frequencies

The groundwater sample collection frequencies provided in this section are determined by monitoring well locations in relation to the hazardous waste management units, location in the conceptualized contaminant plume, spatial location in relationship to other groundwater monitoring and remediation wells, and the relative chemical significance of the data obtained from the well. Groundwater monitoring wells are sampled quarterly for one year after installation. After this initial period, the analytical data are reviewed and a sampling frequency and collection plan for each well is determined.

10.2.1 Volatile Organic Compounds

All groundwater monitoring wells are sampled for volatile organic compounds (VOC) at each scheduled sampling event.

10.2.2 Nitrosamines – NDMA/DMN

Historical analytical data indicate that NDMA and DMN are not present in the 100 and 600 Areas. As a result, NDMA/DMN samples are not routinely collected in these areas. However, in order to confirm the absence of NDMA and DMN in these areas, at least one monitoring well in each area will be sampled annually for NDMA. The monitoring well(s) selected from each area will represent the well(s) most susceptible to NDMA/DMN contamination.

Monitoring wells outside of the 100 and 600 Areas are sampled for NDMA/DMN at each scheduled sampling event.

TABLE 10.1
Post-Closure Care and Appendix IX Monitoring Wells/Zones

Closure Area	PCC Wells/Zones	Appendix IX Wells/Zones
200 Area	200-B-240 200-D-240 200-F-225 200-F-370 200-F-420 200-G-175 200-G-220 200-G-340 200-G-420 200-G-495 200-H-225 200-H-331 200-H-433 200-SG-1	200-F-225 200-G-175 200-H-225
300 Area	300-A-120 300-A-170 300-D-153 300-E-138 300-E-183 NASA 5 NASA 10	300-D-153 300-E-138 NASA 10
400 Area	400-C-118 400-C-143 400-D-195 400-D-275 400-D-335 NASA 6 NASA 9	400-D-195 NASA 9
600 Area	600-D-230 600-D-365 600-D-635 600-D-845 NASA 7 NASA 8	600-D-365 NASA 7

10.2.3 Bromacil

The presence of bromacil in WSTF groundwater is a result of its localized use as a herbicide. Analytical detections of bromacil are likewise localized. All Post-Closure Care monitoring wells provided in Table 10.1 will be sampled for bromacil at each regularly scheduled sampling event. In addition, selected wells are sampled annually for bromacil based on its detection in those wells during a site-wide investigation.

10.2.4 Metals

Every groundwater monitoring well is initially screened for all RCRA metals for at least four quarterly sampling events following installation. Continued sampling for metals is based on a statistical evaluation of the metals results from these samples. In general, monitoring wells with evidence of metals contamination are sampled for those metals on an annual basis. If a statistical analysis is not available or cannot be performed after the first year of sampling, the monitoring well will continue to be sampled for each metal that was detected during the first four sampling events during each subsequent event. Groundwater samples will be collected for the analysts of all RCRA metals at least once every two years until the statistical analysis is performed. Additional metals detected during these biannual events will be added to the well's routine sample schedule.

Because of its historic use at WSTF, chromium is sampled for at each monitoring well on an annual basis (except for wells that are sampled biannually). Additionally, due to elevated chromium concentrations detected in the immediate vicinity of the 600 Area, additional sampling for total chromium is performed at select wells.

Groundwater monitoring wells that are scheduled for Appendix IX sampling in accordance with the GWMP in effect are sampled for additional metals. These metals analyses are described further in Section 12.4.

The criteria above were utilized to develop Table 10.2, which provides the sample collection schedule for each groundwater monitoring well at WSTF. The frequencies established in Table 10.2 are for routine groundwater monitoring. Specific project plans, work plans, or other groundwater monitoring programs/plans may require altered sampling frequencies depending on project and site requirements. The WSTF groundwater sample scheduling database is utilized to schedule groundwater monitoring activities on a monthly basis. This database is continually updated with the most recent and stringent sampling requirements. This ensures that the required samples are collected from each monitoring well in a timely and orderly fashion.

The sampling schedule is reviewed annually to ensure that adequate information is generated to support ongoing and anticipated groundwater-related programs and projects. If modifications to the schedule are necessary, they are included in updated versions of this document.

TABLE 10.2
Groundwater Sample Collection Frequencies

Well ID	Analytical Requirement											
	VOA	NDMA/ DMN	Bromacil	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury	Appendix IX
100-A-182	BA						BA					
100-C-365	BA						BA					
100-D-176	Q		A	Q	Q	Q	Q	Q	Q	Q	Q	
100-E-261	BA						BA					
200-B-240	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
200-C-170	SA	SA	A	SA			A					
200-C-225	SA	SA	A				A					
200-C-270	SA	SA	A				A					
200-D-240	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
200-F-225	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
200-F-370	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
200-F-420	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
200-G-175	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
200-G-220	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
200-G-340	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
200-G-420	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
200-G-495	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
200-H-225	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
200-H-331	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
200-H-433	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
200-I-185	SA	SA	A	SA	SA	BA	SA	SA	SA	SA	SA	
200-I-300	SA	SA	A	SA	SA	BA	SA	BA	SA	SA	SA	
200-I-375	SA	SA	A	SA	SA	SA	SA	SA	SA	SA	SA	
200-I-490	SA	SA	A	SA	SA	SA	SA	SA	BA	SA	SA	
200-I-675	SA	SA	A	SA	SA	SA	SA	BA	SA	SA	SA	
200-I-795	SA	SA	A	SA	SA	SA	SA	BA	BA	SA	SA	
200-SG-1	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
300-A-120	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
300-A-170	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
300-B-166	A	A	A		A		A	A				
300-C-128	A	A	A		A		A					
300-D-153	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA

TABLE 10.2
Groundwater Sample Collection Frequencies

Well ID	Analytical Requirement											
	VOA	NDMA/ DMN	Bromacil	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury	Appendix IX
300-E-138	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
300-E-183	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
400-A-151	SA	SA	A				A					
400-C-118	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
400-C-143	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
400-D-195	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
400-D-275	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
400-D-355	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
600-C-173	SA	SA			SA		SA		A			
600-D-230	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
600-D-365	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
600-D-635	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
600-D-845	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
600-E-280	SA	SA	A	SA	SA	SA	SA	SA	SA	SA	SA	
700-A-253	SA	SA					A					
700-B-510	SA	SA					A					
700-D-186	SA	SA					SA					
700-E-458	A	A					A					
700-F-455	SA	SA	A				SA					
700-H-350	SA	SA		BA	SA	BA	SA	BA	SA	BA	SA	
700-H-535	SA	SA		SA	SA	BA	SA	SA	SA	BA	BA	
700-H-670	SA	SA		SA	SA	BA	SA	BA	SA	BA	BA	
700-J-200	SA	SA		SA	SA	BA	SA	BA	SA	BA	BA	
BLM-1-435	SA	SA	A				SA					
BLM-2-482	SA	SA	A				SA					
BLM-2-630	SA	SA	A				SA	SA				
BLM-3-182	A	A			A		A					
BLM-5-527	A	A					A					
BLM-6-488	Q	Q	A		Q		Q					
BLM-7-509	SA	SA					SA					
BLM-8-418	SA	SA			SA		A					
BLM-9-419	SA	SA	A				A					

TABLE 10.2
Groundwater Sample Collection Frequencies

Well ID	Analytical Requirement											
	VOA	NDMA/ DMN	Bromacil	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury	Appendix IX
BLM-10-517	SA	SA					A					
BLM-13-300	SA	SA					A					
BLM-14-327	SA	SA	A				A					
BLM-15-305	SA	SA	A		SA		A					
BLM-17-493	SA	SA					SA					
BLM-17-550	SA	SA	A				SA					
BLM-18-430	Q	Q					A					
BLM-21-400	SA	SA	A				A					
BLM-22-570	A	A					A					
BLM-23-431	SA	SA			SA		SA					
BLM-24-565	SA	SA					A					
BLM-25-455	SA	SA	A				A					
BLM-26-404	SA	SA					A					
BLM-27-270	SA	SA	A		SA		SA					
BLM-28-425	SA	SA	A				SA		SA			
BLM-28-470	SA	SA	A				SA					
BLM-28-525	SA	SA	A				A					
BLM-30-585	SA	SA					A					
BLM-31-350	SA	SA					A					
BLM-31-485	SA	SA					A					
BLM-32-580	SA	SA		SA	SA	BA	BA	SA	SA	BA	SA	
BLM-32-645	SA	SA		SA	SA	BA	BA	BA	SA	BA	BA	
BLM-32-715	SA	SA		SA	SA	BA	SA	BA	BA	BA	BA	
BLM-36-350	Q	Q	A	Q	Q	BA	Q	BA	BA	Q	BA	
BLM-36-610	Q	Q		Q	Q	BA	Q	BA	Q	BA	BA	
BLM-36-800	Q	Q		Q	Q	BA	Q	BA	BA	Q	BA	
BLM-36-860	Q	Q		Q	Q	BA	Q	Q	BA	BA	BA	
BLM-37-490	Q	Q		Q	Q	BA	Q	Q	BA	BA	BA	
BLN-37-640	Q	Q		Q	Q	BA	BA	BA	Q	BA	Q	
BLM-37-750	Q	Q		Q	Q	BA	Q	Q	Q	BA	BA	
BLM-37-885	Q	Q		Q	Q	BA	Q	BA	Q	BA	BA	
BLM-38-480	Q	Q		Q	Q	BA	Q	Q	Q	BA	BA	

TABLE 10.2
Groundwater Sample Collection Frequencies

Well ID	Analytical Requirement											
	VOA	NDMA/ DMN	Bromacil	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury	Appendix IX
BLM-38-620	Q	Q		Q	Q	BA	Q	BA	Q	Q	Q	
BLM-39-385	Q	Q		Q	Q	BA	BA	BA	Q	BA	BA	
BLM-39-560	Q	Q		Q	Q	BA	BA	BA	Q	BA	BA	
BW-1-268	A	A	A		A		A					
BW-3-180	A	A	A				A					
BW-4-270	SA	SA	A		SA		A					
BW-4-355	SA	SA	A				A					
BW-4-455	SA	SA	A				A					
BW-5-295	A	A					A					
BW-6-355	A	A					A					
BW-7-211	SA	SA	A		SA		A					
JP-1-424	Q	Q					A					
JP-2-447	Q	Q					A					
JP-3-515	Q	Q		Q	Q	BA	Q	BA	BA	BA	BA	
JP-3-695	Q	Q		Q	Q	BA	Q	Q	BA	Q	Q	
JP-3-825	Q	Q		Q	Q	BA	Q	BA	BA	BA	BA	
JP-3-970	Q	Q		Q	Q	BA	Q	BA	BA	Q	BA	
NASA 3	SA	SA					A					
NASA 4	A	A	A		A		A					
NASA 5	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
NASA 6	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
NASA 7	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
NASA 8	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	
NASA 9	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
NASA 10	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA	SA
PL-1-486	SA	SA	A				SA					
PL-2-504	SA	SA					SA					
PL-3-453	Q	Q					A					
PL-4-464	Q	Q					A					
PL-5-495	Q	Q					A					
PL-5-595	SA	SA					A					
PL-5-715	SA	SA	A				A					

TABLE 10.2
Groundwater Sample Collection Frequencies

Well ID	Analytical Requirement											
	VOA	NDMA/ DMN	Bromacil	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury	Appendix IX
PL-5-795	SA	SA					A					
PL-5-895	SA	SA		SA								
PL-5-985	SA	SA			SA		A					
PL-6-545	Q	Q					A					
PL-6-725	Q	Q					A					
PL-6-915	Q	Q		Q			A					
PL-6-1195	Q	Q					A					
PL-6-1335	Q	Q	A				A					
PL-6-1485	Q	Q					A					
PL-6-1645	Q	Q		Q			A					
PL-6-1815	Q	Q			Q		A					
PL-7-480	Q	Q			Q		A					
PL-7-560	Q	Q					A					
PL-7-630	Q	Q					A					
PL-8-455	Q	Q		Q	Q	BA	Q	BA	BA	BA	BA	
PL-8-605	Q	Q		Q	Q	BA	BA	BA	BA	Q	BA	
PL-8-780	Q	Q		Q	Q	BA	Q	BA	BA	BA	BA	
PL-8-965	Q	Q		Q	Q	BA	Q	BA	Q	BA	Q	
PL-10-484	Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	
PL-10-592	Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	
PL-10-813	Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	
PL-10-962	Q	Q		Q	Q	Q	Q	Q	Q	Q	Q	
ST-1-473	Q	Q					A					
ST-1-541	Q	Q	A				A					
ST-1-630	Q	Q			Q		A					
ST-2-466	Q	Q					A					
ST-3-486	Q	Q					Q					
ST-3-586	Q	Q			Q		Q					
ST-3-666	Q	Q	A		Q		A					
ST-3-735	Q	Q			Q		A					
ST-4-481	Q	Q					A					
ST-4-589	Q	Q			Q		A					

TABLE 10.2
Groundwater Sample Collection Frequencies

Well ID	Analytical Requirement											
	VOA	NDMA/ DMN	Bromacil	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury	Appendix IX
ST-4-690	Q	Q	A		Q		Q	Q				
ST-5-481	Q	Q					Q					
ST-5-485	Q	Q					A					
ST-5-655	Q	Q	A				A					
ST-5-815	Q	Q					A					
ST-5-985	Q	Q	A				A					
ST-5-1175	Q	Q		Q	Q		A					
ST-6-535	Q	Q	A	Q	Q	BA	Q	Q	Q	Q	Q	
ST-6-575	Q	Q	A	Q	Q	BA	Q	Q	Q	Q	Q	
ST-6-575	Q	Q	A	Q	Q	BA	Q	Q	Q	Q	Q	
ST-6-830	Q	Q	A	Q	Q	BA	Q	Q	Q	BA	BA	
ST-6-975	Q	Q	A	Q	Q	Q	Q	Q	Q	Q	Q	
ST-7-450	Q	Q		Q	Q	BA	Q	BA	BA	Q	BA	
ST-7-550	Q	Q		Q	Q	BA	Q	BA	Q	BA	BA	
ST-7-785	Q	Q		Q	Q	BA	Q	BA	BA	Q	BA	
ST-7-975	Q	Q		Q	Q	Q	Q	BA	Q	BA	BA	
WB-1-200	SA	A					A					
WB-1-255	SA						A					
WB-1-330	SA						A					
WB-2-245	SA						A					
WB-2-270	SA						A					
WB-2-365	SA						A					
WB-3-330	SA						A					
WB-3-355	SA						A					
WB-3-425	SA						A					
WB-3-450	SA						A					
WB-5-250	SA						A					
WB-5-280	SA						A					
WB-5-345	SA						A					
WB-8-275	A						A					
WB-8-320	A						A					
WB-8-410	A					A	A					

TABLE 10.2
Groundwater Sample Collection Frequencies

Well ID	Analytical Requirement											
	VOA	NDMA/ DMN	Bromacil	Arsenic	Barium	Cadmium	Chromium	Lead	Selenium	Silver	Mercury	Appendix IX
WB-9-310	A						A					
WB-9-335	A						A					
WB-9-360	A						A					
WB-14-520	A						A					
WW-1-452	A	A					A					
WW-2-495	Q	Q		Q	Q	BA	BA	BA	Q	Q	BA	
WW-2-670	Q	Q		Q	Q	BA	BA	BA	Q	Q	BA	
WW-2-845	Q	Q		Q	Q	BA	Q	Q	Q	BA	BA	
WW-2-960	Q	Q		Q	Q	BA	BA	BA	Q	BA	BA	
WW-3-469	Q	Q		Q	Q	BA	Q	BA	Q	BA	BA	
WW-3-569	Q	Q		Q	Q	BA	Q	BA	Q	BA	BA	
WW-3-710	Q	Q		Q	Q	BA	BA	BA	Q	BA	BA	
WW-3-978	Q	Q		Q	Q	BA	BA	Q	Q	BA	BA	
WW-4-423	Q	Q		Q	Q	Q	Q	Q	Q	BA	BA	
WW-4-594	Q	Q		Q	Q	BA	Q	Q	Q	BA	BA	
WW-4-853	Q	Q		Q	Q	Q	Q	BA	Q	BA	BA	
WW-4-953	Q	Q		Q	Q	Q	Q	Q	Q	BA	Q	
WW-5-464	Q	Q		Q	Q	BA	Q	Q	BA	Q	BA	
WW-5-582	Q	Q		Q	Q	Q	Q	Q	Q	Q	BA	
WW-5-814	Q	Q		Q	Q	Q	Q	BA	BA	Q	Q	
WW-5-912	Q	Q		Q	Q	Q	Q	BA	Q	Q	BA	

Q – Indicates that samples for this analytical requirement are collected quarterly.
SA – Indicates that samples for this analytical requirement are collected semi-annually.
A – Indicates that samples for this analytical requirement are collected annually.
BA – Indicates that samples for this analytical requirement are collected biannually

11.0 Post-Sampling Activities

WSTF groundwater monitoring wells do not have designated post-sampling activities. There are however, specific uses for and activities associated with many of the monitoring wells currently used in the groundwater assessment program. These activities include, but are not limited to: well inspections as required as indicated in Section 3.4; Westbay well hydraulic conductivity determinations following the installation of each Westbay monitoring well; monitoring well maintenance activities as required; monitoring wells surveys following installation of each monitoring well; and groundwater elevation measurements prior to each sampling event and at least quarterly. Specific information related to these activities is provided numerous WSTF project plans, work plans, and site-specific documentation.

12.0 Analysis

A variety of chemical analyses are performed on groundwater samples collected at WSTF. This SAP identifies the analytical requirements for routine groundwater sampling. Additional information related to specific sample collection requirements is provided in project-specific work plans that are developed prior to each groundwater-related activity at WSTF. Table 12.1, Table 12.2, and Table 12.3 provide lists of the analytes quantitated during routine groundwater analyses, their respective CAS numbers, the analytical methods used for these constituents, and WSTF's required quantitation limit or quantitation limit goal for each constituent. Method detection limits are determined by the specific laboratory performing the analyses and depend on a variety of elements related to laboratory conditions and equipment. Detailed laboratory reports contain this information, which will be provided the regular analytical reports. Applicable regulatory limits or requirements associated with these constituents as they apply to WSTF are described in project-specific work plans or PCC groundwater monitoring programs.

The analytical methods provided in the tables are the most current available at the time of this document's publication. Analytical technology is constantly evolving, and more advanced analytical methods are developed regularly. NASA strives to utilize only the most applicable analytical technology for a given constituent. As a result, the analytical methods in Table 12.1 will be replaced with more advanced or more sensitive methods as they are approved or recommended by EPA. NASA will provide revised versions of these tables each time this document is updated or when WSTF's analytical method use is impacted by improved technology, refined analytical approaches or laboratory practices, or evolving WSTF project requirements.

12.1 Volatile Organic Compounds

Volatile organic compounds (VOCs) are analyzed by EPA Method 8260B or equivalent. Table 12.1 provides a list of the analytes quantitated by Method 8260B, their respective CAS Numbers, and the WSTF required quantitation limit for each constituent.

Table 12.1
WSTF Analyte List for Routine Groundwater Samples
Volatile Organic Compounds Analyzed by EPA Method 8260B or Equivalent

CAS Number	Analyte	Required Quantitation Limit (µg/L)
100-41-4	Ethylbenzene	1
100-42-5	Styrene	1
10061-01-5	cis-1,3-Dichloropropene	1
10061-02-6	trans-1,3-Dichloropropene	1
106-93-4	1,2-Dibromoethane (EDB)	1
107-02-8	Acrolein	10
107-05-1	Allyl chloride	2
107-06-2	1,2-Dichloroethane	1
107-12-0	Propionitrile	5
107-13-1	Acrylonitrile	4
108-05-4	Vinyl acetate	5
108-10-1	4-Methyl-2-pentanone (MIBK)	5
108-87-2	Methylcyclohexane	10
108-88-3	Toluene	1
108-90-7	Chlorobenzene	1
109-99-9	Tetrahydrofuran	2
110-57-6	trans-1,4-Dichloro-2-butene	1
110-82-7	Cyclohexane	10
123-91-1	1,4-Dioxane	10
124-48-1	Dibromochloromethane	1
126-98-7	Methacrylonitrile	5
126-99-8	2-Chloro-1,3-butadiene (chloroprene)	1
127-18-4	Tetrachloroethene	1
1330-20-7	m+p-Xylene	1
156-59-2	cis-1,2-Dichloroethene	1
156-60-5	trans-1,2-Dichloroethene	1
1634-04-4	Methyl tert-butyl ether (MTBE)	10
306-83-2	2,2-Dichloro-1,1,1-trifluoroethane	1
354-23-4	1,2-Dichloro-1,1,2-trifluoroethane	1
56-23-5	Tetrachloromethane (carbon tetrachloride)	1
591-78-6	2-Hexanone	5
630-20-6	1,1,1,2-Tetrachloroethane	1
67-63-0	2-Propanol	20
67-64-1	Acetone	10
67-66-3	Chloroform	1
71-43-2	Benzene	1

Table 12.1
WSTF Analyte List for Routine Groundwater Samples
Volatile Organic Compounds Analyzed by EPA Method 8260B or Equivalent

CAS Number	Analyte	Required Quantitation Limit (µg/L)
71-55-6	1,1,1-Trichloroethane	1
74-83-9	Bromomethane	2
74-87-3	Chloromethane	2
74-88-4	Iodomethane	5
74-95-3	Dibromomethane	1
75-00-3	Chloroethane	2
75-01-4	Vinyl chloride	1
75-05-8	Acetonitrile	20
75-09-2	Dichloromethane (methylene chloride)	1
75-15-0	Carbon disulfide	1
75-25-2	Bromoform	1
75-27-4	Bromodichloromethane	1
75-34-3	1,1-Dichloroethane	1
75-35-4	1,1-Dichloroethene	1
75-43-4	Dichlorofluoromethane	1
75-69-4	Trichlorofluoromethane	1
75-71-8	Dichlorodifluoromethane	1
76-13-1	1,1,2-Trichloro-1,2,2-trifluoroethane	1
78-83-1	Isobutyl alcohol	50
78-87-5	1,2-Dichloropropane	1
78-93-3	2-Butanone (MEK)	5
79-00-5	1,1,2-Trichloroethane	1
79-01-6	Trichloroethene	1
79-34-5	1,1,2,2-Tetrachloroethane	1
80-62-6	Methyl methacrylate	1
95-47-6	o-Xylene	1
96-12-8	1,2-Dibromo-3-chloropropane (DBCP)	2
96-18-4	1,2,3-Trichloropropane	1
97-63-2	Ethyl methacrylate	1

12.2 Nitrosamines – NDMA and DMN

Nitrosamines (NDMA/DMN) are analyzed by Modified EPA Method 607 or equivalent. Table 12.2 provides a list of the analytes quantitated by Method 607, their respective CAS Numbers, and the WSTF required quantitation limit for each constituent.

Table 12.2
WSTF Analyte List for Routine Groundwater Samples
Compounds Analyzed by EPA Method 607 or Equivalent

CAS Number	Analyte	Required Quantitation Limit (µg/L)
62-75-9	N-nitrosodimethylamine	0.01
4164-28-7	N-nitrodimethylamine	0.01
314-40-9	Bromacil	0.1

12.3 Bromacil

A recent PCC Permit modification authorized the use of Modified EPA Method 607 for the analysis of bromacil in conjunction with nitrosamines analysis. Table 12.2 provides the CAS Number and the WSTF required quantitation limit for bromacil. Bromacil can frequently be more effectively and accurately quantitated by alternative EPA Methods provided by SW-846. NASA anticipates the use of an alternative analytical method during future monitoring. NASA's updated PCC Permit and this SAP provide the language necessary to utilize more accurate analytical technology for the analysis of groundwater constituents. NASA will provide an updated version of this document in the event that an alternative analytical method is selected for the quantitation of bromacil.

12.4 Metals

Metals are quantitated using several analytical methods. Table 12.3 provides a list of the metals quantitated, their respective CAS Numbers, the analytical method utilized for each, and WSTF's quantitation limit goal for each metal. RCRA metals samples are collected routinely during groundwater sampling at WSTF. Additional metals samples are also collected during PCC sampling activities at wells or zones designated for Appendix IX sampling.

Table 12.3
WSTF Analyte List for Routine Groundwater Samples
Metals Analyzed by EPA Method Specified or Equivalent

EPA Method	CAS Number	Analyte	Quantitation Limit Goal (mg/L)
6010B/6020	7429-90-5	Aluminum	0.1
6010B/6020	7440-36-0	Antimony	0.06
6010B/6020/7060A	7440-38-2	Arsenic*	0.005
6010B/6020	7440-39-3	Barium*	0.01
6010B/6020	7440-41-7	Beryllium	0.005
6010B	7440-42-8	Boron	0.2
6010B/6020	7440-43-9	Cadmium*	0.005
6010B	7440-70-2	Calcium	0.5
6010B/6020	7440-47-3	Chromium*	0.01

Table 12.3
WSTF Analyte List for Routine Groundwater Samples
Metals Analyzed by EPA Method Specified or Equivalent

EPA Method	CAS Number	Analyte	Quantitation Limit Goal (mg/L)
6010B/6020	7440-48-4	Cobalt	0.05
6010B/6020	7440-50-8	Copper	0.02
6010B	7439-89-6	Iron	0.1
6010B/6020/7421	7439-92-1	Lead*	0.005
6010B	7439-95-4	Magnesium	0.5
6010B/6020	7439-96-5	Manganese	0.01
7470A	7439-97-6	Mercury*	0.0002
6010B	7439-98-7	Molybdenum	0.25
6010B/6020	7440-02-0	Nickel	0.04
6010B	7440-09-7	Potassium	2.0
6010B/7740	7782-49-2	Selenium*	0.005
6010B/6020	7440-22-4	Silver*	0.01
6010B	7440-23-5	Sodium	0.5
6010B	7440-24-6	Strontium	0.01
6010B/6020/7841	7440-28-0	Thallium	0.01
6010B	7440-31-5	Tin	0.5
6010B	7440-62-2	Vanadium	0.05
6010B/6020	7440-66-6	Zinc	0.02

* Indicates that this analyte is a RCRA metal as described in Section 10.2.4.

12.5 Appendix IX Analyses

As indicated in Section 9, NASA also collects groundwater samples for Appendix IX analytes on a regular basis in accordance with the PCC Permit and associated GWMPs. In addition to volatile organic analysis by EPA Method 8260B and nitrosamines by EPA Method 607, Appendix IX analytical methods consist of EPA Method 8270C for semi-volatile organics, EPA Method 8081A for pesticides, EPA Method 8082 for PCBs, EPA Method 8280 for dioxins and furans, EPA Method 8151 for herbicides, EPA Method 9066 for phenolics, EPA Method 9012 for total cyanide, EPA Method 9030 for total sulfide, and the methods indicated in Table 12.3 for the various Appendix IX metals.

The analytes quantitated by EPA Methods 8260 and 607 are provided in Table 12.1 and Table 12.2, respectively. Table 12.4 provides the analytes quantitated by EPA Method 8270C. Table 12.5 provides the analytes quantitated by EPA Method 8081A. Table 12.6 provides the analytes quantitated by EPA Method 8082. Table 12.7 provides the analytes quantitated by EPA Method 8290. Table 12.8 provides the analytes quantitated by EPA Method 8151. Table 12.9 provides the analyte quantitated by EPA Method 9066. Table 12.10 provides the analyte quantitated by EPA Method 9012A. Table 12.11 provides the analyte quantitated by EPA Method 9030B.

Table 12.4
WSTF Analyte List for Appendix Groundwater Samples
Compounds Analyzed by EPA Method 8270C or Equivalent

CAS Number	Analyte	Required Quantitation Limit (µg/L)
100-01-6	4-Nitroaniline	50
100-02-7	4-Nitrophenol	50
100-51-6	Benzyl Alcohol	10
100-75-4	N-Nitrosopiperidine	10
101-55-3	4-Bromophenyl phenyl ether	10
105-67-9	2,4-Dimethylphenol	10
10595-95-6	N-Nitrosomethylethylamine	10
106-46-7	1,4-Dichlorobenzene	10
106-47-8	P-Chloroaniline	50
106-50-3	P-Phenylenediamine	50
108-60-1	2,2'-oxybis(1-Chloropropane)	10
108-95-2	Phenol	10
109-06-8	2-Picoline	10
110-86-1	Pyridine	50
111-44-4	bis(2-Chloroethyl) ether	10
111-91-1	Bis(2-Chloroethoxy)methane	10
117-81-7	bis(2-Ethylhexyl) phthalate	6 *
117-84-0	Di-n-octyl phthalate	10
118-74-1	Hexachlorobenzene	1 *
119-93-7	3,3'-Dimethylbenzidine	10
120-12-7	Anthracene	10
120-58-1	Isosafrole	10
120-82-1	1,2,4-Trichlorobenzene	10
120-83-2	2,4-Dichlorophenol	10
121-14-2	2,4-Dinitrotoluene	10
122-09-8	a,a-Dimethylphenethylamine	50
122-39-4	Diphenylamine	10
122-66-7	1,2-Diphenylhydrazine	10
126-68-1	o,o,o-Triethyl phosphorothioate	10
129-00-0	Pyrene	10
130-15-4	1,4-Naphthoquinone	50
131-11-3	Dimethyl phthalate	10
1319-77-3	3+4-Methylphenol (m+p-Cresol)	10
132-64-9	Dibenzofuran	10
134-32-7	1-Naphthylamine	10
140-57-8	Aramite	50
1888-71-7	Hexachloropropene	10
191-24-2	Benzo(g,h,i)perylene	10

Table 12.4
WSTF Analyte List for Appendix Groundwater Samples
Compounds Analyzed by EPA Method 8270C or Equivalent

CAS Number	Analyte	Required Quantitation Limit (µg/L)
193-39-5	Indeno(1,2,3-cd)pyrene	0.1 SIM
205-99-2	Benzo(b)fluoranthene	0.1 SIM
206-44-0	Fluoranthene	10
207-08-9	Benzo(k)fluoranthene	0.1 SIM
208-96-8	Acenaphthylene	10
218-01-9	Chrysene	0.1 SIM
2303-16-4	Diallate	10
23950-58-5	Pronamide	10
297-97-2	Thionazin	10
298-00-0	Methyl parathion	10
298-02-2	Phorate	10
298-04-4	Disulfoton	10
3689-24-5	Sulfotepp	10
465-73-6	Isodrin	10
50-32-8	Benzo(a)pyrene	0.1 SIM
510-15-6	Chlorobenzilate	10
51-28-5	2,4-Dinitrophenol	50
534-52-1	4,6-Dinitro-2-Methylphenol	50
53-70-3	Dibenz(a,h)anthracene	0.1 SIM
53-96-3	2-Acetylaminofluorene	10
541-73-1	1,3-Dichlorobenzene	10
55-18-5	N-Nitrosodiethylamine	10
56-38-2	Ethyl Parathion	10
56-49-5	3-Methylcholanthrene	10
56-55-3	Benzo(a)anthracene	0.1 SIM
56-57-5	4-Nitroquinoline-1-Oxide	50
57-97-6	7,12-Dimethylbenz(a)anthracene	10
58-90-2	2,3,4,6-Tetrachlorophenol	10
59-50-7	4-Chloro-3-Methylphenol	10
59-89-2	N-Nitrosomorpholine	10
60-11-7	p-(Dimethylamino)azobenzene	10
60-51-5	Dimethoate	50
606-20-2	2,6-Dinitrotoluene	10
608-93-5	Pentachlorobenzene	10
621-64-7	N-Nitroso-n-dipropylamine	10
62-44-2	Phenacetin	10
62-50-0	Ethyl Methanesulfonate	10
62-53-3	Aniline	10

Table 12.4
WSTF Analyte List for Appendix Groundwater Samples
Compounds Analyzed by EPA Method 8270C or Equivalent

CAS Number	Analyte	Required Quantitation Limit (µg/L)
62-75-9	N-Nitrosodimethylamine	10
66-27-3	Methyl Methanesulfonate	10
67-72-1	Hexachloroethane	10
7005-72-3	4-Chlorophenyl phenyl ether	10
70-30-4	Hexachlorophene	50
76-01-7	Pentachloroethane	10
77-47-4	Hexachlorocyclopentadiene	10
78-59-1	Isophorone	10
82-68-8	Pentachloronitrobenzene	10
83-32-9	Acenaphthene	10
84-66-2	Diethyl Phthalate	10
84-74-2	Di-n-butyl phthalate	10
85-01-8	Phenanthrene	10
85-68-7	Butyl benzyl phthalate	10
86-30-6	N-Nitrosodiphenylamine	10
86-73-7	Fluorene	10
87-65-0	2,6-Dichlorophenol	10
87-68-3	Hexachlorobutadiene	10
88-06-2	2,4,6-Trichlorophenol	10
88-74-4	2-Nitroaniline	50
88-75-5	2-Nitrophenol	10
90-12-0	1-Methylnaphthalene	10
91-20-3	Naphthalene	10
91-57-6	2-Methylnaphthalene	10
91-58-7	2-Chloronaphthalene	10
91-59-8	2-Naphthylamine	10
91-80-5	Methapyrilene	50
91-94-1	3,3'-Dichlorobenzidine	10
92-67-1	4-Aminobiphenyl	50
92-87-5	Benzidine	100
930-55-2	N-Nitrosopyrrolidine	10
94-59-7	Safrole	10
95-48-7	2-Methylphenol	10
95-50-1	1,2-Dichlorobenzene	10
95-53-4	O-Toluidine	10
95-57-8	2-Chlorophenol	10
95-94-3	1,2,4,5-Tetrachlorobenzene	10
95-95-4	2,4,5-Trichlorophenol	10

Table 12.4
WSTF Analyte List for Appendix Groundwater Samples
Compounds Analyzed by EPA Method 8270C or Equivalent

CAS Number	Analyte	Required Quantitation Limit (µg/L)
98-86-2	Acetophenone	10
98-95-3	Nitrobenzene	10
99-09-2	3-Nitroaniline	50
99-35-4	1,3,5-Trinitrobenzene	10
99-55-8	5-Nitro-o-toluidine	10
99-65-0	1,3-Dinitrobenzene	10

Table 12.5
WSTF Analyte List for Appendix Groundwater Samples
Compounds Analyzed by EPA Method 8081A or Equivalent

CAS Number	Analyte	Required Quantitation Limit (µg/L)
1024-57-3	Heptachlor epoxide	0.05
1031-07-8	Endosulfan sulfate	0.1
143-50-0	Kepone	10
309-00-2	Aldrin	0.05
319-84-6	alpha-BHC	0.05
319-85-7	beta-BHC	0.05
319-86-8	delta-BHC	0.05
33213-65-9	beta-Endosulfan	0.1
50-29-3	4,4'-DDT	0.1
5103-71-9	Alpha-Chlordane	0.05
5103-74-2	Gamma-Chlordane	0.05
52-85-7	Famphur	10
57-74-9	Chlordane (technical)	0.5
58-89-9	gamma-BHC (Lindane)	0.05
60-57-1	Dieldrin	0.05
72-20-8	Endrin	0.05
72-43-5	Methoxychlor	0.5
72-54-8	4,4'-TDE (DDD)	0.05
72-55-9	4,4'-DDE	0.05
7421-93-4	Endrin aldehyde	0.1
76-44-8	Heptachlor	0.05
8001-35-2	Toxaphene	1
959-98-8	Alpha-Endosulfan	0.05

Table 12.6
WSTF Analyte List for Appendix Groundwater Samples
Compounds Analyzed by EPA Method 8082 or Equivalent

CAS Number	Analyte	Required Quantitation Limit (µg/L)
11096-82-5	PCB 1260	0.5
11097-69-1	PCB 1254	0.5
11104-28-2	PCB 1221	0.5
11141-16-5	PCB 1232	0.5
12672-29-6	PCB 1248	0.5
12674-11-2	PCB 1016	0.5
53469-21-9	PCB 1242	0.5

Table 12.7
WSTF Analyte List for Appendix Groundwater Samples
Compounds Analyzed by EPA Method 8290 or Equivalent

CAS Number	Analyte	Required Quantitation Limit (µg/L)
1746-01-6	2,3,7,8-TCDD	10
19408-74-3	1,2,3,7,8,9-HxCDD	25
3268-87-9	OCDD	50
35822-39-4	1,2,3,4,6,7,8-HpCDD	25
39001-02-0	OCDF	50
39227-28-6	1,2,3,4,7,8-HxCDD	25
40321-76-4	1,2,3,7,8-PeCDD	25
51207-31-9	2,3,7,8-TCDF	10
55673-89-7	1,2,3,4,7,8,9-HpCDF	25
57117-41-6	1,2,3,7,8-PeCDF	25
57117-44-9	1,2,3,6,7,8-HxCDF	25
57653-85-7	1,2,3,6,7,8-HxCDD	25
60851-34-5	2,3,4,6,7,8-HxCDF	25
67562-39-4	1,2,3,4,6,7,8-HpCDF	25
70648-26-9	1,2,3,4,7,8-HxCDF	25
72918-21-9	1,2,3,7,8,9-HxCDF	25
57117-31-4	2,3,4,7,8-PeCDF	25
NA	Total Hepta-Dioxins	50
NA	Total Hepta-Furans	50
NA	Total Hexa-Dioxins	50
NA	Total Hexa-Furans	50
NA	Total Penta-Dioxins	50
NA	Total Penta-Furans	50
NA	Total Tetra-Dioxins	50

Table 12.7
WSTF Analyte List for Appendix Groundwater Samples
Compounds Analyzed by EPA Method 8290 or Equivalent

CAS Number	Analyte	Required Quantitation Limit (µg/L)
NA	Total Tetra-Furans	50

Table 12.8
WSTF Analyte List for Appendix Groundwater Samples
Compounds Analyzed by EPA Method 8151 or Equivalent

CAS Number	Analyte	Required Quantitation Limit (µg/L)
87-86-5	Pentachlorophenol	1
88-85-7	Dinoseb	0.5
93-72-1	2,4,5-TP (Silvex)	0.5
93-76-5	2,4,5-T	0.5
94-75-7	2,4-D	0.5
1918-00-9	Dicamba	0.5

Table 12.9
WSTF Analyte List for Appendix Groundwater Samples
Compounds Analyzed by EPA Method 9066 or Equivalent

CAS Number	Analyte	Required Quantitation Limit (µg/L)
NA	Total Phenolics	0.005

Table 12.10
WSTF Analyte List for Appendix Groundwater Samples
Compounds Analyzed by EPA Method 9012A or Equivalent

CAS Number	Analyte	Required Quantitation Limit (µg/L)
57-12-5	Total Cyanide	0.01

Table 12.11
WSTF Analyte List for Appendix Groundwater Samples
Compounds Analyzed by EPA Method 9030B or Equivalent

CAS Number	Analyte	Required Quantitation Limit (µg/L)
18496-25-8	Total Sulfide	1

13.0 Statistical Analysis

The requirements for statistical analyses of analytical data are currently established in NASA's Post-Closure Care Permit (No. NM8800019434-2) and consist of tolerance interval evaluations performed by the environmental contractor organization and Analysis of Variance (ANOVA) calculations performed by an off-site statistical contractor. These statistical evaluations are provided in the NASA WSTF Post-Closure Care Report, submitted annually to NMED in April. The PCC Report and NASA's original PCC Permit (No. NM8800019434-2) also provide a description of the calculation procedures for these statistical evaluations, and include sample calculations for each type of analysis. Additionally, NASA regularly prepares and evaluates time concentration plots of several target contaminants in order to develop a better understanding of contaminant movement at WSTF. These evaluations are also provided in the PCC Report, and serve an important informational role in the groundwater assessment program. The environmental contractor organization utilizes these time concentration plots to determine plume movement and development, recognize and understand contaminant trending, anticipate future contaminant movement, and identify potential data gaps.

NASA's RCRA Permit Renew Application provides updated information related to statistical analyses of analytical data in association with the Post-Closure Care Groundwater Monitoring Programs. Additionally, the off-site statistical contractor is currently developing more advanced statistical tools for the evaluation of analytical data obtained from the WSTF groundwater monitoring program. The sheer volume of analytical data generated over the course of the groundwater assessment program at WSTF has made routine statistical evaluations difficult and overly complicated. Efforts to streamline this process will be included in the near future as an update to this document or as a modification to the RCRA Permit.

The need for statistical analyses is also addressed in project-specific work plans and additional monitoring programs outside the scope of this SAP. Specific projects that require groundwater monitoring activities beyond the requirements of the routine sampling described in this document shall require the development of project plans that identify the statistical analyses required to meet project objectives.

14.0 Quality Assurance/Quality Control Procedures

Quality assurance and quality control procedures are provided in the WSTF Quality Assurance Project Plan (QAPP) in Appendix B.

15.0 Analytical Reports and Data Management

15.1 Analytical Reports

The results of NASA's routine groundwater monitoring activities are reported to NMED on a monthly basis. The monthly report typically contains analytical results that were reported to NASA from the contracted analytical laboratories during the preceding month. At the time of

publication of this document, NASA submits a Monthly Activities Report to NMED that provides an update of all pertinent activities at WSTF during the preceding month. Analytical data from the wells is only one component of the currently reporting format. The current monthly report provides updated information on NASA activities, the status of submittals to NMED, groundwater sampling schedules for coming months, analytical reports, and appendices that detail data qualifiers, analytical detection and reporting limits, and a well location map. In addition, the monthly report includes a database of historical and current analytical data.

Although the current monthly report was developed by NASA in conjunction with several NMED bureaus in the past, NASA is investigating the opportunity to expand the current reports to provide NMED with the information requested in the Position Paper "General Reporting Requirements for Routine Groundwater Monitoring and RCRA Sites." The proposed reporting format will provide the information and data required for the following sections:

- title page that identifies the facility name, facility owner/operator, address, required facility identification number(s) (NMED and/or EPA), and the submittal date;
- executive summary that briefly summarizes the purpose, scope, results of groundwater monitoring performed during the preceding reporting period, and conclusions and recommendations based on the results;
- table of contents;
- introduction that identifies the site and all pertinent related information;
- scope of services that summarizes the activities actually performed in the preceding reporting period;
- regulatory criteria section that provides information regarding applicable groundwater remediation requirements;
- groundwater monitoring results, including a variety of monitoring data;
- groundwater chemical analytical data, including the historical analytical database and required instructions;
- remediation system monitoring if not submitted in an alternate report;
- summary that provides discussion, conclusions, and recommendations;
- list of tables that provide the data required in sections above;
- list of figures that supplements analytical and other data; and
- appendices as required.

Continuing negotiations between NASA and NMED will result in the development of an appropriate reporting format.

15.2 Data Management

NASA maintains a comprehensive analytical database consisting of historical and current analytical data obtained from the groundwater monitoring program at WSTF. This database, and its management requirements, is described in the WSTF QAPP.

16.0 References

Barcelona, M., J. Gibb, J. Helfrich, and E. Garske, 1985, Practical Guide for Ground-Water Sampling, Illinois State Water Survey, Champaign, IL, November 1985.

Black, W., H. Smith, F. Patton, 1986, "Multiple-Level Groundwater Monitoring with the MP System", Proceedings of the Surface and Borehole Geophysical Methods and Ground Water Instrumentation Conference and Exposition, National Water Well Association, Denver, CO, October 1986.

Ford, P., P. Turina, and D. Seely, 1984, Characterization of Hazardous Waste Sites - A Methods Manual: Volume II Available Sampling Methods, Second Edition, EPA 600/4-84-076, U.S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring Systems Laboratory, Las Vegas, NV, December 1984.

Environmental Protection Agency, 1986, RCRA Ground Water Monitoring Technical Enforcement Guidance Document, OSWER Directive 9950.1, Office of Solid Waste and Emergency Response (OSWER), Washington D.C., September 1986.

Environmental Protection Agency, 1986, Protocol for Ground-Water Evaluations, OSWER Directive 9080.0-1, Hazardous Waste Ground Water Task Force, Office of Solid Waste and Emergency Response (OSWER), Washington D.C., September 1986.

Environmental Protection Agency, 1989, Interim Final RCRA Facility Investigation Guidance Volumes I-IV, EPA 530/SW-89-031, Waste Management Division, Office of Solid Waste, Washington, DC, May 1989.

Environmental Protection Agency, 1990, Handbook: Ground Water Volume I: Ground Water and Contamination, EPA/625/6-90/016a, Office of Research and Development, Center for Environmental Research Information, Cincinnati, OH, September 1990.

Environmental Protection Agency, 1991, Handbook: Ground Water Volume II: Methodology and Contamination, EPA/625/6-90/016b, Office of Research and Development, Center for Environmental Research Information, Cincinnati, OH, July 1991.

Environmental Protection Agency, 1992, RCRA Ground-Water Monitoring: Draft Technical Guidance, EPA/530-R-93-001, Office of Solid Waste, Washington D.C., November 1992.

Environmental Protection Agency, Region I, 1996, Low Stress (low flow) Purging and Sampling for the Collection of Ground Water Samples From Monitoring Wells, EPA SOP #GW 0001, Revision 2, Washington, DC, July 1996.

Environmental Protection Agency, 1996, Sampler's Guide to the Contract Laboratory Program, (EPA/540/R-96/032), Internet at http://www.epa.gov/superfund/programs/clp/guidance.htm.

Environmental Protection Agency, 1997, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846), Third Edition, Office of Solid Waste and Emergency Response, Washington, D.C., June 1997, Internet at http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm.

Environmental Protection Agency, 1997, Office of Research and Development, National Center for Environmental Research and Quality Assurance, Quality Assurance Division, Glossary of Quality Assurance Terms and Related Acronyms, December 1997

Environmental Protection Agency, 1998, EPA Guidance for Quality Assurance Project Plans, (EPA QA/G-5) EPA/600/R-98/018, February 1998, Internet at http://www.epa.gov/quality/qa_docs.html.

Environmental Protection Agency, 2001, EPA Requirements for Quality Assurance Project Plans, (EPA QA/R-5) EPA/24-/B-1/003, March 2001, Internet at http://www.epa.gov/quality/qa_docs.html.

Environmental Protection Agency, 2001, Draft Guidance on Data Quality Indicators, (EPA QA/G-5i) September 2001, Internet at http://www.epa.gov/quality/qa_docs.html.

National Aeronautics and Space Administration, 2002, "Quality Assurance Project Plan for Groundwater Monitoring Activities", NASA WSTF, Las Cruces, NM, June 2002.

National Aeronautics and Space Administration, 1997, "Groundwater Sampling and Analysis Plan", NASA WSTF, Las Cruces, NM, July 1997.

National Aeronautics and Space Administration, "White Sands Test Facility Job Instruction,":

- WJI ENV-0013, "Conventional Well Sampling Instructions," March 27, 2000;
- WJI ENV-0014, "Hydraulic Conductivity Testing (K-Testing) of Aquifers Through Westbay Multi-Port Wells," 2003 Draft;
- WJI ENV-0018, "Groundwater Level and Well Depth Determinations," November 1, 1996;
- WJI ENV-0019, "Westbay Well Pressure Profiles," March 27, 2000;
- WJI ENV-0020, "Westbay Well Sampling Instructions," March 27, 2000;
- WJI ENV-0048, "Installation of Conventional Wells," 2003 Draft;
- WJI ENV-0049, "Installation of Westbay Wells," 2003 Draft;
- WJI ENV-0052, "Low-Flow Sampling Instructions," March 27, 2000.

National Archives and Records Administration, Office of the Federal Register, 1991, Code of Federal Regulations (CFR), Protection of Environment, Title 40, Parts 100 to 149, Washington, D.C., July 1, 1991.

National Archives and Records Administration, Office of the Federal Register, 1998, Code of Federal Regulations (CFR), Protection of Environment, Title 40, Parts 260 to 299, Washington D.C., July, 1998.

National Environmental Laboratory Accreditation Conference (NELAC), 2001, Chapter 1: Program and Policy Structure Standard, 2001 Standards, Internet at http://www.epa.gov/ttn/nelac.

National Environmental Laboratory Accreditation Conference (NELAC), 2001, Chapter 2: Quality Systems Standard, 2001 Standards, Internet at http://www.epa.gov/ttn/nelac.

New Mexico Environment Department, 2003, "Determination of Administrative Incompleteness: RCRA Permit Renewal Application, Attachment 4," Hazardous Waste Bureau, Santa Fe, NM, May 2003.

New Mexico Environment Department, 2001, Position Paper: Use of Low-Flow and Other Non-Traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring, Hazardous Waste Bureau, Santa Fe, NM, October 30, 2001, Internet at http://www.nmenv.state.nm.us/hwb/data/11-7low-flow%20final.pdf.

New Mexico Environment Department, 2003, Position Paper: General Reporting Requirements for Routine Groundwater Monitoring at RCRA Site, Hazardous Waste Bureau, Santa Fe, NM, February 14, 2003, Internet at http://www.nmenv.state.nm.us/HWB/data/General_Reporting_Requirements_for%20Routine_GW_Monitoring.pdf.

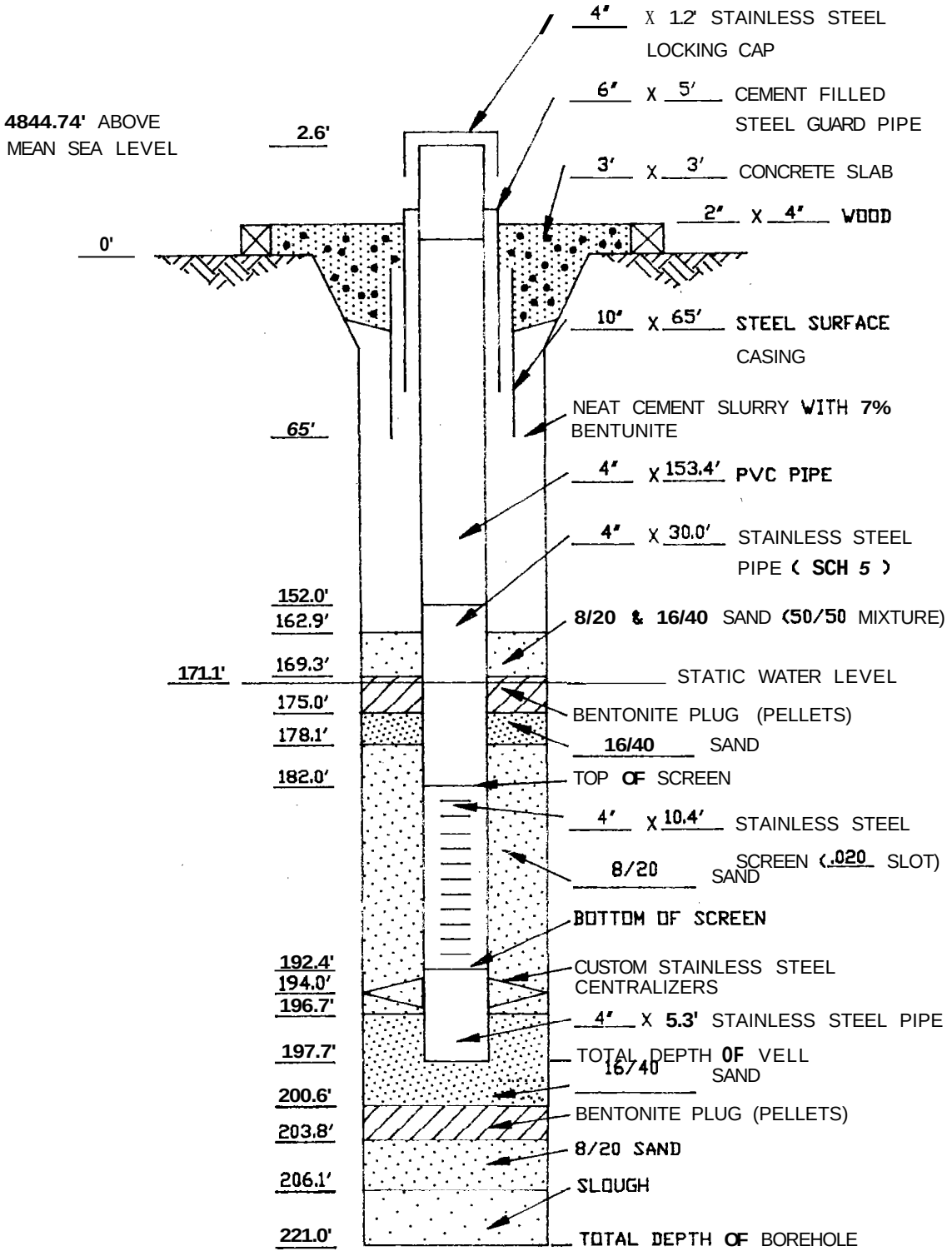
Nielsen, D., 1991, Practical Handbook of Ground-Water Monitoring, Lewis Publishers Inc., Chelsea, MI.

Scalf, M., J. McNabb, W. Dunlap, R. Cosby, and J. Fryberger ,1981. Manual of Ground-Water Sampling Procedures, U. S. Environmental Protection Agency, Office of Research and Development, Robert S. Kerr Environmental Research Laboratory, Ada, OK.

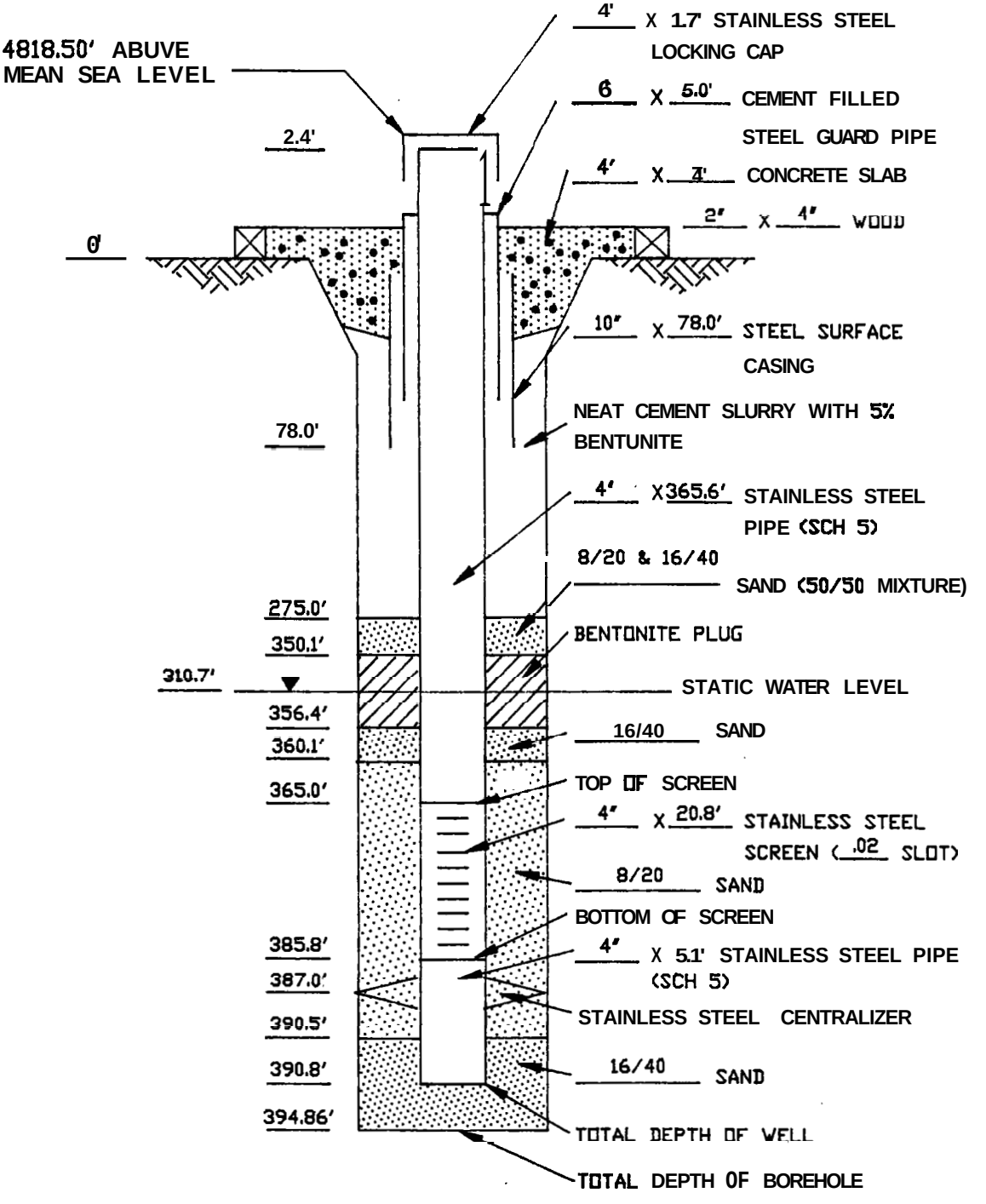
Appendix A

NASA White Sands Test Facility

Groundwater Monitoring Well Completion Diagrams

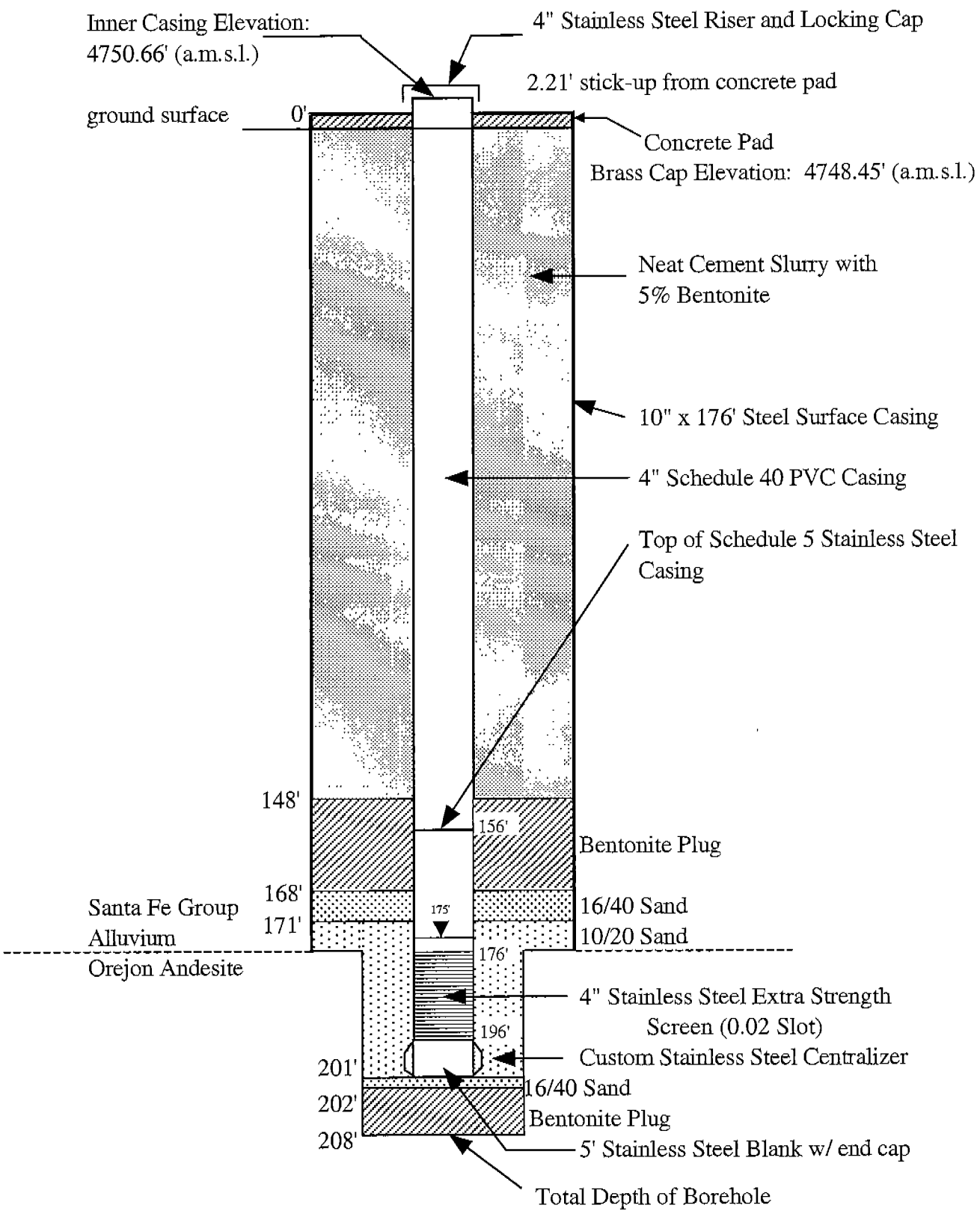


MONITOR VELL 100-A-182 COMPLETION DIAGRAM

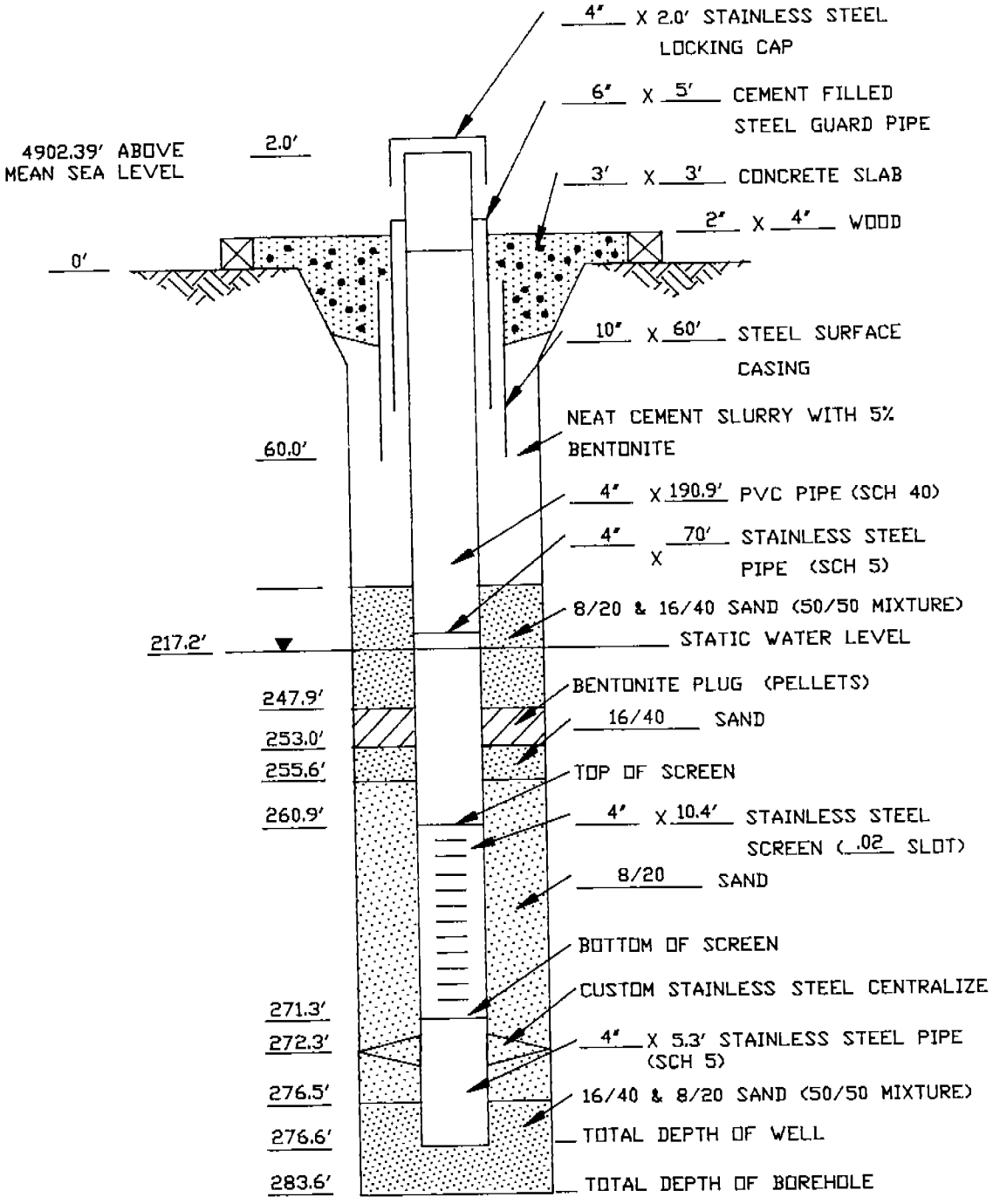


MONITOR WELL COMPLETIUN DIAGRAM 100-C-365

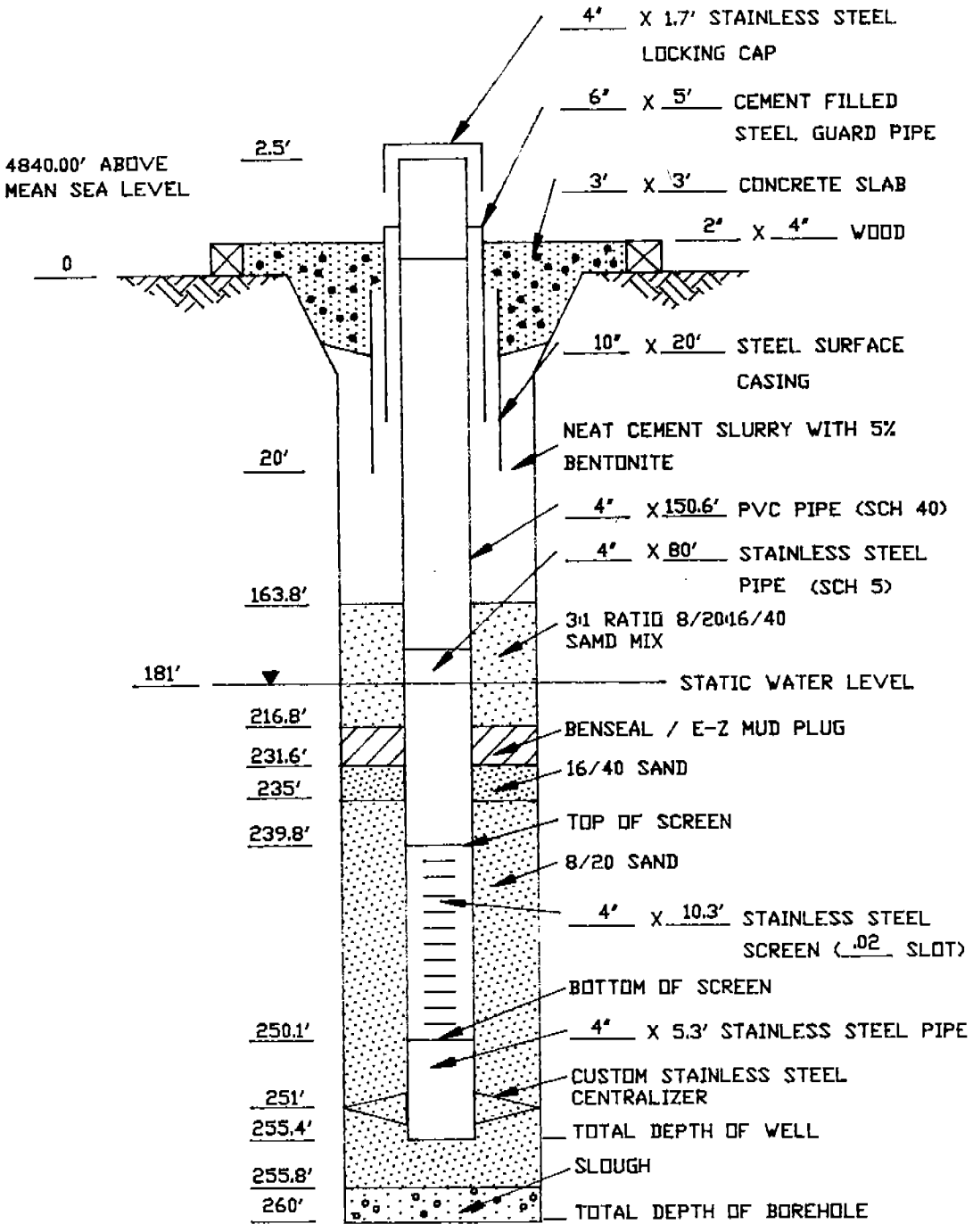
MONITOR WELL 100-D COMPLETION DIAGRAM



Date Drawn: August 13, 1997
Drawn By: P. Egan
Checked By: M. Canavan



MONITOR WELL 100-E-261 COMPLETION DIAGRAM



MONITOR WELL 200-B-240 COMPLETION DIAGRAM

WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: 200-C Location: 200 Area

Date Installed: 1-28-93 Installed by: H+GCL Date Drawn: 1-28-93

Hole Depth: 292' MP Depth: 290' Hole Diameter: 4"(casing)*

Measurement Datum: Ground Level Datum Elevation: 4810.68' (BC)

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
0	0-35' ALLUVIUM (Santa Fe Group)	34	91-268				
		33	91-260		*Westbay casing is installed inside Sch 10 4" stainless steel casing.		
10			91-268			√	√
		32	91-260				
20			91-268				√
		31	91-260		all couples tested with 100 psi for 30 seconds.	√	
30			91-268				√
WELLFILE	35'-290' LIMESTOME (Hueco)	30	91-260			√	
EXIT					all magnetic collars are placed 0.4' above the MP couple		
40			91-268				√
	5" surface casing installed to 47.75'	29	91-260			√	
50			91-268				
		28	91-260	ZONE 6	filter sock used where indicated	√	√
60			91-268				√
		27	91-260			√	
70			91-268				√
		26	91-260			√	
80			91-268				√
		25	92-274			√	
90			91-268				√
		24	92-274			√	
100			91-268				√
		23					

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

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WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: 200-C Location: 200 Area

Date Installed: 1-28-93 Installed by: H+GCL Date Drawn: 1-28-93

Hole Depth: 292' MP Depth: 290' Hole Diameter: 4" (casing)

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
100	LIMESTONE (cont'd)		91-268			√	√
		23	92-274				
110			91-268			√	√
		22	92-274				
120			91-268			√	√
		21	92-274				
130			91-268	ZONE 6		√	√
		20	92-274				
140			91-268			√	√
		19	92-274				
150			7602			√	√
		18	92-271				
			91-268			√	√
		17	5389	109psi/4.51			√
160			91-268			√	√
		16	92-274	ZONE 5			
170			7599		filter sock	√	√
		15	92-274				
180		0	3432			√	√
		14	5388	124psi/4.41		√	√
			91-268			√	√
		13	92-271				
190			91-268			√	√
		12	92-274	ZONE 4			
200			7597				√
		11					

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

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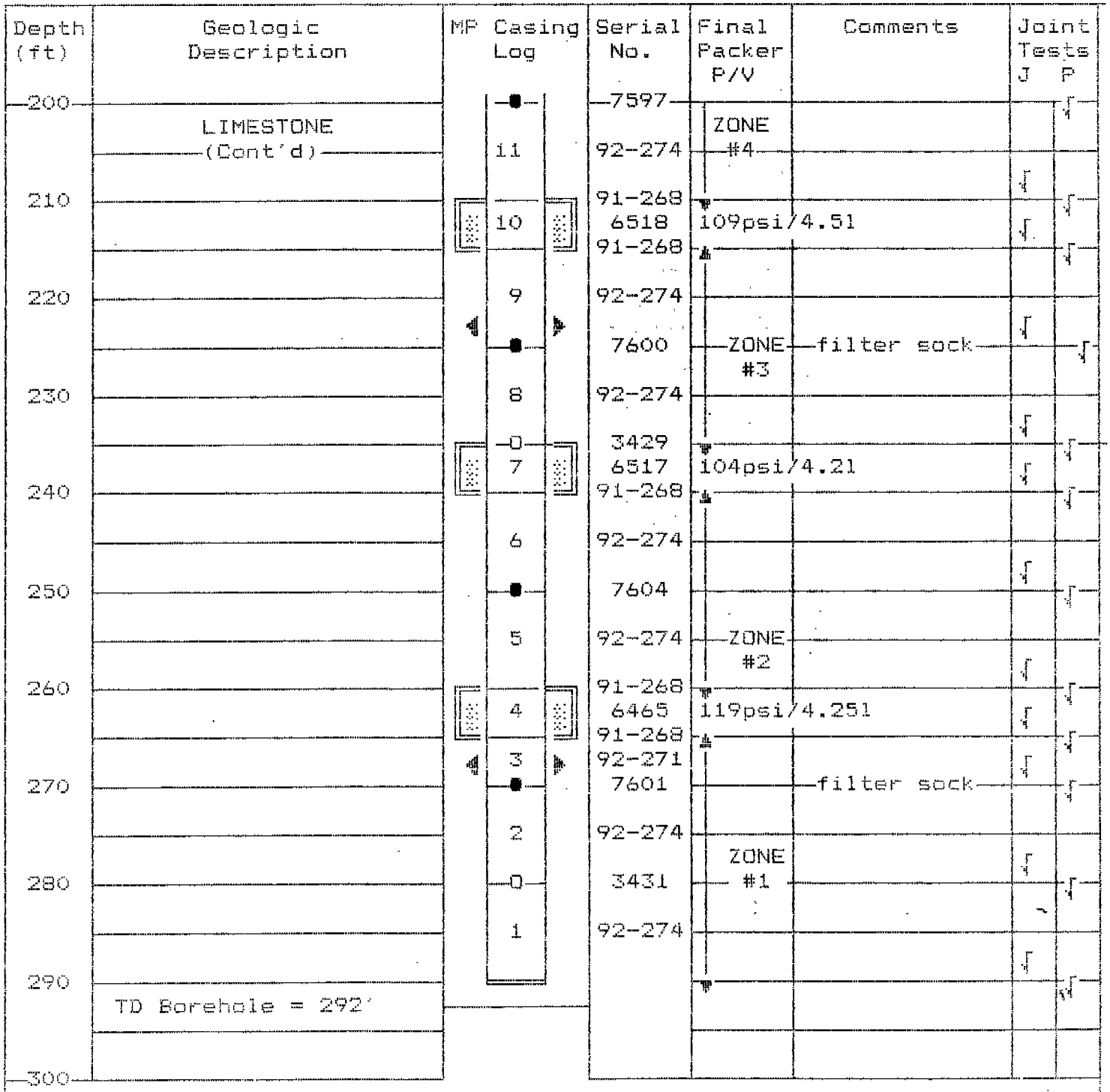
WE TBAY MP SYSTE I
CASIN INSTALLATION LOG

Project: NASA-WSTF Hole No: 200-C Location: 200 AREA

Date Installed: 01-28-93 Installed by: H+GCL Date Drawn: 01-28-93

Hole Depth: 292' MP Depth: 290' Hole Diameter: 4"(casing)



WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No.: 200-F Location: 200 Area

Hole Depth: 600′ MP Depth: 590′ Hole Diam.: 4 1/8"

Date Installed: 10/10/94 Installed By: GCL Elev.(BC): 4879.19

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
0	(ground level)	70	93-326				√
		69	93-330		Each couple tested to	√	
10	0′-17′ ALLUVIUM (Santa Fe Group)		93-326		100 psi for 30 seconds		√
		68	93-330			√	
20	17′-600′ LIMESTONE (Hueco Fmn.)		93-326		All magnetic collars		√
		67	93-330		attached 0.4′ above MP couple	√	
30			93-326		Filter fabric around MP couples where indicated		√
		66	93-330			√	
40			93-326				√
		65	93-330			√	
50	5" steel surface casing set to 48′		93-326				√
		64	93-330			√	
60			93-326				√
		63	93-330			√	
70			93-326				√
		62	93-330			√	
80			93-326				√
		61	93-330			√	
90			93-326				√
		60	93-330			√	
100			93-326				√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 200-F

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
100	LIMESTONE(cont'd)		93-326			√	√
		59	93-330				
110			93-326			√	√
		58	93-330				
120			93-326			√	√
		57	93-330				
130			93-326			√	√
		56	93-330				
140			93-326			√	√
		55	93-330				
150			93-326			√	√
		54	93-330				
160			93-326			√	√
		53	93-330				
170			93-326			√	√
		52	93-330				
180			93-326			√	√
		51	93-330				
190			93-326			√	√
		50	93-330				
200			93-326				√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 200-F

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
200	LIMESTONE (cont'd)		93-326				√
		49	93-330	Zone 9		√	
210			8999				√
		48	93-325			√	
			93-326				√
		47	7809	122psi/5.81		√	
220			93-326				√
		◄ 46 ►	93-325			√	
			8994	Zone 8	filter fabric		√
		45	93-325			√	
230			3446				√
		44	7808	102.3psi/5.01		√	
			93-326				√
		43	93-325			√	
240			93-326				√
		42	93-330			√	
250			93-326				√
		41	93-330			√	
260			93-326				√
		40	200-f-5	Zone 7		√	
270			93-326				√
		39	93-330			√	
280			93-326				√
		38	93-330			√	
290			8998				√
		37	93-330			√	
300			93-326				√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | ◄ ► Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 200-F

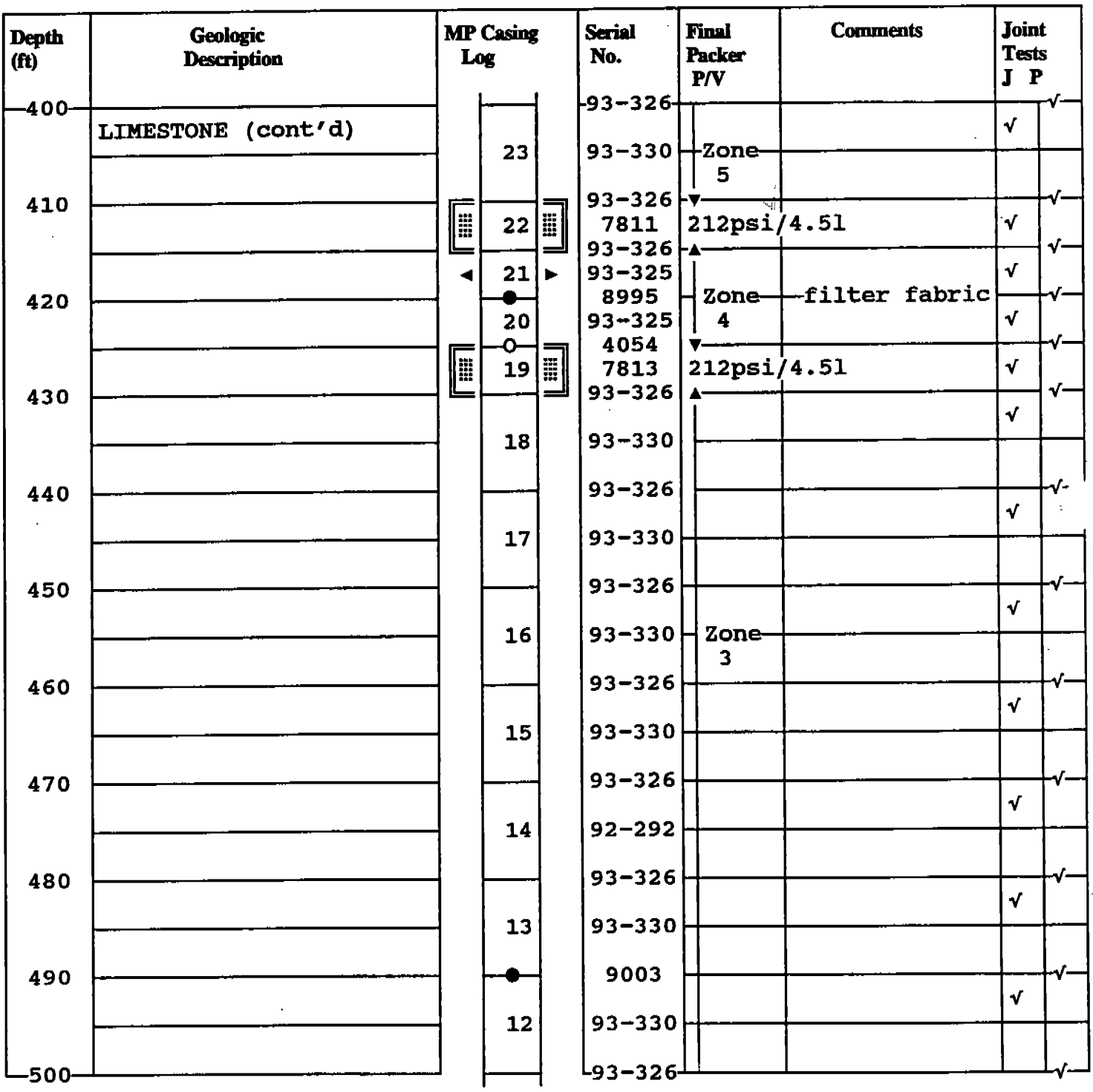
Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
300	LIMESTONE (cont'd)		93-326				√
		36	93-330			√	
310			93-326				√
		35	93-330			√	
320			93-326				√
		34	93-330			√	
330			93-326	Zone 7			√
		33	93-330			√	
340			93-326				√
		32	93-330			√	
350			93-326				√
		31	93-330			√	
360			93-326				√
		30	7802	112psi/5.81		√	
			93-326				√
370		29	93-325	Zone 6	filter fabric	√	
			8996				√
		28	93-325			√	
			4056				√
		27	7806	112psi/6.01		√	
380			93-326				√
		26	93-330			√	
390			93-326				√
		25	93-325	Zone 5		√	
			9002				√
		24	93-325			√	
400			93-326				√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 200-F



LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 200-F

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
500	LIMESTONE (cont'd)		93-326			√	√
		11	93-330	Zone 3			
510			93-326			√	√
		10	93-330				
520			93-326			√	√
		9	93-330				
530			93-326			√	√
		8	93-330				
540			93-326			√	√
		7	93-330				
550			93-326	Zone 3		√	√
		6	93-330				
560		5	93-326				√
			7810	237psi/5.0l		√	
		4	93-326				√
570			93-325	Zone 2	filter fabric	√	√
		3	9001				
			93-325			√	
		2	4060				√
			7812	212psi/5.5l		√	
580			9006				√
		1				√	
			93-330	Zone 1			
590	TD Westbay Casing 590'		endcap				√
	TD Borehole = 600'						
600							

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No.: 200-G Location: 200 Area

Hole Depth: 540' MP Depth: 515' Hole Diam.: 4 1/4"

Date Installed: 11/14/94 Installed By: GCL Elev.(BC): 4875.36

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
0	(ground level)	61					√
		60	94-330		Each couple tested to	√	
	0'-55' ALLUVIUM				100 psi for		
10	(Santa Fe Group)				30 seconds		√
		59	94-330		All regular	√	
					couplings are		
20					Lot # 93-326		√
		58	94-330		All magnetic	√	
					collars		
30					attached 0.4'		√
		57	94-330		above MP couple	√	
					Filter fabric		
40					around MP		√
		56	94-330		couples where	√	
					indicated		
50							√
	55'-540' LIMESTONE	55	94-330			√	
	(Hueco Fmn.)						
60							√
	5" steel surface casing					√	
	set to 65'	54	94-330				
70							√
		53	94-330			√	
80							√
		52	94-330			√	
90							√
		51	94-330			√	
100							√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 200-G

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
100	LIMESTONE(cont'd)	50	94-330			√	√
110		49	94-330			√	√
120		48	94-330			√	√
130		47	94-330			√	√
140		46	94-330	Zone 10		√	√
150		45	94-330			√	√
160		44	92-273 8321			√	√
170		43	7934	95psi/6.81		√	√
		42	92-273 8322		filter fabric	√	√
180		41	94-330	Zone 9		√	√
		40	4179 7933	80psi/6.81		√	√
190		39	94-330	Zone 8		√	√
200							

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 200-G

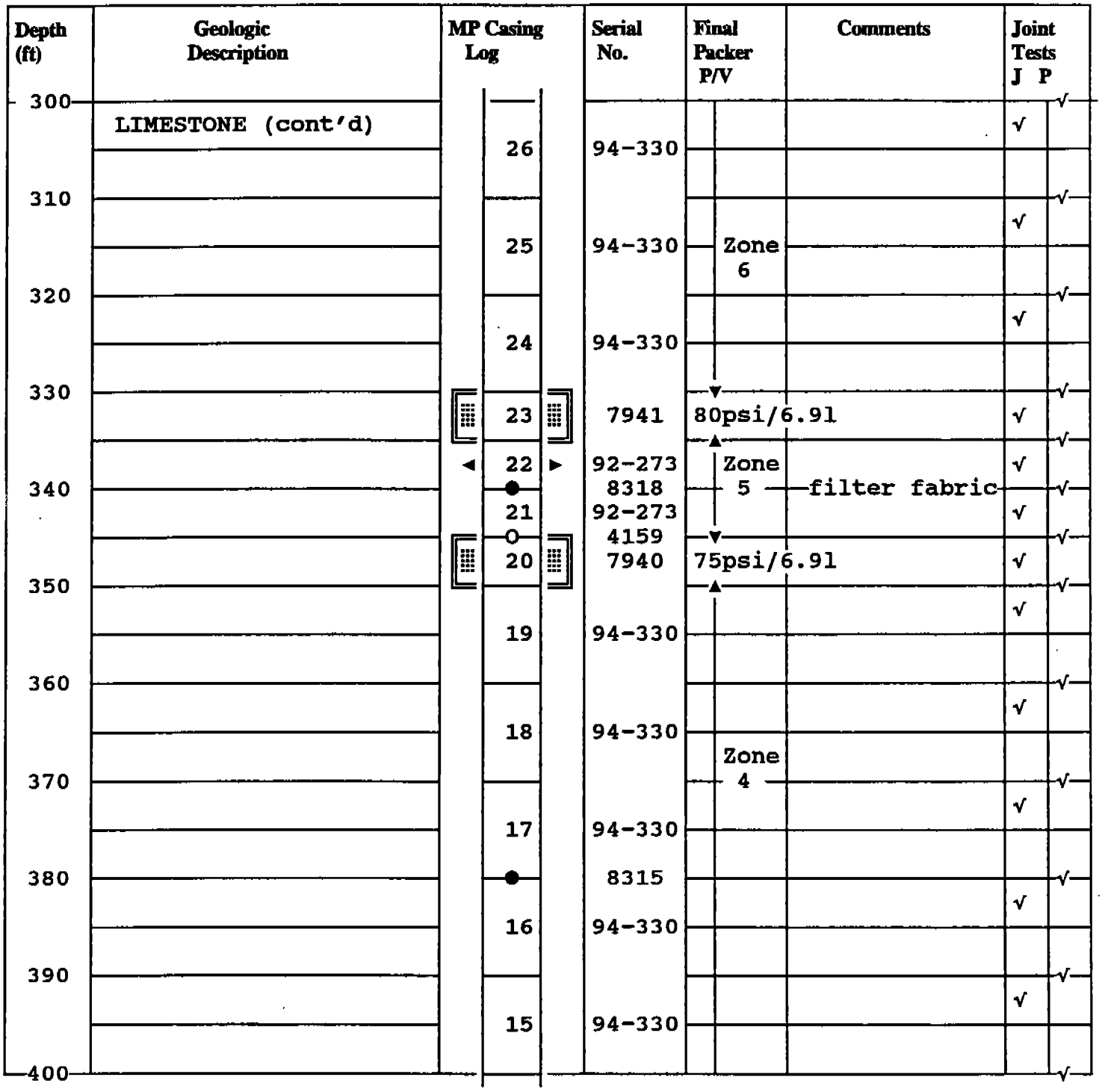
Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
200	LIMESTONE (cont'd)		8319			√	√
		38	94-330	Zone 8			
210		37	7935	80psi/6.81		√	√
		36	92-273 8320	Zone 7	filter fabric	√	√
220		35	92-273 4160			√	√
		34	7936	80psi/6.81		√	√
230						√	√
		33	94-330			√	√
240						√	√
		32	94-330				√
250						√	
		31	94-330				√
260						√	
		30	94-330	Zone 6			
270			8317				√
		29	94-330			√	
280							√
		28	94-330			√	
290							√
		27	94-330			√	
300							√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 200-G



LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 200-G

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
400	LIMESTONE (cont'd)					√	√
		14	94-330	Zone 4			
410		13	7937	80psi/6.8l		√	√
		12	92-273 8313	Zone 3	filter fabric	√	√
420							√
		11	94-330			√	
430		10	4178 7939	84psi/7.5l		√	√
		9	94-330			√	
440							√
		8	94-330			√	
450			8316	Zone 2			√
		7	94-330			√	
460							√
		6	94-330			√	
470							√
		5	94-330			√	
480							√
		4	7938	70psi/7.5l		√	√
490		3	92-273 8314	Zone 1	filter fabric	√	√
		2	92-274			√	
500							

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 200-G

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
500	LIMESTONE (cont'd)	2	4158	Zone 1			√
		O				√	
510		1	92-274				
	TD Westbay Casing 515'			▼			√
520							
530							
540	TD Borehole = 540'						
550							
560							
570							
580							
590							
600							

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

B:\200-G-6

WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No.: 200-H Location: 200 Area

Hole Depth: 464' MP Depth: 458' Hole Diam.: 4 1/2"

Date Installed: 9/21/94 Installed By: GCL Elev.(BC): 4882.13

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
0	(ground level)						
		58	92-274		Top of MP casing is approx. at grade	√	
	0'-75' ALLUVIUM						√
10	(Santa Fe Group)		91-268			√	
		57	91-250				
					Each couple tested to 100 psi for 30 seconds		√
20			91-268			√	
		56	91-250				
30			91-268				√
		55	91-250		All magnetic collars attached 0.4' above MP couple	√	
40			91-268				√
		54	91-250			√	
					Filter fabric around MP couples where indicated		
50			91-268				√
		53	91-250			√	
60			91-268				√
		52	92-274			√	
70			91-268				√
	75'-464' LIMESTONE (Hueco Fmn.)	51	92-274			√	
80			91-268				√
		50	92-274			√	
90			91-268				√
	5" steel surface casing set to 92'	49	92-274			√	
100							√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 200-H

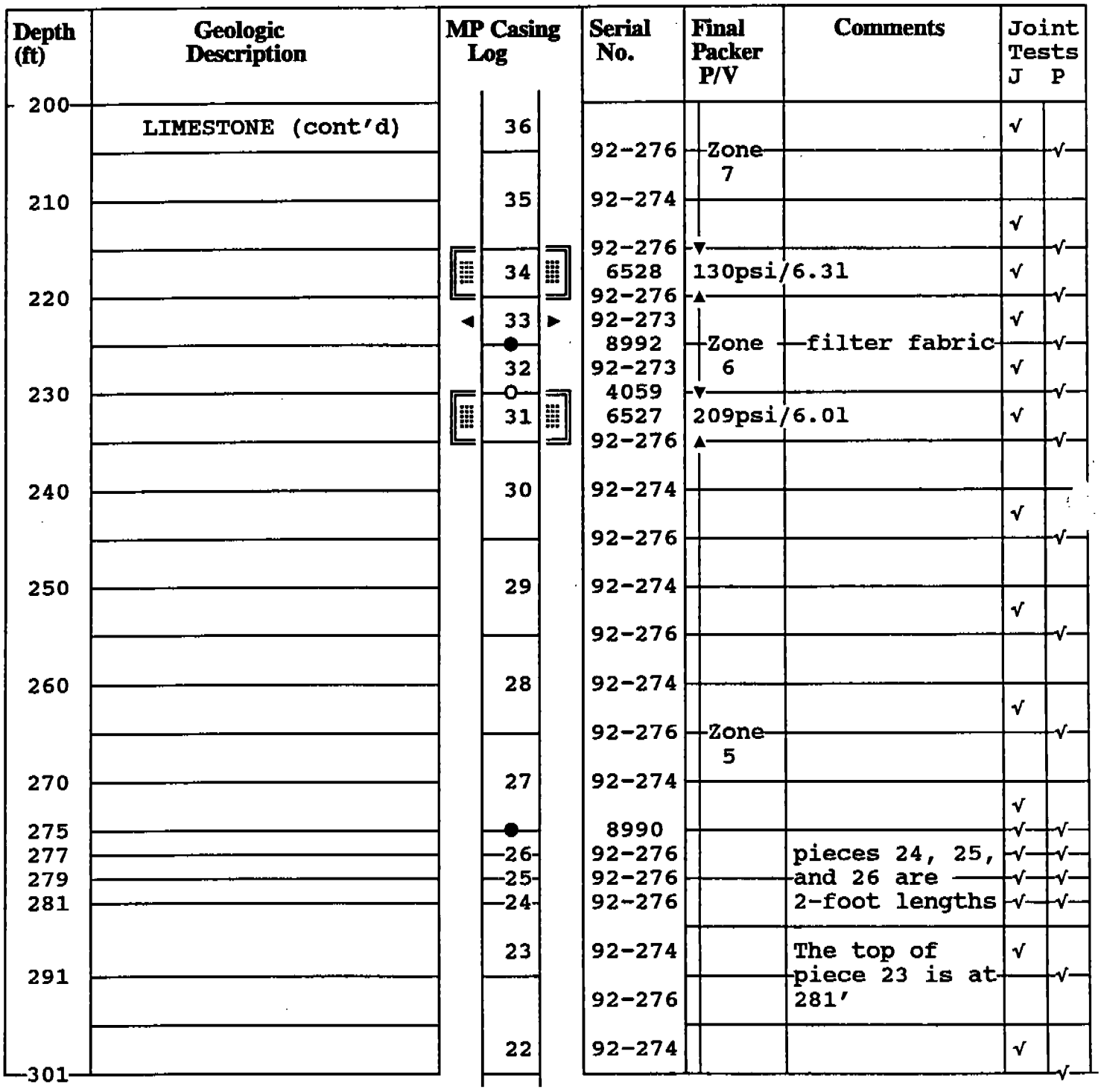
Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
100	LIMESTONE(cont'd)		91-276			√	√
		48	92-274				
110			91-276			√	√
		47	92-274				
120			91-276			√	√
		46	92-274				
130			91-276			√	√
		45	92-274				
140		44	91-276				√
			6521	159psi/6.1l		√	
			91-276	▲			√
		◄ 43 ►	92-273	Zone		√	
150		●	8988	8	filter fabric		√
		42	92-273			√	
		○	4057	▼			√
		41	6522	155psi/6.3l		√	
160			91-276	▲			√
		40	92-273			√	
			91-276				√
170		39	92-274			√	
			91-276				√
180		38	92-274	Zone 7		√	
		●	8991				√
190		37	92-274			√	
			91-276				√
200		36	92-274			√	

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | ◄ ► Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 200-H



LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 200-H

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
301	LIMESTONE (cont'd)		92-276			√	√
		21	92-274				
311			92-276	Zone 5		√	√
		20	92-274				
321			92-276	▼			√
		19	6526	169psi/6.0l		√	
			92-276	▲			√
		18	92-273			√	
331		●	8989		Zone 4 filter fabric		√
		17	92-273			√	
		O	4053	▼			√
		16	6525	150psi/6.3l		√	
341			92-276	▲			√
		15	92-274			√	
			92-276				√
351						√	
		14	92-274				
361			92-276				√
		13	92-274			√	
				Zone 3			
371			92-276				√
		12	92-274			√	
381		●	8987				√
		11	92-274			√	
			92-276				√
391						√	
		10	92-274				
401			92-276				√

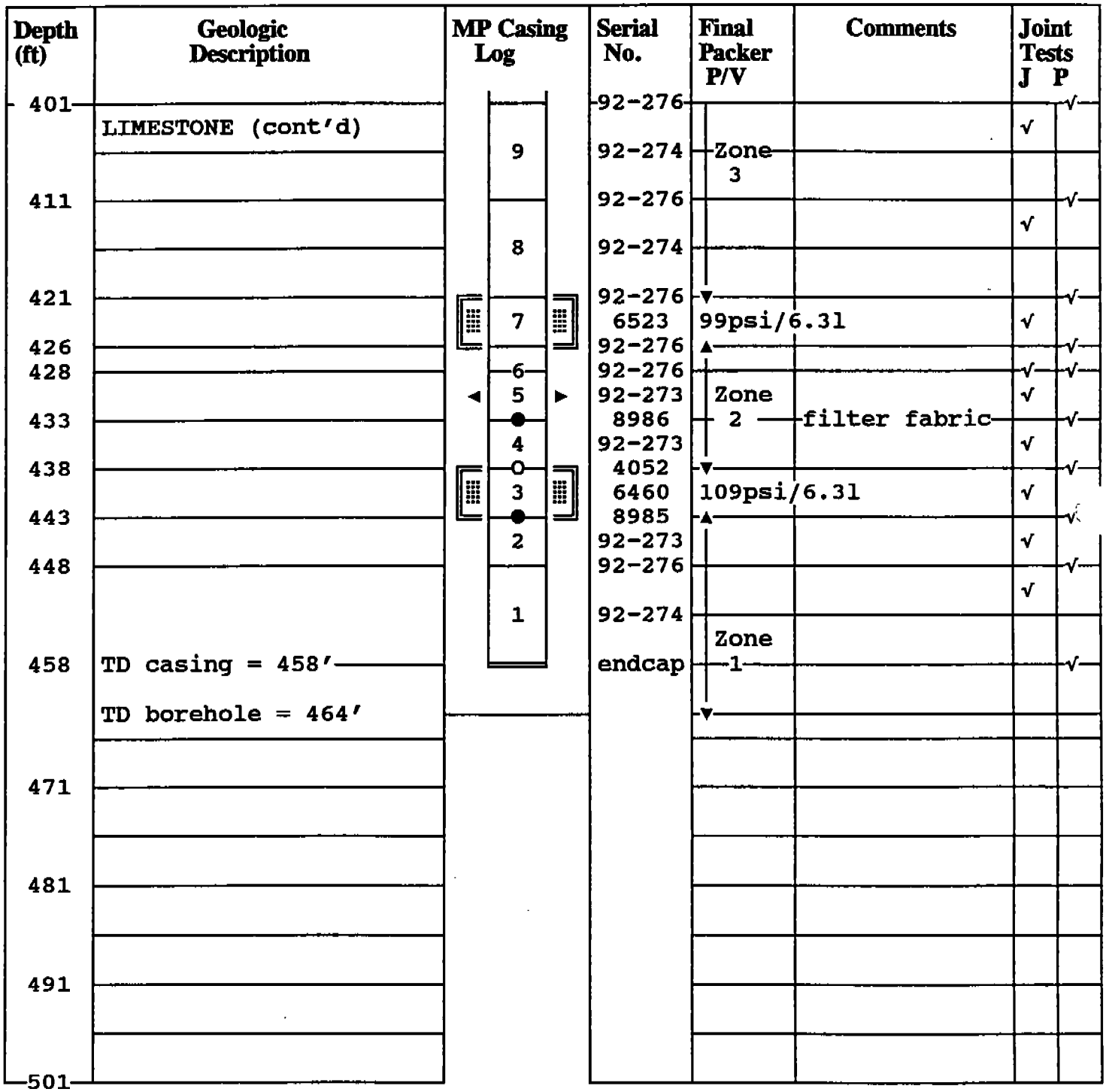
LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

B:\200-H-4

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 200-H



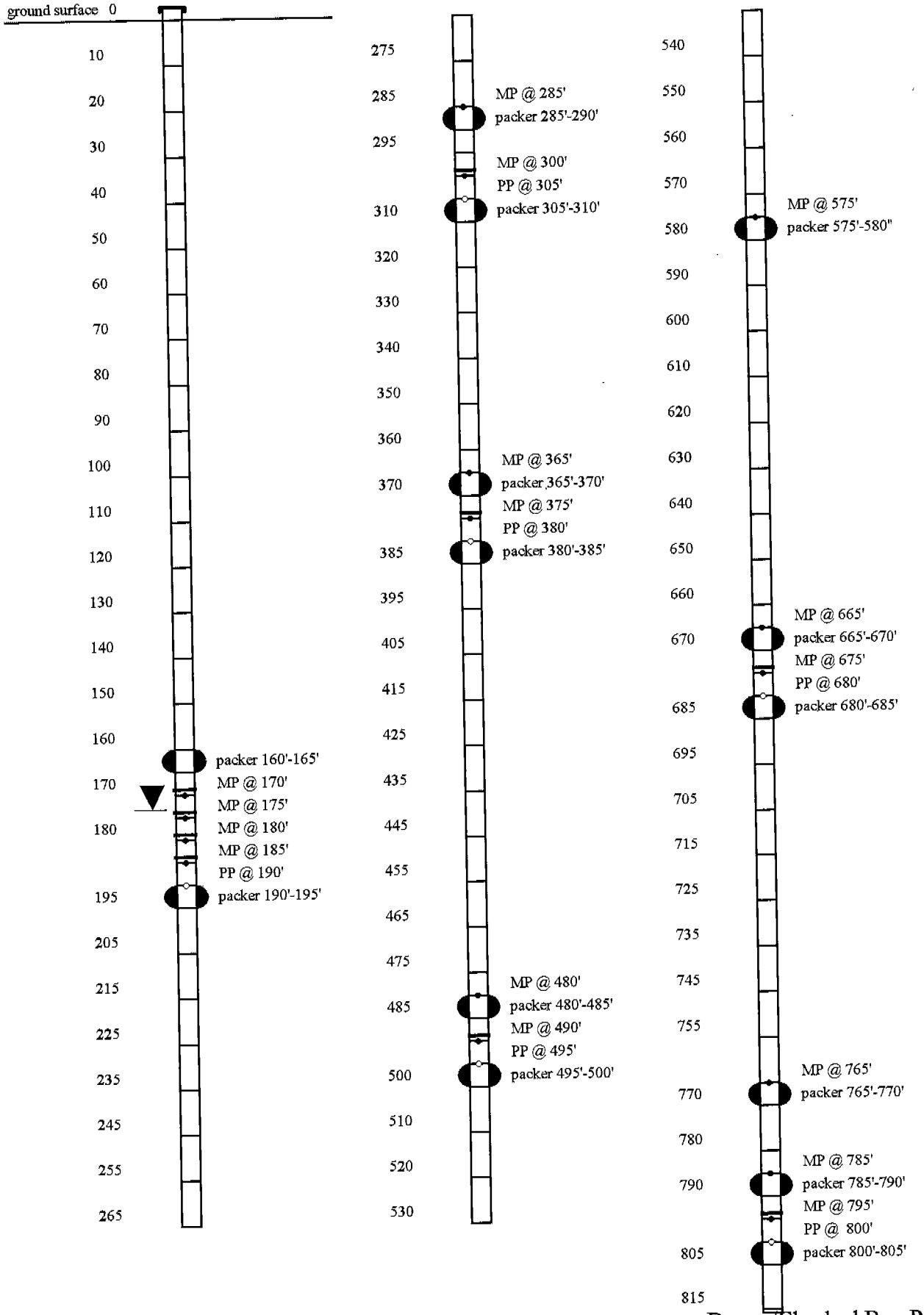
LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

B:\200-H-5

WESTF Y WELL COMPLETION DIA RAM

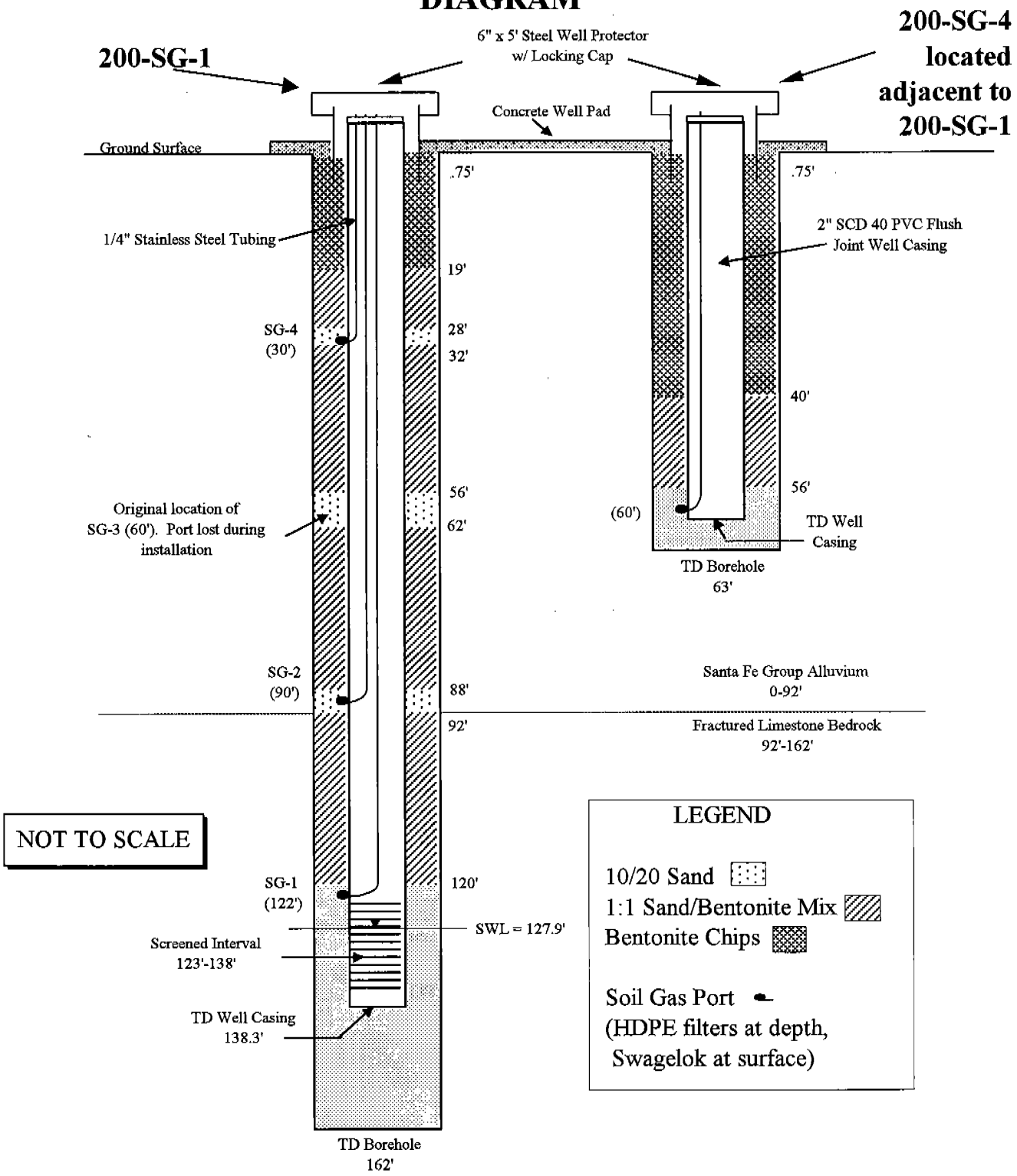
200-I



Installation Date: 6/20/97
Installed By: ATSC
Elevation (BC): 4837.79' a.m.s.l.

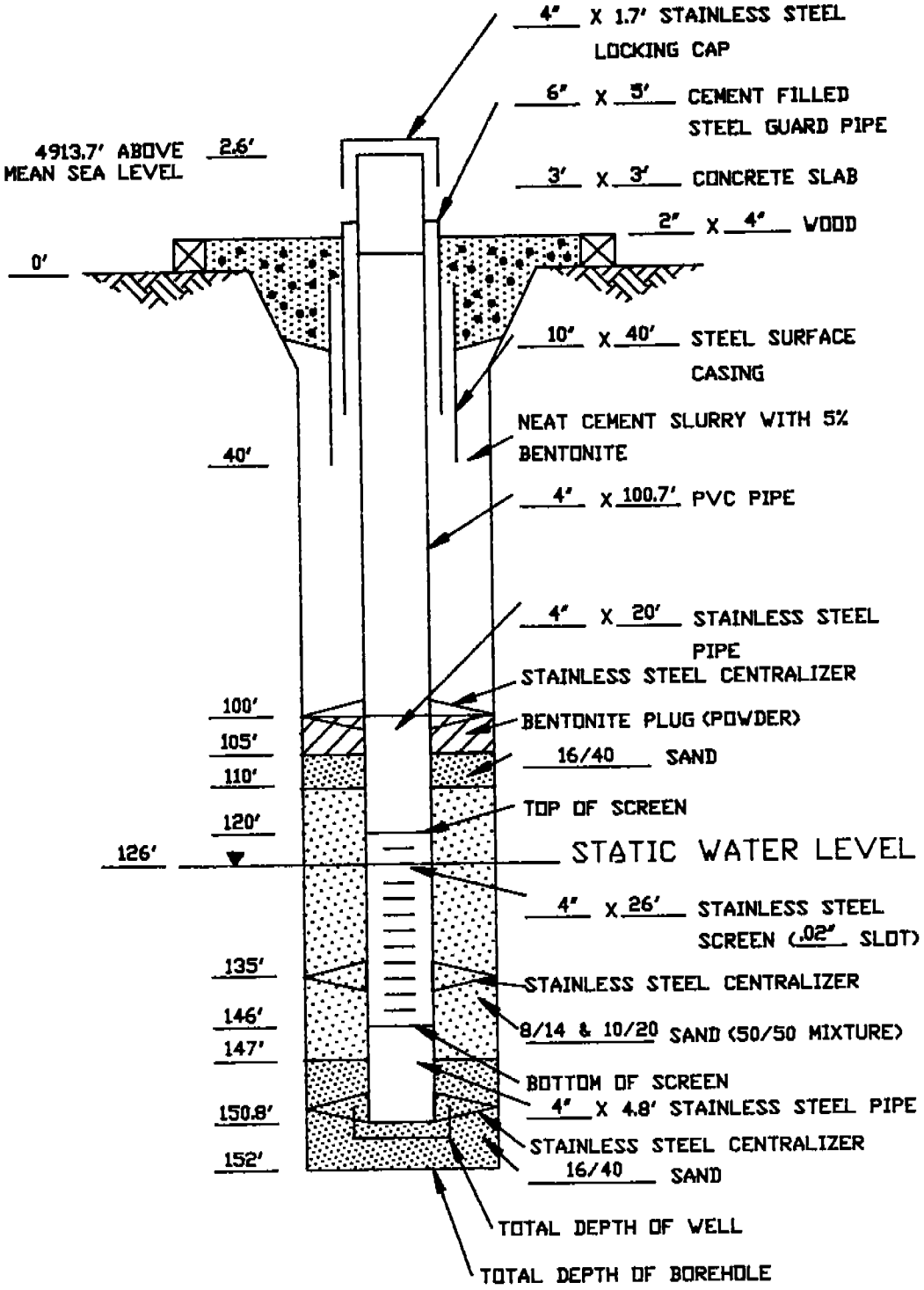
Drawn/Checked By: PSE/MGC
MP Depth: 815'
Borehole Depth: 838'

200-SG-1 COMPLETION DIAGRAM

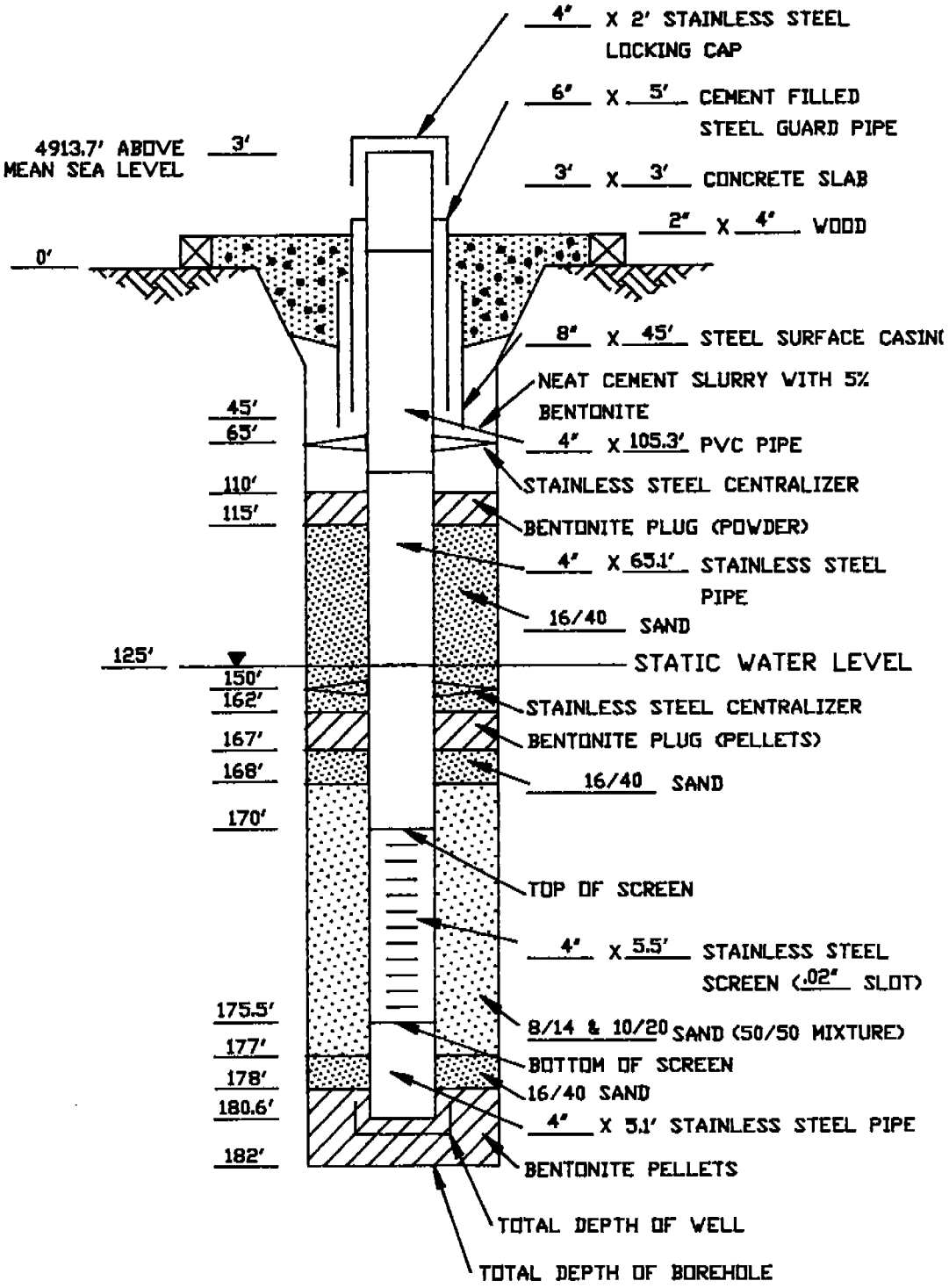


Installation Date: 11/15/97
Installed By: ATSC, DBSA
Elevation: 4787.28 (A.M.S.L.)
(at 200-SG-1 Brass Cap)

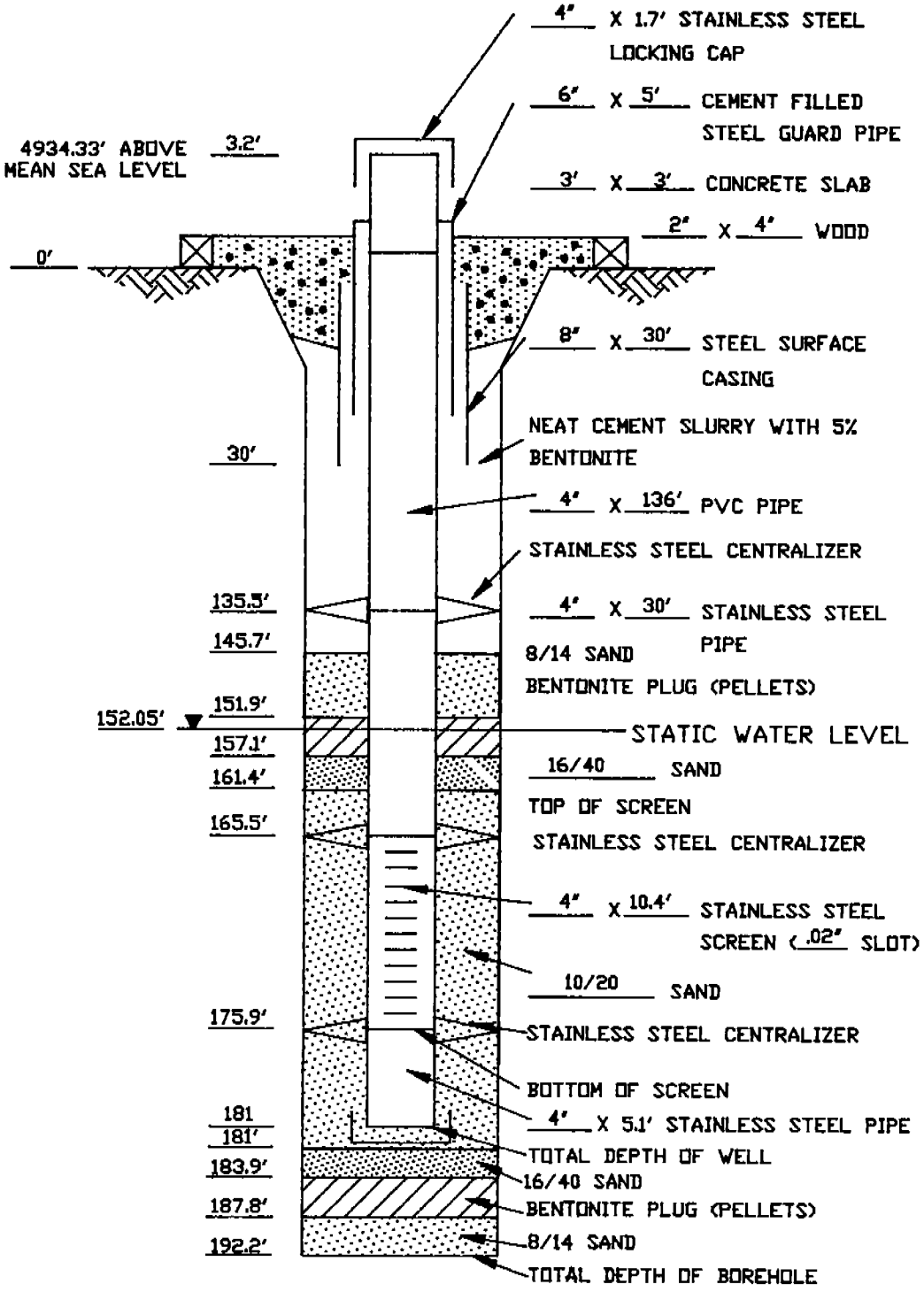
Drawn/Checked By: PSE/MGC
Borehole Depths: 162'
Well Casing Depths: 138.3'



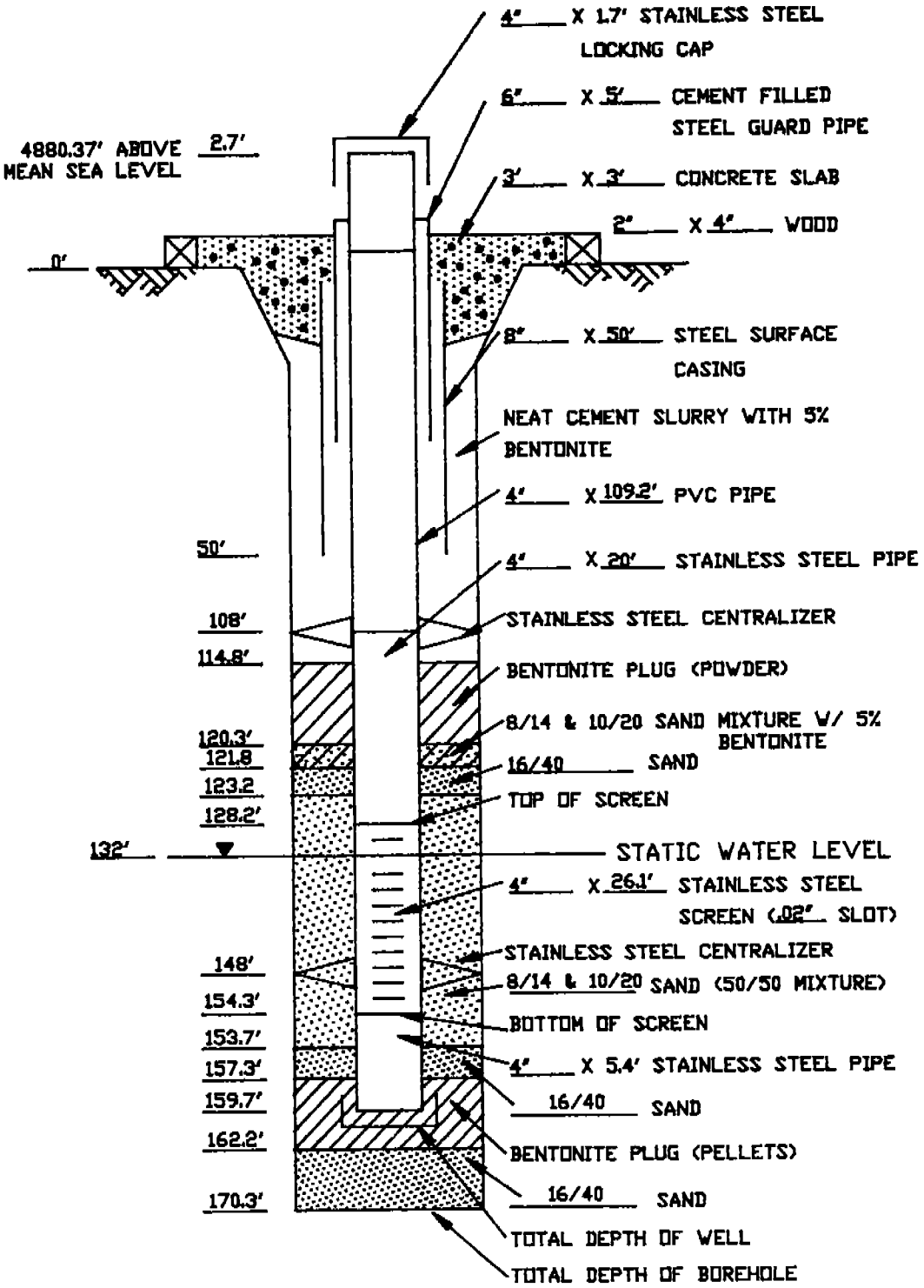
MONITOR WELL 300-A-120 COMPLETION DIAGRAM



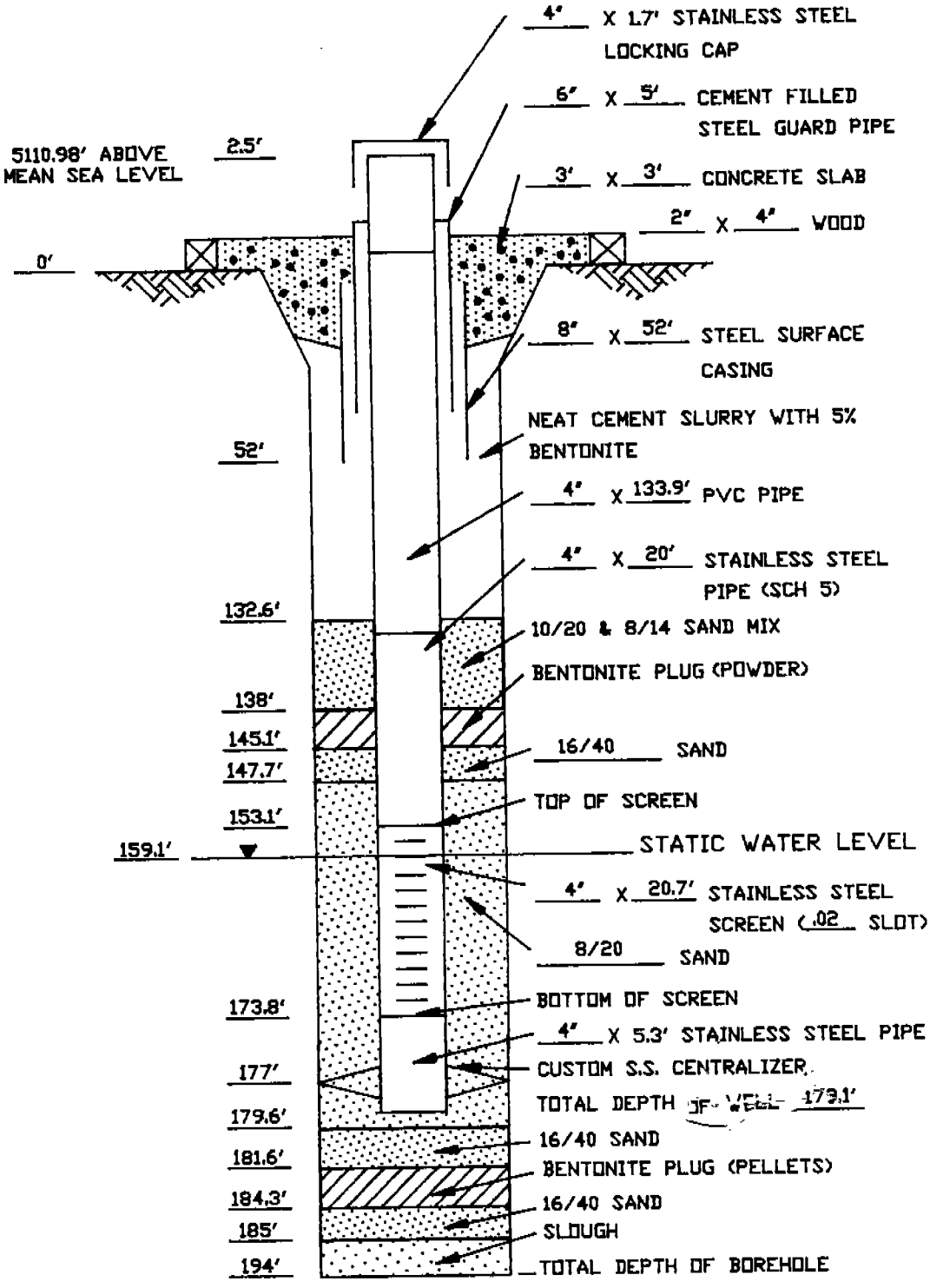
MONITOR WELL 300-A-170 COMPLETION DIAGRAM



MONITOR WELL 300-B-166 COMPLETION DIAGRAM



MONITOR WELL 300-C-128 COMPLETION DIAGRAM



MONITOR WELL 300-D-153 COMPLETION DIAGRAM

WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No.: 300-E Location: 300 Area

Hole Depth: 440′ MP Depth: 395′ Hole Diam.: 4 1/2"

Date Installed: 01-25-95 Installed By: ATSC Elev.(BC):

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
0	(ground level)						
3		52	94-339		Casing–piece #52 sticks-up		
8	0′-91′–ALLUVIUM (Santa Fe Group)		94-343		2 feet above ground level	√	√
		51	94-339				
18			94-343		Each–couple tested to		√
		50	94-339		100–psi–for 30 seconds	√	
28			94-343				√
		49	94-339		All–magnetic collars	√	
38			94-343		attached–0.4′–above MP couple		√
		48	94-339			√	
48			94-343		Filter sock around–MP couples where indicated		√
		47	94-339			√	
58			94-343				√
		46	94-339			√	
68			94-343				√
		45	94-339			√	
78			94-343				√
		44	94-339			√	
88			94-343				√
	91′-174′–ANDESITE (Orejon)	43	94-339			√	
98			93-326				√
100		42					

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 300-E

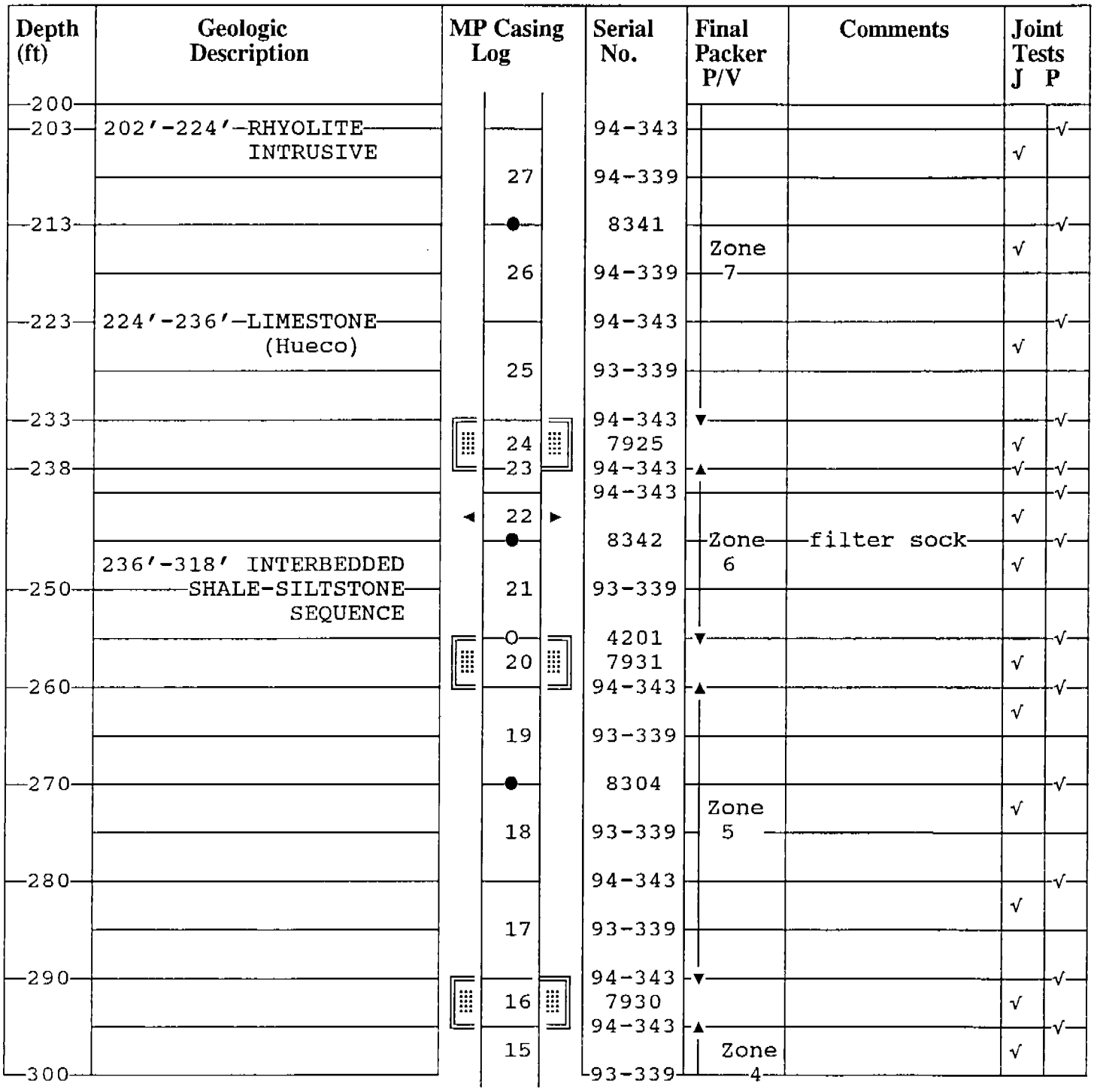
Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
100							
103	ANDESITE--(cont'd)	42	94-339			√	
			93-326				√
						√	
113		41	94-339	Zone 11			
			93-326				√
						√	
123		40	94-339				
				▼			
		●	8338				√
		39	7926	▲		√	
133			93-326				√
		◄ 38 ►				√	
		●	8337	Zone 10	filter sock		√
		37				√	
143		O	4198	▼			√
		36	7922			√	
			93-326	▲			√
		35				√	
153			93-294				√
						√	
		34	94-339				
163		●	8340	Zone 9			√
						√	
		33	94-339				
173	174'-202'--LIMESTONE (Hueco)		93-294	▼			√
		32	7923			√	
			93-294	▲			√
		◄ 31 ►				√	
183		●	8339	Zone 8	filter sock		√
		30				√	
		O	4200	▼			√
		29	7924			√	
193			93-294	▲			√
						√	
		28	94-339	Zone 7			
200							

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 300-E



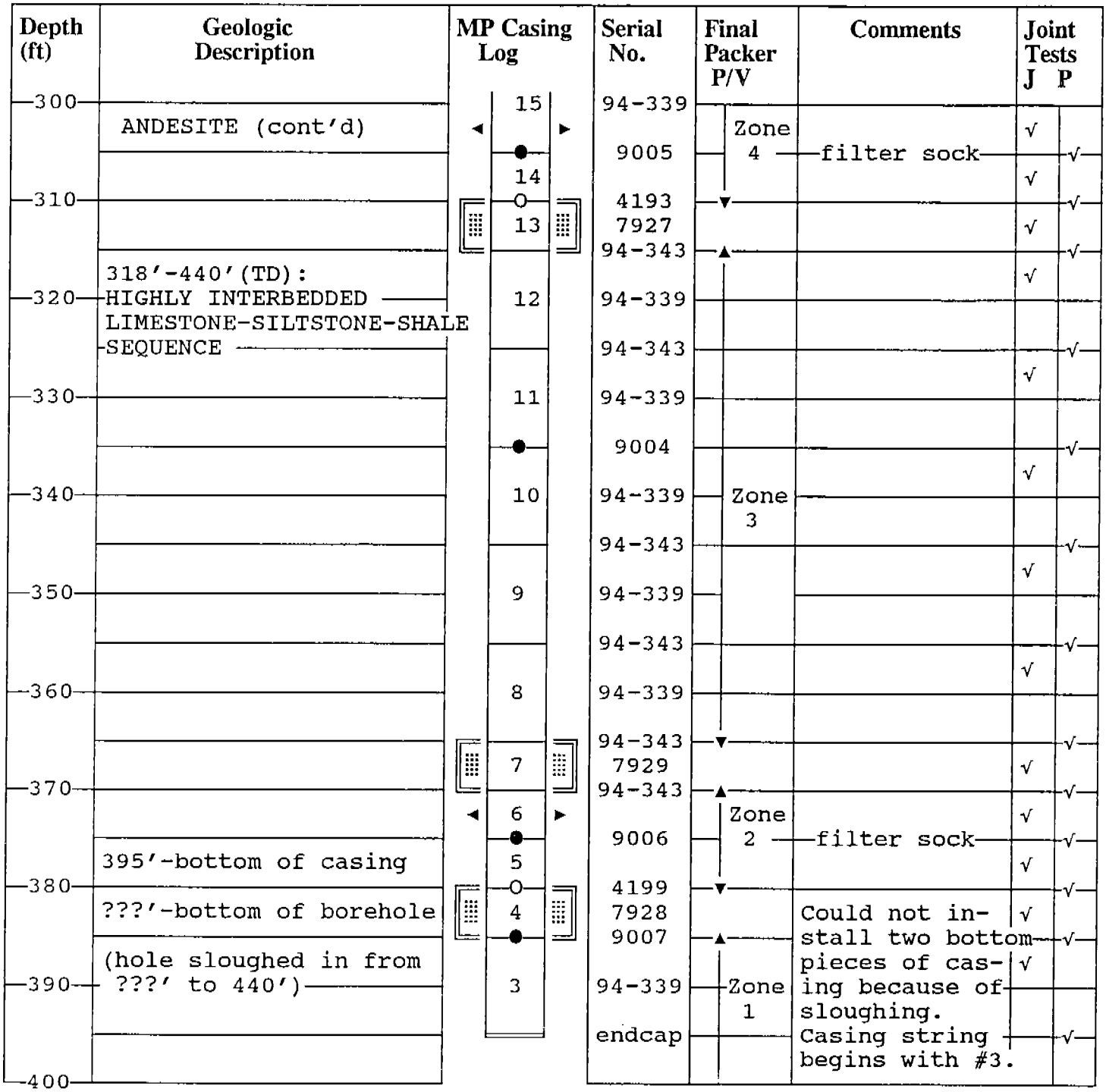
LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

B:\300-E-3

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

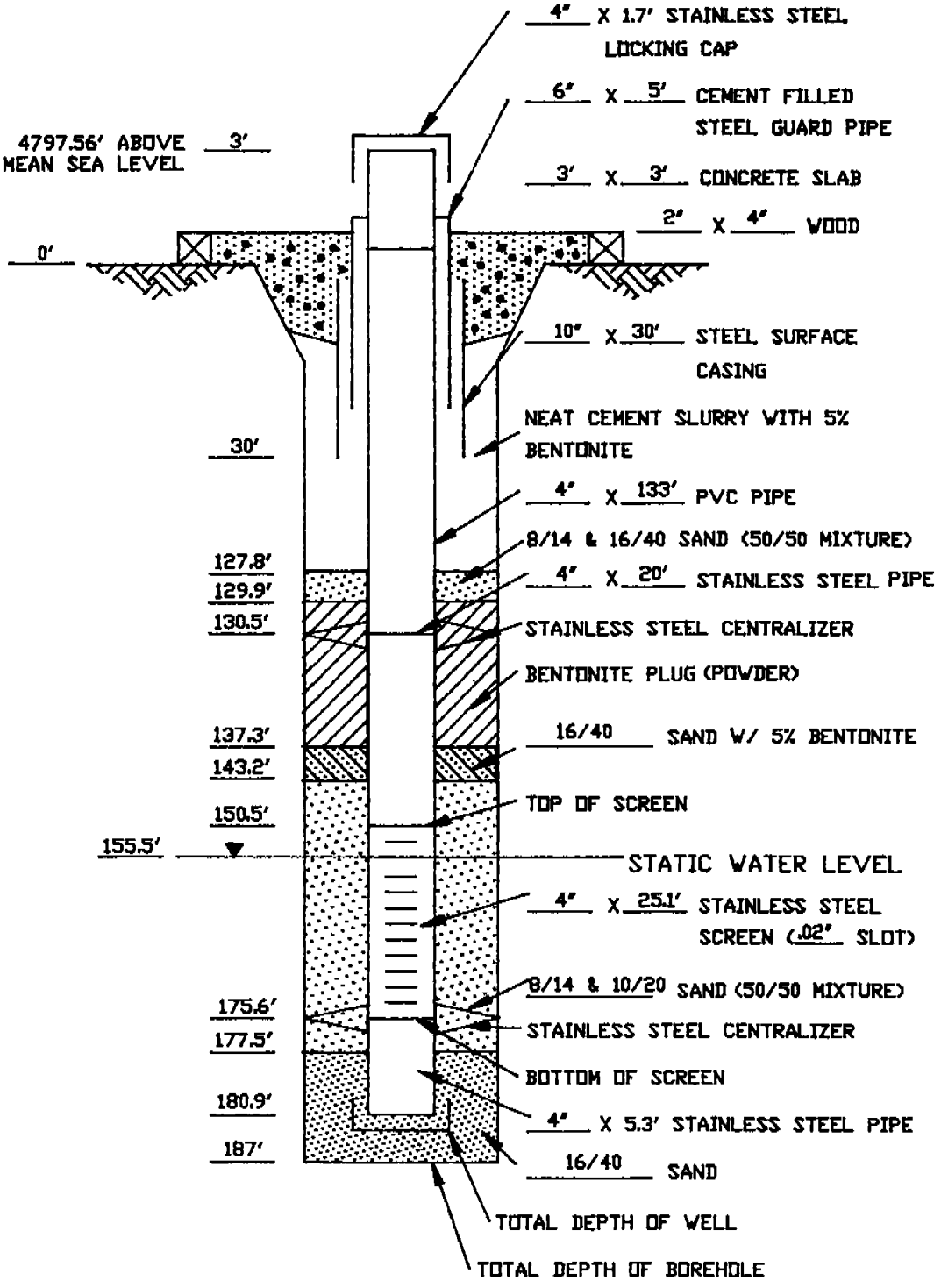
Hole No.: 300-E



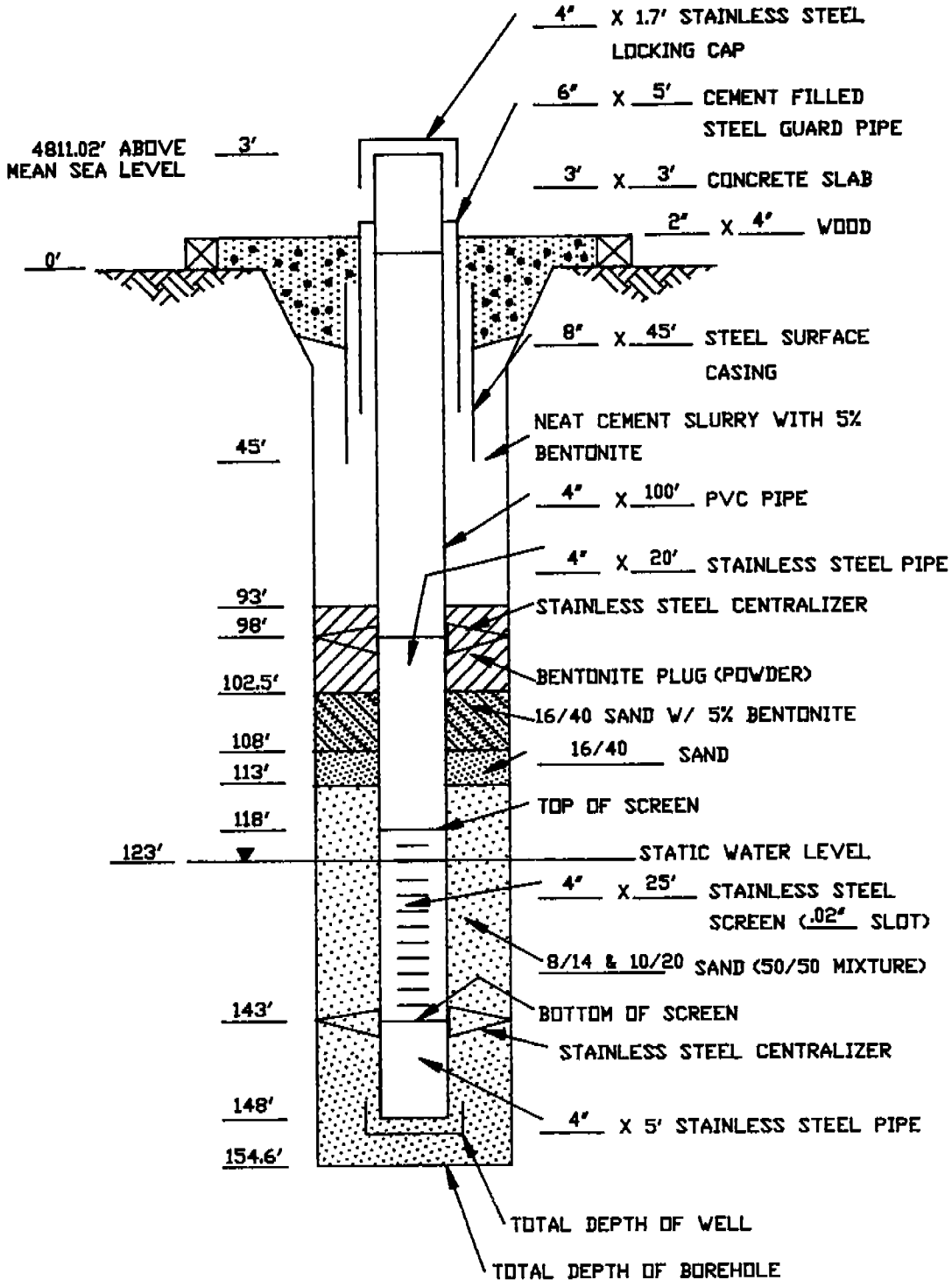
LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

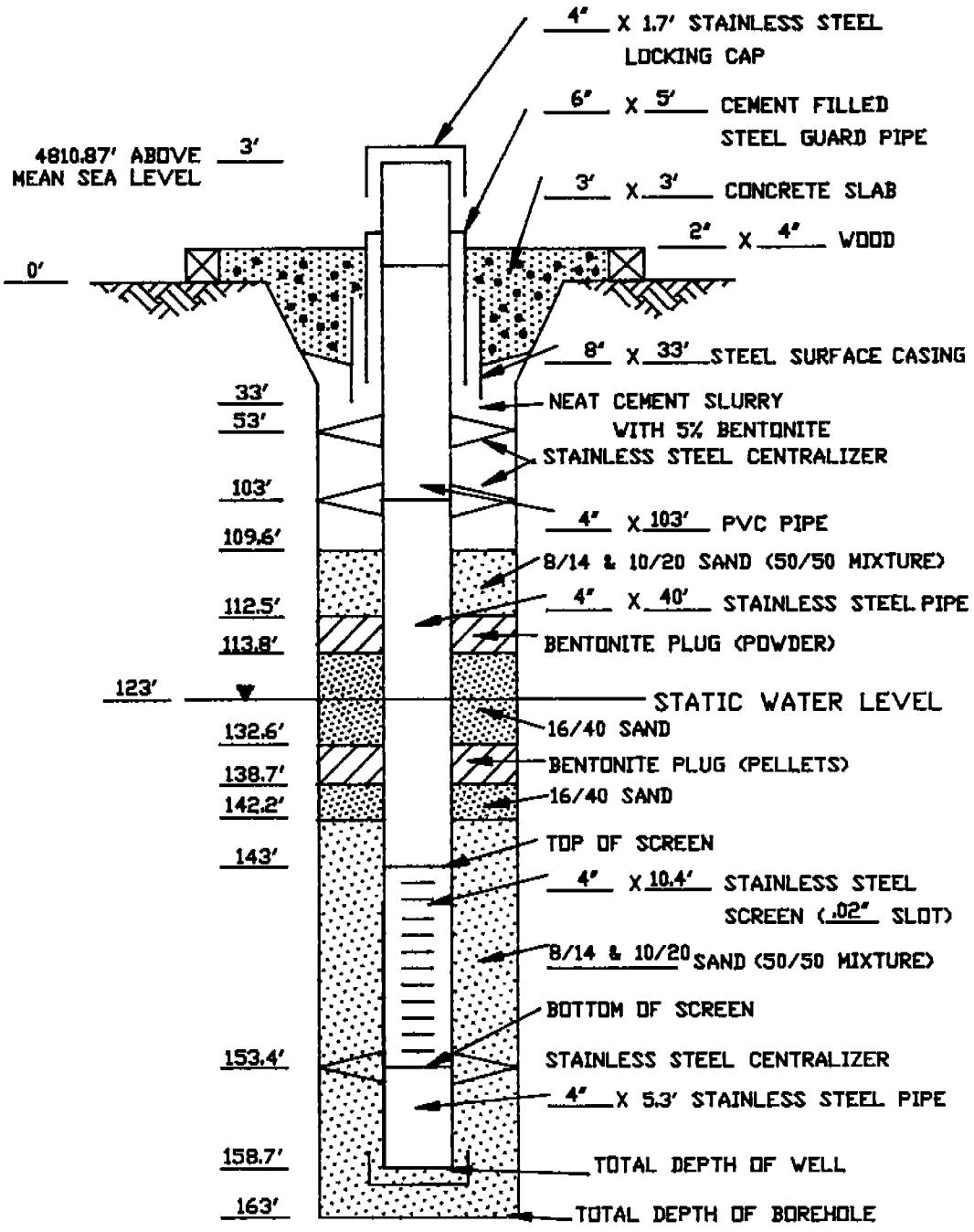
B:\300-E-4



MONITOR WELL 400-A-151 COMPLETION DIAGRAM



MONITOR WELL 400-C-118 COMPLETION DIAGRAM



MONITOR WELL 400-C-143 COMPLETION DIAGRAM

WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No.: 400-D Location: 400 Area

Hole Depth: 385' MP Depth: 380' Hole Diam.: 4 1/2"

Date Installed: 03/27/95 Installed By: ATSC Elev.(BC):

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
0	(ground level)	54	94-354				√
					Each couple	√	
		53	94-339		tested to		
	0'-160' ALLUVIUM				100 psi for		
10	(Santa Fe Group)		94-354		30 seconds		√
						√	
		52	94-339				
					All magnetic		
20			94-354		collars		√
					attached 0.4'	√	
		51	94-339		above MP couple		
30			94-354		Filter sock		√
					around MP	√	
		50	94-339		couples where		
					indicated		
40			94-354				√
						√	
		49	94-339				
50			94-354				√
						√	
		48	94-339				
60			94-354				√
						√	
		47	94-339				
70			94-354				√
						√	
		46	94-339				
80			94-354				√
						√	
		45	94-339				
90			94-354				√
						√	
		44	94-339				
100			94-354				√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 400-D

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
100	ALLUVIUM (cont'd)	43	94-354			√	√
			93-330				
110		42	94-354			√	√
			93-330				
120		41	94-354			√	√
			93-330				
130		40	94-354			√	√
			93-330				
140		39	94-354			√	√
			93-330				
150		38	94-354			√	√
			93-330				
160	160'-385' ANDESITE (Orejon)	37	94-354			√	√
			93-330	▲			
170	5" steel surface casing set to 170'	36	94-354	Zone 7		√	√
			93-330	▼			
180		35	94-354			√	√
			93-325				
		34	9618			√	√
			7805				
190		33	94-354	▲		√	√
			93-325	Zone 6	filter sock	√	√
		32	9617	▼			
200			93-325			√	√
			4191				

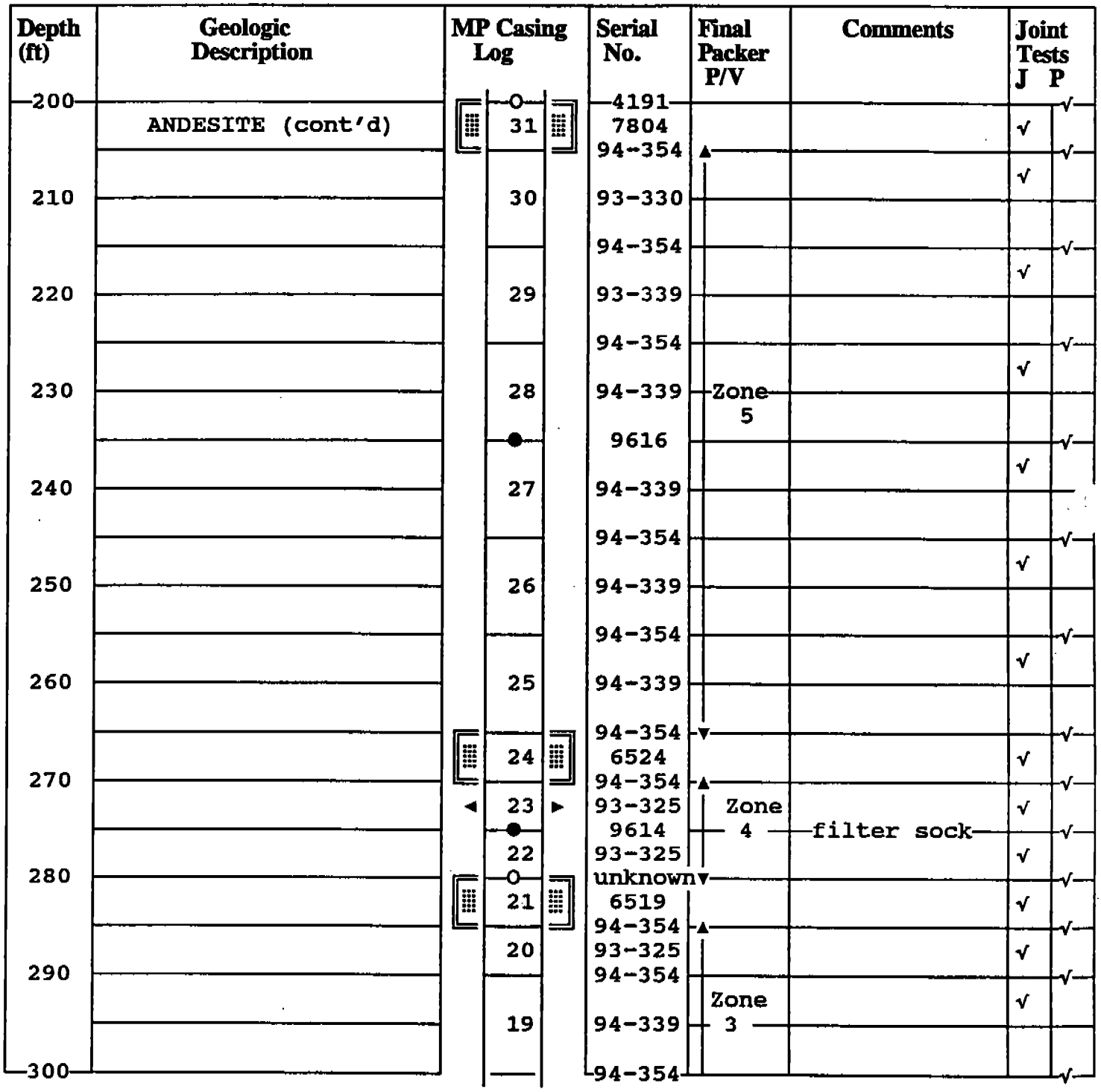
LEGEND

- Regular MP Casing
- MP Packer
- Measurement Port Coupling
- Pumping Port Coupling
- Magnetic Collar

B:\400-D-2

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 400-D



LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

B:\400-D-3

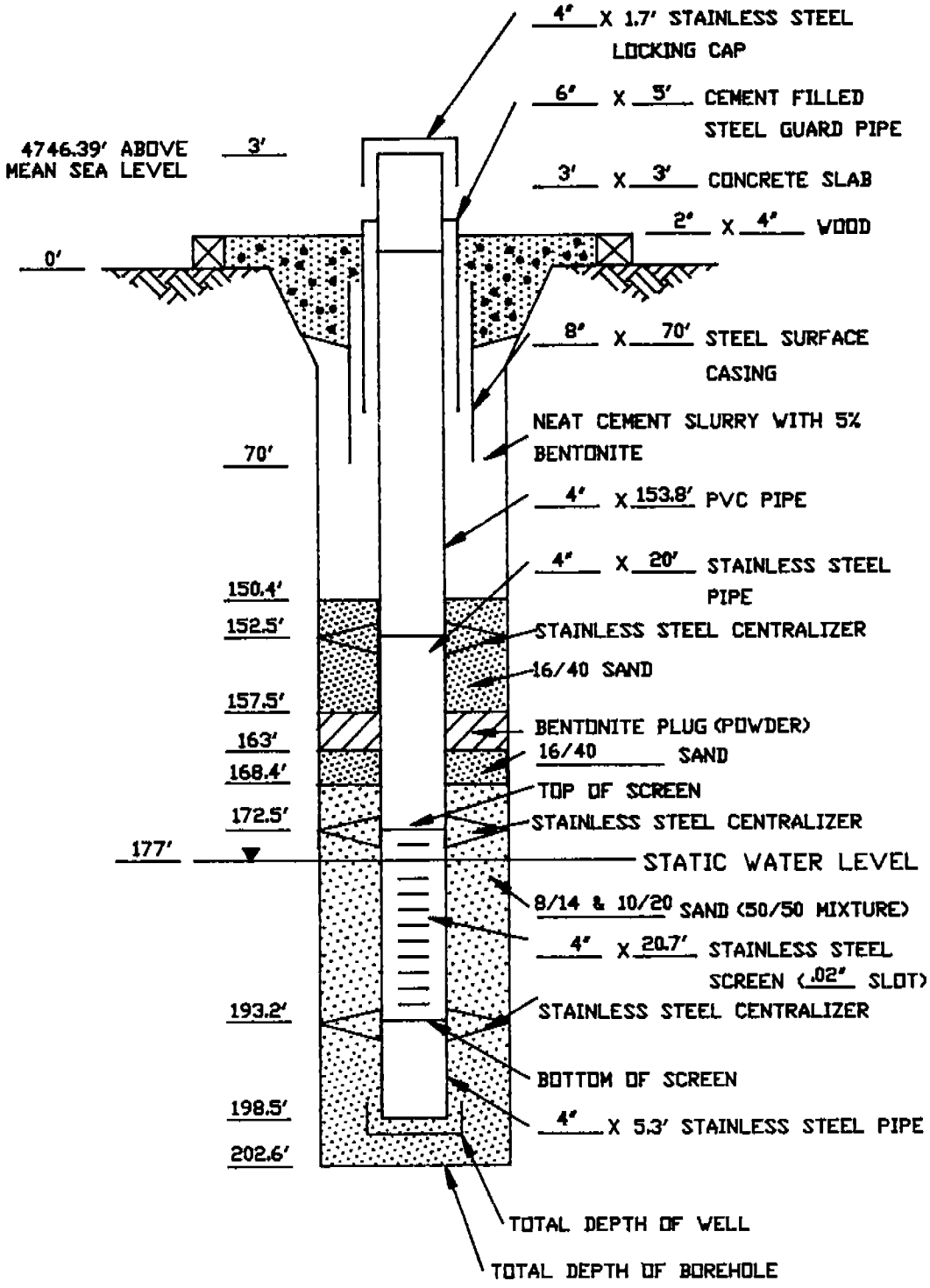
WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: 400-D

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
300	ANDESITE (cont'd)	18	94-354			√	√
			94-339	Zone 3			
310		17	94-354			√	√
			94-339				
320			9615				√
		16				√	
			94-339				
330			94-354				√
		15				√	
			94-339				
340		14	94-354	▼			√
			6520			√	
			94-354	▲			√
		13				√	
350			94-339	Zone 2			
			9621				√
		12	93-325			√	
360			4202	▼			√
		11	7932			√	
			94-354	▲			√
						√	
370		10	94-339				
			9620	Zone 1	Could not install bottom eight pieces of casing because of sloughing. Casing numbers begin with "9".		√
	380'-bottom of casing	9				√	
380	385'-bottom of borehole		endcap				√
	(hole sloughed in from 385' to 460')			▼			
390							
400							

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | ◄ ► Magnetic Collar



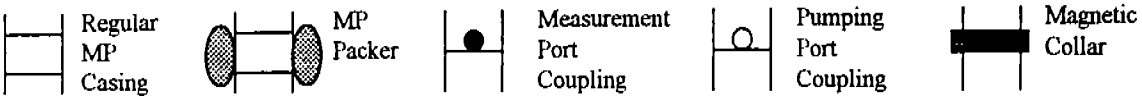
MONITOR WELL 600-C-173 COMPLETION DIAGRAM

WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF
Hole No.: 600-D
Location: 600 Area
Date Installed: 12/5/96
Date Drawn: 2/26/97
Hole Depth: 880', sloughed to 862.5'
Installed By: AlliedSignal
Hole Diameter: 4.5 inches
Measurement Datum: Brass Cap
MP Depth: 860'
Datum Elevation: 4747.51' AMSL

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Coupling Tests *=Pass
	0 - 190' ALLUVIUM (Santa Fe Group)	96			Well 600-D was reinstalled due to ruptured packers. The original casing and couplings removed from well were reused and serial numbers were not recorded. Serial numbers are recorded for new packers and ports used in well. 2' of stick-up at top of well. Each coupling tested to 150 psi for 1 minute. Magnetic collars are attached 0.5' above measurement port coupling	Top coupling not tested
10		95				*
20		94				*
30		93				*
40		92				*
50		91				*
60		90				*
70		89				*
80		88				*
90		87				*
100						

LEGEND

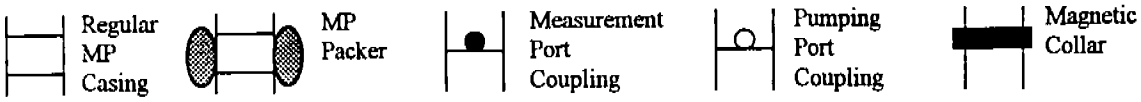


WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Hole No.: 600-D
(cont'd)

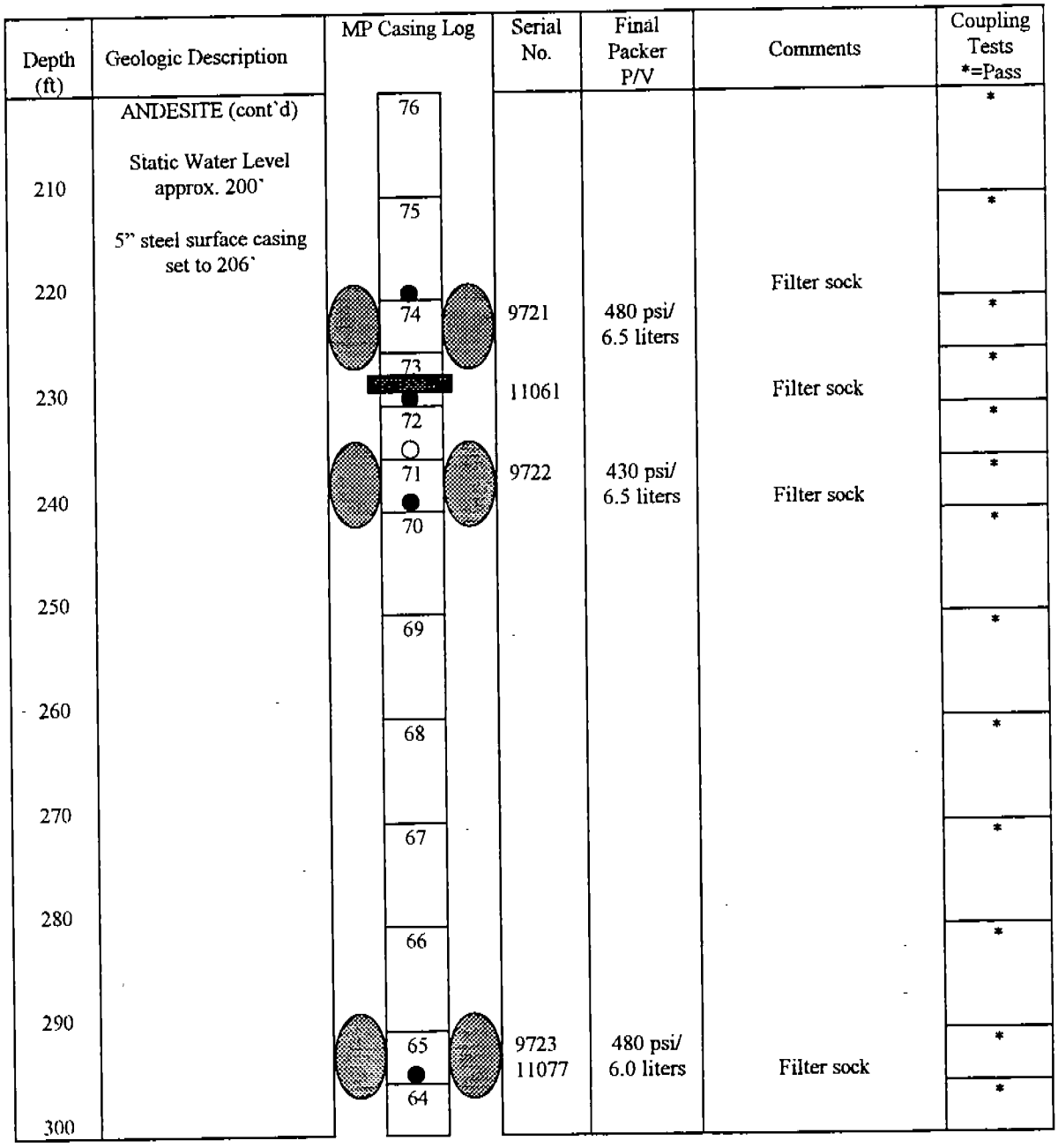
Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Coupling Tests *=Pass
	ALLUVIUM (cont'd)	86				*
110		85				*
120		84				*
130		83				*
140		82				*
150		81				*
160		80				*
170		79				*
180		78				*
190	190' - 883' ANDESITE (Orejon)	77				*
200						

LEGEND



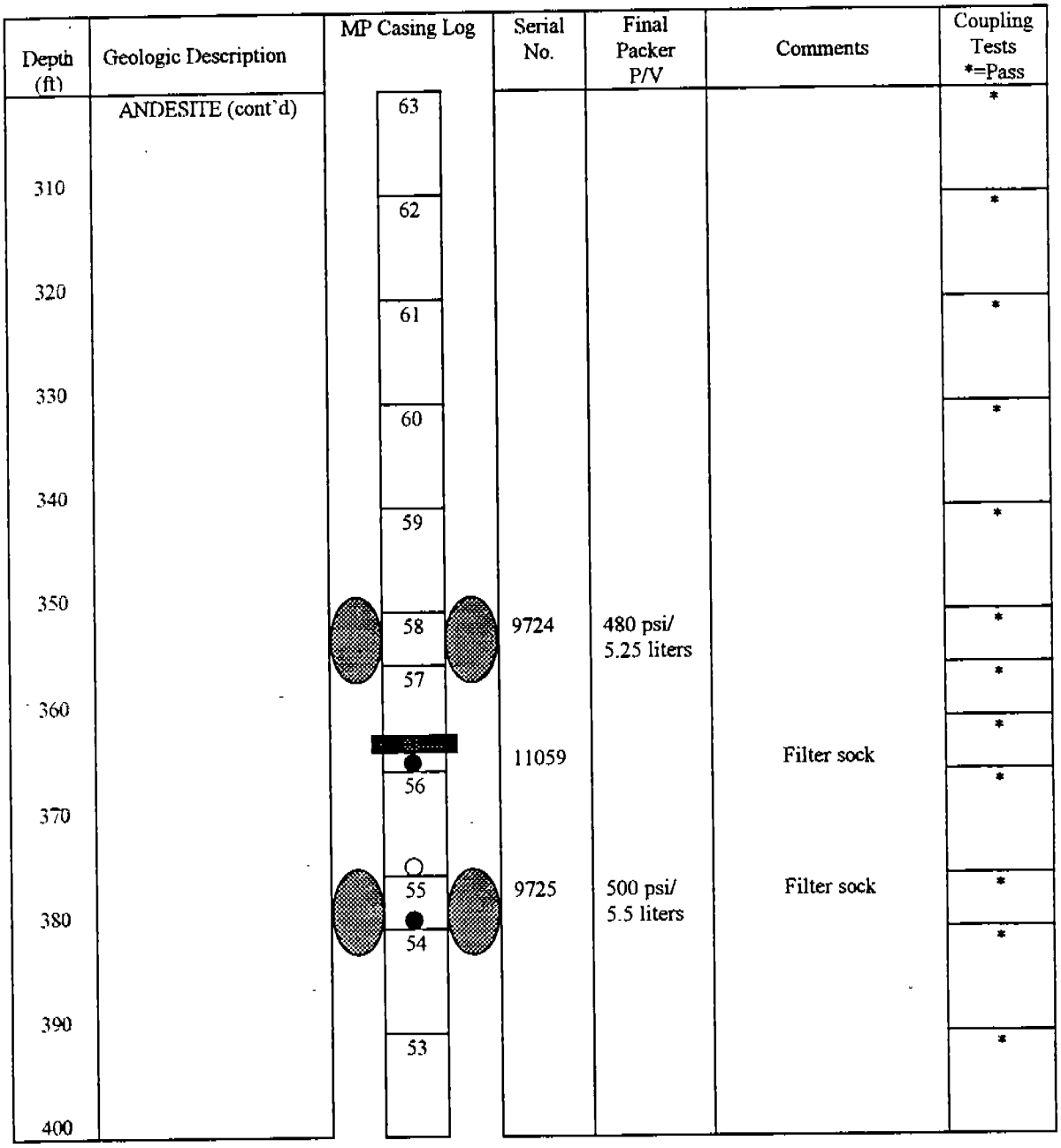
WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Hole No.: 600-D
(cont'd)



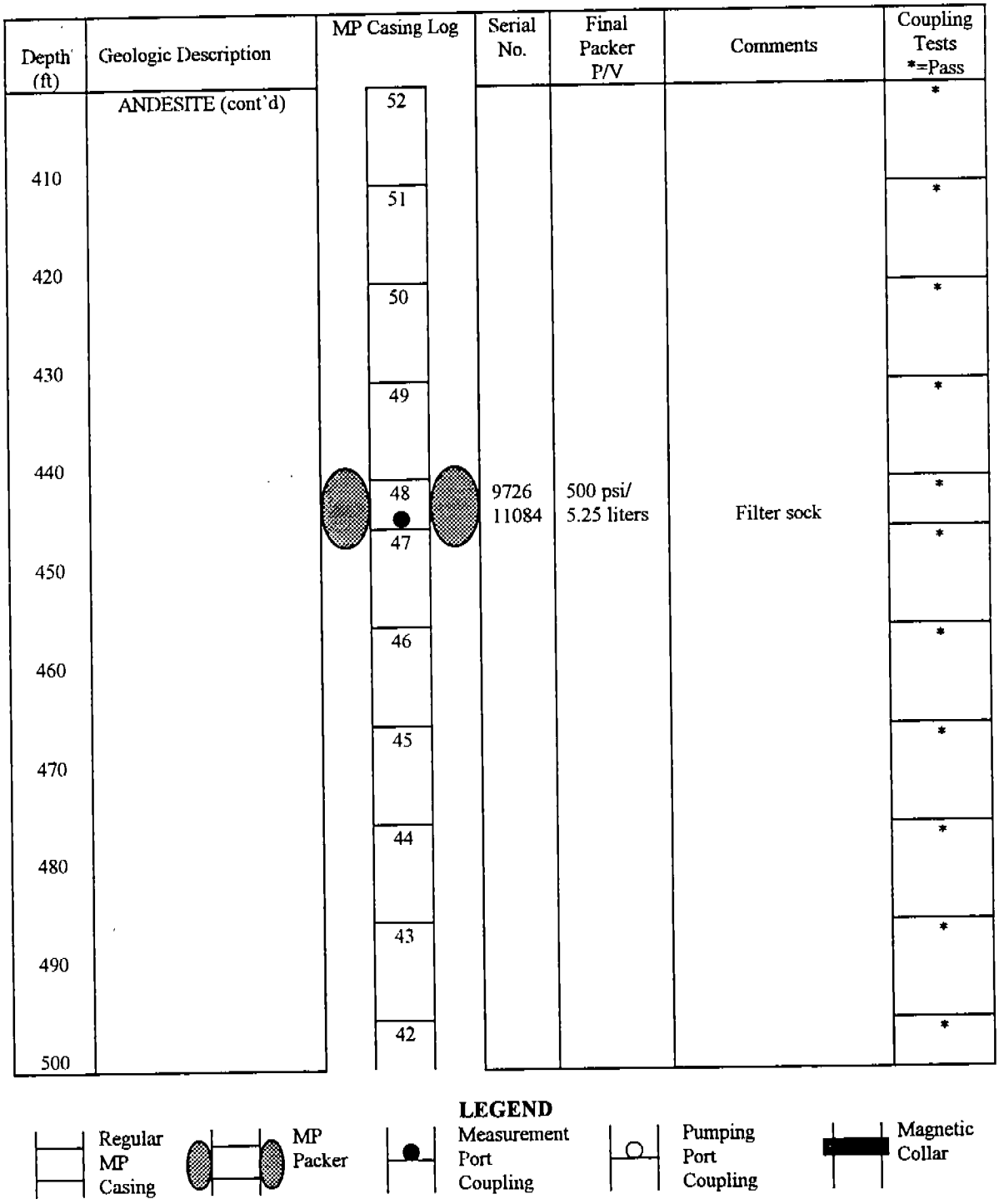
WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Hole No.: 600-D
(cont'd)



WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Hole No.: 600-D
(cont'd)



WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Hole No.: 600-D
(cont'd)

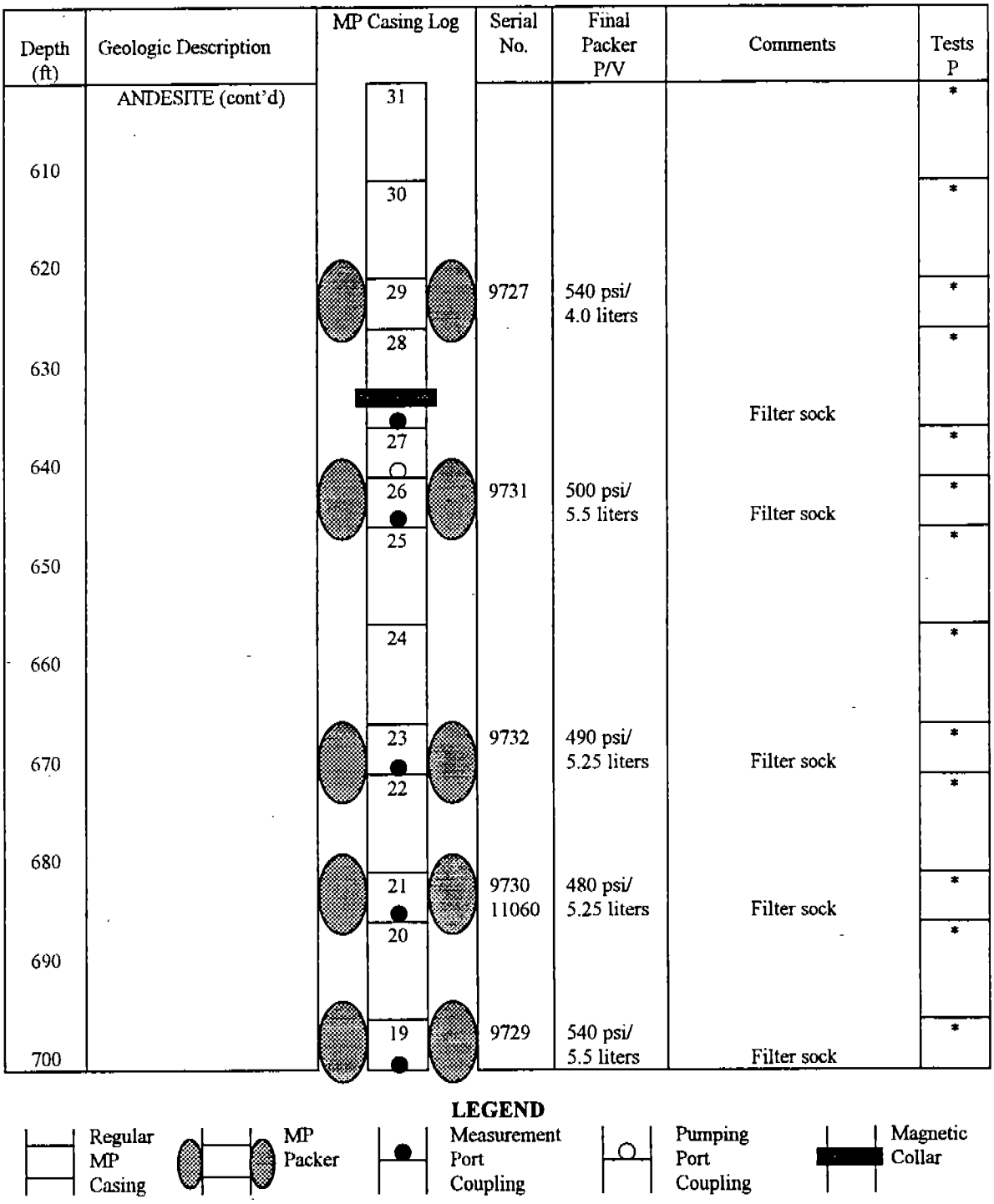
Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Coupling Tests *=Pass
	ANDESITE (cont'd)	42				
510		41				*
520		40				*
530		39				*
540		38	9728	500 psi/ 5.25 liters	Filter sock	*
		37				*
550		36				*
560		35				*
570		34				*
580		33				*
590		32				*
600						

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

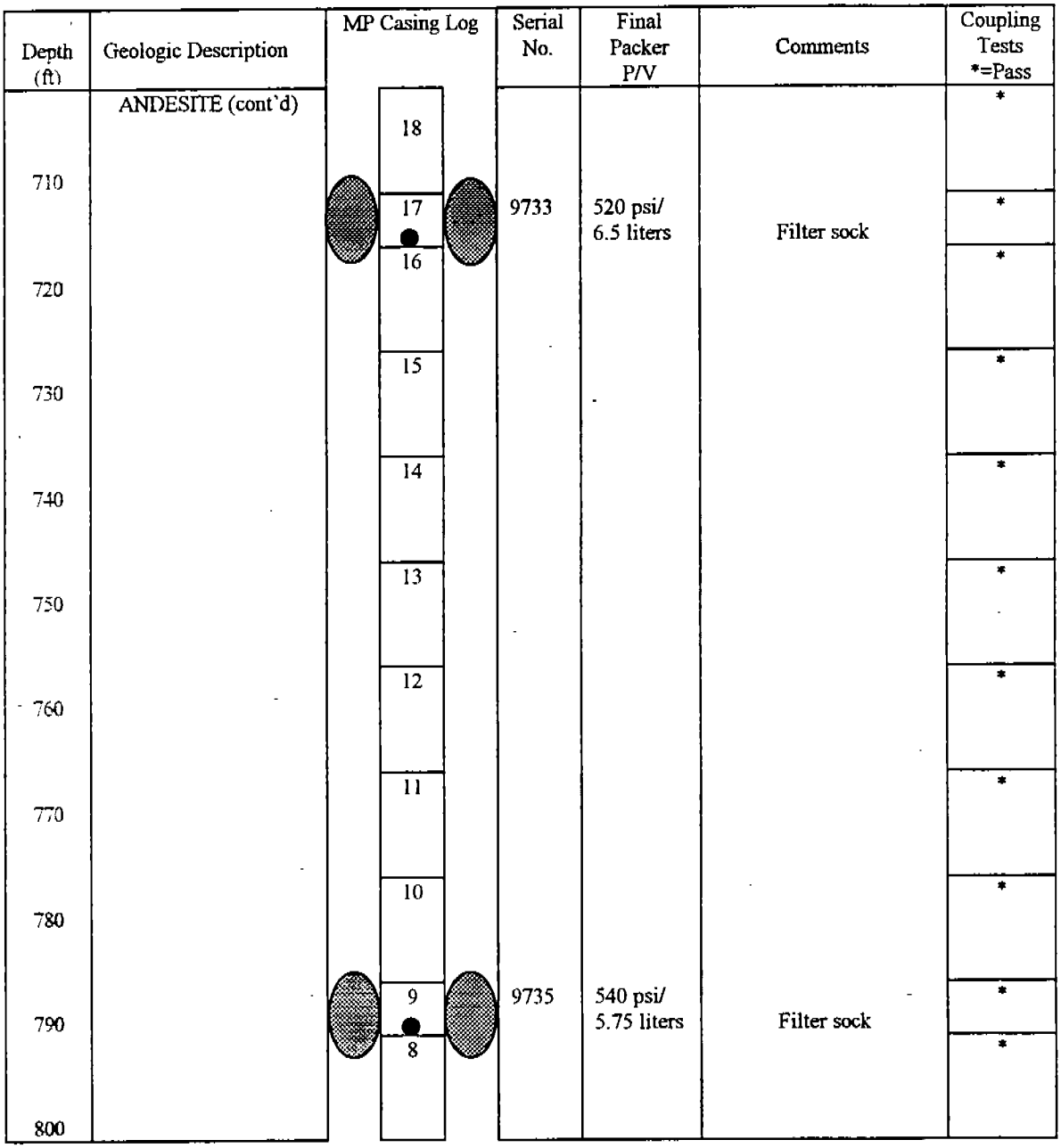
WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Hole No.: 600-D
(cont'd)



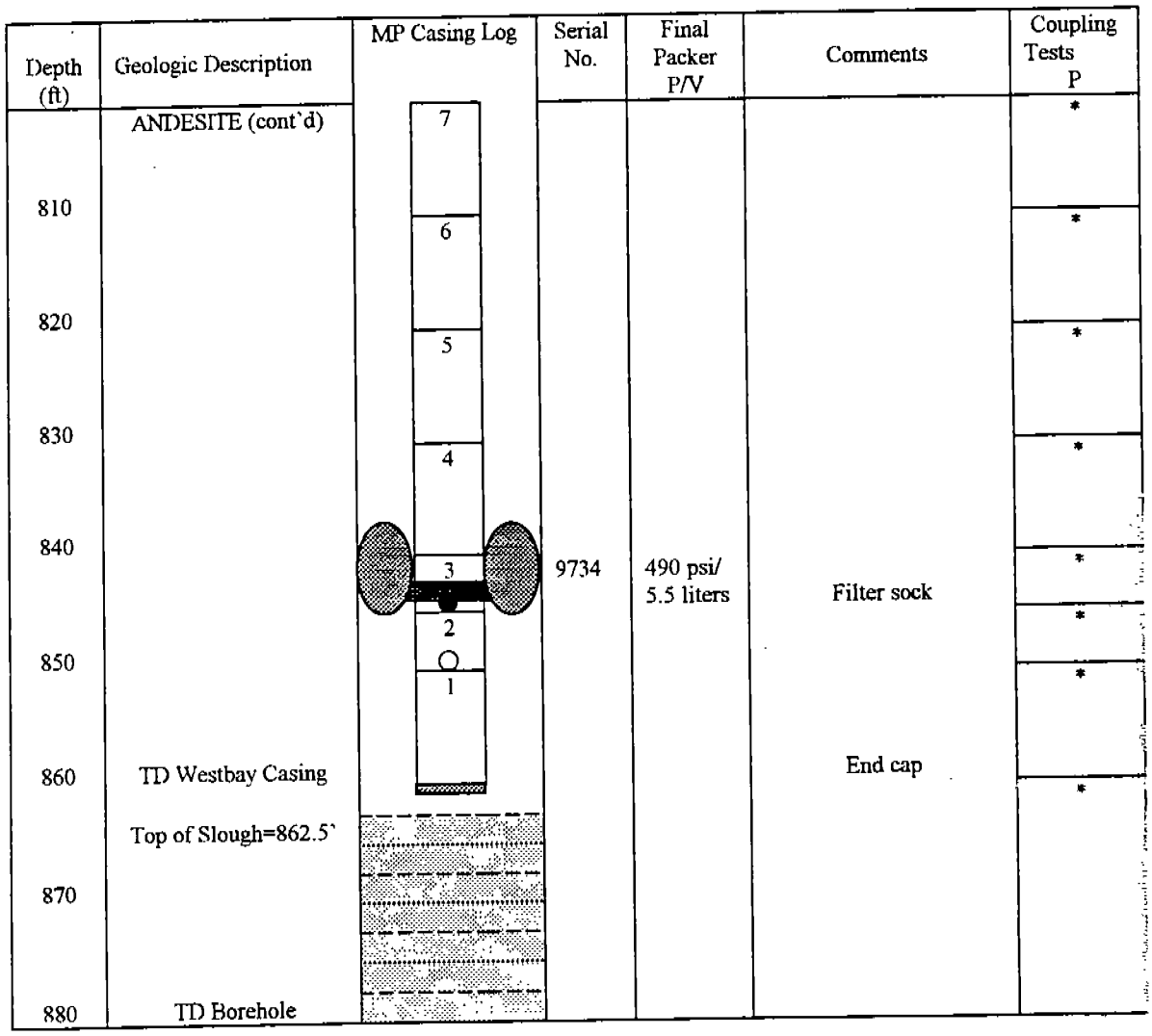
WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Hole No.: 600-D
(cont'd)

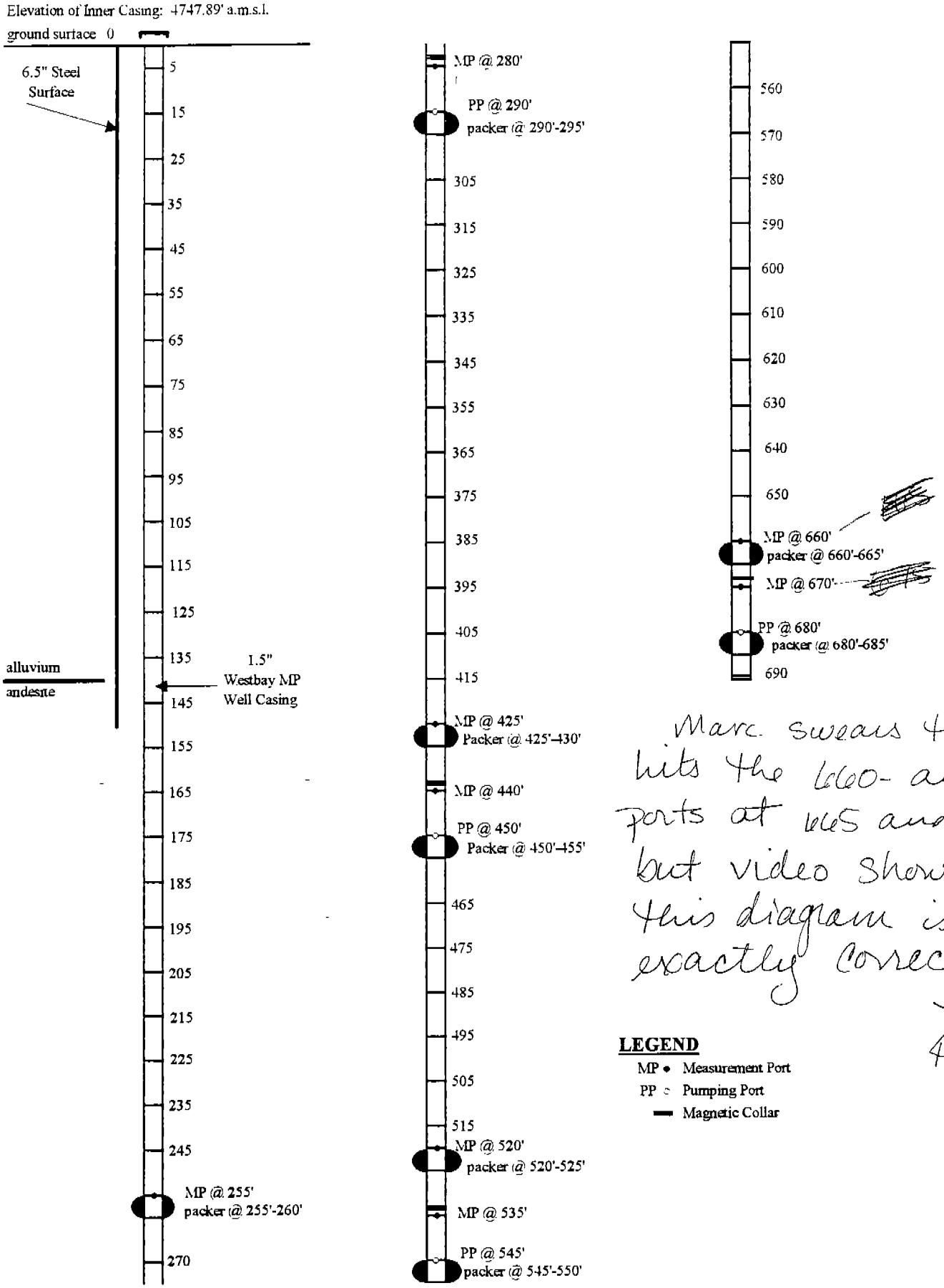


WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Hole No.: 600-D
(cont'd)



WESTE WELL COMPLETION DIA M
600-E



Marc swears that he hits the 660- and 670' ports at 665 and 675 but video shows that this diagram is exactly correct.

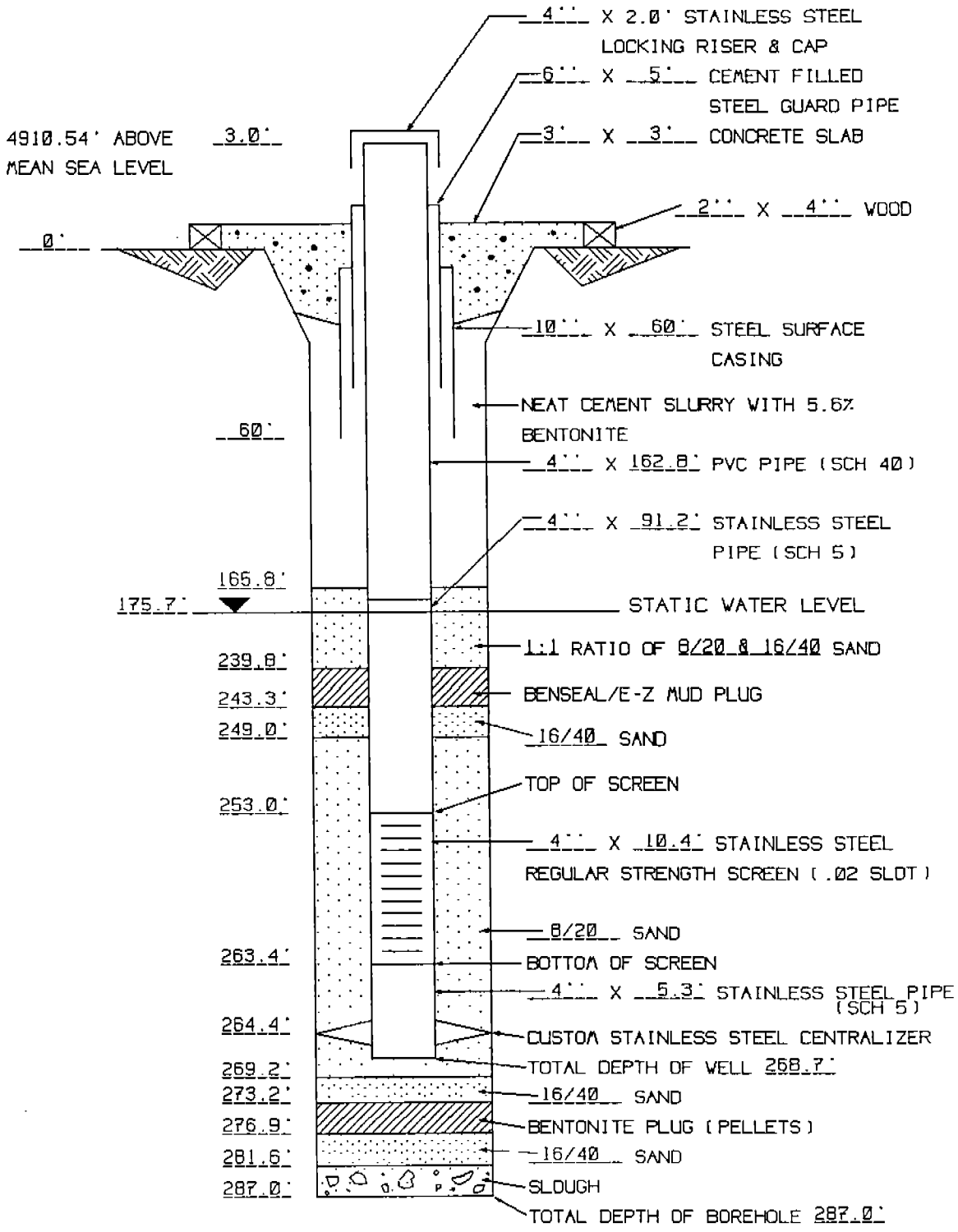
MR
4-10-98

LEGEND

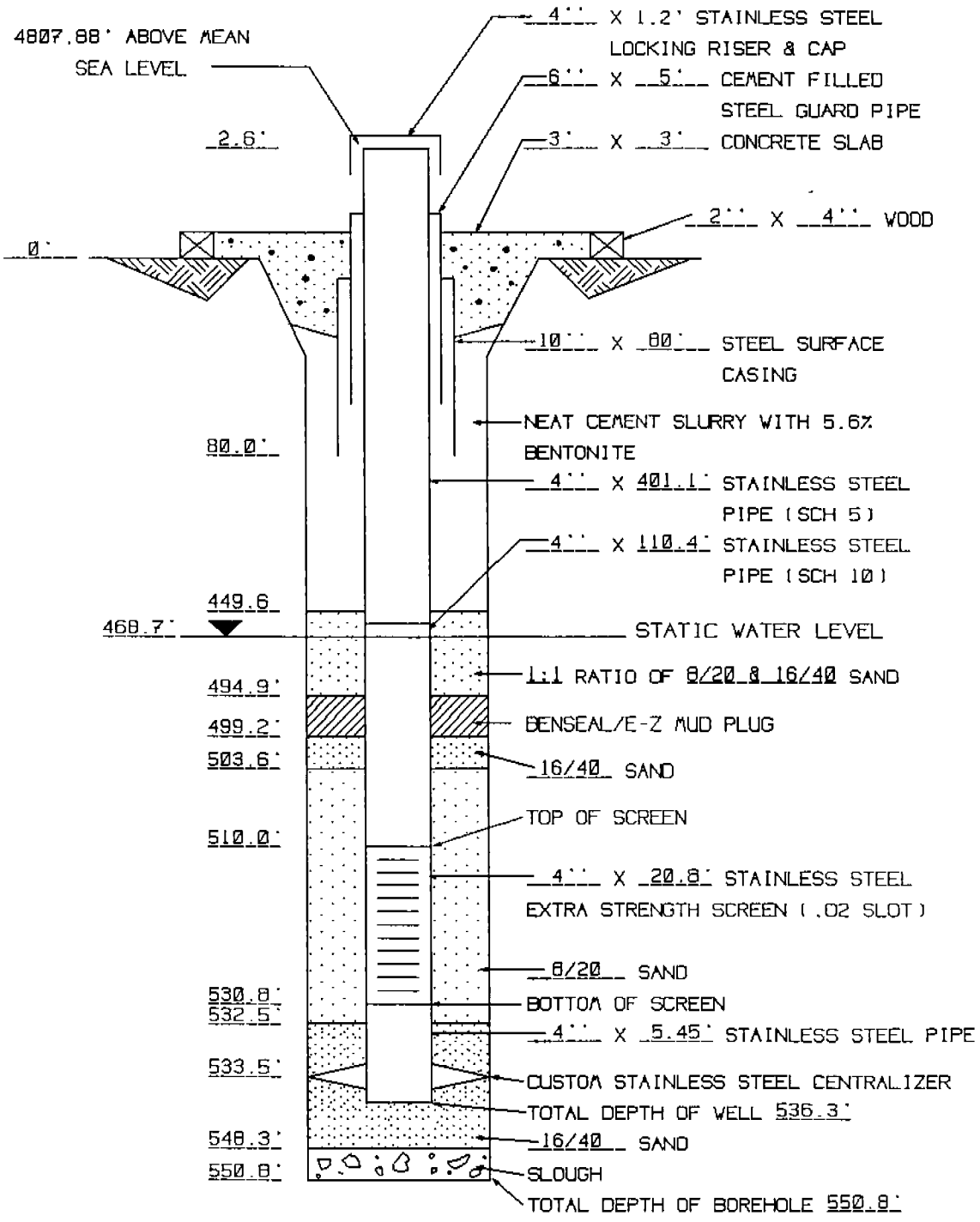
MP • Measurement Port
PP ○ Pumping Port
▬ Magnetic Collar

Installation Date: 10/8-10/97
Installed By: ATSC
Elevation (BC): 4746.17' a.m.s.l.

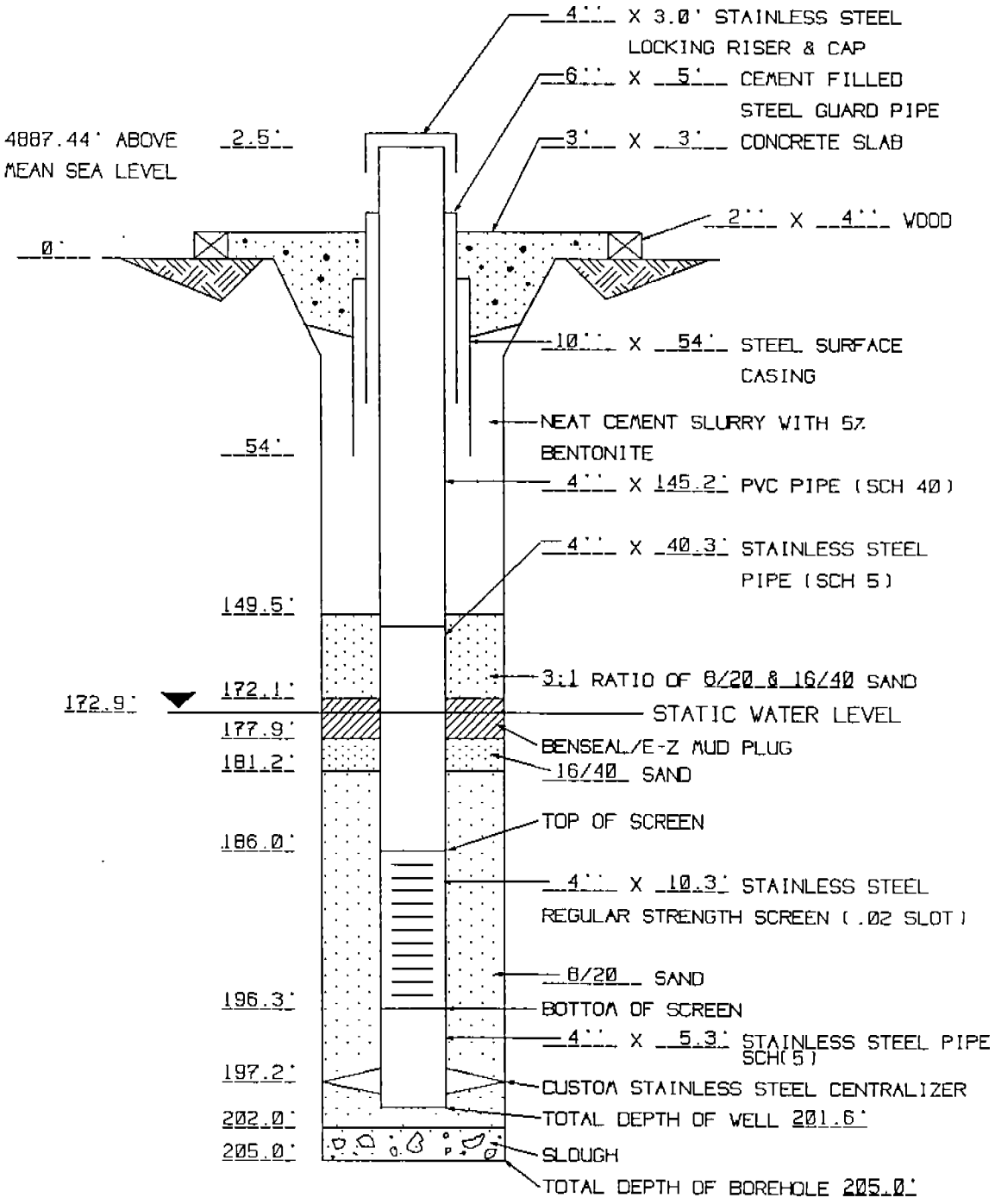
Drawn/Checked By: MER/GCG
Borehole Depth: 703' (logged)
MP Depth: 690'



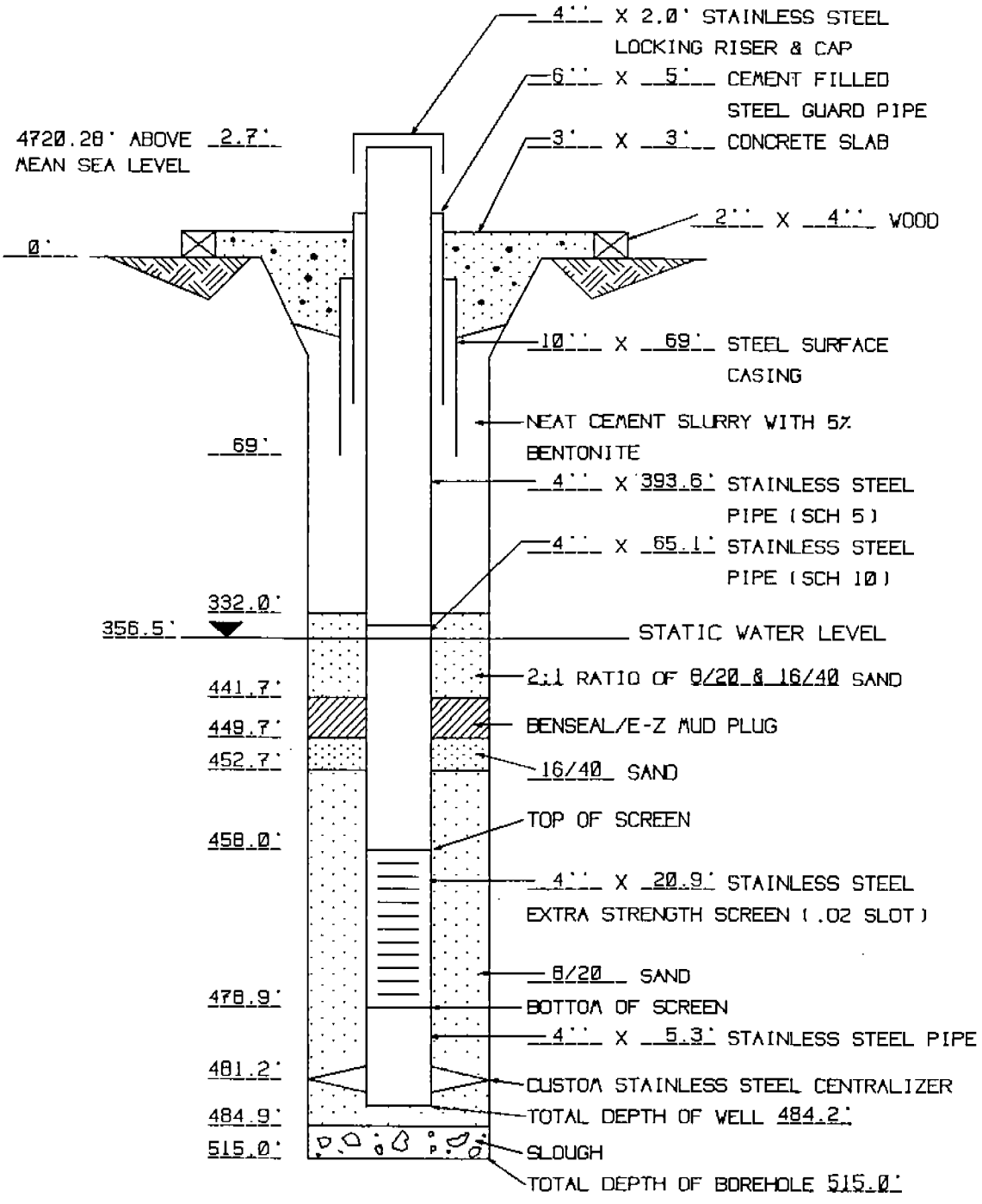
MONITOR WELL 700-A-253 COMPLETION DIAGRAM



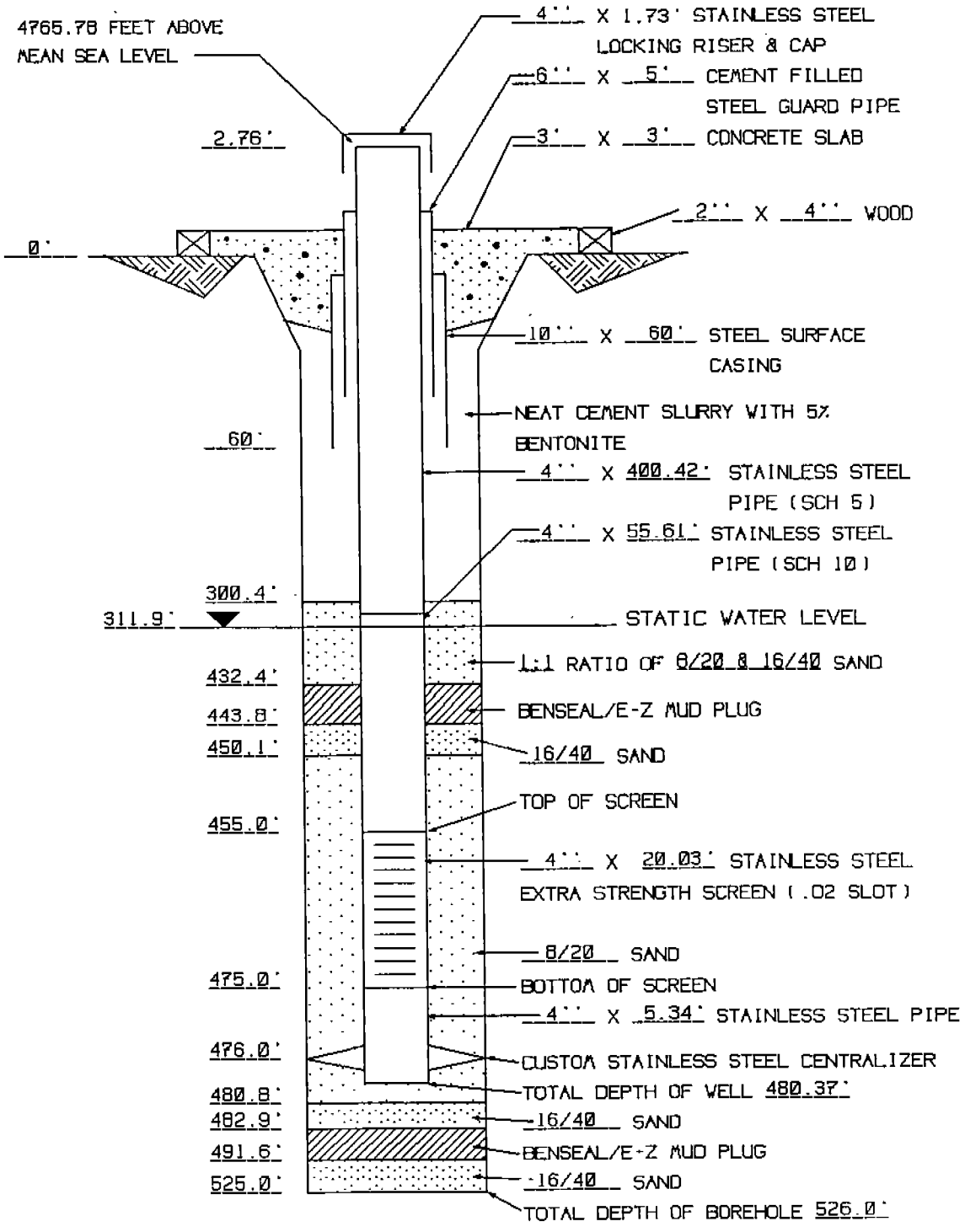
MONITOR WELL 700-B-510 COMPLETION DIAGRAM



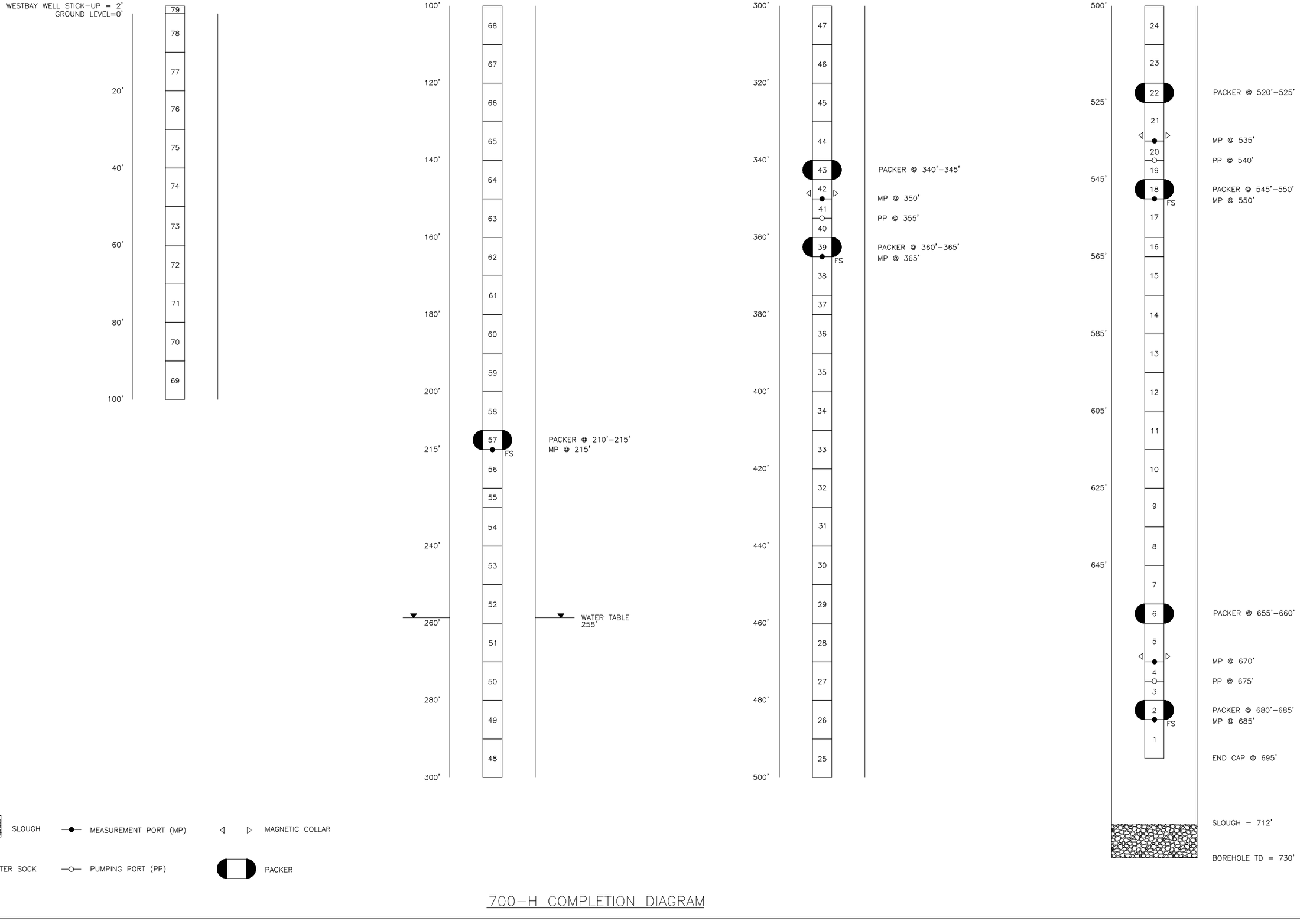
MONITOR WELL 700-D-186 COMPLETION DIAGRAM



MONITOR WELL 700-E-458 COMPLETION DIAGRAM

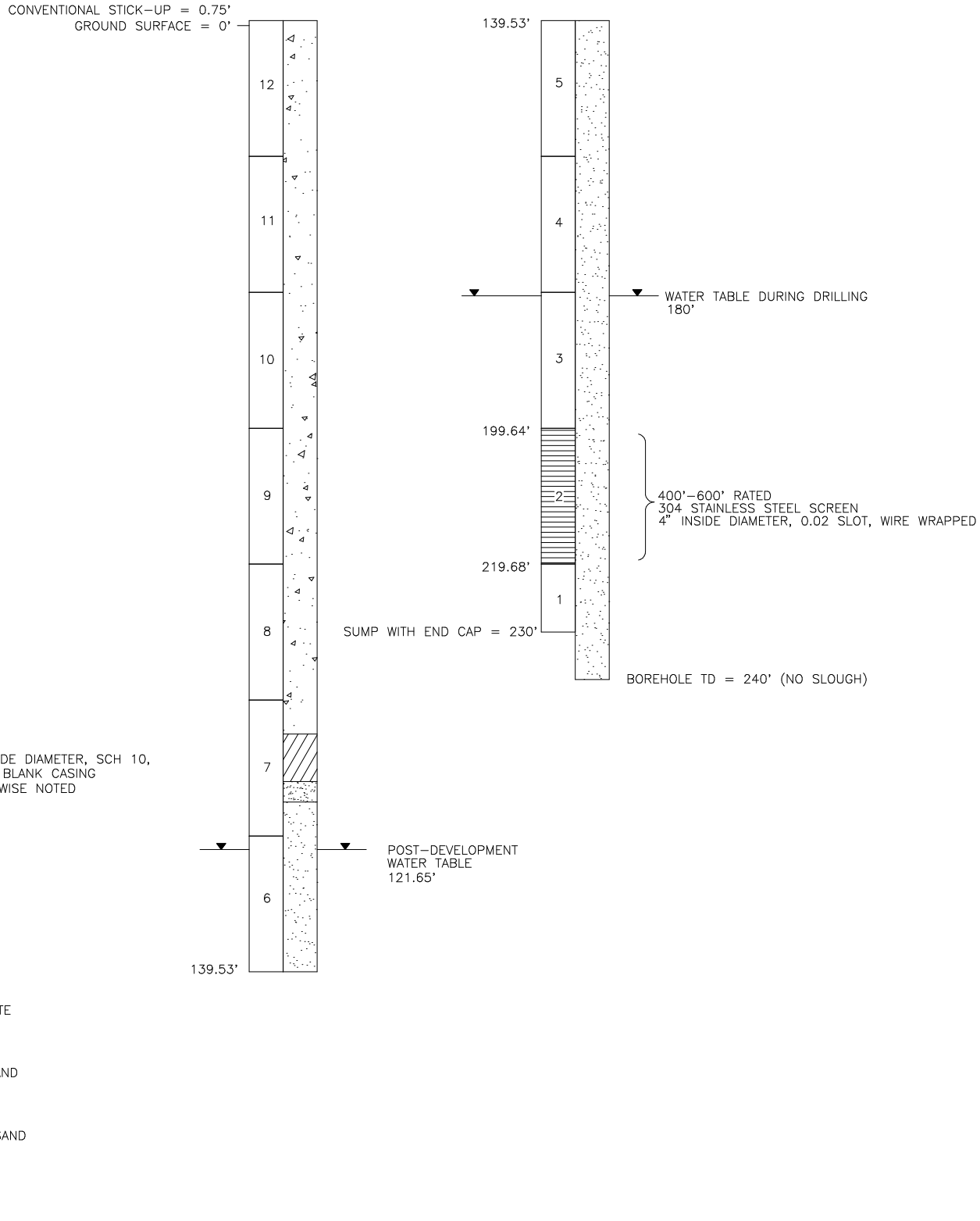


MONITOR WELL 700-F-455 COMPLETION DIAGRAM

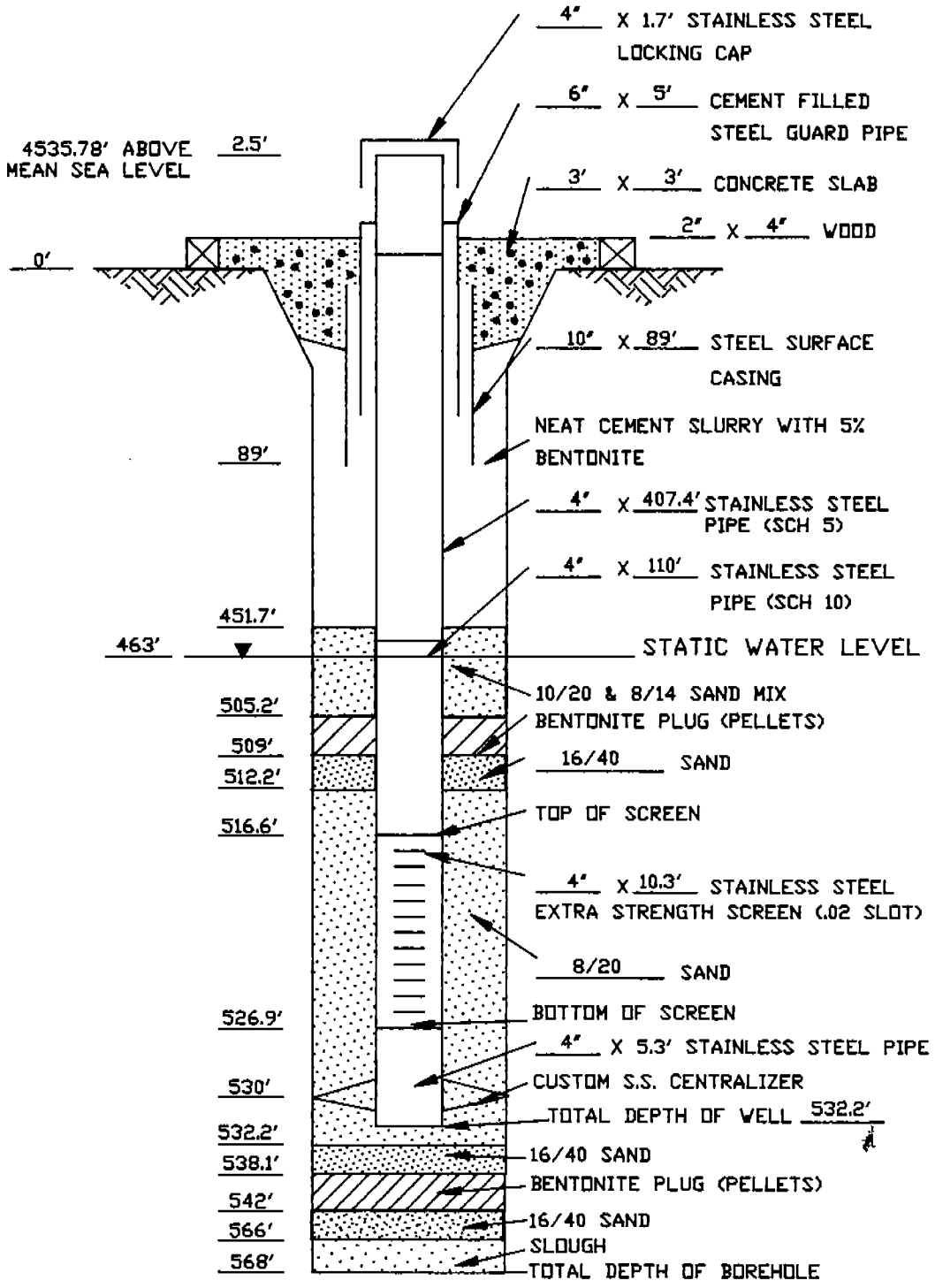


700-H COMPLETION DIAGRAM

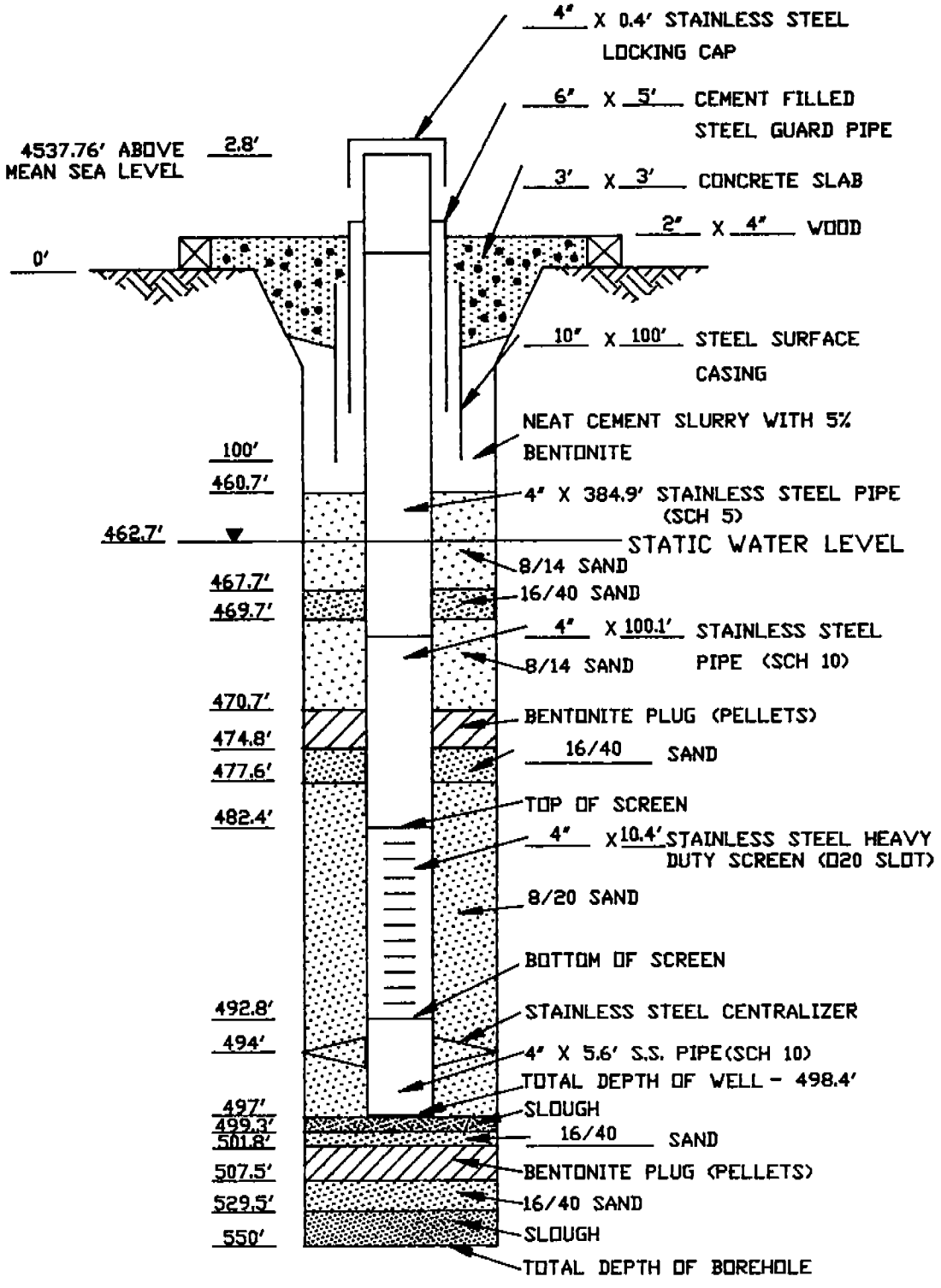
2864



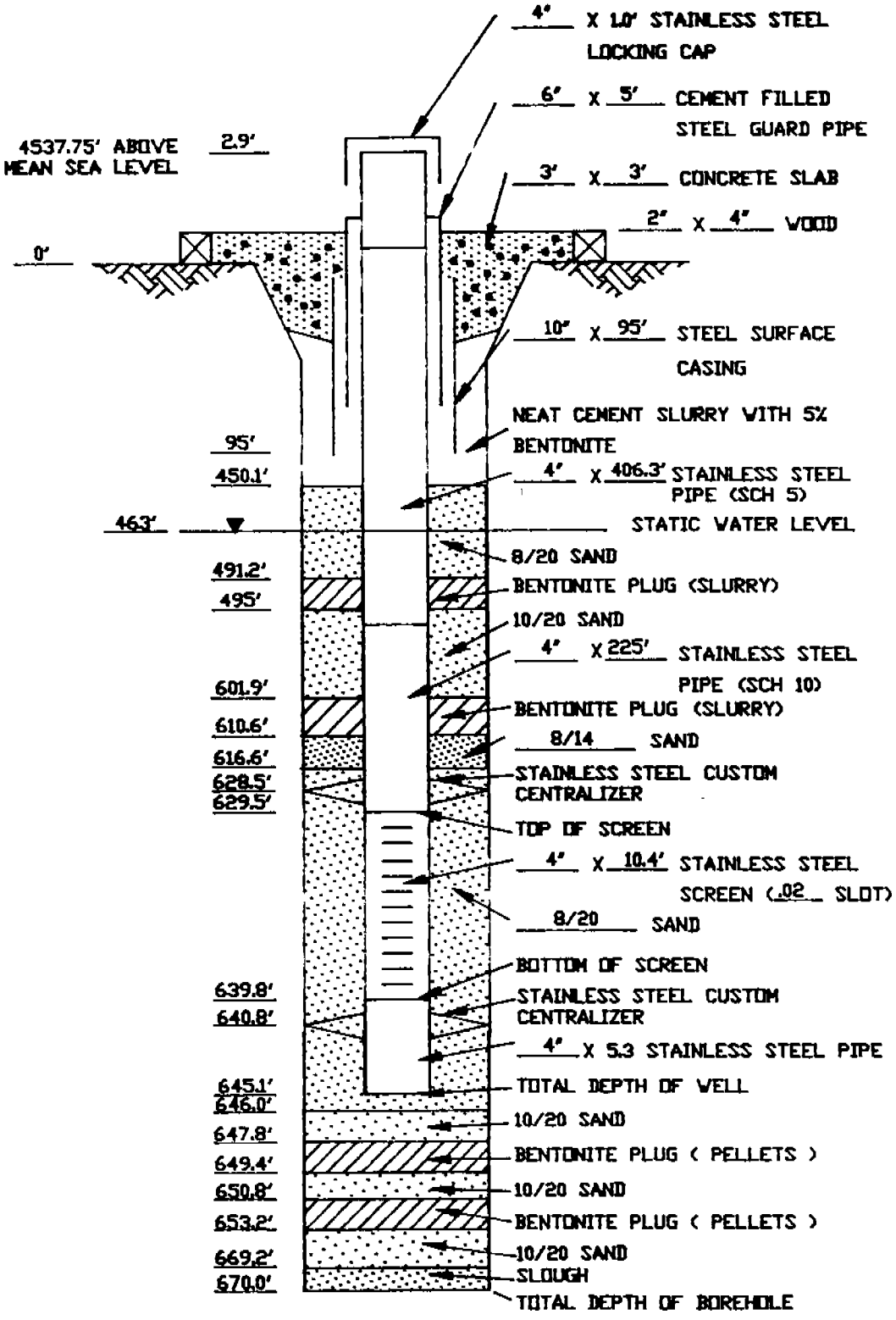
700-J CONVENTIONAL WELL DESIGN



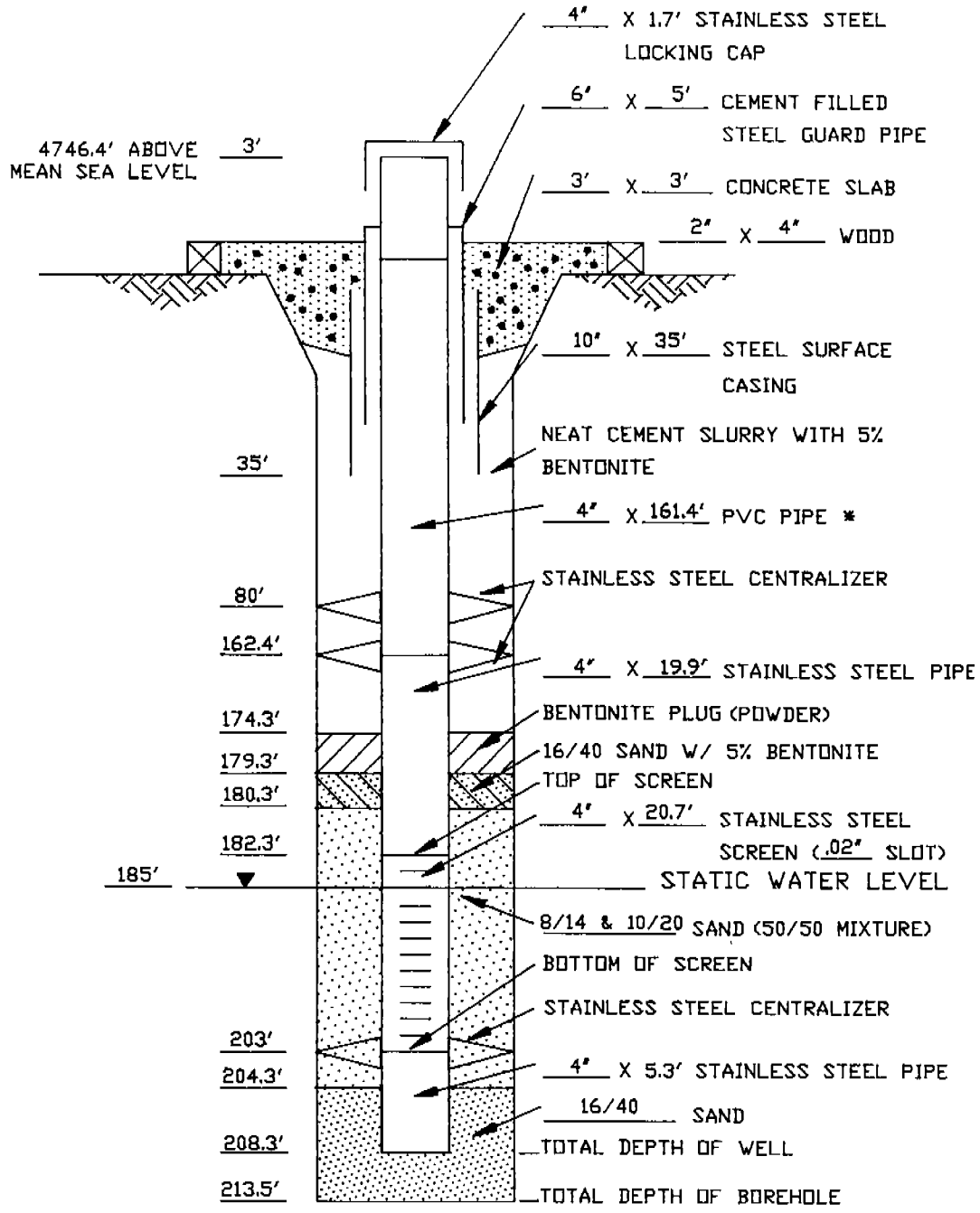
MONITOR WELL BLM-10-517 COMPLETION DIAGRAM



MONITOR WELL BLM-2-482 COMPLETION DIAGRAM

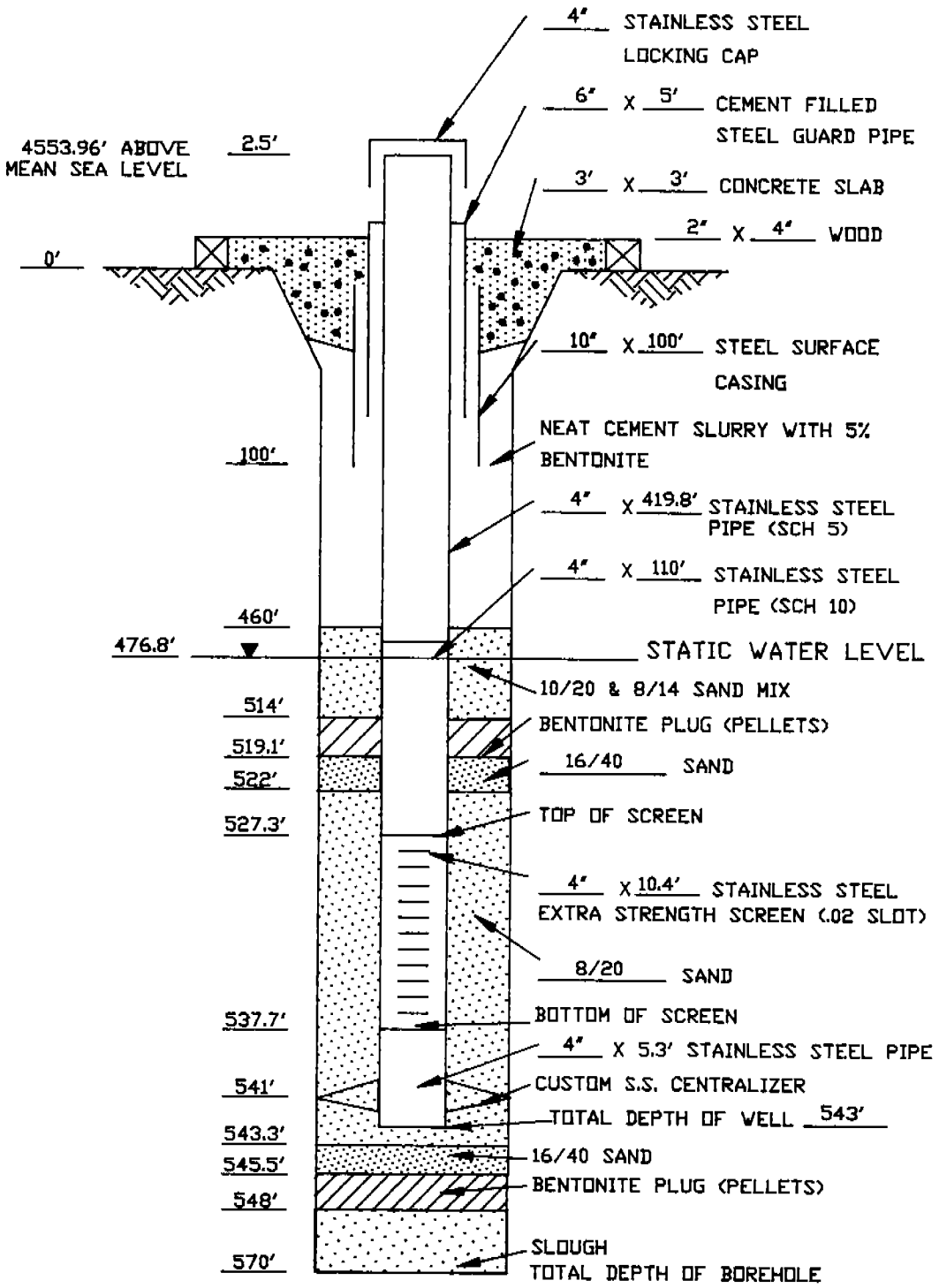


MONITOR WELL BLM-2-630 COMPLETION DIAGRAM

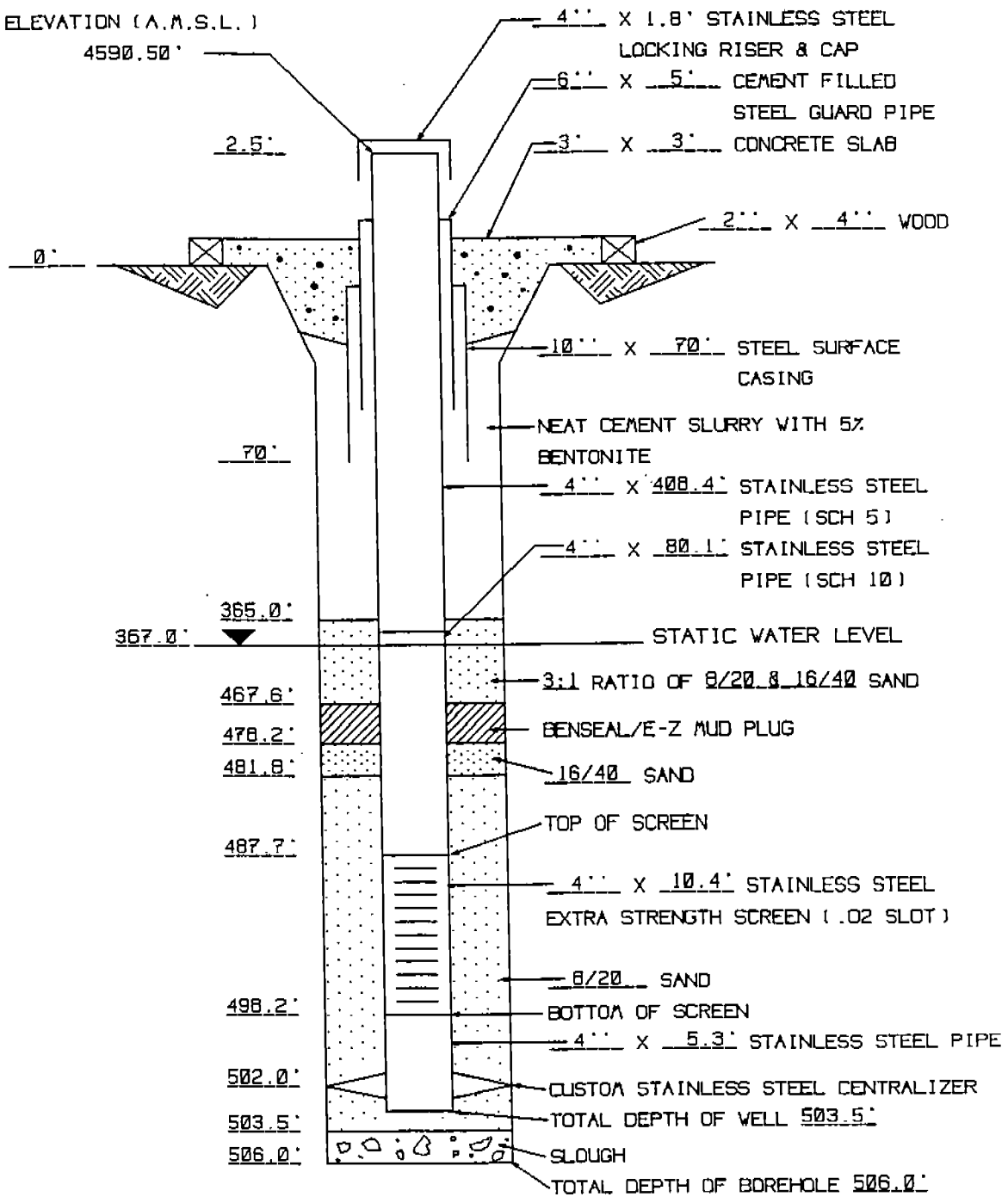


* NOTE: TOTAL LENGTH OF COMPLETION PIPE DOES NOT CORRELATE WITH MEASURED DEPTH OF WELL. TALLY OF PVC PIPE IS PROBABLY IN ERROR AND SHOULD BE 163.7'.

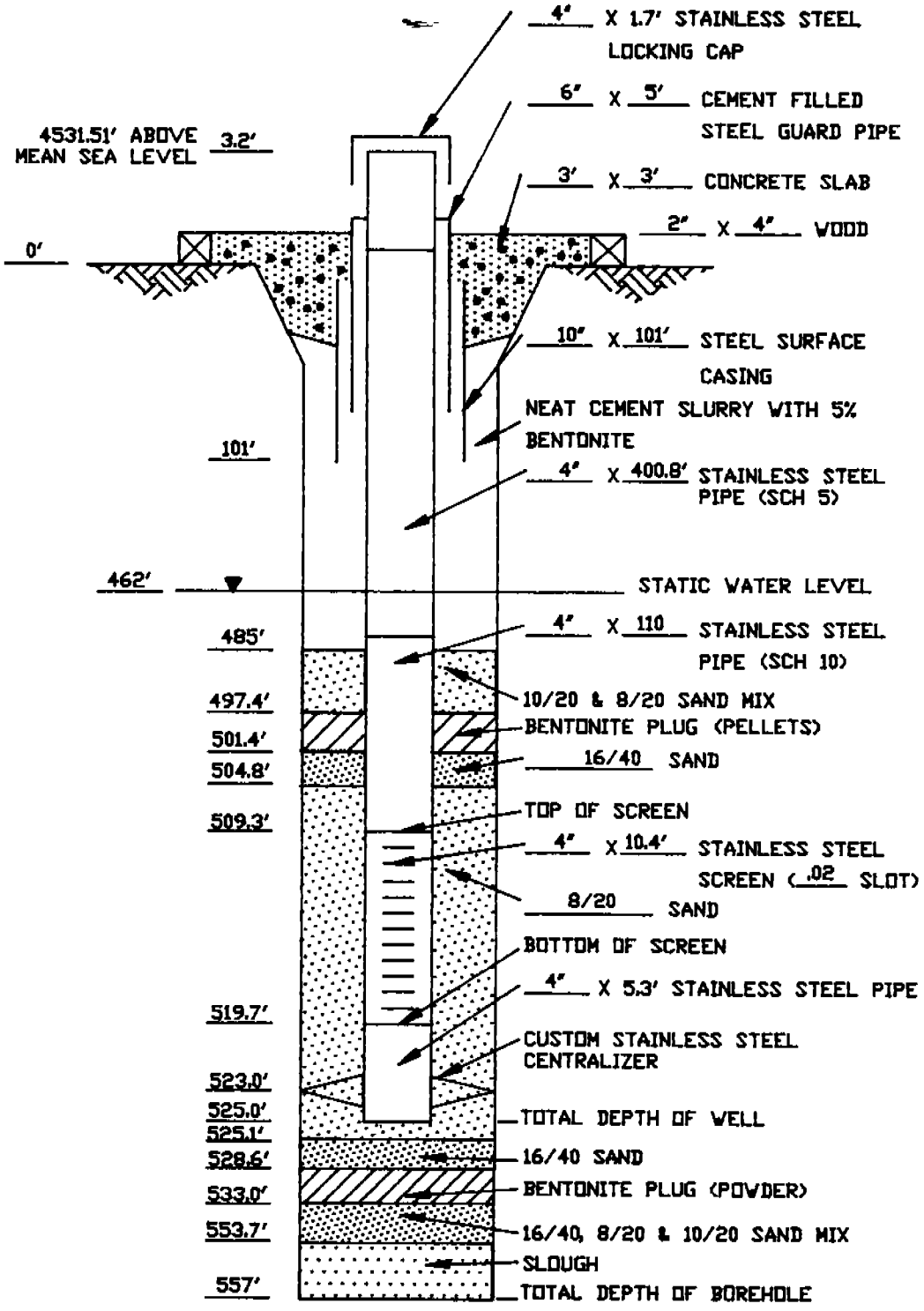
MONITOR WELL BLM-3-182 COMPLETION DIAGRAM



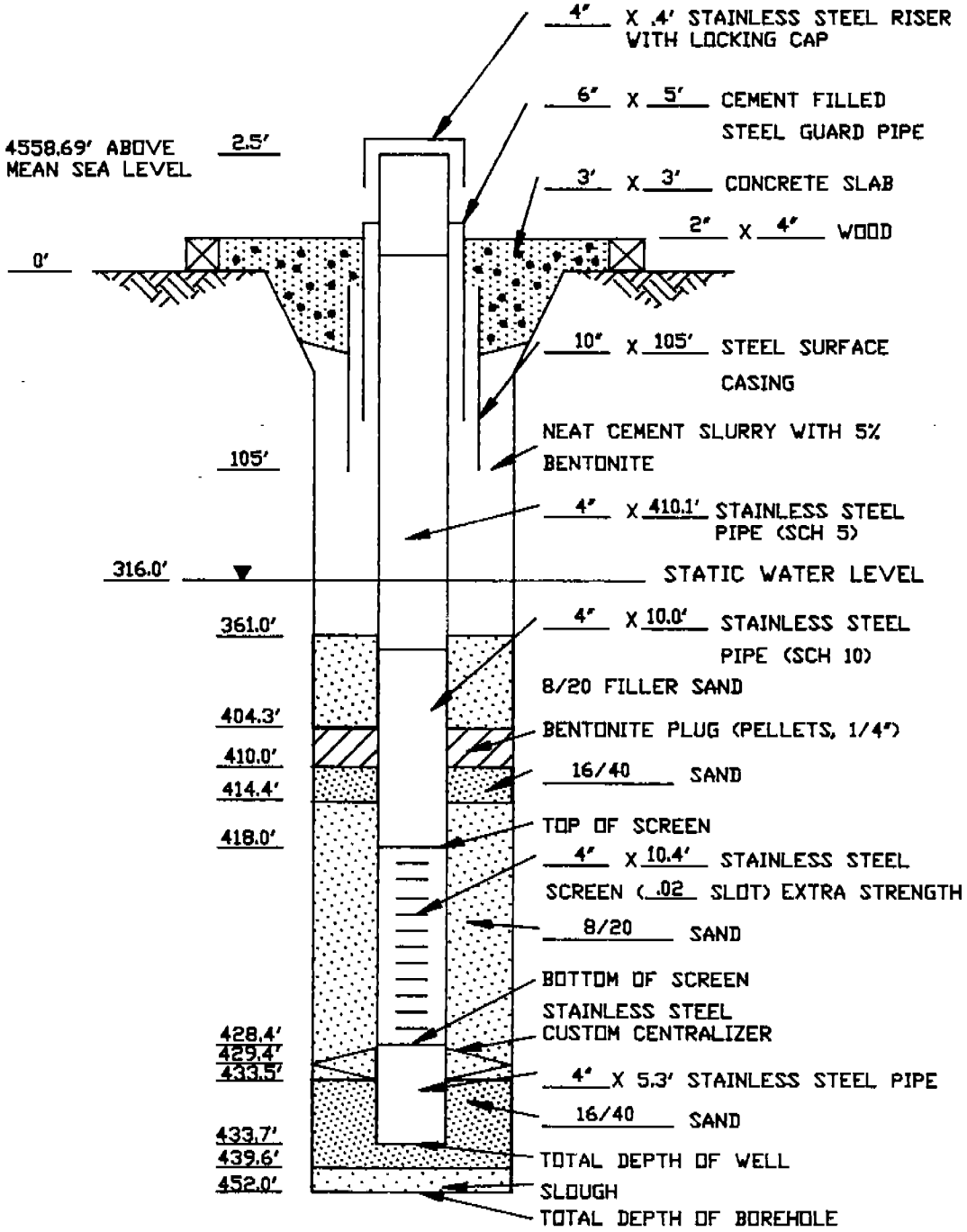
MONITOR WELL BLM-5-527 COMPLETION DIAGRAM



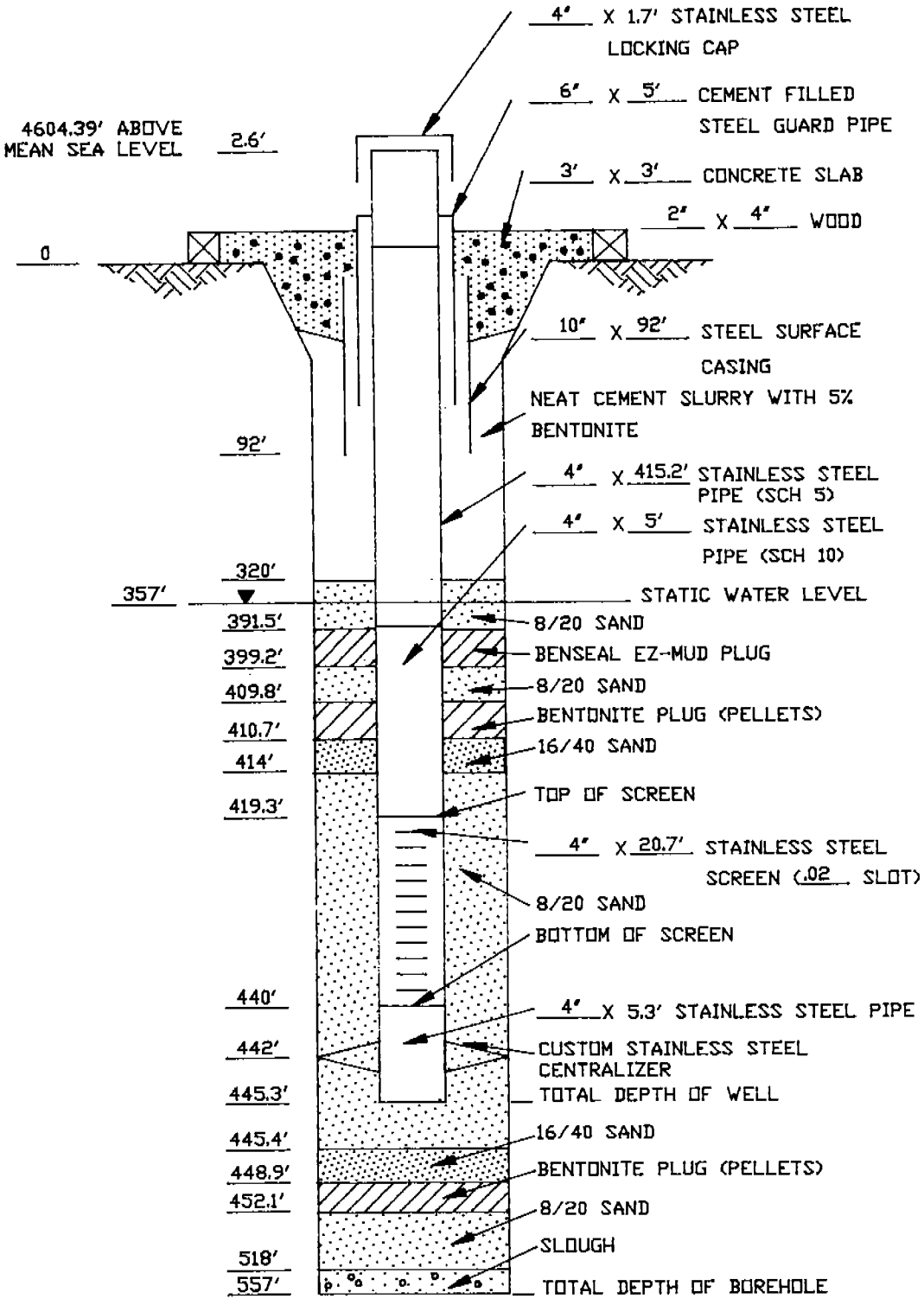
MONITOR WELL BLM-6-488 COMPLETION DIAGRAM



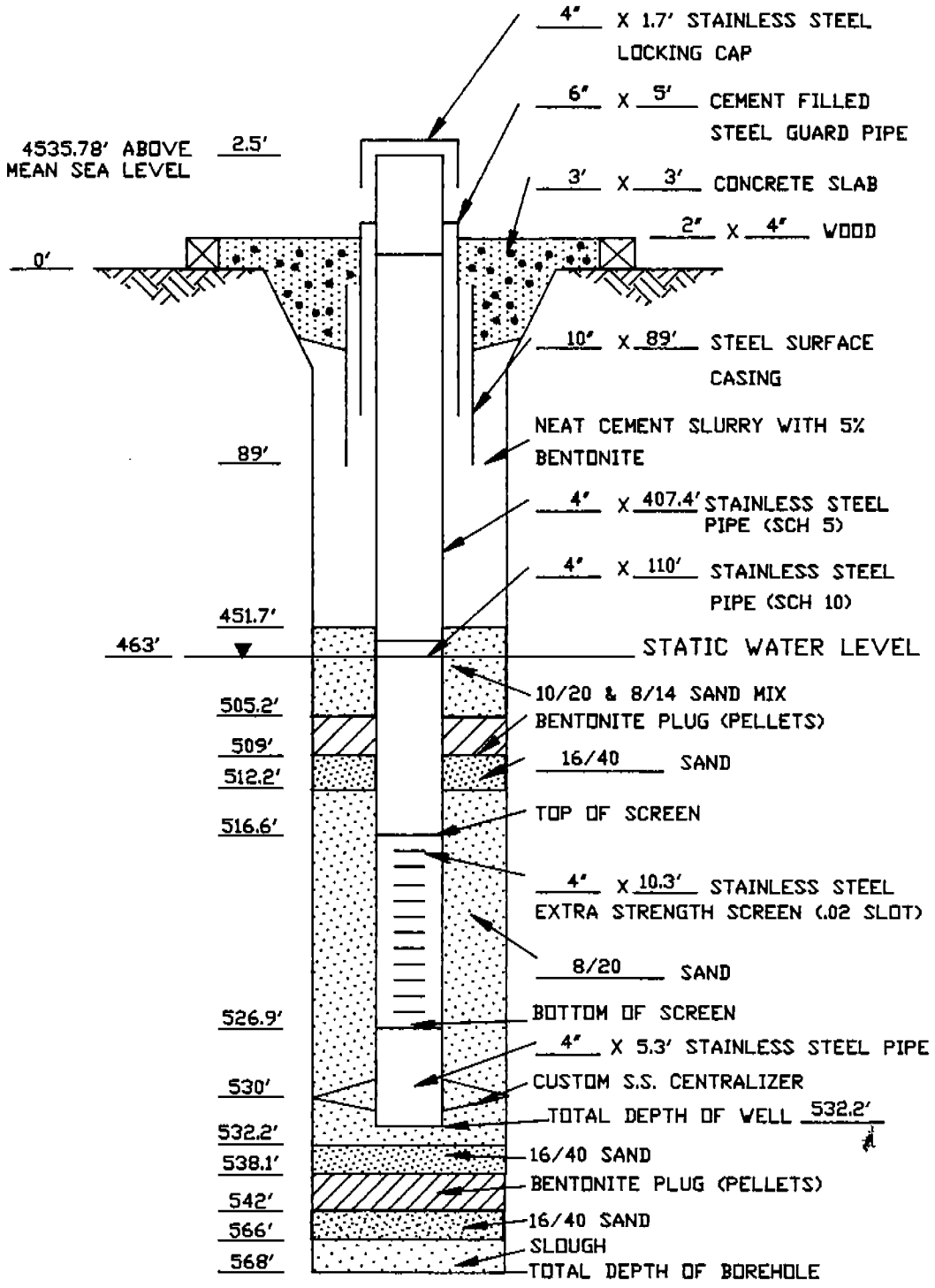
MONITOR WELL BLM-7-509 COMPLETION DIAGRAM



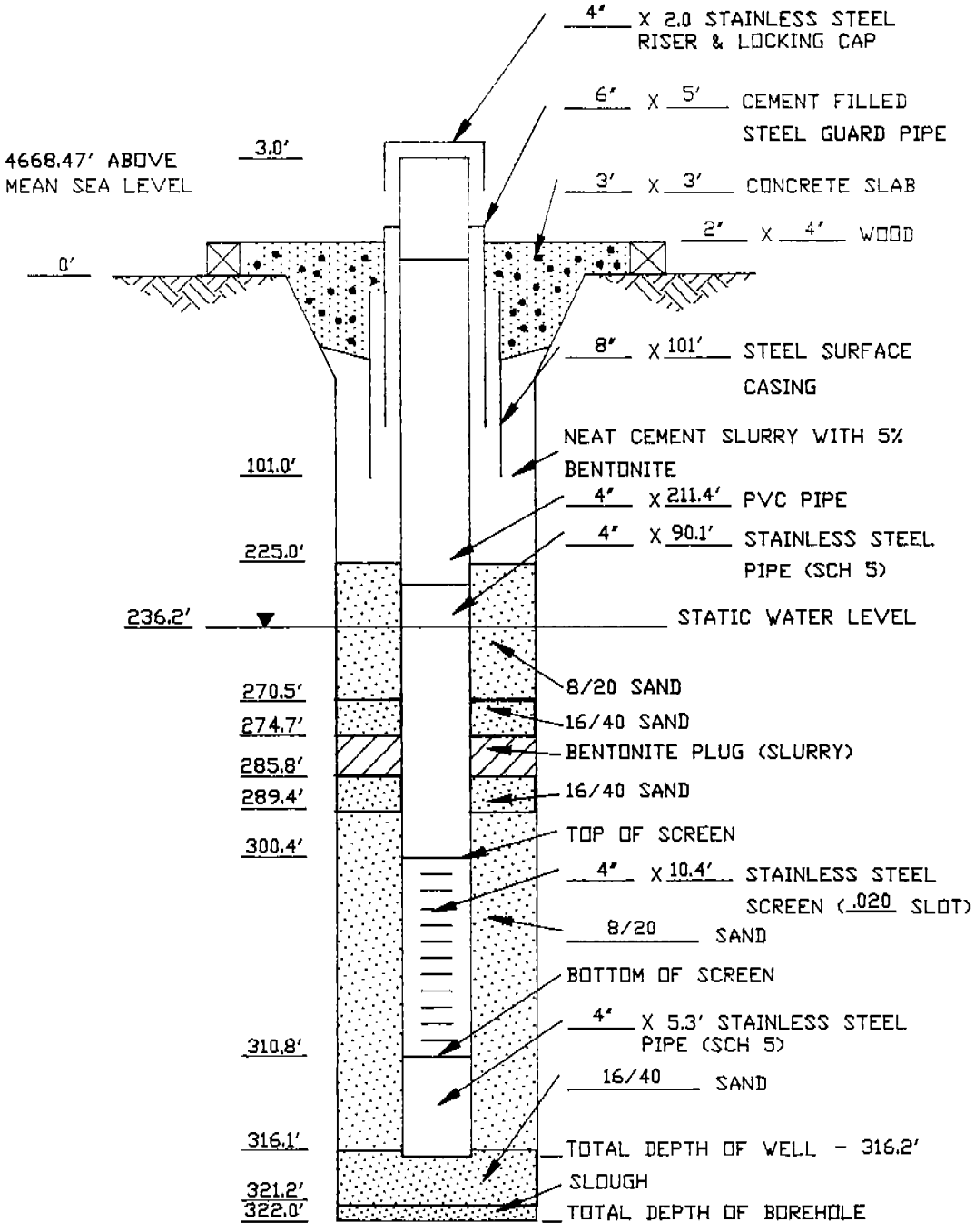
COMPLETION DIAGRAM BLM-8-418



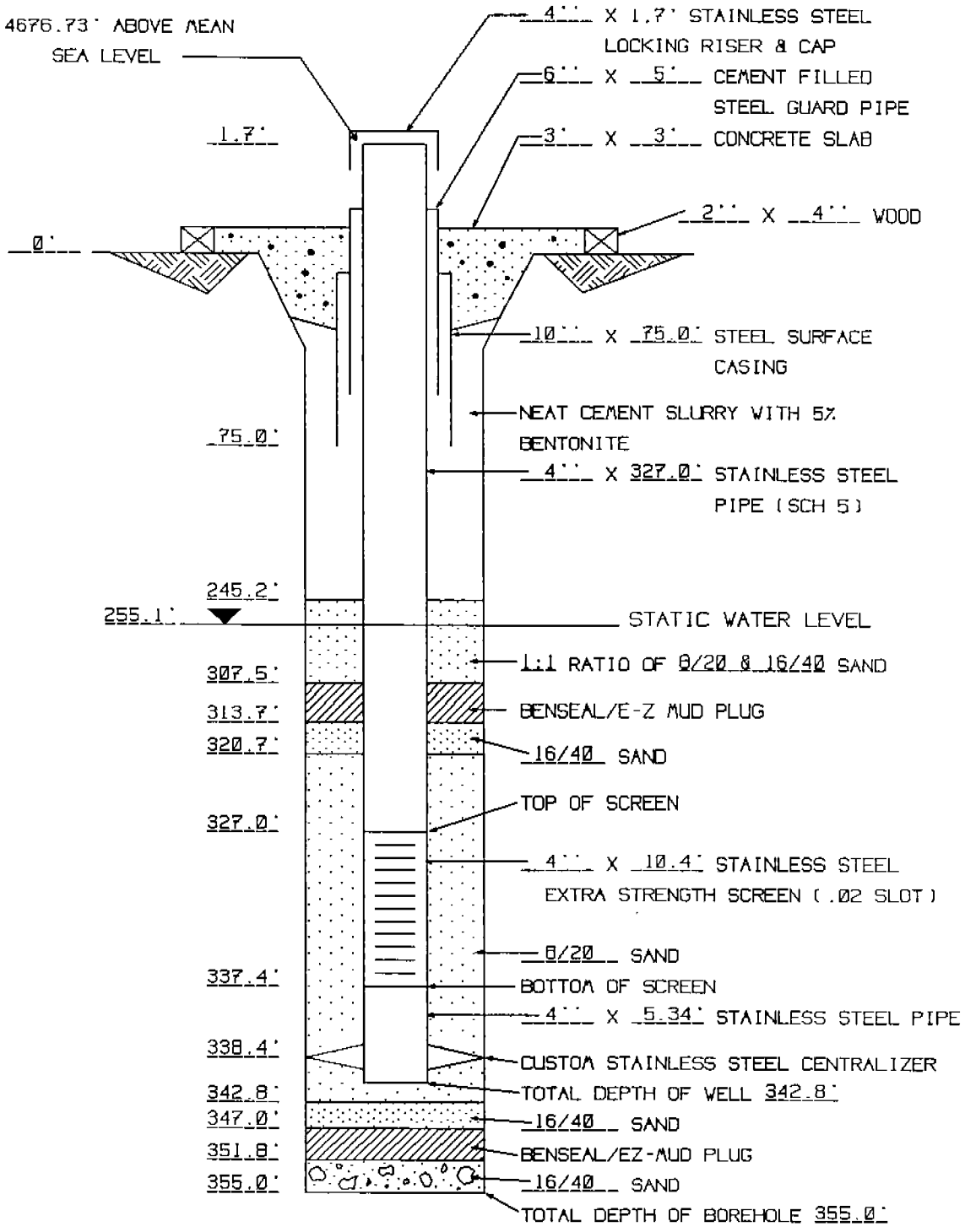
MONITOR WELL BLM-9-419 COMPLETION DIAGRAM



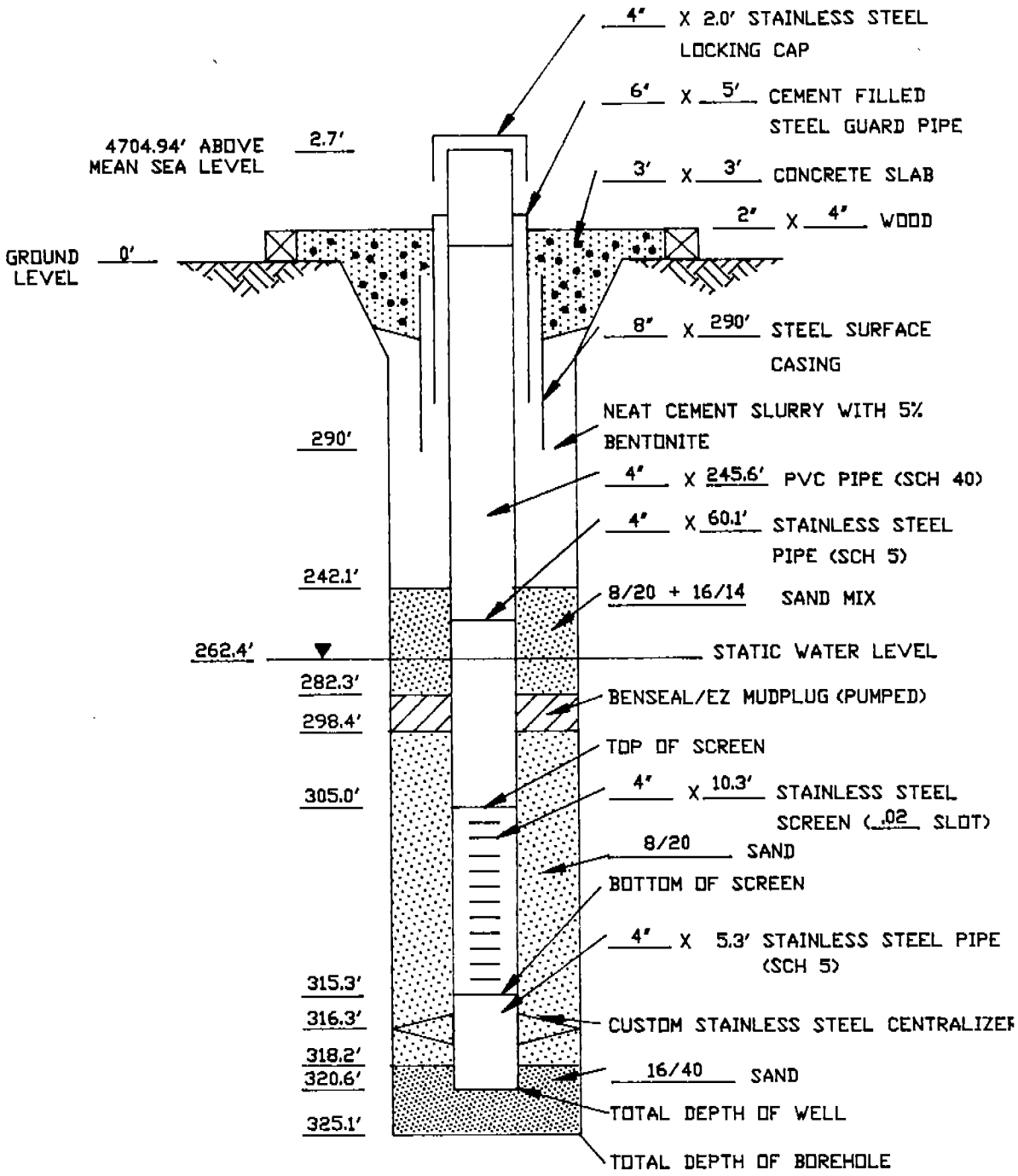
MONITOR WELL BLM-10-517 COMPLETION DIAGRAM



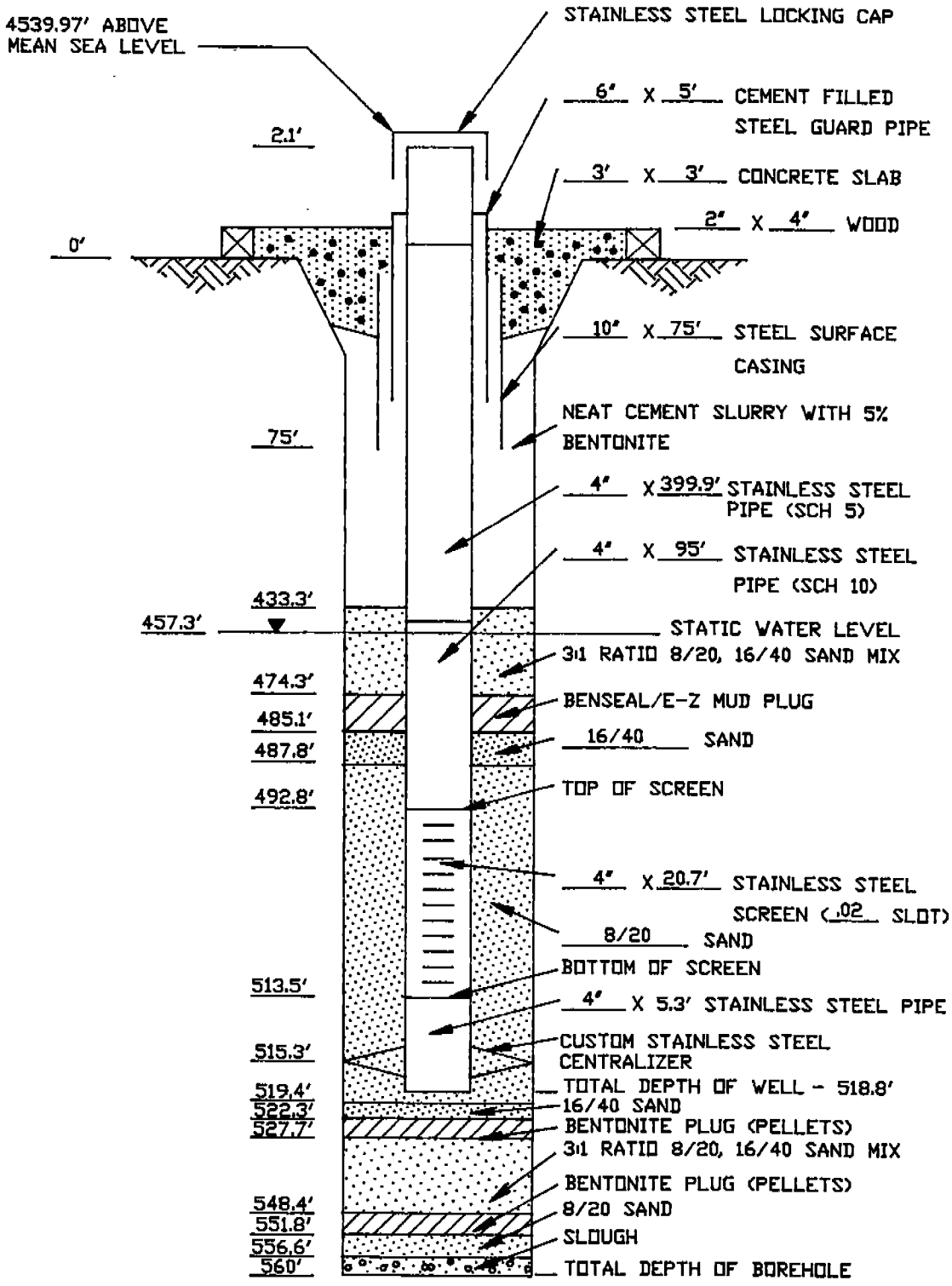
MONITOR WELL BLM-13-300 COMPLETION DIAGRAM



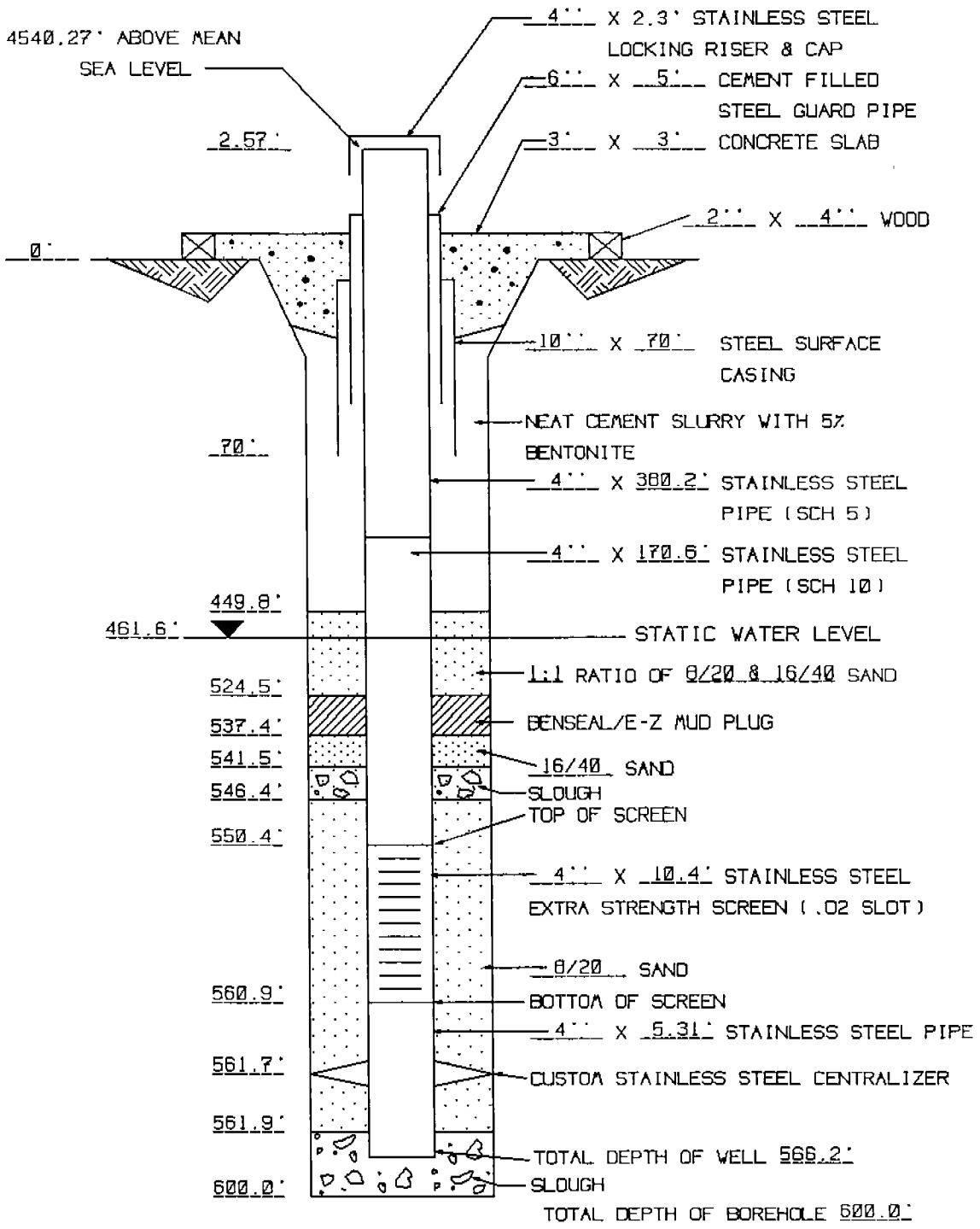
MONITOR WELL BLM-14-327 COMPLETION DIAGRAM



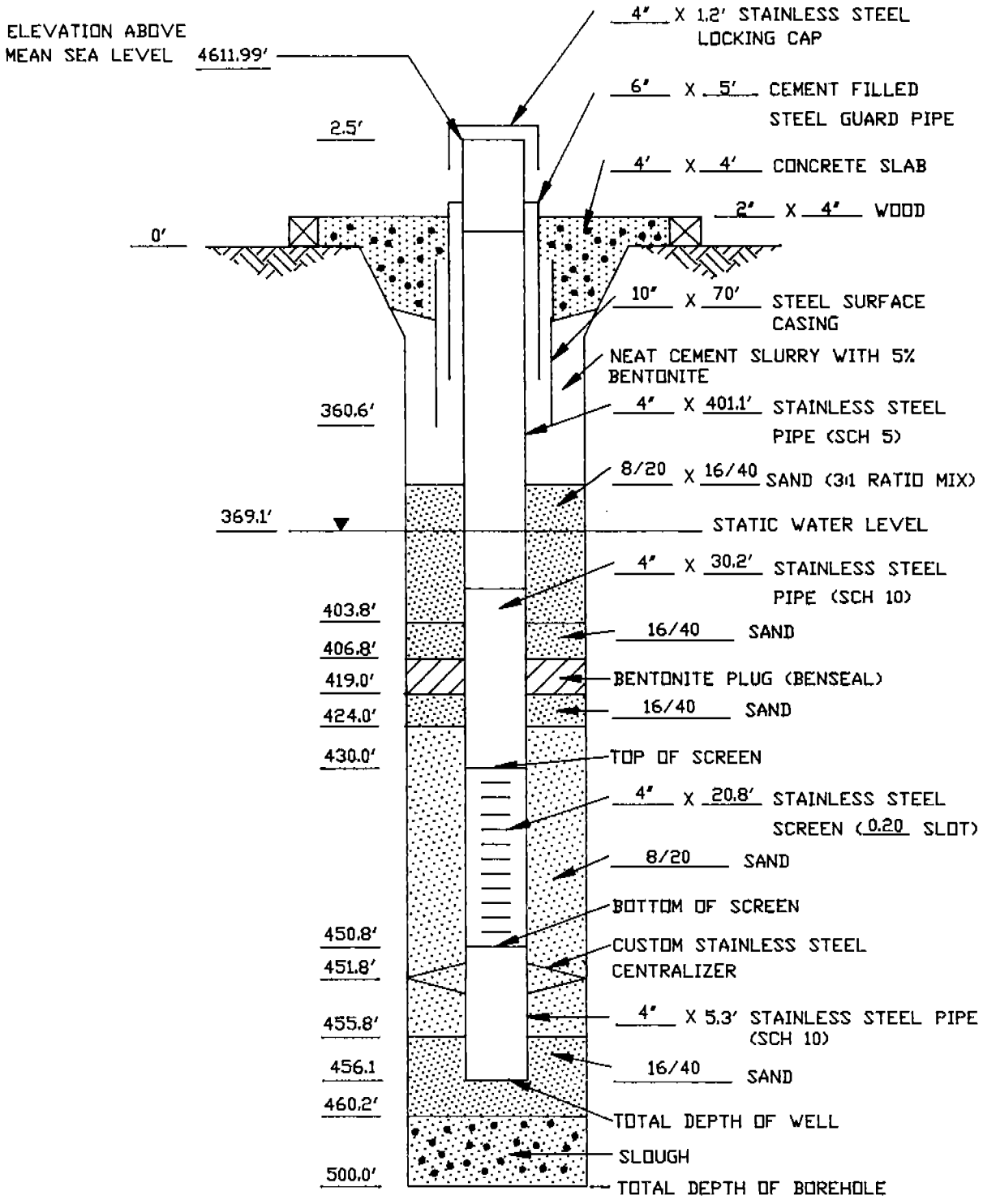
MONITOR WELL BLM-15-305 COMPLETION DIAGRAM



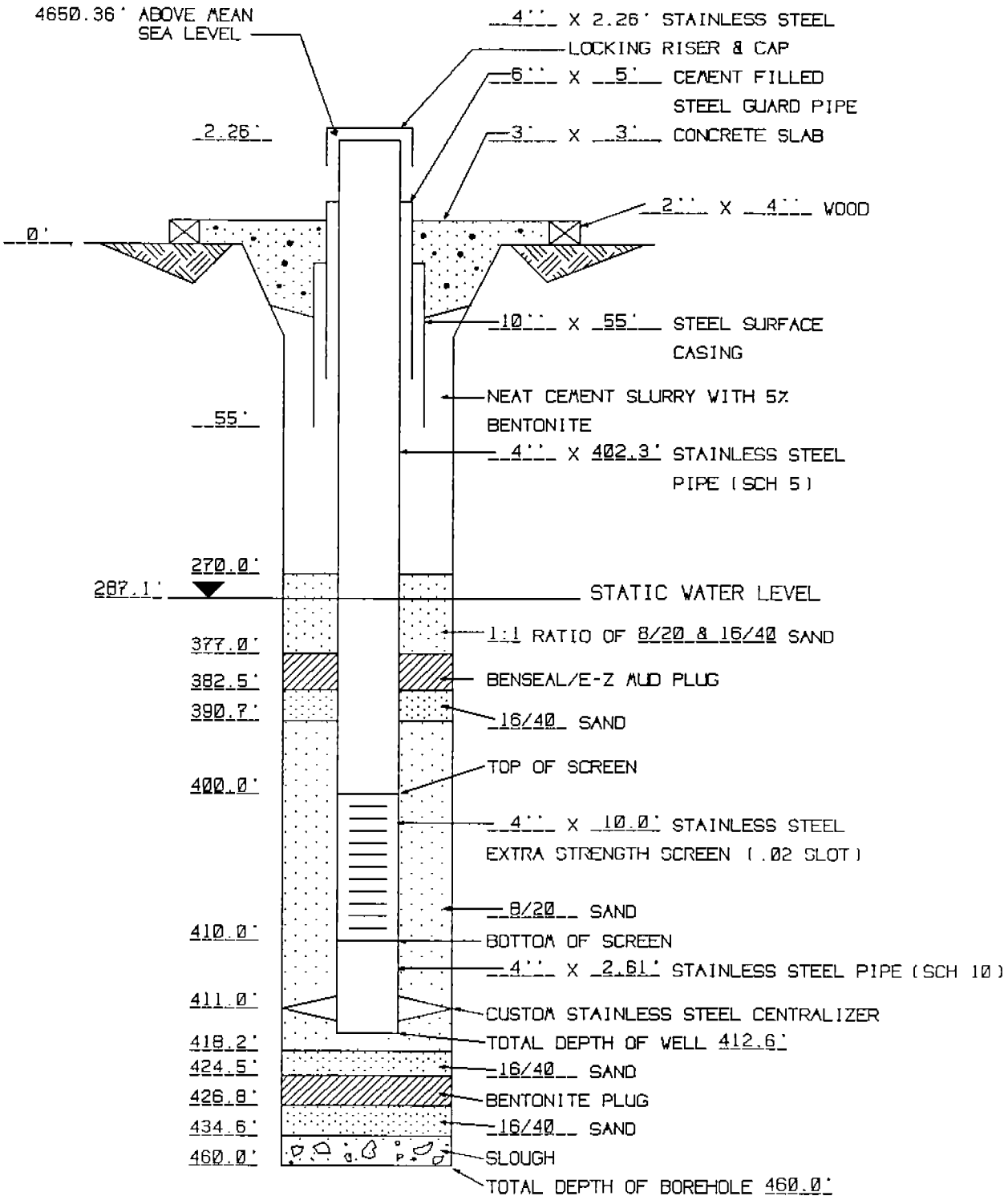
MONITOR WELL BLM-17-493 COMPLETION DIAGRAM



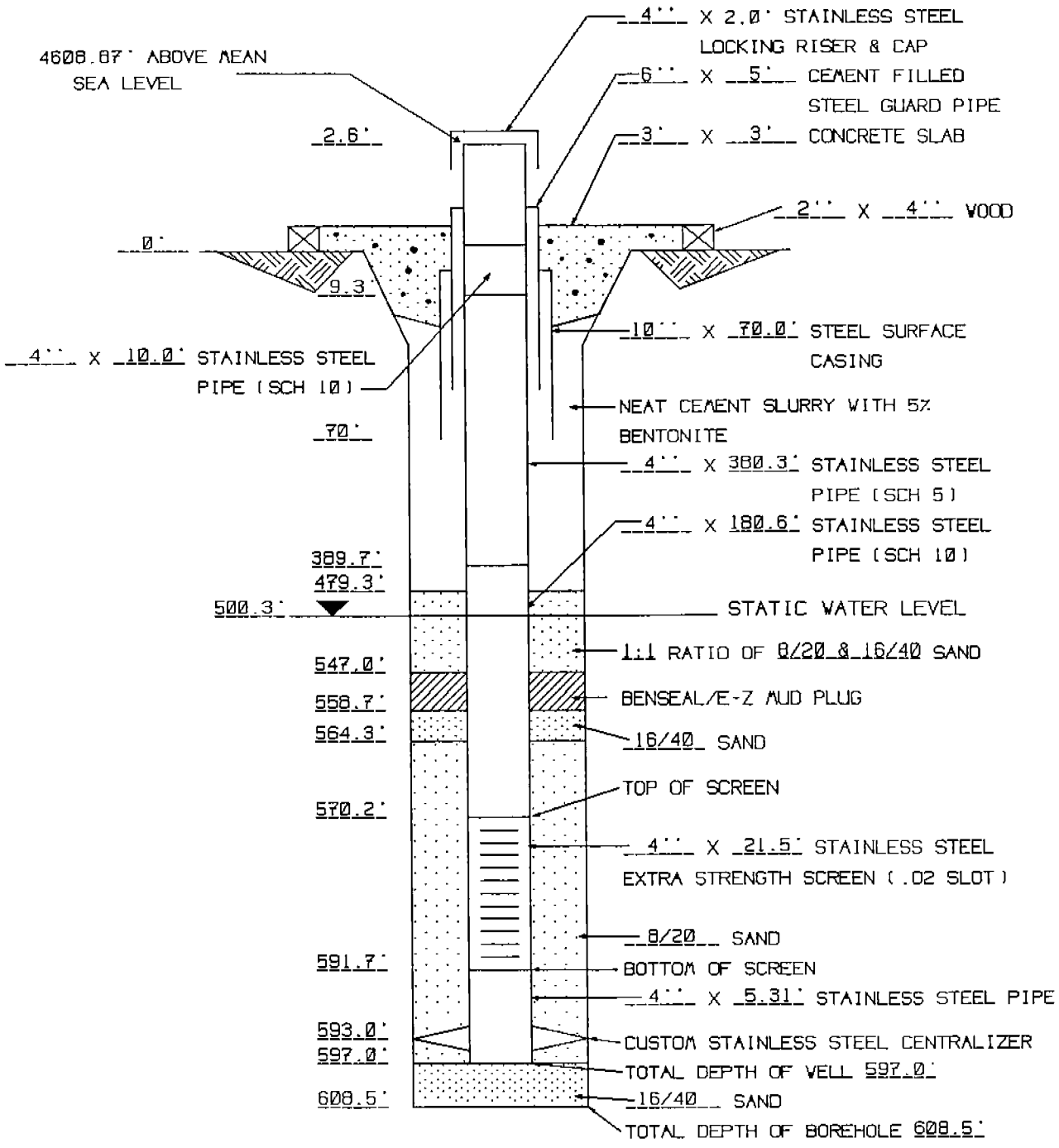
MONITOR WELL BLM-17-550 COMPLETION DIAGRAM



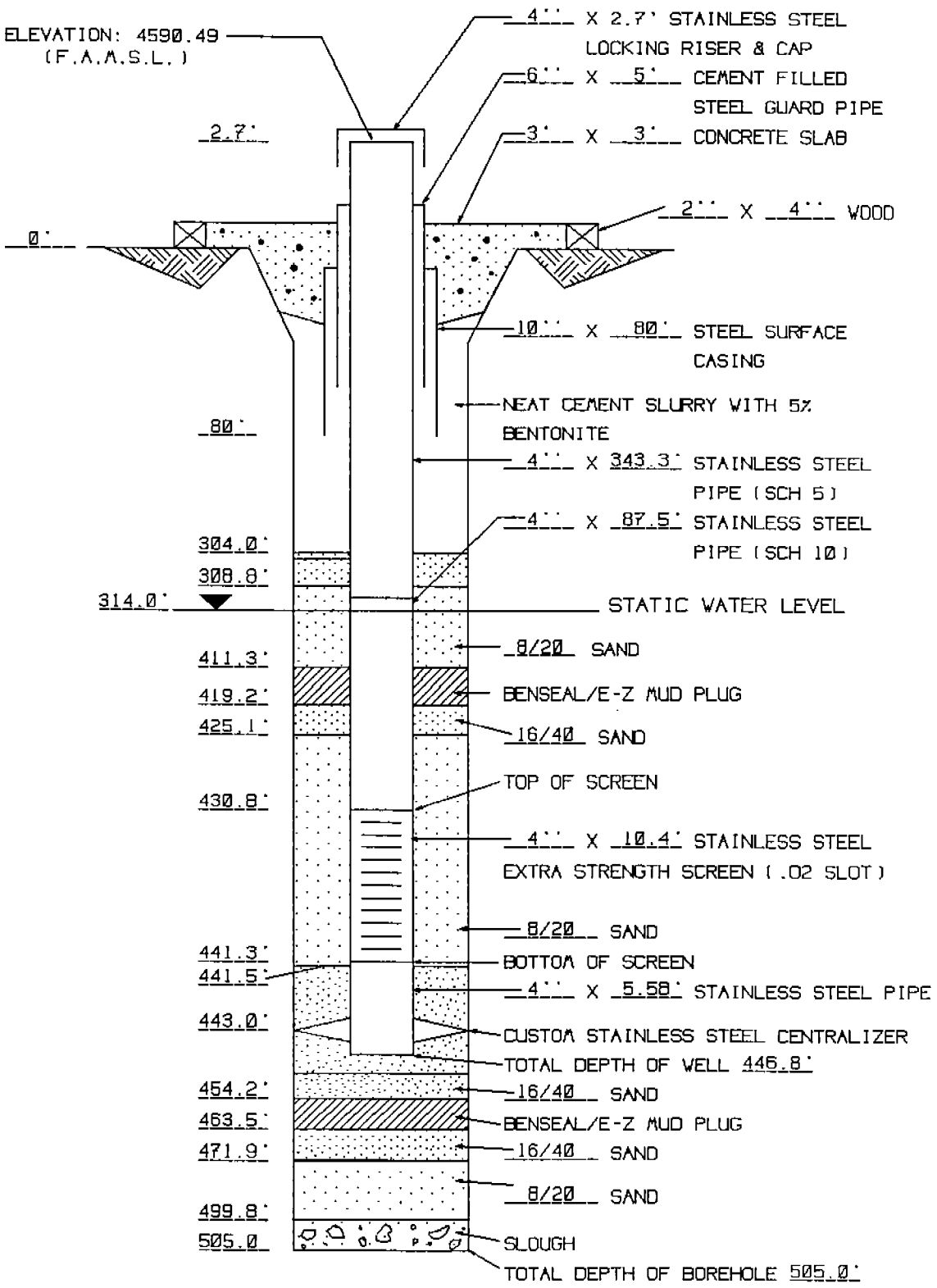
BLM-18-430 COMPLETION DIAGRAM



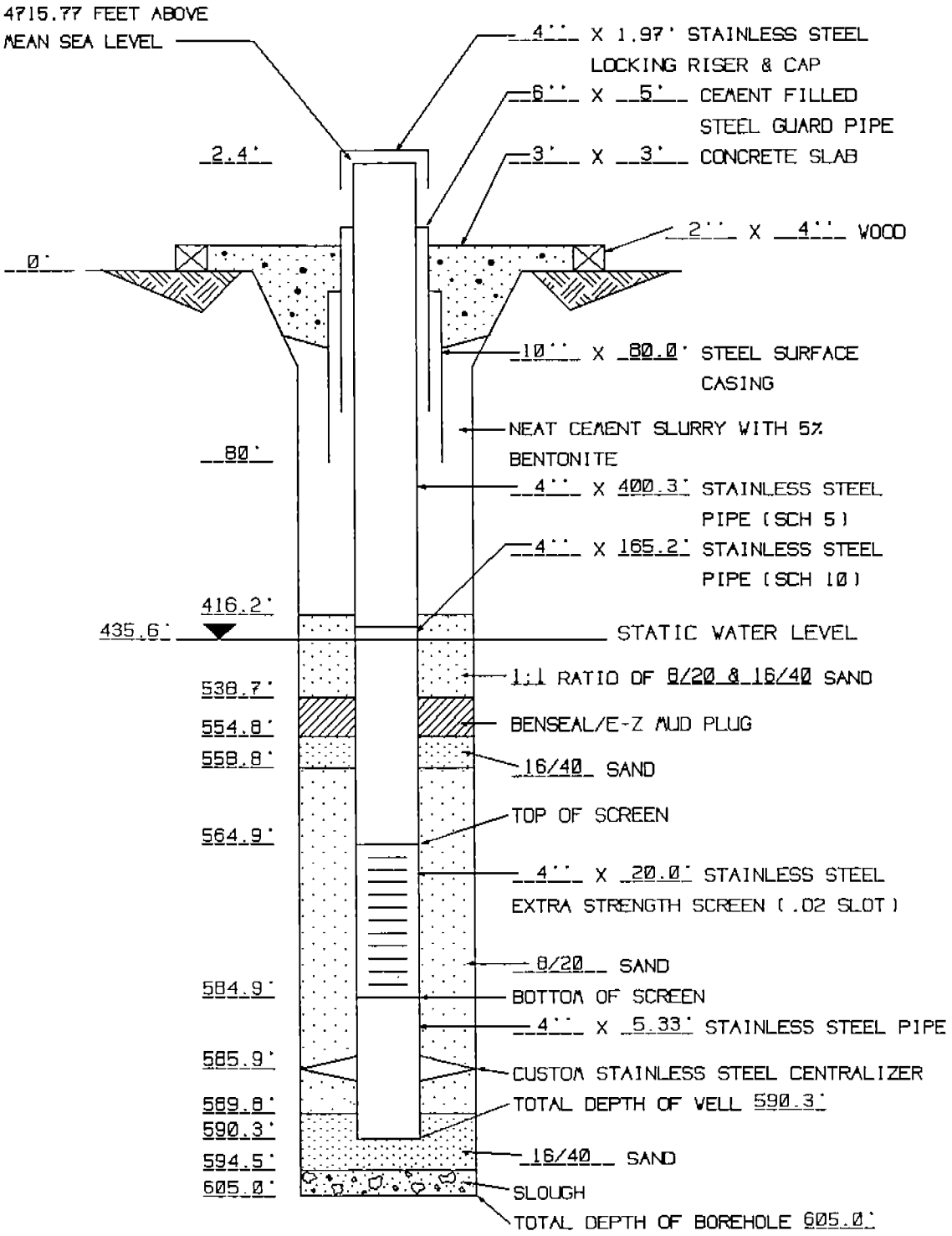
MONITOR WELL BLM-21-400 COMPLETION DIAGRAM



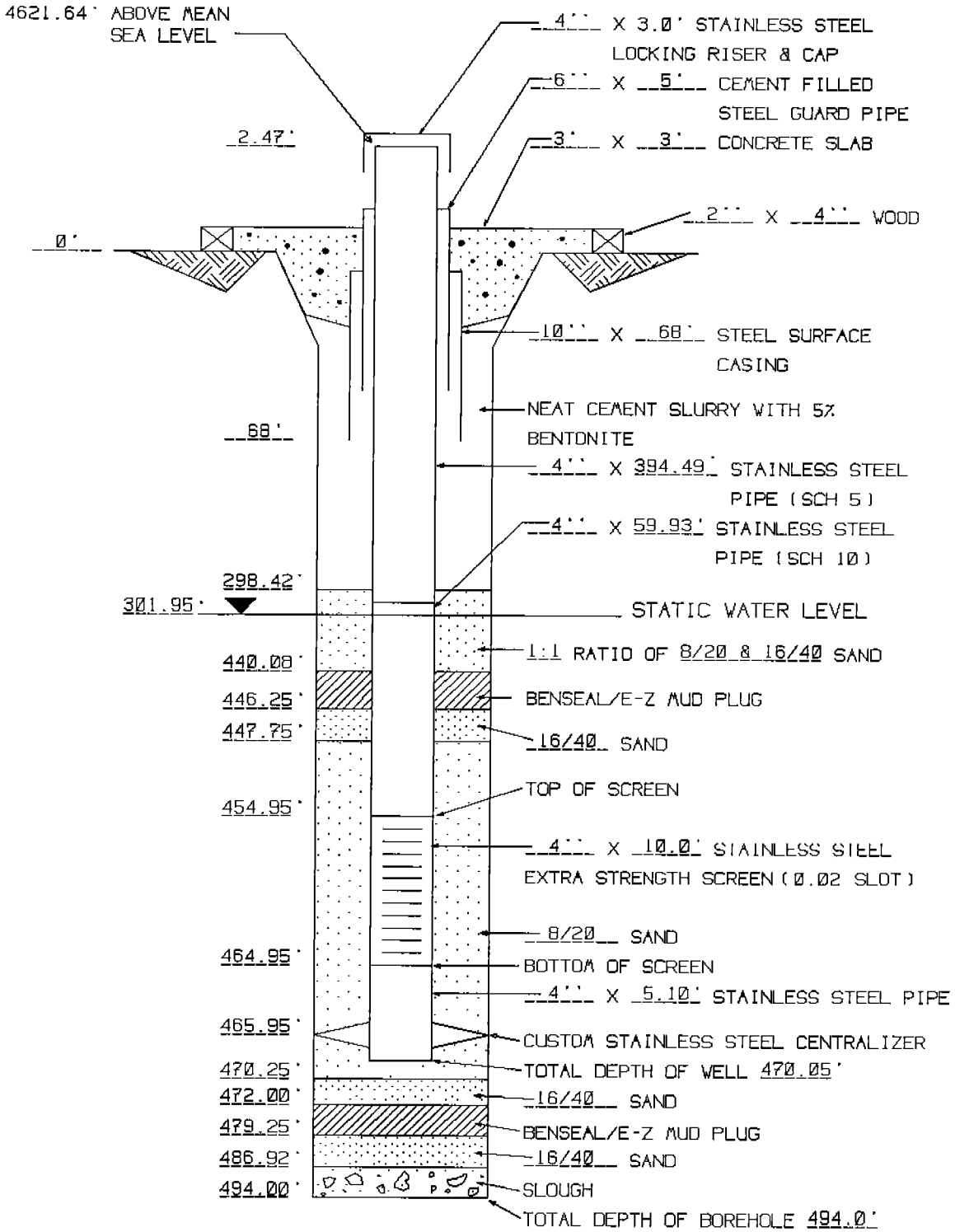
MONITOR WELL BLM-22-570 COMPLETION DIAGRAM



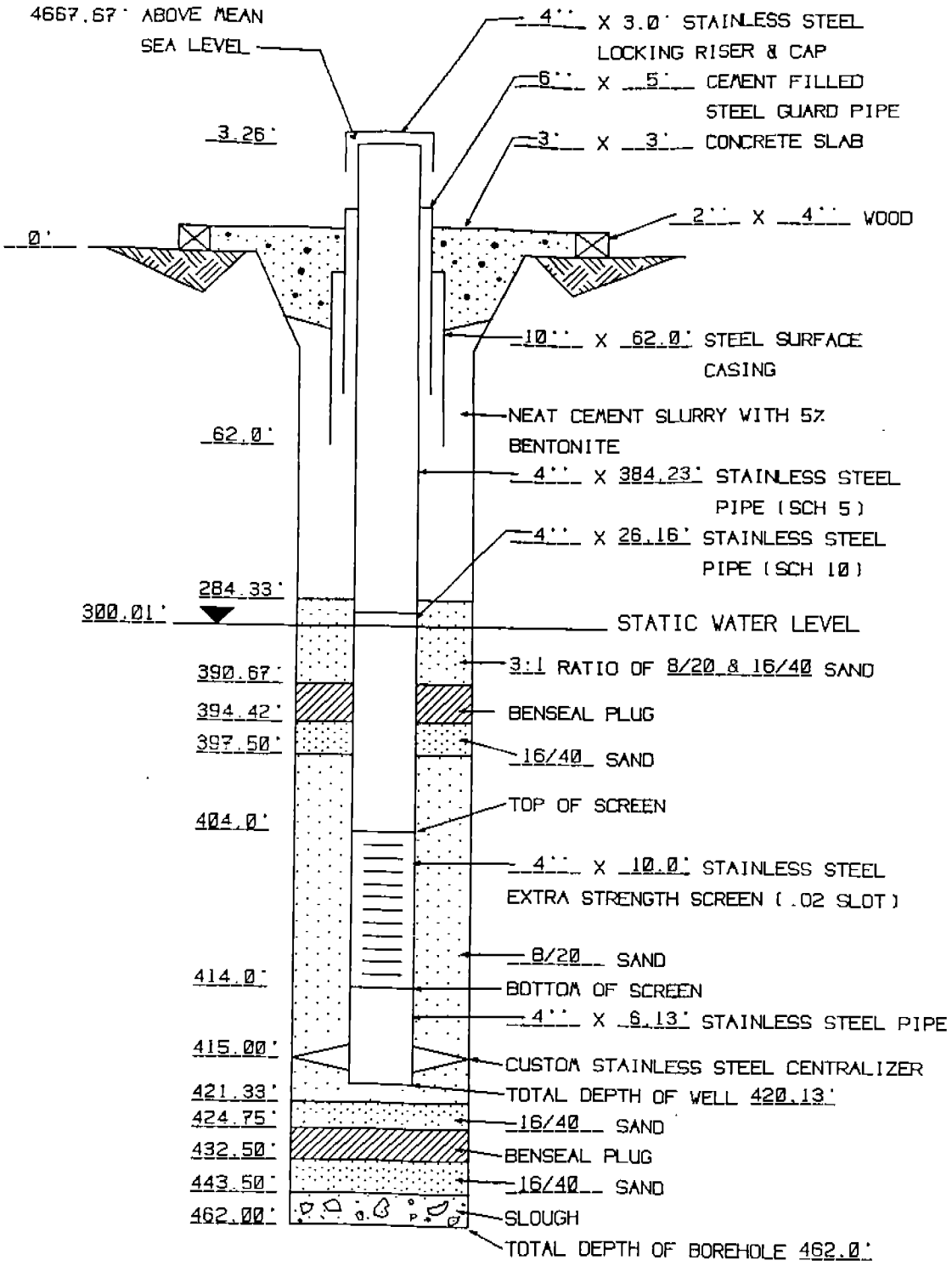
MONITOR WELL BLM-23-431 COMPLETION DIAGRAM



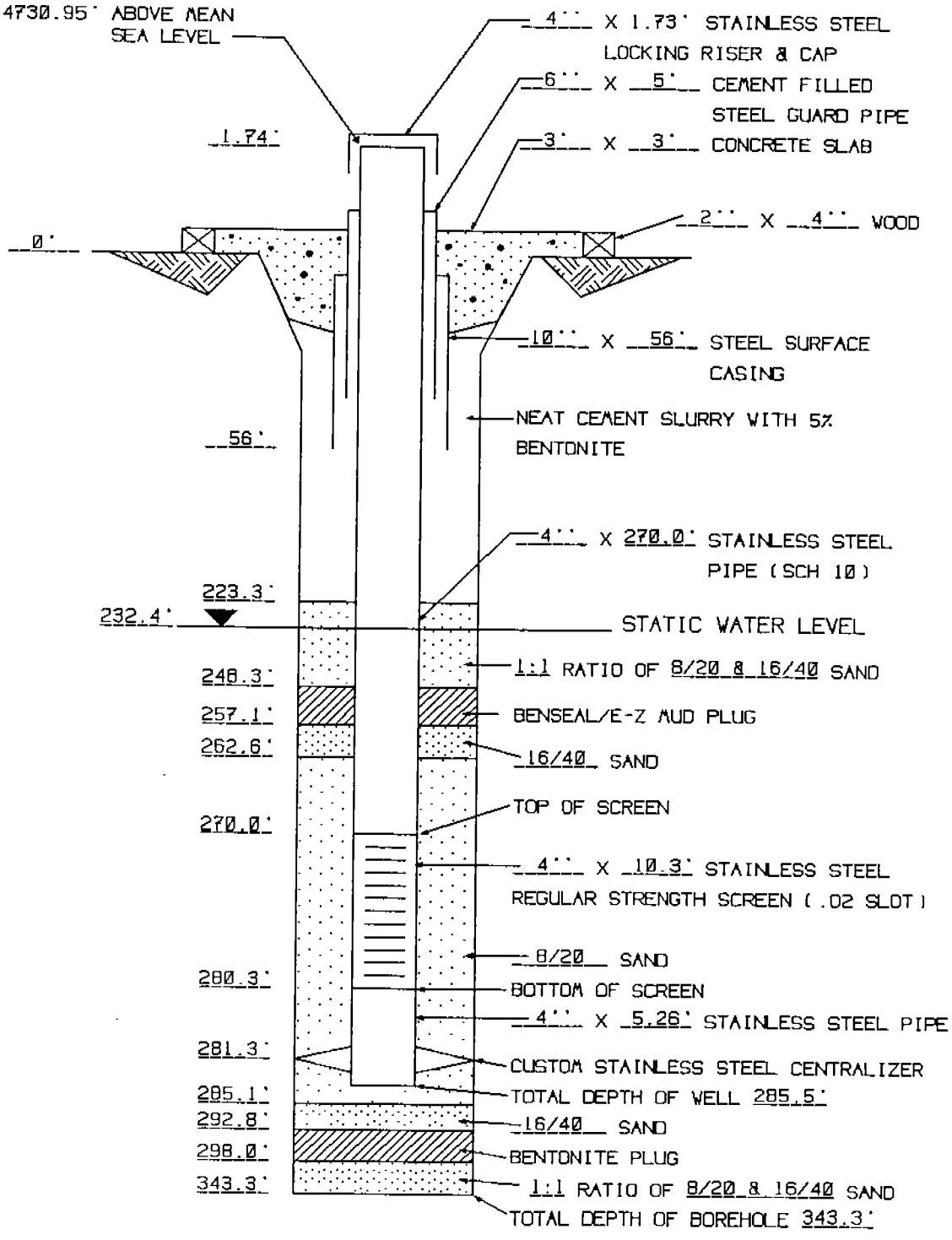
MONITOR WELL BLM-24-565 COMPLETION DIAGRAM



MONITOR WELL BLM-25-455 COMPLETION DIAGRAM



MONITOR WELL BLM-26-404 COMPLETION DIAGRAM



MONITOR WELL BLM-27-270 COMPLETION DIAGRAM

WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No.: BLM-28 Location: Offsite - BLM

Hole Depth: 560.00' MP Depth: 555.0' Hole Diam.: 4 1/2"

Date Installed: 4/9/94 Installed By: GCL Elev.(BC): 4639.30

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
0	(ground level)	61	93-294				
		60	90-232		Each couple tested to 125 psi for 45 seconds		
10	0'-300' ALLUVIUM (Santa Fe Group)		93-294				
		59	93-295				
20			93-294		All magnetic collars attached 0.4' above MP couple		
		58	93-295				
30			93-294		Filter sleeves around MP couples where indicated		
		57	93-295				
40			93-294				
		56	93-295				
50			93-294				
		55	93-295				
60			93-294				
		54	93-295				
70			93-294				
		53	93-295				
80			93-294				
		52	93-295				
90			93-294				
		51	93-295				
100			93-294				

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

B:\BLM-28-1

WESTBAY MP SYSTEM - CASING INSTALLATION DG (Cont'd)

Hole No.: BLM-28

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
100	ALLUVIUM (cont'd)	50	93-294				√
			93-295			√	
110		49	93-294				√
			93-295			√	
120		48	93-294				√
			93-295			√	
130		47	93-294				√
			93-295			√	
140		46	93-294				√
			93-295			√	
150		45	93-294				√
			93-295			√	
160		44	93-294				√
			93-295			√	
170		43	93-294				√
			93-295			√	
180		42	93-294				√
			93-295			√	
190		41	93-294				√
			93-295			√	
200			91-268				√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

B:\BLM-28-2

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-28

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
200	ALLUVIUM (cont'd)	40	91-268				√
			93-295			√	
210		39	91-268				√
			93-295			√	
220		38	91-268				√
			93-295			√	
230		37	91-268				√
			93-295			√	
240		36	91-268				√
			93-295			√	
250		35	91-268				√
			93-295			√	
260		34	91-268				√
			93-295			√	
270		33	91-268				√
			93-295			√	
280		32	91-268				√
			93-295			√	
290		31	91-268				√
	300' - 560' ANDESITE (Orejon)		93-295			√	
300			92-276				√

LEGEND

Regular MF Casing

MP Packer

Measurement Port Coupling

Pumping Port Coupling

Magnetic Collar

B:\BLM-28-3

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-28

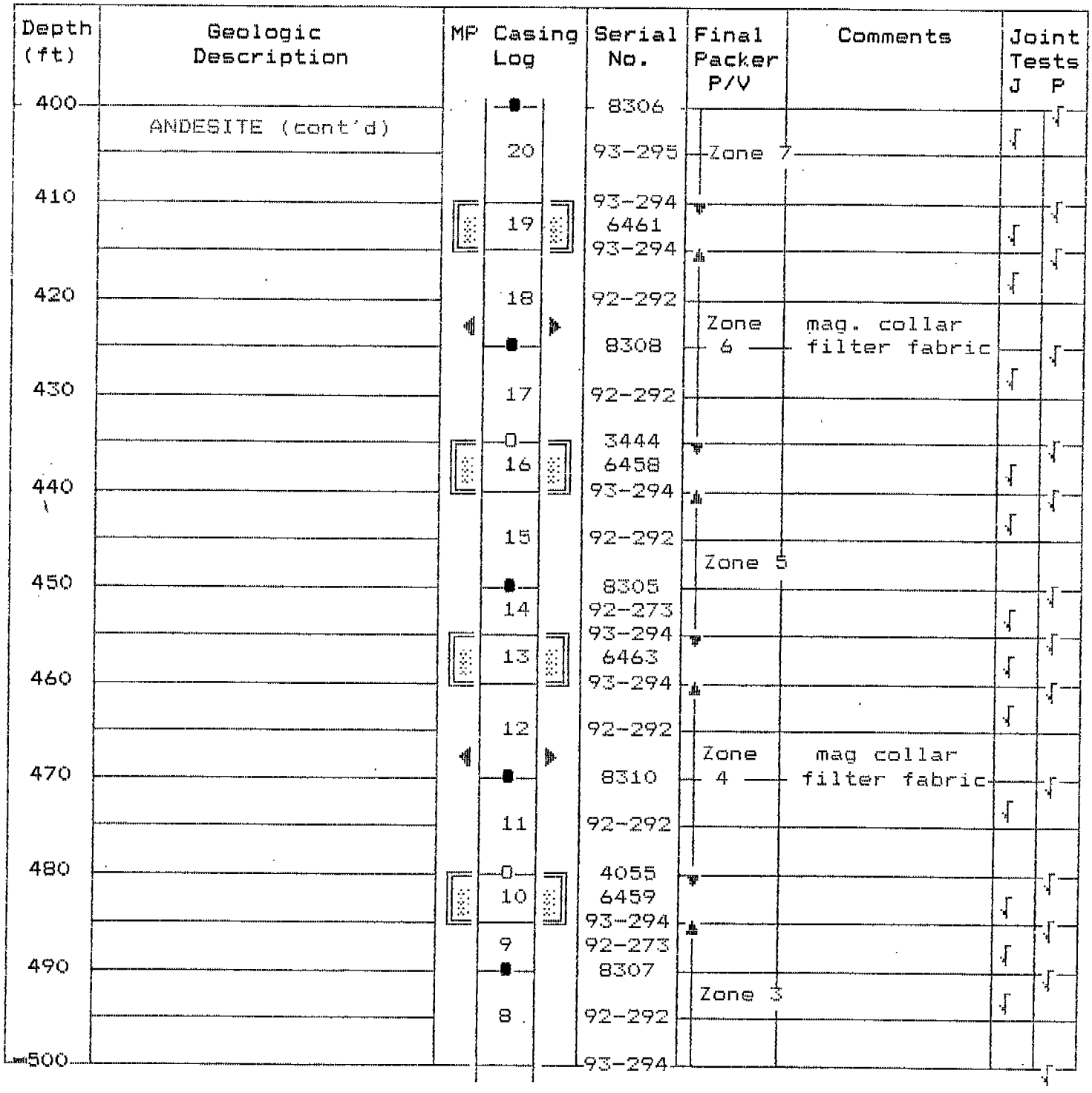
Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
300	300' - 560' ANDESITE--(Orejon) (cont'd)	30	92-276			√	√
			92-292				
310	5" surface casing installed to 310'	29	92-276			√	√
			92-292				
320		28	92-276			√	√
			92-292				
330		27	92-276			√	√
			92-292				
340		26	92-276			√	√
			92-292				
350		25	92-276			√	√
			92-292				
360		24	92-276			√	√
			92-292				
370		23	92-276			√	√
			92-292				
380		22	92-276			√	√
			92-292				
390		21	92-276	ZONE 'Y'		√	√
			92-292				
400			8306				√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-28



LEGEND

Regular MP Casing

MP Packer

Measurement Port Coupling

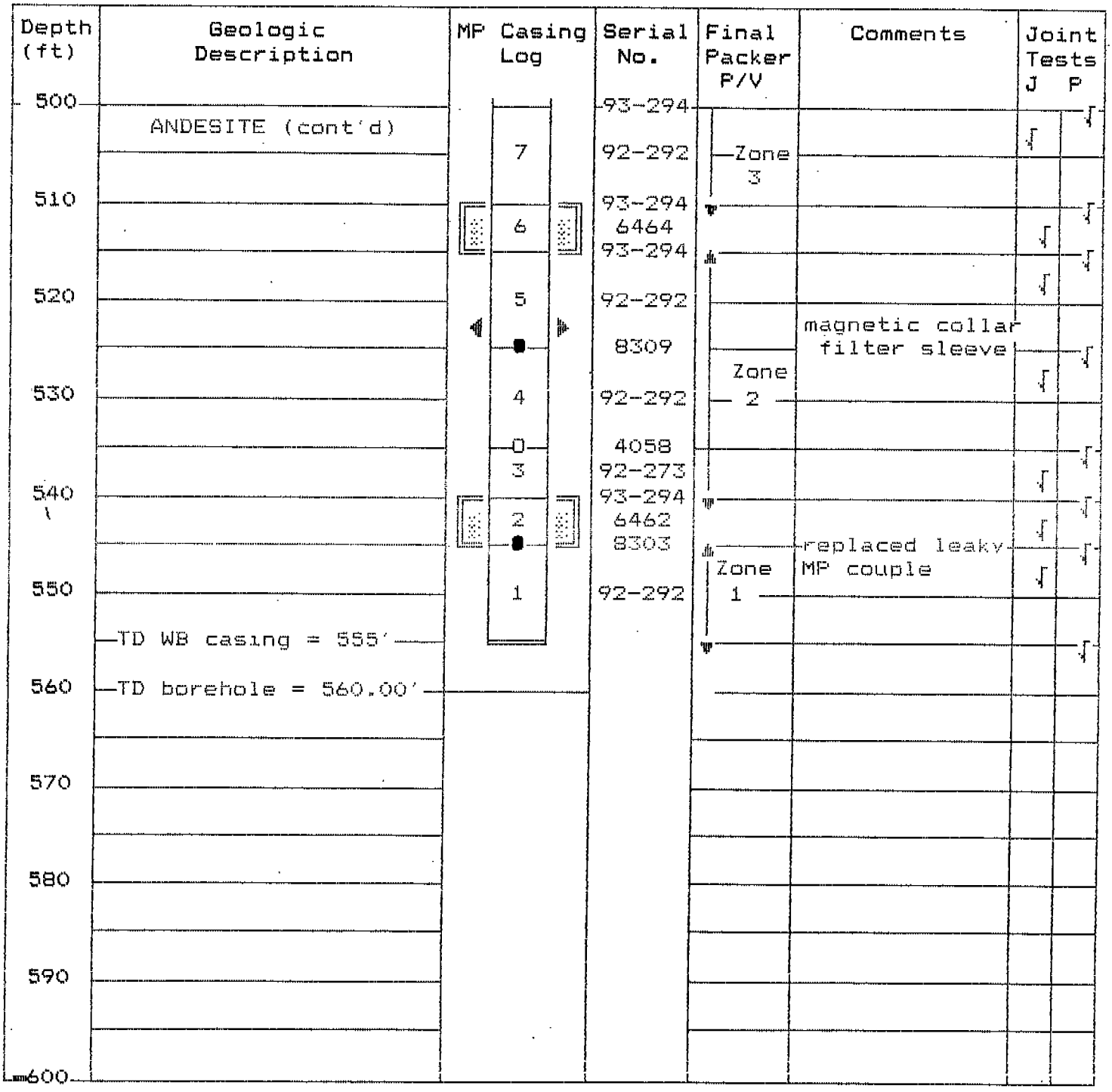
Pumping Port Coupling

Magnetic Collar

B:\BLM-28-5

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-28



LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

B:\BLM-28-6

WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No.: BLM-30 Location: Off-Site

Hole Depth: 670', caved to 620' MP Depth: 605' Hole Diam.: 4 1/2"

Date Installed: 05-15-95 Installed By: ATSC Elev.(BC): 4595.79'

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
0	(ground level)	66	94-354				√
		65	94-374		2 feet of stick-up at top of well	√	
10	0'-382' ALLUVIUM (Santa Fe Group)		94-354				√
		64	94-374		Each couple tested to 100 psi for 30 seconds	√	
20			94-354				√
		63	94-374			√	
30			94-354		All magnetic collars attached 0.4' above MP couple		√
		62	94-374			√	
40			94-354		Filter fabric around MP couples where indicated		√
		61	94-374			√	
50			94-354				√
		60	94-374			√	
60			94-354				√
		59	94-374			√	
70			94-354				√
		58	94-374			√	
80			94-354				√
		57	94-374			√	
90			94-354				√
		56	94-374			√	
100			94-354				√

LEGEND

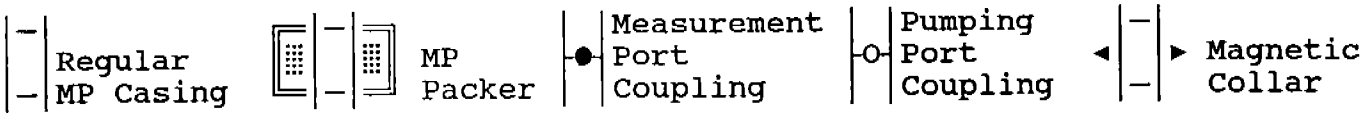
Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-30

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
100	ALLUVIUM (cont'd)		94-354			√	√
		55	94-374				
110			94-354			√	√
		54	94-374				
120			94-354			√	√
		53	94-374				
130			94-354			√	√
		52	94-374				
140			94-354			√	√
		51	94-374				
150			94-354			√	√
		50	94-374				
160			94-354			√	√
		49	94-374				
170			94-354			√	√
		48	94-374				
180			94-354			√	√
		47	94-374				
190			94-354			√	√
		46	94-374				
200			94-354				√

LEGEND



WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-30

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
200	ANDESITE (cont'd)		94-354			√	
		45	94-374				√
210			94-354			√	
		44	94-374				√
220			94-354			√	
		43	94-374				√
230			94-354			√	
		42	94-374				√
240			94-354			√	
		41	94-374				√
250			94-354			√	
		40	94-374				√
260			94-354			√	
		39	94-374				√
270			94-354			√	
		38	94-374				√
280			94-354			√	
		37	94-374				√
290			94-354			√	
		36	94-374				√
300			94-354				√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-30

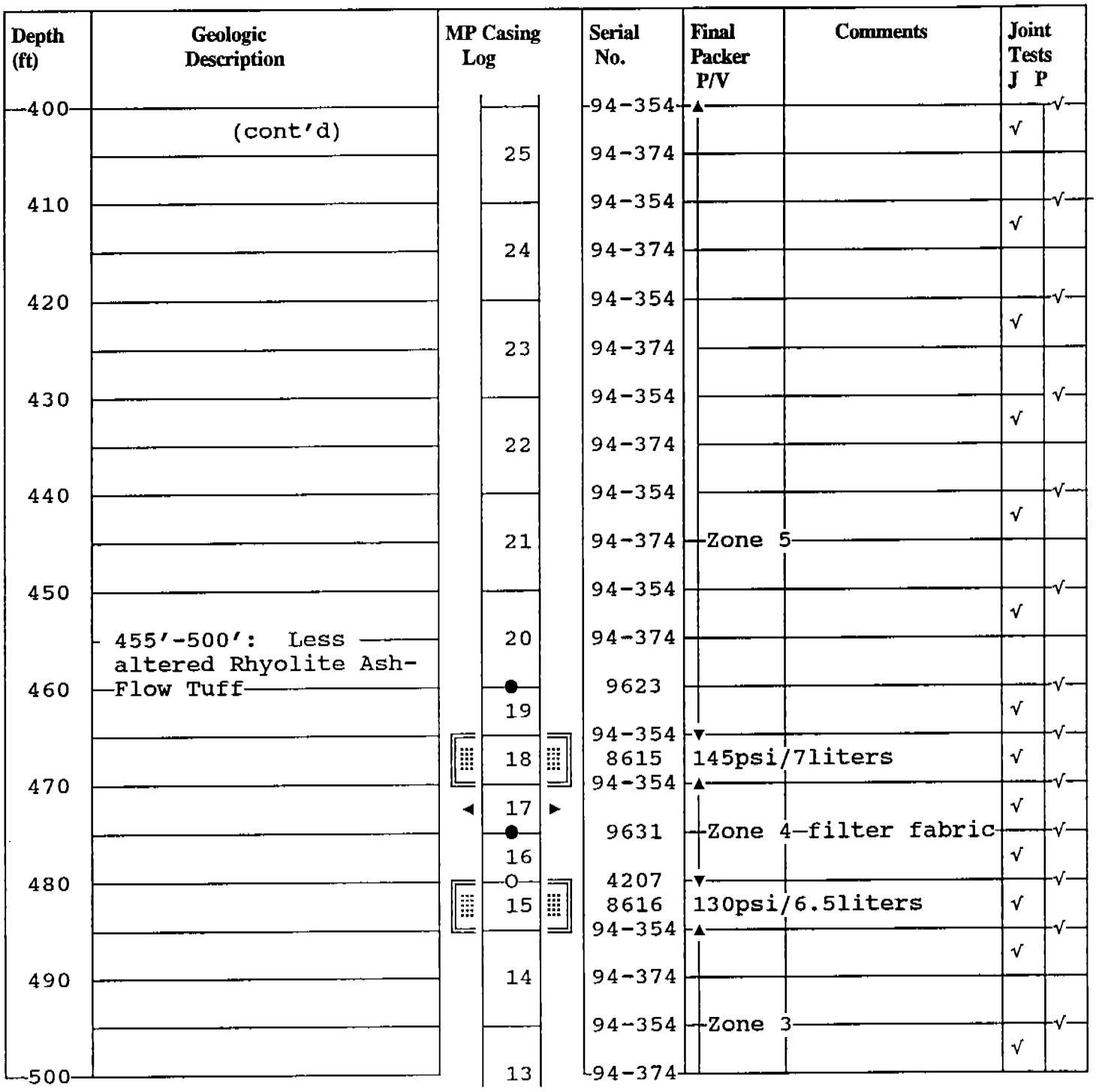
Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
300	ALLUVIUM (cont'd)		94-354			√	√
		35	94-374				
310			94-354			√	√
		34	94-374				
320			94-354			√	√
		33	94-374				
330			94-354			√	√
		32	94-374				
340			94-354			√	√
		31	94-374				
350			94-354			√	√
		30	94-374				
360			94-354			√	√
		29	94-374				
370			94-354			√	√
		28	94-374				
380	382'-455' Heavily Altered Rhyolitic Ash-Flow Tuff		94-354			√	√
		27	94-374				
390	390' - bottom of 5" steel surface casing		94-354			√	√
		26	94-374				
400			94-354				√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-30

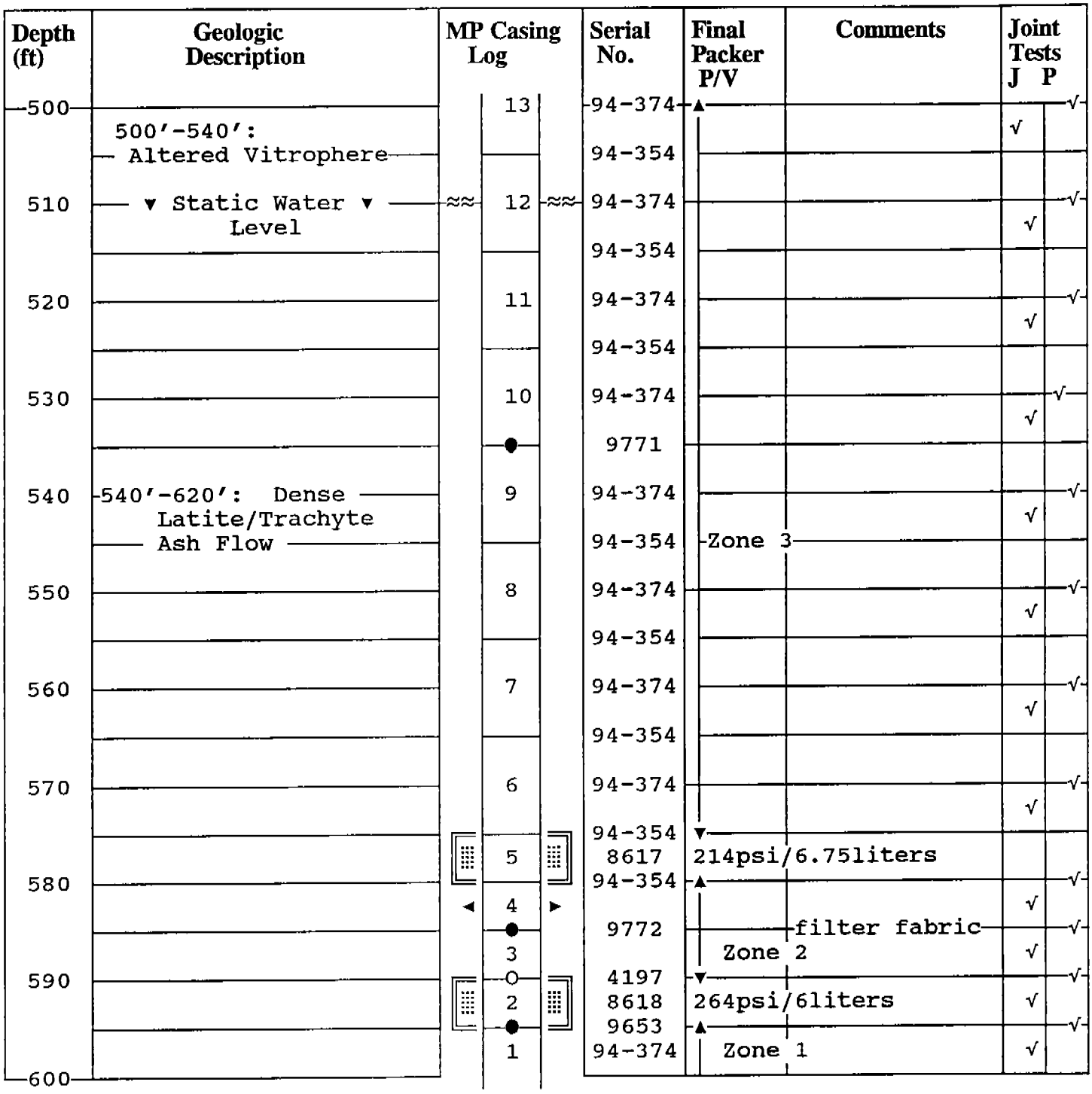


LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-30



LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-30

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
600	ASH-FLOW (cont'd)	1	endcap				
	605' = TD MP Casing						√
610							
620	Borehole collapsed to 620'	---------					
630							
640							
650							
660							
670	670' = TD borehole						
680							
690							
700							

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG

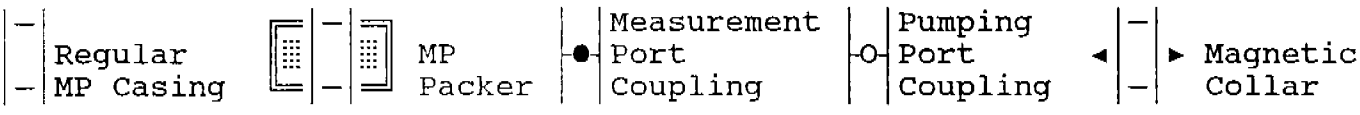
Project: NASA-WSTF Hole No.: BLM-31 Location: 600 Area

Hole Depth: 820' MP Depth: 800' Hole Diam.: 4 1/2"

Date Installed: 03-17-95 Installed By: ATSC Elev.(BC): 4726.98'

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
0	(ground level)	86	94-343			√	√
					2 feet of stick-up at top of well		
		85	94-339				
	0'-200' ALLUVIUM						
10	(Santa Fe Group)		94-343				√
					Each couple tested to 100 psi for 30 seconds	√	
		84	94-339				
20			94-343				√
						√	
		83	94-339				
					All magnetic collars attached 0.4' above MP couple		
30			94-343				√
		82	94-339			√	
40			94-343		Filter fabric around MP couples where indicated		√
		81	94-339			√	
50			94-343				√
		80	93-295			√	
60			94-343				√
		79	93-295			√	
70			94-343				√
		78	93-295			√	
80			94-343				√
		77	93-295			√	
90			93-326				√
		76	93-295			√	
100			93-326				√

LEGEND



WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-31

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
100	ALLUVIUM (cont'd)		93-326			√	√
		75	93-295				
110			93-326			√	√
		74	93-295				
120			93-326			√	√
		73	93-295				
130			93-326			√	√
		72	93-295				
140			93-326			√	√
		71	93-295				
150			93-326			√	√
		70	94-342				
160			92-276			√	√
		69	94-342				
170			92-276			√	√
		68	94-342				
180			92-276			√	√
		67	94-342				
190			92-276			√	√
		66	94-342				
200			92-276				√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-31

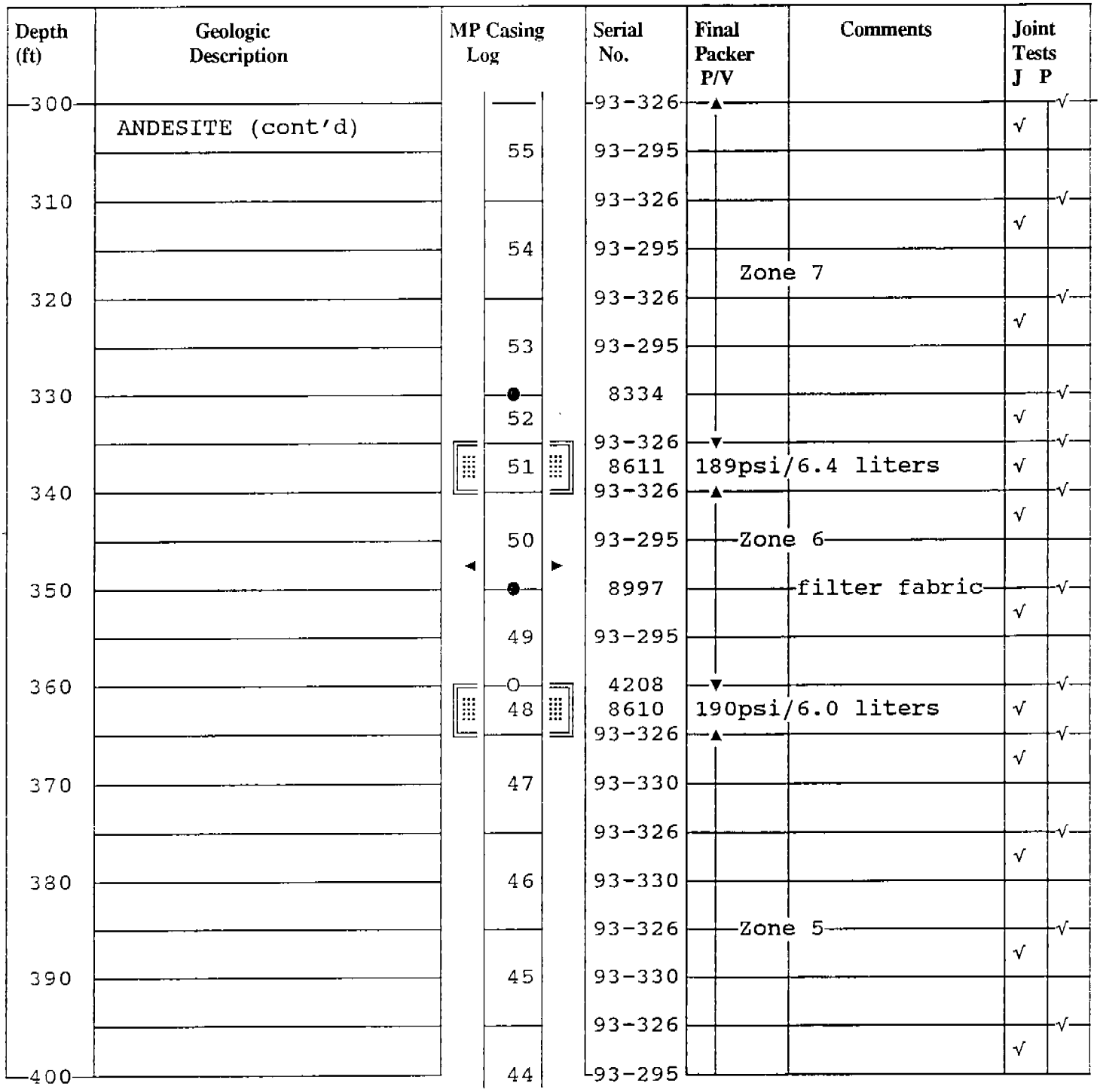
Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
200			92-276			√	√
	200'-820' ANDESITE (Orejon)	65	94-342				
210	Bottom of 5" steel surface casing		94-354			√	√
		64	94-342				
220			94-354			√	√
		63	94-342				
230	▼ Static Water ▼ Level	≈≈	94-354			√	√
		62	94-342				
240			94-354			√	√
		61	94-342				
250			94-354			√	√
		60	93-295				
260			94-354			√	√
		59	93-295				
270			93-326			√	√
		58	93-295				
280			93-326			√	√
		57	93-295				
290			93-326			√	√
		56	93-295				
300			93-326				√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-31

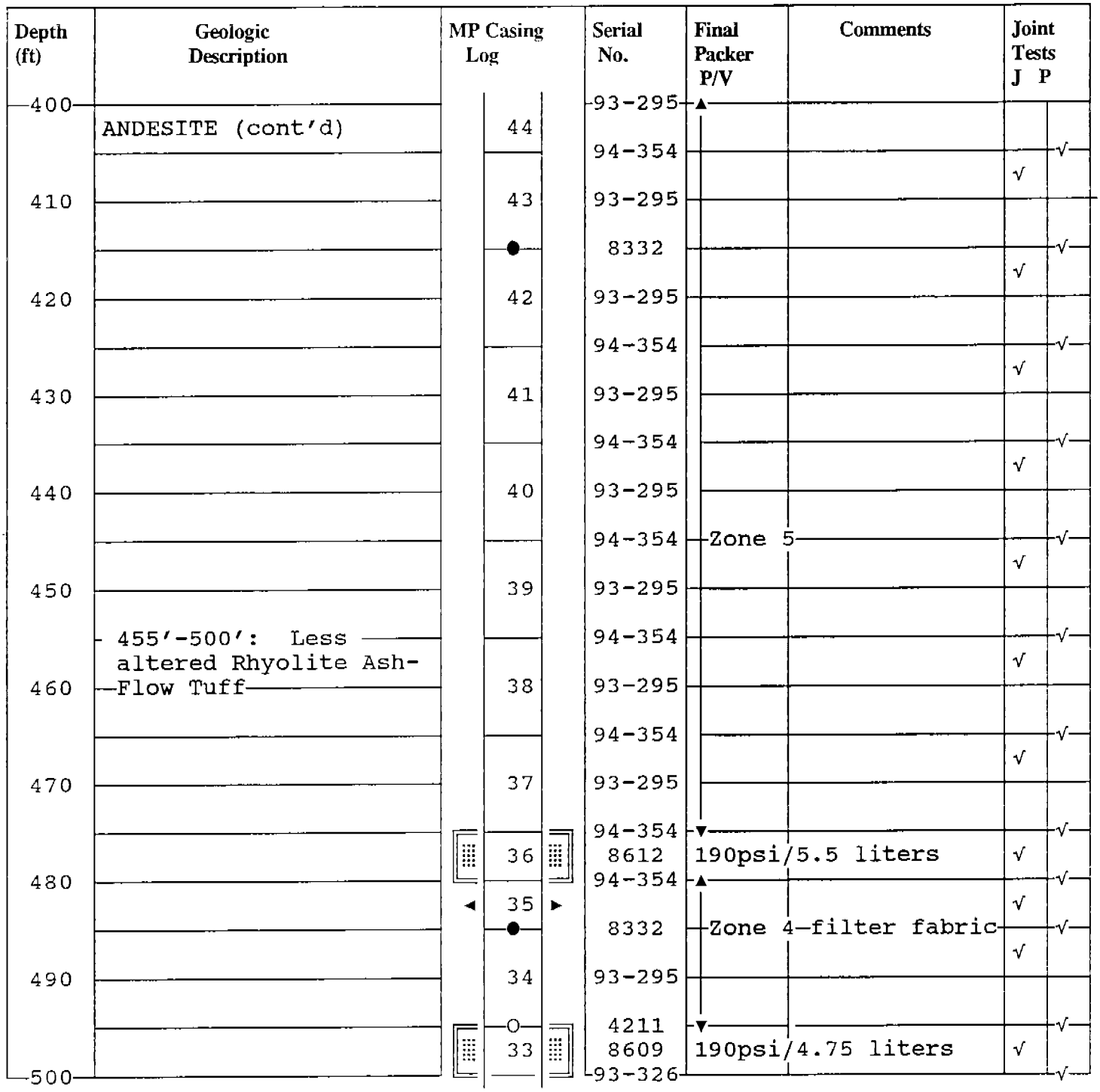


LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-31



LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-31

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
500	ANDESITE (Cont'd)		93-326	▲		√	√
		32	93-295				
510			94-354				√
		31	93-295			√	
520			94-354				√
		30	93-295			√	
530			94-354				√
		29	93-295			√	
540			94-354				√
		28	93-295	Zone 3		√	
550			94-354				√
		27	93-295			√	
560			94-354				√
		26	93-295			√	
570			93-326				√
		25	93-295			√	
580			94-354				√
		24	93-295			√	
590			94-354				√
		23	93-295			√	
600			94-354	▼			√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-31

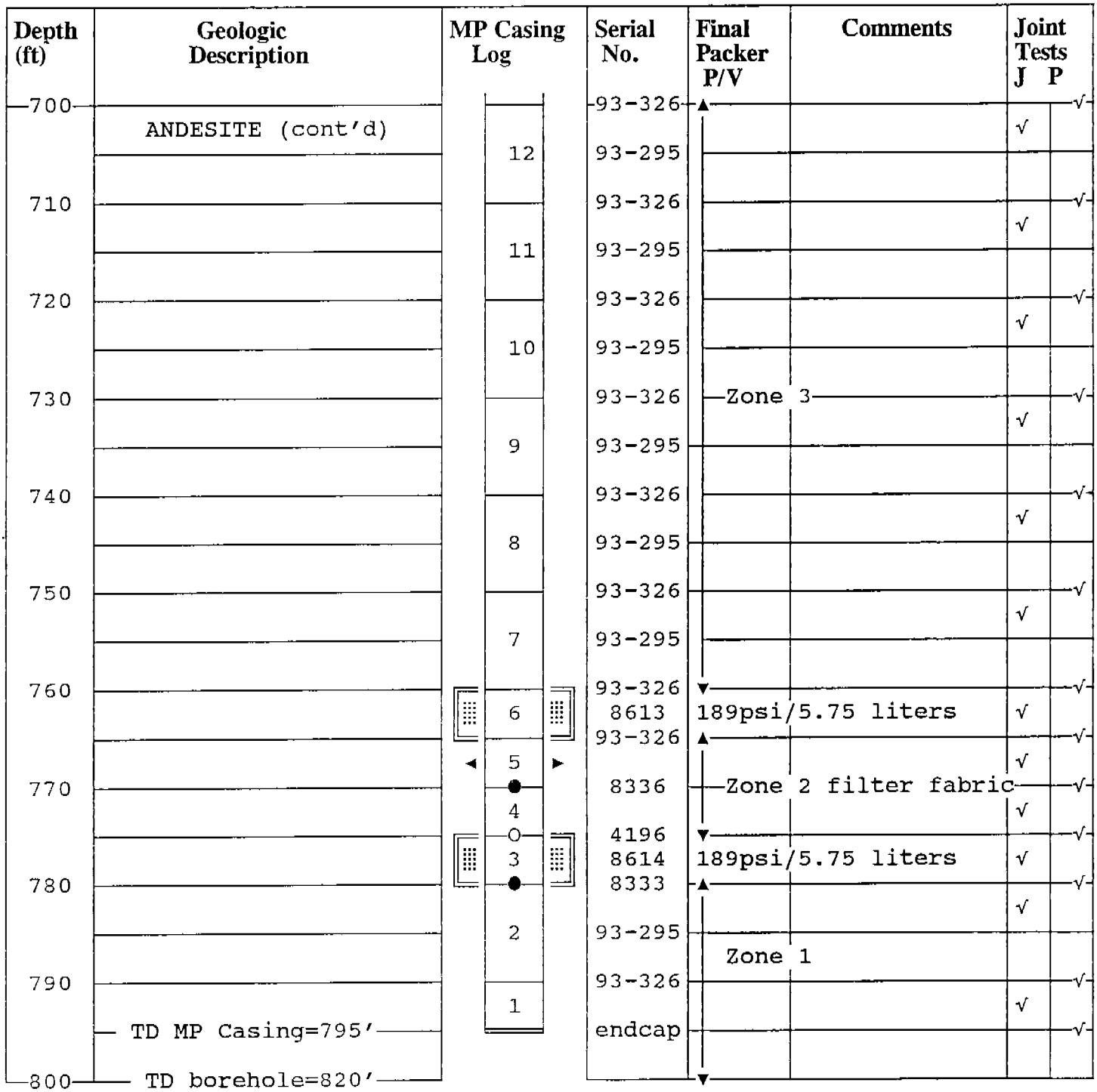
Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
600	ANDESITE (cont'd)		94-354	▲		√	√
		22	93-295				
610			94-354			√	√
		21	93-295				
620			94-354			√	√
		20	93-295				
630		●	8335			√	√
		19	93-295				
640			94-354			√	√
		18	93-295	Zone 3			
650			94-354			√	√
		17	93-295				
660			94-354			√	√
		16	93-295				
670			94-354			√	√
		15	93-295				
680			94-354			√	√
		14	93-295				
690			93-326			√	√
		13	93-295				
700			93-326	▼			√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: BLM-31

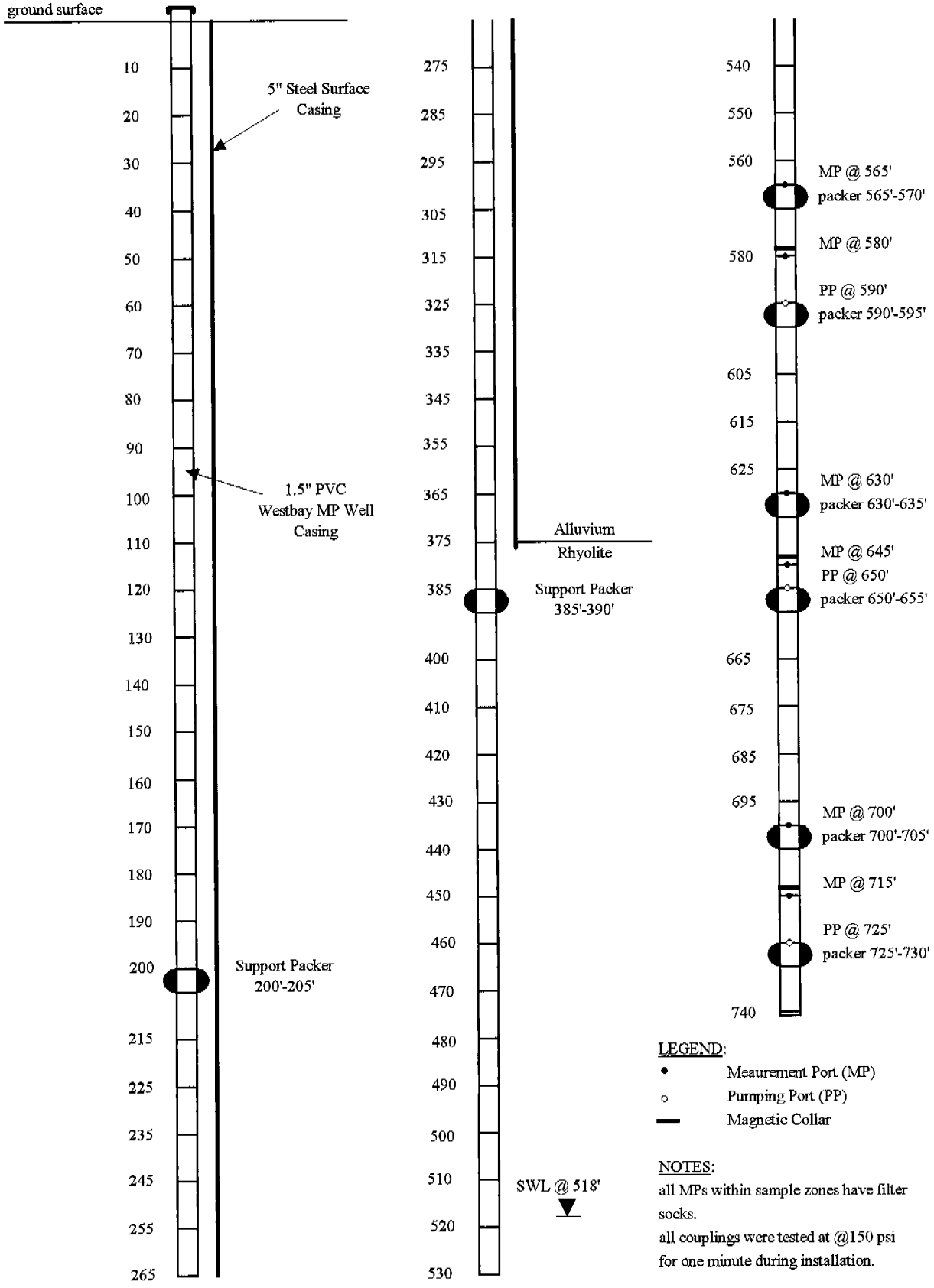


LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WESTBAY WELL COMPLETION DIAGRAM

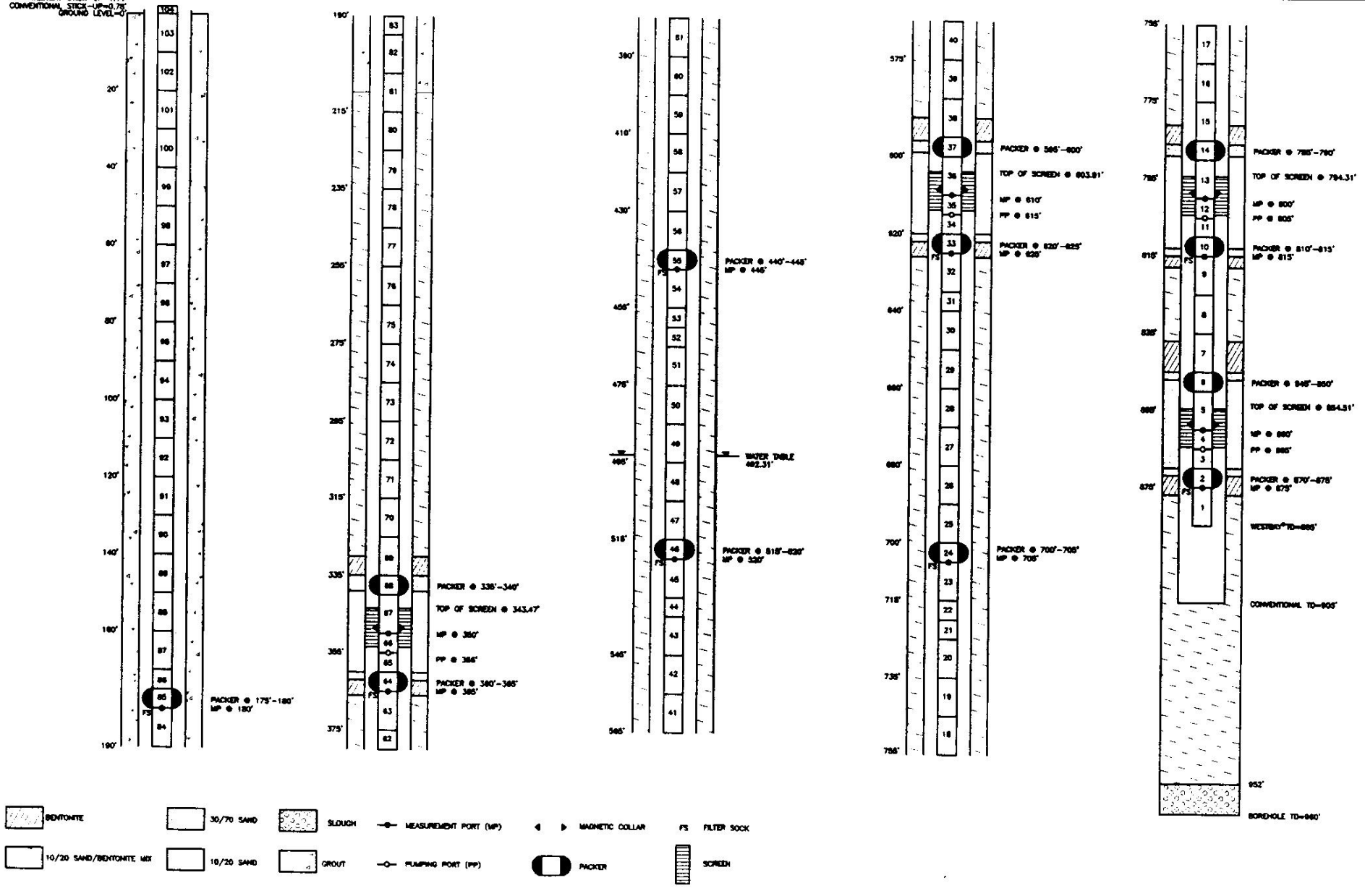
BLM-32



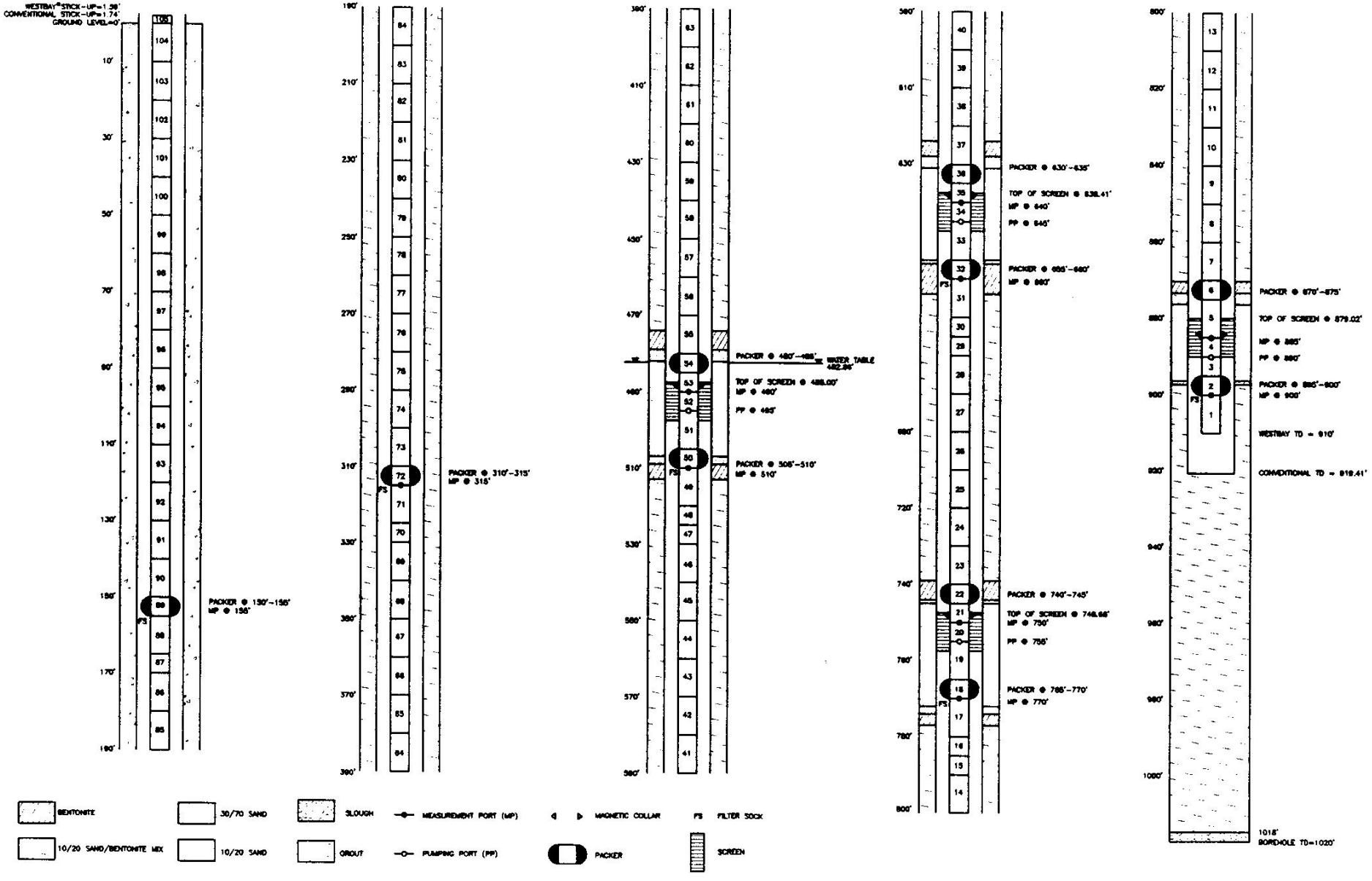
NOTES:
all MPs within sample zones have filter socks.
all couplings were tested at @150 psi for one minute during installation.

Installation Date: 6/18/97
Installed By: ATSC
Elevation (BC): 4595.84' a.m.s.l.

Drawn/Checked By: PSE/MGC
MP Depth: 740'
Borehole Depth: 744'



MONITOR WELL BLM-36 COMPLETION DIAGRAM



MONITOR WELL BLM-37 COMPLETION DIAGRAM

WELL COMPLETION DIAGRAM

RETROFIT WESTBAY® MONITORING WELL

Location ID: **BLM-38** Site ID: **NASA-WSTF, Doña Ana County, NM**

Township and Range: **SE 1/4, NW 1/4, SE 1/4, Sec 33, T20S, R3E**
Site Coordinates: **229333.64 N 406938.44 E (preliminary)**
Elevation (Brass Cap): **4621.99' (preliminary)**
Elevation (Top of Casing): **4622.77' (CW) / 4622.80' (WB) (preliminary)**
Drilling Contractor: **Stewart Brothers Drilling Co.**
Driller: **Randy Stewart and Juan Aguilar**
Total Depth of Borehole (bgs): **650'**
Borehole Diameter: **Reamed 17 1/2" to 118'; 12 1/4" to 650'**
Depth to Bedrock (bgs): **300'**
Depth to Groundwater: **426.60' (TOC - Measured 8/19/99)**
Total Depth Surface Casing (bgs): **118'**
Diameter and Type Surface Casing: **13.5" ID, 14" OD Steel**
Dates Well Installed: **3/2/99 (CW) / 8/19/99 - 8/23/99 (WB)**
Dates Well Developed: **3/8/99 - 7/2/99 (CW) / 3/13/00 - 3/16/00 (WB)**

Field Representative(s): **MR (CW) / MM and MR (WB)**
Total Depth Well Casing(s) (bgs): **640.70' (CW) / 635' (WB)**
Type of Casing(s): **304 Stainless Steel (CW) / MP 38 PVC (WB)**
Diameter Well Casing(s): **4" ID, 4.5" OD (CW) / 1.5" ID, 1.9" OD (WB)**
Casing Schedule: **10 (CW)**
CW Screened Zone(s) (bgs): **374.80' - 384.83', 475.03' - 485.05', and 615.30' - 625.40'**
WB Sampling Zone(s) (bgs): **480' and 620'**
WB Packer Zone(s) (bgs): **470' - 490' and 610' - 635' (TD WB well)**

Comments: **Mid-Plume vertical delineation monitoring well**
CW = Conventional Well and WB = Westbay®
bgs = below ground surface. TOC = Top of Casing
Con Zone at 374.80' not used due to low water

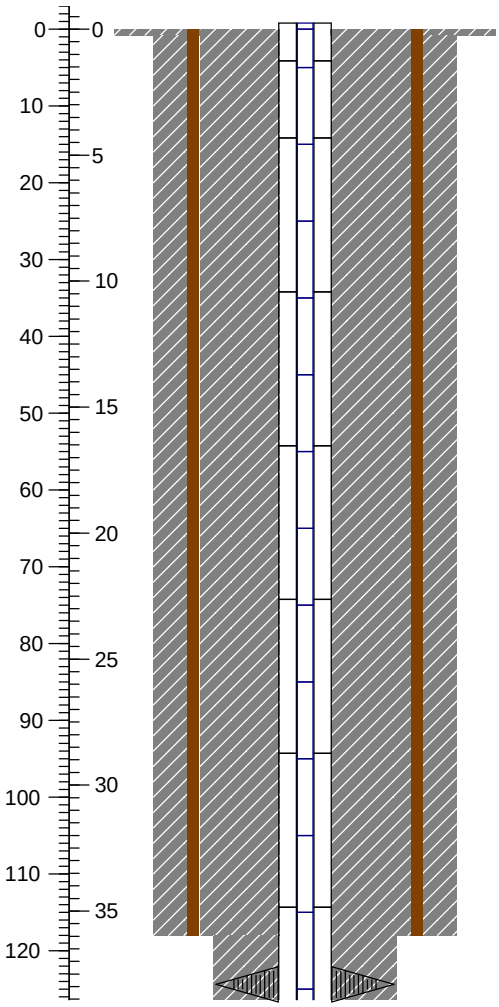
Casing Explanation:

- Surface Casing **14" OD Steel**
- Conventional Casing **4" ID 304 Stainless Steel**
- Conventional Screen **4" ID 304 Stainless Steel 0.020"-Slot**
- Conventional End Cap **4" ID 304 Stainless Steel**
- **Welded Steel Centralizers**
- Water Table
- **1.5" ID Westbay® MP 38 Casing**
- **1.5" ID Westbay® MP 38 End Cap**
- Measurement Port (MP)
- MP with Filter Sock
- Mechanical Pumping Port (PP)
- Magnetic Collar
- Packer

Annular Materials Explanation:

- Cement
- Bentonite (Grout Well DF)
- Bentonite Seal
- 10/20 Sand/ Bentonite Mix
- Slough
- 1/8 Gravel
- 4/8 Sand
- 6/9 Sand
- 8/12 Sand
- 8/20 Sand
- 10/20 Sand
- 16/40 Sand
- 20/40 Sand
- 30/70 Sand

Feet/Meters	**Well Descriptions** All depths listed are bgs (unless noted)	**Annular/Borehole Descriptions** All depths listed are bgs



Westbay® Well Stick-Up = ~0.81'
Conventional Well Stick-Up = ~0.78'

Well completed with ~3' x ~3' cement pad, barrier posts, and locking steel well cap surrounding the casings above ground surface

Top of Cement Grout (Portland II Cement with 5% Bentonite) = 0'

14" OD Steel Surface Casing Depth = 118'

Three steel centralizers welded to casing at ~124.37'

17 1/2" Borehole Cemented to 118'

Surface Casing
14" OD Steel
Conventional Casing
4" ID 304 Stainless Steel
Conventional Screen
4" ID 304 Stainless Steel
0.020"-Slot
Conventional End Cap
4" ID 304 Stainless Steel
Welded Steel Centralizers

Water Table

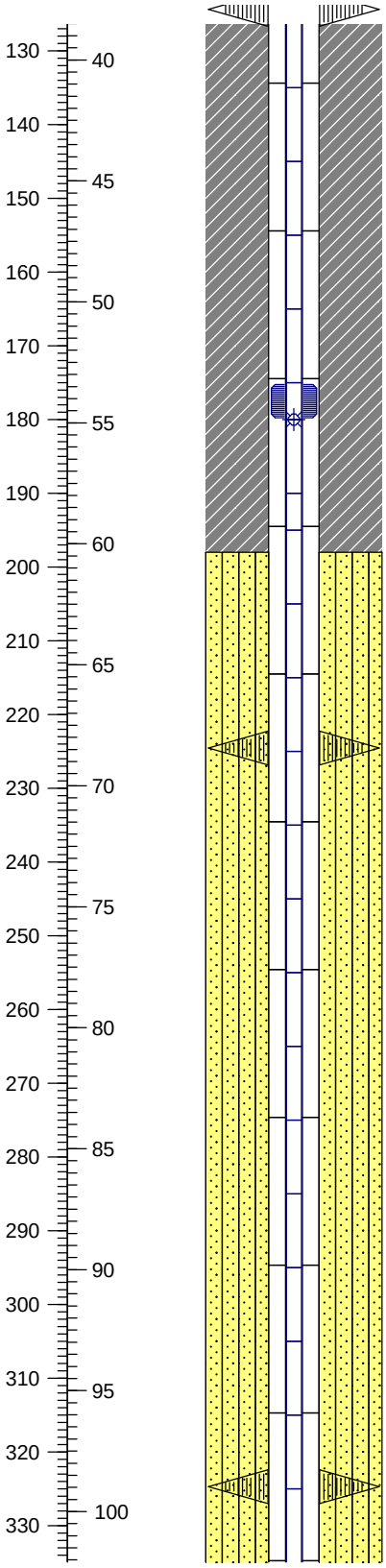
Casing Explanation:

1.5" ID Westbay® MP 38 Casing
1.5" ID Westbay® MP 38 End Cap
Measurement Port (MP)
MP with Filter Sock
Mechanical Pumping Port (PP)
Magnetic Collar
Packer

Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
10/20 Sand/ Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters



Well Descriptions
All depths listed are bgs (unless noted)

Stabilizing Packer Depth = 175'-180'

MP Depth = 180'

Three steel centralizers welded to casing at ~224.54'

Crossover Adapter from Schedule 40 Threads to Schedule 80 Threads on the 4" ID Schedule 10, 304 Stainless Steel Conventional Casing = Unknown Depth

Three steel centralizers welded to casing at ~324.72'

Annular/Borehole Descriptions
All depths listed are bgs

Top of 10/20 Sand/Bentonite Mix = 198'

Volcanic Bedrock Depth = 300'

Surface Casing
14" OD Steel
Conventional Casing
4" ID 304 Stainless Steel
Conventional Screen
4" ID 304 Stainless Steel
0.020"-Slot
Conventional End Cap
4" ID 304 Stainless Steel
Welded Steel Centralizers

Water Table

Casing Explanation:

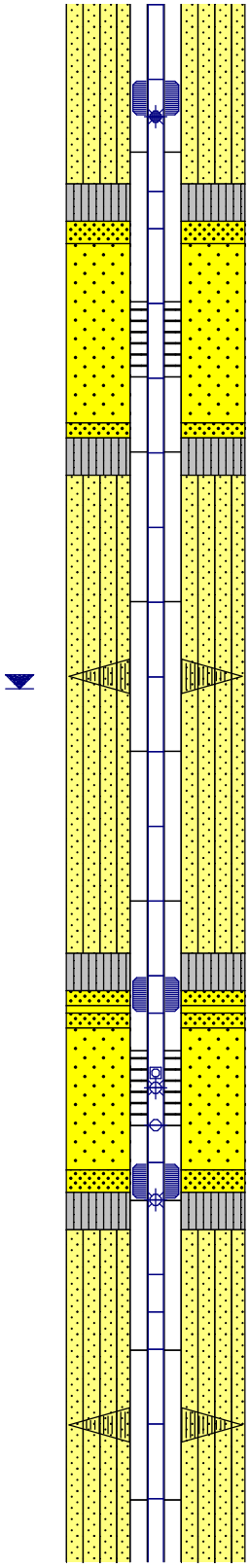
1.5" ID Westbay® MP 38 Casing
1.5" ID Westbay® MP 38 End Cap
Measurement Port (MP)
MP with Filter Sock
Mechanical Pumping Port (PP)
Magnetic Collar
Packer

Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
10/20 Sand/ Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters

340	105
350	
360	110
370	
380	115
390	
400	120
410	
420	125
430	130
440	
450	135
460	
470	140
480	
490	145
500	
510	150
520	
530	155
540	160
	165



Well Descriptions
All depths listed are bgs (unless noted)

Stabilizing Packer Depth = 345'-350'

MP Depth (with Filter Sock) = 350'

Top of 4" ID 304 Stainless Steel 0.020"-Slot Screen = 374.80' (Rated at 400'-600' Depth)

Bottom of 4" ID 304 Stainless Steel 0.020"-Slot Screen = 384.83' (Rated at 400'-600' Depth)

Three steel centralizers welded to casing at ~424.93'

Water Table = 426.60' (TOC - Measured 8/19/99 before Westbay® Casing Installation)

Packer Depth = 465'-470'

Top of 4" ID 304 Stainless Steel 0.020"-Slot Screen = 475.03' (Rated at 400'-600' Depth)

Magnetic Collar Depth = 478'

Sampling MP Depth = 480'

Bottom of 4" ID 304 Stainless Steel 0.020"-Slot Screen = 485.05' (Rated at 400'-600' Depth)

PP Depth = 485'

Packer Depth = 490'-495'

MP Depth = 495'

Three steel centralizers welded to casing at ~784.27'

Annular/Borehole Descriptions
All depths listed are bgs

Top of Upper Bentonite Seal = 359'

Top of Upper 30/70 Sand = 364'
Top of 10/20 Sand = 367'

Top of Lower 30/70 Sand = 391'
Top of Lower Bentonite Seal = 393'

Top of 10/20 Sand/Bentonite Mix = 398'

Top of Upper Bentonite Seal = 462'

Top of Upper 30/70 Sand = 467'
Top of 10/20 Sand = 469'
Top of 30/70 Sand = 470'
Top of 10/20 Sand = 472'

Top of Lower 30/70 Sand = 491'
Top of Lower Bentonite Seal = 494'

Top of 10/20 Sand/Bentonite Mix = 499'

Surface Casing
14" OD Steel
Conventional Casing
4" ID 304 Stainless Steel
Conventional Screen
4" ID 304 Stainless Steel
0.020"-Slot
Conventional End Cap
4" ID 304 Stainless Steel
Welded Steel Centralizers

Water Table

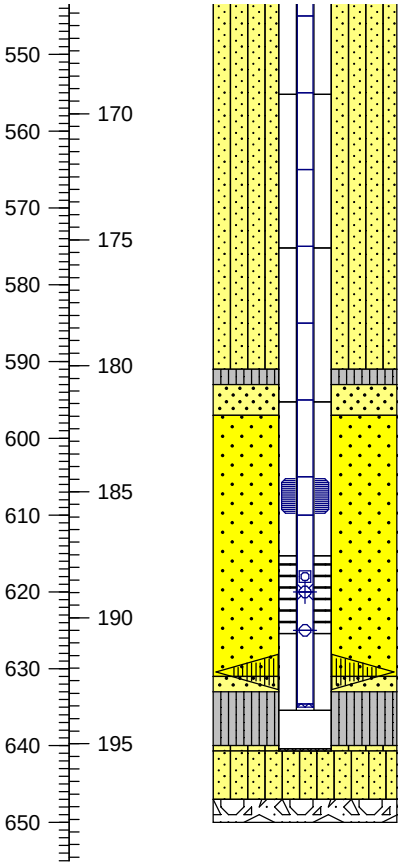
Casing Explanation:

1.5" ID Westbay® MP 38 Casing
1.5" ID Westbay® MP 38 End Cap
Measurement Port (MP)
MP with Filter Sock
Mechanical Pumping Port (PP)
Magnetic Collar
Packer

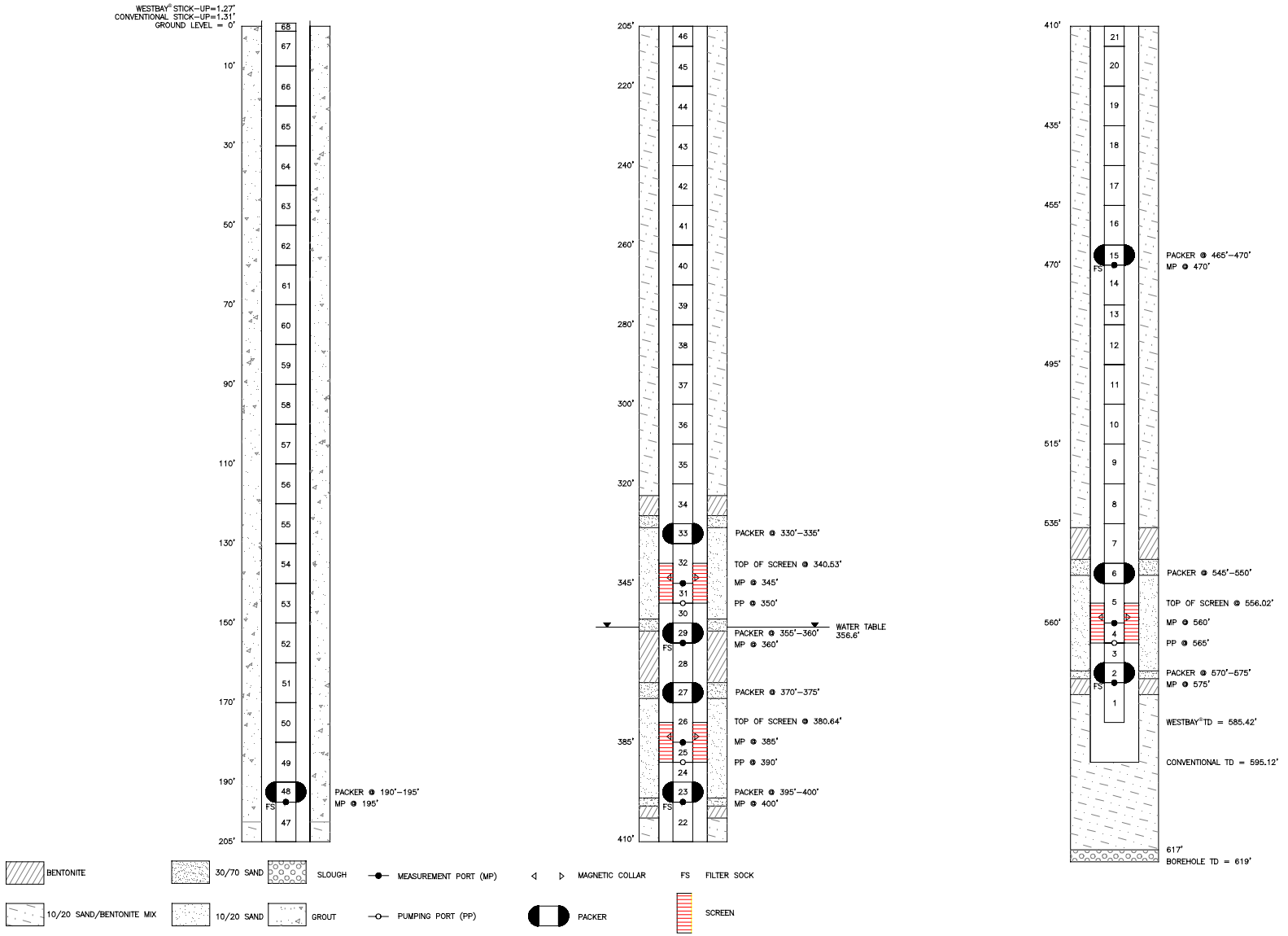
Annular Materials Explanation:

Cement
Bentonite (Grout Well DF)
Bentonite Seal
10/20 Sand/ Bentonite Mix
Slough
1/8 Gravel
4/8 Sand
6/9 Sand
8/12 Sand
8/20 Sand
10/20 Sand
16/40 Sand
20/40 Sand
30/70 Sand

Feet/Meters

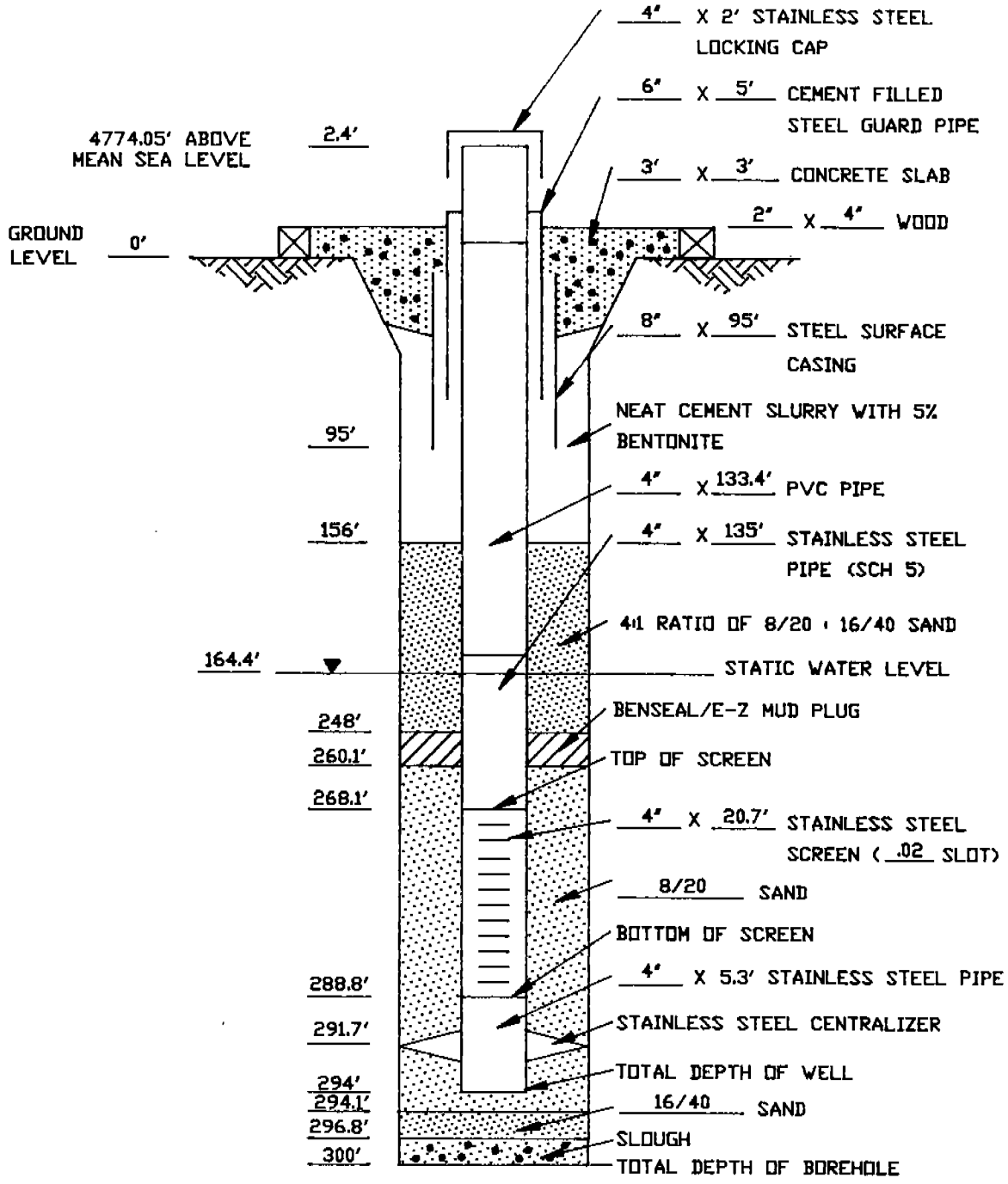


Well Descriptions All depths listed are bgs (unless noted)	**Annular/Borehole Descriptions** All depths listed are bgs
	Top of Upper Bentonite Seal = 591'
	Top of Upper 30/70 Sand = 593'
	Top of 10/20 Sand = 597'
Packer Depth = 605'-610'	
Top of 4" ID 304 Stainless Steel 0.020"-Slot Screen = 615.30' (Rated at 600'-1,000' Depth)	
Magnetic Collar Depth = 618'	
Sampling MP Depth = 620'	
Bottom of 4" ID 304 Stainless Steel 0.020"-Slot Screen = 625.40' (Rated at 600'-1,000' Depth)	
PP Depth = 625'	
Three steel centralizers welded to casing at ~630.40'	
Westbay® MP 38 Casing TD = 635'	
	Top of Lower 30/70 Sand = 631'
	Top of Lower Bentonite Seal = 633'
Conventional 4" 304 Stainless Steel Well TD = 640.70'	
	Top of 10/20 Sand/Bentonite Mix = 640'
	Top of Slough = 647'
	12 1/4" Borehole TD = 650'

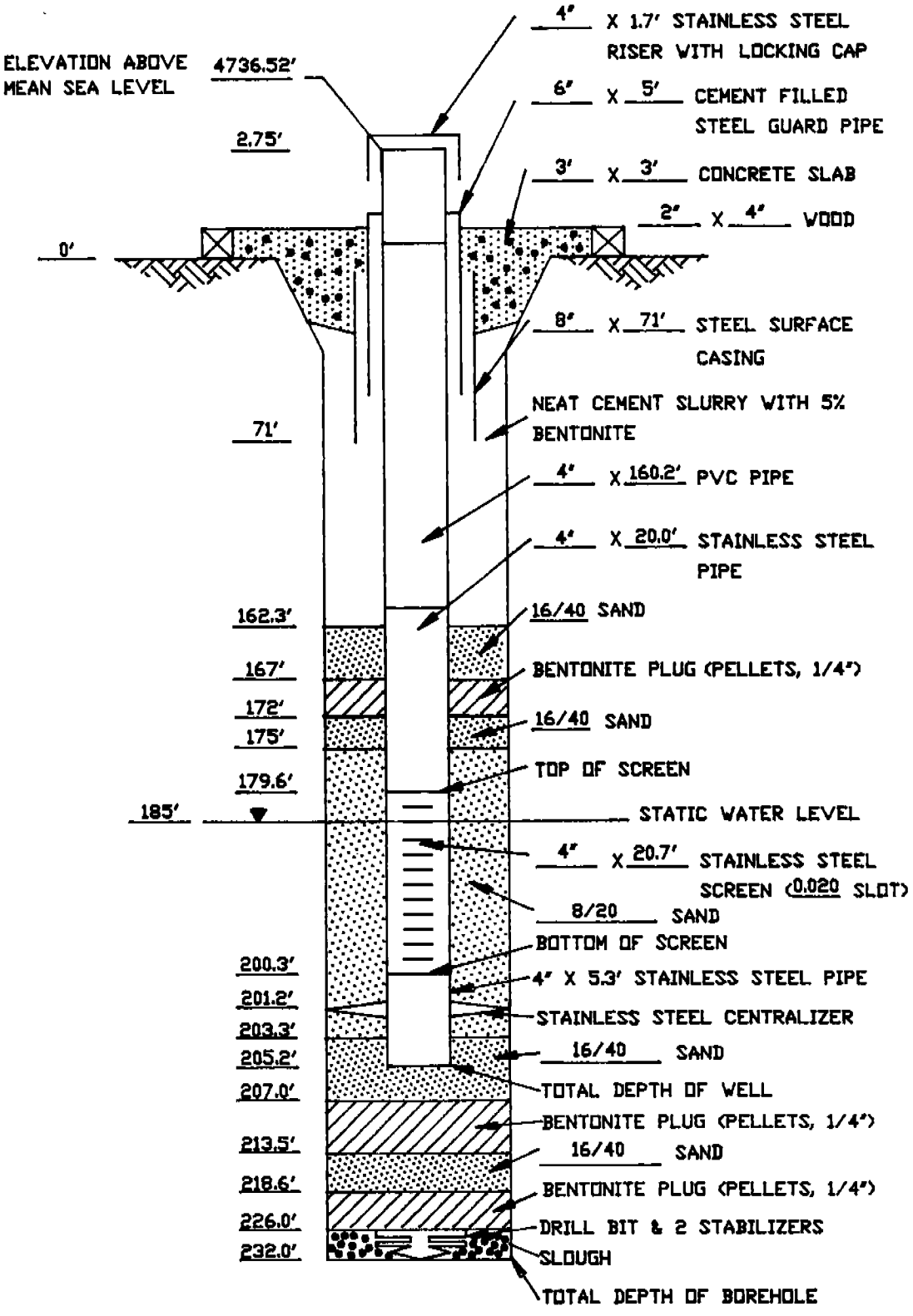


MONITOR WELL BLM-39 COMPLETION DIAGRAM

2882



MONITOR WELL BW-1-268 COMPLETION DIAGRAM



MONITOR WELL BW-3-180 COMPLETION DIAGRAM

WE[illegible] BAY MP SYSTE[illegible]
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: BW-4 Location: W. Facility Boundary

Date Installed: 02-23-93 Installed by: H+SCL Date Drawn: 02-19-93

Hole Depth: 481.0' MP Depth: 475.0' Hole Diameter: 4"

Measurement Datum: Ground Level Datum Elevation: 4750.75 (EC)

Depth (ft)	Geologic Description	MP Casing Log 53	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
0	0'-230' ALLUVIUM (Santa Fe Group)	52	91-268		All couples tested to 100 psi for 30 sec	✓	✓
10		51	90-232				
			91-268			✓	✓
			91-250				
20		50	91-268		All magnetic collars are placed 0.4' above the MP couple	✓	✓
			91-250			✓	
30		49	91-268			✓	✓
			92-272				
40		48	91-268		filter socks used where indicated	✓	✓
			92-272			✓	
50		47	91-268			✓	✓
			92-272				
60		46	91-268			✓	✓
			92-272				
70		45	91-268			✓	✓
			92-272				
80		44	91-268			✓	✓
			92-272				
90		43	91-268			✓	✓
			92-272				
100			91-268			✓	✓

Regular MP Casing

MP Packer

Measurement Port Coupling

Pumping Port Coupling

Magnetic Collar

WEBB MP SYSTEM CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: EW-4 Location: W. Facilty Boundary

Date Installed: 02-23-93 Installed by: H+GCL Date Drawn: 02-19-93

Hole Depth: 447.0' MP Depth: 440.0' Hole Diameter: 4"

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
100			91-268				
		42	92-272				
110			91-268				
		41	92-272				
120			91-268				
		40	92-272				
130			91-268				
		39	92-272				
140			91-268				
		38	92-272				
150			91-268				
		37	92-272				
160			91-268				
		36	92-272				
170			91-268				
		35	92-272				
180			91-268				
			92-272				
		34					
190			91-268				
		33	92-272				
200			91-268				

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

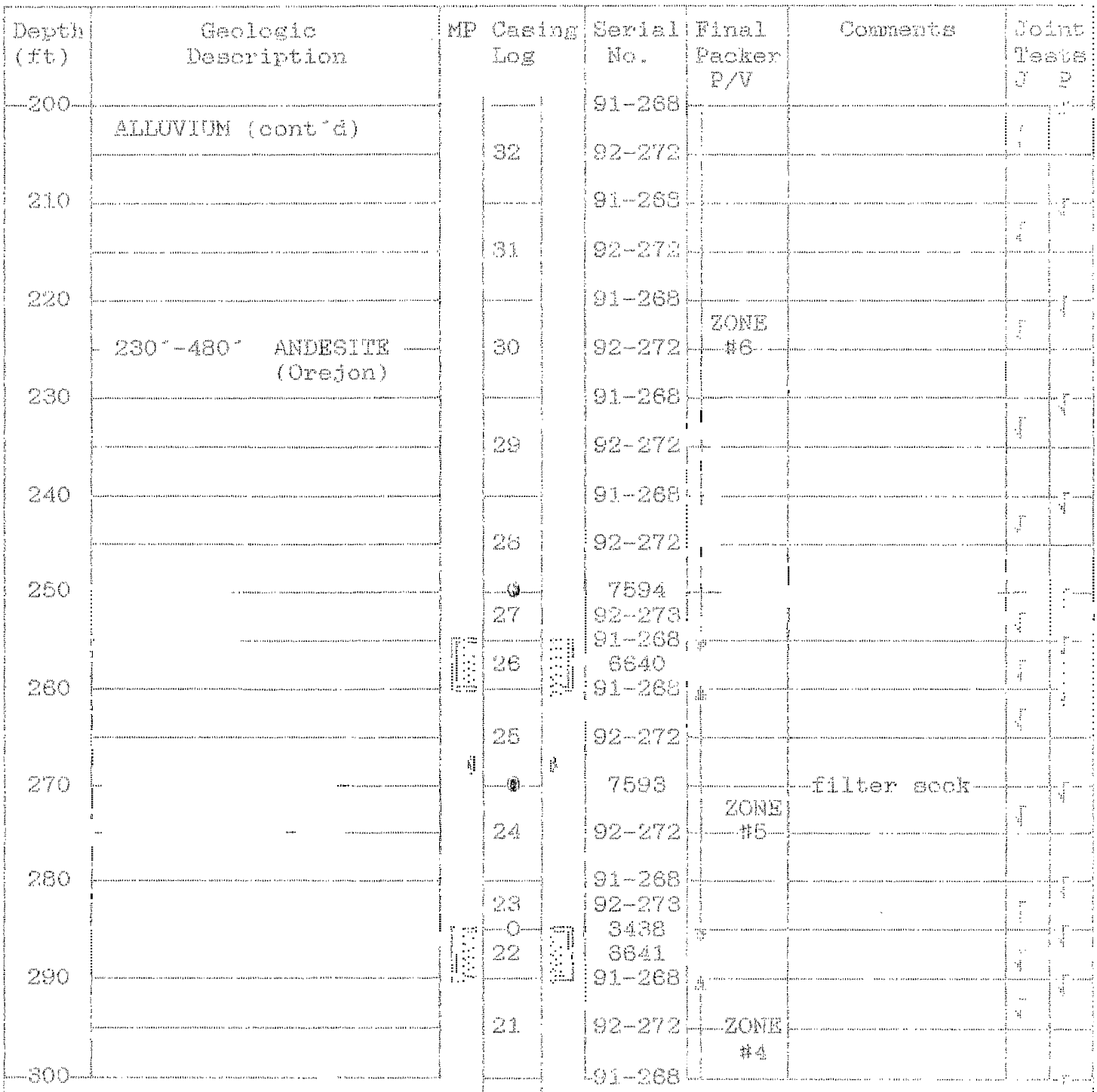
C:\FORMTOOL\PSE\WB\EW-4(2)

WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: BW-4 Location: W. Facility Boundary

Date Installed: 02-23-93 Installed by: H-GCL Date Drawn: 02-19-93

Hole Depth: 481.0' MP Depth: 475.0' Hole Diameter: 4"



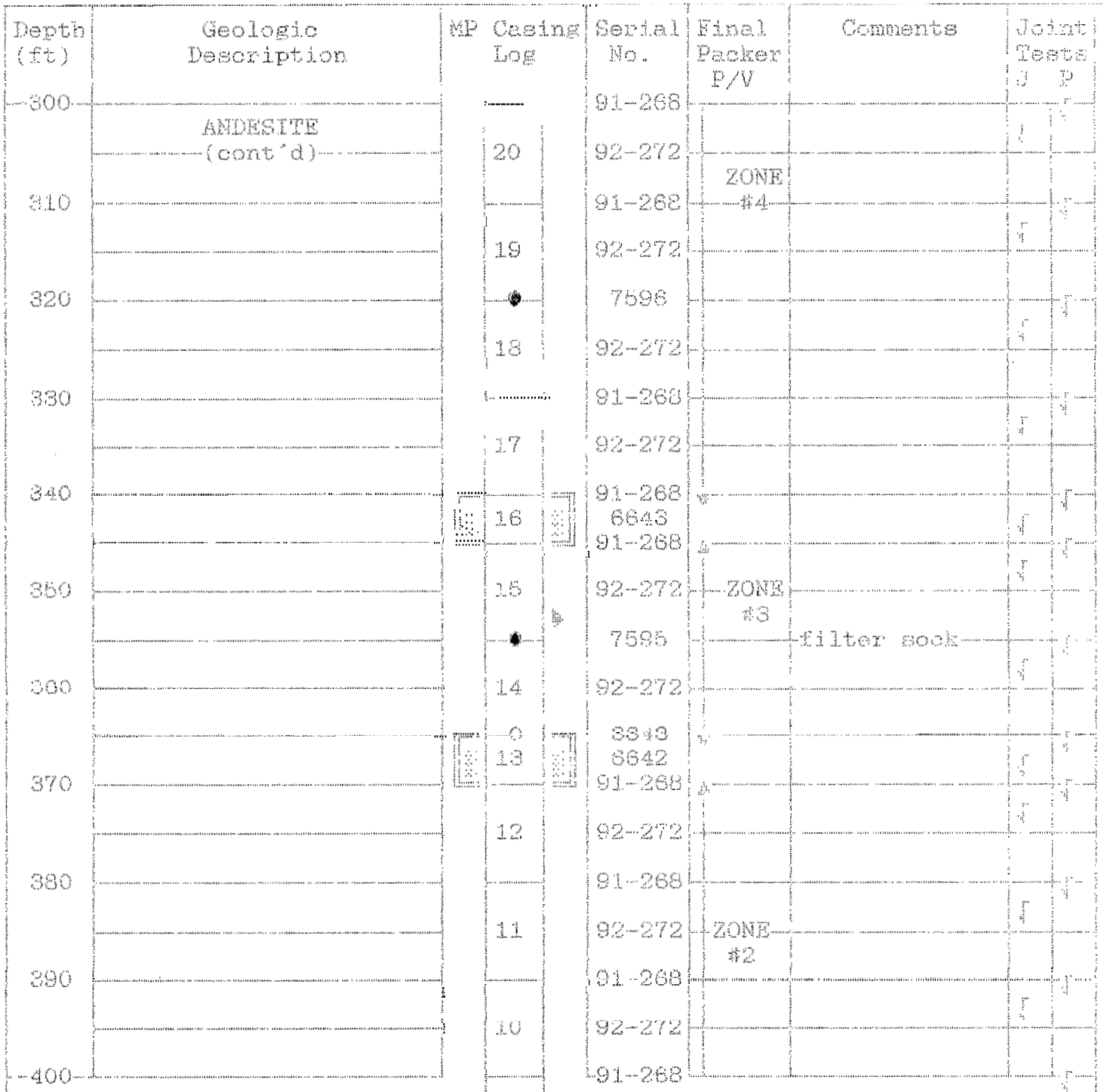
C:\FORMTOOL\PSE\BW-4(3)

WE TBAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: EW-4 Location: W. Facility Boundary

Date Installed: 02-23-93 Installed by: H+GCL Date Drawn: 02-19-93

Hole Depth: 481.0' MP Depth: 475.0' Hole Diameter: 4"



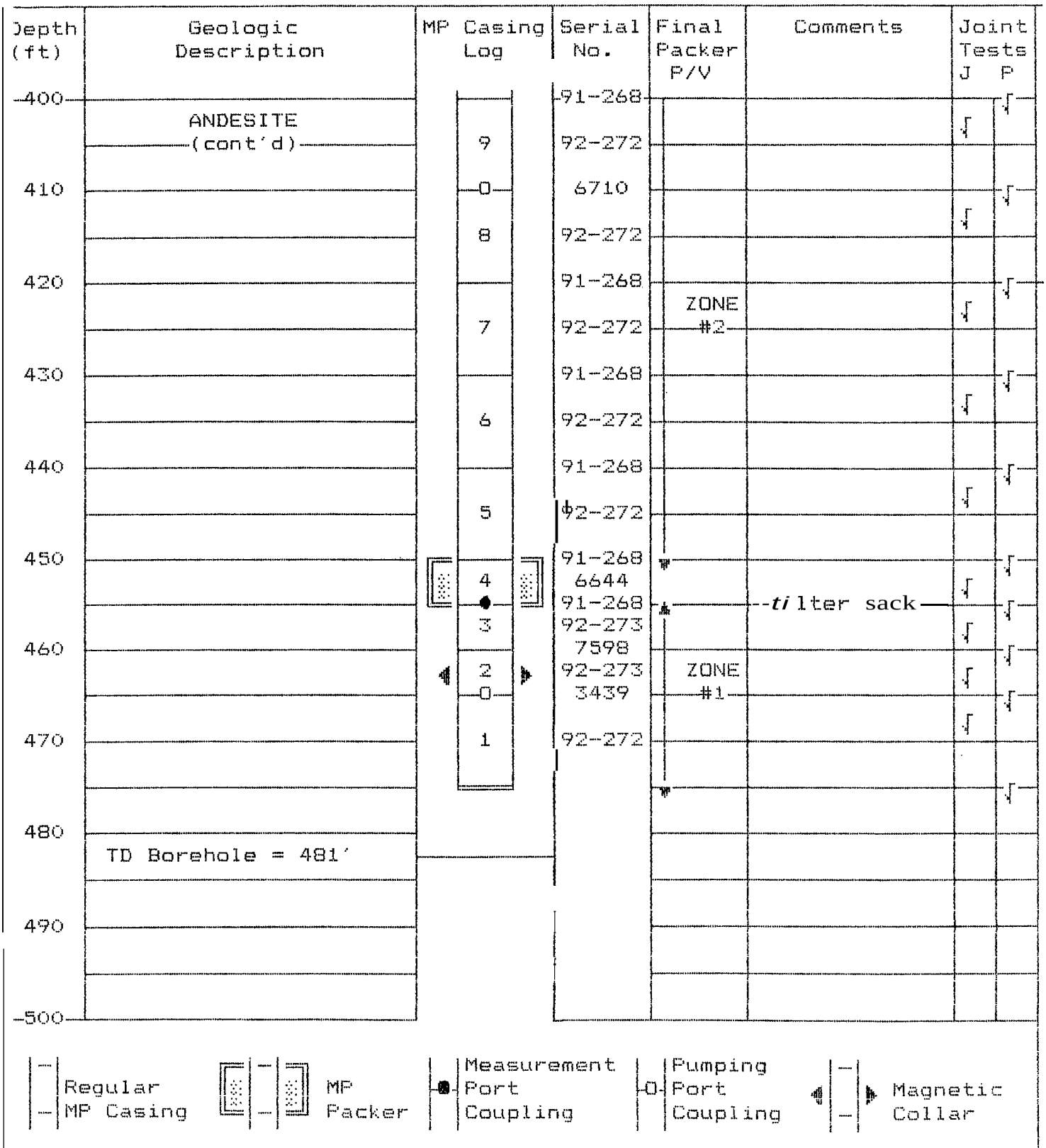
C:\FORMTOOL\PSE\WE\EW-4(4)

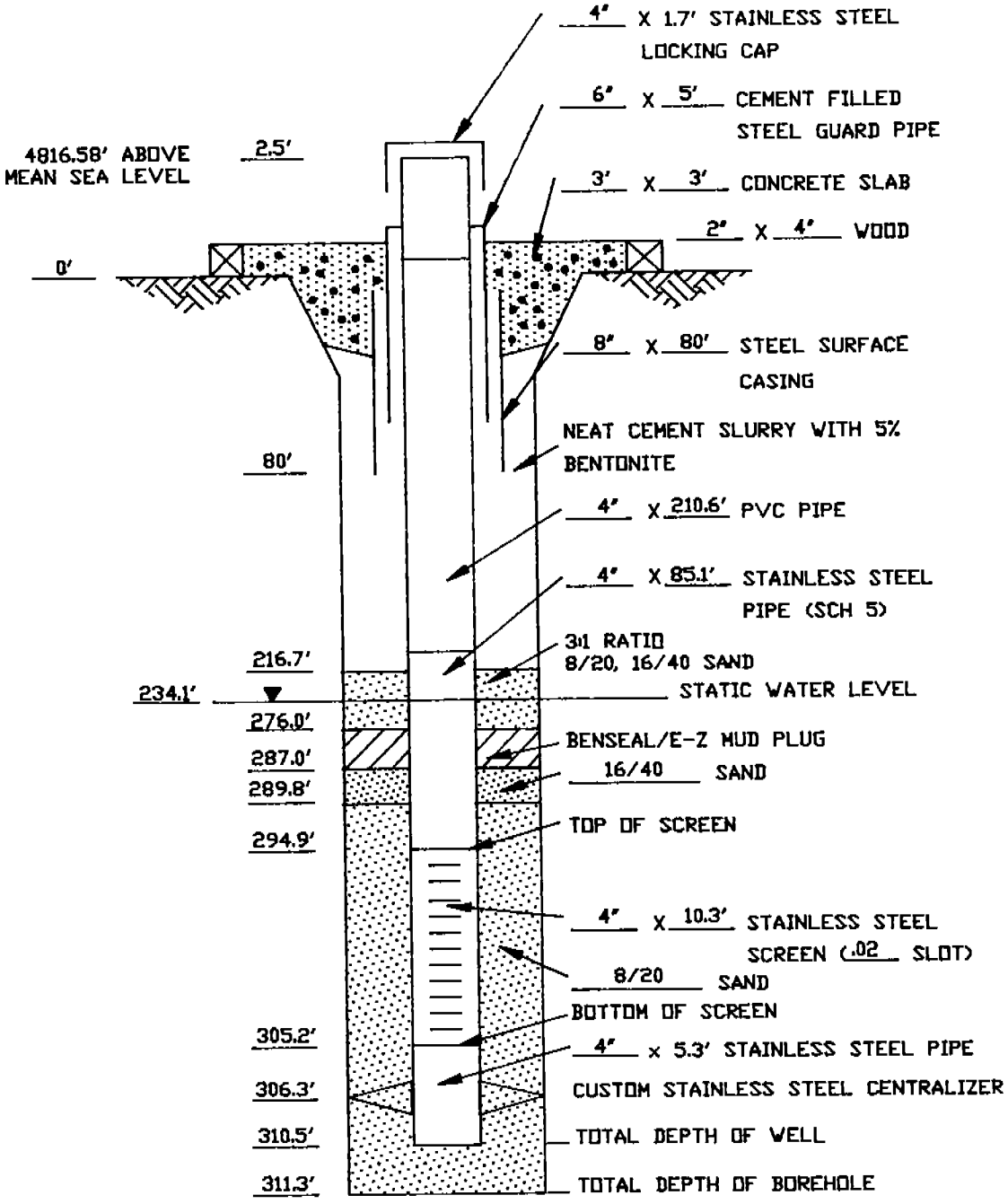
WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: BW-4 Location: SE Facility Boundary

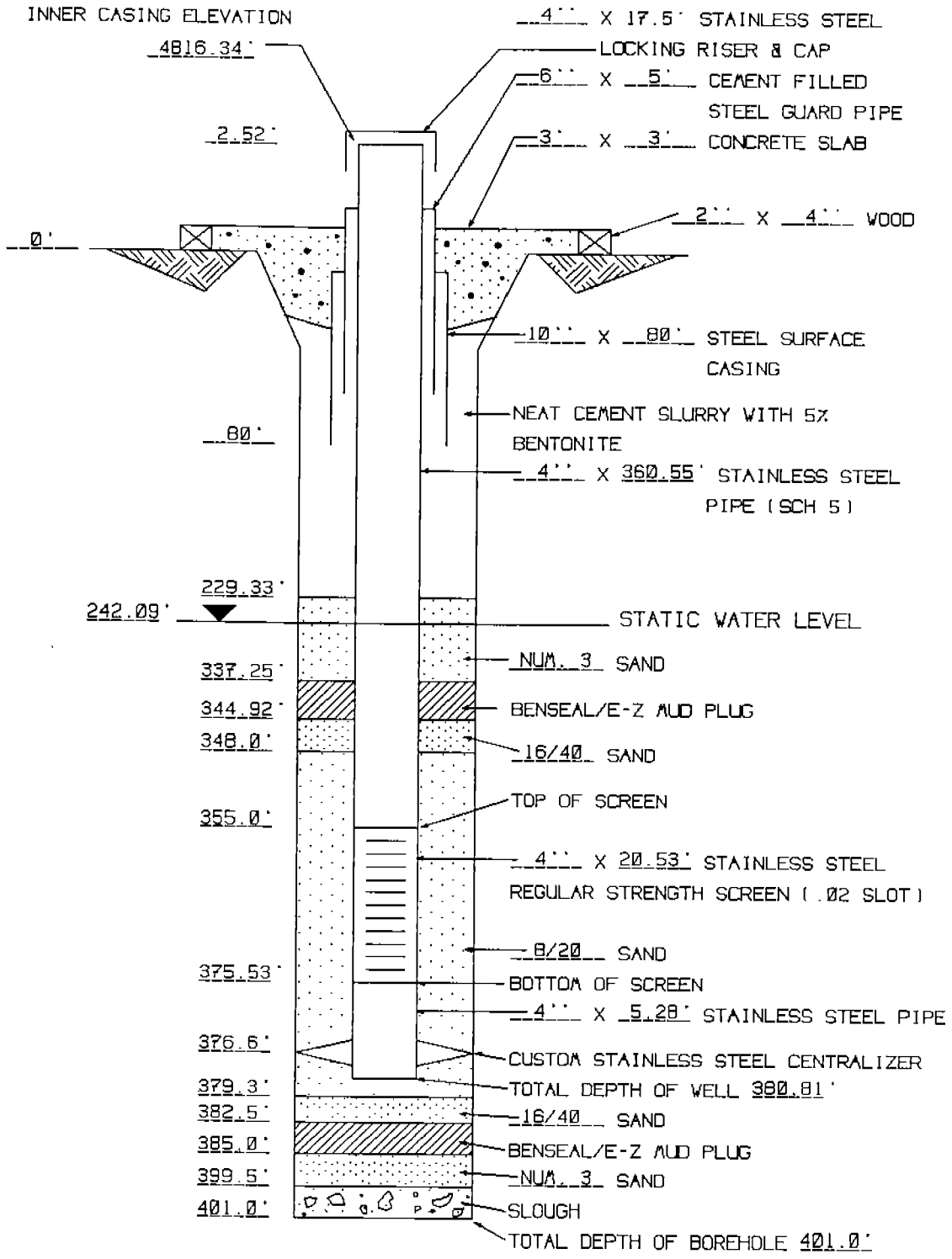
Date Installed: 03-10-93 Installed by: H+GCL Date Drawn: 03-08-93

Hole Depth: 447.0' MP Depth: 440.0' Hole Diameter: 4"

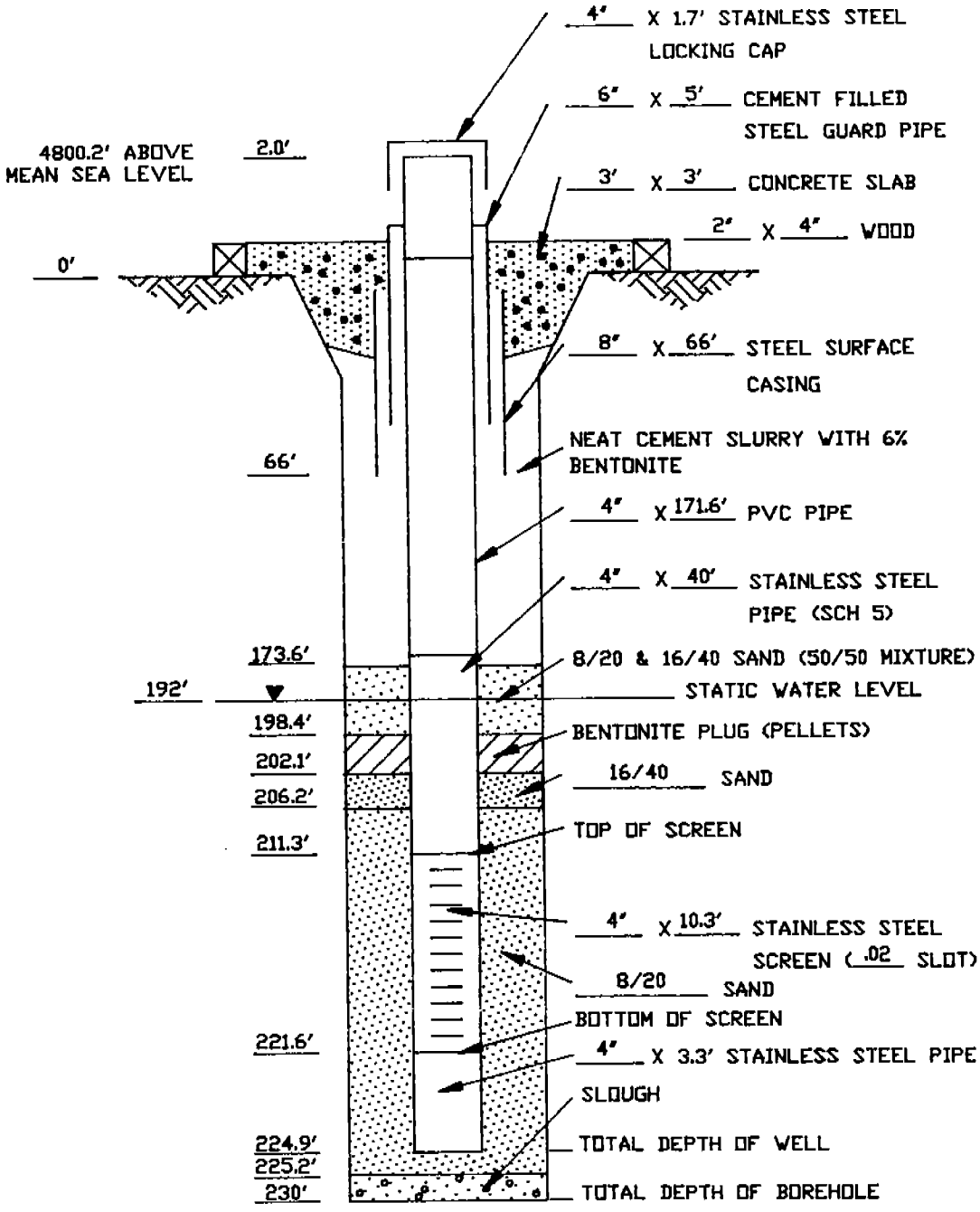




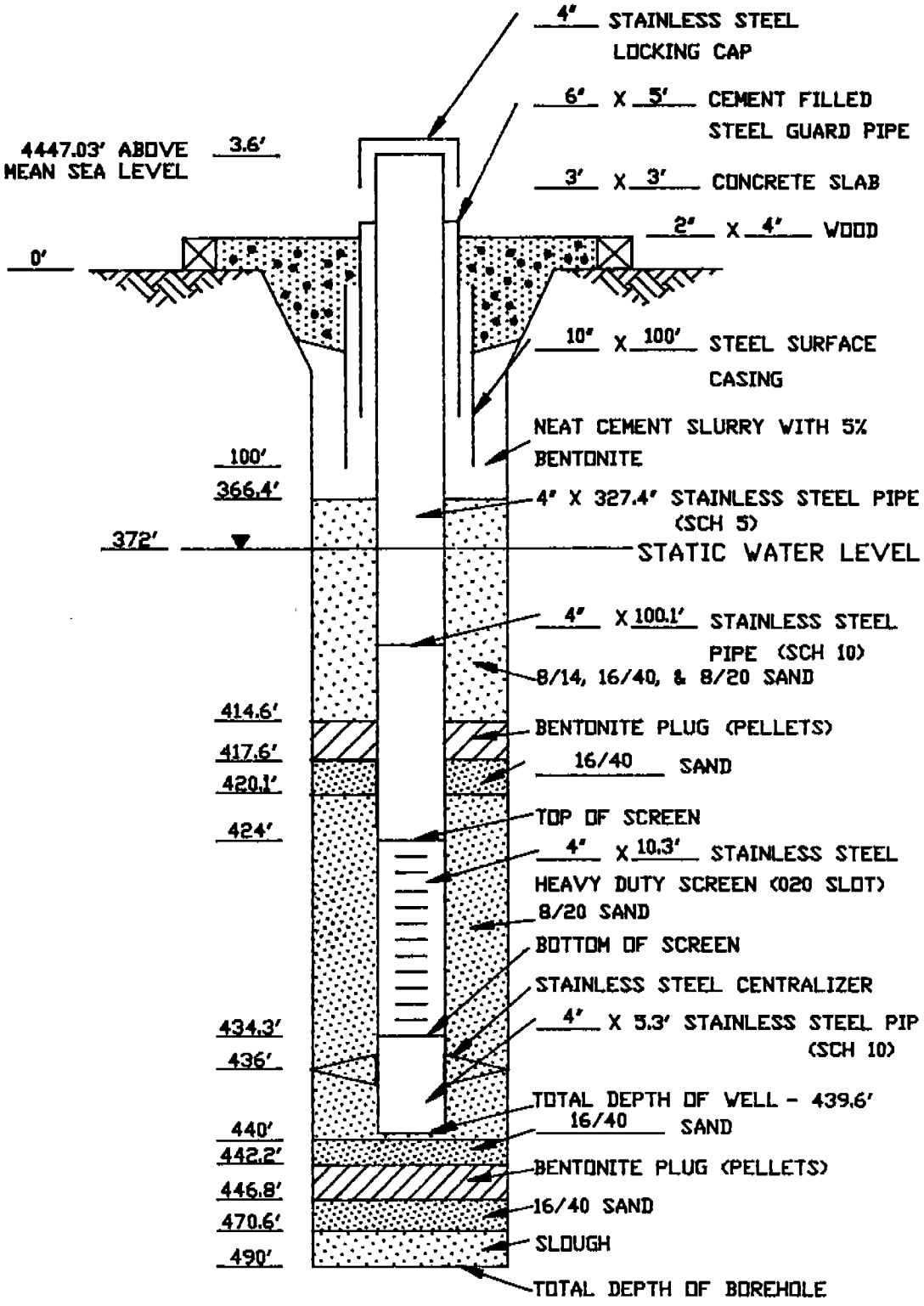
MONITOR WELL BW-5-295 COMPLETION DIAGRAM



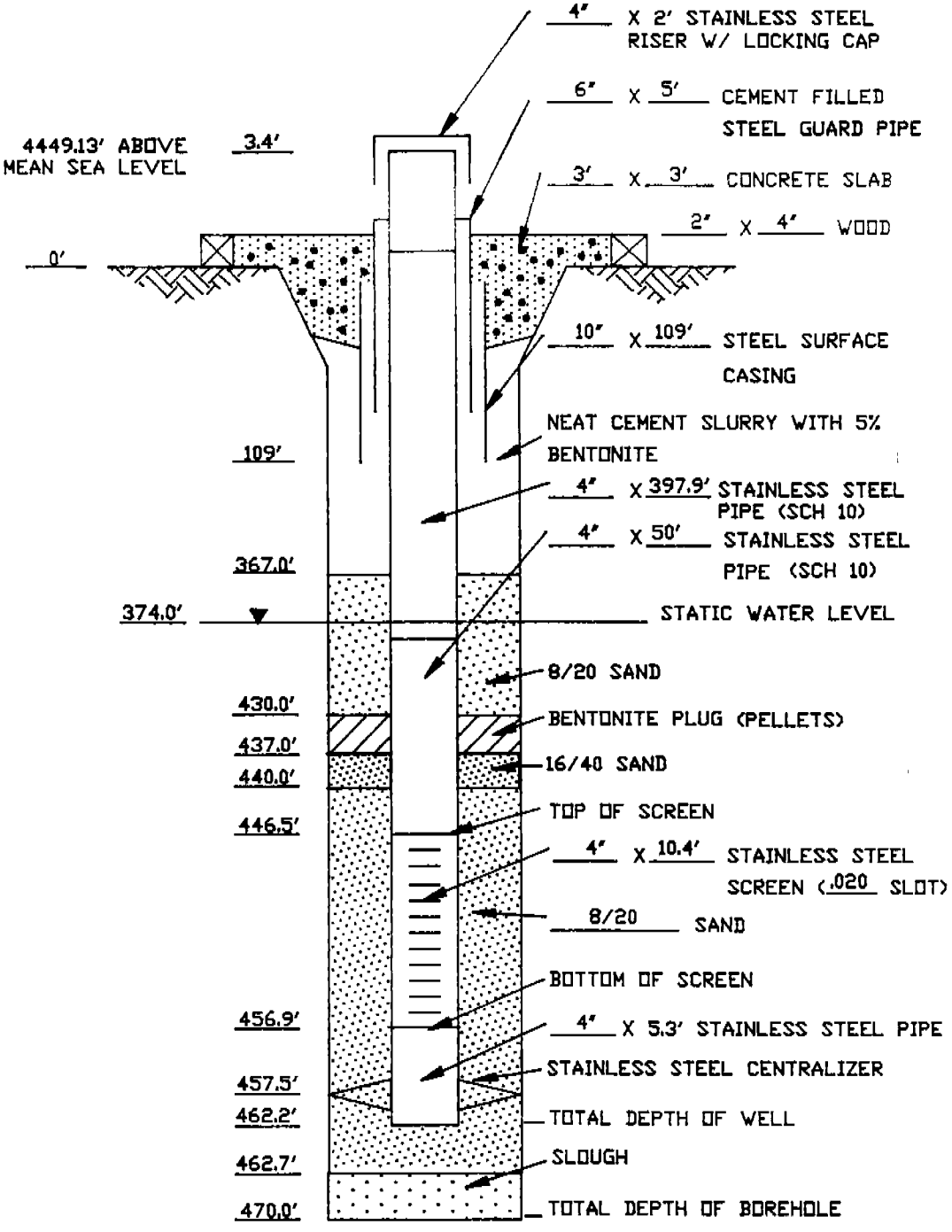
MONITOR WELL BW-6-355 COMPLETION DIAGRAM



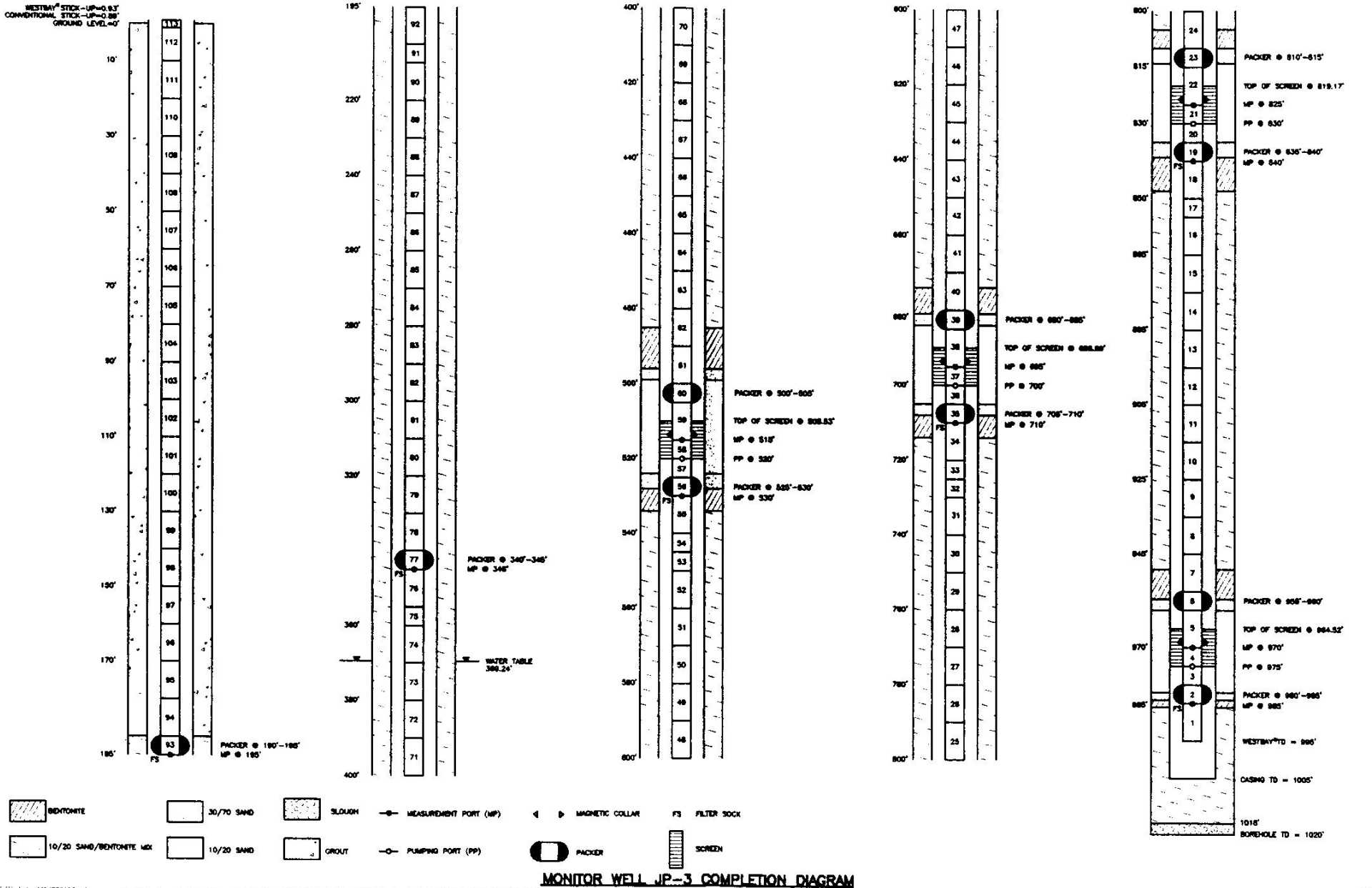
MONITOR WELL BW-7-211 COMPLETION DIAGRAM



MONITOR WELL JP-1-424 COMPLETION DIAGRAM

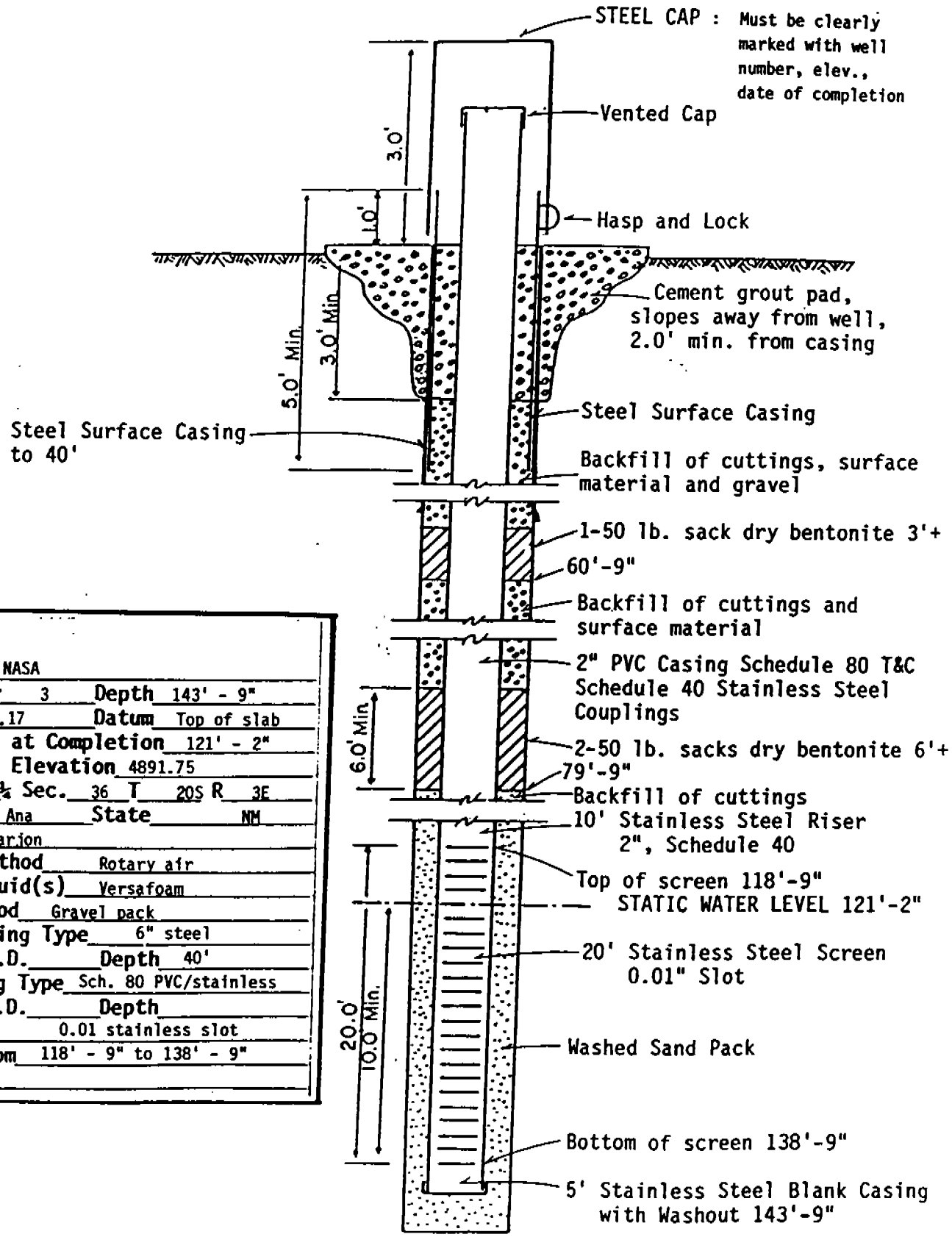


MONITOR WELL JP-2-447 COMPLETION DIAGRAM



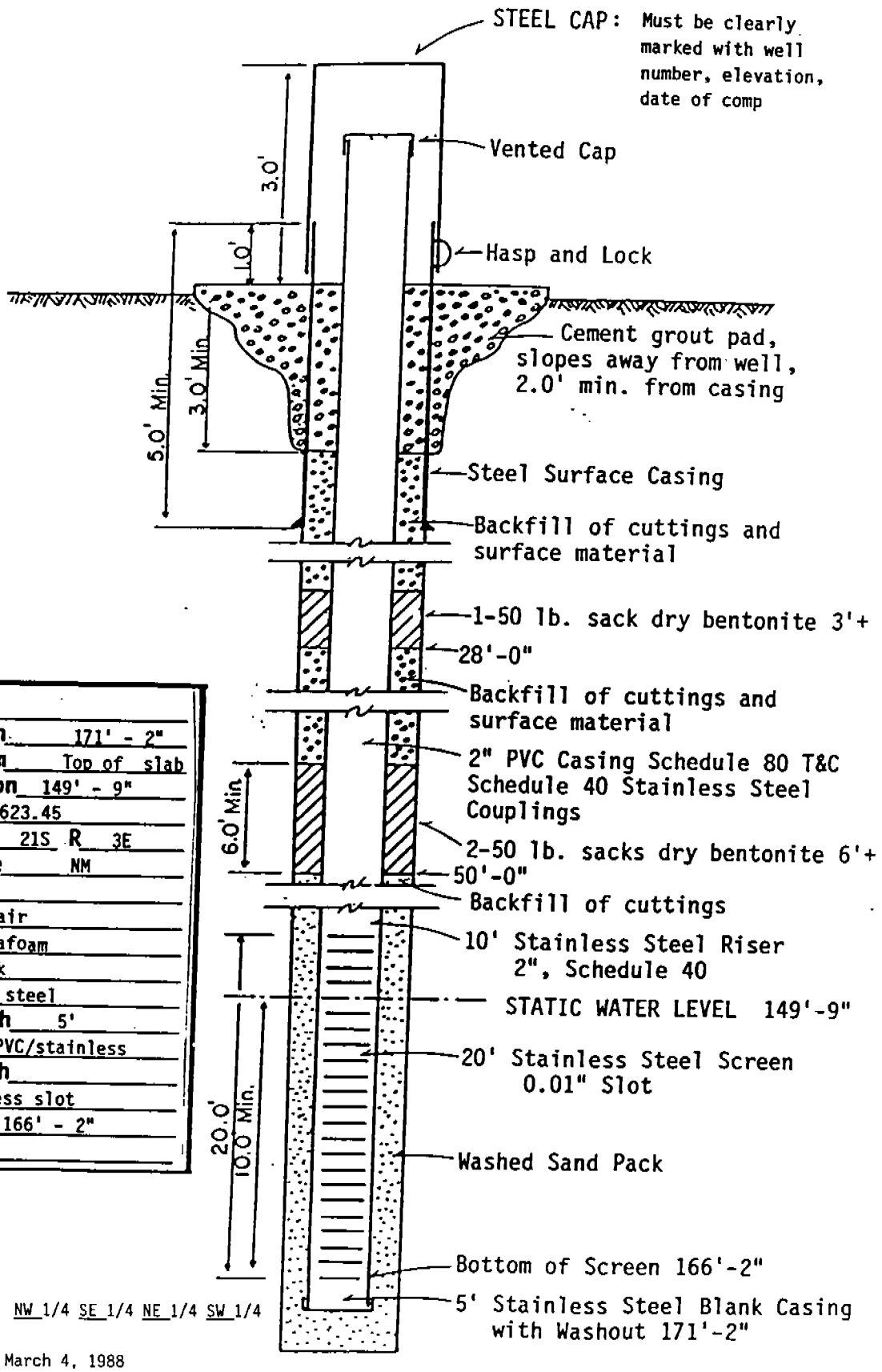
MONITOR WELL JP-3 COMPLETION DIAGRAM

WELL COMPLETION DIAGRAM NASA-3



CLIENT NASA
Well Number 3 Depth 143' - 9"
Elev. 5010.17 Datum Top of slab
Water Level at Completion 121' - 2"
Water Level Elevation 4891.75
NW¼ NE¼ SW¼ Sec. 36 T 20S R 3E
County Dona Ana State NM
Driller Larjon
Drilling Method Rotary air
Drilling Fluid(s) Versafoam
Compl. Method Gravel pack
Surface Casing Type 6" steel
I.D. O.D. Depth 40'
Inner Casing Type Sch. 80 PVC/stainless
I.D. 2" O.D. Depth
Screen Type 0.01 stainless slot
Screened From 118' - 9" to 138' - 9"

WELL COMPLETION DIAGRAM NASA-4

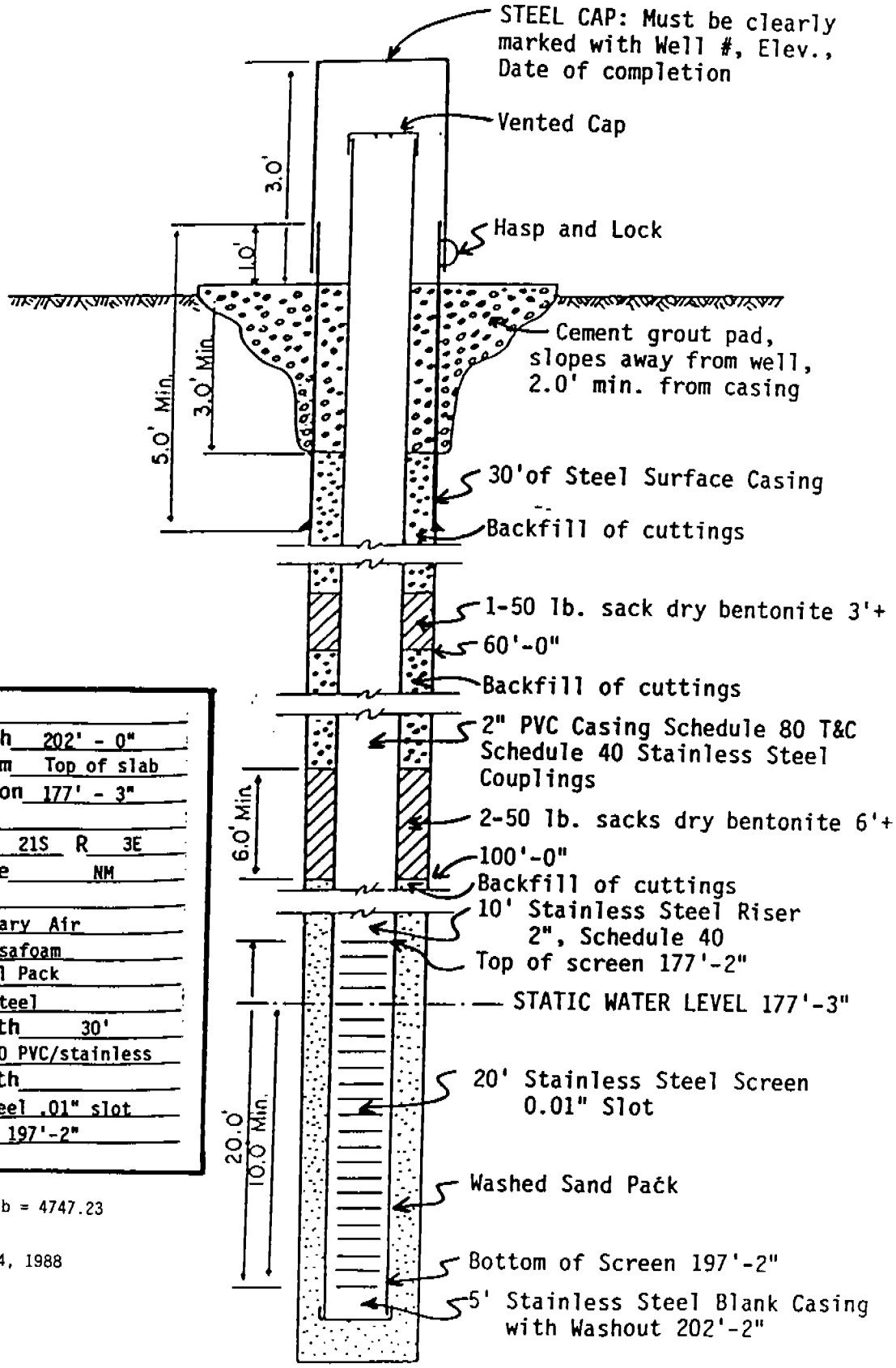


CLIENT NASA
Well Number 4 Depth 171' - 2"
Elev. 4770.20 Datum Top of slab
Water Level at Completion 149' - 9"
Water Level Elevation 4623.45
SW¼ SW¼ SE¼ Sec. 2 T 21S R 3E
County Dona Ana State NM
Driller Larjon
Drilling Method Rotary air
Drilling Fluid(s) versafoam
Compl. Method general pack
Surface Casing Type 6" steel
I.D. O.D. Depth 5'
Inner Casing Type Sch 80 PVC/stainless
I.D. 2" O.D. Depth
Screen Type 0.01" stainless slot
Screened From 146' - 2" to 166' - 2"

Elevation of concrete slab = 4770.44 NW 1/4 SE 1/4 NE 1/4 SW 1/4

Section quarters and elevation amended March 4, 1988

WELL COMPLETION DIAGRAM NASA-7

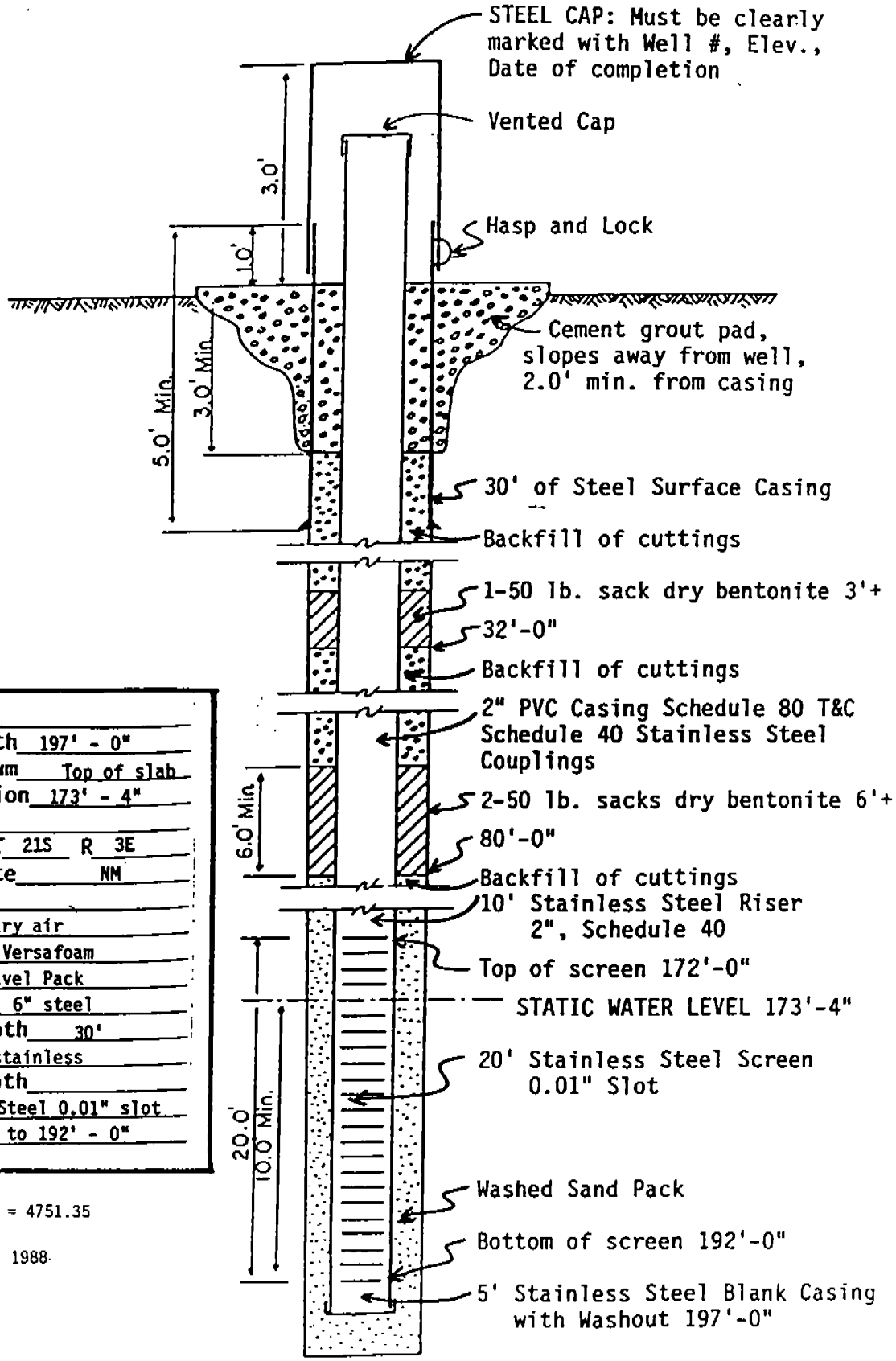


CLIENT NASA WSTF
Well Number 7 Depth 202' - 0"
Elev. 4751.4 Datum Top of slab
Water Level at Completion 177' - 3"
Water Level Elevation
NW¼ NW¼ SW¼ Sec. 2 T 21S R 3E
County Dona Ana State NM
Driller Larion
Drilling Method Rotary Air
Drilling Fluid(s) Versafoam
Compl. Method Gravel Pack
Surface Casing Type 6" Steel
I.D. O.D. Depth 30'
Inner Casing Type Sch. 80 PVC/stainless
I.D. 2" O.D. Depth
Screen Type Stainless Steel .01" slot
Screened From 177'-2" to 197'-2"

Elevation of concrete slab = 4747.23

Elevation amended March 4, 1988

WELL COMPLETION DIAGRAM NASA-8

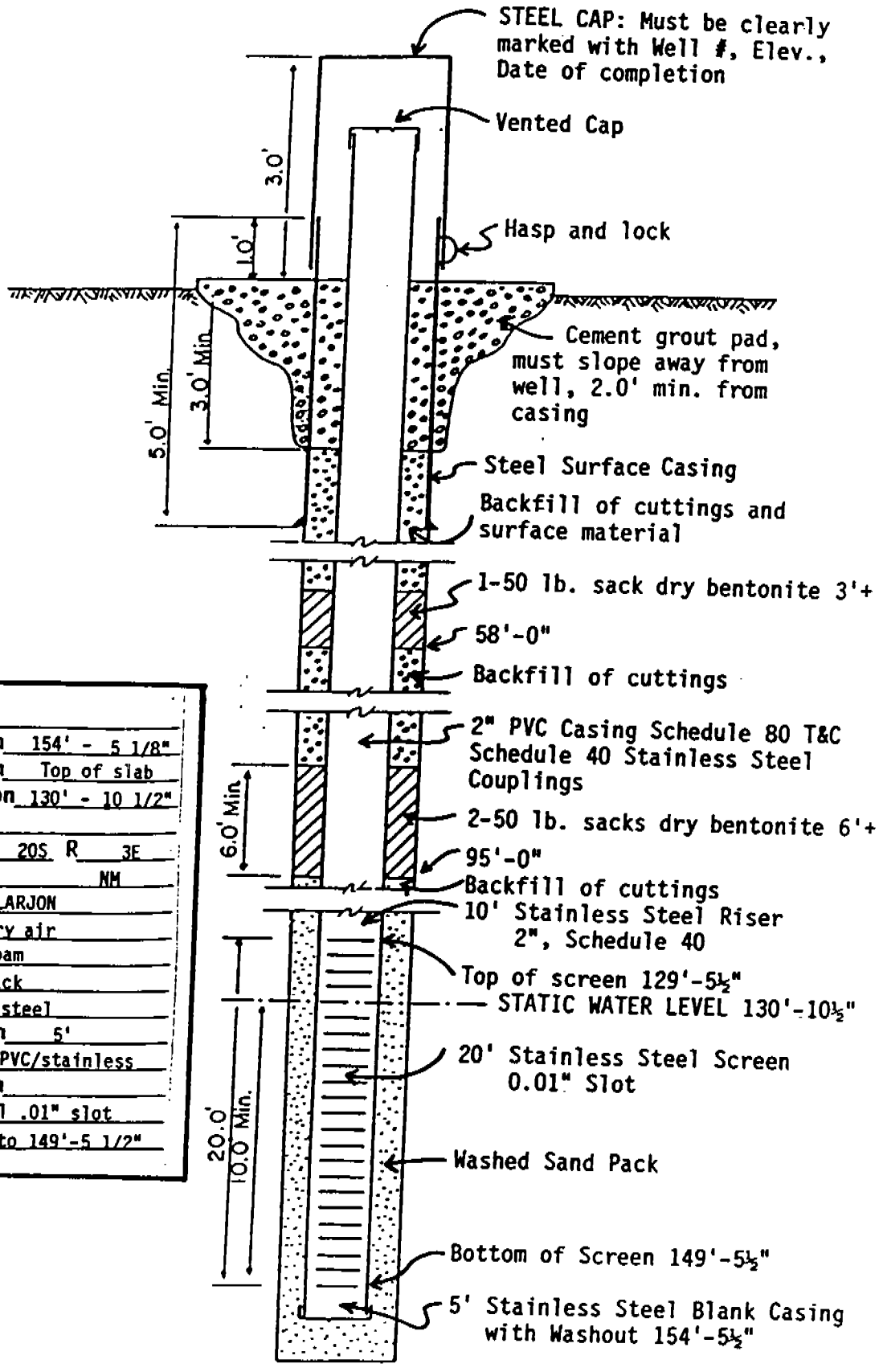


CLIENT NASA WSTF
Well Number 8 Depth 197' - 0"
Elev. 4747.3 Datum Top of slab
Water Level at Completion 173' - 4"
Water Level Elevation
SW¼ NW¼ SW¼ Sec. 2 T 21S R 3E
County Dona Ana State NM
Driller Larjon
Drilling Method Rotary air
Drilling Fluid(s) Versafoam
Compl. Method Gravel Pack
Surface Casing Type 6" steel
I.D. O.D. Depth 30'
Inner Casing Type PVC/stainless
I.D. 2" O.D. Depth
Screen Type Stainless Steel 0.01" slot
Screened From 172' - 0" to 192' - 0"

Elevation of concrete slab = 4751.35

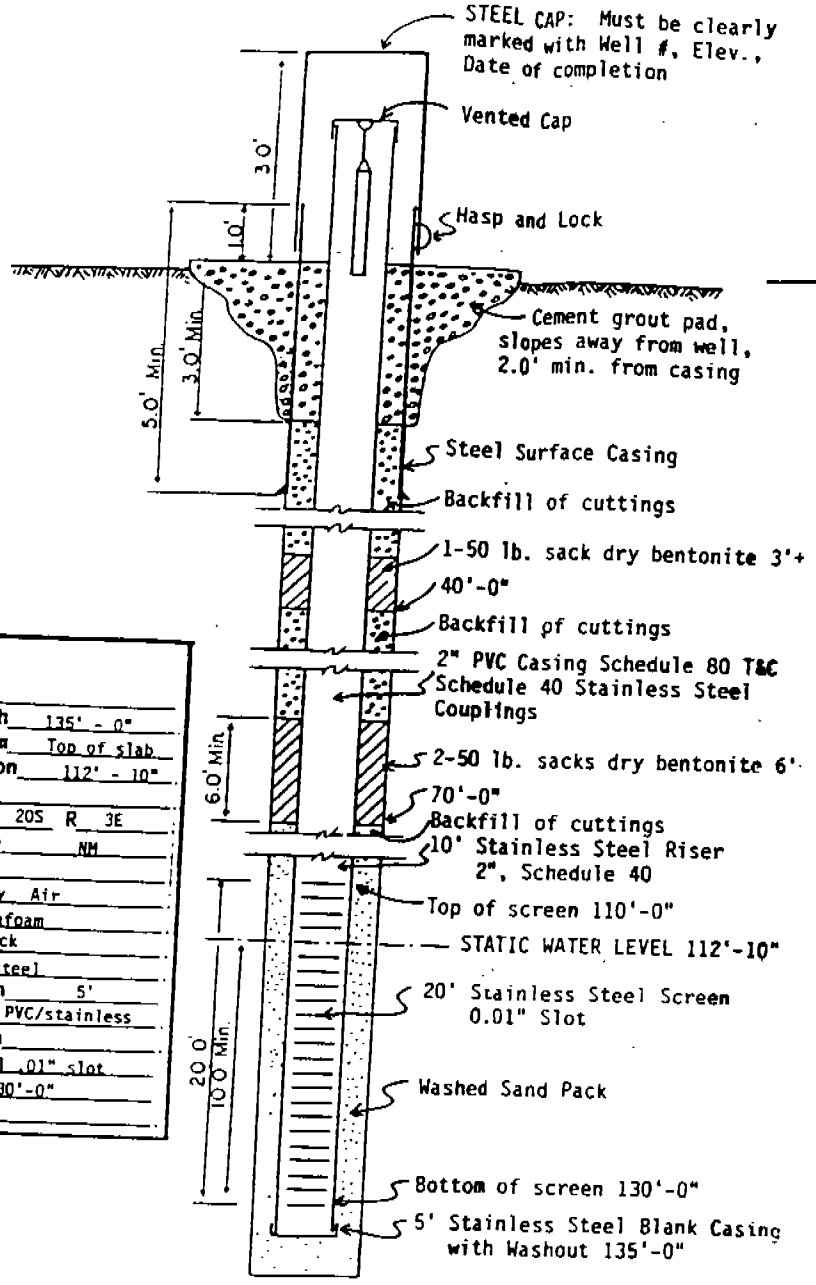
Elevation amended March 4, 1988

WELL COMPLETION DIAGRAM NASA-9

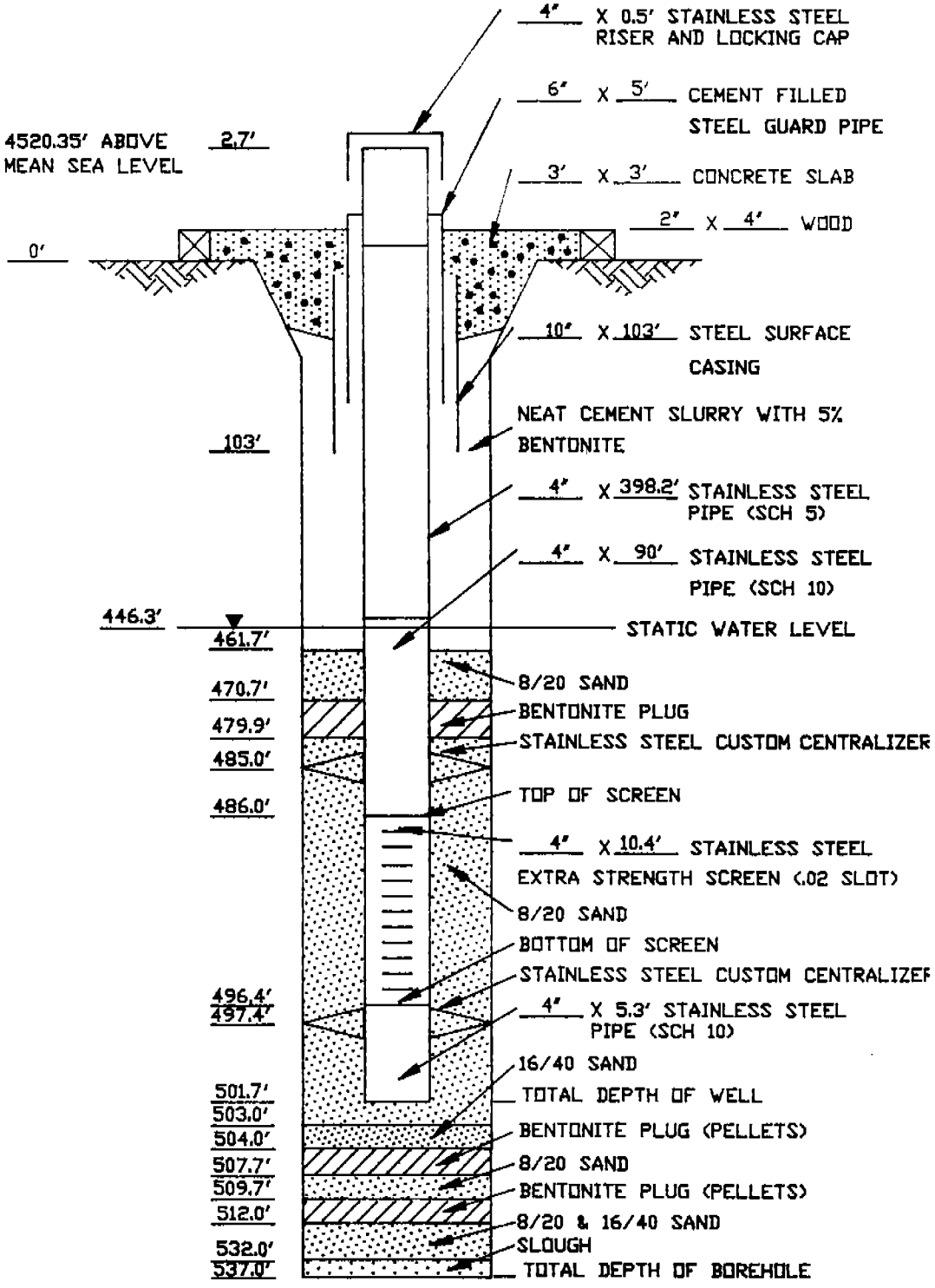


CLIENT NASA WSTF
Well Number 9 Depth 154' - 5 1/8"
Elev. 4822.3 Datum Top of slab
Water Level at Completion 130' - 10 1/2"
Water Level Elevation
SE¼ SE¼ NW¼ Sec. 35 T 20S R 3E
County Dona Ana State NM
Driller LARJON
Drilling Method Rotary air
Drilling Fluid(s) versafoam
Compl. Method Gravel Pack
Surface Casing Type 6" steel
I.D. O.D. Depth 5'
Inner Casing Type Sch. 80 PVC/stainless
I.D. 2" O.D. Depth
Screen Type Stainless steel .01" slot
Screened From 129'-5 1/2" to 149'-5 1/2"

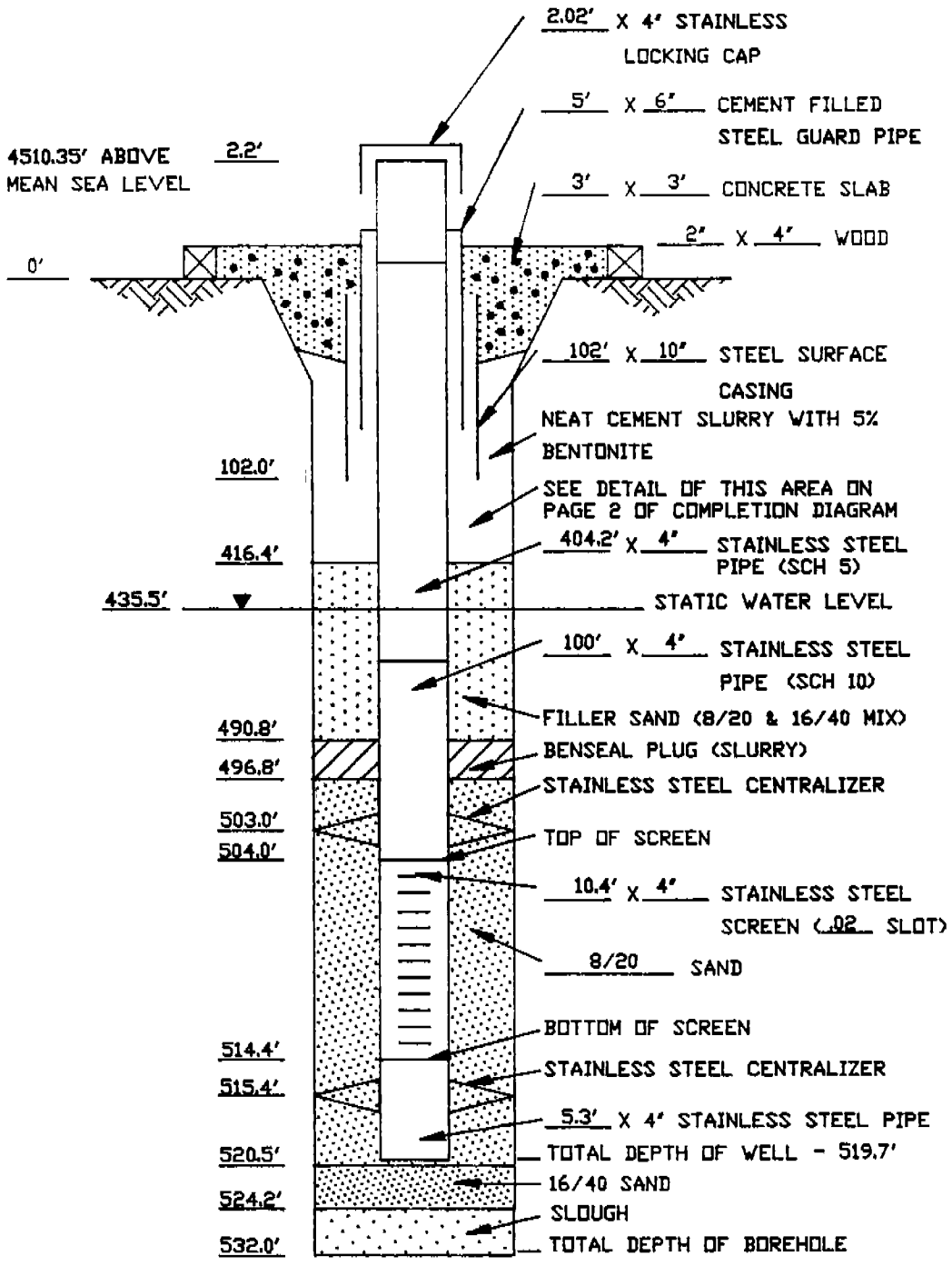
Geosc
Consulta



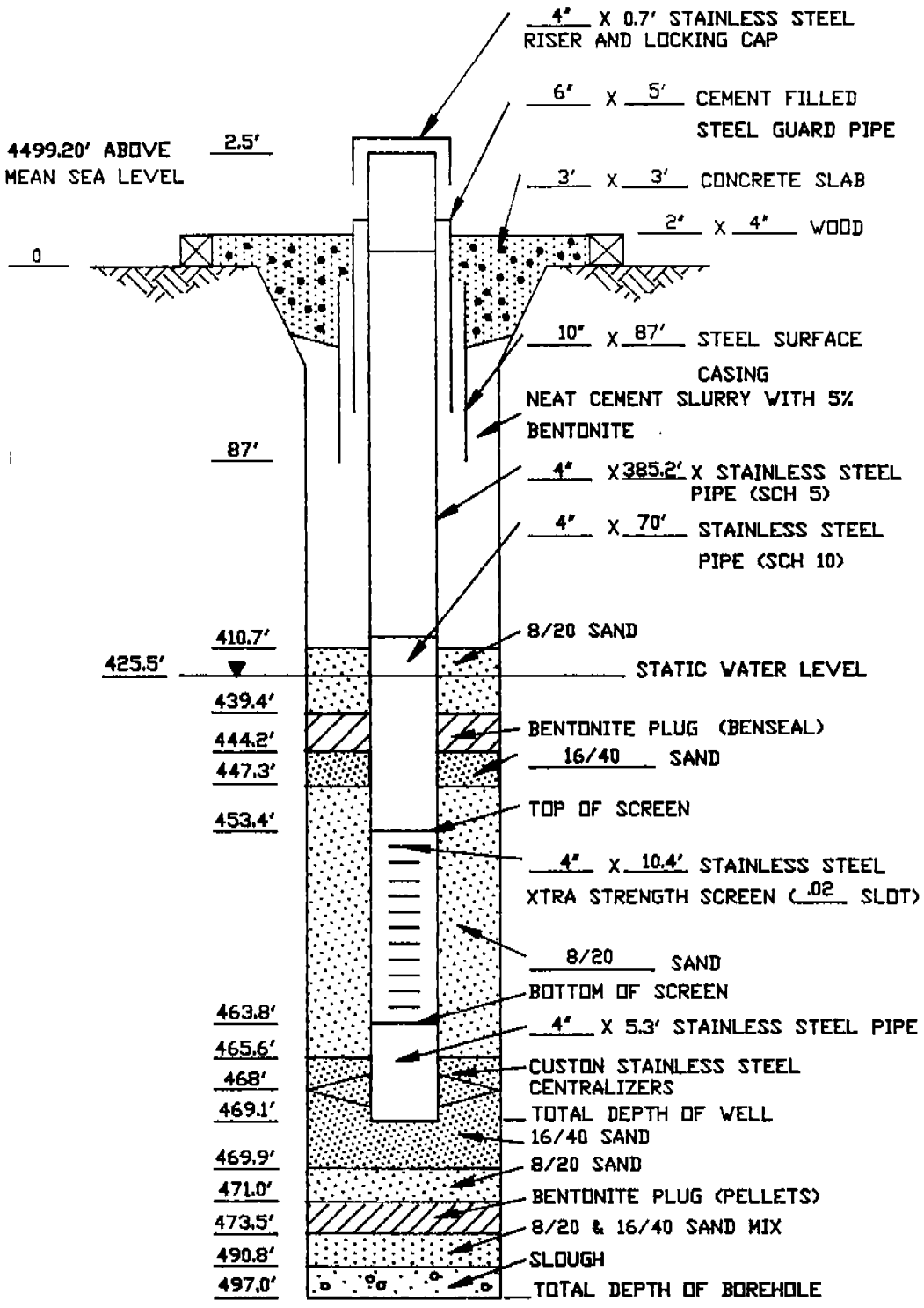
CLIENT NASA WSTF
Well Number 10 Depth 135'-0"
Elev. 4935.4 Datum Top of slab
Water Level at Completion 112'-10"
Water Level Elevation
NE¼ SE ¼ NE ¼ Sec. 35 T 20S R 3E
County Dona Ana State NM
Driller Larjon
Drilling Method Rotary Air
Drilling Fluid(s) Versafoam
Compl. Method Gravel Pack
Surface Casing Type 6" steel
I.D. O.D. Depth 5'
Inner Casing Type Sch. 80 PVC/stainless
I.D. 2" O.D. Depth
Screen Type Stainless Steel .01" slot
Screened From 110'-0" to 130'-0"



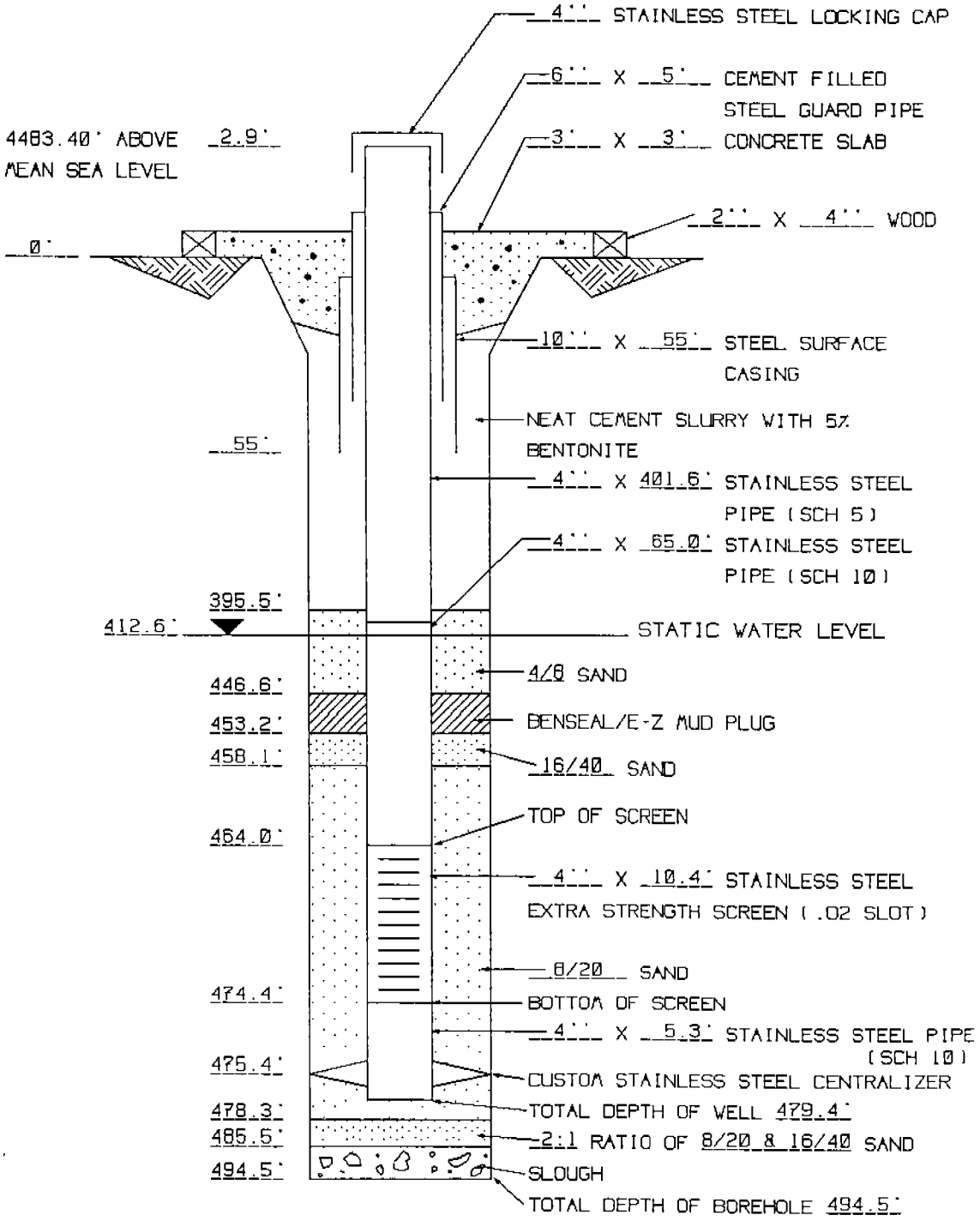
MONITOR WELL PL-1-486 COMPLETION DIAGRAM



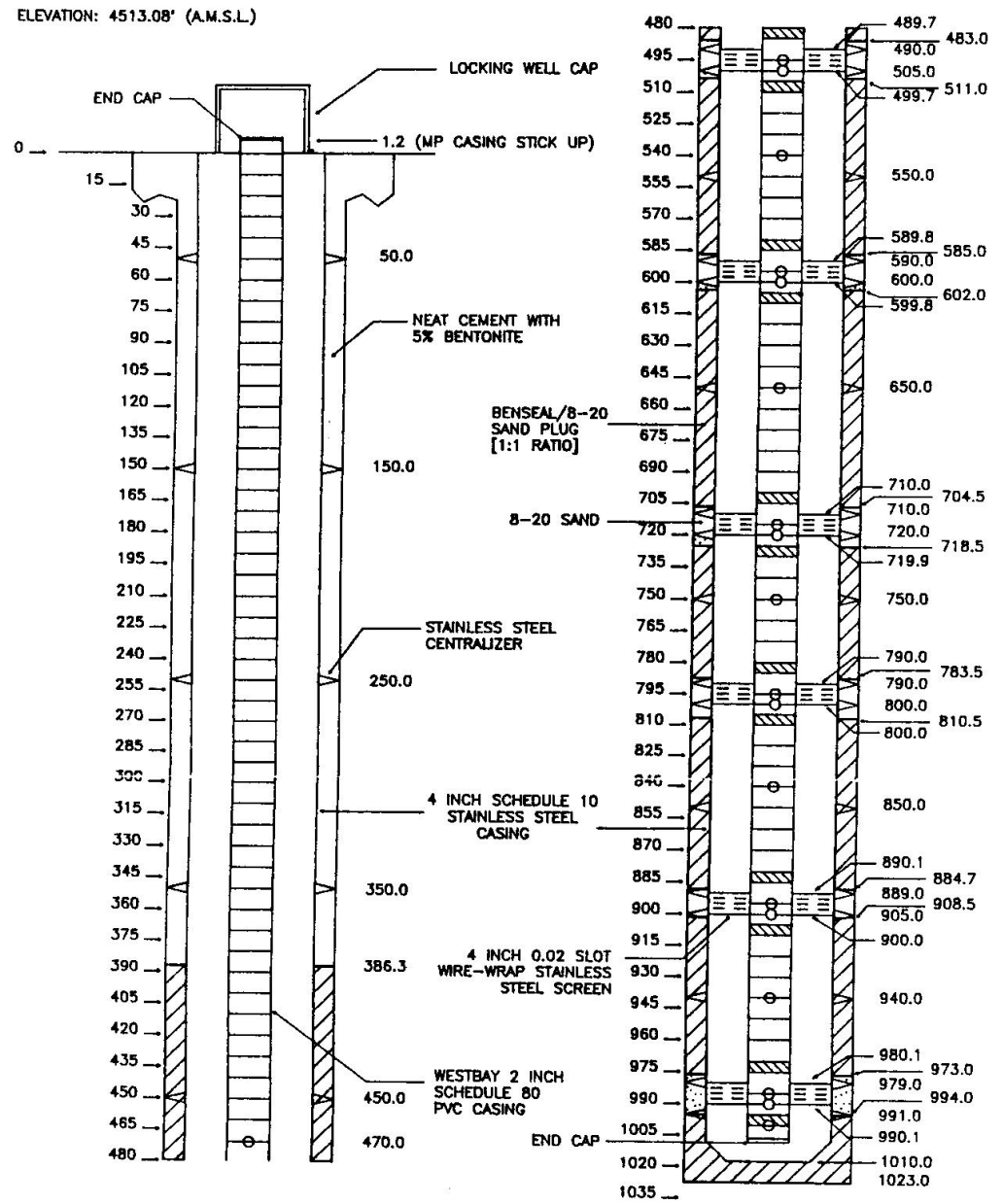
MONITOR WELL PL-2-504 COMPLETION DIAGRAM



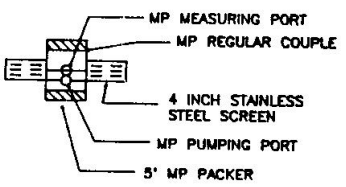
MONITOR WELL PL-3-453 COMPLETION DIAGRAM



MONITOR WELL PL-4-464 COMPLETION DIAGRAM

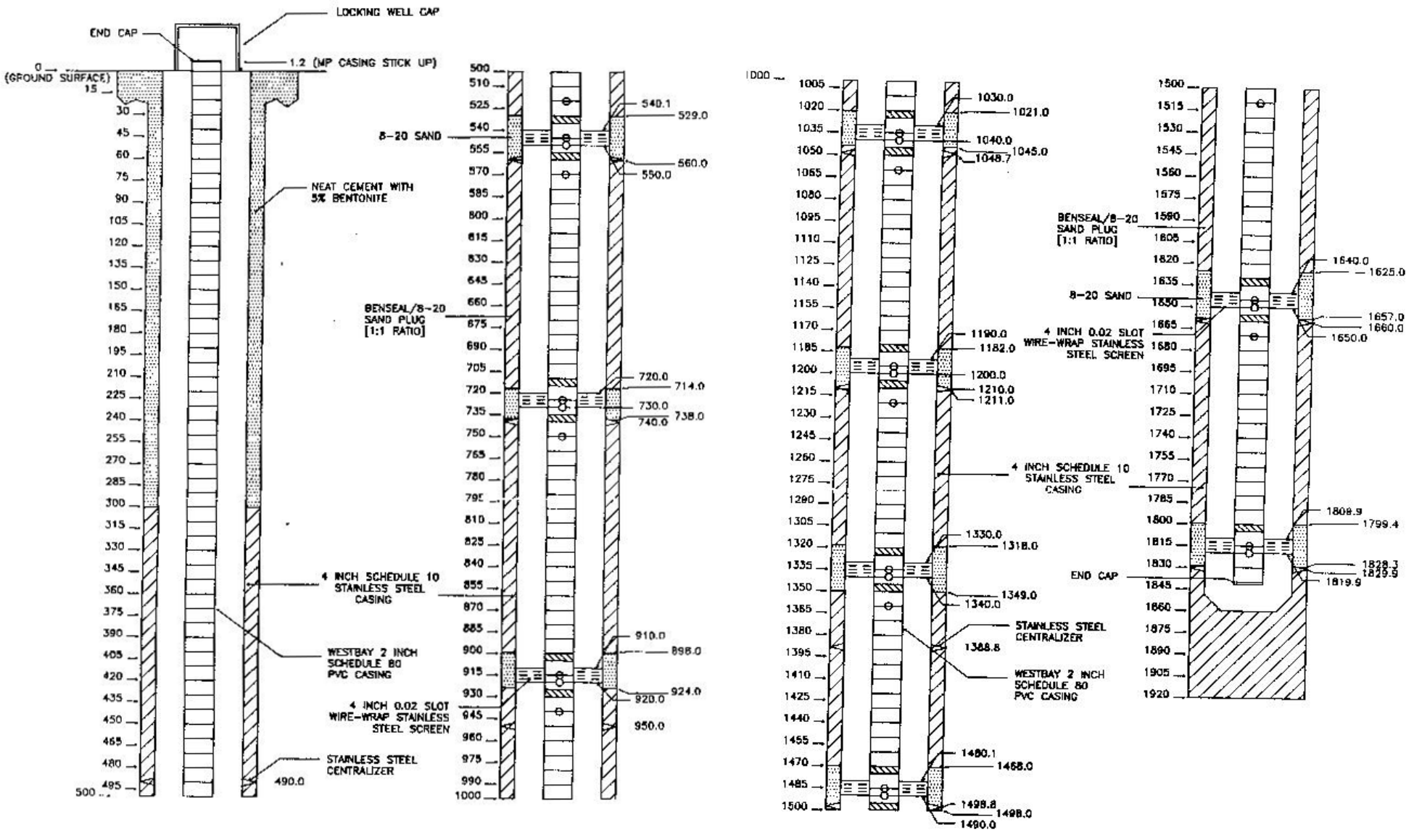


LEGEND

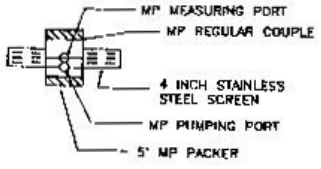


NOTE: ALL UNITS ARE IN FEET

Monitor Well PL-5 Completion Diagram

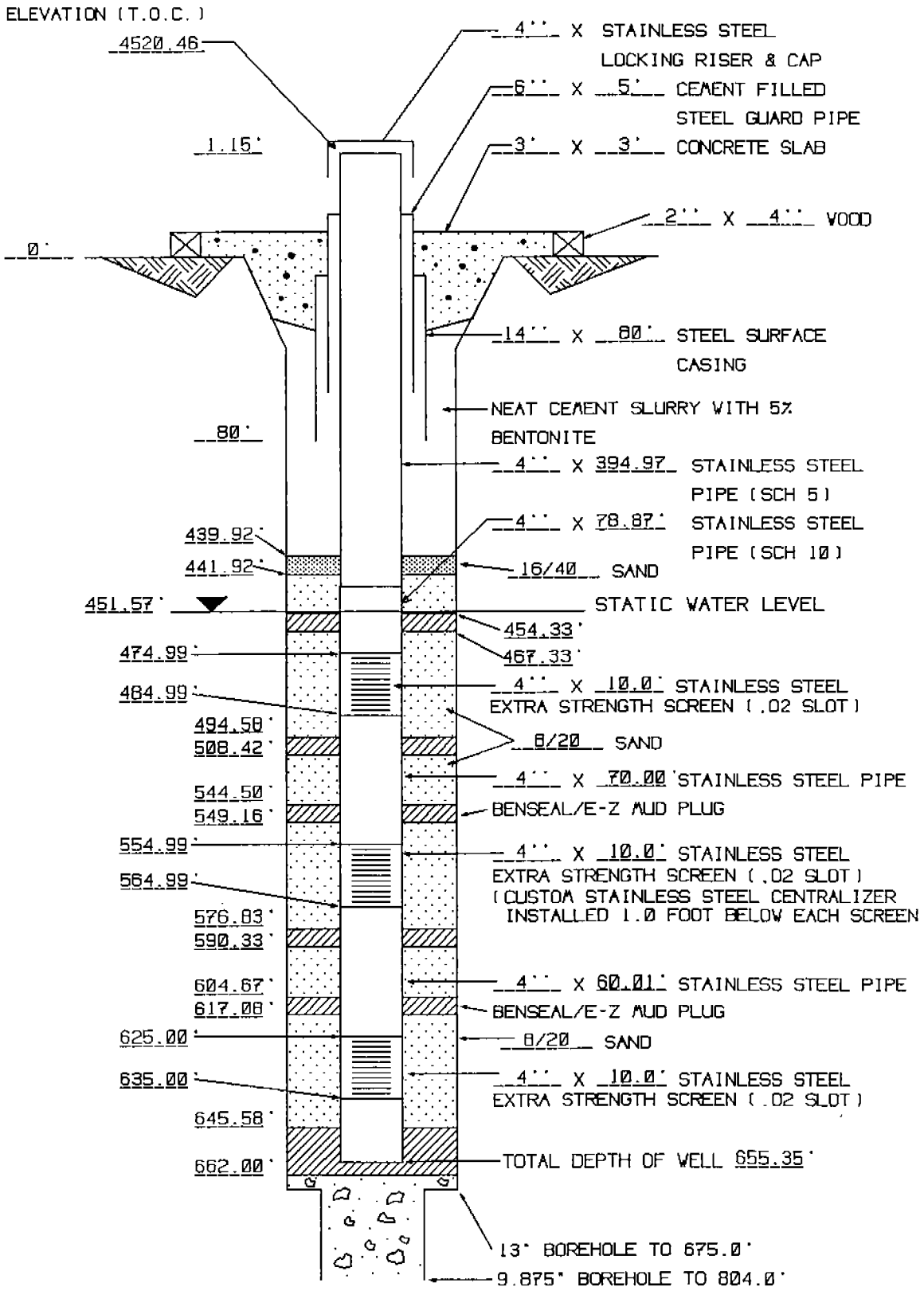


LEGEND

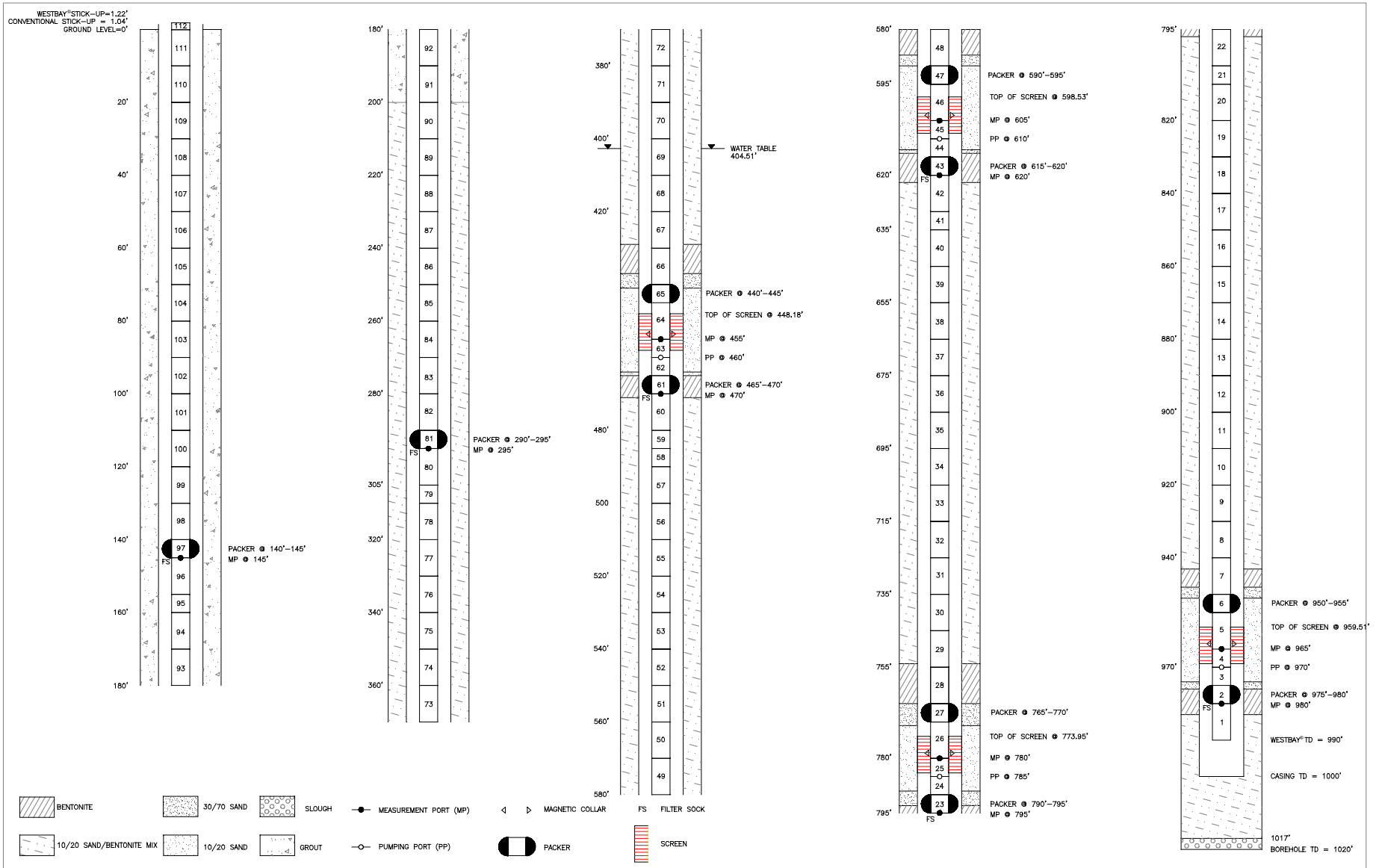


NOTE: ALL UNITS ARE IN FEET

Monitor Well PL-6-B Completion Diagram

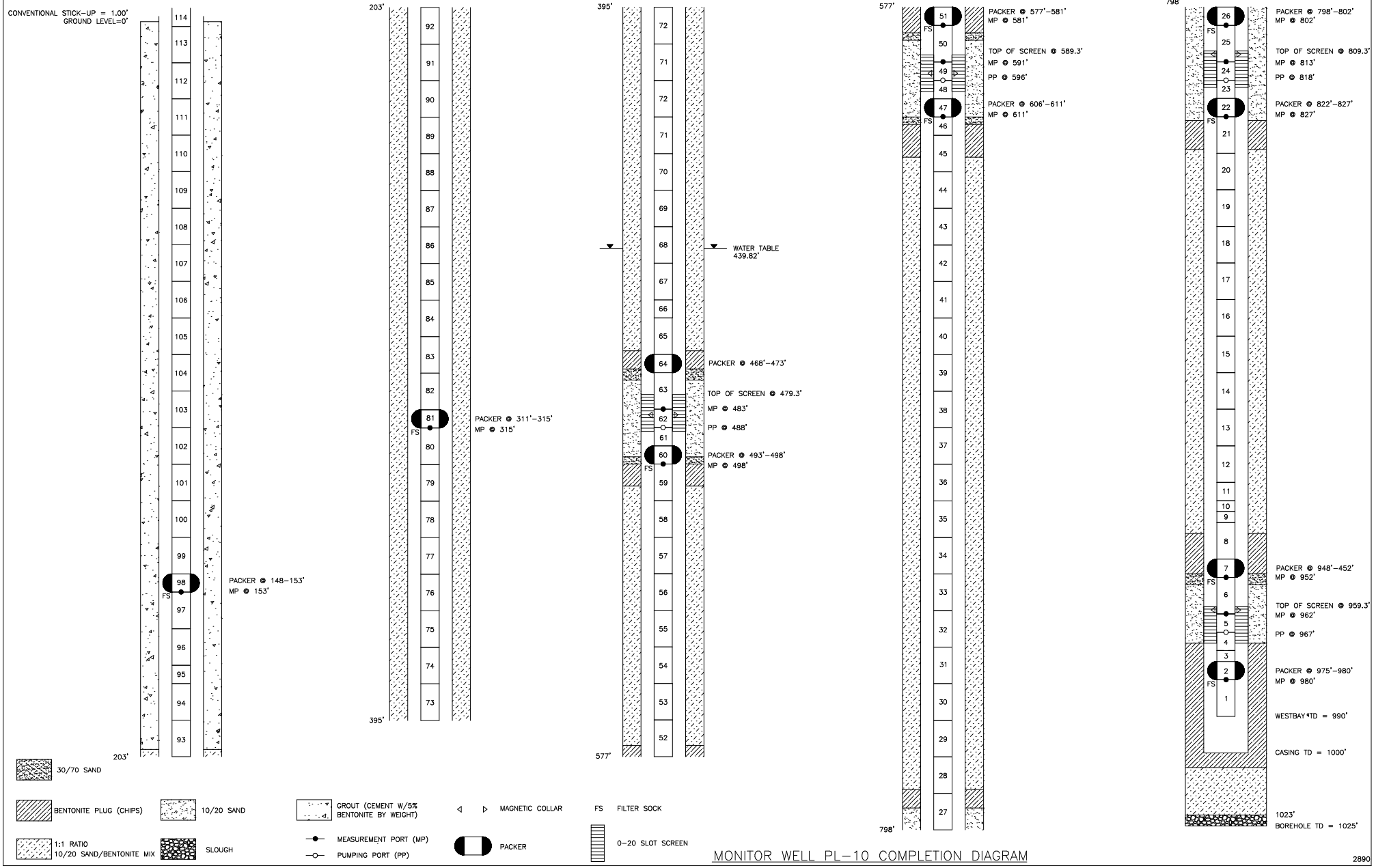


MONITOR WELL PL-7 COMPLETION DIAGRAM



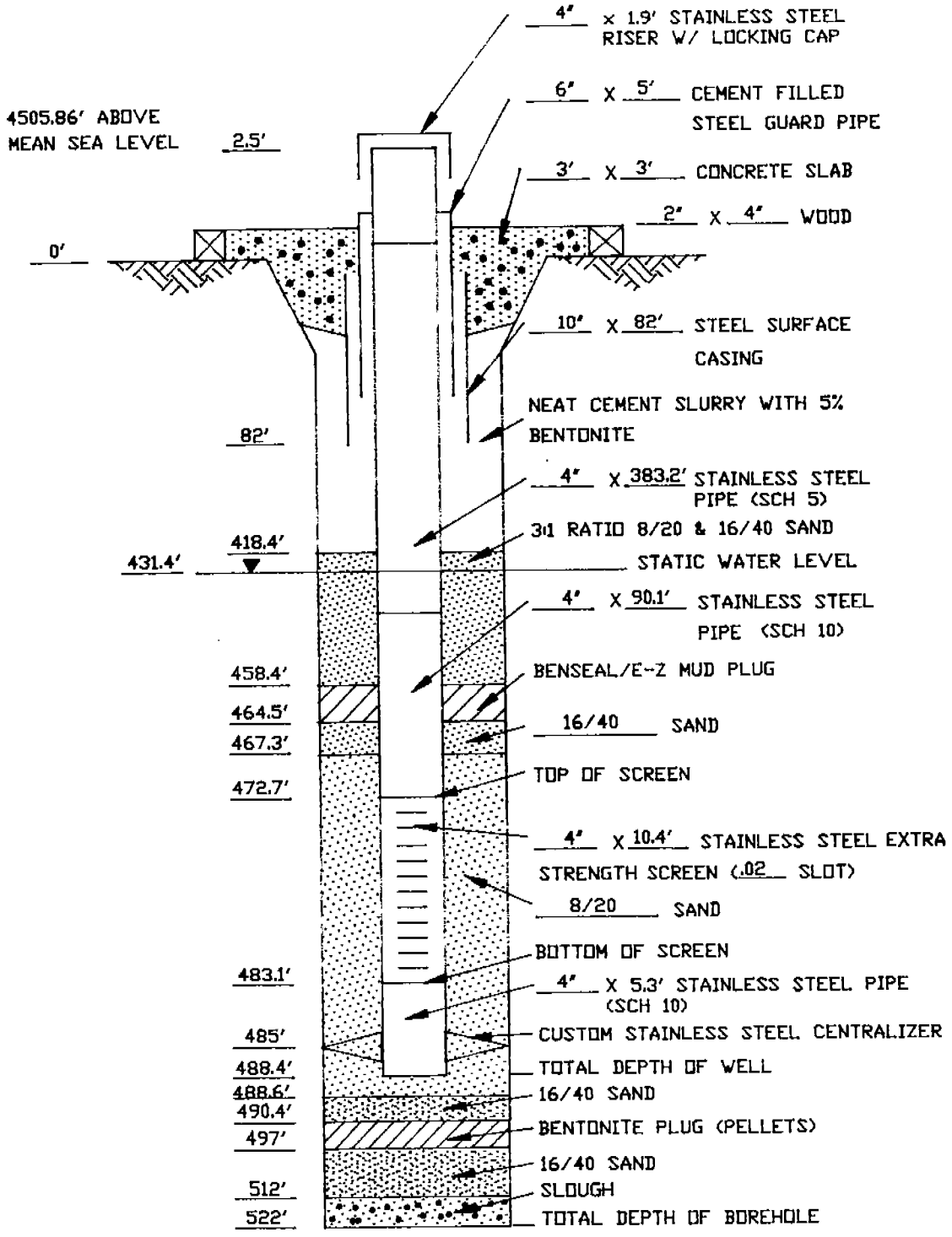
MONITOR WELL PL-8 COMPLETION DIAGRAM

2890

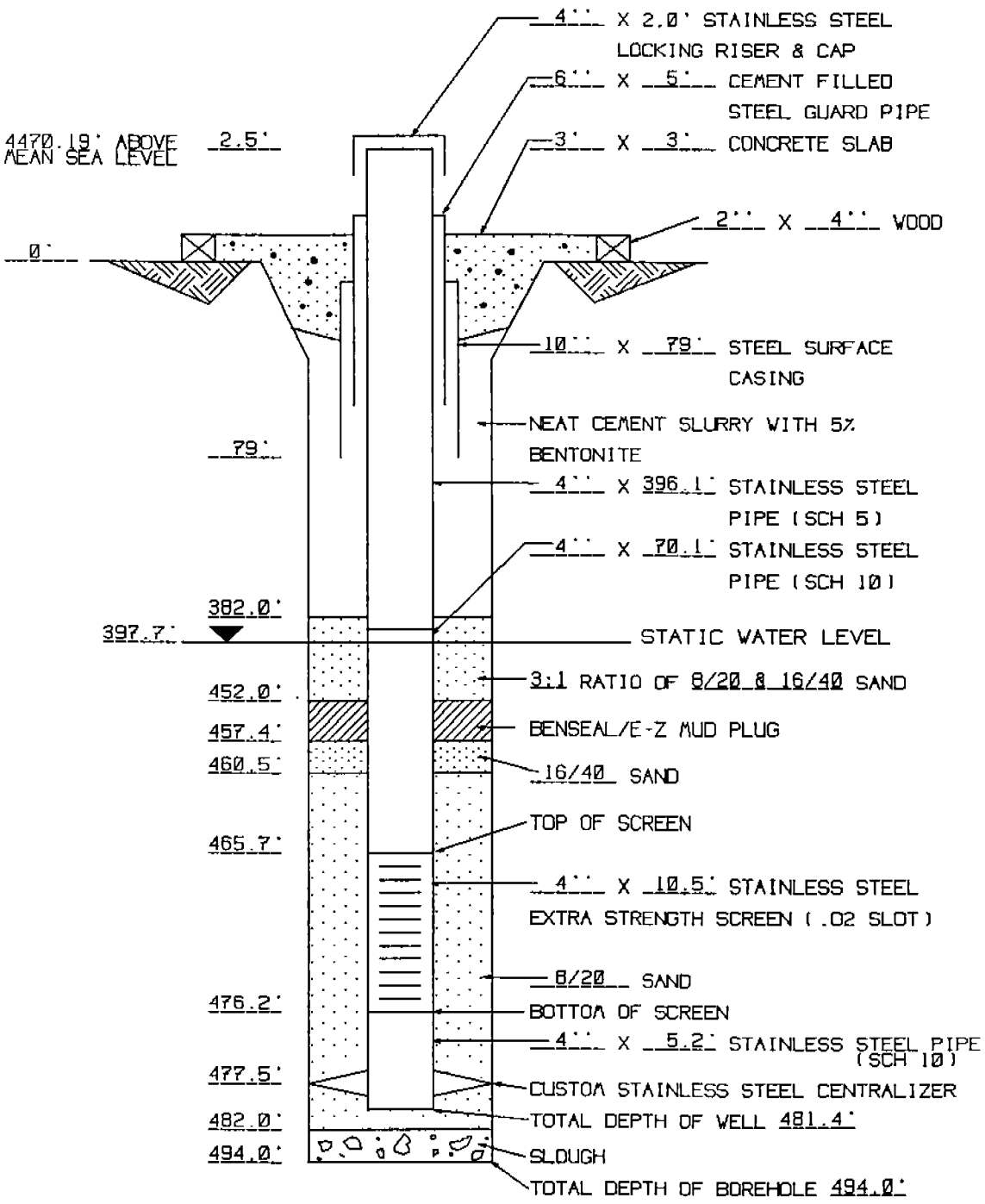


MONITOR WELL PL-10 COMPLETION DIAGRAM

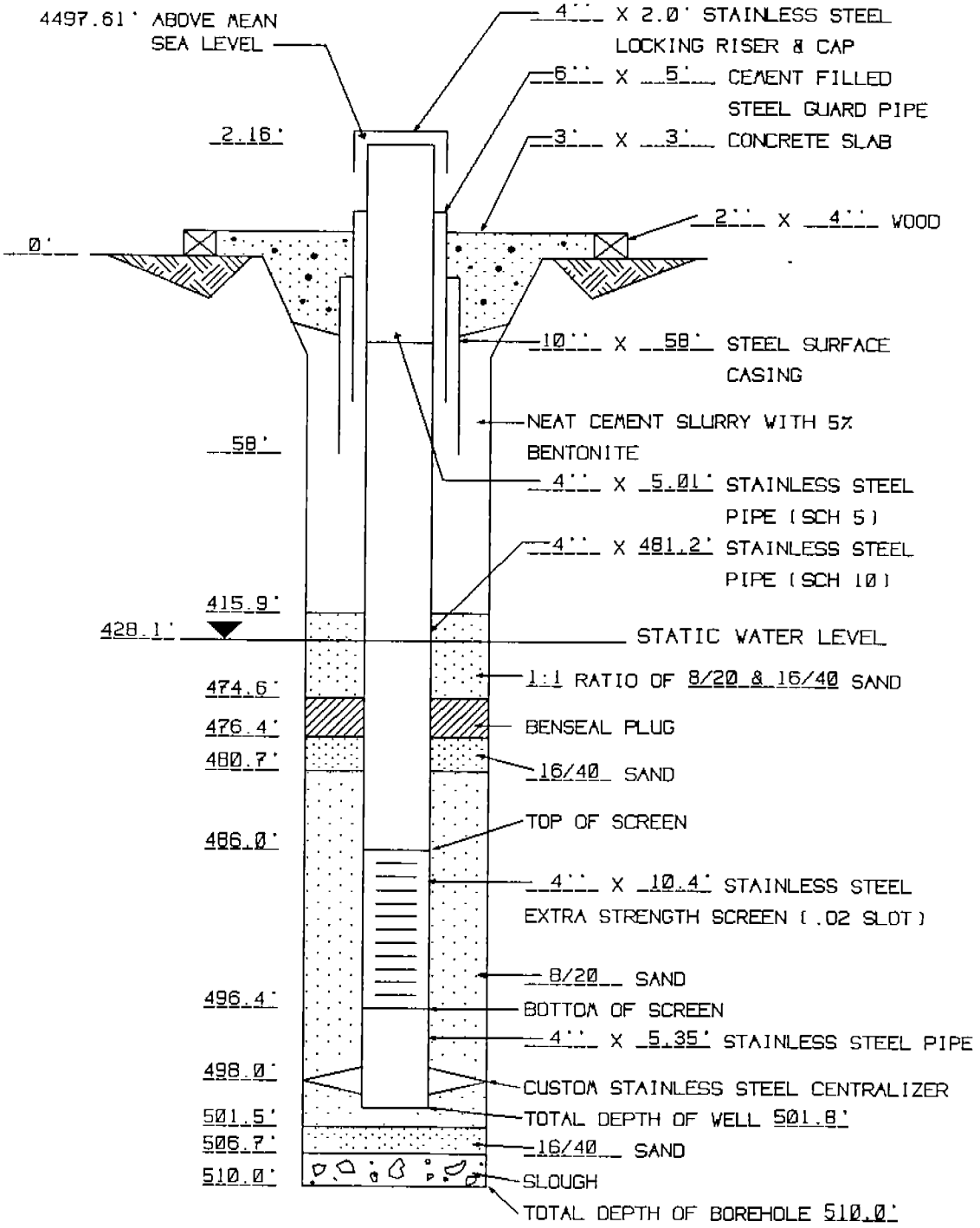
2890



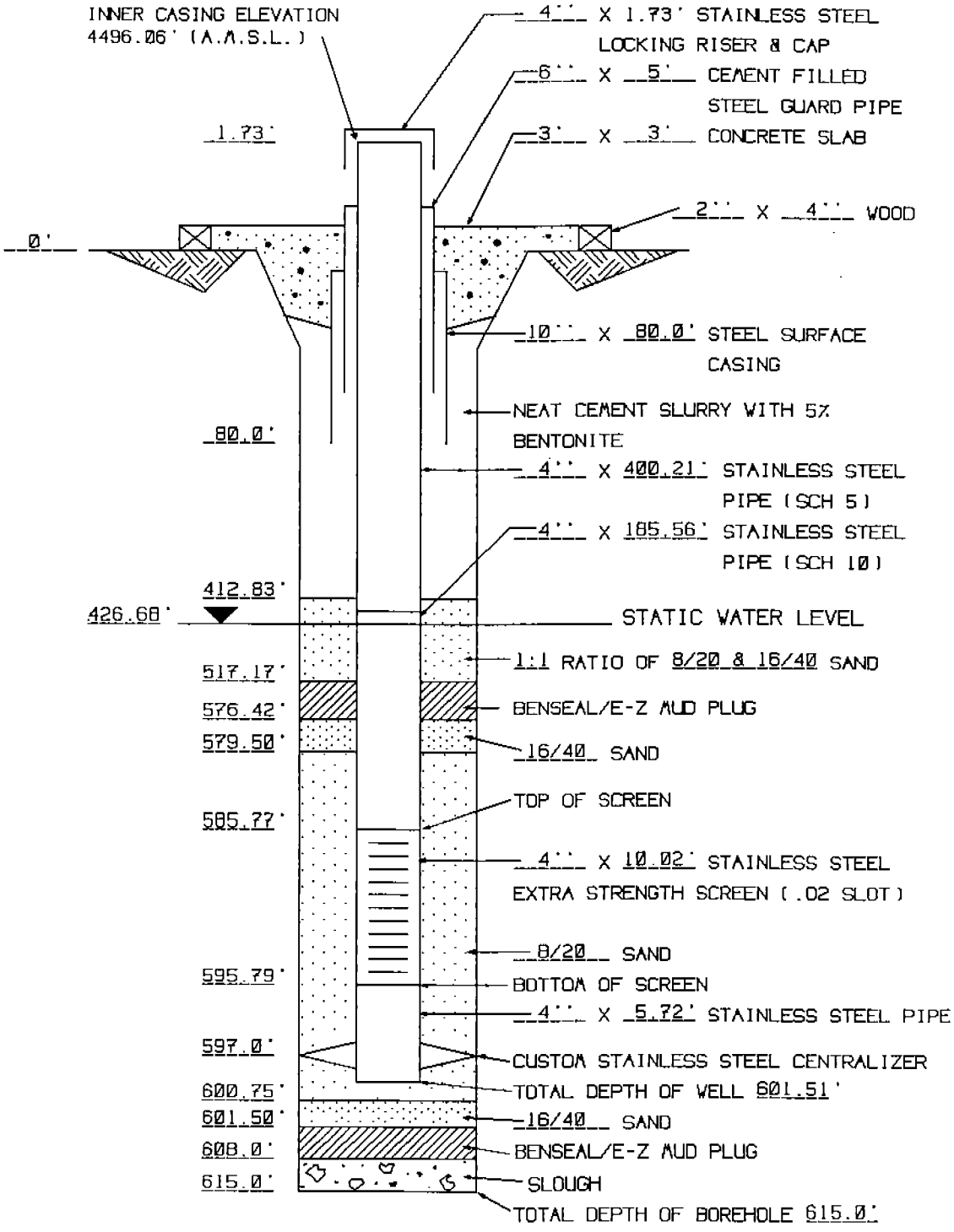
MONITOR WELL ST-1-473 COMPLETION DIAGRAM



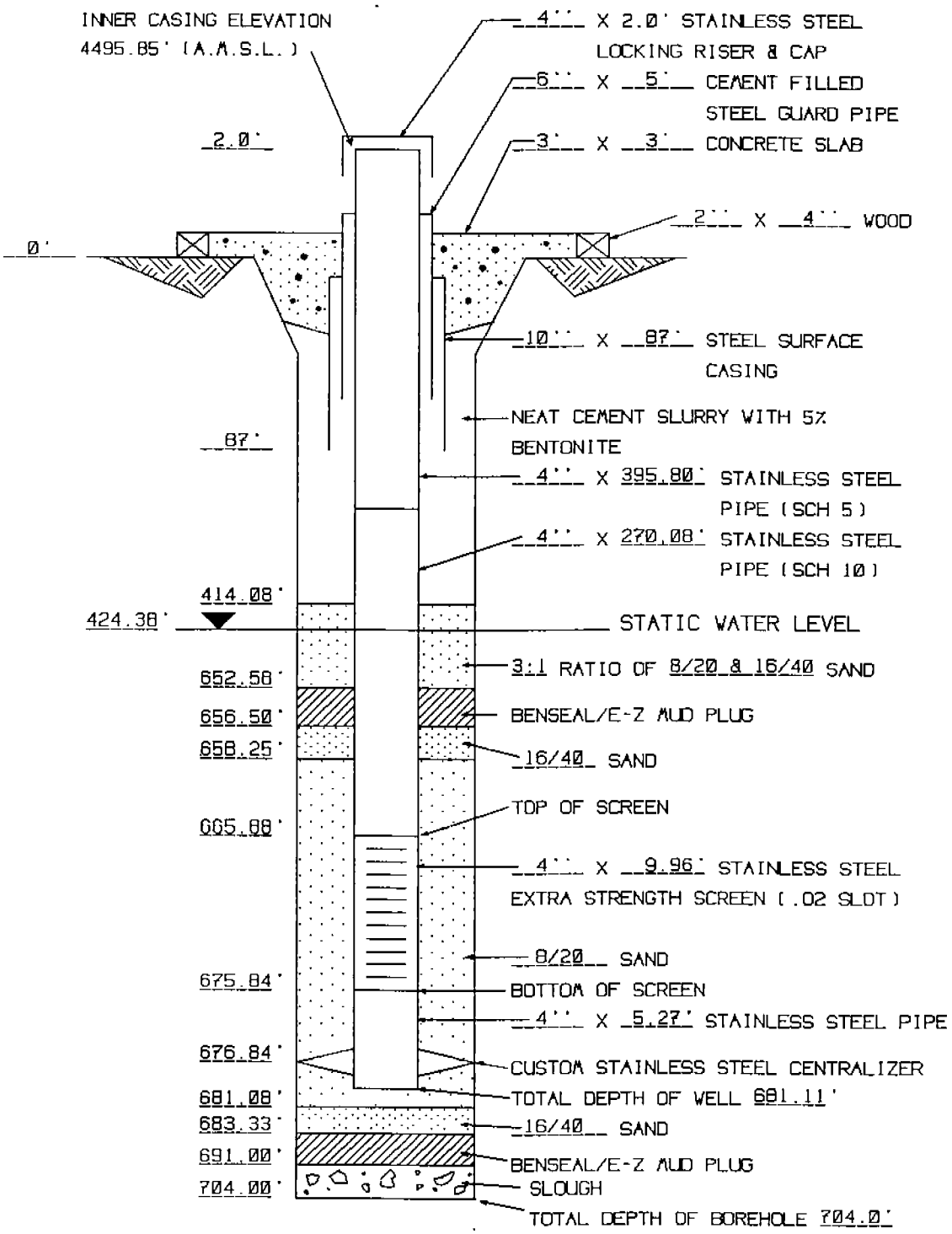
MONITOR WELL ST-2-466 COMPLETION DIAGRAM



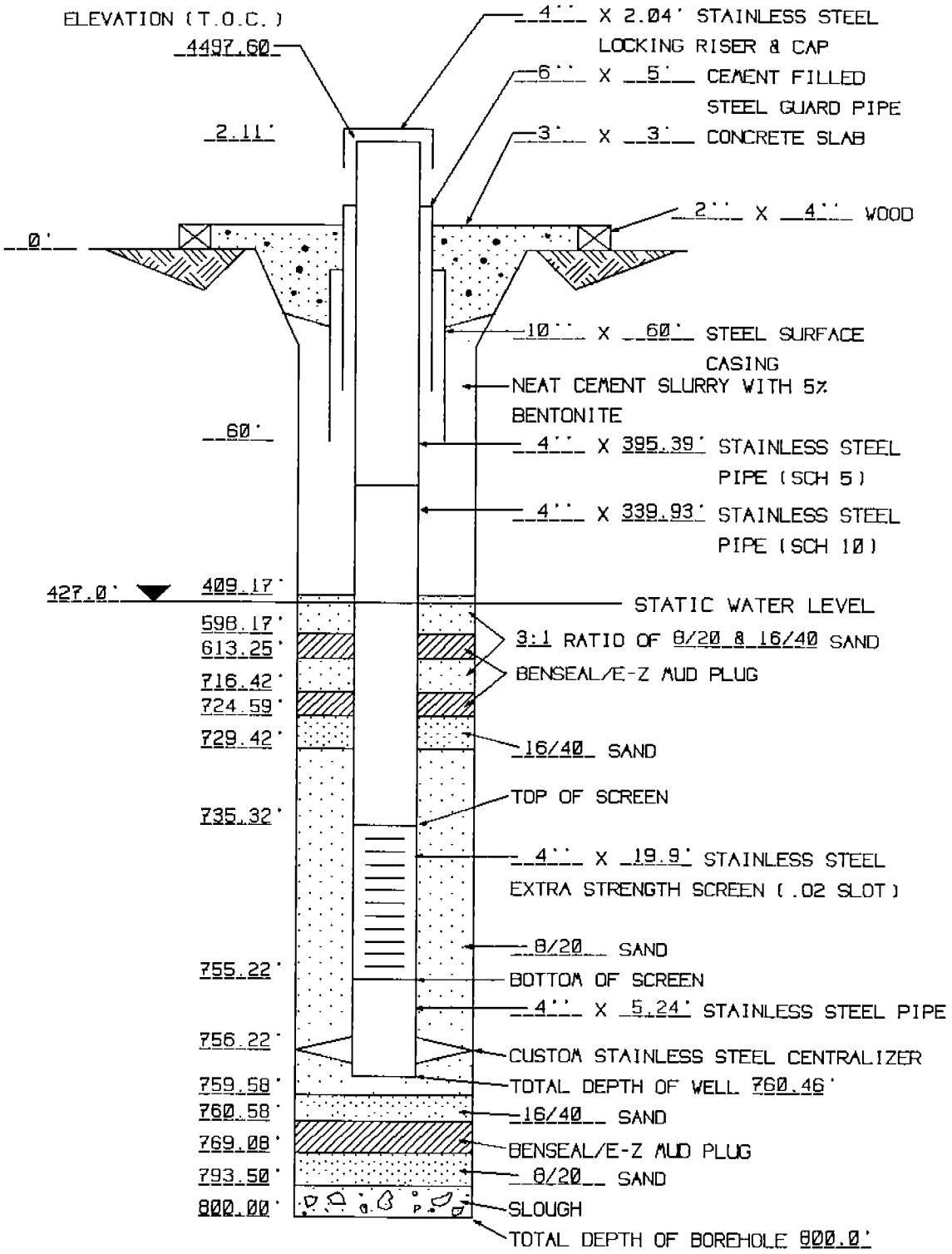
MONITOR WELL ST-3-486 COMPLETION DIAGRAM



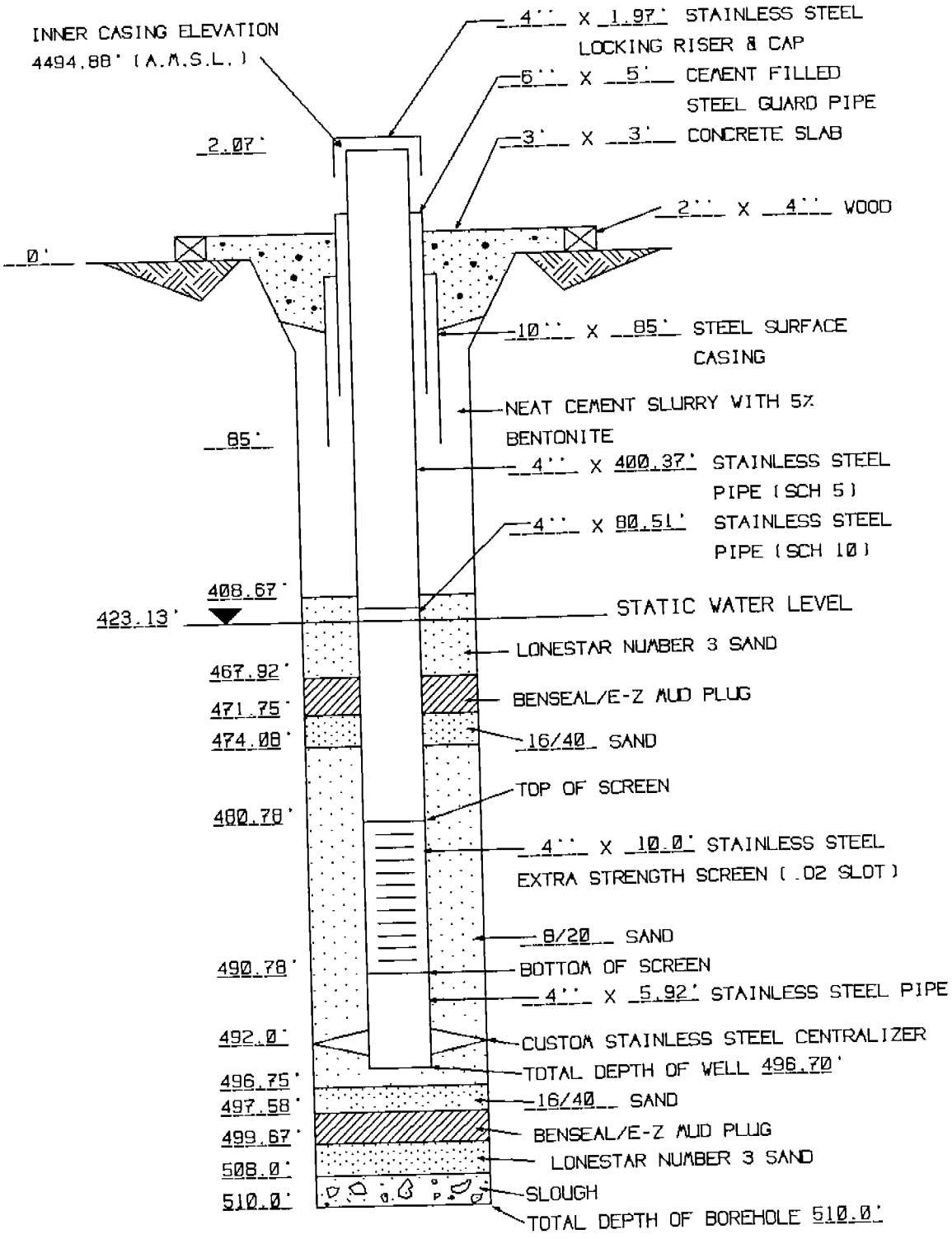
MONITOR WELL ST-3-586 COMPLETION DIAGRAM



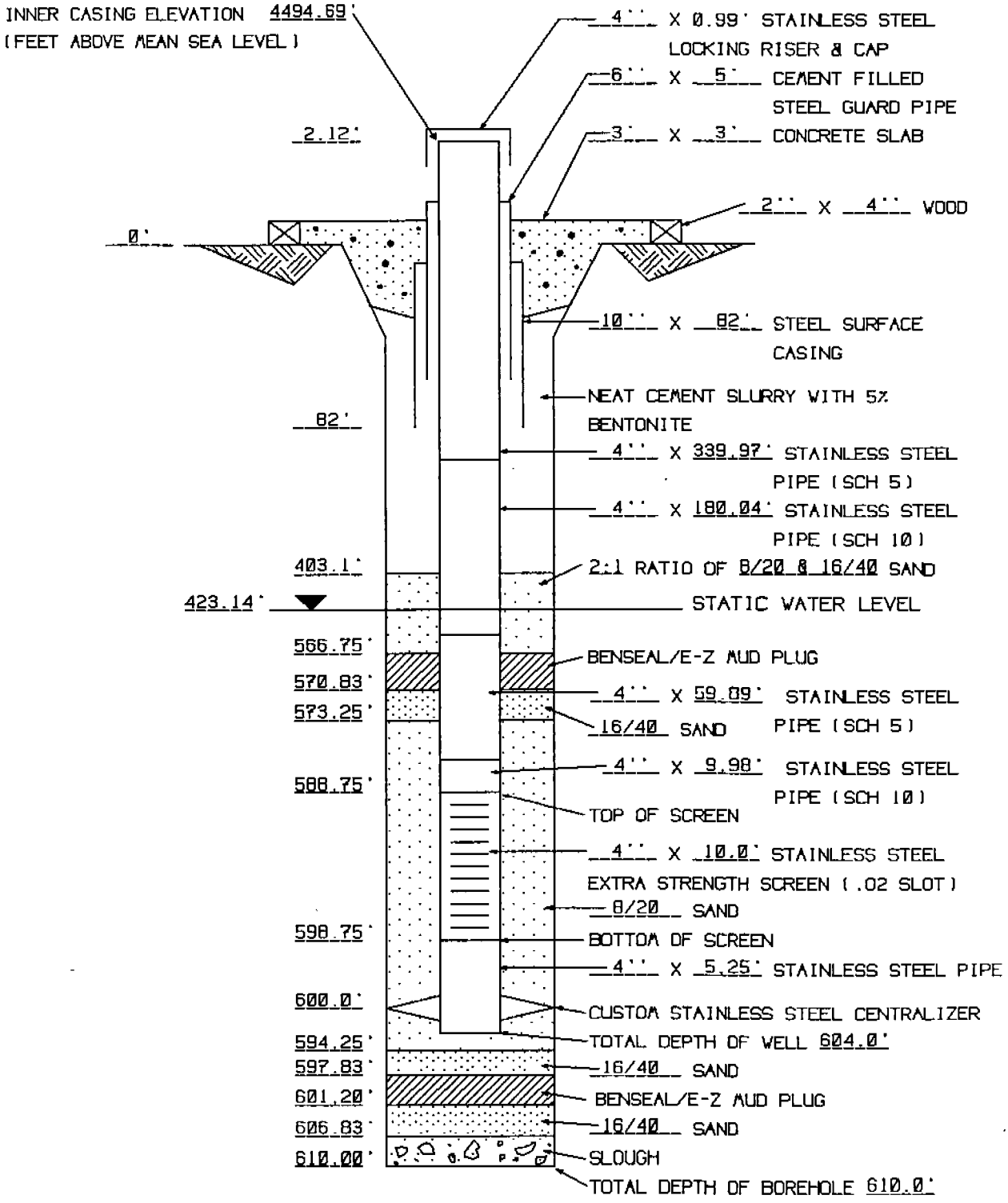
MONITOR WELL ST-3-666 COMPLETION DIAGRAM



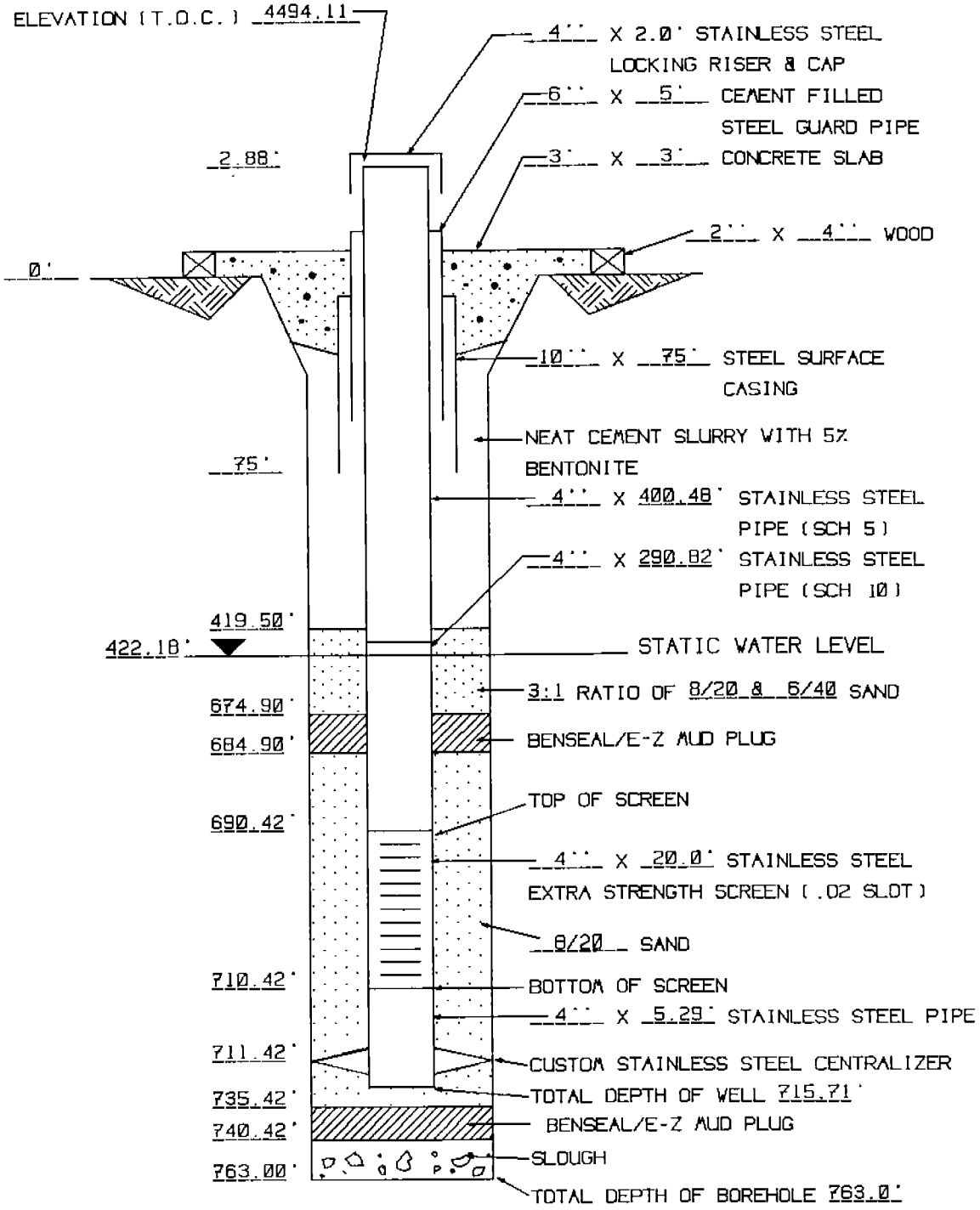
MONITOR WELL ST-3-735 COMPLETION DIAGRAM



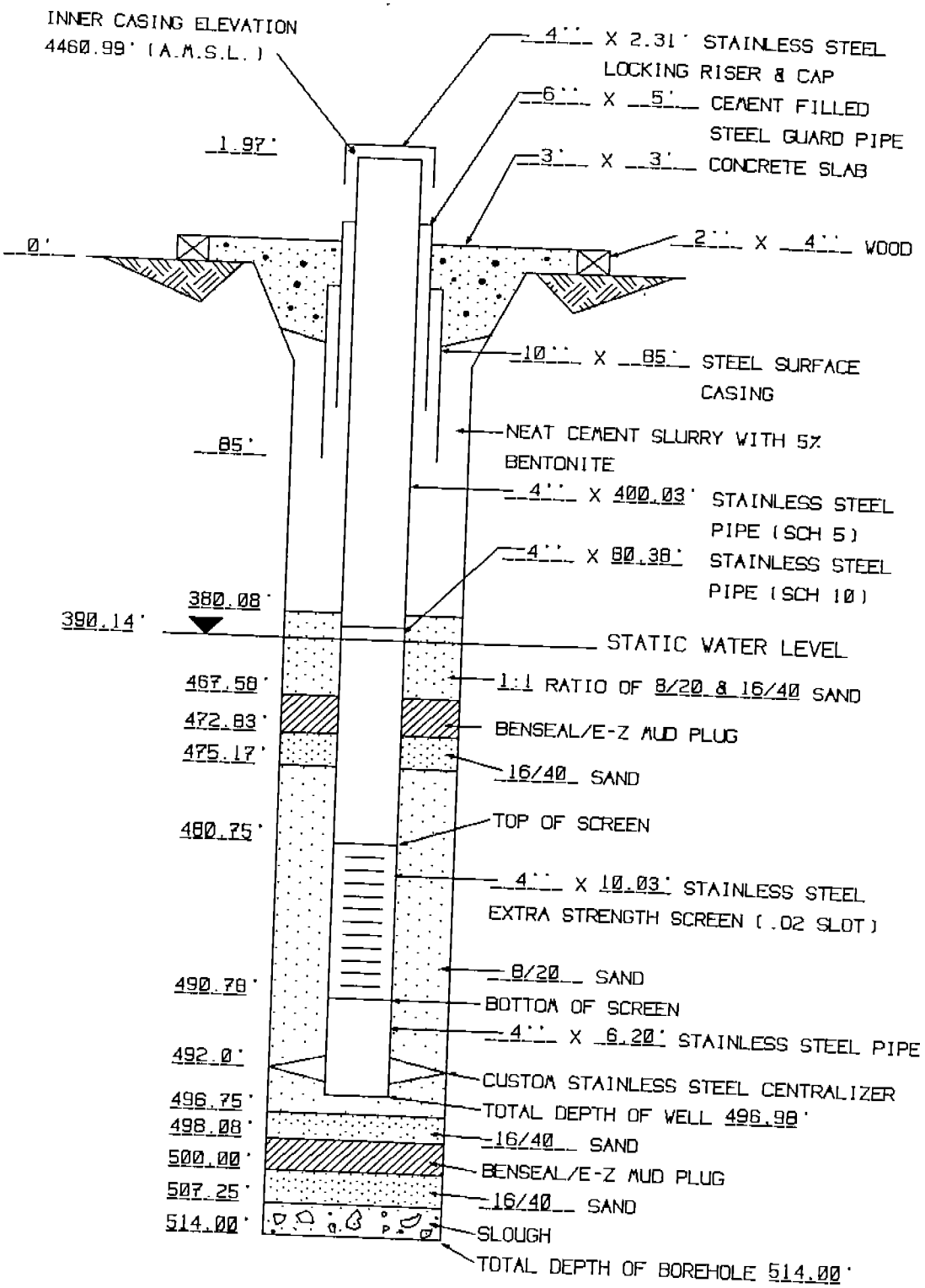
MONITOR WELL ST-4-481 COMPLETION DIAGRAM



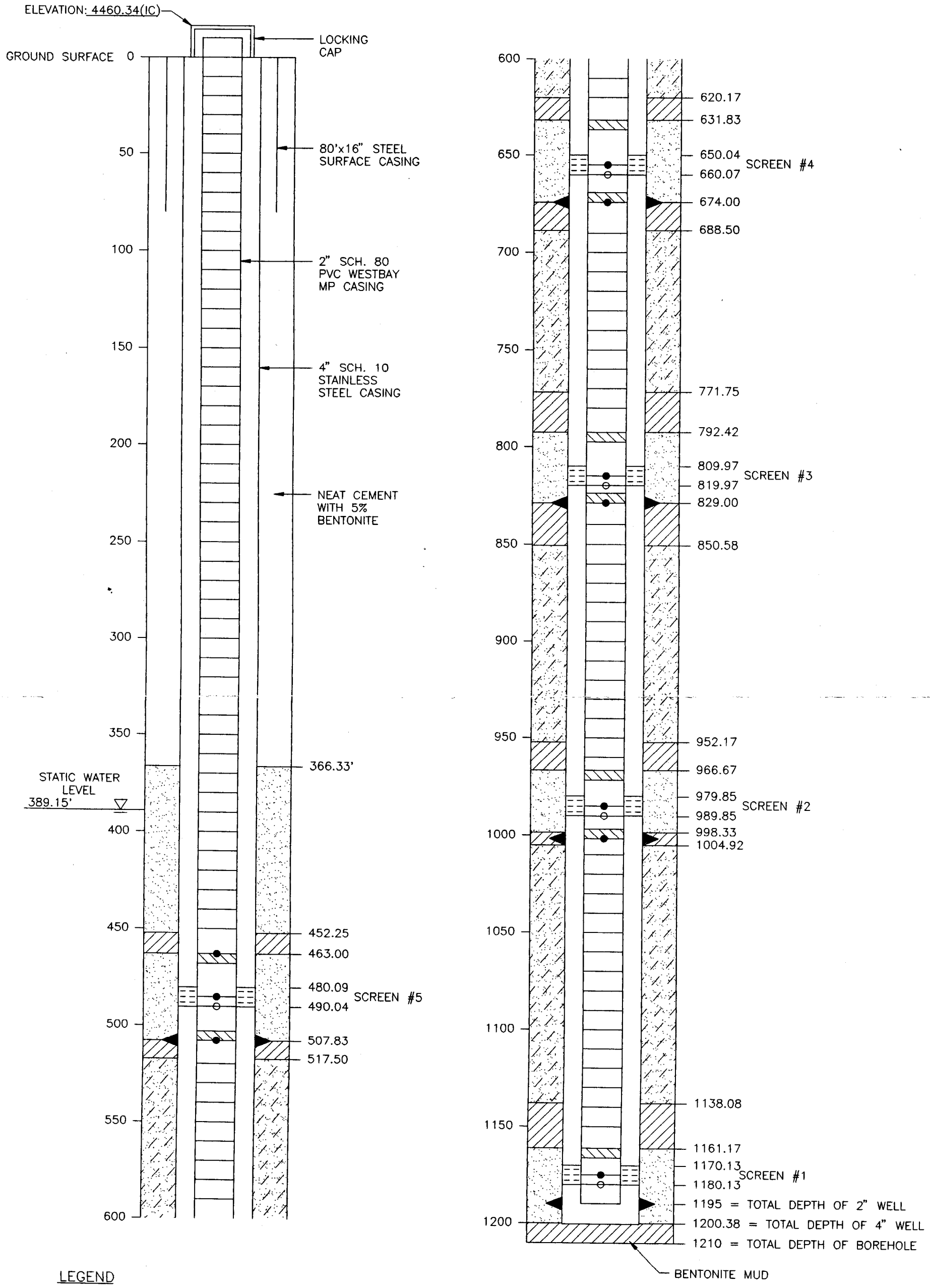
MONITOR WELL ST-4-589 COMPLETION



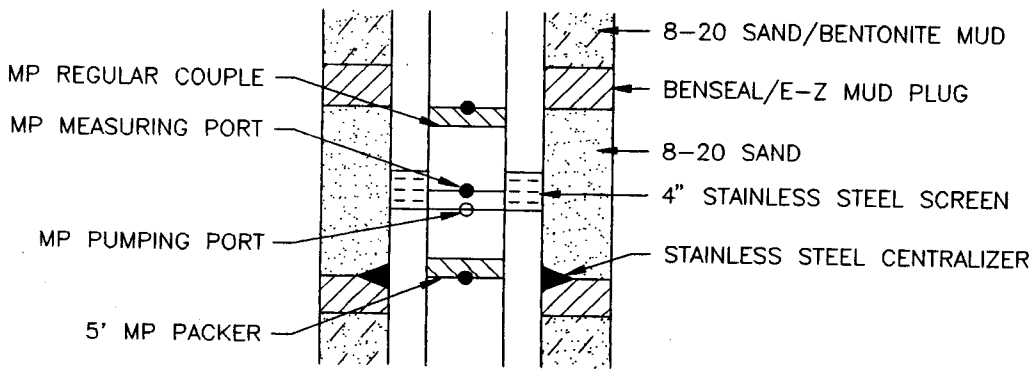
MONITOR WELL ST-4-690 COMPLETION DIAGRAM



MONITOR WELL ST-5-481 COMPLETION DIAGRAM



LEGEND

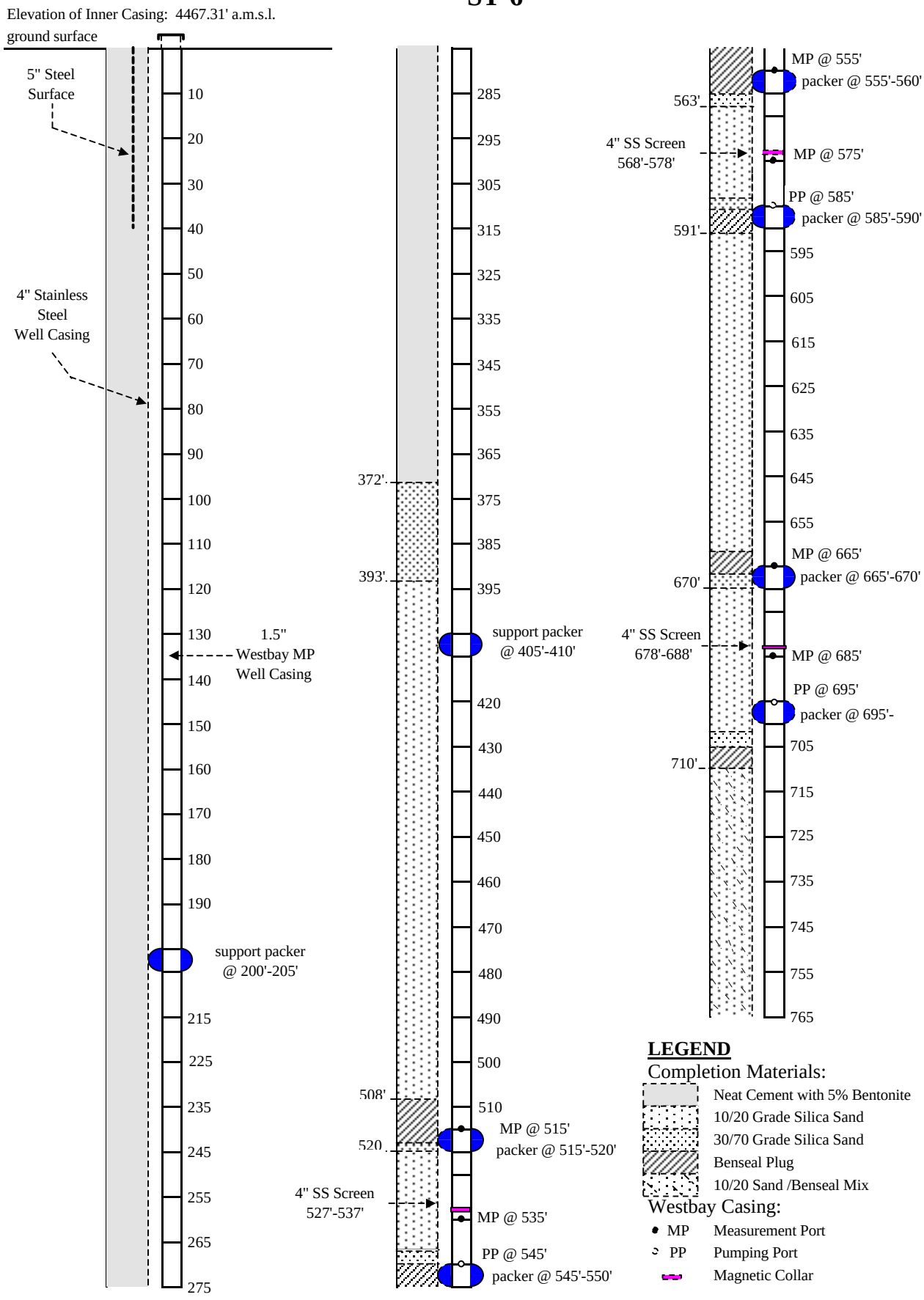


NOTE: ALL UNITS ARE FEET

ST-5-D WELL COMPLETION DIAGRAM

CLIENT: NASA-WSTF	
AUTHOR: PE	DATE: 5-27-93
DRAWN BY: JTN	REV. NO.: 1
CHECKED BY: PE	FILE: \NASA\ST-5-DCD.DWG

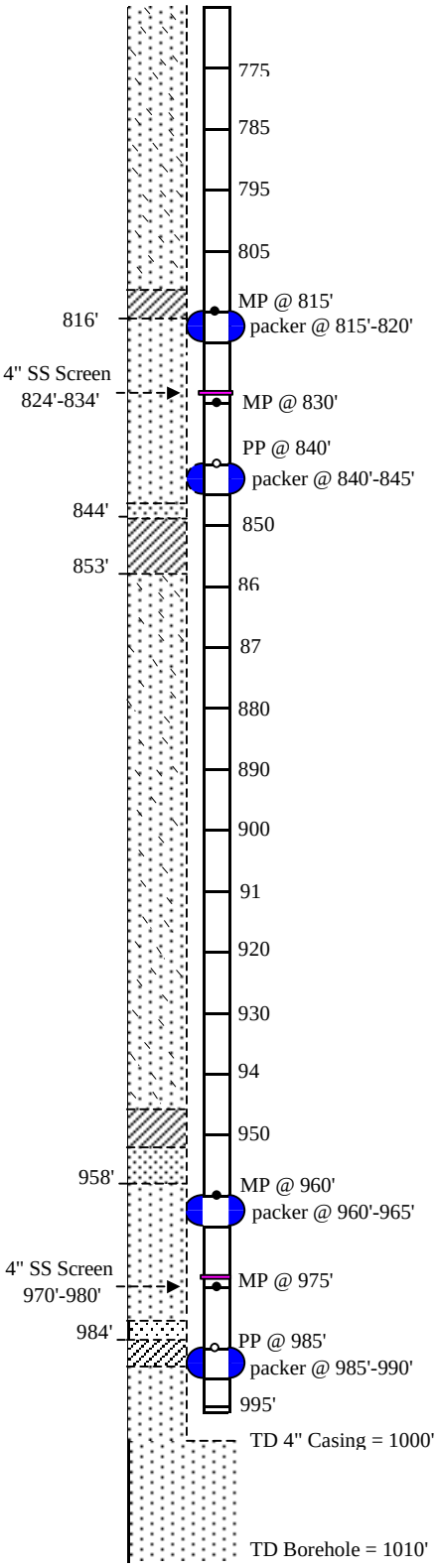
WESTBAY WELL COMPLETION DIAGRAM
ST-6



Installation Date: 10/5/97
Installed By: ATSC
Elevation (BC): 4465.72' a.m.s.l.

Drawn/Checked By: PSE/MGC
Borehole Depth: 1010'
MP Depth: 995'

WESTBAY WELL COMPLETION DIAGRAM
ST-6



LEGEND:

Completion Materials:

- Neat Cement with 5% Bentonite
- 10/20 Grade Silica Sand
- 30/70 Grade Silica Sand
- Benseal Plug
- 10/20 Sand and Benseal Mix

Westbay Casing:

- MP — Measurement Port
- PP — Pumping Port
- Magnetic Collar

NOTES:

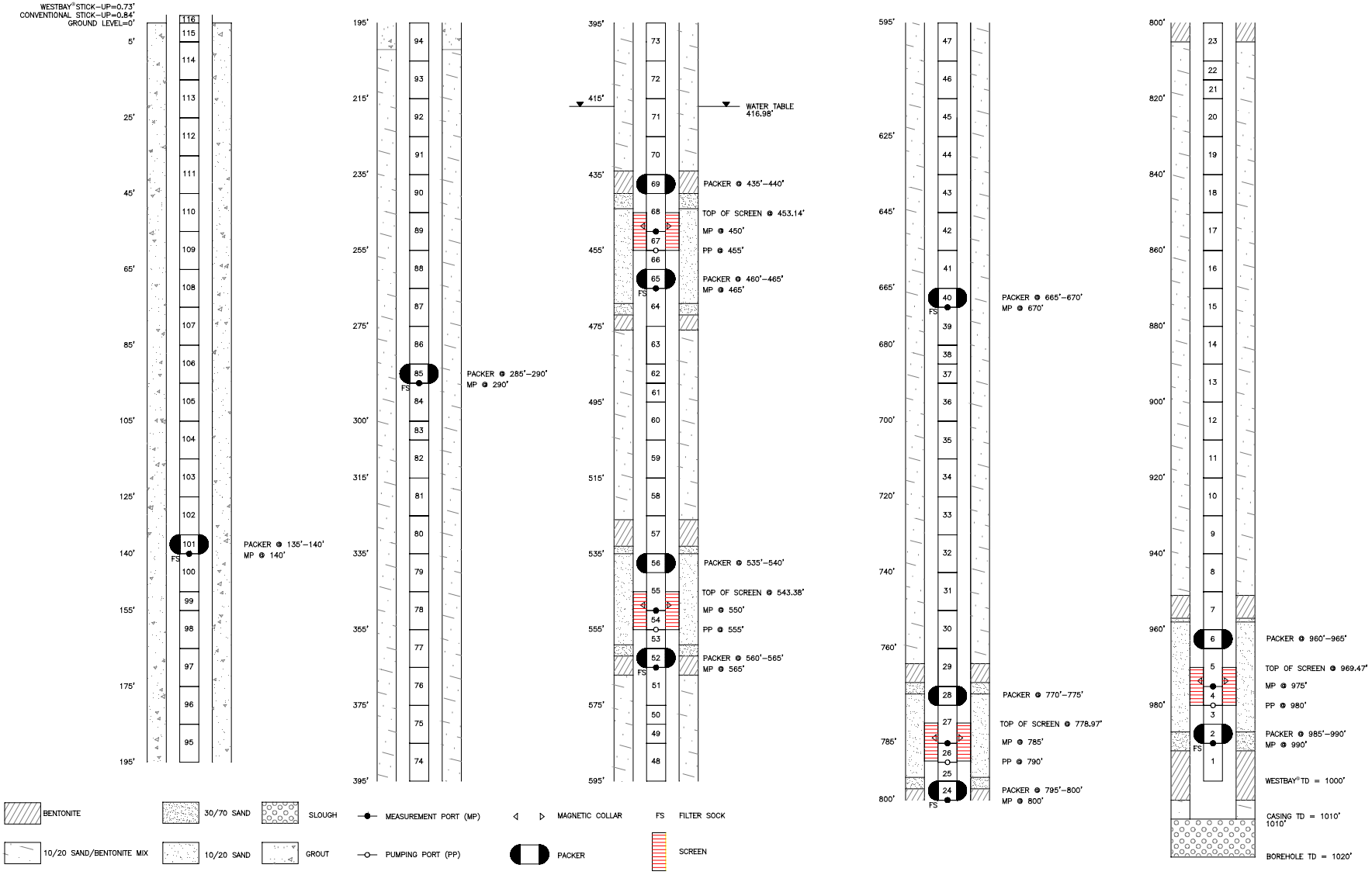
Westbay system is installed within 4" stainless steel casing

All MPs within sample zones have filter socks.

All couplings tested at @ 150 psi for one minute during installation

Installation Date: 10/5/97
Installed By: ATSC
Elevation (BC): 4465.72' a.m.s.l.

Drawn/Checked By: PSE/MGC
Borehole Depth: 1010'
MP Depth: 995'



MONITOR WELL ST-7 COMPLETION DIAGRAM

2887

WEST AY MP SYSTEM
CASING NSTALLATION L JG

Project: NASA-WSTF Hole No: WB-1 Location: 100 AREA

Date Installed: 04-12-90 Installed by: GC/EM/MC Date Drawn: 01-29-90

Hole Depth: 356.4' MP Depth: 355.0' Hole Diameter: 4"

Measurement Datum: Ground Level Datum Elevation: 4840.94 (BC)

Depth (ft)	Geologic Description	MP Casing Log 44	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
0	0'-105' ALLUVIUM (Santa Fe Group)	43			All couples tested to 100 psi for 1 minute (SEE ATTACHED SHEET(S) FOR COMPLETION DETAIL)	√	√
10		42				√	√
20		41				√	√
30		40				√	√
40		39				√	√
50		38				√	√
60		37				√	√
70		36				√	√
80		35				√	√
90		34				√	√
100							√

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

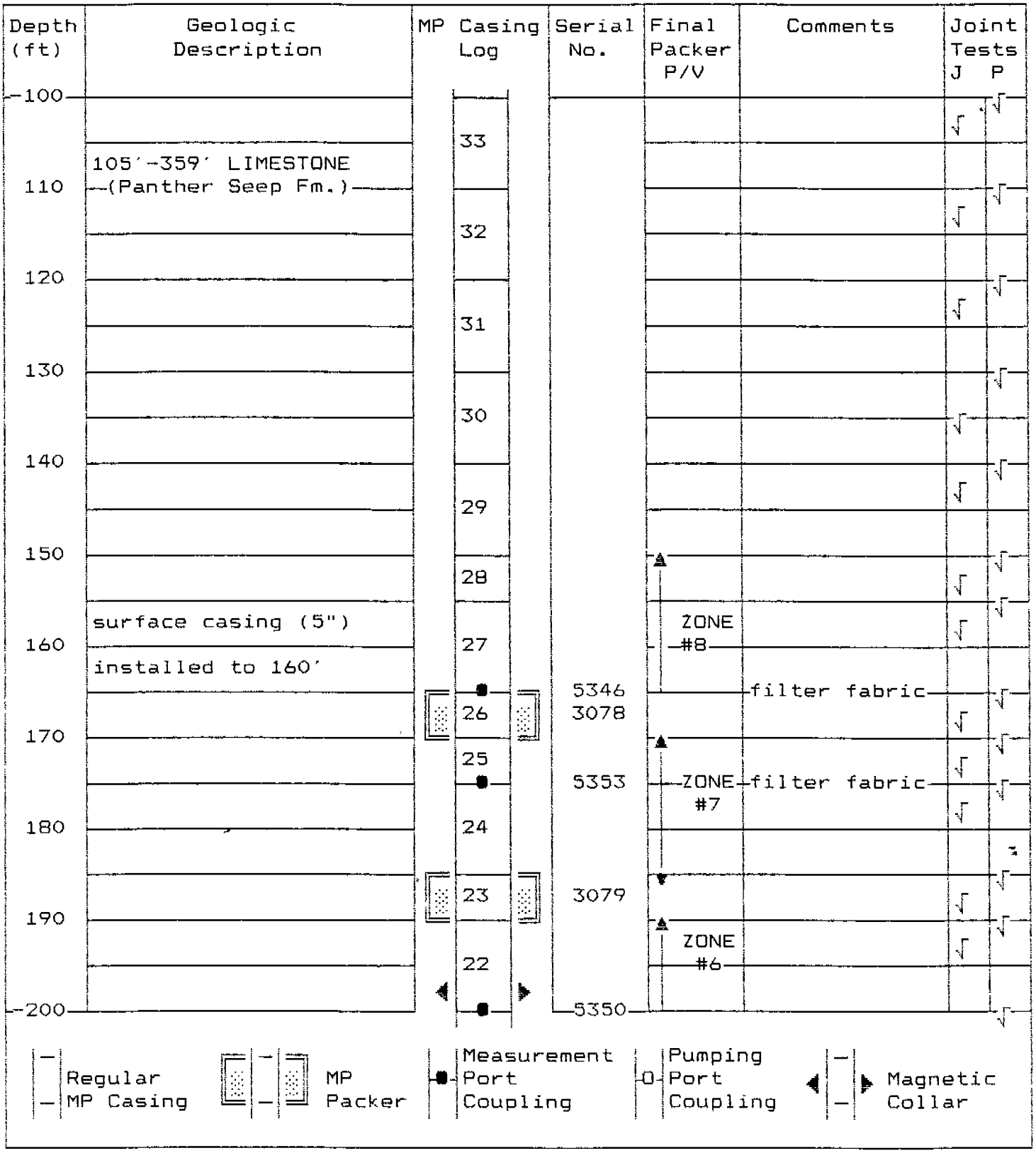
C:\FORMTOOL\PSE\WB\WB-1(1)

WEST AY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: WB-1 Location: 100 AREA

Date Installed: 04-12-90 Installed by: GC/EM/MC Date Drawn: 01-29-90

Hole Depth: 356.4' MP Depth: 355.0' Hole Diameter: 4"



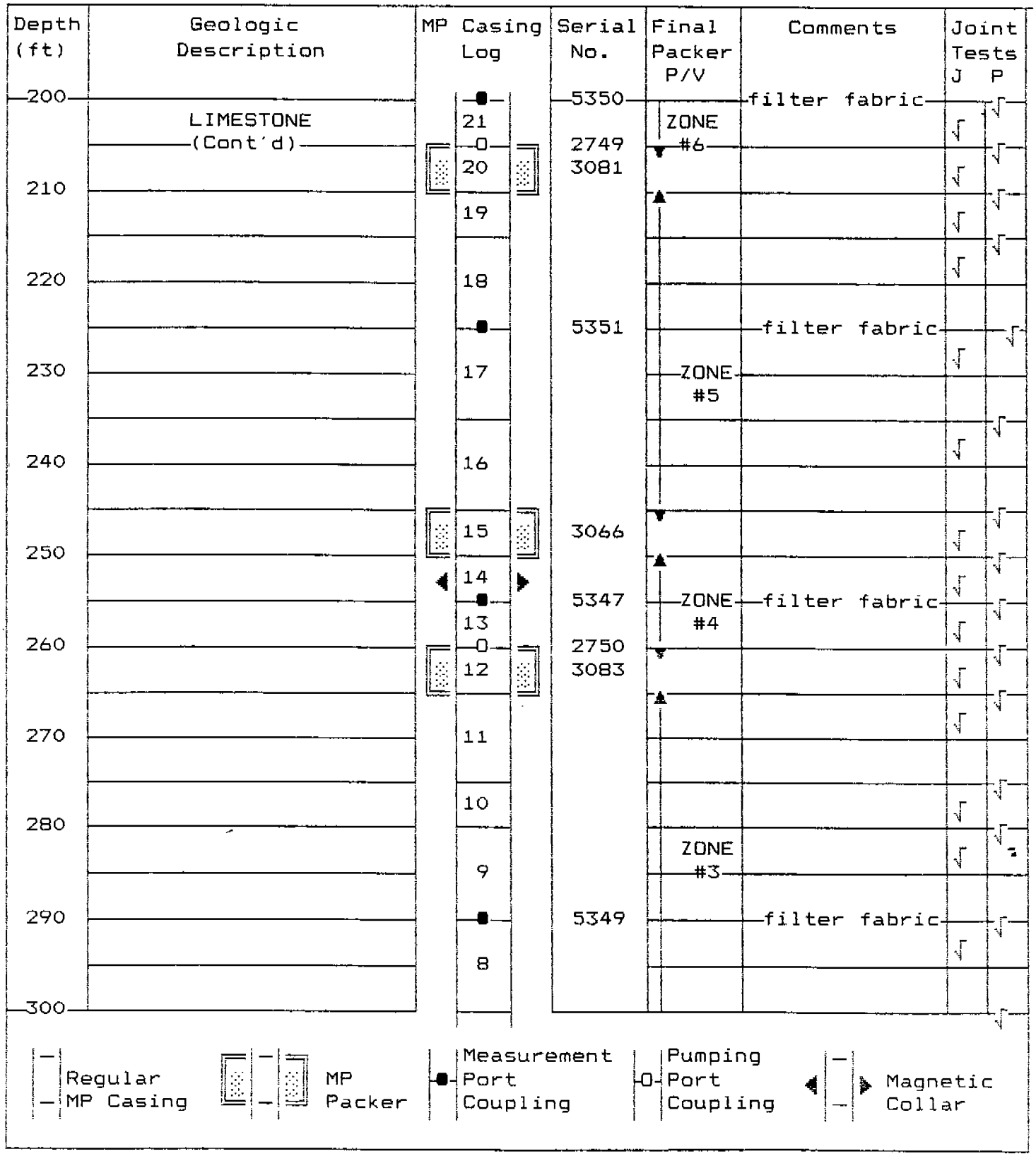
C:\FORMTOOL\PSE\WB\WB-1(2)

WEST AY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: WB-1 Location: 100 AREA

Date Installed: 04-12-90 Installed by: GC/EM/MC Date Drawn: 01-29-90

Hole Depth: 356.4' MP Depth: 355.0' Hole Diameter: 4"



C:\FORMTOOL\PSE\WB-1(3)

WES BAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: WB-1 Location: 100 AREA

Date Installed: 04-12-90 Installed by: GC/EM/MC Date Drawn: 01-29-90

Hole Depth: 356.4' MP Depth: 355.0' Hole Diameter: 4"

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
300	LIMESTONE (cont'd)	7				√	√
310		6		ZONE #3		√	√
320		5	3082			√	√
330		4	5348	ZONE #2	filter fabric	√	√
340		3	2747				√
		2	3064			√	√
350		1	5355	ZONE #1	filter fabric	√	
	TD Borehole = 356.4'						√
360					All joints tested at 100 psi with pump pressure at 240 psi		
370							
380							
390							
400							

Regular MP Casing

MP Packer

Measurement Port Coupling

Pumping Port Coupling

Magnetic Collar

C:\FORMTOOL\PSE\WB\WB-1(4)

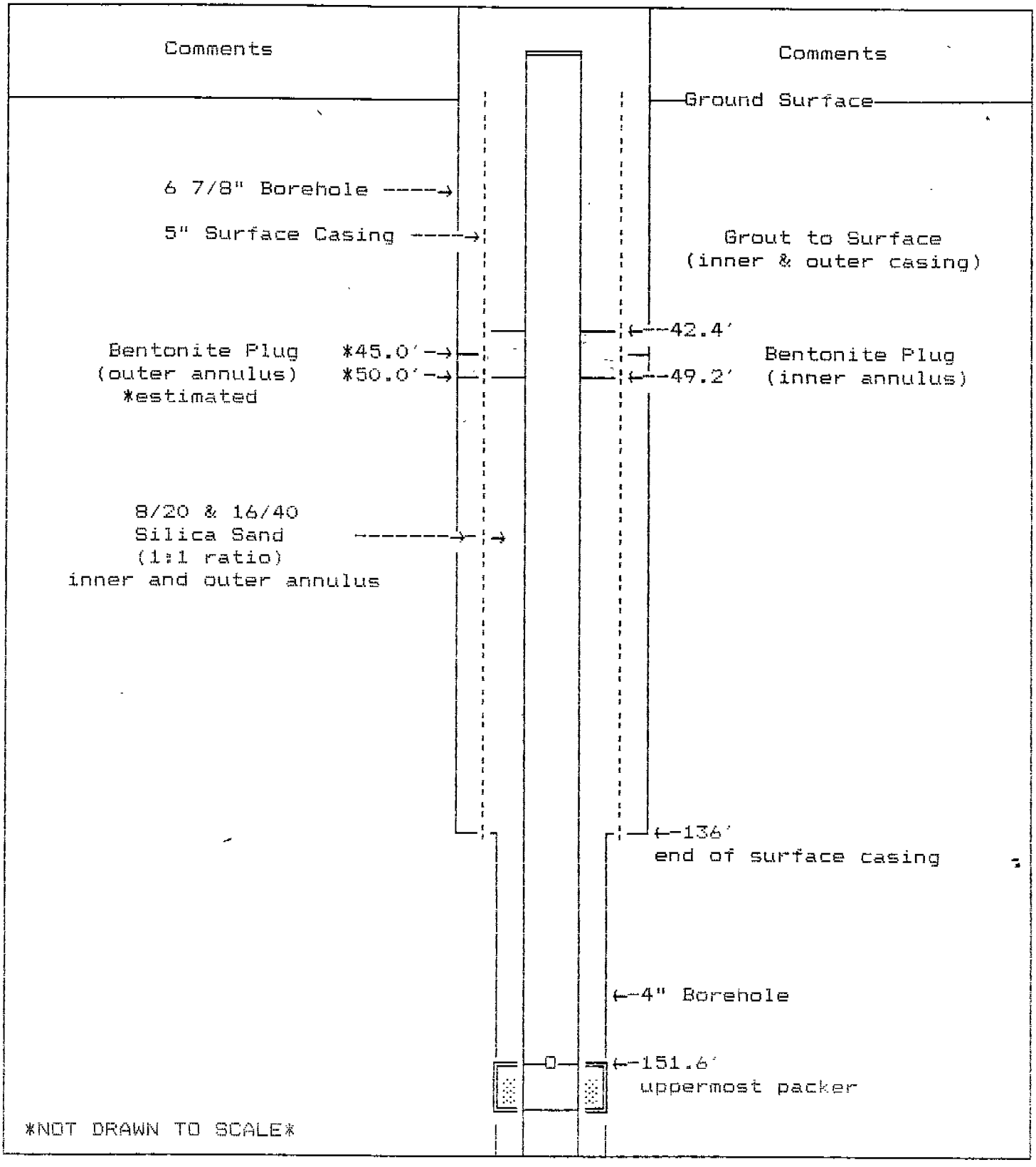
WEST BAY MP SYSTEM COMPLETION DETAIL

Project: NASA-WSTF Hole No: WB-2 Location: 100 Area

Completed by: GC/EM/JK/DB Measurement Datum: Ground Level

Date Drawn: 11-07-90
Drawn By: P.S. Egan

Borehole Diameter: 4"
MP Casing Diameter: 3"



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WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: WB-3 Location: South of 100 Area

Date Installed: 04-09-90 Installed by: GC/EM Date Drawn: 03-19-90

Hole Depth: 488.6' MP Depth: 480.0' Hole Diameter: 4"

Measurement Datum: Ground Level Datum Elevation: 4812.16 (BC)

Depth (ft)	Geologic Description	MP Casing Log 54	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
0	0'-241' ALLUVIUM (Santa Fe Group)	53			Each couple tested to 100 psi for one minute	√	√
10		52					√
						√	
20		51			(SEE ATTACHED SHEET(S) FOR COMPLETION DETAIL)		√
						√	
30		50					√
						√	
40		49					√
						√	
50		48					√
						√	
60		47					√
						√	
70		46					√
						√	
80		45				√	
							√
90		44				√	
							√
100		43					

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

C:\FORMTOOL\PSE\WB\WB-3(1)

WEST BAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: WB-3 Location: South of 100 Area

Date Installed: 04-09-90 Installed by: GC/EM Date Drawn: 03-19-90

Hole Depth: 488.6' MP Depth: 480.0' Hole Diameter: 4"

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
100	ALLUVIUM (cont'd)	43				√	√
110		42				√	√
120		41				√	√
130		40				√	√
140		39				√	√
150		38				√	√
160		37				√	√
170		36				√	√
180		35				√	√
190		34				√	√
200		33					

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

C:\FORMTOOL\PSE\WB\WB-3(2)

WEST BAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: WB-3 Location: South of 100 Area

Date Installed: 04-09-90 Installed by: GC/EM Date Drawn: 03-19-90

Hole Depth: 488.6' MP Depth: 480.0' Hole Diameter: 4"

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
200	ALLUVIUM (cont'd)	33				√	
210		32					√
220		31				√	
230		30					√
240	241'-491' ANDESITE (Orejon)	29				√	
250	surface casing (5") installed to 244'	28					√
260		27				√	
270		26					√
280		25				√	
290		24					√
300		23				√	

Regular MP Casing

MP Packer

Measurement Port Coupling

Pumping Port Coupling

Magnetic Collar

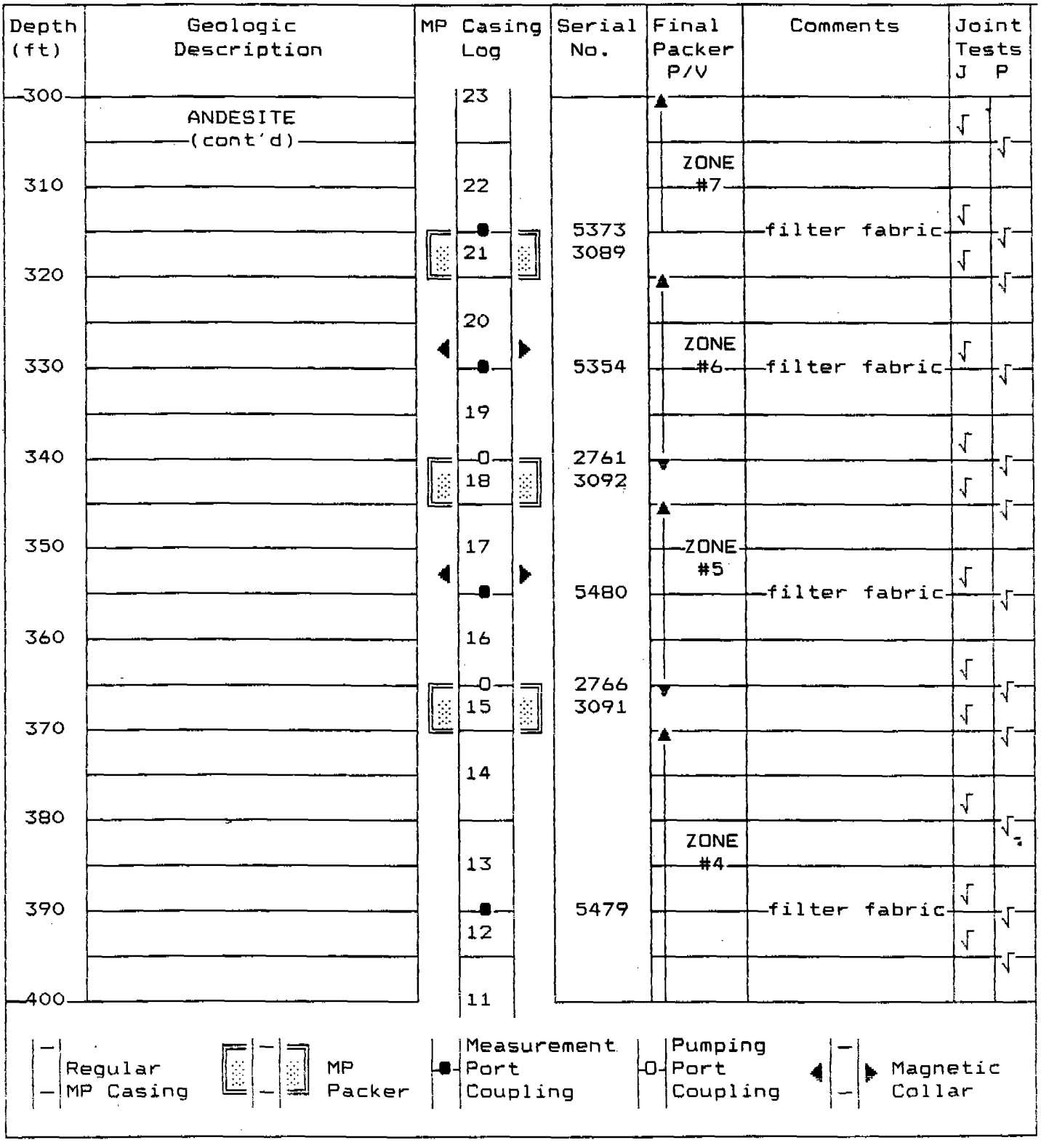
C:\FORMTOOL\PSE\WB\WB-3(3)

WEST BAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: WB-3 Location: South of 100 Area

Date Installed: 04-09-90 Installed by: GC/EM Date Drawn: 03-19-90

Hole Depth: 488.6' MP Depth: 480.0' Hole Diameter: 4"



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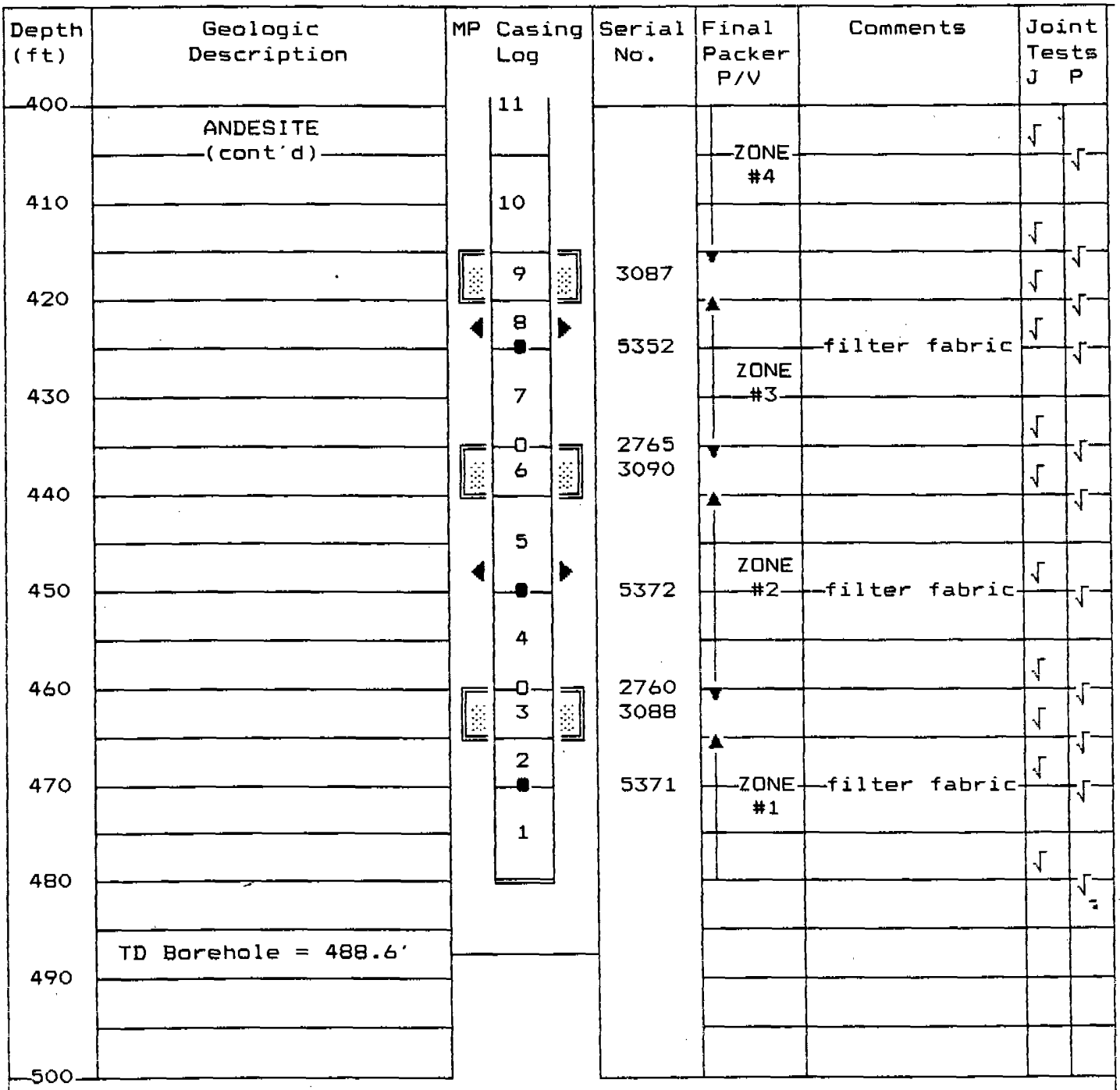
WEST BAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: WB-3 Location: South of 100 Area

Date Installed: 04-09-90 Installed by: GC/EM Date Drawn: 03-19-90

Hole Depth: 488.6' MP Depth: 480.0' Hole Diameter: 4"



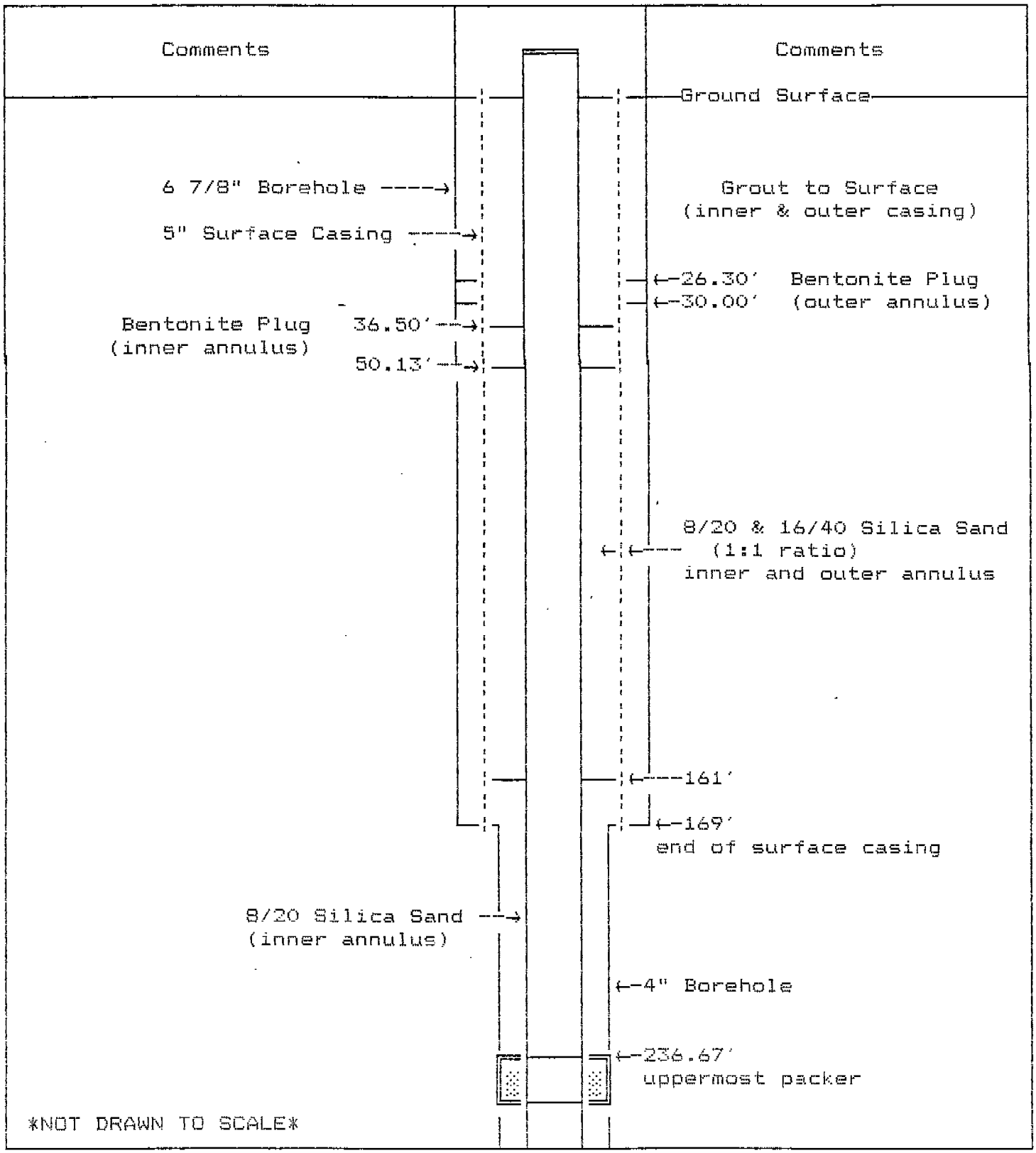
C:\FORMTOOL\PSE\WB\WB-3(5)

WES BAY MP SYSTEM COMPLETION DETAIL

Project: NASA-WSTF Hole No: WB-5 Location: 100 Area

Completed by: PE/MC/JR Measurement Datum: Ground Level

Date Drawn: 11-07-90 Borehole Diameter: 4"
Drawn By: P.S. Egan MP Casing Diameter: 3"



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WESTBAY MP SYSTEM
CASING INSTALLATION LOG

Project: 3488-WSTF Hole No: WB-8 Location: SE Facility Boundary

Date Installed: 03-10-93 Installed by: H+BDL Date Drawn: 03-09-93

Hole Depth: 447.0' MP Depth: 440.0' Hole Diameter: 4"

Measurement Datum: Ground Level Datum Elevation: 4961.68 (BD)

Depth (ft)	Geologic Description	MP Casing Log 49	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
0	0'-195' ALLUVIUM (Santa Fe Group)	48	91-268		All couples tested to 100 psi for 30 sec	✓	✓
10		47	92-272				
20		46	91-268		All magnetic collars are placed 0.4' above the MP couple	✓	✓
30		45	92-272				
40		44	91-268		filter socks used where indicated	✓	✓
50		43	92-272				
60		42	91-268			✓	✓
70		41	92-272				
80		40	91-268			✓	✓
90		39	92-272				
100			91-268			✓	✓

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

C:\FORMTOOL\PSE\WB\WB-8(1)

WEST BAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: WB-8 Location: SE Facilty Boundary

Date Installed: 03-10-93 Installed by: H+GCL Date Drawn: 03-08-93

Hole Depth: 447.0' MP Depth: 440.0' Hole Diameter: 4"

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
100			91-268				
		38	92-272			√	
110			91-268				√
		37	92-272			√	
120			91-268				√
		36	92-272			√	
130			91-268				√
		35	92-272			√	
140			91-268				√
		34	92-272			√	
150			91-268				√
		33	92-272			√	
160			91-268				√
		32	92-272			√	
170			91-268				√
		31	92-272			√	
180			91-268				√
		30	92-272			√	
190			91-268				√
	195'-447' ANDESITE (Orejon)	29	92-272			√	
200			91-268				√

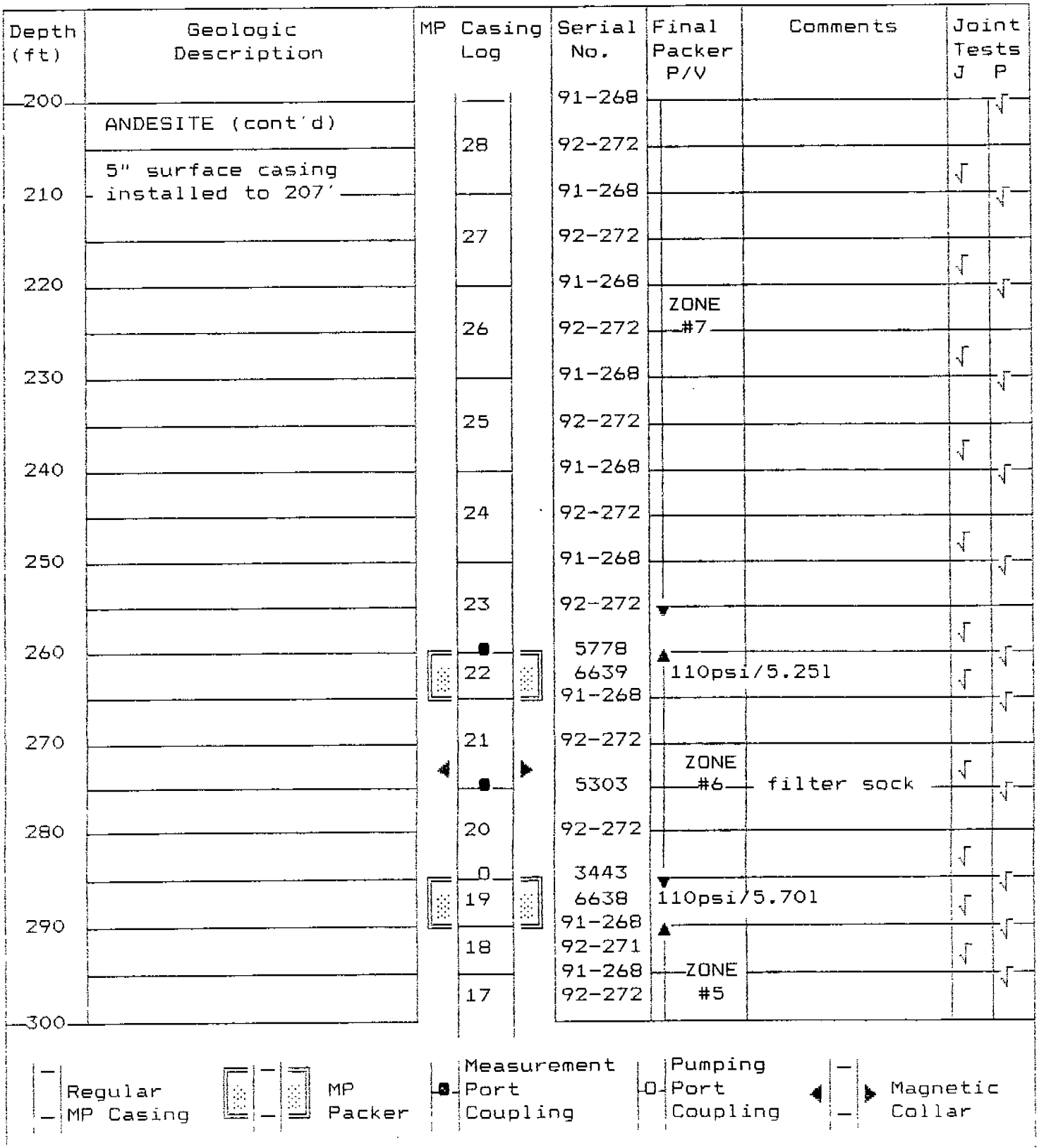
Regular PP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

WEST AY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: WB-8 Location: SE Facility Boundary

Date Installed: 03-10-93 Installed by: H+GCL Date Drawn: 03-08-93

Hole Depth: 447.0' MP Depth: 440.0' Hole Diameter: 4"

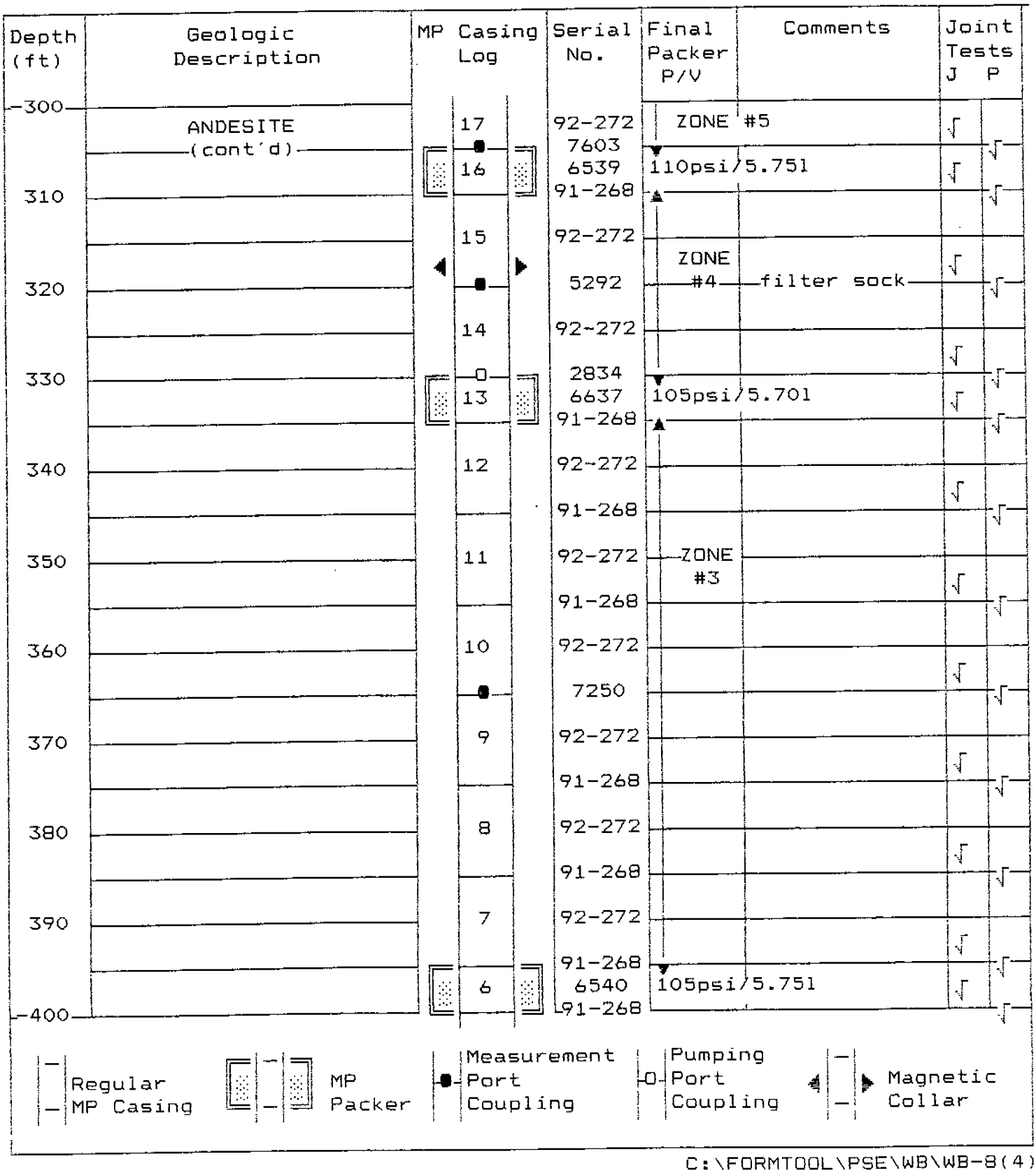


WES BAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: WB-8 Location: SE Facility Boundary

Date Installed: 03-10-93 Installed by: H+GCL Date Drawn: 03-08-93

Hole Depth: 447.0' MP Depth: 440.0' Hole Diameter: 4"



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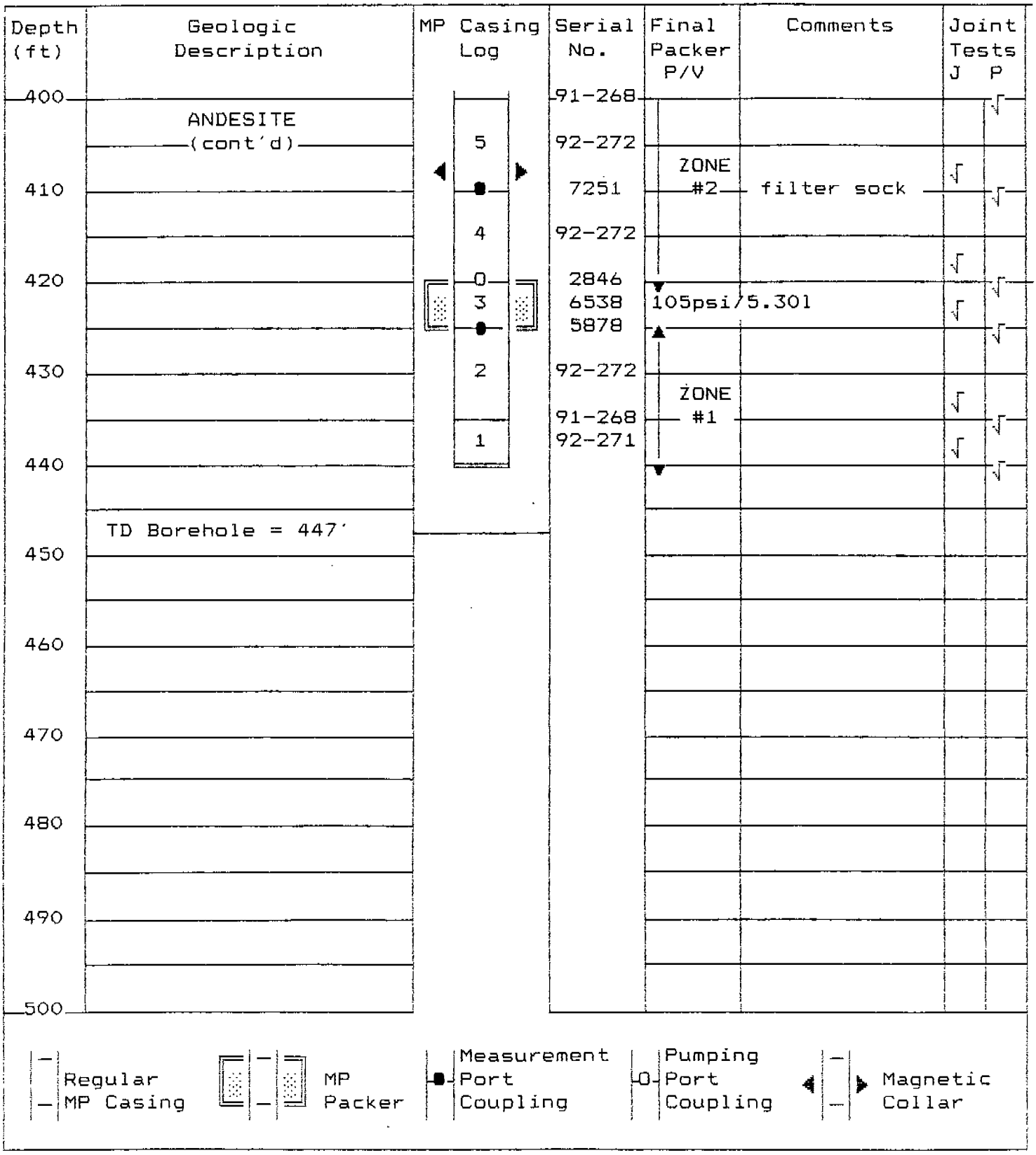
WES BAY MP SYSTEM
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No: WB-8 Location: SE Facility Boundary

Date Installed: 03-10-93 Installed by: H+GCL Date Drawn: 03-08-93

Hole Depth: 447.0' MP Depth: 440.0' Hole Diameter: 4"



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WELLBAY MP SYSTEM 1
CASING INSTALLATION LOG

Project: NASA-WSTF Hole No.: WB-9 Location: SE Boundary

Hole Depth: 380' MP Depth: 375.0' Hole Diam.: 4"

Date Installed: 2-26-92 Installed By: H+GCL (MC,DM,GC)

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
0	(ground level)	46	91-264				√
		45			Each couple tested to 100 psi for one minute	√	
10	0'-129' ALLUVIUM (Santa Fe Group)		"				√
		44				√	
20			"		Note: All regular couples Batch No. 91-264		√
		43				√	
30			"				√
		42			All magnetic collars attached 0.4' above MP couple	√	
40			"				√
		41			Filter sleeves around MP couples where indicated	√	
50			"				√
		40				√	
60			"				√
		39				√	
70			"				√
		38				√	
80			"				√
		37				√	
90			"				√
		36				√	
100			91-264				√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

C:\FORMTOOL\PSE\WB\WB-9(1)

WESTBAY MP SYSTEM CASING INSTALLATION LOG (Cont'd)

Hole No.: WB-9

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
100	ALLUVIUM (cont'd)	35	91-264			√	√
110		34	"			√	√
120		33	"			√	√
130	129'-380' LIMESTONE (Panther Seep Fm.)	32	"			√	√
140	5" steel surface casing installed to 139'	31	"			√	√
150		30	"			√	√
160		29	"			√	√
170		28	"			√	√
180		27	"			√	√
190		26	"			√	√
200			91-264				√

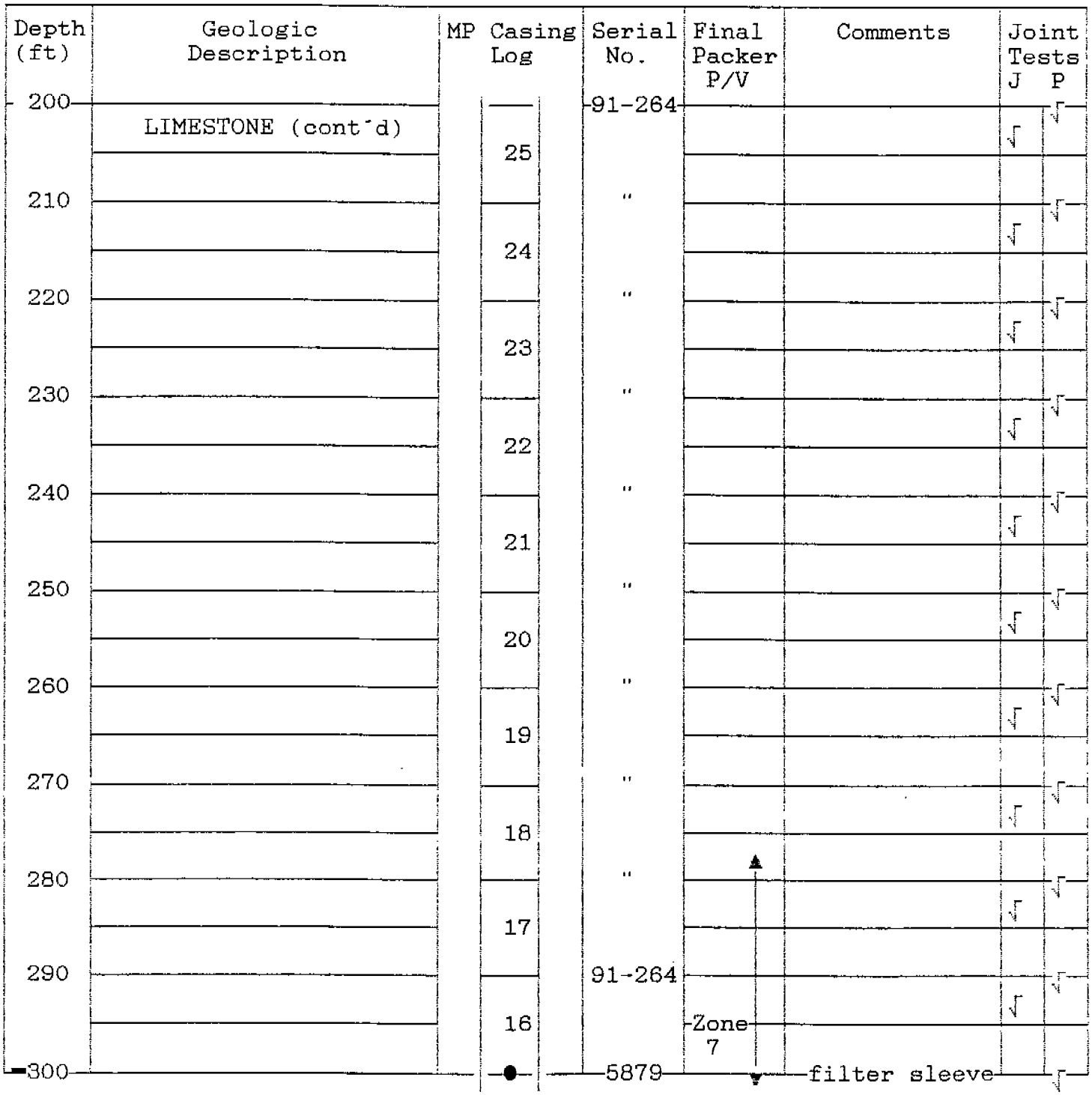
LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

C:\FORMTOOL\PSE\WB\WB-9(2)

WESTBAY MP SYSTEM CASING INSTALLATION LOG (Cont'd)

Hole No.: WB-9



LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

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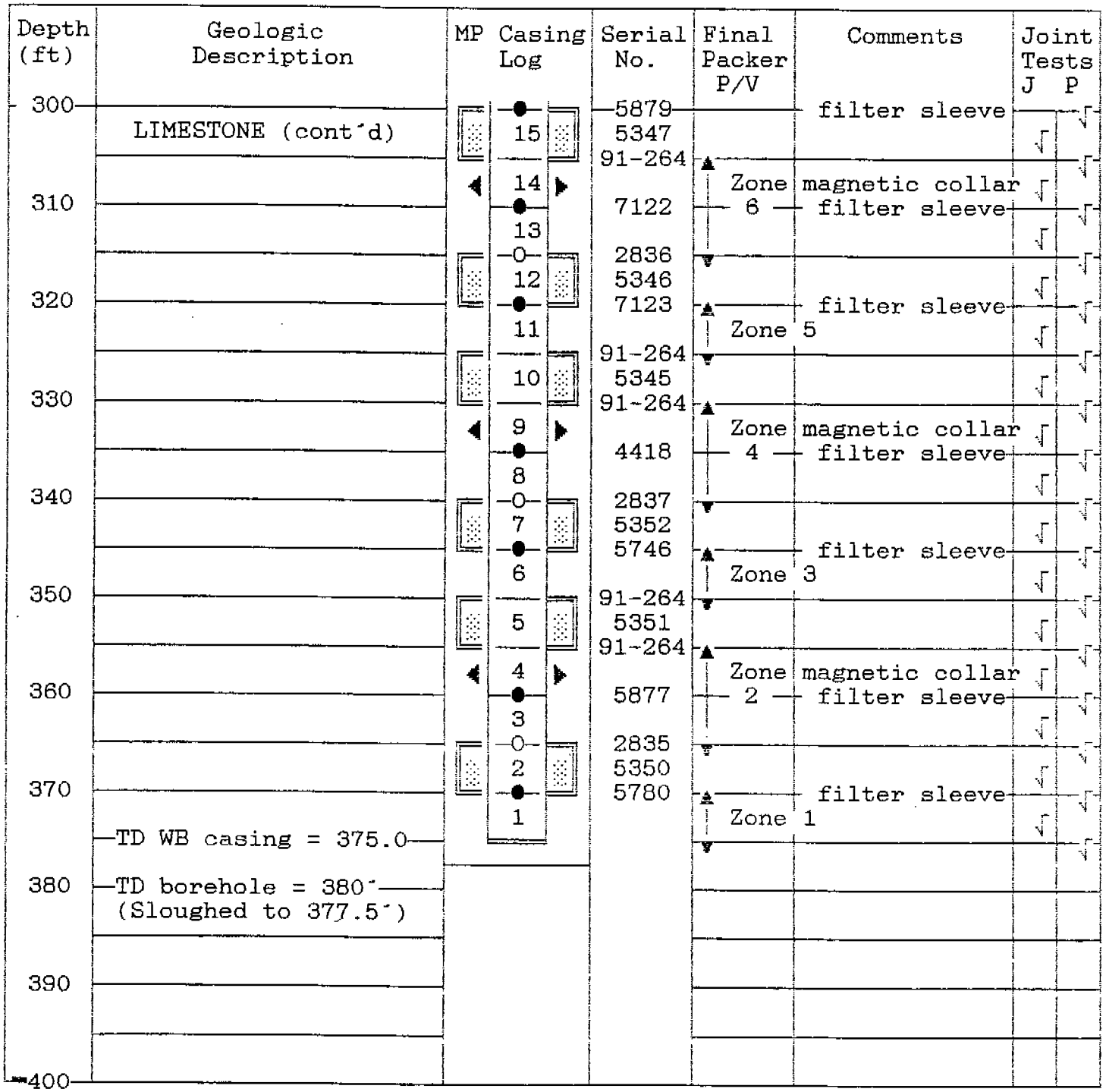
WESTBAY MP SYSTEM 1
CASING INSTALLATION LOG
(Cont'd)

Hole No.: WB-9



LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

C:\FORMTOOL\PSE\WB\WB-9(4)

WESTBAY MP SYSTEM CASING INSTALLATION LOG

Project: NASA-WSTF Hole No.: WB-14 Location: South Boundary

Hole Depth: 550.08' MP Depth: 545.0' Hole Diam.: 4"

Date Installed: 3/18-23/92 Installed By: H+GCL (MC,DM,GC,PE)

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
0	(ground level)	58	90-228				√
		57			Each couple tested to 100 psi for one minute	√	
10	0'-280' ALLUVIUM (Santa Fe Group)		"				√
		56				√	
20			"		All magnetic collars attached 0.4' above MP couple		√
		55				√	
30			"		Filter sleeves around MP couples where indicated		√
		54				√	
40			"				√
		53				√	
50			"				√
		52				√	
60			"				√
		51				√	
70			"				√
		50				√	
80			91-264				√
		49				√	
90			"				√
		48				√	
100			91-264				√

LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

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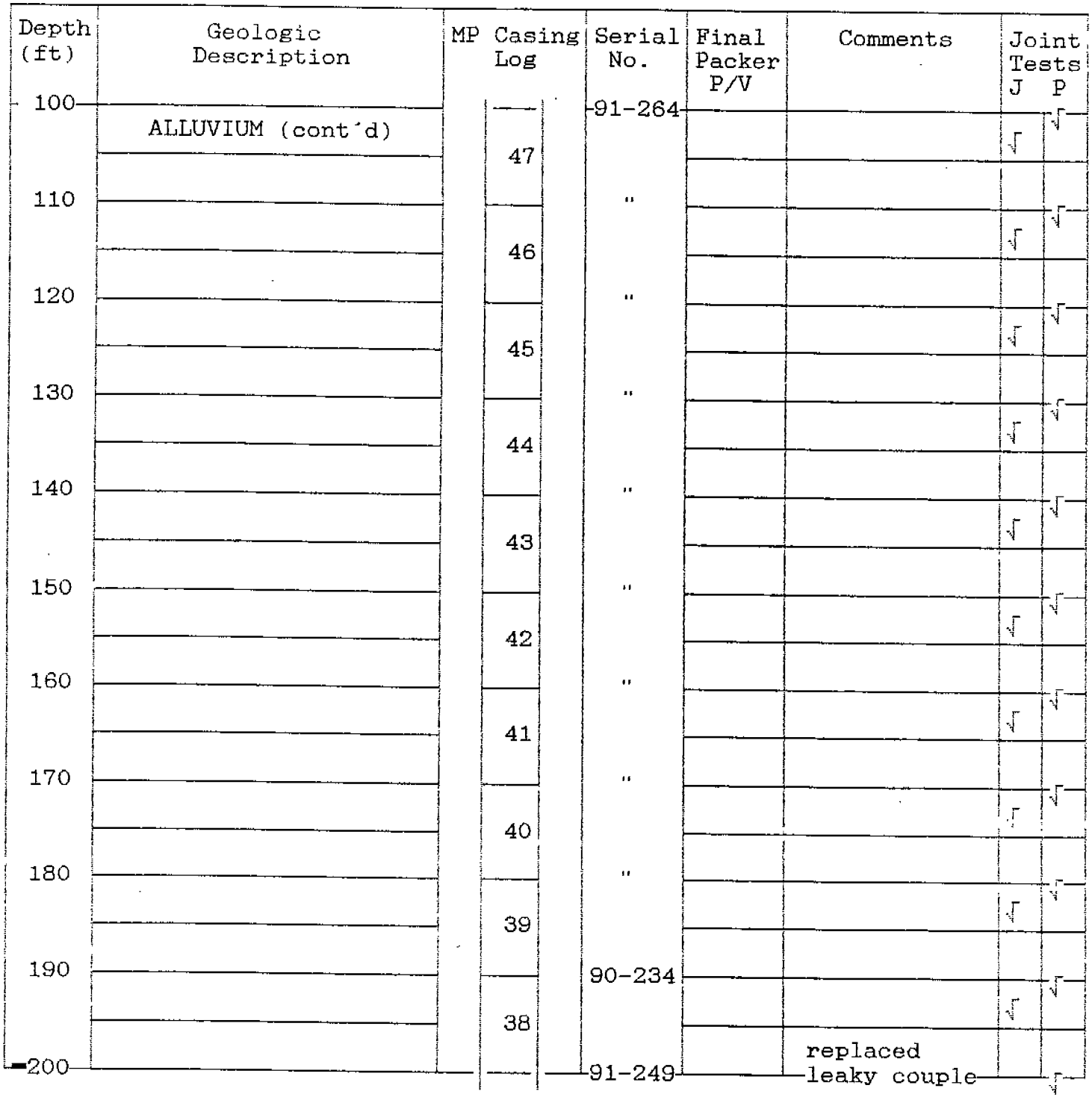
WESTBAY MP SYSTEM CASING INSTALLATION LOG (Cont'd)

Hole No.: WB-14



LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

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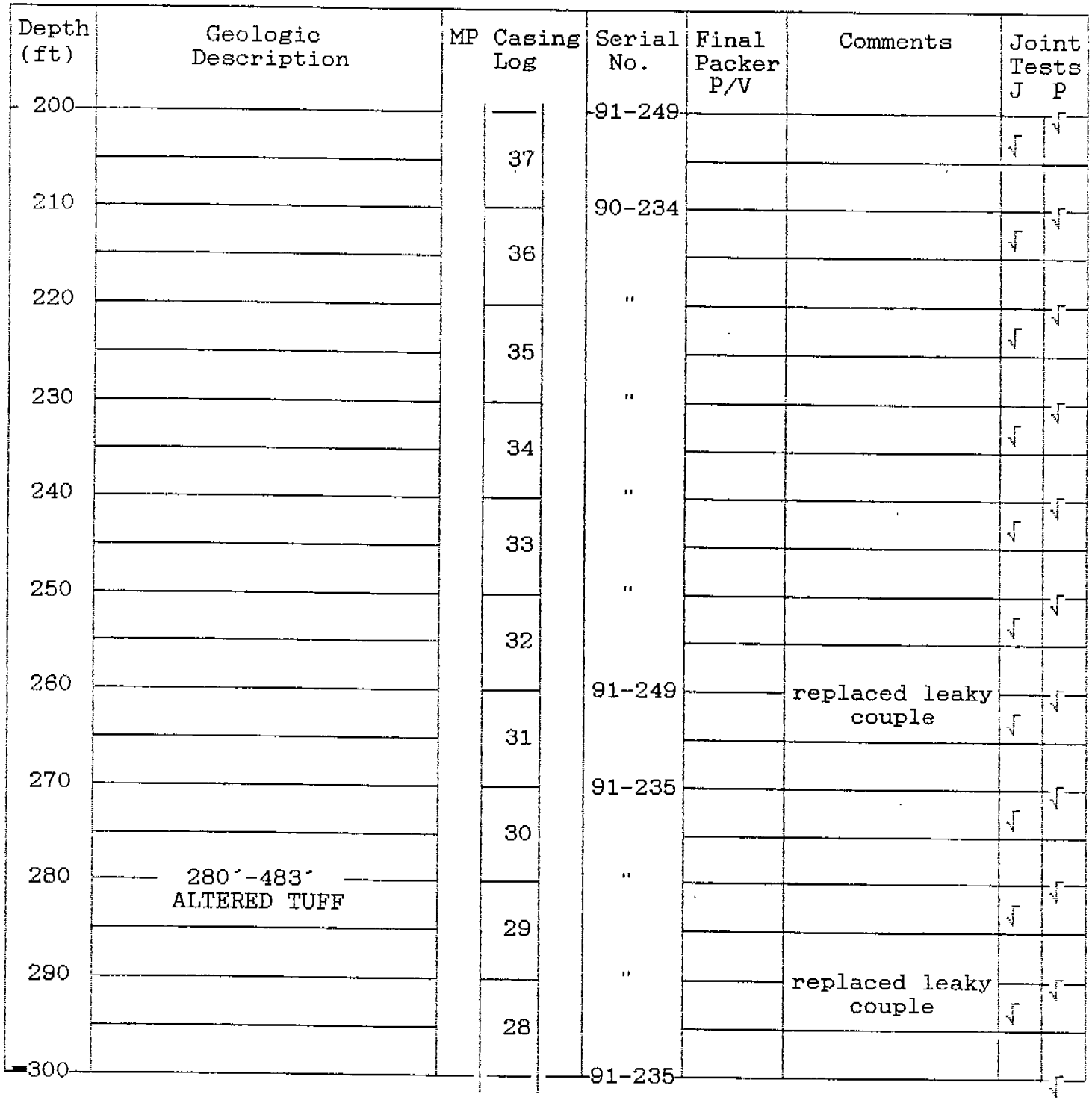
WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: WB-14



LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

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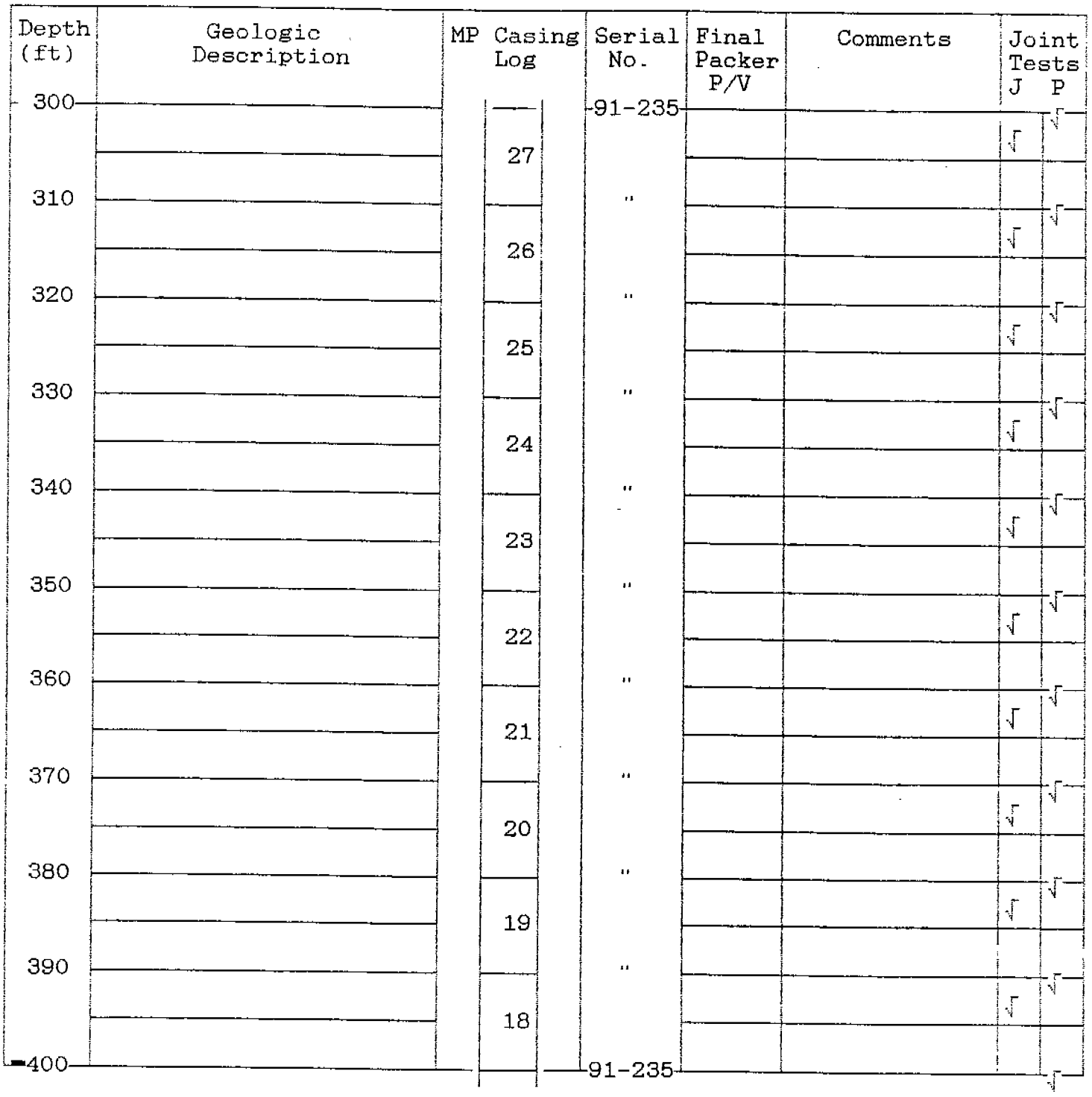
WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

Hole No.: WB-14



LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

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WESTBAY MP SYSTEM CASING INSTALLATION LOG (Cont'd)

Hole No.: WB-14

Depth (ft)	Geologic Description	MP Casing Log	Serial No.	Final Packer P/V	Comments	Joint Tests J	Joint Tests P
400		17	91-235			√	√
410		16	"			√	√
420		15	"			√	√
430		14	"			√	√
440		13	"			√	√
450		12	"			√	√
460		11	"			√	√
470		10	"			√	√
480	483'-550' TUFF	9	"			√	√
490	5" steel surface casing installed 0'-490'	8	91-264			√	√
500			91-264				√

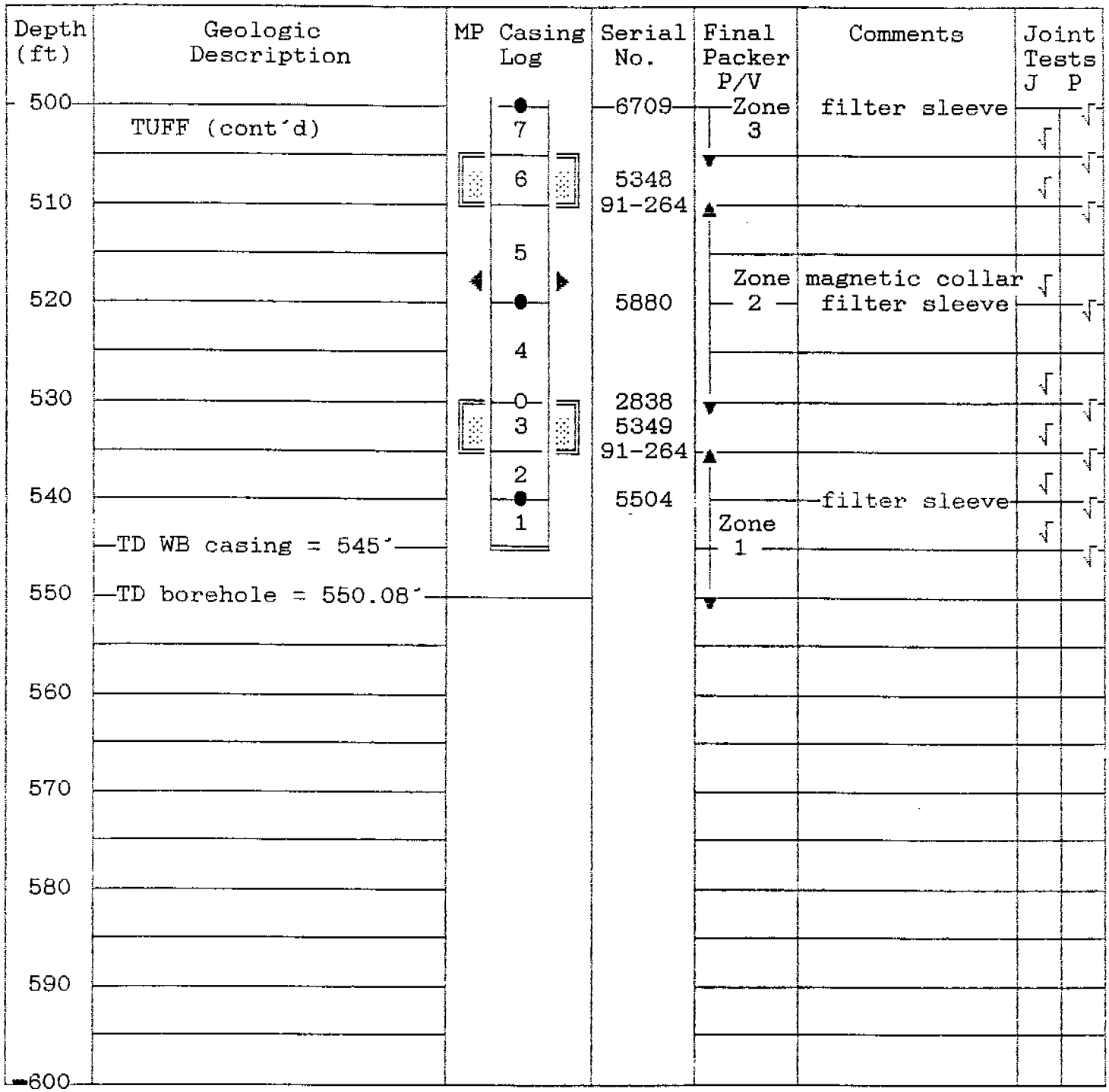
LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

C:\FORMTOOL\PSE\WB\WB-14(5)

WESTBAY MP SYSTEM
CASING INSTALLATION LOG
(Cont'd)

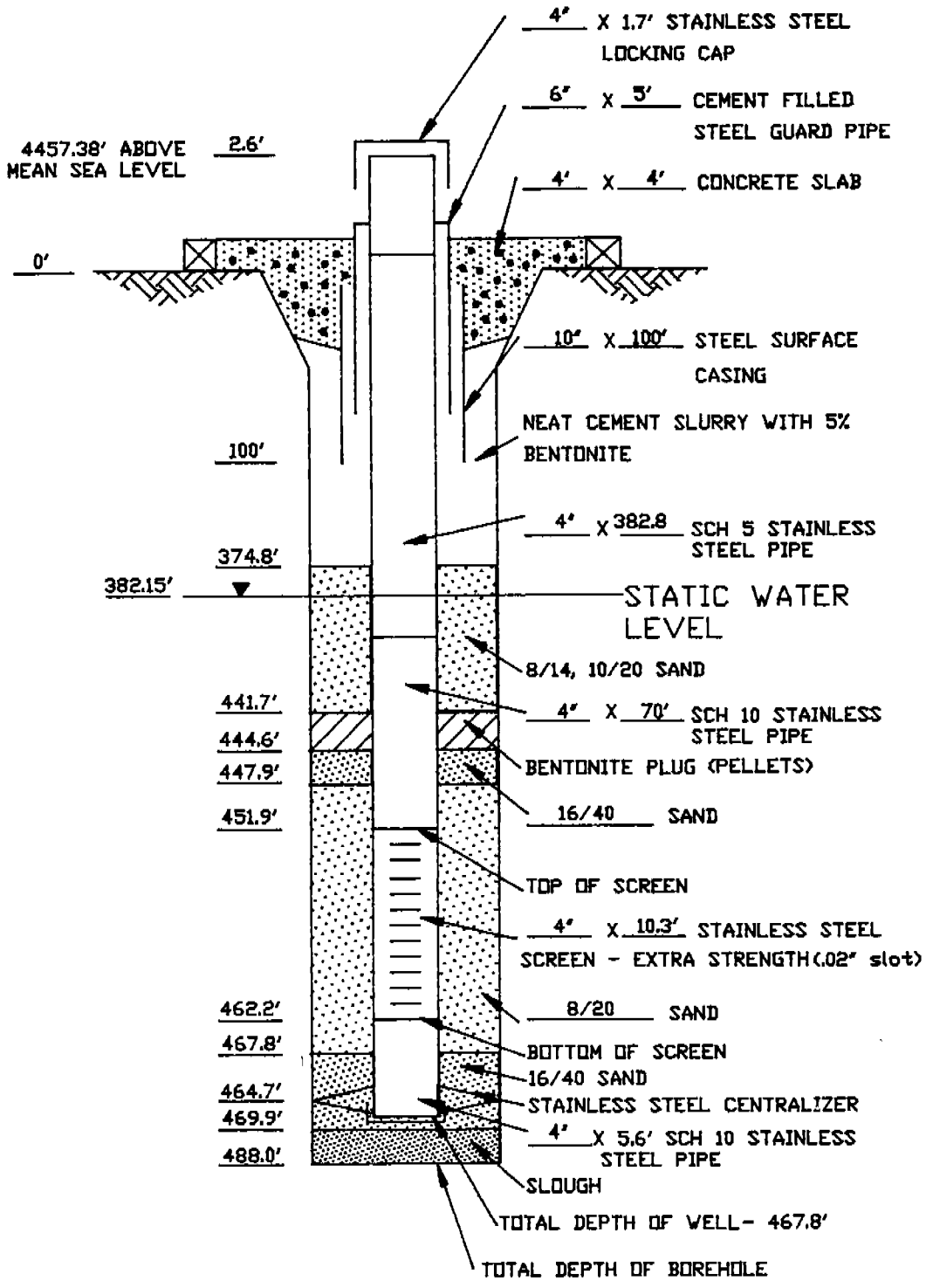
Hole No.: WB-14



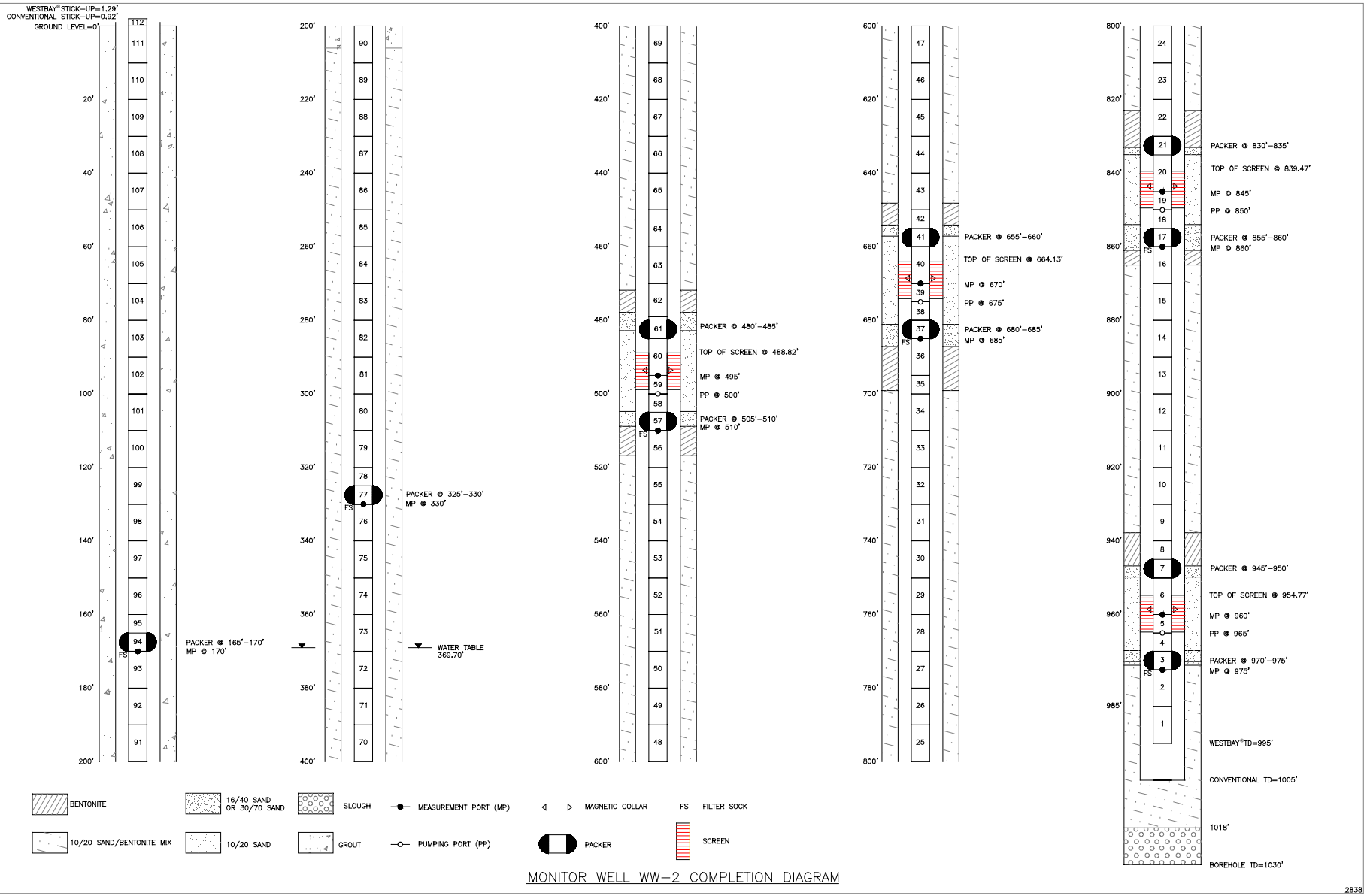
LEGEND

Regular MP Casing | MP Packer | Measurement Port Coupling | Pumping Port Coupling | Magnetic Collar

C:\FORMTOOL\PSE\WB\WB-14(6)

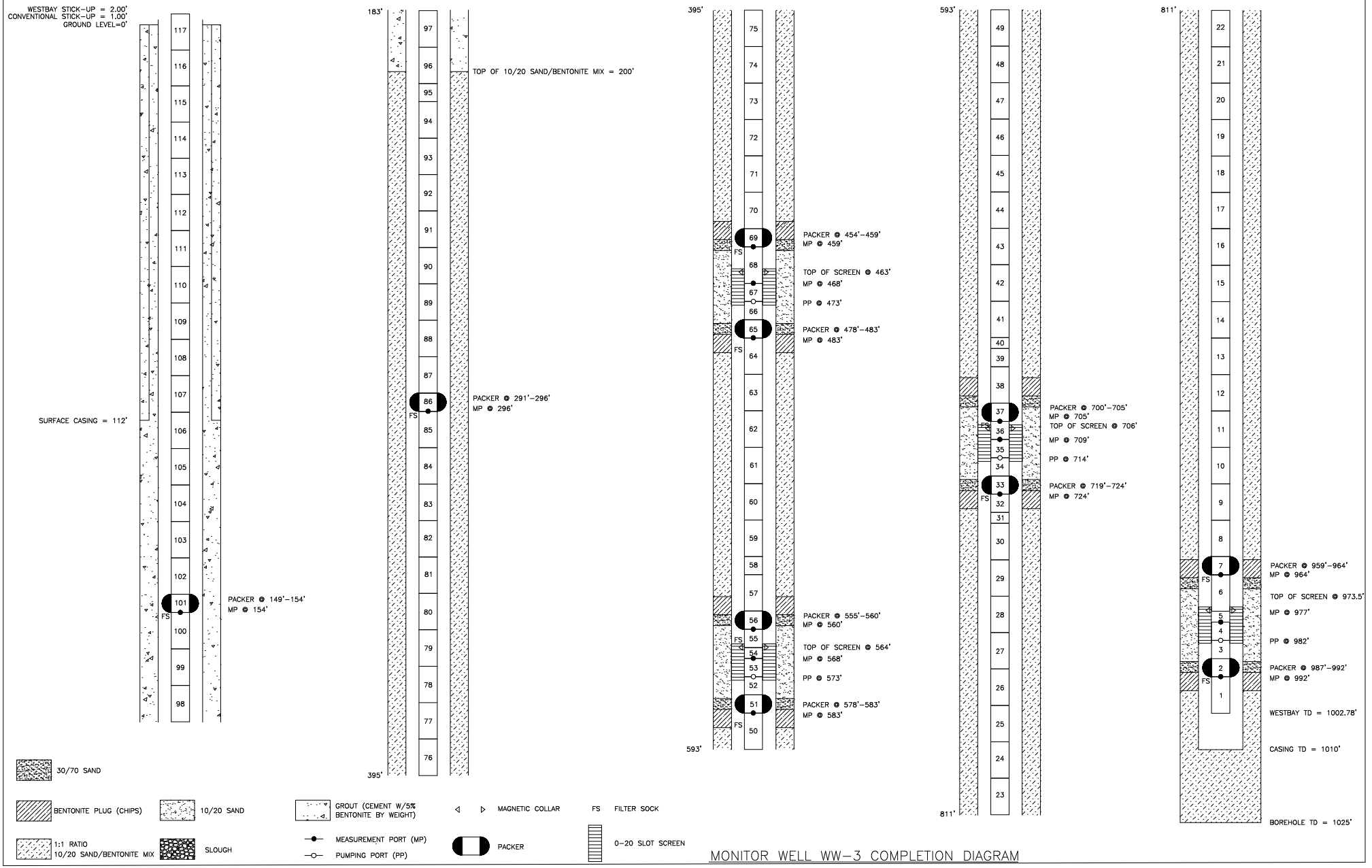


MONITOR WELL WW-1-452 COMPLETION DIAGRAM

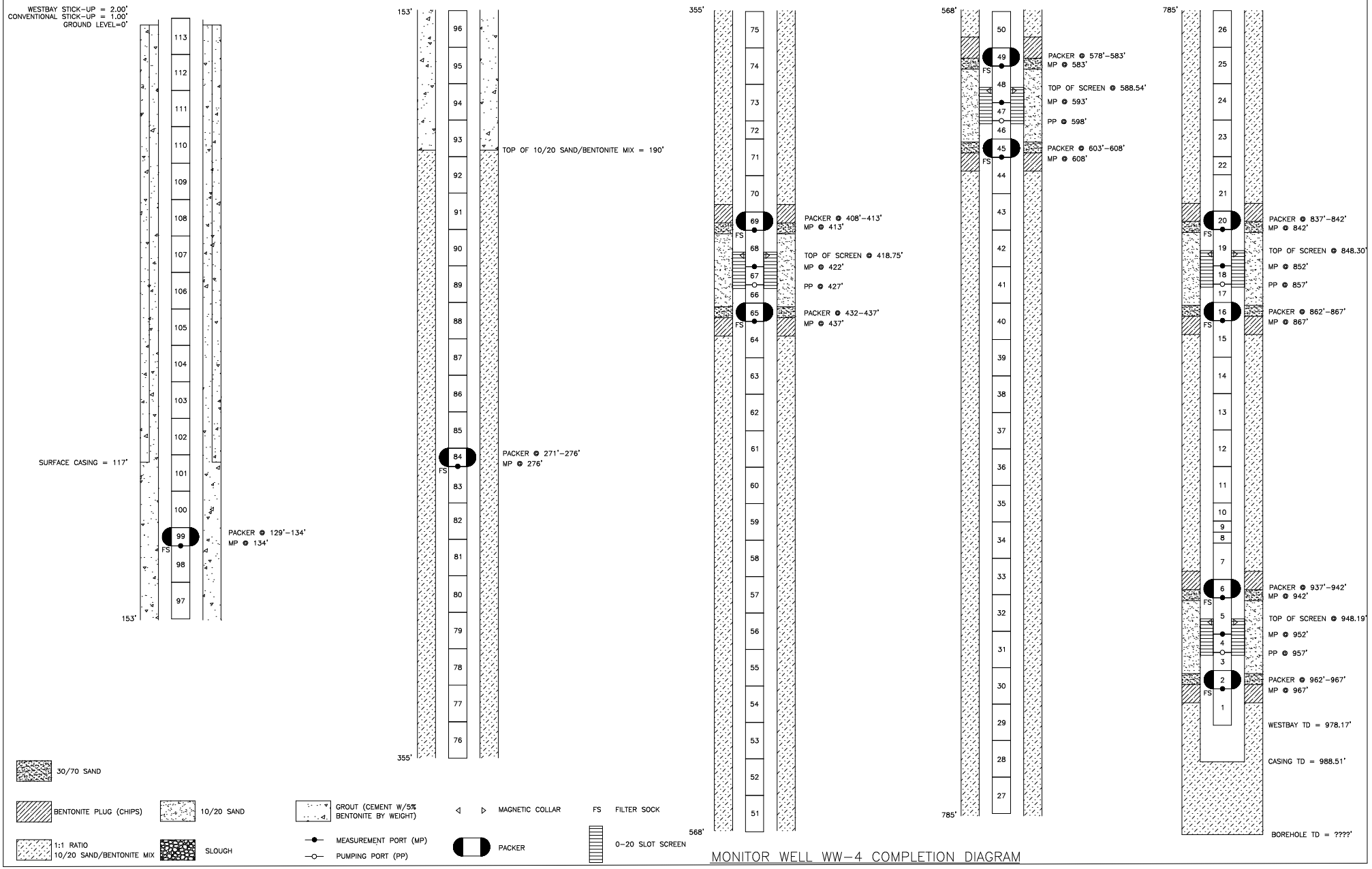


MONITOR WELL WW-2 COMPLETION DIAGRAM

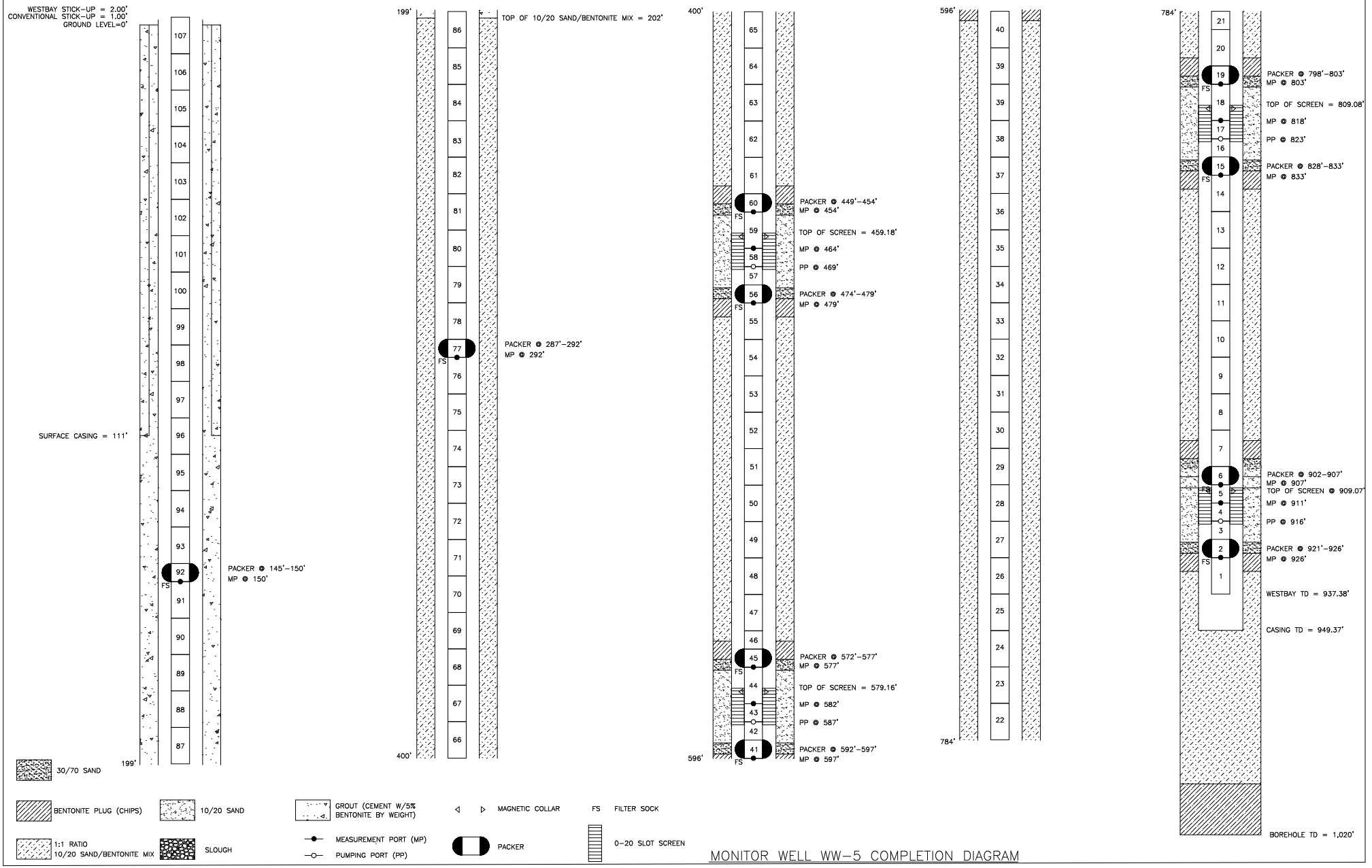
2838



MONITOR WELL WW-3 COMPLETION DIAGRAM



MONITOR WELL WW-4 COMPLETION DIAGRAM

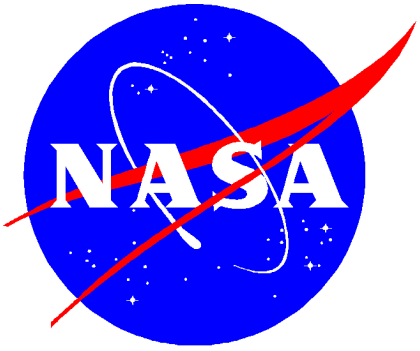


MONITOR WELL WW-5 COMPLETION DIAGRAM

Appendix B

NASA White Sands Test Facility

Groundwater Monitoring Quality Assurance Project Plan



GROUNDWATER MONITORING QUALITY ASSURANCE PROJECT PLAN

NASA JOHNSON SPACE CENTER

WHITE SANDS TEST FACILITY
LAS CRUCES, NEW MEXICO

June 2002

1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

During the course of historical operations at the NASA White Sands Test Facility (WSTF), hazardous constituents were released to the environment. As mandated by 40 CFR Part 264 Subpart F - Releases From Solid Waste Management Units, NASA has established groundwater monitoring programs. The purpose of these programs is to collect data required to: determine the distribution and migration of hazardous constituents; determine potential threats to the environment and public health; and to aid in the design and implementation of remediation systems.

The WSTF contamination is divided into three contaminant categories:

The most prevalent contaminants are halogenated volatile organics. These contaminants were historically released during hardware precision cleaning operations.

The second most widespread category of contaminants are the semivolatile compounds: N-nitrosodimethylamine (NDMA); N-nitrodimethylamine (DMN); and bromacil. NDMA and DMN originated from the use of hydrazine-based rocket fuels. Bromacil contamination is the result of herbicide use around buildings and roadways.

The third type of groundwater contamination is chromium. This compound originated from the precision cleaning of hardware.

1.2 PURPOSE

This Quality Assurance Project Plan (QAPP) establishes guidelines to ensure that the WSTF groundwater monitoring data are scientifically valid and of known quality. To achieve these goals, the following specific QAPP requirements are addressed:

A consistent and acceptable framework for the collection and generation of physical and chemical data;

Performance and acceptance criteria for the data measurements to ensure that data collection and analytical systems provide data of sufficient quality for the program;

The early detection of deficiencies that may affect data quality and provide timely corrective actions; and

A fundamental framework for the storage and management of environmental data.

All data generating steps, including sample collection, analyses, document control, and data reviews are performed using established procedures to ensure data quality, accuracy and completeness. This document, coupled with adherence to procedures outlined in site-specific documentation such as WSTF Job Instructions (WJIs), equipment operation and maintenance manuals, analytical statements of work, and laboratory standard operating procedures, ensures that data meet the requirements of WSTF groundwater monitoring programs.

1.3 SCHEDULED PLAN REVIEWS

This Plan is reviewed annually to ensure that it provides the level of effort necessary to support all WSTF groundwater monitoring programs. If modifications to the Plan are necessary, NASA will submit the revisions to the NMED for concurrence and approval. All historical documents are archived for future reference.

2.0 PROJECT ORGANIZATION

2.1 INTRODUCTION

Groundwater monitoring activities are performed by, or in conjunction with, the on-site contractor Environmental Department. This Department is staffed with scientists, engineers and hydrogeologists. The primary objectives of the Department are the installation of the groundwater monitoring network, the hydrogeologic interpretation of collected data, generation of technical reports, collection of groundwater samples for analysis, technical review of project requirements, management and review of generated environmental data, and regulatory compliance.

All personnel assigned to these projects are required to have the training and expertise necessary to perform their assigned duties. Furthermore, all personnel who collect environmental data must have access to, and a clear understanding of, the Quality Assurance Project Plan, applicable regulatory permits, and all applicable site-specific procedural documentation.

2.2 ENVIRONMENTAL PROGRAM MANAGER

The NASA Environmental Program Manager administers all WSTF environmental programs. The Program Manager provides environmental compliance work directives to the on-site contractor Environmental Department.

2.3 ENVIRONMENTAL DEPARTMENT

The on-site contractor Environmental Department is responsible for work authorizing document generation, monitoring well installation, hydrogeologic interpretation,

establishing sampling and analytical protocols, collecting groundwater samples, prioritizing work, and ensuring that WSTF groundwater monitoring activities are conducted within regulatory and site-specific guidelines. This Department is also responsible for interpreting, evaluating and accepting data generated.

2.4 ENVIRONMENTAL DEPARTMENT PERSONNEL

Environmental Department personnel are the primary participants in the collection, analysis, management, and reporting of environmental data. The following describes the individuals involved in the data collection, generation and review processes. The contractor Environmental Department is responsible for maintaining a list of qualifications for all personnel involved in WSTF groundwater monitoring activities.

2.4.1 Contamination Assessment Supervisor

The Contamination Assessment Supervisor oversees the activities of all personnel involved in the WSTF groundwater monitoring program including the sampling coordinator, hazardous waste compliance technicians, and the QA/QC coordinator. In addition, the Supervisor is responsible for review of all documents produced by the contractor Environmental Department concerning WSTF groundwater monitoring activities.

2.4.2 Groundwater Sampling Coordinator

The Sampling Coordinator directs and participates with Hazardous Waste Compliance Technicians in sample collection using procedures delineated in the applicable Monitoring Program, the WSTF Quality Assurance Project Plan and site-specific procedural documentation. The Coordinator schedules all sampling events and ensures that samples are collected, preserved, documented, and shipped off-site for analysis using proper procedures.

2.4.3 Hazardous Waste Compliance Technicians

Hazardous Waste Compliance Technicians perform field sampling activities. These technicians follow procedures delineated in the applicable WSTF Job Instruction(s) and equipment operation and maintenance manuals to obtain representative samples. In addition, these technicians perform hydrogeological data collection in support of WSTF groundwater monitoring activities.

2.4.4 QA/QC Coordinator

The Environmental Department QA/QC Coordinator is responsible for assessing the quality of reported data. The Coordinator assesses the quality of the reported data using procedures outlined in the WSTF Quality Assurance Project Plan and

the WSTF Job Instruction applicable to groundwater database operations and quality assurance.

2.5 CONTRACTED ANALYTICAL LABORATORIES

WSTF contracts analytical laboratories to analyze groundwater samples in support of the WSTF groundwater monitoring activities. Prior to awarding any analytical support contracts, each laboratory must submit their laboratory Quality Manual to the contractor Environmental Department for review and approval. In addition, contractor Environmental Department personnel will supply the laboratory with a Statement of Work delineating the specific requirements for WSTF sample analyses. These documents ensure that laboratories meet the performance criteria for WSTF groundwater monitoring activities.

3.0 DATA QUALITY

3.1 INTRODUCTION

In environmental studies, measurement is the process of obtaining a quantitative value describing a chemical or physical property of a sampling unit or specimen collected from this unit. Choices made regarding sample collection, handling, preparation, and analysis can influence the quality attributes of the resulting data. Sources of measurement variability include:

- inherent variability in the natural environment;
- physical sample collection protocol;
- sample handling and transport;
- sample preparation and extraction procedures;
- subsampling extract for analysis; and
- analytical determination.

A QA Project Plan describes the processes used to monitor and estimate the magnitude of the more important potential measurement error sources. Quality planning simultaneously establishes data quality criteria appropriate for the project and data use and defines the required data quality indicators (DQIs). DQIs are qualitative and quantitative measures of principal quality attributes, including precision, bias, representativeness, comparability, completeness, and sensitivity.

Results from routine quality control samples are used to contribute to the construction of data quality indicators, most notably precision and bias.

3.2 QUALITY CONTROL SAMPLES

Several types of quality control samples are used to construct data quality indicators. A list of field and analytical quality control samples and a brief description of each is provided in Tables 3.1 and 3.2. The project-specific frequencies for these samples are provided in Tables 3.3 and 3.4.

3.2.1 Quality Control Sample Requirements

It is important that all quality control samples are of the highest possible quality. Reference standards are certified prior to use. The water used for field and laboratory blanks are monitored for non-interference with the analyses. Blind quality control samples are prepared so as to represent the types and concentrations of constituents normally found in the WSTF groundwater.

In order to avoid bias generated by the analytical laboratories, all environmental and quality control samples associated with each sampling event are submitted "blind". Samples are disguised so that laboratory personnel cannot identify the sample composition prior to analysis. The identities of all samples, including quality control samples, are recorded in the field logbook. The information provided to laboratory personnel (i.e., chain of custody forms, sample labels and sample seals) does not contain information concerning sample composition.

TABLE 3.1

DESCRIPTIONS OF FIELD QUALITY CONTROL SAMPLES

Sample Type	Description
Equipment Blank	A sample of pure de-ionized water which has been used to rinse common sampling equipment to check effectiveness of decontamination procedures. This type of blank also indicates contamination in the field which may affect analytical results.
Field Blank	A blank prepared in the field by filling a clean sample container with pure de-ionized water and appropriate preservative, if needed, for the specific sampling activity being undertaken. This type of sample provides a check on reagent quality and contamination derived in the field.
Trip Blank	A sample of pure de-ionized water prepared in a contaminant free environment that is carried to the sampling site and transported to the laboratory for analysis without having been exposed to sampling procedures. This type of sample serves as a check on sample contamination originating from sample handling, transport, shipping, and site conditions.
Blind Quality Control Sample	A sample submitted for analysis with a composition and identity known to the submitter but unknown to the laboratory or analyst. This type of sample serves as an independent check of analytical techniques, handling and standards.
Field Duplicate Sample	A second sample is taken immediately after an original sample at the same sampling location. This sample provides an estimate of the overall system precision.

TABLE 3.2

DESCRIPTION OF ANALYTICAL QUALITY CONTROL SAMPLES

Sample Type	Description
Method Blank	A clean sample processed simultaneously with and under the same conditions as samples containing an analyte of interest through all steps of the analytical procedure.
Laboratory Control Sample	A sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is generally used to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system.
Matrix Spike	A predetermined amount of stock solution, containing an analyte of interest, is added to the sample matrix prior to sample extraction/digestion and analysis. This sample indicates the effects of the sample matrix on analysis and also is a measure of the accuracy of the measurement system.
Matrix Spike Duplicates	Intralaboratory split samples spiked with identical concentrations of target analyte(s). The spiking occurs prior to sample preparation and analysis. These samples are used to document the precision and bias of a method in a given sample matrix.
Surrogate Spike	Introduction of a compound similar to the analytes of interest, but not normally found in environmental samples, blanks and standards. This type of sample provides a continuous monitor of the performance of the analytical system and the effectiveness of the method in dealing with sample matrices.

***Note**: The Quality Manual of contracted laboratories may contain additional, or more stringent, lab-specific requirements.*

TABLE 3.3

FIELD QUALITY CONTROL SAMPLES

CONTROL	VOLATILE ORGANICS METHOD	NITROSAMINES METHOD	METALS
Equipment Blank	100% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	5% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.	5% of all sampling events where non-dedicated sampling equipment is used. Not required if dedicated sampling equipment is used.
Field Blank	Not required if equipment blanks are taken, otherwise 100% of all volatile organics sampling days.	Not required if equipment blanks are taken, otherwise 5% of all nitrosamine sampling days or at least once per month, whichever is the most frequent.	Not required if equipment blanks are taken, otherwise 5% of all Metals sampling days or at least once per month, whichever is the most frequent.
Trip Blank	5% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.	5% of all Metals sampling events or at least once per month, whichever is the most frequent.
Field Duplicate Sample	10% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	10% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.	10% of all Metals sampling events or at least once per month, whichever is the most frequent.
Blind Quality Control Sample	5% of all volatile organics sampling events or at least once per month, whichever is the most frequent.	5% of all nitrosamines sampling events or at least once per month, whichever is the most frequent.	5% of all Metals sampling events or at least once per month, whichever is the most frequent.

TABLE 3.4

ANALYTICAL QUALITY CONTROL SAMPLES

TYPE OF CONTROL	VOLATILE ORGANICS	NITROSAMINES	METALS
Method Blank	One for each preparation batch.	One for each preparation batch.	One for each preparation batch.
Matrix Spike/Matrix Spike Duplicate	5% of samples analyzed.	10% of samples analyzed.	5% of samples analyzed.
Laboratory Control Sample	One for each preparation batch.	One for each preparation batch unless a matrix spike for all analytes is performed with the batch and meets QC criteria.	One for each preparation batch unless a matrix spike for all analytes is performed with the batch and meets QC criteria.
Surrogate Spike	100% of all blanks, samples and standards.	100% of all blanks, samples and standards.	Not applicable.

***Note**: The Quality Manual of contracted laboratories may contain additional, or more stringent, lab-specific requirements.*

3.3 DATA QUALITY INDICATORS

The data quality indicators of greatest consequence to WSTF groundwater monitoring programs are defined in this section. Historically, the two most important indicators were referred to as precision and accuracy. Over time, the environmental data quality community has agreed that these two concepts described by the terms precision and accuracy would be better described as one data attribute, accuracy, divided into two separate, measurable components, precision and bias. Accuracy is formally defined as the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components which are due to sampling and analytical operations.

.3.3.1 PRECISION

Precision is the degree to which a set of measurements of the same property, obtained under similar conditions , conform to themselves. For the purposes of WSTF groundwater monitoring programs, precision is expressed as either relative percent difference between duplicates, or as relative standard deviation where the number of replicates is greater than two.

3.3.1.1 Relative Percent Difference

Precision is determined on the basis of duplicate sample analytical results. When two values are used, precision is expressed in terms of relative percent difference (RPD). RPD is calculated as follows:

$$RPD = [\,|x_1 - x_2|\,/\,((x_1 + x_2)/2)]\,(100)$$

Where:

x_1 and x_2 are the reported concentrations for each duplicate sample.

3.3.1.2 Relative Standard Deviation

When more than two values are used to determine precision, it is calculated as the relative standard deviation (RSD). The RSD is calculated as follows:

$$RSD = (s / \bar{x})\,(100)$$

Where:

s is the standard deviation of a series of measurements, and
$\bar{x}$ is the mean of the series of individual measurements.

The standard deviation (s) for a set of measurements is determined as follows:

$$s = [\Sigma(x_i - \bar{x})^2 / (n - 1)]^{1/2}$$

Where:

x_i represents each of the individual measurements, and
n is the number of measurements.

The mean ($\bar{x}$) of a set of individual measurements is calculated by summing the values for the individual measurements ($x_1....x_n$), then dividing by the number of measurements (n). This calculation is as follows:

$$\bar{x} = (x_1 + x_2 + x_3 + ... + x_n) / n$$

3.3.2 BIAS

Bias is the systematic or persistent distortion of a measurement process, which causes errors in one direction (i.e., the expected sample measurement is different from the sample's true value). For the purposes of WSTF groundwater monitoring programs, bias is expressed as percent recovery. Percent recovery (%R) is calculated as follows:

$$\%R = (R / S) (100)$$

Where:
R is the reported concentration, and
S is the spiked concentration.

3.3.3 REPRESENTATIVENESS

Representativeness is a measure of the degree to which data accurately and precisely represent a population characteristic. Representativeness is a qualitative term that should be evaluated to determine whether measurements are made and physical samples collected in such a manner that the resulting data appropriately reflect the media and phenomenon measured or studied. The representativeness criteria is satisfied by ensuring that samples are collected and analyzed using standardized procedures throughout the sampling and analysis process. These standardized procedures include all applicable WSTF site-specific procedural documentation (e.g., WSTF Job Instructions (WJIs) specific to sample collection and data handling), and current, laboratory-specific standard operating procedures for all analytical methods.

3.3.4 COMPARABILITY

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Sample data should be comparable with other measurement data for similar samples and sample conditions. This goal is achieved using standard collection and analytical techniques and reporting analytical data in appropriate units.

3.3.5 COMPLETENESS

Completeness is a measure of the amount of valid data obtained from a measurement system, expressed as a percentage of the number of valid measurements that should have been collected (i.e., measurements required by the applicable monitoring plan and quality assurance project plan). Percent of completeness (%C) is calculated as follows:

$$\%C = 100 \times (V/T)$$

Where:

V is the number of valid measurements, and
T is the total number of measurements performed.

3.3.6 SENSITIVITY

Sensitivity refers to the capability of a method or instrument to discriminate between measurement responses representing different levels (e.g., concentrations) of a variable of interest. The sensitivity indicators of primary interest are indicators that relate to limits of detection. In determining the detection limit, the focus is on the concentration that can be distinguished from the noise of the method. A number of indicators related to sensitivity have been utilized in the course of WSTF groundwater monitoring activities. Table 3.5 defines the most commonly used sensitivity indicators and describes how they relate to each other. The analytical data currently gathered for the WSTF groundwater monitoring programs has an associated method detection limit and reporting limit or practical quantitation limit (sometime referred to as simply quantitation limit). As it applies to WSTF groundwater monitoring data, the reporting limit is equivalent to the practical quantitation limit.

Table 3.5 Commonly Used Sensitivity Indicators

Sensitivity Indicator	Numerical Definition	Definition	Common Use
Instrument detection limit (IDL)	Defined by instrument manufacturer (e.g., 3 x background noise)	Lowest value at which the *instrument* can distinguish from zero	Provides basis for determining an MDL
Method detection limit (MDL)	MDL = $t_{0.99}$ x s s = standard deviation of 7 replicates of a low level spike $t_{0.99}$ = 3.14	Minimum concentration of a substance that can be reported with 99% confidence that the analyte concentration is greater than zero[1]	Determines the lowest quantifiable concentration for a given method
Practical quantitation limit (PQL)	PQL ≈ 5 x or 10 x MDL (also can be determined or refined by including values near the MDL as the lowest standard on the instrument calibration curve)	The lowest concentration of an analyte that can be reliably measured within specified limits of precision and accuracy during routine laboratory operating conditions[2]	Provides numerical lower limit for critical data
Reporting limit (RL)	Laboratory defined (often; RL = PQL)	Lowest value reported by laboratory without a "J" flag	Laboratory basis for reporting data without any flags
"J" value	MDL < "J" value < RL	Estimated value; quantitated value below the laboratory RL and above the MDL	Alerting the data analyst that the value reported was below the laboratories' RLs.

[1] 40 CFR 136 Appendix B
[2] 50 FR 469906

3.4 DATA QUALITY CRITERIA

The acceptability criteria for data produced in support of this project are provided in Table 3.6. This table provides data quality criteria for sensitivity, precision, bias, and completeness for WSTF groundwater monitoring data. Table 3.7 describes the data qualifiers utilized to identify data that does not meet the criteria outlined in Table 3.6.

TABLE 3.6

DATA QUALITY CRITERIA FOR TARGET ANALYTES

WSTF TARGET ANALYTE	CAS NUMBER	OTHER COMMON DESIGNATIONS AND ACRONYMS	CURRENT ANALYTICAL METHOD	MAXIMUM PRACTICAL QUANTITATION LIMIT (1)	UNITS	PRECISION (2)	BIAS (3)	COMPLETENESS (4)
Dichlorofluoromethane	75-43-4	Freon 21	8260	5	µg/L	25	70-130	80
Trichlorofluoromethane	75-69-4	Freon 11, MF Freon	8260	5	µg/L	25	70-130	80
Trichloromethane	67-66-3	Chloroform	8260	1	µg/L	25	70-130	80
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	Freon 113, TF Freon	8260	5	µg/L	25	70-130	80
1,1,1-Trichloroethane	71-55-6	1,1,1-TCA	8260	5	µg/L	25	70-130	80
Trichloroethene	79-01-6	Trichloroethylene, TCE	8260	1	µg/L	25	70-130	80
Tetrachloroethene	127-18-4	Perchloroethene, PCE	8260	1	µg/L	25	70-130	80
1,2-Dichloro-1,1,2-trifluoroethane	354-23-4	Freon 123A	8260	5	µg/L	25	70-130	80
2,2-Dichloro-1,1,1-trifluorethane	306-83-2	Freon 123	8260	5	µg/L	25	70-130	80
1,1-Dichloroethene	75-35-4	1,1-DCE	8260	1	µg/L	25	70-130	80
N-Nitrosodimethylamine	62-75-9	NDMA	607-modified	0.01	µg/L	25	13-109	80
N-Nitrodimethylamine	4164-28-7	DMN	607-modified	0.01	µg/L	25	13-109	80
Bromacil	314-40-9		607-modified	0.01	µg/L	25	70-130	80
Chromium	7440-47-3		6010	0.01	mg/L	25	75-125	80

(1) Defined as the maximum quantitation limit acceptable for the WSTF Groundwater Monitoring Programs. Lower quantitation limits are acceptable if they are scientifically valid.

(2) As relative percent difference for field duplicates or matrix spike duplicates. These values represent acceptance criteria as recommended by EPA Method 8000 Section 8.54. More stringent laboratory or project-specific criteria will be applied when available.

(3) As percent recovery of matrix spikes. These values represent acceptance criteria as recommended by EPA Method 8000 Section 8.54. More stringent laboratory or project-specific criteria will be applied when available.

(4) Percentage of measurements which meet expressed data quality criteria for precision, bias and quantitation.

TABLE 3.6

DESCRIPTION OF DATA QUALIFERS

Data Qualifier	Description
*	User defined qualifier.
A	Indicates that the result of an analyte for a laboratory control sample (LCS) or continuing calibration verification (CCV) was outside standard limits.
AD	Indicates that the precision for analyst duplicates was outside standard limits.
EB	Indicates that the analyte was detected in the equipment blank.
FB	Indicates that the analyte was detected in the field blank.
G	Indicates that the result is an estimated value greater than the calibration limit.
J	Indicates that the result is an estimated value less than the quantitation limit, but greater than or equal to the detection limit.
NA	Indicates that the value/result was either not analyzed or not applicable.
ND	Indicates that the analyte was not detected at or above the detection limit.
Q	Indicates that the result for a blind sample was outside standard limits.
QD	Indicates that the precision for a field duplicate was outside standard limits.
R	Indicates that the sample results are rejected due to serious deficiencies in the ability to analyze the sample and meet quality control criteria. The presence or absence of the analyte cannot be verified.
RB	Indicates that the analyte was detected in the reagent or method blank.
S	Indicates that the result was determined by the method of standard addition.
SP	Indicates that either the spike recovery or the relative percent difference for spike duplicates was outside standard limits.
T	Indicates that the analyte was analyzed outside the specified holding time.
TB	Indicates that the analyte was detected in the trip blank.
TIC	Indicates that the analyte was tentatively identified by a GC/MS library search and the amount reported is an estimated value.

4.0 SAMPLING AND ANALYSIS PLAN

Sampling and analysis information is provided in the WSTF Sampling and Analysis Plan, a site-wide instructional document for groundwater monitoring personnel.

5.0 ANALYTICAL PROCEDURES

5.1 INTRODUCTION

EPA recommended methods are used, when available, to identify and quantify hazardous constituents in WSTF groundwater samples. In cases where EPA methods are not provided for specific hazardous constituents, the best available technology is researched, utilized and referenced. WSTF primarily analyzes for volatile organics, three specific semivolatile organics, and RCRA metals.

5.2 WSTF ANALYTICAL METHODS

During the course of the WSTF Monitoring Program, minor modifications have been incorporated into the referenced EPA methods to adjust for WSTF site-specific requirements. The following sections outline and explain these modifications.

5.2.1 VOLATILE ORGANICS ANALYTICAL METHOD

WSTF currently utilizes EPA Method 8260 for volatile organics analysis. Four volatile organic compounds specific to the WSTF groundwater contaminant plume are not found on the Method 8260 analyte list as written in SW-846. These compounds are added to the project-specific statement of work and the contracted laboratory is required to calibrate, and analyze for these additional volatile compounds in WSTF groundwater samples. The four additional compounds are dichlorofluoromethane (Freon 21), 1,1,2-trichloro-1,2,2-trifluoroethane (Freon 113), 1,2-dichloro-1,1,2-trifluoroethane (Freon 123A), and 2,2-dichloro-1,1,1-trifluoroethane (Freon 123).

5.2.1 SEMIVOLATILE ORGANICS ANALYTICAL METHOD

WSTF currently uses a modified version of EPA Method 607 for semi-volatile organics analysis. The modification, pursuant to section 12.2[1] of the Method includes a high resolution capillary column and a mass spectral detector in selective ion monitoring mode. Two semivolatile organic compounds specific to the WSTF groundwater contaminant plume, N-nitrodimethylamine and bromacil are not found on the Method 607 analyte list as written in SW-846. These compounds are added to the project-specific statement of work and the contracted laboratory is required to calibrate, and analyze for these additional semivolatile compounds in WSTF groundwater samples.

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[1] Section 12.2 of Method 607 states that "Other packed or capillary (open-tubular) columns, chromatographic conditions, or detectors may be used if the requirements of Section 8.2 are met."

5.3 DOCUMENTATION

Documentation of the analytical effort is outlined in the Quality Manual submitted by the analytical laboratories. The laboratory Quality Manual must be submitted, reviewed, approved, and maintained on file in the site contractor Environmental Department prior to commencing analyses. In addition, site-specific requirements delineated in the Statement of Work must be met. The laboratory's Quality Manual must include, at a minimum, the following:

- Personnel qualifications and training plans;
- Documentation and records management procedures;
- Quality control procedures;
- Work processes, operating procedures and methods; and
- Quality assessment, standardization and response action plans.

When analytical results are received from the analytical laboratory, the QA/QC Coordinator will review the reports for compliance with the laboratory Quality Manual, WSTF protocols and approved plans. If discrepancies are present, they are researched and rectified or documented at this time.

6.0 SYSTEMS AUDITS AND AUDIT REPORTS

6.1 INTRODUCTION

Technical system audits are an essential element in the Quality Assurance Project Plan. These audits are designed to verify compliance with all applicable documentation and to assess the overall quality of the data collection and generation system. Audits evaluate sample collection, sample analysis procedures and data management and reporting techniques.

6.2 SYSTEMS AUDIT

A technical systems audit is a comprehensive qualitative evaluation of the entire data collection and generation system. This audit examines all phases of the sampling and analysis system: collection of samples; preservation and handling of samples; transport of samples; documentation of field and analytical steps; quality control procedures; data reporting; and data management.

This evaluation is performed on at least a quarterly basis by an independent individual with the training and expertise to perform the audit. The auditor submits an audit report to the Environmental Department Contamination Assessment Supervisor. This report presents the results of the audit and provides recommendations for corrective actions.

7.0 CORRECTIVE ACTIONS AND REPORTS TO MANAGEMENT

7.1 CORRECTIVE ACTIONS

The QA/QC Coordinator initiates corrective actions when data evaluation, preparation of environmental reports and/or technical systems audits indicate discrepancies. The corrective actions can include procedural changes, resampling, preparation of additional site-specific quality control samples, additional field audits, review of analytical laboratory procedures, and/or any other procedure that will mitigate the discrepancies. Corrective actions, recommendations and specific steps taken to resolve data quality discrepancies are reported to the contractor Environmental Department Contamination Assessment Supervisor.

7.2 QUALITY ASSURANCE REPORT

The QA/QC Coordinator provides a monthly Quality Assurance Report to the Environmental Department's Contamination Assessment Supervisor. At a minimum, this report includes a summary of quality control procedures utilized, the quantity and type of field quality control samples analyzed, a summary of laboratory quality control procedures/samples used, a list of all samples analyzed and reported with data qualifiers, an overall assessment of the quality of environmental data, and a chronology of any corrective actions initiated to resolve discrepancies.

8.0 DATA MANAGEMENT

8.1 INTRODUCTION

The amount of data produced by WSTF groundwater monitoring activities requires that standard procedures are used to manage, store and process all environmental data. This section discusses the procedures used to ensure that environmental data are effectively processed.

The environmental database used by the site contractor Environmental Department is a modular database system. Modules included in this system are the data management module and the environmental database module. The contractor Environmental Department also retains all documentation related to the data in the database modules. All documentation is managed pursuant to site-specific record management protocol.

8.2 DATA MANAGEMENT MODULE

The data management module is used to gather and organize analytical data for the various reporting requirements associated with WSTF groundwater monitoring activities. A Final Sampling Event Report is generated for each individual sampling event

performed at WSTF. The QA/QC Coordinator organizes the laboratory data and the corresponding QA discussion, sets data qualifiers and prepares the Final Sampling Event Report. Specific instructions for the review of the Final Sampling Event Reports are contained in the site-specific procedural documentation applicable to groundwater database operations and quality assurance. The data quality criteria in Table 3.6 provide the basis for the data quality review. The report is reviewed and approved by the Environmental Sampling Coordinator and the QA/QC Coordinator.

The analytical laboratory is required to maintain raw data, chromatographs, logbooks, and all other relevant analytical information. This information is required to ensure the validity of reported data and to rectify any discrepancies that may arise.

There are several required elements incorporated into a Final Sampling Event Report. These elements are: sampling location/Well I.D.; sampling event date; field logbook copies; sample ID number(s); analytical laboratory name; date received; date extracted or digested; analytical methods used; date analyzed; compounds analyzed for; corresponding CAS numbers; concentrations observed; practical quantitation limits; method detection limits; quality control samples collected; data qualifiers; a table describing data qualifiers used; and all associated QA narratives. QA narratives provide details for all data qualifiers and any additional comments concerning the quality of the sampling event.

8.3 ENVIRONMENTAL DATABASE MODULE

The WSTF environmental database module is managed by the site contractor Environmental Department. Final Sampling Event Reports are reviewed, evaluated and approved by the Environmental Department prior to incorporation into the environmental database module. This module is the final repository for all reviewed and approved data and allows data end-users the ability to use stored data for generating reports, tables, graphs, and other visual presentations.

8.3.2 Database Management

Management of the environmental database is performed pursuant to specific procedures outlined in the site-specific procedural documentation applicable to groundwater database operations and quality assurance. The site contractor Environmental Department is the only organization which can input or edit data in the environmental database module. All other individuals are granted "read only" access. This precludes data modification by personnel other than specified personnel within the contractor Environmental Department.

8.3.3 End-Users of Data

The primary end-users of environmental data are the contractor Environmental Department and the NASA Environmental Program Manager. The contractor

Environmental Department uses the data, in conjunction with collected geophysical data, to interpret and present technical assessments of the hydrogeological system. In addition, the contractor Environmental Department uses the data to prepare regulatory and technical reports. The NASA Environmental Program Manager uses data presentations as guidance for making managerial decisions concerning groundwater monitoring programs.

9.0 REFERENCES

Barcelona, M., J. Gibb, J. Helfrich, and E. Garske, 1985, Practical Guide for Ground-Water Sampling, Illinois State Water Survey, Champaign, IL, November 1985.

Black, W., H. Smith, F. Patton, 1986, "Multiple-Level Groundwater Monitoring with the MP System", Proceedings of the Surface and Borehole Geophysical Methods and Ground Water Instrumentation Conference and Exposition, National Water Well Association, Denver, CO, October 1986.

Ford, P., P. Turina, and D. Seely, 1984, Characterization of Hazardous Waste Sites - A Methods Manual: Volume II Available Sampling Methods, Second Edition, EPA 600/4-84-076, U.S. Environmental Protection Agency, Office of Research and Development, Environmental Monitoring Systems Laboratory, Las Vegas, NV, December 1984.

Environmental Protection Agency, 1986, RCRA Ground Water Monitoring Technical Enforcement Guidance Document, OSWER Directive 9950.1, Office of Solid Waste and Emergency Response (OSWER), Washington D.C., September 1986.

Environmental Protection Agency, 1986, Protocol for Ground-Water Evaluations, OSWER Directive 9080.0-1, Hazardous Waste Ground Water Task Force, Office of Solid Waste and Emergency Response (OSWER), Washington D.C., September 1986.

Environmental Protection Agency, 1989, Interim Final RCRA Facility Investigation Guidance Volumes I-IV, EPA 530/SW-89-031, Waste Management Division, Office of Solid Waste, Washington, DC, May 1989.

Environmental Protection Agency, 1990, Handbook: Ground Water Volume I: Ground Water and Contamination, EPA/625/6-90/016a, Office of Research and Development, Center for Environmental Research Information, Cincinnati, OH, September 1990.

Environmental Protection Agency, 1991, Handbook: Ground Water Volume II: Methodology and Contamination, EPA/625/6-90/016b, Office of Research and Development, Center for Environmental Research Information, Cincinnati, OH, July 1991.

Environmental Protection Agency, 1992, RCRA Ground-Water Monitoring: Draft Technical Guidance, EPA/530-R-93-001, Office of Solid Waste, Washington D.C., November 1992.

Environmental Protection Agency, Region I, 1996, Low Stress (low flow) Purging and Sampling for the Collection of Ground Water Samples From Monitoring Wells, EPA SOP #GW 0001, Revision 2, Washington, DC, July 1996.

Environmental Protection Agency, 1996, Sampler's Guide to the Contract Laboratory Program, (EPA/540/R-96/032), Internet at http://www.epa.gov/superfund/programs/clp/guidance.htm.

Environmental Protection Agency, 1997, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846), Third Edition, Office of Solid Waste and Emergency Response, Washington, D.C., June 1997, Internet at http://www.epa.gov/epaoswer/hazwaste/test/sw846.htm.

Environmental Protection Agency, 1997, Office of Research and Development, National Center for Environmental Research and Quality Assurance, Quality Assurance Division, Glossary of Quality Assurance Terms and Related Acronyms, December 1997

Environmental Protection Agency, 1998, EPA Guidance for Quality Assurance Project Plans, (EPA QA/G-5) EPA/600/R-98/018, February 1998, Internet at http://www.epa.gov/quality/qa_docs.html.

Environmental Protection Agency, 2001, EPA Requirements for Quality Assurance Project Plans, (EPA QA/R-5) EPA/24-/B-1/003, March 2001, Internet at http://www.epa.gov/quality/qa_docs.html.

Environmental Protection Agency, 2001, Draft Guidance on Data Quality Indicators, (EPA QA/G-5i) September 2001, Internet at http://www.epa.gov/quality/qa_docs.html.

National Aeronautics and Space Administration, 1997, "Quality Assurance Project Plan", NASA WSTF, Las Cruces, NM, July 1997.

National Archives and Records Administration, Office of the Federal Register, 1991, Code of Federal Regulations (CFR), Protection of Environment, Title 40, Parts 100 to 149, Washington, D.C., July 1, 1991.

National Archives and Records Administration, Office of the Federal Register, 1998, Code of Federal Regulations (CFR), Protection of Environment, Title 40, Parts 260 to 299, Washington D.C., July, 1998.

National Environmental Laboratory Accreditation Conference (NELAC), 2001, Chapter 1: Program and Policy Structure Standard, 2001 Standards, Internet at http://www.epa.gov/ttn/nelac.

National Environmental Laboratory Accreditation Conference (NELAC), 2001, Chapter 2: Quality Systems Standard, 2001 Standards, Internet at http://www.epa.gov/ttn/nelac.

New Mexico Environment Department, 2001, Position Paper: Use of Low-Flow and Other Non-Traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring, Hazardous Waste Bureau, Santa Fe, NM, October 30, 2001, Internet at http://www.nmenv.state.nm.us/hwb/data/11-7low-flow%20final.pdf.

Nielson, D., 1991, Practical Handbook of Ground-Water Monitoring, Lewis Publishers Inc., Chelsea, MI.

Scalf, M., J. McNabb, W. Dunlap, R. Cosby, and J. Fryberger ,1981. Manual of Ground-Water Sampling Procedures, U. S. Environmental Protection Agency, Office of Research and Development, Robert S. Kerr Environmental Research Laboratory, Ada, OK.

NASA White Sands Test Facility

Sampling and Analysis Plan for Routine Groundwater Sampling

Attachments

Attachment A

NASA White Sands Test Facility Job Instruction

Installation of Conventional Wells

Issued:
Expires:

White Sands Test Facility
Job Instruction

WJI ENV-0048.A

CONVENTIONAL GROUNDWATER WELL INSTALLATION

Work Authorizing Document: Environmental Department Task Memo

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Record of Revisions

Issue	Pages Affected	Reason for Revision	Date Revised

1. PURPOSE

This WJI provides instruction for the installation of conventional groundwater wells. Groundwater wells are required in order to comply with the WSTF 3008(h) Consent Order Agreement, the NMED-issued Post-Closure Care Permit, the Plume-Front Stabilization Work Plan, possible discharge permit compliance, landfill monitoring mandates, or other regulatory directives.

2. REFERENCES

American National Standards Institute (ANSI) Z41 (Protective Footwear), ANSI Z87.1 (Eye and Face Protection), and ANSI Z89.1 (Head Protection).

WJI ENV-0047, “Drilling of Groundwater Well Boreholes”.

WSTF Job Hazard Analyses: GE-001 “Installation of Groundwater Wells”.

3. ATTACHMENTS

A. Casing Tally Form

B. Conventional Well Summary Form

C. Continuation Sheet

4. DEFINITIONS

NONE

5. ABBREVIATIONS AND ACRONYMS

ANSI – American National Standards Institute

bgs – Below ground surface

CFR – Code of Federal Regulations

dBA – Decibels, A-weighted

EPA – Environmental Protection Agency

GSA – Government Services Administration

Mil – Unit of measure equal to 0.001 inch

NASA – National Aeronautics and Space Administration

NMED – New Mexico Environment Department

OSHA – Occupational Safety and Health Administration

PVC – Polyvinyl Chloride

QA/QC – Quality Assurance/Quality Control

SEO – State Engineer Office

WJI – WSTF Job Instruction

WSTF – White Sands Test Facility

6. SAFETY REQUIREMENTS

NOTE:
A SAFETY HAZARD ASSESSMENT FOR THE DRILLING OF GROUNDWATER WELL BOREHOLES HAS BEEN PERFORMED IN ACCORDANCE WITH 29 CFR 1910.132 SUBPART I. THE CERTIFICATION OF HAZARD ASSESSMENT AS REQUIRED BY WSI 25-SW-0007 IS CONTAINED IN THE JOB HAZARD ANALYSIS (JHA) FOR INSTALLATION OF GROUNDWATER WELLS (JHA GE-001). THE AUTHORIZED SIGNATURES OF INDIVIDUALS APPROVING THIS WJI INDICATE THEIR CONCURRENCE WITH THE SAFETY HAZARD ASSESSMENT AND THE PRESCRIBED SAFETY REQUIREMENTS IN THIS DOCUMENT AND THE REFERENCED JHA. ANY CONTRACTOR ENVIRONMENTAL DEPARTMENT PERSONNEL ASSIGNED TO A PROJECT UTILIZING THIS WJI ARE RESPONSIBLE FOR ENSURING THAT ALL PERSONNEL WITHIN THE VICINITY OF THE WELL SITE ABIDE BY THE JHA AND THE FOLLOWING SAFETY REQUIREMENTS.

a. In the event that a well site is located near any occupied areas of WSTF, portable barriers will be erected at least a distance of approximately one and one half times the height of the drilling rig or pulling unit mast to delineate the restricted access boundaries. Access will be restricted to personnel involved with the project who have the required levels of protective equipment and training.

b. Hard hats in accordance with the most recent version of ANSI Z89.1 will be worn by all personnel within a radius of one and one half times the height of the drilling rig or pulling unit mast to protect them from the potential hazard of falling equipment.

c. Steel-toed boots in accordance with the most recent version of ANSI Z41 (MT I/75 C/75) will be worn at the well site to protect the feet from potential drop hazards.

d. Safety glasses in accordance with the most recent version of ANSI Z87.1 will be worn at the well site to protect the eyes from potential airborne debris.

e. All personnel will wear work gloves while handling equipment to protect the hands from scrapes and cuts associated with manual labor.

f. All personnel will use hearing protection if noise levels at the work site exceed 85 dBA in the short term (15 minutes) or 80 dBA in the long term (eight hours). Generally, hearing protection is necessary if vocal communication between persons standing three feet apart requires shouting.

g. One Class ABC fire extinguisher will be kept at the well site and within each GSA field vehicle.

h. A two-way radio will be kept at the well site for communication.

i. A WSTF-issued pager will be kept at the well site for WSTF site emergency notifications.

j. At least two individuals (drilling contractor and/or Contractor Environmental) are required to be present on-site for all field activities.

7. SUPPORT REQUIREMENTS

WSTF Engineering Department heavy equipment support may be required to provide road and well pad maintenance.

8. SPECIAL REQUIREMENTS

NONE

9. INSTRUCTIONS

NOTE:
ALL WELL INSTALLATION TASKS WILL BE PERFOMED BY AUTHORIZED CONTRACTOR ENVIRONMENTAL DEPARTMENT PERSONNEL AND/OR DRILLING CONTRACTOR PERSONNEL.

PRE-INSTALLATION REQUIREMENTS

NOTE:
PERMITS ARE NOT REQUIRED FROM THE SEO OR THE NMED FOR THE DRILLING OR INSTALLATION OF MONITORING WELLS USED TO MONITOR CONTAMINANT PLUMES

a. Verify that NASA has obtained the required SEO permit(s) prior to the commencement of any conventional well installation activities. For injection wells, verify that a discharge permit has also been obtained from the NMED.

b. If the well is to be installed on land not owned by NASA, ensure that NASA has obtained the proper clearance from the land owner to install a well prior to any drilling activities. Also ensure any necessary surveys (archeological, biological, ect.) have been properly performed prior to any drilling activities.

c. Ensure a Hot Work Welding – Cutting Permit (WSTF Form No. 418) has been obtained from the WSTF Fire Department prior to any torching/welding activities at the well site.

d. Prior to the commencement of installation activities, review the following borehole drilling forms in order to be familiar with the borehole and assist with designing the well: Pre-spud Form, Water Usage Log, Lithologic Log, Borehole Development Log, Hydraulic Conditions Form, and the geophysical logs. The purpose of these forms is addressed in WJI ENV-0047, “Drilling of Groundwater Well Boreholes”.

d. A Health and Safety Plan complying with OSHA and EPA standards applicable to the work activities must be provided by the drilling contractor and approved by the Contractor Environmental Department. All drilling contractor personnel must: possess a valid, current certification of OSHA 40-hour Hazardous Waste Operations and Site Investigation training; attend a Contractor Organization Safety Department training class; and, following the safety class, attend a drill-site Contractor Environmental Department briefing concerning the hazards associated with on-site installation operations.

e. If the casing material is steel, Contractor Environmental Engineering personnel will evaluate the salient factors and determine if cathodic protection is required for the well.

f. Direct the drilling crew to the steam cleaning pad to steam clean all casing materials and all down-hole installation equipment.

g. Direct the drilling crew to set the rig or pulling unit up at the site. The drill rig or pulling unit must be underlain with at least six mil (minimum) thickness plastic sheeting. The outer edge of the sheeting must be bermed to contain any discharged fluids, which could potentially contaminate the soil or borehole.

h. Confirm that the grade and composition of the annular materials provided by the drilling contractor match those specified on the well design. The grade and composition of the

sand may vary from shipment to shipment or well to well depending on the screen size. Obtain the appropriate materials if needed.

DOCUMENTATION AND WELL INSTALLATION PROCEDURES

NOTE:
A CONTRACTOR ENVIRONMENTAL DEPARTMENT GEOLOGIST OR AN APPROPRIATE ENVIRONMENTAL DEPARTMENT DESIGNEE WILL BE ON SITE AT ALL TIMES, EXCEPT BRIEF PERIODS TO OBTAIN EQUIPMENT, SUPPLIES, OR SERVICES REQUIRED FOR THE PROJECT. THE GEOLOGIST OR ENVIRONMENTAL DEPARTMENT DESIGNEE WILL BE RESPONSIBLE FOR PROJECT COORDINATION, SITE HEALTH AND SAFETY, AND THE PROJECT DOCUMENTATION OUTLINED IN FOLLOWING STEPS.

i. Maintain the following documentation throughout the installation procedures:

(1) A field logbook containing personnel present, weather conditions, all pertinent events, material usage records, casing footages, annular materials footages, water usage, driller's comments concerning installation, and any other notes that the Contractor Environmental Department geologist or designee deems necessary to record;

(2) A Conventional Well Design;

(3) A Casing Tally Form (Attachment A) to be filled in as the casing is installed; and

(4) A Conventional Well Summary (Attachment B) to be filled in as the project progresses.

j. Contractor Environmental Department personnel will generate a detailed conventional well design using available drilling, hydrogeologic, and geophysical logging data prior to commencement of installation activities. The design will include all casing joints, couplings (if needed), an end cap, and centralizers. The casing joints should be numbered on the design, starting with number "1" at the bottom of the well and progressing upwards. Review the conventional well design against the geophysical logs to ensure the design satisfies monitoring goals and all conventional well installation requirements. The well design will be used as an installation guide (for well component set-up and as a record of installation) and for QA/QC assessments. Study and become familiar with the well design prior to commencement of installation procedures.

k. Using the conventional well design as a guide, transport all needed casing components to the well site, if necessary. Each casing component will be marked with a check on the well design as it is installed.

l. If cathodic protection is to be installed, utilize the appropriate procedural documents during the installation process.

m. Once the drill string and bit are removed, sound the borehole to measure total depth bgs and to document whether sloughing has occurred. If possible, measure and record a static water level depth relative to ground surface.

n. Test the size and grading of the proposed sand or gravel filter pack against the screen to ensure that less than 20% of the filter pack passes through the screen.

o. Lay the casing joints out in the order of installation, if applicable. Ensure that the end cap and each casing joint is measured to the nearest 0.01 foot, and document the lengths on the casing Tally Form (Attachment A). All casing components should preferably be installed in one shift. Avoid partial installation with overnight delays whenever possible.

p. Ensure that all personnel handling well materials wear clean work gloves. The drilling contractor personnel will install the conventional well materials under the supervision of the Contractor Environmental Department geologist or designee. Begin casing installation by installing the end cap to the bottom end of the first casing joint per the well design (by securely threading the end cap to the casing for flush-threaded casing, by inserting a spline into the groove as completely as possible for CertainTeed® Certa-Lok casing, or by securing the end cap with stainless steel screws to the casing). Do not use any lubricant other than clean water, and take care not to compromise the casing O-ring while tightening the joint. Replace the O-ring if necessary. Suspend the end cap and first joint of casing in the borehole, and secure it at ground surface using an elevator clamp and slip plate provided by the drilling contractor.

q. Thread or install couplings to subsequent sections of casing or screen above ground surface. Release the elevator clamp, and carefully lower the casing string using the drilling rig or pulling unit via a threaded plug (lifting sub) and cable attachment. Re-attach the elevator clamp before removing the cable. Mark a check by each joint of casing on the well design as it is installed in the borehole and denote on the Casing Tally Form the time the joint was installed in the borehole. Continue in this manner until the first centralizer location or cathodic protector is reached.

r. Centralizers will be installed by the drilling contractor per the well design. They are usually either steel centralizers welded to the stainless steel casing in sets of three where directed, or bolted, expandable stainless steel centralizers bolted on and tightened to the casing as directed by the Contractor Environmental Department geologist or designee. For PVC casing, the drilling contractor will install the centralizer as appropriate (usually bolted, expandable stainless steel centralizers bolted on and tightened towards the center of casing joints, or bolted on just below the coupling). Be sure all personnel installing the well have the knowledge or documentation for installing centralizers correctly. Document the position of the centralizers on the Casing Tally Form (in the

comments section) as they are installed on the casing and mark a check by the centralizers on the well design to indicate successful installation.

s. Continue installation and documentation as before. At all times during installation, the well should be suspended in the borehole. If the casing string cannot be rotated or is caught on the borehole wall, remove the string and sound the borehole to verify that the total borehole depth bgs is still adequate to permit installation.

t. After the last joint of casing has been connected, suspend the well and/or well screen at the appropriate depth bgs in the borehole by determining the necessary stick-up on the well. Ensure that the casing does not rest on the bottom of the borehole. Measure the stick-up to the nearest 0.01 foot and document it on the Casing Tally Form and Well Completion Diagram. Also document the total casing depth bgs on the Casing Tally Form and Well Completion Diagram (total casing measured minus measured stick-up).

u. Correct the well design for all well components to reflect the actual depths bgs using the measured stick-up and the actual casing lengths measured during installation. This may change the optimum depths bgs for annular materials installation. Correct the diagram appropriately.

v. Insert a small diameter tremie pipe (provided by the drilling contractor) into the annulus between the casing and borehole wall. This tremie pipe will be used for the installation of all annular materials (sand, bentonite, and grout) around the casing string.

w. Install the annular materials into the borehole annulus via the tremie pipe per the well design (corrected for the actual casing installation depths bgs). The well design specifies the appropriate depths, thicknesses and types of materials. Materials may be pumped in below the water level and poured or pumped at depths above the water level. The Contractor Environmental Department geologist or designee is responsible for the final positions of the annular materials. Maintain the position of the tremie pipe in the borehole at approximately five feet above the annular materials. Prevent tremie blockage by retracting the pipe as annular materials fill the borehole.

x. The drilling contractor will be responsible for sounding the level of annular materials in the borehole as directed by the Contractor Environmental Department geologist or designee. Sound the top of the annular materials bgs at each material-type boundary and at any depth bgs the Contractor Environmental Department geologist or designee deems necessary to accurately monitor the changing depths and to assess whether bridging has occurred. Record actual depths bgs of annular materials on the well design. Attempt to install the annular materials at the exact depths bgs specified on the corrected well design. Be especially careful to avoid installing bentonite any closer to the screened interval(s) than designed.

y. If the annular materials bridge (form a blockage within the borehole with free space below the blockage) or block up the tremie pipe, pump water through the tremie pipe to attempt

to clear the blockage. If this does not prove successful, discuss options with the drilling supervisor.

z. Immediately after emplacement of the gravel or sand filter pack across a screened interval and sounding the level bgs of the top of the sand, gently surge the well with a bailer to ensure that the filter pack is properly seated in the borehole. Following surging, sound the top of the annular materials again to determine how much, if any, settling has occurred. If the depth bgs of the sand is lower than designed, add more gravel or sand filter pack until it reaches the appropriate depth bgs as indicated on the well design.

aa. According to the type of well to be installed and the individual well design, install the annular materials as specified on the well design. Well completions typically approximate the specifications described below.

MONITORING WELLS

- Monitoring well designs include one or more discreet screened intervals at or below the water table. Screened intervals are typically ten to 20 feet in length.

- Install the gravel or sand filter pack from five feet below to five feet above each screen. The grade of the sand will depend on the screen slot size and will be specified on the well design.

- Install finer-grained gravel or sand three feet below and three feet above the filter pack interval specified above (if applicable, per well design). The grade of this gravel or sand will also be specified on the well design.

- Install bentonite five feet below and five feet above the finer gravel or sand. Each bentonite layer will be allowed to hydrate for 30 minutes before installation continues. Be especially careful not to install bentonite within or near the screened interval. To avoid bentonite intrusion into the screened interval, if needed, install the bentonite further away from the screen (above and below) than indicated on the well design.

- Install a 50/50 mix of sand and bentonite: 1) in the bottom of the borehole if there is excess space below the lower limit of the bottom gravel or sand interval (if applicable); 2) between the bentonite seal at the top of a screened interval and the bottom of the next screened interval (if applicable); and 3) above the upper-most installed gravel or sand as specified on the well design.

- Install either neat cement grout containing 5% bentonite or bentonite grout in the annulus above the top of the upper 50/50 sand/bentonite mix. The maximum number of feet of cement grout that can be poured at one time between 12-hour curing periods will depend on the well casing material, wall thickness (or schedule), and diameter as well as the cement volume based on the annular

space between the borehole and the well casing. Consult a Contractor Environmental Department engineer and the contractor drilling supervisor to determine the maximum number of feet of cement grout that can be poured between 12-hour curing periods, if applicable. Bentonite grout can be poured in one stage.

EXTRACTION WELLS

- Extraction well designs typically have one continuous screened interval from above a five to 20-foot sump to within 50 feet of the water table.

- Install a ten to 20-foot bentonite plug in the bottom of the borehole (if applicable) within the sump interval and above the screened interval according to the well design. Be especially careful not to install bentonite within or near the screened interval. To avoid bentonite intrusion into the screened interval, if needed, install the bentonite further away from the screen (above and below) than indicated on the well design.

- Install gravel or sand from the bottom of the borehole (or above the lower bentonite plug) to 20 feet above the screened interval. Refer to the well design for the exact footage of the gravel or sand.

- Install a ten-foot thick, finer grade gravel or sand (if applicable, per well design) above the gravel or sand within the screened interval.

- Install a ten to 20-foot bentonite seal above the finer grade gravel or sand (if applicable) or the coarser grade gravel or sand. Refer to the well design for the exact footage of the seal.

- Install a 50/50 mix of sand and bentonite above the bentonite seal as specified on the well design.

- Install either neat cement grout containing 5% bentonite or bentonite grout above the 50/50 sand/bentonite mix according to the well design. The maximum number of feet of cement grout that can be poured at one time between 12-hour curing periods will depend on the well casing material, wall thickness (or schedule), and diameter as well as the cement volume based on the annular space between the borehole and the well casing. Consult a Contractor Environmental Department engineer and the contractor drilling supervisor to determine the maximum number of feet of cement grout that can be poured between 12-hour curing periods, if applicable. Bentonite grout can be poured in one stage.

INJECTION WELLS

- Injection wells will typically have a continuous screened interval from above a five to 20-foot sump interval to within 50 feet above the water table.

- Install a ten to 20-foot bentonite plug in the bottom of the borehole (if applicable) within the sump interval and above the screened interval according to the well design. Be especially careful not to install bentonite within or near the screened interval. To avoid bentonite intrusion into the screened interval where sounding the depth of the well is difficult (usually toward the bottom of the borehole), install the bentonite further away from the screen (above and below) than indicated on the well design.

- Install gravel or sand from the bottom of the borehole (or above the bottom bentonite plug) to 20 feet above the screened interval. Refer to the well design for the exact footage of gravel or sand.

- Install a ten-foot thick finer grade sand (if applicable, per well design) above the coarser gravel or sand interval.

- Install a ten to 20-foot bentonite seal above the finer grade gravel or sand (if applicable) or the coarser grade gravel or sand. Refer to the well design for the exact footage of the seal.

- Install a 50/50 mix of sand and bentonite above the bentonite seal as specified on the well design.

- Install either neat cement grout containing 5% bentonite or bentonite grout above the 50/50 sand/bentonite mix according to the well design. The maximum number of feet of cement grout that can be poured at one time between 12-hour curing periods will depend on the well casing material, wall thickness (or schedule), and diameter as well as the cement volume based on the annular space between the borehole and the well casing. Consult a Contractor Environmental Department engineer and the contractor drilling supervisor to determine the maximum number of feet of cement grout that can be poured between 12-hour curing periods, if applicable. Bentonite grout can be poured in one stage.

bb. Well development may commence once the final stage of cement or bentonite grout has cured for 12 hours. See WJI ENV-0069, “Groundwater Borehole/Well Development” for development instructions.

cc. Schedule Contractor Environmental Department technicians to perform a camera log immediately following well development. The camera log will be reviewed by a Contractor Environmental Department geologist or designee immediately upon

completion. If any issues of concern related to the well are noted in the camera log, Contractor Environmental Department personnel must determine further action to remedy observed problems. A camera log will be repeated after any remedial action is performed on a well. All camera log information will be entered into the Contractor Environmental Department camera log database within one week after the camera log was performed.

dd. For completed monitoring wells, schedule the WSTF Facilities Engineering Department to construct a cement pad around the well head with an embedded brass cap and a locking steel cover over the top of the casing immediately following completion of the final camera log. The cement pad dimensions (typically three feet square) will be specified by Contractor Environmental Department personnel, and the pad should slope gently away from the well head cover to avoid potential surface water ponding. A barrier post will be permanently installed at each corner of the well pad to protect the well head from potential vehicle impact. For extraction or injection wells, consult the Contractor Environmental Department engineer in charge of remediation system installation or maintenance to determine the exact well completion construction necessary.

ee. Schedule the appropriate Contractor Environmental Department personnel to perform a survey-grade final GPS survey of the well head and pad within one week following well pad, brass cap, and barrier post installation. This survey should measure the well(s) northing, easting, and elevation to the nearest 0.01 foot using White Sands Transmercator system (if applicable) and state plane and geodetic coordinate systems. The brass cap and all casing (inner and outer if applicable) will be surveyed.

ff. Schedule the Contractor Environmental Department technicians to stamp the brass cap with the well name, elevation, and location data immediately following the completion of the GPS survey.

gg. At the completion of borehole and well installation, ensure that all documentation is complete and submit it to an alternate geologist or designee for QA/QC. Any discrepancies will be noted and corrected.

(1) Attachment A: The Casing Tally will be annotated during well casing installation and will be available during annular materials installation.

(2) Attachment B: The Well Summary will be annotated during drilling, well installation, and development.

hh. Completed forms are to be provided to the well file Contractor Environmental Department QA/QC geologist or designee for electronic reproduction and filing.

ii. A well file will be compiled with all finalized electronic borehole and well forms within one week after the final GPS survey has been performed.

jj. Annotate the attached Continuation Sheet (Attachment D) with the well name, date completed, and the Contractor Environmental Department geologist's or designee's signature.

kk. If applicable, contact and schedule the Facilities Engineering Department to remove the fence surrounding the well pad and to backfill the mud pits when the mud in the pits has dried sufficiently. The backfilling of mud pits is required to ensure the safety of personnel, animals, or equipment in the vicinity of the well site.

NOTE:
THE FLUID WITHIN THE MUD PITS MUST BE DRY OR NEARLY DRY BEFORE SCHEDULING BACKFILLING AND FENCE DISMANTLING TO AVOID POTENTIAL HARM TO LOCAL WILDLIFE, DOMESTIC ANIMALS, PERSONNEL OR EQUIPMENT THAT MAY TRAVEL OVER THE BACKFILLED AREA.

10. SUMMARY DATA

NONE

11. EMERGENCY INSTRUCTIONS

NONE

Authorization Page

Name	Signature	Initials	Stamp

Permanent Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

Temporary Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

Attachment A:

CASING TALLY FORM

Well Name: ________ Date: ________ Geologist(s): _____________ Page: ______
(or Designee(s))

Casing Number	Measured Length of Casing	Total Length of Casing in the Borehole	Time Casing Placed in Borehole	Casing Type and Comments

Attachment B:

CONVENTIONAL WELL SUMMARY

Location ID: _____ Page 1 of

Field Representative(s): _____

_____

Purpose of Well: _____

_____

Date Started: _____ **Date Completed:** _____

Northing: _____ **Easting:** _____

Brass Cap: _____ **Outer Casing:** _____ **Inner Casing:** _____

Drilling Method and Summary: _____

_____

Drilling Contractor: _____ **Driller:** _____

Total Depth Borehole: _____ **Diameter Borehole:** _____

Total Depth Surface Casing: _____ **Type and Diameter Surface Casing:** _____

Total Depth Conv. Well Casing: _____ **Type, Schedule, and Diameter Well Casing:** _____

Water First Detected: _____ _____

Water Level Open Borehole: _____

Water Level Cased Borehole: _____ **Estimated Water Use:** _____

Screened Zones: _____ to _____ _____ to _____

_____ to _____ _____ to _____

_____ to _____ _____ to _____

_____ to _____ _____ to _____

(continued next page)

Location ID: _____ Page 2 of

Well Casing Used
Blank Risers

Diameter: _____ **Casing Type:** _____ **Schedule Type:** _____

Sump: _____

5-foot: _____ = _____ 5-foot: _____ = _____

10-foot: _____ = _____ 10-foot: _____ = _____

20-foot: _____ = _____ 20-foot: _____ = _____

Total Sch ____ Footage = _____ Total Sch ____ Footage = _____

Total Footage of Blank Risers: _____

Screen

Diameter: _____ **Slot Size:** _____ **Casing Type:** _____

Schedule Type: _____ **Screen Ratings:** _____

5-foot: _____ = _____ **Total Well Casing:** _____

10-foot: _____ = _____ **Stick-up:** _____

20-foot: _____ = _____ **Final Stick-up:** _____

Total Footage of Screen: _____ **Total Depth of Well:** _____

Annular Materials
Based on field notes and drill reports (approximate totals only).

3000-lb. Super Sack _____ Sand: _____ Yards Cement: _____

100-lb. Bags _____ Sand: _____ 94-lb. Bags Cement: _____

100-lb. Bags _____ Sand: _____ 50-lb. Bags Bentonite Grout: _____

100-lb. Bags _____ Sand: _____ 50-lb. Bags Bentonite Chips: _____

(continued next page)

Location ID: _____ Page 3 of

Annular Materials Depths: _____ Grout: _____ to ___
_____ Sand/Bentonite Mix: _____ to ___
Zone 1: Bentonite: _____ to ___ _____ to ___
_____Sand: _____ to ___ _____ to ___
_____Sand: _____ to ___
Sand/Bentonite Mix: _____ to ___

Pertinent Field Notes

For more detail, refer to Field Notebook #s _____ (pages __to __).

Attachment C:
Continuation Sheet

Well I.D.	Date	Geologist's or Designee's Signature

Attachment B

NASA White Sands Test Facility Job Instruction

Installation of Westbay Wells

Issued:
Expires:

White Sands Test Facility
Job Instruction

WJI ENV-0049.A

WESTBAY® MULTI-PORT GROUNDWATER MONITORING SYSTEM INSTALLATION

Work Authorizing Document: Environmental Department Task Memo

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Record of Revisions

Issue	Pages Affected	Reason for Revision	Date Revised

1. PURPOSE

This WJI provides instruction for the installation of Westbay® Multi-Port monitoring systems for groundwater wells. Westbay® monitoring wells contain multiple sampling zones, which allow the vertical delineation of hydrologic properties within an aquifer. Groundwater wells are required in order to comply with the WSTF 3008(h) Consent Order Agreement, the NMED-issued Post-Closure Care Permit, the Plume-Front Stabilization Work Plan, possible discharge permit compliance, landfill monitoring mandates, or other regulatory directives.

2. REFERENCES

American National Standards Institute (ANSI) Z41 (Protective Footwear), ANSI Z87.1 (Eye and Face Protection), and ANSI Z89.1 (Head Protection).

Westbay® Instruments Inc., "Operations Manual Packer Inflation Equipment 1.5-inch Plastic MP System".

WJI ENV-0047, "Drilling of Groundwater Well Boreholes".

WSTF Job Hazard Analyses: GE-001 "Installation of Groundwater Wells".

3. ATTACHMENTS

A. Westbay® Well Summary Form and Westbay® Retrofit Well Summary Form

B. Packer Inflation Calculation Sheet

C. Packer Inflation Chart

D. Diagram of Westbay® Multi-Port Packer Inflation Equipment Set-Up

E. Maximum Packer Volumes and Pressures

F. Continuation Sheet

4. DEFINITIONS

NONE

5. ABBREVIATIONS AND ACRONYMS

ANSI – American National Standards Institute

bgs – Below ground surface

CFR – Code of Federal Regulations

dBA – Decibels, A-weighted

DTW – Depth to Water

GSA – Government Services Administration

EPA – Environmental Protection Agency

Mil – A unit of measure equal to 0.001 inch

MP – Multi-Port

NASA – National Aeronautics and Space Administration

NMED – New Mexico Environment Department

OSHA – Occupational Safety and Health Administration

PCU – Pressure Control Unit

P_{HB} – Hold Back Valve Pressure

P_i – Pressure Inside the Westbay® MP Casing

P_{INJ} – Injection Valve Pressure

psi – pounds per square inch

P_t – Packer Inflation Tool Pressure (in packer inflation set-up)

PVC – Polyvinyl Chloride

QA/QC – Quality Assurance/Quality Control

SEO – State Engineer Office

WJI – WSTF Job Instruction

WSTF – White Sands Test Facility

6. SAFETY REQUIREMENTS

NOTE:
A SAFETY HAZARD ASSESSMENT FOR THE DRILLING OF WESTBAY® MULTI-PORT GROUNDWATER MONITORING WELL SYSTEMS HAS BEEN PERFORMED IN ACCORDANCE WITH 29 CFR 1910.132 SUBPART I. THE CERTIFICATION OF HAZARD ASSESSMENT AS REQUIRED BY WSI 25-SW-0007 IS CONTAINED IN THE JOB HAZARD ANALYSIS (JHA) FOR INSTALLATION OF GROUNDWATER WELLS (JHA GE-001). THE AUTHORIZED SIGNATURES OF INDIVIDUALS APPROVING THIS WJI INDICATE THEIR CONCURRENCE WITH THE SAFETY HAZARD ASSESSMENT AND THE PRESCRIBED SAFETY REQUIREMENTS IN THIS DOCUMENT AND THE REFERENCED JHA. ANY CONTRACTOR ENVIRONMENTAL DEPARTMENT PERSONNEL ASSIGNED TO A PROJECT UTILIZING THIS WJI ARE RESPONSIBLE FOR ENSURING THAT ALL PERSONNEL WITHIN THE VICINITY OF THE WELL SITE ABIDE BY THE JHA AND THE FOLLOWING SAFETY REQUIREMENTS.

a. In the event that a well site is located near any occupied areas of WSTF, portable barriers will be erected at a distance of approximately one and one half times the height of the drilling rig or pulling unit mast to delineate the restricted access boundaries. Access will be restricted to personnel involved with the project who have the required levels of protective equipment and training.

b. Hard hats in accordance with the most recent version of ANSI Z89.1 will be worn by all personnel within a radius of one and one half times the height of the drilling rig or pulling unit mast to protect them from the potential hazard of falling equipment.

c. Steel-toed boots in accordance with the most recent version of ANSI Z41 (MT I/75 C/75) will be worn at the well site to protect the feet from potential drop hazards.

d. Safety glasses in accordance with the most recent version of ANSI Z87.1 will be worn at the well site to protect the eyes from potential airborne debris.

e. Work gloves will be worn by all personnel while handling equipment (except Westbay® casing) to protect the hands from scrapes and cuts associated with manual labor. Clean disposable latex or comparable gloves will be worn when handling Westbay® casing.

f. Hearing protection will be used by all personnel if noise levels at the work site exceed 85 dBA in the short term (15 minutes) or 80 dBA in the long term (eight hours). Generally, hearing protection is necessary if vocal communication between persons standing three feet apart requires shouting.

g. One Class ABC fire extinguisher will be kept at the well site and in each GSA vehicle.

h. A two-way radio will be kept at the well site for communication.

i. A WSTF-issued pager will be kept at the well site for WSTF site emergency notifications.

j. At least two individuals (drilling contractor and/or Contractor Environmental) are required to be present on-site for all field activities.

7. SUPPORT REQUIREMENTS

WSTF Engineering Department heavy equipment support may be required to provide road and well pad maintenance.

8. SPECIAL REQUIREMENTS

NONE

9. INSTRUCTIONS

NOTE:
ALL WELL INSTALLATION TASKS WILL BE PERFOMED BY AUTHORIZED CONTRACTOR ENVIRONMENTAL DEPARTMENT PERSONNEL AND/OR DRILLING CONTRACTOR PERSONNEL.

SECTION 1: PRE-WESTBAY® INSTALLATION PROCEDURES

NOTE:
PERMITS ARE NOT REQUIRED FROM THE SEO OR THE NMED FOR THE DRILLING OR INSTALLATION OF MONITORING WELLS USED TO MONITOR CONTAMINANT PLUMES.

a. If the well is to be installed on land not owned by NASA, ensure that NASA has obtained the proper clearance from the land owner to install a well prior to any drilling activities. Also encure any necessary surveys (archeological, biological, ect.) have been properly performed prior to any drilling activities.

b. Ensure a Hot Work Welding – Cutting Permit (WSTF Form No. 418) has been obtained from the WSTF Fire Department prior to any torching/welding activities at the well site.

c. Review the following borehole drilling forms prior to the commencement of installation activities: Pre-Spud Form; Water Usage Log; Lithologic Log; Borehole Development Log; and Hydraulic Conditions Form. The purpose of these forms is addressed in WJI ENV-0047, “Drilling of Groundwater Well Boreholes”.

d. Ensure that WSTF temporary badges for all personnel have been authorized and are available at the WSTF Main Gate prior to the arrival of drilling and/or Westbay® contractor personnel.

e. The drilling contractor is required to supply a rig or pulling unit and personnel to assist with installation activities. A Health and Safety Plan complying with OSHA and EPA standards applicable to the work activities must be provided by the drilling contractor and approved by the Contractor Environmental Department. All drilling contractor personnel must: possess a valid, current certification of an OSHA 40-hour Hazardous Waste Operations and Site Investigation training; attend a Contractor Organization Safety Department training class; and following the safety class, attend a drill-site Contractor Organization Environmental Department briefing concerning the hazards associated with on-site installation operations.

f. If not already performed (during original mobilization for drilling the borehole), a Contractor Organization representative will examine the condition of the drilling contractor's equipment upon arrival at WSTF. Any significant health or safety concerns will be identified, and the drilling contractor will be allowed to address the concerns. If significant concerns cannot be rectified, it may be cause for termination of the contract.

g. Before mobilization of the rig or pulling unit to the well site, direct the drilling contractor to steam clean the rig or pulling unit and all tools which will be used in the vicinity of the Westbay® system materials (casing, packers, or ports).

h. Steam clean any Westbay® casing or components whose protective plastic covers are not intact. Do not use any component if the lot or serial number is unknown.

i. Direct the drilling crew to mobilize their installation equipment to the well site. The rig or pulling unit must be underlain with at least six mil (minimum) thickness plastic sheeting. The outer edge of the sheeting must be bermed to contain any discharged fluids, which could potentially contaminate the soil, borehole, or well.

Well Installation Responsibilities and Documentation

NOTE:
A CONTRACTOR ENVIRONMENTAL DEPARTMENT GEOLOGIST OR DESIGNEE WILL BE ON SITE AT ALL TIMES, EXCEPT DURING BRIEF PERIODS TO OBTAIN SUPPLIES OR SERVICES REQUIRED FOR THE PROJECT. THE GEOLOGIST OR DESIGNEE WILL BE RESPONSIBLE FOR PROJECT COORDINATION, SITE HEALTH AND SAFETY, AND THE PROJECT DOCUMENTATION OUTLINED IN FOLLOWING STEPS.

j. Maintain the following documentation throughout the well installation procedures:

(1) A field logbook containing all pertinent events, material usage records, personnel present, weather conditions, casing footages, driller's comments concerning installation, and any other notes deemed necessary to record by the Contractor Environmental Department geologist or designee;

(2) A Westbay® Well Design;

(3) A Westbay® Well Summary Form or a Westbay® Retrofit Well Summary Form (Attachment A);

(4) A Packer Inflation Calculation Sheet (Attachment B) to be completed at the beginning of packer inflation operations; and,

(5) Packer Inflation Charts (Attachment C) to be completed as each packer is inflated.

k. Contractor Environmental Department personnel will have generated a Westbay® well design using available drilling and geophysical logging data prior to commencement of installation activities. This well design will serve as a record of installation. The design will include all casing joints, regular couplings, measurement ports, pumping ports, magnetic collars, an end cap, and centralizers. The casing joints and packers should be numbered on the design, starting with number "1" at the bottom of the well and progressing upwards. Review the Westbay® well design against the geophysical logs and, if applicable, the conventional well design (for retrofit installations) to ensure the design satisfies monitoring goals and all Westbay® well installation requirements.

l. Collect all needed support equipment: at least one box of clean disposable latex or comparable gloves; two chain grips or lifting subs; the appropriate slip plate (for either MP 38 or MP 55 Westbay® casing to suspend the casing in the borehole or within the conventional casing); permanent markers; a timer (for timing joint tests and injection valve pressure); a tool box (with needed wrenches to assist with tool assembly; pliers to assist with installing sheer wires; and box cutters to assist with casing lay-out); at least two 55-gallon drums filled with WSTF site non-chlorinated water; the Westbay® installation equipment (hoses; the reel; the gas-operated pump with the PCU or the electric pump; water reservoir; Westbay® tool; Westbay® sheave tripod with a depth counter bgs); and any needed tables; chairs; or other equipment.

m. Using the Westbay® well design as a guide, collect all casing components to be installed in the well. Each casing component will be marked with a check on the well design as it is installed and as the end cap and each coupling are successfully pressure tested. Lay the MP casing components out on tables near the borehole side

by side in the sequence in which they will be installed in the borehole. Ensure that the casing is laid out with the bottom-most well component closest to the borehole. Inspect all casing for damage and foreign matter. Discard and replace any casing components that contain scratches or gouges at the O-ring seals, foreign matter or gouges in the casing interior, or any other defect at the discretion of the Contractor Environmental Department geologist or designee.

CAUTION:
PACKERS SHOULD BE SHADED FROM DIRECT SUNLIGHT AT ALL TIMES DUE TO THE DETRIMENTAL NATURE OF EXPOSURE TO ULTRA-VIOLET RADIATION TO THE URETHANE GLAND.

n. Using the well design as a guide, number the plastic wrapping each joint sequentially with the bottom-most joint labeled as number "1".

CAUTION:
DO NOT MARK DIRECTLY ON THE CASING.

NOTE:
WHEN HANDLING UNWRAPPED WESTBAY® CASING, CLEAN DISPOSABLE LATEX OR COMPARABLE GLOVES WILL BE WORN TO PROTECT THE CASING FROM ANY CROSS CONTAMINATION.

o. Pull the plastic covers on the top of each multi-port casing joint back just enough to attach the end cap and appropriate couplings as indicated on the Westbay® well design. Verify that each coupling is clean and both O-rings are present in the proper groove. Lightly lubricate the O-ring with silicone-based lubricant. Using the well design as a guide, attach the appropriate coupling to the top of each casing joint with the top of the coupling (MP 38 system) oriented outward. The top of MP 38 regular couplings and measurement ports are indicated by an "up" arrow, and the screen of a MP 38 pumping port is located toward the bottom of the port. For the MP 55 system, measurement ports have a helical groove (a lip for the tool to sit in) on the up side, mechanical pumping ports have the screen toward the bottom of the port like the MP 38 system, and regular couplings can be installed either way. Insert a shear wire into the groove of the component (coupling, measurement port, or pumping port) as completely as possible. Confirm that all couplings are oriented "up" (as necessary) and contain shear wires attaching the component to the casing.

p. Serial numbers are listed on the tags of packers, measurement ports, and pumping ports. Denote the serial number of each packer, pumping port, and measurement port on the Westbay® well design. Also note the lot numbers of the casing and regular couplings and the re-seal pressure of each packer on the well design.

q. Attach magnetic collars to the casing in the locations specified by the Westbay® well design.

r. Following proper lay out of the casing, ensure that a minimum of two alternate Contractor Environmental Department personnel perform a QA/QC assessment. The personnel should compare the laid out casing components to the Westbay® well design and verify that each coupling is in the "up" orientation (as necessary) attached to the top of each casing component with a shear wire installed. Following this assessment, the Westbay® well design should be initialed. The initials indicate that the casing components are properly laid out according to the well design and all couplings are properly attached. This design will be retained with the well completion records for this well.

SECTION 2: SET UP WESTBAY® PACKER INFLATION TOOL EQUIPMENT FOR PRESSURE TESTING

a. Lay out the packer inflation equipment.

b. Components include: a graduated water reservoir; the PCU and gas-operated pump or an electric pump; manual hose reel; packer inflation tool; and various hoses. The hoses consist of two larger diameter garden hoses that are approximately ten feet in length, two high pressure line hoses (black with smaller diameters), and the manual inflation hose reel that contains over 1,000 feet of hose. The PCU or electric pump is used to regulate water pressure and flow into the connected high-pressure hoses and measure the static pressure in the hoses at intervals during the inflation of packers.

Equipment Set-Up Option 1 (with gas-operated pump and PCU):

See Attachment D for a diagram of the packer inflation equipment set-up. Connect one end of a garden hose to the water reservoir and the other end to the input valve on the gas-operated pump. Then, connect the other garden hose to the return valve on the PCU, and place the opposite end of the hose in the top of the water reservoir. Connect one of the high-pressure hoses (black) to the output valve on the gas-operated pump and the other end to the supply valve on the PCU. Also connect the other high-pressure hose (black) to the output valve of the PCU, and either hold the other end in the water reservoir to conserve water while flushing air from the system, or secure the hose. (Water pressure is high when the system is circulating water and the hose can be a danger if not held or secured).

Equipment Set-Up Option 2 (with electric pump):

Connect one end of a garden hose to the water reservoir and the other end to the input valve on the electric pump. Then, connect the other garden hose to the return valve on the electric pump, and place the opposite end of the hose in the top of the water reservoir. Connect a high-pressure hose to the output valve on the electric pump and either hold the other end in the water reservoir to conserve water while flushing air from the system, or secure the hose. (Water pressure is

high when the system is circulating water and the hose can be a danger if not held or secured).

NOTE:
THE WATER RESERVOIR MUST REMAIN AT A HIGHER LEVEL THAN THE ELECTRIC PUMP. PLACE THE RESERVOIR AT A HIGHER ELEVATION (ON A TABLE) THAN THE PUMP, AND KEEP THE RESERVOIR FILLED WITH WATER. THE DIFFERENCE IN WATER HEAD FROM THE RESERVOIR TO THE PUMP DRIVES THE PUMP.

c. When equipment assembly is complete, flush entrained air from the system. Fill the water reservoir with non-chlorinated site water. Ensure that the water reservoir remains full at all times while flushing air from the system and that the free end of the hose from the output valve on the PCU or electric pump is secured or held in the reservoir. Start the gas-operated or electric pump (with the line and vent controls closed on the PCU and the vent control closed on the electric pump). The line (Option 1) and vent controls can be opened after the pump is running. This will circulate water through the equipment and flush entrained air from the system. Continue pumping until all air has been evacuated from the system. Shut off the pump. Remove the unconnected end of the high-pressure hose from the reservoir (if applicable), and connect it to the tool (the manual reel hose can be left out of the assembly for pressure testing).

d. Assemble the appropriate packer inflation tool (MP 38 or MP 55) for pressure testing as indicated in the Westbay® Instruments Inc. operations manual without the hold-back valve and vent head section. Hand tighten the tool components during assembly, but tighten the connections to hoses with a wrench.

e. Take the cap off the end of the tool, start the gas-operated pump and open the PCU line control with the vent control closed (for Option 1) or start the electric pump and turn the pressure control dial up (for Option 2). This will pump water through the tool to flush any entrained air out. Once all air has been flushed from the tool, gradually close the line control (Option 1), or gradually turn the pressure control down (Option 2) until water flow is negligible. Holding the tool with the open end up so that no air is entrained, replace the cap. Close the line control.

f. Place the two protective PVC sleeves over the tool packers. The sleeves should be at least six inches long, and will be 1.5 inches in diameter for the MP 38 system or 2.5 inches in diameter for the MP 55 system. The sleeves are the same diameter as the appropriate Westbay® casing.

g. Close the PCU or electric pump vent control, and open the line control (Option 1 only).

h. Adjust (turn up) the pump pressure control (on the PCU for Option 1), or turn on/up the pressure control on the electric pump (for Option 2) until a steady stream of

water is emitted from the injection valve. (Turning the PCU pressure valve or electric pump pressure control clockwise increases the pressure, and turning the PCU pressure valve or electric pump pressure control counterclockwise lowers the pressure). The packers will inflate within the protective PVC sleeves, tightly sealing against the sleeves.

i. Close the PCU line control (Option 1) or turn off the pressure control on the electric pump (Option 2) and wait one minute.

j. During the one-minute interval, confirm that the tool packers are tightly sealed against the protective PVC sleeves by **gently** trying to move the sleeves with respect to the packers. If either packer does not seal tightly, ensure that the packer O-rings are intact. Replace the O-rings, lubricate them with silicon-based lubricant, and retest the tool. If either packer still does not seal tightly to the sleeves, replace both packers and retest. (Replace both packers even if only one packer does not seal properly. A new packer will require more pressure to inflate than a well used packer. If only one packer is replaced, the new packer will still require more pressure to inflate than the used packer, causing the new packer to remain loose when the used packer is sealed tightly against the sleeve). The injection valve pressure may also need to be adjusted to open at a higher pressure to overcome the pressure to inflate the tool packers. (See Adjusting the Injection Valve).

k. Following the one-minute interval, record the line pressure in the field logbook and on the Packer Inflation Calculation Sheet (Attachment B). This value is the injection valve pressure, "P_{INJ}". The optimum injection valve pressure is 180 psi but any setting in the 150 to 200 psi range is acceptable. This pressure is the pressure required to open the injection valve. The difference between the pump pressure and injection valve pressure is the pressure at which the joints are being tested. The couplings and pumping ports should be tested at approximately 150 psi as the well is installed, so set the PCU pump pressure to (or close the pressure control on the electric pump at) the P_{INJ} plus 150 psi. The measurement ports should be tested at 100 psi (so set the PCU pump pressure to, or close the pressure control on the electric pump at, the P_{INJ} plus 100 psi).

l. Open the PCU or electric pump vent control to vent the tool. Repeat Steps e.-j. (of this section) twice to ensure that the injection valve pressure is consistent (within 20 psi). Record all line pressures in the field logbook. If the pressures are not consistent, disassemble and reassemble the tool and retest the injection valve pressures.

m. If the injection valve does not open, adjust it to open at a lower pressure (see Adjusting the Injection Valve). If the injection valve pressure does not fall into the 150 to 200 psi range then it must be adjusted accordingly.

Adjusting the Injection Valve

There are two set screws and a spring in one end of the injection valve. The compression of the spring controls the injection valve pressure. To adjust the setting, loosen the outside set screw (with the appropriate allen wrench) then adjust the inside screw (which compresses or extends the spring). Next, retighten the outside set screw. Compressing the spring (turning the set screw clockwise) increases the injection valve pressure, and backing the screw out (counter clockwise) decreases the injection valve pressure. Retest the tool (repeat Steps e.-k. of this section).

n. Measure the DTW in the open borehole or conventional casing and record it in the field logbook and on the packer inflation sheet.

o. Sound the bottom of the borehole or conventional casing and record the measurement in the field logbook. Check the borehole or conventional casing depth against the Westbay® MP system well design to ensure sufficient depth is available for installation. In a conventional casing, development activities may have caused fine sediment to fill a portion of the bottom of the casing. The borehole or conventional casing should preferably be ten feet deeper than the proposed Westbay® well to allow for installation and potential borehole sloughing that may occur during Westbay® well installation. Make any necessary adjustments to the Westbay® well design and casing layout.

NOTE:
IT WILL NOT HARM THE CASING IF IT IS ALLOWED TO REST ON THE BOTTOM OF THE BOREHOLE. THE PACKERS CAN EVEN BE INFLATED IN THIS SITUATION. HOWEVER, IF SUFFICIENT SPACE IS NOT LEFT BELOW THE INTENDED WELL DEPTH AND BOREHOLE SLOUGHING OCCURS, IT MAY BE IMPOSSIBLE TO INSTALL THE WELL TO THE INTENDED DEPTH.

SECTION 3: CASING INSTALLATION PROCEDURES

a. All casing components should be installed in one shift. Avoid partial installation with overnight delays whenever possible. Place an end cap (with the O-ring lubricated with silicon-based lubricant) on the bottom of the first (lowermost) joint and secure it with a shear wire.

For the MP 38 system: Connect the Westbay® bottom-testing cap, which consists of an end cap with a hose connector, to the top of the first joint of casing with a shear wire. Disconnect the inflation tool from the high-pressure inflation hose (that is connected to the output valve of either the PCU or the electric pump), and then connect the inflation hose to the hose connector on the bottom-testing cap. If the pump has not been left running, restart it.

Option 1: Set the PCU pump pressure to 150 psi (the pressure at which to test the end cap. The tool is not in the assembly at this time, so the injection valve pressure is not included). Open the line control on the PCU and wait for the pressure to stabilize. Or, turn on/up the pressure control on the electric pump, and wait until the pressure begins to rise quickly (Option 2). Close the line control on the PCU.

Option 2: Turn on/up the pressure control on the electric pump, and wait until the pressure begins to rise quickly. Turn off the pressure control when the pressure reached 150 psi (or as close as possible).

For the MP 55 system: Lower the packer inflation tool into the casing. Turn the pump on.

Option 1: Set the PCU pump pressure to the appropriate pressure (150 psi + P_{INJ}). Open the PCU line valve and, wait for the pressure to stabilize. Close the PCU line valve.

Option 2: Turn on/up the pressure control on the electric pump, and wait for the pressure to begin to rise quickly. Turn off the electric pump pressure control at the appropriate testing pressure to test the cap (150 psi + P_{INJ}).

Test the end cap for at least one minute. The line pressure should remain stable.

b. Watch the end cap for signs of leaks. If the end cap leaks, replace the O-ring, re-lubricate it with silicon based lubricant, and retest it. If the leak persists, replace the end cap, lubricate the O-ring, and retest it. If the leak still persists, replace the section of casing and retest the end cap. Mark the Westbay® well design with a check when the end cap was successfully pressure tested and installed.

c. For MP 38 installations, reconnect the high-pressure hose (connected to the output valve of the PCU) to the packer inflation tool, flushing the air out as described in Step e. of Section 2 (SET UP WESTBAY® PACKER INFLATION TOOL EQUIPMENT FOR PRESSURE TESTING). Set the PCU pump pressure to the appropriate pressure (P_{INJ} + 150 psi for pumping ports and regular couplings or P_{INJ} + 100 psi for measurement ports).

d. The high-pressure inflation hose (connected to the tool at one end and the output valve of the PCU or the electric pump at the other end) needs to be marked with tape approximately five and ten feet (for the MP 38 system) or 1.5 and 3 meters (for the MP 55 system) above the injection valve of the appropriate tool. The tape indicates when the tool is located precisely within the casing such that the tool

packers are straddling the coupling. Mark the hose with tape by placing the tool next to the outside of the casing so that the tool packers straddle the coupling connecting one joint to the first five or ten-foot (MP 38) or 1.5 or 3-meter (MP 55) casing joint. The tape should be marked directly above the top of the respective five or ten-foot (or 1.5 or 3-meter) joint of casing so that the tape mark can be seen and used as a guide for packer inflation tool placement during installation. The placement of the tape markers should be tested upon the installation of the first five and ten-foot (or 1.5 or 3-meter) joints.

e. Slip plates will be used to hold the casing suspended in the borehole or conventional casing while attaching another casing joint. The slip plate is usually provided by either the drilling contractor or by Westbay® Instruments, Inc. Alternatively, the Contractor Environmental Department may have one stored with the Westbay® components.

For the MP 38 system: Installation is accomplished with chain grips. Place a chain grip on the first joint of casing approximately one foot below the top coupling. Place the casing in the borehole or conventional casing, and suspend it from the slip plate by the chain grip. Verify that the top coupling has an O-ring, and lightly lubricate the O-ring with silicone-based lubricant. Place a second chain grip, again approximately one foot below the top coupling, on the second joint of casing.

For the MP 55 system: The casing to too heavy to install using chain grips. Special Westbay® lifting subs are used (provided by Westbay® Instruments, Inc.). Attach the lifting sub to the first casing joint. Place the casing in the borehole or conventional casing, and suspend it from the slip plate by the lifting sub. Verify that the top coupling has an O-ring, and lightly lubricate the O-ring with silicone-based lubricant. Place a second lifting sub on the second joint of casing.

For both systems, slide the appropriate packer inflation tool into the second casing joint, and insert the bottom end of the second casing joint into the top of the coupling on the casing joint suspended in the borehole. Secure the couple with a shear wire.

f. Feed the packer inflation tool down the casing to the appropriate tape marker so that the tool packers straddle the couple. Ensure that the pump pressure is set to the injection valve pressure (tested earlier) plus 150 psi.

Option 1: With the vent control closed, open the PCU line control to the tool or turn on/up the pressure control on the electric pump in order to inflate the tool packers and inject water into the coupling, pressurizing to 150 psi. After the line pressure has stabilized or the pressure begins to rise quickly (for the electric pump), close the line control and observe the joint for one minute for any sign of leaks.

Option 2: With the vent control closed, turn on/up the pressure control on the electric pump. This will inflate the tool packers and inject water into the coupling to

pressurize it to 150 psi. When the pressure begins to rise quickly, and turn off the pressure control at the appropriate pressure (P_{INJ} + 150 psi), and observe the joint for one minute for any sign of leaks.

NOTE:
DURING THE ONE-MINUTE LEAK TEST, THE LINE PRESSURE SHOULD REMAIN STEADY (OPTION 1 AND OPTION 2) AND SHOULD EQUAL THE PUMP PRESSURE (WITHIN 20 PSI) FOR OPTION 1. IF IT DOES NOT, THEN EITHER THE INJECTION VALVE IS MALFUNCTIONING (IN WHICH CASE DISASSEMBLE, REASSEMBLE, AND RETRY), OR THE O-RINGS ON THE END-STEMS OF THE TOOL PACKERS NEED TO BE REPLACED.

g. With the PCU line control still closed (Option 1), open the vent control (for both options), which vents the tool, and remove the tool from the casing.

h. If a leak is detected, remove and replace the O-ring from the end of the coupling where the leak was present, lubricate the O-ring with silicon-based lubricant, secure it with a shear wire, and retest it for leaks. If a leak persists, replace the coupling with a new one, lubricate the O-ring, secure it with a shear wire, and retest it for leaks. If a leak still persists, replace the casing joint where the leak was present, and reattach and retest the coupling.

i. If no leaks are detected, add the next section and repeat the leak test on the next coupling. Mark the Westbay® well design with a check for the successfully tested coupling connection and the successfully installed joint.

j. Continue with all joints, changing the pressure appropriately for the different casing components (150 psi + P_{INJ} for regular couplings and pumping ports and 100 psi + P_{INJ} for measurement ports). Secure filter socks to the casing with zip ties where noted on the Westbay® well design. Filter socks are attached over the measurement port couples located immediately below packers and/or outside of sampling zones.

k. As the Westbay® components are connected to the casing string, again verify the casing number sequence, serial numbers, lot numbers, and locations of measurement and pumping ports and magnetic collars on the Westbay® well design, and mark the design with a check for each component as it is installed in the borehole. Be sure to also mark the well design with a check for each positive/successful joint test.

l. When the length of casing submerged below the water level in the borehole approaches 100 feet (for MP 38), or when the casing becomes too buoyant to lower into the borehole (for MP 38 and MP 55), pour non-chlorinated site water into the casing until the casing has lost enough buoyancy to allow installation to continue.

CAUTION:
THE WATER LEVEL IN THE MP 38 CASING SHOULD NEVER BE MORE THAN 200 FEET ABOVE OR BELOW THE STATIC WATER LEVEL IN THE BOREHOLE OR CONVENTIONAL CASING IN ORDER TO AVOID WESTBAY® MP 38 CASING COLLAPSE.

Hydraulic Integrity Test

m. Following the completion of well installation, secure the well at the surface. Measure the DTW inside the Westbay® MP casing with a steam-cleaned water level indicator and confirm that the water level in the MP casing is not even with the water level in the borehole or conventional casing. (It can be either above or below the outside water level). If it is the same (or very close), add approximately 10 feet of non-chlorinated site water to the MP casing, wait at least 15 minutes before proceeding with the hydraulic integrity test, and re-measure the DTW inside the MP casing several times to ensure a static water level. Once a static water level is reached, monitor the water level inside the casing with a water level indicator every five minutes for at least 30 minutes (or measure the water level in the MP casing and leave it overnight. Measure the DTW in the MP casing the following morning). If the water level remains static, there are no leaks in the well. Record the hydraulic integrity test data in the field logbook.

SECTION 4: PACKER INFLATION

NOTE:
THE GRADUATED WATER RESERVOIR SHOULD BE FILLED WITH NON-CHLORINATED SITE WATER PRIOR TO EACH PACKER INFLATION AND SHOULD BE MONITORED TO ENSURE IT CONTAINS ENOUGH WATER TO COMPLETE PACKER INFLATION.

a. Record the measurements and calculations listed below in a field logbook and on the Westbay® Packer Inflation Calculation Sheet (Attachment B).

b. Measure the DTW in the Westbay® MP casing and convert it to psi (DTW(in feet) x 0.4331). This is "P_i" on the Packer Inflation Calculation Sheet.

c. Set up the packer inflation tool equipment as described in Step a. of Section 2-SET UP WESTBAY® PACKER INFLATION TOOL EQUIPMENT FOR PRESSURE TESTING, and flush the entrained air from the system as described in Step b. of Section 2 (if necessary). Prior to tool assembly, inspect the stone filter. The stone filter is located in the holdback valve section. If the stone filter is not clean, replace it. Ensure the graduated water reservoir remains full during the set-up process. Attach the holdback valve section of the tool to the end of the high-pressure hose attached to the output valve of the PCU or the electric pump.

Option 1: Start the gas-operated pump, and open the PCU line control. If water is not flowing through the tool, adjust the PCU pump pressure (up) until steady flow through the end of the tool is achieved. When the line pressure has stabilized, close the line control, and record the line pressure after one minute.

Option 2: Start the electric pump, and turn on/up the pressure control. If water is not flowing through the tool, turn the pressure up until steady flow through the end of the tool is achieved. When the pressure begins to rise quickly, turn the pressure control off, and record the line pressure after one minute.

This value is the hold-back valve setting and "P_{HB}" on the Packer Inflation Calculation Sheet.

d. The hold-back valve setting should be at least 10 psi greater than P_i calculated in Step b. of this section so that the head in the packer inflation line does not release the location arm prior to being submerged below water in the casing. If the hold-back valve setting is not 10 psi greater than P_i, adjust it with an allen wrench (see ADJUSTING THE INJECTION VALVE in Step m. of Section 2 above; the hold-back valve is adjusted similarly). Re-adjust and retest it until the setting is correct.

e. Assemble the appropriate tool as described in the Westbay® Instruments, Inc. operations manual for packer inflation. Set up the tool the same as for pressure testing, but also include the hold-back valve and vent head in the tool assembly. Connect the hoses and flush air from the system as described in Step c. of Section 2, except connect the hose from the PCU output valve or electric pump to the manual reel hose instead of directly to the tool. For Option 1, start the gas-operated pump and circulate clean water from the graduated water reservoir through the PCU and manual reel back into the reservoir long enough to ensure all entrained air has been flushed from the system. For option 2, start the electric pump and circulate water from the reservoir through the electric pump and manual reel back into the reservoir until entrained air has been flushed out. This will require approximately 20 minutes. After flushing air from the reel, connect the reel hose to the packer inflation tool and flush air from the tool as previously described in Step e. of Section 2. A surface test to determine the tool pressure can now be performed.

f. Slide the two 6-inch, 1.5-diameter (or 6-inch, 2.5-inch diameter) protective PVC sleeves over the tool packers and a coupling over the vent head.

g. Close the PCU or electric pump vent control and open the line control or turn on/up the pressure control on the electric pump.

h. Adjust the PCU pump pressure or turn the electric pump pressure control up until a steady flow of water is emitted from the injection valve.

i. Close the line control on the PCU or turn the electric pump pressure control off, and wait one minute.

j. During the one-minute interval, confirm that the sleeves are still tightly held in place (the same as in Step j. of Section 2), and then following the one-minute interval, record the line pressure in the field logbook. This value is the tool pressure, "P_t", for the packer inflation tool configuration. The tool pressure is the pressure required to open the injection valve and is equal to the sum of the holdback and injection valve pressures when the tool is in packer inflation set-up.

k. Vent the tool. To vent the tool, open the vent control on the PCU or the electric pump, gently pull on the vent head assembly (it will release water from the tool), and retract the location arm. The location arm is retracted using an allen wrench placed in the opening to move the opening towards the main body of the tool (the portion with the packers, injection valve and hold-back valve). See the Westbay® Instruments, Inc. operations manual for details.

l. Perform the tool pressure surface test two more times and record the pressures in the logbook. Be sure to vent the tool and retract the location arm before each surface test. The three tool pressures should be within 20 psi of each other. If the tool pressures differ by more than 20 psi, contact Westbay® Instruments, Inc. for advice. Record the overall tool pressure, "P_t", in the field logbook and on the Westbay® Packer Inflation Calculation Sheet.

m. Complete the Packer Inflation Calculation Sheet. Use these calculations to determine the requisite pump pressure. Adjust the pump pressure accordingly using the pump pressure regulator valve on the PCU (for Option 1) or turning the pressure control on the electric pump (for Option 2). (Turning the valve and control clockwise increases the pressure and counterclockwise decreases the pressure).

PUMP PRESSURE CALCULATION

The requisite pump pressure is:
+ tool pressure ("P_t" psi)
+ packer valve pressure ("P_v" psi)
- borehole DTW (psi)
+ maximum packer inflation pressure (psi)
+ 100 psi

The tool pressure is the pressure required to force water through the tool. The packer valve pressure is the pressure required to open the packer valve listed as the reseal pressure on the individual packer labels. Use the highest value listed for all the packers used. The borehole DTW is subtracted because it is the head in the line acting on the tool and not balanced by head in the borehole on the packer. The maximum packer inflation pressure is the pressure required to fill the packer. This number is obtained from the Maximum Packer Volumes and Pressures Sheet (Attachment E). The 100 psi is added to make a positive pressure differential *into* the packer.

n. Packers are inflated starting at the bottom of the casing and progressing toward the top. Confirm that the location arm on the inflation tool is retracted. If the arm is not retracted, retract it as indicated in Step k. of this section or as in the Westbay® Instruments, Inc. operations manual. Feed the manual reel inflation hose through the pulley on the Westbay® sheave tripod. Zero the depth counter on the sheave with the manual reel inflation hose in place and the tool suspended at ground surface. Carefully lower the inflation tool to the bottom of the casing. Note the depth of the inflation tool in the casing by removing all slack from the inflation hose and recording the reading on the counter. The counter will not read the precise depth of the well, due to stretch in the manual reel inflation hose, but will provide a reference point.

o. Perform a blank wall test. Open the PCU line control (Option 1) or turn on/up the electric pump pressure control (Option 2), and add water to the casing until no more water is released. It is commonly ¼ to ½ liter of water. This will release the location arm. Close the PCU line control (Option 1), or turn off the electric pump pressure control (Option 2) and wait one minute while monitoring the pressure. In the field logbook, record the amount of water released. If the pressure does not remain steady, there is a problem with the tool and it should be removed and checked. When the minute is over, open the PCU or electric pump vent control. Watch the water reservoir, and record the amount of water that returns after venting. This is the return volume and is an indication of how much stretch the inflation hose contains. Gently pull up on the inflation hose to vent the tool. The water will vent to the inside of the Westbay® MP casing.

NOTE:
THE MP 38 SYSTEM COUPLINGS, MEASUREMENT PORTS, AND PUMPING PORTS ALL CONTAIN HELICAL SHOULDERS (RIMS FOR THE INFLATION TOOL TO SEAT IN). IN THE MP 55 SYSTEM, HELICAL SHOULDERS ARE ONLY PRESENT IN PUMPING PORTS AND MEASUREMENT PORTS, AND NOT IN REGULAR COUPLINGS.

CAUTION:
ONCE THE LOCATION ARM ON THE INFLATION TOOL IS RELEASED, THE TOOL CAN ONLY BE RAISED UPWARD THROUGH THE CASING. WHEN LOWERED TO THE BOTTOM OF THE CASING, THE ARM WILL ENGAGE IN THE FIRST COUPLING (FOR MP 38 SYSTEM) OR THE FIRST MEASUREMENT PORT (FOR THE MP 55 SYSTEM) ENCOUNTERED AND PREVENT FURTHER DOWNWARD TRAVEL OF THE TOOL.

p. Pull the tool up using the inflation hose one coupling at a time (for the MP 38 system) or to the lowest measurement port (for the MP 55 system), while carefully correlating the relative footage change on the depth counter bgs with that on the Westbay® well design (corrected for any changes during installation). Remove the slack in the hose to record the footage at each coupling or measurement port as

accurately as possible. Continue this process until the location arm of the tool sits in the coupling at the bottom of the first (lowermost) packer (for the MP 38 system) or the measurement port at the bottom of the first (lowermost) packer (for the MP 55 system). Packers will be inflated from the bottom of the well upwards.

q. Confirm that the graduated water reservoir is filled to the zero liter mark and begin injecting water into the packer in one liter increments up to three liters (for MP 38 packers) and up to four or five liters (for MP 55 system packers), and in ½ or ¼ liter increments thereafter. To inject the water, close the vent control on the PCU or the electric pump, and open the line control (Option 1) or turn on/up the electric pump pressure control (Option 2) until the correct volume increment has been injected as indicated by the liter marks on the reservoir. Close the line control (Option 1) or turn off the electric pump pressure control (Option 2). Monitor the pressure for one minute following each injection, and then record the volume and pressure on the MP Packer Inflation Chart (Attachment C). If only ¼ to ½ liter has been injected after 15 minutes, the tool is not located in the coupling or measurement port at the bottom of the packer. Close the PCU line control (Option 1) or turn off the electric pump pressure control (Option 2), open the vent control, and pull gently up on the hose to vent the tool. For the MP 38 system, pull the tool up one more coupling, refill the reservoir, and re-attempt to inject water into the packer. For the MP 55 system, pull the tool up at least ten feet on the depth counter bgs, and let it back down to try and find the appropriate measurement port. When the tool seats, refill the reservoir, and re-attempt to inject water into the packer. If the tool is located at a shallower depth in the casing than the packer, the packer was missed. If this occurs, continue to find and inflate the other packers in the casing at shallower depths. Determine where the tool is by the pattern of 10-foot and 5-foot joints with couplings encountered as the tool is pulled up in the casing for the MP 38 system, and by the depth counter bgs and the pattern of measurement ports the tool seats in on the way up the well casing for the MP 55 system. To inflate the missed packer (usually after all the other packers up the well have been inflated), remove the tool from the casing, retract the arm, and repeat Steps n.-q. of this section.

r. Graph the pressures recorded on the Westbay® MP packer inflation chart following the injection of each increment of water. For stiffened packers, the graph will form a curve, which rises steeply, levels off, and then rises steeply again. For unstiffened packers, the graph will form a curve, which rises then remains level. Stop injecting water when ***one*** of the following occurs: 1) the second steep section of the curve reaches 50 psi greater than the level section of the curve (for stiffened packers), 2) the maximum pressure for the packer is reached, or 3) the maximum inflation volume of the packer is reached. If unsure whether to continue adding water to the packer, or after the final water addition, calculate the final pressure for the packer.

FINAL PACKER PRESSURE CALCULATION

The final packer pressure is: + final line pressure (or last line pressure; "P_l" psi)

+ borehole (or conventional casing) DTW (psi)
- packer reseal pressure ("P_v" psi)
- tool pressure ("P_t" psi)

CAUTION:
DO NOT EXCEED THE MAXIMUM VOLUME OR TARGET PRESSURE OF THE PACKERS

The final packer pressure should never exceed the maximum inflation pressure and should be within $\pm$ 20 psi of the optimum packer pressure listed for the particular packer type (stiffened or unstiffened). Optimum packer pressures are listed in Attachment E.

s. Maximum volume and pressures for different types of packers in various borehole diameters are also listed in Attachment E. For stiffened packers, an increase of 50 psi over the flat part of the pressure-volume chart will indicate that the packer is sufficiently inflated, even if the maximum volume or pressure has not been reached.

t. When the packer is adequately inflated, open the vent control and pull up gently on the packer inflation hose to vent the tool. Be sure to record the volume of water that returns to the reservoir when the vent control is opened. The return volume for each packer inflation can be recorded on the Westbay® MP packer inflation chart for each packer.

u. As in Step p., pull the tool up according to the Westbay® well completion diagram and locate the MP packer inflation tool within the next packer. Return to Step q.

v. Continue until all packers are inflated to specifications.

w. With further assistance from Environmental Department technicians, perform a pressure profile. The technicians will now develop the Westbay® MP well.

x. Schedule Contractor Environmental Department technicians to perform a camera log immediately following well development. For Westbay® wells, two camera logs will be performed, one following borehole or conventional well development and one following Westbay® MP System well installation. The camera log(s) will be reviewed by a Contractor Environmental Department geologist or designee immediately upon completion. If any issues of concern related to the well are noted in the camera log, Contractor Environmental Department personnel must determine further action to remedy observed problems. A camera log will be repeated after any remedial action is performed on a well. All camera log information will be entered into the Contractor Environmental Department camera log database within one week after the camera log was performed.

y. Schedule the WSTF Facilities Engineering Department to construct a cement pad around the well head with an embedded brass cap and a locking steel cover over the top of the casing immediately following completion of the final camera log. The cement pad dimensions (typically three feet square) will be specified by Contractor Environmental Department personnel, and the pad should slope gently away from the well head cover to avoid potential surface water ponding. A barrier post will be permanently installed at each corner of the well pad to protect the well head from potential vehicle impact.

z. Schedule the appropriate Contractor Environmental Department personnel to perform a survey-grade final GPS survey of the well head and pad within one week following well pad, brass cap, and barrier post installation. This survey should measure the well(s) northing, easting, and elevation to the nearest 0.01 foot using White Sands Transmercator system (if applicable) and state plane and geodetic coordinate systems. The brass cap and all casing (inner and outer if applicable) will be surveyed.

aa. Schedule the Contractor Environmental Department technicians to stamp the brass cap with the well name, elevation, and location data immediately following the completion of the GPS Survey.

bb. At the completion of well installation, ensure that all documentation in the attachments list is complete. Submit the documentation to an alternate geologist or designee for QA/QC. Any discrepancies will be noted and corrected and the reviewer will sign the forms and logbook indicating that the review has been completed.

(1) Attachment A: The Westbay® Well Summary Form or the Westbay® Retrofit Well Summary Form will be annotated during drilling , well installation, and development.

(2) Attachment B: The Packer Inflation Calculation Sheet will be annotated by the Contractor Environmental Department geologist or designee following packer inflation tool set up procedures and before the first packer is inflated.

(3) Attachment C: The Packer Inflation Chart will be annotated by the Contractor Environmental Department geologist or designee during packer inflation for each packer.

ee. Completed forms will be provided to the well file QA/QC geologist or designee for electronic reproduction and filing.

ff. A well file will be compiled with all finalized electronic borehole and well forms within one week after the final GPS survey is performed.

cc. Annotate the continuation sheet (Attachment F) with the well name, completion date and installer's signature.

10. SUMMARY DATA

NONE

11. EMERGENCY INSTRUCTIONS

NONE

Authorization Page

Name	Signature	Initials	Stamp

Permanent Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

Temporary Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

Attachment A:
Westbay® Well Summary Form and Westbay® Retrofit Well Summary Form

WESTBAY® WELL SUMMARY

Location ID: _____ Page 1 of

Field Representative(s): _____

_____

Purpose of Well: _____

_____

Date Started: _____ **Date Completed:** _____

Northing: _____ **Easting:** _____

Brass Cap: _____ **Outer Casing:** _____ **Inner Casing:** _____

Drilling Method and Summary: _____

_____

Drilling Contractor: _____ **Driller:** _____

Total Depth Borehole: _____ **Diameter Borehole:** _____

Total Depth Surface Casing: _____ **Type and Diameter Surface Casing:** _____

Total Depth Well Casing: _____ **Type and Diameter Well Casing:** _____

_____

Water First Detected: _____ **Water Level Open Borehole:** _____
(from geophysical log)

Water Level Measurement Port: _____ **Estimated Water Use:** _____
(from pressure profile)

Sampling Zones: Westbay® Zone (packer to packer)		**Measurement Port Depth**	
_____ to _____	_____ to _____	_____	_____
_____ to _____	_____ to _____	_____	_____
_____ to _____	_____ to _____	_____	_____
_____ to _____	_____ to _____	_____	_____
_____ to _____	_____ to _____	_____	_____

(continued next page)

Location ID: _____ Page 2 of

Westbay® xxx Series MP xx Well Casing Used:

MP 38			**MP 55**		
10-foot: _____	=	_____‘	3.0-meter (x.xxx’):	_____	= ____‘
5-foot: _____	=	_____‘	1.5-meter (x.xxx’):	_____	= ____‘
2-foot: _____	=	_____‘	1.0-meter (x.xxx’):	_____	= ____‘
packer: _____	=	_____‘	Packer (x.xxx’):	_____	= ____‘
Regular Couplings: _____			Regular Couplings (x.xxx’):	_____	= ____‘
Pumping Ports: _____			Pumping Ports (x.xxx’): (Mechanical)	_____	= ____‘
Measurement Ports: _____			Measurement Ports (x.xxx’):	_____	= ____‘
End Caps: _____			End Caps (x.xxx’):	_____	= ____‘
Magnetic Collars: _____			Magnetic Collars:	_____	= ____‘

Total Well Casing: _____

Stick-Up: _____

Total Depth of Well: _____

Pertinent Field Notes

For more detail, refer to Field Notebook #s _____ (pages x-xx) and _____ (pages x-xx).

(continued next page)

Location ID: _____ Page 3 of

Pertinent Field Notes (continued)

WESTBAY® RETROFIT WELL SUMMARY

Location ID: _____ Page 1 of

Field Representative(s): _____

_____

Purpose of Well: _____

_____

Date Started: _____ **Date Completed:** _____

Northing: _____ **Easting:** _____

Brass Cap: _____ **Outer Casing:** _____ **Inner Casing:** _____

Drilling Method and Summary: _____

_____

Drilling Contractor: _____ **Driller:** _____

Total Depth Borehole: _____ **Diameter Borehole:** _____

Total Depth Surface Casing: _____ **Type and Diameter Surface Casing:** _____

Total Depth Conv. Well Casing: _____ **Type, Schedule, and Diameter Conv. Well Casing:** _____

_____

Total Depth Westbay® ____ **Casing:** _____ **Diameter Westbay® Casing:** _____

Water First Detected: _____ **Water Level Open Borehole:** ____ (from Geophysical Log) _____

Water Level Conv. Casing: _____ (post-development) **Estimated Water Use**: _____ (pre-development)

Sampling Zones						**Westbay® Zone** (packer to packer)		**Measurement Port Depth**
Screened Zone (____ slot)			**Sand Pack**					
_____	to	_____	_____	to	_____	_____	to _____	_____
_____	to	_____	_____	to	_____	_____	to _____	_____
_____	to	_____	_____	to	_____	_____	to _____	_____
_____	to	_____	_____	to	_____	_____	to _____	_____

(continued next page)

Location ID: _____ Page 2 of

Conventional Well Casing Used
Blank Risers

Diameter: _____ **Casing Type:** _____ **Schedule Type:** ____

5-foot: _____ = _____

10-foot: _____ = _____

20-foot: _____ = _____

Total Footage of Blank Risers: ____

Screen

Diameter: _____ **Slot Size:** _____ **Casing Type:** _____

Schedule Type: _____ **Screen Ratings:** _____

5-foot: _____ = _____ **Total Well Casing:** _____

10-foot: _____ = _____ **Stick-Up:** _____

20-foot: _____ = _____ **Final Stick-Up:** _____

Total Footage of Screen: _____ **Total Depth of Well:** _____

Annular Materials

Based on field notes and drill reports (approximate totals only).

3000-lb. Super Sack _____ Sand: _____ Yards Cement: _____

100-lb. Bags _____ Sand: _____ 94-lb. Bags Cement: _____

100-lb. Bags _____ Sand: _____ 50-lb. Bags Bentonite Grout: _____

100-lb. Bags _____ Sand: _____ 50-lb. Bags Bentonite Chips: _____

(continued next page)

Location ID: _____ Page 3 of

Annular Materials Depths: _____ Grout: _____ to ___
_____ Sand/Bentonite Mix: _____ to ___
Zone 1: Bentonite: _____ to ___ _____ to ___
_____ Sand: _____ to ___ _____ to ___
_____ Sand: _____ to ___
_____ Sand/Bentonite Mix: _____ to ___

Zone 2: Bentonite: _____ to ___ _____ to ___
_____ Sand: _____ to ___ _____ to ___
_____ Sand: _____ to ___
_____ Sand/Bentonite Mix: _____ to ___

Zone 3: Bentonite: _____ to ___ _____ to ___
_____ Sand: _____ to ___ _____ to ___
_____ Sand: _____ to ___
_____ Sand/Bentonite Mix: _____ to ___

Zone 4: Bentonite: _____ to ___ _____ to ___
_____ Sand: _____ to ___ _____ to ___
_____ Sand: _____ to ___
_____ Sand/Bentonite Mix: _____ to ___

Westbay® xxx Series MP xx Casing Used:

MP 38			**MP 55**		
10-foot: _____	=	_____‘	3.0-meter (x.xxx’):	_____	= ____‘
5-foot: _____	=	_____‘	1.5-meter (x.xxx’):	_____	= ____‘
2-foot: _____	=	_____‘	1.0-meter (x.xxx’):	_____	= ____‘
packer: _____	=	_____‘	Packer (x.xxx’):	_____	= ____‘
Regular Couplings: _____			Regular Couplings (x.xxx’):	_____	= ____‘
Pumping Ports: _____			Pumping Ports (x.xxx’): (Mechanical)	_____	= ____‘
Measurement Ports: _____			Measurement Ports (x.xxx’):	_____	= ____‘
End Caps: _____			End Caps (x.xxx’):	_____	= ____‘
Magnetic Collars: _____			Magnetic Collars:	_____	= ____‘

(continued next page)

Location ID: _____ Page 4 of

Total Well Casing: _____

Stick-Up: _____

Total Depth of Well: _____

Pertinent Field Notes

For more detail, refer to Field Notebook #s: _____ (pages x-xx) and _____ (pages x-xx).

Location ID: _____ Page 5 of

Pertinent Field Notes (continued)

Attachment B:
Packer Inflation Calculation Sheet

MP Packer Inflation Calculation Sheet

Well Name: _____ Date: _____

Borehole Size: _____ Completed By: _____

Open Hole TD: _____

Open Hole DTW _____ feet /2.3 = _____ psi

MP DTW: _____ feet /2.3 = _____ psi

Inflation Tool Settings

Packer Valve Pressure (P_V) _____ psi *(low pressure valve ~ 5psi, high pressure valves ~ 140 psi, see packer labels)*

Maximum Packer Pressure (P_{MAX}) _____ psi *(See WJI ENV-0049.A, Attachment E – Maximum Packer Volumes and Pressures.)*

Injection Valve Pressure (P_{INJ}) _____ psi *(calculated by pressuring up tool and reading line pressure after 1 minute, 180 psi optimum, 150-200 OK)*

Hold Back Valve Pressure (P_{HB}) _____ psi *(must be at least 10 psi greater than MP DTW to hold back head in line so that location arm does not open prematurely)*

Tool Pressure (P_T) _____ psi *(measured during surface testing)*

$P_T = P_{INJ}$ when the hold back valve is not in the assembly
$P_T = P_{INJ} + P_{HB}$ when the hold back valve is in the assembly.
$P_{PUMP} - P_T$ = Pressure at which joints are tested.

Test regular couples and pumping ports to 150 psi, measurement ports to 100 psi.

Pump Pressure Calculation (for packer inflation)

Pump Pressure:
$P_{PUMP} = P_{INJ} + P_{HB} + P_V + P_{MAX}$ – borehole DTW + 100

Logic: P_{INJ} and P_{HB} overcome the tool pressure. P_V provides the pressure required to open the packer valve. P_{MAX} is the pressure required to inflate the packer to its full capacity. The borehole DTW is subtracted because that is the surplus head acting on the tool to inflate the packer which is not balanced by head outside the casing. 100 psi is added to provide a positive flow into the packer.
Note: for packers above the borehole DTW, subtract the packer depth instead of the borehole DTW.

3.2808 feet/meter 0.433 psi/foot

Attachment C:
Packer Inflation Chart

MP Packer Inflation Record

Page: of

Project: _____ Completed by: _____

Location: _____ Date Inflated: _____

Hole No: _____ Packer Depth: _____

Packer No: _____ Borehole DTW (ft.): _____ /2.3 = _____ psi

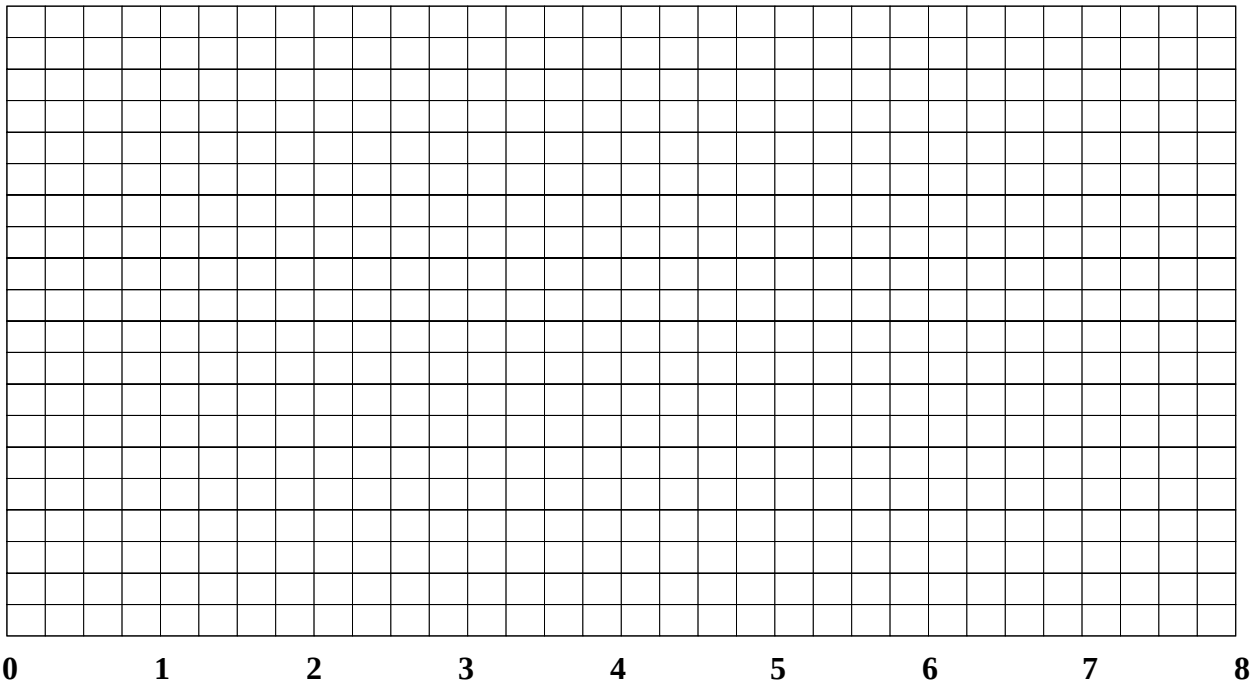
Inflation Tool Pressure (P_t): _____ psi Optimum Packer Pressure: _____ psi

Packer Pressure =
P_l + Borehole DTW (psi) – Pv – P_t = _____ psi

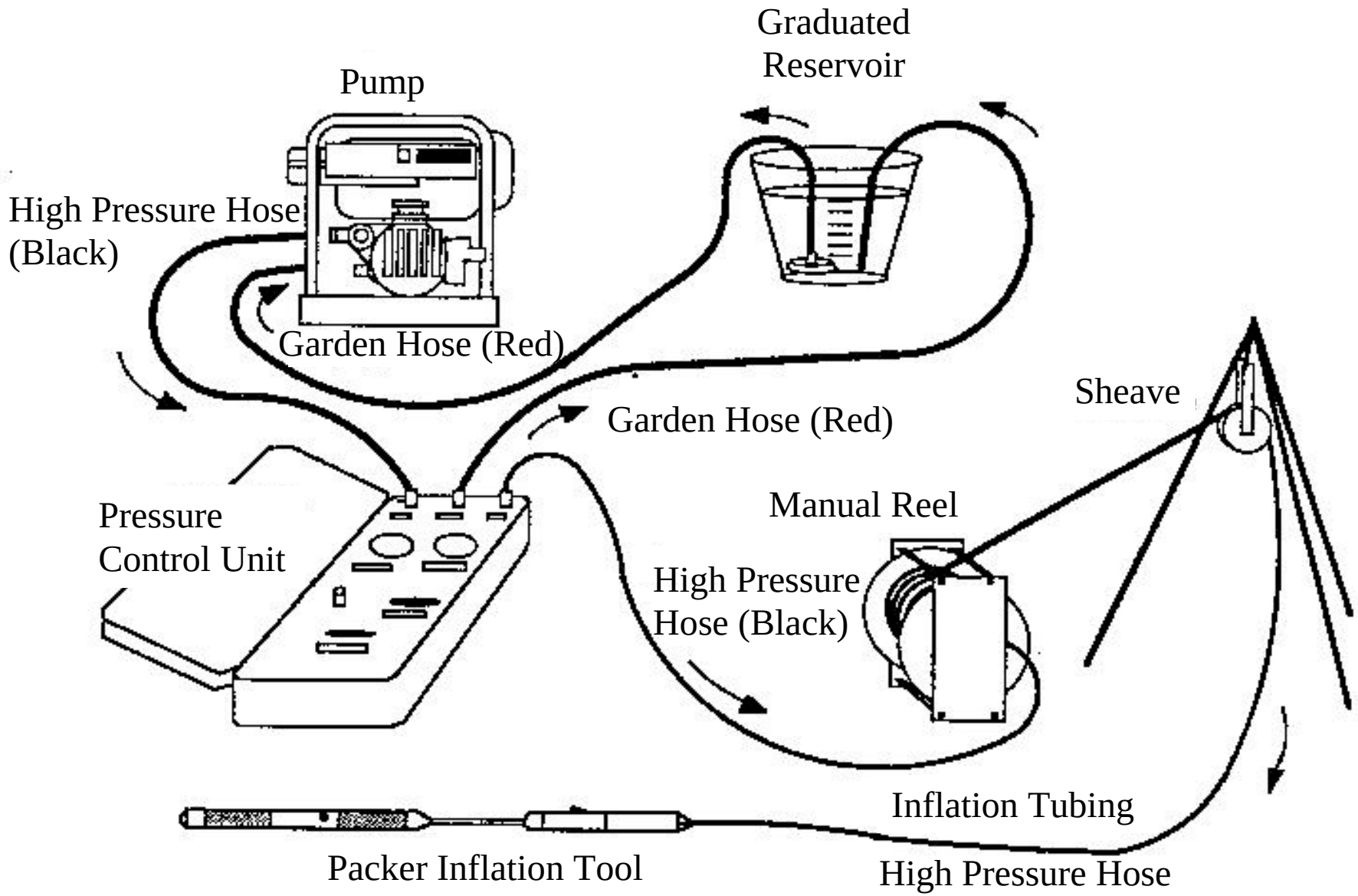
Vent Return Volume: _____ liters

Volume (liters)												
Pressure (psi)												

Plot of Gauge Pressure (psi) vs. Volume (L)



Attachment D:
Diagram of Westbay® MP Packer Inflation Equipment Set-Up Using a gas-operated Pump and PCU


Graduated
Reservoir
Pump
High Pressure Hose
(Black)
Garden Hose (Red)
Garden Hose (Red)
Sheave
Pressure
Control Unit
Manual Reel
High Pressure
Hose (Black)
Inflation Tubing
Packer Inflation Tool
High Pressure Hose

Attachment E:
Maximum Packer Volumes and Pressures

Maximum Packer Volumes and Pressures

DO NOT EXCEED EITHER THE MAXIMUM VOLUME OR THE MAXIMUM PRESSURE.

MP 38 Packers in a **Four-Inch** Borehole

Packer Type	Volume[1] (liters)	Pressure (psi)
Not Stiffened (0228F05)	4.5	140
Stiffened (0229F05)	4.0	180

MP 38 Packers in a **4.5-Inch** Borehole

Packer Type	Volume[1] (liters)	Pressure (psi)
Not Stiffened (0228F05)	6.5	110
Stiffened (0229F05)	5.5	150

MP 55 Packers in a **5.5-Inch** Borehole

Packer Type	Volume[1] (liters)	Pressure (psi)
Part No. 0604 M15	8	150

1 The maximum recommended inflation volume is the net volume in the packer element after subtraction of the system compliance return volume.

NOTE: These numbers were confirmed by e-mail with Dave Mercer of Westbay®, Inc. on August 5, 2003 (LHM).

Attachment F:
Continuation Sheet

Continuation Sheet

Well I.D.	Date	Geologist's or Designee's Signature

Attachment C

NASA White Sands Test Facility Job Instruction

Groundwater Level and Well Depth Determinations

White Sands Test Facility
Job Instruction

Issued: 08/25/03
Expires: NA

WJI ENV-0018.B

GROUNDWATER LEVEL AND WELL DEPTH DETERMINATIONS

Work Authorizing Document:
Environmental Department Task Memo

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Rescissions: This WJI supersedes TPS 2-HWM-940318R.

Record of Revisions

Issue	Issue Date	Page(s) Affected	Description of Changes
B	All	General Update	7/25/03

Permanent Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

Temporary Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

1. PURPOSE

NASA's Post-Closure Care Permit stipulates that static water level and total depth measurements will be obtained at each WSTF conventional groundwater monitoring well on set intervals. This WJI provides instruction for obtaining monthly and quarterly static water level and periodic total depth measurements from conventional groundwater monitoring wells. Instructions for performing this task were formerly provided by TPS 2-HWM-940318R, which was approved by NMED and EPA Region 6.

2. REFERENCES

a. Groundwater Sampling and Analysis Plan, NASA WSTF, May 1998.

b. RCRA Hazardous Waste Facility Post-Closure Care Permit

c. American National Standards Institute (ANSI) Z41 PT91 (Protective Footwear), ANSI Z87.1 (Eye and Face Protection), ANSI Z89.1 (Head Protection), most recent versions.

d. WSI 25-SW-007, "Personal Protective Equipment."

e. WSI 25-SW-0023, "Minimum Access Requirements for 300, 400, and 500 Propulsion Test Areas."

f. WSI 25-SW-0024, "Lightning Protection."

g. JHA HW-007, "Monitoring Well Depth Measurement."

3. ATTACHMENTS

a. Attachment A - Static Water Level and Total Depth Measurement Frequencies

b. Attachment B - NDMA-Contaminated Groundwater Assessment Wells

4. DEFINITIONS

None

5. ABBREVIATIONS AND ACRONYMS

a. CFR - Code of Federal Regulations

b. NDMA - N-Nitrosodimethylamine

6. HEALTH AND SAFETY REQUIREMENTS

NOTE

A SAFETY HAZARD ASSESSMENT OF THE TASKS OUTLINED IN THIS WJI HAS BEEN PERFORMED IN ACCORDANCE WITH 29 CFR 1910.132, SUBPART I. THE CERTIFICATION OF HAZARD ASSESSMENT AS REQUIRED BY WSI 25-SW-0007 IS CONTAINTED IN THE JOB HAZARD ANALYSIS MONITORING WELL DEPTH MEASUREMENT (JHA HW-007). THE AUTHORIZED SIGNATURES OF INDIVIDUALS REVIEWING AND APPROVING THIS WJI INDICATE THEIR CONCURRENCE WITH THE SAFETY HAZARD ASSESSMENT AND THE SAFETY REQUIREMENTS PRESCRIBED IN THIS DOCUMENT AND THE REFERENCED JHA.

THE FOLLOWING HEALTH AND SAFETY REQUIREMENTS SUPPLEMENT THOSE SET FORTH IN THE JHA FOR PERSONAL PROTECTIVE EQUIPMENT (PPE) AND/OR PROVIDE ADDITIONAL INFORMATION FOR HAZARDS ASSOCIATED WITH WELL DEPTH MEASUREMENT ACTIVITIES AT WSTF.

a. Due to the remoteness of many of WSTF monitoring wells, the following safety requirements must be observed.

(1) This task will only be performed by two-person crews.

(2) Each crew performing work specified by this WJI will have a two-way radio for communication.

(3) In the event of minor cuts, scrapes, and abrasions, first aid will be administered in the field. In the event of any non-first aid injury, field activities will be immediately suspended and the WSTF Fire Department will be notified for assistance.

b. The following safety requirements apply to the protective equipment to be utilized by personnel while performing monitoring well depth measurements.

(1) Monitoring well chemical data indicate that specific wells are contaminated with trace amounts of hazardous compounds. Therefore, handle all down-hole equipment with extreme care. At no time should groundwater or contaminated equipment come in contact with personnel skin, eyes, or clothing. At all times during equipment handling, Nytek gloves will be worn.

(2) Because there is no allowable exposure criteria for N-nitrosodimethylamine (NDMA) and N-nitrodimethylamine (DMN), safety goggles that meet the requirements of the most recent version of ANSI Z87.1 and a chemical resistant apron will be worn when handling any down-hole equipment that has come in contact with NDMA or DMN-contaminated water. Refer to Attachment B for a

list of the groundwater assessment wells with known concentrations of NDMA and DMN

(3) During the months of March through September, ambient temperatures at WSTF frequently exceed 90°F. This extreme environment creates the potential for heat stress and overexposure to ultraviolet (UV) radiation. Field personnel shall be familiar with heat stress prevention procedures and will implement them when required by elevated temperatures. Additionally, to protect exposure to UV radiation, sunscreen with a protection factor of at least 30 shall be worn while working in direct, intense sunlight. Umbrellas will be used when working conditions permit.

(4) All personnel will wear protective footwear that meets the requirements of the most recent version of ANSI Z41 (MT I/75 C/75) while working in the field to prevent injuries from dropping heavy equipment.

(5) To prevent possible hand injuries, field personnel will wear work gloves when necessary during work activities that do not require the use of Nytek gloves.

c. Various species of wildlife at WSTF (including snakes, insects, and rodents) can often be found near monitoring wells. Caution will be used to avoid contact with potentially dangerous wildlife at all times while in the field. If any potential natural dangers are detected, contact the responsible contractor environmental department personnel for further instructions.

d. During certain times of the year, thunderstorms can pose an electrical hazard, particularly near an elevated boom or mast. As instructed in WSI 25-SW-0024, Westbay profiling activities will be suspended when lightning is detected within three miles of the well site (15 seconds from flash to thunder). Personnel will seek shelter when operations are suspended and contact the responsible contractor Environmental Department personnel for further instructions.

e. Operations at wells within the 300, 400, and 500 Areas require that personnel coordinate their entry into these areas with the appropriate Blockhouse monitor. WSI 25-SW-0023 specifies that all personnel not permanently assigned to these areas inquire at the Blockhouse and sign in/out prior to entry into and exit from these areas.

7. SUPPORT REQUIREMENTS

a. Depth probe

b. Deionized water for depth probe decontamination

c. Appropriate decontamination water collection/transport container

d. Electronic field logbook to record the measurement event(s)

8. SPECIAL REQUIREMENTS

None

9. DEPTH MEASUREMENT INSTRUCTIONS

Routine static water level measurements are performed monthly for all post-closure care conventional wells and quarterly for all other conventional groundwater monitoring wells. If possible, measurements for all wells are taken within a single day. Attachment A identifies the conventional monitoring wells that require static water level and total depth measurements and provides frequencies at which they will be measured. Routine total depths are measured annually in conventional wells that do not contain dedicated sampling systems and once every five years in wells that contain dedicated sampling systems. Specific WSTF projects may require more frequent groundwater level and/or total depth measurements. When required, these measurements will be collected in accordance with this procedural document.

a. Static Water Level Measurements

NOTE

STATIC WATER LEVEL MEASUREMENTS WILL BE PERFORMED USING STATIC WATER LEVEL METERS. PERSONNEL WILL BE RESPONSIBLE FOR READING, UNDERSTANDING AND UTILIZING THE SPECIFIC INSTRUCTIONS PROVIDED BY THE MANUFACTURER'S MANUAL APPLICABLE TO THE SPECIFIC WATER LEVEL METER USED.

(1) On the day static water levels are to be measured, obtain the barometric pressure from the barometer in the Contamination Assessment building or from a sampling crew utilizing a Westbay probe capable of monitoring the atmospheric pressure. Record the value and the source of the measurement in the electronic field logbook.

(2) Utilize the measurement annotation sheets maintained by the site contractor Environmental Department or contact the appropriate responsible contractor personnel to determine which wells are scheduled for static water level determinations.

(3) Proceed to the scheduled well and remove the well cap(s).

(4) Prior to measuring the depth at the first well of the day, thoroughly rinse the depth probe and the lowermost several feet of measurement tape with deionized water. Ensure that all rinse water is collected in the decontamination water collection/transport container.

NOTE

THE STATIC WATER ELEVATION, OR DEPTH TO WATER, MUST BE MEASURED FROM THE SURVEYED ORIENTATION MARK LOCATED ON THE INNER WELL CASING. ENSURE THAT THE DEPTH PROBE TAPE IS POSITIONED ON THIS MARK WHEN RECORDING THE DEPTH MEASUREMENT.

(5) Slowly lower the water level probe down the well casing, being careful not to cut the measurement tape on the top of the well casing. When the meter indicates the probe has contacted water, raise and lower the probe until a water level to the nearest 0.01 meter is obtained. Raise the probe out of the water and repeat the measurement to ensure an accurate measurement of the static water level.

(6) When two duplicate measurements are obtained, record the measured depth value in the electronic logbook in the appropriate database form. If prompted to by the database, measure the depth again to obtain an accurate measurement and indicate that the depth measurement was repeated.

(7) Retrieve the probe from the well and rinse it with deionized water over the decontamination water collection/transport container.

b. Total Depth Measurements

NOTE

TOTAL DEPTHS CANNOT BE TAKEN ON WELLS WITH DEDICATED PUMP SYSTEMS INSTALLED UNLESS THE PUMP AND TUBING ARE REMOVED FROM THE MONITORING WELL. TOTAL DEPTH MEASUREMENTS ARE MOST RELIABLY OBTAINED BY A CONTACT WATER LEVEL METER WITH A TOTAL DEPTH ATTACHMENT. IF WELL CONDITIONS DO NOT PERMIT USE OF THE CONTACT WATER LEVEL METER, ALTERNATE INSTRUMENTATION WILL BE USED TO PLUMB THE BOTTOM OF THE WELL.

(1) Follow the steps in Section a. above to obtain the depth to water. Record this value in the electronic field logbook.

(2) After water is contacted, continue lowering the probe SLOWLY until the bottom of the well is contacted. If the depth probe is equipped with a total depth attachment, the light or buzzer on the depth probe will turn off. Raise and lower the probe until a total depth measurement is obtained to the nearest 0.01 meter. Raise the probe several feet and repeat the measurement to ensure an accurate measurement of the total depth.

(3) Ensure that the depth probe measurement tape is positioned on the orientation mark on the inner well casing. When two duplicate measurements are obtained, record the measurement in the electronic field logbook. If prompted to by the database, measure the depth again to obtain an accurate measurement.

(4) Retrieve the probe from the well and rinse it with deionized water over the decontamination water collection/transport container.

c. When water level measurement activities have been completed for the day, ensure that all measurements are uploaded into the appropriate database. Notify the responsible contractor environmental personnel of their completion and presence in the database.

d. The responsible contractor environmental personnel will review the groundwater elevation or monitoring well total depth data within seven days of the date it was collected. If questions arise regarding the validity of these measurements, the geological staff performing the review will consult with field technicians and groundwater staff to determine what, if any, further action is required.

e. If the depth to groundwater or well total depth is measured again, the new value will replace the original measurement in the database. If the original measurement is determined to be accurate, the database will be updated with a comment identifying and documenting the anomalous data.

Attachment A issued:

Attachment A:
Static Water Level and Total Depth Measurement Frequencies

WELL ID	STATIC WATER LEVEL FREQUENCY	TOTAL DEPTH FREQUENCY
100-A-182	Quarterly	5 Years
100-C-365	Quarterly	Annually
100-E-261	Quarterly	5 Years
200-B-240	Monthly	5 Years
200-D-109	Monthly	Annually
200-D-240	Monthly	5 Years
300-A-120	Monthly	5 Years
300-A-170	Monthly	5 Years
300-B-166	Quarterly	5 Years
300-C-128	Quarterly	5 Years
300-D-153	Monthly	5 Years
400-A-151	Quarterly	5 Years
400-C-118	Monthly	5 Years
400-C-143	Monthly	5 Years
600-C-173	Monthly	5 Years
700-A-253	Quarterly	5 Years
700-B-510	Quarterly	Annually
700-D-186	Quarterly	5 Years
700-E-458	Quarterly	5 Years
700-F-455	Quarterly	Annually
700-J-200	Quarterly	5 Years
NASA 1	Quarterly	Annually
NASA 2	Quarterly	Annually
NASA 3	Quarterly	5 Years
NASA 4	Quarterly	5 Years
NASA 5	Monthly	5 Years
NASA 6	Monthly	5 Years
NASA 7	Monthly	5 Years
NASA 8	Monthly	5 Years
NASA 9	Monthly	5 Years
NASA 10	Monthly	5 Years
BLM-1-435	Quarterly	5 Years

WELL ID	STATIC WATER LEVEL FREQUENCY	TOTAL DEPTH FREQUENCY
BLM-2-482	Quarterly	Annually
BLM-2-630	Quarterly	Annually
BLM-3-182	Quarterly	Annually
BLM-5-527	Quarterly	Annually
BLM-6-488	Quarterly	Annually
BLM-7-509	Quarterly	Annually
BLM-8-418	Quarterly	5 Years
BLM-9-419	Quarterly	5 Years
BLM-10-517	Quarterly	Annually
BLM-13-300	Quarterly	Annually
BLM-14-327	Quarterly	5 Years
BLM-15-305	Quarterly	Annually
BLM-17-493	Quarterly	Annually
BLM-17-550	Quarterly	5 Years
BLM-18-430	Quarterly	5 Years
BLM-21-400	Quarterly	5 Years
BLM-22-570	Quarterly	Annually
BLM-23-431	Quarterly	Annually
BLM-24-565	Quarterly	5 Years
BLM-25-455	Quarterly	Annually
BLM-26-404	Quarterly	5 Years
BLM-27-270	Quarterly	Annually
BW-1-268	Quarterly	5 Years
BW-3-180	Quarterly	5 Years
BW-5-295	Quarterly	5 Years
BW-6-355	Quarterly	Annually
BW-7-211	Quarterly	Annually
JP-1-424	Quarterly	5 Years
JP-2-447	Quarterly	5 Years
PL-1-486	Quarterly	Annually
PL-2-504	Quarterly	Annually
PL-3-453	Quarterly	Annually
PL-4-464	Quarterly	Annually
ST-1-473	Quarterly	Annually
ST-1-541	Quarterly	5 Years
ST-1-630	Quarterly	5 Years
ST-2-466	Quarterly	Annually

WELL ID	STATIC WATER LEVEL FREQUENCY	TOTAL DEPTH FREQUENCY
ST-3-486	Quarterly	Annually
ST-3-586	Quarterly	5 Years
ST-3-666	Quarterly	5 Years
ST-3-735	Quarterly	5 Years
ST-4-481	Quarterly	5 Years
ST-4-589	Quarterly	5 Years
ST-4-690	Quarterly	5 Years
ST-5-481	Quarterly	5 Years
WB-15	Quarterly	Annually
WW-1-452	Quarterly	5 Years

Attachment B issued:

Attachment B
NDMA/DMN-Contaminated Conventional Wells

NASA 5	BLM-17-550	ST-3-486
NASA 6	BLM-21-400	ST-3-586
NASA 7	BLM-23-431	200-B-240
NASA 10	BLM-26-404	300-A-120
BLM-1-435	BLM-27-270	300-A-170
BLM-2-482	BW-1-268	300-B-166
BLM-2-630	BW-4-270	300-C-128
BLM-9-419	BW-5-295	400-A-151
BLM-14-327	BW-7-211	400-C-118
BLM-15-305	ST-1-541	400-C-143
BLM-17-493		

Attachment D

NASA White Sands Test Facility Job Instruction

Conventional Well Sampling Instructions

White Sands Test Facility
Job Instruction

Issued: 03/27/00
Expires: NA

WJI ENV-0013.A

CONVENTIONAL WELL SAMPLING INSTRUCTIONS

Work Authorizing Document: Environmental Department Task Memo

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Rescissions: This WJI Supersedes TPS 2-HWM-930293R, 6-HWM940230, and WJI ENV-0016.A.

Record of Revisions

Issue	Issue Date	Page(s) Affected	Description of Changes

Permanent Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

Temporary Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

1. PURPOSE

This WJI provides specific environmental sampling instructions for WSTF's conventionally installed groundwater monitoring wells. This instruction was developed using Environmental Protection Agency (EPA) guidelines (References a, b and c) and is used in conjunction with the WSTF Groundwater Sampling and Analysis Plan and the WSTF Quality Assurance Project Plan. Instructions for performing these sampling tasks were formerly provided by TPS 2-HWM-930293R, which was approved by the New Mexico Environment Department (NMED) and EPA Region 6.

2. REFERENCES

a. Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods, U.S. Environmental Protection Agency, SW-846, Third Edition, June 1997.

b. RCRA Ground Water Monitoring Technical Enforcement Guidance Document, U.S. Environmental Protection Agency, OSWER-9950.1, September 1986.

c. RCRA Ground-Water Monitoring: Draft Technical Guidance, U.S. Environmental Protection Agency, November 1992.

d. Groundwater Sampling and Analysis Plan, NASA WSTF, May 1998.

e. Quality Assurance Project Plan, NASA WSTF, May 1998.

f. Well Wizard Sampling System Operation and Maintenance Manuals.

g. Bennett Sample Pump Operations and Maintenance Manual.

h. Operations and Maintenance Manual(s) for Specific Steam Cleaner(s) in Use.

i. Operation and Maintenance Manual for Specific Electrical Generator(s) in Use.

j. Operation and Maintenance Manuals for Parameter Instruments (pH, conductivity, turbidity, etc.).

k. American National Standards Institute (ANSI) Z41 PT91 (Protective Footwear), ANSI Z87.1 (Eye and Face Protection), ANSI Z358.1 (Eyewash Units), most recent versions.

l. OSHA Standard 29 CFR, Part 1910 Subpart I 1910.132 – General Requirements.

m. WJI ENV-0015, “Portable Liquid Nitrogen Dewar Operation.”

n. WSI 25-SW-0024, “Lightning Protection.”

3. ATTACHMENTS

a. Attachment A – NDMA/DMN Contaminated Groundwater Wells

b. Attachment B – Total Depth of Well Casings

c. Attachment C – Packer Depths and Recommended Inflation Pressures

d. Attachment D – New and Modified Conventional Monitoring Wells

e. Attachment E – Parameter Collections Schedules for New and Modified Conventional Monitoring Wells

f. Attachment F – WSTF Groundwater Sampling Record an QA Sheet

4. HEALTH AND SAFETY REQUIREMENTS

NOTE

A SAFETY HAZARD ASSESSMENT FOR THIS WJI HAS BEEN PERFORMED IN ACCORDANCE WITH 29 CFR 1910.132, SUBPART I. THE FOLLOWING HEALTH AND SAFETY REQUIREMENTS HAVE BEEN DEVELOPED IN ACCORDANCE WITH THIS ASSESSMENT. THE AUTHORIZED SIGNATURES OF INDIVIDUALS APPROVING THIS WJI INDICATE THEIR CONCURRENCE WITH THIS ASSESSMENT AND THE SAFETY REQUIREMENTS PRESCRIBED IN THIS DOCUMENT.

a. All groundwater sampling personnel will be certified as Hazardous Waste Handlers prior to engaging in sampling activities. Personnel must also be familiar with WPD 22-03 (Safety), Material Safety Data Sheets (MSDSs) regarding chemicals potentially used and any other pertinent documentation regarding the use of equipment and materials used in the field.

b. Due to the remoteness of most of WSTF's monitoring wells, the following safety requirements must be observed.

(1) Every sampling crew will consist of two sampling personnel.

(2) Each sampling crew will carry a two-way radio.

(3) In the event of minor cuts, scrapes, and abrasions, first aid will be administered in the field. In the event of any non-first aid injury, sampling activities will be immediately suspended and the WSTF Fire Department will be notified for assistance.

c. The following safety requirements apply to the protective equipment to be utilized by sampling personnel while performing sampling activities.

(1) Monitoring well chemical data indicate that specific wells are contaminated with trace amounts of hazardous compounds. Therefore, handle all purged well water

with extreme care. At no time during sampling operations should samples, purged waters, or contaminated equipment come in contact with personnel skin, eyes, or clothing. At all times during sample collection, Nytek gloves will be worn, both to protect sampling personnel and preserve the integrity of the sample.

(2) Because there is no allowable exposure criteria for N-nitrosodimethylamine (NDMA) and N-nitrodimethylamine (DMN), safety goggles that meet the requirements of the most recent version of ANSI Z87.1 will be worn when handling NDMA/DMN contaminated groundwater. Refer to Attachment A for a list of the groundwater assessment wells with known concentrations of NDMA/DMN. Goggles will be worn at these wells during parameter collection, sample collection, and while handling any sampling equipment that has come in contact with contaminated water.

(3) During the months of March through September, ambient temperatures at WSTF frequently exceed 90°F. This extreme environment creates the potential for heat stress and overexposure to ultraviolet (UV) radiation. Field personnel shall be familiar with heat stress prevention procedures and will implement them when required by elevated temperatures. Additionally, to protect exposure to UV radiation, sunscreen with a protection factor of at least 30 shall be worn while working in direct, intense sunlight. Umbrellas will be used when working conditions permit.

(4) All sampling personnel will wear protective footwear that meets the requirements of the most recent version of ANSI Z41 (MT I/75 C/75) while working in the field to prevent injuries from dropping gas cylinders or other heavy equipment.

(5) To prevent possible hand injuries, sampling personnel will wear work gloves when necessary during work activities that do not require the use of Nytek gloves.

d. For groundwater samples that require preservation by acids or bases, the following additional safety precautions are required.

(1) Sampling personnel will wear Nytek (or equivalent) gloves, a chemical resistant apron, and safety goggles and face shield that meet the requirements of the most current version of ANSI Z87.1 while preserving samples with corrosive agents.

(2) A personal eyewash unit conforming to the most recent version of ANSI Z358.1 will be available at the well site during sample preservation. Personal eyewash units will be stored and maintained as directed in the manufacturer's instructions. During extremely hot or cold weather, personal eyewash units will be stored to ensure proper fluid delivery temperature as specified in the most current version of ANSI Z358.1.

(3) If a corrosive agent comes into direct contact with personnel skin or eyes, sampling activities will be suspended and affected personnel will immediately flush the affected area for 15 minutes and notify the WSTF Fire Department.

e. The following safety requirements pertain to the use of electric generators.

(1) Prior to operation of a generator, sampling personnel will become familiar with the safety requirements and operating procedures prescribed in the manufacturer's operation and maintenance manual.

(2) Each field vehicle at the sampling site will contain a class ABC fire extinguisher.

(3) A ground fault circuit interrupter (GFCI) will be used on the generator at all times.

f. The following safety requirements apply to the use of steam cleaners for decontamination of sampling equipment.

(1) Prior to operating steam cleaners, sampling personnel will become familiar with operational and safety requirements specified by the manufacturer's operation and maintenance manual.

(2) Propane tanks will be secured to the steam cleaner while in use.

(3) Sampling personnel will wear Nytek (or equivalent) gloves and safety goggles and face shield that meet the requirements of the most current version of ANSI Z87.1 while decontaminating sampling equipment.

(4) To avoid contact with possible residual contaminants, personnel will first thoroughly decontaminate sampling equipment from a minimum distance of six feet. After initial decontamination, personnel may move closer to complete the decontamination. Smaller items that must be held should be kept at arm length during initial contamination.

g. The following safety requirements apply to the use of liquid nitrogen (LN_2) dewars and high-pressure K-bottles as pressure sources.

(1) LN_2 dewars will only be loaded/unloaded on vehicles and trailers using lift gates or other lifting devices that are rated for at least 1000 lbs. lift capacity.

(2) Sampling personnel utilizing a portable LN_2 dewar as a pressure source will follow the operational procedures and safety precautions prescribed in WJI ENV-0015.

(3) Nitrogen K-bottles will only be loaded/unloaded by two sampling personnel. All personnel will wear safety footwear as prescribed above.

(4) When removed from sampling vehicles for field use, all K-bottles will be adequately secured to prevent tipovers.

(5) All dewars and K-bottles will be secured during transportation and storage.

h. Various species of wildlife at WSTF (including snakes, insects, and rodents) can often be found near monitoring wells. Caution will be used to avoid contact with potentially dangerous wildlife at all times while in the field. If any potential natural dangers are detected, contact the sampling coordinator or other responsible contractor environmental department personnel for further instructions.

i. During certain times of the year, thunderstorms can pose an electrical hazard. As instructed in WSI 25-SW-0024.A, field sampling activities will be suspended when lightning is detected within three miles of the well site (15 seconds from flash to thunder). Personnel will seek shelter when operations are suspended and contact the responsible contractor Environmental Department personnel for further instructions.

5. SUPPORT REQUIREMENTS

a. Equipment

(1) Sampling Equipment

(a) Bladder pump, controller box, and accessories as required

(b) Air-driven reciprocating piston pump and accessories as required

(c) Nitrogen K-bottles or portable LN_2 dewar

(2) Portable purge water collection container

(3) Depth probe

(4) Field logbook to record all field activities

(5) Portable meters for the collection of indicator parameters

(a) pH/temperature meter

(b) Conductivity meter

(c) Turbidity meter

(6) Dedicated Teflon® bailer as required

(7) Portable electric generator (if required)

(8) Five gallon bucket for sample and parameter collection

(9) Graduated beaker for parameter collection

(10) Goggles, faceshield, apron, and Nytek sampling gloves

(11) Poly baggies (small and large) for sample storage

(12) Sample bottles as required for each sampling event

(13) Ice chests and ice for sample storage

(14) Steam cleaning system for equipment decontamination

b. Reagents/Chemicals

WARNING

ALL CONCENTRATED ACIDS AND BASES ARE STORED IN THE CORROSIVES STORAGE CABINET WHEN NOT IN USE. ALL PROPANE TANKS NOT ATTACHED TO THE STEAM CLEANER SYSTEM WILL BE SECURELY STORED OUTSIDE IN THE CYLINDER STORAGE RACKS.

(1) Reagent grade (blank) water

(2) Concentrated nitric, sulfuric, and hydrochloric acid ampules (2 ml each) and other chemicals required for sample preservation

(3) Standards for meter calibration (pH buffers, conductivity, and turbidity)

(4) Propane (steam cleaner fuel)

(5) Gasoline (portable electric generator fuel)

6. SPECIAL REQUIREMENTS

a. To eliminate potential contamination of the sampling equipment and sample containers, gasoline-powered equipment (generators) and gasoline containers must be transported to the field on trailers or in vehicles that do not contain sampling equipment. Additionally, gas-operated equipment must be located downwind of sampling activities at a distance of at least 25 feet.

b. Only sample containers that have been cleaned to the levels appropriate for sample collection can be used. If the integrity of any sample container is questionable, it will be discarded.

c. Environmental Considerations

(1) Historical analytical data indicate that specific wells at WSTF are contaminated with trace amounts of hazardous compounds. Therefore, all groundwater brought to the surface should be handled with extreme care to avoid discharge to the environment. All handling of groundwater should be performed over the concrete well pad or over the appropriate purge water collection container to

ensure all purge water is contained appropriately. If an accidental release occurs, the contractor Environmental Department supervisor or other responsible personnel should be contacted to determine the appropriate course of action.

(2) If gas-powered equipment is fueled in the field, special care will be taken to avoid spilling gasoline. Any spilled gasoline or oil, along with any potentially contaminated soil, will be immediately removed from the site and transported to the appropriate location for storage and/or disposal.

(3) Ensure that all motor vehicle use is restricted to maintained roads, well pads, and other service areas. In the event that these areas become impassable or require maintenance, contact the responsible contractor Environmental Department personnel to arrange for the required corrective action.

7. DECONTAMINATION INSTRUCTIONS

WARNING

DECONTAMINATION PROCEDURES ARE PERFORMED BY TRAINED PERSONNEL WEARING THE PROPER PROTECTIVE CLOTHING. ALL SAFETY REQUIREMENTS PREVIOUSLY LISTED FOR DECONTAMINATION PROCEDURES WILL BE FOLLOWED.

a. General

(1) Steam cleaners will be operated in accordance with the appropriate manufacturer’s operating manual. Required safety precautions previously listed will be adhered to during decontamination operations.

(2) Non-dedicated well sampling equipment (pumps, bailer tips, depth probes, etc.) require decontamination before each use.

(3) Decontamination instructions include steam cleaning and/or rinsing with deionized water. Previous tests indicate this method yields sampling equipment free of contaminants that interfere with WSTF's analyses.

(4) Decontaminated items are protected from contamination by covering them with poly sheets or placing them in plastic baggies.

(5) Field logbook will be annotated at each sampling event to reflect the method of decontamination used for sampling equipment.

b. Equipment Decontamination

NOTE

ALL NEW OR PREVIOUSLY USED DOWN-HOLE EQUIPMENT MUST BE DECONTAMINATED PRIOR TO USE OR INSTALLATION IN WSTF MONITORING WELLS. ANY EQUIPMENT REMOVED FROM A WSTF MONITORING WELL WILL BE DECONTAMINATED BY STEAM CLEANING PRIOR TO DISPOSAL.

(1) Air-Driven Reciprocating Piston Pump

(a) Position the pump in the center of the steam cleaning pad.

(b) Steam clean the entire system thoroughly, with particular attention to the pumphead and the exposed tubing.

(c) Inspect the system for loose fittings and tubing bundle integrity. Repair or replace parts as required.

(d) On at least a weekly basis during periods of use, heat 20 liters of deionized water in a stainless steel stock pot and pump the water through the system. In addition, remove and clean the filter housing and screen assembly.

(e) Cover the entire pump reel and frame with a poly sheet and secure with rubber tie-downs.

(2) Miscellaneous Equipment

(a) Transfer equipment to be decontaminated to the steam cleaning pad.

(b) Disassemble equipment, if possible, and steam clean each piece.

(c) Cover equipment with poly sheets or place in plastic baggies.

8. CALIBRATION, MAINTENANCE, AND USE OF FIELD INSTRUMENTS

NOTE

UNLESS OTHERWISE STATED, CALIBRATION ACTIVITIES AND RELATED INFORMATION WILL BE RECORDED IN A SEPARATE "CALIBRATION LOGBOOK" TO BE MAINTAINED BY FIELD PERSONNEL. ALL FIELD INSTRUMENTS WILL BE LABELED WITH THE MOST APPLICABLE WSTF CALIBRATION DECAL.

a. pH Meter Calibration and Use

NOTE

WSTF CURRENTLY USES VARIOUS MODELS OF pH METERS. ALTHOUGH THE GENERAL STEP-BY-STEP DIRECTIONS FOR SETTING UP THE METERS MAY VARY, THE CALIBRATION AND USE REQUIREMENTS ARE THE SAME. REFER TO THE INDIVIDUAL MANUFACTURER'S OPERATIONS MANUAL FOR SPECIFIC INSTRUMENT CALIBRATION AND USE INSTRUCTIONS.

(1) Turn the meter on and perform a two point calibration as directed in the manufacturer's operation manual for the specific meter in use. This initial calibration should be performed with 7.00 and 10.00 buffers that have not exceeded their expiration dates. Ensure that pH buffers and their secondary containers are clean and free of debris prior to use. Record the calibration readings and pertinent buffer information in the field logbook.

(2) Obtain sample water for initial parameter determination by slowly dispensing collected well water into a clean graduated beaker.

(3) Switch the meter to measure mode, submerge the probe in the beaker, and obtain a pH of the sample after equilibration. If the measured pH is outside of the 7 to 10 pH range, recalibrate with buffers that bracket the measured pH and perform sample measurement again.

NOTE

SOME MODELS OF pH METERS ARE NOT EQUIPPED FOR TEMPERATURE MEASUREMENT. WHEN USING A pH METER THAT CANNOT MEASURE TEMPERATURE, A CONDUCTIVITY METER WITH THE ABILITY TO MEASURE TEMPERATURE MUST BE USED.

(4) If required, switch the meter to temperature mode and obtain a temperature reading.

(5) Record the pH and temperature readings in the field logbook.

(6) After sampling procedures are complete, a post sampling calibration check of the appropriate buffers is performed to identify instrument drift during purging and sampling procedures. Enter these readings in the field logbook with the final indicator parameters. If meter readings have drifted more than 5% from initial calibration readings, recalibrate the instrument, measure the sample media, and annotate the logbook with all relevant information.

(7) If extended purging and sampling procedures are required, periodic checks of the buffers during the day are performed to check for instrument drift. If meter readings have drifted more than 5%, recalibrate the instrument, measure the sample media, and annotate the logbook with all relevant information.

b. Turbidity Meter Calibration and Use

NOTE

BECAUSE WSTF MAY USE VARIOUS TURBIDITY METERS, SAMPLING PERSONNEL WILL UTILIZE THE APPROPRIATE MANUFACTURER'S OPERATIONS MANUAL TO ENSURE THAT METERS ARE MAINTAINED, CALIBRATED, STORED, AND USED IN A MANNER THAT ENSURES RELIABLE COLLECTION OF ACCURATE MEASUREMENTS.

(1) Ensure the turbidity meter is calibrated at least monthly according to the manufacturer's specifications prior to measurement activities. These periodic calibration values, in addition to all pertinent information regarding the calibration activity, should be recorded in the calibration logbook.

(2) Verify meter calibration in the field immediately prior to sample turbidity measurement by using the formazin gel standard prepared by the manufacturer. This standard will be carried with the turbidity meter to all field sampling events. The meter reading should be within ±5% of the secondary standard.

(3) Obtain an aliquot of sample water in the glass measurement cell. Dry the outside of the cell thoroughly, place it in the meter, and close the lid.

(4) Turn the meter on, initiate the measurement cycle, and wait for the digital turbidity reading to equilibrate. Record the turbidity measurement in the field logbook. Do not store the glass turbidity cells in the measurement compartment of the meter. Scratches on the cells could distort turbidity measurements. If visible scratches are detected on a turbidity cell, discard the measurement cell and replace it.

c. Conductivity Meter Calibration and Use

NOTE

SAMPLING PERSONNEL WILL UTILIZE THE APPROPRIATE MANUFACTURER'S OPERATIONS MANUAL TO ENSURE THAT CONDUCTIVITY METERS ARE MAINTAINED, CALIBRATED, STORED, AND USED IN A MANNER THAT ENSURES RELIABLE COLLECTION OF ACCURATE MEASUREMENTS.

(1) Ensure the conductivity meter is calibrated and maintained at least monthly according to the manufacturer's specifications prior to measurement activities. Perform all required function tests at time of calibration to ensure proper meter operation. These periodic calibration values and maintenance activities will be recorded in the calibration logbook.

(2) Insert the conductivity probe into the beaker of well water that was used for pH and temperature determination. Turn the meter on, tune it to the proper conductivity scale, and set the temperature scale to match the temperature of the sample as previously determined with the pH meter.

(3) Wait for the display to equilibrate and record the conductivity reading in the field logbook.

NOTE

SOME MODELS OF CONDUCTIVITY METERS ARE NOT EQUIPPED FOR TEMPERATURE MEASUREMENT. WHEN USING A CONDUCTIVITY METER THAT CANNOT MEASURE TEMPERATURE, A pH METER WITH THE ABILITY TO MEASURE TEMPERATURE MUST BE USED.

(4) If required, switch the meter to temperature mode and obtain a temperature reading.

d. Dissolved Oxygen (DO) Measurement

NOTE

PAST SAMPLING EXERCISES HAVE INDICATED THAT THE REMOVAL OF GROUNDWATER FROM THE AQUIFER TO THE SURFACE CAN OXYGENATE THE SAMPLE ENOUGH SO THAT DO READINGS ARE NOT REPRESENTATIVE OF AQUIFER CONDITIONS. HOWEVER, IF A DO MEASUREMENT IS REQUESTED BY THE WORK AUTHORIZING DOCUMENT FOR ENGINEERING PURPOSES, SAMPLING PERSONNEL WILL UTILIZE THE APPROPRIATE MANUFACTURER'S OPERATIONS MANUAL TO ENSURE THE MOST ACCURATE DO MEASUREMENTS.

(1) Ensure the DO meter is calibrated and maintained according to the manufacturer's specifications prior to measurement activities. Record calibration and maintenance activities in the calibration logbook.

(2) Insert the DO probe into the water sample. Turn the meter on and tune it to read DO in the appropriate units (%, mg/L, etc.).

(3) Allow the reading to stabilize and record the measurement in the field logbook.

9. WELL PURGING INSTRUCTIONS

CAUTION

BEFORE PERFORMING ANY PURGING OR SAMPLING ACTIVITIES, THE WELL HEAD, WELL PAD, AND AREA AROUND THE WELL HEAD SHOULD BE INSPECTED FOR SNAKES, RODENTS, INSECTS, OR OTHER POTENTIAL

NATURAL DANGERS. IF ANY OF THESE ARE OBSERVED, CONTACT THE SAMPLING COORDINATOR OR SUPERVISOR FOR INSTRUCTIONS.

a. General

(1) Prior to each sampling event, review the site-specific sampling documentation (Work Authorizing Document, WJI, TPS, etc.) to ensure all procedures are followed during purging and sampling operations. Obtain from the sampling coordinator or other responsible contractor environmental department personnel the appropriate work authorizing document and any special instructions or notices pertaining to the purging and sampling activities.

NOTE

THE FIELD SAMPLING LOGBOOK IS A CRITICAL PART OF EVERY SAMPLING EVENT. FIELD LOGBOOKS ARE CONSIDERED LEGAL DOCUMENTS, AND METICULOUS ATTENTION TO DETAIL IS REQUIRED.

(2) Immediately after arriving at the well site, the logbook will be annotated with all pertinent information including date, time, location, weather conditions, sampler identification, equipment used and confirmation of decontamination and calibration, indicator parameters, sample information, and any other useful or unusual information concerning the sampling event. The logbook will provide a complete enough record of the entire sampling procedure that a person not associated with the sampling event can recreate the day's procedures from the logbook entries.

(3) Measure the static water level

(a) Carefully unlock and remove the protective cap from the well. Remove the stainless steel inner casing cap if the well is so equipped.

(b) Slowly lower the static water level probe down the well casing, being careful not to cut the measurement tape on the top of the well casing. When the probe contacts water, raise and lower the probe until a water level to the nearest 0.01 meter is obtained from the top of the inner casing. Record the value in the field logbook.

(4) Calculate the volume of water to be purged using the following equations for gallons or liters.

NOTE

IN MOST WELLS, AT LEAST THREE CASING VOLUMES OF WATER WILL BE PURGED PRIOR TO SAMPLING. TOTAL WELL DEPTHS

TO BE USED IN THE FOLLOWING CALCULATIONS ARE LISTED IN ATTACHMENT B.

(a) Gallons

$V = (3)(\pi r^2 h 7.48)$

where:

V = Three casing volumes of water in gallons

r = Radius of well casing in feet

h = Height of water column in feet (total depth – static water level)

7.48 = Number of gallons per cubic foot

NOTE

FOR MORE RAPID USE IN THE FIELD, THE GALLONS CALCULATION HAS BEEN SIMPLIFIED AS FOLLOWS:

IN 4" WELLS USE: $V_{(PURGE)}$ = h (in meters) X 7.54
IN 2" WELLS USE: $V_{(PURGE)}$ = h (in meters) X 1.72
FOR ONE OR TWO CASING VOLUMES, MULTIPLY THIS RESULT BY 0.3333 OR 0.6667, RESPECTIVELY.

(b) Liters

$V = (3)(\pi r^2 h 1000)$

where:

V = Three casing volumes of water in liters

r = Radius of well casing in meters

h = Height of water column in meters (total depth - static water level)

1000 = Number of liters per cubic meter

b. Purge Well Using Appropriate Pump System

NOTE

CONVENTIONAL MONITORING WELLS AT WSTF ARE PURGED AND/OR SAMPLED USING THREE DIFFERENT SYSTEMS: A DEDICATED BLADDER PUMP; A DEDICATED INFLATABLE PACKER/BLADDER PUMP SYSTEM; AND A NON-DEDICATED AIR-DRIVEN RECIPROCATING PISTON PUMP.

ALL PURGE WATER SHOULD BE PROPERLY COLLECTED IN THE APPROPRIATE TRANSPORT CONTAINER UNTIL DISPOSAL IN THE 200 AREA EVAPORATION TANKS.

(1) Dedicated Bladder Pump System

NOTE

HISTORICAL SAMPLING OF THE WELLS EQUIPPED WITH BLADDER PUMPS HAS SHOWN THAT SOME WELLS CAN NOT BE CONSISTENTLY SAMPLED WITH THE INSTRUCTIONS LISTED BELOW. SOME OF THE ANOMALIES NOTED FROM PAST SAMPLING EVENTS INCLUDE: ELEVATED TURBIDITY; INCONSISTENT RECHARGE RATES; AND LEAKING PACKERS. THE RESPONSIBLE CONTRACTOR ENVIRONMENTAL DEPARTMENT PERSONNEL WILL DETERMINE IF SPECIAL PROCEDURES ARE REQUIRED AND PROVIDE INSTRUCTIONS ON THE ENVIRONMENTAL DEPARTMENT TASK MEMO PRIOR TO SAMPLING ANY OF THESE WELLS. SAMPLING PERSONNEL WILL RECORD THE SPECIALIZED INSTRUCTIONS AND ACTIONS TAKEN IN THE LOGBOOK.

(a) Connect a pressure regulator to a nitrogen K-bottle or a portable dewar and ensure the output side of the regulator is backed off completely. If a portable LN_2 dewar is used for a pressure source, refer to WJI ENV-0015 for proper operating instructions**.**

(b) Connect the pressure hose from the regulator to the pump supply inlet fitting on the bladder pump control box.

(c) Connect a pressure hose from the control box pump supply fitting to the gas inlet fitting on the well cap.

(d) Connect a Teflon® delivery tube to the pump discharge fitting on the well cap. Insert the other end of the discharge tube into the appropriate purge water collection container.

(e) Slowly open the main valve on the K-bottle or the gas use valve if using the LN_2 dewar.

(f) Set the discharge and refill timer valves on the control box to the 12 o'clock position.

(g) Slowly increase the output setting on the regulator to 825 kPa (120 psi) if required to purge the well.

(h) Optimize the bladder pump purging cycle using the following instructions.

(i) Adjust the refill and discharge cycles to 10-15 seconds each. Measure the water volume discharged in a single cycle. The volume should be 350-450 milliliters. Increase the refill cycle time if the volume is not achieved.

(ii) Shorten the discharge cycle period (counterclockwise knob adjustment) until the end of the discharge cycle coincides with the end of water flow from the pump outlet tube.

(iii) Shorten the refill cycle until the volume per discharge cycle decreases 10-25% from the maximum value measured in Step (i).

(i) Calculate the purge rate by measuring the time required to purge a known volume (i.e. 5 gallons in 20 minutes is 0.25 gallons per minute). Record the purge rate in the field logbook. Determine the volume of water in two and three casing volumes as instructed previously in this section.

(j) When the equivalent of two casing volumes is purged, measure the initial indicator parameters (pH, temperature, conductivity, and turbidity). Record the values in the field logbook with respective times and volumes purged.

(k) When the equivalent of three casing volumes is purged, measure the secondary indicator parameters and record in the field logbook. If the indicator parameters remain constant (within 10% of the initial values) and the turbidity is less than five NTUs, initiate sample collection. If the parameters do not stabilize or turbidity values exceed five NTUs, continue purging until the criteria are met. In the event the criteria are not met with over-purging, contact the sampling coordinator or other responsible contractor environmental department personnel for further instructions.

(l) When purging a low yield well (one that is not capable of producing three casing volumes), pump the well to dryness. If the recovery rate is greater than three meters per hour, allow the well to recover for one hour, purge to dryness again, and sample when the water rises to a level that permits the pump to function. In cases where the recovery rate is less than three meters per hour, allow the water level to rise to a level

that permits sampling, then collect samples. In all cases record times, water levels, and calculated recovery rates in the field logbook.

(m) After three casing volumes are purged, or the slow recovery instructions have been implemented, purging is complete and sampling may begin.

(2) Purging Using A Dedicated Bladder Pump/Inflatable Packer System

(a) Obtain a static water level depth prior to inflating the packer and record the measurement in the field logbook.

(b) Inflate the packer as follows.

(i) Attach the control unit to the appropriate fitting on the well cap.

(ii) Attach the pressure regulator hose from the nitrogen K-bottle or portable LN_2 dewar to the packer control unit.

(iii) Activate the nitrogen source and inflate the packer while slowly increasing the pressure to the recommended level (recommended packer inflation pressures are listed in Attachment C).

(c) Calculate three casing volumes where h = the total depth of the well minus the depth to the bottom of the packer. Refer to Attachment C for the correct packer depths.

(d) Purge following the bladder pump purging instructions. Proper packer performance is indicated by steady pressure levels on the control unit inflation gauge.

(e) Measure initial and secondary parameters when the appropriate amount of water has been purged (two and three casing volumes). If they have stabilized as previously indicated, purging is complete and sampling can be initiated.

(f) After sampling is complete, deflate the packer by deactivating the nitrogen source and opening the valve on the control unit.

(3) Purging Using an Air-Driven Reciprocating Piston Pump

CAUTION

PRIOR TO TRANSPORTING THE PUMP TO OR FROM THE FIELD, USE TIE-DOWN STRAPS TO SECURE THE PUMP REEL, PUMPHEAD, AND TUBING BUNDLE TO THE TRAILER. DRIVE SLOWLY TO PREVENT PUMP DAMAGE.

(a) At the well site, unload the generator, place it downwind of the well head, and turn on the gasoline supply valve. Remove the locking well cap from the well head.

(b) Wearing protective gloves, remove the inner well cap assembly and the dedicated bailer and wrap them in clean poly sheeting.

(c) Obtain the static water level and calculate two and three casing volumes as previously instructed.

(d) Remove the poly cover from the pump reel. Loosen the tie-down straps and position the pump so the guide rollers are directly over the well head. Ensure the tubing bundle has plenty of clearance and will not drag excessively on the inside of the well casing. Resecure the pump assembly to the trailer with the tie-down straps in the position to be used for purging.

(e) Attach the discharge tube with in-line flow meter to the pump discharge fitting and insert the other end into the appropriate purge water collection container. Plug the electric drive motor into the generator using a GFCI and extension cord and start the generator.

(f) Set the pump water level indicator to the ON position. With protective gloves, slowly lower the pump down the casing using the pump electric drive motor.

(g) Lower the pump until the beeper from the water level indicator sounds. This indicates the static water level in the well.

(h) Lower the pump assembly 1-3 meters below static water level (do not lower the pump to depths at which the protective taping of the tubing bundle contacts the water surface). Turn the generator off when not in use for raising or lowering the pump.

(i) Attach the pressure hose from the K-bottle regulator or from the LN_2 dewar final line regulator to the Bennett reel assembly. Adjust the regulator pressure to 825 kPa (120 psi).

(j) Observe the discharge hose until a steady purge rate has been achieved. Note the flow meter reading and record in field logbook.

(k) When the equivalent of two casing volumes has been purged, take initial indicator parameters and record the values in the field logbook.

(l) When the equivalent of three casing volumes has been purged, measure the secondary parameters and record in the field logbook. If the indicator parameters remain constant (less than 10% variation) and the

turbidity is less than five NTUs, discontinue purging. If the values do not fall in the desired range, continue purging until stabilization. Contact the sampling coordinator or other responsible contractor environmental department personnel for further instructions if the parameter values do not stabilize.

(m) When purging is complete, raise the pumphead out of the water and pump out the excess water in the pump tubing and discharge hose. Record the total volume of water purged in the field logbook.

(n) Reel the pump tubing onto the reel frame, secure the pumphead to the reel, and secure the reel frame to center of the trailer for transport. Shut down the generator and turn the gasoline supply off. Turn off the nitrogen flow to the pump and sample with a dedicated Teflon® bailer.

NOTE

IN SOME CASES THE RECHARGE RATE OF THE WELL IS INSUFFICIENT TO PURGE THREE CASING VOLUMES. IN THESE SITUATIONS, FOLLOW THE INSTRUCTIONS LISTED BELOW.

(o) Instructions for wells in which the recharge rate is insufficient to purge three casing volumes are as follows.

(i) Lower the pump as the water level falls, keeping the pump submerged at least one meter below static water level. This is accomplished by activating the water level indicator switch and using it to estimate the depth of the pump.

(ii) Lower the pump to a level no lower than the bottom of the screened interval and pump the well to dryness.

(iii) Raise the pump five to seven meters above the new water level and allow the well to recover for an hour. Monitor the water level during the recovery period.

(iv) If the recovery rate is less than three meters per hour, remove the pump as instructed above and allow the well to recover a minimum of six meters. Sample using a dedicated Teflon bailer.

(v) If the recovery rate is greater than three meters per hour, lower the pump and evacuate the well to dryness again. Then remove the pump from the well as previously instructed. Allow the well to recover a minimum of six meters, then collect the required samples with the dedicated Teflon® bailer.

a. General

(1) Prior to each sampling event, read all pertinent documents and instructions associated with conventional well sampling. Consult the contractor environmental department QA/QC Coordinator to ensure the required Quality Assurance samples (duplicates, matrix spikes, blanks, and blind controls) are collected at the frequencies required by the most recently approved versions of the Sampling and Analysis Plan and Quality Assurance Project Plan.

(2) Contact the contractor environmental department Sampling Coordinator for a list of the samples to be collected at each well. Obtain the proper sample containers for each type of sample to be collected. Refer to the most recently approved SAP for specific information regarding sample container and sample preservation.

NOTE

INSPECT EACH SAMPLE CONTAINER USED IN THE FIELD FOR VISUAL CONTAMINATION. IF CONTAMINATION IS DETECTED, DISCARD THE CONTAINER. TO PREVENT VOLATILIZATION OF SAMPLES, STORE ALL SAMPLE CONTAINERS ON ICE UNTIL TIME OF SAMPLING. ALL SAMPLES THAT REQUIRE PRESERVATION ARE PRESERVED IN THE FIELD AT THE TIME OF COLLECTION.

(3) Prior to sampling, ensure that all non-dedicated sampling equipment has been decontaminated using the steam cleaner and/or DI water and properly stored for transport to the field as previously instructed in Section 7.

b. Sample Well Using Appropriate Method

(1) Sampling Using a Dedicated Bladder Pump

(a) Connect the bladder/purge pump to the controller box as previously directed and purge three casing volumes of water.

NOTE

TO REDUCE VOLATILIZATION DURING THE COLLECTION OF SAMPLES, SAMPLING PERSONNEL WILL USE A SHORT DISCHARGE TUBE (< 5 FT).

(b) Collect samples sensitive to volatilization (halogenated volatile organics and volatile organics) if required.

NOTE

PREVIOUS SAMPLING EVENTS HAVE DEMONSTRATED THAT THE PURGE RATE REFERENCED BELOW CANNOT ALWAYS BE OBTAINED. FOR THOSE WELLS THAT THE RECOMMENDED PURGE RATE OF APPROXIMATELY 100 ML/MIN CANNOT BE OBTAINED, ADJUST THE PURGE RATE TO THE LOWEST DISCHARGE RATE THAT THE PUMP WILL DELIVER.

(i) Adjust the discharge rate of the bladder pump to approximately 100 ml/min by decreasing the pump supply pressure at the control box.

(ii) Rinse each sample vial with well water. Position the vial under the discharge tube at an angle that allows the water to flow down the inside of the container with a minimum of turbulence.

(iii) As the vial overflows, rotate it to an upright position, and fill until a reverse meniscus is visible.

(iv) Cap the vial and ensure the absence of headspace by inverting the vial and observing for the presence of bubbles. If headspace is detected, discard the sample and refill the vial.

(v) Immediately store the volatile sample on ice. They are stored inverted in the ice chest to minimize potential loss of volatile contaminants through the container septa.

(c) Collect the remaining samples in descending order of sensitivity to volatilization. The discharge rate can be increased for collection of the remaining samples.

NOTE

TYPICALLY, SAMPLES FOR NDMA/DMN ANALYSES ARE COLLECTED AFTER VOLATILE SAMPLES. IN WELLS WITH ELEVATED TURBIDITY, THOUGH, RCRA METALS SAMPLES ARE COLLECTED PRIOR TO NDMA SAMPLES TO AVOID TURBIDITY INTERFERENCE WITH METALS ANALYSIS. IN SUCH CASES, ANNOTATE THE FIELD LOGBOOK ACCORDINGLY.

EPA METHOD 607 FOR NDMA REQUIRES THE SAMPLE TO BE PRESERVED WITH SODIUM THIOSULFATE IF RESIDUAL

CHLORINE IS PRESENT IN THE SAMPLE WATER. HOWEVER, PREVIOUS SAMPLING EVENTS HAVE INDICATED THAT NO RESIDUAL CHLORINE IS PRESENT IN WSTF GROUNDWATER, MAKING SAMPLE PRESERVATION UNNECESSARY.

(i) Before collecting additional samples, rinse each sample container with well water unless otherwise directed in the work authorizing document.

(ii) Fill the appropriate sample container from the discharge tube. Use care not to submerge the tube in the sample water in the container. Minimize headspace and cap the bottle.

(d) Immediately after taking each sample, prepare a label and chain of custody seal with a sample number representing the year, month, day, and time it was collected (i.e. 9302140815 indicates a sample collected on February 14, 1993 at 8:15 am).

NOTE

RCRA METAL ANALYSIS REQUIRES PRESERVATION WITH NITRIC ACID TO A PH LESS THAN 2. PREVIOUS SAMPLING EVENTS HAVE DEMONSTRATED THAT THIS CAN BE ACCOMPLISHED WITH A 2 ML AMPULE OF NITRIC ACID. CHECKING THE PH OF THE SAMPLE WATER AFTER PRESERVATION IS NOT NECESSARY, AS SAMPLE INTEGRITY CAN BE COMPROMISED BY INSERTING THE PH PROBE.

(e) Preserve the sample as indicated in the WSTF SAP or the work authorizing document, attach a completed label and chain of custody seal, place in a poly bag, and store on ice or refrigerate until delivery or shipment to the appropriate laboratory.

(f) After all required samples have been collected, take a final set of indicator parameters, including depth, and enter in the field logbook. Sign and date the logbook when all entries are completed.

(g) Close the main valve on the nitrogen supply or the gas use valve on the LN_2 dewar and allow the pressure to drop to ambient. Remove the pressure regulator and replace cap on K-bottle if used.

(h) Disconnect the air inlet fitting and the sample discharge tubing from the well cap and replace the protective cap.

(i) Disconnect all hoses, remove the pressure regulator, and secure the protective cap on the K-bottle.

(2) Sampling Using a Teflon® Bailer

(a) After removal of the pump, set up the downrigger assembly on the trailer or truck bed so the extendible arm is positioned over the monitoring well casing.

(b) Remove the dedicated bailer from the poly sheeting and attach it to the downrigger's swivel clip.

(c) Slowly lower the bailer into the well, listening for contact with the water. When contact is made, very slowly submerge the bailer fully, allow it to fill, and retrieve to the surface with the downrigger.

(d) When the first bailer is brought to the surface, insert the Teflon® delivery stopcock into the bailer and allow a small amount of water to pass through as a rinse. Obtain water from this first run to determine the final turbidity. Measure the turbidity and record the results in the field logbook.

NOTE

PREVIOUS SAMPLING EVENTS HAVE DEMONSTRATED THAT THE TURBIDITY REQUIREMENTS FOR METALS SAMPLES (< 5 NTUs) CANNOT ALWAYS BE MET. IF THE FINAL TURBIDITY (DETERMINED ABOVE) IS > 5 AND < 15 NTUs, COLLECT RCRA METALS SAMPLES FROM THE FIRST BAILER THAT IS RETRIEVED. IF THE FINAL TURBIDITY IS > 15 NTUs, CONTACT THE SAMPLING COORDINATOR OR OTHER RESPONSIBLE CONTRACTOR ENVIRONMENTAL DEPARTMENT PERSONNEL FOR INSTRUCTIONS. ANNOTATE THE FIELD LOGBOOK WITH THE SAMPLE COLLECTION ORDER IF THIS OCCURS.

(e) Collect samples sensitive to volatilization (halogenated volatile organics and volatile organics) if required.

(i) Rinse each sample vial with well water from the bailer. Position the vial under the Teflon® delivery tube at an angle that allows the water to flow down the inside of the container with a minimum of turbulence.

(ii) As the vial overflows, rotate it to an upright position, and fill until a reverse meniscus is visible.

(iii) Cap the vial and ensure the absence of headspace by inverting the vial and observing for the presence of bubbles. If headspace is detected, discard the sample and refill the vial.

(iv) Immediately store the volatile sample on ice. Store inverted in the ice chest to minimize potential loss of volatile contaminants through the container septa.

(f) Collect the remaining samples in descending order of sensitivity to volatilization. Samples other than volatiles can be collected by pouring from the bailer's pour spout directly into the sample container.

(i) Before collecting additional samples, rinse each sample container with well water unless otherwise directed in the work authorizing document.

(ii) Fill the appropriate sample container directly from the bailer's pour spout. Use care to contain all sample water that spills down the outside of the container. Minimize headspace and cap the bottle.

(g) Attach the appropriate label and custody seal, place the sample in a poly bag, and store on ice or refrigerate until delivery or shipment to the appropriate laboratory.

(h) When all samples have been collected, measure final indicator parameters using the residual water in the bailer. If the water in the bailer is insufficient for parameter collection, retrieve a final bail of well water to obtain parameters. Record the final parameters in the field logbook.

(i) Attach the bailer to the well cap assembly, and hang it inside the monitoring well.

(j) Obtain a final depth measurement and enter in the field logbook.

NOTE

VARIOUS GROUNDWATER MONITORING WELLS AT WSTF ARE DESIGNATED AS POST-CLOSURE CARE (PCC) WELLS. REPLICATE SAMPLES ARE COLLECTED FROM THESE WELLS (LISTED IN ATTACHMENT A) ON A SEMI-ANNUAL BASIS. ADDITIONALLY, TEN PCC WELLS ARE DESIGNATED AS POINTS OF COMPLIANCE AND MUST BE SAMPLED ANNUALLY FOR APPENDIX IX CONTAMINANTS. PCC AND APPENDIX IX SAMPLES ARE COLLECTED USING THE SAME PURGING AND SAMPLING PROCEDURES OUTLINED PREVIOUSLY IN THIS WJI.

c. Post-Closure Care sampling (if required)

(1) Before sampling a PCC well, determine if semi-annual replicate sampling or collection of Appendix IX samples is required. Consult the pertinent site-

specific documentation and the responsible contractor Environmental Department personnel to coordinate PCC and Appendix IX sampling events.

(2) If PCC semi-annual sampling is required, collect PCC and/or Appendix IX samples as follows.

(a) Purge the well using the appropriate system as directed in Section 9 of this WJI.

(b) Collect the first set of replicate samples using the methods previously detailed in this section. If the well is a designated point of compliance, and the annual Appendix IX samples are required, collect the Appendix IX samples as an addition to the first set of PCC replicate samples.

(c) Measure the final indicator parameters following the collection of the first set of samples. These parameters also serve as the initial parameters for the second set of replicate samples. Record the final and initial parameters in the field logbook.

(d) Remove an additional casing volume of water from the well using the appropriate purging device.

(e) Collect the second set of replicate samples using the appropriate equipment. Record all sample information in the field logbook.

(f) Repeat steps (c) through (e) for the third and fourth sets of PCC replicate samples.

(3) Ensure that purge volumes and times, initial and final indicator parameters, and all sample information for the four sets of replicate samples (and Appendix IX samples if collected) are recorded in the field logbook.

(4) Ensure that all samples have been properly preserved, labeled and sealed, and stored until delivery or shipment to the appropriate laboratory.

d. Secure the well and surrounding area and ensure that all sampling equipment is collected and loaded. Complete all necessary information in the logbook and sign and date it.

e. After each sampling event, annotate the sampling activities in WSTF Groundwater Sampling Record and QA Sheet, commonly referred to as the nucleus. An example of this sheet is provided in Attachment F of this instruction. The updated nucleus will be maintained for review in the sampling technicians' office. A hard copy of all past nucleus entries will be maintained by the sampling coordinator or other responsible contractor environmental personnel for reference by other department personnel.

f. Deliver the field logbook to the sampling coordinator to be reviewed and signed. Reviewed and signed sampling logbooks will be appropriately archived in the Department's files for future reference.

11. SAMPLE SHIPMENT INSTRUCTIONS

NOTE

BETWEEN SAMPLE COLLECTION AND SAMPLE SHIPMENT, ALL SAMPLES WILL BE REFRIGERATED AT 4°C TO MAINTAIN SAMPLE INTEGRITY. THE TEMPERATURE OF THE REFRIGERATOR SHOULD BE MONITORED AND KEPT WITHIN +/-2^{O}C OF REQUIRED TEMPERATURE. SAMPLES WILL BE SHIPPED TO THE LABORATORY FOR ANALYSIS WITHIN THE HOLDING TIMES SPECIFIED IN THE SAMPLING AND ANALYSIS PLAN.

a. Obtain appropriate shipping documents from the responsible contractor environmental department personnel. Complete the required chain of custody paperwork and WSTF shipping documents for each sample.

b. Wrap or package all samples as appropriate for sample container. Pack samples securely with ice and packing material in an adequately sized ice chest.

c. Deliver packaged samples to the site warehouse personnel or other designated shipper. Shipping personnel will accept custody of the samples by signing the chain of custody forms. Copies of the WSTF shipping document and the signed chain of custody form will be included with the sample during shipment.

d. Deliver a copy of the shipping document, chain of custody, and copy of the logbook entry for that sampling event to the sampling coordinator or other responsible contractor environmental department personnel. In order to track past sample shipments in case of lab or shipper error, these documents will be maintained for at least six months. After this period, only original documentation (no copies) will be retained. These documents may be kept as hard copies or transferred to electronic format as appropriate.

Attachment A Issued:

Attachment A
NDMA/DMN Contaminated Groundwater Assessment Wells
and Post-Closure Care Monitoring Wells

NDMA/DMN CONTAMINATED GROUNDWATER ASSESSMENT WELLS				
200-B-240	400-C-118	BLM-14-327	BLM-27-270	NASA 6
300-A-120	400-C-143	BLM-15-305	BLM-30	NASA 9
300-A-170	400-D	BLM-17-493	BW-1-268	NASA 10
300-B-166	BLM-1-435	BLM-17-550	BW-4	PL-5
300-C-128	BLM-2-482	BLM-21-400	BW-5-295	ST-1-541
300-E	BLM-2-630	BLM-23-431	BW-7-211	ST-3-586
400-A-151	BLM-9-419	BLM-26-404	NASA 5	ST-3-486

POST-CLOSURE CARE WELLS				
200-B-240	**200-G (175)**	**300-D-153**	**400-D (195)**	**NASA 7**
200-D-109	**200-H (225)**	**300-E (138)**	**600-E (280)**	NASA 8
200-D-240	300-A-120	400-C-118	NASA 5	**NASA 9**
200-F (225)	300-A-170	400-C-143	NASA 6	**NASA 10**

Note: Point of Compliance wells that require Appendix IX sampling are shown in bold type. The Appendix IX zone of each Westbay well is in parentheses.

Attachment B Issued:

Attachment B
Total Depth of Well Casing From Well Completion Diagrams

WELL ID	METERS	FEET	WELL ID	METERS	FEET
100-A-182	61.05	200.29	BLM-22-570	182.74	599.57
100-C-365	119.83	393.17	BLM-23-431	136.99	449.47
100-D-176	61.26	201.00	BLM-24-565	180.64	592.68
100-E-261	84.91	278.57	BLM-25-455	144.01	472.5
200-B-240	78.60	257.87	BLM-26-404	129.03	423.35
200-D-109	42.21	138.48	BLM-27-270	87.54	287.23
200-D-240	78.99	259.18	BW-1-268	90.34	296.39
300-A-120	46.75	153.38	BW-3-180	63.38	207.95
300-A-170	55.96	183.59	BW-5-295	95.40	312.99
300-B-166	56.14	184.18	BW-6-355	116.82	383.30
300-C-128	49.49	162.37	BW-7-211	69.16	226.9
300-D-153	55.35	181.59	JP-1-424	135.07	443.17
400-A-151	56.05	183.89	JP-2-447	141.90	465.58
400-C-118	46.02	150.98	NASA 2	36.31	119.13
400-C-143	49.28	161.68	NASA 3	43.81	143.74
600-C-173	61.41	201.47	NASA 4	52.17	171.17
600-C-210	69.80	229.29	NASA 5	41.22	135.24
600-C-437	137.92	452.50	NASA 6	46.51	152.60
700-A-253	82.80	271.68	NASA 7	61.62	202.18
700-B-510	164.24	538.87	NASA 8	60.04	196.99
700-D-186	62.21	204.10	NASA 9	47.08	154.47
700-E-458	148.39	486.87	NASA 10	40.71	133.57
700-F-455	147.24	483.10	PL-1-486	153.72	504.36
BLM-1-435	137.94	452.59	PL-2-504	159.06	521.88
BLM-2-482	152.75	501.18	PL-3-453	143.73	471.58
BLM-2-630	197.49	647.96	PL-4-464	146.99	482.28
BLM-3-182	64.40	211.28	ST-1-473	149.61	490.87
BLM-5-527	166.25	545.47	ST-1-541	170.43	559.18
BLM-6-488	154.21	505.96	ST-1-630	197.14	646.81
BLM-7-509	160.98	528.18	ST-2-466	147.48	483.89
BLM-8-418	132.94	436.18	ST-3-486	153.59	503.93
BLM-9-419	136.50	447.86	ST-3-586	183.86	603.24
BLM-10-517	162.96	534.67	ST-3-666	208.19	683.06
BLM-13-300	97.28	319.19	ST-3-735	232.40	762.52
BLM-14-327	104.99	344.48	ST-4-481	152.01	498.75
BLM-15-305	98.53	323.29	ST-4-589	184.73	606.09
BLM-17-493	158.76	520.9	ST-4-690	219.02	718.59
BLM-17-550	173.34	568.73	ST-5-481	152.06	498.91
BLM-18-430	139.76	458.56	WW-1-452	143.36	470.37
BLM-21-400	126.43	414.82			

Attachment C Issued:

Attachment C
Packer Depths and Recommended Inflation Pressures

Packer Depths to the Bottom of the Packers

WELL I.D.	PACKER DEPTH (M)	TOTAL WELL DEPTH (M)
100-E-261	79.85	84.91
200-B-240	73.45	78.60
200-D-240	71.93	78.99
300-A-170	50.95	55.96
700-A-253	76.50	82.80
BLM-1-435	132.27	137.94
BW-5-295	90.22	95.40

Recommended Packer Inflation Pressures

PACKER SUBMERGENCE (METERS)	INFLATION PRESSURE (kPa/psi)
6	345/50
12	415/60
18	485/70
24	550/80
30	620/90
80	825/120

Attachment D Issued:

Attachment D
New and Modified Conventional Monitoring Wells

Well ID	Frequency	Contractor Approval	NASA Approval	Initial Sampling Date

Attachment E Issued:

Attachment E
Parameter Collection Schedules for New and Modified Conventional Monitoring Wells

Well ID	HVOA (8021)	VOA (8260)	NDMA (607)	As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Contractor Approval	NASA Approval

X – Indicates that samples are collected at each regularly scheduled sampling event.
Y – Indicates that samples are collected yearly.

Attachment F Issued:

Attachment F
WSTF Groundwater Sampling Record an QA Sheet

Well ID	Date Sampled	Logbook #	HVOA (8021)	VOA (8260)	NDMA (607)	RCRA Metals	Samplers' Initials	Sample Comments / QA Collected

– Indicates sample was collected.
* Indicates duplicate samples collected.
MS Indicates matrix spike samples collected.
NA Indicates no samples collected.

Attachment E

NASA White Sands Test Facility Job Instruction

Low-Flow Sampling Instructions

White Sands Test Facility
Job Instruction
(Draft – Revision)

Issued:
Expires: NA

WJI ENV-0053.B

LOW-FLOW SAMPLING INSTRUCTIONS

Work Authorizing Document: Environmental Department Task Memo

Prepared By: _____
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Lynx, Ltd.

Reviewed By: _____
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R. L. Spencer
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P. H. Pache
Environmental Department Manager
Lynx, Ltd.

Approved By: _____
R. Bunker-Farrah
Environmental Program Manager
NASA

Record of Revisions

Issue	Issue Date	Page(s) Affected	Description of Changes
B		All	General update

Permanent Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

Temporary Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

1. PURPOSE

This WJI provides specific instructions for sampling WSTF's conventionally installed groundwater monitoring wells equipped with dedicated low flow sampling equipment. This instruction was developed using Environmental Protection Agency (EPA) and New Mexico Environment Department (NMED) guidelines (References a, b, c, d, and e) and is used in conjunction with the most current versions of the WSTF Groundwater Sampling and Analysis Plan and the WSTF Quality Assurance Project Plan.

2. REFERENCES

a. Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods, U.S. Environmental Protection Agency, SW-846, Third Edition, June 1997.

b. RCRA Ground Water Monitoring Technical Enforcement Guidance Document, U.S. Environmental Protection Agency, OSWER-9950.1, Latest Edition.

c. RCRA Ground-Water Monitoring: Draft Technical Guidance, U.S. Environmental Protection Agency, November 1992.

d. Low Stress (low flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells, U.S. Environmental Protection Agency, SOP#: GW 0001, Revision 2, July 1996.

e. "Use of Low-Flow and Other Non-Traditional Sampling Techniques for RCRA Compliant Groundwater Monitoring," Position Paper, Hazardous Waste Bureau, New Mexico Environment Department, October 30, 2001.

f. Groundwater Sampling and Analysis Plan, NASA WSTF, May 1998.

g. Quality Assurance Project Plan, NASA WSTF, May 1998.

h. MicroPurge® Flow Cell Model FC4000 User Guide.

i. Well Wizard Sampling System Operation and Maintenance Manuals.

j. Operation and Maintenance Manual for Specific Turbidity Meter in Use.

k. American National Standards Institute (ANSI) Z41 PT91 (Protective Footwear), ANSI Z87.1 (Eye and Face Protection), ANSI Z358.1 (Eyewash Units), most recent versions.

l. OSHA Standard 29 CFR, Part 1910 Subpart I 1910.132 – General Requirements.

m. WJI ENV-0015, "Portable Liquid Nitrogen Dewar Operation."

n. WSI 25-SW-007, "Personal Protective Equipment."

o. WSI 25-SW-0023, “Minimum Access Requirements for 300, 400, and 500 Propulsion Test Areas.”

p. WSI 25-SW-0024, “Lightning Protection.”

q. JHA HW-005, “Conventional Well Sampling.”

3. ATTACHMENTS

a. Attachment A – NDMA/DMN Contaminated Groundwater Wells

b. Attachment B – Flow Cell Probe Use, Calibration, and Maintenance Guidelines and Instructions

c. Attachment C – Dedicated Low-Flow Bladder Pump Intake Locations and Minimum Purge Volumes

d. Attachment D – New and Modified Low Flow Monitoring Wells

e. Attachment E – WSTF Groundwater Sampling Record and QA Sheet

4. HEALTH AND SAFETY REQUIREMENTS

NOTE

A SAFETY HAZARD ASSESSMENT FOR THIS WJI HAS BEEN PERFORMED IN ACCORDANCE WITH 29 CFR 1910.132, SUBPART I. THE CERTIFICATION OF HAZARD ASSESSMENT AS REQUIRED BY WSI 25-SW-0007 IS CONTAINED IN THE JOB HAZARD ANALYSIS MONITORING WELL DEPTH MEASUREMENT (JHA HW-005). THE AUTHORIZED SIGNATURES OF INDIVIDUALS REVIEWING AND APPROVING THIS WJI INDICATE THEIR CONCURRENCE WITH THIS ASSESSMENT AND THE SAFETY REQUIREMENTS PRESCRIBED IN THIS DOCUMENT AND THE ASSOCIATED JHA.

THE FOLLOWING HEALTH AND SAFETY REQUIREMENTS SUPPLEMENT THOSE SET FORTH IN THE JHA FOR PERSONAL PROTECTIVE EQUIPMENT (PPE) AND/OR PROVIDE ADDITIONAL INFORMATION FOR HAZARDS ASSOCIATED WITH CONVENTIONAL WELL SAMPLING ACTIVITIES AT WSTF.

a. All groundwater sampling personnel will be certified as Hazardous Waste Handlers prior to engaging in sampling activities. Personnel must also be familiar with WPD 22-03 (Safety), Material Safety Data Sheets (MSDSs) regarding chemicals potentially used and any other pertinent documentation regarding the use of equipment and materials used in the field.

b. Due to the remoteness of most of WSTF's monitoring wells, the following safety requirements must be observed.

(1) Every sampling crew will consist of two sampling personnel.

(2) Each sampling crew will carry a two-way radio.

(3) In the event of minor cuts, scrapes, and abrasions, first aid will be administered in the field. In the event of any more serious, non-first aid injury, sampling activities will be immediately suspended and the WSTF Fire Department will be notified for assistance.

c. The following safety requirements apply to the protective equipment to be utilized by sampling personnel while performing sampling activities.

(1) Monitoring well chemical data indicate that specific wells are contaminated with trace amounts of hazardous compounds. Therefore, handle all purged well water with extreme care. At no time during sampling operations should samples, purged waters, or contaminated equipment come in contact with personnel skin, eyes or clothing. At all times during sample collection, Nytek gloves will be worn, both to protect sampling personnel and preserve the integrity of the sample.

(2) Because there is no allowable exposure criteria for N-nitrosodimethylamine (NDMA) and N-nitrodimethylamine (DMN), safety goggles that meet the requirements of the most recent version of ANSI Z87.1 will be worn when handling NDMA/DMN contaminated groundwater. Refer to Attachment A for a list of the groundwater assessment wells with known concentrations of NDMA/DMN. Goggles will be worn at these wells during parameter collection, sample collection and while handling any sampling equipment that has come in contact with contaminated water.

(3) During the months of March through September, ambient temperatures at WSTF frequently exceed 90°F. This extreme environment creates the potential for heat stress and overexposure to ultraviolet (UV) radiation. Field personnel shall be familiar with heat stress prevention procedures and will implement them when required by elevated temperatures. Additionally, to protect exposure to UV radiation, sunscreen with a protection factor of at least 30 shall be worn while working in direct, intense sunlight. Umbrellas will be used when working conditions permit.

(4) All sampling personnel will wear protective footwear that meets the requirements of the most recent version of ANSI Z41 (MT I/75 C/75) while working in the field to prevent injuries from dropping gas cylinders or other heavy equipment.

(5) To prevent possible hand injuries, sampling personnel will wear work gloves when necessary during work activities that do not require the use of Nytek gloves.

d. For groundwater samples that require preservation by acids or bases, the following additional safety precautions are required.

(1) Sampling personnel will wear Nytek (or equivalent) gloves, a chemical resistant apron, and safety goggles and face shield that meet the requirements of the most current version of ANSI Z87.1 while preserving samples with corrosive agents.

(2) A personal eyewash unit conforming to the most recent version of ANSI Z358.1 will be available at the well site during sample preservation. Personal eyewash units will be stored and maintained as directed in the manufacturer's instructions. During extremely hot or cold weather, personal eyewash units will be stored to ensure proper fluid delivery temperature as specified in the most current version of ANSI Z358.1.

(3) If a corrosive agent comes into direct contact with personnel skin or eyes, sampling activities will be suspended and affected personnel will immediately flush the affected area for 15 minutes and notify the WSTF Fire Department.

e. The following safety requirements apply to the use of steam cleaners for decontamination of sampling equipment.

(1) Prior to operating steam cleaners, sampling personnel will become familiar with operational and safety requirements specified by the manufacturer's operation and maintenance manual.

(2) Propane tanks will be secured to the steam cleaner while in use.

(3) Sampling personnel will wear Nytek (or equivalent) gloves and safety goggles and face shield that meet the requirements of the most current version of ANSI Z87.1 while decontaminating sampling equipment.

(4) To avoid contact with possible residual contaminants, personnel will first thoroughly decontaminate sampling equipment from a minimum distance of six feet. After initial decontamination, personnel may move closer to complete the decontamination. Smaller items that must be held should be kept at arm's length during initial contamination.

f. The following safety requirements apply to the use of liquid nitrogen (LN_2) dewars and high-pressure K-bottles as pressure sources.

(1) LN_2 dewars will only be loaded/unloaded on vehicles and trailers using lift gates or other lifting devices that are rated for at least 1000 lbs. lift capacity.

(2) Sampling personnel utilizing a portable LN_2 dewar as a pressure source will follow the operational procedures and safety precautions prescribed in WJI ENV-0015.

(3) Nitrogen K-bottles will only be loaded/unloaded by two sampling personnel. All personnel will wear safety footwear as prescribed above.

(4) When removed from sampling vehicles for field use, all K-bottles will be secured to prevent tipovers.

(5) All dewars and K-bottles will be secured during transportation and storage.

g. Various species of wildlife at WSTF (including snakes, insects, and rodents) can often be found near monitoring wells. Caution will be used to avoid contact with potentially dangerous wildlife at all times while in the field. If any potential natural dangers are detected, contact the responsible contractor environmental department personnel for further instructions.

i. During certain times of the year, thunderstorms can pose an electrical hazard. As instructed in WSI 25-SW-0024.A, field sampling activities will be suspended when lightning is detected within three miles of the well site (15 seconds from flash to thunder). Personnel will seek shelter when operations are suspended and contact the responsible contractor Environmental Department personnel for further instructions.

j. Operations at wells within the 300 and 400 Areas require that personnel coordinate their entry into those areas with the appropriate Blockhouse Monitor. WSI 25-SW-0023 specifies that all personnel not permanently assigned to these areas inquire at the Blockhouse and sign in/out prior to entry into and exit from these areas.

5. SUPPORT REQUIREMENTS

a. Equipment

(1) Dedicated Sampling Equipment

(a) Well Wizard bladder pump with Teflon® bladder

(b) Pump supply and Teflon®-lined sample tubing (inside diameter will not exceed 3/8”)

(2) QED Model FC4000 Flow Cell and water analyzer and accessories

(3) Replacement tubing for sample discharge into containers

(4) Nitrogen K-bottles or portable LN_2 dewar

(5) Controller box with pressure accessories

(6) Portable purge water collection container(s)

(7) Depth probe

(8) Field logbook to record all field activities

(9) Portable indicator parameter meter(s)

(10) Five gallon bucket for sample collection

(11) Graduated beaker for indicator parameter collection

(12) Goggles, apron, and Nytek sampling gloves

(13) Poly baggies (small and large) for sample storage

(14) Sample bottles (glass and polyethylene as required for each sampling event)

(15) Ice chests and ice for sample storage

(16) Steam cleaning system for equipment decontamination

b. Reagents/Chemicals

WARNING

ALL CONCENTRATED ACIDS AND BASES ARE STORED IN THE CORROSIVES STORAGE CABINET WHEN NOT IN USE. ALL PROPANE TANKS NOT ATTACHED TO THE STEAM CLEANER SYSTEM WILL BE STORED OUTSIDE IN THE CYLINDER STORAGE RACKS.

(1) Reagent grade (blank) water

(2) Concentrated nitric, sulfuric, and hydrochloric acids, sodium hydroxide, zinc acetate, and other appropriate sample preservatives as required

(3) Standards for meter calibration (pH buffers, conductivity, and turbidity)

(4) Propane (steam cleaner fuel)

6. SPECIAL REQUIREMENTS

a. To eliminate potential contamination of the sampling equipment and sample containers, gasoline-powered equipment (generators) and gasoline containers must be transported to the field on trailers or in vehicles that do not contain sampling equipment. Additionally, gas-operated equipment, if used, must be located downwind of sampling activities at a distance of at least 25 feet.

b. Only sample containers that have been cleaned to the levels appropriate for sample collection can be used. If the integrity of any sample container is questionable, it will be discarded.

c. Environmental Considerations

(1) Historical analytical data indicate that specific wells at WSTF are contaminated with trace amounts of hazardous compounds. Therefore, all groundwater brought to the surface should be handled with extreme care to avoid discharge to the environment. All handling of groundwater should be performed over the concrete well pad or over the appropriate purge water collection container to ensure all purge water is contained appropriately. If an accidental release occurs, the contractor Environmental Department supervisor or other responsible personnel should be contacted to determine the appropriate course of action.

(2) If gas-powered equipment is fueled in the field, special care will be taken to avoid spilling gasoline. Any spilled gasoline or oil, along with any potentially contaminated soil, will be immediately removed from the site and transported to the appropriate location for storage and/or disposal.

(3) Ensure that all motor vehicle use is restricted to maintained roads, well pads, and other service areas. In the event that these areas become impassable or require maintenance, contact the responsible contractor Environmental Department personnel to arrange for the required corrective action.

7. DECONTAMINATION INSTRUCTIONS

WARNING

DECONTAMINATION PROCEDURES ARE PERFORMED BY TRAINED PERSONNEL WEARING THE PROPER PROTECTIVE CLOTHING. ALL SAFETY REQUIREMENTS PREVIOUSLY LISTED FOR DECONTAMINATION PROCEDURES WILL BE FOLLOWED.

a. General

(1) Steam cleaners will be operated in accordance with the appropriate manufacturer’s operating manual. Required safety precautions previously listed will be adhered to during decontamination operations.

(2) Non-dedicated well sampling equipment (pumps, bailer tips, depth probes, etc.) require decontamination before each use.

(3) Decontamination procedures include steam cleaning and/or rinsing with deionized water. Previous tests indicate this method yields sampling equipment free of contaminants that interfere with WSTF's analyses.

(4) Decontaminated items are protected from contamination by covering them with poly sheets or placing them in plastic baggies.

(5) Field logbooks will be annotated at each sampling event to reflect the method of decontamination used for sampling equipment.

b. Equipment Decontamination

NOTE

ALL NEW OR PREVIOUSLY USED DOWN-HOLE EQUIPMENT MUST BE DECONTAMINATED PRIOR TO USE OR INSTALLATION IN WSTF MONITORING WELLS. ANY EQUIPMENT REMOVED FROM A WSTF MONITORING WELL WILL BE DECONTAMINATED BY STEAM CLEANING PRIOR TO DISPOSAL OR REUSE AT ANOTHER LOCATION.

(1) Flow Cell

(a) Disassemble the flow cell and triple rinse each piece with DI water.

(b) Inspect the system for loose probes, fittings, and problems with the tubing. Repair or replace parts as required.

(c) At least once per week during regular use, or prior to use after probe storage of more than two weeks, completely disassemble the flow cell and wash all parts in a tap water/mild detergent solution. Rinse the pieces in DI water and dry thoroughly.

(d) Store the flow cell and accessories in the provided hard case. For temporary storage, store the flow cell with the sonde, or probe body, installed and approximately 1/8” of tap water in the flow cell.

(2) Miscellaneous Equipment

(a) Transfer equipment to be decontaminated to the steam cleaning pad.

(b) Disassemble equipment, if possible, and steam clean each piece.

(c) Cover equipment with poly sheets or place in plastic baggies.

(d) If the equipment cannot be steam cleaned, triple rinse with DI water and store in poly wrap or plastic baggies.

8. CALIBRATION OF FIELD INSTRUMENTS

NOTE

UNLESS OTHERWISE STATED, CALIBRATION ACTIVITIES AND RELATED INFORMATION WILL BE RECORDED IN A SEPARATE "CALIBRATION LOGBOOK" TO BE MAINTAINED BY FIELD PERSONNEL AND STORED APPROPRIATELY IN THE GROUNDWATER OPERATIONS BUILDING. ALL FIELD INSTRUMENTS WILL BE LABELED WITH THE MOST APPLICABLE WSTF CALIBRATION DECAL.

a. Flow cell and water analyzer meter

NOTE

REFER TO THE MICROPURGE® FLOW CELL USER GUIDE FOR SPECIFIC INSTRUCTIONS AND INFORMATION REGARDING THE USE AND CALIBRATION OF THE FLOW CELL AND WATER ANALYZER. REFER TO ATTACHMENT B OF THIS DOCUMENT FOR STORAGE AND MAINTENANCE INSTRUCTIONS FOR THE SENSORS IN THE SONDE.

THE SENSORS IN THE SONDE SHALL BE CALIBRATED IN ACCORDANCE WITH THE INTERVALS OUTLINED IN ATTACHMENT B OF THIS INSTRUCTION. ALL CALIBRATION ACTIVITIES WILL BE RECORDED DAILY IN THE SAMPLING FIELD LOGBOOK.

(1) Calibrate the conductivity sensor.

NOTE

THE FOLLOWING STEPS WILL CALIBRATE THE SENSOR FOR CONDUCTIVITY, SPECIFIC CONDUCTIVITY, SALINITY, AND TOTAL DISSOLVED SOLIDS.

(a) Remove the sonde guard and inspect the sensors to be certain there are no salt deposits around the DO and pH/ORP probes. Refer to the flow cell manual for cleaning instructions if deposits are present. Replace the sonde guard after the sensor cleanliness has been confirmed.

(b) Place approximately 300 mL of 1413 µS/cm conductivity standard in a clean, dry container in which the sonde can be fully immersed.

(c) Insure the sensor is as dry as possible, then rinse the sensor with a small amount of the conductivity standard. Discard the standard used to rinse the sensor.

(d) Carefully immerse the probe end of the sonde in the conductivity solution past the vent hole on the side of the conductivity sensor.

(e) Gently rotate and/or move the sonde up and down to dislodge any bubbles that may be attached to the sensor. Allow at least one minute for the temperature reading to equilibrate.

(f) From the *Calibration Mode* menu, select *Conductivity* and then *SpCond* to access the specific conductivity calibration procedure.

NOTE

THE CALIBRATION VALUE OF THE CONDUCTIVITY STANDARD MUST BE ENTERED IN mS/cm, NOT µS/cm.

(g) Enter the calibration value of the conductivity standard and press <*Enter*>.

(h) Observe the readings for specific conductivity (SpC), conductivity (CND), and temperature (TMP) as they stabilize. When all three readings show no significant change (±5%) for at least 30 seconds, press <*Enter*> to calibrate the sensor.

(i) If the display indicates that the calibration has been accepted, press any key to return to the *Calibration Mode* menu. Rinse the sonde in tap water and dry it with a clean soft cloth.

(2) Calibrate the pH sensor

(a) Clean and dry the container used for calibrating the conductivity sensor. Place enough pH 7 buffer in the container to immerse the pH and temperature sensors.

(b) Rinse the sonde with a small amount of pH 7 buffer to remove excess tap water. Discard the buffer used to rinse.

(c) Carefully immerse the probe end of the sonde in the buffer and allow at least one minute for the temperature to equilibrate.

(d) From the *Calibration Mode* menu select *ISE1 pH* to access the pH calibration options. Select *2 point* and enter input the pH value of the buffer (in this case 7) at the prompt and press <*Enter*>.

(e) Observe the readings for pH and temperature (TMP) until they stabilize within ±5%. When the readings show no significant change for at least 30 seconds, press <*Enter*>.

(f) When the display indicates that the calibration was accepted, press any key to continue. The display will show the calibrated reading for the pH 7 buffer. Press <*Enter*> again to continue the pH calibration.

(g) Rinse the sonde in deionized water and dry with a soft clean cloth. Clean and dry the calibration container.

NOTE

THE PROBE SHOULD BE INITIALLY CALIBRATED WITH pH 10 BUFFER, BUT pH 4 BUFFER SHOULD BE AVAILABLE IN THE FIELD. IF THE INITIAL pH OF THE SAMPLE IS LESS THAN 7, THE PROBE SHOULD BE RECALIBRATED WITH pH 7 AND 4 BUFFERS PRIOR TO MEASURING THE pH OF THE SAMPLE.

(h) Rinse the sonde with a small amount of pH 10 buffer (pH 4 if used to calibrate) to remove excess tap water. Discard the buffer.

(i) Place enough pH 10 buffer in the container to immerse the pH and temperature sensors and carefully immerse the probe end of the sonde.

(j) Allow at least a minute for the temperature to equilibrate, then input the value of the second buffer at the prompt. Press <*Enter*>.

(k) Observe the readings for pH and temperature (TMP) until they stabilize. When the readings show no significant change (±5%) for at least 30 seconds, press <*Enter*>.

(l) When the display indicates that the second calibration has been accepted, press any key to continue. The calibrated reading for the second pH buffer will be displayed.

(m) Press <*Esc*> to return to the *Calibration Mode* menu. Then rinse the sonde in tap water and dry it with a clean soft cloth.

(3) Calibrate the dissolved oxygen (DO) sensor

(a) Place approximately 1/8” of tap water in the bottom of the flow cell.

(b) Insert the probe end of the sonde into the flow cell, but do not thread the sonde into flow cell. Ensure that the DO and temperature probes are not immersed in the water and that the flow cell is vented to the atmosphere.

(c) Allow 15 minutes for the air in the flow cell to become saturated and for the temperature of the thermistor and oxygen probe to equilibrate. Obtain the barometric pressure from the electronic barometer in the Building 638 or from a sampling crew using a Westbay sampling system. To obtain barometric pressure in mm of Hg, multiply inches of

Hg (from barometer) by 25.4 or pounds per square inch (psi, from the Westbay probe) by 51.71.

(d) From the *Calibration Mode* menu, select *Dissolved Oxygen* and then *DO%* to begin the DO calibration sequence. At the prompt, enter the current barometric pressure in mm of Hg, then press <*Enter*>.

(e) Observe the readings for percent dissolved oxygen (DO%) and temperature (TMP). When the readings show no significant change for 30 seconds, press <*Enter*>.

NOTE

IF THE DO SENSOR WILL NOT CALIBRATE, THE TEFLON® MEMBRANE MAY NEED REPLACEMENT. REFER TO ATTACHMENT B AND THE FLOW CELL USER GUIDE FOR APPROPRIATE MAINTENANCE INSTRUCTIONS.

(f) If the display indicates that the calibration has been accepted, press any key to return to the data display. Then press <*Esc*> twice to return to the *Main* menu. The sonde is now ready for use.

b. Turbidity Meter Calibration and Use

NOTE

BECAUSE WSTF MAY USE VARIOUS TURBIDITY METERS, SAMPLING PERSONNEL MUST UTILIZE THE APPROPRIATE MANUFACTURER'S OPERATIONS MANUAL TO ENSURE THAT METERS ARE MAINTAINED, CALIBRATED, STORED, AND USED IN A MANNER THAT ENSURES RELIABLE COLLECTION OF ACCURATE MEASUREMENTS.

(1) Ensure the turbidity meter is calibrated at least monthly according to the manufacturer's specifications prior to measurement activities. These periodic calibration values, in addition to all pertinent information regarding the calibration activity, should be recorded in the calibration logbook.

(2) Verify meter calibration in the field immediately prior to sample turbidity measurement by using the secondary formazin gel standard prepared by the manufacturer. This standard will carried with the turbidity meter to all field sampling events. The meter reading should be within ±5% of the secondary standard.

(3) Obtain an aliquot of sample water in the glass measurement cell. Dry the outside of the cell thoroughly, place it in the meter, and close the lid.

(4) Turn the meter on, initiate the measurement cycle, and wait for the digital turbidity reading to equilibrate. Record the turbidity measurement in the field logbook. Do not store the glass turbidity cells in the measurement compartment of the meter. Scratches on the cells could distort turbidity measurements. If visible scratches are detected on a turbidity cell, discard the measurement cell and replace it.

9. PREPARING THE FLOW CELL AND METER FOR FIELD USE

a. Charge the batteries

CAUTION

DO NOT CHARGE THE INTERNAL NICKEL METAL HYDRIDE (NiMH) BATTERY PACK FOR MORE THAN 48 HOURS. DO NOT CHARGE THE INTERNAL BATTERY PACK IF THE TEMPERATURE EXCEEDS 120°F. SEVERE DAMAGE TO THE BATTERY PACK OR METER COULD RESULT IF THESE GUIDELINES ARE NOT FOLLOWED.

(1) Within one day prior to use, the internal NiMH battery pack should be fully charged using the supplied wall-mount adapter.

(2) Ensure that the 8 D-cell batteries in the auxiliary battery pack are fresh and have adequate charge to operate the meter for several hours.

NOTE

THE FOLLOWING STEPS ARE BEST PERFORMED BEFORE TRANSPORTING THE EQUIPMENT TO THE SAMPLING LOCATION.

b. Prepare the sonde for use as follows.

(1) Ensure that the required probes are installed in the sonde.

(2) Inspect the probes for damage or fouling. Perform maintenance as necessary as described in Attachment B of this instruction or the flow cell user guide.

(3) Inspect the DO membrane and solution. Replace if necessary using the instructions provided in Attachment B of this document.

c. Configure meter and calibrate sensors.

(1) Power up the meter and select the *Setup Meter* menu.

(2) Use the *Setup Sensors* menu to enable all required sensors and the *Setup Parameters* menu to specify the reported parameters.

(3) Calibrate the sensors as instructed in Section 8 of this instruction and install the sonde in the flow cell with approximately 1/4" of tap water to keep the probes moist during transport to the sampling site.

d. Obtain all required equipment and proceed to the well site.

10. PURGING AND SAMPLING THE WELL

CAUTION

BEFORE PERFORMING ANY PURGING OR SAMPLING ACTIVITIES, THE WELL HEAD, WELL PAD, AND AREA AROUND THE WELL HEAD SHOULD BE INSPECTED FOR SNAKES, RODENTS, INSECTS, OR OTHER POTENTIAL NATURAL DANGERS. IF ANY OF THESE ARE OBSERVED, CONTACT THE SAMPLING COORDINATOR OR SUPERVISOR FOR INSTRUCTIONS.

a. General

(1) Prior to each sampling event, refer to the appropriate site specific documentation to ensure the required Quality Assurance samples (duplicates, matrix spikes, blanks, and blind controls) are collected at the frequencies required by the most recently approved Sampling and Analysis Plan and Quality Assurance Project Plan.

(2) Contact the contractor environmental department Sampling Coordinator or designee for a list of the samples to be collected at each well. Obtain the proper sample containers for each type of sample to be collected. Refer to most recently approved QAPP for specific information regarding sample container and sample preservation.

NOTE

INSPECT EACH SAMPLE CONTAINER USED IN THE FIELD FOR VISUAL CONTAMINATION. IF CONTAMINATION IS DETECTED, DISCARD THE CONTAINER. TO PREVENT VOLATILIZATION OF SAMPLES, STORE ALL SAMPLE CONTAINERS ON ICE UNTIL TIME OF SAMPLING. ALL SAMPLES THAT REQUIRE PRESERVATION ARE PRESERVED IN THE FIELD AT THE TIME OF COLLECTION.

(3) Prior to sampling, ensure that all non-dedicated sampling equipment has been decontaminated using the steam cleaner and/or DI water and properly stored for transport to the field as previously instructed in Section 7.

NOTE

THE FIELD SAMPLING LOGBOOK IS A CRITICAL PART OF EVERY SAMPLING EVENT. FIELD LOGBOOKS ARE CONSIDERED LEGAL

DOCUMENTS AND METICULOUS ATTENTION TO DETAIL IS REQUIRED.

(4) Immediately after arriving at the well site, the logbook will be annotated with all pertinent information including date, time, location, weather conditions, sampler identification, equipment used and confirmation of decontamination and calibration, indicator parameters, sample information, and any other useful or unusual information concerning the sampling event. The logbook will provide a complete enough record of the entire sampling procedure that a person not associated with the sampling event can recreate the day's procedures from the logbook entries.

(5) Measure the Static Water Depth

(a) Carefully unlock and remove the protective cap from the well.

(b) Insert the stainless steel static water level probe through the measurement hole in the well cap and slowly lower the probe down the well casing. When the probe contacts water, raise and lower the probe until a water level to the nearest 0.01 meter is obtained from the well cap. Record the value in the field logbook.

(c) Raise the probe a few inches out of the water and allow it to hang in the casing for future water level monitoring.

b. Assemble Low Flow Sampling Equipment

(1) Connect a pressure regulator to a nitrogen K-bottle or a portable dewar and ensure the output side of the regulator is backed off completely. If a portable LN_2 dewar is used for a pressure source, refer to WJI ENV-0015 for proper operating instructions.

NOTE

IF THE PUMP DEPTH IS GREATER THAN 200 FEET, A HIGH PRESSURE CONTROL BOX (MODEL 3013UH) IS REQUIRED FOR PROPER LOW-FLOW PURGING AND SAMPLING.

(2) Connect the pressure hose from the regulator to the pump supply inlet fitting on the Well Wizard control box.

(3) Connect a pressure hose from the control box pump supply fitting to the gas inlet fitting on the well cap.

(4) Using the appropriate adapter from the flow cell connector kit, connect the Teflon® delivery tube to the pump discharge tubing at the well cap. Connect the other end of the delivery tube to the inlet on the flow cell.

(5) Connect a Teflon® discharge tube to the outlet on the flow cell and place the other end of the tube in a purge water collection vessel.

c. Purge the Well Using Low Flow Methods

NOTE

IN ACCORDANCE WITH REGULATORY GUIDANCE, DEDICATED LOW-FLOW BLADDER PUMPS ARE INSTALLED SO THAT PUMP INTAKES ARE LOCATED APPROPRIATELY. TYPICALLY, THE PUMP INTAKE IS LOCATED AT OR SLIGHTLY ABOVE THE MIDDLE OF THE SCREENED INTERVAL, UNLESS PREVIOUS VERTICAL PROFILING (IF REQUIRED) INDICATED AN ALTERNATE PUMP LOCATION.

(1) Refer to Attachment C to determine the pump location within the well.

(2) Turn the refill and discharge timer knobs to approximately the middle of the cycle (represented by the letter C on the knob). Turn the flow throttle control knob completely clockwise to maximize the pumping pressure.

(3) Slowly open the main valve on the K-bottle or the gas use valve if using the LN_2 dewar. Slowly increase the output setting on the regulator to the appropriate pressure as determined by pump depth (in Attachment C). The control box should begin to cycle the pump.

(4) Optimize the Well Wizard purging cycle.

(a) With the refill and discharge timers set on C (pumps deeper than 200 feet should be started at D), measure the water volume discharged in a single cycle. This volume should be 350-450 milliliters. Certain pumps may discharge slightly more than this estimated maximum.

(b) If the control box switches to refill before the discharge of water is complete, lengthen the discharge cycle. Adjust the discharge cycle until the end of the cycle coincides with the end of water flow from the discharge tubing.

(c) Adjust the refill timer (lengthen if the volume is less than 350 mL, shorten if the maximum volume is attained) until the maximum amount of water is purged in the shortest refill cycle.

(5) Monitor the depth to water during well purging operations. Measure the depth to water every two to three pump cycles. If the static water level begins to drop, adjust the purging cycle (by lengthening the refill or lowering the pump pressure) so that the water level is maintained within 10 cm of the initial depth to water. If the static water level drops more than 10 cm during purging

operations, an additional volume equal to the amount of water removed must be purged from the well.

d. Monitor indicator parameters until they stabilize.

(1) Ensure that the sonde is properly installed in the flow cell and that the flow cell is positioned such that any potential air bubbles can escape upwards without contacting the probes. If necessary, remove the flow cell from its box to ensure that water does not come into contact with the water analyzer.

(2) Power up the water analyzer as indicated previously and enter through the on-screen menus until the meter is in *Run Mode*.

(3) Allow the bladder pump to cycle several times so the probes will equilibrate. Then note the initial readings on the meter.

(4) Approximately every five minutes, at the end of the discharge cycle, record the indicator parameter readings from the water analyzer meter.

(5) Record indicator parameters until three consecutive readings (at the specified five minute intervals) are within the following limits.

(a) Turbidity: ±10% for values greater than 1 NTU

(b) DO: ±10%

(c) specific conductance or conductivity: ±10%

(d) temperature: ±10%

(e) pH: ± 0.5 unit

(f) ORP/Eh: ± 10%

NOTE

IF PARAMETERS DO NOT STABILIZE OR TURBIDITY VALUES EXCEED 5 NTUs, CONTINUE LOW-FLOW PURGING UNTIL THE CRITERIA ARE MET. CLOSELY MONITOR THE WATER LEVEL TO ENSURE MINIMAL DRAWDOWN; IF IT DROPS MORE THAN 10 CM, AN ADDITIONAL VOLUME OF WATER EQUAL TO THE DRAWDOWN MUST BE PURGED (DRAWDOWN (m) X 7.54 = ADD'L VOLUME (gal)). CONTACT THE RESPONSIBLE CONTRACTOR ENVIRONMENTAL DEPARTMENT PERSONNEL IF THE CRITERIA ARE NOT MET WITH OVERPURGING OR IF DRAWDOWN DOES NOT STABILIZE.

(6) When three consecutive readings are within these limits, purging is complete. Record the three sets of parameter readings in the field logbook as initial parameters. Collect water to measure the turbidity for the third set of parameters after disconnecting the flow cell from the discharge tubing.

e. Collect the required samples using low flow methods.

(1) Using the flow throttle knob, reduce the pump flow rate to 100 mL/min or less. The refill cycle may also need to be lengthened to meet this requirement.

(2) Disconnect the sample discharge tubing from the well cap and attach a new section of Teflon® tubing to the discharge fitting on the cap. Samples will be collected directly from the new section of Teflon®discharge tube that is attached to the well cap.

NOTE

TO PRESERVE SAMPLE INTEGRITY, IT IS CRITICAL THAT THE DISCHARGE TUBING REMAIN FULL OF GROUNDWATER DURING SAMPLE COLLECTION. IF NECESSARY, A TUBING CLAMP CAN BE USED TO INSURE THE MINIMIZATION OF AIR BUBBLES IN THE SAMPLE DISCHARGE TUBING AND FACILITATE SAMPLE COLLECTION.

(3) Collect samples sensitive to volatilization (halogenated volatile organics and volatile organics) if required.

(a) Rinse each sample vial with well water. Position the vial under the discharge tube at an angle that allows the water to flow down the inside of the container with a minimum of turbulence.

(b) As the vial overflows, rotate it to an upright position, and fill until a reverse meniscus is visible.

(c) Cap the vial and ensure the absence of headspace by inverting the vial and observing for the presence of bubbles. If headspace is detected, discard the sample and refill the vial.

(d) Immediately store the volatile sample on ice. They are stored inverted in the ice chest to minimize potential loss of volatile contaminants through the container septa.

(4) Collect the remaining samples in descending order of sensitivity to volatilization.

NOTE

TYPICALLY, SAMPLES FOR NDMA/DMN ANALYSIS ARE COLLECTED AFTER VOLATILE SAMPLES. IN WELLS WITH ELEVATED TURBIDITY, THOUGH, RCRA METALS SAMPLES ARE COLLECTED PRIOR TO NDMA SAMPLES TO AVOID TURBIDITY INTERFERENCE WITH METALS ANALYSIS. IN SUCH CASES, ANNOTATE THE FIELD LOGBOOK ACCORDINGLY.

EPA METHOD 607 FOR NDMA REQUIRES THE SAMPLE TO BE PRESERVED WITH SODIUM THIOSULFATE IF RESIDUAL CHLORINE IS PRESENT IN THE SAMPLE WATER. HOWEVER, PREVIOUS SAMPLING EVENTS HAVE INDICATED THAT NO RESIDUAL CHLORINE IS PRESENT IN WSTF GROUNDWATER, MAKING SAMPLE PRESERVATION UNNECESSARY.

(a) Before collecting additional samples, rinse each sample container with well water unless otherwise directed in the work authorizing document.

(b) Fill the appropriate sample container from the discharge tube. Use care not to submerge the tube in the sample water in the container. Minimize headspace and cap the bottle.

(5) Immediately after taking each sample, prepare a label and chain of custody seal with a sample number representing the year, month, day, and time it was collected (i.e. 9302140815 indicates a sample collected on February 14, 1993 at 8:15 am).

NOTE

RCRA METAL ANALYSIS REQUIRES PRESERVATION WITH NITRIC ACID TO A PH LESS THAN 2. PREVIOUS SAMPLING EVENTS HAVE DEMONSTRATED THAT THIS CAN BE ACCOMPLISHED WITH A 2 ML AMPULE OF NITRIC ACID. CHECKING THE PH OF THE SAMPLE WATER AFTER PRESERVATION IS NOT NECESSARY, AS SAMPLE INTEGRITY CAN BE COMPROMISED BY INSERTING THE PH PROBE.

(6) Preserve the sample as indicated in the WSTF QAPP or the work authorizing document, attach a completed label and chain of custody seal, place in a poly bag, and store on ice or refrigerate until delivery or shipment to the appropriate laboratory.

(7) After all required samples have been collected, remove the tubing clamp (if used) and collect water to measure the final turbidity.

(8) Reconnect the discharge tubing to the inlet of the flow cell. Allow the pump to cycle 3 to 5 times to ensure that all stagnant water has been removed from the flow cell.

(8) Monitor the indicator parameters on the water analyzer meter until they are stable as indicated previously. Obtain a full set of parameters (including static water level) and record in the field logbook as final parameters.

f. Disassemble the low flow sampling equipment.

(1) Close the main valve on the nitrogen supply or the gas use valve on the LN_2 dewar and allow the pressure to drop to ambient. Remove the pressure regulator and replace cap on K-bottle, if used.

(2) Disconnect the air supply tubing and the sample discharge tubing from the well cap and replace the locking cap.

(3) Disconnect both discharge tubes from the flow cell and store properly. Remove the remaining water from the flow cell and place in the purge water collection container.

(4) Disconnect the pressure hoses from the control box and store all components properly.

g. Secure the well and surrounding area and ensure that all sampling equipment is collected and loaded. Complete all necessary information in the logbook and sign and date it.

h. After each sampling event, annotate the sampling activities in the sampling annotation sheet. An example of the annotation sheet is provided in Attachment F of this instruction. These annotation sheets are maintained for all WSTF sampling activities and are collectively referred to as the nucleus. The updated nucleus will be maintained for review in the sampling technicians' office. A hard copy of all past nucleus entries will be maintained by the sampling coordinator or other responsible contractor environmental personnel for reference by other department personnel.

i. Deliver the field logbook to the responsible contractor environmental personnel to be reviewed and signed. Reviewed and signed sampling logbooks will be appropriately archived in the Department's files for future reference.

11. SAMPLE SHIPMENT INSTRUCTIONS

NOTE

BETWEEN SAMPLE COLLECTION AND SAMPLE SHIPMENT, ALL SAMPLES WILL BE REFRIGERATED AT 4°C TO MAINTAIN SAMPLE INTEGRITY. THE TEMPERATURE OF THE REFRIGERATOR SHOULD BE MONITORED AND

KEPT WITHIN +/-2^{O}C OF REQUIRED TEMPERATURE. SAMPLES WILL BE SHIPPED TO THE LABORATORY FOR ANALYSIS WITHIN THE HOLDING TIMES SPECIFIED IN THE SAMPLING AND ANALYSIS PLAN.

a. Obtain appropriate shipping documents from responsible contractor environmental department personnel. Complete the required chain of custody paperwork and WSTF shipping documents for each sample.

b. Wrap or package all samples as appropriate for sample container. Pack samples securely with ice and packing material in an adequately sized ice chest.

c. Deliver packaged samples to designated shipper or site warehouse personnel. Shipping personnel will accept custody of the samples by signing the chain of custody forms. A copy of this signed form will be included with the sample during shipment.

d. Deliver a copy of the shipping document, chain of custody, and copy of the logbook entry for that sampling event to the responsible contractor environmental department personnel.

Attachment A Issued:

Attachment A
NDMA/DMN Contaminated Groundwater Assessment Wells
and Post-Closure Care Monitoring Wells

NDMA/DMN CONTAMINATED GROUNDWATER ASSESSMENT WELLS				
200-B-240	400-A-151	BLM-17-493	BW-4	ST-1-541
200-D-240	400-C-118	BLM-17-550	BW-5-295	ST-1-630
300-A-120	400-C-143	BLM-21-400	BW-6-355	ST-3-486
200-F-225	400-D	BLM-23-431	BW-7-211	ST-3-586
200-G-175	BLM-1-435	BLM-26-404	NASA 5	ST-3-666
300-A-170	BLM-2-482	BLM-27-270	NASA 6	ST-3-735
300-B-166	BLM-2-630	BLM-30	NASA 9	
300-C-128	BLM-9-419	BLM-36	NASA 10	
300-E-138	BLM-14-327	BLM-38	PL-5	
300-E-183	BLM-15-305	BW-1-268	ST-1-473	

Attachment B Issued:

Attachment B
Flow Cell Probe Use, Calibration, and Maintenance Guidelines and Instructions

Sensor	Daily Before Use	Calibration	Maintenance	Storage
Temp/Cond	• Insure that conductivity calibration has been completed in the range to be measured. • Inspect thermistor and electrodes for corrosion or fouling.	• Type – Single point with KCl standards in the range to be measured. • Frequency – For each new range of conductivities to be measured; after each cleaning with a brush; if values drift or seem suspect.	• Clean thermistor and conductivity electrodes with brush and clean water. Use mild detergent for cleaning if needed.	• Short term – No special storage requirements; can be stored wet or dry; do not store in corrosive fluids. • Long term – Same as short term but recommend cleaning before storage.
DO	• Inspect membrane for punctures or other damage. • Calibrate DO% at temperature for testing using flow cell with 1/4" water for humidity. • Check DO Charge readings and perform maintenance if over 75 or less than 25.	• Type – Single point using air at 100% relative humidity and known barometric pressure. • Frequency – Daily before use; as necessary if values drift or seem suspect.	• Replace Membrane/ Solution – Follow procedure in this attachment when DO Charge is less than 25 or if membrane is damages. • Clean Probe – With clean water as necessary. • Clean Electrodes – With kit when electrodes appear corroded or DO charge is greater than 75.	• Short Term – Store installed sonde with 1/4" – 1/2" of tap water in flow cell for moisture. Do not store directly in water. • Long Term – Store in water with membrane still in place; replace membrane and KCl solution prior to use.
PH/ORP	• Inspect probe for damage or fouling. • Clean probe if necessary.	• Type – Two-point with pH buffer solutions: 4/7 or 7/10, depending on the expected pH range. • Frequency – Once per week or as necessary if values drift of seem suspect.	• Clean with clean water as necessary. • Rehydration of Electrode Junction – Soak probe in 2M KCl solution for eight hours if problems occur during calibration or if readings seem suspect.	• Short term – Store installed in sonde with 1/4" – 1/2" of tap water in flow cell for moisture for up to one week. • Long Term – Store the probe in a 2M KCl solution in the pH/ORP storage bottle; be certain to plug vacant port on the sonde.

Dissolved Oxygen (DO) Sensor Special Instructions

1. Care and Maintenance – For best results, it is recommended that the KCl solution and the Teflon® membrane at the tip of the DO probe be changed prior to each probe deployment or if any of the following occur:

    a. Bubbles are visible under the membrane;

    b. Significant deposits of dried electrolytes are visible on the membrane or O-ring; or

    c. If the probe show unstable readings or other malfunction.

2. Membrane Replacement Procedure – The following procedure should be followed to change the DO sensor membrane.

NOTE

THE FOLLOWING INSTRUCTIONS ARE REPRESENTED IN A DIAGRAM IN THE FLOW CELL USER GUIDE.

a. Remove the sensor guard from the sonde.

b. Remove the used membrane and rinse the sensor with water.

c. Examine the electrodes at the tip of the probe. If either or both of the silver electrodes are black in color, the probe should be resurfaced using the sanding disks provided in the probe reconditioning kit. Directions are provided below.

d. Open the membrane kit and prepare electrolyte as directed in the flow cell user guide.

e. Hold (or securely clamp) the probe vertically and apply a few drops of the KCl solution to the tip. The fluid should completely fill the small moat around the electrodes and form meniscus on the tip of the sensor. Be sure no air bubbles are attached to the face of the sensor. If necessary, shake off the electrolyte and start over.

f. Secure a membrane between your left thumb and the probe body. Always handle the probe membrane with care, touching it only at the ends.

g. With the thumb and forefinger of your right hand, grasp the fee end of the membrane. In one motion, gently stretch the membrane up, over, and down the other side of the sensor. The membrane should conform to the face of the sensor.

h. Secure the end of the membrane under the forefinger of you left hand.

NOTE

AIR BUBBLES SMALLER THAN 1//16" WILL NOT SIGNIFICANTLY AFFECT THE READINGS AND DO NOT REQUIRE REPLACING THE MEMBRANE AND ELECTROLYTE.

i. Roll an O-ring over the end of the probe and make certain there are no wrinkles in the membrane or bubbles trapped under it. Small wrinkles may be smoothed out by gently tugging on the ends of the membrane. If bubbles are present, remove and replace the membrane and solution.

j. Trim off any excess membrane. Ensure that the temperature sensor is not covered by excess membrane.

k. Rinse of the excess KCl solution with tap water.

3. Electrode Reconditioning Procedure

a. Dry the probe tip completely with lens cleaning tissue

CAUTION

USE ONLY THE SANDING DISKS PROVIDED IN THE PROBE MAINTENANCE KIT AND SAND ONLY IN A DIRECTION PARALLEL TO THE GOLD ELECTRODES, OR THE ELECTRODES MAY BE SERIOUSLY DAMAGED.

b. Hold the probe in a vertical position, place one of the sanding disks under your thumb, and stroke the probe face in a direction parallel to the gold electrode. This motion is similar to that used in striking a match. Sand the electrodes with this technique until all of the black deposits have been removed.

c. Repeatedly rinse the probe face with clean water and wipe with a lens cleaning tissue to remove any grit left the resurfacing operation.

d. Thoroughly rinse the entire tip of the probe with DI water and install a new membrane as previously instructed.

Attachment C Issued:

Attachment C
Low-Flow Pump Intake Locations

WELL I.D.	PUMP INTAKE DEPTH (FT)	WELL I.D.	PUMP INTAKE DEPTH (FT)
100-A-182	187	BLM-22-570	580
100-C-365	374	BLM-23-431	436
100-D-176	187	BLM-24-565	574.5
100-E-261	266	BLM-25-455	460
300-B-166	171	BLM-26-404	409
300-C-128	*	BLM-27-270	275
400-A-151	166	BW-1-268	278
600-C-173	187	BW-3-180	189
700-A-253	258	BW-5-295	300
700-B-510	520	BW-6-355	364
700-D-186	191	BW-7-211	216
700-E-458	355	JP-1-424	429
700-F-455	465	JP-2-447	451.5
700-J-200	209	PL-1-486	491
BLM-2-482	487	PL-2-504	506
BLM-2-630	635	PL-3-453	485.5
BLM-3-182	196	PL-4-464	469
BLM-5-527	532.5	ST-1-473	477.5
BLM-6-488	493	ST-1-541	546
BLM-7-509	514	ST-1-630	635
BLM-8-418	423	ST-2-466	470.5
BLM-9-419	429	ST-3-486	491
BLM-10-517	522	ST-3-586	590.5
BLM-13-300	305	ST-3-666	670.5
BLM-14-327	332	ST-3-735	744.5
BLM-15-305	310	ST-4-481	485.5
BLM-17-493	503	ST-4-589	595
BLM-17-550	555	ST-4-690	695
BLM-18-430	440	ST-5-481	485.5
BLM-21-400	405	WW-1-452	457

* Indicates that the water level in this well is currently insufficient for low-flow sampling. The water level is monitored monthly. In the event that it rises to a level that allows low-flow sampling, the pump depth will be determined and reported to NMED in the monthly activity report.

Attachment D Issued:

Attachment D
New and Modified Low Flow Monitoring Wells

Well ID	Pump Intake Depth (ft)	Date Well Installed	Date Low-Flow System Installed	Initial Sampling Date

Attachment E Issued:

Attachment E
WSTF Groundwater Sampling Record an QA Sheet

Well ID	Date Sampled	Logbook #	HVOA (8021)	VOA (8260)	NDMA (607)	RCRA Metals	Samplers' Initials	Sample Comments / QA Collected

– Indicates sample was collected.
* Indicates duplicate samples collected.
MS Indicates matrix spike samples collected.
NA Indicates no samples collected.

Attachment F

NASA White Sands Test Facility Job Instruction

Westbay Well Pressure Profiles

White Sands Test Facility
Job Instruction
(Draft – Revision)

Issued:
Expires: NA

WJI ENV-0019.B

WESTBAY WELL PRESSURE PROFILES

Work Authorizing Document: Environmental Department Task Memo

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Rescissions: This WJI Supersedes TPS 2-HWM-256R.

Record of Revisions

Issue	Issue Date	Page(s) Affected	Description of Changes
B		All	General Update

Permanent Deviation Index

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Temporary Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

1. PURPOSE

NASA's Post-Closure Care Permit stipulates that piezometric pressure profile measurements will be obtained at each WSTF Westbay multi-port groundwater monitoring well on set intervals. This WJI provides instructions for performing pressure profiles in Westbay monitoring wells. Instructions for performing this task were formerly provided by TPS 2-HWM-256R, which was approved by NMED and EPA Region 6. Westbay wells consist of a unique design incorporating multiple measurement ports located in a single well casing string within one borehole. Pressure measurements at each measurement coupling will be determined using an electronic pressure probe in conjunction with a surface data unit. The Westbay pressure probe is equipped with a fluid pressure transducer that reads the pressures inside and outside the well casing. These pressures are used with the depth to water in the casing to calculate the piezometric level of the formation at a specific measurement coupling, or zone. The piezometric levels for all individual zones in a Westbay well are combined to produce the well's piezometric pressure profile.

2. REFERENCES

a. Westbay Operations and Maintenance Manuals.

b. Operation and Maintenance Manual for Specific Electrical Generator in Use.

c. American National Standards Institute (ANSI) Z41 PT91 (Protective Footwear), ANSI Z87.1 (Eye and Face Protection), ANSI Z89.1 (Head Protection), most recent versions.

d. OSHA Standard 29 CFR, Part 1910 Subpart I 1910.132 – General Requirements.

e. WSI 25-SW-007, "Personal Protective Equipment."

f. WSI 25-SW-0023, "Minimum Access Requirements for 300, 400, and 500 Propulsion Test Areas."

g. WSI 25-SW-0024, "Lightning Protection."

h. WSTF JHA EV-2701, "Westbay Well Pressure Profiles."

3. ATTACHMENTS

a. Attachment A – NDMA/DMN Contaminated Groundwater Assessment Wells

b. Attachment B – Westbay Wells Requiring Pressure Profiles

c. Attachment C – New and Modified Westbay Wells Requiring Pressure Profiles

d. Attachment D - Westbay Pressure Profile Annotation Sheet

4. HEALTH AND SAFETY REQUIREMENTS

NOTE

A SAFETY HAZARD ASSESSMENT FOR THIS WJI HAS BEEN PERFORMED IN ACCORDANCE WITH 29 CFR 1910.132, SUBPART I. THE CERTIFICATION OF HAZARD ASSESSMENT AS REQUIRED BY WSI 25-SW-0007 IS CONTAINTED IN THE JOB HAZARD ANALYSIS FOR WESTBAY WELL PRESSURE PROFILES (JHA HW-009). THE AUTHORIZED SIGNATURES OF INDIVIDUALS APPROVING THIS WJI INDICATE THEIR CONCURRENCE WITH THIS ASSESSMENT AND THE SAFETY REQUIREMENTS PRESCRIBED IN THIS DOCUMENT AND THE REFERENCED JHA.

THE FOLLOWING HEALTH AND SAFETY REQUIREMENTS SUPPLEMENT THOSE SET FORTH IN THE JHA FOR PERSONAL PROTECTIVE EQUIPMENT (PPE) AND/OR PROVIDE ADDITIONAL INFORMATION FOR HAZARDS ASSOCIATED WITH WESTBAY PRESSURE PROFILING ACTIVITIES AT WSTF.

a. Due to the remoteness of many of WSTF monitoring wells, the following safety requirements must be observed.

(1) Every sampling crew will consist of two sampling personnel.

(2) Each sampling crew will carry a two-way radio.

(3) In the event of minor cuts, scrapes, and abrasions, first aid will be administered in the field. In the event of any non-first aid injury, sampling activities will be immediately suspended and the WSTF Fire Department will be notified for assistance.

b. The following safety requirements pertain to the use of electric generators.

(1) Prior to operation of a generator, sampling personnel will become familiar with the safety requirements and operating procedures prescribed in the manufacturer's operation and maintenance manual.

(2) Each field vehicle at the sampling site will contain a class ABC fire extinguisher.

(3) A ground fault circuit interrupter (GFCI) will be used on the generator at all times.

c. The following safety requirements apply to the protective equipment to be utilized by personnel while performing Westbay pressure profiles.

(1) Monitoring well chemical data indicate that specific wells are contaminated with trace amounts of hazardous compounds. Therefore, handle all down-hole equipment with extreme care. At no time during sampling operations should groundwater or contaminated equipment come in contact with personnel skin,

eyes, or clothing. At all times during equipment handling, Nytek gloves will be worn.

(2) Because there is no allowable exposure criteria for N-nitrosodimethylamine (NDMA) and N-nitrodimethylamine (DMN), safety goggles that meet the requirements of the most recent version of ANSI Z87.1 will be worn when handling NDMA/DMN contaminated groundwater. Refer to Attachment A for a list of the groundwater assessment wells with known concentrations of NDMA DMN. Goggles will be worn at these wells during parameter collection, sample collection, and while handling any sampling equipment that has come in contact with contaminated water.

(3) During the months of March through September, ambient temperatures at WSTF frequently exceed 90°F. This extreme environment creates the potential for heat stress and overexposure to ultraviolet (UV) radiation. Field personnel shall be familiar with heat stress prevention procedures and will implement them when required by elevated temperatures. Additionally, to protect exposure to UV radiation, sunscreen with a protection factor of at least 30 shall be worn while working in direct, intense sunlight. Umbrellas will be used when working conditions permit.

(4) All sampling personnel will wear protective headgear that meets the requirements of the most current version of ANSI Z89.1 while working beneath the overhead boom.

(5) All sampling personnel will wear protective footwear that meets the requirements of the most recent version of ANSI Z41 (MT I/75 C/75) while working in the field to prevent injuries from dropping gas cylinders or other heavy equipment.

(6) To prevent possible hand injuries, sampling personnel will wear work gloves when necessary during work activities that do not require the use of Nytek gloves.

d. Various species of wildlife at WSTF (including snakes, insects, and rodents) can often be found near monitoring wells. Caution will be used to avoid contact with potentially dangerous wildlife at all times while in the field. If any potential natural dangers are detected, contact the responsible contractor environmental department personnel for further instructions.

e. During certain times of the year, thunderstorms can pose an electrical hazard, particularly near an elevated boom or mast. As instructed in WSI 25-SW-0024, Westbay profiling activities will be suspended when lightning is detected within three miles of the well site (15 seconds from flash to thunder). Personnel will seek shelter when operations are suspended and contact the responsible contractor Environmental Department personnel for further instructions.

f. Operations at wells within the 300, 400, and 500 Areas require that personnel coordinate their entry into these areas with the appropriate Blockhouse monitor. WSI 25-SW-0023 specifies that all personnel not permanently assigned to these areas inquire at the Blockhouse and sign in/out prior to entry into and exit from these areas.

5. SUPPORT REQUIREMENTS

a. Equipment

(1) Westbay pressure profiling equipment

(a) Westbay sampling truck with cable reel and boom

(b) Westbay sampling probe and associated electronic equipment

(2) Depth probe

(3) Portable electric generator (if required)

(4) Electronic field logbook to record the measurement event

6. SPECIAL REQUIREMENTS

a. To eliminate potential contamination of the sampling equipment, gasoline-powered equipment (generators) and gasoline containers must be transported to the field on trailers or in vehicles that do not contain sampling equipment.

b. Environmental Considerations

(1) Historical analytical data indicate that specific wells at WSTF are contaminated with trace amounts of hazardous compounds. Therefore, all groundwater brought to the surface should be handled with extreme care to avoid discharge to the environment. All handling of groundwater should be performed over the concrete well pad or over the appropriate purge water collection container to ensure all excess groundwater is contained appropriately. If an accidental release occurs, the contractor Environmental Department supervisor or other responsible personnel should be contacted to determine the appropriate course of action.

(2) If gas-powered equipment is fueled in the field, special care will be taken to avoid spilling gasoline. Any spilled gasoline or oil, along with any potentially contaminated soil, will be immediately removed from the site and transported to the appropriate location for storage and/or disposal.

(3) Ensure that all motor vehicle use is restricted to maintained roads, well pads, and other service areas. In the event that these areas become impassable or

require maintenance, contact the responsible contractor Environmental Department personnel to arrange for the required corrective action.

7. PRESSURE PROFILING INSTRUCTIONS

NOTE

SPECIFIC INSTRUCTIONS FOR THE FOLLOWING ACTIVITIES ARE PROVIDED IN THE WESTBAY OPERATION AND MAINTENANCE MANUALS.

a. Consult Attachments B and C and the contractor Environmental Department Sampling Coordinator to schedule Westbay pressure profile measurements. Personnel should also review all pertinent documents and instructions prior to pressure profiling activities.

b. Download the appropriate pressure profile information into the database on the electronic field notebook and ensure that the database application is operating correctly.

c. Inspect the Westbay field truck and ensure that the load test certification for the boom is up to date. This date is located on the metal tab attached to one of the boom's support cable attachment points on the headache rack.

d. Obtain all necessary equipment and proceed to the well site.

e. Unload the generator and turn on the gasoline supply. Remove the locking well cap from the well head.

NOTE

THE ELECTRONIC FIELD LOGBOOK IS A CRITICAL PART OF EVERY PROFILING EVENT. FIELD LOGBOOKS ARE CONSIDERED LEGAL RECORDS OF FIELD ACTIVITIES, AND METICULOUS ATTENTION TO DETAIL IS REQUIRED.

f. Immediately after arriving at the well site, the electronic logbook form will be completed with all pertinent information including date, time, location, weather conditions, personnel identification, equipment used, actions performed, and any other useful or unusual information concerning the measurement event. The logbook will provide a complete enough record of the entire measurement procedure that a person not associated with the event can recreate the day's procedures from the logbook entries.

g. Start the generator and plug the Westbay cable reel into the electrical supply. Using the hand held cable reel controller, reel out enough Westbay cable to allow the sheave wheel (located at the end of the Westbay cable at the cable head) to be attached to the

upper end of the boom. Sufficient cable should be reeled out to allow the cable head to hang down to the well head when the boom is raised.

WARNING

WHEN RAISING OR LOWERING THE WESTBAY BOOM, USE EXTREME CAUTION. THIS ACTIVITY WILL BE PERFORMED BY TWO PEOPLE AT ALL TIMES, ONE PERSON ON EACH SIDE OF THE BOOM.

h. Raise the Westbay boom slowly, allowing it to come to rest against the two fixed cables anchoring the boom to the rack on the truck. Ensure that these anchor cables are secure and that they are not twisted at the attachment points.

i. Attach the Westbay probe to the cable head and allow it to hang free. Lower or raise the probe to a level just above the top of the Westbay casing and position the sampling truck so the probe is aligned with the casing opening.

j. Assemble the Westbay surface data unit (PCI and handheld controller) and rinse the assembled pressure probe apparatus with blank water (deionized and purified) to remove any accumulated dust or particulate matter.

k. Perform the following surface checks on the probe.

   (1) Visually inspect the probe housing for deep scratches or dents that could affect the operation of the probe.

   (2) Ensure that the location arm and shoe extend properly.

   (3) Ensure that the handheld controller shows the appropriate displays (pressure, temperature, shoe/arm location, etc.).

   (4) Indicate in the field logbook that the above surface checks were performed.

l. Remove the plastic Westbay casing cap and measure the initial depth to water (to the nearest 0.01 meter) in the Westbay casing with the depth probe. Record this value in the appropriate data field of the field logbook.

NOTE

IF THE INITIAL AND/OR FINAL ATMOSPHERIC CONDITIONS ARE OBSERVED ABOVE 12.60 PSI OR BELOW 12.10 PSI, TURN THE POWER TO THE PROBE OFF, THEN ON. CONFIRM THE PRESSURE READING BEFORE RECORDING IN THE FIELD LOGBOOK.

IF THE INITIAL DEPTH TO WATER IS BELOW A PORT(S), THE INSIDE CASING PRESSURE AT THAT PORT(S) MUST BE NEAR ATMOSPHERIC. IF THE PRESSURE READING IS ABOVE ATMOSPHERIC, REPOSITION THE

PROBE IN THE MEASUREMENT COUPLING AND OBTAIN A NEW PRESSURE READING.

m. Allow the probe to equilibrate at the surface for at least 10 minutes. Obtain the initial atmospheric pressure and temperature and record in the field logbook.

WARNING

BEFORE ACTIVATING THE MOTORIZED REEL TO LOWER OR RAISE THE PROBE IN THE CASING, ENSURE THAT THE REEL AND THE SHEAVE WHEEL AT THE TOP OF THE BOOM ARE READILY VISIBLE TO THE OPERATOR(S). THE REEL AND SHEAVE WHEEL MUST REMAIN IN SIGHT OF THE OPERATOR(S) DURING ALL WESTBAY OPERATIONS.

n. Consult the MP casing installation log or other well-specific information to determine the location of the bottom-most measurement coupling in the Westbay well. Lower the probe in the well casing until it is below the bottom-most measurement coupling. This is indicated by the collar detect “beep” or determined by using the sheave wheel and counter, which is placed on the Westbay cable at the well head. Allow the probe to equilibrate to the casing water temperature for at least 10 minutes.

o. Raise the probe until it is above the measurement coupling, as indicated by the magnetic collar beep or the counter on the sheave wheel. Extend the location arm and lower the probe until the arm seats in the measurement coupling.

p. Allow time for probe equilibration, then note the pressure and temperature readings from inside the casing in the field logbook.

q. Activate the backing shoe to seal the probe face against the measurement port and allow for probe equilibration. Update the appropriate field in the electronic logbook with the pressure and temperature readings from outside the Westbay casing.

r. Retract the backing shoe, allow the pressure and temperature readings to stabilize, and record the readings in the field logbook.

NOTE

MOST WESTBAY WELLS CONTAIN SOME MEASUREMENT COUPLINGS THAT ARE NOT EQUIPPED WITH MAGNETIC COLLARS. TO LOCATE THESE COUPLINGS, POSITION THE PROBE IN THE NEAREST MEASUREMENT COUPLING BELOW THE COUPLING OF INTEREST THAT IS EQUIPPED WITH A MAGNETIC COLLAR. USING THE SHEAVE WHEEL AND COUNTER, RAISE THE PROBE UNTIL THE APPROPRIATE DEPTH IS REACHED. LOWER THE PROBE UNTIL THE ARM SEATS IN THE MEASUREMENT COUPLING.

s. For each measurement coupling located above the bottom-most coupling, raise the probe to the appropriate depth as indicated by the magnetic collar beep or sheave wheel and counter. Locate the probe in the measurement coupling and repeat all necessary steps to obtain the appropriate pressure and temperature readings.

t. After the last, or upper-most measurement coupling is measured, raise the probe out of the casing and allow it to equilibrate to surface conditions for 10 minutes. Record the final atmospheric pressure and temperature readings in the electronic logbook.

u. Obtain the final depth to water and note it in the electronic logbook.

v. Disassemble the surface data unit (PCI and handheld controller). Remove the probe from the cable head and store securely with the electronic controls. Lower the boom, remove the sheave wheel from the boom, and reel in the cable head until it reaches the Westbay cable reel.

w. Shut down the generator and turn off the gas supply. Replace the plastic casing cap and locking well cap. Secure the well site and ensure all equipment is loaded.

x. After each pressure profiling event, update the annotation sheet provided in Attachment D of this instruction. Completed annotation sheets will be kept on file in the appropriate Environmental Department office and used to maintain the pressure profile schedule to ensure wells are profiled in accordance with NASA's Post-Closure Care Permit.

y. At the end of each day in which pressure profiles are performed, upload the days' pressure profile measurements into the profile database. Notify the responsible contractor environmental personnel of the presence of these data on the network.

z. Responsible contractor environmental personnel will confirm the pressure profile measurements and perform the necessary data review before saving the pressure profile into the well's permanent record. The pressure profile database application will calculate and store the piezometric level of each measurement zone.

Attachment A Issued:

Attachment A
NDMA/DMN Contaminated Groundwater Assessment Wells

NDMA/DMN Contaminated Groundwater Assessment Wells				
200-B-240	400-C-118	BLM-14-327	BLM-27-270	NASA 6
300-A-120	400-C-143	BLM-15-305	BLM-30	NASA 9
300-A-170	400-D	BLM-17-493	BW-1-268	NASA 10
300-B-166	BLM-1-435	BLM-17-550	BW-4	PL-5
300-C-128	BLM-2-482	BLM-21-400	BW-5-295	ST-1-541
300-E	BLM-2-630	BLM-23-431	BW-7-211	ST-3-586
400-A-151	BLM-9-419	BLM-26-404	NASA 5	ST-3-486

Attachment B Issued:

Attachment B
Westbay Wells Requiring Pressure Profiles

Westbay Wells Requiring Pressure Profiles		
200-C	BLM-36	ST-7
200-F	BLM-37	WB-1
200-G	BLM-38	WB-2
200-H	BLM-39	WB-3
200-I	BW-4	WB-4
300-E	JP-3	WB-5
400-D	PL-5	WB-8
600-D	PL-6	WB-9
700-H	PL-7	WB-14
BLM-28	PL-8	WW-2
BLM-30	PL-10	WW-3
BLM-31	ST-5	WW-4
BLM-32	ST-6	WW-5

Attachment C Issued:

Attachment C
New and Modified Westbay Wells Requiring Pressure Profiles

Well ID	Frequency	Contractor Approval	NASA Approval	Initial Profile Date

Attachment D Issued:

Attachment D
Pressure Profile Annotation Sheet

Well ID	Date Profiled	Operators' Initials	Field Logbook

Attachment G

NASA White Sands Test Facility Job Instruction

Westbay Well Sampling Instructions

White Sands Test Facility
Job Instruction

Issued: 03/27/00
Expires: NA

WJI ENV-0020.A

WESTBAY WELL SAMPLING INSTRUCTIONS

Work Authorizing Document: Environmental Department Task Memo

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Rescissions: This WJI Supersedes TPS 2-HWM-930292R, 6-HWM-940230, and WJI ENV-0016.A.

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Temporary Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

1. PURPOSE

This WJI provides sampling procedures for WSTF's Westbay Multi-port monitoring wells. This instruction was developed using Environmental Protection Agency (EPA) guidelines (References a, b and c) and is used in conjunction with the WSTF Groundwater Sampling and Analysis Plan and the WSTF Quality Assurance Project Plan. Instructions for performing these sampling tasks were formerly provided by TPS 2-HWM-930292R, which was approved by NMED and EPA Region 6.

2. REFERENCES

a. Test Methods for the Evaluation of Solid Waste, Physical/Chemical Methods, U.S. Environmental Protection Agency, SW-846, Third Edition, June 1997.

b. RCRA Ground Water Monitoring Technical Enforcement Guidance Document, U.S. Environmental Protection Agency, OSWER-9950.1, Latest Edition.

c. RCRA Ground-Water Monitoring: Draft Technical Guidance, U.S. Environmental Protection Agency, November 1992.

d. Groundwater Sampling and Analysis Plan, NASA WSTF, May 1998.

e. Quality Assurance Project Plan, NASA WSTF, May 1998.

f. Westbay Operations and Maintenance Manuals.

g. Operation and Maintenance Manual for Specific Electrical Generator in Use.

h. Operations and Maintenance Manual(s) for Specific Steam Cleaner(s) in Use

i. Operation and Maintenance Manuals for Specific Parameter Instruments (pH, conductivity, turbidity, etc.).

j. American National Standards Institute (ANSI) Z41 PT91 (Protective Footwear), ANSI Z87.1 (Eye and Face Protection), ANSI Z89.1 (Head Protection), ANSI Z358.1 (Eyewash Units), most recent versions.

k. OSHA Standard 29 CFR, Part 1910 Subpart I 1910.132 – General Requirements.

l. WJI ENV-0015, "Portable Liquid Nitrogen Dewar Operation."

m. WPD 22-03.A, "Environmental System Implementation and Operation."

n. WSI 25-SW-0024, "Lightning Protection."

3. ATTACHMENTS

a. Attachment A – NDMA/DMN Contaminated Groundwater Assessment Wells

b. Attachment B – New and Modified Westbay Well Zones

c. Attachment C – Parameter Collection Schedules for New and Modified Westbay Monitoring Well Zones

d. Attachment D - Westbay Sampling Annotation Sheet

4. HEALTH AND SAFETY REQUIREMENTS

NOTE

A SAFETY HAZARD ASSESSMENT FOR THIS WJI HAS BEEN PERFORMED IN ACCORDANCE WITH 29 CFR 1910.132, SUBPART I. THE FOLLOWING HEALTH AND SAFETY REQUIREMENTS HAVE BEEN DEVELOPED IN ACCORDANCE WITH THIS ASSESSMENT. THE AUTHORIZED SIGNATURES OF INDIVIDUALS APPROVING THIS WJI INDICATE THEIR CONCURRENCE WITH THIS ASSESSMENT AND THE SAFETY REQUIREMENTS PRESCRIBED IN THIS DOCUMENT.

a. All groundwater sampling personnel will be certified as Hazardous Waste Handlers prior to engaging in sampling activities. Personnel must also be familiar with WPD 22-03 (Safety), Material Safety Data Sheets (MSDSs) regarding chemicals potentially used and any other pertinent documentation regarding the use of equipment and materials used in the field.

b. Due to the remoteness of most of WSTF's monitoring wells, the following safety requirements must be observed.

(1) Every sampling crew will consist of two sampling personnel.

(2) Each sampling crew will carry a two-way radio.

(3) In the event of minor cuts, scrapes, and abrasions, first aid will be administered in the field. In the event of any non-first aid injury, sampling activities will be immediately suspended and the WSTF Fire Department will be notified for assistance.

c. The following safety requirements apply to the protective equipment to be utilized by sampling personnel while performing sampling activities.

(1) Monitoring well chemical data indicate that specific wells are contaminated with trace amounts of hazardous compounds. Therefore, handle all purged well water with extreme care. At no time during sampling operations should samples, purged waters, or contaminated equipment come in contact with personnel skin, eyes or

clothing. At all times during sample collection, Nytek gloves will be worn, both to protect sampling personnel and preserve the integrity of the sample.

(2) Because there is no allowable exposure criteria for N-nitrosodimethylamine (NDMA) and N-nitrodimethylamine (DMN), safety goggles that meet the requirements of the most recent version of ANSI Z87.1 will be worn when handling NDMA/DMN contaminated groundwater. Refer to Attachment A for a list of the groundwater assessment wells with known concentrations of NDMA/DMN. Goggles will be worn at these wells during parameter collection, sample collection, and while handling any sampling equipment that has come in contact with contaminated water.

(3) During the months of March through September, ambient temperatures at WSTF frequently exceed 90°F. This extreme environment creates the potential for heat stress and overexposure to ultraviolet (UV) radiation. Field personnel shall be familiar with heat stress prevention procedures and will implement them when required by elevated temperatures. Additionally, to protect exposure to UV radiation, sunscreen with a protection factor of at least 30 shall be worn while working in direct, intense sunlight. Umbrellas will be used when working conditions permit.

(4) All sampling personnel will wear protective headgear (hard hats) that meets the requirements of the most current version of ANSI Z89.1 while working beneath the overhead boom.

(5) All sampling personnel will wear protective footwear that meets the requirements of the most recent version of ANSI Z41 (MT I/75 C/75) while working in the field to prevent injuries from dropping gas cylinders or other heavy equipment.

(6) To prevent possible hand injuries, sampling personnel will wear work gloves when necessary during work activities that do not require the use of Nytek gloves.

d. The following safety requirements pertain to the use of electric generators.

(1) Prior to operation of a generator, sampling personnel will become familiar with the safety requirements and operating procedures prescribed in the manufacturer’s operation and maintenance manual.

(2) Each field vehicle at the sampling site will contain a class ABC fire extinguisher.
(3) A ground fault circuit interrupter (GFCI) will be used on the generator at all times.

e. The following safety requirements apply to the use of steam cleaners for decontamination of Westbay sampling equipment.

(1) Prior to operating steam cleaners, sampling personnel will become familiar with operational and safety requirements specified by the manufacturer's operation and maintenance manual.

(2) Propane tanks will be secured to the steam cleaner while in use.

(3) Sampling personnel will wear Nytek gloves and safety goggles and face shield that meet the requirements of the most current version of ANSI Z87.1 while decontaminating sampling equipment.

(4) To avoid contact with possible residual contaminants, personnel will first thoroughly decontaminate sampling equipment from a minimum distance of six feet. After initial decontamination, personnel may move closer to complete the decontamination. Westbay sample collection bottles will be held securely at arm's length during decontamination.

f. For groundwater samples that require preservation by acids or bases, the following additional safety precautions are required.

(1) Sampling personnel will wear Nytek gloves, a chemical resistant apron, and safety goggles and face shield that meet the requirements of the most recent version of ANSI Z87.1 while preserving samples with corrosive agents.

(2) A personal eyewash unit conforming to the most recent version of ANSI Z358.1 will be available at the well site during sample preservation. Personal eyewash units will be stored and maintained as directed in the manufacturer's instructions. During extremely hot or cold weather, personal eyewash units will be stored to ensure proper fluid delivery temperature as specified in the most current version of ANSI Z358.1.

(3) If a corrosive agent comes into direct contact with personnel skin or eyes, sampling activities will be suspended and affected personnel will immediately flush the affected area for 15 minutes and notify the WSTF Fire Department.

g. Various species of wildlife at WSTF (including snakes, insects, and rodents) can often be found near monitoring wells. Caution will be used to avoid contact with potentially dangerous wildlife at all times while in the field. If any potential natural dangers are detected, contact the sampling coordinator or other responsible contractor Environmental Department personnel for further instructions.

h. During certain times of the year, thunderstorms can pose an electrical hazard, particularly near an elevated boom or mast. As instructed in WSI 25-SW-0024.A, Westbay sampling activities will be suspended when lightning is detected within three miles of the sampling site (15 seconds from flash to thunder). Sampling personnel will seek shelter when operations are suspended and contact the sampling coordinator or other responsible contractor Environmental Department personnel for further instructions.

5. SUPPORT REQUIREMENTS

a. Equipment

(1) Westbay multi-port sampling equipment

(a) Westbay sampling truck with cable reel and boom

(b) Westbay sampling probe and associated electronic equipment

(c) Stainless steel sample collection bottles with connectors

(2) Depth probe

(3) Portable purge water collection container

(4) Portable electric generator (if required)

(5) Portable meters for collection of indicator parameters

(a) pH/temperature meter

(b) Conductivity meter

(c) Turbidity meter

(6) Five gallon bucket for sample and parameter collection

(7) Graduated beaker for parameter collection

(8) Protective clothing as listed in Safety Requirements

(9) Field logbook to record all field activities

(10) Poly baggies (small and large) for sample storage

(11) Sample bottles (glass and polyethylene as required for each sampling event)
(12) Ice chests and ice for sample storage and transport

(13) Steam cleaning system for equipment decontamination

b. Reagents/Chemicals

WARNING

ALL CONCENTRATED ACIDS AND BASES ARE STORED IN THE CORROSIVES STORAGE CABINET WHEN NOT IN USE. ALL PROPANE TANKS NOT ATTACHED TO THE STEAM CLEANER SYSTEM WILL BE STORED OUTSIDE IN THE CYLINDER STORAGE RACKS.

(1) Reagent grade (blank) water

(2) Concentrated nitric, sulfuric, and hydrochloric acid ampules (2 ml each)

(3) Standards for meter calibration (pH buffers, conductivity, and turbidity)

(4) Propane (steam cleaner fuel)

(5) Gasoline (portable electric generator fuel)

6. SPECIAL REQUIREMENTS

a. To eliminate potential contamination of the sampling equipment and sample containers, gasoline-powered equipment (generators) and gasoline containers must be transported to the field on trailers or in vehicles that do not contain sampling equipment. Additionally, gas-operated equipment must be located downwind of sampling activities at a distance of at least 25 feet.

b. Only sample containers that have been cleaned to the levels appropriate for sample collection can be used. If the integrity of any sample container is questionable, it will be discarded.

c. Environmental Considerations

(1) Historical analytical data indicate that specific wells at WSTF are contaminated with trace amounts of hazardous compounds. Therefore, all groundwater brought to the surface should be handled with extreme care to avoid discharge to the environment. All handling of groundwater should be performed over the concrete well pad or over the appropriate purge water collection container to ensure all purge water is contained appropriately. If an accidental release occurs, the contractor Environmental Department supervisor or other responsible personnel should be contacted to determine the appropriate course of action.

(2) If gas-powered equipment is fueled in the field, special care will be taken to avoid spilling gasoline. Any spilled gasoline or oil, along with any potentially contaminated soil, will be immediately removed from the site and transported to the appropriate location for storage and/or disposal.

(3) Ensure that all motor vehicle use is restricted to maintained roads, well pads, and other service areas. In the event that these areas become impassable or require maintenance, contact the responsible contractor Environmental Department personnel to arrange for the required corrective action.

7. DECONTAMINATION INSTRUCTIONS

WARNING

DECONTAMINATION PROCEDURES ARE PERFORMED BY TRAINED PERSONNEL WEARING THE PROPER PROTECTIVE CLOTHING. ALL SAFETY REQUIREMENTS PREVIOUSLY LISTED FOR DECONTAMINATION PROCEDURES WILL BE FOLLOWED.

a. General

(1) Steam cleaners will be operated in accordance with the appropriate manufacturer's operating manual.

(2) Non-dedicated well sampling equipment (sample bottles, depth probes, connecting tubes, etc.) requires decontamination before each use.

(3) Decontamination instructions include steam cleaning and/or rinsing with deionized water. Previous sampling activities indicate this method yields sampling equipment free of contaminants that interfere with WSTF's analyses.

(4) Decontaminated items are protected from contamination by covering them with poly sheets or placing them in plastic baggies.

(5) Field logbook will be annotated at each sampling event to reflect the method of decontamination used for sampling equipment.

b. Equipment Decontamination

NOTE

ALL NEW OR PREVIOUSLY USED DOWN-HOLE EQUIPMENT WILL BE DECONTAMINATED PRIOR TO USE OR INSTALLATION IN WSTF MONITORING WELLS. ANY EQUIPMENT THAT IS REMOVED FROM A WSTF MONITORING WELL WITH KNOWN CONTAMINATION WILL BE DECONTAMINATED BY STEAM CLEANING PRIOR TO DISPOSAL.

(1) Westbay Sampling Equipment

(a) Disassemble the Westbay sample tubes and thermoplastic interconnect tubes.

(b) Triple rinse the connectors with deionized water and store in plastic baggies. Do not steam clean the interconnects; damage to the O-rings may result.

(c) Thoroughly steam clean the sample tubes, allow the tubes to cool, wrap in poly sheets, and tape securely for transport to the field.

(2) Miscellaneous Equipment

(a) Transfer equipment to be decontaminated to the steam cleaning pad.

(b) Disassemble equipment, if possible, and steam clean each piece.

(c) Cover equipment with poly sheets or place in plastic baggies before transporting to the sampling site.

8. MAINTENANCE AND USE OF FIELD INSTRUMENTS

NOTE

UNLESS OTHERWISE STATED, CALIBRATION ACTIVITIES AND RELATED INFORMATION WILL BE RECORDED IN A SEPARATE "CALIBRATION LOGBOOK" TO BE MAINTAINED BY FIELD PERSONNEL AND STORED APPROPRIATELY IN THE GROUNDWATER OPERATIONS BUILDING. ALL FIELD INSTRUMENTS WILL BE LABELED WITH THE MOST APPLICABLE WSTF CALIBRATION DECAL.

a. pH Meter

NOTE

WSTF CURRENTLY USES VARIOUS MODELS OF pH METERS. ALTHOUGH THE GENERAL STEP-BY-STEP DIRECTIONS FOR SETTING UP THE METERS MAY VARY, THE CALIBRATION AND USE REQUIREMENTS ARE THE SAME. REFER TO THE INDIVIDUAL MANUFACTURER'S OPERATIONS MANUAL FOR SPECIFIC INSTRUMENT CALIBRATION AND USE INSTRUCTIONS.

(1) Turn the meter on and perform a two point calibration as directed in the manufacturer's operation manual for the specific meter in use. This initial calibration should be performed with 7.00 and 10.00 buffers that have not exceeded their expiration dates. Ensure that pH buffers and their secondary containers are clean and free of debris prior to use. Record the calibration readings and pertinent buffer information in the field logbook.

(2) Obtain sample water for initial parameter determination by slowly dispensing collected well water into a clean graduated beaker.

(3) Switch the meter to measure mode, submerge the probe in the beaker, and obtain a pH of the sample after equilibration. If the measured pH is outside of the 7 to 10 pH range, recalibrate with buffers that bracket the measured pH and perform sample measurement again.

NOTE

SOME MODELS OF pH METERS ARE NOT EQUIPPED FOR TEMPERATURE MEASUREMENT. WHEN USING A pH METER THAT CANNOT MEASURE TEMPERATURE, A CONDUCTIVITY METER WITH THE ABILITY TO MEASURE TEMPERATURE MUST BE USED.

(4) Switch the meter to temperature mode and obtain a temperature reading.

(5) Record the pH and temperature readings in the field logbook.

(6) After sampling procedures are complete, a post sampling calibration check of the buffers is performed to identify instrument drift during purging and sampling procedures. Enter these calibration readings in the field logbook with the final indicator parameters. If meter readings have drifted more than 5% from initial calibration readings, recalibrate the instrument, measure the sample media, and annotate the logbook with all relevant information.

(7) If extended sampling procedures are required, periodic checks of the buffers during the day are performed to check for instrument drift. If meter readings have drifted more than 5%, recalibrate the instrument, measure the sample media, and annotate the logbook with all relevant information.

b. Turbidity Meter

NOTE

BECAUSE WSTF MAY USE VARIOUS TURBIDITY METERS, SAMPLING PERSONNEL WILL UTILIZE THE APPROPRIATE MANUFACTURER'S OPERATIONS MANUAL TO ENSURE THAT METERS ARE MAINTAINED, CALIBRATED, STORED, AND USED IN A MANNER THAT ENSURES RELIABLE COLLECTION OF ACCURATE MEASUREMENTS.

(1) Ensure the turbidity meter is calibrated at least monthly according to the manufacturer's specifications prior to measurement activities. These periodic calibration values, in addition to all pertinent information regarding the calibration activity, should be recorded in the calibration logbook.

(2) Verify meter calibration in the field immediately prior to sample turbidity measurement by using the secondary formazin gel standard prepared by the manufacturer. This standard will carried with the turbidity meter to all field

sampling events. The meter reading should be within 5% of the secondary standard.

(3) Obtain an aliquot of sample water in the glass measurement cell. Dry the cell thoroughly with a clean, lint-free cloth, place it in the meter, and close the lid.

(4) Turn the meter on, initiate the measurement cycle, and wait for the digital turbidity reading to equilibrate. Record the turbidity measurement in the field logbook. Do not store the glass turbidity cells in the measurement compartment of the meter. Scratches on the cells could distort turbidity measurements.

c. Conductivity Meter

NOTE

SAMPLING PERSONNEL WILL UTILIZE THE APPROPRIATE MANUFACTURER'S OPERATIONS MANUAL TO ENSURE THAT CONDUCTIVITY METERS ARE MAINTAINED, CALIBRATED, STORED, AND USED IN A MANNER THAT ENSURES RELIABLE COLLECTION OF ACCURATE MEASUREMENTS.

(1) Ensure the conductivity meter is calibrated and maintained at least monthly according to the manufacturer's specifications prior to measurement activities. These periodic calibration values and maintenance activities will be recorded in the calibration logbook.

(2) Insert the conductivity probe into the beaker of well water that was used for pH and temperature determination. Turn the meter on, tune it to the proper conductivity scale, and set the temperature scale to match the temperature of the sample as previously determined with the pH meter.

(3) Wait for the display to equilibrate and record the conductivity reading in the field logbook.

NOTE

SOME MODELS OF CONDUCTIVITY METERS ARE NOT EQUIPPED FOR TEMPERATURE MEASUREMENT. WHEN USING A CONDUCTIVITY METER THAT CANNOT MEASURE TEMPERATURE, A pH METER WITH THE ABILITY TO MEASURE TEMPERATURE MUST BE USED.

(4) If required, switch the meter to temperature mode and obtain a temperature reading.

d. Dissolved Oxygen (DO) Measurement

NOTE

PAST SAMPLING EXERCISES HAVE INDICATED THAT THE REMOVAL OF GROUNDWATER FROM THE AQUIFER TO THE SURFACE CAN OXYGENATE THE SAMPLE ENOUGH SO THAT DO READINGS ARE NOT REPRESENTATIVE OF AQUIFER CONDITIONS. HOWEVER, IF A DO MEASUREMENT IS REQUESTED ON THE WORK AUTHORIZING DOCUMENT FOR ENGINEERING PURPOSES, SAMPLING PERSONNEL WILL UTILIZE THE APPROPRIATE MANUFACTURER'S OPERATIONS MANUAL TO ENSURE THE MOST ACCURATE DO MEASUREMENTS.

(1) Ensure the DO meter is calibrated and maintained according to the manufacturer's specifications prior to measurement activities. Record calibration and maintenance activities in the calibration logbook.

(2) Insert the DO probe into the water sample. Turn the meter on and tune it to read DO in the appropriate units (%, mg/L, etc.).

(3) Allow the reading to stabilize and record the measurement in the field logbook.

9. SAMPLING INSTRUCTIONS

a. General

(1) Prior to each sampling event, review all pertinent documents and instructions associated with Westbay well sampling. Consult the contractor Environmental Department QA/QC Coordinator to ensure the required Quality Assurance samples (duplicates, matrix spikes, blanks, and blind controls) are collected at the frequencies required by the Sampling and Analysis Plan and Quality Assurance Project Plan.

NOTE

REFER TO THE WSTF GROUNDWATER SAMPLING AND ANALYSIS PLAN FOR THE SAMPLING FREQUENCIES AND PARAMETER COLLECTION SCHEDULES FOR EXISTING WESTBAY MONITORING WELL ZONES. ANY MODIFICATIONS OR NEW MONITORING ZONES WILL BE LISTED IN THE TABLE PROVIDED IN ATTACHMENT B. NEW OR MODIFIED PARAMETER COLLECTION SCHEDULES WILL BE ANNOTATED IN THE TABLE PROVIDED IN ATTACHMENT C.

INSPECT EACH SAMPLE CONTAINER USED IN THE FIELD FOR VISUAL CONTAMINATION. IF CONTAMINATION IS DETECTED, DISCARD THE CONTAINER.

(2) Contact the contractor Environmental Department Sampling Coordinator for a list of the samples to be collected at each well. Obtain the proper sample

containers for each type of sample to be collected. Refer to the most recently approved version of the SAP for specific information regarding sample container and sample preservation.

(3) Prior to sampling, ensure that all necessary Westbay sampling equipment has been decontaminated using the steam cleaner and/or DI water and properly stored for transport to the field as previously instructed in Section 7.

CAUTION

BEFORE PERFORMING ANY SAMPLING ACTIVITIES, THE WELL HEAD, WELL PAD, AND AREA AROUND THE WELL HEAD SHOULD BE INSPECTED FOR SNAKES, RODENTS, INSECTS, OR OTHER POTENTIAL NATURAL DANGERS. IF ANY OF THESE ARE OBSERVED, CONTACT THE SAMPLING COORDINATOR OR SUPERVISOR FOR INSTRUCTIONS.

b. Proceed to the well site and prepare for sampling. Unload the generator, place it downwind of the well head, and turn on the gasoline supply. Remove the locking well cap from the well head.

NOTE

THE FIELD SAMPLING LOGBOOK IS A CRITICAL PART OF EVERY SAMPLING EVENT. FIELD LOGBOOKS ARE CONSIDERED LEGAL DOCUMENTS, AND METICULOUS ATTENTION TO DETAIL IS REQUIRED

c. Immediately after arriving at the well site, the logbook will be annotated with all pertinent information including date, time, location, weather conditions, sampler identification, equipment used and confirmation of decontamination and calibration, indicator parameters, sample information, and any other useful or unusual information concerning the sampling event. The logbook will provide a complete enough record of the entire sampling procedure that a person not associated with the sampling event can recreate the day's procedures from the logbook entries.

NOTE

SPECIFIC INSTRUCTIONS FOR MANY OF THE FOLLOWING ACTIVITIES CAN BE FOUND IN THE WESTBAY OPERATION AND MAINTENANCE MANUALS.

d. Prepare the Westbay sampling equipment for sampling operations as follows.

(1) Start the generator and plug the Westbay cable reel into the electrical supply. Using the hand-held cable reel controller, reel out enough Westbay cable to allow the sheave wheel (located at the end of the Westbay cable at the cable head) to be attached to the upper end of the boom. Enough cable should be

reeled out to allow the cable head to hang down to the well head when the boom is raised.

(2) Ensure that the load test certification for the Westbay boom is up to date. This date is located on the metal tab attached to one of the boom attachment points.

WARNING

WHEN RAISING OR LOWERING THE WESTBAY BOOM, USE EXTREME CAUTION. THIS ACTIVITY WILL BE PERFORMED BY TWO PEOPLE, ONE PERSON ON EACH SIDE OF THE BOOM.

(3) Raise the Westbay boom slowly, allowing it to come to rest against the two fixed cables anchoring the boom to the rack on the sampling truck. Ensure that these anchor cables are secure and that they are not twisted at the attachment points.

(4) Attach the Westbay probe to the cable head and allow it to hang free. Lower or raise the probe to a level just above the top of the Westbay casing and position the sampling truck so the probe is aligned with the casing opening.

NOTE

IF ANOMALIES ARE DETECTED WHILE PERFORMING SURFACE CHECKS ON THE WESTBAY PROBE, DISCONTINUE SAMPLING AND CONTACT THE SAMPLING COORDINATOR OR SUPERVISOR FOR FURTHER INSTRUCTIONS.

e. Perform the following surface checks on the probe.

(1) Visually inspect the probe housing for deep scratches or dents.

(2) Ensure that the location arm and shoe extend properly.

(3) Ensure that the handheld controller shows the appropriate displays (pressure, temperature, shoe/arm location, etc.).

(4) Indicate in the field logbook that the above surface checks were performed.

NOTE

CONSULT THE RESPONSIBLE CONTRACTOR ENVIRONMENTAL DEPARTMENT PERSONNEL TO DETERMINE IF A PRESSURE PROFILE OF THE WELL IS REQUIRED. IF SO, REFER TO WJI ENV-0019 FOR THE

APPROPRIATE INSTRUCTIONS AND PERFORM THE PRESSURE PROFILE BEFORE EQUIPMENT BLANKS OR SAMPLES ARE COLLECTED.

f. Assemble the sampling apparatus and collect equipment blanks using the following instructions.

(1) Raise the probe to an adequate working level using the hand held cable reel control. Attach the appropriate sample bottle connecting tube to the bottom of the probe.

(2) Attach a thermoplastic connecting tube to each sample bottle. Triple rinse each bottle and connecting tube with deionized water.

(3) Fill the first sample bottle with deionized water, close the valve on the connecting tube, and attach the bottle to the probe.

NOTE

AS EACH SAMPLE BOTTLE IS FILLED AND ATTACHED TO THE SAMPLE STRING, RAISE THE PROBE AND BOTTLES TO KEEP THE CONNECTION POINTS AT AN ADEQUATE WORKING LEVEL. OPEN THE VALVE ON EACH CONNECTING TUBE AFTER A BOTTLE IS ATTACHED BELOW IT.

(4) Fill each additional bottle and attach each to the connecting tube on the bottle above it. Continue until all four sample bottles are filled and attached to the probe. Allow the string of sample bottles to hang for thirty minutes.

(5) To collect equipment blanks, position the bottom of the lowermost sample bottle slightly inside the top opening of the five gallon bucket and open the valve using the proper wrench.

(6) As the blank water drains from the sample bottle, collect the equipment blanks in the appropriate sample container in order of volatility. Rinse each sample container with blank water from the Westbay sample bottle unless otherwise instructed in the work authorizing document.

(7) For collection of halogenated volatile organics and volatile organics samples, tilt the vial and allow the water to flow down the inside of the bottle. As the vial overflows, rotate it to an upright position and fill until a reverse meniscus is visible. Cap the vial and check for headspace by inverting it and watching for a bubble. If headspace is detected, discard the sample and refill the vial.

NOTE

VOLATILE SAMPLES ARE STORED INVERTED IN THE ICE CHEST TO MINIMIZE LOSS OF VOLATILE CONTAMINANTS THROUGH THE CONTAINER SEPTA.

(8) For all other samples, place the sample container in the bucket, lower the sample bottles to the container, and allow the water to flow into the container.

NOTE

EPA METHOD 607 REQUIRES THE SAMPLE TO BE PRESERVED WITH SODIUM THIOSULFATE IF RESIDUAL CHLORINE IS PRESENT IN THE SAMPLE WATER. HOWEVER, PREVIOUS SAMPLING EVENTS HAVE INDICATED THAT NO RESIDUAL CHLORINE IS PRESENT IN WSTF GROUNDWATER, MAKING SAMPLE PRESERVATION UNNECESSARY.

RCRA METAL ANALYSIS REQUIRES PRESERVATION WITH NITRIC ACID TO A pH LESS THAN 2. PREVIOUS SAMPLING EVENTS HAVE DEMONSTRATED THAT THIS CAN BE ACCOMPLISHED WITH A 2 mL AMPULE OF NITRIC ACID. IT IS NOT NECESSARY TO CHECK THE pH OF THE SAMPLE WATER AFTER PRESERVATION, AS SAMPLE INTEGRITY CAN BE COMPROMISED BY INSERTING THE pH PROBE.

(9) Preserve samples if necessary, attach appropriate label and chain of custody seal, place in poly baggies, and store on ice or refrigerate until delivery or shipment to the appropriate laboratory.

(10) Water from the sample bottles that is not used for equipment blanks will be discarded into the purge water collection container that was transported the sampling site.

g. Perform the following procedures to obtain groundwater for sample collection.

(1) Remove the plastic Westbay casing cap and measure the depth to water inside the Westbay casing with the depth probe. Obtain the ambient atmospheric pressure reading from the handheld controller display and record in the field logbook with the initial depth to water.

(2) Perform a vacuum check to verify that all the connections in the sample bottle string are secure and that the probe valve is operable.

(a) Connect the vacuum pump coupling to the top of the Westbay casing. Extend the location arm on the sampling probe and lower the probe and sample bottles into the casing until the probe rests in the vacuum pump coupling.

(b) Extend the backing shoe and close the probe valve. Draw a vacuum of less than 3 psi using the hand pump. Monitor the pressure reading on the handheld keypad to ensure that the vacuum on the valve remains

constant. This ensures that the valve and valve seal are in good working order.

(c) Open the valve and pull a vacuum of approximately 5 psi on the sample bottle string. Monitor the pressure reading on the handheld keypad to ensure that the vacuum within the sample bottles remains constant. This ensures that all connections are tight and casing water will not be allowed into the bottles.

(3) Evacuate the sample collection bottles.

(a) Following the vacuum check on the sample bottles, close the valve while the handheld keypad indicates there is a vacuum of approximately 5 psi (or less) on the sample bottles.

(b) Retract the backing shoe and raise the probe from the vacuum pump coupling. Retract the location arm and engage the probe's collar detect mode using the keypad.

(4) Lower the sampling assembly in the casing to a depth just below the level of the desired sampling port as indicated by the collar detect "beep". Extend the location arm and raise the probe until the beep of the magnetic collar is heard.

(5) Lower the probe slowly until the location arm rests in the sample coupling. Allow the pressure reading on the keypad to equilibrate and record the reading in the field logbook.

(6) Activate the backing shoe to seal the probe face against the valve in the sampling port. Record the pressure reading of the sample zone in the field logbook after it stabilizes. Open the valve on the sample probe.

(7) Observe the pressure display on the keypad until it approximates the previously recorded outer pressure reading. Record this pressure reading in the field logbook. Close the valve on the probe.

(8) Retract the backing shoe and allow the pressure reading to equilibrate. Record this reading in the field logbook.

NOTE

IF THE INSIDE CASING PRESSURE DEVIATES MORE THAN 0.10 PSIA DURING SAMPLE COLLECTION, CASING WATER MAY HAVE BEEN COLLECTED. IF THIS OCCURS, MEASURE THE DEPTH TO WATER. IF IT IS NOTABLY DIFFERENT THAN THE INITIAL DEPTH, NOTE THAT CASING WATER MAY HAVE BEEN COLLECTED AND CONTACT THE SAMPLING COORDINATOR OR SUPERVISOR FOR FURTHER INSTRUCTIONS.

(9) Raise the sample assembly to the surface.

h. Using the groundwater obtained in the previous step, collect groundwater for indicator parameters and samples.

(1) Raise the sampling assembly out of the Westbay casing and position the discharge on the lowermost sample bottle slightly inside the five gallon bucket near the well head.

(2) Open the valve on the sample bottle and dispense formation water into the graduated beaker for collection of indicator parameters as previously directed. Record all parameters in the field logbook as initial parameters.

(3) Sample water not used for parameter collection is discarded in the purge water collection container. The first run allows for the collection of indicator parameters and acts as a final rinse of the sample bottles before sample collection begins.

NOTE

THE WESTBAY SYSTEM OBTAINS SAMPLES DIRECTLY FROM THE FORMATION (IN-SITU), REQUIRING NO PURGING OF THE WELL. SOME OF THE WESTBAY SAMPLING ZONES ARE HEAVILY AERATED. FOR SAMPLES THAT REQUIRE COLLECTION AND PRESERVATION WITH ZERO HEADSPACE, IMMEDIATELY CAP THE VIAL AND OBSERVE FOR THE APPEARANCE OF NOTICEABLE BUBBLES. IF THE AERATION CREATES A BUBBLE LARGER THAN ¼" THE SAMPLE SHOULD BE DISCARDED AND REPLACED WITH A FRESH SAMPLE. ANNOTATE THE LOGBOOK FOR ANY SAMPLES THAT REQUIRE THIS PROCESS.

PREVIOUS SAMPLING EVENTS HAVE DEMONSTRATED THAT THE TURBIDITY REQUIREMENTS FOR VOLATILES AND METALS SAMPLES CANNOT BE MET AT SOME SAMPLING ZONES. FOR THOSE ZONES THAT HAVE KNOWN ELEVATED TURBIDITY, MEASURE THE TURBIDITY OF THE SAMPLE AFTER THE COLLECTION OF VOLATILES SAMPLES. IF THE TURBIDITY IS GREATER THAN 5 NTUs, CONTACT THE SAMPLING COORDINATOR OR SUPERVISOR FOR FURTHER INSTRUCTIONS. ANNOTATE THE LOGBOOK IF THIS OCCURS.

(4) Using the procedures outlined in the previous steps, continue collecting groundwater until all required samples have been collected. Collect all samples in the same manner as the equipment blanks. Cap all unfilled sample containers between sample runs to prevent sample contamination.

(5) Preserve samples if necessary, attach appropriate labels and chain of custody seals, place in poly baggies, and store on ice or refrigerate until delivery or

shipment to the appropriate laboratory. Refer to the SAP for pertinent information regarding sample containers and preservation.

(6) After all samples have been collected, use the residual water in the sample bottles to obtain final parameters. An additional run will be made if the residual water is inadequate for parameter collection. Sample water not used for parameter collection is discarded in the purge water collection container.

(7) Record the final parameter values, including the depth to water within the Westbay casing, in the field logbook.

NOTE

VARIOUS GROUNDWATER MONITORING WELLS AT WSTF ARE DESIGNATED AS POST-CLOSURE CARE (PCC) WELLS. REPLICATE SAMPLES ARE COLLECTED FROM THESE WELLS (LISTED IN ATTACHMENT A) ON A SEMI-ANNUAL BASIS. ADDITIONALLY, TEN PCC WELLS ARE DESIGNATED AS POINTS OF COMPLIANCE AND MUST BE SAMPLED ANNUALLY FOR APPENDIX IX CONTAMINANTS. PCC AND APPENDIX IX SAMPLES ARE COLLECTED USING THE SAME SAMPLING PROCEDURES OUTLINED PREVIOUSLY IN THIS WJI.

i. Collect Post-Closure Care replicate samples if required.

(1) Before sampling a PCC well, determine if semi-annual replicate sampling or collection of Appendix IX samples is required. Consult the pertinent site-specific documentation and the sampling coordinator or other responsible contractor Environmental Department personnel to coordinate PCC and Appendix IX sampling events.

(2) If PCC semi-annual sampling is required, collect PCC and/or Appendix IX samples as follows.

(a) Collect the first set of replicate samples using the methods previously detailed in this section. If the well is a designated point of compliance, and the annual Appendix IX samples are required, collect the Appendix IX samples as an addition to the first set of PCC replicate samples.

(b) Obtain final indicator parameters following the collection of the first set of samples and record in the field logbook. This set of parameters serves as final parameters for the first set of PCC samples (and Appendix IX samples if collected) and initial parameters for the second set of PCC replicate samples.

(c) Collect the second set of replicate samples and obtain indicator parameters that will serve as final parameters for the second set of samples and initial parameters for the third set. Record all sample information in the field logbook.

(d) Repeat steps (b) and (c) for the third and fourth sets of PCC replicate samples and the corresponding indicator parameters.

(3) Ensure that initial and final indicator parameters, pressure readings for each sample run, and all sample information for the four sets of replicate samples (and Appendix IX samples if collected) are recorded in the field logbook.

(4) Ensure that all samples have been properly preserved, labeled and sealed, and stored until delivery or shipment to the appropriate laboratory.

j. Terminate sampling operations and tear down the Westbay sampling equipment.

(1) Disassemble the sampling apparatus and the surface control unit. Remove the probe from the cable head and store securely with the electronic controls.

(2) Lower the boom, remove the sheave wheel from the boom, and reel in the cable head until it reaches the Westbay cable reel.

(3) Shut down the generator and turn off the gas. Replace the plastic casing cap and locking well cap

(4) Secure the well and surrounding area and ensure that all sampling equipment is collected and loaded. Complete all necessary information in the logbook and sign and date it.

k. After each sampling event, annotate the sampling activities in the WSTF Groundwater Sampling Record and QA Sheet, commonly referred to as the nucleus. An example of this sheet is provided in Attachment D of this instruction. The updated nucleus will be maintained for review in the sampling technicians' office. A hard copy of all past nucleus entries will be maintained by the sampling coordinator or other responsible contractor environmental personnel for reference by other department personnel.

l. Deliver the field logbook to the sampling coordinator or other responsible contractor environmental personnel to be reviewed and signed. Reviewed and signed sampling logbooks will be appropriately archived in the Department's files for future reference.

10. ARRANGE FOR SAMPLE DELIVERY AND SHIPMENT

NOTE

PRIOR TO SAMPLE SHIPMENT, ALL SAMPLES SHOULD BE REFRIGERATED AT 4°C TO MAINTAIN SAMPLE INTEGRITY. THE TEMPERATURE OF THE

REFRIGERATOR SHOULD BE MONITORED AND KEPT WITHIN +/-2^{O}C OF REQUIRED TEMPERATURE. SAMPLES SHOULD BE SHIPPED FOR ANALYSIS WITHIN THE HOLDING TIMES SPECIFIED IN THE SAP.

a. Obtain the appropriate shipping documents from the responsible contractor Environmental Department personnel. Complete the required chain of custody paperwork for each sample.

b. Wrap or package all samples as appropriate for sample container. Pack samples securely with ice and packing material in an adequately sized ice chest.

c. Deliver packaged samples to the site warehouse personnel or other designated shipper. Shipping personnel will accept custody of the samples by signing the chain of custody forms. Copies of the WSTF shipping document and the signed chain of custody form will be included with the sample during shipment.

d. Deliver a copy of the shipping document, chain of custody, and copy of the logbook entry for that sampling event to the sampling coordinator or other responsible contractor Environmental Department personnel. In order to track past sample shipments in case of lab or shipper error, these documents will be maintained for at least six months. After this period, only original documentation (no copies) will be retained. These documents may be kept as hard copies or transferred to electronic format as appropriate.

Attachment A Issued:

Attachment A
NDMA/DMN Contaminated Groundwater Assessment Wells
And Post-Closure Care Monitoring Wells

NDMA/DMN Contaminated Groundwater Assessment Wells				
200-B-240	400-C-118	BLM-14-327	BLM-27-270	NASA 6
300-A-120	400-C-143	BLM-15-305	BLM-30	NASA 9
300-A-170	400-D	BLM-17-493	BW-1-268	NASA 10
300-B-166	BLM-1-435	BLM-17-550	BW-4	PL-5
300-C-128	BLM-2-482	BLM-21-400	BW-5-295	ST-1-541
300-E	BLM-2-630	BLM-23-431	BW-7-211	ST-3-586
400-A-151	BLM-9-419	BLM-26-404	NASA 5	ST-3-486

POST-CLOSURE CARE WELLS				
200-B-240	**200-G (175)**	**300-D-153**	**400-D (195)**	**NASA 7**
200-D-109	**200-H (225)**	**300-E (138)**	**600-E (280)**	NASA 8
200-D-240	300-A-120	400-C-118	NASA 5	**NASA 9**
200-F (225)	300-A-170	400-C-143	NASA 6	**NASA 10**

Note: Point of Compliance wells that require Appendix IX sampling are shown in bold type. The Appendix IX zone of each Westbay well is in parentheses.

Attachment B Issued:

Attachment B
New and Modified Westbay Monitoring Well Zones

Zone ID	Frequency	Contractor Approval	NASA Approval	Initial Sampling Date

Attachment C Issued:

Attachment C
Parameter Collection Schedules for New and Modified Westbay Monitoring Well Zones

Zone ID	8010/ 8021	8240/ 8260	607	As	Ba	Cd	Cr	Pb	Hg	Se	Ag	Contractor Approval	NASA Approval

X – Indicates that samples are collected at each regularly scheduled sampling event.
Y – Indicates that samples are collected yearly.

Attachment D Issued:

Attachment D
WSTF Groundwater Sampling Record an QA Sheet

Well ID	Date Sampled	Logbook #	HVOA (8021)	VOA (8260)	NDMA (607)	RCRA Metals	Samplers' Initials	Sample Comments / QA Collected

– Indicates sample was collected.
* Indicates duplicate samples collected.
MS Indicates matrix spike samples collected.
NA Indicates no samples collected.

Attachment H

NASA White Sands Test Facility Job Instruction

Hydraulic Conductivity Testing (K-Testing) of Aquifers Through Westbay Multi-Port Wells

White Sands Test Facility
Job Instruction

Issued: 08/25/03
Expires: NA

WJI ENV-0014.A

HYDRAULIC CONDUCTIVITY TESTING (K-TESTING) OF AQUIFERS THROUGH WESTBAY MULTI-PORT WELLS

Work Authorizing Document: Environmental Department Task Memo

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Rescissions: This WJI replaces TPS 2-HWM-226R, Hydraulic Conductivity Determinations in Westbay Multi-Port Wells.

Record of Revisions

Issue	Issue Date	Page(s) Affected	Description of Changes

1.

Permanent Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

Temporary Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

1. PURPOSE

This WJI provides specific instructions for the hydraulic conductivity determination of geologic formations through Westbay multi-port wells.

2. REFERENCES

a. Hermit Data Logger Operator's Manual, October 1997.

b. Transducer Operator's Manual, February 1998.

c. American National Standards Institute (ANSI) Z41 PT91 (Protective Footwear), ANSI Z87.1 (Eye and Face Protection), most recent versions.

d. JHA HW-028, "K-Testing of Groundwater Monitoring Wells."

e. WJI ENV-0019, "Westbay Well Pressure Profiles."

f. WJI ENV-0020, "Westbay Well Sampling Instructions."

g. WSI 25-SW-0024, "Lightning Protection."

h. WPD 22-01, "Environmental Management System."

3. ATTACHMENTS

a. Attachment A – NDMA/DMN Contaminated Groundwater Assessment Wells

b. Attachment B – Continuation Sheet

4. DEFINITIONS

None.

5. ABBREVIATIONS AND ACRONYMS

a. ANSI – American National Standards Institute

b. CFR – Code of Federal Regulations

c. K – hydraulic conductivity

d. PZ – piezometric level

e. WJI – WSTF Job Instruction

f. WSTF – White Sands Test Facility

6. HEALTH AND SAFETY REQUIREMENTS

NOTE

A SAFETY HAZARD ASSESSMENT FOR HYDRAULIC CONDUCTIVITY TESTING HAS BEEN PERFORMED IN ACCORDANCE WITH 29 CFR 1910.132 SUBPART I. THE CERTIFICATION OF HAZARD ASSESSMENT AS REQUIRED BY WSI 25-SW-0007 IS CONTAINTED IN THE JOB HAZARD ANALYSIS MONITORING WELL DEPTH MEASUREMENT (JHA HW-0028). THE AUTHORIZED SIGNATURES OF INDIVIDUALS APPROVING THIS WJI INDICATE THEIR CONCURRENCE WITH THE SAFETY HAZARD ASSESSMENT AND THE SAFETY REQUIREMENTS PRESCRIBED IN THIS DOCUMENT AND THE REFERENCED JHA

THE FOLLOWING HEALTH AND SAFETY REQUIREMENTS SUPPLEMENT THOSE SET FORTH IN THE JHA FOR PERSONAL PROTECTIVE EQUIPMENT (PPE) AND/OR PROVIDE ADDITIONAL INFORMATION FOR HAZARDS ASSOCIATED WITH WELL DEPTH MEASUREMENT ACTIVITIES AT WSTF.

a. All groundwater sampling personnel will be certified as Hazardous Waste Handlers prior to engaging in K-testing activities. Personnel must also be familiar with WPD 22-01 (EMS) and any other pertinent documentation regarding the use of equipment and materials used in the field.

b. Due to the remoteness of most of WSTF's monitoring wells, the following safety requirements must be observed.

(1) Every K-testing crew will consist of two sampling personnel.

(2) Each K-testing crew will carry a two-way radio.

(3) In the event of minor cuts, scrapes, and abrasions, first aid will be administered in the field. In the event of any non-first aid injury, K-testing activities will be immediately suspended and the WSTF Fire Department will be notified for assistance.

c. The following safety requirements apply to the protective equipment to be utilized by personnel while performing K-testing.

(1) Monitoring well chemical data indicate that specific wells are contaminated with trace amounts of hazardous compounds. Therefore, handle all purged well water with extreme care. At no time during K-testing operations should purged waters or contaminated equipment come in contact with personnel

skin, eyes or clothing. At all times during K-testing, Nytek gloves will be worn.

(2) Because there is no allowable exposure criteria for N-nitrosodimethylamine (NDMA) and N-nitrodimethylamine (DMN), safety goggles that meet the requirements of the most recent version of ANSI Z87.1 will be worn when handling NDMA/DMN contaminated groundwater. Unless previous analytical results have proven the absence of NDMA/DMN contamination, goggles and a chemical resistant apron will be worn during bailing of groundwater and while handling any equipment that has come in contact with potentially contaminated water. PPE requirements will be included in the work authorizing document.

(3) During the months of March through September, ambient temperatures at WSTF frequently exceed 90°F. This extreme environment creates the potential for heat stress and overexposure to ultraviolet (UV) radiation. Field personnel shall be familiar with heat stress prevention procedures and will implement them when required by elevated temperatures. Additionally, to protect exposure to UV radiation, sunscreen with a protection factor of at least 30 shall be worn while working in direct, intense sunlight. Umbrellas will be used when working conditions permit.

(4) All field personnel will wear protective footwear that meets the requirements of the most recent version of ANSI Z41 (MT I/75 C/75) while working in the field.

(5) To prevent possible hand injuries, personnel will wear work gloves when necessary during K-testing activities that do not require the use of Nytek gloves.

d. Various species of wildlife at WSTF (including snakes, insects, and rodents) can often be found near monitoring wells. Caution will be used to avoid contact with potentially dangerous wildlife at all times while in the field. If any potential natural dangers are detected, contact the responsible contractor Environmental Department personnel for further instructions.

e. During certain times of the year, thunderstorms can pose an electrical hazard. As instructed in WSI 25-SW-0024.A, K-testing activities will be suspended when lightning is detected within three miles of the testing site (15 seconds from flash to thunder). Personnel will seek shelter when operations are suspended and contact the responsible contractor Environmental Department personnel for further instructions.

f. Operations at wells within the 300, 400, and 500 Areas require that personnel coordinate their entry into these areas with the appropriate Blockhouse monitor. WSI 25-SW-0023 specifies that all personnel not permanently assigned to these

areas inquire at the Blockhouse and sign in/out prior to entry into and exit from these areas.

7. SUPPORT REQUIREMENTS

a. Hermit data logger or equivalent

b. Pressure transducer with sufficient cable

c. Bailer for Westbay casing

d. Depth probe

e. Unchlorinated water

f. Portable purge water collection container

g. Westbay Instruments open/close tool

h. Decontamination equipment and supplies

8. SPECIAL REQUIREMENTS

a. Equipment Decontamination

b. Environmental Considerations

(1) To prevent potential cross-contamination of WSTF monitoring wells, all downhole equipment will be decontaminated between use at different wells. Decontamination includes steam cleaning and/or rinsing with deionized water. Previous sampling activities indicate this method yields sampling equipment free of contaminants that interfere with WSTF's analyses. Decontamination procedures used for Westbay sampling equipment shall be implemented for K-testing equipment that comes into contact with contaminated well water. All K-testing personnel will be familiar with these procedures, which are described in detail in WJI ENV-0020, “Westbay Well Sampling Instructions.”

(2) Historical analytical data indicate that specific wells at WSTF are contaminated with trace amounts of hazardous compounds. Therefore, all groundwater brought to the surface should be handled with extreme care to avoid discharge to the environment. All handling of groundwater should be performed over the concrete well pad or over the appropriate purge water collection container to ensure all purge water is contained appropriately. If an accidental release occurs, the contractor Environmental Department supervisor or other responsible personnel should be contacted to determine the appropriate course of action.

(3) If gas-powered equipment is fueled in the field, special care will be taken to avoid spilling gasoline. Any spilled gasoline or oil, along with any potentially contaminated soil, will be immediately removed from the site and transported to the appropriate location for storage and/or disposal.

(4) Ensure that all motor vehicle use is restricted to maintained roads, well pads, and other service areas. In the event that these areas become impassable or require maintenance, contact the responsible contractor Environmental Department personnel to arrange for the required corrective action.

9. INSTRUCTIONS

NOTE

REVIEW THE HERMIT OPERATOR'S MANUAL AND THE TRANSDUCER OPERATOR'S MANUAL BEFORE COMMENCING K-TEST ACTIVITIES. REVIEW THE K-TESTING LOGBOOK TO DETERMINE IF A TRANSDUCER TEST HAS BEEN PERFORMED DURING THE PRECEDING YEAR. IF NOT, PERFORM THE TEST IN ACCORDANCE WITH THE TRANSDUCER OPERATOR'S MANUAL. RECORD THE RESULTS OF THE TEST IN THE K-TESTING LOGBOOK FOR FUTURE REFERENCE.

a. General

(1) No more than three days before a K-test, perform a pressure profile on the well as instructed in WJI ENV-0019.

(2) Calculate piezometric level of each zone to be K-tested using the following equation:

PZ = Port Depth – [(Formation Press. – Atm. Press)/0.4335)]

(3) Record the piezometric levels in the field logbook. The well will be K-tested starting with the zone with the lowest piezometric level and finishing with the zone with highest. This ensures that bailing to remove excess water is minimized.

NOTE

BEFORE COMMENCING WITH FURTHER STEPS, CONFIRM THAT THE TRANSDUCER CABLE LENGTH IS SUFFICIENT TO REACH A FEW FEET INTO WATER WITH 25 FEET OF DRAWDOWN. IF IT IS NOT, A UNIT WITH A LONGER CABLE MUST BE OBTAINED.

b. Bail the well until the depth to water is at least 25 feet below the piezometric level of the first zone to be tested. This is the minimum amount of drawdown required to perform the K-test. In a formation that recovers rapidly, the water can be bailed down even further. If the depth to water is at least 25 below the piezometric level of the first zone to be tested, the test can be performed with no bailing.

CAUTION

DO NOT EXCEED THE MAXIMUM ALLOWED PRESSURE HEAD CAPACITY OF THE TRANSDUCER. CHECK TRANSDUCER PRESSURE RATING BEFORE USE.

TRANSDUCERS ARE VERY FRAGILE. DROPPING ONE MAY CAUSE DAMAGE WHICH CAN ONLY BE CORRECTED BY THE MANUFACTURER.

c. If the initial water level in the well is such that opening the port will exceed the transducer pressure rating, add unchlorinated water to the casing until the water level is raised enough so that recovery from the zone of interest will not exceed the head capacity of the transducer. If the piezometric level is within 25 feet of the port, adjustments will have to be made, as the pressure transducer cannot be installed below the port. Contact the responsible contractor Environment Department personnel to determine the appropriate course of action.

d. Position the open/close tool at the pumping port of the zone to be tested.

e. Position the Hermit pressure transducer within the Westbay casing.

(1) Lower the pressure transducer to desired depth (a few feet below the water level is sufficient).

(2) Tape the transducer cable securely to the outside of the well head.

(3) After securing the transducer cable to the wellhead with tape, allow at least 15 minutes for the transducer cable to stretch fully before beginning the test. Do not touch transducer or cable during and after this step.

f. Connect one end of the communication cable (jumper cable) to the cable reel. Connect the other end of the jumper cable to the channel jack that corresponds to the transducer you are using (see input of transducer parameters). Each transducer has its own unique input parameters that correspond to a specific channel jack on the side of the datalogger.

NOTE

ALTHOUGH MOST DATALOGGERS CONTAIN A LITHIUM BATTERY PACK, IT IS RECOMMENDED THAT THE 12V ADAPTER BE USED WHENEVER POSSIBLE TO CONSERVE BATTERY POWER.

g. Probe Set up Menu

(1) The probe and other set ups are entirely menu driven. Functions can be highlighted by scrolling with the arrow keys and selected using the enter button much like a computer. A flow chart of menu set ups is provided under the lid of the datalogger for easy reference. First, access the probe menu set up by selecting Probe Menu.

(2) Two pressure probes are already defined on channels 1 and 2, select the probe you intend to use for your test from the list. Quickly view the pre-defined input parameters and definitions to make sure this is the probe you want to use. Probe parameters are constant values that are used to tell the datalogger how to calculate the water level from pressure data. These values should never be changed, as they are unique to each probe. Probe definitions are used for setting units and naming of individual probes. All probes are set for the standard collection units (feet of water). To change probe units, toggle back and forth using the left and right arrow key between meters and feet. If a new probe is going to be used, the probe must be defined and parameters set by the user on a new channel.

h. Test Set Up Menu

(1) Scroll down to test menu set up and select. This option allows the user to define test parameters, select a probe, and name test. The datalogger can store up to 10 tests, scroll down until an open test number is found, and select the desired test number.

(2) After selecting the test number, select “define test” from the menu. Enter the test type and test name. For all K-test, the test type should be “log.” To change test type, use left and right arrow keys to toggle back and forth between test types.

(3) Select the probe you want to use from the list and select “include” to activate your test probe. All others should remain excluded unless testing multiple wells simultaneously.

(4) Scroll down to set sample interval, which is the maximum interval at which the logger will take a reading when set on log scale. Set the sample interval to 2 minutes.

(5) Select "done" at the end of the menu. After inputting test parameters, enter all information related to the test in the field logbook for future reference.

i. Initiate the Test

(1) To start the test, enter the test menu and scroll down to the correct test number you defined above and select it.

(2) Scroll down to the "start manual test" option. The test will not start until the "enter" button is pushed.

NOTE

DURING THE TEST START-UP, THE MP PUMPING PORT MUST BE OPENED BY THE FIELD TECHNICIAN AT THE SAME TIME THE "ENTER" BUTTON IS PUSHED TO INITIATE THE TEST.

(3) Press the "enter" button to start the test when technician feels the pumping port open. Record start time in field logbook.

j. Run the Test

Test should be run for a minimum of 30 minutes and until at least 80% recovery is achieved. Test results can be viewed anytime after the start of the test. To view test results, reenter test menu and select the number that correlates with the test you are running. After selecting the test, scroll down to view "test results" and select. The screen displays the last data point taken and its associated time. To scroll back to previous data, use the "up" arrow key. All data is reported in feet of water unless redefined by the user during the probe set up. Additionally, all data is reported from a "zero" reference point, which is pre-determined in the probe set up menu. Fluctuations from "zero" will be recorded by either a positive or negative number depending on whether water is rising or falling. Water should be rising in all cases.

k. Stop the Test

The test is stopped after a minimum of 30 minutes has elapsed and at least 80% recovery is achieved. When the test has finished, complete the following steps.

(1) To stop the active test, enter the test menu and select the test number you are running. After selecting test number, scroll down until you find the "stop active test" option. Simply push "enter" to stop the test.

(2) After test is stopped, record the stop time in the field logbook along with any other pertinent test information.

(3) Remove all test equipment from the well and stow properly. Decontaminate the test equipment as required and return it to the appropriate storage location.

l. Process the Data

NOTE

ALTHOUGH THE DATALOGGER CAN STORE UP TO 10 COMPLETE TESTS, IT IS IMPORTANT THE RECORDED TEST DATA BE PURGED FROM THE UNIT AS SOON AS POSSIBLE (WITHIN 24 HOURS IF CONDITIONS PERMIT) FOLLOWING THE END OF THE TEST IN ORDER TO FREE UP MEMORY.

(1) Download the test data to a personal computer (PC) for manipulation.

(a) Select a PC (a field laptop or office desktop is acceptable) to be used for manipulation of the hydraulic conductivity test data.

(b) Install the Winsitu 2000 software onto the PC as directed in the operator's manual.

(c) After installing the software, connect the communication cable to the computer's serial port. Connect the other end of the communication cable to the datalogger's RS 232 relay on the back panel.

(d) Open the Winsitu 2000 software and double click on the Hermit 3000 icon. This tells the software to search the memory in this datalogger. The software will retrieve all test stored in memory.

(e) Click on the icon that corresponds to the test # you want to view and retrieve from memory. The software will display details of the test, test data, and other pertinent information.

(2) Perform an initial quality check on the data to insure it meets the specified project requirements.

(a) Check the sample interval and head change to make sure it matches original input parameters.

(b) Ensure that the data is neatly displayed in columns and labeled with proper units. Head change should be displayed as negative numbers from zero to reflect a rising head in the casing.

(c) If required, the header information and data units can be changed to reflect project requirements.

(3) Transfer the data to the PC and purge from the datalogger.

(a) To purge the data, click on “retrieve data” and identify the location you want the data stored on the PC.

(b) When the data has been transferred to the PC, delete the test from the datalogger in preparation for the next test. Click on “delete test” to delete the data from the datalogger.

(c) The data is stored on the PC as a batch file and can be easily saved as a text (.txt) or Excel (.xls) file as needed.

m. Data Evaluation

NOTE

PRIOR TO EVALUATION OF THE RAW K-TEST DATA, ANOTHER GEOLOGIST WILL PERFORM SECONDARY QUALITY ASSURANCE ON THE DATA TO ENSURE PROJECT GOALS CAN BE MET.

(1) Open the AQTESOLV program and select “evaluate slug test data.”

(2) Complete the required input fields, including well completion information and calculation method based on field conditions. The data is then imported and filtered directly in the software program.

(3) Find the location of the stored test data and select “import”. When the data is displayed, select the columns that contain the data that is to be evaluated. The program recognizes times and drawdown automatically, displays the data in a time vs. drawdown graph, and provides a best-fit line to the curve.

(4) Utilizing the Y and X intercepts, AQTESOLV performs the required K calculations. Alter the best-fit line if specific conditions of the test that effected the recovery of data are known by the user. Once a best-fit line is chosen, the program automatically performs the K value calculations and displays the value in preset units, usually ft/sec or ft/min.

(5) Print the complete report of input parameters, field data, and K-values and provide to a staff geologist not associated with the test.

(6) The geologist will then perform the final quality assurance on the reports to ensure all data meets the project requirements and correlates to known historical site conditions. Anomalies must be appropriated addressed at this time. Additional tests can be performed to confirm unexpected or potentially erroneous results. Qualifying remarks will become a part of the final report and the well’s permanent record.

n. Archive the final printed report in the geological sciences permanent files. The electronic reports are saved to both the testing geologist's PC hard drive and the NASA internal network.

10. SUMMARY DATA

None.

11. EMERGENCY INSTRUCTIONS

None.

Attachment A:
Continuation Sheet

WELL AND ZONES TESTED	DATE	INITIALS

Attachment I

NASA WSTF Labels and Custody Seal

for Environmental Sample Collection

NASA WSTF Labels and Custody Seal for Environmental Sample Collection

Label for Vials or Small Bottles

NASA WSTF

Sample #

Collection Location

Preservative

Analysis	Collector

Label for Large Bottles

WSTF
SAMPLE LABEL

Sample No. _____ Chem. Lab. Log No. _____

Collection Location _____

TPS/WJI No. _____ Analysis By: _____

Collected by: _____

Method of Preservation _____

Analysis Required _____

_____

Custody Seal

NASA

JOHNSON SPACE CENTER
WHITE SANDS TEST FACILITY
LAS CRUCES, NEW MEXICO

SAMPLE # _____

COLLECTOR _____

COLLECTION LOCATION _____

DATE SEAL BROKEN

INITIALS

Attachment J

NASA WSTF Chain of Custody Form

for Environmental Sample Shipment

WSTF CHAIN OF CUSTODY RECORD

Date _____ Page _____ of _____

Laboratory / PO #

Return Address for Analytical Reports:

NASA / WSTF / Honeywell
P.O. Box 20

Las Cruces, NM 88004

Attn: ☐ Lori Minnick ☐ Other _____

(505) 524-5119 (505) 524-_____

Analysis Requirements

Special Instructions

Please return coolers and contents of coolers as soon as possible.

Return Address:

NASA / WSTF / Honeywell
Building 120 / Route 70

Las Cruces, NM 88012

Attn: Lori Minnick

Sample No.	Well ID.	# of Containers	Sample Type (Aqueous)	Halogenated Volatile Organics Ice/No Headspace (40 ml Vial) ( )	Volatile Organics Ice/No Headspace (40 ml Vial) ( )	Nitrosamines Ice (1 L Glass Bottle) ( )	RCRA Metals (As, Ba, Cd, Cr, Pb, Hg, Se and Ag) Ice/HNO_3 (500 ml Poly)					Comments

Relinquished By:	Date/Time:	Accepted By:	Date/Time:

WSTF – 381B (02/00)

Columbia Analytical Services INC.
An Employee - Owned Company

QUALITY ASSURANCE MANUAL

©Columbia Analytical Services, Inc.

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October 11, 2002

Approved by:

Laboratory Manager: Mike Perry

Quality Assurance Program Manager: Lisa Reyes

Annual review of this QAM has been performed and the QAM still reflects current practice.
Initials: _____ Date: _____
Initials: _____ Date: _____
Initials: _____ Date: _____

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2.0 TABLE OF CONTENTS

Section	Revision	Heading	Page
1.0	12	Title Page with Provision Signatures	1
2.0	12	Table Of Contents	2
3.0	5.0	Introduction and Company Quality Assurance Policy	4
4.0	7.0	Program Description	5
5.0	0.0	Statement of Professional Conduct and Laboratory Practice	12
6.0	6.0	Project Organization and Responsibilities	13
7.0	2.0	Sampling, Sample Preservation, and Handling Procedures	15
8.0	9.0	Sample Custody	23
9.0	1.0	Quality Control Objectives (Precision, Accuracy, Sensitivity, and Completeness)	26
10.0	9.0	Quality Control Procedures	29
11.0	3.0	Calibration Procedures and Frequency	36
12.0	10	Data Reduction, Validation, and Reporting	39
13.0	4.0	Performance and System Audits	53
14.0	2.0	Preventive Maintenance	54
15.0	2.0	Corrective Action	56
16.0	2.0	Quality Assurance Reports	58
17.0	3.0	Personnel Training	59
18.0	3.0	References for Analytical Procedures	60

Tables		Page
Table 7-1	Sample Preservation and Holding Times	16
Table 12-1	Laboratory Data Deliverables	52

Figures Page

Figure 4-1 CAS/Rochester Laboratory Floor Plan 9
Figure 4-2 CAS/Rochester Laboratory Floor Plan 10
Figure 4-3 CAS/Rochester Laboratory Floor Plan 11
Figure 7-1 Sample Container Label and Custody Seal 21
Figure 7-2 Chain of Custody Form 22
Figure 8-1 Cooler Receipt and Preservation Form 25
Figure 12-1 Evaluation of Method Calibration 43
Figure 12-2 Evaluation of Continuing Calibration 44
Figure 12-3 Evaluation of Method Blank and Instrument Blank Results 45
Figure 12-4 Evaluation of Sample Results for Inorganic Analyses 46
Figure 12-5 Evaluation of Sample Results for Organic Analyses 47
Figure 12-6 Evaluation of Surrogate Compound Recoveries 48
Figure 12-7 Evaluation of Duplicate Sample and/or Duplicate Matrix Spike Results 49
Figure 12-8 Evaluation of Matrix Spike Recoveries 50
Figure 12-9 Evaluation of Laboratory Control Sample (LCS) Results 51
Figure 15-1 Nonconformity and Corrective Action 57

Appendices

Appendix A Major Analytical Equipment
Appendix B Organizational Chart and Resumes of Key Personnel
Appendix C Data Quality Capabilities
Appendix D Data Qualifiers
Appendix E Preventive Maintenance Procedures
Appendix F Certifications/Accreditations/Contracts

3.0 INTRODUCTION AND COMPANY QUALITY ASSURANCE POLICY

Columbia Analytical Services, Inc. (CAS) is a professional consulting laboratory which performs chemical and microbiological analyses on a wide variety of sample matrices, including air filters, air tubes, drinking water, groundwater, surface water, wastewater, soil, sediment, sludge, tissue, industrial and hazardous waste, and other material. CAS/Rochester is a part of a multi Lab Network operating throughout the USA. See Corporate Organization Chart (Appendix B) for locations.

It is a policy at CAS that there will be sufficient Quality Assurance (QA) activities conducted in the laboratory to ensure that all analytical data generated and processed will be scientifically sound, legally defensible, of known and documented quality, and will accurately reflect the material being tested. This goal is achieved by ensuring that adequate Quality Control (QC) procedures are used throughout the monitoring process, and by establishing a means to assess performance of these Quality Control and other QA activities.

We recognize that quality assurance requires a commitment to quality and ethics by everyone in the organization - individually, within each operating unit, and throughout the entire laboratory. All employees of CAS undergo lengthy ethics training and are eligible to participate in CAS open door policy to ensure a quality product and protect employees from any undue pressures. CAS also has stringent requirements and signed statements from employees to protect client confidentiality and ethical agreements.

The information in this document has been organized according to the format described in *National Environmental Laboratory Accreditation Conference (NELAC) Quality Systems Standards*, June 2000, and *Interim Guidance for the Preparation of Quality Assurance Project Plans,* QAM-005, USEPA, 1980; and *Guidance on Preparation of Laboratory Quality Assurance Plans*, USEPA, February 14, 1991. This document is controlled under policies required by CAS Document Control SOP (ADM-DOCCTRL). Each CAS network laboratory maintains its own lab specific Quality Assurance Manual.

4.0 PROGRAM DESCRIPTION

The purpose of the QA program at CAS is to ensure that our clients are provided with analytical data that is scientifically sound, legally defensible, and of known and documented quality. The concept of Quality Assurance can be extended, and is expressed in the Vision of CAS:

> "CAS Holdings, Inc. applies creative thinking and strategic integration of our talents to be the best in all business endeavors we pursue. The Company is a leader in our industry demonstrated by:
>
> - Unprecedented customer satisfaction
> - Sustained profitability
> - Exceptional technical excellence
> - Superior Quality Systems
>
> We value our company's most valuable asset, our employee-owners. We are committed to make CAS Holdings Inc the preferred place to work and grow as individuals and professionals."

In support of this vision, our QA program addresses all aspects of laboratory operations, including laboratory organization and personnel, standard operating procedures, sample management, sample and quality control data, calibration data, standards traceability data, equipment maintenance records, method proficiency data (such as method detection limit studies and control charts), document storage and staff training records.

4.1 Facilities and Equipment

CAS features over 17,000 square feet of laboratory and administrative workspace at its Rochester, NY location. The facility is secured to the rest of the building using a swipe card entry system. Upon hire, each employee is assigned an access card and security code that must be used with their card. This employee-specific card provides access to the lab. SOP's are in place to protect the integrity of samples throughout the laboratory process (SMO-GEN). A company software Quality Assurance plan exists to provide standard procedures to protect the integrity of electronic data. The laboratory has been designed and constructed to provide safeguards against cross-contamination of samples and is arranged according to work function, which enhances the efficiency of analytical operations.

Specialized areas include:

- Shipping and Receiving/Purchasing

- Sample Management Office (including a separate, controlled-access sample storage area)
- Inorganic/Metals Sample Preparation Laboratories (2)
- ICP and ICP/MS Laboratory
- AA Laboratory
- Water Chemistry & General Chemistry Laboratories
- Gas Chromatography Laboratory (including a separate sample preparation laboratory)
- Gas Chromatography/Mass Spectrometry Laboratory (including a separate sample preparation laboratory)
- Volatile Organics Laboratory (including a separate standard preparation laboratory)
- Microbiology Laboratory
- Laboratory Deionized Water System
- Laboratory Management, Client Service, Report Generation and Administration
- Data Archive
- Information Technology (IT) and LIMS
- Hazardous Waste Storage Area

In addition, segregated laboratory areas were designed for efficient and safe handling of a variety of sample types. Figures 4-1, 4-2, and 4-3 shows the facility location and layout of our Rochester, NY location. The laboratory is equipped with state-of-the-art analytical and administrative support equipment. Appendix A lists the major equipment at the Rochester facility, illustrating the laboratory's depth and overall capabilities.

Good housekeeping is an essential practice at CAS. Each department is responsible for their own area, keeping isles clear, counters free of debris and chemicals that may cause contamination during analysis. A contracted cleaning service removes all garbage and recyclables, mops the floors, and vacuums each working day.

4.2 Technical Elements of the Quality Assurance (QA) Program

4.2.1 Standard Operating Procedures (SOPs) and Laboratory Notebooks.

CAS maintains SOPs for use in both technical and administrative functions. Included in the list of available SOPs are procedures for the preparation of an SOP document, and for enforcing the control of documents through the laboratory (ADM-SOP & ADM-DOCCTRL, respectively). Each SOP generated in the laboratory has been reviewed and approved by the Laboratory Director, the Quality Assurance Program Manager and in most cases, the appropriate laboratory supervisor. The document control process associated with an SOP ensures that only the most currently prepared version of an SOP is being used for guidance and instruction. In addition to SOPs, each laboratory supervisor maintains a current file of all the promulgated methodology used to perform analyses. This file is accessible to all laboratory staff regardless of discipline. Laboratory notebook entries have been standardized following the guidelines in the *Making Entries into Logbooks and onto Benchsheets* SOP (SOP No. ADM-DATANTRY). The entries made into laboratory notebooks are reviewed and

approved by the appropriate supervisor at a regular interval (e.g. weekly, monthly, etc...)

4.2.2 Standard Reference Materials

All analytical measurements generated at CAS are performed using materials and/or processes that are traceable to a Standard Reference Material (SRM). Metrology equipment (analytical balances, thermometers, etc...) is calibrated using SRMs traceable to the National Institute of Standards and Technology (NIST). Consumable SRMs routinely purchased by the laboratories (e.g. primary stock standards) are purchased from nationally-recognized, reputable vendors. Most vendors have fulfilled the requirements for ISO 9001 certification and/or are accredited by A_2LA. Traceability throughout the laboratory is accomplished by following the guidelines set in the SOP, *Making Entries Into Logbooks and Onto Benchsheets* (ADM-DATANTRY).

All sampling containers provided to the client by the laboratory are purchased as precleaned (Level 1) containers, with certificates of analysis available for each bottle type. Certifications of Analysis provided by the vendors of reference materials and bottles are kept on file by the laboratory.

4.2.3 Operational Assessments

There are a number of methods used to assess the laboratory and its daily operations. In addition to the routine quality control (QC) measurements used by a laboratory to measure quality, the senior laboratory management staff at CAS examine a number of other performance indicators to more accurately assess the overall ability of the laboratory to successfully perform analyses for its clients. On-time performance, Analytical Report defect rate and Customer Invoice defect rate are a few of the measurements performed at CAS that are used to assess performance from an external perspective (i.e. client satisfaction). A frequent, routine assessment must also be made of the laboratory's facilities and resources in anticipation of accepting an additional or increased workload. CAS utilizes a number of different methods to insure that adequate resources are available in anticipation of the demand for service. Regularly scheduled senior staff meetings, tracking of outstanding proposals and an accurate, current synopsis of incoming work all assist the senior staff in properly allocating resources to achieve the required results.

4.2.4 Deviation from Standard Operating Procedures

When a customer requests a modification to an SOP, the Project Manager handling that project must discuss the proposed deviation with the departmental manager or QA to obtain approval for the deviation. Project-specific requirements must be on-file and with the service request upon logging in the samples.

4.3 Subcontracting

Analytical services are subcontracted when CAS/Rochester needs to balance workload and/or when the requested analyses are not performed in Rochester. However, subcontracting is only done with the knowledge and approval of the client. Subcontracting to another CAS laboratory is preferred over external-laboratory subcontracting. Further, subcontracting is only done to capable and qualified laboratories approved by the client. Subcontractors must be accredited by the applicable state or program to which apply to the samples being analyzed. Established procedures are followed to qualify external subcontract laboratories, see *Qualifying Subcontract Labs* (ADM-SUBLAB).

Figure 4-1
CAS/Rochester Laboratory Floor Plan

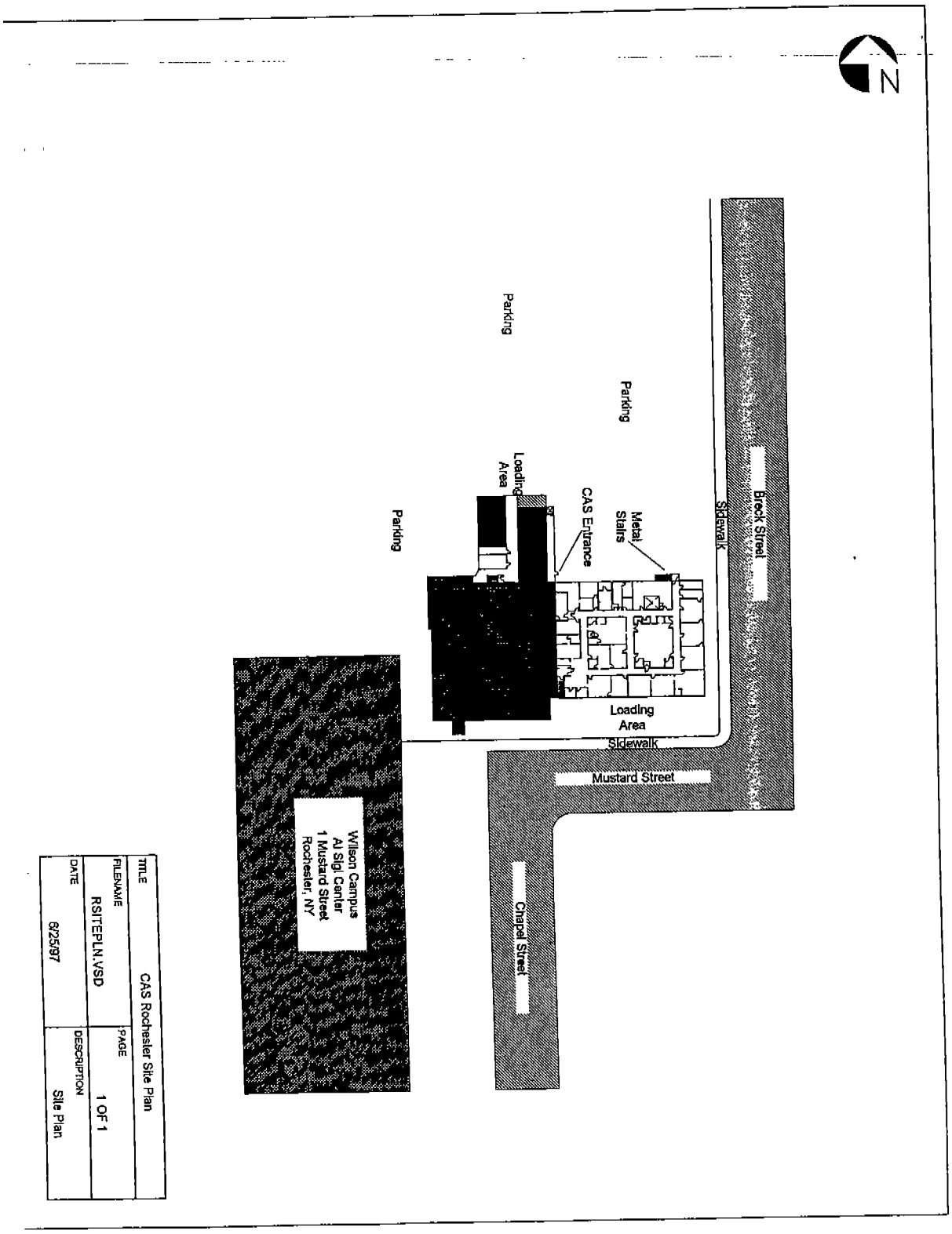


Figure 4-2
CAS/Rochester Laboratory Floor Plan

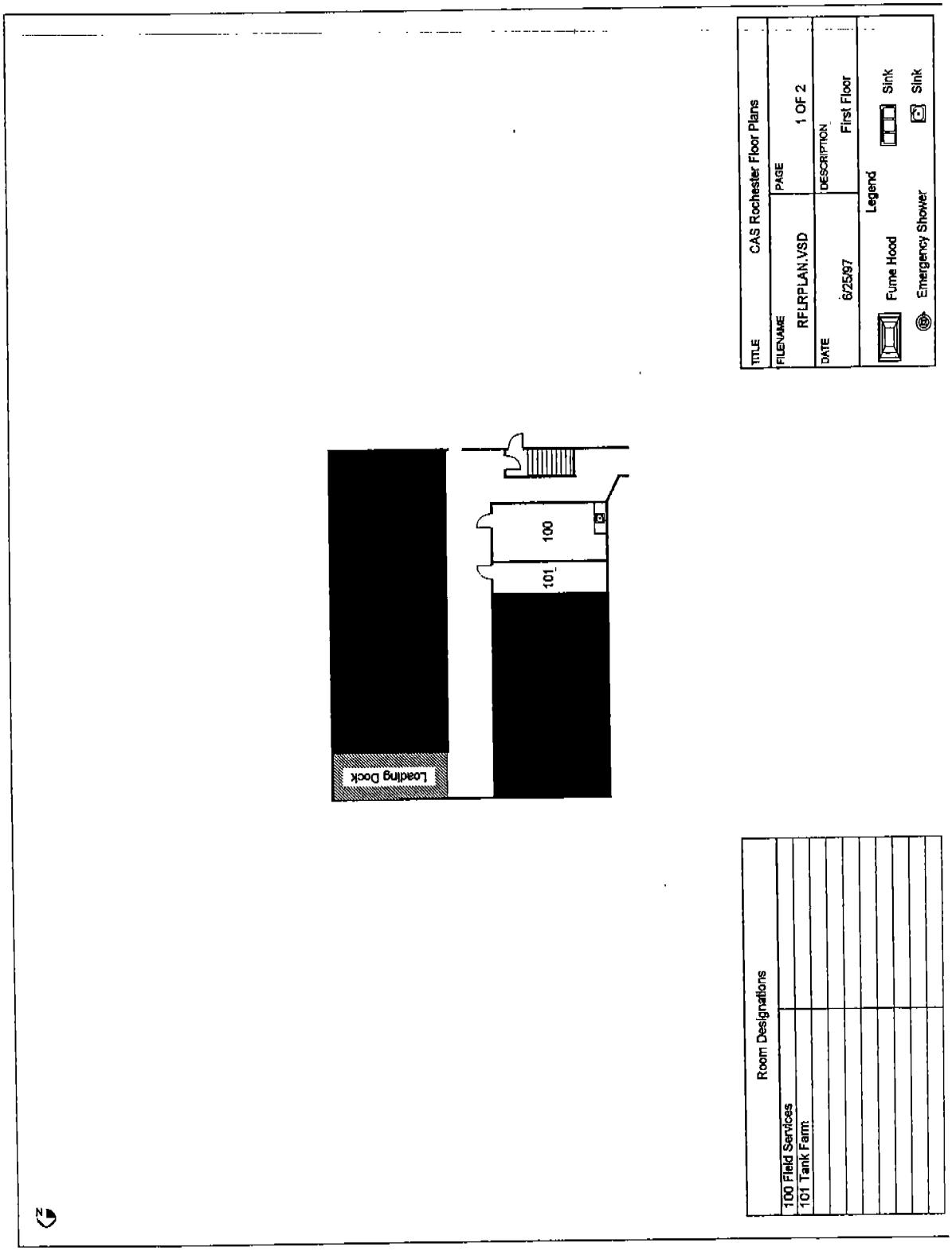
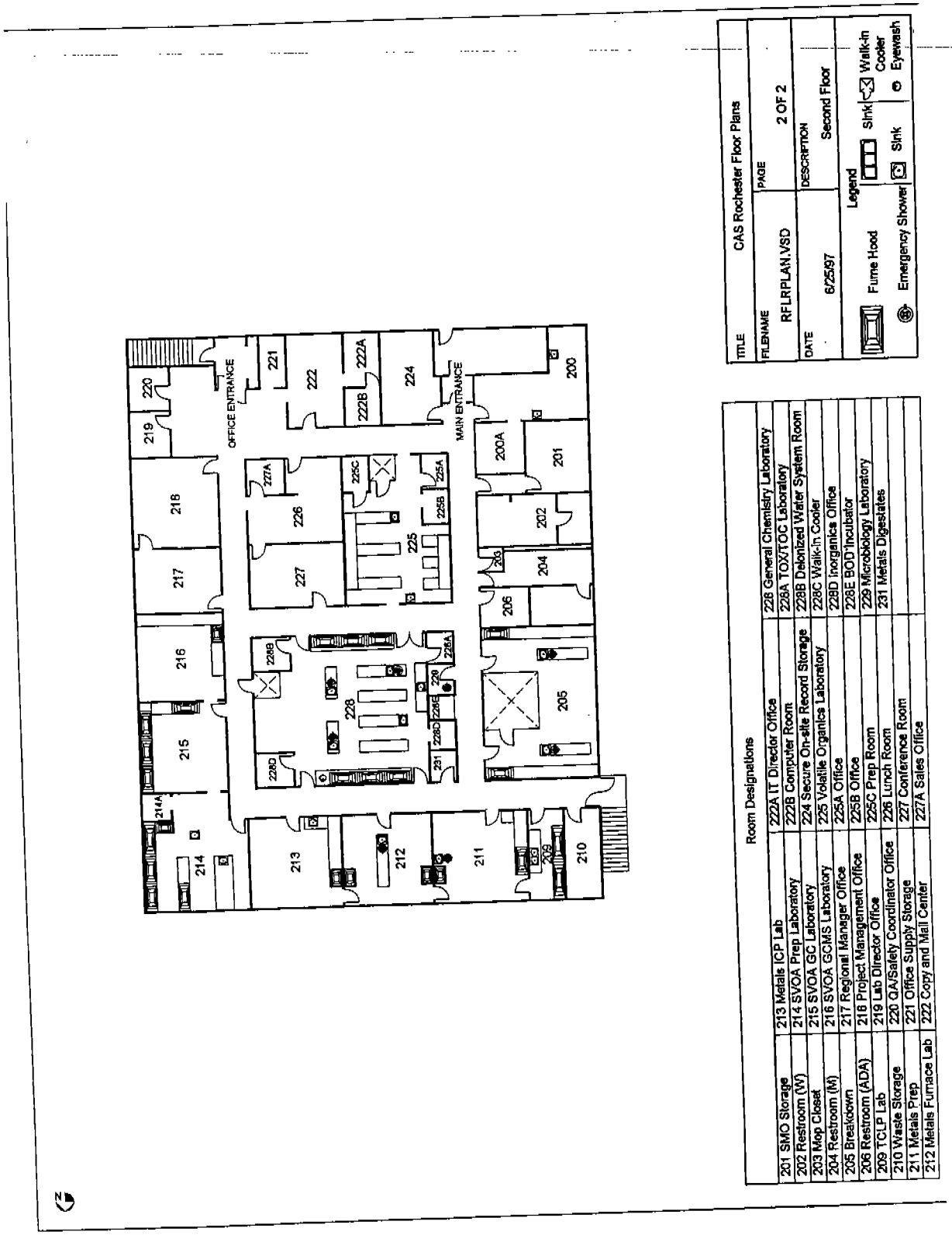


Figure 4-3
CAS/Rochester Laboratory Floor Plan



5.0 STATEMENT OF PROFESSIONAL CONDUCT AND LABORATORY PRACTICE

One of the most important aspects of the success of CAS as a company is the emphasis placed on the integrity of the data that are provided and the services that are performed. To promote product quality, CAS requires certain standards of conduct and ethical performance among our employees. The following examples of documented CAS policy are representative of these standards, and are not intended to be limiting or all-inclusive:

Under no circumstances is the willful act of fraudulent manipulation of analytical data condoned. Such acts are to be reported immediately to senior management for appropriate corrective action.

Unless specifically required in writing by a client, alteration, deviation or omission of written contractual requirements is not permitted. Such changes must be in writing and approved by senior management.

Falsification of data in any form will not be tolerated. While much analytical data is subject to professional judgment and interpretation, outright falsification, whenever observed or discovered, will be documented, and appropriate remedies and punitive measures will be taken toward those individuals responsible.

Unauthorized release of confidential information about the company or its clients is taken very seriously and is subject to formal disciplinary action.

6.0 PROJECT ORGANIZATION AND RESPONSIBILITIES

The CAS/Rochester staff, consisting of approximately 50 employees, includes chemists, technicians and support personnel. They represent diverse educational backgrounds and experience, and provide the comprehensive skills that a modern, state-of-the-art analytical laboratory requires.

CAS is committed to providing an environment that encourages excellence. Everyone within CAS shares responsibility for maintaining and improving the quality of our analytical services. The responsibilities of key personnel within the laboratory are described below. An organizational chart of the laboratory, as well as the resumes of key personnel, can be found in Appendix B. Specific Job Descriptions are available and kept on file by human resources.

- The role of the **Laboratory Director** is to provide technical, operational, and administrative leadership through planning, allocation and management of personnel and equipment resources. This person is responsible for quality, overall laboratory efficiency, and financial performance of the Rochester CAS facility. The Laboratory Director also provides support for business development by identifying and developing new markets and through continuing support of the management of existing client activities.

- The responsibility of the **Quality Assurance Program Manager** (QAPM) is to provide a focus for overall QA activities within the laboratory. This person works with individual laboratory production units to establish effective quality control and assessment plans. The QAPM is also responsible for maintaining this QA Manual and performing an annual review of it, updating it if necessary; reviewing, approving, and controlling SOPs; coordinating PE sample analyses, maintaining record of PE results, preparing responses for missed PE sample results (Section 15.0); reviewing data (Section 12.0); maintaining the laboratory's certifications and approvals (Section 13.0); performing internal QA audits (Section 13.0); preparing QA reports (Section 16.0); maintaining training documentation for all employees including IDCs, CDCs, Training Plan forms, and seminar attendance; maintaining MDL study documentation, responding to QA needs, problems, and requests from technical staff. This person is a technical advisor and is responsible for summarizing and reporting overall unit performance.

- The Quality Assurance Director (Corporate Quality Assurance) is responsible for the overall QA program at all the CAS laboratories. The QA Director is responsible for performing an annual on-site audit at each CAS laboratory and preparing a written report; maintaining a data base of information about state certifications and accreditation programs; writing laboratory-wide SOPs; maintaining a data base of CAS-approved subcontract laboratories; providing assistance to QAPMs and laboratory managers; preparing an annual QA activity report; etc.

- The **Health and Safety Officer** is responsible for the administration of the laboratory health and safety policies. This includes the formulation and implementation of safety policies, the supervision of new-employee safety training, the review of accidents, incidents and prevention plans, the monitoring of hazardous waste disposal and the conducting of departmental safety inspections. The safety officer is also designated as the Chemical Hygiene Officer.
- The **Client Services Manager** is responsible for the Client Services Department (customer services/project managers, and marketing functions). The Client Services Department provides a complete interface with clients from initial project specification to final deliverables.
- The **Project Manager** is a senior-level, non-line scientist assigned to each client to act as a technical liaison between the client and the laboratory. The Project Manager is responsible for ensuring that the analyses performed by the laboratory meet all project, contract, and regulatory-specific requirements. This entails coordinating with the CAS laboratory and administrative staff to ensure that client-specific needs are understood, and that the services CAS provides are properly executed and satisfy the requirements of the client.
- **Information Technology** (IT) staff are responsible for the administration of the Laboratory Information Management System (LIMS) and other necessary support services. Other functions of the IT staff include laboratory network maintenance, education of analytical staff in the use of scientific software, custom software development and implementation, Electronic Data Deliverable (EDD) generation and data back-up, archival and integrity operations.
- The Analytical Laboratory is divided into operational units, based upon specific disciplines. Each department is responsible for establishing, maintaining and documenting a quality control program based upon the requirements within the Quality Assurance Manual. Each **Department Supervisor/Manager** has the responsibility to ensure that quality control functions are carried out as planned, and to guarantee the production of high quality data. Supervisors have the responsibility to monitor the day-to-day operations to ensure that productivity and data quality objectives are met. Each analyst in the laboratory has the responsibility to carry out testing according to prescribed methods, standard operating procedures and quality control guidelines particular to the laboratory in which he/she is working.
- The **Sample Management Office** plays a key role in the laboratory QA program by providing documentation for all samples received by the laboratory, distributing samples, and maintaining proper storage.

Analytical work will be conducted by the laboratory under the approval of the client. If any aspect of a project requires sub-contracting, CAS project manager shall notify the client and obtain approval for any sub-contractors prior to completing the analytical program.

7.0 SAMPLING, SAMPLE PRESERVATION, AND HANDLING PROCEDURES

The quality of analytical results is highly dependent upon the quality of the procedures used to collect, preserve and store samples. CAS recommends that clients follow sampling guidelines described in specificly reference methods including EPA, NIOSH, ASTM, and SW846. Sample handling factors that must be taken into account to insure accurate, defensible analytical results include:

- Amount of sample taken
- Type of container used
- Type of sample preservation
- Sample storage time
- Proper custodial documentation

CAS uses the sample preservation, container, and holding-time recommendations published in a number of documents. The primary documents of reference are: USEPA SW-846, Third Edition (wastewater, soils, and hazardous waste samples), USEPA 600/4-79-020 and 600/4-82-057 (wastewater samples), USEPA 600/4-88-039, 600/4-91-010 and 600/R-93/100 (drinking water samples) and NIOSH, Manual of Analytical Methods 4th Edition (air samples) . The complete citation for each reference can be found in section 18.0 of this document. The container, preservation and holding time information are summarized in Table 7-1.

CAS routinely provides sample containers with appropriate preservatives for our clients. The containers are purchased as "precleaned" to a level 1 status, and conform to the requirements for analytical sample established by the USEPA. Certificates of analysis for the sampling containers are available upon request. Our sample kits typically consist of foam-lined, precleaned shipping coolers, specially prepared and labeled sample containers individually wrapped in bubble wrap, chain-of-custody (COC) forms, and custody seals. An example of a sample container label and a custody seal is shown in Figure 7-1. Figure 7-2 is a copy of the chain-of-custody form used at CAS. For extremely large sample container shipments, the containers may be shipped in their original boxes. Such shipments will consist of several boxes of labeled sample containers and sufficient materials (bubble wrap, COC forms, custody seals, shipping coolers, etc...) to allow the sampling personnel to process the sample containers and return them to CAS. The proper preservative will be always be added to the sample containers or provided in a separate vial prior to shipment, unless otherwise instructed by the client. CAS keeps client-specific shipping requirements on file and utilizes all major transportation carriers to guarantee that sample shipping requirements (same-day, overnight, etc.) are met. CAS also provides its own courier service that makes regularly scheduled trips to the Buffalo, Rochester area.

Table 7-1
Sample Preservation and Holding Times[a]

DETERMINATION	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Bacterial Tests				
Coliform, Fecal and Total	W	P,G	Cool, 4°C, 0.008% $Na_2S_2O_3$,[d]	6-24 hours[e]
Inorganic Tests				
Acidity	W	P,G	Cool, 4°C	14 days
Alkalinity	W	P,G	Cool, 4°C	14 days
Ammonia	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Biochemical Oxygen Demand (BOD)	W	P,G	Cool, 4°C	48 hours
Bromide	W	P,G	None Required	28 days
Chemical Oxygen Demand (COD)	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Chloride	W	P,G	None Required	28 days
Chlorine, Total Residual	W	P,G	None Required	24 hours
Color	W	P,G	Cool, 4°C	48 hours
Cyanide, Total and Amenable to Chlorination	W	P,G	Cool, 4°C, NaOH to pH>12, plus 0.6 g Ascorbic Acid	14 days
Cyanide, Weak Acid Dissociable	W	P,G	Cool, 4°C, NaOH to pH >12	14 days
Fluoride	W	P,G	None Required	28 days
Hardness	W	P,G	HNO_3 or H_2SO_4 to pH<2	6 months
Hydrogen Ion (pH)	W	P,G	None Required	24 hours
Ignitability	W	G	None Required	14 days
Kjeldahl and Organic Nitrogen	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrate	W	P,G	Cool, 4°C	48 hours
Nitrate-Nitrite	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Nitrite	W	P,G	Cool, 4°C	48 hours
Orthophosphate	W	P,G	Filter Immediately, Cool, 4°C	48 hours
Oxygen, Dissolved (Probe)	W	G, Bottle and Top	None Required	Analyze immediately
Oxygen, Dissolved (Winkler)	W	G, Bottle and Top	Fix on Site and Store in Dark	8 hours
Phenolics, Total	W	G Only	Cool, 4°C, H_2SO_4 to pH<2	28 days
Phosphorus, Elemental	W	G Only	Cool, 4°C	48 hours
Phosphorus, Total	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Residue, Total	W	P,G	Cool, 4°C	7 days
Residue, Filterable (TDS)	W	P,G	Cool, 4°C	7 days
Residue, Nonfilterable (TSS)	W	P,G	Cool, 4°C	7 days
Residue, Settleable	W	P,G	Cool, 4°C	48 hours
Residue, Volatile	W	P,G	Cool, 4°C	7 days

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Silica	W	P Only	Cool, 4°C	28 days
Specific Conductance	W	P,G	Cool, 4°C	28 days
Sulfate	W	P,G	Cool, 4°C	28 days
Sulfide	W	P,G	Cool, 4°C, Add Zinc Acetate plus Sodium Hydroxide to pH>9	7 days
Sulfite	W	P,G	None Required	24 hours
Surfactants (MBAS)	W	P,G	Cool, 4°C	48 hours
Tannin and Lignin	W	P,G	Cool, 4°C	28 days
Temperature	W	P,G	None Required	Analyze immediately
Turbidity	W	P,G	Cool, 4°C	48 hours
Metals				
Chromium VI	W	P,G	Cool, 4°C	24 hours
Mercury	W	P,G	HNO_3 to pH<2	28 days
	S	P,G	Cool, 4°C	28 days
Metals, except Chromium VI and Mercury	W	P,G	HNO_3 to pH<2	180 days
	S	G, Teflon-Lined Cap	Cool, 4°C	180 days
	A	Filters in Cassettes	None Required	180 days
Organic Tests				
Oil and Grease	W	G, Teflon-Lined Cap	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Carbon, Total (TOC)	W	P,G	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Halogens, Total (TOX)	W	G, Teflon-Lined Cap	Cool, 4°C, H_2SO_4 to pH<2	28 days
Organic Halogens, Adsorbable (AOX)	W	G, Teflon-Lined Cap	Cool, 4°C, HNO_3 to pH<2	28 days
Petroleum Hydrocarbons, Total Recoverable	W	G, Teflon-Lined Cap	Cool, 4°C, HCl or H_2SO_4 to pH<2	28 days
Petroleum Hydrocarbons, Total	W	G, Teflon-Lined Cap	Cool, 4°C, HCl or H_2SO_4 to pH<2	7 days until extraction; 40 days after extraction
	S	G, Teflon-Lined Cap	Cool, 4°C	14 days until extraction; 40 days after extraction
Petroleum Hydrocarbons, Volatile (Gasoline-Range Organics)	W	G, Teflon-Lined Septum Cap	Cool, 4°C, HCl to pH<2 No Headspace	14 days
	S	G, Teflon-Lined Cap	Cool, 4°C Minimize Headspace	14 days

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Volatile Organics				
Purgeable Halocarbons	W	G, Teflon-Lined Septum Cap	**No Residual Chlorine Present**: HCl to pH<2, Cool, 4°C, No Headspace **Residual Chlorine Present:** 10% $Na_2S_2O_3$, HCl to pH<2, Cool, 4°C, No Headspace	14 days
	S	G, Teflon-Lined Cap	Cool, 4°C, Minimize Headspace	14 days
Purgeable Aromatic Hydrocarbons (including BTEX and MTBE)	W	G, Teflon-Lined Septum Cap	**No Residual Chlorine Present**: HCl to pH<2, Cool, 4°C, No Headspace **Residual Chlorine Present:** 10% $Na_2S_2O_3$, HCl to pH<2, Cool, 4°C, No Headspace	14 days
	S	G, Teflon-Lined Cap	Cool, 4°C, Minimize Headspace	14 days
Acrolein, Acrylonitrile, Acetonitrile	W	G, Teflon-Lined Septum Cap	Adjust pH to 4-5, Cool, 4°C, No Headspace	14 days
Semivolatile Organics				
Petroleum Hydrocarbons, Extractable (Diesel-Range Organics)	W,S	G, Teflon-Lined Cap	Cool, 4°C	7 days until extraction;[f] 40 days after extraction
EDB and DBCP	W,S	G, Teflon-Lined Cap	Cool, 4°C, HCl to pH<2, No Headspace	28 days
Alcohols and Glycols	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Phenols	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Phthalate Esters	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Nitrosamines	W,S	G, Teflon-Lined Cap	Cool, 4°C, Store in Dark[g]	7 days until extraction;[f] 40 days after extraction
Organochlorine Pesticides and PCBs	W,S	G, Teflon-Lined Cap	Cool, 4°C	7 days until extraction;[f] 40 days after extraction

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Nitroaromatics and Cyclic Ketones	W,S	G, Teflon-Lined Cap	Cool, 4°C, Store in Dark[g]	7 days until extraction;[f] 40 days after extraction
Polynuclear Aromatic Hydrocarbons	W,S	G, Teflon-Lined Cap	Cool, 4°C, Store in Dark[g]	7 days until extraction;[f] 40 days after extraction
Haloethers	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Chlorinated Hydrocarbons	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Organophosphorus Pesticides	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Nitrogen- and Phosphorus-Containing Pesticides	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Chlorinated Herbicides	W,S	G, Teflon-Lined Cap	Cool, 4°C[g]	7 days until extraction;[f] 40 days after extraction
Chlorinated Phenolics	W	G, Teflon-Lined Cap	Cool, 4°C[g]	30 days
Resin and Fatty Acids	W	G, Teflon-Lined Cap	Cool, 4°C[g]	30 days
Industrial Hygiene Solvents	A	IH Air Tubes	None Required	14 days from sample collection
Toxicity Characteristic Leaching Procedure (TCLP)				
Mercury	HW	P,G	Sample: Cool, 4°C TCLP extract: HNO_3 to pH<2	28 days until extraction; 28 days after extraction
Metals, except Mercury	HW	P,G	Sample: Cool, 4°C TCLP extract: HNO_3 to pH<2	180 days until extraction; 180 days after extraction
Volatile Organics	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C Minimize Headspace TCLP extract: Cool, 4°C, HCl to pH<2, No Headspace	14 days until extraction; 14 days after extraction
Semivolatile Organics	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C, Store in Dark[g] TCLP extract: Cool, 4°C, Store in Dark[g]	14 days until TCLP ext'n; 7 days until extraction; 40 days after extraction

Table 7-1 (continued)
Sample Preservation and Holding Times[a]

DETERMINATION	MATRIX[b]	CONTAINER[c]	PRESERVATION	MAXIMUM HOLDING TIME
Organochlorine Pesticides	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C TCLP extract: Cool, 4°C	14 days until TCLP ext'n; 7 days until extraction; 40 days after extraction
Chlorinated Herbicides	HW	G, Teflon-Lined Cap	Sample: Cool, 4°C TCLP extract: Cool, 4°C	14 days until TCLP ext'n; 7 days until extraction; 40 days after extraction
Contract Laboratory Program (CLP)				
Cyanide, Total and Amenable to Chlorination	W	P,G	Cool, 4°C, NaOH to pH 12, plus 0.6 g Ascorbic Acid	12 days[h]
	S	P,G	Cool, 4°C	12 days[h]
Mercury	W	P,G	HNO_3 to pH<2	26 days[h]
	S	P,G	Cool, 4°C	26 days[h]
Metals, except Mercury	W	P,G	HNO3 to pH<2	180 days[h]
	S	P,G	Cool, 4°C	180 days[h]
Volatile Organics	W,S	G, Teflon-Lined Cap	Cool, 4°C, Minimize Headspace	10 days[h]
Semivolatile Organics	W,S	G, Teflon-Lined Cap	Cool, 4°C, Store in Dark[g]	5 days until extraction;[h,i] 40 days after extraction
Organochlorine Pesticides and PCBs	W,S	G, Teflon-Lined Cap	Cool, 4°C	5 days until extraction;[h,i] 40 days after extraction

a See Section 18.0 for sources of holding time information.
b W = Water; S = Soil or Sediment; HW = Hazardous Waste; A = Air
c P = Polyethylene; G = Glass
d For chlorinated water samples
e The recommended maximum holding time is variable, and is dependent upon the geographical proximity of sample source to the laboratory.
f Fourteen days until extraction for soil, sediment, and sludge samples.
g If the water sample contains residual chlorine, 10% sodium thiosulfate is used to dechlorinate.
h Number of days following sample receipt at the laboratory.
i Ten days until extraction for soil, sediment, and sludge samples.

Figure 7-1
Sample Container Label and Custody Seal

CLIENT: JOB#: 006
LOCATION:
DATE SAMPLED:
ANALYSIS:
PRESERVATIVE:
COMMENTS:

Custody Seal

Date_____Project _____

Signature_____Container#_____of _____

Columbia Analytical Services, Inc.
An Employee-Owned Company
www.caslab.com

CHAIN OF CUSTODY/LABORATORY ANALYSIS REQUEST FORM

One Mustard St., Suite 250 • Rochester, NY 14609-0859 • (716) 288-5380 • 800-695-7222 x11 • FAX (716) 288-8475 PAGE _____ OF _____

SR #

CAS Contact

Project Name	Project Number
Project Manager	Report CC
Company/Address	
Phone #	FAX#
Sampler's Signature	Sampler's Printed Name

ANALYSIS REQUESTED *(Include Method Number and Container Preservative)*

PRESERVATIVE

NUMBER OF CONTAINERS

GC/MS VOA's ☐ 8260 ☐ 624 ☐ CLP
GC/MS SVOA's ☐ 8270 ☐ 625 ☐ CLP
GC VOA's ☐ 8021 ☐ 601/602
PESTICIDES/ PCB's ☐ 8081 ☐ 608 ☐ CLP ☐ 8082
STARS LIST 8021 ☐ TOTAL ☐ TCLP VOA's
STARS LIST 8270 ☐ TOTAL ☐ TCLP SVOA's
TCLP ☐ VOA's ☐ METALS ☐ SVOA's ☐ HP
WASTE CHARACTERIZATION ☐ React. ☐ Corros. ☐ Ignit.
METALS, TOTAL (List in comments below)
METALS, DISSOLVED (List in comments below)

Preservative Key
0. NONE
1. HCL
2. HNO_3
3. H_2SO_4
4. NaOH
5 Zn. Acetate
6. MeOH
7. $NaHSO_4$
8. Other _____

REMARKS/ ALTERNATE DESCRIPTION

CLIENT SAMPLE ID	FOR OFFICE USE ONLY LAB ID	SAMPLING DATE	SAMPLING TIME	MATRIX

SPECIAL INSTRUCTIONS/COMMENTS
Metals

See QAPP ☐

TURNAROUND REQUIREMENTS
_____ RUSH (SURCHARGES APPLY)
____ 24 hr ____ 48 hr ____ 5 day
_____ STANDARD
REQUESTED FAX DATE
_____
REQUESTED REPORT DATE
_____

REPORT REQUIREMENTS
___ I. Results Only
___ II. Results + QC Summaries (LCS, DUP, MS/MSD as required)
___ III Results + QC and Calibration Summaries
___ IV. Data Validation Report with Raw Data
___ V. Specialized Forms / Custom Report
Edata ____ Yes ____ No

INVOICE INFORMATION
PO#
BILL TO:
SUBMISSION #:

SAMPLE RECEIPT: CONDITION/COOLER TEMP: _____ CUSTODY SEALS: Y N

RELINQUISHED BY	RECEIVED BY	RELINQUISHED BY	RECEIVED BY	RELINQUISHED BY	RECEIVED BY
Signature	Signature	Signature	Signature	Signature	Signature
Printed Name	Printed Name	Printed Name	Printed Name	Printed Name	Printed Name
Firm	Firm	Firm	Firm	Firm	Firm
Date/Time	Date/Time	Date/Time	Date/Time	Date/Time	Date/Time

Distribution: White - Return to Originator; Yellow - Lab Copy; Pink - Retained by Client

SCOC-0402-40

Figure 7-2
Chain of Custody Form

8.0 SAMPLE CUSTODY

Standard Operating Procedures have been established for the receiving of samples into the laboratory. These procedures ensure that samples are received and properly logged into the laboratory, and that all associated documentation, including chain of custody forms, is complete and consistent with the samples received.

Sample Acceptance Policy:

Samples delivered to the CAS Sample Management Office (SMO) and are received by a Sample Custodian. The Chain of Custody (COC) is reviewed for completeness and accuracy and a Cooler Receipt and Preservation Form (CRPF) (Figure 8-1) is used to document the condition of the cooler and its contents as received by the sample custodian. Verification of sample integrity by the Sample Custodian includes the following activities:

- Assessment of custody seal presence/absence, location and signature.
- Temperature of sample containers upon receipt.
- Chain of custody documents present and properly completed.

  Entries should be made in blue or black ink and at a minimum, shall include sample identification, description, date, time, and location of sample collection, the name and signature(s) of the sample collector and intermediate sample custodian(s), date and time of each sample transfer, and signature of the CAS Sample Custodian upon receipt. For an example COC, see Figure 7-2.
- Sample containers checked for integrity (broken, leaking, etc...)
- Sample is clearly marked with the sample ID, date and time of collection.
- Appropriate containers (size, type) are received for the requested analyses.
- Sample container labels and/or tags agree with chain of custody entries (Identification, required analyses, etc...)
- Assessment of proper sample preservation (If inadequate, corrective action is employed).
- VOC containers are inspected for the presence/absence of bubbles. (No assessment of proper preservation is performed for VOC containers by SMO personnel).

Any anomalies or discrepancies observed during the initial assessment are recorded on the CRPF and/or chain of custody documents. All potential problems with a sample shipment are addressed by contacting the client and discussing the pertinent issues. When the Project Manager and client have reached a satisfactory resolution, the log-in process may commence. The laboratory has formally accepted the samples. If resolution cannot be reached with the client

or the samples do not comply with the requirements of the CRPF, these samples may be rejected by the laboratory.

Sample Log-in;

During the log-in process, each sample is given a unique laboratory code and an analytical request form is generated. The laboratory code consists of an order number and submission number. Each sample is given an order number by the LIMS system based upon the order of log-in. A submission number is assigned to a particular job in the same manner. The submission number is coded with the lab location and year as follows:

e.g. Submission No. R20001784 = R - Rochester
20 - Year 2000
001784 - Job Number (sequential number of jobs logged)

The analytical request contains client information, sample descriptions, sample matrix information, required analyses, sample collection dates, analysis due dates and other pertinent information. This analytical request is reviewed by the appropriate Project Manager for accuracy, completeness, consistency of requested analyses and for client project objectives and COC.

Each container received by the lab receives a unique barcode which is scanned by those handling the sample for storage, analysis, or disposal. The sample tracking information from the scan is put in a database which can create a complete Internal Chain of Custody for each sample container. This information is reported in package reports only.

All samples, except those designated for metals analyses, are kept in a refrigerated condition until they undergo analysis. CAS stores samples in one of three walk-in refrigerators. These refrigerators are segregated by method of analysis. The temperature of each storage facility used at CAS is monitored daily and the data recorded in a logbook.

Disposal:

Upon completion of all analyses, most aqueous and soil samples and sample extracts are retained at 0-6°C refrigerators for 30 days (unless other arrangements have been made in advance). Upon expiration of these time limits, the samples are either returned to the client or disposed of according to approved disposal practices. All samples are characterized according to hazardous/non-hazardous waste criteria and are segregated accordingly. All hazardous waste samples are disposed of according to formal procedures outlined in the Sample Disposal SOP (SMO-SPLDIS). It should be noted that all waste produced at the laboratory, including the laboratory's own various hazardous waste streams, is treated in accordance with all applicable local and Federal laws. The bar coding system used to track samples through the lab, including disposal, produces cradle to grave sample history for each sample aliquot.

Figure 8-1

Cooler Receipt And Preservation Check Form

Project/Client_____ Submission Number_____

Cooler received on_____ by:_____ **COURIER:** CAS UPS FEDEX CD&L CLIENT

1.	Were custody seals on outside of cooler?	YES	NO		
2.	Were custody papers properly filled out (ink, signed, etc.)?	YES	NO		
3.	Did all bottles arrive in good condition (unbroken)?	YES	NO		
4.	Did any VOA vials have significant air bubbles?	YES	NO	N/A	
5.	Were **Ice** or **Ice packs** present?	YES	NO		
6.	Where did the bottles originate?	CAS/ROC,	CLIENT		
7.	Temperature of cooler(s) upon receipt:	_____	_____	_____	_____ _____
	Is the temperature within 0° - 6° C?:	Yes	Yes	Yes	Yes Yes
	If No, Explain Below	No	No	No	No No

Date/Time Temperatures Taken: _____

Thermometer ID: 161 or IR GUN Reading From: Temp Blank or Sample Bottle

If out of Temperature, Client Approval to Run Samples_____

Cooler Breakdown: Date :_____ by:_____

1.	Were all bottle labels complete (*i.e.* analysis, preservation, etc.)?	YES	NO
2.	Did all bottle labels and tags agree with custody papers?	YES	NO
3.	Were correct containers used for the tests indicated?	YES	NO
4.	Air Samples: Cassettes / Tubes Intact Canisters Pressurized Tedlar® Bags Inflated		N/A

Explain any discrepancies: _____

		YES	NO	Sample I.D.	Reagent	Vol. Added
pH	Reagent					
12	NaOH					
2	HNO_3					
2	H_2SO_4					
Residual Chlorine (+/-)	for TCN & Phenol					
5-9**	P/PCBs (608 only)					

YES = All samples OK NO = Samples were preserved at lab as listed PC OK to adjust pH_____

**If pH adjustment is required, use NaOH and/or H_2SO_4

VOC Vial pH Verification (Tested after Analysis) Following Samples Exhibited pH > 2				

Other Comments:

P:\QAQC\QA_DOCUM\SOP\DRAFT\Attachments\Cooler Receipt And Preservation Check Form.doc

9.0 QUALITY CONTROL OBJECTIVES (PRECISION, ACCURACY, SENSITIVITY, AND COMPLETENESS)

A primary focus of Columbia Analytical Services Quality Assurance (QA) Program is to ensure the accuracy, precision and comparability of all analytical results. CAS has established Quality Control (QC) objectives for precision and accuracy that are used to determine the acceptability of the data that is generated in its laboratories. These QC limits are either specified in the methodology or are statistically derived and are based on the laboratory's actual historical data obtained from control-charting the various QC measurements for each analytical method. The Quality Control objectives are defined below and the acceptable numeric values are shown in the table in Appendix C. The actual types of QC samples required for analysis is discussed in the specific analytical SOP.

9.1 Accuracy

Accuracy is a measure of the closeness of an individual measurement (or an average of multiple measurements) to the true or expected value. Accuracy is determined by calculating the mean value of results from ongoing analyses of standard reference materials, standard solutions and laboratory-fortified blanks. In addition, laboratory-fortified (i.e. matrix-spiked) samples are also measured; this indicates the accuracy or bias in the actual sample matrix. Accuracy is expressed as percent recovery (% REC) of the measured value, relative to the true or expected value. The acceptance limits for accuracy (shown in the table in Appendix C) originate from two different sources: Where acceptance limits are defined and stated in the individual methods, CAS has adopted the limits without modification. If no acceptance limits are given in a method, CAS adopts the limits derived from control charts that are generated for each appropriate method. These control charts are updated once a year for the appropriate Surrogate, Laboratory Control Sample, and Matrix Spike compounds.

$$\text{Accuracy (\%REC)} = \frac{A - B}{C} \times 100$$

Where A = Analyte total concentration from spiked sample
B = Analyte concentration from unspiked sample
C = Concentration of spike added

9.2 Precision

Precision is the ability of an analytical method or instrument to reproduce its own measurement. It is a measure of the variability, or random error, in sampling, sample handling and in laboratory analysis.

Precision is measured through the use of replicate sample analyses within the same batch and is expressed as the relative percent difference (RPD) between the replicate measurements.

$$RPD = \frac{D1 - D2}{(D1+D2)/2} \times 100$$

Where D1 = Original Result
D2 = Duplicate Result

9.3 Practical Quantitation Limits

The PQLs used at CAS are the routinely reported lower limits of quantitation which take into account day-to-day fluctuations in instrument sensitivity as well as other factors. These PQLs are the levels to which CAS routinely reports results in order to minimize false positive or false negative results. The PQL is normally two to ten times the method detection limit (MDL), which is determined by a procedure outlined in 40 CFR 136, Appendix B. MDLs for analytical methods routinely performed at CAS are determined annually.

9.4 Completeness

Completeness is a measure of the amount of valid data that is obtained, compared to the amount that is expected. It is expected that all analyses conducted in accordance with the approved analytical methods and standard laboratory operating procedures will meet QC acceptance criteria for 95% if the samples tested, however, the CAS objective for completeness is 100%.

$$\text{Completeness (\%)} = \frac{\text{valid data obtained}}{\text{total data planned}} \times 100$$

9.5 Representativeness

Representativeness is the degree to which a samples aliquot that is analyzed gives results identical to analysis of the whole. CAS has sample handling protocols to ensure that the sample given to the laboratory for analysis is thoroughly homogenized before the aliquot for analysis is removed. Further, analytical SOPs specify appropriate sample sizes to further ensure the sample aliquot that is analyzed is representative of the whole.

9.6 Comparability

Comparability expresses the confidence with which one data set can be compared to another. To ensure comparability, SOPs are used for the preservation, handling, and analysis of all samples. Data is reported in units specified by the customer.

10.0 QUALITY CONTROL PROCEDURES

The specific types, frequencies, and processes for quality control sample analysis are described in detail in method-specific standard operating procedures. These sample types and frequencies have been adopted for each method and a definition of each type of QC sample is provided below. In addition, a number of other quality control processes which may impact analytical results are also described below.

10.1 Modified Procedures

CAS strives to perform published methods as described in the referenced documents. If there is a material deviation from the published method, the method is cited as a "Modified" method in the analytical report. Standard operating procedures are available to analysts and are also available to our clients for review. If the modification is such that the method becomes "Performance Based," client approval is obtained for the use of the method prior to the performance of the analysis.

10.2 Procedures for Accepting New Work

Due to the increase in analytes used in the industry and found in the environment, analytes are requested to be analyzed using existing methodologies and/or new methodologies. These requests must be reviewed prior to accepting new work and creating new methodologies. These requests typically include:

1. The addition of analytes to an existing scan.
2. Complete start-up of an established method.
3. Analyte(s) requested with no established method.
4. Specific Confidentiality requests

The addition of analytes to an existing scan.
The analytical method is reviewed to determine if its use is appropriate for the new analyte. The standards are purchased from a commercial vendor and prepared. If the analyte is available from more than one source, a second source may be purchased to verify the calibration standard. A reference is spiked with a mid-level concentration of the appropriate standard and analyzed to determine retention time, resolution, etc. Temperature programs and instrument conditions may be modified to optimize resolution for the analyte. If the analyte may be resolved and detected by the method, an MDL study is performed to determine a detection limit suitable for the analyte. An in-house SOP may be written or modified to include the analyte.

Complete start-up of an established method
The method is obtained and reviewed by the analyst, technical manager, and/or supervisor to determine if the instrumentation and reagents needed by the method are available. If the required instrumentation is available, then reagents, standards, equipment, and supplies are gathered and purchased. If the analyte(s) are available from more than one source, a second source may be purchased to verify the calibration source. A qualified analyst performs the method, elution times are determined, temperature programs are optimized, and batch QC is performed to monitor accuracy and precision. An MDL study is performed to determine detection limit(s) and each analyst performing the method must complete an Initial Demonstration of Capability (IDC) study. An SOP is written and used by the analysts.

Analyte(s) requested with no established method.
The analyte to be analyzed is researched and reviewed by the technical manager for chemical nature, formula, and other related information. The Merck Index and CRC Handbook are reviewed for boiling point, vapor pressure to determine the type of compound. After determining the type of compound, it is assumed that it can be analyzed by an existing method. If not, perhaps a modification of a method or the creation of a method could be tried. The different approaches to testing the analyte may be tried, comparing the efficiency of the various approaches. The method, which allows for the acceptable precision and accuracy, shall be used. Follow procedures outlined in (10.1).

Specific confidentiality requests
Investigate the confidentiality requests of the client. The client may have specific requests regarding the release of the report/data, the retention of the samples and the data, and the disposal of the samples.

10.3 Analytical Batch

The basic unit for analytical quality control is the analytical batch. An analytical batch is that all the samples in a batch, both field samples and quality control samples, are to be handled and processed in exactly the same way, and all of the data from each analysis is to be manipulated in exactly the same manner.

The minimum requirements of an analytical batch are:

1. The number of field samples in a batch is not to exceed 20.

2. All field samples in a batch are of the same matrix.

3. The QC samples to be processed with the field samples include:
   - Method Blank - to determine possible laboratory contamination.
   - Laboratory Control Sample - to assess method performance.
   - Matrix Spike (field sample) - to assess possible matrix problems.
   - Duplicate Matrix Spike or Duplicate (field) Sample - to assess batch precision and possible matrix problems.

4. A single lot of reagents is used to process the batch of samples.

5. Refer to SOP, *Analytical Batches and Sequences* (ADM-BCHSQ), for additional batching requirements. Specific project, program or method requirements may create exceptions. The more stringent QC requirements shall be followed in most all cases.

10.4 Method Blank

The method blank is either analyte-free water or analyte-free soil (when available), subjected to the entire analytical process. When analyte-free soil is not available, anhydrous sodium sulfate, organic-free sand, or an acceptable substitute may be used instead. The method blank is analyzed to demonstrate that the analytical system itself is not contaminated with the analyte(s) being measured. The method blank results should be below the reporting limit for the analyte(s) being tested. A method blank is included with the analysis of every analytical batch, every 20 samples, or as stated in the method, whichever is more frequent.

For Industrial Hygiene samples, blanks shall be analyzed with each batch of samples to detect and measure possible contamination of sampling media and reagents used for analysis. Blanks should be supplied by the client as a representative sampling media of the same lot or batch as the field samples.

10.5 Calibration Blanks

Calibration blanks are prepared along with calibration standards. Calibration blanks are free of the analyte of interest, and provide the zero point of the calibration curve.

10.6 Continuing Calibration Blanks

Continuing calibration blanks (CCBs) are solutions of either analyte-free water or solvent that are analyzed in order to verify the zero point of the analytical system. The frequency of CCB analysis is either once every ten samples or as indicated in the method, whichever is greater.

10.7 Calibration Standards

Calibration standards are solutions of known concentration prepared from primary standard solutions which are, in turn, prepared from stock standard materials. Calibration standards are used to calibrate the instrument response with respect to analyte concentration. Standards are analyzed in accordance with the requirements stated in the particular method being used.

10.8 Initial (or Independent) Calibration Verification Standards

Initial (or independent) calibration verification standards (ICVs) are standards that are analyzed *after* calibration but *prior to* sample analysis, in order to verify the calibration of the analytical system. They are prepared from materials obtained from a source independent of that used for preparing the calibration standards. ICVs are also analyzed in accordance with method-specific requirements.

10.9 Continuing Calibration Verification Standards

Continuing calibration verification standards (CCVs) are midrange standards that are analyzed in order to verify that the calibration of the analytical system is still acceptable. The frequency of CCV analysis is either once every ten samples, or as indicated in the method, whichever is greater.

10.10 Internal Standards

Internal standards consist of known amounts of specific compounds that are added to each sample following sample preparation or extraction. Internal standards are generally used for GC/MS and ICP-MS procedures to correct sample results that have been affected by changes in instrument conditions or changes caused by certain matrix effects. The integrated area of the internal standard compared to the continuing calibration check standard should vary by no more than the limits specified in each method.

10.11 Surrogates

Surrogates are organic compounds which are similar in chemical composition and chromatographic behavior to the analytes of interest, but which are not normally found in environmental samples. Depending on the analytical method, one or more of these compounds is added to method blanks, calibration and check standards, and samples (including duplicates, matrix spike samples, duplicate matrix spike samples and laboratory control samples) prior to extraction and analysis in order to monitor the method performance on each sample. The percent recovery is calculated for each surrogate, and the recovery is a measurement of the overall method performance. The acceptance criteria for these various analytes are listed in Appendix C, along with other data quality capabilities.

10.12 Matrix Spikes

Matrix spiked samples are aliquots of samples to which a known amount of the target analyte (or analytes) has been added. The samples are then prepared and analyzed in the same analytical batch, and in exactly the same manner as are routine samples. The spike recovery measures the effects of interferences caused by the sample matrix and reflects the accuracy of the method for the particular matrix in question. Spike recoveries are calculated as discussed in Section 9.1.

For the appropriate methods, matrix spiked samples are prepared and analyzed at a minimum frequency of one spiked sample (and one duplicate spiked sample, if appropriate) per twenty samples. Control limits are summarized in Appendix C.

Matrix spikes are not applicable with industrial hygiene sampling media for air analysis.

Note: A sample identified as a field blank, equipment blank, or trip blank is not to be matrix spiked.

10.13 Laboratory Duplicates and Duplicate Matrix Spikes

Duplicates are additional replicates of samples that are subjected to the same preparation and analytical scheme as the original sample. Depending on the method of analysis, either a duplicate analysis (and/or a matrix spiked sample) or a matrix spiked sample and matrix spike duplicate sample (MS/MSD) are analyzed. The relative percent difference between duplicate analyses or between an MS and MSD is a measure of the precision for a given method and analytical batch. The relative percent difference (RPD) for these analyses is calculated as discussed in Section 9.2.

Depending on the method of analysis, either duplicate and/or matrix spike duplicate analyses are performed at a minimum frequency of one set per 20 samples. Control limits are summarized in Appendix C.

Duplicate analysis is not applicable with industrial hygiene sampling media for air analysis.

Note: A sample identified as a field blank, equipment blank, or trip blank is not to be duplicated.

10.14 Laboratory Control Samples

The laboratory control sample (LCS) is an aliquot of analyte-free water or analyte-free soil (or anhydrous sodium sulfate or equivalent) to which known amounts of the method analyte(s) is(are) added. A standard reference material (SRM) of known matrix type, containing certified amounts of target analytes, may also be used as an LCS. The LCS sample is prepared and analyzed in the same analytical batch, and in exactly the same manner, as the other routine samples. Stock solutions used for LCSs are purchased or prepared independently of calibration standards. The percent recovery (% REC.) of the target analytes in the LCS assists in determining whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements at the required reporting limit. Comparison of batch-to-batch LCS analyses enables the laboratory to evaluate batch-to-batch precision and accuracy. An LCS is prepared and analyzed at a minimum frequency of one LCS per 20 samples, with every analytical batch or as stated in the method, whichever is more frequent. Acceptance criteria for LCS analyses are summarized in Appendix C.

For industrial hygiene samples (air) LCSs shall be performed in duplicate to assess accuracy and precision for each batch, not to exceed 10 samples. Acceptance criterion of 80 – 120% shall be used until enough data points are available to statistically generate a lab QC limit.

10.15 Interference Check Samples

An interference check sample (ICS) is a solution containing both interfering and analyte elements of known concentration that can be analyzed to verify background and interelement correction factors in metals analyses. The ICS is prepared to contain known concentrations of interfering elements that will provide an adequate test of the correction factors. The ICS is spiked with the elements of interest at concentrations of approximately ten times the instrument detection limits. The ICS is analyzed at the beginning and end of an analytical run or every eight hours, whichever is more frequent, and the results must be within ± 20% of the true values.

10.16 Post Digestion Spikes

Post digestion spikes are samples prepared for metals analyses that have an analyte spike added to determine if matrix effects may be a factor in the results. The spike addition should produce a method-specified minimum concentration above the instrument detection limit. A post digestion spike is analyzed with each batch of samples and recovery criteria are specified for each method.

10.17 Source and Preparation of Standard Reference Materials

CAS relies on a primary vendor for the majority of its analytical supplies. In addition, consumable primary stock standards are obtained from certified commercial sources or from sources referenced in a specific method, as discussed in section 4.2.2 of this document. All reference materials that are received at CAS are recorded by the technical staff in the appropriate notebook(s) and are stored under conditions that provide maximum protection against deterioration and contamination. The notebook entry includes such information as an assigned logbook identification code, the source of the material (i.e. vendor identification), solvent (if applicable) and concentration of analyte(s), reference to the certificate of analysis and an assigned expiration date. In addition, the date that the standard is received in the laboratory is marked on the container.

Stock solutions and/or calibration standard solutions are prepared fresh as often as necessary according to their stability. After preparation, all standard solutions are properly labeled as to name, concentration, date, preparer, and expiration date; these entries are also recorded in the appropriate notebook. See SOP, *Making Entries onto Benchsheets and Logbooks* (ADM-DATANTRY). To ensure traceability, all standards are labeled with an in-house code that can be traced back to the original stock standard received by the vendor and thus, the certificate of analysis. Prior to introduction into the analytical system/process, all reference materials are verified for accuracy with a second, independent source of the material. In addition, the independent source of reference

material is also used to check the calibration standards for signs of deterioration. All standards shall be stored per analytical SOP requirements.

10.18 Control Charting

The generation of control charts is performed annually at CAS. MS, LCS, and Surrogate recoveries are monitored and charted for key parameters to determine new control limits using the data generated in the previous year.. After review of the data by the Quality Assurance Program Manager, the new acceptance criteria may replace the previous criteria and method conformity is assessed using the new values. See SOP for *Determination of Statistical Control Limits* (ADM-CRTL-LIM). Old charts are archived for a period of 10 years.

10.19 Proficiency Testing Participation

Each discipline and test method for most analytes are monitored using NIST approved vendors for Proficiency Testing on a semi-annual basis. Results of the proficiency samples are reviewed by the Laboratory Director, the QA PM, the Corporate QA Director and the laboratory staff. Any problems surfacing during the review are investigated, and corrective action is taken regarding any and all deficiencies.
Interlaboratory Proficiencies are performed annually to determine continued lab performance throughout the network of CAS laboratories. Such studies are organized by Corporate QA. Proficiency test results are also used to show continued acceptable performance per analyst.

10.20 Glassware Washing

Glassware washing and maintenance play an crucial role in the daily operation of a laboratory. The glassware used at CAS undergoes a rigorous cleansing procedure prior to every usage. Departmental specific glassware washing SOP's (GEN-GC, MET-GC and EXT-GC) have been generated that outline the various procedures used at CAS; each is specific to the end-use of the equipment as well as to the overall analytical requirements of the project.

11.0 CALIBRATION PROCEDURES AND FREQUENCY

All equipment and instruments used at CAS are operated, maintained and calibrated according to the manufacturer's guidelines and recommendations, as well as to criteria set forth in the applicable analytical methodology. Operation and calibration are performed by personnel who have been properly trained in these procedures. Documentation of calibration information is maintained in appropriate reference files. The frequency of calibration and concentration of calibration standards are determined by the manufacturers guidelines, the analytical method, or the requirements of special contracts. See specific analytical SOP's for frequency and criteria. Generally, purchased standards have a shelf life of 12-36 months and prepared standards have a shelf life of 1-12 months. Recalibration is required at anytime that the instrument is not operating correctly or functioning at the proper sensitivity. Brief descriptions of the calibration procedures for our major laboratory equipment and instruments are described below.

11.1 Temperature Control Devices

Temperatures are monitored and recorded for all of our temperature-regulating devices including ovens, incubators and refrigerators. Bound record books are kept which contain recorded temperatures, identification and location of equipment, and the initials of the technician who performed the checks. All thermometers have been identified and the calibration of these thermometers is checked annually against a National Institute of Standards and Technology (NIST) certified thermometer. Calibration records are maintained by the QA PM. (See SOP SMO-DALYCK).

11.2 Analytical Balances

Analytical balances are serviced on an annual basis by a professional metrology organization. New certificates of calibration for each balance are issued to the laboratory on an annual basis. The calibration of each analytical balance is checked prior to use with Class-1 verified weights, which assess the accuracy of the balance at the working range. Bound record books are kept which contain the recorded measurements, identification and location of equipment, and the initials of the technician who performed the checks. (See SOP SMO-DALYCK).

11.3 Inductively Coupled Plasma (ICP)

Each emission line on the ICP is calibrated daily against a blank and against standards. Analyses of calibration standards, initial and continuing calibration verification standards, and inter-element interference check samples are carried out as specified in the applicable method being utilized (see Section 18.0 for references).

11.4 Atomic Absorption Spectrophotometers (AAS)

These instruments are calibrated daily using a minimum of four standards and a blank. Calibration is validated using reference standards, and is verified at a minimum frequency of once every ten samples.

11.5 GC/MS Systems

All GC/MS instruments are calibrated daily at five different concentration levels for the analytes of interest, using procedures outlined in Standard Operating Procedures (SOPs) and/or appropriate USEPA method citations. All SRMs used for this function are "EPA-Certified." Compounds selected as system performance check compounds (SPCCs) must show a method-specified response factor in order for the calibration to be considered valid. Calibration check compounds (CCCs) must also meet method specifications for percent difference from the multipoint calibration. Method-specific instrument tuning is regularly checked using bromofluorobenzene (BFB) for volatile organic chemical (VOC) analysis, or decafluorotriphenylphosphine (DFTPP) for semi-volatile analysis. Mass spectral peaks for the tuning compounds must conform both in mass numbers and in relative intensity criteria before analyses can proceed.

11.6 Gas Chromatographs

Calibration and standardization follow SOP guidelines and/or appropriate USEPA method citations. Initial calibration standards are prepared at three to five concentration levels for each analyte of interest. The lowest standard is near the method reporting limit; additional standards define the working range of the GC detector. Results are used to establish response factors and retention-time windows for each analyte. Calibration is verified at a minimum frequency of once every ten samples.

11.7 Infrared Analyzer

The instrument is calibrated using a blank and four standards. The calibration is validated at the beginning of each analysis, and continuing calibration is verified at a minimum frequency of once every ten samples.

11.8 UV-Visible Spectrophotometer (manual colorimetric analyses)

Routine calibrations for colorimetric and turbidimetric analyses involve generating a 5-point calibration curve including a blank. Correlation coefficients must meet method or SOP specifications before analysis can proceed. Independent calibration verification standards (ICVs) are analyzed with each batch of samples. Continuing calibration is verified at a minimum frequency of once every ten samples.

11.9 Flow Injection Analyzer (automated colorimetric analysis)

A minimum of five standards and a blank are used to calibrate the instrument daily. Standard CAS acceptance limits are used to evaluate the calibration curve prior to sample analysis. All linear regressions must have a correlation coefficient of 0.995 or better before analysis may proceed.

11.10 Ion Chromatographs

Calibration of the ion chromatograph (IC) involves generating a 5-point calibration curve. A correlation coefficient of 0.995 or better for the curve is required before analysis can proceed. Quality Control (QC) samples that are routinely analyzed include blanks and laboratory control samples. The target analytes typically determined by the IC include nitrate, chloride, fluoride, and sulfate.

11.11 Turbidimeter

Calibration of the turbidimeter requires analysis of formazin and polymer standards measured as NTU. Quality Control samples that are routinely analyzed include blanks, and duplicates.

11.12 Ion-selective electrode

Two standards are used to calibrate the electrodes before analysis. The slope of the curve must be within acceptance limits before analysis can proceed. Quality Control samples that are routinely analyzed include blanks, LCSs and duplicates.

11.13 Other Instruments

Calibration for the total organic carbon (TOC) and other instruments is performed following manufacturer's recommendations and applicable SOPs.

12.0 DATA REDUCTION, VALIDATION, AND REPORTING

CAS reports the analytical data produced in its laboratories to the client via the certified analytical report (CAR). This report typically includes a transmittal letter, a case narrative, client project information, specific test results, quality control data, chain of custody information, and any other project-specific support documentation. The following procedures describe our data reduction, validation and reporting procedures.

12.1 Laboratory Information Management System (LIMS)

CAS/Rochester currently uses StarLIMS v.6.11a throughout the laboratory. This data management and retrieval system is the PC based StarLIMS that runs on a Novell Network. The LIMS is used for sample tracking, sample workload projections, sample result storage, reporting, and invoicing. The system allows you to acquire data from instrumentation and can generate ASCII, spreadsheet, database, and/or print files.
Periodically, historical data is checked on the LIMs for authenticity and ability to recreate data files. These files are reviewed for data integrity and possible corruption. See Software Quality Assurance Plan.

12.2 Data Reduction and Custody

All data is initially reviewed and processed by analysts using appropriate methods (e.g. chromatographic software, instrument printouts, hand calculation, etc.) The resulting data set is either manually entered (e.g. some general chemistry parameters) into the LIMS system or is electronically transferred into LIMS from the software used to process the original data set (e.g. chromatographic software). A file of all raw data is generated and given to the departmental supervisor or other certified analyst for secondary review. Once the complete data set has been reviewed to be complete and correct by two analysts, the LIMs data is validated against the raw data which allows the data to be available to Project Managers and Report Writers. Upon approval of the data the supervisor relinquishes the raw data file to a Report Writer, who generates a final report from the LIMS system. The resulting final report is then reviewed by the Project Manager for accuracy. Typically, all data is reported in the units and MRLs listed in Appendix C. Assessment of the analytical data includes a check on data consistency by looking for comparability of duplicate analyses, comparability of previous data from the same sampling location (if available), adherence to accuracy and precision control limits, and anomalous low or high parameter values. Once the data has been checked for accuracy and acceptability, the final report and raw data is forwarded to the Lab Director or Quality Assurance Project Manager, who further reviews the data package for errors. When the entire data set has been found to be acceptable the report is signed, distributed, and the raw data is filed for approximately one year, then archived.

All hard copy and electronic backups are archived in a secured room for a period of at least 5 years from the date of the final report (as discussed in section 12.6.1). It is not unusual to have various clients require a 10-year retention of records, therefore, the archivist, project manager, and possibly the client are consulted prior to the destruction of the records.

12.3 Confirmation Analysis

12.3.1 Gas Chromatographic Analyses

For gas chromatographic (GC) analyses, most positive results are confirmed by a second column, a second detector, or by GC/MS analysis, unless exempted by one of the following situations:

- The analyte of interest produces a chromatogram containing "pattern" peaks which match appropriate standards. These analytes include polychlorinated biphenyls (PCBs) and hydrocarbon fuels (e.g., gasoline and diesel).

- The sample is analyzed for benzene, toluene, ethylbenzene and xylenes (BTEX), and the sample is found, by a separate analysis, to contain gasoline. In a sample containing no gasoline, the presence of BTEX compounds will be confirmed.

- The sample meets all of the following requirements:

    1. All samples (liquid or solid) come from the same source (e.g., groundwater samples from the same well) for continuous monitoring.

    2. All analytes have been previously analyzed, identified and confirmed by a second column or by GC/MS. The documents indicating previous confirmation must be available for review.

    3. The resulting chromatogram is relatively simple and does not contain complex or overlapping peaks.

    4. The chromatogram is largely unchanged from the one for which confirmation was carried out.

12.3.2 Confirmation Data

Confirmation data will be provided as specified in the method. Identification criteria for GC or GC/MS methods are summarized below:

- GC Methods - The analyte must fall within plus or minus three times the standard deviation (SD) of the retention time of the daily midpoint standard in order to be qualitatively identified. The retention-time windows will be established and documented, as specified in the appropriate Standard Operating Procedure (SOP).

- GC/MS Methods - Two criteria are used to verify identification:

  1. Elution of the analyte in the sample will occur at the same relative retention time (RRT) as that of the analyte in the standard.

  2. The mass spectrum of the analyte in the sample must, in the opinion of a qualified analyst or the department manager, correspond to the spectrum of the analyte in the standard or the current GC/MS reference library.

12.4 Data Validation

The integrity of the data generated in the laboratory is primarily assessed by the analyst, supervisor and project manager through the use of a variety of measures that may include reagent blanks, laboratory fortified blanks, duplicates, matrix spikes and QC samples. The numerical criteria for evaluation of these QC samples are listed in Appendix C; these various QC sample analyses are evaluated using the flow diagrams found in Figures 12-1 through 12-9. Other validation measures of the data include a check of the linearity of the calibration curve, an accuracy check of the QC standards and a check of the system sensitivity. Data transcriptions and calculations are also reviewed. Specific calculations used for determining the concentration or value of the measured parameters from the raw data are given in each of the analytical methods or CAS SOPs.

12.5 Data Reporting

When an analyst determines that the data has met the data quality objectives (and/or any client-specific data quality objectives) of the method and has qualified any anomalies in a clear, acceptable fashion, the data is validated by the supervisor. Validated data is reported from LIMS by report writers using specialized forms created by LIMS (see SOP, ADM-RG). Prior to release of the report to the client, the project manager must also review the entire body of data for completeness and to ensure that any and all client-specified objectives were successfully achieved. If required, samples exceeding any established state/federal maximum contaminant level or reportable concentration level, must be reported to the client. A case narrative may be written by the project manager to explain any unusual problems with a specific analysis or sample, client-specific objectives, exceedences, etc... The original raw data, along with a copy of the final report, is filed for archiving. CAS maintains control of analytical results by adhering to standard operating procedures and by observing sample custody requirements. All data are calculated and reported in units consistent with project specifications, to enable easy comparison of data from report to report. Typical qualifiers used to flag analytical results are listed in Appendix D.

12.6 Documentation

A document control system ensures that all documents are accounted for when the project is complete. A submission number is assign to each project for reporting and filing purposes. This number is associated with each order number (sample).

12.6.1 Documentation and Archiving of Routine Analysis Data

The archiving system includes all of the following items for each set of analyses performed:

- Benchsheets describing sample preparation (if appropriate)
- Instrument parameters
- Sample analysis sequence
- Analysis benchsheets and instrument printouts
- Chromatograms and peak integration reports for all samples, standards, blanks, spikes and reruns
- Log book ID number for the appropriate standards
- Copies of report submitted to the client

Individual sets of analyses are indexed by analysis date and/or submission number. Since many analyses are performed with computer-based data systems, the final sample concentrations can be automatically calculated. If additional calculations are needed, they are written on the integration report or securely stapled to the chromatogram, if done on a separate sheet. The archive room is a separte file room in which files shall be maintained for a period of at least five years (from date of report issue). It is not unusual to have various clients require a 10-year retention of records, such as NAVY and NYS Drinking Water Programs, therefore the archivist, project manager, and possibly the client are consulted prior to destruction of the records. The archive room is kept locked and access keys are controlled. All documents must be signed out if needed outside of the archive room and returned in a timely manner. A designated archivist monitors filing, incoming, and outgoing data from the archive.

In the event that the laboratory transfer's ownership or goes out of business, laboratory records shall be maintained for the contracted period and clients shall be notified prior to early destruction / disposal of samples or data.

12.6.2 Reporting Deliverables

In order to meet individual project needs, CAS provides several levels of analytical reports. Basic specifications for each level of deliverable are described in Table 12-1. Turnaround time and package level are negotiable on a project to project basis.

12.6.3 Electronic Data Deliverables (EDD)

CAS/Rochester offers standard Excel format as well as a variety of custom developed EDDs such as ASCII, dBase, and GISKEY. EDDs are available upon request on a project to project basis.

Figure 12-1
Evaluation of Method Calibration

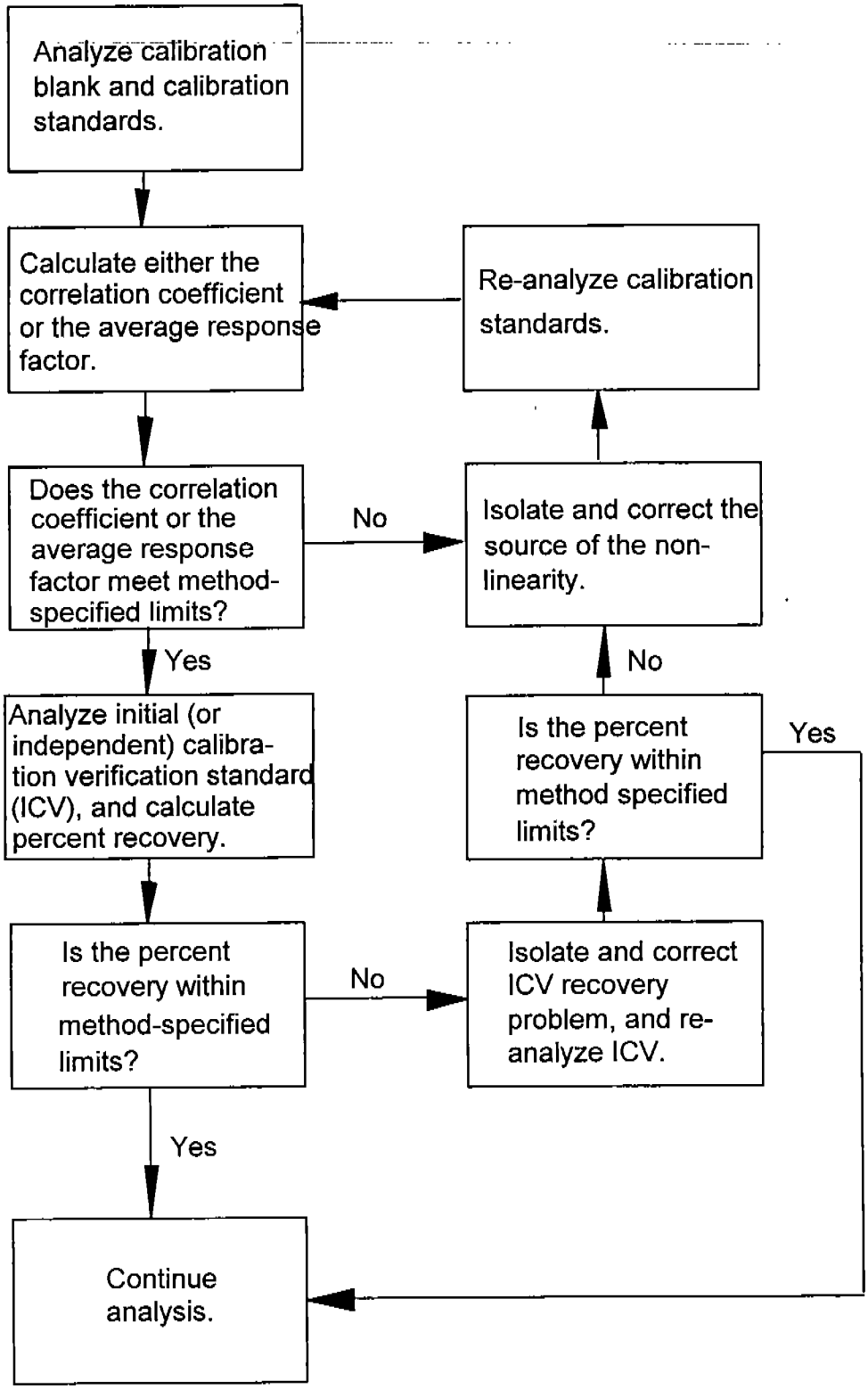


Figure 12-2
Evaluation of Continuing Calibration

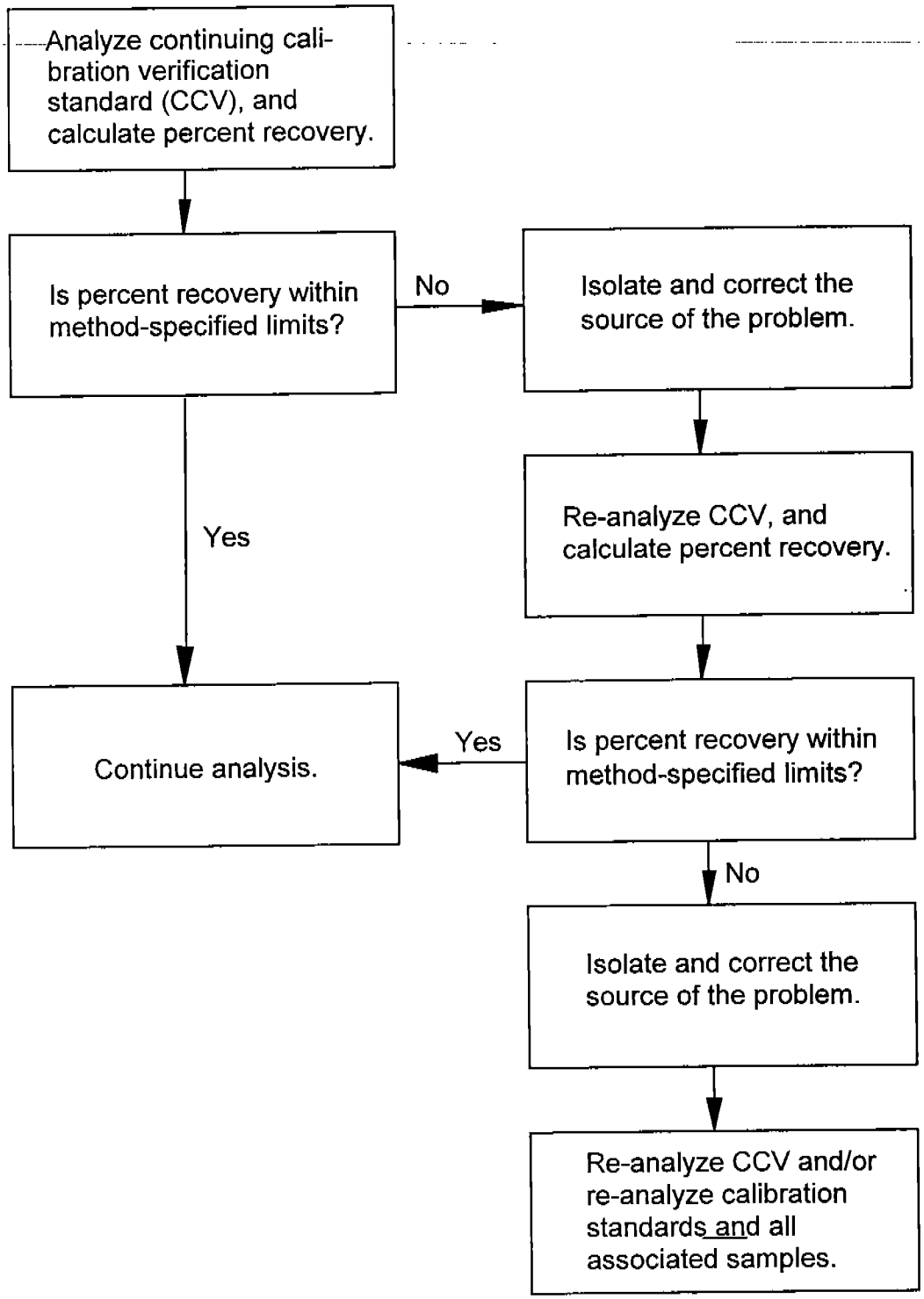


Figure 12-3
Evaluation of Method Blank and Instrument Blank Results

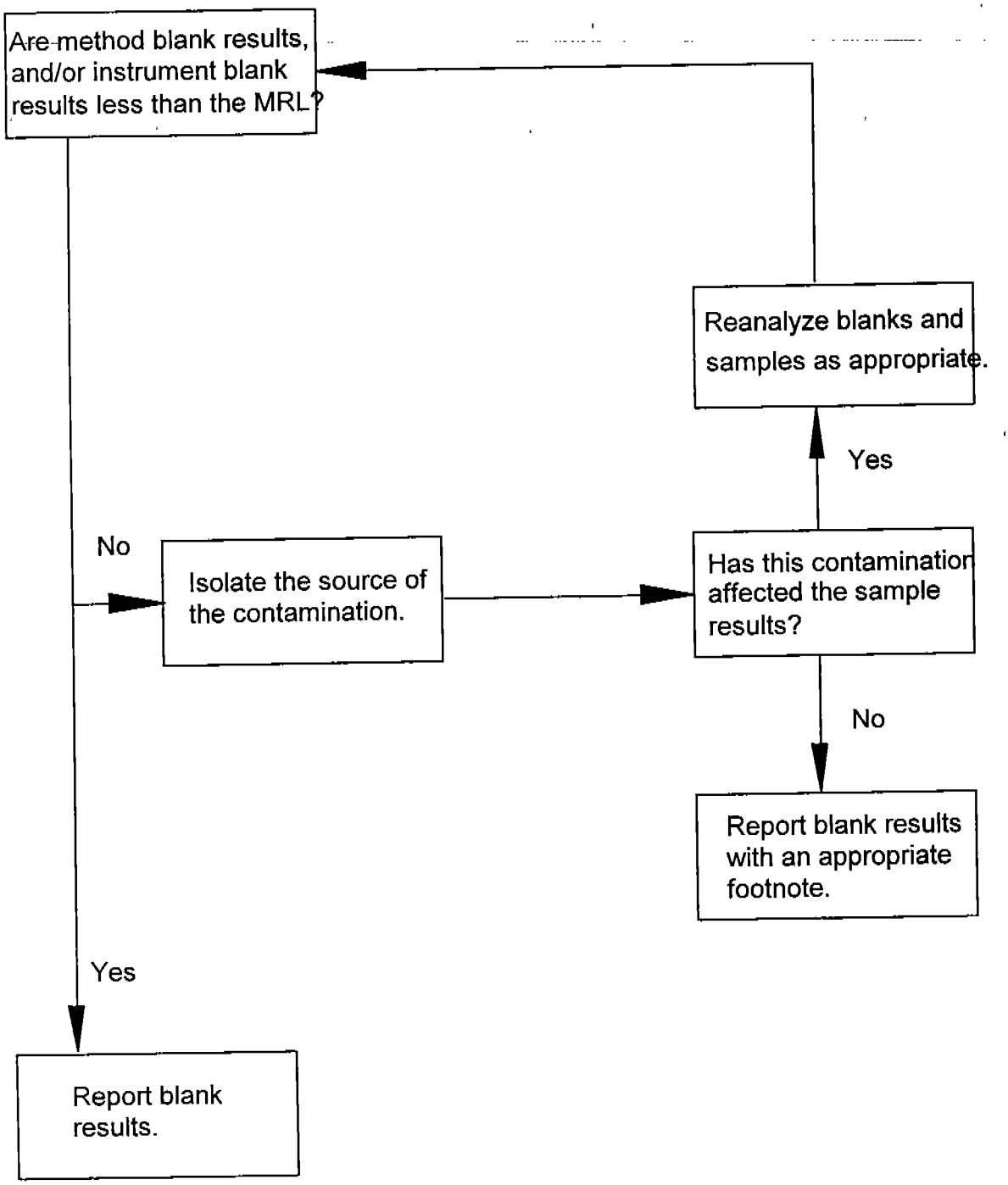


Figure 12-4
Evaluation of Sample Results for Inorganic Analyses

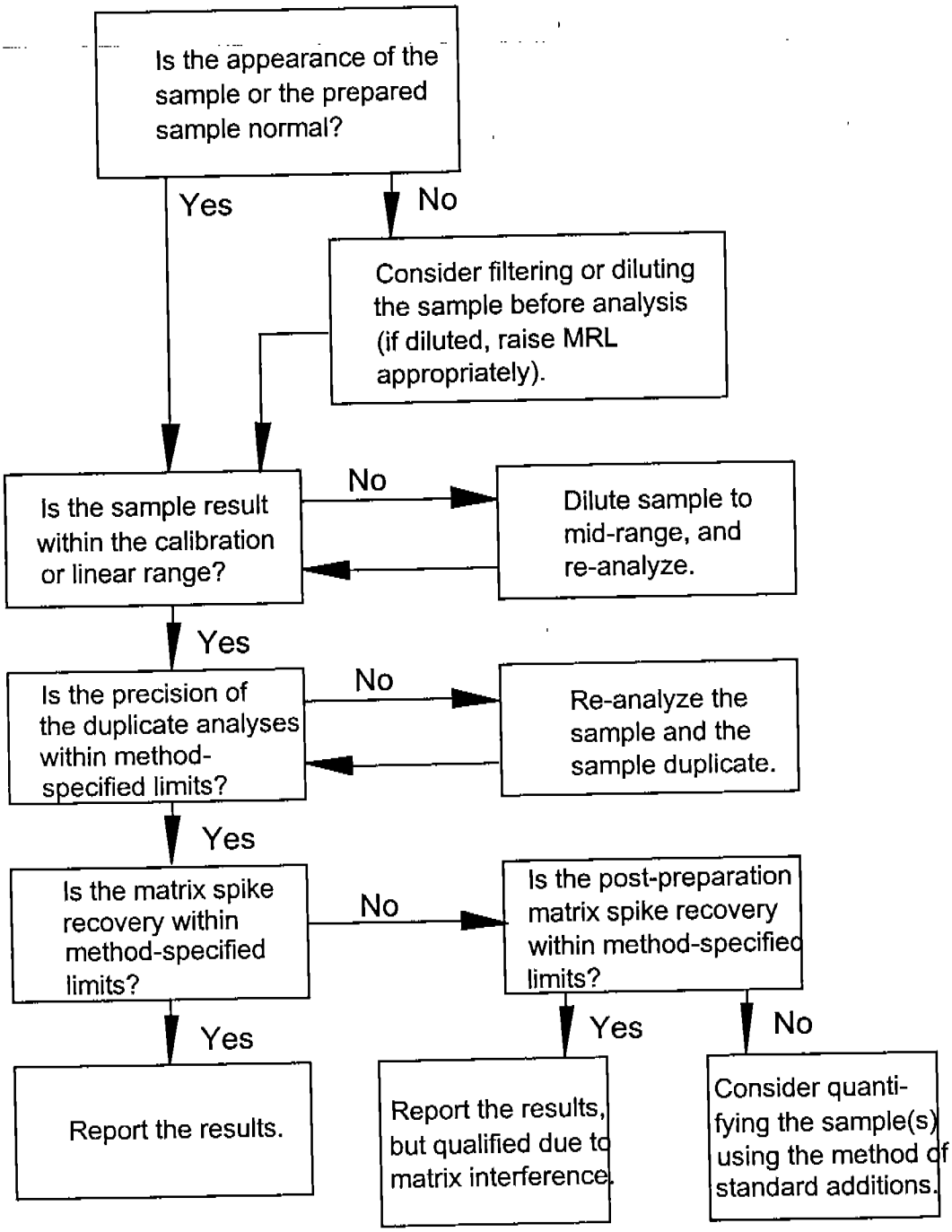


Figure 12-5
Evaluation of Sample Results for Organic Analyses

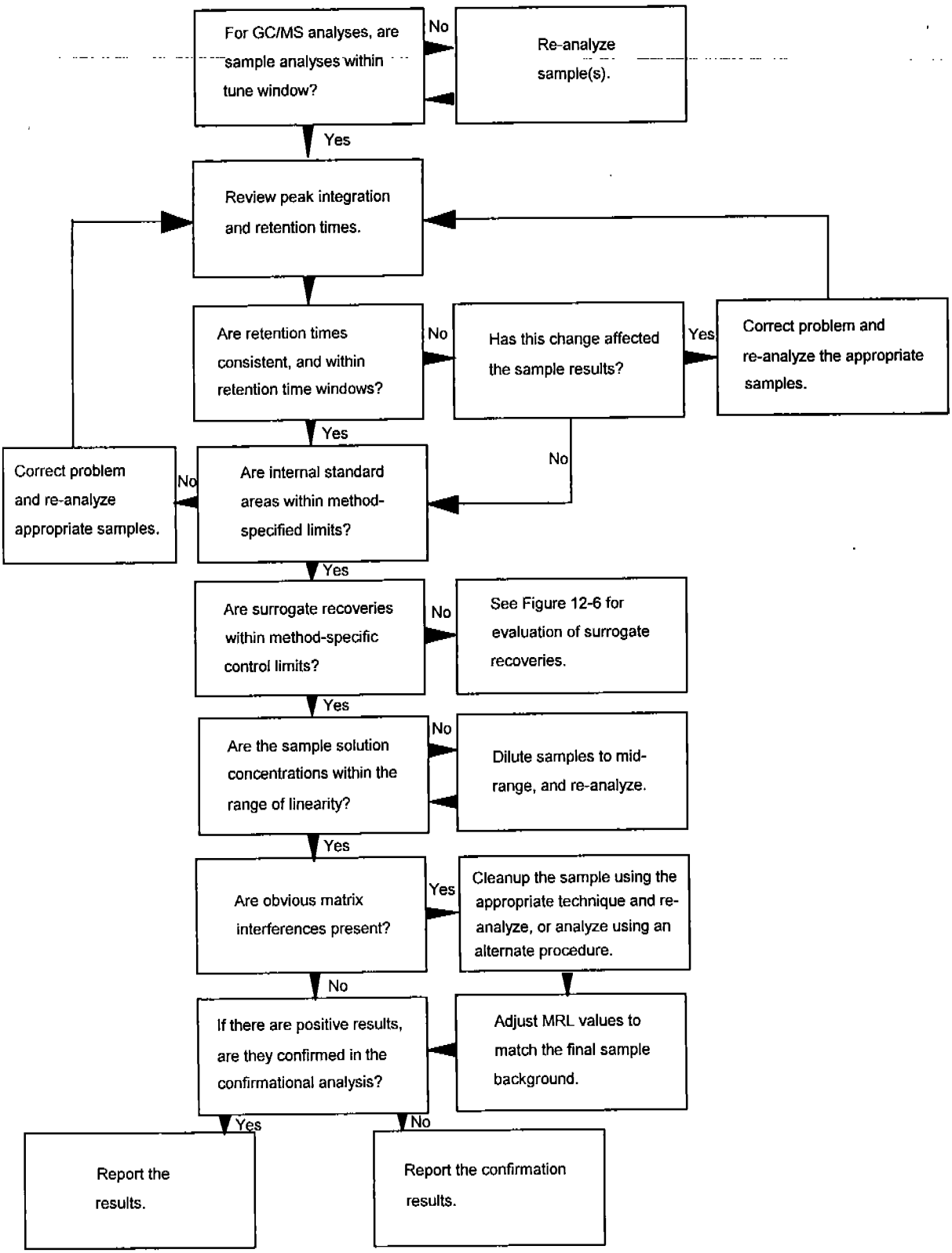


Figure 12-6
Evaluation of Surrogate Compound Recoveries

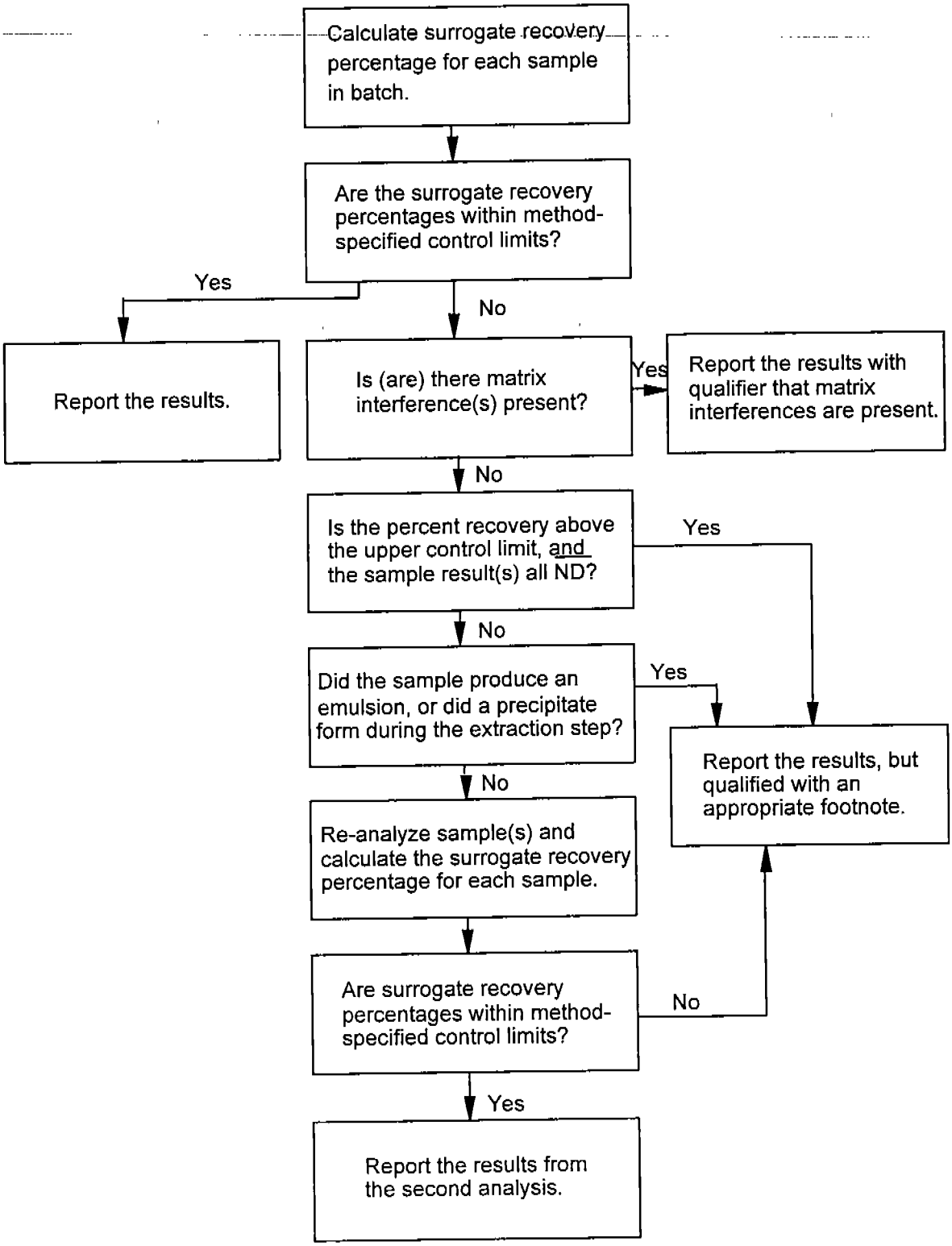


Figure 12-7
Evaluation of Duplicate Sample and/or Duplicate Matrix Spike Results

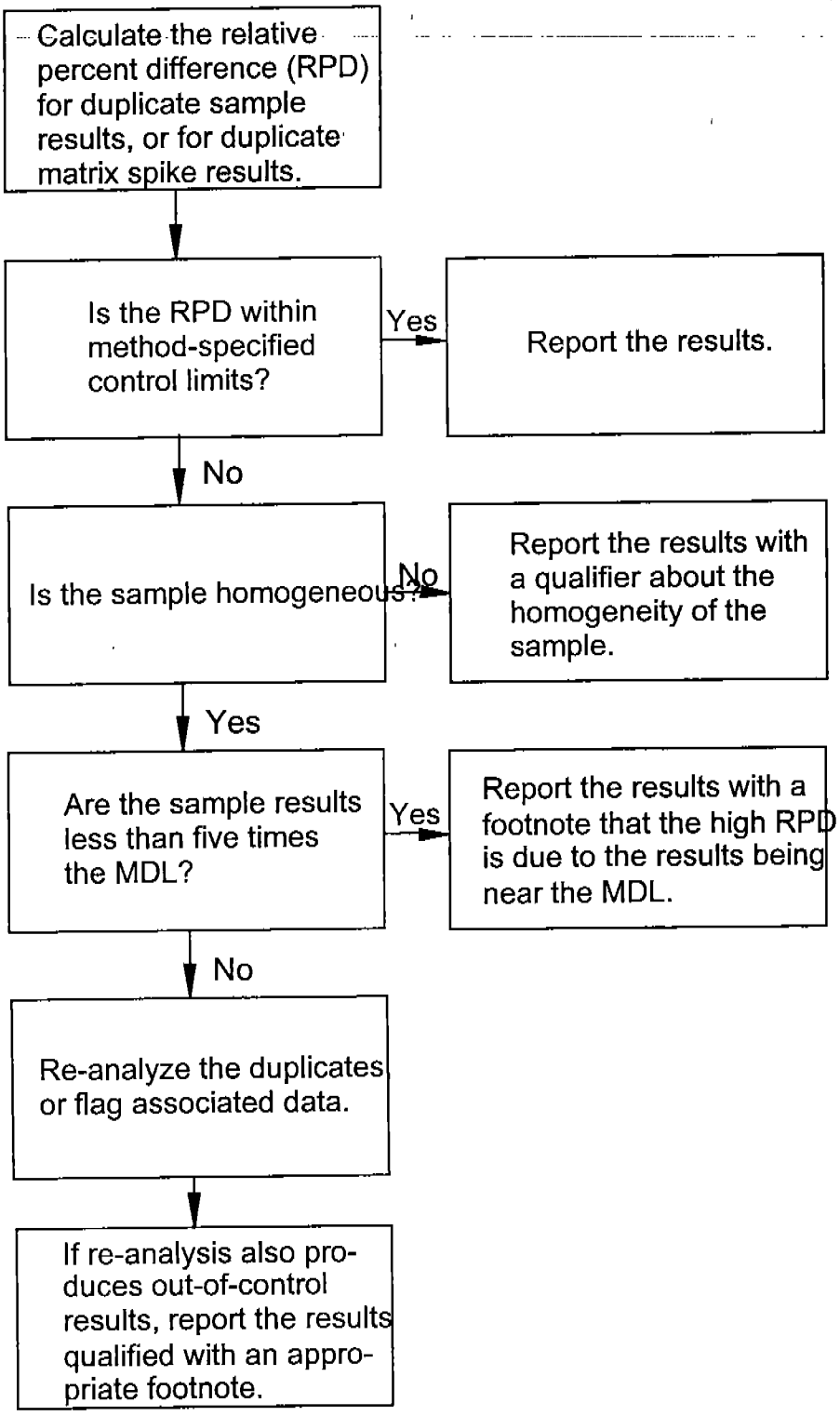


Figure 12-8
Evaluation of Matrix Spike Recoveries

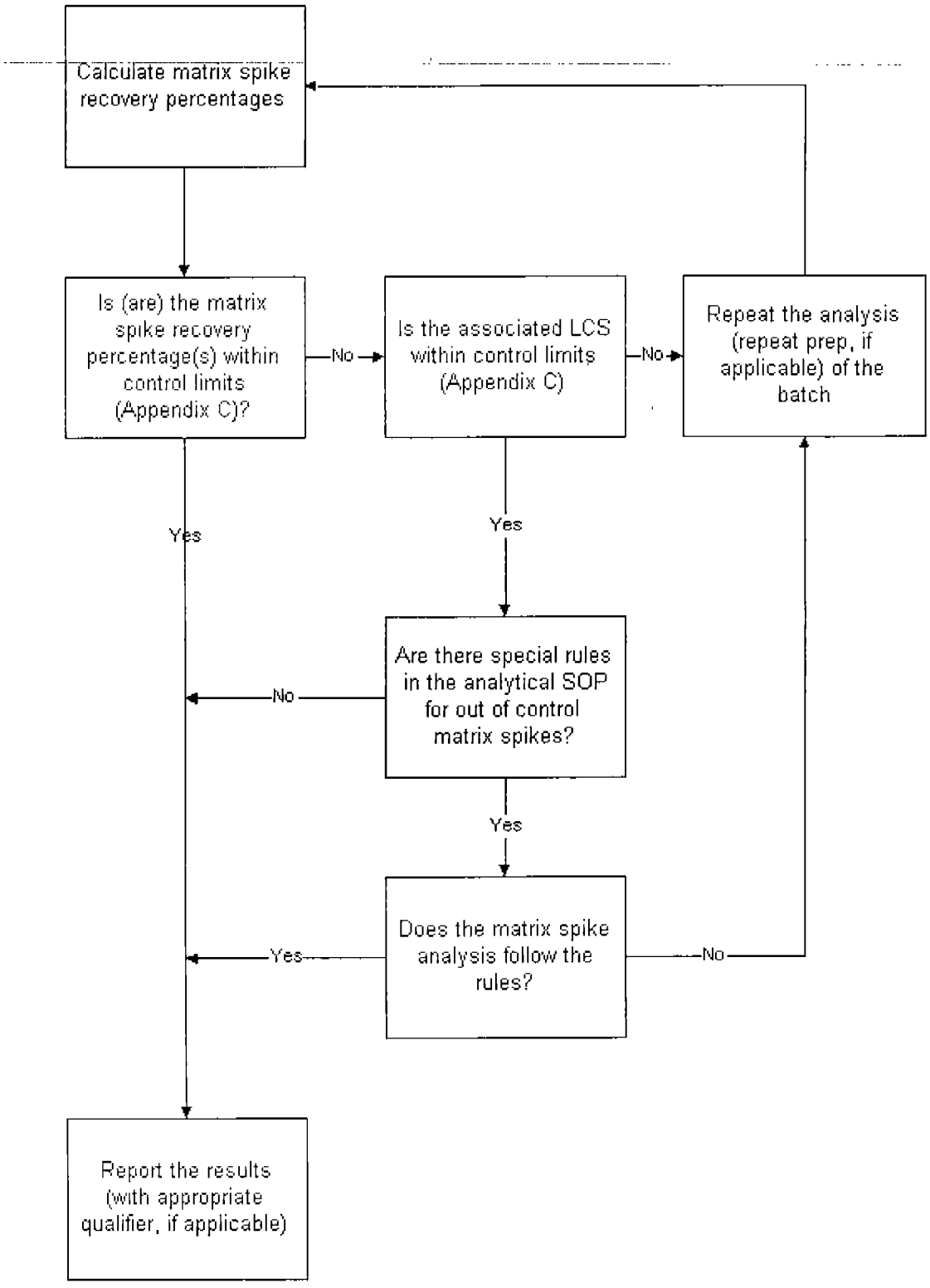


Figure 12-9
Evaluation of Laboratory Control Sample (LCS) Results

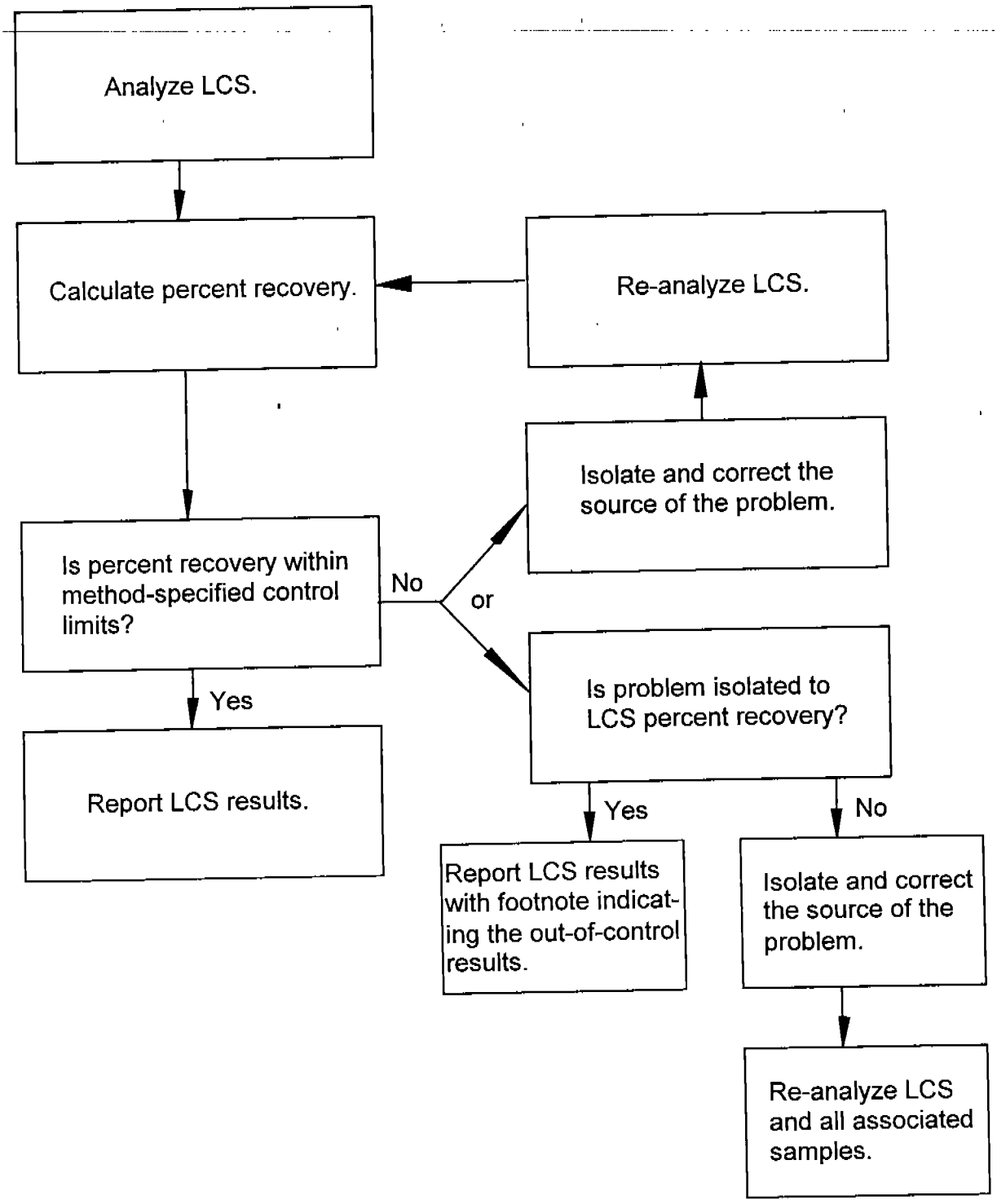


Table 12-1
Laboratory Data Deliverables

Package 1. A Routine Certified Analytical Report Includes the Following

1. Transmittal Letter
2. Sample Analytical Results
3. Method Blank Results
4. Surrogate Recovery Results for appropriate organic methods, including associated EPA or CAS acceptance criteria
5. Chain of Custody Documents

Package 2. In Addition to the Package 1 Deliverables, this Report Includes the Following:

1. Case Narrative

Package 3. In Addition to the Package 2 Deliverables, this Report Includes the Following:

1. Calibration Summaries and Results of initial and continuing calibration verification standards, with calculated recoveries
2. Method Blank Summaries

Package 4. In Addition to the Package 3 Deliverables, this Report Includes the Following:

1. Sample Quantitation Report
2. Standards Prepartation Information

Package 5. Full Data Packages

A complete validatable data package, fulfills all deliverable requirements, as specified in the EPA CLP Statement of Work. The data package may include diskette deliverables, upon request.

13.0 PERFORMANCE AND SYSTEM AUDITS

Quality Control (QC) audits are an essential part of CAS's QA program. There are two types of audits used at the facility: System Audits are conducted to qualitatively evaluate the operational details of the field and laboratory QA program, while Performance Audits are conducted by analyzing performance evaluation samples in order to quantitatively evaluate the outputs of the various measurement systems.

The system audit examines the presence and appropriateness of laboratory systems. External system audits of CAS are conducted regularly by various regulatory agencies and clients. Appendix F summarizes some of the major programs in which CAS/Rochester participates. Additionally, internal system audits of CAS/Rochester are conducted regularly by the Quality Assurance Program Manager and by the CAS Quality Assurance Director. The internal system audits are scheduled as four to five auditing events:

- Comprehensive lab-wide system audit - annually
- Audits examining compliance with all QA program requirements as applied to selected projects - 2 per year.

The results of each audit are reported to the Laboratory Director and Supervisors for review and comment. Any deficiencies noted by the auditor are summarized in an audit report and corrective action is taken within a specified length of time to correct each deficiency. Should problems impacting data quality be found during an internal audit, any client whose data is adversely impacted will be given written notification if not already provided. (See SOP ADM-IAUD).

Additionally, CAS/Rochester participates in the analysis of performance evaluation (PE) samples. Results of the performance evaluation samples and audits are reviewed by the Laboratory Director, the QA Program Manager, the Corporate QA Director and the laboratory staff. Any problems surfacing during the audit are investigated, and corrective action is taken regarding any and all deficiencies.

Page 53

14.0 PREVENTIVE MAINTENANCE

Preventive maintenance is a crucial element of Columbia Analytical Services Quality Assurance program. Instruments at CAS (e.g., GC/MS systems, atomic absorption spectrometers, analytical balances, gas and liquid chromatographs, etc...) are maintained under commercial service contracts or by qualified, in-house personnel. All instruments are operated and maintained according to the instrument operating manuals. All routine and special maintenance activities pertaining to the instruments are recorded in instrument maintenance logbooks. The maintenance logbooks used at CAS contain extensive information about the instruments used at the laboratory.

All preventive maintenance requires a reference to acceptable QC to verify instrument has returned to proper operating functions. An initial demonstration of analytical control is required on **every** instrument used at CAS before sample analyses may proceed. If an instrument is modified or repaired, a return to analytical control is **required** before subsequent sample analyses can continue. When an instrument is acquired at the laboratory, the following information is recommended to be noted in a bound maintenance notebook specifically associated with the new equipment:

- The equipment's serial number.
- Date the equipment was received.
- Date the equipment was placed into service.
- Condition of equipment when received (new, used, reconditioned, etc...)
- Prior history of damage, malfunction, modification or repair (if known).

Preventative maintenance procedures, frequencies, etc... are available for each instrument used at CAS. They may be found in the various SOPs for routine methods performed on an instrument and may also be found in the operating or maintenance manuals provided with the equipment at the time of purchase. Responsibility for ensuring that routine maintenance is performed lies with the section supervisor. Each laboratory section maintains a critical parts inventory. The parts inventories include the items needed to perform the preventative maintenance procedures listed in Appendix E. This inventory or "parts list" also includes the items needed to perform any other routine maintenance and certain in-house non-routine repairs.

When performing maintenance on an instrument (whether preventative or otherwise), additional information about the problem, attempted repairs, etc... is also recorded in the notebook. Typical logbook entries include the following information:

- Details and symptoms of the problem
- Repairs and/or maintenance performed
- Description and/or part number of replaced parts
- Source(s) of the replaced parts
- Analyst's signature and date
- Demonstration of return to analytical control

For most major equipment, back-up equipment is available to avoid downtime. All major analytical equipment is summarized in Appendix A. The section supervisor is responsible to coordinate repair with the manufacturer. The project manager shall assess the effect of the downtime on the samples in-house and notify the appropriate clients of any delays and/or the possibilities of subcontracting.

15.0 CORRECTIVE ACTION

Failure to meet established analytical controls, such as the quality control objectives outlined in Sections 9.0 and 12.0, prompts corrective action. In general, corrective action may take several forms and may involve a review of the calculations, a check of the instrument maintenance and operation, a review of analytical technique and methodology, and reanalysis of quality control and field samples. If a potential problem develops that cannot be solved directly by the responsible analyst, the supervisor, the department manager, and/or the QAPM may examine and pursue alternative solutions. In addition, the appropriate project manager may be notified in order to ascertain if contact with the client is necessary.

The QAPM initiates corrective action due to a performance audit or a check sample problem; the affected laboratory personnel are promptly informed, as are the laboratory supervisors and managers.

In either case, a Nonconformity and Corrective Action Form is generated to document and notify the appropriate personnel of the nonconformity. Procedures for issuing and filing nonconformities are discussed in SOP, *Nonconformity and Corrective Action* (ADM-NCAR).

In special cases, the Laboratory Director may give permission to the analyst, Supervisor, or Project Manager to deviate from CAS Policy. Typically, a Nonconformity form must be issued to the Director and signed off as being acceptable. Otherwise verbal instructions are given and documented on the raw data as being accepted by the Laboratory Director.

In cases were there are complaints from the clients, follow policy procedures outlined in the SOP, *Dealing with Complaints* (ADM-CMPLT).

Figure 15-1

Nonconformity and Corrective Action Report

SAMPLES/SYSTEM/JOB/CLIENT AFFECTED N&CA Report No. _____

NONCONFORMITY

Analysis/Event: _____

Instrument/System: _____ Date: _____

Detailed Description of Nonconformity:

Originator (name): _____ Date: _____

Supervisor Verification: _____ Date: _____

CORRECTIVE ACTION AND OUTCOME

Detailed Description: (Re-establishment of conformity must be demonstrated and documented. Describe the steps that were taken, or are planned to be taken, to correct the particular Nonconformity and prevent the reoccurrence of the Nonconformity.)

Is the data to be flagged in the Analytical Report with an appropriate qualifier? **No** **Yes**

Person Responsible: _____ Date: _____

Supervisor Verification: _____ Date: _____

NOTIFICATION - CUSTOMER/CLIENT - INTERNAL/EXTERNAL

Project Chemist Notified by: _____ Date: _____

Customer Notified? **No** **Yes** If Yes, Notifier: _____ Date: _____

Project Chemist/Customer Comments (Retain record, e.g. telephone record, e-mail) _____

ACCEPTANCE OF CORRECTIVE ACTION

Comments:

Corrective Action(s) have been implemented. QA Pgm Mgr: _____ Date: _____

Original: Client File Photocopies: Supervisor and QA Pgm Mgr N&CA_RPT.DOC 1/26/2001

16.0 QUALITY ASSURANCE REPORTS

Quality assurance requires an active, ongoing commitment by CAS personnel at all levels of the organization. Information flow and feedback mechanisms are designed so that analysts, supervisors and managers are aware of quality assurance issues in the laboratory.

Analysts performing routine tests in the laboratory are aware of the various method acceptance criteria and in-house control limits that must be met in order to generate acceptable results. Any non-conformities and corrective actions may also be attached to the data prior to review. Supervisors, or designee, review all of the completed analytical batches to ensure that all QC criteria have been examined and any deficiencies noted and corrected if possible.

It is the responsibility of each laboratory unit to provide the Project Manager with a final report of the data, accompanied by signature approval. Footnotes and/or narrative notes must also accompany any data package if problems were encountered that require further explanation to the client. Each data package is submitted to the appropriate project manager, who in turn reviews the entire collection of analytical data for completeness. The Project Manager must also review the entire body of data to ensure that any and all client-specified objectives were successfully achieved. A case narrative may be written by the project manager to explain any unusual problems with a specific analysis or sample, etc...

The Quality Assurance Program Manager provides overview support to the Project Manager if required to do so (e.g. contractually specified, etc...) The Quality Assurance Program Manager is also responsible for the oversight of all internal and external audits, for all performance evaluation sample and analysis programs, and for all laboratory certification/accreditation responsibilities.

The QAPM also prepares quarterly reports for the QA Director which summarize the various QA/QC activities that have occurred during the previous quarter. These reports include a summary of the various audits performed during the last quarter, new accreditations/certifications received by the laboratory, scores of the most current performance evaluation studies, updates/revisions to controlled documents, etc...

17.0 PERSONNEL TRAINING

Technical position descriptions are available for all employees, regardless of position or level of seniority. These documents are maintained by the QA Program Manager and Human Resources. In order to assess the technical capabilities and qualifications of a potential employee, all candidates for employment at CAS are evaluated, in part, against the appropriate technical description.

Training begins the first day of employment at CAS when the administrative, quality assurance, and health and safety policies are presented and discussed. Each new employee is presented with example ethical dilemmas and resolutions as an initial Ethics training. Within 12 months, each employee shall participate in an 8-hour company Ethics Training Seminar. Thereafter, ethics training is on-going throughout the tenure of each employee.

Technical training is documented following SOP requirements discussed in *Documentation of Technical Training* (ADM-TRANDOC). Training for analytical procedures typically begins with the reading of the analytical SOP. Hands-on training begins with the observation of an experienced analyst performing the method, followed by the trainee performing the method under close supervision, and culminating with independent performance of the method on quality control samples. Successful completion of the analysis must include an Initial Demonstration of Capability Study of four replicate quality control samples. If quality control samples are not readily available, the following approach may be used to show adequate capability per analyst for particular parameters, such as solids, paint filter, peroxides, etc.

Analyze a fictitiously prepared sample volume or use excess sample volume from historical samples to demonstrate acceptable performance of the method. Use results from another analyst for the same four aliquots to demonstrate accuracy (relative) and precision.

Continued demonstration of capability is monitored by QA or departmental supervisor. Copies of all training forms and certifications (demonstrations of capability) are maintained by QA department.

Safety training begins with the reading of the *Safety Manual*. All employees are recommended to attend quarterly safety meetings during which the safety programs discussed and safety training is presented by the Environmental, Health and Safety Officer.

CAS encourages its personnel to continue to learn and develop new skills that will enhance their performance and value to the company. Ongoing training occurs for all employees through a variety of mechanisms. The "CAS University" education system, external and internal technical seminars and training courses, laboratory-specific training exercises and performance of external PE samples analysis are all used to provide employees with professional growth opportunities.

Safety and QA/QC requirements are integral parts of all technical SOPs and, consequently, are integral parts of all processes at CAS.

18.0 REFERENCES FOR ANALYTICAL PROCEDURES

The analytical methods used at CAS generally depend upon the end-use of the data. Since most of our work involves the analysis of environmental samples for regulatory purposes, specified federal and/or state testing methodologies are used and followed closely. Several factors are involved with the selection of analytical methods to be used in the laboratory. These include the method detection limit, the concentration of the analyte being measured, method selectivity, accuracy and precision of the method, the type of sample being analyzed, and the regulatory compliance objectives. Typical methods used at CAS are taken from the following references:

- *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods*, SW-846, Third Edition, 1986 and Updates I (7/92), II (9/94), IIA (8/93), IIB (1/95), and III (12/96). See Chapters 1, 2, 3, and 4.
- *Methods for Chemical Analysis of Water and Wastes*, EPA 600/4-79-020, Revised March 1983.
- *Methods for the Determination of Metals in Environmental Samples*, EPA 600/4-91-010, June 1991 and Supplement I, EPA/600/R-94/111, May, 1994.
- *Methods for Organic Chemical Analysis of Municipal and Industrial Wastewater*, EPA 600/4-82-057, July 1982 and 40 CFR Part 136, Appendix A.
- *Methods for the Determination of Inorganic Substances in Environmental Samples*, EPA 600/R-93/100, August 1993.
- *Methods for the Determination of Organic Compounds in Drinking Water*, EPA 600/4-88-039, December 1988 and Supplement I (7/90) and Supplement II (8/92).
- *Standard Methods for the Examination of Water and Wastewater*, 16th Edition, 1985; 17th Edition, 1989; 18th Edition, 1992, and 19th Edition, 1995.
- 40 CFR Part 136, Guidelines for Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act.
- 40 CFR Part 141, National Primary Driniking Water Regulations.
- State-specific total petroleum hydrocarbon methods for the analysis of samples for gasoline, diesel, and other petroleum hydrocarbon products.
- Annual Book of ASTM Standards.

- EPA Contract Laboratory Program, Statement of Work for Organics Analysis, OLM04.2. May 1999.
- EPA Contract Laboratory Program, Statement of Work for Inorganics Analysis, ILM04.1.
- *U. S. EPA Contract Laboratory Program National Functional Guidelines for Organic Data Review*, EPA-540/R-94/012, February 1993.
- *U. S. EPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review*, EPA-540/R-94/013, February 1994.
- *Good Automated Laboratory Practices, Priciples and Guidance to Regulations For Ensuring Data Integrity In Automated Laboratory Operations*, EPA 2185, August 1995.
- *National Environmental Laboratory Accreditation Conference, Quality Standards, Chapters 1-5*, June 2001.

APPENDIX A

MAJOR ANALYTICAL EQUIPMENT

October 11, 2002

COLUMBIA ANALYTICAL SERVICES, INC.
MAJOR ANALYTICAL EQUIPMENT
(CAS/Rochester Laboratory)

DATE ACQUIRED	INSTRUMENT	SERIAL #	ANALYSES PERFORMED
1987	HP 5890 GC MS #1 HP 5970 MSD MS #1 Tekmar Auto Samp. 2016/2000	2728A13147 2824a11243 91226013+91227014	VOAs by MS
1988	HP 5970 MSD MS #2 HP 5890 GC MS#2 Tekmar Auto Samp. 2016/2000	2716A10131 2613A11406 91331001	Holding; VOA
2001	HP 5890 GC MS #3 HP 5971B MSD MS #3 Archon Auto. Samp. Tekmar Concentrator (2000)	3133A37456 3118A02764 13070 19015014	VOAs by MS
1991	HP 5890II GC MS #5 HP 5971 MSD MS #5 Archon Auto Samp. Tekmar Concentrator (3000)	3121A35679 3118A0252532 12727 98125008	VOAs by MS
1998	HP 6890 GC MS #6 HP 5973 MSD MS #6 Tekmar Auto Samp. 2016/3000	23178 82311143 94312019+94229003	VOAs by MS
2001	HP 5890II GC MS #7 HP 5971 MSD MS #7 Archon Auto Samp. Tekmar Concentrator (2000)	3235A43994 323A03964 13589 91267022	VOAs by MS
1998	HP 6890 GC MS 5973-A HP 5973 MSD MS 5973-A	US00024148 US82311266	SemiVOAs CLP
1999	HP 6890 GC MS 5973-B HP 5973 MSD MS 5973-B	US00029105 US91911849	SemiVOAs CLP
2002	Agilent 5973-C 6890N GC (G1530N) 5973 MSD (G2578A) 7683 Autosampler (G2614A) 7683 Injector (G2613A)	 US10232036 US21853642 CN23021382 CN23126455	SemiVOAs

COLUMBIA ANALYTICAL SERVICES, INC.
MAJOR ANALYTICAL EQUIPMENT
(CAS/Rochester Laboratory)

DATE ACQUIRED	INSTRUMENT	SERIAL #	ANALYSES PERFORMED
1990	GC HP 5890II (A) FID	3203A41098	Pet Hyd by GC.
1988	GC HP5890II (B) FID	2728A14298	Pet Hyd. by GC
1989	GC HP5890II (C) Dual ECD	2643A11567	HERB/PCB
1998	GC HP 6890 (D) Dual ECD	22174	Pest/PCB/8011
1990	GC HP 5890II (F) Dual ECD	2950A26574	Pest/PCB
1990	GC HP 5890II (L) Dual ECD	2950A27718	Herb/PCB
2002	OI Analytical AP2000 GPC	A122330318	Cleanups
1998	V1 Varian 3400 GC 2016 Autosampler 2000 Concentrator PID/ELCD Detectors	4808 89016001 91063007	VOA by GC
1999	V2 Varian 3300 GC FID Detector	4130	Alcohols/Gases
1999	V3 Varian 3400 GC Varian Archon Autosampler 3000 Concentrator PID/ELCD Detectors	10989 13316 98124003	VOA by GC
2001	V4 Varian 3400 GC Archon Autosampler Encon Concentrator PID/ELCD Detectors	15248 13596 1467101501E	VOA by GC
2001	HP1 HP5890II 2016 Autosampler 2000 Concentrator PID/FID Detectors	3121A35575 8920008 89013002	
1998	T6 Varian 3400 GC 2016 Autosampler 2000 Concentrator PID/FID Detectors	4143 88048011 91178009	VOA/VPH/GRO

COLUMBIA ANALYTICAL SERVICES, INC.
MAJOR ANALYTICAL EQUIPMENT
(CAS/Rochester Laboratory)

DATE ACQUIRED	INSTRUMENT	SERIAL #	ANALYSES PERFORMED
2001	HPLC #1		SemiVOAs
	501 Solvent Delivery System		
	Pump A	SDS 206526	
	Pump B	SDS 206730	
	Dynatech Autosampler LC-241	9843-890	
	470 Scanning fluorescence detector	470-000634	
	484 Tunable Absorbance detector	484PRC498	
	System Interface Module	SIM-011735	
	Temperature Control Module	TCM-001304	
1991	TOC Model 700 OI	1689-8-359	TOC
2001	TOC #2 Dohrmann DC190	9507646	TOC
	Boat sampler 183 s/s1	9507610	

COLUMBIA ANALYTICAL SERVICES, INC.

MAJOR ANALYTICAL EQUIPMENT
(CAS/Rochester Laboratory)

DATE ACQUIRED	INSTRUMENT	SERIAL #	ANALYSES PERFORMED
1997	Perkin Elmer FIMS	1258	Mercury Analyzer
1991	Perkin Elmer AA 4100ZL	6066	Furnace Metals
1998	Perkin Elmer AA 4100ZL	6245	Furnace Metals
1994	Perkin Elmer ICP #1 Optima 3000XL	069N4060401	Metals (low-level)
1999	Perkin Elmer ICP #2 Optima 3000XL	069N6062602	Metals (low-level)
2002	Perkin Elmer SCIEX ICP/MS Elan 9000 AS93Plus Autosampler	PO370203	Metals
2001	Environmental Express Hotblock -1 Environmental Express Hotblock –2		Metals Digestions
Pre1970	Amsco Autoclave		Micro/TPO4

COLUMBIA ANALYTICAL SERVICES, INC.
MAJOR ANALYTICAL EQUIPMENT
(CAS/Rochester Laboratory)

DATE ACQUIRED	INSTRUMENT	SERIAL #	ANALYSES PERFORMED
1986	Lachat System IV		
	Colorimeter	125181	Choride,
	Module	125304	NO2/NO3,
	Pump	125209	TKN, NH3,
	Autosampler	125203	Phosphorus, Silica
1999	Lachat 8000 Series		
	Colorimeter	A83000-1286	Choride, TKN
	Diluter	A89000-739	NO2/NO3, NH3
	Pump	A82000-525	Alkalinity, Hardness
	Autosampler	A81010-168	Phosphorus, Silica, Hex. Chromium
Pre-1982	Technicon #1		
	Printer	199-051241	Cyanide
	Pump	TE80139	
	Colorimeter	19900670	
Pre-1982	Technicon #2		
	Autosampler	681-Rest worn off	Phenol
	Pump	PR0276	
	Module	83035	
	Colorimeter	199-006701D	
	Printer-Recorder	82A3321	
1996	IC #1		
	Ion Chromatograph Dionex Series 4000i		Anions
	Basic Chromatography Module	871602	
	Gradient Pump	871608	
	Conductivity Detector	871242	
	Controller Pump	31528	
	4270 Integrator	037/24782	
	Autosampler	931526	
2000	IC #2		
	Ion Chromatograph Dionex Series 4000i		Anions
	Basic Chromatography Module	13458	
	Gradient Pump Model APG-1	921553	
	Conductivity Detector CDM-2	921513	
	Degas Module EDM-2	930211	
	Autosampler ASM-2	880113	
	Interface ACI-1	925205	

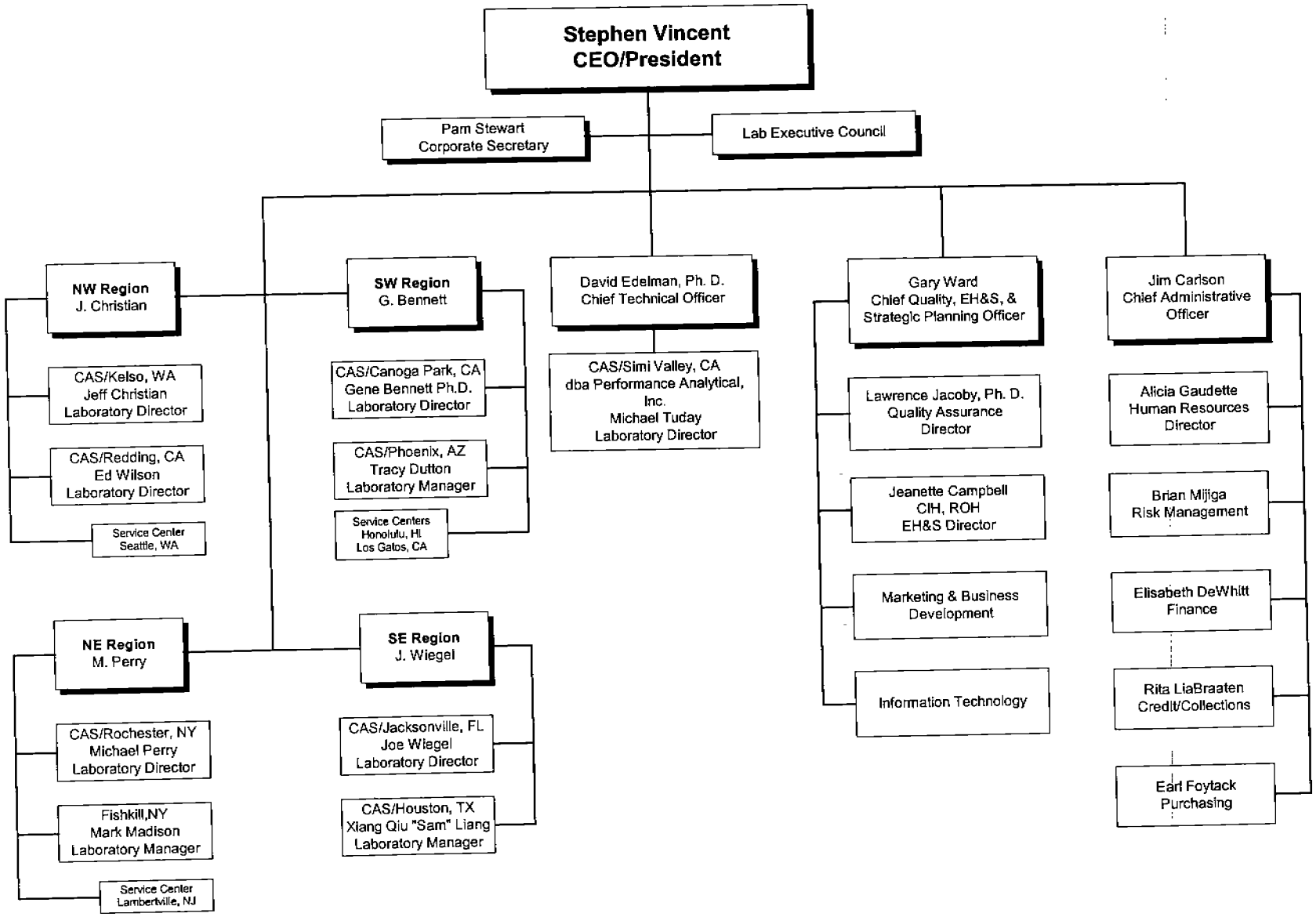
COLUMBIA ANALYTICAL SERVICES, INC.
MAJOR ANALYTICAL EQUIPMENT
(CAS/Rochester Laboratory)

DATE ACQUIRED	INSTRUMENT	SERIAL #	ANALYSES PERFORMED
1997	Midi-Cyanide Distillation System (A)		Cyanide
	Midi-Cyanide Distillation System (B)		Cyanide
1990	Orion pH meter SA520	2305	pH, Temp.
1992	Orion Ion Meter - Model 720A	005012	
	pH Electrode - Orion		pH
	Fluoride Electr. - Orion 9409		Fluoride
	Ref. Electrode - Orion 90-01-00		
2000	HF Scientific Micro 100	609246	Turbidity
2000	Jenway Conductivity/pH Meter Model 4330	1344	Conductivity pH
Analytical Balances:			
1990	Fisher Analytical Balance	08887	Volatiles
1990	Mettler Analytical Balance	F96727	Wetchem
	Mettler Toledo Analytical	120330501	Wetchem
Top Loading Balances:			
2000	Mettler Toledo PB602-1	1118331281	Wetchem/Metals
	American Scientific PTL2500-1	20466	Wetchem
	Denver S-400	25232	Extractables
	Fisher	07384	Metals
	Fisher Scientific 7303 OA	13556	Volatiles
1988	Beckman KF4 Aquameter	none	%Water
1993	Boekel Flashpoint Tester Model 152800	none	Closed cup flash
1989	Open Cup Flash Tester Koehler Instr. Co. model 420	none	Open Cup Flash
Pre-1990	Oxygen Meter - YSI Model 54A	D8024621	DO, BOD
Pre-1990	Oxygen Meter –YSI Model 57	A9016921	DO, BOD
1989	B&L Spectronic 21	1225601	COD, MBAS
1987	B&L (MSR002) Spec.	114	Peroxide
1994	Buck Scientific Total Hydrocarbon Analyzer Model HC404	492	TPH

APPENDIX B

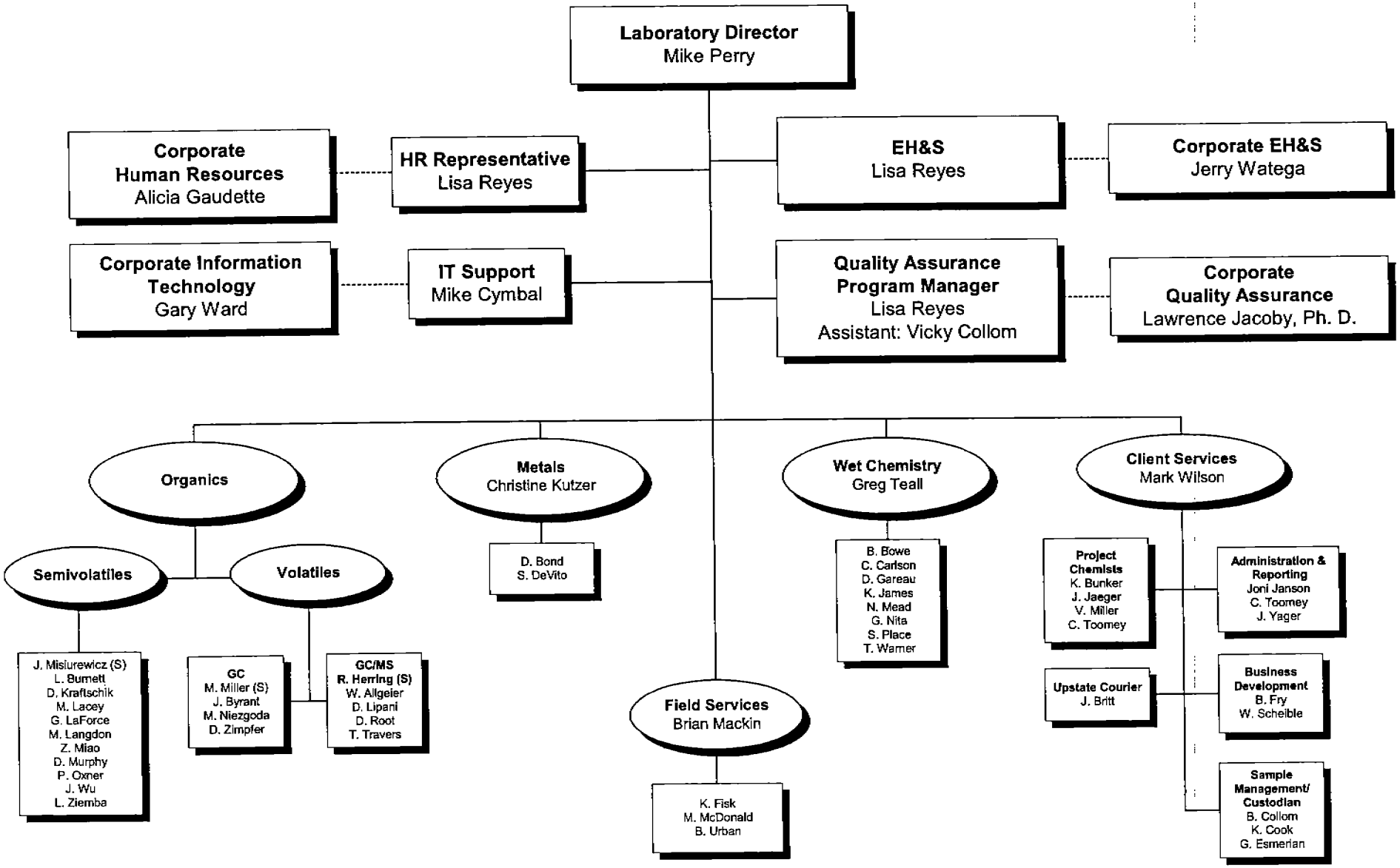
ORGANIZATIONAL CHART and RESUMES OF KEY PERSONNEL

Columbia Analytical Services, Inc.
Laboratory Division Organization



Revised on 05/16/02

Columbia Analytical Services, Inc.
Rochester, New York Laboratory Organization



Revised 3/11/03

MICHAEL K. PERRY *APRIL 1996-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (585)288-5380

Current Position Laboratory Director. 1996-Present.

Responsibilities Primary responsibilities include management of all laboratory departments, scheduling, productivity, reporting and evaluation of analytical methodologies, project planning and Quality Assurance/Quality Control protocols. In addition, other responsibilities include direct responsibility for contracts and consultants relating to the EPA SITE program, ACOE remediation program and the technical interface for the New York State ASP CLP program and other large national based clients.

Experience

Project Chemist Manager - General Testing Corporation, Rochester, New York. In addition to the duties of Laboratory Director listed below, responsibilities expanded to include the supervision of four teams of Project Chemists. Production management was shifted to the Laboratory Supervisors in order to increase client contact. Directly responsible for contracts and consultants relating to the EPA SITE program, ACOE remediation program and the New York State ASP CLP program. 1995-1996

Laboratory Director - General Testing Corporation, Rochester, New York. Primary responsibilities included management of all laboratory departments, scheduling, productivity, reporting and evaluation of analytical methodologies and Quality Assurance/Quality Control protocols. 1985-1995

Instrument Manager - General Testing Corporation, Rochester, New York. Responsibilities included operation and maintenance of all laboratory instruments and supervision of personnel associated with the instrumentation laboratory. Analyses included metals, volatile organics, pesticides/PCBs, and semi-volatile organics. 1979-1985

Senior Quality Assurance Technician - Coca-Cola Corporation, Atlanta, Georgia. Responsible for analysis of raw materials and finished product using both wet chemistry and instrumentation techniques. 1976-1979

Laboratory Technician - Penwalt Pharmaceutical Company, Rochester, New York. Worked in the Quality Control Department. 1975.

Education

Rochester Institute of Technology, Rochester, New York - Matriculated Course work for MS in Chemistry - 1983-1986
ACS Short Course, GC/MS - 1986
ACS Short Course, Effective Management of Chemical Analysis Laboratories - 1985
Georgia State University, Atlanta, Georgia, BS in Chemistry - 1979
State University of New York at Alfred, Alfred, New York - AAS in Chemistry - 1975

Affiliations American Chemical Society (ACS)

JANICE M. JAEGER *APRIL 1996-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (585)228-5380

Current Position **Project Manager. 1996-Present**

Responsibilities Assist clients to determine what analyses are required. Oversee projects from quote initiation to final report submission. Act as liason between client requirements and laboratory capabilities for projects. Update clients on progress if their project and answer any questions they may have. Respond promptly to client requests and develop new client contacts within and outside of our current client base.

Experience

Project Manager- Oversees project management for many of CAS/Rochester's largest clients including GE and Honeywell. Has coordinated Pittsfield/GE where over 6000 samples for PCBs and 1000 samples for Appendix IX were completed over a two-year period. Also managing Honeywell projects related to Onondaga Lake remediation where 700 –1000 samples for full suite have been received to date. Latter required coordination with numerous CAS and non- CAS laboratories whose work also flowed through Rochester for tracking and reporting. 1996-present

LIMS Evaluator--- Participated on company wide study team evaluating available LIMS systems to determine and select next generation of data information system for installation throughout CAS network. 2000-2001

Customer Service Representative/Sample Receiving - General Testing Corporation, Rochester, New York. Primary responsibilities included client services as listed above. Also responsible for sample receipt, log in and distribution as well as bottle preparation. 1989-1996

Surgical Assistant - Penfield Veterinary Hospital Rochester, New York. Primary responsibilities included preparation of instruments, surgical area, and animal for surgery. Also responsible for monitoring the animal before and after surgery. 1984-1989

Education Ohio Wesleyan University, Delaware, Ohio - BA Pre-Veterinary Medicine and Pre-Professional Zoology (double Major), Chemistry Minor - 1983

MARK WILSON *APRIL 1996-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (585)288-5380

Current Position **Client Service Manager. 1996-Present.**

Responsibilities Responsible for supervision of Project Managers, Sales and Sample Management departments. Responsible for project management and client interface regarding analytical services.

Experience

Laboratory Manager - Columbia Analytical Services, Rochester, New York. Responsible for supervision of laboratory staff, scheduling of projects, evaluations of analytical QC procedures, and review of all analytical data. 1996.

Laboratory Manager - General Testing Corporation, Rochester, New York. Responsibilities were primarily same as above. 1992 - 1996.

Assistant Laboratory Director - General Testing Corporation, Rochester, New York. Was responsible for assisting lab director with supervision of lab staff, scheduling of projects, evaluations of analytical and QC procedures, and review of all analytical data. 1988 - 1992.

Organics Department Manager - General Testing Corporation/Columbia Analytical Services, Rochester, New York. Responsible for supervising all organics analyses including GC/MS, GC volatile organics, and GC extractables, and coordinating production and method development. 1986 - 1996.

Organic Extractables Manager - General Testing Corporation, Rochester, New York. Was responsible for GC operation and analysis, GC maintenance, trouble shooting, development, and GC/MS operation and start up. 1985 - 1992.

Staff Technician II - Medical Center University of Kentucky, Lexington, Kentucky. Was responsible for GC and AA analysis on biological fluids, drug screening and monitoring, heavy metals analysis, thin-layer chromatography, HPLC, and water testing. 1979-1985.

Education State University of New York at Buffalo, Buffalo, New York - BS in Medical Technology and 32 hours of Chemistry. 1978

MICHAEL W. CYMBAL *APRIL 1996-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (585)288-5380

Current Position **Systems Analyst I. 1996-Present.**

Responsibilities Responsible for computer systems (Novel Lan, Starlims) and instrument analysis of software. Also responsible for client spreadsheets and disk deliverables, computer maintenance and upgrades.

Experience **Computer Administration** - General Testing Corporation, Rochester, New York. Oversaw computer systems (Novel Lan, Starlims, Seven Reporting Systems) and created client spreadsheets and disk deliverables. 1995-1996

Analyst - General Testing Corporation, Rochester, New York. Responsible for Organic Analyses (Volatile and Semi-Volatile Pesticides) for GC and GC/MS. Also responsible for Instrument Maintenance and Sample Preparation. 1990 - 1995

Education Robert's Wesleyan College, Rochester, New York - BS in Chemistry - 1990

LISA M. REYES *February 1997-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (585)288-5380

Current Position

Rochester Quality Assurance/Quality Control Coordinator. 1997-Present.

Responsibilities

Responsible for the overall coordination of the laboratory QA program and for ensuring that established quality objectives are met. Responsible for Quality Assurance functions including the Quality Assurance Manual, certifications, documenting standard operating procedures, and maintaining performance evaluation records. Oversees balance calibration and sample storage temperature control. Maintains certifications/accreditations for regulatory agencies and client certifications or approval programs. Acts as primary point of contact during laboratory audits. Provides audit responses and initiates any changes in procedures resulting from an audit. Coordinates the analysis of performance evaluation samples required for certification/accreditation programs. Reports and reviews results for these analyses. Conducts internal audits and makes recommendations for corrective action.

Provides technical assistance to laboratory staff on QA/QC issues, project feasibility, and methods interpretation/development.

Experience

Environmental Chemist - TreaTek-CRA Company/Conestoga-Rovers & Associates, Niagara Falls, New York. Data quality, assessments and validations of ASP, CLP, and SW-846 organic and inorganic analytical data. Liaison with analytical contract laboratories, CRA field personnel, and state and federal agencies. Prepared QAPPs, laboratory bidding documents, and contracts. Also responsible for performance of laboratory audits. 1992-1997.

Manager of Quality Management Office - Huntingdon Analytical Services, Middleport, New York. Manager of QA for Environmental, Agrochemical, Asbestos, and Engineering Soil laboratories. Responsible for in-house QA/QC programs, inspections, and instrument maintenance. Also responsible for employee safety and hazardous waste training, as well as manifesting hazardous waste. Routinely performed inorganic analyses, and reviewed analytical data, reports, and CLP packages. 1989-1992.

Research Assistant - Research Foundation, State University of New York College @ Brockport, Brockport, New York. Performed routine sampling of surface water and lakes. Also did inorganic analyses on water and soil matrices. Assisted in graduate projects dealing with fish, plankton, water chemistry, and crayfish. 1986-1989

Education

Westchester Community, Westchester, New York - USEPA Region II Training Course for CLP Inorganic Data Validation. 1993.
Westchester Community, Westchester, New York - USEPA Region II Training Course for CLP Organic Data Validation. 1992.
State University of New York College at Brockport, Brockport, New York - BS in Biology. 1988.

Affiliations

American Chemical Society

RODERICK J. HERRING *APRIL 1996-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (716)228-5380

Current Position **Supervisor MS Volatiles 2002-present.**

Responsibilities Responsible for the daily operations of the GC/MS laboratory, including the scheduling of department analyses, instrument calibration, and troubleshooting/maintenance activities. Accountable for personnel training, data approval, quality program support.

Experience

Scientist I – GC/MS VOA - Columbia Analytical Services, Inc. Rochester, NY. Was responsible for analysis of water, soil, and air samples for specific target contaminants using EPA methods by GC/MS technology. Also responsible for generation of analytical reports via Laboratory Information Management System (LIMS), monitoring activities for second shift, and helping in other laboratory areas as needed. 1996-2002

Scientist I – GC/MS VOA - General Testing Corporation, Rochester, New York. Responsibilities were same as above. 1991-1996.

GC VOAs/2nd Shift Supervisor - General Testing Corporation, Rochester, New York. Was responsible for analysis of water, soil, and air samples via EPA methods, maintaining instrumentation, and helping with departmental organization. 1988-1991.

TOX/TOC Operator - General Testing Corporation, Rochester, New York. Was responsible for analysis of water and soil for organic halogens and organic carbon, maintaining instrumentation, and organizing department and workload. 1988.

Wet Chemistry Technician - General Testing Corporation, Rochester, New York. Was responsible for solids, grease and oils, MBAs, TKNs, alkalinities, other inorganic analyses, organizing daily workload, and reporting. 1987-1988.

Education State University of New York, Utica, New York - BA in Natural Science and Biochemistry, 40 credit hours of chemistry. 1987.
Jamestown Community College, Olean, New York - AS in Biology. 1984.

Publications/ Presentations *The Effects of Phthalate Esters on Spinach and Pea Seedlings*, FEBS Letters 1987, presented at ACS conference in summer of 1988. Rochester, New York. Co-authored with Dr. Larry Bering.

JEANNINE MISUIREWICZ MAY 1996-PRESENT

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (585)288-5380

Current Position

Supervisor - GC and GC/MS Laboratory (Semi-Volatiles). 2001-Present.

Responsibilities

Responsible for preparations, extractions, and analysis of GC & GC/MS semivolatile analyses.

Experience

Scientist II, GC/GCMS Laboratory (Volatiles). – Columbia Analytical Services, Rochester, New York. Responsible for the calibration and maintenance of GC systems equipped with ELCD/PID and PID/FID detectors, and GCMS systems. This includes Tekmar autosampler/Precept/Archon setup and standard preparation. Perform analysis of soils, waters, and airs under GC methods 8021B (Priority Pollutants and Tank Lists), 601/602 and 8015B for GRO and mineral spirits, and GCMS methods 8260B, 524 low levels, and 95-1. Responsible for packages, data entry, and review of jobs before submitting them to department supervisor. Qualified to do data validation when needed. 1997-2001

Scientist I, GC Laboratory (Volatiles) - Columbia Analytical Services, Rochester, New York. Responsibilities were primarily the same as above. 1997.

Scientist I (Summer & Vacation Help), Organics Laboratory – Columbia Analytical Services, Rochester, New York. Extracted and concentrated soils and waters for evaluation. Performed herbicide clean-ups, made surrogates and spiking solutions. Performed clean-ups on concentrated samples. 1996-1997

Analyst (Metals) - General Testing Corporation, Rochester, New York. Responsible for the digestion of soils and waters. Set up the extractions for TCLPs and ZHEs. Digested and performed mercury analysis. Kept an accurate inventory of incoming samples, and cleaned and maintained the lab environment. 1995-1996

Education

University of Buffalo, Buffalo, New York - BS in Chemistry - 1997
Monroe Community College, Rochester, New York - AAS in Chemical Technology - 1995

MATTHEW MILLER APRIL 1996-PRESENT

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (585)288-5380

Current Position **Technical Manager I, GCVOA Laboratory. July 1999-Present.**

Responsibilities Scheduling analyses, sample tracking, training analysts, reviewing and validating data and performing any necessary analyses. Also responsible for writing/reviewing departmental SOP's. Additional duties include troubleshooting, maintenance, and repair of instrumentation.

Experience

GCVOA Analyst-Columbia Analytical Services, Rochester, New York. Responibilities same as for GTC (see below:1994-1996). Also responsible for VPH method development and putting together instrumentation for VPH analysis and for PRECEPTII evaluation. 1997-1999.

Wet Chemistry Analyst-Columbia Analytical Services, Rochester, New York. Responsible for scheduling analyses, training new analysts, supervising analysts' work, reviewing and validating data, and performing wet chem analyses. I was also responsible for maintaining a QA/QC database for Wet Chem. parameters and writing/updating departmental SOP's. 1996-1997.

GC/VOA Analyst - General Testing Corporation, Rochester, New York. Responsibilities included analyzing soils and waters on a GC by methods 8010/8020, 601/602, and 8021. Was also responsible for TOC waters and TOX waters, soils, and oils. 1994-1996.

Metals Analyst - General Testing Corporation, Rochester, New York. Was responsible for digestion of waters and soils for analysis by GFAA, ICP, and Flame AA. Analysis of digested samples by above mentioned methods. Also responsible for performing TCLP extractions and Hg analysis. 1993-1994.

Wet Chemistry Analyst - General Testing Corporation, Rochester, New York. As mircrobiology manager, I was responsible for scheduling analyses, and for analyzing waters and sludges for total and fecal coliform, and SPC by MF, MPN and Colilert methods. I was also responsible for tracking and documenting QA/QC for all micro parameters. In wet chemistry, was responsible for analyzing soils and waters for wet chemistry parameters. 1991-1993.

Education State University of New York at Brockport, Brockport, New York - BS in Aquatic Biology. 1991.
Jefferson Community College, Watertown, New York - AAS in Science/Math Curriculum. 1989.

CHRISTINE KUTZER *APRIL 1996-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (585)228-5380

Current Position **Technical Manager I, Supervisor Metals Laboratory. 1996-Present.**

Responsibilities Plans and manages all activities in the Metals Department. Responsible for coordinating the workload and scheduling employees daily activities. Assist in the operation, troubleshooting, and maintenance of instrumentation. Responsible for scheduling samples from digestion / TCLP extraction to analysis. Accountable for analytical data entry, analytical data approval and High Level package generation through MARRS.

Experience **Analyst III** - Columbia Analytical Services, Rochester, New York. Responsible for instrument troubleshooting and maintenance, digestion of samples, and TCLP extractions. Also responsible for data entry, approval and package review. 1996

Chemist - General Testing Corporation, Rochester, New York. Responsibilities were same as above. 1992-1996.

Education St. Bonaventure University, Olean, New York - BS in Chemistry. 1992.

GREG TEALL *APRIL 1996-PRESENT*

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (585)288-5380

Current Position **General Chemistry Supervisor. 1996-Present.**

Responsibilities Responsible for supervising all activities of wet chemistry and microbiology departments, utilizing Starlims data base, scheduling sample analysis, performing analytical tests, and reviewing and validating completed analytical runs by other department members. Maintains analytical instrument and methodology integrity.

Experience

Inorganics Manager - General Testing Corporation, Rochester, New York. Responsibilities were primarily same as above. 1992-1996.

Wet Chemistry Supervisor - General Testing Corporation, Rochester, New York. Managed general chemistry department analyses for inorganic, non-metallic parameters. 1990-1992.

Computer Services Supervisor - General Testing Corporation, Rochester, New York. Assisted in implementation and development of existing and new computer services. 1990.

QA/QC Department Supervisor - General Testing Corporation, Rochester, New York. Assisted in implementation and development of existing and new QA/QC programs. 1989-1990.

Technician - General Testing Corporation, Rochester, New York. General chemistry laboratory technician responsible for analysis of inorganics and non-metal parameters. 1987-1989.

Teaching Assistant - S.U.N.Y. at Brockport, Brockport, New York. Taught freshwater biology laboratories. 1986.

Education S.U.N.Y. at Brockport, Brockport, New York - MS in Biology. 1988.

BRIAN J. COLLOM NOVEMBER 1998-PRESENT

Columbia Analytical Services, Inc. 1 Mustard Street, Suite #250, Rochester NY 14609 (585)228-5380

Current Position **Scientist I, Sample Management Office (SMO). 1998-Present.**

Responsibilities Responsible for overseeing the Sample Management Office, assisting in receiving incoming samples, login of samples, preparation of samples for testing, bottle prep of containers shipped to clients for sampling as well as basic chemistry: pH, conductivity, and turbidity.

Experience **Store Manager** – Clawson's Grocery, Fairport, New York. Oversee store operations, including staffing, finance, and day to day management. 1989-1998

Education Rochester Institute of Technology, Rochester, New York – Certification in Management of Information Systems. 2000.
Westminster College, New Wilmington, Pennsylvania – B.S. in Environmental Science/Biology. 1995.

APPENDIX C

DATA QUALITY CAPABILITIES

October 11, 2002

METALS ANALYSES QC LIMITS 2002

Method	Analyte	Matrix	Practical Quantitation Limit (PQL)	Estimated Method Detection Limit	Precision (RPD)	Matrix Spike Accuracy (%REC)	LCS Accuracy (%REC)	ICV (%REC)	CCV (%REC)
200.7 (ICP) (ug/L)	Aluminum	Water	100	40	20	70-130	85-115	95-105	90-110
	Antimony		60	6	20	70-130	85-115	95-105	90-110
	Arsenic		10	6	20	70-130	85-115	95-105	90-110
	Barium		20	4	20	70-130	85-115	95-105	90-110
	Beryllium		5	0.8	20	70-130	85-115	95-105	90-110
	Boron		200	17	20	70-130	85-115	95-105	90-110
	Cadmium		5	2	20	70-130	85-115	95-105	90-110
	Calcium		500	78	20	70-130	85-115	95-105	90-110
	Chromium		10	3	20	70-130	85-115	95-105	90-110
	Cobalt		50	3	20	70-130	85-115	95-105	90-110
	Copper		20	4	20	70-130	85-115	95-105	90-110
	Iron		100	32	20	70-130	85-115	95-105	90-110
	Lead		5	2	20	70-130	85-115	95-105	90-110
	Magnesium		500	78	20	70-130	85-115	95-105	90-110
	Manganese		10	2	20	70-130	85-115	95-105	90-110
	Molybdenum		25	5	20	70-130	85-115	95-105	90-110
	Nickel		40	6	20	70-130	85-115	95-105	90-110
	Potassium		2000	100	20	70-130	85-115	95-105	90-110
	Selenium		5	4	20	70-130	85-115	95-105	90-110
	Silver		10	5	20	70-130	85-115	95-105	90-110
	Sodium		500	310	20	70-130	85-115	95-105	90-110
	Thallium		10	7	20	70-130	85-115	95-105	90-110
	Tin		500	50	20	70-130	85-115	95-105	90-110
	Titanium		50	2	20	70-130	85-115	95-105	90-110
	Vanadium		50	11	20	70-130	85-115	95-105	90-110
	Zinc		20	14	20	70-130	85-115	95-105	90-110
206.2 (GFAA) ug/L	Arsenic	Water	10	2	20	75-125	80-120	90-110	90-110
220.2 (GFAA) ug/L	Copper		2	0.3	20	75-125	80-120	90-110	90-110
239.2 (GFAA) ug/L	Lead		5	3	20	75-125	80-120	90-110	90-110
239.2 (GFAA) ug/L	Lead - DW		1	0.7	20	75-125	80-120	90-110	90-110
245.1 (CVAA) ug/L	Mercury		0.3	0.02	20	70-130	85-115	95-105	90-110
270.2 (GFAA) ug/L	Selenium		5	2	20	75-125	80-120	90-110	90-110
279.2 (GFAA) ug/L	Thallium		10	2	20	75-125	80-120	90-110	90-110
6010B (ICP) (mg/Kg)	Aluminum	Soil	10	6	20	75-125	C of A	90-110	90-110
	Antimony		6	0.5	20	75-125	C of A	90-110	90-110
	Arsenic		1	0.7	20	75-125	C of A	90-110	90-110
	Barium		2	0.2	20	75-125	C of A	90-110	90-110
	Beryllium		0.5	0.01	20	75-125	C of A	90-110	90-110
	Boron		20	6	20	75-125	C of A	90-110	90-110
	Cadmium		0.5	0.1	20	75-125	C of A	90-110	90-110
	Calcium		50	7	20	75-125	C of A	90-110	90-110
	Chromium		1	0.1	20	75-125	C of A	90-110	90-110
	Cobalt		5	0.1	20	75-125	C of A	90-110	90-110
	Copper		2	0.4	20	75-125	C of A	90-110	90-110
	Iron		10	2	20	75-125	C of A	90-110	90-110
	Lead		0.5	0.2	20	75-125	C of A	90-110	90-110
	Magnesium		50	4	20	75-125	C of A	90-110	90-110
	Manganese		1	0.2	20	75-125	C of A	90-110	90-110
	Molybdenum		2.5	0.1	20	75-125	C of A	90-110	90-110
	Nickel		4	0.1	20	75-125	C of A	90-110	90-110
	Potassium		200	200	20	75-125	C of A	90-110	90-110
	Selenium		0.5	0.5	20	75-125	C of A	90-110	90-110
	Silver		1	0.1	20	75-125	C of A	90-110	90-110
	Sodium		50	30	20	75-125	C of A	90-110	90-110
	Thallium		1	0.5	20	75-125	C of A	90-110	90-110
	Tin		50	0.7	20	75-125	C of A	90-110	90-110
	Titanium		5	0.5	20	75-125	C of A	90-110	90-110
	Vanadium		5	0.5	20	75-125	C of A	90-110	90-110
	Zinc		2	0.7	20	75-125	C of A	90-110	90-110

METALS ANALYSES QC LIMITS 2002									
Method	Analyte	Matrix	Practical Quantitation Limit (PQL)	Estimated Method Detection Limit	Precision (RPD)	Matrix Spike Accuracy (%REC)	LCS Accuracy (%REC)	ICV (%REC)	CCV (%REC)
7060A (GFAA) mg/Kg	Arsenic	Soil	1	0.2	35	75-125	C of A	90-110	80-120
7211 (GFAA) mg/Kg	Copper		0.2		35	75-125	C of A	90-110	80-120
7421 (GFAA) mg/Kg	Lead		0.5	0.2	35	75-125	C of A	90-110	80-120
7471A (CVAA) mg/Kg	Mercury		0.05	0.02	35	75-125	C of A	90-110	80-120
7740 (GFAA) mg/Kg	Selenium		0.5	0.2	35	75-125	C of A	90-110	80-120
7841 (GFAA) mg/Kg	Thallium		1	0.2	35	75-125	C of A	90-110	80-120
6010B (ICP) (ug/L)	Aluminum	Water	100	40	20	75-125	80-120	90-110	90-110
	Antimony		60	6	20	75-125	80-120	90-110	90-110
	Arsenic		10	6	20	75-125	80-120	90-110	90-110
	Barium		20	4	20	75-125	80-120	90-110	90-110
	Beryllium		5	0.8	20	75-125	80-120	90-110	90-110
	Boron		200	17	20	75-125	80-120	90-110	90-110
	Cadmium		5	2	20	75-125	80-120	90-110	90-110
	Calcium		500	78	20	75-125	80-120	90-110	90-110
	Chromium		10	3	20	75-125	80-120	90-110	90-110
	Cobalt		50	3	20	75-125	80-120	90-110	90-110
	Copper		20	4	20	75-125	80-120	90-110	90-110
	Iron		100	32	20	75-125	80-120	90-110	90-110
	Lead		5	2	20	75-125	80-120	90-110	90-110
	Magnesium		500	78	20	75-125	80-120	90-110	90-110
	Manganese		10	2	20	75-125	80-120	90-110	90-110
	Molybdenum		25	5	20	75-125	80-120	90-110	90-110
	Nickel		40	6	20	75-125	80-120	90-110	90-110
	Potassium		2000	100	20	75-125	80-120	90-110	90-110
	Selenium		5	4	20	75-125	80-120	90-110	90-110
	Silver		10	5	20	75-125	80-120	90-110	90-110
	Sodium		500	310	20	75-125	80-120	90-110	90-110
	Thallium		10	7	20	75-125	80-120	90-110	90-110
	Tin		500	50	20	75-125	80-120	90-110	90-110
	Titanium		50	2	20	75-125	80-120	90-110	90-110
	Vanadium		50	11	20	75-125	80-120	90-110	90-110
	Zinc		20	14	20	75-125	80-120	90-110	90-110
7060A (GFAA) ug/L	Arsenic		10	2	20	75-125	80-120	90-110	80-120
7211 (GFAA) ug/L	Copper		2	0.3	20	75-125	80-120	90-110	80-120
7421 (GFAA) ug/L	Lead		5	0.7	20	75-125	80-120	90-110	80-120
7470A (CVAA) ug/L	Mercury		0.3	0.02	20	75-125	80-120	90-110	80-120
7740 (GFAA) ug/L	Selenium		5	2	20	75-125	80-120	90-110	80-120
7841 (GFAA) ug/L	Thallium		10	2	20	75-125	80-120	90-110	80-120
200.7 CLP-M or ILM 4.1 ** (ug/L)	Aluminum	Water	200	30	20	75-125	85-115	90-110	90-110
	Antimony		60	25	20	75-125	85-115	90-110	90-110
	Arsenic		10	2	20	75-125	85-115	90-110	90-110
	Barium		200	9	20	75-125	85-115	90-110	90-110
	Beryllium		5	0.5	20	75-125	85-115	90-110	90-110
	Cadmium		5	3	20	75-125	85-115	90-110	90-110
	Calcium		5000	240	20	75-125	85-115	90-110	90-110
	Chromium		10	4	20	75-125	85-115	90-110	90-110
	Cobalt		50	4	20	75-125	85-115	90-110	90-110
	Copper		25	6	20	75-125	85-115	90-110	90-110
	Iron		100	14	20	75-125	85-115	90-110	90-110
	Lead		3	2	20	75-125	85-115	90-110	90-110
	Magnesium		5000	230	20	75-125	85-115	90-110	90-110
	Manganese		15	2	20	75-125	85-115	90-110	90-110
	Nickel		40	5	20	75-125	85-115	90-110	90-110
	Potassium		5000	1300	20	75-125	85-115	90-110	90-110
	Selenium		5	3	20	75-125	85-115	90-110	90-110
	Silver		10	4	20	75-125	85-115	90-110	90-110
	Sodium		5000	160	20	75-125	85-115	90-110	90-110
	Thallium		10	2	20	75-125	85-115	90-110	90-110
	Vanadium		50	13	20	75-125	85-115	90-110	90-110
	Zinc		20	7	20	75-125	85-115	90-110	90-110

METALS ANALYSES QC LIMITS 2002

Method	Analyte	Matrix	Practical Quantitation Limit (PQL)	Estimated Method Detection Limit	Precision (RPD)	Matrix Spike Accuracy (%REC)	LCS Accuracy (%REC)	ICV (%REC)	CCV (%REC)
206.2 CLP-M (GFAA) ug.L	Arsenic	Water	10	4	20	75-125	85-115	90-110	80-120
239.2 CLP-M (GFAA) ug/L	Lead		3	1	20	75-125	85-115	90-110	80-120
245.1 CLP-M(CVAA) ug/L	Mercury		0.2	0.02	20	75-125	80-120	90-110	80-120
270.2 CLP-M (GFAA) ug/L	Selenium		5	2	20	75-125	85-115	90-110	80-120
279.2 CLP-M (GFAA) ug/L	Thallium		10	3	20	75-125	85-115	90-110	80-120
200.7 CLP-M or	Aluminum	Soils	40	8	20	75-125	C of A	90-110	90-110
ILM 4.1 **	Antimony		12	1.2	20	75-125	C of A	90-110	90-110
(mg/Kg)	Arsenic		2	1.2	20	75-125	C of A	90-110	90-110
	Barium		40	0.8	20	75-125	C of A	90-110	90-110
	Beryllium		1	0.16	20	75-125	C of A	90-110	90-110
	Cadmium		1	0.4	20	75-125	C of A	90-110	90-110
	Calcium		1000	16	20	75-125	C of A	90-110	90-110
	Chromium		2	0.5	20	75-125	C of A	90-110	90-110
	Cobalt		10	0.6	20	75-125	C of A	90-110	90-110
	Copper		5	0.8	20	75-125	C of A	90-110	90-110
	Iron		20	6.4	20	75-125	C of A	90-110	90-110
	Lead		0.6	0.4	20	75-125	C of A	90-110	90-110
	Magnesium		1000	16	20	75-125	C of A	90-110	90-110
	Manganese		3	0.3	20	75-125	C of A	90-110	90-110
	Nickel		8	1.2	20	75-125	C of A	90-110	90-110
	Potassium		1000	260	20	75-125	C of A	90-110	90-110
	Selenium		1	0.6	20	75-125	C of A	90-110	90-110
	Silver		2	0.8	20	75-125	C of A	90-110	90-110
	Sodium		1000	32	20	75-125	C of A	90-110	90-110
	Thallium		2	0.4	20	75-125	C of A	90-110	90-110
	Vanadium		10	2.6	20	75-125	C of A	90-110	90-110
	Zinc		4	1.4	20	75-125	C of A	90-110	90-110
245.5 CLP-M (CVAA) mg/Kg	Mercury	Soil	0.1	0.004	20	75-125	C of A	80-120	80-120
200.8 (ICP-MS) ug/L	Aluminum	Water	1	0.0339	20	85-115	85-115	90-110	90-110
	Arsenic		10	1.26	20	85-115	85-115	90-110	90-110
	Barium		10	3.97	20	85-115	85-115	90-110	90-110
	Beryllium		1	0.0277	20	85-115	85-115	90-110	90-110
	Boron		1	0.381	20	85-115	85-115	90-110	90-110
	Cadmium		1	0.205	20	85-115	85-115	90-110	90-110
	Chromium		1	0.0178	20	85-115	85-115	90-110	90-110
	Cobalt		1	0.0502	20	85-115	85-115	90-110	90-110
	Copper		1	0.34	20	85-115	85-115	90-110	90-110
	Lead		10	1.82	20	85-115	85-115	90-110	90-110
	Manganese		1	0.266	20	85-115	85-115	90-110	90-110
	Molybdenum		1	0.778	20	85-115	85-115	90-110	90-110
	Nickel		1	0.159	20	85-115	85-115	90-110	90-110
	Selenium		1	0.0388	20	85-115	85-115	90-110	90-110
	Silver		1	0.0237	20	85-115	85-115	90-110	90-110
	Thallium		1	0.343	20	85-115	85-115	90-110	90-110
	Tin		1	0.0459	20	85-115	85-115	90-110	90-110
	Vanadium		1	0.538	20	85-115	85-115	90-110	90-110
	Zinc		1	0.0628	20	85-115	85-115	90-110	90-110

METALS ANALYSES QC LIMITS 2002									
Method	**Analyte**	**Matrix**	**Practical Quantitation Limit (PQL)**	**Estimated Method Detection Limit**	**Precision (RPD)**	**Matrix Spike Accuracy (%REC)**	**LCS Accuracy (%REC)**	**ICV (%REC)**	**CCV (%REC)**
6020A (ICP-MS) ug/L	Aluminum	Water	10	1.85	20	75-125	80-120	90-110	90-110
	Arsenic		1	0.0829	20	75-125	80-120	90-110	90-110
	Barium		1	0.0452	20	75-125	80-120	90-110	90-110
	Beryllium		1	0.0492	20	75-125	80-120	90-110	90-110
	Boron		10		20	75-125	80-120	90-110	90-110
	Cadmium		1	0.0154	20	75-125	80-120	90-110	90-110
	Chromium		1	0.0433	20	75-125	80-120	90-110	90-110
	Cobalt		1	0.0197	20	75-125	80-120	90-110	90-110
	Copper		1	0.45	20	75-125	80-120	90-110	90-110
	Lead		1	0.417	20	75-125	80-120	90-110	90-110
	Manganese		1	0.134	20	75-125	80-120	90-110	90-110
	Molybdenum		1	0.316	20	75-125	80-120	90-110	90-110
	Nickel		1	0.034	20	75-125	80-120	90-110	90-110
	Selenium		1	0.447	20	75-125	80-120	90-110	90-110
	Silver		1	0.0432	20	75-125	80-120	90-110	90-110
	Thallium		1	0.0206	20	75-125	80-120	90-110	90-110
	Tin		1	0.573	20	75-125	80-120	90-110	90-110
	Vanadium		1	0.0147	20	75-125	80-120	90-110	90-110
	Zinc		10	0.614	20	75-125	80-120	90-110	90-110

Legend: NA = Not Applicable

** Estimated MDL results are actually Estimated Instrument Detection Limits for CLP methods per method required Reporting Limits.

C of A Certificate of Analysis QC Limits Provided per manufacturer.

RED = Method Required

BLUE = Lab Limits

WETCHEM QC LIMITS 2002

METHOD	ANALYTE	MATRIX	UNITS	PQL	MDL (approx)	DUP (RPD)	DUP Freq	ACCURACY MS (% REC)	ACCURACY MS Freq	ACCURACY LCS (% Rec)	ACCURACY LCS Frequency	ICV/CCV
310.1	ALKALINITY, TOTAL	WATER	mg/L	2.00	0.746	20	1/10	80-119	1/10	91-113	1/20	90-110
350.1	AMMONIA	WATER	mg/L	0.0500	0.00982	20	1/10	58-129	1/10	90-110	1/20	90-110
350.1 M	AMMONIA	SOIL	mg/Kg	5.00		20	1/10	70-130	1/10	90-110	1/20	90-110
405.1	BOD/CBOD	WATER	mg/L	2.00		20	1/20	44-148	1/20	83-114	1/20	NA
300.0	BROMIDE BY IC	WATER	mg/L	0.100	0.0534	20	1/10	79-124	1/10	90-110	1/20	90-110
300.0 M	BROMIDE BY IC	SOIL	mg/Kg	10.0		20	1/10	70-130	1/10	90-110	1/20	90-110
410.4	CHEMICAL OXYGEN DEMAND-LL	WATER	mg/L	5.00	2.83	20	1/10	54-134	1/10	75-121	1/20	85-115
410.4	CHEMICAL OXYGEN DEMAND-HL	WATER	mg/L	50	12.7	20	1/10	54-134	1/10	75-121	1/20	85-115
410.4 M	CHEMICAL OXYGEN DEMAND	SOIL	mg/Kg	100		20	1/10	54-134	1/10	74-110	1/20	85-115
325.2	CHLORIDE	WATER	mg/L	1.00	0.293	20	1/10	69-129	1/10	91-110	1/20	90-110
325.2 M	CHLORIDE	SOIL	mg/Kg	100	32	20	1/10	69-112	1/10	87-115	1/20	90-110
300.0	CHLORIDE BY IC	WATER	mg/L	0.200	0.0510	20	1/10	79-129	1/10	90-110	1/20	90-110
300.0 M	CHLORIDE BY IC	SOIL	mg/Kg	30.0		20	1/10	69-112	1/10	90-110	1/20	90-110
409A	CHLORINE DEMAND	WATER	mg/L	5.00	NA	20	1/20	NA	NA	NA	NA	NA
330.4	CHLORINE RES (FREE)	WATER	mg/L	0.100		20	1/10	50-150	1/20	80-120	1/20	NA
330.4	CHLORINE RES (TOTAL)	WATER	mg/L	0.300	0.0568	20	1/10	50-150	1/20	80-120	1/20	NA
110.2	COLOR (TRUE)	WATER	mg/L	5.0	NA	+/-5units	1/10	NA	NA	+/-5units	NA	NA
120.1	CONDUCTIVITY	WATER	umhos/cm	na	0.3	20	1/20	NA	NA	90-110	1/10	NA
7196A	CR+6 HEX-CHROM	WATER	mg/L	0.0100	0.0036	20	1/10	85-115	1/10	88-110	1/20	90-110
7199	CR+6 HEX-CHROM	WATER	mg/L	0.0100	0.0022	20	1/20	70-130	1/20	80-120	1/20	90-110
3060/7196A	CR+6 HEX-CHROM	SOIL	mg/Kg	4.00	0.396	20	1/20	85-115	1/10	86-119	1/20	90-110
3060/7199	CR+6 HEX-CHROM	SOIL	mg/Kg	4.00	0.633	20	1/20	70-130	1/20	80-120	1/20	90-110
335.2M CLP	CYANIDE, TOTAL	WATER	mg/L	0.010	0.00539	20	1/20	75-125	1/20	85-115	1/20	85-115
335.2M CLP	CYANIDE, TOTAL	SOIL	mg/Kg	0.500	0.224	20	1/20	53-138	1/20	85-115	1/20	85-115
335.4	CYANIDE TOTAL	WATER	mg/L	0.0100	0.00539	20	1/10	50-145	1/10	90-110	HL & LL 1/20	90-110
9012A	CYANIDE, TOTAL	WATER	mg/L	0.0100	0.00539	20	1/10	50-145	1/10	74-123	HL & LL 1/20	85-115
9012A	CYANIDE, TOTAL	SOIL	mg/Kg	0.500	0.224	20	1/10	53-138	1/10	77-122	HL & LL 1/20	85-115
S. 7.3 SW846	CYANIDE, REACTIVITY	WATER	mg/L	0.0500		20	1/20	NA	1/20	0-23	1/20	85-115
S. 7.3 SW846	CYANIDE, REACTIVITY	SOIL	mg/Kg	5.0	0.632	20	1/20	NA	1/20	0-23	1/20	85-115
340.2	FLUORIDE (ISE)	WATER	mg/L	0.100	0.00746	20	1/20	70-124	1/20	70-124	1/20	90-110
340.2 M	FLUORIDE (ISE)	SOIL	mg/Kg			20	1/20	60-135	1/20	60-135	1/20	90-110
300.0	FLUORIDE BY IC	WATER	mg/L	0.100	0.0301	100	1/10	79-127	1/10	90-110	1/20	90-110
300.0 M	FLUORIDE BY IC	SOIL	mg/Kg	20.0		20	1/10	70-130	1/10	90-110	1/20	90-110
130.2	HARDNESS, TOTAL	WATER	mg/L	2.00	0.391	20	1/10	78-121	1/10	88-113	1/10	NA
CAS	HYDROGEN PEROXIDE	WATER	mg/L	1.00	0.187	20	1/10	80-105	1/10	79-106	1/20	90-110
1010	IGN - CLOSED CUP	WATER	degree C		NA	10	1/20	NA	NA	24.3-29.7 C	1/20	NA
1010.CC	IGN - OPEN CUP	SOIL	degree C		NA	20	1/20	NA	NA	NA	NA	NA

WETCHEM QC LIMITS 2002

METHOD	ANALYTE	MATRIX	UNITS	PQL	MDL (approx)	DUP (RPD)	DUP Freq	ACCURACY MS (% REC)	ACCURACY MS Freq	ACCURACY LCS (% Rec)	ACCURACY LCS Frequency	ICV/CCV
300.0	NITRATE BY IC	WATER	mg/L	0.0500	0.0374	20	1/10	66-127	1/10	90-110	1/20	90-110
300.0 M	NITRATE BY IC	SOIL	mg/Kg	5.00		20	1/10	70-130	1/10	90-110	1/20	90-110
353.2	NITRATE/NITRITE AS N	WATER	mg/L	0.0500	0.00354	20	1/10	31-153	1/10	90-110	1/20	90-110
353.2 M	NITRATE/NITRITE AS N	SOIL	mg/Kg	5.00		20	1/10	70-130	1/10	80-120	1/20	90-110
353.2	NITRITE	WATER	mg/L	0.0100	0.00306	20	1/10	51-144	1/10	90-110	1/20	90-110
351.2	NITROGEN, TOTAL KJELDAHL	WATER	mg/L	0.200	0.173	20	1/10	51-135	1/10	66-118	1/20	90-110(I)85-115(C)
351.2-M	NITROGEN, TOTAL KJELDAHL	SOIL	mg/Kg	20.0	5.18	20	1/10	10-198	1/10	78-105	1/20	90-110(I)85-115(C)
351.2	NITROGEN, TOTAL KJELDAHL LL	WATER	mg/L	0.0500	0.0419	20	1/10	51-135	1/10	66-118	1/20	90-110(I)85-115(C)
413.1	OIL & GREASE	WATER	mg/L	5.00	4	30	1/20	54-147	1/20	54-147	1/20	NA
9071A	OIL & GREASE	SOIL	mg/Kg	500		30	1/20	38-156	1/20	38-156	1/20	NA
1664A	OIL & GREASE BY 1664	WATER	mg/L	5.00	1.59	20	1/20	78-114	1/20	78-114	1/20	NA
300.0	ORTHO-PHOS BY IC	WATER	mg/L	0.100	0.0693	20	1/10	80-120	1/10	90-110	1/20	90-110
365.3	ORTHOPHOSPHATE	WATER	mg/L	0.0100	0.00394	20	1/10	75-114	1/10	90-110	1/20	90-110
9095	PAINT FILTER TEST	SLUDGE	mg/Kg	ND	NA	20	1/20	NA	NA	NA	NA	NA
150.1	PH	WATER	SU	1	NA	±0.10	1/10	NA	NA	NA	NA	±0.05
9040/9045.	PH/CORROSIVITY	WATER	SU	1	NA	±0.10	1/20	NA	NA	NA	NA	±0.05
9040/9045.	PH/CORROSIVITY	SOIL	SU	1	NA	±0.10	1/20	NA	NA	NA	NA	±0.05
420.2	PHENOLICS, LL (0.001)	WATER	mg/L	0.0010	0.000570	20	1/10	43-146	1/10	88-111	1/20	85-115
420.2	PHENOLICS, TOTAL	WATER	mg/L	0.00500	0.000570	20	1/10	43-146	1/10	88-111	1/20	85-115
420.2	PHENOLICS, MANUAL DIST	WATER	mg/L	0.00500		20	1/10	68-118	1/10	68-118	1/20	85-115
9066.	PHENOLICS, TOTAL	WATER	mg/L	0.0050	0.000570	20	1/10	43-146	1/10	88-111	1/20	85-115
9066.	PHENOLICS, TOTAL	SOIL	mg/Kg	0.100		20	1/10	76-109	1/10	76-109	1/20	85-115
365.1 M	PHOSPHORUS, TOTAL, LL	WATER	mg/L	0.00300	0.00076	20	1/10	36-144	1/10	71-118	1/20	90-110
365.1	PHOSPHORUS, TOTAL	WATER	mg/L	0.0500	0.00575	20	1/10	36-144	1/10	90-110	1/20	90-110
365.1-M	PHOSPHORUS, TOTAL	SOIL	mg/Kg	5.00	0.536	20	1/20	75-125	1/10	73-118	1/20	90-110
370.1	SILICA	WATER	mg/L	0.0100	0.00725	20	1/10	86-127	1/10	90-119	1/20	90-110
160.0	SOLIDS, PERCENT	SOIL	mg/Kg	1.0	NA	30	1/10	NA	NA	NA	NA	NA
160.5	SOLIDS, SETTLEABLE	WATER	mg/L	0.100	NA	20	1/20	NA	NA	NA	NA	NA
160.3	SOLIDS, TOTAL (TS)	WATER	mg/L	10.0	NA	20	1/10	NA	NA	80-120	1/20	NA
160.1	SOLIDS, TOTAL DISSOLVED	WATER	mg/L	10.0	NA	20	1/10	NA	NA	80-120	1/20	NA
160.2	SOLIDS, TOTAL SUSPENDED	WATER	mg/L	1.00	NA	20	1/10	NA	NA	80-120	1/20	NA
160.4	SOLIDS, TOTAL VOLATILE	WATER	mg/L	10.0	NA	20	1/10	NA	NA	NA	NA	NA
160.4D	SOLIDS, VOLATILE DISSOLVED	WATER	mg/L	10.0	NA	20	1/10	NA	NA	NA	NA	NA
375.4	SULFATE	WATER	mg/L	5.00	1.63	20	1/10	88-124	1/10	88-124	1/20	NA
300.0	SULFATE BY IC	WATER	mg/L	0.200	0.132	20	1/10	76-127	1/10	90-110	1/20	90-110
300.0 M	SULFATE BY IC	SOIL	mg/Kg	30.0		20	1/10	70-130	1/10	90-110	1/20	90-110

WETCHEM QC LIMITS 2002

METHOD	ANALYTE	MATRIX	UNITS	PQL	MDL (approx)	DUP (RPD)	DUP Freq	ACCURACY MS (% REC)	MS Freq	LCS (% Rec)	LCS Frequency	ICV/CCV
S. 7.3 SW846	SULFIDE REACTIVITY	WATER	mg/L	1.00		20	1/20	0-235	NA	84-224	1/20	NA
S. 7.3 SW846	SULFIDE REACTIVITY	SOIL	mg/Kg	~~20.0~~ 50	13.7	20	1/20	0-235	NA	84-224	1/20	NA
9030B	SULFIDE, TOTAL	WATER	mg/L	1.00	0.797	20	1/10	18-104	1/20	41-94	1/20	NA
9030B	SULFIDE, TOTAL	SOIL	mg/Kg	20.0	8.60	20	1/10	10-123	1/20	57-105	1/20	NA
376.1	SULFIDE, TOTAL	WATER	mg/L	1.00	0.473	20	1/10	33-110	1/20	74-143	1/20	NA
377.1	SULFITE	WATER	mg/L	2.00		20	1/10	NA	NA	NA	NA	NA
425.1	SURFACTANTS	WATER	mg/L	0.0200	0.00719	20	1/20	NA	NA	37-154	1/20 HL	NA
415.1	TOC - LOW LEVEL	WATER	mg/L	0.100	0.0912	20	1/10	67-123	1/10	72-120	1/20	85-115
415.1 M	TOC - REG LEVEL	WATER	mg/L	1.00	0.223	20	1/10	67-123	1/10	72-120	1/20	85-115
9060	TOC - REG LEVEL	WATER	mg/L	1.00	0.223	20	1/10	65-125	1/10	74-116	1/20	85-115
TOCLK	TOC SOIL - LLOYD KAHN	SOIL	mg/Kg	300	62.5	30	1/20	30-168	1/20	82-123	1/20	85-115
TOCWB	TOC - WALKLEY - BLACK	SOIL	mg/Kg	0.10	0.0002	30	1/20	69-105	1/20	83-98	1/10	NA
418.1	TPH by IR	WATER	mg/L	0.500	0.108	20	1/10	50-150	1/10	56-144	1/20	80-120
418.1 M	TPH by IR	SOIL	mg/Kg	33.0	10.8	20	1/10	10-194	1/10	70-136	1/20	80-120
1664A	TPH by 1664A	WATER	mg/L	5.0	1.73	20	1/20	64-132	1/20	64-132	1/20	NA
180.1	TURBIDITY	WATER	NTU	0.10	0.354	10	1/20	NA	NA	90-110	3@run start	90-110

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
504.1	1,2-DIBROMOMETHANE	WATER	0.06	UG/L	0.006	30	50-150	50-150
504.1	1,2-DIBROMO-3-CHLOROPROPANE	WATER	0.06	UG/L	0.004	30	50-150	50-150
524.2	1,1,1,2-TETRACHLOROETHANE	WATER	0.50	UG/L	0.10	20	70-130	
524.2	1,1,1-TRICHLOROETHANE	WATER	0.50	UG/L	0.14	20	70-130	
524.2	1,1,2,2-TETRACHLOROETHANE	WATER	0.50	UG/L	0.15	20	70-130	
524.2	1,1,2-TRICHLOROETHANE	WATER	0.50	UG/L	0.15	20	70-130	
524.2	1,1-DICHLOROETHANE	WATER	0.50	UG/L	0.14	20	70-130	
524.2	1,1-DICHLOROETHENE	WATER	0.50	UG/L	0.22	20	70-130	70-130
524.2	1,1-DICHLOROPROPENE	WATER	0.50	UG/L	0.08	20	70-130	
524.2	1,2,3-TRICHLOROBENZENE	WATER	0.50	UG/L	0.14	20	70-130	
524.2	1,2,3-TRICHLOROPROPANE	WATER	0.50	UG/L	0.15	20	70-130	
524.2	1,2,4-TRICHLOROBENZENE	WATER	0.50	UG/L	0.17	20	70-130	
524.2	1,2,4-TRIMETHYLBENZENE	WATER	0.50	UG/L	0.16	20	70-130	
524.2	1,2-DIBROMO-3-CHLOROPROPANE	WATER	0.50	UG/L	0.26	20	70-130	
524.2	1,2-DIBROMOETHANE	WATER	0.50	UG/L	0.14	20	70-130	
524.2	1,2-DICHLOROBENZENE	WATER	0.50	UG/L	0.13	20	70-130	
524.2	1,2-DICHLOROETHANE	WATER	0.50	UG/L	0.11	20	70-130	
524.2	1,2-DICHLOROPROPANE	WATER	0.50	UG/L	0.13	20	70-130	
524.2	1,3,5-TRIMETHYLBENZENE	WATER	0.50	UG/L	0.16	20	70-130	
524.2	1,3-DICHLOROBENZENE	WATER	0.50	UG/L	0.14	20	70-130	
524.2	1,3-DICHLOROPROPANE	WATER	0.50	UG/L	0.13	20	70-130	
524.2	1,4-DICHLOROBENZENE	WATER	0.50	UG/L	0.16	20	70-130	
524.2	2,2-DICHLOROPROPANE	WATER	0.50	UG/L	0.19	20	70-130	
524.2	2-CHLOROTOLUENE	WATER	0.50	UG/L	0.19	20	70-130	
524.2	4-CHLOROTOLUENE	WATER	0.50	UG/L	0.19	20	70-130	
524.2	BENZENE	WATER	0.50	UG/L	0.10	20	70-130	70-130
524.2	BROMOBENZENE	WATER	0.50	UG/L	0.13	20	70-130	
524.2	BROMOCHLOROMETHANE	WATER	0.50	UG/L	0.12	20	70-130	
524.2	BROMODICHLOROMETHANE	WATER	0.50	UG/L	0.11	20	70-130	
524.2	BROMOFORM	WATER	0.50	UG/L	0.12	20	70-130	
524.2	BROMOMETHANE	WATER	0.50	UG/L	0.23	20	70-130	
524.2	CARBON TETRACHLORIDE	WATER	0.50	UG/L	0.12	20	70-130	
524.2	CHLOROBENZENE	WATER	0.50	UG/L	0.16	20	70-130	70-130
524.2	CHLOROETHANE	WATER	0.50	UG/L	0.26	20	70-130	
524.2	CHLOROFORM	WATER	0.50	UG/L	0.12	20	70-130	
524.2	CHLOROMETHANE	WATER	0.50	UG/L	0.21	20	70-130	
524.2	CIS-1,2-DICHLOROETHENE	WATER	0.50	UG/L	0.11	20	70-130	
524.2	CIS-1,3-DICHLOROPROPENE	WATER	0.50	UG/L	0.12	20	70-130	
524.2	DIBROMOCHLOROMETHANE	WATER	0.50	UG/L	0.10	20	70-130	
524.2	DIBROMOMETHANE	WATER	0.50	UG/L	0.14	20	70-130	
524.2	DICHLORODIFLUOROMETHANE	WATER	0.50	UG/L	0.15	20	70-130	
524.2	ETHYLBENZENE	WATER	0.50	UG/L	0.14	20	70-130	
524.2	HEXACHLOROBUTADIENE	WATER	0.50	UG/L	0.11	20	70-130	
524.2	ISOPROPYLBENZENE	WATER	0.50	UG/L	0.16	20	70-130	
524.2	M+P-XYLENE	WATER	1.00	UG/L	0.33	20	70-130	
524.2	METHYLENE CHLORIDE	WATER	0.50	UG/L	0.21	20	70-130	
524.2	NAPHTHALENE	WATER	0.50	UG/L	0.18	20	70-130	
524.2	N-BUTYLBENZENE	WATER	0.50	UG/L	0.14	20	70-130	
524.2	N-PROPYLBENZENE	WATER	0.50	UG/L	0.14	20	70-130	
524.2	O-XYLENE	WATER	0.50	UG/L	0.16	20	70-130	
524.2	P-ISOPROPYLTOLUENE	WATER	0.50	UG/L	0.15	20	70-130	
524.2	SEC-BUTYLBENZENE	WATER	0.50	UG/L	0.14	20	70-130	
524.2	STYRENE	WATER	0.50	UG/L	0.15	20	70-130	
524.2	TERT-BUTYLBENZENE	WATER	0.50	UG/L	0.15	20	70-130	
524.2	TETRACHLOROETHENE	WATER	0.50	UG/L	0.17	20	70-130	
524.2	TOLUENE	WATER	0.50	UG/L	0.10	20	70-130	70-130
524.2	TRANS-1,2-DICHLOROETHENE	WATER	0.50	UG/L	0.14	20	70-130	
524.2	TRANS-1,3-DICHLOROPROPENE	WATER	0.50	UG/L	0.12	20	70-130	
524.2	TRICHLOROETHENE	WATER	0.50	UG/L	0.16	20	70-130	70-130
524.2	TRICHLOROFLUOROMETHANE	WATER	0.50	UG/L	0.17	20	70-130	

CAS/ROCHESTER ORGANIC QC LIMITS

IOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
4.2	VINYL CHLORIDE	WATER	0.50	UG/L	0.18	20	70-130	
524.2		WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
524.2		WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
524.2 ADDITIONAL COMPOUNDS BY REQUEST								
	TERT-BUTYL ALCOHOL	WATER	20	UG/L	10	20	70-130	
	METHYL-TERT-BUTYL-ETHER	WATER	0.50	UG/L	0.48	30	70-130	
	2-BUTANONE (MEK)	WATER	5.0	UG/L	2.10	20	70-130	
	2-HEXANONE	WATER	5.0	UG/L	2.50	20	70-130	
	4-METHYL-2-PENTANONE (MIBK)	WATER	5.0	UG/L	1.80	20	70-130	
	ACETONE	WATER	5.0	UG/L	3.80	20	70-130	
601	BROMODICHLOROMETHANE	WATER	1.00	UG/L	0.50	30	42-172	42-172
601	BROMOFORM	WATER	1.00	UG/L	0.50	30	13-159	13-159
601	BROMOMETHANE	WATER	1.00	UG/L	0.50	30	d-144	d-144
601	CARBON TETRACHLORIDE	WATER	1.00	UG/L	0.50	30	43-143	43-143
601	CHLOROBENZENE	WATER	1.00	UG/L	0.50	30	38-150	38-150
601	CHLOROETHANE	WATER	1.00	UG/L	0.50	30	46-137	46-137
601	2-CHLOROETHYLVINYL ETHER	WATER	1.00	UG/L	0.50	30	14-186	14-186
601	CHLOROFORM	WATER	1.00	UG/L	0.50	30	49-133	49-133
601	CHLOROMETHANE	WATER	1.00	UG/L	0.50	30	42-172	42-172
601	DIBROMOCHLOROMETHANE	WATER	1.00	UG/L	0.50	30	13-159	13-159
601	1,2-DICHLOROBENZENE	WATER	1.00	UG/L	0.50	30	d-144	d-144
601	1,3-DICHLOROBENZENE	WATER	1.00	UG/L	0.50	30	43-143	43-143
601	1,4-DICHLOROBENZENE	WATER	1.00	UG/L	0.50	30	38-150	38-150
601	1,1-DICHLOROETHANE	WATER	1.00	UG/L	0.50	30	46-137	46-137
601	1,2-DICHLOROETHANE	WATER	1.00	UG/L	0.50	30	14-186	14-186
601	1,1-DICHLOROETHENE	WATER	1.00	UG/L	0.50	30	49-133	49-133
601	TRANS-1,2-DICHLOROETHENE	WATER	1.00	UG/L	0.50	30	d-193	d-193
601	CIS-1,2-DICHLOROETHENE	WATER	1.00	UG/L	0.50	30	24-191	24-191
601	1,2-DICHLOROPROPANE	WATER	1.00	UG/L	0.50	30	d-208	d-208
601	CIS-1,3-DICHLOROPROPENE	WATER	1.00	UG/L	0.50	30	7-187	7-187
601	TRANS-1,3-DICHLOROPROPENE	WATER	1.00	UG/L	0.50	30	42-143	42-143
601	METHYLENE CHLORIDE	WATER	1.00	UG/L	0.50	30	47-132	47-132
601	1,1,2,2-TETRACHLOROETHANE	WATER	1.00	UG/L	0.50	30	51-147	51-147
601	TETRACHLOROETHENE	WATER	1.00	UG/L	0.50	30	28-167	28-167
601	1,1,1-TRICHLOROETHANE	WATER	1.00	UG/L	0.50	30	38-155	38-155
601	1,1,2-TRICHLOROETHANE	WATER	1.00	UG/L	0.50	30	39-136	39-136
601	TRICHLOROETHENE	WATER	1.00	UG/L	0.50	30	35-146	35-146
601	TRICHLOROFLUOROMETHANE	WATER	1.00	UG/L	0.50	30	21-156	21-156
601	VINYL CHLORIDE	WATER	1.00	UG/L	0.50	30	28-163	28-163
601		WATER	NA	UG/L	NA	NA	[illegible]	
601		WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
601		WATER	NA	UG/L	NA	NA	[illegible]	[illegible]

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
[illegible]	BENZENE	WATER	1.00	UG/L	0.50	30	[illegible]	39-150
602	CHLOROBENZENE	WATER	1.00	UG/L	0.50	30	[illegible]	55-135
602	1,3-DICHLOROBENZENE (M)	WATER	1.00	UG/L	0.50	30	[illegible]	50-141
602	1,2-DICHLOROBENZENE (O)	WATER	1.00	UG/L	0.50	30	[illegible]	37-154
602	1,4-DICHLOROBENZENE (P)	WATER	1.00	UG/L	0.50	30	[illegible]	42-143
602	ETHYLBENZENE	WATER	1.00	UG/L	0.50	30	[illegible]	32-160
602	TOLUENE	WATER	1.00	UG/L	0.50	30	[illegible]	46-148
602	M+P-XYLENE	WATER	2.00	UG/L	0.50	30	70-130	70-130
602	O-XYLENE	WATER	1.00	UG/L	0.50	30	70-130	70-130
602	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
601/602 ADDITIONAL COMPOUNDS BY REQUEST								
	DICHLORODIFLUOROMETHANE	WATER	1.00	UG/L	0.50	30	[illegible]	[illegible]
	FREON 113	WATER	1.00	UG/L	0.50	30	70-130	[illegible]
	METHYL-TERT-BUTYL ETHER (MTBE)	WATER	1.00	UG/L	0.50	30	70-130	[illegible]
	TOTAL XYLENES	WATER	3.00	UG/L	0.58	30	70-130	70-130
608	ALDRIN	WATER	0.050	UG/L	0.013	30	42-122	42-122
608	ALPHA-BHC	WATER	0.050	UG/L	0.009	30	[illegible]	37-134
608	BETA-BHC	WATER	0.050	UG/L	0.012	30	[illegible]	17-147
608	GAMMA-BHC	WATER	0.050	UG/L	0.006	30	[illegible]	19-140
608	DELTA-BHC	WATER	0.050	UG/L	0.010	30	[illegible]	32-127
608	CHLORDANE	WATER	0.25	UG/L	0.066	30	[illegible]	45-119
608	4,4'-DDE	WATER	0.10	UG/L	0.010	30	[illegible]	30-145
608	4,4'-DDT	WATER	0.10	UG/L	0.013	30	[illegible]	25-160
608	4,4'-DDD	WATER	0.10	UG/L	0.014	30	[illegible]	31-141
608	DIELDRIN	WATER	0.10	UG/L	0.012	30	[illegible]	36-146
608	ALPHA-ENDOSULFAN	WATER	0.050	UG/L	0.007	30	[illegible]	45-153
[illegible]	BETA-ENDOSULFAN	WATER	0.10	UG/L	0.007	30	[illegible]	d-202
[illegible]	ENDOSULFAN SULFATE	WATER	0.10	UG/L	0.010	30	[illegible]	26-144
[illegible]	ENDRIN	WATER	0.10	UG/L	0.013	30	[illegible]	30-147
608	ENDRIN ALDEHYDE	WATER	0.10	UG/L	0.024	30	[illegible]	24-124
608	HEPTACHLOR	WATER	0.054	UG/L	0.054	30	[illegible]	34-111
608	HEPTACHLOR EPOXIDE	WATER	0.050	UG/L	0.009	30	[illegible]	37-142
608	TOXAPHENE	WATER	1.0	UG/L	0.369	30	[illegible]	41-126
608	PCB 1016	WATER	1.0	UG/L	0.39	30	[illegible]	50-114
608	PCB 1221	WATER	2.0	UG/L	0.34	30	[illegible]	15-178
608	PCB 1232	WATER	1.0	UG/L	0.23	30	[illegible]	10-215
608	PCB 1242	WATER	1.0	UG/L	0.67	30	[illegible]	39-150
608	PCB 1248	WATER	1.0	UG/L	0.23	30	[illegible]	38-158
608	PCB 1254	WATER	1.0	UG/L	0.14	30	[illegible]	29-131
608	PCB 1260	WATER	1.0	UG/L	0.36	30	[illegible]	8-127
608	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
608	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]

CAS/ROCHESTER ORGANIC QC LIMITS

A D	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
[redacted]	ACROLEIN	WATER	10	UG/L	5.48	30	[illegible]	[illegible]
[redacted]	ACRYLONITRILE	WATER	10	UG/L	7.4	30	[illegible]	[illegible]
624	BENZENE	WATER	1.0	UG/L	0.06	30	37-151	37-151
624	BROMODICHLOROMETHANE	WATER	1.0	UG/L	0.18	30	35-155	35-155
624	BROMOFORM	WATER	1.0	UG/L	0.14	30	45-169	45-169
624	BROMOMETHANE	WATER	1.0	UG/L	0.28	30	d-242	d-242
624	CARBON TETRACHLORIDE	WATER	1.0	UG/L	0.18	30	70-140	70-140
624	CHLOROBENZENE	WATER	1.0	UG/L	0.15	30	37-160	37-160
624	CHLOROETHANE	WATER	1.0	UG/L	0.29	30	14-230	14-230
624	2-CHLOROETHYLVINYL ETHER	WATER	10	UG/L	1.12	30	d-305	d-305
624	CHLOROFORM	WATER	1.0	UG/L	0.16	30	51-138	51-138
624	CHLOROMETHANE	WATER	1.0	UG/L	0.48	30	d-273	d-273
624	DIBROMOCHLOROMETHANE	WATER	1.0	UG/L	0.10	30	53-149	53-149
624	1,1-DICHLOROETHANE	WATER	1.0	UG/L	0.16	30	59-155	59-155
624	1,2-DICHLOROETHANE	WATER	1.0	UG/L	0.12	30	49-155	49-155
624	1,1-DICHLOROETHENE	WATER	1.0	UG/L	0.21	30	d-234	d-234
624	TRANS-1,2-DICHLOROETHENE	WATER	1.0	UG/L	0.14	30	54-156	54-156
624	1,2-DICHLOROPROPANE	WATER	1.0	UG/L	0.21	30	d-210	d-210
624	CIS-1,3-DICHLOROPROPENE	WATER	1.0	UG/L	0.13	30	d-227	d-227
624	TRANS-1,3-DICHLOROPROPENE	WATER	1.0	UG/L	0.18	30	17-183	17-183
624	ETHYLBENZENE	WATER	1.0	UG/L	0.13	30	37-162	37-162
624	METHYLENE CHLORIDE	WATER	1.0	UG/L	0.23	30	d-221	d-221
624	1,1,2,2-TETRACHLOROETHANE	WATER	1.0	UG/L	0.25	30	46-157	46-157
624	TETRACHLOROETHENE	WATER	1.0	UG/L	0.15	30	64-148	64-148
624	TOLUENE	WATER	1.0	UG/L	0.16	30	47-150	47-150
624	1,1,1-TRICHLOROETHANE	WATER	1.0	UG/L	0.15	30	52-162	52-162
624	1,1,2-TRICHLOROETHANE	WATER	1.0	UG/L	0.20	30	52-150	52-150
[redacted]	TRICHLOROETHENE	WATER	1.0	UG/L	0.14	30	[illegible]	71-157
[redacted]	TRICHLOROFLUOROMETHANE	WATER	1.0	UG/L	0.21	30	[illegible]	17-181
624	VINYL CHLORIDE	WATER	1.0	UG/L	0.13	30	[illegible]	d-251
624	[redacted]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
624	[redacted]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
624	[redacted]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
624	ADDITIONAL COMPOUNDS BY REQUEST							
624	1,2-DIBROMOETHANE	WATER	1.0	UG/L	1.19	30	70-130	50-150
624	1,2-DICHLOROBENZENE	WATER	1.0	UG/L	0.14	30	18-190	18-190
624	1,3-DICHLOROBENZENE	WATER	1.0	UG/L	0.17	30	59-156	59-156
624	1,4-DICHLOROBENZENE	WATER	1.0	UG/L	0.10	30	18-190	18-190
624	2-BUTANONE (MEK)	WATER	10	UG/L	1.47	30	50-150	50-150
624	2-HEXANONE	WATER	10	UG/L	1.74	30	70-130	50-150
624	4-METHYL-2-PENTANONE (MIBK)	WATER	10	UG/L	1.57	30	70-130	50-150
624	ACETONE	WATER	10	UG/L	2.29	30	50-150	50-150
624	CARBON DISULFIDE	WATER	10	UG/L	0.70	30	70-130	50-150
624	CIS-1,2-DICHLOROETHENE	WATER	1.0	UG/L	0.10	30	70-130	50-150
624	DICHLORODIFLUOROMETHANE	WATER	1.0	UG/L	0.22	30	70-130	50-150
624	M+P XYLENE	WATER	2.0	UG/L	0.28	30	70-130	50-150
624	METHYL-TERT-BUTYL ETHER	WATER	1.0	UG/L	0.66	30	70-130	50-150
624	NAPHTHALENE	WATER	1.0	UG/L	1.22	30	70-130	50-150
624	O-XYLENE	WATER	1.0	UG/L	0.20	30	70-130	50-150
624	STYRENE	WATER	1.0	UG/L	1.02	30	70-130	50-150
624	TERT-BUTYL ALCOHOL	WATER	50	UG/L	30.7	30	50-150	50-150
624	TETRAHYDROFURAN	WATER	10	UG/L	1.62	30	50-150	50-150
625	ACENAPHTHENE	WATER	5.0	UG/L	1.36	30	[illegible]	47-145
[redacted]	ACENAPHTHYLENE	WATER	5.0	UG/L	1.14	30	[illegible]	33-145
[redacted]	ANTHRACENE	WATER	5.0	UG/L	1.17	30	[illegible]	27-133
[redacted]	BENZIDINE	WATER	100	UG/L	42.9	30	[illegible]	10-138
[redacted]	BENZO(A)ANTHRACENE	WATER	5.0	UG/L	0.86	30	[illegible]	33-143
625	BENZO(A)PYRENE	WATER	5.0	UG/L	0.99	30	[illegible]	17-163
625	BENZO(B)FLUORANTHENE	WATER	5.0	UG/L	1.33	30	[illegible]	24-159

CAS/ROCHESTER ORGANIC QC LIMITS

IOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
625	BENZO(G,H,I)PERYLENE	WATER	5.0	UG/L	1.06	30	d-219	d-219
625	BENZO(K)FLUORANTHENE	WATER	5.0	UG/L	1.21	30	11-162	11-162
625	BUTYL BENZYL PHTHALATE	WATER	5.0	UG/L	1.08	30	d-152	d-152
625	DI-N-BUTYLPHTHALATE	WATER	5.0	UG/L	0.95	30	1-118	1-118
625	INDENO(1,2,3-CD)PYRENE	WATER	5.0	UG/L	0.88	30	d-171	d-171
625	BIS(-2-CHLOROETHOXY)METHANE	WATER	5.0	UG/L	1.05	30	33-184	33-184
625	BIS(2-CHLOROETHYL)ETHER	WATER	5.0	UG/L	1.78	30	12-158	12-158
625	2-CHLORONAPHTHALENE	WATER	5.0	UG/L	0.96	30	60-118	60-118
625	2-CHLOROPHENOL	WATER	5.0	UG/L	1.64	30	23-134	23-134
625	2,2'-OXYBIS(1-CHLOROPROPANE)	WATER	5.0	UG/L	2.42	30	36-166	36-166
625	CHRYSENE	WATER	5.0	UG/L	0.89	30	17-168	17-168
625	DIBENZO(A,H)ANTHRACENE	WATER	5.0	UG/L	0.92	30	d-227	d-227
625	1,3-DICHLOROBENZENE	WATER	5.0	UG/L	1.38	30	d-172	d-172
625	1,2-DICHLOROBENZENE	WATER	5.0	UG/L	1.59	30	32-129	32-129
625	1,4-DICHLOROBENZENE	WATER	5.0	UG/L	1.45	30	20-124	20-124
625	3,3'-DICHLOROBENZIDINE	WATER	5.0	UG/L	2.07	30	d-262	d-262
625	2,4-DICHLOROPHENOL	WATER	5.0	UG/L	1.30	30	39-135	39-135
625	DIETHYLPHTHALATE	WATER	5.0	UG/L	1.42	30	d-114	d-114
625	DIMETHYL PHTHALATE	WATER	5.0	UG/L	1.80	30	d-112	d-112
625	2,4-DIMETHYLPHENOL	WATER	5.0	UG/L	2.60	30	39-135	39-135
625	2,4-DINITROPHENOL	WATER	50	UG/L	22.7	30	d-191	d-191
625	2,4-DINITROTOLUENE	WATER	5.0	UG/L	1.66	30	39-139	39-139
625	2,6-DINITROTOLUENE	WATER	5.0	UG/L	1.96	30	50-158	50-158
625	1,2-DIPHENYLHYDRAZINE	WATER	5.0	UG/L	1.34	30	27-141	27-141
625	BIS(2-ETHYLHEXYL)PHTHALATE	WATER	5.0	UG/L	1.40	30	8-158	8-158
625	FLUORANTHENE	WATER	5.0	UG/L	0.93	30	26-137	26-137
625	FLUORENE	WATER	5.0	UG/L	1.42	30	59-121	59-121
625	HEXACHLOROBENZENE	WATER	5.0	UG/L	1.37	30	d-152	d-152
625	HEXACHLOROBUTADIENE	WATER	5.0	UG/L	1.40	30	24-116	24-116
625	HEXACHLOROCYCLOPENTADIENE	WATER	5.0	UG/L	0.81	30	10-93	10-93
625	HEXACHLOROETHANE	WATER	5.0	UG/L	1.27	30	40-113	40-113
625	ISOPHORONE	WATER	5.0	UG/L	0.91	30	21-196	21-196
625	4,6-DINITRO-2-METHYLPHENOL	WATER	50	UG/L	14.86	30	d-181	d-181
625	4-CHLORO-3-METHYLPHENOL	WATER	5.0	UG/L	1.41	30	22-147	22-147
625	NAPHTHALENE	WATER	5.0	UG/L	1.38	30	21-133	21-133
625	NITROBENZENE	WATER	5.0	UG/L	1.66	30	35-180	35-180
625	2-NITROPHENOL	WATER	5.0	UG/L	1.47	30	29-182	29-182
625	4-NITROPHENOL	WATER	50	UG/L	6.72	30	d-132	d-132
625	N-NITROSODIMETHYLAMINE	WATER	5.0	UG/L	0.84	30	11-102	11-102
625	N-NITROSODIPHENYLAMINE	WATER	5.0	UG/L	1.50	30	d-230	d-230
625	DI-N-OCTYL PHTHALATE	WATER	5.0	UG/L	1.12	30	4-146	4-146
625	PENTACHLOROPHENOL	WATER	50	UG/L	1.59	30	14-176	14-176
625	PHENANTHRENE	WATER	5.0	UG/L	1.17	30	54-120	54-120
625	PHENOL	WATER	5.0	UG/L	0.72	30	5-112	5-112
625	4-BROMOPHENYL-PHENYLETHER	WATER	5.0	UG/L	1.32	30	53-127	53-127
625	4-CHLOROPHENYL-PHENYLETHER	WATER	5.0	UG/L	1.44	30	25-158	25-158
625	N-NITROSO-DI-N-PROPYLAMINE	WATER	5.0	UG/L	0.81	30	d-230	d-230
625	PYRENE	WATER	5.0	UG/L	1.08	30	52-115	52-115
625	1,2,4-TRICHLOROBENZENE	WATER	5.0	UG/L	1.48	30	44-142	44-142
625	2,4,6-TRICHLOROPHENOL	WATER	5.0	UG/L	1.32	30	37-144	37-144
625		WATER	NA	UG/L	NA	NA		
625		WATER	NA	UG/L	NA	NA		
625		WATER	NA	UG/L	NA	NA		
625		WATER	NA	UG/L	NA	NA		
		WATER	NA	UG/L	NA	NA		
		WATER	NA	UG/L	NA	NA		

CAS/ROCHESTER ORGANIC QC LIMITS

OD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
[illegible]	MONOCHLOROBIPHENYLS, TOTAL	WATER	0.005	UG/L	0.003	30	50-125	50-125
[illegible]80	DICHLOROBIPHENYLS, TOTAL	WATER	0.006	UG/L	0.003	30	50-125	50-125
680	TRICHLOROBIPHENYLS, TOTAL	WATER	0.006	UG/L	0.004	30	50-125	50-125
680	TETRACHLOROBIPHENYLS, TOTAL	WATER	0.010	UG/L	0.008	30	50-125	50-125
680	PENTACHLOROBIPHENYLS, TOTAL	WATER	0.010	UG/L	0.004	30	50-125	50-125
680	HEXACHLOROBIPHENYLS, TOTAL	WATER	0.020	UG/L	0.006	30	50-125	50-125
680	HEPTACHLOROBIPHENYLS, TOTAL	WATER	0.020	UG/L	0.015	30	50-125	50-125
680	OCTACHLOROBIPHENYLS, TOTAL	WATER	0.040	UG/L	0.039	30	50-125	50-125
680	NONACHLOROBIPHENYLS, TOTAL	WATER	0.025	UG/L	0.019	30	50-125	50-125
680	DECACHLOROBIPHENYLS, TOTAL	WATER	0.040	UG/L	0.024	30	50-125	50-125
680	[illegible]	WATER	NA	UG/L	NA	30	50-125	50-125
680	[illegible]	WATER	NA	UG/L	NA	30	50-125	50-125
8011	1,2-DIBROMOMETHANE	WATER	0.06	UG/L	0.006	30	50-150	50-150
8011	1,2-DIBROMO-3-CHLOROPROPANE	WATER	0.06	UG/L	0.004	30	50-150	50-150
8015B	MINERAL SPIRITS	WATER	100	UG/L	52.1	30	[illegible]	[illegible]
8015B	METHANOL	WATER	1000	UG/L	233	30	[illegible]	[illegible]
8015B	ETHANOL	WATER	1000	UG/L	78.6	30	70-130	50-150
8015B	ISOPROPANOL	WATER	1000	UG/L	127	30	70-130	50-150
8015B	N-BUTANOL	WATER	1000	UG/L	220	30	70-130	50-150
8015B	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8015B	ISO-PENTANE	WATER	10	UG/L	5.70	30	59-127	50-150
8015B	2-BUTANONE (MEK)	WATER	10	UG/L	7	30	50-150	50-150
8015B	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8015B	GASOLINE RANGE ORGANICS	WATER	50	UG/L	38.40	30	70-130	50-150
8015B	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
[illegible]5B	GASOLINE RANGE ORGANICS	SOIL	50	UG/KG	17.00	50	70-130	50-150
[illegible]B	[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]
[illegible]5B	DIESEL RANGE ORGANICS	WATER	100	UG/L	49	30	[illegible]	[illegible]
[illegible]015B	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8015B	DIESEL RANGE ORGANICS	SOIL	40000	UG/KG	6409	50	[illegible]	[illegible]
8015B	[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
8015B ETPH-CT	ETPH	WATER	75	UG/L				
8015B ETPH-CT	FUEL OIL #2	WATER	100	UG/L		30	50-150	50-150
8015B ETPH-CT	FUEL OIL #4	WATER	100	UG/L				
8015B ETPH-CT	FUEL OIL #6	WATER	100	UG/L				
8015B ETPH-CT	KEROSENE	WATER	100	UG/L				
8015B ETPH-CT	MOTOR OIL	WATER	1000	UG/L				
8015B ETPH-CT	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8015B ETPH-CT	ETPH	SOIL	2500	UG/KG				
8015B ETPH-CT	FUEL OIL #2	SOIL	3300	UG/KG		30	50-150	50-150
8015B ETPH-CT	FUEL OIL #4	SOIL	3300	UG/KG				
8015B ETPH-CT	FUEL OIL #6	SOIL	3300	UG/KG				
8015B ETPH-CT	KEROSENE	SOIL	3300	UG/KG				
8015B ETPH-CT	MOTOR OIL	SOIL	33000	UG/KG				
8015B ETPH-CT	[illegible]	SOIL	NA	UG/KG	NA	NA	35-137	35-137
8015B FINGERPRINT	FUEL OIL #2	WATER	1000	UG/L	475	30	50-150	50-150
8015B FINGERPRINT	GASOLINE	WATER	1000	UG/L				
8015B FINGERPRINT	KEROSENE	WATER	1000	UG/L				
8015B FINGERPRINT	MINERAL SPIRITS	WATER	1000	UG/L				
8015B FINGERPRINT	MOTOR OIL	WATER	10000	UG/L				
8015B FINGERPRINT	FUEL OIL #2	SOIL	100000	UG/KG	70000	30	50-150	50-150
8015B FINGERPRINT	GASOLINE	SOIL	100000	UG/KG				
8015B FINGERPRINT	KEROSENE	SOIL	100000	UG/KG				
8015B FINGERPRINT	MINERAL SPIRITS	SOIL	100000	UG/KG				
8015B FINGERPRINT	MOTOR OIL	SOIL	1000000	UG/KG				
8015B RSK	ETHANE	WATER	1.0	UG/L	0.519	30	50-150	50-150
[illegible]B RSK	ETHYLENE	WATER	1.0	UG/L	0.463	30	50-150	50-150
[illegible]B RSK	METHANE	WATER	1.0	UG/L	0.447	30	50-150	50-150
[illegible]5B RSK	PROPANE	WATER	1.0	UG/L	0.396	30	50-150	50-150
[illegible] 310-13	FUEL OIL #2	WATER	1000	UG/L	300	30	50-150	50-150
NY 310-13	GASOLINE	WATER	1000	UG/L	540			
NY 310-13	KEROSENE	WATER	1000	UG/L	200			
NY 310-13	LUBE OIL	WATER	1000	UG/L	420			
NY 310-13	N-DODECANE	WATER	1000	UG/L	190			
NY 310-13	FUEL OIL #2	SOIL	100000	UG/KG	13040	30	50-150	50-150
NY 310-13	GASOLINE	SOIL	100000	UG/KG	15460			
NY 310-13	KEROSENE	SOIL	100000	UG/KG	21320			
NY 310-13	LUBE OIL	SOIL	100000	UG/KG	34500			
NY 310-13	N-DODECANE	SOIL	100000	UG/KG	6150			
8100	DIESEL RANGE ORGANICS	WATER	100	UG/L				
8100	FUEL OIL #2	WATER	100	UG/L	40	30	50-150	50-150
8100	FUEL OIL #4	WATER	100	UG/L				
8100	FUEL OIL #6	WATER	100	UG/L				
8100	KEROSENE	WATER	100	UG/L				
8100	[illegible]	WATER	NA	UG/L		NA	[illegible]	[illegible]
8100	DIESEL RANGE ORGANICS	SOIL	40000	UG/KG				
8100	FUEL OIL #2	SOIL	40000	UG/KG	36800	30	50-150	50-150
8100	FUEL OIL #4	SOIL	40000	UG/KG				
8100	FUEL OIL #6	SOIL	40000	UG/KG				
8100	KEROSENE	SOIL	40000	UG/KG				
8100	[illegible]	SOIL	NA	UG/KG		NA	[illegible]	[illegible]

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
8021B PPL	1,1,1-TRICHLOROETHANE	WATER	1.0	UG/L	0.44	30	70-130	
8021B PPL	1,1,2,2-TETRACHLOROETHANE	WATER	1.0	UG/L	0.45	30	70-130	
8021B PPL	1,1,2-TRICHLOROETHANE	WATER	1.0	UG/L	0.33	30	70-130	
8021B PPL	1,1-DICHLOROETHANE	WATER	1.0	UG/L	0.44	30	70-130	
8021B PPL	1,1-DICHLOROETHENE	WATER	1.0	UG/L	0.41	30	70-130	70-130
8021B PPL	1,2-DICHLOROBENZENE	WATER	1.0	UG/L	0.58	30	70-130	
8021B PPL	1,2-DICHLOROETHANE	WATER	1.0	UG/L	0.42	30	70-130	
8021B PPL	1,2-DICHLOROPROPANE	WATER	1.0	UG/L	0.46	30	70-130	
8021B PPL	1,3-DICHLOROBENZENE	WATER	1.0	UG/L	0.42	30	70-130	
8021B PPL	1,4-DICHLOROBENZENE	WATER	1.0	UG/L	0.64	30	70-130	
8021B PPL	2-CHLOROETHYLVINYL ETHER	WATER	1.0	UG/L	0.70	30	50-150	
8021B PPL	BENZENE	WATER	1.0	UG/L	0.44	30	70-130	70-130
8021B PPL	BROMODICHLOROMETHANE	WATER	1.0	UG/L	0.42	30	70-130	
8021B PPL	BROMOFORM	WATER	1.0	UG/L	0.30	30	70-130	
8021B PPL	BROMOMETHANE	WATER	2.0	UG/L	0.62	30	50-150	
8021B PPL	CARBON TETRACHLORIDE	WATER	1.0	UG/L	0.46	30	70-130	70-130
8021B PPL	CHLOROBENZENE	WATER	1.0	UG/L	0.42	30	70-130	70-130
8021B PPL	CHLOROETHANE	WATER	1.0	UG/L	0.43	30	50-150	
8021B PPL	CHLOROFORM	WATER	1.0	UG/L	0.42	30	70-130	
8021B PPL	CHLOROMETHANE	WATER	1.0	UG/L	0.50	30	50-150	
8021B PPL	CIS-1,2-DICHLOROETHENE	WATER	1.0	UG/L	0.43	30	70-130	
8021B PPL	CIS-1,3-DICHLOROPROPENE	WATER	1.0	UG/L	0.37	30	70-130	
8021B PPL	DIBROMOCHLOROMETHANE	WATER	1.0	UG/L	0.47	30	70-130	
8021B PPL	DICHLORODIFLUOROMETHANE	WATER	1.0	UG/L	0.46	30	50-150	
8021B PPL	ETHYLBENZENE	WATER	1.0	UG/L	0.46	30	70-130	70-130
8021B PPL	FREON 113	WATER	1.0	UG/L	0.37	30	70-130	
8021B PPL	M+P-XYLENE	WATER	2.0	UG/L	0.87	30	70-130	70-130
8021B PPL	METHYLENE CHLORIDE	WATER	1.0	UG/L	0.39	30	70-130	70-130
8021B PPL	O-XYLENE	WATER	1.0	UG/L	0.42	30	70-130	70-130
8021B PPL	TETRACHLOROETHENE	WATER	1.0	UG/L	0.46	30	70-130	
8021B PPL	TOLUENE	WATER	1.0	UG/L	0.43	30	70-130	70-130
8021B PPL	TRANS-1,2-DICHLOROETHENE	WATER	1.0	UG/L	0.46	30	70-130	
8021B PPL	TRANS-1,3-DICHLOROPROPENE	WATER	1.0	UG/L	0.35	30	70-130	
8021B PPL	TRICHLOROETHENE	WATER	1.0	UG/L	0.46	30	70-130	
8021B PPL	TRICHLOROFLUOROMETHANE	WATER	1.0	UG/L	0.38	30	50-150	
8021B PPL	VINYL CHLORIDE	WATER	1.0	UG/L	0.46	30	50-150	
8021B PPL	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8021B PPL	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8021B PPL	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8021B PPL	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
8021B PPL	1,1,1-TRICHLOROETHANE	SOIL	1.0	UG/KG	0.55	30	70-130	
8021B PPL	1,1,2,2-TETRACHLOROETHANE	SOIL	1.0	UG/KG	0.60	30	70-130	
8021B PPL	1,1,2-TRICHLOROETHANE	SOIL	1.0	UG/KG	0.75	30	70-130	
8021B PPL	1,1-DICHLOROETHANE	SOIL	1.0	UG/KG	0.61	30	70-130	
8021B PPL	1,1-DICHLOROETHENE	SOIL	1.0	UG/KG	0.61	30	70-130	70-130
8021B PPL	1,2-DICHLOROBENZENE	SOIL	1.0	UG/KG	0.86	30	70-130	
8021B PPL	1,2-DICHLOROETHANE	SOIL	1.0	UG/KG	0.63	30	70-130	
8021B PPL	1,2-DICHLOROPROPANE	SOIL	1.0	UG/KG	0.55	30	70-130	
8021B PPL	1,3-DICHLOROBENZENE	SOIL	1.0	UG/KG	0.98	30	70-130	
8021B PPL	1,4-DICHLOROBENZENE	SOIL	1.0	UG/KG	0.89	30	70-130	
8021B PPL	2-CHLOROETHYLVINYL ETHER	SOIL	1.0	UG/KG	0.36	30	50-150	
8021B PPL	BENZENE	SOIL	1.0	UG/KG	0.70	30	70-130	[illegible]
8021B PPL	BROMODICHLOROMETHANE	SOIL	1.0	UG/KG	0.56	30	70-130	
8021B PPL	BROMOFORM	SOIL	1.0	UG/KG	0.61	30	70-130	
8021B PPL	BROMOMETHANE	SOIL	2.0	UG/KG	0.49	30	50-150	
8021B PPL	CARBON TETRACHLORIDE	SOIL	1.0	UG/KG	0.67	30	70-130	70-130
8021B PPL	CHLOROBENZENE	SOIL	1.0	UG/KG	0.67	30	70-130	[illegible]
8021B PPL	CHLOROETHANE	SOIL	1.0	UG/KG	0.66	30	50-150	
8021B PPL	CHLOROFORM	SOIL	1.0	UG/KG	0.54	30	70-130	
8021B PPL	CHLOROMETHANE	SOIL	1.0	UG/KG	0.64	30	50-150	
8021B PPL	CIS-1,2-DICHLOROETHENE	SOIL	1.0	UG/KG	0.58	30	70-130	
8021B PPL	CIS-1,3-DICHLOROPROPENE	SOIL	1.0	UG/KG	0.69	30	70-130	
8021B PPL	DIBROMOCHLOROMETHANE	SOIL	1.0	UG/KG	0.62	30	70-130	
8021B PPL	DICHLOROFLUOROMETHANE	SOIL	1.0	UG/KG	0.74	30	50-150	
8021B PPL	ETHYLBENZENE	SOIL	1.0	UG/KG	0.75	30	70-130	[illegible]
8021B PPL	FREON 113	SOIL	1.0	UG/KG	0.60	30	70-130	
8021B PPL	M+P-XYLENE	SOIL	2.0	UG/KG	1.25	30	70-130	[illegible]
8021B PPL	METHYLENE CHLORIDE	SOIL	1.0	UG/KG	0.54	30	70-130	70-130
8021B PPL	O-XYLENE	SOIL	1.0	UG/KG	0.53	30	70-130	[illegible]
8021B PPL	TETRACHLOROETHENE	SOIL	1.0	UG/KG	0.67	30	70-130	
8021B PPL	TOLUENE	SOIL	1.0	UG/KG	0.72	30	70-130	[illegible]
8021B PPL	TRANS-1,2-DICHLOROETHENE	SOIL	1.0	UG/KG	0.67	30	70-130	
8021B PPL	TRANS-1,3-DICHLOROPROPENE	SOIL	1.0	UG/KG	0.68	30	70-130	
8021B PPL	TRICHLOROETHENE	SOIL	1.0	UG/KG	0.74	30	70-130	39-127
8021B PPL	TRICHLOROFLUOROMETHANE	SOIL	1.0	UG/KG	0.76	30	50-150	
8021B PPL	VINYL CHLORIDE	SOIL	1.0	UG/KG	0.58	30	50-150	
8021B PPL	[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]
8021B PPL	[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]
8021B PPL	[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]
8021B PPL	[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
8021 STARS	1,2,4-TRIMETHYLBENZENE	WATER	1.0	UG/L	0.39	30	70-130	50-150
8021 STARS	1,3,5-TRIMETHYLBENZENE	WATER	1.0	UG/L	0.38	30	70-130	50-150
8021 STARS	BENZENE	WATER	0.7	UG/L	0.40	30	70-130	70-130
8021 STARS	ETHYLBENZENE	WATER	1.0	UG/L	0.37	30	70-130	70-130
8021 STARS	ISOPROPYLBENZENE	WATER	1.0	UG/L	0.39	30	70-130	50-150
8021 STARS	M+P-XYLENE	WATER	2.0	UG/L	0.75	30	70-130	70-130
8021 STARS	METHYL-TERT-BUTYLETHER	WATER	1.0	UG/L	0.71	30	70-130	50-150
8021 STARS	NAPHTHALENE	WATER	1.0	UG/L	0.93	30	70-130	50-150
8021 STARS	N-BUTYLBENZENE	WATER	1.0	UG/L	0.43	30	70-130	50-150
8021 STARS	N-PROPYLBENZENE	WATER	1.0	UG/L	0.37	30	70-130	50-150
8021 STARS	O-XYLENE	WATER	1.0	UG/L	0.44	30	70-130	70-130
8021 STARS	P-ISOPROPYLTOLUENE	WATER	1.0	UG/L	0.38	30	70-130	50-150
8021 STARS	SEC-BUTYLBENZENE	WATER	1.0	UG/L	0.43	30	70-130	50-150
8021 STARS	TERT-BUTYLBENZENE	WATER	1.0	UG/L	0.44	30	70-130	50-150
8021 STARS	TOLUENE	WATER	1.0	UG/L	0.38	30	70-130	70-130
8021 STARS	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8021 STARS	1,2,4-TRIMETHYLBENZENE	SOIL	1.0	UG/KG	0.32	30	70-130	[illegible]
8021 STARS	1,3,5-TRIMETHYLBENZENE	SOIL	1.0	UG/KG	0.29	30	70-130	[illegible]
8021 STARS	BENZENE	SOIL	1.0	UG/KG	0.33	30	70-130	[illegible]
8021 STARS	ETHYLBENZENE	SOIL	1.0	UG/KG	0.24	30	70-130	37-132
8021 STARS	ISOPROPYLBENZENE	SOIL	1.0	UG/KG	0.26	30	70-130	[illegible]
8021 STARS	M+P-XYLENE	SOIL	2.0	UG/KG	0.55	30	70-130	34-135
8021 STARS	METHYL-TERT-BUTYLETHER	SOIL	1.0	UG/KG	0.84	30	70-130	[illegible]
8021 STARS	NAPHTHALENE	SOIL	1.0	UG/KG	0.74	30	70-130	[illegible]
8021 STARS	N-BUTYLBENZENE	SOIL	1.0	UG/KG	0.21	30	70-130	[illegible]
8021 STARS	N-PROPYLBENZENE	SOIL	1.0	UG/KG	0.24	30	70-130	[illegible]
8021 STARS	O-XYLENE	SOIL	1.0	UG/KG	0.32	30	70-130	[illegible]
8021 STARS	P-ISOPROPYLTOLUENE	SOIL	1.0	UG/KG	0.19	30	70-130	[illegible]
8021 STARS	SEC-BUTYLBENZENE	SOIL	1.0	UG/KG	0.23	30	70-130	[illegible]
8021 STARS	TERT-BUTYLBENZENE	SOIL	1.0	UG/KG	0.23	30	70-130	[illegible]
8021 STARS	TOLUENE	SOIL	1.0	UG/KG	0.37	30	70-130	[illegible]
8021 STARS	[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]
8041	PENTACHLOROPHENOL	WATER	5.0	UG/L	0.91	30	[illegible]	[illegible]
8041	[illegible]	WATER	NA	UG/L	NA	30	[illegible]	[illegible]

CAS/ROCHESTER ORGANIC QC LIMITS

OD		ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
81A		4,4'-DDD	WATER	0.10	UG/L	0.014	30	[illegible]	
8081A		4,4'-DDE	WATER	0.10	UG/L	0.010	30	[illegible]	
8081A	*	4,4'-DDT	WATER	0.10	UG/L	0.013	30	[illegible]	[illegible]
8081A	*	ALDRIN	WATER	0.05	UG/L	0.013	30	[illegible]	[illegible]
8081A		ALPHA-BHC	WATER	0.05	UG/L	0.009	30	[illegible]	
8081A		ALPHA-CHLORDANE	WATER	0.05	UG/L	0.013	30	[illegible]	
8081A		ALPHA-ENDOSULFAN	WATER	0.05	UG/L	0.007	30	[illegible]	[illegible]
8081A		BETA-BHC	WATER	0.05	UG/L	0.01	30	[illegible]	
8081A		BETA-ENDOSULFAN	WATER	0.10	UG/L	0.007	30	[illegible]	
8081A		CHLORDANE, TECHNICAL	WATER	0.25	UG/L	0.066	30	50-150	50-150
8081A		DELTA-BHC	WATER	0.05	UG/L	0.010	30	[illegible]	
8081A	*	DIELDRIN	WATER	0.10	UG/L	0.012	30	[illegible]	[illegible]
8081A		ENDOSULFAN SULFATE	WATER	0.10	UG/L	0.010	30	[illegible]	
8081A	*	ENDRIN	WATER	0.10	UG/L	0.013	30	[illegible]	[illegible]
8081A		ENDRIN ALDEHYDE	WATER	0.10	UG/L	0.024	30	[illegible]	
8081A		ENDRIN KETONE	WATER	0.10	UG/L	0.005	30	[illegible]	
8081A		FAMPHUR	WATER	10.0	UG/L	0.230	30	50-150	
8081A	*	GAMMA-BHC (LINDANE)	WATER	0.05	UG/L	0.006	30	[illegible]	[illegible]
8081A		GAMMA-CHLORDANE	WATER	0.05	UG/L	0.011	30	[illegible]	
8081A	*	HEPTACHLOR	WATER	0.054	UG/L	0.054	30	[illegible]	[illegible]
8081A	*	HEPTACHLOR EPOXIDE	WATER	0.05	UG/L	0.009	30	[illegible]	60-115
8081A		KEPONE	WATER	10.0	UG/L	3.360	30	50-150	
8081A	*	METHOXYCHLOR	WATER	0.50	UG/L	0.04	30	62-130	62-130
8081A		TOXAPHENE	WATER	1.00	UG/L	0.37	30	[illegible]	
8081A		[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8081A		[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
A		4,4'-DDD	SOIL	3.3	UG/KG	0.27	30	[illegible]	
[illegible]1A		4,4'-DDE	SOIL	3.3	UG/KG	0.21	30	[illegible]	
81A	*	4,4'-DDT	SOIL	3.3	UG/KG	0.47	30	[illegible]	[illegible]
8081A	*	ALDRIN	SOIL	1.7	UG/KG	0.44	30	[illegible]	[illegible]
8081A		ALPHA-BHC	SOIL	1.7	UG/KG	0.62	30	70-130	
8081A		ALPHA-CHLORDANE	SOIL	1.7	UG/KG	0.36	30	[illegible]	
8081A		ALPHA-ENDOSULFAN	SOIL	1.7	UG/KG	0.26	30	[illegible]	
8081A		BETA-BHC	SOIL	1.7	UG/KG	0.32	30	[illegible]	
8081A		BETA-ENDOSULFAN	SOIL	3.3	UG/KG	0.22	30	[illegible]	
8081A		CHLORDANE, TECHNICAL	SOIL	8.3	UG/KG	2.20	30	50-150	50-150
8081A		DELTA-BHC	SOIL	1.7	UG/KG	0.22	30	[illegible]	
8081A	*	DIELDRIN	SOIL	3.3	UG/KG	0.42	30	[illegible]	[illegible]
8081A		ENDOSULFAN SULFATE	SOIL	3.3	UG/KG	0.25	30	[illegible]	[illegible]
8081A	*	ENDRIN	SOIL	3.3	UG/KG	0.39	30	[illegible]	[illegible]
8081A		ENDRIN ALDEHYDE	SOIL	3.3	UG/KG	0.39	30	[illegible]	
8081A		ENDRIN KETONE	SOIL	3.3	UG/KG	0.37	30	70-130	
8081A		FAMPHUR	SOIL	33	UG/KG	6.20	30	50-150	
8081A	*	GAMMA-BHC (LINDANE)	SOIL	1.7	UG/KG	0.15	30	[illegible]	[illegible]
8081A		GAMMA-CHLORDANE	SOIL	1.7	UG/KG	0.25	30	[illegible]	
8081A	*	HEPTACHLOR	SOIL	1.7	UG/KG	0.38	30	[illegible]	[illegible]
8081A	*	HEPTACHLOR EPOXIDE	SOIL	1.7	UG/KG	0.30	30	[illegible]	[illegible]
8081A		KEPONE	SOIL	33	UG/KG	29	30	50-150	
8081A	*	METHOXYCHLOR	SOIL	17	UG/KG	1.03	30	[illegible]	[illegible]
8081A		TOXAPHENE	SOIL	33	UG/KG	9.0	30	46-130	
8081A		[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]
8081A		[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]

CAS/ROCHESTER ORGANIC QC LIMITS

IOD		ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIC (RPD)	LCS (% REC)	MS (% REC)
82	*	PCB 1016	WATER	1.0	UG/L	0.29	30	53-118	50-150
8082		PCB 1221	WATER	2.0	UG/L	0.54	30	70-130	
8082		PCB 1232	WATER	1.0	UG/L	0.43	30	70-130	
8082		PCB 1242	WATER	1.0	UG/L	0.56	30	70-130	
8082		PCB 1248	WATER	1.0	UG/L	0.27	30	[illegible]	
8082		PCB 1254	WATER	1.0	UG/L	0.30	30	70-130	
8082	*	PCB 1260	WATER	1.0	UG/L	0.34	30	[illegible]	[illegible]
8082		[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8082		[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8082	*	PCB 1016	SOIL	33	UG/KG	28.40	30	34-130	33-132
8082		PCB 1221	SOIL	67	UG/KG	16.45	30	70-130	
8082		PCB 1232	SOIL	33	UG/KG	16.51	30	70-130	
8082		PCB 1242	SOIL	33	UG/KG	16.16	30	70-130	
8082		PCB 1248	SOIL	33	UG/KG	13.52	30	70-130	
8082		PCB 1254	SOIL	33	UG/KG	14.72	30	70-130	
8082	*	PCB 1260	SOIL	33	UG/KG	14.17	30	[illegible]	33-132
8082		[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]
8082		[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]
8082		PCB 1016	WIPES	33	UG/WIPE		30	70-130	
8082		PCB 1221	WIPES	33	UG/WIPE		30	70-130	
8082		PCB 1232	WIPES	33	UG/WIPE		30	70-130	
8082		PCB 1242	WIPES	33	UG/WIPE		30	70-130	
8082		PCB 1248	WIPES	33	UG/WIPE		30	70-130	
8082		PCB 1254	WIPES	33	UG/WIPE		30	70-130	
8082		PCB 1260	WIPES	33	UG/WIPE		30	70-130	
8082		[illegible]	WIPES	33	UG/WIPE		30	15-149	15-149
8082		[illegible]	WIPES	33	UG/WIPE		30	11-147	11-147
51A	*	2,4-D	WATER	0.5	UG/L	0.21	30	[illegible]	[illegible]
51A		DICAMBA	WATER	0.5	UG/L	0.13	30	30-130	30-130
8151A		DINOSEB	WATER	0.5	UG/L	0.10	30	30-130	30-130
8151A	*	2,4,5-T	WATER	0.5	UG/L	0.15	30	[illegible]	[illegible]
8151A	*	2,4,5-TP (SILVEX)	WATER	0.5	UG/L	0.21	30	[illegible]	[illegible]
8151A		PENTACHLOROPHENOL	WATER	1.0	UG/L	0.27	30	50-150	50-150
8151A		[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8151A	*	2,4-D	SOIL	10	UG/KG	4.32	30	[illegible]	[illegible]
8151A		DICAMBA	SOIL	10	UG/KG	4.14	30	30-130	30-130
8151A		DINOSEB	SOIL	10	UG/KG		30	30-130	30-130
8151A	*	2,4,5-T	SOIL	10	UG/KG	3.29	30	[illegible]	[illegible]
8151A	*	2,4,5-TP (SILVEX)	SOIL	10	UG/KG	3.24	30	[illegible]	[illegible]
8151A		PENTACHLOROPHENOL	SOIL	20	UG/KG	1.98	30	50-150	50-150
8151A		[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD		ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
[illegible]60B TCL		1,1,1-TRICHLOROETHANE	WATER	5.0	UG/L	1.15	30	70-130	
8260B TCL		1,1,2,2-TETRACHLOROETHANE	WATER	5.0	UG/L	1.35	30	70-130	
8260B TCL		1,1,2-TRICHLOROETHANE	WATER	5.0	UG/L	2.97	30	70-130	
8260B TCL		1,1-DICHLOROETHANE	WATER	5.0	UG/L	1.78	30	70-130	
8260B TCL	*	1,1-DICHLOROETHENE	WATER	5.0	UG/L	0.99	30	70-130	[illegible]
8260B TCL		1,2-DICHLOROETHANE	WATER	5.0	UG/L	1.66	30	70-130	
8260B TCL		1,2-DICHLOROPROPANE	WATER	5.0	UG/L	1.63	30	70-130	
8260B TCL		2-BUTANONE (MEK)	WATER	10	UG/L	1.73	30	50-150	
8260B TCL		2-HEXANONE	WATER	10	UG/L	1.07	30	70-130	
8260B TCL		4-METHYL-2-PENTANONE (MIBK)	WATER	10	UG/L	1.30	30	70-130	
8260B TCL		ACETONE	WATER	20	UG/L	2.97	30	50-150	
8260B TCL	*	BENZENE	WATER	5.0	UG/L	1.69	30	70-130	[illegible]
8260B TCL		BROMODICHLOROMETHANE	WATER	5.0	UG/L	1.45	30	70-130	
8260B TCL		BROMOFORM	WATER	5.0	UG/L	0.75	30	70-130	
8260B TCL		BROMOMETHANE	WATER	5.0	UG/L	2.32	30	50-150	
8260B TCL		CARBON DISULFIDE	WATER	10	UG/L	0.71	30	70-130	
8260B TCL		CARBON TETRACHLORIDE	WATER	5.0	UG/L	1.60	30	70-130	
8260B TCL	*	CHLOROBENZENE	WATER	5.0	UG/L	1.75	30	70-130	70-130
8260B TCL		CHLOROETHANE	WATER	5.0	UG/L	1.58	30	70-130	
8260B TCL		CHLOROFORM	WATER	5.0	UG/L	2.06	30	70-130	
8260B TCL		CHLOROMETHANE	WATER	5.0	UG/L	1.27	30	70-130	
8260B TCL		CIS-1,2-DICHLOROETHENE	WATER	5.0	UG/L	1.85	30	70-130	
8260B TCL		CIS-1,3-DICHLOROPROPENE	WATER	5.0	UG/L	1.30	30	70-130	
8260B TCL		DIBROMOCHLOROMETHANE	WATER	5.0	UG/L	1.01	30	70-130	
8260B TCL		ETHYLBENZENE	WATER	5.0	UG/L	1.64	30	70-130	
8260B TCL		M+P-XYLENE	WATER	10	UG/L	3.79	30	70-130	
[illegible]B TCL		METHYLENE CHLORIDE	WATER	5.0	UG/L	1.80	30	70-130	
[illegible]0B TCL		O-XYLENE	WATER	5.0	UG/L	1.67	30	70-130	
[illegible]0B TCL		STYRENE	WATER	5.0	UG/L	1.79	30	70-130	
8260B TCL		TETRACHLOROETHENE	WATER	5.0	UG/L	3.16	30	70-130	
8260B TCL	*	TOLUENE	WATER	5.0	UG/L	1.69	30	70-130	70-130
8260B TCL		TRANS-1,2-DICHLOROETHENE	WATER	5.0	UG/L	1.10	30	70-130	
8260B TCL		TRANS-1,3-DICHLOROPROPENE	WATER	5.0	UG/L	1.19	30	70-130	
8260B TCL	*	TRICHLOROETHENE	WATER	5.0	UG/L	1.88	30	70-130	[illegible]
8260B TCL		VINYL CHLORIDE	WATER	5.0	UG/L	1.46	30	70-130	
8260B TCL		[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8260B TCL		[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8260B TCL		[illegible]	WATER	NA	UG/L	NA	NA	80-120	80-120
8260B TCL		[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8260B ADDITIONAL COMPOUNDS BY REQUEST									
8260B		1,1,1,2-TETRACHLOROETHANE	WATER	5.0	UG/L	0.59	30	70-130	
8260B		*1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (Freon 113)*	WATER	5.0	UG/L	2.08	30	70-130	
8260B		1,1-DICHLOROPROPENE	WATER	5.0	UG/L	0.63	30	70-130	
8260B		1,2,3-TRICHLOROBENZENE	WATER	5.0	UG/L	1.17	30	70-130	
8260B TCL		1,2,3-TRICHLOROPROPANE	WATER	5.0	UG/L	1.48	30	70-130	
8260B		*1,2,4-TRICHLOROBENZENE*	WATER	5.0	UG/L	1.97	30	70-130	
8260B		1,2,4-TRIMETHYLBENZENE	WATER	5.0	UG/L	0.54	30	70-130	
8260B		*1,2-DIBROMO-3-CHLOROPROPANE*	WATER	5.0	UG/L	2.47	30	50-150	
8260B		*1,2-DIBROMOETHANE*	WATER	5.0	UG/L	1.73	30	70-130	
8260B		*1,2-DICHLOROBENZENE*	WATER	5.0	UG/L	1.90	30	70-130	
8260B		1,3,5-TRIMETHYLBENZENE	WATER	5.0	UG/L	0.72	30	70-130	
8260B		*1,3-DICHLOROBENZENE*	WATER	5.0	UG/L	1.81	30	70-130	
[illegible]60B		1,3-DICHLOROPROPANE	WATER	5.0	UG/L	0.72	30	70-130	
0B		*1,4-DICHLOROBENZENE*	WATER	5.0	UG/L	1.94	30	70-130	
[illegible]60B		1,4-DIOXANE	WATER	100	UG/L	38	30	50-150	
[illegible]60B		2,2-DICHLOROPROPANE	WATER	5.0	UG/L	1.48	30	70-130	
8260B		2-CHLORO-1,3-BUTADIENE	WATER	5.0	UG/L	0.61	30	70-130	
8260B		2-CHLOROETHYLVINYL ETHER	WATER	5.0	UG/L	1.58	30	50-150	

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
8260B	2-CHLOROTOLUENE	WATER	5.0	UG/L	1.22	30	70-130	
8260B	2-NITROPROPANE	WATER	5.0	UG/L	2.04	30	50-150	
8260B	4-CHLOROTOLUENE	WATER	5.0	UG/L	0.52	30	70-130	
8260B	ACETONITRILE	WATER	100	UG/L	27.0	30	70-130	
8260B	ACROLEIN	WATER	100	UG/L	7	30	50-150	
8260B	ACRYLONITRILE	WATER	100	UG/L	5.17	30	50-150	
8260B	ALLYL CHLORIDE	WATER	5.0	UG/L	0.95	30	70-130	
8260B	BROMOBENZENE	WATER	5.0	UG/L	0.72	30	70-130	
8260B	BROMOCHLOROMETHANE	WATER	5.0	UG/L	0.60	30	70-130	
8260B	CYCLOHEXANONE	WATER	100	UG/L	24	30	50-150	
8260B	DIBROMOMETHANE	WATER	5.0	UG/L	0.42	30	70-130	
8260B	*DICHLORODIFLUOROMETHANE*	WATER	5.0	UG/L	1.73	30	70-130	
8260B	DIETHYL ETHER	WATER	5.0	UG/L	0.65	30	70-130	
8260B	ETHYL METHACRYLATE	WATER	10	UG/L	0.77	30	70-130	
8260B	HEXACHLOROBUTADIENE	WATER	5.0	UG/L	1.20	30	70-130	
8260B	IODOMETHANE	WATER	10	UG/L	0.93	30	50-150	
8260B	ISOBUTYL ALCOHOL	WATER	100	UG/L	24	30	50-150	
8260B	*ISOPROPYLBENZENE*	WATER	5.0	UG/L	1.84	30	70-130	
8260B	METHACRYLONITRILE	WATER	20	UG/L	1.43	30	50-150	
8260B	METHYL METHACRYLATE	WATER	10	UG/L	0.47	30	70-130	
8260B	*METHYL-TERT-BUTYL ETHER (MTBE)*	WATER	5.0	UG/L	1.54	30	70-130	
8260B	NAPTHALENE	WATER	5.0	UG/L	1.40	30	50-150	
8260B	N-BUTYLBENZENE	WATER	5.0	UG/L	4.75	30	70-130	
8260B	N-HEPTANE	WATER	5.0	UG/L	0.95	30	70-130	
8260B	N-PROPYLBENZENE	WATER	5.0	UG/L	0.57	30	70-130	
8260B	P-ISOPROPYLTOLUENE	WATER	5.0	UG/L	0.79	30	70-130	
8260B	PROPIONITRILE	WATER	100	UG/L	5.04	30	50-150	
8260B	SEC-BUTYLBENZENE	WATER	5.0	UG/L	0.68	30	70-130	
8260B	TERT-BUTYL ALCOHOL	WATER	100	UG/L	31	30	50-150	
8260B	TERT-BUTYLBENZENE	WATER	5.0	UG/L	0.79	30	70-130	
8260B	TETRA HYDROFURAN	WATER	5.0	UG/L	1.00	30	50-150	
8260B	TRANS-1,4-DICHLORO-2-BUTENE	WATER	5.0	UG/L	1.64	30	50-150	
8260B	TRICHLOROFLUOROMETHANE	WATER	5.0	UG/L	1.15	30	70-130	
8260B	VINYL ACETATE	WATER	10	UG/L	2.32	30	50-150	

CAS/ROCHESTER ORGANIC QC LIMITS

IOD		ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
60B TCL		1,1,1-TRICHLOROETHANE	SOIL	5.0	UG/KG	0.46	30	70-130	
8260B TCL		1,1,2,2-TETRACHLOROETHANE	SOIL	5.0	UG/KG	0.58	30	70-130	
8260B TCL		1,1,2-TRICHLOROETHANE	SOIL	5.0	UG/KG	0.66	30	70-130	
8260B TCL		1,1-DICHLOROETHANE	SOIL	5.0	UG/KG	0.72	30	70-130	
8260B TCL	*	1,1-DICHLOROETHENE	SOIL	5.0	UG/KG	1.08	30	70-130	
8260B TCL		1,2-DICHLOROETHANE	SOIL	5.0	UG/KG	1.25	30	70-130	
8260B TCL		1,2-DICHLOROPROPANE	SOIL	5.0	UG/KG	0.64	30	70-130	
8260B TCL		2-BUTANONE (MEK)	SOIL	10	UG/KG	4.19	30	50-150	
8260B TCL		2-HEXANONE	SOIL	10	UG/KG	2.33	30	70-130	
8260B TCL		4-METHYL-2-PENTANONE (MIBK)	SOIL	10	UG/KG	2.82	30	70-130	
8260B TCL		ACETONE	SOIL	20	UG/KG	5.37	30	50-150	
8260B TCL	*	BENZENE	SOIL	5.0	UG/KG	0.54	30	70-130	
8260B TCL		BROMODICHLOROMETHANE	SOIL	5.0	UG/KG	0.88	30	70-130	
8260B TCL		BROMOFORM	SOIL	5.0	UG/KG	0.41	30	70-130	
8260B TCL		BROMOMETHANE	SOIL	5.0	UG/KG	1.66	30	50-150	
8260B TCL		CARBON DISULFIDE	SOIL	10	UG/KG	0.35	30	70-130	
8260B TCL		CARBON TETRACHLORIDE	SOIL	5.0	UG/KG	0.78	30	70-130	
8260B TCL	*	CHLOROBENZENE	SOIL	5.0	UG/KG	0.93	30	70-130	
8260B TCL		CHLOROETHANE	SOIL	5.0	UG/KG	2.13	30	70-130	
8260B TCL		CHLOROFORM	SOIL	5.0	UG/KG	1.16	30	70-130	
8260B TCL		CHLOROMETHANE	SOIL	5.0	UG/KG	0.96	30	70-130	
8260B TCL		CIS-1,2-DICHLOROETHENE	SOIL	5.0	UG/KG	0.80	30	70-130	
8260B TCL		CIS-1,3-DICHLOROPROPENE	SOIL	5.0	UG/KG	0.51	30	70-130	
8260B TCL		DIBROMOCHLOROMETHANE	SOIL	5.0	UG/KG	0.81	30	70-130	
8260B TCL		ETHYLBENZENE	SOIL	5.0	UG/KG	1.07	30	70-130	
8260B TCL		M+P-XYLENE	SOIL	10	UG/KG	2.64	30	70-130	
0B TCL		METHYLENE CHLORIDE	SOIL	5.0	UG/KG	0.62	30	70-130	
0B TCL		O-XYLENE	SOIL	5.0	UG/KG	1.26	30	70-130	
0B TCL		STYRENE	SOIL	5.0	UG/KG	1.04	30	70-130	
8260B TCL		TETRACHLOROETHENE	SOIL	5.0	UG/KG	1.48	30	70-130	
8260B TCL	*	TOLUENE	SOIL	5.0	UG/KG	0.58	30	70-130	
8260B TCL		TRANS-1,2-DICHLOROETHENE	SOIL	5.0	UG/KG	0.86	30	70-130	
8260B TCL		TRANS-1,3-DICHLOROPROPENE	SOIL	5.0	UG/KG	0.66	30	70-130	
8260B TCL	*	TRICHLOROETHENE	SOIL	5.0	UG/KG	0.60	30	70-130	
8260B TCL		VINYL CHLORIDE	SOIL	5.0	UG/KG	0.96	30	70-130	
8260B TCL			SOIL	NA	UG/KG	NA	NA		
8260B TCL			SOIL	NA	UG/KG	NA	NA		
8260B TCL			SOIL	NA	UG/KG	NA	NA	80-120	80-120
8260B TCL			SOIL	NA	UG/KG	NA	NA		

CAS/ROCHESTER ORGANIC QC LIMITS

OD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIC (RPD)	LCS (% REC)	MS (% REC)
60B ADDITIONAL COMPOUNDS BY REQUEST								
8260B	1,1,1,2-TETRACHLOROETHANE	SOIL	5.0	UG/KG	0.84	30	70-130	
8260B	*1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON 113)*	SOIL	5.0	UG/KG	1.68	30	70-130	
8260B	1,1-DICHLOROPROPENE	SOIL	5.0	UG/KG	0.93	30	70-130	
8260B	1,2,3-TRICHLOROBENZENE	SOIL	5.0	UG/KG	1.40	30	70-130	
8260B	1,2,3-TRICHLOROPROPANE	SOIL	5.0	UG/KG	1.00	30	70-130	
8260B	*1,2,4-TRICHLOROBENZENE*	SOIL	5.0	UG/KG	1.21	30	70-130	
8260B	1,2,4-TRIMETHYLBENZENE	SOIL	5.0	UG/KG	1.23	30	70-130	
8260B	*1,2-DIBROMO-3-CHLOROPROPANE*	SOIL	5.0	UG/KG	1.20	30	50-150	
8260B	*1,2-DIBROMOETHANE*	SOIL	5.0	UG/KG	0.71	30	70-130	
8260B	*1,2-DICHLOROBENZENE*	SOIL	5.0	UG/KG	1.62	30	70-130	
8260B	1,3,5-TRIMETHYLBENZENE	SOIL	5.0	UG/KG	1.26	30	70-130	
8260B	*1,3-DICHLOROBENZENE*	SOIL	5.0	UG/KG	1.43	30	70-130	
8260B	1,3-DICHLOROPROPANE	SOIL	5.0	UG/KG	0.81	30	70-130	
8260B	*1,4-DICHLOROBENZENE*	SOIL	5.0	UG/KG	1.33	30	70-130	
8260B	1,4-DIOXANE	SOIL	100	UG/KG	21	30	50-150	
8260B	2,2-DICHLOROPROPANE	SOIL	5.0	UG/KG	0.59	30	70-130	
8260B	2-CHLOROETHYLVINYL ETHER	SOIL	5.0	UG/KG	1.08	30	50-150	
8260B	2-CHLOROTOLUENE	SOIL	5.0	UG/KG	1.28	30	70-130	
8260B	2-CHLORO-1,3-BUTADIENE	SOIL	5.0	UG/KG	0.49	30	70-130	
8260B	2-NITROPROPANE	SOIL	5.0	UG/KG	3.15	30	50-150	
8260B	4-CHLOROTOLUENE	SOIL	5.0	UG/KG	1.31	30	70-130	
8260B	ACROLEIN	SOIL	100	UG/KG	7.13	30	50-150	
8260B	ACETONITRILE	SOIL	100	UG/KG	68.40	30	70-130	
8260B	ACRYLONITRILE	SOIL	100	UG/KG	7.75	30	50-150	
0B	ALLYL CHLORIDE	SOIL	5.0	UG/KG	1.14	30	70-130	
JB	BROMOBENZENE	SOIL	5.0	UG/KG	1.18	30	70-130	
60B	BROMOCHLOROMETHANE	SOIL	5.0	UG/KG	0.93	30	70-130	
8260B	CYCLOHEXANONE	SOIL	100	UG/KG	22.8	30	50-130	
8260B	DIBROMOMETHANE	SOIL	5.0	UG/KG	1.58	30	70-130	
8260B	*DICHLORODIFLUOROMETHANE*	SOIL	5.0	UG/KG	0.95	30	70-130	
8260B	DIETHYL ETHER	SOIL	5.0	UG/KG	1.31	30	70-130	
8260B	ETHYL METHACRYLATE	SOIL	10.0	UG/KG	1.44	30	70-130	
8260B	HEXACHLOROBUTADIENE	SOIL	5.0	UG/KG	1.43	30	70-130	
8260B	IODOMETHANE	SOIL	10	UG/KG	2.27	30	50-150	
8260B	ISOBUTYL ALCOHOL	SOIL	100	UG/KG	22	30	50-150	
8260B	*ISOPROPYLBENZENE*	SOIL	5.0	UG/KG	1.33	30	70-130	
8260B	METHACRYLONITRILE	SOIL	20	UG/KG	1.28	30	50-150	
8260B	*METHYL-TERT-BUTYL ETHER (MTBE)*	SOIL	5.0	UG/KG	1.18	30	70-130	
8260B	METHYL METHACRYLATE	SOIL	10.0	UG/KG	1.77	30	70-130	
8260B	NAPTHALENE	SOIL	5.0	UG/KG	1.20	30	50-150	
8260B	N-BUTYLBENZENE	SOIL	5.0	UG/KG	1.30	30	70-130	
8260B	N-PROPYLBENZENE	SOIL	5.0	UG/KG	1.53	30	70-130	
8260B	P-ISOPROPYLTOLUENE	SOIL	5.0	UG/KG	1.30	30	70-130	
8260B	PROPIONITRILE	SOIL	100	UG/KG	10.80	30	50-150	
8260B	SEC-BUTYLBENZENE	SOIL	5.0	UG/KG	1.58	30	70-130	
8260B	TERT-BUTYL ALCOHOL	SOIL	100	UG/KG	69	30	50-150	
8260B	TERT-BUTYLBENZENE	SOIL	5.0	UG/KG	1.50	30	70-130	
8260B	TETRA HYDROFURAN	SOIL	5.0	UG/KG	2.08	30	50-150	
8260B	TRANS-1,4-DICHLORO-2-BUTENE	SOIL	5.0	UG/KG	0.88	30	50-150	
8260B	*TRICHLOROFLUOROMETHANE*	SOIL	5.0	UG/KG	1.02	30	70-130	
8260B	VINYL ACETATE	SOIL	10	UG/KG	0.73	30	50-150	

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD		ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
[redacted]70C	*	1,2,4-TRICHLOROBENZENE	WATER	10	UG/L	0.99	30	[illegible]	[illegible]
8270C		1,2-DICHLOROBENZENE	WATER	10	UG/L	1.26	30	[illegible]	
8270C		1,3-DICHLOROBENZENE	WATER	10	UG/L	1.11	30	[illegible]	
8270C	*	1,4-DICHLOROBENZENE	WATER	10	UG/L	1.01	30	[illegible]	[illegible]
8270C		2,2'-OXYBIS(1-CHLOROPROPANE)	WATER	10	UG/L	1.20	30	[illegible]	
8270C		2,4,5-TRICHLOROPHENOL	WATER	10	UG/L	1.30	30	[illegible]	
8270C		2,4,6-TRICHLOROPHENOL	WATER	10	UG/L	1.10	30	[illegible]	
8270C		2,4-DICHLOROPHENOL	WATER	10	UG/L	0.96	30	[illegible]	
8270C		2,4-DIMETHYLPHENOL	WATER	10	UG/L	2.65	30	[illegible]	
8270C		2,4-DINITROPHENOL	WATER	50	UG/L	16.9	30	[illegible]	
8270C	*	2,4-DINITROTOLUENE	WATER	10	UG/L	1.14	30	[illegible]	[illegible]
8270C		2,6-DINITROTOLUENE	WATER	10	UG/L	1.32	30	[illegible]	
8270C		2-CHLORONAPHTHALENE	WATER	10	UG/L	1.06	30	[illegible]	
8270C	*	2-CHLOROPHENOL	WATER	10	UG/L	1.17	30	[illegible]	[illegible]
8270C		2-METHYLNAPHTHALENE	WATER	10	UG/L	0.87	30	[illegible]	
8270C		2-METHYLPHENOL	WATER	10	UG/L	1.00	30	[illegible]	
8270C		2-NITROANILINE	WATER	50	UG/L	1.16	30	[illegible]	
8270C		2-NITROPHENOL	WATER	10	UG/L	0.95	30	[illegible]	
8270C		3,3'-DICHLOROBENZIDINE	WATER	10	UG/L	1.59	30	[illegible]	
8270C		3-NITROANILINE	WATER	50	UG/L	1.86	30	[illegible]	
8270C		4,6-DINITRO-2-METHYLPHENOL	WATER	50	UG/L	0.8	30	[illegible]	
8270C		4-BROMOPHENYL-PHENYLETHER	WATER	10	UG/L	0.98	30	[illegible]	
8270C	*	4-CHLORO-3-METHYLPHENOL	WATER	10	UG/L	0.99	30	[illegible]	[illegible]
8270C		4-CHLOROANILINE	WATER	10	UG/L	4.08	30	[illegible]	
8270C		4-CHLOROPHENYL-PHENYLETHER	WATER	10	UG/L	1.32	30	[illegible]	
8270C		4-METHYLPHENOL	WATER	10	UG/L	2.07	30	40-130	
[redacted]70C		4-NITROANILINE	WATER	50	UG/L	1.79	30	[illegible]	
[redacted]0C	*	4-NITROPHENOL	WATER	50	UG/L	0.8	30	10-130	10-130
[redacted]0C	*	ACENAPHTHENE	WATER	10	UG/L	1.08	30	[illegible]	[illegible]
8270C		ACENAPHTHYLENE	WATER	10	UG/L	1.04	30	[illegible]	[illegible]
8270C		ANTHRACENE	WATER	10	UG/L	0.85	30	[illegible]	
8270C		BENZO(A)ANTHRACENE	WATER	10	UG/L	1.03	30	[illegible]	[illegible]
8270C		BENZO(A)PYRENE	WATER	10	UG/L	1.13	30	[illegible]	[illegible]
8270C		BENZO(B)FLUORANTHENE	WATER	10	UG/L	1.01	30	[illegible]	[illegible]
8270C		BENZO(G,H,I)PERYLENE	WATER	10	UG/L	1.17	30	[illegible]	[illegible]
8270C		BENZO(K)FLUORANTHENE	WATER	10	UG/L	0.97	30	[illegible]	[illegible]
8270C		BENZYL ALCOHOL	WATER	10	UG/L	1.21	30	[illegible]	
8270C		BIS(-2-CHLOROETHOXY)METHANE	WATER	10	UG/L	0.93	30	[illegible]	
8270C		BIS(2-CHLOROETHYL)ETHER	WATER	10	UG/L	0.85	30	[illegible]	
8270C		BIS(2-ETHYLHEXYL)PHTHALATE	WATER	10	UG/L	1.56	30	73-130	
8270C		BUTYL BENZYL PHTHALATE	WATER	10	UG/L	2.23	30	[illegible]	
8270C		CARBAZOLE	WATER	10	UG/L	0.86	30	70-130	
8270C		CHRYSENE	WATER	10	UG/L	0.98	30	[illegible]	
8270C		DIBENZO(A,H)ANTHRACENE	WATER	10	UG/L	1.18	30	[illegible]	
8270C		DIBENZOFURAN	WATER	10	UG/L	1.08	30	[illegible]	
8270C		DIETHYLPHTHALATE	WATER	10	UG/L	1.39	30	[illegible]	
8270C		DIMETHYL PHTHALATE	WATER	10	UG/L	1.30	30	[illegible]	
8270C		DI-N-BUTYLPHTHALATE	WATER	10	UG/L	1.29	30	[illegible]	
8270C		DI-N-OCTYL PHTHALATE	WATER	10	UG/L	1.71	30	65-130	
8270C		FLUORANTHENE	WATER	10	UG/L	1.09	30	[illegible]	[illegible]
8270C		FLUORENE	WATER	10	UG/L	1.37	30	[illegible]	[illegible]
8270C		HEXACHLOROBENZENE	WATER	10	UG/L	0.95	30	58-130	
8270C		HEXACHLOROBUTADIENE	WATER	10	UG/L	1.34	30	[illegible]	
8270C		HEXACHLOROCYCLOPENTADIENE	WATER	10	UG/L	1.2	30	10-130	
[redacted]0C		HEXACHLOROETHANE	WATER	10	UG/L	1.26	30	[illegible]	
[redacted]0C		INDENO(1,2,3-CD)PYRENE	WATER	10	UG/L	1.07	30	[illegible]	
[redacted]0C		ISOPHORONE	WATER	10	UG/L	1.05	30	[illegible]	
8270C		NAPHTHALENE	WATER	10	UG/L	0.88	30	[illegible]	
8270C		NITROBENZENE	WATER	10	UG/L	1.05	30	[illegible]	
8270C		N-NITROSODIMETHYLAMINE	WATER	10	UG/L	0.80	30	[illegible]	

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD		ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
8270C	*	N-NITROSO-DI-N-PROPYLAMINE	WATER	10	UG/L	0.97	30	[illegible]	[illegible]
8270C		N-NITROSODIPHENYLAMINE	WATER	10	UG/L	1.04	30	70-130	
8270C	*	PENTACHLOROPHENOL	WATER	50	UG/L	1.5	30	[illegible]	[illegible]
8270C		PHENANTHRENE	WATER	10	UG/L	0.82	30	[illegible]	[illegible]
8270C	*	PHENOL	WATER	10	UG/L	0.91	30	[illegible]	[illegible]
8270C	*	PYRENE	WATER	10	UG/L	1.37	30	[illegible]	[illegible]
8270C		[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8270C		[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8270C		[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8270C		[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8270C		[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8270C		[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8270C ADDITIONAL COMPOUNDS BY REQUEST									
8270C		1,2-DIPHENYLHYDRAZINE	WATER	10.0	UG/L	1.05	30	[illegible]	
8270C		ANILINE	WATER	10.0	UG/L	3.80	30	[illegible]	
8270C		BENZIDINE	WATER	100	UG/L	54.20	30	10-130	
8270C		PYRIDINE	WATER	50.0	UG/L	1.21	30	[illegible]	
8270C	*	1,2,4-TRICHLOROBENZENE	SOIL	330	UG/KG	27	30	[illegible]	[illegible]
8270C		1,2-DICHLOROBENZENE	SOIL	330	UG/KG	36	30	[illegible]	
8270C		1,3-DICHLOROBENZENE	SOIL	330	UG/KG	31	30	[illegible]	
8270C	*	1,4-DICHLOROBENZENE	SOIL	330	UG/KG	33	30	[illegible]	[illegible]
8270C		2,2'-OXYBIS(1-CHLOROPROPANE)	SOIL	330	UG/KG	36	30	[illegible]	
8270C		2,4,5-TRICHLOROPHENOL	SOIL	330	UG/KG	46	30	[illegible]	
8270C		2,4,6-TRICHLOROPHENOL	SOIL	330	UG/KG	38	30	[illegible]	
8270C		2,4-DICHLOROPHENOL	SOIL	330	UG/KG	27	30	[illegible]	
8270C		2,4-DIMETHYLPHENOL	SOIL	330	UG/KG	84	30	[illegible]	
8270C		2,4-DINITROPHENOL	SOIL	1700	UG/KG	539	30	[illegible]	
8270C	*	2,4-DINITROTOLUENE	SOIL	330	UG/KG	25	30	[illegible]	[illegible]
8270C		2,6-DINITROTOLUENE	SOIL	330	UG/KG	35	30	[illegible]	
8270C		2-CHLORONAPHTHALENE	SOIL	330	UG/KG	32	30	[illegible]	
8270C	*	2-CHLOROPHENOL	SOIL	330	UG/KG	30	30	[illegible]	[illegible]
8270C		2-METHYLNAPHTHALENE	SOIL	330	UG/KG	32	30	[illegible]	[illegible]
8270C		2-METHYLPHENOL	SOIL	330	UG/KG	21	30	[illegible]	
8270C		2-NITROANILINE	SOIL	1700	UG/KG	31	30	[illegible]	
8270C		2-NITROPHENOL	SOIL	330	UG/KG	52	30	[illegible]	
8270C		3,3'-DICHLOROBENZIDINE	SOIL	330	UG/KG	62	30	[illegible]	
8270C		3-NITROANILINE	SOIL	1700	UG/KG	27	30	[illegible]	
8270C		4,6-DINITRO-2-METHYLPHENOL	SOIL	1700	UG/KG	31	30	[illegible]	
8270C		4-BROMOPHENYL-PHENYLETHER	SOIL	330	UG/KG	41	30	[illegible]	
8270C	*	4-CHLORO-3-METHYLPHENOL	SOIL	330	UG/KG	33	30	[illegible]	[illegible]
8270C		4-CHLOROANILINE	SOIL	330	UG/KG	40	30	[illegible]	
8270C		4-CHLOROPHENYL-PHENYLETHER	SOIL	330	UG/KG	30	30	[illegible]	
8270C		4-METHYLPHENOL	SOIL	330	UG/KG	50	30	[illegible]	
8270C		4-NITROANILINE	SOIL	1700	UG/KG	23	30	[illegible]	
8270C	*	4-NITROPHENOL	SOIL	1700	UG/KG	28	30	[illegible]	[illegible]
8270C	*	ACENAPHTHENE	SOIL	330	UG/KG	29	30	[illegible]	[illegible]
8270C		ACENAPHTHYLENE	SOIL	330	UG/KG	25	30	[illegible]	[illegible]
8270C		ANTHRACENE	SOIL	330	UG/KG	26	30	[illegible]	[illegible]
8270C		BENZO(A)ANTHRACENE	SOIL	330	UG/KG	27	30	[illegible]	
8270C		BENZO(A)PYRENE	SOIL	330	UG/KG	37	30	[illegible]	
8270C		BENZO(B)FLUORANTHENE	SOIL	330	UG/KG	37	30	[illegible]	
8270C		BENZO(G,H,I)PERYLENE	SOIL	330	UG/KG	41	30	[illegible]	
8270C		BENZO(K)FLUORANTHENE	SOIL	330	UG/KG	44	30	[illegible]	
8270C		BENZYL ALCOHOL	SOIL	330	UG/KG	44	30	[illegible]	
8270C		BIS(-2-CHLOROETHOXY)METHANE	SOIL	330	UG/KG	35	30	[illegible]	
8270C		BIS(2-CHLOROETHYL)ETHER	SOIL	330	UG/KG	27	30	[illegible]	
8270C		BIS(2-ETHYLHEXYL)PHTHALATE	SOIL	330	UG/KG	46	30	[illegible]	
8270C		BUTYL BENZYL PHTHALATE	SOIL	330	UG/KG	44	30	56-130	
8270C		CARBAZOLE	SOIL	330	UG/KG	33	30	[illegible]	

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD		ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
[illegible]70C		CHRYSENE	SOIL	330	UG/KG	34	30	[illegible]	[illegible]
[illegible]8270C		DIBENZO(A,H)ANTHRACENE	SOIL	330	UG/KG	42	30	[illegible]	[illegible]
8270C		DIBENZOFURAN	SOIL	330	UG/KG	26	30	[illegible]	
8270C		DIETHYLPHTHALATE	SOIL	330	UG/KG	28	30	62-130	
8270C		DIMETHYL PHTHALATE	SOIL	330	UG/KG	28	30	[illegible]	
8270C		DI-N-BUTYLPHTHALATE	SOIL	330	UG/KG	67	30	62-130	
8270C		DI-N-OCTYL PHTHALATE	SOIL	330	UG/KG	56	30	59-130	
8270C		FLUORANTHENE	SOIL	330	UG/KG	29	30	[illegible]	
8270C		FLUORENE	SOIL	330	UG/KG	31	30	[illegible]	
8270C		HEXACHLOROBENZENE	SOIL	330	UG/KG	32	30	56-130	
8270C		HEXACHLOROBUTADIENE	SOIL	330	UG/KG	28	30	[illegible]	
8270C		HEXACHLOROCYCLOPENTADIENE	SOIL	330	UG/KG	63	30	[illegible]	
8270C		HEXACHLOROETHANE	SOIL	330	UG/KG	34	30	[illegible]	
8270C		INDENO(1,2,3-CD)PYRENE	SOIL	330	UG/KG	42	30	[illegible]	
8270C		ISOPHORONE	SOIL	330	UG/KG	30	30	50-130	
8270C		NAPHTHALENE	SOIL	330	UG/KG	26	30	[illegible]	
8270C		NITROBENZENE	SOIL	330	UG/KG	24	30	[illegible]	
8270C		N-NITROSODIMETHYLAMINE	SOIL	330	UG/KG	36	30	[illegible]	
8270C	*	N-NITROSO-DI-N-PROPYLAMINE	SOIL	330	UG/KG	36	30	[illegible]	
8270C		N-NITROSODIPHENYLAMINE	SOIL	330	UG/KG	33	30	[illegible]	
8270C	*	PENTACHLOROPHENOL	SOIL	1700	UG/KG	53	30	[illegible]	
8270C		PHENANTHRENE	SOIL	330	UG/KG	28	30	[illegible]	
8270C	*	PHENOL	SOIL	330	UG/KG	29	30	[illegible]	
8270C	*	PYRENE	SOIL	330	UG/KG	31	30	[illegible]	
8270C		[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	
8270C		[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	
[illegible]70C		[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	
[illegible]70C		[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	
[illegible]70C		[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	
8270C		[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	
8270C ADDITIONAL COMPOUNDS BY REQUEST									
8270C		1,2-DIPHENYLHYDRAZINE	SOIL	330	UG/KG	33	30	[illegible]	
8270C		ANILINE	SOIL	330	UG/KG	79	30	[illegible]	
8270C		BENZIDINE	SOIL	3300	UG/KG	334	30	30-130	
8270C		BENZOIC ACID	SOIL	1700	UG/KG	147	30	30-130	
8270C		PYRIDINE	SOIL	1700	UG/KG	50	30	[illegible]	

CAS/ROCHESTER ORGANIC QC LIMITS

...OD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
...70C SIM	ACENAPHTHENE	WATER	0.20	UG/L	0.04	30	[illegible]	[illegible]
8270C SIM	ACENAPHTHYLENE	WATER	0.20	UG/L	0.07	30	[illegible]	[illegible]
8270C SIM	ANTHRACENE	WATER	0.20	UG/L	0.05	30	[illegible]	
8270C SIM	BENZO(A)ANTHRACENE	WATER	0.10	UG/L	0.05	30	[illegible]	[illegible]
8270C SIM	BENZO(A)PYRENE	WATER	0.20	UG/L	0.08	30	[illegible]	[illegible]
8270C SIM	BENZO(B)FLUORANTHENE	WATER	0.20	UG/L	0.05	30	[illegible]	[illegible]
8270C SIM	BENZO(G,H,I)PERYLENE	WATER	0.20	UG/L	0.09	30	[illegible]	[illegible]
8270C SIM	BENZO(K)FLUORANTHENE	WATER	0.20	UG/L	0.06	30	[illegible]	[illegible]
8270C SIM	CHRYSENE	WATER	0.20	UG/L	0.03	30	[illegible]	
8270C SIM	DIBENZO(A,H)ANTHRACENE	WATER	0.20	UG/L	0.12	30	[illegible]	
8270C SIM	FLUORANTHENE	WATER	0.20	UG/L	0.09	30	[illegible]	[illegible]
8270C SIM	FLUORENE	WATER	0.20	UG/L	0.03	30	[illegible]	[illegible]
8270C SIM	INDENO(1,2,3-CD)PYRENE	WATER	0.20	UG/L	0.12	30	[illegible]	
8270C SIM	NAPHTHALENE	WATER	0.20	UG/L	0.08	30	[illegible]	
8270C SIM	PHENANTHRENE	WATER	0.20	UG/L	0.05	30	[illegible]	
8270C SIM	PYRENE	WATER	0.20	UG/L	0.03	30	[illegible]	[illegible]
8270C SIM	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8270C SIM	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8270C SIM	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
8270C SIM ADDITIONAL COMPOUNDS BY REQUEST								
8270C SIM	2-METHYL NAPHTHALENE	WATER	0.10	UG/L	0.041	30	[illegible]	
8270C SIM	CARBAZOLE	WATER	1.0	UG/L	0.062	30	[illegible]	
8270C SIM	ACENAPHTHENE	SOIL	6.6	UG/KG	1.72	30	[illegible]	[illegible]
8270C SIM	ACENAPHTHYLENE	SOIL	6.6	UG/KG	1.64	30	[illegible]	[illegible]
8270C SIM	ANTHRACENE	SOIL	6.6	UG/KG	2.45	30	[illegible]	[illegible]
8270C SIM	BENZO(A)ANTHRACENE	SOIL	3.3	UG/KG	1.78	30	[illegible]	[illegible]
...C SIM	BENZO(A)PYRENE	SOIL	6.6	UG/KG	2.36	30	[illegible]	[illegible]
...70C SIM	BENZO(B)FLUORANTHENE	SOIL	6.6	UG/KG	1.57	30	[illegible]	[illegible]
...70C SIM	BENZO(G,H,I)PERYLENE	SOIL	6.6	UG/KG	2.51	30	[illegible]	[illegible]
8270C SIM	BENZO(K)FLUORANTHENE	SOIL	6.6	UG/KG	1.94	30	[illegible]	[illegible]
8270C SIM	CHRYSENE	SOIL	6.6	UG/KG	1.56	30	[illegible]	[illegible]
8270C SIM	DIBENZO(A,H)ANTHRACENE	SOIL	6.6	UG/KG	2.80	30	[illegible]	[illegible]
8270C SIM	FLUORANTHENE	SOIL	6.6	UG/KG	2.62	30	[illegible]	[illegible]
8270C SIM	FLUORENE	SOIL	6.6	UG/KG	1.47	30	[illegible]	[illegible]
8270C SIM	INDENO(1,2,3-CD)PYRENE	SOIL	6.6	UG/KG	3.16	30	[illegible]	[illegible]
8270C SIM	NAPHTHALENE	SOIL	6.6	UG/KG	6.01	30	[illegible]	[illegible]
8270C SIM	PHENANTHRENE	SOIL	6.6	UG/KG	1.70	30	[illegible]	[illegible]
8270C SIM	PYRENE	SOIL	6.6	UG/KG	2.46	30	[illegible]	[illegible]
8270C SIM	[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]
8270C SIM	[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]
8270C SIM	[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
[illegible]-1/SOW4.2	1,1,1-TRICHLOROETHANE	WATER	10	UG/L	0.13			
95-1/SOW4.2	1,1,2,2-TETRACHLOROETHANE	WATER	10	UG/L	0.22			
95-1/SOW4.2	1,1,2-TRICHLOROETHANE	WATER	10	UG/L	0.14			
95-1/SOW4.2	1,1-DICHLOROETHANE	WATER	10	UG/L	0.17			
95-1/SOW4.2	1,1-DICHLOROETHENE	WATER	10	UG/L	0.44	14	61-145**	61-145
95-1/SOW4.2	1,2-DICHLOROETHANE	WATER	10	UG/L	0.16			
95-1/SOW4.2	1,2-DICHLOROPROPANE	WATER	10	UG/L	0.16			
95-1/SOW4.2	2-BUTANONE	WATER	10	UG/L	1.36			
95-1/SOW4.2	2-HEXANONE	WATER	10	UG/L	1.68			
95-1/SOW4.2	4-METHYL-2-PENTANONE	WATER	10	UG/L	1.18			
95-1/SOW4.2	ACETONE	WATER	10	UG/L	2.87			
95-1/SOW4.2	BENZENE	WATER	10	UG/L	0.13	11	76-127**	76-127
95-1/SOW4.2	BROMODICHLOROMETHANE	WATER	10	UG/L	0.16			
95-1/SOW4.2	BROMOFORM	WATER	10	UG/L	0.25			
95-1/SOW4.2	BROMOMETHANE	WATER	10	UG/L	0.58			
95-1/SOW4.2	CARBON DISULFIDE	WATER	10	UG/L	0.42			
95-1/SOW4.2	CARBON TETRACHLORIDE	WATER	10	UG/L	0.12			
95-1/SOW4.2	CHLOROBENZENE	WATER	10	UG/L	0.20	13	75-130**	75-130
95-1/SOW4.2	CHLOROETHANE	WATER	10	UG/L	0.42			
95-1/SOW4.2	CHLOROFORM	WATER	10	UG/L	0.10			
95-1/SOW4.2	CHLOROMETHANE	WATER	10	UG/L	0.30			
95-1/SOW4.2	CIS-1,2-DICHLOROETHENE	WATER	10	UG/L	0.19			
95-1/SOW4.2	CIS-1,3-DICHLOROPROPENE	WATER	10	UG/L	0.14			
95-1/SOW4.2	DIBROMOCHLOROMETHANE	WATER	10	UG/L	0.14			
95-1/SOW4.2	ETHYLBENZENE	WATER	10	UG/L	0.16			
95-1/SOW4.2	M+P-XYLENE	WATER	10	UG/L	0.47			
[illegible]/SOW4.2	METHYLENE CHLORIDE	WATER	10	UG/L	0.43			
[illegible]1/SOW4.2	O-XYLENE	WATER	10	UG/L	0.17			
[illegible]1/SOW4.2	STYRENE	WATER	10	UG/L	0.23			
95-1/SOW4.2	TETRACHLOROETHENE	WATER	10	UG/L	0.13			
95-1/SOW4.2	TOLUENE	WATER	10	UG/L	0.13	13	78-122**	[illegible]
95-1/SOW4.2	TRANS-1,2-DICHLOROETHENE	WATER	10	UG/L	0.42			
95-1/SOW4.2	TRANS-1,3-DICHLOROPROPENE	WATER	10	UG/L	0.16			
95-1/SOW4.2	TRICHLOROETHENE	WATER	10	UG/L	0.16	14	71-120**	71-120
95-1/SOW4.2	VINYL CHLORIDE	WATER	10	UG/L	0.28			
95-1/SOW4.2	[illegible]	WATER	NA	UG/L	NA	NA	80-115	80-115
95-1/SOW4.2	[illegible]	WATER	NA	UG/L	NA	NA	76-114	76-114
95-1/SOW4.2	[illegible]	WATER	NA	UG/L	NA	NA	88-110	88-110
SOW List from above plus these additional compounds								
SOW 4.2	*DICHLORODIFLUOROMETHANE*	WATER	10	UG/L	0.65			
SOW 4.2	*TRICHLOROFLUOROMETHANE*	WATER	10	UG/L	0.33			
SOW 4.2	*1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON 113)*	WATER	10	UG/L	0.74			
SOW 4.2	*METHYL ACETATE*	WATER	10	UG/L	1.01			
SOW 4.2	*METHYL TERT-BUTYL ETHER*	WATER	10	UG/L	0.60			
SOW 4.2	*CYCLOHEXANE*	WATER	10	UG/L	0.66			
SOW 4.2	*METHYLCYCLOHEXANE*	WATER	10	UG/L	0.88			
SOW 4.2	*1,2-DIBROMOETHANE*	WATER	10	UG/L	0.23			
SOW 4.2	*ISOPROPYLBENZENE*	WATER	10	UG/L	0.68			
SOW 4.2	*1,3-DICHLOROBENZENE*	WATER	10	UG/L	0.27			
SOW 4.2	*1,4-DICHLOROBENZENE*	WATER	10	UG/L	0.19			
SOW 4.2	*1,2-DICHLOROBENZENE*	WATER	10	UG/L	0.21			
[illegible]W 4.2	*1,2-DIBROMO-3-CHLOROPROPANE*	WATER	10	UG/L	0.41			
[illegible] 4.2	*1,2,4-TRICHLOROBENZENE*	WATER	10	UG/L	0.28			

CAS/ROCHESTER ORGANIC QC LIMITS

OD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
-1/SOW4.2	1,1,1-TRICHLOROETHANE	SOIL	10	UG/KG	2.47			
95-1/SOW4.2	1,1,2,2-TETRACHLOROETHANE	SOIL	10	UG/KG	2.15			
95-1/SOW4.2	1,1,2-TRICHLOROETHANE	SOIL	10	UG/KG	2.33			
95-1/SOW4.2	1,1-DICHLOROETHANE	SOIL	10	UG/KG	0.85			
95-1/SOW4.2	1,1-DICHLOROETHENE	SOIL	10	UG/KG	1.15	[illegible]	[illegible]	[illegible]
95-1/SOW4.2	1,2-DICHLOROETHANE	SOIL	10	UG/KG	1.68			
95-1/SOW4.2	1,2-DICHLOROPROPANE	SOIL	10	UG/KG	1.70			
95-1/SOW4.2	2-BUTANONE	SOIL	10	UG/KG	2.87			
95-1/SOW4.2	2-HEXANONE	SOIL	10	UG/KG	4.59			
95-1/SOW4.2	4-METHYL-2-PENTANONE	SOIL	10	UG/KG	2.26			
95-1/SOW4.2	ACETONE	SOIL	10	UG/KG	8.71			
95-1/SOW4.2	BENZENE	SOIL	10	UG/KG	1.04	[illegible]	[illegible]	[illegible]
95-1/SOW4.2	BROMODICHLOROMETHANE	SOIL	10	UG/KG	1.75			
95-1/SOW4.2	BROMOFORM	SOIL	10	UG/KG	1.79			
95-1/SOW4.2	BROMOMETHANE	SOIL	10	UG/KG	1.94			
95-1/SOW4.2	CARBON DISULFIDE	SOIL	10	UG/KG	1.29			
95-1/SOW4.2	CARBON TETRACHLORIDE	SOIL	10	UG/KG	1.85			
95-1/SOW4.2	CHLOROBENZENE	SOIL	10	UG/KG	1.13	[illegible]	[illegible]	[illegible]
95-1/SOW4.2	CHLOROETHANE	SOIL	10	UG/KG	2.17			
95-1/SOW4.2	CHLOROFORM	SOIL	10	UG/KG	1.25			
95-1/SOW4.2	CHLOROMETHANE	SOIL	10	UG/KG	2.39			
95-1/SOW4.2	CIS-1,2-DICHLOROETHENE	SOIL	10	UG/KG	1.99			
95-1/SOW4.2	CIS-1,3-DICHLOROPROPENE	SOIL	10	UG/KG	1.61			
95-1/SOW4.2	DIBROMOCHLOROMETHANE	SOIL	10	UG/KG	2.01			
95-1/SOW4.2	ETHYLBENZENE	SOIL	10	UG/KG	1.33			
95-1/SOW4.2	M+P-XYLENE	SOIL	10	UG/KG	2.16			
[illegible]/SOW4.2	METHYLENE CHLORIDE	SOIL	10	UG/KG	1.70			
[illegible]1/SOW4.2	O-XYLENE	SOIL	10	UG/KG	1.16			
[illegible]-1/SOW4.2	STYRENE	SOIL	10	UG/KG	1.10			
95-1/SOW4.2	TETRACHLOROETHENE	SOIL	10	UG/KG	5.53			
95-1/SOW4.2	TOLUENE	SOIL	10	UG/KG	0.85	[illegible]	[illegible]	[illegible]
95-1/SOW4.2	TRANS-1,2-DICHLOROETHENE	SOIL	10	UG/KG	2.59			
95-1/SOW4.2	TRANS-1,3-DICHLOROPROPENE	SOIL	10	UG/KG	1.08			
95-1/SOW4.2	TRICHLOROETHENE	SOIL	10	UG/KG	1.46	[illegible]	[illegible]	[illegible]
95-1/SOW4.2	VINYL CHLORIDE	SOIL	10	UG/KG	4.19			
95-1/SOW4.2	[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]
95-1/SOW4.2	[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]
95-1/SOW4.2	[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]
SOW List from above plus these additional compounds								
SOW 4.2	*DICHLORODIFLUOROMETHANE*	SOIL	10	UG/KG	2.77			
SOW 4.2	*TRICHLOROFLUOROMETHANE*	SOIL	10	UG/KG	1.15			
SOW 4.2	*1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE*	SOIL	10	UG/KG	2.27			
SOW 4.2	*METHYL ACETATE*	SOIL	10	UG/KG	4.55			
SOW 4.2	*METHYL TERT-BUTYL ETHER*	SOIL	10	UG/KG	1.81			
SOW 4.2	*CYCLOHEXANE*	SOIL	10	UG/KG	1.53			
SOW 4.2	*METHYLCYCLOHEXANE*	SOIL	10	UG/KG	1.25			
SOW 4.2	*1,2-DIBROMOETHANE*	SOIL	10	UG/KG	2.11			
SOW 4.2	*ISOPROPYLBENZENE*	SOIL	10	UG/KG	1.19			
SOW 4.2	*1,3-DICHLOROBENZENE*	SOIL	10	UG/KG	1.84			
SOW 4.2	*1,4-DICHLOROBENZENE*	SOIL	10	UG/KG	1.60			
SOW 4.2	*1,2-DICHLOROBENZENE*	SOIL	10	UG/KG	1.67			
SOW 4.2	*1,2-DIBROMO-3-CHLOROPROPANE*	SOIL	10	UG/KG	5.05			
[illegible]OW 4.2	*1,2,4-TRICHLOROBENZENE*	SOIL	10	UG/KG	3.67			

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
[illegible]-2/SOW4.2	ACENAPHTHENE	WATER	10	UG/L	0.53	31	46-118	46-118
95-2/SOW4.2	ACENAPHTHYLENE	WATER	10	UG/L	0.74			
95-2/SOW4.2	ANTHRACENE	WATER	10	UG/L	0.46			
95-2/SOW4.2	BENZO(A)ANTHRACENE	WATER	10	UG/L	0.16			
95-2/SOW4.2	BENZO(A)PYRENE	WATER	10	UG/L	0.53			
95-2/SOW4.2	BENZO(B)FLUORANTHENE	WATER	10	UG/L	2.65			
95-2/SOW4.2	BENZO(G,H,I)PERYLENE	WATER	10	UG/L	2.45			
95-2/SOW4.2	BENZO(K)FLUORANTHENE	WATER	10	UG/L	0.66			
95-2/SOW4.2	BUTYL BENZYL PHTHALATE	WATER	10	UG/L	1.38			
95-2/SOW4.2	DI-N-BUTYLPHTHALATE	WATER	10	UG/L	0.35			
95-2/SOW4.2	CARBAZOLE	WATER	10	UG/L	0.56			
95-2/SOW4.2	INDENO(1,2,3-CD)PYRENE	WATER	10	UG/L	2.45			
95-2/SOW4.2	4-CHLOROANILINE	WATER	10	UG/L	0.46			
95-2/SOW4.2	BIS(-2-CHLOROETHOXY)METHANE	WATER	10	UG/L	0.69			
95-2/SOW4.2	BIS(-2-CHLOROETHYL)ETHER	WATER	10	UG/L	1.11			
95-2/SOW4.2	2-CHLORONAPHTHALENE	WATER	10	UG/L	0.18			
95-2/SOW4.2	2-CHLOROPHENOL	WATER	10	UG/L	0.53	40	27-123	27-123
95-2/SOW4.2	2,2'-OXYBIS(1-CHLOROPROPANE)	WATER	10	UG/L	1.22			
95-2/SOW4.2	CHRYSENE	WATER	10	UG/L	0.07			
95-2/SOW4.2	DIBENZ(A,H)ANTHRACENE	WATER	10	UG/L	2.09			
95-2/SOW4.2	DIBENZOFURAN	WATER	10	UG/L	0.21			
95-2/SOW4.2	1,3-DICHLOROBENZENE	WATER	10	UG/L	0.51			
95-2/SOW4.2	1,2-DICHLOROBENZENE	WATER	10	UG/L	0.86			
95-2/SOW4.2	1,4-DICHLOROBENZENE	WATER	10	UG/L	0.53	28	36-97	36-97
95-2/SOW4.2	3,3'-DICHLOROBENZIDINE	WATER	10	UG/L	0.86			
95-2/SOW4.2	2,4-DICHLOROPHENOL	WATER	10	UG/L	0.73			
95-2/SOW4.2	DIETHYLPHTHALATE	WATER	10	UG/L	0.38			
[illegible]/SOW4.2	DIMETHYL PHTHALATE	WATER	10	UG/L	0.54			
[illegible]-2/SOW4.2	2,4-DIMETHYLPHENOL	WATER	10	UG/L	0.36			
[illegible]-2/SOW4.2	2,4-DINITROPHENOL	WATER	25	UG/L	1.99			
95-2/SOW4.2	2,4-DINITROTOLUENE	WATER	10	UG/L	1.78	33	24-96	24-96
95-2/SOW4.2	2,6-DINITROTOLUENE	WATER	10	UG/L	1.31			
95-2/SOW4.2	BIS(2-ETHYLHEXYL)PHTHALATE	WATER	10	UG/L	0.40			
95-2/SOW4.2	FLUORANTHENE	WATER	10	UG/L	0.76			
95-2/SOW4.2	FLUORENE	WATER	10	UG/L	0.63			
95-2/SOW4.2	HEXACHLOROBENZENE	WATER	10	UG/L	1.36			
95-2/SOW4.2	HEXACHLOROBUTADIENE	WATER	10	UG/L	0.48			
95-2/SOW4.2	HEXACHLOROCYCLOPENTADIENE	WATER	10	UG/L	1.59			
95-2/SOW4.2	HEXACHLOROETHANE	WATER	10	UG/L	0.74			
95-2/SOW4.2	ISOPHORONE	WATER	10	UG/L	0.45			
95-2/SOW4.2	2-METHYLNAPHTHALENE	WATER	10	UG/L	0.33			
95-2/SOW4.2	4,6-DINITRO-2-METHYLPHENOL	WATER	25	UG/L	1.40			
95-2/SOW4.2	4-CHLORO-3-METHYLPHENOL	WATER	10	UG/L	0.36	42	23-97	23-97
95-2/SOW4.2	2-METHYLPHENOL	WATER	10	UG/L	2.20			
95-2/SOW4.2	4-METHYLPHENOL	WATER	10	UG/L	0.85			
95-2/SOW4.2	NAPHTHALENE	WATER	10	UG/L	0.14			
95-2/SOW4.2	2-NITROANILINE	WATER	25	UG/L	1.50			
95-2/SOW4.2	3-NITROANILINE	WATER	25	UG/L	0.78			
95-2/SOW4.2	4-NITROANILINE	WATER	25	UG/L	0.94			
95-2/SOW4.2	NITROBENZENE	WATER	10	UG/L	0.90			
95-2/SOW4.2	2-NITROPHENOL	WATER	10	UG/L	1.26			
95-2/SOW4.2	4-NITROPHENOL	WATER	25	UG/L	1.61	50	10-80	1-80
95-2/SOW4.2	N-NITROSODIPHENYLAMINE	WATER	10	UG/L	1.05			
[illegible]-2/SOW4.2	DI-N-OCTYL PHTHALATE	WATER	10	UG/L	2.47			
[illegible]-2/SOW4.2	PENTACHLOROPHENOL	WATER	25	UG/L	2.96	50	9-103	9-103
[illegible]-2/SOW4.2	PHENANTHRENE	WATER	10	UG/L	0.56			
[illegible]-2/SOW4.2	PHENOL	WATER	10	UG/L	0.37	42	12-110	12-110
95-2/SOW4.2	4-BROMOPHENYL-PHENYLETHER	WATER	10	UG/L	0.11			
95-2/SOW4.2	4-CHLOROPHENYL-PHENYLETHER	WATER	10	UG/L	0.75			
95-2/SOW4.2	N-NITROSO-DI-N-PROPYLAMINE	WATER	10	UG/L	0.64	38	41-116	41-116

CAS/ROCHESTER ORGANIC QC LIMITS

LOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
-2/SOW4.2	PYRENE	WATER	10	UG/L	1.59	[illegible]	[illegible]	[illegible]
95-2/SOW4.2	1,2,4-TRICHLOROBENZENE	WATER	10	UG/L	0.47	28	[illegible]	[illegible]
95-2/SOW4.2	2,4,6-TRICHLOROPHENOL	WATER	10	UG/L	1.22			
95-2/SOW4.2	2,4,5-TRICHLOROPHENOL	WATER	25	UG/L	1.83			
95-2/SOW4.2	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
95-2/SOW4.2	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
95-2/SOW4.2	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
95-2/SOW4.2	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
95-2/SOW4.2	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
95-2/SOW4.2	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
95-2/SOW4.2	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
SOW list from above plus these additional compounds								
SOW 4.2	*BENZALDEHYDE*	WATER	10	UG/L	0.86			
SOW 4.2	*ACETOPHENONE*	WATER	10	UG/L	0.96			
SOW 4.2	*CAPROLACTAM*	WATER	10	UG/L	0.91			
SOW 4.2	*1,1'-BIPHENYL*	WATER	10	UG/L	0.28			
SOW 4.2	*ATRAZINE*	WATER	10	UG/L	1.25			
95-2/SOW4.2	ACENAPHTHENE	SOIL	330	UG/KG	18	19	[illegible]	[illegible]
95-2/SOW4.2	ACENAPHTHYLENE	SOIL	330	UG/KG	25			
95-2/SOW4.2	ANTHRACENE	SOIL	330	UG/KG	15			
95-2/SOW4.2	BENZO(A)ANTHRACENE	SOIL	330	UG/KG	5.3			
95-2/SOW4.2	BENZO(A)PYRENE	SOIL	330	UG/KG	18			
95-2/SOW4.2	BENZO(B)FLUORANTHENE	SOIL	330	UG/KG	88			
95-2/SOW4.2	BENZO(G,H,I)PERYLENE	SOIL	330	UG/KG	82			
95-2/SOW4.2	BENZO(K)FLUORANTHENE	SOIL	330	UG/KG	22			
/SOW4.2	BUTYL BENZYL PHTHALATE	SOIL	330	UG/KG	46			
-2/SOW4.2	DI-N-BUTYLPHTHALATE	SOIL	330	UG/KG	12			
-2/SOW4.2	CARBAZOLE	SOIL	330	UG/KG	19			
95-2/SOW4.2	INDENO(1,2,3-CD)PYRENE	SOIL	330	UG/KG	82			
95-2/SOW4.2	4-CHLOROANILINE	SOIL	330	UG/KG	15			
95-2/SOW4.2	BIS(-2-CHLOROETHOXY)METHANE	SOIL	330	UG/KG	23			
95-2/SOW4.2	BIS(-2-CHLOROETHYL)ETHER	SOIL	330	UG/KG	37			
95-2/SOW4.2	2-CHLORONAPHTHALENE	SOIL	330	UG/KG	6.0			
95-2/SOW4.2	2-CHLOROPHENOL	SOIL	330	UG/KG	18	43	[illegible]	[illegible]
95-2/SOW4.2	2,2'-OXYBIS(1-CHLOROPROPANE)	SOIL	330	UG/KG	41			
95-2/SOW4.2	CHRYSENE	SOIL	330	UG/KG	2.3			
95-2/SOW4.2	DIBENZ(A,H)ANTHRACENE	SOIL	330	UG/KG	70			
95-2/SOW4.2	DIBENZOFURAN	SOIL	330	UG/KG	7.0			
95-2/SOW4.2	1,3-DICHLOROBENZENE	SOIL	330	UG/KG	17			
95-2/SOW4.2	1,2-DICHLOROBENZENE	SOIL	330	UG/KG	29			
95-2/SOW4.2	1,4-DICHLOROBENZENE	SOIL	330	UG/KG	18	27	[illegible]	[illegible]
95-2/SOW4.2	3,3'-DICHLOROBENZIDINE	SOIL	330	UG/KG	29			
95-2/SOW4.2	2,4-DICHLOROPHENOL	SOIL	330	UG/KG	24			
95-2/SOW4.2	DIETHYLPHTHALATE	SOIL	330	UG/KG	13			
95-2/SOW4.2	DIMETHYL PHTHALATE	SOIL	330	UG/KG	18			
95-2/SOW4.2	2,4-DIMETHYLPHENOL	SOIL	330	UG/KG	12			
95-2/SOW4.2	2,4-DINITROPHENOL	SOIL	800	UG/KG	66			
95-2/SOW4.2	2,4-DINITROTOLUENE	SOIL	330	UG/KG	59	4	[illegible]	[illegible]
95-2/SOW4.2	2,6-DINITROTOLUENE	SOIL	330	UG/KG	44			
95-2/SOW4.2	BIS(2-ETHYLHEXYL)PHTHALATE	SOIL	330	UG/KG	13			
95-2/SOW4.2	FLUORANTHENE	SOIL	330	UG/KG	25			
95-2/SOW4.2	FLUORENE	SOIL	330	UG/KG	21			
-2/SOW4.2	HEXACHLOROBENZENE	SOIL	330	UG/KG	45			
-2/SOW4.2	HEXACHLOROBUTADIENE	SOIL	330	UG/KG	16			
-2/SOW4.2	HEXACHLOROCYCLOPENTADIENE	SOIL	330	UG/KG	53			
-2/SOW4.2	HEXACHLOROETHANE	SOIL	330	UG/KG	25			
95-2/SOW4.2	ISOPHORONE	SOIL	330	UG/KG	15			
95-2/SOW4.2	2-METHYLNAPHTHALENE	SOIL	330	UG/KG	11			

CAS/ROCHESTER ORGANIC QC LIMITS

METHOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISION (RPD)	LCS (% REC)	MS (% REC)
-2/SOW4.2	4,6-DINITRO-2-METHYLPHENOL	SOIL	800	UG/KG	47			
95-2/SOW4.2	4-CHLORO-3-METHYLPHENOL	SOIL	330	UG/KG	12	22	23-97	42-102
95-2/SOW4.2	2-METHYLPHENOL	SOIL	330	UG/KG	73			
95-2/SOW4.2	4-METHYLPHENOL	SOIL	330	UG/KG	28			
95-2/SOW4.2	NAPHTHALENE	SOIL	330	UG/KG	4.7			
95-2/SOW4.2	2-NITROANILINE	SOIL	800	UG/KG	50			
95-2/SOW4.2	3-NITROANILINE	SOIL	800	UG/KG	26			
95-2/SOW4.2	4-NITROANILINE	SOIL	800	UG/KG	31			
95-2/SOW4.2	NITROBENZENE	SOIL	330	UG/KG	30			
95-2/SOW4.2	2-NITROPHENOL	SOIL	330	UG/KG	42			
95-2/SOW4.2	4-NITROPHENOL	SOIL	800	UG/KG	54	50	10-80	1-114
95-2/SOW4.2	N-NITROSODIPHENYLAMINE	SOIL	330	UG/KG	35			
95-2/SOW4.2	DI-N-OCTYL PHTHALATE	SOIL	330	UG/KG	82			
95-2/SOW4.2	PENTACHLOROPHENOL	SOIL	800	UG/KG	99	31	9-103	1-117
95-2/SOW4.2	PHENANTHRENE	SOIL	330	UG/KG	19			
95-2/SOW4.2	PHENOL	SOIL	330	UG/KG	12	35	12-110	26-90
95-2/SOW4.2	4-BROMOPHENYL-PHENYLETHER	SOIL	330	UG/KG	3.7			
95-2/SOW4.2	4-CHLOROPHENYL-PHENYLETHER	SOIL	330	UG/KG	25			
95-2/SOW4.2	N-NITROSO-DI-N-PROPYLAMINE	SOIL	330	UG/KG	21	38	41-116	41-126
95-2/SOW4.2	PYRENE	SOIL	330	UG/KG	53	36	10-152	35-142
95-2/SOW4.2	1,2,4-TRICHLOROBENZENE	SOIL	330	UG/KG	16	23	39-98	38-107
95-2/SOW4.2	2,4,6-TRICHLOROPHENOL	SOIL	330	UG/KG	41			
95-2/SOW4.2	2,4,5-TRICHLOROPHENOL	SOIL	800	UG/KG	61			
95-2/SOW4.2	[illegible]	SOIL	NA	UG/KG	NA	NA	18-137	18-137
95-2/SOW4.2	[illegible]	SOIL	NA	UG/KG	NA	NA	20-130	20-130
95-2/SOW4.2	[illegible]	SOIL	NA	UG/KG	NA	NA	20-130	20-130
/SOW4.2	[illegible]	SOIL	NA	UG/KG	NA	NA	33-100	34-107
-2/SOW4.2	[illegible]	SOIL	NA	UG/KG	NA	NA	21-117	24-113
2/SOW4.2	[illegible]	SOIL	NA	UG/KG	NA	NA	20-116	30-116
95-2/SOW4.2	[illegible]	SOIL	NA	UG/KG	NA	NA	25-121	20-13
95-2/SOW4.2	[illegible]	SOIL	NA	UG/KG	NA	NA	19-122	19-122
SOW list from above plus these additional compounds								
SOW 4.2	*BENZALDEHYDE*	SOIL	330	UG/KG	29	NA		
SOW 4.2	*ACETOPHENONE*	SOIL	330	UG/KG	32	NA		
SOW 4.2	*CAPROLACTAM*	SOIL	330	UG/KG	30	NA		
SOW 4.2	*1,1'-BIPHENYL*	SOIL	330	UG/KG	9.3	NA		
SOW 4.2	*ATRAZINE*	SOIL	330	UG/KG	42	NA		

CAS/ROCHESTER ORGANIC QC LIMITS

.OD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
-3/SOW4.2	AROCLOR-1016	WATER	1.0	UG/L	0.478			
95-3/SOW4.2	AROCLOR-1221	WATER	2.0	UG/L	0.684			
95-3/SOW4.2	AROCLOR-1232	WATER	1.0	UG/L	0.788			
95-3/SOW4.2	AROCLOR-1242	WATER	1.0	UG/L	0.360			
95-3/SOW4.2	AROCLOR-1248	WATER	1.0	UG/L	0.275			
95-3/SOW4.2	AROCLOR-1254	WATER	1.0	UG/L	0.073			
95-3/SOW4.2	AROCLOR-1260	WATER	1.0	UG/L	0.188			
95-3/SOW4.2	ALDRIN	WATER	0.050	UG/L	0.003	[illegible]	[illegible]	[illegible]
95-3/SOW4.2	ALPHA-BHC	WATER	0.050	UG/L	0.008			
95-3/SOW4.2	BETA-BHC	WATER	0.050	UG/L	0.004			
95-3/SOW4.2	DELTA-BHC	WATER	0.050	UG/L	0.004			
95-3/SOW4.2	GAMMA-BHC (LINDANE)	WATER	0.050	UG/L	0.008	[illegible]	[illegible]	[illegible]
95-3/SOW4.2	ALPHA-CHLORDANE	WATER	0.050	UG/L	0.006			
95-3/SOW4.2	GAMMA-CHLORDANE	WATER	0.050	UG/L	0.003			
95-3/SOW4.2	4,4'-DDD	WATER	0.10	UG/L	0.009			
95-3/SOW4.2	4,4'-DDE	WATER	0.10	UG/L	0.005			
95-3/SOW4.2	4,4'-DDT	WATER	0.10	UG/L	0.003	[illegible]	[illegible]	[illegible]
95-3/SOW4.2	DIELDRIN	WATER	0.10	UG/L	0.014	[illegible]	[illegible]	[illegible]
95-3/SOW4.2	ENDOSULFAN I	WATER	0.050	UG/L	0.006			
95-3/SOW4.2	ENDOSULFAN II	WATER	0.10	UG/L	0.011			
95-3/SOW4.2	ENDOSULFAN SULFATE	WATER	0.10	UG/L	0.007			
95-3/SOW4.2	ENDRIN	WATER	0.10	UG/L	0.014	[illegible]	[illegible]	[illegible]
95-3/SOW4.2	ENDRIN ALDEHYDE	WATER	0.10	UG/L	0.006			
95-3/SOW4.2	ENDRIN KETONE	WATER	0.10	UG/L	0.009			
95-3/SOW4.2	HEPTACHLOR	WATER	0.050	UG/L	0.008	[illegible]	[illegible]	[illegible]
95-3/SOW4.2	HEPTACHLOR EPOXIDE	WATER	0.050	UG/L	0.002			
[illegible]/SOW4.2	METHOXYCHLOR	WATER	0.50	UG/L	0.031			
-3/SOW4.2	TOXAPHENE	WATER	5.0	UG/L	1.02			
-3/SOW4.2	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
95-3/SOW4.2	[illegible]	WATER	NA	UG/L	NA	NA	[illegible]	[illegible]
95-3/SOW4.2	AROCLOR-1016	SOIL	33	UG/KG	15.9			
95-3/SOW4.2	AROCLOR-1221	SOIL	67	UG/KG	22.8			
95-3/SOW4.2	AROCLOR-1232	SOIL	33	UG/KG	26.2			
95-3/SOW4.2	AROCLOR-1242	SOIL	33	UG/KG	12.0			
95-3/SOW4.2	AROCLOR-1248	SOIL	33	UG/KG	9.16			
95-3/SOW4.2	AROCLOR-1254	SOIL	33	UG/KG	2.43			
95-3/SOW4.2	AROCLOR-1260	SOIL	33	UG/KG	6.26			
95-3/SOW4.2	ALDRIN	SOIL	1.7	UG/KG	0.10	[illegible]	[illegible]	[illegible]
95-3/SOW4.2	ALPHA-BHC	SOIL	1.7	UG/KG	0.27			
95-3/SOW4.2	BETA-BHC	SOIL	1.7	UG/KG	0.13			
95-3/SOW4.2	DELTA-BHC	SOIL	1.7	UG/KG	0.13			
95-3/SOW4.2	GAMMA-BHC (LINDANE)	SOIL	1.7	UG/KG	0.27	[illegible]	[illegible]	[illegible]
95-3/SOW4.2	ALPHA-CHLORDANE	SOIL	1.7	UG/KG	0.20			
95-3/SOW4.2	GAMMA-CHLORDANE	SOIL	1.7	UG/KG	0.10			
95-3/SOW4.2	4,4'-DDD	SOIL	3.3	UG/KG	0.30			
95-3/SOW4.2	4,4'-DDE	SOIL	3.3	UG/KG	0.17			
95-3/SOW4.2	4,4'-DDT	SOIL	3.3	UG/KG	0.10	[illegible]	[illegible]	[illegible]
95-3/SOW4.2	DIELDRIN	SOIL	3.3	UG/KG	0.47	[illegible]	[illegible]	[illegible]
95-3/SOW4.2	ENDOSULFAN I	SOIL	1.7	UG/KG	0.20			
95-3/SOW4.2	ENDOSULFAN II	SOIL	3.3	UG/KG	0.37			
95-3/SOW4.2	ENDOSULFAN SULFATE	SOIL	3.3	UG/KG	0.23			
95-3/SOW4.2	ENDRIN	SOIL	3.3	UG/KG	0.47	[illegible]	[illegible]	[illegible]
95-3/SOW4.2	ENDRIN ALDEHYDE	SOIL	3.3	UG/KG	0.20			
[illegible]-3/SOW4.2	ENDRIN KETONE	SOIL	3.3	UG/KG	0.30			
-3/SOW4.2	HEPTACHLOR	SOIL	1.7	UG/KG	0.27	[illegible]	[illegible]	[illegible]
[illegible]-3/SOW4.2	HEPTACHLOR EPOXIDE	SOIL	1.7	UG/KG	0.07			
-3/SOW4.2	METHOXYCHLOR	SOIL	17	UG/KG	1.03			
95-3/SOW4.2	TOXAPHENE	SOIL	170	UG/KG	34.0			
95-3/SOW4.2	[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]

CAS/ROCHESTER ORGANIC QC LIMITS

.OD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
-3/SOW4.2	[illegible]	SOIL	NA	UG/KG	NA	NA	[illegible]	[illegible]

CAS/ROCHESTER ORGANIC QC LIMITS

HOD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIO (RPD)	LCS (% REC)	MS (% REC)
VPH	BENZENE	WATER	0.5	UG/L	0.17	20	70-130	70-130
MAVPH	METHYL-TERT-BUTYL ETHER	WATER	5.0	UG/L	0.64	20	70-130	70-130
MAVPH	C9-C10 AROMATICS	WATER	10	UG/L	1.70	20	70-130	70-130
MAVPH	C9-C12 ALIPHATICS	WATER	20	UG/L	4.81	20	70-130	70-130
MAVPH	C5-C8 ALIPHATICS	WATER	15	UG/L	8.8	20	70-130	70-130
MAVPH	ETHYLBENZENE	WATER	1.0	UG/L	0.19	20	70-130	70-130
MAVPH	NAPHTHALENE	WATER	5.0	UG/L	0.51	20	70-130	70-130
MAVPH	TOLUENE	WATER	1.0	UG/L	0.46	20	70-130	70-130
MAVPH	M+P-XYLENE	WATER	1.0	UG/L	0.70	20	70-130	70-130
MAVPH	O-XYLENE	WATER	1.0	UG/L	0.50	20	70-130	70-130
MAVPH	[illegible]	WATER	NA	UG/L	NA	NA	70-130	70-130
MAVPH	[illegible]	WATER	NA	UG/L	NA	NA	70-130	70-130
MAVPH	BENZENE	SOIL	25	UG/KG	8.60	20	70-130	70-130
MAVPH	METHYL-TERT-BUTYL ETHER	SOIL	250	UG/KG	32.2	20	70-130	70-130
MAVPH	C9-C10 AROMATICS	SOIL	500	UG/KG	85	20	70-130	70-130
MAVPH	C9-C12 ALIPHATICS	SOIL	1000	UG/KG	241	20	70-130	70-130
MAVPH	C5-C8 ALIPHATICS	SOIL	750	UG/KG	442	20	70-130	70-130
MAVPH	ETHYLBENZENE	SOIL	50	UG/KG	9.65	20	70-130	70-130
MAVPH	NAPHTHALENE	SOIL	250	UG/KG	25.6	20	70-130	70-130
MAVPH	TOLUENE	SOIL	50	UG/KG	22.9	20	70-130	70-130
MAVPH	M+P-XYLENE	SOIL	50	UG/KG	35.2	20	70-130	70-130
MAVPH	O-XYLENE	SOIL	50	UG/KG	24.8	20	70-130	70-130
MAVPH	[illegible]	SOIL	NA	UG/KG	NA	NA	70-130	70-130
MAVPH	[illegible]	SOIL	NA	UG/KG	NA	NA	70-130	70-130
MAEPH	ACENAPHTHENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	ACENAPHTHYLENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	ANTHRACENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	BENZO(A)ANTHRACENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	BENZO(A)PYRENE	WATER	0.20	UG/L		20	40-140	40-140
MAEPH	BENZO(B)FLUORANTHENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	BENZO(G,H,I)PERYLENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	BENZO(K)FLUORANTHENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	C9-C18 ALIPHATIC HYDROCARBONS	WATER	100	UG/L	NA	20	40-140	40-140
MAEPH	UNADJUSTED C11-C22 AROMATIC HYDROCAR	WATER	100	UG/L	NA	20	40-140	40-140
MAEPH	C11-C22 AROMATICS	WATER	100	UG/L	NA	20	40-140	40-140
MAEPH	C19-C36 ALIPHATIC HYDROCARBONS	WATER	100	UG/L	NA	20	40-140	40-140
MAEPH	INDENO(1,2,3-CD)PYRENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	CHRYSENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	DIBENZ(A,H)ANTHRACENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	FLUORANTHENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	FLUORENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	2-METHYLNAPHTHALENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	NAPHTHALENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	PHENANTHRENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	PYRENE	WATER	0.50	UG/L		20	40-140	40-140
MAEPH	[illegible]	WATER	NA	UG/L	NA	NA	40-140	40-140
MAEPH	[illegible]	WATER	NA	UG/L	NA	NA	40-140	40-140
MAEPH	[illegible]	WATER	NA	UG/L	NA	NA	40-140	40-140
MAEPH	[illegible]	WATER	NA	UG/L	NA	NA	40-140	40-140
MAEPH	ACENAPHTHENE	SOIL	330	UG/KG	29	20	40-140	40-140
MAEPH	ACENAPHTHYLENE	SOIL	330	UG/KG	28	20	40-140	40-140
MAEPH	ANTHRACENE	SOIL	330	UG/KG	195	20	40-140	40-140
MAEPH	BENZO(A)ANTHRACENE	SOIL	330	UG/KG	43	20	40-140	40-140
MAEPH	BENZO(A)PYRENE	SOIL	330	UG/KG	79	20	40-140	40-140
EPH	BENZO(B)FLUORANTHENE	SOIL	330	UG/KG	44	20	40-140	40-140
EPH	BENZO(G,H,I)PERYLENE	SOIL	330	UG/KG	39	20	40-140	40-140
EPH	BENZO(K)FLUORANTHENE	SOIL	330	UG/KG	67	20	40-140	40-140
MAEPH	C9-C18 ALIPHATIC HYDROCARBONS	SOIL	660	UG/KG	NA	20	40-140	40-140
MAEPH	UNADJUSTED C11-C22 AROMATIC HYDROCAR	SOIL	660	UG/KG	NA	20	40-140	40-140

CAS/ROCHESTER ORGANIC QC LIMITS

.OD	ANALYTE	MATRIX	MRL	UNITS	EST MDL	PRECISIC (RPD)	LCS (% REC)	MS (% REC)
EPH	C11-C22 AROMATICS	SOIL	660	UG/KG	NA	[illegible]	40-140	40-140
AEPH	C19-C36 ALIPHATIC HYDROCARBONS	SOIL	660	UG/KG	NA	[illegible]	40-140	40-140
MAEPH	INDENO(1,2,3-CD)PYRENE	SOIL	330	UG/KG	54	[illegible]	40-140	40-140
MAEPH	CHRYSENE	SOIL	330	UG/KG	93	[illegible]	40-140	40-140
MAEPH	DIBENZ(A,H)ANTHRACENE	SOIL	330	UG/KG	81	[illegible]	40-140	40-140
MAEPH	FLUORANTHENE	SOIL	330	UG/KG	83	[illegible]	40-140	40-140
MAEPH	FLUORENE	SOIL	330	UG/KG	28	[illegible]	40-140	40-140
MAEPH	2-METHYLNAPHTHALENE	SOIL	660	UG/KG	33	[illegible]	40-140	40-140
MAEPH	NAPHTHALENE	SOIL	330	UG/KG	41	[illegible]	40-140	40-140
MAEPH	PHENANTHRENE	SOIL	330	UG/KG	162	[illegible]	40-140	40-140
MAEPH	PYRENE	SOIL	330	UG/KG	50	[illegible]	40-140	40-140
MAEPH	[illegible]	SOIL	NA	UG/KG	NA	NA	40-140	40-140
MAEPH	[illegible]	SOIL	NA	UG/KG	NA	NA	40-140	40-140
MAEPH	[illegible]	SOIL	NA	UG/KG	NA	NA	40-140	40-140
MAEPH	[illegible]	SOIL	NA	UG/KG	NA	NA	40-140	40-140

* Subset of compounds used to control the acceptablitily of the QC sample for the batch. All targets are monitored against the limits provided, however outlying compounds outside of this subset may not stop analysis based upon the judgement of the analyst.

**ASP required limits only. SOW does not require LCS limits/analysis.

Limits for TCLP extracts are the same as the determinative method for the soil matrix.

EST MDL = Estimated Method Detection Limit. For CLP methodologies, [illegible] value is the Instrument Detection Limit.

APPENDIX D

DATA QUALIFIERS

Columbia Analytical Services INC.
An Employee - Owned Company

ACCREDITED IN ACCORDANCE WITH nelac

QUALITY ETHICS SERVICE
ACL Environmental Sciences

INORGANIC QUALIFIERS

C (Concentration) qualifier –

B - if the reported value was obtained from a reading that was less than the Contract Required Detection Limit (CRDL) but was greater than or equal to the Instrument Detection Limit (IDL).
U - if the analyte was analyzed for, but not detected

Q qualifier - Specified entries and their meanings are as follows:

E - The reported value is estimated because of the presence of interference.
J - Estimated Value
M - Duplicate injection precision not met.
N - Spiked sample recovery not within control limits.
S - The reported value was determined by the Method of Standard Additions (MSA).
W - Post-digestion spike for Furnace AA Analysis is out of control limits (85-115), while sample absorbance is less than 50% of spike absorbance.
* - Duplicate analysis not within control limits.
+ - Correlation coefficient for the MSA is less than 0.995.

M (Method) qualifier:

- "P" for ICP
- "A" for Flame AA
- "F" for Furnace AA
- "PM" for ICP when Microwave Digestion is used
- "AM" for Flame AA when Microwave Digestion is used
- "FM" for Furnace M when Microwave Digestion is used
- "CV" for Manual Cold Vapor AA
- "AV" for Automated Cold Vapor AA
- "CA" for Midi-Distillation Spectrophotometric
- "AS" for Semi-Automated Spectrophotometric
- "C" for Manual Spectrophotometric
- "T" for Titrimetric
- " " where no data has been entered
- "NR" if the analyte is not required to be analyzed.

ORGANIC QUALIFIERS

U - Indicates compound was analyzed for but not detected. The sample quantitation limit must be corrected for dilution and for percent moisture.

J - Indicates an estimated value. The flag is used either when estimating a concentration for tentatively identified compounds where a 1:1 response is assumed, or when the mass spectral data indicate the presence of a compound that meets the identification criteria but the result is less than the sample quantitation limit but greater than zero.

N - Indicates presumptive evidence of a compound. This flag is only used for tentatively identified compounds, where the identification is based on a mass spectral library search.

P - This flag is used for a pesticide/Aroclor target analyte when there is a greater than 25% difference for detected concentrations between the two GC columns. The lower of the two values is reported on Form I and flagged with a "P".

C - This flag applies to pesticide results where the identification has been confirmed by GC/MS.

B - This flag is used when the analyte is found in the associated blank as well as in the sample.

E - This flag identifies compounds whose concentrations exceed the calibration range of the instrument for that specific analysis.

D - This flag identifies all compounds identified in an analysis at a secondary dilution factor. If a sample or extract is re-analyzed at a higher dilution factor, as in the "E" flag above, the "DL" suffix is appended to the sample number on the Form I for the diluted sample, and ALL concentration values reported on that Form I are flagged with the "D" flag.

A - This flag indicates that a TIC is a suspected aldol-condensation product.

X - As specified in Case Narrative.

APPENDIX E

PREVENTIVE MAINTENANCE PROCEDURES

December 4, 2001

Preventive Maintenance Procedures

Instrument	Activity	Frequency
Refrigerators and Coolers	Record temperatures	Daily
	Clean coils	As needed
	Check coolant	As needed or if temperature outside limit
Fume Hoods	Face velocity measured	Quarterly
	Sash operation	As needed
Ovens	Clean	As needed or if temperature outside limit
Incubators	Record temperatures	Daily, morning and evening
Water Baths	Wash with disinfectant solution	When water is murky, dirty, or growth appears
Autoclave	Check temperature	Every month
	Clean	When mold or growth appears
Top Loading Balances	Check calibration	Before every use
Analytical Balances	Check alignment	Before every use
	Check calibration	Before every use
	Clean pans and compartment	After every use
Dissolved Oxygen Meter	Change membrane	When fluctuations occur
pH probes	Condition probe	When fluctuations occur
UV-visible Spectrophotometer	Wavelength check	Annually
Total Organic Carbon Analyzers	Check IR zero	Weekly
	Check digestion/condensation vessels	Each use
	Clean digestion chamber	Every 2000 hours, or as needed
	Clean permeation tube	Every 2000 hours, or as needed
	Clean six-port valves	Every 200 - 2000 hours, or as needed
	Clean sample pump	Every 200 - 2000 hours, or as needed
	Clean carbon scrubber	Every 200 - 2000 hours, or as needed
	Clean IR cell	Every 2000 - 4000 hours, or as needed
Total Organic Halogen Analyzers	Change cell electrolyte	Daily, or as needed
	Change electrode fluids	Daily, or as needed
	Change pyrolysis tube	As needed
	Change inlet and outlet tubes	As needed
	Change electrodes	As needed
Flow Injection Analyzer	Check valve flares	Monthly
	Check valve ports	Monthly
	Check pump tubing	Daily
	Check flow cell flares	Quarterly
	Change bulb	Every six months
	Check manifold tubing	Every six months
	Check T's and connectors	Every six months

Preventive Maintenance Procedures

Instrument	Activity	Frequency
Ion Chromatograph	Change column bed supports	Monthly or as needed
	Clean column	Monthly or as needed
	Change column	Every six months or as needed
	Change valve port face & hex nut	Every six months or as needed
	Clean valve slider	Every six months or as needed
	Change tubing	Annually or as needed
	Eluent pump	Annually
Atomic Absorption Spectro-photometers - FAA and CVAA	Check gases	Daily
	Clean burner head	Daily
	Check aspiration tubing	Daily
	Clean optics	Every three months
	Empty waste container	Weekly
Atomic Absorption Spectro-photometers - GFAA	Check gases	Daily
	Check argon dewar	Daily, or as needed
	Change graphite tube	Daily, or as needed
	Clean furnace windows	Monthly
ICP	Check argon dewar	Daily
	Replace peristaltic pump tubing	Daily, or as needed
	Empty waste container	Daily, or as needed
	Clean nebulizer, spray chamber, and torch	Every two weeks, or as needed
	Replace water filter	Quarterly
	Replace vacuum air filters	Monthly
Infrared Spectrophotometer, Fourier Transform	Clean sample cells	Daily, or as needed
Gel-Permeation Chromatographs	Clean and repack column	As needed
	Backflush valves	As needed
Gas Chromatographs, Semivolatiles	Check gas supplies	Daily, replace when pressure reaches 250 psi
	Change in-line filters	Quarterly or after 30 tanks of gas
	Change injection port liner	Daily or as needed
	Clip first foot of capillary column	As needed
	Change guard column	As needed
	Replace analytical column	As needed when peak resolution fails
	Check system for gas leaks	After changing columns
	Clean FID	As needed
	Leak test ECD	Annually

Preventive Maintenance Procedures

Instrument	Activity	Frequency
Gas Chromatograph/Mass Spectrometers, Semivolatiles	Check gas supplies	Daily, replace when pressure reaches 50 psi
	Change in-line filters	Quarterly or after 30 tanks of gas
	Change septum	Daily
	Change injection port liner	Weekly or as needed
	Clip first foot of capillary column	As needed
	Change guard column	As needed
	Replace analytical column	As needed when peak resolution fails
	Clean jet separator	As needed
	Clean source	As needed when tuning problems
	Change pump oil	Every six months
	Oil wick	Every six months
Purge and Trap Concentrators	Change trap	As needed
	Change transfer lines	As needed
	Clean purge vessel	Daily
Gas Chromatographs, Volatiles	Check gas supplies	Daily, replace when pressure reaches 200 psi
	Change in-line filters	Quarterly or after 30 tanks of gas
	Change septum	As needed
	Clip first foot of capillary column	As needed
	Change guard column	As needed
	Replace analytical column	As needed when peak resolution fails
	Check system for gas leaks	After changing columns or as needed
	Replenish ELCD solvents	Weekly
	Clean PID lamp	As needed
	Clean FID	As needed
	Change ion exchange resin	Quarterly
	Replace nickel tubing	Quarterly or as needed
Gas Chromatograph/Mass Spectrometers, Volatiles	Check gas supplies	Weekly, replace when pressure reaches 200 psi
	Change in-line filters	Quarterly or after 30 tanks of gas
	Change septum	Daily
	Clip first foot of capillary column	As needed
	Change guard column	As needed
	Replace analytical column	As needed when peak resolution fails
	Clean jet separator	As needed
	Clean source	As needed when tuning problems
	Change pump oil	Every six months per HP
	Oil wick	Every six months per HP
TCLP/SPLP Extractors	Monitor Room Temperature	Daily
	Monitor RPM of Rotators	Bi-weekly
	Grease fittings	As needed
	O-ring replacement	As needed

APPENDIX F

CERTIFICATIONS/ACCREDITATIONS/CONTRACTS

CAS/Rochester Certifications/Accreditations/Contracts

Federal and National Programs

- NELAP Accreditation, since January 2001.
  Primary Accreditation with New York and Florida
- NYS DEC Analytical Services Protocol Organic and Inorganic Contract (9/97-03/03).
- Naval Facilities Engineering Service Center (NFESC), Approved.
- Army Corp of Engingeers (USACE), Validated.
- ACIL Seal of Excellence (10/02-10/03).

State and Local Programs

- State of Connecticut, Department of Health Services, Approved Public Health Laboratory.
  Certified Laboratory for Potable Water, Waste Water/Trade Waste, Sewage/Effluent, and Soil.
  Examination for Bacteria, Inorganic Chemicals and Organic Chemicals. Certification No. PH-0556.
  Exp. 06/30/2004.
- The Commonwealth of Massachusetts, Department of Environmental Protection
  Certified Laboratory for Potable Water and Non-Potable Water
  Certification No. M-NY032. Exp. 06/30/2003.
- State of New Jersey, Department of Environmental Protection
  State Certified Environmental Laboratory for Drinking Water and Water Pollution.
  Certification No. NY004. Exp. 6/30/2003.
- State of New York, Department of Health, Environmental Laboratory Approval Program.
  Potable Water, Non-Potable Water, Solid and Hazardous Waste, and ASP Certification.
  Certification No. 10145. Exp. 04/01/03.
- State of New Hampshire, Department of Environmental Services
  Full Certification for Non-Potable Water. Certification No. 294102. Exp. 10/2003.
- State of Rhode Island, Department of Health
  Approved for Surface Water, WasteWater, and Sewage. License No. 158. Exp. 12/2002.
- West Virginia Division of Environmental Protection
  Certification for TCL/TAL, GRO, DRO, and TPH parameters in WasteWater and Solid Hazardous Waste.
  Certification No.292 Exp. 01/31/2003.
- State of Delaware, Department of Natural Resources and Environmental Control. Approved for Delaware
  Hazardous Substance Cleanup Act. Exp. 06/30/2003.
- State of Florida, Department of Health.
  Drinking water, Wastewater, Solid Hazardous Waste, CLP. Certification No. E87674. Expires 6/30/2003.
- State of South Carolina, Department of Environmental Control.
  Wastewater, Solid Hazardous Waste. Certification No. 91012. Expires ~~6/2003.~~ 6/2004 UMR 8/27/03

CAS/Rochester Certifications/Accreditations/Contracts

Unregulated State Programs

- State of Minnesota
  Reciprocal Certification for all parameters certified under New York State.
  Exp. 04/1/03.

- State of Georgia Environmental Protection Division
  Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
  Exp. 04/1/03.

- State of Indiana Hazardous Waste Division
  Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
  Exp. 04/1/03.

- State of Michigan - Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
  Exp. 04/1/03.

- Commonwealth of Pennsylvania, Department of Environmental Resources
  Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
  Exp. 04/1/03.

- Commonwealth of Virginia, Department of General Services
  Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
  Exp. 04/1/03.

- State of Mississippi - Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
  Exp. 04/1/03.

- State of Maryland - Reciprocal Approval for Non-Potable/Environmental Waters and Wastes.
  Exp. 04/1/03.

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STANDARD OPERATING PROCEDURE

SOLIDS, TOTAL DISSOLVED (TDS)

GEN-160.1

Revision 1

September 27, 2001

Approved By:

Supervisor	Date
QA Coordinator	Date
Laboratory Manager	Date

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One Mustard St., Suite 250
Rochester, NY 14609

Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
Initials: _____ Date: _____
Initials: _____ Date: _____

DOCUMENT CONTROL
NUMBER: _____
Initials: _____ Date: _____

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1. SCOPE AND APPLICATION

1.1. Applicable Matrices - This method (EPA 160.1) is applicable to the measurement of total dissolved solids in drinking, surface and saline waters, domestic and industrial wastes.

1.2. Range of determination is 10 mg/L to 20,000 mg/L.

1.3. Practical Quantitation Limit (PQL) = 10 mg/L when 100 mLs of sample is evaporated.

2. METHOD SUMMARY

A mixed sample is filtered through a standard glass fiber filter. The filtrate is evaporated and dried to a constant weight at 180°C in a ceramic dish. The increased weight of the dish represents the total dissolved solids.

3. DEFINITIONS

3.1. **Duplicate Sample (DUP**) - A laboratory duplicate. The duplicate sample is a separate field sample aliquot that is processed in an identical manner as the sample proper. The relative percent difference between the samples is calculated and used to assess analytical precision.

3.2. **Method Blank/ Prep Blank** - The method blank is an artificial sample designed to monitor introduction of artifacts into the process. The method blank is carried through the entire analytical procedure.

3.3. **Laboratory Control Sample (LCS)** - A standard solutions of the analyte is analyzed. Percent recoveries are calculated for the analyte detected.

4. INTERFERENCES

4.1. Highly mineralized waters containing significant concentrations of calcium, magnesium, chloride and/or sulfate may be hygroscopic and will require prolonged drying, desiccation, and rapid weighing.

4.2. Samples containing high concentrations of bicarbonate may require prolonged drying at 180°C to insure that all bicarbonate is converted to carbonate.

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4.3. Too much residue in the evaporating dish may crust over and entrap water that will not completely dry. Total residue is limited to about 200 mg.

5. SAFETY

5.1. Wear gloves, lab coat, and safety glasses when handling samples.

6. SAMPLE COLLECTION, CONTAINERS AND STORAGE

6.1. Any type of container, glass or plastic, can be used.

6.2. Samples are cooled upon sampling and kept at 0-6°C until analysis to minimize decomposition of solids.

6.3. Holding time is 7 days.

6.4. Sample handling, storage, and custody procedures are discussed in SMO-GEN.

7. APPARATUS AND EQUIPMENT

7.1. Glass fiber filter discs, 4.7cm, Whatman GF/C.

7.2. Filtration Apparatus

7.3. Porcelain crucibles, 100 ml volume

7.4. Drying Oven

7.5. Steam Bath

7.6. Desiccators

7.7. Analytical Balance, capable of weighing to 0.1 mg.

7.8. Graduated Cylinder

7.9. Portable TDS meter

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8. PREVENTIVE MAINTENANCE

8.1. Replace desiccant in desiccators as needed. Desiccant may be dried and reused.

8.2. Check balance calibration prior to use. Keep balance clean and dry.

9. REAGENTS

9.1. Reference/LCS: Weigh approximately 900 mg NaCl in a weighing dish. Record the actual weight. Quantitatively transfer to a 1 Liter volumetric flask and mix to dissolve. Bring to volume with DI. Store in plastic at 0-6°C for up to 1 year. When analyzing, use as if it were a routine sample.

10. REPONSIBILITIES

10.1. It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. Final review and sign-off of the data is performed by the department supervisor or designee.

11. PROCEDURE

11.1. Test a small amount of sample with a portable TDS meter to approximate the TDS. Determine the amount of sample to be evaporated. The target residue is 10-200 mg. For clean samples, choose a volume of sample up to 100 mLs. For those with high TDS, choose a volume in order not to exceed 200 mg of residue on the dish.

11.2. Preparation of evaporating dishes: Heat clean dishes to 180±2°C for at lease 1 hour. Cool in desiccator and store until needed. Weigh immediately before use.

11.3. Preparation of glass fiber filter disc: Place the disc on membrane filter apparatus. While vacuum is on, wash the disc with three successive volumes of distilled water. Remove all traces of water by continuing to apply vacuum after water has passed through. Discard washings.

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11.4. Assemble the filtering apparatus. Place a 100 ml graduated cylinder inside the collection flask so that it collects the filtrate. Begin suction.

11.5. Filter the sample through the glass fiber filter, collecting up to 100 ml in the graduated cylinder. To avoid any dilution to the sample volume collected, do not rinse the filter with DI.

11.6. Record the volume of the collected filtrate on the bench sheet and transfer the filtrate to a weighed crucible. Evaporate to dryness on a steam bath.

11.7. Dry the evaporated sample for at least one hour at 180 ± 2°C. Cool in a desiccator and weigh. Repeat the drying cycle until a constant weight is obtained or until weight loss is less than 0.0010 g. Record the successive weighings on the benchsheet.

11.8. The temperature of the oven is recorded twice daily in a designated log book to maintain a compliant operating temperature. The time and temperature is also recorded in the "In/Out" log book whenever samples are put in or taken from the oven.

12. **QA/QC REQUIREMENTS**

12.1. Run one duplicate per batch of 10 samples. The DUP should have and RPD< 20%. If they do not, repeat the sample and duplicate or flag the associated sample results in the batch.

12.2. Run a Laboratory Control Sample per batch of 20 samples. The LCS recovery should be ± 20 % of the true value. If it is not, determine the cause, fix the problem, and repeat the samples if volume and holding time permits. If not, flag the samples.

12.3. Run a Method Blank every twenty samples. The result of the blank must be less than the PQL. If it is not, repeat the drying, cooling, desiccating, weighing cycle. If this does not work, investigate further and repeat the samples if volume and holding time permits, or flag the data.

13. **DATA REDUCTION AND REPORTING**

13.1. Calculation:

$$mg\ total\ dissolved\ solids\ /\ L\ =\ \frac{(A - B)\ x\ 1000{,}000}{sample\ volume,\ mL}\ 1$$

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Where:

A = weight of dried residue + dish (g)
B = weight of dish (g)

13.2. Report in mg/L Total Dissolved Solids using three significant figures.

13.3. Reporting limit is 10 mg/L.

13.4. Data review policies and practices are discussed in ADM-DREV.

14. WASTE MANAGEMENT AND POLLUTION PREVENTION

14.1. Samples and sample residue may be washed down the drain. See SMO-SPLDIS for further discussion on waste management.

15. REFERENCES

15.1. Total Dissolved Solids Dried at 180°C, *Method 2540C in Standard Methods for the Examination of Water and Wastewater*, 18th Ed., 1992.

15.2. Residue, Filterable, *Method 160.1 EPA 600/4-79-020*, Revised March 1983.

16. TRAINING OUTLINE

16.1. Read current SOP and applicable methodologies. Demonstrate a general understanding of the methodology and chemistry. Document training dates.

16.2. Observe Sample Preparation and Analysis.

16.3. Participate in the methodology, documentation, and data reduction with guidance.

16.4. Demonstrate Competency by performing the analysis independently. Analyze 4 replicates of a known proficiency or standard. If recovery is within acceptable limits, complete training form and have the supervisor sign-off as being proficient. IDC certificate must be completed by supervisor and filed/approved with QA.

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17. INSTRUMENT ADDENDUM

None.

18. ATTACHMENTS

18.1. Benchsheet

19. CHANGES FROM PREVIOUS REVISION

19.1. Added sections 3, 8, 9, 10, 14, 16, 17, 18, 19 for NELAC compliance.
19.2. Added statement concerning pre-testing the sample with a TDS meter to meet target residue.
19.3. Added statement concerning preparation of evaporating dishes in Section 11.

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STANDARD OPERATING PROCEDURE

DETERMINATION OF ANIONS USING ION CHROMATOGRAGPHY

GEN-300.0

Revision 1

September 27, 2001

Approved By: _____ _____
Supervisor Date

_____ _____
QA Coordinator Date

_____ _____
Laboratory Manager Date

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Annual review of this SOP has been performed and the SOP still reflects current practice.
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1 SCOPE AND APPLICATION

1.1 Method 300.0 applies to the analysis of bromate, bromide, chlorate, chloride, chlorite, nitrate-N, nitrite-N, o-phosphate-P, and sulfate by Ion Chromatography. At this time the lab analyzes for only fluoride, chloride, bromide, nitrate, orthophosphate, and sulfate.

1.2 Applicable Matrices

This method is defined for drinking water, surface water, mixed domestic and industrial wastewaters, groundwater, reagent waters, solids (after extraction procedure), and leachates (when no acetic acid is used).

1.3 Range

The linear range varies for the different anions. Using the settings and calibration techniques outlined in this SOP, the upper range for bromide, fluoride, nitrate and orthophosphate is 5 ppm. The upper range for chloride and sulfate is 10 ppm. Higher concentrations of anions may be determined using appropriate dilutions. Review current calibration for specific ranges.

1.4 Method Detection Limits

The method detection limits determined by 7 replicates of a known concentration, using a pump rate of 2 mL/min. and a 50 µL sample loop are approximately:

Dionex Series 4000i

Analyte	Approximate MDL (mg/L)
Fluoride	0.06
Chloride	0.06
Bromide	0.07
Nitrate-N	0.01
Orthophosphate	0.02
Sulfate	0.06

1.5 The PQL for the current systems are:

Analyte	PQL (mg/L)
Fluoride	0.10
Chloride	0.20
Bromide	0.10
Nitrate-N	0.10

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Orthophosphate	0.10
Sulfate	0.20

2 METHOD SUMMARY

2.1 Sample is injected into an ion chromatograph (Dionex Series 4000i), where the anions of interest are separated and measured. The system consists of:

An automated sampler	(Dionex P/N 39534)
An analytical pump	(Dionex System 4000i)
A guard column	(Dionex AG4A-SC P/N 43175)
A separator column	(Dionex AG4A-SC P/N 43174)
A suppressor device	(Dionex ASRS Ultra P/N 53946)
A conductivity detector	(Dionex P/N 40157)
A 50µL sample loop	

2.2 Ion chromatography is an analytical technique for the determination of all types of ions. It utilizes ion exchange mechanisms and conductivity detection for the separation and quantitation of anions or cations in a water matrix. Anions are the ion of interest for this SOP, but the theory is sound in equilibrium distribution between two different phases. The components migrate through the system only when they are in a mobile phase. The components having distributions favoring the stationary phase migrate slower than those having distributions favoring the mobile phase. Separation then results from different velocities of migration as a consequence of differences in equilibrium distributions.

2.3 The goal in any separation process is to obtain resolution, that is, the ability to separate component 1 from component 2, and is defined mathematically. No assumptions exist except that the peaks are expected to be symmetrical. Of this concept, a relationship is derived that expresses resolution as a function of three fundamental parameters in chromatographic separation, these being selectivity, efficiency, and capacity.

2.4 For our system, the mobile phase is liquid eluent (Sodium Carbonate/Bicarbonate) and the stationary phase is a polystyrene/divinylbenzene resin. The eluent controls the rate of migration through the column by its type and concentration, whereas the separation column separates anion components by their differential affinity for its stationary phase. In other words, larger size and higher charge give species more of an affinity to stay in the column. The mode of separation is High Performance Ion Chromatography utilizing a moderately low resin with a fixed ion exchange capacity of approximately 0.01-0.05 meg/g. This is the mode of choice for common inorganic ions such as F, Cl, NO3, SO4, and other polyvalent anions as well as carbohydrate analysis.

2.5 There are five major properties of IC resins used in packing HPIC columns. The properties are:

2.5.1 material

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2.5.2 crosslink
2.5.3 particle size
2.5.4 functional group identity
2.5.5 capacity

2.5.6 Material base consists of polystyrene. These resins are made by copolymerizing styrene and divinylbenzene. The two functional groups react together to cross-link two polystyrene chains together making them rigid to withstand the viscous forces generated by forcing the eluent through the column.

2.5.7 The higher the cross-link, or more DVB present, the less a resin will swell in a liquid environment. Ions with larger radii will pass more easily through lower cross-linked resins.

2.5.8 Generally, the smaller the resin particle, the greater the efficiency of separation and the greater the system pressure.

2.5.9 Resins with function groups limited to the beads surface are called “pellicular” resins. Resins used in exclusion utilize “porous” resins.

2.5.10 Capacity is defined as the number of functional groups per unit volume or mass. As stated previously, common capacity for HPIC is 0.01-0.05 meg/g.

2.5.11 In addition, resins used for HPIC employ sulfonic groups covalently attached to the surface of the resin bead as a means to attach small totally porous anion exchange beads. It is these exchange particles that provide the separating capability of anions in HPIC columns. The anions separate between the mobile phase and the cationic sites.

2.5.12 The greater the valence of the sample, the greater the attraction for the ion exchange sites. Higher ionic strength eluents are needed to elute ions of the same valence, the larger the ionic radius, the more strongly they are attracted to an ion exchange site because they are more polarized. Another effect of affinity is pH. The affinity of an ion is a function of valence, and valence is a function of the pH of the eluent. Thus, pH can alter retention times of species.

2.5.13 Finally, detection is accomplished by suppressed conductivity. Conductivity is a universal property of ionic species in a solution and shows a simple dependence on concentration. By using chemical suppression, the conductivity background can be reduced to increase sensitivity and selectivity. Suppression is accomplished using an ion exchange membrane.

3 DEFINITIONS

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3.1 **Independent Calibration Verification (ICV)** - ICV solutions are made from a stock solution which is different from the stock used to prepare calibration standards and is used to verify the validity of the standardization. The ICV is analyzed immediately following the calibration standards.

3.2 **Matrix Spike (MS**) - In the matrix spike analysis, predetermined quantities of standard solutions of certain analytes are added to a sample matrix prior to analysis. The purpose of the matrix spike is to evaluate the effects of the sample matrix on the methods used for the analyses. Percent recoveries are calculated for each of the analytes detected. In this method, spikes are very useful in determining proper retention times when a low concentration of an analyte is detected or expected to be adjacent to a large concentration of analyte. When a spike is used to verify retention times calculation of recovery is not necessary.

3.3 **Duplicate Sample (DUP**) - A laboratory duplicate. The duplicate sample is a separate field sample aliquot that is processed in an identical manner as the sample proper. The relative percent difference between the samples is calculated and used to assess analytical precision.

3.4 **Continuing Calibration Verification Standard (CCV)** - A standard analyzed at specified intervals and used to verify the ongoing validity of the instrument calibration.

3.5 **Instrument Blank (ICB/CCB)** - The instrument blank (also called initial or continuing calibration blank) is a volume of blank reagent of composition identical to the samples (ie. not chemically preserved). The purpose of the ICB/CCB is to determine the levels of contamination associated with the instrumental analysis. The ICB is performed once, immediately after the ICV.

3.6 **Laboratory Control Standard (LCS)** - In the LCS or blank spike analysis, predetermined quantities of standard solutions of certain analytes are added to a blank prior to sample analysis. Percent recoveries are calculated for the analyte detected.

4 INTERFERENCES

4.1 Interferences can be caused by substances with retention times that are similar to and overlap those of the anion of interest. Large amounts of an anion can interfere with the peak resolution of an adjacent anion. Sample dilution and/or spiking can be used to solve most interference problems. The most common examples of this are:

4.1.1 High levels of chloride can interfere with the detection of nitrite and even nitrate.

4.1.2 Sulfite will interfere with the sulfate peak.

4.1.3 Thiosulfate can interfere if the run time of the entire chromatogram is too short.

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4.2 The water dip or negative peak which elutes near fluoride can interfere with the integration of the fluoride peak. In order to account for the water dip, choose "void volume treatment" for the fluoride peak in the "data events" section of the "data processing parameters."

5 SAFETY

Normal accepted laboratory safety practices should be followed during reagent preparation and instrument operation. No known carcinogenic materials are used in this method. All samples should be considered hazardous. Appropriate personal protective equipment including gloves, glasses, and lab coat should be worn whenever handling samples or reagents.

6 SAMPLE CONTAINERS, COLLECTION, PRESERVATIONS, AND STORAGE

6.1 Samples should be collected in scrupulously clean glass or polyethylene bottles. Sample handling, storage, and custody procedures are discussed in SMO-GEN.

6.2 Sample preservation and holding times for the anions are:

Analyte	Preservation	Holding Time
Fluoride	Cool to 0-6°C	28 days
Bromide	Cool to 0-6°C	28 days
Chloride	Cool to 0-6°C	28 days
Nitrate-N	Cool to 0-6°C	48 hours
O-Phosphate-P	Cool to 0-6°C	48 hours
Sulfate	Cool to 0-6°C	28 days

7 APPARATUS AND EQUIPMENT

7.1 Analytical Balance, capable of accurately weighing to the nearest 0.0001 g.

7.2 Ion chromatograph- Analytical system complete with ion chromatograph and all required accessories including syringes, analytical columns, compressed gases, detectors, and computerized data collection system.

7.3 Anion guard column: A protector of the separator column. If omitted from the system the retention times will be shorter. Dionex Ionpac AG4A-SC 4×50 mm (P/N 43175)

7.4 Anion analytical column. Dionex Ionpac AS4A-SC 4×250 mm (P/N 43174)

7.5 Anion suppressor device: Dionex anion micro membrane suppressor (P/N 53946).

7.6 Detector-Conductivity Cell: approximately 1.25 µL internal volume.

7.7 Autosampler: Dionex or any compatible with system configuration.

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7.8 Dionex PeakNet 5.0 Chromatography Workstation software or equivalent.

7.9 50 µL sample loop

7.10 Calibrated MicroPipettor and tips.

7.11 Calibrated repipettor.

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8 PREVENTIVE MAINTENANCE

8.1 Samples that contain particles larger than 0.45 µ and reagent solutions that contain particles larger than 0.20 µ require filtration to prevent damage to instrument columns and flow systems. If there is any doubt that a sample may need filtration, filter it.

8.2 Every Friday or Saturday:

8.2.1 Lubricate the pump with 0.2 mL of grease (Dionex P/N 39440).

8.2.2 Disconnect the guard and analytical columns and insert plugs in both ends. Detach the eluant line from pump and attach to a container of DI. Pump DI through heads and valve for 10 -15 minutes.

8.3 Nightly: Release gas pressure in eluant/suppressor bottles and cap both waste ports. Fill in the daily log, recording Date, Column ID, Helium inlet pressure, System backpressure, Eluant pressure, Detector Background, and Reagent flow.

9 STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

9.1 Reagent water: Distilled or deionized water, free of the anions of interest. Water should contain particles no larger than 0.20 µ.

9.2 Stock Eluent solution: Sodium bicarbonate 1.7 mM, sodium carbonate 1.8 mM. Dissolve 11.424 g sodium bicarbonate ($NaHCO_3$) and 15.264 g of sodium carbonate (Na_2CO_3) in reagent water and dilute to 200 mL. Store at room temperature in glass or plastic for up to 1 year.

9.3 Working eluent solution: Filter approximately 5 mLs stock eluant with 0.45µ filter. Dilute 2.5 mLs of stock eluent solution to 1L with reagent grade water. Degas for 5 minutes with Helium. This solution is stable for one week from date of preparation. Store at room temperature in plastic.

9.4 Regeneration solution (micro membrane suppressor): Sulfuric acid 0.1N. Dilute 5.6 mL of conc. sulfuric acid (H_2SO_4) to 2L with reagent grade water. Degas for 5 minutes with Helium. This solution is stable for one week from date of preparation. Store at room temperature in plastic.

9.5 Stock standard solutions: Stock standards are made in house or purchased commercially and expire within the vendor's recommended expiration date or one year from receipt, whichever is sooner. Currently, the lab makes or purchases these standard solutions at 1000 mg/L for all analytes except fluoride. Fluoride is purchased at 100 mg/L. Certificates of analysis of purchased solutions are held in the lab until the standard is no longer used and

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then they are archived by QA. South Carolina requires that stock sources are no more than 30 days old or are verified by a second source prepared within 30 days. Stocks made in the lab are from ACS reagent grade materials (dried at 103-105°C for 30 mins).

9.5.1 Bromide (Br^-) 1000 mg/L: Purchased commercially. Store at 0-6°C. Expires upon manufacturer's indications or 1 year, whichever is sooner (30 days for South Carolina or verified by a second source prepared within 30 days).

9.5.2 Chloride (Cl^-) 1000 mg/L: Dissolve 1.648 g sodium chloride NaCl) in reagent water and dilute to 1 L. Store at room temperature for up to 1 year (30 days for South Carolina or verified by a second source prepared within 30 days).

9.5.3 Fluoride (F^-) 100 mg/L: Purchased commercially. Store at 0-6°C. Expires upon manufacturer's indications or 1 year, whichever is sooner (30 days for South Carolina or verified by a second source prepared within 30 days).

9.5.4 Nitrate NO^-_3-N) 1000 mg/L: Dissolve 7.22 g potassium nitrate (KNO_3) in reagent water in a 1 L volumetric flask. Add 1.0 mL chloroform and dilute to 1 L with DI. Store at room temperature for up to 6 months (30 days for South Carolina or verified by a second source prepared within 30 days).

9.5.5 Phosphate ($PO^{=}_4$-P) 1000 mg/L: Dissolve 4.394 g potassium phosphate (KH_2PO_4) in reagent water and dilute to 1 L. Store at 0-6°C for up to 1 year (30 days for South Carolina or verified by a second source prepared within 30 days).

9.5.6 Sulfate ($SO_4^{=}$) 1000 mg/L: Dissolve 1.479 g sodium sulfate (Na_2SO_4) in reagent water and dilute to 1 L. Store at 0-6°C for up to 1 year (30 days for South Carolina or verified by a second source prepared within 30 days).

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9.6 The standards are prepared as follows: record the pipette ID used in the reagent prep logbook. Add the following mLs of 1000 mg/L Standard Stock (100 mg/L for fluoride) to a 100 mL volumetric flask and dilute to volume with DI resulting in the respective final concentrations. Make fresh each day calibration is performed.

Fluoride								
mLs added	0.00	0.1,	0.2,	0.5,	1.0,	2.5,	4.0,	5.0
final conc.	0.00	0.1	0.2	0.5	1.0	2.5	4.0	5.0
Chloride								
mLs added	0.00	0.02,	0.05,	0.10,	0.30,	0.50,	0.75,	1.00
final conc.	0.00	0.2	0.5	1.0	3.0	5.0	7.5	10.0
Bromide								
mLs added	0.00	0.01,	0.02,	0.05,	0.10,	0.25,	0.40,	0.50
Final conc.	0.00	0.1	0.2	0.5	1.0	2.5	4.0	5.0
Nitrate								
mLs added	0.00	0.005,	0.02,	0.05,	0.10,	0.25,	0.40,	0.50
Final conc.	0.00	0.05	0.2	0.5	1.0	2.5	4.0	5.0
O-Phosphate								
mLs added	0.00	0.01,	0.02,	0.05,	0.10,	0.25,	0.40,	0.50
Final conc.	0.00	0.1	0.2	0.5	1.0	2.5	4.0	5.0
Sulfate								
MLs added	0.00	0.02,	0.05,	0.10,	0.30,	0.50,	0.75,	1.00
Final conc.	0.00	0.2	0.5	1.0	3.0	5.0	7.5	10.0

9.7 Reference Standard Stocks: Reference stocks are made in house or purchased commercially and expire within the vendor's recommended expiration date or one year from receipt, whichever is sooner. Certificates of analysis are held in the lab until the stock is no longer used and then they are archived by QA. South Carolina requires that stock sources are no more than 30 days old or are verified by a second source prepared within 30 days. Stocks prepared in the lab are made from ACS reagent grade materials (dried at 103-105°C for 30 mins).

9.7.1 Fluoride (F^-) 1000 mg/L: Dissolve 2.2100 g sodium fluoride (NaF) in reagent water and dilute to 1 L. Store at 0-6°C for up to 1 year (30 days for South Carolina or verified by a second source prepared within 30 days).

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9.7.2 Bromide (Br^-) 1000 mg/L: purchased commercially. Store at 0-6°C. Expires upon manufacturer's indications or 1 year, whichever is sooner (30 days for South Carolina or verified by a second source prepared within 30 days).

9.7.3 Chloride (Cl^-) 650 mg/L: Dissolve 1.070 g NaCl Crystals in reagent water and dilute to 1 L. Store at room temperature for up to 1 year (30 days for South Carolina or verified by a second source prepared within 30 days).

9.7.4 Nitrate (NO^-_3-N) 180 mg/L: Dissolve 1.300 g KNO_3 crystals in reagent water. Add 1 mL chloroform and dilute to 1 L. Store at room temperature for up to 6 months (30 days for South Carolina or verified by a second source prepared within 30 days).

9.7.5 Phosphate (OPO_4-P) 180 mg/L: Dissolve 0.7909 g KH_2PO_4 crystals in reagent water and dilute to 1 L. Store at 0-6°C for up to 1 year (30 days for South Carolina or verified by a second source prepared within 30 days).

9.7.6 Sulfate (SO_4) 3200 mg/L: Dissolve 5.80 g K_2SO_4 in reagent water and dilute to 1 L. Store at 0-6 °C for up to 1 year (30 days for South Carolina or verified by a second source prepared within 30 days).

9.8 The CCV is prepared as follows:

9.8.1 An intermediate stock solution is prepared by diluting the following volumes of reference stocks for each anion in 1 liter of reagent grade water:

Anion	Stock Conc. (mg/L)	Volume Stock (mL)	Final Conc. (mg/L)	
Fluoride	1000	4.0	4.0	
Chloride	650	20.0	13.0	
Bromide	1000	4.0	4.0	
Nitrate	180	40.0	7.2	
Orthophosphate	180	40.0	7.2	
Sulfate	3200	4.0		12.8

NOTE: The CCV intermediate stock solution expires 6 months from date of preparation (30 days for South Carolina or verified by a stock made within 30 days)

9.8.2 The CCV is then prepared by diluting the intermediate stock solution with equal parts water in small quantity (about 30 mLs DI and 30 mLs intermediate stock solution). The resulting concentrations are half of those of the intermediate solution. Prepare fresh when needed or at least once a week. Store at room temperature in plastic.

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9.9 LCS: The LCS is prepared fresh at the beginning of each week using 1000 mg/L stock solutions (100 mg/L for fluoride). The following volumes for each anion are diluted to 100 mL in DI water:

Anion	Volume stock solution	Concentration (mg/L)
Fluoride	1.25 mL	1.250
Chloride	0.250 mL	2.500
Bromide	0.125 mL	1.250
Nitrate	0.125 mL	1.250
Orthophosphate	0.125 mL	1.250
Sulfate	0.250 mL	2.500

Store at room temperature in glass or plastic for up to one week.

9.10 Matrix Spike Solutions: The matrix spikes are prepared in the same manner as the LCS: 100 mL of sample and the above volumes of the desired analyte(s). A 100 mg/L (or 10 mg/L for fluoride) working stock solution can be made by performing a 1:10 dilution of the standard stock. This working stock can be used to spike 10 mL of sample, giving the above concentrations.

9.11 Consumable materials.

9.11.1 5 mL vials with filter caps. (Dionex P/N 038141)
9.11.2 0.45µm syringe filters.

10 RESPONSIBILITIES

10.1 It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. Final review and sign-off of the data is performed by the department supervisor or designee.

11 PROCEDURE

11.1 Instrument preparation.

11.1.1 Check eluent and regenerant levels in containers and fill to appropriate levels as necessary.

11.1.2 Remove plugs from the waste lines.

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11.1.3 Turn on Helium carrier gas (should be at approximately 17psi.) and compressed air (100 psi.), then start the Dionex Gradient pump and turn on the Conductivity Cell. Allow the system to warm up for about an hour.

11.1.4 While the system is warming up, create the schedule of the day's run in the software according to the analytical sequence described below.

11.2 Sample Preparation

11.2.1 All sample vials and caps should be rinsed to remove any debris present from the manufacture.

11.2.2 If the water sample has no solids floating in it, is not turbid, and is otherwise clean and clear looking the sample may be placed directly in the sample vial. When in doubt filter the sample as described below. The sample vials hold approximately 5 mLs of sample with the vial cap properly installed. Sample should never be poured into the sample vial. Always pipette sample into vial. This will minimize contamination from materials used in the cap liners of sample bottles. Most samples are run at a initial dilution of 1:10 (or greater) so that the desired analytes are within the linear range of the standard curve and minimize contamination of column with metals and organics. See ADM-DIL for making dilutions.

11.2.3 If the sample appears to be or is known to be dirty or turbid the sample needs to be filtered before dilution. For most samples a 0.45µ micron filter on the end of a 10 cc pipette will filter the sample adequately. Use the Millex-HV filter, if possible, since it has been demonstrated free of the anions of interest and does not remove those anions. If other filters are to be used, first test them to see if they meet these requirements.

11.2.4 Soils - Place 1.0 g sample in B-Cup and dilute to 100 g with DI. Shake for 5 minutes. Filter and run as a water sample with 100 being the dilution factor for calculation purposes, and 1 being the reported dilution factor so that the detection limits are met.

11.2.5 Once the sample has been placed in the sample vial, place a vial cap in the vial and use the tool to press the cap down flush with the top of the vial.

11.2.6 The loaded vials should then be placed into cassettes according to the schedule created in compliance with the analytical sequence described below. Place the holder in the autosampler.

11.3 Calibration

11.3.1 The instruments must be calibrated when a new column is put in or when system configuration changes warrant calibration and every 6 months.

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11.3.2 System calibration must have correlation coefficient of 0.995 or better. Delete outlier standards. Standards must be within 10% of their true value. Method 300.0 requires a minimum of 3 standards and a blank. If the removal of outlier standards does not bring the curve into compliance, recalibrate.

11.3.3 Immediately after an acceptable calibration has been achieved, run the ICV, ICB, and an LCS. If these are compliant, continue with samples as described in the daily analytical sequence.

11.4 Daily analytical sequence – If a calibration is not to be run, run samples in the following analytical sequence: CCV, CCB, LCS, 9 samples, CCV, CCB, 10 samples, CCV, CCB, LCS, etc. with a CCV/CCB set after every 10 samples and an LCS after every 20 samples and DUP/MS where appropriate (at no particular position but one set for every 10 samples).

12 QA/QC REQUIREMENTS

12.1 Laboratory Control Standards (LCS)

12.1.1 LCS's must be run daily for all anions being tested for and once every 20 samples for the anion being tested.

12.1.2 LCS's must be within 10% of the true value.

12.1.3 If the LCS is outside the acceptance criteria stop the run, correct the problem and reanalyze the LCS. Otherwise, the samples may be reported for the anions which were in control, but not for the ones which were out of control limits.

12.2 Method Detection Limits (MDL)

MDLs should be performed every 6 months, when a new operator begins work or whenever there is a significant change in the background or instrument response. The result of the MDL must be less than the PQL. If it is not, correct the problem and do another MDL study or raise the PQL. See ADM-MDL for procedure.

12.3 Initial and Continuing Calibration Verification (ICV/CCV)

12.3.1 An ICV is analyzed immediately after the standards. The ICV must be +/- 10% of the true value or the curve may not be used for anions not in control.

12.3.2 A CCV is analyzed every 10 injections.

12.3.3 All CCVs for the anions being tested for must be within 10% of the true value. NOTE: If the analyst is not looking for all 6 of the normal anions then only the

values of the anions in question need be within range. If the CCV is not in control, correct the problem, obtain a compliant CCV and reanalyze all samples bound by the non-compliant CCV. Recalibrate if necessary.

12.4 Continuing Calibration Blanks (CCB)

12.4.1 A CCB must be analyzed every 10 injections immediately following the CCV.

12.4.2 All CCB's must be less than the PQL for the anion being tested. If the CCB is above the PQL, correct the problem and obtain a compliant CCB following a compliant CCV. Reanalyze samples bound by non-compliant CCB. Recalibrate if necessary.

12.5 Matrix Spikes (MS)

12.5.1 A matrix spike must be analyzed for each anion being tested. A matrix spike must be analyzed once every 10 samples for each anion being tested.

12.5.2 The matrix spike must be within the lab-generated limits in the Wetchem QC Table (found in the Quality Assurance Manual). If it is not, remake the matrix spike when possible. If the spike failure is confirmed, notify project chemist to note the outlying recovery in the case narrative.

12.6 Duplicates (DUP)

12.6.1 A DUP must be analyzed every 20 samples per anion being tested.

12.6.2 The acceptance criteria for a DUP is less than 20% RPD or ± the reporting limit if the sample is less than 5 times the reporting limit.

12.6.3 If a DUP is outside of the acceptance criteria, reanalyze to confirm and flag with an asterisk (estimated).

12.7 Data Acceptance

12.7.1 If the concentration of the anion is outside the working range of the instrument then a dilution should be performed. The working range is defined as the low standard concentration to the high standard concentration for the anion being tested.

12.7.2 Be sure the peaks on the chromatogram and the instrument calculated concentration make sense. Sometimes the software will attempt to integrate overrange peaks and will assign them a concentration which would be acceptable for the dilution if it was a reasonable integration.

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12.7.3 On occasion, the software integrates peaks incorrectly. The sample may be reanalyzed or the analyst may use the software to correct the integration. Any manual integration or manipulation of peaks must follow the SOP for the manual integration of peaks in SOP ADM-INT.

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13 DATA REDUCTION AND REPORTING

13.1 Using IC computer terminal download data into GARRS (General Chemistry Analytical Review & Reporting System).

13.1.1 In the PeakNet Main Menu, click on “Batch” icon.

13.1.2 Open file “To GARRS”

13.1.3 Click on “Input, Select.” This will pull up a list of schedules. Double click on the schedule which you want to download.

13.1.4 Click on “Export.” Name the file using date from schedule.

13.2 Using a main computer terminal, double click on the GARRS icon and click on continue for the first 5 screens.

13.2.1 Pull down “Result Uploads menu, Instrument Upload.”

13.2.2 Open the “T” drive, Double click on “Instdata, Genchem, IC, and then on the schedule you want to open.

13.2.3 Pull down “Review Report Data menu, Print General Chemistry Forms”

13.2.4 Continue. Click on EDD Standard File, Review on Screen. Click on the envelope icon and change format to text. Save in “K” drive under data transfer “Ic_xf” overwrite casedd2. Exit GARRS.

13.3 Double click on IC transfer icon. This transfers data to LIMS. QC must then be entered into LIMS manually.

13.4 Data will be reviewed by the analyst and a qualified peer using the Data Quality Checklist and validated by supervisor as outlined in ADM-DREV.

14 WASTE MANAGEMENT AND POLLUTION PREVENTION

Reagents are prepared upon an as-needed basis in small quantities. Minimum sample volumes are used during analysis.
All samples and reagents are aqueous and can be disposed of in any sink. See SMO-SPLDIS.

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15 REFERENCES

15.1 Method 300.0, *Methods for the Determination of Inorganic Substances in Environmental Samples*, EPA/600/R-93/100 Revised August 1993.

15.2 Method 4110 B in *Standard Methods for the Examination of Water and Wastewater*, 18th Ed., 1992.

16 TRAINING OUTLINE

16.1 Read current SOP and applicable methodologies. Demonstrate a general understanding of the methodology and chemistry.

16.2 Observe Sample Preparation and Analysis. Follow items in the IC Training Plan Form.

16.3 Participate in the methodology, documentation, and data reduction with guidance.

16.4 Review Instrument Operation and Maintenance with trainer.

16.5 Demonstrate Competency by performing the analysis independently. Analyze four LCSs in a row for an IDC. If recovery is within acceptable limits, complete Training Plan Form and IDC Certificate and file with QA. Continuing demonstration of competency (CDC) is performed annually by an acceptable PE, single blind, or new 4 replicate study.

17 INSTRUMENT-SPECIFIC ADDENDUM

17.1 Each day the instrument is checked to see that working conditions are consistent. Record the actual readings in a log book on a daily basis.

17.1.1 The incoming pressure of the Helium carrier is checked (should be approx. 17 psi.)

17.1.2 The system pressure is checked (usually around 1500 psi.).

17.1.3 The background of the detector should be around 16-17 µs.

17.1.4 The flow rate of the suppressor coming from the waste line should be 5-6 mL per minute.

17.2 The instrument manuals are located next to the instrument.

18 ATTACHMENTS

None

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19 CHANGES FROM PREVIOUS REVISION

19.1 Changed MS frequency from 1/20 to 1/10 as per method requirements.
19.2 Added reference to SMO-SPLDIS.
19.3 Rounded MDL values in 1.4 to be more estimated, less specific.
19.4 Added PPE in 5.0.
19.5 Changed preservation for bromide and chloride in 6.2 to be consistent with other anions, although none is required.
19.6 Added pipettor and repipettor to 7.0.
19.7 Changed 4°C to 0-6°C and 105°C to 103-105°C.
19.8 Added storage and expiration to standards and reagents where none were listed.
19.9 Changed 11.3.3 for the injection sequence to text instead of list.
19.10 Changed 12.5.2 to lab generated limits listed in Wetchem QC Table instead of listing here.
19.11 Changed acceptance criteria for DUP to include the ± PQL if <5XPQL rule.
19.12 Modified Training Outline 16.0 to reflect Training Plan Form and IDC requirements.
19.13 Added need to review current calibration for linear range in 1.3.
19.14 Changed maintenance 8.2.1 to be 0.2 mLs of grease instead of 0.1 mLs.
19.15 Changed Fluoride standard stock concentration from 1000 to 100 mg/L and adjusted related references to reflect the change.
19.16 Changed Fluoride reference stock concentration from 100 to 1000 mg/L and adjusted related references to reflect the change.
19.17 Added need to remove plugs from waste lines before turning on gases in 11.1.
19.18 Specified filters used in 11.2.
19.19 Changed MDL frequency from “must annually” to “should every 6 months” as per method requirement.
19.20 Added reference stock recipes to reagents in 9.0.
19.21 Changed standard stocks to reflect whether they are purchased or made in the lab in 9.0.
19.22 Added need to use Data Quality Checklists in 13.0.

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STANDARD OPERATING PROCEDURE

for

ANALYSIS OF WATER, SOLIDS AND SOLUBLE WASTE SAMPLES FOR VOLATILE HALOGENATED AND AROMATIC COMPOUNDS VIA GAS CHROMOTOGRAPHY

SOP No.: VOC-8021B
Revision: 4.0

September 28, 2001

Approved by: _____ _____
Supervisor Date

_____ _____
QA Coordinator Date

_____ _____
Laboratory Manager Date

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Rochester, NY 14609

Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
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1. SCOPE AND APPLICATION

Samples are prepared and analyzed for volatile organic contaminants in water, soil and hazardous waste using gas chromatography (GC) Method 8021B uses a photoionization detector (PID) for the analysis of aromatic volatile organic compounds (VOC) and an electrolytic conductivity detector (ELCD) for analysis of halogenated volatile organic compounds. See Table 4 for MRLs and typical MDLs of all analytes analyzed under this method.

2. METHOD SUMMARY

2.1 The analysis is performed in a way to allow for detection and quantitation of volatile aromatic and halogenated compounds in a single analysis. Soil samples are analyzed by direct purge (heated) with helium, or are prepared by methanol extraction followed by dilution into deionized water. Water samples are analyzed by direct purge (unheated) with helium. Target analytes are adsorbed and concentrated on a carbon based trap. Upon completion of the purge step, the trap is heated and target analytes are desorbed into the GC system. Analyte separation is accomplished using a chromatographic column and quantitation is made by comparison of target analyte response to the response of calibration standards over a known concentration range.

2.2 This procedure is applicable for the analysis of target analytes, listed in Table 1 and 4.

2.3 The target analyte list may be analyzed in its entirety, or in part by meeting established method criteria for the compounds of interest. For analytes detected and quantified as a single peak, guidelines for peak confirmation are discussed in section 11.0.

3. DEFINITIONS

3.1 Analytical Batch: a group of field samples, QA/QC samples, standards and blanks analyzed together under a common and unique identification number. Analytical batches are limited to one continuous analytical sequence. Lasting up to 12-hours.

3.2 Analytical Sequence: a batch of samples analyzed in sequential order. A sequence starts with an initial calibration or a continuing calibration verification standard, followed by a system blank, followed by ten samples (inclusive of MS/MSD samples), followed by a continuing calibration verification standard. The closing continuing calibration verification standard for one group of samples may serve as the opening continuing calibration verification standard for the next group of samples. This pattern may be repeated indefinitely until the sequence is complete, or until a continuing calibration verification standard fails acceptance criteria. If an analytical sequence is interrupted (analysis is halted) for a time span in excess of eight hours, the analytical sequence will be closed. Subsequent sample analysis must be initiated with a new calibration or a passing continuing calibration verification standard.

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3.3. Continuing Calibration Blank (CCB): system blank analyzed at a routine frequency throughout the sequence to establish that the instrument is free of target analyte contamination. Unless stated in project specific data quality objectives, the system is considered free of target analyte contamination if the level detected is less than the method reporting limit.

3.4. Continuing Calibration Verification (CCV): standard analyzed at a routine frequency throughout the sequence to establish the instrument is meeting calibration criteria.

3.5 Independent Calibration Verification (ICV): standard analyzed from a source that is different than that used to calibrate the instrument. The ICV is a check on the purity and accuracy of the calibration standards and can be used in preparing matrix spike solutions for spiking of QA/QC samples.

3.6 Relative Percent Difference (RPD): measure of the relative difference between two values. Calculated as follows: (value1-value2)/average.

3.7 % Relative Standard Deviation (%RSD): statistical measure of variation. Used in this method to measure the relative variation of initial calibration standards. Calculated by dividing the standard deviation of the individual calibration factors by the average calibration factor and multiplying by 100 to express as a percentage.

3.8 Method Detection Limit (MDL): a statistically derived value representing the lowest level of target analyte that may be measured by the instrument with 99% confidence that the value is greater than zero.

3.9 Method Reporting Limit (MRL): The minimum amount of a target analyte that can be measured and reported quantitatively. The MRL is equivalent to Practical Quantitation Level (PQL) and Estimated Quantitation Level (EQL). Typically, the MRL is calculated as five times the MDL (although this is a rule of thumb and not intended to be a strict policy of establishing the MRL for a compound).

3.10 QA/QC Samples: Samples added to a sample preparation batch, or an analytical batch to provide quality assurance checks on the analysis. For purposes of evaluating sequencing criteria during an analytical batch, only MS/MSD samples are defined as samples.

3.10.1 Duplicate Sample (DUP): a laboratory duplicate. The duplicate sample is a separate sample aliquot that is processed in an identical manner as the sample proper.

3.10.2 Laboratory Control Sample (LCS): a laboratory blank that has been fortified with target analyte.

3.10.3 Method Blank (MB): a laboratory blank that is used to check that reagents and equipment are free of target analytes. Unless stated in project specific data quality objectives, reagents are considered free of target analyte contamination if the level detected in the Method Blank is less than the MRL. Method blanks for aqueous and solid samples are

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prepared using laboratory reagent water (deionized water). Method Blanks for soluble waste and medium level soil samples are prepared by adding 100uL of methanol to 5.0mL of DI.

3.10.4 Matrix Spike Sample (MS): a duplicate sample aliquot that has been fortified with target analyte.

3.10.5 Matrix Spike Sample/ Matrix Spike Duplicate Sample (MS/MSD): matrix spike samples prepared in duplicate. This is the standard QA/QC sample set recommended for this procedure. It is used to evaluate method precision and matrix effects.

3.10.6 Retention Time Window: the time period established within which a target analyte is qualitatively determined to be present in the sample.

3.11 Surrogate: a non-target analyte that is added to all samples and QA/QC samples that is chemically similar to the compounds of interest. The surrogate is used to evaluate the effectiveness of the analysis.

3.12 Target Analyte: a compound of interest for which the method is capable of measuring. Common acronyms are defined below.

TCE: Trichloroethene
BTEX: Benzene, Toluene, Ethylbenzene, and Xylenes (total)
PCE: Tetrachloroethene
MTBE: Methyl *tert*-Butylether

4. INTERFERENCES

4.1 Samples can become contaminated by diffusion of volatile organics during shipment and storage. If a trip blank is received with the samples, it can serve as check for such contamination.

4.2 Contamination by carryover can occur when high level samples immediately preceed samples containing significantly lower levels of contamination. This can be minimized by running system blanks after samples that are suspected to contain high levels of target analyte. For purposes of evaluating sequencing criteria during an analytical batch, these system blanks are not defined as samples and therefore are not counted in the ten sample groupings.

5. SAFETY

5.1 The toxicity or carcinogenicity of each reagent used in this procedure may not be precisely defined. Material safety data sheets (MSDS) are available on each solvent and standard and should be reviewed as part of employee training. Care should be taken when handling standard material in neat or highly concentrated form.

5.2 Personal protective clothing (safety glasses, gloves and lab coat) are recommended when prepping samples, handling standard material in neat form, or performing maintenance on pressurized systems.

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5.3 The use of pressurized gases is required for this procedure. Care should be taken when moving cylinders. All gas cylinders must be secured to a wall or an immovable counter with a chain or a cylinder clamp at all times. Sources of flammable gases (e.g., pressurized hydrogen) should be clearly labeled.

5.4 The proper use of syringes and glass pipettes should be part of employee training. Care should be taken to avoid personal injury as a result of improper handling techniques.

6. SAMPLE COLLECTION, CONTAINERS, PRESERVATION, AND STORAGE

6.1 Aqueous Samples should be collected (received) in 40 ml VOA vials with zero headspace. Samples should be preserved to pH <2 with hydrochloric acid. Ideally, three VOA vials will be received for each sample. Samples will be refrigerated to 0-6°C upon sample login.

6.2 Solid samples should be collected (received) in 2 or 4 ounce glass jars with Teflon lined septum and packed tightly to minimize interstitial space and reduce headspace. Alternatively, soil samples may be received in brass sleeves prepared in the field. Samples will be refrigerated to 0-6°C upon sample login.

6.2.1 Some state agencies such as Ohio require soil samples to be collected in Encore samples and analyzed within 48-hours or 40 mL vials with sodium bisulfate. See VOC-5035 for details in preparing the sample for analysis.

6.3 Waste samples such as oils can be collected (received) in a variety of sample containers. Typically, glass bottles with Teflon lined septum are preferred. Headspace should be kept to a minimum. Samples will be refrigerated to 0-6°C upon sample log-in.

6.4 For sample handling using internal chains of custody see SMO-GEN SOP.

7. APPARATUS AND EQUIPMENT

7.1 Top Loading Balance
7.2 Centrifuge
7.3 Gas Chromatography System

7.3.1 Gas Chromatograph (GC): analytical system equipped with gas supplies, column inlet, programmable oven, heated detectors (PID/ELCD in series), and a data system for determining peak areas.
7.3.2 Chromatographic Columns: Restek 502.2: 105 m x 0.53 mm ID, 3 µm film thickness.
7.3.3 Purge and Trap Device: Tekmar 2000/2016 meets the minimum requirements for GC purge and trap analysis.
7.3.4 Archon closed Purge and Trap system.
7.3.5 Trap: Supelco K trap meets the minimum requirements for the procedure.
7.3.6 Compressed Gases or Gas Generators: Hydrogen (fuel gas), Air (pneumatic drive and fuel gas), Helium (purge gas and column flow).

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7.4 Glassware and Syringes

7.4.1 Disposable Pipettes: pasteur and serological (1ml, 2 ml, 5 ml)
7.4.2 Graduated Cylinders with Ground Glass Stoppers: 50 ml and 100 ml
7.4.3 Microreaction Vials with Pushpin Syringe Port
7.4.4 Microsyringes: various sizes (10 µl, 25 µl, 100 µl, 250 µl, 500 µl, 1000 µl)
7.4.5 VOA vials (40 ml) with Teflon Lined Septum
7.4.6 Volumetric Flasks: various sizes (5 ml, 10 ml, 25 ml, 50 ml, 100 ml)

7.5 pH Paper: narrow range (0-6 pH units) for measuring aqueous sample pH after analysis
7.6 Stainless Steel Scoopula
7.7 Ultrasonic Bath

8. PREVENTIVE MAINTENANCE

8.1 A maintenance log will be kept documenting maintenance performed on each analytical system. Log entries will include the date maintenance was performed, symptoms of the problem, serial numbers of major equipment upgrades or replacements (defined as any non-consumable part essential to operation), phone logs from technical support contacts, a description of the maintenance performed, a description of the check performed (attach standard data to logbook) to assure the system has returned to acceptable levels of operation, and the analyst's initials

8.1.1 PID: Cleaning the PID lamp using a cleaning kit that can be purchased through CPI. Apply a small amount of powder onto a cotton swab and add a small amount of water to create a paste before applying to window of lamp. Rinse with DI and dry window with lens paper.

8.1.2 ELCD: Repalcing the Nickel reaction tube of the ELCD detector if response on the gases is lost or if response for bromoform is less than 1/2 that of chlorobenzene. Also, add propanol solvent as needed and replace resins if response of brominated compounds is lost or peaks begin to split.

8.1.3 Purge and Trap: Routine maintenance is generally limited to changing the trap, cleaning or replacing the sparge vessel, replacing transfer lines, sample lines and adjusting the purge flow. Trap breakdown is generally indicated by poor recovery of all target anlaytes. Clogged sparge vessels are usually indicated by a noticeable reduction in helium bubbles during the purge step, and by reduced or no surrogate recovery. If purge flow is too fast, lighter compounds will exhibit a reduced recovery. If purge flow is too slow, heavier end compounds will exhibit a reduced recovery.

8.1.4 GC System: Maintenance of the GC system is generally limited to trimming or changing the column. Poor chromatography and reduced resolution of closely eluting peaks is an indication of column breakdown.

8.1.5 Any major maintenance performed on the instrument must be recorded in a maintenance log and must include the date, the person performing , the type and the outcome

of the maintenance. Also include a data file number of a chromatogram exhibiting acceptable chromatography.

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9. STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

9.1 Reagents

9.1.1 Methanol: purge and trap grade

9.1.2 Reagent Water: ASTM Type II or equivalent, free of volatile contaminants of interest.Laboratory deionized water meets these criteria.

9.2 Standards: Unless otherwise noted, standards used in this procedure are prepared in methanol. Standard labels should include the following information: logbook ID number, compounds or compound mix, concentration, solvent, date prepared, expiration date, analyst's initials.

9.2.1 Neat Standard Material: Standards are purchased from a reliable source (e.g., Aldrich). Neat material used for quantitative analysis is given an expiration date equal to the manufacture's recommendation (1 year if no expiration date is provided).

9.2.2 Stock Standards: purchased as solutions from a reliable source (e.g., Supelco) or prepared in high concentration from neat material. . Purchased standards used for quantitative analysis are given an expiration date equal to the manufacture's recommendation or one (1) year if none is given. To prepare stock standards from neat material, accurately weigh the neat material using a four place analytical balance into a tared volumetric flask. Dilute to volume using methanol. Stopper and invert several times to mix. Transfer the solution to an appropriate storage vial (e.g., a microreaction vial), label and place in freezer. When preparing stock standard mixes from neat material, it is recommended that each component of the mix be prepared individually at high concentration then combined as a complete mix at a secondary dilution. Laboratory prepared stocks (~10,000ppm) are assigned an expiration date of 6 months. The following stock standards are used in these procedures:

9.2.2.1 8021B.PPL MIX (Primary Source-Calibrator): 2.0mL ampule at 2000ppm purchased from Supelco.

9.2.2.2 8021B.PPL MIX (Secondary source-Reference): 1.5 mL ampule at 2000ppm purchased from Supelco.

9.2.2.3 2-Chloroethylvinyl ether STD (Primary Source-Calibrator): 2.0mL ampule at 2000ppm purchased from Supelco.

9.2.2.4 2-Chloroethylvinyl ether STD (Secondary Source-Reference): 1.5mL ampule at 2000ppm purchased from Supelco.

9.2.2.5 Methyl tert-Butylether / MTBE (Primary Source-Calibrator): 1.5mL ampule at 2000 ppm solution purchased from ULTRA.

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9.2.2.6 MTBE (Secondary Source-Reference): ~10,000ppm stock prepared from neat.

9.2.2.7 8021B.TL (NYSDEC STARS: Primary Source-Calibrator): 1.5mL ampule at 2000 ppm purchased from NSI

9.2.2.8 8021B.TL (Secondary Source- Reference): 1.5mL ampule at 200 ppm purchased from ULTRA.

9.2.2.9 8021 Surrogate stock solutions: a) 1.5mL ampule of 2000 ppm Bromochloromethane solution purchased from ULTRA. b) Prepared stock solution containing 1,3-Chlorofluorobenzene made at 10,000 ppm in methanol.

9.2.3 **Standards**: Made from purchased solutions or prepared stocks. Standards are prepared from stock solutions by accurately transferring a volume of stock standard into a volumetric flask partially filled with methanol. The volume is further adjusted using the dilution solvent to a known level. Standards not used immediately are transferred to an appropriate storage vial with minimal headspace, labeled and stored in freezer. Intermediate standards used for quantitative analysis are given an expiration date equal to 30 days for laboratory prepared solutions in methanol. The following intermediate standards are used for these analyses:

9.2.3.1 **8021B.PPL calibration standards/ Matrix Spike** (50ppm and 500ppm) a) Prepare a 50 ppm std by diluting 125 uL of 2000 ppm Supelco std to 5 mL in a volumetric flask with methanol. When using the Archon autosampler, prepare a 500 ppm std by diluting 1.25 mL of 2000 ppm Supelco std to 5 mL in a volumtric flask with methanol. b) Also prepare a 50ppm and 500 ppm mix of MTBE and 2-chloroethylvinyl ether in the same manner. These standards are also used as spiking solutions for matrix spike analysis. Prepare monthly.

9.2.3.2 **8021B.PPL/ LCS/ Reference Standards (second source)** (20ppm and 200ppm) a) Prepare a 20 ppm std by diluting 50 ul of 2000 ppm Supelco std to 5 ml in a volumetric flask with methanol. When using the Archon autosampler prepare a 200 ppm std by diluting 500 ul of 2000 ppm Supelco std to 5 ml in a volumtric flask with methanol. b) Prepare a 20ppm and 200ppm 2-chloroethylvinyl ether std in the same manner. c) Prepare a 20ppm and a 200ppm MTBE std by diluting 10uL and 100uL respectively of 10,000ppm stock to 5mL with methanol in a volumetric flask. Prepare monthly.

9.2.3.3 **8021B.TL Calibration Standard/ Matrix Spike**: (50ppm) Prepare a 50 ppm std. by diluting 1.25 mL of 2000 ppm NSI std to 50 mL with methanol in a volumetric flask. Transfer to 40 mL vial. It is also used as a spiking solution for matrix spike analysis. Prepare monthly.

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9.2.3.4 **8021B.TL/ LCS/ Reference Standard**: (20ppm) Prepare a 20 ppm std. by diluting 500 uL of 200 ppm std and 50uL of 2000 ppm MTBE std (both ULTRA) to 5.0 mL with methanol in a volumetric flask. Transfer to 5mL vial. Prepare monthly.

9.2.43.5 **8021B Surrogate Solution** (30ppm): Prepare solution by diluting 150 ul of 10,000 ppm chlorofluorobenzene and 750 uL of 2,000 ppm bromochloromethane stock to 50 ml with methanol. Prepare monthly.

9.2.4 **Initial Calibration (ICAL) Standards**: A series of standards prepared from a common stock ranging in concentration from a value at method reporting limit to a value near the high end of the linear calibration range of the detector. The typical calibration range used is 1.0 ppb to 150 ppb, though it can be 200ppb if the detector allows. Initial calibration standards and continuing calibration standards are prepared in reagent grade water. 5mL of each standard is purged. It is required that a calibration standard be prepared and analyzed at the MRL (method reporting limit). Calibrations will contain a minimum of five concentration levels. The linear calibration range is defined as a level equal to the low calibration standard through a point equal to the high calibration standard. Calibration standards used for these analyses are run at these concentrations as listed below.

Conc (ppb)	Amt cal std (ul)	Amt surrogate (ul)	final vol (ml)
1	1.0	10.0	*50
25	2.5	5.0	5.0
50	5.0	7.5	5.0
100	10.0	15.0	5.0
150	15.0	20.0	5.0

*Purge 5.0mL of this solution

9.2.5 **Independent Calibration Verification Standard (ICV)**: A 20ppb reference std is run immediately following the ICAL to validate the curve. This standard is prepared by adding 5.0uL of 20ppm refrence standard (second source) to 5.0mL DI. Recovery limits are 70-130% for all compounds.

9.2.6 **Reference/LCS std**: This std is prepared in the same manner as the ICV std. above, but is run at a frequency of 1 per 20 samples. Acceptance criteria are outlined in Table 4.

9.2.7 **Continuing Calibration Verification Std. (CCV)**: A 50ppb std is prepared by adding 5.0uL of 50ppm cal std to 5.0mL DI. It is run at a frequency of 1 per 10 samples with acceptance criteria outlined in section 11.7.3.

10. RESPONSIBILITIES

It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. Final review and sign-off of the data is performed by the department supervisor or designee.

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11. PROCEDURE

Sample Preparation: An extraction batch is defined as a group of field samples and QA/QC samples processed together with the same reagents. Extraction batches are limited to 20 field samples prepared the same day. Unless stated in project specific data quality objectives, the standard QA/QC sample set for aqueous and solid matrices is Matrix Spike/Duplicate Matrix Spike and Method Blank. The standard QA/QC sample set for miscible waste samples is a Laboratory Duplicate. Section 12 addresses control limits for these analyses.

11.1 Aqueous Samples:

11.1.1 Aqueous samples may be aliquotted and run by purge and trap methods 5030/5035. 5mL of sample or diluted sample is purged.

11.1.2 Prior to purging, 5.0uL of surrogate std. is added via microliter syringe to a syringe containing 5mL of sample. Add 5uL of the matrix spike solution to MS, and MSD aliquots.

11.1.3 Prepare a Method Blank using 5mL of deionized water spiked with 5.0uL of surrogate standard.

11.1.4 For guidance to prepare dilutions of aqueous samples refer to ADM-DIL.

11.1.5. Following analysis, check and record sample pH using narrow range pH paper. Samples should be preserved to pH<2. If sample pH is not <2, a pH discrepancy form must be filled out and immediately submitted to project chemist.

11.2 Low Level Soil Samples, Direct Purge (heated):

11.2.1 Soil samples will normally run by method 5030. However, when applicable soils will be run by method 5035 using the Archon when requested by a client or required by a State method. (Ex: Ohio VAP, New Jersey and South Carolina). New York State does not currently reqiure soils to be run by method 5035. Soil samples should be homogenized prior to analysis. This procedure should be performed quickly to minimize the loss of volatile compounds. Altenatively, a portion of sample may be cored out of the center of the sample jar providing a representative cross section of the sample.

11.2.2 Weigh 5 grams of sample to a soil sparging tube. Affix the tube to a 2016 autosampler. Add 5mL clean reagent grade water to a 5 ml gastight syringe. Add the appropriate amount of surrogate standard to the 5 ml syringe. Add the aqueous fraction to the tube on the autosampler via the three port valve. Using the same procedure, add the appropriate matrix spike solution to the following QC; MS, and MSD.

11.2.3 The Archon autosampler is used to run soil samples under method 5035. Refer to SOP No: VOC-5035 for proper procedure.

11.2.4 Soil dilutions are performed by weighing less than 5g of sample to the glass tube. Do not use less than 1 gram. If additional dilution is required, prepare the sample by methanol extraction (see sect.11.3).

11.2.5 Prepare a Method Blank by adding 5.0uL of surrogate std. to 5mL of DI.

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11.3 Medium Level Soil Samples, Methanol Extraction:

11.3.1 Solid samples containing >200 ug/Kg VOCs, may be prepared via methanol extraction. Homogenize the sample quickly prior to analysis to avoid loss of volatile compounds. The top layer (approximately 0.5 inch) is scraped away and the sample is mixed inside the sample container. Alternatively, a portion of sample may be cored out of the center of the sample jar providing a representative cross section of the sample.

11.3.2 Weigh 4.0g sample in a 40 ml VOA vial. Record weight to the nearest 0.1g. Quickly add 10 mL methanol. Cap vial and shake for approximately 30 seconds. Let extract sit for 1hr. Transfer extract to a 2 mL vial.

11.3.3 Medium level extracts are run at the instrument by adding an appropriate amount of extract (up to 100uL) to a 5 ml gas tight syringe containing 5mL of DI and 5.0uL of surrogate standard. Based upon extraction weights and volumes, purging 100uL of extract yields a final sample dilution of 1/125. Dilutions are prepared by using smaller volumes of methanol extract diluted in a 5 ml gas tight syringe in the same manner as described above.

11.3.4 Prepare and run a Method Blank using 100uL methanol added to a syringe containing 5mL DI and 5.0uL of surrogate std.

11.4 Oil Wastes

11.4.1 Weigh 1gram of sample to a 40 ml VOA vial. Record weight to the nearest 0.1 gram. Quickly add 10 ml methanol. Cap vial and shake for approximately 30 seconds. Let extract sit for 1hr. Transfer extract to a 2 mL vial. Prepare a Laboratory Duplicate in the same manner.

11.4.2 Oil waste extracts are run at the instrument by adding an appropriate amount of extract (up to 100uL) to a 5 ml gas tight syringe containing 5mL of DI and 5.0uL of surrogate standard. Based upon extraction weights and volumes, purging 100uL of extract yields a final sample dilution of 1/500. Dilutions are prepared by using smaller volumes of methanol extract diluted in a 5 ml gas tight syringe in the same manner as described above.

11.4.3 Prepare and run a Method Blank using 100uL methanol added to a syringe containing 5mL DI and 5.0uL of surrogate standard.

11.5 Gas Chromatography

11.5.1 Program the autosampler. Refer to operator's manual for specifics on programming the various modes on the device. Heated purges should be performed at 40°C. The following purge and trap parameters are suggested. 11min.purge, 3 to 4min. dry purge, desorb 1 to 2min. at 250deg.C, bake trap 15 to 25min at 250deg.C. Run valve and transfer line temperatures at 110 to 120deg.C.

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11.5.2 Establish retention time windows for target analytes. Retention time windows are determined for each column on which analysis is performed and updated upon installation of a new column. Samples may be analyzed on a new column for which formal retention time windows have not been established based on absolute retention time of the compound and a default retention time window of ± 0.10 minutes. However, prior to reporting the data, the retention time windows must be established. If the windows are different, update the method and reprocess the data files.

11.5.2.1 For individual compounds, analyze three midpoint standards over at least a 72 hour period. Calculate the average and standard deviation of the retention times for each compound. Calculate the retention time window as the average retention time plus/minus three times the standard deviation. If the standard deviation is zero, a default window of ± 0.10 minutes will be used.

11.5.2.2 Update retention times daily based on the analysis of an opening continuing calibration verification standard (CCV). For qualitative determination of a target analyte to be accepted, each set of ten samples in the analytical sequence should be bracketed by a compliant CCV. If retention times shift outside of established windows, the cause must be investigated and remedied.

11.6 External Calibration Procedures

11.6.1 Analyze a minimum of 5 calibration standards as described in Section 9.2.4. Analyte responses are tabulated and recorded in the integration software. The software allows for different options for integration (listed below in order of preference). The low point in the ICAL (initial calibration) must be at the MRL (method reporting limit). Note: Two low points are run to satisfy this requirement. One standard is run at 0.50 ppb std for Benzene with an MRL of 0.70 ppb for waters and m,p-Xylenes with a MRL at 1.0 ppb. The second low standard is run at 1.0 ppb for all other analytes.

11.6.2. Average of Response Factor: calibration response factors are calculated as the standard concentration in ppb divided by the total area of the peak or integration range multiplied by 10.4. If the percent relative standard deviation (%RSD) of all points is less than 20%, linearity through the origin may be assumed and the average calibration response factor may be used in quantifying sample data. %RSD can be calculated on the basis of each compound or the average across all compounds.

11.6.3 Calibration Curve, Linear Regression : This option may be used if the correlation coefficient is greater than or equal to 0.99. This method of quantitation uses the equation of a line ($y=mx+b$). The curve must not be forced through zero. It will generally provide an acceptable fit when %RSD is between 0 - 30 percent and is therefore a useful option in evaluating the acceptability of the calibration curve for generating quantitative values.

11.6.4 Verify the calibration by analyzing an independent calibration verification standard. Acceptance criteria for the ICV is 70-130% recovery for all compounds.

11.7 Analytical Sequence:

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11.7.1 Analyze a system blank to establish that the instrument is free of target analyte contamination. Unless stated in project specific data quality objectives, the system is considered free of target analyte contamination if the level detected is less than the method reporting limit.

11.7.2 The first set of 10 samples in an analytical sequence may be analyzed immediately following an acceptable calibration and analysis of a system blank. This set of samples is bracketed with a continuing calibration verification (CCV) standard. This pattern is continued until the sequence is complete, or a CCV fails to meet acceptance criteria described below.

11.7.3 Verify the calibration each working day by the analysis of a CCV (midrange concentration of the calibration curve). Following initial calibration, CCVs are evaluated on the following basis:

Opening CCV: daily CCV evaluated against the initial calibration. The opening CCV is acceptable if RPD is (+/-) 15% for all target analytes. RPD is calculated comparing daily response factors to average response factors obtained in ICAL.

Closing CCV: CCV subsequent to the last sample in the analytical sequence and evaluated against the initial calibration. The closing CCV is acceptable if RPD is (+/-) 15%. for all target analytes. It is also acceptable if RPD is > (+) 15% and the analyte was not detected in the samples. The (+/-) 15% criteria can be calculated either on the basis of each compound or the average across all compounds. If the average across all compounds approach is used, supervisory approval must be obtained to report this data.

11.7.4 An analytical sequence begins with an opening CCV (or initial calibration), followed by an instrument blank, a set of 10 samples inclusive of matrix QC, and a closing CCV. Analysis of this set of 10 samples is acceptable if both the opening and closing CCV's pass criteria.

11.7.5 If the closing CCV also passes criteria for an opening CCV, it may serve as the opening CCV for the next set of 10 samples. However, as a general rule, the initial CCV in the analytical sequence will be designated as the opening CCV. Deviations from this practice should be clearly documented in the raw data.

Analysis continues in this manner until one of the following occurs:

1) Completion of the analytical sequence.
2) 12 hours expire between analysis of the opening CCV and analysis of the last sample in the analytical sequence. At this point a new sequence should be initiated, or a new opening CCV must be designated within the analytical sequence.

11.7.6 If the opening CCV does not meet acceptance criteria, perform maintenance as needed, or recalibrate the instrument.

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11.7.7 For quantitative results to be reported, all samples in a continuous analytical sequence must be analyzed subsequent to a CCV meeting the criteria described in Section 11.7.3.

11.7.8 In the event of a power outage, quantitative results for samples analyzed after the last passing CCV but before the power outage may be reported only if the system passes criteria for an opening CCV upon initiation of the next analytical sequence. This event should be documented in the form of a nonconformity and corrective action report and obtain supervisory approval. As a general rule, samples that were positive for target analyte will reanalyzed to confirm the original result.

11.8 Evaluation of the Analytical Sequence

11.8.1 Check that CCVs and CCBs were interspersed throughout the sequence at the proper frequency (section 11.7). Nonconformities must be documented and obtain supervisory approval before data is accepted.

11.8.2 Check that CCVs and CCBs are acceptable. CCV acceptance criteria are described in section 11.7.3. CCBs should be free of all target analyte contamination at a level less than the MRL. Nonconformities must be documented and obtain supervisory approval before data is accepted.

11.8.3 Check retention times in the initial daily calibration standard and in the continuing calibration varification standards. Update retention times as needed. Section 11.5.2.2 discusses guidelines for evaluating the significance of a retention time shift during the analytical sequence.

11.8.4 Check Method Blank surrogate recoveries. If surrogate recovery is high in the Method Blank, but all target analyte concentrations are below the MRL, no corrective action is required other than flagging the high surrogate recovery in the analytical report. If surrogate recovery is low in the Method Blank, all samples in the batch should be reanalyzed or the data must be flagged to indicate potential bias nexisting in results.

11.8.5 Check QA/QC samples against acceptance criteria. Acceptance criteria are listed in Tables 2 and 4.

11.8.5.1. If matrix spike recoveries are outside acceptance criteria, examine corresponding sample results for potential matrix interferences such as high levels of target analyte (spike levels should be approximately 5 times the background concentration). If no obvious matrix interferences are observed, evaluate the recovery of the laboratory control sample (LCS). Reanalyze if deemed appropriate. Do not reanalyze the matrix spike.

11.8.5.2 Check RPD values on duplicate sample analyses (sample/duplicate or MS/MSD). If values exceed 30% for aqueous samples or 40% for solid and miscible waste samples, examine the chromatograms and bench sheets for potential matrix

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interferences. Examples include product layers on aqueous samples that may result in non-homogenous subsampling, non-homogenous solid samples, chromatographic interferences resulting in poor peak resolution and inconsistent integrations, inefficient extraction or sample purge in one sample compared to another as indicated by significantly different surrogate recoveries. Reanalyze the QA/QC samples if deemed appropriate. Reanalyze (or reextract and reanalyze if deemed more appropriate) only those samples in the batch that do not meet surrogate recovery acceptance criteria. Do not reextract MS/MSD samples. Flag RPD values that are outside of acceptance criteria and explain the anomalies in the form of a case narrative.

11.9 Evaluation of Sample Analysis

CAS acceptance criteria are established based on control charting of analytical results. In most cases, CAS acceptance criteria are more stringent than method specified criteria. Unless stated in project specific data quality objectives, CAS criteria will be used in evaluating acceptability of the analysis. Current CAS acceptance criteria for surrogate recovery, matrix recovery, and relative percent difference on duplicate analyses are listed in Table 2.

11.9.1 Calculate surrogate recovery as the amount detected in the sample (solution concentration) divided by the true value (solution concentration). If surrogate recovery is outside acceptance criteria examine the chromatogram for obvious matrix interferences such as high levels of target analyte or coeluting peaks. If the problem is the result of an obvious matrix interference, flag the recovery value as outside acceptance criteria due to matrix interference. If no obvious interference is observed, reanalyze (or reextract and reanalyze if deemed more appropriate) the sample. If surrogate recovery is again outside criteria (or acceptable but within 5% of the primary analysis), report the original value and flag the recovery as being outside of acceptance criteria due to matrix interference. Otherwise, report the reanalysis.

11.9.2 Examine solution concentrations of target analytes in the samples. If the concentration is greater than the high calibration standard, reanalyze the sample at a dilution. As a general rule, dilutions should be performed to keep target analytes in the upper half of the calibration range.

11.9.3 Check for possible carryover. Pay particular attention to situations where samples containing low levels of target analyte were analyzed one or two runs after samples containing levels of target analyte near the high end of the calibration range. Reanalyze as needed.

11.9.4 Check peak integrations. Where possible, all integrations should be performed consistent with integration of the corresponding calibration standards. The following guidelines are provided:

1) Peaks exhibiting an unresolved coeluting shoulder are dropped on the perpendicular from the low point of the shoulder. Secondary confirmation of the result is recommended.

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2) Peaks eluting as unresolved shoulders on a coelution are dropped on the perpendicular from the low point of the shoulder. Secondary confirmation of the result is recommended.
3) Peaks eluting on an elevated baseline are skimmed on the slope of the baseline.
4) Peaks exhibiting a combination of elevated baseline and coeluting shoulders are integrated to eliminate low biases. This may require inclusion of the coelution, dropping the perpendicular to include the elevated baseline, or a combination of the two practices. Secondary confirmation of the result is recommended.

In all of the preceding situations the analyst must use professional judgment in deciding if the peak exhibits sufficient resolution from interferences to be reported quantitatively or if the MRL should be elevated above the level indicated by the integration. Obtaining a second opinion from an experienced analyst or the supervisor is recommended.

11.10 Secondary Confirmation of Individual Analytes

11.10.1. The following techniques are acceptable for the secondary confirmation of individual target analytes:

1) Site history and previous confirmation of the analyte.
2) Confirmation performed by secondary analysis of sample in question.
3) GC/MS confirmation is useful, especially when chromatographic interferences are present relatively close to the retention time window of the peak in question.

11.10.2 The following guidelines are provided for the reporting of confirmation data:

1) If the compound is not confirmed by secondary analysis, report none detected from the primary analysis. Use the confirmation analysis as supporting data.

2) If the compound is confirmed by secondary analysis but the percent difference between the two analyses is greater than 40%, elevate the MRL to the level of the interference (use the higher of the two results). Report the primary analysis and use the confirmation analysis as supporting data.

3) If the compound is confirmed by secondary analysis and the percent difference between the two analyses is less than 40%, and the secondary analysis is compliant with respect to all method criteria and analytical holding times, report the higher of the two results.

12 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

12.1 Analytical Holding Times: See Table 3 for guidelines on method specific maximum recommended holding times.

12.2 Calibration Criteria: section 11.6 provides guidelines on instrument calibration.

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12.3 Method Blank Criteria: Before running samples a method blank must be clean of all ananytes or contain concentrations below the MRL of each analyte. If this criteria is not met reanalyze method blank. If second blank fails perform necessary maintenance to deal with contamination.

12.4 CAS acceptance criteria are established based on control charting of analytical results. In most cases, CAS acceptance criteria are more stringent than method specified criteria. Unless stated in project specific data quality objectives, CAS criteria will be used in evaluating acceptability of the analysis. Current CAS acceptance criteria for surrogate recovery, matrix spike recovery, and relative percent difference on duplicate analyses are listed in Table 2.

12.4.1 Surrogate Recoveries: If surrogate recoveries are outside limits repeat the sample using a different autosampler position or reanalyze on a different GC system to confirm a matrix problem.

12.4.2 QA/QC Sample Analysis criteria: Each sample preparation batch will contain a maximum of 20 field samples, one to two Method Blanks, one Matrix Spike, and one Matrix Spike Duplicate. Additional QA/QC analyses are performed at a rate of one set per 20 field samples (which may be batched over a 7 day period). Unless stated in project specific data quality objectives, the standard QA/QC sample set for aqueous and solid matrices is a 20 ppb LCS (Laboratory control sample) followed by the sample, sample Matrix Spike and Matrix Spike Duplicate (Laboratory Duplicate for miscible waste samples).

12.4.2.1 QC spike corrective action : If a MS/MSD spike fails on a sample batch the samples are acceptable only if the LCS meets acceptance criteria. If a MS passes but the MSD fails repeat the MSD.

12.4.2.2 If the LCS fails on a sample batch, repeat the LCS. If it fails again remake the LCS and reanalyze. If the LCS still fails perform appropriate maitenance if deemed necessary and recalibrate the instrument.

12.5 Corrective Action: guidelines for appropriate corrective action when a nonconformity or an out of control analysis occurs are provided throughout this document. A nonconformity is defined as a procedure that is performed contradictory to standard operating procedure (unless stated in project specific data quality objectives). Nonconformities must be documented. An out of control analysis is defined as an analysis that does not meet acceptance criteria outlined in this standard operating procedure. Corrective action for an out of control analysis should be documented in the form of a Quality Tracking Report or in the case narrative notes.

12.6 Method Performance

12.6.1 Method detection limit studies should be performed on an annual basis for water and soil matrices. The studies should be performed using preparation procedures appropriate to commonly requested analyses. 8021 PPL and 8021TL MDL studies sould be performed for both soil and water methods. Copies of MDL studies should be forwarded to the QA Department, and maintained in the lab.

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12.6.2 Initial Precision and Recovery studies should be performed as part of analyst training. Copies of the studies should be maintained in the analyst's training file.

12.6.3. Retention time window determinations should be performed with each new column installed. Section 11.5.2 provides guidelines for establishing retention time windows.

12.6.4 Startup QC: When a new GC system is brought into service startup QC should be performed for all methods to be run on the GC system. This is done by analyzing four Reference Checks. The results for each analyte are entered in a table and the average concentration for each analyte from the four Reference Checks is calculated along with the standard deviation (S) and the relative percent recovery.

13.0 DATA REDUCTION AND REPORTING

13.1 External Standard Calibration: the concentration of each compound in the sample is determined by calculating the amount of analyte purged using the calibration curve or the calibration factor. Calculations for determining specific analyte concentrations in the sample are described below.

Calibration Factors: This method uses only external calibration to generate results. The calibration factor is calculated as:

$$Cf = \frac{Ax}{Rx}$$

Where:

Cf = Calibration factor
Rx = Response of the analyte (peak area x 10-4)
Ax = Concentration of analyte purged (ppb).

When the average of calibration factor is used to quantitate sample results, the calibration factor(*Cf*) is calculated as the average response factor for the curve (sum of all calibration factors divided by the number of points in the curve).

When a linear calibration curve is used to quantitate sample results, the curve is not forced through zero and the line is plotted using peak area versus concentration. The cumulative calibration factor (*Cf*) is equal to the linear term (i.e., slope of the line: *m*).

13.1.1 Solution Concentration of Analyte Detected:

Results based on average of response factor or a linear regression are calculated as:

$$Csol = (Rcpd)(Cf)$$

Where:

Csol = Solution concentration of the compound (ug/L)
Rcpd = Response of the compound (peak area x 10-4)
Cf = Calibration factor

13.1.2 Sample Concentration of Analyte Detected

Aqueous Samples: $Rsult(ug / L) = Csol \times Df$

Soil, Solid or Waste Sample: $Rsult(ug / kg) = Csol \times Df$

Where:

Rsult = Sample result (ppb)
Csol = Solution conce*ntration of the compound (ug/L)*
Df = Dilution factor (if no dilution was performed *Df* = 1)

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13.2 Reporting Basis of Solid Samples

Most solid samples are reported on a Dry Weight Basis. Samples collected in Oregon and California are reported on an As Received Basis unless stated otherwise in project specific data quality objectives. Dry Weight calculation is done as follows:

Final Result (ug/kg) = [Instrument result (ug/kg) / DWPS] x 100

13.3 Adjustments to the Method Reporting Limit

13.3.1 Raising MRLs to account for dry weight percent solids: MRLs are elevated for percent solids in the sample as follows: $(MRL/\ \%Solid)\times 100$.

13.3.2 Raising MRLs due to insufficient sample: MRLs are elevated for insufficient sample volume based on the same guidelines described for low percent solids (substitute "*% of Amount Required*" for "*% Solid*").

13.3.3 Raising MRLs due to matrix interference and dilutions: MRLs are elevated above the level of the interference when a peak can not be sufficiently resolved or confirmed by secondary analysis. If dilutions are required due to high levels of target analyte, the MRL for undetected analytes is equivalent to the MRL times the dilution factor from the most concentrated acceptable analysis.

13.3.4 Reporting Lower MRLs: MRLs may be lowered to meet project specific data quality objectives. The following guidelines apply:

1) Quantitative reporting limits may not be less than the level of the lowest point in the initial calibration curve.

2) If lower MRLs are required, sample preparation techniques may be modified to allow for greater concentration of the sample prior to introduction into the GC system. Modifications to the sample prep should be verified with an IPR study performed at a concentration equivalent to 10 or 20 times above the required MRL.

3) Method detection limits are not modified. If sample preparation techniques are modified to provide reduced reporting limits, a new MDL study should be performed if qualitative data must be reported below the new MRL.

13.4. Data Qualifiers

Data should be qualified when significant information regarding the analysis needs to be communicated to assist the user in determining the usability of the results. Acceptable qualifiers should comply with one of three systems:

1) Standard CAS data qualifiers
2) CLP Organics data qualifiers
3) Army Corps of Engineers electronic data deliverable (COELT) data qualifiers

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Data qualifiers should be fully explained in the form of case narrative notes to assist the Project Chemist in writing the case narrative for completion of the project.

13.5 Reporting Data From Multiple Analyses

13.5.1 Section 11.10.2 provides guidelines on reporting secondary confirmation analyses.

13.5.2 As a general rule, the primary analysis is defined as the most concentrated analysis from which data is being reported. Surrogate recoveries are reported from the primary analysis.

13.5.3 The primary analysis is used in evaluating data for compliance with recommended maximum analytical holding times. Secondary and supporting analyses performed outside the maximum recommended holding time should be discussed in the case narrative notes, but are not flagged in the analytical report.

13.6 Data Review: Refer to ADM-DREV SOP for procedure. All data is reviewed and validated by the supervisor.

14. WASTE MANAGEMENT AND POLLUTION PREVENTION

Standards are prepared on an as-needed basis in small quantities and minimum sample volume are used during analysis. Acidic waste is neutralized and poured down the drain with copious amounts of water. All expired standards are disposed of as hazardous flammable solvents and hazardous samples are disposed of either as acidic aqueous waste or as hazardous aqueous waste depending on their analytes' concentrations. These tasks are turned over to staff qualified and equipped for disposal.

15. REFERENCES

15.1 EPA Method 5030B, SW-846, September 1986 (with updates).
15.2 EPA Method 8000B, SW-846, December 1996 Revision 2
15.3 EPA Method 8021B SW-846, December 1996

16. TRAINING OUTLINE

16.1 Review literature by reading EPA Methods 5030/5035 and 8021B.

16.2 Observe the procedure as performed by an experienced analyst at least three times.

16.3 The most recent SOP revision must be reviewed and documented on training records.

16.4 Instrument Operation and Maintenance, if applicable.

16.5 Demonstrate Competency by performing the analysis independently. Analyze a known proficiency or standard. If recovery is within acceptable limits, complete training form and have the supervisor sign-off as being proficient.

17. INSTRUMENT- SPECIFIC ADDENDUM

Instrument manuals are located in the VOA lab.

18. ATTACHMENTS

Table 1 Target Compounds
Table 2 Matrix Spike and Surrogate Control Limits
Table 3 Holding Times
Table 4 Targets, LCS Limits, and Reporting Limits
Estimated Retention Time Windows

19. CHANGES FROM PREVIOUS REVISION

Added ARCHON to equipment list
Addressed method 5035 for low level soils in section 11.2.1
Removed 1,2,3- Trichloropropane as a surrogate.
Stated that linear regressions must not be forced through zero.
Defined the MRL as the low point in the ICAL. Also noted in Section 6 that two low standards are analyzed to confirm special MRLs.
Section 6 cross-referenced the SMO-GEN for sample receipt and custody.
In section 11 cross-referenced the ADM-DIL SOP for sample dilutions.
In section 13 cross-referenced ADM-DREV SOP for data review procedure.
In section 11 added that MEOH extractions may not be held and analyzed for more than 14 days from sample date.
Section 12 added method blank criteria and corrective action.
Section 12 added two paragraphs addressing corrective action for MS/MSD and LCS.
Revised Tables

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Table 1. Applicable Method References, Target Analytes, Detector of Quanititation, and Calibration Technique.

Method	Target Analytes	Detector	Calibration
8021B - P	DICHLORODIFLUROMETHANE	ELCD	External
	CHLOROMETHANE	ELCD	External
	VINYL CHLORIDE	ELCD	External
	BROMOMETHANE	ELCD	External
	CHLOROMETHANE	ELCD	External
	TRICLOROFLUOROMETHANE	ELCD	External
	FREON 113	ELCD	External
	1,1-DICHLOROETHENE	ELCD	External
	METHYLENE CHLORIDE	ELCD	External
	trans-1,2-DICHLOROETHENE	ELCD	External
	1,1-DICHLOROETHANE	ELCD	External
	cis 1,2-DICHLOROETHENE	ELCD	External
	CHLOROFORM	ELCD	External
	1,1,1-TRICHLOROETHANE	ELCD	External
	CARBON TETRACHLORIDE	ELCD	External
	1,2-DICHLOROETHANE	ELCD	External
	TRICHLOROETHENE	ELCD	External
	1,2-DICHLOROPROPANE	ELCD	External
	BROMODICHLOROMETHANE	ELCD	External
	cis 1,3-DICHLOROPROPENE	ELCD	External
	trans 1,3-DICHLOROPROPENE	ELCD	External
	1,1,2-TIRCHLOROETHANE	ELCD	External
	TETRACHLOROETHENE	ELCD	External
	DIBROMOCHLOROMETHANE	ELCD	External
	CHLOROBENZENE	ELCD	External
	BROMOFORM	ELCD	External
	1,1,2,2-TETRACHLOROETHANE	ELCD	External
	1,3-DICHLOROBENZENE	ELCD	External
	1,4-DICHLOROBENZENE	ELCD	External
	1,2-DICHLOROBENZENE	ELCD	External
	BENZENE	PID	External
	TOLUENE	PID	External
	CHLOROBENZENE	PID	External
	ETHYLBENZENE	PID	External
	m+p-XYLENE	PID	External
	o-XYLENE	PID	External
	1,3-DICHLOROBENZENE	PID	External
	1,4-DICHLOROBENZENE	PID	External
	1,2-DICHLOROBENZENE	PID	External
8021B - TL	METHYL-TERT-BUTYLETHER	PID	External
	BENZENE	PID	External
	TOLUENE	PID	External
	ETHYLBENZENE	PID	External
	m+p-XYLENES	PID	External

	o -XYLENES	PID	External	
	ISOPROPYLBENZENE	PID	External	
	n-PROPYLBENZENE	PID	External	
	1,3,5-RIMETHYLBENZENE	PID	External	
	TERTBUTYLBENZENE	PID	External	
	sec-BUTYLBENZENE	PID	External	
	n-BUTLYBENZENE	PID	External	
	NAPTHALENE		External	

Table 2. Data Quality Objectives: Surrogate Recoveries, Matrix Spike Recoveries, and Relative Percent Difference

Compound	**Type**	**Aqueous Sample**	**Lab Control Sample**	**Solid Sample (Dir. Purge)**	**Lab Control Sample**
Spike Recovery	**Accuracy**				
Benzene	Matrix Spike	39-150	39-150	39-150	39-150
Toluene	Matrix Spike	46-148	46-148	46-148	46-148
m,p-Xylene	Matrix Spike	60-121	60-121	60-121	60-121
Chlorobenzene	Matrix Spike	38-150	38-150	38-150	38-150
1,1-Dichloroethene	Matrix Spike	28-167	28-167	28-167	28-167
Methylene Chloride	Matrix Spike	25-162	25-162	25-162	25-162
Trichloroethene	Matrix Spike	35-146	35-146	35-146	35-146
Bromochloromethane	Surrogate	60-138	60-138	66-138	66-138
Chlorofluorobenzene (Hall)	Surrogate	60-140	60-140	60-140	60-140
Chlorofluorobenzene (PID)	Surrogate	60-140	60-140	60-140	60-140
RPD	**Precision**	30%	30%	30%	30%

Table 3. **Maximum Recommended Analytical Holding Times and Preservatives.**

Method	Matrix	Preservative	Extraction Holding Time	Analysis Holding Time
EPA 5030A/8021	Aqueous	pH < 2 with HCL; 4^oC	NA	14 Days (collection)
EPA 5030A, 5035	Soil	4^oC	14 Days (collection)	14 Days (collection)
	Waste	None	14 Days (collection)	14 Days (collection)

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Table 4 QC and Reporting Limits.

Compound	QC LIMITS	MRL/MDL ug/L
Dichlorodifluoromethane	50-150	1.0/ 0.363
Chloromethane	10-193	1.0/ 0.218
Vinyl Chloride	28-163	1.0/ 0.253
Bromomethane	10-144	1.0/ 0.264
Chloroethane	46-137	1.0/ 0.574
Trichloroflouromethane	21-156	1.0/ 0.204
1,1-Dichloroethene	28-167	1.0/ 0.232
Methylene Chloride	25-162	1.0/ 0.231
1,2-Dichloroethene (Trans)	38-155	1.0/ 0.225
1,1-Dichloroethane	47-132	1.0/ 0.190
1,1-Dichloroethene (Cis)	53-140	1.0/ 0.215
Chloroform	49-133	1.0/ 0.207
1,1,1-Trichloroethane	41-138	1.0/ 0.200
Carbon Tetrachloride	43-143	1.0/ 0.222
1,2-Dichloroethane	51-147	1.0/ 0.220
Trichloroethene	35-146	1.0/ 0.255
1,2-Dichloropropane	44-156	1.0/ 0.158
Bromodichloromethane	42-172	1.0/ 0.158
2-Chloroethylvinyl Ether	14-186	1.0/ 0.445
1,3-Dichloropropene (Cis)	22-178	1.0/ 0.273
1,3-Dichloropropene (Trans)	22-178	1.0/ 0.326
1,1,2-Trichloroethane	39-136	1.0/ 0.313
Tetrachloroethene	26-162	1.0/ 0.280
Dibromochloromethane	24-191	1.0/ 0.206
Chlorobenzene	38-150	1.0/ 0.171
Bromoform	13-159	1.0/ 0.268
1,1,2,2-Tetrachloroethane	10-184	1.0/ 0.395
1,3-Dichlorobenzene (m)	10-187	1.0/ 0.183
1,4-Dichlorobenzene (p)	42-143	1.0/ 0.214
1,2-Dichlorobenzene (o)	10-203	1.0/ 0.182
Freon 113	38-155	1.0/ 0.283
Methyl-t-butyl Ether	50-150	1.0/ 0.266
Benzene	39-150	0.70/ 0.150
Toluene	46-148	1.0/ 0.147
Ethylbenzene	32-160	1.0/ 0.420
(m,p) Xylenes	72-120	1.0/ 0.497
(o) Xylene	60-102	1.0/ 0.483
Isopropylbenzene	50-150	1.0/ 0.199
n-Propylbenzene	50-150	1.0/ 0.180
1,3,5-Trimethylbenzene	50-150	1.0/ 0.210

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Table 4 QC and Reporting Limits.

Compound	QC LIMITS	MRL/MDL ug/L
tert-Butylbenzene	50-150	1.0/ 0.224
1,2,4-Trimethylbenzene	50-150	1.0/ 0.185
sec-Butylbenzene	50-150	1.0/ 0.266
p-Isopropyltoluene	50-150	1.0/ 0.218
n-Butylbenzene	50-150	1.0/ 0.193
Naphthalene	50-150	1.0/ 0.348

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STANDARD OPERATING PROCEDURE

SEMIVOLATILE ORGANIC COMPOUNDS BY GC/MS

SOC-8270C

Revision 4.0
September 28, 2001

Approved By: _____ _____
Supervisor — Date

_____ _____
QA Coordinator — Date

_____ _____
Laboratory Manager — Date

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Annual review of this SOP has been performed and the SOP still reflects current practice.
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1. SCOPE AND APPLICATION

1.1. Method 8270C is used to determine the concentrations of Semi-Volatile Organic Compounds in extracts prepared from many types of solid waste matrices, soils, air sampling media, and water. Table 1 indicates the typical compounds that are determined by this method and the practical quantitation limits (PQLs) for water and soil.

1.2. Method 8270C can be used to quantitate most neutral, acidic, and basic organic compounds that are soluble in methylene chloride and capable of being eluted without derivatization as sharp peaks from a gas chromatographic fused-silica capillary column coated with a slightly polar silicone phase. Such compounds include polynuclear aromatic hydrocarbons, chlorinated hydrocarbons and pesticides, phthalate esters, organophosphate esters, nitrosamines, haloethers, aldehydes, ethers, ketones, anilines, pyridines, quinolines, aromatic nitro compounds, and phenols, including nitrophenols.

2. METHOD SUMMARY

2.1. This method provides Gas Chromatography/Mass Spectrometry (GC/MS) conditions for the detection of Semi-volatile Organic Compounds. Prior to the use of this method, an appropriate sample preparation method must be used to recover the analytes of interest. A 1 µL aliquot of the extract is injected into the gas chromatograph (GC). The compounds are separated on a fused silica capillary column. Compounds of interest are detected by a mass spectrometer. Identification of the analytes of interest is performed by comparing the retention times of the analytes with the respective retention times of an authentic standard, and by comparing mass spectra of analytes with mass spectra of reference materials. Quantitative analysis is performed by using the authentic standard to produce a response factor and calibration curve, and using the calibration data to determine the concentration of an analyte in the extract. The concentration in the sample is calculated using the sample weight or volume and the extract volume.

2.2. The following compounds may require special treatment when being determined by this method. Benzidine can be subject to oxidative losses during solvent concentration and the chromatography for this compound is poor. Hexachlorocyclopentadiene is subject to thermal decomposition in the inlet of the gas chromatograph and is subject to a chemical reaction in acetone, and can undergo photochemical decomposition. N-nitrosodimethylamine is difficult to separate from the solvent under the chromatographic conditions described. N-nitrosodiphenylamine decomposes in the gas chromatographic inlet and cannot be separated from diphenylamine. Pentachlorophenol, 2,4-dinitrophenol, 2-nitroaniline, 3-nitroaniline, 4-chloroaniline, and benzyl alcohol are subject to erratic chromatographic behavior, especially if the GC system is contaminated with high boiling material.

3. DEFINITIONS

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3.1. **Batch** - A group of samples which are processed as a unit, not to exceed 20 samples

3.2. **Analytical Sequence** - Samples are analyzed in a set referred to as an analysis sequence. The sequence begins with injection of Decaflurortriphenylphsophine (DFTPP) followed by initial calibration standard(s). Once calibrated, a CCV is evaluated and extracts can be run. The sequence ends after 12 hours based on the DFTPP injection time.

3.3. **Initial Calibration -** analysis of analytical standards for a series of different specified concentrations; used to define the linearity and dynamic range of the response of the electron capture detector to the target compounds.

3.4. **Laboratory Control Sample -** a matrix-specific spiked sample with compounds representative of the target analyte list. This sample is prepared per batch and used to document laboratory performance for the extraction and analysis.

3.5. **Matrix -** the predominant material, component, or substrate (e.g., surface water, drinking water, etc.) of which the sample to be analyzed is composed.

3.6. **Matrix Spike -** an aliquot of sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike is used to document the bias of a method in a given sample matrix.

3.7. **Method Blank -** an analyte-free matrix to which all reagents are added in the sample volumes or proportions as used in sample processing. The method blank should be carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination resulting from the analytical process.

3.8. **Organic- Free Reagent Water** - ASTM Type II Deionized Water .

3.9. **Percent Difference (%D) -** Used to compare two values, the percent difference indicates both the direction and the magnitude of the comparison, i.e., the percent difference may be either negative, positive, or zero. (In contrast, see relative percent difference).

3.10. **Sample -** a portion of material to be analyzed that is contained in single or multiple containers and identified by a unique sample number.

3.11. **Surrogates** (Surrogate Standards) - an organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical process. For semivolatiles and pesticides/Aroclors, surrogate compounds are added to every blank, sample, matrix spike, matrix spike duplicate, LCS, matrix spike blank, and standard. These are used to evaluate analytical efficiency by measuring recovery. Surrogates are not expected to be detected in environmental media.

3.12. **Continuing Calibration Verification Standard (CCV)** - A mid-level standard injected into the instrument at specified intervals and is used to verify the validity of the initial calibration.

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4. INTERFERENCES

4.1. Raw GC/MS data from all blanks, samples, and spikes must be evaluated for interferences. Determine if the source of interference is in the preparation of the samples. Corrective action should be taken to eliminate the interferences.

4.2. Accurate determination of phthalate esters can pose difficulties when using this methodology. Common flexible plastics contain varying amounts of phthalates. These phthalates are easily extracted or leached from such materials during laboratory operations. Cross contamination of clean glassware may occur when plastics are handled during extraction steps, especially when solvent-wetted surfaces are handled. Interferences from phthalates can best be minimized by avoiding contact with any plastic materials. Exhaustive cleanup of reagents and glassware may be required to eliminate background phthalate contamination.

4.3. Contamination by carryover can occur whenever high-concentration and low-concentration samples are sequentially analyzed. To reduce carryover, the sample syringe must be rinsed out between samples with solvent. Whenever an unusually concentrated sample is encountered, it should be followed by the analysis of solvent to check for cross contamination.

5. SAFETY

5.1. The toxicity or carcinogenicity of each reagent used in this method has not been precisely determined; however, each chemical should be treated as a potential health hazard. Exposure to these reagents should be reduced to the lowest possible level. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets should be made available to all personnel involved in these analyses. Specifically, concentrated sulfuric acid and the 50% sodium hydroxide solution are moderately toxic and extremely irritating to skin and mucous membranes. Use these reagents in a fume hood whenever possible and if eye or skin contact occurs, flush with large volumes of water. Always wear safety glasses or a shield for eye protection, and protective clothing, and observe proper mixing when working with these reagents.

6. SAMPLE COLLECTION, CONTAINERS, PRESERVATION, AND STORAGE

6.1. Containers used to collect samples for the determination of semivolatile organic compounds should be soap and water washed followed by methanol (or isopropanol) rinsing. The sample containers should be glass or Teflon, and have screw-caps with Teflon lined septa. In situations where Teflon is not available, solvent-rinsed aluminum foil may be used as a liner. However, acidic or basic samples may react with the aluminum foil, causing eventual contamination of the sample. Plastic containers or lids may NOT be used for the storage of samples due to the possibility of sample contamination from the phthalate esters and other hydrocarbons within the plastic. Samples shall be cooled and stored at 0-6°C while shipped to the laboratory within 48 hrs.

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6.2. Sample containers should be filled with care so as to prevent any portion of the collected sample coming in contact with the sampler's gloves, thus causing contamination. Samples should not be collected or stored in the presence of exhaust fumes. If the sample comes in contact with the sampler (e.g., if an automatic sampler is used), run reagent water through the sampler and use the rinsate as a field blank.

6.3. Water and soil samples must be iced or refrigerated at 0-6°C from the time of collection until extraction.

6.4. Water samples must be extracted within 7 days and the extracts analyzed within 40 days following extraction. Soil samples must be extracted within 14 days and the extract analyzed within 40 days following extraction.

6.5. Sample receipt, handling, and custody is the responsibility of the Sample Management Office. Refer to the SMO-GEN SOP for details.

7. APPARATUS AND MATERIALS

7.1. Gas Chromatograph/Mass Spectrometer System

7.1.1. Gas Chromatograph - An analytical system complete with a temperature-programmable gas chromatograph suitable for splitless injection and all required accessories, including syringes, analytical columns, and gases. The capillary column should be directly coupled to the source (HP5890 and HP6890 GC).

7.1.2. Column: Restek Rtx-5ms - 30 m x 0.25 mm ID x 0.50 µm df fused-silica capillary column with a 10 meter guard column attached (Cat # 12638-127).

7.1.3. Mass Spectrometer - Capable of scanning from 35 to 500 amu every 1 second or less, using 70 volts (nominal) electron energy in the electron impact ionization mode. The mass spectrometer must be capable of producing a mass spectrum for decafluorotriphenylphosphine (DFTPP) which meets all of the criteria in Table 2 when 1 µL of the GC/MS tuning standard is injected through the GC (50 ng of DFTPP) (HP5970 and HP5973).

7.1.4. GC/MS Interface - Any GC-to-MS interface that gives acceptable calibration points at 50 ng per injection for each compound of interest and achieves acceptable tuning performance criteria may be used.

7.1.5. Data System - A computer system must be interfaced to the mass spectrometer. The system must allow the continuous acquisition and storage on machine-readable media of all mass spectra obtained throughout the duration of the chromatographic program. The computer must have software that can search any GC/MS data file for ions of a specific mass and that can plot such ion abundances versus time or scan number. This type of plot

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is defined as an Extracted Ion Current Profile (EICP). Software must also be available that allows integrating the abundances in any EICP between specified time or scan-number limits. The most recent version of the EPA/NIST Mass Spectral Library should also be available.

7.1.6. Appropriate analytical balance (0.0001 g), volumetric flasks, syringes, vials, and bottles for standards preparation.

8. PREVENTATIVE MAINTENANCE

8.1. Glass Insert/ Sleeve- Replace as needed. Indicators are 1.) A significant or sudden change in chromatography, 2.) Difficulty in meeting % deviation criteria for a calibration check 3.) Reduced sensitivity to key compounds (Nitrophenols, Hexachlorocyclopentadiene) is the best symptom of a dirty injector. The insert should always be replaced before a new calibration and the o-ring should be replaced with the insert.

8.2. Septum - Replaced approximately every 150 injections. A retention time shift or poor baseline chromatography is a common symptom.

8.3. Autosampler syringe - Cleaned daily and after samples with a particularly bad matrix. The syringe should be rinsed with methylene chloride; the plunger is rinsed, wiped with a kimewipe, and rinsed again. The syringe should be replaced with a new one if loose action is noted or inconsistent action is evident (uniform fluctuation in response, area counts) or obvious wear.

8.4. Injection Port - The port and the port/column interface should be cleaned as needed (when replacing the insert is ineffective and in conjunction with column pruning). Port should be reamed with a wire brush and swabbed with methylene chloride. Disc and washer can be sonicated in methylene chloride and then silanized, but should be replaced if wear is evident. The capillary inlet should also be cleaned in methylene chloride and the septum nut is sonicated in methylene chloride also.

8.5. Column Pruning - Cut back one revolution as needed. Indicators are same as insert replacement and is another remedy if insert replacement does not yield the desired results. After initial cut a graphite ferrule should first be installed and then another short length of column removed (cut should be carefully examined for smoothness - no jagged edges). The column end should extend 27mm past the ferrule when installed (use the white out or septum marking method for reference).

8.6. Column Replacement - As needed, usually every 2-3 months for moderate sample volumes. Symptoms are ineffectiveness of insert replacement, injector cleaning, or column pruning to rectify a problem or when resolution becomes difficult (such as key isomeric pairs: anthracene/ phenanthrene, chrysene/ benzo(a)anthracene, and benzo (b)/benzo(k)fluoranthene). All ferrules replaced with column change.

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8.7. Syringe Rinse Solvent - Supply is replenished as needed. Old solvent is discarded and vial rinsed before refilling. Rinse waste and sample waste vials are replaced when residue appears.

8.8. Carrier Gas - Tank is changed before pressure reaches approximately 200psi to avoid impurities that may be delivered by a nearly empty tank. Leak check with snoop after change.

8.9. System Baking - When the system is to be idle oven temperature should be set to 100°C to avoid water vapor condensation in column. Baking of injector, column, interface may be done for short periods of time to eliminate contaminants due to sample matrix residuals. Temperatures should not exceed recommended column temperature limits.

8.10. Source Cleaning - Performed on an as-needed basis. Source is cleaned/replaced when persistent difficulty in meeting and maintaining acceptable DFTPP tune checks is encountered. This is indicated by : 1.) reduced high-mass sensitivity (DFTPP m/z 365<1% of 198 or PFTBA m/z 502<0.5%) 2.) High EM setting resulting in excessive signal and incosistent response in both tune file and instrument methods. A dirty source can sometimes be diagnosed by jagged lens-ramp plots in addition to tune difficulties. The procedure for removing and cleaning the ion source is followed as in the instrument Manual.

8.11. Electron Multiplier - Preventive Maintenance or replacement as needed. Method of cleaning and conditioning a new EM can be found in accompanying literature from the manufacturer (Channeltron/Galileo). Cleaning is usually necessary when source replacement is not having a significant effect on instrument sensitivity. Replacement of the EM is necessary when cleaning does not yield the desired results, or when there is a catastrophic event (outlined in literature).

8.12. Leak Detection - A manual tune should be monitored at set intervals for peak characteristics of air leakage (abundance of ions corresponding to N_2, H_2O, O_2), or an Ion gauge reading taken regulary can show changes in vacuum. Proper Ion gauge readings should be in the 10^{-5} - 10^{-6} torr range.

8.13. Internal Standard Syringe - Rinsed with methylene chloride before and after use. The teflon tip is checked for wear regulary and the tip, plunger or entire syringe is replaced when necessary.

8.14. Splitless Liner Preparation - Remove dirty glass wool plug. Solvent rinse splitless liner with methylene chloride. Air dry and pack with glass wool to an approximate 5mm thickness. The glass wool packing should not be very dense. Immerse prepared liners in Sylon solution for deactivation. Rinse with methanol and air dry.

8.15. Maintenence Log - All preventive maintenance as well as instrument repair should be documented in the appropriate instrument maintenance log.

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9. STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

9.1. Solvents: Hexane, acetone, methylene chloride, methanol, and other appropriate solvents. Solvents must be of sufficient purity to permit usage without lessening the accuracy of the determination or introducing interferences.

9.2. Standards - Manufacturers certificates of analysis are retained by the lab and presented upon request. All standards must be traceable using the CAS Lot System, See SOP, ADM-SPSR.

9.2.1. Calibration Standards - A minimum of five calibration standards should be prepared. One of the calibration standards shall be at the method reporting limit; the others should correspond to the range of concentrations found in real samples, but should not exceed the working range of the GC/MS system. Each standard should contain each analyte for detection by this method. Each 1 ml aliquot of calibration standards should be spiked with 10 µL of the internal standard solution prior to analysis. All standards should be stored at <-10°C and should be freshly prepared every six months, or sooner if check standards indicate a problem. The daily calibration standard (80 ppm) should be prepared weekly and stored at <-10°C.

CALIBRATION STANDARDS

Stock Solution is NSI Cat # C-509 Ready Stock (SW846 surr) 5ml x 200ppm
Dilute the following volumes of the 200 ppm Mid-Stock Standard Solution to 1.0 ml with Methylene Chloride.

CALIBRATION STD. CONCENTRATION (ppm)	VOLUME OF 200 ppm MID-STOCK (mL)	FINAL VOLUME (mL)
10	0.05	1.0
50	0.25	1.0
80	0.40	1.0
100	0.50	1.0
120	0.60	1.0
160	0.80	1.0

Add 10 uL of 4000 ppm Internal Standard to each standard prior to analysis.

CCV STANDARDS

Prepare 1 mL of 80 ppm standard and store in 2-ml autosampler vial.
Add 10µl of 4000 ppm internal standard

9.3. Internal Standard Solutions Purchased at 4000ppm - The internal standards are 1,4-dichlorobenzene-d_4, naphthalene-d_8, acenaphthene-d_{10}, phenanthrene-d_{10}, chrysene-d_{12}, and perylene-d_{12} (See method for corresponding compounds). The purchased standard is stored

and expires upon manufacturer's recommendation. Each 1 ml sample extract undergoing analysis should be spiked with 10 µL of the internal standard solution, resulting in a concentration of 40 mg/L of each internal standard.

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9.4. Surrogate Standards - Determine what concentration should be in the blank extracts after all extraction, cleanup, and concentration steps. Determine recovery of surrogate standards in all blanks, spikes, and sample extracts. Take into account all dilutions of sample extracts.

Restek Cat #31086 B/N Surrogate Mix 5000ppm (Nitrobenzene-d5, 2-fluorobiphenyl, Terphenyl-d14)
Restek Cat#31087 AE Surrogate Mix 10,000 ppm (2-fluorophenol, phenol-d6, 2,4,5-Tribromophenol)
Dilute 5 mls each to 250mls in methanol so BN surrogate is at 100ppm and AE surrogate is at 200ppm.
Spike each sample with 1.0 mL Surrogate solution for on-column concentration of 100 ppm for BNs and 200 ppm for ANs.

9.5. DFTPP Tune Solution
1 ml 25 ppm DFTPP (inject 2µl=50ng) diluted from 1000ppm stock to 25 ppm mid-stock.

9.6. Laboratory Control Sample Spiking Solution Purchased (NSI Cat # C-408 TCL BNA LCS Spike 100ppm in methanol.)

9.7. MS/MSD Spiking Solution

NSI Cat # C-365 Working Level Spike 200 ppm AE/ 100 ppm BN in Methanol

4-Chloro -3-methylphenol	200 ppm	Acenaphthene	100 ppm
2-Chlorophenol	200 ppm	1,4- Dichlorobenzene	100 ppm
4- Nitrophenol	200 ppm	2,4-Dinitrotoulene	100 ppm
Pentachlorophenol	200 ppm	N-Nitrosodi-n-propylamine	100 ppm
Phenol	200 ppm	Pyrene	100 ppm
1,2,4-Trichlorobenzene	100 ppm		

10. RESPONSIBILITIES

10.1. It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. This demonstration is in accordance with the training program of the laboratory. Final review and sign-off of the data is performed by the department supervisor/manager or designee.

11. PROCEDURE

11.1. Samples may be prepared using any of the following SOPs, depending upon requirements of the sample matrix and/or client request:

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EXT-3520B	EXT-3640A

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EXT-3540C EXT-3660B
EXT-3550B EXT-3665A
EXT-3580

11.2. Establish gas chromatographic operating parameters equivalent to those indicated in the HP Chemstation Enviroquant Method attached at the end of this SOP.

11.3. Tuning - The GC/MS system must meet the DFTPP ion abundance criteria shown in Table 2. An individual scan can be used or an average of scans can be chosen. Background subtraction should be straight forward and designed only to eliminate column bleed or instrument background noise. If hardware tuning criteria can not be met, the source may need cleaning, filaments replaced or other maintenance. The Analysis may not proceed until the tune meets these criteria.

11.4. Calibration

11.4.1. The internal standards should permit most of the components of interest in a chromatogram to have retention times of 0.80-1.20 relative to one of the internal standards. Use the base peak ion from the specific internal standard as the primary ion for quantitation (See Method 8270C). If interferences are noted, use the next most intense ion as the quantitation ion (i.e. for 1,4-dichlorobenzene-d_4, use 152 m/z for quantitation).

11.4.2. Analyze 1 µL of each calibration standard (containing internal standards) and tabulate the area of the primary characteristic ion against concentration for each compound. Calculate response factors (RFs) for each compound relative to one of the internal standards as follows:

$RF = (A_x C_{is})/(A_{is} C_x)$
where:

A_x	=	Area of the characteristic ion for the compound being measured.
A_{is}	=	Area of the characteristic ion for the specific internal standard.
C_{is}	=	Concentration of the specific internal standard (mg/L).
C_x	=	Concentration of the compound being measured (mg/L).

11.4.3. A system performance check must be performed to ensure that minimum average RFs are met before the calibration curve is used. For semivolatiles, the System Performance Check Compound (SPCCs) are: N-nitroso-di-n-propylamine; hexachlorocyclopentadiene; 2,4-dintro-phenol; and 4-nitrophenol. The minimum acceptable average RF for these compounds is 0.050. The SPCCs typically have very low RFs (0.1-0.2) and tend to decrease in response as the chromatographic system begins to deteriorate or the standard material begins to deteriorate. They are usually the first to show poor performance. Therefore, they must meet the minimum requirement when the system is calibrated. If they are not acceptable, do maintenance; replace septa, linear, disks and/or cut 6-12" off the column.

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11.4.4. The percent relative standard deviation (%RSD) should be less than 15% for each compound. However, the %RSD for each individual Calibration Check Compound (CCC) (see Table 3) must be less than 30%. The relative retention times of each compound in each calibration run should agree within 0.06 relative retention time units.

$$\%RSD = \frac{SD}{\overline{RF}} \times 100$$

where:

RSD = relative standard deviation.
RF = mean of 5 initial RFs for a compound.
SD = standard deviation of average RFs for a compound.

$$SD = \sqrt{\sum_{i=1}^{N} \frac{(RF_i - \overline{RF})^2}{N - 1}}$$

where:

RF_i = RF for each of the 5 calibration levels
N = Number of RF values (i.e., 5)

11.4.5. If the % RSD of any CCC is 30% or greater, then the chromatographic system is too reactive for analysis to begin. Clean or replace the injector liner and/or capillary column, then repeat the calibration procedure.

11.4.6. Linearity - If the % RSD of any compound is 15% or less, then the relative response factor is assumed to be constant over the calibration range, and the average relative response factor may be used for quantitation. For clients and state agencies such as South Carolina, do not allow average RSD, linear regression shall be used provided the correlation factor is ≥ 0.99.

11.4.6.1. If %RSD exceeds 15% the analyst may do one of the following:

11.4.6.1.1. The correlation coeficient is ≥ 0.99 and the origin may not be forced through zero, linerar regression shall be used for quantitation.

11.4.6.1.2. If the compound with the RSD value greater than 15% is a non-target compound or non-detect in the associated samples, the analysis may continue with the present curve.

11.4.6.2. To determine the best approach, the analyst should assess the following:

11.4.6.2.1. Instrument's ability to attain PQL for this analyte. There needs to be sufficient sensitivity.

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11.4.6.2.2. Low and high points of curve accurately quantitate. (Recalculate low and high points using curve. Value calculated should be within 50% on the low point and 30% on the high point). If this is not the case, the calibration needs to be rerun for that analyte. Evaluate performance of each standard. Reanalyze and replace a standard as needed. See CAS Calibration Policy for guidance.

11.4.6.2.3. Obtain a secondary opinion from a senior analyst or supervisor.

11.4.6.2.4. The data user should be made aware of those compounds exceeding 15% RSD.

11.5. Daily GC/MS Calibration

11.5.1. A calibration standard at 80 ppm, containing all semivolatile analytes, including all required surrogates, must be analyzed every 12 hours during analysis. DFTPP must result in a mass spectrum for DFTPP which meets the criteria given in Table 2. These criteria must be demonstrated during each 12 hour shift. Compare the instrument response factor from the standards every 12 hours with the SPCC and response of pentachlorophenol, and benzidine. If significant change is observed, it may mean instrument maintenance is required.

11.5.2. System Performance Check Compounds (SPCCs): A system performance check must be made during every 12 hour shift. For each SPCC compound in the daily calibration a minimum response factor of 0.050 must be obtained. This is the same check that is applied during the initial calibration. If the minimum response factors are not met, the system must be evaluated, and corrective action must be taken before sample analysis begins. The minimum RF for semivolatile SPCCs is 0.050. Some possible problems are standard mixture degradation, injection port inlet contamination, contamination at the front end of the analytical column, and active sites in the column or chromatographic system. This check must be met before analysis begins.

11.5.3. Calibration Check Compounds (CCCs): After the system performance check is met, CCCs listed in Table 3 are used to check the validity of the initial calibration.

Calculate the percent drift using:

$$\%\ Drift = \frac{C_1 - C_c}{C_1} \times 100$$

where:

C_1 = Calibration Check Compound standard concentration.
C_c = Measured concentration using selected quantitation method.

11.5.4. If the percent difference for each CCC is less than or equal to 20%, the initial calibration is assumed to be valid. If the criterion is not met (> 20% drift) for any one CCC, corrective

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action must be taken. Problems similar to those listed under SPCCs could affect this criterion. If no source of the problem can be determined after corrective action has been taken, a new five-point calibration must be generated. This criterion must be met before sample analysis begins. If the % RSD for non-CCC compounds exceeds 30%, the analyst must determine if the response is sufficient to attain PQL for that analyte.

11.5.5. The internal standard responses and retention times in the calibration check standard must be evaluated immediately after or during data acquisition. If the retention time for any internal standard changes by more than 30 seconds from the last calibration check (12 hours), the chromatographic system must be inspected for malfunctions and corrections must be made, as required. If the EICP area for any of the internal standards changes by a factor of two (-50% to +100%) from the last CCV corrections must be made, as appropriate. Once corrections have been made, reanalysis of associated samples is required. Update the reference spectra and retention times in the quanitiation database for the instrument method or ID file. The initial calibration average RF or calibration curve is then used in the quanitiation of subsequent analyses.

11.6. GC/MS Analysis

11.6.1. Spike the 1 ml extract obtained from sample preparation with 10 µL of the internal standard solution just prior to analysis. Use the same operating conditions as was used for initial calibration.

11.6.2. If the response for any quantitation ion exceeds the initial calibration curve range of the GC/MS system, extract dilution must take place. Additional internal standard must be added to the diluted extract to maintain the required 40ng/µL of each internal standard in the extracted volume. The diluted extract must be reanalyzed. Dilutions are performed as per the company ADM-DIL SOP.

11.6.3. Store the extracts at 4°C, protected from light in screw-cap vials equipped with unpierced Teflon lined septa. Archive extract in freezer for 3 months after analysis.

11.7. Data Interpretation

11.7.1. The qualitative identification of compounds determined by this method is based on retention time, and comparison of the sample mass spectrum, after background correction, with characteristic ions in a reference mass spectrum. The reference mass spectrum must be generated by the laboratory using the conditions of this method. The characteristic ions from the reference mass spectrum are defined to be the three ions of greatest relative intensity, or any ions over 30% relative intensity if less than three such ions occur in the reference spectrum. Compounds should be identified as present when the criteria below are met.

11.7.1.1. The intensities of the characteristic ions of a compound maximize in the same scan or within one scan of each other. Selection of a peak by a data system target compound search routine where the search is based on the presence of a target

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chromatographic peak containing ions specific for the target compound at a compound-specific retention time will be accepted as meeting this criterion.

11.7.1.2. The RRT of the sample component is within ± 0.06 RRT units of the RRT of the standard component.

11.7.1.3. The relative intensities of the characteristic ions agree within 30% of the relative intensities of these ions in the reference spectrum.

11.7.1.4. Structural isomers that produce very similar mass spectra should be identified as individual isomers if they have sufficiently different GC retention times. Sufficient GC resolution is achieved if the height of the valley between two isomer peaks is less than 25% of the sum of the two peak heights. Otherwise, structural isomers are identified as isomeric pairs.

11.7.1.5. Identification is hampered when sample components are not resolved chromatographically and produce mass spectra containing ions contributed by more than one analyte. When gas chromatographic peaks obviously represent more than one sample component (i.e., a broadened peak with shoulder(s) or a valley between two or more maxima), appropriate selection of analyte spectra and background spectra is important. Examination of extracted ion current profiles of appropriate ions can aid in the selection of spectra, and in qualitative identification of compounds. When analytes coelute (i.e., only one chromatographic peak is apparent), the identification criteria can be met, but each analyte spectrum will contain extraneous ions contributed by the coeluting compound.

11.7.2. For samples containing components not associated with the calibration standards, a library search may be made for the purpose of tentative identification. (See TIC SOP)

12. QA/QC REQUIREMENTS

12.1. In addition to instrument QC, the ability of each analyst/instrument to generate acceptable accuracy and precision must be documented prior to sample analysis. Refer to ADM-TRANDOC and IDC study requirements.

12.2. QC Sample requirements are shown in the analytical method. Method blanks, laboratory control samples, and matrix spikes are performed once per 20 samples. Client specific QC requirements shall always be considered for matrix-specific QC.

12.3. Acceptance Criteria For QC Samples

12.3.1. Acceptance criteria for lab control samples are listed in Table 4.

12.3.2. Evaluation of method blank acceptability is as follows. The method blank must demonstrate that interferences from the analytical and preparation steps are under control. No

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target analytes should be detected above the PQL in the method blank. If targets are detected greater than the PQL, reextract the batch or flag the data appropriately.

12.3.3. If a surrogate(s) fails acceptance, the sample must be evaluated for matrix interferences and "historical results". Reanalyze the sample to confirm the interference. If confirmed, re-extract the sample unless confirmed by MS/MSD or there is insufficient sample volume. If needed contact client and flag the data in the report. If surrogates are diluted more than 10 times, report as "D", diluted below calibration. For package reports, include initial and confirmation analysis results.

12.3.4. If the lab control sample (LCS) fails acceptance limits for any target compounds, the analyst must evaluate the system and calibration. If no problems are found, then the batch QC must be evaluated to determine what corrective action must be taken. This may involve the Project Manager or Department Supervisor. Corrective action will depend on specific project, client, or state agency. Typically, the sample may be reanalyze to confirm the outliers. The batch shall be re-extracted or the data may be flagged in final report.

12.3.5. If the matrix spike fails acceptance, the sample must be evaluated for matrix interferences requirements. Evaluate the recovery of the duplicate MS and/ or batch LCS. If the LCS is acceptable, continue with the analysis and assume matrix interferences, otherwise the batch should be re-extracted based upon sample availability.

12.3.6. Internal standards must have RT ± 0.5 min from the ICAL for the CCV and ± 0.5 from the CCV for the samples. Any outliers for the ICAL or CCV requires a new ICAL. CCV internal standard area counts must be -50% to 100% of the initial calibration mid-point standard area counts, otherwise, a new curve is required.

12.3.7. Sample internal standard are area counts must be -50% to 100% of the CCV area counts. Any internal standard outlier should be reanalyzed unless a matrix interference can be clearly demonstrated by the first analysis. Associated results from each outlying Internal Standard shall be flagged as estimated.

12.3.8. Additional QA/QC measures include annual evaluation of method detection limits (See ADM-MDL) and control charting of QC (See ADM-CHRT) sample results.

13. DATA REDUCTION AND REPORTING

13.1. Sample concentrations are reported in µg/L for waters and µg/kg for soils and other non-aqueous samples.

13.2. Calculations: When a parameter has been identified, the quantitation of that parameter will be based on the integrated abundance from the EICP of the primary characteristic m/z. Use the base peak m/z for internal and surrogate standards.

13.3. Internal standard calibration - Linear calibration

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13.3.1. The concentration of each analyte in the sample is calculated using the results of the initial calibration, according to one of the following sections, depending on the sample matrix:

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13.3.1.1. Aqueous samples

$$\text{Concentration } (\mu g/L) = \frac{(A_s)(C_{is})(D)(V_i)}{(A_{is})(\overline{RF})(V_s)(1000)}$$

Where:
A_s = Area (or height) of the peak for the analyte in the sample.
A_{is} = Area (or height) of the peak for the internal standard.
C_{is} = Concentration of the internal standard in the concentrated sample extract in µg/L.
D = Dilution factor, if the sample or extract was diluted prior to analysis. If no dilution was made, D=1. The dilution factor is always dimensionless.
V_i= Volume of the extract injected (µL). The nominal injection volume for samples and calibration standards must be the same.
$\overline{RF}$ = Mean response factor from the initial calibration. Unlike calibration factors for external standard calibration, the response factor is dimensionless.
V_s = Volume of the aqueous sample extracted or purged (mL). If units of liters are used for this term, multiply the results by 1000.
The 1000 in the denominator represents the number of µL in 1 mL. If the injection (V_i) is expressed in mL, then the 1000 may be omitted.

Using the units specified here for these terms will result in a concentration in units of ng/mL, which is equivalent to µg/L.

13.3.1.2. Nonaqueous samles

$$\text{Concentration } (\mu g/kg) = \frac{(A_s)(C_{is})(D)(V_i)}{(A_{is})(\overline{RF})(W_s)(1000)}$$

Where:
A_s, A_{is}, C_{is}, D and $\overline{RF}$ are the same as for aqueous samples, and
W_s = Weight of sample extracted (g). Either a dry weight or wet weight nay be used, depending upon specific application of the data. If units of kilograms are used for this term, multiply the results by 1000.
The 1000 in the denomonator represents the number of µL in 1 mL. If the injection (vi) is expressed in mL, then the 1000 may be omitted.

Using the units specified here for these terms will result in a concentration in units of ng/g which is equivalent to µg/kg.

13.4. Use the appropriate report forms, which list the practical quantitation limits (PQLs) in Table 1.

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13.5. Sample concentrations are reported when all QC criteria for the analysis have been met or the results are qualified with a footnote.

13.6. Data reporting and review is handled by a computerized LIMS System. Specifics pertaining to reporting and review are discussed in ADM-DREV.

13.7. Accuracy is a measure of the closeness of an individual measurement (or an average of multiple measurements) to the true or expected value. Accuracy is determined by calculating the mean value of results from ongoing analyses of standard reference materials, standard solutions and laboratory-fortified blanks

$$\text{Accuracy (\%REC)} = \frac{A - B}{C} \times 100$$

Where:
A = Analyte total concentration from spiked sample
B = Analyte concentration from unspiked sample
C = Concentration of spike added

13.8. Precision is the ability of an analytical method or instrument to reproduce its own measurement. It is a measure of the variability, or random error, in sampling, sample handling and in laboratory analysis.

$$\text{RPD} = \frac{D1 - D2}{(D1+D2)/2} \times 100$$

Where:
D1 = Original Result
D2 = Duplicate Result

14. WASTE MANAGEMENT AND POLLUTION PREVENTION

14.1. It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

14.2. Excess, unused sample and testing byproducts are disposed following the procedures in the *SOP for Waste Disposal.*

15. REFERENCES

15.1. Test methods for Evaluating Solid Waste Physical/ Chemical Methods," SW-846 revision 3, Jan. 1995.

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16. TRAINING OUTLINE

16.1. Read current SOP and applicable methodologies. Demonstrate a general understanding of the methodology and chemistry by verbally discussing the procedure with your supervisor. Document SOP revision on training form. Copies of SOP shall not be made unless approved by QA department.

16.2. Observe Sample Preparation and Analysis.

16.3. Participate in the methodology, documentation, and data reduction with guidance.

16.4. Demonstrate Competency by performing the analysis independently. Analyze a known proficiency or standard. If recovery is within acceptable limits, complete training form, initial demonstration of capabilities and have the supervisor sign-off as being proficient.

17. INSTRUMENT SPECIFIC ADDENDUM

None, see instrument manuals located in the instrument lab.

18. ATTACHMENTS

- Table 1 Practical Quantitation Limits
- Table 2 DFTPP Key Ions and Abundance Criteria
- Table 3 Calibration Check Compounds (CCC)
- Table 4 Acceptance Criteria for Surrogates, MS, LCS

- Attachment I HP Chemstation Enviroquant Method Settings, Quant. Ions, and Estimated Retention Times.

19. CHANGES FROM LATEST REVISION

- Added Sections 8.0, 10.0, 13.0, 14.0, 16.0, 17.0, 18.0, and 19.0 for CAS and Nelac compliance.
- Added terms to Section 3.0.
- Revised Section 6.1 to include SOP refernces per Ohio VAP and Navy requirements.
- Revised Section 13.0 to include accuracy and precision.
- Revised Section 11.0 to include calibration and corrective action.

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TABLE 2
DFTPP KEY IONS AND ION ABUNDANCE CRITERIA

Mass	Ion Abundance Criteria
51	30-60% of mass 198
68	< 2% of mass 69
70	< 2% of mass 69
127	40-60% of mass 198
197	< 1% of mass 198
198	Base peak, 100% relative abundance
199	5-9% of mass 198
275	10-30% of mass 198
365	> 1% of mass 198
441	Present but less than mass 443
442	> 40% of mass 198
443	17-23% of mass 442

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TABLE 3
CALIBRATION CHECK COMPOUNDS (CCC)

Base/Neutral Fraction	**Acid Fraction**
Acenaphthene	4-Chloro-3-methylphenol
1,4-Dichlorobenzene	2,4-Dichlorophenol
Hexachlorobutadiene	2-Nitrophenol
Di-n-octyl phthalate	Pentachlorophenol
Fluoranthene	2,4,6-Trichlorophenol
Benzo(a)pyrene	

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TABLE 4
SURROGATE SPIKE PERCENT RECOVERY LIMITS FOR WATER AND SOIL/SEDIMENT SAMPLES

Surrogate Compound	Water	Soil/Sediment
Nitrobenzene-d_5	35-114	23-120
2-Fluorobiphenyl	43-116	30-115
p-Terphenyl-d_{14}	33-141	18-137
Phenol-d_6	10-94	24-113
2-Fluorophenol	21-100	25-121
2,4,6-Tribromophenol	10-123	19-122

MATRIX SPIKE PERCENT RECOVERY LIMITS FOR WATER AND SOIL/SEDIMENT SAMPLES

Matrix Spike Compound	Water	Soil/Sediment
Phenol	12-110	26-90
2-Chlorophenol	27-123	25-102
1,4-Dichlorobenzene	36-97	28--104
N-Nitrosodi-n-propylamine	41-116	41-126
1,2,4-Trichlorobenzene	39-98	38-107
4-Chloro-3-methylphenol	23-97	26-103
Acenaphthene	46-118	31-137
4-Nitrophenol	10-80	11-114
2,4-Dinitrotoluene	24-96	28-89
Pentachlorophenol	9-103	17-109
Pyrene	26-127	35-142

LABORATORY CONTROL SAMPLE PERCENT RECOVERY LIMITS

Compound	Water	Soil/Sediment
Phenol	12-110	26-90
2-Chlorophenol	27-123	25-102
1,4-Dichlorobenzene	36-97	28-104
N-Nitrosodi-n-propylamine	41-116	41-126
1,2,4-Trichlorobenzene	39-98	38-107
4-Chloro-3-methylphenol	23-97	26-103
Acenaphthene	46-118	31-137
4-Nitrophenol	10-80	11-114
2,4-Dinitrotoluene	24-96	28-89
Pentachlorophenol	9-103	17-109

Pyrene	26-127	35-142

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ATTACHMENT I

HP CHEMSTATION ENVIROQUANT METHOD SETTINGS, QUANT. IONS, AND ESTIMATED RETENTION TIMES

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STANDARD OPERATING PROCEDURE

CHLORINATED HERBICIDES by GAS CHROMOTOGRAPHY

SOC-8151A

Revision 1.0

October 7, 2000

Approved by: _____ _____
Supervisor Date

_____ _____
QA Coordinator Date

_____ _____
Laboratory Manager Date

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1 Mustard Street, Suite 250
Rochester, New York 14609

Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
Initials: _____ Date: _____
Initials: _____ Date: _____

DOCUMENT CONTROL

NUMBER: _____

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1. SCOPE AND APPLICATION

1.1 This method is used to determine the concentrations of chlorinated herbicides in water and soil. Table 1 indicates compounds that may be determined by this method and lists the practical quantitation limit (PQL) for each compound in water and soil. The form of each acid herbicide (salts and esters) occurring in the sample is not distinguished by this method. The results are calculated and reported for each analyte as the total free acid herbicide.

1.2 The method is restricted to use by, or under the supervision of analysts experienced in the use of gas chromatographs (GC) and skilled in the interpretation of gas chromatograms. Each analyst must demonstrate the ability to generate acceptable results with this method.

1.3 Only experienced analysts should be allowed to work with diazomethane due to potential hazards associated with its use (explosive, carcinogenic).

2. METHOD SUMMARY

2.1 This method provides gas chromatographic conditions for the detection of chlorinated herbicides. Prior to the use of this method, an appropriate sample extraction technique must be used to recover the analytes. Water and soil samples are adjusted to a pH <2 S.U., and the herbicides in both acid and ester forms are extracted with diethyl ether and hydrolized. Extraneous organic material is removed by a solvent wash. The sample is acidified, and the acid herbicides are extracted. The acids are then converted to their methyl esters using diazomethane. A 1 µL aliquot of the derivatized extract is injected into the gas chromatograph (GC). The compounds are separated on a fused silica capillary column and detected by an electron capture detector.

2.2 Compound identification based on single-column analysis should be confirmed on a second column.

2.3 This method describes a dual-column option. The option allows a hardware configuration of two analytical columns joined to a single injection port. The option allows one injection to be used for dual-column analysis.

2.4 The sensitivity of this method depends on the level of interferences in addition to instrument limitations.

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3. DEFINITIONS

3.1 **Initial Calibration -** analysis of analytical standards for a series of different specified concentrations; used to define the linearity and dynamic range of the response of the electron capture detector to the target compounds.

3.2 **Laboratory Control Sample -** a matrix spiked sample with compounds representative of the target analytes. This is used to document laboratory performance.

3.3 **Matrix -** the predominant material, component, or substrate (e.g., surface water, drinking water, etc.) of which the sample to be analyzed is composed.

3.4 **Matrix Spike -** an aliquot of sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike is used to document the bias of a method in a given sample marix.

3.5 **Method Blank -** an analyte-free matrix to which all reagents are added in the sample volumes or proportions as used in sample processing. The method blank should be carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination resulting from the analytical process.

3.6 **Percent Difference (%D) -** Used to compare two values, the percent difference indicates both the direction and the magnitude of the comparison, i.e., the percent difference may be either negative, positive, or zero. (In contrast, see relative percent difference).

3.7 **Sample -** a portion of material to be analyzed that is contained in single or multiple containers and identified by a unique sample number.

3.8 **Surrogates** (Surrogate Standards) - an organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical process Surrogate compounds are added to every blank, sample, matrix spike, matrix spike duplicate, LCS, matrix spike blank, and standard. These are used to evaluate analytical efficiency by measuring recovery. Surrogates are not expected to be detected in environmental media.

3.9 **Organic Free Reagent Water** - ASTM Type II Deionized Water.

3.10 **Relative Percent Difference -** The difference of two values divided by the absolute value of average of the same two values. Used to compare the precision

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of the analysis. The result is always positive.

3.11 **Batch -** Samples processed together as a unit, not to exceed 20 investigative samples.

4. INTERFERENCES

4.1 Organic acids, especially chlorinated acids, cause the most direct interference with the determination. Phenols, including chlorophenols may also interfere with this procedure. Alkaline hydrolysis and subsequent extraction of the basic solution removes many chlorinated hydrocarbons and phthalate esters that might otherwise interfere with the electron capture analysis. However, hydrolysis may result in the loss of dinoseb and the formation of aldol condensation products if any residual acetone remains from the extraction of solids.

4.2 The herbicides, being strong organic acids, react readily with alkaline substances and may be lost during analysis. Therefore, glassware must be acid-rinsed and then rinsed to constant pH with organic-free reagent water. Sodium sulfate must be acidified.

4.3 Sample extracts should be dry prior to methylation or else poor recoveries will be obtained.

5. SAFETY

5.1 The toxicity or carcinogenicity of each reagent used in this method has not been precisely determined; however, each chemical should be treated as a potential health hazard. Exposure to these reagents should be reduced to the lowest possible level. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets should be made available to all personnel involved in these analyses. Specifically, concentrated sulfuric acid and the 50% sodium hydroxide solution are moderately toxic and extremely irritating to skin and mucous membranes. Use these reagents in a fume hood whenever possible and if eye or skin contact occurs flush with large volumes of water. Always wear safety glasses or a shield for eye protection, and protective clothing, and observe proper mixing when working with these reagents.

5.2 The use of Diazomethane requires special consideration. It is a toxic carcinogen which can explode under certain conditions. The following precautions must be followed:

5.2.1 Use only a well ventilated hood - do not breath the vapors.

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5.2.2 Use a safety screen.

5.2.3 Use mechanical pipetting aides.

5.2.4 Do not heat above 90°C - Explosion may result.

5.2.5 Avoid grinding surfaces, ground glass joints, sleeve bearings, glass stirrers - Explosion may result.

5.2.6 Store away from alkali metals - Explosion may result.

5.2.7 Solutions of diazomethane decompose rapidly in the presence of solid materials such as copper powder, calcium chloride, and boiling chips.

6. SAMPLE COLLECTION, CONTAINERS, PRESERVATION, AND STORAGE

6.1 Sample collection, preservation, and custody management is handled by the sample management office (SMO). Refer to the SMO-GEN for specifics.

6.2 Purchased, precleaned, certified sample containers should be glass or Teflon, and have screw-caps with Teflon lined septa. In situations where Teflon is not available, solvent-rinsed aluminum foil may be used as a liner. However, acidic or basic samples may react with the aluminum foil, causing eventual contamination of the sample. Plastic containers or lids may NOT be used for the storage of samples due to the possibility of sample contamination from the phthalate esters and other hydrocarbons within the plastic. Sample containers should be filled with care so as to prevent any portion of the collected sample coming in contact with the sampler's gloves, thus causing contamination. Samples shall be stored at 0-6°C and shipped to the laboratory within 48 hrs.

6.3 Water and soil samples must be iced or refrigerated at 0-6°C from the time of collection until extraction.

6.4 Water samples must be extracted within 7 days from sample collection and the extracts analyzed within 40 days following extraction. Soil samples must be extracted within 14 days and the extract analyzed within 40 days following extraction.

7. APPARATUS AND EQUIPMENT

7.1 Gas Chromatograph/ Electron Capture Detector (GC/EC) System

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7.1.1 Gas Chromatograph - Hewlett Packard 5890 with a split/splitless injector and dual electron capture detectors.

7.1.2 Columns - two 0.32mm id fused silica capillary columns are used. A separate detector is used for each column. The analytical columns are:

- J & W DB-1701 (30 meter, 0.32 mm id, 0.25 µm df).
- J & W DB-17 (30 meter, 0.32 mm id, 0.25 µm df).

Columns are installed using a deactivated glass "y" connector and a 5 meter Restek siltek deactivated guard column (0.53mm id) which allows simultaneous injection onto both columns.

7.1.3 Carrier Gas - Helium. All GC carrier gas lines must be constructed from stainless steel or copper tubing. Non-polytetrafluorethylene (Ptfe) thread sealants or flow controllers with rubber components are not to be used.

7.1.4 Electron Capture Detector (ECD) - the linearity of the response of the ECD may be greatly dependent on the flow rate of the make-up gas. The make-up gas must be P-5, (argon/methane). Care must be taken to maintain stable and appropriate flow of make-up gas to the detector. The GC/ECD system must be in a room in which the atmosphere has been demonstrated to be free of all contaminants which may interfere with the analysis. The instrument must be vented to a trapping system which prevents the release of contaminants into the instrument room.

7.1.5 Data System - a data system must be interfaced to the GC/EC. The data system must allow the continuous acquisition of data throughout the duration of the chromatographic program and must permit, at the minimum, the output of time vs. intensity (peak height or peak area) data. Also, the data system must be able to rescale chromatographic data in order to report chromatograms meeting the requirements listed within this method.

7.2 Separatory funnel - 2 liter and 500 mL, with Teflon or glass stopcock.

7.3 Erlenmeyer Flasks - 250 mL and 500 mL.

7.4 Kuderna-Danish (K-D) apparatus.

7.4.1 Concentrator tube - 10 ml, graduated (Kontes K-570050-1025 or equivalent).

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7.4.2 Evaporation flask - 250 ml and 500 ml (Kontes K-570001-500 or equivalent). Attach to concentrator tube with clamps.

7.4.3 Snyder column - Three ball macro (Kontes K-503000-0121 or equivalent).

7.4.4 Clamps - (Keck No. 19 and No. 24, or equivalent).

7.5 Glass boiling beads -3 mm glass beads.

7.6 Water bath - Heated, with concentric ring cover, capable of temperature control (± 5°C). The bath should be used in a hood.

7.7 Vials and Caps- 20 mL scintillation vials with screw cap and aluminum foil liner, 2 ml capacity glass with crimp tops for GC auto sampler.

7.8 pH indicator paper - wide range.

7.9 Pipets- glass volumetric 1 mL or 2 mL, and Pasteur 5 ¾" and 9" disposable and microliter syringes.

7.10. Centrifuge Tube - 12 to 15 mL.

7.11. 5 inch Pyrex funnel with a small pad of pyrex glass wool, acid washed.

7.12. Volumetric flasks - 10, 25, 50 and 100 mL for preparation of standards and spikes.

7.13. Graduated Cylinder - 1 L capacity.

7.14. Centrifuge - table top.

7.15. Nitrogen Evaporation Device - equipped with a heated bath that can be maintained at 35-40°C (N-Evap by Organomation Associates, Inc., South Berlin, MA, or equivalent).

7.16. Oven - drying.

7.17 Balance - Analytical, capable of accurately weighing to 0.001g.

7.18 Wrist Shaker - Burrell Model 75.

7.19 Diazomethane generator apparatus - Use 2- 40 mL EPA VOA vials and a source of

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nitrogen. Pierce the VOA vial teflon septas with 2 holes each. Use 4 - 9" pasteur pipets for delivery tubes. The generator assembly is shown in Figure 1. The procedure for using this generator is given in Section 11.

8. PREVENTIVE MAINTENANCE

8.1 Glass Insert/Sleeve-single Gooseneck. Indicators are loss of sensitivity and linearity of the target compounds. The insert should always be replaced before a new calibration and the o-ring should be replaced with the insert.

8.2 Septum - Replaced approximately every 150 injections. A retention time shift or poor baseline chromatography is a common symptom.

8.3 Autosampler syringe - Cleaned daily and after samples with a particularly bad matrix. The syringe should be rinsed with hexane; the plunger is rinsed, wiped with a kim wipe, and rinsed again. The syringe should be replaced with a new one if loose action is noted or inconsistent action is evident (uniform fluctuation in response, area counts) or obvious wear.

8.4 Injection Port - The port and the port/column interface should be cleaned as needed (when replacing the insert is ineffective and in conjunction with column prunning). Port should be reamed with a wire brush and swabbed with hexane. Disc and washer can be sonicated in methylene chloride and then silanized, but should be replaced if wear is evident. The capillary inlet should also be cleaned in hexane and the septum nut is sonicated in hexane also.

8.5 Column Pruning - Cut back one revolution as needed. Indicators are same as insert replacement and is another remedy if insert replacement does not yield the desired results. After initial cut, a graphite ferrule should first be installed and then another short length of column removed (cut should be carefully examined for smoothness - no jagged edges). The column end should extend 7mm past the ferrule when installed (use white out or septum marking method for reference).

8.6 Column Replacement - As needed, usually every 4-6 months for moderate sample volumes. Symptoms are ineffectiveness of insert replacement, injector cleaning, or column pruning to rectify a problem. All ferrules replaced with column change.

8.7 Syringe Rinse Solvent - Supply is replenished as needed. Old solvent is discarded and vial rinsed before refilling. Rinse waste and sample waste vials are replaced when residue appears.

8.8 Carrier Gas - Tank is changed before pressure reaches approximately 200psi to avoid impurities that may be delivered by a nearly empty tank. Leak check with snoop

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after change.

8.9 System baking - When the system is to be idle oven temperature should be set to 100°C to avoid water vapor condensation in column. Baking of injector, column, interface may be done for short periods of time to eliminate contaminants due to sample matrix residuals. Temperature should not exceed recommended column temperature limits.

8.10 Maintenance Log - All preventive maintenance as well as instrument repair should be documented in the appropriate instrument maintenance log.

9. STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

9.1 Reagents

9.1.1 Acetone, methylene chloride, hexane, iso-octane, and methanol - pesticide quality or equivalent. It is recommended that each lot of solvent used be analyzed to demonstrate that it is free of interference before use. See ADM-CTMN. Expires as per manufacturer's indications.

9.1.2 Diethyl Ether, $C_2H_5OC_2H_5$. Burdick and Jackson Cat # 107-4, no preservatives. Do not use ethanol - stabilized ether, the methylation reaction may not proceed efficiently, leading to low recoveries of target analytes. Expires as per manufacturer's indications.

9.1.3 Sodium chloride (crystals), NaCl - EM science Cat #SX0420-22. . Expires as per manufacturer's indications.

9.1.4 Potassium Hydroxide (37% aqueous solution (w/v)), KOH - Dissolve 37 g of potassium hydroxide pellets in organic free reagent water and dilute to 100 mLs.

9.1.5 Sodium sulfate (granular, acidified, anhydrous), Na2SO4 - EM Science Cat # SX0760E-20. Purify by heating at 400°C for 4 hours in a shallow tray, or by precleaning the sodium sulfate with methylene chloride. Acidify by slurrying 100 g sodium sulfate with enough diethyl ether to just cover the solid; then add 0.1 mL of Concentrated sulfuric acid and mix thoroughly. Remove the ether under vacuum. Mix 1 g of the resulting solid with 5 mL of organic - free reagent water and measure the pH of the mixture. It must be below a pH of 4. Store the remaining solid at 130°C.

9.1.6 N-methyl-N-nitroso-p-toluenesulfonamide (Diazald) - High purity Aldrich

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Chemical Co., Cat # D2,800-0. Store at 0-6 °C. Expires upon manufacturer's indications.

9.1.7 Silicic acid H_2SiO_5 - 100-mesh powder, Aldrich Cat #28,877-2. Expires upon manufacturer's indications.

9.1.8 Carbitol (diethylene glycol monoethyl ether), $C_2H_5OCH_2CH_2OCH_2CH_2O$ - Acros Organics Cat# 11789-0025. For producing alcohol-free diazomethane. Expires upon manufacturer's indications.

9.1.9 pH Adjustment Solutions

9.1.9.1 Sodium hydroxide, NaOH, 6 N.

9.1.9.2 Sulfuric acid, H_2SO_4, 12 N.

9.1.9.3 Hydrochloric acid, HCl, concentrated.

9.2 Standards - Manufacturer's certificates of analysis are retained by the lab and presented upon request. All standards must be traceable using the CAS lot system, see ADM-SPSR. . Samples, sample extracts and standards must be stored separately.

9.2.1 Stock standard solutions-are purchased as certified solutions.

9.2.1.1 Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. These standards expire upon manufacturer's indications, or sooner if comparison with check standards indicates a problem. Herbicide stocks are purchased from Ultra Scientific at 100.0 ppm in acetone.

9.2.1.2 The surrogate 2,4 - Dichlorophenyl acetic acid (DCAA) is also purchased from Ultra Scientific at 100.0 ppm in Acetone. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials.These standards expire upon manufacturer's indications, or sooner if comparison with check standards indicates a problem.

9.2.2 Secondary Dilution Standards

9.2.2.1 Using stock standards, prepare secondary dilution standards in hexane that contain the compounds of interest mixed together. Secondary dilution standards are prepared by a 1.0 mL to 100.0 mL dilution of 100 ppm in hexane to yield 1000 ppb mid-stock. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Fresh standards should be prepared every six months, or sooner if comparison with check standards

indicates a problem.

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Preparation of Calibration Standards

Dilute Mid-Stock (1000ppb) Standard in hexane as follows to prepare calibration standards.

Compound	Std 1 (ppb). 25/50 mLs	Std 2 (ppb) 20/50 mLs	Std. 3 (ppb) 12.5/50 mLs	Std 4 (ppb) 5/50 mLs	Std 5 (ppb) 2.5/50 mLs.
DCAA	500	400	250	100	50
Dicamba	500	400	250	100	50
2,4-D	500	400	250	100	50
2,4,5-T	500	400	250	100	50
Silvex	500	400	250	100	50
Dinoseb	500	400	250	100	50

9.3 Surrogate Spiking Solution

9.3.1 2,4 - Dichlorophenylacetic acid (DCAA) solution for soils - a 10.0 mg neat stock obtained from Accustandard (Catalog #P-244N) dissolved in 100.0 mLs of methanol to yield 100 ppm. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Prepare fresh every six months, or sooner if comparison with check standards indicates a problem.

9.3.2 2,4 - Dichlorophenylacetic acid (DCAA) solution for waters – 5.0 mLs of the above soil surrogate solution diluted to 100.0 mLs in methanol to yield 5 ppm. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Prepare fresh every six months, or sooner if comparison with check standards indicates a problem.

9.4 Matrix spike/ Laboratory Control Sample Spiking Solution

9.4.1 MS/LCS Spike for soils – 10.0 mg neat stock in acid form obtained from Accustandard, of the following compounds : 2,4-D, Dinoseb, 2,4,5-T, Dicamba and Silvex, diluted to 100.0 mls in methanol yields a 100 ppm soil spike. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Prepare fresh every six months, or sooner if comparison with check standards indicates a problem.

9.4.2 MS/LCS spike for waters - 2.5 mLs of the above soil spike diluted to 100.0 mLs in methanol yields a 2.5 ppm water spike. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Prepare fresh every six months, or sooner if comparison with check standards indicates a

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problem.

9.5 Samples, sample extracts, and standards must be stored separately.

10. RESPONSIBILITIES

10.1 It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP perform the analysis and interpretation of the results. This demonstration is in accordance with the training program of the laboratory. The department supervisor or designee performs final review and sign-off of the data.

11. PROCEDURE

Aqueous Samples

11.1 Manual Hydrolysis, Preparation, And Extraction.

11.1.1 Mark the water meniscus on the side of the sample bottle for later determination of sample volume. Pour the entire sample into a 2-L separatory funnel. Fortify sample with 1.0 ml of the water surrogate spiking solution.

11.1.2 Add 250 g NaCl to the sample, seal, and shake to dissolve salt.

11.1.3 Add 17 ml of 6 N NaOH to the sample, seal, and shake. Check the pH of the sample with pH paper; if the sample does not have a pH greater than or equal to 12, adjust the pH by adding more 6 N NaOH. Let the sample sit at room temperature for 2 hrs, shaking the separatory funnel and contents periodically.

11.1.4 Add 60 ml methylene chloride to the sample bottle to rinse the bottle, transfer the methylene chloride to the separatory funnel and extract the sample by vigorously shaking the funnel for 2 minutes with periodic venting to release excess pressure. Allow the organic layer to separate from the water phase for a minimum of ten minutes. If the emulsion interface between layers is more than one-third the volume of the solvent layer, the sample must be centrifuged to complete phase separation. Discard the methylene chloride phase.

11.1.5 Add a second 60-ml volume of methylene chloride to the sample bottle and repeat the extraction procedure a second time, discarding the methylene

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chloride layer. Perform a third extraction in the same manner.

11.1.6 Add 17 ml of 12 N H_2S0_4 to the sample, seal, and shake to mix. Check the pH of the sample with pH paper; if the sample does not have a pH less than or equal to 2, adjust the pH by adding more H_2S0_4.

11.1.7 Add 120 ml diethyl ether to the sample, seal, and extract the sample by vigorously shaking the funnel for 2 minutes with periodic venting to release excess pressure. Allow the organic layer to separate from the water phase for a minimum of 10 minutes. If the emulsion interface between layers is more than one third the volume of the solvent layer, the sample must be centrifuged to complete the phase separation. Remove the aqueous phase to a 2-L Erlenmeyer flask and collect the ether phase in a 500-ml Erlenmeyer flask containing approximately 10 g of acidified anhydrous sodium sulfate. Periodically, vigorously shake the sample and drying agent.

11.1.8 Return the aqueous phase to the separatory funnel, add a 60 ml volume of diethyl ether to the sample, and repeat the extraction procedure a second time, combining the extracts in the 500 ml Erlenmeyer flask. Perform a third extraction with 60 ml of diethyl ether in the same manner. Allow the extract to remain in contact with the sodium sulfate for approximately 2 hours.

11.1.9 Determine the original sample volume by refilling the sample bottle to the mark and transferring the water to a 1000-ml graduated cylinder. Record the sample volume to the nearest 5-ml.

11.1.10 Proceed with concentration steps.

11.2 Soil Samples

11.2.1 Add 50 g of the well mixed, moist solid sample to a 500-mL wide-mouth Erlenmeyer flask. Adjust the pH to 2 with concentrated HCl and monitor the pH for 15 minutes with occasional stirring. Insert a clean glass stirring rod into the sample mixture and blot onto pH paper. If necessary, add additional HCl until the pH remains at 2. Spike the sample with surrogate.

11.2.2 Add 20 mL of acetone to the flask and mix the contents with the wrist shaker for 20 minutes. Add 80 mL diethyl ether to the same flask and shake again for 20 minutes. Decant the extract and measure the volume of solvent recovered.

11.2.3 Extract the sample twice more using 20 mL of acetone followed by 80 mL of diethyl ether. After addition of each solvent, the mixture should be shaken with the wrist shaker for 10 minutes and the acetone-ether extract decanted.

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11.2.4 After the third extraction, the volume of extract recovered should be at least 75% of the volume of added solvent. If this is not the case, additional extractions may be necessary. Combine the extracts in a 2-L separatory funnel containing 250 mL of reagent water. If an emulsion forms, slowly add 5 g of acidified sodium sulfate (anhydrous) until the solvent-water mixture separates. A quantity of acidified sodium sulfate equal to the weight of the sample may be added, if necessary.

11.2.5 Check the pH of the aqueous layer by dipping a small strip of pH paper into sample volume using long forceps. If it is not at or below pH 2, add more concentrated HCl until stabilized at the desired pH. Gently mix the contents of the separatory funnel for 1 minute and allow the layers to separate. Collect the aqueous phase in a clean beaker and the extract phase (top layer) in a 500-mL ground glass-stoppered Erlenmeyer flask. Place the aqueous phase back into the separatory funnel and re-extract using 25 mL of diethyl ether. Allow the layers to separate and discard the aqueous layer. Combine the ether extracts in a 500-mL Erlenmeyer Flask.

11.2.6 Add 5 mL of 37% aqueous potassium hydroxide and 30 mL of water to the extract. Add additional boiling chips to the flask. Reflux the mixture on a water bath at 60 - 65°C until the hydrolysis step is completed (usually 1 - 2 hours). Remove the flasks from the water bath and cool to room temperature.

CAUTION: The presence of residual acetone will result in the formation of aldol condensation products which will cause GC interference.

11.2.7 Transfer the hydrolyzed aqueous solution to a 500-mL separatory funnel and extract the solution three times with 100-mL portions of methylene chloride. Discard the methylene chloride phase. At this point, the basic (aqueous) solution contains the herbicide salts.

11.2.8 Adjust the pH of the solution to <2 with cold (4°C) sulfuric acid (1:3) and extract once with 40 mL of diethyl ether and twice with acidified glass wool plugged 20-mL portions of ether. Combine the extracts and pour them through a pre-rinsed acidified glasswool plugged funnel containing acidified anhydrous sodium sulfate. Collect the dried extracts in a 500-mL Erlenmeyer flask (with a 24/40 joint) containing 10 g of acidified anhydrous sodium sulfate. Periodically, vigorously shake the extract and drying agent and allow the drying agent to remain in contact with the extract for a minimum of 2 hours.

11.2.9 Proceed with concentration steps.

11.3 Extract Concentration

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11.3.1 Assemble a Kuderna-Danish (K-D) concentrator by attaching a 10 ml concentrator tube to a 500 ml evaporation flask. Pour the extract into the K-D concentrator. Rinse the Erlenmeyer flask, which contained the solvent extract, with 20-30 ml of diethyl ether and add it to the K-D concentrator flask.

11.3.2 Add one or two clean glass boiling beads to the K-D concentrator and attach a three ball Snyder column. Pre-wet the Snyder column by adding about 1 ml of diethyl ether to the top of the column. Place the K-D apparatus on a hot water bath (80-90°C) so that the concentrator tube is partially immersed in the hot water and the entire lower rounded surface of the flask is bathed with hot vapor. Adjust the vertical position of the apparatus and the water temperature as required to complete the concentration in 10-20 minutes. At the proper rate of distillation the balls of the column will actively chatter, but the chambers will not flood. When the apparent volume of liquid reaches 5-7 ml, remove the K-D apparatus from the water bath and allow it to drain and cool for at least 10 minutes.

11.3.3 Remove the Snyder column and rinse the flask and its lower joints into the concentrator tube with 1-2 ml of diethyl ether.

11.3.4 A nitrogen blow-down technique is used to adjust the extract to the final volume required.

11.3.5 Place the concentrator tube in a warm bath (35-40°C) and evaporate the solvent volume to approximately 1 mL using nitrogen gas. The internal wall of the tube must be rinsed down several times with diethyl ether.

11.3.6 Dilute the extract with 1 mL of isooctane and 0.5 mL of methanol. Dilute to a final volume of 4 mL with diehyl ether. The sample is now ready for esterification.

11.4 Esterification:

11.4.1 Add 10 mL of diethyl ether to the first test tube. Add 2 mL of diethyl ether, 2 mL of Carbitol, 3.0 mL of 37% KOH, and 0.2 - 0.4 g of Diazald to the second test tube. Immediately place the exit tube into the concentrator tube containing the sample extract. Apply nitrogen flow (10 mL/min) to bubble diazomethane through the extract for 10 minutes or until the yellow color of diazomethane persists. The amount of Diazald used is sufficient for esterification of approximately three sample extracts. An additional 0.1 - 0.2 g of Diazald may be added (after the initial Diazald is consumed). To extend the generation of the diazomethane. There is sufficient KOH present in the original solution to perform a maximum of approximately 20 minutes of total esterification.

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11.4.2 Remove the concentrator tube and store at room temperature in a hood for 20 minutes.

11.4.3 Destroy any unreacted diazomethane by adding 0.1 - 0.2 g of silicic acid to the concentrator tube. Allow to stand until the evolution of nitrogen gas has stopped. Transfer the sample to a 20 mL scintillation vial and adjust the sample volume to 10.0 mL with hexane. Transfer the sample to a GC vial, and store refrigerated if further processing will not be performed immediately. Analyze by gas chromatography.

11.4.4 Extracts should be stored at 4°C away from light. Preservation study results indicate that most analytes are stable for 28 days; however, it is recommended that the methylated extracts be analyzed immediately to minimize the trans-esterification and other potential reactions that may occur.

11.5 Gas Chromatograph Operating Conditions

11.5.1 The gas chromatographic analytical conditions are summarized in the instrument specific addendum.

11.5.2 Optimize GC conditions for analyte separation and sensitivity. Once optimized, the same GC conditions must be used for the analysis of all standards, samples, blanks, LCS and MS/MSD. The linearity of the ECD may be greatly dependent on the flow rate of the make-up gas. Care must be taken to maintain stable and appropriate flow of make-up gas to the detector. The same injection volume must be used for all standards, blanks, and samples, including MS/MSD and LCS.

11.6 Initial Calibration

11.6.1 Summary of Initial Calibration.

Prior to the analysis of samples, including MS/MSD and required blanks, each GC/EC system must be initially calibrated at a minimum of five concentrations to determine instrument sensitivity and the linearity of response for single component target compounds and surrogates. The low standard establishes the reporting limit and the high standard establishes the linear range.

11.6.2 Frequency of Initial Calibration

Each GC/ECD system must be initially calibrated, whenever major instrument maintenance or modification is performed (e.g., column replacement or repair, cleaning or replacement of ECD, etc.) or if the calibration verification technical

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acceptance criteria have not been met.

11.6.3 Calibration Factors

Calculate the calibration factor for each analyte at each concentration, the mean calibration factor, and the relative standard deviation (RSD) of the calibration factors, using the formulas below.

11.6.3.1 Calculate the calibration factor for each analyte at each concentration as:

$$CF = \frac{\text{Peak area (or height) of the sta}}{\text{Mass injected (ng)}}$$

11.6.3.2 Calculate the mean calibration factor for each analyte as:

$$\overline{CF} = \sum_{i=}^{n}$$

where n is the number of standards analyzed.

11.6.3.3 Calculate the standard deviation (SD) and the RSD of the calibration factors for each analyte as:

$$SD_{CF} = \sqrt{\frac{\sum_{i=1}^{n} \left(CF_i - \overline{CF}\right)^2}{(n - 1)}} \qquad RSD = \frac{SD_{CF}}{\overline{CF}}$$

If the RSD for each analyte is ≤ 20%, then the response of the instrument is considered linear and the mean calibration factor can be used to quantitate sample results. If the RSD is >20%, then linearity through the origin cannot be assumed. The analyst must use a calibration curve whose correlation coefficient is greater than or equal to 0.99. The regression must not be forced through zero.

11.7 Gas chromatographic analysis of sample extracts.

11.7.1 The same GC operating conditions used for the initial calibration must be employed for samples analyses.

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11.7.2 Verify the calibration each 12 hour shift by injecting calibration verification standards prior to conducting any sample analyses. Analysts should alternate the use of high and low concentration mixtures of single-component analytes for calibration verification. A calibration standard should be injected at intervals of at least once every twenty samples (after every 10 samples is recommended to minimize the number of samples requiring re-injection when QC limits are exceeded) and at the end of the analysis sequence.

11.7.2.1 The calibration factor for each analyte to be quantitated must not exceed a ± 15 percent difference when compared to the initial calibration curve.

$$\%D = \frac{\overline{CF} - CFv}{\overline{CF}} X100$$

11.7.2.2 If this criteria is exceeded for any compound, calculate the average percent difference for all compounds. The average for all percent differences should be within 15% to proceed. If, however there is a positive result for a compound whose percent difference is greater than 15% the sample should be reanalyzed when the percent difference is less than 15%. This should be documented in any case narrative. For states, such as South Carolina, all compounds quantitated above the reporting limit must exhibit a %D<15% to proceed.

If this criterion is exceeded, inspect the gas chromatographic system to determine the cause and perform whatever maintenance is necessary before verifying calibration and proceeding with sample analysis. If routine maintenance does not return the instrument performance to meet the above requirements based on the last initial calibration, then a new initial calibration must be performed.

11.7.3 Compare the retention time of each analyte in the calibration standard with the absolute retention time windows established. As described in Method 8000, the center of the absolute retention time window for each analyte is its retention time in the mid-concentration standard analyzed during the initial calibration. Each analyte in each standard must fall within its respective retention time window. If not, the gas chromatographic system must either be adjusted so that a second analysis of the standard does result in all analytes falling within their retention time windows, or a new initial calibration must be performed and new retention time windows established.

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11.7.4 Tentative identification of an analyte occurs when a peak from a sample extract falls within the absolute retention time window. Each tentative identification must be confirmed with the second GC column.

11.7.5 If the response exceeds the calibration range of the system, dilute the extract and reanalyze. Dilutions are performed as per the company ADM-DIL SOP. Peak height measurements are recommended over peak area integration when overlapping peaks cause errors in area integration.

11.7.6 Each sample analysis must be bracketed with an acceptable initial calibration, calibration verification standard(s) (each 12- hour analytical shift), or calibration standards interspersed within the samples. When a calibration verification standard fails to meet the QC criteria, all samples that were injected after the standard that last met the QC criteria must be re-injected.

11.7.7 Sample injections may continue for as long as the calibration verification standards and standards interspersed with the samples meet instrument QC requirements. It is recommended that standards be analyzed after every 10 samples (required after every 20 samples and at the end of a set) to minimize the number of samples that must be re-injected when the standards fail the QC limits. The sequence ends when the set of samples has been injected or when qualitative and/or quantitative QC criteria are exceeded.

12. QA/QC REQUIREMENTS

12.1 Corrective Action for Surrogate Recovery

12.1.1 If the DCAA surrogate compound fails to meet the recovery acceptance criteria (Table 2), check calculations, sample preparation logs, the surrogate compound spiking solutions, and the instrument operation. If the calculations were incorrect, correct the calculations and verify that the surrogate compound recoveries meet their acceptance criteria. If no surrogate spiking solution was added or if the surrogate spiking solution was improperly prepared, concentrated, or degraded, re-extract and reanalyze the samples. If the instrument malfunctioned, correct the instrument problem and reanalyze the sample extract.

12.1.2 If the above actions do not correct the problem, then the problem may be due to a sample matrix effect. To determine if there was matrix effect, take the following corrective action steps.

12.1.2.1 Re-extract and reanalyze the sample. EXCEPTION: If surrogate compound recoveries in a sample used for a matrix spike and/or

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matrix spike duplicate were considered unacceptable, then it should be re-extracted/ re-analyzed only if surrogate compound recoveries met the surrogate acceptance criteria in both the matrix spike and matrix spike duplicate.

12.1.2.2 If the surrogate compound recoveries meet acceptance criteria in the re-extract/reanalyzed sample then the problem was within the Laboratory's control. Therefore, submit only data from the re-extraction/reanalysis.

12.1.2.3 If the surrogate recoveries fail to meet the acceptance criteria in the re-extracted/reanalyzed sample, then submit data from both analyses. Distinguish between the initial analysis and the re-extraction/ reanalysis on all.

12.2 Corrective Action for Surrogate Compounds Retention Times Outside Acceptance Criteria.

12.2.1 If the surrogate compounds retention times are not within their acceptance criteria, check the instrument for malfunctions. If the instrument malfunctioned, correct the instrument problem and reanalyze the sample extract. If the instrument malfunction affected the calibration, recalibrate the instrument before reanalyzing the sample extract. Sample results shall be reported from analysis with acceptable performance from both surrogates, unless matrix effects are present.

12.2.2 If the above actions do not correct the problem, then the problem may be due to a sample "matrix effect". To determine if there was matrix effect, take the following corrective action steps.

12.2.2.1 Reanalyze the sample extract. EXCEPTION: If the surrogate compounds retention times in a sample used for a matrix spike and/or matrix spike duplicate were outside the acceptance criteria, then it should be reanalyzed only if the surrogate compounds retention times were within the acceptance criteria in both the matrix spike and matrix spike duplicate analysis.

12.2.2.2 If the surrogate compounds retention times are within the acceptance criteria in the reanalyzed sample extract, then the problem was within the Laboratory's control. Therefor, submit only data from the reanalysis with the surrogate compounds retention times within the acceptance limits.

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12.2.2.3 If the surrogate compounds retention times are outside the acceptance criteria in the reanalyzed sample extract, then submit data from both analyses. Distinguish between the initial analysis and the reanalysis.

12.3 Method Blanks

12.3.1 Summary of Method Blanks.

A method blank is a volume of a clean reference matrix (reagent water for water samples, or purified sodium sulfate for soil/sediment samples) that is carried through the entire analytical procedure. The volume or weight of the reference matrix must be approximately equal to the volume or weight of samples associated with the blank. The purpose of a method blank is to determine the levels of contamination associated with the processing and analysis of samples.

12.3.2 Frequency of Method Blanks

A method blank is extracted and analyzed with every batch or 20 samples, whichever is less, to demonstrate that there are no method interferences. If the method blank shows any hits above the reporting limit, corrective action must be taken. Corrective action includes recalculation, reanalysis, system cleaning, or re-extraction and reanalysis.

12.4 Procedure for Preparing MS/MSD

12.4.1 Frequency of MS/MSD/LCS Analysis

A matrix spike and matrix spike duplicate must be extracted and analyzed at least every batch or 20 samples, whichever is fewer.

12.4.2 Water Samples

12.4.2.1 For water samples, measure out two additional 1 L aliquots of the sample chosen for spiking. Adjust the pH of the samples (if required) and fortify each with 1 mL of matrix spiking solution. Using a syringe or volumetric pipette, add 1 mL of surrogate spiking solution to each sample. Extract, concentrate, cleanup, and analyze matrix spikes and matrix spike duplicate according to Section 11.0.

12.4.2.2 Whenever a matrix spike/matrix spike duplicate is prepared, a LCS must also be prepared to demonstrate that poor recoveries are not due to improper spiking solutions. The LCS is prepared by adding 1.0 mL of surrogate spiking solution and 1.0 mL of the matrix spiking

solution to 1000 mL of reagent water.

12.4.3 Soil/Sediment Samples.

12.4.3.1 For soil/sediment samples weigh out two additional 50 g (record weight to the nearest 0.1 g) aliquots of the sample chosen for spiking. Add 1 mL of matrix spiking solution and 1 mL of surrogate solution. Extract, concentrate, cleanup, and analyze matrix spikes and matrix spike duplicates according to Section 11.0.

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12.4.3.2 Whenever a matrix spike/matrix spike duplicate is prepared, a LCS must also be prepared to demonstrate that poor recoveries are not due to improper spiking solutions. The low level soil/sediment matrix spike blank is prepared by adding 1.0 mL of surrogate spiking solution and 1.0 mL of the matrix spiking solution to a 50 g aliquot of anhydrous sodium sulfate.

12.4.4 Calculations for MS/MSD

12.4.4.1 The percent recoveries and the relative percent difference between the recoveries of each of the compounds in the matrix spike samples will be calculated and reported by using the following equations

$$\text{Matrix Spike Recovery} = \frac{SSR - SR}{SA}$$

Where,

SSR = Spike sample result
SR = Sample result
SA = Spike added

$$RPD = \frac{|MSR - MSDR|}{\frac{1}{2}(MSR + MSDR)}$$

Where,

RPD = Relative percent difference
MSR = Matrix spike recovery
MSDR = Matrix spike duplicate recovery

12.4.4.2 The vertical bars in the formula above indicate the absolute value of the difference, hence RPD is always expressed as a positive value.

12.4.5 Technical Acceptance Criteria for MS/MSD/LCS.

12.4.5.1 All MS/MSD/LCS must be prepared and analyzed at the proper frequency on a GC/EC system meeting the initial calibration, calibration verification, and blank technical acceptance criteria.

12.4.5.2 The samples must be extracted and analyzed within the

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required holding times.

12.4.5.3 The retention time for each of the surrogates must be within the retention time windows for both GC columns.

12.4.5.4 The limits for MS/MSD compound recovery are given in Table 2. RPD should be ≤30 for waters and soils.

12.4.5.5 The limits for the compounds in the LCS are 70-130%. These limits are currently being recalculated from analytical data and are subject to change. Failure to meet these limits may require re-extraction and re-analysis of the batch. All outliers shall be discussed in the case narrative.

12.5 Method Performance - Method Detection Limit (MDL) studies should be performed annually for both soil and water matrices. See ADM-MDL for specifics.

13. DATA REDUCTION AND REPORTING

13.1 When using the external calibration procedure, determine the quantity of each component peak in the sample chromatogram which corresponds to the compounds used for calibration purposes, as follows. Proper quantitation requires the appropriate selection of a baseline from which the peak area or height can be determined.

13.1.1 For aqueous samples

$$\text{Concentration } \mu g/L = \frac{(A_x)\ (V_t)\ (Df)}{(CF)\ (V_o)\ (V_i)}$$

Where:

A_x = Area of the peak for the compound to be measured.
CF = mean calibration factor from the initial calibration (area per ng).
V_o = Volume of water extracted in milliliters (mL).
V_i = Volume of extract injected in microliters (µL). (If a single injection is made onto two columns, use one half the volume in the syringe as the volume injected onto each column.)
V_t = Volume of the concentrated extract in microliters (µL).
Df =Dilution factor. The dilution factor for analysis of water samples by this method is defined as follows:

$$\frac{\mu L \text{ most conc. extract used to make dilution} + \mu L \text{ clean solvent}}{\mu L \text{ most conc. extract used to make dilution}}$$

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If no dilution is performed, Df = 1.0.

Using the units specified here for these terms will result in a concentration in units of ng/mL, which is equivalent to µg/L.

13.1.2 For non-aqueous samples:

$$\text{Concentration } \mu\text{g/ Kg (Dry weight basis)} = \frac{(A_x)\ (V_t)\ (Df)}{(\overline{CF})\ (V_i)\ (W_s)\ (D)}$$

Where

A_x , V_t, D, $\overline{CF}$, and V_i are the same as for aqueous samples, and

W_s = Weight of sample extracted (g). The wet weight or dry weight may be used, depending upon specific application of the data. If units of kilograms are used for this term, multiply the result by 1000.

Using the units specified here for these terms will result in a concentration in units of ng/g, which is equivalent to µg/kg.

13.2 Validation of the GC system qualitative performance.

13.2.1 Use the calibration standards analyzed during the sequence to evaluate retention time stability. The retention time windows are established using the absolute retention time of each analyte in the mid-concentration standard during the initial calibration as the mid-point of the window. The widths of the windows are defined as the mid-point plus and minus three times the standard deviations calculated.

13.2.2 Each subsequent injection of a standard during the 12-hour analytical shift (i.e., those standards injected every 20 samples, or more frequently) must be checked against retention time windows. If any of these subsequent standards fall outside their absolute retention time windows, the GC system is out of control. Determine the cause of the problem and correct it. If the problem cannot be corrected, a new initial calibration must be performed.

13.3 Data reporting and review is handled by a computerized LIMS System. Specifics pertaining to reporting and review are contained in the company ADM-DREV SOP.

14. WASTE MANAGEMENT AND POLLUTION PREVENTION

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It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Aqueous samples are typically dumped down the sanitary sewer while solvents are temporarily stored in a 5 gallon Justrite container which is dumped into a 55 gallon drum by qualified personnel for disposal. See SMO-SPLDIS for further information.

15. REFERENCES:

"Test Methods for Evaluating Solid Waste Physical/Chemical Methods," SW-846, 3rd edition, December 1996.

16. TRAINING OUTLINE

- Read current SOP. Demonstrate a general understanding of the methodology and chemistry.
- Observe Sample Preparation and Analysis.
- Participate in the methodology, documentation, and data reduction with guidance.
- Participate in instrument operation, maintenance, and documentation.
- Demonstrate Competency by performing the analysis independently. Analyze a known proficiency or standard. If recovery is within acceptable limits, complete training form and have the supervisor sign-off as being proficient. An IDC study must be performed and the departmental supervisor must approve the study before the new analyst may analyze samples independently. Four replicates must be analyzed within LCS control limits to complete the IDC.

17. INSTRUMENT SPECIFIC ADDENDUM

GC instrument operating parameters in Attachment A.

18. ATTACHMENTS

Table 1	Practical Quantitation Limits
Table 2	QC Recovery Limits
Figure I	Diazomethane Generator

Attachment A Instrument Operating Parameters

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19. **CHANGES SINCE PREVIOUS REVISION**

- Added sections14,16,17,18,19 for NELAC compliance
- Updated prep and expiration instructions for reagents and standards
- Revised Tables 1 and 2 to reflect current compound list and QC limits
- Added Attachment A
- Included confirmation requirements in Section 11.7.4
- Specified extraction pH requirements.
- Specified calibration requirements and reporting levels.
- Omitted reference to quadratic fit and forcing curve through zero.
- Revised corrective action procedures for outlying QC.

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Table 1

PRACTICAL QUANTITATION LIMIS

Compound	Water (ug/L)	Soil (ug/Kg)
2,4-D	0.5	10
Dicamba	0.5	10
Dinoseb	0.5	10
2,4,5-T	0.5	10
2,4,5-TP (Silvex)	0.5	10
Pentachlorophenol	0.5	10

Table 2

QC CRITERIA

Compound	Water Recovery Limits	Soil Recovery Limits
2,4-D	19-127	19-127
Dicamba	50-150	50-150
Dinoseb	10-115	10-115
2,4,5-T	10-115	10-115
2,4,5-TP (Silvex)	21-143	21-143
Pentachlorophenol	50-150	50-150
DCAA-surrogate	52-118	49-120

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ATTACHMENT A

INSTRUMENT OPERATING PARAMETERS

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STANDARD OPERATING PROCEDURE

for

ANALYSIS OF POLYCHLORINATED BIPHENYLS (PCBs)

SOP No.: SOC-8082

Revision: 1.0

October 5, 2000

Approved by: _____ _____
Supervisor Date

_____ _____
QA Coordinator Date

_____ _____
Laboratory Manager Date

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Rochester, NY 14609

Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
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NUMBER: _____

Initials: _____ Date: _____

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1. SCOPE AND APPLICATION

1.1. Method 8082 is used to determine the concentrations of polychlorinated biphenyls (PCBs) as Aroclors in extracts from solid and liquid matrices, using fused-silica, open-tubular, capillary columns with electron capture detectors (ECD). The compounds listed below may be determined by either a single- or dual - column analysis system. Practical Quantitation Limits are listed in Table 1 by matrix.

This method covers the determination of the following polychlorinated biphenyls:

Parameter	CAS No.
Aroclor 1016	12674-11-2
Aroclor 1221	1104-28-2
Aroclor 1232	11141-16-5
Aroclor 1242	53469-21-9
Aroclor 1248	12672-29-6
Aroclor 1254	11097-69-1
Aroclor 1260	11096-82-5

1.2 Aroclors are multi-component mixtures. When samples contain more than one Aroclor, a higher level of analyst expertise is required to attain acceptable levels of qualitative and quantitative analysis. The same is true of Aroclors that have been subjected to environmental degradation ("weathering") or degradation by treatment technologies. Such weathered multi-component mixtures may have significant differences in peak patterns than those of Aroclor standards.

1.3 Compound identification based on single-column analysis should be confirmed on a second column.

1.4 This method describes a dual-column option. The option allows a hardware configuration of two analytical columns joined to a single injection port. The option allows one injection to be used for dual-column analysis.

1.5 This method is restricted to use by, or under the supervision of, analysts experienced in the use of gas chromatographs (GC) and skilled in the interpretation of gas chromatograms. Each analyst must demonstrate the ability to generate acceptable results with this method.

2. SUMMARY OF METHOD

2.1 A measured volume or weight of sample (approximately 1 L for liquids, 2 g to 30 g for solids) is extracted using the appropriate matrix-specific sample extraction technique.

2.2 Liquid samples are extracted at pH 5-9 S.U. with methylene chloride using Method 3510 (separatory funnel).

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2.3 Solid samples are extracted with methylene chloride - acetone (1:1) using Method 3550 (ultrasonic extraction).

2.4 A variety of cleanup steps may be applied to the extract, depending on the nature of the matrix interferences and the target analytes. Suggested cleanups include Florisil (Method 3620), sulfur (Method 3660), and sulfuric acid (Method 3665).

2.5 After cleanup, the extract is analyzed using a dual column narrow- bore capillary gas chromatography/ Electron Capture (GC/EC) technique.

3. DEFINITIONS

3.1 **Initial Calibration** - analysis of analytical standards for a series of different specified concentrations; used to define the linearity and dynamic range of the response of the electron capture detector to the target compounds.

3.2 **Laboratory Control Sample** - a matrix spiked sample with compounds representative of the target analytes. This is used to document laboratory performance.

3.3 **Matrix** - the predominant material, component, or substrate (e.g., surface water, drinking water, ect.) of which the sample to be analyzed is composed.

3.4 **Matrix Spike** - an aliquot of sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike is used to document the bias of a method in a given sample matrix.

3.5 **Method Blank** - an analyte-free matrix to which all reagents are added in the sample volumes or proportions as used in sample processing. The method blank should be carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination resulting from the analytical process.

3.6 **Organic- Free Reagent Water** - ASTM Type II Deionized Water .

3.7 **Percent Difference (%D)** - Used to compare two values, the percent difference indicates both the direction and the magnitude of the comparison, i.e., the percent difference may be either negative, positive, or zero. (In contrast, see relative percent difference).

3.8 **Relative Percent Difference (RPD)** – The difference of two values divided by the absolute value of average of the same two values. Used to compare the precision of the analysis. The result is always positive.

3.9 **Sample** - a portion of material to be analyzed that is contained in single or multiple containers and identified by a unique sample number.

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3.10 **Surrogates** (Surrogate Standards) - an organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical process. For semivolatiles and pesticides/Aroclors, surrogate compounds are added to every blank, sample, matrix spike, matrix spike duplicate, LCS, matrix spike blank, and standard. These are used to evaluate analytical efficiency by measuring recovery. Surrogates are not expected to be detected in environmental media.

3.11 **Batch** – Samples processed together as a unit, not to exceed 20 investigative samples.

4. INTERFERENCES

4.1 Solvents, reagents, glassware, and other sample processing hardware may yield artifacts and/or interferences to sample analysis. All these materials must be demonstrated to be free from interferences under the conditions of the analysis by analyzing method blanks.

4.2 Interferences coextracted from the samples will vary considerably from source to source. If analysis of an extracted sample is prevented due to interferences, further cleanup of the sample extract may be necessary.

4.3 Phthalate esters contaminate may types of products commonly found in the laboratory. Plastics, in particular, must be avoided because phthalates are commonly used as plasticizers and are easily extracted from plastic materials.

4.4 The presence of elemental sulfur will result in broad peaks that interfere with detection of polychlorinated biphenyls. Sulfur contamination should be expected with sediment samples. Method 3660 is suggested for removal of sulfur.

5. SAFETY

The toxicity or carcinogenicity of each reagent used in this method has not been precisely determined; however, each chemical should be treated as a potential health hazard. Exposure to these reagents should be reduced to the lowest possible level. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets should be made available to all personnel involved in these analyses. Specifically, concentrated sulfuric acid and the 50% sodium hydroxide solution are moderately toxic and extremely irritating to skin and mucous membranes. Use these reagents in a fume hood whenever possible and if eye or skin contact occurs, flush with large volumes of water. Always wear safety glasses or a shield for eye protection, and protective clothing, and observe proper mixing when working with these reagents.

6. SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 Sample collection, preservation, and custody management is handled by the sample maintenance office. Refer to the SMO-GEN for specifics.

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6.2 Purchased, precleaned, certified sample containers should be glass or Teflon, and have screw-caps with Teflon lined septa. In situations where Teflon is not available, solvent-rinsed aluminum foil may be used as a liner. However, acidic or basic samples may react with the aluminum foil, causing eventual contamination of the sample. Plastic containers or lids may NOT be used for the storage of samples due to the possibility of sample contamination from the phthalate esters and other hydrocarbons within the plastic. Sample containers should be filled with care so as to prevent any portion of the collected sample coming in contact with the sampler's gloves, thus causing contamination. Samples shall be stored at 0-6°C and shipped to the laboratory within 48 hrs.

6.3 Water and soil samples must be iced or refrigerated at 0-6°C from the time of collection until extraction.

6.4 Water samples must be extracted within 7 days and the extracts analyzed within 40 days following extraction. Soil samples must be extracted within 14 days and the extract analyzed within 40 days following extraction.

7. APPARATUS AND MATERIALS:

7.1 Gas Chromatograph/ Electron Capture Detector (GC/EC) System

7.1.1 Gas Chromatograph - Hewlett Packard 5890 and 6890 with a cool on-column or split/splitless injector and dual electron capture detectors.

7.1.2 Columns - two 0.32mm id fused silica capillary columns are used. A separate detector is used for each column. The analytical columns are:

- Restek Rtx-CLPesticide (30 meter, 0.32 mm id, 0.50 µm df).
- Restek Rtx-CLPesticides II (30 meter, 0.32 mm id, 0.25 µm df).

or

- J & W DB-1701 (30 meter, 0.32 mm id, 0.25 µm df).
- J & W DB-17 (30 meter, 0.32 mm id, 0.25 µm df).

Columns are installed using a deactivated glass "y" connector and a 5 meter Restek siltek deactivated guard column (0.53mm id) which allows simultaneous injection onto both columns.

7.1.3 Carrier Gas - Helium. All GC carrier gas lines must be constructed from stainless steel or copper tubing. Non-polytetrafluorethylene (Ptfe) thread sealants or flow controllers with rubber components are not to be used.

7.1.4 Electron Capture Detector (ECD) - the linearity of the response of the ECD may be greatly dependent on the flow rate of the make-up gas. The make-up gas must be P-5, (argon/methane). Care must be taken to maintain stable and appropriate flow of make-up gas to the detector. The GC/ECD system must be in a room in

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which the atmosphere has been demonstrated to be free of all contaminants which may interfere with the analysis. The instrument must be vented to a trapping system which prevents the release of contaminants into the instrument room.

7.1.5 Data System - a data system must be interfaced to the GC/EC. The data system must allow the continuous acquisition of data throughout the duration of the chromatographic program and must permit, at the minimum, the output of time vs. intensity (peak height or peak area) data. Also, the data system must be able to rescale chromatographic data in order to report chromatograms meeting the requirements listed within this method.

7.2 Vials and Caps - 2 mL capacity for GC auto sampler, 20 mL scintillation vials for dilutions.

7.3 Volumetric Flasks - 10 mL, 25 mL, 50 mL, 100 mL for preparation of standards.

7.4 Pipets - Class A 1 mL, 2 mL, etc, and microsyringes.

8. PREVENTIVE MAINTENANCE

8.1 Glass Insert/Sleeve-single Gooseneck. Indicators are breakdown of endrin and/or DDT and loss of sensitivity of other compounds. The insert should always be replaced before a new calibration and the o-ring should be replaced with the insert.

8.2 Septum - Replaced approximately every 150 injections. A retention time shift or poor baseline chromatography is a common symptom.

8.3 Autosampler syringe - Cleaned daily and after samples with a particularly bad matrix. The syringe should be rinsed with hexane; the plunger is rinsed, wiped with a kim wipe, and rinsed again. The syringe should be replaced with a new one if loose action is noted or inconsistent action is evident (uniform fluctuation in response, area counts) or obvious wear.

8.4 Injection Port - The port and the port/column interface should be cleaned as needed (when replacing the insert is ineffective and in conjunction with column prunning). Port should be reamed with a wire brush and swabbed with hexane. Disc and washer can be sonicated in methylene chloride and then silanized, but should be replaced if wear is evident. The capillary inlet should also be cleaned in hexane and the septum nut is sonicated in hexane also.

8.5 Column Pruning - Cut back one revolution as needed. Indicators are same as insert replacement and is another remedy if insert replacement does not yield the desired results. After initial cut, a graphite ferrule should first be installed and then another short length of column removed (cut should be carefully examined for smoothness - no jagged edges). The column end should extend 7mm past the ferrule when installed (use white out or septum marking method for reference).

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8.6 Column Replacement - As needed, usually every 4-6 months for moderate sample volumes. Symptoms are ineffectiveness of insert replacement, injector cleaning, or column pruning to rectify a problem. All ferrules replaced with column change.

8.7 Syringe Rinse Solvent - Supply is replenished as needed. Old solvent is discarded and vial rinsed before refilling. Rinse waste and sample waste vials are replaced when residue appears.

8.8 Carrier Gas - Tank is changed before pressure reaches approximately 200psi to avoid impurities that may be delivered by a nearly empty tank. Leak check with snoop after change.

8.9 System baking - When the system is to be idle oven temperature should be set to 100°C to avoid water vapor condensation in column. Baking of injector, column, interface may be done for short periods of time to eliminate contaminants due to sample matrix residuals. Temperature should not exceed recommended column temperature limits.

8.10 Maintenance Log - All preventive maintenance as well as instrument repair should be documented in the appropriate instrument maintenance log.

9. STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

9.1 Reagents

Hexane, iso-octane, and methanol - pesticide quality or equivalent, purchased commercially. It is recommended that each lot of solvent used be analyzed to demonstrate that it is free of interference before use. See ADM-CTMN. Store in a flammable cabinet at room temperature. Expires upon manufacturer's recommendation.

9.2 Standards - Manufacturer's certificates of analysis are retained by the lab and presented upon request. All standards must be traceable using the CAS lot system, see SOP, ADM-SPSR.

9.2.1 Stock standard solutions (1000ppm)-Aroclor stocks are purchased as certified solutions from Restek. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Expire upon manufacturer's indications.

9.2.2 Secondary Dilution Standards (10 ppm)

Using stock standards, prepare secondary dilution standards in hexane that contain the compounds of interest either singly or mixed together. Secondary dilution standards are prepared by diluting 1.0 mL of the 1000 ppm solution to 100.0 mL with hexane to yield 10 ppm mid-stock. Store in the freezer at 0-¯20°C in Teflon-

lined screw cap amber bottles/vials. Fresh standards should be prepared every six months, or sooner if comparison with check standards indicates a problem.

9.2.3 Working Standards

9.2.3.1 Surrogate Standard Spiking Solution. - The surrogates, tetrachloro-m-xylene and decachlorobiphenyl, are added to all samples, LCS, matrix spikes, and blanks. Prepare a surrogate spiking solution of 1000ppb of each of the two compounds in acetone. Prepared from Ultra Scientific Pesticide Surrogate Standard Spiking Solution 200ppm (Cat # ISM-320) Dilute 1.0 mL of 200 ppm solution to 200.0 mls with acetone. Store in the freezer at 0-˜20°C in Teflon-lined screw cap amber bottles/vials. Fresh standards should be prepared every six months, or sooner if comparison with check standards indicates a problem.

9.2.3.2 Surrogate Standard Mid-Stock – The surrogates tetrachloro –m-xylene and decachlorobiphenyl are also added to all standards. Prepare a surrogate mid-stock of 2000 ppb of each of the two compounds in hexane. Prepared from Ultra Scientific Pesticide Surrogate Standard Solution 200 ppm (Cat # ISM-320) Dilute 1.0 mL 200 ppm solution to 100.0 mLs with hexane. Store in the freezer at 0—20°C in Teflon-lined screw cap amber bottles/vials. Fresh standards should be prepared every six months, or sooner if comparison with check standards indicates a problem.

9.2.3.3 Matrix Spiking Solution/LCS Spike Solution - Prepare a matrix spiking solution in acetone or methanol that contains a secondary source of Aroclor 1260 at 5 ppm. Prepared from Restek 1000 ppm in hexane (Catalog # 32012) by diluting 1.0 mL 1000 ppm solution to 200.0 mLs with acetone. Store in the freezer at 0-˜20°C in Teflon-lined screw cap amber bottles/vials. Fresh standards should be prepared every six months, or sooner if comparison with check standards indicates a problem.

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9.3.4 Preparation of Calibration Standards with Surrogates

Store in the freezer at 0-20°C in Teflon-lined screw cap amber bottles/vials. Fresh standards should be prepared every six months, or sooner if comparison with check standards indicates a problem.

Calibration Standards - Aroclor 1660 (1016 and 1260 mix), others separate

Compound	Mid-stock (ppm)	STD 1 (ppb) 5 ml/ 50 ml	STD 2 (ppb) 3.75ml/ 50ml	STD 3 (ppb) 2.5 ml/ 50 ml	STD 4 (ppb) 1.25 ml/ 50 ml	STD 5 (ppb) 0.5ml/ 50 ml
Aroclor 1016	10	1000	750	500	250	100
Aroclor 1260	10	1000	750	500	250	100
Aroclor 1221	10			500		
Aroclor 1232	10			500		
Aroclor 1242	10			500		
Aroclor 1248	10			500		
Aroclor 1254	10			500		

	Mid-stock (ppm)	STD 1 (ppb) 0.5 ml/ 50ml	STD 2 (ppb) 1 ml/ 50ml	STD 3 (ppb) 1.5ml/ 50ml	STD 4 (ppb) 2ml/ 50ml	STD 5 (ppb) 2.5ml/ 50ml
Surrogates						
TCMX	2.0	20	40	60	80	100
DCB	2.0	20	40	60	80	100

Note: Samples, sample extracts, and standards must be stored separately.

10. RESPONSIBILITIES

It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. Final review and sign-off of the data is performed by the department supervisor or designee.

11. PROCEDURES:

11.1. Extraction

In general, water samples are extracted at a neutral pH of 5-9 S.U., or as is, with methylene chloride, using Method 3510. Solid samples are extracted using Method 3550 and non-aqueous oils are typically extracted by waste dilution, Method 3580. See EXT-3510C, EXT-3550B, and EXT-3580 for details.

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11.2. Extract Cleanup

A variety of cleanup steps may be applied to the extracts. See EXT – 3660, EXT 3620, and EXT- 3665.

11.3 Gas Chromatograph Operating Conditions

11.3.1 The gas chromatographic analytical conditions are summarized in the instrument specific addendum.

11.3.2 Optimize GC conditions for analyte separation and sensitivity. Once optimized, the same GC conditions must be used for the analysis of all standards, samples, blanks, LCS and MS/MSD. The linearity of the ECD may be greatly dependent on the flow rate of the make-up gas. Care must be taken to maintain stable and appropriate flow of make-up gas to the detector. The same injection volume must be used for all standards, blanks, and samples, including MS/MSD and LCS.

11.4 Initial Calibration

11.4.1 Summary of Initial Calibration.

Prior to the analysis of samples, including MS/MSD/LCS and required blanks, each GC/EC system must be initially calibrated at a minimum of five concentrations for AR1016/1260 to determine instrument sensitivity and the linearity of response for the major aroclor peaks and surrogates. The other five aroclors are analyzed with one standard at the mid-point concentration. The low standard establishes the level of detection and reportability, while the high standard establishes linear range. See CAS calibration policy.

11.4.2 The lowest concentration calibration standard must be at the method reporting limit.

11.4.3 Frequency of Initial Calibration

Each GC/ECD system must be initially calibrated, whenever major instrument maintenance or modification is performed (e.g., column replacement or repair, cleaning or replacement of ECD, etc.) or if the calibration verification technical acceptance criteria have not been met.

Note: Because of the low concentration of Aroclor standards injected on a GC/ECD, column absorption may be a problem when the GC has not been used for a day. Therefore, the GC column should be primed or deactivated by injecting a Aroclor standard mixture approximately 20 times more concentrated than the mid-level standard. Inject this prior to beginning initial or daily calibration.

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11.4.4 Calibration Factors

When external standard calibration is employed, calculate the calibration factor for each analyte at each concentration, the mean calibration factor, and the relative standard deviation (RSD) of the calibration factors, using the formulas below.

11.4.4.1 Calculate the calibration factor for each analyte at each concentration as:

$$CF = \frac{\text{Peak area (or height) of the standard}}{\text{Mass injected (ng)}}$$

11.4.4.2 Calculate the mean calibration factor for each analyte as:

$$\overline{CF} = \frac{\sum_{i=1}^{n} CF_i}{n}$$

where n is the number of standards analyzed.

11.4.4.3 Calculate the standard deviation (SD) and the RSD of the calibration factors for each analyte as:

$$SD_{CF} = \sqrt{\frac{\sum_{i=1}^{n} \left(CF_i - \overline{CF}\right)^2}{(n - 1)}} \qquad RSD = \frac{SD_{CF}}{\overline{CF}} \times 100$$

If the RSD for each analyte is ≤ 20%, then the response of the instrument is considered linear and the mean calibration factor can be used to quantitate sample results. If the RSD is greater than 20%, then linearity through the origin cannot be assumed. The analyst must use a calibration curve whose r value is greater than or equal to 0.9901. The regression must not be forced through zero.

11.5 Gas chromatographic analysis of sample extracts.

11.5.1 The same GC operating conditions used for the initial calibration must be employed for samples analyses.

11.5.2 Verify the calibration each 12 hour shift by injecting calibration verification standards prior to conducting any sample analyses. Analysts should alternate the use of high and low concentration mixtures of Aroclor 1016/1260 for calibration verification. A calibration standard must also be injected at intervals of not less than

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once every twenty samples (after every 10 samples is recommended to minimize the number of samples requiring re-injection when QC limits are exceeded) and at the end of the analysis sequence. Samples bracketed by unacceptable continuing calibration checks must be reanalyzed.

11.5.2.1 The calibration factor for each Aroclor peak to be quantitated must not exceed a ± 15 percent difference when compared to the initial calibration curve.

$$\%D = \frac{\overline{CF} - CFv}{\overline{CF}} X100$$

11.5.2.2 If this criterion is exceeded, inspect the gas chromatographic system to determine the cause and perform whatever maintenance is necessary before verifying calibration and proceeding with sample analysis.

11.5.2.3 If routine maintenance does not return the instrument performance to meet the above requirements based on the last initial calibration, then a new initial calibration must be performed.

11.5.3 Compare the retention time of each Aroclor peak in the calibration standard with the absolute retention time windows established. As described in Method 8000, the center of the absolute retention time window for each Aroclor peak is its retention time in the mid-concentration standard analyzed during the initial calibration. Each analyte in each standard must fall within its respective retention time window. If not, the gas chromatographic system must either be adjusted so that a second analysis of the standard does result in all analytes falling within their retention time windows, or a new initial calibration must be performed and new retention time windows established.

11.5.4 Tentative identification of an analyte occurs when a peak from a sample extract falls within the absolute retention time window. Each tentative identification must be confirmed with the second GC column.

11.5.5 If the response exceeds the calibration range of the system, dilute the extract and reanalyze. Dilutions are performed as per the company ADM-DIL SOP. Peak height measurements are recommended over peak area integration when overlapping peaks cause errors in area integration.

11.5.6 The quantitative results for those 3 -5 peaks are averaged to determine the concentration of a particular aroclor.

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11.5.7 Each sample analysis must be bracketed with an acceptable initial calibration, calibration verification standard(s) (each 12- hour analytical shift), or calibration standards interspersed within the samples. When a calibration verification standard fails to meet the QC criteria, all samples that were injected after the standard that last met the QC criteria must be re-injected.

11.5.8 Sample injections may continue for as long as the calibration verification standards and standards interspersed with the samples meet instrument QC requirements. It is recommended that standards be analyzed after every 10 samples (required after every 20 samples and at the end of a set) to minimize the number of samples that must be re-injected when the standards fail the QC limits. The sequence ends when the set of samples has been injected or when qualitative and/or quantitative QC criteria are exceeded.

12. QA/QC REQUIREMENTS

12.1 Corrective Action for Surrogate Recovery

12.1.1 If the surrogate compounds fail to meet the recovery acceptance criteria (Table 2), check calculations, sample preparation logs, the surrogate compound spiking solutions, and the instrument operation. If the calculations were incorrect, correct the calculations and verify that the surrogate compound recoveries meet their acceptance criteria. If no surrogate spiking solution was added or if the surrogate spiking solution was improperly prepared, concentrated, or degraded, re-extract and reanalyze the samples. If the instrument malfunctioned, correct the instrument problem and reanalyze the sample extract. Sample results shall be reported from analyses with acceptable performance from both surrogates, unless matrix effects are present.

12.1.2 If the above actions do not correct the problem, then the problem may be due to a sample matrix effect. To determine if there was matrix effect, take the following corrective action steps.

12.1.2.1 Re-extract and reanalyze the sample. EXCEPTION: If surrogate compound recoveries in a sample used for a matrix spike and/or matrix spike duplicate were considered unacceptable, then it should be re-extracted/ re-analyzed only if surrogate compound recoveries met the surrogate acceptance criteria in both the matrix spike and matrix spike duplicate.

12.1.2.2 If the surrogate compound recoveries meet acceptance criteria in the re-extract/reanalyzed sample then the problem was within the Laboratory's control. Therefore, submit only data from the re-extraction/reanalysis.

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12.1.2.3 If the surrogate recoveries fail to meet the acceptance criteria in the re-extracted/reanalyzed sample, then submit data from both analyses. Distinguish between the initial analysis and the re-extraction/ reanalysis on all.

12.2 Corrective Action for Surrogate Compounds Retention Times Outside Acceptance Criteria.

12.2.1 If the surrogate compounds retention times are not within their acceptance criteria, check the instrument for malfunctions. If the instrument malfunctioned, correct the instrument problem and reanalyze the sample extract. If the instrument malfunction affected the calibration, recalibrate the instrument before reanalyzing the sample extract.

12.2.2 If the above actions do not correct the problem, then the problem may be due to a sample "matrix effect". To determine if there was matrix effect, take the following corrective action steps.

12.2.2.1 Reanalyze the sample extract. EXCEPTION: If the surrogate compounds retention times in a sample used for a matrix spike and/or matrix spike duplicate were outside the acceptance criteria, then it should be reanalyzed only if the surrogate compounds retention times were within the acceptance criteria in both the matrix spike and matrix spike duplicate analysis.

12.2.2.2 If the surrogate compounds retention times are within the acceptance criteria in the reanalyzed sample extract, then the problem was within the Laboratory's control. Therefor, submit only data from the reanalysis with the surrogate compounds retention times within the acceptance limits.

12.2.2.3 If the surrogate compounds retention times are outside the acceptance criteria in the reanalyzed sample extract, then submit data from both analyses. Distinguish between the initial analysis and the reanalysis.

12.3 Method Blanks

12.3.1 Summary of Method Blanks.

A method blank is a volume of a clean reference matrix (reagent water for water samples, or purified sodium sulfate for soil/sediment samples) that is carried through the entire analytical procedure. The volume or weight of the reference matrix must be approximately equal to the volume or weight of samples associated with the blank. The purpose of a method blank is to determine the levels of contamination associated with the processing and analysis of samples.

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12.3.2 Frequency of Method Blanks

A method blank must be extracted with each batch (not to exceed 20 samples), or each day that samples are extracted, which ever is most frequent. If the method blank shows any hits above the reporting limit, corrective action must be taken. Corrective action includes recalculation, reanalysis, system cleaning, or reextraction and reanalysis.

12.4 Procedure for Preparing MS/MSD

12.4.1 Frequency of MS/MSD/LCS Analysis

A matrix spike and matrix spike duplicate must be extracted and analyzed at least every batch or 20 samples, whichever is fewer.

12.4.2 Water Samples

12.4.2.1 For water samples, measure out two additional 1 L aliquots of the sample chosen for spiking. Adjust the pH of the samples (if required) and fortify each with 1 mL of matrix spiking solution. Using a syringe or volumetric pipet, add 1 mL of surrogate spiking solution to each sample. Extract, concentrate, cleanup, and analyze matrix spikes and matrix spike duplicate according to Section 11.0.

12.4.2.2 Each day samples are extracted and whenever a matrix spike/matrix spike duplicate is prepared, a LCS must also be prepared to demonstrate that poor recoveries are not due to improper spiking solutions. The LCS is prepared by adding 1.0 mL of surrogate spiking solution and 1.0 mL of the matrix spiking solution to 1000 mL of reagent water.

12.4.3 Soil/Sediment Samples.

12.4.3.1 For soil/sediment samples weigh out two additional 30 g (record weight to the nearest 0.1 g) aliquots of the sample chosen for spiking. Add 1 mL of matrix spiking solution and 1 mL of surrogate solution. Extract, concentrate, cleanup, and analyze matrix spikes and matrix spike duplicates according to Section 11.0.

12.4.3.2 Each day samples are extracted and whenever a matrix spike/ matrix spike duplicate is prepared, a LCS must also be prepared to demonstrate that poor recoveries are not due to improper spiking solutions. The low level soil/sediment matrix spike blank is prepared by adding 1.0 mL of

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surrogate spiking solution and 1.0 mL of the matrix spiking solution to a 30 g aliquot of anhydrous sodium sulfate.

12.4.4 Calculations for MS/MSD

12.4.4.1 The percent recoveries and the relative percent difference between the recoveries of each of the compounds in the matrix spike samples will be calculated and reported by using the following equations

$$\text{Matrix Spike Recovery} = \frac{SSR - SR}{SA} \times 100$$

Where,

SSR = Spike sample result
SR = Sample result
SA = Spike added

$$RPD = \frac{|MSR - MSDR|}{\frac{1}{2}(MSR + MSDR)} \times 100$$

Where,

RPD = Relative percent difference
MSR = Matrix spike recovery
MSDR = Matrix spike duplicate recovery

12.4.4.2 The vertical bars in the formula above indicate the absolute value of the difference, hence RPD is always expressed as a positive value.

12.4.5 Technical Acceptance Criteria for MS/MSD/LCS

12.4.5.1 The requirements below apply independently to <u>each</u> GC column and to all instruments used for these analyses. Quantitation must be performed on both GC columns.

12.4.5.2 All MS/MSD/LCS must be prepared and analyzed at the proper frequency on a GC/EC system meeting the initial calibration, calibration verification, and blank technical acceptance criteria.

12.4.5.3 The samples must be extracted and analyzed within the required holding times.

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12.4.5.4 The retention time for each of the surrogates must be within the retention time windows for both GC columns.

12.4.5.5 The limits for MS/MSD/LCS compound recovery and RPD are given in Table 2.

12.4.5.6 The limits for the LCS must be met. Failure to meet these limits will require re-extraction and reanalysis of the MS/MSD/LCS.

12.5 Method Performance

Method Detection Limit (MDL) studies should be performed annually for both soil and water matrices. See CAS SOP ADM-MDL for specifics.

13. DATA REDUCTION AND REPORTING

13.1 Quantitation of PCBs as Aroclors

The Quantitation of PCB residues as Aroclors is accomplished by comparison of the sample chromatogram to that of the most similar Aroclor standard. A choice must be made as to which Aroclor is most similar to that of the residue and whether that standard is truly representative of the PCBs in the sample.

13.1.1 Use the individual Aroclor standards (not the 1016/1260 mixtures) to determine the pattern of peaks on Aroclors 1221, 1232, 1242, 1248, and 1254. The patterns for Aroclors 1016 and 1260 will be evident in the mixed calibration standards.

13.1.2 Once the Aroclor pattern has been identified, compare the responses of 3 to 5 major peaks in the calibration standards with peaks observed in the sample extract, using the external standard calibration technique. The amount of Aroclor is calculated using an individual calibration factor for each of the 3 - 5 characteristic peaks chosen as seen below.

13.2 Determine the quantity of each component peak in the sample chromatogram which corresponds to the compounds used for calibration purposes, as follows. Proper quantitation requires the appropriate selection of a baseline from which the peak area or height can be determined.

For aqueous samples

Where:

$$\text{Concentration } \mu g/L = \frac{(A_x)\ (V_t)\ (Df)}{(\overline{CF})\ (V_o)\ (V_i)}$$

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A_x = Area of the peak for the compound to be measured.
CF = mean calibration factor from the initial calibration (area per ng).
V_o = Volume of water extracted in milliliters (mL).
V_i = Volume of extract injected in microliters (µL). (If a single injection is made onto two columns, use one half the volume in the syringe as the volume injected onto each column.)

V_t = Volume of the concentrated extract in microliters (µL).

Df =Dilution factor. The dilution factor for analysis of water samples by this method is defined as follows:

$$\frac{\mu L \text{ most conc. extract used to make dilution} + \mu L \text{ clean solvent}}{\mu L \text{ most conc. extract used to make dilution}}$$

If no dilution is performed, Df = 1.0.

Using the units specified here for these terms will result in a concentration in units of ng/mL, which is equivalent to µg/L.

For non-aqueous samples:

$$\text{Concentration } \mu g/\text{ Kg (Dry weight basis)} = \frac{(A_x)\ (V_t)\ (Df)}{(\overline{CF})\ (V_i)\ (W_s)\ (D)}$$

where A_x , V_t, D, $\overline{CF}$, and V_i are the same as for aqueous samples, and

W_s = Weight of sample extracted (g). The wet weight or dry weight may be used, depending upon specific application of the data. If units of kilograms are used for this term, multiply the result by 1000.

Using the units specified here for these terms will result in a concentration in units of ng/g, which is equivalent to µg/kg.

13.3 Validation of the GC system qualitative performance.

13.3.1 Use the calibration standards analyzed during the sequence to evaluate retention time stability. The retention time windows are established using the absolute retention time of each analyte in the mid-concentration standard during the initial calibration as the mid-point of the window. The widths of the windows are defined as the mid-point plus and minus three times the standard deviations calculated.

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13.3.2 Each subsequent injection of a standard during the 12-hour analytical shift (i.e., those standards injected every 20 samples, or more frequently) must be checked against retention time windows. If any of these subsequent standards fall outside their absolute retention time windows, the GC system is out of control. Determine the cause of the problem and correct it. If the problem cannot be corrected, a new initial calibration must be performed.

13.4 Identification of mixtures is based on the characteristic "fingerprint" retention time and shape of the indicator peak(s); and quantitation is based on the area under the characteristic peaks as compared to the area under the corresponding calibration peak (s) of the same retention time and shape generated using the external calibration procedures.

13.5 Data reporting and review is handled by a computerized LIMS System. Specifics pertaining to reporting and review are contained in the company ADM-DREV SOP.

14. WASTE MANAGEMENT AND POLLUTION PREVENTION

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Aqueous samples are typically dumped down the sanitary sewer while solvents are temporarily stored in a 5 gallon Justrite container which is dumped into a 55 gallon drum by qualified personnel for disposal. See SMO-SPLDIS for further information.

15. REFERENCES:

"Test Methods for Evaluating Solid Waste Physical/Chemical Methods," SW-846, 3rd edition, December 1996.

16. TRAINING OUTLINE

- Read current SOP. Demonstrate a general understanding of the methodology and chemistry.
- Observe Sample Preparation and Analysis.
- Participate in the methodology, documentation, and data reduction with guidance.
- Participate in instrument operation, maintenance and documentation.
- Demonstrate Competency by performing the analysis independently. Analyze a known proficiency or standard. If recovery is within acceptable limits, complete training form and have the supervisor sign-off as being proficient. An IDC study must be performed and the

departmental supervisor must approve the study before the new analyst may analyze samples independently. Four replicates must be analyzed within LCS control limits to complete the IDC.

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17. INSTRUMENT SPECIFIC ADDENDUM

- GC instrument operating parameters in Attachment A.
- HP instrument manuals are located in the GC instrument lab.

18. ATTACHMENTS

Table 1 Practical Quantitation Limits
Table 2 QC Recovery Limits
Attachment A Instrument Operating Parameters.

19. CHANGES FROM LATEST REVISION

- Added sections 2,3,8,10,13,14,16,17,18,19 for NELAC compliance
- Updated prep and expiration instructions for reagents and standards
- Revised reference to current methodology
- Revised Tables 1 and 2 to reflect current compound list and QC limits
- Added Attachment A
- Included confirmation requirements in Section 11.5
- Specified extraction pH requirements.
- Specified calibration requirements and reporting levels.
- Omitted reference to quadratic fit and forcing curve through zero.
- Revised corrective action procedures for outlying QC.

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TABLE 1 PRACTICAL QUANTITATION LIMITS

Parameter	PQL Water µg/L	Soil µg/kg	Waste Dilutions* µg/kg
Aroclor 1016	1.0	33	10,000
Aroclor 1260	1.0	33	10,000
Aroclor 1221	1.0	33	10,000
Aroclor 1232	1.0	33	10,000
Aroclor 1242	1.0	33	10,000
Aroclor 1248	1.0	33	10,000
Aroclor 1254	1.0	33	10,000

- 1 gram to 10 mL then 1/10 dilution as per Method 3580 for PCBs.

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TABLE 2 QC`````` RECOVERY LIMITS

Parameter	Water Recovery Limits (%)	Soil Recovery Limits (%)
Aroclor 1016	70-130*	70-130*
Aroclor 1260	70-130*	70-130*
Aroclor 1221	70-130*	70-130*
Aroclor 1232	70-130*	70-130*
Aroclor 1242	70-130*	70-130*
Aroclor 1248	70-130*	70-130*
Aroclor 1254	70-130*	70-130*
SURROGATES		
Tetrachloro-m-xylene	50-114	53-118
Decachloro biphenyl	25-127	50-120

*The laboratory based limits for the soils are in the process of being calculated. The 70-130 is a targeted recovery until laboratory limits are established.

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ATTACHMENT A

INSTUMENT OPERATING PARAMETERS

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STANDARD OPERATING PROCEDURE

for

ANALYSIS OF ORGANOCHLORINE PESTICIDES IN WATERS AND SOILS

SOP No.: SOC-8081A

Revision: 5.0

October 6, 2000

Approved by: _____ _____
Supervisor Date

_____ _____
QA Coordinator Date

_____ _____
Laboratory Manager Date

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1 Mustard Street, Suite 250
Rochester, New York 14609

Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
Initials: _____ Date: _____
Initials: _____ Date: _____

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NUMBER: _____

Initials: _____ Date: _____

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1. SCOPE AND APPLICATION

1.1. Method 8081 is used to determine the concentrations of various organochlorine pesticides in extracts from solid and liquid matrices, using fused-silica, open-tubular, capillary column with electron capture detectors (ECD). The compounds listed below may be determined by either a single- or dual - column analysis system. Practical Quantitation Limits are listed in Table 1 by matrix.

1.1.1 This method covers the determination of the following organochlorine pesticides:

Parameter	CAS No.
Aldrin	309-00-2
a-BHC	319-84-6
ß-BHC	319-85-7
δ-BHC	319-86-8
γ-BHC	58-89-9
Chlordane	57-74-9
a-Chlordane	5103-71-9
γ-Chlordane	5103-74-2
4,4'-DDD	72-54-8
4,4'-DDE	72-55-9
4,4'-DDT	50-29-3
Dieldrin	60-57-1
Endosulfan I	959-98-8
Endosulfan II	33212-65-9
Endosulfan sulfate	1031-07-8
Endrin	72-20-8
Endrin aldehyde	7421-93-4
Endrin Ketone	53494-70-5
Famphur	52-85-7
Heptachlor	76-44-8
Heptachlor epoxide	1024-57-3
Hexachlorobenzene	118-74-1
Kepone	143-50-0
Methoxychlor	72-43-5
Mirex	2385-85-5
Toxaphene	8001-35-2

1.2 This revision of Method 8081 no longer includes the PCBs as Aroclors in the list of target analytes. The analysis of PCBs should be undertaken using Method 8082, which includes specific cleanup and quantitation procedures designed for PCB analysis. This change was made to obtain PCB data of better quality and to eliminate the complications inherent in a combined organochlorine pesticide and PCB method. Therefore, if the presence of PCBs

is expected, use Method 8082 for PCB analyses, and this method (8081) for the organochlorine pesticides. If there is no information of the likely presence of PCBs, split the sample prior to any cleanup steps, and process part of the extract for organochlorine pesticide analysis and the other portion for PCB analysis using Method 8082.

1.3 The method is restricted to use by, or under the supervision of analysts experienced in the use of gas chromatographs (GC) and skilled in the interpretation of gas chromatograms. Each analyst must demonstrate the ability to generate acceptable results with this method.

2. SUMMARY OF METHOD

2.1 A measured volume or weight of sample (approximately 1 L for liquids, 2 g to 30 g for solids) is extracted using the appropriate matrix-specific sample extraction technique.

2.2 Liquid samples are extracted at pH 5-9 with methylene chloride using Method 3510 (separatory funnel).

2.3 Solid samples are extracted with methylene chloride - acetone (1:1) using Method 3550 (ultrasonic extraction).

2.4 A variety of cleanup steps may be applied to the extract, depending on the nature of the matrix interferences and the target analytes. Suggested cleanups include Florisil (Method 3620), and sulfur (Method 3660).

2.5 After cleanup, the extract is analyzed using a dual column narrow- bore capillary gas chromatography/ Electron Capture (GC/EC) technique.

3. DEFINITIONS

3.1 **Initial Calibration -** analysis of analytical standards for a series of different specified concentrations; used to define the linearity and dynamic range of the response of the electron capture detector to the target compounds.

3.2 **Laboratory Control Sample -** a matrix spiked sample with compounds representative of the target analytes. This is used to document laboratory performance.

3.3 **Matrix -** the predominant material, component, or substrate (e.g., surface water, drinking water, etc.) of which the sample to be analyzed is composed.

3.4 **Matrix Spike -** an aliquot of sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike is used to document the bias of a method in a given sample matrix.

3.5 **Method Blank -** an analyte-free matrix to which all reagents are added in the sample volumes or proportions as used in sample processing. The method blank should be carried

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through the complete sample preparation and analytical procedure. The method blank is used to document contamination resulting from the analytical process.

3.6 Percent Difference (%D) - Used to compare two values during calibration verification, the percent difference indicates both the direction and the magnitude of the comparison, i.e., the percent difference may be either negative, positive, or zero. (In contrast, see relative percent difference).

3.7 Relative Percent Difference (RPD) – The absolute value of the difference of two values divided by the average of the same two values. Used to compare the precision of the analysis. The result is always a positive number.

3.8 **Sample -** a portion of material to be analyzed that is contained in single or multiple containers and identified by a unique sample number.

3.9 **Surrogates** (Surrogate Standards) - an organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical process. For semivolatiles and pesticides/Aroclors, surrogate compounds are added to every blank, sample, matrix spike, matrix spike duplicate, LCS, matrix spike blank, and standard. These are used to evaluate analytical efficiency by measuring recovery. Surrogates are not expected to be detected in environmental media.

3.10 Organic Free Reagent Water - ASTM Type II Deionized Water.

3.11 Batch – Samples processed together as a unit, not to exceed 20 investigative samples

4. INTERFERENCES

4.1 Solvents, reagents, glassware, and other sample processing hardware may yield artifacts and/or interferences to sample analysis. All these materials must be demonstrated to be free from interferences under the conditions of the analysis by analyzing method blanks.

4.2 Interferences coextracted from the samples will vary considerably from source to source. If analysis of an extracted sample is prevented due to interferences, further cleanup of the sample extract may be necessary.

4.3 Phthalate esters contaminate many types of products commonly found in the laboratory. Plastics, in particular, must be avoided because phthalates are commonly used as plasticizers and are easily extracted from plastic materials.

4.4 Soap residue (e.g. sodium dodecyl sulfate), which results in a basic pH on glassware surfaces, may cause degradation of certain analytes. Specifically, Aldrin, Heptachlor, and most organophosphorus pesticides will degrade in this situation. This problem is especially pronounced with glassware that may be difficult to rinse (e.g., 500-ml K-D flask). These items should be hand-rinsed very carefully to avoid this problem.

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4.5 The decomposition of some analytes has been demonstrated under basic extraction conditions. Organochlorine pesticides may dechlorinate, phthalate esters may exchange, and phenols may react to form tannates. These reactions increase with increasing pH, and are decreased by the shorter reaction times available in Method 3510.

4.6 The presence of elemental sulfur will result in broad peaks that interfere with detection of early- eluting organochlorine pesticides. Sulfur contamination should be expected with sediment samples. Method 3660 is suggested for removal of sulfur.

4.7 Co-elution among the many target analytes in this method can cause interference problems. The following target analytes coelute on the GC columns listed:

- On a RTX - CLPesticide column; Endrin and 4,4'-DDD; 4,4'DDE and Endosulfan I.
- On a RTX-CLPesticide II column; delta-BHC and Heptachlor; gamma-chlordane and endosulfan I.

5. SAFETY

5.1 The toxicity or carcinogenicity of each reagent used in this method has not been precisely determined; however, each chemical should be treated as a potential health hazard. Exposure to these reagents should be reduced to the lowest possible level. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets should be made available to all personnel involved in these analyses. Specifically, concentrated sulfuric acid and the 50% sodium hydroxide solution are moderately toxic and extremely irritating to skin and mucous membranes. Use these reagents in a fume hood whenever possible and if eye or skin contact occurs, flush with large volumes of water. Always wear safety glasses or a shield for eye protection, and protective clothing, and observe proper mixing when working with these reagents.

6. SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 Sample collection, preservation, and custody management is handled by the sample maintenance office. Refer to SMO-GEN for specifics.

6.2 Purchased, pre-cleaned, certified sample containers should be glass or Teflon, and have screw-caps with Teflon lined septa. In situations where Teflon is not available, solvent-rinsed aluminum foil may be used as a liner. However, acidic or basic samples may react with the aluminum foil, causing eventual contamination of the sample. Plastic containers or lids may NOT be used for the storage of samples due to the possibility of sample contamination from the phthalate esters and other hydrocarbons within the plastic. Sample containers should be filled with care so as to prevent any portion of the collected sample coming in contact with the sampler's gloves, thus causing contamination. Samples shall be stored at 0-6°C and shipped to the laboratory within 48 hrs.

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6.3 Water and soil samples must be iced or refrigerated at 0-6°C from the time of collection until extraction.

6.4 Water samples must be extracted within 7 days and the extracts analyzed within 40 days following extraction. Soil samples must be extracted within 14 days and the extract analyzed within 40 days following extraction.

7. APPARATUS AND MATERIALS:

7.1 Gas Chromatograph/ Electron Capture Detector (GC/EC) System

7.1.1 Gas Chromatograph - Hewlett Packard 5890 and 6890 with a cool on-column injector and dual electron capture detectors.

7.1.2 Columns - two 0.32mm id fused silica capillary columns are used. A separate detector is used for each column. The analytical columns are:

- Restek Rtx-CLPesticide (30 meter, 0.32 mm id, 0.50 µm df).
- Restek Rtx-CLPesticides II (30 meter, 0.32 mm id, 0.25 µm df).

Columns are installed using a deactivated glass "y" connector and a 5 meter Restek siltek deactivated guard column (0.53mm id) which allows simultaneous injection onto both columns.

7.1.3 Carrier Gas - Helium. All GC carrier gas lines must be constructed from stainless steel or copper tubing. Non-polytetrafluorethylene (Ptfe) thread sealants or flow controllers with rubber components are not to be used.

7.1.4 Electron Capture Detector (ECD) - the linearity of the response of the ECD may be greatly dependent on the flow rate of the make-up gas. The make-up gas must be P-5, (argon/methane). Care must be taken to maintain stable and appropriate flow of make-up gas to the detector. The GC/ECD system must be in a room in which the atmosphere has been demonstrated to be free of all contaminants which may interfere with the analysis. The instrument must be vented to a trapping system which prevents the release of contaminants into the instrument room.

7.1.5 Data System - a data system must be interfaced to the GC/EC. The data system must allow the continuous acquisition of data throughout the duration of the chromatographic program and must permit, at the minimum, the output of time vs. intensity (peak height or peak area) data. Also, the data system must be able to rescale chromatographic data in order to report chromatograms meeting the requirements listed within this method.

7.2 Vials and Caps - 2 mL capacity for GC auto sampler, 20 mL scintillation vials for dilutions.

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7.3 Volumetric Flasks - 10 mL, 25 mL, 50 mL, 100 mL for preparation of standards.

7.4 Pipets - Class A 1 mL, 2 mL, etc, and microliter syringes.

8. PREVENTIVE MAINTENANCE

8.1 Glass Insert/Sleeve-single Gooseneck. Indicators are breakdown of endrin and/or DDT and loss of sensitivity of other compounds. The insert should always be replaced before a new calibration and the o-ring should be replaced with the insert.

8.2 Septum - Replaced approximately every 150 injections. A retention time shift or poor baseline chromatography is a common symptom.

8.3 Autosampler syringe - Cleaned daily and after samples with a particularly bad matrix. The syringe should be rinsed with hexane; the plunger is rinsed, wiped with a kim wipe, and rinsed again. The syringe should be replaced with a new one if loose action is noted or inconsistent action is evident (uniform fluctuation in response, area counts) or obvious wear.

8.4 Injection Port - The port and the port/column interface should be cleaned as needed (when replacing the insert is ineffective and in conjunction with column prunning). Port should be reamed with a wire brush and swabbed with hexane. Disc and washer can be sonicated in methylene chloride and then silanized, but should be replaced if wear is evident. The capillary inlet should also be cleaned in hexane and the septum nut is sonicated in hexane also.

8.5 Column Pruning - Cut back one revolution as needed. Indicators are same as insert replacement and is another remedy if insert replacement does not yield the desired results. After initial cut, a graphite ferrule should first be installed and then another short length of column removed (cut should be carefully examined for smoothness - no jagged edges). The column end should extend 7mm past the ferrule when installed (use white out or septum marking method for reference).

8.6 Column Replacement - As needed, usually every 4-6 months for moderate sample volumes. Symptoms are ineffectiveness of insert replacement, injector cleaning, or column pruning to rectify a problem. All ferrules replaced with column change.

8.7 Syringe Rinse Solvent - Supply is replenished as needed. Old solvent is discarded and vial rinsed before refilling. Rinse waste and sample waste vials are replaced when residue appears.

8.8 Carrier Gas - Tank is changed before pressure reaches approximately 200psi to avoid impurities that may be delivered by a nearly empty tank. Leak check with snoop after change.

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8.9 System baking - When the system is to be idle oven temperature should be set to 100°C to avoid water vapor condensation in column. Baking of injector, column, interface may be done for short periods of time to eliminate contaminants due to sample matrix residuals. Temperature should not exceed recommended column temperature limits.

8.10 Maintenance log - All Preventive maintenance, as well as instrument repair, should be documented in the appropriate instrument maintenance log.

9. STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

9.1 Reagents

Hexane, iso-octane, and methanol - pesticide quality or equivalent, purchased commercially. It is recommended that each lot of solvent used be analyzed to demonstrate that it is free of interference before use. For further information, see ADM-CTMN. Store in a flammable cabinet at room temperature. Expires as per manufacturer's indications.

9.2 Standards - Manufacturer's certificates of analysis are retained by the lab and presented upon request. All Standards must be traceable using the CAS lot system and stored separately from samples and sample extracts. Protect all standards from light. See ADM-SPSR.

9.2.1 Stock standard solutions-are purchased as certified solutions.

Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Prepare every six months, or sooner if comparison with check standards indicates a problem.

9.2.2 Secondary Dilution Standards

Using stock standards, prepare secondary dilution standards in hexane that contain the compounds of interest either singly or mixed together. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Prepare every six months, or sooner if comparison with check standards indicates a problem.

9.2.3 Working Standards

9.2.3.1 Surrogate Standard Spiking Solution. - The surrogates, tetrachloro-m-xylene and decachlorobiphenyl, are added to all standards, samples, LCS, matrix spikes, and blanks. Prepare a surrogate spiking solution of 1000ppb of each of the two compounds in acetone. Prepared from Ultra Scientific Pesticide Surrogate Standard Spiking Solution 200ppm (Cat # ISM-320) by diluting 1.0 mL of solution to 200.0mls with acetone. Store

in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Prepare every six months, or sooner if comparison with check standards indicates a problem.

9.2.3.2 Matrix Spiking Solution. -Prepare a matrix spiking solution in acetone or methanol that contains the following pesticides at the concentrations specified:

Pesticide	Concentration ppm
gamma-BHC (Lindane)	0.5
4,4'-DDT	1.0
Endrin	1.0
Heptachlor	0.5
Aldrin	0.5
Dieldrin	1.0

Prepared from Restek Pesticide Matrix Spike Mix (expires as per manufacturer's indications or sooner if problem indicated)(Cat # 32018) by diluting 1.0 ml solution to 50.0 mls with Acetone. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Prepare every six months, or sooner if comparison with check standards indicates a problem.

9.2.3.3 Performance Evaluation Mixture (PEM) Prepare the PEM in hexane at the concentration levels listed below.

Compound	Concentration ppb
gamma-BHC	10.0
alpha-BHC	10.0
4,4'-DDT	100.0
beta-BHC	10.0
Endrin	50.0
Methoxychlor	250.0
Tetrachloro-m-xylene	20.0
Decachlorobiphenyl	20.0

Prepared from Restek Pesticide Performance Evaluation Mix with surrogate (expires as per manufacturer's indications or sooner if problem indicated)(Cat # 32074) by diluting 1.0 ml solution to 100.0 mls with hexane. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials and prepare every six months, or sooner if comparison with check standards indicates a problem.

9.2.3.4 Individual Standard Mixtures A and B.

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The single component pesticide standards must be prepared in hexane at five concentrations for each analyte, including the surrogates. Two separate calibration mixtures, A and B (listed below), are used to ensure that each peak is adequately resolved. The low point concentration corresponds to the detection limit for each analyte. The high point concentration defines the upper end of the concentration range for which the calibration is valid.

9.2.3.4.1 Pesticide Standard Mix A - High

Purchase a stock standard for Mix A ranging in concentration from 8-80 ppm in hexane. Restek Cat # 32003 and dilute 1.0 mL solution to 100.0 mL with hexane. Store in the freezer at 0-⁻20°C in Teflon-lined screw cap amber bottles/vials. Prepare every six months, or sooner if comparison with check standards indicates a problem.

Compound	Initial Conc. stock (ppm)	High Point Final Conc Mix A(ppb)
TCMX (surr)	8	80
a-BHC	8	80
Heptachlor	8	80
g-BHC	8	80
Endosulfan I	8	80
dieldrin	16	160
Endrin	16	160
DDD	16	160
DDT	16	160
Methoxychlor	80	800
DCB (surr)	16	160

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9.2.3.4.1 Pesticide Standard Mix B - High

Purchase a stock standard for Mix B in concentration from 8-16 ppm in hexane. Restek Cat # 32004 and dilute 1.0 mL solution to 100.0 mL with hexane. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Prepare every six months, or sooner if comparison with check standards indicates a problem.

Compound	Initial Conc. Stock (ppm)	High Point Final Conc. Mix B (ppb)
TCMX (surr)	8	80
b-BHC	8	80
d-BHC	8	80
Aldrin	8	80
Heptachlor Epoxide	8	80
a-Chlordane	8	80
g-Chlordane	8	80
DDE	16	160
Endosulfan Sulfate	16	160
Endrin Aldehyde	16	160
Endrin Ketone	16	160
Endosulfan II	16	160
DCB (surr)	16	160

9.2.3.5 Toxaphene Mid- Stock (Restek Cat # 32005)

Dilute 1.0 mL of 1000 ppm stock to 100.0 mL in hexane to obtain 10,000 ppb mid-stock. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Prepare every six months, or sooner if comparison with check standards indicates a problem.

9.2.3.6 Technical Chlordane Mid- Stock (Restek Cat # 32021)

Dilute 1.0 mL of 1000 ppm stock to 100.0 mL in hexane to obtain 10,000 ppb mid-stock. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Prepare every six months, or sooner if comparison with check standards indicates a problem.

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9.2.4 Calibration Standards

9.2.4.1 Calibration Standards - Pesticide Standard Mix A

Dilute Standard Mix A high point to the following concentrations to prepare the calibration standards. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Prepare every six months, or sooner if comparison with check standards indicates a problem.

Compound	STD 1 (ppb) 3.125 ml/ 50 ml	STD 2 (ppb) 6.25ml/ 50ml	STD 3 (ppb) 12.5 ml/ 50 ml	STD 4 (ppb) 25.0 ml/ 50 ml	STD 5 (ppb) Mix A
TCMX (surr)	5	10	20	40	80
a-BHC	5	10	20	40	80
Heptachlor	5	10	20	40	80
g-BHC	5	10	20	40	80
Endosulfan I	5	20	20	40	80
dieldrin	10	20	40	80	160
Endrin	10	20	40	80	160
DDD	10	20	40	80	160
DDT	10	20	40	80	160
Methoxychlor	50	100	200	400	800
DCB (surr)	10	20	40	80	160

9.2.4.2 Calibration Standards - Pesticide Mix B

Dilute Standard Mix B to the following concentrations to prepare the calibration standards. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Prepare every six months, or sooner if comparison with check standards indicates a problem.

Compound	STD 1 (ppb) 3.125 ml/ 50 ml	STD 2 (ppb) 6.25 ml/ 50 ml	STD 3 (ppb) 12.5 ml/50 ml	STD 4 (ppb) 25 ml/ 50 ml	STD 5(ppb) Mix B
TCMX (surr)	5	10	20	40	80
b-BHC	5	10	20	40	80
d-BHC	5	10	20	40	80
Aldrin	5	10	20	40	80
Heptachlor Epoxide	5	10	20	40	80
a-Chlordane	5	10	20	40	80
g-Chlordane	5	10	20	40	80
DDE	10	20	40	80	160
Endosulfan Sulfate	10	20	40	80	160
Endrin Aldehyde	10	20	40	80	160
Endrin Ketone	10	20	40	80	160
Endosulfan II	10	20	40	80	160
DCB (surr)	10	20	40	80	160

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9.2.4.3 Calibration Standards - Toxaphene

Dilute Mid-Stock as follows to prepare the calibration standards. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Prepare every six months, or sooner if comparison with check standards indicates a problem.

Compound	STD 1 (ppb) 0.5/50	STD 2 (ppb) 1.25/50	STD 3 (ppb) 2.5/50	STD 4 (ppb) 3.75/50	STD 5 (ppb) 5.0/50
Toxaphene	100	250	500	750	1000
	STD 1 (ppb) 0.5/50	STD 2 (ppb) 1.0/50	STD 3 (ppb) 1.5/50	STD 4 (ppb) 2.0/50	STD 5 (ppb) 2.5/50
TCMX (surr)	20	40	60	80	100
DCB (surr)	20	40	60	80	100

9.2.4.4 Calibration Standards - Technical Chlordane

Dilute Mid-Stock Standard as follows to prepare the calibration standards. Store in the freezer at 0-¯20°C in Teflon-lined screw cap amber bottles/vials. Prepare every six months, or sooner if comparison with check standards indicates a problem.

Compound	STD 1 (ppb) 0.25/100	STD 2 (ppb) 0.25/50	STD 3 (ppb) 0.5/50	STD 4 (ppb) 1.25/50	STD 5 (ppb) 2.5/50
Tech. Chlordane	25	50	100	250	500
	STD 1 (ppb) 1.0/100	STD 2 (ppb) 1.0/50	STD 3 (ppb) 1.5/50	STD 4 (ppb) 2.0/50	STD 5 (ppb) 2.5/50
TCMX (surr)	20	40	60	80	100
DCB (surr)	20	40	60	80	100

Note: Samples, sample extracts, and standards must be stored separately.

10. RESPONSIBILITIES

It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. Final review and sign-off of the data is performed by the department supervisor or designee.

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11. PROCEDURES:

11.1. Extraction

11.1.1. In general, water samples are extracted at a neutral pH (5-9 standard units), or as is, with methylene chloride, using Method 3510. Solid samples are extracted using Method 3550 and non-aqueous oils are typically extracted by waste dilution, Method 3580. See the following analytical SOPs for details:

EXT-3510
EXT-3550
EXT-3580

11.2. Extract Cleanup

11.2.1 A variety of cleanup steps may be applied to the extracts. At a minimum, sulfur cleanups (Method 3660) are employed as well as florisil (Method 3620)
See EXT-3660 and EXT-3620 for details.

11.3 Gas Chromatograph Operating Conditions

11.3.1 The gas chromatographic analytical conditions are summarized in the instrument specific addendum.

11.3.2 Optimize GC conditions for analyte separation and sensitivity. Once optimized, the same GC conditions must be used for the analysis of all standards, samples, blanks, LCS and MS/MSD. The linearity of the ECD may be greatly dependent on the flow rate of the make-up gas. Care must be taken to maintain stable and appropriate flow of make-up gas to the detector. The same injection volume must be used for all standards, blanks, and samples, including MS/MSD and LCS.

11.4 Initial Calibration

11.4.1 Summary of Initial Calibration.

Prior to the analysis of samples, including MS/MSD and required blanks, each GC/EC system must be initially calibrated at a minimum of five concentrations to determine instrument sensitivity and the linearity of response for single component target compounds and surrogates. Multicomponent target compounds (Toxaphene and Chlordane) are also calibrated at five concentrations. The low standard establishes level of detection and reportability, while the high standard establishes linear range. See CAS calibration policy.

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11.4.2 Frequency of Initial Calibration

Each GC/ECD system must be initially calibrated, whenever major instrument maintenance or modification is performed (e.g., column replacement or repair, cleaning or replacement of ECD, etc.) or if the calibration verification technical acceptance criteria have not been met.

***Note**: Because of the low concentration of pesticide standards injected on a GC/ECD, column absorption may be a problem when the GC has not been used for a day. Therefore, the GC column should be primed or deactivated by injecting a pesticide standard mixture approximately 20 times more concentrated than the mid-level standard. Inject this prior to beginning initial or daily calibration.*

11.4.3 Calibration Factors

When external standard calibration is employed, calculate the calibration factor for each analyte at each concentration, the mean calibration factor, and the relative standard deviation (RSD) of the calibration factors, using the formulas below.

11.4.3.1 Calculate the calibration factor for each analyte at each concentration as:

$$CF = \frac{\text{Peak area (or height) of the standard}}{\text{Mass injected (ng)}}$$

11.4.3.2 Calculate the mean calibration factor for each analyte as:

$$\overline{CF} = \frac{\sum_{i=1}^{n} CF_i}{n}$$

where n is the number of standards analyzed.

11.4.3.3 Calculate the standard deviation (SD) and the RSD of the calibration factors for each analyte as:

$$SD_{CF} = \sqrt{\frac{\sum_{i=1}^{n} \left(CF_i - \overline{CF}\right)^2}{(n - 1)}} \qquad RSD = \frac{SD_{CF}}{\overline{CF}} \times 100$$

If the RSD for each analyte is = 20%, then the response of the instrument is considered linear and the mean calibration factor can be used to quantitate sample results. If the RSD is greater than 20%, then linearity through the origin cannot be

assumed. The analyst must use a calibration curve whose r value is greater than or equal to 0.9901. The regression must not be forced through zero.

11.4.4 DDT and endrin are easily degraded in the injection port if the injection port or front of the column is dirty. This is the result of buildup of high boiling point residue from sample injection. Check for degradation problems by injecting a pesticide evaluation mixture containing DDT and endrin as part of the initial calibration as well as each day the instrument is used. If degradation of either DDT or endrin exceeds 15% the analysis must be repeated.

Calculate percent breakdown as follows:

$$\%\ Breakdown = \frac{Total\ DDT\ degradation\ peak\ area\ (DDE + DDD)}{Total\ DDT\ peak\ area\ (DDT + DDE + DDD)}\ x\ 100\ 1$$

$$\%\ Breakdown = \frac{\begin{array}{c}Total\ endrin\ degradation\ peak\ area\\ endrin\ aldehyde + endrin\ Ketone\end{array}}{\begin{array}{c}Total\ endrin\ peak\ area\\ endrin + endrin\ aldehyde + endrin\ Ketone\end{array}}\ x100$$

11.5 Gas chromatographic analysis of sample extracts.

11.5.1 The same GC operating conditions used for the initial calibration must be employed for samples analyses.

11.5.2 Verify the calibration each 12 hour shift by injecting calibration verification standards prior to conducting any sample analyses. Analysts should alternate the use of high and low concentration mixtures of single-component analytes for calibration verification. A calibration standard must also be injected at intervals of not less than once every twenty samples (after every 10 samples is recommended to minimize the number of samples requiring re-injection when QC limits are exceeded) and at the end of the analysis sequence.

11.5.2.1 The calibration factor for each analyte to be quantitated must not exceed a ± 15 percent difference when compared to the initial calibration curve.

$$\%D = \frac{\overline{CF} - CFv}{\overline{CF}} X100$$

11.5.2.2 If this criteria is exceeded for any compound, calculate the average percent difference for all compounds. The average for all percent differences should be within 15% to proceed. If, however there is a positive result for a

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compound whose percent difference is greater than 15% the sample should be reanalyzed when the percent difference is less than 15%. This should be documented in the case narrative. South Carolina requires that all compounds quantitated above the reporting limit exhibit a %D < 15% to proceed.

11.5.2.3 If this criterion is exceeded, inspect the gas chromatographic system to determine the cause and perform whatever maintenance is necessary before verifying calibration and proceeding with sample analysis.

11.5.2.4 If routine maintenance does not return the instrument performance to meet the above requirements based on the last initial calibration, then a new initial calibration must be performed.

11.5.3 Compare the retention time of each analyte in the calibration standard with the absolute retention time windows established. As described in Method 8000, the center of the absolute retention time window for each analyte is its retention time in the mid-concentration standard analyzed during the initial calibration. Each analyte in each standard must fall within its respective retention time window. If not, the gas chromatographic system must either be adjusted so that a second analysis of the standard does result in all analytes falling within their retention time windows, or a new initial calibration must be performed and new retention time windows established.

11.5.4 Tentative identification of an analyte occurs when a peak from a sample extract falls within the absolute retention time window. Each tentative identification must be confirmed with the second GC column.

11.5.6 If the response exceeds the calibration range of the system, dilute the extract and reanalyze. Peak height measurements are recommended over peak area integration when overlapping peaks cause errors in area integration. See ADM-DIL.

11.5.7 Each sample analysis must be bracketed with an acceptable initial calibration, calibration verification standard(s) (each 12- hour analytical shift), or calibration standards interspersed within the samples. When a calibration verification standard fails to meet the QC criteria, all samples that were injected after the standard that last met the QC criteria must be re-injected.

11.5.8 Sample injections may continue for as long as the calibration verification standards and standards interspersed with the samples meet instrument QC requirements. It is recommended that standards be analyzed after every 10 samples (required after every 20 samples and at the end of a set) to minimize the number of samples that must be re-injected when the standards fail the QC limits. The sequence ends when the set of samples has been injected or when qualitative and/or quantitative QC criteria are exceeded.

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12. QA/QC REQUIREMENTS

12.1 Corrective Action for Surrogate Recovery

12.1.1 If any of the surrogate compounds fail to meet the recovery acceptance criteria (Table 2), check calculations, sample preparation logs, the surrogate compound spiking solutions, and the instrument operation. If the calculations were incorrect, correct the calculations and verify that the surrogate compound recoveries meet their acceptance criteria. If no surrogate spiking solution was added or if the surrogate spiking solution was improperly prepared, concentrated, or degraded, re-extract and reanalyze the samples. If the instrument malfunctioned, correct the instrument problem and reanalyze the sample extract. Sample results shall be reported from analysis in which both surrogates have acceptable recovery, unless matrix interferences are present.

12.1.2 If the above actions do not correct the problem, then the problem may be due to a sample matrix effect. To determine if there was matrix effect, take the following corrective action steps.

12.1.2.1 Re-extract and reanalyze the sample. EXCEPTION: If surrogate compound recoveries in a sample used for a matrix spike and/or matrix spike duplicate were considered unacceptable, then it should be re-extracted/ re-analyzed only if surrogate compound recoveries met the surrogate acceptance criteria in both the matrix spike and matrix spike duplicate.

12.1.2.2 If the surrogate compound recoveries meet acceptance criteria in the re-extract/reanalyzed sample then the problem was within the Laboratory's control. Therefore, submit only data from the re-extraction/reanalysis.

12.1.2.3 If the surrogate recoveries fail to meet the acceptance criteria in the re-extracted/reanalyzed sample, then submit data from both analyses. Distinguish between the initial analysis and the re-extraction/ reanalysis on all.

12.2 Corrective Action for Surrogate Compounds Retention Times Outside Acceptance Criteria.

12.2.1 If the surrogate compounds retention times are not within their acceptance criteria, check the instrument for malfunctions. If the instrument malfunctioned, correct the instrument problem and reanalyze the sample extract. If the instrument malfunction affected the calibration, recalibrate the instrument before reanalyzing the sample extract.

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12.2.2 If the above actions do not correct the problem, then the problem may be due to a sample "matrix effect". To determine if there was matrix effect, take the following corrective action steps.

12.2.2.1 Reanalyze the sample extract. EXCEPTION: If the surrogate compounds retention times in a sample used for a matrix spike and/or matrix spike duplicate were outside the acceptance criteria, then it should be reanalyzed only if the surrogate compounds retention times were within the acceptance criteria in both the matrix spike and matrix spike duplicate analysis.

12.2.2.2 If the surrogate compounds retention times are within the acceptance criteria in the reanalyzed sample extract, then the problem was within the Laboratory's control. Therefor, submit only data from the reanalysis with the surrogate compounds retention times within the acceptance limits.

12.2.2.3 If the surrogate compounds retention times are outside the acceptance criteria in the reanalyzed sample extract, then submit data from both analyses. Distinguish between the initial analysis and the reanalysis.

12.3 Method Blanks

12.3.1 Summary of Method Blanks.

A method blank is a volume of a clean reference matrix (reagent water for water samples, or purified sodium sulfate for soil/sediment samples) that is carried through the entire analytical procedure. The volume or weight of the reference matrix must be approximately equal to the volume or weight of samples associated with the blank. The purpose of a method blank is to determine the levels of contamination associated with the processing and analysis of samples.

12.3.2 Frequency of Method Blanks

A method blank is extracted and analyzed with every batch of 20 samples to demonstrate that there are no method interferences. If the method blank shows any hits above the reporting limit, corrective action must be taken. Corrective action includes recalculation, reanalysis, system cleaning, or reextraction and reanalysis.

12.4 Procedure for Preparing MS/MSD

12.4.1 Frequency of MS/MSD/LCS Analysis

A matrix spike and matrix spike duplicate must be extracted and analyzed at least every 20 samples.

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12.4.2 Water Samples

12.4.2.1 For water samples, measure out two additional 1 L aliquots of the sample chosen for spiking. Adjust the pH of the samples (if required) and fortify each with 1 mL of matrix spiking solution. Using a syringe or volumetric pipet, add 1 mL of surrogate spiking solution to each sample. Extract, concentrate, cleanup, and analyze matrix spikes and matrix spike duplicate according to Section 11.0.

12.4.2.2 Whenever a matrix spike/matrix spike duplicate is prepared, a LCS must also be prepared to demonstrate that poor recoveries are not due to improper spiking solutions. The LCS is prepared by adding 1.0 mL of surrogate spiking solution and 1.0 mL of the matrix spiking solution to 1000 mL of reagent water.

12.4.3 Soil/Sediment Samples.

12.4.3.1 For soil/sediment samples weigh out two additional 30 g (record weight to the nearest 0.1 g) aliquots of the sample chosen for spiking. Add 1 mL of matrix spiking solution and 1 mL of surrogate solution. Extract, concentrate, cleanup, and analyze matrix spikes and matrix spike duplicates according to Section 11.0.

12.4.3.2 Whenever a matrix spike/ matrix spike duplicate is prepared, a LCS must also be prepared to demonstrate that poor recoveries are not due to improper spiking solutions. The low level soil/sediment matrix spike blank is prepared by adding 1.0 mL of surrogate spiking solution and 1.0 mL of the matrix spiking solution to a 30 g aliquot of anhydrous sodium sulfate.

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12.4.4 Calculations for MS/MSD

12.4.4.1 The percent recoveries and the relative percent difference between the recoveries of each of the compounds in the matrix spike samples will be calculated and reported by using the following equations

$$\text{Matrix Spike Recovery} = \frac{SSR - SR}{SA} \times 100$$

Where,

SSR = Spike sample result
SR = Sample result
SA = Spike added

$$RPD = \frac{|MSR - MSDR|}{\frac{1}{2}(MSR + MSDR)} \times 100$$

Where,

RPD = Relative percent difference
MSR = Matrix spike recovery
MSDR = Matrix spike duplicate recovery

12.4.4.2 The vertical bars in the formula above indicate the absolute value of the difference, hence RPD is always expressed as a positive value.

12.4.5 Technical Acceptance Criteria for MS/MSD/LCS.

12.4.5.1 The requirements below apply independently to each GC column and to all instruments used for these analyses. Quantitation must be performed on both GC columns.

12.4.5.2 All MS/MSD/LCS must be prepared and analyzed at the proper frequency on a GC/EC system meeting the initial calibration, calibration verification, and blank technical acceptance criteria.

12.4.5.3 The samples must be extracted and analyzed within the required holding times.

12.4.5.4 The retention time for each of the surrogates must be within the retention time windows for both GC columns.

12.4.5.5 The limits for MS/MSD/LCS compound recovery and RPD are given in Table 2.

12.4.5.6 The limits for the LCS must be met. Failure to meet these limits will require re-extraction and re-analysis of the MS/MSD/LCS.

12.5 Method Performance - Method Detection Limit (MDL) studies should be performed annually for both soil and water matrices. See CAS SOP ADM-MDL for specifics.

13.0 DATA REDUCTION AND CALCULATIONS

13.1 Determine the quantity of each component peak in the sample chromatogram which corresponds to the compounds used for calibration purposes, as follows. Proper quantitation requires the appropriate selection of a baseline from which the peak area or height can be determined.

13.1.1 For aqueous samples

Where:

$$\text{Concentration } \mu\text{g/ L} = \frac{(A_x)\ (V_t)\ (Df)}{(\overline{CF})\ (V_o)\ (V_i)}$$

A_x = Area of the peak for the compound to be measured.
CF = mean calibration factor from the initial calibration (area per ng).
V_o = Volume of water extracted in milliliters (mL).
V_i = Volume of extract injected in microliters (µL). (If a single injection is made onto two columns, use one half the volume in the syringe as the volume injected onto each column.)

V_t = Volume of the concentrated extract in microliters (µL).

Df =Dilution factor. The dilution factor for analysis of water samples by this method is defined as follows:

$$\frac{\mu\text{L most conc. extract used to make dilution} + \mu\text{L clean solvent}}{\mu\text{L most conc. extract used to make dilution}}$$

If no dilution is performed, Df = 1.0.

Using the units specified here for these terms will result in a concentration in units of ng/mL, which is equivalent to µg/L.

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13.1.2 For non-aqueous samples:

$$\text{Concentration } \mu\text{g/ Kg (Dry weight basis)} = \frac{(A_x)\ (V_t)\ (Df)}{(\overline{CF})\ (V_i)\ (W_s)\ (D)}$$

where A_x, V_t, D, $\overline{CF}$, and V_i are the same as for aqueous samples, and

W_s = Weight of sample extracted (g). The wet weight or dry weight may be used, depending upon specific application of the data. If units of kilograms are used for this term, multiply the result by 1000.

Using the units specified here for these terms will result in a concentration in units of ng/g, which is equivalent to µg/kg.

13.2 Validation of the GC system qualitative performance.

13.2.1 Use the calibration standards analyzed during the sequence to evaluate retention time stability. The retention time windows are established using the absolute retention time of each analyte in the mid-concentration standard during the initial calibration as the mid-point of the window. The widths of the windows are defined as the mid-point plus and minus three times the standard deviations calculated.

13.2.2 Each subsequent injection of a standard during the 12-hour analytical shift (i.e., those standards injected every 20 samples, or more frequently) must be checked against retention time windows. If any of these subsequent standards fall outside their absolute retention time windows, the GC system is out of control. Determine the cause of the problem and correct it. If the problem cannot be corrected, a new initial calibration must be performed.

13.3 Identification of mixtures (i.e. Chlordane and Toxaphene) is based on the characteristic "fingerprint" retention time and shape of the indicator peak(s); and quantitation is based on the area under the characteristic peaks as compared to the area under the corresponding calibration peak (s) of the same retention time and shape generated using the external calibration procedures.

13.4 If compound Identification or quantitation is precluded due to interference (e.g., broad, rounded peaks or ill-defined baselines are present) cleanup of the extract is warranted. Refer to Method 3600 for the procedures to be followed in sample cleanup.

13.5 Data reporting and review is handled by a computerized LIMS System. Specifics pertaining to reporting and review are contained in the company ADM-DREV SOP.

14. WASTE MANAGEMENT AND POLLUTION PREVENTION

It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

Aqueous sample extract is typically dumped down sanitary sewer. Solvent extracts are disposed of in 5 gallon justrite containers in the lab and dumped periodically by qualified personnel in 55 gallon drums for waste removal. See SMO-SPDIS for further information.

15. REFERENCES:

15.1. "Test Methods for Evaluating Solid Waste Physical/Chemical Methods," SW-846, 3rd edition, December 1996.

16. TRAINING OUTLINE

- Read current SOP. Demonstrate a general understanding of the methodology and chemistry.
- Observe Sample Preparation and Analysis.
- Participate in the methodology, documentation, and data reduction with guidance.
- Participate in instrument operation, maintenance, and documentation.
- Demonstrate Competency by performing the analysis independently. Analyze a known proficiency or standard. If recovery is within acceptable limits, complete training form and have the supervisor sign-off as being proficient. An IDC study must be performed and the departmental supervisor must approve the study before the new analyst may analyze samples independently. Four replicates must be analyzed within LCS control limits to complete the IDC study.

17. INSTRUMENT SPECIFIC ADDENDUM

- GC instrument operating parameters in Attachment A.
- HP instrument manuals are located in the GC instrument lab.

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18. ATTACHMENTS

Table 1 Practical Quantitation Limits
Table 2 QC Recovery Limits
Attachment A Instrument Operating Parameters

19. CHANGES SINCE PREVIOUS REVISION

- Added sections 2,3,8,10,13,14,16,17,18,19 for NELAC compliance
- Updated prep and expiration instructions for reagents and standards
- Revised reference to current methodology
- Revised Tables 1 and 2 to reflect current compound list and QC limits
- Added Attachment A
- Included confirmation requirements in Section 11.5
- Specified extraction pH requirements.
- Specified calibration requirements and reporting levels.
- Omitted reference to quadratic fit and forcing curve through zero.
- Revised corrective action procedures for outlying QC.

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TABLE 1 PRACTICAL QUANTITATION LIMITS

Parameter	PQL Water µg/L	Soil µg/kg	Waste Dilutions* µg/kg
Aldrin	0.05	1.7	50
a-BHC	0.05	1.7	50
ß-BHC	0.05	1.7	50
δ-BHC	0.05	1.7	50
γ-BHC	0.05	1.7	50
Chlordane	0.25	8.5	250
a-Chlordane	0.05	1.7	50
γ-Chlordane	0.05	1.7	50
4,4'-DDD	0.10	3.3	100
4,4'-DDE	0.10	3.3	100
4,4'-DDT	0.10	3.3	100
Dieldrin	0.10	3.3	100
Endosulfan I	0.10	3.3	100
Endosulfan II	0.10	3.3	100
Endosulfan sulfate	0.10	3.3	100
Endrin	0.10	3.3	100
Endrin aldehyde	0.10	3.3	100
Endrin Ketone	0.10	3.3	100
Famphur	1.0	33	1000
Heptachlor	0.05	1.7	50
Heptachlor epoxide	0.05	1.7	50
Hexachlorobenzene	0.05	1.7	50
Kepone	10	330	10000
Methoxychlor	0.5	17	500
Mirex	NA	NA	NA
Toxaphene	1.0	33	1000

1 gram to 10 mL as per Method 3580.

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TABLE 2 QC RECOVERY LIMITS

Parameter	Water Recovery Limits (%)	Soil Recovery Limits (%)
Aldrin	70-130*	70-130*
a-BHC	70-130*	70-130*
ß-BHC	70-130*	70-130*
δ-BHC	70-130*	70-130*
γ-BHC	70-130*	70-130*
Chlordane	70-130*	70-130*
γ-Chlordane	70-130*	70-130*
4,4'-DDD	70-130*	70-130*
4,4'-DDE	70-130*	70-130*
4,4'-DDT	70-130*	70-130*
Dieldrin	70-130*	70-130*
Endosulfan I	70-130*	70-130*
Endosulfan II	70-130*	70-130*
Endosulfan sulfate	70-130*	70-130*
Endrin	70-130*	70-130*
Endrin aldehyde	70-130*	70-130*
Endrin Ketone	70-130*	70-130*
Famphur	70-130*	70-130*
Heptachlor	70-130*	70-130*
Heptachlor epoxide	70-130*	70-130*
Hexachlorobenzene	70-130*	70-130*
Kepone	70-130*	70-130*
Methoxychlor	70-130*	70-130*
Mirex	70-130*	70-130*
Toxaphene	70-130*	70-130*
SURROGATES		
Tetrachloro-m-xylene	46-120	52-120
Decachloro biphenyl	17-133	17-133

* The laboratory based limits are in the process of being calculated. The 70-130 is a targeted recovery until laboratory limits are established.

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ATTACHMENT A

INSTRUMENT OPERATING PARAMETERS

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STANDARD OPERATING PROCEDURE

DETERMINATION OF SULFIDES BY DISTILLATION AND IODIMETRIC TITRATION

GEN-9030B/9034

Revision 1
September 28, 2001

Approved By: _____ _____
Supervisor Date

_____ _____
QA Coordinator Date

_____ _____
Laboratory Manager Date

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One Mustard St., Suite 250
Rochester, NY 14609

Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
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Initials: _____ Date: _____

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1 SCOPE AND APPLICATION

1.1 This procedure is designed for the determination of sulfide in aqueous, solid waste materials, or effluents using SW846 Method 9030B/9034. This procedure is suitable for measuring sulfide concentrations in the range of 0.2-50ppm.

1.2 This method is not applicable to oil or multiphasic samples.

1.3 This method measures total sulfide which is usually defined as the acid-soluble fraction of a waste. Although Method 9030B covers the determination of acid-insoluble sulfides, this SOP does not.

2 METHOD SUMMARY

The sample is distilled under acidic conditions at 70°C under a stream of nitrogen. Hydrogen sulfide is released and collected in gas scrubbing bottles containing zinc(II) and a strong acetate buffer. Zinc sulfide precipitates and is measured by iodimetric titration.

3 DEFINITIONS

3.1 **Matrix Spike (MS**) - In the matrix spike analysis, a predetermined quantity of standard solution of the analyte is added to a sample matrix prior to sample distillation and analysis. The purpose of the matrix spike is to evaluate the effects of the sample matrix on the methods used for the analyses. Percent recovery is calculated for the analyte detected.

3.2 **Duplicate Sample (DUP**) - A laboratory duplicate. The duplicate sample is a separate field sample aliquot that is processed in an identical manner as the sample proper. The relative percent difference between the samples is calculated and used to assess analytical precision.

3.3 **Method Blank** - The method blank is an artificial sample designed to monitor introduction of artifacts into the process. The method blank is carried through the entire analytical procedure.

3.4 **Laboratory Control Sample (LCS)** - In the LCS or blank spike analysis, a predetermined quantity of standard solution of the analyte is added to a blank prior to sample distillation and analysis. Percent recovery is calculated for the analyte detected.

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4 INTERFERENCES

4.1 Aqueous samples must be taken with a minimum of aeration to avoid volatilization of sulfide or reaction with oxygen, which oxidizes sulfide to sulfur compounds that are not detected.

4.2 Reduced sulfur compounds, such as sulfite and hydrosulfite, decompose in acid, and may form sulfur dioxide. This gas may carry over to the zinc acetate gas scrubbing bottles and subsequently react with the iodine in the determinative step to yield false high values. The addition of formaldehyde into the scrubber removes this interference. Any sulfur dioxide entering the scrubber will form an addition compound with the formaldehyde which is unreactive towards the iodine in the acidified mixture. This method shows no sensitivity to sulfite or hydrosulfite at concentrations up to 10 mg/kg of the interferent.

5 SAFETY

5.1 Sulfide gas (H_2S) is highly toxic. Care must be taken with the samples and when preparing references. The threshold odor concentration in clean water is between 0.025 and 0.25 µg/L.

5.2 Formaldehyde and sulfuric acid should be handled with care.

5.3 Lab coat, glasses, and gloves should be worn when performing this test.

6 SAMPLE CONTAINERS, COLLECTION, PRESERVATIONS, AND STORAGE

6.1 Aqueous samples are collected with a minimum of aeration in 300 mL glass BOD bottles or 500 mL certified clean plastic bottles, preserved with 2.0 mLs of 2N zinc acetate and 2-3 pellets of sodium hydroxide. Fill to no headspace and cap tightly. Store at 0-6°C until analysis.

6.2 Soil samples are to be collected in glass jars with no headspace. Store at 0-6°C until analysis.

6.3 Samples are to be analyzed within 7 days of collection.

6.4 Further sample handling, storage, and custody procedures are discussed in SMO-GEN.

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7 APPARATUS AND EQUIPMENT

7.1 See Figures 1 and 2 for Apparatus Configuration

7.2 Midi Distillation Unit (Midi Vap Model MCV 103), if using Midi.

7.3 Distillation tubes (Midi) or flasks (Macro).

7.4 Distillation heads with fritted outlet.

7.5 Absorber (scrubber) tubes.

7.6 Absorber (scrubber) heads with fritted outlet.

7.7 Dropping funnel with stopcock and pressure equalizing arm.

7.8 1/4 inch tubing and quick disconnects.

7.9 Nitrogen source and gas tubing.

7.10 Common laboratory glassware and equipment including 500 mL Erlenmeyer flasks, graduated cylinders, stir plate with stir bars, 10 mL buret with 0.05 mL increments, pipettes, DI bottle, calibrated top loading balance, calibrated analytical balance, calibrated micropipettor, and volumetric flasks.

8 PREVENTIVE MAINTENANCE

8.1 Check all connections on the apparatus for leaks by wetting connections with a weak soap solution and looking for bubbles.

9 STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

9.1 Concentrated Hydrochloric Acid – purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.2 6N Hydrochloric Acid - Carefully add 100 mL of concentrated HCl to 100 mL of DI. Store at room temperature in plastic for up to 1 year.

9.3 Potassium iodide (KI) – purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

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9.4 Iodine – purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.5 Standard iodine solution (0.0250N) - Add 20 - 25 g KI to 50 mL DI and mix. Add 3.2 g iodine. Dilute volumetrically to 1 Liter with DI. Store in amber glass at 0-6°C for up to 1 year. Standardize with each use against 0.0250N $Na_2S_2O_3$ as follows:

9.5.1 Volumetrically place 5.0 mL iodine solution in a small beaker or Erlenmeyer flask.
9.5.2 Titrate with 0.025 N $Na_2S_2O_3$ to a light yellow.
9.5.3 Add approximately 0.5 mL starch indicator.
9.5.4 Continue titrating to colorless.
9.5.5 Calculate the actual normality of the iodine solution:

$$\text{Normality of Iodine} = \frac{(\text{Volume(mLs) of } Na_2S_2O_3)(\text{Normality of } Na_2S_2O_3)}{(\text{Volume of Iodine(mLs)})}$$

9.5.6 Record standardization in standardization log book

9.6 Standard potassium bi-iodate solution (0.025N) - Add 0.81225g $KH(IO_3)_2$ to 800 mL DI in a 1 L volumetric flask and dissolve. Dilute to mark. Prepare fresh daily as needed for standardization of $Na_2S_2O_3$.

9.7 Standard sodium thiosulfate solution (0.0250N) - Dilute commercially prepared stock as necessary. Prepare fresh every 14 days or standardize as follows:

9.7.1 Dissolve approximately 2 g KI in 100 mL DI.
9.7.2 Add 1 mL 6N HCl.
9.7.3 Add 9 mL standard bi-iodate solution.
9.7.4 Dilute to 200 mL, add starch indicator and titrate to colorless with sodium thiosulfate solution.
9.7.5 Calculate the normality of the solution as follows:

$$\text{Normality of } Na_2S_2O_3 = \frac{(\text{Volume of } KH(IO_3)_2\text{(mLs))(Normality of } KH(IO_3)_2)}{\text{Volume of } Na_2S_2O_3\text{(mLs)}}$$

9.8 Starch Indicator - Purchased commercially. Store at 0-6°C in plastic. Expires upon manufacturer's indications, one year from receipt, or when it no longer produces the intended indication effect, whichever is sooner.

9.9 Zinc Acetate ($Zn(C_2H_3O_2)\bullet 2H_2O$) – purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.10 Zinc Acetate Preservative (2N)- Add 220 g $Zn(C_2H_3O_2)\bullet 2H_2O$ to 800 mL DI and mix. Dilute to 1 Liter. Store at 0-6°C in amber glass for up to 1 year.

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9.11 Zinc Acetate Stock (0.5M) - Add 110 g $Zn(C_2H_3O_2)\bullet 2H_2O$ to 800 mL DI and mix. Add 1 mL 6N HCl to prevent the formation of zinc hydroxide and dilute to 1 Liter. Store at 0-6°C in amber glass for up to 1 year.

9.12 Formaldehyde (35-40%) - Purchased commercially. Store in flammable cabinet. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.13 Concentrated, reagent grade sulfuric acid - Purchased commercially.

9.14 Sodium Sulfide crystals ($Na_2S\bullet 9H_2O$) – purchased commercially. Store tightly capped at 0-6 °C. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.15 Sulfide reference solution - Weigh approximately 0.4 g $Na_2S\bullet 9H_2O$ on the analytical balance and record the actual weight. Add the sodium sulfide to a tared glass bottle and dilute to 100g with DI. Store at 0-6°C for up to 1 week. Calculate the concentration of the solution as follows:

$$\text{mg/mL } S^{2-} = \frac{(\text{g } Na_2S\bullet 9H_2O)(0.1333)}{\text{Final Volume(mLs)}} \times \frac{1000\text{mg}}{\text{g}}$$

9.15.1 Standardization of the Sulfide Reference Solution – Pipet 5.0 mLs 0.025N standardized iodine solution into a 250 mL Erlenmeyer flask. Add 100 mLs DI and 2 mLs 1:1 HCl. Add 2 mLs sulfide reference solution to 100 mLs DI and titrate with 0.025N $Na_2S_2O_3$ to a light yellow. Add 1 mL starch and titrate to clear. Calculate as in the sample calculation. Record standardization in standardization log book.

9.16 LCS/MS - Midi -Add 2.0 mL of the sulfide reference solution to 50 mL DI (or sample) or 6 g Ottawa sand (or sample) in the distillation tube.

9.17 LCS/MS - Macro - Add 2.0 mL of the sulfide reference solution to 100 mL DI (or sample) or 10 g Ottawa sand (or sample) in the distillation flask.

10 RESPONSIBILITIES

10.1 It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. Final review and sign-off of the data is performed by the department supervisor or designee.

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11 PROCEDURE

11.1 Sample Preparation

11.1.1 Check and record the pH of the sample. Homogenize sample and measure into sample tube or flask, recording actual weight or volume. Use 10 g or 100 mL for Macro distillation. Use 6 g or 100 mL for Midi distillation. In order to prevent blocking of the distillation head's fritted end and maintain fluid motion, it may be necessary to further limit the mass for the Midi distillation if the sample is porous and will swell in water.

11.1.2 For non-aqueous samples, add an additional 50 mL DI to the sample tube (midi) or 250 mL DI to the sample flask (Macro).

11.1.3 Record the distillations in the distillation log book.

11.2 Apparatus Preparation

11.2.1 The midi distillation unit should be assembled as in Figure 1.
11.2.2 The macro distillation should be assembled as in Figure 2.

11.3 Distillation Procedure

11.3.1 In the scrubber tube, place 20 mL 0.5 M ZnAcetate, 10 mL Formaldehyde, and 50 mL DI.

11.3.2 Assemble system

11.3.3 Place 25 mL (midi) or 75 mL (macro) concentrated sulfuric acid in the dropping funnel.

11.3.4 Turn on Nitrogen gas and adjust delivery to individual scrubbers to about 25 mL gas/ min. Limit the pressure to about 10 psi to prevent excess stress on the glass system and fittings. Purge system for at least 5 minutes.

11.3.5 Heat system to 70°C.

11.3.6 Open dropping funnel to a position that will allow a flow of sulfuric acid of approximately 5 mL/min. Monitor the system until all of the acid has entered the flask. *CAUTION: Violent reactions and foaming can occur*.

11.3.7 Maintain heat and purge for 90 minutes.

11.3.8 Turn off heat and nitrogen supply.

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11.4 Preparation of distilled sample for analysis

11.4.1 Check the pH of the distilled sample. pH should be <1. If the pH is not <1, incomplete distillation may have occurred and the sample should be redistilled at a lesser volume.

11.4.2 Prepare the rinse solution as follows:

11.4.2.1 With a volumetric pipette, place 5.0 mL iodine solution in a 100 mL flask.
11.4.2.2 Add approximately 50 mL DI.
11.4.2.3 Add 2.0 mL 6N HCl.
11.4.2.4 Dilute to approximately 100 mL with DI

11.4.3 Disassemble, pour scrubber solution into a 500 mL Erlenmeyer flask with a minimum of aeration.

11.4.4 Carefully rinse the scrubber tube and head with the rinse solution, being sure to rinse the inside of the fritted end. Do not spill any of this rinse. Collect all the rinseate in the 500 mL Erlenmeyer with the sample. Rinse again with DI and collect rinseate in the 500 mL Erlenmeyer. Pour any remaining rinse solution into the Erlenmeyer for titrimetric analysis.

11.5 Iodimetric Titration Analysis

11.5.1 If the orange color of the iodine disappears, add additional measured portions of iodine solution until the orange color persists. Record total volume of iodine solution used on the benchsheet.

11.5.2 Titrate all rinses and scrubber solution with 0.0250N $Na_2S_2O_3$ to a light yellow.

11.5.3 Add 1 mL starch. Solution will turn blue.

11.5.4 Continue titrating until blue color disappears. Record on the benchsheet the volume of $Na_2S_2O_3$ needed to reach endpoint.

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12 QA/QC REQUIREMENTS

12.1 One blank must be analyzed per batch of 20 or fewer samples. The result of the blank must be less than the detection limit. Positive detections indicate possible laboratory contamination and the batch should be redistilled and reanalyzed.

12.2 One sample must be analyzed in duplicate for every batch of 20 or fewer samples, volume permitting. The %RPD must be less than 20% for samples greater than 5 times the PQL. For samples less than 5 times the PQL, the duplicate must be within the value of the sample +/- the PQL. Poor precision may indicate matrix interferences and these data may be flagged as estimated.

12.3 One spiked sample must be analyzed for every batch of 20 or fewer samples, volume permitting. The % recovery must be within the limits in the Wetchem QC table in the Quality Assurance Manual. Outlying recoveries may indicate matrix interferences and these data may be flagged as estimated. Evaluate the LCS to determine reanalysis.

12.4 One LCS must be analyzed for every batch of 20 or fewer samples. The % recovery must be within the limits in the Wetchem QC table in the Quality Assurance Manual. Outlying recoveries indicate inaccurate distillation or analysis procedures and the batch should be redistilled and reanalyzed.

12.5 An MDL study must be performed annually. The result of the study must be less than the reporting limit. If it is not, fix the problem and repeat the study or raise the reporting limit. For more information, see ADM-MDL.

13 DATA REDUCTION AND REPORTING

13.1 Calculations

$$\text{Sulfide (mg/L or mg/Kg)} = \frac{(A \times B) - (C \times D)}{\text{L or Kg}} \times 16.03$$

Where:
A = volume(mL) iodine used
B = Normality of iodine solution
C = Volume (mL) sodium thiosulfate used
D = Normality of sodium thiosulfate

13.2 Data review policies and procedures are in ADM-DREV.

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14 WASTE MANAGEMENT AND POLLUTION PREVENTION

Reagents are prepared upon an as-needed basis in small quantities. Minimum sample volumes are used during analysis. Acidic waste is neutralized and poured down the drain with copious amounts of water. For more information see SMO-SPLDIS.

15 REFERENCES

15.1 *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, USEPA SW-846, December 1996.

16 TRAINING OUTLINE

16.1 Read current SOP and applicable methodologies. Demonstrate a general understanding of the methodology and chemistry. Follow policies in ADM-TRANDOC.

16.2 Observe Sample Preparation and Analysis. Follow distillation and titration Training Plan Forms.

16.3 Participate in the methodology, documentation, and data reduction with guidance.

16.4 Demonstrate Initial Competency (IDC) by performing the analysis independently. Analyze four replicates of a known mid-range standard. If recovery is within acceptable limits, complete Training Plan Forms and IDC certificate and file with QA. Continuing Demonstration of Capability (CDC) will be demonstrated annually using a PE, single blind, or a new four replicate study.

17 INSTRUMENT-SPECIFIC ADDENDUM

None

18 ATTACHMENTS

18.1 Figure 1: Midi Apparatus

18.2 Figure 2: Macro Apparatus

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19 CHANGES FROM PREVIOUS REVISION

19.1 Added the method number to 1.0.
19.2 Added references to SMO-GEN, ADM-MDL, ADM-DREV, ADM-TRANDOC, and SMO-SPLDIS.
19.3 Removed need to add zinc acetate as a preservative of soils.
19.4 Split out some purchased reagents from prepared solutions.
19.5 Added 500 mL plastic bottles to 6.0.
19.6 Changed listed QC limits to a reference to the Wetchem QC table in the Quality Assurance Manual.
19.7 Explained that the method covers acid-insoluble sulfides but this SOP does not.
19.8 Eliminated interference by tin(II) Chloride since it is not added.
19.9 Added need to check and record the preservation of the sample.
19.10 Changed preservation of sample from 1 small pellet of NaOH to 2-3 pellets.
19.11 Added standardization of sulfide reference solution.
19.12 Added need to record distillations in distillation log book.
19.13 Changed from adding 5.0 mL aliquots in 11.5.1 to “measured” aliquots.

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STANDARD OPERATING PROCEDURE

for

TOTAL CYANIDES USING MIDI DISTILLATION APPARATUS

SOP No.: GEN-9012A/335.4/335.2(CLP-M)

Revision: 2

September 28, 2001

Approved by: _____ _____
Supervisor Date

_____ _____
QA Coordinator Date

_____ _____
Laboratory Manager Date

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1 Mustard Street, Suite 250
Rochester, New York 14609

Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
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1. SCOPE AND APPLICATION

1.1. Method is applicable to cyanides, either as free cyanide, in simple soluble salts or in metal complexes. This method is applicable to USEPA Methods 335.4, 9012A, and 335.2 CLP-M.

1.2. This method is applicable to drinking, surface, and saline waters, domestic and industrial waste. A modified procedure has also been established for soil, sludge, solid, and miscellaneous matrices.

1.3. Typical reporting limits are 0.01 mg/L for water and 0.5 mg/Kg for soils. The working range is 0.010 mg/L to 0.500 mg/L and dilutions can be made to extend this range for higher level samples.

2. METHOD SUMMARY

2.1. Cyanide is released from cyanide complexes and converted to hydrocyanic acid (HCN) during reflux - distillation with sulfuric acid and magnesium chloride ($MgC1_2$) and absorbed in a scrubber containing a sodium hydroxide solution.

2.2. The cyanide ion is then converted to cyanogen chloride (CNCl) by reaction with chloramine-T at a pH less than eight without hydrolyzing to the cyanate. After the reaction is complete, color is formed with the addition of pyridine barbituric acid reagent. The absorbance is read at 578 nm on the Technicon Autoanalyzer.

3. DEFINITIONS

3.1. **Matrix Spike (MS**) - In the matrix spike analysis, a predetermined quantity of standard solution is added to a sample matrix prior to sample distillation and analysis. The purpose of the matrix spike is to evaluate the effects of the sample matrix on the methods used for the analyses. Percent recoveries are calculated for the analyte detected.

3.2. **Duplicate Sample (DUP**) - A laboratory duplicate. The duplicate sample is a separate field sample aliquot that is processed in an identical manner as the sample proper. The relative percent difference between the samples is calculated and used to assess analytical precision.

3.3. **Method Blank** - The method blank is an artificial sample designed to monitor introduction of artifacts into the process. The method blank is carried through the entire analytical procedure.

3.4. **Laboratory Control Sample (LCS)** - In the LCS or blank spike analysis, a predetermined quantity of standard solution is added to a blank prior to sample distillation and analysis. Percent recoveries are calculated for the analyte detected.

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3.5. Independent Calibration Verification/ Continuing Calibration Verification (ICV / CCV) – ICV/CCV solutions are made from a stock solution which is different from the stock used to prepare calibration standards and is used to verify the validity of the standardization.

3.6. Initial Calibration Blank (ICB) - The matrix-matched laboratory deionized water blank (0.25N NaOH) that is run immediately after calibration to determine if the instrument is adequately zeroed.

3.7. Continuous Calibration Blank (CCB) - The matrix-matched laboratory deionized water blank (0.25N NaOH) that is run periodically (every 10 samples after the CCV) to ensure the instrument is still zeroed adequately.

3.8. Batch – Unit of samples distilled on the same day, not to exceed 20 samples.

3.9. VTSR - Verified Time of Sample Receipt

4. INTERFERENCES

4.1. A number of interferences will be eliminated or reduced by using the distillation procedure.

4.2. Nitrates and nitrites can lead to high results as they can form nitrous acid during distillation which will react with some organic compounds to form oximes. Ultimately these can decompose to generate HCN. Sulfamic acid is added prior to addition of sulfuric acid.

4.3. After distillation, sample distillate shall be tested for the presence of sulfides using lead acetate paper. If positive, sulfides are removed by adding an excess of cadmium carbonate powder to the distillate, then filtered.

4.4. The presence of surfactants may cause the sample to foam during refluxing. If this occurs the addition of an anti-foam agent should be added to the distillation flask to prevent the sample from foaming up into the condenser.

5. SAFETY

5.1. Always wear gloves, lab coat, and safety glasses when handling samples or performing the analysis.

5.2. This procedure involves the evolution of hydrocyanic acid (HCN), a highly poisonous gas. Care must be taken during distillation to prevent the release of this gas.

5.3. Caution should be used when preparing and using stock standard solutions and other reagents. The MSDS for each of these should be read before handling.

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5.4. Potassium cyanide (KCN) is highly toxic and is a severe health and contact hazard. Upon contact with acid it will liberate HCN, a highly poisonous gas. Use caution when preparing standards.

5.5. Sulfuric acid (H_2SO_4) is a severe health, reactivity, and contact hazard. Always wear gloves and use caution when handling.

5.6. Sodium hydroxide (NaOH) is a strong caustic and a severe health and contact hazard. Use caution when handling pellets and preparing solutions.

5.7. Chloramine - T is a mutagen, avoid breathing dust and do not purge for an excessive period of time.

5.8. Pyridine is also a health hazard and its odor is very pervasive. Always prepare in a hood, wearing gloves, and keep capped tightly when transporting.

5.9. Cadmium Carbonate is a carcinogen. Use caution when handling.

6. SAMPLE COLLECTION, CONTAINERS, PRESERVATION, AND STORAGE

6.1. Sample bottles can either be glass or plastic and are purchased as certified clean.

6.2. Samples are to be preserved with approximately 2 grams of solid sodium hydroxide per liter of sample, or equivalent, to a pH ≥ 12 at time of collection.

6.3. Water samples must be analyzed within the maximum holding time of 14 days from sample collection. There is no required holding time established for soils, however, all soils are recommended to be analyzed within 14 days of collection. CLP samples must be analyzed within 12 days of sample receipt at the laboratory (VTSR).

6.4. Samples must be stored refrigerated at 0-6°C.

6.5. Oxidizing agents such as chlorine decompose most cyanides and should be removed prior to preservation. Test a drop of sample with potassium iodide - starch test paper previously moistened with pH 4 acetate buffer solution. Blue color indicates the presence of oxidizing agents. Add a few crystals of ascorbic acid until there is no color change with the test paper. This is done in SMO upon breakdown of the samples. Chlorine presence should be communicated by the client so that ascorbic acid may be used in the field.

6.6. Sample handling, storage, and custody procedures are discussed in SOP SMO-GEN.

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7. APPARATUS AND EQUIPMENT

7.1. Use the Midi-vap unit for midi distillation as shown in Figure 1. Laboratory should have equipment and glassware for 20 distillation units and extras, including:

7.2. Distillation tube, approximately 100 ml capacity.

7.3. Absorber tube.

7.4. Absorber top with fritted outlet.

7.5. Cold-finger condenser.

7.6. Distillation head.

7.7. Vacuum source with 500 ml vacuum trap and cooling water supply.

7.8. Laboratory glassware including: graduated cylinders (50 and 100 ml sizes), volumetric flasks (100, 250, 500, and 1000 ml sizes with stoppers); a range of volumetric pipettes, class A; and a micropipettor.

7.9. Colorimetric autoanalyzer system (Technicon AA II).

8. PREVENTIVE MAINTENANCE

8.1. Clean absorber frit immediately after every use: flush with DI water three times. Clean glassware according to GEN-GC.

8.2. Clean midi vap unit after each use by wiping all exterior surfaces with a mild neutralizing agent followed by DI water. Avoid excess solution on or near controls. The heat block holes should also be rinsed.

9. STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

9.1. REAGENTS

9.1.1. Sodium hydroxide, 12.5 N – Purchased commercially. Store at room temperature. Expires as per manufacturer's indications or 3 years from receipt, whichever is sooner.

9.1.2. Sodium hydroxide, 0.25 N - dilute 40 mL of 12.5 N NaOH to 2 L DI water. Store in plastic or glass at room temperature for up to 12 months.

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9.1.3. Sulfuric Acid – concentrated – purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.1.4. Sulfuric acid, 50% (v/v) – Slowly and carefully add a portion of concentrated sulfuric acid to an equal portion of DI water. Prepare in a hood in a cold water bath – will become very hot. Store in glass at room temperature for up to 12 months.

9.1.5. Magnesium chloride ($MgCl_2.6H_20$) - purchased commercially. Store at room temperature. Expires as per manufacturer's indications or 3 years from receipt, whichever is sooner.

9.1.6. Magnesium chloride solution - dissolve 510 g $MgCl_2.6H_20$ in 500 mL DI water and dilute to 1 liter. Store at room temperature in plastic for up to 12 months.

9.1.7. Sulfamic acid - purchased commercially. Store at room temperature. Expires as per manufacturer's indications or 3 years from receipt, whichever is sooner.

9.1.8. Sulfamic acid solution - Dilute 100 g sulfamic acid to 1 L of DI water. Store at room temperature for up to 1 year.

9.1.9. Chloramine-T - purchased commercially. Store at room temperature. Expires as per manufacturer's indications or 3 years from receipt, whichever is sooner.

9.1.10. Chloramine-T solution - dissolve 2.0 g Chloramine-T in 200 mL DI water and mix. Prepare fresh each analytical run.

9.1.11. Pyridine - barbituric acid solution - purchased solution. Store at 0-6°C. Expires as per manufacturer's indications (typically within 2 months) or when heavily precipitated or discolored, whichever is sooner.

9.1.12. Sodium dihydrogen phosphate ($NaH_2PO_4.H_2O$) - purchased commercially. Store at room temperature. Expires as per manufacturer's indications or 3 years from receipt, whichever is sooner.

9.1.13. Sodium dihydrogen phosphate Buffer solution, 1 M - dissolve 138 g $NaH_2PO_4.H_2O$ in DI and bring to 1 liter in DI water. Store in glass at 0-6°C for up to 1 year.

9.1.14. Silver nitrate solution, 0.02N – purchased commercially. Store in the dark at 0-6°C. Expires upon manufacturer's indications or 1 year, whichever is sooner.

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9.1.15. Rhodanine (p-dimethylaminobenzal rhodanine) – purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.1.16. Acetone - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.1.17. Rhodanine indicator solution - dissolve 20 mg of p-dimethylaminobenzal rhodanine in 100 mL acetone. Store at room temperature in glass for up to 1 year.

9.1.18. Cadmium Carbonate powder - purchased commercially. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.1.19. Anti-foam agent, purchased commercially, expires as per manufacturer's indications or 3 years from receipt, whichever is sooner.

9.1.20. Ottawa Sand, purchased commercially. This is used in preparation of the soil Prep Blank and soil LCS. Store at room temperature. Expires when no longer a clean matrix.

9.1.21. Potassium Cyanide (KCN) - purchased commercially, expires as per manufacturer's indications or 3 years from receipt, whichever is sooner.

9.1.22. Potassium Hydroxide (KOH)- purchased commercially, expires as per manufacturer's indications or 3 years from receipt, whichever is sooner.

9.2. STANDARDS:

9.2.1. Primary and Secondary Stocks and Working Standard

9.2.1.1. Primary Stock cyanide standard solution (1000 mg CN/L) - in a hood, carefully weigh out 2.51 g KCN and 2 g KOH and dissolve in DI water, in a 1000 mL volumetric flask. Dilute to volume and mix well. Store in amber glass in the dark at 0-6 °C for up to 1 year. Standardize before first use as follows.

9.2.1.2. Secondary Stock cyanide standard solution (1000 mg CN/L) - in a hood, carefully weigh out 2.51 g KCN (**prepared from a different manufaturer's lot than the primary stock**) and 2 g KOH and dissolve in DI water, in a 1000 mL volumetric flask. Dilute to volume and mix well. Store in amber glass in the dark at 0-6 °C for up to 1 year. Standardize before first use as follows.

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9.2.1.3. Standardization of cyanide stock solutions with standard $AgNO_3$ solution, in triplicate

9.2.1.3.1. Volumetrically pipet 5.00 mL of CN solution into a 250 mL Erlenmeyer flask.

9.2.1.3.2. Add 100 mL of 0.25 N NaOH solution.

9.2.1.3.3. Add 0.5 mL rhodanine indicator solution.

9.2.1.3.4. Titrate with standard $AgNO_3$ titrant to the first change in color from a canary yellow to a salmon hue.

9.2.1.3.5. Also, titrate a blank consisting of 100 mL of 0.25 N NaOH solution and 0.5 mL indicator.

9.2.1.3.6. Calculate:

$$\text{CN, mg/L} = \frac{(\text{net mL } AgNO_3)\ (N)\ (52)\ (1000)}{5}$$

9.2.2. Working standard cyanide solutions (10 mg CN/L) –Prepare 2 working standard solutions - one from the primary source and one from the secondary source. Add 1 mL of stock cyanide standard (1000mg/L) or a volume numerically equal to the "dilution factor" based upon the standardization in mls to a 100 mL glass volumetric flask. Dilute to volume with 0.25 NaOH. Prepare the primary working stock on the day of distillation and the secondary working stock on the day of the Technicon run. The primary working stock may be kept for up to 7 days when stored at 0-6°C in the dark.

9.2.3. LCS – High Level – Add 2.0 mLs primary 10 mg/L working stock to 50 mLs DI. Distill and analyze as a routine sample. True Value = 0.40 mg/L

9.2.4. LCS/MS – Low Level – Add 0.5 mLs primary 10 mg/L working stock to 50 mLs DI (LCS) or sample (MS). Distill and analyze as a routine sample. True Value = 0.10 mg/L

9.2.5. LCS/MS – soil – Add 0.5 mLs primary 10 mg/L working stock to 1.0 g Ottawa Sand (LCS) or 1.0 g sample (MS). Dilute to 50 mLs with DI and distill and analyze as a routine sample. True Value = 5.0 mg/Kg.

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9.2.6. Calibration standards for the Technicon:

Prepare a set of standards and a blank using the primary working standard cyanide solution (10.0 ug CN/mL) and bringing the total volume to 10.0 mL with 0.25 N NaOH solution, in 10 mL dispo cups. Prepare fresh before the analytical run. On the benchsheet, record the pipet ID used to make the standards.

mL 10 mg/L Working Stock	Final Concentration mg CN/L
0.50	0.50
0.40	0.40
0.30	0.30
0.20	0.20
0.10	0.10
0.05	0.05
0.02	0.02
0.01	0.01
0.00 (blank)	0

9.2.7. ICV/CCV – Add 0.30 mLs secondary 10 mg/L working solution to 9.7 mLs 0.25N NaOH. True Value = 0.30 mg/L. Use the solution that was not used for the standards.

9.2.8. ICB/CCB – Use 0.25N NaOH.

10. RESPONSIBILITIES

10.1. It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. Final review and sign-off of the data is performed by the department supervisor or designee.

11. PROCEDURE

11.1. Sample Preparation - The pH of samples should be taken and noted on benchsheet.

11.2. Apparatus Preparation - The midi distillation unit should be assembled as in Figure 1.

11.3. Distillation Procedure

11.3.1. Turn on chiller for cooling water.

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11.3.2. Place 50 mls of well mixed sample (lesser volume is acceptable if necessary), or 1.0 g of well mixed solid sample, diluted to approximately 50 ml, in the distillation tube. If spike is to be added, add to the distillation tube at this time. Insert the distillation head and connect the cold-fingered condenser. Place 50 ml of the 0.25N NaOH solution into absorber jacket, insert absorber top and connect distillation head and absorber top tubing.

11.3.3. Turn on the vacuum pump. Connect vacuum line with absorber top and open valve to start a slow steady stream of air entering the tube through the sample inlet. Adjust the vacuum so that air enters at a rate approximately three bubbles per second. Excessive foaming may be prevented by the addition of 0.25 ml of anti-foam agent.

11.3.4. Add 2 ml of sulfamic acid solution through the inlet tube. Rinse with distilled water and allow the airflow to mix for three minutes.

11.3.5. Slowly add 5 ml 50% sulfuric acid solution through the inlet tube and rinse with distilled water. Allow to mix for three minutes maintaining a steady bubble rate.

CAUTION: Violent reactions and foaming can occur, add slowly.

11.3.6. Add 2 ml of magnesium chloride solution through inlet tube and rinse with distilled water.

11.3.7. Turn on the heating block and set time for 120 minutes and temperature at 124-126°C. System will reach operating temperature in approximately 15 minutes. During this time, adjust vacuum as necessary. Reset timer to 90 minutes.

11.3.8. After 90 minutes, the timer will automatically stop the heating process. Allow to cool for 15 minutes. Turn off vacuum and disconnect absorber head tubing from vacuum coupler.

11.3.9. Check for sulfide by dropping absorber solution onto lead acetate paper. A positive result will turn the paper brown. Indicate positive or negative result on benchsheet. If the result is positive, add an excess of cadmium carbonate to the sample and filter. Repeat the check and treat until the sulfide presence result is negative.

11.3.10. Transfer absorber solution to vials and store at 0-6°C in the dark until analyzed.

11.4. Colormetric Analysis

11.4.1. Prepare the series of CN standards as given under the section for calibration standards. Prepare a calibration curve using the 0.50, 0.40, 0.30, 0.20, 0.10, 0.05,

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0.02, and 0.01 mg CN/mL and a blank by plotting absorbance versus cyanide concentration. Record pipet ID used.

11.4.2. Analytical dilutions may be required for samples analyzed outside of the calibration range. Dilutions shall be prepared as per SOP ADM-DIL.

11.4.3. Set up tray and benchsheet according to the analytical sequence described in 12.

11.4.4. Set up and run the auto analyzer according to the instrument settings and general operating directions given below:

Colorimeter damp: 2
Flow cell: 15 mm
Photo tubes: 34 Q
Light filters: 578 nm
Sampler rate: 30/h, 1:1 sample to wash ratio

12. QA/QC REQUIREMENTS

12.1. QC Samples Required:

12.1.1. The following QC are to be prepared and distilled each day with each analytical batch of 20 samples, or less, of sample delivery group (SDG).

- Lab Control Samples (LCS) - one low-level and one high-level.
- Method Blank (MB): A distilled water blank.

12.1.2. The following QC are to be prepared and distilled each day with each analytical batch of 10 samples, or less, of sample delivery group (SDG).

- One duplicate sample should be distilled for every ten samples or less of a particular matrix (i.e. water, soil, etc.). Samples designated as field blanks are not to be used.
- One matrix spike should be performed for every ten samples or less of a particular matrix (i.e. water, soil, etc.). Spike should be the same sample chosen for the duplicate unless another is designated. Field blanks should not be used, if designated as such.

12.1.3. In addition, the following standards, not distilled, should be analyzed during the auto analyzer run:

- Initial calibration verification (ICV): Should be run as first injection of sample tray immediately after running calibration.

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- Continuing Calibration Verification (CCV): Should be run after every ten samples including duplicates, spikes, MB's, etc. and at the end of the tray.

- Calibration blanks (ICB, CCB) should be after every calibration verification. (i.e., ICB after every ICV and CCB after every CCV)

12.2. An analyses sequence could appear as follows. The distilled QC items may be in a difference order than is described here.

Calibration Standards		
ICV	Sample 3	Sample 10
ICB	Sample 4	Sample 11
MB	Sample 5	Sample 11 Dup.
LCS LL	CCV-1	Sample 11 Spk.
LCS HL	CCB-1	Sample 12
Sample 1	Sample 6	Sample 13
Sample 1Dup.	Sample 7	CCV-2
Sample 1Spk.	Sample 8	CCB-2
Sample 2	Sample 9	

12.3 Acceptance criteria for cyanides is found in the Wetchem QC Table in Appendix C of the Quality Assurance Manual. For sample and duplicate results ≥ 5X RL (reporting limit). If one or both of sample or duplicate is < 5X RL, control limit = $|5 \text{ X RL}|$. If both sample and duplicate are < IDL then RPD is not calculated.

12.4 Corrective Action Requirements

12.4.1 In case of problems encountered with distillation, check vacuum pump performance, apparatus connections, and plugs in tubing. Record any maintenance performed in CN log book.

12.4.2 For problems encountered with Technicon operation, see Technicon troubleshooting guide.

12.4.3 Outlying QC samples requires professional judgment on the behalf of the analyst and in some cases, the supervisor.

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12.4.4 Outlying MS and/or DUP samples will typically require the samples to be redistilled if sample volume is available. Project objectives and matrix problems may alleviate this requirement.

12.4.5 Outlying LCS and/or MB samples require the entire batch of samples to be redistilled. Review project objectives and the availability of sample volume. There may be some exceptions due to the bias indicated by the outlier. For example, if the LCS recovery is high, and the associated sample results are non-detect, redistillation is not required. If the MB indicates laboratory contamination and the associated sample results are non-detect, redistillation is not required.

12.4.6 Outlying ICV, CCV, ICB, or CCBs indicate potential problems during the course of the analytical run. All samples bordering the outlying blank or standard must be reanalyzed and bracketed by acceptable QC.

13. DATA REDUCTION AND REPORTING

13.1. Reportable sample concentrations can be no higher than the highest standard. Make dilutions accordingly.

13.2. Calculate the concentrations of samples and standards from distillate concentrations, taking into account any dilutions made at the instrument, and the initial sample volume, and final distillate volume.

WATERS:

$$e.g.\ CN^{-}mg\ /\ L = \frac{AxBxC}{D}$$

Where A = mg CN^{-}/L read from Technicon (calculated from the curve)
Where B = dilutions made
Where C = final distillate volume (mls)
Where D = initial sample volume (mls)

SOILS:

$$e.g.\ CN^{-}mg\ /\ Kg = \frac{AxBxC}{Dx\%S}$$

Where A = mg CN^{-}/L read from Auto Analyzer (calculated from the curve)
Where B = dilutions made
Where C = final distillate volume (mls)
Where D = initial sample volume (g)
Where %S=Percent Solids as decimal

13.3. Accuracy is calculated using %Recovery from matrix spikes and LCS samples:

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$$\text{Accuracy (\%Recovery)} = \frac{A - B}{C} \times 100$$

Where A = Analyte total concentration from spiked sample
B = Analyte concentration from unspiked sample
C = Concentration of spike added

13.4. Precision is measured through the use of replicate sample analyses within the same batch and is expressed as the relative percent difference (RPD) between the replicate measurements.

$$RPD = \frac{D1 - D2 \times 100}{(D1+D2)/2}$$

Where D1 = Original Result
D2 = Duplicate Result

13.5. Reporting units are mg CN^-/L for waters and mg CN^-/Kg for soils

13.6. MDL study shall be performed every 6 months (for CLP purposes, otherwise, annually) and the results of the MDL must be below the reporting limit. Perform the MDL in accordance with the SOP ADM-MDL.

13.7. An IDL shall be performed quarterly by making seven consecutive measurements of a standard solution at a concentration 3x –5x the expected concentration on three non-consecutive days.

13.8. Data must be reviewed by the analyst and a peer (supervisor or qualified analyst) using a Data Quality Checklist before the results are validated and reported to the client. Further data review policies and procedures are discussed in ADM-DREV.

13.9. Package work must include a copy of the bench sheet and autoanalyzer run, including run time, post run, cal. report and calibration statistics.

14. WASTE MANAGEMENT AND POLLUTION PREVENTION

14.1. Reagents are prepared upon an as-needed basis in small quantities. It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

14.2. Excess, unused sample and testing byproducts are disposed following the procedures in the SOP SMO-SPLDIS.

15. REFERENCE

15.1. USEPA Contract Laboratory Program, document Number ILMO 4.0, Method for Total Cyanide Analysis by MIDI Distillation #335.2 CLP-M.

15.2. *Standard Methods for the Examination of Water and Waste water,* 18th Edition.

15.3. "Test methods for Evaluation Physical/Chemical Methods", SW846, 3rd edition, December 1996.

15.4. *Methods for the Determination of Inorganic Substances in Environmental Samples,* August 1993 EPA/600/R-93/100.

16. TRAINING OUTLINE

16.1. Read current SOP and applicable methodologies. Demonstrate a general understanding of the methodology and chemistry. Follow policies in ADM-TRANDOC.

16.2. Observe Sample Preparation and Analysis. Follow Cyanide Training Plan Form.

16.3. Participate in the methodology, documentation, and data reduction with guidance.

16.4. Perform the analysis independently and show Initial Demonstration of Capability (IDC) by analyzing 4 replicates of a known mid-range standard in succession before client samples are analyzed. If recovery is within acceptable limits, complete IDC certificate and Training Plan Form and file with QA. Continuing Demonstration of Capability (CDC) will be demonstrated annually using a PE sample, single blind, or a new 4 replicate study. Demonstrate Competency by performing the analysis independently.

17. INSTRUMENT-SPECIFIC ADDENDUM

17.1. Technicon guide and Midi –vap manuals are located in the lab for reference.

18. ATTACHMENTS

- Figure 1 Cyanide Distillation Apparatus
- Cyanide Distillation Benchsheet
- Analyzer Benchsheet

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19. CHANGES FROM PREVIOUS REVISION

- Eliminated Holding Time statement from Section 1 and expanded upon the existing statement in 6.
- Added that SMO conducts the chlorine screening test in 6.5.
- Added references to GEN-GC, ADM-TRANDOC.
- Split out purchased reagents from reagent prep.
- Expanded upon expiration and storage, where needed.
- Eliminated standardization and preparation of silver nitrate solution – now purchased.
- Eliminated references to NaCl, and K_2CrO_4 since standardization of silver nitrate is not necessary.
- Expanded upon data review statement in 13.8.
- Referenced the QC table in the QAM and eliminated limits in this SOP.
- Expanded upon the Training Outline to reflect current practice.
- Eliminated need to make primary working stock fresh on day of Technicon run.
- Eliminated need to standardize stocks monthly and added need to standardize before first use.
- Added need to add spike to distillation tube before inserting distillation head in 11.3.2.

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FIGURE 1

CYANIDE DISTILLATION APPARATUS

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STANDARD OPERATING PROCEDURE

NITRATE / NITRITE

COLORIMETRIC BY LACHAT

GEN - 353.2

Revision 1

September 28, 2001

Approved By: _____ _____
Supervisor Date

_____ _____
QA Coordinator Date

_____ _____
Laboratory Manager Date

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One Mustard St., Suite 250
Rochester, NY 14609

Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
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1 SCOPE AND APPLICATION

1.1 This SOP uses EPA 353.2 for the determination of nitrate/nitrite in drinking, ground and surface waters, domestic and industrial wastes, and soils.

1.2 Linear Range and PQL

1.2.1 Regular Level NO_3+NO_2 - The applicable linear range for NO_3+NO_2 using a 17 cm sample loop is 0 to 2.0 mg/L. Dilutions may be made as necessary. The PQL at this level is 0.01 mg/L.

1.2.2 Low Level NO_3+NO_2- The applicable linear range for NO_3+NO_2 using a 150 cm sample loop is 0 to 1.0 mg/L. Dilutions may be made as necessary or run at the regular level if possible. The PQL at this level is 0.002 mg/L.

1.2.3 The applicable linear range for NO_2 is 0 to 1.0 mg /L. The PQL is 0.1 mg/L.

2 METHOD SUMMARY

2.1 Nitrate is quantitatively reduced to nitrite by passage of the sample through a copperized cadmium column. The nitrite (reduced nitrate plus original nitrite) is then determined by diazotizing with sulfanilamide followed by coupling with N (1-naphthyl) ethylenediamine dihydrochloride. The resulting water soluble dye has a magenta color which is read at 520 nm. Nitrite alone is determined by removing the cadmium column. To calculate nitrate alone, analyze separately for nitrite and for (nitrite + nitrate) and subtract the nitrite.

3.0 DEFINITIONS

3.1 Independent Calibration Verification (ICV) - ICV solutions are made from a stock solution which is different from the stock used to prepare calibration standards and is used to verify the validity of the standardization.

3.2 Laboratory Control Sample (LCS) - An aliquot of reagent water to which a known quantity of the method analyte is added in the laboratory. The LCS is analyzed exactly like a sample, and its purpose is to determine whether the methodology is in control, and whether the laboratory is capable of making accurate and precise measurements.

3.3 Matrix Spike (MS) - In the matrix spike analysis, a predetermined quantity of standard solution of the analyte is added to a sample matrix prior to sample analysis. The purpose of the matrix spike is to evaluate the effects of the sample matrix on the methods used for the analyses. Percent recoveries are calculated for each of the analytes detected.

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3.4 Duplicate Sample (DUP) - A laboratory duplicate. The duplicate sample is a separate field sample aliquot that is processed in an identical manner as the sample proper. The relative percent difference between the samples is calculated and used to assess analytical precision.

3.5 Continuing Calibration Verification Standard (CCV) - A standard analyzed at specified intervals and used to verify the ongoing validity of the instrument calibration.

3.6 Instrument Blank (ICB/CCB) - The instrument blank (also called initial or continuing calibration blank) is a volume of blank reagent of composition identical to the samples. The purpose of the CCB is to determine the levels of contamination associated with the instrumental analysis.

4 INTERFERENCES

4.1 EDTA is added to the buffer to reduce interference caused by high concentrations of iron, copper, or other metals in the sample.

4.2 Grease and oils will foul the cadmium column; these may be pre-extracted with organic solvents.

4.5 Residual chlorine can interfere by oxidizing the column.

4.6 A color blank should be analyzed for highly colored samples, or samples which are still turbid after filtering. The color blank is subtracted from the sample result.

5 SAFETY

5.1 Each chemical and/or reagent used in the analysis of nitrate/nitrite should be regarded as a potential health hazard and exposure should be as limited as reasonably possible. Use of proper lab attire (i.e. lab coats, aprons, gloves, and protective eyewear) is required.

5.2 The following chemicals have the potential to be highly toxic or hazardous, for detailed explanations consult the MSDS.

5.2.1 Cadmium
5.2.2 Ammonium hydroxide
5.2.3 Sodium hydroxide
5.2.4 Phosphoric acid
5.2.5 Sulfanilamide

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6 SAMPLE CONTAINERS, COLLECTION, PRESERVATIONS, AND STORAGE

6.1 Samples should be collected in plastic or glass bottles. All bottles should be new and clean. Volumes collected should be sufficient to insure a representative sample, allow for replicate analysis (if necessary), and minimize waste disposal.

6.2 NO_3+NO_2 analyses require preservation of the sample with H_2SO_4 to pH < 2. Samples to be analyzed for NO_2 alone should not have a chemical preservative added.

6.3 Samples should be stored at 0-6 °C until analysis.

6.4 Holding time for preserved NO_3+NO_2 = 28 days. For NO_2, holding time is 48 hours.

6.5 For more information, see SMO-GEN.

7 APPARATUS AND EQUIPMENT

7.1 Lachat QuikChem Automatic Flow Injection Ion Analyzer with Automatic Sampler and Proportioning Pump (either QuikChem IV or 8000)

7.2 Injection module with 17 cm or 150 cm (0.80 mm i.d.) sample loop.

7.3 Colorimeter with flow cell (10 mm, 80 uL) and interference filter, 520 nm.

7.4 Computer with appropriate software.

7.5 Appropriate reaction module.

7.6 Cadmium columns - purchased commercially from Lachat Instruments. Spent columns are returned to Lachat for re-packing. Columns may be prepared in-house if necessary. Consult the Lachat method for details.

7.7 1000 ml volumetric flasks

7.8 1000 uL adjustable pipette and tips

7.9 Disposable plastic 10 ml pipettes

7.10 Repipettor filled with DI water and set/calibrated at 9.0 ml

7.11 10 ml disposable plastic beakers (dispo cup).

7.12 4 ml sample cups

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8 PREVENTIVE MAINTENANCE

8.1 Nearly all of the components of the Lachat can be easily cleaned or replaced. The exception is the valve. When the valve becomes clogged it is necessary to have the unit sent out to be serviced. To avoid this expense and inconvenience, be sure sample cups, and dispo cups are free of particulates by rinsing thoroughly with D.I. water and drying. Visual inspection of this equipment is also recommended before analysis. Turbid samples should also be filtered to prevent valve clogs.

8.2 Be sure to change pump tubes regularly to ensure optimal performance.

8.3 All changes in tubing, hardware, or programming are to be noted in the maintenance logbook. Record the first acceptable run in the logbook after major maintenance.

8.4 Keep the instrument and the bench area clean. Wipe down counters before and/ or after use.

9 STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

9.1 Hydrochloric Acid (HCl) – concentrated – purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.2 Ammonium Hydroxide (NH_4OH) – concentrated - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.3 Disodium ethylenediamine tetracetic acid dihydrate ($Na_2EDTA\ 2H_20$) - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.4 Sodium Hydroxide (NaOH) – 15M - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.5 **Ammonium Chloride Buffer**, pH = 8.5: Under a hood: To a 1 Liter container, transfer 865 g of D.I. water, 126 g of concentrated HCL, 85.0 g of ammonium hydroxide and 1.0 g Na_2EDTA. Stir until dissolved. Adjust the pH up to 8.5 with 15 M NaOH. Store at room temperature in an amber glass container. Expires in 1 year.

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9.6 Phosphoric Acid (H_3PO_4) 85% - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.7 Sulfanilamide - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.8 N-1-napthylethylenediamine dihydrochloride (NED) - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.9 **Sulfanilamide Color Reagent**: To a 1 Liter container, transfer 876 g of water, 170 g 85% phosphoric acid, 40.0 g sulfanilamide and 1.0 g NED. Stir until dissolved. Store in a amber glass bottle at room temperature. Expires in one month or when discolored, whichever is sooner.

9.10 Sodium Nitrite ($NaNO_2$) - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.11 Potassium Nitrite (KNO_2) - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.12 **Nitrite stock standard** (1000 mg N/L as NO_2): In a 1 liter volumetric flask dissolve 4.93g of sodium nitrite or 6.07 g of potassium nitrite in approximately 800 ml D.I. Dilute to volume mix. Store at 0-6°C in amber glass. Expires in one year. Compare new batches to the previous standard to verify the concentration prior to use.

9.13 **Nitrite intermediate standard** (10 mg N/L as NO_2): Perform two 1/10 serial dilutions of the 1000 ppm stock in dispo cups using a calibrated repipettor set to deliver 9 ml of water, and a calibrated micropipettor set to deliver 1 ml of standard. Prepare fresh daily.

9.14 **Nitrite reference stock standard** (180 mg N/L as NO_2): Using a different source (lot# / manufacturer) of $NaNO_2$ or KNO_2 than used in preparation of the standard stock, prepare a reference stock of 180 mg/L by dissolving 1.09 g of KNO_2 or 0.89 g of $NaNO_3$ in about 800 ml water in a 1 L volumetric flask. Bring to volume mix. Store at 0-6°C in amber glass. Expires in 1 year.

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9.15 **Nitrite working standards** - prepare fresh daily in dispo cups as follows:

Conc. (mg/L)	ml of 10 mg/L NO_2 standard	ml DI water
1.00	1.00	9.0
0.50	0.50	9.5
0.20	0.20	9.8
0.10	1.0 ml of 1.00 mg/L standard	9.0
0.05	1.0 ml of 0.50 mg/L standard	9.0
0.02	1.0 ml of 0.20 mg/L standard	9.0
0.01	1.0 ml of 0.10 mg/L standard	9.0
0.00	0.0	10.0

Pour back and forth between two dispo cups to mix.

9.16 **Nitrite LCS, Matrix Spikes** (0.25 mg/L): Into a dispo cup, measure 10 ml DI (LCS) or sample (MS). Add 0.25 ml of 10 mg/L working stock. Pour back and forth between two dispo cups to mix. Prepare fresh per run.

9.17 **Nitrite Reference ICV/ CCV** (0.90 mg/L): Add 1 ml of 180 ppm nitrite reference stock to 9.0 ml of D.I. water to produce an 18 ppm intermediate reference standard. Add 0.5 ml of this 18 ppm std to 9.5 ml of D.I. water to produce a 0.90 ppm working reference solution. Mix by pouring the solution back and forth between two dispo cups. Prepare fresh per run.

9.18 Potassium Nitrate (KNO_3) - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.19 Chloroform - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.20 **Nitrate stock standard** (1000 mg N/L as NO_3): In a 1 liter volumetric flask dissolve 7.22 g potassium nitrate in about 600 ml water. Add 2 ml chloroform. Dilute to volume and invert several times until mixed. Expires in six months. Store at room temperature in amber glass. Compare new standard batches to the previous standard to verify the concentration prior to use.

9.21 **Nitrate reference standard** (180 mg/L N as NO_3): Using a different source (lot# / manufacturer) of KNO_3 than what is used in preparation of the stock standards. Prepare a reference stock of 180 mg/L by dissolving 1.30 g KNO_3 in about 800 ml D.I. in a 1 liter volumetric flask. Add 1 ml of chloroform. Bring to volume and invert to mix. Store at room temperature in amber glass. Expires in 6 months.

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9.22 **Nitrate Intermediate standards** (100 ppm and 10 ppm) - Into two 10 ml dispo cups, dispense 9.0 ml of D.I water using a calibrated repipettor. Using a calibrated micropipettor, transfer 1.0 ml of 1000 ppm Nitrate stock into one of the dispo cups and mix (100 ppm stock). Into the second dispo cup, transfer 1.0 ml of the 100 ppm stock and mix (10.0 ppm stock). Prepare fresh daily.

9.23 **Regular Level Nitrate working standards** - To be used in Regular Level NO_3+NO_2 analysis. Prepare fresh daily in dispo cups as follows:

Conc. (mg/L)	ml of 10 mg/L standard	ml DI water
2.00	2.00	8.0
1.00	1.00	9.0
0.50	0.50	9.5
0.20	0.20	9.8
0.10	1.0 ml of 1.00 mg/L standard	9.0
0.05	1.0 ml of 0.50 mg/L standard	9.0
0.02	1.0 ml of 0.20 mg/L standard	9.0
0.01	1.0 ml of 0.10 mg/L standard	9.0
0.00	0.00	10.0

Pour back and forth between two dispo cups to mix.

9.24 **Regular Level $N0_3$+NO_2 LCS, Matrix Spikes** (0.50 mg/L): Into a dispo cup, measure 10 ml DI (LCS)or sample (MS) using a 10 ml disposable pipette. Add 0.050 ml of 100 mg/L nitrate working stock. Pour back and forth between two dispo cups to mix. Prepare fresh per run.

9.25 **Regular Level NO_3+NO_2 Reference ICV/ CCV** (1.80 mg/L): Add 1 ml of 180 ppm nitrate reference stock to 9.0 ml of D.I. water to produce an 18 ppm intermediate reference standard. Add 1.0 ml of this 18 ppm std to 9.0 ml of D.I. water to produce a 1.80 ppm working reference solution. Mix by pouring the solution back and forth between two dispo cups. Prepare fresh per run.

9.26 **Regular Level Cadmium column efficiency check solutions**: Prepare fresh daily

9.26.1 1.0 ppm NO_2 - Perform three 1/10 serial dilutions of the 1000 ppm NO_2 stock. (alternately, use the 1.00 ppm std prepared for nitrite analysis). Prepare fresh per run.

9.26.2 1.0 ppm NO_3 - Use the 1.00 ppm standard prepared for nitrate analysis. Prepare fresh per run.

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9.27 **Low Level Nitrate working standards** - To be used in Low Level NO_3+NO_2 analysis. Prepare fresh daily in dispo cups as follows:

Conc. (mg/L)	ml of 10 mg/L standard	ml DI water
1.00	1.00	9.0
0.50	0.50	9.5
0.20	0.20	9.8
0.10	1.0 ml of 1.00 mg/L standard	9.0
0.05	1.0 ml of 0.50 mg/L standard	9.0
0.02	1.0 ml of 0.20 mg/L standard	9.0
0.01	1.0 ml of 0.10 mg/L standard	9.0
0.005	1.0 ml of 0.050 mg/L standard	9.0
0.002	1.0 ml of 0.020 mg/L standard	9.0
0.000	0.00	10.0

Pour back and forth between two dispo cups to mix.

9.28 **LowLevel $N0_3$+NO_2 LCS, Matrix Spikes** (0.250 mg/L): Into a dispo cup, measure 10 ml DI (LCS)or sample (MS) using a 10 ml disposable pipette. Add 0.250 ml of 10 mg/L working stock. Pour back and forth between two dispo cups to mix. Prepare fresh per run.

9.29 **Low Level NO_3+NO_2 Reference ICV/ CCV** (0.90 mg/L): Add 1 ml of 180 ppm nitrate reference stock to 9.0 ml of D.I. water to produce an 18 ppm intermediate reference standard. Add 0.50 ml of this 18 ppm std to 9.5 ml of D.I. water to produce a 0.90 ppm working reference solution. Mix by pouring the solution back and forth between two dispo cups. Prepare fresh per run.

9.30 **Low Level Cadmium column efficiency check solutions**: prepare fresh daily

9.30.1 0.50 ppm NO_2 - Perform two 1/10 serial dilutions of the 1000 ppm NO_2 stock. Add 0.50 mls of this 10 ppm working stock to 9.5 mls DI. (alternately, use the 0.50 ppm std prepared for nitrite analysis).

9.30.2 0.50 ppm NO_3 - Use the 0.50 ppm standard prepared for nitrate analysis.

10 RESPONSIBILITIES

10.1 It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. Final review and sign-off of the data is performed by the department supervisor or designee.

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11 PROCEDURE

11.1 Prepare standards and reagents as described in Section 9.

11.2 Turn on the computer and Lachat components.

11.3 Connect the manifold to the instrument (see attached diagram). Inspect the manifold for proper connections and appropriate sample loop and wavelength filter. Place pump tubes loosely in their holders.

11.4 Load the appropriate method into the software and enter sample labels for the first tray in accordance with the analytical sequence described below. The method should be optimized from the suggested operating parameters in the Lachat instrument manual. The Lachat software will calculate all dilutions provided the dilution information is entered.

11.5 Analytical Sequence:

1. NO_2 Column check
2. NO_3 Column check
3. Ref (ICV)
4. Blank (ICB)
5. Blank Spike (LCS)
6 -15. 9 Samples
16. Ref (CCV)
17. Blank (CCB)
18-27. 10 Samples
28. Ref (CCV)
29. Blank (CCB)
30. Blank Spike (LCS)

Analyze CRDLs on the Lachat 8000 to see the response at the low end of the curve since the software does not quantitate the standards in the calibration.

Repeat steps 3-30 until all samples are analyzed. The sequence must end with a Reference and a Blank. Insert DUP/MS where appropriate. Consult the QC section for further QC sample frequency requirements. For the QuikChem IV, do not exceed 30 samples on the first tray because the standards take up 10 positions. Subsequent trays may contain up to 40 sample cups.

For NO_2, follow the sequence above without the column check.

11.6 Load the column check standards, calibration standards, and the samples into the autosampler as entered into the software with standards in order of decreasing concentration. Make sample dilutions in compliance with ADM-DIL.

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11.7 For turbid samples or samples with particulates, filter through a syringe filter which has been shown to be free of nitrate/nitrite and shown not to remove the analyte of interest. Demonstrate these properties by analyzing a filtered blank and a filtered LCS.

11.8 Place all reagent lines in DI to rinse. Be sure all waste lines go to sink.

11.9 Attach lines to pump collars. Turn on pump. Lock in collars. Rinse for a couple of minutes. Inspect for leaks.

11.10 With pump still engaged, place the color reagent, buffer, carrier (DI) and rinse feed lines in their appropriate reagent bottles.

11.11 For NO_3+NO_2, when all bubbles are out of the lines, put column in-line.

11.12 Pump until a stable baseline is established.

11.13 For the QuikChem IV, set the gain (approximately 520 for NO_3+NO_2 or 900 for $N0_2$) and adjust the baseline reading to about 25 mv. The QC8000 automatically sets baseline and gain.

11.14 For the QuickChem IV, manually inject a high standard to set the gain on the colorimeter.

11.15 For the QuikChemIV, position the sample tray in the autosampler so that the first standard (position #33) is positioned in front of sampler needle.

11.16 Start analysis. After the last standard has been analyzed, review the calibration data. The correlation coefficient must be 0.997 or better for the analysis to continue. A standard may be deleted from the calibration curve. If a linear curve is not achieved, stop the analysis, correct the problem, and recalibrate.

11.17 For NO_3+NO_2 analyses, calculate the cadmium column efficiency prior to analysis of samples. Calculate the column efficiency as follows:

$$\text{Reduction efficiency} = ([NO_3 \text{ std}] / [NO_2 \text{ std}]) \times 100\%$$

Record the efficiency in the Cd column Efficiency Log. If the column efficiency is <90%, stop the analysis, insert a new column, restart the analytical sequence including a new column proficiency check, and recalibrate. Send the expired column back to Lachat for repacking.

11.17.1 For best results, a new column should be “shocked” prior to use. To “shock” the column, run four injections of 10 ppm Nitrate followed by four injections of DI.

11.18 After an acceptable calibration is achieved, continue with sample analysis. Each sample must be “bracketed” by an acceptable Reference/Blank set. If a Reference or Blank fails,

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all samples back to the last good Ref/Blk set must be reanalyzed after the problem is corrected and a good Ref/Blk set is obtained.

11.19 For all samples in which the analyte value has exceeded the high standard, proper dilutions must be made of the sample to bring it within the range of the calibration standards.

11.20 Run color blanks for highly colored or turbid samples. Remove the sulfanilamide line from the reagent and place it in a phosphoric acid solution (170 g of 85% H_3PO_4/L). Analyze the desired samples. Subtract the color blank value from the sample result.

11.21 When all samples are analyzed, take the cadmium column off-line, if appropriate, before moving lines to rinse. The column is stored infused with reagents. Keep air from entering the column.

11.22 Place all feedlines in water and rinse for about 5 minutes. Remove all lines from DI and pump to dry for about 5 minutes Turn off the pump and release tension on pump tubes..

11.23 Print the results and the calibration information.

12 QA/QC REQUIREMENTS

12.1 An MDL study must be run annually. The result of the MDL study must be less than the reporting limit. If it is not, correct the problem and repeat the study or raise the reporting limit. See ADM-MDL for more information.

12.2 ICV/CCV – Analyze at the beginning of the run and every 10 samples or fewer. Recovery must be 90-110 % of the true value, or the affected bracketed samples must be repeated. Recalibrate if the ICV fails.

12.3 ICB/CCB - Analyze after the ICV/CCV at the same frequency. The result must be less than the reporting limit. If it is not, correct the problem and re-run the affected samples, or raise the reporting limit.

12.4 LCS - Prepare one for every 20 samples. LCS recovery must be 90-110% of the true value. If it is not, correct the problem and reanalyze the affected samples or flag the data.

12.5 Duplicates – Analyze one duplicate for every 10 or fewer samples. The relative percent difference (RPD) between matrix duplicates should be 20 or less. If they are not, repeat the original and the duplicate or flag the affected data.

12.6 Matrix Spike – Analyze one matrix spike for every 10 samples. Matrix spike recovery must be within the limits in the Wetchem QC table in the Quality Assurance Manual. If the recovery is outside those limits, reanalyze the MS to confirm matrix interference or flag the affected data.

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12.7 Calibration is done by injecting standards. The data system will then prepare a calibration curve by plotting response versus standard concentration. Sample concentration is calculated from the regression equation. A minimum of 5 standards is required for a calibration curve. Selected standards may be deleted to improve correlation coefficient to above 0.997.

12.8 The cadmium column efficiency must be 90-110%.

13 DATA REDUCTION AND REPORTING

13.1 Calibration is done by injecting standards. The data system will then prepare a calibration curve by plotting response versus standard concentration. Lachat software will calculate sample concentration from the regression equation including samples with dilutions, provided that the correct dilution information was entered.

13.2 Report results to 3 significant figures in mg N/L

13.3 Report only those values that fall between the lowest and the highest calibration standards. Samples exceeding the highest standard should be diluted and reanalyzed.

13.4 Soils: mg/kg N = Conc. measured x mLs DI used for the extraction / g sample used.

13.5 Colored samples: Conc. Reported = Conc. measured - Color Blank

13.6 Nitrate calculation: mg/L or mg/kg as NO_3 = [NO_3+NO_2] - [NO_2]. This calculation is done in the LIMS system.

13.7 Data must be reviewed by the analyst and a peer (supervisor or qualified analyst) using a Data Quality Checklist before the results are validated and reported to the client. Further data review policies and procedures are discussed in ADM-DREV.

14 WASTE MANAGEMENT AND POLLUTION PREVENTION

14.1 Standards and reagents should be purchased or prepared on an as-needed basis. Waste lines for these analyses should be run into the sink. Samples are disposed according to SMO-SPLDIS.

15 REFERENCES

15.1 *Standard Methods for Chemical Analyses of Water and Wastewater,* 18th ed. (1992), APHA-AWWA-WPCF, Part 4500, pp. 4-85, 4-87, 4-91, 4-74.

15.2 Lachat QuikChem Method [10-107-04-1-C].

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15.3 *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, USEPA SW-846, September 1986.

15.4 *Methods for the Chemical Analysis of Water and Wastes*, Method 353.2, EPA 600/4-79-020, Rev. 3/83.

16 TRAINING OUTLINE

16.1 Read most current SOP and applicable methodologies. Document dates on training records. Demonstrate a general understanding of the methodology and chemistry. Follow policies in ADM-TRANDOC.

16.2 Observe Sample Preparation and Analysis. Follow Lachat Training Plan Form.

16.3 Participate in the methodology, documentation, and data reduction with guidance.

16.4 Perform an IDC (Initial Demonstration of Competency) by independently analyzing four mid-range standards prior to analyzing client samples. If recovery is within acceptable limits, complete Training Plan Form and file with QA. Continuing proficiency (CDC) will be demonstrated annually using a PE, a single blind, or a new 4 replicate study.

17 INSTRUMENT-SPECIFIC ADDENDUM

Consult Lachat logbook for most current and reliable settings to ensure accurate analysis. The logbooks and instrument manuals are located near the instruments.

18 ATTACHMENTS

- Manifold Diagram

19. CHANGES SINCE LATEST REVISION

19.1 Added references to ADM-DREV, ADM-MDL, ADM-DIL, SMO-GEN, SMO-SPLDIS, ADM-TRANDOC.
19.2 Eliminated QC table and added information to text in 12.0.
19.3 Split out individual reagents from prepared reagents in 9.0. Added storage and expiration where needed.
19.4 Added need to wipe down counters and instrument in 8.0.
19.5 Modified Procedure to reflect other Lachat SOPs.
19.6 Modified Training Outline to reflect current practice.
19.7 Added procedure for shocking the column.

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STANDARD OPERATING PROCEDURE

AMMONIA by FLOW INJECTION ANALYSIS

SOP No.: GEN - 350.1
Revision 1
September 28, 2001

Approved By:

Supervisor	Date
QA Coordinator	Date
Laboratory Manager	Date

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One Mustard St., Suite 250
Rochester, NY 14609

Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
Initials: _____ Date: _____
Initials: _____ Date: _____

DOCUMENT CONTROL NUMBER:

Initials: _____ Date: _____

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1. SCOPE AND APPLICATION

1.1. The procedure uses EPA method 350.1 to determine the concentration of Ammonia in drinking, ground, surface, and saline waters, domestic and industrial wastes, and soils. The method is based on reactions that are specific for the ammonium (NH_4) ion.

1.2. The reporting limit is 0.05 mg/L for regular level analysis and 0.01 mg/L for low level analysis.

2. METHOD SUMMARY

2.1. This method is based on the Berthelot reaction. Ammonia reacts with alkaline phenol, then with sodium hypochlorite to form indophenol blue. Sodium nitroprusside is added to enhance sensitivity. The absorbance of the reaction product is measured at 630 nm, and is directly proportional to the original ammonia concentration in the sample.

3. DEFINITIONS

3.1. **Independent Calibration Verification (ICV)** – The ICV solution is made from a stock solution which is independent from the stock used to prepare calibration standards and is used to verify the validity of the calibration.

3.2. **Matrix Spike (MS**) - In the matrix spike analysis, a predetermined quantity of standard solutions of the analyte is added to a sample matrix prior to sample analysis. The purpose of the matrix spike is to evaluate the effects of the sample matrix on the methods used for the analyses. Percent recoveries are calculated for the analyte detected.

3.3. **Duplicate Sample (DUP**) - A laboratory duplicate. The duplicate sample is a separate field sample aliquot that is processed in an identical manner as the sample proper. The relative percent difference between the samples is calculated and used to assess analytical precision.

3.4. **Continuing Calibration Verification Standard (CCV) -** A standard analyzed at specified intervals and used to verify the ongoing validity of the instrument calibration.

3.5. **Instrument Blank (ICB/CCB) -** The instrument blank (also called initial or continuing calibration blank) is a volume of blank reagent of composition identical to the samples. The purpose of the CCB is to determine the levels of contamination associated with the instrumental analysis.

3.6. **Laboratory Control Sample (LCS) -** An artificial sample to which known quantities of the analyte is added in the laboratory. The LCS is analyzed exactly like a sample, and its purpose is to determine whether the methodology is in control, and whether the laboratory is capable of making accurate and precise measurements.

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4. INTERFERENCE'S

4.1. Calcium and magnesium ions may precipitate if present in sufficient concentration. EDTA or sodium tartrate is added to the sample in-line in order to prevent this problem.

4.2. Color, turbidity and certain organic species may interfere. Turbidity is removed by manual filtration through a 0.45µm filter. Sample color may be corrected for by running the samples through the manifold without color formation.

4.3. Samples with extreme pH will affect color development and result in a negative response. Samples and standards should contain approximately the same amount of chemical preservative.

4.4. Method interferences may be caused by contaminants in the reagent water, reagents, glassware, and any other sample processing apparatus that bias analyte response.

5. SAFETY

5.1. The toxicity and carcinogenicity of each reagent used in this method have not been fully established. Each chemical should be regarded as a potential health hazard and exposure should be as low as reasonably achievable. Cautions are included for known extremely hazardous materials or procedures.

5.2. The following chemicals have the potential to be highly toxic or hazardous. Consult specific MSDS.

5.2.1. Sulfuric Acid (H_2SO_4)

5.2.2. Sodium Nitroprusside ($Na_2Fe(CN)_5NO•2H_2O$)

5.2.3. Phenol, Liquefied (C_6H_5OH)

6. SAMPLE CONTAINERS, COLLECTION, PRESERVATIONS, AND STORAGE

6.1. Samples should be collected in purchased, certified clean plastic or glass bottles. Volumes collected should be sufficient to insure a representative sample, allow for replicate analysis (if necessary), and minimize waste disposal.

6.2. Samples must be preserved with H_2SO_4 to a pH < 2 and cooled to 0-6°C at the time of collection.

6.3. Preserved samples are maintained at 0-6°C and may be held up to 28 days.

6.4. For further sample handling, storage, and custody procedures, see SMO-GEN.

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7. APPARATUS AND EQUIPMENT

7.1. Balance - Analytical, capable of accurately weighing to the nearest 0.0001g.

7.2. Calibrated Micropipet, adjustable 100-1000µL.

7.3. Calibrated repipetor (20.0 mL capacity).

7.4. Lachat QuikChem IV AutoAnalyzer or Lachat QC 8000 AutoAnalyzer with:

7.4.1. Automated Sampler

7.4.2. Multichannel Pump

7.4.3. Manifold or Reaction Module

7.4.4. Heating Block or Water Bath

7.4.5. Colorimetric Detector

7.4.6. Data Recording Device (personal computer)

7.5. Disposable beakers (dispo-cups)

8. PREVENTIVE MAINTENANCE

8.1. Nearly all of the components of the Lachat can be easily cleaned or replaced. The exception is the valve. When the valve becomes clogged it is necessary to have the unit sent out to be serviced. To avoid this expense and inconvenience, be sure sample cups, and dispo cups are free of particulates by rinsing thoroughly with D.I. water and drying. Visual inspection of this equipment is also recommended before analysis. Turbid samples should also be filtered to prevent valve clogs.

8.2. Be sure to change pump tubes regularly to ensure optimal performance.

8.3. All changes in tubing, hardware, or programming must be noted in the maintenance logbook. Record the first acceptable run after major maintenance.

8.4. Keep the instrument and the bench area clean. Wipe down counters before and/or after use.

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9. STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

9.1. Ammonium Chloride (NH_4Cl) – purchased commercially. Dry for two hours at 103-105°C. Cool to room temperature and store in a desiccator. Expires in 3 years.

9.2. Nitrogen Calibration Standard Stock Solution (1000 mg N/L): In a 1-L volumetric flask, dissolve 3.819 g dried Ammonium Chloride (NH_4Cl) in about 800 mL reagent grade water (DI). Dilute to volume with DI water and invert several times until thoroughly mixed. Store at 0-6°C in amber glass. Discard after one year. **Note: This is the same standard as is prepared for total kjeldahl nitrogen analysis. The same stock may be used for both analyses.

9.3. Working Stock Solution (100.0 mg and 10.0 mg N/L): Dispense 9.00 mL of carrier into each of two dispo-cups using an adjustable repipettor or graduated pipet. Add 1.00 mL of 1000 mg/L standard stock solution to the first dispo-cup using an adjustable pipettor (This is 100.0 mg N/L). Mix and then transfer 1.00 mL of the 100 mg/L to the second dispo-cup and mix (This is 10.0 mg N/L). Prepare fresh each run.

9.4. Working Standards: Working standards are prepared directly into the carrier solution and analyzed. Prepare standards in disposable beakers immediately prior to the analysis as follows:

Concentration (ppm)	Carrier (mL)	Working Stock 10 ppm (mL)
2.000	8.00	2.00
1.000	9.00	1.00
0.500	9.50	0.50
0.200	9.80	0.20
0.100	9.00	1.00 mL of 1.000 Std.
0.050	9.00	1.00 mL of 0.500 Std.
0.020	9.00	1.00 mL of 0.200 Std.
0.010	9.00	1.00 mL of 0.100 Std.
0.000	10.0	0.00

9.5. LCS / Matrix Spike (0.500 mg N/L): To 10.0 mL of carrier or sample, add 0.050 mL of 100.0 mg N/L working stock solution. Prepare fresh each run.

9.6. Nitrogen Calibration Reference Stock Solution (180 mg/L): In a 1-L volumetric flask dissolve 0.687 g dried Ammonium Chloride (NH_4Cl), second source, in about 800 mL reagent grade water (DI). Dilute to volume with DI water and invert several times until thoroughly mixed. Store at 0-6°C in amber glass for up to one year.

9.7. ICV/CCV (1.80 mg/L): Dispense 9.00 mL of carrier into each of two dispo-cups using an adjustable repipettor. Add 1.00 mL of reference stock solution to the first dispo-cup (This is 18.0 mg N/L). Mix and then transfer 1.00 mL of the 100 mg/L to the second

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dispo-cup and mix (This is 1.8 mg N/L). This is the working reference standard and will be used for the ICV and all CCV's. Prepare fresh each run.

9.8. Sulfuric Acid - (H_2SO_4) – Instra-Analyzed. Purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years, whichever is sooner.

9.9. Carrier and Diluent: To a 1-L volumetric flask add approximately 900 mL Millipore DI water and then add 2.0 mL Instra-Analyzed Sulfuric Acid. Bring to volume with Millipore DI water and invert several times until thoroughly mixed. Store in plastic. Prepare fresh for each run.

9.10. Liquefied Phenol (C_6H_5OH) 88% - purchased commercially. Store in a flammable cabinet at room temperature. Expires upon manufacturer's indications, when color becomes darker than straw yellow or 3 years from receipt, whichever is sooner.

***CAUTION:** Phenol causes severe burns and is an extreme health hazard through skin absorption. Wear proper protective laboratory clothing including gloves and rinse any exposed skin IMMEDIATELY with copious amounts of water.

9.11. Sodium Hydroxide flakes (NaOH) – purchased commercially with special attention to ammonia content. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.12. Sodium Phenolate: In a 1-L volumetric flask dissolve 94.2 g of 88% liquefied Phenol (C_6H_5OH) in approximately 600 mL Millipore DI water. While stirring, add 32 g of Sodium Hydroxide (NaOH). Cool and bring to volume with Millipore DI. Store at 0-6°C in an amber glass jar. Stable for one year. ***PREPARE IN HOOD!!***

9.13. Bleach – regular Chlorox bleach (5.25% sodium hypochlorite) – store at room temperature. Expires 3 years from receipt. The purchased Chlorox must be "regular" – it can not be "improved" or otherwise altered. If this becomes unavailable, 5.25% sodium hypochlorite may be purchased through a chemical vendor with the same storage and expiration.

9.14. Sodium Hypochlorite: In a 500-mL volumetric flask dilute 250 mL Bleach to the mark with Millipore DI water and invert to mix. Pour into glass jar and prepare fresh for each run.

9.15. Disodium EDTA ($C_{10}H_{14}N_2Na_2O_8 \cdot 2H_2O$) – purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.16. Buffer Solution: In a 1-L volumetric flask, dissolve 50.0 g Disodium EDTA and 9.0 g NaOH in approximately 900 mL Millipore DI water. Bring to volume with Millipore DI water and stir until dissolved. Store in an amber glass jar at room temperature for up to one year.

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9.17. Sodium Nitroprusside ($(Na_2Fe(CN)_5NO•2H_2O)$ – also called nitroferricyanide - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.18. Sodium Nitroprusside Color Reagent: In a 1-L volumetric flask dissolve 3.50 g Sodium Nitroprusside in about 800 mL Millipore DI water. Bring to volume with Millipore DI water and stir until dissolved. Store in an amber glass jar at room temperature. Discard after one year.

10. RESPONSIBILITIES

10.1. It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. Final review and sign-off of the data is performed by the department supervisor or designee.

11. PROCEDURE

11.1. Prepare standards and reagents as described in Section 9.

11.2. Adjust heating coil setting to 60°C. Turn on and allow to preheat.

11.3. Connect the manifold to the instrument (see attached manifold diagram). Inspect manifold for proper connections and appropriate sample loop (75cm) and wavelength filter (630nm) and heating coil length (650 cm). Place pump tubes loosely in their holders.

11.4. Once the heating coil has reached 60°C, place reagent feed lines in DI. Turn the pump on, adjust the tension of the pump tubes and inspect the system for leaks.

11.5. Load the method into the software and enter sample labels for the first tray in accordance with the analytical sequence described below. The method should be optimized from the suggested operating parameters listed in Section 17 using Graphical Events Programming. The Lachat software will calculate all dilutions provided the dilution information is entered.

11.6. Analytical Sequence:

ICV, ICB,LCS
9 samples
CCV,CCB
10 samples
CCV, CCB

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Analyze CRDLs on the Lachat 8000 to see the response at the low end of the curve since the software does not quantitate the standards in the calibration.

Continue with sequence until all samples are analyzed. The sequence must end with a CCV/CCB set. Insert DUP/MS where appropriate. Consult the QC section for further QC sample frequency requirements.

11.7 Load the calibration standards and the samples into the autosampler as entered into the software with standards in order of decreasing concentration. Make sample dilutions with the diluent/carrier in compliance with ADM-DIL.

11.8 For turbid samples or samples with particulates, filter through a syringe filter which has been shown to be free of ammonia and shown not to remove ammonia. Demonstrate these properties by analyzing a filtered blank and a filtered LCS.

11.9 Place the feed lines in the appropriate reagents and allow to pump for about 5 minutes. *Note: Buffer Solution should be the first reagent introduced into the manifold and the color reagent should be the last reagent introduced into the manifold to prevent the formation of clogs due to reagent precipitate.

11.10 Run the standards, references, and samples. Be sure all QC criteria is met and samples are within linear range.

11.11 When finished, place all lines in DI and rinse for about 5 minutes. Remove lines from DI and pump to dry for about 5 minutes. Turn off the pump and heating coil, and release tension on pump tubes.

11.12 Print the results and the calibration information.

12. QA/QC REQUIREMENTS

12.1. An MDL study must be run annually. The result of the MDL must be less than the reporting limit. If it is not, correct the problem and repeat the study or raise the reporting limit. See ADM-MDL for more information.

12.2. ICV/CCV – Analyze at the beginning of the run and every 10 samples or fewer. Recovery must be 90-100% of the true value, or the affected brackets must be repeated. Recalibrate if ICV fails.

12.3. ICB/CCB - Analyze after the ICV/CCV at the same frequency. The result must be less than the reporting limit. If it is not, correct the problem and re-run the affected samples, or raise the reporting limit.

12.4. LCS - Prepare one for every 20 samples. LCS recovery must be 90-110% of the true value. If it is not, correct the problem and reanalyze the affected samples or flag the data.

12.5. Duplicates – Analyze one duplicate for every 10 or fewer samples. The relative percent difference (RPD) between matrix duplicates should be 20 or less. If they are not, repeat the original and the duplicate or flag the affected data.

12.6. Matrix Spike – Analyze one matrix spike for every 10 samples. Matrix spike recovery must be within the limits in the Wetchem QC table in the Quality Assurance Manual. If the recovery is outside those limits, reanalyze the MS to confirm matrix interference or flag the affected data.

12.7. Calibration is done by injecting standards. The data system will then prepare a calibration curve by plotting response versus standard concentration. Sample concentration is calculated from the regression equation. A minimum of 5 standards is required for a calibration curve. Selected standards may be deleted to improve correlation coefficient to above 0.997.

13. DATA REDUCTION AND REPORTING

13.1. Calculations: Lachat software will calculate all results from the regression equation, including those with dilution's, provided that the correct dilution information was entered.

13.2. Report results to 3 significant figures in mg N/L.

13.3. Report only those values that fall between the lowest and the highest calibration standards. Samples exceeding the highest standard should be diluted with carrier and reanalyzed.

13.4. Data must be reviewed by the analyst and a peer (supervisor or qualified analyst) using a Data Quality Checklist before the results are validated and reported to the client. Further data review policies and procedures are discussed in ADM-DREV.

14. WASTE MANAGEMENT AND POLLUTION PREVENTION

14.1. Reagents are prepared upon an as-needed basis in small quantities. Minimum sample volumes are used during analysis.

14.2. All used reagent is collected in a container and disposed of into an inorganic waste carboy for proper disposal.

14.3. Samples are disposed according to SMO-SPLDIS.

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15. REFERENCES

15.1. *Methods for Chemical Analyses of Water and Wastewater*, USEPA, EPA-600/4-79-020, March 1983. Method 350.1

15.2. *Methods for the Determination of Inorganic Substances in Environmental Samples*, USEPA, EPA/600/R-93/100 August 1993. Method 350.1

15.3. Lachat QuikChem Method [10-107-06-1-B].

16. TRAINING OUTLINE

16.1. Read current SOP and applicable methodologies. Demonstrate a general understanding of the methodology and chemistry. Follow policies in ADM-TRANDOC.

16.2. Observe Sample Preparation and Analysis. Follow Lachat Training Plan Form.

16.3. Participate in the methodology, documentation, and data reduction with guidance.

16.4. Observe Instrument Operation and Maintenance.

16.5. Perform an IDC (Initial Demonstration of Competency) by independently analyzing four mid-range standards prior to analyzing client samples. If recovery is within acceptable limits, complete Training Plan Form and file with QA. Continuing proficiency (CDC) will be demonstrated annually using a PE, a single blind, or a new 4 replicate study.

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17. INSTRUMENT-SPECIFIC ADDENDUM

The Lachat Suggested Operating Parameters for the Quikchem 8000

Pump Speed:	35
Cycle Period:	60

Analyte Data:

Concentration Units:	mg N/L
Peak Base Width:	27.0 s
% Width Tolerance:	100
Threshold:	10000
Inject to Peak Start:	41.8s
Chemistry:	direct

Calibration Data:

Calibration Fit Type:	1st Order Polynomial
Calibration Rep. Handling:	Average
Weighting Method:	None
Concentration Scaling:	None
Force through Zero:	No

Sampler Timing:

Min. Probe in Wash Period:	5.0s
Probe in Sample Period:	24s

Valve Timing:

Load Time:	0.0s
Load Period:	15s
Inject Period:	45s

18. ATTACHMENTS

18.1. Manifold Diagram.

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19. CHANGES FROM PREVIOUS REVISION

19.1. Eliminated Method Blank from 3.0. Only an instrument blank needs run.
19.2. Added ADM-DREV, ADM-TRANDOC, ADM-DIL, ADM-MDL, SMO-GEN, and SMO-SPLDIS.
19.3. Split out purchased and dry reagents from prepared solutions.
19.4. Added much to 11.0 to be more specific about procedure.
19.5. Modified the Training Outline to reflect current practice.
19.6. Added Suggested Operating Parameters for the 8000 to 17.0
19.7. Eliminated Tables for Analytical Sequence and QC criteria and included this information in the text.
19.8. Added need to check that the length of the tubing around heating coil is 650 cm in 11.3.
19.9. Added need to discard the liquefied phenol reagent when it is darker than straw yellow in 9.10.
19.10. Added that it is acceptable to purchase sodium hypochlorite from a vendor instead of using commercial Chlorox bleach and to be sure that the Chlorox is “regular” instead of “improved.”
19.11. Added need to add color reagent to the manifold last in 11.9.

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STANDARD OPERATING PROCEDURE

TITRAMETRIC DETERMINATION OF TOTAL ALKALINITY

GEN-310.1

Revision 2.0

September 27, 2001

Approved By:

Supervisor	Date
QA Coordinator	Date
Laboratory Manager	Date

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One Mustard St., Suite 250
Rochester, NY 14609

Annual review of this SOP has been performed and the SOP still reflects current practice.
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1. **SCOPE AND APPLICATION**

This method (EPA 310.1) is applicable to the measurement of alkalinity in drinking, surface, and saline waters, domestic and industrial wastes for all concentration ranges. The PQL is 2.0 mg/L.

2. METHOD SUMMARY

An unaltered sample is titrated to an endpoint of a pH of 4.5 using a pH meter. The procedure determines a sample's acid-neutralizing capacity, which is the sum of its titratable bases.

3. **DEFINITIONS**

3.1. **Initial and Continuing Calibration Verification (ICV/CCV) –** The ICV/CCV solution is used to verify the validity of the meter calibration and performance of the test.

3.2. **Matrix Spike (MS**) **-** In the matrix spike analysis, a predetermined quantity of solution of the analyte is added to a sample matrix prior to sample analysis. The purpose of the matrix spike is to evaluate the effects of the sample matrix on the methods used for the analyses. Percent recoveries are calculated for the analyte detected.

3.3. **Duplicate Sample (DUP**) - A laboratory duplicate. The duplicate sample is a separate field sample aliquot that is processed in an identical manner as the sample proper. The relative percent difference between the samples is calculated and used to assess analytical precision.

3.4. **Instrument Blank (ICB/CCB) -** The blank (also called initial or continuing calibration blank) is a volume of blank reagent of composition identical to the samples (DI in this test). The purpose of the CCB is to determine the levels of contamination associated with the analysis.

3.5. **Laboratory Control Standard (LCS) -** In the LCS or blank spike analysis, predetermined quantities of solutions of the analyte are added to a blank prior to sample analysis. Percent recoveries are calculated for the analyte detected and used to verify the validity of the test.

3.6. **Batch –** Unit of samples run together on the same day, not to exceed 20 samples.

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4. INTERFERENCES

4.1. High sodium concentration at pH > 10 can cause error.

4.2. Samples containing oil may coat the electrode and cause a sluggish response or inaccurate readings. Rinse the probe with methanol after analysis of an oily sample before running other samples.

4.3. Suspended matter or precipitates formed during the titration may cause a sluggish electrode response.

5. SAFETY

5.1. Wear gloves, lab coat, and safety glasses when handling samples and reagents.

6. SAMPLE COLLECTION, CONTAINERS, AND STORAGE

Samples are to be collected with no headspace in plastic bottles with no chemical preservative. Cool to 0-6 ° C until analysis. Holding time is 14 days. Sample handling, storage, and custody procedures are discussed in SMO-GEN.

7. APPARATUS AND EQUIPMENT

7.1. pH meter with electrode which reads to 0.01 pH units and temperature compensation probe.

7.2. Titration buret apparatus.

7.3. Magnetic stirrer, pipets, beakers and stir bars.

8. PREVENTIVE MAINTENANCE

8.1. Store pH probe in solution of 0.5 g KCl and 100 mL pH 7 buffer.

8.2. Change filling solution in the probe weekly.

8.3. Place parafilm or a cap on the top of the buret when not in use to prevent contamination of titrant.

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9. REAGENTS AND REFERENCE SOLUTIONS

9.1. Sulfuric Acid (0.0200 N): Certified, purchased commercially. Store at room temperature. Expires upon manufacturer's indications or one year from receipt, whichever is first. Standardization is not required if the solution is purchased commercially and there is no more than a single dilution made during preparation. Store at room temperature.
If the 0.02 N acid is not purchased as stated above, standardization shall be required. See Method 310.1 Section 5.

9.2. Reference Stock Standard (5000 mg/L $CaCO_3$): Dissolve 5.300 g Na_2CO_3 in DI water and dilute to 1 liter volumetrically. Store refrigerated at 0-6°C in a plastic container for up to 6 months.

9.2.1. High Level ICV and CCV: Titrate 2.0 ml of 5000 mg/L Reference Stock. True Value = 5000 mg/L

9.2.2. High Level LCS: Dilute 5.0 mL 5000 mg/L Reference Stock to 25 mL DI water. True value = 1000 mg/L

9.3. Spike Stock Solution (1000 mg/L $CaCO_3$): Dissolve 1.0589g Na_2CO_3 in DI water and dilute to 1.0 liter volumetrically. Store refrigerated at 0-6°C in a plastic container for up to 6 months.

9.3.1. Low/Regular Level LCS: Add 2.0 mL 1000 mg/L Spike Stock Solution to 100 mL DI water. True value = 20 mg/L

9.4. Reference Solution (50 mg/L as $CaCO_3$) Volumetrically dilute 10.0 ml of 5000 mg/L Stock Solution to 1.0 liter with DI water. Store refrigerated at 0-6°C in a plastic container for up to 6 months.

9.4.1. Low/Regular Level ICV and CCV: Titrate 25 ml of the 50 mg/L Reference Solution. True Value = 50 mg/L

9.5. Blank (ICB/CCB)- titrate 100 mLs DI.

10. RESPONSIBILITIES

10.1. It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of

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the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. Final review and sign-off of the data is performed by the department supervisor or designee.

11. **PROCEDURE**

11.1. Calibrate the pH meter according to manufacturer's instructions using buffers 4 and 10 and checking the calibration with the pH 7 buffer. Record all pertinent meter calibration information in the pH meter book and on the bench sheet.

11.2. Remove parafilm or cap from buret. Rinse and zero the buret with the appropriate titrant. High level and Low level samples requiring separate titrants will require separate runs and separate run QC.

11.3. Place up to 100 mLs of sample, a small stirbar and the probes into a beaker. It is recommended to start with 10-25 mLs sample for most clients. See the Reagents section for the appropriate volumes for the ICV, ICB, LCS. Be sure the sample covers the glass bulb of the probe. Place the beaker under the tip of the buret in such a way that the titrant will drip directly into the sample without first hitting the probes or the side of the beaker.

11.4. Record the ID of the pipet used to spike LCSs and MSs.

11.5. Record the initial pH of the sample.

11.6. Record the initial reading of the buret.

11.7. Add titrant until the meter reads 4.5, being careful to add titrant dropwise as the endpoint is neared. The endpoint is the drop of titrant which drops the pH to or below 4.5. Record the final reading of the buret.

11.7.1. If the sample used less than 2 mLs of titrant, repeat the test with more sample (up to 100 mLs) or add a measured volume of sample and continue titrating in order to obtain good precision. Record the total sample volume on the benchsheet.

11.7.2. If the sample requires a large amount of titrant (more than 25 mLs) repeat the test with less sample in order to obtain a sharp endpoint.

11.7.3. HIGH LEVEL - If when using the 0.02 N titrant, more titrant is used than samples was used, the value will be greater than 1000 mg/L and the test should be repeated using the high level titrant (0.100N).

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11.7.4. LOW LEVEL - If the sample concentration is less than 20 mg/L, record the titrant volume and exact pH at the endpoint and continue titrating to an additional 0.3 pH units lower.

11.7.5. CARBONATE OR BICARBONATE - If the carbonate, bicarbonate, or hydroxide alkalinity is requested and the initial pH is greater than 8.3, record the volume of acid used to lower the pH to 8.3. Use this volume to calculate the PHENOLPHTHALEIN ALKALINITY. Continue to titrate to pH 4.5 and record the titrant volume to obtain the total alkalinity. Refer to the table in the calculation section to calculate the carbonate and bicarbonate alkalinity.

11.8. The Analytical Sequence should follow the following order:

ICV
Blank
LCS

Up to 9 more samples including a DUP and MS

CCV
CCB

Up to 10 samples including a DUP and MS.

CCV
CCB
LCS

Etc., closing with a CCV/CCB

11.9. When finished with the test, replace cap or parafilm on buret and cover the filling hole in the probe.

12. QA/QC REQUIREMENTS

12.1. Run an ICV before any other samples. The result of the ICV shall be within the limits set forth in the Wetchem QC table in the Quality Assurance Manual. If it is not, determine the cause of the problem and obtain a compliant ICV before running any samples.

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12.2. Run an ICB immediately after the satisfactory ICV. The result of the ICB shall be less than the PQL. If it is not, determine the cause of the problem and obtain a compliant ICV/ICB set before continuing.

12.3. Run a CCV/CCB set after every 10 samples and at the close of the day's run. The results shall follow the limits stated for the ICV and ICB. If they do not, determine the cause of the problem, obtain a compliant CCV/CCB set and repeat any samples bound by the out of control CCV/CCB set.

12.4. Run duplicates at a 10% frequency. The DUP should have a RPD as set forth in the Wetchem QC table or +/- PQL if results are less than 5X the PQL. If noncompliant, repeat the sample and duplicate or flag the associated sample results in the batch.

12.5. Run matrix spikes at a 10% frequency. The MS should have a % recovery within the limits set forth in the Wetchem QC table. If it does not, repeat the MS to confirm the failure or flag the associated sample results in the batch.

12.6. Run an LCS per batch of 20 samples. The LCS recovery should be within the limits set forth in the Wetchem QC table. If it is not, determine the cause, fix the problem, obtain a compliant LCS, and repeat any associated samples.

12.7. An MDL study is to be run annually and shall produce a result less than the PQL. See ADM-MDL.

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13. DATA REDUCTION AND REPORTING

13.1. **CALCULATIONS**:

13.1.1. Low Level:

$$Alkalinity,\ mg/L\ CaCO_3 = \frac{(2B - C) \times N \times 50{,}000}{ml\ Sample}$$

Where: B=ml titrant used to pH 4.5
C=Total ml titrant used to pH exactly 0.3 less than actual 4.5 endpoint
N=Normality of titrant used

13.1.2. Regular and High Level:

$$Alkalinity,\ mg/L\ CaCO_3 = \frac{A \times N \times 50{,}000}{ml\ Sample}$$

Where: A=ml titrant used to pH 4.5
N=Normality of titrant used

13.1.3. Calculate Hydroxide, Carbonate, and/or Bicarbonate alkalinity as mg/L $CaCO_3$ according to the following table.

Result of Titration	Hydroxide Alkalinity	Carbonate Alkalinity	Bicarbonate Alkalinity
P=0	0	0	T
P<1/2T	0	2P	T-2P
P=1/2T	0	2P	0
P>1/2T	2P-T	2(T-P)	0
P=T	T	0	0

P = Phenolphthalein Alkalinity
T = Total Alkalinity

13.2. **REPORTING AND DOCUMENTATION**

13.2.1. Record all numbers on benchsheets to three significant figures and report alkalinity as mg/L $CaCO_3$.

13.2.2. PQL (Practical Quantitation Limit) = 2 mg/L $CaCO_3$.

13.2.3. Data review policies and procedures are discussed in ADM-DREV.

14. WASTE MANAGEMENT AND POLLUTION PREVENTION

14.1. Samples and titrated samples may be washed down the drain. See SMO-SPLDIS for further discussion on waste management.

15. **REFERENCES**

15.1. Method 310.1, *Methods for Chemical Analysis of Water and Wastes*, EPA- 600/4-79-020, Revised March 1983.

15.2. Method 2320 B in *Standard Methods for the Examination of Water and Wastewater*, 18th Ed., 1992.

16. TRAINING OUTLINE

16.1. Read current SOP and applicable methodologies. Demonstrate a general understanding of the methodology and chemistry. Document training dates.

16.2. Observe Sample Preparation and Analysis.

16.3. Participate in the methodology, documentation, and data reduction with guidance.

16.4. Demonstrate Competency by performing the analysis independently. Analyze 4 replicates of a known proficiency or standard. If recovery is within acceptable limits, complete training form and have the supervisor sign-off as being proficient. IDC certificate must be completed by supervisor and filed/approved with QA. Continued proficiency shall be demonstrated using outside PE source or an internal unknown.

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17. INSTRUMENT ADDENDUM

None.

18. ATTACHMENTS

Benchsheet

19. CHANGES FROM PREVIOUS REVISION

19.1. Changed Batch definition (Section 3) from “prepared” to “run” on the same day.
19.2. Added corrective action to interferences (Section 4) where appropriate.
19.3. Added recipe for probe storage solution (Section 8).
19.4. Added Blank to reagents section 9.
19.5. Added recommendation to start with 10-25 mLs instead of 100 for sample titration (11.3)
19.6. Added need to have separate runs and QC for High and Regular/Low level samples (11.2)
19.7. Added that analyst may add sample volume to titrated sample if used less than 2 mLs titrant (11.7.1)
19.8. Clarified where to find table referred to in 11.7.5.
19.9. Changed wording in 11.7.5 to clarify phenolphthalein alkalinity.
19.10. Changed from set limits in 12 to use of Wetchem QC table.
19.11. Eliminated extraneous “O” in 13.
19.12. Corrected table in 13.1.3 to be If P<1/2T then bicarbonate alkalinity = T-2P instead of T-P.

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STANDARD OPERATING PROCEDURE

VOLATILE ORGANIC COMPOUNDS BY GC/MS

VOC-8260B

Revision 5.0

September 28, 2001

Approved By: _____ _____
Supervisor Date

_____ _____
QA Coordinator Date

_____ _____
Laboratory Manager Date

© Columbia Analytical Services, Inc., 2000
1 Mustard Street, Suite 250
Rochester, New York 14609

Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
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1. SCOPE AND APPLICATION

This SOP is used to determine the concentration of volatile organic compounds in water and soil using USEPA Method 8260B. This method may also be applicable to various types of aqueous and nonaqueous waste samples. Table 1 lists the compounds that can be routinely determined by this method, and the compounds' practical quantitation limits (PQLs) in water and soil.

2 METHOD SUMMARY

2.1 This method gives gas chromatographic/mass spectrometric (GC/MS) conditions for the detection of parts per billion (ppb) levels of volatile organic compounds. A sample aliquot is injected into the gas chromatograph (GC) by either the purge and trap method or by direct injection. The compounds are separated on a wide bore fused silica capillary GC column or small bore capillary columns. The compounds are detected by a mass selective detector (MSD), which gives both qualitative as well as quantitative information.

2.2 Lower PQLs can be achieved by purging a volume larger than the standard 5mL discussed herein. With a 25mL purge, all reporting limits listed in Table 1 would be one-fifth that value. The analytical procedure, instrumentation, and QC limits are according to the following, however final sample volume would be 25mL. All internal, surrogate, and matrix spike solutions are prepared in the same manner discussed herein, only spiked into a 25mL sample volume thereby diluting the actual concentration by a factor of five. The initial and continuing calibration standards would also require the additional dilution thereby decreasing the range of calibration by a factor of five.

2.3 In the purge and trap process an inert gas, helium, is bubbled through the sample aliquot, at room temperature. This gas stream sweeps the volatile organic compounds out of the aqueous phase and into the gas stream - it purges the compounds out of the sample. The gas stream then passes through a sorbent column which selectively adsorbs, (traps) these compounds out of the helium. After the purging sequence is done, the sorbent column (the trap) is heated and backflushed onto the GC column. The GC column separates the compounds and passes then onto the MSD for identification and quantification.

3 DEFINITIONS

Analysis Window - Samples are analyzed in a set referred to as "a window". The window begins with the injection of the tune verification standard. After this standard has passed the method specific criteria a 12 hour analysis window is started.

Next, a calibration curve or a continuing calibration standard (CCV see below) is run followed by a method blank. If both pass their specific criteria, then samples are run until

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the 12 hour time limit closes. A new window must then be opened and the sequence repeated.

Internal Standards - Internal standards are organic compounds which are similar to the analytes of interest but which are not found in the samples. The chosen internal standards are used to help calibrate the instrument's response.

Independent Calibration Verification (ICV) - Verification of the ratio of instrument response to analyte amount, a calibration check, is done by analyzing for analyte standards in an appropriate solvent. ICV solutions (refered to as laboratory control samples or reference samples) are made from a stock solution which is different from the stock used to prepare calibration standards(Second Source).

Matrix Spike/Duplicate Matrix Spike Analysis - In the matrix spike analysis, predetermined quantities of standard solutions of certain analytes are added to a sample matrix prior to sample extraction and analysis. The purpose of the matrix spike is to evaluate the effects of the sample matrix on the methods used for the analyses. Samples are split into duplicates, spiked, and analyzed. Percent recoveries are calculated for each of the analytes detected. The relative percent difference between the samples is calculated and used to assess analytical precision. The concentration of the spike should be at 5 to 10 times the MRL or at levels specified by a project analysis plan.

Standard Curve - A standard curve is a curve which plots concentrations of a known analyte standard versus the instrument response to the analyte.

Surrogate - Surrogates are organic compounds which are similar to the analytes of interest in chemical composition, extraction, and chromatography, but which are not normally found in environmental samples. The purpose of the surrogates is to evaluate the preparation and analysis of samples. These compounds are spiked into all blanks, standards, samples, and spiked samples prior to analysis. Percent recoveries are calculated for each surrogate.

Continuing Calibration Verification Standard (CCV) - A mid-level standard injected into the instrument at specified intervals and is used to verify the initial calibration. The source of this standard is the same as that used for calibration purposes.

Method Blank (MB) - The method blank (also called continuing calibration blank) is a volume of clean reagent water analyzed on each GC/MS used for sample analysis. The purpose of the blank is to determine the levels of contamination associated with the instrumental analysis itself.

4 INTERFERENCE'S

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4.1 Interference's by common laboratory extraction solvents, such as Methylene Chloride and Acetone can cause problems. The area where volatile organic analyses are performed should be free of these solvents.

4.2 Other interference's include but are not limited to impurities in the inert purge gas, dirty plumbing/purge vessels, cross contamination of highly contaminated samples, in transport and storage, and carry over from one analysis to subsequent ones.

5 SAFETY

The toxicity or carcinogenicity of each compound or reagent used with this method is not known. Each compound, mix of standards, internal standards and surrogates as well as the samples should be treated as a potential health hazard. Exposure to each should be reduced to the lowest level possible through the use of gloves and a hood. Reference files of Material Safety Data Sheets (MSDS) are available to all personnel. CAS also has a file of the current OSHA regulations regarding the safe handling of the compounds specified in this method.

6 SAMPLE CONTAINERS, COLLECTION, PRESERVATIONS, AND STORAGE

6.1 All sample containers for volatile organic analyses are purchased precleaned and certified from major lab equipment suppliers. All containers should be of glass or amber glass and equipped with a screw top cap and PFTE (teflon) lined septa and capable of containing a minimum of 40 mL of aqueous sample or 2-4 oz. of soil sample. All new lots of vials acquired are recorded by our SMO area and routinely checked for cleanliness and target compound contamination.

6.2 Aqueous Samples

Collect all samples in duplicate, triplicate when possible. Prepare the proper number of sample bottles/containers prior to the sampling event with preservatives to adjust the samples pH to <2 with 1:1 HCl.

Slowly fill aqueous sample bottles to just overflowing taking care not to flush out the preservative or to entrain air bubbles in the samples. Seal the bottles with PFTE lined septa toward the sample and invert to check for entrained air bubbles.

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6.3 Soil Samples

Soil samples are collected per individual state, agency, or QAP requirements. See State Summary spreadsheet in VOA lab office for details. The following options are available:

Option 1:
Soil jars with PFTE lined septa are used to collect soil samples. The soil is pressed into the jar to the top to eliminate any headspace.(New York State). Holding time is 14 days from sample collection to analysis.

Option 2.
Encore style sampler and capsules are sent to the field and a fraction of either approximately 5 gm or 25 gm are collected by field personnel and shipped back to the laboratory, chilled temperature of 0-6°C while in transit. The laboratory then has 48 hrs from sampling to preserve the soil fractions in sodium Bisulfate for the low concentration fractions and Methanol for high concentration fraction. Or optionally the samples must be run within 48 hours of sampling.

Option 3.
Soil vials are prepared by laboratory personnel. Two 40 ML VOA vials containing a 5 mL solution of Sodium Bisulfate(1gm/5mL) are sealed labled and Tarred, sent with this is a 40 mL VOA vial containing 10 mL of Purge And Trap Methanol, sealed, labled and tarred. A Top Loading balance is supplied to the field personnel and a 5 gm fraction is added to each of the three supplied Vials. Optionally a Encore sampler may be used to sample these fractions, then added to the above mentioned vials. The field sampler then returns the fractions (40mL vials) back to the laboratory chilled to 0-6°C. At which time the lab re-weighs the vials to determine soil content and must perform the analysis within 14 days of sampling. (See VOC-5035).

6.4 All samples must be stored at 0-6°C and must be analyzed within 14 days of collection. Aqueous samples not prepreserved with HCl must be analyzed within 7 days of collection.

7 APPARATUS AND EQUIPMENT

7.1 Gas chromatograph/Mass Selective Detector Systems

Each GC/MS system is set up with a GC, injection onto a wide bore capillary column, and either a glass or stainless steel jet separator at the columns detector end prior to the transfer line interfaced with the MSD. Each MSD is a HP5970B, or HP5971 that is controlled by the HP-MSDOS Chemstation software.

7.2 Purge and Trap with Autosampler

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7.2.1 Each volatile GC/MS analytical system uses a purge and trap to introduce the sample onto the GC column. Each purge and trap has an autosampler (A/S) attached to run multiple samples, one at a time, and run unattended for extended periods of time. A Tekmar ALS 2016 or its equivalent for extended unattended automated running is needed.

New generation purge and trap instruments have evolved to include greater production capabilities. These new autosamplers have the capability of running up to 50 positions continuously unattended. They also afford the ability to add both Internal Standards and Surrogate Standards automatically from two individual recepticals, removing some of the inconsistencies related to the repetitive analyst setup of the older autosampler technology. These new instruments include Varians Archon autosamplers and Tekmars new Precept II's. All lend themselves nicely to the new requirements of EPA Method 5035. In turn the sample and standard preparation vary for both methods 5030 and 5035 using these autosamplers. The preparation of both samples and standards for method 8260B by 5030 and 5035 will be addressed below.

7.2.2 Adsorbent Traps: Supelco K-Traps Carboxen Vocarb 3000

7.3 GC Columns

Column 1: Restex RTX-502.2; 105 M x 0.53mm id fused silica column 3.0 micron film thickness

Column 2: Hewlett Packard HP-624, 25 M, 0.2 mm id fused silica, 1.12 micron film thickness

Column 3: J&W DB624, 60 M, 0.32 mm ID fused silica, 1.8 micron film thickness

8 PREVENTATIVE MAINTANENCE

8.1 All maintenance activities are recorded in a maintenance logbook kept for each instrument. Most routine maintenance and troubleshooting is performed by CAS staff. Other maintenance or repairs may, or may not require factory service, depending upon the nature of the task. Typical preventive maintenance measures include, but are not limited to, the following items:

- Check gas supply
- Change in-line filters, septum, and injection port liner, as needed
- Clip column and change guard column, as needed
- Clean source and jet separator

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9 STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

9.1 Solvents

Methanol, purge and trap grade or equivalent and reagent water, prepared from deionized water.

9.2 Stock Standard Solutions

Commercially prepared and certified stock standards are used routinely for all the routine method analytes. All such mixtures are also routinely checked against an independent source for both analyte identification and analyte concentration. All such stock standard mixtures have expiration dates given by the manufacturer. Once opened, the mixtures must be replaced after 6 months, or sooner if the composition with the independent check standards indicates a problem. Store with minimal headspace, at -10° to -20°C and protect from light.

9.3 Calibration Standards (Tekmar 2016 - 5 mL or 5 gm aliquots)

A minimum of five different concentration levels for all the analytes are prepared by diluting the stock standards into prepared reagent water. The lowest concentration level shall be at the method reporting level. The remaining four levels should define the working linear range of the analytical system.

The suggested levels 5, 20, 50, 100, and 200 ppb for waters and soils. All calibration solutions are made up daily using the following procedures:

9.3.1 Calibration Standard Mix (50 ppm) - Prepare a standard mix from purchased standard mixes which typically include a 200 ppm Volatiles Mix with gases, and a 200 ppm Custom Volatiles Mix and 300 ppm Baseline Std mix 2.

- Calibration Standard Mix 1 (50 ppm) = 0.625 mL of each of 200 ppm standard Volatile + gases mixes and 200 ppm Custom Volatile Mix above and dilute to 5.0 mL with methanol. Prepare weekly, unless verified by a second source with each use and store at -10° to -20°C.

- Calibration Standard Mix 2 (300 ppm) = 0.750 mL of Acrolein/ Acylonitrile at 2000 ppm and dilute to 5.0 mL with methanol. Prepare monthly, unless verified by a second source with each use and store at -10° to -20°C.

- Internal / Surrogate Mix (50 ppm) = 2500 ppm purchased Stock 1 mL/10mL Meoh = 250 ppm , 1mL 250 ppm /5mL = 50 ppm.

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Prepare monthly, unless verified by a second source with each use and store at -10° to -20°C.

Calibration Standards are prepared using the 50 ppm mix as follows:

Standard Concentration (ppb)	uL's of 50 ppm Mix 1	uL's of 300 ppm Mix 2	Final Volume (mL)**
5	5.0	5.0	50 (then 5.0 mL purge)
20	2.0	2.0	5.0
50	5.0	5.0	5.0
100	10.0	10.0	5.0
200	20.0	20.0	5.0

***Internal Standards and Surrogates are added to all standards and samples at a rate of 5 ul of 50 ppm to each 5 mL aliquot.*

The surrogates recommended are Dibromofluoromethane, toluene-d_8 and 4-bromofluorobenzene. The internal standards recommended are pentafluorobenzene, 1,4-difluorobenzene, 1,4-dichlorobenzened$_4$ and chlorobenzene-d_5. The other internal standards and surrogates may be used, depending on the analysis requirements. All surrogates and internal standards are added to every standard, sample, blank and spike at 50 mg/L (5 ul of a 50 ppm working standard mix to 5.0 mL sample volume) for waters and soils.

9.3.2 Internal/Surrogate Stock Standards (2500 ppm) are purchased and used to prepare working standards for spiking purposes. Purchased stocks expire upon manufacturer's expiration date and stored at -10° to -20°C.

Internal/Surrogate Working Standard (50 ppm). Prepare monthly and store at -10° to -20°C.

- Prepare a 500 ppm Stock Standard by diluting 1.0 mL each of the purchased 2500 ppm stock to 5.0 mL with methanol.
- Internal/Surrogate Working Standard Mix (50 ppm) = 0.500 mL of the 500 ppm stock standard and dilute to 5.0 mL with methanol.

9.4 Calibration Standards (Archon Autosampler using 40 mL VOA vials).

9.4.1 Calibration Standard Mix (500 ppm) - Prepare a standard mix from purchased standard mixes which typically include a 500 ppm Volatiles Mix with gases, and a 500 ppm Custom Volatiles Mix + 54 Targets. Store at -10° to -20°C.

- Calibration Standard Mix 1 (500ppm) = 2.50 mL of each of 1000 ppm standard gases mixes and dilute to 5.0 mL with methanol.

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Prepare weekly, unless verified by a second source with each use and store at -10° to -20°C.

- Calibration Standard Mix 2 (500 ppm) = 1.25mL 2000 ppm 54 Targets and 1.25 mL Custom volatile mix dilute to 5.0 mL in a class A volumetric flask, with methanol. Prepare monthly, unless verified by a second source with each use and store at -10° to -20°C.

- Internal / Surrogate Mix (250 ppm) = Internal Std 2500 ppm purchased Stock 1.0 mL/10mL methanol = 250 ppm, Surrogate Std 2500 ppm purchased Stock -1.0 mL/10mL methanol = 250 ppm. Prepare monthly, unless verified by a second source with each use and store at -10° to -20°C.

Calibration Standards are prepared daily using the 500 ppm mix's as follows:

Standard Concentration (ppb)	ul's of 500 ppm Mix 1	ul's of 500 ppm Mix 2	Final Volume (mL)
5	1.0	1.0	100
20	2.0	2.0	50
50	5.0	5.0	50
100	10.0	10.0	50
200	20.0	20.0	50

- Internal Standards and Surrogates are added to all standards and samples at a rate of 1 ul of 250 ppm to each 5 mL aliquot. This is accomplished by the Archon Auto-Sampler at the time of analysis.The sample or standard is transfered from the Archon through a nickel transfer line, past a ported valve that is calibrated to deliver 1 ul of IS/Surr mix. The sample fraction is transferred to a fritted sparge chamber on the Tekmar 2016 Concentrator at which time the sample or standard is purged on to the adsorbent trap.

- In the case of water analysis on the Archon autosampler, setup differs from the 2016 sampler in that a filled 40 mL VOA vial takes the place of the 5 mL fraction added to 2016. This setup is preferable in that the sample or standard is retained with zero headspace until just prior to analysis. This does in fact change the procedure for calibration which is noted above, that of addition of standard solution to a 40 mL VOA vial.

It should be noted that in the cases where calibrating for the analysis of soils by 5035/8260B that the standard solution above must contain the same amount of Sodium Bisulfate as the samples being analyzed.

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9.5 Internal Standards and Surrogate Standards

The surrogates recommended are Dibromofluoromethane, toluene-d_8 and 4-bromofluorobenzene. The internal standards recommended are pentafluorobenzene, 1,4-difluorobenzene, 1,4-dichlorobenzened$_4$ and chlorobenzene-d_5. The other internal standards and surrogates may be used, depending on the analysis requirements. All surrogates and internal standards are added to every standard, sample, blank and spike at 50 ug/L (1 ul of a 250 ppm working standard mix to 5.0 mL sample volume) for waters.

9.5.1 Internal/Surrogate Stock Standards (2500 ppm) are purchased and used to prepare working standards for spiking purposes.

Internal/Surrogate Working Standard (250 ppm)

- Prepare a 250 ppm Stock Standard by diluting 1.0 mL each of the purchased 2500 ppm stock's to 10.0 mL with methanol.
- This mix is transferred to a sealed glass ampule that acts as a reservoir where the auto-samplers adds a 1 ul fraction per addition.

9.6 Tune Standard (25 ppm)

9.6.1 A second source BFB (surrogate standard diluted to 25 ppm) is directly injected into the instrument or purged on the Tekmar on a daily basis as the BFB Tune.
The standard is added at a rate of 2ul of 25 ppm BFB/ 5 mL or 50 ng on column.

9.7 Matrix Spike (50 ppb)

Routinely five compounds recommended by the method for determining accuracy on a particular sample matrix are 1,1-dichloroethene, trichloroethene, benzene, toluene, and chlorobenzene. All samples designated for MS analysis are spiked at 50 ug/L (4.25 ul of a 500ppm working standard mix to 40 mL sample vial).

9.7.1 Although method 8260 requires monitoring recoveries for the five above mentioned compounds it is our practice to spike our Matrix Spike/ Matrix Spike Dups with all Target Compounds specified by our clients. This is accomplished by spiking samples as though they were a 50 ppb initial calibration point. 4.25 ul Std Mix 1 500 ppm, 4.25 ul Std Mix 2 500ppm/ 40 mL VOA sample vial. After adding the spiking standard the vial is inverted 3 times to insure equilibration of the standard addition.

9.8 Laboratory Control Sample (20 ppb)

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By definition a LCS or commonly known Reference is a standard aquired from a secondary source than that of the Target Compounds used for the initial calibration.

- Volatile Reference Mix1 (20 ppm) - Commercially available 200 ppm 54 component mix diluted 1mL / 10 mL Meoh (20 ppb = 5 ul /5mL DI)

- Volatile Reference Mix2 (20/200 ppm) = Commercially available 1000 ppm Acrolein/Acrylonitrile 1 mL/ 5 mL Meoh, HSL 400 ppm, .250 mL / 5mL Methanol

Prepare the 20 ppb LCS or Reference = 50ul Mix1 + 50 ul Mix2 / 50 mL DI.

10 RESPONSIBILITIES

10.1 It is the responsibility of the analyst to perform the analysis according to the instructions in this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are only to be performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. This demonstration is in accordance with the training program of the laboratory. Final review and sign-off of the data is performed by the department supervisor/manager or designee.

11 PROCEDURE

11.1 Sample Preparation

11.1.1 Water Samples

No preparation is generally required, other than dilution with reagent water to bring analytes into the upper half of the calibration range. Thus, a 5 mL sample volume is run straight from the sample vial.

11.1.2 All water samples should be checked to have a pH of 2 (pH < 2). The pH shall be noted in the run log.

11.1.3 Samples requiring dilutions due to targets above the linear range of the instruments are prepared as follows:

1:5 = 10 mL sample adjusted to 50 mL in a 50 mL ground glass graduated cylinder inverted twice and transfered to a 40 mL VOA vial

1:25 = 2.0 mL sample adjusted to 50 mL in a 50 mL ground glass graduated cylinder inverted twice and transfered to a 40 mL VOA vial

1:50 = 1.0 mL sample adjusted to 50 mL in a 50 mL ground glass graduated cylinder inverted twice and transfered to a 40 mL VOA vial

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- Spiking of the diluted sample is similar to the 50 ppb CCV: 5 ul Mix1 + 5 ul Mix2 invert and add to 40 mL VOA vial.

Note: At no time should less than 1 mL of the original sample fraction be used for the preparation of the diluted sample. This insures a representative fraction of sample is diluted.

11.2 Calibration

11.2.1 BFB Tuning Criteria

Each volatile GC/MS analytical system set up to run 8260B must meet the criteria listed in Table 2 of the method for a 50 ng injection of BFB. An acceptable BFB tune must be run prior to any analysis or every twelve hours there after.

The analyst may use documented approaches suggested by the instrument manufacturer or other to acquire scans for the BFB tune. Do not background subtract part of the BFB peak

11.2.2 GC/MS Analytical System 5 Point Calibrations

Prior to conducting any sample analyses, a 5 point calibration must be run. Recommended calibration levels are 5, 20, 50, 100, and 200 ppb. Starting with the lowest level, analyze each calibration standard and tabulate the area response of the characteristic quantitation ions versus concentration for each compound, internal standards and surrogate. The low level standard used during calibration shall be the reporting level for the analysis. Calculate the response factors (RF) for each compound and surrogate relative to the specified internal standard by:

$$RF_x = \frac{(A_x)(C_{ISTD})}{(A_{ISTD})(C_x)}$$

Where:

A_x = Area of the characteristic quantitation ion for compound x.
A_{ISTD} = Area of the characteristic quantitation ion for the specified internal standard.
C_x = The concentration of the compound added.
C_{ISTD} = The concentration of the specified internal standard.

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Calculate the mean response factor $(\overline{RF_x})$ for each analyte and surrogate from the five calibration levels. Calculate standard deviation (SD) and the percent relative standard deviations (%RSD) for each analyte from the mean with:

$$\%RSD = \frac{(SD)}{(\overline{RF_x})} 100.$$

The % RSD should be less than 15% for each target compound. However, the % RSD for each individual CCC must be less than 30%. The CCC's are: 1,1-Dichloroethene, Chloroform, 1,2-Dichloropropane, toluene, Ethylbenzene and Vinyl Chloride.

If a % RSD greater than 30% is measured for any CCC, then corrective action to eliminate a system leak and/or column reactive sites is required before reattempting calibration.

If the % RSD for any target compound is 15% or less, linearity can be assumed over the calibration range, and the relative response factor for each analyte and surrogate is used to quantitate sample analytes.

If the % RSD of any compound is > 15%, construct a linear calibratio curves of area ratio (A/A_{is}) versus concentration.

If a curve scheme is to used: the required Corr.Coef. must be greater than 0.99 and the origin must not be used inclusively as a point of the curve. It is good lab practice to mark all target compounds on a curve with an asterisk to identify target compounds calculated using linear regression. It is also a requirement that if a client's sample contains a compound calculated via non-linear curve, that he or she be notified by the laboratory. *(See Method 8000B)*

Due to the large compound lists quoted in 8260B, some compounds are problematic by nature. It is stated in the methodology that if certain compounds exceed 15 % RSD and that the mean % RSD of all target compounds in the curve do not exceed 15% that the curve is valid. This is frowned upon by our laboratory but may sometime be used if the compound in question is known to be continually a problematic or non typical compound. In any case these issues would be addressed in a case narrative.

Note: For some states, such as South Carolina, all reported target compounds must be quantitated from an initial calibration yielding an RSD ≤15% for that particular compound.

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The response of 5 SPCC's must also be checked for their minimum $\overline{RF_x}$:

Chloromethane	>0.10
1,1-Dichloroethane	>0.10
Bromoform	>0.10
Chrorobenzene	>0.30
1,1,2,2-Tetrachloroethane	>0.30

After the 5 point calibration has passed all of the above criteria, and the mid-point (CCV) has been checked against the curve, then samples can be analyzed.

11.3 Daily GC/MS Calibration

11.3.1 The start of a 12-hour analysis window requires a check of the MSD's tune via an injection of 50 ng of BFB. If the criteria found in Table 2 of USEPA 8260B are met, then a check of the initial calibration curve is done. If the first run of the BFB fails, retry. If the second run also fails, inform your supervisor. You may have to retune and recalibrate the system.

11.3.2 After the tuning criteria have been verified, the initial calibration must be checked and verified by analyzing a midrange calibration standard (CCC). The 50 ppb level is recommended. For 8260B, water daily check standards are 5µl of the 50 ppm 8260 working standard spiked into 5 mL of reagent water. The results are compared with those of the initial calibration's $\overline{RF}$ using the following equation:

$\%Drift = (RF_1 - RF_2)/ RF_1 \times 100$

where:

RF_1 = Average response factor form the initial calibration
RF_2 = Response factor from the continuing calibration check standard

If the percent drift is less than 20 %, the Initial Calibration is assumed to be valid. Also, the criteria for the SPCCs and the CCCs, as outlined above, must be met.

11.3.3 If the tune criteria and the continuing calibration criteria are met, then the retention times of all compounds, surrogates, and internal standards are checked against the initial calibration. If the retention time for any internal standard changes by more than 30 seconds from the last calibration check (12 hours), the system must be inspected for malfunctions and corrections must be made, as required. If the area for any of the internal standards

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changes by a factor of 2 (-50% to +100%) from the last daily calibration check std., corrections must be made to the system.

11.4 Identification of Analytes

The MSD data system software identifies a sample component by first finding and identifying the surrogate and internal standards. After they have been integrated, the extracted ion chromatogram is searched for all calibrated analytes. Any peak associated with the proper retention time window having the primary characteristic quantitation ion identified has it's results calculated. If there is no peak found for an analyte in the expected retention time window and the mass spectra does not match according to the method criteria, then the analyte is "not found". Example retention times are provided in Appendix I, however must only be used as a reference due to the variability on a daily basis due to instrument conditions

12 QA/QC REQUIREMENTS

12.1 12-Hour Analysis Window Requirements

For every 12-hour analysis window, after meeting the tune and continuing calibration criteria, at least one method blank must be run and reportable for each matrix.All blanks reported must be free from target analytes with the exception of known common laboratory contaminants, These compounds may include Acetone and Mecl2 at a level no greater than 5 times the compounds PQL and all samples effected should be marked with the appropriate lab flag.

12.2 Analytical Batch Requirements

For each batch of samples (20 samples maximum), a minimum of one MS/MSD pair and an LCS for each matrix must be analyzed to ensure instrument performance.

12.3 Acceptance Criteria and Corrective Action

12.3.1 The acceptance criteria for tuning verification, initial, and continuing calibration verification are discussed in the procedure.

12.3.2 For every 12-hour analysis window, after meeting the tune and continuing calibration criteria, at least on method blank must be analyzed and reported for each matrix. All method blanks reported must be free from all target compounds quantitated above the reporting limit during the 12-hour sequence.
Exception: if a target analyte is greater than ten times the method blank contaminant, the analysis may continue since the sample concentration

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is high enough that possible contamination has not effected it's concentration.

12.3.2 Table 3 contains the acceptance criteria for evaluating matrix spikes and surrogate recoveries. LCS recovery requirements for all target compounds is 70-130% (method-required limits until lab generated limits are recalculated). Matrix spikes and LCSs are performed on a 5% frequency. When batches are less than 20 samples, LCS standards are performed on a per batch basis.

- Any MS/MSD that fails the required QC Accuracy or precision requirements will be reanalyzed and the precision and accuracy data checked. It is a requirement that a LCS be run concurrently with any matrix spikes. If the LSC passes QC requirements it is presumed that matrix has effected the spiked samples and the run may continue. If the concurrent LCS fails for the same compound or any other compound the validity of the LCS should be looked at and any samples prior to the LCS and after the last CCV should be reanalyzed.

- Typically, a full LCS spike is analyzed to evaluate the performance of all samples, however only the 5 method specific compounds may be reported with sample results. For some states, such as South Carolina, the full LCS spike is reported and target compound recoveries are required to be within laboratory limits for all compounds quantitated above the reporting limit.

- When instances of Surrogate or internal area count failures occur, the associated sample is repeated and the results are compared. If the questioned samples fail a second run, the first run is reported to the client and the sample flagged with an "*" indicating a probable matrix interference exists. In the case where Tier package work is required and the appropriate forms need to be generated, the second analytical analysis is also reported to the client.

12.4 Calculate the recovery of each matrix spike compound as follows:

$$\text{Matrix Spike Recovery} = \frac{SSR - SR}{SA} \times 100$$

Where,
SSR = Spiked sample result
SR = Sample result
SA = Spike added

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12.5 Calculate the relative percent difference (RPD) of the recoveries of each compound in the matrix spike and matrix spike duplicate as follows:

$$RPD = \frac{|\ MSR - MSDR|}{\frac{1}{2}(\ MSR + MSDR\ )} \times 100$$

Where,
MSR = Matrix spike recovery
MSDR = Matrix spike duplicate recovery

12.6 Method Performance - Method Detection Limit (MDL) studies should be performed annually for both soil and water matrices. See CAS SOP ADM-MDL for specifics.

13 DATA REDUCTION AND REPORTING

13.1 Calculations

The GC/MS data stations, in current use, all use the H-P RTE Integrator to generate the raw data used to calculate the standards $\overline{RF_x}$ values, the sample amounts, and the spike values. The software does three passes through each data file. The first two identify and integrate each internal standard and surrogate. The third pass uses the time-drift information from the first two passes to search for all method analytes in the proper retention times and with the proper characteristic quantitation ions.

13.1.1 The results for a water sample are calculated as follows when $\overline{RF_x}$ is used:

$$A_x = \frac{(Resp_x)(Amt_{ISTD})}{(Resp_{ISTD})(\overline{RF_x})} \times DilFactor$$

Where:
A_x = the amount, in ppb, of the analytes in the sample;
$Resp_x$ = the peak area of the analytes of interest;
$Resp_{ISTD}$ = the peak area of the associated internal standard;
Amt_{ISTD} = the amount, in ppb, of internal standard added; and
$\overline{RF_x}$ the average response from the five-point for the analytes of interest.

13.1.2 The results for a soil sample are broken into two types, the low-level type and the high-level type.

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13.1.2.1 The low-level type is a direct heated purge of soil and requires its own separate five-point. For soil, 5 grams is weighed out into the sample vial, and is purged with 5 mL of blank reagent water at a temperature of 40°C ±2°. The results for low-level soil work are calculated by taking the normal print out, in ppb, (see the water results outlined above) and correcting for the total, dry soil sample actually purged:

$$(A_x) * \frac{(5\ grams)}{(ASW_t\ gr)(\%\ Solids)} = A_x\ Low\text{-}Level\ Soil$$

Where:
A_x = the amount, in ppb, from the data station;
5 grams = the nominal amount of soil that is heated and purged;
ASW_t = the actual soil wet weight, in grams, that is purged
% Solids = the correction factor for dry weight.

It is to be noted that new methods evolve due to the requirement of outside agencies. This includes the adoption of method 5035. Although similar to the above mentioned low level soil methods, specific criteria must be met for this methodology. This includes running all low level soils against an appropriate curve in which all standards in the calibration were heated. Although the method differs due to autosampler requirements, data calculation and reduction remains the same. For further information and procedures in regards to this method see Method 5035.

13.1.2.2 The high-level type is an extraction method and is only done when needed. In general, a four gram wet weight of soil is extracted with 10 mL of purge-and-trap methanol. A 100 ul aliquot of this extract is run against the results for a high-level soil extract are calculated as follows:

$$(A_x) * \frac{(Dilution)(5\ ml)}{(ASW_t)(\%\ Solids)} = A_x\ High\text{-}Level\ Soil\ Amt.$$

Where:
A_x = the data station results, in ppb;
Dilution = the dilution of the extract.
5 mL = the amount of methanol used to extract the soil;
ASW_t = the actual wet weight of soil extracted
% Solids = the dry soil correction.

It should be noted that some states and governing agencies require differing amounts of soil and Methanol ratio be maintained these ratios are generally, 1:2.5, 1:2, 1:1. The amount of extract added is never greater than 100 ul per 5 mL DI. As an example, the Archon

autosampler would require the addition of 1.0 mL to 49 mL DI. This is then transfered to a 40 mL VOA vial. See the included table in method 5035 for specific state regulation on soil to Methanol ratios.

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13.2 Reporting

Most reports are generated using STARLIMS. All data is transferred electronically from the instrument into STARLIMS. The report is composited and all applicable QC reported.

14 WASTE MANAGEMENT AND POLLUTION PREVENTION

14.1 It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

14.2 Excess, unused sample and testing byproducts are disposed following the procedures in the *SMO-SPDIS*.

15 REFERENCES

15.1 *Test Methods for Evaluating Solid Waste Physical/Chemical Methods*, USEPA SW-846, Third Edition, December 1996.

16 TRAINING OUTLINE

16.1 Read current SOP and applicable methodologies. Demonstrate a general understanding of the methodology and chemistry.

16.2 Observe Sample Preparation and Analysis.

16.3 Participate in the methodology, documentation, and data reduction with guidance

16.4 Instrument Operation and Maintenance, if applicable

16.5 Demonstrate Competency by performing the analysis independently. Analyze a known proficiency or standard. If recovery is within acceptable limits, complete training form and have the supervisor sign-off as being proficient. An IDC study must be performed and the departmental supervisor must approve the study before the new analyst may analyze samples independently. Four replicates must be analyzed within LCS control limits to complete the IDC study.

17.0 INSTRUMENT-SPECIFIC ADDENDUM

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See Operations Manual

18.0 ATTACHMENTS

Table 1	Summary of Target Compounds and Reporting Limits
Table 2	BFB Tune QC Criteria
Table 3	Surrogate/Matrix Spike/Reference Standard QC Criteria
Appendix I	Example Retention Times

19.0 CHANGES FROM PREVIOUS REVISION

- Expanded Section 6.0 to include options for soil sample collection and holding times.
- Revised expiration dates for VOA standards in Section 9.0. Revised preparation sections to reflect current standards purchased.
- Discussed tune criteria and scan requirements further in Section 11.0.
- Omitted options to use quandratic fit.
- Included a statement that the low level standard during an ICAL was to be used as the lowest level of detection and discouraged the use of averaging RSD values for ICAL acceptance.
- Revised method blank acceptance criteria in section 12.0.
- Added calculations for accuracy and precision in Section 12.0.
- Added annual MDL study requirements to Section 12.0.
- Included IDC study requirements under Section 16.0.

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TABLE 1
VOLATILE ORGANIC COMPOUNDS VIA EPA METHOD 8260B

Compound	*LOW(25 ml) Water (ug/L)*	*REG(5 ml) Water (ug/L)*	*LOW Soil (ug/Kg)*	*5035Medium Soil (ug/Kg)*	*(OLD 4G/10ML Medium Soil (ug/Kg)*
1,1,1-Trichloroethane (TCA)	1.0	5.0	5.0	500	625
1,1,2,2-Tetrachloroethane	1.0	5.0	5.0	500	625
1,1,2-Trichloroethane	1.0	5.0	5.0	500	625
1,1-Dichloroethane	1.0	5.0	5.0	500	625
1,1-Dichloroethene	1.0	5.0	5.0	500	625
1,2-Dichloroethane	1.0	5.0	5.0	500	625
1,2-Dichloropropane	1.0	5.0	5.0	500	625
2-Butanone (MEK)	5.0	10	10	1000	1250
2-Hexanone	5.0	10	10	1000	1250
4-Methyl-2-pentanone (MIBK)	5.0	10	10	1000	1250
Acetone	10	20	20	2000	2500
Benzene	1.0	5.0	5.0	500	625
Bromodichloromethane	1.0	5.0	5.0	500	625
Bromoform	1.0	5.0	5.0	500	625
Bromomethane	1.0	5.0	5.0	500	625
Carbon Disulfide	5.0	10	10	1000	1250
Carbon Tetrachloride	1.0	5.0	5.0	500	625
Chlorobenzene	1.0	5.0	5.0	500	625
Chloroethane	1.0	5.0	5.0	500	625
Chloroform	1.0	5.0	5.0	500	625
Chloromethane	1.0	5.0	5.0	500	625
cis-1,2-Dichloroethene	1.0	5.0	5.0	500	625
cis-1,3-Dichloropropene	1.0	5.0	5.0	500	625
Dibromochloromethane	1.0	5.0	5.0	500	625
Ethylbenzene	1.0	5.0	5.0	500	625
Methylene Chloride	1.0	5.0	5.0	500	625
Styrene	1.0	5.0	5.0	500	625
Tetrachloroethene (PCE)	1.0	5.0	5.0	500	625
Toluene	1.0	5.0	5.0	500	625
Total Xylenes	1.0	5.0	5.0	500	625
trans-1,2-Dichloroethene	1.0	5.0	5.0	500	625
trans-1,3-Dichloropropene	1.0	5.0	5.0	500	625
Trichloroethene (TCE)	1.0	5.0	5.0	500	625
Vinyl Chloride	1.0	5.0	5.0	500	625

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TABLE 2

4-BROMOFLUOROBENZENE CHARACTERISTIC ION ABUNDANCE CRITERIA

Mass/é ratio	Ion Abundance Criteria
50	15 - 40% of mass/é 95
75	30 - 60% of mass/é 95
95	base peak, 100% relative abundance
96	5 - 9% of mass/é 95
173	<2% of mass/é 174
174	>50% of mass/é 95
175	5 - 9% of mass/é 174
176	>95%; <101% of mass/é 174
177	5 - 9% of mass/é 176

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Table 3

Surrogate/Matrix Spike QC Criteria

	Soil	Water
Surrogates		
Dibromofluoromethane	80-120	86-118
Toluene-d8	81-117	88-110
4-Bromofluorobenzene	74-121	86-115
Matrix Spikes		
1,1-Dichloroethene	59-172	61-145
Benzene	66-142	76-127
Trichloroethene	62-137	71-120
Toluene	59-139	76-125
Chlorobenzene	60-133	75-130

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APPENDIX I

Example Retention Times

STANDARD OPERATING PROCEDURE

ANALYSIS OF POLYCHLORINATED DIBENZO-*p*-DIOXINS AND POLYCHLORINATED DIBENZOFURANS BY HIGH-RESOLUTION GAS CHROMATOGRAPHY/LOW-RESOLUTION MASS SPECTROMETRY (HRGC/LRMS)

SOP Code: LRMS-8280A

Revision: 2.1

05/31/01

Approved by: _____ _____
Jane Freemyer, Quality Assurance Manager — Date

_____ _____
Xiangqiu Liang, Laboratory Director — Date

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Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
Initials: _____ Date: _____
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Standard Operating Procedure

ANALYSIS OF POLYCHLORINATED DIBENZO-*p*-DIOXINS AND POLYCHLORINATED DIBENZOFURANS BY HIGH-RESOLUTION GAS CHROMATOGRAPHY/LOW-RESOLUTION MASS SPECTROMETRY (HRGC/LRMS)

1.0 SCOPE AND APPLICATION

1.1 This method is appropriate for the detection and quantitative measurement of 2,3,7,8-tetrachlorinated dibenzo-p-dioxin (2,3,7,8-TCDD), 2,3,7,8-tetrachlorinated dibenzofuran (2,3,7,8-TCDF), and the 2,3,7,8-substituted penta-, hexa-, hepta-, and octachlorinated dibenzo-p-dioxins (PCDDs) and dibenzofurans (PCDFs) in water, soil, fly ash, and chemical waste samples, including still bottoms, fuel oil, and sludge matrices.

1.2 In addition the method contains procedures for reporting the total concentration of all PCDDs/PCDFs in a given level of chlorination, although complete chromatographic separation of all 210 possible PCDDs/PCDFs is not possible under the instrumental conditions provided .

1.3 Calculation of the 2,3,7,8-TCDD toxicity equivalence is in accordance to the procedures given in the U.S. Environmental Protection Agency "Update of Toxicity Equivalency Factors (TEFs) for Estimating Risks Associated with Exposures to mixtures of Chlorinated Dibenzo-p-Dioxins and Dibenzofurans (CDDs/CDFs)" February 1989.See Table 11.

1.4 The calibration range is dependent on the compound and the sample size. The sample size varies by matrix. Table 2 lists the quantitation limits for the various matrices. If the expected concentrations of the PCDDs and PCDFs are below the quantitation limits in Table 2, use of Method 8290 may be more appropriate.

1.5 This method is restricted for use only by analysts experienced with residue analysis and skilled in HRGC/LRMS. Each analyst must demonstrate the ability to generate acceptable results with this method

2.0 METHOD SUMMARY

2.1 This procedure uses a matrix-specific extraction, analyte-specific cleanup, and high-resolution capillary column gas chromatography/low-resolution mass spectrometry (HRGC/LRMS) techniques.

2.2 The method provides cleanup procedures to aid in the elimination of interferents should they be encountered.

2.3 A specified amount of sample is spiked with internal standards and extracted according to a matrix-specific extraction procedure. Aqueous samples with one percent or more solids are filtered through a 0.5-µm filter. The solid (including the filter) and the aqueous phases are extracted separately and the extracts combined prior to cleanup. Solid samples with an aqueous phase are centrifuged before extraction.

3.0 DEFINITION

3.1. Abbreviations

PCDD	=	Polychlorinated dibenzo-*p*-dioxin
PCDF	=	Polychlorinated dibenzofuran
TCDD	=	Tetrachlorodibenzo-*p*-dioxin
PeCDD	=	Pentachlorodibenzo-*p*-dioxin
HxCDD	=	Hexachlorodibenzo-*p*-dioxin
HpCDD	=	Heptachlorodibenzo-*p*-dioxin
OCDD	=	Octachlorodibenzo-*p*-dioxin
TCDF	=	Tetrachlorodibenzofuran
PeCDF	=	Pentachlorodibenzofuran
HxCDF	=	Hexachlorodibenzofuran
HpCDF	=	Heptachlorodibenzofuran
OCDF	=	Octachlorodibenzofuran
HxCDPE	=	Hexachlorodiphenyl ether
HpCDPE	=	Heptachlorodiphenyl ether
OCDPE	=	Octachlorodiphenyl ether
NCDPE	=	Nonachlorodiphenyl ether
DCDPE	=	Decachlorodiphenyl ether
CS	=	Cleanup standard
IS	=	Internal standard
RS	=	Recovery standard

HRGC	=	High-resolution gas chromatography
LRMS	=	Low-resolution mass spectrometry
TEF	=	Toxicity equivalence factor
TEQ	=	Toxicity equivalent

3.2 Isotope-Labeled Standards

3.2.1 Internal standards are added to the sample before extraction. Losses of internal standards reflect losses occurring during both extraction and cleanup. It is difficult to recover the internal standard (and the analytes) from some sample matrices. Severe losses of internal standards may result in impaired detection limits.

3.2.2 The cleanup standard is added to the sample extract prior to initiation of cleanup procedures. Loss of cleanup standard reflects losses occurring during cleanup. Generally, greater losses of cleanup standard occur when exhaustive cleanup techniques are indicated.

3.2.3. Recovery standards are added to the sample extract immediately before analysis by HRGC/LRMS. Recoveries of the cleanup and internal standards are determined by comparing the peak areas of the cleanup and internal standards with the peak areas of the recovery standards.

3.3. Toxicity Equivalence Factors

Not all of the 17 regulated dioxin/furan isomers have the same degree of toxicity. International Toxicity Factors (I-TEF), relative to the most toxic dioxin/furan isomer, 2,3,7,8-TCDD,have been established. The concentration of each 2,3,7,8-congener is multiplied by the appropriate toxicity equivalence factor (I-TEF). The individual results of these calculations are summed to determine the Total Dioxin/Furan (17 substituted isomers) Adjusted TEF. See Table 11.

4.0 INTERFERENCES

4.1 Solvents, reagents, glassware and other sample processing hardware, and PVC gloves may be sources of laboratory contamination. Matrix-specific method blanks are extracted with each analytical batch to demonstrate the absence of contamination introduced by the laboratory.

4.2 High purity reagents and pesticide grade solvents are used in order to minimize interference problems.

4.3 Interferants co-extracted from the sample will vary based on the sample source. PCDDs and PCDFs are often associated with other interfering chlorinated compounds such as PCBs and polychlorinated diphenyl ethers which may be found at concentrations several orders of magnitude higher than those of the analytes of interest.

4.3 High-resolution capillary columns are used to resolve as many isomers as possible; however, no single column is known to resolve all of the 210 possible PCDDs and PCDFs isomers. When the 2,3,7,8-TCDF analyte is detected through the analysis with the DB-5 column, re-analysis of the sample is necessary using a DB-225 column. The detected peak must meet the retention time and signal to noise criteria. Sections 15.1 and 15.3.1.

5.0 SAFETY

5.1 Safety training for working with PCDDs and PCDFs is required prior handling these chemicals.

5.3. Because of the extreme toxicity of these compounds, the analyst must take necessary precautions to prevent exposure to himself, or to others, of materials known or believed to contain PCDDs or PCDFs.

5.4. Low-level contamination is always a possibility for HRGC/LRMS analysis, due to the chemical properties of dioxins/furans.

5.5. Disposable glassware is used every time an extraction batch is started.

6.0 SAMPLE COLLECTION, CONTAINERS, PRESERVATION, AND STORAGE

6.1. Samples are typically delivered by a standard shipping service or by the client.

6.2. Samples are logged into the Sample Receiving Logbook, and labeled. A database entry is also made, which triggers the printing of a set of tracking forms.

6.3. All samples are stored in the dark and at $4^{\circ}C$, extracted within 30 days and completed analyzed within 45 of extraction.

6.4 If visual inspection of a sample indicates that it is not homogeneous, the entire contents of the sample container is transferred to a glass or stainless steel pan and then mixed thoroughly with a stainless steel spatula prior to removing an aliquot for analysis.

6.5. If a soil, sediment, or paper pulp sample contains more than 25 percent water, the two phases are separated, the aqueous phase is discarded, and the remaining solid phase is analyzed.

6.5.1. Transfer an estimated 50-g aliquot of the sample to a centrifuge tube. Centrifuge for 15 minutes at 1000 rpm.

6.5.2. Thoroughly mix the solid with a stainless steel spatula, and weigh out aliquots for analysis and dry weight determination.

6.5.3. Return the remaining sample to the original sample container.

6.6. If a water sample has a solids content greater than or equal to 1 percent, then the solid phase is separated from the aqueous phase, and both phases are extracted separately.

6.6.1. Filter the sample through a 0.5-µm filter.

6.6.2. Extract the filter and solids as for a soil sample. Extract the aqueous filtrate as for a water sample.

6.6.3. Combine the two extracts and proceed with the cleanup and analysis.

7.0 APPARATUS AND EQUIPMENT

7.1. HP 5973N MS

7.2. HP 6890 GC

7.3 Balances capable of accurately weighing to 0.01g and 0.0001g.

7.4 Centrifuge.

7.5 Water bath, equipped with concentric ring covers and capable of being temperature controlled within $\pm$ 2°C.

7.6 Stainless steel or glass container large enough to hold contents of one pint sample container.

7.7 250mL polypropylene beaker.

7.8. Drying oven.

7.9. 20mL scintillation vials.

7.10 Laboratory hoods.

7.11. Pipets, disposable, Pasteur, 150mm long x 5mm ID.

7.12. Pipets, disposable, serological, 10mL, for the preparation of the carbon columns.

7.13. Electric meat grinder with a 3 to 5mm hole size inner plate.

7.14. Auto sampler vial with 150uL insert.

7.15 Teflon boiling chips (or equivalent).

NOTE: Teflon boiling chips may float in methylene chloride, may not work in the presence of any water phase, and may be penetrated by nonpolar organic compounds.

7.16. 6mL and 60mL polypropylene reservoirs.

7.17. Frits that fit in the polypropylene reservoirs.

7.18. Glass fiber filters, 0.50µm, Whatman GFF, or equivalent.

7.19. Dean-Stark trap, 5 or 10mL, with T-joints, condenser and 125mL flask.

7.20. All glass Soxhlet apparatus, 500mL flask.

7.21. Soxhlet/Dean Stark extractor (optional), all glass, 500mL flask.

7.22. Glass funnels, sized to hold 170mL of liquid.

7.23. Desiccator.

7.24. 2-liter screw top jars.

7.25. Rotary evaporator with a temperature controlled water bath.

7.26. 2 mL screw top vials.

7.27. Glass wool.

7.28. Extraction jars, glass, 250mL, with teflon lined screw cap.

7.29. Volumetric flasks, Class A - 5mL to 100mL.

7.30. Auto sampler vials with 150uL inserts.

NOTE: Reuse of glassware should be minimized to avoid the risk of contamination. All glassware that is reused must be scrupulously cleaned as soon as possible after use, according to the following procedure: Rinse glassware with water. Soak glassware overnight in a mixture of equal parts of water, Alconox and RBS-35. Rinse with water and allow to dry. Rinse with high purity acetone, toluene, dichloromethane and hexane. Store in a clean environment

8.0 PREVENTIVE MAINTENANCE

8.1 All maintenance activities are recorded in a maintenance logbook kept for each instrument.

8.2 Carrier gas - Inline purifiers or scubbers should be in place for all sources of carrier gas. These are selected to remove water, oxygen, and hydrocarbons. Purifiers should be changed as recommended by the supplier.

8.3 Gas Chromatograph

8.3.1 Whenever GC maintenance is performed, care should be taken to minimize the introduction of air or oxygen into the column. Injection port maintenance includes changing the injection port liner, seal, washer, o-ring, septum, column ferrule, and autosampler syringe as needed. Liners and seals should be changed when recent sample analyses predict a problem with chromatographic performance. In some cases liners and seals may be cleaned and re-used.

8.3.2 Clipping off a small portion of the head of the column often improves chromatographic performance. When cutting off any portion of the column, make sure the cut is straight and "clean" (uniform, without fragmentation) by using the proper column cutting tool.

8.3.3 Over time, the column will exhibit poorer overall performance, as contaminated sample matrices are analyzed. The length of time for this to occur will depend on the samples analyzed. When a noticeable decrease in column performance is evident and other maintenance options do not result in improvement, the column should be replaced. This is especially true when evident in conjunction with calibration difficulties.

8.4 Mass Spectrometer

8.4.1 For units under service contract, certain maintenance is performed by instrument service staff, including pump oil changed, vacuuming boards, etc., as recommended by the manufacturer.

8.4.2 The source cleaning should be performed as needed, depending on the performance of the unit. This may be done by the analyst or by instrument service staff.

9.0 STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

9.1. All standards should be logged in and numbered when delivered. Details of all dilutions of standards should also be entered in the PCDD/PCDF Standards Log Book. *Note:* store at room temperature in the dark—do not refrigerate.

9.2. Calibration solutions . Set contains one 0.2-ml ampule each of CC1, CC2, CC3, CC4, and CC5 solutions to be kept on hand. See Table 1

9.3. Internal standard solution .It is supplied in snap and drop ampules (100ul) .See Table 3.

9.4. Cleanup standard solution. A 100ul of solution is spike before cleanup. See Table 3.

9.5. Recovery standard solution. A 100ul of solution is spiked before GC/MS analysis. See Table 3.

9.6. Matrix spiking solution. .It is supplied in snap and drop ampules (1000ul). See Table 5

9.7. Combined window defining/column performance solution . This solution contains the first and last eluting isomers for the tetra through hepta congener groups. In addition, it contains the three nonspecific TCDD isomers used to verify column performance.See Table 6.

9.8. Organic-free reagent water - All references to water in this method refer to organic-free reagent water

9.9 Carbon 120-440 mesh (Supelco Envi-Carb or equivalent); weigh 0.5g into 20mL scintillation vials and activate overnight at a minimum of 100 C.

9.10. Silica gel, high purity grade, type 60, 70-230 mesh. Activate overnight at a minimum

temperature of 120°C. Store in a glass bottle sealed with a teflon lined screw cap.

9.11. Silica gel impregnated with sodium hydroxide. Add one part (by weight) of 1M NaOH solution to two parts (by weight) silica gel (activated) in a screw cap bottle and mix with a glass rod until free of lumps. Store in desiccator in a glass bottle sealed with a Teflon lined screw cap.

9.12. Silica gel impregnated with 40 percent (by weight) sulfuric acid. Add two parts (by weight) concentrated sulfuric acid to three parts (by weight) silica gel (activated), mix with a glass rod until free of lumps. Store in desiccator in a glass bottle sealed with a Teflon lined screw cap.

9.13. Quartz sand.

9.14. Extraction thimbles, 43mm x 123mm.

9.15. Sulfuric acid, concentrated, ACS grade, specific gravity 241.84.

9.16. Sodium chloride, analytical reagent, 5 percent (w/v) in organic-free reagent water.

9.17. Desiccating agent

9.18. Sodium sulfate (powder, anhydrous), Na_2SO_4.

9.19. Solvents
- 9.19.1 Methylene chloride. High purity, distilled in glass or highest available purity.
- 9.19.2 Hexane. High purity, distilled in glass or highest available purity.
- 9.19.3 Methanol. High purity, distilled in glass or highest available purity.
- 9.19.4 Nonane. High purity, distilled in glass or highest available purity.
- 9.19.5 Toluene. High purity, distilled in glass or highest available purity.
- 9.19.6 Tridecane, High purity, distilled in glass or highest available purity.
- 9.19.7 Acetone. High purity, distilled in glass or highest available purity.

10.0 RESPONSIBILITIES

It is the responsibility of the analyst to perform the analysis according to the instructions in this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are only to be performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. This demonstration is in accordance with the training program of the laboratory. Final review and sign-off of the data is performed by the department supervisor/manager or designee.

10.1. Problems that require corrective action are to be documented by the analyst, and brought to the attention of the Laboratory Director.

10.2. Contamination problems, if they arise, should be investigated systematically.

10.3 Contaminated chemicals (including solvents) should be discarded. If one or more additional containers of the chemical with the same lot number are present in the laboratory, the additional quantity of chemical should be evaluated for contamination prior to use.

10.4. Contaminated glassware should be discarded.

10.5. Problems associated with low standard recoveries are usually attributed to one of the following:

10.5.1. Low recoveries of internal standard (for samples where the cleanup standard recoveries are normal) indicate that extraction is inefficient. The analysis should be repeated. If the low recoveries of internal standards are still a problem, then the cause may be a matrix effect. Low recoveries of internal standard are frequently a problem if the sample is a charcoal filter or a fly ash.

10.5.2. Low recoveries of both internal standards and cleanup standards indicate that losses are taking place during the cleanup process. Such losses may simply be due to inefficient transfers, or losses may be taking place during carbon column cleanup. Contaminants in the sample extract may interact with the carbon and alter the retention times of analytes on the carbon column. The analysis should be repeated, and fractions eluting before and after the analytes should be collected. If low recoveries are still encountered, those additional fractions should be analyzed.

10.5.3. If any of the standards are completely absent from the selected ion profile, the possibility should be considered that addition of that standard to the sample or extract has not taken place.

10.5.4. If the chromatographic peak area for a standard is approximately double the anticipated area, the possibility should be considered that two aliquots of that standard have been added to the sample or extract.

10.6. Low sensitivity (poor signal-to-noise ratio) may be attributed to a number of causes.

10.6.1 A leaking septum might result in losses of sample during injection. Another consequence of a leaking septum (or any leak in the inlet system of the gas chromatograph) is reduced flow of carrier gas, resulting in increased retention times.

10.6.2. Accumulation of particles of septum or ferrule material in the injection port can lead to adsorptive losses. Similar losses are encountered when the injection port or the injection port liner are contaminated by the residues of 'dirty' samples.

10.6.3 A degraded column can cause peak distortion, and may also lead to adsorptive losses. Excessive bleed of stationary phase from the column may result in high background levels and, consequently, elevated noise levels (thus decreasing the signal-to-noise ratio). The problem is commonly restricted to the first few centimeters of the column, and can be corrected by cutting off 10 to 20 cm of the column.

10.6.4. High background levels can also be attributed to bleed from an inappropriate septum. This is a particular problem with the PeCDF channels. Alltech XLB septa are suitable for the analysis of PCDDs/PCDFs, but other "low-bleed" septa that we have evaluated are not. While they may have a low overall bleed rate, they exhibit excessive bleeding at one or more of the ions monitored for the analysis of PCDDs/PCDFs.

10.6.5. Retuning of the mass spectrometer might improve the sensitivity, or the problem may be due to a contaminated ion source. If, over a period of time, continual increases in the electron multiplier voltage are needed to obtain adequate sensitivity.

11.0 PROCEDURE

11.1 Addition of Internal Standard

11.1.1 Use a portion of 10g of the sample to be analyzed. Transfer the sample portion to a tared extraction thimble and determine its weight.

11.1.2 Except for adipose tissue, add an appropriate quantity of internal spiking standard to the sample. All samples should be spiked with 100µL of the internal spiking standard.

11.1.3 For the fortification water samples, mix the labeled spiking standard with

10.0mL acetone in a labeled scintillation vial.

11.2 Extraction of Adipose, Fish and Paper Pulp Samples

11.2.1 Weigh out a properly labeled 500mL flat bottom flask with boiling chips. Record the weight in the tared vial section of the batch log book.

NOTE: Add 0.5g to the tared weight to compensate for the 500uL of tridecane that will be added as a keeper before evaporation.

11.2.2 To a tared thimble, add approximately 30g anhydrous sodium sulfate to a 10g portion of a homogeneous fish samples and mix thoroughly with a pasteur pipet. After breaking up any lumps, place the spiked fish/sodium sulfate mixture in the Soxhlet apparatus. Add approximately 270mL hexane/methylene chloride (1:1) to the Soxhlet apparatus and reflux for 16 hours. The solvent must cycle completely through the system five times per hour. Follow the same procedure for partially de-watered paper pulp sample (using a 10g sample, 30 g of anhydrous sodium sulfate and 270mL of toluene).

NOTE: As an option, a Soxhlet/Dean Stark extractor system may be used, with toluene as the solvent. NOTE: As an option, a rotary evaporator may be used in place of the KD apparatus for the concentration of the extracts.

11.2.3 Add 500uL tridecane. Concentrate the extract on a rotary evaporator to an apparent volume of 0.5mL.

11.2.4 Add 20mL hexane to the 500mL flask. Again concentrate 0.5mL. Weigh the flask and record the weight.

NOTE: The methylene chloride must have been completely removed before proceeding with the next step.

11.2.5 Add 20mL hexane and decant the contents of the 500mL flask into a 250mL screw top flask. Rinse the 500mL flask with two additional 20mL portions of hexane in the sonicator and add the rinses to the jar.

11.2.6.1. Spike with 100uL cleanup standard and proceed with sulfuric acid cleanup.

11.3 Wet Fuel Oil/Still Bottom/Oil

11.3.1 Take a portion of the sample and add to either dichloromethane or hexane. Choose the solvent that it dissolves in. Extract aqueous sludge or wet fuel oil samples by mixing 1g of sample with 60mL of dichloromethane or hexane in a 250mL jar. Spike with 100 µL internal spiking standard.

11.3.2 Sample is now ready for sulfuric acid cleanup.

11.4 Fly Ash

NOTE: Because of the tendency of fly ash to "fly", all handling steps should be performed in a hood in order to minimize contamination.

11.4.1 Weigh about 10g fly ash to two decimal places in a tared 250 mL extraction jar. Add 100µL internal spiking standard to the sample. Add 150mL of 1M HCl to the fly ash sample. Seal the jar with the Teflon lined screw cap and shake for 3 hours at room temperature.

11.4.2 Rinse a 0.5um filter with organic-free reagent water, and filter the sample through, placed in a Buchner funnel, into a 1L flask. Wash the fly ash cake with approximately 500mL organic-free reagent water. A disposable filter apparatus can be used.

11.4.3 Place the sample and the filter paper into an extraction thimble. Add 10g anhydrous powdered sodium sulfate.

11.4.4 Extract in a Soxhlet extraction apparatus charged with approximately 270mL toluene for 16 hours using a five cycle/hour schedule.

NOTE: As an option, a Soxhlet/Dean Stark extractor system may be used, with toluene as the solvent. No sodium sulfate is added when using this option.

11.4.5 Cool and add 0.5mL tridecane to the 500mL round bottom flask. Concentrate the extract to near dryness on a rotary evaporator at 40-50^{0}C. Add 20mL hexane and evaporate to near dryness.

11.4.6 Transfer the concentrate to a 250 screw top jar using

20mL hexane. Rinse the flask in a sonicator with two 20mL portions of hexane and add the rinses to the jar.

11.4.7 The sample is now ready for sulfuric acid clean up.

11.5 Aqueous samples

11.5.1 Allow the sample to come to ambient temperature. Spike 100 µL internal spiking standard into a 20 mL scint vial. Add 10 mL acetone and pour into the appropriate sample jar.

11.5.2. When the sample is judged to contain 1 percent or more solids, the sample must be filtered through a 0.5µm filter. If the suspended solids content is too great to filter through the filter, centrifuge the sample, decant, and then filter the aqueous phase.

NOTE: Paper mill effluent samples normally contain 0.02%-0.2% solids, and would not require filtration. However, for optimum analytical results, all paper mill effluent samples should be filtered, the isolated solids and filtrate extracted separately, and the extracts recombined.

11.5.3. Combine the solids from the centrifuge bottle(s) with the particulates on the filter and with the filter itself and proceed with the Soxhlet extraction.

11.5.4. Pour the aqueous filtrate into a 2L screw top jar. Add 100mL methylene chloride to the sample bottle, seal and shake for 3 minutes to rinse the inner surface. Periodic venting is necessary.

11.5.5. Allow the organic layer to separate from the water phase for a minimum of 10minutes. If the emulsion interface between layers is more than one third the volume of the solvent layer, the analyst must employ mechanical techniques to complete the phase separation (e.g., centrifuge the extract).

11.5.6. Transfer the methylene chloride 250mL polypropylene beaker.

11.5.7 Repeat the extraction once more with fresh 50mL portions of methylene chloride. Once all water has been removed from the methylene chloride extract, transfer to a 250 mL screw top jar.

11.5.8 After extracting the water sample, pour into a 1L graduated cylinder and record the volume.

11.5.9 If the extract is colorless or has a light tint, add 500 uL tridecane and evaporate to near 0.5 mL and proceed with the silica gel/carbon column

clean up. If the extract has a medium to dark tint, evaporate to near 500ul and proceed to sulfuric acid clean up.

11.6. Soil/Sediment

11.6.1 Add approximately 20g anhydrous powdered sodium to an extraction thimble. Tare the thimble. Transfer 10g of sample to the thimble. Spike with internal spiking standard.

NOTE: As an option, a Soxhlet/Dean Stark extractor system may be used, with toluene as the solvent.

11.6.2 Add approximately 270mL toluene to the Soxhlet apparatus and reflux for 16 hours. The solvent must cycle completely through the system five times per hour.

11.6.3. Cool the extraction apparatus. Add 500uL tridecane to the flask and concentrate to near dryness on a rotary evaporator at 45- 50°C. Add 20mL hexane to the flask and evaporate to near dryness.

11.6.4. Transfer the extract to a 250mL screw top jar with 20mL hexane. Rinse the 500mL flat bottom in a sonicator with 2 additional rinses of 20mL hexane and transfer to the screw top jar. Final volume should be approximately 60mL hexane.

11.6.5. If the extract is colorless or has a light tint, add 500uLof tridecane and evaporate to near 0.5 mL and proceed with the silica gel/carbon column clean up. If the extract has a medium to dark tint, proceed to sulfuric acid clean up.

11.7. Clean up Procedures

All samples must be spiked with 100 µL cleanup standard before any clean up procedure is performed.

11.7.1 Sulfuric Acid Clean up

11.7.1.1 The sample extract volume should be in 60 mL hexane. Partition the hexane extract against approximately 10mL of concentrated sulfuric acid. Shake for t 30 seconds. Allow a minimum of 1 hour for separation. Remove and discard the sulfuric acid layer

(bottom). Repeat the acid washing until little color is visible in the acid layer (perform a maximum of four acid washings).

11.7.1.2 Partition the extract against 20mL of 5 percent (w/v) aqueous sodium chloride. Shake for 30 seconds. Allow a minimum 20 minutes for separation. Remove and discard the aqueous layer (bottom).

11.7.1.3 Add 500uL tridecane to each sample jar and allow to evaporate near dryness. The tridecane will prevent the sample from going to complete dryness.

11.7.1.4 The sample is now ready for column cleanup.

11.7.2 Silica/Carbon Column Cleanup

11.7.2.1 Pack a 6mL column as follows: Insert a frit at the bottom of the column. Remove the pre-weighed, activated carbon from the oven, and add approximately 2ml toluene. Cool down is not necessary. Transfer the slurry to the 6mL column and allow the carbon to settle. Rinse the 20mL vial with addition rinses of toluene until most of the carbon has been transferred. Rinse the column sides of residual carbon. Allow the toluene to completely drain. Insert a frit on top and push down to the top of the carbon. Elute with 5mL dichloromethane then 5mL hexane. Discard the eluate. Check the column for channeling. If channeling is observed, discard the column. Do not tap a wetted column..

11.7.2.2 Pack a 60ml reservoir, with silica gel as follows: Insert a frit and push it to the bottom. Place 1 teaspoon activated neutral silica gel in the column and tap the column gently to settle the silica gel. Add 1 teaspoon sodium hydroxide-impregnated silica gel, 2 teaspoon sulfuric acid-impregnated silica gel, and 1 teaspoon sodium sulfate. Tap the column gently after each addition. Elute with 30mL hexane and stop the flow just before exposure of the top layer of sodium sulfate to air. Discard the eluate. Check the column for channeling. If channeling is observed, discard the column. Do not tap the wetted column.

11.7.2.3 Place the silica gel column on top of the vacuum manifold and the carbon column of the bottom(opposite). The column is now ready for loading of sample extract.

11.7.2.4 Add approximately 2mL hexane to the sample extract.

11.7.2.5 Transfer the 2mL extract to the silica gel column and allow to elute until the extract level is at the top of the sodium sulfate. A slow vacuum can be used to facilitate the extract into the column.

11.7.2.6 Rinse the flask containing the extract with 5mL hexane and load into the silca gel column. Allow to elute until the extract level is at the top of the sodium sulfate. A slow vacuum can be used to facilitate the extract into the column.

11.7.2.7 Slowly add 30mL hexane to the silica gel column. Add another 30mL, then 20mL more hexane when space permits for a total of 80 mL hexane.

NOTE: At this point, pressure nor vacuum is necessary. Do not adjust the drip rate.

11.7.2.8 Remove the used silica gel column when the drip form the carbon column stops . Reverse the carbon column by placing on top of the manifold.

11.7.2.9. Elute the column with 5mL dichloromethane, then 5mL of 1:1 ethyle acetate/hexane.

11.7.3.0 Place a labeled 20mL scintillation vial under the carbon column and elute with a total of approximately 20mL toluene. Be sure to collect the toluene. Allow the extract to evaporate to dryness under the fume hood.

11.7.3.1. Add approximately 2mL hexane to the scint vial. Vortex and sonicate, then transfer the extract to a clear 2mL screw top vial. Allow to evaporate to dryness under the fume hood.

NOTE: If possible, transfer the extract to the labeled autosampler vial when the volume reaches approximately 150µL.

11.7.3.2. Add 160uL hexane to the 2mL vial. Rinse the sides of the 2mL vial with only the 160uL that was added. Transfer to an appropriately labeled autosampler vial. Allow sample to evaporate to dryness.

11.7.3.3. The sample is ready to be spiked with 100uL recovery spiking standard.

12.0.GC/MS Analysis

Optimize the operating conditions for sensitivity and resolution, and employ the same conditions for both calibration and sample analysis. See Figure 1

12.1. Chromatographic conditions

Establish the GC operating conditions necessary to achieve the resolution and sensitivity required for the analyses.

12.2. Chromatographic resolution criteria

12.2.1. The resolution criteria must be evaluated using measurements made on the selected ion current profile.

12.3. Evaluation and GC resolution criteria for the DB-5Column

12.3.1. Chromatographic peak separation between the unlabeled *2,3,7,8-TCDD* and the peaks representing all other unlabeled *TCDD* isomers should be resolved with a valley of 25 percent or less.See Figure 1

12.4. Evaluation and GC resolution criteria for the DB-5Column (*CC3-SOLUTION*)

12.4.1. The chromatographic resolution is evaluated before the analysis of any calibration standard by the analysis of a 2µL aliquot of the combined Column Performance / Window Defining mix solution containing the *1,2,3,7/1,2,3,8-TCDD* pair and the *1,2,3,9-TCDD* which elute most closely with the *2,3,7,8-TCDD*. See Figure 1

12.4.2. The chromatographic peak separation in the CC3 solution between the $^{13}C_{12}$*-1,2,3,4-TCDD* peak and the $^{13}C_{12}$*-2,3,7,8-TCDD* peak must be resolved with a valley of 25 percent or less. See Figure 2

12.4.3. The chromatographic peak separation in the *CC3* solution between the unlabeled 1,2,3,4,7,8-HxCDD peak and the *1,2,3,6,7,8-HxCDD* peak shall be resolved with a valley of less or equal to 50 percent. See Figure 3

12.4.4. This chromatographic separation is evaluated using the *CC3* calibration standard during both the initial calibration and the daily calibration verification.

12.5. Evaluation and GC resolution criteria for the DB- 225 Column.

12.5.1. Chromatographic peak separation between the unlabeled *2,3,7,8-TCDF* and the peaks representing all other unlabeled *TCDF* isomers should be resolved with a valley of 25 percent or less. See Figure 5

12.5.2. The chromatographic resolution is evaluated before the analysis of any calibration standard by the analysis of a 2µL aliquot of the Column Performance solution containing the *2,3,4,7-TCDF* and the *1,2,3,9-TCDF* which elute most closely *2,3,7,8-TCDF*.

12.6. SIM descriptors and switching times.

12.6.1. Establish SIM descriptors encompassing the ions specified in Table 7 Establish descriptors such that each ion monitored in that descriptor will be scanned every second or less.

12.6.2. The descriptor switching times are set such the isomers that elute from the GC during a given retention time window will also be those isomers for which the ions are monitored.

13.0 GC/MS Calibration

Calibration of the GC/MS system involves three separate procedures, mass calibration of the MS, establishment of GC retention time windows, and calibration of the target analytes. Samples should not be analyzed until acceptable descriptor switching times, chromatographic resolution, and calibrations are achieved and documented.

NOTE: The injection volume for all sample extracts, blanks, quality control samples and calibration solutions must be the same.

13.1 Mass calibration

13.1.1. In order to achieve better response for the later eluting compounds tune the MS for greater sensitivity in the high mass range.

13.2. Retention time windows

13.2.1 Inject a 2 µL aliquot of the Window Defining Mix .Verify that the first and last eluting isomers in each homologue are present. If not adjust the switching times for the SIM descriptors and reanalyze the Window Defining Mix. Analysis of the calibration standards can not proceed until the appropriate switching times have been established and documented.

13.3.Calibration of target analytes

Two types of calibration procedures, initial calibration and calibration verification are necessary. The initial calibration is needed before any samples are analyzed for PCDDs/PCDFs , and intermittently throughout sample analysis, as dictated by the results of the calibration verification . The calibration verification (CC3) is necessary at the beginning of each 12-hour time period during which samples are analyzed.

13.4. Initial Calibration

Inject 2 µL of the Window Defining /Column Performance Mix and verify the descriptor switching times.

Note: If any of the first and last eluting isomers in a homologue are missing adjust the switching times and reanalyze before analyzing the concentration calibration solutions.

13.4.1.Verify that the GC resolution meets the criteria specified in sections 12.2 through 12.5.

Note:If the GC resolution criteria is not met corrective action must be taken and documented.

13.4.2.Inject 2-µL of each of the concentration calibration solutions (CC1-CC5), described in Table 1.

13.4.3. Evaluate the GC resolution using the CC3 solution and verify that it meets the criteria specified in section 12.4.

Note: If the GC resolution criteria is not met corrective action must be taken.

13.4.4..Verify that the relative ion abundance criteria presented in Table 9. (the lower and upper limits of the ion abundance ratios represent a ±15% window around the theoretical abundance ratio for each pair of selected ions) is met for all PCDD/PCDF peaks , including the labeled internal and recovery standards, in all solutions. The ion abundance ratio criterion do not apply to the $^{37}Cl_4$-2, 3, 7,8-TCDD cleanup standard.

Note: If the relative ion abundance ratio criteria for any PCDD/PCDF peak is not met in a concentration calibration solution the solution must be reanalyzed.

13.4.5. Once all of the criteria in sections 13.4.1 through 13.4.4 have been met calculate the relative response factors (RF_s) for the seventeen unlabeled

target analytes relative to their appropriate internal standards (RF_n) (Table 10) according to the formula:

$$RF_n = \frac{(A_n^1 + A_n^2) \times Q_{is}}{(A_{is}^1 + A_{is}^2) \times Q_n}$$

Where:

$A_n^1 + A_n^2$ = integrated areas of the two quantitation ions of the isomer of interest (Table 6)

$A_{is}^1 + A_{is}^2$ = integrated areas of the two quantitation ions of the corresponding internal standard.

Q_n = quantity in nanograms of unlabelded standard injected.

Q_{is} = quantity in nanograms of internal standard injected.

Q_{rs} = quantity in nanograms of recovery standard injected.

13.4.6. For the seven unlabeled analytes and the $^{37}Cl_4$-2,3,7,8-TCDD cleanup standard that are found only in the CC3 solution, only one RF is calculated for each analyte. For the other 10 unlabeled analytes, calculate the RF of each analyte in each calibration standard.

13.4.7. Calculate the RFs for the five labeled internal standards and the cleanup standard relative to the appropriate recovery standard (RF_{is}) (Table 10), in each calibration standard , according to the formula.

NOTE: There is only one quantitation ion for the ^{37}Cl cleanup standard. Calculate the relative response factor as described for RF_{is}, using one area for the cleanup standard, and the sum of the areas of the ions from the recovery standard.

13.5. Relative Response Factor Criteria

13.5.1. Calculate the mean RF and percent relative standard deviation (%RSD) of the five RFs (CC1-CC5) for each unlabeled PCDD/PCDF and labeled internal standards present in all five concentration calibration solutions.

$$\%RSD = \frac{S\,\text{tan}\,dard\;\;deviation}{\overline{RRF}} \times 100$$

13.5.2. No mean RF or %RSD calculations are possible for the 2,3,7,8-substituted isomers or the cleanup standard found only in the CC3 solution.

13.5.3. The %RSD of the five RFs (CC1-CC5) for the unlabeled PCDDs/PCDFs and the internal standards should not exceed 15%.
If the %RSD for any of the five RFs (CC1-CC5) for the unlabeled PCDDs/PCDFs or the internal standards exceeds 15 % the initial calibration must be reanalyzed.

13.6. Calibration Verification

The calibration verification consists of two parts: evaluation of the chromatographic resolution, and verification of the RF values to be used for quantitation.

13.6.1. Inject a 2-µL aliquot of the Window Defining /Column Performance Mix into the GC/MS using the same GC/MS/DS conditions used for the analysis of the initial calibration solutions.

13.6.2. Verify that the first and last eluters of each homologue are present before proceeding.

13.6.3. Verify that the GC resolution meets the initial calibration criteria specified in sections 12.3 and 12.5.

13.6.4. Inject a 2 µL aliquot of the calibration verification solution (CC3) into the GCMS using the same GC/MS/DS conditions used for the analysis of the initial calibration solutions.

13.6.5. Evaluate the chromatographic resolution using the QC criteria specified in section 12.4.

13.6.6. Calculate the RFs for the seventeen unlabeled target analytes relative to their appropriate internal standards RF_n and the response factors for the five labeled internal standards and the cleanup standard relative to the appropriate recovery standard RF_{rs} according to the formula in section 13.4.5.

13.6.7. Calculate the RFs for the unlabeled PCDDs/PCDFs relative to the recovery standards (RF_{rs}), where:

$$RF_{rs} = RF_n \times RF_{is}$$

Note:Do not proceed with sample analyses until the calibration verification criteria have been met for:

13.6.8. GC Column Resolution criteria - The chromatographic resolution on the DB-5 column must meet the QC criteria in sections 12.3 and 12.4.

13.6.9. Ion Abundance Criteria - The relative ion abundances listed in Table ? must be met for all PCDD/PCDF peaks, including the labeled internal and recovery standards.

13.6.10. Instrument Sensitivity Criteria - For the CC3 solution , the (S/N) signal-to-noise ratio must be greater than 2.5 for the unlabeled PCDD/PCDF ions, and greater than 10.0 for the unlabeled internal and recovery standards.

13.6.11. Response Factor Criteria - The measured RFs of each analyte and internal standard in the CC3 solution must be within ± 30.0 % of the mean RFs established during initial calibration for the analytes in all five calibration standards, and within ± 30.0 % of the single-point RFs established during initial calibration for those analytes present in only the CC3 standard.

$$\%Difference = \frac{(RF_i - RF_c)}{RF_i} \times 100$$

RF_i = Relative response factor established during initial calibration.

RF_c = Relative response factor established during calibration verification.

13.6.12. In order to demonstrate that the GC/MS system has retained adequate sensitivity during the course of sample analyses , the lowest standard from the initial calibration is analyzed at the end of each 12-hour time period (the 12-hour window begins with the analysis of the CC3 solution on the DB-5 column, and the Column Performance Mix on the DB-225 column) during which samples are analyzed. This analysis must utilize the same injection volume and instrument operating conditions as were used for the preceding sample analyses.

13.6.13. The results of this analysis must meet the acceptance criteria for retention times, ion abundances, and S/N ratio that are listed in Section 13.6.10. for

the continuing calibration standard. Response factors do not need to be evaluated in this end-of-shift standard. If this analysis fails either the ion abundance or S/N ratio criteria, then any samples analyzed during that 12-hour period that indicated the presence of any PCDDs/PCDFs below the method quantitation limit or where estimated maximum possible concentrations were reported must be reanalyzed. Samples with positive results above the method quantitation limit need not be reanalyzed.

14.0 GC/MS analysis of samples

14.1 Add 100µL of the recovery standard to each extract and vortex.

14.2. Inject a 2-µL aliquot of the Method Blank extract into the GC/MS instrument. Analyze the extract by GC/MS, and monitor all of the ions listed in Table 8 . The same MS parameters used to analyze the calibration solutions must be used for the sample extracts.

14.3. It must be demonstrated that the GC/MS system is clean prior to the analysis of the sample extracts. If the concentration of any of the unlabeled target analytes in this analysis is above the MRL for that analyte either analyzed another Method Blank or an instrument blank must be analyzed.

14.4. Inject 2-µL aliquots of the sample extracts into the GC/MS and analyze according to Section 14.2 for the remainder of the 12-hour window allowing enough time to inject the CC1 solution within the 12-hour time period.

14.5. Dilution of the sample extract is necessary if the concentration of any PCDD/PCDF in the sample has exceeded the calibration range, or the detector has been saturated. An appropriate dilution will result in the largest peak in the diluted sample falling between the mid-point and high-point of the calibration range.

14.6. Dilute an appropriate size aliquot of the original extract with the recovery solution and vortex.

14.7. Inject a 2 -µL aliquot of the diluted sample extract into the GC/MS and analyze according to Section 14.4.

15.0 Data Evaluation

Identification criteria – For a gas chromatographic peak to be unambiguously identified as a PCDD or PCDF , it must meet all of the following criteria.

15.1.Retention times

15.1.1.In order to make a positive identification of the 2,3,7,8-substituted isomers for which an isotopic labeled internal or recovery standard is present in the sample extract, the absolute retention time (RT) at the maximum peak height of the analyte must be within –1 to +3 seconds of the retention time of the corresponding labeled standard.

15.1.2.In order to make a positive identification of the 2,3,7,8-substituted isomers for which a labeled standard is not available, the relative retention time (RRT) if the analyte must be within 0.05 RRT units of the RRT established by the calibration verification. The RRT is calculated as follows

$$RTT = \frac{\text{Re}\,tention\ time\ \text{of the analyte}}{\text{Re}\,tention\ time\ of\ the\ corresponding\ \text{int}\,ernal\ s\ \text{tan}\,dard}$$

15.1.3.For non-2,3,7,8-sustituted compounds (tetra-hepta), the retention time must be within the retention time windows established by the window defining mix for the corresponding homologue.
In order to assure that retention time shifts do not adversely affect the identification of PCDDs/PCDFs, the absolute retention times of the two recovery standards added to every sample extract immediately prior to analysis may not shift by more than ± 10 seconds from their retention times in the calibration verification standard.

15.2.Peak identification

15.2.1 The ions listed in Table 8 for each PCDD/PCDF homologue and labeled standards must be present in the SICP.

15.2.2. Current response for the two quantitation ions and the M-[COCL] $^{+}$ ions for the analytes must maximize simultaneously (± 2 seconds). This requirement also applies to the internal standards and recovery standards. For the cleanup standard, only one ion is monitored.

15.3.Signal-to-noise ratio

15.3.1. The integrated ion current for each analyte ion listed in Table 8 must be at least 2.5 times background noise and must not have saturated the detector.See Figure 4

15.3.2. The internal standard ions must be at least 10.0 times background noise and must not have saturated the detector.

15.3.3. If the M-[COCL] $^{+}$ ion does not meet the 2.5 times S/N requirement(Figure 4) but meets all the other criteria listed above and, in the judgement of the analyst the peak is a PCDD/PCDF, the peak may be reported as positive and the data flagged on the report form.

15.4. Ion abundance ratios

15.41. The relative ion abundance criteria listed Table 9 for unlabeled analytes and internal standards must be met using peak areas to calculate ratios.

15.4.2. If interferences are present, and ion abundance ratios are not met using peak areas, but all other qualitative identification criteria are met (RT,S/N, presence of all 3 ions) , then use peak heights to evaluate the ion ratio.

15.4.3. If, in the judgement of the analyst, the peak is a PCDD/PCDF, then report the ion abundance ratios determined using peak heights, quantitate the peaks using peak heights rather than areas for both the target analyte and the internal standard, and flag the result on the report form.

15.5. Polychlorinated diphenyl ether (PCDPE) interferences.

15.5.1. The identification of a GC peak as a PCDF cannot be made if a signal having S/N greater than 2.5 is detected at the same time ($\pm$ 2 seconds) in the corresponding PCDPE channel.

15.5.2. If a PCDPE is detected, an Estimated Maximum Possible Concentration (EMPC) should be calculated for this GC peak according to the formulae below regardless of the ion abundance ratio, and reported.

All matrices other than water:

$$EMPC_n = (ug / Kg) = \frac{Q_{is} \times (A_n^1 + A_n^2) \times D}{W \times (A_{is}^1 + A_{is}^2) \times RF_n}$$

See definition on 13.4.5

Water:

$$EMPC_n = (ng/L) = \frac{Q_{is} \times (A_n^1 + A_n^2) \times D}{V \times (A_{is}^1 + A_{is}^2) \times RF_n}$$

16.0.Calculations

16.1.For GC peaks that have met all the identification criteria outlined in 15.1. calculate the concentration of the individual PCDD or PCDF isomers using the formula:

All matrices other than water:

$$C_n = (ug/Kg) = \frac{Q_{is} \times (A_n^1 + A_n^2)}{W \times (A_{is}^1 + A_{is}^2) RF_n}$$

Water:

$$C_n = (ng/L) = \frac{Q_{is} \times (A_n^1 + A_n^2)}{V \times (A_{is}^1 + A_{is}^2) \times RF_n}$$

In instances where peak heights are used to evaluate ion abundance ratios due to interferences , substitute peak heights for areas in the formula above.

where:

$A_n^1 + A_n^2$ = integrated ion abundances (peak area) of the quantitation ions of the isomer of interest (Table 6).

$A_{is}^1 + A_{is}^2$ = integrated ion abundance(peak area) of the quantitation ions of the corresponding internal standard.

C_n = concentration of the unlabeled PCDD/PCDF found in the sample.

RF_n = calculated relative response factor from the calibration verification.

Q_{is} = quantity in nanograms of the corresponding internal standard added to the sample prior to extraction.

W = weight of the sample extract in grams

V = volume of the sample extract in liters.

17.0.Dilution

17.1. If the area of any internal standard in a diluted sample is less than 10% of the area of that internal standard in the calibration verification standard, then the unlabeled PCDD/PCDF concentrations in the sample shall be estimated using the recovery standard, using the formulae below to ensure that there is an adequate MS response for quantitation in the diluted extract.

All matrices other than water:

$$C_n = (ug/Kg) = \frac{Q_{rs} \times (A_n^1 + A_n^2) \times D}{W \times (A_{rs}^1 + A_{rs}^2) \times RF_{rs}}$$

Water:

$$C_n = (ng/L) = \frac{Q_{rs} \times (A_n^1 + A_n^2) \times D}{V \times (A_{rs}^1 + A_{rs}^2) \times RF_{rs}}$$

See definition on 16.1.

17.2. Total homologues

17.2.1. In addition to the concentrations of specific isomers, the total homologue concentrations are also reported Calculate the total concentration of each homologue of PCDDs/PCDFs as follows:

Total concentration = sum of the concentrations of every positively identified isomer of each PCDD/PCDF homologue

17.2.2. The total must include the non-2,3,7,8-substituted isomers that are also reported separately.

17.2.3. The total number of GC peaks included in the total homologue concentration should be reported.

17.2.4. For homologues that contain only one 2,3,7,8-substituted isomer , the RF of the 2,3,7,8-substituted isomer from the calibration verification will be used to quantitate both the 2,3,7,8-substituted isomers and the non-2,3,7,8-isomers.

17.2.5. For homologues that contain more than one 2,3,7,8-substituted isomer, the RF used to calculate the concentration of each 2,3,7,8-substituted isomer will be the RF determined for that isomer .

17.2.6. For homologues that contain one or more non-2,3,7,8-substituted isomer, the RF used to calculate the concentration of these isomers will be the lowest of the RFs determined during the calibration verification for the 2,3,7,8-substituted isomers in that homologue. This will yield the highest possible concentration for the non-2,3,7,8-substituted isomers.

17.3. Internal Standard / Cleanup Standard Recoveries

17.3.1. Calculate the percent recovery, R_{is}, for each internal standard and the cleanup standard in the sample extracts and the Batch QC extracts, using the formula:

$$R_{is}\% = \frac{(A_{is}^1 + A_{is}^2) \times Q_{rs}}{(A_{rs}^1 + A_{rs}^2) \times RF_{is} \times Q_{is}} \times 100$$

$R_{is}, A_{is}, A_{rs}, Q_{rs}, RF_{is}, and\ Q_{is}$ are defined in section 13.4.5.

17.3.1. The $^{13}C_{12}$-1,2,3,4-TCDD is used to quantitate the TCDD and TCDF internal standards and the cleanup standard, and the $^{13}C_{12}$-1,2,3,7,8,9-HXCDD is used to quantitate the HxCDD, HpCDF and OCDF internal standards.

17.3.2. If the original sample extract prior to any dilutions, has any internal standard with a percent recovery of less than 25% or greater than 150%, re-extraction and reanalysis of that sample is necessary.

17.4. Sample specific estimated detection limit

17.4.1. The sample specific estimated detection limit (EDL) is the estimate made by the laboratory of the concentration of given analyte required top produce a signal with a peak height of at least 2.5 times the background signal level. The estimate is specific to a particular analysis of the sample , and will be affected by sample size, dilution etc.

17.4.2. An EDL is calculated for each 2,3,7,8-substituted isomer that is <u>not</u> identified , regardless of whether or not non-2,3,7,8-substituted isomers in that homologue are present.

17.4.3. The EDL is also calculated for 2,3,7,8-substituted isomers giving a response for either of the quantitation ions that is less than 2.5 times the background level.

17.4.4. Calculate an EDL for each absent 2,3,7,8-substituted PCDD/PCDF using the formulae below. The background level (H_n) is determined by measuring the height of the noise at the expected retention times of both the quantitation ions of the particular 2,3,7,8-substituted isomer.

All matrices other than water:

$$EDL\,(ug/Kg) = \frac{2.5 \times Q_{is} \times (H_n^1 + H_n^2) \times D}{W \times (H_{is}^1 + H_{is}^2) \times RF_n}$$

Water:

$$EDL\,(ng/L) = \frac{2.5 \times Q_{is} \times (H_n^1 + H_n^2) \times D}{V \times (H_{is}^1 + H_{is}^2) \times RF_n}$$

where:

$H_n^1 + H_n^2$ = the peak heights of the noise for both of the quantitation ions of the 2,3,7,8-substituted isomer of interest.

$H_{is}^1 + H_{is}^2$ = the peak heights of the noise for both of the quantitation ions of the corresponding internal standard.

D = Dilution factor

V, Q_{is}, RF_n are difened in section 13.4.5. and 16.1.

17.4.5. If none of the isomers within a homologue are detected ,then the EDL for the "total" homologue concentration is the lowest EDL for any of the 2,3,7,8-substituted isomers that were not detected. Do not add together the EDLs for the various isomers.

17.4.6. If a 2,3,7,8-substituted isomer is reported in the homologue, then no EDL for the "total" is calculated.

18.0 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

18.1. With each batch of samples, a method blank and a lab spike are analyzed. The method blank checks for contamination, while the lab spike checks for accuracy. The size of a batch may not exceed 20 samples. Thus, a method blank and a lab spike must be run at least once for every 20 samples. Moreover, even if a batch consists of a single sample, it must be accompanied by both a method blank and a lab spike (also known as a laboratory control sample).

18.2. A method blank is performed by executing all of the specified extraction and cleanup steps, except for the introduction of a sample. The method blank is also spiked with the internal standards, cleanup standards, and recovery standard at appropriate stages of analysis. For water samples, one liter of organic-free water should be used as the method blank. Quartz sand may be used as the method blank for other matrices. An acceptable laboratory method blank must not contain any chemical interference or electronic noise at the *m/z* of the specified unlabeled PCDD/PCDF ions that is greater than 5% of the signal of the appropriate internal standard quantitation ion. A peak that meets identification criteria in the method blank must not exceed 2% of the signal of the appropriate internal standard. If these criteria are not met, the source of contamination should be determined and eliminated before repeating the analyses or proceeding with additional analyses. Recoveries of the internal and cleanup standards should be between 25 and 150%. Any blank that does meet these criteria is invalid.

18.3. The lab spike is analyzed under the same conditions as the blank, except that 100 µL of matrix spike working solution (Section 8.6.1) is added to the material being analyzed (quartz sand or water) prior to analysis. Lab spike recoveries should be within 50% of the actual values. Recoveries of the internal and cleanup standards should be between 25 and 150%. Any lab spike that does meet these criteria is invalid.

18.4. Performance evaluation samples should be analyzed at least once per year.

18.5. Additional QC analyses that may be run at the request of the client include matrix duplicates, matrix spikes, matrix spike duplicates, field blanks, and rinsates.

18.5.1. A matrix duplicate is an environmental sample that is divided into two aliquots that are analyzed separately. Comparison of the data from the two aliquots provides an indication of precision based upon native concentrations of analytes (if any). The division is conducted in the laboratory, and care should be taken to ensure that the sample is divided into homogeneous fractions. Data for the two aliquots should agree within 25% RSD.

18.5.2. A matrix spike is an environmental sample to which known concentrations of specific analytes have been added prior to analysis. Like the lab spike, the matrix spike provides data for evaluation of accuracy, but it is also matrix-specific. The matrix spike analysis is conducted in the same manner as the lab spike, and with the same QC criteria. Matrix spike

recoveries should be within 50% RSD of the actual values. Recoveries of the internal and cleanup standards should be between 25 and 150%. Any matrix spike that does meet these criteria is invalid.

18.5.3. A matrix spike duplicate is an additional aliquot of the environmental sample employed for the matrix spike analysis. Comparison of the data from the matrix spike and matrix spike duplicate provides an indication of precision based upon known amounts of analytes. The division of the matrix spike and matrix spike duplicate aliquots of the sample is conducted in the laboratory, and care should be taken to ensure that the sample is divided into homogeneous fractions. Data for the two aliquots should agree within 50% RSD. Recoveries of the internal and cleanup standards should be between 25 and 150%. Any matrix spike duplicate that does meet these criteria is invalid.

18.5.4. A fortified field blank is an uncontaminated soil, sediment, or water sample to which known concentrations of specific analytes have been added prior to analysis. Like the lab spike, the fortified field provides data for evaluation of accuracy but, unlike the matrix spike, it is not strictly matrix-specific. The fortified field blank analysis is conducted in the same manner as the lab spike, and with the same QC criteria. Fortified field blank recoveries should be within 50% RSD of the actual values. Recoveries of the internal and cleanup standards should be between 25 and 150%. Any fortified field blank that does meet these criteria is invalid.

18.6. GC column resolution must be demonstrated initially and verified prior to analyzing any sample in a 12-hr period. The GC column performance check solution must be analyzed under the same chromatographic and mass spectrometric conditions used for other samples and standards.

18.7. The continuing calibration must be performed at the beginning of a 12-hour window and the low standard must be analyzed at the end of the 12–hour window. If the CC1 standard analyzed at the end of the window fails the criteria specified in Section 11.4.3.4.2

19.0 DATA REDUCTION AND REPORTING

19.1. All stages of the analysis must be carefully documented. Some clients require delivery of some or all of this documentation along with the analytical data. Sufficient documentation should be maintained to determine (a) what was done, (b) by whom, and (c) when.

19.2. Documentation begins with sample receipt. The chain-of-custody is signed and dated. Details concerning each group of samples ("project") received are entered into the Sample Receiving Logbook. Such information includes client name and address, client contact, phone and fax numbers, courier (and airbill number, if applicable), and a description of the packaging materials (type, temperature, presence of custody tags/seals). Any problems or special instructions are noted, and the identity of the refrigerator in which the samples are stored is given. A table contains the following information: (a) Lab ID, (b) Client ID, (c) Matrix, and (d) Comments. The entry is signed and dated.

19.3. The client may require the use of a checklist to ensure that all sample login procedures have been completed.

19.4. If any problems are noted during sample login (broken sample containers, inadequate volumes of sample, discrepancies in client documentation), the client is notified immediately by telephone. Details of the resolution of the problem are entered onto a Lab/Client Telephone Communication form. That form is signed, dated, and faxed to the client. The form contains instructions for the client to sign, date, and return the form by fax.

19.5. Sample information is also entered into the electronic database, which triggers the generation of tracking forms. All activities relating to the analysis are entered onto the tracking forms. Critical activities (such as addition of standards to a sample or its extract) must be witnessed, and there are spaces on the forms for the witness to initial.

19.6. The client may require that checklists be used by the analyst, supervisor, and quality assurance officer to ensure that data review is completed as required.

19.7. All documents relating to a project are stored in the project folder. Photocopies of relevant pages in log books, as well as custody tags/seals are also placed in the project folder as they are made. Thus, when data pack assembly commences, all of the required documentation will be at hand.

19.8 All calculations are conducted by preprogrammed spreadsheets, so that calculation errors by the analyst are avoided. The spreadsheet formulas have been validated according to GALP requirements, using appropriate sample sets of data.

20.0 REFERENCES

Tondeur, Y., Niederhut, W.N., Campana, J.E. and Missler, S.R. (1987) A hybrid HRGC/MS/MS method for the characterization of tetrachlorinated-*p*-dioxins in environmental samples. *Biomed. Environ. Mass Spectrom.* **14**:449-456.

USEPA (1990a) Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd edn., Proposed Update II, Office of Solid Waste and Emergency Response, USEPA, Washington.

USEPA (1990b) Method 1613: Tetra- through Octa- Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS, Office of Water Regulations and Standards, USEPA, Washington, 44 pp.

Webster, G.R.B., Olie, K. and Hutzinger, O. (1985) Polychlorodibenzo-*p*-dioxins and polychlorodibenzofurans. In Mass Spectrometry in Environmental Sciences (eds. F.W. Karasek,

STANDARD OPERATING PROCEDURE

for

DETERMINATION OF METALS AND TRACE ELEMENTS BY INDUCTIVELY COUPLED PLASMA ATOMIC EMISSION SPECTROMETRY (ICP)

SOP No.: MET-200.7/6010B/CLP

Revision: 7.0

May 10, 2001

Approved by: _____ 5/10/01
Department Supervisor — Date

_____ 5/11/01
Laboratory Manager — Date

_____ 5/11/01
QA Coordinator — Date

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1. SCOPE AND APPLICATION

Inductively coupled plasma-atomic emission spectrometry (ICP-AES) determines trace elements, including metals, in solution. The method is applicable to all of the elements listed in Table 1. All matrices, including ground water, aqueous samples, TCLP and EP extracts, industrial and organic wastes, soils, sludges, sediments, and other solid wastes, require digestion prior to analysis. All analytical methods used are in accordance with EPA methods from SW-846 and other method references, the EPA Contract Laboratory Program (CLP) statement of work (SOW), and the NYSDEC Analytical Services Program (ASP).

1.1. Detection limits, sensitivity, and the optimum and linear concentration ranges of the elements can vary with the wavelength, spectrometer, matrix and operating conditions. The Practical Quantitation Limits (PQL) are listed in Table 1. The reported PQL may be adjusted if required for specific project requirements, however, the capability of achieving other reported PQLs must be demonstrated. Results may be reported to the Instrument Detection Limits (IDLs) upon request. IDL reporting limits are required for CLP analyses.

2. SUMMARY OF METHOD

2.1. This method describes multielemental determinations by ICP-AES using sequential or simultaneous optical systems and axial or radial viewing of the plasma. The instrument measures characteristic emission spectra by optical spectrometry. Samples are nebulized and the resulting aerosol is transported to the plasma torch. Element-specific emission spectra are produced by a radio-frequency inductively coupled plasma. The spectra are dispersed by a grating spectrometer, and the intensities of the emission lines are monitored by photosensitive devices. Background correction is required for trace element determination. Background must be measured adjacent to analyte lines on samples during analysis. The position selected for the background-intensity measurement, on either or both sides of the analytical line, will be determined by the complexity of the spectrum adjacent to the analyte line. In one mode of analysis the position used should be as free as possible from spectral interference and should reflect the same change in background intensity as occurs at the analyte wavelength measured. Background correction is not required in cases of line broadening where a background correction measurement would actually degrade the analytical result. The possibility of additional interferences named in Section 4.0 should also be recognized and appropriate corrections made.

3. DEFINITIONS

3.1. Calibration Blank - A volume of reagent water acidified with the same acid matrix as in the calibration standards. The calibration blank is a zero standard and is used to calibrate the ICP instrument.

3.2. Calibration Standard (CAL) - A solution prepared from the dilution of stock standard solutions. The CAL solutions are used to calibrate the instrument response with respect to analyte concentration

3.3. Dissolved Analyte - The concentration of analyte in an aqueous sample that will pass through a 0.45 µm membrane filter assembly prior to sample acidification.

3.4. Instrument Detection Limit (IDL) - The concentration equivalent to the analyte signal which is equal to three times the standard deviation of a series of 10 replicate measurements of the calibration blank signal at the same wavelength.

3.5. Initial/Continuing Calibration Verification Solution (ICV/CCV) - A solution of method analytes, used to evaluate the performance of the instrument system with respect to a defined set of method criteria.

3.6. Internal Standard - Pure analyte(s) added to a sample, extract, or standard solution in known amount(s) and used to measure the relative responses of other method analytes that are components of the same sample or solution. The internal standard must be an analyte that is not a sample component

3.7. Laboratory Duplicates - Two aliquots of the same sample taken in the laboratory and analyzed separately with identical procedures. Analyses of duplicates and indicates precision associated with laboratory procedures, but not with sample collection, preservation, or storage procedures.

3.8. Laboratory Control Sample (LCS) - An aliquot of to which known quantities of the method analytes are added in the laboratory. The LCS is analyzed exactly like a sample, and its purpose is to determine whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements.

3.9. Matrix Spike - An aliquot of an environmental sample to which known quantities of the method analytes are added in the laboratory. The matrix spike is analyzed exactly like a sample, and its purpose is to determine whether the sample matrix contributes bias to the analytical results.

3.10. Preparation Blank (PB) - An aliquot of reagent water or other blank matrices that are treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents, and internal standards that are used with other samples. The PB is used to determine if method analytes or other interferences are present in the laboratory environment, reagents, or apparatus.

3.11. Linear Range - The concentration range over which the instrument response to an analyte is linear.

3.12. Method Detection Limit (MDL) - The minimum concentration of an analyte that can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero.

3.13. Plasma Solution - A solution that is used to determine the optimum height above the work coil for viewing the plasma.

3.14. Interference Check Solution (ICS) - A solution of selected method analytes of higher concentrations which is used to evaluate the procedural routine for correcting known interelement spectral interferences with respect to a defined set of method criteria.

3.15. Contract Required Detection Limit (CRDL or CRI) – Standard prepared with a known concentration of elements to check accuracy at the low end of the curve.

3.16. High Check – A standard prepared at the bench at a high concentration to encompass the range of the samples being analyzed. This standard is used to assess accuracy at the high end of the linear range.

4. INTERFERENCES

4.1. There are several types of interferences by the ICP's: Spectral interferences can be from an overlap of spectral lines, background points or background from line emissions of high concentration elements. Physical interferences are effects associated with the sample introduction process, example high dissolved solids buildup on the nebulizer tip. Chemical interferences caused by the sample matrix itself. IEC's aid in eliminating some of these interferences. IECs are interelement correction factors that the instrument uses to compensate for spectral overlap when analyzing samples with complex spectra. Refer to Method 6010B Section 3.0 or Method 200.7 Section 4.0 for more detail and suggested procedures to correct and adjust the instrument due to interferences.

5. SAFETY

5.1. Corrosives - Because all samples and standards are diluted in 2% HNO_3 and 5% HCl, there is a danger of exposure to corrosives, sufficient care must be taken in handling these solutions. Safety glasses must be worn while preparing and handling the solutions.

5.2. High Voltage - The power unit supplies high voltage to the RF generator which is used to form the plasma. The unit should never be opened. Exposure to high voltage can cause injury or death.

5.3. UV Light - The plasma when lit is a very intense light, and must not be viewed with the naked eye. Protective lenses are in place on the instrument. Glasses with special protective lenses are available.

6. SAMPLE COLLECTION, PRESERVATION, AND STORAGE

6.1. Solid samples require no preservation prior to analysis other than storage at 0-6°C. Sample containers may be glass or plastic. Samples are analyzed within 6 months of collection.

6.2. For aqueous samples, glass or plastic sample containers are acceptable. Sample volume should be acid preserved with (1+1) nitric acid to pH <2. Samples are analyzed within 6 months of sample collection.

6.3. For the determination of the dissolved elements, the sample must be filtered through a 0.45 µm pore diameter membrane filter at the time of collection or as soon thereafter as practically possible. (Glass or plastic filtering apparatus are recommended to avoid possible contamination. Only plastic apparatus should be used when the determinations of boron and silica are critical.) Use a portion of the filtered sample to rinse the filter flask, discard this portion and collect the required volume of filtrate. Acidify the filtrate with (1+1) nitric acid immediately following filtration to pH <2.

Note: When the nature of the sample is either unknown or is known to be hazardous, acidification should be done in a well ventilated area or fume hood.

6.4. Samples received by the ICP lab as digestates containing nitric and hydrochloric acid. Digestates are stored at room temperature in plastic B-cups.

6.5. Following analysis, digestates are stored until all results have been reviewed. Digestates are diluted and disposed of through the sewer system in approximately 90 days after receipt of sample.

7. APPARATUS AND EQUIPMENT

7.1. Inductively coupled argon plasma emission spectrometer:

7.2. Computer-controlled emission spectrometer with background correction.

7.3. Optional mass flow controller for argon nebulizer gas supply.

7.4. Optional peristaltic pump.

7.5. Optional Autosampler.

7.6. Argon gas supply - high purity.

7.7. Volumetric flasks of suitable precision and accuracy.

8. PREVENTIVE MAINTENANCE

All maintenance activities are recorded in a maintenance logbook kept for each instrument. Most routine maintenance and troubleshooting is performed by CAS staff. Other maintenance or repairs may, or may not require factory service, depending upon the nature of the task. Record the analytical run filename of the first acceptable run after major maintenance in the maintenance log book. Typical preventive maintenance measures include, but are not limited to, the following items:

- Cleaning the pump tubing as needed
- Empty waste container, as needed
- Cleaning the nebulizer, spray chamber, and torch, as needed
- Replace water and vacuum filters, as needed

9. STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

9.1. Trace metals grade chemicals shall be used in all tests.

9.1.1. Hydrochloric acid (conc), HCl. Purchased commercially. Store at room temperature. Expires one year from receipt or upon manufacturer's indications, whichever is sooner.

9.1.2. Hydrochloric acid (1:1), HCl. Add 500 mL concentrated HCl to 400 mL water and dilute to 1 liter in an appropriately sized beaker. Store at room temperature. Expires one year from preparation.

9.1.3. Nitric acid (conc), HNO_3. Purchased commercially. Store at room temperature. Expires one year from receipt or upon manufacturer's indications, whichever is sooner.

9.1.4. Nitric acid (1:1), HNO_3. Add 500 mL concentrated HNO_3 to 400 mL water and dilute to 1 liter in an appropriately sized beaker. Store at room temperature. Expires one year from preparation.

9.2. Reagent Water. All references to water in the method refer to DI Type II water unless otherwise specified. Reagent water will be interference free.

9.3. All standards are prepared from NIST traceable stock standard solutions. Manufacturers expiration dates are used to determine viability of standards. Preparatory procedures for standards and QC solutions vary between instruments due to the working ranges. All preparatory information for the QA/QC samples are provided in Appendix I.

9.3.1. Mixed Calibration Standards are prepared by combining appropriate volumes of the stock solutions in volumetric flasks. Matrix match with the appropriate acid and dilute to 100ml with water. Calibration standards should be verified using a quality control sample (LCS, ICV, or CCV). Calibration standards should be stored at room temperature in glass volumetric flasks with a shelf-life of 48 hours.

9.3.2. Initial and Continuing Calibration Verification (ICV and CCV) Standards are prepared by combining compatible analytes at concentrations equivalent to the midpoint of their respective calibration curves. The ICV and CCV standards should be prepared from a separate source independent from that used in the calibration standards. ICV / CCV standards should be stored at room temperature in glass volumetric flasks with a shelf-life of 48 hours.

9.3.3. CRI Standards are prepared to contain known concentrations of elements at two times the

CRDL to confirm accuracy at the low-end of the curve. CRI standards should be stored in plastic containers with a shelf-life of 6 months.

9.3.4. Interference Check Solutions A and AB are prepared to contain known concentrations of interfering analytes that will provide an adequate test of the correction factors. ICSA / ICSAB standards should be stored in plastic containers with a shelf-life of 6 months.

9.3.5. Laboratory Control Sample and Matrix Spike are purchased as custom mixes stored in plastic containers with a shelf-life of 6 months at the concentrations recommended in the method. Certificates of analysis are attached in Appendix I. Each sample, up to 100 ml, is spiked with 1.0 ml of spike solution.

9.4. Blanks

9.4.1. Method Blanks must contain all the reagents and in the same volumes as used in the preparation of samples. The method blanks must be carried through the complete procedure and contain the same acid concentration in the final solution as the samples.

9.4.2. The Calibration Blank is prepared by acidifying reagent water to the same concentrations of acid found in the standards and samples.

9.5. Reagent Receiving Log

The manufacturer, lot number, standard /reagent name, concentration, date received and expiration date are recorded in a reagent log.

10. RESPONSIBILITIES

10.1. It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. Final review and sign-off of the data is performed by the department supervisor or designee.

11. PROCEDURE

All samples are digested prior to analysis. Refer to the following Metals Digestion SOPs:

MET-3005A	Metals Digestion, Waters, Total Recoverable and Dissolved for ICP
MET-3010A	Metals Digestion, Waters for ICP
MET-3020A	Metals Digestion, Waters for GFAA
MET-3050B	Metals Digestion, Soils, Sediments and Sludges for ICP and GFAA
MET-CLP	Metals Digestion, Waters and Soils for CLP
MET-200.3	Sample Preparation of Total Recoverable Elements in Tissue

11.1. Set up the instrument with proper operating parameters established as detailed below. The instrument must be allowed to become thermally stable before beginning (usually requiring at least 45 minutes of operation prior to calibration). Operating conditions - The analyst should follow the instructions provided by the instrument manufacturer.

11.2. Before using this procedure to analyze samples, there must be data available documenting initial demonstration of performance. The required data documents the selection criteria of background correction points; linear ranges, and the upper limits of those ranges; the method and instrument detection limits; and the determination and verification of interelement correction equations or other routines for correcting spectral interferences. This data must be generated using the same instrument, operating conditions and calibration routine to be used for sample analysis. These documented data must be kept on file and be available for review by the data user or auditor.

11.3. Turn on power supply for the instrument, computer, printer and light the plasma. Allow instrument to warm-up for 45-60 minutes before operation. The cooling water and the argon are on when the instrument are on.

11.4. MN Peak source. The peak source is used to optimize the torch viewing position for maximum intensity and should be done daily, or when any maintenance is done on the instrument.

11.5. The internal standard technique is used on the Perkin Elmer Optima 3000XL ICP's. An internal standard solution consisting of 100 mg/L of Yttrium and 100 mg/L of Cesium is prepared. This solution is then added to the blank, calibration standards and samples before analysis to give an apparent concentration of 1.00 mg/L Yttrium. The

Yttrium intensity is used by the instrument to ratio the analyte intensity signals for both calibration and quantitation. Cesium is used only as a stabilizer.

11.5.1. After the calibration blank, the calibration standard, ICV/CCV standards, CRI, ICSA, and ICSAB are poured up to 40 mL in a 50 mL centrifuge tube and 0.80 mL of the internal standard solution is added. All other samples, preparation blanks and laboratory control samples are poured up to 10 mL in a 15 mL centrifuge tube and 0.20 mL of internal standard solution is added.

11.6. Calibration and Analytical Run

11.6.1. The analytical run scheme will be calibrated consisting of a standard and a blank for each analyte. The sequence of the run shall be as follows:

- ◊ High Check; ICV; ICB; CRI; ICSA; ICSAB; CCV; CCB;
- ◊ 10 environmental samples (including PBs and LCSs); CCV; CCB; repeat to the end of the run.....
- ◊ Last 10 samples; CCV; CCB, CRI, ICSA, ICSAB; CCV, CCB.
- ◊ For more information, refer to ADM-BCHSQ for Batches and Sequences.

11.6.2. Rinse the system with the calibration blank solution before the analysis of each sample. The rinse time will be one minute. Each laboratory may establish a reduction in this rinse time through a suitable demonstration.

11.7. Sensitivity, instrumental detection limit, precision, linear dynamic range, and interference effects must be established for each individual analyte line on each particular instrument. All measurements must be within the instrument linear range where the correction equations are valid.

11.8. Method detection limits must be established for all wavelengths utilized for each type of matrix commonly analyzed. The matrix used for the MDL calculation must contain analytes of known concentrations within 3-5 times the anticipated detection limit. See Table 2 for wavelengths per instrument. See ADM-MDL for more information.

12. QA/QC REQUIREMENTS

12.1. Instrument values are based on triplicate emission readings for the Leeman PS3000 and duplicate readings for the Optima 3000XL. Precision between the emission readings shall not exceed 20 %RSD. If RSD values exceed 20%, the sample reanalyzed and reported.

12.2. Preparation Blanks must be analyzed at least one PB with each batch of 20 or fewer samples of the same matrix. PB values must not exceed the PQL which would indicated laboratory or reagent contamination. Fresh aliquots of the samples must be prepared and analyzed again for affected analytes after the source of the contamination has been corrected and acceptable PB values have been obtained. If detections are greater than the PQL, the batch needs to be redigested if sample concentration is less than 10 times the concentration found in the prep blank. If the sample concentration is less than the PQL the sample does not require redigestion.

12.3. High Check – high standard used in curve is reanalyzed immediately following the curve to check calibration. Results should agree within ±5% of the true value or recalibration is required.

12.4. ICV/CCV - Calibration Verification Standards must immediately follow each calibration, after every tenth sample, and at the end of the sample run. Initial Calibration Verification must verify that the instrument is within ±5% of calibration for Method 200.7 and ±10% for Method 6010B. Continuing Calibration Verification standards must confirm the calibration within ±10% throughout the analyses. If the recovery of an analyte falls outside the required control limits, the analysis is judged to be out of control, and the source of the problem should be identified and resolved before continuing analysis. Recalibrate the instrument.

12.5. The results of the calibration blank (CCB) must be less than the MRL. If not, terminate the analysis, correct the problem, recalibrate, and reanalyze the samples effected.

12.6. Dilute and reanalyze samples that exceed the linear calibration range or use an alternate, less sensitive line for which quality control data is already established. See ADM-DIL for more information.

12.7. Analyze a matrix spiked and duplicate samples at a frequency of one per matrix batch (max. 20 samples) or one per 10 for Method 200.7. A matrix spike and duplicate sample is a sample brought through the entire sample preparation and analytical process.

12.7.1. The spiked sample or spiked duplicate sample recovery is to be within ± 25% of the actual value or within the documented historical acceptance limits for each matrix. Sample concentrations greater than four times the spike concentration are not valid and shall not be evaluated. If the matrix spike does not meet these criteria, analyze a Post Digestion Spike.

12.7.2. A control limit of ± 20% RPD shall be used for original and duplicate samples greater than or equal to 5X the CRDL. A control limit of ± the CRDL shall be used if either the sample or duplicate value is less than 5 times the CRDL. CRDL values are given in Table 1.

12.8. Laboratory Control Sample – verify sample preparation and analysis using reagent water spiked with a known amount of analytes of interest. Results should be within ± 15% of the true value for method 200.7 and ± 20% for CLP and 6010B. Outlying recoveries may indicate loss of analyte due to digestion procedures or laboratory contamination. If an LCS is found to be out of the specified limits, recalibrate and reanalyze. If the LCS remains out of the specified limits, redigestion of the entire batch should occur if the recovery is less than 85% for method 200.7 and 80% for CLP and 6010B. If the LCS recovery is greater than 115% for method 200.7 and 120% for CLP and 6010B, redigestion of all positive results (greater than the PQL) should occur.

12.9. CRDL- A standard 2 times the CRDL is analyzed at the beginning and end of each analytical run but not before the ICV. There are no limits in the 200.7 or 6010B methods, but the CAS guideline used is +/- 50% of the true value. If the limits are not met the analysis is stopped and the instrument is recalibrated. Control limits of 80-120% are required by CLP analyses. The same corrective action is taken if recoveries are outside 80-120%.

12.10. Interference Check Samples- The ICSA and ICSAB need to be run consecutively at the beginning and end of each analytical run. Results from the ICSA solution shall be monitored for false positive detections of analytes not present in the mix. Positive results are flagged as estimate for EPA CLP programs only. The analyte recoveries for the AB solution must fall within 20% of the true value otherwise the run must be stopped, recalibrated and reanalyzed.

12.11. Serial Dilution Test If the analyte concentration is sufficiently high (minimally, a factor of 50 times above the IDL), an analysis of a 1:5 dilution should agree within ± 10% of the original determination. If not, a chemical or physical interference effect should be suspected and data may be flagged accordingly.

12.12. Post Digestion Spike Addition (for 6010B analyses): Typically if a matrix spike does not yield acceptable results, a post-digestion spike may be added to a portion of a prepared sample, or its dilution, and should be recovered to within 75% to 125% of the known value. The spike addition should produce a minimum level of 10 times and a maximum of 100 times the IDL. If the spike is not recovered within the specified limits, a matrix effect has been confirmed.

12.13. Instrument Performance

12.13.1. InterElement Correction Factors (IEC) are analyzed annually, or as needed.
12.13.2. Linear Ranges (LR) are run biannually and must be ±5% of true value.
12.13.3. Instrument Detection Limits (IDL) are analyzed quarterly, or as needed.
12.13.4. Method Detection Limits (MDL) are analyzed annually.

13. DATA REDUCTION AND REPORTING

13.1. Calculations: If dilutions were performed, the appropriate factors must be applied to sample values. All results should be reported with up to three significant figures. Refer to ADM-DREV for guidance in data review and acceptability.

13.1.1. Sample Calculation (water)

$$\text{Conc. (mg/L)} = \frac{\text{Instrument Reading (mg/L) x Final digestion volume (L)}}{\text{Initial volume (L)}}$$

13.1.2. **Sample Calculation (soils)**

$$\text{Conc. (mg/g)} = \frac{\text{Instrument Reading (mg/L) x Final digestion volume (L)}}{\text{Initial mass (g) x Percent Solids expressed as a decimal}}$$

13.1.3 Matrix Spike Recovery is calculated to determine accuracy for matrix and blank pikes using the following equation:

$$\text{Accuracy (\%REC)} = \frac{A - B}{C} \times 100$$

Where
A = Analyte total concentration from spiked sample
B = Analyte concentration from unspiked sample
C = Concentration of spike added

13.1.4 **Precision** is measured through the use of replicate sample analyses within the same batch and is expressed as the relative percent difference (RPD) between the replicate measurements.

$$RPD = \frac{D1 - D2}{(D1+D2)/2} \times 100$$

Where
D1 = Original Result
D2 = Duplicate Result

Report each analyte concentration to the proper significant figures in mg/L or µg/L as required.

14. WASTE MANAGEMENT AND POLLUTION PREVENTION

14.1. Reagents are prepared upon an as-needed basis in small quantities. Minimum sample volumes are used during analysis.

14.2. Acidic waste is neutralized and poured down the drain with copious amounts of water.

14.3. Samples with analyte concentrations exceeding TCLP regulatory limits are disposed of as hazardous waste, see SOP *SMO-SPLDIS*.

15. REFERENCES

15.1. *Test Methods For Evaluating Solid Waste, Physical/Chemical Methods*. USEPA SW-846, 3rd Edition, December 1996.

15.2. *Methods For the Determination of Metals in Environmental Samples Supplement I*. USEPA/600/R-94/111, May 1994.

15.3. EPA Contract Laboratory Program, Statement of Work for Inorganic Analysis, SOW No. ILM04.0.

15.4. Analytical Services Protocol (ASP), New York State Department of Environmental Conservation, December 1995.

16. TRAINING OUTLINE

16.1. Read current SOP and applicable methodologies. Demonstrate a general understanding of the methodology and chemistry. Follow policies in ADM-TRANDOC.

16.2. Observe Sample Preparation and Analysis. Follow Training Plan Form (see attached).

16.3. Participate in the methodology, documentation, and data reduction with guidance.

16.4. Instrument Operation and Maintenance.

16.5. Demonstrate Competency by performing the analysis independently. Analyze four replicates of a known mid-range standard. If recovery is within acceptable limits, complete Training Plan Form and IDC certificate and file with QA. Continuing demonstration (CDC) will be performed annually using a Proficiency, an internal unknown, or a new 4 replicate study.

17. INSTRUMENT-SPECIFIC ADDENDUM

- Perkin Elmer Optima 300XL (Optima #1)
- Perkin Elmer Optima 300XL (Optima #2)
- Leeman
- For operation: Refer to Manufacturer Operation Manuals located in ICP lab.

18. ATTACHMENTS

Metals Analysis Training Plan Form
Table 1 List of Analytes and Practical Quantitation Limits
Table 2 Instrument Wavelengths
Appendix I Standard Preparation

19. CHANGES FROM PREVIOUS REVISION

- Eliminated radio frequency generator and volumetric pipets from 7.0.
- Added statement concerning documentation of first acceptable run after maintenance.
- Added storage and expiration to 9.0 where none were listed.
- Changed expiration of LCS and MS solutions to 6 months.
- Eliminated need to turn on cooling water and argon supply since they are on when the instrument is on.
- Added references to ADM-MDL, ADM-DIL, ADM-TRANDOC, and SMO-GEN
- Modified Training Outline to reflect current practice.
- Changed 11.5.1 so that the Calibration Standard, ICV/CCV are prepared the same as the CRI and ICSAs.

Table 1 - List of Analytes, CRDLs, and Practical Quantitation Limits

Analyte	*CRDL*	*PQLs*			*Typical IDL*
		Water-Leeman	*Water-Optima*	*Soil*	
		mg/L	*mg/L*	*ug/g*	*ug/L*
Silver	10	0.010	0.010	1.00	0.632
Aluminum	200	0.100	0.100	10.0	6.57
Arsenic	10	0.500	0.0100	50.0	6.89
Boron		0.200	0.200	20.0	37.3
Barium	200	0.0200	0.0200	2.00	12.2
Beryllium	5	0.0050	0.0050	0.500	0.26
Calcium	5000	0.500	0.500	50.0	167
Cadmium	5	0.0050	0.0050	0.500	0.489
Cobalt	50	0.0500	0.0500	5.00	3.03
Chromium	10	0.0100	0.0100	1.0	1.81
Copper	25	0.0200	0.0200	2.00	3.02
Iron	100	0.100	0.100	5.00	44.1
Potassium	5000	2.00	2.00	100	857
Magnesium	5000	0.500	0.500	50.0	124
Manganese	15	0.0100	0.0100	1.0	1.78
Molybdenum		0.0250	0.0250	2.50	3.08
Sodium	5000	0.500	0.500	50.0	193
Nickel	40	0.0400	0.0400	4.00	3.92
Lead	3	0.0500	0.00500	5.00	1.29
Antimony	60	0.100	0.0600	10.0	3.72
Selenium	5	0.500	0.00500	50.0	12.5
Tin		1.00	0.500	100	15.8
Titanium		0.0500	0.0500	5.00	3.15
Thallium	10	0.300	0.0100	30.0	7.77
Vanadium	50	0.0500	0.0500	5.00	2.74
Zinc	20	0.0200	0.0200	1.0	2.47

Metals Instrument Analysis Training Plan

Procedure:_____

SOP:_____ Revision:_____ Date:_____

Trainee:_____

1. Read SOP Trainer:____ Trainee:____ Date:____

2. Demonstrated understanding of the scientific basis of the analysis including:
   -the chemical and physical principals behind the measurement by the instrument

   Trainer:____ Trainee:____ Date:____

3. Demonstrated familiarity with related SOPs

-ADM-BATCHSEQ	-ADM-PCAL	-ADM-SIGFIG
-ADM-DATAENTRY	-ADM-DIL	-ADM-SPSR
-ADM-MDL	-ADM-DREV	-ADM-TRANDOC

   Trainer:____ Trainee:____ Date:____

4. Observe performance of SOP
   -standard and reagent prep and documentation – including pipet used
   -instrument power up and warm-up
   -instrument set-up, daily maintenance and checks
   -use and loading of autosampler
   -sample analysis including:
      -calibration
      -sample dilution
      -software command of instrument
      -use of QC samples and QC criteria
      -common troubleshooting
   -instrument logbook use
   -data reduction, reporting, and review

   Trainer:____ Trainee:____ Date:____

5. I have read, understood and agree to perform the most recent version of the SOP:

   Signature:_____ Date:_____

6. Perform SOP with supervision
   - including all items in 4.

   Trainer:____ Trainee:____ Date:____

7. Independent performance of the SOP
   -all of the item listed in 4
   -IDC Trainer:____ Trainee:____ Date:____

APPENDIX I

PREPARATION PROCEDURES FOR STANDARDS AND QC

OPTIMA CALIBRATION STANDARD (Standard is prepared daily.)

	Element	CAS Lot #	Conc. (ppm)	Vol. (mls)	Final Vol. (mls)	Final Conc. (ppm)	Matrix	Analyst/ Date	Letter ID	Nitric Acid Lot#	Hydrochloric Acid Lot #	Pipet ID
Cal Std 1	CA		5000	2.00	200	50.0	2%HNO3		A			
	MG		5000			50.0	5%HCl		B			
	K		5000			50.0			C			
	NA		5000			50.0			D			
Cal Std 2	AG		100	2.00		1.00			E			
	CR		100			1.00			F			
	MN		150			1.50			G			
	NI		400			4.00			H			
	ZN		200			2.00			I			
Cal Std 3	AL		2000	2.00		20.0			J			
	BA		2000			20.0			K			
	BE		50			0.500			L			
	CO		500			5.00			M			
	CU		250			2.50			N			
	FE		1000			10.0			O			
	V		500			5.00			P			
Cal Std 4	AS		100	4.00		2.00			Q			
	CD		50			1.00			R			
	PB		50			1.00			S			
	SE		50			1.00			T			
	TL		100			2.00			U			
Single Elements	SB		1000	2.00		10.0			V			
	SN		1000	2.00		10.0			W			
	B		1000	1.00		5.00			X			
	MO		1000	1.00		5.00			Y			
	TI		1000	1.00		5.00			Z			

OPTIMA ICV/CCV STANDARD (Standard is prepared daily.)

	Element	CAS Lot #	Conc. (ppm)	Vol. (mls)	Final Vol. (mls)	Final Conc. (ppm)	Matrix	Analyst/ Date	Letter ID	Nitric Acid Lot#	Hydrochloric Acid Lot #	Pipet ID
Cal Std 1	CA		5000	1.00	200	25.0	2%HNO3		A			
	MG		5000			25.0	5%HCl		B			
	K		5000			25.0			C			
	NA		5000			25.0			D			
Cal Std 2	AG		100	1.00		0.500			E			
	CR		100			0.500			F			
	MN		150			0.750			G			
	NI		400			2.00			H			
	ZN		200			1.00			I			
Cal Std 3	AL		2000	1.00		10.0			J			
	BA		2000			10.0			K			
	BE		50			0.250			L			
	CO		500			2.50			M			
	CU		250			1.25			N			
	FE		1000			5.00			O			
	V		500			2.50			P			
Cal Std 4	AS		100	2.00		1.00			Q			
	CD		50			0.500			R			
	PB		50			0.500			S			
	SE		50			0.500			T			
	TL		100			1.00			U			
Single Elements	SB		1000	1.00		5.00			V			
	SN		1000	1.00		5.00			W			
	B		1000	0.500		2.50			X			
	MO		1000	0.500		2.50			Y			
	TI		1000	0.500		2.50			Z			

OPTIMA CRI STANDARD

Element	CAS Lot #	Conc. (ppm)	Vol. (mls)	Final Vol. (mls)	Final Conc. (ppm)	Matrix	Analyst/ Date	ID Letter	Nitric Acid Lot #	Hydrochloric Acid Lot #	Expiration Date	Pipet ID
CRDL STD		Multi	0.500	500	Multi	5% HCL 2%HNO3		A				
AG		20			0.0200			B				
AS		20			0.0200			C				
BE		10			0.0100			D				
CD		10			0.0100			E				
CR		20			0.0200			F				
CO		100			0.100			G				
CU		50			0.0500			H				
MN		30			0.0300			I				
NI		80			0.0800			J				
PB		6			0.00600			K				
SB		120			0.120			L				
SE		10			0.0100			M				
TL		20			0.0200			N				
V		100			0.100			O				
ZN		40			0.0400			P				
								Q				

ICSA

Element	CAS Lot #	Conc. (ppm)	Vol. (mls)	Final Vol. (mls)	Final Conc. (ppm)	Matrix	Analyst/ Date	ID Letter	Nitric Acid Lot #	Hydrochloric Acid Lot #	Expiration Date	Pipet ID
Int. A Sol'n		Multi	100	1000	Multi	5% HCL		A				
AL		5000			500	2%HNO3		B				
CA		5000			500			C				
FE		2000			200			D				
MG		5000			500			E				

ICSAB

Int. A Sol'n		Multi	100	1000	Multi		AA				
AL		5000			500		BB				
CA		5000			500		CC				
FE		2000			200		DD				
MG		5000			500		EE				
Int. B Sol'n		Multi	10.0		Multi		FF				
AG		100			1.00		GG				
BA		50			0.500		HH				
BE		50			0.500		II				
CD		100			1.00		JJ				
CO		50			0.500		KK				
CR		50			0.500		LL				
CU		50			0.500		MM				
MN		50			0.500		NN				
NI		100			1.00		OO				
PB		100			1.00		PP				
V		50			0.500		QQ				
ZN		100			1.00		RR				
							SS				
							TT				
							UU				

OPTIMA INTERNAL STANDARD

Element	CAS Lot #	Conc. (ppm)	Vol. (mls)	Final Vol. (mls)	Final Conc. (ppm)	Matrix	Analyst/ Date	ID Letter	Nitric Acid Lot #	Hydrochloric Acid Lot #	Expiration Date	Pipet ID
Y		1000	50.0	500	100	2% HNO3		A				
Cs		1000	50.0	500	100	5% HCL		B				
								C				
								D				
								E				
								F				
								G				
								H				
								I				
								J				
								K				
								L				
								M				
								N				
								O				
								P				
								Q				
								R				
								S				

LEEMAN CRI STANDARD

Element	CAS Lot #	Conc. (ppm)	Vol. (mls)	Final Vol. (mls)	Final Conc. (ppm)	Matrix	Analyst/ Date	ID Letter	Nitric Acid Lot #	Hydrochloric Acid Lot #	Expiration Date	Pipet ID
CRDL STD	M1780015U	Multi	0.500	500	Multi	5% HCL 2%HNO3	SD 3/14/01	A	M1780021D	M1780023G ~~M210~~ SD 3/14/01	6/23/01	MB/MII
AG		20			0.0200		SD 4/11/01	B	〃	〃	6/23/01	MB/MII
AS		20			0.0200		SD 5/8/01	C	〃	M1780024M	6/23/01	MB/MII
BE		10			0.0100			D				
CD		10			0.0100			E				
CR		20			0.0200			F				
CO		100			0.100			G				
CU		50			0.0500			H				
MN		30			0.0300			I				
NI		80			0.0800			J				
PB		6			see below			K				
SB		120			0.120			L				
SE		10			0.0100			M				
TL		20			0.0200			N				
V		100			0.100			O				
ZN		40			0.0400			P				
								Q				
								R				
PB	M1780024C	1000	0.050		0.106			S				

LEEMAN ICV/CCV STANDARD (Standard is prepared daily.)

	Element	CAS Lot #	Conc. (ppm)	Vol. (mls)	Final Vol. (mls)	Final Conc. (ppm)	Matrix	Analyst/ Date	Letter ID	Nitric Acid Lot#	Hydrochloric Acid Lot #	Pipet ID
Cal Std 1	CA		5000	2.00	200	50.0	2%HNO3		A			
	MG		5000			50.0	5%HCl		B			
	K		5000			50.0			C			
	NA		5000			50.0			D			
Cal Std 2	AG		100	1.00		0.500			E			
	CR		100			0.500			F			
	MN		150			0.750			G			
	NI		400			2.00			H			
	ZN		200			1.00			I			
Cal Std 3	AL		2000	1.00		10.0			J			
	BA		2000			10.0			K			
	BE		50			0.250			L			
	CO		500			2.50			M			
	CU		250			1.25			N			
	FE		1000			5.00			O			
	V		500			2.50			P			
Cal Std 4	AS		100	4.00		2.00			Q			
	CD		50			1.00			R			
	PB		50			1.00			S			
	SE		50			1.00			T			
	TL		100			2.00			U			
Single Elements	SB		1000	1.00		5.00			V			
									W			
									X			
									Y			
									Z			

LEEMAN CALIBRATION STANDARD (Standard is prepared daily.)

	Element	CAS Lot #	Conc. (ppm)	Vol. (mls)	Final Vol. (mls)	Final Conc. (ppm)	Matrix	Analyst/ Date	Letter ID	Nitric Acid Lot#	Hydrochloric Acid Lot #	Pipet ID
Cal Std 1	CA		5000	2.00	100	100	2%HNO3		A			
	MG		5000			100	5%HCl		B			
	K		5000			100			C			
	NA		5000			100			D			
Cal Std 2	AG		100	1.00		1.00			E			
	CR		100			1.00			F			
	MN		150			1.50			G			
	NI		400			4.00			H			
	ZN		200			2.00			I			
Cal Std 3	AL		2000	1.00		20.0			J			
	BA		2000			20.0			K			
	BE		50			0.500			L			
	CO		500			5.00			M			
	CU		250			2.50			N			
	FE		1000			10.0			O			
	V		500			5.00			P			
Cal Std 4	AS		100	4.00		4.00			Q			
	CD		50			2.00			R			
	PB		50			2.00			S			
	SE		50			2.00			T			
	TL		100			4.00			U			
Single Elements	SB		1000	1.00		10.0			V			
									W			
									X			
									Y			
									Z			

SOP ADDENDUM

SOP REFERENCE NUMBER: MET-200.7/6010B/CLP

REVISION NUMBER: 7

EFFECTIVE DATE: 6/1/01

Section 12.0

All QC limits referenced in Section 12.0 of this SOP have been updated based upon current QC charts available through the QA department. Revised QC limits and reporting limits are listed in Appendix C of the current Quality Assurance Manual. The tables listed in Appendix C override the QC limits and reporting limits listed in this SOP. All corrective actions discussed in this SOP are still valid and should be followed.

STANDARD OPERATING PROCEDURE

for

DETERMINATION OF MERCURY IN WATER BY COLD VAPOR ATOMIC ABSORPTION SPECTROMETRY

SOP No.: MET-7470A/245.1

Revision: 4.0

November 1, 2001

Approved by: Christine Kutzer — Supervisor — 11/1/01 — Date

Lena Reyes — QA Coordinator — 11/1/01 — Date

Michael K Perry — Laboratory Director — 11/1/01 — Date

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Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
Initials: _____ Date: _____
Initials: _____ Date: _____

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1. SCOPE AND APPLICATION

1.1. Methods 245.1 and 7470A are cold-vapor atomic absorption procedures used in determining the concentration of mercury in drinking, surface, ground, industrial, and domestic wastewater. The range of the method is 0.2 to 10 ug/L. The range may be extended above or below the normal range by increasing or decreasing the sample size.

2. METHOD SUMMARY

2.1. A known portion of a water sample is transferred to a BOD bottle with a ground glass stopper. It is digested in diluted potassium permanganate-potassium persulfate solutions and oxidized for two hours at 95°C. Mercury in the digested water sample is reduced with stannous chloride to elemental mercury and measured by the conventional cold vapor atomic absorption technique.

3. DEFINITIONS

3.1. **Calibration Blank** - A volume of reagent water acidified with the same acid matrix as in the calibration standards. The calibration blank is a zero standard and is used to auto-zero the instrument.

3.2. **Calibration Standard** - A solution prepared from the dilution of stock standard solutions. The CAL solutions are used to calibrate the instrument response with respect to analyte concentration.

3.3. **Laboratory Duplicates** - Two aliquots of the same sample taken in the laboratory and analyzed separately with identical procedures. Analyses of duplicate sample indicates precision associated with laboratory procedures, but not with sample collection, preservation, or storage procedures.

3.4. **Laboratory Control Sample (LCS)** - An aliquot of DI to which a known quantity of the method analyte is added in the laboratory. The LCS is analyzed exactly like a sample, and its purpose is to determine whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements.

3.5. **Matrix Spike (MS)** - An aliquot of an environmental sample to which a known quantity of the method analyte is added in the laboratory. The MS is analyzed exactly like a sample, and its purpose is to determine whether the sample matrix contributes bias to the analytical results. The background concentrations of the analytes in the sample matrix must be determined in a separate aliquot and the measured values in the LFM corrected for background concentrations.

3.6. **Preparation Blank (PB)** - An aliquot of reagent water or other blank matrices that are treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents, and internal standards that are used with other samples. The PB is used to determine if the method analyte or other interferences are present in the laboratory environment, reagents, or apparatus.

3.7. **Linear Dynamic Range (LDR)** - The concentration range over which the instrument response to an analyte is linear.

3.8. **Method Detection Limit (MDL)** - The minimum concentration of an analyte that can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero.

3.9. **Standard Addition** - The addition of a known amount of analyte to the sample in order to determine the relative response of the detector to an analyte within the sample matrix. The relative response is then used to assess either an operative matrix effect or the sample analyte concentration.

3.10. **Batch** – Unit of samples prepared together on the same day, not to exceed 20 samples.

4. INTERFERENCES

4.1. Interferences have been reported for waters containing sulfide, chloride, copper and tellurium. Organic compounds, which have broad band UV absorbance (around 253.7 nm), are confirmed interferences. The concentration levels for interferants are difficult to define.

4.2. Low level mercury sample preparation, digestion, and analysis may be subject to environmental contamination if preformed in areas with high ambient backgrounds where mercury was previously employed as an analytical reagent in analyses such as total kjeldahl nitrogen (TKN) or chemical oxygen demand (COD).

5. SAFETY

5.1. The toxicity and carcinogenicity of each reagent used in this method has not been fully established. Each chemical should be regarded as a potential health hazard and exposure to these compounds should be minimized by good laboratory practices. Normal accepted laboratory safety practices should be followed during reagent preparation and instrument operation. Always wear safety glasses or full-face shield for eye protection when working with these reagents.

6. SAMPLE CONTAINERS, COLLECTION, PRESERVATIONS, AND STORAGE

6.1. Because of the extreme sensitivity of the analytical procedure and the presence of mercury in a laboratory environment, care must be taken to avoid extraneous contamination. Sampling devices, sample containers and plastic items should be determined to be free of mercury; the sample should not be exposed to any condition in the laboratory that may result in contamination from airborne mercury vapor.

6.2. Aqueous samples can be collected in polyethylene or glass containers. Samples are acidified with (1+1) nitric acid to pH <2 (normally, 3 ml of (1+1) acid per liter of sample is sufficient for most ambient and drinking water samples). Preservation may be done at the time of collection, or at the laboratory. Following acidification, the sample should be mixed, held for 16 hours, and then verified to be pH <2 just prior withdrawing an aliquot for processing. If for some reason such as high alkalinity the sample pH is verified to be >2, more acid must be added and the sample held for additional 16 hours until verified to be pH <2.

6.3. The preserved sample should be analyzed within 28 days of collection. Once digested, samples are analyzed as soon as possible.

6.4. Sample Receiving procedures are discussed in SOP, SMO-GEN.

7. APPARATUS AND EQUIPMENT

7.1. Atomic Absorption Spectrophotometer equipped with a vapor generator, quartz absorption cell and mercury hollow cathode lamp.
7.2. 300ml BOD bottles
7.3. Hot water bath capable of maintaining a temperature of 90-95°C.
7.4. Pipettes and graduated cylinders.

8. PREVENTIVE MAINTENANCE

All maintenance activities are recorded in a maintenance logbook kept for each instrument. CAS staff performs most routine maintenance and troubleshooting. Other maintenance or repairs may, or may not require factory service, depending upon the nature of the task. Typical preventive maintenance measures include, but are not limited to, the following items:

- Check gases and tubing, daily
- Check optic tubes and filter membrane for moisture

9. STANDARDS AND REAGENTS

9.1. Mercury stock solution (1,000 mg/L) - Purchased. Store at room temperature. Dispose per manufacturer's expiration date.

9.2. Intermediate Stock Solution (10 mg/L) - Prepare a 1/100 dilution of the 1000mg/L Stock Solution in a volumetric flask and dilute with DI water. Acidify with 0.5ml of concentrated HNO_3. Store at room temperature for up to 1 week.

9.3. Working Solution (100 µg/L) - Prepare a 1/100 dilution of the 10mg/L Intermediate Stock Solution in a volumetric flask and dilute with DI water. Acidify with 0.5 of concentrated HNO_3. Prepare fresh each day the analysis is performed.

9.4. Calibration Standards - Transfer 0, 0.2, 0.5, 1.0, 2.0, 5.0, 10.0 ml aliquots of the 100 µg/L working solution to a series of labeled 300 ml BOD bottles. Add the appropriate amount of reagent water to bring each bottle to a final volume of 100 ml. Mix thoroughly and add 5 ml of concentrated H_2SO_4 and 2.5 ml of concentrated HNO_3 to each bottle. Continue procedure at step 11.2.

9.5. ASTM Type II water.

9.6. Concentrated Nitric Acid - Metals Grade.

9.7. Concentrated Sulfuric Acid - Metals Grade.

9.8. 5% w/v Potassium Permanganate Solution - Dissolve 50 g of $KMnO_4$ in 1 L of reagent water. Store at room temperature for up to 6 months.

9.9. 5% w/v Potassium persulfate solution - Dissolve 50 g of $K_2S_2O_8$ in 1 L of reagent water. Store at room temperature for up to 6 months.

9.10. 12% w/v Sodium chloride-hydroxylamine chloride solution - Dissolve 120 g of NaCl and 120 g of hydroxylamine hydrochloride (NH_2OH*HCl) in 1 L reagent water. (Hydroxylamine sulfate $(NH_2OH)_2$ H_2SO_4 may be used in place of hydroxylamine hydrochloride. Store at room temperature for up to 6 months.

9.11. 1.1% Stannous chloride + 3% HCl solution - Add 11.0 g of $SnCl_2 \bullet 2H_2O$ to 1L of 3% HCl. Prepare fresh each use.

9.12. The calibration blanks (ICB and CCB) must contain all reagents in the same concentrations and in the same volume as used in preparing the calibration solutions.

9.13. The preparation blank (PB) is prepared in the same manner as the calibration blank and is carried through the entire preparation scheme with each batch of samples to be analyzed.

9.14. The laboratory control sample (LCS) is prepared by fortifying 100 ml DI water with 1.0 ml of 100 µg/L CCV standard in 300 ml BOD bottle. The LCS must be carried through the entire sample preparation scheme with each batch of samples to be analyzed.

9.15. Continuing Calibration Verification Standard (CCV) - Prepare an intermediate stock solution and working solution of 10 mg/L and 100 µg/L as described in 9.2 and 9.3.

above using a different stock source. Transfer 3.0 ml of 100 µg/L solution (prepared daily) to a 300 ml BOD bottle. Add 5 ml of H_2SO_4 and 2.5 ml of HNO_3 mixing after each addition. Continue procedure at step 11.2.

9.16. The matrix spike sample (MS) is prepared by fortifying a 100 ml sample with 1.0 ml of 100 µg/L CCV standard in 300 ml BOD bottle. The MS must be carried through the entire analytical procedure.

10. RESPONSIBILITIES

10.1. It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. Final review and sign-off of the data is performed by the department supervisor or designee.

11. PROCEDURES

11.1. Shake the sample and measure 100 ml into a 300 ml BOD bottle. Add 5 ml of H_2SO_4 and 2.5 ml of concentrated HNO_3, mixing after each addition. Record all sample volumes and dilutions in the Mercury Run Log.

11.2. Add 15 ml of potassium permanganate to each sample, QC samples, and calibration standards. Let stand 15 minutes to ensure purple color persists.

Note: Samples with high organic content may required additional permanganate. Shake and add additional permanganate solution, if necessary, until the purple color persists for at least 15 minutes. Ensure that equal amounts of permanganate are added to all samples, standards and blanks.

11.3. Add 8.0 ml of potassium persulfate to each bottle and heat for 2 hr in a water bath maintained at 95°C.

11.4. Cool and add 6.0 ml of sodium chloride/hydroxylamine hydrochloride solution. The samples are now ready to be analyzed.

11.5. The final step of adding the stannous chloride solution to the sample volume to release the elemental mercury is done automatically by the vapor generator.

11.6. Analyze the standards and samples using the Perkin Elmer Flow Injection Mercury System. See Operations Manual for details.

11.7. Sample concentrations exceeding the Linear Range require sample dilution. Dilutions should be performed so that the instrument concentration will fall in the mid-range of the calibration curve. See ADM-DIL

12. QA/QC REQUIREMENTS

12.1. Calibration and Standardization: Calibration Standards for the initial calibration must be prepared with each analysis. For samples analyzed under Method 245.1 protocol, a blank and 5 standards are required. For samples analyzed under Method 7470A, a blank and 5 standards is required. The correlation coefficient for each calibration must ≥0.995.

12.2. Method Detection Limit (MDL) - A mercury MDL must be determined annually using 7 replicates of a fortified blank solution at a concentration of 2-3 times the estimated detection limit. Practical Quantitation Limits (PQLs) are calculated from the MDL by multiplying the MDL by a factor of at least 3. The PQLs are generally used as CAS Reporting Limits. To determine the MDL, refer to CAS SOP *ADM-MDL*.

12.3. Method Performance Data Assessment and Corrective Actions

12.3.1. Preparation Blanks must be analyzed at least one PB with each batch of 20 or fewer samples of the same matrix. PB values must not exceed the MRL (method reporting level). If the PB is out of control, fresh aliquots of the samples must be reprepared and analyzed again for affected analytes after the source of the contamination has been corrected and acceptable PB values have been obtained.

12.3.2. Laboratory Control Samples assess laboratory performance against the required control limits listed in Appendix C of the Quality Assurance Manual. If the recovery of mercury falls outside the required control limits, the analysis is judged to be out of control, and the source of the problem should be identified and resolved before continuing analysis. Redigestion and analysis is required until acceptable LCS recovery is performed.

12.3.3. Calibration Verification Standards must immediately follow each calibration, after every tenth sample, and at the end of the sample run. Initial Calibration Verification must verify that the instrument is within ±5% of calibration for Method 245.1 and ±10% for Method 7470A. Continuing Calibration Verification standards must confirm the calibration within ±10% throughout the analyses. Refer to Appendix C of the Quality Assurance Manual. If the recovery of mercury falls outside the required control limits, the analysis is judged to be out of control, and the source of the problem should be identified and resolved before continuing analysis. Reanalysis of any sample(s) associated with the outlying ICV or CCV standards is required. All samples must be bracketed with acceptable ICV and CCV standards.

12.3.4. Sample Matrix Accuracy and Precision are assessed based upon MS and Duplicated performance. Refer to Appendix C of the Quality Assurance Manual for frequency and QC criteria per method of analysis. If the recovery of mercury falls outside the required control limits, the analysis is judged to be out of control or interferences are present and the source of the problem should be identified and resolved before continuing analysis. Redigest and analyze the QC samples to

confirm the outlying recovery or precision. If QC is confirmed, report original data. If QC is acceptable, the original digestion is suspected and the entire batch needs to be redigested and analyzed.

13. DATA REDUCTION AND REPORTING

13.1. Calculations:

13.1.1. From the prepared calibration curve compute sample values by comparing response with the standard curve. Calculate the mercury concentration in the sample by the formula:

µg/L Mercury = (µg Hg in aliquot)*(1000 / ml of aliquot)*dilution

13.2. Reporting

13.2.1. Record all sample volumes and dilutions in the Mercury Run Log.

13.2.2. Record all concentrations determined at the instrument and calculate the final results in µg/L. Print out a lims run report and attach to the instrument print out.

13.2.3. Data Review shall be in accordance to SOP ADM-DREV.

13.2.4. Report mercury concentrations to the proper significant figures in mg/L or µg/L as required.

14. WASTE MANAGEMENT AND POLLUTION PREVENTION

Reagents are prepared upon an as-needed basis in small quantities. Minimum sample volumes are used during analysis. Acidic waste is neutralized and poured down the drain with copious amounts of water. Samples with mercury concentrations exceeding 0.2 ppm are disposed of as hazardous waste, see CAS SOP *SMO-SPLDIS.*

15. REFERENCES

15.1. *Test Methods For Evaluating Solid Waste, Physical/Chemical Methods*. USEPA SW-846, 3rd Edition, September 1994.

15.2. *Methods For the Determination of Metals in Environmental Samples Supplement I.* USEPA/600/R-94/111, May 1994

15.3. EPA Contract Laboratory Program, Statement of Work for Inorganic Analysis, SOW No. ILM04.0.

15.4. Analytical Services Protocol (ASP), New York State Department of Environmental Conservation, December 1995.

16. TRAINING OUTLINE

16.1. Read current SOP and applicable methodologies. Demonstrate a general understanding of the methodology and chemistry.

16.2. Observe Sample Preparation and Analysis.

16.3. Participate in the methodology, documentation, and data reduction with guidance.

16.4. Review Instrument Operation and Maintenance.

16.5. Demonstrate Competency by performing the analysis independently. Analyze a known proficiency or standard four times to establish Initial Demonstration of Capability. If recovery is within acceptable limits, complete training form and certificate and file with QA. Continuing Demonstration of Capability is required on an annual basis, refer to ADM-TRANDOC.

17. INSTRUMENT-SPECIFIC ADDENDUM

17.1. Perkin Elmer Flow Injection Mercury System (FIMS)

17.2. Refer to Manufacturer Operation Manuals located near FIMS instrument.

18. ATTACHMENTS

Analytical Preparation Log

19. CHANGES FROM PREVIOUS REVISION

- Revised Section 9.0 to make standards and reagents consistent in units, final volume, and matrix.
- Revised Section 12.0 to reference Appendix C in the Quality Assurance Manual for QC frequency and evaluation criteria.
- Revised Section 12.3.1 to omit preparation blank criteria other than being less than the reporting limit.
- Revised Section 16.5 to include certificate completion.

Columbia Analytical Services

Analysis For: Hg **EPA Method: 7470 / 7471 / 245.1 / 245.5** **Analyst:** _____

[redacted] Temp: _____ **Report: Routine / ASP / Pkg.5** Date Prepped: _____

[redacted]ne In: _____ **File Name:** _____ Date Analyzed: _____

Time Out: _____

	Client / Submission #	Sample Number	Initial Wgt/Volume (g/ml)	Final Volume (ml)		Client / Submission #	Sample Number	Initial Wgt/Volume (g/ml)	Final Volume (ml)
1					31				
2					32				
3					33				
4					34				
5					35				
6					36				
7					37				
8					38				
9					39				
10					40				
11					41				
12					42				
13					43				
14					44				
15					45				
16					46				
[redacted]					47				
					48				
19					49				
20					50				
21					51				
22							**Std 0.2***	0.20ml of 0.1ppm	100
23							**Std 0.5***	0.50ml of 0.1ppm	100
24							**Std 1.0***	1.00ml of 0.1ppm	100
25							**Std 2.0***	2.00ml of 0.1ppm	100
26							**Std 5.0***	5.00ml of 0.1ppm	100
27							**Std 10.0***	10.0ml of 0.1ppm	100
28							**ICV/CCV****	3.00ml of 0.1ppm	100
29							**LCSW/MS****	1.00ml of 0.1ppm	100
30							**CRDL***	0.20ml of 0.1ppm	100

Lot # of Reagents Used:

HNO3: _____ H2SO4: _____ HCL: _____ K2S2O8: _____ KMnO4: _____

SnCl2: _____ NaCl: _____ NH2OH-HCL: _____ LCSS CAS Lot#: _____

LCSS ERA Lot#: _____

*Source Standard: (Vendor/Lot #)_____ **ICV Standard: (Vendor/Lot #)_____

*(10ppm stock Lot#: _____) **(10ppm stock Lot#: _____)

[redacted]1ppm working std Lot#: _____) **(0.1ppm working std Lot#: _____)

Comments/Problems: _____

_____

STANDARD OPERATING PROCEDURE

for

DETERMINATION OF MERCURY IN SOLID OR SEMISOLID WASTE BY COLD VAPOR ATOMIC ABSORPTION SPECTROMETRY

SOP No.: MET-7471A/245.5

Revision: 3.0

November 1, 2001

Approved by: _____ 11/1/01
Supervisor Date

_____ 11/1/01
QA Coordinator Date

_____ 11/1/01
Laboratory Director Date

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Annual review of this SOP has been performed and the SOP still reflects current practice.
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Initials: _____ Date: _____

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1. SCOPE AND APPLICATION

1.1. Methods 245.5 and 7471A are cold-vapor atomic absorption procedures used in determining the concentration of mercury in soils, sediments, bottom deposits and sludge-type materials. The range of the method is 0.2 to 10 ug/L. The range may be extended above or below the normal range by increasing or decreasing the sample size.

2. METHOD SUMMARY

2.1 A known portion of a soil sample is transferred to a BOD bottle with a ground glass stopper. It is digested in diluted potassium permanganate solution and oxidized for thirty minutes at 95°C. Mercury in the digested water sample is reduced with stannous chloride to elemental mercury and measured by the conventional cold vapor atomic absorption technique.

3. DEFINITIONS

3.1. Calibration Blank - A volume of reagent water acidified with the same acid matrix as in the calibration standards. The calibration blank is a zero standard and is used to auto-zero the instrument.

3.2. Calibration Standard - A solution prepared from the dilution of stock standard solutions. The CAL solutions are used to calibrate the instrument response with respect to analyte concentration.

3.3. Laboratory Duplicates - Two aliquots of the same sample taken in the laboratory and analyzed separately with identical procedures. Analyses of duplicate sample indicates precision associated with laboratory procedures, but not with sample collection, preservation, or storage procedures.

3.4. Laboratory Control Sample (LCS) - An aliquot of an ERA soil sample with a known concentration. The LCS is analyzed exactly like a sample, and its purpose is to determine whether the methodology is in control and whether the laboratory is capable of making accurate and precise measurements.

3.5. Matrix Spike (MS) - An aliquot of an environmental sample to which a known quantity of the method analyte is added in the laboratory. The MS is analyzed exactly like a sample, and its purpose is to determine whether the sample matrix contributes bias to the analytical results. The background concentrations of the analytes in the sample matrix must be determined in a separate aliquot and the measured values in the LFM corrected for background concentrations.

3.6. Preparation Blank (PB) - An aliquot of reagent water or other blank matrices that are treated exactly as a sample including exposure to all glassware, equipment, solvents, reagents, and internal standards that are used with other samples. The PB is used to

determine if the method analyte or other interferences are present in the laboratory environment, reagents, or apparatus.

3.7. **Linear Dynamic Range (LDR)** - The concentration range over which the instrument response to an analyte is linear.

3.8. **Method Detection Limit (MDL)** - The minimum concentration of an analyte that can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero.

3.9. **Standard Addition** - The addition of a known amount of analyte to the sample in order to determine the relative response of the detector to an analyte within the sample matrix. The relative response is then used to assess either an operative matrix effect or the sample analyte concentration.

3.10. **Batch** - Unit of samples prepared together on the same day, not to exceed 20 samples.

4. INTERFERENCES

4.1. Interferences have been reported for soils containing sulfide, chloride, copper and tellurium. Organic compounds, which have broad band UV absorbance (around 253.7 nm), are confirmed interferences. The concentration levels for interferants are difficult to define.

4.2. Low level mercury sample preparation, digestion, and analysis may be subject to environmental contamination if preformed in areas with high ambient backgrounds where mercury was previously employed as an analytical reagent in analyses such as total kjeldahl nitrogen (TKN) or chemical oxygen demand (COD).

5. SAFETY

5.1. The toxicity and carcinogenicity of each reagent used in this method has not been fully established. Each chemical should be regarded as a potential health hazard and exposure to these compounds should be minimized by good laboratory practices. Normal accepted laboratory safety practices should be followed during reagent preparation and instrument operation. Always wear safety glasses or full-face shield for eye protection when working with these reagents.

6. SAMPLE CONTAINERS, COLLECTION, PRESERVATIONS, AND STORAGE

6.1. Because of the extreme sensitivity of the analytical procedure and the presence of mercury in a laboratory environment, care must be taken to avoid extraneous contamination. Sampling devices, sample containers and plastic items should be determined to be free of mercury; the sample should not be exposed to any condition in the laboratory that may result in contamination from airborne mercury vapor.

6.2. Non-aqueous samples are maintained at 4°C from receipt until analysis.

6.3. The preserved sample should be analyzed within 28 days of collection. Once digested, samples are analyzed as soon as possible.

6.4. Sample Receiving procedures are discussed in SOP, SMO-GEN.

7. APPARATUS AND EQUIPMENT

7.1. Atomic Absorption Spectrophotometer equipped with a vapor generator, quartz absorption cell and mercury hollow cathode lamp.
7.2. 300ml BOD bottles
7.3. Hot water bath capable of maintaining a temperature of 90-95°C.
7.4. Pipettes and graduated cylinders.

8. PREVENTIVE MAINTENANCE

8.1 All maintenance activities are recorded in a maintenance logbook kept for each instrument. CAS staff performs most routine maintenance and troubleshooting. Other maintenance or repairs may, or may not require factory service, depending upon the nature of the task. Typical preventive maintenance measures include, but are not limited to, the following items:

- Check gases and tubing, daily
- Check optic tubes and filter membrane for moisture before analysis

9. STANDARDS AND REAGENTS

9.1. Mercury stock solution (1,000 mg/L) - Purchased. Store at room temperature. Dispose per manufacturer's expiration date.

9.2. Intermediate Stock Solution (10 mg/L) - Prepare a 1/100 dilution of the 1000mg/L Stock Solution in a volumetric flask and dilute with DI water. Acidify with 0.5 ml of concentrated HNO_3. Store at room temperature for up to 1 week.

9.3. Working Solution (100 µg/L) - Prepare a 1/100 dilution of the 10mg/L Intermediate Stock Solution in a volumetric flask and dilute with DI water. Acidify with 0.5 ml of concentrated HNO_3. Prepare fresh each day analysis is performed.

9.4. Calibration Standards - Transfer 0, 0.2, 0.5, 1.0, 2.0, 5.0, 10.0 ml aliquots of the 100 µg/L working solution to a series of labeled 300 ml BOD bottles. Add the appropriate amount of reagent water to bring each bottle to a final volume of 10 ml. Add 5 ml of aqua regia, then proceed to 11.2.

9.5. ASTM Type II water

9.6. Concentrated Nitric Acid – Metals Grade, purchased commercially. Expires as per manufacturer's indications.

9.7. Concentrated Sulfuric Acid – Metals Grade, purchased commercially. Expires as per manufacturer's indications.

9.8. Aqua regia: Prepare immediately before use by carefully adding three volumes of concentrated HCl to one volume of concentrated HNO_3.

9.7. 5% w/v Potassium Permanganate Solution - Dissolve 50 g of $KMnO_4$ in 1 L of reagent water. Store at room temperature for up to 6 months.

9.8. 12% w/v Sodium chloride-hydroxylamine chloride solution - Dissolve 120 g of NaCl and 120 g of hydroxylamine hydrochloride ($NH_2OH*HCl$) in 1 L of reagent water. (Hydroxylamine sulfate $(NH_2OH)_2\ H_2SO_4$ may be used in place of hydroxylamine hydrochloride. Store at room temperature for up to 6 months.

9.9. 1.1% Stannous chloride + 3% HCl solution - Add 11.0 g of $SnCl_2*2H_2O$ to 1 L of 3% HCl. Prepare daily.

9.10. The calibration blanks (ICB and CCB), prepared daily, must contain all reagents in the same concentrations and in the same volume as used in preparing the calibration solutions.

9.11. The preparation blank (PB) is prepared in the same manner as the calibration blank and is carried through the entire preparation scheme with each batch of samples to be analyzed.

9.12. With each batch of samples to be analyzed, prepare a laboratory control sample (LCS) by weighing a 0.60g portion of an ERA soil standard and place in the bottom of a 300 ml BOD bottle. The LCS must be carried through the entire sample preparation scheme.

9.13. Continuing Calibration Verification Standard (CCV) - Prepare an intermediate stock solution and working solution of 10 mg/L and 100 µg/L as described in 9.2 and 9.3. above using a different stock source. Transfer 3.0 ml of 100 µg/L solution (prepared daily) to a 300 ml BOD bottle. Add 7 ml of reagent water and 5 ml of aqua regia, then proceed to 11.2.

9.14. The matrix spike sample (MS) is prepared by fortifying a 0.6g sample with 1.0 ml of 100 µg/L CCV standard in 300 ml BOD bottle and is carried through the entire digestion and instrument procedure as if it was a routine sample.

10. RESPONSIBILITIES

10.1. It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. Final review and sign-off of the data is performed by the department supervisor or designee.

11. PROCEDURES

11.1. Weigh 0.6g portion of a representative sample (approx. 0.2g portions from three areas of the sample) and place in the bottom of a 300 ml BOD bottle. Add 5 ml of reagent water and 5 ml of aqua regia.

11.2. Heat in the water bath for 2 minutes at 95°C. Cool, then add 50 ml of reagent water and 15 ml of potassium permanganate solution. Mix thoroughly and place in the water bath for 30 minutes at 95°C.

Note: Samples with high organic content may required additional permanganate. Shake and add additional permanganate solution, if necessary, until the purple color persists for at least 15 minutes. Ensure that equal amounts of permanganate are added to all samples, standards and blanks.

11.3. Cool and add 6.0 ml of sodium chloride/hydroxylamine hydrochloride solution. Add 50 ml of reagent water and the samples are now ready to be analyzed.

11.4. The final step of adding the stannous chloride solution to the sample volume to release the elemental mercury is done automatically by the vapor generator.

11.5. Analyze the standards and samples using the Perkin Elmer Flow Injection Mercury System. See Operations Manual for details.

11.6. Sample concentrations exceeding the Linear Range require sample dilution. Dilutions should be performed so that the instrument concentration will fall in the mid-range of the calibration curve. See ADM-DIL.

12. QA/QC REQUIREMENTS

12.1. Calibration and Standardization: Calibration Standards for the initial calibration must be prepared with each analysis. For samples analyzed under Method 245.1 protocol, a blank and 5 standards are required. For samples analyzed under Method 7470A, a blank and 5 standards is required. The correlation coefficient for each calibration must ≥ 0.995.

12.2. Method Performance Data Assessment and Corrective Actions

12.2.1. Preparation Blanks must be analyzed at least once per batch of 10 or fewer samples of the same matrix for Method 245.5 and once per batch of 20 or fewer samples for Mehtod 7471A. PB values must not exceed the MRL (method reporting limit). If the PB is out of control, fresh aliquots of the samples must be prepared and analyzed again for affected analytes after the source of the contamination has been corrected and acceptable PB values have been obtained.

1.1.1. 12.2.2. Laboratory Control Samples assess laboratory performance against the required control limits. The control limit range is specific for each lot and is recorded on a certificate from the manufacturer. If the recovery of mercury falls outside the required control limits, the analysis is judged to be out of control, and the source of the problem should be identified and resolved before continuing analysis. Redigestion and analysis is required until acceptable LCS recovery is performed.

12.2.3. Calibration Verification Standards must immediately follow each calibration, after every tenth sample, and at the end of the sample run. Initial Calibration Verification must verify that the instrument is within ±5% of calibration for Method 245.5 and ±10% for Method 7471A. Continuing Calibration Verification standards must confirm the calibration within ±10% throughout the analyses. If the recovery of mercury falls outside the required control limits, the analysis is judged to be out of control, and the source of the problem should be identified and resolved before continuing analysis. Reanalysis of any sample(s) associated with the outlying ICV or CCV standards is required. All samples must be bracketed with acceptable ICV and CCV standards.

12.2.4 Sample Matrix Accuracy and Precision are assessed based upon MS and Duplicated performance. Refer to Appendix C of the Quality Assurance Manual for frequency and QC criteria per method of analysis. If the recovery of mercury falls outside the required control limits, the analysis is judged to be out of control, and the source of the problem should be identified and resolved before continuing analysis. Redigest and analyze the QC samples to confirm the outlying recovery or precision. If QC is confirmed, report original data. If QC is acceptable, the original digestion is suspected and the entire batch needs to be redigested and analyzed.

12.2.5 Method Detection Limit (MDL) - A mercury MDL must be determined annually using 7 replicates of a fortified blank solution at a concentration of 2-3 times the estimated detection limit. Practical Quantitation Limits (PQLs) are calculated from the MDL by multiplying the MDL by a factor of at least 3. The PQLs are generally used as CAS Reporting Limits. To determine the MDL, refer to CAS SOP *ADM-MDL*.

13. DATA REDUCTION AND REPORTING

13.1. Calculations:

13.1.1. From the prepared calibration curve compute sample values by comparing response with the standard curve. Calculate the mercury concentration in the sample in mg/Kg by using the formula:

mg/Kg = Vol. (ml)/sample Wt(g) **x** 1mg/1000ug **x** 1L/1000ml **x** 1000g/1Kg **x** C **x** dilution

C = concentration of Hg in digestate, in ug/L

13.2. Reporting

13.2.1. Record all sample masses and dilution factors in the Preparation and Run Log.

13.2.2. Record all concentrations determined at the instrument and calculate the final results in mg/Kg to three significant figures. Print out a LIMS run report and attach to the instrument print out.

13.2.3. Data Review shall be in accordance with SOP, ADM-DREV.

14. WASTE MANAGEMENT AND POLLUTION PREVENTION

Reagents are prepared upon an as-needed basis in small quantities. Minimum sample volumes are used during analysis. Acidic waste is neutralized and poured down the drain with copious amounts of water. Samples with mercury concentrations exceeding 0.2 ppm are disposed of as hazardous waste, see CAS SOP *SMO-SPLDIS.*

15. REFERENCES

15.1. *Test Methods For Evaluating Solid Waste, Physical/Chemical Methods*. USEPA SW-846, 3rd Edition, September 1994.

15.2. *Methods For the Determination of Metals in Environmental Samples Supplement I.* USEPA/600/R-94/111, May 1994

15.3. EPA Contract Laboratory Program, Statement of Work for Inorganic Analysis, SOW No. ILM04.0.

15.4. Analytical Services Protocol (ASP), New York State Department of Environmental Conservation, December 1995.

16. TRAINING OUTLINE

16.1 Read current SOP and applicable methodologies. Demonstrate a general understanding of the methodology and chemistry.

16.2 Observe Sample Preparation and Analysis.

16.3 Participate in the methodology, documentation, and data reduction with guidance.

16.4 Review Instrument Operation and Maintenance.

16.5 Demonstrate Competency by performing the analysis independently. Analyze a known proficiency or standard four times to establish Initial Demonstration of Capability. If recovery is within acceptable limits, complete training form and certificate and file with QA. Continuing Demonstration of Capability are required on an annual basis, refer to ADM-TRANDOC.

17. INSTRUMENT-SPECIFIC ADDENDUM

17.1. Perkin Elmer Flow Injection Mercury System (FIMS)

17.2. Refer to Manufacturer Operation Manuals located near the FIMS instrument.

18. ATTACHMENTS

- Mercury Preparation Log

19. CHANGES FROM PREVIOUS REVISION

- Revised Section 9.0 to make standards and reagents consistent in units, final volume, and matrix.
- Revised Section 12.0 to reference Appendix C in the Quality Assurance Manual for QC frequency and evaluation criteria.
- Revised Section 12.3.1 to omit preparation blank criteria other than being less than the reporting limit.
- Revised Section 16.5 to include certificate completion.

Columbia Analytical Services

Analysis For: Hg **EPA Method:** 7470 / 7471 / 245.1 / 245.5 **Analyst:** _____

[redacted] Temp: _____ **Report:** Routine / ASP / Pkg.5 Date Prepped: _____

[redacted]me In: _____ **File Name:** _____ Date Analyzed: _____

Time Out: _____

	Client / Submission #	Sample Number	Initial Wgt/Volume (g/ml)	Final Volume (ml)			Client / Submission #	Sample Number	Initial Wgt/Volume (g/ml)	Final Volume (ml)
1						31				
2						32				
3						33				
4						34				
5						35				
6						36				
7						37				
8						38				
9						39				
10						40				
11						41				
12						42				
13						43				
14						44				
15						45				
16						46				
[redacted]						47				
[redacted]						48				
19						49				
20						50				
21						51				
22								Std 0.2*	0.20ml of 0.1ppm	100
23								Std 0.5*	0.50ml of 0.1ppm	100
24								Std 1.0*	1.00ml of 0.1ppm	100
25								Std 2.0*	2.00ml of 0.1ppm	100
26								Std 5.0*	5.00ml of 0.1ppm	100
27								Std 10.0*	10.0ml of 0.1ppm	100
28								ICV/CCV**	3.00ml of 0.1ppm	100
29								LCSW/MS**	1.00ml of 0.1ppm	100
30								CRDL*	0.20ml of 0.1ppm	100

Lot # of Reagents Used:

HNO3: _____ H2SO4: _____ HCL: _____ K2S2O8: _____ KMnO4: _____

SnCl2: _____ NaCl: _____ NH2OH-HCL: _____ LCSS CAS Lot#: _____

LCSS ERA Lot#: _____

*Source Standard: (Vendor/Lot #)_____ **ICV Standard: (Vendor/Lot #)_____

*(10ppm stock Lot#: _____) **(10ppm stock Lot#: _____)

[redacted].1ppm working std Lot#: _____) **(0.1ppm working std Lot#: _____)

Comments/Problems: _____

_____

STANDARD OPERATING PROCEDURE

DETERMINATION OF TRACE METALS BY GRAPHITE FURNACE ATOMIC ABSORPTION SPECTROMETRY (GFAA)

SOP Code: MET-GFAA

Revision: 3.0

September 27, 2001

Approved by: _____ 11/1/01
Department Manager — Date

_____ 11/1/01
Quality Assurance Coordinator — Date

_____ 11/1/01
Laboratory Director — Date

© Columbia Analytical Services, Inc.
1 Mustard Street, Suite 250
Rochester, New York 14609

Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
Initials: _____ Date: _____
Initials: _____ Date: _____

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Will Not Be Updated

1.0 SCOPE AND APPLICATION

1.1 This procedure describes the procedure for the analysis of soil, sludge and water digestates by graphite furnace atomic absorption (GFAA) spectrometry. Typically, this procedure is applicable to the analytes and EPA methods listed in Table 1. Other elements may be determined when reference is made to the applicable published method. All analytical methods used are in accordance with EPA methods from SW-846 and EPA 200 Series, the EPA Contract Laboratory Program (CLP) statement of work (SOW), and the NYSDEC Analytical Services Program (ASP).

1.2 The Practical Quantitation Limits (PQL) are listed in Table 1. The reported PQL may be adjusted if required for specific project requirements, however, the capability of achieving other reported PQLs must be demonstrated. Results may be reported to the Instrument Detection Limits (IDLs) upon request. IDLs are updated quarterly. The Method Detection Limits (MDLs) are updated annually and are available upon request.

2.0 METHOD SUMMARY

2.1 Prior to analysis, samples must be digested using appropriate sample preparation methods. A representative aliquot of sample is prepared as described in the applicable digestion SOP. Refer to the following Metals Digestion SOPs:

MET-3005A	Metals Digestion, Waters, Total Recoverable and Dissolved for ICP
MET-3010A	Metals Digestion, Waters for ICP
MET-3020A	Metals Digestion, Waters for GFAA
MET-3050B	Metals Digestion, Soils, Sediments and Sludges for ICP and GFAA
MET-CLP	Metals Digestion, Waters and Soils for CLP

2.2 The digestate is analyzed for the element(s) of interest, using GFAA conditions (See Instrument Specifications by Metal Manual in the GFAA lab) for the element to be determined. Absorbance is measured as a function of element concentration.

2.3 For GFAA analyses by CLP procedures, see the applicable CLP SOW or ASP.

3.0 DEFINITIONS

3.1 **Analytical Sequence** - Samples are analyzed in a set referred to as an analytical sequence. The sequence begins with instrument calibration followed by analysis of sample digestates interspersed with analysis of calibration verification standards.

3.2 **Initial Calibration Verification (ICV)** - ICV solutions are made from a stock solution which is different from the stock used to prepare calibration standards and is used to verify the validity of the standardization.

3.3 **Matrix Spike** (MS) - In the matrix spike analysis, predetermined quantities of standard solutions of certain analytes are added to a sample matrix prior to sample digestion and analysis. The purpose of the matrix spike is to evaluate the effects of the sample matrix on the methods used for the analyses. Percent recoveries are calculated for each of the analytes detected.

3.4 **Duplicate Sample** (DUP) - A laboratory duplicate. The duplicate sample is a separate field sample aliquot that is processed in an identical manner as the sample proper. The relative percent difference between the samples is calculated and used to assess analytical precision.

3.5 **Method Blank** - The method blank is an artificial sample designed to monitor introduction of artifacts into the process. The method blank is carried through the entire analytical procedure.

3.6 **Continuing Calibration Verification Standard (CCV)** - A standard analyzed at specified intervals and used to verify the ongoing validity of the instrument calibration.

3.7 **Instrument Blank (CCB)** - The instrument blank (also called continuing calibration blank) is a volume of blank reagent of composition identical to the digestates. The purpose of the CCB is to determine the levels of contamination associated with the instrumental analysis.

4.0 INTERFERENCES

Interferences are dealt with through the use of matrix modifiers (commonly Ni and Pd) and post digestion spikes. Detailed discussion of interferences may be found in the applicable EPA method.

Interferences from contaminated reagents must be eliminated. The purity of acids must be established by the laboratory as being high enough to eliminate the introduction of contamination above the Method Detection Limit.

5.0 SAFETY

Normal precautions as per the CAS EH&S Manual are to be followed. In addition, because acids are used in the procedure, there is a danger of exposure to corrosives. Sufficient care must be taken in handling acidic solutions. Safety glasses must be worn while preparing and handling the solutions. Gloves and a laboratory coat should be worn while handling samples, acids, and sample digestates.

6.0 SAMPLE COLLECTION, CONTAINERS, PRESERVATION, AND STORAGE

6.1 Either glass or plastic sample containers may be used.

6.2 All aqueous samples are preserved with nitric acid to a pH of <2.

6.3 Soil and aqueous samples for GFAA analyses by CLP procedures are stored at 0-6 °C. from time of receipt until digestion. Soil and aqueous samples for GFAA analyses by other procedures are stored at ambient temperature from time of receipt until digestion.

6.4 Holding time for samples for GFAA analyses is 6 months (sample collection to digestion).

6.5 Samples are received in the GFAA analysis laboratory as 0.5% nitric acid digestates. Sample digestates are stored in labeled plastic B-cups or Hot Block digestion vessels.

7.0 APPARATUS AND EQUIPMENT

7.1 Graphite furnace atomic absorption spectrophotometer (AAS). See Appendix A for element-specific instrument parameters.

7.2 Hollow Cathode Lamp (HCL) or Electrodeless Discharge Lamp (EDL) for each metal analyzed by this procedure.

7.2.1 Electrodeless Discharge Lamp power supply.

7.3 100-1000uL Eppendorfs

7.4 2 ml Beaker cups compatible with the AAS autosampler.

7.5 Volumetric flasks of suitable precision and accuracy.

8.0 PREVENTIVE MAINTENANCE

All maintenance activities are recorded in a maintenance logbook kept for each instrument. Most routine maintenance and troubleshooting is performed by CAS staff. Other maintenance or repairs may, or may not require factory service, depending upon the nature of the task. Typical preventive maintenance measures include, but are not limited to, the following items:

- Cleaning the quartz windows
- Changing the graphite tubes

- Cleaning the capillary tube
- Change filter in Separator Trap annually or if necessary
- Inspection and cleaning of electrodes, shroud, and cells as needed.

9.0 STANDARDS, REAGENTS, AND CONSUMABLE MATERIALS

9.1 Concentrated Nitric Acid – Metals Grade or higher to eliminate the introduction of contamination above the method detection limit.

9.2 Matrix Modifiers

Palladium Modifier Dilute 10 mls Palladium Nitrate (1%) plus 1.0 ml Magnesuim Nitrate (2%) with 100.0 ml DI. Expires within 6 months at room temperature. Used for arsenic, selenium, and thallium.

Ammonium Dihydrogen Phosphate (purchased) Dilute 1.0 g to 100 mls DI. Expires 6 months at room temperature. Used for lead analysis.

9.3 Standards

9.3.1 1000 ppm Stock Standards (AA Grade) - Commercially available certified solutions.

9.3.2 The GFAA Calibration Stock Standard is made by pipetting the volume of the 1000 ppm As, Pb, Se, and Tl stock standards shown in the table below, plus 0.50 ml of concentrated nitric acid into a 100 ml volumetric flask and diluting to volume with DI water. Prepare Calibration Stock Standard weekly.

Analyte	**ml of Stock Std. (1000 ppm)**	**Add 0.50 ml conc. HNO_3 and dilute to**	**Final Concentration (mg/L)**
Arsenic	0.50	100 ml	5.0
Lead	0.45	100 ml	4.5
Selenium	0.50	100 ml	5.0
Thallium	0.50	100 ml	5.0
Lead - DW	0.30	100 ml	3.0

9.3.3 The GFAA Calibration Working Standard is prepared by diluting 1.0 ml of the GFAA Calibration Stock Standard and 0.5 ml of concentrated nitric acid to 100 ml with DI water. Final concentrations range from 0.030 to 0.050 mg/L. Prepare calibration working standard fresh each day.

9.3.4 The GFAA Initial and Continuing Calibration Verification (ICV andCCV) Stock Standard is made by pipetting the volume of the 1000 ppm As, Pb, Se, and Tl

stock standards shown in the table below, plus 0.50 ml of concentrated nitric acid into a 100 ml volumetric flask and diluting to volume with DI water. Prepare the ICV / CCV Stock Standard from a second source, weekly.

Analyte	ml of Stock Std. (1000 ppm)	Add 0.50 ml conc. HNO_3 and dilute to	Final Concentration (mg/L)
Arsenic	0.25	100 ml	2.5
Lead	0.20	100 ml	2.0
Selenium	0.25	100 ml	2.5
Thallium	0.25	100 ml	2.5
Lead - DW	0.14	100 ml	1.4

9.3.5 The GFAA CCV Working Standard is prepared by diluting 1.0 ml of the GFAA CCV Stock Standard and 0.5 ml of concentrated nitric acid to 100 ml with DI water. Final concentrations range from 0.014 to 0.025 mg/L. Prepare CCV working standard fresh each day.

9.3.6 The Continuing Calibration Blank (CCB) is prepared by diluting 5.0 ml of concentrated HNO_3 to 1000 ml with DI water.

10.0 RESPONSIBILITIES

It is the responsibility of the analyst to perform the analysis according to the instructions in this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are only to be performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. This demonstration is in accordance with the training program of the laboratory. Final review and sign-off of the data is performed by the department supervisor/manager or designee.

11.0 PROCEDURE

11.1 Instrument Operation and Data Acquisition Procedure

11.1.1 Instrument performance specifications are specified in the operations manual located in the GFAA Lab. Refer to these when setting the parameters for acquisition and select the set of parameters applicable to the element being measured. For Arsenic, Lead, Selenium, and Thallium, the gas type is 95% argon-5% hydrogen. The modifiers used are 500 ppm Pd and 500 ppm $Mg(NO_3)_2$.

11.1.4 Turn on computer and instrument. Install appropriate HCL or EDL lamp and turn on by going to the Align Lamps screen. Allow the Hollow Cathode Lamp to warm up atleast 15 minutes and the Electrodeless Discharge Lamp atleast one hour. This warm up time is used to insure maximium optimization is achieved.

11.1.5 Wipe down the autosampler tip before each analysis. Inspect and clean, if necessary, the electrodes, shroud, lens and cells. If the instrument has a fume extractor be sure the Separator Trap is filled with deionized water.

11.1.6 Select Automatic Run and choose the appropriate program for analysis.

11.1.7 Go to Align Lamp screen and optimize lamp alignment.

11.1.8 Insert sample analysis sequence into Instrument Run Log. Create Sample Information File (sample labels) from logbook. Open the Method Editor and go to the Checks page. Assign a post digestion spike to the proper samples by setting parameters where is asks "Perform Recovery Measurements".

11.1.9 Load autosampler wheel with standards, blank, modifier, and sample digestates being analyzed, being sure to identify samples by their autosampler position in the instrument log book.

11.1.10 Start automatic run.

11.1.11 Monitor the analytical run for calibration and sample abnormalities.

11.1.12 Dilutions for samples with results over the calibration range are to be made manually and added to the autosampler.

11.2 Calibration

11.2.1 The analysis begins with the analysis of calibration standards. Analyze an instrument blank and four calibration standards. The correlation coefficient for each calibration shall be checked to determine that the coefficient is equal to or greater than 0.995.

11.2.2 Following calibration, analyze an ICV standard. The resulting value must be within 95-105% of the true value for 200 Series metals and 90-110% of the true value for SW-846 and ASP / CLP4.1. If not, prepare new standards and recalibrate the system.

11.3 Sample Analysis

11.3.1 Following calibration, analyze samples and QC samples in an analytical sequence. Refer to the *SOP for Analytical Batches and Analytical Sequences.*

11.3.2 Prepare and analyze post-digestion spiked samples. For ASP / CLP4.1 analyses, all samples must be post-spiked and analyzed. For routine analyses, one sample per submission / job number is spiked and evaluated. If the spike recovery is outside the control limits of 85-115%, all the samples in the batch are post-spiked and analyzed. If spike recoveries are within the acceptable limits, analysis is continued with no further spiking. If the post-digestion spike is <40% recovery the sample is diluted by a factor of 5-10 and reanalyzed. If the post-digestion spike is between 40-85% and the sample concentration is less than half of the spike the data is reported. For CLP4.1 a "W" flag will be on the Form I when this occurs.

11.3.3 Method of Standard Additions (MSA) analysis is required when an outlying post-digestion spike recovery is between 40-85% or >115% AND the sample absorbance or concentration is less than 50% of the spike. Quantitation is bias to some unknown interference that has been confirmed and dilution and reanalysis does not improve performance, therefore MSA must be performed by analyzing the sample plus 3 spikes at 50, 100, and 150% of the sample concentration (single injection is only required). Plot a linear regression curve of concentration vs. absorbance and quantitate sample concentration from the curve. Refer to the CLP SOW or NYSDEC ASP for proper qualifications of sample data.

12.0 QA/QC REQUIREMENTS

12.1 All GFAA sample analyses shall be performed with duplicate burns and the average reported. Duplicate burns should not exceed 20%RSD to maintain precision throughout the run. If RSD exceeds 20%, reanalyze once; if continues to be >20%, dilute 1:2 and reanalyze to avoid interference.

12.2 The correlation coefficient for each calibration must be equal to or greater than 0.995. The software produces the calibration curve point by point and does not reject a calibration that has a correlation coefficient < 0.995. The run must be stopped by the operator if the correlation coefficient fails.

12.3 Analyze CCV standards and CCBs no less frequently then every ten samples in the analytical sequence.

12.3.1 For CCVs, the resulting value must be 90-110% of the true value for CLP analyses and 80-120% for routine analyses. If not, recalibrate the system and reanalyze samples run since the last acceptable CCV.

12.3.2 For CCBs, the resulting value must be less than the PQL. Check the CCB result for carryover. Re-analyze if the CCB result is above the PQL.

12.4 Each sample preparation batch must have a method blank associated with it. The method blank result should be < PQL. If not, redigest the batch of samples.

12.5 A laboratory control sample (LCS) is digested one per batch, or per 20 samples. The LCS recovery criteria is listed in Appendix C of the Quality Assurance Manual. If the LCS fails the acceptance criteria, redigest the batch of samples.

12.6 Post-digestion spike recovery acceptance limits are 85-115%. If outside these limits for the Preparation Blank stop analysis, correct problem and reanalyze. If routine sample recovery fails all samples in the corresponding submission / job # must be spiked. If post-spike recovery is > 40%, samples may be run by the method of standard additions to prevent further dilution see sections 11.3.2 and 11.3.3.

12.7 A duplicate sample is digested one per batch, or per 20 samples (one per 10 if 200 Series is requested). Frequency and QC criteria are listed in Appendix C of the Quality Assurance Manual. If the RPD is greater than the limit, determine if the sample is non-homogenous. Redigest if necessary, otherwise data may be flagged with a "*" for job specific QC samples.

12.8 A matrix spiked sample is digested one per batch, or per 20 samples. Frequency and QC criteria are listed in Appendix C of the Quality Assurance Manual. If outside acceptance limits, redigest if necessary, otherwise the data may be flagged with a "N" for job specific QC samples. If the sample concentration is >4x the spike level, no action is required.

12.9 Additional QC measures include annual determination of method detection limits. Refer to ADM-MDL for procedure and requirements.

13.0 DATA REDUCTION AND REPORTING

13.1 Results for aqueous samples are calculated as follows and are reported in mg/L:

$$mg/L\ (sample) = C^{*} \times (Digestion\ Dilution\ Factor) \times (Post\text{-}Digestion\ Dilution\ Factor) \div 1000$$

13.2 Results for soil and solid samples are calculated as follows and are reported in mg/Kg.

$$mg / Kg\ (Sample) = C^{*} \times Post\ Digestion\ Dilution\ Factor \times \frac{Digestion\ Vol.\ (ml)}{Sample\ wt.\ (g)} \times \frac{1mg}{1000g} \times \frac{1L}{1000ml} \times \frac{1000g}{1Kg}$$

where C * is the concentration of the analyte as measured at the instrument in µg/L.

14.0 WASTE MANAGEMENT AND POLLUTION PREVENTION

14.1 It is the laboratory's responsibility to comply with all federal, state, and local regulations governing waste management, particularly the hazardous waste identification rules and land disposal restrictions, and to protect the air, water, and land by minimizing and controlling all releases from fume hoods and bench operations. Compliance with all sewage discharge permits and regulations is also required.

14.2 Excess, unused sample and testing byproducts are disposed following the procedures in the *SOP for Waste Disposal.*

15.0 REFERENCES

Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, EPA SW-846, 3rd Edition; (September 1986) and Updates I (July 1992), II (September 1994), IIA (August 1993), IIB (January 1995), III (December 1996).

Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, (Revised March 1993).

Methods for the Determination of Metals in Environmental Samples, EPA/600/4-91/010 (June 1991) and Supplement I, EPA/600/R-94/111 (May 1994).

EPA Contract Laboratory Program, Statement of Work for Inorganic Analysis, SOW No. ILM04.0.

Analytical Services Protocol (ASP), New York State Department of Environmental Conservation, December 1995.

16.0 TRAINING OUTLINE

16.1 Read current SOP and applicable methodologies. Demonstrate a general understanding of the methodology and chemistry.

16.2 Observe Sample Preparation and Analysis.

16.3 Participate in the methodology, documentation, and data reduction with guidance.

16.4 Instrument Operation and Maintenance, if applicable.

16.5 Demonstrate Competency by performing the analysis independently. Analyze a known proficiency or standard four times to establish Initial Demonstration of Capability. If recovery is

within acceptable limits, complete training form and certificate and file with QA. Continuing Demonstration of Capability is required on an annual basis, refer to ADM-TRANDOC.

17.0 INSTRUMENT-SPECIFIC ADDENDUM

See Operations Manual in GFAA Lab.

18.0 ATTACHMENTS

Table 1 Summary of Parameters, Methodology, and Reporting Limits

19.0 CHANGES FROM PREVIOUS REVISION

- Added reference to the Instrument Specifications per Metal Manual to Section 2.2.
- Changed Independent to Initial in Section 3.2
- Added reference to Hot Block digestion vessels in Section 6.5
- Added EDL Lamp and EDL power supply to Section 7
- Inserted how often the Calibration and ICV / CCV Standard Stocks should be prepared in Section 9.3.2 and 9.3.4
- Sections 11.0, 12.0 of previous SOP were revised to include more detail and referenced Appendix C of Quality Assurance Manual for QC criteria and frequency requirements.
- Deleted all references to analyzing Antimony by GFAA.

Table 1

Parameters, Methodology, and Reporting Limits

Parameter	Methology	Practical Quantitation Limit (PQL)	
		Water (mg/L)	Soil (ug/g)
Arsenic	206.2/7060A/CLP	0.0050	0.50
Lead	239.2/7421	0.0050	0.50
Lead	CLP	0.0030	0.30
Lead in Drinking Water	239.2	0.0010	
Selenium	270.2/7740/CLP	0.0050	0.50
Thallium	279.2/7841/CLP	0.010	1.0

*Contract Laboratory Program (CLP) references refer to ILM04.1 and/or 6010B-CLPM (ASP 1995).

STANDARD OPERATING PROCEDURE

PHENOLICS, TOTAL

GEN-420.2/9066
Revision 2

November 1, 2001

Approved By: _____ Supervisor — 11/13/01 Date

_____ QA Coordinator — 11/1/01 Date

_____ Laboratory Manager — 11/21/01 Date

©COLUMBIA ANALYTICAL SERVICES, INC. 2001
One Mustard St., Suite 250
Rochester, NY 14609

Annual review of this SOP has been performed and the SOP still reflects current practice.
Initials: _____ Date: _____
Initials: _____ Date: _____
Initials: _____ Date: _____

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Will Not Be Updated

1 SCOPE AND APPLICATION

1.1 This SOP is for the colorimetric determination of phenolic materials using EPA method 420.2 in drinking, surface and saline waters. SW846 9066 is used for ground waters, wastes, and soil. Modifications are discussed for soil and sludge analysis.

1.2 Practical Quantitation Limit (PQL) for waters is 0.005 mg/L and for soils is 0.10 ug/g (wet weight). The PQL may be extended down to 0.001 mg/L in clean waters using an additional calibration standard.

2 METHOD SUMMARY

In line distilled phenolic material reacts with 4-aminoantipyrine in the presence of potassium ferricyanide at a pH of 10 to form a stable reddish-brown colored antipyrine dye which is measured at 505 nm. The amount of color produced is a function of the concentration of phenolic material.

3 DEFINITIONS

3.1 **Matrix Spike (MS)** - In the matrix spike analysis, a predetermined quantity of standard solution is added to a sample matrix prior to distillation and analysis. The purpose of the matrix spike is to evaluate the effects of the sample matrix on the methods used for the analyses. Percent recoveries are calculated for the analyte detected.

3.2 **Duplicate Sample (DUP)** - A laboratory duplicate. The duplicate sample is a separate field sample aliquot that is processed in an identical manner as the sample proper. The relative percent difference between the samples is calculated and used to assess analytical precision.

3.3 **Method Blank** - The method blank is an artificial sample designed to monitor introduction of artifacts into the process. The method blank is carried through the entire analytical procedure.

3.4 **Laboratory Control Sample (LCS)** - In the LCS or blank spike analysis, predetermined quantities of standard solutions of certain analytes are added to a blank prior to sample distillation and analysis. Percent recoveries are calculated for the analyte detected.

3.5 **Initial and Continuing Calibration Verification (ICV/CCV)** – The ICV/CCV solution is prepared from a separate stock from the calibration standards and is used to verify the validity of the instrument calibration.

3.6 **Instrument Blank (ICB/CCB)** - The blank (also called initial or continuing calibration blank) is a volume of blank reagent of composition identical to the samples (DI in this test). The purpose of the CCB is to determine the levels of contamination associated with the analysis.

3.7 **Batch** - A group of no more than 20 samples that are analyzed together on the same day.

4 INTERFERENCES

4.1 Interferences from sulfur compounds may be eliminated by acidifying the sample to a pH <2 with H_2SO_4, aerating briefly with stirring, and adding $CuSO_4$.

4.2 Oxidizing agents such as chlorine can be removed immediately after sampling by the addition of an excess of ferrous ammonium sulfate. If chlorine is not removed, the phenolic compounds may be partially oxidized and the results may be low.

4.3 Most interferences are removed by distillation.

5 SAFETY

5.1 Wear a lab coat, safety glasses, and gloves when handling samples and reagent materials.

5.2 Material safety data sheets (MSDS) should be read prior to use of any chemicals required for the test.

6 SAMPLING HANDLING, COLLECTION, PRESERVATION, AND STORAGE

6.1 Sample bottles are 250 or 500 ml amber glass jars for waters and 4 or 8 oz. soil jars for solids.

6.2 Biological degradation is inhibited in waters by the addition of H_2SO_4 to a pH of <2.

6.3 Sample should be stored at 0-6°C until analysis. Holding time is 28 days from sample collection (26 days from VTSR for ASP).

6.4 Further sample handling, storage, and custody procedures are discussed in SMO-GEN.

7 APPARATUS AND EQUIPMENT

7.1 pH meter

7.2 In-line Microdistillation Unit - Refer to Instrument manual/method for settings.

7.3 Colorimetric Autoanalysis System - Refer to Section 17 for Instrument settings (additional information is provided in the instrument manual and methodologies).

7.4 8.5 mL Autoanalyzer Sample Cups

7.5 Disposable Microbeakers

7.6 Calibrated adjustable Micropipet with disposable tips

7.7 "Prefilters" – Nalgene 25 mm membrane pre-filters made of surfactant free cellulose acetate with acrylic housing.

7.8 small beakers (50-250 mLs)

7.9 Class A Pipets

7.10 Manual Distillation Materials

7.10.1 1000 mL Distillation Flasks with Stoppers
7.10.2 Glass Boiling Beads
7.10.3 Condensers
7.10.4 Heating Mantels
7.10.5 250 mL Erlenmeyer Flasks
7.10.6 pH Paper

8 PREVENTIVE MAINTENANCE

8.1 Change pump tubing regularly.

8.2 Occasionally clean the condenser with concentrated sulfuric acid. When the bulb of the condenser no longer holds liquid, it needs to be cleaned.

8.3 Occasionally change the silicon oil in the heating bath or it will gel.

8.4 Record all maintenance in the Phenols maintenance log book.

9 REAGENTS / STANDARDS

REAGENTS:

Note: All prepared reagents, unless noted, may be stored up to one year.

9.1 Acid solutions:

9.1.1 Concentrated Sulfuric Acid (H_2SO_4)- purchased commercially. Store at room temperature. Expires 3 years from receipt.

9.1.2 10% Sulfuric Acid - Add 10 mL Concentrated Sulfuric Acid to 90 mL Deionized Water (DI) and mix. Store at room temperature.

9.1.3 Concentrated Phosphoric Acid (H_3PO_4) - purchased commercially. Store at room temperature. Expires 3 years from receipt.

9.1.4 Distillation Reagent - Add 100 mL Concentrated Phosphoric Acid (H_3PO_4) to 900 mL DI and mix.

9.2 Bases:

9.2.1 Concentrated Sodium Hydroxide Solution - NaOH (50%) - purchased commercially. Store at room temperature. Expires 3 years from receipt.

9.2.2 5% NaOH - Add 10 mL of concentrated NaOH (50%) to 90 mL of DI and mix. Store at room temperature.

9.3 Copper sulfate - $CuSO_4 \bullet 5\ H_2O$ - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.4 Copper sulfate solution – Dissolve 100 g copper sulfate in DI and dilute to 1 L.

9.5 Sampler Wash Solution - Fill a flask with approximately 4 L DI. Bring to pH<2 with concentrated H_2SO_4 then adjust to pH 4.0±0.5 with concentrated NaOH solution. Prepare fresh each run.

9.6 Potassium Ferricyanide - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.7 Boric Acid - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.8 Potassium Chloride - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.9 Brij - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.10 Buffered Potassium Ferricyanide Solution (Phenols Color Reagent) - To 400 mL of DI add: 1.0g Potassium Ferricyanide, 1.56g Boric Acid, and 1.88g Potassium Chloride. Adjust pH to 10.3 using concentrated NaOH. Add DI to just below the line on the volumetric flask and add 0.5 mLs Brij. Dilute to 500 mLs with DI and mix. Store at 0-6 °C. Expires one week.

9.11 Aminoantipyrine (4-AAP) - purchased commercially. Store at room temperature. Expires upon manufacturer's indications or 3 years from receipt, whichever is sooner.

9.12 Aminoantipyrine solution: Dissolve 0.163g of 4-AAP (purchased commercially, expires upon manufacturer's indications or 3 years from receipt, whichever is sooner) in DI water and dilute to 250 mL. Prepare fresh each run.

STANDARDS:

9.13 Stock Standard Phenol Solution (1000 mg/L) - Purchased commercially. Store at 0-6 °C. Expires upon manufacturer's indications or one year from date of receipt, whichever is sooner.

9.14 Working Solution A (10 mg/L) - Dilute 1.0ml stock standard phenol solution (1000 mg/L) to 100 mL with wash solution or do two 1/10 serial dilutions of the 1000 mg/L standard. Working Solution A is used for LCS and MS spikes. Make fresh each run.

9.15 Working Solution B (1.0 mg/L): Dilute 1.0 mL of working solution A (10 mg/L) to 10 mL with wash solution. Working Solution B is used for curve standards. Make fresh each run.

9.16 Curve Standards: Fresh each run

	mL of 1.0 mg/L Working Solution B	mL of DI Wash Solution	Curve Standard Concentration (mg/L)
	1.50	8.5	0.150
	1.00	9.0	0.100
	0.70	9.3	0.070
	0.50	9.5	0.050
	0.20	9.8	0.020
	1/10 dilution of 0.100 mg/L standard		0.010
	1/10 dilution of 0.050 mg/L standard		0.005
(LL)	1/10 dilution of 0.010 mg/L standard		0.001
	0.00	10.0	0.000

9.17 Stock Reference Phenol Solution (1000 mg/L) – purchased commercially from a separate source as the Stock Standard Phenol Solution. Store at 0-6°C. Expires upon manufacturer's indications or 1 year from receipt, whichever is sooner.

9.18 ICV/CCV (0.10 mg/L) - Using 1000 mg/L Stock Reference Phenol Solution, do four 1:10 serial dilutions. Fresh each run.

9.19 LCS/MS Manual Distillation- Add 0.8 mLs Working Solution A (10 mg/L) to 200 mLs or 10.0 g sample prior to distillation. TV = 0.040 mg/L. Fresh each run.

9.20 LCS/MS InLine Distillation – Add 0.040 mLs Working Solution A (10 mg/L) to 10 mLs sample or DI. TV= 0.040 mg/L Fresh each run.

10 RESPONSIBILITIES

It is the responsibility of the analyst to perform the analysis according to this SOP and to complete all documentation required for data review. Analysis and interpretation of the results are performed by personnel in the laboratory who have demonstrated the ability to generate acceptable results utilizing this SOP. Final review and sign-off of the data is performed by the department supervisor or designee.

11 PROCEDURE

11.1 Manual Distillation - typically for soils, sludges, and oil matrices.

11.1.1 Turn water on for condenser.

11.1.2 For water samples, measure 200mL and 50 ml DI (or an aliquot diluted to 250ml) and add to the distillation flask. For soils, weigh 10g and add to the distillation flask and dilute with 250ml of DI.

11.1.3 Add glass boiling beads to each distillation flask.

11.1.4 Add 2.5 mL $CuSO_4$ solution to the distillation flask if sulfur compounds are suspected.

11.1.5 Place a 250ml erlenmeyer flask at the end of the condenser which has been marked at 200 mLs by weighing 200 g of DI in the flask and marking the meniscus.

11.1.6 Place the distillation flask on the heating mantle, connect to the condenser, and stopper the flask. Be sure both of these ground glass connections are secure.

11.1.7 Turn on heating mantle and distill approximately 180 ml, at a rate of approximately 1 drop per second.

11.1.8 Rinse the condenser with DI water and dilute the distillate to 200ml in the marked Erlenmeyer flask. If the distillate is turbid, filter about 6 mLs through a "pre-filter" into the sample cup just prior to analysis.

11.1.9 Proceed to colorimetric analysis, 11.2

11.2 In-line Distillation and Analysis - typically for waters and manual distilled samples.

Note: Be sure that the DI wash container is full of wash solution and that all lines are in the container.

11.2.1 Degas each reagent, except the ferricyanide reagent, with helium for 5 minutes.

11.2.2 Stretch pump tubing assembly over the pump using the middle hole on the left side and the outer hole on the right side.

11.2.3 Install pump plate to activate pump. Turn on the colorimeter (damp 2), distillation unit, and cooling water jacket feed. Pump the wash solution for several minutes. Place lines in reagents - baseline may take 30-45 minutes to settle. After about 15 minutes, place pen in chart recorder and turn chart recorder on. When baseline is stable, be sure the baseline is around 10 -15. If it is not, adjust to approximately this range and be sure it is stable.

11.2.4 Decant about 20-60 mLs of liquid from the top of a settled sample into a small, labeled beaker. This helps to avoid some filtering since most particulates are left on the bottom of the sample jar.

11.2.5 Adjust pH of samples to 4.0 ± 0.5 with NaOH and H_2SO_4 prior to analysis. If sulfur compounds are suspected, add $CuSO_4$ at a rate of 1g/L (0.1 g/ 100 mLs). If turbid, filter through a "pre-filter" into the sample cup.

11.2.6 Prepare standards while baseline is settling. Document which pipet(s) is used.

11.2.7 Prepare bench sheet and load samples into autoanalyzer sample cups using the following analytical sequence. All sample dilutions are made using the DI wash solution.

Standards in order of decreasing concentration
ICV/ICB
LCS
9 samples
CCV/CCB
10 samples
CCV/CCB
LCS
9 samples
CCV/CCB
Etc. until all samples are analyzed. Analyze DUP/MS every 10 samples in no particular position. Close run with CCV/CCB set.

11.2.7 Sample Dilutions – Sample peaks must be within the peak heights of the curve standards. Peak heights over the high standard must be diluted in accordance with ADM-DIL. Samples overdiluted must be run at a lesser dilution. Unless there is matrix interference, diluted samples with a peak height less than the height of the 0.020 mg/L curve standard should be run at a lesser dilution.

Analytical Notes:

⇒ *Sharp erratic peaks result from samples with interference and must be either diluted further or manually distilled.*

⇒ *A baseline with sharp erratic peaks may sometimes be fixed by slightly adjusting the baseline knob.*

⇒ *Baseline is manually determined because it is often erratic and drifts downward after a high sample. A straight line is drawn from the flat region on one side of a peak to that on the other side. The peak height is then determined from that line. A small peak that follows a large one should be determined with caution and may need to be repeated due to interferences from the large one.*

⇒ *Buildup of salts in the distillation coil will occasionally cause a clog in the system. The coil should be removed and cleaned with concentrated H_2SO_4, followed by a DI rinse.*

⇒ *If the condensate passes only to waste and not to the debubbler, the condenser should be removed and cleaned with acetone, followed by a DI rinse, concentrated H_2SO_4, and a final DI rinse.*

⇒ *For additional information, refer to Phenol AA Instrument Time/Maintenance Log.*

11.3 After the final sample peak has been drawn on the chart recorder:

11.3.1 Turn off the chart recorder and colorimeter. Remove pen from chart recorder.

11.3.2 Place reagent lines in DI wash and rinse for 10 minutes. Turn off distillation unit and continue rinsing for 10 minutes.

11.3.3 Turn off cooling water and remove pump plate.

11.3.4 Dispose of debubbler waste, DI wash reservoir waste, 4-AAP, sample, colorimeter and pump wastes into the sink. Put color reagent in the reagent cooler.

12 QA/QC REQUIREMENTS

12.1 QA/QC Samples Required

12.1.1 A Laboratory control sample (LCS) are analyzed per analytical batch or per 20 samples, which ever is more frequent. The result of the LCS must be within the limits set in the Wetchem QC table (QAM). If it is not, fix the problem, achieve an acceptable LCS, and reanalyze the affected samples.

12.1.2 A method blank must be manually distilled per manual distillation batch or for every 20 samples, which ever is more frequent. The result of the method blank must be less than the PQL. If it is not, the source of the contamination must be eliminated, the samples redistilled with an acceptable blank or the PQL may be increased.

12.1.3 One DUP is analyzed per 10 samples or fewer samples. The result of the DUP must be less than 20% RPD. If it is not, reanalyze the sample and DUP or flag the associated data.

12.1.4 One MS is analyzed per 10 or fewer samples. The result of the MS should be within the limits set in the Wetchem QC table (QAM). If it is not, respike a new aliquot and repeat to confirm or flag the associated samples.

12.1.5 The ICV is analyzed after the curve standards. The CCV is analyzed after every 10 samples throughout the analytical run. The result of the ICV and CCV's must be within the limits set in the Wetchem QC table. If it is not, the problem must be corrected, an acceptable CCV must be obtained and the affected samples must be re-analyzed.

12.1.6 The ICB is analyzed after the ICV. The CCBs are analyzed after every CCV. The result of the ICB/CCB must be less than the PQL. If it is not, fix the problem, achieve a compliant CCB, and reanalyze the affected samples.

12.1.7 An MDL study is performed annually and shall produce a result less than the PQL. For further discussion, refer to ADM-MDL.

13 DATA REDUCTION AND REPORTING

13.1 CALCULATIONS

13.1.1 Prepare a linear regression by plotting the absorbance (peak height) versus the concentration. The correlation coefficient must be ≥0.995. Determine sample concentration (mg/L) directly from the standard curve and multiply by the dilution factor.

13.1.2 Calculate final concentration by the following methods:

mg/L:

$$mg / L = \frac{mg / L \text{ (in solution)} \times \text{Final volume (ml)}}{\text{InitialVolume (ml)}}$$

mg/Kg as received:

$$mg / Kg = \frac{mg / L \text{ (in solution)} \times \text{Final volume (mL)}}{\text{Initial weight (g)}}$$

mg/Kg, Dry weight:

$$mg / Kg \text{ (Dry weight)} = \frac{mg / Kg \text{ (as received)}}{\% \text{ solids (in decimal form)}}$$

13.2 Reporting Limit = 0.005 mg/L or 0.001 mg/L for Low Level.

13.3 Record all numbers on benchsheets to three significant figures.

13.4 Data must be reviewed by the analyst and a peer (supervisor or qualified analyst) using a Data Quality Checklist before the results are validated and reported to the client. Further data review policies and procedures are discussed in ADM-DREV.

14 WASTE MANAGEMENT AND POLLUTION PREVENTION

All samples and reagents may be disposed of down the drain with copious amounts of water. For further information refer to SMO-SPLDIS.

15 REFERENCES

15.1 "Methods for the Chemical Analysis of Water and Wastes," USEPA 600/4-79-020, March 1983.

15.2 "Test Methods for Evaluating Solid Waste, Physical/Chemical Methods," SW-846, Third Edition, September 1986 (with updates).

16 TRAINING OUTLINE

16.1 Read current SOP and applicable methodologies. Demonstrate a general understanding of the methodology and chemistry. Follow policies in ADM-TRANDOC.

16.2 Observe Sample Preparation and Analysis. Follow Technicon Analysis Training Plan.

16.3 Participate in the methodology, documentation, and data reduction with guidance.

16.4 Perform Initial Demonstration of Competency by performing the analysis independently and analyzing a mid-range standard four times. If recovery is within acceptable limits, complete Training Plan Form and IDC Certificate and file with QA. Continuing proficiency shall be demonstrated annually using an outside PE source, an LCS, an internal unknown, or a new 4 replicate study.

17 INSTRUMENT ADDENDUM

Instrument Settings:

Colorimeter multiplier - 10.0
Colorimeter damp - 2
Distillation heater - 150 °C
Flowcell - 50 mm
Phototubes - 34Q
Light filters - 505 nm
Sample cam - 10/hour, 1:2 sample to wash ratio

Phenol module:

Green	Air	Green
Black	Air	Black
Purple	Sampler water	Black (silicone)
Green	Sample from sample cup	Green
White	Waste from cooling coil	White
Yellow	Sample after distillation	Yellow
Gray	Sample after debubbler	Gray
Orange	Distillation reagent	Orange
Green	To flowcell	Green
Black	Ferricyanide	Black
Black	4 - AAP	Black

18 ATTACHMENTS

Benchsheet

19 CHANGES TO PREVIOUS REVISION

- Added 9066 to method reference in title, header, and paragraph 1.1.
- Deleted previous 1.2 regarding the upper limit of the method.
- Clarified that sulfuric acid is added to waters (not soils) for preservation in 6.2.
- Added LCS to acceptable CDC in 16.4.
- Added pH adjust to benchsheet

Total Phenolics, EPA 420.2/9066

Columbia Analytical Services
1 Mustard Street
Rochester, NY 14609

Analyst: _____

Date: _____

Start Time: _____

CC:_____ Y-int:_____

Pipet ID: _____

Cup #	Subm. #	Order #	Pk Hght	mg/L	Dil'n	mg/L	Distillation Factor	mg/L	Adjust to pH 3.5 - 4.5 (y/n)
1									
2									
3									
4									
5									
6									
7									
8									
9									
0									
1									
2									
3									
4									
5									
6									
7									
8									
9									
0									

Comments:

White Sands Test Facility
Job Instruction

Issued: 09/15/99
Expires: N/A

WJI-CHEMLAB-0268.B

DETERMINATION OF PROPELLANT HYDRAZINES IN AQUEOUS SOLUTION USING HEWLETT PACKARD HPLC 1100 SERIES WITH AMPEROMETRIC DETECTION

Work-Authorizing Document: Laboratory Work Order

Prepared By: ORIGINAL SIGNED BY: _____
Wendy L. A. Fleming
Chemist
ATSC Team

Reviewed By: ORIGINAL SIGNED BY: _____
Catherine A. Hart
Quality Assurance
ATSC Team

Approved By: ORIGINAL SIGNED BY: _____
Andy Randall, Supervisor
Chemistry and Metallurgy Section
ATSC Team

ORIGINAL SIGNED BY: _____
David Baker
Laboratory Manager
NASA Laboratories Office

Rescissions: None.

Record of Revision

Issue	Date Revised	Pages Affected	Description of Changes
WJI-CHEMLAB-0268.B	09/15/99	All	Corrections and Updated Procedures

1. PURPOSE

The purpose of this WJI is to establish a routine procedure for the operation of the Hewlett Packard 1100 Series equipped with a Hewlett Packard 1049A Programmable Electrochemical Detector for the determination of hydrazine, monomethylhydrazine, and 1, 1-dimethylhydrazine in aqueous solutions.

2. REFERENCES

2.1 RD WSTF-0004, *WSTF Laboratories Department Chemical Hygiene Plan*

2.2 WJI-LSAFETY-0229, *Hazardous Chemical Spill Procedures*

2.3 User's Manual, *Hewlett Packard 1049A*

2.4 Installation and Maintenance Manual, *Autosampler*

2.5 User's Manual, *Hewlett Packard 1100 Series*

2.6 User's Manual, *Understanding Your ChemStation*

2.7 Johnson, D. L. and D. L. Baker. *Determination of Hydrazine, MMH, and UDMH in Aqueous Solution Using Cation Exchange HPLC with Amperometric Detection; Application to Airborne Propellant.* CPIA-PUB-588, August 1992.

2.8 Luskus, L. J. and H. J. Kilian. *Field Sampling and Analysis of Hydrazines and UDMH Vapors in Air: The Firebrick Method*. USAF School of Medicine. Report SAM-TR-82-29, October 1982.

3. ABBREVIATIONS AND ACRONYMS

CIC	Chemist in Charge
ICS	Instrument Check Standard
HPLC	High Performance Liquid Chromatography
LWO	Laboratory Work Order
MMH	Monomethylhydrazine
MSDS	Material Safety Data Sheet
S/N	Serial Number
OSHA	Occupational Safety and Health Administration
PVC	Poly Vinyl Chloride
RPD	Relative Percent Difference
UDMH	1, 1-dimethylhydrazine
WJI	White Sands Test Facility Job Instruction

4. ATTACHMENTS

4.1 Attachment A, Validation Data and Calibration Data

5. SAFETY REQUIREMENTS

5.1 OSHA Requirements

To meet the OSHA requirements of the Office of the Federal Register National Archives and Records Administration Title 29, Part 1910, Section 1450 "Occupational Exposure to Hazardous Chemicals in Laboratories," the *WSTF Laboratories Chemical Hygiene Plan* and all relevant MSDS's must be read.

5.2 Personal Protective Equipment

The following personal protective equipment must be worn when handling standards and samples to prevent exposure to hazardous substances:

- Safety goggles
- Lab coat
- Vinyl or PVC gloves when handling dilute solutions
- Pylox or butyl rubber gloves, in addition to goggles, face shield and rubber apron when handling neat propellants

Hydrazines used in this method are known or suspected carcinogens. Chemicals that are encountered in this procedure include:

- Hydrazine
- Monomethylhydrazine
- 1, 1-dimethylhydrazine
- Phosphoric acid
- Potassium phosphate, monobasic
- Potassium chloride
- Isopropanol

The samples and standards analyzed in this procedure are generally preserved by acidification to pH<2 with hydrochloric acid. When unacidified samples are encountered, they should be kept in a hood in sealed vials and analyzed as soon as possible.

6. GENERAL

6.1 Methodology

This method is used for the quantitative determination of propellant hydrazines at trace concentrations. Analytes are separated by cation exchange chromatography in a potassium phosphate buffer at pH 2.3 and detected amperometrically on a platinum working electrode. Retention times vary as the column ages. Hydrazine is the first analyte to elute, then MMH, followed by UDMH. This method measures free hydrazines.

6.2 Personnel Qualifications

Personnel performing the operation must be qualified as a Liquid Chromatograph Analyst according to the *WSTF Certification Plan* and demonstrate the ability to meet the performance criteria summarized in Table 1.

6.3 Quality Control

Data quality from this analysis is monitored by the analysis of check standards, blanks, spikes, duplicates, and control samples. Table 1 specifies the minimum required QA/QC samples. The analysis of additional QA/QC samples is up to the discretion of the CIC.

Table 1. QA/QC Requirements for Fuels by HPLC

Control Type	Minimum Frequency	Control Limits	Comments
Instrument Check Std.	Beginning and end of analysis	± 15% of Known Value	Verify Calibration
Reagent Blanks	Beginning and end of analysis	< Reporting Limit	Establish the System is Clean
Spiked Samples	Chemist's discretion	75% - 125%	Verify Accuracy
Duplicate Samples	Chemist's discretion	RPD ≤ 20%	Verify Precision

6.3.1 CALIBRATE BEFORE USE

The HP HPLC 1100 Series is a calibrate before use instrument. Quantitative analysis is achieved by the comparison of the instrument's response to a sample versus a calibration curve obtained by using propellant grade fuels conforming to their current Mil Specs. The identity of the fuels and the traceability to the Mil Spec analysis of the fuels must be recorded in the Analytical Laboratory Liquid Chromatography Standards Logbook. The identity of the instrument check standard(s) (and the calibration

standards, if applicable) and the corresponding samples analyzed must be recorded in the HP 1100 HPLC Calibrate Before Use Logbook with enough information provided to achieve traceability of samples to standards. At a minimum the logbook will include the following:

- Date of Analysis
- Analysts Initials
- Date last calibrated.
- ICS concentration and preparation date.
- Samples Analyzed (or reference to samples). At a minimum annotate the sequence file name.

Calibration reports/curves must be maintained in the Calibration Logbook. This logbook will include, at a minimum, the instrument's ID number, a reference to previous Calibration Logbooks, and a complete record of all calibration activities performed to date, including identification and source of standards. The calibration standard preparation dates will also be included.

All instrument maintenance must be recorded in the instrument maintenance logbook.

6.3.2 INSTRUMENT CHECK STANDARD

One ICS must be run at the beginning of an analytical batch. The CIC will determine the appropriate ICS concentration to be analyzed. It must contain all the fuels that are analyzed in the batch. The result must be within ± 15 percent of the nominal value. If not within accepted limits, re-analyze the check standard. If the results are still outside accepted limits, notify the CIC for resolution of the problem. The instrument may require recalibration.

The check standard must be run at the end of the batch to verify system calibration throughout the analyses. If the check standard fails, all results for samples analyzed after the last passing check standard are considered invalid and these samples must be reanalyzed or appropriately qualified.

6.3.3 BLANK

After calibration has been verified, a reagent blank must be analyzed before any samples to ensure the system is free of contamination. The reagent blank must be run at the end of the batch to verify system cleanliness throughout the analyses. Eluent should be run as the reagent

blank. If an analyte is found at a level ≥ the reporting limit all results for samples analyzed after the last passing blank are considered invalid and these samples must be reanalyzed or appropriately qualified.

6.3.4 MATRIX SPIKE

A matrix spike is an aliquot of sample spiked with a known concentration of a target analyte. The spike concentration should be at least 10 times the WSTF reporting limit for the analyte of interest or greater than the sample concentration, whichever is higher. Consult the CIC when preparing a matrix spike. Prepare the matrix spike again if the recovery is not within ± 25 percent of the known spike concentration. If it fails again, consult the CIC.

6.3.5 DUPLICATES

A duplicate is the analysis of the same sample twice. The calculation of duplicate precision is described in Step 8.7.3. If the RPD is not ≤ 20 % consult the CIC.

6.4 Data Acquisition

ChemStation is a Hewlett Packard product for data acquisition and reduction as well as instrument control. The HP ChemStation user interface is designed into Views that group software functionality according to typical analytical tasks. Three standard views are present in all software configurations:

- Method and Run Control view, for controlling and acquiring data from the instrument.
- Data Analysis view, for reviewing and reevaluating data that has been acquired.
- Report Layout view, for designing specific report layouts.

A method is comprised of three components:

- Method information, descriptive information about the method.
- Instrument control, defines the parameters that control the instrument or its components. Parameters such as mobile phase composition, flow rate, injection volume, the detector settings, etc.
- Data analysis defines the parameters that control the data processing: signal details, integration events, peak identification, peak quantification, calibration, and the report.

The graphical user interface of the HP ChemStation system comprises toolbars and a status bar in the Method and Run Control View of the HP ChemStation. The status bar comprises a system status field and information on the currently loaded method and sequence. If they were modified after loading they are marked with a red triangle. A yellow EMF symbol reminds the user that usage limits set for consumables have been exceeded. Consult the ChemStation manual for more detailed information on EMF.

Method and Run Control View illustrates a graphical representation of your HPLC system. An icon represents each component. The diagram allows quick access to dialog boxes for setting parameters for each system component. Using the following color-coding, the current status is displayed:

- yellow- not ready
- green- ready
- blue- run
- red- error

7. SYSTEM VALIDATION

The HPLC 1100 Series system was validated in accordance with good analytical practices. System validation documentation is found in Attachment A. Also refer to Reference 2.7.

8. PROCEDURE

8.1 Reagents and Apparatus

All chemicals should conform to analytical reagent grade specifications or otherwise be of suitable purity (free of interfering substances). The water used to prepare the reagents and buffer should be purified such as that from the Milli-Q system. For best system performance and results, filter particulates from all solutions including samples.

8.1.1 ELUENT SOLUTION

The eluent is a potassium phosphate buffer with a pH of 2.3. The eluting cation is the potassium ion at a concentration of 0.066 M. The buffer is prepared by dissolving 0.35 g of KCl, 9.00 g of KH_2PO_4, and 4.0 mL of conc. H_3PO_4 diluted up to 1.00 L of deionized water. The buffer is filtered under vacuum through a 0.45 µm nylon filter. Transfer to the eluent reservoir. The reservoir should be labeled with the contents. Excess eluent should be refrigerated.

8.1.2 STOCK FUEL STANDARDS

When preparing stock standards from neat propellant, use the proper handling procedures associated with this task. Prepare 500 mL of 1% v/v H_3PO_4 by bringing 5 mL of conc. H_3PO_4 up to 500 mL with deionized water. Clean three 100 mL volumetric flasks thoroughly with deionized water. Add 1% v/v H_3PO_4 almost to the line on the flasks. Stopper the flasks and label each flask with ~1000 mg/L and the fuel name. In the Analytical Laboratory Liquid Chromatography Standards Logbook record the grams of each stoppered flask to 4 decimal places. Add 0.10 g of the appropriate fuel to the appropriate flask.

Fuel	Density
Hydrazine	1.0036 g/mL
MMH	0.874 g/mL
UDMH	0.782 g/mL

Stopper the flasks and record the grams to 4 decimal places. Use the difference of the gross weight and the initial weight to determine the mg of fuel added. Bring each flask to volume with 1% v/v H_3PO_4 and calculate the concentration in mg/L taking into account the actual purity of the neat propellant. Record the Hoke S/N of each propellant used with the associated LWO number of the Military Specification analysis performed on that propellant, date of preparation, and preparer's initials in the Analytical Laboratory Liquid Chromatography Standards Logbook.

Transfer each standard to a plastic bottle or other suitable storage container (i.e. I-Chem). Label each with the calculated analyte concentration, matrix, Hoke S/N, LWO number of the Military Specification analysis, date of preparation, and preparer's initials.

8.1.3 CALIBRATION STANDARDS

Use the formula $C_1V_1 = C_2V_2$ to calculate the volume of stock fuel standard needed to result in a 100 mg/L fuel standard mix in a 100 mL volumetric flask. Prepare the dilution with eluent.

From the 100 mg/L fuel standard mix, perform the appropriate dilutions, with eluent, required to generate the necessary calibration curve. Store the calibration standards in suitable storage containers labeled with concentration of standard, matrix, preparation date, preparer's initials, and reference the stock standards prepared from. Record the preparation of each standard in the Analytical Laboratory Liquid Chromatography Standards Logbook.

8.1.4 INSTRUMENT CHECK STANDARD

The ICS and calibration standards must be prepared from independently prepared stock fuel standards. The preparation of these and the traceability to each Hoke and Mil. Spec. analysis will also be recorded in the Analytical Laboratory Liquid Chromatography Standards Logbook.

8.1.5 APPARATUS

In addition to general laboratory glassware, required apparatus includes 5 mL plastic syringes, 13 mm filters with 0.2 or 0.45 micron porosity, HPLC vials and caps, pipettes, and plastic transfer pipettes.

8.2 Instrument Setup

The liquid chromatograph, column, and conditions are given below. Virtually all of the operating parameters are retained in the memory and controlled through HP ChemStation.

8.2.1 HPLC

Hewlett Packard Model 1100 Series high performance liquid chromatograph equipped with a Model 1049A Electrochemical Detector. Injections are made using an autosampler.

8.2.2 COLUMN

The column is a strong cation exchange column (i.e. Whatman Partisil 10 SCX, 4.6 mm x 250 mm). See Section 9.3 for column maintenance.

8.2.3 DEGASSER

Eluent flows from the reservoir through channel A of the vacuum degasser. The degasser is generally left on and is operating properly when both lights on the front panel (Power and Monitor) are illuminated.

8.2.4 PUMP

The pump is set to deliver eluent at a flow rate of 1.000 mL/min during analyses. The backpressure from the system is typically about 43 bar at this flow rate. If the pressure exceeds 60 bar, indicating a blockage, investigate. The high pressure limit parameter is set to 400 bar; the pump will go into ERROR mode if this pressure is reached.

8.2.4.1 Pump Parameters (ChemStation)

Accessed by using the mouse to click on the pump/injection portion of the diagram

FLOWRATE 1.000 mL/min

STOPTIME	10.00min (may be increased if needed)
SOLVENT	A: 100% Phosphate Buffer (isocratic)
PRESSURE LIMITS	Max 400 bar Min 0 bar
INJECTION WITH NEEDLE WASH	
INJECTION VOLUME	Variable. Method dependent.
WASH VIAL	71
AUXILLIARY	draw speed 200 µL eject speed 200 µL draw position 0.0 min compressibility $100x10^{-6}$ max flow rate 100.00 mL/min

8.2.5 AUTOSAMPLER

The design of the autosampler provides for very little carryover. Contamination of the outside of the sampling needle or needle seat are the sources of cross contamination or carryover. The HP 1100 Series has a rinse cycle programmed in the method.

These precautions do not protect against needle seat contamination. Analytes from highly concentrated samples are carried on the needle tip to the needle seat during injections. A rinse is not practical during this part of the injection. The best safeguard against needle seat contamination is to simply dilute samples that are suspected to be highly concentrated. If needle seat contamination occurs, consult the maintenance CD-ROM.

8.2.2.1 HP 1100 Series Autosampler

The parameters are set up in the **HP 1100 SERIES PUMP, (Section 8.2.4.1)**.

8.2.3 DETECTOR

The analytes are detected by oxidation at a platinum working electrode relative to a Ag/AgCl reference electrode. The cell body is made of graphitized Teflon and functions as the counter electrode.

The detector is programmed to condition the platinum working electrode by pulsing the voltage between it and the auxiliary electrode for 84 seconds prior to each run. The detector begins pretreatment when it receives a START REQUEST from the autosampler. The detector sends a NOT READY signal to the autosampler during the pretreatment period. This period is 4.5 minutes to allow the baseline to stabilize in the direct current mode before injection.

The HP 1100 series system is equipped with the 1049A electrochemical detector controlled through ChemStation. Use the mouse to click on the detector to edit the parameters.

8.2.3.1 HP 1049A Electrochemical Detector Parameters

STOPTIME	as pump 10.00 min (may be increased if needed)
ECD POTENTIAL LC-ECD	
MODE	Pretreat
MORE	Potential
	P1 = 1.100V
	P2 = -0.200V
	P = 1.000V
	Time
	T1 = 20ms
	T2 = 100ms
	T3 = 20ms
	Cycles = 600
	Pretreat = Prepare
POTENTIAL	+ 1.000V
LIMITS	- 0.400V to + 1.400V

INCREMENT OFF

REPETITIONS not used

DRIFTRIGGER OFF

PREPARE TIME 4.5 min

STOPTIME as pump 10.00 min (may be increased if needed)

POSTTIME OFF

PEAKWIDTH 0.20min (Response time 2.00 sec)

ZERO CONTROL STOP

INSTRUMENT FULL SCALE 500(µA)

POLARITY oxidation

THERMOSTAT not used

SIGNAL DETAILS LC-ECD

AVAILABLE SIGNALS ECD1 A, Pretreat, Pot = 1.000
start 0.000 end 0.000 delay 0.000

8.3 Analysis of Samples

8.3.4 SAMPLE PREPARATION

8.3.4.1 Firebrick Sample Tube Preparation

Firebrick sampling tubes can either be purchased or prepared in the laboratory. The following steps outline the preparation of a firebrick tube within the laboratory.

8.3.4.1.1 Glass Tubing

Sampling tubes are prepared in 7 mm OD glass tubing. Rinse the tubing with 5% (v/v) HNO_3 followed by deionized water. Dry with GN_2. Cut into 3.5 in segments. Firepolish each end and create a

restriction near one end by heating. Purge each tube with GN_2 to remove any condensate.

8.3.4.1.2 Inert Support Material

To prepare 100 g of solid sorbent place 100 g of 45/60 Gas Chrom R (Alltech Associates) in 450 mL of deionized water in a 1000 mL beaker. Quickly heat to boiling, and boil for 2 minutes, then decant the cloudy washing liquid. Repeat the boiling process once, then repeat with room temperature deionized water until the water wash is clear (3-5 washes). Filter the firebrick slurry under vacuum through a Buchner funnel with filter. Air dry for 3 minutes, then transfer the filter to a 70°C N_2 purge oven to dry for 30-40 minutes.

8.3.4.1.3 Active Media

To prepare a 6M H_2SO_4 add approximately 50 mL deionized water to a 100 mL volumetric flask, then add 33 mL concentrated H_2SO_4 (18M). Bring to volume with deionized water.

To prepare a 0.86M H_2SO_4/methanol solution, add approximately 400 mL of methanol to a 500 mL volumetric flask, then add 72 mL of 6M H_2SO_4. Bring to volume with methanol.

Place 40 to 50g of dried firebrick into a tared 1000 mL beaker. Determine the weight in grams of firebrick in the beaker. Multiply the weight by 2.75. The result is the volume of 0.86M H_2SO_4 methanol solution to add to the firebrick. Pour the resulting slurry into several large petri dishes and dry in a 60°C N_2 purge oven for 30 minutes. The resulting sulfuric acid content will be approximately 60 mg per 300 mg acidified firebrick or 19% (w/w). Store the material in a closed labeled glass container.

8.3.4.1.4 Tube Loading

Place a small wad of Pyrex or glass wool in the tube from the end that is not restricted and gently press it down to the restriction. Using a funnel, pour 300 mg ± 15 mg of sulfuric acid coated firebrick into the tube. Gently press a second wad of Pyrex wool onto the top of the firebrick. Keep packing of the sorbent to a minimum. Fit clean, unused plastic caps to the tube ends and store the tubes in a closed glass container away from amines and hydrazines.

NOTE

USED CAPS CAN CONTAMINATE THE FIREBRICK!!!!

8.3.4.2 Firebrick Elution

Transfer the firebrick material and glass wool plugs from the firebrick tube to a test tube that will hold at least 12 mL. Add 10 mL of eluent solution using a digital or volumetric pipette. Cap and **agitate** (vortex, shake, invert or gently sonicate) the tube periodically or continually for 10 minutes. Draw approximately 2 mL of the firebrick eluent into a 5 cc syringe. Equip the syringe with a 13 mm 0.45 micron porosity filter. Expel the eluent through the filter into an HPLC vial. Cap the vial and label with the sample ID and total eluent volume.

8.3.4.3 Solid Sample Elution

Determine if the requestor requires hydrazine concentration by dry weight or wet weight. Dry the sample if required. Accurately weigh a portion of the sample (typically 1-2 g) into a clean Erlenmeyer flask or test tube. Record the sample weight on the work authorizing document. Add 10 mL of eluent solution using a digital or volumetric pipette. Cover and agitate the container for 10 minutes then sonicate for 10 minutes. Draw approximately 2 mL of the eluent into a 5 cc syringe. Equip the syringe with a 13 mm 0.45 micron porosity filter. Expel the eluent through the filter into an HPLC vial. Cap the vial and label with the sample ID and total eluent volume.

8.3.4.4 Liquid Samples

If the customer requires a total ug determination of hydrazines measure the total volume of the sample and record on the work authorizing document. Filter the sample through a 13mm 0.45 micron porosity filter via a 5 cc plastic syringe into an HPLC vial. Cap the vial and label with the sample ID.

8.3.4.5 Cleanup

Remove the filter from the syringe and dispose of in accordance with the current Waste Stream Profile. Rinse the syringe thoroughly with water and dispose of it in an ordinary laboratory trash can.

8.3.1 INSTRUMENT STARTUP

8.3.1.1 Open the HP ChemStation folder. Open LC-ECD online. A diagram of the system appears on the screen. You are in the **Method and**

Run Control View. It will be **red**; indicating the system is **not ready**.

8.3.1.2 Turn on the pump by clicking the mouse on the button next to the pump diagram. The pressure should increase to about 44 bar. If not, contact the CIC. Reservoir A, containing the phosphate buffer pH 2.3, should be selected indicated by the arrow. When the pump is on, the diagram will turn **green** indicating the system is in **ready** mode. The pump has a seal wash option which helps decrease corrosion of the pump seals when using corrosive buffers. A 10% isopropyl alcohol solution is used as the seal wash and runs continuously throughout the analysis. Prime the wash. Adjust the flow to a steady but slow drip at the outlet. When the instrument is not in use, the system should be rinsed with deionized water before it is brought down. This also will minimize corrosion and system blockage from salt build up.

8.3.1.3 Turn on the detector by clicking the **ON** button. The software will alert the operator to ensure that there is adequate flow of eluent.

8.3.2 AUTOSAMPLER

8.3.2.1 Fill a vial with eluent, cap it, and place it in position 71 of the tray. This is the wash vial. Label the vial "Blank".

8.3.2.2 Place another blank and a fuels standard in the tray, usually in positions 1 and 2 respectively. Load the vials to be analyzed. The sequence file must match the vial order.

8.3.2.3 If the injection volume needs to be changed, per the CIC, click on the syringe in the diagram. Enter the appropriate injection volume. Low concentration samples can be run at 100 µL, while higher concentrations can be run at 10, 1, or 0.1 µL. Injection volume should be selected such that the analyte concentration (in ng/µL) multiplied by injection volume (in µL) is less than 1000 when calibrated to 100 mg/L. An example calibration is from 0.10 mg/L to 10 mg/L with a 10 µL injection volume resulting in a reporting limit of 0.10 mg/L for hydrazine, MMH and UDMH.

8.3.3 SEQUENCE FILE

Create or edit a sequence file by clicking on Sequence then New Sequence or Load Sequence, respectively. Then click on Sequence and Sequence Table. Create or edit the sequence table. Enter the method, the number of injections

per vial, and sample type or identification, and the dilution factor if necessary. When the sequence is complete, click OK, then under **Sequence** go to the **Save Sequence As** command and save the sequence as the run date (e.g. 971107).

To save data files click on the directory path, under the illustration of the autosampler tray, then sequence parameters. Change the subdirectory to the run date (e.g. 971107). Click on **OK.** The files will automatically be saved as the vial number, sequence line, and injection number under the subdirectory which is saved as the run date. For example, the first injection of the first sample written in the first line of the sequence run on 11/07/97 will be 001-0101.d (sequence line, vial number, injection number) in the subdirectory 971107. The data file is located in **hpchem\2\data\971107\001-0101.d**. The software will warn you when there is a danger of overwriting files that already exist.

To program the sequence file for automatic pump and detector shutdown see Step 8.4.1

Click on **START**. If at anytime you wish to terminate the analysis, click on **STOP**. Real time view of the analysis in progress can be seen by maximizing the **Online Plot** window.

When analyzing a single vial, select the single vial icon at the top left of the Method and Run Control diagram. Then click on the vial titled MAIN SEAT. In the Sample Info screen enter the file name, and the run date under subdirectory. Identify the vial position. Click on OK, then START. To run a partial sequence select the partial sequence option under sequence. Click the boxes in the Sel column of the vials to be analyzed, then click on Run Sequence.

8.3.4 REINTEGRATION OF CHROMATOGRAMS

To reintegrate a chromatogram and save the new file select Data Analysis. Select file, load signal and then select the file to be reintegrated. Click OK. Select the appropriate integration task icons and reintegrate. To save reintegration select view, window functions, save window then click OK twice. The reintegrated file will be saved as chromreg.win under the original data file folder. To retrieve the chromreg.win file select file, load signal, and select the original data file. Then select view, window functions, load window and chromreg.win.

8.4 Automatic Instrument Shut Down

8.4.1 PUMP AND DETECTOR

In the **SEQUENCE PARAMETERS**, under **SHUTDOWN**, check **Post-sequence cmd/Macro** and then select **standby**. Standby will turn off the lamp and the pump immediately after the last run in the sequence table.

8.4.2 DETECTOR

Automatic shutdown of the lamp can be obtained by pressing <CELL ON/OFF> on the detector front panel. Press <⮟> to display AUTO CELL = CELL OFF. Press <⮟> again to display AFTER = 0; off. Determine how many runs remain in the sequence and multiply by 15 minutes (don't forget the blanks and standards). Use the numeric keypad to enter this number of minutes, then press <ENTER>. The cell will shut off after the specified time. Turning the cell on resets this condition.

8.5 Manual Shutdown

8.5.1 DETECTOR

Press <CELL ON/OFF> <⮞> <⮟> <ENTER> on the detector to turn the cell off **OR preferably** click on the **OFF** button on the diagram on the computer screen to turn the cell off and the pump off simultaneously. **NEVER** leave the cell on while the pump is off.

8.5.2 PUMP

Turn off the pump by clicking on the button next to the pump and hitting **OK** to turn off the pump. Remember to cinch off the 10% IPA seal wash solution.

8.6 Cleanup and Disposal

8.6.1 Empty the waste eluent according to the current Waste Stream Profile.

8.6.2 When directed by the responsible chemist, dispose of spent samples, blanks, standards, vials, and caps in accordance with the current waste profiles.

8.6.3 Leave the area clean for the next person. Pick up stray debris from the floor, empty the trashcans, and place any dirty glassware on the cart for cleaning. If any glassware has been broken, clean it up immediately.

8.7 Data Reduction and Reports

8.7.1 RESPONSE FACTORS

Linear calibration has been established for the three propellant hydrazines from 1.0 ng to 1000 ng injected (Reference 2.7). Calibration is based on peak areas. Response factors for each component are calculated as amount/response. Calibration of each analyte is done in the **Data Analysis View** under the "**scales**" or calibration version of the window.

8.7.2 Matrix spike recoveries are calculated by:

$$((C_{ms} - C_s) / C_{sp}) * 100 \quad \textbf{(1)}$$

Where:
C_{ms} is the concentration of matrix spike
C_s is the concentration of sample
C_{sp} is the concentration of spike

Matrix spike recoveries will be between 75 and 125 percent; if not, they will be re-analyzed or another matrix spike will be prepared and analyzed.

8.7.3 Duplicate precision is defined as relative percent difference and is calculated as follows. The RPD must be ≤ 20%; if not, they must be re-analyzed.

$$RPD = \frac{/ D_1 - D_2 /}{Mean} * 100 \quad \textbf{(2)}$$

Where:
D_1 = Duplicate 1
D_2 = Duplicate 2

8.8 Data Archival

8.8.1 The data obtained by this WJI are recorded on the report attached to the LWO and are archived with the data package from Chemistry Metallurgy Section.

8.8.2 ChemStation data files are archived frequently to appropriate storage media.

9. MAINTENANCE

NOTE

ALL INSTRUMENT MAINTENANCE MUST BE LOGGED IN THE INSTRUMENT MAINTENANCE LOGBOOK.

9.1 Detector Working Electrode

Fouling of the electrode is evidenced by broad, tailing peaks and/or increased baseline noise. A spare electrode is kept by the responsible chemist for replacement purposes. Locate the spare electrode and polish it as described on page 7-5 of the *1049A Operator's Handbook*. Turn the cell OFF and the pump OFF then replace the electrode as described on page 7-4 of the Operator's Handbook.

9.2 Autosampler Needle Seat Cleaning

Highly concentrated samples can leave residues of analytes on the needle seat of the autosampler. This will result in carryover that can linger for many injections. In extreme cases, replace the needle seat using the procedure on page 4-10 of the Autosampler Installation and Maintenance manual. Minor contamination can be rinsed from the needle seat with deionized water. Follow the procedure on page 4-10 to put the autosampler in the CHANGE NEEDLE mode, and remove the inner cabinet as described. Place a dry Kimwipe in the trough between the needle seat and the leak sensor. Rinse the needle seat using a 5-mL syringe filled with deionized water. Repeat the rinse several times using a fresh Kimwipe each time. Replace the inner cabinet and exit the CHANGE NEEDLE mode as described in the manual.

9.3 Column Replacement

As the column ages, its capacity decreases and retention times decrease. A new column should be installed when peaks are no longer resolved. Since new columns are shipped with methanol in them, they must be purged with deionized water before buffer is used. Flush the lines with deionized water (Reservoir C). Turn the pump off and disconnect the old column. Connect the new column. Turn the pump on and pump deionized water through the column for 30 minutes. Switch from the deionized water (Reservoir C) to the eluent reservoir (Reservoir A) and continue to pump through the column for at least 2 hours. Turn the detector cell on and run a standard multiple times.

9.4 Other

Procedures for nonroutine maintenance are described in the instrument manuals and in the maintenance CD-ROM.

Permanent Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

Temporary Deviation Index

Dev. No.	Dev. Sheet	Affected Page(s)	Affected Step(s)	Description	Entered By

Attachment A Issued: 09/15/99

Attachment A:
Validation Data and Calibration Data

Shown in the table below, standards independent of the calibration standards containing hydrazine, MMH, and UDMH were analyzed and the data reduced for precision and accuracy statistics.

TABLE I

Fuel Standard	Precision (%RSD)	Accuracy (%)
Hydrazine (1 mg/L)	1.2	99.0
Hydrazine (10 mg/L)	0.40	109
MMH (1 mg/L)	1.9	101
MMH (10 mg/L)	1.6	109
UDMH (10 mg/L)	0.82	99.8

Accuracy is also shown through the analysis of Blind Controls (CAH093 and 1CAH097B). Reference LWO 685164.

Calibration curves generated from duplicate injections of four standards (0.1 mg/L, 1.0 mg/L, 10 mg/L and 100 mg/L) establish linearity from 0.1 mg/L to 100 mg/L with correlation coefficients greater than 0.999 with an injection volume of 10 µL. This data satisfies the requirement outlined in TPS 2-LAB-972609.

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Division 01

Chemistry and Chemical
Engineering Division

QUALITY ASSURANCE PLAN
FOR
ANALYTICAL AND ENVIRONMENTAL SERVICES

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QUALITY ASSURANCE PLAN FOR ANALYTICAL AND ENVIRONMENTAL SERVICES

SwRI AUTHORIZATION SIGNATORIES

This is to certify that the Chemistry and Chemical Engineering Division Quality Assurance Plan for Analytical and Environmental Services has been reviewed and approved by the following personnel:

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TABLE OF CONTENTS

Section Title **Page No.**

IDENTIFICATION OF SUBMITTAL LABORATORY ..... **v**
INTRODUCTION **1**

1. MANAGEMENT RESPONSIBILITY **3**

1.1 Organization 3
1.2 Quality Council 5
1.3 Management Review 5

2. QUALITY SYSTEM **6**

2.1 Commitment to Quality Assurance (QA) 6
2.2 Quality Assurance Policy 6
2.3 Certification Programs/Audit Reports/Performance Evaluation Samples 6
2.4 Internal Laboratory Controls 6

3. CONTRACT REVIEW **7**

3.1 Review
3.2 Amendments to Contracts 7

4. DESIGN CONTROL **7**

5. DOCUMENT AND DATA CONTROL **7**

5.1 Test and Analytical Procedures 7
5.2 Data Review and Validation 8
5.3 Laboratory Notebooks 8

6. PURCHASING **9**

7. Control of Customer-Supplied Product **9**

8. ITEM IDENTIFICATION AND TRACEABILITY **9**

9. PROCESS CONTROL **10**

9.1 Documented Procedures 10
9.2 Security Controls 10
9.3 Environmental Controls 10

10. INSPECTION AND TESTING **12**

10.1 Analytical Procedures 12
10.2 Disposal of Samples 12

11. CONTROL OF INSPECTION, MEASURING, AND TEST EQUIPMENT **13**

11.1 Calibration Laboratory 13
11.2 Balances, Refrigerators, and Ovens 13

12. INSPECTION AND TEST STATUS **14**

13. CONTROL OF NONCONFORMANCES **14**

14. CORRECTIVE AND PREVENTIVE ACTION 14

15. HANDLING, STORAGE, PACKAGING, PRESERVATION, AND DELIVERY 15

16. CONTROL OF QUALITY RECORDS 16

16.1 Responsibility 16
16.2 Disposal of Records 16

17. INTERNAL QUALITY AUDITS AND SURVEILLANCES 16

18. TRAINING 17

18.1 New Staff Training 17
18.2 Demonstration of Capability 17

19. SERVICING 17

20. STATISTICAL TECHNIQUES 18

21. BIBLIOGRAPHY 19

GLOSSARY/DEFINITIONS 20

APPENDICES

Appendix A **Analytical Data Quality Objectives for Precision, Accuracy, and Detectability for Inorganic and Organic Parameters**

Appendix B **Method Detection Limits**

Appendix C **Analytical Instrumentation**

Appendix D **Division Organizational Charts**

Appendix E **Laboratory Analytical Methods**

Appendix F **Required Containers, Preservation Techniques, and Holding Times**

Appendix G **Personnel Resumes (available upon request)**

IDENTIFICATION OF SUBMITTAL LABORATORY

(Legal Identification)

Document Title:	Quality Assurance Plan for Analytical and Environmental Services for Southwest Research Institute's Department of Analytical and Environmental Department in San Antonio, Texas
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Plan Coverage:	Department of Analytical and Environmental Chemistry laboratory in San Antonio, Texas.

INTRODUCTION

Southwest Research Institute (SwRI) is a not-for-profit corporation organized under the laws of the State of Texas. It is a public service institution organized to work in the public interest in cooperation with industry, government, and individuals to produce a better way of life through science and technology. This objective is realized by making available a creative and thoroughly equipped scientific and engineering team, which works on behalf of its clients on a contractual basis. The Department of Analytical and Environmental Chemistry (DAEC) operates within the Chemistry and Chemical Engineering Division (C&CED) of Southwest Research Institute. The DAEC is identifiable within the organization of SwRI as a whole.

The C&CED of SwRI shall devote the necessary personnel and equipment to fulfill the quality assurance/quality control (QA/QC) requirements of all projects. The SwRI DAEC has implemented the Quality Assurance Program (QAP) described in this document to assure monitoring analytical measurement data of known acceptable quality to meet the requirements of each project's statement of work.

Each client program performance is ultimately directed by the contract. Deviations or conflicts between the contractual, SwRI Operating Procedures and Policies (OPP), or C&CED procedures are addressed through the use of project-specific plans. The Quality System Management is identified through the International Organization Standards (ISO) 9002 Standard Operating Procedures (SOP). The technical performance is controlled using Test and Analytical Procedures (TAPs) that are prepared to address the requirements of the contract, specific methods, and project-specific plans, if necessary. The laboratory assures client confidentiality in accordance with the OPP, Section 1.1.2.

The National Sanitation Foundation-International Strategic Registrations, Ltd (NSF-ISR) certified the C&CED to the ISO 9002 requirements April 2001. The laboratory performs analysis in the mixed waste programs for the Department of Energy. SwRI maintains a Radioactive Materials License (L00775) issued by the Texas Department of Health for the handling and analysis of radiochemical materials. A copy of this license and the safety procedures followed will be provided upon request.

The purpose of this QAP is to convey the philosophy, organizational structure, and procedures governing the QA/QC program for environmental sampling and analytical services performed by the Department of Analytical and Environmental Chemistry in San Antonio. This plan has been prepared in accordance with ISO 9002 Quality Systems Standard (International Organization of Standardization); *EPA Requirements for Quality Management Plans*, EPA QA/R-2, March 2001; *EPA Requirements for Quality Assurance Project Plans*, EPA QA/R-5, March 2001; *Quality Assurance*, Department of Energy Order 414.1a; American Society of Mechanical Engineers (ASME)/NQA-1, *Quality Assurance Program Requirements for Nuclear Facilities, and National Environmental Laboratory Accreditation Conference (NELAC)* Quality Systems elements.

The Institute Quality Systems at Southwest Research Institute is an independent organizational element that reports directly to the President of SwRI. The Division Quality Assurance support for projects has been tailored to meet the quality requirements imposed by organizations including:

- Department of Energy (DOE)
- Department of Defense (DOD)
- Nuclear Regulatory Commission (NRC)
- Environmental Protection Agency (EPA)
- Air Force Center for Environmental Excellence (AFCEE)
- Missouri River Division Authority (MRDA)
- Army Corp of Engineer (COE)
- Navy Installation Restoration Program (NIRP)

These quality programs have been designed to satisfy applicable requirements of quality documents such as:

- MIL-Q-9858A, MIL-I-45208A, MIL-STD-45662A
- Federal Acquisition Regulations (FAR) Paragraphs 52.246-1 through 52.246-8
- Food and Drug Administration (FDA)
- Good Laboratory Practices (GLP)
- Current Good Manufacturing Practices (cGMP)
- Environmental Protection Agency (EPA) Contract Laboratory Program (CLP)
- Comprehensive Environmental Response Compensation and Liability Acts (CERCLA)
- Resource Conservation and Recovery Act (RCRA)
- Safe Drinking Water Act (SDWA)
- Clean Water Act (CWA)
- Clean Air Act (CAA)
- Toxic Substances Control Act (TSCA)
- Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)

SwRI's Program Quality Plan (PQP-Nuclear), *Nuclear Services* describes an effective and economical Quality Assurance (QA) Program that complies with the requirements of 10 CFR 50, Appendix B, ASME NQA-1, and DOE 414.1. The procedures within this plan establish the basic quality requirements for activities such as Engineering, Inspection, and Testing performed by applicable C&CED personnel.

1. MANAGEMENT RESPONSIBILITY

1.1 Organization

This section details the organization of SwRI and the interrelationship of each division. Organization charts are presented in **Appendix D**. This section also covers the quality policy, authority and responsibility, resources, management representative, and management assessment. The laboratory provides managerial staff with the authority and resources needed to discharge duties as shown in the responsibilities outlined below. C&CED **SOP-01-1.1**, *Organization of the Chemistry and Chemical Engineering Division,* describes this element in detail and indicates the C&CED and the DAEC organizational structure. All personnel are free from any commercial, financial and other undue pressures, which might adversely affect the quality of the work as identified in the OPP, Section 1.1.4, *Employee Standards of Conduct*. The SwRI Quality System Manual establishes general quality element descriptions and requires division implementation through the development and use of specific procedures, as applicable, to the C&CED operations.

This Quality Assurance Plan defines all sampling, analytical services, and environmental measurements performed by the DAEC within C&CED. The items identified in the QAP ensure that the integrity of the laboratory organization and independence of judgment is maintained at all times. Responsibilities and functions of the positions identified in the DAEC have been qualified and evaluated to meet the educational and experience requirements. The tasks for each position may include, but are not limited to, the tasks shown.

1.1.1 Director

The Director has overall responsibility and authority for the administrative and technical operations of the Department, including, but not limited to, the following:

- Delegate technical and administrative authority
- Direct and coordinate the staff
- Direct and coordinate all technical, promotional, and administrative aspects of the Department activities
- Authorize final implementation of corrective actions
- Authorize final resolution of client complaints
- Approve staff training
- Conduct meetings with the staff to allocate resources
- Conduct meetings with senior staff to discuss present and future requirements of the Department

1.1.2 Project Manager

- Design the work plan/technical proposal
- Prepare proposals and bids
- Oversee technical and financial performance and completion of projects according to contractual agreements
- Apply scientific and engineering skills with effective administrative capability
- Assure maintenance of project records covering all project details
- Select trained and qualified test personnel
- Supervise assigned personnel
- Know proper use of laboratory equipment
- Oversee quality of reported data
- Establish client liaison
- Prepare reports
- Implement quality, technical, and safety procedures
- Perform other duties as assigned by management

1.1.3 Analytical Group Leader/Manager

- Supervise personnel
- Maintain/Supervise laboratory facilities and environment
- Maintain/Supervise laboratory equipment and calibration
- Perform sample and test control
- Implement quality, technical, and safety procedures
- Perform promotional efforts
- Provide technical oversight of activities in group or section
- Interface with clients
- Plan for future resource needs
- Implement staff development and training

1.1.4 Analyst/Technician

- Perform analyses
- Calculate analytical results
- Calculate quality control results
- Maintain control charts
- Report problems to the Analytical Group Leader/Manager for resolution

1.1.5 Quality Assurance Manager

- Responsible for the Quality System and its implementation
- Have direct access to the highest level of management of the laboratory and is independent from the laboratory operations
- Serve as the designated management representative providing direction and coordination of all quality aspects within the Division
- Serve as QA liaison between the all Departments within the division and Division Management
- Coordinate responses to Institute Quality Systems and external client audits
- Monitor the Division Quality System through inspections, surveillances, and internal audits on a planned and scheduled basis
- Serve as the point of contact for Institute Quality Systems and external client audits
- Assure that when audit findings cast doubt on the correctness or validity of laboratory test results, immediate corrective action is taken, including the immediate notification of any client whose work may have been affected
- Perform nonconformance and corrective action trending and provide this information to the Institute QA Manager

- Assist in preparing the Quality Assurance Project Plans
- Schedule internal system audits, blind spiked samples, proficiency testing twice a year per matrix, and performance audits

1.1.6 Quality Coordinator

- Perform periodic review of control charts
- Check instrument conditions and calibrations
- Report results of quality activities to Division C&CED QA Manager
- Conduct internal inspections/audits
- Coordinate sample shipments from the field to the lab
- Establish QC requirements, holding times, and deliverables required by the client and communicate to the analyst through the work order system
- Report analytical and QC data to the sponsor
- Check holding times of sample extraction and analysis and track status of analytical results
- Spot check QC on analytical results and report any problems to the project manager
- Provide finished data package to project manager for review

In the event a technical director or quality assurance manager are absent from their duties, authority can be delegated in accordance with **SOP-01-1.1**, *Organization of the Chemistry and Chemical Engineering Division*.

1.2 Quality Council

The Vice President of the C&CED assigns staff in the C&CED Quality Council to ensure representation of all the C&CED departments. The Quality Council is made up of a representative from each department, the Division Quality Assurance manager, and the Institute Quality Assurance Engineer assigned to C&CED. The Quality Council operates and reports to management in accordance with ISO **SOP-01-1.2**, *Functions and Responsibilities of the Quality Council*.

1.3 Management Review

The ultimate responsibility for the project activities of the C&CED resides with the Division Vice President. The Division Vice President is responsible for the implementation of the ISO 9002 Quality System. The Division Vice President also ensures that the Quality System functions and that the requirements placed upon the division are defined and implemented with appropriate corrective action when quality deficiencies are identified. An annual review of the Quality System shall be performed, as defined in the quality system procedure **SOP-01-1.3**, *Management Review*. The Division Vice President and the respective departmental staff shall ensure that quality and technical procedures are consistently applied to all work and that all procedures are updated regularly to reflect current requirements of clients and regulatory agencies. The Vice President shall identify and provide resources to manage, perform, and verify that the Quality System is implemented.

2. QUALITY SYSTEM

2.1 Commitment to Quality Assurance (QA)

The SwRI Quality System is comprised of the following procedures:

- SwRI Quality System Manual 1994 (QSM) – based on the requirements of IS0 9001:1994 requirements
- SwRI Quality System Manual 2000 (QSM) – based on the requirements of IS0 9001:2000 requirements
- SwRI Operating Policy and Procedures (OPP) – define established procedures of SwRI
- C&CED Standard Operating Procedures (SOP) – define the quality system requirements applicable to C&CED activities
- Test and Analytical Procedures (TAPs) – provide specific work instructions for technical performance
- Plans – provide additional quality, safety, technical, and training requirements needed to meet specific detailed contractual obligations

This system avoids revision of C&CED operating procedures for any single contract while allowing compliance with any contract requirement

2.2 Quality Assurance Policy

The C&CED management planning efforts are directed toward the development and execution of a Quality System that will comply with the quality requirements imposed by client contracts. This process will provide for effective monitoring to verify implementation. The C&CED has developed a Quality System in accordance with the ISO 9002 Quality Management System Standard. The C&CED management has established a Division Quality Policy.

QUALITY POLICY

"The goal of the Chemistry and Chemical Engineering Division is to provide the highest quality services and products to meet or exceed the expectations of the client."

2.3 Certification Programs/Audit Reports/Performance Evaluation Samples

Audit reports are available upon request for the ISO 9002 Certification program, Water Pollution (WP) Program and Drinking Water (WS) Program, Utah State Department of Health, and any other audit records that may be of assistance in qualification evaluations.

2.4 Internal Laboratory Controls

Internal quality control measures are performed and are traceable to methods or laboratory procedures. Interlaboratory comparisons are done through round robin and proficiency testing to assure method traceability and to provide qualification of staff.

Internal laboratory controls consist of certified reference materials, laboratory blanks, spike recoveries, and other method-related controls. Out of control situations may result in retesting and client coordination. Control charts are utilized to provide the analyst monitoring tools for out of control situations. Other internal controls are instrument or method based and will be provided through Test and Analytical Procedures. Method detection limit studies are provided in **Appendix B** of this document. Initial and continuing calibrations, and other method-based controls are identified within the Test and Analytical Procedures. Laboratory equipment and precision and accuracy information is provided in **Appendix A** and **Appendix C**, respectively.

3. CONTRACT REVIEW

The C&CED maintains a documented system for review of contracts and coordination of review activities. This process is described in **SOP-01-3.1***, Preparation, Review, and Approval of Proposals*. Contracts are reviewed in accordance with **SOP-01-3.2**, *Review and Approval of Contracts*, to ensure that the technical and quality requirements are adequately defined and understood by SwRI personnel and the client.

3.1 Review

Contracts prepared by SwRI are reviewed for technical and quality provisions prior to delivery to the client. Contracts prepared by the client are reviewed for technical and quality issues prior to initiation of work. This review is conducted using a Contract Action Form (PC-5) generated by SwRI Contracts. Institute OPP 4.1.1, "*Contract Administration*" and Institute Quality Systems Operating Procedure "C*ontract Review and Initial Quality Planning*" cover contract review requirements of the QAP. The laboratory reviews all new work to ensure that it has the appropriate facilities and resources prior to submission of contract.

3.2 Amendments to Contracts

Amendments to contracts are reviewed and approved in the same manner as initial contracts. Amendments are considered modifications and shall be initiated using the same Contract Action Form, PC-5.

4. DESIGN CONTROL

This element is not applicable to the Department of Analytical and Environmental Chemistry.

5. DOCUMENT AND DATA CONTROL

The division QA Manager and division document control are responsible for the proper control and documentation in accordance with ISO **SOP-01-5.1**, *Preparation and Revision of Standard Operating Procedures*, **SOP-01.5.2**, *Preparation and Revision of Plans*, **SOP-01 5.3**, *Preparation and Revision of Test Analytical Procedures*, **SOP-01-5.4**, *Revision of Forms*, and **SOP-01-5.6**, *Laboratory Notebook Requirements*. These SOPs provide instruction to generate, control, and manage all documents and data pertaining to the quality program. Changes/revisions to all documents/data are reviewed and approved by the same functions as the original review and approval. All original documentation is maintained to provide the historical developments and the disposition of obsolete documents.

5.1 Test and Analytical Procedures

Test and Analytical Procedures (TAPs) are provided to document work instructions to the staff. Formatting requirements for the TAPs are provided in **SOP-01-5.3**, *Preparation and Revision of Test Analytical Procedures*. TAPs for NELAC accredited analytes/methods, contain the minimum requirements as specified in NELAC Chapter 4 of the Quality System Section 5.10.1.2. TAPs written provide reference test methods or procedures within each analytical section. In cases where modifications to the published method have been made by the laboratory or where the referenced test method is ambiguous or provides insufficient detail, these changes or clarifications are clearly described.

5.2 Data Review and Validation

All submitted documents are reviewed and approved by the Program/Project Manager and the Director or C&CED Vice President. Data review includes C&CED Quality Assurance as well as the individual analytical Group Leader/ Manager or peer review of associated analytical data. This review is documented on the raw data package submission and individual laboratory notebooks.

Minimum requirements for data reporting and review are identified in **SOP-01-5.5**, *Data Control and Reporting*. The purpose of this procedure is to provide the control and reporting requirements for data released to clients.

To provide high quality data to the client, certain quality control measures must be incorporated into every scope of work and implemented. **SOP-01-5.5** provides instruction on the control of generated data and reporting requirements. This control is applicable to drawings, procedures, project plans, work instructions, manuals, reports, and data (both hard copy and electronic deliverables).

The client contract/statement of work will specify the numbers and types of quality control samples. The Project Manager and C&CED QA Manager shall review the requirements and incorporate them, along with any additional requirements necessary, into the work order, or the technical and/or QA project plans developed for the project. Technical data review includes checks for reasonableness of data and compares results between replicates and other QC samples and reference materials. The C&CED QA Manager will be consulted to ensure consistency with organizational goals.

Data is submitted to the Division Quality Assurance for validation in accordance with **TAP-01-0407-034** *Validation of Data*. Data is validated to verify that the requested analyses were performed according to contractual requirements, statement of work, and method requirements. Out-of-control results are reported with qualifiers and documented in the narrative. Out of tolerances found during validation are documented in the nonconformance report as referenced in **SOP-01-13.1**, *Nonconformance Reporting* and data are returned to the laboratory for correction and further review.

5.3 Laboratory Notebooks

Each instrument is assigned a specific controlled logbook in which the information shall be recorded as written in laboratory procedures. Laboratory notebooks will be controlled and maintained in accordance with **SOP-01-5.6**, *Laboratory Notebook Requirements*. Information documented in the laboratory notebook will be copied and provided as contract required by contract with the final report.

All documentation in logbooks and other documents shall be in black water-resistant ink. If an error is made, corrections are made by crossing through the error with a single line and entering the correct information. Changes shall be dated and initialed. Inserts shall be taped on page with initials and date of insert written over both insert and logbook page. No information shall be obliterated or rendered unreadable. A copy of the instrument logbook covering all the samples of a project shall be filed in the project file.

6. PURCHASING

C&CED **SOP-01-6.1**, *Purchasing*, identifies the process to ensure that purchased items that may include products, services, materials, components, standards, chemicals, equipment, appliances, and assemblies meet all contract requirements. Suppliers of critical items must be part of the SwRI Approved Supplier List (ASL) maintained by SwRI Institute Quality Systems Operating Procedure, *Purchasing*. Suppliers shall be periodically assessed by Institute Quality Systems personnel for quality purposes. Subcontractors are considered suppliers and will be subjected to periodic review and placement on the ASL.

Purchases of materials, items, and equipment or services that affect the testing process shall be requested using the standard SwRI purchase requisition form (PR1) that identifies acceptance criteria (QA codes), purchase review notation, and approvals.

The Quality Assurance Program requirements include the use of NIST traceable reference material where applicable. Chemical reagents and standards used for testing purposes are purchased from commercial-grade suppliers capable of providing the required grade of chemical with certification documentation. When these requirements do not apply, the reagents or standards must be physically marked for research and development (R&D) use only and cannot be used as reference material on any sample analysis.

The quality requirements for supplied item procurement are identified by a “Q code” placed on the requisition form. Q codes that may be used on the purchase requisitions for standards will include Q7 for Material Safety Data Sheet (MSDS) supply and/or Q3 or Q16 for certification of NIST traceability where applicable.

7. CONTROL OF CUSTOMER-SUPPLIED PRODUCT

C&CED **SOP-01-7.1**, *Control of Customer-Supplied Product,* delineates procedures that are used to identify, store, and control custody of the customer-supplied product from receipt to the end product of related testing activities. Products include materials, components, standards, chemicals, equipment, appliances, and assemblies. These will be inspected or tested to meet specified requirements.

Receipt of samples will be documented in accordance with **SOP-10.1**, *Inspection and Testing,* and **TAP-01-0407-001**, *Sample Receipt and Log-in*; which both provide technical instruction for sample controls.

8. ITEM IDENTIFICATION AND TRACEABILITY

Sample traceability from sample receipt through sample disposal is maintained by internal chain of custody records documenting all phases of the sample history.

All standards used for analysis of samples are reagent grade or higher purity and will be made from neat standards or solutions provided by an outside source traceable to the NIST where applicable. All standard materials must have a certificate of analysis on file in the laboratory. Reference materials are received, identified and are traceable to the work being performed through standard lot numbers and solution identification. Standards will be controlled in accordance with C&CED **SOP-01-8.1**, *Item Identification and Traceability*.

All standards will be stored in designated areas assigned exclusively to the storage of such standards. All neat standards shall be kept in a refrigerator specifically assigned to the storage of such standards. Only pesticide grade or equivalent solvents will be used to prepare working standards. Samples will be stored separate from standards. If indicated, analytical standards shall be prepared within the laboratory hood. When standards are received, they are logged in. Verification and acceptability of the standards is provided during analysis. When standards are used for preparing solutions, a unique identification is provided to trace the solutions back to the initial standard material received.

9. PROCESS CONTROL

C&CED **SOP-01-9.1**, *Process Control,* outlines control conditions for documentation, security, and environmental facility operational processes that may impact product quality. The requirements established within this procedure serve to provide a mechanism for the evaluation and control of this process. This SOP does not address all controls required on a program; however, it does address those that are generic to any program. Additional technical controls are presented in TAPs for specific tasks.

This procedure serves to identify and control those activities or processes within the C&CED that impact product quality. Controls have been established to identify trends in performance within the following areas:

- Documented Procedures
- Division Security Controls
- Environmental Controls

9.1 Documented Procedures

The project manager is responsible for providing accurate work instruction and facility requirements for each task. Additional technical controls are presented in TAPs for specific tasks. Environmental conditions that may adversely affect performance of tests are documented in laboratory notebooks and provided to the client. Any work performed under adverse conditions is evaluated and the report is documented to provide the affect on the data. Compliance with reference standards, developed plans, and other documented procedures shall be verified by Division Quality Assurance through surveillance, inspection, validation, and internal audit activities.

9.2 Security Controls

Security controls include restricted access and personnel identification policies in force within all division facilities. External doors are secured and employees have access by key. The receptionist is responsible for controlling the accessible entrance(s) during working hours. Individual laboratory areas may be secured depending on contract requirements. Temporary employees or visitors shall not be issued building keys. Visitors are provided a visitor's badge and are provided escorts through the laboratory.

9.3 Environmental Controls

The workplace environment is monitored and controlled through numerous mechanisms. The primary control immediately available to the Division is employee observation of workplace conditions. Other controls include procedure approvals, Laboratory Chemical Hygiene Plans (CHP), SwRI Safety Plan, and Occupational Safety and Health Administration (OSHA) regulations. Measures shall be taken to ensure good housekeeping in the laboratory to the extent that safety, efficiency, and the quality of the data are not adversely affected by the conditions in which the testing or analytical processes are being conducted.

9.3.1 Personnel Safety

The purpose of a laboratory safety program is to provide convenient information for hazard recognition and control. Fires, explosions, and exposure to chemical, biological agents, and other hazards can usually be anticipated and therefore prevented.

For these reasons, Southwest Research Institute has developed a *Safety Policies and Procedures Manual* (SPPM), which is distributed to every employee. In addition to the Safety Policies and Procedures Manual, every employee is familiarized and instructed to the proper use of safety equipment in his/her laboratory. According to the Federal OSHA Hazard Communication, each laboratory has a continually updated notebook of Material Safety Data Sheets. A division *Chemical Hygiene Plan* (CHP-008) is provided to all personnel through the C&CEDIntranet website.

9.3.2 Computer Software/Hardware

C&CED **SOP-01-9.2**, *Control of Computer Software and Hardware, covers computer software and hardware*. This procedure identifies the Computer and Instrumentation Service Group (CSG) as the responsible section for inventory and documented control of purchases for both software and hardware. Software used in the laboratory is evaluated under the Good Automated Laboratory Guidelines 2185 (GALP), 1995.

Software developed for laboratory use or specific programs is developed and controlled in accordance with **SOP-01-9.3** *In-House Developed Software.* This procedure provides requirements for requests, changes, testing, and historical documentation.

The Laboratory Information Management System (LIMS) software is an in-house developed software to provide a work order and tracking system of all samples received at the laboratory. The LIMS provides the ability of each project manager or analytical group leader/manager to review in-house sample capacity and to schedule within each section. The LIMS documents the tracking of the sample from receipt to final disposal. This software allows the project manager or analytical group leader/manager the capability of attaching e-mail instructions to each work order for final report preparation.

9.3.3 Equipment Maintenance

Equipment maintenance within the testing areas is performed in accordance with **SOP-01-9.4**, *Equipment Maintenance*, and is documented in laboratory notebooks as referenced in **SOP-01-5.6**, *Laboratory Notebook Requirements*. Functional maintenance checks performed prior to testing are provided in individual TAPs. A more detailed description of calibration and verification of equipment are provided in Section 11.0, *Control of Inspection, Measuring, and Test Equipment*.

10. INSPECTION AND TESTING

Upon receipt or prior to use of an item, the contents are inspected and verified as being compliant with the SwRI purchase order. This inspection is conducted according to **SOP-01-10.1, *Inspection and Test Conduct***. Documented procedures have been established for inspection and testing activities on items that may include products, materials, services, components, standards, chemicals, equipment, appliances, assemblies, and samples. Client samples are received and documented in a laboratory work order through the LIMS according to **TAP-01-0407-001**, *Sample Receipt and Login*. This procedure provides detailed instructions for the logging in of samples. Sample control is provided through **TAP-01-0407-035**, *Sample/Extract Storage and Custody,* and **TAP-01-0407-037**, *Sample Security*.

Tests are not performed on any client-supplied item until the item has been identified in accordance with **SOP-01-8.1**, *Item Identification and Traceability*. C&CED personnel shall verify each item as the appropriate item to be tested. Results of any inspections or testing for any item shall be documented on **FRM-109**, *Item Receipt Report*, or equivalent. Discrepancies shall be documented by using the web-based Sample Discrepancy online application made available on the Division 01 Intranet. Traceability of the item shall be maintained in accordance with **SOP-01-8.1**.

10.1 Analytical Procedures

The laboratory handles EPA, ASTM, SW-846, and other methods used for routine analytical services and special analytical services (see **Appendix E**). Methods identified as certifying methods to the *National Environmental Laboratory Accreditation Program* (NELAP) are identified in **Appendix C**. These individual methods are readily available to all analysts with detection limits and matrix requirements. If variances or modifications are required, the client is contacted in writing regarding these modifications and the purpose for any changes. Noncompliant conditions are immediately provided to the client with recommendations or for further instructions from the client. A notation is made in the analytical report to identify the approval of modification. Procedures that do not provide a specific method are performed as method development. For those methods requiring analytical development, documentation of the method, which is performed and approved, are referenced as a TAP. Each analytical area is responsible for the methods performed in the laboratory. C&CED Document Control maintains TAPs as “controlled documents” on the C&CED Intranet website. TAPs become accessible to division personnel when management approval has been acquired, after implementation, and after revision.

All chemical and standards will be labeled with the date received, the date opened, initial of the staff that opened it, and expiration date. Any prepared solution will be labeled with the type of solution prepared, date prepared, initial of the staff member that prepares it, lot number of the solution (to reference to the standard logbook with the solution preparation information) and expiration date. The labels will either be hand written or printed using any computer system. The label will be covered with a layer of clear tape once it is pasted on the vessel.

10.2 Disposal of Samples

Following testing, samples are routinely disposed of 60 days following the submission of the final report or as specified in the contract. Organic extracts are maintained for 180 days following submission of data or as specified in the contract.

11. CONTROL OF INSPECTION, MEASURING, AND TEST EQUIPMENT

All instruments, major equipment and reference measurement standards will be maintained in accordance with manufacturer's recommendations and normal laboratory practice. All maintenance will be documented and maintained in permanent records by the individual responsible for each instrument. This will include routine, scheduled maintenance, and unscheduled maintenance required by operational failures. Maintenance and documentation will be performed in accordance with **SOP-01-11.1** *Control of Measuring and Test Equipment*.

11.1 Calibration Laboratory

Southwest Research Institute maintains a Calibration Laboratory that is accredited by ANSI Z540/ISO Guide 25 (17025) and is American Association for Laboratory Testing Accreditation (A2LA) for performing routine maintenance. Routine maintenance of equipment is performed on 6-month and annual schedules depending on the equipment requirements. Division instrumentation personnel in the CSG section, in accordance with vendor requirements, perform the laboratory maintenance. Coordination with the vendor is performed during maintenance of instruments and equipment. Analysts and instrumentation/calibration personnel, as needed, also perform preventive maintenance on analytical balances, pipettes, syringes, thermometers, ovens, furnaces, refrigerators, freezers, incubators, and centrifuge systems. Out-of-control events require a Nonconformance Report (Form 079), and equipment must be properly labeled that it is not to be used. Responses, in accordance with **SOP-01-13.1**, *Nonconformance Reporting,* will identify the effect on data generated during the out-of-tolerance situation.

11.2 Balances, Refrigerators, and Ovens

Calibration of all laboratory balances shall be verified and the results documented in a logbook on a monthly basis with a complete set of "S" weights by grams. Calibration of balances located in the laboratories shall be verified upon use by the analyst and documented in a separate bound logbook. The Institute Calibration Group shall check balances every 6 months with NIST traceable standards. A dated and initiated inspection sticker shall be placed on the balance and an inspection report filed. Balances are verified daily or upon use by the analyst using the balance and documented in a bound logbook. The SwRI Calibration Laboratory will be contacted for out-of-tolerance situations so the balance can be recalibrated, if necessary.

The temperatures of all refrigerators/probes, freezers, and drying ovens are monitored daily with NIST traceable thermometers verified to calibrated thermometers, and the results documented in a bound logbook. The SwRI Calibration Laboratory does thermometer calibration. Logbooks shall contain the required temperature for each refrigerator and oven with tolerance ranges. When the tolerances are exceeded, it shall be documented, the discrepancy reported, and the equipment repaired if required. If the ovens being used for drying glassware deviate from analytical temperature, it will be documented.

12. INSPECTION AND TEST STATUS

C&CED **SOP-01-12.1, *Inspection and Test Status,*** identifies procedures for the inspection and test status of products. The status may be indicated by documentation in logbooks, markings, labels, inspection records, physical location, or other means of identification as specified in the procedure or specific quality plan as applicable. During the process of inspection and testing, out-of-compliance situations are documented immediately and the client is notified.

13. CONTROL OF NONCONFORMANCES

All assigned project personnel shall remain diligent to identify, report, and promptly rectify problems affecting data quality as they occur. Nonconformances shall be documented by recording in the NCR Online Program in accordance with **SOP-01-13.1**, *Nonconformance Reporting*. C&CED QA verifies that nonconformances are documented and that identified corrective measures are implemented. C&CED QA maintains records of all nonconformances, dispositions, and corrective measures taken. C&CED QA will perform nonconformance trending as described in **SOP-01-20.2** *Quality System Trending*. Trending is submitted quarterly to upper management and presented in chart form at the annual Management Review.

14. CORRECTIVE AND PREVENTIVE ACTION

C&CED **SOP-01-14.1,** *Corrective Actions,* and **SOP-01-14.2,** *Processing of Client Complaints,* define the mechanism to implement corrective and preventive measures where nonconformance trends indicate a need. These procedures provide a means of continually communicating suggestions, concerns, and status of all activities within the C&CED and to identify areas that can be improved. Involvement of the staff in policy and procedure development is essential for continuous improvement. Corrective actions are initiated for external audit findings, proficiency sample failures, and nonconformance trends.

The ultimate responsibility for maintaining quality of the sampling and analyses lies with the management of the department and division. The routine operation of the quality assurance/quality control program, however, falls upon the analysts, analytical group leaders/managers, project managers, and the QA manager. For further information refer to SwRI **SOP-01-12.1,** *Inspection and Test Status*.

Corrective action relates to the overall QA management scheme: who is responsible for taking corrective actions; when corrective actions are to be taken; and who follows up to see that corrective actions have been taken and that they have produced the desired results. Results from the following QA activities may indicate a need for corrective action:

- Performance audits
- Systems audits
- Inter-laboratory comparison studies
- Non-conformance trending issues

Noncompliance will be minimized through specification (in the project plan or operating protocols) and implementation of internal controls prior to an adverse project impact. Each measurement system shall have limits to establish when corrective action must be taken. A procedure shall be established for each measurement system to show what corrective action will be followed when established limits for these procedures have been exceeded. The level within the organization that is responsible for taking corrective action shall also be specified.

This corrective action process involves the areas involved and management. Responses to corrective actions that indicate the cause of the problem and corrective actions to prevent recurrence provide continuous improvement and shall be submitted for inclusion in the final report. Corrective actions shall be documented on a **Corrective Action Request Form** (**FRM-024**).

Preventive action is provided through the responsibility of the project personnel. Project personnel will identify perceived problems that may affect data quality and to report these problems both to their analytical group leader/manager and to their quality team contact. If the analytical group leader/manager regards the problem as serious enough to potentially impact data quality, a corrective action will be initiated.

Client complaints are defined as communication with a client based on some unfulfilled contractual requirement; for example, data delivery date, holding times, test data that was not conducted per contract, errors in final data submitted to client, and other discrepancies that are client concerns. Client complaints are documented in an electronic program that provides immediate information to the project manager and notification to the director in accordance with **SOP-01-14.2**, *Processing of Client Complaints*.

Customer satisfaction is documented by submittal of a letter and Customer Satisfaction Survey form from the vice president of Chemistry and Chemical Engineering Division. These surveys are provided at the end of the project and annually for on-going programs. The Quality Council reviews the returned surveys with feedback to the project manager, director, and the vice president. Trends are performed and submitted during the Annual Management Review.

15. HANDLING, STORAGE, PACKAGING, PRESERVATION, AND DELIVERY

C&CED **SOP-01-15.1,** *Handling, Storage, Packaging, Preservation, and Delivery of Items,* provides procedures for documenting the handling, storage, marking, packaging, preservation, and delivery of items, such as products, materials, components, standards, chemicals, equipment, appliances, assemblies, and samples. Container, preservation techniques, and holding time requirements are provided in **Appendix F**. When contractually required, the laboratory will provide containers and coolers for sampling.

Samples are stored in a manner to reduce contamination in accordance with **TAP-01-0407-040**, *Prevention of Sample Contamination*. Samples, extracts, and standards shall be kept free from contamination throughout the entire process of receipt inspection, analysis, and disposition, and each will be stored in separate refrigerators/locations.

16. CONTROL OF QUALITY RECORDS

C&CED **SOP-01-16.1**, *Storage and Maintenance of Quality Records*, and **SOP-01-16.2**, *Software Records*, provide procedures that specify the processes and controls required for the identifying, accessing, filing, storage, maintenance, and disposition of quality records. Additional technical procedures apply to the control of records. The procedures identify the required quality control documents maintained and location of the documents. **TAP-01-0407-017**, *Project Record Preparation, Archival, Access, and Disposition*.

16.1 Responsibility

C&CED Quality Assurance or department administrative staff provides archival storage of quality records. These records shall be stored in restricted record storage areas with limited access to authorized personnel. Records shall be stored in a manner to prevent damage from light, stacking, electromagnetic fields, temperature, and humidity. Data package deliverables are scanned and stored on CD.

16.2 Disposal of Records

Records shall be disposed of 3 years following the submission of a report unless otherwise specified in the contract or a specific certification program. Specific records that will require program life storage include all reports both draft and final, nonconformances, weekly reports, training records, contractual monitoring, and change actions.

17. INTERNAL QUALITY AUDITS AND SURVEILLANCES

C&CED **SOP-01-17.1**, *Internal Quality Audits*, provides direction for surveillances by C&CED Quality Assurance. Annual audits by Institute QA personnel are performed according to OP-17.0-30.1. Qualifications of auditors are identified in OP-17.0-30.2.

Audit response, surveillance, and verification records include checklists, reports, and nonconformance and corrective action reports. These records shall be controlled in accordance with **SOP-01-16.1,** *Storage and Maintenance of Quality Records*. Surveillances are performed throughout the year by qualified DQA staff that is independent of the activity audited. The surveillances performed may be programmatic surveillances of the Quality System or a specific plan, technical processes, or verifications to deficiencies documented in nonconformance reports, corrective action reports, and client complaint reports. Random TAPs are selected as a system audit to determine proper performance of the technical procedures.

External audits are organized in accordance with **SOP-01-17.2,** *External Quality Audits*. External audit findings are reported to the laboratory areas through review and response of corrective actions in accordance with **SOP-01-14.1** *Corrective Actions*. Responses to audit findings are provided to the client and follow-up surveillances are performed to verify the corrective actions.

18. TRAINING

All professional staff members in the laboratory shall have a complete understanding of the requirements of the Quality System and the Quality Assurance Program. The QA manager or designee will provide a controlled copy of each revision of the plan and a briefing on the Quality System and QAP.

The C&CED QA Manager will review the QA requirements specific to each project with the analytical group leader/manager and project manager prior to starting the project. A Quality Assurance Project Plan (QAPjP) will be prepared for any project that requires more in-depth specific requirement than the current Quality Assurance Plan. The QAPjP will be prepared in accordance with the project requirements. Upon project start-up, the remaining project assigned will be made. All personnel assignments to tasks affecting data quality shall be made based on adequate education, training, and experience. Inexperienced personnel will be closely supervised and provided with test and analytical procedures and contractual statements of work located on the C&CED Intranet website. All project personnel will be trained in QA/QC responsibilities upon assignment to the project. Qualifications and method proficiency will be documented and provided in training files as needed or upon completion. Analytical group leaders/managers will provide follow-up technical training for the staff assigned to that section.

18.1 New Staff Training

New laboratory technicians shall be shown the location of controlled copies of the QAP, QAPjP when required, Standard Operating Procedures, and Test and Analytical Procedures and how to retrieve them from C&CED Intranet website. The QA manager and the analytical group leader/manager will formally train them. Documentation of any training is maintained in a training file for each employee. Training is performed in accordance with **SOP-01-18.1**, *Qualifications and Training*. Revision to all procedures shall be available to C&CED personnel on the **C&CED Intranet website**. Prior to any actual work procedures requiring Good Laboratory Practices (GLP) or Nuclear procedures, the C&CED QA manager will train staff for GLP procedures and Institute QA will perform nuclear training. Training files will be updated to show the latest training and will be evaluated annually.

18.2 Demonstration of Capability

Demonstration of capability requirements are performed through laboratory control spike replicates on the method and instrumentation to provide method based performance training on staff. Performance evaluation (PE) samples are also evaluated to the method and matrix of the samples. If the proficiency of the performance evaluation sample is not met, additional samples are provided for further evaluation. PE samples are performed in accordance with **TAP-01-0407-025** *Performance Evaluation Reporting and Archiving*. Method detection limit studies provide proficiency of the analyst to the method and instrumentation.

19. SERVICING

For feedback on customer service, **SOP-01-14.2,** *Processing of Client Complaints,* provides information on processing customer complaints. Customer Satisfaction Surveys, Form 282, are provided for feedback from the client following project completion. Both the Client Complaints and Customer Satisfaction Survey are evaluated and presented in the annual Management Review.

20. STATISTICAL TECHNIQUES

Statistical techniques are provided in accordance with **SOP-01-20.1,** *Statistical Techniques*. Statistical analysis of data generated within C&CED generally fall into three classes:

- Analysis of quality control data to evaluate performance of methods, operators, and instruments
- Summarization of data for a client (central tendency, variability)
- Analysis of data resulting from scientific investigations
- Statistical methods performed in accordance with appropriate documented procedures

Quality trending provides statistical measurement of nonconformances, corrective actions, and client complaints. Trending is performed in accordance with **SOP-01-20.2,** *Quality System Trending*. The C&CED QA Manager will provide trending as evaluated in the C&CED Quality Council quarterly meetings to management. This trending will be used in the annual management review meetings to determine the effect of the quality system. The Quality Council will utilize minutes and action items from this management review for quality improvement recommendations to the C&CED management staff.

21. BIBLIOGRAPHY

ISO 9002 Quality Systems Standard, International Organization of Standardization, 1994 Edition.

SW-846, Test Methods for Evaluating Solid Wastes, Chapter 1.

EPA Requirements for Quality Management Plans, EPA QA/R-2, March 2001"

EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5, March 2001

Quality Assurance Requirements, DOE 414.1, Office of Nuclear Energy, Office of Environment, Safety, and Health.

American Society of Mechanical Engineers (ASME)/NQA-1, Quality Assurance Program Requirements for Nuclear Facilities.

National Environmental Laboratory Accreditation Conference (NELAC) Quality Systems, Chapter 5, March 19, 2001.

Handbook for Analytical Quality Control in Water and Wastewater Laboratories, EPA-600/4-79-019, March 1979

Manual of Analytical Quality Control for Pesticides and Related Compounds in Human and Environmental Samples, EPA-600/1-79-008, January 1979

Quality Assurance for Environmental Measurements, J. K. Taylor and T. W. Stanley (eds.), ASTM STP867, 1985

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I, "Principles", EPA-600/9-76-005, March 1976

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II, "Ambient Air Specific Methods", EPA-600/4-77-027a, May 1977

Quality Assurance Handbook for Air Pollution Measurement Systems, Volume III, "Stationary Source Specific Methods", EPA-600/4-77-027b, August 1977

EPA Regional Environmental Analytical Procurement Program (ENVIRONMENTAL AND ANALYTICAL SERVICES 01.0) June 1998.

GLOSSARY/DEFINITIONS

Acceptance Criteria: specified limits placed on characteristics of an item, process, or service defined in requirement documents. (ASQC)

Accreditation: the process by which an agency or organization evaluates and recognizes a laboratory as meeting certain predetermined qualifications or standards, thereby accrediting the laboratory. In the context of the National Environmental Laboratory Accreditation Program (NELAP), this process is a voluntary one. (NELAC)

Accrediting Authority: the Territorial, State, or federal agency having responsibility and accountability for environmental laboratory accreditation and which grants accreditation (NELAC, 1.5.2.3)

Accrediting Authority Review Board (AARB): five voting members from Federal and State Accrediting Authorities and one nonvoting member from USEPA, appointed by the NELAP Director, in consultation with the NELAC Board of Directors, for the purposes stated in 1.6.3.e. (NELAC, 1.6.3)

Accuracy: the degree of agreement between an observed value and an accepted reference value. Accuracy includes a combination of random error (precision) and systematic error (bias) components which are due to sampling and analytical operations; a data quality indicator. (QAMS)

Assessor Body: the organization that actually executes the accreditation process, i.e., receives and reviews accreditation applications, reviews QA documents, reviews proficiency testing results, performs on-site assessments, etc., whether EPA, the State, or contracted private party. (NELAC)

Analyst: the designated individual who performs the "hands-on" analytical methods and associated techniques and who is the one responsible for applying required laboratory practices and other pertinent quality controls to meet the required level of quality. (NELAC)

Analytical Spike: An additional aliquot of digested or undigested sample spiked with a known amount of analyte and taken through the same quantitation procedure.

Applicant Laboratory or **Applicant:** the laboratory or organization applying for NELAP accreditation. (NELAC)

Assessment: the evaluation process used to measure or establish the performance, effectiveness, and conformance of an organization and/or its systems to defined criteria (to the standards and requirements of NELAC). (NELAC)

Assessment Criteria: the measures established by NELAC and applied in establishing the extent to which an applicant is in conformance with NELAC requirements. (NELAC)

Assessment Team: the group of people authorized to perform the on-site inspection and proficiency testing data evaluation required to establish whether an applicant meets the criteria for NELAP accreditation. (NELAC)

Assessor: one who performs on-site assessments of accrediting authorities and laboratories' capability and capacity for meeting NELAC requirements by examining the records and other physical evidence for each one of the tests for which accreditation has been requested. (NELAC)

Audit: a systematic evaluation to determine the conformance to quantitative *and qualitative* specifications of some operational function or activity. (EPA-QAD)

Batch: environmental samples that are prepared and/or analyzed together with the same process and personnel, using the same lot(s) of reagents. A **preparation batch** is composed of one to 20 environmental samples of the same NELAC-defined matrix, meeting the above-mentioned criteria and with a maximum time between the start of processing of the first and last sample in the batch to be 24 hours. An **analytical batch** is composed of prepared environmental samples (extracts, digestates or concentrates), which are analyzed together as a group. An analytical batch can include prepared samples originating from various environmental matrices and can exceed 20 samples. (NELAC Quality Systems Committee)

Blank: a sample that has not been exposed to the analyzed sample stream in order to monitor contamination during sampling, transport, storage or analysis. The blank is subjected to the usual analytical and measurement process to establish a zero baseline or background value and is sometimes used to adjust or correct routine analytical results. Blanks include:

Calibration Blank: A volume of deionized, distilled water acidified with HNO3 and HCL.

Equipment Blank: a sample of analyte-free media which has been used to rinse common sampling equipment to check effectiveness of decontamination procedures. (NELAC)

Field Blank: blank prepared in the field by filling a clean container with pure de-ionized water and appropriate preservative, if any, for the specific sampling activity being undertaken. (EPA OSWER)

Instrument Blank: a clean sample (e.g., distilled water) processed through the instrumental steps of the measurement process; used to determine instrument contamination. (EPA-QAD)

Method Blank: a sample of a matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses. (NELAC)

Reagent Blank: (method reagent blank): a sample consisting of reagent(s), without the target analyte or sample matrix, introduced into the analytical procedure at the appropriate point and carried through all subsequent steps to determine the contribution of the reagents and of the involved analytical steps. (QAMS)

Blind Sample: a sub-sample for analysis with a composition known to the submitter. The analyst/laboratory may know the identity of the sample but not its composition. It is used to test the analyst's or laboratory's proficiency in the execution of the measurement process. (NELAC)

Calibration: to determine, by measurement or comparison with a standard, the correct value of each scale reading on a meter, instrument, or other device. The levels of the applied calibration standard should bracket the range of planned or expected sample measurements. (NELAC)

Calibration Curve: the graphical relationship between the known values, such as concentrations, of a series of calibration standards and their instrument response. (NELAC)

Calibration Method: a defined technical procedure for performing a calibration. (NELAC)

Calibration Standard: a substance or reference material used to calibrate an instrument. (QAMS)

Calibration Standards (ICB-initial calibration blank, CCB-continuing calibration blank): A series of known standard solutions used by the analyst with the same amount of acids, as were the samples and standards.

Certified Reference Material (CRM): a reference material one or more of whose property values are certified by a technically valid procedure, accompanied by or traceable to a certificate or other documentation which is issued by a certifying body. (ISO Guide 30-2.2)

Chain of Custody Form: record that documents the possession of the samples from the time of collection to receipt in the laboratory. This record generally includes: the number and types of containers; the mode of collection; collector; time of collection; preservation; and requested analyses. (NELAC)

Clean Air Act: the enabling legislation in 42 U.S.C. 7401 *et seq.*, Public Law 91-604, 84 Stat. 1676 Pub. L. 95-95, 91 Stat., 685 and Pub. L. 95-190, 91 Stat., 1399, as amended, empowering EPA to promulgate air quality standards, monitor and to enforce them. (NELAC)

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA/Superfund): the enabling legislation in 42 U.S.C. 9601-9675 *et seq*., as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), 42 U.S.C. 9601*et seq.*, to eliminate the health and environmental threats posed by hazardous waste sites. (NELAC)

Confidential Business Information (CBI): information that an organization designates as having the potential of providing a competitor with inappropriate insight into its management, operation or products. NELAC and its representatives agree to safeguarding identified CBI and to maintain all information identified as such in full confidentiality.

Confirmation: verification of the identity of a component through the use of an approach with a different scientific principle from the original method. These may include, but are not limited to: second column confirmation, alternate wavelength, derivatization, mass spectral interpretation, alternative detectors, or additional cleanup procedures. (NELAC)

Conformance: an affirmative indication or judgment that a product or service has met the requirements of the relevant specifications, contract, or regulation; also the state of meeting the requirements. (ANSI/ASQC E4-1994)

Continuing Calibration Verification (CCV): Used to assure calibration accuracy during each analysis run. It must be run for each analyte as described in the particular analytical method. At a minimum, it should be analyzed at the beginning of the fun and after the last analytical sample. Its concentration should be at or near the mid-range levels of the calibration curve.

Contributor: a participant in NELAC who is not a Voting Member. Contributors include representatives of laboratories, manufacturers, industry, business, consumers, academia, laboratory associations, laboratory accreditation associations, counties, municipalities, and other political subdivisions, other federal and state officials not engaged in environmental activities, and other persons who are interested in the objectives and activities of NELAC. (NELAC, Art III, Const)

Corrective Action: the action taken to eliminate the causes of an existing nonconformity, defect or other undesirable situation in order to prevent recurrence. (ISO 8402)

CRDL: Contract Required Detection Limit.

Data Audit: a qualitative and quantitative evaluation of the documentation and procedures associated with environmental measurements to verify that the resulting data are of acceptable quality (i.e., that they meet specified acceptance criteria). (NELAC)

Data Reduction: the process of transforming raw data by arithmetic or statistical calculations, standard curves, concentration factors, etc., and collation into a more useable form. (EPA-QAD)

Deficiency: an unauthorized deviation from acceptable procedures or practices, or a defect in an item. (ASQC)

Delegate: any environmental official of the States or the Federal government not sitting in the House of Representatives, who is eligible to vote in the House of Delegates. (NELAC)

Demonstration of Capability: a procedure to establish the ability of the analyst to generate acceptable accuracy. (NELAC)

Denial: to refuse to accredit in total or in part a laboratory applying for initial accreditation or resubmission of initial application. (NELAC, 4.4.1)

Detection Limit: the lowest concentration or amount of the target analyte that can be identified, measured, and reported with confidence that the analyte concentration is not a false positive value. See Method Detection Limit. (NELAC)

Document Control: the act of ensuring that documents (and revisions thereto) are proposed, reviewed for accuracy, approved for release by authorized personnel, distributed properly and controlled to ensure use of the correct version at the location where the prescribed activity is performed. (ASQC)

Dissolved: those elements that will pass through a 0.45 um membrane filter.

Environmental Laboratory Advisory Board (ELAB): a Federal Advisory Committee, with members appointed by EPA and composed of a balance of non-state, non-federal representatives, from the environmental laboratory community, and chaired by an ELAB member. (NELAC, 1.6.2)

Environmental Monitoring Management Council (EMMC): an EPA Committee consisting of EPA managers and scientists, organized into a Policy Council, a Steering Group, *ad hoc* Panels, and work groups addressing specific objectives, established to address EPA-wide monitoring issues. (NELAC)

Federal Insecticide, Fungicide and Rodenticide Act (FIFRA): the enabling legislation under 7 U.S.C. 135 *et seq.,* as amended, that empowers the EPA to register insecticides, fungicides, and rodenticides. (NELAC)

Federal Water Pollution Control Act (Clean Water Act, CWA): the enabling legislation under 33 U.S.C. 1251 *et seq.*, Public Law 92-50086 Stat. 816, that empowers EPA to set discharge limitations, write discharge permits, monitor, and bring enforcement action for non-compliance. (NELAC) *[effective July 1, 2001[*

Field of Accreditation: (previously Field of Testing) NELAC's approach to accrediting laboratories by matrix, technology/method and analyte/analyte group. Laboratories requesting accreditation for a matrix-technology/method-analyte/analyte group combination or for an updated/improved method are required to submit only that portion of the accreditation process not previously addressed. (NELAC, Section 1.8 ff)

Field of Proficiency Testing: NELAC's approach to offering proficiency testing by matrix, technology, and analyte/analyte group.

Finding: an assessment conclusion that identifies a condition having a significant effect on an item or activity. An assessment finding is normally a deficiency and is normally accompanied by specific examples of the observed condition. (NELAC)

Governmental Laboratory: as used in these standards, a laboratory owned by a Federal, state, or tribal government; includes government-owned contractor-operated laboratories. (NELAC).

Holding Times (Maximum Allowable Holding Times): the maximum times that samples may be held prior to analysis and still be considered valid or not compromised. (40 CFR Part 136)

Initial Calibration Verification (ICV): A certified (EPA or other) or independently prepared solution used to verify the accuracy of the initial calibration. For ICP analysis, it must be run at each wavelength used in the analysis.

Instrument Check Standard: A Multielement standard of known concentrations prepared by the analyst to monitor and verify instrument performance on a daily basis.

Instrumental Detection Limit: the concentration equivalent to a signal, due to the analyte, which is equal to three times the standard deviation of a series of ten replicate measurements of a reagent blank signal at the same wavelength.

Interference Check Sample (ICS): A solution containing both interfering and analyte elements of known concentrations that can be used to verify backgrounds and interelement correction factors.

Inspection: an activity such as measuring, examining, testing, or gauging one or more characteristics of an entity and comparing the results with specified requirements in order to establish whether conformance is achieved for each characteristic. (ANSI/ASQC E4-1994)

Interim Accreditation: temporary accreditation status for a laboratory that has met all accreditation criteria except for a pending on-site assessment which has been delayed for reasons beyond the control of the laboratory. (NELAC)

Internal Standard: a known amount of standard added to a test portion of a sample as a reference for evaluating and controlling the precision and bias of the applied analytical method. (NELAC)

Laboratory: a body that calibrates and/or tests. (ISO 25)

Laboratory Control Sample (however named, such as laboratory fortified blank, spiked blank, or QC check sample): a sample matrix, free from the analytes of interest, spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is generally used to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system. (NELAC)

Laboratory Duplicate: aliquots of a sample taken from the same container under laboratory conditions and processed and analyzed independently. (NELAC)

Laboratory Fortified Blank (LFB): A reagent blank spiked with all the analytes at the required detection limits that is digested and analyzed with each SDG to demonstrate that the laboratory is able to consistently meet the required detection limits for all analytes.

Legal Chain of Custody Protocols: procedures employed to record the possession of samples from the time of sampling until analysis and are performed at the special request of the client. These protocols include the use of a Chain of Custody Form that documents the collection, transport, and receipt of compliance samples by the laboratory. **In addition, these protocols document all handling of the samples within the laboratory**. (NELAC)

Linear Dynamic Range: The concentration range over which the analytical curve remain linear.

Manager (however named): the individual designated as being responsible for the overall operation, all personnel, and the physical plant of the environmental laboratory. A supervisor may report to the manager. In some cases, the supervisor and the manager may be the same individual. (NELAC)

Matrix: the substrate of a test sample.

Method Detection Limit (MDL): The minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero. The MDL is determined from analysis of a sample matrix containing analyte, which has been processed through the preparative procedure.

Field of Accreditation Matrix: these matrix definitions shall be used when accrediting a laboratory (see Field of Accreditation).

Drinking Water: any aqueous sample that has been designated a potable or potential potable water source.

Nonpotable Water: any aqueous sample excluded from the definition of Drinking Water matrix. Includes surface water, groundwater, effluents, water treatment chemicals, and TCLP or other extracts.

Solid and Chemical Materials: includes soils, sediments, sludges, products and by-products of an industrial process that results in a matrix not previously defined.

Biological Tissue: any sample of a biological origin such as fish tissue, shellfish, or plant material. Such samples shall be grouped according to origin.

Air and Emissions: whole gas or vapor samples including those contained in flexible or rigid wall containers and the extracted concentrated analytes of interest from a gas or vapor that are collected with a sorbent tube, impinger solution, filter, or other device. (NELAC)

Quality Control Samples: A solution obtained from an outside source having known, concentration values to be used to verify the calibration standards.

Quality System Matrix: These matrix definitions are an expansion of the field of accreditation matrices and shall be used for purposes of batch and quality control requirements (NELAC, Chapter 5, Appendix D). These matrix distinctions shall be used:

Aqueous: any aqueous sample excluded from the definition of Drinking Water matrix or Saline/Estuarine source. Includes surface water, groundwater, effluents, and TCLP or other extracts.

Saline/Estuarine: any aqueous sample from an ocean or estuary, or other salt water source such as the Great Salt Lake.

Nonaqueous Liquid: any organic liquid with <15% settleable solids.

Solids: includes soils, sediments, sludges and other matrices with >15% settleable solids.

Chemical Waste: a product or by-product of an industrial process that results in a matrix not previously defined.

Matrix Spike (spiked sample or fortified sample): a sample prepared by adding a known mass of target analyte to a specified amount of matrix sample for which an independent estimate of Target analyte concentration is available. Matrix spikes are used, for example, to determine the effect of the matrix on a method's recovery efficiency. (QAMS)

Matrix Spike Duplicate (spiked sample or fortified sample duplicate): a second replicate matrix spike prepared in the laboratory and analyzed to obtain a measure of the precision of the recovery for each analyte. (QAMS)

May: denotes permitted action, but not required action. (NELAC)

Method: see Test Method

Method Detection Limit: the minimum concentration of a substance (an analyte) that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte. (40 CFR Part 136, Appendix B)

Method of Standard Addition: The standard addition technique involves the use of the unknown and the unknown plus a known amount of standard.

Must: denotes a requirement that must be met. (Random House College Dictionary)

National Accreditation Database: the publicly accessible database listing the accreditation status of all laboratories participating in NELAP. (NELAC)

National Institute of Standards and Technology (NIST): an agency of the US Department of Commerce's Technology Administration that is working with EPA, States, NELAC, and other public and commercial entities to establish a system under which private sector companies and interested States can be accredited by NIST to provide NIST-traceable proficiency testing (PT) to those laboratories testing drinking water and wastewater. (NIST)

National Environmental Laboratory Accreditation Conference (NELAC): a voluntary organization of State and Federal environmental officials and interest groups purposed primarily to establish mutually acceptable standards for accrediting environmental laboratories. A subset of NELAP. (NELAC)

National Environmental Laboratory Accreditation Program (NELAP): the overall National Environmental Laboratory Accreditation Program of which NELAC is a part. (NELAC)

National Voluntary Laboratory Accreditation Program (NVLAP): a program administered by NIST that is used by providers of proficiency testing to gain accreditation for all compounds/matrices for which NVLAP accreditation is available, and for which the provider intends to provide NELAP PT samples. (NELAC)

Negative Control: measures taken to ensure that a test, its components, or the environment do not cause undesired effects, or produce incorrect test results. (NELAC)

NELAC Standards: the plan of procedures for consistently evaluating and documenting the ability of laboratories performing environmental measurements to meet nationally defined standards established by the National Environmental Laboratory Accreditation Conference. (NELAC)

NELAP Recognition: the determination by the NELAP Director that an accrediting authority meets the requirements of the NELAP and is authorized to grant NELAP accreditation to laboratories. (NELAC)

Nongovernmental Laboratory: any laboratory not meeting the definition of the governmental laboratory. (NELAC)

Optimum Concentration Range: A range defined by its limits expressed in concentration, below which scale expansion must be used and above which curve correction should be considered. This range will vary with the sensitivity of the instrument and the operating conditions employed.

Performance Audit: the routine comparison of independently obtained qualitative and quantitative measurement system data with routinely obtained data in order to evaluate the proficiency of an analyst or laboratory. (NELAC)

Performance Based Measurement System (PBMS): a set of processes wherein the data quality needs, mandates or limitations of a program or project are specified and serve as criteria for selecting measurement processes which will meet those needs in a cost-effective manner. (NELAC)

Positive Control: measures taken to ensure that a test and/or its components are working properly and producing correct or expected results from positive test subjects. (NELAC)

Precision: the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves; a data quality indicator. Precision is usually expressed as standard deviation, variance or range, in either absolute or relative terms. (NELAC)

Predigestion Spike (MS: Matrix Spike, MSD: Matix Spike Duplicate): An additional amount aliquot of sample taken through the digestion procedure and spiked with a known amount of analyte.

Preparation Spike (LCS-Laboratory Control Sample): Preparatin blank spiked with known quantities of analytes of interest and carried through the digestion procedure.

Preservation: refrigeration and/or reagents added at the time of sample collection (or later) to maintain the chemical and/or biological integrity of the sample. (NELAC)

Primary Accrediting Authority: the agency or department designated at the Territory, State or Federal level as the recognized authority with responsibility and accountability for granting NELAC accreditation for a specified field of testing. (NELAC, 1.5.2.3)

Proficiency Testing: a means of evaluating a laboratory's performance under controlled conditions relative to a given set of criteria through analysis of unknown samples provided by an external source. (NELAC, 2.1)

Proficiency Testing Oversight Body/Proficiency Testing Provider Accreditor (PTOB/PTPA): an organization with technical expertise, administrative capacity and financial resources sufficient to implement and operate a national program of PT provider evaluation and oversight that meets the responsibilities and requirements established by NELAC standards. (NELAC)

Proficiency Testing Program: the aggregate of providing rigorously controlled and standardized environmental samples to a laboratory for analysis, reporting of results, statistical evaluation of the results and the collective demographics and results summary of all participating laboratories. (NELAC)

Proficiency Testing Study Provider: any person, private party, or government entity that meets stringent criteria to produce and distribute NELAC PT samples, evaluate study results against published performance criteria and report the results to the laboratories, primary accrediting authorities, PTOB/PTPA, and NELAP. (NELAC)

Proficiency Test Sample (PT): a sample, the composition of which is unknown to the analyst and is provided to test whether the analyst/laboratory can produce analytical results within specified acceptance criteria. (QAMS)

Protocol: a detailed written procedure for field and/or laboratory operation (e.g., sampling, analysis) which must be strictly followed. (EPA-QAD)

Quality Assurance: an integrated system of activities involving planning, quality control, quality assessment, reporting and quality improvement to ensure that a product or service meets defined standards of quality with a stated level of confidence. (QAMS)

Quality Assurance [Project] Plan (QAPP): a formal document describing the detailed quality control procedures by which the quality requirements defined for the data and decisions pertaining to a specific project are to be achieved. (EPA-QAD)

Quality Control: the overall system of technical activities whose purpose is to measure and control the quality of a product or service so that it meets the needs of users. (QAMS)

Quality Control Sample: an uncontaminated sample matrix spiked with known amounts of analytes from a source independent from the calibration standards. It is generally used to establish intra-laboratory or analyst specific precision and bias or to assess the performance of all or a portion of the measurement system. (EPA-QAD)

Quality Manual: a document stating the management policies, objectives, principles, organizational structure and authority, responsibilities, accountability, and implementation of an agency, organization, or laboratory, to ensure the quality of its product and the utility of its product to its users. (NELAC)

Quality System: a structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, accountability, and implementation plan of an organization for ensuring quality in its work processes, products (items), and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required QA and QC. (ANSI/ASQC E-41994)

Quantitation Limits: levels, concentrations, or quantities of a target variable (e.g., target analyte) that can be reported at a specified degree of confidence. (NELAC)

Radioactive Samples/Material: SwRI has established a practical release criterion for materials, equipment, and waste based upon the use of field survey instruments. Materials, equipment, system components, waste items, or waste containers are considered radioactive if:

- On contact survey the net count rate above mean background with any surface is greater that 100 cpm above mean background (usually 50 cpm) using a survey instrument;
- The concentrations of any radionuclides contained in the material matrix equal or exceed those specified in applicable federal, DOE, state or local regulations;
- They are labeled as “radioactive”.

Range: the difference between the minimum and the maximum of a set of values. (EPA-QAD)

Raw Data: any original factual information from a measurement activity or study recorded in a laboratory notebook, worksheets, records, memoranda, notes, or exact copies thereof that are necessary for the reconstruction and evaluation of the report of the activity or study. Raw data may include photography, microfilm or microfiche copies, computer printouts, magnetic media, including dictated observations, and recorded data from automated instruments. If exact copies of raw data have been prepared (e.g., tapes which have been transcribed verbatim, data and verified accurate by signature), the exact copy or exact transcript may be submitted. (EPA-QAD) *[effective July 1, 2001[*

Reagent Blank (Method Blant): A value of deonized, distilled water containing the same acid matrix as the calibration standards carried through the entire analytical scheme.

Recognition: previously known as reciprocity. The mutual agreement of two or more parties (i.e., states) to accept each other’s findings regarding the ability of environmental testing laboratories in meeting NELAC standards. (NELAC, 1.5.3)

Reference Material: a material or substance one or more properties of which are sufficiently well established to be used for the calibration of an apparatus, the assessment of a measurement method, or for assigning values to materials. (ISO Guide 30-2.1)

Reference Method: a method of known and documented accuracy and precision issued by an organization recognized as competent to do so. (NELAC*)*

Reference Standard: a standard, generally of the highest metrological quality available at a given location, from which measurements made at that location are derived. (VIM-6.08)

Reference Toxicant: the toxicant used in performing toxicity tests to indicate the sensitivity of a test organism and to demonstrate the laboratory's ability to perform the test correctly and obtain consistent results (NELAC, Chapter 5, Appendix D, Section 2.1f)

Replicate Analyses: the measurements of the variable of interest performed identically on two or more sub-samples of the same sample within a short time interval. (NELAC)

Requirement: denotes a mandatory specification; often designated by the term "shall". (NELAC)

Resource Conservation and Recovery Act (RCRA): the enabling legislation under 42 USC 321 *et seq.* (1976), that gives EPA the authority to control hazardous waste from the "cradle-to-grave", including its generation, transportation, treatment, storage, and disposal. (NELAC)

Revocation: the total or partial withdrawal of a laboratory's accreditation by the accrediting authority. (NELAC, 4.4.3)

Safe Drinking Water Act (SDWA): the enabling legislation, 42 USC 300f *et seq.* (1974), (Public Law 93-523), that requires the EPA to protect the quality of drinking water in the U.S. by setting maximum allowable contaminant levels, monitoring, and enforcing violations. (NELAC)

Sample Holding Time: The storage time allowed between sample collection and sample analysis when the designated preservation and storage techniques are employed.

Sample Tracking: procedures employed to record the possession of the samples from the time of sampling until analysis, reporting, and archiving. These procedures include the use of a Chain of Custody Form that documents the collection, transport, and receipt of compliance samples to the laboratory. In addition, access to the laboratory is limited and controlled to protect the integrity of the samples. (NELAC)

Secondary Accrediting Authority: the Territorial, State or federal agency that grants NELAC accreditation to laboratories, based upon their accreditation by a NELAP-recognized Primary

Accrediting Authority. See also **Recognition** and **Primary Accrediting Authority**. (NELAC, 1.5.2.3)

Selectivity: (Analytical chemistry) the capability of a test method or instrument to respond to a target substance or constituent in the presence of non-target substances. (EPA-QAD)

Sensitivity: the capability of a method or instrument to discriminate between measurement responses representing different levels (e.g., concentrations) of a variable of interest. (NELAC)

Shall: denotes a requirement that is mandatory whenever the criterion for conformance with the specification requires that there be no deviation. This does not prohibit the use of alternative approaches or methods for implementing the specification so long as the requirement is fulfilled. (ANSI)

Should: denotes a guideline or recommendation whenever noncompliance with the specification is permissible. (ANSI)

Spike: a known mass of target analyte added to a blank sample or sub-sample; used to determine recovery efficiency or for other quality control purposes. (NELAC)

Standard: the document describing the elements of laboratory accreditation that has been developed and established within the consensus principles of NELAC and meets the approval requirements of NELAC procedures and policies. (ASQC)

Standard Operating Procedures (SOPs): a written document which details the method of an operation, analysis or action whose techniques and procedures are thoroughly prescribed and which is accepted as the method for performing certain routine or repetitive tasks. (QAMS)

Standardized Reference Material (SRM): a certified reference material produced by the U.S. National Institute of Standards and Technology or other equivalent organization and characterized for absolute content, independent of analytical method. (EPA-QAD)

Statistical Minimum Significant Difference (SMSD): the minimum difference between the control and a test concentration that is statistically significant; a measure of test sensitivity or power. The power of a test depends in part on the number of replicates per concentration; the significance level selected, e.g., 0.05, and the type of statistical analysis. If the variability remains constant, the sensitivity of the test increases as the number of replicates is increased. (NELAC)

Supervisor (however named): the individual(s) designated as being responsible for a particular area or category of scientific analysis. This responsibility includes direct day-to-day supervision of technical employees, supply and instrument adequacy and upkeep, quality assurance/quality control duties and ascertaining that technical employees have the required balance of education, training and experience to perform the required analyses. (NELAC)

Surrogate: a substance with properties that mimic the analyte of interest. It is unlikely to be found in environment samples and is added to them for quality control purposes. (QAMS)

Suspended: Those elements which are retained by a 0.45 um membrane filter.

Suspension: temporary removal of a laboratory's accreditation for a defined period of time, which shall not exceed six months, to allow the laboratory time to correct deficiencies or area of noncompliance with the NELAC standards. (NELAC, 4.4.2)

Technical Director: individual(s) who has overall responsibility for the technical operation of the environmental testing laboratory. (NELAC)

Technology: a specific arrangement of analytical instruments, detection systems, and/or preparation techniques.

Test: a technical operation that consists of the determination of one or more characteristics or performance of a given product, material, equipment, organism, physical phenomenon, process or service according to a specified procedure. The result of a test is normally recorded in a document sometimes called a test report or a test certificate. (ISO/IEC Guide 2-12.1, amended)

Test Method: an adoption of a scientific technique for a specific measurement problem, as documented in a laboratory SOP or published by a recognized authority. (NELAC)

Testing Laboratory: a laboratory that performs tests. (ISO/IEC Guide 2-12.4)

Test Sensitivity/Power: the minimum significant difference (MSD) between the control and test concentration that is statistically significant. It is dependent on the number of replicates per concentration, the selected significance level, and the type of statistical analysis. (NELAC, Chapter 5, Appendix D, Section 2.4.a)

Tolerance Chart: A chart in which the plotted quality control data is assessed via a tolerance level (e.g., ±10% of a mean) based on the precision level judged acceptable to meet overall quality/data use requirements instead of a statistical acceptance criteria (e.g., ±3 sigma) (applies to radiobioassay laboratories). (ANSI)

Total: the concentration determined of an unfiltered sample following vigorous digestion, or the sum of the dissolved plus suspended concentrations.

Total Recoverable: The concentration determined on an unfiltered sample following treatment with hot, dilute mineral acid.

Toxic Substances Control Act (TSCA): the enabling legislation in 15 USC 2601 *et seq.*, (1976), that provides for testing, regulating, and screening all chemicals produced or imported into the United States for possible toxic effects prior to commercial manufacture. (NELAC)

TCLP: Toxicity characteristic leaching procedure.

Traceability: the property of a result of a measurement whereby it can be related to appropriate standards, generally international or national standards, through an unbroken chain of comparisons. (VIM-6.12)

United States Environmental Protection Agency (EPA): the federal governmental agency with responsibility for protecting public health and safeguarding and improving the natural environment (i.e., the air, water, and land) upon which human life depends. (US-EPA)

Validation: the process of substantiating specified performance criteria. (EPA-QAD)

Verification: confirmation by examination and provision of evidence that specified requirements have been met. (NELAC) NOTE: In connection with the management of measuring equipment, verification provides a means for checking that the deviations between values indicated by a measuring instrument and corresponding known values of a measured quantity are consistently smaller than the maximum allowable error defined in a standard, regulation or specification peculiar to the management of the measuring equipment. The result of verification leads to a decision either to restore in service, to perform adjustment, to repair, to downgrade, or to declare obsolete. In all cases, it is required that a written trace of the verification performed shall be kept on the measuring instrument's individual record.

Voting Member: officials in the employ of the Government of the United States, and the States, the Territories, the Possessions of the United States, or the District of Columbia and who are actively engaged in environmental regulatory programs or accreditation of environmental laboratories. (NELAC)

Work Cell: a well-defined group of analysts that together perform the method analysis. The members of the group and their specific functions within the work cell must be fully documented. (NELAC)

Sources:

40CFR Part 136

American Society for Quality Control (ASQC), Definitions of Environmental Quality Assurance Terms,

1996

American National Standards Institute (ANSI), Style Manual for Preparation of Proposed American

National Standards, Eighth Edition, March 1991

ANSI/ASQC E4, 1994

ANSI N42.23-1995, Measurement and Associated Instrument Quality Assurance for Radiobioassay Laboratories

International Standards Organization (ISO) Guides 2, 30, 8402

International Vocabulary of Basic and General Terms in Metrology (VIM): 1984. Issued by BIPM, IEC,

ISO and OIML

National Institute of Standards and Technology (NIST)

National Environmental Laboratory Accreditation Conference (NELAC), July 1998 Standards

Random House College Dictionary

US EPA Quality Assurance Management Section (QAMS), Glossary of Terms of Quality Assurance Terms, August 31, 1992 and December 6, 1995

US EPA Quality Assurance Division (QAD)

Webster's New World Dictionary of the American Language

Revision 2
Extensive revision to provide ISO formatting and include NELAC, DOE 414, and new EPA requirements. Added a section for “definitions” and inserted new references

Revision 3
10 In second paragraph of section 10, reworded reporting requirements to specify that the FRM-109 shall be used for the inspection and testing results of items and the Sample Discrepancy online application shall be utilized to identify discrepancies.
10.1 Created second paragraph to identify the requirement of labeling chemicals and standards with date received, date opened, the initialing of the staff that opened it, and the inclusion of the expiration date

Glossary/Definitions:
Removed “2001 NELAC Standards Chapter 1” from underneath the “Glossary/Definitions” title specifying exclusive association with NELAC definitions
Added 24 other definitions relevant to laboratory activities

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DETERMINATION OF NDMA, DMN, BROMACIL BY GC/MS/SIM METHOD

REV 2

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Revised By: _____ Date: 05/20/2003

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Director: _____ Date: 5/20/03

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SOUTHWEST RESEARCH INSTITUTE

CHEMISTRY AND CHEMICAL ENGINEERING	Test/Analytical Procedure 01.0408 Bioanalytical Chemistry	Procedure Number TAP-01-0408-031	Prepared By: Gang Sun	
	Title: ***Determination of NDMA, DMN, BROMACIL by GC/MS/SIM Method***	Effective Date: May 2003	Revision 2	Page 1 of 6

1.0 SCOPE

1.1 This procedure is applicable to ground water and drinking water samples extracted according to EPA_SW-846 Method 3510C.

1.2 This procedure is to be used in the GC/MS/SIM analysis for determination of N-Nitrosodimethylamine (NDMA), N-Nitrodimethylamine (DMN), and Bromacil with detection limit at 10 ppt level and MDL at about 5 ppt level.

2.0 PURPOSE

This procedure defines the method for determination of NDMA-DMN-Bromacil by GC/MS/SIM.

30 RESPONSIBILITIES

3.1 It is the responsibility of the laboratory supervisor to assure that all steps described in this procedure are performed.

3.2 It is the responsibility of the laboratory personnel to comply with all the criteria described in this procedure any deviations from this TAP will documented in the project narrative.

4.0 REFERENCES

4.1 The NDMA, Bromacil, and internal standards must be certified when available. Since the DMN standard is not commercially available, a research standard from academic laboratory is acceptable.

4.2 1,4-Dichlorobenzene-d4 and phenanthrene-d10 will be used as internal standards.

4.3 Five different levels of working standards are prepared, corresponding to a range from 0.01 to 10 ng/μL. Stock internal standard solution is added to each standard and sample extracts so that the concentration of internal standard in 0.2 ng/μL.

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5.0 PROCEDURE

5.1 Materials – Equipment

5.1.1 A GC/MS instrument equipped with data acquisition and analysis software.

5.1.2 A 30 m x 0.25 mm i.d. DB-1701 column.

5.2 Instrument Preparation

5.2.1 Gas Chromatograph Preparation

5.2.1.1 The injector liner is removed and cleaned and the injector septum is replaced as needed, based upon the number of samples, type of samples and calibration performance.

5.2.1.2 Set GC operating parameters. Typical values are as follows:

Carrier Gas (Helium, GC Grade)	1.5-2 mL/min
Column Head pressure	7 psi
Injector Temperature	240 °C

5.2.1.3 Set the GC oven program as following

▪ Initial Temperature	40 °C
▪ Initial Time	4.0 min
▪ Rate	10 °C/min
▪ Temperature	150 °C
▪ Rate	20 °C/min
▪ Final Temperature	270 °C
▪ Held Time	4.0 min
▪ Injection Volume	3 µL

5.2.2 Mass Spectrometer Preparation

▪ Source Temperature	200 °C
▪ Electron Energy	70 eV
▪ Emission Current Approx.	100 µA

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5.2.3 The GC/MS selected-ion-monitoring (SIM) acquisition is then set up using the following procedure.

Compound	Monitored Ions	Quantitation Mass
1,4-Dichlorobenzene-d4(IS)	150, 152	150
Phenanthrene-d10 (IS)	188, 94	188
N-Nitrosodimethylamine	74, 59	74
N-Nitrodimethylamine	90, 60	90
Bromacil	205, 207	205

5.3 Sample Preparation

5.3.1 1000 mL water sample will be extracted according to EPA_SW-846 Method 3510C with final volume of 1.0 mL in methylene chloride.

5.3.2 Prior to extract analysis, the gas chromatograph is calibrated using the five working standards as shown in section 4.3.

5.3.3 A mid-level continuing calibration standard is analyzed at the beginning and ending of each analytical sequence and as necessary.

5.3.4 A volume of 1000 µL of each extract solution is pipetted into its respective vial. Internal standard solution is added to the sample vial so that the concentration of each internal standard in the extract is 0.20 ng/µL. The vial is immediately closed with a crimp cap. The meniscus level on each vial is marked. The sample vials are then inserted in an autosampler tray in the proper sequence.

5.4 Instrument Calibration

5.4.1 As soon as possible upon completion of the five calibration standards, the data will be evaluated to verify proper calibration of the instrument.

5.4.2 A hardcopy of all selected ion chromatograms will be printed, signed and dated by the analyst and entered into the study archive.

5.4.3 All chromatograms are inspected to insure that the baseline is properly assigned. Chromatograms that are not properly integrated will be manually re-integrated.

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5.4.4 Calibration will be performed using the reconstructed ion chromatograms of the selected masses. Relative response factors (RRF) for each target analyte will be determined by:

$$RRF = (A_t \times C_{is})/(A_{is} \times C_t)$$

Where
A_t = the integrated area of the quantitation mass selected ion chromatogram peak for the target analyte
A_{is} = the integrated area for the quantitation mass of the selected ion chromatogram for the quantitation mass of the internal standard
C_{is} = the concentration of the internal standard
C_t = the concentration of the target analyte in the standard.

5.4.5 Over the calibration range, the mean relative response factor (mean RRF) and the percent relative standard deviation (%RSD) are calculated for each target analyte.

5.4.6 Calibration is successful when the %RSD for each target analyte is less than or equal to 35%.

5.4.7 If a target analyte has a calibration outside the 35 % RSD range, the sequence will be aborted. An attempt will be made by the analyst to ascertain the source of the calibration drift. If the problem is corrected, the calibration process repeated. If the problem cannot be determined, the laboratory supervisor is contacted for further instructions.

5.4.8 All maintenances will be recorded in the instrument maintenance log-book.

5.5 Acceptance Criteria - Quality Control

5.5.1 Solvent blanks will be analyzed for each extraction batch. Acceptance criteria for blanks is less than reporting limit. If blank results are outside of this criterion, reanalyze blanks to determine whether the problem is instrument carryover. If blank re-analysis does not meet criteria, document the problem, then proceed.

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5.5.2 Matrix spikes of all target analytes will be performed. Lab control spikes (LCS) sample will be spiked at 0.50 ppb level before the extraction. One sample matrix spike or one LCS will be performed for each sample extraction batch. Acceptable recoveries for matrix spikes are list as following:

- N-Nitrosodimethylamine (NDMA): 13-110 %
- N-Nitrodimethyl amine (DMN): 30-150 %
- Bromacil: 50-190 %

5.5.3 If matrix spikes are outside the accepted range, re-analyze the spikes. If spikes are still outside acceptable criteria, repeat the matrix spike extraction. If the spikes are still outside the accepted range, document the problem and notify the project manager.

5.6 Determination of Method Detection Limit (MDL) and Reporting Limit

5.6.1 The reporting limit is decided by the lowest concentration point in five-point calibration range.

5.6.2 The method detection limit (MDL) is determined by extract and analyze seven replicate LCS samples that is spiked at the lowest level of five-point calibration curve, and then calculated according to its statistics results.

5.6.3 The MDL is determined annually.

6.0 MAINTENANCE

All maintenance performed on the pumps, autosampler or detector will be done in accordance with the manufacturers operations manuals or upon approval of the laboratory supervisor.

7.0 SAFETY

7.1 Since this procedure involves the analysis of samples from known or suspected hazardous waste sites, all sample extracts should be handled with caution.

7.2 All personnel working on this procedure should be familiar with the SwRI division 01 Chemical Hygiene Plans and associated addendum(s) for the laboratories they are working in.

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8.0 RECORDS

8.1 All observations and procedures used for standard preparation will be immediately recorded in the laboratory notebook by the analyst.

8.2 All spreadsheets, raw chromatograms, sequence files, calibration files and quantitation files will be signed and dated by the analyst and will become part of the study archive.

8.3 All instrument maintenance performed will be entered into the instrument maintenance logbook.

REVISION 2
Updated TAP to include the analysis of DMN and Bromacil in this procedure.

STL Denver LQM

Manual Cover Page 1
LQM Interim Changes 2
Purpose and Scope 4
Table of Contents 5
Section 1.0 Management Commitment and Organization 15
Section 2.0 Quality System and Description 26
Section 3.0 Document Control and Records Management 29
Section 4.0 Staff Qualification, Orientation and Training 33
Section 5.0 Procurement of Supplies and Services 37
Section 6.0 Computer Hardware and Software 43
Section 7.0 Contract Review and Project Planning 49
Section 8.0 Work Processes and Operations 54
Section 9.0 Quality Assessment and Response 92
Table of Section 100
Table 2.4-1 LQM Source Documents Requirements Matrix 101
Table 2.4-2 Cross-Reference of LQM to NELAC 108
Table 2.4-3 STL Denver Quality Documents and Required Approval 112
Table 3.4-1 STL Denver Records & Retention Schedule 113
Table 5.2-1 List of STL Quality-Related Items 115
Table 6.-1 GALP Cross Reference To LQM 116
Table 7.2 Certifications, Licenses and Approvals 121
Table 8.0-1 Instrument List 142
Table 8.2-2 Standard Operating Procedures 146
Table 8.2-3 Wet Chemistry Methods 151
Table 8.2-4-1 Wet Chemistry Methods, MDL and Reporting Limits 170
Table 8.2-4-2 GFAA Metals and Mercury 173
Table 8.2-4-3 Conventional ICP Metals Methods 174
Table 8.2-4-4 Trace ICP Metals 176
Table 8.2-4-5 ICP/MS Metals-Methods 177
Table 8.2-4-6 Method 601 CWA Hologenated Volatile Organics 178
Table 8.2-4-7 Method 8021B Haologenated and Aromatic Volatile Organics 180
Table 8.2-4-8 Gasoline and Diesel Range Organics 182
Table 8.2-4-9 Method 602 CWA Aromatic Volatile Organics 183
Table 8.2-10 Method 608 CWA Pesticides and PCBs 184
Table 8.2-11 Method 8081A Target Compound List and Appendix IX Pesticides 185
Table 8.2-12 Method 8082 PCBS 186
Table 8.2-13 Method 8141A Target Compound List and Appendix IX Pesticides 187
Table 8.2-14 Method 8151A Herbicides 188

Table 8.2-15 Method 8330 Explosives by HPLC 189
Table 8.2-16 Method 8310 Polynuclear Aromatic Hydrocarbons 190
Table 8.2-17 Method 524.2 Pargeable Organic Compounds in Water by GC/MS..... 191
Table 8.2-18 Method 624 CWA Volatile Organics by GC/MS 194
Table 8.2-19 Method 8260B Volatile Organics by GC/MS 195
Table 8.2-20 Method 625 CWA Semivolatile Organics by GC/MS 198
Table 8.2-19 Method 8260B Volatile Organics by GC/MS (Cont.)..... 199
Table 8.2-21 Method 8270C Semivolatile Organics by GC/MS... 201
Table 8.2-19 Method 8260B Volatile Organics by GC/MS (Cont.)..... 202
Table 8.4-7 Radiological Quality Control Samples 206
Table 8.4-1 Field Quality Control Samples 217
Table 8.4-2 Laboratory Quality Control Samples..... 218
Table 8.4-3 Laboratory Performance Quality Control Samples ... 219
Table 8.4-4 Matrix Specific Quality Control Samples 219
Table 8.4-5 Inorganic Laboratory Quality Control Samples..... 220
Table 8.4-6 Organic Laboratory Quality Control Samples 263
Table 8.5-1 Inorganic Sample Containers, Preservatives, and Holding Times..... 286
Table 8.5-2 Organic Sample Containers, Preservatives, and Holding Times..... 298
Table 8.5-5 Sample Containers, Preservatives, and Holding Times for TCLP and SPLP 307
Table 8.5-6 Periodic Equipment Calibrations 308
Table 8.5-7 Summary of Inorganic Method Calibrations 309
Table 8.5-8 Summary of Organic Method Calibrations..... 324
Table 8.6-1 Precision and Accuracy Measurements 331
Table 8.11-1 Instrument Maintenance Schedule Ion Chromatograph..... 333
Table 8.11-2 Instrument Maintenance Schedule Colorimetric Autoanalyzer..... 333
Table 8.11-3 Instrument Maintenance Schedule Total Organic Halide Analyzer..... 334
Table 8.11-4 Instrument Maintenance Schedule ICAP/MS 334
Table 8.11-5 Instrument Maintenance Schedule ICP 335
Table 8.11-6 Instrument Maintenance Schedule Graphite Furnance Atomic Absorption 336
Table 8.11-7 Instrument Maintenance Schedule Cold Vapor Atomic Absorption..... 336
Table 8.11-8 Instrument Maintenance Schedule Gas Chromatograph..... 337

Tables 8.11-8 Instrument Maintenance Schedule Gas Chromatograph (Cont.) 338
Tables 8.11-9 Instrument Maintenance Schedule High Pressure Liquid Chromatograph 338
Table 8.11-10 Instrument Maintenance Schedule Mass Spectrometer 340
Table 8.11-12 Instrument Maintenance Schedule Sonicator 341
Table 8.11-13 Instrument Maintenance Schedule Analytical/Top Loading Balances 341
Table 8.11-14 Instrument Maintenance Schedule Refrigerators/Walk-in Coolers 341
Table 8.11-15 Instrument Maintenance Schedule Ovens 341
Table 8.11-16 Instrument Maintenance Schedule Specific Digital Ion Analyzer 342
Table 8.11-17 Instrument Maintenance Schedule Turbidimeter 342
Table 8.11-18 Instrument Maintenance Schedule Dissolved Oxygen Meter 342
Table 8.11-19 Instrument Maintenance Schedule Conductance Meter 343
Table 8.11-20 Instrument Maintenance Schedule Chemical Oxygen Demand (COD) Reactor 343
Table 8.11-21 Instrument Maintenance Schedule Spectrophotometer 343
Table 8.11-22 Instrument Maintenance Schedule pH Meter 344
Table 8.11-23 Instrument Maintenance Schedule Total Organic Carbon Analyzer 344
Table 8.11-24 Instrument Maintenance Schedule APCI/ESI LC/MS/MS 345
Table 8.11-25 Instrument Maintenance Schedule Digestion Block 346
Table 8.11-26 Flash Point Tester 346
Table 9.4-1 Proficiency Testing Programs 347
Acronyms and Initialisms 348
Glossary 354

Total Number of Pages in this Package 378

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SEVERN TRENT SERVICES

STL Denver

Laboratory Quality Manual for

STL Denver

4955 Yarrow Street
Arvada, Colorado 80002
(303) 736-0100

Approved by:

Timothy O'Shields, Laboratory Director & Technical Director — Date: 9/28/00

Larry Penfold, Quality Assurance Manager — Date: 9-28-00

Revision 0
September 27, 2000
Controlled Copy Number: Uncontrolled

LQM Interim changes

Change Number	Section Effected	Location	Subject of change
LQM IC A	6.5	Following page 27	Change cross-reference from referring to section 9.2.2.1 to refer to 9.4.2
LQM IC B	Table 6.1	Following page 87	8.1.2--References in this section to 9.2.2.1 should be 9.4.2. 8.3--References to 9.2 should be 9.4.2 and 9.4.3 8.3.2—References to LQM 1.61 should be 1.6.1
LQM IC C	Page xi Title for section 2.4-2	Following page xi	QAMP should be LQM
LQM IC D	Acronyms and Initialisms	Following page 288	Inclusion of LQM Laboratory Quality Manual
LQM IC E	Acronyms and Initialisms	Following page 289	Omit QAMP definition
LQM IC F	Glossary	Following page 299	Inclusion of LQM definition
LQM IC G	Glossary	Following page 304	Replace QAMP with LQM
LQM IC H	Glossary	Following page 293	Replace Quanterra with STL Denver
LQM IC I	Section 7.2	Following page 89	Inclusion of Laboratory Certification table
LQM IC J	Section 1.5	Following page 2	Insert NELAC/Rule 444-14…
LQM IC K	Section 9.3	Following page 70	Insert systematic error notification statement.
LQM IC L	Section 8.2.3	Following page 36	MDL and RDL Access Statement
LQM IC M	Section 4.1	Following page 16	Reference to Job Descriptions
LQM IC N	Section 5.3	Following page 21	Written notice of Sub Contractor
LQM IC O	Table 2.4-1	Following page 76, 77, and 78	Include DOE O 414.1A in LQM
LQM IC P	Table 8.4-7	Following page 154	Radiochemical Quality Control

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Purpose and Scope

The purpose of this Laboratory Quality Manual (LQM) is to describe the implementation the Severn Trent Laboratories (STL) Quality System at the STL Denver laboratory. The LQM is written within the guidelines of the STL Quality Management Plan (QMP), which applies to all STL laboratories. The organization of this LQM is based on the "EPA Requirements for Quality Management Plans" (EPA QA/R-2, August 1994). This LQM outlines specific policies, organization, responsibilities, and activities required to assure high quality laboratory services. The LQM also fulfills the requirements of our clients and government agencies for laboratory quality manual. Particular emphasis is given to the requirements of the National Environmental Laboratory Accreditation Conference (NELAC) standards, and the Utah Rule R444-14 implementing the NELAC guidelines.

This LQM contains references to other essential STL quality documents. The company-wide QMP, STL Denver LQM, and referenced policies and SOPs are interrelated. Together they provide an integrated quality foundation that meets the objectives of the STL Quality Assurance Policy, as stated in Section 1.2.

The requirements set forth in this document are applicable to all employees at the STL Denver laboratory. The policies and practices described here are presented as minimum guidelines only. Based on good scientific judgment, more rigorous requirements may be applied by laboratory employees. Specific requirements delineated in project plans may supersede general quality requirements described in this manual.

Table of Contents

Page

Table of Contents
Title and Signature Page i
Copyright Statement ii
Purpose and Scope iii
Table of Contents iv
List of Figures x
List of Tables xi

1.0 Management Commitment and Organization 1
1.1 STL Management Statement of Commitment to Quality Assurance 1
1.2 STL Quality Assurance Policy 1
1.4 Ethics, Waste, Fraud and Abuse 1
1.5 Organizational Structure and Relationships 2
1.6 Quality Organization 6
1.6.1 Quality Assurance Manager 6
1.6.2 Laboratory Director 6
1.6.3 Operations Manger 7
1.6.4 Laboratory Technical Director 7
1.6.5 Systems Manager 7
1.6.6 Customer Service Manager 8
1.6.7 Project Manager 8
1.6.8 Group Leader or Supervisor 8
1 6.9 Analyst 9
1.6.10 Sample Custodian 9
1.6.11 Report Production Staff 9

2.0 Quality System and Description 10
2.1 Objectives of the STL Quality System 10
2.2 Structure of the STL Quality System 10
2.3 Quality Assurance and Quality Control 10
2.4 Quality Documents 10
2.4.1 STL Quality Management Plan (QMP) 11
2.4.2 STL Company-Wide Polices 11
2.4.3 Laboratory Quality Manual (LQM) 11
2.4.4 STL Denver Quality Policy Documents 11
2.4.5 Standard Operating Procedures 11

Table of Contents (continued)

Page

2.0 Quality System and Description (continued)
2.4.6 Quality Assurance Project or Program Plans (QAPPs) 11
2.4.6.1 Quality Assurance Summaries 12
2.4.7 Quality Assurance Summaries 12

3.0 Document Control and Records Management 13
3.1 Objectives for Control of Quality Documents and Vital Records 13
3.2 Document Control Procedures 13
3.3 Document Review, Approval and Revision 13
3.4 Records Management 14
3.5 Document and Record Storage, Retention and Disposal 14
3.6 Data Confidentiality 15

4.0 Staff Qualification, Orientation and Training 16
4.1 Qualifications 16
4.2 Orientation and Technical Training 16
4.2.1 Quality Assurance (QA) Orientation 16
4.2.2 Quality Training 17
4.2.3 Health and Safety, Orientation and Training 17
4.2.4 Radiation Safety Training 17
4.3 Training Files 17
4.4 Technical Proficiency Demonstration 18

5.0 Procurement of Supplies and Services 19
5.1 Selection of Vendors 19
5.2 Controlling Quality of Purchased Items 19
5.2.1 Evaluation of Off-the-Shelf Items 20
5.2.2 Evaluation of Instruments 20
5.2.3 Evaluation of Critical Solvents and Acids 20
5.2.4 Evaluation of Chemical Standards and Reference Materials 20
5.2.5 Corrective Action for Failure to Meet Required Specifications 21
5.3 Procurement of Subcontract Laboratory Services 21

6.0 Computer Hardware and Software 23
6.1 Computer Hardware 23
6.1.1 Wide-Area Systems 23
6.1.2 Local Systems 23

Table of Contents (continued)

Page

6.0 Computer Hardware and Software (cont.)
6.2 Facilities and Security 24
6.2.1 Central Computer Facilities 24
6.2.1 Local Computer Facilites 24
6.2.3 Controlled Sofware Access 24
6.2.4 Virus Protection 24
6.3 LIMS Raw Data 24
6.4 Software 25
6.4.1 Industry Standard Software 25
6.4.2 Testing of STL-Developed Software 25
6.4.3 Control of Software Changes 26
6.4.4 Software Maintenance 26
6.4.5 Software Revalidation 27
6.5 Comprehensive System Testing 27
6.6 Records Retention 27

7.0 Contract Review and Project Planning 28
7.1 Contract Review 28
7.2 Certifications and Approvals 28
7.3 Data Collection Process 29
7.4 Project Organizational Responsibilities 29
7.5 Communicating Project Requirements Internally 31
7.6 Contingency Planning 31
7.61 Staffing 31
7.6.2 Backup Instrumentation 32

8.0 Work Processes and Operations 33
8.1 Traceability of Measurements 33
8.2 Analytical Methods 33
8.2.1 Standard Operating Procedures 34
8.2.2 Method Validation and Verification 34
8.2.2.1 Method Verification 34
8.2.2.2 Method Validation 35
8.2.3 Method Detection Limits 36
8.2.4 Instrument Detection Limits 36
8.2.5 Reporting Limits 36

Table of Contents (continued)

Page

8.0 Work Processes and Operations (continued)

8.3 Data Quality Objectives....37
8.3.1 Precision and Accuracy....37
8.3.2 Completeness....38
8.3.3 Representativeness....38
8.3.4 Comparability....38
8.4 Quality Control Samples....38
8.4.1 Field QC Samples....39
8.4.2 Laboratory QC Samples....39
8.4.2.1 Quality Control (QC) Batch....39
8.4.2.2 Method Blank....40
8.4.2.3 Instrument/Calibration Blank....40
8.4.2.4 Laboratory Control Sample....40
8.4.2.5 Matrix Spike....41
8.4.2.6 Matrix Spike Duplicate....41
8.4.2.7 Sample Duplicate....41
8.4.2.8 Surrogates....41
8.4.2.9 Analytical Spike....41
8.4.2.10 Interference Check Sample....42
8.4.2.11 Internal Standards....42
8.5 Data Collection Operations....42
8.5.1 Field Collection and Shipment....42
8.5.2 Sample Containers, Shipping Containers, Preservatives, and Holding Times....45
8.5.2.1 Sample Containers....45
8.5.2.2 Shipping Containers....46
8.5.2.3 Sample Preservatives....46
8.5.2.4 Sample Holding Times....46
8.5.3 Sample Handling....46
8.5.3.1 Sample Receipt....46
8.5.3.2 Exceptions or Discrepancies....49
8.5.3.3 Sample Log-in....49
8.5.3.4 Sample Storage....49
8.5.3.5 Internal Sample Chain-of-Custody and Interlaboratory Transfers....50
8.5.3.6 Subsampling....51
8.5.3.7 Sample Disposal and Return Chain-of-Custody....51

Table of Contents (continued)

Page

8.0 Work Processes and Operations (continued)
8.5.4 Calibration Procedures and Criteria....51
8.5.4.1 Physical Reference Standards....52
8.5.4.2 Chemical Reference Standards and Reagents....52
8.5.4.3 Standard Verification....53
8.5.4.4 Periodic Calibration....54
8.5.4.5 Operational and Continuing Calibration....54
8.6 Quality Assessment....55
8.6.1 Data Quality Assessment....55
8.6.2 Statistical Evaluation of Data....56
8.7 Data Recording Procedures....56
8.8 Data Reduction and Verification Procedures....56
8.8.1 Data Reduction and Initial Verification....57
8.8.2 Data Verification....60
8.8.3 Completeness Verification....60
8.9 Data Reporting....61
8.9.1 Data Reports....61
8.9.2 Final Report Details....62
8.9.3 Verbal Results....62
8.9.4 Reporting Analytical Results....63
8.9.5 Reissued Deliverables....63
8.9.6 Client Confidentiality....64
8.10 Data Validation....64
8.11 Preventive Maintenance and Service....64
8.11.1 Analytical Instrumentation and Equipment....64
8.11.2 Frequency of Equipment Maintenance....65
8.11.3 Facilities....65
8.11.4 Facility Security....65
8.12 Requirements for Ancillary Equipment and Materials....66
8.12.1 Water....66
8.12.2 Compressed Air and Gases....66
8.12.3 Glassware Preparation....66
8.12.4 Chemical Storage....67
8.12.5 Waste Management....67

9.0 Quality Assessment and Response....69
9.1 Nonconformances....69
9.1.1 Nonconformance Memo (NCM)....69
9.2 Client Complaints....70

Table of Contents (continued)

Page

9.0 Quality Assessment and Response (continued)

9.3 Corrective Actions 70
9.3.1 Monitoring Corrective Actions 70
9.4 Internal Audits 71
9.4.1 Audit Types and Frequency 71
9.4.2 Systems Audits 71
9.4.3 Data Audits 72
9.4.4 Spot Assessments 72
9.4.5 Proficiency Testing 72
9.4.5.1 External PT Samples 73
9.4.5.2 Internal PT Samples 73
9.5 External Audits 73
9.6 Management Reviews 73
9.6.1 Quality Reports to Management 73
9.6.2 Management Review of QA Systems 74

List of Figures

Figure	Title	Page
1.4-1	STL Ethics Agreement	3
1.5-1	STL Denver Organizational Structure	4
1.5-2	STL Denver Key Personnel	5
4-1	Employee Minimum Training Requirements	18
7.2-1	Data Collection Process Flow Diagram	30
8.5-1	Example STL Chain-of-Custody Form	44
8.5-2	Example STL Condition Upon Receipt Anomaly Report (CUR)	48
8.8-1	Data Reduction, Verification, and Reporting	59
8.11-1	Floor Plan	68
9.4-1	Audit Types and Frequency	71

List of Tables

Table No.	Title	Page
	Tables Cover Page	75
2.4-1	LQM Source Documents Requirements Matrix	76
2.4-2	Revised 1/10/03 Cross-Reference of QAMP Sections Addressing NELAC Quality Manual Requirements	79
2.4-3	STL Denver Quality Documents and Required Approvals	83
2.4-4	STL Quality Document Review Frequency	83
3.4-1	STL Denver Records and Retention Schedule	84
5.2-1	List of STL Quality-Related Items that Require Evaluation Prior to Use	86
6-1	GALP Cross Reference to LQM	87
8.0-1	Instrument List	90
8.2-2	Standard Operating Procedures	94
8.2-3	Wet Chemistry Methods	99
	Methods for Mercury by Cold Vapor Atomic Absorption	105
	Methods for Metals by Graphite Furnace Atomic Absorption	106
	Methods for Metals by ICP	108
	Methods for Metals by ICP/MS	111
	Metals Sample Preparation Methods	112
	Organic Sample Preparation and Analysis Methods	113
	Organic Methods of Analysis	115
8.2-4	Inorganic MDLs and RLs	118
	Organic MDLs and RLs	126
8.4-1	Field Quality Control Samples	156
8.4-2	Laboratory Quality Control Samples	157
8.4-3	Laboratory Performance Quality Control Samples	158
8.4-4	Matrix Specific Quality Control Samples	158
8.4-5	Inorganic Laboratory Quality Control Samples	159
8.4-6	Organic Laboratory Quality Control Samples	202
8.4-7	Revised 1/6/03 Radiochemical Quality Control Samples	154a
8.5-1	Inorganic Sample Containers, Preservatives, and Holding Times	225
8.5-2	Organic Sample Containers, Preservatives, and Holding Times	237
8.5-5	Sample Containers, Preservatives, and Holding Times for TCLP and SPLP	246
8.5-6	Periodic Equipment Calibrations	247
8.5-7	Summary of Inorganic Method Calibrations	248
8.5-8	Summary of Organic Method Calibrations	269

Implementation Date 12-19-00

STL-Denver

Interim SOP Change - This is a controlled document

SOP NUMBER:

SOP TITLE: Laboratory Quality Manual (LQM)

SOP SECTION(S) AFFECTED BY CHANGE: Page xi Title for section 2..4-2

REASON FOR CHANGE(S): Correct reference from QAMP to LQM

Change section *{insert section #}* **from:** 2.4-2 Cross-Reference of QAMP....

To: 2.4-2 Cross-Reference of LQM....

SUBMITTED BY/DATE: 12/14/00

APPROVED BY:

Technical Reviewer — Date 12/14/00

James S. Kelly, Health and Safety Coordinator — Date 12/14/00

Larry Penfold, Quality Assurance Manager — Date 12/14/00

Timothy M. O'Shields, Laboratory Director — Date 12/14/00

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List of Tables (continued)

Table No.	Title	Page
8.6-1	Precision and Accuracy Measurements	270
8.11	Instrument Preventative Maintenance Schedules	272
9.4-1	Proficiency Testing Programs	286
	Acronyms and Initialisms	287
	Glossary	291

1.0 Management Commitment and Organization

1.1 STL Management Statement of Commitment to Quality Assurance

STL management is committed to providing the highest quality data and the best service in the environmental testing industry. To ensure that the data produced and reported by STL meet the requirements of its clients and comply with the letter and spirit of municipal, state and federal regulations, STL maintains a Quality System that is clear, effective, well communicated, and supported at all levels in the company.

1.2 STL Quality Assurance Policy

It is STL's policy to:

- provide high quality, consistent, and objective environmental testing services that meet all relevant federal, state, and municipal regulatory requirements;
- generate data that are scientifically sound, legally defensible, meet project objectives, and are appropriate for their intended use;
- provide STL clients with the highest level of professionalism and the best service practices in the industry;
- build continuous improvement mechanisms into all laboratory administration, and managerial activities; and
- maintain a working environment that fosters open communication with both clients and staff

1.4 Ethics, Waste, Fraud and Abuse

Establishing and maintaining a high ethical standard is an important element of a Quality System. In order to ensure that all personnel understand the importance the company places on maintaining high ethical standards at all times, STL has established an Ethics Agreement (see Figure 1.4-1). Ethics is also a major component of the STL QA training program (see Section 3 for more discussion). A central tenant is that management must consistently convey the message to analysts that financial pressures can never be allowed to compromise the quality of work.

See the following policies related to ethics in the laboratory:

LQM Section 6 – Computer Hardware and Software
QA-008 – Data Recording Requirements
QA-010 – Maintaining Time Integrity
QA-011 – Acceptable Manual Integration Practices
P-T-001 – Selection of Data Points Required for an Initial Calibration Curve

Revised MLG 07/31/07

1.5 Organizational Structure and Relationships

STL Denver has day-to-day independent operational authority, and is overseen by corporate officers (President, Commercial Director, Chief Operating Officer, Corporate Quality Assurance, etc.). The responsibilities and authorities of the members of the Severn Trent Laboratories, Inc. corporate staff employees are described in the STL QMP. The STL Denver laboratory operational and support staff work under the direction of the Laboratory Director. The organizational structure for STL Denver is presented in Figure 1.5-1. A list of key STL Denver personnel qualifications is provided in Figure 1.5-2. The lab also maintains Job Descriptions that contain general job responsibilities for all laboratory employees. The following section outlines responsibilities and authorities for all employees of the STL Denver laboratory, as they relate to quality management.

The STL Denver QA Manager (QAM) is independent from day-to-day laboratory operations, has no direct analytical testing responsibilities, and is free from financial and other undue pressures which might adversely affect the quality of work. The QAM, a key member of the laboratory's management team, has direct access to the Corporate Quality Assurance Director on all matters involving quality. The QAM is available to any lab employee to resolve quality or ethical issues. The QAM, if required, has the authority to cease operations adversely affecting the validity or integrity of the analytical data.

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STL DENVER
Interim SOP Change

SOP NUMBER: **LQM Revision No.: 0**

SOP TITLE: **STL Denver LQM**

SOP SECTION(S) AFFECTED BY CHANGE: **1.5**

REASON FOR CHANGE: Compliance with NELAC and Utah Rule 444-14 regarding STL Denver organization and designees.

CHANGE: NELAC and Utah Rule 444-14 require that the laboratory designate a QA Manager, a Deputy QA Manager, a Technical Director, and a Deputy Technical Director. The deputies assume the responsibilities and authority of the senior positions, as shown in Section 1.6, in the absence of the QA Manager or the Technical Director. These positions are a required part of the STL Denver organization, and the designees must be clearly indicated on the organization chart, as shown in Figure 1.5-1.

SUBMITTED BY/DATE: Michael Schmitt, 07/30/01

APPROVED BY:

Timothy O'Shields, Laboratory Director & Technical Director — Date: 7-31-01

Larry Penfold, Quality Assurance Manager — Date: 7/30/01

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1.5 Organizational Structure and Relationships

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NELAC and Utah Rule 444-14 require that the laboratory designate a QA Manager, a Deputy QA Manager, a Technical Director, and a Deputy Technical Director. The deputies assume the responsibilities and authority of the senior positions, as shown in Section 1.6, in the absence of the QA Manager or the Technical Director. These positions are a required part of the STL Denver organization, and the designees must be clearly indicated on the organization chart, as shown in Figure 1.5-1.

The STL Denver QA Manager (QAM) is independent from day-to-day laboratory operations, has no direct analytical testing responsibilities, and is free from financial and other undue pressures which might adversely affect the quality of work. The QAM, a key member of the laboratory's management team, has direct access to the Corporate Quality Assurance Director on all matters involving quality. The QAM is available to any lab employee to resolve quality or ethical issues. The QAM, if required, has the authority to cease operations adversely affecting the validity or integrity of the analytical data.

Figure 1.4-1 STL Ethics Agreement

It is the policy of STL to incorporate the highest standard of quality with all analytical programs by adhering to the following practices:

STL will only offer environmental analyses for which it can consistently demonstrate compliance with high quality, traceable and legally defensible performance standards.
All STL staff is committed to the practice of complete honesty in the production and reporting of data.
Staff who are aware of misrepresentation of facts or data manipulation to bypass established QA/QC requirements, are required to immediately inform their supervisor or any member of the upper management.

All employees are asked to sign a copy of the statement below upon their first day of employment.

I, _____(print name) understand that high standards of integrity are required of me with regard to the duties I perform and the data I report in connection with my employment at the Company. I agree that in the performance of my duties at the Company:
I will not intentionally report data values that are not the actual values obtained;
I will not intentionally report the dates, times, sample or QC identifications, or method citations of data analyses that are not the actual dates, times, sample or QC identifications, or method citations;
I will not intentionally misrepresent another individual's work; and
If a supervisor or a member of STL management requests me to engage in or perform an activity that I feel is compromising data validity or quality, I will not comply with the request and report this action immediately to a member of the upper management, up to and including the president of Severn Trent Laboratories Inc.
I will not intentionally report data values that do not meet established quality control criteria as set forth in the Method and/or Standard Operation Procedures, or as defined by Company Policy.

I agree to inform my Supervisor of any accidental reporting of non-authentic data by me in a timely manner. I agree to inform my Supervisor of any accidental or intentional reporting of non-authentic data by other employees. I have read this Ethics Agreement and understand that failure to comply with the conditions stated above will result in disciplinary action, up to and including termination from the Company.

Compliance with this policy of business ethics and conduct is the responsibility of every STL employee. Disregard or failing to comply with this standard of business ethics and conduct could lead to disciplinary action, up to and including possible termination of employment.

Figure 1.5-1 STL Denver Organizational Structure

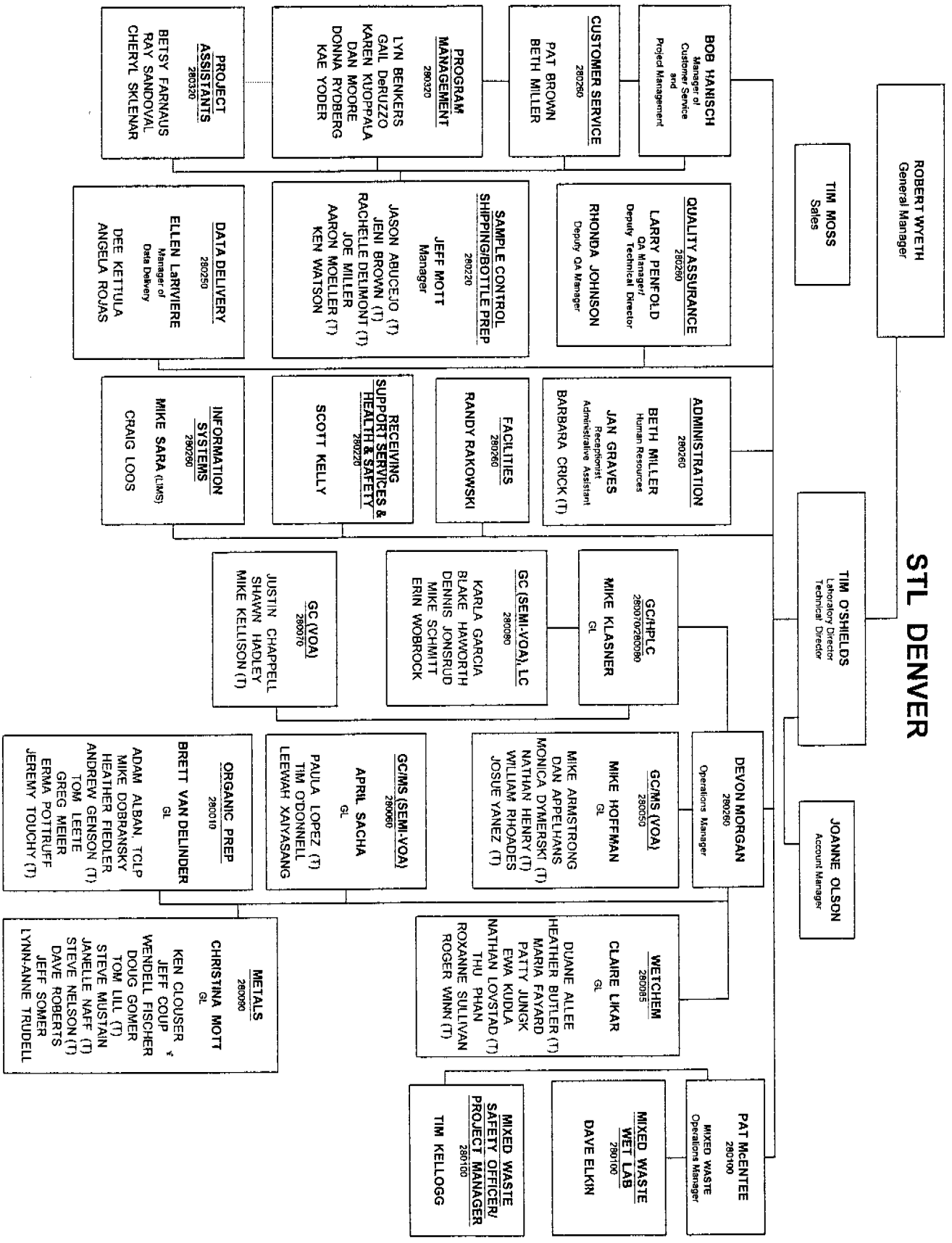

Figure 1.5-2 STL Denver Key Personnel

Position	Name	Degree(s), Institution(s), Year	Years Environmental Lab Experience	Years with Company
Laboratory Manager/ Technical Director	Timothy O'Shields	B. S. Chemistry Furman University, 1980	19	3
Operations Manager	Devon Morgan	M. S. Chemistry Prairie View A&M, 1985	13	2
Mixed Waste Operations Manager	Pat McEntee	B.A. Geology University of Colorado, Bolder, 1986	12	12
Customer Service and Project Management Manager	Robert Hanisch	M. A. Chemistry University of Northern Colorado, 1974	30	9
Quality Assurance Manager	Larry Penfold	Chemistry California State University, 1979	27	6
Data Delivery Manager	Ellen LaRiviere	MS Environmental Health Colorado State University, 1983	20	8
GC/MS Volatiles Group Leader	Mike Hoffman	B. S. Chemistry Oklahoma Christian College, 1980	20	14
GC/MS Semivolatile Group Leader	April Sacha	B. S. Biological Sciences, Chemistry Minor Oklahoma State University, Stillwater, 1994	6	1
GC/HPLC Group Leader	Michael Klasner	B. S. Chemistry MacMurray College, 1990	9	1
Information Systems	Mike Sara	B. S. Chemistry University of South Florida, 1984	14	7
Sample Control/Bottle Preparation Manager	Jeff Mott	Relevant Work Experience	12	1
Organic Prep Manager	Brett VanDelinder	B. S. Geology University of Texas – El Paso, 1983	17	3
Wet Chemistry Group Leader	Claire Likar	B. S. Chemistry University of New Mexico, 1991	2	2
Metals Group Leader	Christina Mott	B.A. Chemistry George Mason University, Fairfax, 1988	11	3

Table of Contents

1.6 Quality Organization

All personnel are responsible for quality, which includes complying with all QA/QC requirements that pertain to their organizational/technical function. This section outlines the primary QA responsibilities for each position.

1.6.1 Quality Assurance Manager

- Reports directly to the Laboratory Director and, for all QA matters, to the Corporate QA Director to maintain independence of QA oversight
- Responsible for the implementing and communicating the QMP
- Maintains, approves, and implements the LQM
- Has joint signature authority, with the Laboratory Director and Technical Manager for approval of quality documents, e.g., LQM, policies, and SOPs
- Directs controlled distribution laboratory quality documents
- Provides Quality System training to all new personnel
- Reviews and approves documentation of analyst training records
- Serves as a focal point for QA and QC issues, reviews corrective actions and recommends resolution for recurring nonconformances within the laboratory
- Assists in maintaining regulatory analytical compliance, including maintaining certifications, and in this regard has signature authority for laboratory quality documents
- Monitors data quality measures via statistical methods to verify that the laboratory routinely meets stated quality goals
- Performs systems, data, contract compliance, and surveillance audits.
- Hosts external audits conducted by outside agencies
- Responsible for approving quality control reference data changes in the LIMS
- Oversees the selection, review, and approval of analytical subcontractors
- Prepares monthly QA Reports to management describing significant quality events
- Has the final authority to accept or reject data and to stop work in progress in the event that procedures or practices compromise the validity and integrity of analytical data

1.6.2 Laboratory Director

- Reports directly to the Regional General Manager
- Responsible for implementation and adherence by lab staff to the STL QMP, STL Denver LQM and all policies and procedures within the laboratory.

- Has signature authority for LQM, policies, SOPs, and contracts (as detailed in STL policy)

- Annually assesses the effectiveness of the QMP and LQM within the operation
- Maintains adequate trained staffing documented on organization charts
- Responsible for implementing internal/external audit findings corrective actions.

1.6.3 Operations Manager

- Reports directly to the Laboratory Director
- Supervises daily activities of the Operational Groups
- Schedules analytical operations
- Supervises QC activities performed as a part of routine analytical operations
- Implements data review procedures
- Supervises the preparation and maintenance of laboratory records
- Supervises maintenance of instruments and scheduling of repairs
- Works with the Project Managers and Group/Team Leaders to assure the requirements of projects are met in a timely manner
- Responsible for meeting quality requirements

1.6.4 Laboratory Technical Director

- Reports directly to Laboratory Director
- Responsible for the technical operation of the laboratory
- Responsible for coordinating the development and implementation of SOPs
- Has joint signature authority for LQM, policies, SOPs, and training records
- Performs technical training in area(s) of expertise
- Interfaces with management on technical needs and solving day-to-day technical issues
- Determines qualifications required for technical positions and evaluates job candidates against those requirements
- Investigates technical issues related to projects as directed by QA
- Evaluates new methods, technical proposals, and statements of work
- Certifies technical laboratory personnel based on education and background to ensure that staff have demonstrated capability in the activities for which they are responsible
- Performs other tasks as required by NELAC.

The Technical Director meets the requirements specified in the Section 4.1.1.1 of the NELAC standards.

1.6.5 Systems Manager

- Reports directly to the Laboratory Director

- Supervises daily activities of the Project Management, and/or Sample Control, and/or Administrative, and/or Report Production Groups
- Works with the Operations Manager and/or Group/Team Leaders to ensure the requirements of projects are met in a timely manner

1.6.6 Customer Service Managers (CSMs)

- Reports directly to the Laboratory Director
- Has signature authority for contracts for laboratory services, as detailed in STL policy, and for laboratory reports.
- Defines customer requirements through project definition
- Assesses and assures customer satisfaction
- Provides feedback to management on changing customer needs
- Brings together resources necessary to ensure customer satisfaction.

1.6.7 Project Manager

- Reports directly to the Customer Service Manager
- Monitors analytical and QA project requirements for a specified project
- Acts as a liaison between the client and the laboratory staff
- Prepares Quality Assurance Summary (QAS) or equivalent summary form and communicates project-specific requirements to all parties involved
- Assists the laboratory staff with interpretation of work plans, contracts, and QAPP requirements
- Reviews project data packages for completeness and compliance to client needs
- Has signature authority for final reports
- Keeps the laboratory and client informed of project status
- Together with the QA Manager, approves customer requested variances to methods and to standard laboratory protocols
- Monitors, reviews, and evaluates the progress and performance of projects
- Reports client inquiries involving data quality issues or data acceptability to the facility QA Manager and to the operations staff
- Prepares reissue requests for project data
- Responsible for meeting quality requirements.

1.6.8 Group Leader or Supervisor

- Reports directly to the Operations Manager
- Supervises daily activities of analyses within the group
- Supervises QC activities performed as a part of routine analytical operations
- Implements data review procedures
- Supervises the preparation and maintenance of laboratory records

- Evaluates instrument performance and supervises the calibration, preventive maintenance, and scheduling of repairs
- Oversees or performs review and approval of all analytical data
- Reports nonconformances to the appropriate managers
- Responsible for generation of SOPs for their section
- Responsible for meeting quality requirements.

1.6.9 Analyst

- Performs analytical methods and data recording in accordance with documented procedures
- Performs and documents calibration and preventive maintenance
- Performs data processing and data review procedures
- Reports nonconformances to the Supervisor/Manager and QA Manager
- Ensures sample and data integrity by adhering to internal chain-of-custody procedures
- Responsible for meeting quality requirements defined in this LQM and other supporting QA procedures.

1.6.10 Sample Custodian

- Ensures implementation of proper sample receipt procedures, including maintenance of chain-of-custody
- Reports nonconformances associated with condition-upon-receipt of samples
- Logs samples into the LIMS
- Ensures that all samples are stored in the proper environment
- Assists Environmental Health and Safety staff with sample disposal
- Responsible for meeting quality requirements.

1.6.11 Report Production Staff

- Accurately generates and compiles analytical reports and associated deliverables for delivery to the client
- Responsible for meeting quality requirements
- Produce as needed reports that meet the NELAC requirements.

2.0 Quality System and Description

2.1 Objectives of the STL Quality System

The Quality System is a set of management principles, objectives, policies, responsibilities, and implementation plans at the organizational and project-specific levels. The goal of the STL Quality system is to ensure that business operations are conducted with the highest level of professionalism in the industry. To achieve this goal, it is necessary to provide STL clients with not only scientifically sound, well documented, and regulatory compliant data, but also to ensure that STL provides the highest quality service available in the industry. A well-structured and well-communicated Quality System is essential in meeting this goal. STL's Quality System is designed to minimize systematic error, encourage constructive, documented problem solving, and provide a framework for continuous improvement within the organization.

2.2 Structure of the STL Quality System

At the highest level, the STL Quality Management Plan (QMP) is the basis for STL's Quality System. The QMP provides the guidance under which all STL facilities conduct their operations. This Laboratory Quality Manual (LQM) describes the implementation of the Quality System at the STL Denver laboratory. This LQM and the series of associated quality documents described in Section 2.3 define the organization, project-specific principles, goals, controls, and tools of the Quality System as it is applied at this laboratory. The Quality System as described in this LQM demonstrates the commitment to accepted laboratory practices by STL Denver.

2.3 Quality Assurance and Quality Controls

Quality Assurance (QA) is defined as the system of activities which ensures the quality of a process, product, or service. Quality controls (QC) are the tools used to monitor and regulate the the desired type and quality of product. The QA activities and QC controls employed in STL Denver are defined in the following quality documents.

2.4 Quality Documents

The STL Quality System is developed from the reference documents shown in Table 2.4-1. The review and control of the STL Denver documents described in the following subsections is described in Section 3 of this LQM. A cross-reference of the LQM to NELAC requirements quality manuals is presented in Table 2.4-2.

2.4.1 STL Quality Management Plan (QMP)

The requirements set forth in the QMP are applicable to all STL facilities. The policies and practices outlined in the QMP are minimum guidelines only. Requirements that are more rigorous may be applied for specific client or regulatory programs.

2.4.2 STL Company-Wide Policies

Severn Trent Laboratories has certain policies that apply company-wide. These policies are consistent with the QMP, and set forth requirements that all STL facilities are to follow.

2.4.3 Laboratory Quality Manual (LQM)

This STL Denver LQM along with the associated policies and SOPs, provides the criteria and specifications for the generation of environmental analytical data. The LQM provides QC criteria for standard procedures, facility-specific instrumentation, and reporting.

2.4.4 STL Denver Quality Policy Documents

Quality policies are referenced throughout the LQM that provide further detail to specific requirements of the QMP and LQM. These policies describe general quality objectives and guidelines in effect for this facility, rather than the details of specific practices. Refer to Table 2.4-3 for a list of the STL Denver quality policies and required approvals. Table 2.4-4 lists the frequency of review for the documents.

2.4.5 Standard Operating Procedures

Standard Operating Procedures (SOPs) describe step-by-step instructions for performing a method or activity. In addition, there are SOPs that relate to other support services performed in the laboratory. Details of SOP format and document control are described in Policy QA-001, "Standard Operating Procedures." SOPs that are actively used in this laboratory are listed in Table 8.2-2. SOPs are living documents and may supersede some requirements in this document until the LQM is updated annually.

2.4.6 Quality Assurance Project or Program Plans (QAPPs)

Regulations and contracts may contain QA requirements that are different from those described in this LQM. To address unique project requirements, Quality Assurance Project Plans (QAPjPs) may be prepared and implemented. The requirements documented in a QAPjP and as agreed to by STL Denver take precedence over the

LQM for that project. Typical specifications contained in a QAPjP or similar documentation include:

- New or modified testing methods
- Unique QC logic
- Special requirements for equipment use and maintenance
- Special handling due to safety considerations
- Project-specific detection and reporting limits
- Project-specific accuracy and precision limits or the statistical treatment of data
- Additional or unique documentation or records management requirements.

2.4.6.1 Quality Assurance Summary

Quality Assurance Summaries (QAS) or equivalent (e.g., Client Requirement Checklist in LIMS) are used to distill client-specific requirements typically documented in project QA plans onto a concise format, highlighting the requirements that are different than the laboratory standard practice. The summary describes for each project the required quality control samples, batching schemes, flagging conventions, deliverables, or other special client requests that may differ from routine laboratory operations. The QAS or equivalent is disseminated to laboratory operations by the Project Manager or Quality Assurance Manager to document client or program specific requirements. The QAS may be used alone or in conjunction with the project-specific QA plans.

2.4.7 Other Documents

Other documents which can affect the quality program may include the Chemical Hygiene Plan (CHP), the Radiation Safety Manual, memos, guidance documents, work instructions, and periodic management assessment reports. These documents may further define or guide the implementation of quality standards at STL but shall not conflict with the LQM or diminish the effectiveness of the Quality System.

3.0 Document Control and Records Management

3.1 Objectives for Control of Quality Documents and Vital Records

Quality Documents - The quality documents discussed in Section 2 define the framework of the STL Quality System. Control and security of these documents are necessary to ensure that all staff have access to current policies and procedures at all times, to ensure that all changes to the policies and procedures are properly reviewed, to ensure that the history of use of documents can be reconstructed, and to ensure that confidential information is not improperly distributed. The system described in this section is designed to accomplish these objectives.

Vital Records – Vital records are the documents that provide objective evidence of the performance of a process or observations of an item. Records management ensures that results produced by the laboratory are scientifically and legally defensible, and ensures that project events can be reconstructed. Confidentially of the records and records retention requirements are discussed in this section.

3.2 Document Control Procedures

Unambiguous identification of a controlled document is maintained by identification of the following items in the document header:

- document title,
- unique document number,
- revision number,
- revision date,
- effective or implementation date, and number of pages

Controlled documents are marked as such, and the QA department keeps records of document distribution. Controlled distribution may be achieved by either electronic or hardcopy means. The effective date is the date when controlled copies are distributed. Controlled documents must be available in the immediate areas where the related work is performed. Details of the numbering system, required format, and restrictions for uncontrolled distribution of documents are in Policy # QA-001, "Standard Operating Procedures". Requirements for STL corporate quality documents are described in SOP # S-Q-001.

3.3 Document Review, Approval and Revision

Controlled quality documents are authorized by the Laboratory Director/Technical Manager, and the QA Manager. They indicate their authorization by signing the cover page of the document. STL Denver quality documents, the individuals responsible for

reviewing the documents, and the required frequency of review are listed in Table 2.4-3 and Table 2.4-4. In addition to periodic review and revision, quality documents must be revised when a procedure or activity changes in a significant manner. Amendments to documents must be reviewed and approved by the same parties approving the original document, distributed in a controlled manner, and clearly indicated in the document. Obsolete versions of documents are removed from service when new revisions are issued. The QA Department maintains a record of history of use of all documents based on the effective date. For further details see Policy # QA-001, "Standard Operating Procedures".

3.4 Records Management

Records may be either hardcopy or electronic copies. It is not required to maintain both if they are properly secured and are complete and true copies. The record keeping system allows for reconstruction of all laboratory activities that produced the analytical results. The history of the sample is readily understood through the documentation. This includes

- chain-of-custody records, including intra-laboratory and inter-laboratory transfers of samples;
- records identifying the personnel involved in sampling, preparation, calibration, and testing;
- observations, calculations, and derived data;
- information relating to laboratory facilities, equipment, analytical test methods, and related laboratory activities (e.g., sample preparation, standards preparation, and data verification);
- original records clearly identifying all subcontracted test data, and
- a copy of the final test report.

Requirements for data recording are described in Policy # QA-008, "Data Recording Requirements". Details concerning control of electronic records are given in Section 6. The types of vital records maintained are listed in Table 3.4-1.

3.5 Document and Record Storage, Retention and Disposal

It is the policy of STL Denver that company records will be available to meet business needs and comply with all applicable legal records retention and disposition requirements. STL Denver retains copies of records in a manner that allows prompt retrieval of documents and records for inspection purposes. In accordance with NELAC, all quality documents and records are stored for at least five years. Other types of records have different retention requirement, refer to Table 3.4-1 for details.

Specific projects and regulatory programs have longer record retention requirements than the standard STL record retention time. Refer to the QMP Table 5 for a listing of examples of special program requirements. The inventory sheet accompanying the stored records must

include disposal instructions which take into account any special requirements, and who to contact for authorization prior to destroying the data.

When records, as contained in files, are transferred to a records storage area or off-site storage area, they shall be placed in suitable containers and include an inventory sheet (hard copy or electronic) prepared by the person submitting the records. The contents of each container shall be compared to the inventory sheet and labeled. If there are any discrepancies, the container and inventory sheet shall be returned to the person who prepared the box for correction. Archives are indexed such that records are accessible on a project or temporal basis. Archives are protected against fire, theft, loss, deterioration, and vermin. Backup copies of electronic media are stored in off-site archive facilities and are protected against deterioration caused by magnetic fields and/or electronic deterioration. Access to archives is controlled and documented. Further details of the laboratory's document and records archiving process are described in SOP # DEN-QA-0005.

If the laboratory transfers ownership, vital records will be transferred to the new owner. If the laboratory goes out of business, vital records will be transferred to another operating STL laboratory or to our clients.

3.6 Data Confidentiality

Data and sample materials provided by the client or at the client's request, and the results obtained by STL, shall be held in confidence (unless such information is generally available to the public or is in the public domain or client has failed to pay STL for all services rendered or is otherwise in breach of the terms and conditions set forth in the STL and client contract) subject to any disclosure required by law or legal process. STL's reports, and the data and information provided therein, are for the exclusive use and benefit of client, and are not released to a third party without written consent from the client.

In some cases the client may identify projects requiring confidentiality due to national security. Information concerning these projects will be limited only to those STL Denver associates with a need to know.

The audit reports supplied by federal, state, and local regulatory agencies are public information and can be released without written consent of those agencies. However, specific client audits are confidential and must be approved by the client before releasing them to a third party.

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STL DENVER
Interim SOP Change

SOP NUMBER: LQM Revision No.:0

SOP TITLE: STL Denver LQM

SOP SECTION(S) AFFECTED BY CHANGE: 4.1

REASON FOR CHANGE: Response to on-site inspection report by Utah.

CHANGE: STL Denver maintains job descriptions for all positions. These are readily accessible in a binder titled "Job Descriptions". The job descriptions specify the minimum qualifications for education and experience, knowledge and skills, which are necessary to perform at a satisfactory level. Qualifications of professional staff are documented by resumes that include academic credentials, employment history, experience, and professional registrations. A copy of each person's resume is maintained in an electronic file, and is readily available for inspection.

SUBMITTED BY/DATE: Michael Schmitt, 07/31/01

APPROVED BY:

Timothy O'Shields, Laboratory Director — Date: 7-31-01

Larry Penfold, Quality Assurance Manager — Date: 7/31/01

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4.0 Staff Qualification, Orientation and Training

All activities performed by STL Denver shall be accomplished by qualified personnel. Each staff member must have the combination of experience and education needed to demonstrate the required knowledge for his or her position. Each must also have an appropriate general knowledge of laboratory operations, test methods, quality assurance and quality control procedures, and records management. Minimum training requirements are shown in Figure 4-1 at the end of this Section. SOP # CORP-QA-0013 describes details of the training process and documentation. The Chemical Hygiene Plan (CHP) describes details for health and safety training. The Radiation Safety Manual provides training guidelines for radiation work.

Revised 8/31/01

4.1 Qualifications

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4.2 Orientation and Technical Training

Each new staff member shall receive orientation in quality and in health and safety. Each new staff member shall be supervised in their assigned duties by their supervisor or a knowledgeable individual designated by the supervisor. The ability and authorization to perform independently shall be documented in the training files, as described below, with technical duties approved by the Technical Director or designee.

4.2.1 Quality Assurance (QA) Orientation

Each new staff member will receive a QA orientation. The QA Manager or designee will conduct this orientation within two weeks of the new employee's first day on the job. The orientation will, at a minimum, include the following topics:

- STL Quality System and hierarchy of quality documents (QMP, LQM, policies, and SOPs);
- key elements of the LQM and the Quality Control Policy (QA-003);
- introduction to the nonconformance memo (NCM) system and corrective action procedures;
- proper data recording practices;
- STL ethics agreement, including the potential consequences of unethical behavior; and
- the role of the QA department.

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- proper data recording practices;
- STL ethics agreement, including the potential consequences of unethical behavior; and

The QA orientation will be documented on a checklist, which is signed by the trainee. The documentation will be placed in the employee's training file.

4.2.2 Quality Training

Continued training in the mission and goals of the QMP and LQM shall be provided at least annually. These may be done in a single session or divided into separate sessions conducted at different times throughout the year. Formal training sessions are conducted and documented by the QA Manager or designee. In addition, each lab staff member shall read and document their awareness of the quality documents related to his or her position.

4.2.3 Health and Safety, Orientation and Training

Each new employee, contract worker, or working visitor is required to go through health and safety orientation and training as described in the CHP. The Health and Safety Coordinator must conduct the orientation as soon as possible after the individual reports to work and before chemicals are handled. More comprehensive health and safety training, both initial and on going, must be completed at the frequency given in the CHP.

4.2.4 Radiation Safety Training

The training of every employee in the fundamentals of radiation safety is required for every employee. More detailed training, as specified in the Radiation Safety Manual, is required for radiation workers.

4.3 Training Files

Each active STL Denver staff member has an individual training file maintained by the QA Manager or designee. This file can be documented on paper forms or in a database. The following sections shall be included in the training files at a minimum:

- Resume - containing hardcopy or a reference to the electronic file
- Quality Assurance - containing documentation of QA/QC orientation and training completed
- Health and Safety - orientation and training documents
- Technical Proficiency - initial and on-going demonstrations of proficiency, one-on-one training, training courses or workshops on specific equipment or analytical methods is documented in this file. Note that proficiency with technical SOPs is documented on the demonstration of capability forms (see next section).

Other types of records to be included in the training file include work place regulatory compliance training, and professional development courses. The exact contents will vary depending upon a person's job function and tenure with the company. Details of requirements for training records and the approval process are given in SOP CORP-QA-0013.

4.4 Technical Proficiency Demonstration

All new personnel are required to demonstrate competency in performing a particular method by successfully completing a Demonstration of Capability (DOC) before conducting analysis independently on client samples. On-going proficiency must be demonstrated annually.

DOCs are most commonly performed by analysis of four replicate QC check samples. Results of successive LCS analyses can be used to fulfill the DOC requirement. As required by the referenced method, the accuracy and precision, measured as average recovery and standard deviation (using n-1 population), of the four replicates are calculated and compared to the method limits or against current laboratory limits if multi-laboratory method acceptance limits are not specified. Use of single-blind proficiency samples and other NELAC acceptable proficiency samples as ongoing demonstration of proficiency are described in SOP # CORP-QA-0013. The DOC Certification documentation must be signed by the Technical Director and the Quality Assurance Manager and filed in the employee's training file (see example in CORP-QA-0013). The DOC Certification documentation must include a statement that the individual has read, understood, and agreed to perform the most recent version of the test procedure.

Figure 4-1 Employee Minimum Training Requirements

Required Training	Time Frame	Employee Type
Environmental Health & Safety	Initial training before start of production work	All
	Additional training as specified in the CHP	As required
Radiation Safety	Orientation within 1 month of hire date	All
	Training before handling radioactive materials	All radiation workers
Quality Assurance	Orientation within 2 weeks of hire date	All
	Annual QA program training	All
Technical Proficiency	Initial demonstration prior to unsupervised method performance	Technical staff
	Annual on-going demonstration	Technical staff

STL DENVER
Interim Change # R

SOP NUMBER: LQM, Revision No. 0

SOP TITLE: STL Denver LQM

SOP SECTION(S) AFFECTED BY CHANGE: Revise Section 4.4

REASON FOR CHANGE: This is not a change in lab practice, but rather a clarification. The use of multi-lab control limits is not allowed for technical proficiency demonstrations. The limits must be based on method limits or STL Denver statistical limits.

CHANGE:

From: As required by the referenced method, the accuracy and precision, measured as average recovery and standard deviation (using n-1 population), of the four replicates are calculated and compared to the method limits or against current laboratory limits if multi-laboratory method acceptance limits are not specified.

To: As required by the referenced method, the accuracy and precision, measured as average recovery and standard deviation (using n-1 population), of the four replicates are calculated and compared to the method limits or against current laboratory limits.

SUBMITTED BY/DATE: Larry Penfold, 11/8/03

APPROVED BY:

Timothy M. O'Shields, Laboratory Director — Date: 11/11/03

Larry Penfold, Quality Assurance Manager — Date: 11-8-03

Received NOV 1 1 2003 Tim O'Shields

5.0 Procurement of Supplies and Services

Controlling the quality of supplies and services is necessary to ensure that STL Denver provides high quality analytical services to our clients. The STL procurement program requires:

- assurance that purchased items and services meet requirements set by STL Denver and perform as expected
- definition of the levels of documentation required for applicable technical and administrative procurement functions
- maintenance of records of all suppliers from whom we obtain services or supplies required for our analytical testing

5.1 Selection of Vendors

Materials and supplies are purchased from approved vendors. Prospective vendors are selected based upon criteria appropriate to the materials or supplies provided. STL Corporate Policy # PG-001 "Procurement and Contracts" details the process used. For national vendors and contracts, the vendor is selected by the STL Procurement Director through a competitive bidding process, strategic business alliance or negotiated vendor partnership. Potential vendors are required to complete a vendor acceptance application and are evaluated on the following criteria, as appropriate:

- the vendor's history of providing identical or similar products that perform satisfactorily in actual use
- the vendor's service record and ability to provide a complete product line and commensurate service
- the vendor's ability to administer inventory at the STL Denver facility through an inventory management system that will ensure correct stocking levels as well as shelf-life tracking
- objective evaluation of the vendor's current quality records, supported by documentation
- results of audits by STL of the vendor's technical and quality capabilities

Vendors that provide measuring equipment, solvents, chemical standards, instrument service contracts, or subcontracted laboratory services shall be subject to more rigorous controls than vendors that provide off-the-shelf items.

5.2 Controlling Quality of Purchased Items

The quality of equipment, reagents, solvents, chemical standards, gases, and laboratory containers used in analyses must be of known quality so that their effect upon analytical results can be defined. These quality specifications are derived from analytical method requirements, project-specific requirements, and defined national standards for analytical testing. Quality specifications of materials are described in analytical SOPs. These quality specifications shall be included or referenced in the purchasing documents for the

items being purchased. This includes specifications for the purity of standards, reagents, or chemicals, and technical specifications for accuracy and precision (e.g., Class A volumetric glassware). Reference to a catalogue number, model, lot number, or chemical grade is sufficient.

The Laboratory Director has the responsibility for approving purchase orders. The section supervisors or designees are responsible for ensuring that the requested quality of materials ordered matches those received, for verifying that material storage is properly maintained and for removing materials from use when shelf life has expired.

5.2.1 Evaluation of Off-the-Shelf Items

For items that are used regularly by STL Denver where no unique requirements or specifications exist, the items may be purchased off-the-shelf. These items are ordered from the supplier on the basis of specifications set forth in the supplier's published product description. These include items such as glassware, filter paper, pipettes, and chromatography columns. The items are evaluated as a function of the standard analytical process.

5.2.2 Evaluation of Instruments

Evaluation of instruments purchased shall be conducted according to an acceptance testing plan . The acceptance testing plan may be defined by the vendor or the method demonstration requirements specified in the laboratory analytical SOPs. Acceptance criteria may include instrument reliability, sensitivity, stability, selectivity, accuracy, precision, and ability to interface with existing computer systems.

5.2.3 Evaluation of Critical Solvents and Acids

STL Denver is part of a group of STL laboratories that conducts additional evaluations for certain solvents and chemical reagents where our criteria for purity are more stringent than the vendor's. These chemicals are listed in Table 5.2-1. These chemicals are subject to analysis on a lot-by-lot basis before they are put into use. They are tested at one of the STL laboratories, and the chemical test results are evaluated by a designated quality representative. If the solvents or reagents meet the specifications given in SOP # CORP-QA-0001, an approval memorandum is issued to all participating laboratories. All laboratories then use the same lot, and reject any lots received at the facility that have not been tested.

5.2.4 Evaluation of Chemical Standards and Reference Materials

Where available chemical standards will be traceable to the National Institute of Standards Technology (NIST) or an equivalent source. This is largely limited to physical and inorganic chemical standards. If NIST traceability is not commercially available, commercially certified materials shall be used, which are

then tested for accuracy before reporting data. Details of the testing procedures and documentation are described in the laboratory SOP. Standards must be received with a certification report from the vendor with information such as purity/concentration, traceability, lot number, expiration date, preparation date, unique identification number, formula weight, density, radionucleide half-life, mass and/or volume of standards, and suggested storage requirements. Further details about labeling and handling of standards is described in Section 8 of this LQM.

5.2.5 Corrective Action for Failure to Meet Required Specifications

Corrective actions for failure of an item to meet required specifications are as follows:

- review of current supplies to eliminate the problem item
- notification to the STL Procurement Director to avoid additional problems at other STL labs
- return of the problem item to the vendor
- evaluate the impact on product or process

The QA Manager shall be notified of any significant or systematic quality problems. The STL Procurement Director and the STL Quality Assurance Director shall be notified of any quality problems with national vendors.

Revised aug 07/31/01

5.3 Procurement of Subcontract Laboratory Services

Whether external to STL or not, all subcontracting from the STL Denver laboratory to another laboratory is arranged with the documented consent of the client. All QC guidelines specific to the client's analytical program are transmitted to the subcontractor and agreed upon before sending the samples to the subcontract facility. For intracompany subcontracting, the originating laboratory is responsible for communicating QA/QC, reporting, and other project requirements. Documentation of required certifications from the subcontract facility are maintained in STL project records. Where applicable, specific QC guidelines, QAPjPs, and similar project documents are transmitted to the subcontract laboratory. Samples are subcontracted under formal Chain of Custody (COC).

Subcontract laboratories may receive an on-site audit by a representative of STL's QA staff if it is deemed appropriate by the QA Manager. The audit involves an assessment of compliance with the required test method, QC requirements, documentation, as well as any special client requirements.

Project reports received from external laboratories are not altered and are included in original form in the final report provided by STL. The final report from STL Denver clearly identifies what testing was performed by other laboratories.

STL DENVER
Interim SOP Change

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SOP NUMBER: LQM Revision No.:0

SOP TITLE: STL Denver LQM

SOP SECTION(S) AFFECTED BY CHANGE: 5.3

REASON FOR CHANGE: Response to on-site inspection report by Utah.

CHANGE: STL Denver shall advise the client in writing of its intention to subcontract any portion of the testing to another laboratory. The laboratory shall not proceed without documented consent of the client. All QC guidelines specific to the client's analytical program are transmitted to the subcontractor and agreed upon before sending the samples to the subcontract facility.

SUBMITTED BY/DATE: Michael Schmitt, 07/31/01

APPROVED BY:

Timothy O'Shields, Laboratory Director — **Date** 7-31-01

Larry Penfold, Quality Assurance Manager — **Date** 7/31/01

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then tested for accuracy before reporting data. Details of the testing procedures and documentation are described in the laboratory SOP. Standards must be received with a certification report from the vendor with information such as purity/concentration, traceability, lot number, expiration date, preparation date, unique identification number, formula weight, density, radionucleide half-life, mass and/or volume of standards, and suggested storage requirements. Further details about labeling and handling of standards is described in Section 8 of this LQM.

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The QA Manager shall be notified of any significant or systematic quality problems. The STL Procurement Director and the STL Quality Assurance Director shall be notified of any quality problems with national vendors.

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6.0 Computer Hardware and Software

The primary purpose of quality assurance systems for computer hardware and software is to protect the integrity of computer-resident data. Procedures are in place at STL-Denver to assure that computer-resident data are accurate, traceable to a known source, protected against loss, and secure.

STL's computer and hardware controls are based on the guidance in EPA's "Good Automated Laboratory Practices" (GALP), August, 1995. This includes both corporate level Information Technology (IT) functions and STL-Denver IT functions. Some GALP requirements, such as management responsibilities and the training program, are addressed in other sections of the LQM. Some corporate level IT functions, such as the system change management procedures, are described in more detail in corporate IT documents. Table 6-1 provides a cross reference of practices outlined in Section 8 of the GALP manual to corresponding sections of STL's QA and IT documents.

6.1 Computer Hardware

Computer hardware used in the generation, measurement, or assessment of client data shall be of appropriate design and adequate capacity to function according to specifications. Computer equipment must be installed in accordance with the manufacturer's recommendations, and undergo documented acceptance testing.

6.1.1 Wide-Area Systems

STL-Denver's LIMS (QuantIMS) and the Office Network run on a wide-area network (WAN) serving multiple laboratories. The central node for the network is located at the Denver facility. The central processor is an IBM AS-400 with multiple servers and Cisco routers. Records for the system architecture, testing and maintenance, such as Initial Program Loads (IPLs), are documented in the AS-400 System Log, which is also in Denver. Records for installation of the network hardware are maintained by the central System Administrator.

6.1.2 Local Systems

The local systems consist of computer equipment for analytical instruments, data evaluation, and upload to the LIMS. A local-area network (LAN) supports the local office software. Testing, maintenance, and repair of the local computer hardware is the responsibility of the STL-Denver LAN Analyst. Documentation for the local systems is maintained by the LAN Analyst.

6.2 Facilities and Security

6.2.1 Central Computer Facilities

The environmental conditions of the facility housing the LIMS are controlled to protect against data loss. Access to the central computer facility in Denver is restricted by keypad entry used by IT staff. The central computer room is temperature controlled, and has an Uninterrupted Power Supply (UPS) plus a power generator to ensure that the WAN functions are not disrupted by power failures. Backup media, such as tapes and disks, are maintained daily. In addition, full volume backup copies of the raw data are shipped offsite to a commercial facility specially designed to store electronic data.

6.2.2 Local Computer Facilities

Facilities for housing local computer hardware must meet manufacturer's recommendations. Electronic data must be protected against environmental hazards such as fire, water damage, and strong electromagnetic fields. Data files will have backup copies made at regular intervals to protect against accidental loss through hardware or software failure.

6.2.3 Controlled Software Access

The integrity of data is also assured by maintaining limited access to administrative functions through a hierarchy of operating system shells controlled by passwords. Access is granted by the LAN Administrator depending on a persons experience, training, and assigned duties (see SOP# CORP-IT-0005 for more details).

Firewalls are in place to protect against unauthorized access from the Internet.

6.2.4 Virus Protection

Commercial virus protection programs are installed on all computers to detect and remove computer viruses. LAN Analysts are to be notified whenever a virus is detected so that they can isolate any portions of the systems that may be at risk.

6.3 LIMS Raw Data

QuantIMS raw data and instrument raw data from instrument data systems such as Target, IDB, and Chemstation are stored on the Office Automation servers (e.g., QARVCO01). The Systems Administrator and the LAN Analyst are responsible for maintaining the servers.

The individuals responsible for entering and recording raw data must be uniquely identified in the data, together with the date and time the data were entered. The instrument transmitting raw data must be uniquely identified, together with the date and

time of the transmission. Further data recording requirements exist to document manual integrations (see Policy # QA-011 for details).

Procedures for verifying raw data are discussed in LQM Sections 8.8-8.8.3.

6.4 Software

If computer software is used to acquire, process, or report client data, that software is tested to ensure that it correctly performs its intended function. Software are validated or verified, depending upon its complexity, size, and whether it was purchased or developed by STL. The following definitions are used by STL:

- Validation - the process of establishing documented evidence which provides a high degree of assurance that a specific process will consistently produce a product meeting predetermined specifications and quality attributes. This process demonstrates and documents that the software performs correctly and meets all specified requirements.

- Verification - the process of checking the accuracy of automatically (electronically) calculated information.

6.4.1 Industry Standard Software

Industry standard software programs are defined as those which are purchased and widely used without modification to the program itself. The program is initially verified for use by using test problems with known solutions to demonstrate that the program is operational for the desired application.

All purchased software must be used in accordance with the terms of its software license. Any use of software contrary to its license terms is expressly prohibited by STL

6.4.2 Testing of STL-Developed Software

For programs used to process client data and developed within STL, and externally prepared programs that are modified by STL, validation or verification must be performed. The process used is dependent upon the function of the software as follows:

- Large complex systems consisting of several programs operating in unison to produce an intended result must be validated.

- For smaller software which only performs numerical manipulation, sample sets of numbers for which results are known should be processed and the results verified. In this case, known results are usually generated by performing hand

calculations using the same equations and procedures as the software to verify that the software produces identical results.

- Software which performs as part of instrument operation should be verified as previously described and by processing reference materials through the instrument system. Processed instrument response should be evaluated against expected instrument response and performance.

IT SOPs governing software development and testing include CORP-IT-0001, CORP-IT-0007, and CORP-IT-0013.

6.4.3 Control of Software Changes

STL has a well established process for prioritizing and managing changes to LIMS and LIMS-related software (see CORP-IT-0001 and CORP-IT-0007). Proposals to modify software are written in a Software Enhancement Request, which includes a description of the task to be accomplished, the software to be modified, its functional requirements, and necessary algorithms. The Software Enhancement Request is submitted to the Change Management Committee for approval. The Committee includes representatives from each lab on the QuantIMS network. The Committee establishes a develop schedule and approves the resources needed. Documentation of changes, version control, and historical records of changes is the responsibility of the IT Manager of "Change Management and QA". Because these are modern networked systems, the documentation is kept on the network, rather than keeping redundant records at each facility as GALP suggests. All system software changes are developed in a test area and must pass the designed tests before it is installed in the working area.

The same principles of documenting software changes apply to spreadsheets, small databases, or other small programs that are used solely at the STL-Denver lab. The verification/validation records must explain the functional requirements, the algorithms and formulas used, the testing performed. Upon completion, the verification/validation documentation is provided to the lab QA Manager or designee.

6.4.4 Software Maintenance

Software problems are presented to the local LIMS Administrator (LAS) in a Software Problem Report. The LAS presents the issue to a group of the network LASs. The problem is discussed to make sure it is understood, and then a solution is determined and prioritized. Changes to LIMS software for maintenance purposes are announced to each of the QuantIMS locations after revalidating the software.

6.4.5 Software Revalidation

Whenever a program is changed, the change is evaluated to determine if it is significant enough to make revalidation necessary. If features have been added, previous test problems are rerun to demonstrate that their function has not been affected. New test problems are processed, as previously discussed, to verify added performance. If software revision changes the basic operation of the program, complete revalidation of the program may be required.

Spreadsheets and unprotected software used to acquire, process, or report client data must be documented and reverified when changes are made. The test problems used to provide initial verification is reprocessed and the results compared to demonstrate that performance of the software is unchanged.

Laboratory operations is responsible for the generation of the validation and verification documentation for instrument level software. Completed records are provided to QA. STL Information Technology is responsible for generation and maintenance of documentation relating to verification and validation of the STL QuanTIMS system. This is described in SO# CORP- IT-0013, Software Quality Assurance.

6.5 Comprehensive System Testing

Comprehensive system testing is performed periodically. Independent auditors, such as Price Waterhouse, include computer systems in their audits, which are commissioned by the laboratory executive management. Extensive testing of all software was performed for the lab's Y2K readiness excercises.

As described in LQM Section 9.2.2.1, the STL-Denver QA Manager is responsible for ensuring an annual internal audit of all lab areas is performed, including the local IT functions. Revised 12/14/00 IC A

6.6 Records Retention

As required by NELAC, electronic raw data and computer documentation are stored for a minimum of five years. See LQM Section 3.0 for further records retention details.

Implementation date 12/7/00 **STL-Denver**

Interim SOP Change - This is a controlled document

SOP NUMBER: **Laboratory Quality Manual for STL-Denver**

SOP TITLE: Laboratory Quality Manual for STL-Denver

SOP SECTION(S) AFFECTED BY CHANGE: 6.5

REASON FOR CHANGE(S): Correct cross reference

Change section *{6.5}* **from:** (Second paragraph) .....As described in LQM Section **9.2.2.1**.....

To:

(Second paragraph) .....As described in LQM Section **9.4.2**.....

[Change highlighter with bold lettering]

SUBMITTED BY/DATE: 11/30/00

APPROVED BY:

Technical Reviewer	**Date** 12/05/00
James S. Kelly, Health and Safety Coordinator	**Date** 12/1/00
Larry Penfold, Quality Assurance Manager	**Date** 12/1/00
Timothy M. O'Shields, Laboratory Director	**Date** 12-5-00

N:\QA\SOPS\DENVER\INTERIMS\LQM IC A

7.0 Contract Review and Project Planning

The generation of environmental analytical data is an intricate process. Success is dependent upon the timely execution of interrelated steps. For many environmental sampling and analysis programs, testing design is site or project specific and is not necessarily the same as the laboratory's standard service. It is STL's intent to provide both standard and customized laboratory services to our clients, provided that any special requirements are documented in writing, and provided performing the work in this manner does not cause the laboratory to violate relevant regulatory requirements. STL Denver has an organizational system in place to ensure that projects are properly planned prior to project initiation. This means that laboratory personnel understand project requirements, that the client clearly understands the lab's capabilities, that the laboratory has the facilities and resources needed to perform the required tests, that samples will be properly handled, that contingency plans are in place, and that analytical data will be reported in accordance with project needs.

7.1 Contract Review

The process of client request for proposal (RFP) and the laboratory's tender of a written response is a process of communication between both parties to understand project requirements and the laboratory's capabilities. All contracts for new work entered into by STL Denver are reviewed by the Customer Service Manager (CSM) or designee. Agreements for continuing work are the responsibility of laboratory Project Managers (PMs) or the CSM. Depending on the size and scope of the proposed project, the Laboratory Director and other STL management staff can also be involved. Technical staff (Operations Manager, QA Manager, and IT staff) can be called upon to perform a review of the technical and QA/QC requirements. The CSM or PM, with this internal support, will work with clients to align project requirements with laboratory capabilities. Any contract requirement or contract modification communicated to STL verbally is documented and communicated to the client in writing. Any discrepancy between client requirements and STL's capability to meet those requirements is resolved in writing before acceptance of the contract

All contracts, Quality Assurance Project Plans (QAPP), Sampling and Analysis Plans (SAPs), contract amendments and documented communications become part of the permanent project record as detailed in Section 3.5.

7.2 Certifications and Approvals

A necessary part of the review and work acceptance procedure is the evaluation of project needs for laboratory certification. The persons reviewing the prospective project must determine if project work plans or regulatory permits are tied to specific laboratory certifications or approvals. Where such requirements exist, the laboratory must have the certifications or approvals in place before the work begins. QA personnel coordinate with the state certification agencies to maintain or add additional parameters. Copies of

current laboratory certifications are maintained by the QA office, and are available upon request.

7.3 Data Collection Process

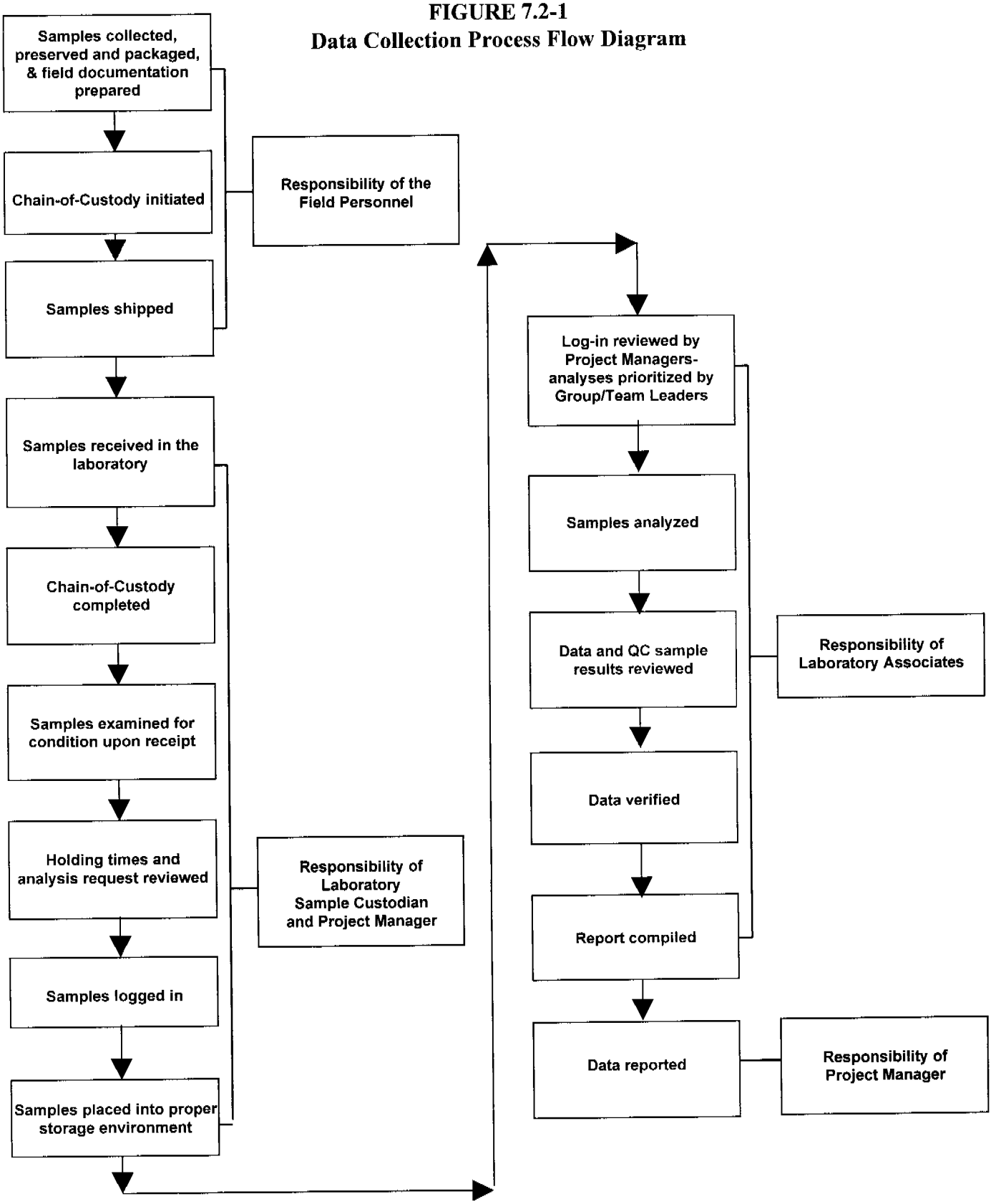
The sample collection and data generation processes are shown in Figure 7.2-1. These processes are designed to produce analytical data that accurately reflect the nature of the site or sampling point.

7.4 Project Organizational Responsibilities

Each laboratory client is assigned a single point of contact, usually a PM, to ensure that there is a strong line of communication between the client and STL Denver. As a matter of policy, CSMs or designee, PMs, and Operations Managers work together to accomplish the following prior to receipt of samples at the laboratory:

- Samples are scheduled for arrival at the laboratory
- All unique project requirements have been identified and communicated to all appropriate personnel
- Standardized client, state, federal, or STL programs are appropriately selected
- Fully-qualified subcontract laboratories have been selected if needed
- A review has been performed on all pre-project documents such as proposals, contracts, and/or QAPPs to identify the type of tests required and to ensure project requirements are within the scope of the laboratory being used
- All appropriate and required preparations have been made at the laboratory to accommodate or meet project requirements as described in proposals, contracts, and/or QAPPs
- It has been determined that the laboratory has the capability and the capacity to analyze the samples including equipment, staff, space and workload
- The laboratory is capable of meeting the required sample holding times and is able to report the resulting data within the time line specified by the client
- All known safety hazards associated with the samples have been communicated to all appropriate personnel.

FIGURE 7.2-1
Data Collection Process Flow Diagram



Approval and issuance of a quote, bid or contract document is documentation that this process has occurred. For particularly large or involved projects, STL Denver encourages our clients to visit the laboratory and/or participate in kickoff meetings with the laboratory staff. STL has found it very effective to invite the client into the laboratory's project preparations.

7.5 Communicating Project Requirements Internally

STL Denver PMs shall document all project-specific requirements prior to receipt of samples. The LIMS system, QuantIMS, requires the PM to enter a "quote" before any samples can be logged in. In addition to price information, the "quote" is a detailed technical specification of the work to be performed. The quote includes identification of project personnel, numbers and types of samples, tests to be performed, reporting limits, QC to be performed, control limits, data qualifier flags to be used, significant figures to be used, and the types of deliverables required. This is the primary means of communicating routine project requirements to laboratory personnel.

Brief non-routine project requirements are entered into the comments section of the Client Requirements Checklist portion of the quote. The Checklist is reviewed by analysts as analyses are being scheduled and before testing has started. If the special requirements are too lengthy for the Client Requirements Checklist, the PM must prepare a Quality Assurance Summary (QAS) or equivalent, which is a written document describing all requirements that are different than routine work. The QAS is referenced in the Client Requirements Checklist, and is distributed by the PM to each of the operational groups involved. For complex projects, project kickoff meetings are conducted by the PM with each of the operational groups involved.

7.6 Contingency Planning

An effective QA program must emphasize contingency planning, actions to prevent problems from reoccurring, and to ensure timely and effective completion of a measurement effort. The following are considered relative to contingency planning.

7.6.1 Staffing

A primary objective is to ensure that qualified staff are available to perform the necessary analytical work, regardless of employee turnover, vacation, illness, or other absences. STL Denver is a relatively large laboratory with multiple staff capabilities for the majority of tests performed. However, other sources of trained personnel are potentially available to assist in the event of unforeseen absences. Given sufficient time for necessary orientation, temporary agency staff can be used. More significantly, STL is a large laboratory network and a large pool of qualified staff can be made available from other STL laboratories.

7.6.2 Backup Instrumentation

Within STL Denver, duplicate instrumentation is available for most methods to allow uninterrupted work flow if one piece of equipment fails. The laboratory may also choose to lease equipment. However, in circumstances where a catastrophic instrument failure occurs, alternative, but equivalent, methods may be recommended to the client for approval.

- Preventive Maintenance - STL's preventive maintenance program is designed to minimize analytical instrument malfunctions, permit simple adjustments, and to ensure fewer and shorter breakdowns of critical analytical equipment. (See Section 8.11, "Preventive Maintenance and Service".)

- STL Laboratories & Subcontractor Laboratories - To support the laboratory during peak periods or in the event of a critical instrument malfunction, STL has the capability to arrange for the use of other STL laboratories or other qualified analytical laboratories as subcontractors for short-term backup analytical support. **However, use of a subcontractor laboratory must be approved by the client in writing.** For projects requiring NELAC approval, the subcontractor must also be NELAC approved. See Section 5.3 for other procedures related to the control of subcontract laboratory services.

- Uninterruptable Power Supply - An Uninterruptable Power Supply (UPS) system which provides line conditioning and backup power to the LIMS computer system/server. This contingency allows sufficient time for the main computer system to be shut down and for data archival. All electronically generated data that are stored on the main computer system and on individual personal computer (PC) hard drives are backed up at regular intervals. In the event that the main laboratory computer system fails, the analytical data can be retrieved from the PC hard drives.

8.0 Work Processes and Operations

Many activities related to environmental projects activities are planned and designed externally to the laboratory or field operation, and are presented to the laboratory in the form of a contract, work plan, sampling and analysis plan (SAP) or QA Project Plan (QAPP). Laboratory and field activities are in turn planned, implemented, and assessed by STL to meet client requirements according to approved procedures and methodologies. The LQM describes the system to document and implement these activities. The execution and assessment of the implemented operational systems are detailed in STL SOPs. The entire process is assessed on a regular basis for conformance to prescribed requirements.

Standard practices for STL Denver operations are detailed in this section. Specific project or program requirements that differ from those described here can be met, but they must be explicitly stated in approved contracts, work plans, QAPPs or other project documents. Special project requirements can generally be accommodated provided that they are properly documented, communicated, and they do not cause the laboratory to violate relevant regulatory requirements.

Table 8.2-3 lists the test methods performed by STL Denver. Table 8.2-2 lists the SOPs associated with those methods. Table 8.0-1 provides a list of the major equipment in place at the laboratory, and Figure 8.11 (at the end of this Section) shows the laboratory floor plan.

8.1 Traceability of Measurements

STL documents all laboratory activities in sufficient detail to allow their reconstruction. To this end, documentation is generated to trace a sample from its point of origin, through receipt in the laboratory, analysis, reporting and disposal.

The required documentation includes, but is not limited, to:

- Chain of custody documenting movement and possession of samples
- Sample preparation
- Sample analysis
- Calibration and QC data associated with the samples
- Instrument maintenance
- Control of ancillary equipment and materials (e.g., DI water and glassware)
- Sample disposal
- Final reports

These topics are described in this section. Traceability of chemical standards is also discussed in Section 5.2.4.

8.2 Analytical Methods

Whenever possible, STL operations use industry- and regulatory agency-recognized analytical methods from source documents published by agencies such as the Environmental Protection Agency (EPA), Department of Energy (DOE), and the American Society for Testing and Materials (ASTM) as described in STL's SOPs. Analytical methods performed

by STL Laboratories are given in Table 8.2-3 lists the methods routinely performed at the laboratory. The methods pending or approved by a NELAC Accrediting Authority are indicated in the table.

Method performance data, as described in Section 8.2.2 below, are developed by the laboratory operations staff to demonstrate method proficiency. The operations staff and the QA staff evaluate and approve the performance data before a methodology is performed routinely. The method must also be described and documented in an SOP.

8.2.1 Standard Operating Procedures

SOPs are required for all repetitive analytical and administrative activities ranging from the receipt of samples in the laboratory through their analysis, reporting, and subsequent disposal. Training, health and safety procedures, QC, method procedures, and instrument and equipment calibrations are included in SOPs. SOP requirements are discussed in the Policy # QA-001, "Standard Operating Procedures". The specifications in the policy meet NELAC requirements. Table 8.2-2 lists laboratory standard operating procedures.

New SOPs and proposed SOP revisions are reviewed by technically qualified lab personnel. SOPs are controlled documents and are distributed and maintained as described in Policy QA-001. Requirements for SOP approval and frequency of review are listed in Tables 2.4-3 and 2.4-4. All significant modifications to the published method are described in a section of the SOP. All operations must be performed as described in these SOPs.

Planned changes in procedure which may occur due to expected sample matrix effects or project requirements are documented in the project files. These planned changes may be documented using nonconformance memos, NCMs (see discussion of NCMs in section 9.1), project-specific case narratives, or as modifications or additions to associated QAPPs.

Unplanned deviations in the SOPs, which may occur due to sample matrix or other events, are documented in NCMs and in the project-specific case narratives.

8.2.2 Method Validation and Verification

Before analyzing samples by a new method or method modification, the method must be verified or validated.

8.2.2.1 Method Verification

Method verification is required for methods developed by authoritative agencies, such as EPA or ASTM. The level of verification can vary depending on the type of method or level of modification, but generally should include:

- Determination of method sensitivity,

- Determination of working range,
- An initial demonstration of capability (as specified by NELAC), and
- A written SOP or project-specific written protocol.

Each of these are described in the next section.

8.2.2.2 Method Validation

A complete validation is required for methods developed by STL Denver. While method validation can take a variety of courses, the following are the key concerns:

Determination of Method Selectivity

Method selectivity is the demonstrated ability to discriminate the analyte(s) of interest from other compounds in the specific matrix or matrices. In some cases, to achieve the required selectivity for an analyte, a confirmation analysis is required as part of the method

Determination of Method Sensitivity

Method sensitivity is normally demonstrated using the 40CFR 136B method detection limit protocol (see MDLs, section 8.2.3, below), but can also be based on variance of blank results, and signal-to-noise ratios.

Determination of Interferences

This is demonstrated by analyzing samples of the matrix of interest that is known to be free of the analyte(s) of interest.

Determination of Range

In most cases, analytical range is determined and demonstrated by comparison of the response of an analyte at different concentrations to targeted criteria. Often the targeted criteria are represented by the goodness of fit or linearity of the experimental data to a continuous mathematical function or curve. The curve is used to establish the range of quantitation, with the lower and upper values representing the upper and lower quantitation limits. Curves are not limited to linear relationships.

Determination of Accuracy and Precision

Accuracy and precision studies are generally performed using replicate analysis of samples of known concentration. The resulting percent recovery and relative standard deviation, or other precision measure, is calculated and compared to a set of target criteria.

Documentation of Method

The method is formally documented in an SOP (see policy QA-001 for details). If a method modification is being performed for a specific short-term project, the modification should be described in a written protocol that

is approved by the lab's client, in addition to the in-house approvals required by QA-001.

Continued Demonstration of Method Performance
Continued ability of the lab to perform the method is addressed in the SOP. Generally this is accomplished with the specified calibration and batch QC requirements.

Revised 03/31/00

8.2.3 Method Detection Limits (MDLs)

It is STL Denver's policy to follow the specification in the U.S. EPA 40 CFR Part 136 Appendix B in determining MDLs for chemical tests. The STL requirement for this procedure is further detailed in Policy QA-005 entitled "Determination of Method Detection Limits for Chemical Tests." This policy requires that the MDLs be determined for each analyte of interest representing the aqueous and solid matrices within the capability of the primary analytical methods. The laboratory's current MDLs are given in Table 8.2-4 .

8.2.4 Instrument Detection Limits (IDLs)

IDLs are required to be performed quarterly for metals constituents and cyanide when analyses are performed in support of Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) activities or when the USEPA CLP SOW protocol is required. IDLs are not required by the SW-846 methods, with the exception of method 6020.

When required, IDLs will be performed in accordance with the procedures defined in the applicable USEPA SOW, ILMO3.0 or subsequent versions, and Policy QA-014, "Determination of Instrument Detection Limits".

Prior to acceptance and use for reporting purposes, all data from detection limit studies and reporting limits must undergo technical review and approval by the laboratory management and QA staff.

8.2.5 Reporting Limits

Revised 11-11-02

Reporting limits are established and modified within STL according to the STL Policy QA-009, "Reporting Limits." Two reporting limit conventions are discussed in the policy: the standard Reporting Limit (RL) and the Project-Specific Reporting Limit (PSRL). The standard STL Reporting Limit (RL) is the lowest level at which measurements become quantitatively meaningful. The RL is always greater than the statistically determined MDLs. PSRLs are used when project data quality objectives (DQO) require a reporting limit other than the RL. PSRLs tailor STL's product to meet customer requirements. Higher PSRLs may be established based on maximum contaminant level (MCLs), applicable or relevant and appropriate requirements (ARARs), or project-specific data quality objectives (DQOs). PSRLs below the lab's standard RL may be used, but they must be

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STL DENVER
Interim Change # T

SOP NUMBER: LQM, Revision No. 0

SOP TITLE: STL Denver LQM

SOP SECTION(S) AFFECTED BY CHANGE: Revise Section 8.2.5

REASON FOR CHANGE: Clarify the distinction between reporting limit (RL) and quantitation limit (QL).

Replace with the following:

8.2.5 Reporting Limit and Quantitation Limit

Reporting limits are established and modified following STL Denver Policy # QA-009, "Reporting Limits." The reporting limit is a threshold value below which results are qualified (e.g., J qualifier for positive results or < qualifier for non-detects). STL Denver has a general requirement that the lowest point on calibration curves must be at or below the RL concentration and that the RL must be greater than the MDL. Establishing project–specific RLs different than the lab's standard RLs is discussed in QA-009. It is important to note that the quantitation limit (QL) is the lowest concentration for which results are reported within some specified uncertainty, which is not necessarily the same as the RL. Lacking other criteria, STL Denver will default to a 10-sigma quantitation limit, i.e., approximately three times the MDL.

SUBMITTED BY/DATE: Larry Penfold, 11/8/03

APPROVED BY:

Timothy M. O'Shields, Laboratory Director — Date: 11/10/03

Received NOV 17 2003 Tim O'Shields

Larry Penfold, Quality Assurance Manager — Date: 11-10-03

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STL DENVER
Interim SOP Change

SOP NUMBER: **LQM Revision No.:0**

SOP TITLE: **STL Denver LQM**

SOP SECTION(S) AFFECTED BY CHANGE: **8.2.3**

REASON FOR CHANGE: Response to on-site inspection report by Utah.

CHANGE: It is STL Denver's policy to follow the specification in the U.S. EPA 40 CFR Part 136 Appendix B in determining MDLs for chemical tests. The STL requirement for this procedure is further detailed in Policy QA-005 entitled "Determination of Method Detection Limits for Chemical Tests." This policy requires that the MDLs be determined for each analyte of interest representing the aqueous and solid matrices within the capability of the primary analytical methods. The laboratory's current MDLs are given in Table 8.2-4. MDLs and the associated reporting limits are stored in the laboratory LIMS system, and are accessible to all personnel with the QC Browser program, one of the TraQAr modules

SUBMITTED BY/DATE: Michael Schmitt, 07/31/01

APPROVED BY:

Timothy O'Shields, Laboratory Director — **Date** 7-31-01

Larry Penfold, Quality Assurance Manager — **Date** 7/31/01

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is approved by the lab's client, in addition to the in-house approvals required by QA-001.

Continued Demonstration of Method Performance
Continued ability of the lab to perform the method is addressed in the SOP. Generally this is accomplished with the specified calibration and batch QC requirements.

8.2.3 Method Detection Limits (MDLs)

It is STL Denver's policy to follow the specification in the U.S. EPA 40 CFR Part 136 Appendix B in determining MDLs for chemical tests. The STL requirement for this procedure is further detailed in Policy QA-005 entitled "Determination of Method Detection Limits for Chemical Tests." This policy requires that the MDLs be determined for each analyte of interest representing the aqueous and solid matrices within the capability of the primary analytical methods. The laboratory's current MDLs are given in Table 8.2-4. MDLs and the associated reporting limits are stored in the laboratory LIMS system, and are accessible to all personnel with the QC Browser program, one of the TraQAr modules.

8.2.4 Instrument Detection Limits (IDLs)

IDLs are required to be performed quarterly for metals constituents and cyanide when analyses are performed in support of Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) activities or when the USEPA CLP SOW protocol is required. IDLs are not required by the SW-846 methods, with the exception of method 6020.

When required, IDLs will be performed in accordance with the procedures defined in the applicable USEPA SOW, ILMO3.0 or subsequent versions, and Policy QA-014, "Determination of Instrument Detection Limits".

Prior to acceptance and use for reporting purposes, all data from detection limit studies and reporting limits must undergo technical review and approval by the laboratory management and QA staff.

8.2.5 Reporting Limits

Reporting limits are established and modified within STL according to the STL Policy QA-009, "Reporting Limits." Two reporting limit conventions are discussed in the policy: the standard Reporting Limit (RL) and the Project-Specific Reporting Limit (PSRL). The standard STL Reporting Limit (RL) is the lowest level at which measurements become quantitatively meaningful. The RL is always greater than the statistically determined MDLs. PSRLs are used when project data quality objectives (DQO) require a reporting limit other than the RL. PSRLs tailor STL's product to meet customer requirements. Higher PSRLs may be established based on maximum contaminant level (MCLs), applicable or relevant

supported MDL and the instrument calibration. Alternatively, a standard at the PSRL taken through the entire preparation and analysis procedure may be used to support a PSRL with QA approval. The STL RLs and PSRLs are maintained in the LIMS.

8.3 Data Quality Objectives

Data quality objectives (DQOs) are qualitative and quantitative statements used to ensure the generation of the type, quantity, and quality of environmental data that will be appropriate for the intended application (EPA 1994)[1]. Typically, DQOs are identified during project scope and the development of sampling and analysis plans. In this LQM, however, we refer to only the analytical DQOs because laboratories generally do not have any authority over sample collection, shipment, or other field-related activities that may affect the data quality of the environmental sample before the sample is received in the laboratory. The EPA has established six primary analytical DQOs for environmental studies. These DQOs are precision, accuracy, representativeness, completeness, comparability, and detectability.

The components of analytical variability (uncertainty) can be estimated when QA and QC samples of the right types and quantities are incorporated into measurement procedures at the analytical laboratory. STL incorporates numerous QA and QC samples to obtain data for comparison with the analytical DQOs and to ensure that the measurement system is functioning properly. The QA/QC samples and their applications, described in Section 8.4, are selected on the basis of method- or client-specific requirements. Field blanks, field duplicates, and performance evaluation (PE) samples are received from the client as unknown samples. Analytical laboratory QC samples for inorganic, organic, and radionuclide analyses may include calibration or instrument blanks, method blanks, background, duplicates, replicates, laboratory control samples (LCSs), calibration standards, matrix spikes (MSs), matrix spike duplicates (MSDs), surrogate spikes, and yield monitors.

8.3.1 Precision And Accuracy

Precision is an estimate of variability, that is, it is an estimate of agreement among individual measurements of the same physical or chemical property, under prescribed similar conditions. The precision of a measurement system is affected by random errors. Precision is expressed either as relative standard deviation (RSD) for replicate measurements greater than two or as relative percent difference (RPD) for duplicate measurements. Table 8.6-1 illustrates the formulae used to calculate units of precision (i.e., RSD and RPD).

Accuracy is the degree of agreement between a measurement and the true or expected value, or between the average of a number of measurements and the true or expected value. Systematic errors affect accuracy. For chemical properties, accuracy is expressed either as a percent recovery (R) or as a percent bias (R - 100).

[1] "Guidance for the Data Quality Objectives Process", EPA 600/R-96/005, September 1994.

The precision and accuracy measures that are to be used in evaluating inorganic and organic constituents at STL are provided in Tables 8.4-5 through 8.4-7, in method-specific SOPs, and in the documentation for the analytical method of interest.

Precision and accuracy are determined, in part, by analyzing data from matrix spike and matrix spike duplicates, unspiked duplicates, LCSs, and single blind audit samples. For radiochemical determinations, counting statistics can also provide an estimate of uncertainty. A description of these QC samples is provided in Section 8.4.

8.3.2 Completeness

Completeness is a measure of the percentage of measurements that are judged to be valid measurements. At a minimum, the objective for completeness of data is 90% for each constituent analyzed.

8.3.3 Representativeness

Representativeness is the degree to which data accurately and precisely represent a characteristic of a population, a variation in a physical or chemical property at a sampling point, or an environmental condition. Data representativeness is primarily a function of sampling strategy; therefore, the sampling scheme must be designed to maximize representativeness. Representativeness also relates to ensuring that, through sample homogeneity, the sample analysis result (concentration) is representative of the constituent concentration in the sample matrix. At STL, reasonable efforts are made to analyze an aliquot that is representative of the original sample, and to ensure the homogeneity of the sample before subsampling (see SOP# DEN-QA-0023).

8.3.4 Comparability

Comparability is a measure of the confidence with which one data set can be compared to another. To ensure comparability, all laboratory analysts are required to use uniform procedures (i.e., SOPs) and a uniform set of units and calculations for analyzing and reporting environmental data.

8.4 Quality Control Samples

Two types of Quality Control (QC) samples are field QC samples and laboratory QC samples. Field QC samples are collected during the sampling event and are useful in determining sampling precision and accuracy and monitoring for contamination that may occur during collection, transport or storage of environmental samples. Laboratory QC samples are routinely added at the laboratory to the normal sample stream. Successful analysis of these samples demonstrates that the laboratory is operating within prescribed requirements for accuracy and precision. In addition, utilizing matrix-specific laboratory QC samples, information regarding the effect of the matrix or field conditions on the analytical results can be obtained. The following sections describe common field and laboratory QC samples.

8.4.1 Field QC Samples

When field QC sample collection and analysis are required for a project, it is the responsibility of the project sampling supervisor to ensure that this sampling is performed correctly and at the project-required frequencies. Field QC samples may or may not be identified as such to the laboratory and are considered by the laboratory as field samples for the purpose of QC batching, sample preparation and analysis. Field QC sample results are reported in the same manner as actual field samples, unless a specific deliverable is requested by the client. No correction of the analytical data is done in the laboratory based on the analysis of field QC samples. Field QC sample types, applicability to organic and inorganic analyses, precision and accuracy applications and by whom they are introduced are summarized in Table 8.4-1.

8.4.2 Laboratory QC Samples

Laboratory performance QC is required to ensure the laboratory systems (instrumentation, sample preparation, analysis, data reduction, etc.) are operating within acceptable QC guidelines during data generation as required to meet the client's objectives. Laboratory QC samples consist of method blanks (MB), instrument blanks, laboratory control samples (LCS) and calibration verification samples. In addition to laboratory performance QC, matrix-specific QC is utilized to determine the effect of the sample matrix on the data being generated. Typically, this includes matrix spikes (MS), matrix spike duplicates (MSD), sample duplicates, and the use of surrogate compounds.

Laboratory and matrix-spike QC sample types are summarized in Tables 8.4-2 through 8.4-4. In addition, Tables 8.4-5 through 8.4-7 list laboratory QC samples, acceptance criteria and corrective actions by reference method for inorganic methods, organic methods, and the USEPA CLP Statements of Work respectively. The following sections provide descriptions of laboratory QC samples and their frequency of use. Policy QA-003, "Quality Control Program", describes in detail the QC data evaluation process.

8.4.2.1 Quality Control (QC) Batch

The QC batch consists of a set of up to 20 field samples that behave similarly (i.e., same matrix) and are processed using the same procedures, reagents, and standards within the same time period. This definition of a QC batch is utilized by STL unless there is clear regulatory guidance, contract specifications, or differing client requirements that are explicitly documented. Further details and requirements for the application of the definition of QC batch are described in Policy QA-003. Environmental samples are associated to QC samples in LIMS via the analytical batch number, which is clearly indicated on each analytical report as a cross-reference between the samples and associated QC.

8.4.2.2 Method Blank

The method blank (MB) is a QC sample that consists of all reagents specific to the method and is carried through every aspect of the procedure, including preparation, cleanup, and analysis. The method blank is used to identify any interferences or contamination of the analytical system that may lead to the reporting of elevated analyte concentrations or false positive data. Potential sources of contamination include solvent, reagents, glassware, other sample processing hardware, or the laboratory environment. In general, the method blank is a volume of deionized laboratory water for water samples, or a purified solid matrix for soil/sediment samples, that is processed as a sample. In the event that no appropriate solid matrix exists, deionized water may be used. The volume or weight of the method blank must be approximately equal to the sample volume or sample weight processed. A method blank shall be prepared with each group of samples processed.

8.4.2.3 Instrument/ Calibration Blank

The instrument blank is an unprocessed aliquot of reagent used to monitor the contamination of the analytical system at the instrument. System contamination may lead to the reporting of elevated analyte concentrations or false positive data. The instrument blank does not undergo the entire analytical process and generally consists of an aliquot of the same reagent(s) used for a sample dilution. Instrument blanks are also referred to as continuing calibration blanks (CCBs).

Revised 11-14-03

8.4.2.4 Laboratory Control Sample

A laboratory control sample (LCS) is a laboratory-prepared suitable clean matrix sample that is fortified with target analytes or a solid reference material purchased from an approved vendor. The LCS contains all target analytes specified in the method, and must contain the same analytes as the matrix spike and matrix spike duplicate. For certain regulatory or client programs, an LCS may contain a full list of analytes. However, in these cases, a subset of analytes, as defined by the program, is used to determine the acceptability of a batch of sample data. The LCS recovery data are used to monitor the analytical method performance in terms of analytical accuracy. On-going evaluation of the LCS recoveries demonstrates that the laboratory is performing the method within statistical control (i.e., accuracy and precision) in the absence of matrix interference. The LCS results, coupled with MS data, help determine whether the laboratory performed the method correctly or the sample matrix affected the analytical results. When a laboratory control sample duplicate (LCSD) is required, a percent recovery for each target analyte is calculated, as well as a relative percent difference (RPD) between the LCS and the LCSD.

STL DENVER
Interim Change # S

SOP NUMBER: LQM, Revision No. 0

SOP TITLE: STL Denver LQM

SOP SECTION(S) AFFECTED BY CHANGE: Revise Section 8.4.2.4

REASON FOR CHANGE: This is not a change in practice, but rather a clarification to state explicitly that DoD programs require spiking with all compounds of interest.

CHANGE:

From: The LCS contains all target analytes specified in the method, and must contain the same analytes as the matrix spike and matrix spike duplicate. For certain regulatory or client programs, an LCS may contain a full list of analytes. However, in these cases, a subset of analytes **as defined by the program**, is used to determine the acceptability of a batch of sample data.

To: The LCS must be spiked using all compounds required by the method and all compounds required by the project. The default requirement for some environmental programs (e.g., USACE, AFCEE, and US Navy) is to spike and evaluate for all analytes. The matrix spike and matrix spike duplicate must be prepared and analyzed using the same analytes as the LCS.

SUBMITTED BY/DATE: Larry Penfold, 11/8/03

APPROVED BY:

Timothy M. O'Shields, Laboratory Director — Date: 11/1/03

Received
NOV 14 2003
Tim O'Shields

Larry Penfold, Quality Assurance Manager — Date: 11-10-03

8.4.2.5 Matrix Spike

A matrix spike (MS) is an environmental sample to which known concentrations of target analytes have been added. MS samples are analyzed to evaluate the effect of the sample matrix on the analytical methodology. MS samples are generated by taking a separate aliquot of an actual field sample and spiking it with the selected target analyte(s) prior to sample extraction. The MS sample then undergoes the same extraction and analytical procedures as the unfortified client sample. Due to the potential variability of the matrix of each sample, these results may have immediate bearing only on the specific sample spiked and not on samples collected at other locations that are included in the QC batch.

Revised 2/11-11-03 1-10 10/11-17-03

8.4.2.6 Matrix Spike Duplicate

A matrix spike duplicate (MSD) is a second aliquot of a sample that is spiked with the selected target analyte(s) and analyzed with the associated sample and MS sample. The results of the MS and MSD are used together to determine the effect of a matrix on the accuracy and precision of the analytical process. Due to the potential variability of the matrix of each sample, the MS/MSD results may have immediate bearing only on the specific sample spiked and not all samples in the QC batch.

8.4.2.7 Sample Duplicate

A sample duplicate is a second aliquot of an environmental sample taken from the same sample container that is processed identically with the first aliquot of that sample. That is, sample duplicates are processed as independent samples within the same QC batch. The results are compared to determine the sample homogeneity and the precision of the analytical process.

8.4.2.8 Surrogates

Surrogates are organic compounds that are similar in chemical composition and behavior to the target analytes but that are not normally found in environmental samples. Surrogates are added to all appropriate samples and QC samples being tested for organic analytes to monitor the effect of the sample matrix and the procedure on the accuracy of the process.

8.4.2.9 Analytical Spike

An analytical spike is created by spiking target analytes into a prepared portion (i.e., post digestion) of a sample just prior to analysis. It provides information on matrix effects encountered during analysis such as suppression or enhancement of instrument signal levels. It is most often used in elemental analysis involving various forms of atomic emission or atomic absorption spectroscopy. A single analytical spike serves as a single point application of the "method of standard additions" or MSA.

STL DENVER
Interim Change # U

SOP NUMBER: LQM, Revision No. 0

SOP TITLE: STL Denver LQM

SOP SECTION(S) AFFECTED BY CHANGE: Revise Section 8.4.2.5

REASON FOR CHANGE: This is not a change in practice, but rather to clarification how samples are selected for use as matrix spikes.

Add:
From the laboratory perspective, each preparation batch requires an MS/MSD pair. If specific instructions are not provided by the client, then analysts pick a sample (not a blank) at random to satisfy this requirement. From a data user's perspective, matrix spikes only provide useful information if they are prepared in samples from the site of interest. For that reason, some programs (e.g., USACE and AFCEE) require that client/field personnel must indicate the samples to be used for matrix spiking on the chain-of-custody form, in which case the MS/MSDs are logged in as separate samples. Communication between project personnel is essential for this to work properly.

SUBMITTED BY/DATE: Larry Penfold, 11/8/03

APPROVED BY:

Received
NOV 12 2003

Timothy M. O'Shields, Laboratory Director — **Date** 11/12/03 Tim O'Shields

Larry Penfold, Quality Assurance Manager — **Date** 11-11-03

8.4.2.10 Interference Check Sample

An interference check sample (ICS) is a solution containing known concentrations of both interfering and analyte elements. Analysis of this sample can be used to verify background and interelement correction factors.

8.4.2.11 Internal Standards

An internal standard (IS) is a compound or element with similar chemical characteristics and behavior in the analysis process to the target analytes, but is not normally found in environmental samples. The internal standard is usually added after sample preparation. The primary function of the internal standard is quantitation, however, it also provides a short-term indication of instrument performance. For isotope dilution methods, internal standards are added during sample preparation and are used for quantitation.

8.5 Data Collection Operations

Laboratory analyses are designed to produce data that are representative of existing conditions present at the time the sample was obtained. The data collection design includes field sampling events, sample handling and custody, analytical operations, data recording procedures, data assessments, data verification, and data reporting requirements and techniques to assess limitations of data use. These operations are discussed in this section through section 8.10.

8.5.1 Field Collection and Shipment

In order to provide a sample that most accurately represents the test matrix, field sample collection personnel must abide by the sample collection guidelines and procedures established by involved regulatory agencies. A significant part of the efforts of regulatory agencies include the use of "approved" sample containers, chemical and physical preservation techniques, and observance of specified holding times. It is imperative that all samples be collected and preserved according to the appropriate analytical method specified in the QAPP (if one exists). Although sampling may be performed by non-STL personnel, sampling and transportation of samples to the laboratory is important and must be considered during data validation.

Sampling requirements must be communicated to the sampling team prior to field collection.

Field personnel are responsible for labeling each individual sample collected with the following information:

- Project name
- Unique client sample number
- Sample location (including as appropriate: borehole and depth or grid coordinates)

- Sampling date and time
- Sample preservation
- Analysis required.

An overriding consideration for the resulting analytical data is the ability to demonstrate that the samples have been obtained from the locations stated and that they have reached the laboratory without alteration. Evidence of collection, shipment, laboratory receipt, laboratory custody, and disposal must be documented to accomplish this. Figure 8.5-1 shows an example Chain-of-Custody (COC) form that is used by the STL laboratory to document this evidence. Field personnel are responsible for initiating the COC form.

The prompt shipment of samples to the laboratory is necessary to ensure that required holding times are met. Samples should be shipped by an overnight carrier, be hand-delivered, or transported in a manner that assures prompt delivery to the laboratory. Some sites require an extensive radioactive screening process before a sample may be shipped. In these cases, it is imperative for the Project Manager to maintain good communications with the client to assure proper staffing of the laboratory in response to a decreased holding time.

Radioactive samples that are shipped to STL radiochemistry operations must be screened upon receipt and found not to contain radioactivity that exceeds the level stated in the laboratory's radiological license. Samples received by a STL facility containing radioactivity exceeding their license limit will immediately be returned to the project site.

FIGURE 8.5-1
Example STL Chain-of-Custody Form

[redacted]

Chain of Custody Record

SEVERN TRENT SERVICES **Severn Trent Laboratories, Inc.**

STL-4124 (0700)

Client	Project Manager	Date	Chain of Custody Number 016206
Address	Telephone Number (Area Code)/Fax Number	Lab Number	Page ____ of ____
City / State / Zip Code	Site Contact / Lab Contact	Analysis (Attach list if more space is needed)	Special Instructions/ Conditions of Receipt
Project Name and Location (State)	Carrier/Waybill Number		
Contract/Purchase Order/Quote No.	Matrix / Containers & Preservatives		

Sample I.D. No. and Description (Containers for each sample may be combined on one line)	Date	Time	Air	Aqueous	Sed.	Soil	Unpres	H2SO4	HNO3	HCl	NaOH	ZnAc/ NaOH

Possible Hazard Identification
☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal
☐ Return To Client ☐ Disposal By Lab ☐ Archive For ____ Months
(A fee may be assessed if samples are retained longer than 3 months)

Turn Around Time Required
☐ 24 Hours ☐ 48 Hours ☐ 7 Days ☐ 14 Days ☐ 21 Days ☐ Other____

QC Requirements (Specify)

1. Relinquished By	Date	Time	1. Received By	Date	Time
2. Relinquished By	Date	Time	2. Received By	Date	Time
3. Relinquished By	Date	Time	3. Received By	Date	Time

Comments

DISTRIBUTION: WHITE - Stays with the Sample; CANARY - Returned to Client with Report; PINK - Field Copy

Table of Contents

8.5.2 Sample Containers, Shipping Containers, Preservatives, and Holding Times

8.5.2.1 Sample Containers

A sample container is defined as the sealed enclosure, usually made of plastic or borosilicate glass that the sample is collected in and stored in until analysis. All sample containers provided by STL operations for environmental sampling are new, with the exception of some air sampling canisters, which must be recertified before reuse, and demonstrated to be clean for their appropriate use. All documentation certifying sample container cleanliness must be maintained by the laboratory or the vendor and can be provided to the client upon request. The sample containers to be supplied are listed in Tables 8.5-1 through 8.5-5. Container volumes listed in these tables may be decreased with the approval of the laboratory QA Manager or Technical Director to accommodate reduced sample volumes required by the facility SOP. Volumes must be increased with the need for duplicates or matrix spikes.

8.5.2.2 Shipping Containers

Shipping containers are defined as the sealed enclosure in which the sample containers are stored during shipment from the sample collection site to the analytical laboratory. Shipping containers must be of sufficient number and size to accommodate the samples in an upright condition. Shipping containers must also meet all requirements for the shipment of environmental and/or radioactive samples.

Packaged samples must be shipped to the analytical laboratory in a safe manner that preserves the integrity of the samples. The most common method of sample shipment employs coolers or ice chests that are sealed with custody tape and shipping tape. These coolers must be durable and resistant to crushing during shipment. All coolers must be well maintained and cleaned to prevent cross-contamination of the samples. It is the ultimate responsibility of the person collecting and packaging the sample for shipment to ensure that the shipping containers are clean and functional.

To help prevent sample breakage during shipment, additional consideration must be given to providing shock absorbency to all samples packaged inside the shipping container. Use of bubble-wrap around each sample container is the best way to provide this protection. Foam packing materials and vermiculite are also successfully used.

8.5.2.3 Sample Preservatives

Most analytes have a finite holding time in a given sample matrix. Sample preservation is the chemical or physical means by which samples are treated during and/or following sample collection to aid in the stability of the analytes of interest in that matrix. Sample holding times are also adversely affected when samples are improperly preserved, or shipped unpreserved. The preservation of samples at the time of sample collection will follow the requirements of the analytical methods used. This preservation includes the addition of reagents to deter chemical and biochemical degradation and the maintenance of refrigeration during transit and ultimate storage in the laboratory. The required preservatives for the analysis to be performed on each matrix are included in Tables 8.5-1 through 8.5-5.

8.5.2.4 Sample Holding Times

Holding time is defined as the maximum allowable time a sample can be stored after sample collection and preservation (or laboratory receipt for CLP) until appropriate processing occurs (preparation or analysis). The holding time may vary according to method or client requirements. Tests designated with holding times as "analyze immediately or ASAP" are considered parameters that should be tested by field personnel or on-site. Each operation has a system in place to ensure that holding times are monitored by each group within the operating unit. It is the responsibility of each STL associate processing the sample to assure that holding times are met. STL is responsible for meeting all holding times for properly preserved samples received within 48 hours of collection or if less than half the holding time has passed. If these conditions are not met, STL will attempt to expedite sample analysis as soon as possible. When holding times are exceeded, the laboratory uses a Nonconformance Memo (NCM) to identify and document the root cause of the holding time violation.

Sample holding times are listed in Tables 8.5-1 through 8.5-5.

8.5.3 Sample Handling

STL Denver's SOP# DEN-QA-0003 describes the sample receipt and log-in process in detail. Additional requirements for radioactive samples are given in SOP# AU-HPM-R001. The following sections describe the general policies followed by STL.

8.5.3.1 Sample Receipt

Samples shall be received and logged in at STL by a designated sample custodian or other properly trained associate. Two receiving areas are established, one for samples without significant levels of radioactivity and one for radioactive samples. Clients are instructed by the laboratory Project Manager which of the two receiving area will take delivery of their samples.

Additional training and procedures, as specified in the Radiation Safety Manual, are required for personnel receiving radioactive samples. Upon sample receipt, the sample custodian shall, as appropriate:

- Wear appropriate personal protective equipment. At a minimum, this consists of gloves, a lab coat, and safety glasses
- Examine the shipping containers to verify that the custody tape is intact
- Examine all sample containers for damage
- Open shipping containers in adequately ventilated areas to assure worker safety
- Determine if the temperature required by the requested testing program has been maintained during shipment. Document the shipping container temperature on the COC
- Compare samples received against those listed on the COC
- Verify that sample holding times have not been exceeded
- Examine all shipping records for accuracy and completeness
- Determine sample pH (if required for the scheduled analysis) (except VOA samples) and record on the COC
- Sign and date the COC immediately (only after shipment is accepted) and attach the waybill
- Note any problems associated with the coolers and samples on the COC, immediately initiate a Condition Upon Receipt Report (CUR) or equivalent format, and notify the PM who in turn notifies the client
- Attach durable (water-resistant) laboratory sample container labels with unique laboratory identification number and test
- Place the samples in proper laboratory storage.

A CUR or an equivalent form/system is generated by sample control during the sample log-in process to document anomalies identified upon the receipt of samples in the laboratory. These anomalies are outside of laboratory control and do not require corrective actions to be taken within the laboratory. The affected client shall be notified by the PM or designee of all CURs generated for their samples. The PM is responsible for resolving with the client how to proceed with the samples and documenting the decision to proceed with the analysis of compromised samples. CURs must be resolved prior to sample preparation and analysis. The completed CUR form shall be stored in the project file. An example CUR is shown in Figure 8.5-2. The report narrative will include an explanation of sample receiving related anomalies. Further details are given in SOP # DEN-QA-0003.

FIGURE 8.5-2
Example STL Condition Upon Receipt Anomaly Report (CUR)

Client: _____ Date/Time: _____

Lot No: _____ Initiated by: _____

Affected Samples COC# _____

Client ID	Lab ID	Analyses Requested

CONDITION/ANOMALY/VARIANCE (CHECK ALL THAT APPLY):

❑COOLERS
- ❑Not Received, No Chain of Custody (COC)
- ❑Not Received but COC(s) Available
- ❑Leaking
- ❑Other: _____

❑ TEMPERATURE (greater than 6° C)
- ❑Cooler Temp _____
- ❑Temperature Blank _____

❑CONTAINERS
- ❑Leaking
- ❑Broken
- ❑Extra
- ❑Without Labels
- ❑VOA Vials with Headspace _____mm
- ❑Other: _____

❑CUSTODY SEALS (COOLER(S)/CONTAINER(S)
- ❑None
- ❑ Not Intact
- ❑Other: _____

❑CHAIN OF CUSTODY (COCs)
- ❑Not relinquished by Client: No date/time Relinq.
- ❑ Incomplete Information
- ❑Other: _____

❑ CONTAINER LABELS
- ❑Not the same ID/info as in COC
- ❑ Incomplete

❑ID COLLECTION ❑Time ❑Date ❑PRESERVATIVE
- ❑ Markings/Info smeared or illegible
- ❑Torn
- ❑Other: _____

❑ SAMPLES

❑Samples NOT RECEIVED but listed on COC ------ ❑will be noted on COC ❑ Client to send samples with new COC
- ❑Samples received but NOT LISTED on COC
- ❑Logged based on Label Information
- ❑Logged based on info from other samples on COC
- ❑ Logged according to Work Plan
- ❑Logged on HOLD UNTIL FURTHER NOTICE
- ❑ Other: _____

- ❑ Mislabeled as to tests, preservatives, etc.
- ❑Holding time expired
- ❑ Improper container used
- ❑Not preserved / Improper preservative used
- ❑ Improper pH _____ ❑ Lab to preserve sample
- ❑ Insufficient quantities for analysis

Comments: _____

Corrective Action:
- ❑ Client Informed: verbally on: _____ By: _____: In writing on: _____ By: _____
- ❑ Sample(s) processed "as is". _____
- ❑ Sample(s) on hold until: _____ If released, notify: _____

Sample Control Supervisor Review: _____ Date: _____

Project Management Review: _____ Date: _____

SIGNED ORIGINAL MUST BE RETAINED IN THE PROJECT FILE

8.5.3.2 Exceptions or Discrepancies

STL reserves the right to reject samples for any of the following reasons:

- No custody seals as required by project
- No chain of custody documentation provided
- Preservation inappropriate for analysis requested
- Sample container inappropriate for analysis requested
- Sample received out of holding time for analysis requested
- Incomplete sample information provided
- Discrepancies between COC and sample labels
- Samples have high levels of polychlorinated dibenzo-p-dioxins/ dibenzo furans (PCDD/PCDFs)
- Samples have a high level gross alpha or beta radiation
- Samples are from a site known to contain chemical warfare agents (CWAs) and the samples have not been screened for them.

These or any other project exceptions or discrepancies are discussed with the client and agreed upon action taken.

8.5.3.3 Sample Log-in

Sample log-in activities at STL are fully documented in SOP# DEN-QA-0003. The following is a general description of the log-in process:

- Enter the samples in the laboratory sample log-in book, and/or the LIMS which contains the following information at a minimum:
- Project name or identification number
- Unique sample numbers (both client and internal laboratory)
- Type of samples
- Required tests
- Date and time of laboratory receipt of samples
- Field ID supplied by field personnel
- Notify the PM and appropriate Group/Team Leader(s) of sample arrival
- Place the completed COCs, waybills, and any additional documentation in the project file.

8.5.3.4 Sample Storage

The primary considerations for sample storage are:

- Maintenance at the method prescribed temperature, if required
- Maintenance of sample integrity through adequate protection from contamination from outside sources or from cross-contamination of samples. Low-level and high-level samples, when known, must be stored separately. Samples and standards must be stored in separate refrigerators or freezers. Storage areas for volatile organic test requests

should be monitored twice per month by the analysis of a holding (refrigerator) blank (an aliquot of contaminant-free water stored in a VOA vial)
- Security of samples within the laboratory.

The requirements listed in Tables 8.5-1 through 8.5-5 for temperatures and holding times shall be used. Placing of samples in the proper storage environment is the responsibility of sample control personnel. STL will assign individuals the responsibility of notifying the Group/Team Leaders or their designees if there are any samples that must be analyzed immediately because of holding time requirements.

8.5.3.5 Internal Sample Chain-of-Custody and Interlaboratory Transfers

Sample custody within STL laboratories is described in SOP # DEN-QA-0003. Internal COC may be required for programs defined by state or federal agency. The sample custody documentation shall include the following minimum requirements:

- Name of associate taking custody of the sample from the sample storage area for preparation or analysis
- Dates sample removed from and returned to the sample storage area
- Identification of tests to be performed on the sample aliquot(s) selected by the associate
- Sample matrix
- Laboratory sample numbers
- Sample storage location.

Additional custody records can be provided by the laboratory at the specific request of the client. Access to STL is restricted to prevent any unauthorized contact with samples, extracts, or documentation.

Samples transferred to a different laboratory than the original receiving facility are transferred under chain-of-custody (COC). The COC is maintained whether the laboratory is another STL facility or a subcontracted laboratory. If the entire sample volume is transmitted, the original copy of the client's COC form will be used to document the relinquishing of the sample and will accompany the sample to its destination. A copy of the completed COC form shall be retained in the laboratory project file. In the case where an aliquot of a sample is shipped from the laboratory, a new COC will be generated by the laboratory and shipped with the sample aliquot. The original COC will be retained in the project file at the site holding the original sample container.

Samples are not transferred to other STL facilities or to subcontractor laboratories without prior approval of the client.

8.5.3.6 Subsampling

Sample preparation procedures are referenced in the method SOPs. SOP# DEN-QA-0023 describes processes for obtaining representative subsamples.

8.5.3.7 Sample Disposal and Return Chain-of-Custody

After the requested analyses on the samples have been completed, any remaining portions of the samples will be maintained by the sample custodian until the samples are disposed of or returned to the client. The disposal of each sample is recorded on the client's COC form, in LIMS, or referenced in the project file. Sample disposal procedures and documentation are described in operation-specific SOPs. STL's routine sample retention period is at least thirty days after the analytical report is issued to the client, unless otherwise specified by the client.

For Nuclear Regulatory Commission (NRC) or state licensed laboratories, a real-time inventory of all radioactive isotopes contained in the laboratory (including radioactive samples), as required by the NRC or state, is maintained by the Radiation Safety Officer (RSO). If the quantities of radioactive materials in-house approach the limits stipulated by the laboratory NRC or state license, appropriate action must be taken to ensure the licensed level is not exceeded. This may involve returning samples to clients immediately.

If samples are returned to the client rather than disposed of by the laboratory, the original COC or a new COC is used to document custody transfer back to the client from the laboratory. A copy of the completed COC is retained in the laboratory project file.

8.5.4 Calibration Procedures and Criteria

All equipment and instruments used at STL operations for quantitative measurements are controlled by a formal calibration program. Table 8.0-1 lists the lab's major analytical instrumentation , and Tables 8.5-6 through 8.5-9 outline calibration requirements. Calibrations may be periodic or operational. These are described in the lab's method SOPs. The Policy P-T-001, "Selection of Data Points Required for an Initial Calibration Curve," is applicable when the number of data points is not described in the method. At a minimum, these calibration procedures shall include:

- Instrument to be calibrated
- Reference standards used for calibration
- Calibration technique (e.g., linear, quadratic)

- Acceptable performance tolerances and corrective actions required if specifications are not met
- Frequency of calibration

Whenever possible, recognized procedures such as those published by ASTM or the USEPA or procedures provided by manufacturers shall be adopted. If established procedures are not available, a procedure shall be developed considering the type of equipment, stability characteristics of the equipment, required accuracy, and the effect of operation error on the quantities measured.

8.5.4.1 Physical Reference Standards

Physical reference standards associated with periodic calibrations include weights for calibrating balances and certified thermometers for calibrating working thermometers. Whenever possible, physical reference standards shall be calibrated by a body that can provide traceability to nationally or internationally recognized standards. If these standards are not available, the basis for the reference standard shall be documented.

Physical reference standards shall be used only for calibration procedures and shall be stored separately from equipment used for analysis.

8.5.4.2 Chemical Reference Standards and Reagents

Chemical reference standards are generally associated with operational calibration. These standards include reference materials traceable to recognized standards suppliers. This may include vendor-certified materials traceable to national or international standard reference materials (e.g., NIST). This topic is also discussed in the Section on "Procurement of Supplies and Services" (see 5.2.4).

All chemical reference standards maintained in the laboratory for use in calibrations (or as QC spiking solutions) and reagents prepared in the laboratory shall be labeled or referenced to appropriate documentation (hard copy or electronic) with the following information at a minimum:

- A unique identification including concentration (solutions containing several analytes can be identified such that the solution constituents and concentrations can be referenced to a logbook)
- Medium prepared in
- Preparation date
- Expiration date
- Initials of preparer.

Vials containing standard solutions that are not large enough to accommodate labels listing the above information may be referenced to a laboratory logbook/ notebook entry or standards software. The expiration

date of the working standard and reagent must not exceed the expiration date of the original material. These records should provide sufficient detail to allow one to reproduce the standard or reagent.

Records for all purchased standards and reagents shall include the date of receipt, the date opened, and, where applicable, the expiration date.

8.5.4.3 Standard Verification

When possible, reference standards are purchased from a vendor that has already been approved by STL. Standards are verified by quantitation against a second known standard before reporting data. The standard for verification must meet the laboratory's criteria for the independent/second source ICV verification. Therefore, the verification of a new standard initial calibration with a second source ICV meets this verification requirement. Realizing that some "bad acting" analytes may not meet these criteria, specific allowances for these analytes must be approved by QA before use. Standard spiking solutions and surrogates shall be verified by analyzing an LCS with the new standards and verifying against historical criteria limits. Special standards that are obtained from another source must also be independently verified at the lab. Verification by the laboratory of a reference standard from neat materials is also necessary.

Extending the use of an expired standard may not be allowed by some programs and generally is not recommended. As permitted by the relevant program, if it is necessary to extend the use of an expired standard, reverification is required and the reverification analysis must produce acceptable data. The verification of an expired standard is performed against a current, independent standard reference material by analyzing within a valid calibration and QC.

Stock and working standards and reagents are checked regularly for signs of deterioration, such as discoloration, formation of precipitates, or change in concentration. Care is exercised in the proper storage and handling of standard and reagent solutions. Standards and reagents are always stored separately from samples.

An independent or second source standard is used to verify initial calibrations. An independent/second source standard is defined as a standard composed of the same target constituents as, but from a different source than those used in the standards for the initial calibration. An independent standard may be a laboratory-prepared or a certified independent standard solution(s). Independence of reference material can be achieved by: (1) purchasing reference materials from two separate vendors, (2) using a different lot from the same vendor that is certified by the vendor as an independent standard or (3) having two separate

individuals prepare the calibration and verification standard solutions if independent sources are not available.

8.5.4.4 Periodic Calibration

Periodic calibration is performed at prescribed intervals. In general, equipment that can be calibrated periodically is a distinct, singular purpose unit and is relatively stable in performance. These include balances, micropipettors, counters, thermometers, refrigerators, freezers, and ovens. Equipment employed at STL requiring periodic calibration are listed along with their respective calibration requirements in Tables 8.5-6. NELAC requires mechanical volumetric dispensing devices (except Class A glassware) to be checked for accuracy or at least a quarterly basis if in use. The laboratory unit has an SOP in place for the calibration of this equipment if in use at their location.

8.5.4.5 Operational and Continuing Calibration

Operational calibration is routinely performed as part of instrument usage, such as the development of a standard calibration curve (see Tables 8.5-7 to 8.5-9). The accuracy of initial calibrations will be verified prior to sample analysis through the use of an independent standard in situations where the source method requires calibration verification.

When an initial calibration is not performed on the day of analysis, the validity of the initial calibration verification must be verified prior to sample analyses by analyzing a continuing instrument calibration verification with each analytical batch. The following items are essential elements of continuing instrument calibration verification:

- The details of the continuing instrument calibration procedure, calculations and associated statistics are referenced in the laboratory method SOPs.
- A continuing instrument calibration verification must be repeated at the beginning and end of each analytical batch. The concentrations of the calibration verification shall be varied within the established calibration range. If an internal standard is used, only one continuing instrument calibration verification must be analyzed per analytical batch.
- Sufficient raw data must be retained to permit reconstruction of the continuing instrument calibration verification, e.g., test method, instrument, analysis date, each analyte name, concentration and response, and calibration curve or response factor.
- Criteria for the acceptance of a continuing instrument calibration verification, such as the relative percent difference must be established.

- If the continuing instrument calibration verification results obtained are outside the established acceptance criteria, corrective actions must be performed. If routine corrective action procedures fail to produce a second consecutive (immediate) calibration verification within acceptance criteria, then either the laboratory has to demonstrate performance after corrective action with two consecutive successful calibration verifications or a new initial instrument calibration must be performed. If the laboratory has not demonstrated acceptable performance, sample analyses must not occur until a new initial calibration curve is established and verified. However, sample data associated with an unacceptable calibration verification may be reported as qualified data under the following special conditions:
  - When the acceptance criteria for the continuing calibration verification is exceeded high, i.e., high bias, and there are associated samples that are non-detects, then those non-detects may be reported. Otherwise the samples affected by the unacceptable calibration verification shall be reanalyzed after a new calibration curve has been established, evaluated and accepted.
  - When the acceptance criteria for the continuing calibration verification is exceeded low, i.e., low bias, those sample results may be reported if they exceed a maximum regulatory limits. Otherwise the samples affected by the unacceptable calibration verification shall be reanalyzed after a new calibration curve has been established, evaluated and accepted.

8.6 Quality Assessment

The effectiveness of the QA practices is measured by the quality of data generated by the laboratory. Procedures are in place to detect, prevent, and correct quality problems and to ensure quality improvement. Items and processes that do not meet established requirements must be investigated to determine their cause. Improvements must be implemented in the operations that will prevent a recurrence of these quality problems and provide overall quality performance. All phases of laboratory work should be designed with the objective of preventing problems and improving quality on a continuous basis.

8.6.1 Data Quality Assessment

Data quality is judged in terms of precision, accuracy, representativeness, completeness and comparability. The areas of representativeness, comparability, and completeness for an overall project, inclusive of sampling issues, may be beyond the control of the laboratory. The elements over which the laboratory has direct control are precision, accuracy, and completeness relative to analytical testing results.

Precision and accuracy assessments are made as part of the evaluation of laboratory QC data generated during sample preparation and analysis. The QC samples employed at STL Denver as part of routine sample analysis are summarized in Section 8.4 of this document. Table 8.6-1 shows the precision and accuracy measurements employed. Analytical method SOPs and STL Policy Number QA-003 include information on requirements for the type of QC samples, frequencies, and acceptance criteria. Additionally, the SOPs and Policy describe the appropriate actions to be taken when a QC sample result does not meet acceptance criteria.

8.6.2 Statistical Evaluation of Data

In-house limits for all QC data must be evaluated at least annually and compared to the limits published in the methods for applicable matrices. Method limits will be employed until sufficient QC data are acquired. A minimum of 20 to 30 data points are recommended to establish the in-house QC limits. Calculated results of the QC (LCS) samples are evaluated by comparing against control limits (3-sigma).

Control charts are used to develop control limits, trouble-shoot analytical problems, and, in conjunction with the non-conformance system, to monitor for trends. Program-specific data analysis requirements for control charts are followed as required for data generated under those programs. These additional requirements shall be documented in a QAPP or QAS.

Precision and accuracy measurements employed by STL Denver are shown in Table 8.4-3 through 8.4-7. Calculated results of these QC samples are evaluated using statistical tables or control charts.

8.7 Data Recording Procedures

To ensure data integrity, all documentation of data and records generated or used during the process of data generation must be performed in compliance with SOP Number QA-008, "Data Recording Requirements".

8.8 Data Reduction and Verification Procedures

Data review procedures comprise a set of computerized and manual checks applied at appropriate levels of the measurement process. Data review begins with the reduction or processing of data and continues through verification of the data and the reporting of analytical results. Calculations are checked from the raw data to the final value prior to reporting results for each group of samples. Data reduction can be performed by the analyst who obtained the data or by another analyst. Data verification starts with the analyst who performs a 100 percent review of the data to ensure the work was done correctly the first time. Data verification continues with review by a second reviewer who verifies that data reduction has been correctly performed and that the analytical results correspond to the data acquired and processed. This procedure is outlined in Figure 8.8-1.

8.8.1 Data Reduction and Initial Verification

Data reduction and initial verification may be performed by more than one analyst depending upon the analytical method employed. The preparation and analytical data may be reviewed independently by different analysts. In these instances, each item may not be applicable to the subset of the data verified or an item may be applicable in both instances. It is the responsibility of the analyst to ensure that the verification of data in his or her area is complete. The data reduction and initial verification process must ensure that:

- Sample preparation information is correct and complete including documentation of standard identification, solvent lot numbers, sample amounts, etc.
- Analysis information is correct and complete including proper identification of analysis output (charts, chromatograms, mass spectra, etc.)
- Analytical results are correct and complete including calculation or verification of instrument calibration, QC results, and qualitative and quantitative sample results with appropriate qualifiers
- The appropriate SOPs have been followed and are identified in the project records
- Proper documentation procedures have been followed
- All nonconformances have been documented
- Special sample preparation and analytical requirements have been met.
- The data generated have been reported with the appropriate number of significant figures as defined by the analytical method in the LIMS or otherwise specified by the client.

In general, data will be processed by an analyst in one of the following ways:

- Manual computation of results directly on the data sheet or on calculation pages attached to the data sheets
- Input of raw data for computer processing
- Direct acquisition and processing of raw data by a computer.

If data are manually processed by an analyst, all steps in the computation shall be provided including equations used and the source of input parameters such as response factors (RFs), dilution factors, and calibration constants. If calculations are not performed directly on the data sheet, they may be attached to the data sheets.

Manual integrations are sometimes necessary to produce good chromatography, but must only be performed when necessary. Further discussion of manual integrations and the required documentation is given in Policy Number QA-011, "Acceptable Manual Integration Practices".

For data that are input by an analyst and processed using a computer, a copy of

the input shall be kept and uniquely identified with the project number and other information as needed. The samples analyzed must be clearly identified.

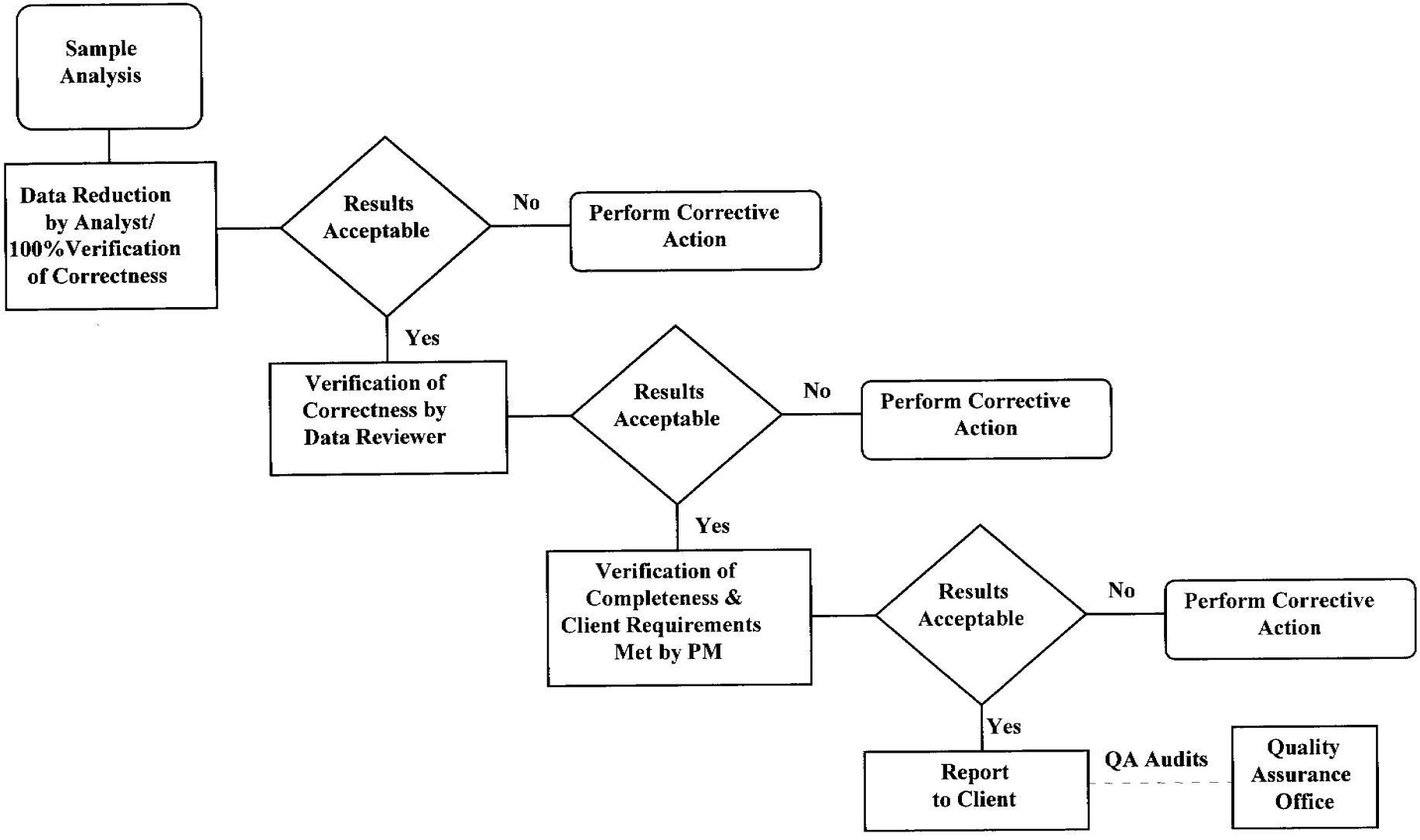
If data are directly acquired from instrumentation and processed, the analyst must verify that the following are correct:

- Project and sample numbers
- Calibration constants and RFs
- Units
- Numerical values used for reporting limits.

Analysis-specific calculations for methods are provided in SOPs. In cases where computers perform the calculations, software must be validated or verified, as described in Section 6.0 of this document, before it is used to process data.

The data reduction is documented, signed and dated by the analyst completing the process. Initial verification of the data reduction by the same analyst is documented on a data review checklist, signed and dated by the analyst. Data review requirements are described in Section 5.3.6 of the QMP.

FIGURE 8.8-1
Data Reduction, Verification, and Reporting



8.8.2 Data Verification

Following the completion of the initial verification by the analyst performing the data reduction, a systematic check of the data that has been fully reduced and checked through Level 1 review is performed by an experienced peer, supervisor, or designee. This check is performed to ensure that level 1 review has been completed correctly and thoroughly. This review includes an evaluation of all items required in the raw data package. Any exceptions noted by the analyst must be reviewed. Included in this review is an assessment of the acceptability of the data with respect to:

- Adherence of the procedure used to the requested analytical method SOP
- Correct interpretation of chromatograms, mass spectra, etc.
- Correctness of numerical input when computer programs are used (checked randomly)
- Correct identification and quantitation of constituents with appropriate qualifiers
- Numerical correctness of calculations and formulas (checked randomly)
- Acceptability of QC data
- Documentation that instruments were operating according to method specifications (calibrations, performance checks, etc.)
- Documentation of dilution factors, standard concentrations, etc.
- Sample holding time assessment.

This review also serves as verification that the process the analyst has followed is correct in regard to the following:

- The analytical procedure follows the methods and specific instructions given on the project QAS or equivalent summary form
- Nonconforming events have been addressed by corrective action as defined on a nonconformance memo
- Valid interpretations have been made during the examination of the data and the review comments of the initial reviewer are correct
- The package contains all of the necessary documentation for data review and report production and results are reported in a manner consistent with the method used for preparation of data reports.

The specific items covered in the second stage of data verification may vary according to the analytical method, but this review of the data must be documented by signing the same checklist. Data review requirements are described in Section 5.3.6 of the QMP.

8.8.3 Completeness Verification

A third-level review is performed by the PM. This review is required before results are submitted to clients. This review serves to verify the completeness

of the data report and to ensure that project requirements are met for the analyses performed. The items to be reviewed are:

- Analysis results are present for every sample in the analytical batch, reporting group, or sample delivery group (SDG)
- Every parameter or target compound requested is reported with either a value or reporting limit
- The correct units and correct number of significant figures are utilized
- All nonconformances, including holding time violations, and data evaluation statements that impact the data quality are accompanied by clearly expressed comments from the laboratory
- The final report is legible, contains all the supporting documentation required by the project, and is in either the standard STL Denver format or in the client-required format.
- Implement checks to monitor the quality of laboratory results using correlation of results for different parameters of a sample (for example, does the TOC result justify the concentration of organic compounds found by GC/MS.)
- A narrative to accompany the final report will be finalized by the PM. This narrative will include relevant comments collected during the earlier reviews.

8.9 Data Reporting

8.9.1 Data Reports

STL Denver is capable of developing a variety of data deliverable reports. Standard reports will contain:

- Cover Letter/Narrative - Information on sample types, tests performed, any problems encountered, and general comments are provided.
- Analytical Data - Data are reported by sample or by test with the appropriate significant figures and reporting limits, and have been adjusted for dilution, if appropriate. Pertinent information including dates sampled, received, prepared, extracted, and analyzed are provided.
- Laboratory Performance QC Information - The results of LCSs and method blanks analyzed with the project are listed. Any data or QC anomalies are discussed in the narrative.
- Matrix-Specific QC Information - Results of any sample duplicates and MS/MSDs analyzed with the samples as batch QC are reported. Other project-specific QC requested by the client are also reported. The results include supporting information such as amount spiked, percent recovery, or percent difference/RPD.
- Methodology - Reference for analytical methodology used is cited.
- Other Deliverables - Other deliverables available include disk deliverables, electronic data transfer, sample raw data packages, complete

deliverable packages, and custom report formats. Requirements for electronic reporting are defined in Policy CORP-QA-017, "Electronic Reporting".

8.9.2 Final Report Details

STL Denver will provide paginated reports or a uniquely defined, identifiable certificate/report (i.e. electronic file, CD). The report will include:

a) Report title, name, address and phone number of the laboratory.
b) Name and address of client/project name/client identification number.
c) Description (lab ID of sample).
d) Dates and Time of sample collections (if known), receipt, preparation and analysis.
e) If the required holding time is 48 or less, time of sample preparation and analysis.
f) Method identifiers traceable to all procedures used.
g) Reporting limit and/or method detection limit.
h) Test result with appropriate units and how reported (wet weight/dry weight). Also identify any results outside of quantitation limits. When required, a statement of the estimated uncertainty of the test result should be added.
i) If appropriate, description of any QC failures or deviations from SOPs.
j) Signature and title of the individual responsible for the report. Electronic signature is acceptable.
k) Date of issue.
l) All subcontract work must be clearly identified, and name and address of outside subcontractor noted.
m) Where relevant, a statement to the effect that the results relate only to the items tested or to the sample as received by the laboratory
n) Where relevant, a statement that the certificate or report shall not be reproduced except in full, without the written approval of the laboratory.

After final report any correction, addition, or deletion must clearly identify its purpose and meet the above reporting requirements as appropriate.

All applicable elements from above should be available for review if not issued in a formal report by an in-house or captive laboratory.

8.9.3 Verbal Results

STL Denver, as a policy, discourages the release of data verbally or without full data review. If however, the client requests analytical results to be communicated verbally or by facsimile prior to final review, they must be clearly identified as "Preliminary" results. The client must understand that the data have not undergone the required levels of review and may potentially

change.

8.9.4 Reporting Analytical Results

Sample results are reported according to analytical method SOPs or client specifications. Normally, the laboratory uses the STL Denver Reporting Limit (RL) at which any analyte of interest detected at or above that level is reported as a positive value and any analyte of interest not detectable or detected below that level is reported as "not detected" at the RL. The laboratory will normally report results within the calibration, however, any reported results outside of the calibration range will be documented in the final report.

Data reported with samples associated with failed QC measurements must be qualified.

The laboratory must certify that the test results meet all NELAC requirements or provide reasons and/or justification if they do not.

In some cases a contract, QAPP, or documented client request may require the laboratory to report sample results in a specified manner. Some examples are given below:

- The laboratory may be requested to report all analytes of interest that are less than the laboratory's RL but are greater than the MDL. This data will be flagged with an appropriate qualifier or noted in the report case narrative. (See precautions in "Establishing Reporting Limits", Policy Number QA-009).
- The laboratory may be requested to report any tentatively identified compounds (TICs). These data will be flagged with an appropriate qualifier.
- The laboratory may be requested to report sample results using an RL that is higher than their normal level. In this case, only the analytes of interest found at or above that level would be reported as positive values. In this case, the laboratory will state the PSRL rather than the RL. All analytes of interest not detected or detectable below that level would be reported as "not detected" at the PSRL.

  In this situation, the laboratory must include documentation in the project file that supports the reporting procedure employed.
  It is the responsibility of the laboratory to provide for a reporting system that assures that any problems associated with an analysis are properly documented on a nonconformance memo, communicated to the appropriate STL Denver staff, and addressed appropriately in the data report.

8.9.5 Reissued Deliverables

If, after issuance of a report, STL Denver observes any mistake that affects the results reported or the QC interpretation of those results, the client will be

notified. After issuance of the report, the laboratory report remains unchanged. Any material amendments to a report after issue made only in the form of a further document, or data transfer must include the statement "Supplement to Test Report" or otherwise identified. For further discussion see SOP# DPOL-QA-003.

8.9.6 Client Confidentiality

Data and sample materials provided by the client or at the client's request, and the results obtained by STL, shall be held in confidence, unless such information is generally available to the public or is in the public domain. STL's reports, and the data and information provided therein, are for the exclusive use and benefit of our clients, and are not released to a third party without written consent from the client. Data confidentiality is also discussed Section 3.6.

8.10 Data Validation

Data validation for STL refers to data reviews conducted in accordance with the USEPA CLP "Laboratory Data Validation Functional Guidelines for Evaluating Organic Analyses" and "Laboratory Data Validation Functional Guidelines for Evaluating Inorganic Analyses", or modifications thereof, for non-CLP type analyses.

This form of data validation provides an impartial evaluation of the laboratory's results. Data validation may be requested by the client for a percentage of data and is usually performed by a third party, one which was not involved with the sample analysis. Qualifiers are assigned to data, when required, according to the requirements of the data validation protocol being used.

8.11 Preventive Maintenance and Service

Facilities, instruments, equipment, and parts are subject to wear, deterioration, or change in operational characteristics. Within STL, preventive maintenance, coupled with vendor service agreements, is an organized program of actions taken to maintain facilities and equipment in control.

8.11.1 Analytical Instrumentation and Equipment

The primary purpose of the maintenance program is to prevent instrument and equipment failure and to minimize down time. A properly implemented maintenance program increases the reliability of a measurement system.

Each instrument or piece of equipment shall be uniquely identified. The laboratory maintains the following:

- Instrument/equipment inventory list
- Instrument/equipment major spare parts list or inventory
- External service agreement documents (if applicable)

- Instrument-specific preventive maintenance logbook or file for each functional unit.

The records of routine maintenance and non-routine maintenance shall include at a minimum:

- Name and serial number of the item or equipment
- Details of maintenance performed
- Dates and results of recalibrations/ reverifications indicating return to control
- Analyst initials and the date maintenance was performed whether by the analyst or a contracted service representative.

Any item or equipment that does not perform to specifications or defective shall be taken out of service, and tagged as out of service until it has been repaired and shown by calibration/ verification to perform satisfactorily.

8.11.2 Frequency of Equipment Maintenance

The frequency of maintenance must consider manufacturer's recommendations and previous experience. Frequency of preventive maintenance along with the recommended preventive maintenance schedules are given in Tables 8.11-1 through 8.11-30 for analytical instrumentation and equipment or defined in operation specific routine maintenance SOPs. Frequency of maintenance for the facility systems is documented in the CHP.

8.11.3 Facilities

Another important aspect of the laboratory operation is the existence and maintenance of adequate, safe, and clean facilities including appropriate engineering controls such as proper ventilation, lighting, dust control, hoods, air flow, protection from extreme temperatures, waste disposal, and a source of stable power. The facility floor plan is provided in Figure 8.11.

The maintenance and use of these facilities and proper operations are described in the Chemical Hygiene Plan (CHP). The Laboratory Director has responsibility for ensuring a properly maintained facility. The Laboratory Director also has the responsibility for ensuring that facilities are available to store samples properly without contamination, work areas are equipped with adequate bench, hood and operational space, and that procedures are in place to ensure the areas are free from chemical and radiological contamination that may affect analytical results.

8.11.4 Facility Security

The laboratory building is a limited access, secure facility. To ensure that only authorized personnel are able to enter the building from an entrance that is not monitored, entry into each building is limited in one or more of the following

ways at a minimum:

- The use of key pads or electronic locks activated by swipe or magnetic cards which are issued only to authorized personnel
- Locking doors and issuing keys only to authorized personnel
- Alarm systems to detect unauthorized entrance

During business hours, entry is possible only through the main entrance. This entrance is monitored at all times, usually by a receptionist. All guests are required to sign in by using a visitor logbook.

8.12 Requirements for Ancillary Equipment and Materials

8.12.1 Water

High purity water (e.g., ASTM reagent grade or equivalent water) will be used in all metals, radiological, wet chemistry, and organic analyses. Demonstration of contaminant-free water is shown through the analysis of method blanks consisting of the reagent water on a daily basis for the analyte of interest. This water is obtained by the use of either a commercial ion-exchange deionizing, distillation, or reverse osmosis unit plus an appropriate polishing unit. The resulting water has a maximum conductivity of 1.0 umho-cm at 25°C or a minimum resistivity of 1.0 Mohm at 25°C. Conductivity or resistivity will be monitored and documented daily or on each day that water is dispensed for analytical use.

For volatile analyses the water may be further purified by purging with an inert gas before use to remove potential traces of organic solvents. This is described further in SOP # DEN-QA-0013.

8.12.2 Compressed Air and Gases

Ultra high-purity compressed gases from preapproved vendors or in-house gas generators will be used when required for instrumentation. These air and gases must meet the requirements and specifications of the analytical methods performed. In-line filters will be used when appropriate to minimize contamination and moisture from the gases.

8.12.3 Glassware Preparation

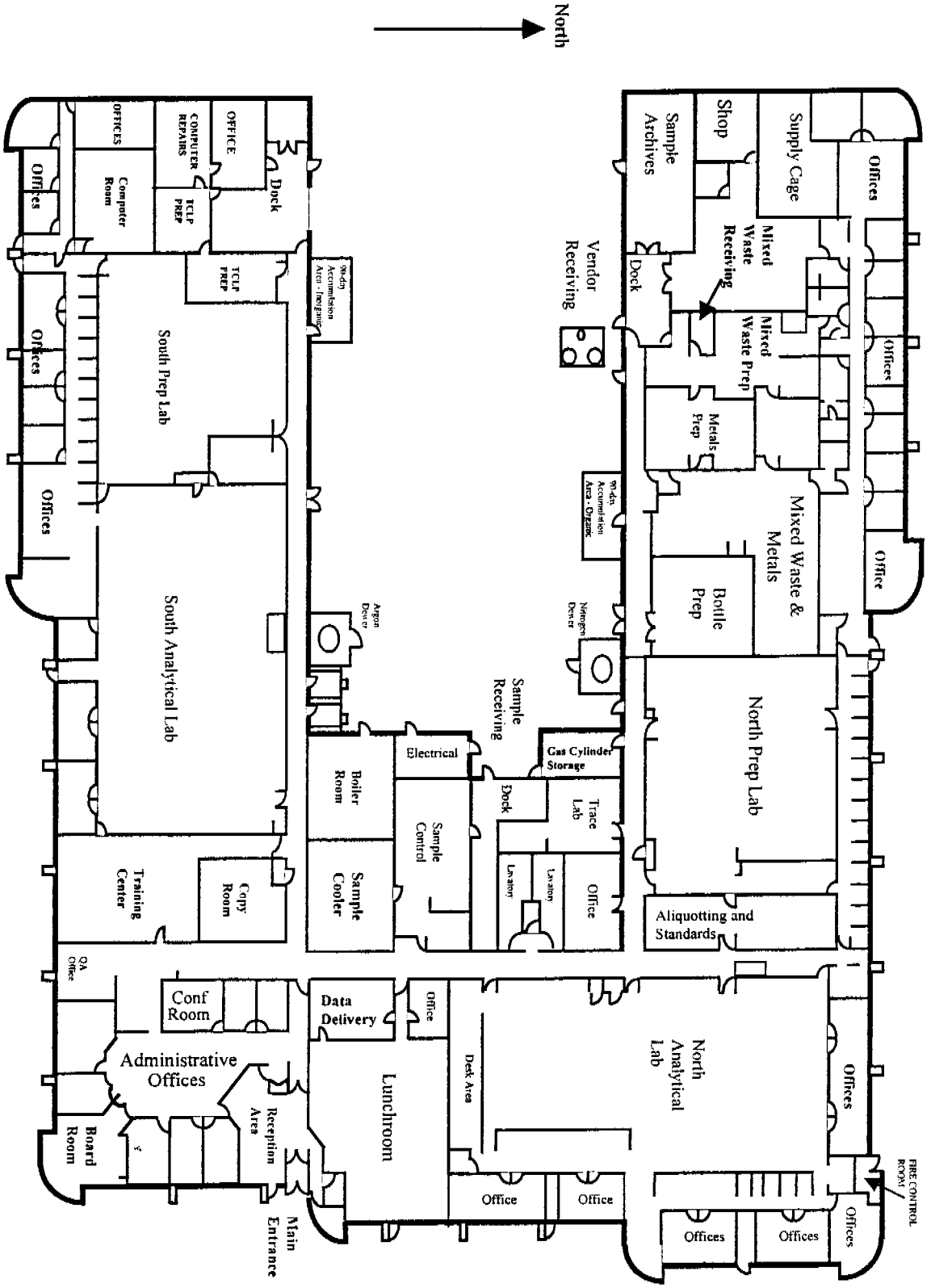
Glassware preparation procedures implemented at operating units are designed to ensure that contaminants are not introduced during sample analysis. Procedures describing glassware preparation are detailed in operation-specific SOPs DEN-IP-0005 (inorganic glassware) and DEN-OP-0004 (organic glassware).

8.12.4 Chemical Storage

Storage of chemicals shall be conducted in a manner to minimize the potential for fire or release of hazardous material resulting from an unplanned chemical reaction. Refrigerators used for storing flammable liquids must have spark-free interior construction. Flammable solvents shall be stored in appropriate cabinets meeting all necessary codes. All chemicals are stored according to chemical compatibility. Further details regarding chemical storage are provided in the CHP.

8.12.5 Waste Management

The goal of STL's policy for waste management is to ensure that laboratory wastes are disposed of safely and in a manner consistent with applicable federal, state and local regulations. The waste disposal program is designed to assure that minimal harm to people and the environment shall result from the disposal of laboratory chemicals. This goal is accomplished by requiring that the laboratory comply with the procedures presented in the CHP.


North
Sample Archives
Shop
Supply Cage
Offices
Vendor Receiving
Dock
Mixed Waste Receiving
Mixed Waste Prep
Offices
Metals Prep
Mixed Waste & Metals
Bottle Prep
Office
North Prep Lab
Aliquotting and Standards
Sample Receiving
Gas Cylinder Storage
Dock
Trace Lab
Office
Electrical
Boiler Room
Sample Control
Sample Cooler
Training Center
Copy Room
South Analytical Lab
South Prep Lab
Offices
Computer Room
OFFICES
COMPUTER REPAIRS
OFFICE
Dock
TCLP PREP
Offices
Conf Room
Data Delivery
Office
Lunchroom
Desk Area
North Analytical Lab
Offices
Administrative Offices
Reception Area
Board Room
Main Entrance
Office
Office
Offices
Offices
Offices
FIRE CONTROL ROOM
STL Denver

9.0 Quality Assessment and Response

9.1 Nonconformances

A nonconformance is an unplanned deviation from an established protocol or plan and in some cases may be exceptionally permitted departures from the documented policies and procedures or from standard specifications. The deviation may be the result of STL's actions as a systematic error, then termed a deficiency. A single isolated event or event beyond the control of STL is termed an anomaly.

Nonconformances can be identified on the basis of internal or external systems or performance audits, sample processing, routine calibration and monitoring of analytical and support equipment, or QC sample analyses. The Technical Director, Operations Manager, Project Manager, QA Manager, Group Leader, and Analyst may be involved in identifying the most appropriate corrective action. If previously reported data are affected, the issue is immediately brought to the attention of QA.

9.1.1 Nonconformance Memo (NCM)

All nonconformances, deficiencies and anomalies, are documented via an electronic process or on a paper form that meets NCM requirements as approved by QA. An allowed exception is log-in conformance problems, which are documented on a Condition Upon Receipt Form (see Section 8.5). A detailed description of the procedure and responsibilities associated with nonconformance documentation, communication, and resolution is described in SOP # CORP-QA-0010.

The Clouseau NCM program, available on the local-area network throughout the laboratory, is the main vehicle for documenting and communicating NCMs. The program allows anyone in the laboratory to document a nonconformance, explain the cause of the problem, and link to the LIMS system to identify the samples and clients involved. The program uses the local e-mail to automatically notify the person's supervisor, the Project Managers associated with the samples, and the QA department. The program is used to document approval and completion of the immediate corrective actions for the samples involved, and can be used to document long-term corrective actions. It provides a place to document resolution of problems with the clients, and it provides routines to query the associated data base to examine trends and prepare management reports. A copy (paper or electronic) of the nonconformance memo will be kept in the project files together with the data it refers to. A copy, paper or electronic, shall also be kept in the quality files.

9.2 Client Complaints

Client inquiries and complaints are generally received through the PM or Customer Services Manager. Typically, the PM or CSM communicates with the client to determine the details of the inquiries, including technical data problems, deliverable issues, turn-around-time problems, etc. Technical and deliverable issues are coordinated by the PM and usually involve input from operations, QA, and management staff. A formal written response to the client is coordinated by the PM, but may on occasion be delivered by the CSM or the Account Manager. Details of the types and levels of complaints and required documentation are provided in Section 4.8 of the QMP. Client complaints are recorded as a type of NCM in the Clouseau database, which are summarized in the monthly QA Reports to Management (see Section 9.6 for more about the monthly QA reports).

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9.3 Corrective Actions

Corrective actions are measures taken to rectify conditions adverse to quality and, where possible, to prevent their reoccurrence. Investigations of potential problems and corrective actions should be timely, determine the root cause, and evaluate any propagation of the error or problem. Whenever a systematic error is discovered that affects the accuracy or defensibility of results reported to STL's clients, Corporate QA involvement followed by client notification will be part of the corrective action.

Corrective actions should be implemented with an understanding of the technology and work activities associated with the quality element, with appropriate training of STL associates and vendors, and should be monitored for progress and success. Depending on the nature of the problem, the corrective action employed may be formal or informal. In either case, occurrence of the problem, the corrective action employed, and verification that the problem has been eliminated must be documented properly. On-the-spot actions are used to correct minor problems, such as recalibration, retuning, or a minor repair (e.g., replacement of a minor part) of a malfunctioning instrument or the correction of poor analytical technique being used by an analyst. These occurrences are documented in the appropriate injection, run, or analysis logbooks. Similarly, routine instrument maintenance, malfunctions, and power failures are also documented in the appropriate instrument maintenance logbooks. These events do not require a formal NCM process, provided reported analytical results are not affected. Corrective actions specific to quality controls for analytical methods are discussed in the operational-specific SOPs.

9.3.1 Monitoring Corrective Actions

All formal corrective action documentation is maintained by the QA department, either in the Clouseau data base or in paper files. The QA department reviews all corrective actions and selects one or more of the significant corrective actions for inclusion in the annual systems audit. The QA department may also implement a spot assessment audit. The purpose of these audits is to monitor the

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STL DENVER
Interim SOP Change

SOP NUMBER: LQM Revision No.:0
SOP TITLE: STL Denver LQM
SOP SECTION(S) AFFECTED BY CHANGE: 9.3
REASON FOR CHANGE: Response to on-site inspection report by Utah.
CHANGE: Insert: Whenever a systematic error is discovered that affects the accuracy, validity, or defensibility of calibrations or test results reported to STL's clients, our clients will be notified in writing immediately when the nature and extent of the problem is understood. The STL Corporate QA Director must also be notified.
SUBMITTED BY/DATE: Michael Schmitt, 07/30/01
APPROVED BY:
Timothy O'Shields, Laboratory Director — Date: 7-31-01
Larry Penfold, Quality Assurance Manager — Date: 7-31-01

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9.2 Client Complaints

Client inquiries and complaints are generally received through the PM or Customer Services Manager. Typically, the PM or CSM communicates with the client to determine the details of the inquiries, including technical data problems, deliverable issues, turn-around-time problems, etc. Technical and deliverable issues are coordinated by the PM and usually involve input from operations, QA, and management staff. A formal written response to the client is coordinated by the PM, but may on occasion be delivered by the CSM or the Account Manager. Details of the types and levels of complaints and required documentation are provided in Section 4.8 of the QMP. Client complaints are recorded as a type of NCM in the Clouseau database, which are summarized in the monthly QA Reports to Management (see Section 9.6 for more about the monthly QA reports).

9.3 Corrective Actions

Corrective actions are measures taken to rectify conditions adverse to quality and, where possible, to prevent their reoccurrence. Investigations of potential problems and corrective actions should be timely, determine the root cause, and evaluate any propagation of the error or problem.

Whenever a systematic error is discovered that affects the accuracy, validity, or defensibility of calibrations or test results reported to STL's clients, our clients will be notified in writing immediately when the nature and extent of the problem is understood. The STL Corporate QA Director must also be notified.

Corrective actions should be implemented with an understanding of the technology and work activities associated with the quality element, with appropriate training of STL associates and vendors, and should be monitored for progress and success. Depending on the nature of the problem, the corrective action employed may be formal or informal. In either case, occurrence of the problem, the corrective action employed, and verification that the problem has been eliminated must be documented properly. On-the-spot actions are used to correct minor problems, such as recalibration, retuning, or a minor repair (e.g., replacement of a minor part) of a malfunctioning instrument or the correction of poor analytical technique being used by an analyst. These occurrences are documented in the appropriate injection, run, or analysis logbooks. Similarly, routine instrument maintenance, malfunctions, and power failures are also documented in the appropriate instrument maintenance logbooks. These events do not require a formal NCM process, provided reported analytical results are not affected. Corrective actions specific to quality controls for analytical methods are discussed in the operational-specific SOPs.

9.3.1 Monitoring Corrective Actions

All formal corrective action documentation is maintained by the QA department, either in the Clouseau data base or in paper files. The QA department reviews all corrective actions and selects one or more of the significant corrective actions for

implementation of the corrective action and to determine whether the action taken has been effective in overcoming the issue identified.

9.4 Internal Audits

Internal audits are performed to assess the degree of adherence to established policies, procedures and standards. These assessments are conducted by STL personnel who are independent of the area being evaluated. Audits can identify areas for improvement with regard to compliance with policies, procedures and standards. Audits also provide a means for correction prior to system failure.

Audits and assessments are generally conducted through the use of checklists and relevant reference documents. The findings of all audits and assessments are documented as is the laboratory response and any corrective actions. Follow-up checks are performed and the status of implementation of corrective actions is documented for all categories of audits and assessments. This cycle continues until all issues are closed.

9.4.1 Audit Types and Frequency

The following types of audits are performed at STL Denver:

Figure 9.4-1 Audit Types and Frequency

Audit Type	Performed By	Frequency
Systems Audits	QA Department or designee	Annual per lab section
Data Audits	QA Department	Target of 5% of all reports
Spot Assessment	QA Department or designee	As needed to monitor specific issues
Proficiency Testing	Coordinated by QA Dept.	Two samples per year per program as required by NELAC

Note that some programs, e.g., AFCEE, require data audits conducted by QA at a higher frequency for work done in support of that program.

9.4.2 Systems Audits

Facility systems audits are comprehensive technical and systems evaluations covering each operational and support area at least once per year. The systems audits may be done on a rotating schedule that is established throughout the year to ensure adequate coverage of all areas. This schedule may change as situations in the lab warrant. The objectives and schedule of the audit are communicated to the lab groups being assessed in advance of the audit. At the completion of the audit, a debriefing is held to outline the findings, including identification of

positive performance, to discuss areas of deficiencies, and to answer questions. The audit report issued by the QA Manager within 21 calendar days of the audit. The audit report is addressed to the area supervisor and/or manager, and copied to the General Manager and Laboratory Director. Written audit responses are required within 21 calendar days of the date of the audit report. The audit response from the lab areas must follow the format of the original audit report, and is sent from the respondents to all individuals copied on the audit report. Where a corrective action requires longer than 21 days to complete, the target date for the corrective action is stated and evidence of corrective action is submitted to the QA department in the agreed upon time frame.

9.4.3 Data Audits

Data audits are routinely performed and documented to ensure that project records meet project requirements as described in method SOPs, project plans, or other documented requirements. The data audit is used to identify any lab errors that may have occurred. Significant issues found in the course of the audit are brought to the attention of appropriate personnel for clarification, and overseeing correction of final reports if necessary. The target frequency of QA data audits is 5% of report packages, or more as required by individual national programs. Data audits include spot-checking manual integrations to determine if they are appropriate and documented according to policy QA-011. Errors found in client project reports are revised and the revision sent to the client (also see Section 8.9.5).

9.4.4 Spot Assessments

Spot assessments, equivalent to special audits in the STL QMP, are conducted on as needed basis, generally as a follow up to specific issues such as client complaints, validator concerns, corrective actions, control chart or NCM trends, proficiency testing results, data audits, or external audit issues. Spot assessments are focused on a specific issue. The frequency, report format, distribution, and time frames are tailored to address the nature of the issue.

9.4.5 Proficiency Testing

Proficiency testing samples (PTs) are analyzed to verify the ability of the laboratory to correctly identify and quantitate compounds in PT samples. PT samples may be supplied internally or externally as single-blind or double-blind samples. They can be used to assess if a deficiency has been corrected, they can be used to document the proficiency of the analyst perform the analysis, or they can be used to assess the overall performance of an analytical method.

In accordance with the NELAC standards and Utah Rule R444-14, PT samples are handled and tested in the same manner as environmental samples - it is not

acceptable to run multiple replicates that would not otherwise be performed, it is not acceptable to average multiple results, and PT results cannot be shared among labs in advance of the close of the study. PT test sample data is archived using the same requirements as for project and raw data record retention.

9.4.5.1 External PT Samples

STL Denver participates in a number of PT studies, as shown in Table 9.4-1. The primary one being the NELAC PT program, which involves a minimum of two PT rounds each year for NELAC field of testing for which the lab is maintaining certification. In addition, under the 12/99 SDWA requirements, the laboratory also analyzes annually a PT sample for each drinking water method, where more than one method is used for a given analyte.

9.4.5.2 Internal PT Samples

Each STL facility performing chemical analyses also participates in a double-blind performance evaluation annually. An external vendor is contracted to submit double blind samples to the STL labs. Both the level of customer service and the accuracy of the test results is assessed objectively by the external contractor. The PT contractor provides a detailed report to the Corporate QA Manager and to each of the STL facilities.

9.5 External Audits

STL Denver is regularly audited by clients and external regulatory authorities. STL is available for these audits, and makes every effort to provide the auditors with the personnel, documentation and assistance they require. STL recommends that all audits be scheduled with the QA department so that all necessary personnel are available on the day of the audit. All deficiencies reported to the laboratory must be responded to within the time frame specified by the auditors. It is the responsibility of the QA Manger to coordinate the response to the audit report. The development and implementation of the corrective actions is the responsibility of the operations management of the affected areas. All responses must be approved by the Laboratory Director or Operations Manager prior to submitting the final response. It is the responsibility of the QA Manager to verify implementation of the corrective actions and inform the responsible manager of the closure of all deficiencies from the audit.

9.6 Management Reviews

9.6.1 Quality Reports to Management

A monthly QA report is prepared by the QA Manager and forwarded to the Laboratory Director, the General Manager, and the Corporate QA Manager. The

reports include metrics (i.e., frequency and number of revised reports, frequency and number of client complaints) to assess the effectiveness of the Quality System. The contents of the monthly report include:

- Audits
  Results of internal systems audits performed
  Results of external systems audits hosted
  Data audits performed, percent of total packages per month plus any issues
- Revised Reports / Client Complaints
  Frequency of revised reports
  Total number of client complaints, issues, and resolution
- Certification / Parameter Changes
- Proficiency Testing
  Score for each PT as a percentage of maximum score
  Note repeat failures and/or significant problems
- Miscellaneous QA and Operational Issues
  Narrative outling improvements, regulatory compliance issues, general concerns, and assistance required from management

This information is compiled by the Corporate QA Manager together with similar information from and about other STL laboratories, which is then presented in a report to the STL Chief Operating Officer.

9.6.2 Management Review of QA Systems

The Laboratory Director will conduct annual evaluations the status of the quality systems in the laboratory to review their suitability and effectiveness, and to introduce necessary changes or improvements. The evaluation shall consider:

- The suitability of policies and procedures
- Reports from managerial and supervisory personnel
- The outcome of recent internal audits
- Corrective and preventative actions
- Assessments by external bodies
- The results of interlaboratory comparisons and proficiency tests
- Status of QA documents
- Reviews of QA related requirements in RFPs, SOWs, SAPs, and QAPjPs
- Changes in the volume and type of work and the effects on QA systems
- Client feedback
- Complaints
- Quality control activities
- Resources and staff training

Revised 11-8-03 see following pages

STL DENVER
Interim Change # Q

SOP NUMBER: LQM, Revision No. 0

SOP TITLE: STL Denver LQM

SOP SECTION(S) AFFECTED BY CHANGE: Add Section 9.7

REASON FOR CHANGE: Include Preventative Action Plan, as required by NELAC

CHANGE: Insert these 3 pages after page 74 of the LQM

SUBMITTED BY/DATE: Larry Penfold, 11/8/03

APPROVED BY:

Timothy M. O'Shields, Laboratory Director — Date: 11/10/03

Received
NOV 10 2003
Tim O'Shields

Larry Penfold, Quality Assurance Manager — Date: 11-8-03

9.7 Preventative Action Plan

Preventative action is defined as a feedback system that allows the laboratory to detect and correct a problem before non-conformances or serious problems occur. The feedback tools employed must be broad enough in scope to detect a wide variety of potential failures in lab processes, methods, or procedures. Instituting a preventative action plan is a requirement of the STL QMP that derives from ISO Guide 17025 (Section 4.11). It is also consistent with the DOE Quality Assurance Order (O 414.1A) requiring that the laboratory have a system of assessment activities to promote quality improvements.

9.7.1 Quality System Indices

There are defined quality indices that are reported to laboratory managers on a regular basis to allow them to monitor trends in laboratory quality systems. The assessment activities themselves are described in previous sections of this chapter. The indices and reports used by management include:

Index	Minimum Reporting Frequency	Party Responsible for Reports
PT Scores	Weekly & Monthly	QA Manager
Client Complaints – percent of all reports	Monthly	QA Manager
SOP Status – percent of SOPs reviewed within 24 months	Monthly	QA Manager
MDL Status – percent of MDLs established within last 12 months	Monthly	QA Manager
External Audit Findings – number and nature	Monthly	QA Manager
Internal Audit Findings – number and nature	Monthly	QA Manager
QA Systems Audit Findings – number and nature	Annual	Lead Auditor Appointed by Corp. Quality Director
Score from Management Review of Quality Systems – percent score defined in report	Annual	Laboratory Director

9.7.2 Data Quality Trending

Each operational groups is responsible for appointing analysts to monitor control charts for select compounds for trends that might lead to out-of-control situations. The selected compounds are indicators proven to be most sensitive to stability of standards, preparation technique, and/or instrument maintenance conditions. If trends are detected, they are reported to the area supervisor so that direction can be provided for improvement.

9.7.3 Laboratory Operations Key Result Indicators

The areas deemed vital to client satisfaction are monitored by laboratory management as Key Result Indicators (KRIs). This self-generated, ongoing measurement system is used to monitor how well we are meeting requirements.

KRIs	Minimum Reporting Frequency	Responsible Party
On-Time Delivery – percent of all reports	Weekly	Operations Manager
Average Turnaround Time – percent of all reports	Weekly	Operations Manger
Holding Time Violations – number of HTVs	Weekly	QA Manager
Revised Reports – percent of all reports	Monthly	QA Manager

We determine gaps between expectations and performance. This information is the basis of decisions to conduct further investigation to better understand lagging performance indices, and to potentially effect improvements.

Revised 11/16/2000

Table Section

Revised #25 6/16/00

TABLE 2.4-1
LQM Source Documents Requirements Matrix

STL LQM	EPA QA/R-2	ANSI/ASQC E4-1994	NQA-1[1]	5700.6C[2]	ANSI N 13.30	ANSI/ASQC Q2-1991[3]
1.0 Management Commitment and Organization	1 Management and Organization	2.1 Management and Organization	1 Organization	9.a. General	1.1 Introduction 1.2 Purpose 1.3 Scope	5.0 Management Responsibility
2.0 Quality System and Description	2 Quality System and Description	2.2 Quality System and Description	2 Quality Assurance Program	1 Program	2.1 Special Word Usage 2.2 Specific Terms 5.1 Quality Assurance 5.2 Quality Control	5.2 Quality System
3.0 Document Control and Records Maagement	5 Documentation and Records	2.5 Documents and Records	6 Document Control 17 Quality Assurance Records	4 Documents and Records	3.6 Direct Bioassay-Record Retention 4.5 Indirect Bioassay Record Retention	8.4 Quality Documentation and Records
4.0 Staff Qualification, Orientation and Training	3 Personnel Qualification and Training	2.3 Personnel Training and Qualification		2 Personnel Training and Qualification	3.2 Personnel Preparation	14.0 Personnel
5.0 Procurement of Supplies and Services	4 Procurement of Items and Services	2.4 Procurement of Items and Services	4 Procurement Document Control 7 Control of Purchased Items and Services	7 Procurement	N/A	7.0 Quality in Procurement 13.0 Subcontracting
6.0 Computer Hardware and Software	6 Computer Hardware and Software	2.6 Computer Hardware and Software	3 Design Control 11 Test Control	N/A	N/A	ISO 9000-3[4]

Revised

TABLE 2.4-1
LQM Source Documents Requirements Matrix (cont.)

LQM	EPA QA/R-2	ANSI/ASQC E4-1994	NQA-1[1]	5700.6C[2]	ANSI N 13.30	ANSI/ASQC Q2-1991[3]
7.0 Contract Review and Project Planning	7 Planning	2.7 Planning 3.1 Planning and Scoping 3.3 Implementation of Planned Operations	2 Quality Assurance Program 3 Design Control 5 Instructions, Procedures, and Drawings 8 Identification and Control of Items 9 Control of Processes 11 Test Control 13 Handling, Storage, and Shipping	1 Program 6 Design N/A	3.1 Facility Criteria 3.4 Direct Bioassay-Performance Criteria for Service Laboratories 3.5 Direct Bioassay-Reporting Results 4.1 Indirect Bioassay-Responsibilities of the Service Laboratory Customer 4.2 Indirect Bioassay-Analytical Methodology 4.3 Indirect Bioassay-Performance Criteria for Service Laboratories 5.2 Quality Control	6.3.3 Quality Plans
8.0 Work Processes and Operations	8 Implementation of Work Processes	2.8 Implementation of Work Processes	1 Organization 5 Instructions, Procedures, and Drawings	5 Work Processes 6 Design	3.1 Facility Criteria	8.0 Laboratory Operations Quality Assurance 9.0 Control of Measuring and Test Equipment 10.0 Data Validation 15.0 Use of Statistical Methods

Table of Contents

Revised 4/5 6/16/00

TABLE 2.4-1
LQM Source Documents Requirements Matrix (Cont.)

LQM	EPA QA/R-2	ANSI/ASQC E4-1994	NQA-1[1]	5700.6C[2]	ANSI N 13.30	ANSI/ASQC Q2-1991[3]
	8 Implementation of Work Processes (Continued)	3.2 Design of Data Collection Operations	10 Inspection 12 Control of Measuring and Test Equipment 14 Inspection, Test, and Operating Status	8 Inspection and Acceptance Testing		
9.0 Quality Assessment and Response	9 Assessment and Response[5]	2.9 Assessment and Response 3.4 Assessment and Response 3.5 Assessment and Verification of Data Usability	2 Quality Assurance Program 13 Handling, Storage, and Shipping 15 Control of Non-conforming Items 16 Corrective Action 18 Audits	9 Management Assessment 10 Independent Assessment	3.3 Direct Bioassay-Interpretation of Measurements 3.5 Direct Bioassay-Reporting Results 4.4 Indirect Bioassay-Reporting Results 6.1 Direct Bioassay Measurements 6.2 Indirect Bioassay Measurements	16.0 Nonconformity 17.0 Corrective Action 18.0 Auditing the Quality System
N/A	9 Quality Improvement[5]	2.10 Quality Improvement	N/A	3 Quality Improvement	N/A	N/A

Footnotes

Section II, "Basic Requirements."
Criterion from Section 9, "Requirements."
Technically equivalent to ISO 9001.
Quality Management and Quality Assurance Standards, ISO 9000, Part 3, "Guidelines for the Application of ISO 9001 tolte Development, Supply and Maintenance of Software."
This document has two sections numbered "9."

STL DENVER
Interim Change #P 0 01/16/02

SOP NUMBER: LQM, Revision No. 0
SOP TITLE: STL Denver LQM
SOP SECTION(S) AFFECTED BY CHANGE: Table 2.4-1
REASON FOR CHANGE: Replace **NQA-1** column in matrix with **DOE QA Order O 414.1A.**
CHANGE: Page 76, 77, and 78 (LQM Source Documents Requirements Matrix) – Changed column NQA-1 to reference DOE QA Order O 414.1A sections.
SUBMITTED BY/DATE: Michael Schmitt, 01/11/02
APPROVED BY:
Timothy M. O'Shields, Laboratory Director — **Date** 1/11/02
Larry Penfold, Quality Assurance Manager — **Date** 1-11-02

01/16/02

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TABLE 2.4-1
LQM Source Documents Requirements Matrix

STL LQM	EPA QA/R-2	DOE QA Order O 414.1A	ANSI/ASQC E4-1994	5700.6C[2]	ANSI N 13.30	ANSI/ASQC Q2-1991[3]
1.0 Management Commitment and Organization	1 Management and Organization	1 Objectives	2.1 Management and Organization	9.a. General	1.1 Introduction 1.2 Purpose 1.3 Scope	5.0 Management Responsibility
2.0 Quality System and Description	2 Quality System and Description	3 Applicability 4 Requirements	2.2 Quality System and Description	1 Program	2.1 Special Word Usage 2.2 Specific Terms 5.1 Quality Assurance 5.2 Quality Control	5.2 Quality System
3.0 Document Control and Records Maagement	5 Documentation and Records	4.b.(1)(d) Documents and Records	2.5 Documents and Records	4 Documents and Records	3.6 Direct Bioassay-Record Retention 4.5 Indirect Bioassay Record Retention	8.4 Quality Documentation and Records
4.0 Staff Qualification, Orientation and Training	3 Personnel Qualification and Training	4.b.(1)(b) Personnel Training and Qualification	2.3 Personnel Training and Qualification	2 Personnel Training and Qualification	3.2 Personnel Preparation	14.0 Personnel
5.0 Procurement of Supplies and Services	4 Procurement of Items and Services	4.b.(2)(c) Criterion 7 Procurement	2.4 Procurement of Items and Services	7 Procurement	N/A	7.0 Quality in Procurement 13.0 Subcontracting
6.0 Computer Hardware and Software	6 Computer Hardware and Software	4.b(2)(a) Work Processes Attachment I 2.b(1) Work Processes (2) Design	2.6 Computer Hardware and Software	N/A	N/A	ISO 9000-3[4]

Table of Contents

TABLE 2.4-1
LQM Source Documents Requirements Matrix (cont.)

LQM	EPA QA/R-2	DOE QA Order O 414.1A	ANSI/ASQC E4-1994	5700.6C[2]	ANSI N 13.30	ANSI/ASQC Q2-1991[3]
7.0 Contract Review and Project Planning	7 Planning	4.b(1)(a) Criterion 1 Program Attachment I 1 General Requirements 2.a(1) Criterion 1 Program	2.7 Planning 3.1 Planning and Scoping 3.3 Implementation of Planned Operations	1 Program 6 Design N/A	3.1 Facility Criteria 3.4 Direct Bioassay-Performance Criteria for Service Laboratories 3.5 Direct Bioassay-Reporting Results 4.1 Indirect Bioassay-Responsibilities of the Service Laboratory Customer 4.2 Indirect Bioassay-Analytical Methodology 4.3 Indirect Bioassay-Performance Criteria for Service Laboratories 5.2 Quality Control	6.3.3 Quality Plans
8.0 Work Processes and Operations	8 Implementation of Work Processes	4.b(2) Performance Attachment I 2.b(1) Criterion 5 Work Processes	2.8 Implementation of Work Processes	5 Work Processes 6 Design	3.1 Facility Criteria	8.0 Laboratory Operations Quality Assurance 9.0 Control of Measuring and Test Equipment 10.0 Data Validation 15.0 Use of Statistical Methods

Table of Contents

TABLE 2.4-1
LQM Source Documents Requirements Matrix (Cont.)

LQM	EPA QA/R-2	DOE QA Order O 414.1A	ANSI/ASQC E4-1994	5700.6C[2]	ANSI N 13.30	ANSI/ASQC Q2-1991[3]
	8 Implementation of Work Processes (Continued)	2.b(2) Criterion 6 Design	3.2 Design of Data Collection Operations	8 Inspection and Acceptance Testing		
9.0 Quality Assessment and Response	9 Assessment and Response[5]	4.b(3) Assessment 2.c Assessment	2.9 Assessment and Response 3.4 Assessment and Response 3.5 Assessment and Verification of Data Usability	9 Management Assessment 10 Independent Assessment	3.3 Direct Bioassay-Interpretation of Measurements 3.5 Direct Bioassay-Reporting Results 4.4 Indirect Bioassay-Reporting Results 6.1 Direct Bioassay Measurements 6.2 Indirect Bioassay Measurements	16.0 Nonconformity 17.0 Corrective Action 18.0 Auditing the Quality System
N/A	9 Quality Improvement[5]	4.b(1)(c) Criterion 3 Quality Improvement	2.10 Quality Improvement	3 Quality Improvement	N/A	N/A

otnotes

Criterion from Section 9, "Requirements."
Technically equivalent to ISO 9001.
Quality Management and Quality Assurance Standards, ISO 9000, Part 3, "Guidelines for the Application of ISO 9001 to the Development, Supply and Maintenance of Software."
This document has two sections numbered "9."

TABLE 2.4-2
Cross-Reference of LQM to NELAC Requirements for Quality Manuals

NELAC QUALITY MANUAL: REQUIRED ELEMENTS*	LQM, QA POLICY, AND/OR QA SOP REFERENCE
a) A quality policy statement, including objectives and commitments, by top management	LQM Chapter 1
b) The organization and management structure of the laboratory, its place in any parent organization and relevant organizational charts	LQM Chapter 1
c) The relationship between management, technical operations, support services and the quality system	LQM Chapter 1 LQM Chapter 7
d) Procedures to ensure that all records required under this chapter are retained as well as procedures for control and maintenance of documentation through a document control system which ensures that all standard operating procedures, manuals, or documents clearly indicate the time period during which the procedure or document was in force	LQM Chapter 2 LQM Chapter 3
e) Job descriptions of key staff and reference to the job descriptions of other staff	LQM Chapter 1 and Chapter 4 Separate document (hardcopy and/or electronic) provides job descriptions
f) Identification of the laboratory's approved signatories; at a minimum, the title page of the Quality Manual must have the signed concurrence, (with appropriate titles) of all responsible parties including the QA officer, technical director, and the agent who is in charge of all laboratory activities such as the laboratory director or laboratory manager	LQM Title/Approval Page
The laboratory's procedures for achieving traceability of measurements	LQM Chapter 8

*National Environmental Laboratory Accreditation Conference Standard, Quality Systems, July 1, 1999

TABLE 2.4-2
Cross-Reference of LQM to NELAC Requirements for Quality Manuals (cont.)

NELAC QUALITY MANUAL: REQUIRED ELEMENTS*	LQM, QA POLICY, AND/OR QA SOP REFERENCE
h) A list of all test methods under which the laboratory performs its accredited testing	LQM Table 8.2-1
i) Mechanisms for ensuring that the laboratory reviews all new work to ensure that it has the appropriate facilities and resources before commencing such work	LQM Chapter 7
j) Reference to the calibration and/or verification test procedures used	LQM Chapter 8 Tables 8.5-6 through 8.5-7
k) Procedures for handling submitted samples	LQM Sections 8.5.2 and 8.5.3
l) Reference to the major equipment and reference measurement standards used as well as the facilities and services used by the laboratory in conducting tests	Equipment list is Table 8.0-1 LQM Sections 5.2.4, 8.1, 8.5.4, 8.11 to 8.12
m) Reference to procedures for calibration, verification and maintenance of equipment	Calibrations in Tables 8.5-6 through 8.11-30 LQM Sections 8.5.4, 8.11 to 8.12
n) Reference to verification practices including interlaboratory comparisons, proficiency testing programs, use of reference materials and internal quality control schemes	LQM Section 9.4.5
Procedures to be followed for feedback and corrective action whenever testing discrepancies are detected, or departures from documented policies and procedures occur	LQM Chapter 9 SOP CORP-QA-0010, "Nonconformance and Corrective Action"

ational Environmental Laboratory Accreditation Conference Standard, Quality Systems, July 1, 1999

TABLE 2.4-2
Cross-Reference of LQM to NELAC Requirements for Quality Manuals (cont.)

NELAC QUALITY MANUAL: REQUIRED ELEMENTS*	LQM, QA POLICY, AND/OR QA SOP REFERENCE
p) The laboratory management arrangements for exceptionally permitting departures from documented policies and procedures or from standard specifications	LQM Section 7.4 and 9.1
q) Procedures for dealing with complaints	LQM Section 9.2
r) Procedures for protecting confidentiality and proprietary rights (including national security concerns)	LQM Section 8.9.6
s) Procedures for audits and data reviews	LQM Section 5.3.6, 8.8 and 9.4 SOP CORP-QA-0004 "Independent QA Data Review"
t) Processes/procedures for establishing that personnel are adequately experienced in the duties they are expected to carry out and/or receive any needed training	LQM Chapter 4 SOP CORP-QA-0013, "Employee Orientation and Training"
u) Process/procedures for educating and training pesonnel in their ethical and legal responsibilities including the potential punishments and penalties for improper, unethical or illegal actions	LQM Section 1.4 Policy QA-008 – Data Recording Requirements QA-010 – Maintaining Time Integrity QA-011 – Acceptable Manual Integration Practices P-T-001 – Selection of Data Points Required for Initial Calib.
Reference to procedures for reporting analytical results	LQM Section 8.9 Policy QA-004 "Rounding and Significant Figures" Policy QA-009 "Reporting Limits"

Table of Contents

TABLE 2.4-2
Cross-Reference of LQM to NELAC Requirements for Quality Manuals (cont.)

NELAC QUALITY MANUAL: REQUIRED ELEMENTS*	LQM, QA POLICY, AND/OR QA SOP REFERENCE
w) A table of contents and applicable list of references, glossaries, and appendices	LQM Table of Contents List of Policies and SOPs Table 2.3-2

*National Environmental Laboratory Accreditation Conference Standard, Quality Systems, July 1, 1999

TABLE 2.4-3
STL Denver Quality Documents and Required Approval

Quality Document	Required Approvals
Laboratory Quality Manual (LQM)	• Laboratory Director • Technical Director • Quality Assurance Manager
STL Denver Policies	• Laboratory Director or designee • Quality Assurance Manager
STL Denver Standard Operating Procedures (SOPs)	• Laboratory Director • Technical Specialist • Laboratory Health and Safety Coordinator(1) • Quality Assurance Manager

(1) Required only if procedure encompasses more than standard office safety requirements.

TABLE 2.4-4
STL Quality Document Review Frequency

Document Type	Frequency of Review	Responsible Party
Laboratory Quality Manual (LQM)	Every Two Years	Quality Assurance Manager
Standard Operating Procedures (SOP)	Every Two Years Note that SOPs that are incorporated into licenses, permits, work plans, or QAPjPs require approvals by outside parties before they can be changed, which can delay the process.	Quality Assurance Manger & Operations Manager

TABLE 3.4-1

STL Denver Records & Retention Schedule

Type of Record	Retention	Disposition
General Laboratory Documents		
Instrument output	5 yrs from project completion	Shred or burn
Quality control data	5 yrs from project completion	Shred or burn
Field sample data	5 yrs from project completion	Shred or burn
Final analytical reports	5 yrs from project completion	Shred or burn
Instrument logbooks	5 yrs from last entry	Shred or burn
Equipment monitoring & maintenance records	5 yrs from last entry	Shred or burn
Instrument calibration records	5 yrs from last entry	Shred or burn
Standard preparation logs	5 yrs from last entry	Shred or burn
Standards certificates	5 yrs from last entry	Shred or burn
Measurement & test equipment logs (e.g., refrig., balances, etc.)	5 yrs from last entry	Shred or burn
Method & instrument validation records	5 yrs from last entry	Shred or burn
Instrument manuals	Retain until superseded	Trash
Project management files	5 yrs from date of archival	Shred or burn
Quotes & proposals	2 yrs from date of expiration	Shred or burn
LQM, policies, & SOPs	5 yrs from date of archiving	Shred or burn
Analyst demonstrations of proficiency	5 yrs from date of archival	Shred or burn
Quality assurance audits	5 yrs from last entry	Shred or burn
Certifications & approvals	5 yrs from last entry	Shred or burn
Employee signature list	5 yrs from date of archival	Shred or burn
MDL Studies	5 yrs from last entry	Shred or burn
Performance testing studies	5 yrs from last entry	Shred or burn
QA reports to management	5 yrs from last entry	Shred or burn
Quality control charts	5 yrs from last entry	Shred or burn

TABLE 3.4-1

STL Denver Records & Retention Schedule

Type of Record	Retention	Disposition
Environment, Health and Safety Records		
Medical records	Retain while active & 30 yrs from last entry	Shred or burn
Employee exposure & monitoring records	Retain while active & 30 yrs from last entry	Shred or burn
Workers compensation files & first report of injury	Retain while active & 30 yrs from last entry	Shred or burn
Accident logs (OSHA Form 200)	5 yrs from last entry	Shred or burn
Accident reports	5 yrs from last entry	Shred or burn
Environmental permits	5 yrs from last entry	Shred or burn
Environmental management, e.g., discharge reports	5 yrs from last entry	Shred or burn
Health & safety audits	5 yrs from last entry	Shred or burn
Chemical Hygiene Plan	5yrs from archival	
Safety Inspections	5 yrs from last entry	Shred or burn
Radioactive materials records	5 yrs from last entry	Shred or burn
NRC or state radioactive materials handling inspections	5 yrs from last entry	Shred or burn
TLD exposure records	5 yrs from last entry	Shred or burn
EH&S training	5 yrs from last entry	Shred or burn
Accounting	See Accounting and Controls Procedures Manual	
Administrative		
Personnel records (not including medical or disability records)	7 years from last entry	Shred or burn

TABLE 5.2-1
List of STL Quality-Related Items
that Require Evaluation Prior to Use

Quality-Related Item	Standard Operating Procedure for Quality Testing
Acetone	CORP-QA-0001
Dichloromethane	CORP-QA-0001
Hexane	CORP-QA-0001
Hydrochloric acid	CORP-QA-0001
Freon	CORP-QA-0001
Methanol	CORP-QA-0001
Nitric acid	CORP-QA-0001
Hydrogen Peroxide	CORP-QA-0001
Sulfuric acid	CORP-QA-0001
Toluene	CORP-QA-0001

Revised y 12/14/00 IC B

TABLE 6-1
GALP Cross Reference To LQM

GALP Section	GALP Guidance	STL Document
8.1 Laboratory Management	8.1.1 ensure that personnel clearly understand the functions they are to perform	LQM 1.6.2, 1.6.4, and 4.0
	8.1.2 ensure that QAU monitors computer activities	LQM 9.2.2.1
	8.1.3 ensure that personnel, resources, and facilities are adequate and available as scheduled	CORP-IT-0002; LQM 1.6.1-1.6.4
	8.1.4 receive reports of QAU inspection and audit reports, and ensure corrective actions are promptly taken in response to any deficiencie	LQM 9.2.2.1
	8.1.5 approve SOPs related to the computer activities, and ensure that devations to the SOPs are documented	LQM 3.3 and 9.1.4
	8.1.6 assure that GALP provisions are followed	CORP-IT-013; LQM 6.0
8.2 Personnel	8.2.1 must have adequate education, training, and experience to perform assigned IT functions	CORP-IT-013; LQM 4.0
	8.2.2 a summary of training, experience, and job description must be maintained	LQM 4.1
	8.2.3 personnel must be of sufficient number for timely and proper operation of the computer systems	CORP-IT-0002; LQM 1.6.2
8.3 Quality Assurance Personnel	8.3.1 shall be separate and independent of IT personnel, and shall report directly to laboratory management	LQM 1.6.1
	8.3.2 shall have immediate access to the computer data, SOPs, and other records	LQM 1.61 and will be added to 9.2
	8.3.3 inspect the LIMS at intervals to ensure the integrity of LIMS raw data, and shall present inspection reports to management	LQM 9.2
	8.3.4 determine that no deviations from approved SOPs were made without proper authorization and documentation	LQM 9.1.1
	8.3.5 periodically audit raw data to ensure their integrity	9.2
	8.3.6 maintain adequate records of the QAU operations	9.2
8.4 LIMS Raw Data	8.4.1 LIMS raw data and the storage media on which they reside must be identified and documented. The documentation shall be included in the lab's SOPs.	System map is with IS Director
	8.4.2 the individual(s) responsible for entering and recording LIMS raw data must be uniquely identified, together with the date and time the data were entered	QA-008
	8.4.3 the instrument transmitting raw data must be uniquely identified in the record, together with the date and time of transmission	QA-008

Implementation date 12/7/00 **STL-Denver**

Interim SOP Change - This is a controlled document

SOP NUMBER: **Laboratory Quality Manual for STL-Denver**

SOP TITLE: Laboratory Quality Manual for STL-Denver

SOP SECTION(S) AFFECTED BY CHANGE: Table 6.1

REASON FOR CHANGE(S): Correct cross reference

Change section *{8.1.2-STL Document column}* **from:** Reference to LQM Section 9.2.2.1

To:

Reference to Section 9.2.2.1 should actually be to Sections 9.4.2.

Change section *{8.3-STL Document column}* **from:** References to LQM Section 9.2

To:

All reference to Section 9.2 should actually be to Sections 9.4.2 and 9.4.3

Change section *{8.3.2-STL Document column}* **from:** Reference to LQM 1.61

To:

Reference to Section 1.61 should actually be 1.6.1

SUBMITTED BY/DATE: 11/30/00

APPROVED BY:

Technical Reviewer — **Date** 12/05/00

James S. Kelly, Health and Safety Coordinator — **Date** 12/1/00

Larry Penfold, Quality Assurance Manager — **Date** 12/1/00

Timothy M. O'Shields, Laboratory Director — **Date** 12-5-00

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TABLE 6-1
GALP Cross Reference To LQM (cont.)

	8.4.4 procedures and practices used to verify LIMS raw data must be documented in controlled SOPs	CORP-IT-0007; LQM 8.8-8.8.3
8.5 Software	8.5.1 SOPs shall be established for: a. software development b. software testing c. change control d. version control e. maintaining historical file	CORP-IT-013; CORP-IT-0001; CORP-IT-0007
	8.5.2 documentation shall be maintained for: a. software description & functional requirements b. algorithms and formulas c. testing and quality assurance	CORP-IT-013
	8.5.3 all documentation is readily available in the facility where the software is used and SOPs are readily available where procedures are performed	CORP-IT-013 includes this statement, but we are on a WAN and documentation is not duplicated at each lab
	8.5.4 a historical file of software and documentaiton shall be retained	CORP-IT-0001, Sect 4.14.1
8.6 Security	Laboratory management shall ensure that security practices are adequate to assure the integrity of data	LQM 6.2 [more detail can be added to this section]; CORP-IT-0005; CORP-IT-013
8.7 Hardware	8.7.1 must be of adequate design and capacity, and a documented description maintained	LQM 6.1; CORP-IT-013
	8.7.2 must be installed in accordance with manufacturer's recommendations, and undergo documented acceptance testing as described in a laboratory SOP	CORP-IT-0001; CORP-IT-013; LQM 6.1
	8.7.3 testing, maintenance, and repair must be described in a laboratory SOP	CORP-IT-013 includes this statement
8.8 Comprehensive Testing	Management shall ensure that comprehensive testing shall be documented at least every 24 months or more frequently as a result of software changes.	CORP-IT-0001; LQM 6.3.4
8.9 Records Retention	Procedures must be in place for the retention of LIMS raw data and documentation and records pertaining to LIMS	QMP; LQM 3.4-3.5
8.10 Facilities	8.10.1 the environmental conditions of the facility housing the LIMS must be controlled to protect against data loss	LQM 6.2
	8.10.2 environmental conditions for storing LIMS raw data and records must be adequate	LQM 6.2

TABLE 6-1
GALP Cross Reference To LQM (cont.)

8.11 SOPs	8.11.1 SOPs, as described above, must be maintained and readily available where the procedure is performed	LQM 3.1-3.2; SOP Index
	8.11.2 SOPs must be reviewed periodically to ensure that they are accurate	LQM 3.3
	8.11.3 SOPs must be authorized and controlled, with all changes subject to the same approvals and control	LQM 3.3
	8.11.4 an historical file of SOPs must be maintained	LQM 3.5

STL-Denver
Interim Change I to LQM, Revision 0

SOP SECTION(S) AFFECTED BY CHANGE: Section 7.2, Certifications and Approvals

REASON FOR CHANGE(S): Arizona regulation A.A.C. R9-14-615.B.8 requires that the lab's quality manual include details of our license.

Change

1. Revise 7.2 **From:** "Copies of current laboratory certifications are maintained by the QA office, and are available upon request."

To: "Laboratory certifications are maintained by the QA office. See certification in Table 7.2."

2. Insert this approval notice and Table 7.2 immediately after Table 6-1, page 89.

SUBMITTED BY/DATE: Larry Penfold 3/19/01

APPROVED BY:

Technical Reviewer, Devon Morgan — **Date** 3/19/01

Health and Safety Coordinator, James Scott Kelly — **Date** 3/19/01

Quality Assurance Manager, Larry Penfold — **Date** 3/19/01

Laboratory Director, Timothy O'Shields — **Date** 3/19/01

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TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Alabama Water Supply Program Dept. of Environmental Management P.O. Box 301463 Montgomery, AL 36130-1463 (334) 271-7791 FAX (334) 279-3051 Thomas S. DeLoach **(Colorado reciprocity)**	Drinking Water: Inorganics: Sb, As, Ba, Be, Cd, Cr, Cyanide, Fluoride, Pb, Hg, Ni, Nitrate, Nitrite, Se, Sulfate, Tl, and all Secondary Inorganics VOC: Benzene, Carbon tetrachloride, o-Dichlorobenzene, para-dichlorobenzene, 1,2-Dichloroethane, 1,1-Dichloroethylene, cis-1,2-Dichloroethylene, trans-1-2-Dichloroethylene, Dichloromethane, 1,2-Dichloropropane, Ethylbenzene, Monochlorobenzene, Styrene, Tetrachloroethylene, Toluene, 1,2,4-Trichlorobenzene, 1,1,1-Trichloroethane, 1,1,2-Trichloroethane, Trichloroethylene, Vinyl chloride, Xylenes (Total), and all Unregulated VOCs	#40730 4/30/01	
Alaska State of Alaska Division of Environmental Quality Juneau Environmental Analysis Lab 10107 Bentwood Place Juneau, AK 99801 Phone: (907) 790-2169 Fax: (907) 790-2451 Sara Rairick	UST (waters & solids): PAHs by 8270 and 8310, VCSs by 8260B, PCBs by 8082, As (6010B, 6020, 7060A), Ba (6010B, 6020), Cd (6010B, 6020, 7131A), Cr (6010, 6020, 7191), Ni (6010, 6020), Pb (EPA 6010B, 6020, 7421), V (6010, 6020)	UST-30 4/5/01 Application for renewal submitted 2/12/01	

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Arizona Environmental Laboratory Licensure Dept. of Health Services 1740 West Adams, Room 203 Phoenix, AZ 85007 (602) 364-0720 (602) 364-0759 (fax) Marilyn Lancelot, Lab Coord. Steven D. Baker, Program Dir.	Hazardous Waste: Metals by 6010A ICP (Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Li, Mg, Mn, Mo, Na, Ni, K, Se, Ag, Sr, Tl, V, Zn); Metals by 6020 ICP/MS (Sb, As, Ba, Be, Cd, Cr, Co, Cu, Ni, Ag, Tl, Zn); Metals by 7000 series GFAA (As, Cd, Cr, Cu, Pb, K, Se, Ag, Tl); Hg by 7470A/7471A; TCLP 1311; Corrosivity (pH) by 9040A & 9045B, Organic Preparations (3050B, 3500B, 3510C, 3520C, 3550B, 5030B); Volatile Organics 8260B; Volatile Organics 8021B, Semivolatile Compounds 8270C; Organochlorine pesticides 8081A; PCBs 8082; Polynuclear Aromatics 8310; TOC 9060; TOX 9020B. Safe Drinking Water: Aromatic and Halogenated Volatiles 524.2; Sulfate 375.2 Wastewater: Alkalinity 310.1; Ammonia 350.1; Metals by 200.7 (Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Ag, Na, V, Zn); Metals by GFAA (Sb, As, Cd, Cr, Cu, Pb, Se, Ag, Tl); Hg 245.2; Hardness 200.7 & SM 2340B; BOD 405.1; COD 410.4; Anions by 300.0 (Cl, F, NO3, NO2, SO4); Chloride 325.2; Fluoride 340.2; pH 150.1; TKN 351.2; NO3 353.1; Phenols 420.2; Tot. Phosphorous 365.4; TDS 160.1; TSS 160.2; Specific Conductance 120.1; TOC 415.1; Purgeables 624	#AZ0615 12/20/01	On-site audit 1/01

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Arkansas Technical Services Division Dept. of Pollution Control & Ecology 8001 National Drive Little Rock, AR 72219-8913 (501) 682-0955 Jeff Ruehr	Alkalinity, Ammonia, BOD, Chloride, COD, Nitrate, Nitrite, Oil & Grease, pH, Specific Conductance, Sulfate, Sulfide, TDS, TOC, TSS, Turbidity, Cyanide, Al, Sb, As, Ba, Be, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Mo, Ni, K, Se, Ag, Na, Tl, Ti, V, Zn, Herbicides, Pesticides and PCBs, Semivolatile Organics, TPHC, Volatile Organics Note: Certifications apply to water, soil, wastewater, and hazardous waste	No number. 12/7/01	
California Dept. of Health Services 2151 Berkeley Way, Annex 2 Berkeley CA 94704-1011 Program Chief Dr. George Kulasingam 510) 540-2800 aboratory Coordinator 213) 580-5731 osalinda Lomboy	Hazardous Waste: Ignitability, Corrosivity (pH), Reactivity, Metals by 6010 and 6020:[Sb (7041), As (7060), Ba, Be, Cd (7131), Cr (7191), Co, Cu, Pb (7421), Hg (7470 & 7471), Mo, Ni, Se (7740), Ag (7761), Tl (7841), V, Zn,], Cr+6 (7196), Cyanide (9010A & 9012), Fluoride (300.0 & 340.2), Sulfide (9030), California Waste Extraction Test (WET), TCLP (all classes), 8270C, 8260B, 8010B, TPH/GRO, TPH/DRO, 8020A, 8021B, 8081A, 8082, 8151A, 8310, 8330 Wastewater: Alkalinity (310.2), Ammonia (350.1), BOD (405.1), COD (410.4), Chloride (325.1), CN (335.3), TKN (351.2), NO3 (353.1), NO2 (353.1), O&G (413.1), TOC (415.1), pH (150.1), Phenols (420.2), TDS (160.1), TSS (160.2), Specific Conductance (120.1), SO4 (375.2), TOX (9020), Metals by 200.7 (Al, Sb, As, B, Ba, Be, Cd, Cr, Co, Cu, Ca, Fe, Pb, Mg, Mn, Mo, Ni, K, Na, Se, Ag, Si, Sn, V, Zn), Metals by 200.8 (Ni, Se, Tl), Hg (245.2), 624, 608	Cert #: 2427 7/31/01	On-site audit 10/98

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Colorado Department of Public Health and Environment Laboratory and Radiation Services 8100 Lowry Blvd Denver, CO 80220 (303) 692-3291 Yvonne K. Herman	Drinking Water (SDWA): Sb (200.8), As (SM3113B), Ba (200.7), Be (200.7), Cd (200.7), Cr (200.7), Cu (200.7), Hg (245.1 & 245.2), Pb (200.8), Ni (200.7), Se (200.8), Tl (200.8), Nitrate-N, Nitrite-N, Fluoride, Benzene, Carbon Tetrachloride, 1,2-Dichlorobenzene, 1,2-Dichloroethane, 1,1-Dichloroethylene, Trichloroethylene, Vinyl Chloride, Chlorobenzene, 1,4-Dichlorobenzene, *cis*-1,2-Dichloroethylene, *trans*-1,2-Dichloroethylene, 1,2-Dichloropropane, Ethylbenzene, Styrene, Tetrachloroethylene, Toluene, 1,1,1-Trichloroethane, Xylenes (Total), Dichloromethane, 1,2,4-Trichlorobenzene, 1,1,2-Trichloroethane, Total Cyanide	#C0026 04/30/01 Renewal application submitted 3/6/01	On-site audit 4/8/98

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Connecticut Connecticut Dept. of Public Health Division of Environmental Health Laboratory Certification 410 Capitol Avenue, MS #51LAB P.O. Box 340308 Hartford, CT 06134-0308 (860) 509-7389 (phone) (860) 509-7378 (fax) Nicholas P. Macelletti Jr. Dermot Jones **(Colorado and Utah reciprocity)**	Potable Water: Fluoride, Nitrate, Nitrite, Metals (Sb, As, Ba, Be, Cd, Cr, Cu, Hg, Ni, Tl,), CN, Purgeable Aromatics, Purgeable Halocarbons, VOCs Wastewater: pH, Conductivity, Alkalinity, Hardness, Sulfate, Sulfide, Chloride, Fluoride, Ammonia, TKN, Nitrite, Orthophosphate, Total phosphate, BOD, COD, TOC, Metals (Sb, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Mn, Hg, Ni, Ag, Na, Sn, Tl, V, Zn), TDS, TVS, TSS, CN, BNAs, Total Phenols, PAHs, Purgeable Aromatics, Purgeable Halocarbons, O&G, Gross Hydrocarbons Solid Waste / Soil: pH, Conductivity, Sulfide, Chloride, Ammonia, TKN, Nitrite, Orthophosphate, Total phosphate, BOD, COD, TOC, Metals (Al, Sb, As, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, Mn, Hg, Mo, Ni, K, Se, Ag, Na, Sn, Tl, V, Zn), TDS, TVS, TSS, CN, Ignitability, BNAs, Haloethers, Herbicides, Nitroaromatics, PCBs, PCBs in oil, Pesticides, Total Phenols, Phthalate esters, PAHs, PAHs, Purgeable Aromatics, Purgeable Halocarbons, O&G, Gross Hydrocarbons	#PH-0686 9/30/02	

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Florida Dept. of Environmental Protection Quality Assurance Section Tallahassee, FL 32399-2400 (850) 488-2796 Sylvia S. Labie, QA Director Debbie Coran reviews CompQAP	RCRA/CERCLA: pH (150.1, 9045), Anions (300.0), Total Cyanide (9010), Specific Conductance (SM 2510B), As (206.2), Pb (239.2, 7421), Se (270.2, 7740), Tl (279.2, 7841), Sb (7041), 200.7/6010 Metals (Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Sr, Tl, Sn, V, Zn), Hg (245.1, 7470, 7471), Halogenated Volatile Organics (601, 8010), Aromatic Volatile Organics (602, 8020), Volatile Organics (624, 8240, 8260), Organochlorine Pesticides and PCBs (608, 8080), Organophosphorus Pesticides (8140), Polynuclear Aromatic Hydrocarbons (610, 625, 8270, 8310), Nitroaromatics and Nitramines by High Performance Liquid (625, 8270), BNA (625, 8270)	CompQAP #200035 4/19/01	
Idaho State of Idaho Dept. of Health and Welfare Division of Health Bureau of Laboratories 200 Old Penitentiary Road Boise, ID 83712 (208) 334-2235 FAX (208)334-2382 Jon Donaly (CO reciprocity)	SDWA: *Inorganics*: Sb (200.8), As (3113B), Ba (200.7), Be (200.7), Cd (200.7), Cr (200.7), Cu (200.7), Pb (200.8), Mercury (245.1, 245.2) Ni (200.7), Se (200.8), Tl (200.8); Cyanide (4500CN-E), Fluoride (300.0), Nitrate (353.2), Nitrite (353.2); *Organics*: VOCs (524.2), Vinyl chloride (524.2).	No identifier 4/30/01	

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Kansas Dept. of Health & Environment Health & Environmental Laboratory Forbes Field, Bldg. 740 Topeka, KS 66620-0001 (785) 296-8068 (fax) (785) 296-6198 Aurora Shields (785) 296-1639 Jack McKenzie **(Utah reciprocity)**	Hazardous Waste: Ignitability (1010), Reactivity (§7.3 & 8.3), TCLP (1311), Total & Amenable Cyanide (9010B & 9012A), Ortho-Phosphate (9056), Metals by 6010B (Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mo, Ni, K, Se, Ag, Na, Tl, Sn, V, Zn), Metals by 6020 (Sb, As, Ba, Be, Cd, Cr, Co, Cu, Pb, Ni, Se, Ag, Tl, Zn), Hg (7470A & 7471A), Chloride (9251), Sulfate (9036), pH (9040B & 9045C), Specific Conductance (9050A), Nitrate (9056), Organochlorine Pesticides (8081A), PCBs (8082), Organophosphorus Pesticides (8141A), Chlorinated Herbicides (8151A), GC/MS Semivolatile Organics (8270C), Polynuclear Aromatics (8310), Nitroaromatics & Nitramines by HPLC (8330), GC/MS Volatiles (8260B) Wastewater: BOD (405.1), COD (410.4), TOC (415.1), Cyanide (335.3), Metals by 200.7: As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, Se, Ag, Na, Tl , Sn, V, Zn; Metals by 200.8: As, Ba, Be, Cd, Cr, Co, Pb, Mn, Ni, Se, Ag, Tl, V, Zn; Hg (245.1), Alkalinity (310.1 and 310.2), Chloride (325.2), Fluoride (340.2), Hardness (130.2), pH (150.1), Phenols (420.2), Ammonia (350.1), Total Kjeldahl Nitrogen (351.2), Nitrite (354.1), Sulfate (375.4), Ortho-Phosphate (365.3), Total Phosphorous (365.4), Specific Conductance (120.1), TDS (160.1), TSS (160.2), Volatile Residue (160.4), BNAs (625), VOAs (624)	#E-10166 04/30/01	

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Louisiana Louisiana DEQ Office of Management and Finance ELAP P.O. Box 82231 Baton Rouge, LA 70884-2231 (225) 765-5551 Louis R.C. Johnson FAX (225) 765-2408	Clean Water Methods Metals by ICP 200.7 (Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, Se, Ag, Na, Sn, V, Zn), Mercury (245.1 & 245.2), Thallium (279.2), BOD (405.1), COD (410.4), TOC (415.1), DO (360.1), Alkalinity (310.1 & 310.2), Chloride (300.0 & 325.2), Fluoride (300.0, manual distillation required), pH (150.1), Specific Conductance (120.1), Sulfate (300.0 & 375.2), Bromide (300.0), Cyanide (335.3), Phenolics (420.2),), Tubidity (180.1), Ammonia (350.1), TKN (351.2), Nitrate (300.0), Nitrate-Nitite (353.1), Orthophosphate (300.0), Phosphorous(365.2), TDS (160.1), TSS (160.2), Organochlorine Pesticides (608) Solid and Hazardous Waste Methods Metals by ICP/MS (Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, K, Se, Ag, Na, Tl, V, Zn), Metals by ICP 6010B (Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Ni, Se, Ag, Na, Sn, V, Zn), Mercury (245.1 & 245.2), Chromium VI (7196A), Lead (7421), Thallium (7841), TCLP-nonvolatile (1311), TCLP-volatile (1311), Chloride (9251 & 9056), Fluoride (9056), pH (9040B), Specific Conductance (9050A), Sulfate (9036 & 9056), Nitrate (9056), Nitrite (9056), Orthophosphate (9056), Bromide (9056), Cyanide (9012A), Total Phenolics (9066), TOX (9020), Organochlorine Pesticides (3520C/8081A), PCBs (3520C/8082), Chlorophenoxy Acid Herbicides (8151A), Corrosivity (9040B), Purgeable Halocarbons & Aromatics (5030B & 5035 / 8021B) TPH Gasoline (5030 & 5035 / 8015B), TPH Diesel (3510C & 3520C / 8015B), Base Neutrals & Acids (625, 3510C & 3520C / 8270C), Purgeables (624, 5030 & 5035 / 8260B), Polynuclear Aromatics (3510C/8310)	02096 12/31/01	8/29-8/31/00 (EQM)

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Maryland Dept. of Health and Mental Hygiene 201 West Preston Baltimore, MD 21201 (410) 767-6150 FAX (410) 333-5403 Mary Stancavage	Drinking Water (SDWA): *Trace Metals 1*: Pb (200.8), Cu (200.7); *Trace Metals 2*: Sb (200.8), As (SM3113B), Ba (200.7), Be (200.7), Cd (200.7), Cr (200.7), Hg (245.1,245.2), Se (200.8), Tl (200.8); *Inorganics 1*: Nitrate-N (353.2, 300.0); *Inorganics 2*: Nitrite-N (353.2, 300.0); *Inorganics 3*: Fluoride (300.0); *Inorganics 5*: Cyanide (SM4500-CN, -F,-E); and *VOC 1*: 524.2 Volatiles: Benzene, 1,2-DCA, Trichloroethylene, 1,1-Dichloroethylene, 1,1,1-TCA, 1,4-DCB, Vinyl chloride, 1,2-DCB, cis-1,2-DCB, trans-1,2-DCB, trans-1,2-Dichloropropane, Ethylbenzene, Styrene, Tetrachloroethylene, Toluene, (total) Xylenes, Monochlorobenzene, Dichloromethane, 1,2,4-Trichlorobenzene, 1,1,2-Trichloroethane	# 268 Extended to 3/31/01	
Minnesota Minnesota Department of Health 717 Delaware Street Southeast P.O. Box 9441 Minneapolis, MN 55440-9441 12) 676-5680 l Tupy	Clean Water: CN, Total Phenol, TSS, Metals (Al,Sb,As,Ba,Be,B,Cd,Ca,Cr,Co,Cu,Fe,Pb,Mg, Mn,Hg,Mo,Ni,K,Se,Ag,Na,Tl,V,Zn), Volatile Organics (see compound list in certificate) Semivolatile Organics (see compound list in certificate), Chlorinated Pesticides (see compound list in certificate), PCBs, Safe Drinking Water: CN, Fluoride, Nitrate, Nitrite, Sulfate, Metals (Sb, As, Ba, Be, Cd, Cr, Cu, Pb, Hg, Ni, Se, Tl), Volatile Organics (see compound list in certificate) RCRA: Metals (As, Ba, Cd, Cr, Cu, Pb, Hg, Mo, Ni, Se, Ag, Zn), TCLP extraction, Volatile Organics (see compound list in certificate), Semivolatile Organics (see compound list in certificate), Chlorinated Pesticides (see compound list), PCBs, Phenoxy Acid Herbicides (see compound list in certificate)	# 008-999-342 3/4/02	3/1- 3/2/00

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Nevada Nevada Dept. of Conservation Division of Env. Protection 333 W. Nye Lane, Room 138 Carson City, NV 89706 (775) 688-2888 Dr. Jack Ruckman	Minerals: pH, Conductivity, TDS, Total Hardness, Calcium Hardness, Calcium, Magnesium, Sodium, Potassium, Alkalinity, Chloride, Fluoride, Sulfate Nutrients: Ammonia nitrogen, Nitrate-nitrogen, Ortho-phosphate, Total Phosphorous Demands: BOD, COD, TOC Miscellaneous: Non filterable residue (TSS), Total solids Note: NV certification program does not include RCRA methods	CO-262000-69 6/30/01	
North Carolina DEHNR/DEM Laboratory Section 4405 Reedy Creek Road Raleigh, NC 27607-6445 (919) 733-3908 rederick Bone	Wastewater/Groundwater: BOD, COD, Chloride, Cyanide, Total Hardness, Nitrate, Total Phosphorous, pH, Inorganic Phenols, TOC, TCLP extraction (metals & organics), Metals I Reg. Level (Al, As, Be, Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, Se, V, Zn), Metals II Reg. Level (Sb, Ag, Tl), Metals I Low Level (Al, As, Be, Cd, Co, Cu, Cr, Fe, Pb, Mn, Ni, Se, V, Zn), Metals II Low Level (Sb, Ag, Tl), Ba, Hg, Purgeable Halocarbons (601 & 5030/8021, Purgeable Aromatics (602, 5035 / 8260 & 5030/8021), Polynuclear Aromatics (8310), Organochlorine pesticides & PCBs (608 & 3500 series / 8081), PCBs (8082 & 3500 series), Purgeable Organics (624, 5030/8260, & 5035/8260), Base Neutral/Acid Organics (625 & 3500 series / 8270) Note: NC cert. Program does not recognize ICP/MS	#358 12/31/03	On-site audit 3/01

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
North Dakota Dept. of Health & Consolidated Laboratories Consolidated Laboratories Branch 2635 East Main Avenue P.O. Box 937 Bismarck, ND 58502-0937 (701) 328-6145 (fax) (701) 328-6172 Errol Erickson **(Utah reciprocity)**	RCRA: *Metals* by 6010B: (Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mo, Ni, K, Se, *Ag, Na, Sn, Tl, V, Zn); *Metals* by 6020: (Al, Sb, As, Ba, Be, Cd, Cr, Co, Cu, Ni, *Ag, Tl, Zn); *Other Metals*: Hg (*7470A, *7471A) *Miscellaneous*: Acid Digestion for Metals (3005A, 3010A, 3050B), Chloride (9251), Cyanide Total (9010A & 9012A), Oil and Grease (9070), Nitrate (9056), Phosphate (9056), Sulfate (9036) Ignitability (1010), pH (9040B & 9045C), Paint Filter Liquid Test (9095), Reactivity (Section 2.1.3 & 8.3), Specific Conductance (9050A), TCLP: [Metals, Semivolatiles, and Volatiles (1311)], Organic Extractions (3510C, 3520C, 3550A, 5030B, 5035), Organochlorine Pesticides (8081A), PCBs (*8082), Organophosphorous Pesticides (8141A), Chlorinated Herbicides (8151A), Volatiles (8260B), Semivolatiles (8270C), Nitroaromatics (8330), CWA: *Metals* by 200.7 (Sb, As, Ba, Be, Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, Se, Ag, Tl, Ca, Mg, Na, Sn, V, Zn); *Metals* by 200.8 (Sb, As, Ba, Be, Cd, Cr, Co, Pb, Mn, Ni, Se, Ag, Tl, V, Zn); Hg (245.1); *Minerals*: Alkalinity (310.1 & 310.2), Chloride (325.2), Fluoride (340.2), Hardness (130.2), pH 150.1, Specific Conductance (120.1); *Nutrients*: Ammonia (350.1), Nitrite (354.1), Orthophosphate (365.3), Phosphorous (365.4), Sulfate (375.4), TKN (351.2); *Residue*: Residue Filterable TDS (160.1), Residue Non-filterable TSS (160.2), Residue Volatile (160.4); *Demand*: BOD (405.1), COD (410.4), TOC (415.1); *Organic:* Base Neutral Acids (625), Purgeables (624); *Inorganic*: Cyanide (335.3), Oil and Grease (413.1), Phenols (420.2)	#R-034 3/31/00 Application for renewal submitted 1/15/01	

Table of Contents

TABLE 7.2

Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Oklahoma Dept. of Environmental Quality Laboratory Certification Program 707 N. Robinson (P.O. Box 1677) Oklahoma City, OK 73101-1677 (405) 271-5240 Anthony Bright (405) 702-6100 Ken Pence	Metals: Al, Sb, As, Ba, Be, B, Cd, Ca, Cr, Co, Cu, Au, Ir, Fe, Pb, Mg, Mn, Hg, Mo, Ni, Os, Pd, Pt, K, Rh, Se, Si, Ag, Na, Tl, Sn, Ti, V, Zn Nutrients: NH_3 as N, Total Kjeldahl Nitrogen, Nitrate as N, Nitrate + Nitrite as N, Nitrite as N, Orthophosphate Phosphorus, Total Phosphorus Demands: 5 Day BOD, COD and TOC General Chemistry I: Acidity, Alkalinity, Bromine, Bromide, Ca, Chloride, Color, Cu, Fluoride, Hardness, Hydrogen Ion (pH), Fe, Mg, Mn, Nitrate, TSS, TDS, Total Residue, Settleable Residue, Volatile Residue, Sulfate, Turbidity, Zn General Chemistry II: Total Residual Chlorine, Total CN, CN amenable to Chlorination, Oil and Grease, Dissolved Oxygen, Phenolics, Specific Conductance, Sulfide, Sulfite, Surfactants, Corrosivity-Calcium Carbonate Stability Microbiology: Total Coliforms and Fecal Coliforms Extractable Organics, Pesticides-Herbicides-PCBs, Purgeable Organics (Refer to the certificate for specific parameters) TCLP	#8614 8/31/01	

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Rhode Island Department of Health Cannon Building, Three Capitol Hill Providence, RI 02908-5097 Debra Dehmel (401) 222-2566 Wayne Farrington (401) 222-2566	Chemistry: Inorganic Chemistry: Surface water, Wastewater/Sewage, Potable water Organic Chemistry: Surface water, Wastewater/Sewage, Potable water Lead: Soil	#230 12/30/01	
South Carolina Dept. of Health and Environmental Control Office of Environmental Laboratory Certification Bureau of Environmental Services .O. Box 72 tate Park, SC 29147 303) 896-0976 AX (803) 896-0850 Ir. Tony Lofton **Utah reciprocity)**	Solid & Hazardous Wastes (RCRA): TCLP Bottle Extraction (1311), TCLP-Zero Headspace (1311), pH (9045C), Cyanide (9010B/9012A), Metals by 6010B (Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Ni, K, Ag, V, Zn), Metals by 6020 (Al, Sb, As, Ba, Be, Cd, Cr, Co, Cu, Ni, Ag, Tl, Zn); Hg (7470A/7471A), Semi-Volatiles (3520C/8270C, 3550B/8270C), Purgeables (5030B/8260B) [Refer to the certificate for 8270C (3520C & 3550B), and 8260B (5030B) compounds]	#72002001 03/31/01	

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Tennessee Dept. of Health and Environment Laboratory Quality Assurance 630 Ben Allen Road Nashville, TN 37247-0801 (615) 262-6358 Ryan Casparis **(Colorado reciprocity)**	Drinking Water (SDWA): Inorganic: As, Ba, Cd, Cr, Cyanide, Fluoride, Hg, Ni, Nitrogen/Nitrate (Total), Nitrite, Se, Sb (Total), Be (Total), Tl (Total), Pb, Cu. VOC: All including Vinyl Chloride	#02944 2/2/03	

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Utah STL Denver's Primary Accrediting Authority for NELAP certification Division of Laboratory Services Bureau of Laboratory Improvement 46 N. Medical Drive Salt Lake City, UT 84113-1105 (801) 584-8466 (801) 584-8501 (fax) Alyze Wasden avid Mendanhall, Bureau irector	**RCRA Program** Characteristics: Ignitability (1010), TCLP (1311 – metals, semivolatiles, volatiles), SPLP (1312) Inorganics: Total & amenable cyanide (9030B/9024), TOX (9020B), EOX (9023), Sulfide (9030B/9034), Sulfate (Turbidimetric 9038), pH (9040C), pH (9045C), Specific Conductance (9050A), Anions (Cl, F, NO3, NO2, NO3, OPO4, SO4 9056), TOC (9060), Phenolics (9066), Chloride (9251) Metals Digestions: Total Recoverable or Dissolved (3005A), Total (3010A), Total for GFAA (3020A), Soils (3050B) Metals Analysis: 6010B (Al, Sb, As, Ba, Be, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Li, Mg, Mn, Mo, Ni, P, K, Se, SiO2, Si, Ag, Na, Sr, Tl, Sn, Ti, V, Zn); 6020 (Al, Sb, As, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Ni, Se, Ag, Tl, V, Zn); GFAA (Sb 7041, As 7060A, Cd 7131A, Cr 7191, 7421 Pb, Se 7740, Tl 7841); Cr+6 (7196A), Hg (7470A & 7471A) Organic Cleanups: Florisil (3620B), GPC (3640A), Sulfur removal (3660B) Organic Extractions: Separatory funnel (3510C), CLLE (3520C), SPE (3535), Soxhlet (3540C), Sonication (3550B), Waste dilution (3580A) Volatile Organic Preparations: Purge & trap for water (5030B), Purge & trap for soil (5035) Organic Instrumental Analysis (for list of approved compounds see Utah NELAP certificate): Hydrocarbons (8015B), Volatile aromatics & halocarbons (8021B), Chlorinated pesticides (8081A), PCBs (8082), Organophosphorous pesticides (8141A), Phenoxyacid herbicides (8151A), Volatile organics (8260B), Semivolatile organics (8270C), Polynuclear aromatics (8310), Herbicides & explosives (8321), Explosives (8330) (see continuation on next page)	#QUAN5 8/31/01	On-site audit 1/99

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Utah (cont.)	**Clean Water Program** Color (110.2), Conductance (120.1), Hardness (130.2), pH (160.1), TDS (160.1), TSS (160.2), TS (160.3), TVS (160.4), SS (160.5), Metals by 200.7 (Al, Sb, As, Ba, Be, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Li, Mn, Mo, Ni, K, Se, Si, Ag, Na, Sr, Tl, Sn, Ti, V, Zn); Metals by 200.8 (Al, Sb, As, Ba, Be, Cd, Cr, Co, Cu, Pb, Mn, Ni, Se, Ag, Tl, V, Zn); Metals by GFAA (Sb, As, Cd, Cr, Pb, Se, Tl); Hg (245.1); Alkalinity (2320B), Hardness (2340B), Anions (Cl, F, NO3, NO2, NO3, OPO4, SO4 300.0), Acidity (305.1), Alkalinity (310.1 & 310.2), Cyanide total & amenable (335.1 & 335.3), Fluoride (ISE 340.2), Ammonia (350.1), TKN (351.2), NO3/NO2 (353.2), Phosphorous (365.3), Sulfide (376.2), Sulfite (377.1), BOD (405.1), COD (410.1 & 410.4), TOC (415.1), Phenols (420.2) Organic Methods: Volatiles (601 & 624), Chlorinated pesticides (608), Phenoxyacid herbicides (615), Semivolatile organics (625) **Safe Drinking Water Program** pH (150.1), TDS (160.1), Turbidity (180.1), Metals by ICP (Al, As, Ba, Cd, Ca, Cr, Cu, Fe, Mg, Mn, Ni, SiO2, V, Zn 200.7), Metals by ICP/MS (Al, Sb, As, BA, Be,Cd, Cr, Cu, Mn, Ni, Se, Ag, Tl, V, Zn 200.8), Mercury (245.1), Color (2120B), Anions (F, NO3, NO2 300.0), Metals by GFAA (Sb, As, Cd, Cr, Pb, Se, Ag, Tl 3113B), Cyanide (4500-CN-E), NO3 & NO3/NO2 (353.2), Volatile Organics (524.2)	#QUAN5 8/31/01	On-site audit 1/99

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Utah UST Program Utah Solid and Hazardous Waste Control Board 46 North Medical Drive Salt Lake City, UT 8411301105 Dale Urban (801) 536-4100	8015B, 8260B	See above	
Washington Dept. of Ecology Quality Assurance Section P.O. Box 488 Manchester, WA 98353-0488 phone: (360) 895-6149 Fax: (360) 895-6180 Jerry Brake jbra461@ecy.wa.gov **(USACE reciprocity)**	Environmental Laboratory Accreditation (ELAP): Metals by 200.7/6010: [Ca, Mg, K, Na, Al, Sb, As, Ba, Be, Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, Ag, V, Zn]; Other Metals: As (206.2/7060A), Hg (245.1/7470), Se (270.2/7740), Tl (279.2/7841); Anions by 300.0A (Chloride, Fluoride, Nitrate, Nitrite, OPO4, Orthophosphate, Sulfate); Total Cyanide (9010/9012), pH (9040), Sulfide (376.2), TOC (9060), Chlorinated Herbicides (8151), Nitroaromatics & Nitroamines (8330), OCPs (8081), PCBs (8082), BNA Ext. (Semivolatile) Organics (625/8270), Purgeable (Volatile) Organics (624/8260)	#C090 08/03/01	On-site audit 11/92

Table of Contents

TABLE 7.2

Certifications, Licenses and Approvals

AGENCY	CERTIFIED PARAMETERS/METHODS	CERTIF./LICENSE NUMBER, EXPIRATION DATE	AUDITS
Wisconsin Dept. of Natural Resources Office of Technical Services P.O. Box 7921 Madison, WI 53707-7921 phone: (608) 266-2621 fax: (608) 267-5231 Alfredo Sotomayor	Wastewater & Solid/Hazardous Waste: **Nitrogen:** (ammonia as N, nitrite as N, nitrate as N, TKN); **Physical:** (O&G, TDS, TS, TSS, TVS); **General I:** (alkalinity/acidity, color, hardness, silica, silicate, sulfite); **General III:** (corrosivity, ignitability, total releasable cyanide, reactivity, total releasable sulfide, TCLP, TOC, TOX); **Metals I:** (Ag, Al, As, B, Ba, Be, Ca, Cd, Co, Cr (total), Cu, Fe, Hg, K, Mg, Mn, Mo, Na, Ni, Pb, Sb, Se, Sr, Tl, V, Zn); **Organics; Purgeable:** Purgeable Aromatics, Purgeable Halocarbons, Volatile Organics (VOCs); **Organics; Organochlorine:** PCBs and Organochlorine Pesticides.	#999615430 8/31/01	On-site audit 5/94

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

FEDERAL PROGRAMS			
U.S. Air Force Center for Environmental Excellence (AFCEE) HQ AFCEE / ERC 2307 North Road, Building 532 Brooks AFB, TX 78235-5363 (210) 536-5226 Major Kevin Kuhn	1998 AFCEE QAPP, Revision 3.0 2001 AFCEE QAPP, Revision 3.1	Active	On-site audit 6/12–6/16/00
U.S. Army Corps of Engineers (USACE) Missouri River Division Environmental, Hazardous, Toxic and Radioactive Waste Division P.O. Box 103, Downtown Station Omaha, NE 68101-0103 402) 697-2574 m Lazanis, Lab ertifications 402) 221-7494 evin Coates	Hazardous and Toxic Waste: Anions (300.0), Explosives (8330), Herbicides (8151A), Organochlorine Pesticides (8081A), Polychlorinated Biphenyls (8082), Semivolatile Organics (8270C), TAL Metals (SW-846) [Al, Sb, As, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Ni, K, Se, Ag, Na, Tl, V, and Zn],, TPH GRO/DRO, Volatile Organics (8260B) (Certification is for solid and water samples)	6/10/01	On-site audit 4/99

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

DOE EMCAP U.S. Department of Energy Oak Ridge Operations P.O. Box 2001 Oak Ridge, TN 37830 David Carden, Program Manager (865) 576-9262 Virgene Ideker, Rocky Flats Field Office (303) 966-3437	Approved for mixed waste organics, inorganics, and wet chemistry	No ID number	On-site audit 12/00 & 2/2/01
USFDA Denver Federal Center - Bldg. 20 P.O. Box 25087 Denver, CO 80225-0087 (303) 236-3000 Gary Dean, Director of Field Activities ranch	No specific methods, audited for extractable organics by GC/MS and GC/MS SIM	Bar Code #: RR-75188. Lab last registered 2/00	On-site audit 3/96 Auditors stated lab is listed as a "specialty lab"

Table of Contents

TABLE 7.2
Certifications, Licenses and Approvals

USDA USDA Animal & Plant Health Inspection Service, Unit 136 4700 River Road Riverdale, MD 20737 Local Office/Contact at DIA: (303) 342-7459 Jack Hansen	Soil Permit Permit to import foreign soils and soils from control areas of the continental USA. (Refer to the permit for specific criteria and conditions.)	#S-35342 12/31/02	On-site audit 6/5/97
ACIL P.O. Box 8032 Newark, DE 19714 (302) 995-2290 Patrick McMahon	Seal of Excellence	Lab # 76 4/2/02	

TABLE 8.0-1 Instrument List

Instrument Type	Manufacturer	Model	Purchase Date	Autosampler
GC Semivolatiles	Hewlett-Packard (E) S/N 3121A35858	5890II Dual ECD	1992	Yes
	Hewlett-Packard (A) S/N 2750A16891	5890A Dual FID	1987	Yes
	Hewlett-Packard (B) S/N 2541A06663	5890A Dual ECD	1988	Yes
	Hewlett-Packard (N) S/N 2843A19457	5890A Dual ECD	1988	Yes
	Hewlett-Packard (Z) S/N 2618A08124	5890A Dual FID	1988	Yes
	Hewlett-Packard (W) S/N 3126A36250	5890II Dual ECD	1990	Yes
	Hewlett-Packard (D) S/N DE00020818	6890 Dual NPD	1997	Yes
	Hewlett-Packard S/N US00029514	6890 Dual ECD	1999	Yes
GC Volatiles	Hewlett-Packard (Y) S/N 2843A19484	5890A PID/FID	1988	Yes
	Hewlett-Packard (H) S/N 2750A16573	5890A Dual PID Single FID	1988	Yes
	Hewlett-Packard (K) S/N 2843A19497	5890A Dual PID Single FID	1988	Yes
	Hewlett-Packard (L) S/N 2336A00164	5890A FID	1988	Yes
	Hewlett-Packard (P) S/N 2518A05337	5890A Dual PID Single FID	1990	Yes
	Hewlett-Packard (B) S/N 3019A28634	5890II PID / FID	1990	Yes
	Hewlett-Packard (F) S/N LR47359C	5890II Dual ELCD	1990	Yes
	Hewlett-Packard (J) S/N US00026194	6890 Dual PID / Dual ELCD	1997	Yes

TABLE 8.0-1 Instrument List

Instrument Type	Manufacturer	Model	Purchase Date	Autosampler
HPLC	Hewlett-Packard (Q) S/N 2314G00287	1090A	1985	Yes
	Hewlett-Packard (Y) S/N 2734A00535	1090A	1987	Yes
	Hewlett-Packard S/N DE91606289 (Quat Pump)	1100 Multiple wavelength / Fluorescence detectors	1999	Yes
GC/MS Semivolatiles	Hewlett-Packard (Y) S/N US00007291	5973	1996	Yes
	Hewlett-Packard (P) S/N US00007321	5973	1996	Yes
	Hewlett-Packard (D) S/N US00007319	5973	1996	Yes
GC/MS Volatiles	Hewlett-Packard (S) S/N 3336A60702	5890II – GC 5972 – MSD	1994	Yes
	Hewlett-Packard (Z) S/N 3336A60013	5890II – GC 5972 – MSD	1996	Yes
	Hewlett-Packard (H) S/N 3336A60700	5890II – GC 5972 – MSD	1994	Yes
	Hewlett-Packard (J) S/N 3336A60701	5890II – GC 5972 – MSD	1994	Yes
	Hewlett-Packard (E) S/N 3336A60699	5890II – GC 5972 – MSD	1997	Yes
ICP	Thermo Jarrell Ash S/N 89090	61E ICAP	1989	Yes
	Thermo Jarrell Ash S/N 389590	61E Trace	1992	Yes
ICP/MS	Perkin Elmer SCIEX S/N 305970360	ELAN 6000	1996	Yes
GFAA	Perkin Elmer S/N 131178	5100 PC	1988	Yes
	Perkin Elmer S/N 132350	5100 PC	1988	Yes

TABLE 8.0-1 Instrument List

Instrument Type	Manufacturer	Model	Purchase Date	Autosampler
Mercury Analyzer	CETAC S/N 019903MAS	M-6000A	1997	Yes
Ion Chromatograph	Dionex S/N 98040510	DX-120	1997	Yes
	Dionex S/N 105180	2110i	1988	Yes
	Dionex S/N 105139	4000I	1988	Yes
TOC	LECO S/N 3032	CR-12 (Solid)	1988	No
	Shimadzu S/N 30724214	TOC-5000	1992	Yes
TOX	MCI S/N 43F30588	TSX-10	1987	No
	Mitsubishi S/N 75R01382	TOX-10E	1992	No
	Thermo-Glass S/N 993752	1200	1997	Yes
TKN Digestion System	Tecator System 2040 S/N 662	1000-3454	1985	No
UV/VIS	Milton Roy S/N 3800107006	Spectronic 301	1985	No
	Milton Roy S/N 3PCA178001	Spectronic Genesys 2PC	1996	No
Wet Chemistry	Technicon (1) S/N 84084	AAII	1982	Yes
	Alpkem (1) S/N 908893427	A002393	1997	Yes
	Alpkem (2) S/N 917893398	A002393	1997	Yes
	Lachat S/N 2000-0526	Quick Chem AE	1992	Yes
Ion Analyzer	Orion Research S/N PX94A	EA940	1985	No

TABLE 8.0-1 Instrument List

Instrument Type	Manufacturer	Model	Purchase Date	Autosampler
Autotitrator (pH, Alkalinity, Conductance)	Radiometer S/N 77R08N072	TTT85	1986	Yes
pH Meter	Corning S/N 5707	140	1987	No
Dissolved Oxygen Meter	Wheaton S/N 9104	8000	1988	No
	YSI S/N 91C27855	50B	1987	No
Turbidimeter	HACH S/N 13525	2100A	1989	No
Automated Distillation Apparatus	Westco S/N 1028	483-W001-01 Easy Dist	1997	No
COD	HACH S/N 860708038	16500-10	1985	No
	HACH S/N 890112048	16500-10	1985	No
	HACH S/N 881011613	16500-10	1985	No

Table 8.2-2 Standard Operating Procedures

SOP No.	Rev. No.	Rev. Date	Title
Preparation Methods			
CORP-IP-0002DEN	2	1/12/00	Acid Digestion of Soils, SW-846 Method 3050B
CORP-IP-0003	0	12/9/95	Acid Digestion of Aqueous Samples by SW-846 and 200 Series Methods
CORP-IP-0004	1	2/1/00	Toxicity Characteristic Leaching Procedure and Synthetic Leaching Procedure (TCLP)
DEN-IP-0005	0 Last Review	12/13/95 1/17/00	Inorganic Glassware Washing Procedure
DEN-IP-0006	0	2/29/00	Acid Digestion of Aqueous Samples by Standard Methods 3030E for GFAA Metals Analysis
DEN-IP-0007	1	3/10/00	Acid Digestion of Aqueous Samples by Standard Methods 3030C for Acid-Extractable Metals (ICP)
DEN-IP-0008	0	4/5/00	California Waste Extraction Test (WET)
DEN-IP-0009	0	5/17/00	Acid Digestion of Aqueous Samples for Metals Analysis by ICP/MS Method 6020
DEN-IP-0010	0	6/12/00	Acid Digestion of Aqueous Samples for Metals Analysis by SW846 and MCAWW (ICP)
DEN-OP-0004	2	6/9/00	Organic Glassware Washing Procedures
CORP-OP-0001DEN	3.2	6/9/00	Extraction and Cleanup of Organic Compounds from Waters and Soils, Based on SW-846 3500 Series, 3600 Series, 8151A and 600 Series Methods
DEN-QA-0023	1	5/1/00	Subsampling
Organics – GC & LC			
CORP-GC-0001DEN	5.2	6/8/00	Gas Chromatographic Analysis Based on Methods 8000B, 8021B, 8081A, 8082, and 8151A, SW-846
DEN-GC-0002	3	4/13/00	Diesel Range Organics by GC/FID
DEN-GC-0010	1	4/13/00	Gasoline Range Organics by GC/FID
DEN-GC-0015	0	7/9/99	Gas Chromatographic Analysis for Alcohols by 8015B
DEN-GC-0016	0	2/14/99	Chlorinated Pesticides & PCBs by Method 608
DEN-GC-0018	0	9/19/00	N-Nitrosodimethylamine by Gas Chromatography, Methods 607 & 8070A
DEN-LC-0002	5	4/25/00	Nitroaromatics And Nitroamines By High Performance Liquid Chromatography (HPLC) Method 8330
DEN-LC-0009	1	6/12/00	Polynuclear Aromatic Hydrocarbons By HPLC, SW-846 Method 8310
Organics - GC/MS			
CORP-MS-0001DEN	2.3	8/29/00	GC/MS Analysis Based on Method 8270C and 625
CORP-MS-0002DEN	3.1	8/31/00	Determination of Volatile Organics by GC/MS Based on Method 8260B, 624, and 524.2
DEN-MS-0009	0	9/27/99	Volatiles Screening Analysis by GC/FID

Table 8.2-2 Standard Operating Procedures

SOP No.	Rev. No.	Rev. Date	Title
Metals			
CORP-MT-0001DEN	3.1	9/20/00	Inductively Coupled Plasma-Atomic Emission Spectroscopy, Spectrophotometric Method for Trace Element Analysis, Method 6010B and Method 200.7
CORP-MT-0003	2	7/15/99	Graphite Furnace Atomic Absorption Spectroscopy, SW-846 Method 7000A and MCAWW 200 Series Methods (implementation planned 12/99)
CORP-MT-0005DEN	1.2 Interim change	5/20/99 11/19/99	Preparation and Analysis of Mercury in Aqueous Samples by Cold Vapor Atomic Absorption, SW-846 7470A and MCAWW 245.1
CORP-MT-0007DEN	2	8/1/99	Preparation and Analysis of Mercury in Solid Samples by Cold Vapor Atomic Absorption, SW-846 7471A and MCAWW 245.5 (planned implementation 11/99)
DEN-MT-0002	5	9/20/00	Inductively Coupled Plasma-Mass Spectrometry, EPA Methods 6020 and 200.8
Wet Chemistry			
DEN-MT-0008	0	3/3/98	Ignitability
CORP-WC-0001DEN	1	10/1/99	Total Organic Halides in Water by SW-846 Method 9020B (implementation planned 12/99)
CORP-WC-0002DEN	2.1	12/15/99	Determination of Solids in Waters and Wastes
CORP-WC-0003	1	1/14/00	HEM/SGT-HEM Method 1664 (Formerly Oil and Grease/TPH)
CORP-WC-0004	0	1/1/97	Ignitability of Solids for Waste Characterization, EPA SW-846 Chapter 7, Section 7.1
DEN-WC-0001	3	9/14/00	Soil and Waste pH
DEN-WC-0003	3	10/19/99	Cyanide Analysis
DEN-WC-0006	1	6/14/99	Carbon in Water (TOC, TIC, DOC, TC)
DEN-WC-0007	1	3/30/00	Nitrate, Nitrite by Automated Cadmium Reduction (353.2)
DEN-WC-0013	1 Interim change	5/24/96 7/18/97	Total Recoverable Phenolics
DEN-WC-0017	0	7/16/96	Total, Hydrolyzable and Ortho-Phosphorus by Auto Analyzer
DEN-WC-0018	2	9/12/00	Chemical Oxygen Demand
DEN-WC-0019	2	7/16/99	Biochemical Oxygen Demand
DEN-WC-0020	1 Last review	6/9/99 6/7/00	Determination Of Inorganic Anions By Ion Chromatography
DEN-WC-0021	1 Last review	2/26/96 6/7/00	Hexavalent Chromium By Method 7196A
DEN-WC-0022	1	7/23/99	Turbidimetric Sulfate
DEN-WC-0023	0	1/12/96	Total, Fixed And Volatile Solids; % Water (Soils/Wastes)
DEN-WC-0025	2.0	12/14/99	pH, Specific Conductance, and Alkalinity (Automatic Titrator)
DEN-WC-0026	0	6/28/00	Total kjeldahl Nitrogen (TKN) by EPA 351.2
DEN-WC-0030	0	10/29/96	Alkalinity (Manual Titration)
DEN-WC-0031	1	8/27/97	Manual pH
DEN-WC-0032	0	10/1/96	Settleable Solids
DEN-WC-0034	0	11/15/96	Chloride Analysis (Technicon AAII)

Table 8.2-2 Standard Operating Procedures

SOP No.	Rev. No.	Rev. Date	Title
DEN-WC-0035	0	9/30/96	Acidity
DEN-WC-0036	0	2/21/97	D.I. Leach
DEN-WC-0038	0	3/15/99	Total Organic Halides in Waters by SW-846 Method 9020B
DEN-WC-0040	0	7/16/99	Ammonia Nitrogen by Autoanalyzer
DEN-WC-0041	0	1/28/00	Reactive Sulfide and Cyanide Sample Preparation
DEN-WC-0042	0	1/27/00	Total Sulfide Sample Preparation
DEN-WC-0044	0	1/28/00	Acid-Soluble Sulfide Titration by 9034 and 376.1
DEN-WC-0045	0	4/5/00	Extractable Organic Halides (EOX) in Solids
LM-RMA-1116	1.0	6/9/92	Total Organic Carbon in Soils & Sediments
Quality Assurance			
QMP	3	4/7/00	STL Quality Management Plan
LQM	0	9/27/00	Laboratory Quality Manual for STL Denver
QA-001	2 Interim change	6/1/98 11/2/98	Preparation and Management of Standard Operating Procedures
QA-003	2 Interim change	7/13/98 10/1/99	Quanterra Quality Control Program
QA-004	1	6/1/98	Rounding and Significant Figures
QA-005	3 Interim change	5/1/99 10/8/99	Determination of Method Detection Limits for Chemical Tests
QA-008	2 Interim change	10/5/98 12/31/99	Data Recording Requirements
QA-009	3	1/1/99	Reporting Limits
QA-010	2	7/15/98	Maintaining Time Integrity
QA-011	2 Interim change	7/15/98 4/19/99	Acceptable Manual Integration Practices
QA-012	1	8/15/98	Technical Data Review Requirements
QA-013	1	9/15/99	Procedures to Address Customer Complaints
QA-014	0	8/15/97	Determination of Instrument Detection Limits
QA-015	0	6/1/99	Quanterra Requirements for Intra-Company Transfer of Work
QA-017	0	7/7/99	Electronic Reporting
QA-018	0	8/13/99	Vendor Approval
QA-019	0	8/13/99	Vendor Review and Oversight
DPOL-QA-001	0	3/11/97	Quality Control for Drinking Water Programs
DPOL-QA-002	0	1/31/00	Repeat Analyses and Reporting
DPOL-QA-003	0	3/10/00	Results and Report Revisions
CORP-QA-0001	3 Interim change	12/15/98 6/8/99	Quality Testing of Solvents, Acids, and Reagents (QRI Program)

Table 8.2-2 Standard Operating Procedures

SOP No.	Rev. No.	Rev. Date	Title
CORP-QA-0004	4	10/12/98	Independent QA Data Review
CORP-QA-0010	2	6/15/99	Nonconformance and Corrective Action System
CORP-QA-0012	1 Interim change	2/5/98 9/21/99	Selection and Evaluation of Subcontractor Laboratories
CORP-QA-0013	1	12/15/98	Employee Orientation and Training
CORP-QA-0014	1	8/1/99	Laboratory Internal Systems Audit
P-T-001	1	8/1/00	Selection of Calibration Points
DEN-QA-0001	4	5/19/99	Thermometer Calibration Procedure
DEN-QA-0003	6	4/27/99	Sample Receipt and Chain-of-Custody
DEN-QA-0005	3	8/16/99	Document Archiving Procedure
DEN-QA-0008	3	8/25/00	Calibration Verification of Mechanical Pipettes
DEN-QA-0010	1	7/1/98	Document Control
DEN-QA-0012	2	9/12/00	Monitoring Refrigerator Temperature
DEN-QA-0013	2	8/26/99	Refrigerator Blank and Trip Blank Monitoring
DEN-QA-0014	1.0 Interim change	1/17/97 3/31/97	Balance Daily Check Procedure
DEN-QA-0015	2.0	4/15/98	Verification and Storage of Calibration Standards
DEN-QA-0017	1.0	9/9/97	Bottle Preparation and Cooler Shipment
DEN-QA-0019	0	5/9/00	Quarantine Soils Procedure
DEN-QA-0020	1	10/28/99	Level II Organic Data Review
DEN-QA-0022	1	8/31/99	Report Package Assembly and Review
Health and Safety			
CHP	5	1/15/00	Chemical Hygiene Plan
EHS-001	1	1/6/98	Health and Safety Policy
Mixed Waste			
AURSM	1	10/2/00	Radiation Safety Manual
AU-HPM-R001	0	3/1/95	Standard Operating Procedure for Radioactive Sample Control
AU-HPM-R002	0	3/1/95	Standard Operating Procedure for Radioactive Material Inventory Control
AU-HPM-R003	0	3/1/95	Standard Operating Procedure for Radiation Contamination Control by Frisking
AU-HPM-R004	0	3/1/95	Standard Operating Procedure for Lab RAM Waste
AU-HPM-R005	0	3/1/95	Standard Operating Procedure for Performing Removable Radioactive Surface Contamination Surveys
AU-HPM-R006	0	3/1/95	Standard Operating Procedure for Radiation Exposure Rate Surveys
AU-HPM-R007	2	8/30/96	Standard Operating Procedure for Health Physics Testing on Incoming Radioactive Materials Packages
AU-HPM-R008	0	3/1/95	Standard Operating Procedure for Handling, Packaging and Transport of Low Level Excepted Radioactive, Limited Quantity N.O.S.

Table 8.2-2 Standard Operating Procedures

SOP No.	Rev. No.	Rev. Date	Title
AU-HPM-R009	0	3/1/95	Standard Operating Procedure for Determination of Radioactive Materials Packages External Radiation dose Rates and Labeling Requirements for Shipment Under 49 CFR part 173
AU-HPM-R010	0	3/1/95	Standard Operating Procedure for Personnel Radiation Dosimetry
AU-HPM-R011	0	3/1/95	Standard Operating Procedure for Emergencies Involving Radioactive Material
AU-HPM-R012	0	3/1/95	Standard Operating Procedure for Airborne Radioactive Monitoring
AU-HPM-R013	0	3/1/95	Standard Operating Procedure for Performing Daily (When in Use) Instrument Checks
Information Technology			
IT-011	1	5/17/99	Electronic Mail
IT-012	1	5/17/99	Internet Policy
IT-013	0	6/2/97	Software Quality Assurance
IT-014	0	7/21/97	Software and Hardware Licensing, Security and Backup
CORP-IT-0001	0	7/21/97	Software and Hardware Change Management
CORP-IT-0002	0	10/3/97	Information Technology Service Request
CORP-IT-0005	0	7/22/97	LIMS User Profile Setup and Maintenance
CORP-IT-0007	0	6/13/97	Software Testing, Validation, and Verification
CORP-IT-0008	0	1/17/00	Tracking and Management of Client Deliverables

TABLE 8.2-3
Wet Chemistry Methods

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
Acidity	Water	---	EPA 305.1	---	---
	Waste	---	EPA 305.1	---	---
	Solid	---	EPA 305.1 (M)	---	---
Alkalinity	Water	SM 2320B	EPA 310.1	---	---
	Waste	---	---	---	---
	Solid	---	310.1 (M)	---	---
Biochemical Oxygen Demand	Water	---	EPA 405.1	---	---
	Waste	---	---	---	---
Bromide	Water	EPA 300.0	EPA 300.0	EPA 9056	---
	Waste	---	EPA 300.0	EPA 9056	
	Solid	---	EPA 300.0 (M)	EPA 9056	---
Chemical Oxygen Demand	Water	---	EPA 410.4	---	---
	Waste	---	EPA 410.4	---	---
Chloride	Water	EPA 300.0	EPA 300.0 EPA 325.2	EPA 9056	---
	Waste	---	EPA 300.0	EPA 9056	---
	Solid	---	EPA 300.0 (M)	EPA 9056	---
Chromium, Hexavalent	Water	---	SM 3500-Cr-D	EPA 7196A	---
	Waste	---	SM 3500-Cr-D	EPA 7196A	---
	Solid	---	---	---	---
Color	Water	SM 2120B	EPA 110.2 SM 2120B	---	---
	Waste	---	---	---	---
	Solid	---	---	---	---

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
Specific Conductance	Water	SM 2510B	EPA 120.1	EPA 9050A	---
	Waste	---	EPA 120.1	EPA 9050A	---
	Solid	---	---	EPA 9050A	---
Cyanide (Amenable)	Water	---	EPA 335.3	EPA 9010B/9012A	---
	Waste	---	---	---	---
	Solid	---	---	EPA 9010B/9012A	---
Cyanide (Reactive)	Water	---	---	Section 7.3	---
	Waste	---	---	Section 7.3	---
	Solid	---	---	Section 7.3	---
Cyanide (Total)	Water	---	EPA 335.3	EPA 9010B/9012A	---
	Waste	---	---	EPA 9010B/9012A	---
	Solid	---	---	EPA 9010B/9012A	---
Cyanide (Weak and Dissociable)	Water	---	SM 4500-CN I	---	ASTM D-2036-81
	Waste	---	---	---	ASTM D-2036-81 (M)
	Solid	---	---	---	ASTM D-2036-81
Fluoride	Water	EPA 300.0	EPA 300.0 EPA 340.2	EPA 9056	---
	Waste	---	EPA 340.2 (M) EPA 300.0 (M)	EPA 9056	---
	Solid	---	EPA 340.2 (M) EPA 300.0 (M)	EPA 9056	---
Hardness	Water	EPA 130.2	EPA 130.2	---	---

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
	Waste	---	---	---	---
Ignitability	Waste	---	---	EPA 1010	---
	Solid	---	---	EPA 1010	---
Moisture	Solid	---	---	EPA 160.2 (M) ASTM D2216	---
Nitrogen, Ammonia	Water	---	EPA 350.1	---	---
	Waste	---	EPA 350.1	---	---
	Solid	---	EPA 350.1	---	---
Nitrite (NO_2)	Water	EPA 300.0 EPA 353.2	EPA 300.0 EPA 353.2	EPA 9056	---
	Waste	---	EPA 300.0 (M)	EPA 9056	---
	Solid	---	EPA 300.0 (M)	EPA 9056	---
Nitrate (NO_3)	Water	EPA 300.0 EPA 353.2	EPA 300.0 EPA 353.2	EPA 9056	---
	Waste	---	EPA 300.0 (M)	EPA 9056	---
	Solid	---	EPA 300.0 (M) EPA 353.2 (M)	---	---
Nitrate plus Nitrite	Water	EPA 300.0 EPA 353.2	EPA 300.0 EPA 353.2	EPA 9056	---
	Waste	---	EPA 300.0 EPA 353.2	EPA 9056	---
Total Kjeldahl Nitrogen (TKN)	Water	---	EPA 351.3	---	---
	Waste	---	EPA 351.3	---	---
	Solid	---	EPA 351.3	---	---
Oil and Grease (Hexane Extractable Material)	Water	---	EPA 1664	---	---
	Waste	---	EPA 1664	---	---

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
	Solid	---	---	---	---
Ortho-phosphate $o\text{-}PO_4$	Water	EPA 300.0	EPA 300.0 EPA 365.3	EPA 9056	---
	Waste	---	EPA 300.0 (M)	EPA 9056	
	Solid	---	EPA 300.0 (M) EPA 365.3 (M)	EPA 9056	---
pH	Water	EPA 150.1	EPA 150.1	EPA 9040B	---
	Waste	---	---	EPA 9045C	---
	Solid	---	---	EPA 9045C	---
Phenolics	Water	---	EPA 420.2	---	---
	Waste	---	---	EPA 9066	---
	Solid	---	---	EPA 9066	---
Phosphorus (Total)	Water	EPA 365.3	EPA 365.3	---	---
	Waste	---	EPA 365.3	---	---
	Solid	---	EPA 365.3	---	---
Sulfate (SO_4)	Water	EPA 300.0 EPA 375.2	EPA 300.0 EPA 375.4	EPA 9056 EPA 9038	---
	Waste	---	EPA 300.0 (M) EPA 375.4	EPA 9056 EPA 9038	---
	Solid	---	EPA 300.0 (M)	EPA 9056 EPA 9038 (M)	---
Sulfide	Water	---	EPA 376.2	EPA 9030B/9034	---
Sulfide (Reactive)	Water	---	---	Section 7.3	---
Sulfide (Reactive)	Waste	---	---	Section 7.3	---
	Solid	---	---	Section 7.3	---

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
Sulfite (SO_3) Sulfite (SO_3)	Water	EPA 377.1	EPA 377.1	---	---
	Waste	---	EPA 377.1 (M)	---	---
	Solid	---	EPA 377.1 (M)	---	---
Total Organic Carbon (TOC)	Water	---	EPA 415.1	EPA 9060	---
	Waste	---	---	EPA 9060	---
	Solid	---	EPA 415.1 (M)	EPA 9060 (M)	---
Total Organic Halides (TOX)	Water	---	---	EPA 9020B	---
	Waste	---	---	---	---
	Solid	---	---	EPA 9020B	---
Total Petroleum Hydro-carbons	Water	---	EPA 1664 (SGT-HEM)	---	---
	Waste	---	EPA 1664 (SGT-HEM)	---	---
	Solid	---	---	---	---
Total Solids	Water	---	EPA 160.3	---	2540B
	Waste	---	EPA 160.3	---	---
	Solid	---	EPA 160.3 (M)	---	---
Total Dissolved Solids	Water	SM 2540C	EPA 160.1	---	2540C
Total Suspended Solids	Water	EPA 160.2	EPA 160.2	---	2540C
Volatile and Volatile Suspended Solids	Water	---	EPA 160.4	---	---
Settleable Solids	Water	---	EPA 160.5	---	EPA 2540 F

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
Turbidity	Water	EPA 180.1	EPA 180.1	---	---

TABLE 8.2-3 (cont.)
Methods for Mercury by Cold Vapor Atomic Absorption

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
Mercury	Water	EPA 245.1	EPA 245.1	EPA 7470A	---
	TCLP Leachate	---	---	EPA 7470A	---
	Waste	---	---	EPA 7471A	---
	Solid	---	EPA 254.5	EPA 7471A	---

TABLE 8.2-3 (cont.)
Methods for Metals by Graphite Furnace Atomic Absorption

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
Antimony	Water	SM 3113B	EPA 204.2 SM 3113B	EPA 7041	---
	Waste	---	---	EPA 7041	---
	Solid	---	EPA 204.2 SM 3113B	EPA 7041	---
Arsenic	Water	SM 3113B	EPA 206.2 SM 3113B	EPA 7060A	---
	Waste	---	---	EPA 7060A	---
	Solid	---	EPA 206.2 SM 3113B	EPA 7060A	---
Cadmium	Water	SM 3113B	EPA 213.2 SM 3113B	EPA 7131A	---
	Waste	---	---	EPA 7131A	---
	Solid	---	EPA 213.2 SM 3113B	EPA 7131A	---
Chromium	Water	SM 3113B	EPA 218.2 SM 3113B	EPA 7191	---
	Waste	---	---	EPA 7191	---
	Solid	---	EPA 218.2 SM 3113B	EPA 7191	---
Lead	Water	SM 3113B	EPA 239.2 SM 3113B	EPA 7421	---
	Waste	---	---	EPA 7421	---
	Solid	---	EPA 239.2 SM 3113B	EPA 7421	---
Selenium	Water	SM 3113B	EPA 270.2 SM 3113B	EPA 7740	---
	Waste	---	---	EPA 7740	---

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
Selenium	Solid	---	EPA 270.2 SM 3113B	EPA 7740	---
Thallium	Water	SM 3113B	EPA 279.2	EPA 7841	---
	Waste	---	---	EPA 7841	---
	Solid	---	EPA 279.2	EPA 7841	---

TABLE 8.2-3 (cont.)
Methods for Metals by ICP

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
Aluminum	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Antimony [1]	Water	---	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Arsenic [1]	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Barium	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Beryllium	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Boron	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Calcium	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Cadmium [1]	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Cobalt	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Chromium	Water	EPA 200.7	EPA 200.7	EPA 6010B	---

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Copper	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Iron	Water	EPA 200.7	EPA 200.7	EPA 6010B	
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Lead [1]	Water	---	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Lithium	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Magnesium	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Manganese	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Molybdenum	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Nickel	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Phosphorous	Water	EPA 20.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Potassium	Water	EPA 200.7	EPA 200.7	EPA 6010B	---

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
	Waste	---	---	EPA 6010B	---
	Solid	---	---	EPA 6010B	---
Selenium [1]	Water	---	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Silicon	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	----	---	EPA 6010B	---
Silver	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Sodium	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	---	EPA 6010B	---
Strontium	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Tin	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Thallium [1]	Water	---	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---
Titanium	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	---	EPA 6010B	---
Vanadium	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	---	EPA 6010B	---
Zinc	Water	EPA 200.7	EPA 200.7	EPA 6010B	---
	Waste	---	---	EPA 6010B	---
	Solid	---	EPA 200.7	EPA 6010B	---

Footnotes

[1] These metals are usually analyzed by Trace ICP.

TABLE 8.2-3 (cont.)
Methods for Metals by ICP/MS

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
Antimony Arsenic Barium Beryllium Cadmium Chromium Cobalt Copper Lead Manganese Molybdenum Nickel Selenium Silver Thallium Tin Uranium Vanadium Zinc	Water	200.8	200.8	EPA 6020	---
Arsenic Barium Cadmium Chromium Lead Selenium Silver Thallium	TCLP Leachate	---	---	EPA 6020	---

TABLE 8.2-3 (cont.)
Metals Sample Preparation Methods

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
Toxicity Characteristic Leaching Procedure (TCLP)	Water	---	---	EPA 1311	---
	Waste	---	---	EPA 1311	---
	Solid	---	---	EPA 1311	---
ICP Metals	Water	EPA 200.7	EPA 200.7	EPA 3005A EPA 3010A	---
	TCLP Leachate	---	---	EPA 3010A	---
	Waste	---	---	EPA 3050B	---
	Solid	---	---	EPA 3050B	---
CVAA	Water	EPA 245.1	EPA 245.1	EPA 7470A	---
	TCLP Leachate	---	---	EPA 7470A	---
	Waste	---	---	EPA 7471A	---
	Solid	---	---	EPA 7471A	
GFAA Metals	Water	Sample preparation procedures are detailed in the determinative EPA for each element.	Sample preparation procedures are detailed in the determinative EPA for each element.	EPA 3020A	---
	TCLP Leachate	---	---	EPA 3020A	---
	Waste	---	---	EPA 3020A	---
	Solid	---	---	EPA 3050B	---

TABLE 8.2-3 (cont.)
Organic Sample Preparation and Analysis Methods

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
Volatiles by GC/MS	Water	EPA 524.2	EPA 624	EPA 5030B	---
	Waste	---	---	EPA 5030B EPA 5035	---
	Solid	---	---	EPA 5035	---
Halogenated Volatiles by GC	Water	---	EPA 601	EPA 5030B	---
	Waste	---	---	EPA 5030B EPA 5035	---
	Solid	---	---	EPA 5035	---
Aromatic Volatiles by GC	Water	---	EPA 602	EPA 5030B	---
	Waste	---	---	EPA 5030B EPA 5035	---
	Solid	---	---	EPA 5035	---
Semivolatiles by GC/MS	Water	---	EPA 625	EPA 3510C EPA 3520C	---
	TCLP Leachate	---	---	EPA 3510C EPA 3520C	---
	Waste	---	---	EPA 3550B EPA 3580A	---
	Solid	---	---	EPA 3550B EPA 3580A	---
Pesticides/ PCBs by GC	Water	---	EPA 608	EPA 3510C EPA 3520C	---
	TCLP Leachate	---	---	EPA 3510C EPA 3520C	---
	Waste	---	---	EPA 3550B EPA 3580A	---
	Solid	---	---	EPA 3550B	---
Pesticides (Organophos-phorus) by GC	Water	---	---	EPA 3510C EPA 3520C	---
	TCLP Leachate	---	---	EPA 3510C EPA 3520C	---
	Waste	---	---	EPA 3540C	---
	Solid	---	---	EPA 3540B	---

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
PAHs by GC	Water	---	---	EPA 3510C EPA 3520C	---
	Solid	---	---	EPA 3550B	---
PAHs by HPLC	Water	---	---	EPA 3510C EPA 3520C	---
	Solid	---	---	EPA 3550B	---
Herbicides by GC	Water	---	EPA 615	EPA 8151A	---
	Waste	---	---	EPA 8151A	---
	Solid	---	---	EPA 8151A	---
Total Petroleum Hydrocarbons (gasoline range) by GC	Water	---	---	EPA 5030B	---
	Waste	---	---	EPA 5030B EPA 5035	---
	Solid	---	---	EPA 5035 EPA 5035	---
Total Petroleum Hydrocarbons (diesel range) by GC	Water	---	---	EPA 3510C EPA 3520C	---
	TCLP Leachate	---	---	EPA 3510C EPA 3520C	---
	Waste	---	---	EPA 3550B EPA 3580A	---
	Solid	---	---	EPA 3550B	---

TABLE 8.2-3 (cont.)
Organic Methods

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
Volatiles by GC/MS	Water	EPA 524.2	EPA 624	EPA 8260B	---
	Waste	---	---	EPA 8260B	---
	Solid	---	---	EPA 8260B	---
Halogenated Volatiles by GC	Water	---	EPA 601	EPA 8021B	---
	Waste	---	---	EPA 8021B	---
	Solid	---	---	EPA 8021B	---
Aromatic Volatiles by GC	Water	---	EPA 602	EPA 8021B	---
	Waste	---	---	EPA 8021B	---
	Solid	---	---	EPA 8021B	---
Semivolatiles by GC/MS	Water	---	EPA 625	EPA 8270C	
	Waste	---	---	EPA 8270C	---
	Solid	---	---	EPA 8270C	---

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
Pesticides/ PCBs by GC	Water	---	EPA 608	Pesticides 8081A PCBs 8082	---
	TCLP Leachate	---	---	Pesticides 8081A PCBs 8082	---
	Waste	---	---	Pesticides 8081A PCBs 8082	---
	Solid	---	---	Pesticides 8081A PCBs 8082	---
Pesticides (Organophos-phorus) by GC	Water	---	---	EPA 8141A	---
	Waste	---	---	EPA 8141A	---
	Solid	---	---	EPA 8141A	---
PAHs by GC	Water	---	---	EPA 8310	---
	Waste	---	---	EPA 8310	---
	Solid	---	---	EPA 8310	---
Phenoxyacid Herbicides by GC	Water	---	EPA 615	EPA 8151A	---
	TCLP Leachate	---	---	EPA 8151A	---
	Waste	---	---	EPA 8151A	---
	Solid	---	---	EPA 8151A	---
Gasoline Range Organics by GC	Water	---	---	EPA 8015B (M)	API Method CA LUFT
	Waste	---	---	EPA 8015B (M)	---
	Solid	---	---	EPA 8015B (M)	API Method CA LUFT
Total Petroleum Hydrocarbons (diesel range) by GC/FID	Water	---	---	EPA 8015B (M)	EPA API
	Waste	---	---	EPA 8015B (M)	---
	Solid	---	---	EPA 8015B (M)	API Method CA LUFT

Analytical Parameters	Matrix	Fields of Testing			
		SDWA	CWA	RCRA (SW846)	Other
Hydrocarbons by GC/FID	Water	---	---	EPA 8015B	---
	Solid	---	---	EPA 8015B	---
Explosives by HPLC	Water	---	---	EPA 8330	---
	Solid	---	---	EPA 8330	---

TABLE 8.2-4-1
Wet Chemistry Methods, Method Detection Limits (MDL) and Reporting Limits (RL)(1)

Parameter	CAS Number	Method	Water MDL Date	Water MDL mg/L	Soil MDL Date	Soil MDL mg/kg	Water RL mg/L	Soil RL mg/Kg
Acidity	76-40-0	EPA 305.1	3/10/00	2.0	---	---	10	--
Alkalinity	477520-60-0	EPA 310.1	8/19/98	0.50	4/3/97	6.9	5	50
Biochemical Oxygen Demand	1-00-2	EPA 405.1	5/14/98	0.23	N/A	N/A	2.0	N/A
Bromide	28-20-0	EPA 300.0	9/18/99	0.022		---	0.2	---
		SW846 9056	9/18/99	0.022		0.22*	0.2	2.0
Chemical Oxygen Demand (COD)	1-00-4	410.4 (Hach)	6/15/00	4.06	N/A	N/A	20	N/A
Chloride	1-00-3	EPA 300.0	9/18/99	0.10		1.0*	3.0	30
		SW846 9056	9/18/99	0.10		1.0*	3.0	30
		EPA 325.3	8/18/99	0.36		---	2.5	---
Chromium, hexavalent	18540-29-9	3500-Cr-D	2/22/00	0.0042			0.01	
		SW846 7196A	6/7/00	0.003	6/7/00	0.03	0.01	0.10
Conductivity, specific	1-01-1	EPA 120.1	N/A	N/A	N/A	N/A	2 µmhos/cm	2 µmhos/cm
		SW846 9050	N/A	N/A	N/A	N/A		
Cyanide	5955-70-0	9010B/9012A	12/15/99	0.0065	6/1/00	0.12	0.01	0.50
		EPA 335.3						
Fluoride	66-30-0	EPA 300.0	9/18/99	0.035	---	---	1.0	---
		SW846 9056	9/18/99	0.035	9/18/99	0.35*	1.0	10
		EPA 340.2	2/4/99	0.01	---	---	0.1	---
Hardness	35-50-0	SM 2340B	2/16/00	0.16	---	---	5.0	---
Ignitability	1-01-3	SW846 1010	---	---	---	---	---	---
Nitrogen, Ammonia	310-90-0	EPA 350.1	6/12/00	0.031	---	0.29*	0.1	1.0
Nitrite as N	15-90-0	EPA 300.0	9/18/99	0.020	---	---	0.50	---
		SW846 9056	9/18/99	0.020	---	0.20*	0.50	5.0
Nitrate plus Nitrite	1-00-5	EPA 353.2	6/1/00	0.021	6/1/00	0.21	0.1	1.0
Nitrate as N	25-90-0	EPA 300.0	9/18/99	0.020	---	---	0.5	---
		SW846 9056	9/18/99	0.020	---	0.20*	0.5	5.0
Nitrogen, Total Kjeldahl	5228003-90-0	EPA 351.2	8/22/00	0.246	8/22/00	9.435	0.5	50
Oil and Grease	1-00-7	EPA 1664 (HEM)	5/5/99	1.94		N/A	5.0	N/A

TABLE 8.2-4-1
Wet Chemistry Methods, Method Detection Limits (MDL) and Reporting Limits (RL)(1)
(Continued)

Parameter	CAS Number	Method	Water MDL Date	Water MDL mg/L	Soil MDL Date	Soil MDL mg/kg	Water RL mg/L	Soil RL mg/Kg
Orthophosphate	226750-80-0	EPA 365.3	6/9/00	0.0154	---	---	0.05	0.5
		EPA 300.0	9/18/99	0.020	---	---	0.50	---
		SW846 9056	9/18/99	0.020	---	0.20*	0.50	5.0*
Phosphorus, total	6791520-80-0	EPA 365.3	6/22/00	0.0216	8/19/97	0.63	0.05	5
Phenolics, total recoverable	54-30-0	EPA 420.2	4/29/98	0.013	---	---	0.02	---
		SW846 9066	4/29/98	0.013	7/18/97	0.57	0.02	2.0
Sulfate	3-03-5	EPA 300.0	9/18/99	0.10			5.0	---
		SW846 9056	9/18/99	0.10	---	1.0*	5.0	50
		EPA 375.4	7/17/00	2.31		---	5.0	---
		SW846 9038	7/17/00	2.31	---	--	5.0	--
Sulfide	1055-70-0	EPA 376.2	6/12/00	0.007	---	---	1.0	---
		SW846 9034	7/19/00	0.51	7/20/00	1.04	4.0	5.0
		SW846 Section 7.3	---	---	---	---	50	50
Sulfite	18-20-0	EPA 377.1	6/12/96	0.84	---	---	2	
Total Organic Carbon (TOC)	1-01-2	EPA 415.1	5/17/00	0.37	---	---	1.0	---
		SW846 9060	5/17/00	0.37	5/17/00	648	1.0	2000
Total Organic Halides (TOX)	59473-04-0	SW846 9020B	12/23/98	0.0028	4/2/97	0.075	0.01	0.3
Total Recoverable Petroleum Hydrocarbons	5289290-40-0	EPA 1664 (SGT-HEM)	5/6/99	2.9	N/A	N/A	5.0	N/A
Total Dissolved Solids	1-01-0	EPA 160.1	4/7/98	5.36	N/A	N/A	10	N/A
Total Suspended Solids	1-00-9	EPA 160.2	1/13/99	1.23	N/A	N/A	4.0	N/A
Total Solids	1-00-8	EPA 160.3	2/11/98	4.34	---	---	10	0.1%
Volatile Suspended Solids	8279840-70-0	EPA 160.4	---	---	N/A	N/A	10	N/A
Settleable Solids	3069938-50-0	EPA 160.5	---	---	N/A	N/A	1mL/L	N/A
		SM 2540F	---	---	N/A	N/A	1mL/L	N/A
Turbidity	3-01-6	EPA 180.1	8/14/00	0.025 NTU	N/A	N/A	0.10 NTU	N/A

Footnotes

TABLE 8.2-4-1
Wet Chemistry Methods, Method Detection Limits (MDL) and Reporting Limits (RL)(1)
(Continued)

1 Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

*The soil MDL was calculated based on the water MDL, assuming a leaching factor of 10.

TABLE 8.2-4-2
GFAA Metals and Mercury by Cold Vapor AA
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]

Element	CAS Number	Water MDL (µg/L)	Soil MDL (mg/Kg)	Water RL (µg/L)	Soil RL (mg/Kg)
Arsenic	7440-38-2	0.65	--	10	--
Lead	7439-92-1	1.3	0.078	3	0.3
Selenium	7782-49-2	0.82	0.271	10	0.5
Thallium	7440-28-0	1.4	0.246	10	1
Antimony	7440-36-0	1.2	0.365	10	1
Cadmium	7440-43-9	0.13	0.015	1	0.1
Chromium	7440-47-3	0.53	0.053	5	0.5
Silver	7440-22-4	0.18	0.023	1	0.1
Mercury[3]	7439-97-6	0.028	0.0037	0.2	0.033

Footnotes

[1] Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The MDL studies for waters for the GFAA metals were analyzed 82/00 & 8/3/00. The MDL studies for soils for the GFAA metals were analyzed between 4/1/99 and 5/6/99. The MDL studies for mercury were completed on 3/4/99 (water) and 4/12/99 (soil).

[3] Analyzed by Cold Vapor AA. Soil MDL run on 3/21/00. Water MDL run on 3/23/00.

TABLE 8.2-4-3
Conventional ICP Metals Methods 6010B/200.7
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[2]

Element	CAS Number	Water MDL (µg/L)	Soil MDL[5] (mg/Kg)	Water RL (µg/L)	Soil RL[5] (mg/Kg)
Aluminum	7429-90-5	22	3.1	100	10
Antimony	7440-36-0	N/A	N/A	N/A	N/A
Arsenic[3]	7440-38-2	N/A	N/A	N/A	N/A
Barium	7440-39-3	1.5	0.12	10	1
Beryllium	7440-41-7	0.50	0.14	5	0.5
Boron	7440-42-8	6.2	0.51	100	10
Cadmium[3]	7440-43-9	N/A	N/A	N/A	N/A
Calcium	7440-70-2	48	3.2	200	20
Chromium	7440-47-3	2.1	0.44	10	1
Cobalt	7440-48-4	N/A	N/A	N/A	N/A
Copper	7440-50-8	2.1	0.27	10	2
Iron	7439-89-6	12	2.0	100	10
Lead[3]	7439-92-1	N/A	N/A	N/A	N/A
Lithium	7439-93-2	2.19	0.22	10	5
Magnesium	7439-95-4	11	1.53	200	20
Manganese	7439-96-5	0.85	0.14	10	1
Molybdenum	7439-98-7	N/A	N/A	N/A	N/A
Nickel	7440-02-0	3.8	0.72	40	4
Phosphorus	7723-14-0	61	4	3000	300
Potassium	7440-09-7	180	31	3000	300
Selenium[3]	7782-49-2	N/A	N/A	N/A	N/A
Silica as SiO_2	7404-20-0	14	N/A	500	N/A
Silver	7440-22-4	N/A	N/A	N/A	N/a
Sodium	7440-23-5	350	120	5000	500
Strontium	7440-24-6	0.50	0.15	10	1
Thallium[3]	7440-28-0	N/A	N/A	N/A	N/A
Tin	7440-31-5	N/A	N/A	N/A	N/A

TABLE 8.2-4-3
Conventional ICP Metals Methods 6010B/200.7
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[2]
(continued)

Element	CAS Number	Water MDL (µg/L)	Soil MDL (mg/Kg)	Water RL (µg/L)	Soil RL (mg/Kg)
Titanium	7440-32-6	0.50	0.20	10	1
Vanadium	7440-62-2	1.6	0.35	10	1
Zinc	7440-66-6	2.7	0.73	20	2

Footnotes

[1] Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2]The MDL studies were completed on 2/16/00 (waters) and 4/1/99 and 2/16/00 (soils).

[3]These elements are routinely analyzed by GFAA or Trace ICP, refer to those tables for laboratory RLs and MDLs.

TABLE 8.2-4-4
Trace ICP Metals – Methods 6010B/200.7
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]

Element	CAS Number	Water MDL (µg/L)	Soil MDL (mg/Kg)	Water RL (µg/L)	Soil RL (mg/Kg)
Antimony	7440-36-0	3.4	0.35	10	1
Arsenic	7440-38-2	3.6	0.49	10	1
Cadmium	7440-43-9	0.50	0.10	5	0.5
Lead	7439-92-1	1.8	0.39	3	0.8
Selenium	7782-49-2	4.4	0.45	5	1.3
Thallium	7440-42-8	4.9	0.42	10	1.2

Footnotes

[1] Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The MDL studies were completed on 3/2/00 and 7/23/00 (Waters) and 2/17/00 and 8/29/00 (Soils)

TABLE 8.2-4-5
ICP/MS Metals - Methods 6020/200.8
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[2]

Element	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (mg/Kg)
Antimony	7440-36-0	0.2	20	2.0	0.2
Arsenic	7440-38-2	0.2	7.6	5.0	0.5
Barium	7440-39-3	0.092	26.5	1.0	0.1
Beryllium	7440-41-7	0.2	2.3	1.0	0.1
Cadmium	7440-43-9	0.057	2.7	1.0	0.1
Chromium	7440-47-3	0.212	33.6	2.0	0.2
Cobalt	7440-48-4	0.200	2.2	1.0	0.1
Copper	7440-50-8	0.165	61.4	2.0	0.2
Lead	7439-92-1	0.228	20.0	1.0	0.1
Manganese	7439-96-5	0.076	25.2	1.0	0.1
Molybdenum	7439-98-7	0.200	2.0	2.0	0.2
Nickel	7440-02-0	0.200	11.1	2.0	0.1
Selenium	7782-49-2	1.14	18.0	5.0	0.5
Silver	7440-22-4	0.054	2.0	1.0	0.1
Thallium	7440-28-0	0.020	2.0	1.0	0.1
Tin	7440-31-5	2.0	1.97	10	1.0
Uranium	7440-61-1	0.020	2.0	1.0	0.1
Vanadium	7440-62-2	0.20	7.0	5.0	0.5
Zinc	7440-66-6	7.064	125	10	1.0

Footnotes

[1] Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The MDL studies were completed on 3/23/00 and 4/20/00 for waters and 3/17 – 22/99 for soils.

TABLE 8.2-4-6
Method 601 CWA Halogenated Volatile Organics
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Bromodichloromethane	75-27-4	0.151	1.0
Bromoform	75-25-2	0.236	5.0
Bromomethane	74-83-9	0.164	5.0
Carbon Tetrachloride	56-23-5	0.133	0.5
Chlorobenzene	108-90-7	0.270	2.0
Chloroethane	75-00-3	0.201	5.0
2-Chloroethylvinyl ether	110-75-8		
Chloroform	67-66-3	0.167	0.5
Chloromethane	74-87-3	0.158	5.0
1,2-Dichlorobenzene	95-50-1	0.406	0.5
1,3-Dichlorobenzene	541-73-1	0.341	0.5
1,4-Dichlorobenzene	106-46-7	0.259	0.5
Dichlorodifluoromethane	75-71-8	0.434	5.0
1,1-Dichloroethane	75-34-3	0.050	0.5
1,2-Dichloroethane	107-06-2	0.241	1.0
1,1-Dichloroethene	75-35-4	0.142	0.5
trans-1,2-Dichloroethene	156-60-5	0.099	0.5
cis-1,2-Dichloroethene	156-59-2	0.070	0.5
1,2-Dichloropropane	78-87-5	0.240	1.0
cis-1,3-Dichloropropene	10061-01-5	0.141	2.0
trans-1,3-Dichloropropene	10061-02-6	0.178	1.0
Dibromochloromethane	124-48-1	0.184	1.0
Methylene Chloride	75-09-2	0.182	5.0
1,1,2,2-Tetrachloroethane	79-34-5	0.402	1.0
Tetrachloroethene	127-18-4	0.178	0.5
1,1,1-Trichloroethane	71-55-6	0.106	0.5
1,1,2-Trichloroethane	79-00-5	0.296	1.0
Trichloroethene	79-01-6	0.160	0.5

TABLE 8.2-4-6
Method 601 CWA Halogenated Volatile Organics(1)
Method Detection Limits (MDL)(2) and Reporting Limits (RL)(3)
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Trichlorofluoromethane	75-69-4	0.055	5.0
Vinyl Chloride	75-01-4	0.150	1.0

Footnotes

[1] Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The Method Detection Limit study was completed in August 1999.

TABLE 8.2-4-7
Method 8021B Halogenated and Aromatic Volatile Organics
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (µg/Kg)
Halogenated Compounds					
Bromodichloromethane	75-27-4	0.151	7.0	1.0	100
Bromoform	75-25-2	0.236	17	5.0	500
Bromomethane	74-83-9	0.164	7.2	5.0	500
Carbon Tetrachloride	56-23-5	0.133	7.4	0.5	50
Chlorobenzene	108-90-7	0.270	33	2.0	200
Chloroethane	75-00-3	0.201	11	5.0	500
2-Chloroethyl vinyl ether	110-75-8		6.9	5.0	500
Chloroform	67-66-3	0.167	5.5	0.5	50
Chloromethane	74-87-3	0.158	11	5.0	500
Dibromochloromethane	124-48-1	0.184	12	1.0	100
1,2-Dibromoethane (EDB)	106-93-4	0.380	11	2.0	100
1,2-Dichlorobenzene	95-50-1	0.406	33	2.0	100
1,3-Dichlorobenzene	541-73-1	0.341	22	2.0	100
1,4-Dichlorobenzene	106-46-7	0.259	25	2.0	100
Dichlorodifluoromethane	75-71-8	0.434	26	5.0	500
1,1-Dichloroethane	75-34-3	0.050	5.7	0.5	50
1,2-Dichloroethane	107-06-2	0.241	11	1.0	100
1,1-Dichloroethene	75-35-4	0.142	5.0	0.5	50
trans-1,2-Dichloroethene	156-60-5	0.099	8.8	0.5	50
cis-1,2-Dichloroethene	156-59-2	0.070	6.6	0.5	50
1,2-Dichloropropane	78-87-5	0.240	7.6	1.0	100
cis-1,3-Dichloropropene	10061-01-5	0.141	7.0	2.0	200
trans-1,3-Dichloropropene	10061-02-6	0.178	11	1.0	100
Methylene Chloride	75-09-2	0.182	16	5.0	500
1,1,2,2-Tetrachloroethane	79-34-5	0.402	23	1.0	100
Tetrachloroethene	127-18-4	0.148	7.5	0.5	50

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (µg/Kg)
1,1,1-Trichloroethane	71-55-6	0.106	7.6	0.5	50
1,1,2-Trichloroethane	79-00-5	0.296	12	1.0	100
Trichloroethene	79-01-6	0.160	6.3	0.5	50
Trichlorofluoromethane	75-69-4	0.055	11	5.0	500
1,1,2-Trichloro-1,2,2-trifluoromethane	76-13-1	0.182	15	0.5	100
Vinyl Chloride	75-01-4	0.150	6.4	1.0	100
Aromatic Compounds					
Benzene	71-43-2	0.057	2.50	0.50	50
Chlorobenzene	108-90-7	0.050	2.50	0.50	50
1,2-Dichlorobenzene	95-50-1	0.054	2.72	0.50	50
1,3-Dichlorobenzene	541-73-1	0.085	4.26	0.50	50
1,4-Dichlorobenzene	106-46-7	0.075	2.66	0.50	50
Ethylbenzene	100-41-4	0.051	2.50	0.50	50
tert-Methyl-butyl ether (MTBE)	1634-04-4	0.070	9.11	5.0	50
Toluene	108-88-3	0.053	2.58	1.24	50
m- & p-Xylene	61-30-0	0.123	2.50	1.0	50
o-Xylene	95-47-6	0.160	3.32	0.50	50
Xylene (total)	1330-20-7	0.250	5.00	1.5	50

Footnotes

[1] Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The Method Detection Limit studies were completed on 8/2 and 24/99 (halogenated – waters), 10/21/96 (halogenated – soils), 1/5/00 (aromatics - waters), and 2/16/00 (aromatics - soils).

TABLE 8.2-4-8
Gasoline and Diesel Range Organics
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[4] (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
Gasoline (by purge and trap) API Method	3999176-70-0	2.00	100	25	1200
Gasoline (by purge and trap) 8015 Modified	3999176-70-0	3.84	151	10	500
Diesel (by extraction) 8015 Modified	3948788-70-0	19	3600	250	10000

Footnotes

[1] Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The MDL studies for gasoline in water were completed on 3/15/00 (8015M) and 9/10/97 (API). The MDL studies for gasoline in soil were completed on 2/7/00 (8015M) and 9/12/97 (API). The MDL study for diesel in water was completed on 1/11/00 and in soil on 7/31/00.

TABLE 8.2-4-9
Method 602 CWA Aromatic Volatile Organics
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Benzene	71-43-2	0.057	0.50
Chlorobenzene	108-90-7	0.050	0.50
Ethylbenzene	100-41-4	0.051	0.50
1,2-Dichlorobenzene	95-50-1	0.054	0.50
1,3-Dichlorobenzene	541-73-1	0.085	0.50
1,4-Dichlorobenzene	106-46-7	0.075	0.50
tert-Methyl-butyl ether (MTBE)	1634-04-4	0.070	5.0
Toluene	108-88-3	0.053	0.50
m- & p-Xylene	61-30-0	0.123	0.50
o-Xylene	95-47-6	0.160	0.50
Xylene (total)	1330-20-7	0.250	0.50

Footnotes

[1] Specific quantitation limits (MDL and RL) are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The Method Detection Limit study was completed on 1/5/00.

TABLE 8.2-10
Method 608 CWA Pesticides and PCBs
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Aldrin	309-00-2	0.011	0.050
a-BHC	319-84-6	0.005	0.050
b-BHC	319-85-7	0.006	0.050
d-BHC	319-86-8	0.007	0.050
g-BHC (Lindane)	58-89-9	0.006	0.050
Chlordane, Technical	57-74-9	0.056	0.50
4,4'-DDD	72-54-8	0.022	0.10
4,4'-DDE	72-55-9	0.006	0.10
4,4'-DDT	50-29-3	0.009	0.10
Dieldrin	60-57-1	0.006	0.10
Endosulfan I	959-98-8	0.006	0.050
Endosulfan II	33213-65-9	0.008	0.10
Endosulfan sulfate	1031-07-8	0.011	0.10
Endrin	72-20-8	0.033	0.10
Endrin Aldehyde	7421-93-4	0.008	0.10
Heptachlor	76-44-8	0.006	0.050
Heptachlor Epoxide	1024-57-3	0.005	0.050
Aroclor 1016	12674-11-2	0.10	1.0
Aroclor 1221	11104-28-2	0.21	2.0
Aroclor 1232	11141-16-5	0.42	1.0
Aroclor 1242	53469-21-9	0.38	1.0
Aroclor 1248	12672-29-6	0.43	1.0
Aroclor 1254	11097-69-1	0.13	1.0
Aroclor 1260	11096-82-5	0.10	1.0
Toxaphene	8001-35-2	0.78	5.0

Footnotes

[1] Specific quantitation limits (MDL and RL) are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The MDL study for single component pesticides was completed on 12/12/99, except for Tecchnical Chlordane which was completed on 2/17/96 and Toxaphene which was completed on 6/6/00. The MDL study for PCBs was completed on 1/11/00.

TABLE 8.2-11
Method 8081A Target Compound List and Appendix IX Pesticides
Method Detection Limit (MDL)(1) and Reporting Limits (RL)(1)

Analyte	CAS Number	Water MDL (µg/L)	Water MDL Study Date	Soil MDL (µg/Kg)	Soil MDL Study Date	Water RL (µg/L)	Soil RL (µg/Kg)
Aldrin	309-00-2	0.011	12/22/99	0.62	3/16/00	0.050	1.7
a-BHC	319-84-6	0.005	12/22/99	0.17	3/16/00	0.050	1.7
b-BHC	319-85-7	0.006	12/22/99	0.17	3/16/00	0.050	1.7
d-BHC	319-86-8	0.007	12/22/99	0.17	3/16/00	0.050	1.7
g-BHC (Lindane)	58-89-9	0.006	12/22/99	0.17	3/16/00	0.050	1.7
Chlordane (Tech)	57-74-9	0.056	2/17/96	2.5	2/17/96	0.50	17
a-Chlordane	5103-71-9	0.006	12/22/99	0.17	3/16/00	0.050	1.7
g-Chlordane	5103-74-2	0.006	12/22/99	0.52	3/16/00	0.050	1.7
Chlorobenzilate	510-15-6	0.10	7/7/99	2.95	7/13/99	2.0	33
4,4'-DDD	72-54-8	0.022	12/22/99	0.17	3/16/00	0.10	1.7
4,4'-DDE	72-55-9	0.006	12/22/99	0.17	3/16/00	0.10	1.7
4,4'-DDT	50-29-3	0.009	12/22/99	0.39	3/16/00	0.10	1.7
Diallate	2303-16-4	0.26	7/7/99	5.76	7/13/99	1.0	33
Dieldrin	60-57-1	0.006	7/7/99	0.17	3/16/00	0.05	1.7
Endosulfan I	959-98-8	0.006	12/22/99	0.17	3/16/00	0.050	1.7
Endosulfan II	33213-65-9	0.008	12/22/99	0.17	3/16/00	0.10	1.7
Endosulfan sulfate	1031-07-8	0.011	12/22/99	0.81	3/16/00	0.10	1.7
Endrin	72-20-8	0.033	12/22/99	0.17	3/16/00	0.10	1.7
Endrin Aldehyde	7421-93-4	0.008	12/22/99	0.17	3/16/00	0.10	1.7
Endrin ketone	53494-70-5	0.012	12/22/99	0.17	3/16/00	0.10	1.7
Heptachlor	76-44-8	0.006	12/22/99	0.17	3/16/00	0.050	1.7
Heptachlor Epoxide	1024-57-3	0.005	12/22/99	0.17	3/16/00	0.050	1.7
Isodrin	465-73-6	0.015	7/7/99	0.45	7/13/99	0.10	1.7
Kepone	143-50-0	0.15	1/13/00	0.83	1/18/99	1.0	33
Methoxychlor	72-43-5	0.014	12/22/99	0.17	3/16/00	0.1	3.3
Toxaphene	8001-35-2	0.78	6/6/00	1.17	6/3/00	2.0	17

Footnotes

[1] Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

TABLE 8.2-12
Method 8082 PCBs
Method Detection Limit (MDL)[1,2] and Reporting Limits (RL)[1]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (µg/Kg)
Aroclor 1016	12674-11-2	0.10	11	1.0	33
Aroclor 1221	11104-28-2	0.21	8.3	1.0	33
Aroclor 1232	11141-16-5	0.42	3.4	1.0	33
Aroclor 1242	53469-21-9	0.38	3.3	1.0	33
Aroclor 1248	12672-29-6	0.43	4.2	1.0	33
Aroclor 1254	11097-69-1	0.13	4.6	1.0	33
Aroclor 1260	11096-82-5	0.10	18	1.0	33

Footnotes

[1] Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The MDL studies were completed on 1/11/00 (water) and 12/8/99 (soil).

TABLE 8.2-13
Method 8141A Target Compound List and Appendix IX Pesticides
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL[4] (µg/Kg)	Water RL (µg/L)	Soil RL[4] (µg/Kg)
Azinphos methyl (Guthion)	86-50-0	0.073	4.12	2.5	83
Bolstar (Sulprofos)	35400-43-2	0.044	1.96	0.5	17
Chlorpyrifos (Dursban)	2921-88-2	0.051	2.92	0.5	8.3
Coumaphos	56-72-4	0.074	2.48	0.5	17
Demeton, o,s (total)	8065-48-3	0.44	6.43	0.5	8.3
Diazinon	333-41-5	0.061	1.97	0.5	8.3
Dichlorvos (Vapona)	62-73-7	0.17	4.46	0.5	17
Dimethoate	60-51-5	0.096	3.75	0.5	17
Disulfoton (Disyston)	298-04-4	0.20	2.09	0.5	8.3
Ethoprop	13194-48-4	0.12	2.99	0.5	8.3
Ethyl parathion	56-38-2	0.077	1.49	0.5	8.3
Famphur	52-85-7	0.16	2.55	1.0	33
Fensulfothion	115-90-2	0.11	5.7	2.5	30
Fenthion (Baytex)	55-38-9	0.19	5.81	0.5	8.3
Malathion	121-75-5	0.11	4.97	1.2	20
Merphos	150-50-5	1.0	5.55	0.5	8.3
Methyl parathion	298-00-0	0.078	4.94	0.5	8.3
Mevinphos (Phosdrin)	7786-34-7	0.097	3.48	6.2	30
Naled (Dibrom)	300-76-5	1.1	82.32	10	250
o,o,o-Triethylphosphorothioate	126-68-1	0.41	2.17	0.5	8.3
Phorate (Thimet)	298-02-2	0.078	2.21	0.5	8.3
Ronnel	299-84-3	0.097	3.8	10	8.3
Sulfotepp	3689-24-5	0.044	1.98	0.5	8.3
Tetrachlorovinphos (Stirophos)	961-11-5	0.050	2.66	2.5	30
Thionazin	297-97-2	0.068	2.13	0.5	8.3
Tokuthion (Prothiophos)	53-10-0	0.092	2.01	0.5	8.3
Trichloronate	327-98-0	0.075	2.19	0.5	8.3

Footnotes

[1] Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The MDL studies were completed on 7/17/99 and 5/15/00 for waters and 11/17/99 and 1/15/00 for soils.

TABLE 8.2-14
Method 8151A Herbicides
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (µg/Kg)
2,4-D	94-75-7	0.30	11.2	4.0	80
2,4-DB	94-82-6	0.86	22.2	4.0	80
Dalapon	75-99-0	0.42	6.94	2.0	40
Dicamba	1918-00-9	0.050	1.24	2.0	40
Dichlorprop	120-36-5	0.025	2.03	4.0	80
Dinoseb	88-85-7	0.09	4.60	0.6	12
MCPA	94-74-6	16.9	721	400	8000
MCPP	93-65-2	12.0	515	400	8000
2,4,5-T	93-76-5	0.02	0.89	1.0	20
2,4,5-TP (Silvex)	93-72-1	0.01	0.90	1.0	20

Footnotes

1 Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

2 The MDL studies were completed on 9/24/98 (water) and 10/12/98 (soil).

TABLE 8.2-15
Method 8330 Explosives by HPLC
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[2]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/g)	Water RL (µg/L)	Soil RL (µg/g)
2-Amino-4,6-dinitrobenzene	355-72-78-2	0.182	0.093	0.25	0.25
4-Amino-2,6-dinitrotoluene	1946-51-0	0.144	0.137	0.25	0.25
1,3-Dinitrobenzene	99-65-0	0.134	0.073	0.25	0.25
2,4-Dinitrotoluene	121-14-2	0.142	0.148	0.25	0.25
2,6-Dinitrotoluene	606-20-2	0.155	0.100	0.25	0.25
HMX	2691-41-0	0.100	0.136	0.25	0.25
Nitrobenzene	98-95-3	0.111	0.101	0.25	0.25
Nitroglycerin	55-63-0	0.661	0.051	2.5	5.0
2-Nitrotoluene	88-72-2	0.084	0.199	0.25	0.25
3-Nitrotoluene	99-08-1	0.185	0.237	0.25	0.25
4-Nitrotoluene	99-99-0	0.202	0.160	0.25	0.25
PETN	78-11-5	0.785	0.218	2.5	1.0
RDX	121-82-4	0.204	0.216	0.25	0.25
Tetryl	479-45-8	0.120	0.068	0.50	0.50
1,3,5-Trinitrobenzene	99-35-4	0.166	0.125	0.25	0.25
2,4,6-Trinitrotoluene	118-96-7	0.078	0.128	0.25	0.25

Footnotes

[1] Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The MDL studies were completed on 10/27/99 (water by SPE) and 2/2 - 16/99 (soil).

TABLE 8.2-16
Method 8310 Polynuclear Aromatic Hydrocarbons
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/Kg)	Water RL (µg/L)	Soil RL (µg/Kg)
Acenaphthene	83-32-9	0.26	26.83	1.0	200
Acenaphthylene	208-96-8	0.29	24.33	1.0	200
Anthracene	120-12-7	0.040	5.30	0.10	20
Benzo(a)anthracene	56-55-3	0.042	2.27	0.10	20
Benzo(a)pyrene	50-32-8	0.026	4.59	0.10	20
Benzo(b)fluoranthene	205-99-2	0.026	2.40	0.10	20
Benzo(g,h,i)perylene	191-24-2	0.028	2.68	0.20	40
Benzo(k)fluoranthene	207-08-9	0.012	1.22	0.10	20
Chrysene	218-01-9	0.057	3.52	0.20	40
Dibenzo(a,h)anthracene	53-70-3	0.025	2.47	0.20	40
Fluoranthene	206-44-0	0.031	2.71	0.20	40
Fluorene	86-73-7	0.040	7.37	0.20	40
Indeno(1,2,3-cd)pyrene	193-39-5	0.024	2.40	0.20	40
1-Methylnaphthalene	90-12-0	0.31	24.97	1.0	200
2-Methylnaphthalene	91-57-6	0.34	26.47	1.0	200
Naphthalene	91-20-3	0.30	26.13	1.0	200
Phenanthrene	85-01-8	0.040	5.56	0.20	40
Pyrene	129-00-0	0.048	5.46	0.20	40

Footnotes

[1] Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The MDL studies were completed on 3/17/00.

TABLE 8.2-17
Method 524.2 Purgeable Organic Compounds in Water by GC/MS
Method Detection Limits (MDL)(1,2) and Reporting Limits (RL)(2)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Benzene	71-43-2	0.10	1.0
Bromobenzene	108-86-1	0.10	1.0
Bromochloromethane	74-97-5	0.13	1.0
Bromodichloromethane	124-48-1	0.11	1.0
Bromoform	75-25-2	0.11	1.0
Bromomethane	74-83-9	0.15	2.0
n-Butylbenzene	104-51-8	0.10	1.0
sec-Butylbenzene	135-98-8	0.10	1.0
tert-Butylbenzene	98-06-6	0.10	1.0
Carbon tetrachloride	56-23-5	0.10	1.0
Chlorobenzene	108-90-7	0.10	1.0
Chloroethane	75-00-3	0.10	2.0
Chloroform	67-66-3	0.10	1.0
Chloromethane	74-87-3	0.21	2.0
2-Chlorotoluene	95-49-8	0.10	1.0
4-Chlorotoluene	106-43-4	0.14	1.0
Dibromochloromethane	75-27-4	0.10	1.0
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	0.28	2.0
1,2-Dibromoethane (EDB)	106-93-4	0.16	1.0
Dibromomethane	74-95-3	0.15	1.0
1,2-Dichlorobenzene	95-50-1	0.12	1.0
1,3-Dichlorobenzene	541-73-1	0.15	1.0
1,4-Dichlorobenzene	106-46-7	0.10	1.0
Dichlorodifluoromethane	75-71-8	0.16	2.0
1,1-Dichloroethane	75-34-3	0.10	1.0
cis-1,2-Dichloroethene	156-59-2	0.11	0.5
trans-1,2-Dichloroethene	156-60-5	0.12	0.5
1,2-Dichloroethane	107-06-2	0.14	1.0

TABLE 8.2-17
Method 524.2 Purgeable Organic Compounds in Water by GC/MS
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
1,1-Dichloroethene	75-35-4	0.14	1.0
1,2-Dichloropropane	78-87-5	0.12	1.0
1,3-Dichloropropane	142-28-9	0.10	1.0
2,2-Dichloropropane	594-20-7	0.10	1.0
1,1-Dichloropropene	563-58-6	0.10	1.0
cis-1,3-Dichloropropene	10061-01-5	0.10	1.0
trans-1,3-Dichloropropene	10061-02-6	0.10	1.0
Ethylbenzene	100-41-4	0.10	1.0
Hexachlorobutadiene	87-68-3	0.14	1.0
Isopropylbenzene	98-82-8	0.10	1.0
4-Isopropyltoluene	99-87-6	0.10	1.0
Methylene Chloride	75-09-2	0.19	1.0
Naphthalene	91-20-3	0.68	1.0
n-Propylbenzene	103-65-1	0.10	1.0
Styrene	100-42-5	0.10	1.0
1,1,1,2-Tetrachloroethane	630-20-6	0.10	1.0
1,1,2,2-Tetrachloroethane	79-34-5	0.23	1.0
Tetrachloroethene	127-18-4	0.10	1.0
Toluene	108-88-3	0.10	1.0
1,2,3-Trichlorobenzene	87-61-6	0.10	1.0
1,2,4-Trichlorobenzene	120-82-1	0.11	1.0
1,1,1-Trichloroethane	71-55-6	0.10	1.0
1,1,2-Trichloroethane	79-00-5	0.18	1.0
Trichloroethene	79-01-6	0.10	1.0
Trichlorofluoromethane	75-69-4	0.15	2.0
1,2,3-Trichloropropane	96-18-4	0.10	1.0
1,2,4-Trimethylbenzene	95-63-6	0.10	1.0
1,3,5-Trimethylbenzene	108-67-8	0.10	1.0

TABLE 8.2-17
Method 524.2 Purgeable Organic Compounds in Water by GC/MS
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Vinyl Chloride	75-01-4	0.13	1.0
m&p-Xylenes	61-30-0	0.13	0.5
o-Xylene	95-47-6	0.11	0.5

Footnotes

[1] Specific quantitation limits (MDL and RL) are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The MDL study was completed on 1/8/99.

TABLE 8.2-18
Method 624 CWA Volatile Organics by GC/MS
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
1,1,1-Trichloroethane	71-55-6	1.37	5.0
1,1,2-Trichloroethane	79-00-5	1.00	5.0
Trichloroethene	79-01-6	1.33	5.0
Trichlorofluoromethane	75-69-4	0.96	10
Vinyl Chloride	75-01-4	1.37	10

Footnotes

[1] Specific quantitation limits (MDL and RL)are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The Method Detection Limit study was completed on 3/10/00.

TABLE 8.2-19
Method 8260B Volatile Organics by GC/MS
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL 5035 Low Level (µg/Kg)	Soil MDL 5035 High Level (µg/Kg)	Water RL (µg/L)	Soil RL 5035 Low Level (µg/Kg)	Soil RL 5035 High Level (µg/Kg)
Acetone	67-64-1	1.88	3.42	252	10	20	1000
Acrylonitrile	107-13-1	2.39	16.80	361	20	100	5000
Benzene	71-43-2	0.21	0.50	23.6	1.0	5.0	250
Bromobenzene	108-86-1	0.24	1.07	20.0	1.0	5.0	250
Bromochloromethane	74-97-5	0.21	0.50	20.0	1.0	5.0	250
Bromodichloromethane	75-27-4	0.22	0.50	30.0	1.0	5.0	250
Bromoform	75-25-2	0.32	0.50	41.8	1.0	5.0	250
Bromomethane	74-83-9	0.30	0.50	43.1	2.0	10	500
2-Butanone (MEK)	78-93-3	0.93	2.34	302	5.0	20	1000
n-Butylbenzene	104-51-8	0.26	1.99	20.0	1.0	5.0	250
sec-Butylbenzene	135-98-8	0.26	1.63	20.0	1.0	5.0	250
tert-Butylbenzene	98-06-6	0.29	1.40	21.7	1.0	5.0	250
Carbon disulfide	75-15-0	0.19	1.04	20.3	1.0	5.0	250
Carbon tetrachloride	56-23-5	0.19	0.54	23.7	1.0	5.0	250
Chlorobenzene	108-90-7	0.30	1.01	34.9	1.0	5.0	250
Chlorodibromomethane	124-48-1	0.38	0.50	32.6	1.0	5.0	250
Chloroethane	75-00-3	0.25	0.50	21.8	2.0	10	500
2-Chloroethyl vinyl ether	110-75-8	0.13	1.16	39.2	2.0	50	2500
Chloroform	67-66-3	0.23	0.50	20.0	1.0	10	250
Chloromethane	74-87-3	0.30	0.91	39.7	2.0	10	500
2-Chlorotoluene	95-49-8	0.31	1.60	27.2	1.0	5.0	250
4-Chlorotoluene	106-43-4	0.25	1.78	20.2	1.0	5.0	250
1,2-Dibromo-3-chloropropane (DBCP)	96-12-8	0.25	0.68	31.6	2.0	10	500
1,2-Dibromoethane (EDB)	106-93-4	0.36	0.50	38.4	1.0	5.0	250
Dibromomethane	74-95-3	0.44	0.50	50.6	1.0	5.0	250
1,2-Dichlorobenzene	95-50-1	0.24	1.64	20.0	1.0	5.0	250
1,3-Dichlorobenzene	541-73-1	0.26	2.07	20.1	1.0	5.0	250

TABLE 8.2-19
Method 8260B Volatile Organics by GC/MS
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL 5035 Low Level (µg/Kg)	Soil MDL 5035 High Level (µg/Kg)	Water RL (µg/L)	Soil RL 5035 Low Level (µg/Kg)	Soil RL 5035 High Level (µg/Kg)
1,4-Dichlorobenzene	106-46-7	0.24	1.73	23.7	1.0	5.0	250
Dichlorodifluoromethane	75-71-8	0.23	0.62	38.7	2.0	10	500
1,1-Dichloroethane	75-34-3	0.17	0.65	25.3	1.0	5.0	250
1,2-Dichloroethane	107-06-2	0.28	0.56	20.8	1.0	5.0	250
1,1-Dichloroethene	75-35-4	0.20	0.71	20.7	1.0	5.0	250
cis-1,2-Dichloroethene	156-59-2	0.26	0.56	33.1	1.0	2.5	125
trans-1,2-Dichloroethene	156-60-5	0.27	0.77	20.0	0.5	2.5	125
1,2-Dichloroethene (total)	540-59-0	0.53	1.31	55.2	1.0	5.0	250
1,2-Dichloropropane	78-87-5	0.21	0.50	23.3	1.0	5.0	250
1,3-Dichloropropane	142-28-9	0.26	0.51	41.5	1.0	5.0	250
2,2-Dichloropropane	594-20-7	0.21	0.50	20.0	5.0	5.0	250
1,1-Dichloropropene	563-58-6	0.22	0.76	20.0	1.0	5.0	250
cis-1,3-Dichloropropene	10061-01-5	0.28	0.72	31.5	1.0	5.0	250
trans-1,3-Dichloropropene	10061-02-6	0.42	0.53	40.8	1.0	5.0	250
Ethylbenzene	100-41-4	0.28	1.14	42.0	1.0	5.0	250
Hexachlorobutadiene	87-68-3	0.29	2.47	27.4	1.0	5.0	250
2-Hexanone	591-78-6	0.70	1.66	124	5.0	20	1000
Isopropylbenzene (Cumene)	98-82-8	0.31	1.23	37.6	1.0	5.0	250
p-Isopropyltoluene	99-87-6	0.30	1.91	23.1	1.0	5.0	250
Methylene Chloride	75-09-2	0.89	0.50	43.9	1.0	5.0	250
4-Methyl-2-Pentanone	108-10-1	0.79	1.20	69.9	5.0	20	1000
Methyl-tert-butyl ether (MTBE)	1634-04-4	0.21	0.85	29.3	5.0	20	250
Naphthalene	91-20-3	0.15	1.25	151	1.0	5.0	250
n-Propylbenzene	103-65-1	0.23	1.59	20.6	1.0	5.0	250
Styrene	100-42-5	0.27	1.25	37.1	1.0	5.0	250
1,1,1,2-Tetrachloroethane	630-20-6	0.22	1.30	32.2	1.0	5.0	250
1,1,2,2-Tetrachloroethane	79-34-5	0.31	0.50	46.0	1.0	5.0	250

TABLE 8.2-19
Method 8260B Volatile Organics by GC/MS
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL 5035 Low Level (µg/Kg)	Soil MDL 5035 High Level (µg/Kg)	Water RL (µg/L)	Soil RL 5035 Low Level (µg/Kg)	Soil RL 5035 High Level (µg/Kg)
Tetrachloroethene	127-18-4	0.36	1.02	42.4	1.0	5.0	250
Tetrahydrofuran	109-99-9	0.32	1.00	67.4	5.0	20	1000
Toluene	108-88-3	0.29	0.81	35.6	1.0	5.0	250
1,2,3-Trichlorobenzene	87-61-6	0.16	2.08	25.98	1.0	5.0	250
1,2,4-Trichlorobenzene	120-82-1	0.20	2.07	20.0	1.0	5.0	250
1,1,1-Trichloroethane	71-55-6	0.26	0.50	20.0	1.0	5.0	250
1,1,2-Trichloroethane	79-00-5	0.39	0.98	53.9	1.0	5.0	250
Trichloroethene	79-01-6	0.22	0.62	25.7	1.0	5.0	250
Trichlorofluoromethane	75-69-4	0.28	1.16	51.5	2.0	10	500
1,2,3-Trichloropropane	96-18-4	0.29	1.13	95.4	1.0	5.0	250
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	0.21	0.96	30.2	1.0	5.0	1000
1,2,4-Trimethylbenzene	95-63-6	0.22	1.82	20.0	1.0	5.0	250
1,3,5-Trimethylbenzene	108-67-8	0.29	1.66	20.8	1.0	5.0	250
Vinyl Acetate	108-05-4	0.31	1.00	45.4	2.0	10	500
Vinyl Chloride	75-01-4	0.21	0.78	29.2	1.0	10	500
m- & p-Xylenes	5113-90-0	0.69	2.08	85.6	2.0	2.5	125
o-Xylene	95-47-6	0.27	1.05	41.4	1.0	2.5	125
Xylenes (total)	1330-20-7	0.95	3.08	70.0	2.0	5.0	250

Footnotes

[1] Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The water MDL study was completed on 3/10-14/00 except for Carbon Disulfide, 2-chlrorethyl vinyl ether, Allyl chloride and cyclohexane which were run on 1/6/00. The low-level soil MDL study was completed on 4/14/00 except for Carbon Disulfide, 2-chloroethyl vinyl ether, Methyl tert-butyl ether, tetrehydrofuran, 1,1,2-Trichloro-1,2,2-trifluoroethane and Vinyl acetate which were run on 2/18/99. The high-level soil MDL study was completed on 1/5/00.

TABLE 8.2-20
Method 625 CWA Semivolatile Organics by GC/MS
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
Acenaphthene	83-32-9	3.6	10
Acenaphthylene	208-96-8	3.4	10
Anthracene	120-12-7	1.5	10
Benzidene	92-87-5	15	100
Benzo(a)anthracene	56-55-3	4.0	10
Benzo(b)fluoranthene	205-99-2	5.1	10
Benzo(k)fluoranthene	207-08-9	3.7	10
Benzo(g,h,i)perylene	191-24-2	4.3	10
Benzo(a)pyrene	50-32-8	4.0	10
4-Bromophenyl-phenylether	101-55-3	3.3	10
Butyl benzyl phthalate	85-68-7	4.4	10
bis(2-Chloroethoxy)methane	111-91-1	3.9	10
bis(2-Chloroethyl) ether	111-44-4	4.4	10
bis(2-Chloroisopropyl) ether	108-60-1	4.4	10
4-Chloro-3-methylphenol	59-50-7	4.4	10
2-Chloronaphthalene	91-58-7	3.1	10
2-Chlorophenol	95-57-8	4.1	10
4-Chlorophenylphenylether	7005-72-3	3.6	10
Chrysene	218-01-9	3.4	10
Dibenzo(a,h)anthracene	53-70-3	3.6	10
Di-n-butylphthalate	84-74-2	4.5	10
1,2-Dichlorobenzene	95-50-1	5.6	10
1,3-Dichlorobenzene	541-73-1	4.9	10
1,4-Dichlorobenzene	106-46-7	5.1	10
3,3'-Dichlorobenzidine	91-94-1	1.9	20
2,4-Dichlorophenol	120-83-2	3.8	10
Diethylphthalate	84-66-2	4.4	10

TABLE 8.2-19
Method 8260B Volatile Organics by GC/MS
Method Detection Limits (MDL)(1,2) and Reporting Limits (RL)(1)
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
2,4-Dimethylphenol	105-67-9	3.3	10
Dimethylphthalate	131-11-3	4.0	10
4,6-Dinitro-2-methylphenol	534-52-1	31	50
2,4-Dinitrophenol	51-28-5	24	50
2,4-Dinitrotoluene	121-14-2	4.4	10
2,6-Dinitrotoluene	606-20-2	3.4	10
Di-n-octylphthalate	117-84-0	3.9	10
1,2-Diphenylhydrazine	122-66-7	--	10
bis(2-Ethylhexyl) phthalate	117-81-7	5.3	10
Fluoranthene	206-44-0	4.7	10
Fluorene	86-73-7	3.2	10
Hexachlorobenzene	118-74-1	5.1	10
Hexachlorobutadiene	87-68-3	5.3	10
Hexachlorocyclopentadiene	77-47-4	3.3	--
Hexachloroethane	67-72-1	6.2	10
Indeno(1,2,3-cd)pyrene	193-39-5	3.7	10
Isophorone	78-59-1	3.9	10
Naphthalene	91-20-3	3.4	10
Nitrobenzene	98-95-3	5.3	10
2-Nitrophenol	88-75-5	3.6	10
4-Nitrophenol	100-02-7	21	50
N-Nitrosodimethylamine	62-75-9	3.7	10
N-Nitroso-di-n-propylamine	621-64-7	5.5	10
N-Nitrosodiphenylamine	86-30-6	5.9	10
Pentachlorophenol	87-86-5	20	50
Phenanthrene	85-01-8	3.7	10
Phenol	108-95-2	5.0	10
Pyrene	129-00-0	4.1	10
1,2,4-Trichlorobenzene	120-82-1	5.0	10

TABLE 8.2-19
Method 8260B Volatile Organics by GC/MS
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Water RL (µg/L)
2,4,6-Trichlorophenol	88-06-2	4.3	10

Footnotes

[1] Specific quantitation limits (MDL and RL) are highly matrix dependent. The quantitation limits listed herein are provided for guidance and may not always be achievable.

[2] The MDL study was completed on 10/2/98 and 2/27/99.

TABLE 8.2-21
Method 8270C Semivolatile Organics by GC/MS
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL (µg/kg)
Acenaphthene	83-32-9	1.39	34.7	10	330
Acenaphthylene	208-96-8	1.73	36.5	10	330
Acetophenone	98-86-2	1.4	33.0	10	330
2-Acetylaminofluorene	53-96-3	1.0	33.0	100	3300
4-Aminobiphenyl	92-67-1	12	81.8	50	1600
Aniline	62-53-3	2.77	70.5	10	330
Anthracene	120-12-7	1.43	52.9	10	330
Aramite	140-57-8	2.0	66.0	20	660
Azobenzene	103-33-3	1.75	35.2	10	330
Benzenethiol	108-98-5	29	1400	100	3300
Benzidine	92-87-5	15	160.0	100	3300
Benzo(a)anthracene	56-55-3	1.1	42.4	10	330
Benzo(b)fluoranthene	205-99-2	2.21	37.9	10	330
Benzo(j)fluoranthene	205-82-3	---	---	10	330
Benzo(k)fluoranthene	207-08-9	1.91	79.8	10	330
Benzoic acid	65-85-0	18.66	409.4	50	1600
Benzo(g,h,i)perylene	191-24-2	2.0	42.9	10	330
Benzo(a)pyrene	50-32-8	1.73	47.2	10	330
Benzyl alcohol	100-51-6	3.75	75.2	10	330
4-Bromophenyl-phenylether	101-55-3	2.72	45.1	10	330
Butyl benzyl phthalate	85-68-7	2.89	45.8	10	330
Carbazole	86-74-8	1.73	48.8	10	330
4-Chloroaniline	106-47-8	6.86	64.9	10	330
bis(2-Chloroethoxy)methane	111-91-1	2.5	51.1	10	330
bis(2-Chloroethyl)ether	111-44-4	3.00	49.4	10	330
bis(2-Chloroisopropyl)ether (2,2'-oxybis(1-Chloropropane)	108-60-1	1.19	47.3	10	330
Chlorobenzilate	510-15-6	1.8	36.5	10	330

TABLE 8.2-19
Method 8260B Volatile Organics by GC/MS
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL (µg/kg)
4-Chloro-3-methylphenol	59-50-7	2.04	58.7	10	330
1-Chloronaphthalene	90-13-1	1.3	33.0	50	2500
2-Chloronaphthalene	91-58-7	1.36	33.0	10	330
2-Chlorophenol	95-57-8	2.16	50.1	10	330
4-Chlorophenyl phenyl ether	7005-72-3	1.62	53.8	10	330
Chrysene	218-01-9	1.81	53.2	10	330
Diallate	2303-16-4	2.0	66.0	20	660
Dibenz(a,j)acridine	224-42-0	4.1	33.0	20	660
Dibenzo(a,h)anthracene	53-70-3	2.21	51.7	10	330
Dibenzofuran	132-64-9	1.54	43.5	10	330
Di-n-butylphthalate	84-74-2	2.27	57.9	10	330
1,2-Dichlorobenzene	95-50-1	2.06	52.7	10	330
1,3-Dichlorobenzene	541-73-1	1.44	58.3	10	330
1,4-Dichlorobenzene	106-46-7	2.09	50.4	10	330
3,3'-Dichlorobenzidine	91-94-1	5.08	167.8	50	1600
2,4-Dichlorophenol	120-83-2	2.2	45.9	10	330
2,6-Dichlorophenol	87-65-0	1.0	33.0	10	330
Diethylphthalate	84-66-2	1.24	41.7	10	330
Dimethoate	60-51-5	1.1	33.5	20	660
4-Dimethylaminoazobenzene	60-11-7	2.8	42.3	20	660
7,12-Dimethylbenz(a)anthracene	57-97-6	1.0	37.8	20	660
3,3'-Dimethylbenzidine	95-53-4	8.34	57.0	20	660
a,a-Dimethylphenethylamine	122-09-8	35.8	174	50	1600
2,4-Dimethylphenol	105-67-9	2.79	67.5	10	330
Dimethyl phthalate	131-11-3	1.78	38.4	10	330
1,3-Dinitrobenzene	99-65-0	1.0	42.4	10	330
1,4-Dinitrobenzene	100-25-4	1.0	33.0	10	330

TABLE 8.2-19
Method 8260B Volatile Organics by GC/MS
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL (µg/kg)
4,6-Dinitro-2-methylphenol (4,6-Dinitro-o-cresol)	534-52-1	2.61	191.5	50	1600
2,4-Dinitrophenol	51-28-5	5.77	485.1	50	1600
2,4-Dinitrotoluene	121-14-2	1.44	43.6	10	330
2,6-Dinitrotoluene	606-20-2	1.15	51.9	10	330
Di-n-octylphthalate	117-84-0	2.01	46.3	10	330
Diphenylamine	12-39-4	5.9	44.9	10	330
1,2-Diphenylhydrazine	122-66-7	---	35.2	10	330
Disulfoton	298-04-4	3.3	33.0	50	1600
bis(2-Ethylhexyl) phthalate	117-81-7	2.02	58.4	10	330
Ethyl methanesulfonate	62-50-0	1.0	44.5	10	330
Famphur	52-85-7	23.7	99.8	200	660
Fluoranthene	206-44-0	1.92	56.8	10	330
Fluorene	86-73-7	1.60	41.1	10	330
Hexachlorobenzene	118-74-1	2.73	48.5	10	330
Hexachlorobutadiene	87-68-3	2.25	41.8	10	330
Hexachlorocyclopentadiene	77-47-4	5.0	33.0	50	1600
Hexachloroethane	67-72-1	1.72	61.5	10	330
Hexachlorophene	70-30-4	303	33.0	1000	3300
Hexachloropropene	1888-71-7	2.0	40.0	100	3300
Indene	95-13-6	1.9	56.7	100	330
Indeno(1,2,3-cd)pyrene	193-39-5	1.73	53.0	10	330
Isodrin	465-73-6	1.1	33.0	10	330
Isophorone	78-59-1	2.01	52.5	10	330
Isosafrole	120-58-1	3.2	66.0	20	660
Kepone	143-50-0	---	--	---	---
Methapyrilene	91-80-5	16.05	56.7	50	1600
3-Methylcholanthrene	56-49-5	2.1	33.0	20	660
6-Methylchrysene	1705-85-7	---	33.0	10	330

TABLE 8.2-19
Method 8260B Volatile Organics by GC/MS
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL (µg/kg)
Methyl methanesulfonate	66-27-3	1.2	36.3	10	330
1-Methylnapthalene	90-12-0	2.31	56.2	10	330
2-Methylnaphthalene	91-57-6	1.6	57.5	10	330
Methyl parathion	298-00-0	1.6	33.6	50	1600
2-Methylphenol (o-cresol)	95-48-7	3.18	44.0	10	330
3-Methylphenol (m-cresol) & 4-Methylphenol (p-cresol)	108-39-4 & 106-44-5	5.1	58.9	10	330
3-Methylphenol (m-cresol)	108-39-4	---	---	---	---
4-Methylphenol (p-cresol)	106-44-5	---	---	---	---
Naphthalene	91-20-3	1.76	50.8	10	330
1,4-Napthoquinone	130-15-4	1.0	33.0	50	1600
1-Naphthylamine	134-32-7	7.9	83.9	10	330
2-Naphthylamine	91-59-8	7.6	77.9	10	330
2-Nitroaniline	88-74-4	2.52	44.9	50	1600
3-Nitroaniline	99-09-2	3.58	57.0	50	1600
4-Nitroaniline	100-01-6	2.18	68.4	50	1600
Nitrobenzene	98-95-3	2.45	68.0	10	330
2-Nitrophenol	88-75-5	2.77	42.8	10	330
4-Nitrophenol	100-02-7	7.14	160.0	50	1600
4-Nitroquinoline-1-oxide	56-57-5	15.77	42.7	100	3300
N-Nitroso-di-n-butylamine	924-16-3	1.5	33.0	10	330
N-Nitrosodiethylamine	55-18-5	1.2	37.0	10	330
N-Nitrosodimethylamine	62-75-9	2.33	57.8	10	330
N-Nitrosodiphenylamine (Diphenylnitrosamine)	86-30-6	2.91	56.0	10	330
N-Nitroso-di-n-propylamine	621-64-7	2.33	62.9	10	330
N-Nitrosomethylethlyamine	10595-95-6	1.0	45.9	10	330
N-Nitrosomorpholine	59-89-2	1.5	52.7	10	330
N-Nitrosopiperidine	100-75-4	1.4	33.0	10	330

TABLE 8.2-19
Method 8260B Volatile Organics by GC/MS
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]
(Continued)

Analyte	CAS Number	Water MDL (µg/L)	Soil MDL (µg/kg)	Water RL (µg/L)	Soil RL (µg/kg)
N-Nitrosopyrrolidine	930-55-2	1.1	36.6	10	330
5-Nitro-o-toluidine	99-55-8	3.2	58.8	20	660
Parathion	56-38-2	1.3	70.0	50	1600
Pentachlorobenzene	608-93-5	1.4	33.0	10	330
Pentachloroethane	76-01-7	1.4	33.0	50	1600
Pentachloronitrobenzene	82-68-8	1.0	33.0	50	1600
Pentachlorophenol	87-86-5	5.00	160.0	50	1600
Phenacetin	62-44-2	1.0	48.8	20	660
Phenanthrene	85-01-8	2.01	41.7	10	330
Phenol	108-95-2	1.75	50.3	10	330
4-Phenylenediamine	106-50-3	30.9	839	100	1600
Phorate	298-02-2	2.0	33.0	50	1600
2-Picoline	109-06-8	1.4	33.0	20	660
Pronamide	23950-58-5	1.0	33.0	20	660
Pyrene	129-00-0	2.00	38.0	10	330
Pyridine	110-86-1	6.04	160.0	20	660
Quinoline	91-22-5	5.5	33.0	50	1600
Safrole	94-59-7	1.7	36.7	50	660
1,2,4,5-Tetrachlorobenzene	95-94-3	1.9	33.0	10	330
2,3,4,6-Tetrachlorophenol	58-90-2	1.2	47.9	50	1600
Sulfotepp (Tetracthyldithiopyrophosphate)	3689-24-5	1.0	33.0	50	1600
Thionazin	297-97-2	1.15	48.2	10	1600
2-Toluidine	95-53-4	4.6	98.3	10	660
1,2,4-Trichlorobenzene	120-82-1	1.78	35.6	10	330
2,4,5-Tricholorphenol	95-95-4	2.45	33.0	10	330
2,4,6-Trichlorophenol	88-06-2	2.27	36.4	10	330
O,O,O-Triethyl phosphorothioate	126-68-1	1.6	35.1	50	1600
1,3,5-Trinitrobenzene	99-35-4	1.4	48.2	50	1600

STL DENVER
Interim Change # P

SOP NUMBER: LQM, Revision No. 0
SOP TITLE: STL Denver LQM
SOP SECTION(S) AFFECTED BY CHANGE: Add Table 8.4-7
REASON FOR CHANGE: Include QC requirements for radiochemical tests
CHANGE: See tables in following 8 pages
SUBMITTED BY/DATE: Larry Penfold, 1/10/03
APPROVED BY:

Timothy M. O'Shields, Laboratory Director — Date: 1/10/03

Received JAN 17 2003 Records Services

Larry Penfold, Quality Assurance Manager — Date: 1/10/03

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TABLE 8.4-7
Radiochemical Quality Control Samples

Analysis	QC Sample	Method	SDWA & CWA[1]	Method	RCRA (SW846)[2]
Gross Alpha & Gross Beta	Method Blank	900.0	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Measured activity less than the MDA, with MDA of the blank less than the reporting limit Corrective Action: Investigate & correct sources of contamination, reprepare & reanalyze associated samples	9310	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Measured activity less than the MDA, with MDA of the blank less than the reporting limit Corrective Action: Investigate & correct sources of contamination, reprepare & reanalyze associated samples
	Laboratory Control Sample	900.0	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Within laboratory established 3 standard deviation control limits, not to exceed 75-125% Corrective Action: Investigate sources of error, reprepare & reanalyze all associated samples	9310	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Within laboratory established 3 standard deviation control limits, not to exceed 75-125% Corrective Action: Investigate sources of error, reprepare & reanalyze all associated samples
	Matrix Spike	900.0	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Within laboratory established 3 standard deviation control limits, not to exceed 80-120% for SDWA compliance or 60-140% for DOE programs Corrective Action: Investigate sources of error, reprepare & reanalyze all associated samples	9310	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Within laboratory established 3 standard deviation control limits, not to exceed 80-120% for SDWA compliance or 60-140% for DOE programs Corrective Action: Investigate sources of error, reprepare & reanalyze all associated samples

Analysis	QC Sample	Method	SDWA & CWA[1]	Method	RCRA (SW846)[2]
Gross Alpha & Beta (cont.)	Duplicate Sample	900.0	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Relative error ratio (RER) ≤ 3 (see equation in policy QA-003) Corrective Action: Qualify reported results, flag and/or case narrative	9310	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Relative error ratio (RER) ≤ 3 (see equation in policy QA-003) Corrective Action: Qualify reported results, flag and/or case narrative
	Significant Negative Results	900.0	Frequency: Evaluate samples in every batch Criteria: If activity in 2 or more samples plus TPU is a negative value, corrective action is required Corrective Action: Check frequency of significant negative results for blanks. If > 5%, check processing technique & reestablish background levels. If < 5%, recheck TPU calculation	9310	Frequency: Evaluate samples in every batch Criteria: If activity in 2 or more samples plus TPU is a negative value, corrective action is required Corrective Action: Check frequency of significant negative results for blanks. If > 5%, check processing technique & reestablish background levels. If < 5%, recheck TPU calculation
Alpha Spectroscopy (Pu, Am, U, & Th)	Method Blank	U-02	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Activity < reporting limit or < 1/10 concentration in associated samples Corrective Action: Investigate & correct sources of contamination, reprepare & reanalyze associated samples	Sc-03 (HASL-300)	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Measured activity less than the MDA, with MDA of the blank less than the reporting limit Corrective Action: Investigate & correct sources of contamination, reprepare & reanalyze associated samples

Analysis	QC Sample	Method	SDWA & CWA[1]	Method	RCRA (SW846)[2]
Alpha Spectroscopy (cont.)	Laboratory Control Sample	U-02	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Within laboratory established 3 standard deviation control limits, not to exceed 80-120% Corrective Action: Investigate sources of error, reprepare & reanalyze all associated samples	Se-03 (HASL-300)	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Within laboratory established 3 standard deviation control limits, not to exceed 75-125% Corrective Action: Investigate & correct sources of contamination, reprepare & reanalyze associated samples
	Matrix Spike	U-02	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Within laboratory established 3 standard deviation control limits, not to exceed 80-120% Corrective Action: If LCS & MS fail then samples must be reprepared and reanalyzed, otherwise qualify reported results, flag and/or case narrative	Se-03 (HASL-300)	----
	Duplicate Samples	U-02	Frequency: 1 per 10 field samples and at least 1 per batch Criteria: Relative error ratio (RER) $\leq$ 3 (see equation in policy QA-003) Corrective Action: Qualify reported results, flag and/or case narrative	Se-03 (HASL-300)	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Relative error ratio (RER) $\leq$ 3 (see equation in policy QA-003) Corrective Action: Qualify reported results, flag and/or case narrative
	Tracers	U-02	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: 30-110% recovery, Pk width FWHM $\leq$ 100 keV,	Se-03 (HASL-300)	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: 30-110% recovery, Pk width FWHM $\leq$ 100 keV,

Analysis	QC Sample	Method	SDWA & CWA[1]	Method	RCRA (SW846)[2]
			Pk energy ± 50 keV Corrective Action: Reanalzye sample		Pk energy ± 50 keV Corrective Action: Reanalzye sample
Alpha Spectroscopy (cont.)	Significant Negative Results	900.0	Frequency: Evaluate samples in every batch Criteria: If activity in 2 or more samples plus TPU is a negative value, corrective action is required Corrective Action: Check frequency of significant negative results for blanks. If > 5%, check processing technique & reestablish background levels. If < 5%, recheck TPU calculation	9310	Frequency: Evaluate samples in every batch Criteria: If activity in 2 or more samples plus TPU is a negative value, corrective action is required Corrective Action: Check frequency of significant negative results for blanks. If > 5%, check processing technique & reestablish background levels. If < 5%, recheck TPU calculation
Gamma Spectroscopy	Method Blank	901.1 & 7120B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Measured activity less than the MDA, with MDA of the blank less than the reporting limit or less than MDA for all samples Corrective Action: Investigate & correct sources of contamination, reprepare & reanalyze associated samples	---	---
	Laboratory Control Sample	901.1 & 7120B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery within 75-125% of expected value Corrective Action: Investigate sources of error, reprepare & reanalyze all associated samples	---	---

Analysis	QC Sample	Method	SDWA & CWA[1]	Method	RCRA (SW846)[2]
Gamma Spectroscopy (cont.)	Matrix Spike	901.1 & 7120B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Within laboratory established 3 standard deviation control limits, not to exceed 60-140% Corrective Action: Investigate sources of error, recount samples	---	---
	Duplicate Samples	901.1 & 7120B	Frequency: 1 with each 9310 or DOE batch of samples Criteria: Relative error ratio (RER) $\leq$ 3 (see equation in policy QA-003) Corrective Action: Qualify reported results, flag and/or case narrative	---	---
	Significant Negative Results	901.1 & 7120B	Frequency: Evaluate samples in every batch Criteria: If activity in 2 or more samples plus TPU is a negative value, corrective action is required Corrective Action: Check frequency of significant negative results for blanks. If > 5%, check processing technique & reestablish background levels. If < 5%, recheck TPU calculation	---	---

Analysis	QC Sample	Method	SDWA & CWA[1]	Method	RCRA (SW846)[2]
Radium-226	Method Blank	7500-Ra B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Measured activity less than the reporting limit or less than 1/10 the activity level in associated samples Corrective Action: Investigate & correct sources of contamination, reprepare & reanalyze associated samples	---	---
	Laboratory Control Sample	7500-Ra B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery within 80-120% of expected value for SDWA compliance testing, 75-125% for other programs Corrective Action: Investigate sources of error, reprepare & reanalyze all associated samples	---	---
	Matrix Spike	7500-Ra B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Within 80-120% for SDWA compliance, 75-125% for other programs Corrective Action: If LCS & MS fail then samples must be reprepared and reanalyzed, otherwise qualify reported results, flag and/or case narrative	---	---

Analysis	QC Sample	Method	SDWA & CWA[1]	Method	RCRA (SW846)[2]
Radium-226 (cont.)	Duplicate Samples	7500-Ra B	Frequency: 1 per 10 field samples and at least 1 per batch Criteria: Relative error ratio (RER) ≤ 3 (see equation in policy QA-003) Corrective Action: Qualify reported results, flag and/or case narrative	---	---
	Significant Negative Results	7500-Ra B	Frequency: Evaluate samples in every batch Criteria: If activity in 2 or more samples plus TPU is a negative value, corrective action is required Corrective Action: Check frequency of significant negative results for blanks. If > 5%, check processing technique & reestablish background levels. If < 5%, recheck TPU calculation	---	---
Radium-228	Method Blank	EPA RA-05	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Measured activity less than the reporting limit or less than the activity level in associated samples Corrective Action: Investigate & correct sources of contamination, reprepare & reanalyze associated samples	---	---

Analysis	QC Sample	Method	SDWA & CWA[1]	Method	RCRA (SW846)[2]
Radium-228 (cont.)	Laboratory Control Sample	EPA RA-05	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery within 80-120% of expected value for SDWA compliance testing, 75-125% for other programs Corrective Action: Investigate sources of error, reprepare & reanalyze all associated samples	---	---
	Matrix Spike / Matrix Spike Duplicate	EPA RA-05	Frequency: 1 pair with each batch of samples processed not to exceed 20 samples Criteria: Within 80-120% for SDWA compliance, 60-140% for other programs Corrective Action: Investigate sources of error, reprepare & reanalyze all associated samples	---	---
	Duplicate Samples	EPA RA-05	Frequency: 1 per batch, not to exceed 20 samples Criteria: Relative error ratio (RER) $\leq$ 3 (see equation in policy QA-003) Corrective Action: Qualify reported results, flag and/or case narrative	---	---
	Significant Negative Results	EPA RA-05	Frequency: Evaluate samples in every batch Criteria: If activity in 2 or more samples plus TPU is a negative value, corrective action is required Corrective Action: Check frequency of significant negative results	---	---

Analysis	QC Sample	Method	SDWA & CWA[1]	Method	RCRA (SW846)[2]
			for blanks. If > 5%, check processing technique & reestablish background levels. If < 5%, recheck TPU calculation		

TABLE 8.2-19
Method 8260B Volatile Organics by GC/MS
Method Detection Limits (MDL)[1,2] and Reporting Limits (RL)[1]
(Continued)

Footnotes

[1] Quantitation limits (MDL and RL) shown for soils are on a wet weight basis. Quantitation limits on a dry weight basis will be higher. Specific quantitation limits are highly matrix dependent, the quantitation limits listed herein are provided for guidance only, and may not always be achievable.

[2] The MDL studies for water were completed on 10/20/96, 10/2/98, 11/3/98, 2/27/99, 7/9/99, 7/17/99, 9/8/99, 2/19/00, 3/2/00, 3/16/00, 4/6/00, 5/12/00. The MDL studies for soil were completed 9/25/97, 4/19/99, 5/11/99, 8/3/99, 11/30/99, 2/28/00, 3/14/00 and 3/15/00.

Comments:

1) N-Nitrosodiphenylamine decomposes in the gas chromatographic inlet and cannot be distinguished from diphenylamine.
2) Hexachlorophene is not amenable to analysis by this method.
3) 3-Methylphenol cannot be separated from 4-methylphenol by the conditions specified in this method.
4) Azobenzene is formed by decomposition of 1,2-diphenylhydrazine. If 1,2-diphenylhydrazine is requested, it will be analyzed as azobenzene.

TABLE 8.4-1
Field Quality Control Samples

Type	Applicability		Accuracy and Precision Application	Introduced By
	Inorganic	Organic		
Trip Blank (volatiles)	No	Yes	Accuracy	Supplier of Containers
Field Blank	Yes	Yes	Accuracy	Field Sampler
Rinsate Blank	Yes	Yes	Accuracy	Field Sampler
Collocated Sample	Yes	Yes	Precision	Field Sampler
Split Sample	Yes	Yes	Precision	Field Sampler
Field Duplicate	Yes	Yes	Precision	Field Sampler
Field Matrix Spike	Yes	Yes	Accuracy	Field Sampler

TABLE 8.4-2
Laboratory Quality Control Samples

Type	Frequency	Applicability		Accuracy and Precision Application	Introduced By
		Inorganic/ Radiochemical	Organic		
Analytical Spike	As specified in methods, or as needed	Yes	No	Accuracy	Analyst/ Prep
Duplicate	1 out of 20 or at least 1/month/run	Yes	Yes	Precision	Analyst/ Prep
Instrument Blank	As specified methods, or as needed	Yes	Yes	Accuracy	Analyst
Interference Check Sample	As specified in methods	Yes	No	Accuracy	Analyst
Internal Standard	Each sample and standard	Yes	Yes	Both	Analyst/ Prep
Laboratory Control Sample	1 per each group of samples processed up to 20 samples.	Yes	Yes	Accuracy	Analyst/ Prep
Matrix Spike	1 per each group of samples processed up to 20 samples.	Yes	Yes	Accuracy	Analyst/ Prep
Matrix Spike Duplicate	1 per each group of samples processed up to 20 samples.	Yes	Yes	Both	Analyst/ Prep
Method Blank	1 per each group of samples processed up to 20 samples.	Yes	Yes	Accuracy	Analyst/ Prep
Surrogate	All standards, method blanks, LCS, and samples.	No	Yes Method Dependent	Accuracy	Analyst/ Prep
Yield Monitor	Operation-specific	Yes	No	Accuracy	Prep

TABLE 8.4-3
Laboratory Performance Quality Control Samples

Sample/Measurement	Purpose
Method Blanks	Demonstrates that the laboratory systems (*e.g.*, glassware cleaning procedures) and laboratory reagents used for the preparation and analysis of samples have not contributed to a false positive or negative measurement.
Instrument Blank	Demonstrates that the analytical system has not contributed to a false positive or negative measurement.
Laboratory Control Sample	Demonstrates the laboratory's ability to perform an analysis within the performance requirements of the method.

TABLE 8.4-4
Matrix Specific Quality Control Samples

Quality Control Sample	Purpose
Duplicate Samples	Estimates the ability of the laboratory to obtain precise measurements on a sample. This measure is dependent on the homogeneity of the sample being duplicated. Solid samples often portray poor sample homogeneity and therefore often have poor duplication with regards to the sample result.
Matrix Spike Sample	Estimates the ability of the laboratory to obtain accurate measurements on a sample. The measure is dependent on the bias a sample matrix may cause regarding a given analyte.
Matrix Spike Duplicate Sample	In addition to verifying the accuracy of the matrix spike sample, the matrix spike duplicate can be used with the matrix spike sample as a measure of precision by calculating the relative percent difference (RPD).

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Acidity	Method Blank	305.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	305.1	Not Applicable	—	Not Applicable
	Matrix Spike	305.1	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	305.1	Not Applicable	—	Not Applicable
	Duplicate	305.1	Frequency: 1 per batch of 10 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Alkalinity	Method Blank	310.1 2320B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	310.1 2320B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	310.1 2320B	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	310.1 2320B	Not Applicable	—	Not Applicable
	Duplicate	310.1 2320B	Frequency: 1 per batch of 10 samples Criteria 310.1: ≤ 20 % RPD[3] Criteria 2320B: ≤ 25 % RPD[3] Corrective Action: Flag data outside of limit.	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Ammonia	Method Blank	350.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	350.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	350.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	350.1	Not Applicable	—	Not Applicable
	Duplicate	350.1	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Ammonia & TKN	Method Blank	351.2 351.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	351.2 351.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	351.2 351.3	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	351.2 351.3	Not Applicable	—	Not Applicable
	Duplicate	351.2 351.3	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
BOD	Method Blank	405.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	405.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	405.1	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	405.1	Not Applicable	—	Not Applicable
	Duplicate	405.1	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Bromide	Method Blank	300.0[5]	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	300.0[5]	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within control limits, rerun all associated samples	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within control limits, rerun all associated samples
	Matrix Spike	300.0[5]	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data associated with MS outside of limit
	Matrix Spike Duplicate	300.0[5]	Not Applicable	9056	Not Applicable
	Duplicate	300.0[5]	Methods 300.0, 320.1: Not Applicable Frequency: Method D1246: 1 with each batch of samples processed not to exceed 20 samples	9056	Frequency: 1 with each batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data associated with duplicates outside of laboratory RPD[3] limits

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Chemical Oxygen Demand (COD)	Method Blank	410.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	410.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	410.4	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	410.4	Not Applicable	—	Not Applicable
	Duplicate	410.4	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Chloride	Method Blank	300.0[5] 325.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	300.0[5] 325.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within control limits, rerun all associated samples	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	300.0[5] 325.2	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Method 9056 Corrective Action: Flag data associated with MS outside of limits

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Chloride (continued)	Matrix Spike Duplicate	300.0[5] 325.2	Not Applicable	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits/< 20 % RPD[3] Corrective Action: Flag data outside of limit Method 9056: MSD is not applicable
	Duplicate	300.0[5] 325.2	Methods 300.0, 325.1, 325.2, 325.3: Not Applicable Method 4500-Cl E: Frequency: 1 with each batch of samples processed not to exceed 20 samples	9056	Method 9056: Frequency: 1 with each batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data associated with duplicates outside of laboratory RPD[3] limits
Chromium (Cr^{+6})	Method Blank	3500 Cr-D	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	7196A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Chromium (Cr^{+6}) cont.	Laboratory Control Sample	3500 Cr-D	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	7196A	Frequency: 1 with each batch of samples processed not to exceed 20 samples prepped Criteria: percent recovery for water must be within ± 15 % and for solids must be within ± 20% Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	3500 Cr-D	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag data outside of limit	7196A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Advisory limits are 75% - 125% recovery Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	3500 Cr-D	Not Applicable	7196A	Not Applicable
	Duplicate	3500 Cr-D	Not Applicable	7196A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] limit Corrective Action: Flag data outside of limit.

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Color	Method Blank	110.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	110.2	Not Applicable	—	Not Applicable
	Matrix Spike	110.2	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	110.2	Not Applicable	—	Not Applicable
	Duplicate	110.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	—	Not Applicable
Conductivity	Method Blank	120.1	Not Applicable	9050A	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Conductivity (continued)	Laboratory Control Sample	120.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9050A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	120.1	Not Applicable	9050A	Not Applicable
	Matrix Spike Duplicate	120.1	Not Applicable	9050A	Not Applicable
	Duplicate	120.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	9050A	Frequency: 1 with each batch of samples processed not to exceed 10 samples
Cyanide (Amenable)	Method Blank	335.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9010B/ 9012A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Cyanide (Amenable) (continued)	Laboratory Control Sample	335.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9010B/ 9012A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	335.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9010B/ 9012A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Advisory limits are 75% - 125% recovery Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	335.1	Not Applicable	9010B/ 9012A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Advisory limits are 75% - 125% recovery Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	335.1	Not Applicable	9010B/ 9012A	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Cyanide (Total)	Method Blank	335.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9010B/ 9012A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	335.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9010B/ 9012A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	335.3	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9010B/ 9012A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Advisory limit is 75% - 125% recovery Corrective Action: Flag data associated with unacceptable Matrix Spike

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Cyanide (Total) (continued)	Matrix Spike Duplicate	335.3	Not Applicable	9010B/ 9012A	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Limit is 75% - 125% recovery Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	335.3	Methods 335.2, 335.3: Not Applicable Method 4500-CN E: Frequecny: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	9010B/ 9012A	Not Applicable
Fluoride	Method Blank	300.0[5] 340.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Fluoride (cont.)	Laboratory Control Sample	300.0[5] 340.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within control limits, rerun all associated samples
	Matrix Spike	300.0[5] 340.2	Frequency: 1 per 10 samples by IC Criteria: Must be within laboratory QC limits Corrective Action: Flag data outside of limit	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data associated with outside of limit
	Matrix Spike Duplicate	300.0[5] 340.2	Not Applicable	9056	Not Applicable
	Duplicate	300.0[5] 340.2	Not Applicable	9056	Frequency: 1 with each batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data associated with duplicates outside of laboratory RPD[3] limits

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Hardness	Method Blank	130.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	130.2 2340B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	130.2 2340B	Method 130.2, Not Applicable Method 2340B: Frequency , Criteria, and Corrective Action: See ICP Metals Method 200.7 Requirements	—	Not Applicable
	Matrix Spike Duplicate	130.2 2340B	Method 130.2, Not Applicable Method 2340B: Frequency, Criteria, and Corrective Action: See ICP Metals Method 200.7 Requirements	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Hardness (cont.)	Duplicate	130.2 2340B	Frequency: 1 per 20 samples, minimum of one per batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
Ignitability	Method Blank	—	Not Applicable	1010	Not Applicable
	Laboratory Control Sample	—	Not Applicable	1010	Not Applicable
	Matrix Spike	—	Not Applicable	1010	Not Applicable
	Matrix Spike Duplicate	—	Not Applicable	1010	Not Applicable
	Duplicate	—	Not Applicable	1010	Frequency: 1 per batch of ≤20 samples Criteria: RPD[3] must be ≤ 20% Corrective Action: Flag data associated with unacceptable Duplicate

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Methylene Blue Active Substances (MBAS)	Method Blank	425.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	425.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	425.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	425.1	Not Applicable	—	Not Applicable
	Duplicate	425.1	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitrate	Method Blank	300.0[5] 353.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Criteria 9210: Concentration must be < 1 mg/L of Nitrate Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	300.0[5] 353.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Criteria 9210: 90-110% Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	300.0[5] 353.2	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Must be within laboratory control limits Corrective Action: Flag data outside of limit	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Criteria 9210: 75-125% Corrective Action: If not within laboratory control limits, flag all associated samples

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitrate (cont.)	Matrix Spike Duplicate	300.0[5] 353.2	Not Applicable	9056	Not applicable
	Duplicate	300.0[5] 353.2	Not Applicable	9056	Method 9056: Frequency: 1 per 10 samples Criteria: RPD[3] must be within laboratory control limits Corrective Action: If not within laboratory control limits, flag all associated samples Method 9210: Not applicable
Nitrite	Method Blank	300.0[5] 353.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	300.0[5] 353.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitrite (cont.)	Matrix Spike	300.0[5] 353.2	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Must be within laboratory control limits Corrective Action: Flag data outside of limit	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, flag all associated samples
	Matrix Spike Duplicate	300.0[5] 353.2	Not Applicable	9056	Not Applicable
	Duplicate	300.0[5] 354.1	Not Applicable	9056	Frequency: 1 per 10 samples Criteria: RPD[3] must be within laboratory control limits Corrective Action: If not within laboratory control limits, flag all associated samples

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitrate-Nitrite	Method Blank	300.0 353.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	300.0 353.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	353.1 353.2 353.3	Frequency: 1 per 20 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	353.1 353.2 353.3	Not Applicable	—	Not Applicable
	Duplicate	353.1 353.2 353.3	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Oil & Grease (Hexane Extractable)	Method Blank	1664	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Sample provided by external source, must be < RL Corrective Action: If not within laboratory control limits, reprepare rerun all associated samples	---	Not Applicable
	Laboratory Control Sample	1664	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: HEM Recovery 79-114% HEM RPD ± 18% SGT-HEM Recovery 66-114% SGT-HEM RPD ± 24% Corrective Action: If not within laboratory control limits, reprepare and rerun all associated samples	---	Not Applicable
	Matrix Spike	1664	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: HEM Recovery 79-114% HEM RPD ± 18% SGT-HEM Recovery 66-114% SGT-HEM RPD ± 24% Corrective Action: Consult with client. Qualified data might be reported to client.	---	Not Applicable
	Matrix Spike Duplicate	1664	Not Applicable	---	Not Applicable
	Duplicate	1664	Not Applicable	---	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
pH	Method Blank	150.1	Not Applicable	9040B 9045C	Not Applicable
	Laboratory Control Sample	150.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Sample provided by external source, must be within ± 0.05 pH units Corrective Action: If not within laboratory control limits, rerun all associated samples	9040B 9045C	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Sample provided by external source, must be within ± 0.05 pH units Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	150.1	Not Applicable	9040B 9045C	Not Applicable
	Matrix Spike Duplicate	150.1	Not Applicable	9040B 9045C	Not Applicable
	Duplicate	150.1 4500-H^+ B	Method 150.1 Frequency: 1 with each batch of samples processed not to exceed 20 samples Method 4500-H^+ B Frequency: 1 with each batch of 10 samples Method 150.1 Criteria: ≤ 20 % RPD[3] limit Method 4500-H^+ B Criteria: ≤ 25 % RPD[3] limit Corrective Action: Flag data outside of limit.	9040B 9045C	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Advisory limits are ≤ 20% RPD[3] Corrective Action: Flag data associated with unacceptable Duplicate

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Phenolics	Method Blank	420.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9066	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	420.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9066	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	420.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data associated with unacceptable Matrix Spike	9066	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data
	Matrix Spike Duplicate	420.2	Not Applicable	9066	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Phosphate	Method Blank	---	Not Applicable	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	---	Not Applicable	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples
	Matrix Spike	---	Not Applicable	9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data associated with MS outside of limits
	Matrix Spike Duplicate	---	Not Applicable	9056	Not Applicable
	Duplicate	---	Not Applicable	9056	Frequency: 1 with each batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data associated with duplicates outside of laboratory RPD[3] limits

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Phosphorus (Total and Ortho-phosphate)	Method Blank	300.0[4,5] 365.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable
	Laboratory Control Sample	300.0[4,5] 365.3	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	300.0[4,5] 365.3	Frequency: 1 per 10 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	300.0[4,5] 365.3	Not Applicable	—	Not Applicable
	Duplicate	300.0[4,5] 365.3	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Reactivity (Cyanide and Sulfide)	Method Blank	---	Not Applicable	Chapter 7[6] Sections 7.3.3.2 and 7.3.4.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	---	Not Applicable	Chapter 7[6] Sections 7.3.3.2 and 7.3.4.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	---	Not Applicable	Chapter 7[6] Sections 7.3.3.2 and 7.3.4.2	Follow QC sample requirements of determinative method
	Matrix Spike Duplicate	---	Not Applicable	Chapter 7[6] Sections 7.3.3.2 and 7.3.4.2	Follow QC sample requirements of determinative method
	Duplicate	---	Not Applicable	Chapter 7[6] Sections 7.3.3.2 and 7.3.4.2	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Solids	Method Blank	160.1 160.2 160.3 160.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: If analyte level in method blank is ≥ RL for the analyte of interest in the sample, all associated samples with reportable levels of analyte are reprepared and reanalyzed. SOP No. CORP-WC-0002.	—	Not Applicable
	Laboratory Control Sample	160.1 160.2 160.3 160.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, reprepare and rerun all associated samples	—	Not Applicable
	Matrix Spike	160.1 160.2 160.3 160.4	Not Applicable	—	Not Applicable
	Matrix Spike Duplicate	160.1 160.2 160.3 160.4	Not Applicable	—	Not Applicable
	Duplicate	160.1 160.2 160.3 160.4 160.5	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Sample results should agree within 20% if both the sample and sample duplicate results are > 5 X RL Corrective Action: Flag data	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Sulfate	Method Blank	300.0[5] 375.2 375.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9038 9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	300.0[5] 375.2 375.4	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9038 9056	Frequency: 1 with each batch of samples processed not to exceed 20 samples Method 9038 Criteria: Percent recovery must be within ± 15 % Method 9056 Criteria: Percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS (ICV)
	Matrix Spike	300.0[5] 375.2 375.4	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9038 9056	Frequency: 1 with each batch of samples processed not to exceed 10 samples (Method 9038) or 20 samples (Method 9056) Method 9038 Criteria: Limits are 75% - 125% recovery Method 9056 Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Dup.	300.0[5] 375.2	Not Applicable	9038 9056	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Sulfate (continued)	Duplicate	300.0[5] 375.2 375.4	Not Applicable	9038 9056	Frequency: 1 with each batch of samples processed Criteria: RPD[3] must be within laboratory control limits Corrective Action: Flag data associated with duplicates outside of laboratory RPD[3] limits
Sulfide	Method Blank	376.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9030B/ 9034	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	376.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9030B/ 9034	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Sulfide (continued)	Matrix Spike	376.2	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9030B/ 9034	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data
	Matrix Spike Duplicate	376.2	Not Applicable	9030B/ 9034	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data Method 9034: Not Applicable
	Duplicate	376.2	Not Applicable	9030B/ 9034	Not Applicable
Sulfite	Method Blank	377.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Sulfite (continued)	Laboratory Control Sample	377.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	377.1	Frequency: 1 per 20 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	—	Not Applicable
	Matrix Spike Duplicate	377.1	Not Applicable	—	Not Applicable
	Duplicate	377.1	Not Applicable	—	Not Applicable
Temperature	Method Blank	170.1	Not Applicable	---	Not Applicable
	Laboratory Control Sample	170.1	Not Applicable	---	Not Applicable
	Matrix Spike	170.1	Not Applicable	---	Not Applicable
	Matrix Spike Duplicate	170.1	Not Applicable	---	Not Applicable
	Duplicate	170.1	Not Applicable	---	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Total Organic Carbon (TOC)	Method Blank	415.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9060	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	415.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	9060	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	415.1	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag data outside of limit	9060	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Reanalyze if sample remaining. If not, flag data associated with unacceptable Matrix Spike

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Total Organic Carbon (TOC) (continued)	Matrix Spike Duplicate	415.1	Not Applicable	9060	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Reanalyze if sample remaining. If not, flag data associated with unacceptable Matrix Spike Duplicate
	Duplicate	415.1	Not Applicable	9060	Not Applicable
Total Organic Halides (TOX)	Method Blank	---	Frequency: 1 with each set of 8 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	9020B	Frequency: Run in duplicate between each group of 8 analytical determinations Criteria: Concentration less than reporting limit or less than 2 X MDL or RL whichever is lower Corrective Action: Rerun all samples associated with unacceptable blank SOP NO. CORP-WC-0001
	Laboratory Control Sample	---	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery of analyte must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS (ICV)	9020B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery of analyte must be within 90-110% Corrective Action: Rerun all samples associated with unacceptable LCS (ICV) SOP NO. CORP-WC-0001

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Total Organic Halides (TOX) (continued)	Matrix Spike	---	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Must be within laboratory control limits Corrective Action: Reanalyze if sample remaining. If not, flag data with unacceptable Matrix Spike	9020B	Frequency: 1 per batch of 10 samples Criteria: Must be within laboratory control limits Corrective Action: Flag data associated with unacceptable Matrix Spike SOP NO. CORP-WC-0001
	Matrix Spike Duplicate	---	Not Applicable	9020B	Not Applicable
	Duplicate	---	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] limit Corrective Action: Flag data outside of limit.	9020B	Frequency: All samples will be analyzed in duplicate Criteria: ≤ 20 % RPD[3] limit if both the sample and sample duplicate results are > 10 X MDL. Corrective Action: Flag data outside of limit. SOP NO. CORP-WC-0001
Turbidity	Method Blank	180.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Turbidity (continued)	Laboratory Control Sample	180.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples	—	Not Applicable
	Matrix Spike	180.1	Not applicable	—	Not Applicable
	Matrix Spike Duplicate	180.1	Not Applicable	—	Not Applicable
	Duplicate	180.1	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Must be within laboratory QC limits Corrective Action: Flag data outside of limit Not Applicable.	—	Not Applicable
Water Content	Method Blank	—	Not Applicable	—	Not Applicable
	Laboratory Control Sample	—	Not Applicable	—	Not Applicable
	Matrix Spike	—	Not Applicable	—	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Water Content (continued)	Matrix Spike Duplicate	—	Not Applicable	—	Not Applicable
	Duplicate	—	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] Corrective Action: Flag data outside of limit.	—	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: ≤ 20 % RPD[3] limit Corrective Action: Reanalyze if sample remaining. If not, flag data outside of limit.
GFAA and Flame AA Metals, Mercury by CVAA	Method Blank	200 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank SOP NO. CORP-MT-0003	7000A series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank SOP NO. CORP-MT-0003
	Laboratory Control Sample	200 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery of analyte must be within ± 20 % Corrective Action: Rerun all samples associated with unacceptable LCS SOP NO. CORP-MT-0003	7000A series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery of analyte must be within ± 20 % Corrective Action: Rerun all samples associated with unacceptable LCS SOP NO. CORP-MT-0003

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
GFAA and Flame AA Metals, Mercury by CVAA (continued)	Matrix Spike	200 series	Frequency: with each batch of samples processed not to exceed 20 samples Criteria: Recovery must be within 75-125 % Corrective Action: Flag data associated with unacceptable MS. (See SOP NO. CORP-MT-0003 for detailed corrective action procedure and for other QC procedures.)	7000A series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery must be within 75-125 % Corrective Action: Flag data associated with unacceptable MS. (See SOP NO. CORP-MT-0003 for detailed corrective action procedure and for other QC procedures.)
	Matrix Spike Duplicate	200 series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery must be within 75-125 % , RPD[3] must be within 20 % Corrective Action: Flag data associated with unacceptable MSD SOP NO. CORP-MT-0003	7000A series	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery must be within 75-125 % , RPD[3] must be within 20 % Corrective Action: Flag data associated with unacceptable MSD SOP NO. CORP-MT-0003
	Duplicate	200 series	Not Applicable	7000A series	Not Applicable
	Post Digestion Spikes	200 series	Post Digestion Spike is conducted on all samples	7000A series	Post Digestion Spike is conducted on all samples
ICP Metals	Method Blank	200.7	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank SOP NO. CORP-MT-0001	6010B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank SOP NO. CORP-MT-0001

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
ICP Metals (continued)	Laboratory Control Sample	200.7	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery of analyte must be ± 85-115% Corrective Action: Rerun all samples associated with unacceptable LCS SOP NO. CORP-MT-0001	6010B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery of analyte must be ± 20 % Corrective Action: Rerun all samples associated with unacceptable LCS SOP NO. CORP-MT-0001
	Matrix Spike	200.7	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Limits for percent recovery are 75-125% Corrective Action: Flag data associated with unacceptable Matrix Spike SOP NO. CORP-MT-0001	6010B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Limits for percent recovery are 75-125% Corrective Action: Flag data associated with unacceptable Matrix Spike SOP NO. CORP-MT-0001
	Matrix Spike Duplicate	200.7	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Limits for percent recovery are 75-125%, RPD[3] must be within 20 % Corrective Action: Flag data associated with unacceptable Matrix Spike SOP NO. CORP-MT-0001	6010B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Limits for percent recovery are 75-125%, RPD[3] must be within 20 % Corrective Action: Flag data associated with unacceptable Matrix Spike SOP NO. CORP-MT-0001

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
ICP Metals (continued)	Duplicate	200.7	Not Applicable	6010B	Not Applicable
	Serial Dilution	200.7	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: 10 % Difference Corrective Action: Flag data associated with unacceptable Serial Dilution SOP NO. CORP-MT-0001	6010B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: 10 % Difference Corrective Action: Flag data associated with unacceptable Serial Dilution SOP NO. CORP-MT-0001
ICP/MS Metals	Method Blank	200.8	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	6020	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	200.8	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS	6020	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Recovery within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable blank
	Matrix Spike	200.8	Frequency: 1 per 10 samples, minimum of one per batch of samples processed Criteria: Recovery within laboratory control limits Corrective Action: Qualify data "suspect/matrix"	6020	Not Applicable

TABLE 8.4-5
Inorganic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
ICP/MS Metals (continued)	Matrix Spike Duplicate	200.8	Not Applicable	6020	Not Applicable
	Duplicate	200.8	Not Applicable	6020	Frequency: 1 per 20 samples, minimum of one per batch of samples processed Criteria: 20% RPD[3] Corrective Action: Re-analyze samples associated with unacceptable duplicate
	Post Duplicate Spike	200.8	Not Applicable	6020	Frequency: 1 per 20 samples Criteria: 75-125% Corrective Action: Dilute and reanalyze
	Serial 5x Dilution	200.8	Not Applicable	6020	Frequency: 1 per 20 samples Criteria: ± 10% D Corrective Action: Use alternate isotope or quality data "suspect/matrix"

Footnotes

(1) National Pollutant Discharge Elimination System
(2) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996).
(3) RPD-Relative Percent Difference
(4) Orthophosphate only
(5) Method not listed in 40 CFR Part 136.
(6) Current promulgated method is a Guidance Method Only, SW-846, Final Update III, Rev.3, 12/96.

TABLE 8.4-6
Organic Laboratory Quality Control Samples

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Aromatic Volatiles by GC	Method Blank	602	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8021B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank SOP NO. CORP-GC-0001
	Laboratory Control Sample	602	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8021B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte must be within laboratory acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS SOP NO. CORP-GC-0001
	Matrix Spike	602	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8021B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike SOP NO. CORP-GC-0001

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Aromatic Volatiles by GC (continued)	Matrix Spike Duplicate	602	Not Applicable	8021B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike SOP NO. CORP-GC-0001
	Duplicate	602	Not Applicable	8021B	Not Applicable
	Surrogates	602	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria	8021B	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Reprepare and reanlayze samples or flag sample data not meeting surrogate criteria SOP NO. CORP-GC-0001
	Internal Standards	602	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.	8021B	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate. SOP NO. CORP-GC-0001

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Halogenated Volatiles by GC	Method Blank	601	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8021B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank SOP NO. CORP-GC-0001
	Laboratory Control Sample	601	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8021B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte must be within laboratory acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS SOP NO. CORP-GC-0001
	Matrix Spike	601	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8021B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike SOP NO. CORP-GC-0001

Halogenated Volatiles by GC (cont.)	Matrix Spike Duplicate	601	Not Applicable	8021B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike SOP NO. CORP-GC-0001
	Duplicate	601	Not Applicable	8021B	Not Applicable
	Surrogates	601	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria	8021B	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be within laboratory established control limits before sample analysis may proceed. Sample Criteria: Reprepare and reanlayze samples or flag sample data not meeting surrogate criteria SOP NO. CORP-GC-0001
	Internal Standards	601	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate.	8021B	Optional: Internal standards are added to the method blank and all samples (QC included). If used, same compounds as used for surrogates may be appropriate. SOP NO. CORP-GC-0001

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitrosamines by GC	Method Blank	607	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Re-extract all samples associated with unacceptable blank	8070A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Re-extract all samples associated with unacceptable blank SOP NO. DEN-GC-0018
	Laboratory Control Sample	607	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Re-extract all samples associated with unacceptable LCS	8070A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte must be within laboratory acceptance limits Corrective Action: Re-extract and reanalyze all samples associated with unacceptable LCS SOP NO. DEN-GC-0018
	Matrix Spike	607	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8070A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike SOP NO. DEN-GC-0018

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitrosamines (cont.	Matrix Spike Duplicate	607	Not Applicable	8070A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within laboratory control limits Corrective Action: Flag data associated with unacceptable matrix spike sample SOP NO. DEN-GC-0018
	Duplicate	607	Not Applicable	8070A	Not Applicable
	Internal Standards	607	Not Applicable	8070A	Optional

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Herbicides	Method Blank	615 [3]	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Re-extract all samples associated with unacceptable blank	8151A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Re-extract all samples associated with unacceptable blank SOP NO. CORP-GC-0001
	Laboratory Control Sample	615 [3]	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Re-extract all samples associated with unacceptable LCS	8151A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte must be within laboratory acceptance limits Corrective Action: Re-extract and reanalyze all samples associated with unacceptable LCS SOP NO. CORP-GC-0001
	Matrix Spike	615 [3]	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: Percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8151A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike SOP NO. CORP-GC-0001

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Herbicides (continued)	Matrix Spike Duplicate	615 [3]	Not Applicable	8151A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within laboratory control limits Corrective Action: Flag data associated with unacceptable matrix spike sample SOP NO. CORP-GC-0001
	Duplicate	615 [3]	Not Applicable	8151A	Not Applicable
	Surrogates	615 [3]	Not Applicable	8151A	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must fall within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract and reanalyze samples or flag sample data not meeting surrogate criteria SOP NO. CORP-GC-0001
	Internal Standards	615 [3]	Not Applicable	8151A	Optional
Nitro-aromatics by HPLC	Method Blank	--	Not Applicable	8330	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Nitro-aromatics by HPLC (continued)	Laboratory Control Sample	--	Not Applicable	8330	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte must be within laboratory acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	--	Not Applicable	8330	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	--	Not Applicable	8330	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	--	Not Applicable	8330	Not Applicable
	Surrogates	--	Not Applicable	8330	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must fall within laboratory established control limits before sample analysis may proceed. Sample Criteria: Re-extract and reanalyze samples or flag sample data not meeting surrogate criteria
	Internal Standards	--	Not Applicable	8330	Not Applicable

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Organo-phosphorus Pesticides	Method Blank	--	Not Applicable	8141A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	--	Not Applicable	8141A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	--	Not Applicable	8141A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable MS
	Matrix Spike Duplicate	--	Not Applicable	8141A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable MS
	Duplicate	--	Not Applicable	8141A	Not Applicable

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Organo-phosphorus Pesticides (continued)	Surrogates	--	Not Applicable	8141A	Surrogates spiked into method blank and all samples (QC included) Method Blank and LCS Criteria: Results must fall within laboratory-established control limits Sample Criteria: Re-extract and reanalyze samples or flag sample data not meeting surrogate criteria
PAHs by GC and HPLC	Method Blank	610	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8310	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank
	Laboratory Control Sample	610	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8310	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte must be within laboratory acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
PAHs by GC and HPLC (continued)	Matrix Spike	610	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8310	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Matrix Spike Duplicate	610	Not Applicable	8310	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike
	Duplicate	610	Not Applicable	8310	Not Applicable
	Surrogates	610	Not specified in method	8310	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: Results must fall within laboratory established control limits Sample Criteria: Re-extract and reanalyze samples or flag sample data not meeting surrogate criteria
	Internal Standards	610	Optional	8310	Optional

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Pesticides/ PCBs	Method Blank	608	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8081A 8082	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Reprepare and reanalyze all samples associated with unacceptable blank, see SOP CORP-GC-0001
	Laboratory Control Sample	608	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8081A 8082	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte must be within laboratory acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS SOP NO. CORP-GC-0001
	Matrix Spike	608	Frequency: 1 per 10 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8081A 8082	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike, see SOP CORP-GC-0001

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Pesticides/ PCBs (continued)	Matrix Spike Duplicate	608	Not Applicable	8081A 80882	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike, see SOP CORP-GC-0001
	Duplicate	608	Not Applicable	8081A 8082	Not Applicable
	Surrogates	608	Not specified in method	8081A 8082	Surrogates spiked into method blank and all samples (QC included) Method Blank Criteria and LCS: Results must fall within laboratory established control limits Sample Criteria: Re-extract and reanalyze samples or flag sample data not meeting surrogate criteria, see SOP CORP-GC-0001
	Internal Standards	608	Optional	8081A 8082	Optional

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Petroleum Hydro-carbons/Oil and Grease	Method Blank	413.1 413.2 418.1	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank Method 413.1: Not Applicable	9070 9071A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Petroleum Hydro-carbons/Oil and Grease (continued)	Laboratory Control Sample	413.1 413.2 418.1	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: If not within laboratory control limits, rerun all associated samples Method 413.1: Not Applicable	9070 9071A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within ± 20% Corrective Action: Rerun all samples associated with unacceptable LCS
	Matrix Spike	413.1 413.2 418.1	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data Method 413.1: Not Applicable	9070 9071A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated data
	Matrix Spike Duplicate	413.1 413.2 418.1	Not Applicable	9070 9071A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated Method 9071: Not Applicable

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Petroleum Hydro-carbons/Oil and Grease (continued)	Duplicate	413.1 413.2 418.1	Not Applicable	9070 9071A	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Percent recovery must be within laboratory control limits Corrective Action: Flag associated Method 9070: Not Applicable
	Surrogates	413.1 413.2 418.1	Not Applicable	9070 9071A	Not Applicable
	Internal Standards	413.1 413.2 418.1	Not Applicable	9070 9071A	Not Applicable
Petroleum Hydro-carbons	Method Blank	1664[4]	Frequency: 1 with each preparation batch Criteria: Concentration must be less than the reporting limit Corrective Action: Rerun all samples associated with unacceptable blank SOP NO. CORP-WC-0003	---	---

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Petroleum Hydro-carbons (continued)	Laboratory Control Sample	1664[4]	Frequency: 1 with each analytical batch Criteria: Waters - See limits in Table 2 of SOP No.: CORP-WC-0003 Soils - Percent recovery must be within laboratory control limits Corrective Action: Rerun all samples associated with unacceptable LCS SOP NO. CORP-WC-0003	---	---
	Matrix Spike	1664[4]	Frequency: 1 with every 10 samples per site Criteria: See percent recovery limits in Table 2 of SOP No. CORP-WC-0003 Corrective Action: See Section 9.6.1 of SOP No. CORP-WC-0003	---	---
	Matrix Spike Duplicate	1664[4]	Frequency: 1 with every 10 samples per site Criteria: See percent recovery and RPD limits in Table 2 of SOP No. CORP-WC-0003 Corrective Action: See Section 9.6.1 of SOP No. CORP-WC-0003	---	---
	Duplicate	1664[4]	Not Applicable	---	---

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Semivolatiles	Method Blank	625	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8270C	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Reextract and reanalyze all samples associated with unacceptable blank, see Section 9.3, SOP No. CORP-MS-0001
	Laboratory Control Sample	625	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery must be within acceptance limits given in method for each analyte Corrective Action: Rerun all samples associated with unacceptable LCS	8270C	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte must be within laboratory acceptance limits Corrective Action: Reextract and reanalyze all samples associated with unacceptable LCS, see Section 9.5.2, SOP No. CORP-MS-0001
	Matrix Spike	625	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8270C	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike, see Section 9.6, SOP No. CORP-MS-0001

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Semivolatiles (continued)	Matrix Spike Duplicate	625	Not Applicable	8270C	Frequency: 1 with each extraction batch of samples not to exceed 20 samples Criteria: percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike, see Section 9.6, SOP No. CORP-MS-0001
	Duplicate	625	Not Applicable	8270C	Not Applicable
	Surrogates	625	Surrogates spiked into method blank and all samples (QC included) Method Blank and LCS Criteria: All surrogates must be in control before sample analysis may proceed Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria	8270C	Surrogates spiked into method blank and all samples (QC included) Method Blank and LCS Criteria: All surrogates must be in control before sample analysis may proceed Sample Criteria: Re-extract and reanalyze samples or flag sample data not meeting surrogate criteria, see Section 9.7.2, SOP No. CORP-MS-0001
	Internal Standards	625	Frequency: Internal standards spiked into method blank and all samples (QC included) Criteria: All internal standard recoveries must be within laboratory control limits Corrective Action: Flag sample data not meeting internal standard recovery requirements	8270C	Internal Standards are added to all samples (QC samples included). Internal standard area of daily standard must be within 50% to 200% of the response in the mid level of the initial calibration standard. The retention time (RT) for any internal standard (IS) in the continuing calibration must not exceed ± 0.5 minutes from mid level initial calibration standard IS RT.

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Volatiles by GC/MS	Method Blank	624	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank	8260B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: Concentration less than reporting limit Corrective Action: Rerun all samples associated with unacceptable blank, see Section 9.4, SOP No. CORP-MS-0002
	Laboratory Control Sample	624	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8260B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte must be within laboratory acceptance limits Corrective Action: Rerun all samples associated with unacceptable LCS, see Section 9.5, SOP No. CORP-MS-0002
	Matrix Spike	624	Frequency: 1 per ≤ 20 samples from each site or 1 per month, whichever is more frequent Criteria: percent recovery for each analyte should be within advisory limits given in method Corrective Action: Flag data associated with unacceptable Matrix Spike	8260B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike, see Section 9.6, SOP No. CORP-MS-0002

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Analysis	QC Sample	Method	NPDES[1]	Method	RCRA (SW846)[2]
Volatiles by GC/MS (continued)	Matrix Spike Duplicate	624	Not Applicable	8260B	Frequency: 1 with each batch of samples processed not to exceed 20 samples Criteria: percent recovery for each analyte should be within laboratory acceptance limits Corrective Action: Flag data associated with unacceptable Matrix Spike, see Section 9.6, SOP No. CORP-MS-0002
	Duplicate	624	Not Applicable	8260B	Not Applicable
	Surrogates	624	Surrogates spiked into Method Blank and all samples (QC included) Method Blank Criteria: All surrogates must be in control before sample analysis may proceed. Sample Criteria: Re-extract samples or flag sample data not meeting surrogate criteria	8260B	Surrogates spiked into Method Blank and all samples (QC included) Method Blank Criteria and LCS: All surrogates must be in control before sample analysis may proceed. Sample Criteria: Re-extract and reanalyze samples or flag sample data not meeting surrogate criteria, see Section 9.3, SOP No. CORP-MS-0002
	Internal Standards	624	Frequency: Internal standards spiked into method blank and all samples (QC included) Criteria: All internal standard recoveries must be within laboratory control limits Corrective Action: Flag sample data not meeting internal standard recovery requirements	8260B	Internal Standards are added to all samples (QC samples included). Internal standard area of daily standard must be within 50% to 200% of the response in the mid level of the initial calibration standard. The retention time (RT) for any internal standard (IS) in the continuing calibration must not exceed ± 0.5 minutes from mid level initial calibration standard IS RT.

TABLE 8.4-6
Organic Laboratory Quality Control Samples
(Continued)

Footnotes

(1) National Pollutant Discharge Elimination System

(2) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996).

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Acidity	Water	100 mL	305.1	250 mL plastic or glass, Cool, 4°C, 14 days	---	Not Applicable
	Solid[5]	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Alkalinity	Water	100 mL	310.1 2320B	250 mL plastic or glass, Cool, 4°C, 14 days	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Ammonia	Water	400 mL	350.1	500 mL plastic or glass, Cool, 4°C H_2SO_4 to pH < 2, 28 days	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Biochemical Oxygen Demand (BOD)	Water	200 mL	405.1	1000 mL plastic or glass, Cool, 4°C 48 hours	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Bromide	Water	100 mL	300.0[7]	250 mL plastic or glass, No preservative required, 28 days	9056	Cool, 4°C, analyze ASAP after collection
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Chemical Oxygen Demand (COD)	Water	100 mL	410.4	250 mL glass or plastic, Cool, 4°C, H_2SO_4 to pH < 2, 28 days	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Chloride	Water	50 mL	300.0[7] 325.2	250 mL plastic or glass, No preservative required, 28 days	9056	Method 9056: Cool, 4°C, analyze ASAP after collection.
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Chromium (Cr^{+6})	Water	100 mL	3500 Cr-D	Method 218.4: 200 mL plastic or glass, Cool, 4°C, 24 hours Method 3500 Cr-D: 200 mL quartz, TFE, or polypropylene HNO_3 to pH <2 Cool, 4°C Analyze ASAP after collection	7196A	200 mL plastic or glass, Cool, 4°C, 24 hours
	Solid	Not Applicable	---	Not Applicable	7196A	250 mL plastic or glass, 30 days to digestion, 96 hours after digestion
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Color	Water	100 mL	110.2	250 mL plastic or glass, Cool, 4°C, 48 hours	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Conductivity	Water	100 mL	120.1	200 mL glass or plastic, Cool, 4°C, 28 days	9050A	200 mL glass or plastic, Cool, 4°C, 24 hours
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Cyanide (Amenable)	Water	IL	335.3	1 liter plastic or glass, NaOH to pH >12 0.6g ascorbic acid[6] Cool, 4°C, 14 days unless sulfide is present. Then maximum holding time is 24 hours	9010B/ 9012A	1 liter plastic or glass, NaOH to pH >12 0.6g ascorbic acid[6] Cool, 4°C, 14 days
	Solid	50g	---	Not Applicable	9010B/ 9012A	Not Specified
	Waste	50g	---	Not Applicable	9010B/ 9012A	Not Specified
Cyanide (Total)	Water	IL	335.3	1 liter plastic or glass, NaOH to pH >12 0.6g ascorbic acid[6] Cool, 4°C, 14 days unless sulfide is present. Then maximum holding time is 24 hours	9010B/ 9012A	1 liter plastic or glass, NaOH to pH >12 0.6g ascorbic acid[6] Cool, 4°C, 14 days
	Solid	50g	--	Not Applicable	9010B 9012A	8 or 16 oz glass Teflon-lined lids, Cool, 4°C, 14 days

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Cyanide (Total) (continued)	Waste	50g	--	Not Applicable	9010B/ 9012A	8 or 16 oz glass Teflon-lined lids, Cool, 4°C
Flashpoint (Ignitability)	Liquid	Not Applicable	---	Not Applicable	1010	No requirements, 250 mL amber glass, Cool, 4°C is recommended
	Solid	Not Applicable	--	Not Applicable	---	Not Applicable
	Waste	Not Applicable	--	Not Applicable	---	Not Applicable
Fluoride	Water	300 mL	300.0[7] 340.2	500 mL plastic, No preservation required, 28 days	9056	Cool, 4°C, analyze ASAP after collection
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Hardness (Total)	Water	50 mL	130.2 2340B	250 mL glass or plastic, HNO_3 to pH < 2, 6 months	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Iron (Ferrous)	Water	100 mL	3500-Fe D	1 liter glass or polyethylene container, 6 months **This test should be performed in the field.**	-	Not Applicable
	Solid	Not Applicable	-	Not Applicable	-	Not Applicable
	Waste	Not Applicable	-	Not Applicable	-	Not Applicable

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Methylene Blue Active Substances (MBAS) (Surfactant)	Water	100 mL	425.1	250 mL plastic or glass, Cool, 4°C, 48 hours	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Nitrate	Water	100 mL	300.0[7] 353.2	Method 300.0: 250 mL plastic or glass, Cool, 4°C, 48 hours. Method 352.1: 250 mL plastic or glass, Cool, 4°C, 48 hours.	9056	Method 9056: Cool, 4°C, analyze ASAP after collection Method 9210: Cool, 4°C Preserve by adding 1 mL of 1M boric acid solution per 100 mL of sample
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	9210	Not Specified
Nitrite	Water	50 mL	300.0[7] 353.2	250 mL plastic or glass Cool, 4°C, 48 hours	9056	Cool, 4°C, analyze ASAP after collection
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Nitrate-Nitrite	Water	100 mL	353.3	250 mL plastic or glass, H_2SO_4 to pH < 2, 28 days	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Ortho-phosphate	Water	50 mL	300.0[7] 365.3	100 mL plastic or glass, Filter on site Cool, 4°C, 48 hours	9056	Cool, 4°C, analyze ASAP collection
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
pH	Water	50 mL	150.1 4500-H' B	100 mL plastic or glass. Analyze immediately. **This test should be performed in the field.**	9040B	100 mL plastic or glass. Analyze immediately. **This test should be performed in the field.**[8]
	Solid	Not Applicable	---	Not Applicable	9045C	4 oz glass or plastic, Cool, 4°C, Analyze as soon as possible.[8]
	Waste	Not Applicable	---	Not Applicable	9045C	4 oz glass or plastic, Cool, 4°C, Analyze as soon as possible.[8]
Phenolics	Water	100 mL	420.2	500 mL glass, Cool, 4°C, H_2SO_4 to pH < 2, 28 days	9066	1 liter glass recommended, Cool, 4°C, H_2SO_4 to pH < 4, 28 days
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	9065	Not Specified
Phosphate	Water	50 mL	365.3	Not Applicable	9056	Cool, 4°C, analyze ASAP collection
	Solid	Not Applicable	---	Not Applicable	9056	Not Applicable
	Waste	Not Applicable	---	Not Applicable	9056	Not Applicable

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Phosphorus (Total)	Water	50 mL	365.3	100 mL plastic or glass, H_2SO_4 to pH < 2, 28 days	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Reactivity (Cyanide and Sulfide)	Liquid	10 g	---	Not Applicable	Chapter 7 Sections 7.3.3.2 and 7.3.4.2	10 oz amber glass, Cool, 4°C, no headspace, analyze as soon as possible.
	Solid	10 g	---	Not Applicable	Chapter 7 Sections 7.3.3.2 and 7.3.4.2	10 oz amber glass, Cool, 4°C, no headspace, analyze as soon as possible.
	Waste	10 g	---	Not Applicable	Chapter 7 Sections 7.3.3.2 and 7.3.4.2	10 oz amber glass, Cool, 4°C, no headspace, analyze as soon as possible.
Settleable Solids	Water	1000 mL	160.5	1000 mL plastic or glass, Cool, 4°C, 48 hours	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Specific Conductance	Water	50 mL	120.1	250 mL plastic or glass, Cool, 4°C, 24 hours	9050A	250 mL plastic or glass, Cool, 4°C, 28 days
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Sulfate (SO_4)	Water	100 mL	300.0[7] 375.2	100 mL plastic or glass, Cool, 4°C, 28 days	9056 9038	Method 9056: Cool, 4°C, analyze ASAP collection Method 9038: 200 mL plastic or glass, Cool, 4°C, 28 days
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	100 mL	---	Not Applicable	9038	200 mL plastic or glass, Cool, 4°C, 28 days
Sulfide	Water	100 mL	376.2	500 mL plastic or glass, Cool, 4°C, Add 2 mL zinc acetate plus NaOH to pH > 9, 7 days	9030B/ 9034	500 mL plastic, no headspace, Cool, 4°C, Add 4 drops of 2N zinc acetate per 100 mL of sample, adjust the pH to > 9 with 6 N NaOH solution, 7 days
	Solid	50 g	---	Not Applicable	9030B 9034	Cool, 4°C, fill surface of solid with 2N Zinc acetate until moistened, store headspace-free
	Waste	50 g	---	Not Applicable	9030B 9034	Cool, 4°C, fill surface of solid with 2N Zinc acetate until moistened, store headspace-free

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Sulfite (SO_3)	Water	100 mL	377.1	100 mL plastic or glass, No preservative required, analyze immediately **This test should be performed in the field.**	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Total Dissolved Solids (Filterable)	Water	100 mL	160.1	250 mL plastic or glass, Cool, 4°C, 7 days	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Total Kjeldahl Nitrogen (TKN)	Water	500 mL	351.3	500 mL plastic or glass, Cool, 4°C, H_2SO_4 to pH < 2, 28 days	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Total Organic Carbon (TOC)	Water	100 mL	415.1	100 mL plastic or glass, Cool, 4°C, H_2SO_4 to pH < 2, 28 days	9060	100 mL glass or 40 mL VOA vials, Cool, 4°C, H_2SO_4 or HCl to pH < 2, 28 days
	Solid	Not Applicable	---	Not Applicable	9060	Not Specified
	Waste	Not Applicable	---	Not Applicable	9060	Not Specified

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Total Organic Halides (TOX)	Water	100 mL	---	Method 5320B: 500 mL amber glass, Teflon®-lined lid, Cool, 4°C, HNO_3 to pH <2, no headspace, 14 days Method 450.1: 500 mL amber glass, Teflon®-lined lid, Cool, 4°C, HNO_3 to pH <2, no headspace, 28 days	9020B	500 mL amber glass, Teflon®-lined lid, Cool, 4°C, H_2SO_4 to pH < 2, no headspace, 28 days
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Total Solids	Water	100 mL	160.3	250 mL plastic or glass, Cool, 4°C, 7 days	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Total Suspended Solids (Nonfilterable)	Water	100 mL	160.2	250 mL plastic or glass, Cool, 4°C, 7 days	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Turbidity	Water	50 mL	180.1	250 mL plastic or glass, Cool, 4°C, 48 hours	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable
Volatile Solids	Water	100 mL	160.4	250 mL plastic or glass, Cool, 4°C, 7 days	---	Not Applicable
	Solid	Not Applicable	---	Not Applicable	---	Not Applicable
	Waste	Not Applicable	---	Not Applicable	---	Not Applicable

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3], [7]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method	Requirements
Water Content	Water	Not Applicable	---	Not Applicable	---	Not Applicable
	Solid	10 g	---	Refer to specific method used	---	Refer to specific method used
	Waste	10 g	---	Refer to specific method used	---	Refer to specific method used
Metals (excludes Hg)	Water	100 mL	200 series	1 liter glass or polyethylene container, HNO_3 to pH $\leq$ 2, 6 months	6010B, 6020, 7000A series	1 liter glass or polyethylene container, HNO_3 to pH $\leq$ 2, 6 months
	Solid	200 g	200 series	8 or 16 oz glass or polyethylene container storage at 4 °C	6010B, 6020, 7000A series	8 or 16 oz glass or polyethylene container, storage at 4°C, 6 months
	Waste	200 g	200 series	Not Applicable	6010B, 6020, 7000A series	8 or 16 oz glass or polyethylene container, storage at 4°C, 6 months
Mercury (CVAA)	Water	100 mL	245.1	1 liter glass or polyethylene container, HNO_3 to pH $\leq$ 2, 28 days	7470A	1 liter glass or polyethylene container, HNO_3 to pH $\leq$ 2, 28 days
	Solid	200 g	245.5	8 or 16 oz glass or polyethylene container, Cool, 4°C, 28 days	7471A	8 or 16 oz glass or polyethylene container, Cool, 4°C, 28 days (CORP-MT-0007)
	Waste	200 g	--	Not Applicable	7471A	8 or 16 oz glass or polyethylene container, Cool, 4°C, 28 days (CORP-MT-0007)

TABLE 8.5-1
Inorganic Sample Containers, Preservatives, and Holding Times
(Continued)

Footnotes

(1) Minimum sample size indicates sample amount needed for a single analysis. Matrix spikes or duplicates will require an additional sample amount of at least this amount for each additional QC sample aliquot required.
(2) National Pollutant Discharge Elimination System - MCAWW, March 1983.
(3) Holding times are calculated from date of collection.
(4) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA, (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996).
(5) Solid matrix type includes soil, sediment, sludge and other solid materials not classified as waste.
(6) Samples to be analyzed for cyanide should be field-tested for residual chlorine. If residual chlorine is detected, ascorbic acid should be added.
(7) Method not listed in 40 CFR Part 136.
(8) If not done in the field (ASAP) per the method and requested by client, analyze in lab within 48 hours.

TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
Aromatic Volatiles	Water	40 mL	602	40 mL glass, VOA vial (in triplicate) with Teflon®-lined septa without headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine, 7 days with pH > 2, 14 days with pH < 2	8021B	40 mL glass, VOA vial (in triplicate) with Teflon®-lined septa without headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine, 1:1 HCl to pH < 2, 14 days with pH < 2
	Solid[5]	5 g or 25 g	--	Not Applicable	8021B	4 or 8 oz glass with Teflon®-lined lid, Cool 4 °C, 14 days. Field preserved with sodium bisulfate solution for low level analysis, or with methanol for medium level analysis. Soil sample can also be taken by using the EnCore™ sampler and preserved in the lab within 48 hours of sampling. Maximum holding time for Encore Sampler is 48 hours (before the sample is added to methanol or sodium bisulfate).Cool, 4°C (See Note 12 Page 136 for holding time.)
	Waste	5 g or 25 g	--	Not Applicable	8021B	4 or 8 oz glass with Teflon®-lined lid, Cool 4 °C, 14 days. Field preserved with sodium bisulfate solution for low level analysis, or with methanol for medium level analysis.

TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	Method	NPDES[2], [3]		RCRA (SW846)[3], [4]
				Requirements	Method[6]	Requirements
Aromatic Volatiles (continued)	Waste	5 g or 25 g	--	Not Applicable	8021B	Soil sample can also be taken by using the EnCore™ sampler and preserved in the lab within 48 hours of sampling. Maximum holding time for Encore Sampler is 48 hours (before the sample is added to methanol or sodium bisulfate). Cool, 4°C. (See Note 12 Page 136 for holding time.)
Halogenated Volatiles By GC	Water	40 mL	601	Not Applicable	8021B	40 mL glass, VOA vial (in triplicate) with Teflon®-lined septa without headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine, 1:1 HCl to pH ≤ 2, 14 days
	Solid[5]	5 g or 25 g	601		8021B	4 or 8 oz glass with Teflon®-lined lid, Cool 4 °C, 14 days. Field preserved with sodium bisulfate solution for low level analysis, or with methanol for medium level analysis. Soil sample can also be taken by using the EnCore™ sampler and preserved in the lab within 48 hours of sampling. Maximum holding time for Encore Sampler is 48 hours (before the sample is added to methanol or sodium bisulfate). Cool, 4°C. (See Note 12 Page 136 for holding time.)

TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times
(Continued)

Nitrosamines	Water	1L	607 [10]	1 liter amber glass with Teflon®-lined lid, Sodium thiosulfate or ascorbic acid if residual chlorine present, Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction	8070A	1 liter amber glass with Teflon®-lined lid. If residual chlorine present, add 3 mL sodium thiosulfate per gallon. Cool, 4°C, Extraction, 7 days Analysis, 40 days of the start of the extraction
Herbicides	Water	1L	615 [10]	1 liter amber glass with Teflon®-lined lid, Sodium thiosulfate or ascorbic acid if residual chlorine present, Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction	8151A	1 liter amber glass with Teflon®-lined lid. If residual chlorine present, add 3 mL sodium thiosulfate per gallon. Cool, 4°C, Extraction, 7 days Analysis, 40 days of the start of the extraction
	Solid	50 g	--	Not Applicable	8151A	4 or 8 oz glass widemouth with Teflon®-lined lid, Cool 4 °C, Extraction, 14 days Analysis, 40 days of the start of the extraction
Nitroaromatics	Water	1L	--	Not Applicable	8330	1 liter amber glass with Teflon®-lined lid. If residual chlorine present, add 3 mL sodium thiosulfate per gallon. Cool, 4°C, Extraction, 7 days Analysis, 40 days of the start of the extraction
	Solid	50 g	---	Not Applicable	8330	4 or 8 oz glass widemouth with Teflon®-lined lid Cool, 4°C, Extraction, 14 days Analysis, 40 days of the start of the extraction

TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
Nitroaromatics (continued)	Waste	50 g	---	Not Applicable	8330	4 or 8 oz glass widemouth with Teflon®-lined lid Cool, 4 °C, Extraction, 14 days Analysis, 40 days of the start of the extraction
Organo-phosphorus Pesticides	Water	1L	---	Not Applicable	8141A	1 liter amber glass with Teflon®-lined lid. If residual chlorine present, add 3 mL sodium thiosulfate per gallon. Cool, 4°C, Extraction, 7 days Analysis, 40 days of the start of the extraction
	Solid	50 g	---	Not Applicable	8141A	4 or 8 oz glass widemouth with Teflon®-lined lid Cool, 4°C, Extraction, 14 days Analysis, 40 days of the start of the extraction
	Waste	50 g	---	Not Applicable	8141A	4 or 8 oz glass widemouth with Teflon®-lined lid, Cool, 4°C, Extraction, 14 days Analysis, 40 days of the start of the extraction
PAHs by GC and HPLC	Water	1L	610	1 liter amber glass with Teflon®-lined lid, Adjust pH to 5-9 if extraction not to be done within 72 hours of sampling. Add sodium thiosulfate if residual chlorine present. Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction	8310	1 liter amber glass with Teflon®-lined lid, If residual chlorine present, add 3 mL sodium thiosulfate per gallon, Cool, 4°C, Extraction, 7 days Analysis, 40 days of the start of the extraction

TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
PAHs by GC and HPLC (continued)	Solid	50 g	---	Not Applicable	8310	4 or 8 oz glass wide mouth with Teflon®-lined lid, Cool, 4°C, Extraction, 14 days Analysis, 40 days of the start of the extraction
	Waste	50 g	---	Not Applicable	8310	4 or 8 oz glass wide mouth with Teflon®-lined lid, Cool, 4°C Extraction, 14 days Analysis, 40 days of the start of the extraction
Pesticides/ PCBs	Water	1L	608	1 liter amber glass with Teflon®-lined lid, Adjust pH to 5-9 if extraction not to be done within 72 hours of sampling. Add sodium thiosulfate if residual chlorine present and aldrin is being determined. Cool, 4°C, Extraction, 7 days Analysis, 40 days after extraction	8081A 8082	1 liter amber glass with Teflon®-lined lid, If residual chlorine present, add 3 mL 10% sodium thiosulfate per gallon, Cool, 4°C, Extraction, 7 days Analysis, 40 days of the start of the extraction
	Solid	50 g	---	Not Applicable	8081A 8082	4 or 8 oz glass wide mouth with Teflon®-lined lid, Cool, 4°C, Extraction, 14 days Analysis, 40 days of the start of the extraction
	Waste	50 g	---	Not Applicable	8081A 8082	4 or 8 oz glass wide mouth with Teflon®-lined lid, Cool, 4°C Extraction, 14 days Analysis, 40 days of the start of the extraction

TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
Petroleum Hydrocarbons/ Oil and Grease	Water	1L	413.1 413.2 418.1	1 liter glass, Cool, 4°C, HCl to pH <2, 28 days	9070	1 liter glass with Cool, 4°C, HCl to pH <2, 28 days
	Solid	---	---	Not Applicable	9071A	8 oz. glass with Teflon®-lined lid, Holding Time not specified
	Waste	---	---	Not Applicable	9071A	8 oz. glass with Teflon®-lined lid, Holding Time not specified
	Water	1 L	1664[7]	1 liter glass, Cool, 0-4°C HCl or H_2SO_4 to pH <2 28 days	---	---
	Solid	30 g	1664[7]	8 or 16 oz. wide mouth glass jar, Cool, 0-4°C, 28 days	---	---
	Waste	---	---	Not Applicable	---	---

TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
Semivolatiles	Water	1L	625	1 liter amber glass with Teflon®-lined lid, Cool, 4°C, Extraction, 7 days Analysis, 40 days	8270C	1 liter amber glass with Teflon®-lined lid, If residual chlorine present, add 3 mL sodium thiosulfate per gallon, Cool, 4°C, Extraction, 7 days Analysis, within 40 days of extraction
	Solid	50 g	---	Not Applicable	8270C	8 or 16 oz glass wide mouth with Teflon-lined lid, Cool, 4°C, Extraction, 14 days Analysis, within 40 days of extraction
	Waste	50 g	---	Not Applicable	8270C	8 or 16 oz glass wide mouth with Teflon®-lined lid, Cool, 4°C, Extraction, 14 days Analysis, within 40 days of extraction
Volatile Organics	Water	40 mL	624	40 mL glass, VOA vial (in triplicate) with Teflon®-lined septa without headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine, 7 days with pH > 2, 14 days with pH ≤ 2[8]	8260B	40 mL glass, VOA vial (in triplicate) with Teflon®-lined septa without headspace, Cool, 4°C, Add sodium thiosulfate if residual chlorine, 1:1 HCl to pH ≤ 2, 14 days with pH ≤ 2[9]

TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times
(Continued)

Analytical Parameters	Matrix	Minimum Sample Size[1]	NPDES[2], [3]		RCRA (SW846)[3], [4]	
			Method	Requirements	Method[6]	Requirements
Volatile Organics (continued)	Solid[5]	5 g or 25 g	--	Not Applicable	8260B	4 or 8 oz glass with Teflon®-lined lid, Cool 4 °C, 14 days. Field preserved with sodium bisulfate solution for low level analysis, or with methanol for medium level analysis. Soil sample can also be taken by using the EnCore™ sampler and preserved in the lab within 48 hours of sampling. Maximum holding time for Encore Sampler is 48 hours (before the sample is added to methanol or sodium bisulfate). Cool, 4°C. (See Note 12 Page 136 for holding time.)
	Waste	5 g or 25 g	--	Not Applicable	8260B	4 or 8 oz glass with Teflon®-lined lid, Cool 4 °C, 14 days. Field preserved with sodium bisulfate solution for low level analysis, or with methanol for medium level analysis. Soil sample can also be taken by using the EnCore™ sampler and preserved in the lab within 48 hours of sampling. Maximum holding time for Encore Sampler is 48 hours (before the sample is added to methanol or sodium bisulfate). Cool, 4°C. (See Note 12 Page 136 for holding time.)

TABLE 8.5-2
Organic Sample Containers, Preservatives, and Holding Times (Continued)

Footnotes

(1) Minimum sample size indicates sample amount needed for a single analysis. Matrix spikes or duplicates will require an additional sample amount of at least this amount for each additional QC sample aliquot required.
(2) National Pollutant Discharge Elimination System - 40 CFR Part 136, Appendix A.
(3) Holding times are calculated from the date of collection.
(4) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996).
(5) Solid matrix type includes soil, sediment, sludge or other solids not classified as waste.
(6) Only one determination method is listed when separate methods are required for preparation and analysis.
(7) **Method 1664 was promulgated by the EPA with an effective date of June 14, 1999.**
(8) **For acrolein and acrylonitrile the pH should be adjusted to 4-5. This pH adjustment is not required if acrolein is not measured. Samples requiring analysis of acrolein that received no pH adjustment must be analyzed within three days of sampling.**
(9) **For acrolein and acrylonitrile the pH should be adjusted to 4-5.**
(10) Method not listed in 40 CFR Part 136.
(11) Should only be used in the presence of residual chlorine.
(12) Depending on regulatory programs, EnCore™ samplers may be preserved for up to 14 days from sampling by freezing at -5 to -12°C until analysis. Alternatively the EnCore™ sample may be transferred to a 40-ml VOA vial and preserved by freezing at -5 to -12°C until analysis. Some regulatory agencies may require 4 or 8 oz glass with Teflon®-lined lid, Cool 4°C, 14 days. This technique is not recommended, but will be supported where required. (Preservation and holding times are subject to client specifications.)

TABLE 8.5-5
Sample Containers, Preservatives, and Holding Times for TCLP[1] and SPLP[2]

Analytical Parameters	Matrix	Minimum Sample Size[3]	TCLP Method 1311 and SPLP Method 1312 Requirements	
			From Field Collection to TCLP/SPLP Extraction	From TCLP/SPLP Extraction to Analysis
Mercury	Liquid Solid Waste	1L	1L glass, Cool, 4°C, 28 days	Glass or polyethylene 28 days
Metals (except mercury)	Liquid Solid Waste	1L	1L glass, Cool, 4°C, 180 days	Glass or polyethylene 180 days
Semivolatiles	Liquid Solid Waste	1L	1L glass, Cool 4°C, 14 days	1L glass Extraction of leachate within 7 days of TCLP extraction, Analyze extract within 40 days
Volatiles	Liquid Solid Waste	6 oz	4 oz glass, Cool 4°C, 14 days	40 mL glass, 14 days

Footnotes

(1) TCLP = Toxicity Characteristic Leaching Procedure

(2) SPLP = Synthetic Precipitation Leaching Procedure

(3) Smaller sample size is adequate for solid samples or individual fractions. A combined volume of 32 oz. is recommended for semivolatiles and metals. A separate 4 oz. container should always be used for the volatile fraction. Volatile fractions should be stored with minimal headspace.

TABLE 8.5-6
Periodic Equipment Calibrations

Type of Equipment	Calibration Requirements
Balances	• Must be serviced and calibrated annually by an approved vendor. • Calibration must be checked daily or before use by analyst with weight(s) classified as Class 1 (formerly termed Class S) by NIST or Class 1 traceable. Acceptance criteria vary according to weight used and accuracy of balance. Acceptance criteria must be documented in the log. • All Class 1 weights must be certified by an outside vendor every three years. • All non-Class 1 weights must be checked annually against NIST Class 1 weights annually.
Thermometers	• Working glass thermometers must be calibrated against a certified NIST thermometer at least annually as described in operation-specific SOPs. • Working non-glass thermometers must be calibrated against a certified NIST thermometer annually as described in operation-specific SOPs. • The NIST thermometer must be recertified every three years.
Refrigerators/Freezers	• Thermometers must be immersed in a liquid such as mineral oil or glycol • Temperature of units used for sample or standard storage must be checked daily as described in operation-specific SOPs. Refrigerator acceptance limits: 4°C ± 2°C Freezer acceptance limits: < - 10°C
Ovens	• Temperature of units must be checked daily or before use. • Acceptance limits vary according to use as described in operation-specific SOPs and must be documented in the temperature log.
Micropipettors	• Calibrations are checked gravimetrically as required by the operation-specific SOP. • Must be calibrated at the frequency (normally quarterly) required by the manufacturer at a minimum.
Syringes, Volumetric Glassware and Graduated Glassware	• All syringes and volumetric glassware are purchased as Class A items. • Class A items are certified by the manufacturer to be within ± 1% of the measured volume, therefore, calibration of these items by STL® laboratories is not required. • All analysts are trained in the proper use and maintenance of measuring devices to ensure the measurement of standards, reagents and sample volumes are within method tolerances.

TABLE 8.5-7
Summary of Inorganic Method Calibrations

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Acidity	Initial	305.1	2 point calibration of pH meter (± 0.05 pH units of true value)	--	Not Applicable
	Continuing	305.1	Not Applicable	--	Not Applicable
	Ending	305.1	Not Applicable	--	Not Applicable
Alkalinity	Initial	310.1 2320B	2 point calibration of pH meter (± 0.05 pH units of true value)	--	Not Applicable
	Continuing	310.1 2320B	Not Applicable	--	Not Applicable
	Ending	310.1 2320B	Not Applicable	--	Not Applicable
Ammonia	Initial	350.1	6 levels including blank, "r"[3] ≥ 0.995	--	Not Applicable
	Continuing	350.1	1 level or LCS every 10 samples ± 10% of true value	--	Not Applicable
	Ending	350.1	1 level or LCS every 10 samples ± 10% of true value	--	Not Applicable
Biochemical Oxygen Demand (BOD)	Initial	405.1	a. Winkler titration: Iodometric with standard thiosulfate b. Membrane electrode: Read in air and in water with zero dissolved oxygen	--	Not Applicable
	Continuing	405.1	Not Applicable	--	Not Applicable
	Ending	405.1	Not Applicable	--	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Bromide	Initial	300.0[4]	Method 300.0: 5 levels plus a blank, "r"[3] ≥ 0.995 Method 320.1: Not Applicable	9056	Method 300.0: 5 levels plus a blank, "r"[3] ≥ 0.995
	Continuing	300.0[4]	Method 300.0 : 1 level every 10 samples ± 10% of true value Method 320.1 Not Applicable	9056	Method 300.0: Not Applicable
	Ending	300.0[4]	Not Applicable	9056	Not Applicable
Chemical Oxygen Demand (COD)	Initial	410.4	Method 410.4: 5 levels plus a blank"r"[3] ≥ 0.995	--	Not Applicable
	Continuing	410.4	Method 410.4: 1 level every 10 samples ± 10% of true value Methods 410.1: Not Applicable	--	Not Applicable
	Ending	410.4	Method 410.4: 1 level ± 10% of true value Methods 410.1 & 410.2: Not Applicable	--	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Chloride	Initial	300.0[4] 325.2	Method 300.0 and 325.2: 5 levels plus blank "r"[3] ≥ 0.995	9056	Method 9056: 3 levels plus a blank
	Continuing	300.0[4] 325.2	Method 300.0 and 325.2: 1 level every 10 samples ± 10% of true value	9056	Method 9056: 1 per batch of 20 samples, ± 10% of true value
	Ending	300.0[4] 325.2	Method 300.0 and 325.2: 1 level every 10 samples ± 10% of true value	9056	Method 9056: Not Applicable
Chromium Cr^{+6}	Initial	3500 Cr-D	Method 3500 Cr-D: 3 levels plus blank	7196A	5 levels plus blank "r"[3] ≥ 0.995
	Continuing	3500 Cr-D	1 level every 10 samples ± 10% of true value	7196A	1 level every 10 samples ± 15%
	Ending	218.4 3500 Cr-D	1 level ± 10% of true value	7196A	1 level ± 15%

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Color	Initial	110.2	3 levels plus blank	--	Not Applicable
	Continuing	110.2	1 level every 10 samples	--	Not Applicable
	Ending	110.2	1 level	--	Not Applicable
Conductivity	Initial	120.1	Standard KCl solution	9050A	1 level to determine cell constant
	Continuing	120.1	Not Applicable	9050A	Not Applicable
	Ending	120.1	Not Applicable	9050A	Not Applicable
Cyanide (Amenable)	Initial	335.3	7 levels plus blank "r"[3] ≥ 0.995	9010B/ 9012A	7 levels plus blank "r"[3] ≥ 0.995
	Continuing	335.3	1 level every 10 samples ± 10% of true	9010B/ 9012A	1 mid-level every 10 samples ± 15% of true value
	Ending	335.3	1 level ± 10 % of true value	9010B/ 9012A	± 15% of true value
Cyanide (Total)	Initial	335.3	7 levels plus blank "r"[3] ≥ 0.995	9010B/ 9012A	7 levels plus blank "r"[3] ≥ 0.995
	Continuing	335.3	1 mid-level every 10 samples ± 10 % of true value	9010B/ 9012A	1 mid-level every 10 samples ± 15% of true value
	Ending	335.1 335.2	1 mid-level ± 10 % of true value	9010B/ 9012A	± 15% of true value

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Flashpoint	Initial	--	Not Applicable	1010	p-Xylene reference standard must have flashpoint of 27.2°C ± 1.1°C
	Continuing	--	Not Applicable	1010	Not Applicable
	Ending	--	Not Applicable	1010	Not Applicable
Fluoride	Initial	300.0[4] 340.2	Method 300.0: 5 levels plus a blank, "r"[3] ≥ 0.995 Method 340.2: 6 levels "r"[3] ≥ 0.995	9056	3 levels plus a blank
	Continuing	300.0[4] 340.2	1 mid-level every 10 samples ± 10% of true value	9056	1 per batch of 20 samples ± 10% of true value
	Ending	300.0[4] 340.2	1 mid-level ± 10% of true value	9056	Not Applicable
Hardness	Initial	130.2 2340B	Method 130.2: Standardize titrant Method 2340B: See ICP Metals 200.7	--	Not Applicable
	Continuing	130.2 2340B	Method 130.2: Not Applicable Method 2340B: See ICP Metals 200.7	--	Not Applicable
	Ending	130.2 2340B	Method 130.2: Not Applicable Method 2340B: See ICP Metals 200.7	--	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Iron (Ferrous)	Initial	3500-Fe D	3 levels plus a blank, "r"[3] ≥ 0.995	-	Not Applicable
	Continuing	3500-Fe D	1 mid-level every 10 samples ± 10% of true value	-	Not Applicable
	Ending	3500-Fe D	1 mid-level ± 10% of true value	-	Not Applicable
Methylene Blue Active Substances (MBAS)	Initial	425.1	4 levels plus blank "r"[3] ≥ 0.995	--	Not Applicable
	Continuing	425.1	1 level every 10 samples ± 10 % of true value	--	Not Applicable
	Ending	425.1	1 level ± 10 % of true value	--	Not Applicable
Nitrate	Initial	300.0[4] 353.2	5 levels plus a blank "r"[3] ≥ 0.995	9056	3 levels plus a blank
	Continuing	300.0[4] 353.2	1 mid-level every 10 samples ± 10% of true value	9056	1 per batch of 20 samples, ± 10% of true value
	Ending	300.0[4] 353.2	1 mid-level ± 10% of true value	9056	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Nitrite	Initial	300.0[4] 353.2	5 levels plus a blank "r"[3] ≥ 0.995	9056	3 levels plus a blank
	Continuing	300.0[4] 353.2	1 mid-level every 10 samples ± 10% of true value	9056	1 per batch of 20 samples, ± 10% of true value
	Ending	300.0[4] 353.2	1 mid-level ± 10% of true value	9056	Not Applicable
Nitrate-Nitrite	Initial	353.3	5 levels plus blank "r"[3] ≥ 0.995	--	Not Applicable
	Continuing	353.3	1 level every 10 samples ± 10% of true value	--	Not Applicable
	Ending	353.3	1 mid-level ± 10% of true value	--	Not Applicable
Phosphorus (total and Ortho-phosphate)	Initial	300.0[4] 365.3	3 levels plus a blank	--	Not Applicable
	Continuing	300.0[4] 365.3	1 level every 10 samples ± 10% of true value	--	Not Applicable
	Ending	300.0[4] 365.3	± 10% of true value	--	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
pH	Initial	150.1	2 level calibration that bracket the expected pH of the sample (± 0.05 pH units of true value)	9040B 9045C	2 point calibration (± 0.05 pH units of true value)
	Continuing	150.1	1 buffer check every 10 samples ± 5% of true value	9040B 9045C	Not Applicable
	Other	150.1	Third point check	9040B 9045C	Third point check
	Ending	150.1 4500-H^+ B	1 buffer check ± 5% of true value	9040B 9045C	Not Applicable
Phenolics	Initial	420.2	5 levels plus a blank "r"[3] ≥ 0.995	9066	5 levels plus a blank "r"[3] 0.995
	Continuing	420.2	1 mid-level every 10 samples ± 10% true value	9066	1 mid-level ± 15% true value
	Ending	420.2	1 mid-level ± 10% true value	9066	1 mid-level ± 15% true value
Phosphate	Initial	---	Not Applicable	9056	3 levels plus a blank
	Continuing	---	Not Applicable	9056	1 per batch of 20 samples, ± 15% of true value
	Ending	---	Not Applicable	9056	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Reactivity	Initial	--	Not Applicable	Chap 7	See Total Cyanide and Sulfide
	Continuing	--	Not Applicable		
	Ending	--	Not Applicable		
Settleable Solids	Initial	160.5	Not Applicable	--	Not Applicable
	Continuing	160.5		--	Not Applicable
	Ending	160.5		--	Not Applicable
Silica, Dissolved	Initial	370.1	Approximately 6 levels plus blank "r"[3] ≥ 0.995	--	Not Applicable
	Continuing	370.1	1 level ± 15% of true value	--	Not Applicable
	Ending	370.1	1 level ± 15% of true value	--	Not Applicable
Sulfate	Initial	300.0[4] 375.2 375.4	Method 300.0/375.2: 5 levels plus blank "r"[3] ≥ 0.995 Method 375.4: 3 levels plus blank "r"[3] ≥ 0.995	9038 9056	Method 9038: 3 levels plus a blank for every hour of continuous sample analysis. Method 9056: 3 levels plus a blank
	Continuing	300.0[4] 375.2 375.4	Method 300.0/375.2: 1 mid-level after every 10 samples ± 10% of true value Method 375.4: 1 level every 3 or 4 samples ± 10% of true value	9038 9056	Method 9038: Independent-prepared check standard every 15 samples Method 9056: 1 per batch of 20 samples, ± 10% of true value
	Ending	300.0[4] 375.2 375.4	± 10% of true value	9038 9056	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Sulfide	Initial	376.2	5 levels plus a blank "r" [3] ≥ 0.995	9030B/ 9034	This is a colorimetric titration. Therefore, calibration is not applicable.
	Continuing	376.2	1 level every 10 samples ± 10% of true value	9030B/ 9034	This is a colorimetric titration. Therefore, calibration is not applicable.
	Ending	376.2	± 10% of true value	9030B/ 9034	This is a colorimetric titration. Therefore, calibration is not applicable.
Sulfite	Initial	377.1	This is a colorimetric titration. Therefore, calibration is not applicable.	--	Not Applicable
	Continuing	377.1		--	Not Applicable
	Ending	377.1		--	Not Applicable
Temperature	Initial	170.1	Not Applicable	--	Not Applicable
	Continuing	170.1	Not Applicable	--	Not Applicable
	Ending	170.1	Not Applicable	--	Not Applicable
Total Dissolved Solids	Initial	160.1	This is a gravimetric determination. Calibrate balance prior to analysis	--	Not Applicable
	Continuing	160.1		--	Not Applicable
	Ending	160.1		--	Not Applicable
Total Kjeldahl Nitrogen (TKN)	Initial	351.3	Titrimetric: Standardize titrant Colorimetric: 7 levels plus blank	--	Not Applicable
	Continuing	351.3	Not Applicable	--	Not Applicable
	Ending	351.3	Not Applicable	--	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Total Organic Carbon (TOC)	Initial	415.1	3 levels plus blank	9060	3 levels plus blank "r"[3] ≥ 0.995
	Continuing	415.1	1 mid-level every 10 samples ± 15% of true value	9060	1 mid-level every 10 samples ± 15% of true value
	Ending	415.1	± 15% of true value	9060	± 15% of true value
Total Organic Halides (TOX)	Initial	---		9020B	Daily instrument calibration standard and blank in duplicate ± 10% of true value (calibration std.) Verify with independently-prepared check standard – ICV ± 10% SOP NO. CORP-WC-0001
	Continuing	---		9020B	CCV ± 10% of true value SOP NO. CORP-WC-0001
	Ending	---		9020B	CCV ± 10% of true value SOP NO. CORP-WC-0001
Total Solids	Initial	160.3	This is a gravimetric determination. Calibrate balance before use.	--	Not Applicable
	Continuing	160.3		--	Not Applicable
	Ending	160.3		--	Not Applicable
Total Suspended Solids (Nonfilterable)	Initial	160.2	This is a gravimetric determination. Calibrate balance before use.	--	Not Applicable
	Continuing	160.2		--	Not Applicable
	Ending	160.2		--	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Turbidity	Initial	180.1	Minimum of 1 level in each instrument range Follow manufacturer's instructions	--	Not Applicable
	Continuing	180.1	Not Applicable	--	Not Applicable
	Ending	180.1	Not Applicable	--	Not Applicable
Volatile Solids	Initial	160.4	This is a gravimetric determination. Calibrate balance before use.	--	Not Applicable
	Continuing	160.4		--	Not Applicable
	Ending	160.4		--	Not Applicable
Water Content	Initial	--	Calibrate Balance	--	Calibrate Balance
	Continuing	--	Not Applicable	--	Not Applicable
	Ending	--	Not Applicable	--	Not Applicable

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
GFAA Metals (excludes Hg)	Initial	200 series	3 levels plus blank ICV ± 10% of true value "r"[3] ≥ 0.995 SOP NO. CORP-MT-0003	7000A series	3 levels plus blank ICV ± 10% of true value "r"[3] ≥ 0.995 SOP NO. CORP-MT-0003
	Continuing	200 series	Every 10 samples ± 10% of true value SOP NO. CORP-MT-0003	7000A series	Every 10 samples ± 20% of true value SOP NO. CORP-MT-0003
	Ending	200 series	± 10% of true value SOP NO. CORP-MT-0003	7000A series	± 20% of true value SOP NO. CORP-MT-0003
	Other	200 series	Annually - Instrument detection limits SOP NO. CORP-MT-0003	7000A	Annually - Instrument detection limits SOP NO. CORP-MT-0003
ICAP Metals (excludes Hg)	Initial	200.7	1 level and blank Rerun high calibration standard: verify quantitation at ± 5% of true value,ICV RSD < 3% from replicate (SOP No. CORP-MT-0001)	6010B	1 level and blank Rerun high calibration standard: verify quantitation at ± 5% of true value, ICV RSD < 5% from replicate (SOP No. CORP-MT-0001)
	Continuing	200.7	Every 10 samples ± 5% of true value CCV RSD < 5% from replicate (SOP No. CORP-MT-0001)	6010B	Mid-level calibration standard Every 10 samples ± 10% of true value CCV RSD < 5% from replicate (SOP No. CORP-MT-0001)
	Ending	200.7	± 5% of true value CCV RSD < 5% from replicate (SOP No. CORP-MT-0001)	6010B	Mid-level calibration standard ± 10% of true value CCV RSD < 5% from replicate (SOP No. CORP-MT-0001)
	Other	200.7	ICSA, ICSAB: Analyze at beginning of run. For ICSA, AB criteria see Section 9.8, SOP No. CORP-MT-0001. Annually: ICP interelement correction factors Instrument detection limits	6010B	ICSA, ICSAB: Analyze at beginning of run. For ICSA, AB criteria see Section 9.8, SOP No. CORP-MT-0001. Annually: ICP interelement correction factors Instrument detection limits
ICP/MS Metals	Initial	200.8	1 level and blank, ICV: ± 10% of true	6020	1 level and blank, ICV: ± 10% of true

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
	Continuing	200.8	Mid-level calibration standard Every 10 samples, ± 10% of true value	6020	Mid-level calibration standard Every 10 samples, ± 10% of true value
	Ending	200.8	Not specified	6020	Mid-level calibration standard, ± 10% of true value
	Other	200.8	Initial tuning standard deviation ≤ 5% for five replicates; Mass calibration ≤ 0.1 amu from true; Resolution ≤ 0.75 amu full width at 5% peak height; Analyze ICSA and ICSAB at the beginning of each run and every 12 hours	6020	Initial tuning standard deviation ≤ 5% for four replicates; Mass calibration ≤ 0.1 amu from true; Resolution ≤ 0.9 amu full width at 10% peak height; Analyze ICSA and ICSAB at the beginning of each run and every 12 hours

TABLE 8.5-7
Summary of Inorganic Method Calibrations
(Continued)

Analysis	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Mercury by CVAA	Initial	245.1 245.5	5 levels plus blank ICV ± 10% of true value "r"[3] ≥ 0.995 SOP NO. CORP-MT-0005/0007	7470A 7471A	5 levels plus blank ICV ± 10% of true value "r"[3] ≥ 0.995 SOP NO. CORP-MT-0005/0007
	Continuing	245.1 245.5	Daily or every 10 samples, whichever is more frequent ± 20% of true value SOP NO. CORP-MT-0005/0007	7470A 7471A	Every 10 samples ± 20% of true value SOP NO. CORP-MT-0005/0007
	Ending	245.1 245.5	± 20% of true value SOP NO. CORP-MT-0005/0007	7470A 7471A	± 20% of original prepared standard SOP NO. CORP-MT-0005/0007
	Other	245.1 245.5	Annually: - Instrument detection limits	7470A 7471A	Annually - Instrument detection limits

Footnotes

(1) National Pollutant Discharge Elimination System

(2) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December, 1996).

(3) "r" = correlation coefficient

(4) Method not listed in 40 CFR Part 136.

TABLE 8.5-8
Summary of Organic Method Calibrations

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Aromatic Volatiles by GC	Initial	602	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8021B	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed. SOP No. CORP-GC-0001
	Continuing	602	Analyze QC check sample and evaluate per method requirements	8021B	Mid-level calibration standard analyzed every 10 samples. % D ≤ 15%, gases 20% D. Evaluate per SOP No. CORP-GC-0001 requirements.
	Ending	602	Not Applicable	8021B	Mid-level calibration standard % D ≤ 15%. Evaluate per SOP No. CORP-GC-0001 requirements.
	Other	602	Not Applicable	8021B	Not Applicable
Halogenated Volatiles by GC	Initial	601	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8021B	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed. SOP No. CORP-GC-0001
	Continuing	601	Analyze QC check sample and evaluate per method requirements	8021B	Mid-level calibration standard analyzed every 10 samples. % D ≤ 15%, gases 20% D. Evaluate per SOP No. CORP-GC-0001 requirements.
	Ending	601	Not Applicable	8021B	Mid-level calibration standard % D ≤ 15%. Evaluate per SOP No. CORP-GC-0001 requirements.
	Other	601	Not Applicable	8021B	Not Applicable

TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Nitrosamines by GC	Initial	607	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8070A	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed. SOP No. DEN-GC-0018
	Continuing	607	1 or more calibration standards analyzed daily % D ± 15% of predicted response	8070A	Mid-level calibration standard analyzed every 10 samples. % D < 15% of predicted response for any analyte quantitated and reported. SOP No. DEN-GC-0018
	Ending	607	Not Applicable	8070A	Mid-level calibration standard. % D < 15% of predicted response for any analyte quantitated and reported. SOP No. DEN-GC-0018
	Other	607	Not Applicable	8070A	Not Applicable
Herbicides by GC	Initial	615[9]	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8151A	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed. SOP No. CORP-GC-0001
	Continuing	615[9]	1 or more calibration standards analyzed daily % D ± 15% of predicted response	8151A	Mid-level calibration standard analyzed every 10 samples. % D < 15% of predicted response for any analyte quantitated and reported. SOP No. CORP-GC-0001
	Ending	615[9]	Not Applicable	8151A	Mid-level calibration standard. % D < 15% of predicted response for any analyte quantitated and reported. SOP No. CORP-GC-0001
	Other	615[9]	Not Applicable	8151A	Not Applicable

TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Nitroaromatics by HPLC	Initial	--	Not Applicable	8330	Minimum of 5 levels. Curve should be linear with zero intercept.
	Continuing	--	Not Applicable	8330	Midpoint calibration standard at beginning and after the midpoint of sample run. %D < 15% of predicted response for any analyte quantitated and reported.
	Ending	--	Not Applicable	8330	Midpoint calibration standard. %D: < 15% of predicted response for any analyte quantitated and reported.
	Other	--	Not Applicable	8330	Not Applicable
Polyaromatic Hydrocarbons by GC or HPLC	Initial	610	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8310	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.
	Continuing	610	1 or more calibration standards analyzed daily % D ± 15% of predicted response	8310	Mid-level calibration standard analyzed every 10 samples. % D < 15% of predicted response for any analyte quantitated and reported.
	Ending	610	Not Applicable	8310	Mid-level calibration standard. % D ± 15% of predicted response for any analyte quantitated and reported.
	Other	610	Not Applicable	8310	Not Applicable
Pesticides/ PCBs by GC	Initial	608	Minimum of 3 levels If % RSD < 10%, use avg RF. Otherwise, calibration curve employed	8081A 8082	Minimum of 5 levels. If % RSD < 20%, use avg RF. Otherwise, calibration curve employed. (See SOP No. CORP-GC-0001)
	Continuing	608	1 or more calibration standards analyzed daily % D ± 15% of predicted response	8081A 8082	Mid-level calibration standard analyzed every 10 samples. % D < 15% of predicted response for any analyte quantitated

TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Pesticides/ PCBs by GC (continued)	Ending	608	Not Applicable	8081A 8082	Mid-level calibration standard. % D < 15% of predicted response for any analyte quantitated and reported. (See SOP No. CORP-GC-0001)
	Other	608	Not Applicable	8081A 8082	Not Applicable
Petroleum Hydrocarbons/ Oil and Grease	Initial	413.1 413.2 418.1	Method 413.1: This is a gravimetric determination. Calibrate balance before use. Method 413.2/418.1: 3 levels plus a blank "r" ≥ 0.995	9070 9071A	This is a gravimetric determination. Calibrate balance before use
	Continuing	413.1 413.2 418.1	Not Applicable	9070 9071A	Not Applicable
	Ending	413.1 413.2 418.1	Not Applicable	9070 9071A	Not Applicable
	Initial	1664[8]	Calibrate analytical balance at 2 mg and 1000 mg Calibration must be ± 10% at 2 mg and ± 0.5% at 1000 mg or recalibrate balance SOP No. CORP-WC-0003	--	--
	Continuing	1664[8]	Not Applicable	--	--
	Ending	1664[8]	Not Applicable	--	--
Organophos-phorous Pesticides by GC	Initial	--	Not Applicable	8141A	Minimum of 5 levels If % RSD < 20%, use avg RF. Otherwise, calibration curve employed.

TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Organophos-phorous Pesticides by GC (continued)	Continuing	--	Not Applicable	8141A	Mid-level calibration standard analyzed every 10 samples. % D < 15% of predicted response for any analyte quantitated and reported.
	Ending	--	Not Applicable	8141A	Mid-level calibration standard % D < 15% of predicted response for any analyte quantitated and reported.
	Other	--	Not Applicable	8141A	Not Applicable
Semivolatiles	Initial	625	Minimum of 3 levels, lowest near but above MDL If % RSD ≤ 35%, use avg RF Otherwise calibration curve employed. SOP No. CORP-MS-0001	8270C	Minimum of 5 levels, % RSD for RF for CCCs[4] < 30% SPCCs[5]: RF > 0.050 SOP No. CORP-MS-0001
	Continuing	625	1 level every 24 hours Acceptance criteria are found in the method and SOP No. CORP-MS-0001	8270C	Mid-level standard every 12 hours (after tuning) %D for CCCs[4] < 20 % between RF from standard and avg RF from initial SPCCs[5]: RF > 0.050 SOP No. CORP-MS-0001
	Ending	625	Not Applicable	8270C	Not Applicable
	Other	625	DFTPP[7] tuning every 24 hours before standard or sample runs. SOP No. CORP-MS-0001	8270C	DFTPP[7] tuning at the beginning of every 12 hour shift. SOP No. CORP-MS-0001

TABLE 8.5-8
Summary of Organic Method Calibrations
(Continued)

Analytical Parameter	Calibration	NPDES[1]		RCRA (SW846)[2]	
		Method	Requirement	Method	Requirement
Volatiles	Initial	--	Not Applicable	8260B	Minimum of 5 levels, %RSD for RF for CCCs[4] < 30.0% SPCCs[5]: RF ≥ 0.300 for Chlorobenzene and 1,1,2,2-tetrachloroethane, Chloromethane and 1,1-dichloroethane, and RF > 0.100 for Bromoform (See Table 11, SOP No. CORP-MS-0002)
	Continuing	--	Not Applicable	8260B	Mid-level standard every 12 hours (after tuning) %Drift for CCCs[4] < 20.0% between RF from standard and avg RF from initial SPCCs[5]: RF ≥ 0.300 for Chlorobenzene and 1,1,2,2-tetrachloroethane, Chloromethane and 1,1-dichloroethane, and RF > 0.100 for Bromoform SOP No. CORP-MS-0002
	Ending	--	Not Applicable	8260B	Not Applicable
	Other	--	Not Applicable	8260B	BFB[6]tuning at the beginning of every 12 hour shift. SOP No. CORP-MS-0002

Footnotes

(1) National Pollutant Discharge Elimination System
(2) Resource Conservation and Recovery Act, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, (SW-846), Third Edition, September 1986. Contains Final Update I (July 1992), Final Update IIA (August 1993), Final Update II (September 1994), Final Update IIB (January 1995), and Final Update III (December 1996).
(3) TCDD - 2,3,7,8-Tetrachlorodibenzo-p-dioxin
(4) CCC - Continuing Calibration Compounds
(5) SPCC - System Performance Check Compound
(6) BFB - Bromofluorobenzene
(7) DFTPP - Decafluorotriphenylphosphine
(8) Footnote deleted
(9) Method not listed in 40 CFR Part 136.

TABLE 8.6-1
Precision and Accuracy Measurements

Measurement	Definition
Accuracy	The degree of agreement of a measurement with an accepted reference or true value. The only true or known values in the laboratory are spiked samples. Expressed as laboratory control sample (LCS) percent recovery (% R): $$LCS\ \%\ Recovery = \frac{X}{t} x\ 100$$ where: X = observed concentration t = concentration of spike added Expressed as matrix spike/matrix spike duplicate (MS/MSD) sample percent recovery (% R): $$MS / MSD\ \%\ Recovery = \frac{X_s - X}{t} x\ 100$$ where: X_S = observed concentration in spiked sample X = observed concentration in unspiked sample t = concentration of spike added
Precision	The measure of analytical reproducibility of two values. Expressed as the relative percent difference (RPD) of two values. $$RPD = \left[\frac{\lvert X_1 - X_2 \rvert}{\left(\frac{X_1 + X_2}{2} \right)} \right] x\ 100$$ where: X_1 = first observed concentration X_2 = second observed concentration

TABLE 8.6-1
Precision and Accuracy Measurements
(Continued)

Measurement	Definition
Arithmetic mean	The average of a set of values. $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$ where: $\bar{x}$ = the mean x_i = the ith data value n = number of data values
Standard Deviation	A measure of the random (probable) error associated with a single measurement within a data set. $s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$ where: s = sample standard deviation $\bar{x}$ = the mean x_i = the ith data value n = number of data values
Quality Control Chart	A graphical representation of analytical accuracy. Displays the arithmetic mean of a data set, the upper and lower warning limits and the upper and lower control limits.
ACCURACY	
Upper Control Limit (UCL)	$UCL = \bar{x} + 3s$
Upper Warning Limit (UWL)	$UWL = \bar{x} + 2s$
Lower Warning Limit (LWL)	$LWL = \bar{x} - 2s$
Lower Control Limit (LCL)	$LCL = \bar{x} - 3s$
PRECISION	
RPD	Zero to (mean RPD + 3s)

TABLE 8.11-1
Instrument Maintenance Schedule
Ion Chromatograph

As Needed	Daily	Weekly	Monthly	Semi-annually
Clean micromembrane suppressor when decreases in sensitivity are observed.	Check plumbing/leaks.	Check pump heads for leaks.	Check all air and liquid lines for discoloration and crimping, if indicated.	Lubricate left hand piston.
Check fuses when power problems occur.	Check gases.	Check filter (inlet)	Check/change bed supports guard and analytical columns, if indicated.	Clean conductivity cell.
Reactivate or change column when peak shape and resolution deteriorate or when retention time shortening indicates that exchange sites have become deactivated.	Check pump pressure.			Check conductivity cell for calibration.
	Check conductivity meter.			
	Check eluent level			
	De-gas pump head when flow is erratic.			

TABLE 8.11-2
Instrument Maintenance Schedule
Colorimetric Autoanalyzer

As Needed	Daily	Monthly	Semi-annually
Prepare fresh reagents. Replace tubing Clean detector cell	Check detector. Make sure there are no trapped bubbles in detector cell. Check filters Check peristaltic tubing. Check sampler Check auto diluter Clean sample probe shaft.	Clean pump, diluter, and XYZ Sampler.	Lubricate pump roller.

TABLE 8.11-3
Instrument Maintenance Schedule
Total Organic Halide Analyzer

Daily	As Needed
Check electrodes for damage, polish the electrodes.	Examine and clean or replace pyrolysis tube.
Replace dehydrating fluid and electrolyte fluid.	Clean titration cell.
Clean quartz boat.	Observe gas flow.
Observe check valves during use for backfeed.	Replace reference electrode fluid.
At end of each day of use, wash out absorption module, empty electrolyte and fill cell with DI water. Empty dehydrator tube	Change quartz wool.
Perform cell performance check.	Replace o-rings and seals.

TABLE 8.11-4
Instrument Maintenance Schedule
Inductively Coupled Argon Plasma/Mass Spectrometry (ICAP/MS)

Daily	Weekly	Monthly	Quarterly	As Needed
Check sample waste container level.	Check peristaltic pump: proper roller pressure, sample introduction tubing, correct pump rotation, condition of drain tubing.	Clean all filters and fans.	Replace oil in roughing pumps.	Check electronic settings for optimum sensitivity: resolution, mass calibration, ion optics, CEM, deflector voltage.
Check quartz torch condition.	Check condition of sampler and skimmer cones.	Check recirculator water level.		
Measure quartz torch for proper alignment.	Check and drain oil mist eliminator on roughing pumps.			
Clean spray chamber and nebulizer.				
Check oil level of roughing pumps.				

TABLE 8.11-5
Instrument Maintenance Schedule
ICP

Daily	Monthly or As Needed	Semi-annually	Annually
Check gases Check that argon tank pressure is 50-60 psi and that a spare tank is available. Check aspiration tubing	Clean plasma torch assembly to remove accumulated deposits.	Change vacuum pump oil.	Notify manufacturer service engineer for scheduled preventive maintenance service.
For Trace instruments, check vacuum pump gage. (<10 millitorr)	Clean nebulizer and drain chamber; keep free flowing to maintain optimum performance.	Replace coolant water filter. (may require more or less frequently depending on the quality of water)	
Check that cooling water supply system is full and drain bottle is not full.	Clean filters on back of power unit to remove dust.		
Check that nebulizer is not clogged.	Replace when needed: peristaltic pump tubing sample capillary tubing autosampler sipper probe		
Check that capillary tubing is clean and in good condition.	Check yttrium position. Check O-rings Clean/lubricate pump rollers.		
Check that peristaltic pump windings are secure.			
Check that high voltage switch is on.			
Check that exhaust screens are clean.			
Check that torch, glassware, aerosol injector tube, bonnet are clean.			

TABLE 8.11-6
Instrument Maintenance Schedule
Graphite Furnace Atomic Absorption

Daily	Weekly	Monthly	Semi-annually	Annually
Check gas lines and gas supply.	Clean optical windows.	Check coolant level in cooling unit.	Change graphite contacts	Notify manufacturer service engineer to clean optics.
Clean contact cylinders.				Check optics
Check tubes and platform; replace if corroded, flaking, or if low absorbance results. Check autosampler tubing and alignment. Flush autosampler tubing				
As needed, trim sampling capillary.				
Check drain lines and waste containers; empty as needed.				
Check acid rinse containers; fill as needed.				

TABLE 8.11-7
Instrument Maintenance Schedule
Cold Vapor Atomic Absorption

Daily	As Needed	Monthly
Clean aspirator by flushing with DI water.	Change source lamp	Clean cell in aqua regia.
Check tubing and replace if needed.		Clean aspirator in aqua regia.
Change silica gel in drying tube.		Clean windows with methanol.
Check argon gas supply.		
Adjust lamp.		

TABLE 8.11-8
Instrument Maintenance Schedule
Gas Chromatograph

Daily	As Needed	Quarterly/Semi-annually/Annually
Check for sufficient supply of carrier and detector gases. Check for correct column flow and/or inlet pressures.	Replace front portion of column packing or guard column or break off front portion of capillary columns. Replace column if this fails to restore column performance or when column performance (e.g. peak tailing, poor resolution, high backgrounds, etc.) indicates it is required.	Quarterly ELCD: change-roughing resin, clean cell assembly. Quarterly FID: clean detector
Check temperatures of injectors and detectors. Verify temperature programs.	Change glass wool plug in injection port and/or replace injection port liner when front portion of column packing is changed or front portion of capillary column is removed.	Semi-annually ECD: perform wipe test.
Check inlets, septa. Clean injector port	Replace septum	Annually ELCD: change finishing resin, clean solvent filter. ECD: detector cleaning and re-foiling, every five years or whenever sensitivity changes significantly, or erratic response or failing resolution is observed.
Check baseline level.	Perform gas purity check (if high baseline indicates that impure carrier gas may be in use).	Clean PID window
Check reactor temperature of electrolytic conductivity detector. Inspect chromatogram to verify symmetrical peak shape and adequate resolution between closely eluting peaks.	Replace or repair flow controller if constant gas flow cannot be maintained. Replace fuse. Reactivate external carrier gas dryers.	
	Detectors: clean when baseline indicates contamination or when response is low. FID: clean/replace jet, replace ignitor. NPD: clean/replace collector assembly. PID: clean lamp window monthly or replace as needed, replace seals. ELCD: check solvent flow weekly, change reaction tube, replace solvent, change reaction gas, clean/replace Teflon® transfer line. ECD: follow manufacturers suggested maintenance schedule Reactivate flow controller filter dryers when presence of moisture is suspected.	

TABLE 8.11-8
Instrument Maintenance Schedule
Gas Chromatograph
(Continued)

Daily	As Needed
GC (continued) Clean sparger with inert gas, and clean with methanol as needed.	HP 7673 Autosampler: replace syringe, fill wash bottle, dispose of waste bottle contents.
	Purge & trap devices: periodic leak checks quarterly, replace/condition traps (when poor response or disappearance of reactive or poorly trapped compounds), clean sample lines & valves (if they become contaminated), clean glassware. Check purge flow monthly. Bake trap as needed to correct for high background. Change trap annually or as needed whenever loss of sensitivity, or erratic response or failing resolution is observed.
	Purge & trap autosamplers: leak check system, clean sample lines, valves.
	PTA-30 autosampler (Mixed Waste area) also requires cleaning the syringes, frits, valves, and probe needles, adjustment of micro switches, replacement of Teflon® valve, and lubrication of components.

TABLE 8.11-9
Instrument Maintenance Schedule
High Pressure Liquid Chromatograph

Daily	As Needed
Check level of solution in reservoirs. If adding, verify that solvent is from the same source. If changing, rinse gas and delivery lines to prevent contamination of the new solvent.	Replace columns when peak shape and resolution indicate that chromatographic performance of column is below method requirements.
Check gas supply.	Oil autosampler slides when sample does not advance.
Pre-filter all samples	Rinse flow cell with 1N nitric acid if sensitivity low.
.	Change pump seals when flow becomes inconsistent.
	Flush with an appropriate solvent to remove all bubbles.
	If pressure increases, change the column frit.
	Repack front end of column Backflush column.

TABLE 8.11-10
Instrument Maintenance Schedule
Mass Spectrometer

Daily	Weekly	As Needed[2]	Quarterly	Annually
Check for sufficient gas supply. Check for correct column flow and/or inlet pressure.	Check mass calibration (PFTBA or FC-43)	Check level of oil in mechanical pumps and diffusion pump if vacuum is insufficient. Add oil if needed between service contract maintenance.	Check vacuum, relays, gas pressures and flows	Replace the exhaust filters on the mechanical rough pump every 1-2 years.
Check temperatures of injector, detector. Verify temperature programs.		Replace electron multiplier when the tuning voltage approaches the maximum and/or when sensitivity falls below required levels.		Change oil in the mechanical rough pump.
Check inlets, septa.		Clean Source, including all ceramics and lenses - the source cleaning is indicated by a variety of symptoms including inability of the analyst to tune the instrument to specifications, poor response, and high background contamination.		Relubricate the turbomolecular pump-bearing wick.
Check baseline level.		Repair/replace jet separator.		
Check values of lens voltages, electron multiplier, and relative abundance and mass assignments of the calibration compounds.		Replace filaments when both filaments burn out or performance indicates need for replacement.		

TABLE 8.11-12
Instrument Maintenance Schedule
Sonicator

Daily	As Needed
Daily when used: Inspect probe tips for inconsistencies (etching/pitting).	Replace probe tip.
	Disassemble and clean sonicator probe tips.
	Tune sonicator assembly.

TABLE 8.11-13
Instrument Maintenance Schedule
Analytical/Top Loading Balances

Daily	Annually
Check using Class S-verified weights once daily or before use Clean pan and weighing compartment	Manufacturer cleaning and calibration.

TABLE 8.11-14
Instrument Maintenance Schedule
Refrigerators/Walk-in Coolers

Daily	As Needed
Temperatures checked and logged.	Refrigerant system and electronics serviced.

TABLE 8.11-15
Instrument Maintenance Schedule
Ovens

Daily	As Needed
Temperatures checked and logged.	Electronics serviced.

TABLE 8.11-16
Instrument Maintenance Schedule
Specific Digital Ion Analyzer

Daily	As Needed
Daily when used: Calibrate with check standards. Inspect electrode daily, clean as needed. Inspect electrode proper levels of filling solutions daily, fill as needed. Clean probe, each use.	Electronics serviced.

TABLE 8.11-17
Instrument Maintenance Schedule
Turbidimeter

Daily	Monthly	As Needed
Daily when used: Adjust linearity on varying levels of NTU standards. Standardize with NTU standards. Inspect cells.	Clean instrument housing	Electronics serviced.

TABLE 8.11-18
Instrument Maintenance Schedule
Dissolved Oxygen Meter

Daily	As Needed
Daily when used: Calibrate with check standards. Check probe membrane for deterioration Clean and replace membrane with HCl solution.	Electronics serviced.

TABLE 8.11-19
Instrument Maintenance Schedule
Conductance Meter

Daily	As Needed
Daily when used: Check probe and cables. Standardize with KCl. Inspect conductivity cell	Electronics serviced.

TABLE 8.11-20
Instrument Maintenance Schedule
Chemical Oxygen Demand (COD) Reactor

Daily	As Needed
Daily when used: Calibrate with check standards.	Electronics serviced.

TABLE 8.11-21
Instrument Maintenance Schedule
Spectrophotometer

As Needed	Daily	Monthly	Annually
Dust the lamp and front of the front lens.	Check the zero %A adjustment.	Clean windows	Perform wavelength calibration.
Replace labmp	Clean sample compartment		Clean and align optics.
	Clean cuvettes		

TABLE 8.11-22
Instrument Maintenance Schedule
pH Meter

As Needed	Daily
Clean electrode.	Inspect electrode. Verify electrodes are properly connected and filled.
Refill reference electrode.	Inspect electrode proper levels of filling solutions. Make sure electrode is stored in buffer.

TABLE 8.11-23
Instrument Maintenance Schedule
Total Organic Carbon Analyzer

Daily	As Needed	Weekly	Monthly	Semi-Annually
Check: Oxygen supply Acid supply Carrier gas flow rate (~ 150 cc/min) IR millivolts for stability (after 30 min. warm-up) Reagent reservoirs Check syringe for leaks	Check injection port fitting after 50-200 runs. Tube end-fitting connections after 100 hours or use. Indicating drying tube. NDIR zero, after 100 hours of use. Change or recondition catalyst	Check injection port septum	Clean digestion vessel Clean condenser column Do the leak test	Change pump tubing Change halogen scrubber Change CO2 scrubber

TABLE 8.11-24
Instrument Maintenance Schedule
APCI/ESI LC/MS/MS

Daily	As Needed	Semi-annually	Annually
Check helium sparge supply for adequate pressure	Oil autosampler when it is noisy or picking up the tray	Replace rough-pump oil	Replace turbo-pump oil
Check solvent reservoirs for sufficient level of solvent	Change pump seals		Vacuum system components including fans and fan covers
Verify that pump is primed, operating pulse free	Change filters in autosampler		
Check needle wash reservoir for sufficient solvent	Replace column if excessive pressure or poor performance		
Verify capillary heater temperature	Rinse capillary with MeOH		
Verify vaporizer heater temperature	Clear capillary if clogged		
Verify manifold heater temperature	Rinse and clean corona needle		
Verify manifold pressure (~5 x 10^{-6})	Replace sample inlet tube in APCI (10.1 cm)		
Verify fore-pump pressure (~30 to 200mtorr)	Replace fused silica tube in ESI interface		
Verify rough pump and turbo-pump oil levels	Clean lenses		
Verify nitrogen pressure for auxiliary and sheath gasses	Clean skimmer		
Verify that corona and multiplier are functioning			

TABLE 8.11-25
Instrument Maintenance Schedule
Digestion Block

Annually
Check temperature with NIST thermometer

TABLE 8.11-26
Instrument Maintenance Schedule
Flash Point Tester

Daily	As Needed
Check tubing. Clean sample cup each use.	Check thermometer against NIST thermometer, when used.
Check gas.	
Clean flash assembly	
Check stirrer	

TABLE 9.4-1
Proficiency Testing Programs

PT Sample Program Description	Analysis Performed	Frequency of Participation
Water Pollution Program Samples provided by Environmental Resource Associates, a NIST-approved PT Provider	Trace Metals, Minerals, Nutrients, Demand, PCBs in Water, PCBs in Transformer Oil, Pesticides (Insecticides), Volatile Halocarbons, Volatile Aromatics, Semivolatiles (base/neutrals/acids), Polynuclear Aromatic Hydrocarbons (HPLC) and Miscellaneous (TSS, Cyanide, Total Phenolics)	Semi-annual
Water Supply Program Samples provided by Environmental Resource Associates, a NIST-approved PT Provider	All methods performed for: Trace Metals, Nitrate/Nitrite/Fluoride, Pesticides, Herbicides, Trihalomethanes, Volatile Organics, and Miscellaneous (TDS, Hardness, pH, Alkalinity, Sodium, Sulfate, Cyanide, Turbidity, and TOC)	Semi-annual
Hazardous Waste Program Samples provided by Environmental Resource Associates, a NIST-approved PT Provider	Semivolatile Organics (BNA), Pesticides, Herbicides, Volatile Organics, Metals, Anions, PAH, TPH Gas and Diesel, Explosives	Semi-annual
Army Corps of Engineers - MRD	Anions, Explosives, Herbicides, Organochlorine Pesticides, Polychlorinated Biphenyls, Semivolatile Organics, Volatile Organics, TAL Metals	18 months
USGS	Metals, nutrients, organics	Annually
Allied Signal	Volatile Organics, Semivolatile Organics, Metals, BOD, COD, TSS, TPH	Annually
STL Corporate Double Blind	Voalite Organics, Metals, General Chemistry, Base/Neutral Acid Extractables, Project Management	Annually
STL Denver Lab Internal PEs	As needed	As a follow-up to unacceptable PTs from other programs.

Acronyms and Initialisms

A2LA	American Association for Laboratory Accreditation
AA	Atomic Absorption
ANSI	American National Standards Institute
AR/COC	Analysis Request/Chain-of-Custody
ASQC	American Society for Quality Control
ASTM	American Society for Testing and Materials
BFB	Bromofluorobenzene
BLK	Blank
BOD	Biochemical Oxygen Demand
CCC	Calibration Check Compound
CEO	Chief Executive Officer
CF	Calibration Factor
CFR	Code of Federal Regulations
CHP	Chemical Hygiene Plan
CLP	Contract Laboratory Program
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act (Superfund)
COC	Chain-of-Custody
COD	Chemical Oxygen Demand
CRDL	Contract Required Detection Limit
CRQL	Contract Required Quantitation Limit
CSM	Customer Service Manager
CSRM	Certified Standard Reference Material
CST	Customer Service Team
CUR	Condition Upon Receipt
CV	Coefficient of Variation
CVAA	Cold Vapor Atomic Absorption (Spectroscopy)
DFTPP	Decafluorotriphenylphosphine
DOC	Dissolved Organic Carbon
DOE	Department of Energy
DOT	Department of Transportation
DQO	Data Quality Objective

Acronyms and Initialisms (continued)

EH&S	Environmental Health and Safety
EPA	(U. S.) Environmental Protection Agency
FAS	Field Analytical Services
FLAA	Flame Atomic Absorption (Spectroscopy)
FTIR	Fourier Transform Infrared (Spectrometry)
GC	Gas Chromatograph(y)
GC/MS	Gas Chromatography/Mass Spectrometry
GFAA	Graphite Furnace Atomic Absorption (Spectroscopy)
HDPE	High Density Polyethylene
HPLC	High Performance Liquid Chromatography
HRGC	High Resolution Gas Chromatography
HRMS	High Resolution Mass Spectrometry
ICAP	Inductively Coupled Argon Plasma (Spectroscopy)
ICAP/MS	Inductively Coupled Argon Plasma/Mass Spectrometry
ICS	Interference Check Sample
IDL	Instrument Detection Limit
IR	Infrared (Spectroscopy)
IS	Information Systems
IS	Internal Standard
ISO	International Organization for Standardization
IT	Information Technology
KRI	Key Result Indicator
LAN	Local Area Network
LCL	Lower Control Limit
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LIMS	Laboratory Information Management System
LRGC	Low Resolution Gas Chromatography
LRMS	Low Resolution Mass Spectrometry
LWL	Lower Warning Limit
MBAS	Methylene Blue Active Substance

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STL-Denver

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Timothy M. O'Shields, Laboratory Director	**Date** 12/14/00

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Acronyms and Initialisms (continued)

MDC	Minimum Detectable Concentration
MDL	Method Detection Limit
MS	Matrix Spike
MSA	Method of Standard Additions
MSD	Matrix Spike Duplicate
MSDS	Material Safety Data Sheet
NELAC	National Environmental Laboratory Accreditation Conference
NELAP	National Environmental Laboratory Accreditation Program
NCM	Nonconformance Memo
NIOSH	National Institute for Occupational Safety and Health
NIST	National Institute of Standards Technology
NMOC	Non-Methane Organic Compounds
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
NRM	National Reference Material
PAH	Polynuclear Aromatic Hydrocarbons (or PNA)
PC	Personal Computer
PCB	Polychlorinated Biphenyls
PDS	Post Digestion Spike
PE	Performance Evaluation
PEM	Performance Evaluation Mixture
PM	Project Manager
PQL	Practical Quantitation Limit
PSRL	Project-Specific Reporting Limit
PUF	Polyurethane Foam
QA	Quality Assurance
QAMP	Quality Assurance Management Plan
QAPP	Quality Assurance Project Plan or Quality Assurance Program Plan
QAS	Quality Assurance Summary
QC	Quality Control
QS	Quality System

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Acronyms and Initialisms (continued)

QuantIMS	STL xxxx Laboratory Information Management System
QRI	Quality-Related Item
RCRA	Resource Conservation and Recovery Act
RF	Response Factor
RFP	Request for Proposal
RFQ	Request for Quote
RL	Reporting Limit
RPD	Relative Percent Difference
RRF	Relative Response Factor
RSD	Relative Standard Deviation
RSO	Radiation Safety Officer
SDG	Sample Delivery Group
SOP	Standard Operating Procedure
SOW	Statement of Work
SPCC	System Performance Check Compounds
SPLP	Synthetic Precipitation Leaching Procedure
SRL	Standard Reporting Limit
SRM	Standard Reference Material
TCLP	Toxicity Characteristic Leaching Procedure
TIC	Tentatively Identified Compound
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TOX	Total Organic Halides
UCL	Upper Control Limit
UPS	Uninterruptable Power Supply
USEPA	United States Environmental Protection Agency
UWL	Upper Warning Limit
VOA	Volatile Organic Analysis
VOST	Volatile Organic Sampling Train
WAN	Wide Area Network
WS	Water Supply
WP	Water Pollution

Glossary

acceptance limits

Data quality limits specified for analytical method performance.

accuracy

Accuracy is the degree of agreement between a measurement and the true or expected value, or between the average of a number of measurements and the true or expected value. Systematic errors affect accuracy. For chemical properties, accuracy is expressed either as a percent recovery (R) or as a percent bias (R - 100).

aliquot, aliquant

A measured portion of a sample taken for analysis.

analytical spike

A sample created by spiking target analytes into a prepared portion of a sample just prior to analysis. (Also see matrix spike.)

anomaly

See nonconformance.

areas needing improvement

Represent isolated instances of noncompliance or issues that are judged to have a less immediate impact on data quality. Laboratory management must correct the situation or otherwise ensure that the condition does not recur. This term replaces the previous term used "Observations."

arithmetic mean

The arithmetic mean ($\bar{x}$) is the average of a set of values. It is equal to the sum of the observed values divided by the number of observations. Also called "average".

where: $\bar{x}$ = the mean

x_i = the ith data value

n = number of data values

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

Glossary (continued)

assessment
The evaluation process used to measure the performance or effectiveness of a system and its elements. Assessment is used as an all-inclusive term to denote any of the following: performance, systems, data and compliance audits, management systems reviews, peer reviews, inspections, or spot assessments.

associate
Employee.

audit
A planned and documented investigative evaluation of an item or process to determine its adequacy and effectiveness as well as compliance with established procedures, instructions, drawings, quality management plans, and other applicable documents.

benchmarking
A step-by-step method of improving performance by identifying and studying best practices and comparing them to industry practices.

bias
A systematic (consistent) error in test results. Bias is expressed as the difference between the population mean and the true or reference value, or as estimated from sample statistics, the difference between the sample average and the reference value.

blind performance evaluation sample
A sample either submitted to the laboratory or prepared in the laboratory whereby the concentrations of parameters of concern are known by the preparer and not by the laboratory.

calibration
Establishment of a relationship between various calibration standards and the measurements of them obtained by a measurement system, or portions thereof. The levels of the calibration standard should bracket the range of levels at which actual measurements are to be made. Calibration is also the act of making a scheduled comparison of instrument performance against national standards for

Glossary (continued)

instruments which measure physical parameters such as mass, time, and temperature. This type of calibration is independent of use in specific analyses and projects.

calibration curve
The graphical relationship between the known values for a series of calibration standards and instrument responses.

calibration factor (CF)
The ratio of the instrument response of an analyte to the amount injected. CFs are used in external standard calibrations.

$$CF = \frac{Total\ Area\ of\ Peak}{Mass\ Injected}$$

calibration standard
A standard used to quantitate the relationship between the output of a sensor and a property to be measured. Calibration standards should be traceable to standard reference materials (provided by NIST, or other recognized standards agencies) or a primary standard.

Certificate of Analysis
A Quanterra® report format containing analytical results without supporting/backup information.

Revised 4/12/14100 IC H

certified reference material
A reference material accompanied by a certificate issued by an organization certifying the contents and concentration(s) of the material. (See also standard reference material.)

chain-of-custody (COC)
A system of documentation demonstrating the physical custody and traceability of samples.

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Glossary (continued)

check standard analyses
A standard (often a midpoint standard) analyzed at a frequency specified in the method or in a SOP to verify the continuing calibration of the standard curve.

client
Any individual or organization for whom items or services are furnished or work is performed in response to defined requirements and expectations.

client sample
The material or collection media submitted to the laboratory for analysis. Field QC samples are considered client samples but laboratory QC samples are not counted as client samples when counting samples for QC batches.

coefficient of variation (relative standard deviation)
A measure of precision (relative dispersion). It is equal to the standard deviation (s) divided by the mean ($\bar{x}$) and multiplied by 100 to give a percentage value.

$$CV\ (RSD) = \left(\frac{s}{\bar{x}}\right) x\ 100$$

collocated samples
Independent samples collected in such a manner that they are equally representative of the variable(s) of interest at a given point in space and time. The results will indicate sampling as well as analytical variability.

comparability
Comparability is a measure of the confidence with which one data set can be compared to another. To ensure comparability, all laboratory analysts are required to use uniform procedures (i.e., SOPs) and a uniform set of units and calculations for analyzing and reporting environmental data.

Glossary (continued)

completeness

Completeness is a measure of the percentage of measurements that are judged to be valid measurements. At a minimum, the objective for completeness of data is 90% for each constituent analyzed. It is usually expressed as a percentage:

$$\%\ Completeness\ =\ \frac{V}{n}\ x\ 100$$

where: V = number of measurements judged valid
n = total number of measurements

composite

A sample composed of two or more increments.

control chart

A graphical representation of analytical accuracy. Displays the arithmetic mean of a data set, the upper and lower warning limits and the upper and lower control limits.

control table

A tabular presentation of test results with respect to time or sequence of measurement, together with limits within which the results are expected to lie when the analytical process is in a state of control.

controlled document

A document for which the distribution is known. Updates of the document are sent to the original recipients, unless the copy distributed is an uncontrolled copy.

corrective action

A measure taken to rectify conditions adverse to quality and, where necessary, to preclude their recurrence.

Glossary (continued)

correlation coefficient

The correlation coefficient (r) is a determination of how closely data "fits" a straight line. It is a number between -1 and 1 that indicates the degree of linear relationship between two sets of numbers. A correlation coefficient of +1 (usually calculated to three decimal places or 1.000) means the data falls exactly on a straight line with positive slope. A correlation coefficient of -1 (or -1.000) means the data falls exactly on a straight line with negative slope.

customer

See client.

data quality objective (DQO)

Data quality objectives (DQOs) are qualitative and quantitative statements used to ensure the generation of the type, quantity, and quality of environmental data that will be appropriate for the intended application (EPA 1994). Typically, DQOs are identified during project scope and development of sampling and analysis plans. In this QA manual, however, we refer to only the analytical DQOs because laboratories generally do not have any authority over sample collection, shipment, or other field-related activities that may affect the data quality of the environmental sample before the sample is received in the laboratory. EPA has established six primary analytical DQOs for environmental studies: precision, accuracy, representativeness, completeness, comparability, and detectability.

The components of analytical variability (uncertainty) can be estimated when QA and QC samples of the right types and quantities are incorporated into measurement procedures at the analytical laboratory. Quanterra® incorporates numerous QA and QC samples to obtain data for comparison with the analytical DQOs and to ensure that the measurement system is functioning properly. The QA and QC samples and their applications, described in Section 8.4 and are selected on the basis of method- or client-specific requirements. Field blanks, field duplicates, and performance evaluation (PE) samples are received from the client as unknown samples. Analytical laboratory QC samples for inorganic, organic, and radionuclide analyses may include calibration or instrument blanks, method blanks, background, duplicates, replicates, laboratory control samples (LCSs), calibration standards, matrix spikes (MSs), matrix spike duplicates (MSDs), surrogate spikes, and yield tracers.

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Glossary (continued)

data validation
See validation - data.

data verification
See verification - data.

deficiency
See nonconformance or finding.

degrees of freedom
The number of independent deviations used in calculating an estimate of the standard deviation.

double blind performance evaluation sample
A sample that contains select parameters at defined levels. The levels are unknown to the laboratory. The laboratory is also unaware that the sample is a performance evaluation sample.

duplicate sample analyses
Different aliquots of the same sample are analyzed to evaluate the precision of an analysis.

error
The difference between an observed or measured value and its true value.

field blank
A blank that is prepared and handled in the field and analyzed in the same manner as its corresponding client samples.

field matrix spike
A sample created by spiking target analytes into a sample in the field at the point of sample acquisition.

Glossary (continued)

finding

Noncompliant practices or policies which have significant adverse impact on data quality, technical defensibility, or regulatory acceptance of data. Findings require immediate attention by the laboratory management and must be resolved to comply with Quanterra's® quality documents and laboratory-established procedures often called deficiencies by auditors.

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geometric mean

The nth root of the product of all values in a set of n values or the antilogarithm of the arithmetic mean of the logarithms of all the values of a set of n values. The geometric mean is generally used when the logarithms of a set of values are nearly normally (Gaussian) distributed, such as is the case of much population data.

initial calibration

Analysis of a series of analytical standards at different specified concentrations; used to define the linearity and dynamic range of the response of an instrument to the target compounds prior to the analysis of samples.

inspection

Examination or measurement of an item or activity to verify conformance to specific requirements.

instrument detection limit (IDL)

IDL is a calculated estimate of instrument detectability defined by the USEPA Contract Laboratory Program (CLP).

internal standard (IS)

A compound added to every standard, QC sample, client sample, or sample extract at a known concentration prior to analysis for the purpose of quantitation. For example, internal standards are used as the basis for quantitation of the target compounds by GC/MS.

Glossary (continued)

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linear regression
A statistical method for finding a straight line that best fits a set of two or more data points, thus providing a relationship between two or more variables.

matrix
The component or substrate which contains the analyte(s) of interest. Examples of matrices are water, soil or sediment, and air. Matrix is not synonymous with phase (liquid or solid).

matrix effect
An interference in the measurement of analyte(s) in a sample that is caused by materials in the sample. Matrix effects may cause elevated reporting limits or may prevent the acquisition of acceptable results.

matrix spike (MS)
An aliquot of a matrix fortified (spiked) with known quantities of specific compounds and subjected to an entire analytical procedure in order to indicate the appropriateness of the method for a particular matrix. The percent recovery for the respective compound(s) is then calculated.

matrix spike duplicate (MSD)
A second aliquot of the same matrix as the matrix spike (above) that is spiked in order to determine the precision of the method.

may
Denotes permission but not a requirement.

mean
See arithmetic mean.

measurement
The process or operation of ascertaining the extent, degree, quantity, dimensions, or capability with respect to a standard.

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Interim SOP Change - This is a controlled document

SOP NUMBER:

SOP TITLE: Laboratory Quality Manual (LQM)

SOP SECTION(S) AFFECTED BY CHANGE: Page 299

REASON FOR CHANGE(S): Addition

Change section *{insert section #}* **from:** As it currently reads

To: Include the following immediately before the Linear Regression section:

Laboratory Quality Manual (LQM)

The Laboratory Quality Manual of environmental analysis (LQM) is a formal document that describes quality systems in terms of organizational structure, functional responsibilities of management, and staff, and lines of authority. The LQM documents the QMS and describes both the organizational and project-specific principles, goals, controls and tools of the QMS. The LQM provides the criteria and specifications for the generation of environmental analytical data.

SUBMITTED BY/DATE: 12/14/00

APPROVED BY:

Technical Reviewer	**Date** 12/14/00
James S. Kelly, Health and Safety Coordinator	**Date** 12/14/00
Larry Penfold, Quality Assurance Manager	**Date** 12/14/00
Timothy M. O'Shields, Laboratory Director	**Date** 12/14/00

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Glossary (continued)

median
The middle value of a set of data when the data set is ranked in increasing or decreasing order.

method
An assemblage of techniques.

method blank (MB)
An analytical control consisting of all reagents, which may include internal standards and surrogate standards, that is carried through the entire analytical procedure. The method blank is used to define the level of laboratory background contamination. Examples of method blanks are a volume of deionized or distilled laboratory water for water samples, a purified solid matrix for soil/sediment samples, or a generated zero air.

method detection limit (MDL)
The minimum concentration of an analyte that, in a given matrix and with a specific method, can be identified, measured, and reported with 99% confidence that the analyte concentration is greater than zero. The MDL is operationally defined as:

$$MDL = st_{(n-1,\ \alpha=0.99)}$$

where:

s = the standard deviation of a number of measurements of a blind or sample matrix containing the analyte at a concentration near the lowest standard recommended in the method and

$t_{(n-1,\ \alpha=0.99)}$ = the student's value for a one-sided t-statistic appropriate for the number of samples used to determine (s), at the 99% confidence level and n-1 degrees of freedom.

modified method
A standard or reference method which has been changed to meet project or matrix requirements.

must
Denotes a requirement is mandatory and has to be met.

Glossary (continued)

notable practices

Laboratory practices that increase effectiveness and quality and represent improvements with respect to conventional laboratory operations.

nonconformance

An unplanned deviation from an established protocol or plan. The deviation may be the result of Quanterra's® actions, then termed a deficiency. If the deviation is the result of events beyond the control of Quanterra®, it is termed an anomaly.

Revised 4 12/14/00 IC H

operational calibration

Routinely performed as part of instrument usage, such as the development of a standard calibration curve. Operational calibration is generally performed for instrument systems.

outlier

A result excluded from the statistical calculations due to being deemed "suspicious" when applying the "Grubbs Test" (or equivalent).

parameter

A constant or coefficient that describes some characteristic of a population (e.g., standard deviation, mean, regression coefficients). Also, a chemical being measured, i.e., an analyte.

percent difference

When two independent measurements of the same characteristics are available, it is possible to use the percent difference instead of the coefficient of variation to measure precision.

$$\%D = \left| \frac{X_1 - X_2}{X_1} \right| x\ 100\%$$

where: $\%D$ = percent difference
X_1 = first value
X_2 = second value

Glossary (continued)

percent recovery
A measure of accuracy determined from the comparison of a reported spike value to its true spike concentration.

$$\%R = \frac{observed\ conc. - sample\ conc.}{true\ spike\ conc.} \times 100\%$$

performance audit
See performance evaluation.

performance evaluation (PE)
A type of audit in which a known or characterized value is compared to the result obtained through the routine analysis of the sample in the laboratory to evaluate the proficiency of an analyst or laboratory.

periodic calibration
A calibration that is performed at prescribed intervals for equipment such as balances, thermometers, and balance weights. In general, they are performed on equipment that are distinct, singular purpose units, and are relatively stable in performance.

population
A generic term denoting any finite or infinite collection of individual things, objects, or events.

practical quantitation limit (PQL)
The lowest concentration a method can reliably achieve within limits of precision and accuracy and is derived from empirical, matrix-free method performance studies.

precision
Precision is an estimate of variability, that is, it is an estimate of agreement among individual measurements of the same physical or chemical property, under prescribed similar conditions. The precision of a measurement system is affected by random errors. Precision is expressed either as

Glossary (continued)

relative standard deviation (RSD) for replicate measurements greater than two or as relative percent difference (RPD) for duplicate measurements. Table 8.6-1 illustrates the formulae used to calculate units of precision (i.e., RSD and RPD).

preventive maintenance

An organized program within Quanterra® laboratories of actions (such as equipment cleaning, lubricating, reconditioning, adjustment and/or testing) taken to maintain proper instrument and equipment performance and to prevent instruments and equipment from failing during use.

Revised 4/12/14/00 IC H

primary standard

A material having a known, stable property that can be accurately measured or derived from established physical or chemical constants. It is readily reproducible and can be accepted (within stated limits) and used to establish the same value of another substance or item.

procedure

Detailed instructions to permit replication of a method. (See standard operating procedure.)

proficiency testing

A series of planned tests which will determine the ability of field technicians or laboratory analysts to perform routine analyses. The results from this testing may be used for comparison against established criteria or for relative comparisons among the data from a group of technicians or analysts.

project-specific reporting limit (PSRL)

See reporting limit.

protocol

Methodology specified in regulatory, authoritative, or contractual situations.

QC batch

The QC batch consists of a set of up to 20 field samples that behave similarly (i.e., same matrix) and are processed using the same procedures, reagents, and standards within the same time period.

Glossary (continued)

QC check sample
A reference matrix containing known concentrations of parameters of interest. If prepared in the laboratory, it is made using stock standard solutions independent of those used for calibration. If the results of these parameters do not meet acceptance criteria, corrective actions are taken.

qualification (personnel)
The characteristics of abilities gained through education, training, or experience, as measured against established requirements, such as standards or tests, that qualify an individual to perform a required function.

quality
The sum of features and properties/characteristics of a process, item, or service that bears on its ability to meet the stated needs of the user. Quanterra® has defined quality as meeting the needs of our clients, both internal and external. Revised 4/12/14/00 IC H

quality assurance (QA)
An integrated system of management activities involving planning, implementation, assessment, reporting, and quality improvement to ensure that a process, item, or service is of the type and quality needed and expected by the customer.

Quality Assurance Directive
QA directives are memos issued by the QA Director (or the QA Managers for their facility) to clarify policies, Procedures, and the QAMP; or to give direction for an immediate action to ensure or maintain quality.

Quality Assurance Management Plan (QAMP) Revised 4/12/14/00 IC G
The Quality Assurance Management Plan for Environmental Analyses (QAMP) is a formal document that describes quality systems in terms of organizational structure, functional responsibilities of management, and staff, and lines of authority. The QAMP documents the QMS and describes both the organizational and project-specific principles, goals, controls, and tools of

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Interim SOP Change - This is a controlled document

SOP NUMBER:

SOP TITLE: Laboratory Quality Manual (LQM)

SOP SECTION(S) AFFECTED BY CHANGE: Page 304

REASON FOR CHANGE(S): Edit and Removal

Change section from: As it reads in the Quality Assurance Directive Section

To: Replace QAMP with LQM

Change section *{insert section #}* **from:** As it currently reads

To: Omit section on Quality Assurance Management Plan (QAMP)

SUBMITTED BY/DATE: 12/14/00

APPROVED BY:

Technical Reviewer	**Date** 12/14/00
James S. Kelly, Health and Safety Coordinator	**Date** 12/14/00
Larry Penfold, Quality Assurance Manager	**Date** 12/14/00
Timothy M. O'Shields, Laboratory Director	**Date** 12/14/00

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Glossary (continued)

the QMS. The QAMP provides the criteria and specifications for the generation of environmental analytical data.

Quality Assurance Project or Program Plan (QAPP)
A formal document describing in comprehensive detail the necessary QA, QC, and other technical activities that must be implemented to ensure the results of the work performed will satisfy the stated performance criteria.

quality control (QC)
The overall system of technical activities that measures the attributes and performance of a process, item, or service against defined standards to verify that it meets the stated requirements established by the client or by Quanterra®. Revised 12/14/00 IC H

quality improvement
The process of improving the quality of operations. This process encourages worker recommendations for improvement of work processes and requires timely management evaluation and feedback or implementation.

quality management
That aspect of the overall management system of the organization that determines and implements the quality policy. Quality management includes strategic planning, allocation of resources, and other systematic activities (e.g., planning, implementation, and assessment) pertaining to the quality management system.

quality management system (QMS)
A structured and documented management system describing the policies, objectives, principles, organizational authority, responsibilities, and implementation plan of an organization for ensuring quality in its work processes, products, and services. The quality system provides the framework for planning, implementing, and assessing work performed by the organization and for carrying out required QA and QC.

Glossary (continued)

random error
Variations of repeated measurements that are random in nature and individually not predictable.

range
The difference between the largest and smallest numbers in a set of numbers.

raw data
All documentation associated with the original recording of analytical results pertinent to a specific sample or set of samples. This may include laboratory worksheets, calculation forms, instrument-generated output, analyst notes, etc., from sample receipt through final reporting.

reagent water
Water in which an interferant is not observed at or above the minimum quantitation limit of the parameters of interest. The reagent water's purity and acceptability is verified by analysis with each set of samples.

recovery
See percent recovery.

reference method
A method of known and demonstrated accuracy.

regression coefficients
The quantities describing the slope and intercept of a regression line.

relative error
An error expressed as a percentage of the true value or accepted reference value.

relative percent different (RPD)
Statistic for evaluating the precision of a replicate set. For replicate results:

Glossary (continued)

$$RPD = \left[\frac{|X_1 - X_2|}{\left(\frac{X_1 + X_2}{2} \right)} \right] x\ 100$$

where: X_1 = first observed concentration
X_2 = second observed concentration

relative response factor (RRF)
A measure of the relative mass spectral response of a compound compared to its internal standard. RRFs are determined by analysis of standards and are used in the calculation of concentrations of analytes in samples. Because a RRF is the comparison of two responses, it is a unitless number. RRFs are determined by the following equation:

$$RRF = \frac{A_x}{A_{IS}} x \frac{C_{IS}}{C_x}$$

where: A = area of the characteristic ion measured
C = concentration
IS = internal standard
x = analyte of interest

relative standard deviation (RSD)
See coefficient of variation.

reporting limit (RL)
One of two types of reporting limit conventions within Quanterra®. The Reporting Limit (RL) is a uniform, Quanterra® -wide reporting limit based on an evaluation of the PQLs at Quanterra® laboratories and the expected method performance in routine water and soil matrices. Project Specific Reporting Limits (PSRLs) are reporting limits that are defined by project requirements.

Revised 9/12/14/00 JC H

Glossary (continued)

representative sample
A sample taken to represent a lot or population as accurately and precisely as possible.

representativeness
Representativeness is the degree to which data accurately and precisely represent a characteristic of a population, a variation in a physical or chemical property at a sampling point, or an environmental condition. Data representativeness is primarily a function of sampling strategy; therefore, the sampling scheme must be designed to maximize representativeness. Representativeness also relates to ensuring that, through sample homogeneity, the sample analysis result (concentration) is representative of the constituent concentration in the sample matrix. At each Quanterra® laboratory, every effort must be made to analyze an aliquot that is representative of the original sample, and to ensure the homogeneity of the sample before subsampling.

reproducibility
The precision, usually expressed as a standard deviation, measuring the variability among results of measurements of the same sample at different laboratories.

response factor (RF)
A factor derived from the calibration of a compound that is used in the quantitation calculation of sample analytes. A response factor may be derived from an external standard calibration (then called a Calibration Factor) or from an internal standard calibration (then called a Relative Response Factor).

secondary standard
A material having a property that is calibrated against a primary standard.

self assessment
Assessments of work conducted by individuals, groups, or organizations directly responsible for overseeing or performing the work.

shall
Denotes a requirement that is mandatory and has to be met.

Glossary (continued)

should
Denotes a guideline or recommendation.

standard addition
The procedure of adding known increments of the analyte of interest to a sample to cause increases in detection response to subsequently establish, by extrapolation of the plotted responses, the level of the analyte of interest present in the original sample.

standard deviation
A measure of the dispersion about the mean of the elements in a population. The square root of the variance of a set of values:

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

where: s = standard deviation
Σ = sum of
X = observed values
n = number of observations

standardization
The establishment of the value of a potential standard with respect to an established or known standard.

standard method
A method of known and demonstrated precision issued by an organization generally recognized as competent to do so.

Glossary (continued)

standard operating procedure (SOP)
A written document that details an operation, analysis, or action, with prescribed techniques and steps, that is officially approved as the method for performing certain routine or repetitive tasks.

standard reference material (SRM)
A material produced in quantity, of which certain properties have been certified by the National Institute of Standards and Technology (NIST), formerly NBS, or other agencies to the extent possible to satisfy its intended use.

standard verification
Standard is checked by Quanterra® or the vendor versus a known specification. See Section 8.5.4.3.

Revised 9/12/14/00 JC H

statistic
A constant or coefficient that describes some characteristic of a sample. Statistics are used to estimate parameters of populations.

stock solution
A concentrated solution of analyte(s) or reagent(s) prepared and verified by prescribed procedure(s), and used for preparing working standards or standard solutions.

subsample
A portion taken from a sample. A laboratory sample may be a subsample of a gross sample; similarly, a test portion may be a subsample of a laboratory sample.

supplier
See vendor.

surrogate (surrogate standard)
Compounds, when required by a method, that are used added to every blank, sample, LCS, matrix spike, matrix spike duplicate, and standard. They are used to evaluate analytical efficiency by

Glossary (continued)

measuring recovery. Surrogates include brominated, fluorinated, or isotopically-labeled compounds that are not expected to be detected in environmental media.

systematic error

The condition of a consistent deviation of the results of a measurement process from the reference or known level.

systems audit or evaluation

A systematic on-site qualitative review of facilities, procedures, equipment, training, record keeping, data verification, and reporting aspects of a quality assurance system to arrive at a measure of the capability of the system. Within Quanterra®, system audits or evaluations are performed on a periodic basis under the direction of the Quanterra® Corporate Director of Quality Assurance.

technique Revised 4 12/14/00 IC H

Physical or chemical principle for characterizing materials of chemical systems.

traceability of data

The entire documented chain of acquired data from the original acquisition effort through to the final tabulation, synthesis, reduction, and storage activities. The documentation will allow complete reconstruction of the data.

traceability of samples

During all environmental monitoring field efforts, acquired samples will be assigned specific and unique identification numbers. These sample numbers shall be accompanied by documentation (chain-of-custody form) which clearly identifies all parameters associated with sample acquisition. All additional sample numbering systems applied to the sample must be clearly cross-referenced to the field sample number to provide for traceability of samples from acquisition to reporting of sample results.

traceability of standards

The ability of an analytical standard material used for calibration purposes to be traced to its source. The standards used by Quanterra® must be traceable via written documentation to sources which

Glossary (continued)

produce or sell verified or certified standards, i.e., National Institute for Standards and Technology, or vendors preparing standards from those sources which they have certified.

validation - computer software
The process of establishing documented evidence which provides a high degree of assurance that a specific process will consistently produce a product meeting predetermined specifications and quality attributes. This process demonstrates and documents that the software performs correctly and meets all specified requirements.

validation - data
The process of a second party performing a systematic review of the raw and final data produced by a laboratory using predetermined criteria to ascertain the validity of the data with respect to the criteria (e.g., HAZWRAP data validation).

vendor
Any individual or organization furnishing items or services or performing work according to a procurement document. This is an all-inclusive term used in place of any of the following: supplier, seller, contractor, subcontractor, or consultant.

verification - computer software
The process of checking the accuracy of manually entered or automatically (electronically) calculated information.

verification - data
The process of reviewing data to ensure that data reduction has been correctly performed and that analytical results to be reported correspond to the data acquired and processed.

Appendix J - Decision, Responsibility, and Communication Flow Charts

NASA White Sands Test Facility
Plume-Front Stabilization System
Decision, Responsibility, and Communication Matrix

Input

Environmental Contractor - Data and Collection Management Group Troy Wiebe

Environmental Contractor - Geosciences Group Geoff Giles

Environmental Contractor - Engineering Group Don Minnick

Environmental Contractor - Department Management Jack Kirby and Peter Pache

NASA - WSTF Environmental Office Radel Bunker-Farrah and Michael Zigmond

Output

System operational data **Automated**

Normal Operational Parameters?

YES

NO

Unregulated discharge?

YES

NO

Troubleshoot, mitigate

Continue routine O&M

- Mitigate
- Notification within 24 hrs
- Submittal of corrective action plan within 15 days

Measure groundwater monitoring well elevations and depths

Collect and submit samples to analytical lab

Receive analytical results

Load data in database

QA Results (within 24 hrs.)

Download data and generate monthly internal report(s)

NO

Generate internal report (automatic limit comparison)

Do COC results for effluent or GW monitoring wells exceed DP-1255 limits or MCL's?

Evaluate data w/ respect to:
- pieziometric analysis
- COC trending
- particle tracking

Evaluate data w/ respect to:
- mass removal
- destruction efficiency
- effluent COC trending

YES

Notification

Significant Action Required?

YES

Significant Action Required?

YES

Notify NASA

Notify NMED
- within 24 hrs. for analytical data exceedance

NMED notification
- Groundwater Bureau
- Hazardous Waste Bureau

NO

NO

Resample within 5 days

Implement minor action (if required)

Inspect system within 24 hrs if COC exceedance has occurred. Implement action (if required)

Assign responsibility for implementation of NMED directive

Notify Contractor Environmental Department

Regulatory directives/ guidance

Monthly (or as required) status meetings
- revise project plan if required

Status briefing
System Operator

Compile system data/ Coordinate and produce draft status reports(s)

Report review

Compile system data/ Coordinate and produce final status reports(s)

Approve and route report(s) to NASA

Review and submit report(s)

Report as appropriate:
- NMED Hazardous Waste Bureau
- NMED Ground Water Bureau
- New Mexico State Engineer Office
- New Mexico State Land Commission